FT SENSOR CALIBRATION

Rev.	Prepared by		Date	Approved		Date
0.0	P&M	Tome D.	15/04/2011			15/04/2011
1.0	iCubFacility	Tome D. – Michelini S.	05/03/2014	iCubFacility	Randazzo M.	05/03/2014

Revision history

Rev.	Date	Revision description
0.0	15/04/2011	Preliminary emission
1.0	05/03/2014	Added section 2.1 Matlab replaced by Octave New report template

Contents

1 TEST REQUIREMENTS

1.1 *Software Requirements*

- A PC with OS Windows XP or higher
- "Icub" software installed at path "c:\Software\iCub"
- "ftSensCalib" software installed at path "c:\Software\ftSensCalib"
- "Canloader" software (included in iCub)
- "Canreal" software (included in iCub)
- "Gulp" software
- "Octave" software running on the provided virtual machine
- "TortoiseSVN" subversion software

1.2 *Hardware Requirements*

- 1 strain gauge sensor "**GS**" (Figure 1)
- 1 bottom cover for strain gauge sensor "**BC**"(Figure 1)
- 1 top cover for Strain Gauge Sensor "**TC**"(Figure 1)
- 1 PCB STRAIN "**STR**" (Figure 1)
- 3 sets of 6 tinned cables with these spec : length = 33mm , colors : Blue, Red, Yellow, Green, Black, White "**CBL1**" (Figure 1)
- 1 cable for connecting the sensor to power and CAN-USB "**CAB2**"(Figure 1)

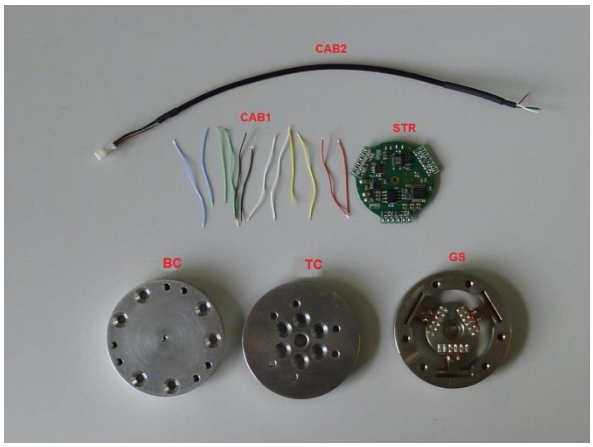


Figure 1: Strain gauge sensor, strain pcb, cables and covers

- 6 6x12x2 mm screws "SC3" (Figure 2)
- 6 6x8x2 mm screws "SC4" (Figure 2)

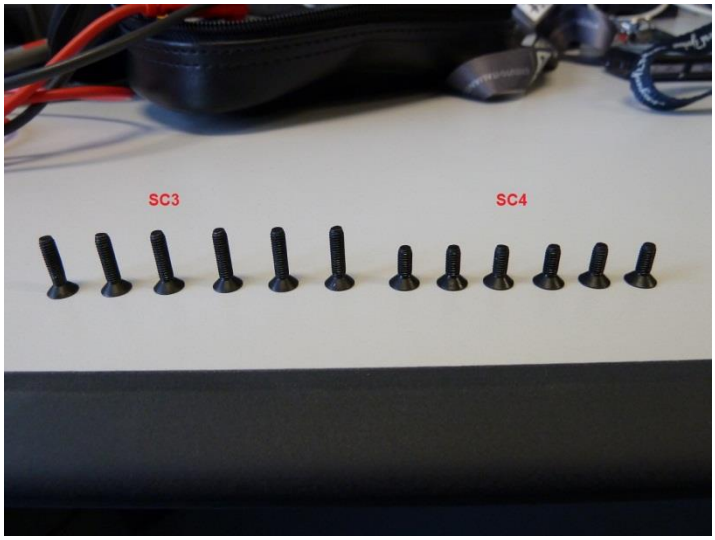


Figure 2: Screws

- 1 custom made cross "**CR1**" (Figure 3)
- 1 custom made head "**H1**" (Figure 3)
- 1 custom made head "**H2**" (Figure 3)
- 1 nut FeZn 10MA.2 "**N1**" (Figure 3)
- 6 3x16x2mm inox countersunk hexagonal screws "**SC1**" (Figure 3)
- 6 3x18x2.5mm inox hexagonal screws "**SC2**" (Figure 3)

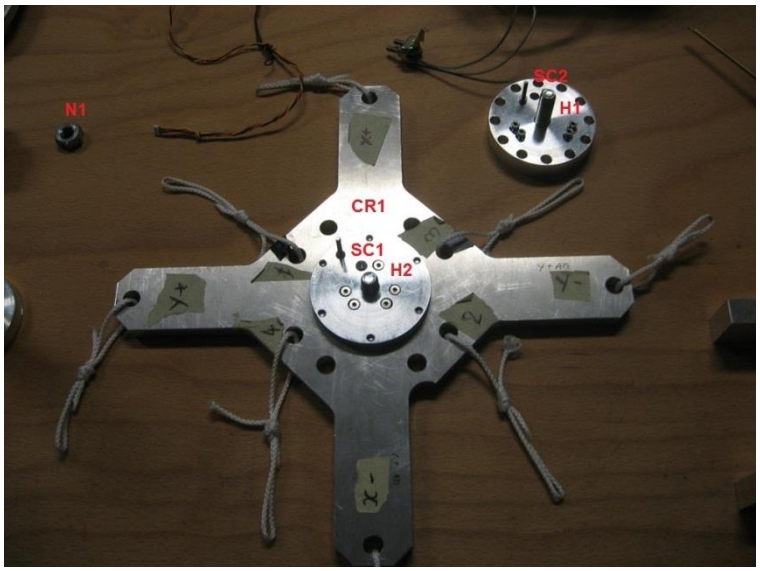


Figure 3: Custom made cross, heads and the nut

- 1 custom made "H" bracket "**BR1**" (Figure 4)

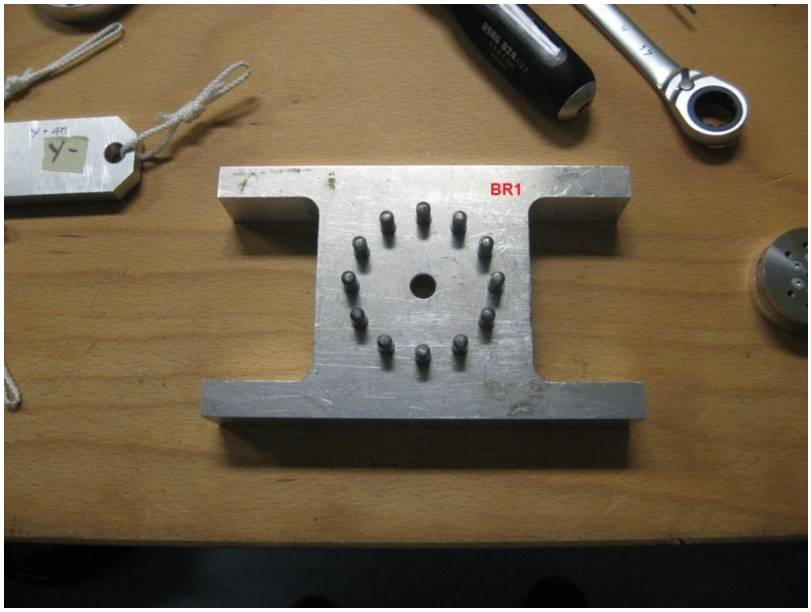


Figure 4: Custom made H bracket

- 1 tightening knob "**K1**" (Figure 5)
- 1 Set of spacers "**S1**" (Figure 5)
- 1 Z axis extension "**EXT1**" (Figure 5)

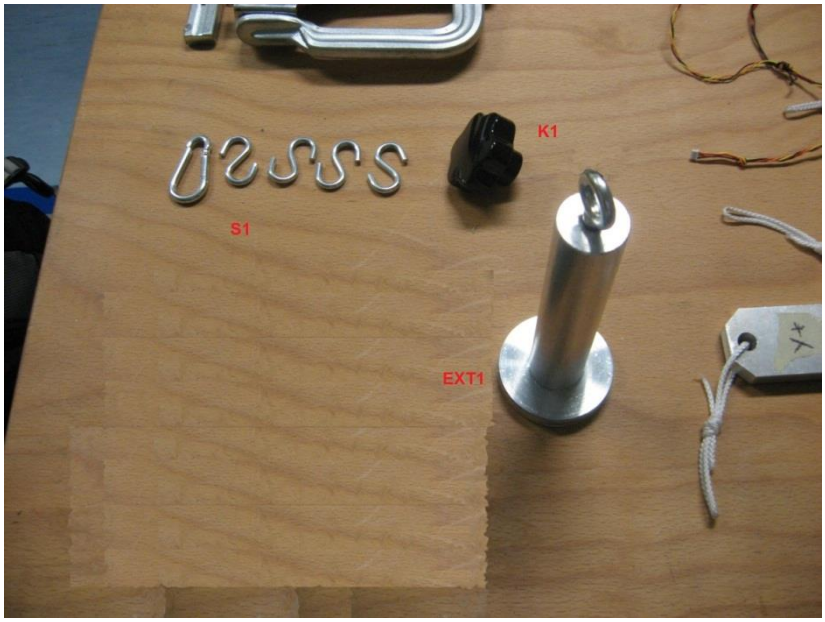


Figure 5: Custom made spacer, Z axis extension and knob

- 1 Z axis extension "**EXT2**" (Figure 6)

Figure 6: Custom made Z axis extension

- 1 2mm torque screwdriver "**TS1**" (Figure 7)
- 1 2mm hexagonal screwdriver "**HS1**" (Figure 7)
- 1 2.5mm hexagonal screwdriver "**HS2**" (Figure 7)
- 1 wrench 17mm "**W1**" (Figure 7)

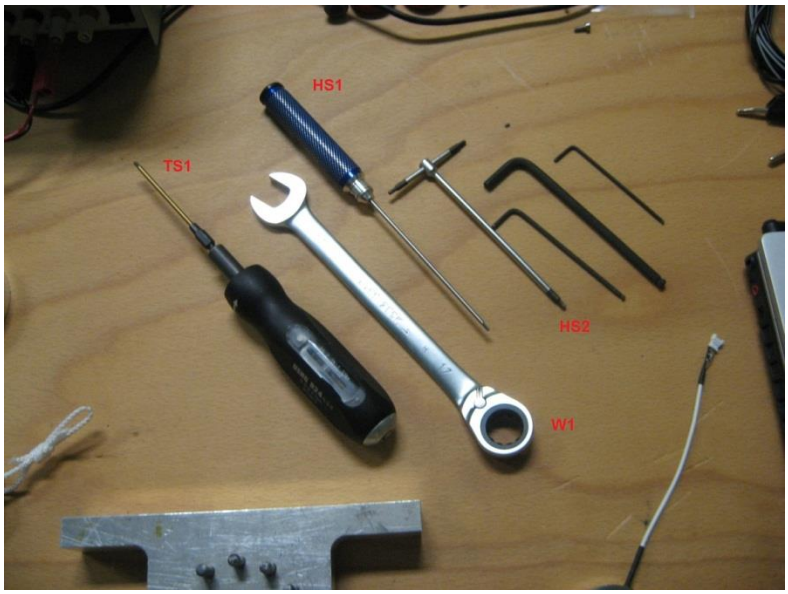


Figure 7: Screwdrivers

- Clamps to fix the structure "**CL1**" (Figure 8)

