Bertec PY6 Load Cell

Version 1.0.0
March 2012

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CE

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INTRODUCTION

Bertec Corporation's pylon transducers were originally developed to measure the loads transmitted by lower limb prostheses. This design has formed the basis for many multi-component load transducers presently available in the market for other applications, including industrial load measurements. Through the use of strain gauge technology, innovative design, and quality manufacturing, Bertec's load cells are well suited for both static and dynamic applications. Each load cell is manufactured from high strength aluminum and designed to have a high natural frequency. Years of experience in load cell design enables Bertec to customize all models to suit customers' requirements. Most of the models, for example, can be retrofitted to be waterproof or the sizes of standard models can be modified for specific applications.

Bertec load cells range from simple one-component load transducers to higher end six-component devices, which measure the three orthogonal components of the resultant force acting on the transducer and the three components of the resultant moment in the same orthogonal coordinate system. The point of application of the force and the couple acting on the transducer can be readily calculated from the measured force and moment components.

Bertec load transducers use a state-of-the-art 16-bit digital technology for signal acquisition and conditioning. This new technology makes the use of calibration matrices obsolete, since each transducer comes with the calibration matrix already digitally stored on it. External amplifiers paired with the load cells provide the user with three signal output alternatives: digital, analog, or dual digital/analog outputs. The digital signal output can be directly plugged into the standard USB port of a personal computer without the requirement of an additional PC card for analog-to-digital (A/D) signal conversion. This plug-and-play technology allows a simpler installation procedure in a minimum amount of time. The digital data acquisition software, provided with the digital force transducers as a standard item, enables the user to collect data quickly without the need of additional custom designed software. Upon request, software libraries and device drivers are available from Bertec so that the user can write his/her own digital data acquisition software.

The analog output of the load cells can be fed into an A/D board so that data can be collected using conventional techniques. Depending on the application, signal amplification can be performed for analog output using external amplifiers. External amplifiers are either fixed gain (factory set according to customer requirements) or adjustable gain (seven adjustable gains). These amplifiers enable the user to establish a trade-off between the measurement range and resolution of the force transducers.

DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

Load cell: a Bertec device that measures pressure and movement in different axises.

Center of Pressure (CoP): The point on the surface of a platform through which the ground reaction force acts. It corresponds to the projection of the subject's center of gravity on the platform surface when the subject is motionless.

AM6500: a digital signal converter that connect a load cell to a USB cable.

AM65*xx*: an analog amplifier that connects a load cell to an analog device.

AM6800: a dual output, adjustable gain amplifier that connects a load cell to an analog device or USB cable.

INSTALLATION AND SETUP

All Bertec load cells are pre-assembled in the factory. Therefore, they are ready to be installed and used by mounting as dicated by the usage design, and connecting the cables.

Do not attempt to disassemble the load cell, damage can occur to the transducer components or electronics. The Limited Warranty is void if the load cell or any of the accessories are disassembled without the authorization of Bertec.

