Triple Multi Modal Unit, TMMU

User guide

NTNU
Det skapende universitet

Contents

1 Product overview

The TMMU prototype is a multi modal sensor unit designed for use in upper limb prosthesis research. The sensor consists of a series of different components, that can be assembled in different ways for a range of applications. Please see Suleng (2012) for detailed information on the design and development of the finished product.

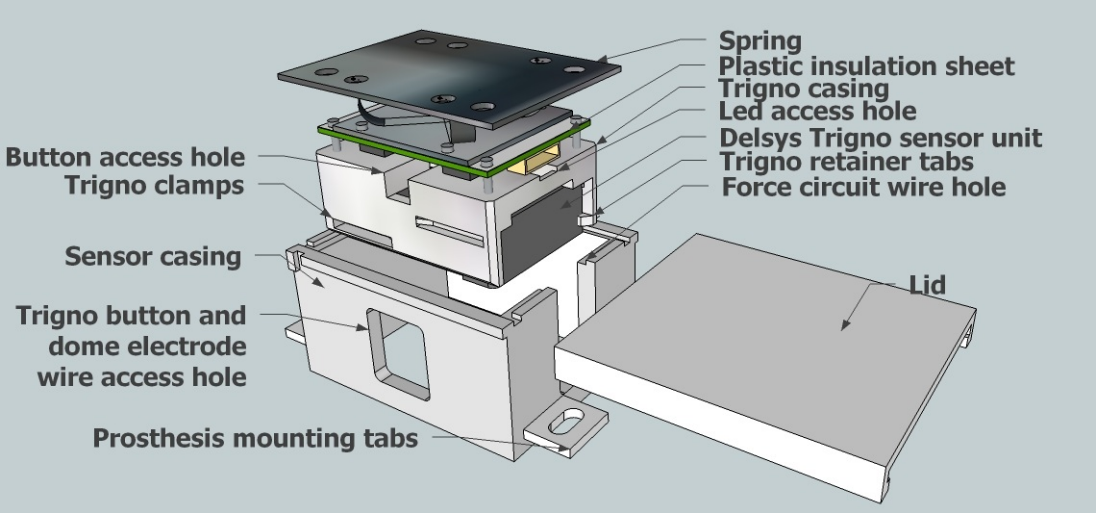

Figure 1: TMMU prototype

1.1 Sensor casing

The sensor casing is milled out of a block of durable plastic. It features a sliding lid that makes removal of the internal components a quick and easy task. The casing has four external tabs that can be used to secure it to the prosthesis socket with screws or other fasteners.

1.2 Force circuit

The unit includes a force sensor circuit that features four linear FSS1500 load cells from *Honeywell* (2012) (*FSS-SMT Series Low Profile Force Sensor* 2009) and four INA22 instrumentation amplifiers (*INA122 Single Supply, MicroPower instrumentation amplifier* 1997) from *Texas Instruments* (2012). It is originally designed to be used for research on movement artefacts in SEMG-signals, and can be mounted on top of different SEMG-sensors to measure the force acting on it from the residual limb. The circuit can also be used with other sensors if a corresponding sensor casing has been designed.

The circuits uses are not just limited to this task alone. It can also be used for other applications like being mounted alone inside a prosthesis socket to gather force data from specific points in a socket.

The circuit features screw holes for sensor case and spring mounting. The circuit needs to be calibrated in software as the sensors tend to have zero point offsets.

1.3 Trigno casing

The prototype is mainly designed to be used with a Delsys Trigno wireless SEMG and accelerometer device, but users are free to design their own casing for different sensors. The Trigno casing is designed to let the user be able to easily remove the device from the TMMU for charging in the Trigno base station. It features screw holes for attaching the force circuit with the supplied screws.

The top surface of the casing is flat to enable the user to modify or extend the design according their needs.

1.4 Spring

To allow the Trigno or another connected sensor to travel vertically inside the casing, a spring is included in the prototype. The spring is hand made from sheet metal and features two diagonally mounted coils that ensure stability in the horizontal plane without restricting movement in the vertical plane. The bottom plate of the spring features four holes for securing the spring to the circuit board. The top plate of the spring features eight holes for easy access to the screws underneath.

2 Technical specifications

2.1 Force circuit

Component	Parts-number	Supplier
FSS1500NGT, Force sensor	785-FSS1500NGT	Mouser
INA122UA, instrumentation amplifier	595-INA122UA	Mouser
ERA6AEB622V, 6K2 Resistor 0,1%	1670238	Farnell
MBR0530T1, Diode Schottky	2296548	Farnell
QTLP630C-4, LED, Green	3599681	Farnell
SM08B-SRSS-TB, Header 8 way	1679124	Farnell
AMP 1-825437-0 Header	3417920	Farnell
MC 0.1W 0805 1% 220R Resistor	9332804	Farnell

Table 1: Components

Parameter	Min	Avarage	Max	Unit
Supply Voltage	3.0	5.0	6.0	Volts
Force	0.0	-	14.7	Newton
Temperature	-40[40]	-	85[185]	°C/[°F]
Output	0.0	-	5.0	Volts

Table 2: Technical parameters

Pin	Data
1	sensor UL(FSS2)
2	sensor DL(FSS4)
3	Supply voltage
4	Not connected
5	Not connected
6	Ground
7	sensor DR(FSS3)
8	sensor UR(FSS1)

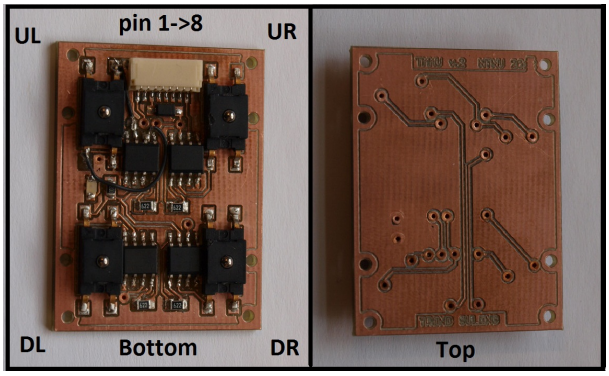

Figure 2: Pin I/O

See *FSS-SMT Series Low Profile Force Sensor* (2009), *INA122 Single Supply, MicroPower instrumentation amplifier* (1997) and Suleng (2012) for more detailed information.

