Manual for Dynamic Triaxial Cell

Pedersen, Thomas Schmidt; Ibsen, Lars Bo

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Thomas Schmidt Pedersen
Lars Bo Ibsen

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Manual for Dynamic Triaxial Cell

by

Thomas Schmidt Pedersen
Lars Bo Ibsen

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Contents

1 Test description

This report is a test report that describes the test setup for a dynamic triaxial cell at the Laboratory for Geotechnique at Aalborg University. The dynamic triaxial cell has the same construction as a standard triaxial cell, but with the possibility to apply any kind of load sequence to the test sample. A sketch of the test setup is illustrated on Figure 1.1.

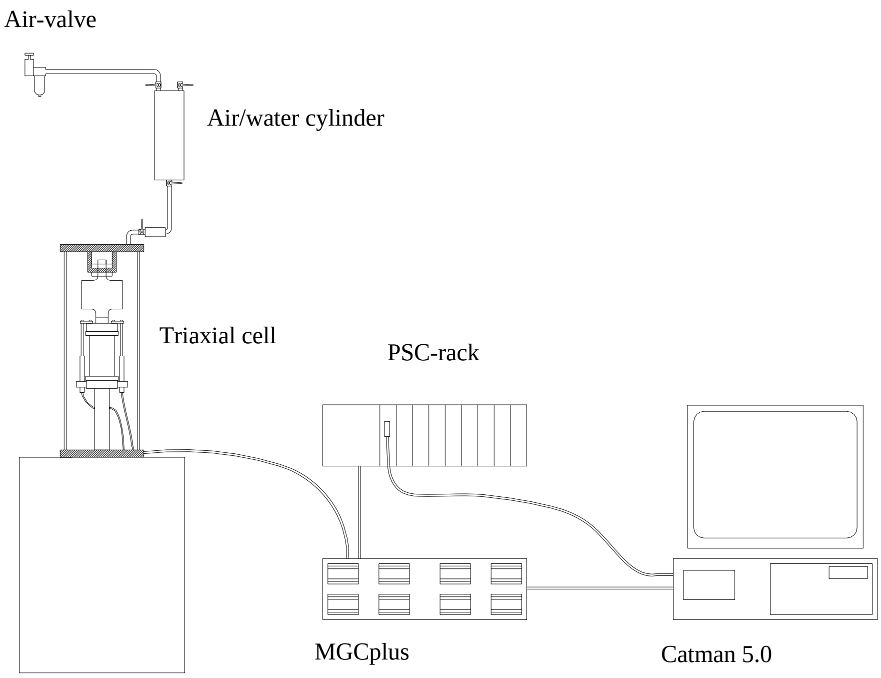


Figure 1.1 Dynamic triaxial cell setup.

The figure shows how the dynamic triaxial tests are conducted via a computer and an amplifier system that controls a hydraulic piston. The hydraulic piston applies the load to the test sample. During the test, data is being collected through various transducers placed in the triaxial cell, to a data file on the computer.

In the following, the test setup is described including the different instruments used to perform the tests. The tests are controlled from the control station shown in Figure 1.2.

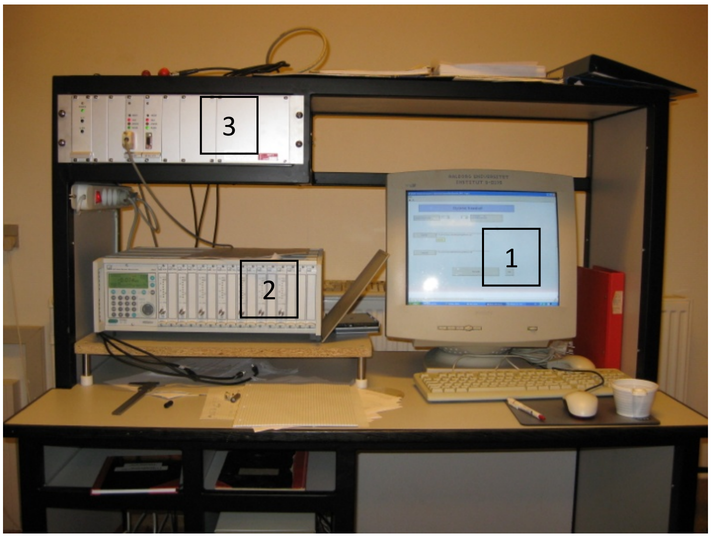


Figure 1.2 Control station.

The control station consists of three different instruments. A computer that both run a pre-programmed load sequence and store collected data in a data file. The computer is numbered 1 in Figure 1.2. The computer is directly connected to the amplifier system MGCplus numbered 2 in Figure 1.2. The amplifier system is controlled through the program Catman. 5.0. When the load sequence is executed in Catman 5.0, a volt signal is send from the MGCplus to the Programmable Servo Controller card (PSC-card) placed in a PSC-rack numbered 3 in Figure 1.2.

The PSC-card controls the hydraulic piston through a hydraulic servo valve and a feedback signal from one of the transducers in the triaxial cell. The PSC-card constantly controls whether or not the feedback signal is in accordance with the desired load and corrects the piston movement accordingly. The piston has a build in displacement transducer that can be used for the feedback signal.

The triaxial cell has five transducers inside, a load cell, two displacement transducers and two pressure transducers. The load cell and one of the displacement transducers can also be used for the feedback signal. Hence the triaxial test can be controlled through load and deformation. The load cell is placed on top of the test sample in the cell. The two displacement transducers are placed on each side of the test sample. One of the pressure transducers measures the pressure in the cell and the other measure the pressure in the sample.

The five transducers in the cell and the build in displacement transducer in the piston transmit the signals to the MGCplus amplifier system that relays it both to the computer and the PSC-rack. The computer stores the data on the hard disk.

2 The triaxial cell

The triaxial cell is constructed at the Laboratory for Geotechnique at Aalborg University. It is constructed as the other triaxial cells in the laboratory but with a hydraulic piston to apply load to the test sample instead of an electrical motor. The triaxial cell is shown in Figure 2.1 and the control board that allows air and water flow is shown in Figure 2.2. The control board both control the water and air flow to the cell and the test sample.

Figure 2.1 Triaxial cell.

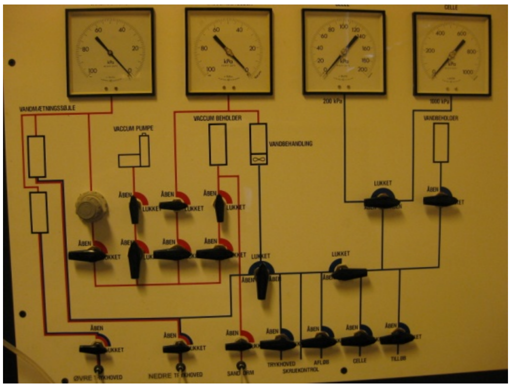


Figure 2.2 Control board for water/air flow.

The hydraulic piston used in the cell has to be turned on before each test and off after the test to protect the hydraulic pump. The pump is activated on the circuit breaker panel, cf. Figure 2.3, by switching “Styrestrøm” to on and then press the “on” button. This should light up “Kontrollampe pumpe” and activate the hydraulic piston.

Figure 2.3 Circuit breaker panel for hydraulic pump.

Another difference from the standard triaxial cells is the method to apply cell pressure. The cell pressure is applied with air from the air pressure supply system in the laboratory. This is done through an air valve cf. Figure 2.4 connected to the triaxial cell via a cylinder cf. Figure 2.5.

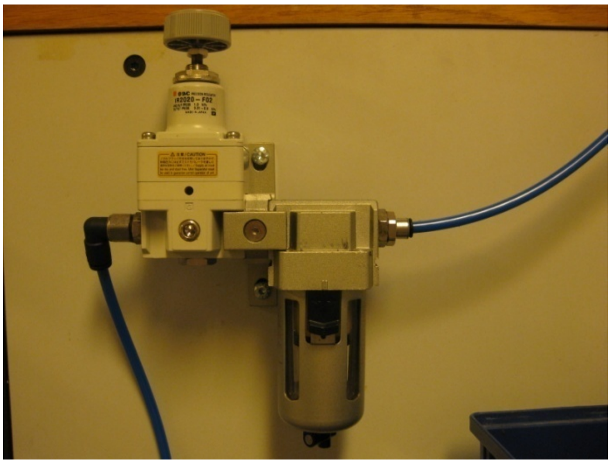


Figure 2.4 Air valve.

Figure 2.5 Air/water cylinder.

The valve applies air pressure to the cylinder which is approximately half full with water. The air pressure is supplied via an entry in the top of the cylinder and is thereby applied to the water in the cylinder. The water in the cylinder is connected to the triaxial cell via an exit in the bottom of the cylinder. The pressure can be monitored on a manometer on top of the cylinder but a more correct value is measured from the cell transducer monitored on the MGCplus amplifier system. Before applying the pressure, be sure to open the connection from the air valve to the triaxial cell because a sudden increase in cell pressure can damage the test sample.

3 PSC-rack

When performing the tests in the triaxial cell a Moog M 2000 Programmable Servo Control (PSC) is used to control the hydraulics. The system consists of a card rack that can contain a max of nine cards. The system described in the following is the used system for the dynamic triaxial cell.

3.1 Definition of the control system

The control of the load on the test sample is conducted by controlling the hydraulic piston described in chapter 0. The hydraulic servo valve is controlled via the PSC-card connected to the PC. A control file is uploaded to the PSC-card from the PC. This control file is explained in chapter 7. A sketch of the load system is illustrated on Figure 3.1

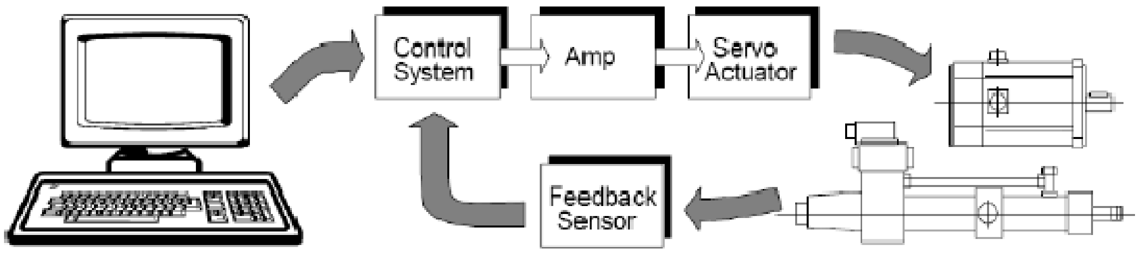


Figure 3.1 A sketch of the load system.