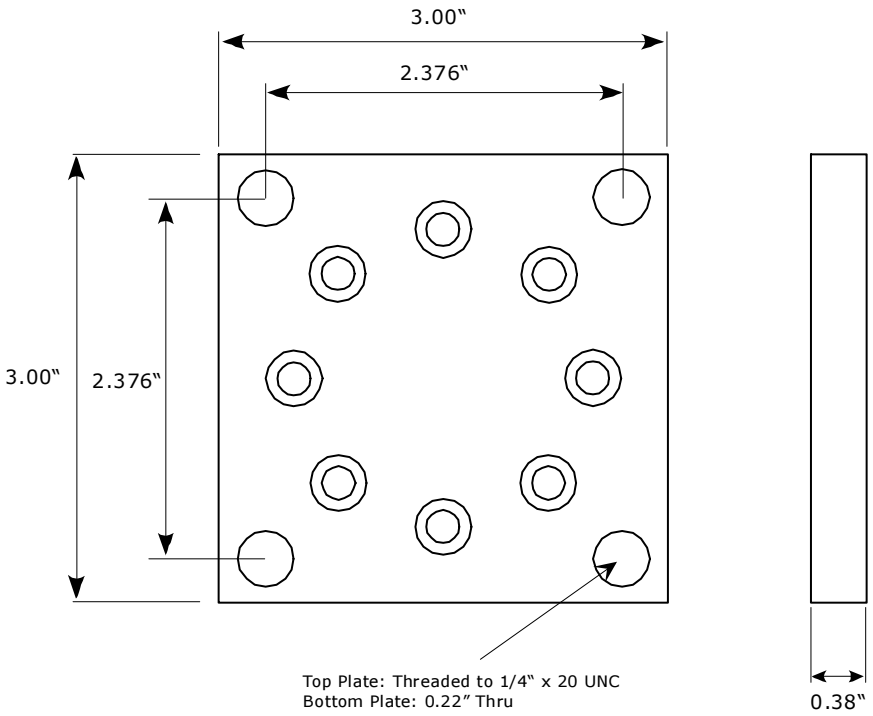
Unsecured cables pose a serious tripping and injury hazard, in addition to possibly damaging the equipment. Make sure that all cables are secured using tie downs, tape, or a cable raceway.

MOUNTING THE LOAD CELL

To obtain a high quality measurement from Bertec load cells, they should be installed in a way that is suitable for the type of measurement to be performed. The floor and structure underneath should be prepared to be as rigid as possible in order to minimize any vibrations. Bertec load cells are very sensitive devices, and they will pick up any vibration coming from the support structure. Overstraining them during installation or while in use might introduce errors into the measurements.

ANCHOR LOCATIONS

Four anchor locations are provided on each square adapter plate (optional, size 3” x 3”) so that the load transducer can be attached to peripheral devices. Top plate anchor locations are threaded to ¼” – 20 UNC, and the bottom plate contains four thru holes for 10 – 24 UNC machine bolts.



Attachment plate anchor locations.

CABLES AND AMPLIFIER CONNECTIONS

After the load cell is mounted, the next step in the installation is making the cable connections with external amplifiers and the computer. The standard output of Bertec load cells is an 8-pin male round receptacle. The standard output cable is 10 m (33') long, has an 8-pin round female connector at the load cell end, and a 9-pin male D-Sub connector at the other end.

To connect the load cell output cable to the load cell:

- Identify the 8-pin female round connector on the load cell output cable.
- Match the keys of the plug and receptacle.
- Push in the connector and rotate (about ¼ turn) clockwise until the two fully engage and lock.

Depending on the configuration of the system, the 9-pin male connector plugs into an external amplifier or signal converter. Analog output from Bertec signal conditioning amplifiers is a standard 15-pin female D-Sub connector. The output of the external amplifier connects to the computer used for data acquisition. For analog outputs an additional A/D signal conversion card on the PC is necessary. Digital output of the amplifiers plugs directly into the USB port of the computer using the USB cable provided with the system. Pin configuration for the analog output is given the ***General Specifications*** section.

Additional analog output cables to connect amplifiers to A/D boards are available from Bertec Corporation. One end of these cables is always a 15-pin male D-Sub connector, which plugs into the amplifier. The other end is manufactured depending on specific customer order (e.g. BNC, bare wire leads, etc.).

The electrical network that is used to supply power to the data acquisition systems and load cells should be properly grounded. Poor grounding is a common source of signal noise in electronic systems. Although all Bertec load cells and amplifiers carry the CE mark of the European Union to ensure high signal quality, improper grounding and external power sources might degrade signal characteristics.

DATA ACQUISITION AND LOAD CALCULATIONS

All Bertec products use a novel 16-bit digital technology for signal acquisition and conditioning. The output signal of the load transducers are already digitized and conditioned in the load cell by using state-of-the-art electronics developed by Bertec Corporation. With this new technology the output signal has a very high signal-to-noise ratio, which means increased sensitivity and accuracy for the load cells. In addition, the digital technology makes the use of calibration matrices obsolete, since each plate comes with the calibration matrix already digitally stored on it. Depending on the configuration, the system provides the user with a digital, analog, or dual digital/analog output.

