Trigno™ Wireless System
User's Guide

TRIGNO™ Wireless System

User's Guide

PM-W01

MAN-012-2-7

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Important Information

Intended Use

The Trigno™ Wireless EMG System is a physiological monitoring device that enables researchers and clinicians to acquire EMG and related signals from subjects for biofeedback purposes. Inerpretation of the EMG and supporting signals by a qualified individual is required.

Rx ONLY

Contraindications

DO NOT USE on Patients with implanted electronic devices of any kind, including cardiac pace-makers or similar assistive devices, electronic infusion pumps, and implanted stimulators.

DO NOT USE on irritated skin or open wounds.

DO NOT USE on Patients with allergies to Silver.

DO NOT USE in critical care applications.

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

Warnings and Precautions

Consult all accompanying documents for precautionary statements and other important information.

Consult accompanying user's guide for detailed instructions.

Keep the device dry. The presence of liquids may compromise the safety features of the device.

Handle with care.

Sensitive electronic device. Avoid static discharges. Do not operate or store near strong electrostatic, electromagnetic, magnetic or radioactive fields. Interference from external sources may decrease the signal-to-noise ratio or result in corrupted data.

Connect only to Delsys-approved devices.

Connecting a patient to high-frequency surgical equipment while using Delsys EMG systems may result in burns at the site of the EMG sensor contacts.

Immediately discontinue device use if skin irritation or discomfort occurs.

Immediately discontinue device use if a change in the device's performance is noted. Contact Delsys technical support for assistance.

Delsys Inc. guarantees the safety, reliability, and performance of the equipment only if assembly, modifications and repairs are carried out by authorized technicians; the electrical installation complies with the appropriate requirements; and the equipment is used in accordance with the instructions for use.

Device contains a Lithium-Polymer battery. Do not damage, crush, burn, freeze or otherwise mishandle the device. Recharge only with the approved power supply and recharger.

Trigno Systems should be stored and operated between 5 and 50 degrees Celsius due to the presence of an internal Lithium Polymer rechargeable cell. Storing or operating the device, and consequently the cell, outside of this temperature range may compromise the integrity and the safety features of the cell.

Device Information

C E   Complies with Requirements put forth by the Medical Device Directive 93/42/EEC. Class I device, Annex VII.

Type BF device (IEC 60601-1)

Isolated device, (Class II, IEC 60601-1)

Do not dispose this product with house waste. Contact Delsys Inc. for instructions on responsibly disposing this device. This product should not be mixed with other commercial wastes.

Date of Manufacturing (appears on device)

SN   Serial Number (appears on device)

EC | REP

EMERGO EUROPE
Molenstraat 15
2513 BH, The Hague
The Netherlands

Authorized Representative

DELSYS INC.
23 Strathmore Rd.
Natick MA 01760
USA

Manufacturer

FCC ID: W4P-SP-W02 (Trigno Base Station)
FCC ID: W4P-SP-W01 (Trigno Sensor)
IC: 8138A-DST01 (Model: Trigno Wireless EMG System)

FC This device complies with Part 15 of the FCC Rules and Industry Canada's RSS-210 License Exempt Standards. Operation is subject to the following two conditions: (1) This device may not cause harmful interference. and (2) this device must accept any interference received, including interference that may cause undesired operation.

This product complies with FCC OET Bulletin 65 radiation exposure limits set forth for an uncontrolled environment.

Changes not expressly approved by Delsys Inc.could void the User's authority to operate the equipment

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that required for successful communication.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. There is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- **Reorient or relocate the receiving antenna.**

- **Increase the separation between the equipment and receiver.**

- **Connect the equipment into outlet on a separate circuit.**

Disclaimer

DELSYS INC. makes no warranties, express or implied, as to the quality and performance of this product including but not limited to, any implied warranty of applicability for other than research uses by qualified individuals. DELSYS INC. shall not be liable to any person for any medical expenses or any direct or consequential damages resulting from any defect, failure or malfunction, whether a claim for such damages is based upon theory of warranty, contract, tort or otherwise. No representative, agent, or licensed practitioner is authorized to waive this disclaimer. DELSYS INC. makes no diagnosis or prescription by virtue of anything about this product.

System Requirements

- EMGworks 4.0.9 or later
- Windows 7, Windows Vista or Windows XP with service pack 3. 64-bit or 32-bit operating systems supported. Windows 7 is recommended for optimal performance.
- One USB 2.0 port
- At least 2.0 GHz processor clock speed
- At least 2 GB system memory
- 1280x1024 (SXGA) display resolution or better
- 1 GB hard disk storage (minimum)
- Users of Windows 7 and Vista can simply ensure that they have a Windows Experience Index of 4.0 or greater.

Trigno™ Wireless EMG System Overview

The Trigno™ Wireless EMG System is a high-performing device designed to make EMG signal detection reliable and easy. Each EMG sensor has a built-in triaxial accelerometer, a transmission range of 20 m and a rechargeable battery lasting a minimum of 7 hours. The system is capable of streaming data to EMGworks Acquisition and Analysis software, and of generating 16 EMG and 48 accelerometer analog channels for integration with motion capture and other 3rd party data acquisition systems. Full triggering features further expand the possibility for integration with additional measurement technologies.

Wireless EMG Sensor

Each Trigno Sensor is equipped with the following features:

- transmission range of 20m
- inter-sensor latency < 500us (< 1 sample period)
- self-contained rechargeable battery
- EMG signal bandwidth 20- 450 Hz
- EMG signal sampling rate of 2000 samples/sec
- EMG baseline noise of <750 nV RMS
- CMRR > 80dB
- 16-bit EMG signal resolution
- integrated triaxial accelerometer
- software selectable accelerometer sensitivity of ± 1.5g or ±6g
- LED User feedback
- battery charge monitoring and status indicator
- environmentally sealed device
- proven parallel bar electrode technology
- contoured sensor-skin interface for maximum signal stability
- auto shutoff
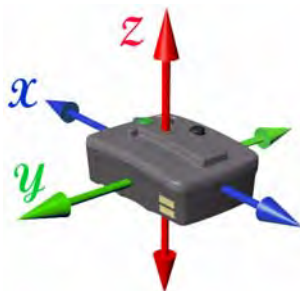
Inertial Sensing Axes   *EMG Electrodes*

Figure 1. Trigno wireless 4-channel sensor.

Sensor LED Indicator Status

Status	LED Behavior	LED
Data Streaming	Flashing green, 1 Hz	🟢 🟢
Scanning	Alternating green/amber flash, 1Hz	🟢 🟡
Pairing Successful	Rapid green flashing, 3x, button depressed	🟢🟢🟢
Pairing Unsuccessful	Rapid red flashing, 3x, button depressed	🔴🔴🔴
Mode Switch	Rapid green flashing, 3x	🟢🟢🟢
Firmware Update	Rapid green flashing, 3x	🟢🟢🟢
Battery Charging	Solid amber, in cradle	🟡
Charging Complete	Solid green, in cradle	🟢
Sensor Off	LED off	⚪

Base Station

Figure 2. Trigno Base Station.

