TRIGNO™ Wireless System SDK

User's Guide

MAN-025-3-3

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1 Important Information

1.1 Intended Use

The Trigno SDK is a software development tool to be used in conjunction with the Trigno Wireless EMG biofeedback system. The SDK alone does not perform any therapeutic or diagnostic function. It is intended to be used as a software component of a parent software package. The function of the SDK is to manage the transfer of data from the Trigno System to the parent software, and is designed to work exclusively with the Trigno System.

1.2 Technical Service and Support

For information and assistance visit our web site at:
www.delsys.com

Contact us at:
E-mail: support@delsys.com
Telephone: (508) 545 8200

1.3 Device Information

Please see the Trigno Wireless EMG System User Guide for information on the EMG Device.

1.4 System Requirements

Trigno Wireless EMG System
Windows 7 or newer, 64-bit or 32-bit operating systems supported
One USB 2.0 port
2.0 GHz processor clock speed (minimum)
2 GB system memory (minimum)
1 GB hard disk storage (minimum)

1.5 Trigno System Firmware Requirements

Version 3.5.X of the Trigno SDK requires the following firmware version:

Analog Base Station: MA2909-BE1503-DS0801-US2004-DA0900

Digital Base Station: MA2909-BE1503-DS0801-US2004-DA0000

Trigno Sensors: v30-18

Trigno IM Sensors: v25-66

Trigno Avanti Sensors: v40-34

2 Trigno Wireless System SDK Overview

The Trigno Wireless System SDK is a software package designed to allow programmers to interact with the Delsys Hardware. The SDK runs as a TCP/IP server with the Trigno Control Utility.

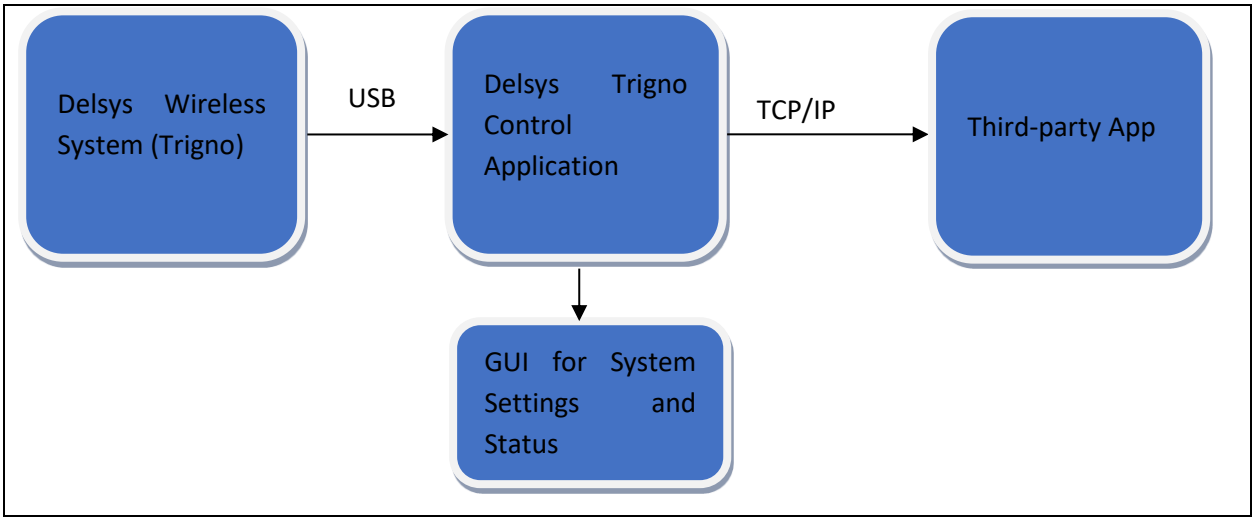

Figure 1: Data flow and SDK sub-system components.

3 Getting Started with the SDK

To use the SDK – install the software on a PC meeting the minimum requirements (listed above), and connect a Trigno Base Station (part of the Trigno Wireless EMG System) to the PC.

Use the Trigno Control Utility to pair sensors to desired slots (see the Trigno Wireless EMG System User Guide for help with pairing).

While the Trigno Control Utility is running, any other software can connect to the command port and instruct the base to begin streaming data. The command port is port 50040 on the host (running the Trigno Control Utility) computer.

To receive data, connect to the appropriate ports:

IM Sensor EMG Data	Port 50043
IM Sensor AUX Data	Port 50044
Hybrid or Other Sensors EMG Data	Port 50041
Hybrid or Other Sensors AUX Data	Port 50042

All data values are IEEE floats containing 4 bytes each. If multiple channels are being streamed over a port, the data are multiplexed. For example, in normal operation on port 50042 the first three samples received will be sample number 1 from each of the 3 AUX data channels.

All data can be found on IM EMG Data (port 50043) for EMG channels and IM AUX Data (50044) for additional channels. Any sensors with fewer than 4 channels will also have data duplicated on ports 50041 and 50042.

4 Using the SDK

Please read the Trigno Wireless EMG System User Guide for information about using the Trigno hardware.

To use the SDK, a parent software application must perform the following tasks:

- Connect to the Trigno SDK Server via TCP/IP
- Configure the hardware (pair sensors, etc.). Please see the next section "Configuring the Trigno Hardware" for information on this.
- Start the system
- Send the command "START" over the command port (50040)
- Trigger the system (optional). Send a start trigger to the Trigno Base Station. For more information on this please see the Trigno Wireless EMG System User Guide.
- Receive Data
- Process the data streams that are being sent over the data ports. For synchronization purposes, always process bytes in segments determined by multiples of the following factor: (16 Sensors) * (Number of channels on port) * (4 bytes/sample)

5 Configuring the Trigno Hardware

The Trigno Base Station can have up to 16 sensors paired at once. To pair a sensor via the SDK, turn the sensor on, and use the command "SENSOR *n* PAIR". This will initiate the pair process. Once the process is initiated, the user must press and hold the sensor button until the pair complete message is received.

Each Trigno Wireless sensor has a configurable digital setting which controls gains and accelerometer ranges (dependent on sensor type). For more information about sensor settings, please see the Trigno Wireless EMG System User Guide.

To configure the sensor via the SDK, use the command "SENSOR *n* SETMODE *x*". This will set the sensor paired to slot *n* to mode *x*. For example, "SENSOR 1 SETMODE 3" will set Sensor 1 to Mode 3.

6 Technical Specifications

6.1 Data Ports

The command interface is implemented on a single port 50040. This port both receives commands and sends replies.

All sensors' EMG data are streamed (output only) on port 50043.

All sensors' other data channel (ACC, GYRO, MAG, etc.) are streamed on port 50044.

The EMG data for sensors with <4 channels are streamed (output only) on port 50041.

The Accelerometer data for sensors with <4 channels are streamed (output only) on port 50042.

The Trigno Control application listens for incoming connections in the background on these ports, and handles data routing to any applications that connect.

By default, the sampling rate of each port is upsampled to match the fastest sampling rate natively on that port. The sampling rate can be calculated as (samples per frame)/(frame interval). The frame interval is fixed at 0.0135s. For more information on sampling rates see the Backwards Compatibility and Sensor Samples commands.

6.1.1 Channel Allocation for Multibandwidth Sensors

In the case of sensors using multibandwidth modes, such as a quattro sensor, the EMG channels are grouped together. A quattro may appear to occupy slots 1,5,9,13 in the control utility, but the corresponding data will appear on the EMG data port on channels 1,2,3,4. A sensor paired in slot 2 would then have its emg channel pushed to channel 5 in the SDK. (In this case "channel" refers to the position in the SDK Port buffer).

The query **"SENSOR n STARTINDEX?"** will return what position in the buffer the first channel for a given sensor will be.

6.2 Packet Structure

The TCP stream is broken into packets for commands and packetized data transfer. Each command is terminated with <CR><LF>. The end of a command packet is terminated by two consecutive <CR><LF> pairs, and the server will process all command received to this point when a two <CR><LF> pairs are received.

Control commands and replies are human-readable ASCII text, so telnet (or Hyperterminal) can be used to test communication with the server.

6.3 Control Commands

6.3.1 Protocol Version

Trigno SDK Server responds to an incoming connection by returning its version.

6.3.2 Triggers

Use query "TRIGGER?" return the state of the input and output triggers.

Use command "TRIGGER [START/STOP] [ON/OFF]" to arm or disarm start or stop input triggers.

6.3.3 Backwards Compatibility

Use query "BACKWARDS COMPATIBILITY?" to query the backwards compatibility flag. Indicates if backwards compatibility is on or off. When backwards compatibility is off (the default), the sample rates for the EMG ports will scale up to the highest configured EMG sample rate, and the sample rates for the AUX ports will scale up to the highest configured auxiliary rate. With backwards compatibility on, the sample rates will be locked to either 2000 Hz or $1925.\overline{925}$ and $1111.\overline{111}$ Hz for EMG ports, and $148.\overline{148}$

Hz for auxiliary ports. See the UPSAMPLING command query for more information on sample rates in Backwards Compatibility mode.

Use command “BACKWARDS COMPATIBILITY [ON/OFF]” to set the backwards compatibility flag.

6.3.4 Upsampling

Use query “UPSAMPLING?” to query the upsampling flag. Indicates if upsampling is turned on or off. If backwards compatibility is on, when upsampling is turned on, all high frequency channels will be sampled at 2000Hz. If backwards compatibility is on and upsampling is off, EMG channels will be sampled at $1925.\overline{925}$ Hz (EMG Data) or $1111.\overline{111}$ Hz (IM EMG Data) and all AUX ports will be sampled at $148.\overline{148}$

If backwards compatibility is off, the upsampling flag has no effect on sample rates.

Use command “UPSAMPLE [ON/OFF]” to set the upsampling flag.

6.3.5 Max Samples EMG

Use the query “MAX SAMPLES EMG?” to query to the maximum number of samples per frame for the EMG channels.

6.3.6 Max Samples AUX

Use the query “MAX SAMPLES AUX?” to query the maximum number of samples per frame for the AUX channels.

6.3.7 Frame Interval

Use the query “FRAME INTERVAL?” to query the sampling frame interval.

6.3.8 Sensor Type

Use query “SENSOR *n* TYPE?” to query the type of a given sensor.

6.3.9 Sensor Serial

Use query “SENSOR *n* SERIAL?” to query the serial number of a given sensor.

6.3.10 Sensor Firmware

Use query “SENSOR *n* FIRMWARE?” to query the firmware version of a given sensor.

6.3.11 Sensor Pair Status

Use query “SENSOR *n* PAIRED?” to query the paired state of a given sensor. Will indicate “YES” for a paired sensor, and “NO” for an unpaired sensor.

Use command “SENSOR *n* PAIR” to pair a sensor.

6.3.12 Sensor Active Status

Use query “SENSOR n ACTIVE?” to query the active state of a given sensor. Will indicated “YES” for a currently active sensor, and “NO” for an inactive sensor.

6.3.13 Sensor EMG Channels

Use query “SENSOR n EMGCHANNELCOUNT?” to query the number of EMG channels in use on a given sensor.

6.3.14 Sensor AUX Channels

Use query “SENSOR n AUXCHANNELCOUNT?” to query the number of AUX channels in use on a given sensor

6.3.15 Sensor Start Index

Use query “SENSOR n STARTINDEX?” to query which position in the data buffer a given sensor’s first channel will appear.

6.3.16 Sensor Channels

Use query “SENSOR *n* CHANNELCOUNT?” to query the number of channels in use on a given sensor.

