Sensur av hovedoppgaver

Høgskolen i Buskerud og Vestfold
Fakultet for teknologi og maritime fag

Prosjektnummer: **2014-05**
For studieåret: **2013/2014**
Emnekode: **SFHO3201**

Prosjektnavn
Smart DDSV Demonstrator

Utført i samarbeid med: FMC Technologies

Ekstern veileder: Vetle Stokke Vintervold

Sammendrag: Gruppen har laget en demonstrator for å kunne vise fordelene ved å bruke en DDSV i et Subsea anlegg. Denne demonstratoren skal FMC Technologies kunne bruke til å "selge" denne teknologien videre til sine kunder. Ventilen som er benyttet er en Moog d638-ventil. Gruppen har laget et hydraulisk system montert på et portabelt bord som skal vise mulighetene med ventilen. Systemet blir overvåket og styrt av et LabVIEW grensesnitt basert på CANbus kommunikasjon.

Stikkord:
- Direct Drive Servo proportional Valve (DDSV)
- Hydraulikk
- CAN-kommunikasjon

Tilgjengelig: DELVIS, se attachment to censorship.

Prosjekt deltagere og karakter:

Navn	Karakter
Snorre Kløcker	
Marit Hammer	
Eirik Kristoffersen	
Håkon Mørk Solaas	
Nicolai Skjelsbæk	

Dato: 12. Juni 2014

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Antonio L. L. Ramos
Intern Veileder

____
Karoline Moholth
Intern Sensor

____
Vetle S. Vintervold
Ekstern Sensor

Attachment to censorship

Three documents from the Smart DDSV Demonstrator Project are classified as secret. These documents are:

- G-ID, Idea Document
- G-MT, Main Technical Report
- G-FR, Final Project Report

These documents are classified as secret to protect possible future applications and patents originating from this project, and to keep FMC Technologies' intellectual property away from publications at this point. This is in accordance with appendix to "Standardavtale for studentenes arbeid med bacheloroppgaven med eksterne oppdragsgivere ved Høgskolen i Buskerud og Vestfold - Fakultet for teknologi og maritime fag - Kongsberg institutt for ingeniørfag", stating that FMC Technologies reserve all rights to this project and appurtenant results. Høgskolen i Buskerud og Vestfold can refer to these results in general terms during lectures.

Vetle S. Vintervold
External Sensor
FMC Technologies

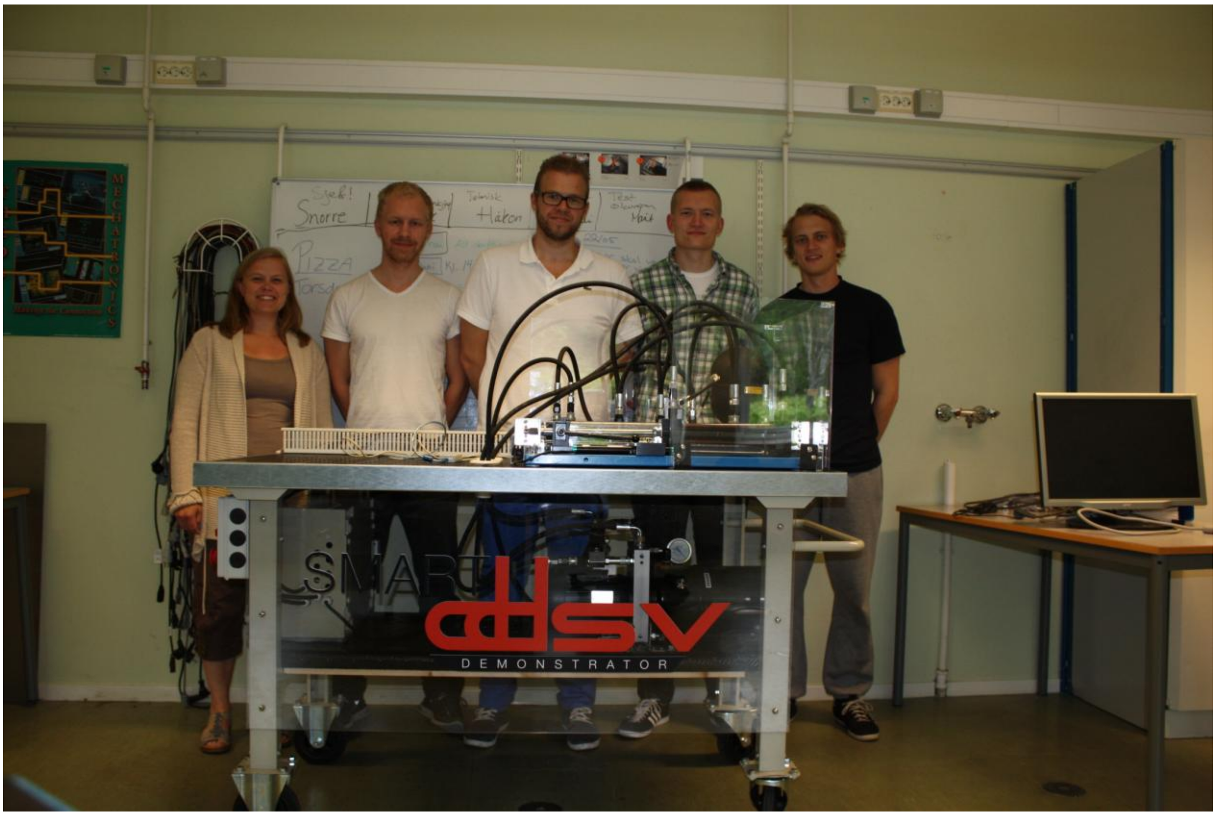
Nicolai Skjelsbæk
Document Responsible
Smart DDSV Demonstrator

SMART

DEMONSTRATOR

Document folder

26.05.2014



Smart DDSV Demonstrator documents

1.0 Planning documents

P-xx

Project Plan

P-PP

Version	Date	Main Author	Co-Author	Approved by
1	14.02.2014	Snorre Kløcker		Nicolai Skjelsbæk
2	24.03.2014	Snorre Kløcker		Håkon M. Solaas
3	21.05.2014	Snorre Kløcker		Nicolai Skjelsbæk

Changes:

Version	Date	Changes	Released by	Approved by
1→2	24.03.2014	Project model added Activity and milstones changed	Snorre Kløcker	Håkon M. Solaas
2→3	21.05.2014	Activitys changed. Updated according to template	Snorre Kløcker	Nicolai Skjelsbæk

This document contains the project plan used through the Smart DDSV demonstrator bachelor thesis

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
DDSV	Direct Drive proportional Servo Valve
S.K	Snorre Kløcker
M.H	Marit Hammer
E.K	Eirik Kristoffersen
N.S	Nicolai Skjelsbæk
H.M.S	Håkon Mørk Solaas

Table 1: Abbreviations

2.0 Introduction

This project plan gives an overview over all the activities in the project. It shows the duration of every activity and who is responsible for the activity. The person who is responsible for the activity, may delegate the work to other members of the group. Activity ID's are defined in the Activity plan P-AP [1].

Some activities have an activity follower, which shows related activities.

The project plan can change due to phase and iteration reviews. Please notice document version.

Please see following documents in accordance with the project plan: P-AP [1], P-PI [2], P-TP [3] and P-DP [4].

2.1 Project model

The project model is based on an evolutionary model, and consists of four different phases. Each phase includes 3 iterations. For more information about project model see P-PI [2].

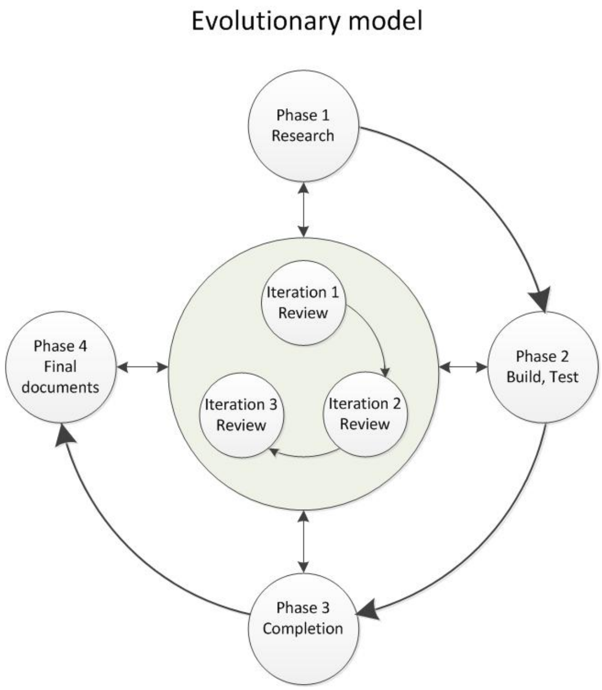


Figure 1: Project model

2.2 Explanations

Special dates

Milestone
Presentation
Exam/Easter

Symbols

Iteration

Status

100 %
50 %
0 %

Phase

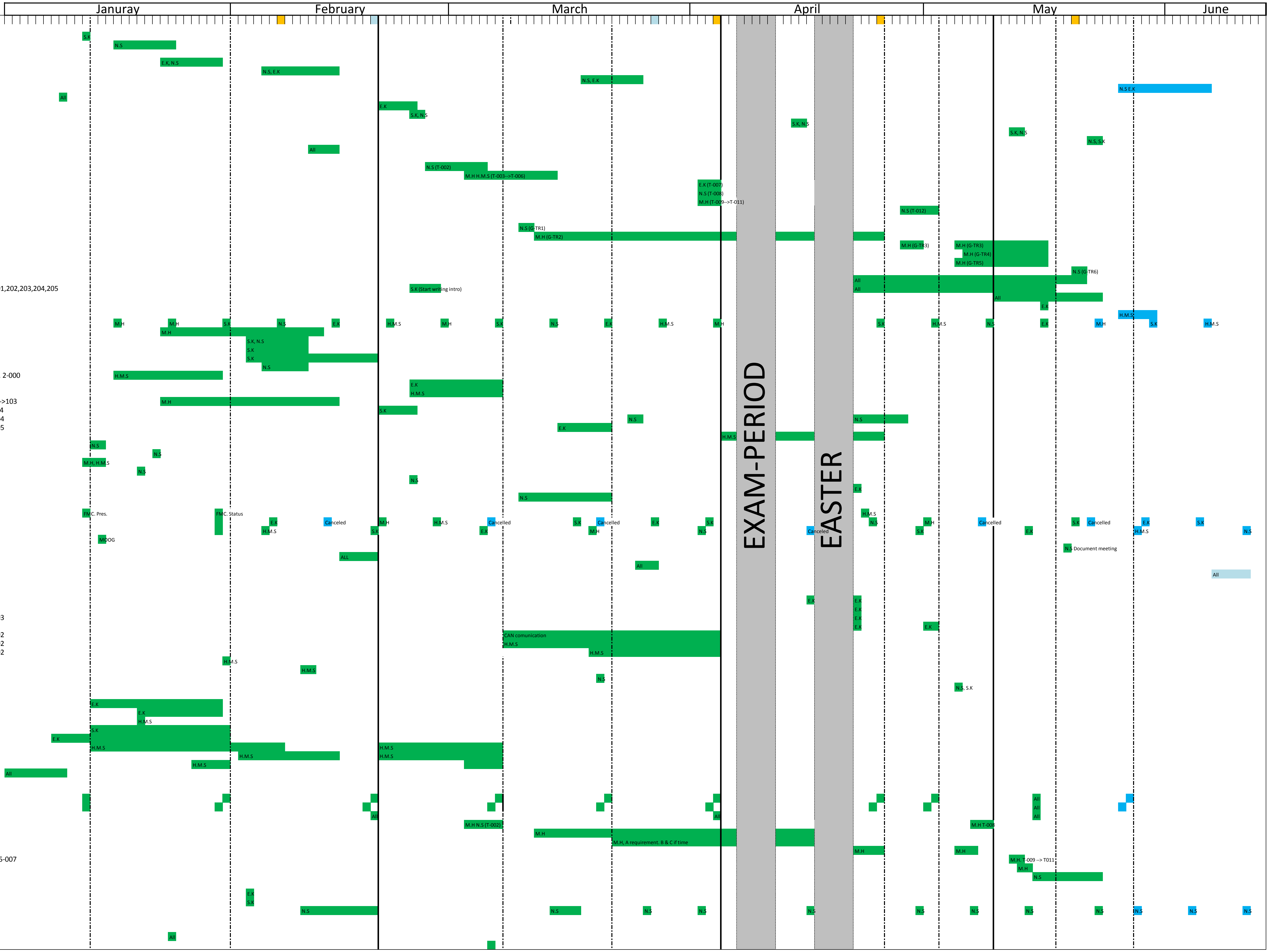
2.3 Milestones

Milestone	Description	Date
1	Project plan should be finished Requirement specification should be finished Components for demonstrator should be ordered	07.02.2014
2	Interface, GUI finished	04.04.2014
3	Demonstrator completed and tested	29.04.2014
4	All documentation finished	20.05.2014
5	Last presentation finished	11.06.2014

Table 2: Milestones

3.0 Project Plan

Activity ID	Activity Name	Related act.
Documentation		
1-000	Idea Document	4-103
1-001	Risk Analysis	1-000
1-002	Minutes of Meeting	2-000-->002
1-003	Budget	4-xxx
1-004	First Presentation	
1-005	Second Presentation	
1-006	Final Presentation	
1-007	General Presentations	
1-008	Logistics Report	
1-009	First Phase and Iteration repor	5-000 -> 002
1-010	Second Phase and Iteration re	5-001,5-002
1-011	Third Phase and Iteration repo	5-001,5-002
1-012	Fourth Phase and Iteration rep	5-001,5-002
1-013	Contract	
1-016	Test procedures	4-xxx
	(T-002)	
	(T-003-->T-006)	
	(T-007)	
	(T-008)	
	(T-009-->T-011)	
	(T-012)	
1-017	Test Results reports	1-016, 5-XXX
	(T-002)	
	(T-003-->T-006)	
	(T-007)	
	(T-008)	
	(T-009-->T-011)	
	(T-012)	
1-018	Final project report	all
1-019	Main Technical report	1-017,200,201,202,203,204,205
1-020	Post Analysis report	all
1-021	Deviation report	1-003
1-022	Wall Chart	
1-100	Follow-Up document	1-003
1-101	Test Plan	
1-102	Activity Plan	
1-103	Phase and Iteration plan	
1-104	Project Plan	1-104
1-105	Document Plan	1-103
1-200	Requirement Specification	1-000, 4-103, 2-000
1-201	Specification, Hydraulic System	4-000-->004
1-202	Specification, Interface and GU	4-100-->102
1-203	Specification, Test	1-200,4-000-->103
1-204	Specification, valve	4-000-->4-004
1-205	Specification, Electrical	1-201,202,204
1-300	User manual, hydraulic System	1-201,204,205
1-301	User manual, Interface and GU	1-202,205
1-400	Documentation Template	
1-401	Minutes of Meeting Template	
1-402	Hour list Template	
1-403	Follow up template	
1-404	Test Report Template	
1-405	Deviation Teport Template	
1-500	Design Document	3-201
Presentations and Meetings		
2-000	FMC general meetings	1-002, 1-007
2-001	Internal supervisor at HBV	1-002, 1-100
2-002	External supervisor at FMC	1-002
2-003	Supplier	1-002, 1-007
2-004	Internal discussion	
2-100	First presentation	1-004
2-101	Second presentation	1-005
2-102	Third presentation	1-006
Design and Construction		
3-000	Log-splitter	4-000
3-001	FESTO-components	4-001
3-002	Return spring	3-004,4-002
3-003	DDSV	4-000,001,003
3-004	Mounting components on tabl	3-201,5-007
3-100	CAN	4-100,101,102
3-101	GUI	4-100,101,102
3-102	Regulation	4-100,101,102
3-200	Logo	
3-201	3D-model of demonstrator	3-000-->003
3-202	Mounting of table	
3.203	Electrical	
Research		
4-000	Log-splitter	1-000,4-xxx
4-001	FESTO-components	1-000,4-xxx
4-002	Return spring	1-000,4-xxx
4-003	DDSV	1-000,4-xxx
4-004	System	1-000,4-xxx
4-100	CAN	1-000,4-xxx
4-101	GUI	1-000,4-xxx
4-102	Regulation	1-000,4-xxx
4-103	Define task	
4-200	Prezi	
Test and Review		
5-000	Customer review	2-000
5-001	Iteration review	2-000
5-002	Phase review	5-000,001
5-004	Pressure test (T-002, T-008)	1-016
5-005	SW test (T-003)	1-016
5-006	Simulator test (T-004-->T-006)	1-016
5-007	Pre-assembly test (T-007)	1-016
5-008	System test (T-009-->T-011)	1-016,5-003,5-007
5-009	FAT (T-012)	1-016
5-010	Final document review	1-XXX
Other		
6-000	Order parts for hydr. system	4-001, 4-002
6-001	Order valve	4-001, 4-003
6-002	Web/Sharepoint	
6-003	Software setup FMC computer	
6-004	Logistics	
6-100	Cleaning lab facilities	
6-101	Teambuilding	



4.0 References

[1] Smart DDSV Demonstrator, *P-AP - "Activity plan,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *P-PI - "Phase and Iteration plan,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *P-TP - "Test plan,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *P-DP - "Document Plan,"* HBV, Kongsberg, 2014.

Document plan

P-DP

Version	Date	Main Author	Co-Author	Approved by
1	05.02.2014	Nicolai Skjelsbæk	Snorre Kløcker	Håkon M. Solaas
2	24.03.2014	Nicolai Skjelsbæk	Snorre Kløcker	Eirik Kristoffersen
3	15.05.2014	Nicolai Skjelsbæk	Snorre Kløcker	Marit Hammer
4	21.05.2014	Nicolai Skjelsbæk	Snorre Kløcker	Håkon M. Solaas

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	24.03.2014	More documents	Nicolai Skjelsbæk	Eirik Kristoffersen
2 → 3	15.05.2014	Reviewed and updated	Nicolai Skjelsbæk	Marit Hammer
3 → 4	21.05.2014	Document Review	Nicolai Skjelsbæk	Håkon M. Solaas

This document is a plan over the documents in the "Smart DDSV Demonstrator" project.

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Index of Tables

1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
DDSV	Direct Drive proportional Servo Valve
E.K	Eirik Kristoffersen
GUI	Graphical User Interface
H.M.S	Håkon Mørk Solaas
HBV	Buskerud/Vestfold university college
M.H	Marit Hammer
N.S	Nicolai Skjelsbæk
S.K	Snorre Kløcker

Table 1: Abbreviations

1.1 Reference documents

No	Document name	Description
1.	P-PP	Project plan
2.	P-PI	Phase and Iteration plan

Table 2: Reference documents

2.0 Scope

This document is a plan over all the documents in the project "Smart DDSV demonstrator", and is meant for internal use in the group. It will include:

- Document name
- Short description of document
- Who has the main responsibility for each document?
- Date for when the document should be finished
- First release date.

This will help the group to have a better document flow, and to have control over the documentation. Some of the documents will be edited throughout the project time. This plan will only include which date the first release should be finished, and which date the document was first released.

3.0 Weekly documents

Two documents shall be released every week:

- Follow-up document
    - This is a document that includes what the group have done this week and a schedule for next week. This document shall be sent to internal supervisor, and should be sent to external supervisor. The whole group are responsible for this document.
- Hour list
    - Each group member shall write a separate hour list every week. This shall include activities and how many hours they have used on each activity. This document shall be sent to internal supervisor with the follow up document.
- Minutes of meeting
    - There shall be written a minutes of meeting to every meeting the group has. If needed there shall be made a presentation to the meetings.

4.0 Phase 1

Phase 1 is the first phase of the project, this will be from 03. January until 19. February.

Document name	Short description	Responsibility	Should be finished	First Release date
G-BU	Budget	N.S, E.K	30.01.2014	29.01.2014
G-CO	Contract	ALL, HBV, FMC	14.02.2014	21.03.2014
G-FP	First presentation	N.S, E.K	14.02.2014	15.02.2014
G-ID	Idea Document	S.K	13.01.2014	24.01.2014
G-RA	Risk Analysis	N.S	24.01.2014	27.01.2014
P-AP	Activity plan	S.K, N.S	10.02.2014	03.02.2014
P-DP	Document plan	N.S, S.K	10.02.2014	05.02.2014
P-PI	Phase and Iteration plan	S.K	10.02.2014	14.02.2014
P-PP	Project Plan	S.K	19.02.2014	17.02.2014
P-TP	Test plan	M.H	12.02.2014	14.02.2014
S-RS	Requirement Specification	H.M.S	30.01.2014	29.01.2014
S-TS	Test Specification	M.H	14.02.2014	14.02.2014
T-DT	Documentation Template	N.S	15.01.2014	15.01.2014
T-FU	Follow-Up template	N.S	20.01.2014	20.01.2014
T-HL	Hour List template	M.H, H.M.S	15.01.2014	15.01.2014
T-MM	Minutes of Meeting template	N.S	23.01.2014	22.01.2014

Table 3: Phase 1

5.0 Phase 2

Phase 2 is the mid phase of the project, this will be from 20. February until 04. April.

Document name	Short description	Responsibility	Should be finished	First Release date
D-DD	Design Document	N.S	21.03.2014	14.04.2014
G-FPI	First Phase and Iteration report	S.K, N.S	25.02.2014	27.02.2014
G-LR	Logistics report	E.K	24.03.2014	24.03.2014
G-SP	Second Presentation	N.S, E.K	25.03.2014	25.03.2014
G-TP1	Test Procedures for T-002	N.S	05.03.2014	04.03.2014
G-TP2	Test Procedure for T-003 – T006	M.H, H.M.S	14.03.2014	24.03.2014

G-TR1	Test Result report for T-002	N.S	11.03.2014	13.03.2014
S-HS	Hydraulic system specification	E.K	07.03.2014	14.03.2014
S-IS	Interface and GUI specification	H.M.S	07.03.2014	24.03.2014
S-VS	Valve Specification	S.K	24.02.2014	27.02.2014
T-TR	Test report Template	N.S	24.02.2014	24.02.2014
U-HS	User manual: Hydraulic system	E.K	21.03.2014	12.05.2014

Table 4: Phase 2

6.0 Phase 3

Phase 3 is the last phase with documents before end result, this will be from 05. April until 09. May.

Document name	Short description	Responsibility	Should be finished	First Release date
G-SPI	Second Phase and Iteration report	S.K, N.S	15.04.2014	16.04.2014
G-TP3	Test Procedure for T-007	E.K	04.04.2014	23.04.2014
G-TP4	Test Procedure for T-008	N.S	04.04.2014	29.04.2014
G-TP5	Test Procedure for T-009 – T011	M.H	04.04.2014	23.04.2014
G-TP6	Test Procedure for T-012	N.S	02.05.2014	01.05.2014
G-TR2	Test Result report for T-003 – T006	M.H	25.04.2014	24.03.2014
S-ES	Electrical Specification	N.S	28.04.2014	28.04.2014
T-DR	Deviation Report template	E.K	22.04.2014	29.04.2014
U-IG	User manual: Interface and GUI	H.M.S	25.04.2014	01.05.2014

Table 5: Phase 3

7.0 Phase 4

Some of the documents in phase 4 would usually be written after the project is delivered, but since this is a student project, the documents will be written before delivery date. Phase 4 is from 10. May until 16. June.

Document name	Short description	Responsibility	Should be finished	First Release date
G-DR	Deviation report	E.K	17.05.2014	16.05.2014
G-FOP	Fourth Phase and Iteration report	S.K, N.S	22.05.2014	21.05.2014
G-FR	Final project report	All	21.05.2014	21.05.2014
G-MT	Main technical report	All	17.05.2014	15.05.2014
G-PA	Post Analysis report	All	23.05.2014	21.05.2014
G-TR3	Test Result report for T-007	E.K	16.05.2014	16.05.2014
G-TR4	Test Result report for T-008	M.H	16.05.2014	13.05.2014
G-TR5	Test Result report for T-009 – T011	M.H	16.05.2014	19.05.2014
G-TR6	Test Result report for T-012	N.S	21.05.2014	19.05.2014
G-WC	Wall Chart	H.M.S	30.05.2014	

Table 6: Phase 4

Phase and Iteration Plan

P-PI

Version	Date	Main Author	Co-Author	Approved by
1	14.02.2014	Snorre Kløcker		Håkon Mørk Solaas
2	24.03.2014	Snorre Kløcker		Marit Hammer
3	20.05.2014	Snorre Kløcker		Nicolai Skjelsbæk

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	24.03.2014	Document updated after review	Snorre Kløcker	Marit Hammer
2 → 3	20.05.2014	Document updated after final review	Snorre Kløcker	Nicolai Skjelsbæk

This document describes planned activities for Smart DDSV demonstrator project.

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Index of Tables

1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Controller Area Network
DDSV	Direct Drive proportional Servo Valve
E.K	Eirik Kristoffersen
FMC	FMC Technologies
GUI	Graphical User Interface
H.M.S	Håkon Mørk Solaas
HBV	Buskerud/Vestfold university college
M.H	Marit Hammer
N.S	Nicolai Skjelsbæk
S.K	Snorre Kløcker
SW	Software

Table 1: Abbreviations

2.0 Introduction

This document shows a scheduled overview over Smart DDSV Demonstrator's bachelor project. For more information about the activity number ID, see P-AP [1].

There is a possibility for changes in this document after each iteration review, please notice document version.

3.0 Project model

The project model used during this thesis is based on an evolutionary model. The model consists of four phases. In each phase there are three iterations. At the end of each iteration and phase, there are project reviews. There will be two separate reviews: One with the customer, and one internally in the student group. Review with the customer will make sure that progress, documentation and product are according to what they have in mind. Group review will monitor the environment within group as well as the project status. This will help the group monitor project status and discover possible problems. The review will also make it possible for the bachelor group to go back and change requirements, etc. Reviews will be documented in G-FPI [2], G-SPI [3], G-TPI [4], and G-FOP [5].

Phase 1 – Research and define task.

Phase 2 – Build demonstrator, start working with SW and testing.

Phase 3 – Complete the demonstrator and final testing.

Phase 4 – Finish all documents and third presentation.

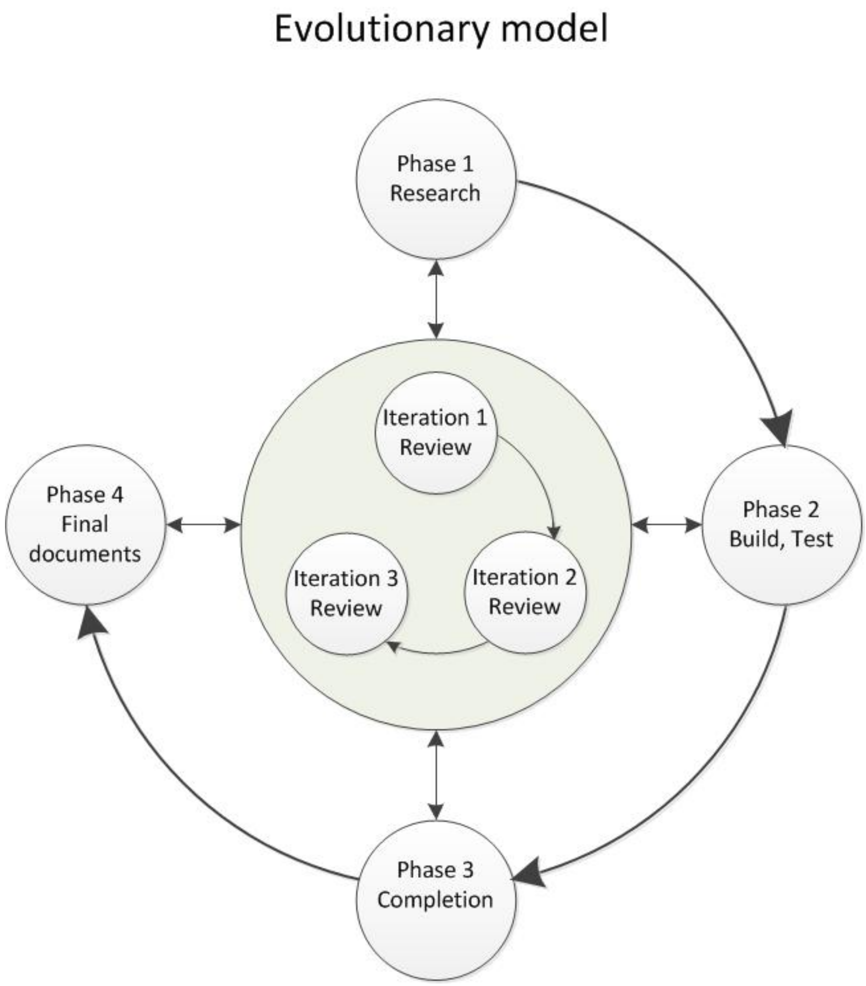

Figure 1: Project model

4.0 Phase and Iteration Plan

4.1 Phase 1

Phase 1		**Duration: 03.01.2014 – 19.02.2014**	
Research, system specification, order components for demonstrator and first presentation.			
Iteration 1/3		Duration: 03.01.2014 – 13.01.2014	
Get an overview of the assignment, requirements and define goals.			
ID	Responsibility	Activity	Time estimate
1-000	S.K	Idea document [G-ID]	7,5
1-007	All	Presentation for FMC	7,5
1-402	H.M.S, M.H	Hour list template [T-HL]	7,5
2-000	All	Meeting with FMC	3
4-004	E.K	System	37,5
4-103	All	Define assignment	20
4-103	All	Define goals; Main and additional	37,5
5-000	All	Customer review	3
5-001	All	Iteration review	4
Iteration 2/3		Duration: 14.01.2014 – 31.01.2014	
Concentrate about getting the correct components for the demonstrator. All components must work together. This is a critical phase because of the 8 weeks delivery time of the DDSV.			
ID	Responsibility	Activity	Time estimate
1-001	N.S	Risk analysis [G-RA]	40
1-003	N.S	Budget [G-BU]	16
1-100	All	Follow-up documents [P-FU]	6
1-101	M.H	Test Plan [P-TP]	80
1-200	H.M.S	Requirement specification [S-RS]	50
1-203	M.H	Test Specification [S-TS]	20
1-400	N.S	Documentation template [T-DT]	5
1-401	N.S	Minutes of meeting template [T-MM]	1
1-403	N.S	Follow-up template [T-FU]	1
2-002	All	Meeting supervisor FMC	2
2-001	All	Meeting supervisor HBV	2
2-003	All	Meeting with MOOG	4
2-300	H.M.S	Logo	4
4-000	E.K	Log splitter	16
4-001	E.K	FESTO component	40

4-002	H.M.S	Return spring	4
4-003	S.K	DDSV specification	40
4-004	E.K	System	80
4-100	H.M.S	CAN	40
4-102	H.M.S	Regulation	40
5-000	All	Customer review	6
5-001	All	Iteration review	4
6-100	All	Cleaning lab facility	8
Iteration 3/3		Duration: 01.02.2014 – 19.02.2014	
Ordering parts for demonstrator, write required documentation and prepare for first presentation			
ID	Responsibility	Activity	Time estimate
1-004	E.K, N.S	First presentation, Prezi [G-FP]	100
1-013	All/FMC/HBV	Contract [G-CO]	4
1-100	All	Follow-up documents [P-FU]	4
1-101	M.H	Test Plan [P-TP]	37,5
1-102	S.K	Activity plan [P-AP]	8
1-103	S.K	Phase and Iteration plan [P-PI]	37,5
1-104	S.K	Project plan [P-PP]	37,5
1-105	N.S	Document plan [P-DP]	20
1-203	M.H	Test specification [S-TS]	90
2-001	All	Meeting supervisor HBV	3
2-002	All	Meeting supervisor FMC	3
2-100	All	First presentation. Prepare	100
2-100	All	Print/DVD with all necessary documentation for presentation. **Shall be delivered 15.02.2014!**	2
3-201	H.M.S	Make 3D model	10
4-100 4-101	H.M.S	Interface (Simulator, Simulink/Labview and CAN)	65
5-000	All	Customer review	3
5-001	All	Iteration review	4
5-002	All	Phase review 1	10
6-001 6-000	S.K, E.K	Ordering components	10
6-002	N.S	Web/Sharepoint	16

Table 2: Phase 1

4.2 Phase 2

Phase 2		Duration: 20.02.2014 – 04.04.2014	
Interface, demonstrator, documentation and second presentation			
Iteration 1/3		Duration: 20.02.2014 – 07.03.2014	
Concentrate on GUI and CAN interface. Begin writing technical documentation			
ID	Responsibility	Activity	Time estimate
1-008	E.K	Logistics report [G-LR]	16
1-009	S.K, N.S	First Phase and Iteration report [G-FPI]	16
1-016	N.S	Test Procedure T-002 [G-TP1]	30
1-016	M.H, H.M.S	Test Procedure T-003 → T-006 [G-TP2]	7,5
1-019	S.K	Main Technical report [G-MT]	16
1-100	All	Follow-up documents [P-FU]	6
1-201	E.K	Specification, Hydraulic system [S-HS]	45
1-202	H.M.S	Specification, Interface and GUI [S-IS]	45
1-204	S.K	Valve Specification [S-VS]	24
1-404	N.S	Test Report template [T-TR]	4
2-001	All	Meeting supervisor HBV	3
2-002	All	Meeting supervisor FMC	3
3-202	N.S	Mounting of table	3
4-100	H.M.S	CAN	75
4-101	H.M.S	GUI	75
4-102	H.M.S	Regulation	37,5
5-000	All	Customer review	3
5-001	All	Iteration review	4
5-004	M.H, N.S	T-002	16
6-002	N.S	Sharepoint/Web	7,5
6-101	All	Teambuilding	
Iteration 2/3		Duration: 08.03.2014 – 21.03.2014	
Start testing interface on FMC lab. Start writing SW documentation			
ID	Responsibility	Activity	Time estimate
1-005	N.S, E.K	Second Presentation [G-SP]	45
1-016	M.H, H.M.S	Test Procedure T-003 → T-006 [G-TP2]	30
1-017	N.S	Test Results report, T-002 [G-TR1] 5-004	15
1-100	All	Follow-up documents [P-FU]	4

1-205	N.S	Electrical Specification [S-ES]	7,5
1-300	E.K	User manual, hydraulic system [U-HS]	40
1-500	N.S	Design document [D-DD]	40
2-001	All	Meeting supervisor HBV	3
2-002	All	Meeting supervisor FMC	3
4-100	H.M.S	CAN	60
4-101	H.M.S	GUI	60
4-102	H.M.S	Regulation	20
5-000	All	Customer review	3
5-001	All	Iteration review	4
6-002	N.S	Sharepoint/Web	7,5
Iteration 3/3		Duration: 22.03.2014 – 04.04.2014	
Finish required documentation and prepare for second presentation			
ID	Responsibility	Activity	Time estimate
1-005	N.S, E.K	Make second presentation [G-SP]	25
1-016	E.K	Test Procedure T-007 [G-TP3]	22,5
1-016	N.S	Test Procedure T-008 [G-TP4]	22,5
1-016	M.H	Test Procedure T-009 → T-011 [G-TP5]	22,5
1-017	M.H	Test Results report, T-003 → T-006 [G-TR2] 5-005, 5-006	8
1-100	All	Follow-Up Document [P-FU]	4
2-001	All	Meeting supervisor HBV	3
2-002	All	Meeting supervisor FMC	3
2-101	All	Prepare for second presentation	120
4-100	H.M.S	CAN	40
4-101	H.M.S	GUI	40
4-102	H.M.S	Regulation	20
5-000	All	Customer review	3
5-001	All	Iteration review	4
5-002	All	Phase review 2	8
5-005	M.H	T-003	40
5-006	M.H	T-004 → T-006	40
6-002	N.S	Sharepoint/Web	7,5

Table 3: Phase 2

4.3 Phase 3

Phase 3		**Duration: 05.04.2014 – 09.05.2014**	
Demonstrator completion and overall testing/review. All testing should be finished in this period. Demonstrator shall be fully functional.			
Iteration 1/3		Duration: 05.04.2014 – 25.04.2014 **(07.04 – 11.04, Exam period), (17.04 -21.04, Easter)**	
Focus on SW/Interface			
ID	Responsibility	Activity	Time estimate
1-010	S.K, N.S	Second Phase and Iteration report [G-SPI]	16
1-017	M.H	Test Results report, T-003 → T-006 [G-TR2] 5-005, 5-006	8
1-018	All	Final Project report [G-FR]	
1-019	All	Main Technical report [G-MT]	
1-100	All	Follow-up document [P-FU]	4
1-205	N.S	Electrical Specification [S-ES]	30
1-301	H.M.S	User manual, Interface and GUI [U-IG]	40
1-405	E.K	Deviation Report template [T-DR]	7,5
2-001	All	Meeting supervisor HBV	3
2-002	All	Meeting supervisor FMC	3
3-001 3-002 3-003 3-004	E.K	Install components on demonstrator	7,5
3-203	N.S, S.K	Electrical	15
5-000	All	Customer review	3
5-001	All	Iteration review	4
5-004	N.S, M.H	T-008	7,5
5-005	M.H	T-003 (Lab)	40
5-006	M.H	T-004 → T-006 (Lab)	40
5-007	M.H	T-007	7,5
5-004 5-008	M.H	T-008 → T-011	75
6-002	N.S	Sharepoint/Web	7,5
Iteration 2/3		Duration: 26.04.2014 – 02.05.2014	
Focus on demonstrator and testing the completed system			
ID	Responsibility	Activity	Time estimate

1-016	N.S	Test Procedure, T-012 [G-TP6]	37,5
1-017	E.K	Test results report, T-007 [G-TR3] 5-007	22,5
1-018	All	Final project report [G-FR]	37,5
1-019	All	Main Technical report [G-MT]	10
1-100	All	Follow-up document [P-FU]	4
1-205	N.S	Electrical Specification [S-ES]	10
2-001	All	Meeting supervisor HBV	3
2-002	All	Meeting supervisor FMC	3
3-004	E.K	Mounting components on table	20
5-000	All	Customer review	3
5-001	All	Iteration review	4
6-002	N.S	Sharepoint	7,5
Iteration 3/3		Duration: 03.05.2014 – 09.05.2014	
Writing test documentation			
ID	Responsibility	Activity	Time estimate
1-017	E.K	Test results report, T-007 [G-TR3] 5-007	7,5
1-017	M.H	Test results report, T-008 [G-TR4] 5-004	7,5
1-018	All	Final project report [G-FR]	7,5
1-019	All	Main technical report [G-MT]	7,5
1-100	All	Follow-up document [P-FU]	4
3-203	N.S S.K	Electrical	14
5-004	M.H	Pressure test, T-008	90
5-007	M.H	Pre- assembly test, T-007	60
6-002	N.S	Web/Sharepoint	7,5

Table 4: Phase 3

4.4 Phase 4

Phase 4		Duration: 10.05.2014 – 16.06.2014	
Documentation will be the main focus. If all main goals are reached, look at additional goals.			
Iteration 1/3		Duration: 10.05.2014 – 17.05.2014	
Testing			
ID	Responsibility	Activity	Time estimate
1-011	S.K, N.S	Third Phase and Iteration report [G-TPI]	7,5
1-017	M.H	Test Results report, T-008 5-004	7,5
1-017	M.H	Test Results report, T-009→T-011 5-008	7,5
1-018	All	Final project report [G-FR]	10
1-019	All	Main technical report [G-MT]	7,5
1-020	All	Post Analysis report [G-PA]	30
1-021	E.K	Deviation report [G-DR]	7,5
1-100	All	Follow-up document [P-FU]	2
2-002	All	Meeting supervisor FMC	2
5-000	All	Customer review	2
5-001	All	Iteration review	4
5-002	All	Phase review 3/4	4
5-008	M.H	System test, T-009→T-011	30
5-009	M.H	FAT, T-012	30
5-010	N.S	Final document review	20
6-002	N.S	Web/Sharepoint	5
Iteration 2/3		Duration: 18.05.2014 – 27.05.2014	
Document delivery dead line on Tuesday 27.05			
ID	Responsibility	Activity	Time estimate
1-006	N.S E.K	Final presentation	50
1-012	S.K, N.S	Fourth Phase and Iteration report [G-FOP]	7,5
1-017	N.S	Test Results report, T-012 [G-TR6] 5-009	10
1-018	All	Final project report	12
1-020	All	Post Analysis report [G-PA]	17,5
1-022	H.M.S	Wall Chart [G-WC]	15
1-100	All	Follow-up document [P-FU]	4

2-004	All	Document meeting	2
2-001	All	Meeting supervisor HBV	3
5-000	All	Customer review	3
5-001	All	Iteration review	4
5-010	All	Final document review	120
6-002	N.S	Sharepoint	7,5
		Dead line for document submission **(26.05.2014)**	
Iteration 3/3		Duration: 28.05.2014 – 16.06.2014	
Third presentation			
ID	Responsibility	Activity	Time estimate
1-006	N.S, E.K	Third Presentation [G-TP]	120
1-022	H.M.S	Wall Chart	30
1-100	All	Follow-up document [P-FU]	8
2-001	All	Meeting supervisor HBV	3
2-002	All	Meeting supervisor FMC	3
2-102	All	Pre presentation for audience(FMC) [G-TP]	37,5
2-102	All	Third presentation	120
5-000	All	Customer review	3
5-001	All	Iteration review	4
5-002	All	Phase review 4	8
6-002	N.S	Sharepoint	7,5

Table 5: Phase 4

5.0 References

[1] Smart DDSV Demonstrator, *P-AP* - *"Activity plan,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *G-FPI* - *"First Phase and Iteration Report,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *G-SPI* - *"Second Phase and Iteration Report,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *G-TPI* - *"Third Phase and Iteration Report,"* HBV, Kongsberg, 2014.

[5] Smart DDSV Demonstrator, *G-FOP* - *"Fourth Phase and Iteration report,"* HBV, Kongsberg, 2014.

Activity Plan

P-AP

Version	Date	Main Author	Co-Author	Approved by
1	03.02.2014	Snorre Kløcker	Nicolai Skjelsbæk	Håkon Mørk Solaas
2	24.03.2014	Snorre Kløcker	Nicolai Skjelsbæk	Eirik Kristoffersen
3	20.05.2014	Snorre Kløcker	Nicolai Skjelsbæk	Marit Hammer

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	24.03.2014	Added activities	Snorre Kløcker	Eirik Kristoffersen
2 → 3	20.05.2014	Added activities	Snorre Kløcker	Marit Hammer

This document is an overview of all activities with activity ID. These activity-IDs will be used in hour list and follow-up.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Controller Area Network
DDSV	Direct Drive proportional Servo Valve
FMC	FMC Technologies
GUI	Graphical User Interface
HBV	Buskerud/Vestfold university college

Table 1: Abbreviations

2.0 Activities

Following codes are used on activities ID:

[A-BCD]

A is activity category

B is sub-activity category

CD is activity number

Following activities are presented:

1- BCD	Documents
2- BCD	Presentations and Meetings
3- BCD	Design and Construction
4- BCD	Research
5- BCD	Test and Review
6- BCD	Other

Table 2: Activities

2.1 Documents

Activity ID [A-BCD]:

B = 0 → G – General

B = 1 → P – Plan, schedule

B = 2 → S – Specification

B = 3 → U – User manuals

B = 4 → T – Templates

B = 5 → D – Design

First letter in document abbreviation describes which category each document belongs too.

ID	Activity	Document Name
1-000	Idea Document	G-ID
1-001	Risk Analysis	G-RA
1-002	Minutes of Meeting	G-MM
1-003	Budget	G-BU
1-004	First Presentation	G-FP
1-005	Second Presentation	G-SP
1-006	Final Presentation	G-TP
1-007	General Presentations	G-GP
1-008	Logistics Report	G-LR
1-009	First Phase and Iteration report	G-FPI
1-010	Second Phase and Iteration report	G-SPI
1-011	Third Phase and Iteration report	G-TPI
1-012	Fourth Phase and Iteration report	G-FOP
1-013	Contract	G-CO
1-016	Test Procedures	G-TP (1 – 6)
1-017	Test Results Reports	G-TR (1 – 6)
1-018	Final project Report	G-FR
1-019	Main Technical report	G-MT
1-020	Post Analysis report	G-PA
1-021	Deviation Report	G-DR
1-022	Wall Chart	G-WC
1-100	Follow-Up document	P-FU
1-101	Test Plan	P-TP
1-102	Activity Plan	P-AP

1-103	Phase and Iteration plan	P-PI
1-104	Project Plan	P-PP
1-105	Document Plan	P-DP
1-200	Specification, Requirements	S-RS
1-201	Specification, Hydraulic System	S-HS
1-202	Specification, Interface and GUI	S-IS
1-203	Specification, Test	S-TS
1-204	Specification, valve	S-VS
1-205	Specification, Electrical	S-ES
1-300	User manual, hydraulic System	U-HS
1-301	User manual, Interface and GUI	U-IG
1-400	Documentation Template	T-DT
1-401	Minutes of Meeting Template	T-MM
1-402	Hour List Template	T-HL
1-403	Follow Up Template	T-FU
1-404	Test Report Template	T-TR
1-405	Deviation Report Template	T-DR
1-500	Design Document	D-DD

Table 3: Documents

2.2 Presentations and Meetings

Activity ID [A-BC]:

B = 0 → Meeting

B = 1 → Presentation

ID	Activity
2-000	FMC general meetings
2-001	Internal supervisor at HBV
2-002	External supervisor at FMC
2-003	Supplier
2-004	Internal Discussion
2-100	First presentation
2-101	Second presentation
2-102	Third presentation

Table 4: Presentations and meetings

2.3 Design and Construction

Activity ID [A-BC]:

B = 0 → Hydraulic system

B = 1 → Interface

B = 2 → Other

ID	Activity
3-000	Log-splitter
3-001	FESTO-components
3-002	Return spring
3-003	DDSV
3-004	Mounting components on table
3-100	CAN
3-101	GUI
3-102	Regulation
3-200	Logo
3-201	3D-model of demonstrator
3-202	Mounting of table
3-203	Electrical

Table 5: Design and construction

2.4 Research

Activity ID [A-BC]:

B = 0 → Hydraulic system

B = 1 → Interface

B = 2 → Other

ID	Activity
4-000	Log-splitter
4-001	FESTO-components
4-002	Return spring
4-003	DDSV
4-004	System
4-100	CAN
4-101	GUI
4-102	Regulation

4-103	Define task
4-200	Prezi

Table 6: Research

2.5 Test and Review

Activity ID [A-BC]:

B = 0 →

B = 1 →

B = 2 →

ID	Activity	Test ID
5-000	Customer review	
5-001	Iteration review	
5-002	Phase review	T-001-1, T001-2, T001-3, T001-4
5-004	Pressure test	T-002, T-008
5-005	SW test	T-003
5-006	Simulator test	T-004, T-005, T-006
5-007	Pre-assembly test	T-007
5-008	System test	T-009, T010, T011
5-009	FAT	T-012
5-010	Document review	

Table 7: Test and review

2.6 Other

ID	Activity
6-000	Order parts for hydr. system
6-001	Order valve
6-002	Web/Sharepoint
6-003	Software setup FMC computer
6-004	Logistics
6-100	Cleaning lab facilities
6-101	Teambuilding

Table 8: Other

Test Plan

P-TP

Version	Date	Main Author	Co-author	Approved by
1	14.02.2014	Marit Hammer	Snorre Kløcker	Eirik Kristoffersen
2	26.02.2014	Marit Hammer	Snorre Kløcker	Nicolai Skjelsbæk
3	24.03.2014	Marit Hammer	Snorre Kløcker	Eirik Kristoffersen
4	20.05.2014	Marit Hammer	Snorre Kløcker	Håkon Mørk Solaas

Changes:

Version	Date	Changes	Released by	Approved by
1→2	26.02.2014	Corrections	Marit Hammer	Nicolai Skjelsbæk
2→3	24.03.2014	Change dates and removed safety test(implemented in other tests)	Marit Hammer	Eirik Kristoffersen
3→4	20.05.2014	Changes according to document template	Marit Hammer	Håkon Mørk Solaas

This document is a schedule of when the different tests are to be implemented in "Smart DDSV demonstrator" project.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Controller Area Network
E.K	Eirik Kristoffersen
H.M.S	Håkon Mørk Solaas
HBV	Buskerud/Vestfold university college
M.H	Marit Hammer
N.S	Nicolai Skjelsbæk
S.K	Snorre Kløcker
SW	Software

Table 1: Abbreviations

2.0 Introduction

For Smart DDSV demonstrator project there will be built a demonstrator which consists of both hardware and software. Some of the hardware components, we have permission to borrow from HBV. The rest of the hardware components will have to be ordered, and the delivery time is approximately 8 weeks. Until we receive the components, we will use a simulator at the FMC test laboratory. To verify and validate that we meet the requirements from both FMC and the bachelor group [1], we shall implement different tests during the project period. And some of the tests shall be implemented several times, in different phases of the project.

Ahead of each test, a test procedure shall be written. This is a detailed and carefully description of how the test has to be performed.

When the test has been performed, a test report shall be written. This report is based on what is described in test procedure. The test procedure describes how the test should be performed and the report describes how the test actually was performed.

3.0 Test

ID	Type	Start	Deadline	Responsible
T-001-1	First phase review	19.02.2014	19.02.2014	All
T-001-2	Second phase review	04.04.2014	04.04.2014	All
T-001-3	Third phase review	09.05.2014	09.05.2014	All
T-001-4	Fourth phase review	16.06.2014	16.06.2014	All
T-002	Hydraulic, components from HBV	03.03.2014	11.03.2014	N.S
T-003	SW, communication	22.03.2014	16.04.2014	M.H
T-004	SW A-requirement Simulator	22.03.2014	16.04.2014	M.H
T-005	SW B-requirement Simulator	22.03.2014	16.04.2014	M.H
T-006	SW C-requirement Simulator	22.03.2014	16.04.2014	M.H
T-007	Pre-assembly	22.03.2014	05.05.2014	M.H
T-008	Pressure test, hydraulic	06.05.2014	06.05.2014	N.S, M.H
T-009	System test, A-requirement	07.05.2014	08.05.2014	M.H
T-010	System test, B-requirement	07.05.2014	08.05.2014	M.H
T-011	System test, C-requirement	07.05.2014	08.05.2014	M.H
T-012	FAT Factory Acceptance Test	09.05.2014	09.05.2014	M.H

Table 2: Test plan

4.0 References

[1] Smart DDSV Demonstrator, *S-RS - Requirement Specification*, HBV, Kongsberg, 2014.

2.0 Design documents

D-xx

Design Document

D-DD

Version	Date	Main Author	Co-Author	Approved by
1	14.04.2014	Snorre Kløcker		Marit Hammer
2	19.05.2014	Snorre Kløcker		Marit Hammer

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	19.05.2014	Added more text and updated document due to review.	Snorre Kløcker	Marit Hammer

This document describes the demonstrator design and tells why the bachelor group ended with that design.

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Index of Tables

1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
A	Ampere
DDSV	Direct Drive proportional Servo Valve
FMC	FMC Technologies
HPP	Hydraulic Power Pack
Hz	Hertz
MoVaPuCo	Moog Valve and Pump Configuration softvare
V	Voltage

Table 1: Abbreviations

2.0 Introduction

The demonstrator was designed to meet the requirements in the requirements specification [1]. It shall be easy to use, portable and most importantly, safe for personnel and the environment. In addition it has to have a visually good design since FMC will present it for their customers.

Early in the project a 3D prototype model was made to get a better idea of how the finished demonstrator should be. This helped the project group to see which solutions that will work and how components can be mounted. The model was also presented to the client before ordering parts, to be sure that they agreed on the design.

Figure 1: Demonstrator table, 3D model

This document will describe why and how the bachelor group has designed the demonstrator to meet the requirements.

In Appendix A there are pictures that document the building process.

3.0 Demonstrator design

3.1 Safety

Please notice that the operator shall always have safety as first priority, and that safety hazards still may occur due to the safety measures that is already taken.

The hydraulic system has a working pressure at maximum 60bar and has moving parts, an example is the cylinder. Therefore safety needs to be thought of in every part of the bachelor project, from design to finished product. Early in the project students analyzed plausible risks [2] for various safety events that could happen during the project. To prevent injuries during and after the Smart DDSV Demonstrator project there were listed different safety requirements [1] to prevent this.

The hydraulic system uses hydraulic oil as fluid. Since the demonstrator will operate with high pressure, it will be disastrous if a leakage occurs. Therefore the space around the couplings is covered with plexiglas. The cylinder's piston rod is also covered with plexiglas due to moving parts (piston rod) and in case of leakage through the piston rod sealing.

The DDSV used in this project have a 'fail safe' position that is used when power supply is lost. This function will ensure that the outlet side of the valve will be depressurized by routing the oil back to tank. The 'fail safe' function can also be activated by pressing the emergency stop button. This will make the whole system powerless included the HPP. It is important to notice that the valve's inlet side can be pressurized if the emergency button is activated, 'fail safe' function is on or even if the pump is stopped. Therefore a ball valve is installed between the high pressure filter and the accumulator. The ball valve allows the user to bleed the pressure on the inlet side of the valve.

All switches and connectors are placed outside the hydraulic risk area, so that they can be operated safely even if a hydraulic leakage should occur. The emergency switch is placed on the left side of the table so it should be very easy to push if an emergency situation occurs. The demonstrator is powered through a 1~ 230V/50Hz supply. This ensures that the demonstrator can be connected through a regular power supply and do not need special power connectors or 3~ supply.

A rubber mat is used on the tabletop to protect the table from oil spill and make sure that tools and laptops will have a good grip and not slide off the table. The rubber mat will also make sure that the demonstrator is easy to keep clean.

See documents U-HS [3] and U-IG [4] for user manuals.

3.2 Work bench

To meet the requirements regarding portability and durability[1], it was naturally to look after a work bench in steel that were mounted on wheels. The bachelor group picked out a work bench from the criteria listed in Table 2.

Workbench criteria	
Criteria	Reason
Rugged steel structure	Since the hydraulic components are heavy and that the table shall be portable the work bench must be rugged.
Mounted on wheels	If the demonstrator shall be portable, the easiest way is to have a work bench that has mounted wheels.
Comfortable working height	If testing, maintenance or modifying is necessary it should be easy to do this while standing in a good working height.
Easy to mount components on tabletop	Hydraulic components shall be mounted on the tabletop. It is important that these components are well mounted and that they should not unintentionally come loose with time. Therefore the tabletop must be in a way that allows drilling through the table plate.
Tabletop size must be big enough to mount all the components	To have good enough space, the table must have a length of 1500mm. The table must not exceed a width of 800mm because of the portable requirement. And with this width it is ensured that the table can be transported through most of the standard doors.
Possibility to mount components beneath the table	To get the hydraulic system pressurized, a mini hydraulic pump shall be used. This pump is driven by an electric motor. For safety issues and noise damping this must be mounted beneath the tabletop.
Price	The workbench must be made out of quality materials. But since the bachelor group has a limited budget, price must not be too high.

Table 2: Workbench criteria

After some research for suitable workbenches, the bachelor group found out that a workbench from 'AJ-Produkter' was the best option. This workbench met all of the requirements and looked good as well.

Specification workbench	
Manufacture	AJProdukter.no
Art. NO	22178
Material	Steel (chipboard surface)
Length (mm)	1500
Width (mm)	800
Height (mm)	940-1195 (Adjustable)
Max load (kg)	400

Table 3: Specification workbench

The workbench is covered with a rubber mat to ensure grip and to prevent oil from retracting into the chipboard surface. The plate beneath the tabletop is made out of two glued laminated wooden plates and has a total thickness of 40 mm; this ensures high stability and strength. Between the plate and table structure there is used silicone to dampen vibrations from the HPP. This plate is also covered with a rubber mat. There is used silicon to seal every hole that is made in the rubber mats.

The mounting plate for the hydraulic components is fastened with 5 bolts. The mechanism for connecting the components requires additional 2mm of length beneath this plate. To ensure that it is enough clearance this plate is lifted 4mm above the tabletop. On the same bolts that are used to fasten the mounting plate, there are also installed mounting brackets for the plexiglas plates.

3.3 Hydraulic system

The hydraulic system is designed to be easy to maintain and to have the possibility to easy add or remove components in the future. Most of the components that are used in the hydraulic system are module based. This means that the components are fitted on an adapter-plate which easily can be mounted on an accompanying plate. The adapter-plates have a quick-connection type fitting that makes it easier to connect/disconnect hydraulic hoses. This is better than using solid tubing that requires authorized hydraulic personnel when mounting or modifying the system.

When designing hydraulic systems, loading force is often known. Since the group was going to build a demonstrator which could be used to show different possibilities and regulation principles, the load must be variable. This meant that the hydraulic cylinder and power pack had to be defined before selecting the correct valve. The system also needed to be dimensioned to handle future requirements and test setups.

To meet the requirement that the user shall visually confirm the regulation [1], the cylinder is placed in front of the mounting plate. In that way it is possible to verify that the cylinder piston is moving according to DDSV operation. The pressure gauges are also placed in the front side of the profile plate to ensure that the user can see an indication of the inlet and outlet pressure of the valve without having to stretch over the table.

The HPP is placed beneath the tabletop to ensure that leakage from the pump will not do any damage on persons and surroundings. This will also save place, and dampen noise from the gear-pump and the electric motor. The HPP is mounted vertically according to the HPP user manual; this was also the easiest way to do it considering the mounting holes. There are used rubber inlays between the mountings and pump to dampen vibrations from the HPP. Hoses from the pump pressure, tank return and cylinder leakage goes through bushings mounted in the table and down to the HPP. This is done to save hose length and make sure that none of the hoses slings outside the demonstrator area. When choosing the correct hose length, the bend radius[1] was taken in to account.

[1] As a rule of thumb: the distance between the ‘hose-termination’ and ‘were the bend starts’ shall be 1.5 times the hose’s outside diameter.

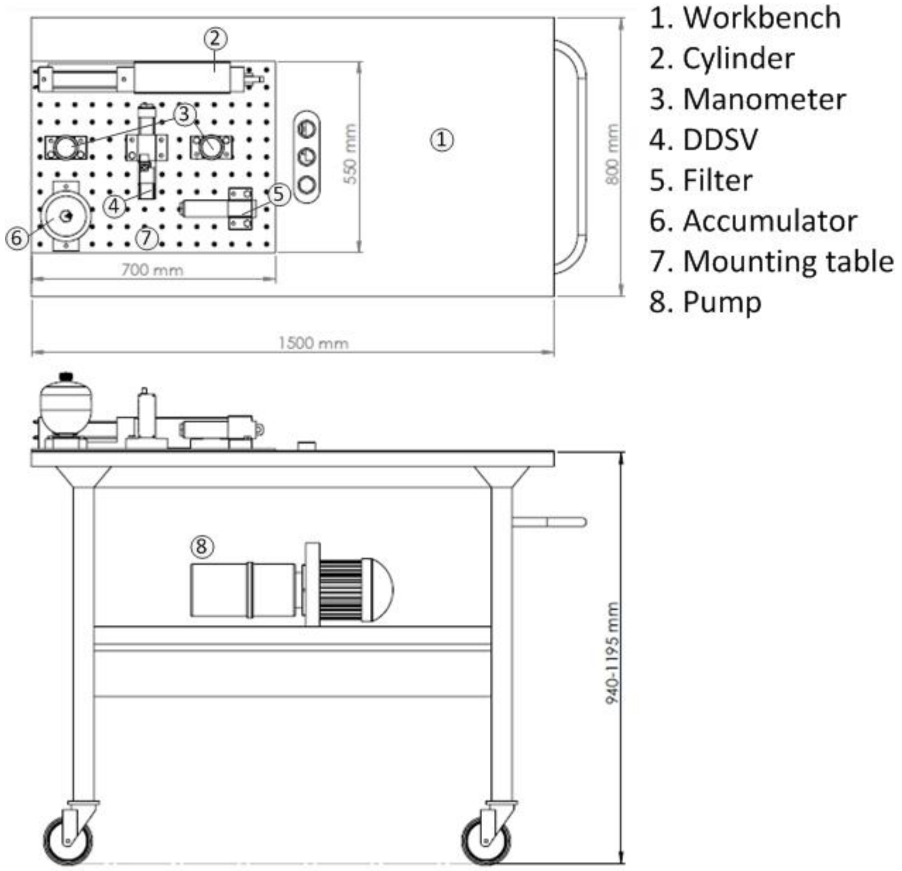


Figure 2: Demonstrator table

See document S-HS [5] and S-VS [6] for more information.

3.4 SW

For valve setup, Moog’s configuration tool (MoVaPuCo) is used. This program is supporting IXXAT CAN-USB interfaces. LabVIEW is used to take care of the message handling and high level regulations, since this program already are supporting the same CAN-USB interface as MoVaPuCo uses.

The LabVIEW GUI is constructed in a way that makes it easy for the end user to read and send standard parameters, without the need for extensive training. It has also the possibility to manually build messages to ensure access to more advanced functions and parameters, but this requires professional knowledge about CAN-messages.

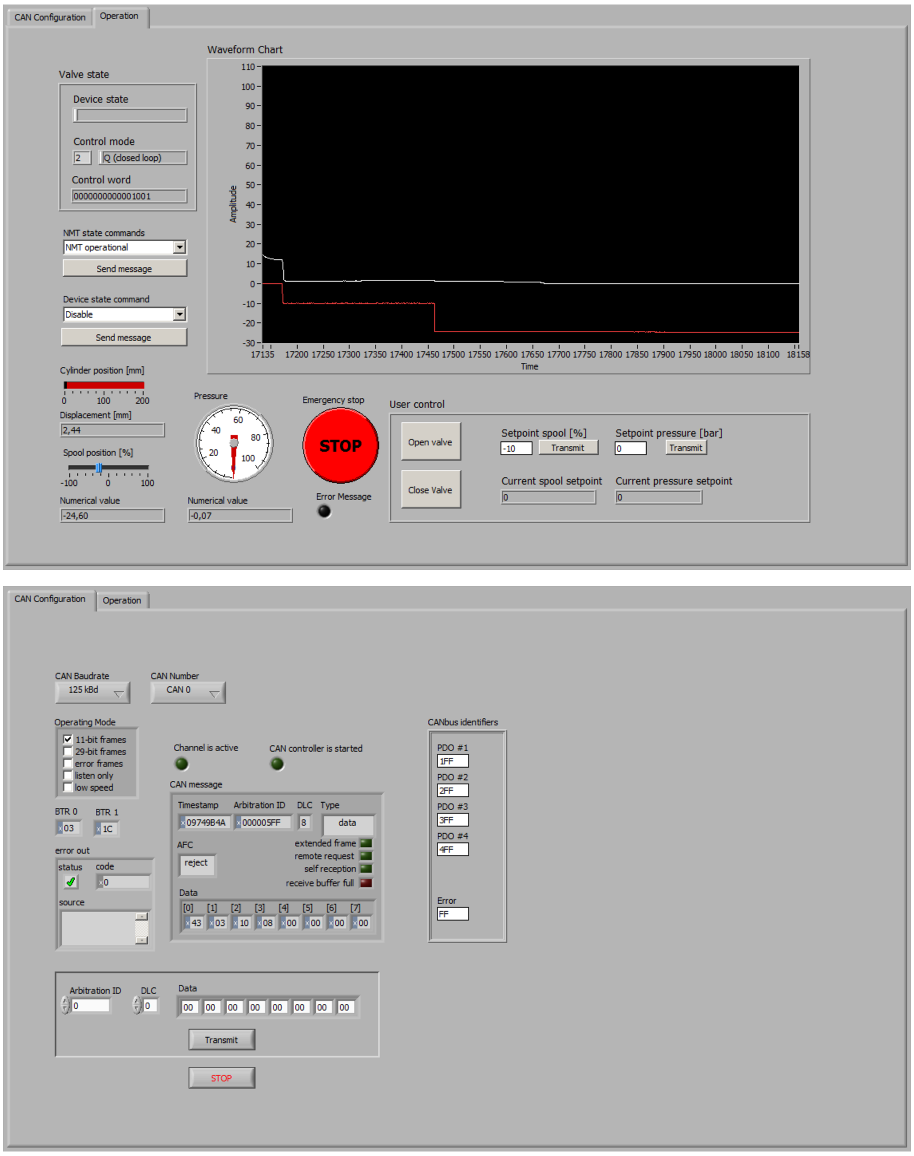


Figure 3: LabVIEW GUI

To ensure that system monitoring is close to the CAN-USB connector and a 'real time' process, a laptop or tablet computer can be placed on the left side on the tabletop. On the same side the user also has easy access to the communication and sensor wiring.

See Do. NO S-IS [7] and U-IG [4] for more information.

3.5 Electrical

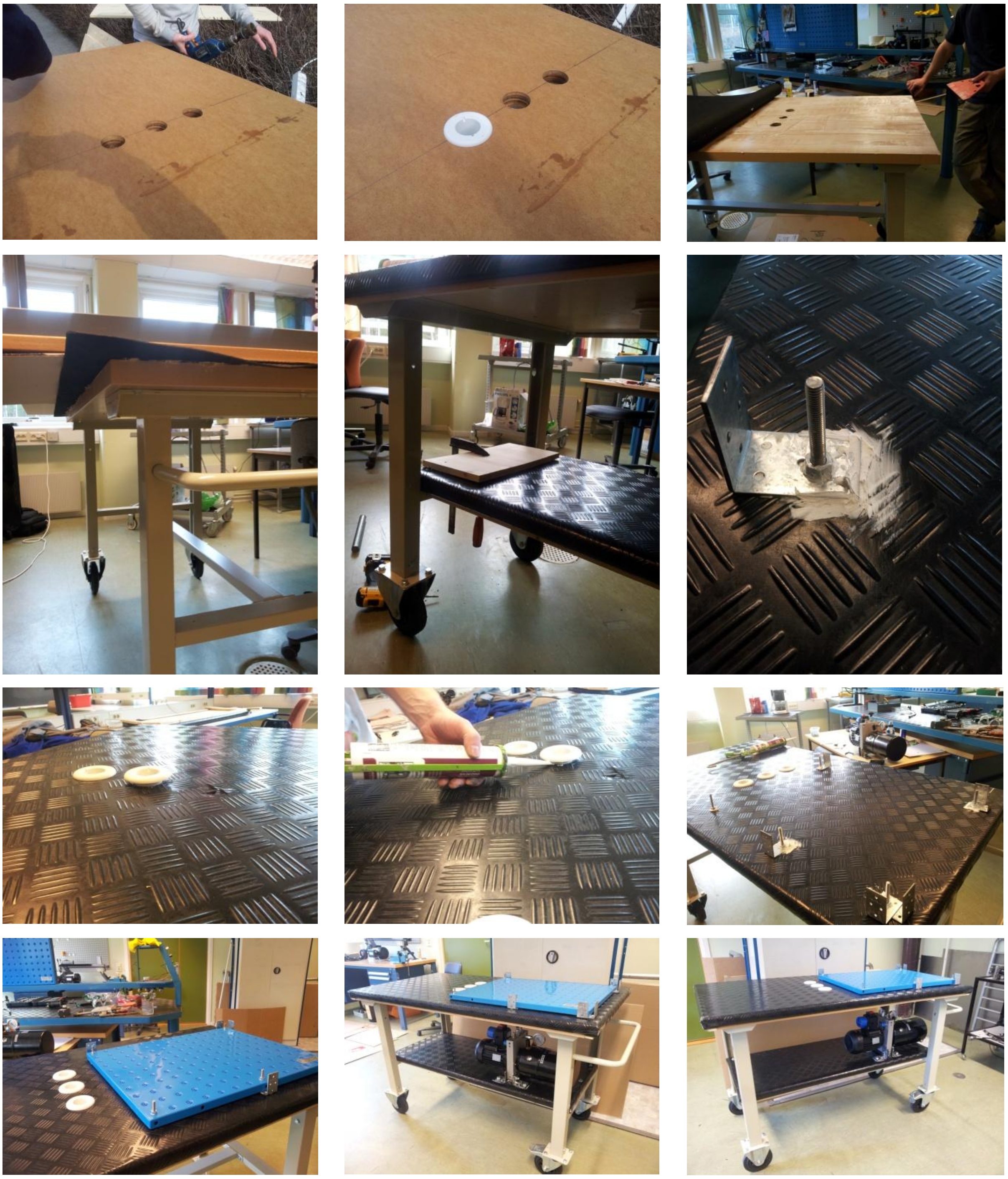
The main power supplied is as mentioned earlier in this document 1~ 230V/50Hz. It allows the user to connect the demonstrator on a regular 16A outlet. This ensures great mobility and flexibility regarding areas where the demonstrator can be used. The main power supply cabinet is placed beneath the table top, this to separate the 230V from operator. In this cabinet it is placed a 10A fuse, motor breaker, 230VAC/24VDC (10A) transformer, 24VDC/10VDC converter and some rail connectors.

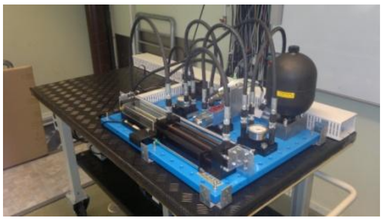
On the table top a cable channel including connectors with 24VDC and 10VDC output is placed. This makes it easy to connect different equipment, the DDSV also get its supply from here. To make sure that the operators do not need to connect anything in the high pressure area, there is also placed rail connectors on the table top which are interfacing the valve analogue inputs, outputs and CAN connection. This allows the operator to easy disconnect and connect test equipment, etc.

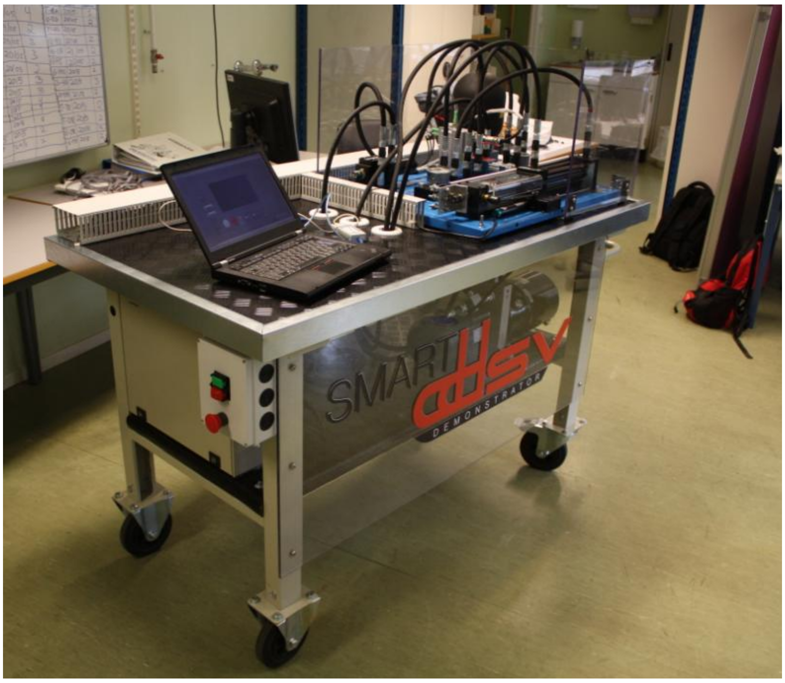
See document S-ES [8] for more information.

4.0 Appendix A

Pictures that document the building process of the demonstrator.






SMART
DEMONSTRATOR

5.0 References

[1] Smart DDSV Demonstrator, *S-RS* - *"Requirement Specification,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *G-RA* - *"Risk Analysis,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *U-HS* - *"User manual, Hydraulic System,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *U-IG* - *"User manual, Interface and GUI,"* HBV, Kongsberg, 2014.

[5] Smart DDSV Demonstrator, *S-HS* - *"Hydraulic System specification,"* HBV, Kongsberg, 2014.

[6] Smart DDSV Demonstrator, *S-VS* - *"Valve specification,"* HBV, Kongsberg, 2014.

[7] Smart DDSV Demonstrator, *S-IS* - *"Interface and GUI Specification,"* HBV, Kongsberg, 2014.

[8] Smart DDSV Demonstrator, *S-ES* - *"Electrical Specification,"* HBV, Kongsberg, 2014.

3.0 Specification documents

S-xx

Requirement Specification

S-RS

Version	Date	Main Author	Co-Author	Approved by
1	29.01.2014	Håkon Mørk Solaas		Snorre Kløcker
2	07.02.2014	Håkon Mørk Solaas		Snorre Kløcker
3	24.03.2014	Håkon Mørk Solaas		Nicolai Skjelsbæk
4	19.05.2014	Håkon Mørk Solaas		Nicolai Skjelsbæk

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	07.02.2014	Added Requirements	Håkon Mørk Solaas	Snorre Kløcker
2 → 3	24.03.2014	Added Requirements	Håkon Mørk Solaas	Nicolai Skjelsbæk
3 → 4	19.05.2014	Document Review	Håkon Mørk Solaas	Nicolai Skjelsbæk

A presentation of the requirement specification for the bachelor project "Smart DDSV Demonstrator".

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1.0 Abbreviations and definitions

1.1 Abbreviations

Abbreviations	Description
DDSV	Direct Drive Servo Valve
FMC	FMC Technologies
GUI	Graphical User Interface

Table 1: Abbreviations

1.2 Definitions

Definition	Description
A-Priority requirements	Requirements that are absolutely vital for a completing the project, and/or requirements that left unfulfilled may cause damage to people, environment or assets.
B-Priority requirements	Requirements that are not absolutely necessary but provide important additional functionality.
C-Priority requirements	Requirements that are useful and logical extensions of the project, but do not play an important role in reaching the project goals
End user	The person operating the demonstrator.

Table 2: Definitions

2.0 Introduction

2.1 Background

In different phases of a subsea operation the hydraulic supply needs to be at different pressures. The solution today is to supply these from topside through separate lines in the umbilical. This leads to a complex umbilical, resulting in high costs.

A solution to reduce umbilical complexity could be to connect the hydraulic supply lines to a series of DDSV's. The DDSV's will function as a hydraulic multiplexer, and will have the ability to regulate pressure to different levels in different hydraulic lines.

DDSV's are already in use in several industries. However the oil-industry is generally slow to adopt new technology, thus there is a need for methods to convince the customer that there is a benefit of adopting DDSV's for subsea operations.

2.2 Scope

The purpose of this bachelor project is to construct a simple, portable demonstrator that will visualize some of the possibilities of using DDSV's subsea. The goal of the project is that this demonstrator will function as an effective sales pitch.

This document will present the requirements that will provide the guidelines for how the demonstrator should be made, as well as general requirements for the execution of the project.

3.0 Functional requirements

This section will present requirements that specify how the demonstrator should function to meet our goals. These requirements will give an outline of what functions the end user should be able to do using the GUI, as well as what the demonstrator should be capable of.

3.1 General system requirements

ID	Requirement	Issued by	Priority
SYRQ-100	Demonstrator must be able to communicate with computer	FMC	A
SYRQ-101	Demonstrator shall be able to regulate based on pressure	FMC	B
SYRQ-102	Demonstrator should be able to regulate based on flow	FMC	C
SYRQ-103	Demonstrator should tackle variable loads on the hydraulic cylinder	FMC	C
SYRQ-104	Demonstrator shall have an emergency stop function	FMC	A

Table 3: General system requirements

3.2 GUI Requirements

ID	Requirement	Issued by	Priority
GIRQ-100	User must be able to view the position of the spool	FMC	A
GIRQ-101	User must be able to open the DDSV	FMC	A
GIRQ-102	User must be able to close the DDSV	FMC	A
GIRQ-103	User should be able to send a required value of pressure, which will be used as a set point for P-regulation of the valve	FMC	B
GIRQ-104	User shall be able to see variations in pressure over time	FMC	B
GIRQ-105	User shall be able to see variations in flow over time	FMC	C
GIRQ-106	User should be able to send a required value of flow, which will be used as a set point for Q-regulation of the valve	FMC	C
GIRQ-107	User should be able to view accumulated flow	FMC	C
GIRQ-108	User should be able to compare stored signature curves to detect wear on the valve	FMC	C
GIRQ-109	User should be able to set a desired pressure curve for nonlinear P-regulation of the valve	FMC	C

Table 4: GUI requirements

4.0 Technical requirements

This section tackles the technical aspects of the project. It will give a presentation of the components and connections, and how they should perform in order to fulfil the functional requirements.

