MSA-6 MiniAmp: Strain Gage Amplifier

Instruction Manual

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1.0 General Description

The AMTI MSA-6 instrument is a six channel strain gage amplifier designed for use with AMTI biomechanics force platforms, multi-component force/torque sensors or other suitable strain gage devices. It is a cost effective, compact instrument suitable for high resolution measurements. It comes in a sturdy case that can be used on a desk top, singly rack mounted using an optional bracket, or a pair can be mounted side by side taking up only one 1.75 inch (4.45 cm) high slot.

The MSA-6 features easy bridge balancing using a single push button auto zero located on the front panel. The MSA-6 features 1000 Hz low-pass fixed filters and jumper selectable gains and excitation voltages for each channel. Both gains and excitation voltages can be individually set for each channel. The MSA-6 has both analog and digital capability. In the analog mode the output signal is rated up to +/- 10 Volts and is suitable for input into an A/D converter or other device. In the digital mode the output consists of an RS-232 serial connection. A serial to USB converter can be purchased separately if a USB output is desired. Amplifier inputs and outputs are conveniently provided through single connectors located in the back of the case. One additional feature included with the MSA-6 is the ability to send a synchronization signal into the RS-232 port.

The amplifier is designed primarily for use with a computer aided data acquisition system and requires very little user interaction. Specifications for the MSA-6 are provided in Table 1. The following sections are designed to familiarize the user with the MSA-6 and help them get started quickly. Figure 1 shows a picture of the components shipped as part of the MSA-6 system. These include the amplifier, a power supply, and brackets to allow panel mounting of the amplifier. The manual describes the features of the MSA-6 as well as the installation and set up.

Table 1: MSA-6 Specifications

Inputs: Six four-arm Wheatstone Bridges (350 ohm minimum)

Bridge
Excitation: 2.5VDC, 5VDC, or 10VDC. Each channel is jumper selectable.

Gain: 1000, 2000, and 4000. Each channel is jumper selectable.

Auto-Zero: Single Push Button Front Panel Balancing[1]

Filter: Two pole low-pass 1000 Hz filter

Output: +/- 10VDC into a minimum 10K ohm load

Speed (Data sets per second): SN 6394 and higher

Digital Mode with RS232: 50, 60, 100, 120, or 200
Digital Mode with USB: 50, 60, 100, 120, 200, 240, 300, 400, 500, 600, 1000, 1200 (Software selectable)

Connectors:
RS 232 – DB9S **(The RS-232 output cable to the computer should be wired straight through pin-to-pin)**
SYNC. – RCA Phono
PWR. – 2.1 mm Power Jack
ANALOG OUTPUT – DB25S or Equivalent
TRANSDUCER INPUT – Souriau 851-02E16-26S50-44

Environmental Conditions: 0 to 125 deg F (-18 to 52 deg. C); 0-70% RH; Indoor/Laboratory Environment

Power Supply: Furnished with 15 VDC external supply rated at .3 amps requiring 110-250 VAC 50/60 Hz input.

Power requirements: 15 VDC @ .3 amps.

Weight: 4.75 lb. (2.2 kg)

Dimensions: 8.5 in (21.6 cm) wide x 10.25 in (26.0 cm) deep x 1.72 in (4.37cm) high

RoHS compliant

[1] This is a “coarse” correction that results in a zero of less than 1% of full scale.

Figure 1: MSA-6 MiniAmp System

2.0 MSA-6 Operating Controls

The front panel of the MSA-6 is shown in Figure 2. The front panel contains two switches, the Power switch and the Zero push button. The Power switch simply turns on or off the power to the amplifier. A green LED indicates when the power is on. The Zero push button is a momentary type switch that is used to automatically balance and zero the six amplifier channels. The back panel, shown in Figure 3 includes five connectors. Their functions are described below:

RS 232 This is the conventional digital 9-pin RS 232 connection.

SYNC This connector provides a means to send a signal to the computer via the RS 232 cable to mark an event. It requires software in the computer with which to communicate. It is only functional in the Digital mode.

PWR This is the connection for the 15 VDC power supply furnished with the MSA-6.

Analog Output This DB25S connector provides access to the +/- 10VDC analog outputs.

Transducer Input The output cable from the force sensor or platform is connected to here.

An electrical schematic of the MSA-6 is provided in Appendix A. This diagram includes all of the circuitry of the amplifier. The pin details of all the connectors are also included in a separate diagram located in Appendix A.

Symbols

CE The CE mark is a declaration that the MSA-6 amplifier has passed the requirement of EN-61010 including Safety, Emissions, and Immunity.

$\boxed{!}$

Triangle ! This symbol indicates that the user is responsible for reading and understanding the documentation before using the MSA-6.

This symbol indicates the power input is DC.