6.3.17 Sensor Gain

Use query “SENSOR *n* CHANNEL *m* GAIN?” to query the gain of a given channel on a given sensor.

6.3.18 Sensor Samples

Use query “SENSOR n CHANNEL m SAMPLES?” to query the native samples per frame of a given channel on a given sensor.

6.3.19 Sensor Units

Use query “SENSOR *n* CHANNEL *m* UNITS?” to query the gain of a given channel on a given sensor.

6.3.20 Sensor Mode

Use query “SENSOR *n* MODE?” to query to current mode of a given sensor. This is the configurable mode of the sensor, most often the Accelerometer gain setting.

Use command “SENSOR *n* SETMODE *y*” to set the mode the given sensor. Mode can be set to modes 1-4.

6.3.21 Base Serial

Use query “BASE SERIAL?” to query the serial number of the connected base station.

6.3.22 Base Firmware

Use query “BASE FIRMWARE?” to query the firmware version of the connected base.

6.3.23 Data Format

Use query “ENDIANNESS?” to query the currently set endianness for the returned data.

Use command “ENDIAN BIG” to set the returned data format to big-endian.

Use command “ENDIAN LITTLE” to set the returned data format to little-endian (the default).

6.3.24 Data Collection

Use command “START” to start data collection.

Use command “STOP” to stop data collection.

6.3.25 Trigger Stop

When a stop trigger is received, the server will output the command “STOPPED”.

6.3.26 Disconnection

Use command “QUIT” to stop data collection and close the server session.

6.3.27 Version

Use query “VERSION?” to get the current version of the Trigno SDK

6.3.28 Orientation Filter

Use query “ORIENTATION FILTER?” to determine if the real time orientation filter is currently turned on or off.

Use command “ORIENTATION FILTER ON” to turn the real time orientation filter for IM data on.

Use command “ORIENTATION FILTER OFF” to turn the real time orientation filter for IM data off.

Use query “ORIENTATION DATA FORMAT?” to determine the output format of the orientation filter. This will either be “PRY” or “QUAT”

Use command “ORIENTATION DATA QUAT” to set the output format of the orientation filter to quaternions.

Use command “ORIENTATION DATA PRY” to set the output format of the orientation filter to Pitch/Roll/Yaw

Use command “ORIENTATION FILTER ZERO” to line up sensors with respect to a common reference frame.

Use command “ORIENTATION FILTER CALIBRATE” to load the calibration program for paired sensors

Use command “ORIENTATION PATH ‘pathname’ ” to specify the path to the current calibration file. Use the pathname (note the single quotes) parameter to indicate the path.

Use query “ORIENTATION FILTER VERSION?” to get the version number of the currently installed orientation filter.

For more details about the orientation filter please see Section 1

6.3.29 Master/Slave Connections

While the first connection to be created will default as the Master Connection, other connections can be made master instead.

Use query “MASTER” from a connection to make it master. Note that this command should only be sent when data collection is not running.

6.3.30 Set Range

Use command “SETRANGE” with arguments “LOW” or “HIGH” to configure a Trigno Avanti sensor’s input range between +/-5.5mV (“LOW”) or +/-11mV (“HIGH”).

Use query “RANGE?” to query the current range setting for a Trigno Avanti sensor, where a returned value of “LOW” indicates +/-5.5mV and a returned value of “HIGH” indicates +/-11mV.

6.3.31 Set Bandwidth

Use command “SETBANDWIDTH” with arguments “NARROW” or “WIDE” to configure a Trigno Avanti sensor’s input bandwidth between 20-450HZ (“NARROW”) or 10-850Hz (“WIDE”).

Use query “BANDWIDTH?” to query the current bandwidth setting for a Trigno Avanti sensor, where a returned value of “NARROW” indicates 20-450Hz input bandwidth and a returned value of “WIDE” indicates 10-850Hz.

6.4 Control Command Replies

The server will respond “OK” to a command which is valid and has been processed.

The server will respond “INVALID COMMAND” to an unknown command or a known command with invalid data.

The server will respond “CANNOT COMPLETE” to a command which is valid, but cannot be completed due to the current state of the system (for example, a configuration command issued while data is streaming).

6.4.1 Data Format

Data are streamed independently for EMG channels and accelerometer channels. The sampling rate is different for EMG and accelerometer channels, so byte data will arrive at different rates on the EMG data port (50041) and the accelerometer data port (50042).

6.4.2 EMG Data

EMG data are returned as 16 multiplexed channels, where each sample is an IEEE float occupying 4 bytes. The byte order is controlled by the ENDIAN command.

The data will begin streaming when the first valid sample or trigger is received.

To maintain synchronization, always read or process bytes in multiples of 64 bytes. (16 channels * 4 bytes/channel = 64 bytes). 64 bytes of data will contain 1 EMG sample from each sensor.

6.4.3 Accelerometer Data (from non-IM sensors)

Accelerometer data are returned as 48 multiplexed channels (16 sensors * 3 axes/sensor = 48 channels), where each sample is an IEEE float occupying 4 bytes. The byte order is controlled by the ENDIAN command.

The data will begin streaming when the first valid sample or trigger is received.

To maintain synchronization, always read or process bytes in multiples of 192 bytes (48 channels * 4 bytes/channel = 192 bytes). 192 bytes of data will contain 1 accelerometer sample from each of the 48 channels.

6.4.4 IM Sensor Data

IM Sensor data are returned as 144 multiplexed channels (16 sensors * 3 axes/measurement unit * 3 measurements units = 144 channels), where each sample is an IEEE float occupying 4 bytes. The byte order is controlled by the ENDIAN command.

The data will begin streaming when the first valid sample or trigger is received.

To maintain synchronization, always read or process bytes in multiples of 576 bytes (144 channels * 4 bytes/channel = 576 bytes). 576 bytes of data will contain 1 sample from each of the 144 channels.

7 Sensor Information and Details

Several queries above refer to sensor properties such as type, mode, or channels. The full description of each sensor type with its available channels and modes are in the table below:

Description	# Type	α Type	Channels	Modes
Trigno Legacy EMG Sensor	0	A	EMG + 3 ACC	Dual Range Accelerometer (+/-1.5g, +/-6g)
Trigno Spring Contact Adapter	1	B	EMG + 3 ACC	Dual Range Accelerometer (+/-1.5g, +/-6g)
Trigno Snap Lead EMG Sensor	2	C	EMG + 3 ACC	Dual Range Accelerometer (+/-1.5g, +/-6g)
Trigno Standard EMG Sensor	3	D	EMG + 3 ACC	Quad Range Accelerometer (+/-1.5g, +/-4g, +/-6g, +/-9g)
Trigno FSR Adapter	4	E	4 Footswitch Channels	No variable mode control
Trigno EKG Biofeedback Sensor	5	F	EKG + 3 ACC	Dual Range Accelerometer (+/-1.5g, +/-6g)
Trigno Load Cell Adapter	6	G	1 Load Cell Channel	Three gain modes (506 V/V, 1015 V/V, 2025 V/V)
Trigno Goniometer Adapter	7	H	2 Goniometer Channels	Three gain modes (1813 V/V, 1413 V/V, 2221 V/V)
Trigno MiniHead Sensor	9	J	EMG + 3 ACC	Dual Range Accelerometer (+/-1.5g, +/-6g)
Trigno Analog Input Adapter	10	K	4 Analog Input Channels	No variable mode control
Trigno IM Sensor	11	L	EMG + 3 ACC + 3 GYRO + 3 MAG	Quad range IM chip (± 2g, ±250 dps), (± 4g, ±500 dps), (± 8g, ±1000 dps), (± 2g, ±2000 dps) (dps = degrees/sec)
Trigno DR Sensor	12	M	EMG	Configurable bandwidth and gain for EMG channel: (150 V/V Gain, 20-450 Hz Bandwidth), (300 V/V, 20-450Hz), (150 V/V, 10-850HZ), (300 V/V, 10-850Hz)
Trigno Trigger Adapter	13	N	Trigger Chan	No variable mode control
Trigno Avanti Sensor	14	O	Variable, see Avanti section	Configurable bandwidth and gain for EMG channel. Configurable sensitivity for accelerometer. Configurable sensitivity for gyroscope.
Trigno Quattro Sensor	16	Q		Configurable bandwidth and gain for EMG channel. Configurable sensitivity for accelerometer.

				Configurable sensitivity for gyroscope.
Trigno Galileo Sensor	17	R		Configurable bandwidth and gain for EMG channel. Configurable sensitivity for accelerometer. Configurable sensitivity for gyroscope.

8 Trigno Avanti Sensor Details

The Trigno Avanti sensor has a much more complex list of modes than the classic trigno sensors. Refer to the chart below for possible "MODE" settings:

Modes Imitating Classic Modes:

Mode #	Mode Description	Data Output	Selectable Range	Selectable Bandwidth	Slot Occupancy
0	EMG plus Accelerometer (+/- 2g)	4 channels, Standard Data Ports	☑	☑	1
1	EMG plus Accelerometer (+/- 4g)	4 channels, Standard Data Ports	☑	☑	1
2	EMG plus Accelerometer (+/- 8g)	4 channels, Standard Data Ports	☑	☑	1
3	EMG plus Accelerometer (+/- 16g)	4 channels, Standard Data Ports	☑	☑	1
4	EMG plus Gyroscope (+/- 250dps)	4 channels, Standard Data Ports	☑	☑	1
5	EMG plus Gyroscope (+/- 500dps)	4 channels, Standard Data Ports	☑	☑	1
6	EMG plus Gyroscope (+/- 1000dps)	4 channels, Standard Data Ports	☑	☑	1
7	EMG plus Gyroscope (+/- 2000dps)	4 channels, Standard Data Ports	☑	☑	1
8	EMG plus IMU (+/- 2g, +/- 250dps)	10 channels, IMU Ports	☑		1
9	EMG plus IMU (+/- 4g, +/- 250dps)	10 channels, IMU Ports	☑		1
10	EMG plus IMU (+/- 8g, +/- 250dps)	10 channels, IMU Ports	☑		1
11	EMG plus IMU (+/- 16g, +/- 250dps)	10 channels, IMU Ports	☑		1
12	EMG plus IMU (+/- 2g, +/- 500dps)	10 channels, IMU Ports	☑		1
13	EMG plus IMU (+/- 4g, +/- 500dps)	10 channels, IMU Ports	☑		1
14	EMG plus IMU (+/- 8g, +/- 500dps)	10 channels, IMU Ports	☑		1
15	EMG plus IMU (+/- 16g, +/- 500dps)	10 channels, IMU Ports	☑		1
16	EMG plus IMU (+/- 2g, +/- 1000dps)	10 channels, IMU Ports	☑		1
17	EMG plus IMU (+/- 4g, +/- 1000dps)	10 channels, IMU Ports	☑		1
18	EMG plus IMU (+/- 8g, +/- 1000dps)	10 channels, IMU Ports	☑		1
19	EMG plus IMU (+/- 16g, +/- 1000dps)	10 channels, IMU Ports	☑		1

20	EMG plus IMU (+/- 2g, +/- 2000dps)	10 channels, IMU Ports	☑		1
21	EMG plus IMU (+/- 4g, +/- 2000dps)	10 channels, IMU Ports	☑		1
22	EMG plus IMU (+/- 8g, +/- 2000dps)	10 channels, IMU Ports	☑		1
23	EMG plus IMU (+/- 16g, +/- 2000dps)	10 channels, IMU Ports	☑		1
39	EMG plus Orientation	5 channels, IMU Ports	☑		1

New Modes:

Mode #	Mode Description	Data Output	Selectable Range	Selectable Bandwidth	Slot Occupancy
40	EMG (2148Hz)	1 Channel, Standard Port	☑	☑	1
42	EMG (1926Hz) plus ACC (74Hz, 2g)	4 Channels, Standard Ports	☑	☑	1
43	EMG (1926Hz) plus ACC (74Hz, 4g)	4 Channels, Standard Ports	☑	☑	1
44	EMG (1926Hz) plus ACC (74Hz, 8g)	4 Channels, Standard Ports	☑	☑	1
45	EMG (1926Hz) plus ACC (74Hz,16g)	4 Channels, Standard Ports	☑	☑	1
46	EMG (1926Hz) plus Gryo (74Hz, 250dps)	4 Channels, Standard Ports	☑	☑	1
47	EMG (1926Hz) plus Gryo (74Hz, 500dps)	4 Channels, Standard Ports	☑	☑	1
48	EMG (1926Hz) plus Gryo (74Hz, 1000dps)	4 Channels, Standard Ports	☑	☑	1
49	EMG (1926Hz) plus Gryo (74Hz, 2000dps)	4 Channels, Standard Ports	☑	☑	1
50	EMG (1259Hz) plus Acc (148Hz, 2g) and Gyro (148Hz, 250dps)	7 Channels, IMU Ports	☑		1
51	EMG (1259Hz) plus Acc (148Hz, 4g) and Gyro (148Hz, 250dps)	7 Channels, IMU Ports	☑		1
52	EMG (1259Hz) plus Acc (148Hz, 8g) and Gyro (148Hz, 250dps)	7 Channels, IMU Ports	☑		1
53	EMG (1259Hz) plus Acc (148Hz, 16g) and Gyro (148Hz, 250dps)	7 Channels, IMU Ports	☑		1
54	EMG (1259Hz) plus Acc (148Hz, 2g) and Gyro (148Hz, 250dps)	7 Channels, IMU Ports	☑		1
55	EMG (1259Hz) plus Acc (148Hz, 4g) and Gyro (148Hz, 500dps)	7 Channels, IMU Ports	☑		1
56	EMG (1259Hz) plus Acc (148Hz, 8g) and Gyro (148Hz, 500dps)	7 Channels, IMU Ports	☑		1
57	EMG (1259Hz) plus Acc (148Hz, 16g) and Gyro (148Hz, 500dps)	7 Channels, IMU Ports	☑		1
58	EMG (1259Hz) plus Acc (148Hz, 2g) and Gyro (148Hz, 1000dps)	7 Channels, IMU Ports	☑		1
59	EMG (1259Hz) plus Acc (148Hz, 4g) and Gyro (148Hz, 1000dps)	7 Channels, IMU Ports	☑		1
60	EMG (1259Hz) plus Acc (148Hz, 8g) and Gyro (148Hz, 1000dps)	7 Channels, IMU Ports	☑		1
61	EMG (1259Hz) plus Acc (148Hz, 16g) and Gyro (148Hz, 1000dps)	7 Channels, IMU Ports	☑		1

62	EMG (1259Hz) plus Acc (148Hz, 2g) and Gyro (148Hz, 2000dps)	7 Channels, IMU Ports	☑		1
63	EMG (1259Hz) plus Acc (148Hz, 4g) and Gyro (148Hz, 2000dps)	7 Channels, IMU Ports	☑		1
64	EMG (1259Hz) plus Acc (148Hz, 8g) and Gyro (148Hz, 2000dps)	7 Channels, IMU Ports	☑		1
65	EMG (1259Hz) plus Acc (148Hz, 16g) and Gyro (148Hz, 2000dps)	7 Channels, IMU Ports	☑		1
66	EMG (1778Hz) plus Orientation (74Hz, 16bits)	5 Channels, IMU Ports	☑		1
67	EMG (1482Hz) plus Orientation (74Hz, 32bits)	5 Channels, IMU Ports	☑		1
68	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 2g) and Gryo (296Hz, 250dps)	7 Channels, IMU Ports	☑		1
69	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 4g) and Gryo (296Hz, 250dps)	7 Channels, IMU Ports	☑		1
70	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 8g) and Gryo (296Hz, 250dps)	7 Channels, IMU Ports	☑		1
71	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 16g) and Gryo (296Hz, 250dps)	7 Channels, IMU Ports	☑		1
72	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 2g) and Gryo (296Hz, 500dps)	7 Channels, IMU Ports	☑		1
73	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 4g) and Gryo (296Hz, 500dps)	7 Channels, IMU Ports	☑		1
74	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 8g) and Gryo (296Hz, 500dps)	7 Channels, IMU Ports	☑		1
75	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 16g) and Gryo (296Hz, 500dps)	7 Channels, IMU Ports	☑		1
76	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 2g) and Gryo (296Hz, 1000dps)	7 Channels, IMU Ports	☑		1
77	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 4g) and Gryo (296Hz, 1000dps)	7 Channels, IMU Ports	☑		1
78	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 8g) and Gryo (296Hz, 1000dps)	7 Channels, IMU Ports	☑		1
79	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 16g) and Gryo (296Hz, 1000dps)	7 Channels, IMU Ports	☑		1
80	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 2g) and Gryo (296Hz, 2000dps)	7 Channels, IMU Ports	☑		1
81	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 4g) and Gryo (296Hz, 2000dps)	7 Channels, IMU Ports	☑		1
82	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 8g) and Gryo (296Hz, 2000dps)	7 Channels, IMU Ports	☑		1
83	EMG (148Hz RMS, 100ms win) plus Acc (296Hz, 16g) and Gryo (296Hz, 2000dps)	7 Channels, IMU Ports	☑		1
84	EMG (4370Hz)	1 Channel, Standard Port	☑	☑	2
86	EMG (1259Hz) plus Acc (518Hz, 2g) and Gryo (519Hz, 250dps)	7 Channels, IMU Ports	☑		2
87	EMG (1259Hz) plus Acc (518Hz, 4g) and Gryo (519Hz, 250dps)	7 Channels, IMU Ports	☑		2
88	EMG (1259Hz) plus Acc (518Hz, 8g) and Gryo (519Hz, 250dps)	7 Channels, IMU Ports	☑		2
89	EMG (1259Hz) plus Acc (518Hz, 16g) and Gryo (519Hz, 250dps)	7 Channels, IMU Ports	☑		2
90	EMG (1259Hz) plus Acc (518Hz, 2g) and Gryo (519Hz, 500dps)	7 Channels, IMU Ports	☑		2
91	EMG (1259Hz) plus Acc (518Hz, 4g) and Gryo (519Hz, 500dps)	7 Channels, IMU Ports	☑		2
92	EMG (1259Hz) plus Acc (518Hz, 8g) and Gryo (519Hz, 500dps)	7 Channels, IMU Ports	☑		2
93	EMG (1259Hz) plus Acc (518Hz, 16g) and Gryo (519Hz, 500dps)	7 Channels, IMU Ports	☑		2
94	EMG (1259Hz) plus Acc (518Hz, 2g) and Gryo (519Hz, 1000dps)	7 Channels, IMU Ports	☑		2
95	EMG (1259Hz) plus Acc (518Hz, 4g) and Gryo (519Hz, 1000dps)	7 Channels, IMU Ports	☑		2

96	EMG (1259Hz) plus Acc (518Hz, 8g) and Gryo (519Hz, 1000dps)	7 Channels, IMU Ports	☑		2
97	EMG (1259Hz) plus Acc (518Hz, 16g) and Gryo (519Hz, 1000dps)	7 Channels, IMU Ports	☑		2
98	EMG (1259Hz) plus Acc (518Hz, 2g) and Gryo (519Hz, 2000dps)	7 Channels, IMU Ports	☑		2
99	EMG (1259Hz) plus Acc (518Hz, 4g) and Gryo (519Hz, 2000dps)	7 Channels, IMU Ports	☑		2
100	EMG (1259Hz) plus Acc (518Hz, 8g) and Gryo (519Hz, 2000dps)	7 Channels, IMU Ports	☑		2
101	EMG (1259Hz) plus Acc (518Hz, 16g) and Gryo (519Hz, 2000dps)	7 Channels, IMU Ports	☑		2
102	EMG (1259Hz) plus Acc (963Hz, 2g) and Gyro (74Hz, 250dps)	7 Channels, IMU Ports	☑		2
103	EMG (1259Hz) plus Acc (963Hz, 4g) and Gyro (74Hz, 250dps)	7 Channels, IMU Ports	☑		2
104	EMG (1259Hz) plus Acc (963Hz, 8g) and Gyro (74Hz, 250dps)	7 Channels, IMU Ports	☑		2
105	EMG (1259Hz) plus Acc (963Hz, 16g) and Gyro (74Hz, 250dps)	7 Channels, IMU Ports	☑		2
106	EMG (1259Hz) plus Acc (963Hz, 2g) and Gyro (74Hz, 500dps)	7 Channels, IMU Ports	☑		2
107	EMG (1259Hz) plus Acc (963Hz, 4g) and Gyro (74Hz, 500dps)	7 Channels, IMU Ports	☑		2
108	EMG (1259Hz) plus Acc (963Hz, 8g) and Gyro (74Hz, 500dps)	7 Channels, IMU Ports	☑		2
109	EMG (1259Hz) plus Acc (963Hz, 16g) and Gyro (74Hz, 500dps)	7 Channels, IMU Ports	☑		2
110	EMG (1259Hz) plus Acc (963Hz, 2g) and Gyro (74Hz, 1000dps)	7 Channels, IMU Ports	☑		2
111	EMG (1259Hz) plus Acc (963Hz, 4g) and Gyro (74Hz, 1000dps)	7 Channels, IMU Ports	☑		2
112	EMG (1259Hz) plus Acc (963Hz, 8g) and Gyro (74Hz, 1000dps)	7 Channels, IMU Ports	☑		2
113	EMG (1259Hz) plus Acc (963Hz, 16g) and Gyro (74Hz, 1000dps)	7 Channels, IMU Ports	☑		2
114	EMG (1259Hz) plus Acc (963Hz, 2g) and Gyro (74Hz, 2000dps)	7 Channels, IMU Ports	☑		2
115	EMG (1259Hz) plus Acc (963Hz, 4g) and Gyro (74Hz, 2000dps)	7 Channels, IMU Ports	☑		2
116	EMG (1259Hz) plus Acc (963Hz, 8g) and Gyro (74Hz, 2000dps)	7 Channels, IMU Ports	☑		2
117	EMG (1259Hz) plus Acc (963Hz, 16g) and Gyro (74Hz, 2000dps)	7 Channels, IMU Ports	☑		2
118	EMG (1259Hz) plus Acc (296Hz, 2g) and Gyro (741Hz, 250dps)	7 Channels, IMU Ports	☑		2
119	EMG (1259Hz) plus Acc (296Hz, 4g) and Gyro (741Hz, 250dps)	7 Channels, IMU Ports	☑		2
120	EMG (1259Hz) plus Acc (296Hz, 8g) and Gyro (741Hz, 250dps)	7 Channels, IMU Ports	☑		2
121	EMG (1259Hz) plus Acc (296Hz, 16g) and Gyro (741Hz, 250dps)	7 Channels, IMU Ports	☑		2
122	EMG (1259Hz) plus Acc (296Hz, 2g) and Gyro (741Hz, 500dps)	7 Channels, IMU Ports	☑		2
123	EMG (1259Hz) plus Acc (296Hz, 4g) and Gyro (741Hz, 500dps)	7 Channels, IMU Ports	☑		2
124	EMG (1259Hz) plus Acc (296Hz, 8g) and Gyro (741Hz, 500dps)	7 Channels, IMU Ports	☑		2
125	EMG (1259Hz) plus Acc (296Hz, 16g) and Gyro (741Hz, 500dps)	7 Channels, IMU Ports	☑		2
126	EMG (1259Hz) plus Acc (296Hz, 2g) and Gyro (741Hz, 1000dps)	7 Channels, IMU Ports	☑		2
127	EMG (1259Hz) plus Acc (296Hz, 4g) and Gyro (741Hz, 1000dps)	7 Channels, IMU Ports	☑		2
128	EMG (1259Hz) plus Acc (296Hz, 8g) and Gyro (741Hz, 1000dps)	7 Channels, IMU Ports	☑		2