As shown in Figure 3.1, the hydraulic piston relays a feedback signal to the PSC-card to ensure that the hydraulic piston applies the correct load. The feedback is relayed from the load transducer during load controlled tests and from the displacement transducer during deformation controlled tests. The piston can also be controlled, when not performing test, through a build in displacement transducer. With this control it is possible to place the piston before and after the test in a desired position.

3.1.1 Moog M 2000 Programmable Servo Control

The control system for the used test setup consists of a card-rack containing two PSC-cards but only one is used. The card-rack is illustrated on Figure 3.2 and Figure 3.3.

Figure 3.2 Front side of PSC-rack.

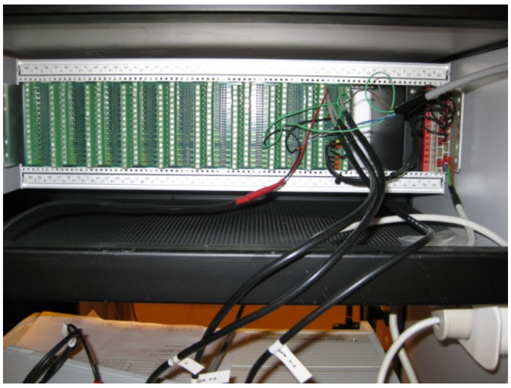


Figure 3.3 Rear side of PSC-rack.

The PSC-rack consists of nine slots, that each can contain a PSC-card or a feedback-card. Each slot contains 32 entries as illustrated on Figure 3.4 that relays the signal to the inserted card. The 32 entries in each slot are numbered on Figure 3.4, where the inscribed symbols also are shown.

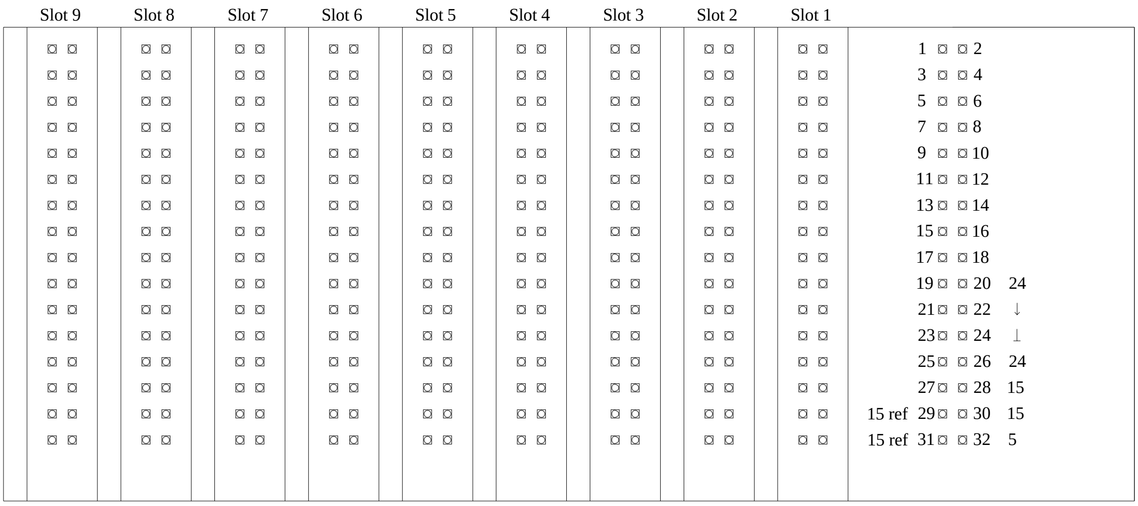


Figure 3.4 Sketch of the rear side of the PSC-rack.

The 32 entries have different specifications stated in Table 3.1.

Table 3.1 Entries in the PSC-rack.

Pin Number	Pin Type	Function
1	Analogue input 1	Analogue input channel
2	Analogue input 2	Analogue input channel
3	Analogue input 3	Analogue input channel
4	Analogue input 4	Analogue input channel
5	Analogue input 5	Analogue input channel
6	Analogue input 6	Analogue input channel
7	Analogue output 1	Analogue output channel
8	Analogue output 2	Analogue output channel
9	Digital input 1	Digital input channel
10	Digital input 2	Digital input channel
11	Digital input 3	Digital input channel
12	Digital input 4	Digital input channel
13	Digital output 0 V	Digital output channel
14	Digital output 1	Digital output channel
15	Digital output 2	Digital output channel
16	Digital output 3	Digital output channel
17	Digital output 4	Digital output channel
18	Shutdown +	An executable shutdown function
19	Shutdown -	An executable shutdown function
20	+ 24 V	Input for power supply
21	SI1A	Connection between cards, input
22	0VR	0 V reference
23	SI1B	Connection between cards, output
24	0V	0 V power
25	SI2A	Connection between cards, input
26	-24V	Input for power supply
27	SI2B	Connection between cards, output
28	+15 V	Supply voltage
29	15 V	Clock input
30	- 15 V	Supply voltage
31	15 V	Clock output
32	+5 VAC	Supply voltage

3.1.2 PSC-card

The controlling element in the Moog M 2000 system is the PSC-card, named Moog E122-211 shown in Figure 3.5.

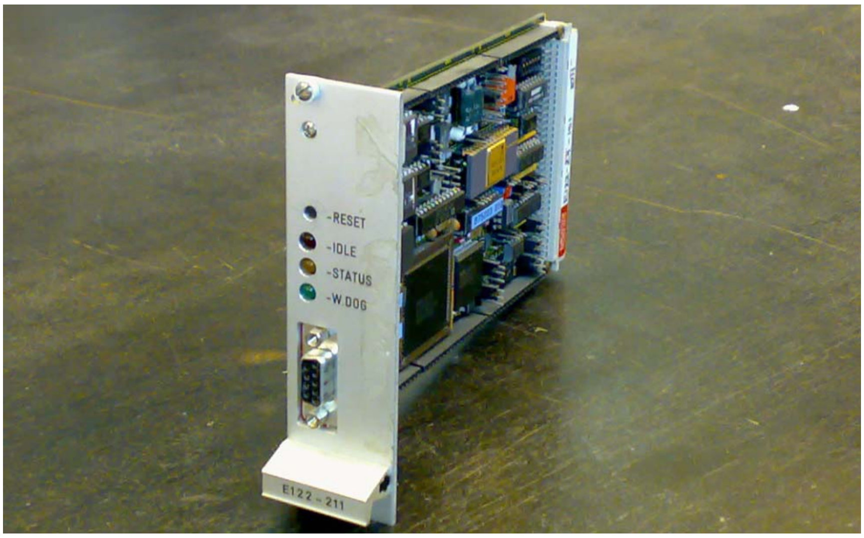


Figure 3.5 PSC-card E122-211.

One PSC-card can control two axes thus a PSC-rack can control up to 18 axes using nine PSC-cards. The PSC-card is connected to a computer, from which it is possible to upload program files to the card. The card has a memory that can store the program files. The PSC-card controls the hydraulic piston by using a PID-adjustment loop. P, I and D (potential, integral, differential) are different measures for the size of the error between the actual and the expected position of the piston. The PSC-card receives information about the actual piston position from the amplifier system MGCplus. Only one feedback signal from a transducer can be used at a time.

The uploaded program files inform the card which of the feedback signals the PSC-card should use and that the hydraulic piston is to be controlled from an extern volt-signal. It also provides the user with a user interface on the computer where it is possible to switch between feedback signals and change the position of the piston.

4 Amplifier system

An amplifier system and an appurtenant computer program are used both to control the triaxial tests and to collect the data from the tests. The program used is Catman 5.0. The program registers the signals from the amplifier system, converts the signals to values and stores the values in a data file. The amplifier system named MGCplus is able to collect data on a max of 16 channels. Only six channels are used to collect data during the triaxial tests. A seventh channel is used to transmit the desired load sequence as a volt signal. The amplifier system is illustrated in Figure 4.1.

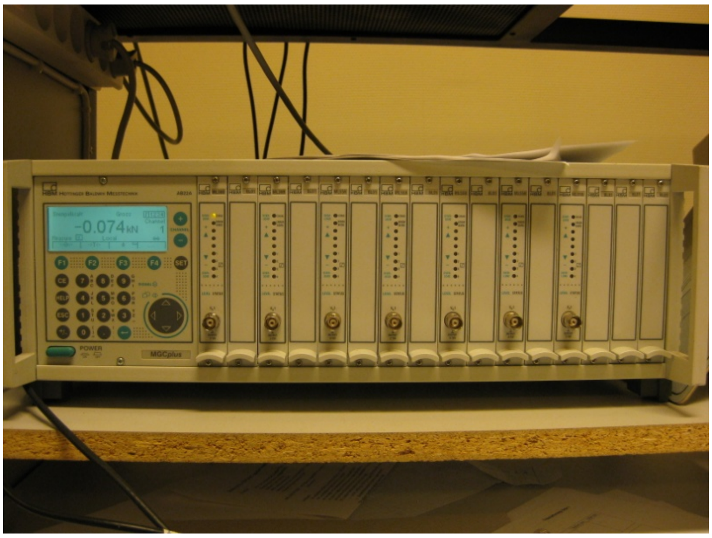


Figure 4.1 Amplifier system.

4.1 Amplifier plug-in modules

Using the MGCplus amplifier system offers the user several plug-in modules. Each module has a unique function, hence it is important to use the correct module for the required measurement in the MGCplus.

To transmit the volt signal from the MGCplus to the PSC-card a module named ML01B is used. To register the signals from the transducers two different modules are used. An ML55B module with the ability to measure the bridge circuit as a half or a full bridge, and a ML30B that only is able to measure the bridge circuit as a full bridge. Because of this the ML30B cannot be used for the displacement transducers. An example of amplifier plug-in modules are shown in Figure 4.2

Figure 4.2 Amplifier plug-in modules.

