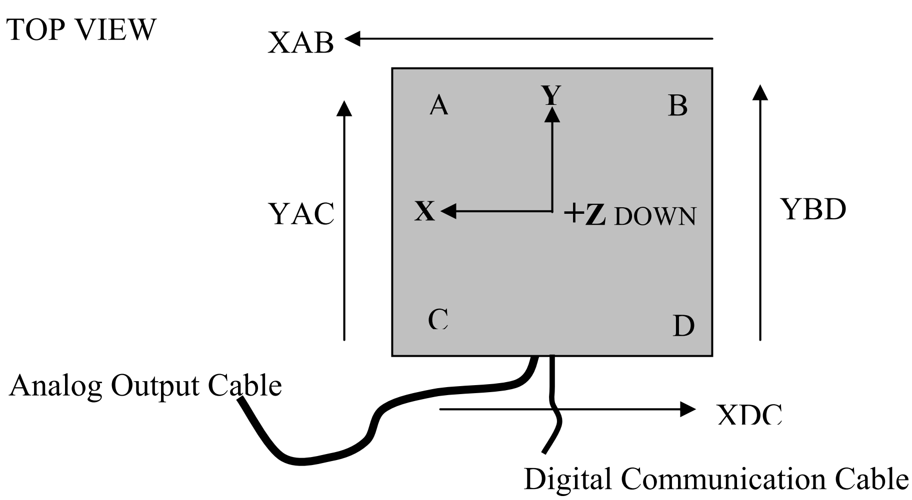
Appendix A: AMTI Hall-Effect Sensor Force Plate 8-Channel Analog Interface

This document describes how to calculate the force and moment output of an AMTI Hall-effect force plate, using the 8-channel analog output. This document is applicable to AMTI's AccuSway^{Plus}, AccuGait, HE6x6, and other AMTI Hall-Effect based force plates with analog voltage outputs.

Description

The Hall-Effect force plate is a ground reaction measurement device. The force plate has three Hall-Effect sensors (X, Y, and Z) in each of the four corners. The eight analog voltage output signals are directly related to the four Z sensor readings in each corner, along with two X channels and two Y channels. This 8-channel convention is also used by some other force plate manufacturers. Note that the Z analog output is negative down for each corner, and the XDC channel is opposite the global sign convention. For this reason, there will be negative values in the calibration matrix. The global sign convention is given in bold print in the figure below.



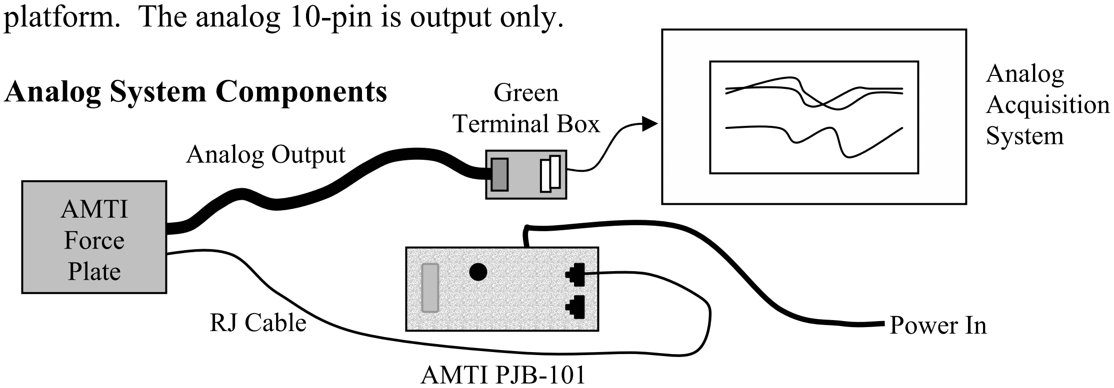
Each force plate is calibrated at AMTI for both digital and analog outputs. The results of the analog calibration are the force and moment sensitivities given in a 6 x 8 element array. The name of this file is Analogxxxx.ACL, where xxxx represents the force plate serial number.

Setup

A 10-pin connector is used for the analog signal outputs. It is intended to be connected (via the green terminal box) to the users analog data acquisition system, such as a multi-channel voltmeter or analog to digital (A/D) converter commonly installed in personal computers. If you require BNC output connectors please contact us and we can provide you with the correct cable.

