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## GIB Connections

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Introduction

The Motion Lab Systems Goniometer Interface Box (GIB) makes it very easy to use any Biometrics electro goniometer in a biomechanics, motion capture, or research setting. Requiring only a minimum of power (less than 20mA at 4-10V DC unregulated), the GIB device not only powers the electro goniometer but also amplifies the goniometer signal to produce an adjustable signal output in the range of tens of millivolts per degree of flexion instead of the default ten microvolts per degree. This allows the user to interface any Biometrics electro goniometer directly to an analog to digital converter (ADC) or any other measuring device such as a digital voltmeter, oscilloscope or a Motion Lab Systems EMG system.

The GIB device has three BINDER style connectors - two of these connect directly to the Biometrics electro goniometer (extension cables are available if required), while the third cable connects the GIB to any suitable power supply and provides two output signals. The GIB can be used with either two single axis electro goniometers, or a single twin axis electro goniometer. The two electro goniometer connectors are interchangeable (4-pin sockets) while the output connector is a single 5-pin connector, ensuring positive error-free connections.

It is very important to note that the electro Goniometer Interface Box DOES NOT PROVIDE ANY ELECTRICAL ISOLATION between the electro goniometer and connections to the battery or signal monitoring system. If the electro Goniometer Interface Box (GIB) is used with humans, it is recommended that the system is connected to either battery operated equipment or used with a system that provides full electrical isolation for the subject such as a Motion Lab Systems EMG system or similar equipment.

The connections to the GIB device are pressure snap-locks that mate positively. Please use care when connecting or disconnecting the electro goniometer to the GIB device to avoid the risk of mechanical damage to the Biometrics electro goniometer. Please read the Biometrics electro goniometer User Manual before attempting to connect an electro goniometer to the GIB device.
Strain Gauges

The Biometrics goniometers are strain gauge devices that report the angle between the two end-blocks of the goniometer based on a measurement of the strain applied to the internal sensor. The first strain gauges were invented in the 1930s by American mechanical engineers working in California and attempting to find a way of measuring the seismic stresses applied to structures during an earthquake using principles described in 1856 by Lord Kelvin who reported observing a relationship between mechanical strain and the electrical resistance of wire conductors.

The most common type of strain gauge consists of a flexible backing which supports a metallic foil pattern that is adhesively attached and as the backing is deformed by an external strain, the strain gauge foil is deformed, causing its electrical resistance to change. As the foil is stretched its resistance increases, while compression causes the foil resistance to decrease enabling the goniometer to be built measure both positive and negative angles. This resistance change is very small and is typically measured using a Wheatstone bridge.

The Motion Lab Systems Goniometer Interface Box supports two independent strain gauge measurements, designed to work with a twin axis goniometer measuring motion in the X and Y planes, or two independent single axis goniometers. Each GIB channel is electrically independent with a stabilized power supply for each channel and separate amplifiers, each with independent gain and zero controls.

GIB DC Power Requirements

The GIB device requires 5 milliamps when supplied with 5.0 volt DC power and can operate from any unregulated DC power supply in the range of 4 to 10 volts. Each electro goniometer axis will add approximately 6 milliamps to the GIB device power requirements, so a GIB with a twin axis electro goniometer can draw a total of 17 milliamps while a single axis goniometer or torsimeter only requires about 11 milliamps. Each GIB includes independent, regulated, power supplies for each electro goniometer axis. Do not reverse the power supply polarity or exceed +13.5V applied to the DC power input as this may damage the GIB device.

If the GIB is connected to an ADC, or any other device that supplies a higher voltage, then a resistor and diode can be placed in series with the power supply to reduce the applied voltage when no electro goniometers are connected to +10 volts, with the diode provide protection from accidental power supply reversal.

GIB Output Signal

The GIB device outputs each have a range of up to ±2 volts when used with a Biometrics goniometer flexion range of +180° to −180° although the exact output voltage is subject to the GIB internal gain settings and the characteristic of the electro goniometer and may vary from one electro goniometer to another. The magnitude of each GIB channel output signal is determined by the internal gain settings.