129	EMG (1259Hz) plus Acc (296Hz, 16g) and Gyro (741Hz, 1000dps)	7 Channels, IMU Ports	☑		2
130	EMG (1259Hz) plus Acc (296Hz, 2g) and Gyro (741Hz, 2000dps)	7 Channels, IMU Ports	☑		2
131	EMG (1259Hz) plus Acc (296Hz, 4g) and Gyro (741Hz, 2000dps)	7 Channels, IMU Ports	☑		2
132	EMG (1259Hz) plus Acc (296Hz, 8g) and Gyro (741Hz, 2000dps)	7 Channels, IMU Ports	☑		2
133	EMG (1259Hz) plus Acc (296Hz, 16g) and Gyro (741Hz, 2000dps)	7 Channels, IMU Ports	☑		2
134	EMG (2370Hz) plus Orientation (222Hz, 32bits)	5 Channels, IMU Ports	☑	☑	2
153	EMG (4000Hz) plus Acc (74Hz, 2g) and Gyro (74Hz, 250dps)	7 Channels, IMU Ports	☑	☑	2
154	EMG (4000Hz) plus Acc (74Hz, 4g) and Gyro (74Hz, 250dps)	7 Channels, IMU Ports	☑	☑	2
155	EMG (4000Hz) plus Acc (74Hz, 8g) and Gyro (74Hz, 250dps)	7 Channels, IMU Ports	☑	☑	2
156	EMG (4000Hz) plus Acc (74Hz, 16g) and Gyro (74Hz, 250dps)	7 Channels, IMU Ports	☑	☑	2
157	EMG (4000Hz) plus Acc (74Hz, 2g) and Gyro (74Hz, 500dps)	7 Channels, IMU Ports	☑	☑	2
158	EMG (4000Hz) plus Acc (74Hz, 4g) and Gyro (74Hz, 500dps)	7 Channels, IMU Ports	☑	☑	2
159	EMG (4000Hz) plus Acc (74Hz, 8g) and Gyro (74Hz, 500dps)	7 Channels, IMU Ports	☑	☑	2
160	EMG (4000Hz) plus Acc (74Hz, 16g) and Gyro (74Hz, 500dps)	7 Channels, IMU Ports	☑	☑	2
161	EMG (4000Hz) plus Acc (74Hz, 2g) and Gyro (74Hz, 1000dps)	7 Channels, IMU Ports	☑	☑	2
162	EMG (4000Hz) plus Acc (74Hz, 4g) and Gyro (74Hz, 1000dps)	7 Channels, IMU Ports	☑	☑	2
163	EMG (4000Hz) plus Acc (74Hz, 8g) and Gyro (74Hz, 1000dps)	7 Channels, IMU Ports	☑	☑	2
164	EMG (4000Hz) plus Acc (74Hz, 16g) and Gyro (74Hz, 1000dps)	7 Channels, IMU Ports	☑	☑	2
165	EMG (4000Hz) plus Acc (74Hz, 2g) and Gyro (74Hz, 2000dps)	7 Channels, IMU Ports	☑	☑	2
166	EMG (4000Hz) plus Acc (74Hz, 4g) and Gyro (74Hz, 2000dps)	7 Channels, IMU Ports	☑	☑	2
167	EMG (4000Hz) plus Acc (74Hz, 8g) and Gyro (74Hz, 2000dps)	7 Channels, IMU Ports	☑	☑	2
168	EMG (4000Hz) plus Acc (74Hz, 16g) and Gyro (74Hz, 2000dps)	7 Channels, IMU Ports	☑	☑	2
169	EMG (4000Hz) plus Orientation (74Hz, 16bits)	5 Channels, IMU Ports	☑	☑	2
170	EMG (3740Hz) plus Orientation (74Hz, 32bits)	5 Channels, IMU Ports	☑	☑	2

Additionally, use SETRANGE and SETBANDWIDTH to configure the sensor's flexible input range and input bandwidth (Note that not all modes support settable bandwidth)

When streaming from the Trigno Avanti sensor, all data parsing rules (sections 6.42, 6.4.3, 6.4.4) apply.

9 Trigno Galileo and Quattro Sensor Details

The Trigno Galileo and Quattro sensors each contain 4 EMG sensing points, generating 4 channels of EMG data per sensor. Refer to the chart below for possible "MODE" settings:

Mode #	Mode Description	Data Output	Selectable Range	Selectable Bandwidth	Slot Occupancy
245	EMG RMS x4 (222Hz) plus Acc (74Hz, 2g) and Gyro (74Hz, 250dps)	10 Channels, IMU Ports	☑		1
246	EMG RMS x4 (222Hz) plus Acc (74Hz, 4g) and Gyro (74Hz, 250dps)	10 Channels, IMU Ports	☑		1
247	EMG RMS x4 (222Hz) plus Acc (74Hz, 8g) and Gyro (74Hz, 250dps)	10 Channels, IMU Ports	☑		1
248	EMG RMS x4 (222Hz) plus Acc (74Hz, 16g) and Gyro (74Hz, 250dps)	10 Channels, IMU Ports	☑		1
249	EMG RMS x4 (222Hz) plus Acc (74Hz, 2g) and Gyro (74Hz, 500dps)	10 Channels, IMU Ports	☑		1
250	EMG RMS x4 (222Hz) plus Acc (74Hz, 4g) and Gyro (74Hz, 500dps)	10 Channels, IMU Ports	☑		1
251	EMG RMS x4 (222Hz) plus Acc (74Hz, 8g) and Gyro (74Hz, 500dps)	10 Channels, IMU Ports	☑		1
252	EMG RMS x4 (222Hz) plus Acc (74Hz, 16g) and Gyro (74Hz, 500dps)	10 Channels, IMU Ports	☑		1
253	EMG RMS x4 (222Hz) plus Acc (74Hz, 2g) and Gyro (74Hz, 1000dps)	10 Channels, IMU Ports	☑		1
254	EMG RMS x4 (222Hz) plus Acc (74Hz, 4g) and Gyro (74Hz, 1000dps)	10 Channels, IMU Ports	☑		1
255	EMG RMS x4 (222Hz) plus Acc (74Hz, 8g) and Gyro (74Hz, 1000dps)	10 Channels, IMU Ports	☑		1
256	EMG RMS x4 (222Hz) plus Acc (74Hz, 16g) and Gyro (74Hz, 1000dps)	10 Channels, IMU Ports	☑		1
257	EMG RMS x4 (222Hz) plus Acc (74Hz, 2g) and Gyro (74Hz, 2000dps)	10 Channels, IMU Ports	☑		1
258	EMG RMS x4 (222Hz) plus Acc (74Hz, 4g) and Gyro (74Hz, 2000dps)	10 Channels, IMU Ports	☑		1
259	EMG RMS x4 (222Hz) plus Acc (74Hz, 8g) and Gyro (74Hz, 2000dps)	10 Channels, IMU Ports	☑		1
260	EMG RMS x4 (222Hz) plus Acc (74Hz, 16g) and Gyro (74Hz, 2000dps)	10 Channels, IMU Ports	☑		1
261	EMG RMS x4 (222Hz) plus Orientation (74Hz, 20bits)	8 Channels, IMU Ports	☑		1
262	EMG x4 (1111Hz)	4 Channels, IMU Ports	☑	☑	2
263	EMG x4 (963Hz) plus Acc (148Hz, 2g, 10bits) and Gyro (148Hz, 250dps, 10bits)	10 Channels, IMU Ports	☑		2
264	EMG x4 (963Hz) plus Acc (148Hz, 4g, 10bits) and Gyro (148Hz, 250dps, 10bits)	10 Channels, IMU Ports	☑		2
265	EMG x4 (963Hz) plus Acc (148Hz, 8g, 10bits) and Gyro (148Hz, 250dps, 10bits)	10 Channels, IMU Ports	☑		2
266	EMG x4 (963Hz) plus Acc (148Hz, 16g, 10bits) and Gyro (148Hz, 250dps, 10bits)	10 Channels, IMU Ports	☑		2
267	EMG x4 (963Hz) plus Acc (148Hz, 2g, 10bits) and Gyro (148Hz, 500dps, 10bits)	10 Channels, IMU Ports	☑		2
268	EMG x4 (963Hz) plus Acc (148Hz, 4g, 10bits) and Gyro (148Hz, 500dps, 10bits)	10 Channels, IMU Ports	☑		2
269	EMG x4 (963Hz) plus Acc (148Hz, 8g, 10bits) and Gyro (148Hz, 500dps, 10bits)	10 Channels, IMU Ports	☑		2
270	EMG x4 (963Hz) plus Acc (148Hz, 16g, 10bits) and Gyro (148Hz, 500dps, 10bits)	10 Channels, IMU Ports	☑		2
271	EMG x4 (963Hz) plus Acc (148Hz, 2g, 10bits) and Gyro (148Hz, 1000dps, 10bits)	10 Channels, IMU Ports	☑		2
272	EMG x4 (963Hz) plus Acc (148Hz, 4g, 10bits) and Gyro (148Hz, 1000dps, 10bits)	10 Channels, IMU Ports	☑		2
273	EMG x4 (963Hz) plus Acc (148Hz, 8g, 10bits) and Gyro (148Hz, 1000dps, 10bits)	10 Channels, IMU Ports	☑		2
274	EMG x4 (963Hz) plus Acc (148Hz, 16g, 10bits) and Gyro (148Hz, 1000dps, 10bits)	10 Channels, IMU Ports	☑		2

