

MotionPak[®] II



Low Cost – 6 Degrees of Freedom
Multi-Axis Inertial Sensing System
User's Guide

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MotionPak II

Set-Up and Operation

SAFETY AND HANDLING INFORMATION

- **DO NOT DROP!** The MotionPak II is a precision instrument. Excessive shock can affect sensor performance.
- Avoid exposing the MotionPak II to electrostatic discharge (ESD). Observe proper grounding while handling.
- Insure that power leads are installed properly before applying power to the MotionPak II.
- Insure that when operating in Single Power Supply Mode, pin 2 is grounded to pin 3.
- Do not ground Ratiometric zero out
- Do not connect Ratiometric zero out to analog return

PATENT INFORMATION

The MotionPak II is protected by the following patents:

U.S. 4,654,663; U.S. 4,524,619; U.S. 4,899,587; U.S. 5,072,619;

U.S. 4,926,680; U.S. 5,002,301; U.S. 5,065,626; U.S. 5,095,749;

U.S. 4,955,233; U.S. Re.33,479; plus other U.S. and foreign patents and patents pending.

GENERAL DESCRIPTION

The SDI MotionPak II is a “solid-state” MEMS six degree of freedom inertial sensing system used for measuring linear accelerations and angular rates in instrumentation and control applications. It is a highly reliable, compact and rugged package providing both analog and digital (RS232) outputs. With three orthogonally mounted micromachined quartz angular rate sensors and three silicon based accelerometers, the MotionPak II is a fully self-contained motion measurement package utilizing internal power regulation and signal conditioning electronics.

The MotionPak II contains three Quartz Rate Sensors with a measurement range of +/-75 degrees per second and three Silicon Accelerometers with a range of either $\pm 1.5g$, or $\pm 2.7g$. Performance details are provided on pages 11 through 14.

The MotionPak II can be operated in one of two modes.

When operating in the Dual Power Supply Mode:

1. The MotionPak II is powered using dual +15 Vdc and -15 Vdc power supplies.
2. The MotionPak II provides Low Analog Outputs of +0.5 Vdc to +4.5 Vdc for each of the rate and acceleration channels.
3. The MotionPak II also provides High Analog Outputs of 0 to ± 10 Vdc for each of the rate and acceleration channels.
4. The MotionPak II provides an RS-232 serial data output.
5. A Temperature Sensor Output, that monitors the internal package temperature is available on pin 23.
6. Typical input current on the positive supply is < 125 milliamperes.
7. Typical input current on the negative supply is < 35 milliamperes.

When operating in the Single Power Supply Mode:

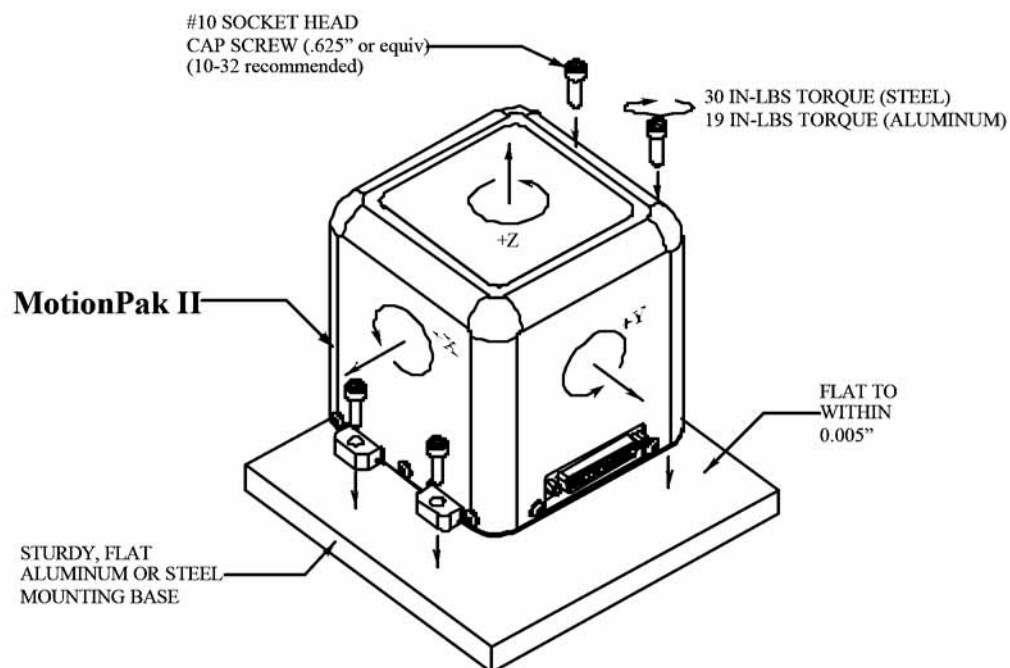
1. The MotionPak II is powered using a single +12 Vdc power supply.
2. The MotionPak II provides Low Analog Outputs of +0.5 Vdc to +4.5 Vdc for each of the rate and acceleration channels.
3. The MotionPak II does not provide High Analog Outputs in this mode.
4. The MotionPak II provides an RS-232 serial data output.
5. A Temperature Sensor Output, that monitors the internal package temperature is available on pin 23.
6. Typical input current on the positive supply is < 125 milliamperes.
7. The negative power supply input (Pin 2) is tied to ground (Pin 3) in this mode.