The rear connection board used in the MGCplus on all channels is an AP01i as shown in Figure 4.3. The card contains two sockets. One socket with 15 pins for input signals from transducers, and one socket with 25 pins to transmit output signals. The 25 pins socket is used to relay the signal from the transducers to the PSC-card.

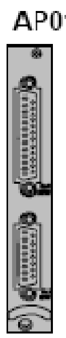


Figure 4.3 Rear connection board.

5 Transducers

When conducting the triaxial tests different devices are used to monitor the sample. The force applied to the test sample is measured through a load cell. The pressure inside the test sample and in the triaxial cell is measured, and the deformation of the test sample during the test is measured. In the following is a description of the different transducers. An excel-file can be found on the enclosed DVD containing the calibration of the transducers.

5.1 Load cell

The load on the test sample is constantly monitored during the tests from a load cell. The load cell shown in Figure 5.1 is a 2000 N load cell and is installed on the lid of the triaxial cell.

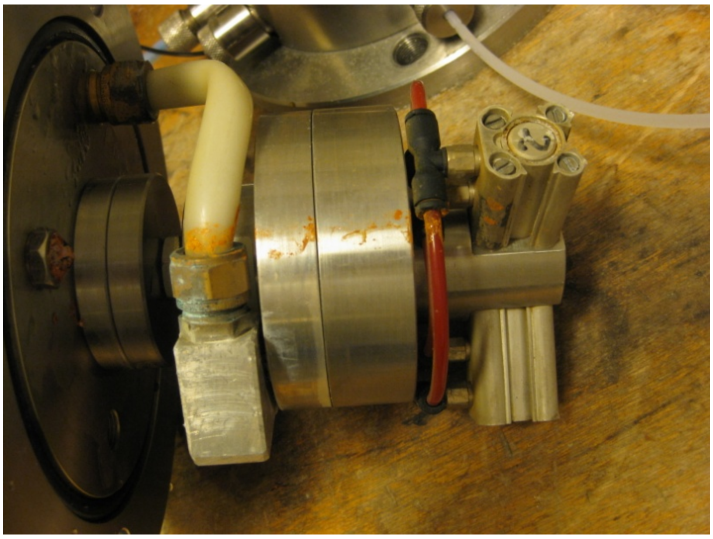


Figure 5.1 Load cell.

The load cell is a HBM Type U2A 2000 N. The transducer circuit of the load cell is a SG full bridge with an excitation of 5 volt. The load cell is calibrated before use. The correlation between the load in Newton and the signal in mV/V is shown in Figure 5.2. The equation for the regression line and the regression factor R^2 is also shown on the figure. A value of R^2 = 1 indicates full linearity between the measured values.

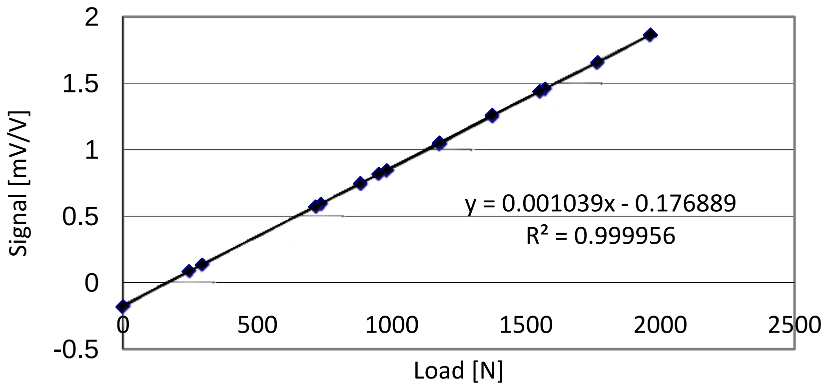


Figure 5.2 Correlation between load and signal.

The gradient of the regression line states the calibration factor used in Catman, hence a load of 2000 Newton transmits a signal from the transducer to the MGCplus of 2.078 mV/V. This value is entered in Catman.

5.2 Displacement transducers

During the triaxial tests two transducers measure the vertical deformation of the test sample by measuring the displacement of the top pressure head. The transducers are a type HBM 30 mm and the transducer circuit is a half bridge with an excitation of 2.5 volt. A transducer is shown in Figure 5.3 and installed in the cell in Figure 5.4.

Figure 5.3 Displacement transducer.

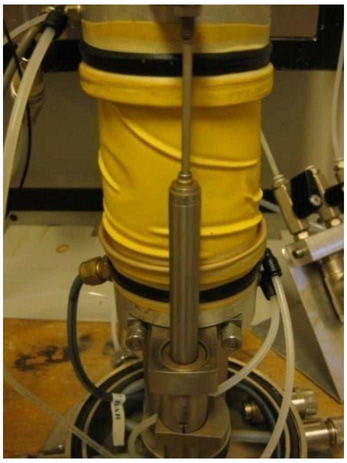


Figure 5.4 Displacement transducer installed in cell.

Both strain transducers are calibrated before use, and the correlation between displacement in mm and the signal in mV/V is shown in Figure 5.5.

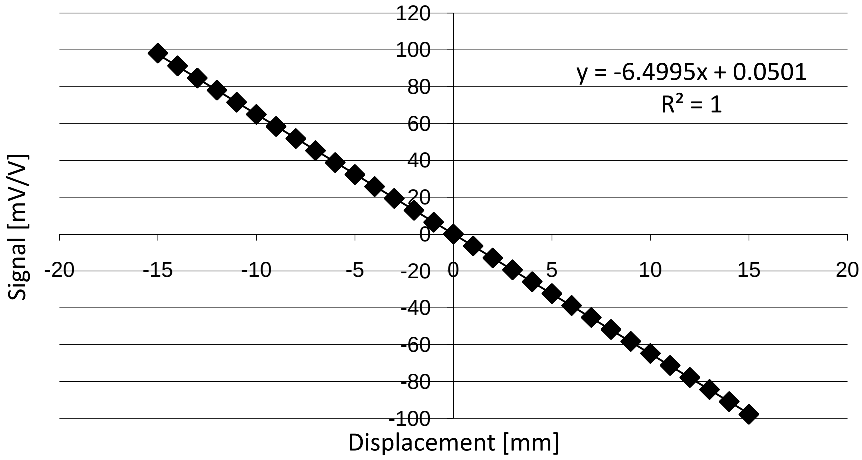


Figure 5.5 Correlation between displacement and signal.

The gradient of the regression line states the calibration factor used in Catman, hence a displacement of 30 mm transmit a signal from the transducer to the MGCplus of 195.0 mV/V. This value is entered in Catman. The value of the other transducer is 181.3 mV/V at a displacement of 30 mm.

5.3 Pressure transducer

Two pressure transducers are used during the triaxial tests. One transducer is built into the pressure head placed at the bottom of the soil sample and one is build into the triaxial cell. The one in the pressure head is a HBM 700 kPa and measures the pore pressure in the soil sample. The other is a HBM 1000 kPa and measures the pressure inside the triaxial cell. The pressure transducers are shown in Figure 5.6 and Figure 5.7.

Figure 5.6 Cell pressure transducer.

Figure 5.7 Pore pressure transducer built into pressure head.

Both pressure transducers are calibrated before the tests, and the correlation between pressure in kPa and the signal in mV/V is shown in Figure 5.8. The transducer circuit of both transducers is a SG full bridge with an excitation of 2.5 volt

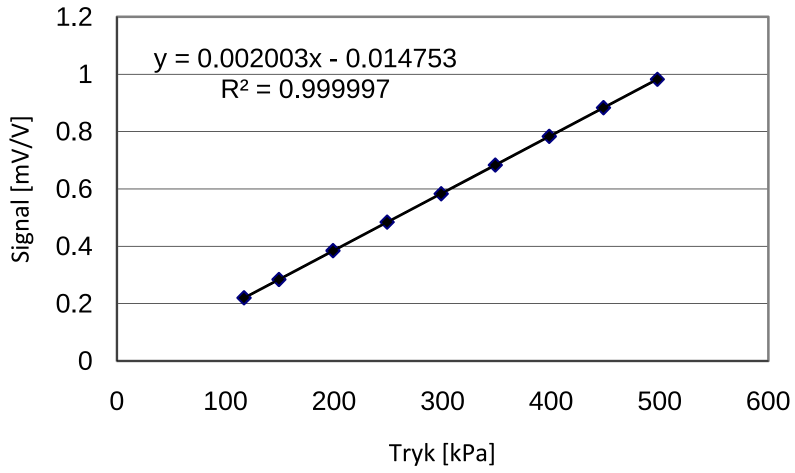


Figure 5.8 Correlation between pressure and signal.

The gradient of the regression line states the calibration factor used in Catman, hence a pressure of 1000 kPa transmit a signal from the transducer to the MGCplus of 2.003 mV/V. This value is entered for the cell pressure in Catman. The value of the pore pressure transducer is 2.660 mV/V at a pressure of 700 kPa.

6 Connection setup between systems

The three systems used to control the dynamic triaxial cell are setup as described in the following.

6.1 Connection between Pc and MGCPlus amplifier system

The computer used for controlling the test and for data acquisition is connected to the amplifier system through a GPIB (IEEE 488) connection. The cable is connected to the computer as shown in Figure 6.1 and to the MGCplus amplifier system as shown in Figure 6.2.

Figure 6.1 Cable between MGCplus and computer connected to computer.

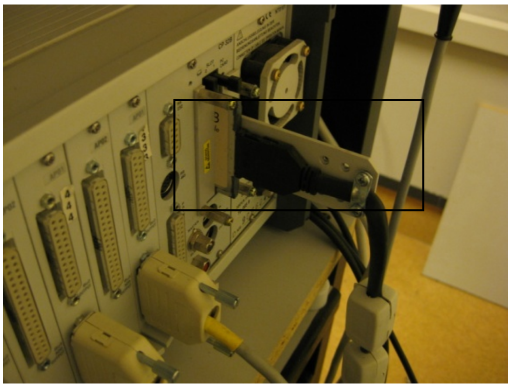


Figure 6.2 Cable between MGCplus and computer connected to MGCplus.