275	EMG x4 (963Hz) plus Acc (148Hz, 2g, 10bits) and Gyro (148Hz, 2000dps, 10bits)	10 Channels, IMU Ports	☑		2
276	EMG x4 (963Hz) plus Acc (148Hz, 4g, 10bits) and Gyro (148Hz, 2000dps, 10bits)	10 Channels, IMU Ports	☑		2
277	EMG x4 (963Hz) plus Acc (148Hz, 8g, 10bits) and Gyro (148Hz, 2000dps, 10bits)	10 Channels, IMU Ports	☑		2
278	EMG x4 (963Hz) plus Acc (148Hz, 16g, 10bits) and Gyro (148Hz, 2000dps, 10bits)	10 Channels, IMU Ports	☑		2
279	EMG x4 (963Hz) plus Acc (74Hz, 2g, 16bits) and Gyro (74Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑		2
280	EMG x4 (963Hz) plus Acc (74Hz, 4g, 16bits) and Gyro (74Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑		2
281	EMG x4 (963Hz) plus Acc (74Hz, 8g, 16bits) and Gyro (74Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑		2
282	EMG x4 (963Hz) plus Acc (74Hz, 16g, 16bits) and Gyro (74Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑		2
283	EMG x4 (963Hz) plus Acc (74Hz, 2g, 16bits) and Gyro (74Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑		2
284	EMG x4 (963Hz) plus Acc (74Hz, 4g, 16bits) and Gyro (74Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑		2
285	EMG x4 (963Hz) plus Acc (74Hz, 8g, 16bits) and Gyro (74Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑		2
286	EMG x4 (963Hz) plus Acc (74Hz, 16g, 16bits) and Gyro (74Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑		2
287	EMG x4 (963Hz) plus Acc (74Hz, 2g, 16bits) and Gyro (74Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑		2
288	EMG x4 (963Hz) plus Acc (74Hz, 4g, 16bits) and Gyro (74Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑		2
289	EMG x4 (963Hz) plus Acc (74Hz, 8g, 16bits) and Gyro (74Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑		2
290	EMG x4 (963Hz) plus Acc (74Hz, 16g, 16bits) and Gyro (74Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑		2
291	EMG x4 (963Hz) plus Acc (74Hz, 2g, 16bits) and Gyro (74Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑		2
292	EMG x4 (963Hz) plus Acc (74Hz, 4g, 16bits) and Gyro (74Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑		2
293	EMG x4 (963Hz) plus Acc (74Hz, 8g, 16bits) and Gyro (74Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑		2
294	EMG x4 (963Hz) plus Acc (74Hz, 16g, 16bits) and Gyro (74Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑		2
295	EMG x4 (963Hz) plus Orientation (74Hz, 28bits)	8 Channels, IMU Ports	☑		2
296	EMG x4 (2222Hz)	4 Channels,	☑	☑	4
297	EMG x4 (2000Hz) plus Acc (148Hz, 2g, 16bits) and Gyro (148Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
298	EMG x4 (2000Hz) plus Acc (148Hz, 4g, 16bits) and Gyro (148Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
299	EMG x4 (2000Hz) plus Acc (148Hz, 8g, 16bits) and Gyro (148Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
300	EMG x4 (2000Hz) plus Acc (148Hz, 16g, 16bits) and Gyro (148Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
301	EMG x4 (2000Hz) plus Acc (148Hz, 2g, 16bits) and Gyro (148Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
302	EMG x4 (2000Hz) plus Acc (148Hz, 4g, 16bits) and Gyro (148Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
303	EMG x4 (2000Hz) plus Acc (148Hz, 8g, 16bits) and Gyro (148Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
304	EMG x4 (2000Hz) plus Acc (148Hz, 16g, 16bits) and Gyro (148Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
305	EMG x4 (2000Hz) plus Acc (148Hz, 2g, 16bits) and Gyro (148Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
306	EMG x4 (2000Hz) plus Acc (148Hz, 4g, 16bits) and Gyro (148Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
307	EMG x4 (2000Hz) plus Acc (148Hz, 8g, 16bits) and Gyro (148Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4

308	EMG x4 (2000Hz) plus Acc (148Hz, 16g, 16bits) and Gyro (148Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
309	EMG x4 (2000Hz) plus Acc (148Hz, 2g, 16bits) and Gyro (148Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
310	EMG x4 (2000Hz) plus Acc (148Hz, 4g, 16bits) and Gyro (148Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
311	EMG x4 (2000Hz) plus Acc (148Hz, 8g, 16bits) and Gyro (148Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
312	EMG x4 (2000Hz) plus Acc (148Hz, 16g, 16bits) and Gyro (148Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
313	EMG x4 (2000Hz) plus Orientation (74Hz, 32bits)	8 Channels, IMU Ports	☑	☑	4
314	EMG x4 (1926Hz) plus Acc (222Hz, 2g, 16bits) and Gyro (148Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
315	EMG x4 (1926Hz) plus Acc (222Hz, 4g, 16bits) and Gyro (148Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
316	EMG x4 (1926Hz) plus Acc (222Hz, 8g, 16bits) and Gyro (148Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
317	EMG x4 (1926Hz) plus Acc (222Hz, 16g, 16bits) and Gyro (148Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
318	EMG x4 (1926Hz) plus Acc (222Hz, 2g, 16bits) and Gyro (148Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
319	EMG x4 (1926Hz) plus Acc (222Hz, 4g, 16bits) and Gyro (148Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
320	EMG x4 (1926Hz) plus Acc (222Hz, 8g, 16bits) and Gyro (148Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
321	EMG x4 (1926Hz) plus Acc (222Hz, 16g, 16bits) and Gyro (148Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
322	EMG x4 (1926Hz) plus Acc (222Hz, 2g, 16bits) and Gyro (148Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
323	EMG x4 (1926Hz) plus Acc (222Hz, 4g, 16bits) and Gyro (148Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
324	EMG x4 (1926Hz) plus Acc (222Hz, 8g, 16bits) and Gyro (148Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
325	EMG x4 (1926Hz) plus Acc (222Hz, 16g, 16bits) and Gyro (148Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
326	EMG x4 (1926Hz) plus Acc (222Hz, 2g, 16bits) and Gyro (148Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
327	EMG x4 (1926Hz) plus Acc (222Hz, 4g, 16bits) and Gyro (148Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
328	EMG x4 (1926Hz) plus Acc (222Hz, 8g, 16bits) and Gyro (148Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
329	EMG x4 (1926Hz) plus Acc (222Hz, 16g, 16bits) and Gyro (148Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
330	EMG x4 (1704Hz) plus Acc (296Hz, 2g, 16bits) and Gyro (370Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
331	EMG x4 (1704Hz) plus Acc (296Hz, 4g, 16bits) and Gyro (370Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
332	EMG x4 (1704Hz) plus Acc (296Hz, 8g, 16bits) and Gyro (370Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
333	EMG x4 (1704Hz) plus Acc (296Hz, 16g, 16bits) and Gyro (370Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
334	EMG x4 (1704Hz) plus Acc (296Hz, 2g, 16bits) and Gyro (370Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
335	EMG x4 (1704Hz) plus Acc (296Hz, 4g, 16bits) and Gyro (370Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
336	EMG x4 (1704Hz) plus Acc (296Hz, 8g, 16bits) and Gyro (370Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
337	EMG x4 (1704Hz) plus Acc (296Hz, 16g, 16bits) and Gyro (370Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
338	EMG x4 (1704Hz) plus Acc (296Hz, 2g, 16bits) and Gyro (370Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
339	EMG x4 (1704Hz) plus Acc (296Hz, 4g, 16bits) and Gyro (370Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
340	EMG x4 (1704Hz) plus Acc (296Hz, 8g, 16bits) and Gyro (370Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4

341	EMG x4 (1704Hz) plus Acc (296Hz, 16g, 16bits) and Gyro (370Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
342	EMG x4 (1704Hz) plus Acc (296Hz, 2g, 16bits) and Gyro (370Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
343	EMG x4 (1704Hz) plus Acc (296Hz, 4g, 16bits) and Gyro (370Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
344	EMG x4 (1704Hz) plus Acc (296Hz, 8g, 16bits) and Gyro (370Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
345	EMG x4 (1704Hz) plus Acc (296Hz, 16g, 16bits) and Gyro (370Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑	☑	4
346	EMG x4 (1111Hz) plus Acc (741Hz, 2g, 16bits) and Gyro (741Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑		4
347	EMG x4 (1111Hz) plus Acc (741Hz, 4g, 16bits) and Gyro (741Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑		4
348	EMG x4 (1111Hz) plus Acc (741Hz, 8g, 16bits) and Gyro (741Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑		4
349	EMG x4 (1111Hz) plus Acc (741Hz, 16g, 16bits) and Gyro (741Hz, 250dps, 16bits)	10 Channels, IMU Ports	☑		4
350	EMG x4 (1111Hz) plus Acc (741Hz, 2g, 16bits) and Gyro (741Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑		4
351	EMG x4 (1111Hz) plus Acc (741Hz, 4g, 16bits) and Gyro (741Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑		4
352	EMG x4 (1111Hz) plus Acc (741Hz, 8g, 16bits) and Gyro (741Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑		4
353	EMG x4 (1111Hz) plus Acc (741Hz, 16g, 16bits) and Gyro (741Hz, 500dps, 16bits)	10 Channels, IMU Ports	☑		4
354	EMG x4 (1111Hz) plus Acc (741Hz, 2g, 16bits) and Gyro (741Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑		4
355	EMG x4 (1111Hz) plus Acc (741Hz, 4g, 16bits) and Gyro (741Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑		4
356	EMG x4 (1111Hz) plus Acc (741Hz, 8g, 16bits) and Gyro (741Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑		4
357	EMG x4 (1111Hz) plus Acc (741Hz, 16g, 16bits) and Gyro (741Hz, 1000dps, 16bits)	10 Channels, IMU Ports	☑		4
358	EMG x4 (1111Hz) plus Acc (741Hz, 2g, 16bits) and Gyro (741Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑		4
359	EMG x4 (1111Hz) plus Acc (741Hz, 4g, 16bits) and Gyro (741Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑		4
360	EMG x4 (1111Hz) plus Acc (741Hz, 8g, 16bits) and Gyro (741Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑		4
361	EMG x4 (1111Hz) plus Acc (741Hz, 16g, 16bits) and Gyro (741Hz, 2000dps, 16bits)	10 Channels, IMU Ports	☑		4

Additionally, use SETRANGE and SETBANDWIDTH to configure the sensor's flexible input range and input bandwidth (Note that not all modes support settable bandwidth)

When streaming from the Trigno Quattro and Galileo sensors, all data parsing rules (sections 6.42, 6.4.3, 6.4.4) apply.

10 Real Time Orientation Filter

The real time Orientation Filter transforms the raw data from Trigno IM sensors into orientation data, which provides the orientation of each sensor in a variable format. (Note: this does not apply to the Avanti, Galileo, or Quattro sensor using orientation mode).

10.1 Data Output

When the filter is turned on, the IM data aux port (TCP/IP Port 50044) will begin transmitting either 3 or 4 channels of orientation data (depending on the format, 4 channels for QUAT or 3 channels for PRY). When the filter is off, this port transmits all 9 raw data channels from the sensor (3xACC, 3xGYRO, 3xMAG).

Note: The channel parsing and values/sensor indicated here only applies to the IM sensor using the orientation filter. This does not apply to the Avanti Sensor, Galileo Sensor, or Quattro sensor using orientation mode.

10.2 Quaternion (QUAT) Format

If the data format is set to QUAT, the data will be a stream containing 80 multiplexed channels ([16 sensors]*[5 values/sensor] = 80 channels), where each sample is an IEEE float occupying 4 bytes.

The 5 values per sensor are quaternions corresponding to the following:

Channel1 = q0

Channel2 = q1

Channel3 = q2

Channel4 = q3

Channel5 = reserved

Note: The channel parsing and values/sensor indicated here only applies to the IM sensor using the orientation filter. This does not apply to the Avanti Sensor, Galileo Sensor, or Quattro sensor using orientation mode.

10.3 Pitch/Roll/Yaw (PRY) Format

If the data format is set to PRY, the data will be a stream containing 80 multiplexed channels ([16 sensors] * [5 values/sensor] = 80 channels), where each sample is an IEEE float occupying 4 bytes.

The first 3 values contain Pitch Roll and Yaw data, while the fourth and fifth values are currently reserved.

Quaternion to PRY formula we use:

$$\text{pitch} = \operatorname{atan2}\left(2(q_2q_3 - q_0q_1), 2q_0^2 - 1 + 2q_3^2\right)$$

$$\text{roll} = -\arctan\left(\frac{2(q_1q_3 + q_0q_2)}{\sqrt{1 - (2q_1q_3 + 2q_0q_2)^2}}\right)$$

$$\text{yaw} = \operatorname{atan2}\left(2(q_1q_2 - q_0q_3), 2q_0^2 - 1 + 2q_1^2\right)$$

Note: The channel parsing and values/sensor indicated here only applies to the IM sensor using the orientation filter. This does not apply to the Avanti Sensor, Galileo Sensor, or Quattro sensor using orientation mode.

10.4 Calibration

A calibration file is required to optimize the filter's performance. Calibration allows environment variables to be taken into account, and will help accommodate for drift in the gyroscope signal.