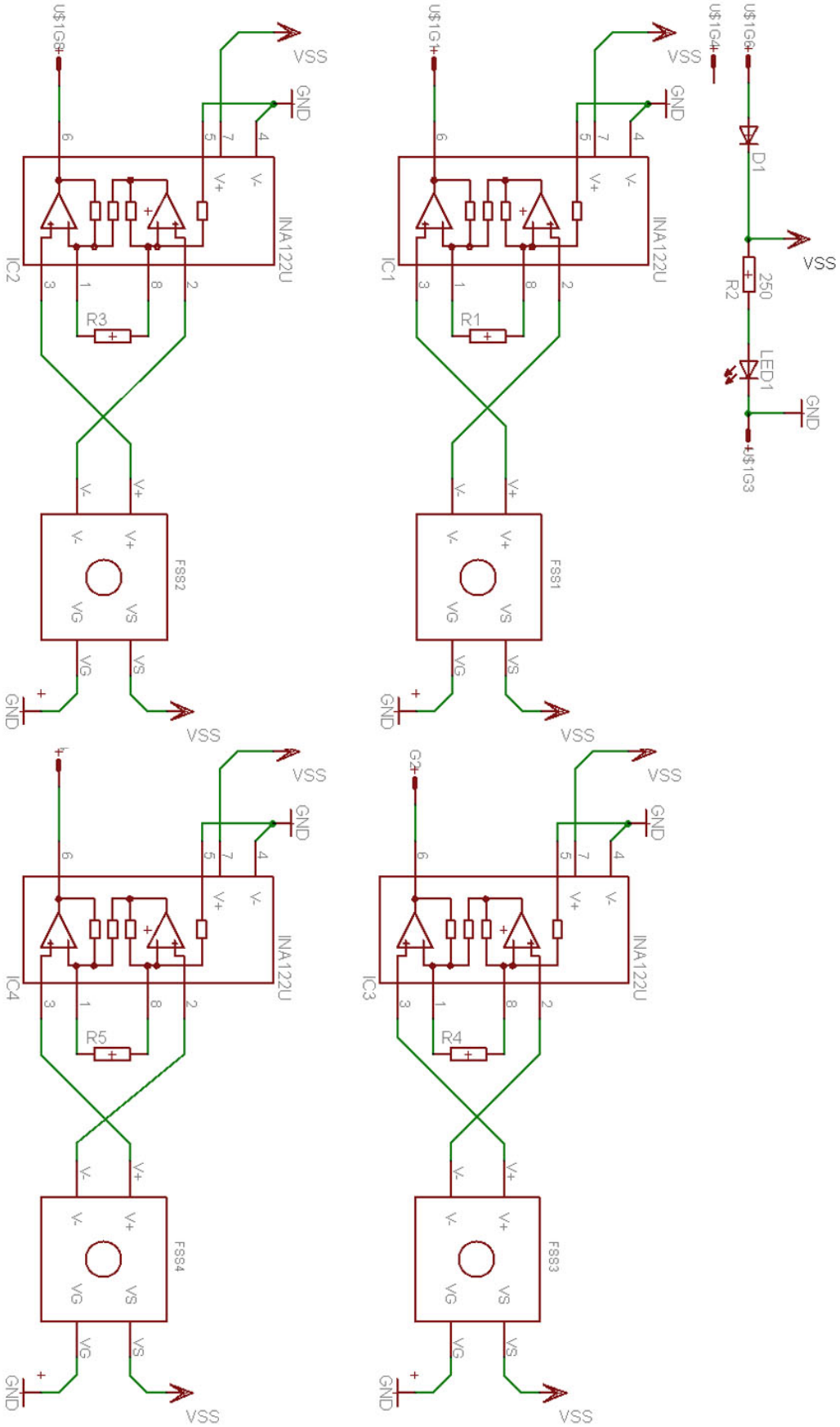

Figure 3: Force sensor schematic

2.2 Spring

The springs are hand made, and therefore specific data from one individual spring is not considered to be accurate for all springs.