1	**Wireless Sensor**	**5**	**Analog Output Connectors**
2	**Base Station**	**6**	**Trigger Port**
3	**USB Port**	**7**	**Antenna**
4	**Power Jack/Power Supply**	**8**	**EMGworks Software**

Each Base Station is equipped with the following features:

- recharging cradle for 16 sensors
- high speed USB communication with PC
- 64-channel analog output connector (16 EMG, 48 ACC)
- ± 5V analog output range
- detachable antenna
- full trigger capability (Start/Stop, Input/Output)
- communication & power feedback LEDs
- convenient carry case design

Power Supply

Trigno Systems are equipped with an isolated medical grade power supply. The green power LED on the base station will illuminate when power is connected to the Base Station. The power supply is provided with interchangeable country-specific plug adapters. The power supply can be conveniently stored in the Base Station storage space when the system is not in use.

Figure 3. Trigno SC-P05 International Medical Power Supply with plug adapter kit.

Trigno System are specifically designed and approved to function only with the Power Supply provided. Power Supply substitutions constitute a violation of the medical safety approvals and will void the warranty.

If using a mains-powered PC then an additional isolation transformer is required for medical compliance to IEC60601-1. Refer to Appendix I for further details. No PC isolation is required for operation on a battery-powered laptop.

Getting Started with the Trigno™ System

Software Installation

The Trigno EMG system is controlled by a PC through the USB port, and thus requires software. Trigno Systems include a Delsys Software DVD containing EMGworks Signal Acquisition and Analysis Software and the Trigno Control Utility software for use with 3rd party data acquisition systems.

Install EMGworks from the Delsys Software DVD prior to connecting the Trigno Base Station to the computer.

Powering the Base Station

Connect the Trigno power supply to the circular DC jack located on the side of the Base Station. Energize the power supply by connecting it to a Mains outlet or to an isolation transformer. Ensure that the PC to be used with the Base Station is connected to the same isolation transformer. Please refer to Appendix I for clarification on using an Isolation Transformer. The power LED on the Base Station will illuminate anytime power is applied. Ensure that the Base Station antenna is securely attached to the antenna connector.

Figure 4. Connecting the Trigno Base Station power supply.

Connecting the Base Station

It is important to install EMGworks software prior to connecting the Base Station to the PC. If not, the "Found New Hardware" dialog will appear and Windows will prompt for a driver location. Cancel this dialog and install EMGworks from the Delsys DVD in order to register the Trigno drivers with the operating system. Once

the software is correctly installed, the PC will automatically detect the Trigno Base Station when connected to the USB port.

Charging the Sensors

Before using the system, the sensors should be fully charged by placing them in the Base Station cradle slots. Ensure the Base Station is powered and that the green power LED is illuminated. When charging, the sensor LEDs will illuminate to an amber color. Once the sensor battery is fully charged the sensor LED will turn green. A complete charge cycle from a fully depleted sensor takes approximately 2.5 hours.

Do not force the sensors into the recharging cradles of the Base Station. The sensors are keyed so that they can only be inserted in one orientation. Check the sensor orientation and check for obstructions in the cradle if physical resistance is met while cradling the sensors.

Recharge only with the approved power supply (SC-P05) originally included with the system. Charging with any other power supply may damage the device and will void the warranty.
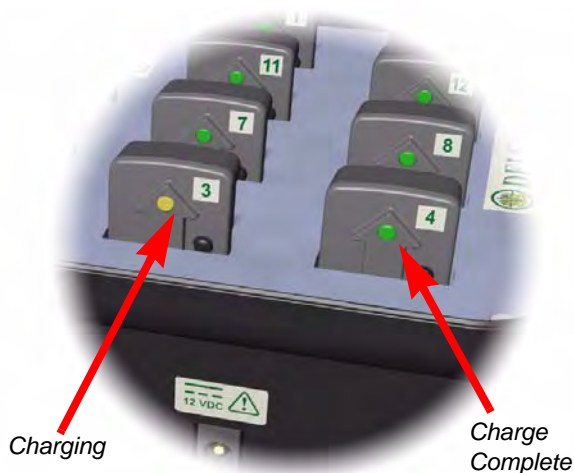
Figure 5. Sensor LED feedback for battery charging status.

Acquiring Data in EMGworks Acquisition

Refer to the "Acquiring and Plotting Data" video tutorial (provided on the DVD) for a brief introduction to configuring the EMGworks software with the Trigno system. This and additional EMGworks tutorials can be found on our website.

Refer to the EMGworks documentation (accessible in the Help menu of the software) for detailed instructions on setting up data collection in EMGworks.

Whenever data are collected in EMGworks, the analog outputs on the base station are also active, so it is possible to collect data in EMGworks and in a secondary data acquisition system simultaneously.

Sampling the Analog Outputs

If samplig the analog output signals from the Trigno System using a 3rd party data acquisition system, refer to the "Using the Analog Outputs" section of this guide.

Digital Outputs (Trigno SDK)

The Trigno SDK presents digital outputs that can be read into several common data collection platforms. Please refer to our online help for more information.

Using the Wireless EMG Sensors

Orienting the EMG Sensors on the Skin

Trigno EMG Sensors employ 4 silver bar contacts for detecting the EMG signal at the skin surface. For maximum signal amplitude, it is important to orient these bars perpendicular to the muscle fiber direction. The top of the sensor is shaped with an arrow to aid in the determination of this orientation. The arrow should be placed parallel to the muscle fibers underneath the sensor. The sensor should also be placed in the center of the muscle belly away from tendons and the edge of the muscle. The sensor is easily attached to the skin using the Delsys Adhesive Sensor Interface.

muscle-fiber direction
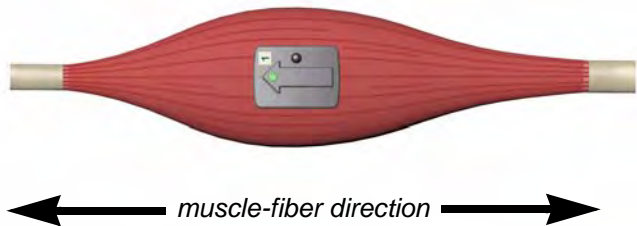
Figure 6. EMG Sensors must be properly oriented with the muscle fibers. Align the sensor's arrow with the direction of the underlying muscle fibers.