6.2 Connection between PC and PSC-card

Prior to starting the test, a control file is loaded to the PSC-card. The PSC-card is connected to the computer through an RS 232 serial link. This is via a 9 way D type connector setup as a Modem Equipment cf. the PSC's user manual. The link is connected to the PC in a COM port cf. Figure 6.3 and to the front of the PSC-card cf. Figure 6.4.

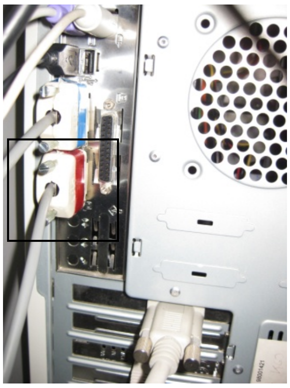


Figure 6.3 Cable between computer and PSC-card connected to computer.

Figure 6.4 Cable between computer and PSC-card connected to PSC-card.

6.3 Connection between MGCplus and PSC-rack

The MGCplus amplifier system is transmitting a volt signal to the PSC-rack to control the hydraulic piston and it relays the signal from three transducers in the triaxial cell. All links between the MGCplus amplifier system and the PSC-rack consists of a cable with to wires. The cable is connected to an AP01 connection board on the MGCplus amplifier system and to the PSC-rack as shown in Table 6.1 and Table 6.2.

Table 6.1 Connection to MGCplus system.

Cable name	Slot	Signal	Wire	Pin No	Pin type
Single ended 1	13	Control	Green Grey	12 24	V_{O2} Output 0 V Power
Single ended 2	1	Feedback load cell	Green Grey	13 25	V_{O1} Output 0 V Power
Diff input 2	11	Feedback position	Green Grey	13 25	V_{O1} Output 0 V Power
Diff input 3	7	Feedback deformation	Green Grey	13 25	V_{O1} Output 0 V Power

Table 6.2 Connection to PSC-rack.

Cable name	Signal	Wire	Pin No	Pin type
Single ended 1	Control	Green Grey	1 24	Analog input 1 0 V Power
Single ended 2	Feedback load cell	Green Grey	2 24	Analog input 2 0 V Power
Diff input 2	Feedback position	Green Grey	3 24	Analog input 3 0 V Power
Diff input 3	Feedback deformation	Green Grey	5 24	Analog input 5 0 V Power

Diff input 2 and 3 are actually connected to pin no 13. But this pin no is also connected to pin no 24 which relays the 0 V Reference signal to pin no 13. For easy connection a metal plate with four sockets has been installed on the rear side of PSC-racket and the cables from the MGCplus amplifier system are connected to these sockets.

6.4 Connection between PSC-rack and hydraulic piston

The PSC-card constantly monitors the feedback signal and the control signal from the MGCplus amplifier system and transmits a new volt signal to the hydraulic piston. The cable that transmits the signal to the hydraulic piston has four wires and is connected to the PSC-rack as shown in Table 6.3

Table 6.3 Connection to PSC-rack from hydraulic piston.

Wire	Pin No	Pin type
Green	24	0 V Power
Blue	24	0 V Power
Grey	22	0 V Reference
Brown	7	Analog Output 1

7 Used software during dynamic triaxial tests

Besides the physical instruments used for the dynamic triaxial tests, a number of software programs has been used to control the hydraulic piston and the amplifier system and store collected data. Two programs has been used, Catman 5.0 for control of the amplifier system and data collection, and Engineering User Interface used to control the hydraulic piston. With both programs it is possible to create a specific user interface for a desired task. In the following it will be described how to set up the two programs and use the programmed user interface.

7.1 Catman 5.0

In Catman 5.0 the user has the possibility to program a user interface that can only work with a specific setup of the amplifier system. When the user has to transmit a control signal from the MGCplus amplifier system a user interface is necessary. The user interface consists of three things. 1) A setup file for the MGCplus amplifier system. 2) An “online page” that serves as the graphic interface. 3) A “Script” that contains all the events possible from the “online page” and matching routines. If no changes are made to the script, the user interface can be activated by double clicking “Dyntriax” on the desktop. The files can be opened in Catman by opening the project “dyntriax”. **When changes are made to any of the files it is very important so save the file in the same library as written in the script.**

7.1.1 1) Setup file for MGCplus amplifier system

As described in Chapter 4, seven slots of the amplifier system MGCplus have been used. Six of them for data collection, and three of these six for feedback signals to the PSC-card. The seventh slot is used for the output signal to the PSC-card. Before creating the specific user interface the program has to register the MGCplus amplifier system with the individual transducers.

Catman works with two kinds of channels, the internal channels of the program and the physical channels of the MGCplus amplifier system. The channels are defined under the “I/O definitions” and are shown in Figure 7.1. The internal channels are numbered from one to 10 and are shown left of the green dots with the white arrow. The physical channels are shown in the column named Connection. These have uneven numbers because only every second slot of the MGCplus amplifier system has been used.

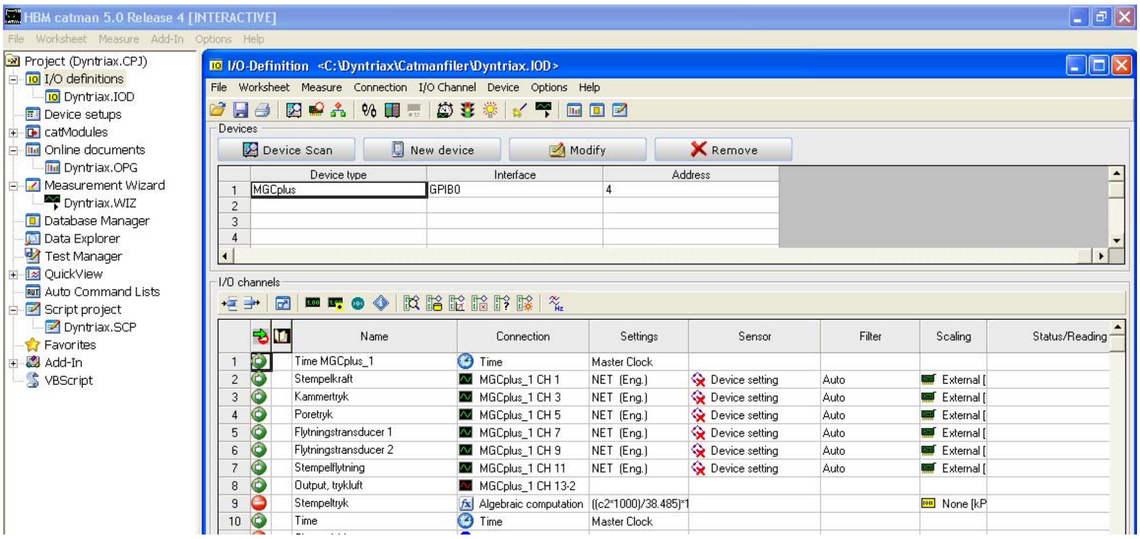


Figure 7.1 Definition of channels.

What also is seen in the figure is that the first internal channel and the 10th internal channel are used to measure the time of the test. Channel two to eight are used for data collection and channel nine is used to calculate the stress on the test sample. Channel nine has been switch off but can easily be activated with few changes.

Besides registering the different physical channels from the MGCplus amplifier system, it is necessary to setup the different transducers in the program. This is done in "device setup" in the tab "Transducers" cf. Figure 7.2 and the tab "Input characteristic" cf. Figure 7.3.

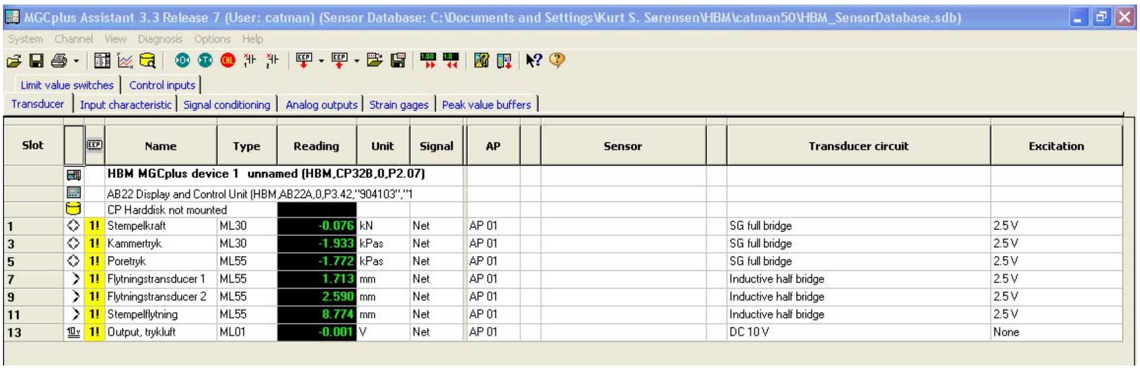
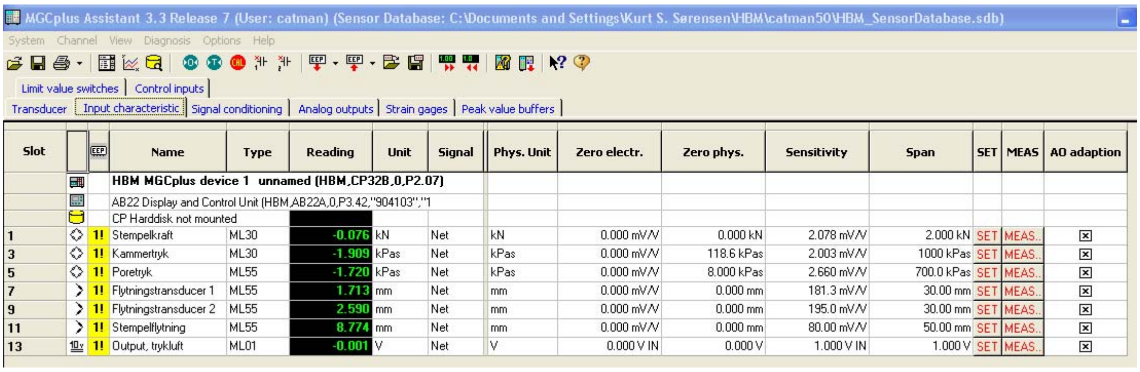


Figure 7.2 Transducer setup 1.