INSTALLATION

A. Mounting

1. Prepare the mounting surface. It should be sturdy and rigid, and must be flat within 0.005 inches. If the mounting surface flexes or vibrates, the MotionPak II will respond to this motion as an input.
2. Mount the MotionPak II using four 10-32 socket head cap screws or equivalent (Figure 1).

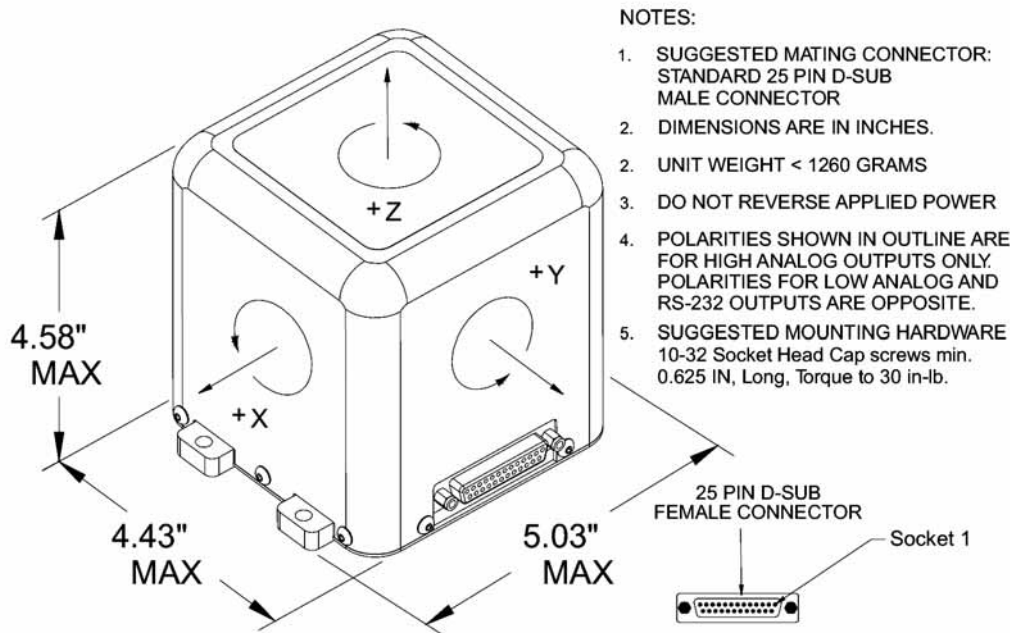
Figure 1. **Mounting Diagram**



3. Tighten screws to 19 in-lbs of torque for mounting onto aluminum or 30 in-lbs for steel. Over-torquing may damage the case.

- The sensitive axis orientation and polarity for the three rate sensors and three accelerometers is shown in Figure 2.

Figure 2. Sensitive Axes Orientation and Polarity for Quartz Rate Sensors and Accelerometers



B. Connection

- Verify power supply polarity before connecting the MotionPak II. The instrument's internal electronics are not protected against reverse-polarity voltage.**
- Packaged with each MotionPak II is a mating connector, which comes unassembled so that you may customize the wire lengths to your installation.
- Verify that the connector wiring matches the wiring assignments specified in Table 1. No external load or termination is necessary for signal outputs.
- Case grounding provides a shield for the internal electronics and should make good contact with other chassis or shield grounds. Case Ground (Pin 4) should be connected to chassis ground. Connect the Power Return (Pin 3) to the common return (ground) of the power supplies. Analog Return (Pin 6) is provided as a signal ground for the output signals. The RS232 GND (Pin 12) is provided as a common for the RS-232 TD and RD signals. See Table 1.
- Shield power input lines and signal lines if you are operating the MotionPak II in the presence of high levels of electromagnetic interference (EMI). Sources of EMI include switching power supplies and radio transmitters.