Figure 2: Front Panel

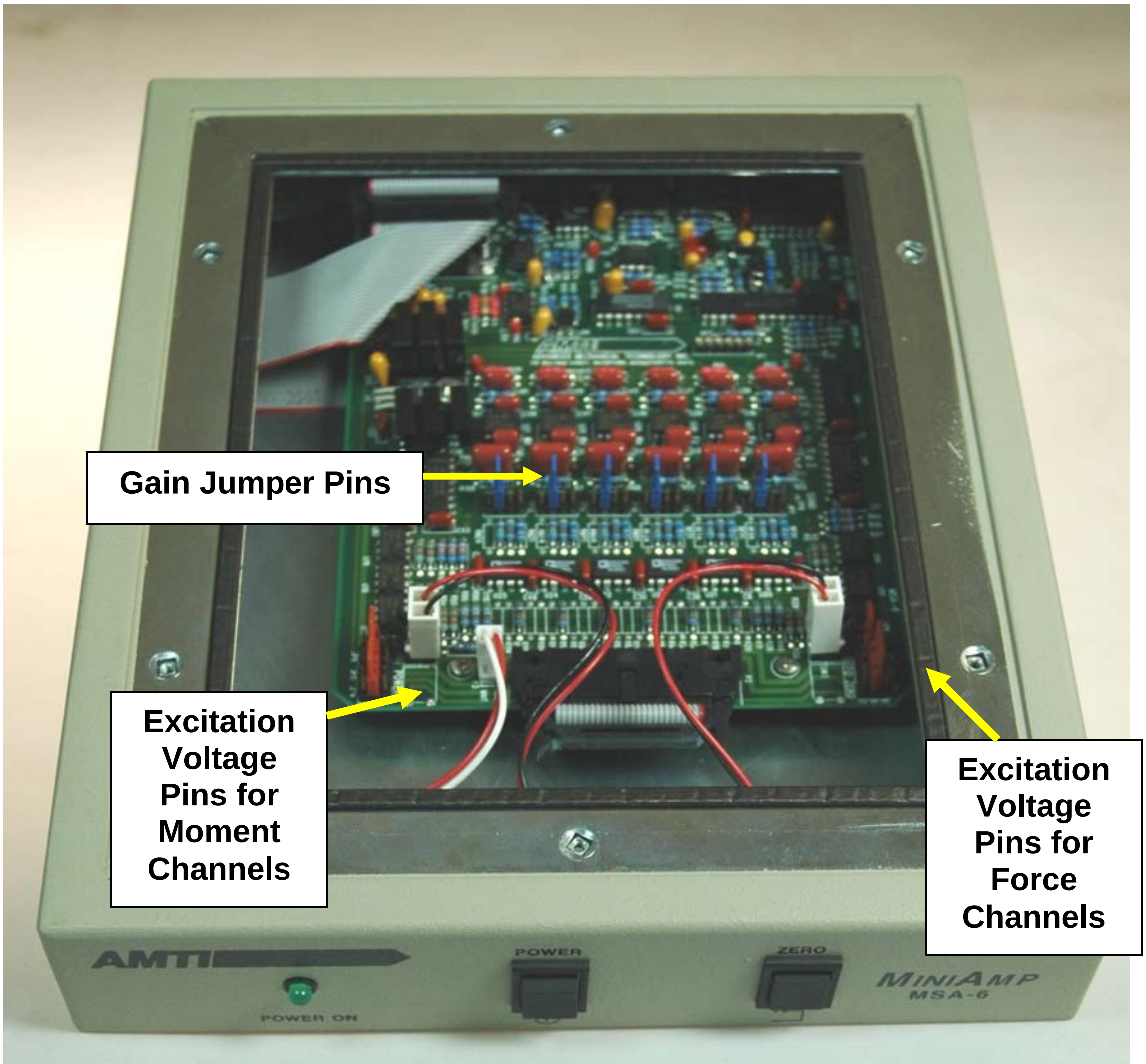
Figure 3: Rear Panel

3.0 Gain and Excitation Voltage

3.1 Setting the Gain and Excitation Voltage:

This section describes the method of setting the gain and excitation voltage. The first step is to remove the top cover of the MSA-6. This is simply done by removing the six screws holding down the cover. The MSA-6 with the cover removed is shown in Figure 4.

Figure 4: MSA-6 With Top cover removed



The location of the jumpers can now be seen. (While the board is not overly sensitive, before touching the board, the user should ground himself by touching the metal case of a grounded piece of equipment such as a desktop PC). The six sets of gain jumper pins are located in the center of the board. With the front panel facing the user, the excitation jumper pins for the force channels are located on the lower right corner of the board and the jumper pins for moment channels in the lower left corner of the board. The jumpers are shown in detail in Figures 5 & 6, however, the pin designations are also given here:

Pin	Function	Channel
JP1	Excitation Voltage	Fx
JP2	Excitation Voltage	Fy
JP3	Excitation Voltage	Fz
JP4	Excitation Voltage	Mx
JP5	Excitation Voltage	My
JP6	Excitation Voltage	Mz
JP7	Gain	Fx
JP8	Gain	Fy
JP9	Gain	Fz
JP10	Gain	Mx
JP11	Gain	My
JP12	Gain	Mz

Three gain options for each channel are shown in Figure 5. The jumper pins for the six channels Fx, Fy, Fz, Mx, My, and Mz are marked and go from right to left in the figure. The user simply places the jumper across the pins marked 1K, 2K, or 4K to select gains of 1,000, 2,000, or 4,000 respectively. **Only one jumper per channel should be used for gain selection.**

The procedure for selecting excitation voltage is similar to that for the gain. A jumper is placed across the pins corresponding to the excitation voltage desired. Figure 6 shows the excitation voltage pin locations for the Fx, Fy, Fz, Mx, My, and Mz force and moment channels. The pins for an excitation voltage of 2.5 VDC are the pair farthest to the left, the 5 VDC pair are in the middle and the 10 VDC pair are farthest to the right. **Only one jumper per channel should be used for excitation voltage selection.**