The digital output of the system is always in the form of calibrated data in their respective units selected by the user (N and N•m, or lb and lb•in). The analog output requires an additional scaling depending on the external amplification used in data acquisition.

ANALOG DATA ACQUISITION

The output of the load cell is in the form of a 16-bit digital signal. External digital-to-analog (D/A) converters are used in order to obtain analog output to be used in conventional data acquisition systems. The D/A converters are also analog amplifiers with either a fixed (65XX series) or adjustable gain (6800 series) setting (for a detailed description of amplifiers please refer to the ***Amplifiers and Signal Converters*** section). The pin configuration for the 15-pin analog output is given in the ***General Specifications*** section.

Before starting to collect data, make sure that the cables from the load cell to the amplifier, and from the amplifier to the PC is properly connected. Power to the amplifier should be connected, and the amplifier should be turned on (in 6800 series only).
The force transducer system reaches thermal stability in about 5 minutes. Therefore, always allow the equipment to warm up at least for 5 minutes before collecting data.

ANALOG AUTO ZERO

All analog amplifiers are equipped with an "*Auto Zero*" button. This button allows zeroing offset loads up to full scale. This functionality can be used to remove tare weight of equipment such as a chair or a step, placed onto the load cell as part of the measurement protocol. When the amplifier is first turned on, of the two green lights next to the *auto zero* button, only the bottom one will be on, confirming that the amplifier is powered. This indicates that zero has not been set yet. Simply press and release the *auto zero* button in order to zero the bridges on the amplifier. When zero is set, both lights next to the *auto zero* button will be on.

For the variable gain 6800 series amplifiers, the *auto zero* button is next to the power switch on the front panel. For the fixed gain amplifiers (65XX series), it is located next to the 15-pin output connector.

Note that auto zeroing sets all channels to near zero. True zeroing should be done by software at the time of data collection, by subtracting a baseline reading from the collected data.

The analog data acquisition procedure can be summarized as follows:

- Check all the cables, and make sure that they are properly connected.
- Turn on the amplifiers and allow the system to warm up at least for 5 minutes.
- For the 6800 series variable gain amplifiers, set a proper gain value for the data channels using the gain switch on the front panel of the amplifier.
- Press the *auto zero* button in order to remove any offset load on the load cell.
- Collect analog data using software. Remember to remove a baseline reading from the signals using software in order to set the signal mean values to true zero.

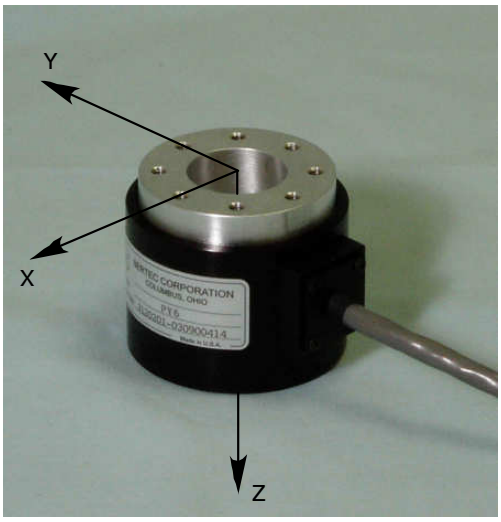
CALCULATING LOAD VALUES

Each load cell is calibrated individually and the calibration matrix is stored digitally in the load cell. Therefore, the analog output from the amplifier provides full-scale calibrated output (±5 V) per rated load range of the attached load cell. The voltage output of each channel is a scaled form of the load in the units of N and N•m for the forces and moments respectively. The scale factor for each channel for a gain of unity is given in the product data sheet supplied with the transducer. The force and moment values are calculated by multiplying the signal values with corresponding scale factors, as given in the following equation:

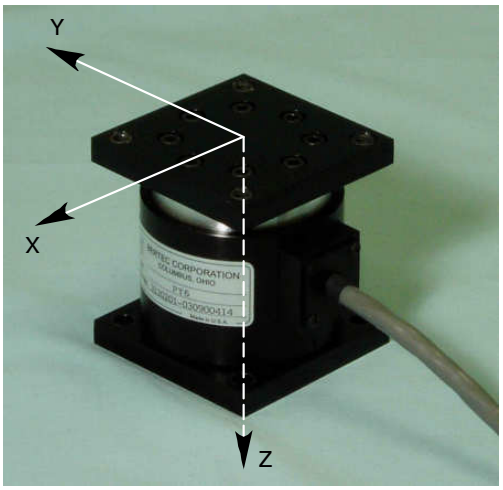
$$F_x = C_1 \cdot S_1$$
$$F_y = C_2 \cdot S_2$$
$$F_z = C_3 \cdot S_3$$
$$M_x = C_4 \cdot S_4$$
$$M_y = C_5 \cdot S_5$$
$$M_z = C_6 \cdot S_6$$

Force and signal scale factors

where, F's and M's are the force and moment components in the force transducer coordinate system (***Coordinate system for load measurements*** figure, next page), and S's are the output signals corresponding to the channels indicated by their subscripts, in volts, divided by the respective channel gain. The origin of the coordinate system is centered on the top surface of the load cell (see ***Coordinate system for load measurements*** and ***Force and Couple equation***, next page). The standard coordinate system is such that the positive y-direction is opposite to the connector end; x-axis is to the left when looking in the y-axis direction; and the z-axis is defined downwards by the right hand rule.



Standard load cell coordinate system for a six-component PY6 transducer without attachment plates. The origin is on the top surface of the upper flange and at the center of the transducer. Positive y-direction is opposite to the connector end; x-axis is to the left when looking in the y-axis; and the z-axis is defined downwards by the right hand rule.



Standard load cell coordinate system for a six-component PY6 transducer with attachment plates. The orientation is the same as above, but the Z origin is on the top surface of the square plate.

CALCULATION OF THE POINT OF APPLICATION OF FORCE AND COUPLE

A load system acting on a load transducer can be completely described by the six load components (i.e. the three force and three moment components) calculated from the ***Force and signal scale factors*** equation. Alternatively, the same information can be given as the three force components, the point of application of the force vector (x_p, y_p), and a couple (sometimes also referred as "torque" or "free moment") acting on the load cell. The point of application of the force and the couple are calculated from the force and moment components as:

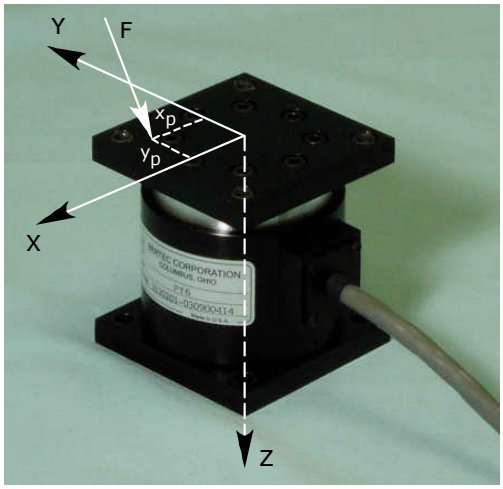
$$x_p = -\frac{M_y}{F_z}$$

$$y_p = \frac{M_x}{F_z}$$

$$T_z = M_z - x_p \cdot F_y + y_p \cdot F_x$$

Force and Couple equation

Where x_p and y_p are the coordinates of the point of application for the force (i.e. center of pressure) on the load transducer, and T_z is the couple acting on the load cell.



Force F and the point of application of the force.