6. When operating in the Single Power Supply Mode, the -VDC Power Input (Pin 2) should be connected to Power Return (Pin 3). The Ratiometric Zero Out is invalid if Pin 2 is left open-circuited.

Table 1. Connector Pin Wiring Assignments

PIN ASSIGNMENT	
PIN NO.	DESCRIPTION
1	+VDC POWER INPUT
2	-VDC POWER INPUT (*)
3	POWER RETURN / GROUND
4	CASE GROUND
5	X RATE OUT – HIGH ANALOG
6	ANALOG RETURN / GROUND
7	Y RATE OUT – HIGH ANALOG
8	RS232 TD (TRANSMIT DATA)
9	Z RATE OUT – HIGH ANALOG
10	RS232 RD (RECEIVE DATA)
11	X ACCEL OUT – HIGH ANALOG
12	RS232 GND / GROUND
13	SPARE
14	Y ACCEL OUT – HIGH ANALOG
15	SPARE
16	Z ACCEL OUT – HIGH ANALOG
17	SPARE
18	X RATE OUT – LOW ANALOG
19	Y RATE OUT – LOW ANALOG
20	Z RATE OUT – LOW ANALOG
21	RATIOMETRIC ZERO OUT
22	Y ACCEL OUT – LOW ANALOG
23	TEMP SENSOR OUT
24	X ACCEL OUT – LOW ANALOG
25	Z ACCEL OUT – LOW ANALOG

HIGH ANALOG OUTPUT

LOW ANALOG OUTPUT

RS232

Temperature Sensor

*= If no -VDC supply is used, connect Pin2 to Pin 3 (ground)

OPERATION AND TROUBLESHOOTING

When properly installed and connected, the MotionPak II will meet or exceed the specifications given on pages 11 through 14.

A. Operation

The MotionPak II can be operated in one of two modes.

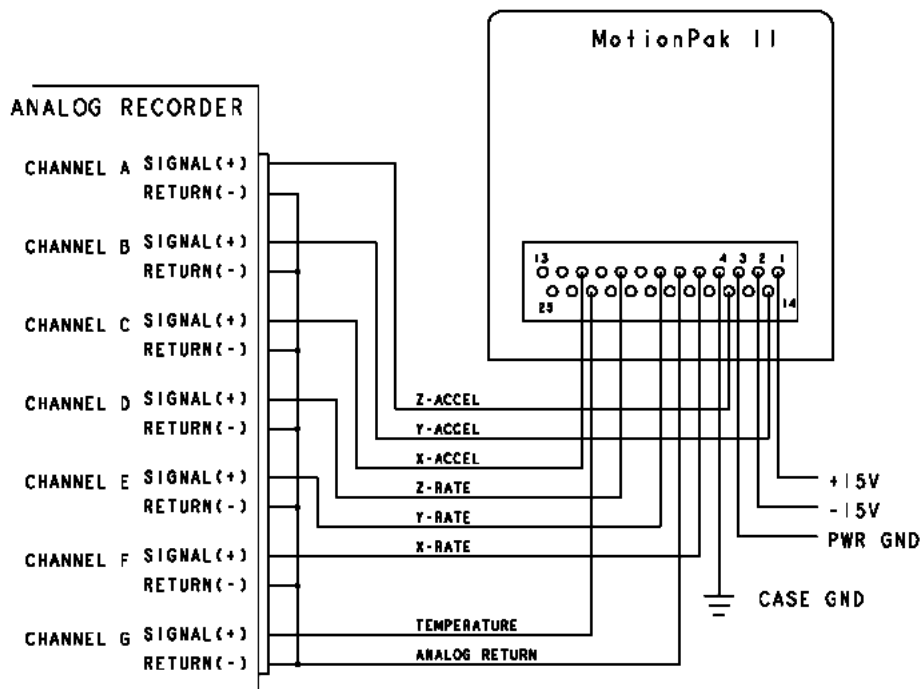
When operating in the Dual Power Supply Mode:

1. The MotionPak II is powered using dual +15 Vdc and -15 Vdc power supplies.
2. The MotionPak II provides Low Analog Outputs of +0.5 Vdc to +4.5 Vdc for each of the rate and acceleration channels.
3. The MotionPak II also provides High Analog Outputs of 0 to ±10 Vdc for each of the rate and acceleration channels.
4. The MotionPak II provides an RS-232 serial data output.
5. A Temperature Sensor Output, that monitors the internal package temperature is available on pin 23.
6. Typical input current on the positive supply is < 125 milliamperes.
7. Typical input current on the negative supply is < 35 milliamperes.