Figure 5: Gain Setting Options

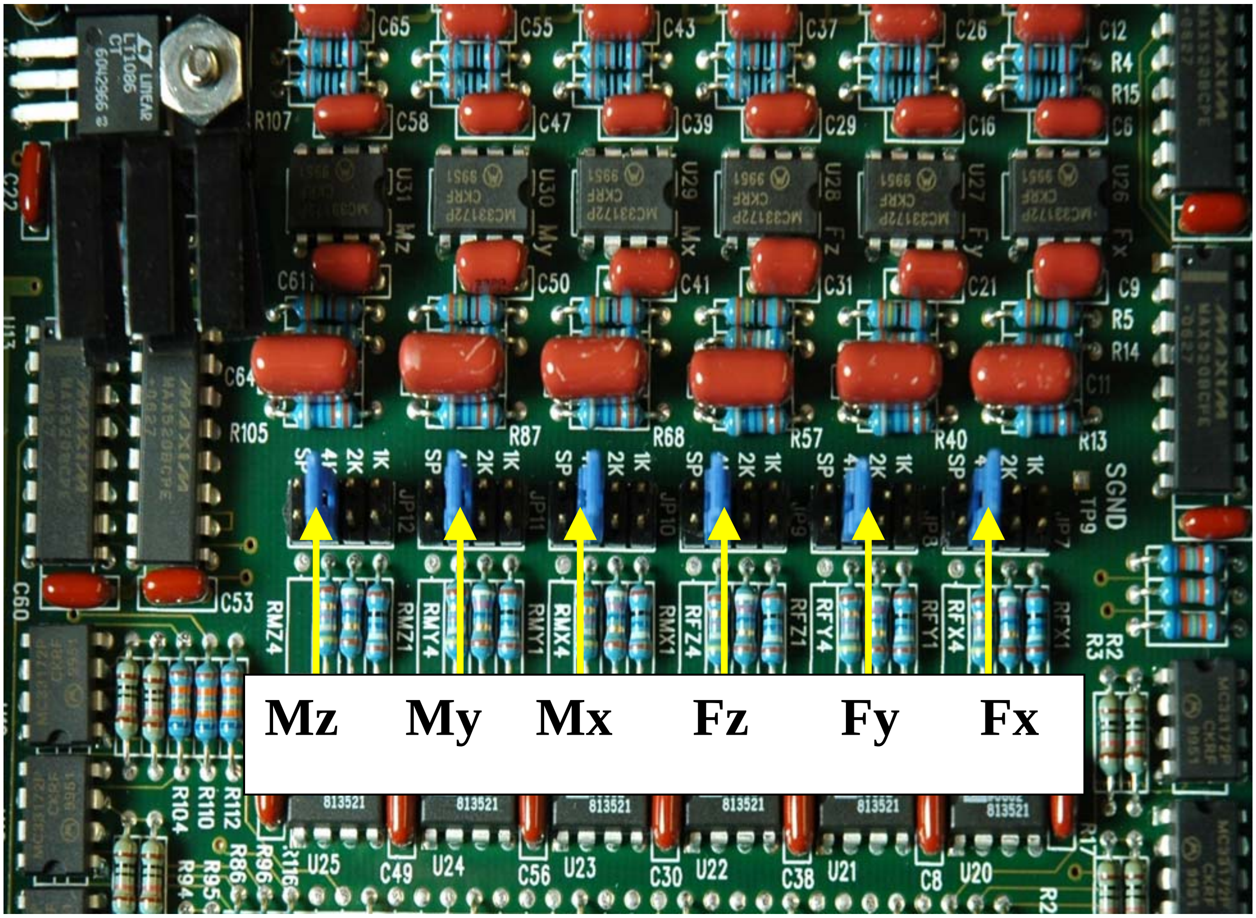
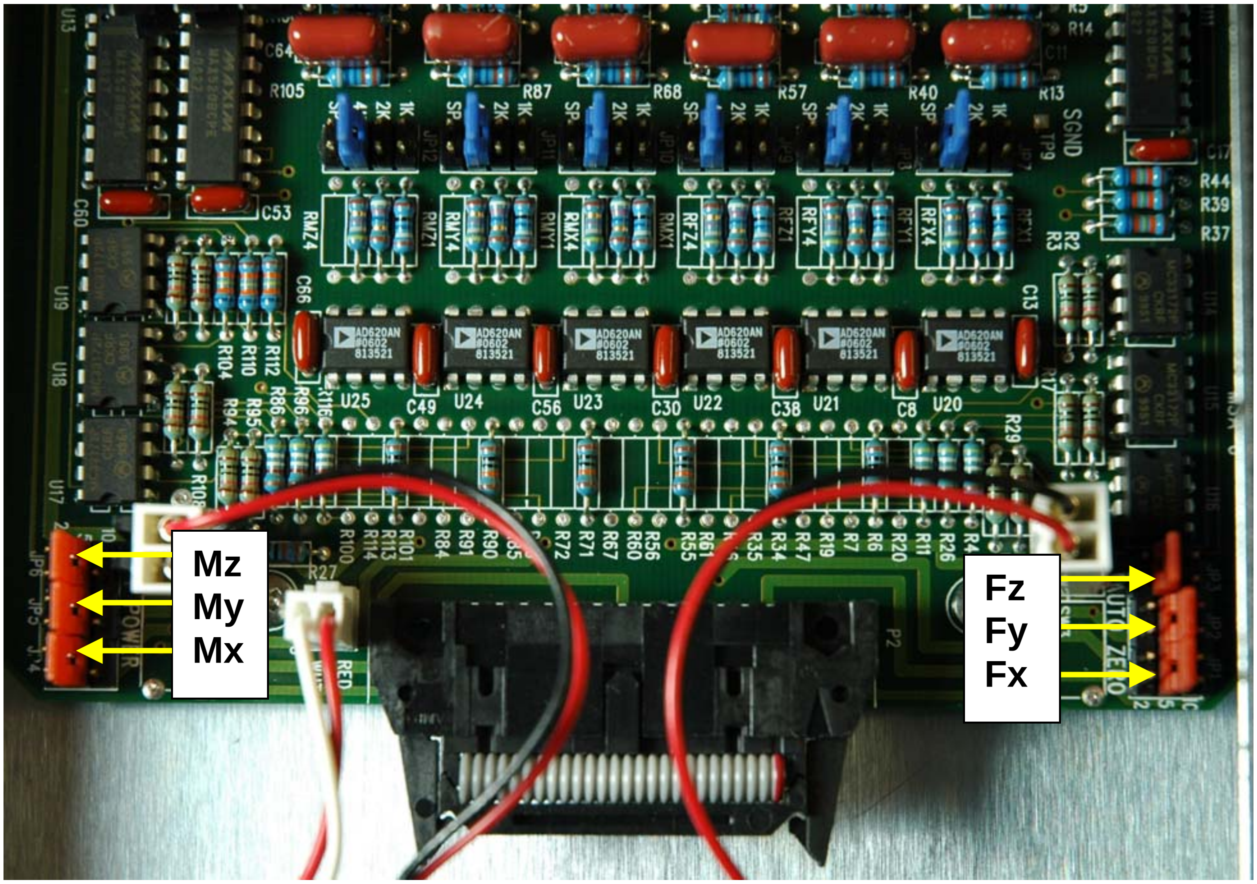