GIB device controls

The GIB has four internal potentiometers that can be accessed by removing the cover via the four screws in the GIB base. These potentiometers are preset when the device is built and tested and do not normally need adjusting.
The potentiometers control the gain and zero setting of each channel in the GIB device and can be adjusted if necessary as described in this manual. These adjustments are:

- **ZERO**  This is the electrical zero adjustment for the GIB and electro goniometer. Adjust this potentiometer for zero volts output from the GIB with the electro goniometer connected to the GIB device and set to zero degrees deflection.
- **GAIN**  This potentiometer sets the gain (or span) for each channel of the GIB device.

### GIB Electrical Adjustment Procedure

This electrical adjustment procedure is performed when the GIB is initially built and tested - it should not normally be performed in the field as most data acquisition systems can calibrate and scale their signals using a simple software calibration and scaling procedure. This information is included here for service engineers and researchers only - sample calibration and scaling procedures are described in the following sections.

Always read the Biometrics goniometer care and handling instructions, summarized below, before performing any GIB adjustments or calibration with an electro goniometer:

- The maximum permissible value of bend radius must be observed at all times, particularly when attaching and removing the sensors from the calibration setup. Failure to do this may result in reduced life.
- Never remove the goniometer from the calibration setup by pulling on the measuring element and protective spring. The end-blocks must be removed individually and carefully making sure that the maximum permissible bend radius is never exceeded, particularly where the measuring element enters the end-blocks.
- When using SG and Q series sensors, care should be taken during mounting so that the measuring element always forms a single simple bend. If there are multiple bends in the measuring element then this will reduce the measurement accuracy.
- When using F series goniometers, the unit should not be bent more than ± 20° in the Y-Y plane otherwise reduced life or failure may result.

Before making any adjustments to the Goniometer Interface Box settings the GIB must be connected to a power source, and a goniometer connected to the GIB inputs, with the ability to precisely set the goniometer to known angles. Each GIB channel must be adjusted independently, according to the goniometer physical setting.

1. With the electro goniometer set to zero degrees deflection, adjust the ZERO pot for zero volts DC at the output of the GIB device for each electro goniometer channel.
2. Move the electro goniometer to the maximum angle expected to be applied to the device; typically this is 90 degrees of deflection. Adjust the GAIN pot for the desired output voltage (1.00 volts DC) at the output of the GIB. The maximum output from the GIB is approximately 2 volts DC at 180̊ of flexion.

3. The ZERO and GAIN adjustments within each channel interact; changing each channel gain will affect the channel zero offset adjustment so you may need to repeat the procedure until the required output voltages are stable.

The electro-mechanical calibration of the electro goniometer needs to be performed as part of the goniometer data collection protocol. This means that you need to record the magnitude of the electrical output of the GIB device with the electro goniometer set to at least two known positions. Generally these are a neutral or zero deflection, and a 90̊ deflection in one direction, preferably the primary direction of deflection that the electro goniometer will be measuring.

If the electro goniometer is measuring deflections about its zero point (both positive and negative angles) then it is recommend that you record the output of the device at zero deflection, and both positive and negative deflection ranges for each goniometer axis.

**Electro Goniometer Calibration Calculations**

To demonstrate the calibration calculation, assume that one axis of the electro goniometer produces positive 0.80 volts output from the GIB with the electro goniometer at 90 degrees of flexion, and negative 0.15 volts (-150mV) at zero degrees with the electro goniometer neutral (0 degrees of flexion). This means that a change of 90 degrees in the angle measured by the electro goniometer axis results in a change in the output of the GIB device of 0.95 Volts (0.80 + 0.15). Therefore one degree change of deflection of the electro goniometer changes the voltage output of the GIB by:

\[
\frac{(0.8 + 0.15)}{90} = 0.0106 = 10.6 \text{ mV}
\]

Once we know this value (10.6mV in this example), and the value of the electro goniometer zero (−150mV), we can convert any voltage output signal from the GIB device directly into degrees of positive or negative flexion.