Parameter	Min	Max	Unit
Travel	0	5.0	Millimeters
Force	0	2	Newton

Table 4: Technical parameters

3 Physical specifications

3.1 Sensor casing

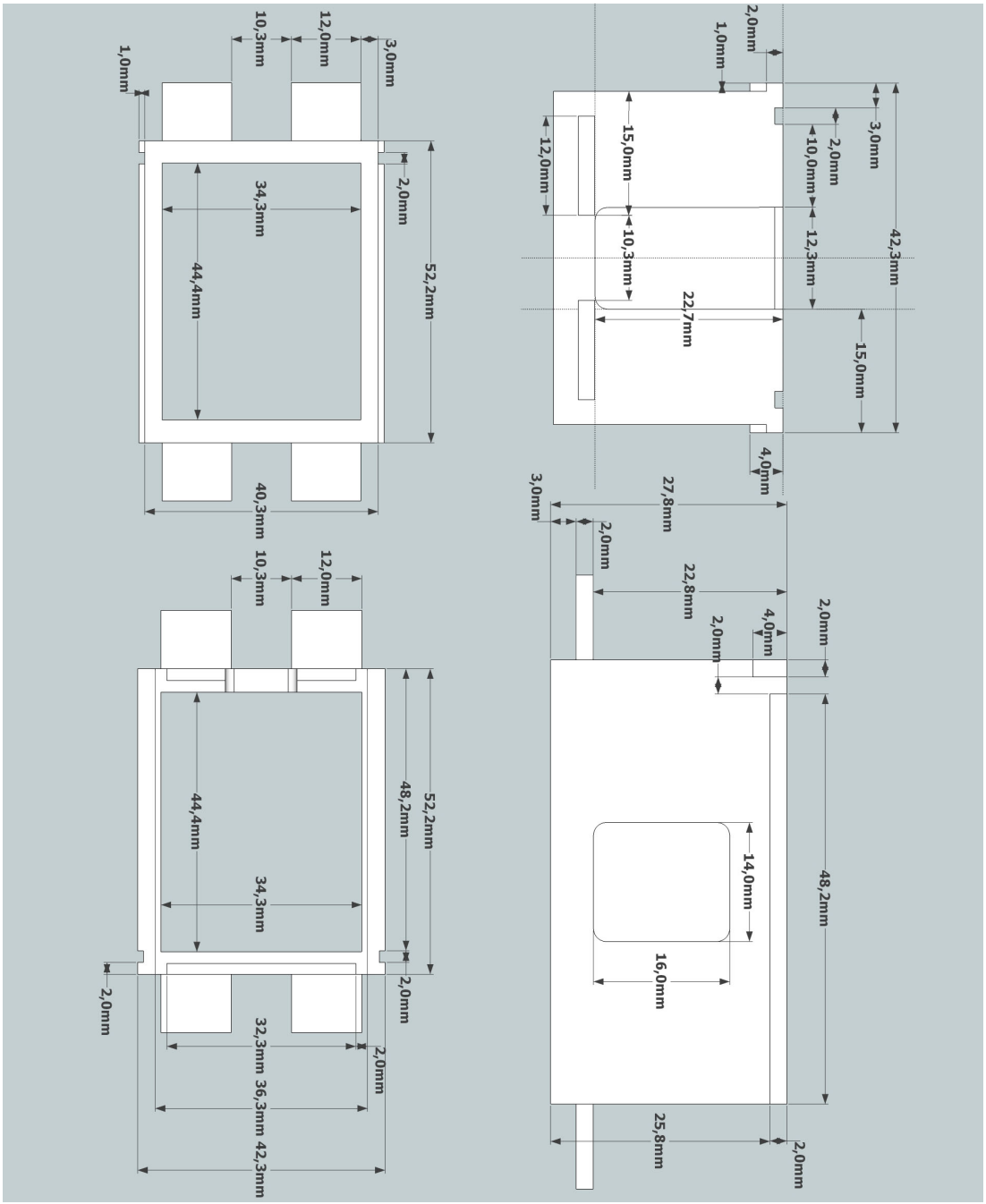

Figure 4: Sensor casing

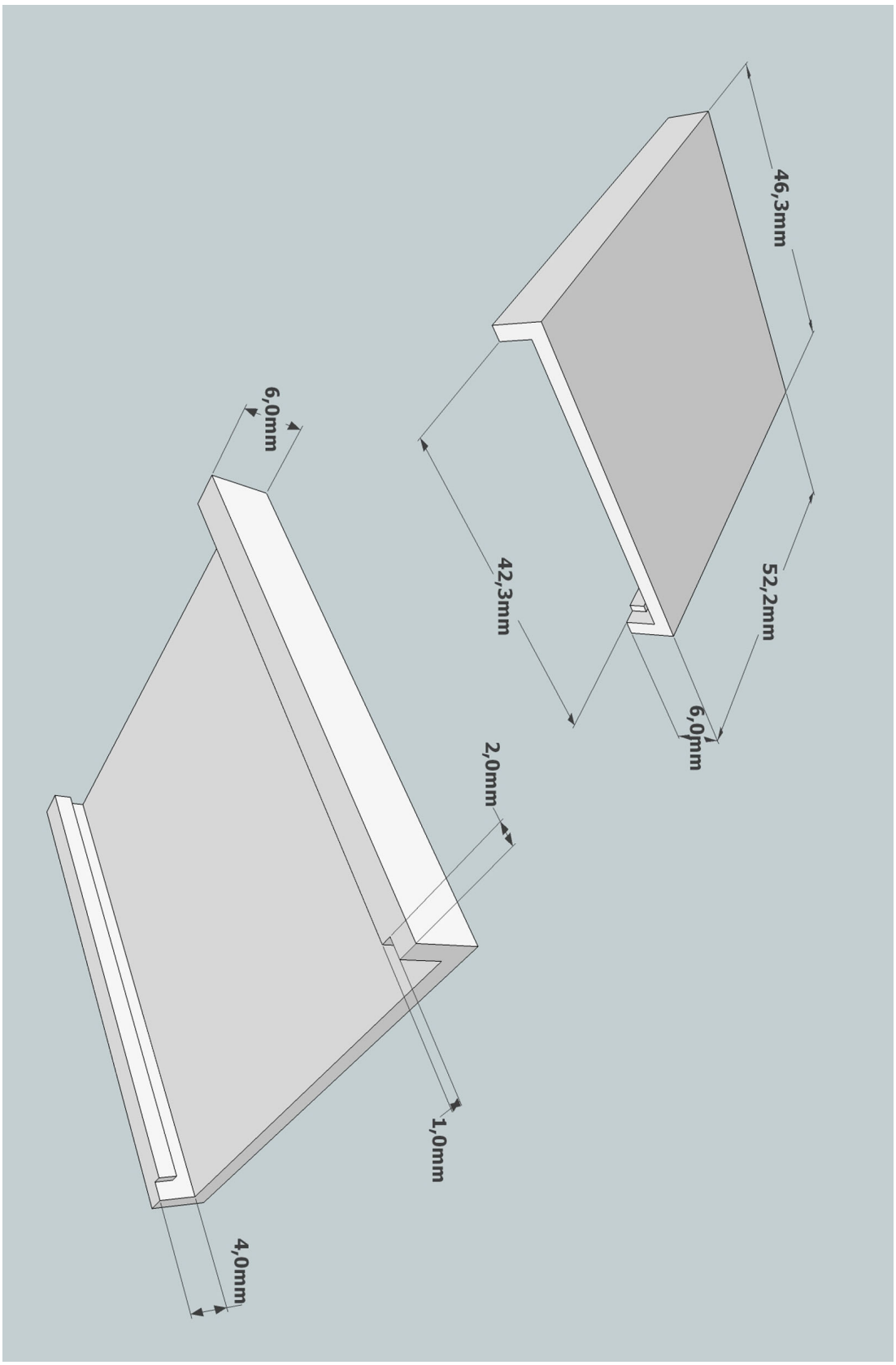

Figure 5: Sensor casing lid

3.2 Force circuit

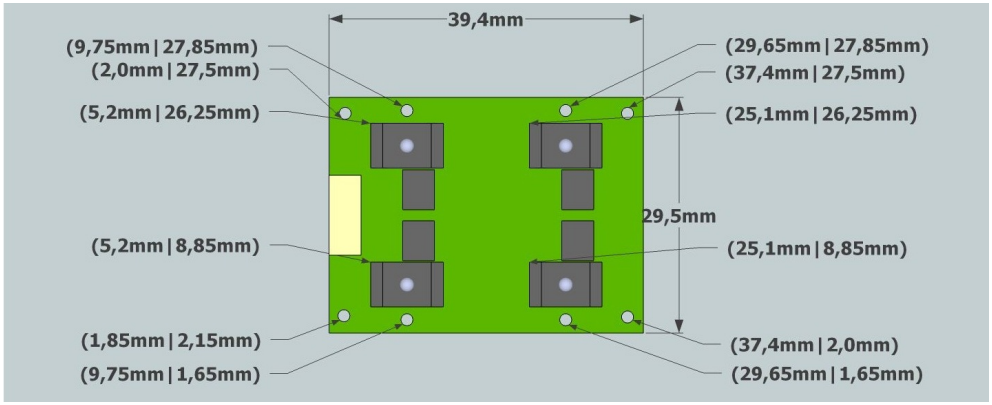

Figure 6: Force circuit

3.3 Spring

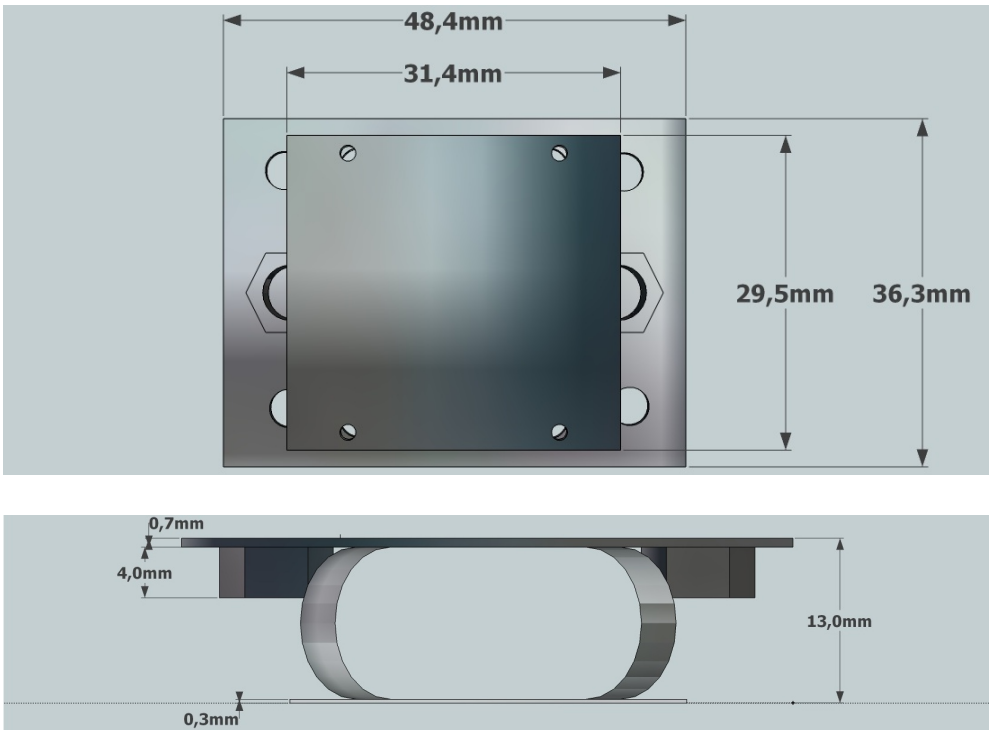

Figure 7: Spring

3.4 Trigno casing

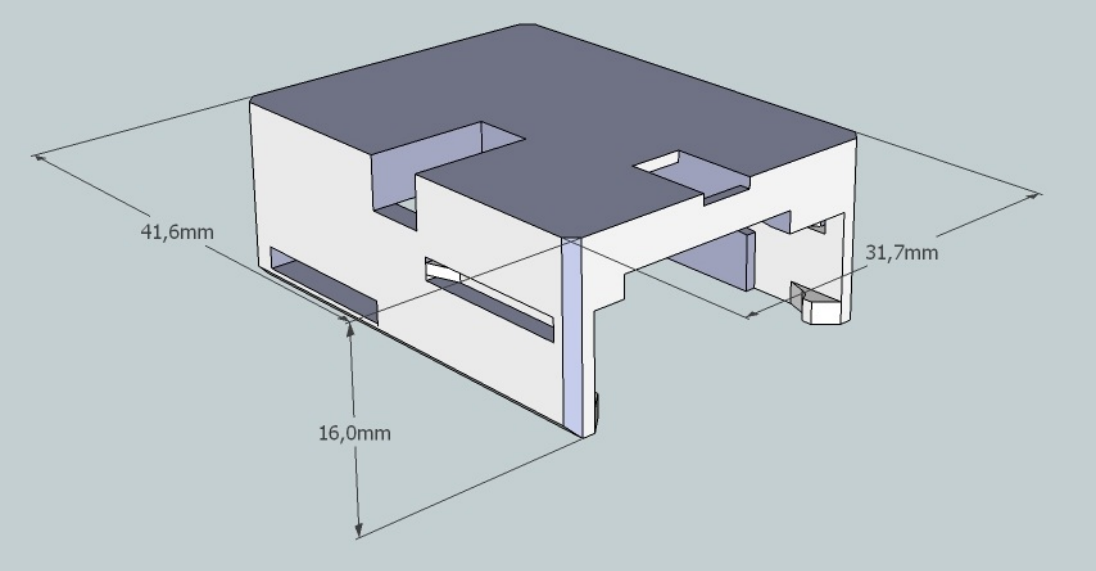

Figure 8: Trigno casing

4 Getting started

4.1 Assembly

4.1.1 Trigno casing

The Trigno easily snaps in to position in the Trigno casing as follows. The arch in the back of the casing makes it easier to push the Trigno device out again for charging or replacement. Four plastic arms and two retainers keep the sensor in place while in use, and two holes in the top enables the user to operate the button and view the status LED without removing the device from the casing.