When operating in the Single Power Supply Mode:

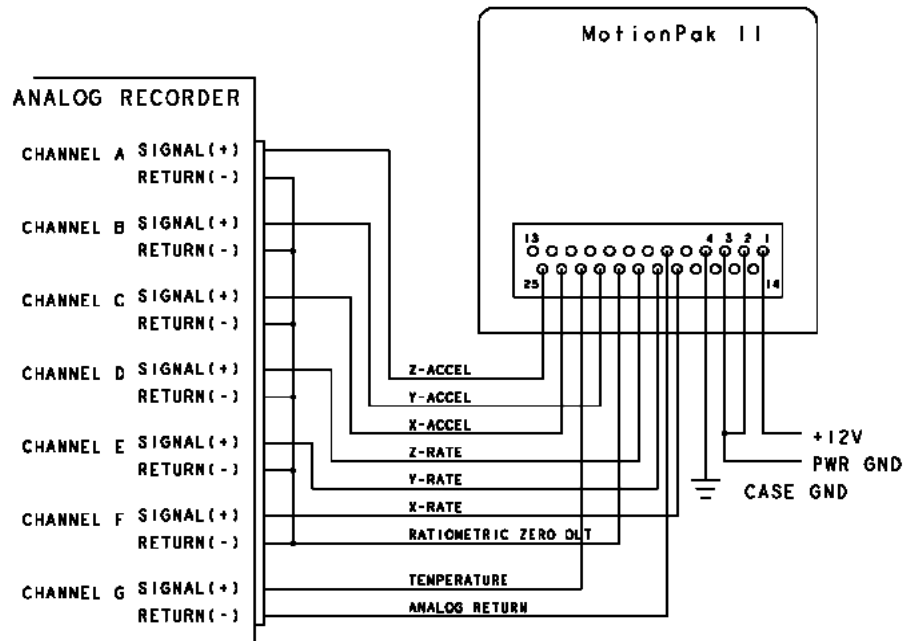
1. The MotionPak II is powered using a single +12 Vdc power supply.
2. The MotionPak II provides Low Analog Outputs of +0.5 Vdc to +4.5 Vdc for each of the rate and acceleration channels.
3. The MotionPak II does not provide High Analog Outputs in this mode.
4. The MotionPak II provides an RS-232 serial data output.
5. A Temperature Sensor Output, that monitors the internal package temperature is available on pin 23.
6. Typical input current on the positive supply is < 125 milliamperes.
7. The negative power supply input (Pin 2) is tied to ground (Pin 3) in this mode.

Figure 3a. **Connection Diagram**



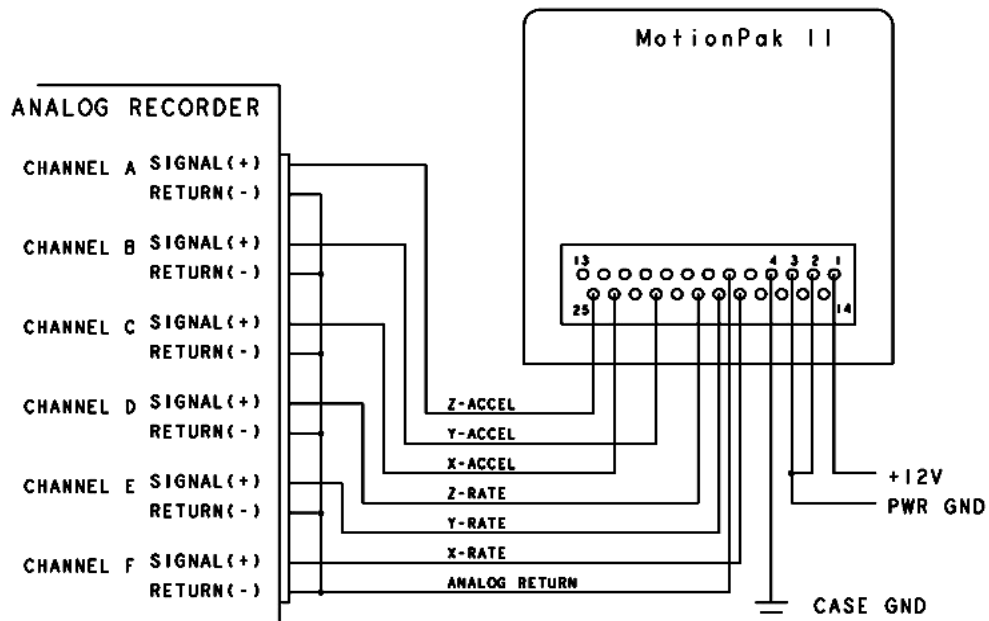
+/-15 VOLT POWER, HIGH-ANALOG OUT, & TEMPERATURE MONITOR