In the tab "transducers" the Transducer circuit and excitation is setup. As described in chapter 5 the load cell and the pressure transducers are setup with a SG full bridge and an excitation of 2.5 V. The displacement transducers are setup with an inductive half bridge and an excitation of 2.5 V. The output channel is setup with a 10 V DC current and no excitation. The color of the values in the column "Reading" indicates whether or not the transducer is connected and setup correctly.

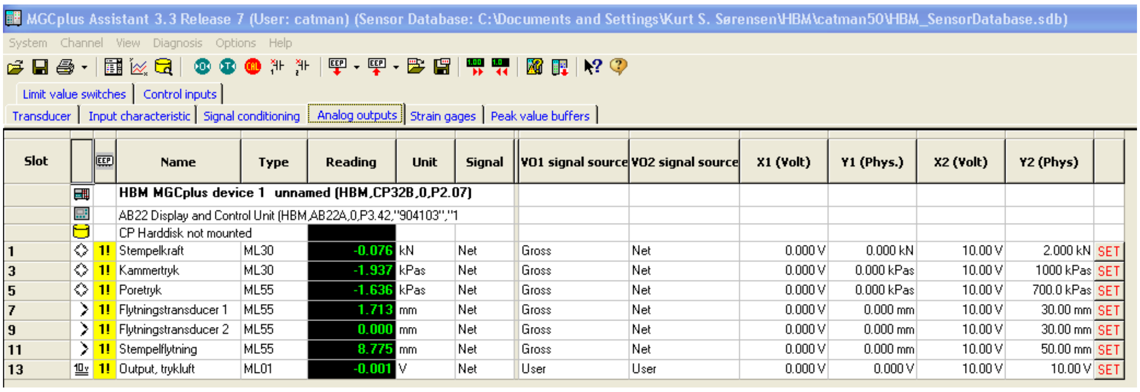
The calibration factors calculated in Chapter 5 are used in the tab "Input characteristic" cf. Figure 7.3 . The values are entered in the column "Sensitivity" and "Span" after the unit has been chosen in the column "Unit".



Slot			Name	Type	Reading	Unit	Signal	Phys. Unit	Zero electr.	Zero phys.	Sensitivity	Span	SET	MEAS	AO adaption
			HBM MGCplus device 1 unnamed (HBM,CP32B,0,P2.07)												
			AB22 Display and Control Unit (HBM,AB22A,0,P3.42,"904103","1												
			CP Harddisk not mounted												
1		1!	Stempelkraft	ML30	-0.076	kN	Net	kN	0.000 mV/V	0.000 kN	2.078 mV/V	2.000 kN	SET	MEAS..	☒
3		1!	Kammertryk	ML30	-1.909	kPas	Net	kPas	0.000 mV/V	118.6 kPas	2.003 mV/V	1000 kPas	SET	MEAS..	☒
5		1!	Poretryk	ML55	-1.720	kPas	Net	kPas	0.000 mV/V	8.000 kPas	2.660 mV/V	700.0 kPas	SET	MEAS..	☒
7	>	1!	Flytningstransducer 1	ML55	1.713	mm	Net	mm	0.000 mV/V	0.000 mm	181.3 mV/V	30.00 mm	SET	MEAS..	☒
9	>	1!	Flytningstransducer 2	ML55	2.590	mm	Net	mm	0.000 mV/V	0.000 mm	195.0 mV/V	30.00 mm	SET	MEAS..	☒
11	>	1!	Stempelflytning	ML55	8.774	mm	Net	mm	0.000 mV/V	0.000 mm	80.00 mV/V	50.00 mm	SET	MEAS..	☒
13	10v	1!	Output, trykluft	ML01	-0.001	V	Net	V	0.000 V IN	0.000 V	1.000 V IN	1.000 V	SET	MEAS..	☒

Figure 7.3 Transducer setup 2.

Three of the transducers are used for feedback signals to the PSC-card and one channel is used as the output value of the control signal. This has to be setup under the tab "Analog outputs" cf. Figure 7.4.



Slot			Name	Type	Reading	Unit	Signal	V01 signal source	V02 signal source	X1 (Volt)	Y1 (Phys.)	X2 (Volt)	Y2 (Phys)	
			HBM MGCplus device 1 unnamed (HBM,CP32B,0,P2.07)											
			AB22 Display and Control Unit (HBM,AB22A,0,P3.42,"904103","1											
			CP Harddisk not mounted											
1		1!	Stempelkraft	ML30	-0.076	kN	Net	Gross	Net	0.000 V	0.000 kN	10.00 V	2.000 kN	SET
3		1!	Kammertryk	ML30	-1.937	kPas	Net	Gross	Net	0.000 V	0.000 kPas	10.00 V	1000 kPas	SET
5		1!	Poretryk	ML55	-1.636	kPas	Net	Gross	Net	0.000 V	0.000 kPas	10.00 V	700.0 kPas	SET
7	>	1!	Flytningstransducer 1	ML55	1.713	mm	Net	Gross	Net	0.000 V	0.000 mm	10.00 V	30.00 mm	SET
9	>	1!	Flytningstransducer 2	ML55	0.000	mm	Net	Gross	Net	0.000 V	0.000 mm	10.00 V	30.00 mm	SET
11	>	1!	Stempelflytning	ML55	8.775	mm	Net	Gross	Net	0.000 V	0.000 mm	10.00 V	50.00 mm	SET
13	10v	1!	Output, trykluft	ML01	-0.001	V	Net	User	User	0.000 V	0.000 V	10.00 V	10.00 V	SET

Figure 7.4 Output signals setup.

The max voltage the MGCplus amplifier system can transmit is 10 V, hence the maximum value of the transducers are set to transmit 10 V. The same conditions apply for the control signal but this value will be computed in the "Script" why both the X2 value and the Y2 value are set to 10 V. In the column V01 signal source it is set to user. Because of this the value can be controlled from the "Script".

When the setup is complete it is very important to store the setup file as an mgc-file, because the file will be used later in the programmed user interface. If a new zero value is desired this can be done by right clicking the green value and press "zero adjust". If this is done remember to store the file again.

7.1.2 2) Online page

The online page applies the user with the graphic interface. For the dynamic triaxial cell two online pages have been made cf. Figure 7.5 and Figure 7.6. On the first online page the user has to decide whether a force controlled or a deformation controlled test is required.

Furthermore the program needs to know where the Input file is placed on the hard disk. The input file contains the desired load or deformation the user needs during the test and consists of one column of values. Catman will load the input file and transmit the value with the frequency chosen in the box “Sampling frequency”. In other words, if an input file consists of 10 values and a sampling frequency of 5 Hz is chosen, it will take 2 seconds to finish the input file. The input-file can be made in the Matlab-program CyclicLoadGenerator.m.

Also the “Data storage frequency” has to be chosen. This frequency decides how many values to store per second in the output file.

Finally the program needs to know where to store the collected data on the hard disk. This is chosen under Output file.

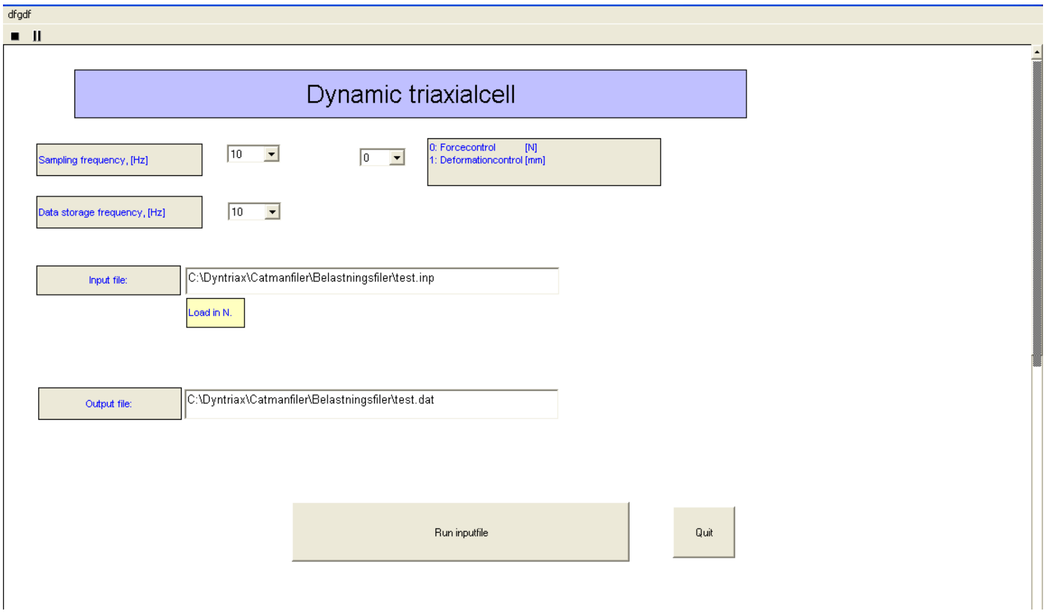


Figure 7.5 Online page 1.

With the different values entered, the button “Run inputfile” is pressed. This leads to the second online page. On this page it is possible to monitor the force on the test sample and the deformation of the test sample as a function of time during the test. The test will start when the “Start” button is activated. The bigger an input file, the longer it will take to start the test because Catman has to load the entire file before starting. The test will automatically stop when the entire input file has been used or if the “stop” button is activated.