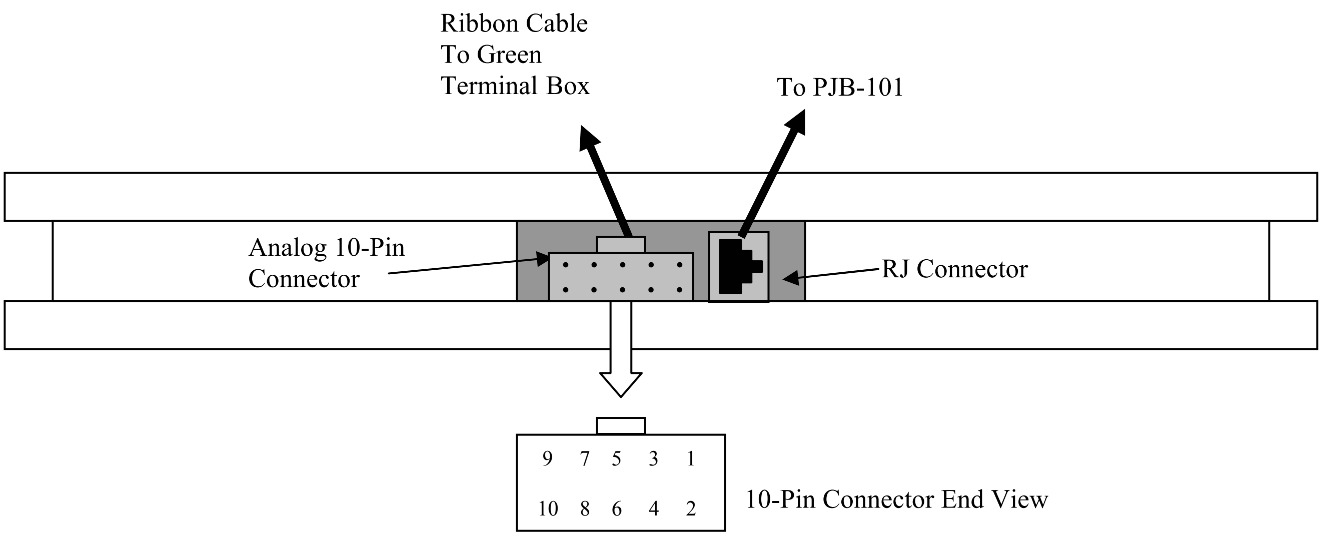
The force plate is normally controlled by the RJ "telephone style" cable when connected to a digital acquisition system. This cable transmits and receives commands to the platform. The analog 10-pin is output only.

Analog System Components



AMTI's PJB-101 allows use of the force plate without any connection to an RS-232 control system. The user must connect the PJB-101 to the force plate with the RJ cable, and provide power through the PJB-101. The ZERO button must be pressed manually after the force plate warms up to initiate the autozero routine. Two power supplies are required to operate two force plates through a PJB-101. The analog output will connect to the green terminal box, which provides outputs via screw terminals. If you require outputs via BNC connectors please contact us and we can provide you with the correct cable.

Side View of AccuGait & AccuSway^{Plus} Force Plate



Analog Voltage Signals and Filtering

When the force plate is powered, eight voltage signals are always present at the 10-pin output connector. These signals are always filtered by a primary 200Hz low-pass, two-pole filter.

Analog Signal Connector Pin-Out for AccuGait & AccuSway^{Plus}

PIN Number	Description	Shorthand Notation
1	Z output from corner C	Cz
2	Z output from corner D	Dz
3	Z output from corner A	Az
4	Z output from corner B	Bz
5	Y output from A and C combined	YAC
6	X output from D and C combined	XDC
7	X output from A and B combined	XAB
8	Y output from B and D combined	YBD
9	Signal reference ground	SGND
10	Chassis ground	GNS

These pin numbers directly correlate to the screw terminal outputs on the green terminal box as well. If you request a cable with BNC outputs the outputs will be labeled.

Voltage Signal Output

Units before Serial Number 0232

After pressing the ZERO button on the PJB-101, or sending the autozero command digitally, all eight analog channels should be at a nominal value of 2.5 volts. It is recommended to acquire and save this voltage to tare out each channel. After tare, each channel should be 0.0 Volts when unloaded. The full-scale voltage output is then +/-2.5 Volts from this normalized zero value. By normalizing the analog voltage channels to zero, the correct sign convention will result.

Units after and including Serial Number 0232

The analog output range of these later units is ±10.0 Volts with auto zeroed values of approximately 0 volts. Although these near zero values are quite small, it is still recommended that these small values be used for the software tare on the outputs.