Figure 3b. **Connection Diagram**



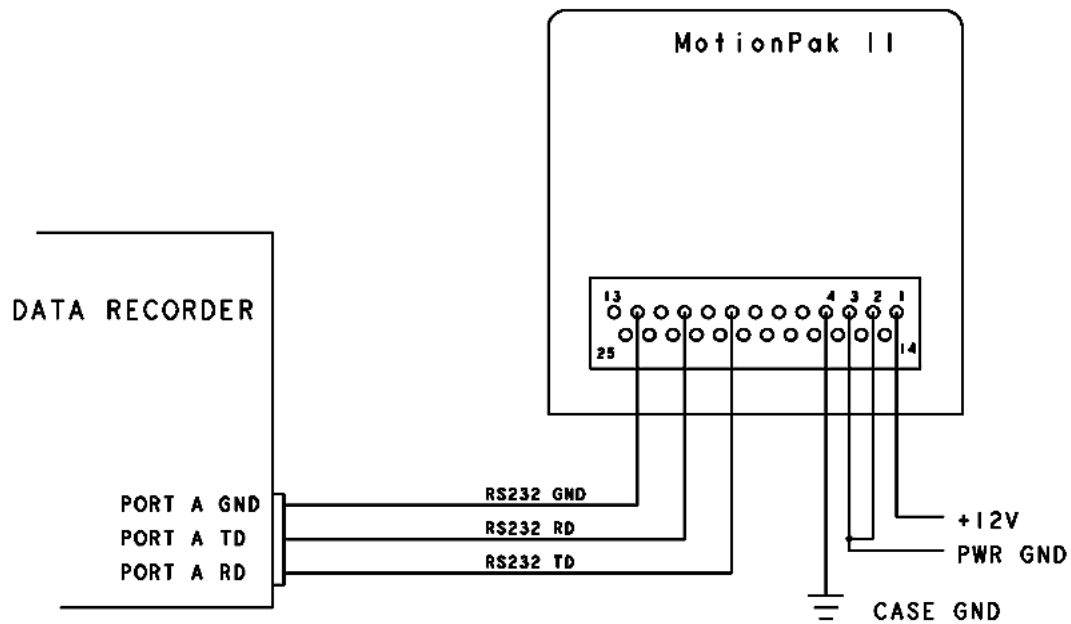
12 VOLT POWER, LOW-ANALOG OUT, & TEMPERATURE MONITOR
 LOW-ANALOG RATIO METRIC MODE - REQUIRES PIN 2 BE CONNECTED TO PWR GND
 ALSO REQUIRES RECORDER WITH ISOLATED FLOATING DIFFERENTIAL INPUTS

Figure 3c. **Connection Diagram**



+12 VOLT POWER, LOW-ANALOG OUT
 LOW-ANALOG GROUND-REFERENCE MODE - ZERO REFERENCE IS +2.50 VOLTS

Figure 3d. **Connection Diagram**



+12 VOLT POWER, RS-232 OUTPUT

B. Troubleshooting

If you are having difficulty operating your MotionPak II, the following recommendations may resolve the problem.