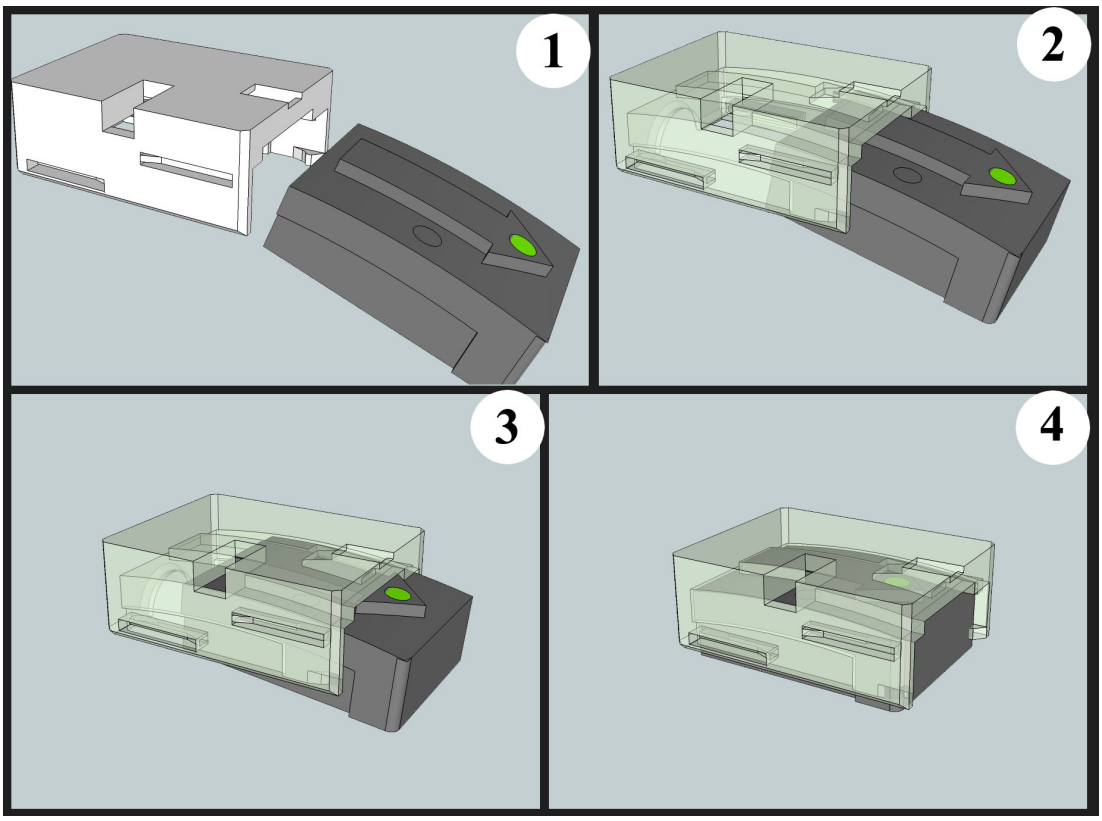

Figure 9: Use of Trigno casing

4.1.2 Mounting force circuit

The force circuit is mounted on the Trigno casing with four long screws inserted into threaded holes in the casing (figure 10, A). The top part of the screws are not threaded to minimize the friction between the circuit board and the screws. By releasing or tightening the screws the user is able to tune the force sensor physically. A rubber pad or similar flexible material should be inserted between the sensor and the Trigno casing before fastening the screws. This is because the force circuit needs to have simultaneous contact of all four load cells for correct measurement of the contact force. A thin plastic sheet should be placed between the two in order to prevent short circuiting the circuit board as the spring is made of conductive metal. Mounting the spring is described in the next section of the guide.

Tips: By tightening or loosening the screws the individual force sensors can be physically calibrated to counteract offsets in zero point measurements.

Caution: Take care as to not tighten the screws to hard as this can result in tearing of the treads in the porous plastic of the Trigno casing.

Caution: Make sure that the connector on the circuit board faces towards the LED-hole on the Trigno casing, due to a manufacturing error the bottom left hole for the screw in figure 6 is offset slightly. This could compromise correct operation of the unit or even damage it.