4.1 Performance requirements

ID	Requirement	Issued by	Priority
PERQ-100	The system shall use no more than 1 second before responding to user input	Students	A
PERQ-101	All individual hydraulic components must withstand pressures at 1.5 x working pressure	FMC	A
PERQ-102	The full demonstrator must withstand pressures at 1.58 x working pressure	FMC	A
PERQ-103	Measured value for all external sensors shall be within +/- 2.5% of full pressure gauge	FMC	B
PERQ-105	Settling time for regulation shall not exceed 20 s	Students	B
PERQ-106	The percentage overshoot for regulation should not exceed 20%	Students	B
PERQ-107	The extension of the hydraulic cylinder should be slow enough to provide the end user with a clear visualization of changes in pressure	Students	A
PERQ-109	Pressure reduction after 15 minutes at 1.58 x WP must be no more than 2% of maximum test pressure	FMC	A
PERQ-110	Pressure reduction after 1 hour at WP must be no more than 2%	FMC	A

Table 5: Performance requirements

4.2 Component requirements

ID	Requirement	Issued by	Priority
CORQ-100	DDSV must be supplied by Moog	FMC	A
CORQ-101	DDSV must be a 3-way valve	FMC	A
CORQ-102	Valve should have sufficient number of analog inputs to connect external sensors	Students	B
CORQ-103	Valve shall be able to P- and Q-regulate without a communication link to other components	Students	B
CORQ-104	External sensors should detect flow	FMC	C
CORQ-105	Valve should be set up using software provided by Moog	Students	A
CORQ-106	External sensors should detect leakage	Students	C

Table 6: Component requirements

4.3 Hydraulic requirements

ID	Requirement	Issued by	Priority
HYRQ-100	System shall have a working pressure at minimum 25 bar	Moog	A
HYRQ-101	Demonstrator must use a hydraulic mineral oil according to DIN 51524	Moog	A
HYRQ-102	Initial hydraulic testing should be performed	FMC	A
HYRQ-103	Qualified personnel must verify that the hydraulic components in the demonstrator are safe to use	FMC	A
HYRQ-104	While operating demonstrator, the pressure filters contamination indicator shall be checked every 10th minute.	Students	A
HYRQ-105	No hydraulic components shall have visible leakage of hydraulic fluid.	Students	A

Table 7: Hydraulic requirements

4.4 Communication requirements

ID	Requirement	Issued by	Priority
CMRQ-100	The valve shall be able to read 4-20 mA	FMC	A
CMRQ-101	The valve shall communicate using CANbus	FMC	A
CMRQ-102	The CANbus communication shall be according to CANopen CiA 408	Moog	A
CMRQ-103	GUI shall be able to communicate with simulator using CANbus	Students	A

Table 8: Communication requirements

5.0 Other requirements

5.1 Non-functional requirements

ID	Requirement	Issued by	Priority
NFRQ-100	GUI must be easy to understand	FMC	A
NFRQ-101	Demonstrator must have a simple design	FMC	A
NFRQ-102	Demonstrator must be safe to use	FMC	A
NFRQ-103	Demonstrator must be portable	FMC	A
NFRQ-104	Demonstrator must be rugged	FMC	A
NFRQ-105	Demonstrator must have visual appeal	FMC	B

Table 9: Non-functional requirements

5.2 Documentation requirements

ID	Requirement	Issued by	Priority
DORQ-100	All documentation shall follow the template set up by the students	Students	A
DORQ-101	All documentation besides releases shall have a document history which describes changes done to the documents	Students	A
DORQ-102	All documentation shall meet the criteria set up by HBV	HBV	A
DORQ-103	The documentation shall follow the progress of the project	Students	A
DORQ-104	The end user shall have access to a user manual that will provide guidelines for safe operation of the demonstrator	Students	A

Table 10: Documentation requirements

5.3 Access requirements

ID	Requirement	Issued by	Priority
ACRQ-100	FMC – IWOCS shall have access to all documentation	FMC	A
ACRQ-101	HBV shall have access to all documentation	HBV	A
ACRQ-102	Students shall preferably have access to hydraulics lab at HBV	Students	A
ACRQ-103	Access to the demonstrator should be restricted to people involved in the project	FMC	A
ACRQ-104	Students shall preferably have access to FMC intranet	Students	B
ACRQ-105	Students shall preferably have access to office space at FMC Kongsberg	Students	B

Table 11: Access requirements

Test Specification

S-TS

Version	Date	Main Author	Co-Author	Approved by
1	14.02.2014	Marit Hammer	Snorre Kløcker Håkon M.Solaas	Nicolai Skjelsbæk
2	26.02.2014	Marit Hammer	Snorre Kløcker Håkon M.Solaas	Håkon M. Solaas
3	24.03.2014	Marit Hammer		Snorre Kløcker
4	21.05.2014	Marit Hammer		Snorre Kløcker

Changes:

Version	Date	Changes	Released by	Approved by
1→2	26.02.2014	Correction. Verified ID T-001-1	Marit Hammer	Håkon M. Solaas
2→3	24.03.2014	Removed security test, verified T-003	Marit Hammer	Snorre Kløcker
3→4	21.05.2014	Updated according to template	Marit Hammer	Snorre Kløcker

This document contains a description of all the tests which is listed in Test Plan.

Table of Contents

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Controller Area Network
DDSV	Direct Drive Servo proportional Valve
DIN	German institute for standardization
E.K	Eirik Kristoffersen
FAT	Factory Acceptance Test
FMC	FMC Technologies
G-FPI	First Phase and Iteration Report
GUI	Graphical User Interface
H.M.S	Håkon Mørk Solaas
HBV	Buskerud/Vestfold university college
ID	Identification
LVDT	Linear Variable Differential Transducer
M.H	Marit Hammer
N.S	Nicolai Skjelsbæk
P	Pressure
PDO	Process Data Object
P-TP	Test Plan
Q	Flow
S.K	Snorre Kløcker
S-RS	Requirement Specification
SW	Software
USB	Universal Serial Bus
WP	Working Pressure

Table 1: Abbreviations

2.0 Introduction

This document will contain a specification for each of the tests that are listed in the test plan[1]. Tests will meet the requirement specifications listed in requirement specification[2]. Each test has a procedure description and describes the acceptance requirements.

3.0 Test

3.1 Safety

In this project safety is first priority, both in the bachelor group and at FMC. Since the demonstrator is operating at high pressure, the focus regarding safety is high.

Prior and during all the different tests, the security precautions shall be read and understood. Every test has a procedure for how the test shall be performed, and in this procedure shall all safety precautions be listed and followed.

3.2 Phase and iteration

This test will ensure that all produced documents are according to documentation plan after first phase. First phase is in time period 03.01.2014 to 19.02.2014.

ID	**T-001-1**
What	First Phase review
Location	HBV
Equipment list	All produced documents in first phase.
Present	The bachelor group
Responsible	All of the group members
Related to requirement-ID	DORQ-100, DORQ-101, DORQ-102, DORQ-103.
Acceptance criteria	The produced documents are following the template. And the progress is according to the project plan.
Priority	A
Procedure	• Make sure that the produced documents are following the templates for documentation. • Go through project plan and verify that the project is on schedule. • Write the first phase and iteration report. • If progress is behind schedule, update the project plan.
Approved	Yes. See[3]. February 24th

Table 2: ID T-001-1

This test will ensure that all produced documents are according to documentation plan after second phase. Second phase is in time period 20.02.2014 to 04.04.2014.

ID	**T-001-2**
What	Second Phase review
Location	HBV
Equipment list	All documents produced in second phase.
Present	The bachelor group
Responsible	All of the group members
Related to requirement-ID	DORQ-100, DORQ-101, DORQ-102, DORQ-103, DORQ-104
Acceptance criteria	The produced documents are following the template
Priority	A

Procedure	• Make sure that the produced documents are following the templates for documentation. • Go through project plan and verify that the project is on schedule. • Write the second phase and iteration report. • If progress is behind schedule, update the project plan. • Create a user manual with guidelines for safe use of the demonstrator.
Approved	Yes, see [4] April 16th

Table 3: ID T-001-2

This test will ensure that all produced documents are according to documentation plan after third phase. Third phase is in time period 05.04.2014 to 09.05.2014.

ID	**T-001-3**
What	Third Phase review
Location	HBV
Equipment list	All produced documents in third phase
Present	The bachelor group
Responsible	All of the members
Related to requirement-ID	DORQ-100, DORQ-101, DORQ-102, DORQ-103, DORQ-104
Acceptance criteria	The produce documents are following the template.
Priority	A
Procedure	• Make sure that the produced documents are following the templates for documentation. • Go through project plan and verify that the project is on schedule. • Write the third phase and iteration report. • If progress is behind schedule, update the project plan. • Create a user manual with guidelines for safe use of the demonstrator.
Approved	Yes, see [5] May 15th

Table 4: ID T-001-3

This test will ensure that all produced documents are according to documentation plan after fourth phase. Fourth phase is in time period 10.05.2014 to 16.06.2014.

ID	**T-001-4**
What	Fourth Phase review
Location	HBV
Equipment list	All produced documents in fourth phase.
Present	The bachelor group
Responsible	All of the group members
Related to requirement-ID	DORQ-100, DORQ-101, DORQ-102, DORQ-103.
Acceptance criteria	All produced documents are following the template.
Priority	A
Procedure	• Make sure that the produced documents are following the templates for documentation. • Go through project plan and verify that the project is on schedule. • Write the fourth phase and iteration report.
Approved	

Table 5: ID T-001-4

3.3 Hydraulic

Pressure test of components borrowed from HBV. They must be safe to use and work like expected with no leakage.

ID	**T-002**
What	Components borrowed from HBV
Location	Hydraulic lab at HBV, C151
Equipment list	See G-TP1[6]
Present	The bachelor group, qualified resources from FMC
Responsible	M.H, N.S
Related to requirement-ID	PERQ-101
Acceptance criteria	Must not leak hydraulic oil, must withstand 1.5x working pressure. Pressure gauge (HBV) must show correct value.
Priority	A

Procedure	[6]
Approved	Yes, see [7] April 18th

Table 6: ID T-002

3.4 Software

This test is to verify that communication with CANbus is possible. Test will verify that the LabVIEW GUI is able to read CANbus data sent from a CANbus simulator.

ID	T-003
What	Code review of HMI SW Verify CAN communication
Location	SW lab, FMC
Equipment list	See G-TP2 [8]
Present	Bachelor group, qualified resources from FMC
Responsible	M.H
Related to requirement-ID	CMRQ-103
Acceptance criteria	Code does not have syntax errors. GUI is able to read signals from CAN module. Program is running without fault.
Priority	A
Procedure	[8]
Approved	Yes, see [9] March 19th

Table 7: ID T-003

3.5 Simulator

Due to long delivery time of the valve, a simulator must be used to simulate the valve's response to different inputs. This test is to verify that A-requirements are met.

ID	T-004
What	Verify A-requirement, simulator
Location	SW lab, FMC
Equipment list	See G-TP2 [8]
Present	The bachelor group, qualified resources from FMC
Responsible	M.H
Related to requirement-ID	GIRQ-100, GIRQ-101, GIRQ-102, PERQ-100, CMRQ-102, CMRQ-103
Acceptance criteria	The program runs without fault GUI is able to read spool position

	GUI can send open/close command to the valve
Priority	A
Procedure	[8]
Approved	Voided see [9]

Table 8: ID T-004

This test is to verify that B-requirements are met.

ID	T-005
What	Verify B-requirement, pressure. Simulator.
Location	SW lab, FMC
Equipment list	See G-TP2 [8]
Present	The bachelor group, qualified resources from FMC
Responsible	M.H
Related to requirement-ID	GIRQ-103, GIRQ-104, PERQ-105, PERQ-106
Acceptance criteria	The program runs without fault GUI is able to read pressure value User is able to send pressure value demand to the valve Pressure regulation is working with the following characteristics: Settling time under 20 seconds Overshoot no more than 20%
Priority	B
Procedure	[8]
Approved	Voided see [9]

Table 9: ID T-005

This test is to verify that C-requirements are met. This will be conducted if the bachelor group got enough time.

ID	T-006
What	Verify C-requirement, flow. Simulator.
Location	SW lab, FMC
Equipment list	See G-TP2 [8]
Present	The bachelor group, qualified resources from FMC
Responsible	M.H
Related to requirement-ID	GIRQ-105, GIRQ-106, GIRQ-107, GIRQ-108, GIRQ-109

Acceptance criteria	The program runs without fault GUI is able to read flow value User is able to send flow demand to the valve Flow regulation is working with the following characteristics: Settling time under 20 seconds Overshoot no more than 20% GUI displays signature curves for spool position Simulator is able to regulate after a pressure curve
Priority	C
Procedure	[8]
Approved	Voided see [9]

Table 10: ID T-006

3.6 Pre-assembly

This test will be conducted after all of the ordered parts are received. According to the supplier this will be in the middle of April. This test is to see if the parts are according to what has been ordered, and that they are working as expected. To have progress with the project this test has to be approved before further testing.

ID	T-007
What	Pre-assembly. Check that received components are correct.
Location	Hydraulic lab C151 at HBV and FMC's test site at Notodden
Equipment list	See G-TP3[10]
Present	The bachelor group
Responsible	M.H
Related to requirement-ID	CORQ-100, CORQ-101, CORQ-102, CMRQ-100, CMRQ-101, CMRQ-102
Acceptance criteria	DDSV is a 3-way valve from Moog, and must have sufficient number of analog inputs. The valve must be able to P- and Q-regulate without a communication link to other components. The sensor output shall be 4-20mA, the valve shall communicate using CANbus and according to CANopen CiA 408. The valve must be mounted correctly to the adapter, and the ordered mounting brackets fit the cylinder.
Priority	A
Procedure	[10]

Approved	Yes, see [11] May 15th

Table 11: ID T-007

3.7 System

Pressure test of complete system, there shall not be any leakage and system shall withstand 1.65x working pressure.

ID	T-008
What	Pressure system test
Location	FMC's test facilities at Notodden
Equipment list	According to G-TP4 [12]
Present	The bachelor group, qualified resources from FMC
Responsible	M.H
Related to requirement-ID	PERQ-102, HYRQ-101, HYRQ-102, HYRQ-103, HYRQ-105
Acceptance criteria	Must not leak hydraulic oil and must withstand 1.65x working pressure. The demonstrator shall use hydraulic mineral oil according to DIN 51524. Initial hydraulic testing should be performed by qualified personnel at FMC's facilities. The pressure contamination indicator shall be checked every 10th minute.
Priority	A
Procedure	[12]
Approved	Yes, see [13] May 13th

Table 12: ID T-008

This test will be regarding the A-requirements. These requirements are our first priority, and shall be approved before further testing.

ID	T-009
What	System test, A-requirement
Location	FMC's test facilities at Notodden
Equipment list	See G-TP5 [14]
Present	The bachelor group, FMC personnel that is present at the test site.
Responsible	M.H

Related to requirement-ID	GIRQ-100, GIRQ-101, GIRQ-102, PERQ-100, PERQ-107, SYRQ-100, SYRQ-104, HYRQ-100, HYRQ-101, HYRQ-104, HYRQ-105, NFRQ-100, NFRQ-101, NFRQ-102, NFRQ-103, NFRQ-104, DORQ-104
Acceptance criteria	The components shall fit together, and use hydraulic mineral oil DIN 51524. Working pressure shall be at minimum 25bar, and it shall have an emergency stop function. The system shall use no more than 1 second before responding to user input. The change in spool position at the cylinder shall be slow enough to visualize. GUI must be easy to understand. Demonstrator shall have simple design, safe to use, portable and shall be rugged. The demonstrator shall be able to communicate with PC. The user must be able to open and close the valve, and view the position of the spool. The end user shall have access to an user manual Every 10th minute shall the pressure filter contamination indicator be checked. No visible leakage at any components. No pressure reduction must not be more than 2 % of WP
Priority	A
Procedure	[14]
Approved	Yes, see [15] May 12th

Table 13: ID T-009

This test is regarding the B-requirement for the whole demonstrator. This test will be performed after the A-requirements are approved.

ID	**T-010**
What	System test, B-requirement.
Location	FMC's test facilities at Notodden
Equipment list	See G-TP5 [14]
Present	The bachelor group, FMC personnel that is present at the test site
Responsible	M.H
Related to requirement-ID	GIRQ-103, GIRQ-104, SYRQ-101, PERQ-105, PERQ-106, NFRQ-105
Acceptance criteria	The valve shall be able to regulate based on pressure, by changing setpoint. The curve at the screen is changing

	simultaneously when changing the pressure. The settling time for regulation shall not exceed 20 seconds. Overshoot should not exceed 20 %. The demonstrator must have visual appeal.
Priority	B
Procedure	[14]
Approved	Yes, see [15] May 16th

Table 14: ID T-010

If we have enough time we can conduct this test. This test T-011 is regarding the C-requirement, and what requirements this is, are listed in Table 15. The demonstrator will not be affected if these requirements are not approved.

ID	**T-011**
What	System test, C-requirement
Location	FMC's test facilities at Notodden
Equipment list	See G-TP5 [14]
Present	The bachelor group, FMC personnel that is present at test site.
Responsible	M.H
Related to requirement-ID	GIRQ-105, GIRQ-106, GIRQ-107, GIRQ-108, GIRQ-109, SYRQ-102, SYRQ-103, CORQ-104, CORQ-106
Acceptance criteria	The demonstrator is regulating based on flow, by changing setpoint, and tackle variable loads on the hydraulic cylinder. See variations in flow in time, and see accumulated flow. The end user should be able to compare stored signature curves to detect wear of the valve, and be able to set a desired pressure curve for nonlinear P-regulation of the valve. External sensor should detect leakage, and also detect flow.
Priority	C
Procedure	[14]
Approved	No, see [15] May 16th

Table 15: ID T-011

The final test is the FAT. This test will include some of the A-, B- and C-requirements, and FAT is approved when A-requirements are approved.

ID	**T-012**
What	FAT

Location	FMC's test facilities at Notodden
Equipment list	According to G-TP6 [16]
Present	The bachelor group, external supervisor
Responsible	N.S
Related to requirement-ID	GIRQ-100, GIRQ-101, GIRQ-102, SYRQ-102, SYRQ-103, PERQ-108, CORQ-104, CORQ-106, HYRQ-104. HYRQ-105
Acceptance criteria	User must be able to view the position of the spool. User must be able to open and close the valve. The pressure filters contamination indicator shall be checked every 10th minute. There shall be no visible leakage at any components, and there shall be external sensors that detect leakage. External sensors should detect flow. Calculated flow should be +/- 5% of actual flow rate. FAT is approved when A-requirements are met.
Priority	A
Procedure	[16]
Approved	Yes, see [17] May 16th

Table 16: ID T-012

4.0 References

[1] Smart DDSV Demonstrator, *P-TP - Test plan*, HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *S-RS - Requirement Specification*, HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *G-FPI - First Phase and Iteration Report*, HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *G-SPI - Second Phase and Iteration Report*, HBV, Kongsberg, 2014.

[5] Smart DDSV Demonstrator, *G-TPI - Third Phase and Iteration Report*, HBV, Kongsberg, 2014.

[6] Smart DDSV Demonstrator, *G-TP1 - Test Procedure for T-002*, HBV, Kongsberg, 2014.

[7] Smart DDSV Demonstrator, *G-TR1 - Test result report T-002*, HBV, Kongsberg, 2014.

[8] Smart DDSV Demonstrator, *G-TP2 - Test Procedure for T-003--T006*, HBV, Kongsberg, 2014.

[9] Smart DDSV Demonstrator, *G-TR2 - Test result Report T-003*, HBV, Kongsberg, 2014.

[10] Smart DDSV Demonstrator, *G-TP3 - Test Procedure for T-007*, HBV, Kongsberg, 2014.

[11] Smart DDSV Demonstrator, *G-TR3 - Test result Report T-007*, HBV, Kongsberg, 2014.

[12] Smart DDSV Demonstrator, *G-TP4 - Test Procedure for T-008*, HBV, Kongsberg, 2014.

[13] Smart DDSV Demonstrator, *G-TR4 - Test result Report T-008*, HBV, Kongsberg, 2014.

[14] Smart DDSV Demonstrator, *G-TP5 - Test Procedure for T-009--T-011*, HBV, Kongsberg, 2014.

[15] Smart DDSV Demonstrator, *G-TR5 - Test result Report T-009-->T-011*, HBV, Kongsberg, 2014.

[16] Smart DDSV Demonstrator, *G-TP6 - Test Procedure for T-012*, HBV, Kongsberg, 2014.

[17] Smart DDSV Demonstrator, *G-TR6 - Test result Report T-012*, HBV, Kongsberg, 2014.

Hydraulic system specification

S-HS

Version	Date	Main Author	Co-Author	Approved by
1	14.03.2014	Eirik Kristoffersen		Nicolai Skjelsbæk
2	24.03.2014	Eirik Kristoffersen		Nicolai Skjelsbæk
3	20.05.2014	Eirik Kristoffersen		Marit Hammer

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	24.03.2014	More specifications and updated schematic	Eirik Kristoffersen	Nicolai Skjelsbæk
2 → 3	20.05.2014	Updated the document	Eirik Kristoffersen	Marit Hammer

This document gives an overview of the hydraulic system for Smart DDSV Demonstrator

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
µm	Micro-Meters
Cm	Centimeter
cSt	centiStoke
DBS	Dowty-Bonded-Seals
DDSV	Direct-Drive-proportional-Servo-Valve
DIN	Deutsches-Institut-für-Normung
G	British Standard Pipe (BSP)
Hz	Hertz
IEC	International-Electro technical-Commission
ISO	International-Standard-Organization
KW	Kilo Watt
l/min	Liters-per-minute
LVDT	Linear-Variable-Differential-Transducer
mm	Millimeter
MPa	Mega-Pascal
NG	NennGröβe
Ø	Diameter
P	Pressure
Psi	Pound-per-square-inch
rpm	Revolutions-per-minute
RxC	Rows*Columns

Table 1: Abbreviations

2.0 Introduction

This document contains a thorough description of components and specifications for the hydraulic system used for this bachelor project. It includes different opportunities for coupling of cylinder. Sizing and mounting system. International standards for the Demonstrator are described.

3.0 Standards

This section describes international standards used associated with hydraulics in this project.

Standard	Description	Standard size	Description
ISO 4401	Specifies the dimensions and other data relating to surfaces on which four-port hydraulic directional control valves are mounted in order to ensure their interchangeability	03	Specifies the exact standard size related to the ISO standard.
DIN 24340	Specifies the dimensions and other data relating to surfaces on which four-port hydraulic directional control valves are mounted in order to ensure their interchangeability	NG6	Specifies the exact standard size related to the DIN standard.
ISO VG 32	Specifies the viscosity grade of the hydraulic mineral oil.	Shell Tellus 32	The hydraulic mineral oil used in this Demonstrator.
		(G$^{1}/_{4}$”)	Specifies thread size for mounting of nipples, measured in inches.

Table 2: International standards

Explained in further detail, this means that the ISO 4401 is the same as DIN 24340. The same applies to standard size 03 which equals NG6. Where the number 6 is measured by the metric system and refers to 6 mm.

DIN: “Deutsches Institut für Normung” meaning German institute for standardization.

NG: “NennGröβe” meaning nominal size often referred to in English as NW (Nominal Width).

Note:

Caution is advised when reading a screw thread designation labeled BSP. A British Standard Pipe (BSP) screw thread could be a shortened version of British Standard Pipe Parallel (BSPP) screw thread or British Standard Pipe Taper (BSPT) screw thread.

Unit	Equivalent unit
1 inch	2,54 cm
1 bar	0,1 MPa ≈ 14,5 psi
1cSt	1 mm^2/s
1 rpm	$\frac{1}{60} Hz = \frac{2\pi}{60} rad/s$

Table 3: Equivalent units

4.0 Components

This section gives an overview of the components used for the Demonstrator, and the specifications for each component.

Component:	Quantity:	Manufactured by:
Hydraulic Power pack	1	FESTO
Pressure Filter	1	FESTO
Accumulator	1	HYDAC
T-Distributor	2	FESTO
Pressure Gauge	2	FESTO
Proportional Servo-Valve	1	MOOG
Cylinder	1	FESTO
Profile-Plate	1	FESTO
Base-Plate	1	FESTO
Hose line	10	TESS
Ball-valve	1	FMC
Extension Spring Coil	3	Unknown
Displacement potentiometer	1	FESTO
Portable Demonstrator Table	1	AJ-produkter
Customized adapter plate	1	FMC

Table 4: List of components

All the components listed in this table are interchangeable for different setups. If other components are used, precautions shall be taken. Pressure tolerance and dimensions may diverge from parts in this list. There are nine hose lines used on the Demonstrator, and one hose line is in reserve. All the components with mounting adapter can be upgraded to the new mounting system Quick-Fix®. This does not apply for the customized adapter plate for the accumulator. For new mounting system, an aluminum profile plate with mounting slots is acquired. The mounting adapter has to be upgraded with new mounting brackets if the system is upgraded.

4.1 Item ID

Listed in this section are all the components with identification number, and couplings used for each component.

Component:	ID:	Couplings:
*Hydraulic Power Pack: (**HPP**-01)*	**HPP**-01	**HPP**-01/C-17 **HPP**-01/C-17
*Pressure filter: (**PF**-01)*	**PF**-01	**PF**-01/C-15 **PF**-01/C-16
*Bladder Accumulator: (**BA**-01)*	**BA**-01	**BA**-01/C-14
*T-Distributor: (**TD**-01)*	**TD**-01	**TD**-01/C-11 **TD**-01/C-12 **TD**-01/C-13
*T-Distributor: (**TD**-02)*	**TD**-02	**TD**-02/C-20 **TD**-02/C-21 **TD**-02/C-22
*Pressure Gauge: (**PG**-01)*	**PG**-01	**PG**-01/C-03 **PG**-01/C-04
*Pressure gauge: (**PG**-02)*	**PG**-02	**PG**-02/C-09 **PG**-02/C-10 **PG**-02/C-24
*Servo Valve: (**DDSV**-01)*	**DDSV**-01	
*Double Acting Cylinder: (**DAC**-01)*	**DAC**-01	**DAC**-01/C-01 **DAC**-01/C-02
*Profile Plate: (**PP**-01)*	**PP**-01	
*Base plate: (**BP**-01)*	**BP**-01	**BP**-01/C-05 **BP**-01/C-06 **BP**-01/C-07 **BP**-01/C-08
*Hose Line: (**HL**)*	**HL**-0X	**HL**-01 ⇨ **HL**-10
*Extension Spring Coil: (**ESC**-01)*	**ESC**-01	
*Ball valve: (**BV**-01)*	**BV**-01	**BV**-01/C-23
*Displacement Potentiometer: **(DP-01)***	**DP**-01	
*Portable Demonstrator Table: **(PDT-01)***	**PDT**-01	

Table 5: Item identification

4.2 Hydraulic Power pack

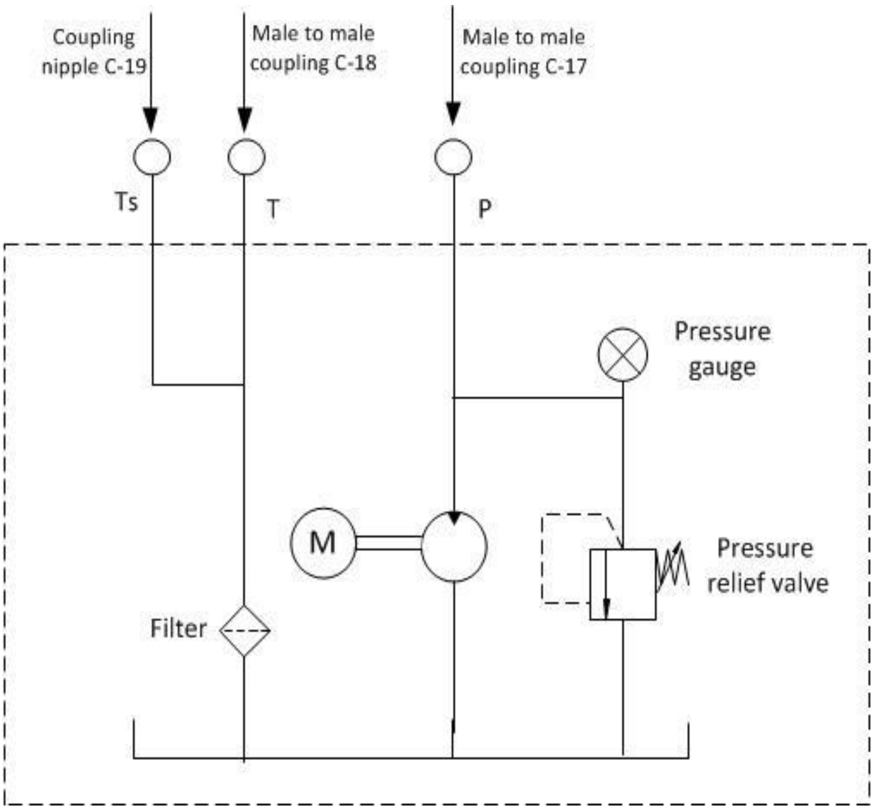
<table>
<tr><th colspan="2">Hydraulic Power Pack (HPP-01)</th><th>Schematic</th></tr>
<tr><td>Operating pressure</td><td>60 bar</td><td rowspan="14">

Figure 1: HPP-01</td></tr>
<tr><td>Width</td><td>580 mm</td></tr>
<tr><td>Depth</td><td>300 mm</td></tr>
<tr><td>Height</td><td>180 mm</td></tr>
<tr><td>Coupling</td><td>1 Nipples (male G$^1/_4$”)
2 male to male couplings</td></tr>
<tr><td>Sealing</td><td>2 DBS sealing’s</td></tr>
<tr><td>Frequency</td><td>50 – 60 Hz</td></tr>
<tr><td>Flow</td><td>2,2 – 2,7 l/min</td></tr>
<tr><td>Nominal power rating</td><td>650 W</td></tr>
<tr><td>Nominal voltage</td><td>230 V</td></tr>
<tr><td>Nominal current</td><td>3,1 A</td></tr>
<tr><td>Nominal speed</td><td>1320 rpm</td></tr>
<tr><td>Tank volume</td><td>5 Liters</td></tr>
</table>

Table 6: Hydraulic Power Pack

The hydraulic circuit is powered by a hydraulic power pack. This is an integrated unit containing a constant displacement pump, external gear motor, pressure relief valve, pressure gauge, tank, filter, sight glass and connectors. [1]

The power pack must be operated using the pressurizing/venting screw or the tank may burst. The venting screw must at all times be above the oil level.

Always check oil level before start up, the pump shall never run dry.

The power pack is designed for 50% duty cycle, for other use an external oil cooler is required.

If the thermostatic switch of the electric motor is triggered, the red off switch must be actuated after a cooling phase and after checking and eliminating the cause. Normal operation can be re-started after this.

4.2.1 Motor

External gear motor with nominal voltage of 230 V. It also includes AC single phase with overload protection, start capacitor and ON/OFF switch. The motor can run with frequency's ranging from 50 to 60 Hz, giving a rated output of 0, 65 KW.

4.2.2 Pump

Constant displacement pump with operating pressure of 60 bar (870 psi). The rated flow is dependent on operating frequency, giving a range from 2,2 - 2,7 l/min.

4.2.3 Pressure relief valve

Adjustable pressure relief valve with range from 0 - 60 bar.

4.2.4 Pressure gauge

Internal pressure gauge with indicating range of 0 – 100 bar. Displayed measuring range is measured in Psi and MPa.

4.2.5 Tank

The tank is provided with 5 l volume, sight glass for visualization of oil content, temperature display, and drain screw. The recommended tank fluid is mineral oil with viscosity of 22 - 32 cSt (ISO VG 22 or ISO VG 32). Fluid applied for the Demonstrator is Shell Tellus 32.

4.2.6 Filter

Air filter and return filter. The return filter has a filtration grade of 90 µm.

4.2.7 Connectors

Unit is provided with IEC connector for power supply. The power pack has a connecting flange for measuring container return (**Ts**). The unit is provided with coupling nipple for unpressurised return and male to male couplings for **P** (pressure) and **T** (tank).

4.3 Accumulator

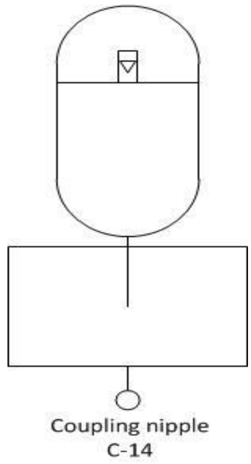
<table>
<tr><th colspan="2">Bladder-Accumulator (BA-01)</th><th>Schematic</th></tr>
<tr><td>P.max</td><td>210</td><td rowspan="7">

Figure 2: BA-01</td></tr>
<tr><td>Length</td><td>130 mm</td></tr>
<tr><td>Width</td><td>80 mm</td></tr>
<tr><td>Height</td><td>60 mm</td></tr>
<tr><td>Coupling</td><td>1 Nipples (male G$^{1}/_{4}$”)</td></tr>
<tr><td>Pre-charge</td><td>Nitrogen</td></tr>
<tr><td>Sealing</td><td>Self-sealing nipple</td></tr>
</table>

Table 7: Bladder Accumulator

The accumulator is mounted to a custom adapter. The accumulator has been tested with a maximum pressure of 95 bar, and is pre-charged with nitrogen at approximately 40 bar. Pre-charging require a custom connector from Hydac. It is provided with one male G$^{1}/_{4}$” coupling nipple. The coupling nipple and the accumulator are mounted to the adapter plate with loctite 577 and activator. If the accumulator is to be changed, a new layer of loctite and activator should be added.

4.3.1 Custom adapter plate

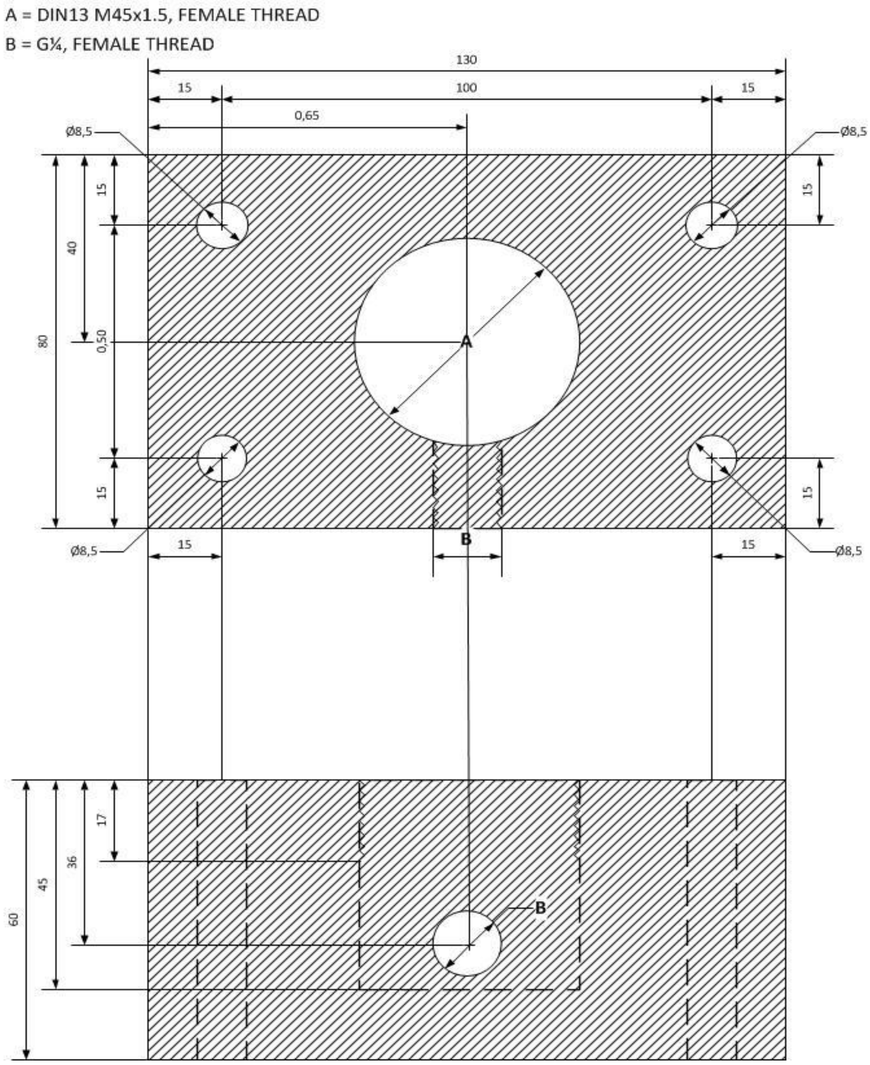
<table>
<tr><th colspan="2">Custom adapter plate</th><th>Schematic</th></tr>
<tr><td>P.max</td><td>Unspecified</td><td rowspan="3">

Figure 3: Adapter drawing</td></tr>
<tr><td>Coupling</td><td>1 Nipples (male G$^{1}/_{4}$”)</td></tr>
<tr><td>Sealing</td><td>Self-sealing nipple</td></tr>
</table>

Table 8: Custom adapter plate

The customized adapter plate for the accumulator has a length of 130 mm and width of 80 mm. The adapter plate has a transition from 45 mm to (G$^{1}/_{4}$”) threaded connection fitted with a self-sealing coupling nipple. The adapter plate is not provided with a standard mounting system such as Quick-Fix®. Adaptive screws are used to mount the adapter plate.

4.4 T-distributor

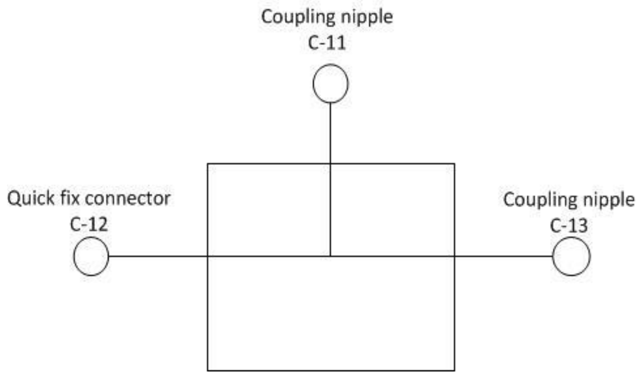
T-Distributor (TD-01)		Schematic
P.max	120 bar	 *Figure 4: TD-01*
Coupling	2 Nipples (male G$^{1}/_{4}$”) 1 Quick fix connector	
Sealing	2 DBS sealing’s	

Table 9: T-Distributor

The T-distributor is a loose component, which means that it is not attached to a base-plate/adapter. The distributor has 3 ports total. TD-01 is provided with two male threaded coupling nipples and one coupling socket. Coupling nipples are fitted with DBS sealing’s. The maximum permissible operating pressure is 120 bar (1700 psi).

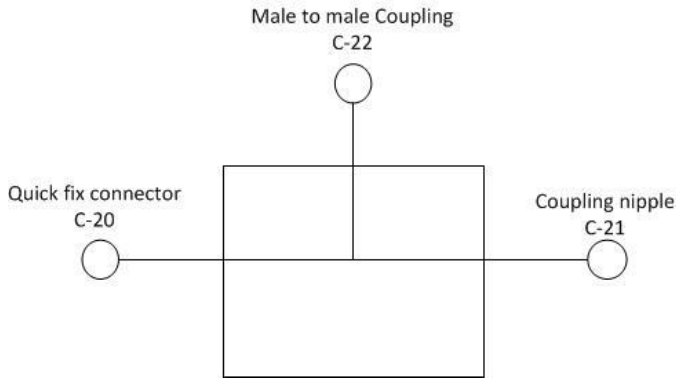
T-Distributor (TD-02)		Schematic
P.max	120 bar	 *Figure 5: TD-02*
Coupling	1 Nipples (male G$^{1}/_{4}$”) 1 Quick fix connector 1 male to male coupling	
Sealing	1 DBS sealing	

Table 10: T-Distributor

The T-distributor TD-02 is provided with one coupling nipple, one quick fix connector, and one male to male coupling. Coupling nipple is fitted with DBS sealing.

4.5 Pressure filter

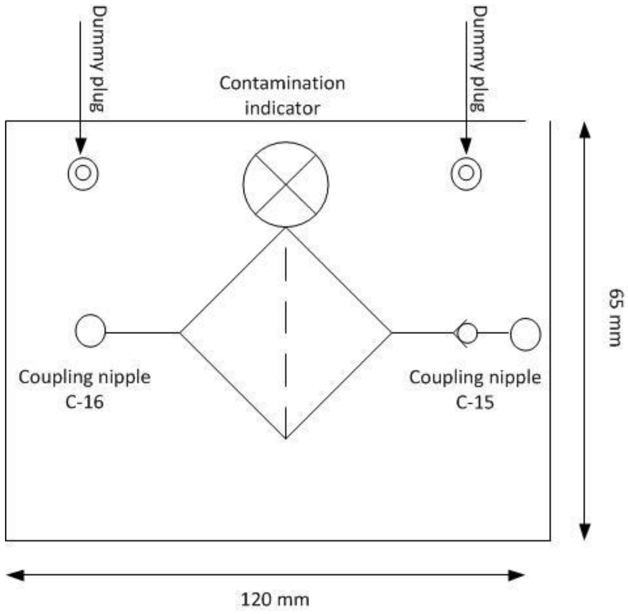
<table>
<tr><th colspan="2">Pressure Filter (PF-01)</th><th>Schematic</th></tr>
<tr><td>P.max</td><td>160 bar</td><td rowspan="7">

Figure 6: PF-01</td></tr>
<tr><td>Filter purity</td><td>5µm ≤</td></tr>
<tr><td>Dummy plugs</td><td>2</td></tr>
<tr><td>Coupling</td><td>2 Nipples (male G$^1/_4$”)</td></tr>
<tr><td>Check valve</td><td>1 integrated in coupling nipple C-15</td></tr>
<tr><td>Length</td><td>120 mm</td></tr>
<tr><td>Width</td><td>65 mm</td></tr>
</table>

Table 11: Pressure Filter

Pressure filter is provided with two coupling nipples and contamination indicator. It is provided with a check valve integrated in coupling C-15. It has a replaceable filter cartridge with poor size of 5 µm. The maximum permissible operating pressure is 160 bar (2300 psi). The mounting system to the profile plate is the old version of Quick-Fix®.

4.6 Pressure gauge

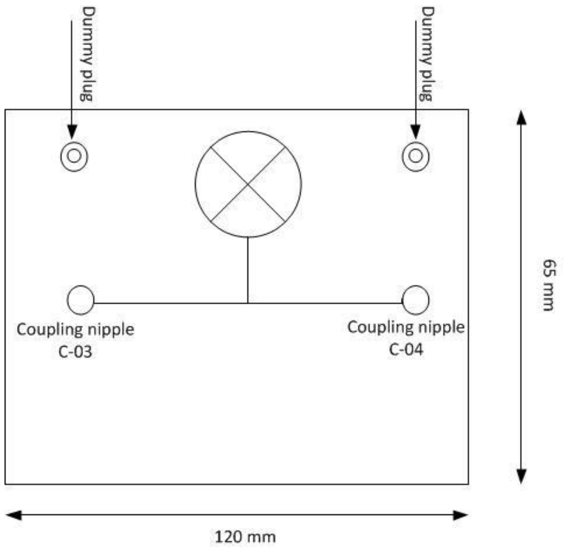
<table>
<tr><th colspan="2">Pressure Gauge (PG-01)</th><th>Schematic</th></tr>
<tr><td>P.max</td><td>160 bar</td><td rowspan="5">

Figure 7: PG-01</td></tr>
<tr><td>Range</td><td>0 – 100 bar</td></tr>
<tr><td>Dummy plugs</td><td>2</td></tr>
<tr><td>Coupling</td><td>2 Nipples (male G$^1/_4$”)</td></tr>
<tr><td>Sealing’s</td><td>2 DBS sealing’s</td></tr>
</table>

Table 12: Pressure Gauge

The pressure gauge has a displayed measuring range of 0 – 100 bar (0 – 1400 psi). Maximum allowed pressure is 160 bar (2300 psi). It is provided with two coupling nipples and two dummy plugs. Dummy plugs are fitted with DBS sealing. The mounting system to the profile plate is the old version of Quick-Fix®.

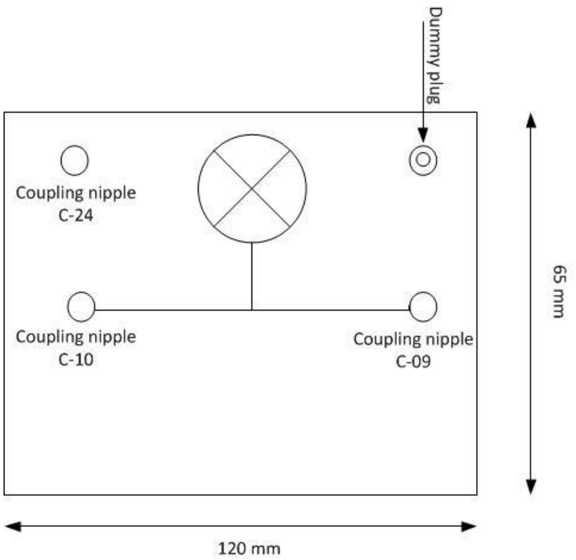
<table>
<tr><th colspan="2">Pressure Gauge (PG-02)</th><th>Schematic</th></tr>
<tr><td>P.max</td><td>160 bar</td><td rowspan="5">

Figure 8: PG-02</td></tr>
<tr><td>Range</td><td>0 – 100 bar</td></tr>
<tr><td>Dummy plugs</td><td>1</td></tr>
<tr><td>Coupling</td><td>3 Nipples (male G$^1/_4$”)</td></tr>
<tr><td>Sealing’s</td><td>1 DBS sealing</td></tr>
</table>

Table 13: Pressure Gauge

The pressure gauge PG-02 is provided with three coupling nipples and one dummy plug. The dummy plug is fitted with DBS sealing.

4.7 Servo-valve

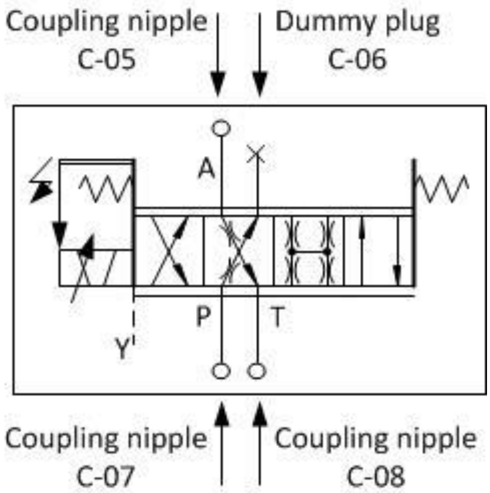
Servo-Valve (DDSV-01)		Schematic
P.max	350 bar	 *Figure 9: DDSV-01*
Length	259 mm	
Width	49 mm	
Ports	A,B,P,T (Port B plugged)	
Leakage port	Y (Plugged)	
Coupling	3 Nipples (male G$^1/_4$")	
Dummy plugs	1	
Sealing's	1 DBS sealing	

Table 14: Servo Valve

The servo valve is a 3 way DDSV, also referred to as a 4/3 valve with port **B** (C-06) closed. Coupling nipples and dummy plug is attached to base plate. It is also equipped with a plugged leakage Y-port. A permanent magnet linear force motor is used to control the valve spool. The model is a d638 and is manufactured by MOOG [2].

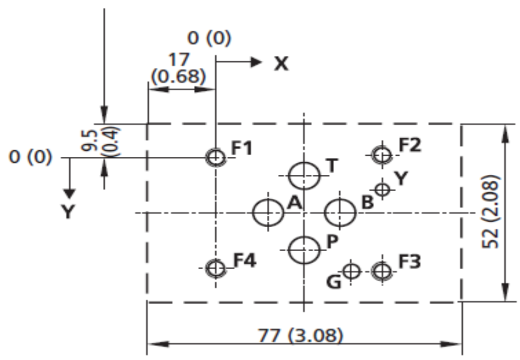
Dimension/Distances [mm]										ISO 4401-03 / DIN 24340 NG6
	P	A	B	T	Y	F_1	F_2	F_3	F_4	 *Figure 10: Mounting pattern*
	7,5	7,5	7,5	7,5	3,3	M5	M5	M5	M5	
X	21,5	12,7	30,2	21,5	40,5	0	40,5	40,5	0	
Y	25,9	15,5	15,5	5,1	9	0	0,75	31,75	31	

Table 15: Dimensions and mounting pattern for the DDSV

Table 15shows the dimensions and the mounting pattern on the servo-valve, which is adapted to the base-plate [3].

4.8 Cylinder

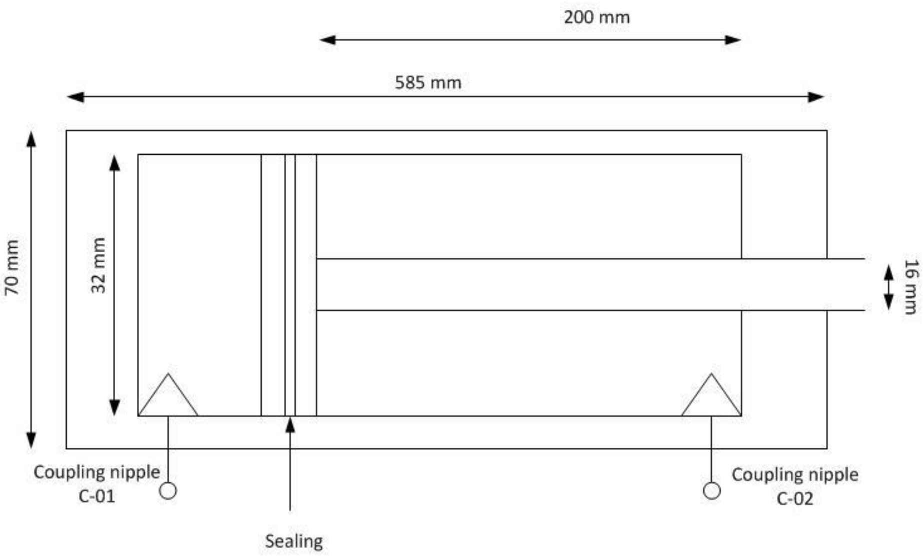
<table>
<tr><th colspan="2">Cylinder (DAC-01)</th><th>Schematic</th></tr>
<tr><td>P.max</td><td>160 bar</td><td rowspan="10">

Figure 11: DAC-01</td></tr>
<tr><td>Length</td><td>585 mm</td></tr>
<tr><td>Width</td><td>70 mm</td></tr>
<tr><td>Capacity, volume</td><td>0,16 l</td></tr>
<tr><td>Diameter, piston</td><td>32 mm</td></tr>
<tr><td>Diameter, piston rod</td><td>16 mm</td></tr>
<tr><td>Length, piston rod</td><td>200 mm</td></tr>
<tr><td>Coupling</td><td>2 Nipples (male G$^{1}/_{4}$”)</td></tr>
<tr><td>Sealing’s</td><td>2 Gaskets</td></tr>
</table>

Table 16: Double Acting Cylinder

The cylinder is a double acting cylinder with an attached brake handle. It is provided with protective cover, and two coupling nipples. The piston is provided with a magnet fitted with a locking device to attract magnetic particles. An external bracket is fitted alongside piston rod for sensor fitting. The maximum allowed pressure is 160 bar (2300 psi).The mounting system to the profile plate is the old version of Quick-Fix®.

4.9 Profile plate

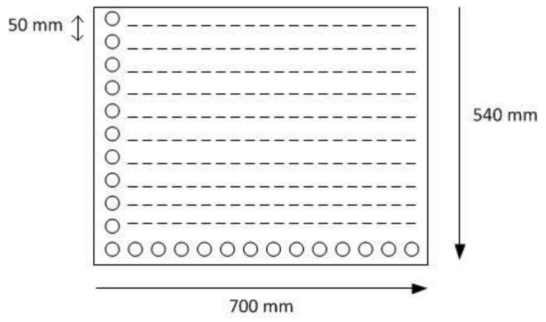
Profile Plate (PP-01)		**Schematic**
Length	700 mm	 *Figure 12: PP-01*
Width	540 mm	
Grid space	50 mm	
RxC	11x14	

Table 17: Profile Plate

Profile plate has the old version of Quick-Fix® mounting system. This means that all components with the old mounting system can easily be mounted to the profile plate. The profile plate is provided with holes for mounting, with approximately 50 mm grid spacing from slot to slot. The profile plate has eleven rows, and 14 columns.

4.10 Ball-valve

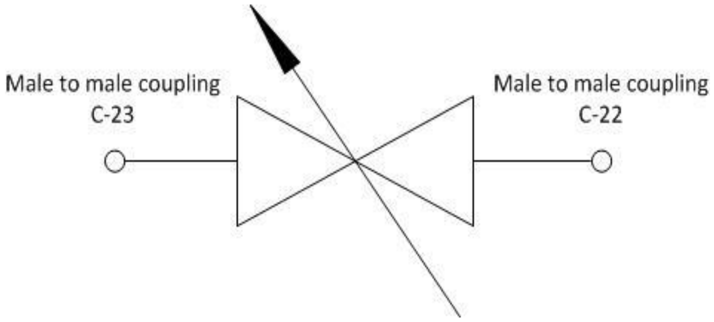
Ball-Valve (BV-01)		Schematic
P.max	500 bar	
Coupling	2 Male to male couplings	
Sealing	2 DBS sealing’s	*Figure 13: BV-01*

Table 18: Ball Valve

The ball-valve has a maximum pressure tolerance of 500 bar. It is provided with two male to male couplings, sealed with DBS sealing’s. The ball-valve shall only be used to bleed of pressure between pressure filter and servo-valve if necessary.

4.11 Others

4.11.1 Spring

Three extension spring coils, mounted on an aluminum bracket. The spring force can be adjusted by extending the connection. The springs have a retracting force of approximately 1 – 3 bar.

4.11.2 Displacement potentiometer

Linear output displacement potentiometer, with output range of 0 – 10V.

4.11.3 Hoses & couplings

Connections for the system consist of quick-fix, quick-release connectors, and male to male connectors. Couplings for the system consist of male to male coupling, and coupling nipples. In some connection points, male to male connectors has been applied with a 90° angel to reduce the bending on the hose. Hoses and male to male connectors are used to connect all hydraulic components.

The hose lines are “Hose Assey 5528-04 x 0.76 meter” with quick-fix connectors and male to male connections from TESS.

4.11.4 Base-plate

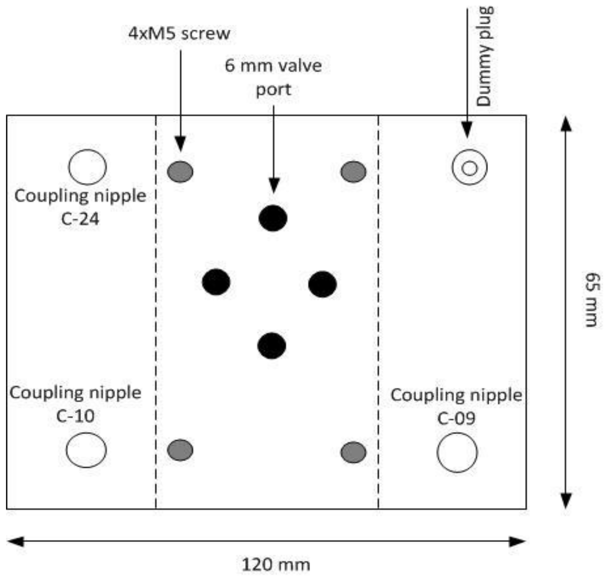
<table>
<tr><th colspan="2">Base Plate (BP-01)</th><th>Schematic</th></tr>
<tr><td>P.max</td><td>160 bar</td><td rowspan="8">

Figure 14: BP-01</td></tr>
<tr><td>Range</td><td>0 – 100 bar</td></tr>
<tr><td>Dummy plugs</td><td>1</td></tr>
<tr><td>Coupling</td><td>3 Nipples (male G$^1/_4$”)</td></tr>
<tr><td>Sealing’s</td><td>1 DBS sealing</td></tr>
<tr><td>Mounting screws</td><td>4xM5</td></tr>
<tr><td>Length</td><td>120 mm</td></tr>
<tr><td>Width</td><td>65 mm</td></tr>
</table>

Table 19: Base Plate

The Base-plate has 4 G¼" threaded connections. Three connections are coupling nipples, and one is blocked with a dummy plug. The dummy plug is fitted with DBS sealing. This component is used to attach the valve to a unit that can be mounted on the profile plate. The base-plate is adapted to the servo valve port pattern. The valve is mounted to the base plate, with four M5 screws. This is a standardized pattern [4].

5.0 Mounting system

<table>
<tr><th colspan="2">Old version of Quick-Fix®</th><th colspan="2">New version of Quick-Fix®</th></tr>
<tr><td>Mounting:
screws</td><td rowspan="4">
Figure 15: Old mounting system</td><td>Mounting:
rubber feet</td><td rowspan="4">
Figure 16: New mounting system</td></tr>
<tr><td>Grid spacing:
50 mm</td><td>Grid spacing:
50 mm</td></tr>
<tr><td>Brackets:
Plastic</td><td>Brackets:
aluminum</td></tr>
<tr><td>Bracket length:
82 mm</td><td>Bracket length:
unknown</td></tr>
</table>

Table 20: Mounting system

Table 20 shows the different mounting opportunities for all components with adapter plate. The new mounting system provides the possibility of using an aluminum plate with mounting on both sides. It also gives an advantage if expansion of the Demonstrator is wanted or required. This is due to production of old mounting system that has expired.

6.0 Assembly

6.1 Precautions

For the assembly of the demonstrator, precautions shall come first. As with all electric products and pressurized units, precautions shall be observed during handling and assembly to prevent injuries. Under no circumstances shall power be connected, nor shall any pressure occur during assembly. All assembly shall be done in accordance to a hydraulic schematic.

6.2 Mounting description

The demonstrator is a portable unit, which means that the components are mounted on to a portable table. This applies to all components except T-distributors and the ball-valve. Before mounting any other components, the profile plate shall be attached to the table’s first rack.

The power pack should be placed in second rack on the table. This is for practical reasons such as conserving space and dividing oil tank from the rest of the circuit. The power pack shall always be mounted vertically or horizontal with pressure gauge facing upwards. If not, oil leakage through the air filter may occur. It is important that the power pack is mounted properly in order to avoid damages and unnecessary noise. A hose line with quick-fix coupling and male to male coupling is connected up through the first rack on the table, and to the pressure filter. The pressure filter must at all circumstances be the first connected unit to the power pack. This is to prevent contamination throughout the system.

From the pressure filter, a T-distributor is inserted and connected by a hose line to the filter. This is to be able to connect the accumulator in the circuit. From the other side of the T-distributor another hose line connects with a pressure gauge. Three mounting nipples are used, and one port is blocked with a dummy plug.

From the pressure gauge a hose line connects the base-plate which the valve is mounted on. Another hose line connects to the ball-valve. From the base-plate, a hose line makes a connection between the valve and the other pressure gauge. From this pressure gauge a hose line is connected to piston side of the cylinder. The last nipple on the base-plate is coupled to tank.

For alternative operating mode, a hose line can be inserted between pressure gauge and cylinder. Then the connection C-21 at T-distributor TD-02 must be blocked. See Figure 18

7.0 Operation mode

This demonstrator can operate in different modes, depending on how it is connected. With the parts included in this system, the user can connect the demonstrator in two different ways.

Note: Y-port on servo-valve cannot be used with the base-plate in this Demonstrator

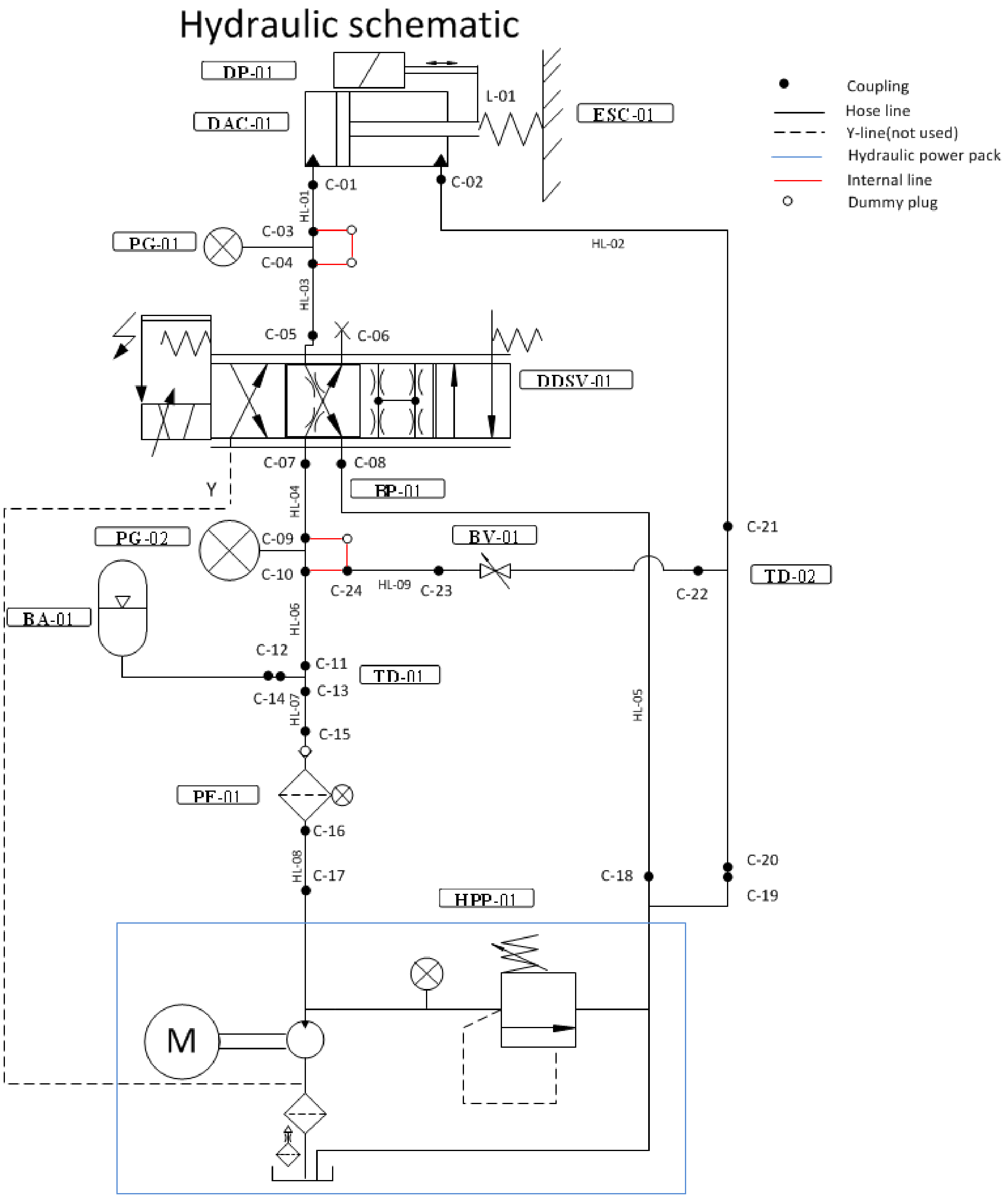


Figure 17: Smart DDSV demonstrator mode

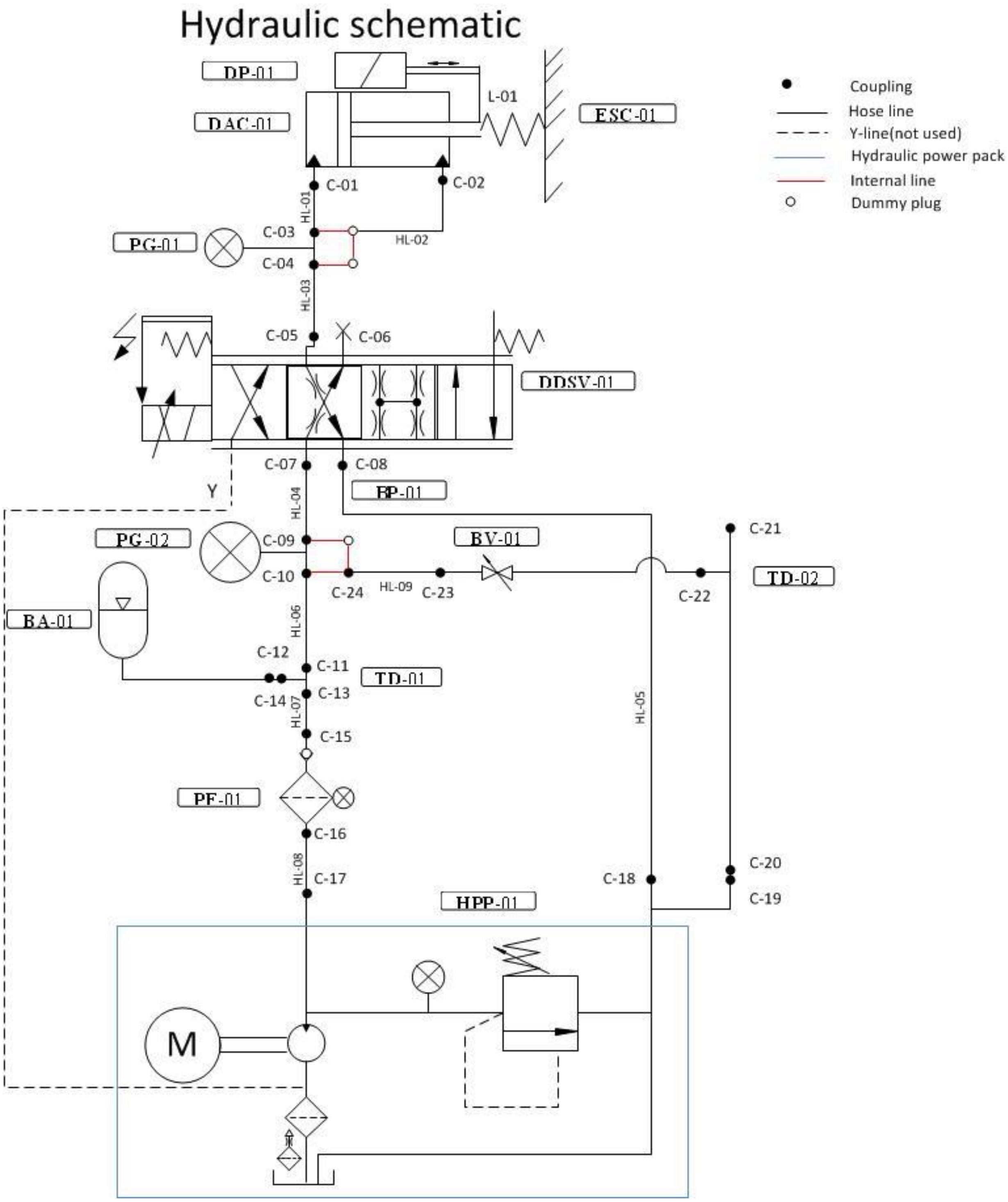


Figure 18: Alternative mode “Kolbenstangenumschaltung”

1. “**Smart DDSV demonstrator” mode**

   This is the normal operating mode, which only connects pressure to the piston, see Figure 17. This mode require a significant spring load in order to pull the piston back to initial position, and to work as a linear load against the pressure. For variable load, the external brake handle can be used. This creates a disturbance in the regulation of the valve, which will put the regulation loop to the test. This connection also requires ventilation of the piston rod side of the cylinder. This can be obtained by connecting a hose line to the tank.

2. **Alternative mode “Kolbenstangenumschaltung”**

   This is another way to connect the hydraulic circuit. It is called:”Kolbenstangenumschaltung” in German, and means: piston rod changeover. This means that we connect pressure on the piston side and on the piston rod side see Figure 18. By doing this, two forces are opposing each other and the working area (piston rod side) will be reduced from about 8 cm^2 to2 cm^2. The advantage of doing this is that the system can run on a higher frequency with the small power unit, and that the spring force can be reduced.

8.0 References

[1] Festo Didactic, "Datasheet Hydraulic power pack," ed, 2014.

[2] Smart DDSV Demonstrator, *S-VS - "Valve specification,"* HBV, Kongsberg, 2014.

[3] Moog. *d636&d638*. http://www.moog.com/literature/ICD/Moog-ServoValves-D638_D639-Catalog-en.pdf (10/2-2014-)

[4] *"Hydraulic fluid power -- Four-port directional control valves -- Mounting surfaces"*, ISO 4401:2005, 2005

Interface and GUI specification

S-IS

Version	Date	Main Author	Co-Author	Approved by
1	24.03.2014	Håkon Mørk Solaas		Snorre Kløcker
2	21.05.2014	Håkon Mørk Solaas		Snorre Kløcker

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	21.05.2014	Updated due to document review	Måkon Mørk Solaas	Snorre Kløcker

This document gives an overview of the interface and GUI of the Smart DDSV Demonstrator. It will present the communication standards used, the signal path and the structure of the software.

Table of Contents

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1.0 Abbreviations

1.1 General abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Controller Area Network
DDSV	Direct Drive Servo Valve
FMC	FMC Technologies
GUI	Graphical user interface
ISO	International Organization for Standardization
LVDT	Linear Variable Differential Transducer
mm	millimeter
MoVaPuCo	Moog Valve and Pump Configuration
SI	International system of units
SW	SoftWare
USB	Universal Serial Bus
V	Volt
VI	Virtual Instrument

Table 1: General abbreviations

1.2 CAN abbreviations

Abbreviations	Description
CiA	Can in Automation
COB-ID	Communication Object Identifier
DSM	Device State Machine
EDS	Electronic Data Sheet
NRZ	Non-Return to Zero
OSI	Open Systems Interconnection
PDO	Process Data Object
USB	Universal Serial Bus
VCI	Virtual CANbus Interface

Table 2: CAN abbreviations

2.0 Introduction

This document will present the techniques used to develop a GUI that is able to monitor and control a Moog d638 DDSV. The DDSV will be mounted in a simple hydraulic system that is designed with the purpose to demonstrate the possibilities in a DDSV.

As specified by the client FMC, the communication standards used should be according to those that are currently in use in subsea systems. This means that sensor outputs should be 4-20mA and that the serial communication between the DDSV and computer should be implemented using CANbus. The communication will follow the device profile specified in CiA 408: CANopen device profile fluid power technology. [1] The GUI shall as a minimum give the end user the ability to monitor pressure, and spool position, as well as transmitting an open/close-signal to the DDSV [2]. This GUI will be implemented in LabVIEW.

3.0 The signal path

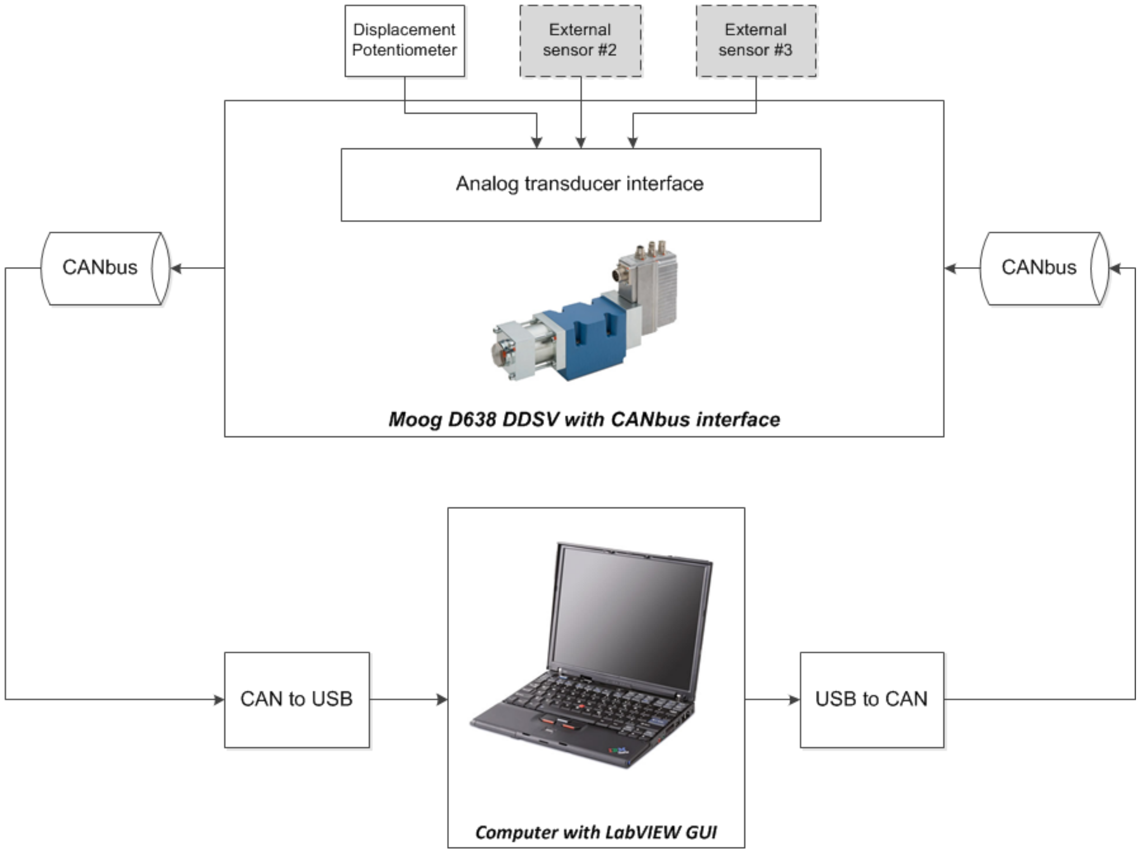

Figure 1: Signal path

Figure 1 gives an overview of the signal path of the demonstrator. Signals going through the CANbus will be sent as serial data, while the signals from the displacement potentiometer will be analog signals at 0-10V. The reason for using 0-10V rather than 4-20 mA was that a displacement potentiometer was already available to the group, and this is something that is easy to change for future use. The analog sensor signals will be sent to the transducer interface, which will scale the signals from -200% and up to 200%, and represent them as signed 16 bit integers. The DDSV valve used on the demonstrator will allow up to 3 external analog sensors.

4.0 CAN and CANopen

CAN is a communication standard for serial data. It was originally developed for the automotive industry, but is now found in several industries including subsea.

CAN follows the 7-layer OSI model shown in figure 2. The ISO-11898 standard specifies physical and data link layer. Layers three to six are intended for exchanging and sending telegrams, and are not needed for real-time field bus systems. In the ISO-11898 standard, these layers are not implemented.