LOAD COMPUTATION EXAMPLE

Consider a case where the external amplifier gain is set to 10 (note that the gain value is always the same for all of the six channels). If, at an instant in time, the amplifier voltage outputs for the six channels are:

CHANNEL	OUTPUT, V
1	-1.450
2	2.235
3	4.765
4	3.095
5	-0.575
6	-1.016

Then, by dividing each output by the corresponding gain, the output signal values to be used in the ***Force and signal scale factors*** equation are obtained:

S_1 = -1.450/10 = -0.145 V

$S_2 = 2.235/10 = 0.2235$ V

$S_3 = 4.765/10 = 0.4765$ V

$S_4 = 3.095/10 = 0.3095$ V

$S_5 = -0.575/10 = -0.0575$ V

$S_6 = -1.016/10 = -0.1016$ V

Let us use hypothetical scale factors, in N/V and N•m/V [1]:

$C_1 = 1000$ N/V

$C_2 = 1000$ N/V

$C_3 = 1500$ N/V

$C_4 = 300$ N•m/V

$C_5 = 300$ N•m/V

$C_6 = 250$ N•m/V

Then from the ***Force and signal scale factors*** equation:

$F_x = 1000 \bullet (-0.145) = -145.0$ N

$F_y = 1000 \bullet (0.2235) = 223.5$ N

$F_z = 1500 \bullet (0.4765) = 714.8$ N

$M_x = 300 \bullet (0.3095) = 92.9$ N•m

$M_y = 300 \bullet (-0.0575) = -17.3$ N•m

$M_z = 250 \bullet (-0.1016) = 25.4$ N•m

To calculate the point of application of the force, the ***Force and Couple equation*** is used:

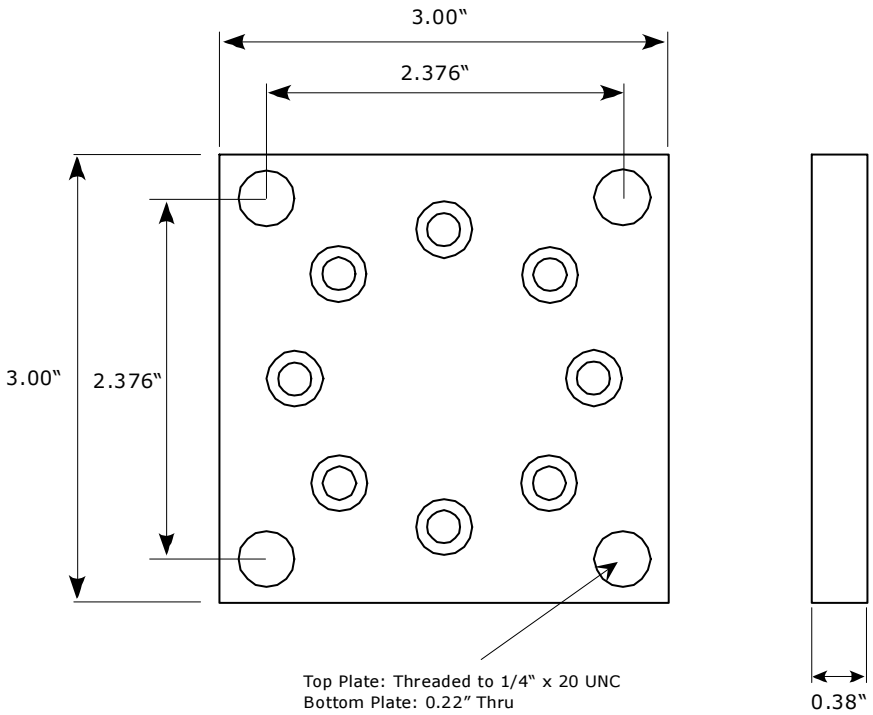
$$x_p = \frac{17.3}{714.8} = 0.024 \text{ m}$$

$$y_p = \frac{9.3}{714.8} = 0.013 \text{ m}$$

[1] Note that if the results are needed in English Units, an alternative to converting them at the end of calculations is to convert the scale factors to English Units by converting the first three factors from N/V to lb/V, and the last three factors from N•m/V to ft•lb/V. This can be done by multiplying the first three scale factors by 0.2248 lb/N, and last three scale factors by 0.7376 (ft•lb)/(N•m).