Figure 6: Excitation Voltage Jumper Pin Locations



3.2 Determining Gain and Excitation Voltage Settings

<u>Analog Mode</u>

The objective in determining gain and excitation voltage is to set the output of the amplifier close to the maximum dynamic range of the force or moment. This allows the user to get the greatest range and accuracy from the sensor. The maximum output for the analog system is +/- 10 VDC. Ideally if the test load maximum is 2000 lb (9000 Newtons) then the target output should be 10 VDC at 2000 lb. In practice it is best to leave a margin between the maximum output and maximum load to avoid saturating the output.[2] The MSA-6 output voltage when fully saturated is 11.5 VDC**.** **<u>Non-linear performance occurs at outputs above 10 VDC.</u>**

When the user attempts to maximize the output signal by adjusting the excitation voltage and gain, it is better to increase the excitation voltage before increasing the gain (or decrease the gain before decreasing the excitation voltage) in order to minimize system noise. The equation relating load, output, gain, sensitivity and excitation voltage is:

$$V = F \times G \times Vexc \times Sens(Load) \times 10^{-6} \qquad \text{Eq. 3.1}$$

Or

$$V = M \times G \times Vexc \times Sens(Moment)\ 10^{-6} \qquad \text{Eq. 3.2}$$

Where:

V – Output Voltage (Maximum Value is 10 VDC)
F - Load to be Measured. lb (Newtons)
M – Moment to be measured. In-lb (N-m)
G - Gain
Vexc. – Excitation Voltage VDC
Sens(Load) - Sensitivity in micro-Volts/(Vexc-lb) or micro-Volts/(Vexc-N)
Sens(Moment) – Sensitivity in micro-Volts/(Vexc-in-lb) or micro-Volts/(Vexc-N-m)

Following is an illustrative example:

Assume you have purchased a sensor with a 2000 lb (9000 Newton) capacity in the Fz direction and the Fz sensitivity[3] is 0.38 microvolt/Vexc-lb. We will now calculate the preferred gain and excitation for tests of 2000 lb (9000 N), 1000 lb (4500 N), and 500 lb (2270 N).

Using the Equation 3.1 for calculating output, we find that only one set of conditions works for a 2000 lb (9000 N) load. An excitation voltage of 10 VDC and a gain of 1000 results in an output voltage of 7.6 volts. Higher gains result in outputs greater than 10 volts.[4]

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[2] This term refers to reaching the 10 VDC output ceiling before the measured value is attained.
[3] The actual calibrated force and moment sensitivities of the sensor are included on data sheets shipped with the force sensor that was purchased. The values found in AMTI's brochures are nominal values.
[4] If you find that you cannot measure a load below the full load capacity of your sensor, it most likely that your gain and/or your excitation voltage is set too high.

If we are running tests at 1000 lb with the same sensor, we find that an excitation voltage/gain pairs of 10VDC/2000 and of 5VDC/4000 both result in output voltages of 7.6 volts. The best choice would be to use the higher excitation voltage (10VDC) with the lower gain (2000) to minimize noise. Lastly, a test with a 500 lb load would require using a gain of 4000 with an excitation voltage of 10 VDC for a 7.6 volt output.

This would be a good time to introduce the concepts of amplifier calibration and excitation voltage correction for lead wire voltage drop. Every amplifier is shipped with a calibration sheet similar to that in Table 2 (this is a sample, the actual calibration sheet for the amplifier belonging to this manual is colored yellow and can be found in the binder shipped with your order). Actual gains do not correspond exactly to the nominal gains. Each amplifier is tested with a precision voltmeter and calibration bridge. In this way the actual calibrated gain of each channel is obtained. For example, the Fz channel of the amplifier illustrated in Table 2 shows gains of 3959.9, 1985.6, and 983.6 corresponding to nominal values of 4000, 2000, and 1000. The precise excitation voltages at the amplifier/transducer connector are also given in Table 2. These are 2.499 VDC, 5.005 VDC, and 10.003 VDC corresponding to nominal values of 2.5 VDC, 5 VDC, and 10 VDC respectively

The cable between the transducer and the amplifier should also be corrected for line loss. The bottom table of the calibration sheet gives the excitation voltage loss as a function of excitation voltage and bridge resistance. The bridge resistance of your sensor is included in the sensor manual or in AMTI's brochure and data sheets. For the 2000 lb sensor (Bridge resistance of 350 ohms), at an excitation of 10 VDC, the voltage loss is 3.707 mV/ft. Assuming a 30 ft cable, the excitation voltage has a drop of .111 volts resulting in a corrected excitation voltage of 9.892 Vdc (10.003-.111).

Returning to the example above, the calibrated gain value and the corrected excitation voltage should be used rather than the nominal ones. In the calculation for the 2000 lb sensor load with a sensitivity of 0.38 microvolts/Vexc-lb, the Fz channel gain is 983.6 and the excitation voltage 9.892. The output for a 2000 lb load would now be 7.395 VDC not the 7.6 calculated earlier.

Digital Mode

For the digital mode the user adds one step to the calculation done above. On the calibration sheet shown in Table 2, conversion factors (A/D Conv.) in millivolts per bit (mV/bit) are given for all the channels. For example, for the Fz channel, the conversion is 4.897 mV/bit. To convert the output voltage (7.395 VDC) of the 2000 lb calculation above into bits, use the following calculation:

Bits = Output Voltage (V) x 1000 mV/V divided by mV/bit

Or

1510 = (7.395 V x 1000mV/V)/4.897 mV/Bit

Table 2: Sample Calibration Sheet

Model: **MSA-6** uP Checksum: 4Fbb 57.6 kbaud
SN: **6335** Recorded by: ECV
Date: **6/16/06** DVM Used: 36073227
CBX Used: 1199

Excitation Volts:	Nominal	Actual
	2.50	2.501
	5.00	4.995
	10.00	10.006

Channel	Nominal	Gains	Channel	Nominal	Gains
FX	4000	3949.5	MX	4000	3963.5
	2000	1982		2000	1979.8
	1000	995.1		1000	992.9
	A/D conv factor	4.901 mV/bit		A/D conv factor	4.903 mV/bit
FY	4000	3969.5	MY	4000	3961.9
	2000	1987		2000	1976.2
	1000	991.3		1000	989.4
	A/D conv factor	4.901 mV/bit		A/D conv factor	4.901 mV/bit
FZ	4000	3942.3	MZ	4000	3971.5
	2000	1976.2		2000	1988.4
	1000	989.6		1000	995.4
	A/D conv factor	4.904 mV/bit		A/D conv factor	4.905 mV/bit

Excitation voltage at transducer is cable length dependent
due to excitation voltage drop from cable resistance.
Standard 28 gauge cable resistance will decrease excitation voltage
as per the following chart.