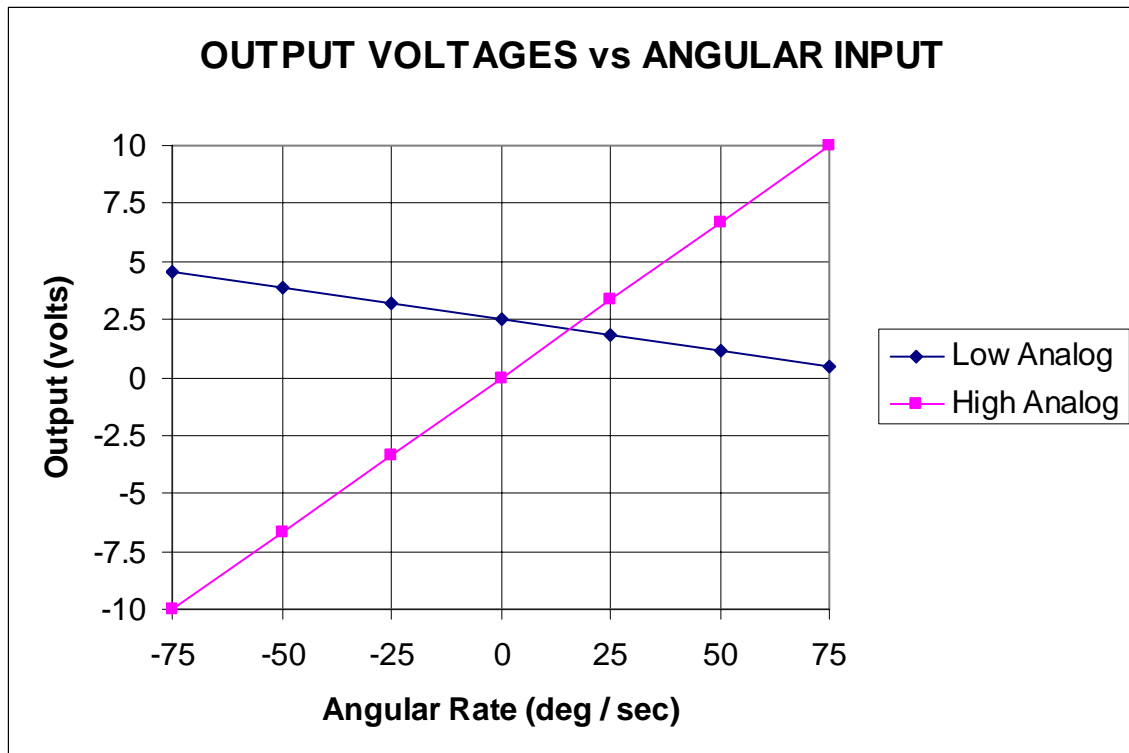
1. Check wiring connections shown in Table 1 and Figure 3.
2. Verify proper input voltage and input current.
3. If the MotionPak II is over-ranged in any of the six axes, sensor output voltage may saturate (reach the maximum voltage output). Immediately after the over-ranged condition is removed, the MotionPak II will return to normal operation.

C. Sample Outputs and Graphs

Output Voltages vs Angular Input

MP2K-CCC-777-100

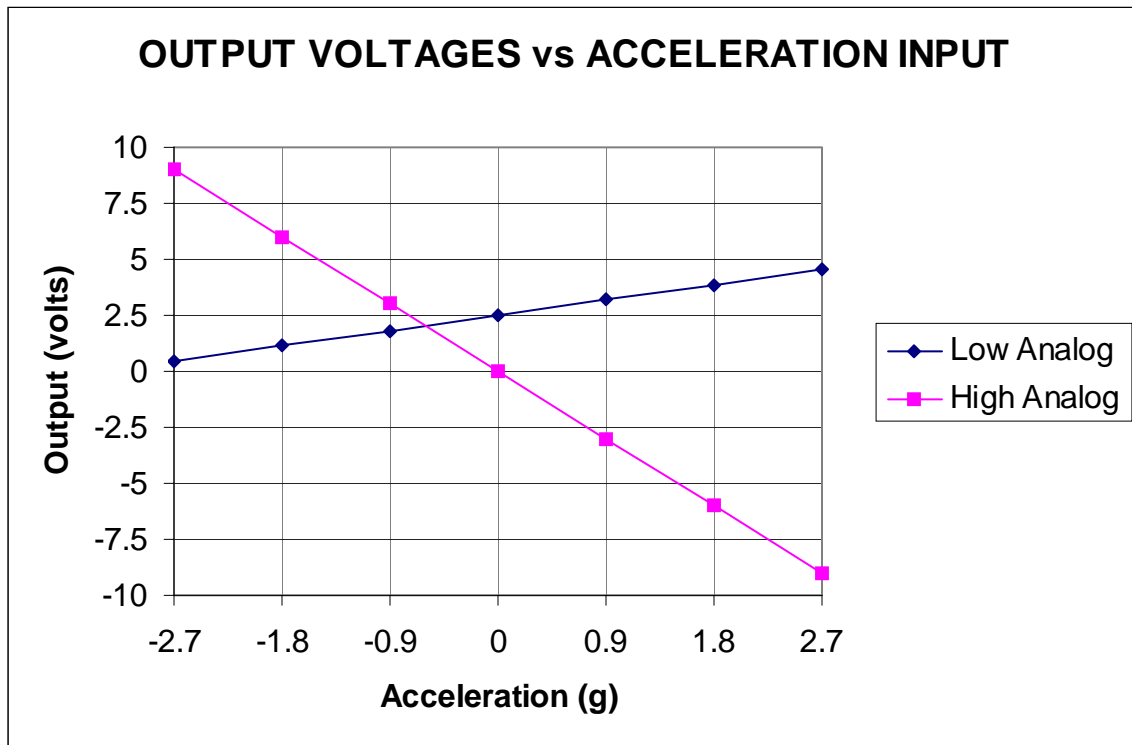
RATE °/sec	Low Analog	High Analog	RS-232 (12-bit word)	
	Volts	Volts	Hex	Decimal
75	0.475	9.975	0185	389
50	1.15	6.65	03AE	942
25	1.825	3.325	05D7	1495
0	2.5	0	0800	2048
-25	3.175	-3.325	0A29	2601
-50	3.85	-6.65	0C52	3154
-75	4.525	-9.975	0E7B	3707