Using these two values, we can determine that we will record measurements from the GIB device in the range of +1.758 volts ((180 * 0.0106) − 0.15) at +180̊ of bending, through to −2.058 volts ((180 * 0.0105) + 0.15) at −180̊ of bending where zero bending (neutral with the goniometer straight) results in a measurement of −0.15 volts. A change of one degree of bending will produce a 10.6mV change in the output of the GIB.

This range of data can be easily recorded using an ADC with a range of ±2.5 volts. If the recorded ADC signal is to be scaled directly in degrees then the fixed calibration values will be:

\[
\frac{\text{ADC Range}}{10.6mV} = \frac{2.5 \text{ V}}{0.0106 \text{ V}} = 235.849 = 236
\]

This result is a potential range of ±236 degrees once the GIB device output is scaled into the ±2.5 volt ADC range provided that this does not exceed the mechanical limits of the electro goniometer. It is important to realize that the GIB and electro goniometer cannot actually produce a signal of this magnitude; this is simply the range of the ADC that is used to record the data.

Thus, the electro goniometer can be quickly and easily calibrated in the experimental environment by making two simple measurements that record the GIB device output at zero deflection, and the GIB output at 90 degrees, allowing a simple calculation to convert the GIB voltage output into an angle measured in degrees.
Scaling C3D Files with electro goniometers

Data recorded in a C3D file can be scaled directly into angular degrees by making a simple data recording on each channel that records both a known bending angle and a zero angle using the same basic method described above. These measurements can be performed as separate recordings or, more conveniently, recorded into a single file. If a single calibration recording is made then a recording of only ten seconds can record the electro goniometer set at +90°, 0° and -90° of angular bending. Two separate recordings will be needed to be made if you need to calibrate both axis of a twin axis electro goniometer.

For the purposes of this example we will consider a twin channel electro goniometer connected to an MA300 system using the MA300 channels labeled "Low A" and "Low B" respectively. If your C3D file uses INTEGER values to store the analog data then the following calibration procedure can be used to scale the C3D data directly into degrees of bending:

- Assuming that the C3D ANALOG:GEN_SCALE parameter is 1.00, set the individual ANALOG:SCALE parameters for the electro goniometer channels to 1.00 in the data collection configuration, and use the default ANALOG:OFFSET value of 2047 for 12-bit resolution data, or 32768 for 16-bit resolution data. Ask your ADC manufacturer if you are unsure what resolution you are using.

- Then collect C3D data with each trial containing three electro goniometer angles of +90°, 0° and -90° degrees. This is usually easily done by attaching two small blocks onto a standard physical therapists plastic “scissors” style goniometer, and attaching the electro goniometer to the blocks. Start the trial recording with the goniometer at +90° and then quickly set the goniometer to 0° and finally -90° to record the three angles in a single trial. This will establish the baseline, unscaled measurements that will allow you to calculate the correct ANALOG:OFFSET and ANALOG:SCALE parameters for each analog channel.

- You can use the MLSviewer application (a free download from the Motion Lab Systems web site) to directly view the data that you have stored in the C3D file. Note that the MLSviewer can display both the scaled and un-scaled values by using the View:Scale Data toggle in MLSviewer while the View:Plots toggle allows the viewer to switch between the default graphical view of the analog data channel and the individual numerical sample values.

- For this example we will assume that data has been collected using a 16-bit ADC and our C3D file contains three static values which are 45257 (+90°), 33014 (0°) and 20771 (-90°). Assuming that the data has been collected with the default scale values (above), these numbers translate to scaled values of 12489, 246 and -11997 in this channel by subtracting the offset value of 32768 from each of the recorded values But what we actually want here is the actual angular values of +90°, 0° and -90° therefore we need to change the ANALOG:SCALE and ANALOG:OFFSET value in the C3D file for this channel to rescale the data.