10.4.1 Generating a new calibration file

The calibration application will be run. In the current orientation filter, calibration must be run on each sensor. As long as user is in the same location, the same calibration can be used. When a user changes locations, the sensor must be recalibrated.

Clicking on the option to generate a new calibration file will guide a user through the process of calibration. This calibration will be run for ALL currently paired IM sensors. After following all steps outlined in the interactive calibration program, the user will have the option to save the calibration file.

10.4.2 Loading a saved calibration file

Prior to data collection, users should load a calibration file corresponding to the sensors to be used. These calibrations will then be used to optimize the orientation filter.

11 Trigno IM Sensor Calibration Process

When using the orientation filter, data from the Trigno IM sensor must have a calibration applied to account for distortions in the local magnetic field environment and to compensate for inherent offsets in the system. The IM Sensor Calibration application is used to generate calibration files which are used by the orientation filter. The sensor calibration application is found in the following location:

C:\Program Files (x86)\Delsys, Inc\Trigno Server 2.x\DelsysImuApp.exe

Once on the home screen of the Calibration app, navigate to "File→Connect" to establish a connection between the Trigno system and PC. Select the *Calibrate* button located in the center of the screen. The magnetometer is the first component to be calibrated.

Note: Make sure all Trigno IM sensors are paired to desired channels and turned on before beginning calibration. This requires the Trigno Control Utility to be running.

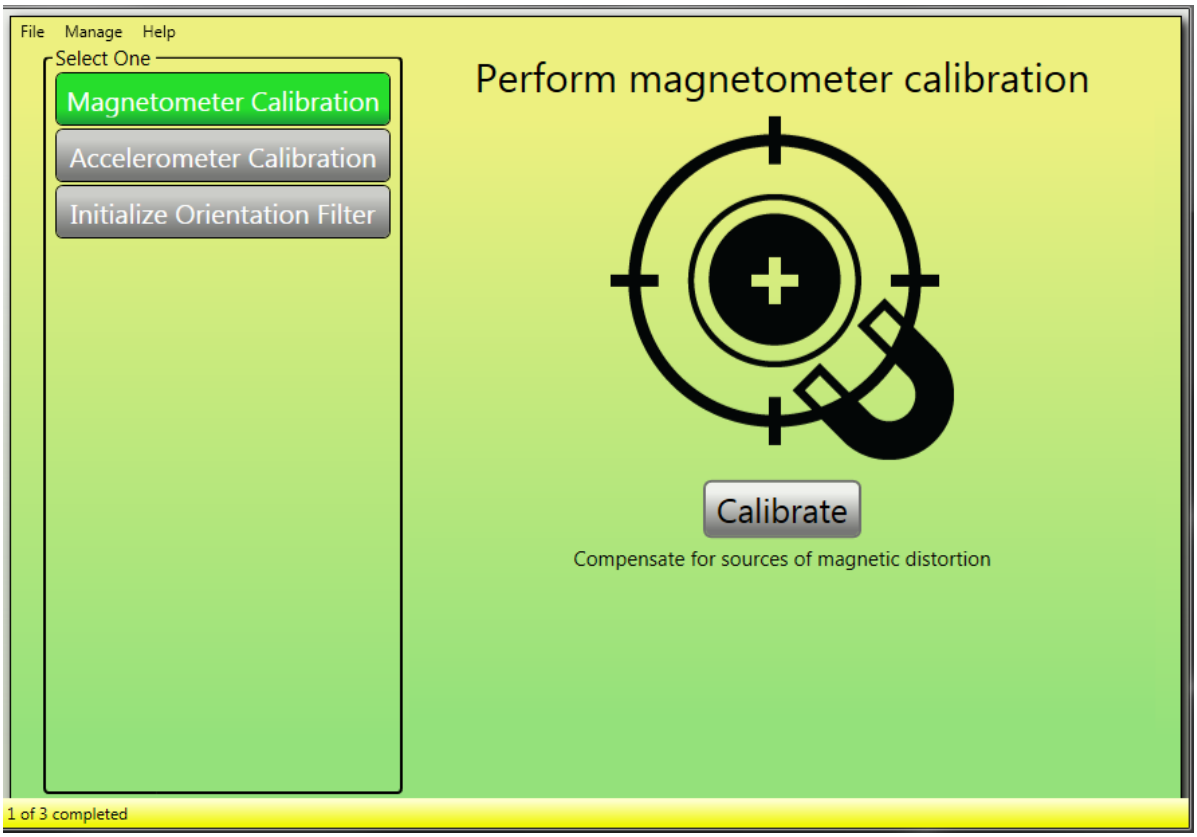

Figure 2: The Calibration Application home screen.

11.1 Magnetometer Calibration

After selecting the *Calibrate* button on the home screen, confirm the number of sensors that appear on the following screen and select *Start*.

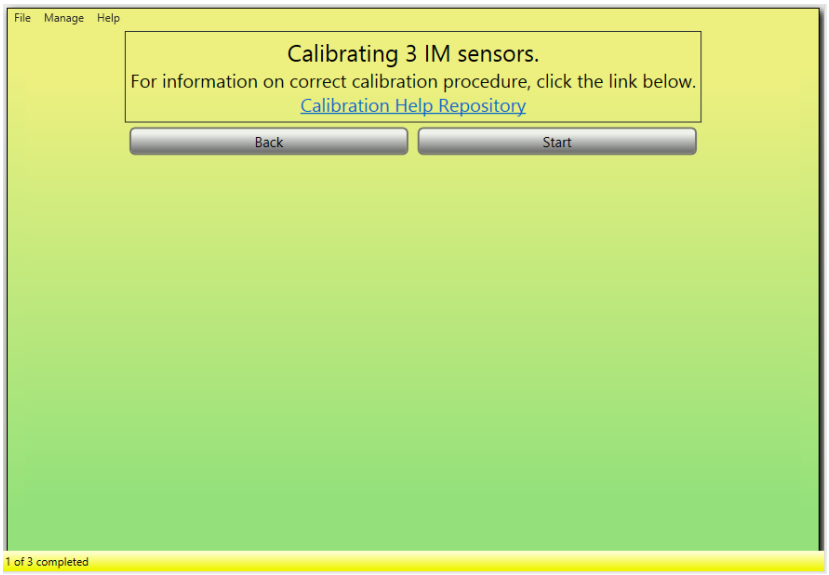

Figure 3: Calibrating the magnetometer.

Clicking the link will take you to an online repository of helpful documents and videos on the calibration process.

A collection summary screen will appear next, begin by selecting *Calibrate Sensor 1.*

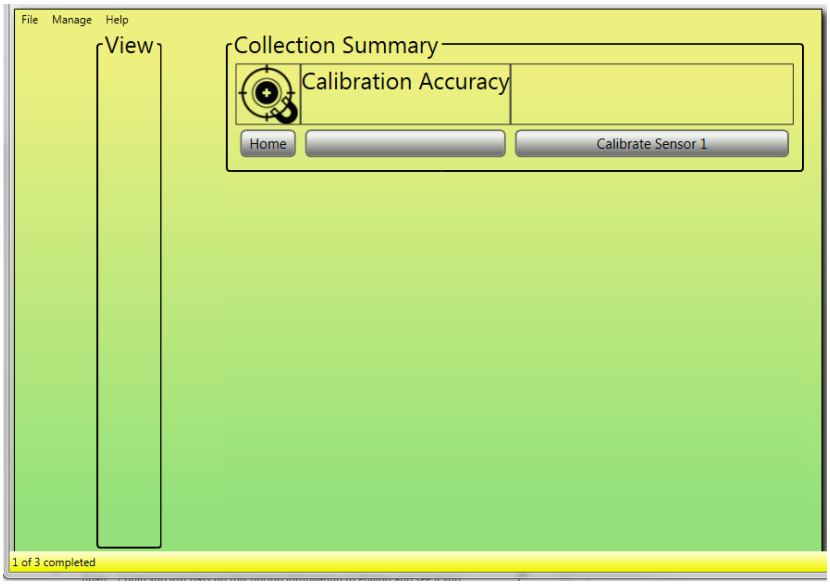

Figure 4: Data collection summary.

A figure with a set of three axes, represented as black lines, will appear. Once the calibration begins, points will be mapped to the figure as the Trigno IM sensor moves through space. The goal of the

calibration is to map out a sphere centered on the origin (intersection point of the 3 axes), such that the points are spaced evenly along the surface of the sphere.

The Calibration app will prompt you to begin the calibration. Move the Trigno IM sensor through as many different orientations as possible. We recommend a loose "figure-8" motion while trying to keep the Delsys arrow pointed in the sensor's direction of travel. Rotating the sensor while waving will also help the calibration succeed. **Note:** Rapid movement and large translations (movement side-to-side and up-and-down) are not necessary during calibration.

An example of a successful calibration is shown below.

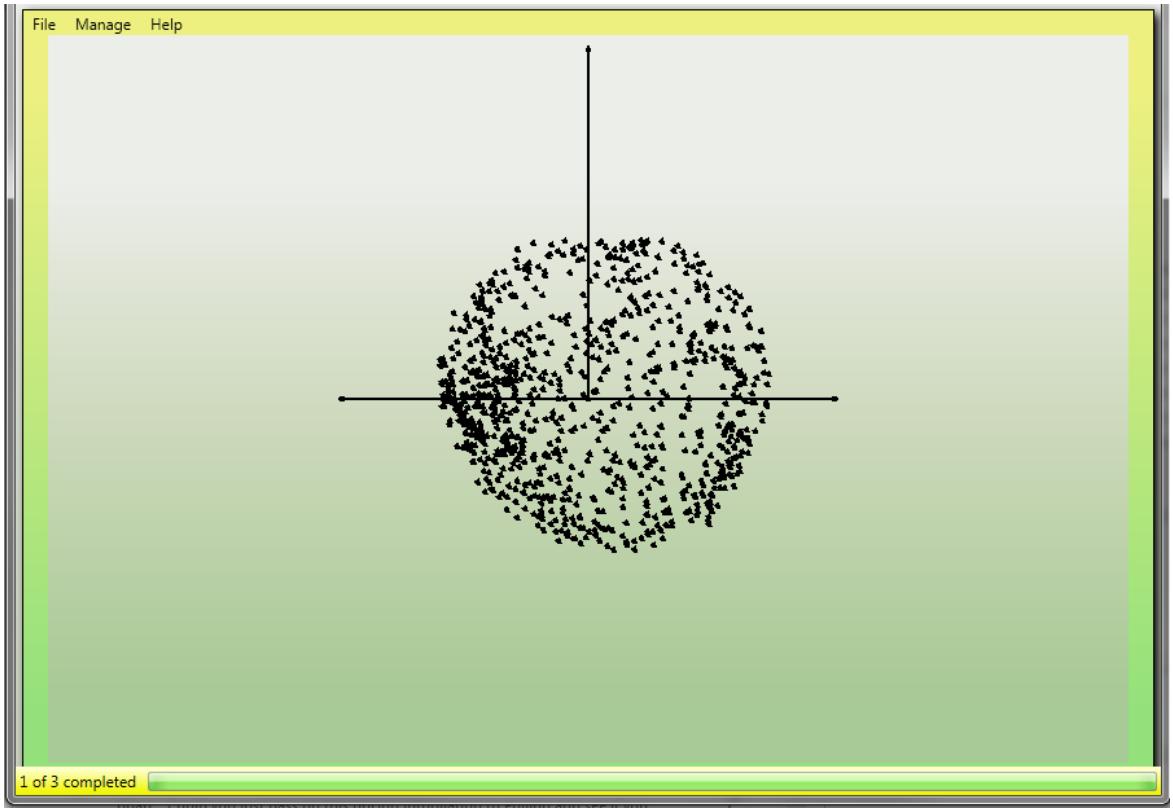

Figure 5: Example of a successful magnetometer calibration.