CAN services such as error signaling, automatic re-transmission of erroneous frames are user transparent, which means the device with CAN will automatically perform these services. So when developing SW for CAN the developer can mostly focus most on the data link and application layer, where the CAN messages will be perceived as serial data. [3]

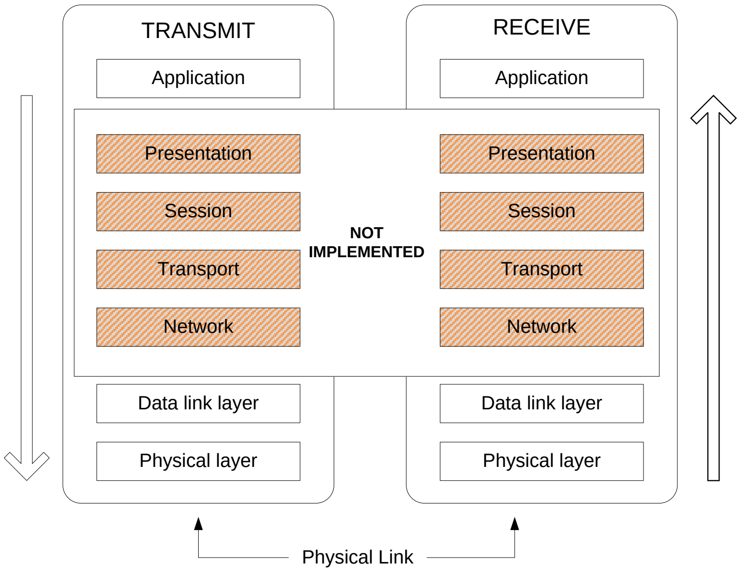

Figure 2: 7-layer OSI model

4.1 Physical layer

The demonstrator will be using devices that are already compliant with the CANopen standard, so apart from the wiring from the valve to the computer, the physical layer is in practice invisible for this application. However to have a better understanding of the signals, a short introduction is in order.

There are two common physical layer standards: ISO-11898-2 high speed and ISO-11898-3 fault-tolerant. The DDSV supports both these standards, and in this project the high speed standard will be used. This standard support bit rates up to 1 Mbit/s for bus lengths of up to 40m. For longer bus lengths the bit rate must be lower. [4]

Different units that are connected to the bus are referred to as nodes. In this case the nodes will be the CAN-USB Interface and the DDSV. The bus must be terminated with 120 Ω resistors at both ends. The connection of multiple nodes is shown in figure 3. The end terminations are used to prevent signal reflection on the CANbus. This method of connection also makes the bus insensitive to electromagnetic interference; both bus lines will be affected in the same way, and the voltage differential will remain the same. [4]

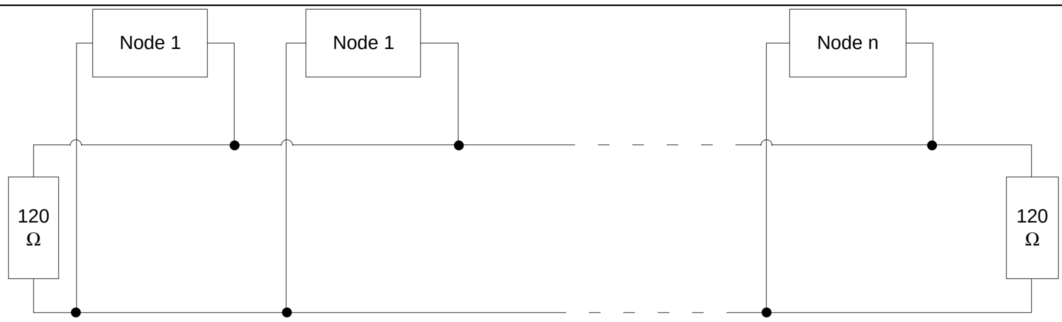

Figure 3: Node connections and end termination

The bit stream is coded using the NRZ-method which means that the serial data is represented as either high or low. Which in the ISO-11898-2 high speed standard corresponds to -2V (CAN_L) or +7V (CAN_H).

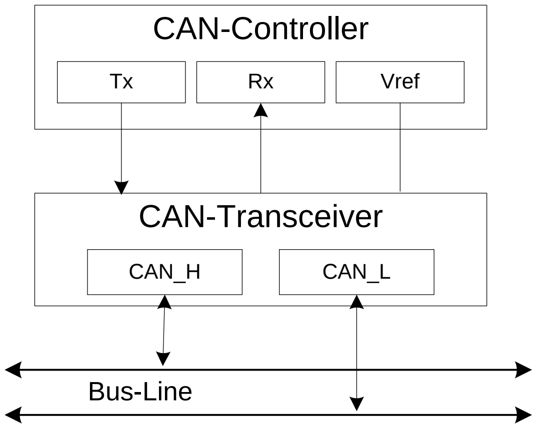

Figure 4: CAN physical layer

4.2 Data link layer

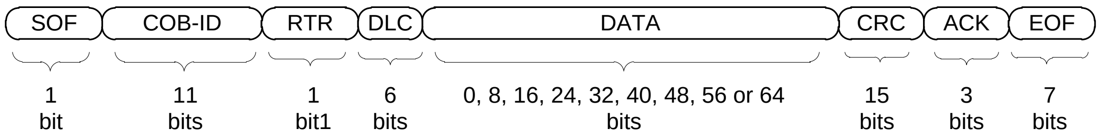

Figure 5: CAN message format

All CAN messages are built up after a specified data frame. The CAN data frame can carry up to 8 bytes (64 bit) of data. All CAN services are assigned a COB-ID, this value addresses a specific CAN service. The lowest COB-ID values have the highest priority. For example the Emergency protocol has a COB-ID of 0x080+Node-ID. [5]

4.3 Application layer

4.3.1 CANopen object dictionary

It is common for CANopen compliant devices to have an object dictionary. This is an index where separate application parameters are stored, and can then be easily accessed. Each CANopen node must implement its own object dictionary. For communication between CANopen and a computer, an EDS is often implemented. This is in practice a dictionary that the SW developer may use in order to translate the CAN messages to a format that is easily understood. In this project the EDS will not be implemented, as there is only a limited amount of CAN objects to handle.

4.3.2 EMCY protocol

The EMCY protocol is a method to indicate device specific errors. When an error occurs, a message with the COB-ID 0x080+Node-ID is transmitted. Simple error handling will be implemented in the LabVIEW application.

For further information on error handling, refer to Moog Firmware manual chapter 8 “Diagnostics”.[6].

4.3.3 PDO protocol

For cyclic transmission and receiving of real-time data the PDO-protocol will be utilized. The PDO channels give us a method of sending multiple object dictionary entries in a single message. In each PDO-channel it is possible to send a total of 8 bytes or 64 bit. An example of a typical PDO-channel message is shown in figure 4 (only including identifier and data).

CANbus message

Analog input value		Pressure actual value		Spool poition actual value		Status word		COB-ID
Byte 8	Byte 7	Byte 6	Byte 5	Byte 4	Byte 3	Byte 2	Byte 1	

Figure 6: PDO-channel message standard

CANopen includes four TxPDO-channels for transmission, and four RxPDO-channels for reception. All PDO channels are assigned a COB-ID. The first PDO protocols have the highest priority (lowest COB-ID).

The assignment of the various object dictionary entries to different PDO-channels is referred to as PDO-mapping. For the DDSV the PDO-mapping configuration can be done through the SW supplied by Moog.

In the DDSV, four different modes of transmission are supported: synchronous, event or timer driven transmission. In this project timer driven cyclic transmission of three TxPDO channels will be used. An alternative method is to make the DDSV wait for a SYNC message before it transmits a PDO message, so you can confirm that the message reading the CAN messages is ready to receive a new message. In this project a relatively low baudrate will be used, and both the computer and the valve responds quickly to incoming messages, so there is not much probability that messages will be lost.

For transmission of PDO messages from the computer, all PDO channels will be sent with timer driven transmission.

4.3.4 SDO Objects

SDO objects are used when it is necessary to change the parameters of how the DDSV is configured. They are transmitted non real-time and have a low priority. These objects are not included in the LabVIEW application, as the configuration of the DDSV will be done in the SW provided by moog. This will also be a factor in improving the safety of the LabVIEW, as the end user will not have the possibility to reconfigure the valve during operation.

5.0 DDSV control

5.1 Configuration

In order to reduce the amount of functions that needs to be implemented in LabVIEW, the group will use the MoVaPuCo SW to set up the DDSV. This includes setting up what values that will be sent on the PDO-channels, configuring controller parameters and choosing baudrate. This means the main application for the LabVIEW VI is to monitor the PDO-messages, and controlling the device and NMT states of the valve.

5.1.1 Parameters for configuration of the DDSV in MoVaPuCo

5.1.1.1 RxPDO

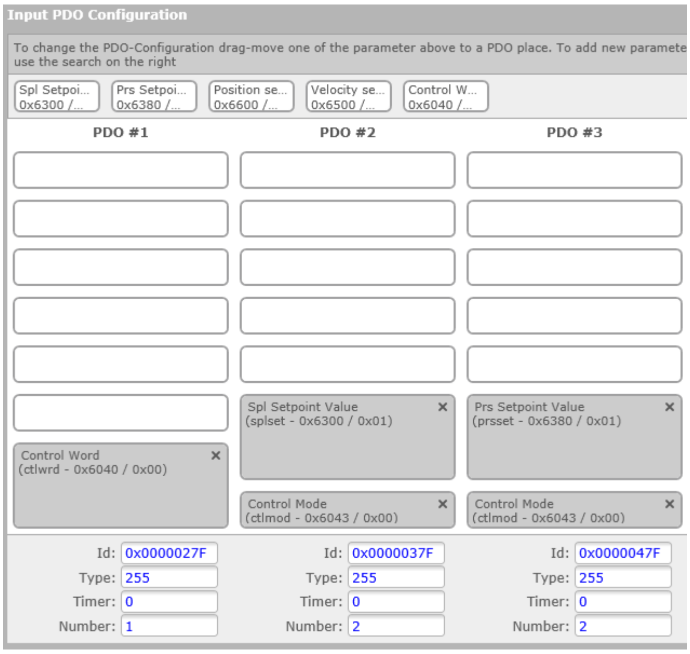

Figure 7: RxPDO Configuration

For the valve's operation in the demonstrator the PDO-channels will be set up in the way shown in Figure 7. PDO channel 1 will control the device state, channel 2 is used for sending spool setpoints, and channel 3 will be used when sending pressure setpoints.

None of the PDO channels will use a timer, so all channels will be read when a message with an identifier corresponding to the RxPDO ID is received.

5.1.1.2 TxPDO

The configuration for the transmission channels is set to transmit messages every 100 ms. For easier implementation in LabVIEW the values are sorted in categories. Channel 1 will be used for transmitting the valve state and control mode; Channel 2 will transmit the controller variables, and channel 3 will transmit external sensor values. The timer value has been set to 100, and the type is set to 255, which means that the valve will transmit these messages every 100 ms. Messages on PDO channel 1, which has the lowest value identifier, will be transmitted first.

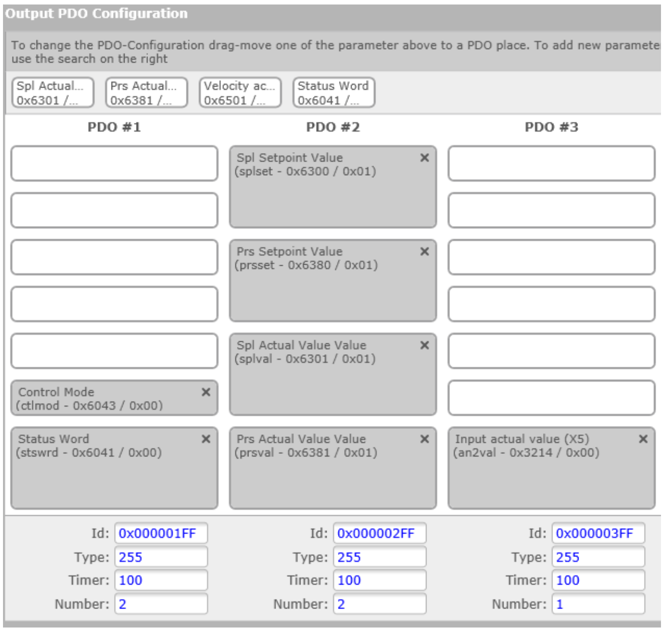

Figure 8: TxPDO Configuration

5.1.1.3 Fault reactions

Several fault reactions may be configured in the Moog software. For this configuration the default configuration specified in the Moog firmware manual [6] will be used. These fault reactions will happen when a critical error in the valve occurs. Once an error is discovered in the valve, the user may configure a fault reaction which will set the valve to a specified device state. An example is when the spool position transducer wire is broken, this will set the valve state to “Disabled”, which ensures the spool returns to the fail-safe position.

5.1.1.4 *Start-up configuration*

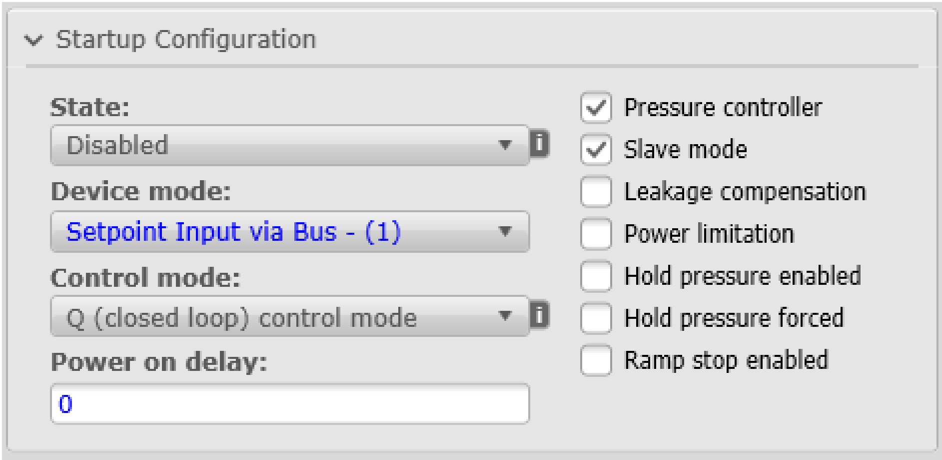

Figure 9: MoVaPuCo - Startup Configuration

For safety, the valve is set to disabled state once it is powered on, the default controller mode is set to Q(closed loop) and the device mode is set to receive messages from the bus. The valve will be set to slave mode in order to make it react to NMT state messages sent from the computer.

5.2 Network management state machine

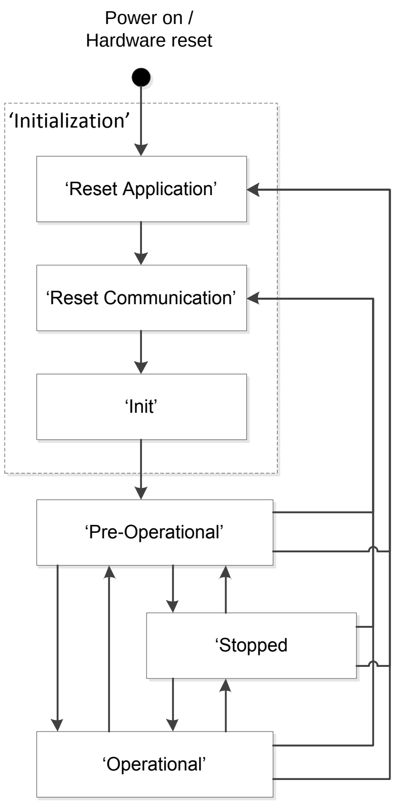

Figure 10: NMT state machine

All CANopen devices must support the NMT slave state machine. After setting a master node, this node can transmit messages which can dictate what state a specific node should enter. For this application the computer will be the master node, and the valve will be set to slave. The table below shows which protocols are supported in each NMT state. In order to start transmitting PDO messages the DDSV must be set to operational mode. The message for setting the DDSV into operational mode must be implemented in the LabVIEW VI.

NMT states	**Available services**			
	SDO	**PDO**	**EMCY**	**NMT**
'Stopped'				x
'Reset Communication	x		x	x
'Operational'	x	x	x	x

Table 3: NMT states and available services

5.3 Device state machine

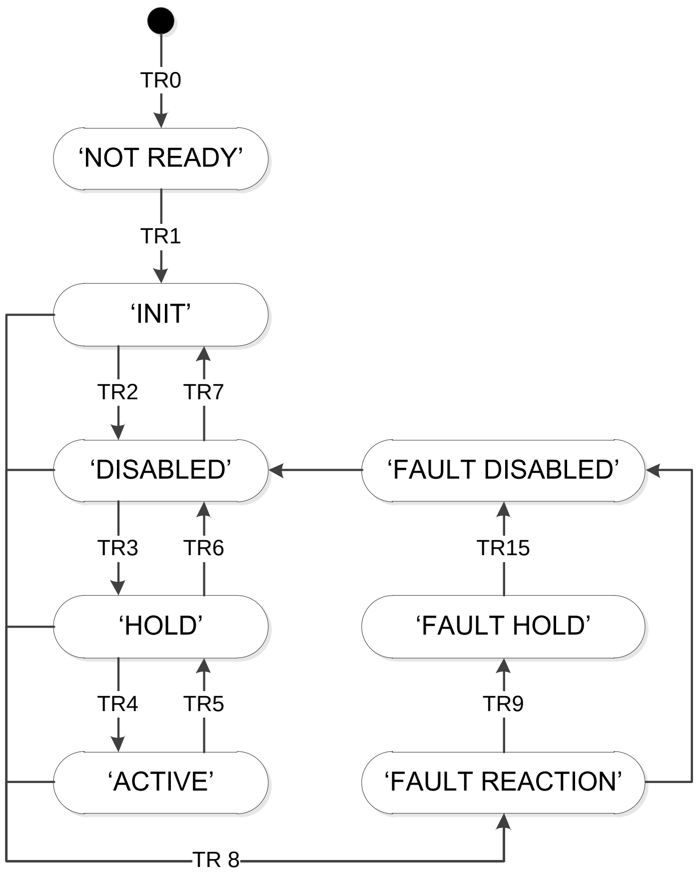

Figure 11: The DSM

The device state machine describes the status of the DDSV and the transitions between them. For example, in the "NOT READY", "INIT" and "DISABLED" the spool position will be in the defined failsafe position. The current device status can be read in the status word that will be cyclically transmitted on the PDO channel 1. A control of these states will be implemented in the LabVIEW VI. This is done by transmitting the correct status word object on RxPDO channel 1. Table 4 shows the values for the lower four bytes for the status and control word for each device state.

Device state		**R**	**M**	**H**	**D**
NOT READY	Control word		0	0	0
	Status word	0	0	0	0
INITIALIZE	Control word		0	0	0
	Status word	1	0	0	0
DISABLED	Control word		x	x	1
	Status word	1	0	0	1
HOLD	Control word		x	1	1
	Status word	1	0	1	1
ACTIVE	Control word		1	1	1
	Status word	1	1	1	1
FAULT REACTION	Status word	0	0	0	1
FAULT HOLD	Status word	0	0	1	1
FAULT DISABLED	Status word	0	1	1	1

Table 4: Device state control and status word values

5.4 Configuring the pressure controller

As requirement PERQ-104 specifies, the valve should tackle variable loads on the hydraulic cylinder. Requirement PERQ specifies that the overshoot should be less than 20% of the setpoint value, and the settling time should be no more than 20 seconds.

The challenge of configuring the controller is that the hydraulic system will act very different as the cylinder extends, an approximate curve of the force acting against the cylinder is shown in Figure 12, where the force after the full extension of 200 mm is essentially infinitely high.

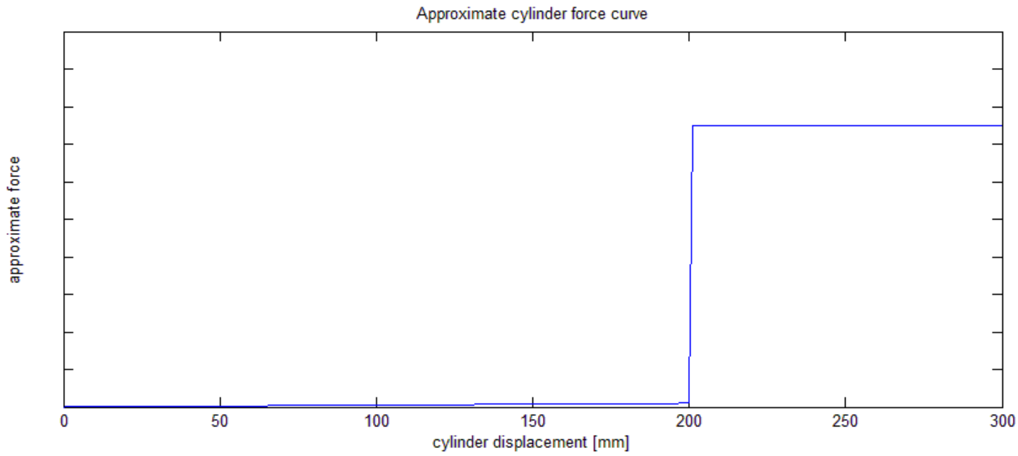

Figure 12: Approximate cylinder force curve

During the period when the cylinder is extending the spring force acting against the cylinder will not be sufficient to build up pressure. This leads to a fast increase in volume, which means pressure will not be able to build up. The pressure controller in the DDSV will then demand that the valve opens port P→A, (a positive increase in spool position) further, allowing more fluid to flow through. Once the cylinder reaches full extension very little changes in flow may result in large changes in pressure. So with a high gain it is very likely that the system will have a large pressure overshoot, or even introduce instability.

However a high proportional gain is required in order to quickly bleed off pressure to account for the sudden load change when the cylinder reaches full extension. The solution used on the demonstrator was to lower the upper limit of the spool to 15% to reduce the flow through the valve. This will make the reaction somewhat slower, as it will take significantly longer to extract the cylinder.

The long period with a pressure considerably below the setpoint may also result in what is referred to as an integral wind-up. The integral part of the controller may be saturated, and this will result in the controller using a long time before it starts reducing the gain. To avoid integral wind-up an upper limit at 10% for the integral part has been set.

Figure 13 shows how the demonstrator reacts to when the valve receives a 30 bar setpoint for pressure regulation. The setpoint was given when the cylinder was fully retracted. From the plot we can see that the valve requires a 15% spool position (the set upper limit) when the cylinder is extracting, and once it reaches full extension it significantly reduces the spool position to account for the load change. After full cylinder extension the pressure slowly builds up to the setpoint. Total time from the valve receives the setpoint, and to the system reaches the given pressure is around 17 seconds.

Figure 14 shows how the valve reacts when responding to a setpoint while the cylinder is in full extension. The pressure has no overshoot, and the settling time is well under 1 second, which is well within the requirements set in S-RS [2].

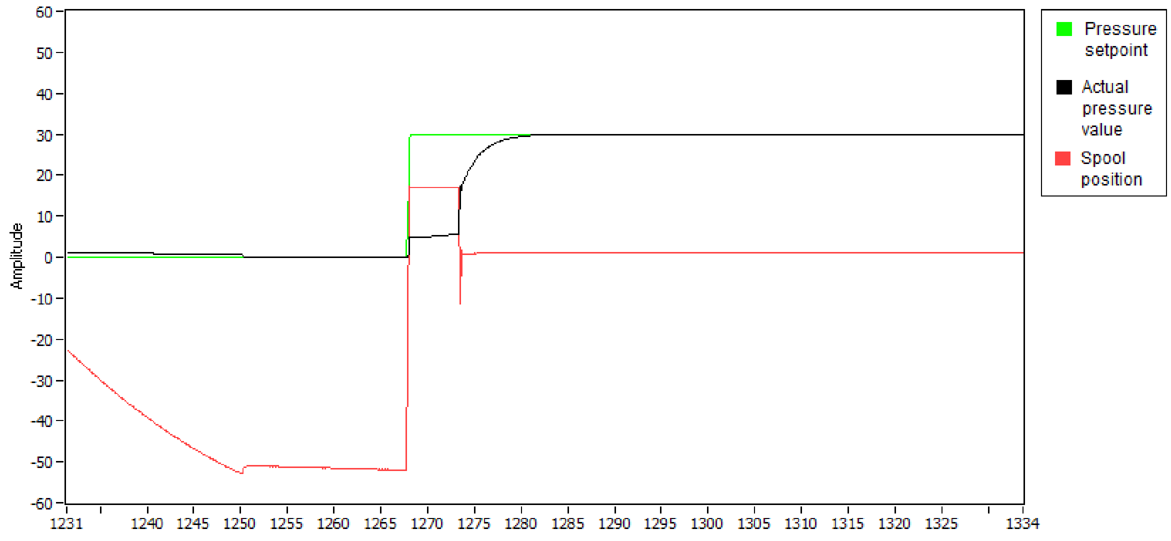

Figure 13: Response to 30 bar setpoint

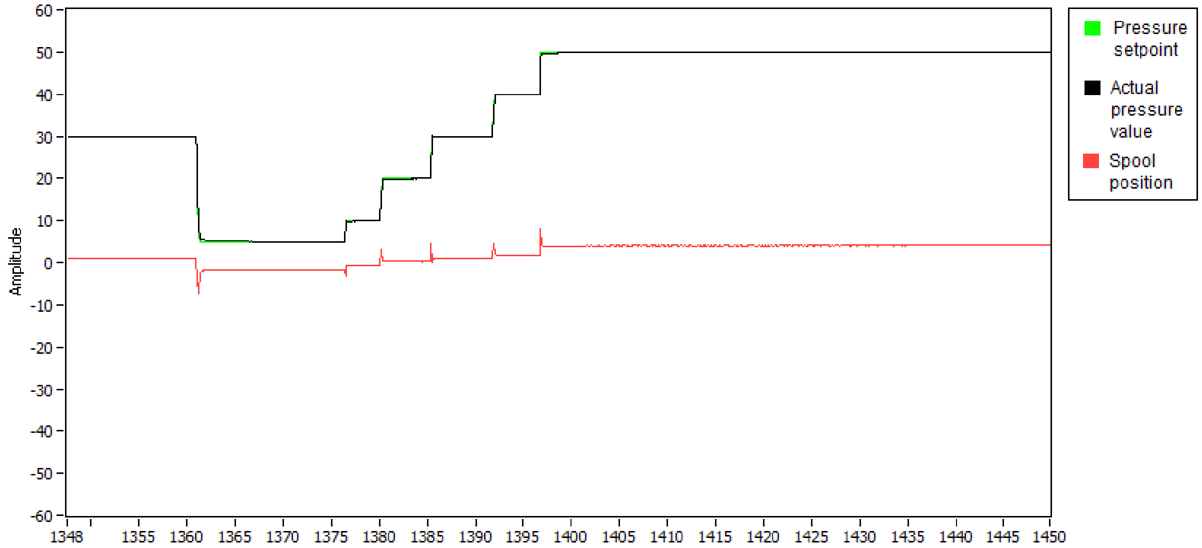

Figure 14: Regulation with full cylinder extension

6.0 The GUI

6.1 CAN-to-USB

The interface for connecting the DDSV to the computer will be IXXAT USB-to-CAN Compact. DE9 connectors will be used to connect the IXXAT to the CANbus. Figure 15 shows the wiring for connecting the DDSV to the computer. The DE9 connectors will have the pin configuration shown in Figure 16.

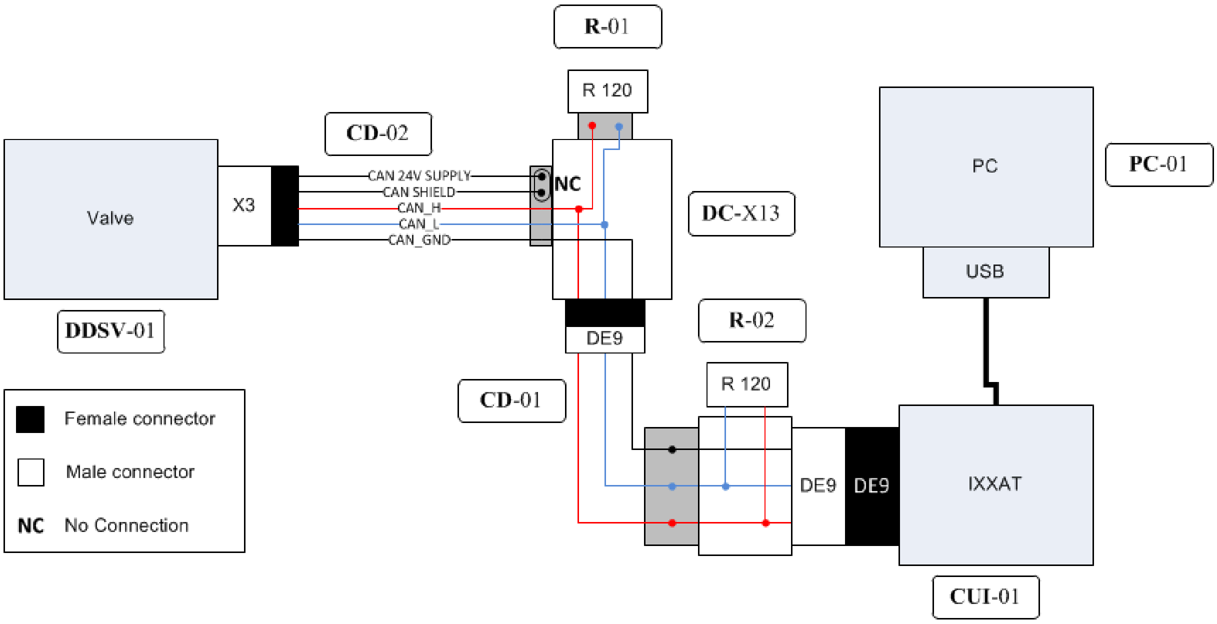

Figure 15 : Wiring for CAN communication

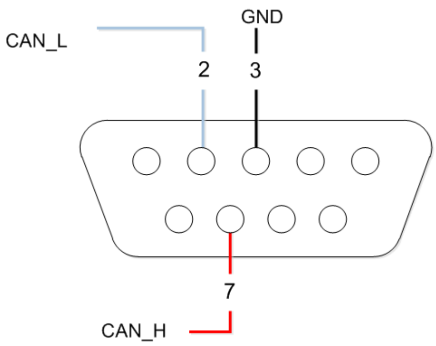

Figure 16: DE9 Pin out male connector

6.1.1 *Accessing the CANbus using the VCI*

To access the CANbus in LabVIEW, the IXXAT VCI will be used. The VCI is a shared library which gives access to a number of functions which can be called in LabVIEW, or another application to get access to the CANbus. An example of a LabVIEW VI which receives and generates messages has been developed by IXXAT. This LabVIEW VI was tested in T-003 [7] and was verified to work. This LabVIEW VI will serve as a guideline for developing the initializing part of the GUI.

6.1.2 Reading CANbus messages from VCI message channel

From LabVIEW the function canChannelReadMessage may be called. This function will read messages from the receive buffer in the VCI, if there are no messages available, the functions will wait for a specified amount of time. This time is determined by the parameter dwMSTimeout, if the time runs out the function will return an error message to the GUI. [8]

The received message will have the following structure:

```
typedef  struct
{
        UINT32 dwTime; //
        UINT32dwMsgID;
        CANMSGINFO uMgInfo;
        UINT8 abData[8];
}       CANMSG, *PCANMSG;
```

Brief description of the data in the message:

- *Dwtime* – contains the relative time the message was received.
- *DwMsgID* – Message identifier (Arbitration ID)
- *uMsgInfo* – Various information about the message, including the data-length code.
- *abData* – Message data

The most important values for this application are the arbitration ID and the message data. The arbitration ID will correspond to the COB-ID specified for the node, and will be used to sort out messages that are of interest.

6.1.3 Transmitting CANbus messages from VCI message channel

The VCI function for transmitting messages is *canChannelSendMessage*. It stores the message in a free entry in the transmit buffer. If the message has not been written after a specified time, the function will return the value *VCI_E_TIMEOUT*, which will tell the program that the message was not successfully transmitted. Following parameters must be used:

```
HRESULT canChannelSendMessage (
        HANDLE hChannel,
        UINT32 dwMsTimeout,
        PCANMSG pCANMsg);
```

Short description of the parameters:

- hChannel – handle of opened message channel
- dwMsTimeout – maximum waiting time in millisecond before error code VCI_E_TIMEOUT is returned
- pCANMsg **-** Pointer to an initialized structure of type CANMSG with the CAN message to be transmitted

For further information on CANbus communication using the VCI, refer to VCI C-API Programming Manual. [8]

6.2 Main functions

The initial plan for the GUI was to program it in Matlab. However the group later received a student version of LabVIEW, and found out that this was a development environment more suited for the programming the GUI. LabVIEW is a visual programming language that is commonly used for instrument control, data acquisition and industrial automation. Since the programming is visual, it will also be easier to expand the SW with additional functionality.
Figure 18 shows the main functions that will be implemented in the VI.

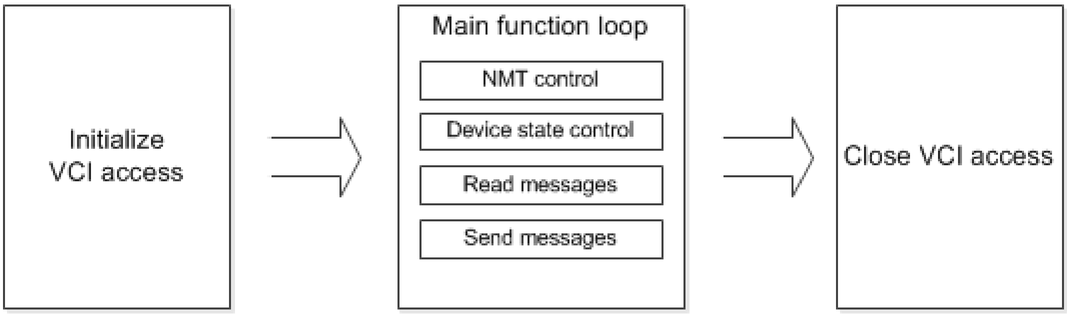

Figure 17: Main functions

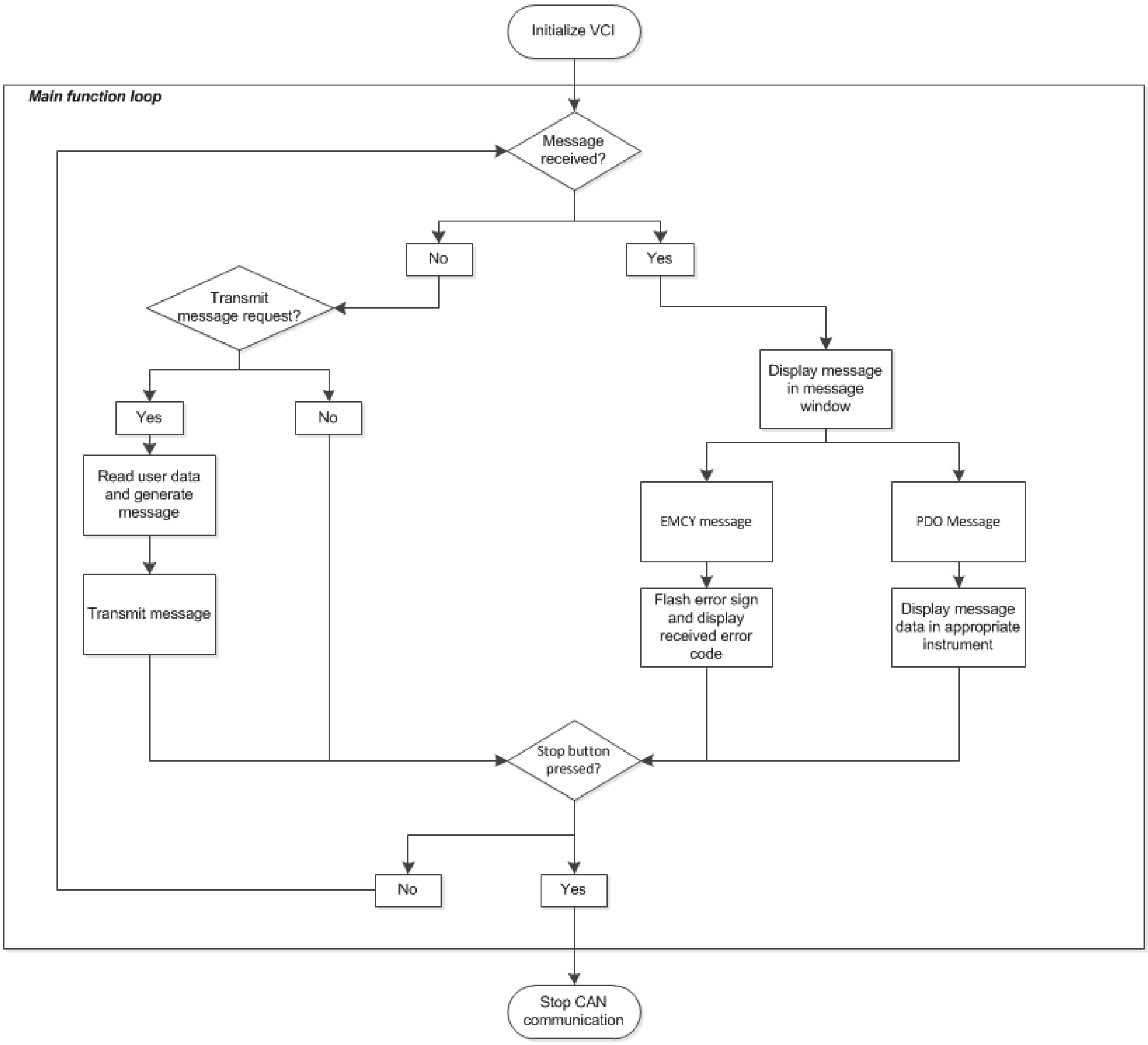

Figure 18: Main function loop

6.2.1 PDO-mapping

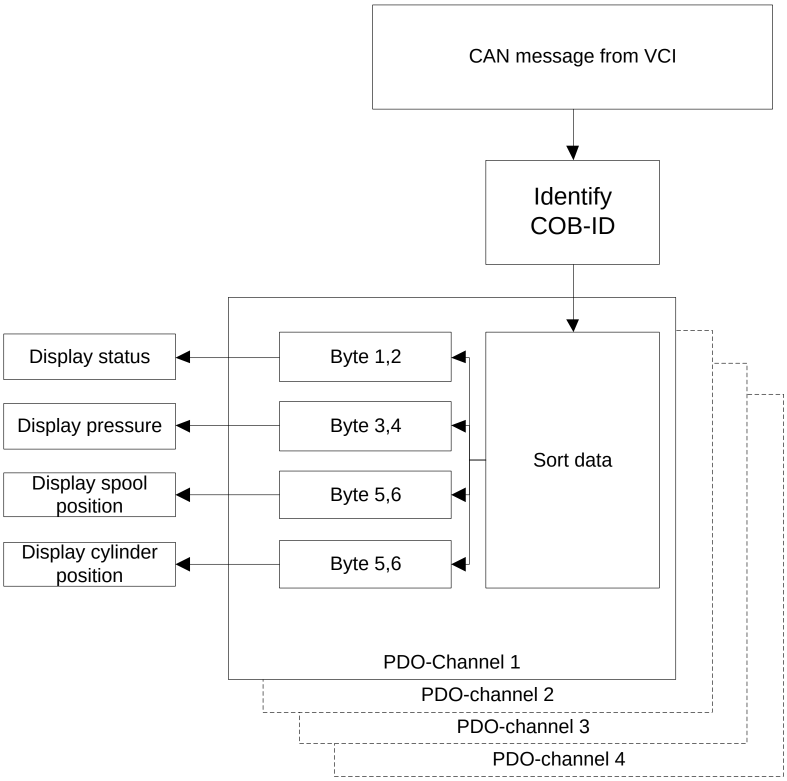

Figure 19: PDO-Mapping example

The process of PDO-mapping is illustrated in Figure 19, it shows how the message from the USB-CAN interface will be interpreted in the case of a PDO-message. Since the TxPDO-channels in the DDSV contain different set of data, a PDO-mapping routine must be implemented in the GUI. In short, the PDO-channel must be identified using the COB-ID, and the data bytes must be sorted and sent to the correct internal variables.

6.2.2 Transmitting messages to the DDSV

LabVIEW must be able to generate messages that follow the format defined in the RxPDO protocol for the DDSV. In essence this will be a reverse of the read function. The internal variables that will be transmitted to the DDSV must be converted to a series of 8-bit unsigned integers and then sent to the correct data byte in a CAN message according to the CAN message standards specified in the RxPDO protocol on the valve.

7.0 Implementing the CANopen protocols in LabVIEW

7.1 Initializing the communication

IXXAT supplies a demonstration LabVIEW application, this has been used as a guide when developing the LabVIEW GUI.

7.1.1 Hardware enumeration

This routine is run in order to connect the hardware to the VCI, in this case the IXXAT USB-to-CAN Compact.

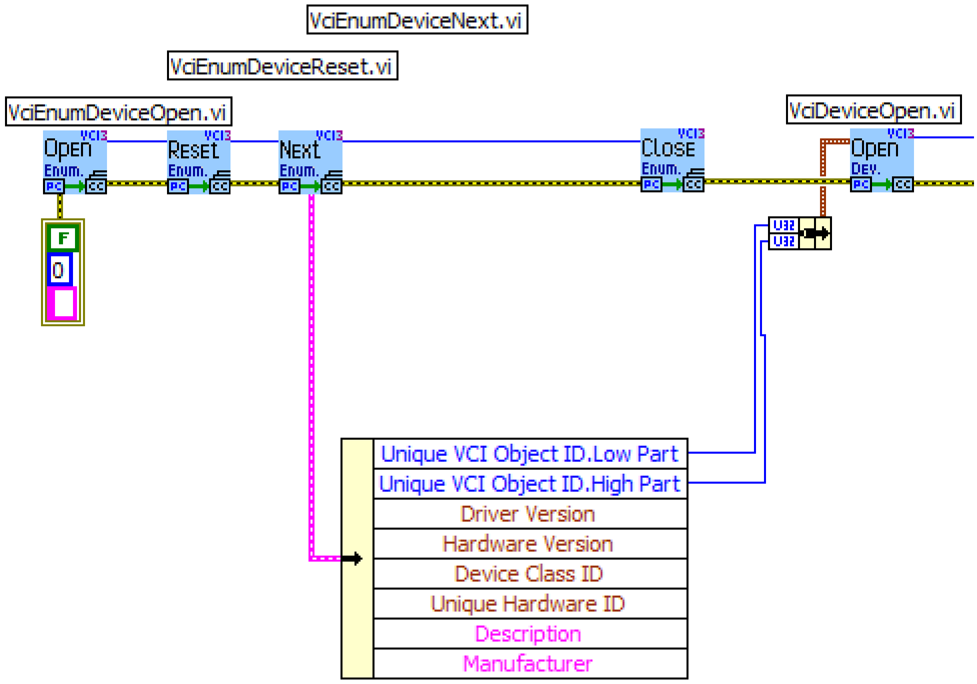

Figure 20: Hardware enumeration

SUB VI	Input	Description	Output
VciEnumDeviceOpen	None	This opens the device list of all CAN interface with VCI support that are currently connected.	Address of HANDLE If successfully run it returns the value VCI_OK, otherwise it will return an error code.

VciEnumDeviceReset	*hEnum* Handle of the opened device list	Resets the internal list index of the device list called with the previous function.	VCI_OK when run successfully, otherwise error code.
VciEnumDeviceNext	*hEnum* Handle of the opened device list	This function is used to provide information about the device that is the first entry on the device list.	Handle to the device list Adress of a data structure, that saves information on the CAN interface board. VCI_OK when run successfully, otherwise error code.
VciEnumDeviceClose	*hEnum* Handle of the opened device list	Closes the device list.	VCI_OK when run successfully, otherwise error code.
VciDeviceOpen	*rVciidDevice* Device ID of the CAN interface board to be used.	Opens connection with the interface board with the specified device ID.	Address of handle of the opened CAN interface board. VCI_OK when run successfully, otherwise error code.

Table 5 : Hardware enumeration sub VI's

7.1.2 Controller initialization

The controller initialization is run to configure and control the CAN control unit. Here parameters such as baudrate and message filters will be configured.

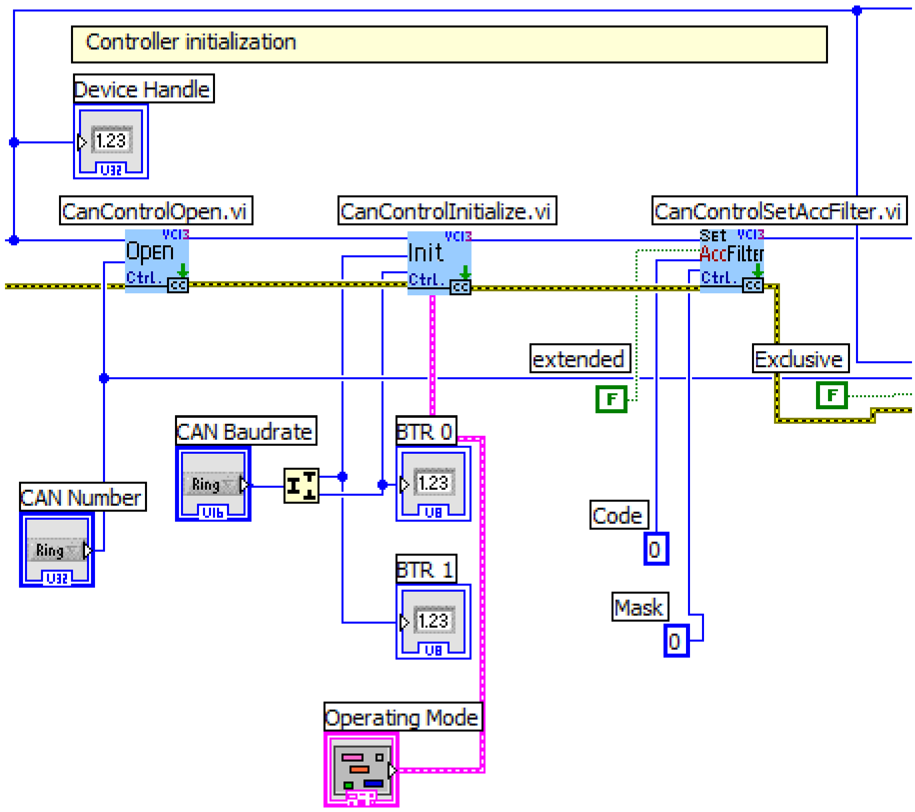

Figure 21: Controller initialization

SUB VI	Inputs	Description	Outputs
CanControlOpen	*hDevice* Handle of the opened CAN interface board	Opens the control unit of a CAN connection on a CAN interface board.	Handle of the opened CAN controller VCI_OK when run successfully, otherwise error code.

CanControlInitialize	*hControl* Handle of the opened CAN controller *bMode* Operating mode of the CAN controller. *bBtr0* Value for bus timing register 0 *bBtr1* Value for bus timing register 1	Sets the operation mode and bitrate of the current CAN connection.	VCI_OK when run successfully, otherwise error code.
CanControlSetAccFilter	*hControl* Handle of the opened CAN controller *fExtended* Selection of the acceptance filter. *dwCode* Bit sample of the ID *dwMask* Bit sample of the relevant bits in dwCode[1]	Sets up the 11- or 29-bit acceptance filter, which filters out messages that does meet the filter criteria.	VCI_OK when run successfully, otherwise error code.

Table 6: Controller initialization sub VI's

[1] For further information on the function of the Acceptance filter, see section 3.1.2.2 in the IXXAT C-API Programming manual. [8] IXXAT, *C-API Programming Manual, Version 1.5*, 2012,

7.1.3 Channel initialization

The Channel initialization opens the message channel, so that the application may receive and transmit messages on the CAN bus.

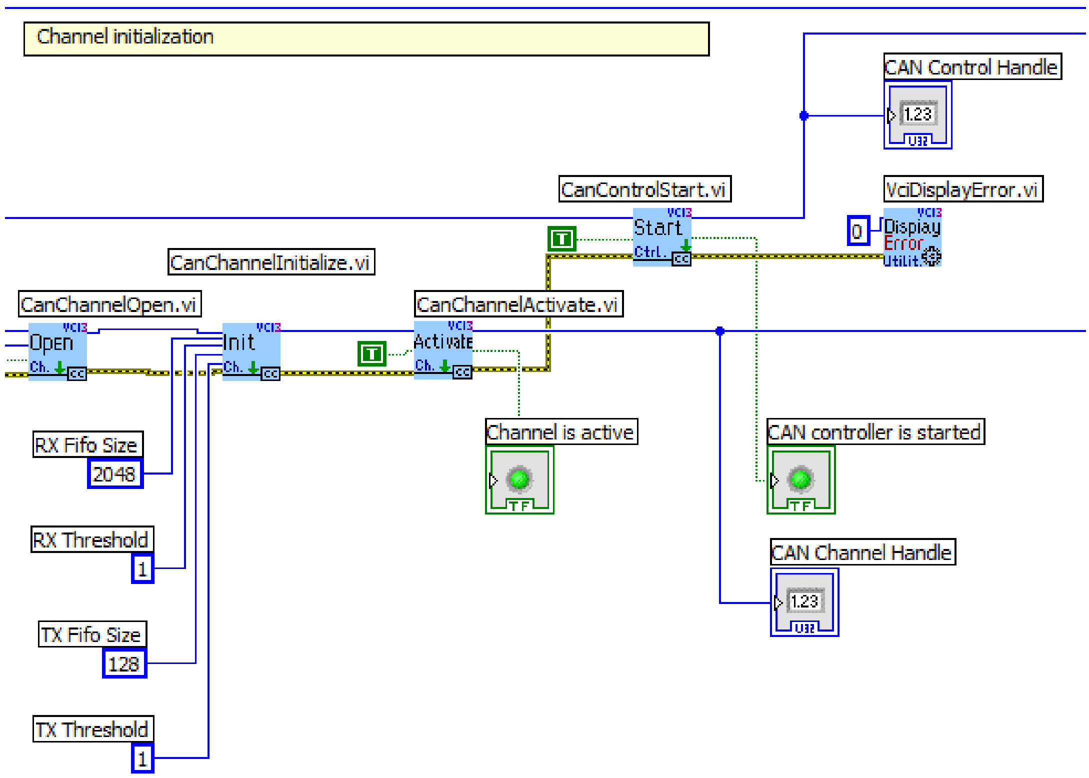

Figure 22: Channel initialization

SUB VI	Inputs	Description	Outputs
CanChannelOpen	*hDevice* Handle of the CAN interface board *dwCanNo* Number of the CAN connection of the control unit to be opened. *fExclusive* A boolean that specifies whether the CAN connection is used exclusively for the new message channel	Creates a channel for a CAN connection of a CAN interface board.	Handle of the opened CAN message channel. VCI_OK when run successfully, otherwise error code.

CanChannelInitialize	*hChannel* Handle of the opened message channel *wRxThreshold* Threshold value for the receive event. *wTxFifoSize* Size of the transmit buffer in number of CAN messages *wTxThreshold* Threshold value for the receive event	Initializes the receive and transmit buffers of a message channel.	VCI_OK when run successfully, otherwise error code.
CanChannelActivate	*hChannel* Handle of the opened message channel *fEnable* Activates/Deactivates message flow between CAN controller and the message channel.	Activates or deactivates the message channel	VCI_OK when run successfully, otherwise error code.
CanControlStart	*hChannel* Handle of the opened message channel *fStart* Boolean that starts or stops the CAN controller	Starts or stops the CAN controller	VCI_OK when run successfully, otherwise error code.
VciDisplayError	*hwndParent* Handle of the higher order window *pszCaption* Pointer to a 0-terminated character string with the text for the title line of the message window. *hrError* Error code for the message to be displayed.	Displays a message window that corresponds to the input error code.	None

Table 7: Channel initialization sub VI's

7.2 Receiving messages

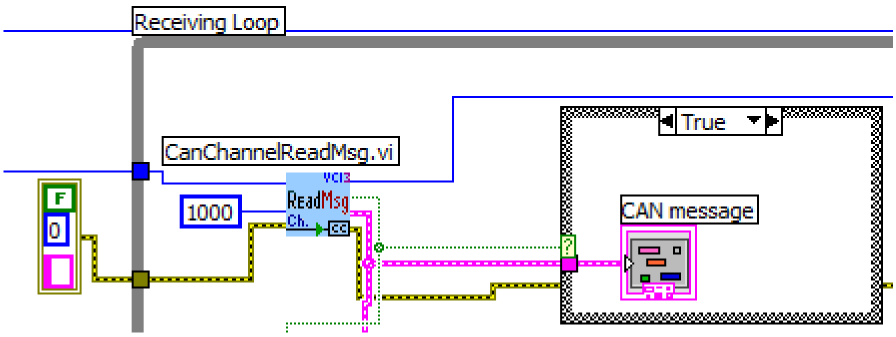

Figure 23: Message reception

Once the channel has been initialized, one may call the receive CanChannelReadMsg VI. The inputs will be the CAN channel handle, a specified timeout period in ms and an error state. It will return a struct containing the CAN message in the format specified in section 6.1.2. It will also return the CAN channel handle, an error code and a boolean that specifies whether the message is valid or not. Once a valid message is received the GUI will enter the CAN message reception case, so the message will be displayed in the GUI, and it will enter the message identification function.

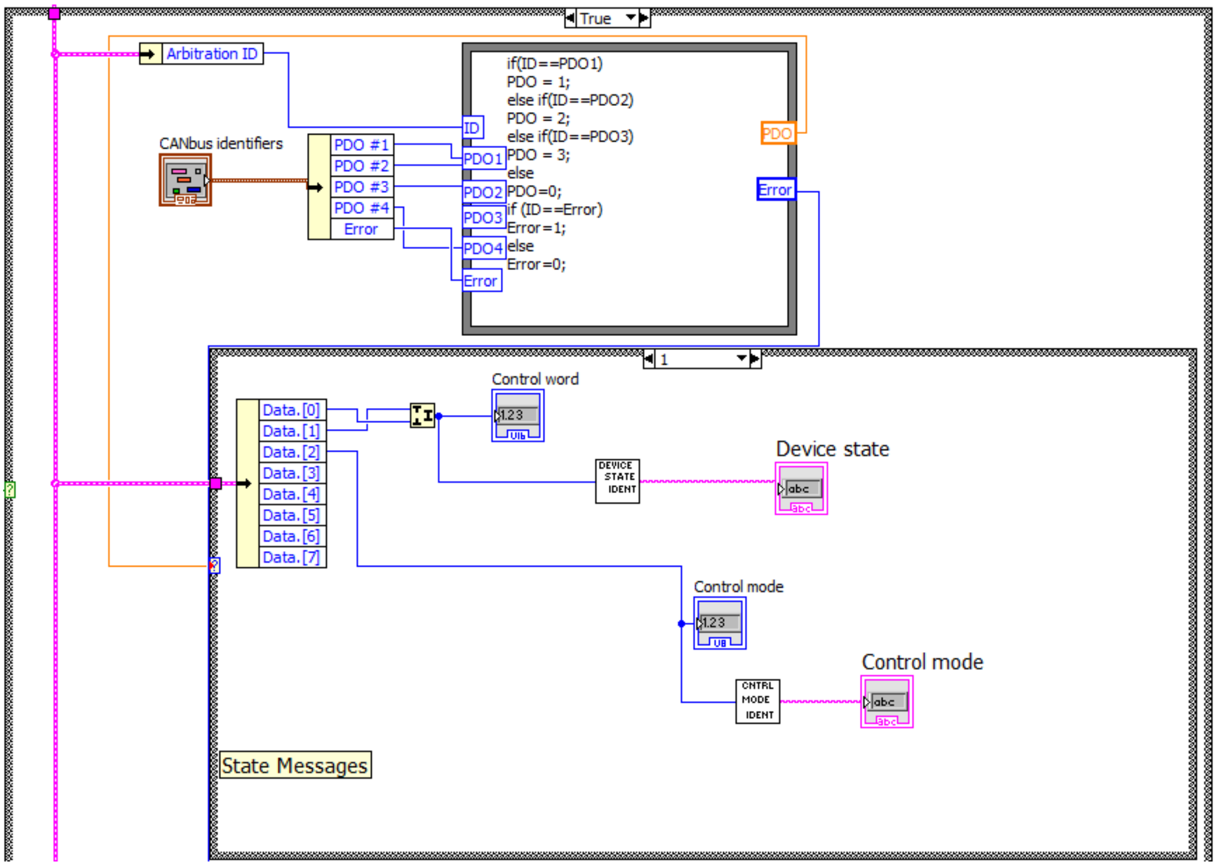

Figure 24: Message identification

The message identification sorts out the CANbus messages that are of interest to the end user, such as the PDO-messages and the emergency messages. The message identification case will run every time the GUI receives a valid message. The end user may specify what PDO identifiers that shall be used, and the formula node will then see whether or not the identifier of the incoming message matches one of the PDO channels or the EMCY protocol. If it matches the identifier of a given PDO channel, the formula node will set the output «PDO» to the appropriate channel number (1, 2 or 3). This will in turn will enter a case where the incoming data is sorted to the correct internal variables according to the specified data on the given PDO channel.

Figure 24 shows how this works if a message with an identifier corresponding to PDO channel 1 is received, the first two bytes will be read as the status word. The numerical value of the status word is sent into a sub-VI which will use this value to index a string array, and return the current control word in a string which will be easy to understand for the end user. A similar function is used for the third byte, which holds the current control mode, and the string array functionality is shown in Figure 25.

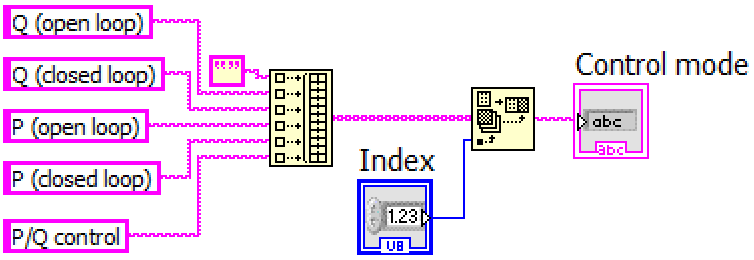

Figure 25: Displaying control mode

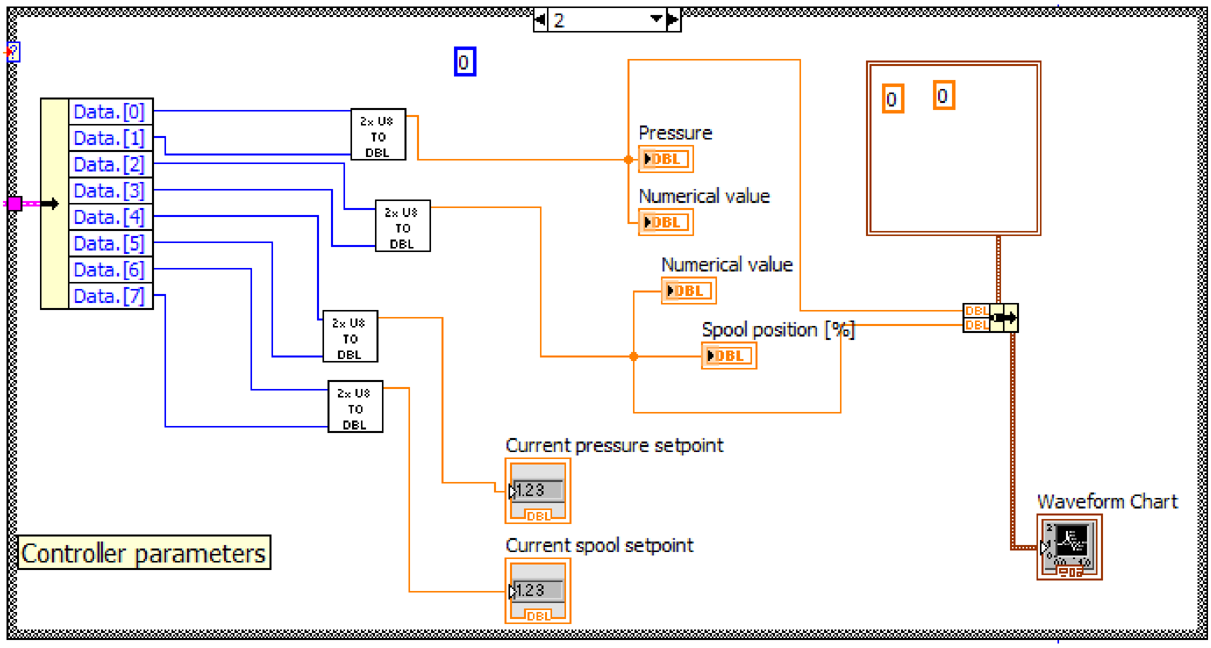

Figure 26: PDO channel 2 case

7.2.1.1 Displaying sensor values

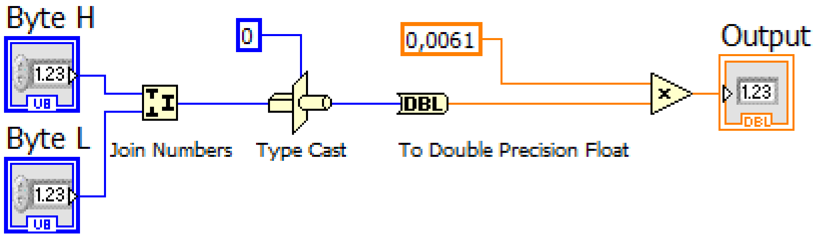

Figure 27: Sub VI: Conversion from 2xU8 to double precision value

The parameter values are transmitted as signed integers with different data length, this is not a practical way to display these values. In order to make the GUI easy to understand for the end user, these values must first be converted to SI-units, and then displayed on a meter in the GUI. For example the actual value of the 0-10 V analog input will be transmitted as a signed 16-bit value with a range from -200% and up to 200%. This means the range 0-10V is represented in $2^{16-1} = 32768$ levels and each level will represent 200/32768≈ 6.1*10^{-3} V or 6.1 mV. As the values received in LabVIEW will be understood at an unisgned 16-bit, the signal must first typecasted into a 16 bit signed variable, and then it can be converted to a double precision float with appropriate scaling. The block diagram that implements this function is shown in Figure 27.

After this conversion, the values are represented as floating point double precision variables which then may be approximately scaled to display the correct SI-unit. The potentiometer is extended 200mm when the output is 0V and 10V when it is fully retracted. Since the sensor is linear, the converted value may simply be scaled with a factor of 2 to present the user with the mm value. Similar conversion must be carried out for all transmitted values from the DDSV, refer to Moog Firmware Manual[6] for information on the formatting for each value.

7.2.2 Emergency messages

If an emergency message is received. An indication light will be lit, and the error code will be shown as a bit sequence in the GUI. The end user may then refer to the Moog Firmware Manual[6] in order to decipher the error code.

7.3 Transmitting messages

The transmit message function is called whenever the end user presses one of the transmit message buttons in the front panel. Each button will have it's own case, and a case may have several cases.

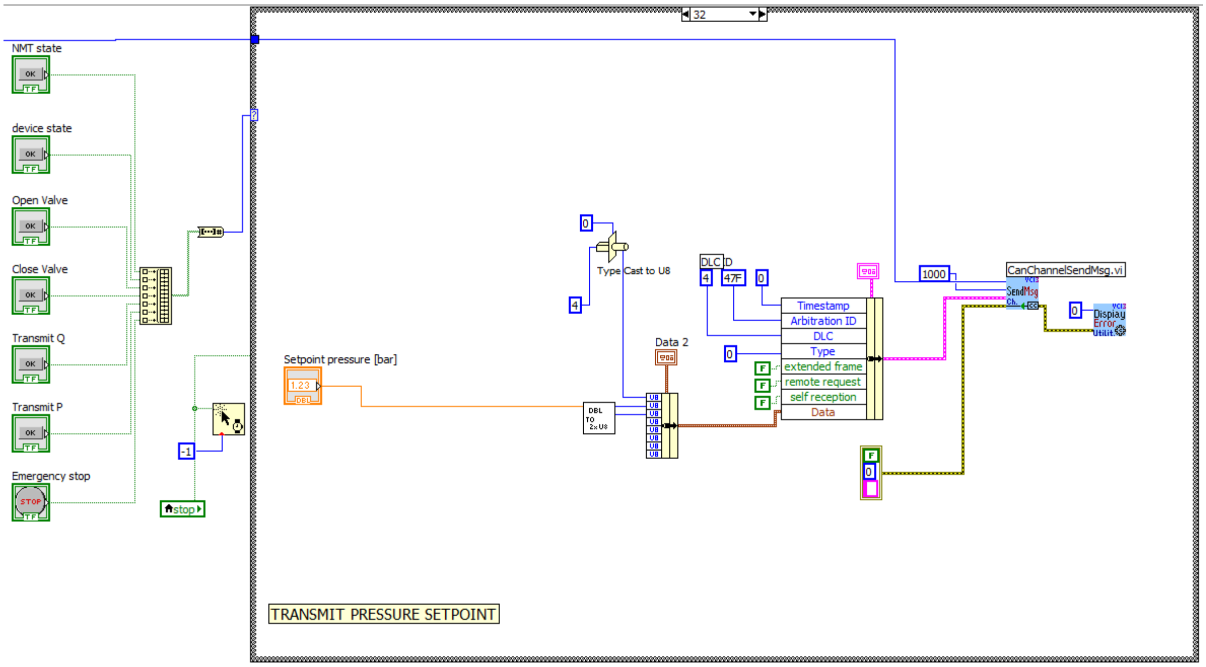

Figure 28: Transmitting message

7.3.1 NMT state commands

Figure 29 shows how the LabVIEW GUI implements the transmission of NMT state commands. The message identifier is zero, and the data sent is first the actual NMT state command 0x80, and the second byte is the device ID of the valve. The specific state command will be able to be selected from the Ring "NMT state commands", and the message will be transmitted when the user hits the send message button.

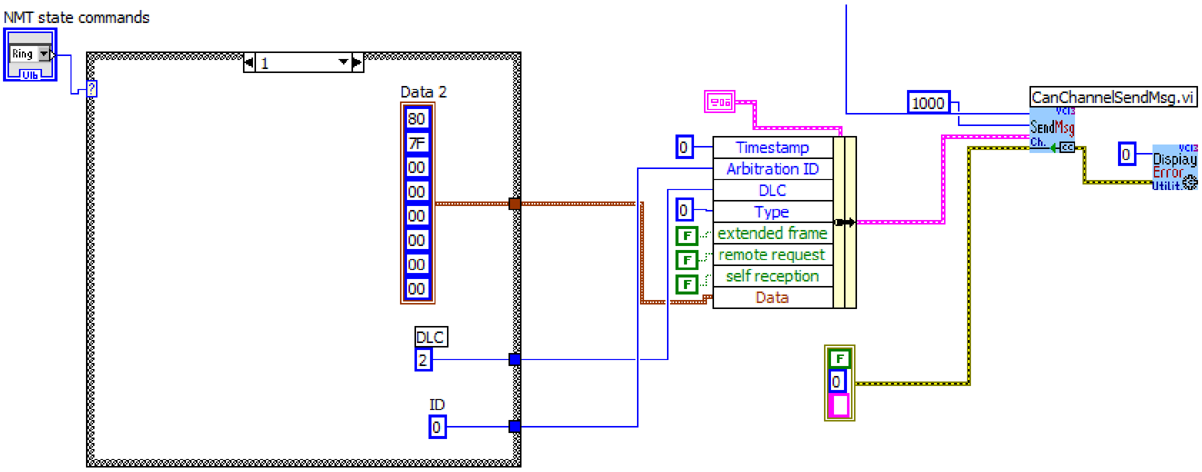

Figure 29: Transmitting NMT state commands

7.3.2 PDO messages

The important thing to consider when transmitting the PDO messages is that the message corresponds to the RxPDO parameters set up on the valve. In short: the identifier must be identical, and the data from the LabVIEW GUI must be sent to right byte in the CANbus message.

7.3.2.1 Device state commands

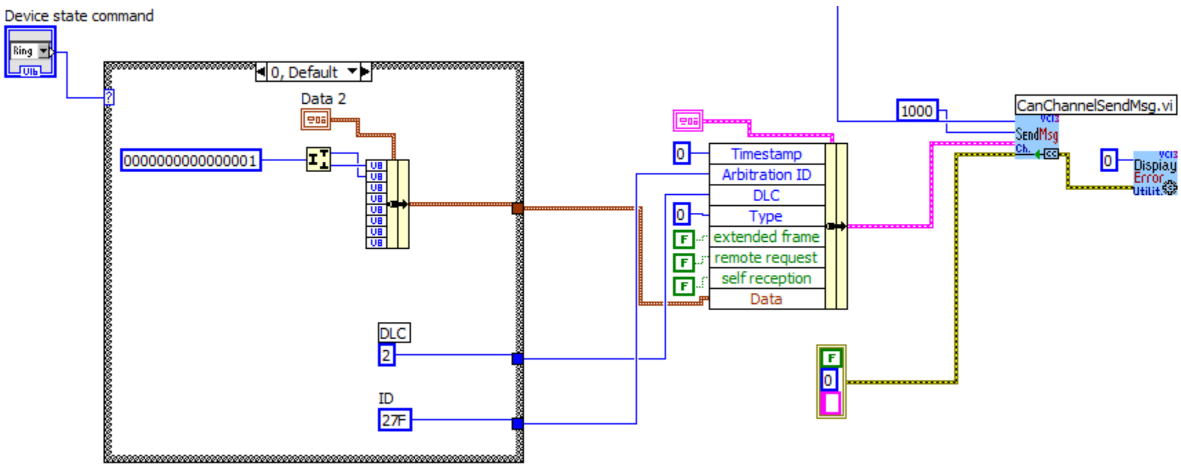

Figure 30: Transmitting device state commands

The device state commands are transmitted so they can be read on the valve's first RxPDO channel. This channel has the identifier 0x27F, and expects the first two bytes to be the current control word, which will indicate the device state the valve should enter.

7.3.2.2 Setpoints

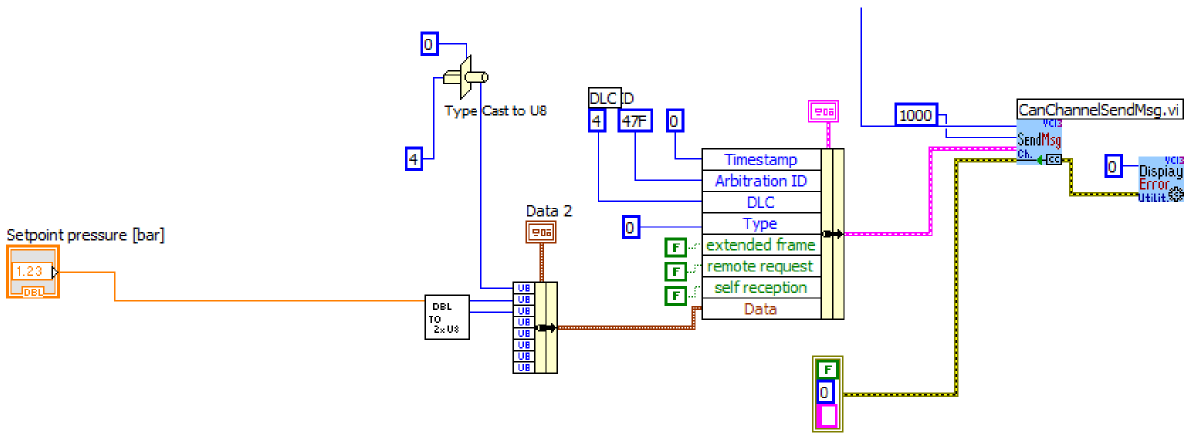

Figure 31: Transmitting setpoint for pressure

Figure 31 shows the transmission of a pressure setpoint. The valve expects the setpoint to be transmitted on the third RxPDO channel which has the identifier 0x47F. The first byte will be set control mode, and the next two bytes will be read as the pressure setpoint. The user may enter a value for a pressure setpoint, which will be sent to a sub VI. This sub VI will convert the numerical value of the setpoint into two unsigned 8-bit integers. The same process is applied when sending a spool setpoint, except the control mode is set to 2 (Spool closed loop), and the message is sent with the arbitration ID 0x37F, which corresponds to the second RxPDO channel on the valve.

7.4 Closing CAN communication

This sequence will first close the message channel, then the CAN controller and finally the devices connection to the VCI. It is important that this sequence is run to ensure that other applications may use the VCI connection to the device without having to reconnect the communication link.

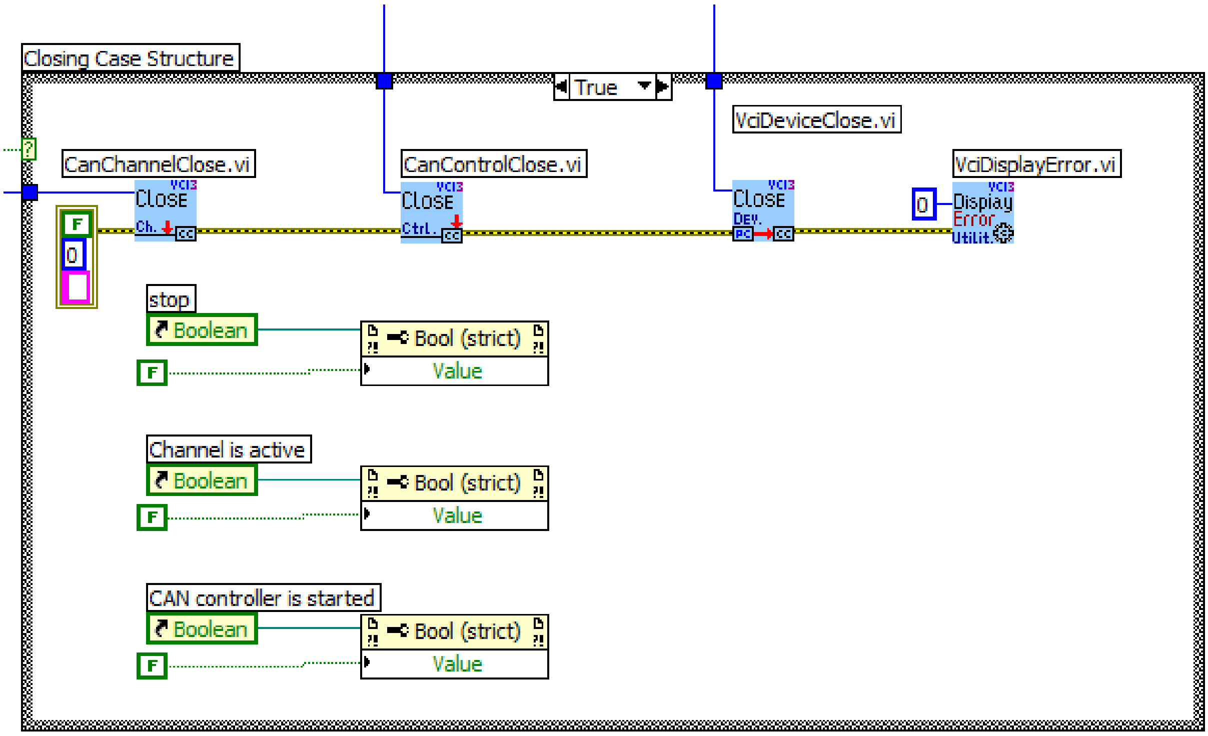

Figure 32: Closing CAN communication

7.4.1 Functions called

SUB VI	Inputs	Description	Outputs
CanChannelClose	*hChannel* Handle of the opened message channel *pCaps* Pointer to structure, will save the feature of the CAN connection in the specified memory area.	Closes the opened message channel.	VCI_OK when run successfully, otherwise error code.
CanControlClose	*hControl* Handle of the CAN controller that should be closed	Closes the active CAN controller	VCI_OK when run successfully, otherwise error code.

VciDeviceClose	*hDevice* Handle of the CAN interface board to be closed	Closes an opened interface board with the specified device handle.	VCI_OK when run successfully, otherwise error code.
VciDisplay Error	*hwndParent* Handle of the higher order window *pszCaption* Pointer to a 0-terminated character string with the text for the title line of the message window. *hrError* Error code for the message to be displayed.	Displays a message window that corresponds to the input error code.	None

Table 8: CAN channel close sub VI's

8.0 References

[1] CiA, *CiA 408: Device profile for fluid power technology proportional valves and hydrostatic transmissions*, 2005,

[2] Smart DDSV Demonstrator, *S-RS - "Requirement Specification,"* HBV, Kongsberg, 2014.