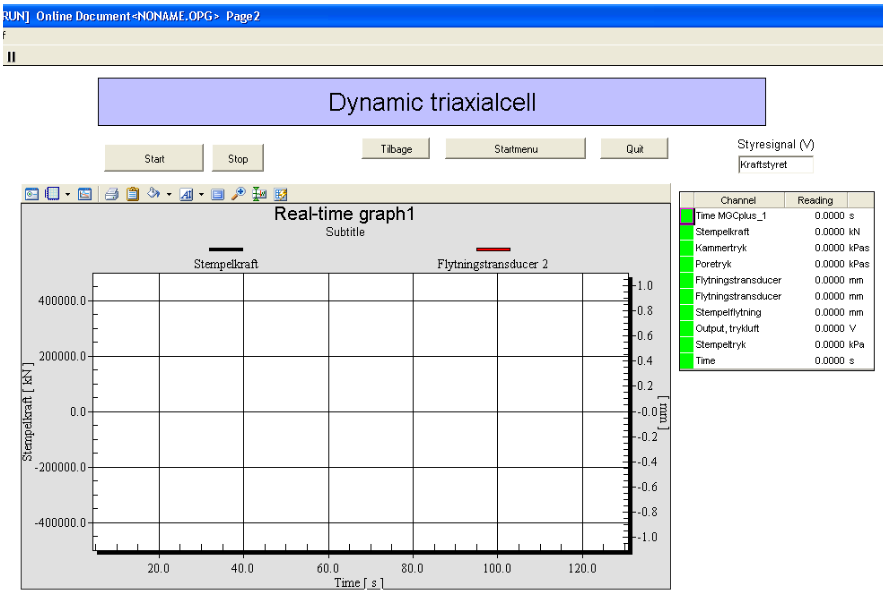


Figure 7.6 Online page 2.

7.1.3 Script

To make the events in the "Online pages" work, a "Script" has to be programmed. The "Script" is programmed in the Script editor shown in Figure 7.7. A more detailed description of the code is explained in Chapter 9. When changes have been made to the "Script" it is necessary to compile the "Script" to make an executable program. This is done by first pressing "Compile Module" and the press "Create executable file".

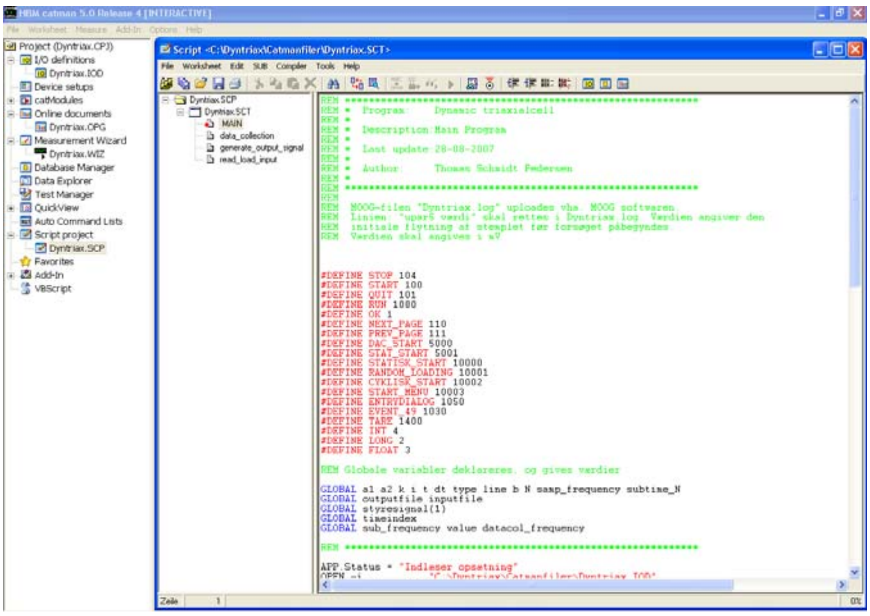


Figure 7.7 Script editor

7.2 Engineering user interface.

To be able to control the hydraulic piston correctly a PSC-rack with a PSC-card is used cf. Chapter 3. The MGCplus amplifier system is only able to transmit the control signal and the feedback signals from the transducers. The PSC-card constantly controls if the desired position from the control signal is in accordance with the real position from the feedback signal. To do this the PSC-card needs to know where the control signal and the feedback signals are connected to the PSC-rack and witch feedback signal to use. For this a small program is made and loaded to the PSC-card. The program consists of two text files named a LOG file and a MOO-file. Furthermore an OUI-file is made that defines the user interface in the program. A description of the three files is made in Chapter 10.

To use the program it has to be loaded to the PSC-card. This is done from the Engineering User Interface. The interface is shown in Figure 7.8 and is activated by double clicking on the MOOG symbol on the desktop. To control if the connection is made to the PSC-card enter “upar1” and press enter. If the program replies with “=>0” the connection is established. If the correct cable is used between the computer and the PSC-card and nothing happens another possibility can be the value in the lower right corner. This has to be 000. If this is not the case, it can be changed with the command “Connect=0” succeeded by enter.

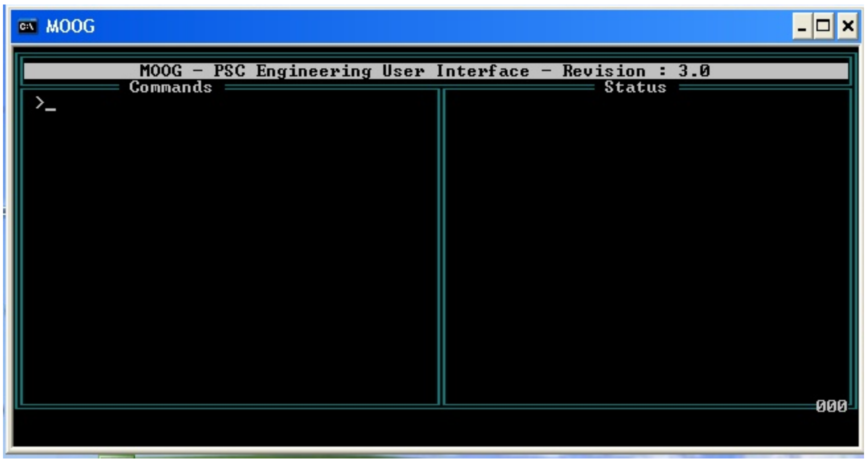


Figure 7.8 Engineering User Interface.

To upload the program, press the F2 key on the keyboard and then enter the name of the LOG-file and press enter. In this case the name is “dyntriax.log”. The log-file will be shown on the screen as it uploads to the PSC-card. The LOG-file automatically loads the MOO-file to the PSC-card.

When the LOG-file has been loaded correctly to the PSC-card, the users own user interface can be activated in the “Engineering User Interface”. This is done by pressing the “Shift” and “F1” keys. This will activate the screen shown in Figure 7.9 that is a standard screen.

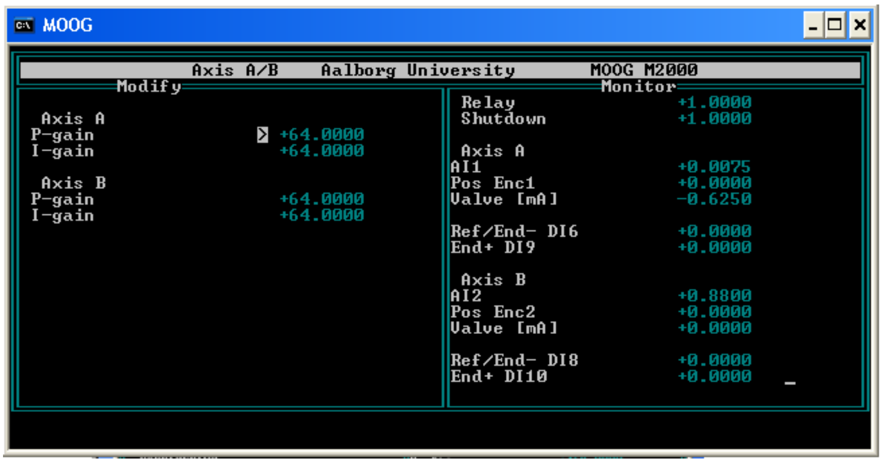


Figure 7.9 Standard screen in "Engineering User Interface".

From this screen the "F2" key is activated and the file "Dyntriax.oui" is chosen. With this command the users own user interface is activated, cf. Figure 7.10.

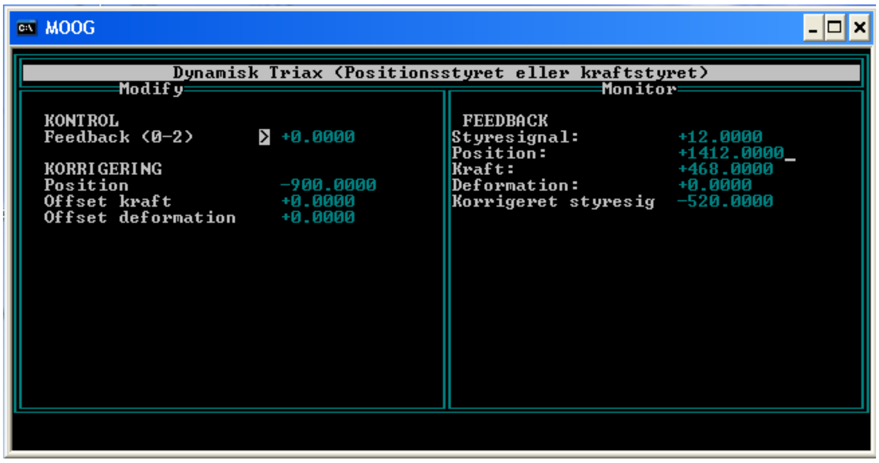


Figure 7.10 User interface in "Engineering User Interface".

From this interface it is possible to change which feedback signal to use, hence if the piston is controlled by position (0), by force on the test sample (1) or by deformation of the test sample (2). When the feedback signal has been chosen the piston position can be moved by changing the value next to "Position". If force feedback has been chosen the piston can be moved by changing the value in "Offset kraft", and the same apply with "Offset deformation" if deformation feedback has been chosen. The values in the right column monitor the signals.

The feedback signal is best kept at position (0) until the test sample has been placed in the triaxial cell, and the desired cell pressure has been applied. An increase in cell pressure will affect the load cell and thereby the feedback signal from the load cell.

8 Conducting dynamic triaxial tests

In the following the test procedure for conducting the dynamic triaxial test is listed.