Figure 8: Clamps

- 1 CAN-USB with power and can bus connection cables (Figure 9)

Figure 9: CAN-USB with its cables

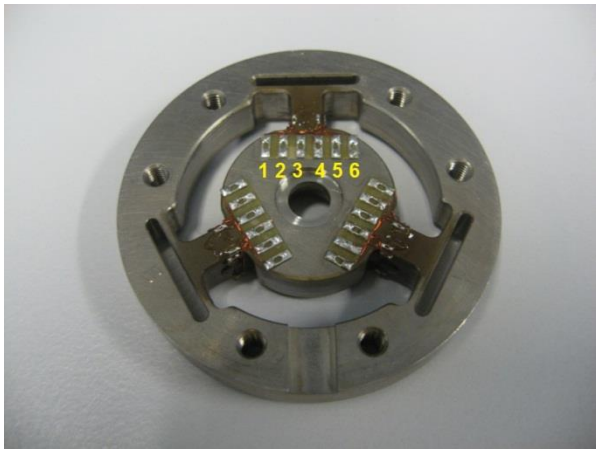
- 1 25Kg load
- 1 5Kg load

2 SENSOR ASSEMBLY

Handle the sensor taking care not to break thin wires

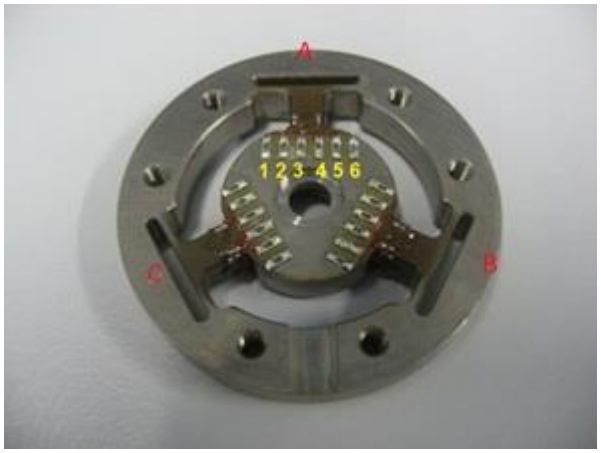
2.1 *Strain Gauge Resistance check*

TEST: Take the sensor and measure the resistance of each couple of pads for each of three groups as shown below and fill in the respective test report field.



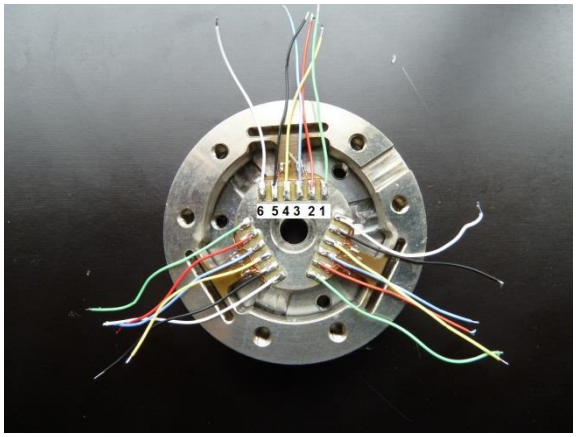
Pads Couple	Resistance +/- 40%
1-2	430 Ohm
2-6	430 Ohm
3-5	430 Ohm
4-5	430 Ohm

Figure 10: Strain gauge sensor resistance check



Fill in the table in the test reports with values of the resistive strain gauge. Attention! comply with the pairs as shown.

- Solder the wires CAB1 (*Figure 1*) to the sensor as shown below



1	GREEN
2	RED
3	BLUE
4	YELLOW
5	BLACK
6	WHITE

Figure 11: Sensor wired

- Pass the wires CAB1 (*Figure 1*) according images below

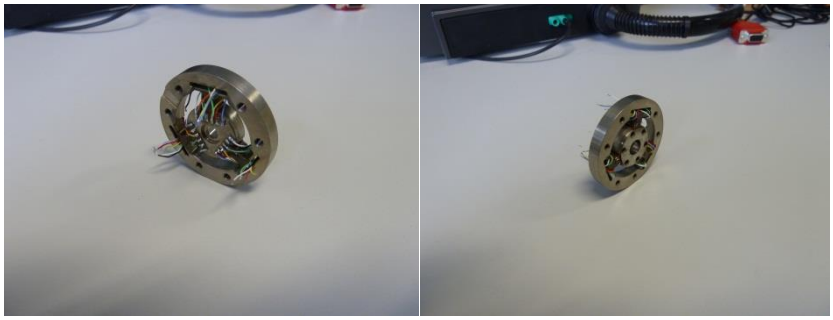
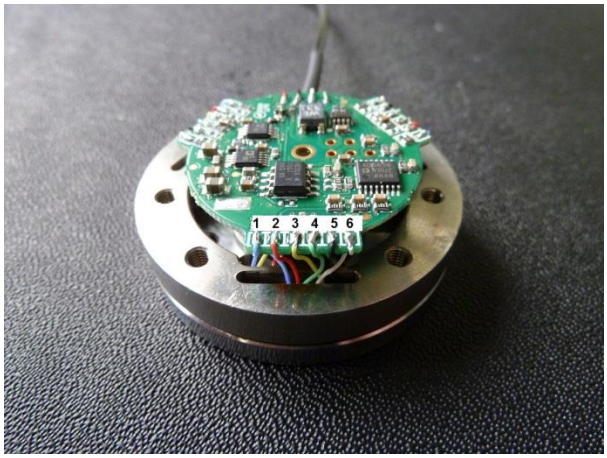


Figure 12: Wire configuration

- Solder the wires CAB1 (*Figure 1*) to the Strain PCB as shown below



1	BLUE
2	RED
3	YELLOW
4	GREEN
5	BLACK
6	WHITE

Figure 13: Sensor wired to the Strain PCB

- Solder the wires CAB2 (*Figure 1*) to the Strain PCB as shown below

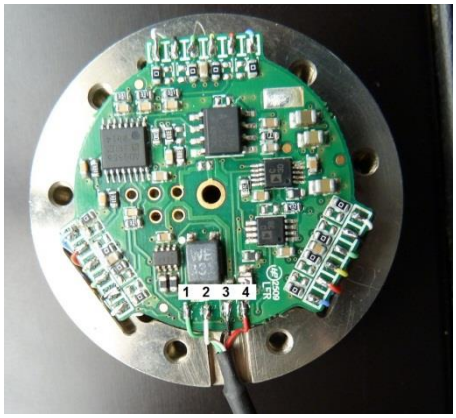
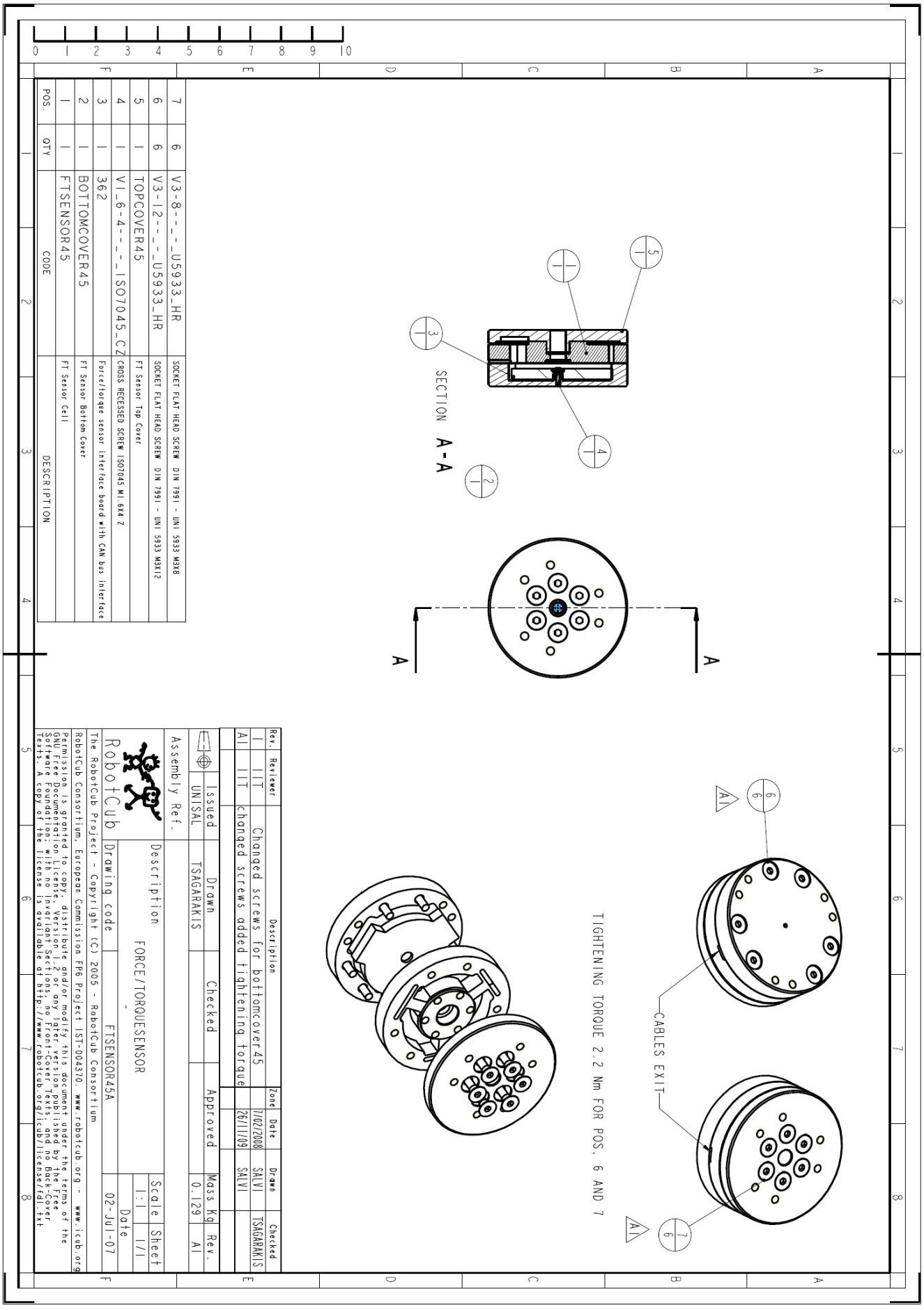


Figure 14: CAN and POWER cables soldered to the Strain PCB

1	GREEN
2	WHITE
3	BLACK
4	RED

- Assembly the sensor with its covers TC and BC (*Figure 1*) using appropriate screws tightening them using the torque screwdriver TS1 (*Figure 7*) settled at 2N/m as described in the following page



POS.	QTY	CODE	DESCRIPTION
7	6	V3-8---_U5933_HR	SOCKET FLAT HEAD SCREW DIN 7991 - UNI 5933 M3X8
6	6	V3-12---_U5933_HR	SOCKET FLAT HEAD SCREW DIN 7991 - UNI 5933 M3X12
5	1	TOPCOVER45	FT Sensor Top Cover
4	1	VI_6-4---_ISO7045_CZ	CROSS RECESSED SCREW ISO7045 M1.6X4 Z
3	1	362	Force/torque sensor interface board with CAN bus interface
2	1	BOTTOMCOVER45	FT Sensor Bottom Cover
1	1	FTSENSOR45	FT Sensor Cell

Rev.	Reviewer	Description	Zone	Date	Drawn	Checked
1	IIT	Changed screws for bottomcover45		7/02/2008	SALVI	TSAGARAKIS
A1	IIT	changed screws added tightening torque		26/11/09	SALVI	

Issued	Drawn	Checked	Approved	Mass Kg	Rev.
UNISAL	TSAGARAKIS			0.129	A1

Assembly Ref.