[3] CiA. *Controller Area Network*. http://www.can-cia.org/index.php?id=16 (03/03-2014)

[4] CiA. *CAN - physical layer*. http://www.can-cia.org/index.php?id=systemdesign-can-physicallayer (03/03-2014)

[5] Moog. *Digital interface, CANopen*. http://www.moog.com/literature/ICD/Moog-Valves-DIV_pQ_CANopen_Firmware-Manual-en.pdf (26/2-2014)

[6] Moog. *Digital interface firmware manual, CANopen*. http://www.moog.com/literature/ICD/Moog-Valves-DIV_pQ_CANopen_Firmware-Manual-en.pdf (26/2-2014)

[7] Smart DDSV Demonstrator, *G-TR2 - "Test result Report T-003,"* HBV, Kongsberg, 2014.

[8] IXXAT, *C-API Programming Manual, Version 1.5*, 2012,

Valve specification

S-VS

Version	Date	Main Author	Co-Author	Approved by
1	27.02.2014	Snorre Kløcker		Marit Hammer
2	24.03.2014	Snorre Kløcker		Håkon Mørk Solaas
3	20.05.2014	Snorre Kløcker		Nicolai Skjelsbæk

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	24.03.2014	Added electrical connections	Snorre Kløcker	Håkon Mørk Solaas
2 → 3	20.05.2014	Changed valve's serial number, updated document due to document review	Snorre Kløcker	Nicolai Skjelsbæk

This document contains specifications for the valve used in the Smart DDSV Demonstrator.

Table of Contents

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Contrroller Area Network
DDSV	Direct Drive proportional Servo Valve
FMC	FMC Technologies
GND	Ground
HBV	Buskerud/Vestfold university college
HNBR	Hydrogenated Nitrile Butadiene Rubber
HPP	Hydraulic Power Pack
ISO	International Standard Organization
LVDT	Linear Variable Differential Transducer
mA	Millie Ampere
P	Pressure
PID	Proportional-Integrate-Derivative
Q	Flow
SW	Software
V	Volt

Table 1: Abbreviations

2.0 Introduction

This document contains a specification of the valve used in the Smart DDSV bachelor project and explains how the group has chosen the correct valve. For the requirements regarding the valve, see document S-RS [1].

3.0 Moog DDSV

In the requirement specification [1] it is specified that Moog shall be the valve manufacturer. Through a meeting with FMC, Moog and students it was decided that valve d636 or d638 was the best option. The d636 and 638 series are made in ISO size 3, which is a preferred size for the demonstrator's small scale hydraulic system. These valves also have many possibilities regarding internal regulation and communication.

D636/638 valves are direct drive servo proportional valves with integrated electronics. A permanent magnet linear force motor is used to control the valve spool, which is controlled by the integrated electronics. In both d636 and d638 an internal LVDT is measuring the spool position, in d638 there is also a pressure transducer that measures the pressure in port A. The integrated regulator will use input from the LVDT and pressure sensor to implement a wide range of functions. The different functions that are available with the integrated electronics will vary, and are dependent on the valve's operating mode (p, Q or pQ mode). The main difference between these two valves is that d636 only provide Q regulation while d638 provides both p and Q regulation.

Both valves can be operated via bus communication or analog signals. Operation can be done in two different ways; the first one is to use the integrated electronics for regulation, the second method is to control the valve slide externally.

Please see following document [2] , [3] and [4] provided by Moog, in combinations with this document.

3.1 Specification

The valve will be used for different test purposes and therefore the specifications are chosen to meet a wide range of possibilities, not only for the specific test setup that the bachelor group have designed. To meet requirements regarding regulation and future possibilities, valve d638 is the best option because of its many features.

In order to choose correct specifications for the d638 valve the hydraulic system must be known [5].

From d638 datasheet [2], (p. 18) and in cooperation with Michael Shön at Moog GmbH, following valve serial number were derived: 638-335-0001 R04VB1F0HE92NBCP1J1 see Table 2. The different specifications are discussed from page 7 in this document.

Valve specification			
No.	Description	Details	Code
1	Valve version	Servo valve with integrated electronics	**R**
2	Rated flow [l/min] at 35bar pressure drop pr. land	10[l/min]	**04**
3	Rated pressure	100bar	**V**
4	Bushing / spool	3-way P →A, A→T (1,5 – 3% positive overlap)	**B**
5	Linear motor	Standard	**1**
6	Spool position without electrical supply	P→B, A→T (-20% opening)	**F**
7	Y-port	Closed with plug	**0**
8	Seal material	HNBR	**H**
9	Main connector X1	11+PE	**E**
10	Signals for flow Q and pressure p	Field bus digital	**9**
11	24V Supply voltage	24 VDC	**2**
12	Valve function	Pressure and flow control with pressure limitation	**N**
13	Enable function	w/o enable signal spool goes in defined fail-safe position	**B**
14	Field bus option	CANbus	**C**
15	External inputs	3x Analog	**P1**
16	Device capabilities	Full axis control functionality	**J1**

Table 2: Valve specification

3.1.1 Rated Flow

Rated flow, Q_r is a measurement of flow for a given pressure drop. Moog uses *Eq. 1* to calculate rated flow for 100% control signal [2] (p.5). *Eq.2* is given by Eq.1, and then Q_r can be calculated.

$$Eq.1: \quad \frac{Q}{Q_r} = \sqrt{\frac{\Delta p}{\Delta p_r}}$$

$$Q = actual\ flow$$
$$Q_r = rated\ flow$$
$$\Delta p = pressure\ drop$$
$$\Delta p_r = rated\ pressure\ drop$$

$$Eq.2: \quad Q_r = Q / \sqrt{\frac{\Delta p}{\Delta p_r}}$$

Eq.1 can be obtained from the equation from turbulent fluid flowing through an orifice. From page 71 in ref. [6], equation for turbulent flow through an orifice is:

$$Eq.3: \quad Q = Kx\sqrt{\delta P}\ ,$$

$$K = constant\ (viscocity, Raynolds\ number, etc)$$
$$x = orifice\ area$$
$$\delta P = pressure\ drop\ over\ the\ orifice\ (\Delta p)$$

$$Eq.4: \quad \frac{Q}{Q_r} = \frac{Kx}{Kx} * \frac{\sqrt{\Delta p}}{\sqrt{\Delta p_r}}$$

By using *Eq.3* as a reference value (100% control signal), and dividing this with itself *(Eq.4)*, a relationship between Q and Q_r be found. Kx will then be canceled and result in *Eq.1*.

Then it is possible to find rated flow, Q_r with a given pressure drop. This will be according to a reference pressure and flow.

Since one of the requirements is that the regulation of the cylinder rod should be visually confirmable, an acceptable Q must be derived from the maximum piston speed.

Flow rate are estimated from two different systems. Art. No 011733 is the cylinder that is borrowed from HBV, and art. No 184490 are a new cylinder from FESTO. Since the client may have to change the cylinder in the future, the valve has been dimensioned to work with both cylinders. Through discussion with Moog it was decided that flow rate option (04) is the best option for the demonstrator.

In Table 3, Δp is assumed to be 1bar, this is because the variable load may vary from 0- to 100%.

Cylinder specification								Valve specification
Art.No	Piston Ø[mm]	Cylinder length, L [mm]	Piston area, A [cm^2]	Cylinder volume, V [l]	Time to fully extend, t [s]	Max speed, Vs [m/s]	Needed flow, Q [l/min]	Rated flow, Qr [l/min]
011733	32	200	8,042	0,161	6	0,033	1,608	9,516
184490	25	200	4,908	0,098	6	0,033	0,988	5,808
			$(\pi * r^2) * (10^{-2})$	$A * V * 10^{-4}$		$\frac{L * 10^{-3}}{t}$	$\left(\frac{l}{t}\right) * 60$	$Q / \sqrt{\frac{\Delta p}{\Delta p_r}}$

Table 3: Flow rate calculations

It was recommended that the flow-rate should be adjusted up to nearest standard instead of downwards. If flow-rate is estimated too small, the valve will not take advantage of the full bandwidth. If flow-rate is too big, the valve will open to quick and cause a smaller resolution.

3.1.2 Rated Pressure

D638 have an internal pressure transducer that measures pressure in port A. This transducer is offered in ranges from 25 to 350bar. To achieve the highest possible resolution, a 100bar pressure transducer is the best choice, when the maximum pump pressure is 60bar.

3.1.3 Bushing/Spool

According to the hydraulic scheme [5], the DDSV shall work in a 3-way mode. Therefore the valve is ordered with 3-way spool design. This is graphically shown in Figure 1. This design is only available with 1.5 to 3% spool overlap. This means that there will be a minor leakage from P to A when the valve is closed. By operating the valve in p or Q mode zero leakage can be obtained. See also ref [2] for more information about function description.

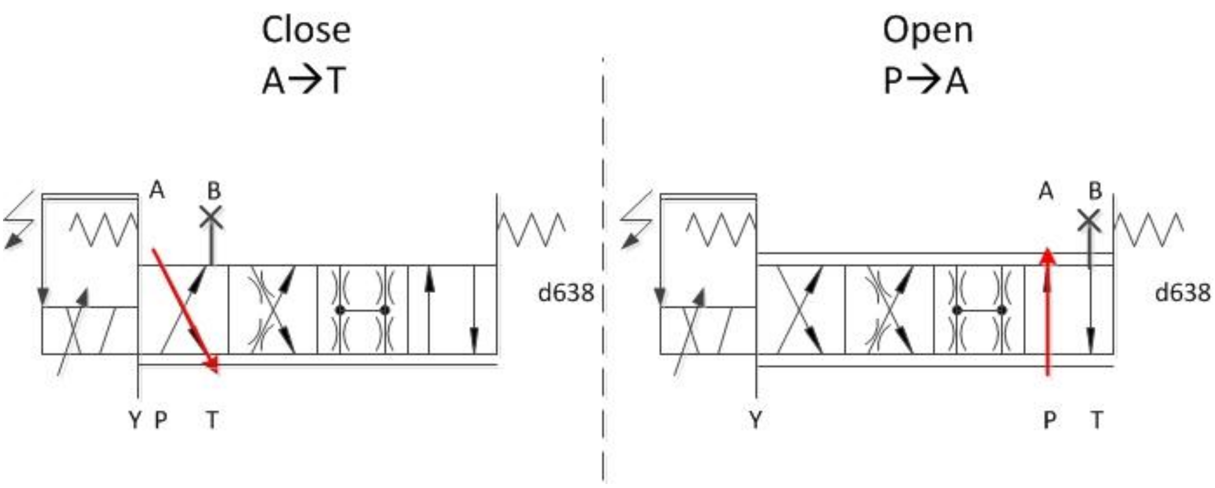


Figure 1: Valve arrangement

3.1.4 Spool position without electric supply / enable function

To maintain fail safe functionality, valve spool will go to position: P → B and A → T when the electrical power is lost. This is the most important specification, since there may be working personnel around the demonstrator when it is pressurized. If power is lost, there shall not be any chance for the valve to pressurize the consumer side of the system. Moog offers an enable function, were the valve will go into fail safe position when the enable signal is lost. Valve-spool will then slide into fail safe position (-20% valve slide opening) and empty the consumer side into tank.

3.1.5 Y-port

Y-port is the valves internal leakage port. In those cases were the tank pressure will exceed 50 bar, Y-port must be used. Since the return spring of the cylinder is not capable to generate pressure over 50bar, the Y-port will be blinded.[1]

3.1.6 Seal material

HNBR is a standard seal material. Since the hydraulic system will use standard hydraulic oil (DIN 51524 / ISO VG 22/32), HNBR works fine for the demonstrator.

3.1.7 Main connector X1

Some of the CAN-bus parameters can also be accessed through the analog connector X1. This connector allows user to read p and Q parameters, and set reference points for valve flow and spool position with analog signals. The valve is able to read 4-20mA, 0-10mA, 0-10V and ±10V. This can be configured in the Moog valve and configuration SW [7]. Resolution of the analog inputs on connector X1 is 12bits. The analog output can be read in 4-20mA or 2-10V.

Moog offers two types of X1 connectors for d638, 6+PE and 11+PE, see Table 4.

Overview over X1 connector functionality	
6+PE	11+PE
Enable input	Enable input
Command input (p or Q)	Command input, flow function
	Reference point input
	Spool position output
	Command input, pressure function
Pressure output	Pressure output
Supply voltage	Supply voltage
Ground (Power /signal)	Ground (Power /signal)
	Digital output (error monitoring)
Protective earth	Protective earth

Table 4: X1 connector

[1] The return pressure caused by the cylinder's return spring will be slightly lower than 50bar. The springs used in the demonstrator causes a return pressure of 1-3bar. [5]

With the 11+PE, the user is able to get p and Q readings simultaneously, set commands and reference points. This will ensure that the user will have more flexibility regarding future use. Therefore 11+PE were the preferred option for X1 connector [3].

3.1.8 Signals for flow Q and pressure P

See: 3.1.10 Field bus options.

3.1.9 Valve function

For valve d636, only Q- function can be implemented. The valve d638 can provide p, Q and pQ function. This means that the control of flow and pressure can be done with the same valve. This will increase the test and regulation possibilities. The bachelor group also needs pQ-control to meet the requirements regarding regulation. The different modes can be switched through CANbus.

3.1.10 Field bus options

In addition to analog communication, d636/638 also offers communication over CANopen, Profibus DP-V1, and EtherCAT. Since FMC uses CAN protocol for a range of other products, it was the natural choice to use the CANopen communication protocol. CAN communication will be able through connectors X3 and X4.

3.1.11 External inputs

Since option P1 is not listed in any documentation, this is mentioned in Table 5. This is provided upon request from Moog customer support in Germany [3]

Code	Type	Connector name
P1	3x Analog M8 X1 (4 slots)	X5, X6, X7

Table 5: External inputs options. (Obtained from Moog customer support)

D636 &D638 series valves are able to interface sensors. To meet all regulation requirements, the following sensors must be present (Figure 2):

- "Time of Flight" flow meter. Ultrasonic flow meter to measure actual flow between DDSV and cylinder. *(This is not part of the bachelor group end-product due to high cost, but are an example of future usage)*
- LVDT. Measures cylinder rod displacement.
- Leak detection. Measures leakage from DDSV or HPP *(C- requirement, not implemented)*

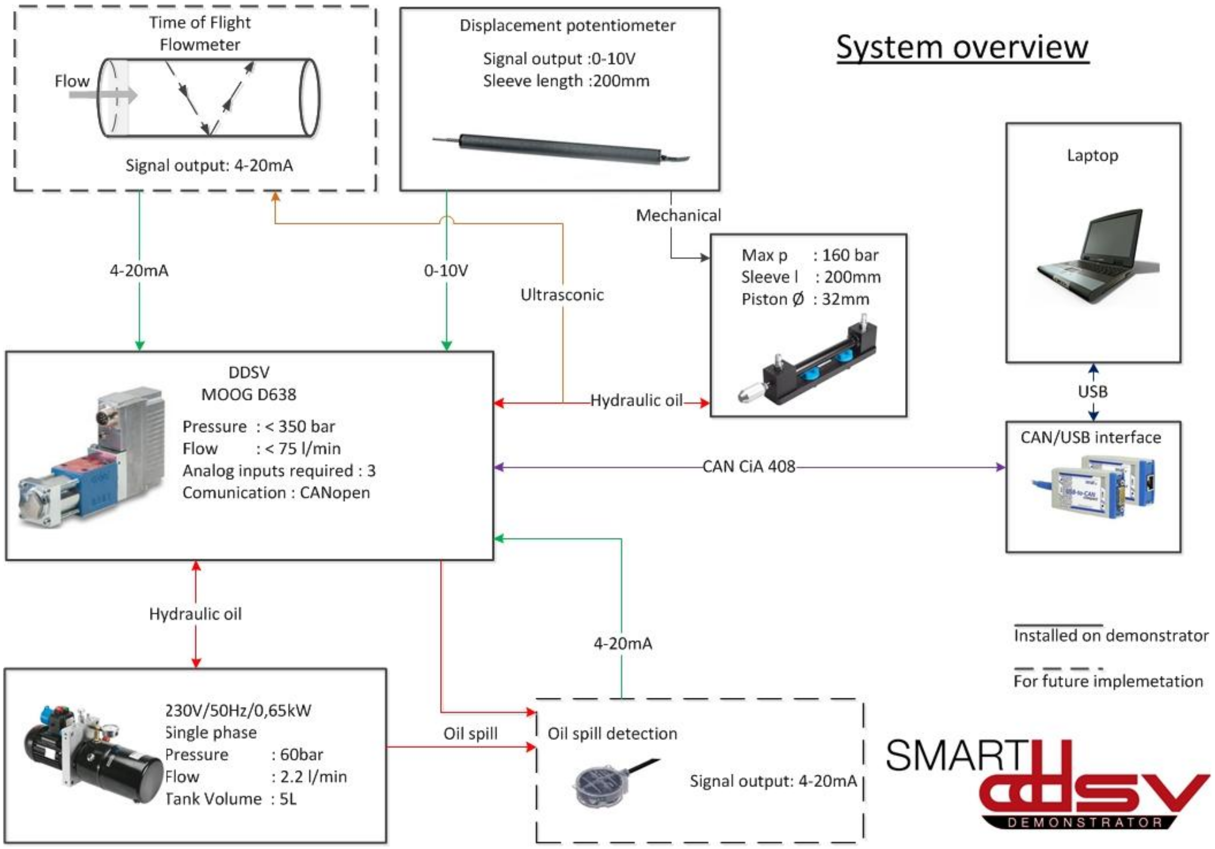


Figure 2: System overview

FMC mostly use 4-20mA as sensor outputs. The external analog connectors are able to read 4-20mA, 0-10mA, 0-10V and ±10V. This can be configured in the Moog valve and configuration SW [7]. External analog inputs can be accessed through connector X5-X7 and have a resolution of 14bits.

3.1.12 Device capabilities

Since option J1 is not listed in any documentation, this is mentioned in Table 6. This is provided upon request from Moog customer support in Germany [3], [8] .

Code	Functions
J1	Flow control (Q)
	Pressure control (p)
	Flow- and pressure control (pQ)
	Pressure difference control (Δp)
	Pressure compensated flow control
	Position control
	Force control
	Velocity control
	Parallel position control of multiple axis

Table 6: Option J1

Since option P1 (external inputs) allows 3 external inputs, some additional internal functions can be implemented. With option J1 functions in Table 6 will be implemented in the valves firmware, but some of them need additional feedback from external sensors to operate. This will reduce the need for external controllers and wiring. For more information see [8].

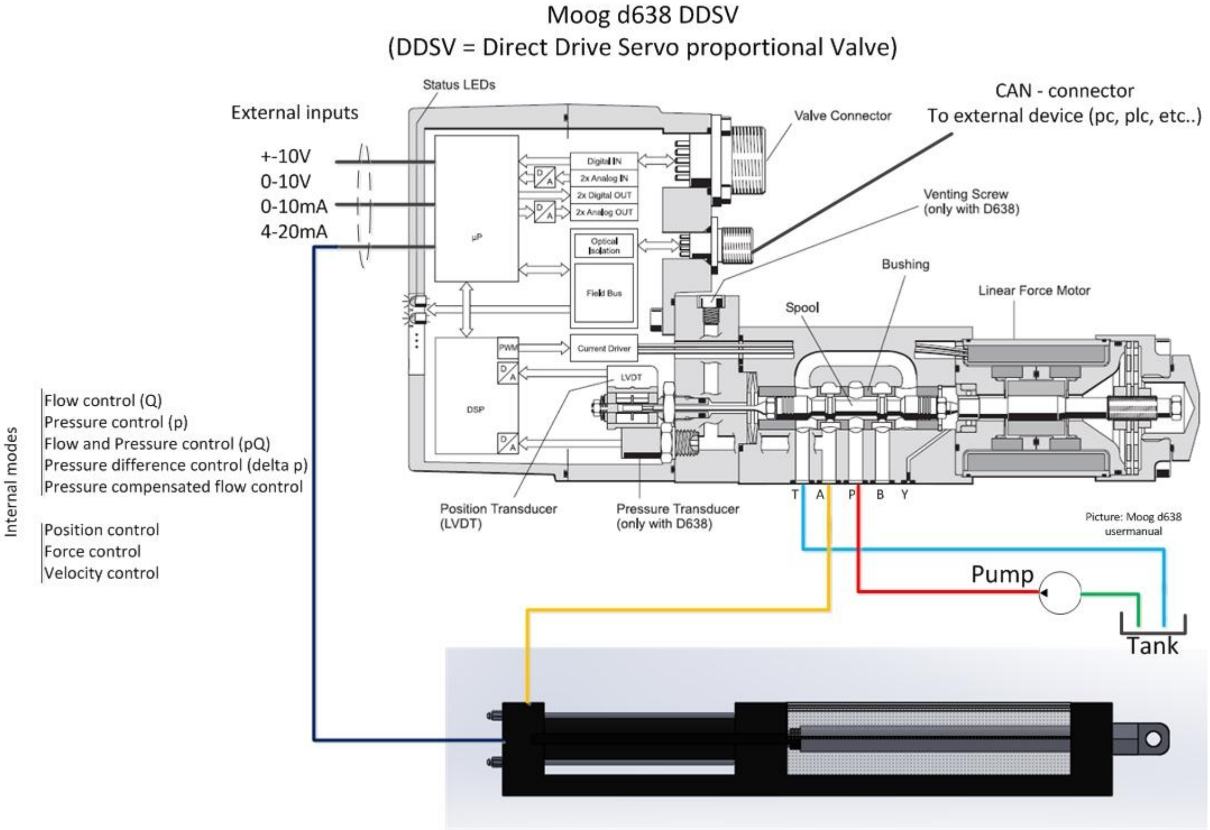


Figure 3: Moog d638 setup

3.2 Eletrical connections

See [9] and [10] for more information about the demonstrator electrical wiring.

See [3] for Moog user manual about electrical setup of the valve.

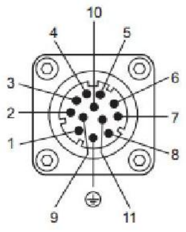
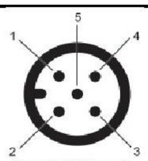
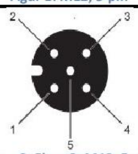
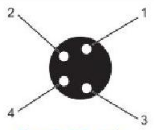
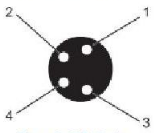
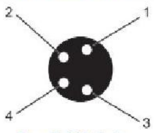
Connector - Valve side					Connector – Terminal side	
		Layout	Pin	Description	Pin	Terminal
X1	Main connector		1	Supply 24V DC, max. 1.2 A	1	
			2	Supply 0V	2	
			3	Enable referred to GND	3	
			4	Analog input 0. Current or voltage input referred to pin 5	4	
			5	Reference point for analog input 0 and input 1. (pin 4 and pin 7)	5	
			6	Analog output 0. 4-20mA or 2-10V referred to GND	6	
			7	Analog input 1. Current or voltage input referred to pin 5.	7	
			8	Analog output 1. 4-20mA or 2-10V referred to GND	8	
			9	Supply voltage 24V (18-32V) DC based on GND	9	
			10	GND	10	
			11	Digital output 1. Monitoring (negative logic)	11	
			PE	Protective conductor contact	12	
X3	CAN	 Figur 1: M12, 5-pin	1	CAN_SHLD. Shield	13	
			2	CAN_V+. Not connected in the valve	14	
			3	CAN_GND. Isolated ground to supply zero	15	
			4	CAN_H. Transceiver H	16	
			5	CAN_L. Transceiver L	17	
X4	CAN	 Figur 2: Figur 2: M12, 5-pin	1	CAN_SHLD. Shield	18	
			2	CAN_V+. Not connected in the valve	19	
			3	CAN_GND. Isolated ground to supply zero	20	
			4	CAN_H. Transceiver H	21	
			5	CAN_L. Transceiver L	22	X13
X5	Analog input	 Figur 3: M8, 4-pin	1	Transducer supply. 24V. Imax (X2+X5+X6+X7) = 300mA referred to pin 3	23	
			2	Reference point of analog input (pin 4)	24	
			3	Transducer supply 0V. (Supply zero)	25	
			4	Analog input. Current or voltage input referred to pin 2	26	
X6	Analog input	 Figur 4: M8, 4-pin	1	Transducer supply. 24V. Imax (X2+X5+X6+X7) = 300mA referred to pin 3	27	
			2	Reference point of analog input (pin 4)	28	
			3	Transducer supply 0V. (Supply zero)	29	
			4	Analog input. Current or voltage input referred to pin 2	30	
X7	Analog input	 Figur 5: M8, 4-pin	1	Transducer supply. 24V. Imax (X2+X5+X6+X7) = 300mA referred to pin 3	31	
			2	Reference point of analog input (pin 4)	32	
			3	Transducer supply 0V. (Supply zero)	33	
			4	Analog input. Current or voltage input referred to pin 2	34	

Figure 4: Electrical connections

4.0 References

[1] Smart DDSV Demonstrator, *S-RS - "Requirement Specification,"* HBV, Kongsberg, 2014.

[2] Moog. *d636&d638*. http://www.moog.com/literature/ICD/Moog-ServoValves-D638_D639-Catalog-en.pdf (10/2-2014-)

[3] Moog. *Eletrical interfaces*. http://www.moog.com/literature/ICD/Moog-Valves-DIVelectricalInterfaces-Manual.pdf (26/2-2014-)

[4] Moog. *Digital interface, CANopen*. http://www.moog.com/literature/ICD/Moog-Valves-DIV_pQ_CANopen_Firmware-Manual-en.pdf (26/2-2014-)

[5] Smart DDSV Demonstrator, *S-HS - "Hydraulic System specification,"* HBV, Kongsberg, 2014.

[6] J. G. A. Michael J. Pinches, *Power Hydraulics*. UK, Sheffield City Polytechnic: Prentice Hall, 1989.

[7] M. GmbH, "Moog Valve and Pump Configuration Software," 1.0 ed, 2011.

[8] Moog. *Digital and Axis control servo valves*. http://www.moog.com/literature/ICD/Moog-ServoValves-DCV_ACV-Overview-en.pdf (26/2-2014-)

[9] Smart DDSV Demonstrator, *S-ES - "Electrical Specification,"* HBV, Kongsberg, 2014.

[10] Smart DDSV Demonstrator, *S-ES-A - "Electrical Specification-Attachment A,"* HBV, Kongsberg, 2014.

Electrical Specification

S-ES

Version	Date	Main Author	Co-Author	Approved by
1	28.04.2014	Nicolai Skjelsbæk		Snorre Kløcker
2	15.05.2014	Nicolai Skjelsbæk		Snorre Kløcker

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	15.05.2014	Added missing information and updated to last template	Nicolai Skjelsbæk	Snorre Kløcker

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This document gives an overview of the electrical system in the smart DDSV demonstrator. The document will describe components and usage of them.

Table of Contents

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Index of Tables

1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
AC	A Current
AL	Aluminum
CAN	Controller Area Network
CU	Copper
DC	Direct Current
DDSV	Direct Drive Servo proportional Valve
DP	Displacement Potentiometer
FMC	FMC Technologies
GND	Ground
HPP	Hydraulic Power Pack
HRS	Hours
NEK	Norsk Elektroteknisk Komite
PS	Power Supply
RPM	Rotation Per Minute
TYP	Typical
WV	Working Voltage

Table 1: Abbrevations

2.0 Introduction

The demonstrator will need electrical power, and this document contains a thorough description of each electrical component and the specification of them. It will also introduce the “Smart DDSV Demonstrator” setup of the system. A complete wiring schematic and wiring diagram can be found in attachment A [1].

3.0 Standards

The following table describes which standards Smart DDSV Demonstrator has used for their electrical system:

Standard	Description
NEK 400:2010, 4.issue	Norwegian electro technical norm. Electrical low voltage installations

Table 2: Standards

4.0 Expressions

Expression	Explanation
3G1.5 mm^2	The G means that the cable is including GND.
7 x 1.5 mm^2	The x means that the cable is not including GND
Degree of protection IP*XY*	*X* defines the degree of protection against intrusion of solid objects, and protection so that persons are prevented from being close to or touching moving parts inside the housing. *X* goes from 0 to 6 [2]. *Y* defines the degree of protection against intrusion of water. *Y* goes from 0 to 8 [2].
M8 x 4pin	M8 is a 4-pin plug, this is to connect sensors to the DDSV [3].
M12 x 5pin	M12 is a 5 pin plug, this is used for the CAN communication [4].
PUR	Sensor/Actuator cable

Table 3: Expressions

5.0 Precautions

When handling electrical components precautions shall be taken. There shall never be done any work on the electrical system with the power cable connected. There is a risk of getting an electrical shock if the electrical system is worked on with the power cable connected. Before any work is started with the electrical system, there shall be measured if there is any power. Every electrical box is visible marked with a warning sign.

6.0 Components

Part	Quantity	Manufactured by
Cable Channel	1	
Circuit breaker	1	AEG
Electrical boxes	3	MARLANVIL, ABB and SCHNEIDER ELECTRIC
Double Outlet 230 V AC	1	BILTEMA
Emergency Switch	1	BILTEMA
Electric motor	1	FESTO
M12 connector with cable	1	PHOENIX CONTACT
M8 connector with cable	1	PHOENIX CONTACT
3-pole switch	1	BILTEMA
ON/OFF switch	1	FESTO
Power supply/Transformer 230V – 24V	1	PULS
Prototype circuit board	1	VELLEMAN
Terminal Blocks	70	PHOENIX CONTACT
Terminal blocks for circuit board	2	METZ CONNECT
Voltage Regulator	1	TEXAS INSTRUMENTS
DIN rail	3	
Capacitor 0.1 µF	1	PANASONIC
Cable 12 G1.5 mm^2	2 m	ALPHA
Cable 3G1.5 mm^2	3 m	FESTO
Cable 7 x 1.5 mm^2	5 m	BILTEMA
Capacitor 0.33 µF	1	PANASONIC

Table 4: Components

Some of the components in this table are interchangeable, but it is not recommended to change any of them. If other components shall be used, precautions shall be taken. Make sure that there are the same input-output tolerance, and that there are no interference. It is also important to think about the degree of protection if there shall be changes. No work shall be done on the electrical system by uncertified personnel. To work on the electrical system, personnel shall have an electrician degree of group L.

6.1 Circuit breaker

AEG Elfa E92 C10.		Picture
Characteristics	C	
Input current range	0 – 10 A	
Input voltage range	0 – 400 V	
Mounting system	DIN	
Connected to GND	No	

Figure 1: Circuit breaker

Table 5: Circuit Breaker

The circuit breaker is very important for the demonstrator’s electrical system. This will break the circuit if there is a higher current then it should and it can also be used as an extra emergency switch. This is placed inside the box with the internal bus bar and DIN rail. The circuit breaker shall be mounted on the DIN rail.

6.2 230 V AC double outlet

BILTEMA 230 V AC double outlet		Picture
Degree of protection	IP 54	
Input voltage	230 V AC	
Output voltage	230 V AC	
Mounting system	Screwed	
Connected to GND	Yes	

Figure 2: 230 V AC Outlet

Table 6: 230 V AC double outlet

6.3 ON/OFF switch

<table>
<tr><th colspan="2">ON/OFF switch</th><th>Picture</th></tr>
<tr><td>Input voltage</td><td>230</td><td rowspan="6">

Figure 3: ON/OFF switch</td></tr>
<tr><td>Output voltage</td><td>230</td></tr>
<tr><td>On</td><td>Green</td></tr>
<tr><td>Off</td><td>Red</td></tr>
<tr><td>Mounting system</td><td>4 Screws</td></tr>
<tr><td>Connected to GND</td><td>Yes, internal</td></tr>
</table>

Table 7: ON/OFF switch

The ON/OFF switch is delivered as a internal part of the HPP [5], but for the demonstrators electrical system, it is moved inside the Marlanvil electrical box. This is to make it easier to manually start and stop the electric motor. Internal in the switch there's a relay including holding magnets, so if the motor is using to much current the magnets will let go, and the switch will automatically turn off the motor. This is to protect the motor. The switch can be used to manually start and stop the motor.

6.4 Emergency switch

<table>
<tr><th colspan="2">Biltema Emergency switch</th><th>Picture</th></tr>
<tr><td>Input voltage range</td><td>0 – 400 V</td><td rowspan="4">

Figure 4: Emergency switch</td></tr>
<tr><td>Output voltage (when pushed)</td><td>0 V</td></tr>
<tr><td>Mounting system</td><td>22,5 mm hole</td></tr>
<tr><td>Connected to GND</td><td>No</td></tr>
</table>

Table 8: Emergenzy switch

The emergency switch is an extra safety precaution. If a major error who could lead to injuries or damages occurs, the user shall be able to “kill” the demonstrator as fast as possible. The emergency switch is mounted in the same box as the ON/OFF switch.

6.5 Plugs and Cables

Biltema 7 x 1.5 mm^2		**Picture**
Type	RKKB	 *Figure 5: RKKB Cable 7 x 1.5 mm^2*
Length	5 m	
CU or AL	CU	
Color	Black	
GND	No	

Table 9: 7 x 1.5 mm^2

This cable is used as a power cable for the ON/OFF switch and emergency switch.

Festo 3G1.5 mm^2		**Picture**
Type	H05VV-F	 *Figure 6: H05VV-F Cable 3G1.5 mm^2*
Length	3 m	
CU/AL	CU	
Color	Black	
GND	Yes	

Table 10: 3G1.5 mm

This cable is used as the power cable to the demonstrator. It has a male connector at one of the ends to plug directly into a wall socket. The other end is coupled at the bottom of the circuit breaker [1].

Alpha 12G1.5 mm^2		**Picture**
Type	LLH1241	
Length	12 X 2 m	
CU/AL	AL	
Color	White	

GND	Yes	*Figure 7: Cable 12G1.5 mm^2*

Table 11: 12G1.5 mm

This cable is used for the X1 main DDSV connector and terminated in X13 [1]. It is a self made cable who includes 12 times 2 meters of Alpha wire AL, who are connected to the mating connector for the analog communication and DDSV power supply [3].

6.6 Electrical boxes

Marlanvil electrical box		Picture
Degree of protection	IP 66	 *Figure 8: IP66 electrical box*
Length	190 mm	
Width	145 mm	
Height	70 mm	

Table 12: Marlanvil Electrical box

The Marlanvil electrical box is used for mounting the DDSV PS and the emergency switch, and includes the supply cables from connector X11 to the switches. The box is mounted on the side of the tabletop [1]. It is mounted with two screws in the table leg, and in this leg there is a hole that shall only be used for cables.

Schneider Electric AC electrical box		Picture
Length	325 mm	 *Figure 9: AC electrical box*
Width	175 mm	
Height	430 mm	

Table 13: Schneider Electrical AC box

The Schneider Electric AC electrical box is for mounting the AC components with their associated wires. This box will also include the T1 and T2 transformer, and the AC terminal blocks. The box is lockable with a key, so it is not available for unqualified personnel.

ABB AP9P electrical box		Picture
Degree of protection	IP65	 *Figure 10: AP9P electrical box*
Length	85 mm	
Width	85 mm	
Height	35 mm	

Table 14: ABB electrical box

The ABB AP9P box is mounted on the top of the electrical motor with 4 screws. This is for the internal couplings in the motor.

6.7 Motor switch

Biltema 3-pole switch		Picture
Input voltage range	0 - 690 V	 *Figure 11: 3-pole switch*
Input current range	0 – 40 A	
Connected to GND	No	

Table 15:Biltema 3-pole switch

The Biltema 3-pole switch is used as a motor switch, the reason for having a motor switch in the electrical system is to have the possibility to isolate the electric motor from the rest of the system for testing and measurements. When this switch is used, there is not needed to “kill” the whole system to do any work on the motor. For schematics, see Attachment A [1].

6.8 Electrical motor

AC current, single-phase convection-cooled electric motor		Picture
Nominal Voltage	230 V	 *Figure 12: Electrical motor*
Nominal current	3.1 A	
Nominal power rating	0.65 kW	
Nominal speed	1320 rpm	

Frequency	50 Hz	

Table 16: Electrical motor

The electrical motor is used to drive the HPP. It has an overload protection in form of the relay in the ON/OFF switch, but it can also be manually driven with this switch. The motor is mounted on the HPP, and is seen as a part of the HPP [5]. The electrical motor is connected to power through the X11 connector [1].

6.9 Transformers

6.9.1 T1 230 V AC to 24 V DC

Puls QS10 series transformer		Picture
Input voltage range	100 V AC – 240 V AC	 *Figure 13:QS10 series transformer*
Output voltage range	24 V – 28 V DC	
Input current range	At 230 V AC: 1.22 A	
Output current range	Continuous: - 10 A at 24 V - 9 A at 28 V	
	For typical 4s: - 15 A at 24 V - 13.5 A at 28 V	
Output power	Continuous: - 0.24 kW	
	For typical 4s: - 0.36 kW	
Output ripple voltage	50 mV peak to peak	
Mounting system	DIN	

Table 17: T1 transformer

The T1 230 V AC to 24 V DC transformer is used to transform the input voltage to the correct DC voltage that the DDSV needs. The transformer is mounted inside the AC Schneider Electric electrical box on a DIN rail. It uses the X11 connectors to supply the X12 connectors [1].

6.9.2 T2 24 V DC to 10 V DC

The T2 24 V DC to 10 V DC transformer consists of one regulator and two capacitors.

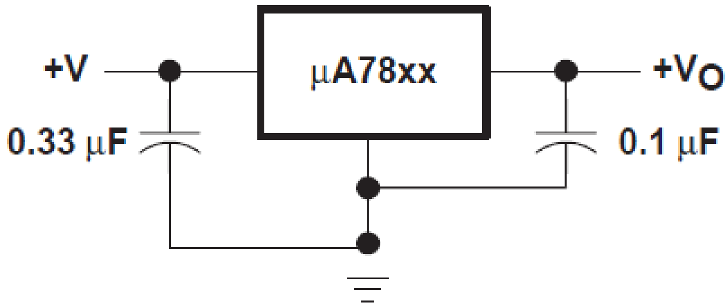


Figure 14: Fixed Output regulator[6]

Figure 14 shows how the transformer is connected.

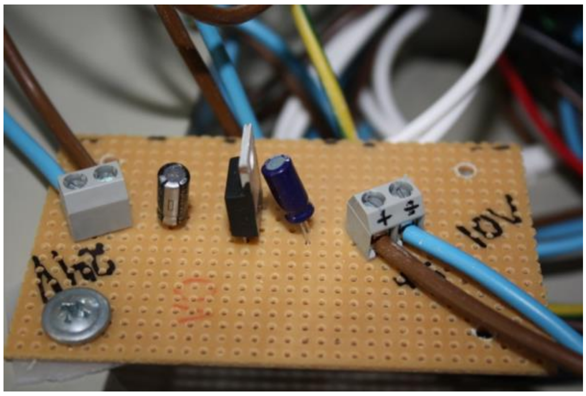
Prototype circuit board		Picture
Length	100 mm	
Width	160 mm	
Thickness	1.6 mm	
Compatible with	Eurodin connectors: - DIN41617 - DIN41612	*Figure 15: Prototype circuit board*

Table 18: Prototype circuit board

The T2 transformer circuit is brazed on to the prototype circuit board, and then mounted inside the AC Schneider Electric electrical box [1]

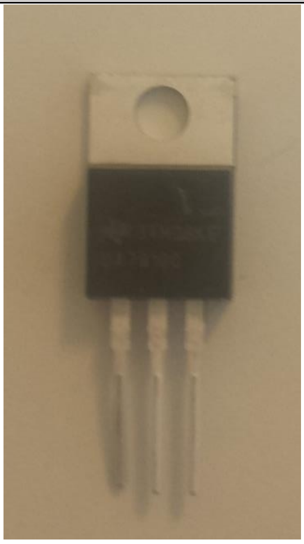
Texas Instruments Regulator [6]				**Picture**
Type	µA7810CKC			
Input voltage	**Min**	**Max**		
	12.5 V DC	28 V DC		
Output voltage	**Min**	**Typ**	**Max**	
At 25°C	9.6 V DC	10 V DC	10.4 V DC	
At 0°C to 125°C	9.5 V DC	10 V DC	10.5 V DC	
GND	Yes			*Figure 16: Regulator*

Table 19: KC regulator

The µA7810CKC regulator is a 3-terminal regulator, the terminals are output, common and input, see Figure 17.

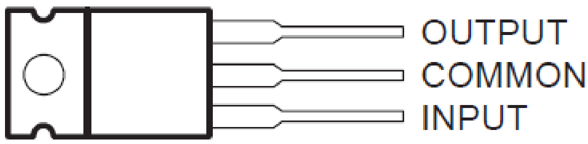


Figure 17: KC Regulator [6]

The T2 transformer is used with an input voltage of 24 V DC, and it will have a typical output voltage of 10 V DC. This output voltage will be used to supply the DP, and are connected through X12 and X13 who are the connectors inside one of the cable channels.

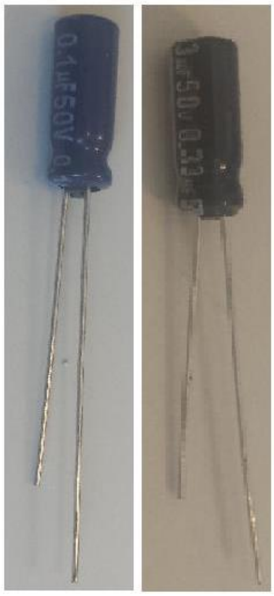
Panasonic capacitors [7]		**Picture**
Capacitors	- 0.33 µF - 0.1 µF	 *Figure 18: 0.1 µF and 0.33 µF capacitors*
Temperature range	-55 °C to +105 °C	
Rated WV	50 V DC	
Endurance	1000 hrs	

Table 20: Capacitors

See Figure 14 for how the capacitors shall be coupled to the circuit.

6.10 Connectors

Phoenix Contact, M8 with cable [8]		Picture
Rated current at 40 °C	4 A	 *Figure 19: M8 plug with cable*
Rated voltage	30 V	
Number of pins	4	
Degree of protection	IP 65	
Length of cable	5 m	
Stripping length of free conductor end	50 mm	
Type of cable	PUR halogen-free	

Table 21: M8 plug

The M8 connector is used for the analog inputs X5, X6 and X7 [1]. Smart DDSV Demonstrator uses only the X5 input, but the DDSV has three analog inputs to include possibilities for later extensions.

Phoenix Contact, M12 with cable [9]		Picture
Rated current at 40 °C	4 A	 *Figure 20: M12 plug with cable*
Rated voltage	60 V	
Number of pins	5	
Degree of protection	IP 65	
Length of cable	1.5 m	
Stripping length of free conductor end	50 mm	
Type of cable	PUR halogen-free	

Table 22: M12 plug

The M12 connector is used for DDSV connections X3 and X4 [1]. Smart DDSV Demonstrator uses only the X3 input, but the DDSV has another CAN input to include possibilities for later extensions.

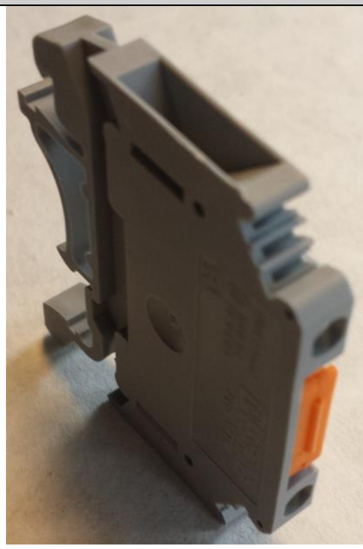
Phoenix Contact terminal blocks		Picture
Voltage range	0 to 300 V	 *Figure 21: Terminal block*
Current range	0 to 15 A	
Cable dimension	≤ 2,5 mm^2	
Mounting system	DIN	

Table 23: Phoenix Contact terminal blocks

The terminal blocks are used inside the electrical boxes to connect cables with components.

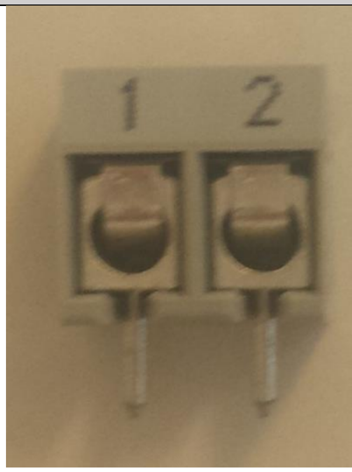
Metz Contact terminal blocks for circuit boards [10]		Picture
Voltage range	0 to 200 V	 *Figure 22: Terminal block for circuit boards*
Current range	0 to 13 A	
Cable dimension	≤ 1,5 mm^2	

Table 24: Metz Contact terminal blocks

The circuit board terminal blocks are used for input and output from the T2 transformer.

6.11 Mounting

Cable channel		Picture
Length	1470 mm	 *Figure 23: Cable channel*
Width	120 mm	

Table 25: Cable channel

The cable channel is used on the demonstrator's tabletop, it includes the connectors X12 and X13 with cables. This is the DC input for DDSV-01.

Small cable channel		Picture
Length	410 mm	 *Figure 24: Small cable channel*
Width	35 mm	

Table 26: Small cable channel

This cable channel is only for cables, it will include the cable input to DP-01.

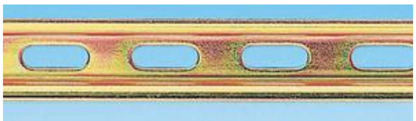
DIN rail		**Picture**
Length	1. 205mm 2. 185mm 3. 250mm 4. 250mm	 *Figure 25: DIN-rail [11]*

Table 27: DIN rail

The DIN rails are used to mount most of the electrical components inside the electrical boxes. There are one for mounting inside the AC electrical box, and two rails inside the cable channel.

7.0 References

[1] Smart DDSV Demonstrator, *S-ES-A - "Electrical Specification-Attachment A,"* HBV, Kongsberg, 2014.

[2] Norsk Elektroteknisk Komite, "NEK 400:2010, Elektriske lavspenningsinstallasjoner," ed: Standard Online, 2010.

[3] Smart DDSV Demonstrator, *S-VS - "Valve specification,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *S-IS - "Interface and GUI Specifiaction,"* HBV, Kongsberg, 2014.

[5] Smart DDSV Demonstrator, *S-HS - "Hydraulic System specification,"* HBV, Kongsberg, 2014.

[6] Texas Instruments, - *"Data sheet, µA7800 Series, Positive-Voltage Regulators,"* Dallas, Texas, 1976 - Revised 1999.

[7] Panasonic, - *"Aluminum Electrolytic Capacitors,"* 2010.

[8] Phoenix Contact, - *"Data sheet, SAC-4P-M 8MS/5,0-PUR,"* 2012.

[9] Phoenix Contact, - *"Data sheet, SAC-5P- 1,5-PUR/M12FS,"* 2012.

[10] Metz contact, - *"Data sheet, RT015xxHDWC,"* 2012.

[11] Elfa Distrelec. *DIN-rail 35mm top hat 2m*. (14.05-2014)

Attachment A

S-ES-A

Version	Date	Main Author	Co-Author	Approved by
1	16.05.2014	Snorre Kløcker		Håkon Mørk Solaas

This document is attachment A for S-ES and describes the electrical connections and wiring for the demonstrator.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
A	Ampere
AC	Alternating Current
DC	Direct Current
DDSV	Direct Drive Servo proportional Valve
DP	Displacement Potentiometer
HPP	Hydraulic Power Pack
V	Volt

Table 1: Abbreviations

2.0 Wiring schematic

2.1 Components overview

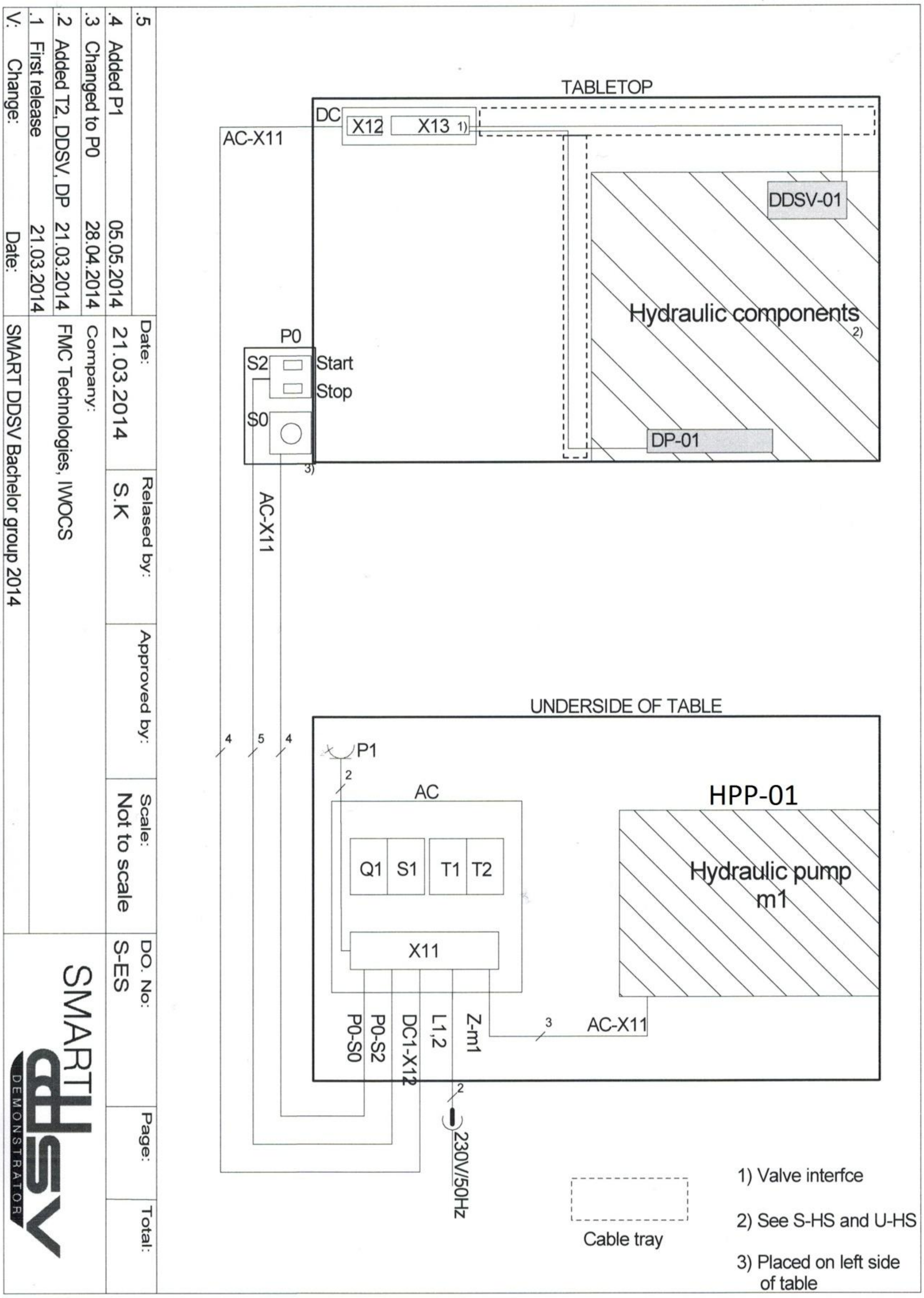


Figure 1: Components overview

2.2 Main power schematic

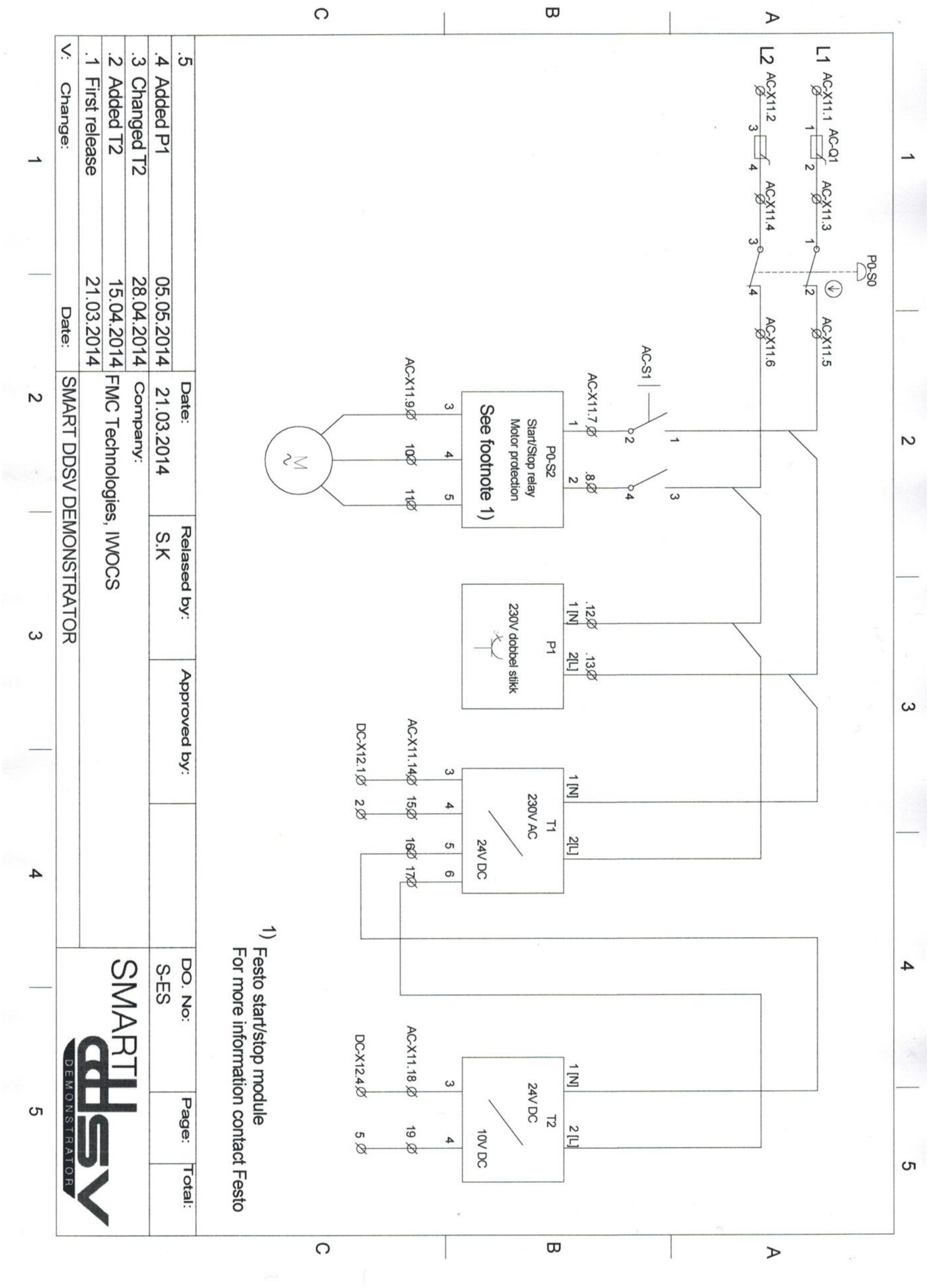


Figure 2: Main power schematic

3.0 Wiring diagram

3.1 Component description

ID	Explanation
AC	AC distribution cabinet
DC	DC distribution cabinet
DDSV-01	Direct Drive Servo proportional Valve
DP-01	Displacement Potentiometer
L1/L2	230V / 50Hz, supply
M1	HPP electric motor
P0	Start/stop cabinet and emergency stop cabinet
Q1	Automatic fuse (10A)
S0	Emergency stop push button
S1	Motor power supply switch for M1
S2	Start/stop button
T1	230VAC / 24VDC transformer
T2	24VDC / 10VDC transformer
X11	Cable rail connectors (main power)
X12	Cable rail connectors (DC distribution)
X13	Cable rail connectors (Valve and sensor interface)
HPP-01	HPP

Table 2: Component description

3.2 Connector X11

Wire side		Connector X11	Cabinet side Valve connector	
L1	230V Supply [N]	1	Q1:1	10A fuse
L2	230V Supply [L]	2	Q1:3	“
P0-S0:1	Emergency stop	3	Q1:2	“
P0-S0:3	“	4	Q1:4	“
P0-S0:2	“	5	S1:1	Motor switch
P0-S0:4	“	6	S1:3	“
P0-S2:1	Start/Stop	7	S1:2	Motor switch
P0-S2:2	“	8	S1:4	“
P0-S2:3	“	9	M1:1	Electric motor
P0-S2:4	“	10	M1:2	“
P0-S2:5	“	11	M1:3	“
P1:1	230V distribution	12	S1:1	Motor switch
P1:2	“	13	S1:3	“
DC:X12.1	24VDC distribution	14	T1:3	DC 24V GND
DC:X12.2	“	15	T1:4	DC 24V SUPPLY
T2:1	24/10 VDC	16	T1:5	DC 24V GND
T2:2	“	17	T1:6	DC 24V SUPPLY
DC:X12.4	10VDC distribution	18	T2:3	DC 10V GND
DC:X12.5	“	19	T2:4	DC 10V SUPPLY

Table 3: Connector X11

3.3 Connector X12

Wire side		Connector X12	Cabinet side Valve connector	
DC:X13.1		1	AC:11.14	DC 24V GND
DC:X13.2		2	AC:11.15	DC 24V SUPPLY
	Spare	3		DC 24V GND
	Spare	4		DC 24V SUPPLY
DP-01.1 DC:X13.25		5	AC:11.18	DC 10V GND
DP-01.2		6	AC:11.19	DC 10V SUPPLY
	Spare	7		DC 10V GND
	Spare	8		DC 10V SUPPLY

Table 4: Connector X12

3.4 Connector X13

Note: Blank fields in table are not filled out because description will vary by the actual test-setup.

Wire side		Connector X13	Cabinet side Valve connector	
		1	X1.1	Supply 24V DC
		2	X1.2	Supply 0V
X12.2	24V DC	3	X1.3	Enable referred to GND
		4	X1.4	Analog input 0
		5	X1.5	Reference point for analog input 0 and input 1
		6	X1.6	Analog output 0
		7	X1.7	Analog input 1
		8	X1.8	Analog output 1
X12.2	24V DC	9	X1.9	Supply voltage 24V (18-32V) DC based on GND
X12.1	0V	10	X1.10	GND
		11	X1.11	Digital output 1
		12	X1.PE	Protective conductor
		13	X3.1	CAN_SHLD
		14	X3.2	CAN_V+
C1.3	GND	15	X3.3	CAN_GND
C1.7	CAN-High	16	X3.4	CAN_H
C1.2	CAN-Low	17	X3.5	CAN_L
		18	X4.1	*Reserved for future use*
		19	X4.2	
		20	X4.3	
		21	X4.4	
		22	X4.5	
		23	X5.1	Transducer supply. 24V
X12.5	0V	24	X5.2	Reference point of analog input (pin 4)
		25	X5.3	Transducer supply 0V
DP-01.3	0-10V	26	X5.4	Analog input
		27	X6.1	Transducer supply. 24V
		28	X6.2	Reference point of analog input (pin 4)
		29	X6.3	Transducer supply 0V
		30	X6.4	Analog input
		31	X7.1	*Reserved for future use*
		32	X7.2	
		33	X7.3	
		34	X7.4	

Table 5: Connector X13

3.5 Valve interface

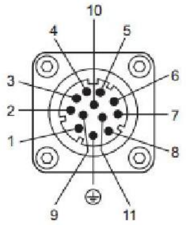
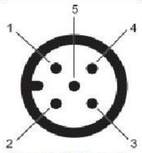
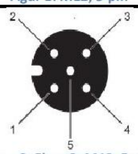
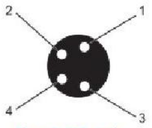
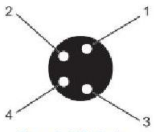
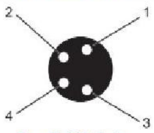
Connector - Valve side					Connector – Terminal side	
		Layout	Pin	Description	Pin	Terminal
X1	Main connector		1	Supply 24V DC, max. 1.2 A	1	
			2	Supply 0V	2	
			3	Enable referred to GND	3	
			4	Analog input 0. Current or voltage input referred to pin 5	4	
			5	Reference point for analog input 0 and input 1. (pin 4 and pin 7)	5	
			6	Analog output 0. 4-20mA or 2-10V referred to GND	6	
			7	Analog input 1. Current or voltage input referred to pin 5.	7	
			8	Analog output 1. 4-20mA or 2-10V referred to GND	8	
			9	Supply voltage 24V (18-32V) DC based on GND	9	
			10	GND	10	
			11	Digital output 1. Monitoring (negative logic)	11	
			PE	Protective conductor contact	12	
X3	CAN	 Figur 1: M12, 5-pin	1	CAN_SHLD. Shield	13	
			2	CAN_V+. Not connected in the valve	14	
			3	CAN_GND. Isolated ground to supply zero	15	
			4	CAN_H. Transceiver H	16	
			5	CAN_L. Transceiver L	17	
X4	CAN	 Figur 2: Figur 2: M12, 5-pin	1	CAN_SHLD. Shield	18	
			2	CAN_V+. Not connected in the valve	19	
			3	CAN_GND. Isolated ground to supply zero	20	
			4	CAN_H. Transceiver H	21	
			5	CAN_L. Transceiver L	22	X13
X5	Analog input	 Figur 3: M8, 4-pin	1	Transducer supply. 24V. Imax (X2+X5+X6+X7) = 300mA referred to pin 3	23	
			2	Reference point of analog input (pin 4)	24	
			3	Transducer supply 0V. (Supply zero)	25	
			4	Analog input. Current or voltage input referred to pin 2	26	
X6	Analog input	 Figur 4: M8, 4-pin	1	Transducer supply. 24V. Imax (X2+X5+X6+X7) = 300mA referred to pin 3	27	
			2	Reference point of analog input (pin 4)	28	
			3	Transducer supply 0V. (Supply zero)	29	
			4	Analog input. Current or voltage input referred to pin 2	30	
X7	Analog input	 Figur 5: M8, 4-pin	1	Transducer supply. 24V. Imax (X2+X5+X6+X7) = 300mA referred to pin 3	31	
			2	Reference point of analog input (pin 4)	32	
			3	Transducer supply 0V. (Supply zero)	33	
			4	Analog input. Current or voltage input referred to pin 2	34	

Table 6: Valve interface

4.0 General documents

G-xx

4.1 Reports

G-xR

First Phase and Iteration report

G-FPI

Version	Date	Main Author	Co-Author	Approved by
1	27.02.2014	Snorre Kløcker	Nicolai Skjelsbæk	Håkon Mørk Solaas
2	20.05.2014	Snorre Kløcker	Nicolai Skjelsbæk	Håkon Mørk Solaas

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	19.05.2014	Document review	Snorre Kløcker	Håkon Mørk Solaas

This document is the first phase & iteration review report for Smart DDSV Demonstrator.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Controller Area Network
DDSV	Direct Drive Servo proportional Valve
FMC	FMC Technologies
GUI	Graphical User Interface
HBV	Buskerud and Vestfold university college.
mA	Millie Amperes
SW	Software
USB	Universal Serial Bus

Table 1: Abbreviations

2.0 Introduction

To keep the planned progress in the project, the bachelor group will review the progress according to project plan. Each iteration review will contain an iteration summary and a control matrix. The phase review describes the status for all of the main activities through the phase.

3.0 Iteration review

3.1 Iteration 1

Iteration 1 was the first week of the project, so this iteration mainly contained research and defining the thesis.

Control matrix		**Date: 03.01.2014 – 13.01.2014**
Control questions	Status	Actions performed
Is the project plan on schedule?		
Are project members working well together?	Y	
Is the communication between project members and supervisors good?	Y	• Only external supervisor provided
Are the documents according to templates?		
Are the documents according to document plan?		
Are there any new requirements?		
Is interface according to the plan?		

Table 2: Control matrix, Iteration 1

3.2 Iteration 2

This iteration consisted of a lot of research, meeting with the DDSV supplier and meeting with the client. The group got some new requirements for the hydraulic system. They started up with looking into the possibilities with using tap water as a medium. This would not work because there is not enough pressure from the water tap and because of the corrosion risk. Moog came up with a new requirement that the group needed to use hydraulic fluid as a medium with a minimum of 25-bar pressure. The group started looking at using components from a log splitter. The document flow is according to plan, and the group is following the templates.

Control matrix		**Date: 14.01.2014 – 31.01.2014**
Control questions	Status	Actions performed
Is the project plan on schedule?	N	• Pushed supplier • Started SW work for the simulator earlier than planned. • Customer meetings • Changes to system • Changes in project plan

Are project members working well together?	Y	
Is the communication between project members and supervisors good?	Y	• Only external supervisor provided
Are the documents according to templates?	Y	
Are the documents according to document plan?	Y	
Are there any new requirements?	Y	• Changed system from water to hydraulic fluid. • Safety requirements (Higher pressure)
Is interface according to the plan?	Y	• Research

Table 3: Control matrix, Iteration 2

3.3 Iteration 3

In this iteration the group decided to not use a log splitter, and this was accepted by the client. It proved to be a better solution to use module based components mainly from FESTO, FMC also wanted an accumulator to prevent pump strokes. The DDSV is ordered, but there is a long delivery time (8 weeks). There has been meetings with both client and supervisors, and phone meetings with both Moog and FESTO. The group has been working with their first presentation.

Control matrix		**Date: 01.02.2014 – 19.02.2014**
Control questions	Status	Actions performed
Is the project plan on schedule?	N	• All parts are not ordered. • Pushing component supplier. • Working with simulator.
Are project members working well together?	Y	
Is the communication between project members and supervisors good?	Y	
Are the documents according to templates?	Y	• Template changed • Old documents updated to new versions.
Are the documents according to document plan?	Y	
Are there any new requirements?	Y	• Log splitter solution discarded • New hydraulic system requirements
Is interface according to the plan?	Y	• Research

Table 4: Control matrix, Iteration 3

4.0 Phase review

The group started up the phase with defining the task, and did a lot of research to get familiar with the topic. The client defined what they wanted out from the assignment and some criterions for it. One of them was that the group should use tap water as system fluid. According to Kongsberg municipality, tap water pressure is approximately at 5-bar. The Bachelor group called for a meeting with Moog (valve supplier) and FMC to discuss choice of valve and hydraulic system. Moog informed that 5-bar was not enough pressure. The smallest valve was dimensioned to 25 bar, so 5 bar would lead to low resolution. The water would also lead to corrosion problems with the valve. The group, Moog and FMC then decided that it has to be used hydraulic fluid. Because of this, a hydraulic aggregate shall be used. This lead to new requirements to the project and higher cost, most important were the safety issues due to higher working pressure.

4.1 Hydraulic systems

In this phase the bachelor group has decided amongst many different systems. After it was decided that tap water was not a good solution, the group started looking at using components from a log splitter. The log splitter included most of the components for the demonstrator, and for a small cost. This seemed to be a good idea until more research were done. A log splitter was brought in to the group's lab facilities for more research.

Figure 1: Log Splitter

The group disassembled the log splitter to see if it would prove to be a good solution. To use the log splitter, a lot of modifications were needed. The included valve must be disabled since the group will use an external valve. But since the log splitter valve is also working as a cylinder cover, the group needed to use the valve inlets for pressurizing the cylinder. This required TIG welding to seal some of the valve outlets. The cylinder casing is used as a tank, so the log splitter does not have an included external return spot, the group would have to drill a hole in the casing. Because of the safety issues, this has to be done at a workshop that will include extra cost and delay. These modifications are shown in Figure 2 and Figure 3.

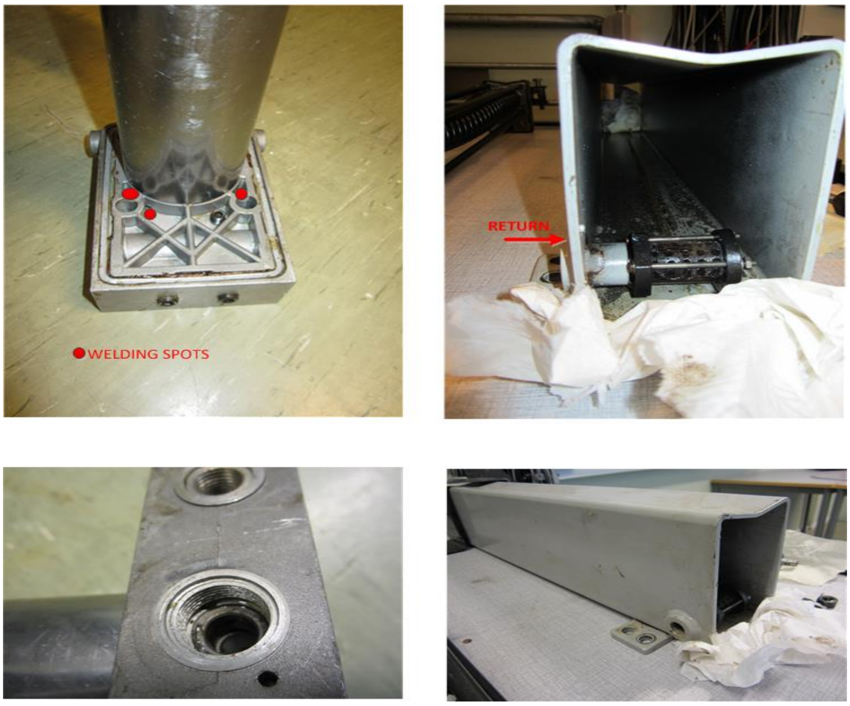

Figure 2: Log splitter modifications

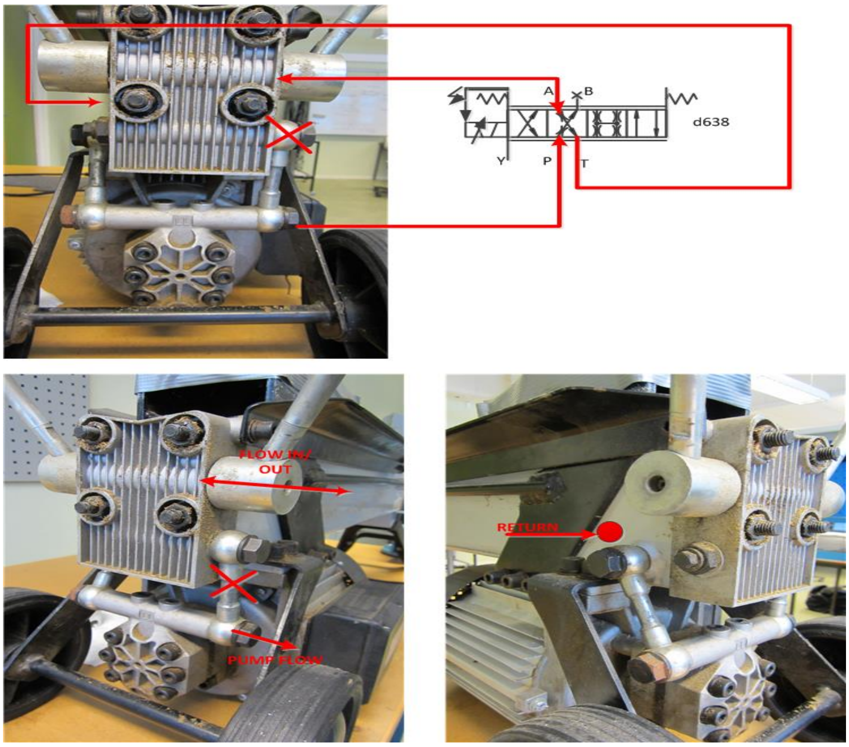

Figure 3: Log splitter solution

The group had another solution as well. HBV has earlier bought some components from FESTO, so the group looked into using those. The group has also talked with Hydac about choosing the correct accumulator and price estimate. This lead to a change of the demonstrators design, the group was thinking about building the demonstrator as one component, but found out that it would be a better solution to have a mounting table with loose components instead. This will simplify the complexity of the system, and it will be easy to do modifications with the demonstrator if needed. Figure 4 shows an example of how FESTO components can be mounted. For this solution the components will be more costly, but the cost of work will be reduced compared to the log splitter solution. It will also ease the work if the client wants to do modifications on demonstrator in the future.

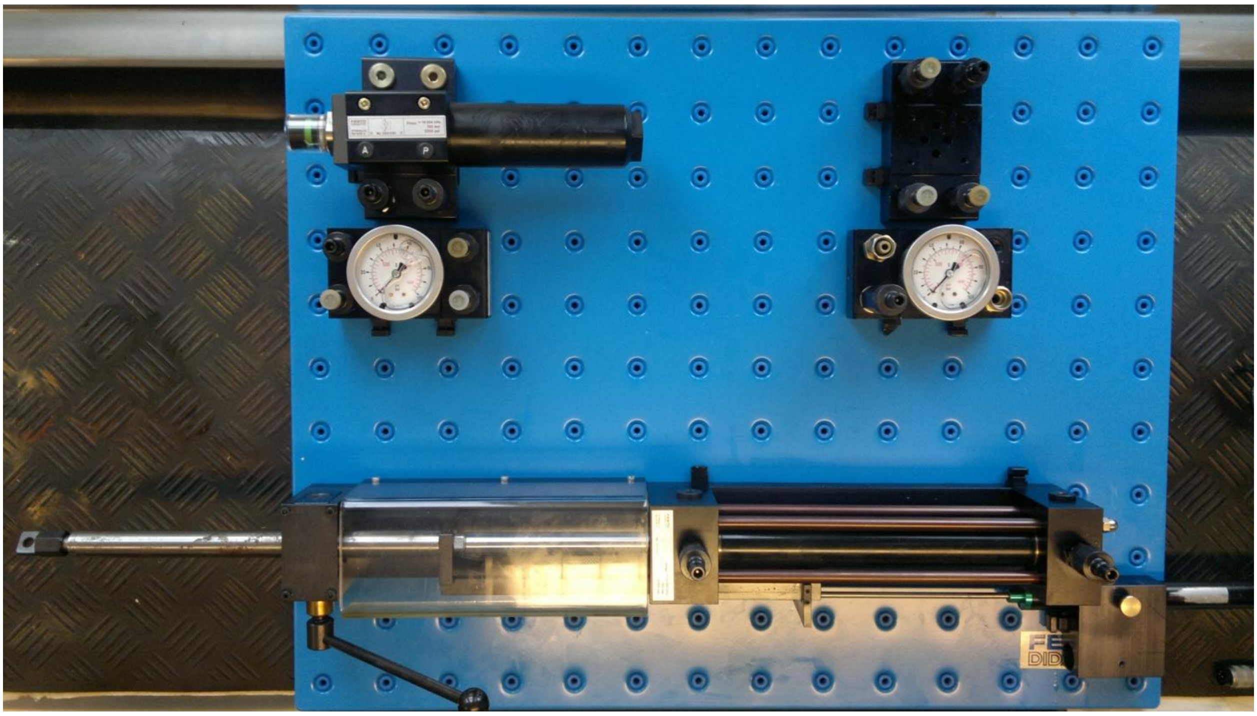

Figure 4: FESTO components

These matters needed to be decided as soon as possible, since the group could not choose the DDSV before the system had been decided. The valve could not be the same for both systems.

4.1.1 Final solution

The group decided that the FESTO solution seemed to be the best. Both the Log splitter and FESTO solution were presented and discussed with a meeting between client and students. The client agreed that the FESTO solution would be best.

When this was decided between the group and their client, the valve was ordered. Due to the delay, the group has to focus on system testing and using a SW simulator against GUI to make sure that everything is working properly when the valve arrives.

4.2 Interface

From the beginning, it was decided that the communication standards to be used on the demonstrator should be according to those that are currently in use on subsea installations. FMC required that sensor outputs should be 4-20mA, and that CANbus communication shall be used when communicating with the valve.

The valve has a number of analog inputs, so the valve will function as an interface. All external sensors will be connected to the valve, and the valve will send the measured data through CANbus.