ANCHOR LOCATIONS

Four anchor locations are provided on each square adapter plate (optional, size 3” x 3”) so that the load transducer can be attached to peripheral devices. Top plate anchor locations are threaded to ¼” – 20 UNC, and the bottom plate contains four thru holes for 10 – 24 UNC machine bolts.



Attachment plate anchor locations.
Top plate has four holes tapped to ¼” x 20 UNC and bottom plate has 4 thru holes for 10 x 24 UNC.

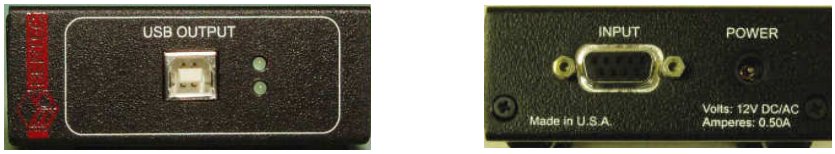
AMPLIFIERS AND SIGNAL CONVERTERS

Signal conditioning and amplification for the load cells are provided by means of external amplifiers. Each load cell has an internal digital preamplifier, which digitizes the analog signal from the transducer strain gauges, and conditions it through oversampling, preliminary amplification, and filtering. The calibration matrix of the load cell is digitally stored on the preamplifier so that the output is already calibrated data having the units of Newtons and Newton-meters. The output of the load cell is a 16-bit digital signal using RS-485 format.

AM6500 DIGITAL SIGNAL CONVERTER

AM6500 Signal Converter

The AM6500 series external converter is used to collect data through the USB port of the computer. The input-output connections for the AM6500 module are shown in the figure below. The output is a standard B-type USB connector. Next to the connector are two LED lights. The lower light is on when the unit is powered, and the upper light comes on if the unit is connected to the USB port of the computer. The input to the module is via a 9-pin D-Sub connector located at the back of the unit located next to the power input. An external, universal power supply is used to provide power to the amplifier.



AM6500 Digital Signal Converter connections

AM6501/AM6504 ANALOG AMPLIFIER

AM65xx analog amplifier

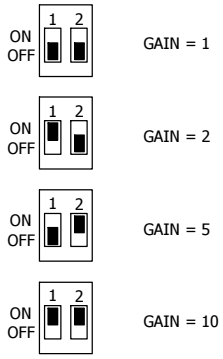
The **AM65XX** series external analog amplifiers are utilized to convert the digital output of the load cells to an analog signal using a **fixed** or **variable** gain value. The number of gain values is indicated by the suffix XX in the model identifier (i.e. 6501 – unity gain, 6504 – gain of four, etc.). These amplifiers also provide an *auto zero* button to remove tare load offset. An external, universal power supply is used to provide power to the amplifier.

The input and output connections to the AM65XX modules are shown in the figure below. The pin assignments for the analog output channels are shown in the ***General Specification*** section. The output voltage range for all channels is ±5V. Shorting pins 9 and 10 on the 15-pin output connector has the same effect as pushing the *autozero* button.

AM65XX series connections

The lower light is on when the unit is powered. A blinking LED indicates that the unit is not connected to a load cell. If the LED is blinking, check all the cable connections to the load cell.

The AM6504 has two additional dipswitches on the top surface to set the gain for the output signal. Each switch has an ON/OFF setting. The gains corresponding to each setting are given below:



Gain switch settings for the AM6504

AM6800 DUAL OUTPUT, ADJUSTABLE GAIN AMPLIFIER

AM6800 Dual output adjustable gain amplifier

The **AM6800** amplifier incorporates both analog and digital outputs into one unit. The gain of the analog output is user selectable, and has 7 different settings (1, 2, 5, 10, 20, 50, 100). A single gain selection switch is provided for all 6 output channels. A three-digit LED display on the front panel shows the current gain setting. The channel signal indicators show the polarity of the analog output for the six load cell channels. The *auto zero* button is utilized to remove tare load offset from each channel output. The mains power input is a universal input with the range 100-240 V, 50-60 Hz. The digital output is a USB signal.