RobotCub

Description

FORCE/TORQUESENSOR

-

Drawing code	FTSENSOR45A	Scale	Sheet
		1:1	1/1
		Date	
		02-Jul-07	

2.2 *Short circuit Check*

- Test the wires black red green and white (molex connector) between them and read the resistive values.

RED - GREEN	MΩ
RED - WHITE	MΩ
RED - BLACK	MΩ
GREEN - WHITE	± 70KΩ
GREEN - BLACK	MΩ
WHITE - BLACK	MΩ
BLACK - chassy of the sensor	Open Circuit
WHITE - chassy of the sensor	Open Circuit
RED - chassy of the sensor	Open Circuit
GREEN - chassy of the sensor	Open Circuit

- If you do not respect the values shown in the table STOP CALIBRATION AND GIVE BACK TO IIT THE SENSOR FOR INVESTIGATION

2.3 *Pre calibration Check*

- Connect the sensor to the PC using the CAN-USB device and wait at least 5 seconds to let the board has been initialized (Figure 9)
- Launch "Canloader.exe" application
- **Click on "Connect" button and you should get this (Figure 15)**

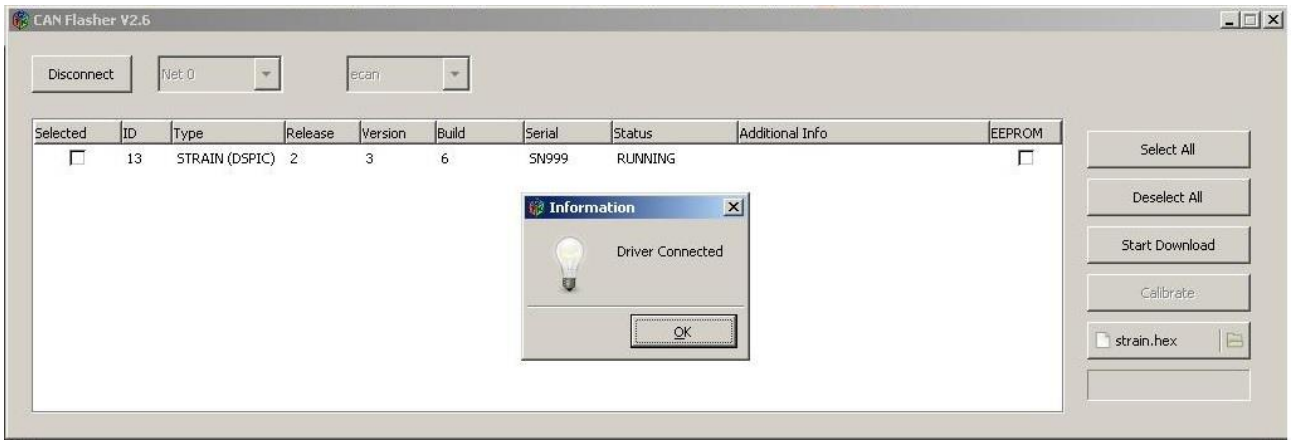


Figure 15: Canloader connected to the device

- Click OK
- Check if the firmware version is the latest one; if not Download again the firmware "strain.hex" located at "***C:\Software\iCub\firmware\build***" , disconnect the sensor and restart from point 2.2
- Edit the "ID" field by typing "13"

- Check both “Selected” and “EEPROM” check boxes
- Click on “Calibrate” button and you should get this (Figure 16)

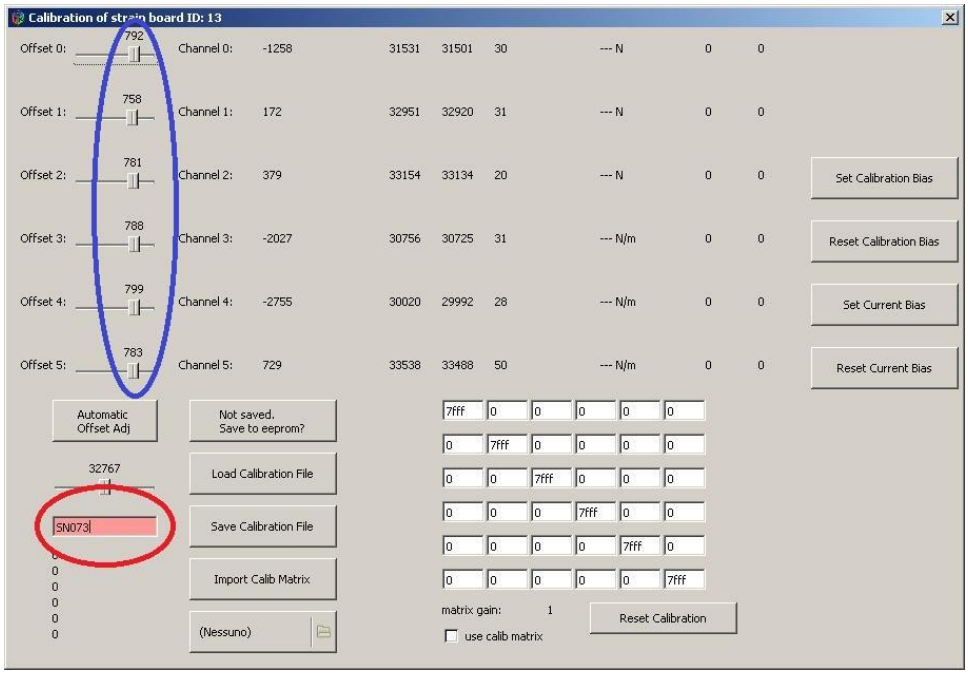
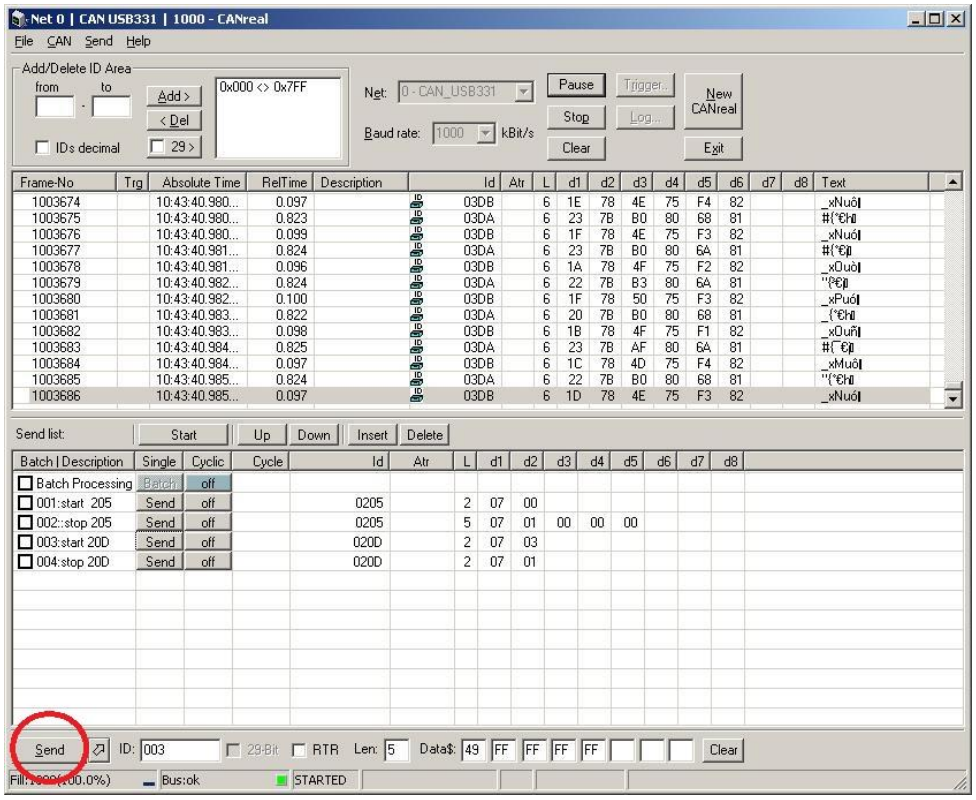


Figure 16: Canloader "Calibrate" window

- Fill in the box highlighted in red (Figure 16) with the serial number of the sensor in the “SNXXX” format.
- Click on the “Automatic Offset Adj” button and make sure that all the values highlighted in blue (Figure 16) are between 700 and 800; if not DO NOT CONTINUE THE CALIBRATION PROCEDURE.
- All values under the serial number box must be at 0; if not Download again the firmware “strain.hex” located at “***C:\Software\iCub\firmware\build***” , disconnect the sensor and restart from point 2.3
- All values in the matrix grid just above the “Reset Calibration” button must be identical to the Figure 16 ; if not Download again the firmware “strain.hex” located at “***C:\Software\iCub\firmware\build***” , disconnect the sensor and restart from point 2.3
- Click on the “Not Saved. Save to eeprom?” button and close the window.
- Click on the “Disconnect” button of the CanLoader main window.
- Launch “Canreal.exe” application

Load the “canreal_conf.cspsl” configuration file using “Send->Load List” . The configuration file is in the “***C:\ftSensCalib\software\sensAcquisitionArchive\calib_config_files***” repository

- Click on the “Send” button in the bottom left corner.



- Now you'll see the Can bus pockets in the window

- Launch the Gulp "graph.exe" application

Load the "gulp_conf.gup" configuration file using "File->Load Parameters" menu. The configuration file is in the "[…]\ftSensCalib\software\sensAcquisitionArchive\calib_config_files" repository under revision control (https://svn.icub.iit.local/repos/mecha/ftSensCalib/trunk)

- Click on "Start" button on the bottom right and you should see 6 colored lines
- Refer to the picture (Figure 17) place the sensor on the table , press near the three couple of screw holes (A,B,C) and you should see lines moving DOWN in the gulp window (Figure 18) ; if not DO NOT CONTINUE THE CALIBRATION PROCEDURE.