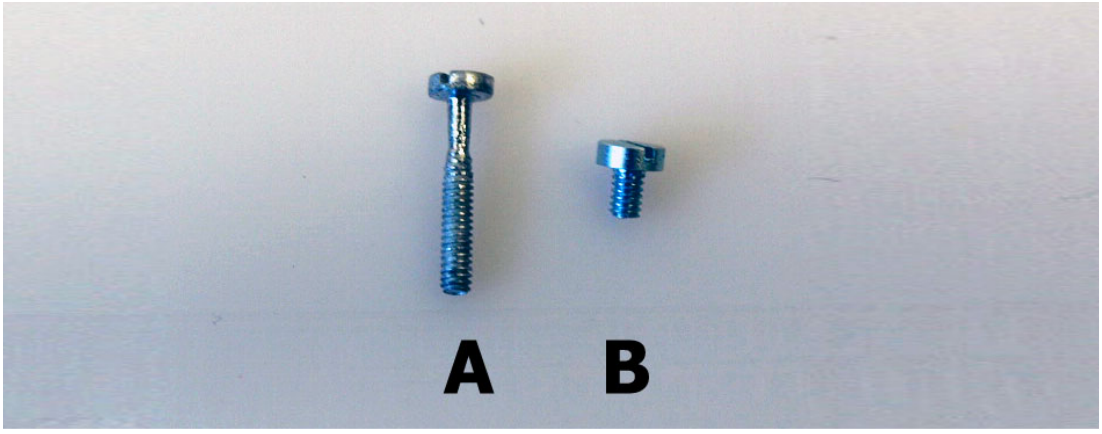

Figure 10: Screws

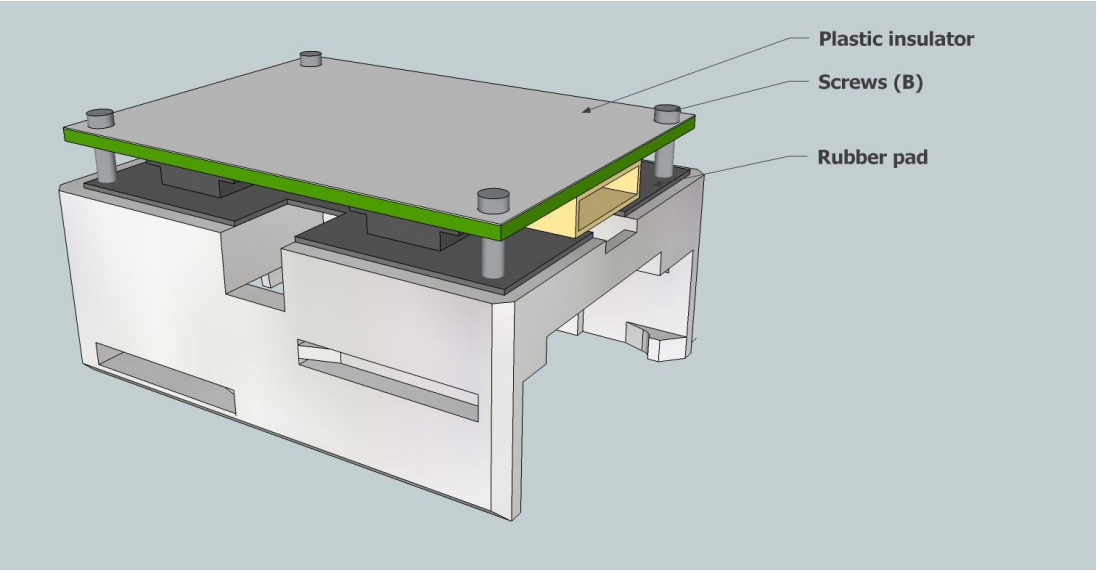

Figure 11: Mounting force circuit to the Trigno casing

4.1.3 Mounting the spring

After connecting the force circuit to the Trigno casing, the spring is secured to the force circuit. The bottom part of the spring is secured to the circuit board with four screws that fit into threaded holes in the circuit board (figure 10, B).

Caution: Be careful not to compress the springs to far. This can result in deformation of the coils and change the springs properties. The two nuts welded on the top plate during assembly is designed to prevent the spring from being completely compressed, thus preventing deformation from excessive compression.

Caution: Take care as to not tighten the screws to hard as this can result in tearing of the treads in the circuit board.

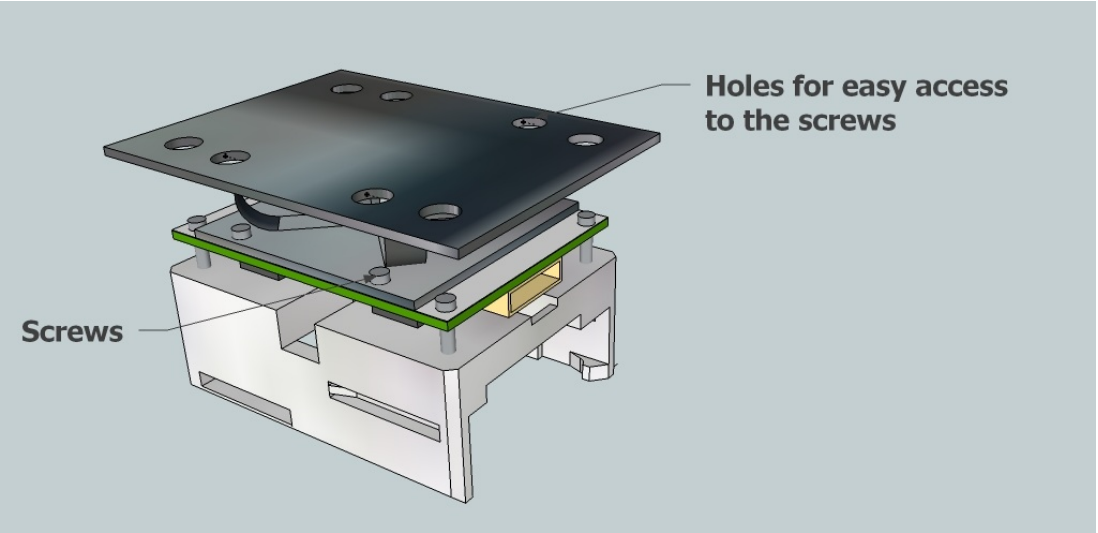

Figure 12: Connecting the spring

4.1.4 Putting it all together

On the inside of the sensor casing there is a small groove that the top panel of the spring is designed to rest on. When the lid is closed, the whole configuration of the internal parts is held in place without being able to move in any direction except for the intended vertical movement of the spring.