Cleaning the Sensor Site

Prior to affixing the EMG sensor on the surface of the skin, the sensor site must be properly cleaned to remove dry dermis and any skin oils. Wiping the skin prior to sensor application helps ensure a qualtiy signal. If excessive hair is present, it will also be necessary to shave the site. In cases where the skin is excessively dry, it may be useful to dislodge dry skin cells by dabbing the site with medical tape. The dry cells will attach the tape's adhesive when it is removed. Be sure to wipe with isopropyl alcohol to remove any adhesive residue that may remain.

Applying the Trigno Adhesive Skin Interfaces

Trigno System are supplied with specially-designed adhesive interfaces to simplify sensor attachment. These hypo-allergenic interfaces are manufactured from medical grade adhesive approved for dermatological applications. Usage of the interface promotes a high quality electrical connection between the sensor bars and the

skin, minimizing motion artifacts and the ill-effects of line interference. To ensure a strong bond with the skin, it is advised to remove excessive hair and wipe the skin area and the EMG Sensor with isopropyl alcohol to remove oils and surface residues. Allow the skin to dry completely before applying the interfaces.

Adhesive Sensor Interfaces are for single use only.

Immediately discontinue use if skin irritation or discomfort occurs. All Adhesive Sensor Interfaces and Reference Electrodes are for single use only. Discard after using. Reseal storage bag to maintain freshness.

Do not use on Patients with allergies to silver.

Do not apply over open wounds or irritated skin.

Turning the Sensors ON

Trigno Sensors are turned on by depressing the rubber button for approximately one second. The green LED on the sensor will immediately begin to flash, and begin searching for a Base Station that has been properly paired and is within its range. If no Base Station is found, the LED will alternate between amber and green, indicating that it does not have an established communication link. As soon a link is established with the Base Station, the sensor LED will flash green approximately once per second, indicating that data are streaming.

Figure 7. Turning the Trigno Sensor "ON".

Trigno Sensor Status Console

A Status console for Trigno Sensors is available when operating EMGworks and when using the Trigno Control Utility. The console tracks all Trigno sensors in the system in real-time, relaying their on/off state, their battery charge level and their communication quality in the network. Additionally, this console hosts the sensor pairing function and can send an "off" command to all sensors.

A compact display of this information is accessible in EMGworks by hovering over the notification area icon for the Trigno hardware. The full dialog is displayed by double-slicking this icon.
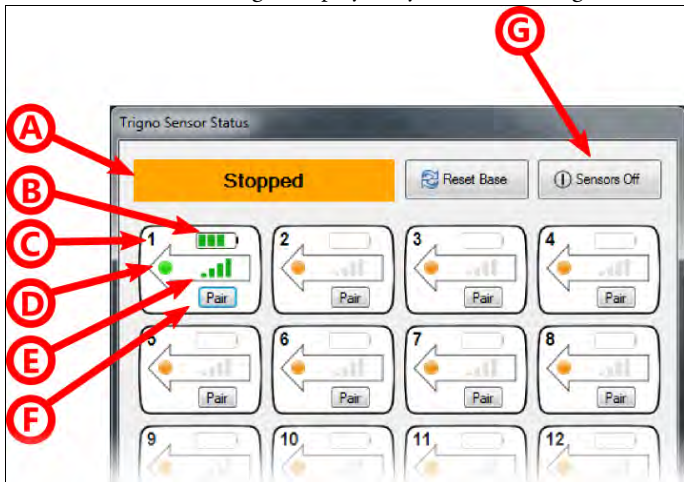
Figure 8. The Trigno Sensor Status Console offers real-time sensor feedback. A) data acquisition status, B) battery charge state, C) sensor number, D) sensor power, E) wireless signal strength, F) sensor pairing, G) off command.

Turning the Sensors Off

There are several mechanisms for turning the Trigno sensors off, described as follows:

• Send an "off" command via software

• Dock the sensor in an active charge cradle

• Hold sensor button for approximately 20 seconds

• 5 minute time-out if sensor is not communicating with base station

Using the Analog Outputs

The Trigno System provides simultaneous analog signal reconstruction of data being detected by all active sensors. These signals are made available on the 68-pin connectors located on the Base Station. EMG signals at these outputs are amplified by a factor of 909, with full dynamic range of ±5V. Similarly accelerometer signals are presented with a nominal full range of ±5V. These must be calibrated according to their selected operational range (±1.5g, ±6g). Note that the EMG and accelerometer signals exhibit fixed 48 and 96ms delays respectively, from the time the sensor detects the event to the time the analog signal is reproduced.

Figure 9. Analog output connectors.

Analog Output Connectors

Channels 1-16, EMG Signals

The pinout of this connector replicates the pinout of the Bagnoli desktop EMG systems to facilitate connectivity between shared equipment. Only EMG signals are provided on this connector. Note that this pinout is also compatible to that of National Instruments data acquisition modules.

Channels 1-64, all Signals

This connector makes available all 64 analog output channels in the 68-pin connector. This connector is compatible with some 80-channel data acquisition modules from National Instruments.
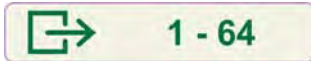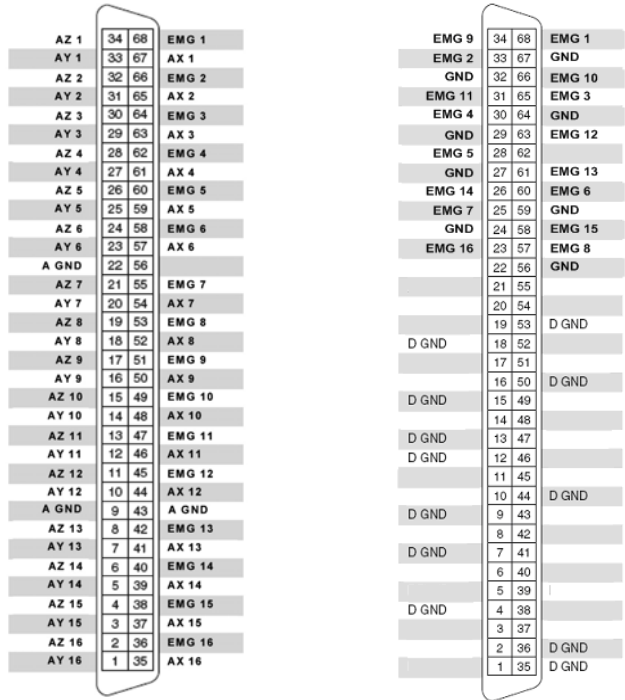
1 - 64