Figure 17:Gulp Pressing Point-Lines association

POINT PRESSED	LINE MOVING
A	BLUE
B	CYAN
C	RED

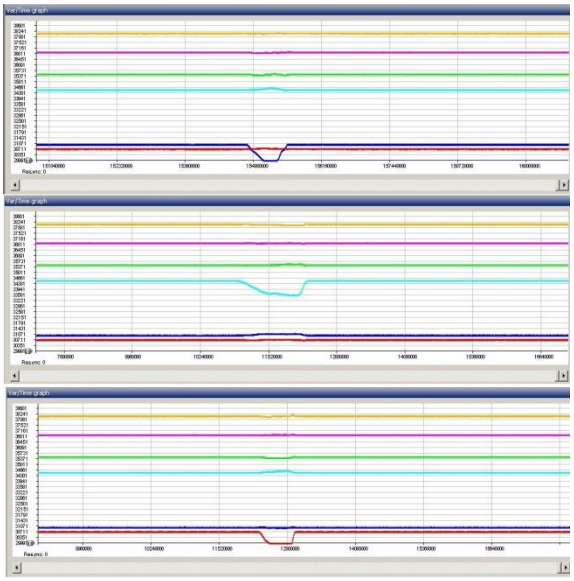


Figure 18: Compression Gulp lines moving

- Refer to the picture (*Figure 19*) take the sensor in your hands , and moving your hands as described I n the table you have to see lines moving () ; if not DO NOT CONTINUE THE CALIBRATION PROCEDURE.

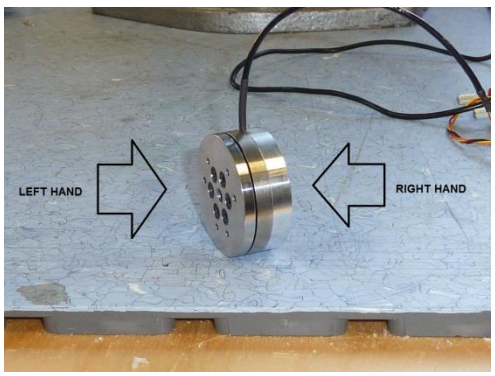


Figure 19: Sensor in hands moving directions

Right Hand Moving Direction	Left Hand Moving Direction	Orange, Violet and Green GULP lines moving direction
clockwise	counterclockwise	DOWN
counterclockwise	clockwise	UP

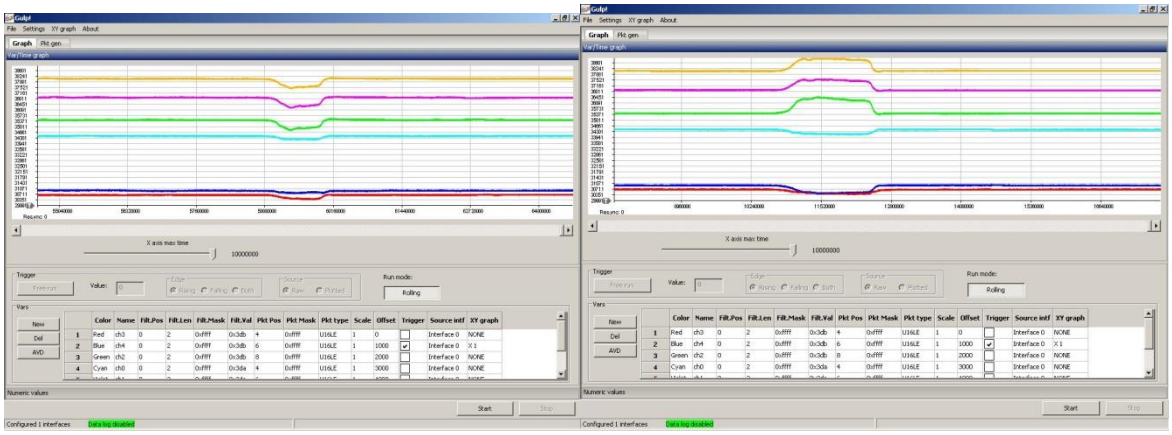


Figure 20: Torque Gulp lines moving.

- Click on “Stop” button both in the “Gulp” and “CanReal” applications
- Close both the applications

3 CALIBRATION SETUP ASSEMBLY

1) Assembly H1 to the sensor using SC2 screws as follow

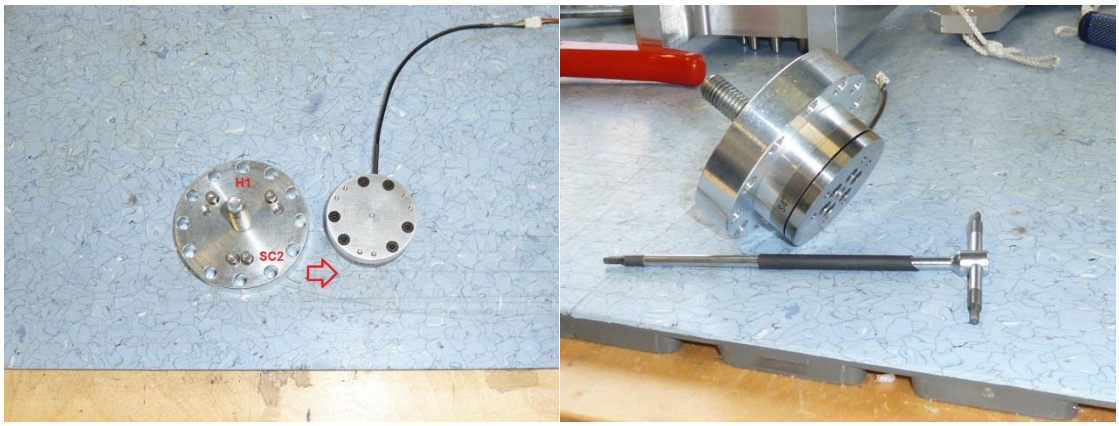


Figure 21: H1 head assembly

2) Place the sensor on the bracket BR1 as follow

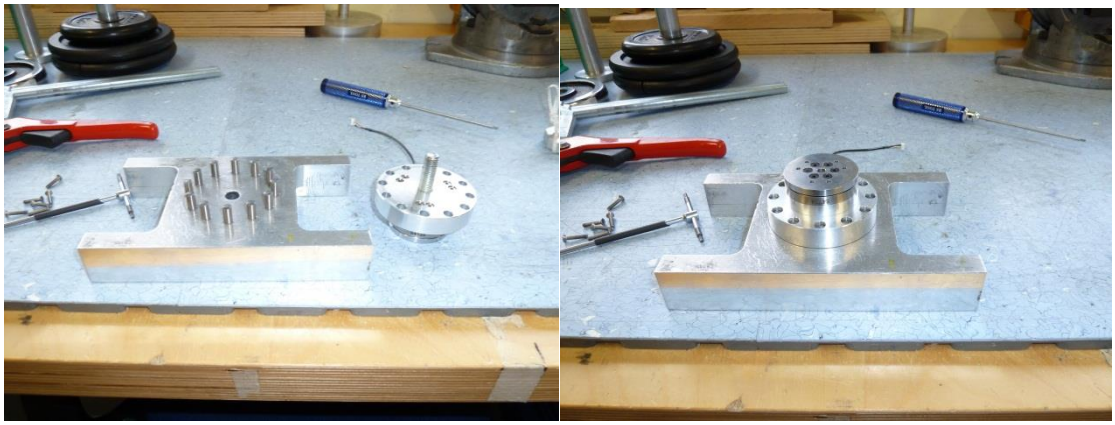


Figure 22: BR1 bracket assembly

3) Assembly the cross CR1 to the sensor using SC1 screws and N1 nut taking care that the sensor cable is in the "X-" label direction as follow

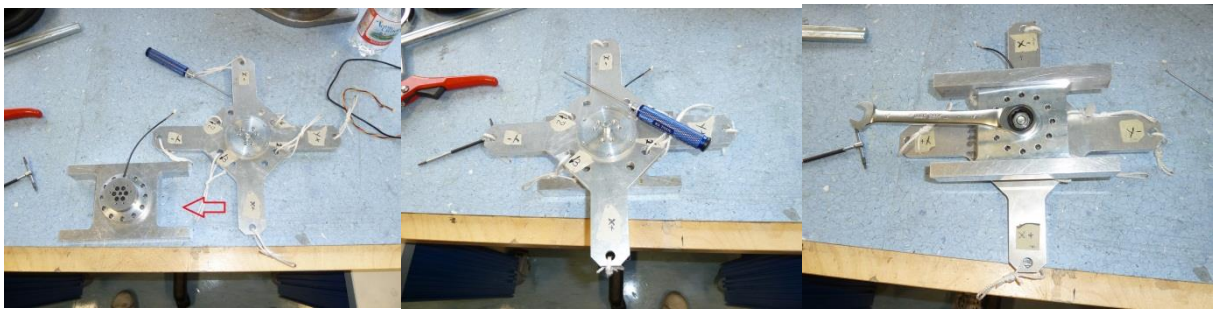


Figure 23: Cr1 cross assembly

4 SENSOR CALIBRATION PROCEDURE

Handle with care the loads and wear accident prevention shoes for your safety!

- Connect the sensor to the PC using USB-CAN device
- Launch the "ftSensCalibDataAq.exe" application and you should get this window that contains the sequence of data acquisition needed to calibrate the sensor.
  Follow the steps from 1 to 13 to complete data acquisition.
  Each step gives you indication about the setup configuration.

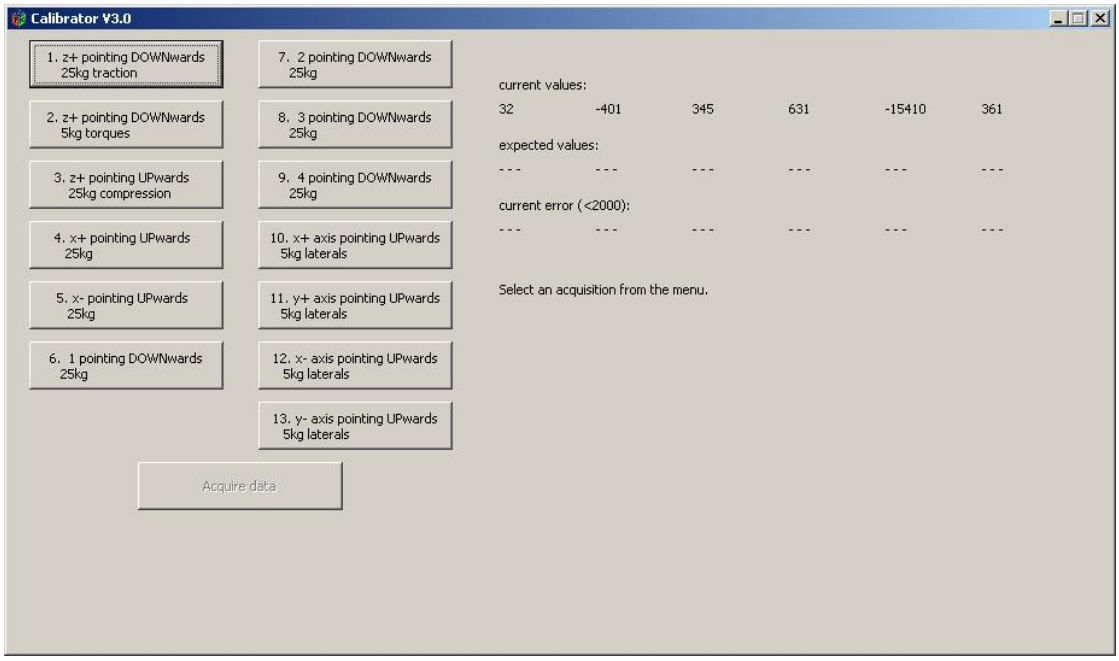


Figure 24: Sensor calibration window

4.1 *Z+ pointing downwards 25kg traction*

- Click on button concerning step 1
- Place the setup with the Z+ axis pointing downwards with EXT2 Z axis extension mounted ,without loads and press “Acquire data” button as shown below