	Bridge Excitation		
Bridge resistance	10 V	5 V	2.5 V
350 ohm	3.707 mv/ft	1.854 mv/ft	0.927 mv/ft
700 ohm	1.854 mv/ft	0.927 mv/ft	0.463 mv/ft
1400 ohm	0.927 mv/ft	0.464 mv/ft	0.232 mv/ft

4.0 Analog System Set-up

The Analog System set-up is shown in Figure 7A. The system consists of force sensor/platform, MSA-6, A/D board (installed in the computer), cabling, interfaces, and software. In Figure 7A we show a specific application using parts available from AMTI. The user is free to choose other options. As a general rule, all the connections and cables should be installed before power is applied to any of the hardware.

The force sensor/platform should be connected with a cable (P/N 7615-30) from the connector on the platform to the connector marked Transducer Input on the back of the MSA-6 (See Figure 3). The power supply should be connected to the back of the MSA-6 to the PWR plug and the other end to the AC power source (the power supply we furnish is normally rated for the local voltage and frequency).

Next the amplifier outputs should be connected to the A/D board. This presents a problem because the amplifier output cable (P/N 5405E) has a DB25 connector and an A/D board generally needs a different connector. For example, the DT3002 A/D board that AMTI offers only accepts a 100 pin ribbon cable. To make the connection simple, AMTI offers an interface box, the ADI-32 (See Figure 8). The ADI-32 is a control panel that allows the user to connect up to four force platforms/transducers and 8 external devices to the 32 channel DT3002 A/D board. Four 6-channel amplifier outputs can be connected to the ADI-32 channels 1-24 via the 5405E cables. The SYNC inputs for up to four MSA-6 amplifiers can be initiated from the ADI-32 rather than from the SYNC ports located on MSA-6 back panels. An auto zero button is also provided on the ADI-32 for each of the MSA-6 amplifiers connected to it. The user has the option of plugging the amplifier power supply into the back of the amplifier or into the top/end of the ADI-32.

An additional connector at the bottom of the ADI-32 is labeled A/D channels 25-32. This connector allows the user to access the last eight channels on the DT3002 A/D board through the ADI-32. These inputs can be up to any +/- 10 VDC signal from other devices. The output from the ADI-32 can be accessed from either of two connectors at the top of the box. The very top connector attaches to a 100 pin ribbon cable (P/N 5405B) which connects the ADI-32 box to the DT3002 A/D board. The second connector from the top is a DB37S connector which allows the user to connect the output to another A/D board or device.

Once all of the connections are made, switch on the amplifier. It is recommended that the amplifier be allowed to warm up for one hour before zeroing and taking data. . You can use the amplifier before one hour to check out the system, however, one should let everything come to a steady temperature before zeroing the system and taking data. If you will be using the MSA-6 daily or for extended periods of time, AMTI recommends leaving the power on continuously.

The last thing you will need is software to acquire and analyze your data. There are several options here. If you are a force sensor user only, you can use AMTI's NetForce software to acquire data and display it in real time. It also exports the data into most common spreadsheet packages so you can have force and moment data displayed in engineering units. There are also other products such as Labview (National Instruments) that you can use for data acquisition and analysis. If you are more ambitious you may write your own software.

For users with force platform systems, AMTI's NetForce/BioAnalysis software is available as well as others provided by motion companies and other third party vendors.