AZ 1	34	68	EMG 1
AY 1	33	67	AX 1
AZ 2	32	66	EMG 2
AY 2	31	65	AX 2
AZ 3	30	64	EMG 3
AY 3	29	63	AX 3
AZ 4	28	62	EMG 4
AY 4	27	61	AX 4
AZ 5	26	60	EMG 5
AY 5	25	59	AX 5
AZ 6	24	58	EMG 6
AY 6	23	57	AX 6
A GND	22	56	
AZ 7	21	55	EMG 7
AY 7	20	54	AX 7
AZ 8	19	53	EMG 8
AY 8	18	52	AX 8
AZ 9	17	51	EMG 9
AY 9	16	50	AX 9
AZ 10	15	49	EMG 10
AY 10	14	48	AX 10
AZ 11	13	47	EMG 11
AY 11	12	46	AX 11
AZ 12	11	45	EMG 12
AY 12	10	44	AX 12
A GND	9	43	A GND
AZ 13	8	42	EMG 13
AY 13	7	41	AX 13
AZ 14	6	40	EMG 14
AY 14	5	39	AX 14
AZ 15	4	38	EMG 15
AY 15	3	37	AX 15
AZ 16	2	36	EMG 16
AY 16	1	35	AX 16

EMG 1 - 16

EMG 9	34	68	EMG 1
EMG 2	33	67	GND
GND	32	66	EMG 10
EMG 11	31	65	EMG 3
EMG 4	30	64	GND
GND	29	63	EMG 12
EMG 5	28	62	
GND	27	61	EMG 13
EMG 14	26	60	EMG 6
EMG 7	25	59	GND
GND	24	58	EMG 15
EMG 16	23	57	EMG 8
	22	56	GND
	21	55	
	20	54	
	19	53	D GND
D GND	18	52	
	17	51	
	16	50	D GND
D GND	15	49	
	14	48	
D GND	13	47	
D GND	12	46	
	11	45	
	10	44	D GND
D GND	9	43	
	8	42	
D GND	7	41	
	6	40	
	5	39	
D GND	4	38	
	3	37	
	2	36	D GND
	1	35	D GND

Figure 10. Pinouts of the analog output connectors.

Screw Terminal Connections

Many data acquisition systems are equipped with screw-type wire terminations. In these cases Delsys can supply a cable assembly that mates with the analog output connectors and breaks out the individual channels onto single conductors. Please contact Delsys for details regarding this particular wire assembly or other connectivity needs. Please refer to Appendix II for further details regarding the DC-A22 Unterminated Output Cable.

Figure 11. DC-A22 Unterminated Output Cable.

Trigno Control Utility Software

The Trigno Control Utility software operates on a PC independently from EMGworks Data Acquisition and Analysis software. The Trigno Control Utility is designed to configure and control the Trigno System so that it becomes a full analog instrument. In this scenario, all data acquisition is performed by sampling the analog channels with 3rd party acquisition systems, often used with Motion Capture Systems.

Additionally, the Trigno Control Utility serves to provide digital samples if using the Trigno SDK.

Installing the Software

The Trigno Control Utility software is included on the Delsys Software DVD. Installing EMGworks will also install the Trigno Control Utility software.

The Trigno Control Utility software can also be obtained by downloading the EMGworks installer from the Delsys web site at: http://www.delsys.com/Products/EMGworks.html

There is no license required to use the Trigno Control Utility.

The system requirements for the Trigno Control Utility software is the same as EMGworks, detailed in the EMGworks User's Guide: http://www.delsys.com/KnowledgeCenter/NetHelp

Launching the Software

When installed, the Trigno Control Utility software may be launched from the Start menu under "Delsys, Inc." To create a desktop shortcut to the Trigno Control Utility, navigate to the program in the Start menu, right click the icon, and select "Send To --> Desktop (create shortcut)".

The Trigno Control Utility application must remain running on the PC for the analog outputs to remain active.

The wireless sensor configuration window is accessible from the "configure" button. "Start" and "Stop" controls activate and deactivate the analog outputs, and define the Start and Stop output trigger events. All settings are locked once the "Start" button is depressed, and can only be changed after the "Stop" button is pressed
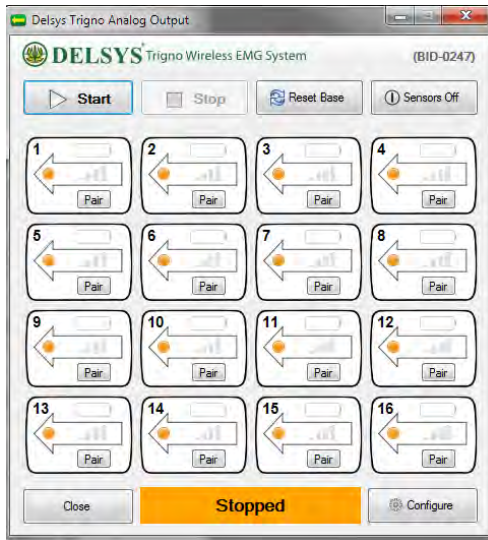
Figure 12. Trigno Control Utility software.

Figure 13. Trigno Control Utility software with active outputs

Configuration Options for Trigno System

Accessing Configuration Options

When editing a configuration in EMGworks, the hardware options for the base station can be set in the Hardware node of the Configuration Tree when the Trigno Wireless System is selected as the primary A/D device.
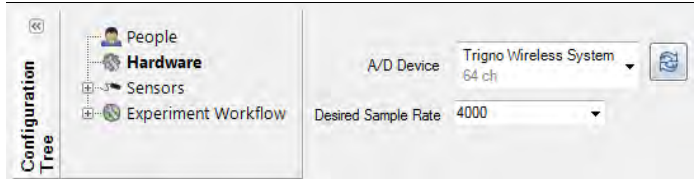

Figure 14. Selecting the Trigno system as the primary A/D device in the Hardware node of the Configuration Tree in EMGworks.

When using the Trigno Control Utility, these options can be set by clicking the Configure button.
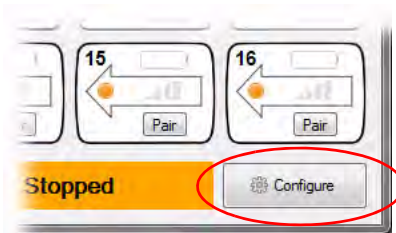

Figure 15. Configure button in Trigno Control Utility

Trigno System Information

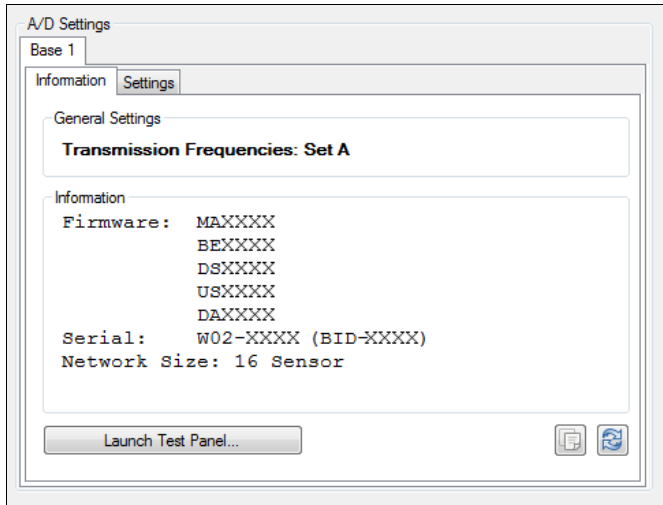The Information tab presents information pertaining to the system and its settings.