Figure 25: Setup Configuration

- Place a 25Kg load on the z+ axis , wait that the load is stable (not swing) and check the numbers in the window. They must be all in green, if not take note of strange values in the report

Figure 26: Load Configuration

- Press “Acquire data” button and remove the load

4.2 *Z+ pointing downwards 5kg torques*

- Click on button concerning step 2
- Place the setup with the Z+ axis pointing downwards without EXT2 Z axis extension , without loads and press “Acquire data” button as shown below

Figure 27: Setup Configuration

- Following the window instructions place a 5Kg load on the “Y-“ axis (and then for the other 3 axes), wait that the load is stable (not swing) and check the numbers in the window. They must be all in green, if not take note of strange values in the report

Figure 28: Load configurations

- Press “Acquire data” button and remove the load

4.3 *Z+ pointing upwards 25kg compression*

- Click on button concerning step 3
- Place the setup with the Z+ axis pointing upwards with EXT1 Z axis extension mounted , without loads and press “Acquire data” button as shown below

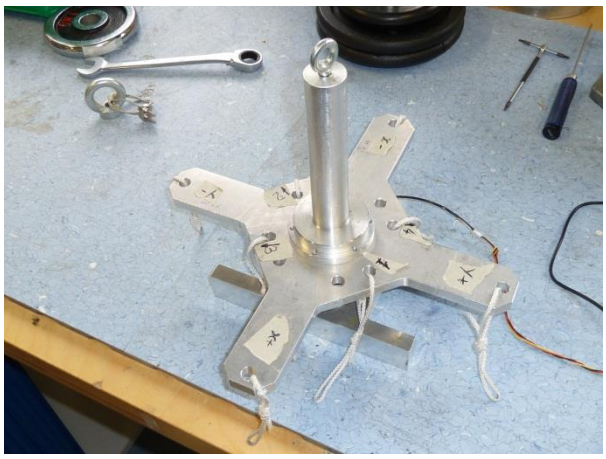


Figure 29: Setup Configuration

- Following the window instructions place a 25Kg load on the “Z+“ axis and check the numbers in the window. They must be all in green, if not take note of strange values in the report

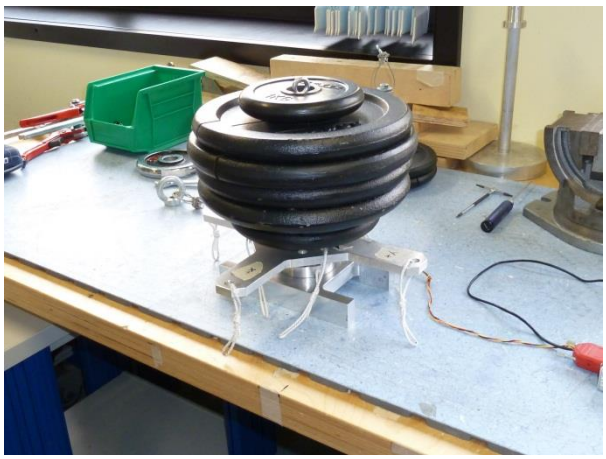


Figure 30: Load configuration

- Press “Acquire data” button and remove the load
- Fill in the respective calibration report field

4.4 *X+ pointing upwards 25kg*

- Click on button concerning step 4
- Place the setup with the X+ axis pointing upwards without loads and press “Acquire data” button as shown below

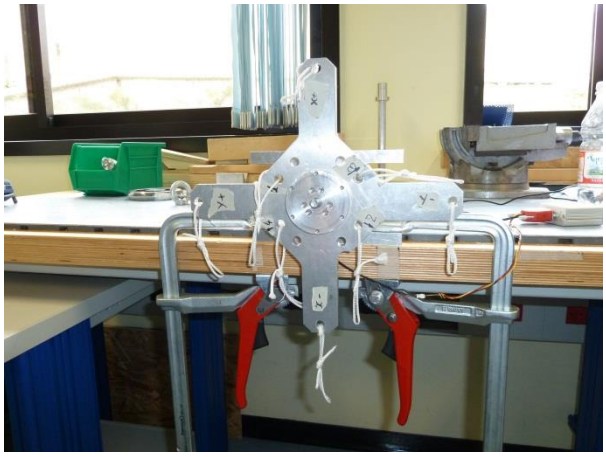


Figure 31: Setup Configuration

- Following the window instructions place a 25Kg load on the “X-“ axis ,wait that the load is stable (not swing) and check the numbers in the window. They must be all in green, if not take note of strange values in the report

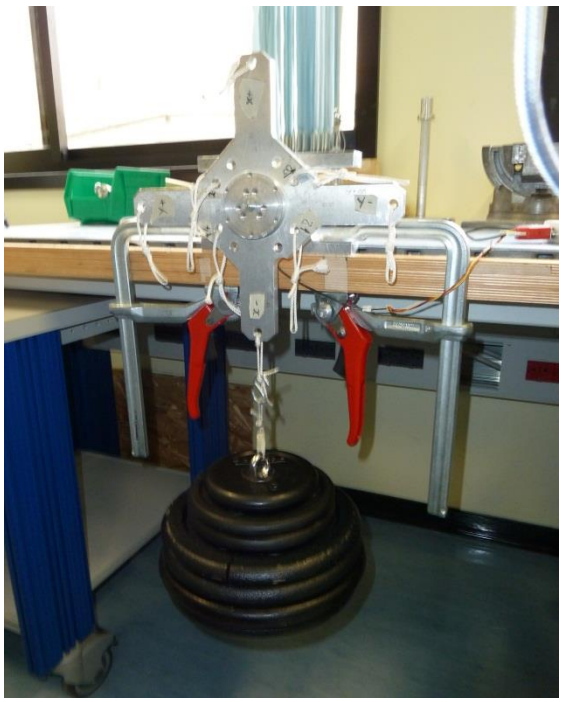


Figure 32: Load configuration

- Press “Acquire data” button and remove the load
- Fill in the respective calibration report field

4.5 *X- pointing upwards 25kg*

- Click on button concerning step 5
- Place the setup with the X- axis pointing upwards without loads and press “Acquire data” button as shown below

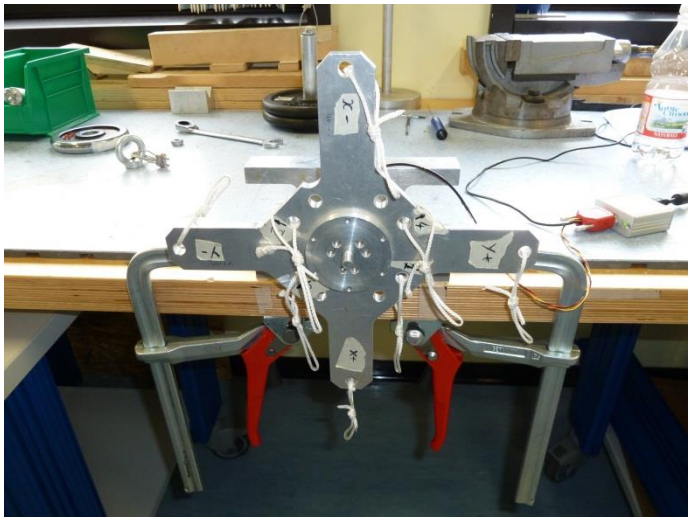


Figure 33: Setup Configuration

- Following the window instructions place a 25Kg load on the “X+“ axis ,wait that the load is stable (not swing) and check the numbers in the window. They must be all in green, if not take note of strange values in the report

Figure 34: Load configuration

- Press “Acquire data” button and remove the load
- Fill in the respective calibration report field

4.6 *"1" pointing downwards 25kg*

- Click on button concerning step 6
- Place the setup with the label "1" pointing downwards without loads and press "Acquire data" button as shown below

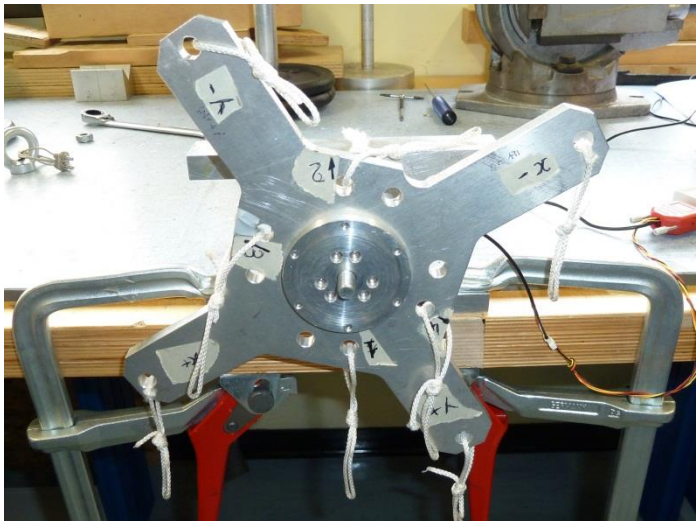


Figure 35: Setup Configuration

- Following the window instructions place a 25Kg load on the "1" label ,wait that the load is stable (not swing) and check the numbers in the window. They must be all in green, if not take note of strange values in the report

Figure 36: Load configuration

- Press "Acquire data" button and remove the load
- Fill in the respective calibration report field

4.7 *"2" pointing downwards 25kg*

- Click on button concerning step 7
- Place the setup with the label "2" pointing downwards without loads and press "Acquire data" button as shown below

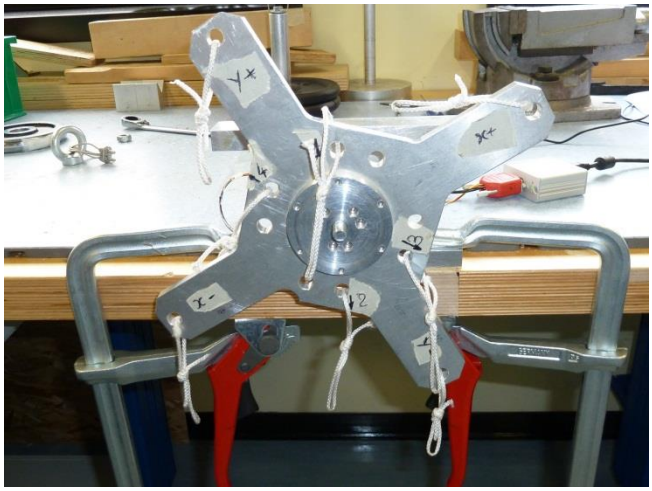


Figure 37: Setup Configuration

- Following the window instructions place a 25Kg load on the "2" label ,wait that the load is stable (not swing) and check the numbers in the window. They must be all in green, if not take note of strange values in the report