- Correct the analog zero offset value first. Using the unscaled zero value in the C3D file of 33014 we can calculate the correct offset for this channel of 246 (33014 - 32768). Most motion capture systems will allow you to set a default offset value - called ANALOG:OFFSET - for each individual channel when the C3D file is created. The offset value needs to be adjusted by 246 for this channel (32768 - 246). The correct value of 32522 will make our scaled "zero degrees" measurement in the C3D file actually read as 0°. If you system supports the ANALOG:UNITS parameter then enter “DEG” for the units to indicate that this channel is scaled in angular degrees.

- Using the un-scaled measurements from the calibration trial we find that difference between the +90 and 0 angles is 45257 - 33014 = 12243 so we need to change our ANALOG:SCALE value for this channel in the C3D file to 90/12243 = 0.007351 to get readings of +90, 0, and -90 degrees directly scaled in the C3D file.

- Thus the electro goniometer channel will be calibrated for +90° to -90° with the ANALOG parameters OFFSET set to 32522 and a SCALE of 0.007351. You can now repeat the initial calibration trial and the resulting recording will scale the data between +90 and -90 degrees. Although we have recorded three angular measurements in the trials, only two of these are used in the calculations to scale the data - the third measurement is simply a check that the calibration procedure is working and that subsequent trials will correctly scale the electro goniometer measurements throughout the entire range of the device when using the GIB.
Most 3D motion capture systems that support C3D files will allow the user to configure the analog data collection system directly, enabling the user to enter the values calculated above into the analog setup so that the goniometer data will be calibrated when it is recorded. In some circumstances the user will have to edit the C3D file post-collection to set the necessary scaling values via a C3D file editing program, such as the Motion Lab Systems C3Deditor, that can edit the parameters and data values in a C3D file.

The initial data collection procedure is the same as before - start by collecting C3D data with each trial containing three electro goniometer angle measurements of +90°, 0°, and -90° degrees. Start the trial recording with the goniometer at +90° and then quickly set the goniometer to 0° and finally -90° to record the three angles in a single trial. This will establish the baseline measurements that will allow you to calculate new ANALOG:OFFSET and ANALOG:SCALE parameters for each analog channel. You can use the MLSviewer application to directly view the data that you have stored in the C3D file or use the Motion Lab Systems RData2 application to export the data to an ASCII text format file that can be read by a spreadsheet application.

For the example we will assume that using the REAL formatted C3D data contains three static analog values which are 1.312V (+90°), -0.017V (0°) and -1.430V (-90°). These are the actual voltage measurements from the GIB device averaged from 100 samples at each angle.

In order to scale the C3D data to read the physical angular values of +90°, 0° and -90° we need to edit the ANALOG:SCALE and ANALOG:OFFSET values for this channel in the C3D file. Using the C3Deditor, open the C3D file and located the ANALOG:OFFSET parameter - check that this is a FLOAT data type. If the ANALOG:OFFSET parameter the data type is INTEGER then you must first change the data type before editing the OFFSET value for the GIB channel. Note that the ANALOG:OFFSET parameter is normally an INTEGER parameter and setting it to the FLOAT data type will modify the C3D file format but does not change the stored analog data values. Some applications may fail to read the new FLOAT data type OFFSET values correctly. If this is a problem then you must contact the application manufacturer to request a fix.

Once the ANALOG:OFFSET parameter is a FLOAT data type you can enter the OFFSET value for the GIB channel - in this example you will enter -0.017 measured from the GIB device when the electro goniometer is in the neutral position (straight). Since the units for these measurements will be angular degrees, you should also change ANALOG:UNITS for this channel to “DEG.”

Then enter the ANALOG:SCALE value which is 68.62 (90/1.312) - entering 68.62 for the GIB channel ANALOG:SCALE will result in a scale of +90°, 0° and -90° when the GIB channel is plotted. Note that the actual displayed values will almost never be exactly 90° due to measurement errors in positioning the goniometer and calculating the scale and offset values from the GIB output voltages all contribute to the final measurements.