1) The hydraulic piston is activated on the circuit breaker panel as described in Chapter 2.
2) The program "Dyntriax.log" is uploaded to the PSC-card as described in Section 7.2 which should activate the hydraulic piston.
3) The test sample is placed in the cylinder in accordance with the procedures for the normal triaxial cell.
4) If new zero values for the transducers are needed, enter this in Catman 5.0 as described in section 7.1.
5) The pressure inside the cell is applied as described in Chapter 2.
6) The control method is chosen from the "Engineering User Interface" cf. section 7.2. When this is chosen and the hydraulic piston is in the right position, exit the program.
7) Bring up the programmed user interface in Catman 5.0 by double clicking "Dyntriax" on the desktop. Choose the control method, the sampling frequency and the path to the load-file.
8) Start the test in Catman 5.0.

9 Script to Catman 5.0

In the following the programmed script for Catman 5.0 is explained. The script consists of a main script and three subscripts.

9.1 Main script

#DEFINE STOP 104	Keys used in the online document are activated
#DEFINE START 100	
#DEFINE QUIT 101	
#DEFINE RUN 1080	
#DEFINE OK 1	
#DEFINE NEXT_PAGE 110	
#DEFINE PREV_PAGE 111	
#DEFINE DAC_START 5000	
#DEFINE STAT_START 5001	
#DEFINE STATISK_START 10000	
#DEFINE RANDOM_LOADING 10001	
#DEFINE CYKLISK_START 10002	
#DEFINE START_MENU 10003	
#DEFINE ENTRYDIALOG 1050	
#DEFINE EVENT_49 1030	
#DEFINE TARE 1400	
#DEFINE INT 4	
#DEFINE LONG 2	
#DEFINE FLOAT 3	
GLOBAL a1 a2 k i t dt type line b N samp_frequency subtime_N	Global variables are declared
GLOBAL outputfile inputfile	
GLOBAL styresignal(1)	
GLOBAL timeindex	
GLOBAL sub_frequency value datacol_frequency	
APP.Status = "Indlæser opsætning"	The text written in the status line in Catman.
	The following commands loads the defined "I/O-definitions", "Device setup" and "Online document" files.
OPEN -i "C:\Dyntriax\Catmanfiler\Dyntriax.IOD"	
IODEVICE[1].Setup "C:\Dyntriax\Catmanfiler\Dyntriax.mgc"	
OPEN -o "C:\Dyntriax\Catmanfiler\Dyntriax.OPG"	

FOR i = 1 TO 17 DBCHAN[i].Clear NEXT	Empties the database that temporary stores the data collected before a new test
APP.OLClose = 1	The online document does not close down after the program has been executed
APP.Status = "Input and output file"	The text written in the status line in Catman
DO 0	Executes a "do" loop
SELECT CASE	
CASE Event = NEXT_PAGE	By activating NEXT_PAGE (Run Inputfile" in "Online page" the following commands will be executed
Event = 0	
type = testtype.Text	To define if the test should be force of deformation controlled
cvnum type type	Reads type as numbers
inputfile = inputfile.Text	Definition of input file
outputfile = outputfile.Text	Definition of output file
samp_frequency = samp_f.Text	The sampling frequency in Hz. This is used to calculate the sub frequency and the control signal
cvnum samp_frequency samp_frequency	Reads type as numbers
sub_frequency = samp_f.Text	Defines the sub frequency that controls the number of additional data points.
cvnum sub_frequency sub_frequency	Reads the sub frequency as a number
datacol_frequency = datacol_f.Text	Defines the frequency to store data in the outputfile
cvnum datacol_frequency datacol_frequency	Reads the data collection frequency as a number
subtime_N = sub_frequency/samp_frequency	
Page.show 2	Change to page 2 of the Online page"
APP.Status = "Målinger startes ved tryk på start"	The text written in the status line in Catman
CALL read_load_input	Loads the sub program "read_load_input"
CASE Event = OK	Ok ("Start" button on the Online page) is activated
Event = 0	
i=-1	
ACQTimeReset	Resets the internal timer
CreateObject "LoadingTimer" "TIMER"	Creates two objects
timeindex = 0	Timeindex is set to nul
k = subtime_N	The value of the variable "k" is defined

LoadingTimer.Interval = 1000/sub_frequency	Time interval is changed to ms
LoadingTimer.IRQProg = "generate_output_signal"	Name of the sub program that is set to Loading timer
LoadingTimer.Event = RANDOM_LOADING	The activated event at Loading timer
LoadingTimer.Enabled = 1	Loading timer is activated
CALL data_collection	Loads the sub program "data_collection"
CASE Event = START_MENU	By activating START_MENU the user is returned to the first Online page
Event = 0	
ARRAY_FREE styresignal	Deletes the values in "styresignal"
Page.show 1	The page that will be returned to
APP.Status = "Valg af forsøgstype"	The text written in the status line in Catman
CASE Event = QUIT	By activating QUIT the following events will happen
Event = 0	
AO_wrt 8 0	The value 0 is transmitted on channel 8 which is the channel that transmits the control signal
EXIT	Exit from the online page
END SELECT	Ends the "do" loop
LOOP	Creates the loop

9.2 Datacollection script

APP.MousePointer = 11	The mouse pointer changes to an hour glass
ACQInit ALL	Initiates all the I/O-channels for data collection
APP.MousePointer = 0	
ACQStart 0 100	Data acquisition is initiated. 0 indicates that the amplifier system is a MGCplus system and 100 indicates the data acquisition frequency. This is also the frequency of the control signal
DO 0	A "do" loop is activated
IF timeindex < N	
IF k = subtime_N	
APP.Status = "Data is being collected..."	The text written in the status line in Catman
ACQRead -1 5000	Reading data on channels. -1 indicates that it reads all data that is transmitted and 5000 indicates the period in ms that Catman will wait for data
ACQstore	The values are stored in the database in Catman
Update –p	Updates all values in the Online page
ENDIF	Terminates the test if one of the following is executed
SELECT CASE	
CASE Event = STOP	The "Stop" button is activated and the following is executed

Event = 0	
AO_wrt 8 0	The value 0 is transmitted on channel 8
BREAK	
END SELECT	
ELSE	Otherwise the test will stop at the end of the input file
Event = 0	
BREAK	
ENDIF	
LOOP	Creates loop
APP.Status = "Data collection is stopped - data is saved to file."	The text written in the status line in Catman
LoadingTimer.Enabled = 0	Loading timer is deactivated
ACQStop	Data acquisition is stopped
	The following stores the data from the database in a dat-file
DB[11] = CONVERTSAMPLERATE DB[2] datacol_frequency DB[12] = CONVERTSAMPLERATE DB[3] datacol_frequency DB[13] = CONVERTSAMPLERATE DB[4] datacol_frequency DB[14] = CONVERTSAMPLERATE DB[5] datacol_frequency DB[15] = CONVERTSAMPLERATE DB[6] datacol_frequency DB[16] = CONVERTSAMPLERATE DB[7] datacol_frequency DB[17] = CONVERTSAMPLERATE DB[10] datacol_frequency	Converts the sample rate from the data acquisition frequency set to 100 Hz to the chosen frequency in the online page
FOR i = 11 TO 17	
DBCHAN[i].Export = 1	Marks the channels to export
DBCHAN[i].ExportPrecision = 1	
NEXT	
EXPORT.FileName = outputfile	The name of the file
EXPORT.Format = 1	The format of the file. 1 indicates that both channel information and data is stored to the file
EXPORT.Append = 0	A file with same name is overwritten
EXPORT.Execute	Executes the export
FOR i = 11 TO 17	
DBCHAN[i].Export = 0	Removes the marking of the channels
NEXT	
APP.Status = "Finished!"	The text written in the status line in Catman

9.3 Read_load_input script

FILE[1].Name = inputfile	The input file that is to be loaded
FILE[1].Open 1	Opens the file. 1 indicates that the file is a ASCII text file
line = 0	
	The following "do" loop determines the length of the file

```
DO 0
        line = line + 1
        FILE[1].Read N LONG
        b = FILE[1].EOF
        IF b > 0
                BREAK
        ENDIF
LOOP                                    Closes the loop
FILE[1].Close                           Closes the file
N = line

ARRAY_ALLOC styresignal N+100           Allocates space in the program for the values in the input
                                        file

FILE[1].Name = inputfile                The input file that is to be loaded
FILE[1].Open 1                          Opens the file
line = 0
                                        The following "do" loop computes the control signal
DO 0

line = line + 1
FILE[1].Read value LONG                 The length of the file is used
cvnum value value                       The value is changed to a number

IF type = 0                             If type 0 (Force controlled) is chosen the control signal is
                                        computed as in the following

                        The following defines a lower and upper limit for the control signal a max
                        of 200 Newton is chosen but can be altered if chosen
IF value < -200
   value = -200
ENDIF
IF value > 200
   value = 200
ENDIF
styresignal(line) = value*0.005         The values in volts are calculated from the input file that
                                        contains the values in Newton
TEXTBOX_1.Text = "Kraftstyret"

ELSE                                    If 1 (deformation control) is chosen the control signal is
                                        computed as in the following
IF value < -30          The following defines a lower and upper limit for the control signal a max
                        of 30 millimeters is chosen but can be altered if chosen
   value = -30
ENDIF
IF value > 30
  value = 30
ENDIF
```

styresignal(line) = value*0.3333	The values in volts are calculated from the input file that contains the values in millimeters
TEXTBOX_1.Text = "Deformationsstyret"	
ENDIF	The following ends reading of the file when the end of the file is reached
b = FILE[1].EOF IF b > 0 BREAK ENDIF	
LOOP	Closes the loop
FILE[1].Close	Closes the file

9.4 Generate_Output_Signal script

This subprogram transmits the generated control signal to the PSC-card. The program has been created so that it can calculate additional values if too few have been generated from the output file.

```
IF k = subtime_N
   timeindex = timeindex + 1
   a1 = styresignal(timeindex)
   a2 = styresignal(timeindex+1)
   value = a1
   k = 1
   TEXTBOX_1.Text = a1
ELSE
   value = a1 + k/subtime_N*(a2-a1)
   k = k + 1
ENDIF
```