Figure 38: Load configuration

- Press "Acquire data" button and remove the load
- Fill in the respective calibration report field

4.8 *"3" pointing downwards 25kg*

- Click on button concerning step 8
- Place the setup with the label "3" pointing downwards without loads and press "Acquire data" button as shown below

Figure 39: Setup Configuration

- Following the window instructions place a 25Kg load on the "3" label ,wait that the load is stable (not swing) and check the numbers in the window. They must be all in green, if not take note of strange values in the report

Figure 40: Load configuration

- Press "Acquire data" button and remove the load
- Fill in the respective calibration report field

4.9 *"4" pointing downwards 25kg*

- Click on button concerning step 9
- Place the setup with the label "4" pointing downwards without loads and press "Acquire data" button as shown below

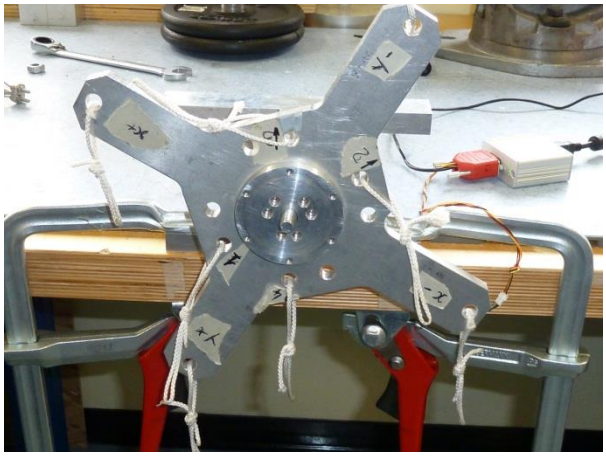


Figure 41: Setup Configuration

- Following the window instructions place a 25Kg load on the "4" label ,wait that the load is stable (not swing) and check the numbers in the window. They must be all in green, if not take note of strange values in the report

Figure 42: Load configuration

- Press "Acquire data" button and remove the load
- Fill in the respective calibration report field

4.10 *X+ pointing upwards 5kg laterals*

- Click on button concerning step 10
- Place the setup with the axis "X+" pointing upwards with the EXT1 Z axis extension mounted, without loads and press "Acquire data" button as shown below

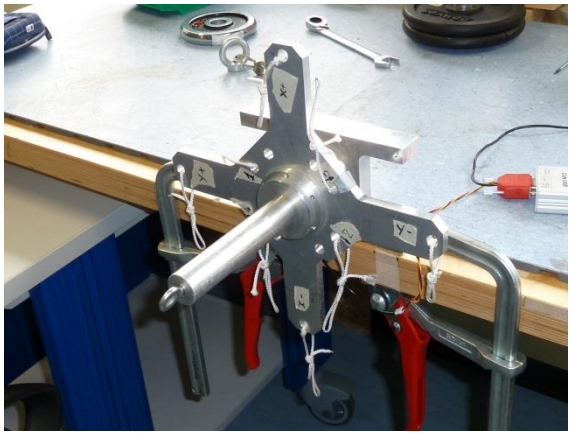


Figure 43: Setup Configuration

- Following the window instructions place a 5Kg load on the Y- axis (then on the Z+ and Y+ axes), wait that the load is stable (not swing) and check the numbers in the window. They must be all in green, if not take note of strange values in the report

Figure 44: Load configurations

- Press "Acquire data" button and remove the load
- Fill in the respective calibration report field

4.11 *Y+ pointing upwards 5kg laterals*

- Click on button concerning step 11
- Place the setup with the axis "Y+" pointing upwards with the EXT1 Z axis extension mounted, without loads and press "Acquire data" button as shown below

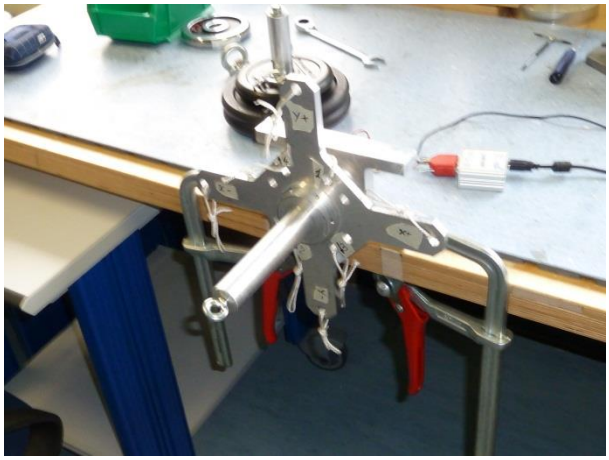


Figure 45: Setup Configuration

- Following the window instructions place a 5Kg load on the X+ axis (then on the Z+ and X- axes), wait that the load is stable (not swing) and check the numbers in the window. They must be all in green, if not take note of strange values in the report

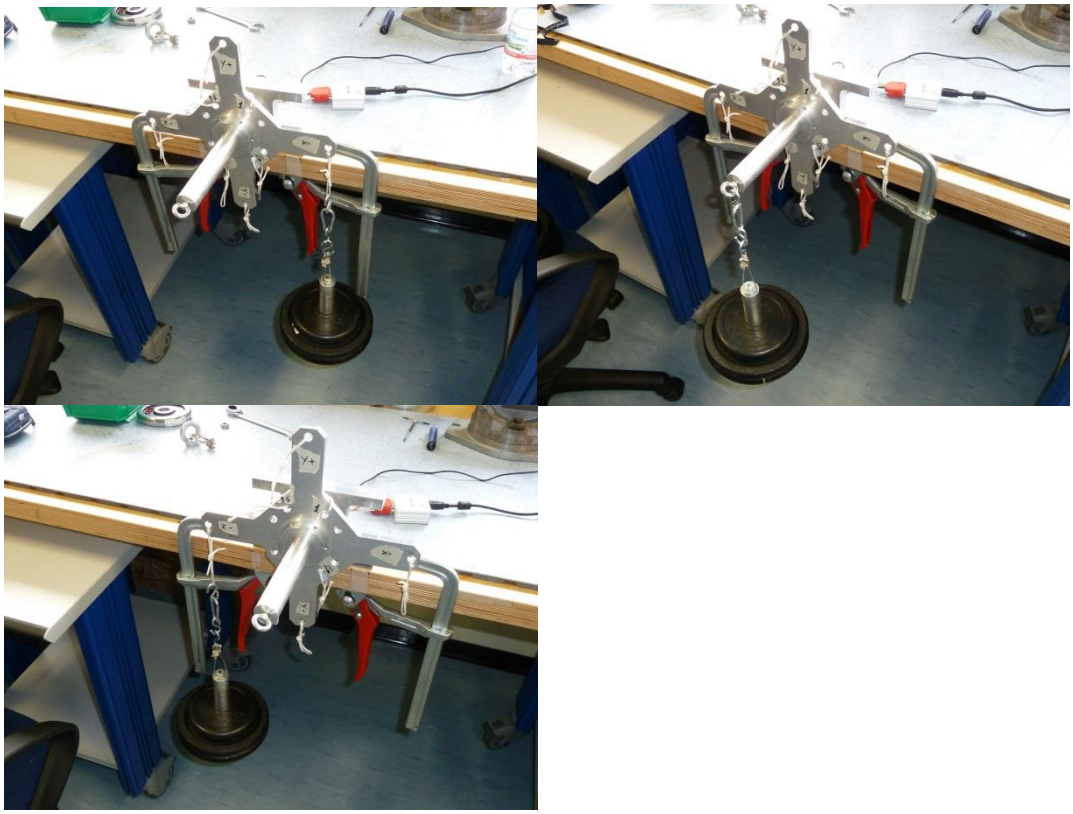


Figure 46: Load configurations

- Press "Acquire data" button and remove the load
- Fill in the respective calibration report field

4.12 *X- pointing upwards 5kg laterals*

- Click on button concerning step 12
- Place the setup with the axis "X-" pointing upwards with the EXT1 Z axis extension mounted, without loads and press "Acquire data" button as shown below

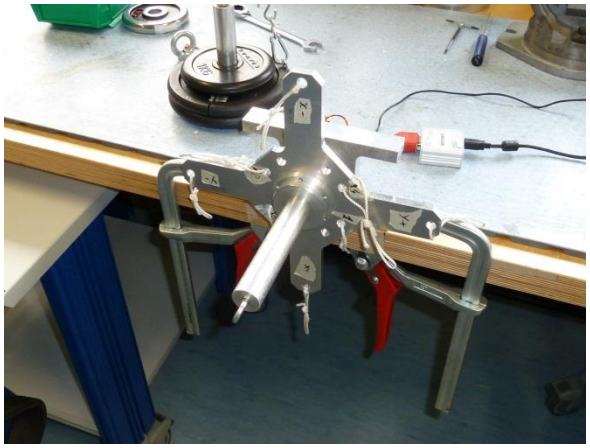


Figure 47: Setup Configuration

- Following the window instructions place a 5Kg load on the Y+ axis (then on the Z+ and Y- axes), wait that the load is stable (not swing) and check the numbers in the window. They must be all in green, if not take note of strange values in the report

Figure 48: Load configurations

- Press "Acquire data" button and remove the load
- Fill in the respective calibration report field

4.13 *Y- pointing upwards 5kg laterals*

- Click on button concerning step 13
- Place the setup with the axis "Y-" pointing upwards with the EXT1 Z axis extension mounted, without loads and press "Acquire data" button as shown below

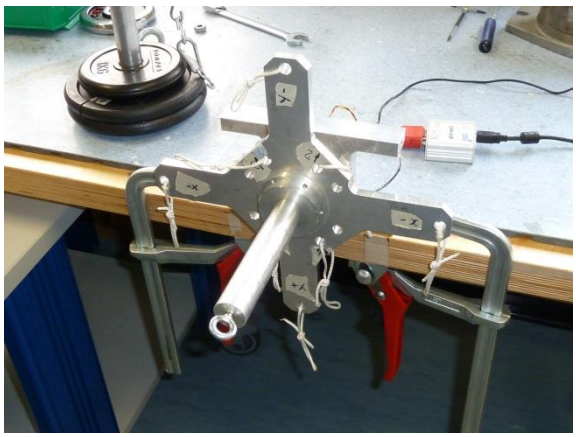


Figure 49: Setup Configuration

- Following the window instructions place a 5Kg load on the X- axis (then on the Z+ and X+ axes), wait that the load is stable (not swing) and check the numbers in the window. They must be all in green, if not take note of strange values in the report