Output Voltages vs Acceleration Input

MP2K-CCC-777-100

ACCEL	Low Analog	High Analog	RS-232 (12-bit word)	
g	Volts	Volts	Hex	Decimal
2.7	4.525	-8.991	0E7B	3707
1.8	3.85	-5.994	0C52	3154
0.9	3.175	-2.997	0A29	2601
0	2.5	0	0800	2048
-0.9	1.825	2.997	05D7	1495
-1.8	1.15	5.994	03AE	942
-2.7	0.475	8.991	0185	389



Technical Assistance

If you have questions or require assistance in operating your MotionPak II, please call one of our Applications Engineers at Systron Donner Inertial: 866-BEI-GYRO (866-234-4976), Monday through Friday, 7:00am to 4:00pm PST.

CONTACT INFORMATION

Systron Donner Inertial

355 Lennon Lane · Walnut Creek, California 94598

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Sales and Technical Support: 866-BEI-GYRO (866-234-4976)
E-Mail: sales@systron.com · Web Site: www.systron.com

European Business Office: ++44 (0) 1227 776460 · FAX: ++44 (0) 1227 363289
E-Mail: bei.tech@ukonline.co.uk

MotionPak® II Specifications

SINGLE SUPPLY OPERATION (LOW & RS232 OUTPUTS)

INPUT POWER **=====** SINGLE SUPPLY **=====**

Input Voltage +13.5 Vdc \pm 2.5 Vdc (+12Vdc Nominal)
Input Current <125 milliamps

PERFORMANCE **=====** RATE SENSOR ACCELEROMETERS **=====**

Range \pm 75°/sec \pm 1.5g
Full Range **LOW** Analog Output +0.5/+4.5
Scale Factor **LOW**, nominal -0.027 V/°/sec 1.2V/g
Scale Factor Error, maximum (1) \pm 6% \pm 5%
Bias **LOW** Analog, nominal +2.5 Vdc
Bias Error, maximum (2) \pm 5.0°/sec \pm 125mg
Input Axis Alignment 1° typical
Output Noise **LOW** Analog (3) 6 mVrms 5 mVrms
Start-up Time, Maximum 1.0 Second
Bandwidth, flat \pm 3dB DC to >30Hz DC to >20Hz
Non-linearity (% of Full Scale) 3% maximum

ENVIRONMENTS **=====**

Operating/ storage temperature -40 to + 85°C
Vibration survival 4g RMS (20-2KHz)
Shock 200g PK 2 msec ½ sine pulse

RS232 FEATURE **=====**

Data Transfer Rate: 32 Hz maximum (measuring all seven (7) "12Bit" WORDS)
LSB = 1.2 mVdc (Least Significant Bit)
8 Data Bits, 1 Start Bit, 1 Stop Bit, No Parity
Baud Rate Range: 1200-9600 Autodetect

TEMPERATURE SENSOR **=====**

LM335 – internally mounted -40°C (233.15°K) = +2.33 Vdc
10 mVdc/°K; \pm 4°K +85°C (358.15°K) = +3.58 Vdc

- (1) Sum of factory setting and non-linearity, over operating temperature range
- (2) Sum of factory setting and temperature effect, over operating temperature range
- (3) Output noise, maximum, DC to 50Hz

Specification subject to change without notice

MotionPak® II Specifications

DUAL SUPPLY OPERATION

(HIGH, LOW & RS232 OUTPUTS)

INPUT POWER **=====** DUAL SUPPLY (BIPOLAR) **=====**

Input Voltage $\pm 14 \text{ Vdc} \pm 2 \text{ Vdc}$ ($\pm 15 \text{ Vdc}$ Nominal)
Input Current Plus Supply <125 milliamps
Minus Supply <35 milliamps