Figure 16. Trigno Wireless System information. If multiple bases are connected, the settings for each base are shown on a separate, top level tab.

Transmission Frequencies

Wireless communication occurs on varieties of frequencies throughout the acceptable 2.4 GHz spectrum. Four frequency sets are available ("A", "B", "C" and "D"). The current frequency set is shown here.

Firmware Version

Delsys may occasionally release firmware upgrades to improve and evolve the functionality of Trigno Systems. The current firmware version is shown here.

Serial Number

Each Trigno Base Station has a unique serial number and identifier address which is shown here.

Network Size

Indicates the number of sensors supported by this base.

Launch Test Panel

Places the Trigno Base Station in a test mode to assist with verification of analog output signal connections. Each of the 64 analog output channels is configured to

produce a unique sinusoid which can be verified by properly sampling these channels with secondary acquisition system.

Refresh ⟳

This button refreshes the status information.

Copy 🗏

Copies the data the in the Information tab to the clipboard.

Trigno System Settings

The Settings tab allows several system parameters to be modified as needed.
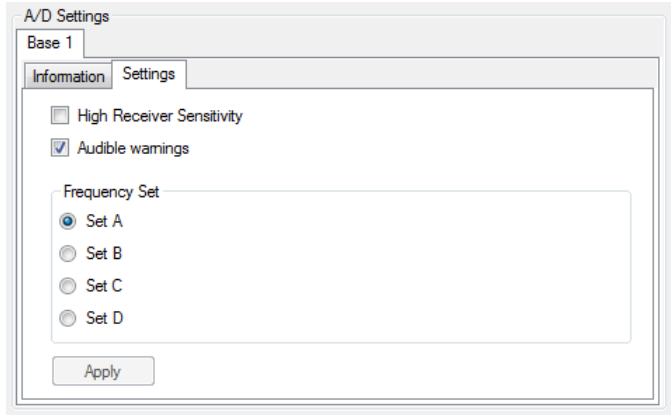
Figure 17. Configuring Trigno Sensor Settings

Frequency Set

Use this setting to change the frequencies being used for wireless communication. The default set is "A". The frequency set should only be changed if nearby sources are interfering with Trigno communications or the particular operating environment is causing significant path loss on the current frequency set. Note that changing the communication frequency set will require sensor re-pairing. Frequencies within the sets are defined by the system and cannot be changed by the User.

Audible Warnings

This option will generate an audible "ping" along with a small message, whenever a sensor falls out of range or it's battery is excessively low.

Mode Control (Analog Output Software Only)

In the Analog Output application, the sensor mode is controlled on the Mode Control tab of the Configuration dialog.

Information on mode control is available through our EMGworks online help:

http://www.delsys.com/Products/EMGworks.html

Test Panel

The Test Panel is used to verify the analog signal connections with the data acquisition module by outputting predefined and unique signals on each channel. The test signals are sinusoidal in nature and defined by an amplitude, a frequency and an offset. The

expected outputs for each analog channels are listed in the Test
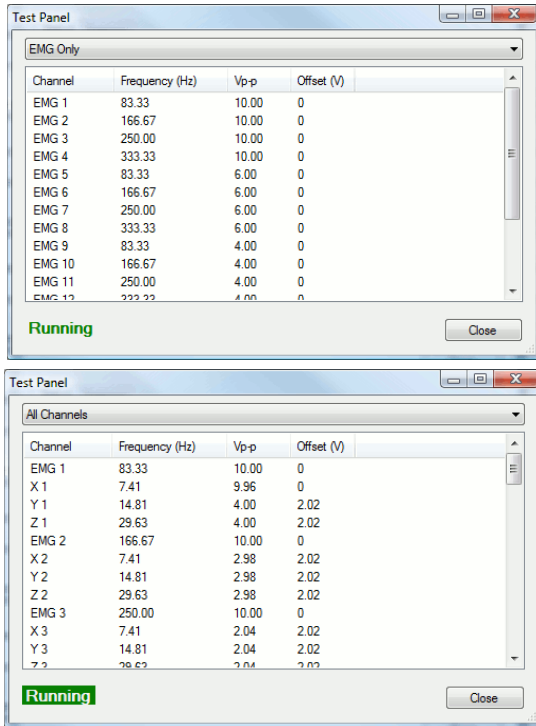Panel window once the option is slected.

Figure 18. The Test Panel Signals.

Additional Sensor Information

Sensor Pairing

Trigno sensors communicate with a custom wireless protocol that links each sensor to a unique Base Station. This linking process is known as sensor "pairing", and is initiated through the "Pair" command.

Trigno systems are shipped with all sensors appropriately paired. Sensor pairing is typically needed if sensors are being replaced within the network group, when the communication frequency sets are changed, and after a firmware upgrade is performed.

1. Initiate sensor pairing in software.

When using EMGworks, initiate pairing by right-clicking the Trigno hardware icon in the system notification area, and selecting the appropriate menu item.
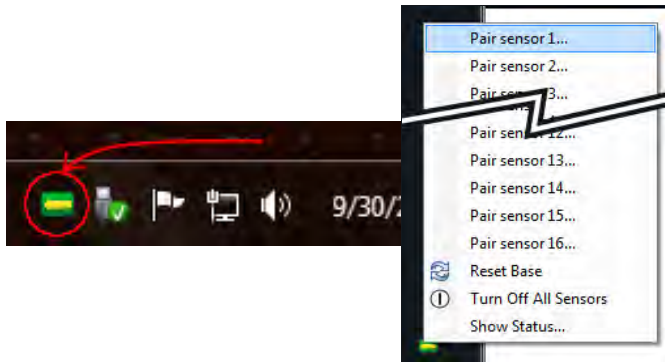

Figure 19. Location of the Trigno hardware icon in the system notification area, and the pairing menu item.

When using Trigno Control Utility, click the "Pair" button on the Sensor Status Console.

Figure 20. Pair button in the Sensor Status Console.

2. Complete the pairing process by depressing the desired sensor button for a minimum of 3 seconds. Successful pairing will result in 3 green LED flashes on the sensor, and a confirmational message in the software.

Figure 21. Complete the process by depressing the sensor button for 3 sec.