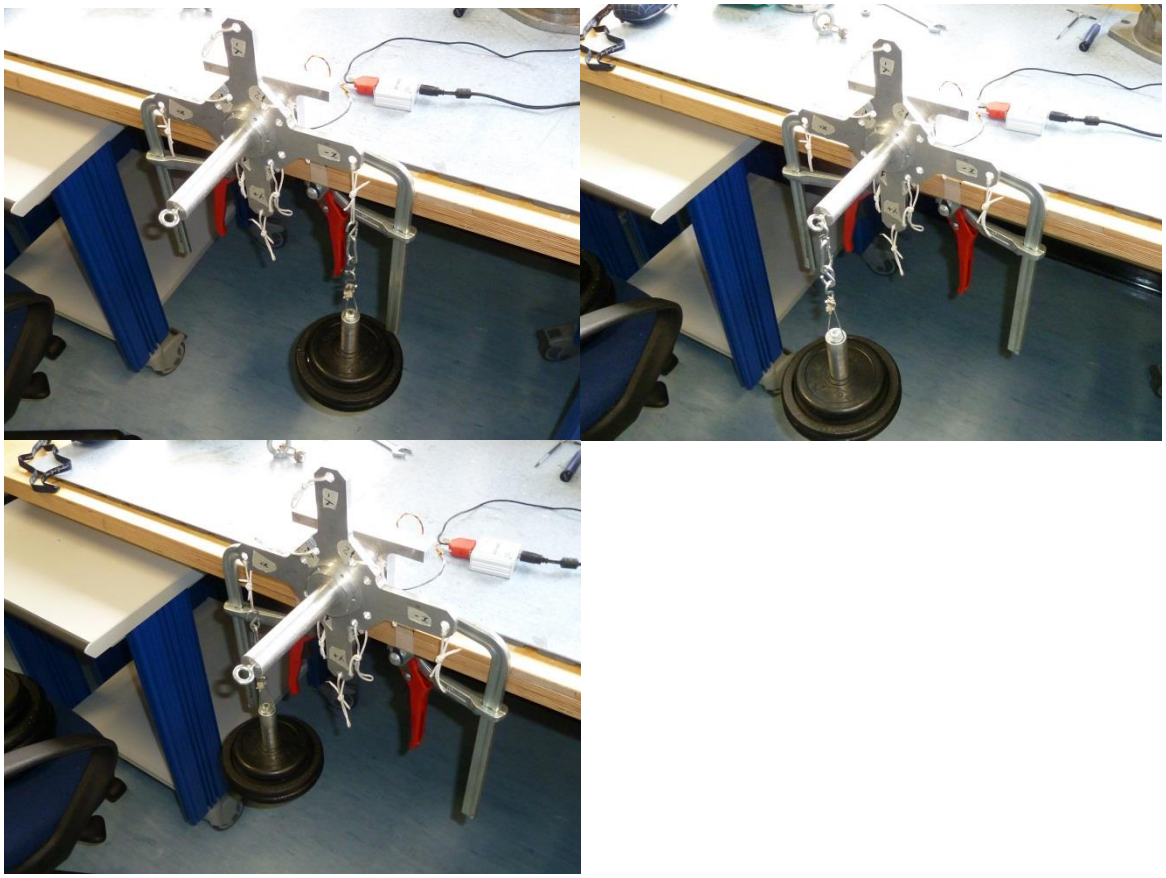


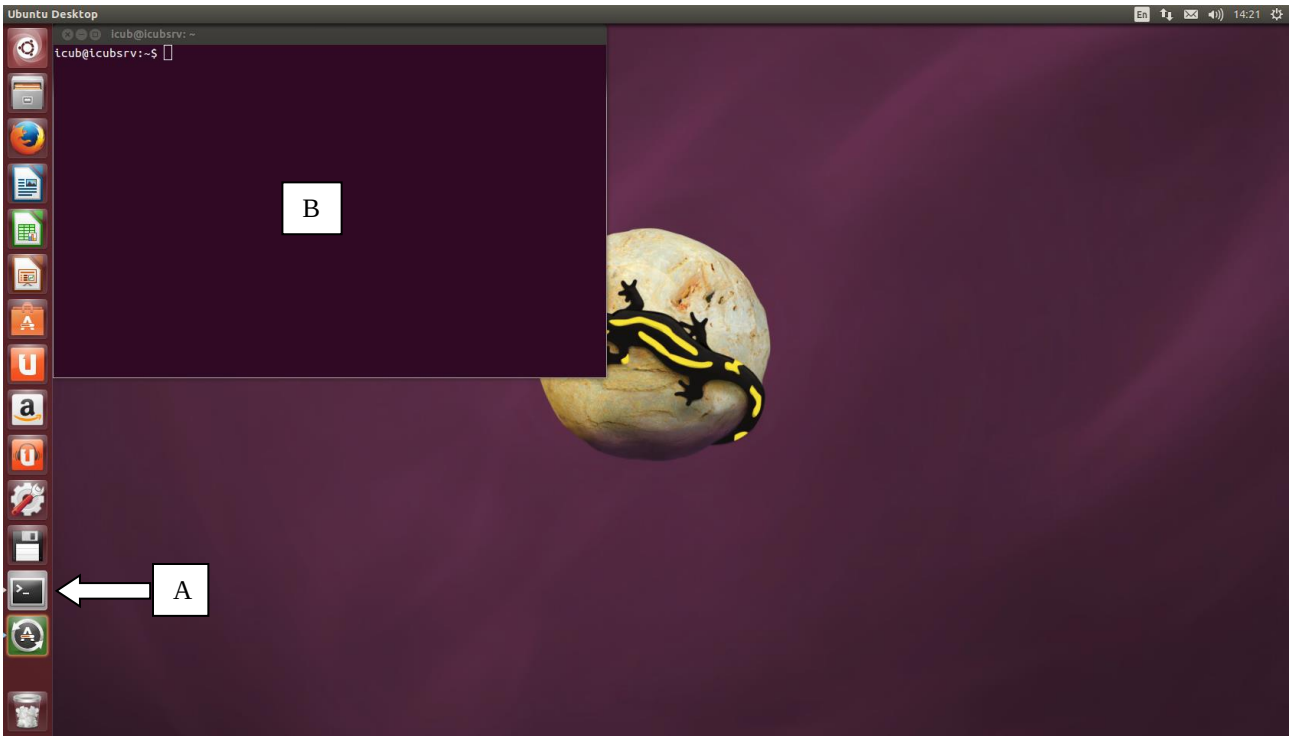
Figure 50: Load configurations

- Press "Acquire data" button and remove the load
- Fill in the respective calibration report field

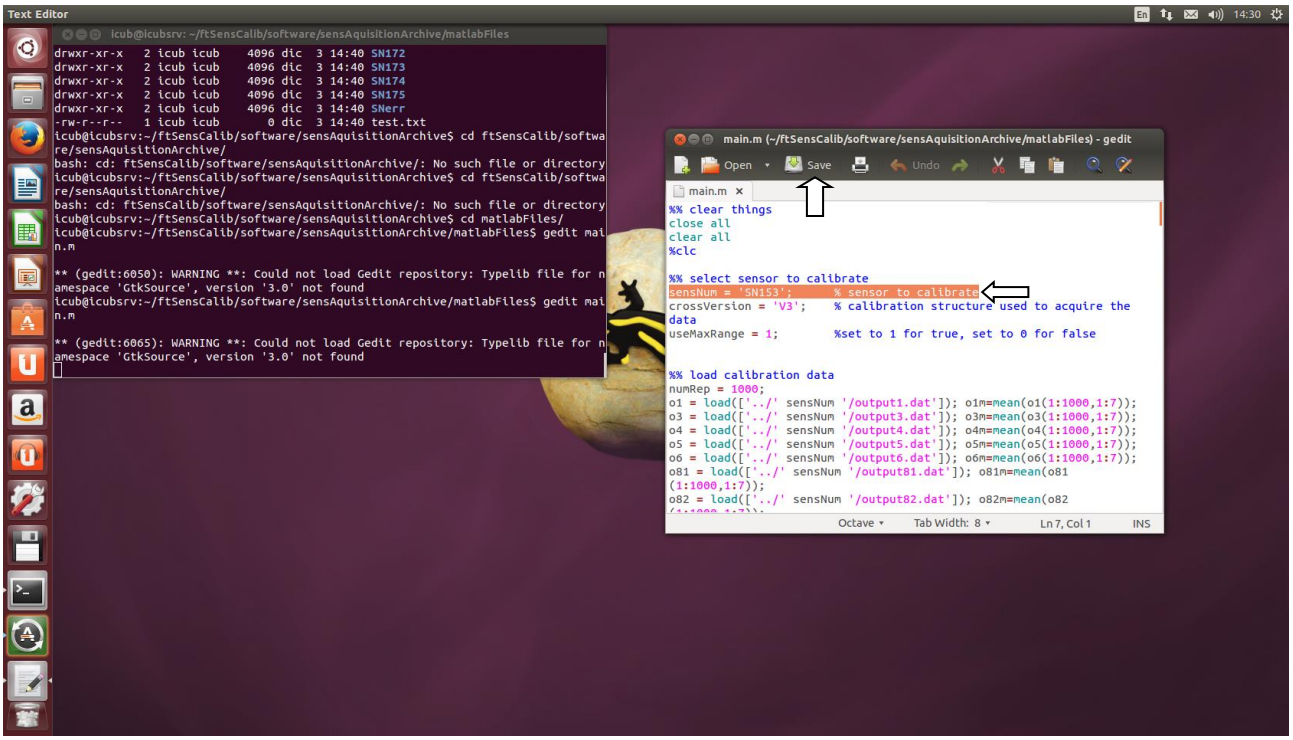
4.14 *Generating Calibration Matrix*

- Close the “ftSensCalibDataAq.exe” application.
- Disassemble the calibration setup from the sensor and keep it connected to the PC
- Create a directory named
  C: \ftsenscalib\software\sensAquisitionArchive\SNxxx
  Where “SNXXX” is the serial number of the sensor under test.
- Copy all files just generated by “ftSensCalibDataAq.exe” application
  From : ***C:\ftsenscalib\software\acquisitionV3\build\release\Data***
  To : ***C:\ftsenscalib\software\sensAquisitionArchive\SNxx***

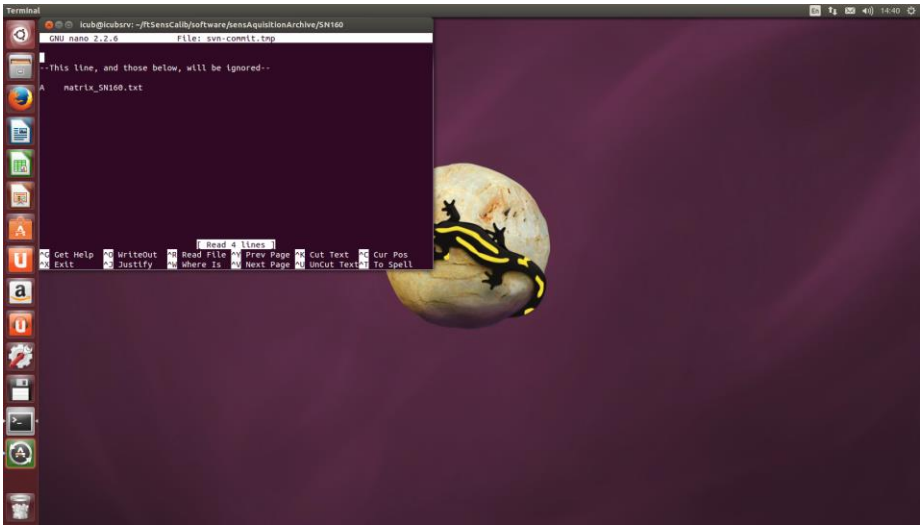
- Do SVN Add and then Commit of the sensor’s folder (SNxxx)
- Copy the Ubuntu VM (\\storage01.icub.iit.local\repository\production\SoftwareToInstall\Ubuntu 64-bit (2)) on your PC and run it (VMware Player -> Select Ubuntu -> Play virtual machine)
  User: icub
  password: icub
- Click on terminal icon (A) and a new terminal will open (B) :