Figure 7: MSA-6 System Diagrams

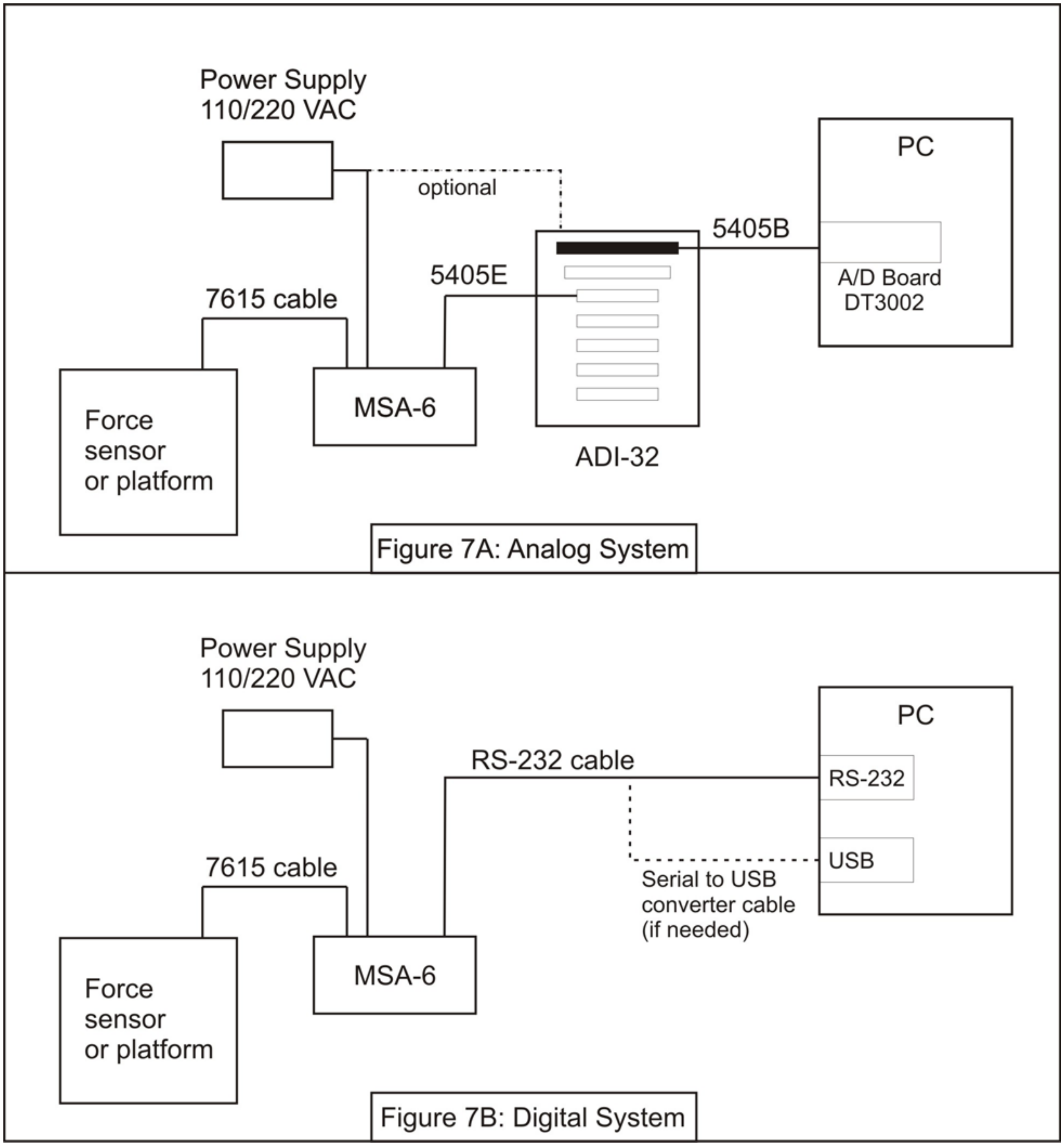


Figure 7A: Analog System

Figure 7B: Digital System

Figure 8: ADI-32 Interface

5.0 Digital System Set-Up

The digital system set-up is shown schematically in Figure 7B. The system consists of the force sensor/platform, MSA-6, computer RS-232 serial port and cabling and software. In Figure 7B we show a specific application using parts that can be obtained from AMTI. The user is free to choose other options. As a general rule, all the connections and cables should be installed before power is applied to any of the hardware.

The force sensor/platform should be connected with a cable (P/N 7615-xxx-x-x, you may have a 7615-030-2-2) from the connector on the platform to the connector marked Transducer Input on the back of the MSA-6 (See Figure 3). The power supply should be connected to the jack on the back of the MSA-6 labeled PWR and the other end to the AC power source (the power supply we furnish is normally rated for the local voltage and frequency). The connection from the MSA-6 amplifier to the computer is much simpler for the digital system than the analog.

An RS- 232 DB9 cable runs from the MSA-6 to the computer serial port. **This RS-232 cable should be wired straight through, pin-to-pin.** This RS-232 extension cable is supplied with every MSA-6 and also can be purchased from a local computer store. The cable connector is female at the amplifier end and male at the computer serial port. Once all of the connections are made, switch on the amplifier. It is recommended that the amplifier be allowed to warm up for one hour before zeroing and taking data. You can use the amplifier before one hour to check out the system, however, one should let everything come to a steady temperature before zeroing the system and taking data. If you will be using the MSA-6 daily or for extended periods of time, AMTI recommends leaving the power on continuously.

The last thing you will need is software to acquire and analyze your data. There are several options here. If you are a force sensor user only, then you can use AMTI's NetForce software to acquire data and display it in real time. NetForce also exports the data into most common spreadsheet packages so you can have force and moment data displayed in engineering units. There are also a number of products such as Labview (National Instruments) that you can use for data acquisition and analysis. If you are more ambitious you may write your own software. Appendix B provides a protocol for allowing the user to access the data coming through the RS-232 interface. This is provided for the user's convenience and relies on the user having the expertise to use it. AMTI's technical support policy does not extend to the development of software interfaces to our products. We will, however, be happy to assist you on a "for fee" basis.

For users with force platform systems, AMTI's NetForce/BioAnalysis software product is available.

6.0 Mounting the MSA-6.

The MSA-6 is designed to be used as both a desk top or rack mounted unit. It comes with a fully enclosed case with four soft rubber feet on the bottom for use on a desk or table. It also comes with two brackets that allow the unit to be installed in a rack mount system. (Note: remove the rubber feet before mounting in a 19 inch rack.) Figure 9 shows one of the brackets mounted to the front side of the MSA-6. The MSA-6 case is designed so that two units can be mounted together by two 10-32 screws as shown in Figure 10. They are designed to fit in a standard 19 inch (48.3 cm) by 1.75 inch (4.45 cm) standard rack mount panel. If only one unit is being installed, a bracket is available that will attach to the side of the MSA-6 making it fit the 19 inch rack.

Figure 9: MSA With Panel Bracket

Figure 10: Two MSA's In Panel Mount Configuration

7.0 Maintenance, Storage and Cleaning

There are no user-serviceable components inside the MSA-6. If service is required, contact AMTI first. It is recommended that the original container be used to store the MSA-6 for extended periods of non-use. The MSA-6 can be cleaned with a dry brush and may be disinfected with 70% isopropyl alcohol applied with a clean towel.

Appendix A

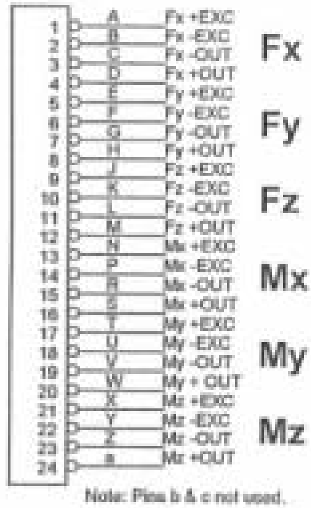
Electrical Schematics

NOTES:

1. VALUES SHOWN ARE FOR 1000Hz BANDPASS
2. PRIOR TO SN 5196, R4 SERIES WAS 30.1K, R15 SERIES WAS 499 OHMS.
3. BRIDGE SHUNTING RESISTORS, 100K, AS SHOWN ON UNITS MADE AFTER AUG 2002.