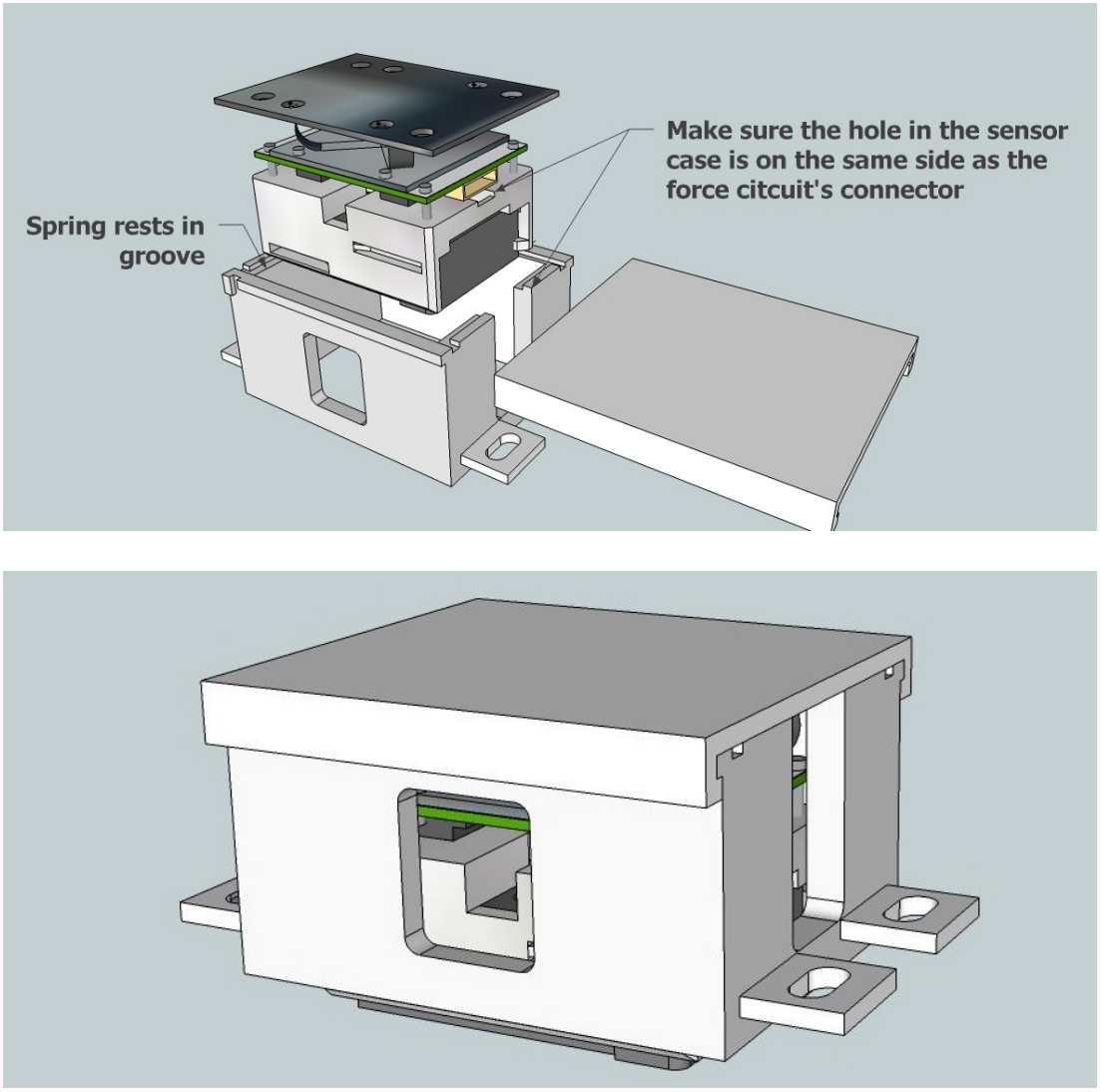

Figure 13: Final assembly

4.1.5 Connecting the force circuit

The force circuit can be connected to a computer with a National Instruments (*National Instruments* 2012) Data Acquisition Device (DAQ). The DAQ used in the development of the TMMU was a National Instruments USB-6211. It has 16 analogue input channels, and can support up to four force circuits at the same time. During the testing of the prototype, a D-sub cable with appropriate connector headers was used to connect the prototype to the DAQ. The user is free to decide how to connect the force circuit to a computer, but the use of National instrument devices is recommended. See the technical specifications for information on supply and output voltage, temperature range, and force range. Figure 14 shows the channels used to connect one TMMU to the USB-6211. The image is collected from the help file in the National Instruments Measurement and Automation explorer program.

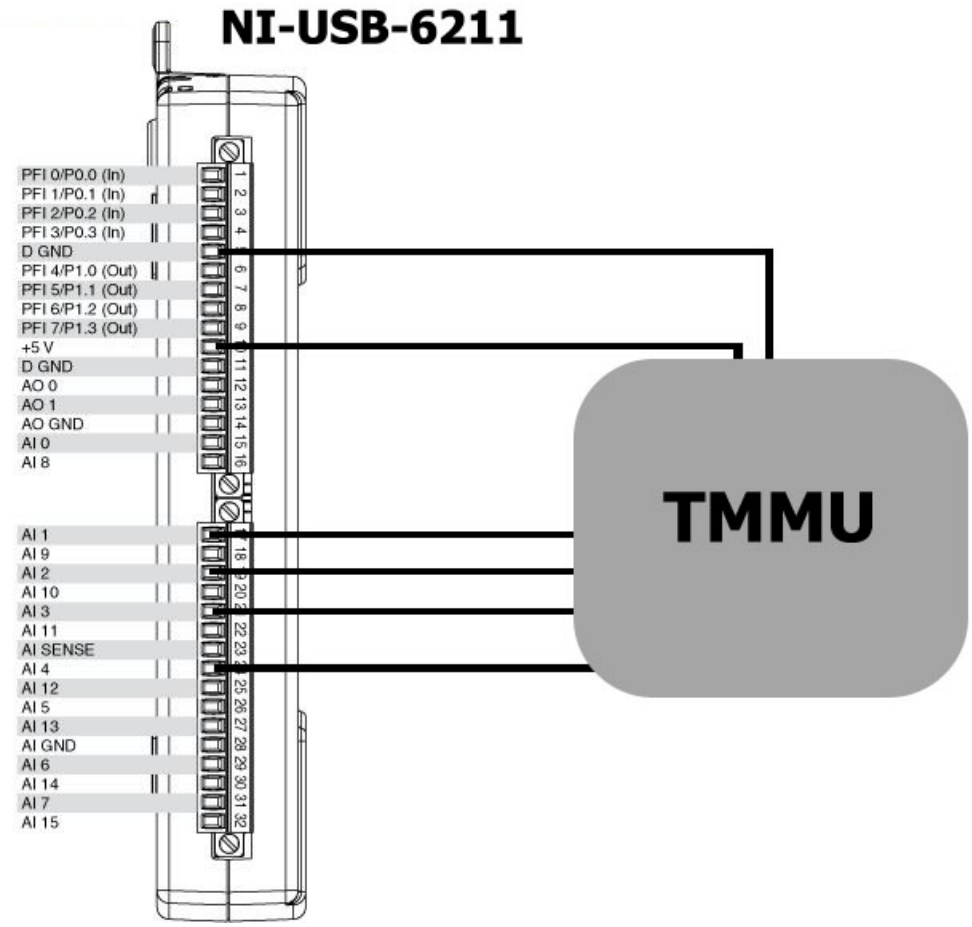

Figure 14: Connecting the force circuit to USB-6211

4.1.6 Connecting the Trigno base station

To enable the user to collect data from the Trigno sensor modules, the user needs to install device drivers and software from *Delsys* (2012). There are currently a number of choices available for connecting the Trigno basestation and gathering data. In all cases the user needs to install the Delsys Trigno Analogue Output program. Delsys has released an SDK for the Trigno system(*Trigno Digital SDK brochure* 2012). It contains sample source code for MATLAB, LabView, Google, Android-based mobile devices, Windows(C# or C), and Linux. The TMMU is designed for use with Labview, and was tested by utilising the VI from the SDK to transfer the data over the base stations USB-cable to a LabView program. One can also use the Delsys DC-A22 Unterminated Output Cable to transfer individual data from the base station. It features a 68 pin dsub connector and separate wires 4 for each Trigno unit, for transfer of sensor data to an external data acquisition device. For more detailed information on the use of the Delsys Trigno products please see the official Trigno user guide (*Trigno Wireless System User's Guide* 2009).