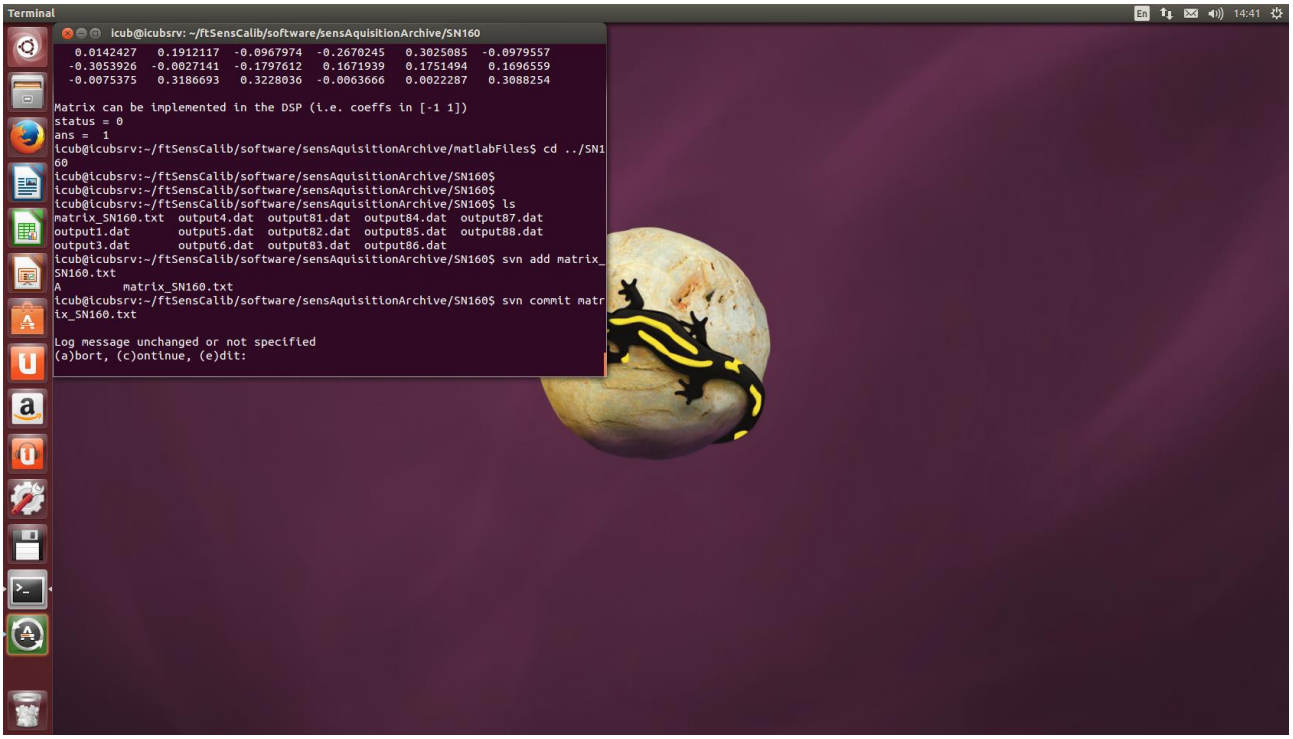
- Type “cd ftSensCalib/software/sensAquisitionArchive/”
- Type “svn up”
- Type “cd matlabFiles/”
- Type “gedit main.m”
- Change the “sensNum = 'SNxxx'; % sensor to calibrate” statement with your sensor number and click Save



- Type “octave main.m”
- Type “cd ../SNxxx” where xxx is your sensor number
- Check if the matrix_SNxxx.txt is present
- Type “svn add matrix_SNxxx.txt”
- Type “svn commit matrix_SNxxx.txt”; the window shown below will open, type “CTRL+X”.



- At the choice below answer “c”



- Now you can close Ubuntu VM and do SVN update on windows.

4.15 *Uploading calibration matrix*

- Launch “CanLoader.exe” application
- Click on “Connect” button then on the “OK” button
- Check both “Selected” and “EEPROM” check boxes
- Click on “Calibrate” button
- Click on the “Automatic Offset Adj” button
- Click on the “Not Saved. Save to eeprom?” button
- Click on the button labeled “(Nessuno)” and browse for the calibration matrix file generated from Octave in the folder ***C:\ftsenscalib\software\sensAquisitionArchive\SNxx***
- Click on “Import Calib Matrix” button and you must see the matrix grid just above the “Reset Calibration” button filled in with new values
- Click on the “Not Saved. Save to eeprom?” button
- Check the “use calib matrix” checkbox
- Click on the “Set Calibration Bias” button
- Click on the “Not Saved. Save to eeprom?” button
- Place a 1Kg load over the sensor (Figure 51)

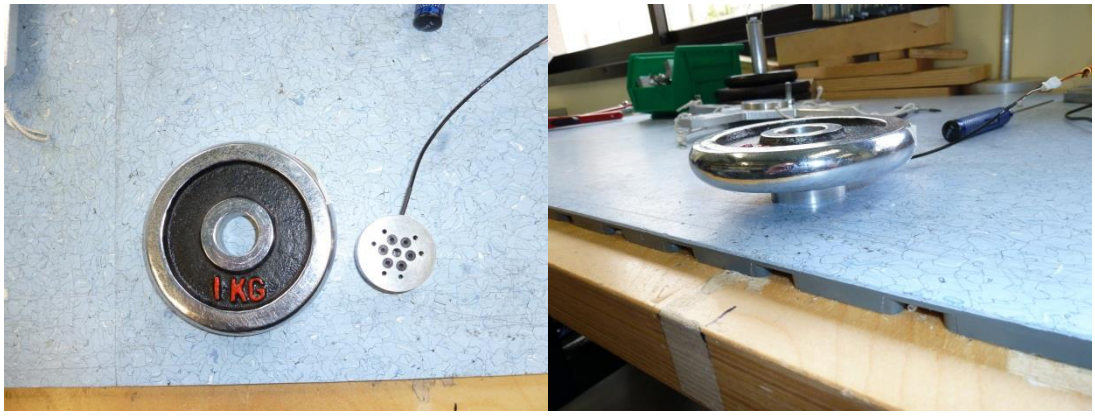


Figure 51: 1Kg final check

- Check if the value highlighted in red is about +10 or -10 (it depends on which side you apply the load)

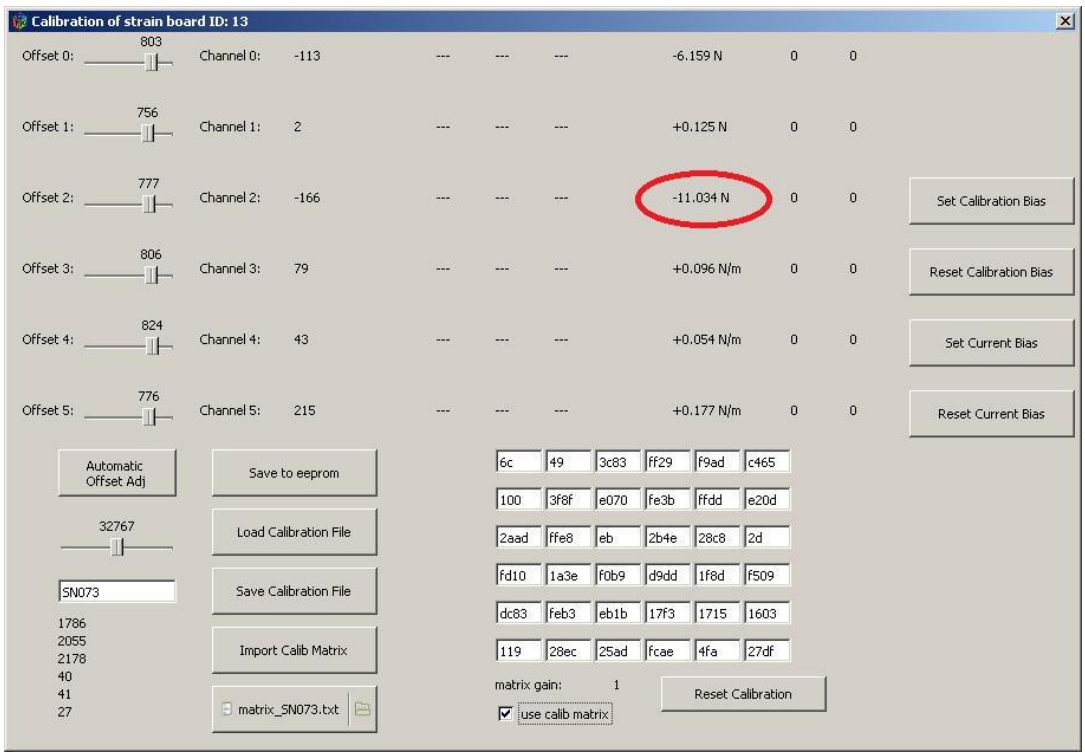


Figure 52: 1Kg value check

- Click on the “Save Calibration File”
- Close the window
- Click on the “Disconnect” button
- Copy the file just generated named “**calibrationDataSNXXX.dat**”
  From : ***C:\icub-main\build\bin\Release***
  To : ***C:\ftsenscalib\software\sensAquisitionArchive\SNxx***
- Disconnect the sensor from the CAN-USB device
- Fill in the respective calibration report field

4.16 *Committing sensor calibration folder*

- Browse for "***C:\ftsenscalib\software\sensAquisitionArchive"*** folder
- Right click on "SNXXX" folder
- Select "TortoiseSVN➔+Add" command
- Click "OK"
- Right click on the "SNXXX" folder and select "SVN Commit…" command
- Click "OK"

5 SENSOR CALIBRATION REPORT

SENSOR S/N:	
Test Date:	**Tester:**
Strain Gauge S/N:	

Test	Passed	Failed
2.1 Strain Gauge Resistance check		
Note:		

Pads Couple	Resistance +/- 40%	A	B	C
1-2	430 Ohm			
2-6	430 Ohm			
3-5	430 Ohm			
4-5	430 Ohm			

2.2 Short circuit Check		
Note:		
4.1 Z+ pointing downwards 25kg traction		
Note:		
4.2 Z+ pointing downwards 5kg torques		
Note:		
4.3 Z+ pointing upwards 25kg compression		
Note:		
4.4 X+ pointing upwards 25kg		
Note:		
4.5 X- pointing upwards 25kg		
Note:		
4.6 “1” pointing downwards 25kg		
Note:		
4.7 “2” pointing downwards 25kg		
Note:		
4.8 “3” pointing downwards 25kg		
Note:		
4.9 “4” pointing downwards 25kg		
Note:		
4.10 X+ pointing upwards 5kg laterals		
Note:		

4.11 Y+ pointing upwards 5kg laterals		
Note:		
4.12 X- pointing upwards 5kg laterals		
Note:		
4.13 Y- pointing upwards 5kg laterals		
Note:		