Using the Analog Calibration Matrix to Calculate Force and Moment Output.

As described previously, there are eight analog channels which should be normalized to 0.0 Volts. To normalize each channel, subtract the acquired unloaded value (2.5 Volts nominal for SN before 0232; 0 Volts nominal for SN after and including 0232) from each force plate output signal. Let Table 1 represent the analog voltage values after auto zero:

Table 1.

Cz	Dz	Az	Bz	YAC	XDC	XAB	YBD

Example: Cz = 2.49V, Dz = 2.55V, etc… (newer models: Cz = -.010, Dz = .050, etc…)

When the force plate is unloaded, collect and save the offset value for each channel.

Table 2.

Czoff	Dzoff	Azoff	Bzoff	YACoff	XDCoff	XABoff	YBDoff

Example: Czoff = 2.49V, Dzoff = 2.55V, etc… (Czoff = -.010, Dzoff = .050, etc…)

Acquire the data set from the desired event. Subtract the offset values in Table 2 from the acquired event data. Let Table 3 represent one row of the "offset corrected" acquired data.

Example Acquired Event Data: Cz = 2.89V, Dz = 1.02V (Cz = 0.41V, Dz = -1.58V)

Table 3.

ΔCz	ΔDz	ΔAz	ΔBz	ΔYAC	ΔXDC	ΔXAB	ΔYBD

Example: ΔCz = Cz event data - Czoff = 2.89 - 2.49 = 0.40V (0.41-ˉ0.01= 0.40V)
ΔDz = Dz event data - Dzoff = 1.02 - 2.55 = -1.53V (-1.48-0.05 = -1.53V)

Let Table 4 represent the force plate calibration matrix Analogxxxx.acl, as provided to the customer on CD, where xxxx is the platform serial number. The engineering units of the calibration matrix are pounds / volt or inch-pounds / volt.

Table 4.

S11	S12	S13	S14	S15	S16	S17	S18
S21	S22	S23	S24	S25	S26	S27	S28
S31	S32	S33	S34	S35	S36	S37	S38
S41	S42	S43	S44	S45	S46	S47	S48
S51	S52	S53	S54	S55	S56	S57	S58
S61	S62	S63	S64	S65	S66	S67	S68

To calculate the force and moment values, multiply each of the readings in Table 3 by each row of the calibration matrix in Table 4. Then sum the product of each row. The equations for the 6 orthogonal force and moment calculations are given here:

Force Calculations:

Fx = $(\Delta Cz * S11) + (\Delta Dz * S12) + (\Delta Az * S13) + (\Delta Bz * S14)$
$+ (\Delta YAC * S15) + (\Delta XDC * S16) + (\Delta XAB * S17) + (\Delta YBD * S18)$ Lbs

Fy = $(\Delta Cz * S21) + (\Delta Dz * S22) + (\Delta Az * S23) + (\Delta Bz * S24)$
$+ (\Delta YAC * S25) + (\Delta XDC * S26) + (\Delta XAB * S27) + (\Delta YBD * S28)$ Lbs

Fz = $(\Delta Cz * S31) + (\Delta Dz * S32) + (\Delta Az * S33) + (\Delta Bz * S34)$
$+ (\Delta YAC * S35) + (\Delta XDC * S36) + (\Delta XAB * S37) + (\Delta YBD * S38)$ Lbs

Moment Calculations:

Mx = $(\Delta Cz * S41) + (\Delta Dz * S42) + (\Delta Az * S43) + (\Delta Bz * S44)$
$+ (\Delta YAC * S45) + (\Delta XDC * S46) + (\Delta XAB * S47) + (\Delta YBD * S48)$ inch-Lbs

My = $(\Delta Cz * S51) + (\Delta Dz * S52) + (\Delta Az * S53) + (\Delta Bz * S54)$
$+ (\Delta YAC * S55) + (\Delta XDC * S56) + (\Delta XAB * S57) + (\Delta YBD * S58)$ inch-Lbs

Mz = $(\Delta Cz * S61) + (\Delta Dz * S62) + (\Delta Az * S63) + (\Delta Bz * S64)$
$+ (\Delta YAC * S65) + (\Delta XDC * S66) + (\Delta XAB * S67) + (\Delta YBD * S68)$ inch-Lbs

Customer Support

AMTI provides customer support for all products at no charge to the customer. For assistance with the use of the analog voltage signals or calculations, please contact support at support@amtimail.com.