If the unit is not connected to a load cell, the digital display will read "**PLA**" or "**PL7**". After the load cell is properly connected to the unit, when the amplifier is turned on, the display will briefly (about 0.5 sec.) show the message "**CAL**", which indicates that the amplifier has successfully recognized the load cell. Finally, the gain setting will display on the digital readout. The pin assignments for the analog output channels are shown in the ***General Specification*** section.

A 19" rack mounting adaptor for AM6800 is available upon request from Bertec Corporation.

AM6800 amplifier

On the front panel of the AM6800 amplifier, the two lights between the auto zero button and power switch, the bottom one comes on when the unit is switched on, and the top light is lit after the auto zero button is pressed.

The input and output to the unit is through 9-pin and 15-pin female D-Sub connectors respectively.

GENERAL SPECIFICATIONS

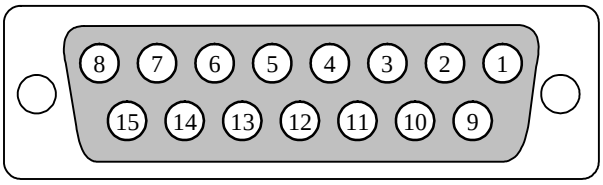
The AM65XX series and AM6800 amplifiers provide a ±5 V full-scale calibrated analog output per rated load range for each of the six load cell channels. For example, if the load cell has a ±10 kN load range for the Fz channel, then for a gain of unity, the –5.00 V output corresponds to –10 kN, and +5.00 V stands for +10 kN (i.e. a sensitivity of 0.5 mV/N). The analog gain used in data acquisition represents a trade-off between maximum load range and load cell sensitivity. If the same load cell above is used with an amplifier gain of 5, then the load range will be limited to ±2 kN. This means the plate now has an increased sensitivity of 2.5 mV/N. The analog load scale factors for specific load cells, given on the product data sheet supplied with the load cell, are specified for a gain of one.

The analog output signals are filtered so that they have a standard bandwidth of 500 Hz. The actual analog gain ratios are applied to the digital signal with an accuracy of 99.997%.

The *auto zero* button removes the signal offset and sets the analog output signal within ±5 mV. This feature can be used to increase the useful measurement range of the load cell by shifting the signal baseline. Note that *auto zero* might not set the mean value of the signal to true zero. Therefore, an additional offset removal through software is suggested.

The digital input to all external amplifiers and signal converters is a female 9-pin D-Sub connector, whereas the analog output is in the form of a female 15-pin D-Sub connector with the pin assignments shown below. Shorting pins 9 and 10 has the same effect as pushing the autozero button on the AM6501 and AM6800.

The output range for each channel is ±5V.



CH1 : Pin 3
CH2 : Pin 4
CH3 : Pin 5
CH4 : Pin 6
CH5 : Pin 7
CH6 : Pin 8
GRND : Pin 10
Autozero: Pin 9

Pin configuration for the standard analog 15-pin connector

TROUBLESHOOTING

Problem: the data capture program is not capturing data

Solution: make sure that all cables are connected and that power is supplied. For USB devices, make sure that the current drivers are installed. For analog devices, make sure that all software for them are set up correctly – you may need to contact the analog vendor or Bertec Technical Support for further resolution.

Problem: the Bertec device reads incorrect data, such as too much weight on the plate

Solution: if using a hardware zero capable device, remove all weight from the device and press the *auto zero* button. For some data capture applications, you will need to compute a zero baseline and normalize against that.

For any other issues, please contact Bertec Technical Support.

CUSTOMER SUPPORT

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Suggestions or comments about Bertec products are always welcomed.

DOCUMENT REVISION HISTORY

Date	Revision	Description	Author
09/10/2010	1.00	Initial Revision	Todd Wilson
03/27/2011	1.01	Updated layout	Todd Wilson