Sensor Factory Calibration

The Trigno system stores calibration information for sensors which have been paired with it. When collecting data with EMGworks, this calibration information is used to accurately display measured values, in many cases without the need for a user-initiated manual calibration.

After a pairing operation is completed, the system automatically searches for pre-existing factory calibration data on the particular sensor. If the sensor has never been paired with the system (for example, in the case of a new additional sensor), the software will prompt the user to enter factory calibration data, which can be obtained from Delsys. Factory calibration data are a string of numbers and letters which encode the calibration values for a specific sensor. Factory calibrations are specific to a single sensor and will not be accepted by the software for use on another sensor.

At any time a nominal, "default" calibration may be selected for a sensor, or the specific factory calibration may be re-entered. This feature is accessed by re-pairing the sensor.
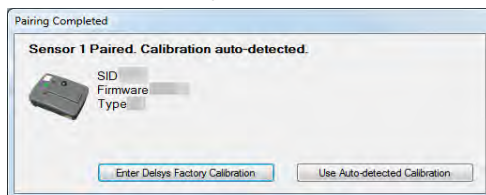

Figure 22. Factory Calibration Prompt. The calibration can be either auto-detected, or entered manually if the sensor is being paired for the first time.

Smart Sensors

After pairing, the association of sensors to the base station is retained for all future uses. Any configuration in EMGworks can be made to reflect the last paired set of sensors by clicking the "Refresh Smart Sensors" button in the "Add Sensors" pane in EMGworks. When data collection starts, the software will verify that the sensors currently communicating match those used in the configuration. If there is a mismatch, cancel the recording and re-pair the sensors.

Figure 23. Refresh Smart Sensors button.

Sensor Modes in EMGworks

Each Trigno sensor can operate in one of 4 possible data collection modes, which determines the type of data being collected. When using EMGworks, the sensor mode can be set on the sensor settings pane for each sensor. Note that the number of modes available is determined by the Trigno sensor type.
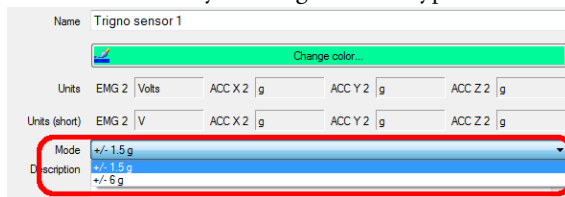

Figure 24. Setting sensor modes in EMGworks.

Using Tandem Trigno Systems

Two Trigno systems may be used in tandem, connected to the same computer as a synchronized 32 sensor, 128 channel system.

Initial Connectivity

To use two Trigno systems in a tandem configuration, connect the USB cable from each base station to the same computer. If using EMGworks, also connect the Trigger Cross-Over Cable (DC-C02) between the trigger ports on the two base stations. After connecting the USB cables and powering each base station, launch either the Trigno Control Utility application or EMGworks. Note that the trigger cross-over cable will work irrespective of orientation.

Trigger Cross-Over Cable
DC-C02
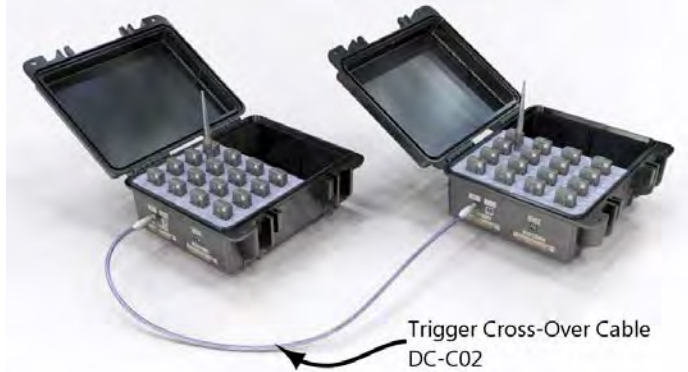
Figure 25. Installation of the Trigger Cross-Over cable to synchronize two base stations when used with EMGworks.

Communication Frequencies

When the software detects the presence of two bases connected to the computer, the frequency sets on each base are automatically changed to allow the simultaneous communication of 32 sensors. The user is required to re-pair each sensor to use these new communication frequencies. Similarly, when reverting to the use of a single base, the communication frequency set will be restored to the option selected by the user (Set A, B, C, or D) and the sensors must again be re-paired.

Synchronization

All channels of data collected in a tandem configuration are fully synchronized between the two bases.

User Interface

User interface options are expanded to reflect the presence of additional sensors.

Figure 26. The Status Console when tandem bases are used.

Maintenance and Care

Trigno Sensors

Trigno sensor are encased in a sealed polycarbonate enclosure. The following points should be kept in mind when handling the sensors.
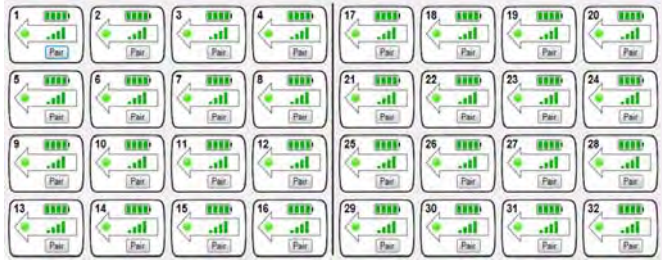
- All sensors should be visually inspected before each use to ensure that no mechanical deterioration has occurred.

- The sensors can be cleaned and sterilized with a damp cloth and mild detergent, or with 70% isopropyl alcohol swabs. Ensure that the sensor contacts remain clean at all times for proper operation.

- While the sensors are sealed and are water-resistant, these should never be completely submerged in any liquid. They are design to be used on damp skin surfaces and in the presence of sweat without compromise to safety, sensor integrity or operation.

- The sensor contacts are made of pure silver and are quite soft. Care should be taken to preserve the integrity of these contacts. Do not scrape or dent these contacts.

- Handle the sensors with care: do not drop them on the ground or step on them.

Do not submerge the sensors in any liquid under any circumstance.

The sensors contain sensitive electronic circuitry. Static discharges and intense magnetic fields should be avoided to prevent the risk of irreparable damage to the sensors.

Trigno Base Station

The Trigno System is designed to provide years of reliable service when proper care is followed. While the Base Station enclosure is made of durable plastic, the following points should be kept in mind during its use and handling:

- The device and its accessories should be visually inspected before every use to ensure that no mechanical deterioration has occurred.

- The Base Station can be easily cleaned with a 70% solution of isopropyl alcohol if necessary. Do not expose the base station to any liquid. It is not a sealed device.

- The units are not shockproof and should not be dropped or be subjected to excessive forces or accelerations.

The recharging Base Station is not water-resistant. Under no circumstance should this unit be exposed to water or any other type of liquids.