Trigno output	Cable pin	Conductor Color Primary/Secondary		Trigno output	Cable pin	Conductor Color Primary/Secondary	
EMG1	68	Violet	Orange	AY9	16	Tan	Violet
AX1	67	Blue	Orange	AZ9	17	Tan	Gray
AY1	33	Orange	Blue	EMG10	49	Blue	Tan
AZ1	34	Orange	Violet	AX10	48	Green	Tan
EMG2	66	Green	Orange	AY10	14	Tan	Green
AX2	65	Yellow	Orange	AZ10	15	Tan	Blue
AY2	31	Orange	Yellow	EMG11	47	Yellow	Tan
AZ2	32	Orange	Green	AX11	46	Orange	Tan
EMG3	64	Gray	Pink	AY11	12	Tan	Orange
AX3	63	Violet	Pink	AZ11	13	Tan	Yellow
AY3	29	Pink	Violet	EMG12	45	Pink	Tan
AZ3	30	Pink	Gray	AX12	44	Brown	Tan
EMG4	62	Blue	Pink	AY12	10	Tan	Brown
AX4	61	Green	Pink	AZ12	11	Tan	Pink
AY4	27	Pink	Green	EMG13	42	Violet	White
AZ4	28	Pink	Blue	AX13	41	Blue	White
EMG5	60	Yellow	Pink	AY13	7	White	Blue
AX5	59	Orange	Pink	AZ13	8	White	Violet
AY5	25	Pink	Orange	EMG14	40	Green	White
AZ5	26	Pink	Yellow	AX14	39	Yellow	White
EMG6	58	Gray	Brown	AY14	5	White	Yellow
AX6	57	Violet	Brown	AZ14	6	White	Green
AY6	23	Brown	Violet	EMG15	38	Orange	White
AZ6	24	Brown	Gray	AX15	37	Pink	White
EMG7	55	Green	Brown	AY15	3	White	Pink
AX7	54	Yellow	Brown	AZ15	4	White	Orange
AY7	20	Brown	Yellow	EMG16	36	Brown	White
AZ7	21	Brown	Green	AX16	35	Tan	White
EMG8	53	Orange	Brown	AY16	1	White	Tan
AX8	52	Pink	Brown	AZ16	2	White	Brown
AY8	18	Brown	Pink	GND	9	White	Gray
AZ8	19	Brown	Orange	GND	22	Brown	Blue
EMG9	51	Gray	Tan	GND	43	Gray	White
AX9	50	Violet	Tan	NC	56	Blue	Brown

Table 5: Delsys DC-A22 unterminated output cable wiring

Figure 15: Delsys DC-A22 unterminated output cable (*Trigno Wireless System User's Guide* 2009)

4.1.7 Prosthesis socket mounting

Using the four external plastic tabs the sensor casing can be secured to a prosthesis. The user is free to choose what type of screws to use. Corresponding holes needs to be drilled in the four tabs and in the prosthesis. The user is not limited to screws for securing the TMMU to the socket. The casing can also be glued in place or moulded directly into the socket during fabrication.

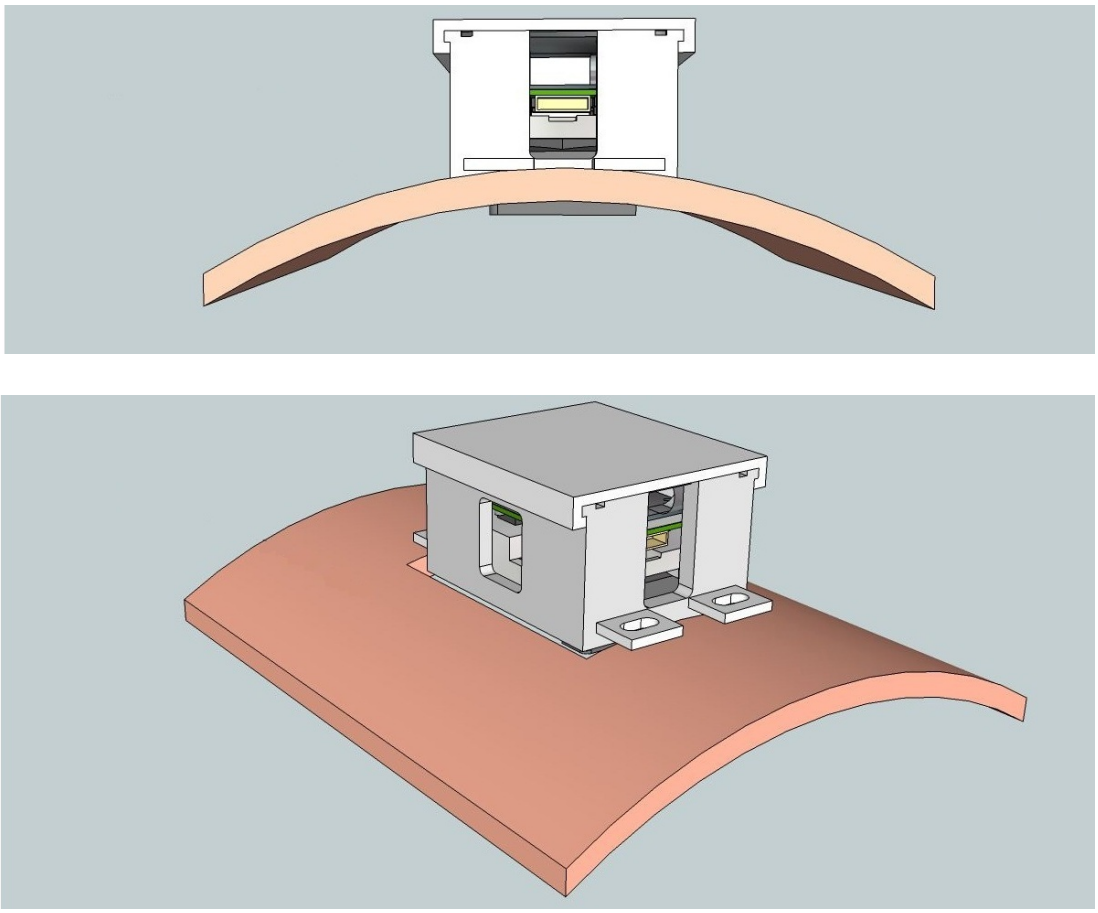

Figure 16: Prosthesis mounting

5 Additional information

The finished TMMU prototype was designed and manufactured at the Department of Engineering Cybernetics at the Norwegian University of Science and Technology. The finished product is a result of research done by Trond Suleng in his master thesis project in 2012.

The people responsible for the development of the product presented in this guide resumes no responsibilities for complications arising from misuse of the product.

6 Bibliography

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