For testing and simulation the group will have to develop a Simulink model. Moog will provide a Simulink model of the valve, and the group will have to expand this model with models of the cylinder and other hydraulic components. This model should also be able to send and transmit CANbus messages in the same format as the actual valve.

The group’s first solution was to use Labview for developing the GUI, and doing the valve simulation in Simulink. Labview had built in support for the USB-CAN-Interface, which would have provided an easier monitoring of valve. However, for a simpler implementation of the Simulink model provided by Moog, the group decided to use Matlab instead of Simulink to develop the GUI.

4.3 Test

Throughout this first phase the test plan were produced. There will be a lot of testing before receiving the valve, and mainly simulation testing. Because of the high working pressure in the demonstrator, the safety shall be in focus. The group takes safety seriously, and therefore there are safety tests in the test plan. Description of all tests is listed in test specification, and is related to the test plan. Both plan and specification is subject to change. Throughout the first phase there has not been much testing. This first phase and iteration review is a part of the test plan, and changes to the project plan had to be made, because of issues mentioned earlier.

4.4 Documentation

Documentation has been an ongoing process throughout the phase. The group started up with making a template that shall be used for all of their documents. A document plan was also constructed to always have control over when documents shall be released and approved. This has been working well, and documents have been according to the document plan and template.

4.5 Phase summary

The first phase of the project has been a busy phase for the group, it has been a steep learning curve for all of the group members. There have been some delays because of system choice and a long delivery time on the DDSV. The group has taken this into consideration, and changed their project plan accordingly. Testing will go as planned, but more of the tests will be performed with the simulator.

Second Phase and Iteration report

G-SPI

Version	Date	Main Author	Co-Author	Approved by
1	16.04.2014	Nicolai Skjelsbæk	Snorre Kløcker	Håkon Mørk Solaas
2	21.05.2014	Nicolai Skjelsbæk	Snorre Kløcker	Marit Hammer

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	21.05.2014	Changes according to template	Snorre Kløcker	Marit Hammer

This document is the second phase & iteration review report for Smart DDSV Demonstrator.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Controller Area Network
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GUI	Graphical User Interface
HBV	Buskerud and Vestfold university college.
SW	Software
USB	Universal Serial Bus

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2.0 Introduction

To keep the planned progress in the project, the bachelor group will review the progress according to project plan. Each iteration review will contain an iteration summary and a control matrix. The phase review describes the status for all of the main activities through the phase.

3.0 Iteration review

3.1 Iteration 1

Arrival dates for the valve and pump are set, and since these components will arrive earlier than expected, the project plan was modified. Testing and documentation which needs that the pump and valve are physically present were modified to get a better flow in the project.

SW research period has been extended because of problems regarding which method to use when developing GUI. Through a meeting with a CAN-expert at FMC the group is a step closer the correct solution.

The group has started a pressure test on components from school. It quickly turned out that the cylinder were leaking and one pressure gauge had deviation from the reference calibrator. FMC have been informed and the group is awaiting answer from Olaf H.Graven regarding a sale of HBV components before students put time and money into fixing these components. Olaf promised that HBV will have a final decision on Monday 10.03.2014. The bachelor group was aware of that some of the components from HBV may be damaged due to the age. So alternative parts were found and quoted early in the project. If the cylinder is not possible to fix, cylinder No. 152857 from Festo is a good replacement. Replacement for the pressure gauge can be bought from TESS.

Control matrix		**Date: 19.02.2014 – 07.03.2014**
Control questions	Status	Actions performed
Is the project plan on schedule?	N	• SW-research period extended. • Meeting with CAN expert at FMC • Supervisors informed
Are project members working well together?	Y	
Is the communication between project members and supervisors good?	Y	
Are the documents according to templates?	Y	
Are the documents according to document plan?	Y	
Are there any new requirements?	Y	• Requirement regarding pressure test
Is interface according to the plan?	N	

Table 2: Control matrix, Iteration 1

3.2 Iteration 2

The group ordered new gaskets through TESS for the cylinder, as soon as these are received the cylinder has to be tested that there is no leakage.

The group started up working with GUI with LabView, and tested the CAN-communication at FMC. The communication worked, but there is still a lot of work to do with the GUI.

The group decided for what kind of accumulator they shall have for the demonstrator.

The portable table was received in this iteration, so the group started working with the assembly of the table. The group had ordered the tabletop in steel, but it was delivered in chipboard surface instead. This lead to changes in the design document, and the group decided that it was not a problem since it was planned to use a rubber mat on the tabletop. Actually it made it easier to drill the holes they needed, and to bolt the components to the table.

HBV approved that the group could have the school components for free in this iteration, so further testing of these will be done. The group has an ongoing discussion with their client about approving the first pressure test.

Control matrix		**Date: 08.03.2014 – 21.03.2014**
Control questions	Status	Actions performed
Is the project plan on schedule?	N	• Delay on SW due to change from Matlab to LabVIEW • Cylinder gasket not received
Are project members working well together?	Y	
Is the communication between project members and supervisors good?	Y	
Are the documents according to templates?	Y	
Are the documents according to document plan?	N	• D-DD – Design document • G-TP2 – Test procedure T-003 → T-006 • S-IS – Interface and GUI specification • U-HS – User manual: Hydraulic systems
Are there any new requirements?	Y	• HYRQ-104
Is interface according to the plan?	N	• Decided on LabVIEW GUI

Table 3: Control matrix, Iteration 2

3.3 Iteration 3

The group did some more work with the portable table. The holes for the hydraulic hoses were drilled, and a wooden plate to have beneath the table was made. This plate is for mounting the hydraulic power pack, and to have room for a box including all of the “loose” equipment.

In phase 3, a FAT- test of the complete system is to be performed. The students have arranged a location at FMC’s department in Notodden to perform this test. On Monday 31.03.2014 the students were at a visit to check out the test- facilities and the available equipment.

In this iteration the group tried to order the accumulator. This was challenging because the supplier would not deliver an accumulator directly to the group. This had to be ordered through FMC. This led to a delay regarding ordering and delivery of the accumulator. Another challenge with the accumulator is the coupling between the accumulator and the system. The group did not find any adapter that fits their system. The group made drawings of an adapter that has to be made, and this have been sent over to FMC’s department in Notodden, asking for assistance with this. There were also a question regarding were to perform the nitrogen pre-charge of the accumulator, it turned out that they have equipment to do this at FMC Notodden. So this will be done in combination with the FAT- test.

The group received the new gaskets for the double acting cylinder, and had a small verification test. The test was done to make sure that there was no leakage in the cylinder. This was approved, and the cylinder will have a new pressure test during Easter.

The group worked further with their GUI, and the CAN-communication has been tested further and verified.

The group had their second presentation, so a lot of work with preparation for this was done. The group will have an exam in the next iteration, so they saw that there will be some more delays in the project plan. To obtain this delay, the group has to work during Easter.

Control matrix		**Date: 22.03.2014 – 04.04.2014**
Control questions	Status	Actions performed
Is the project plan on schedule?	N	• Behind schedule with GUI • Documentation
Are project members working well together?	Y	
Is the communication between project members and supervisors good?	Y	
Are the documents according to templates?	Y	
Are the documents according to document plan?	N	• D-DD – Design document • G-TP3 – Test procedure T-007 • G-TP4 - Test procedure T-008 • G-TP5 – Test procedure T-009 → T-011 • S-ES – Electrical specification • U-HS - User manual: Hydraulic systems
Are there any new requirements?	Y	• PERQ-103 • HYRQ-105
Is interface according to the plan?	N	

Table 4: Control matrix, Iteration 3

4.0 Phase review

This phase has included some good news about arrival of components earlier than first planned. This led to changes in the project plan. The group has already received the hydraulic power pack and the portable table, so the phase included some work with the table. It was important that the table was as completed as possible before arrival of the rest of the components.

The phase has included some challenges with delays, and there has been a lot of other school work beside the bachelor thesis. The group feels that this has been solved in a good way by moving some of the work to the Easter. The group feels that they have good control over the project plan. There is still a lot of work to do in phase 3, but if the group continues with the excellent collaboration the project will be completed according to plan.

In the start of phase 3, the group will have a review of all of their "plan documents", to make sure that the group can manage to keep the good pace.

4.1 Hydraulic system

In this phase the hydraulic components from FESTO was ordered. The order was approximately one week delayed due to some uncertainties about which components that were necessary. The following components were ordered from FESTO:

Component	Quantity
Hydraulic power pack	1
T-distributor	2
Replacement filter cartridge	1

Table 5: Components ordered from Festo

The group had to make a backup budget because of the first test results. The main concern was the cylinder with the load break handle. If the cylinder proved to not be useful, some extra components had to be acquired. Therefore the group made a new hydraulic schematic with the extra components to simulate the load on the cylinder.

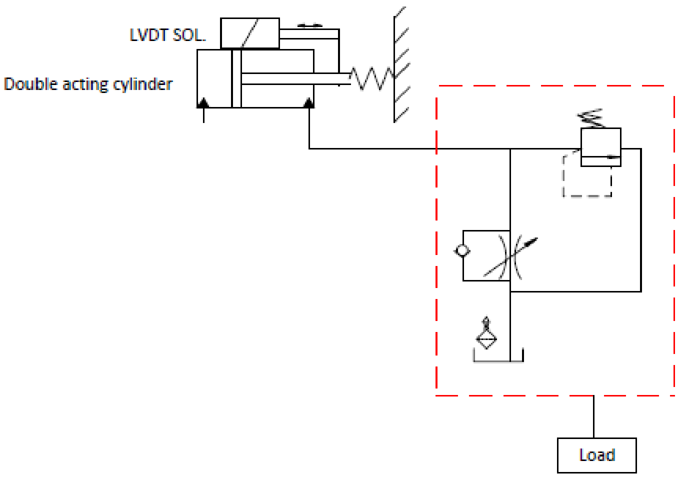

Figure 1: Extra components

The new components also presented some extra challenges with the mounting system and interaction between new and old components. Because the old components were out of production, it would be necessary to do some upgrades to fit with the new mounting system. For this reason we had to do more research to find suitable components and get a price estimate.

Due to the small pressure test of the cylinder, this solution was discarded. This means that all hydraulic components are specified, as long as everything is working as planned. The coupling nipples for the new components are to be replaced with the old ones. There is also some uncertainty about this matter, because the old coupling nipples may not provide proper sealing when mounted on the new components. Still, this matter is taken into account and further tests will be executed to verify this.

The next step concerning the hydraulics is to find a solution for the cylinder to retract by a spring device. The group also needs to figure out how to connect an external tank device on the piston rod side. To simplify references to different components, the group has planned to give all items an ID. This will be added to the hydraulic specifications.

4.2 Interface

During the first iteration the group was uncertain of whether they would be provided with a license for LabVIEW or not. Because of this, the development of the GUI was put on hold. This caused a significant delay compared to the original project plan. After deciding on using LabVIEW the group has developed a LabVIEW GUI, which through testing has been verified to be able to communicate with a CAN subsea simulator used at FMC. The software is capable of doing simple mapping of PDO-channels, and sending a set of CAN messages. The functions implemented in this GUI are very similar to those that will be needed for communicating with the valve, so further development should be relatively straight forward.

As of now very little work has been done on the regulation part of the project. Moog has provided a dynamic model of the valve, in order to tune the controller the group must expand the model with the cylinder and accumulator. The group originally intended that this simulator should be used to test the GUI by generating a LabVIEW application that transmitted the values from the simulator in real time. However a lot of work would have to be done in order to make the simulator send out CAN-messages that mimics the messages from the valve. This extra work would not provide much benefit later in the progress, as there is no guarantee that the valve will act in the same manner as the simulator configured by the group.

4.3 Test

To verify that the components from school were approved for this project, the bachelor group had a pressure test. For this test, the bachelor group could lend a hand pump and a calibrator from Devotek. It was performed March 6th and was on schedule. The bachelor group had some challenges with the double acting cylinder but this was solved by replacing the gaskets. There will be a new pressure test in Easter to verify that the new gaskets for the cylinder are approved. The pressure test for the completed demonstrator will be performed at FMC's test facilities at Notodden, the group will also use FMC's test facilities for test T-009 →T-012. This is the test for A-, B- and C-requirements, and also finally FAT.

There have been some challenges due to the software, and there has been performed some tests at FMC's software test lab. The results from these tests are good, so the communication between LabVIEW and IXXAT USB-CAN is working. After some research further testing with simulator, which will include A-, B- and C-requirements will not be performed. This is because the configuration in the simulator is different from the valve.

The test plan is not on schedule at this point, due to the delay in software. But the bachelor group is working on this issue, and it is positive that the group will solve this challenge.

4.4 Documentation

The documentation has been an ongoing process throughout the phase, and every group member has done his/hers part. There have been some delays to a couple of documents, but this is not a big challenge because the group has the Easter holiday to get back on track. The group will have a review of all of their “plan documents” in the start of phase 3, and the document and project plan will be updated due to the review.

4.5 Phase summary

Second phase has mostly followed the project plan. There has been some challenges regarding the hydraulic components from school, but this has been solved. The group came to a final decision regarding the SW and communication solution and successfully tested the CAN-communication part. Documents that are delayed are to be finished during the Easter holidays. All in all, second phase has been a period with some challenges but they have been solved very well.

Third Phase and Iteration report

G-TPI

Version	Date	Main Author	Co-Author	Approved by
1	13.05.2014	Snorre Kløcker		Eirik Kristoffersen
2	21.05.2014	Snorre Kløcker		Eirik Kristoffersen

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	21.05.2014	Updated according to template	Snorre Kløcker	Eirik Kristoffersen

This document is the third phase & iteration review report for Smart DDSV Demonstrator.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Controller Area Network
DDSV	Direct Drive Servo proportional Valve
FMC	FMC Technologies
GUI	Graphical User Interface
HBV	Buskerud and Vestfold university college.
SW	Software
USB	Universal Serial Bus
FAT	Factory Acceptance Test
GUI	Graphical User Interphase

Table 1: Abbreviations

2.0 Introduction

To keep the planned progress in the project, the bachelor group will review the progress according to project plan. Each iteration review will contain an iteration summary and a control matrix. The phase review describes the status for all of the main activities through the phase.

3.0 Iteration review

3.1 Iteration 1

This iteration had a long time span due to Easter and exam period. In this iteration it was important that the group finished their demonstrator table so that it is ready for testing in iteration 2 and 3. The group decided to do some work during the Easter holidays to catch up with some delayed work.

The valve, IXXAT CAN-USB and power supply was received 16.04.2014. The accumulator was received 23.04.2014. There have also been made a technical drawing for an accumulator adapter. This drawing has been sent to FMC's department at Notodden for construction.

The displacement potentiometer has been tested and verified that it is ok. Since the sensor supply is 10V, a 24VDC to 10VDC converter has been ordered together with some other electrical components that the group needed to complete the electrical part.

There are many documents that are not released according to the document plan. This is because of the Easter and exam period, and the documents were not moved in the project plan because it was not a big issue that they were delayed.

Control matrix		**Date: 05.04.2014 – 25.04.2014**
Control questions	Status	Actions performed
Is the project plan on schedule?	N	Iteration review
Are project members working well together?	Y	
Is the communication between project members and supervisors good?	Y	
Are the documents according to templates?	Y	
Are the documents according to document plan?	N	Extended release date
Are there any new requirements?	N	
Is interface according to the plan?	Y	

Table 2: Control matrix, iteration 1

3.2 Iteration 2

Besides writing documents in this iteration, a lot of time has been used to prepare for the testing in Notodden. The group has arranged transportation of the demonstrator by using a lend-car from FMC. Transportation will be done on Tuesday in the next iteration. The group received some components for the 24VDC – 10VDC converter from Elfa. This converter were made and successfully tested. Plexiglas- plates were received from FMC and mounted. A sticker for the Plexiglas that covers the front of the demonstrator were ordered and mounted. The hydraulic hoses were connected to make sure that the system was complete. Due to changes in the hydraulic scheme there were also ordered a ball valve and one extra hose line for this. The preassembly test were started to make sure that the most important components were fitting together.

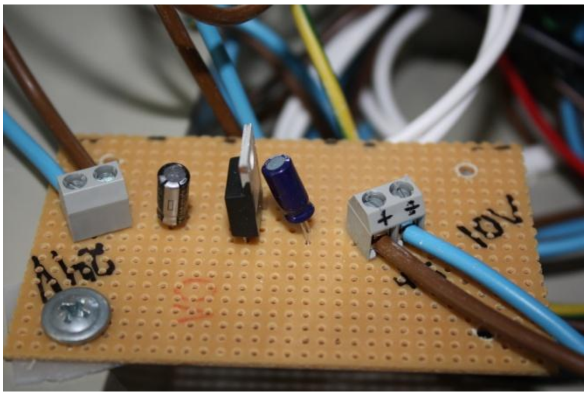

Figure 1: 24VDC to 10VDC converter

Figure 2: Preparations for the testing at Notodden

All the electrical components that were delayed were picked up at Team Trade in Hokksund. The electrical parts will be mounted early in the next iteration.

The project is on schedule but there have been some changes regarding the dates for the testing and test-reports. This has been done because the group has to adapt their testing to the schedule at FMC, Notodden.

Control matrix		Date: 26.04.2014 – 02.05.2014
Control questions	Status	Actions performed
Is the project plan on schedule?	Y	
Are project members working well together?	Y	
Is the communication between project members and supervisors good?	Y	
Are the documents according to templates?	Y	
Are the documents according to document plan?	Y	
Are there any new requirements?	N	
Is interface according to the plan?	Y	

Table 3: Control matrix, iteration 2

3.3 Iteration 3

At the start of this iteration the electrical system were mounted and wired. This required a lot of modification to the cabinets but the group was very satisfied with the result. The final preparation for the testing at Notodden was done. A check list was written on the whiteboard to make sure that the group remembered everything before traveling to Notodden.

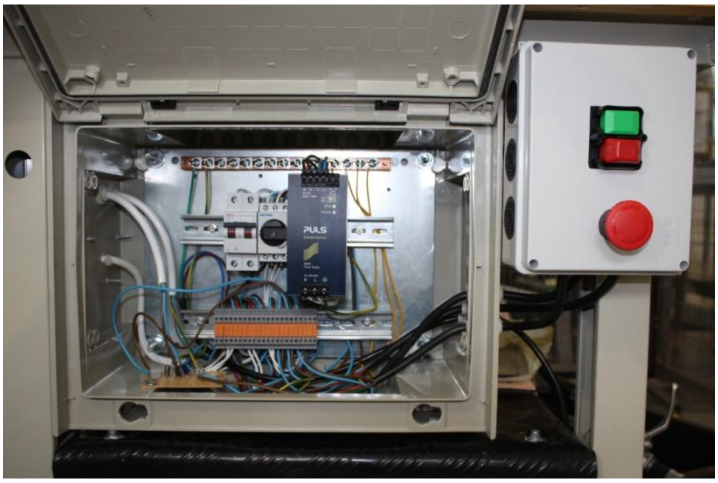

Figure 3: Main electrical and start/stop/emergency cabinets

Figure 4: Transportation of the demonstrator

The accumulator adaptor that was made at Notodden was received, there were some challenges with the sealing between the accumulator and the adapter but this were solved with some special thread glue (Loctite and activator).

Figure 5: Mounting the accumulator to the adapter

Figure 6: Accumulator and quick- connection mounted on to the adapter

The day that the group transported the demonstrator to Notodden was stressful. A lot of equipment should be packed in addition to make sure that nothing was missing on the demonstrator. When the demonstrator was installed and the group was settled, the rest of day was assigned to learn the procedures of the equipment that the group was going to use.

When the group started with the testing, it was obvious that the testing required more time than expected. Therefore the system test and FAT was postponed into week 20. There were also discovered some issues with the accumulator pre- charging connector. During the ordering process of the accumulator the students asked Hydac if it was possible to do the pre- charging by ourselves, and they said that this was not a problem. When the group were to pre- charge the accumulator it turned out that the connector was not a standard connector and needed to be supplied from Hydac. The students called to Hydac and the required connector was ordered, and was received the day after.

Figure 7: Pre- charging connectors

When pre- assembly test and flushing of the system was done the group started on the pressure test. The pressure test was a bit challenging due to some leakages, which was fixed during the test. There were also some new requirements and test setups which lead to changes in the test procedure and schematic.

Figure 8: Marit is checking the wiring during the pre-assembly test

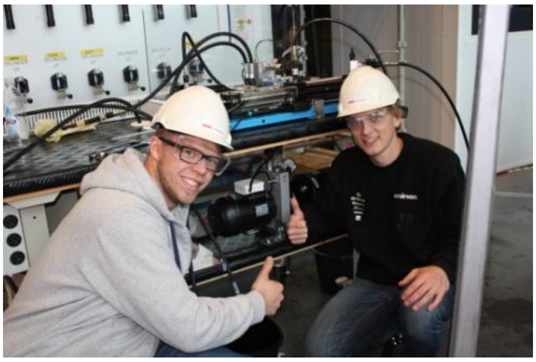

Figure 9: The HPP electric motor successfully tested

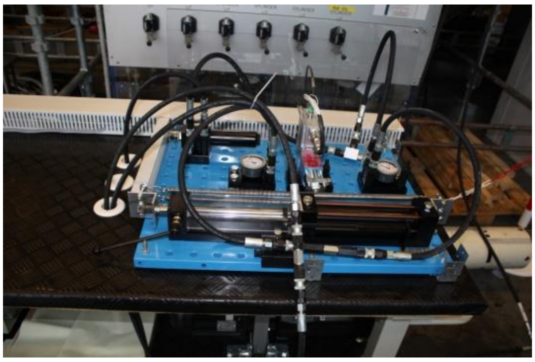

Figure 10: Hydraulic system

Figure 11: The system is ready for flushing

Figure 12: Preparing for pressure-test

Figure 13: Nicolai is operating the pump used during the pressure- test

Control matrix		**Date: 03.05.2014 – 09.05.2014**
Control questions	Status	Actions performed
Is the project plan on schedule?	Y	
Are project members working well together?	Y	
Is the communication between project members and supervisors good?	Y	
Are the documents according to templates?	Y	
Are the documents according to document plan?	Y	
Are there any new requirements?	Y	New requirement regarding some of the test-procedures. (T-008, T-009→T-011, T-012)
Is interface according to the plan?	Y	

Table 4: Control matrix, iteration 3

4.0 Phase review

4.1 Hydraulic system

The hydraulic system is now finished. There have been some upgrades on the schematic like a ball valve for bleeding the system on the accumulator side. An adapter for the accumulator was drawn by the students and machined by FMC at Notodden. This adapter was successfully tested and mounted on to the accumulator.

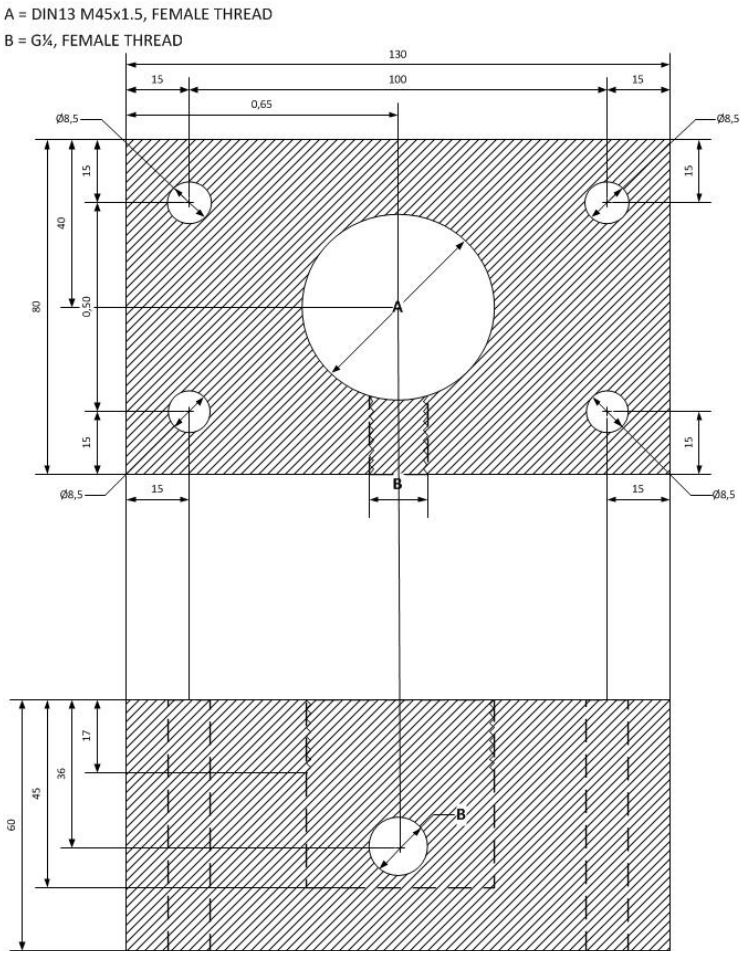

Figure 14: Accumulator adapter

After all components and hoses were flushed the system was successfully pressure tested with a hand pump at 95 bar as maximum test pressure. The pressure test was performed without the valve since it has some internal leakage that causes a pressure drop. After the pressure test was performed, the hydraulic power pack was connected with all the components. This was the first start up of the power pack, and it proved to work as intended. It was also powerful enough to run the system as the students predicted.

4.2 Interface

The LabView GUI has been upgraded and is now ready for the system test. The group has done some dry testing with the valve to verify that the communication is working. Functions like open/close, different modes of operation, cylinder displacement and spool position are now implemented.

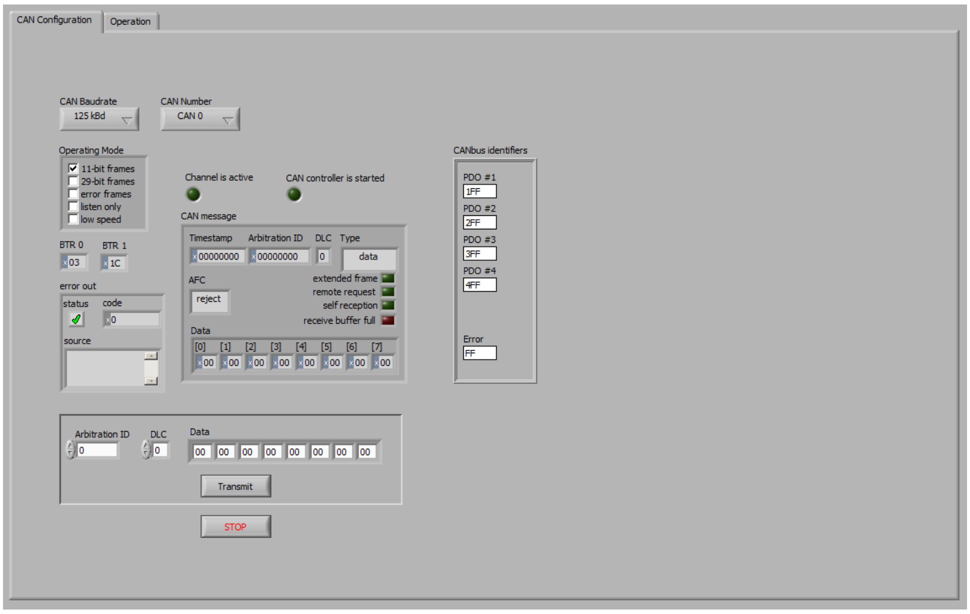

Figure 15: GUI configuration screen

This screen is used for configuration of the valve, and will be used to set up the CANbus communication between the valve and the computer.

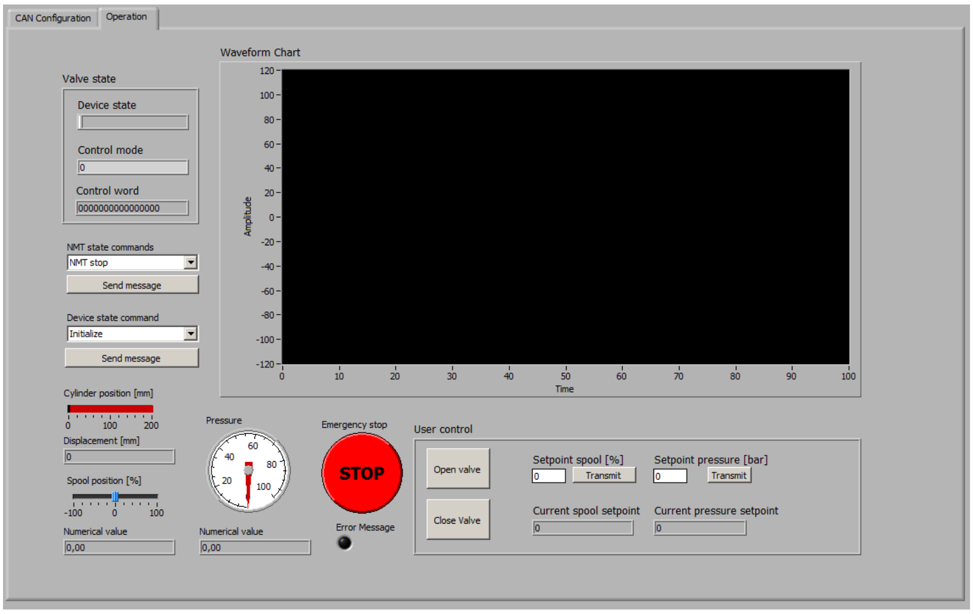

Figure 16: GUI operational screen

This is the operational tab of the GUI, and is used to control valve state, transmitting setpoints for regulation. The waveform chart currently only displays the spool position, but this will be extended so that also the pressurecurve and current spool/pressure setpoints will be displayed.

4.3 Test

During this phase all of remaining test procedures has been finished. In the end of iteration three, the students traveled to FMC at Notodden to do the final testing. Pre- assembly and pressure test was successfully performed and approved. There was done some changes to the pressure- test, system- test and FAT after advises from the test manager at Notodden. These changes was regarding the flushing-procedure and pressure stability requirements. The hydraulic aggregate at FMC test site were used to pre-flush some of the components one by one. After mounting these components together, the whole system without the accumulator and DDSV were pre-flushed. Hand-pump was used to pre-flush the accumulator. The tests to verify A-, B- and C-requirements and FAT are being performed at the beginning of phase four.

4.4 Documentation

The documentation was a little delayed in start of this phase but the group managed to get ‘back on track’ by doing some work during the Easter. Some of the documents have been released delayed and released later than scheduled, but this has not caused harm to project process. It is expected that all of the documents will be released before the delivery date.

4.5 Phase summary

In this phase, completion and testing of the demonstrator have been in focus. The demonstrator is now finished. The testing of the demonstrator was done at FMC’s test facilities at Notodden. Some of the testing has been postponed to the next phase (T-009→T-011 and T-012) due to iteration review. Before the pressure test was started the whole system was thoroughly flushed to be sure that the system was clean. The pressure test was approved. After this phase, project and documentation is according to schedule.

Fourth Phase and Iteration report

G-FOP

Version	Date	Main Author	Co-Author	Approved by
1	21.05.2014	Snorre Kløcker	Nicolai Skjelsbæk	Eirik Kristoffersen

This document is the fourth phase & iteration review report for Smart DDSV Demonstrator.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
DDSV	Direct Drive Servo proportional Valve
FMC	FMC Technologies
HBV	Buskerud and Vestfold university college.
FAT	Factory Acceptance Test
SW	Software

Table 1: Abbreviations

2.0 Introduction

To keep the planned progress in the project, the bachelor group will review the progress according to project plan. Each iteration review will contain an iteration summary and a control matrix. The phase review describes the status for all of the main activities through the phase.

3.0 Iteration review

3.1 Iteration 1

In this iteration the group has finished the testing at Notodden. System test and the FAT were successfully done at the beginning of the iteration. The group transported the demonstrator back to the school.

The focus is now to write all test procedures and complete the rest of the documents. All documents shall be ready for review and release during the next iteration. The final project report should have been released, but it’s not. This is because the testing period at Notodden took some more time than expected. Beside the final project report the document and project-plan are as scheduled.

Control matrix		**Date: 10.05.2014 – 17.05.2014**
Control questions	Status	Actions performed
Is the project plan on schedule?	N	Document review
Are project members working well together?	Y	
Is the communication between project members and supervisors good?	Y	
Are the documents according to templates?	N	Documents will be reviewed next iteration to match the newest template
Are the documents according to document plan?	N	Final project report is delayed. Release date postponed to 21.05.2014
Are there any new requirements?	N	
Is interface according to the plan?	Y	A requirement regarding SW are ok. Some of the B requirements are ok.

Table 2: Control matrix, Iteration 1

3.2 Iteration 2

The test period in Notodden is finished, so iteration 2 is mainly used for writing test reports. When all of the test reports were written, the group started their final document review. The document review includes that the group members shall go through every written document and make sure that they are according to template.

At 26th of May, all of the documents shall be delivered. This date is at the end of iteration 2, so this report had to be written before fourth phase was finished. When all of the documents are delivered, the group will start the preparations for their final presentation. This will include making the presentation, updating web/sharepoint and making a wall chart for HBV.

Control matrix		**Date: 18.05.2014 – 27.05.2014**
Control questions	Status	Actions performed
Is the project plan on schedule?	Y	
Are project members working well together?	Y	
Is the communication between project members and supervisors good?	Y	
Are the documents according to templates?	Y	Documents are reviewed and updated according to new templates
Are the documents according to document plan?	Y	
Are there any new requirements?	N	
Is interface according to the plan?	Y	B-requirements are now approved, one C-requirement is approved [1]

Table 3: Control matrix, Iteration 2

3.3 Iteration 3

Iteration 3 is the last and final iteration of the Smart DDSV Demonstrator project. This iteration will include the same as the end of iteration 2. The group will keep on working with preparations for the final presentation. The Smart DDSV Demonstrator project has been successful, and the group members are very pleased with the result they have gotten.

Control matrix for the whole project		**Date: 28.05.2014 – 16.06.2014**
Control questions	Status	Actions performed
Has the project plan been on schedule?	Y/N	The project plan has been both on schedule and delayed. This is something that will happen to almost every real life projects as well. There are almost impossible to get the first version of the project plan to be valid throughout the whole project. The project plan has been very helpful, and is an important tool for project management.
Has the project members been working well together?	Y	The cooperation has been nothing less than perfect throughout the whole project. There has been a professional tone between the members, and the work environment has been very good.
Has the communication between project members and supervisors been good?	Y	The supervisors have been very important for the group. The group has tried to work independent throughout the whole project, but the feedback from both the internal and external supervisors has been very helpful. The group had regularly contact with the supervisors, and there has never been a problem to contact them with questions.
Are the delivered documents according to templates?	Y	Documents are reviewed and updated according to the templates.
Has the documents been according to document plan?	Y/N	The document plan has been both on schedule and delayed. This is something that will happen to almost every real life projects as well. There are almost impossible to get the first version of the document plan to be valid throughout the whole project. The document plan has been very helpful, and is an important tool for project management.

Table 4: Control matrix for the whole project

4.0 Phase review

4.1 Test

In this phase there has been a lot of testing. The demonstrator was finished in this phase, so it had to be tested. The testing was performed at FMC's test facilities in Notodden. The testing has been successful, and all of the A- and B requirements are now verified [2]. The tests that has been done on the demonstrator is a Pre-assembly test [3], Pressure test [4], System test [5] and the Factory acceptance test [1]

4.2 Documentation

All of the documents has been reviewed in this phase, and are ready for delivery at 26th of May.

4.3 Phase summary

This phase has been stressful, but all of the group members have learned a lot about testing in the test period at Notodden. The rest of the phase was used for finishing the rest of the documents, final document review, and preparations for the group's final presentation.

For a summary of the whole project, the group recommend to read the final project report, G-FR [6], and the post analysis report, G-PA [7]

5.0 References

[1] Smart DDSV Demonstrator, *G-TR6 - "Test result Report T-012,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *S-RS - "Requirement Specification,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *G-TR3 - "Test result Report T-007,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *G-TR4 - "Test result Report T-008,"* HBV, Kongsberg, 2014.

[5] Smart DDSV Demonstrator, *G-TR5 - "Test result Report T-009-->T-011,"* HBV, Kongsberg, 2014.

[6] Smart DDSV Demonstrator, *G-FR - "Final Project Report,"* HBV, Kongsberg, 2014.

[7] Smart DDSV Demonstrator, *G-PA - "Post Analysis report,"* HBV, Kongsberg, 2014.

Logistics Report

G-LR

Version	Date	Main Author	Co-Author	Approved by
1	24.03.2014	Nicolai Skjelsbæk		Eirik Kristoffersen
2	20.05.2014	Eirik Kristoffersen	Nicolai Skjelbæk	Marit Hammer

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	20.05.2014	Updated due to document review	Eirik Kristoffersen	Marit Hammer

This document discusses how "Smart DDSV Demonstrator" has solved the logistics problems.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
A	Ampere
CAN	Controller Area Network
DBS	Dowty Bonded Seals
DDSV	Direct Drive Servo proportional Valve
DIN	Deutsches-Institut-für-Normung
FMC	FMC Technologies
HBV	Høyskolen I Buskrud og Vestfold
m	meter
ml	milliliters
mm	Millimeters
NN	Nomen nescio (unknown)
USB	Universal Serial Bus
V	Volt

Table 1: Abbreviations

2.0 Introduction

"Smart DDSV demonstrator" has solved their logistics in collaboration with their client, FMC Technologies. This document is meant to be internal in the project and shall be followed and read by all group members before anything is ordered, to be sure that not any problems occur with the logistics.

3.0 Logistics

All components that shall be ordered in the "Smart DDSV Demonstrator" project, shall at all times have billing address at FMC Technologies. This is a request from FMC Technologies which is discussed and agreed upon. By solving the logistics this way, the group can order parts rapidly without being processed through FMC. The components shall be delivered at HBV with one of the project member's as a reference. HBV shall not have any responsibilities over components delivered at their locations.

Billing address:
FMC Kongsberg Subsea AS
Ref: Børge Bjørnaas
P.B 1012
3601 Kongsberg
Norway

Shipping address:
Høgskolen i Buskerud og Vestfold
Ref: *Student, name* / M: *phone*
Frogsvei 41
3611 Kongsberg
Norway

If there are any components ordered from a nearby location, the project group should try to avoid shipping costs. This can be done by order the component without shipping, and retrieve the components their self. It is important that the purchaser get a receipt, and keep this safe to maintain control of the expenses. All the purchased parts shall be added to this document. The parts shall be declared in the budget. If the expenses of an item exceed the budget, the purchase shall be approved by FMC. If it does not exceed the budget, the purchaser shall declare this with the economic responsible.

4.0 Components

This is a table over all of the components that shall be ordered. If there is any deviations to this table, there shall be constructed a deviation report, and a new updated version of this document shall be written. This report shall include a description of why there is a deviation, and what shall be done instead of using the component.

Component	**Supplier**	**Quantity**
DDSV	Moog	1
Power supply module	Moog	1
Mating connector11+PE	Moog	1
Interface card USB to CAN	Moog	1
Power cable	Moog	1
Potentiometer (position sensor)	School	1
Accumulator	Hydac	1
Differential cylinder 32/16/200 with cover	School	1
Hydraulic Power pack with a constant displacement pump,230V	Festo	1
Profile plate	School	1
Pressure gauge	School	2
High pressure filter	School	1
Filter cartridge	Festo	1
T-distributor	Festo	2
Hose line	Tess	10
Extension spring coil	Students	3
Hydraulic oil (DIN51524) 20 liter	Tess	1
Emergency switch	Biltema	1
Prezi	Prezi.com	1
Portable table	AJ-produkter.no	1
Gasket, replacement set for cylinder	Tess	1
Adapter plate for accumulator	FMC	1
Ball valve	FMC	1
Others		1
Electrical components		1

Table 2: Components

4.1 Others

In this table all the items under the “other” post are listed. These items are purchased and retrieved in a store at listed supplier except the plexi glas which was custom made at FMC. The items are mainly smaller parts that are necessary to build the Demonstrator.

Item	**Order no.**	**Supplier**	**Quantity**
Drill bit 6,5 mm	19042	Biltema	1
Drill bit 13 mm	20199	Biltema	1
Screws (M8x100)	19391	Biltema	5

Angle brackets (70x70x55mm)	19607	Biltema	4
Table implementation (38 mm)	25433	Biltema	3
Nuts (M8)	19894	Biltema	10
Hexagon socket screw (M6x60)	870182	Biltema	1
Sunken woodscrew (5x30)	87645	Biltema	35
Planar disc	19874	Biltema	25
Screws (M8x75)	19390	Biltema	5
Stainless steel washers (6,4x12)	19131	Biltema	25
Threaded rod (M8x1000 mm)	19387	Biltema	1
Shelf (1500x300x18 mm)	86553	Biltema	1
Shelf (1500x400x18 mm)	86554	Biltema	2
Sunken woodscrew (5x30)	87612	Biltema	200
Silicone (300 mL)	36099	Biltema	1
Locknuts (M6)	19912	Biltema	25
Angel brackets (50x50x35 mm)	19611	Biltema	6
Dummy plug DBS sealing (G1/4)	7188-04 7001-04	Tess	8 8
DBS sealing (G1/4)	7001-04	Tess	30
Hexagon screw (M12x75)	19559	Biltema	5
Fiberlene clean		Sport 1	1
Grease Bucket Funnel Sanding sheets		Biltema	1 1 1 1
Plexiglas		FMC	4
Body plate disc M5	11-1129-531	Clas Ohlson	1
Screw 6-point M5x2	11-1123-520	Clas Ohlson	1
Wago	36-3410	Clas Ohlson	1
Corner fittings	NN	Tele Blikk	1
Screws M12x50 Plate 80x220x1, 5	7244832	Monter	1
2 pack Decorating Disc NR8	NN	Jernia	1
Track bolt M5x30	11-1125-530	Clas Ohlson	2
Locknut M5	11-1936-5	Clas Ohlson	2
Double outlet	357131	Biltema	1
Stickers	NN	Kopisenteret	1

Sikaflex	NN	Europris	1
Angle 26x13x2	7031729	Monter	2

Table 3: Others

4.2 Electrical components

In this table all the items under the “electrical components” post are listed. These items are mainly purchased and retrieved in a store at listed supplier. Some of the items listed in this table are additional parts for the emergency switch.

Item	**Order no.**	**Supplier**	**Quantity**
Automatic fuse	36-3075	Clas Ohlson	1
Terminal box (86x86x39 mm)	36-5409	Clas Ohlson	1
Terminal box (190x145x70 mm)	32-7417	Clas Ohlson	1
Main switch (40A, 690V)	350077	Biltema	1
Cable (5 m)	34201	Biltema	1
Step-down converter	74706383	Elfa	1
DIN rail	NN	Elektrikeren Kongsberg AS	1
CAN Dsub fieldbus connector + DIN mounting bracket	NN	Elfa	1
Cable bushings	36-1221	Clas Ohlson	5

Table 4: Electrical components

Deviation report

G-DR

Version	Date	Main Author	Co-Author	Approved by
1	16.05.2014	Eirik Kristoffersen		Snorre Kløcker
2	19.05.2014	Eirik Kristoffersen		Snorre Kløcker
3	20.05.2014	Eirik Kristoffersen		Marit Hammer

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	19.05.2014	Added table and figure list according to new template	Eirik Kristoffersen	Snorre Kløcker
2 → 3	20.05.2014	Corrections	Eirik Kristoffersen	Marit Hammer

This document contains the deviations from the logistics report. All group members involved in purchase of components shall read and sign this document.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Controller Area Network
DDSV	Direct Drive Servo proportional Valve
DIN	Deutsches-Institut-für-Normung
EK	Eirik Kristoffersen
LVDT	Linear Variable Differential Transducer
MH	Marit Hammer
mm	milimeters
NS	Nicolai Skjelsbæk
SK	Snorre Kløcker
USB	Universal Serial Bus

Table 1: Abbreviations

2.0 Introduction

This document gives a description of deviations related to the logistic report [1]. It will provide a description of why the deviation occurred, and what shall be done instead. All group members that have been involved in purchase of the components listed in the next section shall read and sign this document.

3.0 Components

The following components were planned to be ordered for the Smart DDSV Demonstrator.

Component	Supplier	Quantity	Order No.
DDSV	Moog	1	1
Power supply module	Moog	1	2
Mating connector 11+PE	Moog	1	3
Interface card, USB to CAN	Moog	1	4
Power cable	Moog	1	5
LVDT	School	1	6
Accumulator	Hydac	1	7
Differential cylinder 32/16/200 with cover	School	1	8
Hydraulic Power pack with a constant displacement pump,230V	Festo	1	9
Profile plate	School	1	10
Pressure gauge	School	2	11
T-distributor	Festo	2	12
Hose line with quick release couplings (760 mm)	Tess	13	13
Extension spring coil	Lesjöfors	1	14
Hydraulic oil (DIN51524) 20 liter	Tess	1	15
Emergency switch	Biltema	1	16
Touchscreen	Komplett.no	1	17
Prezi	Prezi.com	1	18
Portable table	AJ-produkter.no	1	19
Electrical components	Biltema	1	
Others		1	

Table 2: List of components

4.0 Deviation

Listed in this section are the deviations for the Smart DDSV Demonstrator. Column is marked Y/N due to what have caused the deviation. If the deviation column is marked "Y", a short description shall be written by the person responsible for this purchase. If the deviation occurred because more parts or components were needed, then these shall be added to the budget, and written in an updated logistic report. The following deviations occurred:

Item Ordered by: SK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
DDSV	N					
Description: According to plan.						

Table 3: Order No. 1

Item Ordered by: SK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Power supply module	N					
Description: According to plan.						

Table 4: Order No.2

Item Ordered by: SK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Mating connector 11+PE	N					
Description: According to plan.						

Table 5: Order No.3

Item **Ordered by: SK**	**Deviation: Y/N**	**Supplier: Y/N**	**Quantity: Y/N**	**Component: Y/N**	**Requirement: Y/N**	**Others: Y/N**
Interface card, USB to CAN	N					
Description: According to plan.						

Table 6: Order No.4

Item **Ordered by: SK**	**Deviation: Y/N**	**Supplier: Y/N**	**Quantity: Y/N**	**Component: Y/N**	**Requirement: Y/N**	**Others: Y/N**
POWER CABLE	N					
Description: According to plan.						

Table 7: Order No.5

Item **Ordered by: EK**	**Deviation: Y/N**	**Supplier: Y/N**	**Quantity: Y/N**	**Component: Y/N**	**Requirement: Y/N**	**Others: Y/N**
LVDT	Y	N	N	N	N	Y
Description: The LVDT from school turned out to be a potentiometer instead. Nevertheless, this component will be used.						

Table 8: Order No.6

Item Ordered by: SK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Accumulator	N					
Description: According to plan.						

Table 9: Order No.7

Item Ordered by: EK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Differential cylinder 32/16/200 with cover	N					
Description: According to plan.						

Table 10: Order No.8

Item Ordered by: EK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Hydraulic Power pack with a constant displacement pump,230V	N					
Description: According to plan.						

Table 11: Order No.9

Item Ordered by: EK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Profile plate	N					
Description: According to plan.						

Table 12: Order No.10

Item Ordered by: EK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Pressure gauge	N					
Description: According to plan.						

Table 13: Order No.11

Item Ordered by: EK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
T-distributor	N					
Description: According to plan.						

Table 14: Order No.12

Item Ordered by: SK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Hose line with quick release couplings (760 mm)	Y	N	Y	Y	N	Y
Description: The planned quantity of hose lines was set to be 13. Due to changes in the hydraulic schematic, this has now been reduced to 10. Length of hoses is adapted to distance from component. The quick release couplings from school were used instead of buying new ones. So hoses will be delivered without quick release couplings, this caused a price reduction.						

Table 15: Order No.13

Item Ordered by: EK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Extension spring coil	Y	Y	Y	N	N	N
Description: The supplier of the extension spring coil was set to be Lesjöfors. The group decided to use 3 extension springs provided privately instead.						

Table 16: Order No.14

Item Ordered by: MH	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Hydraulic oil (DIN51524) 20 liter	N					
Description: According to plan.						

Table 17: Order No.15

Item Ordered by: SK	**Deviation: Y/N**	**Supplier: Y/N**	**Quantity: Y/N**	**Component: Y/N**	**Requirement: Y/N**	**Others: Y/N**
Emergency switch	N					
Description: According to plan.						

Table 18: Order No.16

Item Ordered by: SK	**Deviation: Y/N**	**Supplier: Y/N**	**Quantity: Y/N**	**Component: Y/N**	**Requirement: Y/N**	**Others: Y/N**
Touchscreen	Y	N	N	Y	N	N
Description: The touch screen was canceled because it was considered to be unnecessary, and to simplify a solution for control of the system.						

Table 19: Order No.17

Item Ordered by: NS	**Deviation: Y/N**	**Supplier: Y/N**	**Quantity: Y/N**	**Component: Y/N**	**Requirement: Y/N**	**Others: Y/N**
Prezi	N					
Description: According to plan.						

Table 20: Order No.18

Item Ordered by: SK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Portable table	Y	N	N	N	N	Y
Description: The portable table was delivered with chipboard instead of steel. Nevertheless, this table will be used.						

Table 21: Order No.19

4.1 Additional components

In this section all the additional components are listed. These components were not listed in the logistic report, but will be necessary to complete the Demonstrator.

Item Ordered by: EK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Filter cartridge	Y	N	N	Y	N	N
Description: A replacement filter cartridge was order due to the age of the old filter. This component is declared in the budget, and was necessary for optimum purity of the system.						

Table 22: Filter cartridge

Item Ordered by: SK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Adapter plate for accumulator	Y	N	N	N	N	Y
Description: The adapter plate was necessary to be able to connect the accumulator in the circuit with quick-fix couplings. It will also help to stabilize the accumulator and simplify the mounting.						

Table 23: Adapter plate

Item Ordered by: EK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Ball valve	Y	N	N	N	N	Y
Description: The ball valve was ordered for safety reasons. If the servo-valve would go into fail-safe mode, a ball valve is necessary to be able to bleed the pressure.						

Table 24: Ball valve

Item Ordered by: SK	Deviation: Y/N	Supplier: Y/N	Quantity: Y/N	Component: Y/N	Requirement: Y/N	Others: Y/N
Gasket	Y	N	N	N	N	Y
Description: The gasket was ordered because the cylinder had an internal leakage. The old gaskets had to be replaced in order to get a well functional cylinder.						

Table 25: Piston gasket

5.0 Confirmation

All responsible purchasers shall sign this section to confirm purchase and/or deviation of item. This is to confirm that the Smart DDSV group has received the necessary parts and tools to build the Demonstrator, and to confirm the budget for the bachelor thesis.

By signing this document the following statements are declared:

1. I have read and understood this document.
2. I am responsible for the item signed with my initials.
3. I have written and accepted the description for the deviation of the item with my initials.
4. I confirm this document.

Smart DDSV purchasers:


Signature: ....
(Snorre Kløcker)

Signature: ....
(Eirik Kristoffersen)

Signature: ....
(Nicolai Skjelsbæk)

Signature: ....
(Marit Hammer)

Figure 1: Signatures

6.0 References

[1] Smart DDSV Demonstrator, *G-LR - "Logistics Report,"* HBV, Kongsberg, 2014.

Post Analysis Report

G-PA

Version	Date	Main Author	Co-Author	Approved by
1	21.05.14	Nicolai Skjelsbæk	Håkon Mørk Solaas	Snorre Kløcker

This document is the post analysis for the Smart DDSV Demonstrator bachelor project.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
DDSV	Direct Drive Servo proportional Valve
FMC	FMC Technologies
IWOCS	Installation/Workover control systems
HBV	Buskerud/Vestfold university college
SW	Software
GUI	Graphical User Interface
MoVaPuCo	Moog Valve and Pump Configuration tool

Table 1: Abbreviations

2.0 Introduction

This document is the post analysis report for the "Smart DDSV Demonstrator" bachelor project. The purpose of the document is to give a detailed view of how the project has been executed. What kind of challenges have been met, and how the group's cooperation with their client, supervisors and between group members has worked.

3.0 Achievement of project goals

The group feels that they have successfully reached the project goal by completing the portable DDSV demonstrator. There have been many challenges with completing the demonstrator, but the group feels that they have solved these challenges with success.

3.1 Project results

The Smart DDSV Demonstrator group received their project from FMC, IWOCS-department, and in G-ID [1] the project goal is given as: "The goal of the project is to build a simple, portable demonstrator that can validate some of the possibilities with a DDSV. FMC should be able to show the model to customers for introducing the DDSV technology". This goal has been met, the demonstrator is mounted on a portable table which means that it is possible to transport the demonstrator to show it to customers. For more information about the design of the demonstrator see D-DD [2].

It was important for the whole group to meet both FMC's and HBV's expectations to the thesis. Therefore, both the practical part and the documentation part had to be accurate and thorough. The documentation has flowed throughout the whole project, and each of the members had responsibilities for different documents. For more information about the documentation process, see P-DP[3].

This technology is new for the subsea business, but is already used for different land based technological aspects. Therefore, it has been important for the group to do a thorough research for how they could expect the DDSV to perform before the group could be able to test it. For more information about the DDSV research, see S-VS [4].

The thesis includes a demanding technical part, so the group has spent a lot of time on the technical aspect of the thesis. Both a hydraulic system and a GUI has been developed for the portable demonstrator. More documentation on how each part was developed can be found in S-IS [5] and S-HS[6]. More information about the technical part, and the documentation of the end results can be found in G-MT [7].

3.2 Project economy

The group has kept a strict budget throughout the project. This has been because FMC had a budget that set an upper limit for how much that could be invested when developing the demonstrator. The group has been able to get the practical part to be according to the budget, and they feel that this project could develop into a financial gain for FMC. For more information about the project's economy, see G-BU [8].

4.0 Project execution

4.1 Project working methods and project plan.

The project has been planned thoroughly in a project plan made in Microsoft excel [9]. It was first planned to use Microsoft Project, but the group experienced that this was to time demanding, since none of the group members had any experience with this SW. Supporting planning documents has been the Phase and Iteration plan[10], Activity plan [11] and the Document plan [3]. These documents have been a great support for the group members. The group could at all time see where they were in the project, what was delayed and what needed some extra focus for a period. Without the planning documents, the project would not have been successful.

The planning documents has gone through several reviews, this is because in a project there will be changes throughout the project time. This is not always the group's fault, the project has had delays due to late delivery of components, and because of not available test equipment for example.

The group has learned a lot from planning their own project. They did some mistakes, but solved the challenges with correcting the mistake again. These experiences will help all of the group members in the future. The project has been related to a real engineering project, and has included a lot of the challenges from a "real life" project.

4.2 Evaluation of the cooperation between group members

The five group members had already cooperated on other school assignments, so they knew all members had good work ethics and that all would take responsibilty for finishing the project. Three of the members had an internship at FMC in their fourth semester at HBV, so they started scouting for projects there. Before the sixth semester started the group had already had a couple of meetings with FMC and had decided on choosing "Smart DDSV Demonstrator" assignment from IWOCS as the subject of their bachelor thesis.

Already from the start the whole group agreed on that they did not want a purely theoretical thesis, they also wanted to end up with a physical product at the end of the project. The group members understood that having a practical part in the thesis would include a lot of extra work for the group members. To account for this the project's risk analysis [12] was created, which listed a series of possible scenarios, the risk of them happening, and solutions to them.

Each of the group members had their own responsibility. This was not meant to be the only thing the group members should work with, but it was their responsibility that this area would be finished. The group early decided that they wanted to work across their responsibilities. This has been a great learning experience for all the group members. The documentation delivered by the project group shows the diversity in the performed work, all of the group members have contributed in all fields of the project. The different projects areas was too demanding for everybody to be experts at every field, but all of the group members feel that they have learned a lot from this experience.

The group feels that the cooperation between them has been nothing less than perfect, both the work environment and the internal tone have been friendly and accommodating.

4.3 Evaluation of cooperation between group and external resources

The group has been lucky to have many great resources at FMC. All of the involved personnel there have showed a high interest in the project, and without their support the project had not been as successful as it is. The whole group would like to thank their supporters at FMC. See G-FR [13]

4.4 Time estimate

The bachelor assignment schedule has been changed since the previous years, which means the group only had one semester to complete their demonstrator. The group experienced that this was quite a tight schedule when a full working demonstrator was to be constructed, especially since the project start up at HBV was delayed and the group did not receive a place to work before early in February.

HBV had decided that the estimated total working hours for completing the project should be 600 hours for each student. Even though the hour lists show that not all students in the group have reached a full 600 working hours, the group members agrees that all members have contributed equally and that the final delivery has reached their high standards.

The group feels that the estimated hour for each activity has been fairly accurate. Some activities such as logistics and software research took longer than first expected due to unforeseen circumstances. However the group managed to finish most of their documentation and activities before the deadlines date in the project plan.

5.0 Conclusion

The group members feel that this project has been successful in terms of group composition and teamwork. The group has completed a functional demonstrator that reaches the performance requirements, and hope that the demonstrator will prove to be a valuable resource to FMC in the future. The group feels that they have managed to deliver a successful bachelor project with their goals and expectation met.

6.0 Credits

Smart DDSV bachelor group would like to thank following persons for their contribution to the bachelor project:

Kjetil Halset	Technical manager, IWOCS. FMC Technologies *For providing the bachelor group with the perfect thesis*
John Mulholland	Business Develop manager, Technology. FMC Technologies *Ordered plexiglas plates on short notice*
Vetle S.Vintervold	External supervisor / Product engineer, IWOCS. FMC Technologies *For being a good supervisor that provided the project members with much feedback and help during the whole project*
Svein Kjenner	Specialist system engineer, WAS. FMC Technologies *The 'inventor' of the Smart DDSV project. Thanks for being so interested in the project and for bringing many good ideas to us.*
Paul Vis	Team leader product responsible, IWOCS. FMC Technologies *Thanks for being critical and to see challenges were anyone else did not. Thanks for being a great supporter to the hydraulic part of the project.*
Børge Bjørnaas	Technical training manager, WAS. FMC Technologies *Thanks for the economic support, and for bringing good ideas.*
Joakim Lerstang	Test manager, Test. FMC Technologies *Thanks for the great hospitality shown regarding equipment and test facilities. Joakim and the other employees at Notodden have also been great supporters during the testing.*
Clas Andreasson	Key account manager at Moog Norden *Thanks for the help and interest during the project.*
Antonio Ramos	Internal supervisor at HBV. *Thanks for showing a high interest in our project and good supervising along the way.*
Devotek	Technical Company *For lending the bachelor group a hand pump for testing*
Karoline Moholt	Internal Sensor at HBV *Thanks for giving us feedback and being our sensor*

Arne Bjørnar Ness (HBV), Rolf Longva (HBV), Richard Thue (HBV), Morten Bermingrud (TESS), Roar Kristensen (Festo), Bjørn Gjevik (Professor in Hydrodynamics, UiO), Michael Schoen (Moog), Ian Whiting (Moog), Rune Røraas

and

Family and fellow students

7.0 References

[1] Smart DDSV Demonstrator, *G-ID - "Idea document,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *D-DD - "Design Document,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *P-DP - "Document Plan,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *S-VS - "Valve specification,"* HBV, Kongsberg, 2014.

[5] Smart DDSV Demonstrator, *S-IS - "Interface and GUI Specification,"* HBV, Kongsberg, 2014.

[6] Smart DDSV Demonstrator, *S-HS - "Hydraulic System specification,"* HBV, Kongsberg, 2014.

[7] Smart DDSV Demonstrator, *G-MT - "Main Technical report,"* HBV, Kongsberg, 2014.

[8] Smart DDSV Demonstrator, *G-BU - "Budget,"* HBV, Kongsberg, 2014.

[9] Smart DDSV Demonstrator, *P-PP - "Project Plan,"* HBV, Kongsberg, 2014.

[10] Smart DDSV Demonstrator, *P-PI - "Phase and Iteration plan,"* HBV, Kongsberg, 2014.

[11] Smart DDSV Demonstrator, *P-AP - "Activity plan,"* HBV, Kongsberg, 2014.

[12] Smart DDSV Demonstrator, *G-RA - "Risk Analysis,"* HBV, Kongsberg, 2014.

[13] Smart DDSV Demonstrator, *G-FR - "Final Project Report,"* HBV, Kongsberg, 2014.

4.2 Test results

G-TRx

Test Result Report for T-002

G-TR1

Version	Date	Main Author	Co-Author	Approved by
1	13.03.14	Nicolai Skjelsbæk		Håkon Mørk Solaas

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	20.05.2014	Corrections and update according to last template	Nicolai Skjelsbæk	Snorre Kløcker

This is the test result report for test T-002, the pressure test of HBV components

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
DDSV	Direct Drive Servo proportional Valve
FMC	FMC Technologies
HBV	Buskerud/Vestfold university college
L	Liters
SJA	Safety Job Analysis
WP	Working Pressure

Table 1: Abbreviations

2.0 Introduction

This document is the report for test T-002[1]. It will present how the hydraulic components from HBV were pressure tested. The components that needed to be tested were two pressure gauges, one pressure filter and one double acting cylinder.

2.1 Personnel allowed at test site

Before the test was started, all of the personnel signed that they had read and understood the procedure and their responsibilities.

Name	Responsibility	From	Signature
Rune Røraas	Test responsible	Self-employed	Rune Røraas
Marit Hammer	Operator	Smart DDSV Demonstrator	Marit Hammer
Nicolai Skjelsbæk	Operator	Smart DDSV Demonstrator	[illegible]
Eirik Kristoffersen	Operator	Smart DDSV Demonstrator	Eirik Kristoffersen
Snorre Kløcker	Operator	Smart DDSV Demonstrator	[illegible]
Håkon Mørk Solaas	Operator	Smart DDSV Demonstrator	[illegible]
Vetle Stokke Vintervold	Observer	FMC	
Antonio Luis Lopes Ramos	Observer	HBV	

Table 2: Personnel present

3.0 Safety

3.1 Toolbox talk

The test started up with a toolbox talk. This was to make sure that personnel at site could raise questions about the procedure, and to make sure that test personnel agreed that the test procedure was approved.

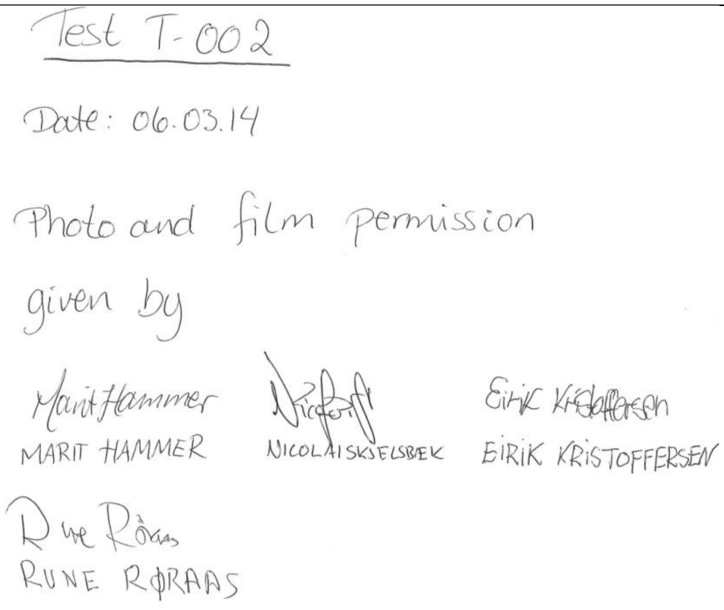
Test responsible issued that for the pressure test, we should consider to either do it more than once, or take a random sample after the predetermined pressures were tested. Test responsible also issued that the pressure gauges should be tested for visible leaks each time the system shall be used. Multiple tests must be conducted before the gauges could be approved.

The SJA [2] was also one of the topics in the toolbox talk, this was gone through and discussed. Test responsible approved each point of the SJA.

Location: Hydraulic lab C151 at HBV		**Test ID:** T-002	**SJA No.** 1	
Date: 06/03-14		**Test responsible:** Rune Røraas		
Activity	**Risk element**	**Damages (personnel, equipment, location)**	**Action to prevent**	**Performed**
Connect hoses to cylinder	Oil spill from hoses	Oil spill at persons who could lead to injuries The floor becomes slippery and causes a person fall.	Wear gloves and safety glasses, and be aware of oil spill from the hoses Have a protection mat on the floor and bench	RR
Connect hoses to the hand pump	Pressure from the pump is leaking before hoses are connected properly to the pump	Oil splatter at high pressure and cause personnel injuries	Be sure that the pump is not set, and wear gloves and protective glasses during test	RR
Set the pump	The hoses are not connected properly and loosens due to the pressure	Oil spill at personnel and area.	Be sure that all hoses are connected properly	RR
Cylindertest	Moving part	Injuries	Test operator shall have control over cylinder during test	RR

Table 3: SJA

A photo permit was also signed by all, see Figure 1.


Test T-002

Date: 06.03.14

Photo and film permission given by

MARIT HAMMER NICOLAI SKJELSBEK EIRIK KRISTOFFERSEN

RUNE RØRAAS

Figure 1: Photo permit

3.2 Required personal aid

- Safety goggles were worn during test
- Safety gloves were worn during test
- Test procedure were read and understood before test is performed.
- Emergency kit was approved by test responsible.

3.3 Warning signs

The test area were clearly marked, there were visible warning signs at each door. Room was closed for unauthorized personnel.

3.4 Equipment used under test

Test equipment was according to this table:

Equipment	**Quantity**
Safety goggles	One for each person present
Safety gloves	One pair for each person present
Emergency kit	1
Warning signs	2
Cylinder	1
Pressure filter	1
T-distributors	1
Pressure gauges	2
Hand pump (Enerpac P 141)	1
Druck Pressure Calibrator DPI 610	1
Hydraulic hose lines	4

Coupling sockets screw	2
Coupling sockets female thread	5
Spill containment unit	1
Oil suction gun	1
Funnel	1
Hydraulic oil (ISO VG 32)	1 L

Table 4: Equipment

4.0 Testing

The test was carried out in this order:

- Pre flushing
- Deviation test of pressure gauges
- Pressure test of cylinder
- Pressure test of pressure filter

4.1 Pre flushing

The pre flushing process was changed during the toolbox talk, the test personnel found out that it was better to use the hand pump to drive air out of the components.

4.1.1 Pressure gauges

The process started up with flushing the pressure gauges, and it was done in this order:

Number	Action
1	Coupled hand pump to pressure gauges
2	Pressure gauges were coupled in series, and there was coupled a hose from one of them to the spill containment unit.
3	Made sure that the bleeding valve on the hand pumps was open.
4	Filled hand pump with new fluid
5	Pumped fluid through the pressure gauges until there was no air left in the components.

Table 5: Pre-flushing procedure for pressure gauges

4.1.2 Cylinder

Pre-flushing of the cylinder was done in this order:

Number	Action
1	Emptied cylinder for old fluid through a drain screw on one of the cylinders sides.
2	Coupled hand pump to piston rod side of the cylinder, and piston side was coupled to the spill containment unit
3	Made sure that the bleeding valve on the hand pump was open.

4	Refilled hand pump with new fluid
5	Pumped fluid through the cylinder until there was no air left in the component. It was important that the drain screw was open, and that the cylinder was oriented in such a way that so that the drain screw was at the highest point of the cylinder.

Table 6: Pre-flushing procedure for cylinder

4.1.3 Pressure filter

Pre-flushing of the pressure filter was done in this order:

Number	Action
1	Coupled hand pump to pressure filter
2	Made sure that the hand pumps bleeding valve stood open.
3	Refilled hand pump with new fluid
4	Pumped fluid through the filter until there was no air left in the component.

Table 7: Pre-flushing procedure for pressure filter

4.2 Test Procedure

4.2.1 Deviation test

HBV has two pressure gauges at school that the bachelor group are wondering about using for their system, but they has to be tested first. They shall be tested to see if there are any deviation. FMC has a requirement that there shall not be deviation greater than ± 2.5 % of 1.65 x WP [3], where this systems WP are 60 bar.

4.2.2 Pressure test

All components shall be pressure tested. This is a test where the components will be tested for several pressures over a short amount of time. The demonstrator has a WP of 60 bar, and this test will go up to 1.65 x WP. It is important that the test starts at a lower pressure than this in case of leakage. The test shall include all the pressures from this table:

Percentage of 1.65 x WP	Pressure	Test time
50	50	10 min
75	75	10 min
90	90	10 min
100	100	15 min

Table 8: Test Pressures

The pressure drop shall maximum be 2 % of test pressure [3]. The test time shall not start before the pressure has been stable for 5 min. Under this test it shall be monitored if there is any fluid leakage. The test will not be approved if there is any leakage of fluid.

Before this test, the components shall be pre flushed to make sure that the components are cleaned for “old” fluid.

This procedure will use a hand pump for each test. This is not a requirement for the tests but will simplify them. Another pump may be used as well. The pump that will be used in the tests should have an internal pressure gauge to see what pressure it delivers. If the pump does not include an internal pressure gauge, there shall be connected an extra gauge to the test systems.

4.3 Pressure gauges test

The test was coupled as in Figure 2.

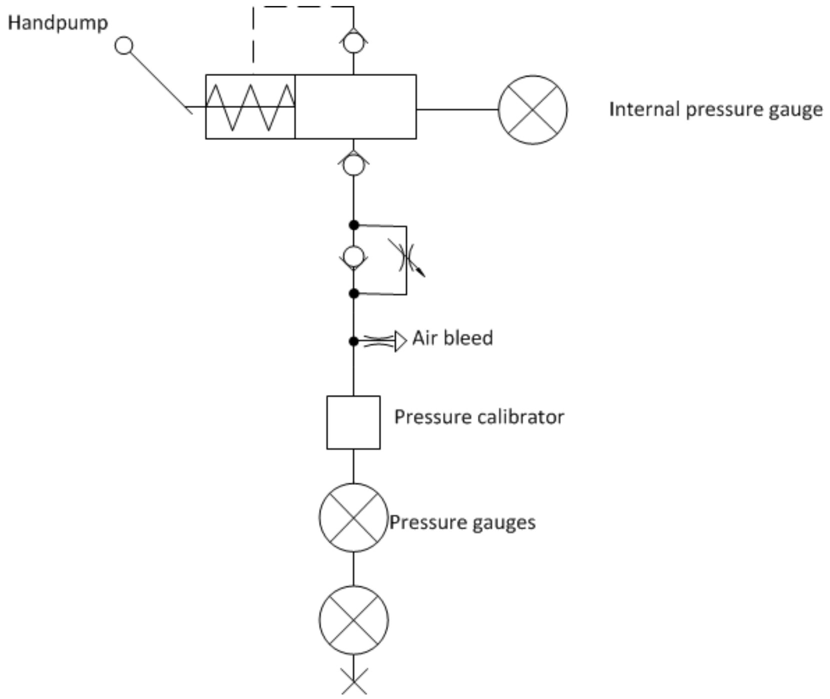


Figure 2: Schematic of pressure gauges test

The two pressure gauges was coupled in series after the hand pump and pressure calibrator. The first time there was pressure in the system it was very unstable. It was impossible to get the pressure to stabilize. The test responsible noticed that the coupling nipple was slightly leaking. The test personnel tried to tighten the coupling a bit, this did not help. The pressure gauges are mounted on a base with four inputs that are coupled together, so the personnel blocked the sweating input and used one of the others. This one did not sweat, but the pressure did not stabilize. The test personnel agreed that the test should proceed despite the unstable pressure. The unstable pressure was not a problem when doing the deviation test.

Hand pump gauge	External gauge 1 [bar]	External gauge 2 [bar]	Deviation [%]		~~Approved~~ [Signature]
			1	2	
50 bar	49,5	50	1	0	[illegible]
75 bar	74	73	1,4	2,7	[illegible]
90 bar	89	88	1,1	2,3	[illegible]
100 bar	99,5	97	0,5	3,1	[illegible]

Table 9: Deviation test

The procedure said that the test were approved if the deviation were less then ± 2.5 % of the hand-pump pressure gauge value [3]. This is not approved for all the values. However, if the requirement is changed to ± 2.5 % of 1.65 x WP, where WP is 60 bar so the deviation shall not be greater than 2.5 bar, the new table will look like this:

Hand pump gauge	External gauge 1 [bar]	External Gauge 2 [bar]	Deviation 1 [bar]	Deviation 2 [bar]	Approved by FMC [Signature]
50 bar	49,5	50	0,5	0	
75 bar	74	73	1	2	
90 bar	89	88	1	2	
100 bar	99,5	97	0.5	3	

Table 10: Deviation test according to new requirement

If the requirement is changed to the new one, there will only be pressure gauge 2 for 100 bar who is not approved. This has to be discussed further between the group and the client. The DDSV includes an internal pressure sensor, so the external pressure gauges are just to see that we have pressure working on the system. It is not essential that the gauges are showing exactly the correct value.

Another issue that is worth mentioning is that pressure gauge 1 is slow to respond to changes at low pressures. It was tested with 20 bars and the gauge was not responding well.

4.4 Double acting cylinder test

This part of the test was coupled as in Figure 3.

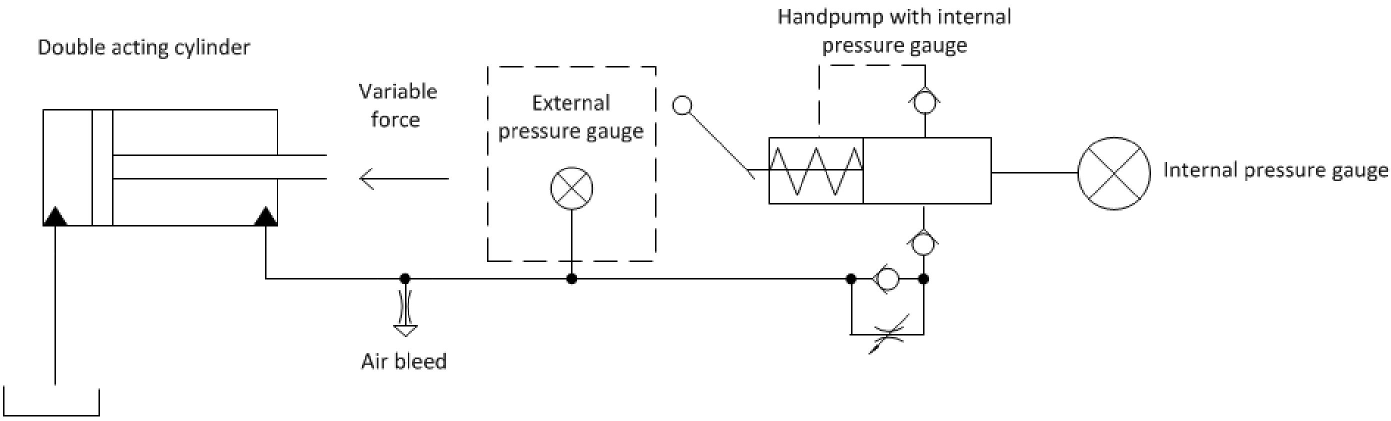


Figure 3: Schematic of first part of cylinder test

The test used one of the external pressure gauges that already where deviation tested as the external pressure gauges. The reason for using this extra gauge was that the scale on the internal gauge in the hand pump was greater than in the external. This made it hard to get the values to be where the test should have them. External pressure gauge 1 was used because this had less deviation than gauge 2.

The test started with slowly pumping the pressure up to 50 bar, when this was done the cylinder started leaking fluid, and the pressure decreased at once. The test personnel agreed that it looked like it was the piston gasket that was not sealing the way it should. There was no reason for testing the cylinder further before this was fixed. So the test for the double acting cylinder was not approved.