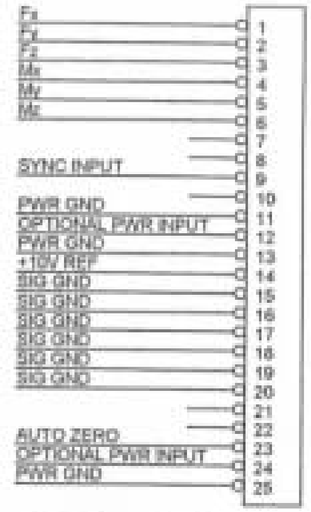
ADVANCED MECHANICAL TECHNOLOGY, INC.
176 WALTHAM STREET WATERTOWN, MA 02472-4800

Title	SCHEMATIC, MINIAMP, MSA-6	
Size D	Document Number ATC-26656	Rev F
Date: Wednesday, August 21, 2002	Sheet 1 of 1	



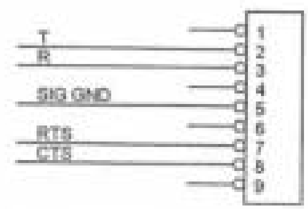
Note: Pins b & c not used.

Transducer Input
Connector 851-02E16-26S50-44



Analog Output
Connector DB25S

Power Jack
Connector



RS-232
Connector DB9S

Connector Diagrams

ADVANCED MECHANICAL TECHNOLOGY, INC. 176 WALTHAM STREET WATERTOWN, MA 02472-4800		
Title: CONNECTOR PIN ASSIGNMENTS, MSA-6		
Size: A	Document Number: ATA-26937	Rev: B
Date: Monday, November 26, 2001	Sheet 1 of 1	

Appendix B: MSA-6 Digital Interface Description

Operation

The connection between the host computer and AMTI's transducers is provided via an RS-232 (Serial Port) interface. The transducers will respond to a set of simple commands to start and stop the data acquisition process. The commands are described in the section immediately below and the returned data format is described in the section Data Format below.

Commands

Several commands are provided. Each command is a single byte (8 bits) data value chosen from the ASCII character codes. Each command will either echo or send a acknowledgment as indicated by the 2nd value in the command column.

ASCII cmd,ack	Command	Hex Value		Acknowledgment
Q,U	Start Data	0x51	one platform	0x55 followed by data
Q,V	Transmission		two platform	0x56 followed by data
R	Stop	0x52		None, data stops
S,T	Autozero	0x53	one platform	0x54 followed by 12 zero offsets
S,d			two platform	0x64 followed by 24 zero offsets

Autozero immediately returns the ack char, then spends some time, currently ~650 mS performing the autozero process internally, and then transmits the offset dac values.

r,r	Set Baud Rate	57.6k baud 50 Hz.	0x72	0x72
f,f	Set Baud Rate	115.2k baud 100 Hz	0x66	0x66
v,v	Set Baud Rate	115.2k baud 200 Hz	0x76	0x76
u,u	Set Baud Rate	230.4k baud 400 Hz	0x75	0x75

14 MHz crystal, rev J PCB ~ 5/9/06

a,a	Set Data Rate	400 Hz / 460 Kbaud	0x61	0x61	
b,b	Set Data Rate	500 Hz / 460 Kbaud	0x62	0x62	
c,c	Set Data Rate	600 Hz / 460 Kbaud	0x63	0x63	
d,d	Set Data Rate	1000 Hz / 460 Kbaud	0x64	0x64	single platform only
e,e	Set Data Rate	1200 Hz / 460 Kbaud	0x65	0x65	single platform only

Additional data sampling rates

These data sampling rates do not change the baud setting. These commands only change the data rate, and don't check the baud – the user must insure that a sufficiently fast baud rate has been established by issuing one of the previous commands before changing to one of these data rates.

j,j	Set Data Rate	60 Hz	0x6a	0x6a	min baud	57.6k
k,k	Set Data Rate	120 Hz	0x6b	0x6b	min baud	115.2k
l,l	Set Data Rate	240 Hz	0x6c	0x6c	min baud	115.2k
m,m	Set Data Rate	300 Hz	0x6d	0x6d	min baud	230.4k

X,x	Serial Num Request	one platform	0x58	0x78 followed by 4 bytes
X,x	Serial Num Request	two platform	0x58	0x78 followed by 9 bytes

#	channel number request	0x23	1 byte: 0x61 or 0x62

read # of channels in data set 12/14 returns ascii a or b respectively
(not applicable in Slave mode)

Data Format

When the transducer receives a start command it will respond by sending a 1 byte acknowledgment followed by a continuous stream of data. The data stream will be maintained until the stop command is received.

The transducer will output data at a rate of 50, 60, 100, 120, 200, 240, 300, 400, 500, 600, 100, or 1200 data sets per second. Each data set consists of 6 consecutive 2 byte words. The data sets are organized Fx, Fy, Fz, Mx, My, and Mz representing the three orthogonal forces and moments at each of the four corners of the platform.

Word Format

Each word of the data stream will be a 16 bit word, the low byte of the word will be transmitted first, followed by the high byte. The transducers digitize at 12 bit resolution, this twelve bit data is encoded in the two nibbles of the low byte and the lower nibble of the high byte. The high nibble (bits 4,5,6 and 7) of the high byte is used to encode the channel number of the data word which can be used to synchronize on data set boundaries.

```
Low Byte              High Byte
Data0    Data7        Data8
|        |            |
01234567              01234567
                          |
                        Data12
```

Synchronization Scheme

As mentioned previously the high nibble of the high word contains the channel count which can be used for synchronization purposes to maintain alignment of received data on data set boundaries. This nibble will range from 0 to 5 corresponding to channels Fx, Fy, Fz, Mx, My, and Mz. In our software we use a scheme that assembles 12 bytes in a circular buffer then xors successive bytes with values corresponding to the channel values. The xored results are summed and checked. If the result is 0 then a data set has been properly assembled, if not then the next byte in the data stream is shifted in and the process is repeated. This technique prevents the loss of synchronization which might occur if a single byte is dropped as the result of a communications error.