AO_wrt 8 value	The computed values is transmitted on channel 8 to the PSC-card

10 Program files for the PSC-card

10.1 LOG-file

Reset PSC-card

runflag=0	When resetting the PSC-card runflag and conflag must be set to 0
conflag=0	
dbcontrol=3	Deleting all parameter values
dbcontrol=0	Resets to standard values

Initialise global and upar's

speriod=1500	The sample period is defined to 15 ms
imult=1	This command together with speriod determines how often to run the loop
upar1 0	This value determines if the control is Position (1) force (2) or deformation (3) controlled
upar2 0	The zero value for position control
upar3 0	The zero value for force control
upar4 0	The zero value for deformation control
upar5 -900	When changing to position control, this is new zero value
upar6 80	When changing to force control, this is new zero value
upar7 0	When changing to deformation control, this is new zero value

Upar 5, 6 and 7 is possible to change in the user created user interface

Enable analog output

ao1.enable=1	Analog output 1 is activated
ao1.invert=1	Analog output 1 is inverted
ao1.offset=0	The offset of analog output 1 is set to zero

ao1.inptr=a.limao.outvalue The value of Analog output 1 is set to a defined maximum limit

Enable analog input

ai1.enable=1	Analog input 1 is activated	Control signal from Catman
ai1.offset=0	The offset of analog input 1 is set to zero	
ai1.invert=0	Analog input 1 is not inverted	
ai2.enable=1	Analog input 2 is activated	Feedback from position transducer
ai2.offset=0	The offset of analog input 2 is set to zero	
ai2.invert=1	Analog input 2 is inverted	
ai3.enable=1	Analog input 3 is activated	Feedback from deformation transducer
ai3.offset=0	The offset of analog input 3 is set to zero	
ai3.invert=1	Analog input 3 is inverted	
ai5.enable=1	Analog input 5 is activated	Feedback from load cell
ai5.offset=0	The offset of analog input 5 is set to zero	
ai5.invert=1	Analog input 5 is inverted	

Enable summing junction

The summing junction command is used to transmit the signal to the hydraulic piston. The signal is corrected according to the feedback signal by subtracting the input values 1-3 from the zero value. The letter a indicates that the summing junction is activated for the a-axis.

a.sji.enable=1	Summing junction is activated
a.sji.inptr1=ai2.outvalue	First input value is set to the value from Analog input 2 (Feedback from position transducer)
a.sji.inptr2=ai1.outvalue	Second input value is set to the value from Analog input 1 (control signal from Catman)
a.sji.inptr3=upar5	Third input value is set to the value from upar5 (Change in cylinder position)
a.sji.inptr0=upar2	Zero input value is set to the value from upar 2 (zero value for position control)

Filter translation

The PID filter involves three separate parameters; the proportional, the integral and derivative values. The proportional value determines the reaction to the current error, the integral value determines the reaction based on the sum of recent errors, and the derivative value determines the reaction based on the rate at which the error has been changing. The weighted sum of these three actions is used to adjust the hydraulic piston.

(k):0.3	The overall gain of the filter
(p):1.0	The proportional gain

(i):0.0	The integral gain
(d):0.0	The derivative gain
(Wd):50.0 Hz	The derivative roll off can remove high frequent noise
(t);50.0 ms	The sample period
a.g1i.enable 1	Enables the PID filter G1 for the a axis
a.g1i.inptr a.sji.outvalue	The value from the summing junction command is used as input value
fnkey 5	The filter can be changed in the user interface by pressing the “F5” key
a.g1i	
PD	Of the three available parameters only P and D is used
1 1 0 0.02 50 5	The values are entered as k p I d wd t

Limiting analog output

a.limao.inptr0 a.g1i.outvalue	A limit is introduced to the output value of the PID filter
a.limao.enable 1	The limit function is activated
a.limao.mode 0	
a.limao.min -500	The minimum value allowed
a.limao.max 500	The maximum value allowed

Load configuration for the a-axis

A small program named the MOO-file is uploaded to the PSC-card through the LOG-file. The MOO-file is described later

a.intr.enable 1	The a-axis is activated. Only one axis is used
fnkey 4	Activates the compiling of the MOO-file
dyntriax	The name of the MOO-file
0	Determines which axis the MOO-file is controlling. 0 means that the axis is listed in the MOO-file
fnkey 6	Loads the compiled MOO-file to PSC-card
dyntriax	The name of the compiled MOO-file
0	Determines the axis the MOO-file is controlling

Enable flag generator

Te flag generator has to be enabled for the program to work.

fgen1.enable=1	Activates the flag generator
fgen1.mode 2	Compares the value of flag generator 1 with a chosen min/max value
conflag=1	Close the generated loop
runflag=1	Close the generated loop
relay=1	Allows a volt output on the Analog Output channels

10.2 MOO-file

The MOO-file is a sub program used by the OUI-file. The MOO-file defines which commands that should be influenced when a change is made in the users own user interface

Definition of correction values

The correction values are values used when changing from one feedback signal to another and thereby one control form to another. These values are used to apply a small effect on the hydraulic piston when a change is made. For instant, when changing to force control a small force has to be applied to the test sample for the hydraulic piston to be stable.

assign cor2=40	The correction value when changing to position control
assign cor3=40	The correction value when changing to deformation control
assign cor5=60	The correction value when changing to force control
Begin:	A loop is commenced

SWITCH TO POSITION CONTROL

if (upar1=0) then	If upar 1 is set to 0 the control will switch to position control
set a.sji.inptr1 & ai2.outvalue	First value in summing junction is set to the value from Analog input 2 (Feedback from position transducer)
set a.sji.inptr2 & ai1.outvalue	Second value in summing junction is set to the value from Analog input 1 (The control signal from Catman)
set a.sji.inptr3 & upar5	Third input value in summing junction is set to the value from upar 5 (Change in cylinder position)
set a.sji.inptr0 & upar2	The zero value in summing Junction is set to the value from upar 2 (Zero point for cylinder position)

set upar3 ai5.outvalue+cor5	upar 3 (zero point for force control) is set to the value from analog input 5 (feedback from load cell) plus the correction value
set upar6 0	Change in force control is set to zero
set upar4 ai3.outvalue+cor3	upar 4 (zero point for deformation control) is set to the value from Analog input 3 (feedback from deformation transducer) plus the correction value
set upar7 0	Change in deformation control is set to zero
endif	Ends the if-loop

SWITCH TO FORCE CONTROL

if (upar1=1) then	If upar 1 is set to 1 the control will switch to force control
set a.sji.inptr1 & ai5.outvalue	First value in summing junction is set to the value from Analog input 5 (Feedback from load cell)
set a.sji.inptr0 & upar3	The zero value in summing Junction is set to the value from upar 3 (Zero point for force control)
set a.sji.inptr2 & ai1.outvalue	Second value in summing junction is set to the value from Analog input 1 (The control signal from Catman)
set a.sji.inptr3 & upar6	Third input value in summing junction is set to the value from upar 6 (Change in force control)
set upar2 ai2.outvalue+cor2	upar 2 (zero point for position control) is set to the value from Analog input 2 (feedback from position transducer) plus the correction value
set upar5 0	The change in cylinder position is set to 0
set upar4 ai3.outvalue+cor3	upar 4 (zero point for deformation control) is set to the value from Analog input 3 (feedback from deformation transducer) plus the correction value
set upar7 0	Change in deformation control is set to zero
endif	Ends the if-loop

SWITCH TO DEFORMATION CONTROL

if (upar1=2) then	If upar 1 is set to 2 the control will switch to deformation control
set a.sji.inptr1 & ai3.outvalue	First value in summing junction is set to the value from Analog input 3 (Feedback from deformation transducer)

set a.sji.inptr0 & upar4	The zero value in summing Junction is set to the value from upar 4 (Zero point for deformation control)
set a.sji.inptr2 & ai1.outvalue	Second value in summing junction is set to the value from Analog input 1 (The control signal from Catman)
set a.sji.inptr3 & upar7	Third input value in summing junction is set to the value from upar 7 (Change in deformation control)
set upar2 ai2.outvalue+cor2	upar 2 (zero point for position control) is set to the value from Analog input 2 (feedback from position transducer) plus the correction value
set upar5 0	The change in cylinder position is set to 0
set upar3 ai5.outvalue+cor5	upar 3 (zero point for force control) is set to the value from analog input 5 (feedback from load cell) plus the correction value
set upar6 0	Change in force control is set to zero
endif	Ends the if-loop
GOTO Begin	Go to the beginning of the if-loop
End	Ends the program

10.3 OUI-file

The OUI-file dictates which values can be altered and which values can be monitored in the Engineering user interface

Dynamisk Triax (Positionsstyret eller kraftstyret)	The name of the program
KONTROL	Text shown on screen
upar1, Feedback (0-2),1.0	upar 1 is the value that can be altered and Fedback (0-2) is the text on screen. 1.0 is a scaling factor that can be altered by the user
KORRIGERING	Text on screen

upar5, Position,1.0	upar 5 is the value that alters the position and position is the text on screen
upar6, Offset kraft,1.0	upar 6 is the value that alters the force applied on the test sample
upar7, Offset deformation,1.0	upar 7 is the value that alters the deformation of the test sample
FEEDBACK	Text on screen
ai1.outvalue, Styresignal:,1	The value of Analog input 1 is shown on screen but cannot be altered. Styresignal is the text shown on screen
ai2.outvalue, Position:,1	As before but with Analog input 2
ai3.outvalue, Kraft:,1	As before but with Analog input 3
ai4.outvalue, Deformation:,1	As before but with Analog input 4
a.sji.outvalue, Korrigeret styresignal:,1	As before but with corrected control signal from the summing junction command

11 List of enclosed files

Catman

- Dyntriax.CPJ (Catman project file)
- Dyntriax.mgc (media catalog file)
- Dyntriax.iod (IOD-file)
- Dyntriax.opg (OPG-file)
- Dyntriax.txt (a Script-file)
- Dyntriax.sct (a Script-file)
- Dyntriax.scb (a Script-file)

Moog system

- EUI.exe (Engeenering User Interface program used to control PSC-card)
- Dyntriax.log (LOG-file)
- Dyntriax.oui (OUI-file)
- Dyntriax.moo (MOO-file)

Matlab

- DynamicLoadGenerator.m

Excel

- Kalibrering

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