This test was not approved. R.R

Figure 4: Double acting cylinder test

4.5 Pressure filter test

The test was coupled as in Figure 5*:*

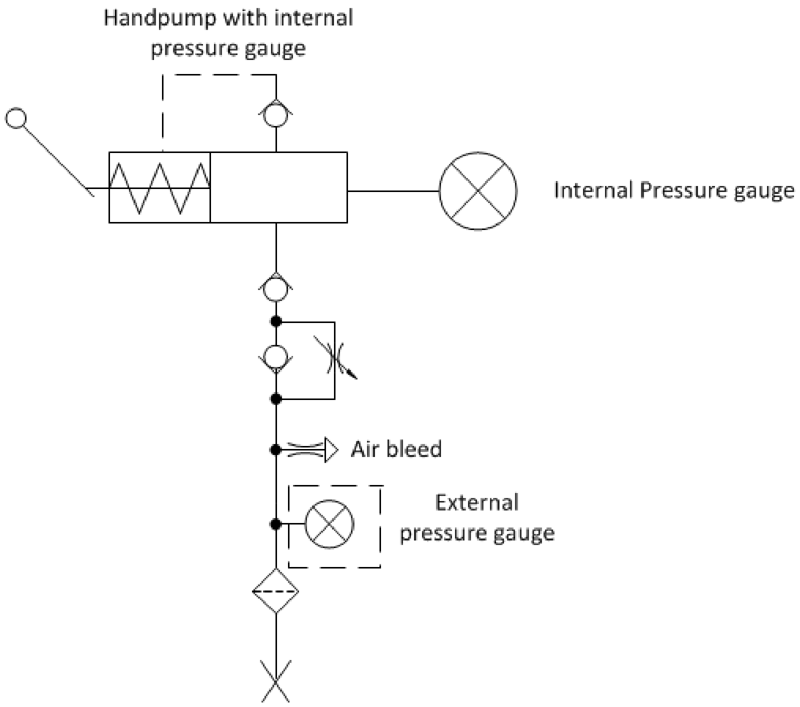


Figure 5: Schematic of pressure filter test

In the pressure filter test, pressure gauge 1 was used as an external gauge just like in the double acting cylinder test. The pressure did not stabilize for this test either. The personnel agreed on that there was nothing to do with this.

After 10 or 15 minutes, the end value was noted, see Table 11.

Hand pump gauge	Test time	Pressure at start of test [bar]	Pressure at end of test [bar]	Fluid leakage [Y/N]	~~Approved~~ [Signature]
50 bar	10 min	51	48	N	MR
75 bar	10 min	77	75	N	RR
90 bar	10 min				
100 bar	15 min				

Table 11: Pressure test

This test was not finished the first test day, so the pressure filter was tested for two values first. Preliminary results are according to this table:

Hand pump gauge	Test time	Pressure at start of test [bar]	Pressure at end of test [bar]	Pressure drop [%]	Fluid leakage [Y/N]
50 bar	10 min	51	48	5.88	N
75 bar	10 min	77	75	2.60	N

Table 12: Preliminary test of pressure filter

The group tried to test this again. Before this test started the coupling nipples and the pressure filter housing was tightened. To make sure that the filter was tested properly, the test started from 50 bars.

Hand pump gauge	Test time	Pressure at start of test [bar]	Pressure at end of test [bar]	Pressure drop [%]	Fluid leakage [Y/N]	Approved by FMC [Signature]
50 bar	10 min	51	48	5.88	N	
75 bar	10 min	76	74	2.63	Small Sweat	X

Table 13: Pressure filter test nr 2

The test personnel saw a small sweating on between the base plate and the filter in the 75 bars test. The filter was tightened to the base plate, and the test was taken again.

Hand pump gauge	Test time	Pressure at start of test [bar]	Pressure at end of test [bar]	Pressure drop [%]	Fluid leakage [Y/N]	Approved by FMC [Signature]
75 bar	10 min	75	73	2.67	N	
90 bar	10 min	93	91.5	1.61	N	
100 bar	15 min	101	exceeded	?	N	X

Table 14: Pressure filter test nr 3

For the 100 bars test, the scale was exceeded, the pressure increased. Test responsible concluded that this was because of sunshine from the windows in the test area, which resulted in a temperature increase in the system. Since the maximum pressure at the pressure gauges is 100bar, it was determined by the test personnel to do the pressure test with 95 bars instead.

Hand pump gauge	Test time	Pressure at start of test [bar]	Pressure at end of test [bar]	Pressure drop [%]	Fluid leakage [Y/N]	Approved by FMC [Signature]
95 bar	15 min	94.5	92.5	2.11	N	

Table 15: Pressure filter test nr 4

The test is only approved according to the requirements of being less than 2 % pressure drop [3] for the 90 bars test. This has to be discussed between the group and client, if it is approved for the other tests as well.

5.0 Improvements.

This was the group's first test, so there are some things the group should improve until next test.

Subject	Improvement
Toolbox talk	• Go through the procedure even more carefully, the test shall not bring any surprises about couplings etc. • There shall not be any questions to the procedure when the test starts.
System	• Consider using a ball valve before pressure gauge to decrease couplings. • Using a needle valve at the end of the system to bleed out air if there are any. • Consider changing the O-ring sealing's between mounting base and components. • Change O-rings on cylinder and test again.
Responsibilities	• There shall be a clearer definition of the responsibility for each test personnel
Documentation	• Make sure that cameras have full battery capacity, and that everything is documented under the test. • There shall be taken good notes under the test
Time	• Client has to consider letting group do testing on their own. There is a lot of time wasted waiting for someone to test with the group. • Setting some ground rules for what the group can do on their own.

Table 16: Improvements

6.0 Conclusion

The components that the group is considering to borrow from HBV are older than 25 years. This is highly visible for this test. Almost none of the tests were approved according to the requirements, so this has to be discussed further between the group and their client. Are there enough time to try to repair the components and test them again, is it better to invest in new components for the demonstrator or should the tests be approved as is. The cylinder needs repairing either way, and has to be tested again.

7.0 References

[1] Smart DDSV Demonstrator, *G-TP1* - *"Test Procedure for T-002,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *SJA* - *"Safety Job Analysis,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *S-RS* - *"Requirement Specification,"* HBV, Kongsberg, 2014.

Test Result Report for T-002(2)

G-TR1

Version	Date	Main Author	Co-Author	Approved by
1	24.04.2014	Nicolai Skjelsbæk		Håkon Mørk Solaas

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	20.05.2014	Corrections and update according to last template	Nicolai Skjelsbæk	Snorre Kløcker

This is the report for the second pressure test of the HBV components. Test T-002

Table of Contents

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
DDSV	Direct Drive Servo proportional Valve
FMC	FMC Technologies
HBV	Buskerud/Vestfold university college
L	Liters
SJA	Safety Job Analysis
WP	Working Pressure

Table 1: Abbreviations

2.0 Introduction

This document is the report for test T-002 [1]. It will present how the hydraulic components from HBV were pressure tested. The components that needed to be tested were two pressure gauges, one pressure filter and one double acting cylinder. This report is for the second pressure test who took place at 18.04.2014.

2.1 Personnel allowed at test site

Before the test was started, all of the personnel signed that they had read and understood the procedure and their responsibilities.

Name	Responsibility	From	Signature
Rune Røraas	Test responsible	Self-employed	
Marit Hammer	Operator	Smart DDSV Demonstrator	
Nicolai Skjelsbæk	Operator	Smart DDSV Demonstrator	[illegible]
Eirik Kristoffersen	Operator	Smart DDSV Demonstrator	Eirik Kristoffersen
Snorre Kløcker	Operator	Smart DDSV Demonstrator	
Håkon Mørk Solaas	Operator	Smart DDSV Demonstrator	
Vetle Stokke Vintervold	Observer	FMC	
Antonio Luis Lopes Ramos	Observer	HBV	

Table 2: Test personnel

3.0 Safety

3.1 Toolbox talk

The test started up with a toolbox talk. This was to make sure that personnel at site could raise questions about the procedure, and to make sure that test personnel agreed that the test procedure was approved.

At the first test, the test responsible at that point raised the issue that a pressure test should be done more than once. The first time we tested the double acting cylinder leaked fluid, so we had to take the test again.

For this test, the SJA [2] from the first pressure test was still valid [3].

Location: Hydraulic lab C151 at HBV		**Test ID:** T-002	**SJA No.** 1	
Date: 06/03-14		**Test responsible:** Rune Røraas		
Activity	**Risk element**	**Damages (personnel, equipment, location)**	**Action to prevent**	**Performed**
Connect hoses to cylinder	Oil spill from hoses	Oil spill at persons who could lead to injuries The floor becomes slippery and causes a person fall.	Wear gloves and safety glasses, and be aware of oil spill from the hoses Have a protection mat on the floor and bench	RR
Connect hoses to the hand pump	Pressure from the pump is leaking before hoses are connected properly to the pump	Oil splatter at high pressure and cause personnel injuries	Be sure that the pump is not set, and wear gloves and protective glasses during test	RR
Set the pump	The hoses are not connected properly and loosens due to the pressure	Oil spill at personnel and area.	Be sure that all hoses are connected properly	RR
Cylindertest	Moving part	Injuries	Test operator shall have control over cylinder during test	RR

Table 3: SJA

3.2 Required personal aid

- Safety goggles were worn during test
- Safety gloves were worn during test
- Test procedure were read and understood before test is performed.
- Emergency kit was approved by test responsible.

3.3 Warning signs

The test area were clearly marked, there were visible warning signs at each door. Room was closed for unauthorized personnel.

3.4 Equipment used under test

Test equipment was according to this table:

Equipment	Quantity
Coupling sockets female thread	5
Coupling sockets screw	2
Double acting cylinder	1
Emergency kit	1
Funnel	1
Hand pump (Enerpac P 141)	1
Hydraulic hose lines	4
Hydraulic oil (ISO VG 32)	1 L
Oil suction gun	1
One way valve	1
Pressure filter	1
Pressure gauges	2
Safety gloves	One pair for each person present
Safety goggles	One for each person present
Spill containment unit	1
T-distributors	1
Warning signs	2

Table 4: Equipment

4.0 Testing

The test was carried out in this order:

- Pre flushing
- Pressure test of pressure gauges
- Pressure test of cylinder
- Pressure test of pressure filter
- Test of double acting cylinder’s brake handle
- Test of coupling with new T-distrubutor

4.1 Pre-flushing

4.1.1 Pressure gauges

The process started up with flushing the pressure gauges, and it was done in this order:

Number	Action
1	Coupled hand pump to pressure gauges
2	Pressure gauges were coupled in series, and there was coupled a hose from one of them to the spill containment unit.
3	Made sure that the bleeding valve on the hand pumps was open.
4	Filled hand pump with new fluid
5	Pumped fluid through the pressure gauges until there was no air left in the components.

Table 5: Pre-flushing procedure of pressure gauges

4.1.2 Cylinder

Pre-flushing of the cylinder was done in this order:

Number	Action
1	Emptied cylinder for old fluid through a drain screw on one of the cylinders sides.
2	Coupled hand pump to piston rod side of the cylinder, and piston side was coupled to the spill containment unit
3	Made sure that the bleeding valve on the hand pump was open.
4	Refilled hand pump with new fluid
5	Pumped fluid through the cylinder until there was no air left in the component. It was important that the drain screw was open, and that the cylinder was oriented in such a way that so that the drain screw was at the highest point of the cylinder.

Table 6: Pre-flushing procedure for cylinder

4.1.3 Pressure filter

Pre-flushing of the pressure filter was done in this order:

Number	Action
1	Coupled hand pump to pressure filter
2	Made sure that the hand pumps bleeding valve stood open.
3	Refilled hand pump with new fluid
4	Pumped fluid through the filter until there was no air left in the component.

Table 7: Pre-flushing procedure for pressure filter

4.2 Test Procedure

4.2.1 Deviation test

At this pressure test the group did not have the pressure calibrator present, so the deviation test from the group's first T-002 test is valid.

4.2.2 Pressure test

All components shall be pressure tested. This is a test where the components will be tested for several pressures over a short amount of time. The demonstrator has a WP of 60 bar, and this test will go up to 1.58 x WP [4]. It is important that the test starts at a lower pressure than this in case of leakage. The test shall include all the pressures from this table:

Test pressure	**Test time**
50	10 min
75	10 min
90	10 min
95	15 min

Table 8: Test pressures

The pressure drop shall maximum be 2 % of maximum test pressure [4]. The test time shall not start before the pressure has been stable for 5 min. Under this test it shall be monitored if there is any fluid leakage. The test will not be approved if there is any leakage of fluid.

This procedure will use a hand pump for each test. This is not a requirement for the tests but will simplify them. Another pump may be used as well. The pump that will be used in the tests should have an internal pressure gauge to see what pressure it delivers. If the pump does not include an internal pressure gauge, there shall be connected an extra gauge to the test systems.

4.3 Pressure gauges test

A deviation test for the pressure test was not performed in this test, results listed in **Feil! Fant ikke referansekilden.** were found in the first T-002 test, and will be valid for future reference.

Hand pump gauge	External gauge 1 [bar]	External gauge 2 [bar]	Deviation [%] 1	2	~~Approved~~ [Signature]
50 bar	49,5	50	1	0	[illegible]
75 bar	74	73	1,4	2,7	[illegible]
90 bar	89	88	1,1	2,3	[illegible]
100 bar	99,5	97	0,5	3,1	[illegible]

Table 9: Deviation test

The procedure said that the test were approved if the deviation were less then ± 2.5 % of the hand-pump pressure gauge value [4]. This is not approved for all the values. However, if the requirement is changed to ± 2.5 % of 1.65 x WP, where WP is 60 bar so the deviation shall not be greater than 2.5 bar, the new table will look like this:

Hand pump gauge	External gauge 1 [bar]	External Gauge 2 [bar]	Deviation 1 [bar]	Deviation 2 [bar]
50 bar	49,5	50	0,5	0
75 bar	74	73	1	2
90 bar	89	88	1	2
100 bar	99,5	97	0.5	3

Table 10: Deviation test according to new requirement

If the requirement is changed to the new one, there will only be pressure gauge 2 for 100 bar who is not approved. This has to be discussed further between the group and the client. The DDSV includes an internal pressure sensor, so the external pressure gauges are just to see that we have pressure working on the system. It is not essential that the gauges are showing exactly the correct value.

Another issue that is worth mentioning is that pressure gauge 1 is slow to respond to changes at low pressures. It was tested with 20 bars and the gauge was not responding well.

4.3.1 Pressure drop test

The test was coupled as in Figure 4, and tested as described in 4.2.2. The results the group got was according to this table:

Hand pump gauge	**Test time**	**Pressure at start of test [bar]**		**Pressure at end of test [bar]**		**Deviation [bar]**		**Fluid leakage [Y/N]**	**Test resp [Signature]**
		1	**2**	**1**	**2**	**1**	**2**		
50 bar	10 min	50	50	48	48	2	2	N	
75 bar	10 min	74	74	73	73	1	1	N	
90 bar	10 min	92.5	90	88	89	4.5	1	N	
95 bar	15 min	95	96	91	95	4	1	N	

Table 11: Pressure drop test

4.4 Double acting cylinder test

The test used one of the external pressure gauges that already where deviation tested as the external pressure gauge. The reason for using this extra gauge was that the scale on the internal gauge in the hand pump was greater than in the external. This made it hard to get the values to be where the test should have them. External pressure gauge 1 was used because this had less deviation than gauge 2.

4.4.1 Piston rod side

This part of the test was coupled as in Figure 1.

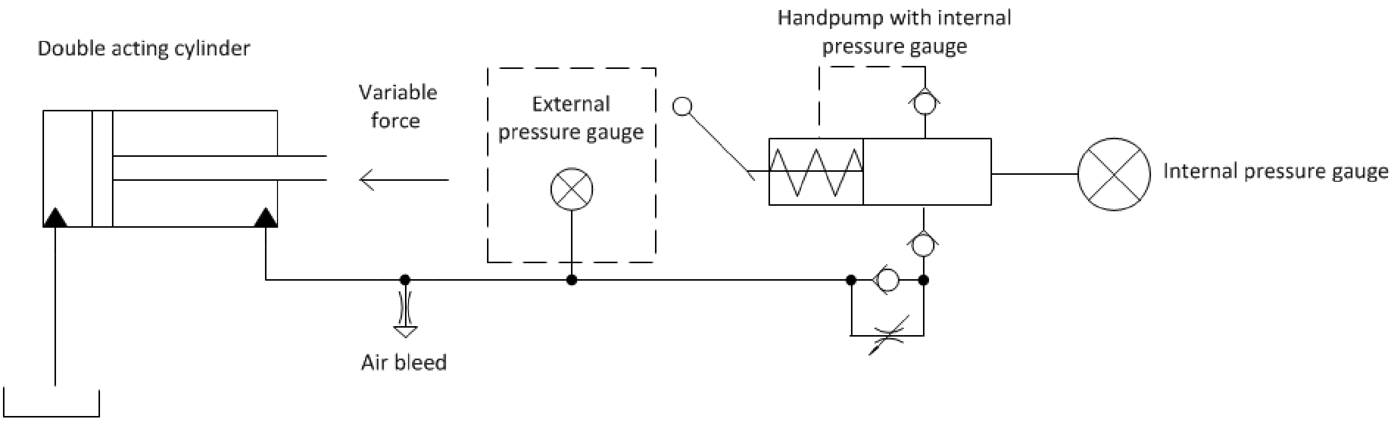


Figure 1: Schematic of first part of cylinder test

The group has changed the gaskets in the double acting cylinder since last pressure test. So the test started with a function test. This worked, so the group tested the cylinder according to section 4.2.2.

Hand pump gauge	Test time	Pressure at start of test [bar]	Pressure at end of test [bar]	Deviation [bar]	Fluid leakage [Y/N]	Test resp [Signature]
50 bar	10 min	49	47	2	N	Eirik Kristoffersen
75 bar	10 min	74	73	1	N	Eirik Kristoffersen
90 bar	10 min	90	89	1	N	Eirik Kristoffersen
95 bar	15 min	96	96	0	N	Eirik Kristoffersen

Table 12: Pressure test of cylinder

The group also decided to test the brake handle on the cylinder. This was tested by setting the brake on full, and increasing the pressure until the brake could no longer stop the movement of the piston. The maximum pressure the brake handle could take was approximately 53 bars.

4.4.2 Piston side

The test was coupled as in Figure 2*:*

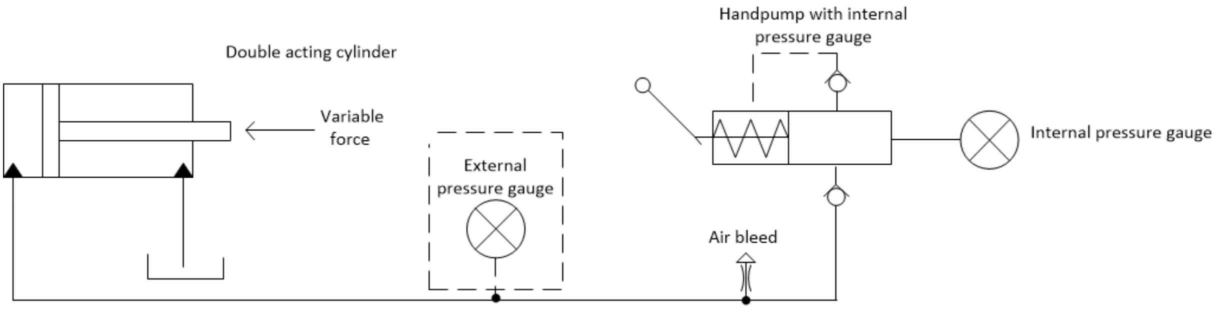


Figure 2: Schematic of second part of cylinder test

The test was performed according to section 4.2.2.

Hand pump gauge	Test time	Pressure at start of test [bar]	Pressure at end of test [bar]	Deviation [bar]	Fluid leakage [Y/N]	Test resp [Signature]
50 bar	10 min	49	47	2	N	Eirik Kristoffersen
75 bar	10 min	74	73	1	N	Eirik Kristoffersen
90 bar	10 min	89	89	0	N	Eirik Kristoffersen
95 bar	15 min	96	96	0	N	Eirik Kristoffersen

Table 13: Pressure test 2 of cylinder

The group decided not to take the third part of the test because it is not relevant for our demonstrator.

4.5 Pressure filter test

The test was coupled as in Figure 3*:*

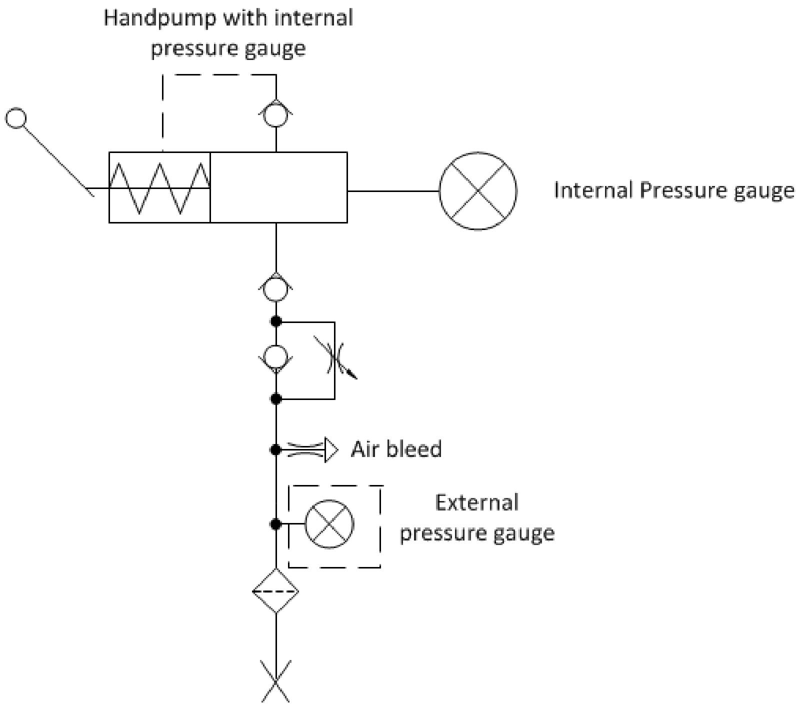


Figure 3: Schematic of pressure filter test

The pressure filter test also used pressure gauge 1 as the external gauge because of the same reasons as the double acting cylinder test. The pressure test was done according to section 4.2.2.

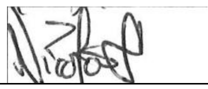
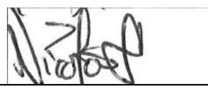
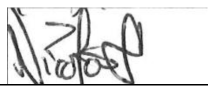
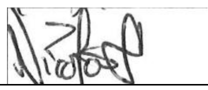
Hand pump gauge	Test time	Pressure at start of test [bar]	Pressure at end of test [bar]	Deviation [bar]	Fluid leakage [Y/N]	Test resp [Signature]
50 bar	10 min	50	47	3	N	
75 bar	10 min	75	74	1	N	
90 bar	10 min	90	89	1	N	
95 bar	15 min	96	96	0	N	

Table 14: Pressure test of pressure filter

The group decided to take another test for 50 bar:

Hand pump gauge	Test time	Pressure at start of test [bar]	Pressure at end of test [bar]	Deviation [bar]	Fluid leakage [Y/N]	Test resp [Signature]
50 bar	10 min	55	54	1	N	

Table 15: Extra test of pressure filter

4.6 T-distributor

The group has bought in new T-distributors from Festo Didactic.

Figure 4: T-distributor

The sockets you can see in Figure 4 are a new type of sockets, and do not fit the demonstrators system, so the group needed to use old sockets. The group bought in o-rings to have between the old sockets and the t-distributor. The supplier of the o-ring could not answer of this was enough to prevent leakage, so this had to be tested.

Hand pump gauge	Test time	Pressure at start of test [bar]	Pressure at end of test [bar]	Deviation [bar]	Fluid leakage [Y/N]	Test resp [Signature]
50 bar	5 min	50	47	3	N	Eirik Kristoffersen
75 bar	5 min	75	74	1	N	Eirik Kristoffersen

Table 16: Pressure test of T-distributor

5.0 Conclusion

Since the groups pressure gauges has a range of 0-100 bar, the new maximum test pressure was changed to 1.58 x WP = 95 bar. This has the following consequences for the requirements. The maximum pressure drop can now be 2 % of 95 bar, this is 1.9 bars. So there are still some results that are not approved according to the requirements.

5.1 Pressure gauges

Pressure gauge 1 is not approved for the 50, 90 and 95 bar tests, and pressure gauge 2 is not approved for the 50 bar test. The pressure gauges are not that important for the demonstrator, they are only present to verify that the demonstrator is pressurized. The group thinks that this shall be approved as is.

5.2 Double acting cylinder

The double acting cylinder was approved for all the results besides two. For both tests, the double acting cylinder had a pressure drop of 2 bars for the 50 bars test. This is 0.1 bar too much. The group thinks that since this is so small, it shall be approved as is.

6.0 References

[1] Smart DDSV Demonstrator, *G-TP1 - "Test Procedure for T-002,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *SJA - "Safety Job Analysis,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *G-TR1 - "Test result report T-002,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *S-RS - "Requirement Specification,"* HBV, Kongsberg, 2014.

Test report T-003—T-006

G-TR2

Version	Date	Main Author	Co-Author	Approved by
1	24.03.2014	Marit Hammer	Håkon M. Solaas	Snorre Kløcker
2	23.04.2014	Marit Hammer	Håkon M. Solaas	Eirik Kristoffersen
3	21.05.2014	Marit Hammer		Eirik Kristoffersen

Changes:

Version	Date	Changes	Released by	Approved by
1→ 2	23.04.2014	Added report of T-004→T-006	Marit Hammer	Eirik Kristoffersen
2→ 3	21.05.2014	Changes due to change in template	Marit Hammer	Eirik Kristoffersen

This document includes the report for software tests T-003, T-004, T-005 and T-006.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Controller Area Network
CAN_H	CAN High signals
CAN_L	CAN Low signals
DDSV	Direct Drive Servo Valve
DLC	Data Length Code
DSP	Digital Signal Process
ESD	Electrostatic Discharge
FMC	FMC Technologies
HW	HardWare
INT	Integer
PDO	Process Data Object
PT	Pressure transmitter
SDO	Service Data Object
SIL	Safety Integrity Level
SW	SoftWare
TT	Temperature transmitter
UINT	Unsigned Integer
USB	Universal Serial Bus
V	Volt
VCI	Virtual CAN Interface
VI	Virtual Instrument

Table 1: Abbreviations

2.0 Introduction

The test T-003 was performed at FMC's software lab, and it is performed to verify that LabVIEW VI communicates with IXXAT USB-CAN. The test has to be approved before further software testing.

2.1 Following persons were present

Name	Responsibility	From	Signature
Håkon M.Solaas	Test responsible	Smart DDSV Demonstrator	
Marit Hammer	Operator	Smart DDSV Demonstrator	

Table 2: Persons present

2.2 Operating system used on the test computer

System	
Operating system	Windows 7
Computer specifications	Lenovo T420, ThinkPad Intel i7, 64 bit

Table 3: Operating system

3.0 Safety

All the safety precautions were taken and this was done to make sure that not any electrical equipment will be destroyed by high voltage electronic discharge. [1]

When entering the software lab, shoes with strips were used. An ESD check was performed, before entering the ESD zone. The equipment manuals were read. The wiring between the different equipment were checked twice, and verified twice that the correct voltage were set.

4.0 Initial test of CAN communication with LabVIEW

4.1 Procedure

This is a step-by-step procedure of how the test was performed. The test was divided in two parts. The first part is for step 1-6 and the second part is for step 7-8.

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Turn on computer	Shall be on	OK	H.M.S M.H	14.03.14
2.	Open LabVIEW	LabVIEW shall open	OK	H.M.S M.H	14.03.14
3.	Connect CAN-USB interface to computer	Indication light on CAN-USB interface lights up	OK	H.M.S M.H	14.03.14
4.	Run VCI3_Demo.vi	Indication light in the front panel shall light up	OK	H.M.S M.H	14.03.14
5.	Connect the CAN test device to the CAN-USB interface	CAN test device shall be on	OK	H.M.S M.H	14.03.14
6.	Start transmission of messages from CAN test device to CAN-USB interface	Indication light for CANbus traffic on the USB-CAN interface shall light up.	OK	H.M.S M.H	14.03.14
7.	Monitor the LabVIEW VI and see that it receives messages	- Messages shall be displayed in the LabVIEW VI - Arbitration ID and DLC shall be the same as is specified in the CAN device	See Table 7	H.M.S H.M	19.03.14
8.	Send CAN message from LabVIEW	- No error code is returned in the LabVIEW VI	OK	H.M.S M.H	19.03.14

Table 4: Test result

4.2 First part

This test is to verify that the communication between USB-CAN and LabVIEW is working. For the first 6 steps of the procedure the following equipment was used;

Equipment	Quantity
Computer with LabVIEW and IXXAT VCI v3 driver installed	1
LabVIEW VI provided by IXXAT: VCI_Demo.vi	1
IXXAT CAN-USB interface	1

Electrical wire with connectors, Simulator →CAN	1
Electrical wire with connectors, CAN→Power supply	1
Clamp on DSP Subsea Simulator, CAN test device [CAN 443 ASVD]	1
EX355 Power supply 24V	1
DE-9 serial connectors with several standards	1
DE-9 male to female adapter	1

Table 5: Equipment list part one

The test was mounted like the set up in Figure 1. There are two resistors connected between CAN_L and CAN_H, this is to prevent signal reflection. There are one built-in the IXXAT USB-CAN interface and the other one is connected to DE-9 connector to the simulator. The picture in Figure 2 show how the test setup was with the simulator.

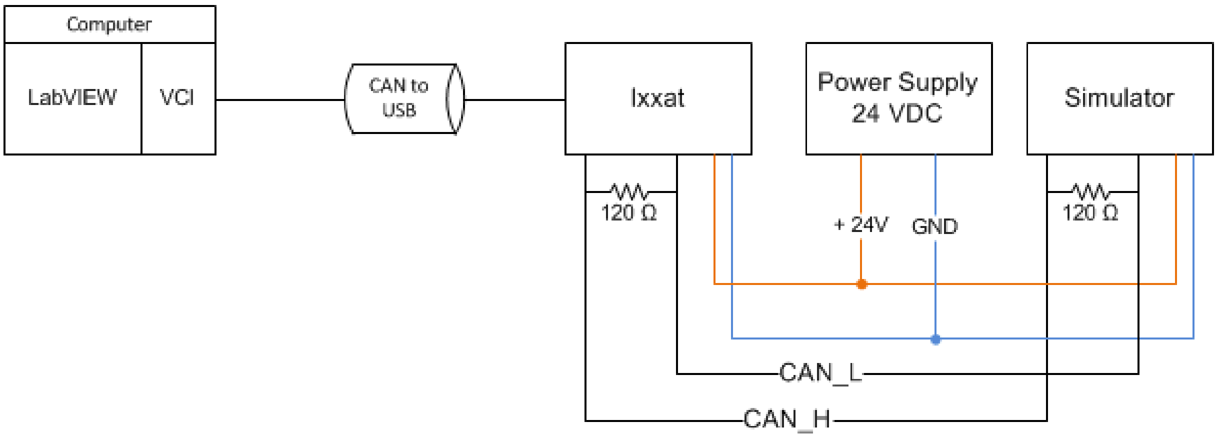

Figure 1: Test setup

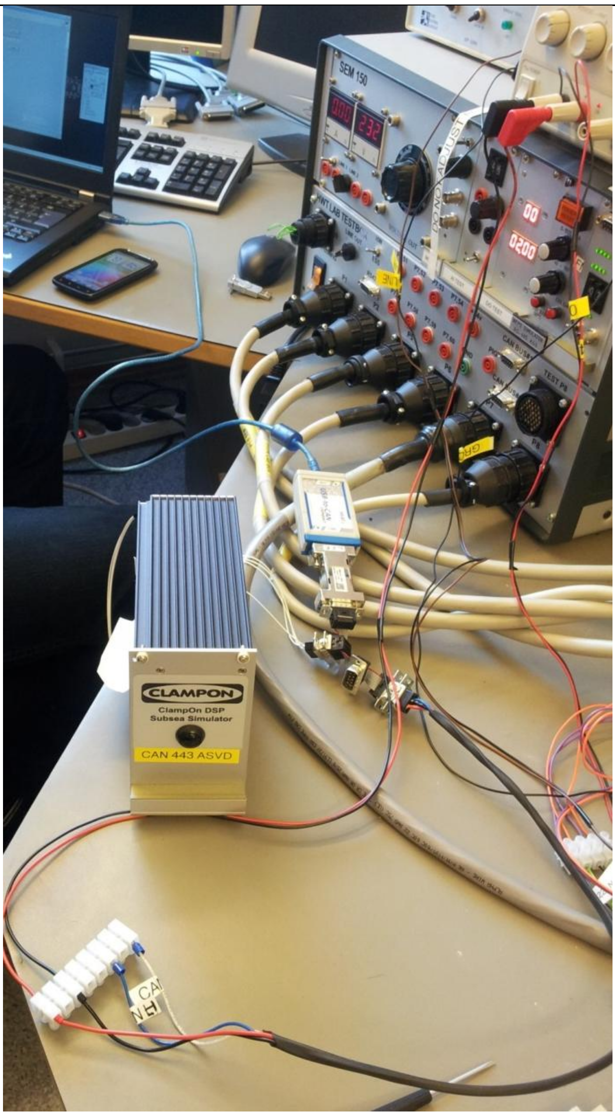

Figure 2: First part of the test

The computer was turned on, and then the LabVIEW was opened. When the USB-CAN interface was connected to the computer through USB, a green light at the interface lit. This light indicates that there is connection between the computer and the USB-CAN interface. If the light is red, there is not any connection. Simultaneously, a green light in LabVIEW program lit as well, so there is connection between computer with LabVIEW and USB-CAN interface. The simulator needs power to run, and for this set up there is a one-to-one communication, and there is not an internal power. To get power to the simulator, an external power supply had to be connected. This was connected with an electrical wire. The demo that the bachelor group got from IXXAT was opened and ran. When the demo program (VCI3_Demo.vi) was running, there was an indicator in LabVIEW that showed that the message was sent. There was not any indicator in the simulator that showed if the simulator was receiving the message. On the simulator there was a button, and when this button was pushed, it would transmit a boot-up message. When this button was pushed, the indicator in the LabVIEW program showed that it was receiving messages.

To verify the last steps in the procedure, two computers with LabVIEW installed have to be used. This will be performed when LabVIEW is installed at another computer.

4.3 Second part

For the second part of the test, (step 7 and 8) the monitor program miniMon was used. This program is developed by IXXAT. The second part was performed with another CAN-open simulator, but the test setup was mounted like the first part. This new simulator was a PT/TT device which had pressure/temperature parameters that was possible to adjust. This made it possible to verify both the transmitted and received communication.

The equipment that was used in the second part of the test was almost the same as for the first part. The difference is an extra resistor (because of the length of the wires), another type of power supply and another test device. See Table 6.

Equipment	**Quantity**
Computer with LabVIEW and IXXAT VCI v3 driver installed	1
LabVIEW VI provided by IXXAT: VCI_Demo.vi	1
IXXAT CAN-USB interface	1
Electrical wire with connectors, Simulator →CAN	1
Electrical wire with connectors, USB-CAN→Power supply	1
Expro Weps Simualtor CAN open HS SIL2 [Simulator 8529]	1
EX354D Power supply	1
DE-9 serial connectors with several standards	1
Resistor 120Ω	1

Table 6: Equipment list part two

The computer was turned on, and LabVIEW and miniMon were opened. USB-CAN interface was connected to the computer and a green light was lit in LabVIEW. Simultaneously the green light lit in the USB-CAN interface as well. The connection was working well. All the other equipment was connected to each other through DE-9 connectors. Then the demo was running, and it could transmit and receive messages. Now the miniMon was tested.

To transmit and receive messages, both USB-CAN interface and the simulator must have the same baud rate. The baud rate was set to 50b/s. The type of transmitted messages and results of the test is listed in Table 7. All the transmitted messages are 8 bytes. [2]

Transmitted message		**Observed change in CAN traffic**	**As expected**
Identifier	**Data [Hex]**		
0x000	01 05	Started transmission of PDO messages	Yes
0x000	02 05	Stopped transmission of PDO messages	Yes

Table 7: Transmitted messages

5.0 Conclusion

For further simulator testing, the simulator shall be the type who can both receive and transmit messages. Following tests will use a LabVIEW VI developed by the students that can filter out PDO messages, which will be close to the final GUI. After having an introduction to the software test facilities at FMC, the bachelor group members can do the testing on their own. The test went well and proved that the requirement CMRQ-103 is met. [3] So this test is approved.

6.0 Requirement tests T-004→T-006

There has been some research on how to set up messages that shall be sent through CAN and to the simulator. To configure a new simulator that will simulate the behavior of the valve will lead to a lot of extra testing and work. There is also no guarantee that the new simulator we configure will generate the same CAN traffic as the valve. So after some internal discussion there was an agreement that software testing with a new simulator was not necessary. The bachelor group will instead use their time in getting the right CANbus set up for the valve.

Therefore test T-004, T-005 and T-006 will not be performed.

7.0 References

[1] Smart DDSV Demonstrator, *G-TP2 - Test Procedure for T-003--T006*, HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *S-IS - Interface and GUI Specification*, HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *S-RS - Requirement Specification*, HBV, Kongsberg, 2014.

Test Report for T-007

G-TR3

Version	Date	Main Author	Co-Author	Approved by
1	16.05.2014	Marit Hammer		Eirik Kristoffersen
2	21.05.2014	Marit Hammer		Eirik Kristoffersen

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	21.05.2014	Changes due to change in template	Marit Hammer	Eirik Kristoffersen

This document is a report that includes the result of the pre-assembly test T-007.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Controller Area Network
DDSV	Direct Drive Servo proportional Valve
E.K	Eirik Kristoffersen
FMC	FMC Technologies
HBV	Buskerud/Vestfold university college
L	Liters
M.H	Marit Hammer
N.S	Nicolai Skjelsbæk
S.K	Snorre Kløcker
SJA	Safety Job Analysis
USB	Universal Serial Bus
V	Voltage

Table 1: Abbreviations

2.0 Introduction

This test was performed in different days. All of the components were not received at the same time, but this was not affecting the steps that were performed. So therefor there are different dates for when the tests were performed and approved.

3.0 Safety

Different stages in this test were performed by different persons, and everyone took security precautions. No power supply was connected, and the testing area was clean and tidy. The medical cabinet was approved.

The procedure was gone through and understood. A SJA was not required for this test, because the system was depressurized and the power disconnected.

4.0 Prerequisites

In Table 2, all the equipment that was used during the test is listed.

4.1 Equipment used in the test

Equipment	Quantity	Present	Signature
230VAC / 24VDC converter	1	X	
Accumulator	1	X	
Accumulator bracket w/ 1 male coupling nipple	1	X	
Cylinder rod return spring + brackets	1	X	
DDSV + 4 O-rings for the ports	1	X	
DDSV base plate w/ 3 male coupling nipples + 4 screws to fasten the DDSV	1	X	
Demonstrator table	1	X	
Double acting cylinder w/plexiglas cover	1	X	
Emergency kit	1	X	
Hydraulic hose line w/ quick fix connector in one end, and 90° bend G$^1/_4$ male to male connector in the other end[1550mm]	3	X	
Hydraulic hose line w/ quick fix connector in both ends [1720mm]	1	X	
Hydraulic hose line w/ quick fix connector in both ends [660mm]	5	X	
Hydraulic oil (ISO VG 32) Shell Tellus 32	20L can	X	
Hydraulic power pack w/ connections for T and P port (already installed on demonstrator table)	1	X	
IXXAT USB-CAN	1	X	
M5 x 55mm screws with Allan head	4	X	
M8 nuts	4		
Pressure filter w/ 2 male coupling nipples	1	X	
Pressure gauge w/ 2 male coupling nipples	1	X	
Pressure gauge w/ 3 male coupling nipples	1	X	
Specification, S-ES [1], Smart DDSV bachelor group	1	X	
Specification, S-HS [2], Smart DDSV bachelor group	1	X	
Specification, S-VS [3], Smart DDSV bachelor group	1	X	
Design Document, D-DD [4], Smart DDSV bachelor group	1	X	
User Manual, U-HS [5], Smart DDSV bachelor group	1	X	
T-distributor w/ 2 coupling nipples and 1 quick fix connector	1	X	
T-distributor w/ 1 coupling nipple, 1 male to male coupling,	1	X	

and 1 quick fix connector			
User manual, Moog DDSV	1	X	
Multimeter	1	X	

Table 2: Equipment list

5.0 Procedure

5.1 Components

The procedure for each of the components was followed step-by-step.

5.1.1 Accumulator

The accumulator was received April 23rd at HBV. The accumulator was checked for visual damages. It was labeled that it was pre-charged with 2bar from the supplier Hydac.

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Check product number	Shall be SBO 210-2,8E1/112U-210AB	Ok	M.H	24/4-14
2.	Check for visual damages	No visual damages	Ok	M.H	24/4-14

Table 3: Accumulator test

5.1.2 Accumulator adapter

The accumulator adapter was produced at FMC test site at Notodden by Arvid Sørensen by drawings from the bachelor group. The bachelor group got this adapter at May 7th when the bachelor group arrived at Notodden. In Table 4 the result from verification of the accumulator adapter is documented.

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Check for visual damages	No visual damages	OK	EK	07/05
2.	Check that the adapter is according to the drawings [2]	Measurements is according to the drawings	OK	EK	07/05

Table 4: Accumulator adapter

5.1.3 DDSV

The DDSV was received April 16th at HBV, and the content of this package was checked. This package contained DDSV, power supply and IXXAT USB-CAN, so this was according to what has been ordered. See Table 5 to view the result of the verification of this part.

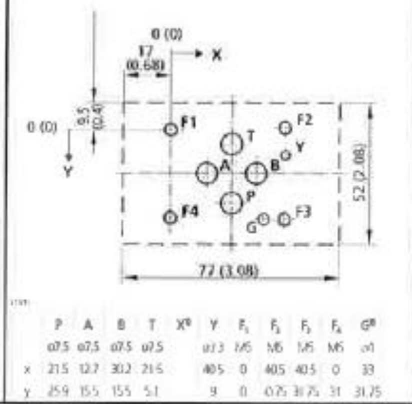
Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Check product number	Shall be D638-335-0001 R04VB1F0HE92NBCP1J1	Ok	M.H	24/4-14
2.	Check for visual damages	No visual damages	Ok	M.H	24/4-14
3.	Check that the valve connector X1 (Main connector) is present and according to [6]	Connector X1 shall be present and according to [6]	Ok	M.H	24/4-14
4.	Check that connector X3 and X4 (CAN) is present and according to [6]	Connector X3 and X4 shall present and according to [6]	Ok	M.H	24/4-14
5.	Check that connector X5, X6 and X7 (analog input) is present and according to [6]	Connector X5, X6 and X7 shall present and according to [6]	Ok	M.H	24/4-14
6.	Unscrew the protection plate for the hydraulic ports. Check that the O-rings are present and ok.	O-rings are present. The O-rings shall not be broken and the rubber shall be soft.	Ok	M.H	24/4-14
7.	Check pattern for hydraulic ports	Pattern for hydraulic ports shall be according to ISO 4401-03-03-0-05 	Ok	M.H	24/4-14

Table 5: DDSV

5.1.4 DDSV base plate

The bachelor group used the base plate that was at HBV, and the mounting holes matched the DDSV mounting holes. The dimension was checked carefully before the decision of using this base plate.

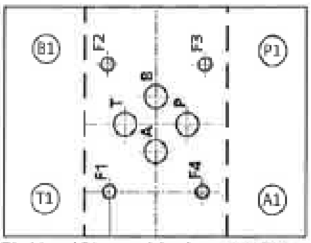
Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Check for visual damages	No visual damages	Ok	M.H	29/4-14
2.	Check pattern for hydraulic ports	Pattern for hydraulic ports shall be according to ISO 4401-03-03-0-05  T1, A1 and P1 are quick release couplings wile B1 will be blocked with a blind plug	Ok	M.H S.E	29/4-14
3.	Check the quick release connectors	Three coupling nipples shall be mounted on to the base plate and connected to A1, P1 and T1. A blind plug shall be mounted in B1. The coupling nipples shall be correctly tightened.	Ok	M.H S.E	29/4.14

Table 6: DDSV adapter

5.2 Demonstrator table

The table was received March 17th, and it was mounted few days later. At April 12th and 13th the rubber mat was mounted on the table, and holes were drilled for hoses.

5.2.1 General

In Table 7 the result of the verification of how some of the components was mounted together.

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Check all penetrations through the rubber mat covering the tabletop	All penetrations shall be sealed with silicone	Ok	M.H	24/4-14
2.	Check the rubber mat covering the table top for damages and cracks	There shall be no damages or cracks in the rubber mat	Ok	M.H	24/4-14
3.	Check all penetrations through the rubber mat covering the plate beneath the tabletop	All penetrations shall be sealed with silicone	Ok	M.H	24/4-14
4.	Check the rubber mat covering the plate below table top for damages and cracks	There shall be no damages or cracks in the rubber mat	Ok	M.H	24/4-14
5.	Check the demonstrator wheels and brakes	The table shall be able to move when brakes are off. When brakes are on, the table shall not be able to move.	Ok	M.H	24/4-14
6.	Check that the mounting holes in the plexiglas plates are matching the mountings in the table	The mounting holes in the plexiglas plates shall match the mountings in the table	Ok	S.L	06/05-14

Table 7: General

5.2.2 Electrical wiring

The electrical wiring was checked by using a Mulitmeter. This was performed at FMC test site at Notodden.

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Check wiring on X11	Wiring shall be marked and wired correctly according to S-ES [1], attachment A. All connectors shall be properly tightened.	Not marked yet	M.H S.G	8/5-14
2.	Check wiring on X12	Wiring shall be marked and wired correctly according to S-ES [1], attachment A. All connectors shall be properly tightened.	Not marked yet	M.H S.G	8/5-14
3.	Check wiring on X13	Wiring shall be marked and wired correctly according to S-ES [1], attachment A. All connectors shall be properly tightened.	Not marked yet	M.H S.G	8/5-14
4.	Check cable connector X1	Cable shall be marked and wired correctly according to X1 pin arrangement S-VS [3]	~~Not marked yet~~ OK	M.H S.G	8/5-14
5.	Check cable connector X3	Cable shall be marked and wired correctly according to X3 pin arrangement S-VS [3]	Not marked yet	M.H S.G	8/5-4
6.	Check cable connector X5	Cable shall be marked and wired correctly according to X5 pin arrangement S-VS [3].	Not marked yet	M.H S.G	8/5-14
7.	Check cable connector X6	Cable shall be marked and wired correctly according to X6 pin arrangement S-VS [3]	Not marked yet	M.H S.G	8/5-14
8.	Check cable connector X7	Cable shall be marked and wired correctly according to X7 pin arrangement S-VS [3]	Not present	M.H S.G	8/5-14

Table 8: Electrical wiring

5.3 Assembly test

D-DD [4] for component placement description. Pictures from parts of the assembly test are taken, see Table 10.

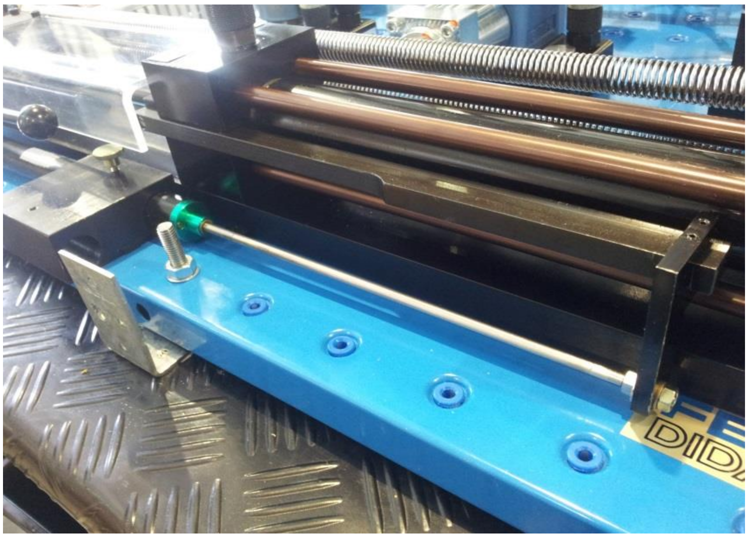
Step	Description	Acceptance criteria	Result	Tested by	Date
Accumulator and adapter plate					
1.	Clean the accumulator outlet and adapter inlet with a 'dust free' wipe and lubricate the connections with ISO VG32 oil	Connections shall be clean and lubricated with oil.	OK	NS	07/05
2.	Screw the accumulator into the M45x1,5 threads on the accumulator adapter with sufficient force	The accumulator shall easy be entered in the adapter	OK	NS	07/05
3.	Mount the accumulator adapter with the accumulator installed on the mounting bolts on the profile plate, tighten the 4 M8 nuts.	Adapter shall easily enter the mounting screws.	OK	EK	07/05
Cylinder and displacement potentiometer					
4.	Mount the cylinder on to the profile plate	Cylinder shall be properly connected	ok	S.K	06/05
5.	Mount the displacement potentiometer on to the profile plate	Displacement potentiometer shall be properly connected	ok	S.K	08/05
6.	Mount the displacement potentiometer rod to the cylinder rod	Displacement potentiometer shall be properly connected to the cylinder rod	ok	S.K	08/05
Pressure gauge and filter					
7.	Mount the two pressure gauges to the profile plate	Pressure gauges shall be properly connected	OK	EK	06/05
8.	Mount the filter to the profile plate	Filter shall be properly connected	OK	EK	06/05
DDSV and adapter plate					
9.	Clean the DDSV ports and adapter ports with a 'dust free' wipe and lubricate the connections with ISO VG32 oil.	Connections shall be clean and lubricated with oil.	OK	MH S.K	29/4-14

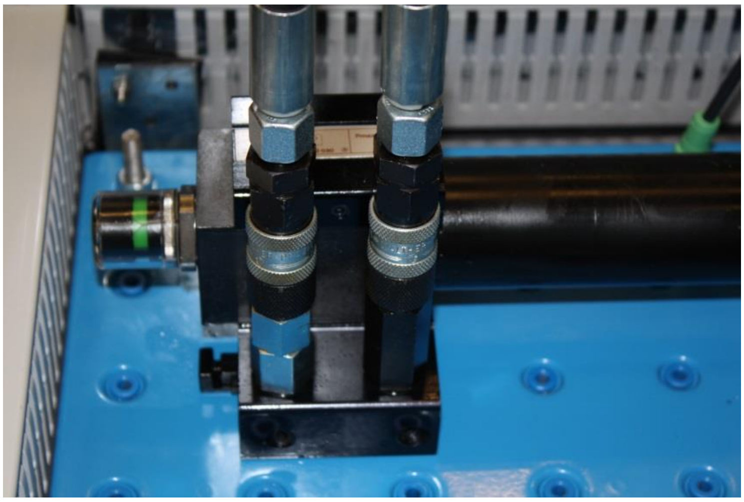
10.	Make sure that the port- O-rings are placed correctly, and then mount the DDSV on the base plate. Use 4pcs M5 x 55mm screws with Allan head and tighten the screws with an tightening torque of 6.8Nm [6]	The valve shall be correctly tightened to the base plate. DDSV and the base plate shall have a matching port arrangement.	Ok	M.H S.K	29/4-14
11.	Mount the DDSV base plate with the DDSV installed to the profile plate	DDSV shall be properly connected	Ok	M.H S.K	29/4-14
		Hose lines			
12.	Clean all quick connections with a 'dust free' wipe	Connections shall be clean	OK	EK	30/04
13.	Connect all hose- lines according to U-HS [5]	Make sure that the connections are connected correctly	OK	EK	30/04
14.	Check bend radius of hydraulic hose lines	Distance between the 'hose-termination' and 'were the bend starts' shall be 1.5 times the hose's outside diameter.	OK	EK	30/04
		Others			
15.	Connect the IXXAT USB-CAN interface to C1. Connect the USB to a laptop and place the laptop on the tabletop.	There shall be enough space for a laptop/screen on the tabletop.	Ok	M.H	6/5-14
16.	Mount the plexiglas plates to the demonstrator table	The plexiglas plates shall be properly mounted and not interfere with any other component.	Ok	M.H	6/5-14

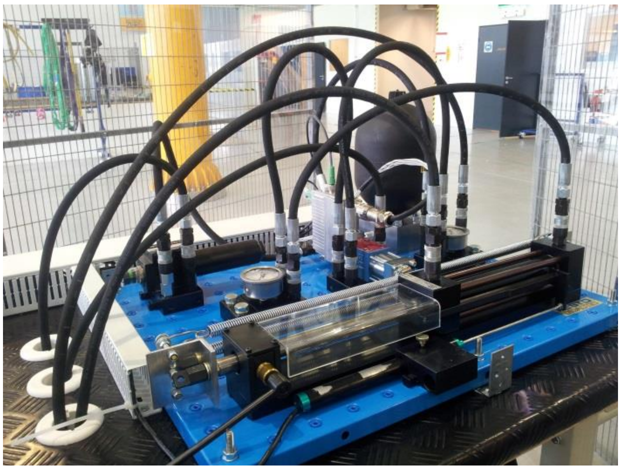
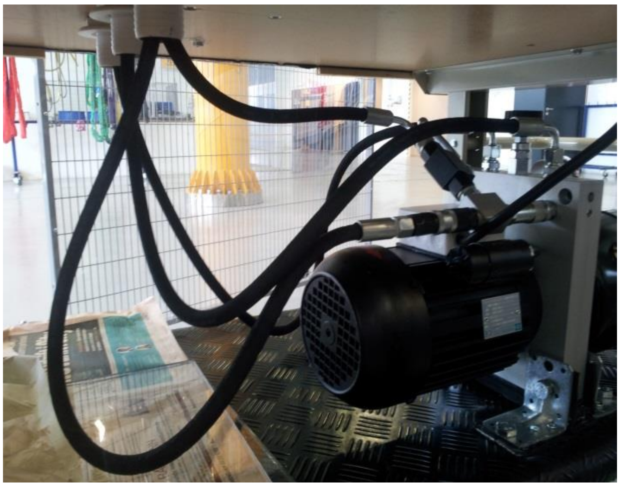
Table 9: Assembly test

6.0 Pictures

In Table 10 there are some pictures that were taken during assembly of the components.

Test No:	Picture
5.4.3 The accumulator with accumulator adapter mounted on the profile plate	
5.4.6 The displacement potentiometer rod mounted to the cylinder rod	 *Figure 2:Displacement potentiometer*

5.4.7 Both pressure gauges mounted to the profile plate	 *Figure 3: PG-01*  *Figure 4: PG-02*
5.4.8 The filter mounted to the profile plate	 *Figure 5: Pressure filter*

5.4.11 The DDSV with the DDSV base plate mounted to the profile plate	 *Figure 6: DDSV on Base plate*
5.4.13 All the hose-lines are connected according to U-HS [5].	 *Figure 7: Hose lines on the table top*  *Figure 8: Hose line under the table*

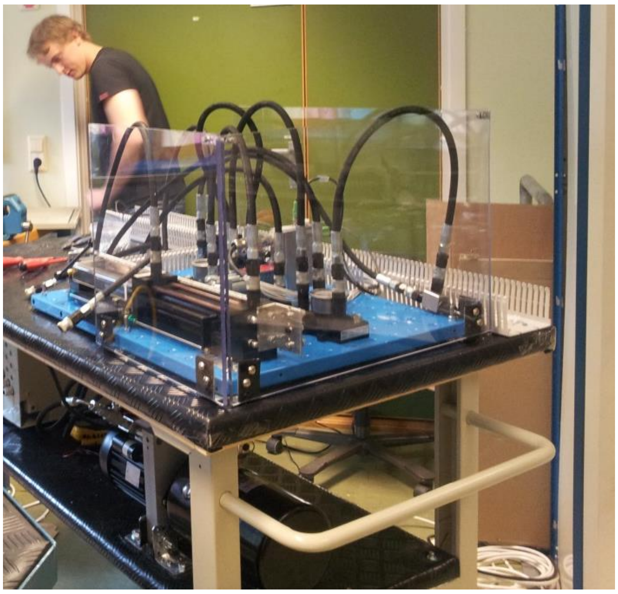
5.4.16 The Plexiglas plates are mounted at the demonstrator table	 *Figure 9: Plexiglas*

Table 10: Pictures from assembly test

7.0 References

[1] Smart DDSV Demonstrator, *S-ES* - *"Electrical Specification,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *S-HS* - *"Hydraulic System specification,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *S-VS* - *"Valve specification,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *D-DD* - *"Design Document,"* HBV, Kongsberg, 2014.

[5] Smart DDSV Demonstrator, *U-HS* - *"User manual, Hydraulic System,"* HBV, Kongsberg, 2014.

Test Report for T-008

G-TR4

Version	Date	Main Author	Co-Author	Approved by
1	13.05.2014	Nicolai Skjelsbæk		Snorre Kløcker
2	22.05.2014	Nicolai Skjelsbæk		Snorre Kløcker

Changes:

Version	Date	Changes	Released by	Approved by
1→2	22.05.2014	Updated accordingly to the last template and document review	Nicolai Skjelsbæk	Snorre Kløcker

This document is a report that includes the result of the pressure test T-008.

Table of Contents

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Index of Tables

1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
BA	Bladder Accumulator
BV	Ball Valve
DAC	Double Acting Cylinder
DDSV	Direct Drive Servo proportional Valve
EK	Eirik Kristoffersen
FMC	FMC Technologies
HBV	Buskerud/Vestfold university college
HMS	Håkon Mørk Solaas
HPP	Hydraulic Power Pack
L	Liters
MH	Marit Hammer
NS	Nicolai Skjelsbæk
PF	Pressure Filter
PG	Pressure Gauge
PPE	Personal Protective Equipment
SJA	Safety Job Analysis
SK	Snorre Kløcker
TD	T-Distributor
WP	Working pressure

Table 1: Abbreviations

2.0 Introduction

T-008 was a pressure test of the DDSV demonstrator with the HPP and DDSV isolated. The reason for isolating these components is because the HPP could not deliver more than 60 bars, and the test had a maximum test pressure of 95 bars. Therefore an enerpac hand pump was used. The DDSV has an internal leakage of 0.3 l per minute, so with this included in the test, it would include a mayor pressure drop to each test.

2.1 Following persons were present

Table 2 includes the signatures of personnel present at the test:

Name	Responsibility	From	Signature
Joakim Lerstang	Test responsible	FMC	Joakim Lerstang
Marit Hammer	Operator	Smart DDSV Demonstrator	Marit Hammer
Nicolai Skjelsbæk	Operator	Smart DDSV Demonstrator	[illegible]
Eirik Kristoffersen	Operator	Smart DDSV Demonstrator	Eirik Kristoffersen
Snorre Kløcker	Operator	Smart DDSV Demonstrator	[illegible]
Håkon Mørk Solaas	Operator	Smart DDSV Demonstrator	[illegible]
Vetle Stokke Vintervold	Observer	FMC	
Svein Kjenner	Observer	FMC	
Paul Vis	Observer	FMC	
Børge Bjørnaas	Observer	FMC	
John Mulholland	Observer	FMC	
Antonio Luis Lopes Ramos	Observer	HBV	
FMC personnel with access to test facilities.	Observer	FMC	

Table 2: Personnel present at test

The personnel has signed that they have read and understood the procedure.

3.0 Safety

All the safety precautions[1] were taken and this was done to make sure that there were no injuries or damage to equipment.

3.1 Toolbox talk

The personnel from Table 2 had a tool box talk before the test was started. Under the toolbox talk, the procedure where gone through in detail, and questions to it was raised. The procedure was changed due to that test responsible had some useful tips to improve and simplify the procedure.

3.1.1 SJA

The test personnel also made an SJA[2] for the test, see Table 3:

Location: FMC test facilities Notodden		**Test ID: T-008**	**SJA No. 2**	
Date: 07.05.2014		**Test responsible:** Joakim Lerstang		
Activity	**Risk element**	**Damages (personnel, equipment, location)**	**Action to prevent**	**Performed**
Flushing	Oil spill	Personnel, environment	PPE, lexan wall, spill kit	
Pressure test Requirement test FAT	Oil spill	Personnel, equipment, environment	PPE, lexan wall, spill kit, emergency stop	
	Flying object	Personnel, equipment, environment	PPE, lexan wall that secure the area, warning signs	
Pre-charging of accumulator	Flying object, gas	Personnel, equipment, environment	PPE, lexan wall that secure the area, warning signs	

Table 3: SJA

4.0 Prerequisites

In Table 4, all the equipment that was used during the test is listed.

4.1 Equipment used in the test

Equipment	**Quantity**
Accumulator	1
Coupling nipple	23
Coupling sockets female thread	22
Double acting cylinder	1
Emergency kit	1
Enerpac hand pump	1
FMC Aggregate	1
Funnel	1
Hydraulic hose lines	10
Hydraulic oil (ISO VG 32)	6 L

Oil suction gun	1
Pressure filter	1
Pressure gauges	2
Safety gloves	One pair for each person present
Safety goggles	One for each person present
Spill containment unit	1
T-distributors	2
Warning signs	Permanently mounted at facility
Extension spring coil	3
Base plate	1
Ball valve	2

Table 4: Equipment list

5.0 Test results

5.1 Procedure

This report will include both the results from a body proof test of an adapter plate for the BA, and a pressure test of the system. Both the body proof test and the pressure test will use the test pressures from the following table:

Percentage of 1.58 x WP [%]	Pressure [bar]	Test time [min]
50	48	10
75	71	10
90	85	10
100	95	15

Table 5: Test pressures

The HPP has a WP of 60 bars, so the test pressures are set around this. For the body proof test, the requirement is that the adapter plate shall have no visual damage, and it shall withstand the test pressures. For the pressure test, the requirement is that there shall be no visual damage, and the pressure drop shall be maximum 2 % of 100 % of 1.58 x WP [3].

5.2 Pre-flushing

Before the testing could start, the system needed to be pre-flushed, this is to make sure that there is no air or contaminated fluid in the system. Since air is compressible, it can cause errors in the test results. For the pre-flushing procedure, it was important that all the hydraulic hoses also were flushed, so the system was coupled as in Figure 1:

Preflushing schematic

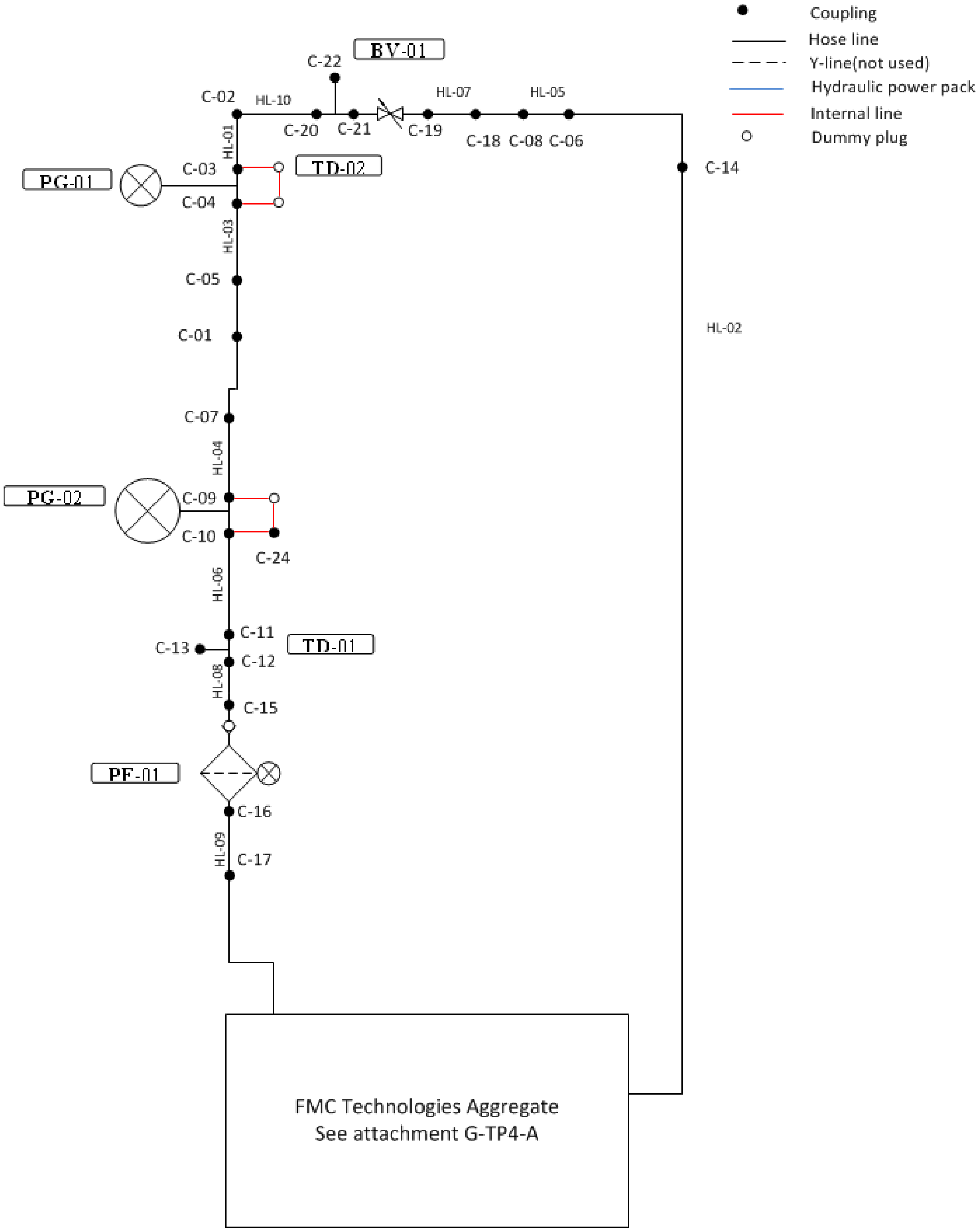


Figure 1: Pre-flushing schematic

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Check that system is coupled as in *figure 2*	Shall be exactly coupled as in *figure 2*	OK	EK	07/05
2.	Check that couplings are tightened	Go over couplings and tighten by hand.	OK	EK	07/05
3.	Make sure that HL-02 is coupled to tank in FMC aggregate.	HL-02 shall be coupled to tank.	OK	EK	07/05
4.	Set up lexan walls.	Lexan walls shall cover demonstrator	OK	EK	07/05
5.	Start the FMC aggregate	FMC aggregate shall be started.	OK	EK	07/05
6.	Close BV on FMC aggregate and adjust pressure relief valve.	BV shall be closed and pressure relief valve shall be adjusted to deliver correct pressure.	OK	EK	07/05
7.	Set pressure to 50 bar	Pressure gauges shall show 50 bar ± 5 bar, and there shall be a high flow	OK	EK	07/05
8.	Open BV on FMC aggregate.	BV shall be open	OK	EK	07/05
9.	Push lever up	Flow shall be delivered to demonstrator.	OK	EK	07/05
10.	Let the system be for 60 minutes, check regularly for visual leakage	The system shall run the preflushing for 60 minutes. There shall be no leakage.	OK	EK	07/05
11.	Stop the aggregate	The aggregate shall stop.	OK	EK	07/05

Table 6: Procedure for pre-flushing of system

The system was flushed with 50 bar system pressure which delivered a flow of 6 liters per minute.

5.2.1 Pre-flushing of DAC

After the system from Figure 1 had been flushed, the DAC needed to be pre-flushed. Test responsible told that to flush the cylinder, it needed to be driven back and forth some times, this would fill and empty the cylinder tank a couple of times. The return flow was driven directly to a spill bucket. The pre-flushing of the cylinder was coupled as in Figure 2:

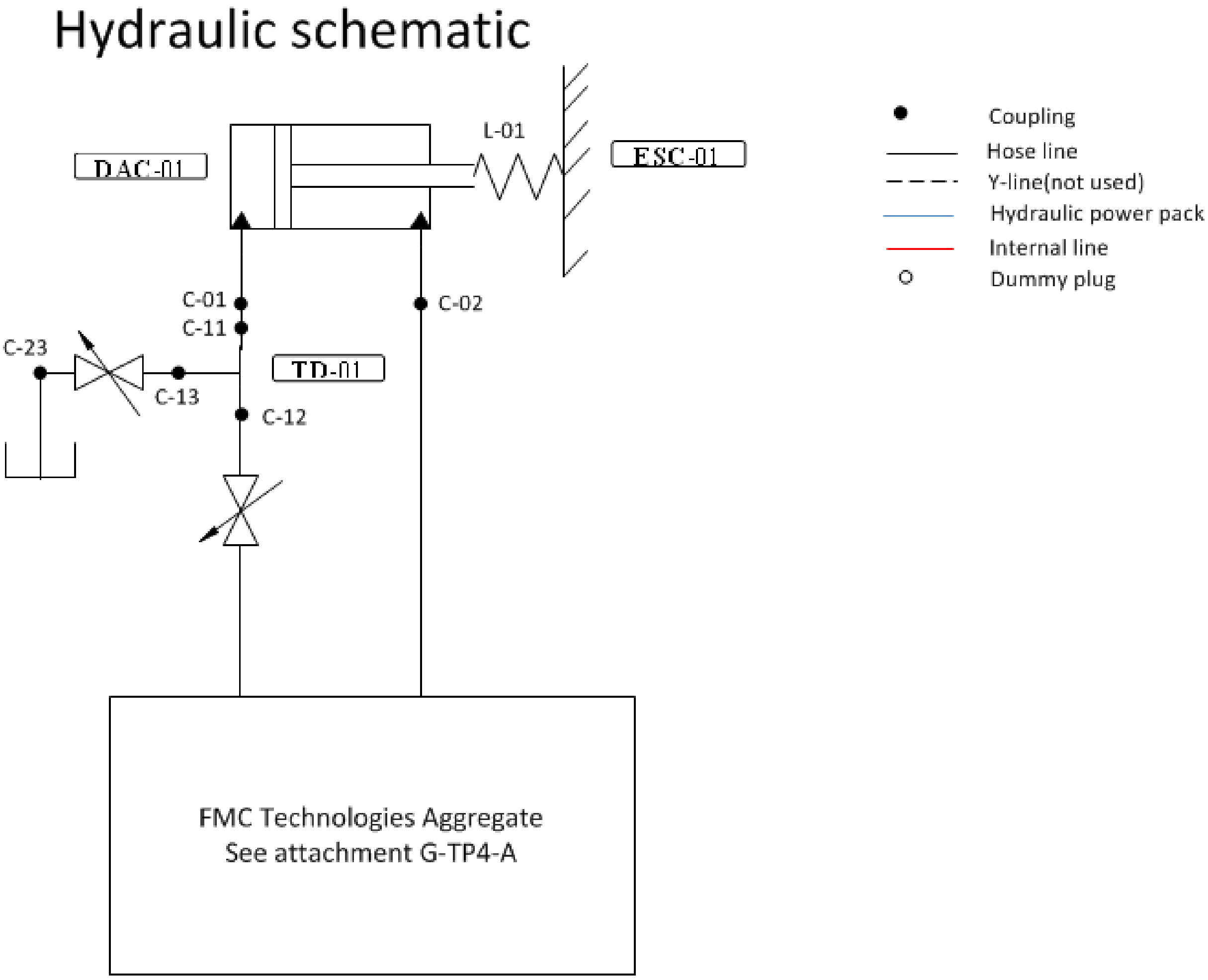


Figure 2: Pre-flushing schematic DAC

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Check that system is coupled as in *figure 3*	Shall be exactly coupled as in *figure 3*	OK	NS	08/05
2.	Check that couplings are tightened	Go over couplings and tighten by hand.	OK	NS	08/05
3.	Set up lexan walls.	Lexan walls shall cover demonstrator	OK	EK	08/05
4.	Start the FMC aggregate	FMC aggregate shall be started.	OK	NS	08/05
5.	Close BV on FMC aggregate and adjust pressure relief valve.	BV shall be closed and pressure relief valve shall be adjusted to deliver correct pressure.	OK	NS	08/05
6.	Make sure that BV between cylinder and tank are closed.	BV shall be closed.	OK	NS	08/05

7.	Set pressure to 50 bar	Pressure gauges shall show 50 bar ± 5 bar, and there shall be a high flow	OK	NS	08/05
8.	Open BV on FMC aggregate.	BV shall be open	OK	NS	08/05
9.	Push aggregate handle up	Flow shall be delivered to cylinder, and cylinder shall move.	OK	NS	08/05
10.	Close BV on FMC aggregate	BV shall be closed	OK	NS	08/05
11.	Open BV to tank	Cylinder shall retract, and fluid shall go to tank.	OK	NS	08/05
12.	Close BV to tank and repeat step 5 to 12 five times.	Cylinder shall be flushed thoroughly.	OK	NS	08/05
13.	Stop the aggregate	The aggregate shall stop.	OK	NS	08/05

Table 7: Procedure for Pre-flushing of DAC

5.3 Body proof testing

FMC had made an adapter plate for the BA, this had to be tested to check if there was any visual damages and that it can withstand the pressures that the DDSV shall work with. For the body proof test an Enerpac hand pump instead of the aggregate, this is to simplify the test, and to decrease the number of hoses for the test setup. The system was coupled up as in Figure 3:

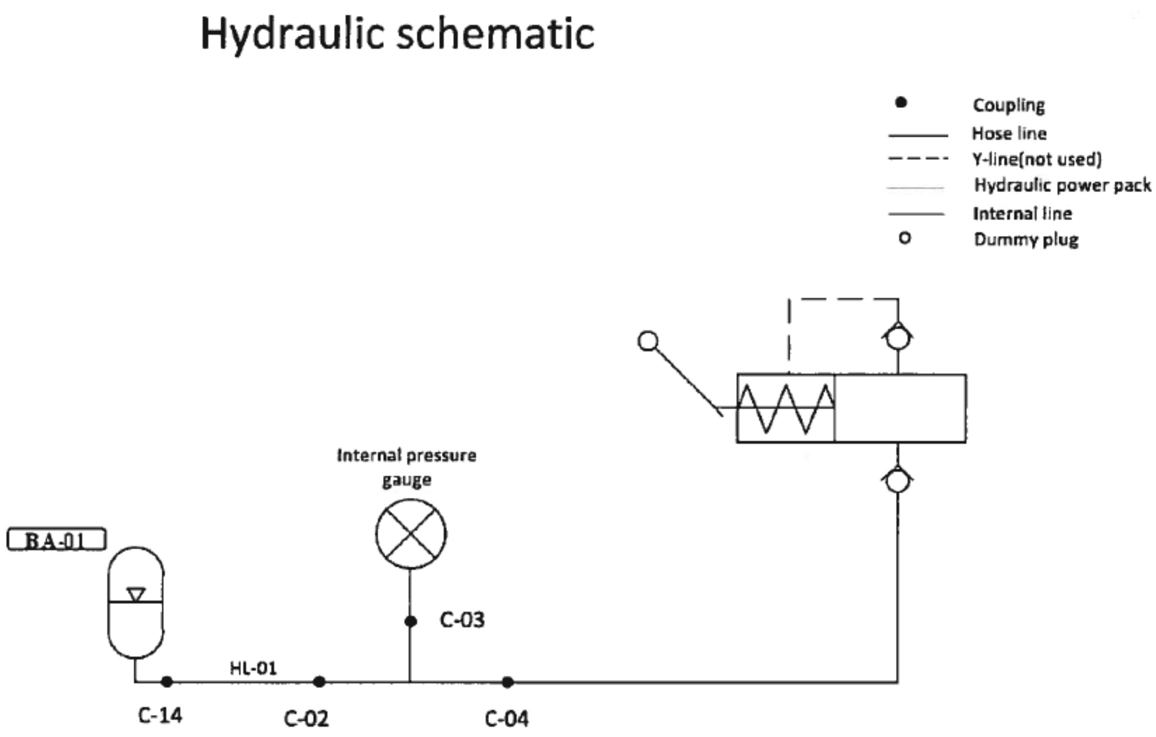


Figure 3: Body proof testing of BA adapter plate

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Mount accumulator with loctite 577.	Accumulator shall be coupled with loctite 577	OK	US	07/05
2.	Make sure that accumulator is properly tightened	There shall not be possible to tighten accumulator CW with wrench.	OK	US	07/05
3.	Mount coupling nipple with loctite 577	Coupling nipple shall be coupled with loctite 577	OK	EK	07/05
4.	Make sure that coupling nipple is properly tightened	There shall not be possible to tighten coupling nipple CW with wrench.	OK	EK	07/05
5.	Check that system is coupled as in *figure 5*	System shall be coupled as in *figure 5*	OK	NS	09/05
6.	Check that couplings are tightened	Go over couplings and tighten by hand.	OK	NS	09/05
7.	Set up lexan walls	Lexan walls shall cover accumulator	OK	NS	09/05
8.	Make sure venting cap is set to vent.	Venting cap shall be set to vent	OK	EK	09/05
9.	Make sure internal pressure relief valve is closed	It shall not be possible to turn internal pressure relief valve CW	OK	EK	09/05

10.	Pump up pressure to 48 bar	Pressure gauge shall indicate 48 bar ± 2 bar.	OK	NS	09/05
11.	Check for visual leakage	There shall be no visual leakage	OK	EK	09/05
12.	Let the system be for 10 minutes	There shall be no visual leakage or damage after 10 minutes	OK	NS	09/05
13.	Pump up pressure to 71 bar	Pressure gauge shall indicate 71 bar ± 2 bar.	OK	EK	09/05
14.	Check for visual leakage	There shall be no visual leakage	OK	EK	09/05
15.	Let the system be for 10 minutes	There shall be no visual leakage or damage after 10 minutes	OK	NS	09/05
16.	Pump up pressure to 85 bar	Pressure gauge shall indicate 85 bar ± 2 bar.	OK	NS	09/05
17.	Check for visual leakage	There shall be no visual leakage	OK	EK	09/05
18.	Let the system be for 10 minutes	There shall be no visual leakage or damage after 10 minutes	OK	EK	09/05
19.	Pump up pressure to 95 bar	Pressure gauge shall indicate 95 bar ± 2 bar.	OK	NS	09/05
20.	Check for visual leakage	There shall be no visual leakage	OK	NS	09/05
21.	Let the system be for 15 minutes	There shall be no visual leakage or damage after 15 minutes	OK	NS	09/05
22.	Turn internal pressure relief valve as far as possible CCW	Pressure gauge shall show 0 bar.	OK	NS	09/05

Table 8: Procedure of body proof testing of BA adapter plate

When this test was finished, the test responsible suggested testing the bladder. This could be done by pre-charging the accumulator to some pressure, couple it back to the hand pump, and start pumping. If the bladder is working as it shall, the pressure gauge shall show the pre-charged pressure almost at once.