Recording the goniometer data

The GIB can be used with any ADC that can sample analog data with a range of ±2.5V at a rate fast enough to measure the goniometer motion; generally a sample rate of 40 samples per second or more is adequate for recording most motion in any biomechanical environment.

For example DATAQ Instruments, in Akron Ohio, offer a number of ADC options that include analog recording and real-time data display software. The WINDAQ software package contains both recording and playback software allowing the user to record the goniometer waveforms directly and continuously to disk while monitoring a real time display of the waveforms on the computer screen. The WINDAQ software can be downloaded from the DATAQ Instruments web site [https://www.dataq.com](https://www.dataq.com) and installs on all current versions of the Microsoft Windows operating system to enable any DATAQ ADC to collect and store the goniometer motion via the GIB. The following descriptions will describe the general details of goniometer data collection with a DATAQ ADC although any ADC can be used.
The exact details will depend on the ADC and the version of the software used but the general principles are described and illustrated here. When interfacing the GIB to an ADC, each GIB channel (X and Y) that generates the goniometer data must first be connected to an ADC analog input channel and DC power supplied to the GIB. The GIB will then generate a signal, proportional to the goniometer orientation, with a range of ±2.5V from the GIB. The default ADC range setting when the DATAQ software is first started is ±10 volts which is adjusted in the example shown, monitoring a single channel connected to ADC input #8 with the goniometer set in the neutral position with the end-blocks in a straight line and the ADC range set to ±2.5 volts. The measured voltage from the GIB with the goniometer in neutral position is -.007 volts and is displayed on the left of the graph. The ADC sample rate is shown in the lower left corner and is 200 S/s/CHAN, 200 samples per second per channel which is adequate for most biomechanics motion.

Using WINDAQ to scale electro goniometer data

The WINDAQ data display and data acquisition program from Dataq Instruments can display and record goniometers data scaled in angular degrees when the GIB is connected to a WINDAQ ADC system by calibrating the software to display the voltage generated by the GIB as goniometer angles in real-time as well as recording them for analysis. The precise method will vary depending on the ADC and software used.

First set the goniometer to neutral with the end blocks in a straight line for a goniometer setting of 0 degrees. Note the voltage reading and then adjust the goniometer to +90° and from the Edit menu, select the Engineering Unit Settings option. This opens the menu that allows you to set the calibration values to record and display the voltages from the GIB in terms of goniometer angles. When the Engineering Unit Settings opens, enter the Upper Level voltage, set the Engineering Units (EU) to 90 and change the EU Tag to “Deg” to calibrate the GIB output to match the current goniometer angle. Then set the Lower Level to the neutral voltage measured in the first configuration set, setting the EU value to .000, the live WINDAQ display will now show the physical angle of the electro goniometer and will update the display as the goniometer angle changes. The static value of the goniometer will be displayed on the left, by the ADC channel assignment.

Once the calibration procedure has been completed for each goniometer axis then data can be recorded to disk and exported to ASCII text or C3D files for analysis and data processing.

The procedure described above calibrates one goniometer axis - if you are using a twin axis electro goniometer with the GIB then each goniometer channel must be calibrated independently.
Recording with an Arduino

The Motion Lab Systems Goniometer Interface Box (GIB) can be used with Arduino microcontrollers to read twin joint angles from a goniometer. This example demonstrates this application using an Arduino Uno or similar device with a minimum of additional components.

Software Interface

The Arduino analog inputs can be sampled using the `analogRead(n)` function which reads the voltage applied to the specified analog pin. The circuit described here improves this resolution by connecting the AREF pin to an external +3V reference, and using the external analog reference function to instruct the Arduino to use this reference instead of the default +5V internal reference. This improves the Arduino analog resolution to 0.0029 volts (2.9mV) thus increasing the sensitivity of the ADC input - you must place `analogReference(EXTERNAL)` in the Arduino `setup()` code section to select the external reference voltage prior to any command that accesses the Arduino analog inputs.