Upon completion of the calibration, you will be taken back to the summary screen and provided with the results of the collection. The percentage will be color-coded: green is good, amber is okay, and red is a bad calibration. In the case of a low scoring calibration, relevant error messages will be displayed. While a green score will represent an optimal fit, in certain environments it will be difficult to achieve. In these cases, an amber reading should be sufficient.

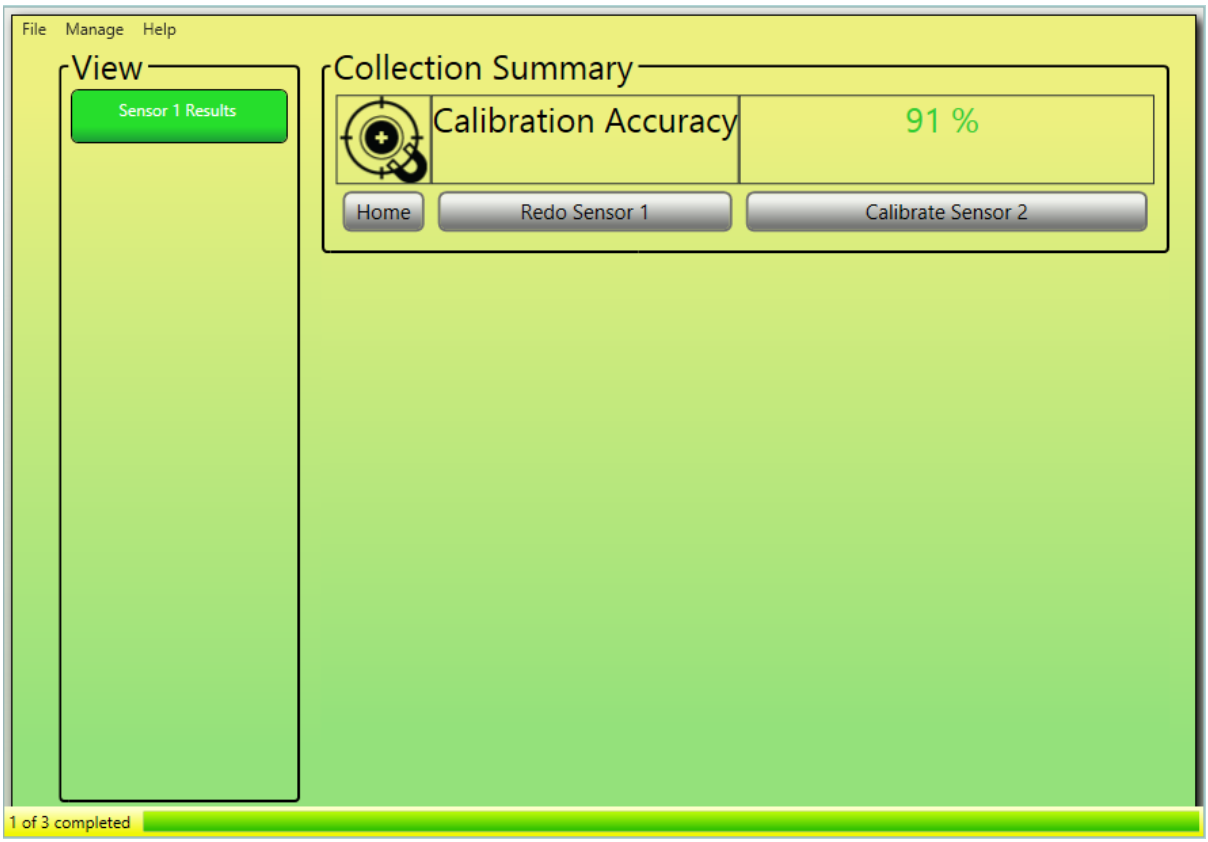

Figure 6: Calibration accuracy estimate.

If unable to obtain a satisfactory calibration, one may re-calibrate by selecting the *Redo Sensor X* button. If the calibration was successful, may proceed by clicking *Calibrate Sensor 2*. Repeat this process to calibrate all paired sensors. After each calibration you will be returned to the summary screen where you can click through the results of all your magnetometer calibrations.

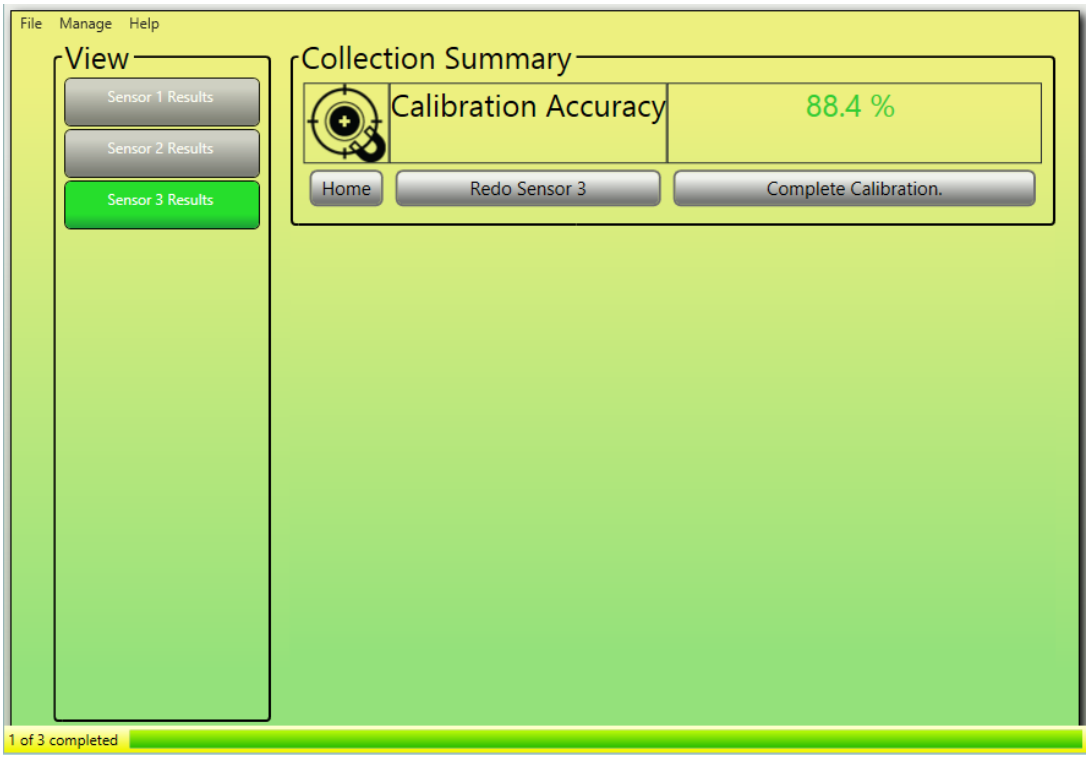

Figure 7: Summary of all calibrated sensors.

Once the task has been completed for all sensors, return to the main screen by selecting *Complete Calibration.* You will be able to return to this page at any time in your session.

11.2 Accelerometer Calibration

Once back on the home screen upon completing the magnetometer calibration, make sure *Accelerometer Calibration* is highlighted and proceed by clicking *Calibrate* in the middle of the screen. You will then be asked to lay all Trigno IM sensors on a flat surface with silver electrodes facing down. When ready, select *Start* and an accelerometry plot will appear. Allow this to run in its entirety. Please note that this calibration applies to ALL sensors.

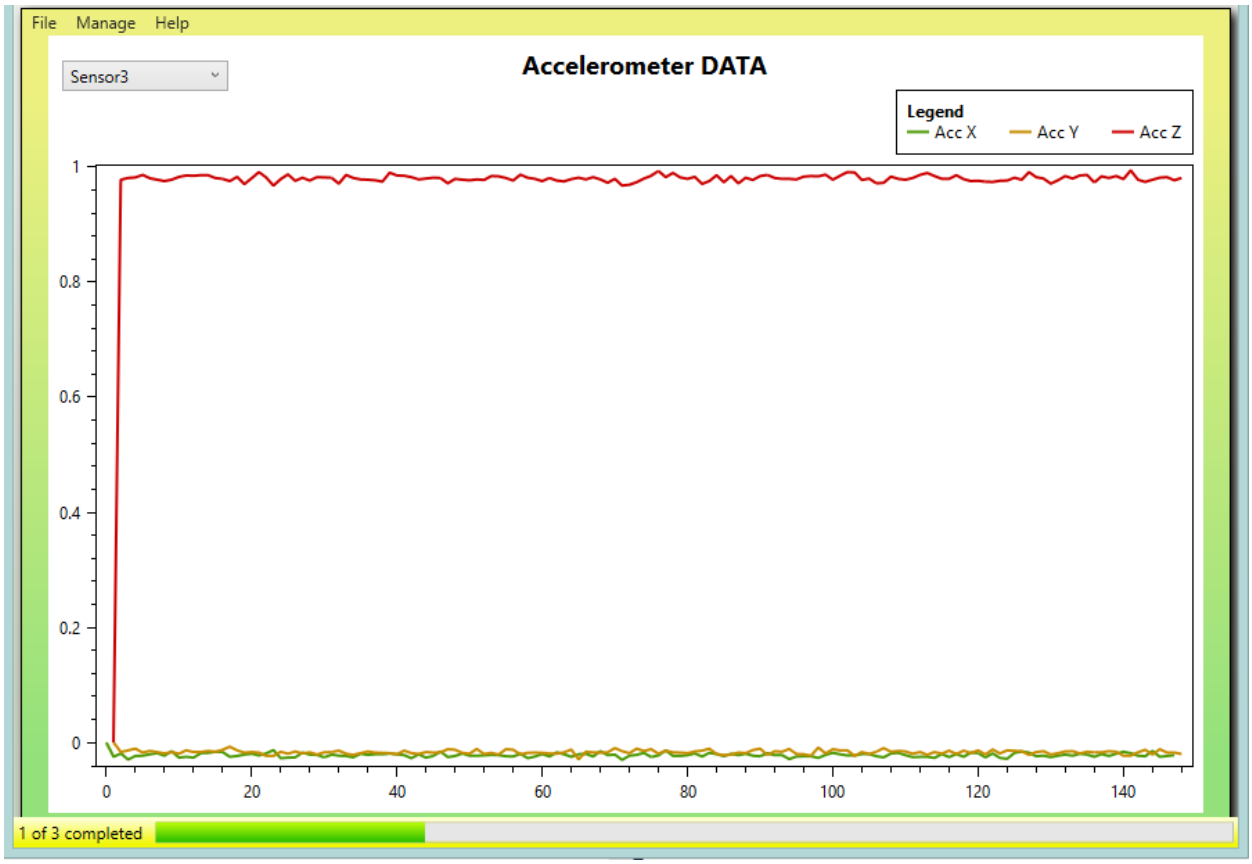

Figure 8" Running the accelerometry calibration.

You will then be brought to a screen with a *Home* button. Select this to proceed.

11.3 Saving the Calibration File

After returning to the home screen, save your calibration by navigating to "File→Save As…".

This file can be loaded later to avoid unnecessarily repeating the calibration process. **Note:** Calibration files should only be loaded if testing is being performed in the same location under similar conditions. We recommend recalibrating before the first test of each day.