The accumulator was pre-charged to 40 bars, and when it was coupled back to the hand pump, and one of the personnel started pumping, the pressure gauge showed 40 bars after 2-3 pumps. This concluded that the bladder is working as it shall.

5.4 Pressure testing

The pressure test was coupled as in Figure 4:

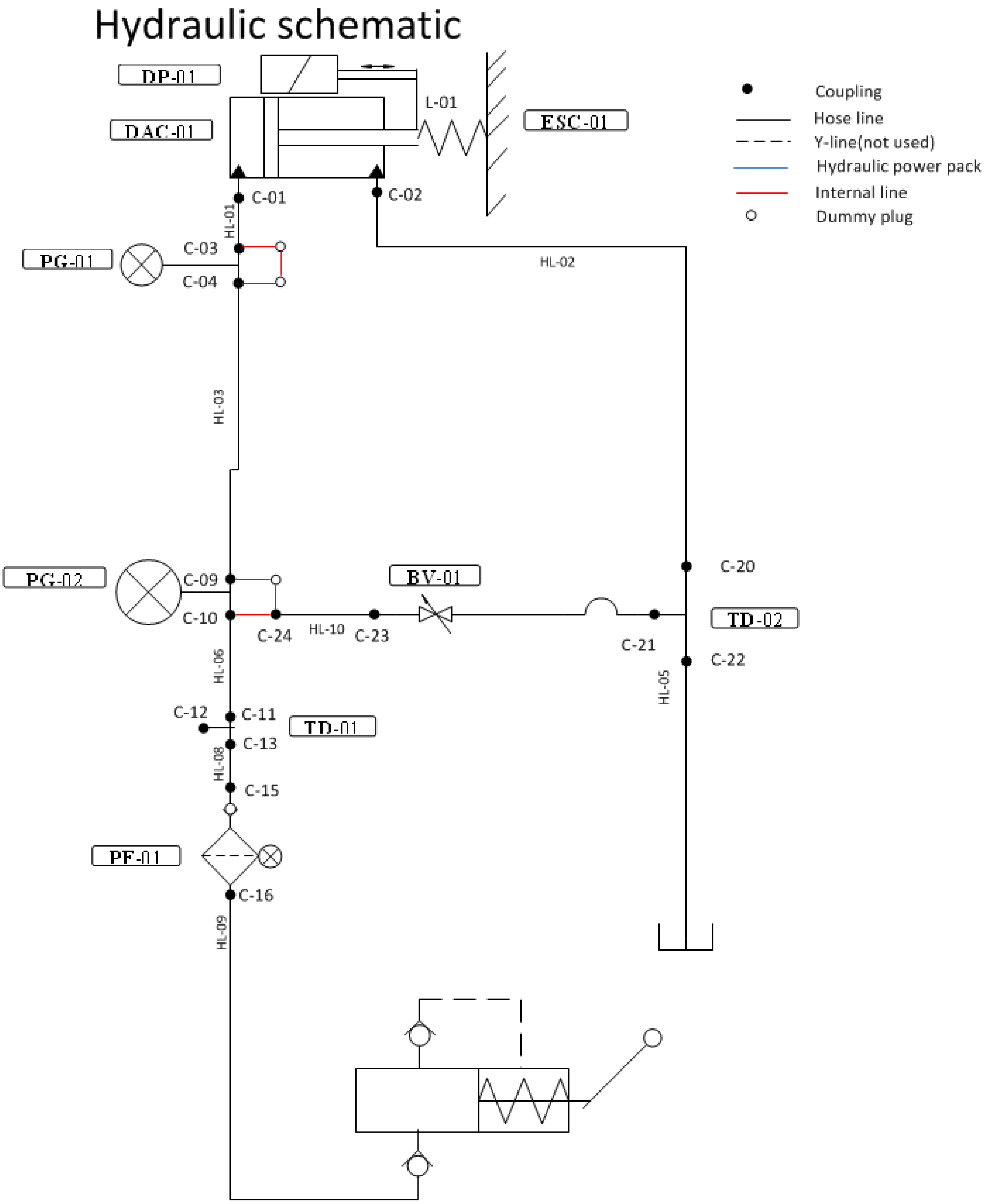


Figure 4: Pressure test schematic

The schematic includes the DAC, both of the PG's, a BV, both of the TD's and the PF. All of these components has been tested earlier [4], but not coupled together. T-008 is meant to check the pressure drop for the complete system besides the DDSV and HPP. The complete system including the DDSV and HPP will go through a leak test in T-012 [5]. Table 8 is the procedure including signatures for the pressure test, and Table 9 is the pressure results.

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Preflushing shall be done. See section 5.1	System shall be preflushed.	OK	NS EK	08/05
2.	Check that system is coupled as in *figure 6*	Shall be exactly coupled as *figure 6*(HL-02 and HL-05 shall go to tank)	OK	NS EK	08/05
3.	Check that couplings are tightened.	Go over coupling and tighten by hand.	OK	NS	08/05
4.	Set up lexan walls.	Lexan walls shall cover demonstrator	OK	NS	08/05
5.	Pump up pressure to 48 bar.	Pressure gauge shall show 48 ± 5 bar	OK	NS	09/05
6.	Let the system be for 5 minutes.	Pressure gauge shall still show 48 ± 5 bar	OK	NS	09/05
7.	Visually check if there are any fluid leakages	There shall be no fluid leakage	OK	EK	09/05
8.	Start test time, and let the system be for 10 minutes. When 10 minutes has passed, check pressure gauge.	Pressure drop shall be less than 1.9 bars.	OK	EK	09/05
9.	Visually check if there are any fluid leakages	There shall be no fluid leakage	OK	NS	09/05
10.	Pump up pressure to 71 bar.	Pressure gauge shall show 71 ± 5 bar	OK	HMS, MH	09/05
11.	Let the system be for 5 minutes.	Pressure gauge shall still show 71 ± 5 bar	OK	HMS, MH	09/05
12.	Visually check if there are any fluid leakages	There shall be no fluid leakage	OK	HMS, MH	09/05
13.	Start test time, and let the system be for 10 minutes. When 10 minutes has passed, check pressure gauge.	Pressure drop shall be less than 1.9 bars.	OK	HMS	09/05
14.	Visually check if there are any fluid leakages	There shall be no fluid leakage	OK	HMS	09/05
15.	Pump up pressure to 85 bar.	Pressure gauge shall show 85 ± 5 bar	OK	HMS	09/05
16.	Let the system be for 5 minutes.	Pressure gauge shall still show 85 ± 5 bar	OK	HMS	09/05
17.	Visually check if there are any fluid leakages	There shall be no fluid leakage	OK	HMS	09/05
18.	Start test time, and let the	Pressure drop shall be less	Not OK	HMS	09/05

	system be for 10 minutes. When 10 minutes has passed, check pressure gauge.	than 1.9 bars.			
19.	Visually check if there are any fluid leakages	There shall be no fluid leakage	Ok	HMS	09/05
20.	Pump up pressure to 95 bar.	Pressure gauge shall show 95 ± 5 bar	Ok	HMS	09/05
21.	Let the system be for 5 minutes.	Pressure gauge shall still show 95 ± 5 bar	Ok	HMS	09/05
22.	Visually check if there are any fluid leakages	There shall be no fluid leakage	Ok	HMS	09/05
23.	Start test time, and let the system be for 15 minutes. When 15 minutes has passed, check pressure gauge.	Pressure drop shall be less than 1.9 bars.	Ok	HMS	09/05
24.	Visually check if there are any fluid leakages	There shall be no fluid leakage	Ok	HMS	09/05
25.	Turn internal hand pump pressure relief valve CCW as far as possible.	It shall not be possible to turn relief valve more CCW	Ok	HMS	09/05
26.	Open BV-01	The system shall be depressurized, and PG-01 and PG-02 shall show 0 bar.	OK	HMS	09/05
27.	Make sure that the system is depressurized.	Pressure gauges shall show 0 bars.	Ok	HMS	09/05

Table 9: Procedure for pressure test

Hand pump gauge	**Test time [min]**	**Pressure at start of test [bar]**	**Pressure at end of test [bar]**	**Deviation [bar]**
48 bar	10	49	48	1
71 bar	10	75	74,5	0,5
85 bar	10	85	83	2
95 bar	15	95	94	1

Table 10: Pressure results

The test personnel decided to take another test as a random test:

Hand pump gauge	**Test time [min]**	**Pressure at start of test [bar]**	**Pressure at end of test [bar]**	**Deviation [bar]**
60 bar	10	60	58	2

Table 11: Pressure result random test

Table 7, Table 8 and Table 9 shows that the some of the tests has a pressure drop of 2 bar. This is 0.1 bars over the requirement of 2 bar [3]. The test personnel decided that this should be approved, because 2 bars is not a mayor pressure drop for a demonstrator.

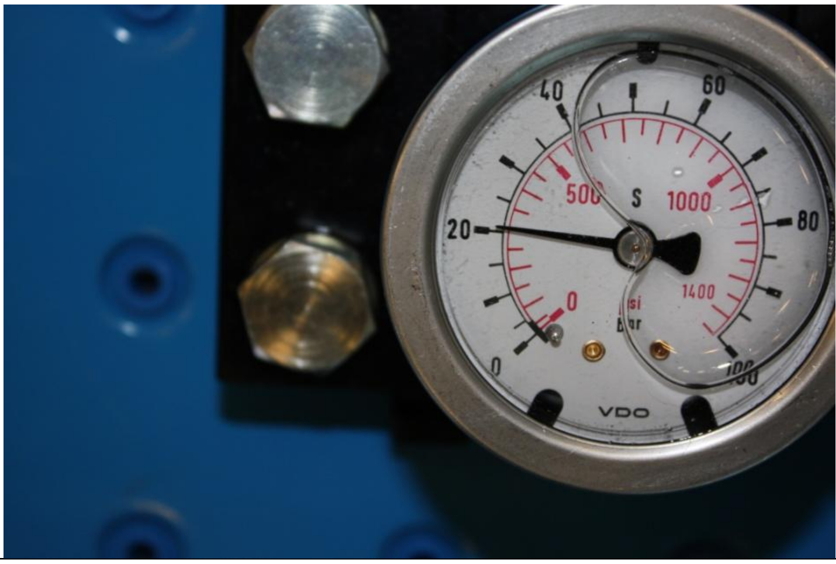
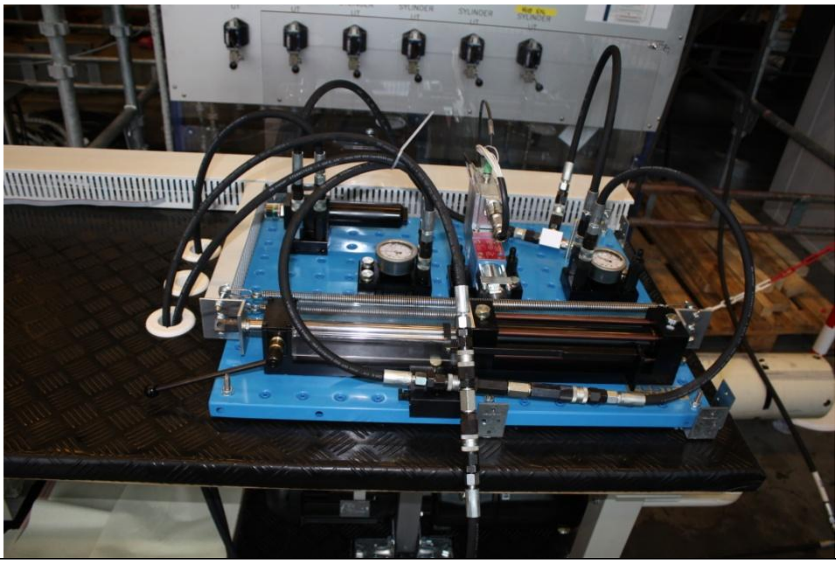
6.0 Conclusion

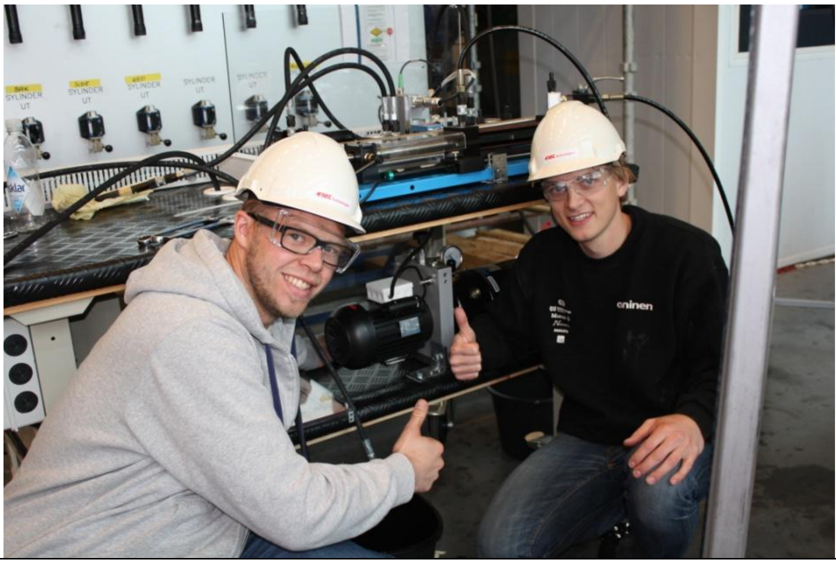
Test	Comments	Date
T-008	The test has gone well, the results are as expected and the requirements are fulfilled. After getting a tip from one of the employees at FMC's facilities in Notodden, the group increased the settling time from 5 min to approximately 15 min. The test has verified these requirements: • PERQ-101 • PERQ-102 • PERQ-104 (2 bar is approximately 2.1 %) • HYRQ-102 (Started to verify this requirement) [3]	13.05.2014

Table 12: Conclusion

7.0 Pictures from the test

Picture	Comment
	Mounting of accumulator to adapter base plate to get it ready for body proof testing.
	The accumulator is mounted on the adapter base plate, and is ready for the body proof test.

	Eirik and Håkon working to get the system ready for pre-flushing.
	PG-01 showing approximately 20 bar.
	The system is soon ready for pre-flushing. All of the hydraulic hoses is coupled together.

	Marit is going over the electrical wiring.
	Snorre and Nicolai have tested the electrical motor, and it is working perfectly.

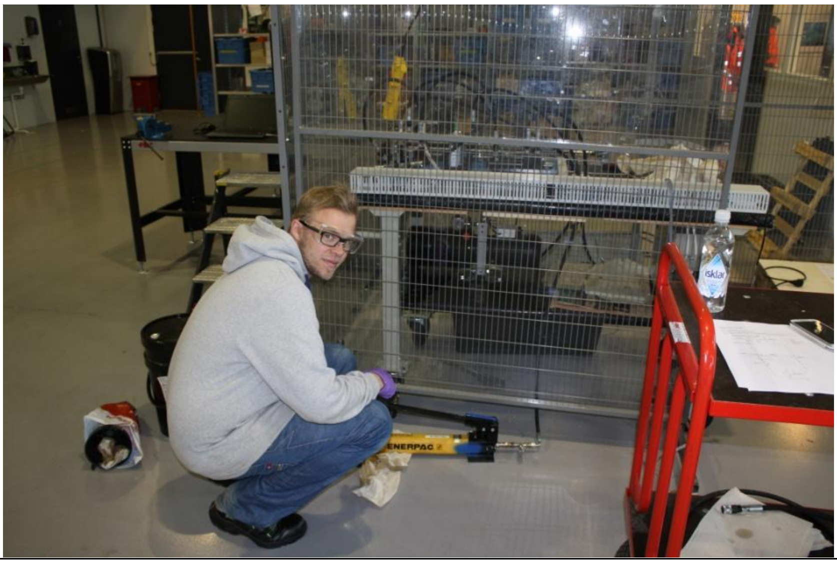
	Håkon is getting the software ready.
	Nicolai is pressurizing the system with the enerpac hand pump.

Table 13: Pictures

8.0 References

[1] Smart DDSV Demonstrator, *S-RS* - *"Requirement Specification,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *SJA* - *"Safety Job Analysis,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *S-RS* - *"Requirement Specification,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *G-TR1* - *"Test result report T-002,"* HBV, Kongsberg, 2014.

[5] Smart DDSV Demonstrator, *G-TP6* - *"Test Procedure for T-012,"* HBV, Kongsberg, 2014.

Test Report for T-009—T-011

G-TR5

Version	Date	Main Author	Co-Author	Approved by
1	19.05.2014	Marit Hammer		Snorre Kløcker
2	20.05.2014	Marit Hammer		Nicolai Skjelsbæk

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	20.05.2014	Updated due to final document review	Marit Hammer	Nicolai Skjelsbæk

This is a report of the verification of the system tests T-009 to T-011.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Communication Area Network
DDSV	Direct Drive Servo proportional Valve
DIN	Deutsches-Institut-für-Normung
E.K	Eirik Kristoffersen
FAT	Factory Acceptance Test
FMC	FMC Technologies
GUI	Graphical User Interface
H.M.S	Håkon Mørk Solaas
HBV	Buskerud/Vestfold university college
HPP	Hydraulic Power Pack
HW	Hardware
L	Liter
M.H	Marit Hammer
MB	Mega Byte
MHz	Mega Hertz
MoVaPuCo	Moog Valve and Pump Configuration
N.S	Nicolai Skjelsbæk
S.K	Snorre Kløcker
SJA	Safety Job Analysis
SW	Software
USB	Universal Serial Bus
VI	Virtual Instrument
WP	Working Pressure

Table 1: Abbreviations

2.0 Introduction

This test was performed at FMC test site at Notodden. The pressure test T-008 was approved May 09th, and further testing could continue.

2.1 Personnel allowed at the test site

In Table 2 the persons that was present at the test site has signed. Joakim Lerstang had gone through the procedure with the bachelor group ahead of these tests. After checking the couplings he vouch for, the bachelor group could do the system test without him present at the test site.

Name	Responsibility	From	Date	Signature
Joakim Lerstang	Test responsible	FMC		
Snorre Kløcker	Operator	Smart DDSV Demonstrator	12/5	Snorre Kløcker
Nicolai Skjelsbæk	Operator	Smart DDSV Demonstrator	12/5	[illegible]
Eirik Kristoffersen	Operator	Smart DDSV Demonstrator	12/5	Eirik Kristoffersen
Håkon Mørk Solaas	Operator	Smart DDSV Demonstrator	12/5	[illegible]
Marit Hammer	Operator	Smart DDSV Demonstrator	12/5	Marit Hammer
Antonio Luis Lopes Ramos	Observer	HBV		
Vetle Stokke Vintervold	Observer	FMC		
FMC personnel with access to test facilities	Observer	FMC		

Table 2: Personnel present at the test

3.0 Safety

The personnel that were present at the test had its own personal security equipment. And all are informed about the safety precautions that shall be taken at FMC test site. The bachelor group had gone through a HSE introduction video before getting access to the test site.

3.1.1 Toolbox talk

Ahead of the pressure test May 7th, Joakim Lerstang went through the toolbox talk and filled in SJA with the whole bachelor group present [1]. He vouched that the toolbox talk shall apply for following tests: T-008 → T-012.

3.1.2 SJA

In Table 3 the SJA that was filled in with test responsible Joakim Lerstang May 7th.

Location: FMC test facilities Notodden		**Test ID: T-008→T-012**	**SJA No. 2**	
Date: 07.05.2014		**Test responsible:** Joakim Lerstang		
Activity	**Risk element**	**Damages (personnel, equipment, location)**	**Action to prevent**	**Performed**
Flushing	Oil spill	Personnel, environment	PPE, lexan wall, spill kit	
Pressure test Requirement test FAT	Oil spill	Personnel, equipment, environment	PPE, lexan wall, spill kit, emergency stop	
	Flying object	Personnel, equipment, environment	PPE, lexan wall that secure the area, warning signs	
Pre-charging of accumulator	Flying object, gas	Personnel, equipment, environment	PPE, lexan wall that secure the area, warning signs	

Table 3: SJA

3.2 Precautions

The wiring was verified twice according to wiring scheme in the Electrical Specification Attachment A [2]. The couplings was checked, and they were according to the hydraulic schematic [3]. Warning signs were present at the test site.

4.0 Prerequisites

4.1 Computer

There was one computer that was used throughout all of the tests, and this computer met the system requirements. In Table 4 the operating system of the computer are filled in.

Operating system	Windows 7 - 64 bit
Computer specifications	Intel i7 2,7GHz 4GB RAM

Table 4: Operating system

4.2 Equipment

In Table 5, all the equipment that was present at the test is listed. By the term of 'complete demonstrator' means all the components described in Design Document [4], Electrical Specification [5] and Interface Specification [6].

Equipment	Quantity
Complete demonstrator	1
Gloves	One pair for each present person
Safety goggles	One pair for each present person
Safety shoes	One pair for each present person
Warning signs	Mounted at the facilities
Hydraulic Specification [3]	1
Electrical Specification [5]	1

Table 5: Equipment

5.0 Test

5.1 Common procedures

This step-by-step procedure in Table 6 was performed first and then the verification of the different requirements was performed. In step 8, the HPP was set to 30bar.

Step	Description	Acceptance criteria	Result	Tested by	Date
1	Check all hydraulic connections	Shall be connected as specified in the hydraulic schematic, see [11]	Ok	MH	12.05
2	Check that all components are connected as specified in the electrical schematic	Shall be connected as specified in the electrical schematic, see [12]	OK	N.S H.M.S.	12.05
3 [HYRQ-101]	Check the oil-level at the HPP, and that it is used hydraulic mineral oil according to DIN 51524	Hydraulic oil level shall be up to the sight glass, and the hydraulic mineral oil shall be according to DIN 51524	Ok	NS EK MH	12.05
~~#~~9 [HYRQ-100]	Check that the WP is minimum 25 bar	WP shall be minimum 25 bar	OK	US SK	12.05
~~1~~4	Power on the valve and run MoVaPuCo and load it to the valve	Shall be no error message returned from MoVaPuCo	OK	HMS	12.05
5	Close MoVaPuCo and reconnect the USB-CAN interface and open the LabVIEW GUI	Shall be no error message returned from LabVIEW GUI	OK	HMS	12.05
6	Send the operational command from the GUI	Valve shall start sending PDO-messages	OK	HMS	12.05
7 [PERQ-100]	Take the time from sending a command to the DDSV is responding	Shall be no more than 1 second	OK	HMS	12.05
8	Start HPP by pushing the start button	HPP shall start	OK	NS	12.05

Table 6: Test result of common procedure

5.2 Test result from T-009

The results of verifying A-requirements are listed in Table 7, and the result of verification of the nonfunctional requirements can be viewed in the end evaluation in Table 8

When performing step 3, the DDSV is closed and there will not be any hydraulic oil that goes to tank, therefore the cylinder is not moving. In step 4, the open command was sent, and the cylinder was already filled up, so the cylinder kept the same position. When the emergency button was pushed in step 5, the DDSV did not get any power. So it could not display the spool position in LabVIEW. The procedure of these steps is changed in FAT T-012 [7].

Step	Description	Acceptance criteria	Result	Tested by	Date
1 [GIRQ-100, SYRQ-100]	Monitor the spool position in LabVIEW, see if the values they show are according to those that are expected	All LabVIEW instruments must show the correct value according to the current state of the valve. In start-up spool shall be in fail-safe position.	OK	HMS	12.05
2 [GIRQ-101]	Send an open command from the GUI	Valve opens. The spool position displayed in LabVIEW changes. And the cylinder shall move.	OK	HMS	12.05
3 [GIRQ-102]	Send a close command from the GUI	Valve closes. Spool position displayed in LabVIEW changes as expected. ~~The cylinder shall move.~~	OK	HMS	12.05
4	Do step 2 again	Valve opens. The spool position displayed in LabVIEW changes. ~~And the cylinder shall move.~~	OK	HMS	12.05
5 [SYRQ-104]	Push the emergency button	The valve shall enter a fail-safe mode. ~~Spool position must be displayed in LabVIEW as closed.~~	OK	NS	12/05
6 [PERQ-110]	Check WP after 1 hour	Pressure reduction shall not be 2 % from WP	OK	HMS NS	12/05

Table 7: Test result of A-requirements

Requirement ID	Description	Evaluation	Verified by	Date
PERQ-107	The extension of the hydraulic cylinder should be slow enough to prove the end user with a clear visualization of changes in pressure	The extension is a bit fast, but slow enough to see changes	NS M.H S.K HMS EK	12/05
HYRQ-104	While operating demonstrator, the pressure filters contamination indicator shall be checked every 10th minute.	Indicator checked => OK	NS M.H S.K HMS EK	12/05
HYRQ-105	No hydraulic components shall have visible leakage of hydraulic fluid.	OK	NS MH EK HMS SK	12/05
NFRQ-100	GUI must be easy to understand	OK	NS MH EK SK HMS	12/05
NFRQ-101	Demonstrator must have a simple design	OK	NS MH EK SK HMS	12/05
NFRQ-102	Demonstrator must be safe to use	OK	NS EK MH SK HMS	12/05
NFRQ-103	Demonstrator must be portable	OK	NS EK MH S.K HMS	12/05
NFRQ-104	Demonstrator must be rugged	OK	NS MH EK HMS SK	12/05
DORQ-104	The end user shall have access to an user manual that will provide guidelines for safe operation of the demonstrator	U-HS U-IG	NS MH EK HMS S.K	12/05

Table 8: Test result of end evaluation

5.3 Test result from T-010

The verification of B-requirements was performed in two different days. The same operating system for the computer was used in both days.

While performing step 2 in Table 9 the response in Figure 1 was conducted. The red curve is from the internal spool in the DDSV, and the black curve is the pressure after the DDSV. From the start the DDSV was in a fail-safe mode, therefore the spool begins at -20. And there is 0bar pressure out from the valve. At the time 6606 the set point in pressure were set to 30bar. From 6606 and to 6612 the cylinder is changing position from closed to open. When the curve reaches 6612 and the cylinder is open, the black curve has some noise in the start, but has a nice curve up to the reference, which is 30bar. The settling time is within 20 seconds and has no overshoot.

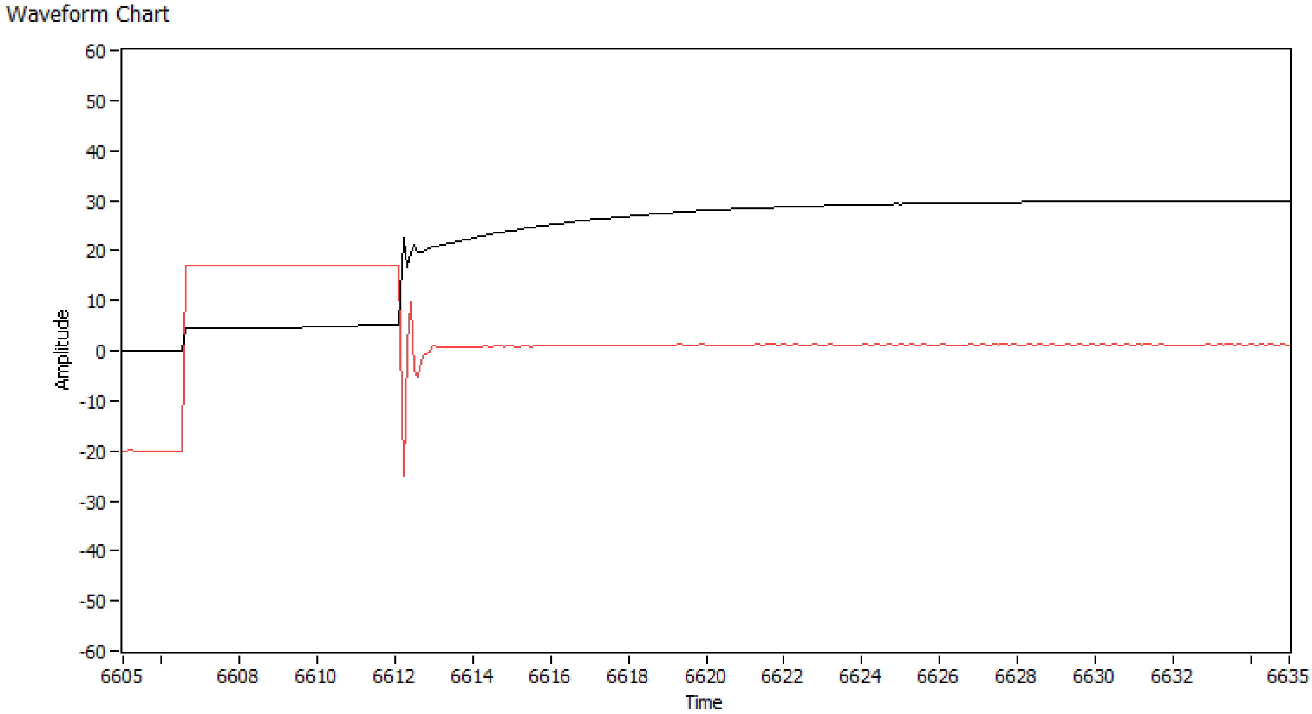

Figure 1: Change of set point

Step	Description	Acceptance criteria	Result	Tested by	Date
1 [SYRQ-101, GIRQ-103, GIRQ-104]	Change set point for pressure in LabVIEW and send it to the valve	The valve shall respond and start to regulate. See the variation of pressure in the LabVIEW plot.	OK	H.M.S	12.05
2 [PERQ-105, PERQ-106]	Evaluate pressure curve response for a step in reference in LabVIEW.	Overshoot shall not exceed 20 % and the settling time shall not exceed 20 seconds.	~~NOT~~ OK	HMS	16.05

Table 9: Test result of B-requirements

There was one B-requirement that has a end evaluation. The result can be viewed in Table 10.

Requirement ID	Description	Evaluation	Verified by	Date
NFRQ-105	Demonstrator must have visual appeal	Looks good	HMS	16.05

Table 10: Test result of end evaluation

5.4 Test results from T-011

While verifying the C-requirements, the bachelor group disregarded the step-by-step procedure that was set up in [8]. If there is enough time the bachelor group will try to verify the last steps in the procedure that is left. C-requirements are not the highest priority for the bachelor group. The test result from T-011 is viewed in Table 11.

Step	Description	Acceptance criteria	Result	Tested by	Date
1 [SYRQ-102, GIRQ-105, GIRQ-106]	Change set point for flow in LabVIEW and send it to the valve	The valve shall respond and start to regulate. See the variation of flow in the LabVIEW plot.			
2 [SYRQ-103]	Change the load on the hydraulic cylinder while in Q-regulation control mode.	The valve shall be able to regulate flow with varying load on the hydraulic cylinder.			
3 [SYRQ-103]	Change the load on the hydraulic cylinder while in P-regulation control mode.	The valve shall be able to regulate pressure with varying load on the hydraulic cylinder.	OK	HMS	15.05
4 [GIRQ-107]	Start the accumulated flow plot in the LabVIEW VI	Verify that the accumulated flow plot is correct.			
5 [GIRQ-108]	Load two stored curve and compare them	Verify that both curves are stored and see that the end user can read the curves.			
6 [GIRQ-109]	Use the generator function to set a desired pressure curve in LabVIEW	Verify that the valve is responding according to the pressure curve			

Table 11: Test result of C-requirements

6.0 Conclusion

The conclusion of how the tests went is summarized in Table 12. Ahead of the tests, there were used a lot of time to be sure that the components were safe to use and that the software are correct.

Test	Comments	Deviations	Date
T-009	All the steps were performed and approved, and there were not any accidents during the test.	None	May 12th
T-010	All steps were performed and approved, and there were not any accidents during the tests.	None	May 16th
T-011	One step is performed and approved.	Following requirement-ID was not performed: SYRQ 102, SYRQ 103, GIRQ 105, GIRQ 106, GIRQ 107, GIRQ 108, GIRQ 109. These requirements are not performed due to the short time. FMC Technologies can do this after the bachelor group is finished with their thesis.	May 16th

Table 12: Summary of the results

7.0 References

[1] Smart DDSV Demonstrator, - *"SJA No.2,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *S-ES-A* - *"Electrical Specification-Attachment A,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *S-HS* - *"Hydraulic System specification,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *D-DD* - *"Design Document,"* HBV, Kongsberg, 2014.

[5] Smart DDSV Demonstrator, *S-ES* - *"Electrical Specification,"* HBV, Kongsberg, 2014.

[6] Smart DDSV Demonstrator, *S-IS* - *"Interface and GUI Specifiaction,"* HBV, Kongsberg, 2014.

[7] Smart DDSV Demonstrator, *G-TR6* - *"Test result Report T-012,"* HBV, Kongsberg, 2014.

[8] Smart DDSV Demonstrator, *G-TP5* - *"Test Procedure for T-009--T-011,"* HBV, Kongsberg, 2014.

Test Report for T-012

G-TR6

Version	Date	Main Author	Co-Author	Approved by
1	19.05.2014	Nicolai Skjelsbæk		Snorre Kløcker
2	21.05.2014	Nicolai Skjelsbæk		Håkon Mørk Solaas

Changes:

Version	Date	Changes	Released by	Approved by
1→2	21.05.2014	Document review	Nicolai Skjelsbæk	Håkon Mørk Solaas

This document is the test result report for the FAT-test of the DDSV demonstrator system.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Communication Area Network
DDSV	Direct Drive Servo proportional Valve
FAT	Factory Acceptance Test
FMC	FMC Technologies
GUI	Graphical User Interface
HPP	Hydraulic Power Pack
HW	Hard Ware
MoVaPuCo	Moog Valve and Pump Configuration
PDO	Process Data Object
SJA	Safety Job Analysis
SW	Soft Ware
USB	Universal Serial Bus
WP	Working Pressure

Table 1: Abbreviations

1.1 Definitions

Word	Definition
FAT	The factory acceptance test is conducted at the vendor’s premises, usually by a third party. The test is conducted to verify that the system is operating according to the requirements.
WP	The demonstrator’s working pressure is 60 ± 10 bar.

Table 2: Definitions

2.0 Introduction

This document is the result report for test T-012 [1]. This is the last test of the Smart DDSV demonstrator. The test will include all of the components, and shall verify the requirements that the group has managed to finish.

2.1 Following persons were present

Table 3 includes the signatures of personnel present at the test.

Name	Responsibility	From	Signature
Joakim Lerstang	Test responsible	FMC	
Marit Hammer	Operator	Smart DDSV Demonstrator	
Nicolai Skjelsbæk	Operator	Smart DDSV Demonstrator	
Eirik Kristoffersen	Operator	Smart DDSV Demonstrator	
Snorre Kløcker	Operator	Smart DDSV Demonstrator	
Håkon Mørk Solaas	Operator	Smart DDSV Demonstrator	
Vetle Stokke Vintervold	Observer	FMC	
Svein Kjenner	Observer	FMC	
Børge Bjørnaas	Observer	FMC	
John Mulholland	Observer	FMC	
Antonio Luis Lopes Ramos	Observer	HBV	
FMC personnel with access to test facilities.	Observer	FMC	

Table 3: Personnel present

The personnel has signed that they have read and understood the procedure, they have also signed that they have gone through the SJA [2].

3.0 Safety

Due to the high pressure and moving parts in the demonstrator, the safety is set to highest priority. So it was very important that everyone who was present at the test site had this in mind throughout the tests.

3.1 General

All the safety precautions [2] were taken to make sure that there were no injuries, or damage to environment or equipment.

3.2 Toolbox talk

The personnel from Table 3 had a toolbox talk before the test was started. Under the toolbox talk, the procedure was gone through in detail- Questions regarding the procedure was raised, and some small changes to the procedure was made.

3.2.1 SJA

The test personnel also made a SJA [2] for the test, see Table 4:

Location: FMC test facilities Notodden		**Test ID: T-012**	**SJA No. 2**	
Date: 07.05.2014		**Test responsible:** Joakim Lerstang		
Activity	**Risk element**	**Damages (personnel, equipment, location)**	**Action to prevent**	**Performed**
Flushing	Oil spill	Personnel, environment	PPE, lexan wall, spill kit	
Pressure test Requirement test FAT	Oil spill	Personnel, equipment, environment	PPE, lexan wall, spill kit, emergency stop	
	Flying object	Personnel, equipment, environment	PPE, lexan wall that secure the area, warning signs	
Pre-charging of accumulator	Flying object, gas	Personnel, equipment, environment	PPE, lexan wall that secure the area, warning signs	

Table 4: SJA

4.0 Prerequisites

The test required that the facility was set up to provide representative test conditions for the components. For safety the following measures was taken:

- One copy of test procedure G-TP6 [1] available at the test site.
- Qualified personnel had verified that the demonstrator's components were safe to use.

Table 5 and Table 6 lists all of the equipment used for the test.

4.1 Equipment needed for test

4.1.1 HW

Equipment	Quantity
Safety goggles	One for each person present
Safety gloves	One pair for each person performing the test
Safety helmet	One for each person present
Safety shoes	One for each person present
Complete demonstrator	1
Computer that meets the minimum specification	1
Ixxat USB-CAN compact	1
5m ribbon cable with one male and three female DE-9 connectors	1
Cable: 3-wire to DE-9 Male	1
End termination 120 Ω	1
Specification U-HS, Smart DDSV Demonstrator [3]	1
Specification U-IG, Smart DDSV Demonstrator [4]	1

Table 5: HW equipment

4.1.2 SW

Equipment
LabVIEW
MoVaPuCo
GUI LabVIEW VI
Configuration files for the valve

Table 6: SW equipment

5.0 FAT Requirements

The FAT shall confirm and verify compliance of the Smart DDSV Demonstrator against specified requirements. These are specified in S-RS [5]. The requirement specification includes three priorities A-, B- and C-requirements. This FAT includes all of the A- and B-requirements. The group has not finished all of the C-requirements, so the FAT could not include all of these. But SYRQ-103 has been verified.

The demonstrator's hydraulic system was coupled as in Figure 1

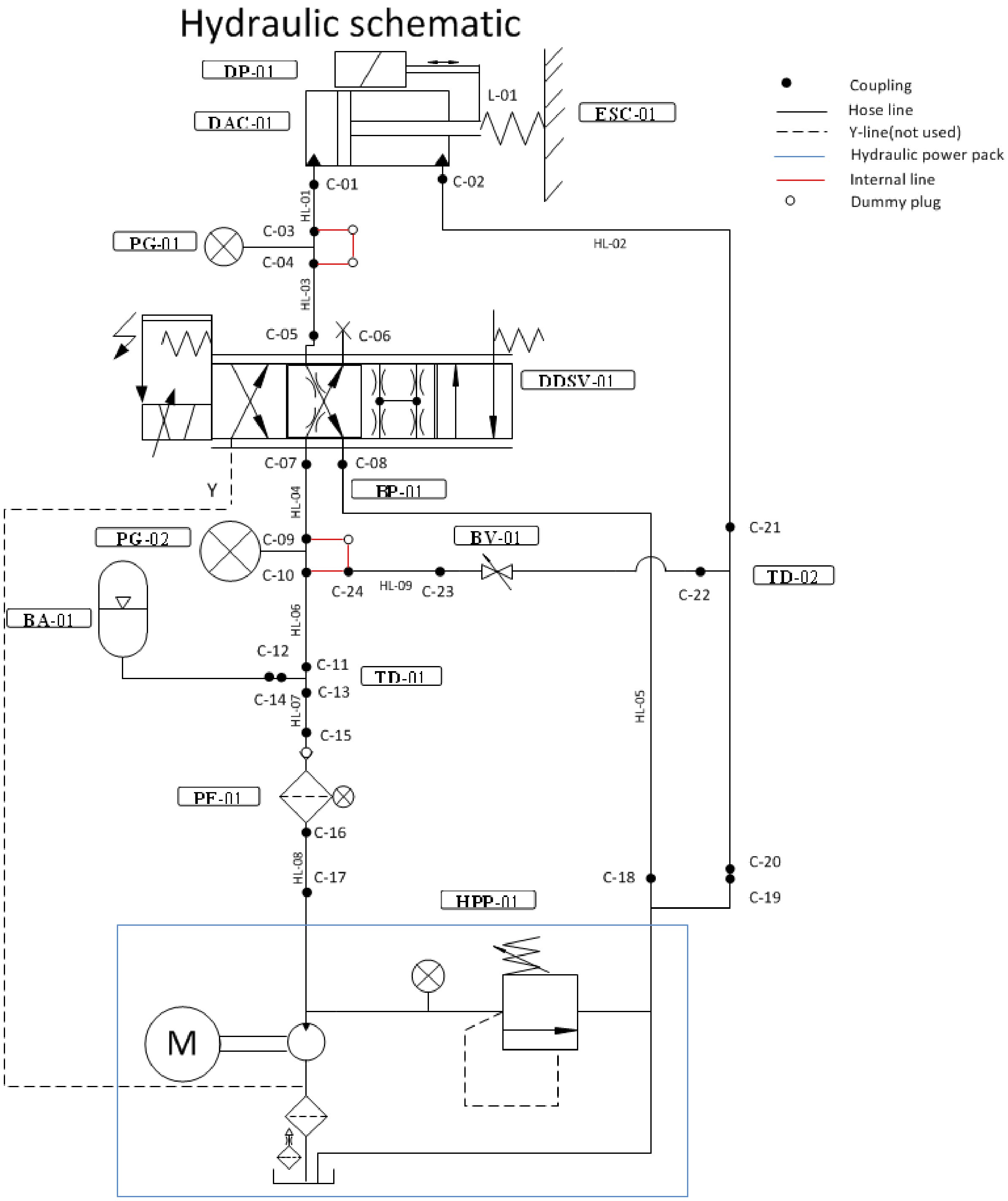

Figure 1: Hydraulic schematic [6]

5.1 Computer requirements

There are some system requirements that are issued by the valve supplier Moog [7], and this to be sure that the configuration software is working as expected throughout the test period. These are as follows:

- CPU with minimum 133 MHz
- Windows7 or later [8]

• 64 MB RAM
• 40 MB free hard disc capacity
• Monitor 640x480 Pixel resolution
• Keyboard, mouse

Table 7 includes the information about the computer which was used for the FAT.

Operating system	Windows 7, 64-bit
Computer specifications	Intel i7 2,7 Ghz – 4 GB RAM

Table 7: Computer information

The CAN-network was connected as in Figure 2*:*

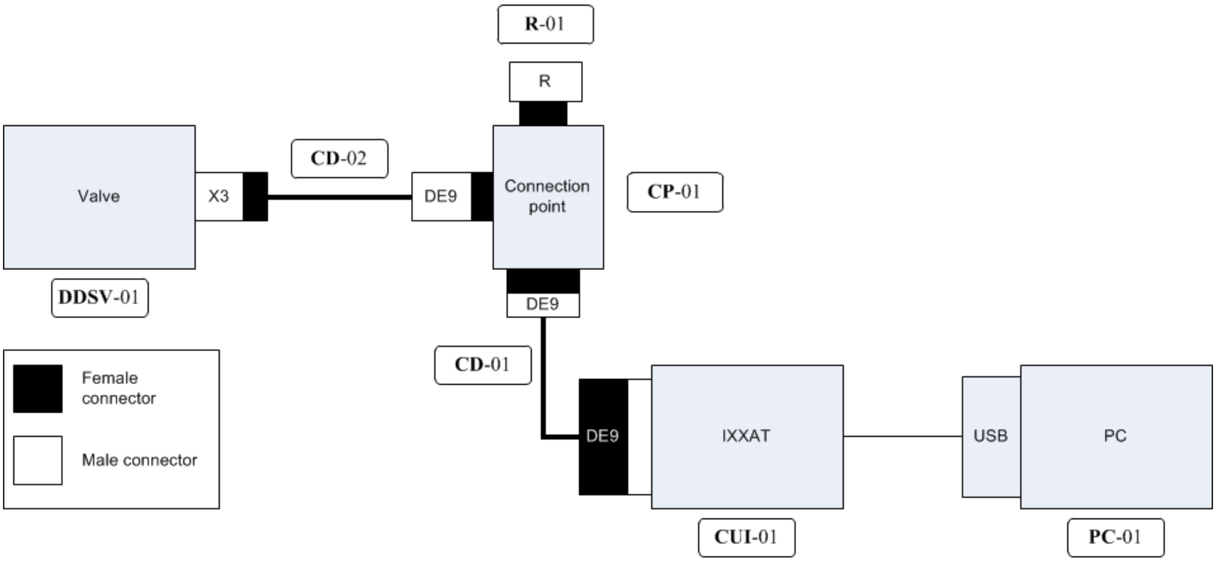

Figure 2: Test connection

6.0 Procedure

Before the test could start, a common procedure had to be passed through. This had to be done each time some of the hydraulic couplings were changed or when one of the procedures was started. Each test ended with an end-evaluation, this should have been done by the client, but since no one from FMC could be present, they approved that the group could do the end-evaluation.

There were no changes to the hydraulic system, but the FAT went over three days, so the procedure in Table 8 was gone through three times, but only signed the first time.

6.1 Before each procedure

Step	Description	Acceptance criteria	Result	Tested by	Date
1	Check all hydraulic connections	Shall be connected as specified in the hydraulic schematic, see [3]	OK	N.S EK	13/05
2.	Check that all hydraulic connections are properly tightened	Shall not be possible to tighten anymore by wrench.	OK	N.S EK	13/05
3.	Check that all components are connected as specified in the electrical schematic	Shall be connected as specified in the electrical schematic, see [9]	OK	N.S	13/05
4.	Check the oil-level at the HPP	Hydraulic oil level shall be up to the sight glass	OK	EK MH	13/05
5.	Power on the valve and run MoVaPuCo and load it to the valve	Shall be no error message returned from MoVaPuCo	OK	HMS	13/05
6.	Close MoVaPuCo and reconnect the USB-CAN interface and open the LabVIEW GUI	Shall be no error message returned from LabVIEW GUI	OK	HMS	13/05
7. [CMRQ-101]	Send the operational command from the GUI	Valve shall start sending PDO-messages.	OK	HMS	13/05
8.	Start HPP by pushing the start button	HPP shall start	OK	NS	13/05
9. [HYRQ-100]	Set HPP to WP	Pressure gauges shall show 60 ± 10 bar.	OK	NS EK	

Table 8: Start up procedure

6.2 A requirements

The first time the group started the A-requirements procedure, they got an error code from the MoVaPuCo SW. The firmware manual from MOOG [9] told that the DDSV had to be sent for service by their technicians. So the group used the rest of the day on phone with MOOG Germany. After a while the group, in accordance with MOOG Germany, found out that this error code does not apply for their DDSV, so the FAT could go on the next day.

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Make sure that section 6.1 is gone through	System shall be running with a pressure of WP, and be ready to be tested.	Ok	NS	13/05
2. [SYRQ-100]	Monitor the spool position in LabVIEW, see if the values they show are according to those that are expected	All LabVIEW instruments must show the correct value. Valve shall be closed.	OK	HMS	14/05
3. [GIRQ-100, GIRQ-101]	Send an open command from the GUI	Valve opens. The spool position displayed in LabVIEW changes. PG-01 shall show pressure increase.	OK	N.S	14/05
4. [GIRQ-102]	Send a close command from the GUI	Valve closes. Spool position displayed in LabVIEW changes as expected. PG-01 shall show pressure decrease.	Ok	HMS	14/05
5.	Do step 3 again	Valve opens. The spool position displayed in LabVIEW changes. PG-01 shall show pressure increase.	Ok	NS	14/05
6. [PERQ-100]	Measure response time for system.	The system shall use no more than 1 second responding to user input	OK	N.S	14/05
7.	Do step 4 again and then step 3 again.	Valve closes. Spool position displayed in LabVIEW changes as expected. PG-01 shall show pressure decrease. Then the valve opens again. The spool position displayed in LabVIEW changes. PG-01 shall show pressure increase.	Ok	HMS	14/05
8. [SYRQ-104]	Push the emergency button	The valve shall enter a fail-safe mode. ~~Spool position must be displayed in LabVIEW as closed~~. PG-01 shall show pressure decrease.	Ok	N.S HMS	14/05

Table 9: A-requirements procedure

In Table 9, step 8 the group has crossed out "Spool position must be displayed in LabVIEW as closed" when the emergency button is pushed. The reason for this is that when the emergency button is pushed, the power to the CAN network is shut down, which means that no communication is possible. Therefore the group could not monitor the spool position in their GUI. If the emergency button is used on a later stage, the monitoring of the spool position is not that important, because in an emergency it is more important to evacuate personnel than to monitor spool position.

6.2.1 Leak Test

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Make sure that section 6.1 and 6.2 is gone through	System shall be running with a pressure of WP, and be ready to be tested.	OK	N.S	14/05
2. [SYRQ-100]	Monitor the spool position in LabVIEW, see if the values they show are according to those that are expected	All LabVIEW instruments must show the correct value; Pressure shall be approximately 0 bar and spool in fail-safe position.	OK	HMS	14/05
3. [GIRQ-101]	Send an open command from the GUI	Valve opens. The spool position displayed in LabVIEW changes. PG-01 shall show pressure increase.	OK	N.S	14/05
4. [HYRQ-100]	Make sure the system has a pressure equal to WP.	Pressure gauges shall show 60 ± 10 bar	OK	EK	14/05
5. [HYRQ-105]	Visually check for any fluid leakage	There shall be no fluid leakage	OK	EK	14/05
6. [PERQ-110]	Start test time and let the system be for 60 minutes.	Pressure drop shall be less than 1.2 bars, and there shall be no visual fluid leakage.	OK	HMS	14/05
7.	Stop HPP	HPP shall stop running.	OK	HMS	14/05
8.	Set valve to disabled state in the GUI.	Valve shall enter fail-safe position. PG-01 shall drop to 0 bar.	OK	HMS	14/05
9.	Open ball valve.	System shall be depressurized, and the pressure gauges shall show 0 bar.	OK	HMS	14/05

Table 10: Leak test procedure

Table 10 is mainly the procedure for verifying the PERQ-110 requirement which will test if the demonstrator is leaking. In short terms it says that the pressure drop after 1 hour at WP shall not exceed 2%. In Table 11, the exact pressure drop percent after 60 minutes at WP is logged.

WP HPP	Test time	Pressure at start of test [bar]		Pressure at end of test [bar]		Deviation [%]		Fluid leakage [Y/N]
		PG-01	PG-02	PG-01	PG-02	PG-01	PG-02	
54.5 bar	60 min	54,5	54,5	54	54	0.92	0.92	N

Table 11: Pressure drop

6.2.2 End Evaluation

Step	Description	Evaluation	Verified by	Date
1. [CORQ-100]	DDSV shall be supplied by MOOG	OK	N.S	14/05
2. [CORQ-101]	DDSV shall be 3 way	OK	HMS	14/05
3. [PERQ-107]	The extension of the hydraulic cylinder should be slow enough to prove the end user with a clear visualization of changes in pressure	Ok, a bit fast, but slow enough for visuali-zation. Need's more load	NS	14/05
4. [HYRQ-104]	While operating demonstrator, the pressure filters contamination indicator shall be checked every 10th minute.	OK	HMS	14/05
5. [HYRQ-105]	No hydraulic components shall have visible leakage of hydraulic fluid.	OK	NS	14/05
6. [NFRQ-100]	GUI must be easy to understand	OK	HMS	14/05
7. [NFRQ-101]	Demonstrator must have a simple design	OK	N.S	14/05
8. [NFRQ-102]	Demonstrator must be safe to use	OK	HMS	14/05
9. [NFRQ-103]	Demonstrator must be portable	OK	N.S	14/05
10. [NFRQ-104]	Demonstrator must be rugged	OK	H.M.S	14/05
11. [DORQ-104]	The end user shall have access to an user manual that will provide guidelines for safe operation of the demonstrator	U-HS U-IG OK	N.S	14/05

Table 12: End evaluation A-requirements

So Table 9, Table 10, Table 11 and Table 12 shows that all A-requirements were verified.

6.3 B-Requirements

When the group was at FMC's test facilities in Notodden, they had not finished any of their B-requirements, so these were not tested there. The B-requirements was finished when the group had some time to work with them at school, so the B-requirements procedure was gone through at a later stage. See Table 13:

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Make sure that section 6.1 is gone through	System shall be running with a pressure of WP, and be ready to be tested.	OK	HMS	16/05
2. [SYRQ-100]	Monitor the spool position in LabVIEW, see if the values they show are according to those that are expected	All LabVIEW instruments must show the correct value. Valve shall be closed.	OK	HMS	16/05
3. [GIRQ-101]	Send an open command from the GUI	Valve opens. The spool position displayed in LabVIEW changes. PG-01 shall show pressure decrease.	OK	HMS	16/05
4. [SYRQ-101, GIRQ-103, GIRQ-104]	Change set point for pressure in LabVIEW and send it to the valve	The valve shall respond and start to regulate. See the variation of pressure in the LabVIEW plot.	OK	HMS	16ø05
5. [PERQ-105, PERQ-106]	Evaluate pressure curve response for a step in reference in LabVIEW.	Overshoot shall not exceed 20 % and the settling time shall not exceed 20 seconds.	OK	HMS	16/05
6.	Stop HPP	HPP shall stop running.	OK	HMS	16/05
7.	Set valve to disabled state in the GUI.	Valve shall enter fail-safe position. PG-01 shall drop to 0 bar.	OK	HMS	16/05
8.	Open ball valve.	System shall be depressurized, and the pressure gauges shall show 0 bar.	OK	HMS	16/05

Table 13: B-requirements procedure

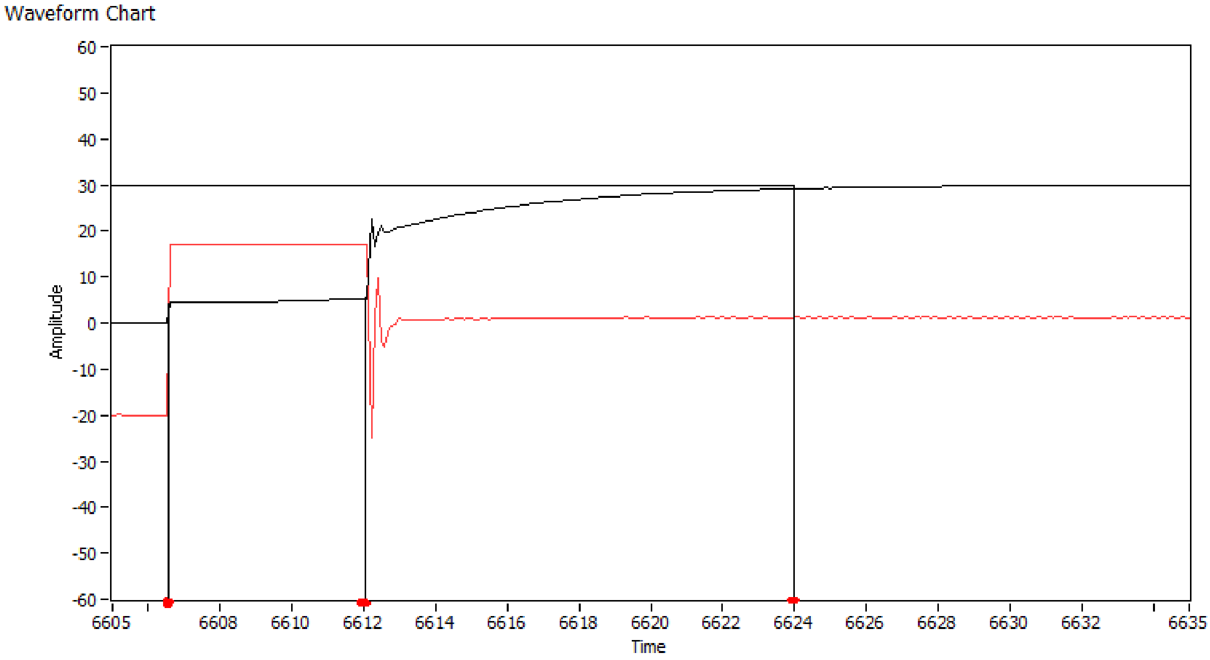

Figure 3: Pressure curve

Figure 3 shows a pressure curve after applying a 30 bar setpoint, and is related to step 5 in Table 13. This verifies requirements PERQ-105 and PERQ-106. The red line is the DDSV's spool position, and the black line is the output pressure. The curve starts with the DDSV closed, so that there is 0 bar output pressure. Then the group opened the DDSV and transmitted a reference point at 30 bars, and as Figure 3 shows, the spool opens at around 6606,5 seconds. Then the double acting cylinder starts to move and fill up with fluid. At 6612 seconds in Figure 3, the cylinder is filled up, and the pressure is building up against the reference point. There is no overshoot, and the system has settled at 6624 seconds, so the settling time is 17,5 seconds.

6.3.1 End Evaluation

Step	Description	Evaluation	Verified by	Date
1. [NFRQ-105]	Demonstrator must have visual appeal	OK	HMS MH	16/05
2. [CORQ-102]	DDSV shall have a sufficient number of analog inputs.	Ok	HMS MH	16/05

Table 14: End evaluation B-requirements

So Figure 3, Table 13 and Table 14 verify all of the B-requirements.

6.4 C-Requirements

The group has not finished all of them. But they have managed to solve SYRQ-103 in P-regulation mode. This will say that in P-regulation mode, the demonstrator can respond to changes in supplied load. This requirement was at a later step than some other C-requirements, so the group has not fulfilled all of the steps before this requirement. See Table 15

Step	Description	Acceptance criteria	Result	Tested by	Date
1.	Make sure that section 6.1 is gone through	System shall be running with a pressure of WP, and be ready to be tested.	Ok	HMS	16/05
2. [SYRQ-100]	Monitor the spool position in LabVIEW, see if the values they show are according to those that are expected	All LabVIEW instruments must show the correct value. Valve shall be closed.	OK	HMS	16/05
3. [GIRQ-101]	Send an open command from the GUI	Valve opens. The spool position displayed in LabVIEW changes. PG-01 shall show pressure increase.	OK	HMS	16/05
4. [SYRQ-102, GIRQ-105, GIRQ-106]	Change set point for flow in LabVIEW and send it to the valve	The valve shall respond and start to regulate. See the variation of flow in the LabVIEW plot.			
5.[SYRQ-103]	Change the load on the hydraulic cylinder	The valve shall respond due to change in the load	Ok	HMS	16/05
6. [GIRQ-107]	Start the accumulated flow plot in the LabVIEW VI	Verify that the accumulated flow plot is correct.			
7. [GIRQ-108]	Load two stored curves and compare them	Verify that both curves are stored and see that the end user can read the curves.			
8. [GIRQ-109]	Use the generator function to set a desired pressure curve in LabVIEW	Verify that the valve is responding according to the pressure curve			
9.	Stop HPP	HPP shall stop running.			
10.	Set valve to disabled state in the GUI.	Valve shall enter fail-safe position. PG-01 shall drop to 0 bar.			
11.	Open ball valve.	System shall be depressurized, and the pressure gauges shall show 0 bar.			

Table 15: Procedure for C-requirements

6.4.1 End Evaluation

Step	Description	Evaluation	Verified by	Date
1. [CORQ-104]	External sensors shall detect flow.			

Table 16: End evaluation C-requirements

The DDSV demonstrator was originally planned to be equipped with an ultrasonic time of flight sensor. This could have detected the flow in the system. After some research the group decided that this sensor was too expensive, and decided not to use it. This was also approved by FMC. So the only external sensor in the DDSV demonstrator is the potentiometer, which detects movement done by the double acting cylinder.

Table 15 verifies the C-requirement SYRQ-103.

7.0 Conclusion

Test	Comments	Date
T-012	The FAT has verified all of the A- and B-requirements and one of the C-requirements. So the demonstrator is fully functional and working as it shall.	19.05.2014

Table 17: Conclusion

8.0 References

[1] Smart DDSV Demonstrator, *G-TP6 - "Test Procedure for T-012,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, - *"SJA No.2,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *U-HS - "User manual, Hydraulic System,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *U-IG - "User manual, Interface and GUI,"* HBV, Kongsberg, 2014.

[5] Smart DDSV Demonstrator, *S-RS - "Requirement Specification,"* HBV, Kongsberg, 2014.

[6] Smart DDSV Demonstrator, *S-HS - "Hydraulic System specification,"* HBV, Kongsberg, 2014.

[7] Moog. *d636&d638*. http://www.moog.com/literature/ICD/Moog-ServoValves-D638_D639-Catalog-en.pdf (10/2-2014-)

[8] Moog. *Moog Software download*. http://moogsoftwaredownload.com/ (01/05-2014)

[9] Moog. *Digital interface firmware manual, CANopen*. http://www.moog.com/literature/ICD/Moog-Valves-DIV_pQ_CANopen_Firmware-Manual-en.pdf (26/2-2014)

4.3 Other

G-xx

Risk Analysis

G-RA

Version	Date	Main Author	Co-Author	Approved by
1	27.01.2014	Nicolai Skjelsbæk		Eirik Kristoffersen
2	05.02.2014	Nicolai Skjelsbæk		Eirik Kristoffersen
3	26.02.2014	Nicolai Skjelsbæk		Eirik Kristoffersen
4	05.03.2014	Nicolai Skjelsbæk	Eirik Kristoffersen	Håkon Mørk Solaas
5	20.05.2014	Nicolai Skjelsbæk		Eirik Kristoffersen

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	05.02.2014	Edited after FMC meeting	Nicolai Skjelsbæk	Eirik Kristoffersen
2 → 3	26.02.201	Small corrections.	Nicolai Skjelsbæk	Eirik Kristoffersen
3 → 4	05.03.2014	Added "Risks during testing"	Nicolai Skjelsbæk Eirik Kristoffersen	Håkon Mørk Solaas
4 → 5	20.05.2014	Updated due to document review	Nicolai Skjelsbæk	Eirik Kristoffersen

This document is the risk analysis for the student project "SMART DDSV Demonstrator"

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
DDSV	Direct Drive proportional Servo Valve
SW	Software
WP	Working Pressure
HSE	Health, Safety and Environment

Table 1: Abbreviations

2.0 Introduction

2.1 Scope

This document is a risk analysis for the student project “SMART DDSV demonstrator”, It describes what methods that has been used to identify the probability and size of risks. It will include what shall be done to prevent the risks, and if the risk occurs, what kind of solutions there will be to move on with the assignment.

3.0 Risk analysis

3.1 Risk matrix

Probability \ Effect	1 Small	2 Medium	3 Critical	4 Disastrous
4 Very Likely	4	8	12	16
3 Likely	3	6	9	12
2 Possible	2	4	6	8
1 Unlikely	1	2	3	4

Figure 1: Risk matrix

The project group has used this matrix to identify the probability and size of risks. This maps what probability there is of the risk occurring, then what kind of effect the risk could have for the project. The group has taken both probability and effect in consideration when the risk is given a value. Therefore, some risks with greater effect than others can have a lower risk value because there is a small probability that it will happen.

For example, if there is a risk which is likely to happen and will lead to critical effect, then the risk will be $row * column = 3 * 3 = 9$. This has the color red, which means that it will damage the assignment greatly. Yellow means that we need to put resources into fixing the occurred risk. Green means that this is not a big problem, but it should be looked into.

3.2 Risks

3.2.1 HSE

These are just some overall risks about HSE. Further information can be found in the test specification [1].

3.2.1.1 Personnel damage

Case	A group member gets injured.
Risk analysis	This can happened, and could lead to critical effect on the project.
Risk value	6.
Consequences	• Not enough resources • The project could be delayed
Prevention	• Make sure that you have control over what you are working with • Use safety equipment when working with high pressure, or electrical components • Seek guidance if needed
Solutions	If there are injuries, contact medical personnel immediately. Go through the routine to make sure that this does not happen again

Table 2: Personnel damage

3.2.1.2 Environmental damage

Case	Environmental damage occurs due to the demonstrator.
Risk analysis	This can happen, and will be critical.
Risk value	6.
Consequences	• Injuries • The project could be stopped • The demonstrator could get damaged
Prevention	• Have control over the demonstrator at all time • Always think about what you are doing • Seek guidance
Solutions	If there are injuries, if needed contact medical personnel immediately. Map the damage that are done, and contact environmental expertise as soon as possible. Go through the routines to make sure that this does not happen again.

Table 3: Environmental damage

3.2.2 The assignment

Case	If the assignment fails.
Risk analysis	This is unlikely to happen, but it will be disastrous for the project.
Risk value	4.
Consequences	The study will be delayed with one year.
Prevention	• Create and follow a good project plan • Weekly follow up with supervisors • Make sure that the project plan is up to date • Ratio of delays shall be 1:1
Solutions	This has no solution.

Table 4: Assignment

3.2.3 The requirements

Further information on requirements can be found in the requirement specification [2].

3.2.3.1 A – Requirements

Case	If the demonstrator does not meet the A-requirements.
Risk analysis	This is unlikely to happen, but it will be disastrous.
Risk value	4.
Consequences	The study will not be finished, and it will not meet the critical requirements from our client.
Prevention	• Create and follow a good project plan • Prioritize A – requirements • Dedicate enough resources
Solutions	The client has to use their resources to finish the demonstrator.

Table 5: A-requirements

3.2.3.2 B-requirements

Case	If the demonstrator does not meet the B-requirements.
Risk analysis	This is possible to happen, and it will be critical for the project.
Risk value	6.
Consequences	The demonstrator will be completed, but not completely functional.
Prevention	• Create and follow a good project plan • Dedicate enough resources • As soon as the A-requirements are finished, prioritize B-requirements
Solutions	The client has to use their resources to make the demonstrator as functional as they like.

Table 6: B-requirements

3.2.3.3 C-Requirements

Case	If the demonstrator does not meet the C-requirements.
Risk analysis	This is likely to happen, but it will not have a big effect.
Risk value	3.
Consequences	The demonstrator will be finished, but it will not meet the extra requirements from our client.
Prevention	• Create and follow a good project plan • As soon as the B-requirements are finished, prioritize C-requirements, if there is time
Solutions	The client has to use their resources to make the demonstrator as functional as they like.

Table 7: C-requirements

3.2.4 Information

Case	If critical information about the demonstrator is leaked.
Risk analysis	This is unlikely to happen, but if it happens, it will have critical effect for the project.
Risk value	3.
Consequences	• There is a possibility that the relationship between client, suppliers and bachelor group will be damaged • The patent process may be in danger
Prevention	• Control the sensitive information • Make sure of good document control • Have good control of this risk
Solutions	If critical information is leaked, all of the involved parties need to be informed. Go through the procedure and improve.

Table 8: Critical Information

3.2.5 The bachelor group

Case	If there is illness, injuries or diversion in the bachelor group.
Risk analysis	This is possible to happen, and it could have critical effect on the project.
Risk value	6.
Consequences	• This could damage the project • The demonstrator may not be finished
Prevention	• Keep team spirit high • There shall be good communication
Solutions	If there is illness or injuries, the group must delegate properly. If there is any diversion, this shall be prioritized and fixed as soon as possible.

Table 9: Bachelor group

3.2.6 Supervisors

Case	Bad communication with supervisors and not enough guidance.
Risk analysis	This is unlikely to happen, but could have critical effect on the project.
Risk value	3.
Consequences	• This could damage the project • The demonstrator may not be finished • The project could get out of course without the bachelor group knowing it
Prevention	• The group shall have regular contact with supervisors • The communication with supervisors shall be good
Solutions	The bachelor group shall talk to the supervisor. If this does not work, they have to seek guidance elsewhere.

Table 10: Supervisors

3.2.7 Risks during testing

Case	Test supervisor does not meet for testing.
Risk analysis	This is unlikely to happen but will have critical effect on the project.
Risk value	3.
Consequences	• Components will not be tested when they shall • Project will be delayed
Prevention	• Regular contact with supervisor
Solutions	Schedule new appointment with test supervisor, and update project plan.

Table 11: Test Responsible

Case	Components are not sealed properly [2].
Risk analysis	This is possible to happen and will have critical effect on the project.
Risk value	4.
Consequences	• Injury may occur • Environmental damage • Test will not be approved • Sealing has to be changed • More cost for the project
Prevention	• If possible, make sure sealing is not broken and placed correctly
Solutions	If there are injuries and environmental damage, if needed contact medical personnel and environmental personnel immediately. Replace damaged sealing, and test component again. Talk to client about increased cost for component.

Table 12: Component sealing

Case	Cylinder is not working properly.
Risk analysis	This is possible to happen and will have critical effect on the project.
Risk value	4.
Consequences	• Injury may occur • Test will not be approved • More cost for the project • Project will be delayed
Prevention	• Check that everything is fitted correctly
Solutions	If there are injuries, if needed contact medical personnel immediately. If possible, repair cylinder, if not buy new cylinder, and test component again. Talk to client about increased cost for component. Update project plan.

Table 13: Cylinder

Case	Components has a pressure drop greater than 2 % of 1.65 x WP [2].
Risk analysis	This is possible to happen and will have critical effect on the project.
Risk value	4.
Consequences	• Injury may occur • Environmental damage • Test will not be approved • More cost for the project • Project will be delayed
Prevention	• Check that everything is fitted correctly
Solutions	If there are injuries and environmental damage, if needed contact medical personnel and environmental personnel immediately. If possible, repair component, if not buy new component, and test again. Talk to client about increased cost for project. Update project plan.

Table 14: Pressure drop

Case	Pressure gauge has a deviation greater than 2.5% [2].
Risk analysis	This is possible to happen but will have small effect on the project.
Risk value	2.
Consequences	• Test will not be approved • More cost for the project • Project will be delayed
Prevention	• Check that everything is fitted correctly
Solutions	If possible, repair gauge, if not buy new component, and test again. Talk to client about increased cost for project. Update project plan.

Table 15: Deviation

3.2.8 The demonstrator

3.2.8.1 Parts

Case	Wrong parts are ordered and delivered.
Risk analysis	This is unlikely to happen but could have disastrous effect on the project.
Risk value	4.
Consequences	• The demonstrator may not be finished
Prevention	• Go through component list with specialist
Solutions	Talk to supplier about getting the correct part as soon as possible, if they cannot provide the correct part in time, the bachelor group have to use SW to simulate the real valve.

Table 16: Parts

Case	The components are not working together.
Risk analysis	This could happen, and it will have critical effect on the demonstrator.
Risk value	6.
Consequences	• The demonstrator may not be finished • The project can be delayed
Prevention	• Go through component list with specialist
Solutions	Talk too supplier about getting the correct part as soon as possible, if they cannot provide the correct part in time, the bachelor group have to use SW to simulate the real valve.

Table 17: Functionality

3.2.8.2 Damage

Case	The demonstrator is damaged.
Risk analysis	This is unlikely to happen but could have disastrous effect on the project.
Risk value	4.
Consequences	• The demonstrator may not be finished • The project will fail
Prevention	• Have control over the demonstrator at all time
Solutions	Talk to supplier about getting new parts to fix the problem as soon as possible if they cannot provide the new parts in time, the bachelor group have to use SW to simulate the real valve.

Table 18: Damage

4.0 References

[1] Smart DDSV Demonstrator, *S-TS* - *"Test Specification,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *S-RS* - *"Requirement Specification,"* HBV, Kongsberg, 2014.

5.0 User-Manual documents

U-xx

User manual: Hydraulic system

U-HS

Version	Date	Main Author	Co-Author	Approved by
1	12.05.2014	Eirik Kristoffersen	Nicolai Skjelsbæk	Håkon Mørk Solaas
2	20.05.2014	Eirik Kristoffersen	Nicolai Skjelsbæk	Håkon Mørk Solaas

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	20.05.2014	Document review	Eirik Kristoffersen	Håkon Mørk Solaas

This document is the user manual for the hydraulic system to the Smart DDSV Demonstrator.

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1.0 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
HSE	Health Safety and Environment
GUI	Graphical User Interface
DDSV	Direct Drive Servo proportional Valve
HPP	Hydraulic Power Pack
PF	Pressure Filter
TD	T-Distributor
BA	Bladder Accumulator
PG	Pressure Gauge
BP	Base Plate
DAC	Double Acting Cylinder
DP	Displacement Potentiometer
ESC	Extension Spring Coil
BV	Ball Valve
HL	Hose Line

Table 1: Abbreviations

1.1 Definitions

Definition	Description
	Contents are under pressure, important to use correct HSE equipment.
	System has a dangerous voltage, risk of electric shock. Work under voltage should be avoided if possible.
	HSE, eye protection shall be worn at all time while using or handling the running demonstrator.
	HSE, protective gloves shall be worn at all time while using or handling demonstrator.
	Warning, potential danger.
	The demonstrator’s surface can be hot, so be careful with touching the surface.

	The demonstrator has moving parts, so there is a potential for crushing. When the demonstrator is running, manipulation of components shall be avoided.

Table 2: Definitions

2.0 Introduction

This document gives a description of how to use and operate the hydraulic system for the Smart DDSV Demonstrator. It will guide you through the steps from pre-start to shut down of the system.