The code shown in this illustration will read and display both x-axis and y-axis goniometer output signals and display them via the Arduino IDE serial plotter. The code samples the raw goniometer data at a rate controlled by the 4800 baud serial display baud rate. A baud rate of 4800 means 4800 bits are sent per second which usually requires 10 bits to send each byte of data, so at 4800 baud you are sending 480 characters per second. Each transmitted value is an ASCII integer in the range of 0 to 1024 so the average sample rate is 480 divided by three characters - effectively about 160 samples per second which allows signals up to 80Hz to be recorded.

The code shown here is very simple but requires that the Arduino processor allocate a significant number of processing cycles to read and display goniometer measurements. This polled sampling code could be replaced with a more complex interrupt service routine (ISR) code if you need faster measurements with a lower processing overhead. Please contact Motion Lab Systems for additional details.

Connecting an Arduino

The Arduino Uno contains a multi-channel, 10-bit analog to digital converter (ADC) that maps input voltages between 0 and 5 volts into integer values between 0 and 1023 to yield a measurement resolution of 0.0049 Volts (4.9mV) over the 5V input range. Since the EMG output signal from the GIB has both positive and negative values with reference to the ground, if the GIB outputs were to be connected directly to the Arduino ADC input it would only measure the positive angle values.
Therefore, in order to make the GIB output signals compatible with the Arduino input, the GIB common reference must be connected to a voltage divider (R1, R2, and R3) which holds the GIB common reference at +1.5 Volts DC, with reference to the Arduino ground. This also generates a +3 volt external reference voltage (AREF) that can be connected to the Arduino AREF pin to increase the Arduino ADC sensitivity. The use of an external +3 Volt analog voltage reference, together with the voltage divider, allows the Arduino ADC to map the preamplifier EMG signals to the range of 0 to 1023. This allows the Arduino ADC input to sample both positive and negative GIB output values, returned INT 0 for the maximum -ve value, INT 1023 for the maximum +ve value. Refer to the Arduino documentation for details of the external reference function.

The Interface Circuitry

The circuit powers the GIB via a 6V DC battery comprising of four standard AA cells. The negative battery terminal is connected to a resistor chain (R1, R2, R3) that offsets the GIB ground (0V) to +1.5V with reference to the Arduino Ground. This provides a positive DC offset to the goniometer output signals so that they (nominally +1.5 to -1.5 Volts) can be accurately sampled by the Arduino ADC (default input range 0-5V DC). The resistor chain provides a +3V analog reference at the junction of R1 and R2 that is applied to the Arduino Aref pin which improves the Arduino ADC resolution by making the full range of the ADC 0-3 Volts instead of the default 0-5V.

Because the GIB common is offset by +1.5V DC via the interface circuit, the two amplified goniometer outputs from the GIB (X-axis and Y-axis signals) can be connected directly to the Arduino Uno analog input pins. This allows the full range of the Biometrics goniometer to be sampled in real time.

It is important that the 6V battery used to power the GIB is only connected to this interface circuit in the manner described. It cannot be used to power the Arduino. You must use a separate power source to power the Arduino board to preserve the DC offset needed to allow the Arduino ADC to sample the full output signal range.

Safety

It is important to note that Motion Lab Systems Goniometer Interface Box accessories and the circuits illustrated here do not provide any electrical isolation between the subject and the connected equipment. If your Arduino is not powered by a battery, or is connected to any AC line powered equipment, then you need to be alert to the dangers of electric shock in the event that any AC line power equipment connected to your equipment malfunctions.
# GIB Connections

## Goniometer Interface Box Connectors

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<tr>
<th>4-pin electro goniometer input connector</th>
<th>GIB goniometer X-axis input - connections as viewed looking into the connector socket from outside the GIB.</th>
</tr>
</thead>
</table>
|                                          | 1. +ve input  
|                                          | 2. Ground  
|                                          | 3. -ve input  
|                                          | 4. Excitation  |