Specifications

Trigno Sensors

GENERAL SPECIFICATIONS	
Typical Operating Range[1]	20 m
RF Frequency Band	2400-2483 MHz (ISM band)
Power Consumption	<65 mW
Effective Radiated Power	9 mW
RF Protocol	Proprietary
Case Dimension	27 x 37 x 15 mm
Full-charge Operation Time[2]	8 hours (typical)
Recharge Time[3]	<2.5 hours
Mass	14.7 g
Auto Shut-down timer	300 seconds
Temperature Range[4]	5 - 50 degrees Celsius

(1) Range is characterized in open office environments. Interfering RF sources in the 2.4GHz spectrum, as well as absorptive objects occluding the RF communication path may degrade transmission distance. Stated range can be exceeded under favorable RF conditions.

(2) Battery duration is a function of charge and discharge conditions. Optimal battery performance is obtained when the device is operated at room temperature. Note that the stated Operation Time reflects the expected performance of a fully charged new battery used in a sensor that is transmitting data. Operation Time is expected to decrease as a function of charge cycles, and when the sensor is searching for a network.

(3) 80% of original battery capacity is maintained after 300 discharge/recharge cycles or after 2 years if recharge cycles are less than 300. These values represent typical expectations under normal conditions. Actual performance will vary depending on usage conditions.

(4) Operation beyond these temperature limits may damage the rechargeable battery.

EMG SENSOR SPECIFICATIONS	
Range[1]	11 mV (r.t.i.)
Resolution (EMG Signal)[2]	168 nV/bit (LSB)
Bandwidth (EMG Signal)[3]	20±5 Hz, >40 dB/dec 450±50 Hz, >80 dB/dec
Passband Ripple[3]	<2%
Overall Channel Noise[4]	<0.75uV
CMRR[5]	>80 dB
Sampling Rate[6]	2000 samples/sec, 1925.93 sampes/sec*
Number of Contacts	4

EMG SENSOR SPECIFICATIONS	
Contact Dimension	5 x 1 mm.
Contact Material[7]	99.9% Silver

(1) Range is specified for the input of the EMG sensor and is sampled with 16 bits

(2) ADC Resolution is specified for the input of the sensor.

(3) Filter is designed as a maximally flat Butterworth to preserve EMG signal amplitude and phase linearity.

(4) Input-referred noise is calculated as a root mean square over a 5 second window sampled at 2kHz.

(5) CMRR is measured for a minimum 1 V common mode input signal at a frequency of 60Hz.

(6) EMG signal sampling rate is intrinsic to the sensor and cannot be changed. This has been optimized for the communication bandwidth and signal conditioning designs. *Sensor firmware version 30-08 and later support 1925.93 samples/sec.

(7) Sensor skin contacts are made from pure silver and should not be used if allergic reactions to silver are expected or found to occur.

ACCELEROMETER SPECIFICATIONS	
Number of Axis	3 DOF
Range[1,2]	±1.5g, ±4g, ±6g, ±9g*
Sampling Resolution[2]	0.0040 ± 0.0003 g/bit (at ±1.5g)* 0.0105 ± 0.0006 g/bit (at ±4g)* 0.016 ± 0.001 g/bit (at ±6g)* 0.039 ± 0.004 g/bit (at ±9g)*
Accelerometer Noise[3]	0.007g (rms, ±1.5g) 0.016g (rms, ±4g) 0.024g (rms, ±6g) 0.061g (rms, ±9g)
Bandwidth	DC - 50±5 Hz, 20dB/dec
Offset Error[4]	±0.201g (XY, 1.5g) +0.201g / -0.343g (Z, 1.5g) ±0.055g (XY, 1.5g) +0.055g / -0.087g (Z, 4g) ±0.052g (XY, 6g) +0.052g / -0.088g (Z, 6g) ±0.015g (XY, 9g) +0.015g / -0.025g (Z, 9g)
Sampling Rate[5]	148.1 samples/sec

(1) Accelerometer range is software selectable.

(2) Resolution is calculated with 8 bits over the full 3.3V dynamic range, encompassing accelerometer ideal maximum outputs of ±2.1g and ±8.0g. Ratings exceeding the nominal range may be non linear and are not guaranteed. *Sensor firmware version 30-08 and later support additional ranges of 4g and 9g with improved resolution of 10 bits.

(3) Calculated over a 50 Hz bandwidth and 10 bits of resolution.

(4) Offset errors can be nulled in software by referencing measurements to the 1g output readings.

(5)   Accelerometer sampling rates are intrinsic to the sensor and cannot be changed.

Trigno Recharging Base Station

GENERAL SPECIFICATIONS	
Typical Operating Range[1]	20 m
RF Frequency Band	2400-2483 MHz (ISM)
Power Consumption	<6 W (operation) <14W (during recharge)
Sensor Recharge Time	< 2.5 hours
USB type	USB 2.0 compliant, high speed
Temperature Range	5 - 50 degrees Celsius
Maximum number of Sensors	16
Inter-sensor delay[2]	0 seconds
Dimensions	276 x 241 x 127 mm

(1)   Range is characterized in normal office environments. Interfering RF sources in the 2.4GHz spectrum, as well as absorptive objects occluding the RF communication path may degrade transmission distance. Stated range can be exceeded under favorable RF conditions.
(2)   All data packets are guaranteed to by synchronized within the established sensor network.

EMG ANALOG OUTPUT SPECIFICATIONS	
Number of outputs	16
Signal group delay[1]	48 ms
EMG Signal Range	±5 V
Effective EMG Signal Gain[2]	909 V/V ±5%
Channel Offset (r.t.o.)[3]	±157 mV (max)
Baseline Noise	<0.5mV RMS
DAC Filter Bandwidth	DC-500 Hz, 160 dB/Dec.
Passband Ripple[4]	<2% with Sin(X)/X correction
Connector Type	SCSI-68, Type II

(1)   Delay from sensor event to analog output is fixed for all channels, and referenced as a "group delay". In the case of EMG channels, this delays consists of the following elements: a) Sensor Filter (1.5 ms), b) Digitization Delay (41 ms), c) SinX/X Correction (2 ms), and d) Analog Low Pass Filtering (3.5 ms).
(2)   This parameter relates the detected voltage input at the sensor to the reproduced voltage at the EMG channel output.
(3)   The channel offset is the sum of the base sation offset and the EMG sensor offset.
(4)   Sin(X)/X correction is applied to each channel for cancelling the distorting effects of the DAC sampling process.