11.4 Initializing Orientation Filter

The final step of the calibration procedure involves applying the calibration file to the sensors and setting up the orientation filter. To begin, make sure *Initialize Orientation Filter* is selected on the home screen and click *Calibrate.* You will then be prompted to select the appropriate calibration file.

The master stream will now open and the screen will read *Converged* once the orientation filter has successfully initialized.

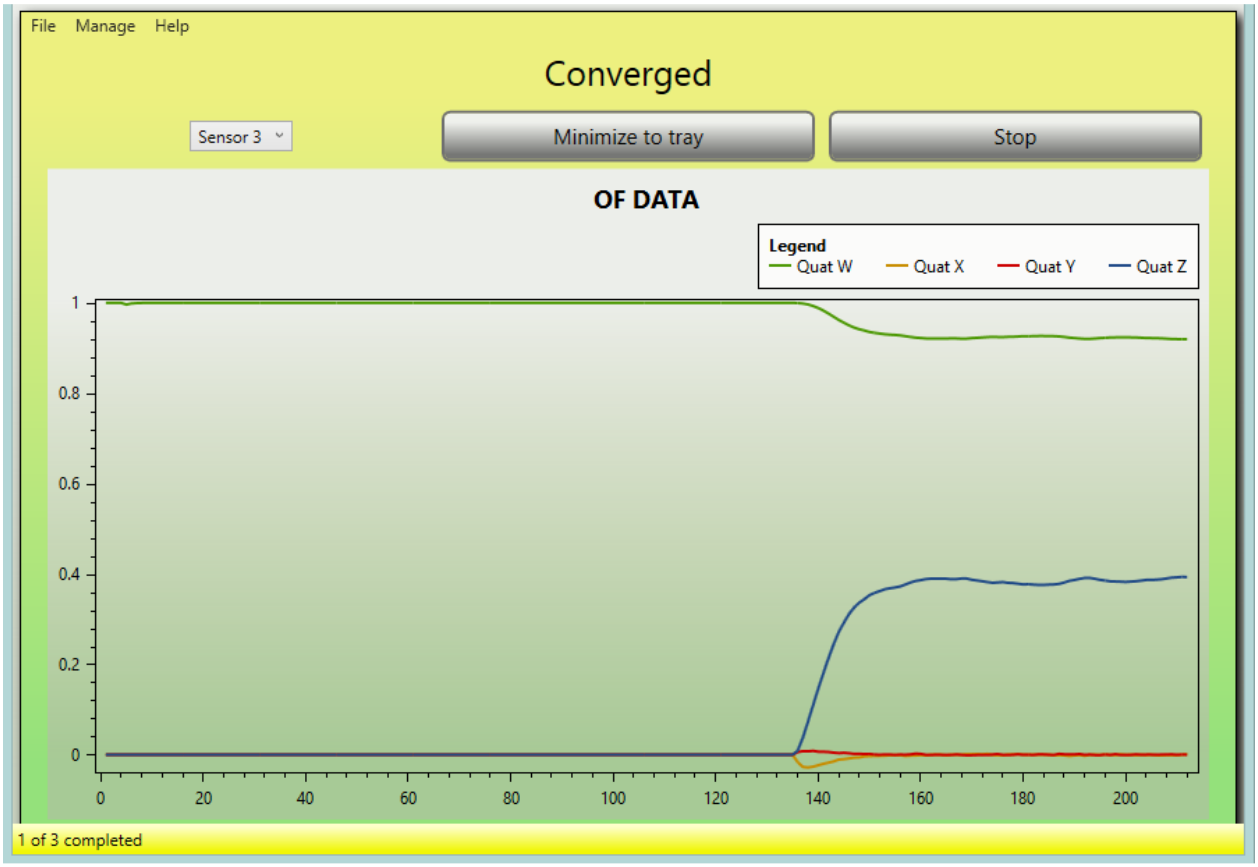

Figure 9: Filter convergence plot.

The application should remain open, as this prevents the need for re-initialization during signal acquisition. The sensors are now ready for data collection**.**

You should select *Minimize to tray* to conserve resources. The application will then appear in the Windows system tray should you need to access it afterwards.

12 Appendix I: Command/Query Reference Table

QUERY	DESCRIPTION	EXAMPLE	EXAMPLE REPLY
"SENSOR *n* TYPE?"	Returns the type of the sensor *n* in letter form.	"SENSOR 1 TYPE?"	"A"
"SENSOR *n* CHANNELCOUNT?"	Returns the number of active channels on sensor *n*	"SENSOR 1 CHANNELCOUNT?"	"4"
"SENSOR n EMGCHANNELCOUNT?"	Returns the number of active emg channels on sensor n	"SENSOR 1 EMGCHANNELCOUNT?"	"4"
"SENSOR n AUXCHANNELCOUNT?"	Returns the number of active auxiliary channels on sensor n	"SENSOR 1 AUXCHANNELCOUNT?	"6"
"SENSOR n STARTINDEX?"	Returns the position in the data the first channel will appear on sensor n	"SENSOR 1 STARTINDEX?"	"1"
"SENSOR *n* MODE?"	Returns the configurable mode state of sensor *n*	"SENSOR 1 MODE?"	"MODE 1 (1.5g)"
"SENSOR n CHANNEL m SAMPLES?"	Returns the native samples per frame on channel m of sensor n	"SENSOR 1 CHANNEL 1 SAMPLES?"	"26"
"SENSOR *n* CHANNEL *m* GAIN?"	Returns the gain on channel *m* of sensor *n*	"SENSOR 1 CHANNEL 1 GAIN?"	"300"
"SENSOR *n* CHANNEL *m* UNITS?"	Returns the units on channel *m* of sensor *n*	"SENSOR 1 CHANNEL 1 UNITS?"	"Volts"
"SENSOR *n* FIRMWARE?"	Returns the firmware version of sensor *n*	"SENSOR 1 FIRMWARE?	"30-06"
"SENSOR *n* SERIAL?"	Returns the serial number of sensor *n*	"SENSOR 1 SERIAL?"	"SID-1234"
"SENSOR *n* PAIRED?"	Returns yes or no, indicating sensor *n* is paired	"SENSOR 1 PAIRED?"	"YES"

“SENSOR n ACTIVE?”	Returns yes or no, indicated sensor n is active	“SENSOR 1 ACTIVE?”	“YES”
“TRIGGER?”	Returns status of both start and stop trigger	“TRIGGER?”	“START ON STOP OFF” “START OFF STOP OFF”
“BACKWARDS COMPATIBILITY?”	Returns whether backwards compatibility on is currently enabled. With backwards compatibility on, the emg ports will be locked to 1926/1111 Hz or 2000 Hz (see Upsampling command).	“BACKWARDS COMPATIBILITY?”	“YES”
“UPSAMPLING?”	Returns upsampling setting. By default upsampling is turned on and the EMG channel will be upsampled to 2000Hz for all sensors if backwards compatibility is enabled.	“UPSAMPLING?”	“UPSAMPLING OFF”
“FRAME INTERVAL?”	Returns the Trigno System frame interval, which is the length in time between frames.	“FRAME INTERVAL?”	“0.0135”
“MAX SAMPLES EMG?”	Returns the expected maximum samples per frame for EMG channels. Divide by the frame interval to get expected EMG sample rate	“MAX SAMPLES EMG?”	“27”
“MAX SAMPLES AUX?”	Returns the expected maximum samples per frame for AUX channels. Divide by the frame	“MAX SAMPLES AUX?”	“4”

	interval to get the expected AUX samples rate.		
“ENDIANNESS?”	Returns the currently set endianness for the streaming data. Reply indicates big endianness (data streams in big-endian format), or little endianness (data streams in little-endian format).	“ENDIANNESS?”	“LITTLE” “BIG”
“BASE FIRMWARE?”	Returns the firmware version of the connected Trigno Base Station	“BASE FIRMWARE?”	“Firmware: MA2902-BE1500-DS0801-US2001-DA0900”
“BASE SERIAL?”	Returns the serial number of the connected Trigno Base Station”	“BASE SERIAL”	“BID: 0222”
“ORIENTATION FILTER?”	Returns yes or no, indicating the real time orientation filter is turned on or off. (applies only to IM sensors, type 11)	“ORIENTATION FILTER?”	“YES”
“ORIENTATION DATA FORMAT?”	Returns the output format of the real time orientation filter. Either QUAT or PRY. (applies only to IM sensors, type 11)	“ORIENTATION DATA FORMAT?”	“QUAT” “PRY”
“ORIENTATION FILTER VERSION?”	Returns the version number of the currently installed orientation filter. (applies only to IM sensors, type 11)	“ORIENTATION FILTER VERSION?”	“2.5.1”
“MASTER?”	Queries whether current connection is Master	“MASTER?”	“YES”

"SLAVE"	Queries whether current connection is Slave	"SLAVE?"	"NO"
COMMAND	DESCRIPTION	EXAMPLE	EXAMPLE REPLY
"SENSOR *n* PAIR"	Places the requested sensor number in pair mode, allowing user to complete the pairing process by turning on a sensor and holding down the button.	"SENSOR 1 PAIR"	"PAIR INITIATED, PRESS AND HOLD SENSOR BUTTON TO COMPLETE PAIR" After pair is complete: "SENSOR 1 PAIR COMPLETE"
"SENSOR *n* SETMODE"	Sets the configurable mode of the currently paired sensor	"SENSOR 1 SETMODE 2"	"Sensor 1 set to MODE 2"
"TRIGGER [START/STOP] [ON/OFF]"	Configures the triggers	"TRIGGER START ON" "TRIGGER STOP OFF"	"OK"
"BACKWARDS COMPATIBILITY [ON/OFF]"	Turns backwards compatibility mode on or off. When backwards compatibility mode is off, sample rates scale dynamically up to the highest rate. Otherwise, sample rates are locked by port (See UPSAMPLE command).	"BACKWARDS COMPATIBILITY ON"	"OK"
"UPSAMPLE [ON/OFF]"	Turns upsampling on or off for the EMG channel of all sensors. By default, upsampling is turned on, and the EMG channels will be upsampled to 2000Hz. Only applies when Backwards Compatibility mode is on.	"UPSAMPLE OFF"	"OK"

“ENDIAN [BIG/LITTLE]”	Sets the endianness of the streaming data.	“ENDIAN BIG” “ENDIAN LITTLE”	“OK”
“START”	Starts data collection. The SDK server will respond once communication with hardware is complete.	“START”	“OK”
“STOP”	Stops data collection. The SDK server will respond once communication with the hardware is complete.	“STOP”	“OK”
“ORIENTATION FILTER [ON/OFF]”	Turns the real-time orientation filter on or off. (applies only to IM sensors, type 11)	“ORIENTATION FILTER ON” “ORIENTATION FILTER OFF”	“OK”
“ORIENTATION DATA FORMAT [QUAT/PRY]”	Sets the output format of the real time orientation filter. (applies only to IM sensors, type 11)	“ORIENTATION DATA FORMAT QUAT” “ORIENTATION DATA FORMAT PRY”	“OK”
“ORIENTATION FILTER ZERO”	Aligns sensors to a common reference frame. (applies only to IM sensors, type 11)	“ORIENTATION FILTER ZERO”	“OK”
“ORIENTATION PATH ‘PATH’ ”	Instructs the program to load a previously acquired calibration file (note path in single quotes) (applies only to IM sensors, type 11)	“ORIENTATION PATH ‘C:\Users\Default\Documents’ ”	“OK”
“MASTER”	Sets current connection as master, making all connections slave.	“MASTER”	“NEW MASTER”
“QUIT”	Stops data collection and closes the server session.	“QUIT”	“BYE”