<table>
<thead>
<tr>
<th>4-pin electro goniometer input connector</th>
<th>GIB goniometer Y-axis input - connections as viewed looking into the connector socket from outside the GIB.</th>
</tr>
</thead>
</table>
|                                          | 1. +ve input  
|                                          | 2. Ground  
|                                          | 3. -ve input  
|                                          | 4. Excitation  |

<table>
<thead>
<tr>
<th>5-pin GIB output connector</th>
<th>GIB output connections - connections as viewed looking into the male connector from outside the GIB [with MLS cable colors].</th>
</tr>
</thead>
</table>
|                            | 1. X-axis signal [- white -]  
|                            | 2. Ground [- shield -]  
|                            | 3. Y-axis signal [- green -]  
|                            | 4. Ground [- black -]  
|                            | 5. DC power (+ve) [- red -]  |
## Goniometer Interface Box Cables

<table>
<thead>
<tr>
<th>CAB-GIB-000</th>
<th>A single 5-pin BINDER with one, 50&quot; shielded cable terminated with solder tipped ends. This is the default cable supplied with a GIB if the cable type is not specified.</th>
</tr>
</thead>
</table>
|             | 1. White  X-axis Goniometer Signal  
|             | 2. Shield  Internal Ground  
|             | 3. Green  Y-axis Goniometer Signal  
|             | 4. Black  Power and signal common  
|             | 5. Red Positive (+ve) DC power  

<table>
<thead>
<tr>
<th>CAB-GIB-002</th>
<th>A single 5-pin BINDER with one 50&quot; shielded cable with a single 4-pin BINDER connector wired for the MA300 backpack AUX input.</th>
</tr>
</thead>
</table>
|             | 1. Green  Inputs B & D  
|             | 2. Red  +5V  
|             | 3. Black  Common  
|             | 4. White  Inputs A & C  

<table>
<thead>
<tr>
<th>CAB-GIB-002E</th>
<th>A single 5-pin BINDER with two 50&quot; shielded cables, each with one 4-pin BINDER connector wired for an MA300 backpack EMG input.</th>
</tr>
</thead>
</table>
| BINDER #1    | 1. Black  
|             | 2. Red  
|             | 3. n/c  
|             | 4. White + 910k SMT resistor  
| BINDER #2    | 1. Black  
|             | 2. Red  
|             | 3. n/c  
|             | 4. Green + 910k SMT resistor  

<table>
<thead>
<tr>
<th>CAB-GIB-PIB</th>
<th>A single 5-pin BINDER with two shielded cables, each with one 4-pin BINDER connector wired for the PIB interface box.</th>
</tr>
</thead>
</table>
| BINDER #1    | 1. Ground (black)  
|             | 2. +9V DC (red)  
|             | 3. n/c  
|             | 4. X output (white)  
| BINDER #2    | 1. Ground (black)  
|             | 2. +9 DC (red)  
|             | 3. n/c  
|             | 4. Y output (white)  

<table>
<thead>
<tr>
<th>CAB-GIB-003</th>
<th>A single 5-pin BINDER with one 50&quot; shielded cable with a single 4-pin LEMO connector wired for the MA300 backpack AUX input.</th>
</tr>
</thead>
</table>
|             | 1. White  Inputs A & C  
|             | 2. Black  Common  
|             | 3. Red  +5V  
|             | 4. Green  Inputs B & D  

<table>
<thead>
<tr>
<th>CAB-GIB-003E</th>
<th>A single 5-pin BINDER with two 50&quot; shielded cables, each with one 4-pin LEMO connector wired for an MA300 backpack EMG input.</th>
</tr>
</thead>
</table>
| LEMO #1      | 1. White + 910k SMT resistor.  
|             | 2. n/c  
|             | 3. Red  
|             | 4. Black  
| LEMO #2      | 1. Green + 910k SMT resistor.  
|             | 2. n/c  
|             | 3. Red  
|             | 4. Black  

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