ACCELEROMETER ANALOG OUTPUT SPECIFICATIONS	
Number of outputs	16 X Axis 16 Y Axis 16 Z Axis
Signal group delay[1]	96 ms
Accelerometer Output Signal Range	±5 V
Nominal Accelerometer Signal Gain[2]	2.424±0.192 V/g (±1.5g range) 0.933±0.066 V/g (±4g range) 0.624±0.057 V/g (±6g range) 0.253±0.035 V/g (±9g range)
Channel Offset[3]	±0.764 V (XY, 1.5g) +0.764 V / -1.264 V (Z, 1.5g) ±0.564 V (XY, 1.5g) +0.564 / -0.864g (Z, 4g) ±0.764g (XY, 6g) +0.764g / -1.264g (Z, 6g) ±0.564g (XY, 9g) +0.564g / -0.864g (Z, 9g)
Baseline Noise	0.5mV RMS
DAC Filter Bandwidth	DC-50 Hz, 160 dB/Dec
Passband Ripple[4]	<2% with Sin(X)/X correction
Connector Type	SCSI-68, Type II

(1) Delay from sensor event to analog output is fixed for all channels, and referenced as a "group delay". In the case of Accelerometer channels, this delays consists of the following elements: a) Acc Filter (2 ms), b) Digitization Delay (41 ms), c) SinX/X Correction (27 ms), and d) Analog Low Pass Filtering (26 ms).
(2) This parameter relates the nominal uncalibrated voltage differential for an inertial displacement of 1 g.
(3) Offset is the sum of the sensor offsets and the channel path offset.
(4) Sin(X)/X correction is applied to each channel for cancelling the distorting effects of the DAC sampling process.

Appendix I

Mains Isolation

The Trigno Base Station is provided with Medical Grade isolated power supply which is compliant with IEC60601 series of harmonized standards for Medical Devices. However, full compliance with IEC60601-1 Basic Safety for Medical Devices requires that the PC operating the software be isolated as well. This stems from the basic requirement to have all patients electrically isolated from equipment within their reach, and since the PC running the Trigno Software is conceivably within their reach, it too must be isolated.

Delsys does not supply isolation transformers for Personal Computers and their peripherals.

Delsys recommends model IS1000HG manufactured by Tripp Lite (www.tripplite.com) for this task. This device is a medial grade isolation transformer capable of delivering up to 1000 W. A smaller similar version for 500W is also available (IS500HG).

Similar products compliant with IEC60601-1 are acceptable.

Appendix II

DC-A22 Unterminated Output Cable

The DC-A22 Unterminated Output Cable provides access to all 64 analog output channels from the Trigno System on discrete wires for data acquisition systems with screw-type terminations.

The DC-A22 cable connects directly to the output connector labeled "1-64"on the Trigno System and terminates in 67 signal conductors with pre-stripped ends (64 analog output signals and 3 GND conductors).

Each conductor employs a unique color scheme to identify its signal. The conductor jacket is the primary color, and it is marked with a secondary color. An example of the coloring scheme is shown in Figure 27 below.
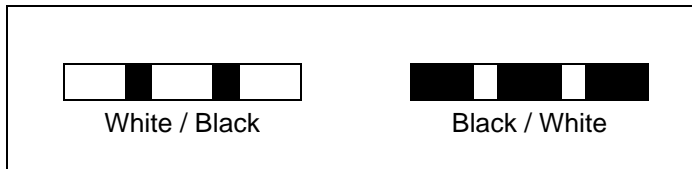

White / Black   Black / White

Figure 27. Wire color scheme example.

Installation

Refer to Figure 28 for installing the DC-A22 cable. Please observe the following points:

- Connect the GND wires to the data acquisition system ground for analog inputs. It is recommended to twist all three wires together and connect these to a common ground point on the measurement system to avoid the risk of creating ground loops.

- Ensure that any unused conductors are not exposed and will not come into contact with each other or any other signal or voltage potential. This can be done by clipping the bare ends of the conductors or using heat shrink tubing or electrical tape to enclose the bare ends.

All output signals are low voltage and low current and thus pose no reasonable risk to the operator while handling these during installation. None-the-less, only qualified personel should make these connections. Care should be taken to ensure that these are properly secured and covered once the installation is complete.

DC-A22 Conductor Assignments

Trigno Output	Trigno Pin	Conductor Color Primary / Secondary	Trigno Output	Trigno Pin	Conductor Color Primary / Secondary
EMG 1	68	Violet / Orange	AY 9	16	Tan / Violet
AX 1	67	Blue / Orange	AZ 9	17	Tan / Gray
AY 1	33	Orange / Blue	EMG 10	49	Blue / Tan
AZ 1	34	Orange / Violet	AX 10	48	Green / Tan
EMG 2	66	Green / Orange	AY 10	14	Tan / Green
AX 2	65	Yellow / Orange	AZ 10	15	Tan / Blue
AY 2	31	Orange / Yellow	EMG 11	47	Yellow / Tan
AZ 2	32	Orange / Green	AX 11	46	Orange / Tan
EMG 3	64	Gray / Pink	AY 11	12	Tan / Orange
AX 3	63	Violet / Pink	AZ 11	13	Tan / Yellow
AY 3	29	Pink / Violet	EMG 12	45	Pink / Tan
AZ 3	30	Pink / Gray	AX 12	44	Brown / Tan
EMG 4	62	Blue / Pink	AY 12	10	Tan / Brown
AX 4	61	Green / Pink	AZ 12	11	Tan / Pink
AY 4	27	Pink / Green	EMG 13	42	Violet / White
AZ 4	28	Pink / Blue	AX 13	41	Blue / White
EMG 5	60	Yellow / Pink	AY 13	7	White / Blue
AX 5	59	Orange / Pink	AZ 13	8	White / Violet
AY 5	25	Pink / Orange	EMG 14	40	Green / White
AZ 5	26	Pink / Yellow	AX 14	39	Yellow / White
EMG 6	58	Gray / Brown	AY 14	5	White / Yellow
AX 6	57	Violet / Brown	AZ 14	6	White / Green
AY 6	23	Brown / Violet	EMG 15	38	Orange / White
AZ 6	24	Brown / Gray	AX 15	37	Pink / White
EMG 7	55	Green / Brown	AY 15	3	White / Pink
AX 7	54	Yellow / Brown	AZ 15	4	White / Orange
AY 7	20	Brown / Yellow	EMG 16	36	Brown / White
AZ 7	21	Brown / Green	AX 16	35	Tan / White
EMG 8	53	Orange / Brown	AY 16	1	White / Tan
AX 8	52	Pink / Brown	AZ 16	2	White / Brown
AY 8	18	Brown / Pink	GND	9	White / Gray
AZ 8	19	Brown / Orange	GND	22	Brown / Blue
EMG 9	51	Gray / Tan	GND	43	Gray / White
AX 9	50	Violet / Tan	NC	56	Blue / Brown

Figure 28. DC-A22 Conductor Assignments