A sync or trigger line is provided for the purpose of synchronizing with external events. This synchronization is provided by a control line input into the platform. When the sync control line is toggled from the unsignaled to the signaled state the data stream transmitted by the platform will respond accordingly. The high nibble of the channel 0 is used to indicate the state of the sync line. In the unsignaled state the high nibble will be 0, corresponding to the channel index as in the above paragraph. However in the signaled state the high nibble of channel 0 will be set to 0xF. The following illustrates the data stream as would be transmitted during unsignaled and signaled states of the sync line.

XXX0 XXX1 XXX2 XXX3 XXX4…………XXXB
(Sync line unsignaled)

XXXF XXX1 XXX2 XXX3 XXX4……..…. XXXB
(Sync line signaled)
Time →

Note that the sync line is sampled at every data acquisition interval and the high nibble of channel 0 is set to indicate the state at that time. So at 100 Hz the sync line would have to be held high 10 ms to guarantee a transition in the output data stream.

Numerical Representation

The 12 bit data is encoded in offset binary with values ranging from 0 to 4096. As the transducers are bipolar (i.e. their range swings from negative to positive) the offset binary values must be conditioned by subtracting 2048 from the raw values to produce a twos complement value. Also note that the data is encoded in 12 bits, so negative numbers must be properly sign extended by type casting or other mechanism when moving the data into 16 bit words used by the PC.

Auto Zero

When the auto zero command is sent the amplifier responds by internally measuring current transducer outputs. These measured amplified outputs are trimmed to near 0 V by an internally produced analog signal offset correction voltage that is added to an input of the onboard amplifiers to “zero” the transducer reading. This essentially guarantees that the amplifier/transducer will be able to operate within its full dynamic range. In serial mode the autozero command will cause the amplifier to transmit an acknowledgment as per the above table and will send back six bytes (one for each channel) representing the internal offset voltage used to zero the transducer's output from the amplifier. The manual zero button will cause the same sequence of internal operations leading to the trimming of the amplifer/transducer output to near 0 V.

RS-232 Interface

The RS-232 (Serial Port) interface portion of the MSA-6 is a three wire interface, consisting of transmit and receive wires and ground. These wires are provided on a standard DB9 connector. Please see our hardware data sheet for a complete description of the DB9 connector pin out.

The following table delineates the required RS-232 communications settings.

Baud	57.6, 115.2, 230, 460	kBaud
Word Length	8	Bits
Stop Bits	1	Bit
Handshaking	None	

Serial number return format.

One Platform returns four bytes following ack each byte an ASCII character.

Two platforms return nine bytes following ack. First four byte first platform serial number, fifth byte is a seperator ASCII y, last four bytes serial number of platform 2.

Two Platform Operation

The Accusway electronics and communications software are designed to support a dual platform configuration. The two platforms are interconnected using an AMTI supplied interconnection box. This interconnection box connects the two platforms in a master slave configuration. In this cascaded arrangement a start command to the master platform will be relayed to the slave platform. The resulting data stream will be comprised of 12 word data sets where the first six words will be from the master platform and the subsequent six words will be from the slave platform.

Setting Baud Rate

To set the baud rate set your baud rate to 57600 and send the the 0x72 57600 baud rate command 5 times until you get a 0x76 response. If the platform does not understand your commands it automatically changes to 57600 baud. Then send the new baud rate command and adjust your baud rate.

Offsets and Calibration – Too write code for the platform you will have to write software to zero in software and also functions to tailor your data with the proper sensitivities.

To zero in software first do a hardware zero. Then collect many data sets (for example 50). Average each channel and store results. Later subtract this offset value when acquiring real data. We will call this averaged value from a zeroed platform the offset.

Appendix C: MSA-6 Sync Input

The Sync input is provided to allow a customer supplied digital signal to be easily captured along with the MSA-6's (MiniAmp) force measurement data. This allows the user to synchronize the collected data with an externally provided digital signal.

Input

The Sync input connector is a female RCA phono connector labeled “SYNC” located on the rear panel of the MSA-6.

The signal is a 0-5 V digital input with the zero volt reference tied to the MSA-6 signal ground (RCA outer shield wire is signal ground.)

The Sync signal input (RCA center wire) has a 100K Ohm pull-up resistor to the MSA-6's internal +5VDC. When switched to ground by a customer supplied mating cable and switch, the normally high (+5 V) Sync signal is pulled low (0 V.)

Alternatively, an open collector transistor switch may be used to introduce this signal into the Sync input or a TTL/CMOS digital signal may be directly wired to the Sync input. This permits the customer to use a wide variety of sensor inputs that make sense in their application; light curtains, pressure switches, LED flasher (to synchronize motion capture video frame and force data.)

Output

The value of the Sync signal is available through either the analog interface or Serial RS-232 operation mode.

The Sync signal is available on the MSA-6 analog output connector. Analog output connector Pin 9 is connected to the Sync input signal terminal.

When using AMTI’s ADI-32, analog to digital interface, the Sync signal on each MSA-6's analog output connector is wired to one of four digital inputs of the host DT3002 PCI ADC card, depending on ADI-32 connector used. The Sync signals on the analog connector pin 9 from each MSA-6 plugged in to the ADI-32 analog amplifier input connectors 1, 2, 3, and 4 connect to the DT3002 signals B0, B1, B2, and B3 respectively.

In RS-232 digital interface operation the Sync input level is sampled every data sample time and the logical signal level is encoded in each data set sent to the computer.

The Sync signal level is received along with the force data. Data collection and amplifier operation are not affected by the Sync signal level. The data acquisition software may take various actions based on the level of the Sync signal in the incoming data, AMTINetForce software's External Trigger setting allows the user to configure the software to start saving data when a Sync signal level change is detected in the acquired force data.