<table>
<tr><th colspan="3">Important safety instructions</th></tr>
<tr><td>
</td><td>CAUTION

RISK OF ELECTRIC SHOCK, DO NOT OPEN ANY COVERS, PRESSURIZED UNIT.</td><td></td></tr>
<tr><td colspan="3">Caution: To reduce the risk of electric shock, do not remove cover. Do not release any couplings during operation. No user serviceable parts inside. Refer servicing to qualified personnel.</td></tr>
<tr><td colspan="2">1. Read these instructions.
2. Keep these instructions.
3. Read all warnings.
4. Follow all instructions.
5. Clean only with lint free cloth, or dry paper.
6. Do not block any ventilation openings.
7. Do not move device while operating.
8. Install in accordance with a hydraulic schematic and user manual.</td><td>9. Do not install near any heat sources such as radiators, heat registers, or other heat producing devices.
10. Only use attachments/accessories included with this device.
11. Refer all the service to qualified personnel. Servicing is required if the device is damaged such as power supply plug is damaged, liquid leakage, device does not operate normally or device has been dropped.</td></tr>
</table>

Table 3: Important safety instructions

In case of a hydraulic leakage:

Skin contact	Wash with soap and water
Eye contact	Rinse thoroughly with water immediately. If needed consult medical personnel.
Ingestion	Contact medical personnel immediately.
Wounds	Rinse thoroughly and use Band-Aid. If needed contact medical personnel.

Table 4: In case of hydraulic leakage

3.0 Installation

3.1 Equipment list

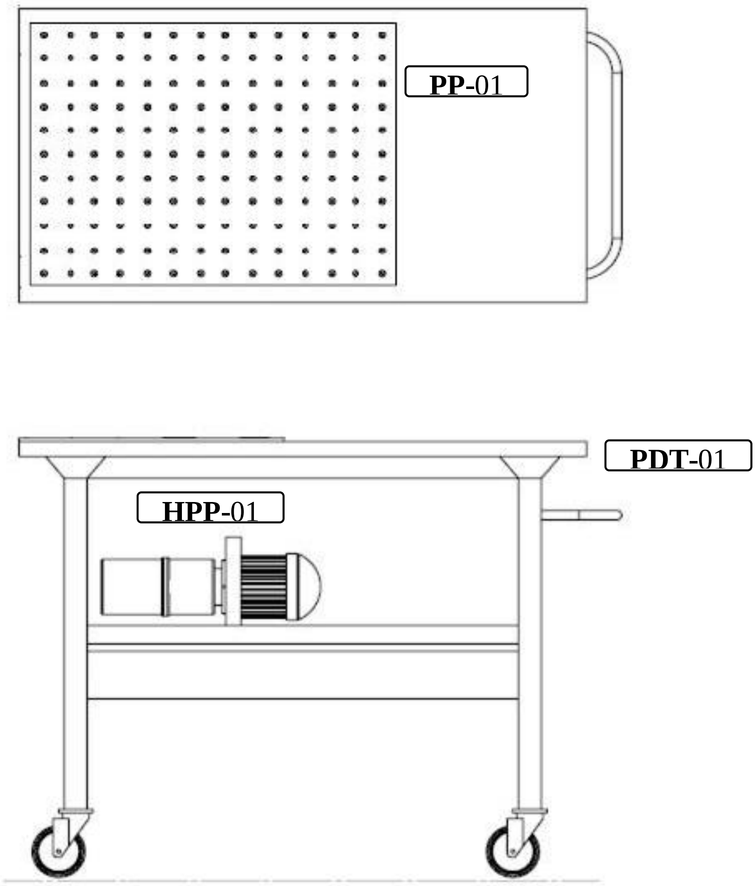
Part	Quantity
Portable demonstrator table	1
Profile plate	1
Hydraulic Power pack	1
Pressure Filter	1
T-Distributor	2
Accumulator	1
Pressure Gauge	2
Servo-Valve	1
Cylinder	1
Base-Plate	1
Ball valve	1
Hose line	10
Displacement potentiometer	1
Extension spring coil	3

Table 5: Equipment list

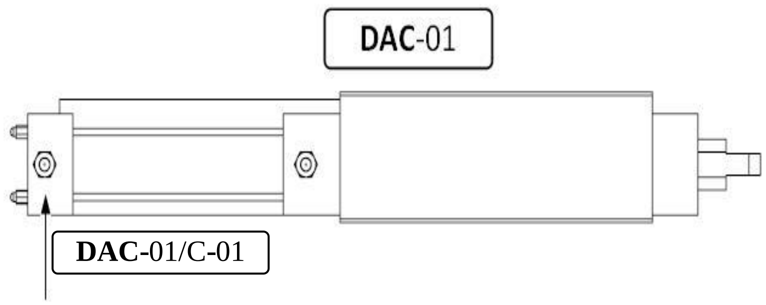
Make sure that all parts from this table are included. If anything is missing contact supplier.

3.2 Assembly

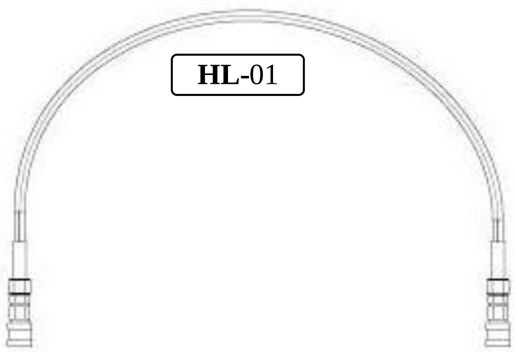
Before assembling of any components, make sure that the hydraulic power pack **HPP**-01 and the profile plate **PP**-01 is firmly attached to the portable table **PDT**-01.



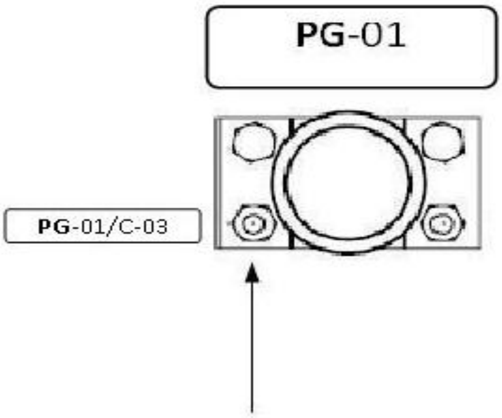
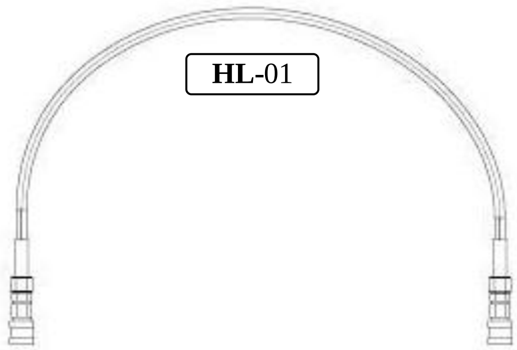
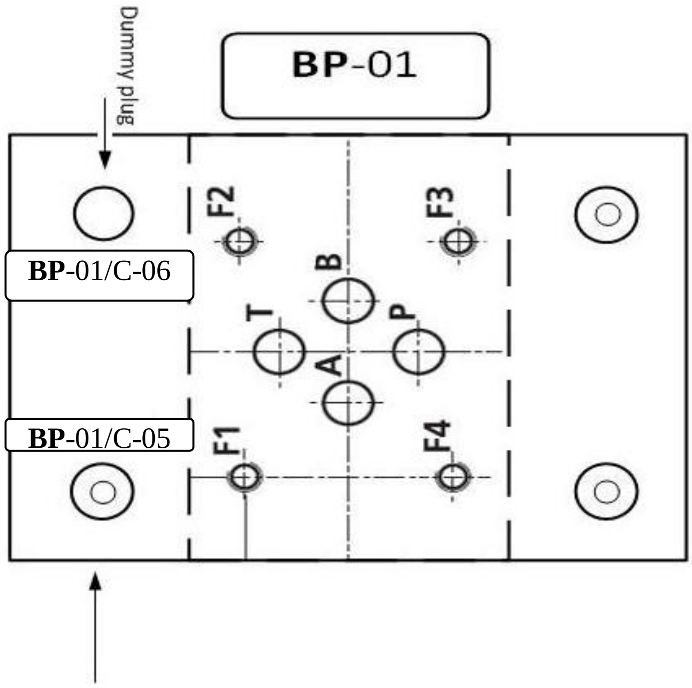
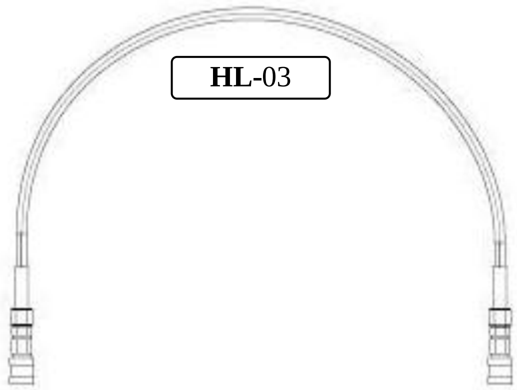
(1).

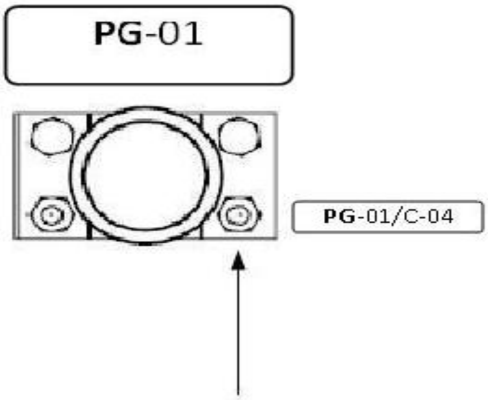


(2). Select item **DAC**-01 and mount it to marked area on **PP**-01

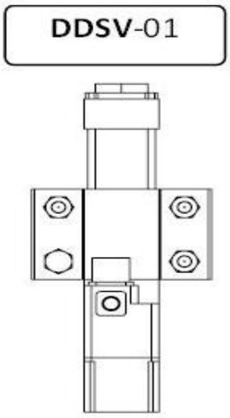


(3). Attach it with **HL**-01 to coupling nipple **DAC**-01/C-01

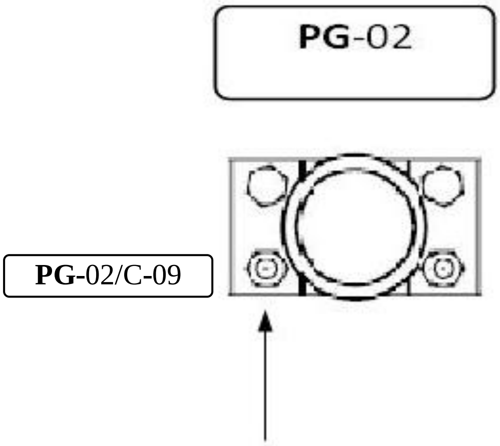
 (4). Select item **PG**-01 , and mount it to marked area on **PP**-01	 (5). Attach it with **HL**-01 to coupling nipple **PG**-01/C-03
 (6). Select item **BP**-01 , and mount it to marked area on **PP**-01 . Make sure coupling **BP**-01/C-06 is blocked by dummy plug	 (7). Attach hose **HL**-03 to coupling nipple **BP**-01/C-05



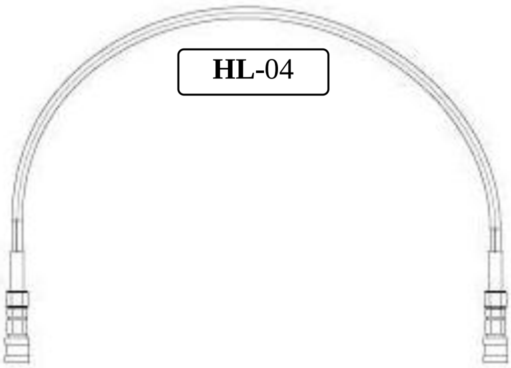
(8). Attach hose **HL**-03 to coupling nipple **PG**-01/C-04



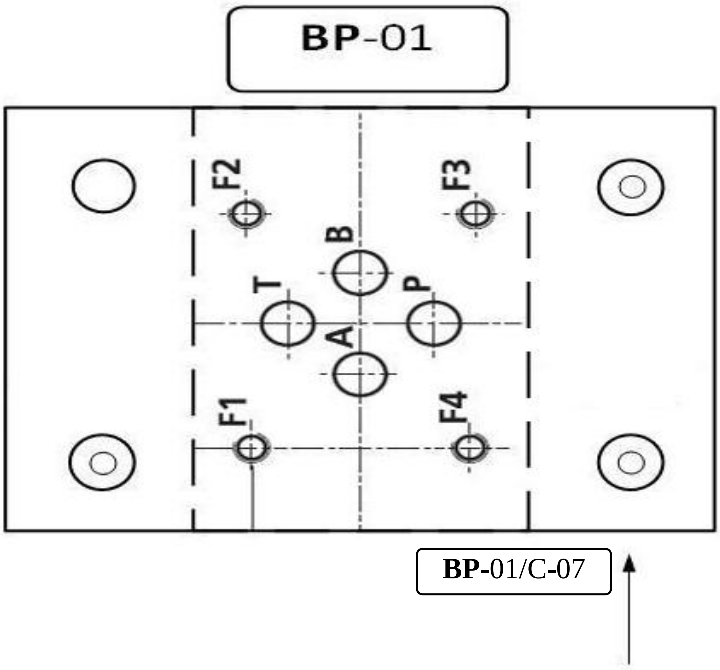
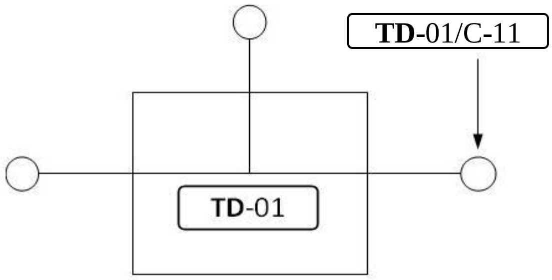
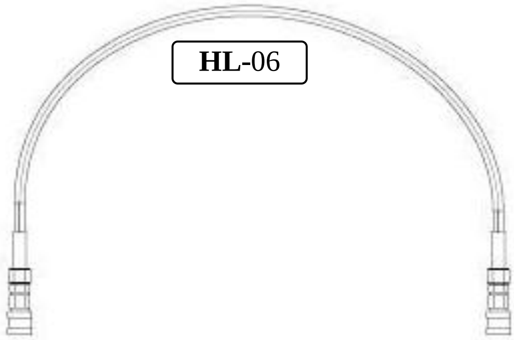
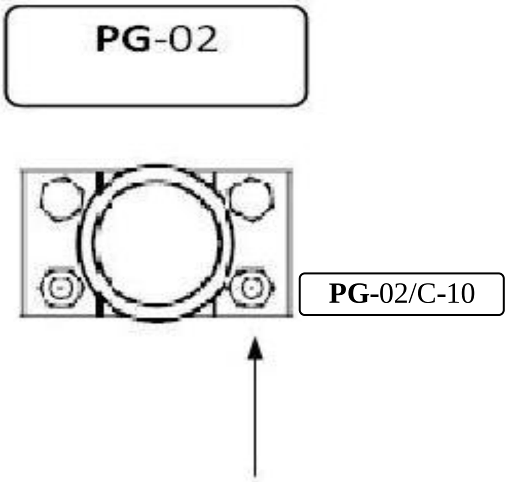
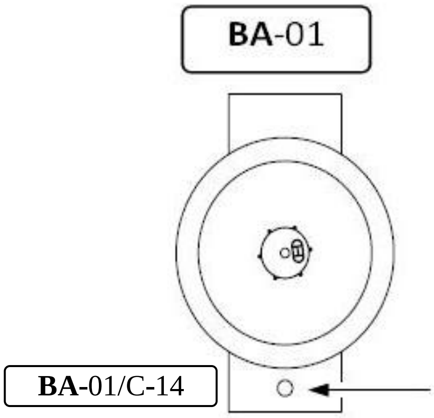
(9). Select item **DDSV**-01 and mount it with four M5x55 on to **BP**-01

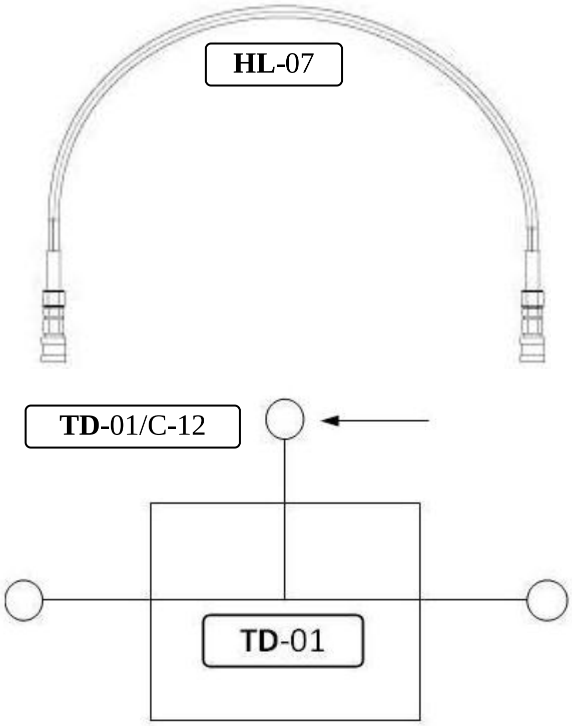


(10). Select item **PG**-02 and mount it to marked area on **PP**-01

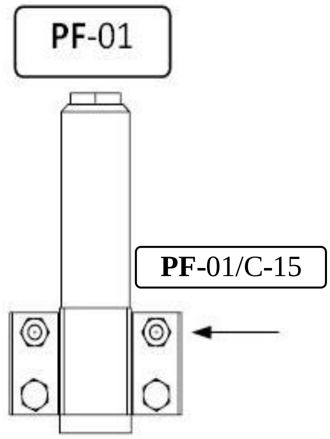


(11). Attach hose **HL**-04 to coupling nipple **PG**-02/C-09

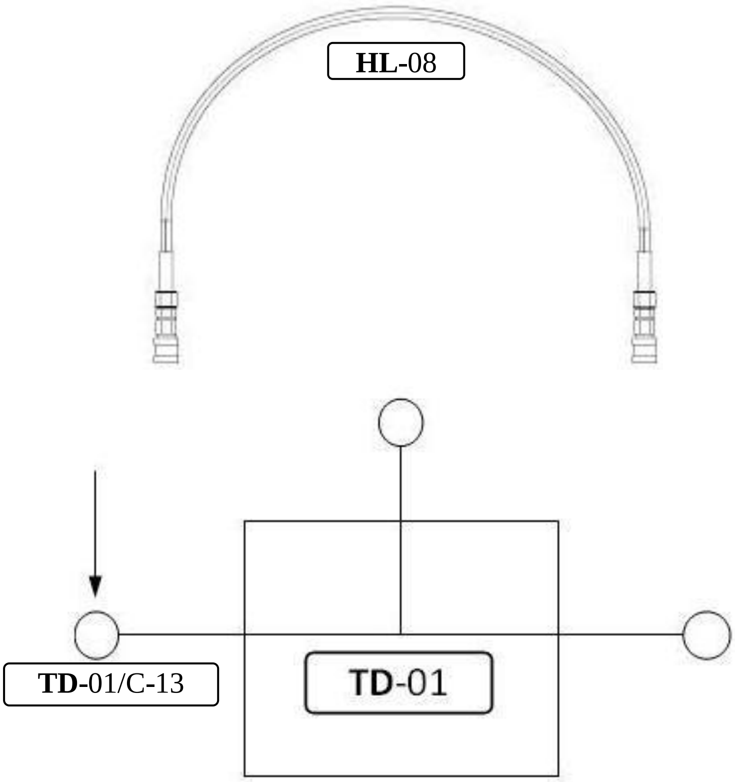
 (12). Attach hose HL-04 to coupling nipple BP-01/C-07	  (13). Select item TD-01 and attach hose HL-06 to coupling nipple TD-01/C-11
 (14). Attach hose HL-06 to coupling nipple PG-02/C-10	 (15). Select item BA-01 and mount it to marked area on PP-01



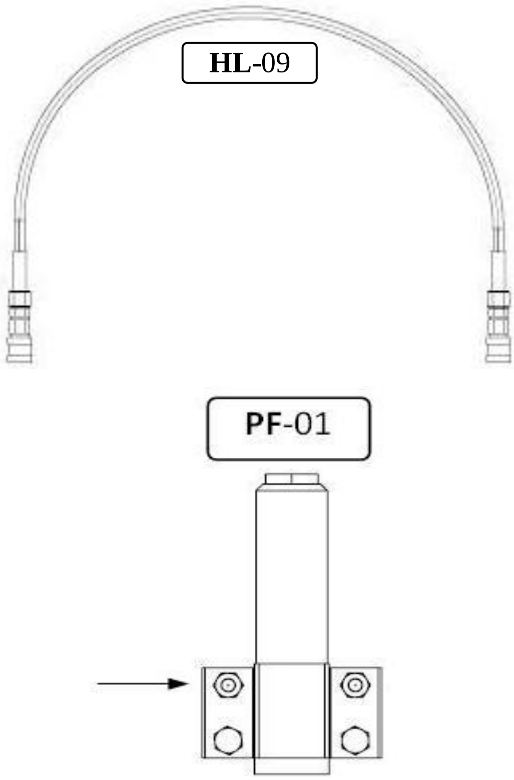
(16). Attach hose **HL-07** to coupling nipple **BA-01/C-14** and coupling nipple **TD-01/C-12**



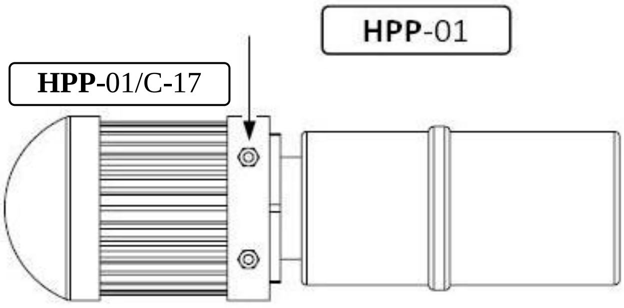
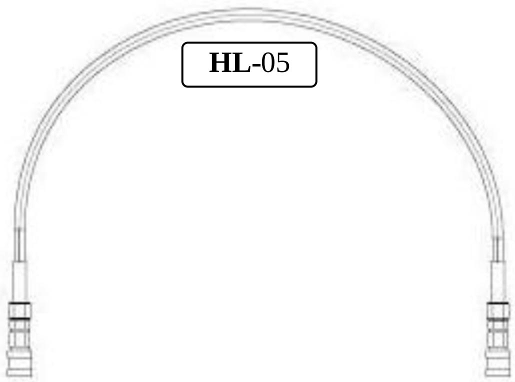
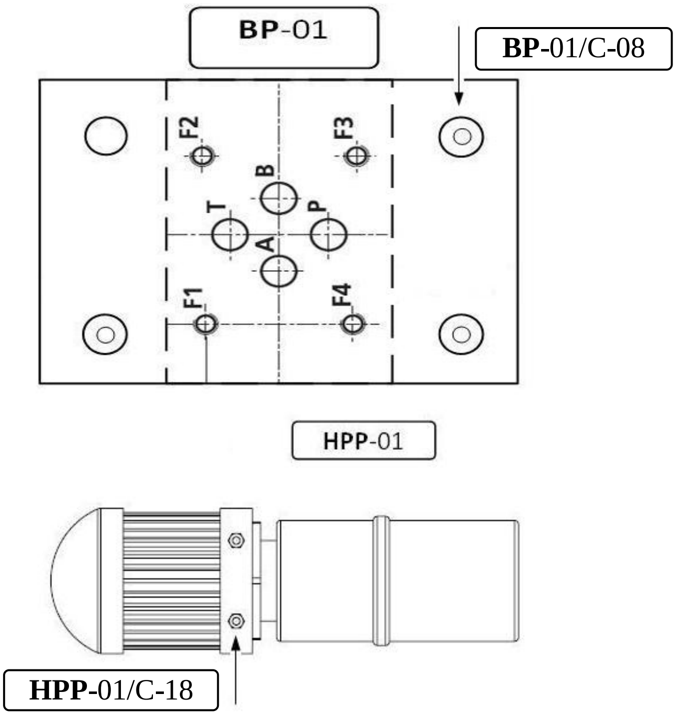
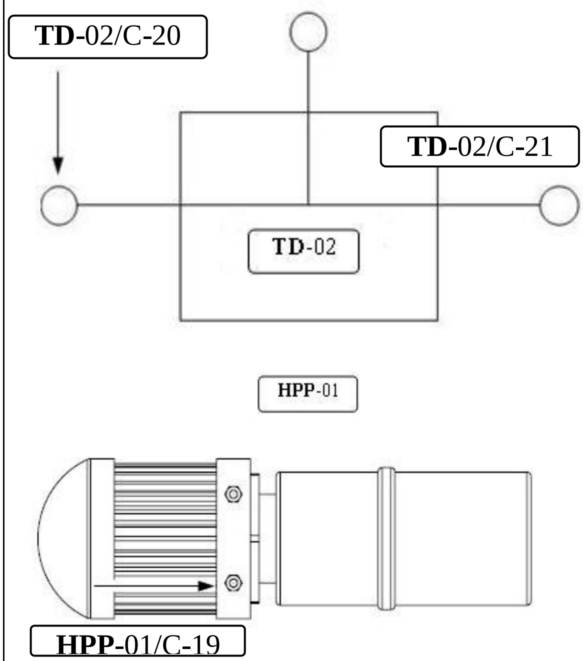
(17). Select item **PF-01** an mount it to Marked area on **PP-01**



(18). Attach hose **HL-08** to coupling nipple **PF-01/C-15** and coupling nipple **TD-01/C-13**



(19). Attach hose **HL-09** to coupling nipple **PF-01/C-16**

 (20). Attach hose HL-09 to coupling nipple HPP-01/C-17	 (21). Select hose HL-05
 (22). Attach hose to coupling nipple BP-01/C-08 and coupling HPP-01/C-18	 (23). Select item TD-02 and attach coupling socket TD-02/C-20 to coupling nipple HPP-01/C-19

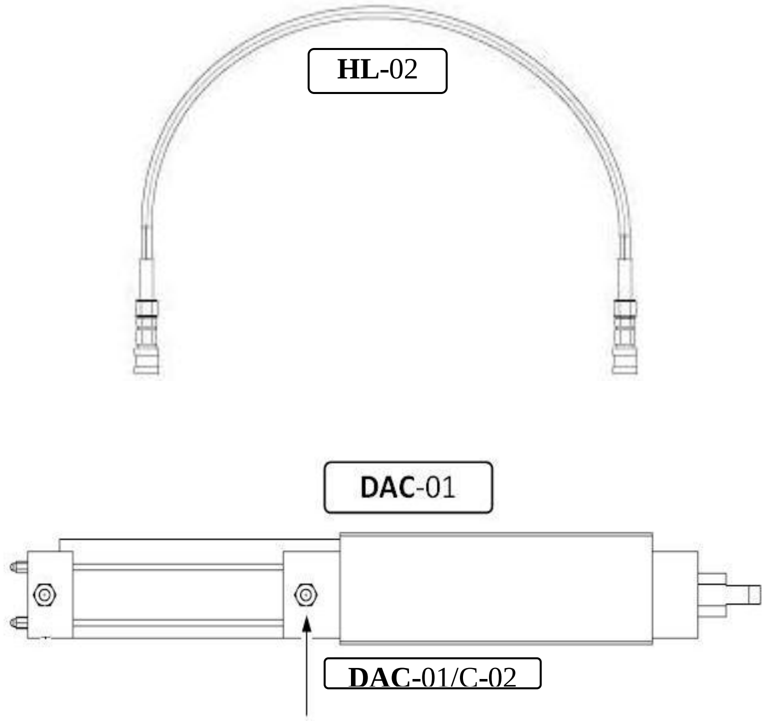
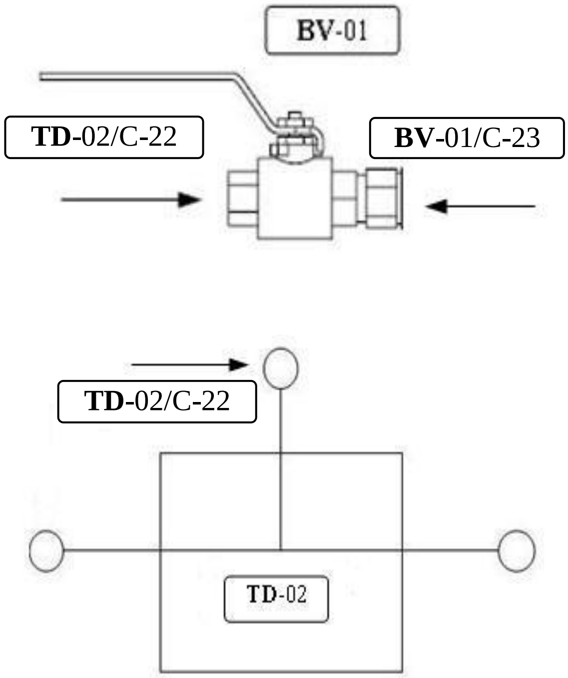
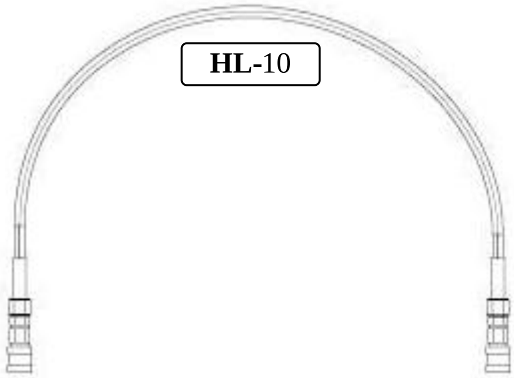
 (24). Attach hose HL-02 to coupling nipple DAC-01/C-02 and coupling nipple TD-02/C-21	 (25). Select item BV-01 and attach it to coupling TD-02/C-22 on TD-02
 (26). Select hose HL-10 and attach it to coupling nipple BV-01/C-23 and PG-02/C-24	(27).Mount the displacement potentiometer DP-01 to the cylinder DAC-01

Table 6: Assembly instructions

3.3 Hydraulic schematic

The assembly shall be done in accordance to the schematic illustrated below. Any deviation from this schematic may accentuate risk of injury and cause damage to the demonstrator.

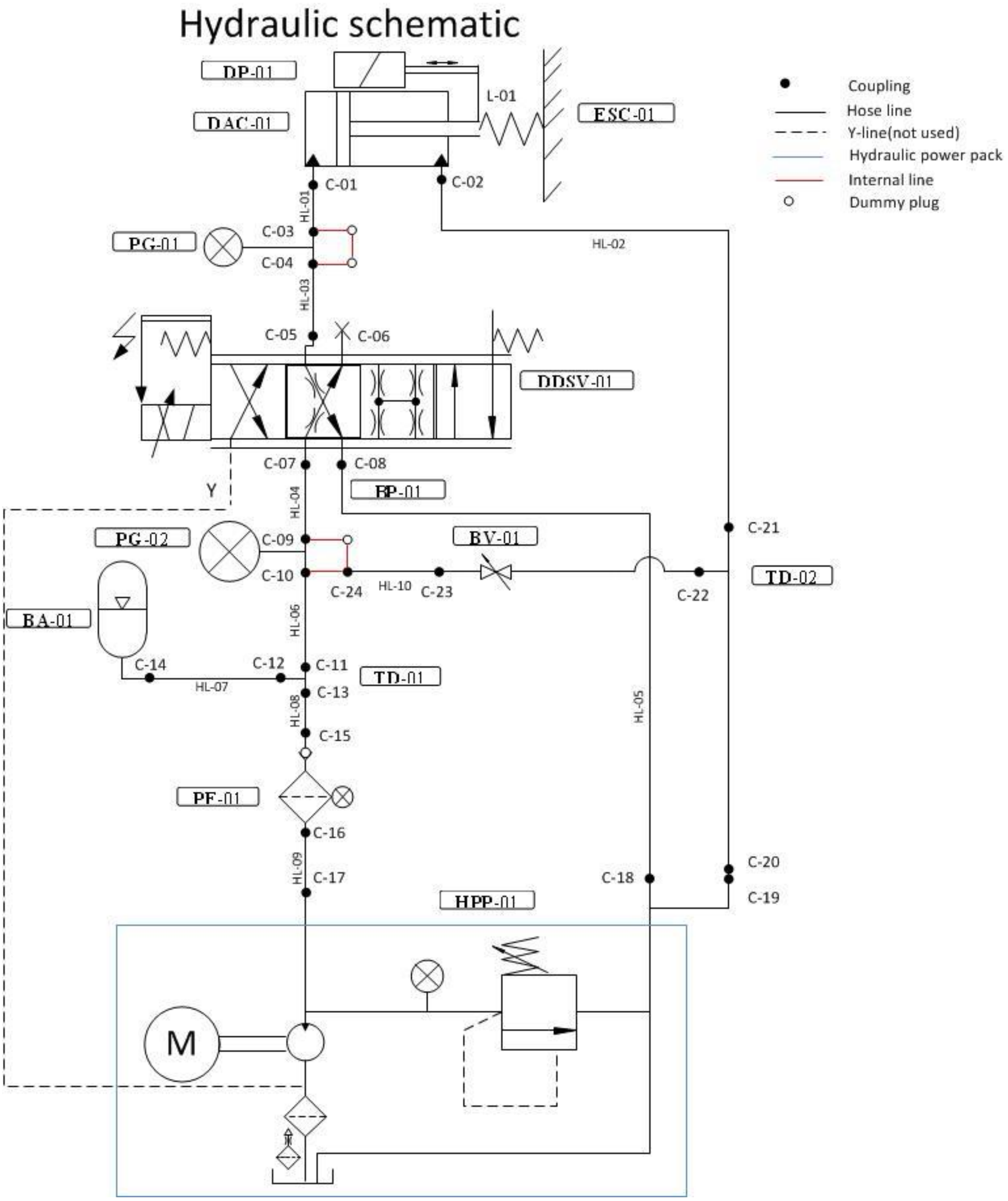


Figure 1: Hydraulic schematic

3.4 Electric schematic

For information about the electric system and electrical schematic see S-ES [1] and S-ES-A [2].

4.0 CAUTION: Read this before operating the demonstrator

4.1 Important precautions

To assure safety for users and the finest performance, please read this manual carefully. Keep it in a safe place for future reference.

CAUTION

1. HSE gear shall be worn at all time. 2. Install the demonstrator in a well ventilated, cool, dry and clean place away from direct sunlight, heat sources, vibration, dust, moisture, and/or cold. 3. Do not expose the demonstrator to sudden temperature change. 4. Avoid placing the demonstrator where foreign objects may fall onto it. 5. Do not place foreign objects on the demonstrator. 6. The demonstrator shall never be covered when in use, in order to obstruct heat radiation and contamination. 7. Do not mount the components of the demonstrator in another way than this manual says. 8. When disconnecting the power cable/AC adaptor from the wall outlet, grasp the AC plug; do not pull the cord. 9. Do not use unnecessary force on switches or hoses.	10. Operation in potentially explosive areas is not allowable. 11. The operator of the demonstrator is responsible for HSE. 12. Modifying, changing and interfering in the internal area of the DDSV may cause serious injury, and are not allowable. 13. Moving, interfering and modifying components shall be done by qualified personnel. 14. If a leakage occurs, the demonstrator shall not be used until repairs by qualified personnel are complete. 15. There shall at all time be fluid above marked minimum level in the tank. 16. The DDSV shall have good ventilation at all time. 17. It is not allowed to use the demonstrator under water. 18. The demonstrator may become very hot while in operation. 19. The demonstrator has moving parts, so when it is running it is not allowable to manipulate components.

Table 7: Important precautions

4.2 Maintenance

	Ongoing or daily	Every week or after 40 hours	Every month or after 160 hours	Every quarter or after 500 hours	Every six month or after 1000 hours	Every year or after 2000 hours
Pressure Fluid						
Level						
Temperature						
Change of fluid						
Filter						
Contamination						
Change of filter cartridge						
Clean airfilter						
Accumulator						
Control pre charged pressure						
Others						
External leakage						
Purity level area of demonstration						
Visible damages						
Noise						
Measurement devices						

While operating

Pre-start

Table 8: Maintenance

4.3 HPP service

This section describes service for the hydraulic power pack. This simple description is intended for some of the problems that may occur in the troubleshooting section 6.0 as well as the pre-start section 5.1.

Hydraulic power pack

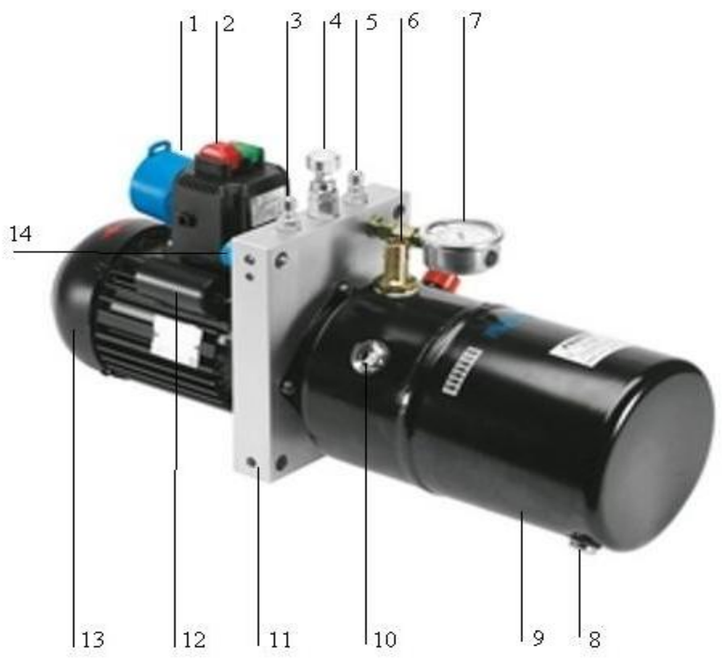


Figure 2: HPP-01

1. Fill the HPP tank (9) with Shell tellus 32 by unscrewing the orange cap. Make sure the oil level does not exceed the oil-level indicator in position (10).
2. Adjust the pressure relief valve in position (4) to the desired value.
3. To drain fluid in the tank; unscrew CCW the drain screw in position (8). Make sure a spill containment unit is placed beneath the drain screw to capture the fluid.

Table 9: HPP service

5.0 User guide

5.1 Pre-start

The very first thing that needs to be done before usage of demonstrator is to read this manual thoroughly. It is not allowable to operate or manipulate the demonstrator without reading this manual first.

Before commissioning, the complete hydraulic system shall be flushed and the hydraulic fluid shall be filtered. Make sure that the brake handle on the cylinder is “open”. All of the connections shall be checked, it is important that they are thoroughly fitted. Go over the demonstrator and check if there are any visible damages, if there are the demonstrator cannot be used. Check fluid level in tank, there shall at all times be fluid above marked minimum level in the tank. Check contamination indicator on the pressure filter, there shall be no contamination. Check that there are no kinks on the hoses. Place the portable demonstrator where it shall be and lock the brakes at the workbench wheels. It is important that the portable work bench is not moved while operating, this may cause a small quantity of fluid to exit from the HPP’s tank through the air filter. Make sure that the connection to the discharge measurement tank is capped. If the accumulator is not pre charged, this shall be done by qualified personnel.

5.2 Operating

The operation of the demonstrator is mainly done through the GUI [3], there is only a few things that need to be noticed for hydraulics while operating the demonstrator. It is important that the pressure is inside marked range on pressure gauges. If the pressure is greater/less than this range, the pressure relief valve needs to be adjusted. Make sure that there are not any foreign objects present close by the demonstrator. Do not attempt to move the demonstrator while operating. The filter has a contamination indicator, this needs to be checked visible every 10th minute [4].

If there are any clearly visible errors or unusual noises, the operation has to be stopped, and the troubleshooting section needs to be gone through thoroughly.

5.3 Post-operation

After operating the demonstrator, there are some things that shall be checked. Make sure that the demonstrator is completely turned off before starting this procedure. To be certain push down the emergency switch and disconnect the power cable.

How to check	Action
Hearing	The demonstrator shall not make any noise when turned off. If there is noise, go through these points to make sure everything is done correctly: • HPP is turned off by pushing on/off button. • Stopped demonstration through GUI • Emergency switch pushed down. • Power cable is disconnected. If there still is a noise in the system after going through these points, contact qualified personnel for repairs.
Visible	There shall be no movement in the demonstrator when turned off. If there is movement go through the same points as over.
	The pressure gauge shall show that there is no pressure left in the system. If the gauges shows that there are pressure, go through these points to make sure that everything is done correctly: • HPP is turned off by pushing on/off button. • Bleed valve is open fully. • Emergency switch is pushed down. • Power cable is disconnected. If the pressure gauges still indicates that there is pressure in the system, contact qualified personnel for repairs.
	The fluid level in the tank shall be above marked minimum level. If the level is less than this, the tank shall be refilled with Shell Tellus 22/32.
	The demonstrator shall be placed at a ventilated area, there shall not be sunlight directed at the demonstrator and the demonstrator shall not be exposed to sudden temperature changes.
	The pressure filters contamination indicator shall be checked.

Table 10: Post-operation

6.0 Troubleshooting

Before attempting to identify the problem, make sure that the demonstrator is properly turned off, and that the power cable is disconnected. Refer to the table below if the device is not working properly. If the problem you are experiencing is not listed in table below, or if the instruction below does not help contact qualified service personnel immediately. Do not attempt self-service.

Problem	Cause	Solution
The device does not start.	Power cable in not connected.	Connect the AC power cable to wall socket.
	Emergency switch is pushed in	Pull out the emergency switch
	GUI not started properly	Restart GUI
	Thermostatic switch of the electric motor is triggered internally in the HPP	Push down “off” button. Normal operation should be able to restart after a cooling phase.
The device has a leakage.	Couplings are not mounted correctly.	Attach couplings properly
	A sealing is broken.	Identify leakage position, and contact qualified service personnel for repairs.
	Hose lines are damaged	Change damaged hose line with a new one.
	Pressure gauge display is not mounted correctly to adapter plate.	Attach pressure gauge display properly to the adapter plate.
	Hose lines are not mounted correctly.	Attach hose lines properly.
There is a leakage in the DDSV’s linear force motor’s plug	Motor failure	Check ports P and T if the connection is proper. Check the maximum pressure in ports T or Y. When the Y port is not in use, the return pressure in T shall not exceed 50 bar (724 psi).
Leak at the DDSV’s connection surface	O-rings between DDSV and base-plate are damaged	Make sure that o-rings are properly seated and installation screws are tight.
Power pack has a leakage	Power pack is not mounted correctly	Mount power pack properly, follow instructions from this manual in section 3.2
The device is making unusual noises.	Fluid level is too low	Refill fluid on power supply tank, follow instructions from this manual in section 4.3

	Too high pressure	Check readings, adjust the 3-way pressure reducing valve, follow instructions from this manual in section 4.3
	Power pack is not mounted properly	Attach power pack properly to the table; make sure that all screws are tightened correctly.
	Components are not mounted properly.	Attach components properly to profile plate.
Cylinder rod is not retracting.	Spring coil is not mounted correctly.	Tightened spring coil properly.
	Brake handle tightened	Loosen brake handle.
Pressure filter indicates contamination.	Filter cartridge needs to be replaced	Unscrew filter housing, replace cartridge. Make sure that the filter housing is properly tightened when mounting it again.
Potentiometer is not working.	Potentiometer is not connected to cylinder	Connect the potentiometer to the cylinder; make sure that screws are tightened properly.
Operating pressure too high	Internal pressure relief valve in power pack not adjusted correctly.	Adjust the valve to correct position. See marking range on power pack.
Filled power pack with wrong fluid.	Instruction not read properly	Open drain screw, wait for 5 minutes and make sure that the tank is properly emptied. Pre-flush system with recommended fluid, see instructions from this manual in section 4.3

Table 11: Troubleshooting

7.0 References

[1] Smart DDSV Demonstrator, *S-ES* - *"Electrical Specification,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *S-ES-A* - *"Electrical Specification-Attachment A,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *S-IS* - *"Interface and GUI Specification,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *S-RS* - *"Requirement Specification,"* HBV, Kongsberg, 2014.

User manual: Interface and GUI

U-IG

Version	Date	Main Author	Co-Author	Approved by
1	01.05.2014	Håkon Mørk Solaas		Nicolai Skjelsbæk
2	20.05.2014	Håkon Mørk Solaas		Nicolai Skjelsbæk

Changes:

Version	Date	Changes	Released by	Approved by
1 → 2	20.05.2014	Updated due to final document review	Håkon Mørk Solaas	Nicolai Skjelsbæk

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1.0 Definitions and abbreviations

1.1 Abbreviations

The following abbreviations are used throughout the document:

Abbreviations	Description
CAN	Controller Area Network
DDSV	Direct drive servo valve
GUI	Graphical User Interface
HSE	Health, Safety and Environment
HW	HardWare
kB/s	Kilo Byte per Second
LED	Light Emitting Diode
MoVaPuCo	Moog Valve and Pump Configuration
MS	Module status
NMT	Network Management
NS	Network status
PDO	Process Data Object
SDO	Service Data Object
SW	SoftWare
USB	Universal Serial Bus
VCI	Virtual Can Interface
VI	LabView

Table 1: Abbreviations

1.2 Definitions

Abbreviations	Description
Demonstrator	Smart DDSV Demonstrator
IXXAT	IXXAT CAN-USB Compact
VI	LabVIEW Virtual Instrument file

Table 2: Definitions

2.0 Introduction

This user manual is concerned exclusively with the operation of the GUI for the demonstrator. It will not be a complete guide for operation, please see section 2.1 “Related documentation” for more information on what documents should be taken into consideration before operating the full demonstrator.

As the DDSV Demonstrator will be pressurized under operation, the operator shall follow the safety instructions provided in this document.

<table>
<tr><th colspan="3">Important safety instructions</th></tr>
<tr><td>
</td><td>CAUTION

RISK OF ELECTRIC SHOCK, DO NOT OPEN ANY COVERS. PRESSURIZED UNIT.</td><td></td></tr>
<tr><td colspan="3">Caution: To reduce the risk of electric shock, do not remove any covers. Do not release any couplings during operation. There are no user serviceable parts inside. Refer servicing to qualified personnel.</td></tr>
<tr><td colspan="2">1. Read these instructions.
2. Keep these instructions.
3. Read all warnings.
4. Follow all instructions.
5. Clean only with lint free cloth, or dry paper.
6. Do not block any ventilation openings.
7. Do not move device while operating.
8. Install in accordance with a hydraulic schematic and user manuals.</td><td>9. Do not install near any heat sources such as radiators, heat registers, or other heat producing devices.
10. Only use attachments/accessories included with this device.
11. Refer all the service to qualified personnel. Servicing is required if the device is damaged such as power supply plug is damaged, liquid leakage, device does not operate normal or device has been dropped.</td></tr>
</table>

Table 3: Important safety instructions

In case of a hydraulic leakage:

Skin contact	Wash with soap and water
Eye contact	Rinse thoroughly with water immediately. If needed consult medical personnel.
Ingestion	Contact medical personnel immediately.
Wounds	Rinse thoroughly and use Band-Aid. If needed contact medical personnel.

Table 4: In case of hydraulic leakage

2.1 Related documentation

Before operating the demonstrator, the following documentation shall be taken into consideration:

2.1.1 Documentation provided by Smart DDSV demonstrator group

- S-IS [1]
- S-VS [2]
- S-HS [3]
- S-ES [4]
- U-HS [5]
- U-IG (This document)

2.1.2 Documentation on valve provided by Moog

- User manual – Electrical interfaces [6]
- Moog – D636/D638 [7]

2.2 Intended operation

The GUI has been developed to provide a simple monitoring and controlling of the demonstrator.

Do not attempt to operate the GUI on a CANbus network other than the one specified in this document.

3.0 Installation

3.1 Equipment list

3.1.1 HW

Part	Quantity
Fully assembled demonstrator	1
Ixxat CAN-USB Compact	1
1 DE-9 male to DE-9 Female cable	1
Computer running Windows 7 or later versions	1

Table 5: Equipment list HW

3.1.2 SW

Part	Quantity
LabVIEW 2013	1
Moog Valve and Pump Configuration Tool	1
GUI LabVIEW project file (GUIDDSV.lvproj)	1
Configuration file for MoVaPuCo	1
IXXAT VCI3 Drivers	1

Table 6: Equipment list HW

The VI-file and the configuration file for MoVaPuCo will be stored on a CD. This CD shall always be stored with the DDSV. If anything is missing contact supplier. Please make sure all software is properly installed before attempting to run the GUI.

3.2 Interface connections

3.2.1 Valve interface connections

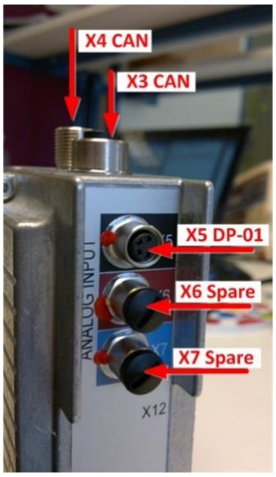


Figure 1: Valve interface connections

The valve is delivered with the X3 connector wired to the CAN network, the X5 connector wired to a displacement potentiometer, and the X1 connector wired to the 24VDC power supply. All connectors pins on the valve are wired out to the terminal blocks labelled X13. These terminal blocks are located on the demonstrator table top. For more information on the valve connections refer to S-ES [4].

Different configurations of external analog sensors may be used, but this requires a reconfiguration of the valve Firmware, as well as the LabVIEW GUI. Please contact supplier for further details on this.

3.2.2 Connecting computer to CAN-network

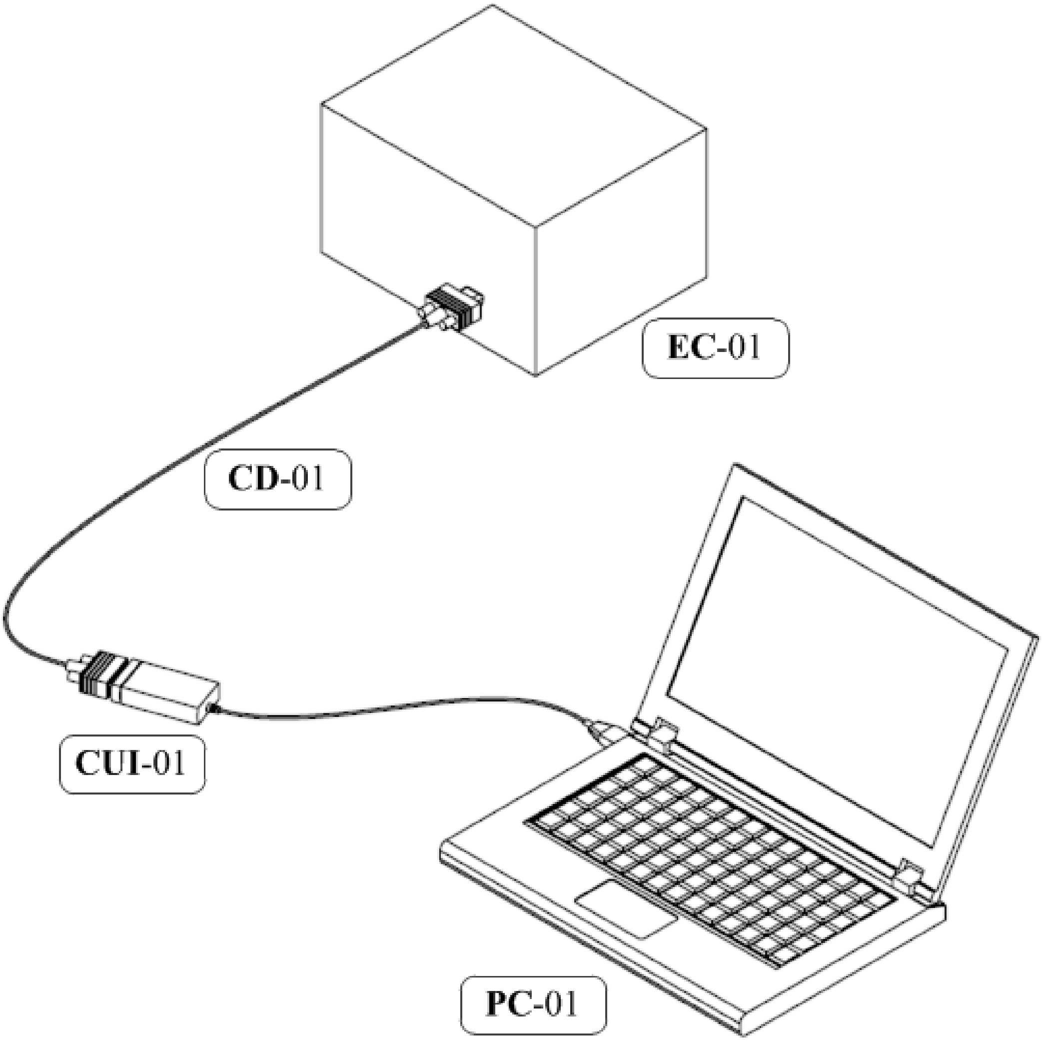


Figure 2: Wiring the computer to the demonstrator

Wire the DE-9 Cable **CD**-01 from the IXXAT **CUI**-01 to the connection point on the electrical enclosure **EC**-01 on the DDSV demonstrator. Then connect the USB-cable from the IXXAT to the computer. **PC**-01

The IXXAT has two status LED's, one labeled USB and one labeled CAN. When connecting the interface to the computer the USB light shall light green, and the CAN led shall flash green when messages is received.

4.0 Configuring the valve in MoVaPuCo

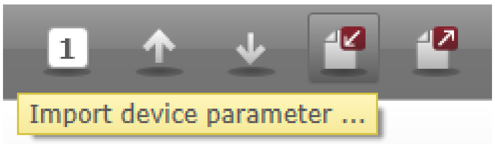
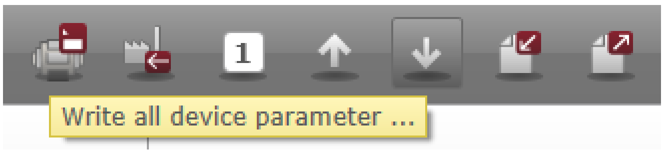
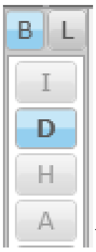
Step	Description
1	Turn on supply power to the valve by plugging the demonstrators power cable into the wall socket. Power outlets are conveniently mounted on the side of the demonstrator and may be used for charging a laptop.
2	Open MoVaPuCo. If connected properly the valve shall be displayed with the node ID 127.
3	 Select "Import device parameter" from the top bar menu.
4	 Select "File…" and browse to find the file smartddsv.log on the attached CD. Select "All device parameter" and select import.
5	 Select write all device parameter, to write the parameter to the valve.
6	 Verify that the mode of the valve is set to bus mode, and the device mode is disabled.
7	Close MoVaPuCo

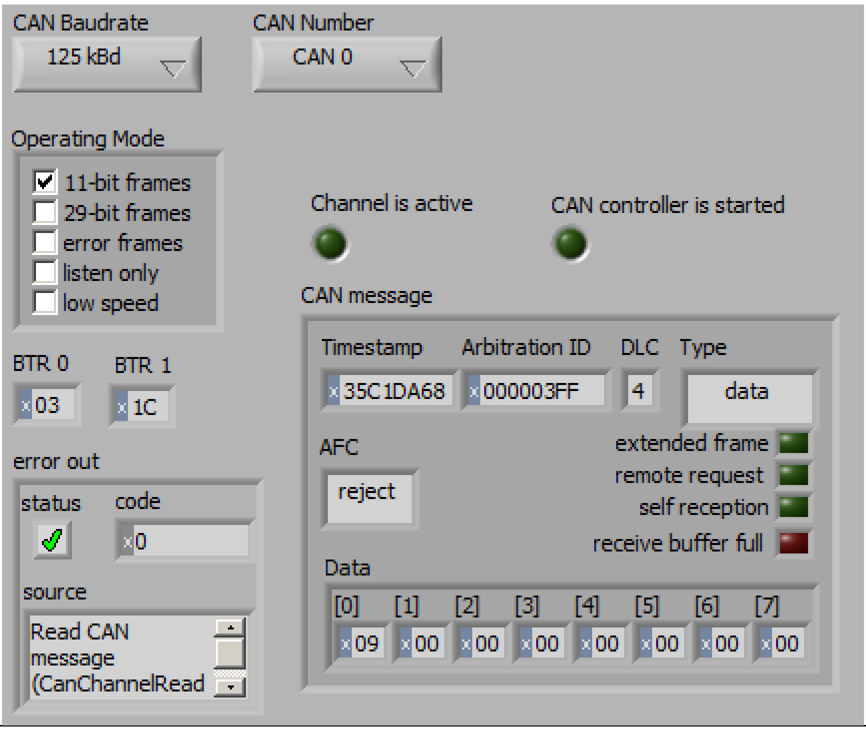
Table 7: Valve configuration steps

5.0 Configuring the LabVIEW GUI

5.1 Start-up

<table>
<tr><th>Step</th><th>Description</th></tr>
<tr><td>1</td><td>Disconnect and reconnect the USB cable to the computer.</td></tr>
<tr><td>2</td><td>Open LabVIEW project “GUIDDSV.lvproj” found on the attached CD</td></tr>
<tr><td>3</td><td>Open the VI “GUIDDSV.vi”</td></tr>
<tr><td>4</td><td>Open the CAN configuration tab:

Baud rate shall be set to 125 kB/s
CAN Number shall be set to 0
Operating mode shall be set to 11-bit frames


</td></tr>
</table>

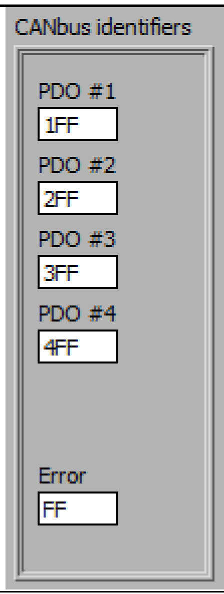
5	In the field labeled CANbus identifiers enter the values shown in the picture on the right.	
6	Run the LabVIEW VI. Make sure that no error message is returned, and that the indication lights “Channel Active” and “CAN controller started” has a green light.	
7	On the DDSV back panel there is a light labeled “NS”, this should now be flashing green, indicating that the valve has entered “NMT Pre-operational”.	
8	Under the operation tab, open the pull down menu labeled “NMT state” commands. Select “NMT operational”, and press “Send message”. Control that the “NS” light on the valve is shining green.	
9	The GUI should now be able to read the sensor values from the valve.	
10	Open the CAN configuration tab, check if the CAN message field is constantly updating.	

Table 8: LabVIEW configuration steps

5.2 Initialization

On start up the valve will be in a disabled mode to ensure that it starts up in the fail-safe position. In order for the valve to start transmitting messages, it will need to run an initialization routine. It is important that the demonstrator is in depressurized state when the initialization is run.

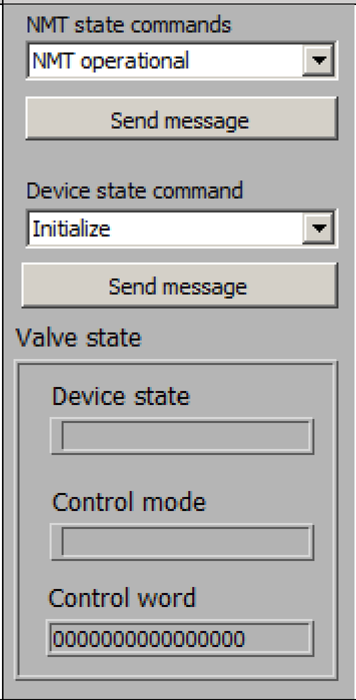
Step	Description
1	 Open the drop down labeled “Device state command” select “Enable”. The valve will now enter enabled state, and the MS light shall have a constant light. The spool position should now be 0%.
2	Check that the device state displayed in LabVIEW is showing the correct state, and that the control mode is set to “Q open loop”.

Table 9: LabVIEW initialization steps

5.3 Pre operational check routine

This routine needs to be followed before pressurizing the system. The purpose of this routine is to make sure that the communication between the valve and computer is working properly before introducing any pressure.

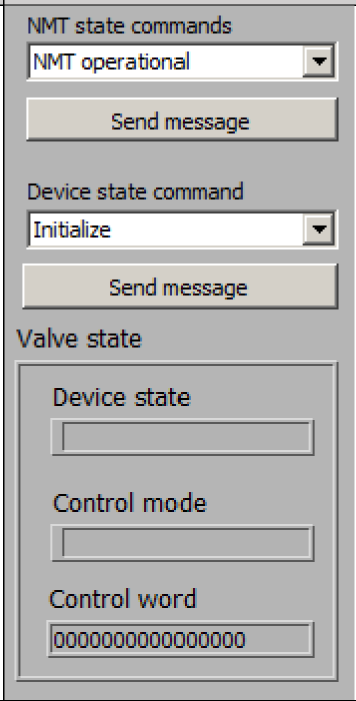
<table>
<tr><th>Step</th><th colspan="2">Description</th></tr>
<tr><td>1</td><td>
</td><td>Open the drop down labeled “Device state command”, select “Enable”. The valve will now enter enabled state, and the NS LED on the valve shall have a constant green light. The spool position should now be 0%.</td></tr>
<tr><td>2</td><td colspan="2">Check that the device state displayed in LabVIEW is showing the correct state, and that the control mode is set to “Q open loop”.</td></tr>
<tr><td>3</td><td colspan="2">Press the open valve button. If successful the valve will make a noise, and the displayed spool position in LabVIEW will be displayed as 100%.</td></tr>
<tr><td>4</td><td colspan="2">Press the close valve button. If successful the valve will make a noise, and the displayed spool position in LabVIEW will be displayed as 0%.</td></tr>
<tr><td>5</td><td colspan="2">Send an arbitrary value (0%-100%) as a set point for spool position. The displayed spool position should adjust to this position, and the same value shall be displayed in the field labeled “current set point spool”. The displayed control mode shall now be “spool (closed loop).</td></tr>
<tr><td>6</td><td colspan="2">Send an arbitrary value (0-60 bar) as a set point for pressure. Check that the displayed value in the field labeled “current set point pressure” is the same as the value sent from the computer. The displayed control mode shall now change to “pressure (closed loop)”.</td></tr>
<tr><td>7</td><td colspan="2">Change the device state to disabled, the spool position should now read -22.7% (fail-safe-mode).</td></tr>
</table>

Table 10: Pre operational check routine

6.0 Operating the demonstrator

Once the pre-operational check routine has been run, the valve will be ready for operation. And the operator may follow the instructions in U-HS [5] to start the hydraulic system.

6.1 CAUTION: read before introducing pressure

 **CAUTION** 	
1. HSE gear shall be worn at all time. 2. Install the demonstrator in a well ventilated, cool, dry and clean place away from direct sunlight, heat sources, vibration, dust, moisture, and/or cold. 3. Do not expose the demonstrator to sudden temperature change. 4. Avoid placing the demonstrator where foreign objects may fall onto it. 5. Do not place foreign objects on the demonstrator. 6. The demonstrator shall never be covered when in use, in order to obstruct heat radiation and contamination. 7. Do not mount the components of the demonstrator in another way than this manual or U-HS [5] says. 8. When disconnecting the power cable/AC adaptor from the wall outlet, grasp the AC plug; do not pull the cord. 9. Do not use unnecessary force on switches or hoses.	10. Operation in potentially explosive areas is not allowable. 11. The operator of the demonstrator is responsible for HSE. 12. Modifying, changing and interfering in the internal area of the DDSV may cause serious injury, and are not allowable. 13. Moving, interfering and modifying components shall be done by qualified personnel. 14. If a leakage occurs, the demonstrator shall not be used until repairs by qualified personnel are complete. 15. There shall at all times be fluid above marked minimum level in the tank. 16. The DDSV shall have good ventilation at all time. 17. It is not allowed to use the demonstrator under water. 18. The demonstrator may become very hot while in operation. 19. The demonstrator has moving parts, so when it is running it is not allowable to manipulate components.

Table 11: Read before introducing pressure

6.2 Controlling the hydraulic pump

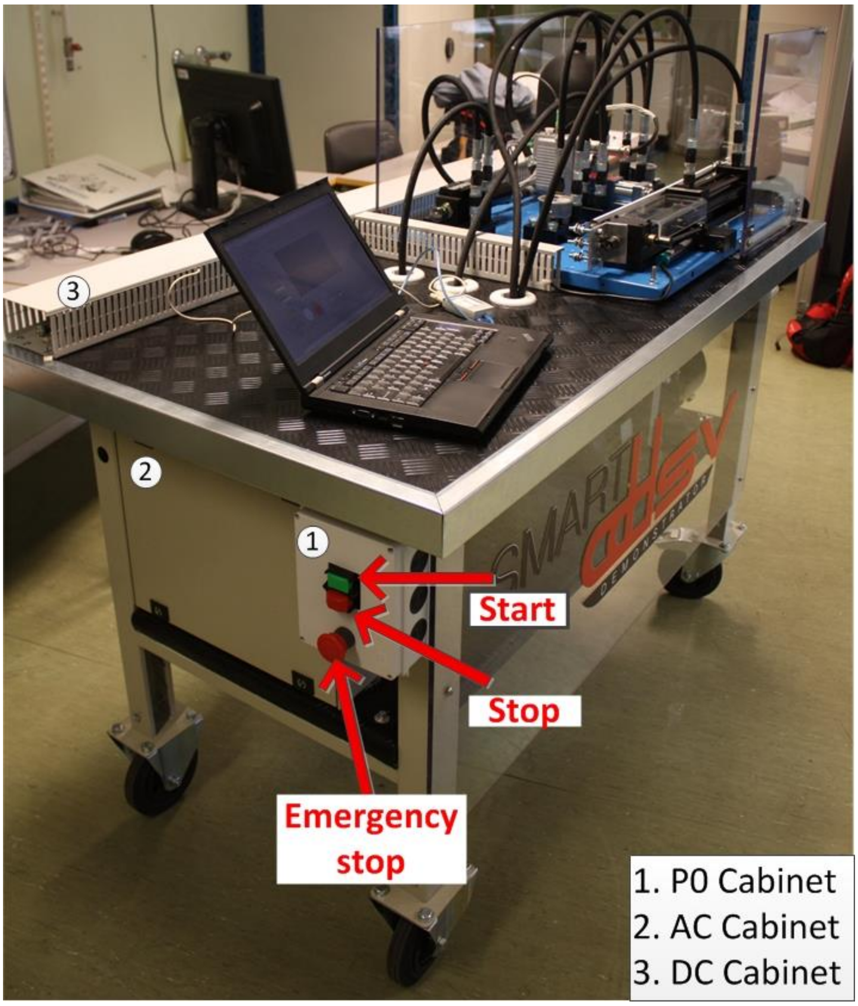


Figure 3: Demonstrator pump control

Figure 3 shows the full demonstrator table, the end user may control the pump by using the three buttons located on the P0 cabinet.

6.2.1 Pump start-up

Step	Description
1	Make sure that the valve is set to disabled mode.
2	Verify that the ball valve located at the pumps return port is closed, and that the fluid level in the tank is above the marked minimum level. For more information see U-HS. [5]
3	Press the start button on the P0 cabinet.
4	The pump should now be running, and the working pressure may be adjusted by using the pressure relief valve on the pump.

Table 12: Pump start-up

6.3 Emergency stop procedure

If an emergency occurs it is important that this procedure is followed.

Step	Description
1	Push the emergency stop button.
2	Relocate to a safe distance.
3	Make sure the demonstrator has returned to a safe state.
4	Once the demonstrator is verified to be in a safe state the user may open the ball valve located at the pumps return port to bleed off the pressure. The hydraulic fluid should now be returned to the tank.
5	Start the troubleshooting procedure.

Table 13: Emergency stop

6.4 Pump shut-down

Step	Description
1	Set the valve to disabled mode.
2	Push the pumps stop button located on the P0 cabinet.
3	Let the system settle for 5 minutes, and open the ball valve located at the pumps return port.

Table 14: Pump shut-down

6.5 Main functions

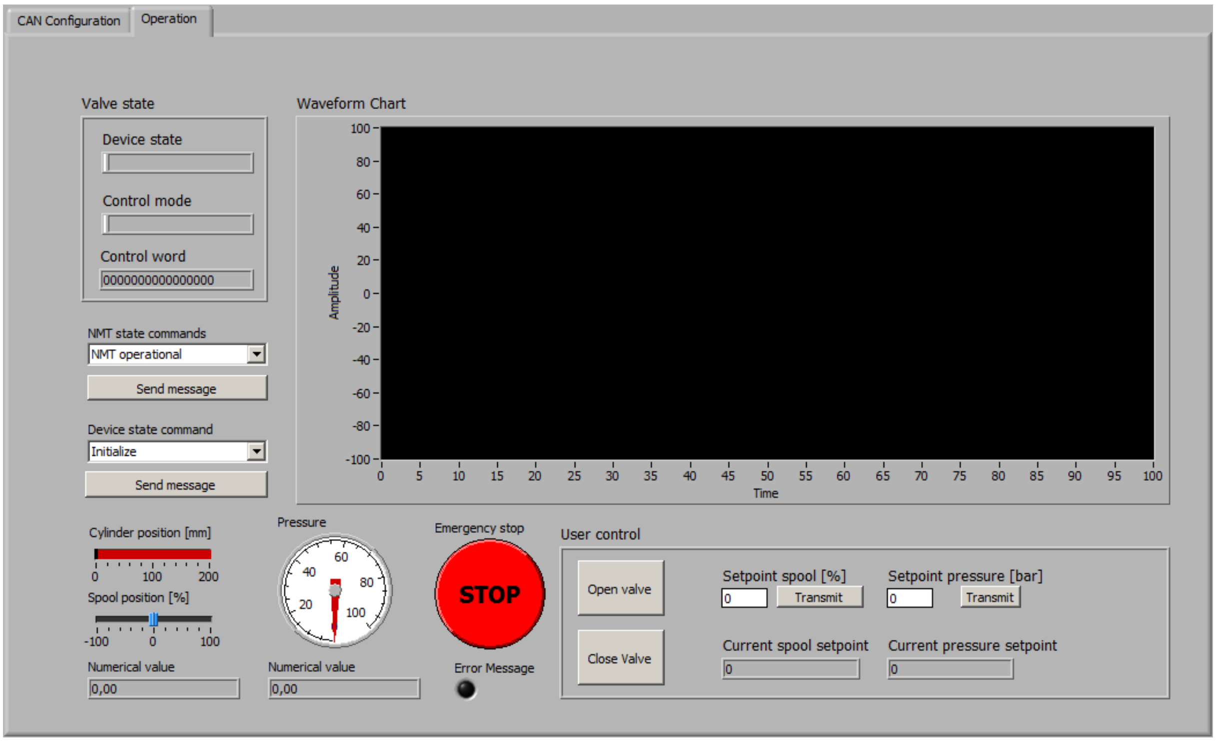


Figure 4: Smart DDSV Demonstrator GUI

Once the system has been pressurized the user may use the GUI to operate the valve to control pressure and flow on the demonstrator.

6.5.1 Open/close

The functions for opening and closing the valve are located in the “User control” panel. By pressing the buttons labeled “Open valve” or “Close valve”, the valve spool position will change accordingly.

6.5.2 Sending pressure/spool set point

The functions for sending spool and pressure set points are located in the “User Control” panel. From here the user may send a requested pressure from 0-60 bar, or a spool set point from 0-100%. Once the user presses the transmit button the valve will automatically switch to the requested control mode.

7.0 Shut down

Step	Description
1	Send a device state command to set the valve in disabled mode.
2	Send a NMT state command to set the valve in NMT Pre-operational, to prevent it from receiving unwanted control commands.
3	Run the post-operation routine specified in U-HS [5]
4	Unplug the demonstrators power cable.

Table 15: Shut down procedure

8.0 Troubleshooting

8.1 Status indicators

An understanding for the status indicator lights is helpful when troubleshooting, as it will give a clearer idea of what component is causing the error.

8.1.1 Status lights IXXAT

8.1.1.1 LED "USB"

LED "USB"	Description
Off	No power
Green	CAN communication is possible
Red	CAN communication not possible

Table 16: USB status lights IXXAT

8.1.1.2 LED "CAN"

LED "CAN"	Description
Off	No power
Flashing green	Message received or transmitted without error
Flashing red	Messages received with error
Constant red	"Bus off" mode

Table 17: CAN status lights IXXAT

8.1.2 Status lights valve

8.1.2.1 Module LED MS

Module status LED "MS"	Description	Device state (Status word)
Off	No Power Supply	
Blinking green	Standby operational mode	'INIT' or 'DISABLED'
Green	Normal operation	'HOLD' or 'ACTIVE'
Blinking red	Correctable fault	'FAULT' or 'FAULT_HOLD'
Red	Unrecoverable error	'NOT_READY'

Table 18: Valve LED MS

8.1.2.2 Module LED NS

Module status LED "NS"	Description	Network management status (NMT)
Off	No power supply or in the 'STOPPED' status	'Stopped'
Blinking green	SDO communication is possible.	'Pre-operational'
Green	Device is in 'Operational' mode, both PDO and SDO communication is possible.	'Operational

Table 19: Valve LED NS

8.1.3 Status LabVIEW

Status indicator	Cause	Solution
'CAN controller started'	Initialized communication with the CANbus network is successful.	
'Channel is active'	Receiving messages from the CANbus network.	
'Extended frame'	Extended frame message received.	
'Remote request'	Remote frame message received.	
'Self reception'	Reception of messages sent from the computer.	
'Receive buffer full'	Not able to receive new messages from the IXXAT VCI.	
'Error Message'	Error message sent from valve.	

Table 20: Status messages LabVIEW

8.2 Errors

Problem	Cause	Solution
Computer unable to connect to the IXXAT.	USB-cable not properly connected	Reconnect USB-cable
	VCI V3 driver not installed	Install VCI V3 driver and reconnect.
Communication between computer and valve is not working	Cable break	Check that electrical wiring is according to S-ES [4]
	Baud rate is set to the wrong value.	Stop running the GUI. Set the baud rate to 125 kb/s. Reconnect the USB cable and run again.
	PDO-channels in LabVIEW GUI is not configured correctly	See section 5.0 , open the configuration tab and follow the steps.
	PDO-channels are not set up correctly in MoVaPuCo.	Stop running the LabVIEW GUI. Reconnect the USB cable and open MoVaPuCo. Run the configuration routine.
	Valve has been assigned the wrong node-ID	Stop running the LabVIEW GUI. Reconnect the USB cable and open MoVaPuCo. Run the configuration routine
Valve does not power on	Cable break	Check that electrical wiring is according to S-ES-A [8]
Computer is able to change the device state, but does not receive sensor values	PDO configuration is not correct.	Open the CAN configuration tab in LabVIEW, check that the CANbus identifiers are according to the values in section 5.0.
Valve unexpectedly enters disabled mode	Safety feature that indicates a communication breakdown.	Stop the LabVIEW GUI, check all interface cables and run setup again.

Table 21: Troubleshooting

9.0 References

[1] Smart DDSV Demonstrator, *S-IS* - *"Interface and GUI Specification,"* HBV, Kongsberg, 2014.

[2] Smart DDSV Demonstrator, *S-VS* - *"Valve specification,"* HBV, Kongsberg, 2014.

[3] Smart DDSV Demonstrator, *S-HS* - *"Hydraulic System specification,"* HBV, Kongsberg, 2014.

[4] Smart DDSV Demonstrator, *S-ES* - *"Electrical Specification,"* HBV, Kongsberg, 2014.

[5] Smart DDSV Demonstrator, *U-HS* - *"User manual, Hydraulic System,"* HBV, Kongsberg, 2014.

[6] Moog. *Eletrical interfaces*. http://www.moog.com/literature/ICD/Moog-Valves-DIVelectricalInterfaces-Manual.pdf (26/2-2014-)

[7] Moog. *d636&d638*. http://www.moog.com/literature/ICD/Moog-ServoValves-D638_D639-Catalog-en.pdf (10/2-2014-)

[8] Smart DDSV Demonstrator, *S-ES-A* - *"Electrical Specification-Attachment A,"* HBV, Kongsberg, 2014.