PERFORMANCE **=====** RATE SENSOR ACCELEROMETERS **=====**

Range $\pm 75^\circ/\text{sec}$ $\pm 1.5\text{g}$
Full Range **HIGH** Analog Output $\pm 10 \text{ Vdc}$
Full Range **LOW** Analog Output $+0.5/+4.5 \text{ Vdc}$
Scale Factor **HIGH**, nominal $0.133 \text{ V}/^\circ/\text{sec}$ $-6.66 \text{ V}/\text{g}$
Scale Factor **LOW**, nominal $-0.027 \text{ V}/^\circ/\text{sec}$ $1.2\text{V}/\text{g}$
Scale Factor Error, maximum (1) $\pm 6\%$ $\pm 5\%$
Bias **HIGH** Analog, nominal 0 Vdc
Bias **LOW** Analog, nominal 2.5 Vdc
Bias Error, minimum (2) $\pm 5.0^\circ/\text{sec}$ $\pm 125\text{mg}$
Input Axis Alignment 1° typical
Output Noise **HIGH** Analog (3) 28mVrms
Output Noise **LOW** Analog (3) 6 mVrms 5 mVrms
Start-up Time, maximum 1.0 Second
Bandwidth, flat $\pm 3\text{dB}$ $\text{DC to } >30\text{Hz}$ $\text{DC to } >20\text{Hz}$
Non-linearity (% of Full Scale) 3% maximum

ENVIRONMENTS **=====**

Operating/ storage temperature $-40 \text{ to } + 85^\circ\text{C}$
Vibration survival 4g RMS (20-2KHz)
Shock $200\text{g PK 2 msec } \frac{1}{2} \text{ sine pulse}$

RS232 FEATURE **=====**

Data Transfer Rate: 32 Hz maximum (measuring all seven (7) "12Bit" WORDS)
LSB = 1.2 mVdc (Least Significant Bit)
8 Data Bits, 1 Start Bit, 1 Stop Bit, No Parity
Baud Rate Range: $1200\text{-}9600$ Autodetect

TEMPERATURE SENSOR **=====**

LM335 – internally mounted $-40^\circ\text{C (233.15}^\circ\text{K)} = +2.33 \text{ Vdc}$
 $10 \text{ mVdc}/^\circ\text{K}; \pm 4^\circ\text{K}$ $+85^\circ\text{C (358.15}^\circ\text{K)} = +3.58 \text{ Vdc}$

- (2) Sum of factory setting and non-linearity, over operating temperature range
(2) Sum of factory setting and temperature effect, over operating temperature range
(3) Output noise, maximum, DC to 50Hz

Specification subject to change without notice

MotionPak® II Specifications (3g version)

SINGLE SUPPLY OPERATION

(LOW & RS232 OUTPUTS)

INPUT POWER **=====** DUAL SUPPLY (BIPOLAR) **=====**

Input Voltage + 13.5 Vdc \pm 2.5 Vdc (+12Vdc Nominal)
Input Current <125 milliamps

PERFORMANCE **=====** RATE SENSOR ACCELEROMETERS **=====**

Range \pm 75°/sec \pm 2.7g
Full Range **LOW** Analog Output +0.5/+4.5 Vdc
Scale Factor **LOW**, nominal -0.027 V/°/sec 0.75V/g
Scale Factor Error, maximum (1) \pm 6% \pm 5%
Bias **LOW** Analog, nominal 2.5 Vdc
Bias Error, minimum (2) \pm 5.0°/sec \pm 200mg
Input Axis Alignment 1° typical
Output noise **LOW** Analog (3) 5m VRMS
Start-up Time, maximum 1.0 Second
Bandwidth, flat \pm 3dB DC to >30Hz DC to >250Hz
Non-linearity (% of Full Scale) 3% maximum

ENVIRONMENTS **=====**

Operating/ storage temperature -40 to + 85°C
Vibration survival 4g RMS (20-2KHz)
Shock 200g PK 2 mSec ½ sine pulse

RS232 FEATURE **=====**

Data Transfer Rate: 32 Hz maximum (measuring all 7 "12Bit" WORDS)
LSB = 1.2 mVdc (Least Significant Bit)
8 Data Bits, 1 Start Bit, 1 Stop Bit, No Parity
Baud Rate Range: 1200-9600 Autodetect

TEMPERATURE SENSOR **=====**

LM335 – internally mounted -40°C (233.15°K) = +2.33 Vdc
10 mVdc/°K; \pm 4°K +85°C (358.15°K) = +3.58 Vdc

- (1) Sum of factory setting and non-linearity, over operating temperature range
- (2) Sum of factory setting and temperature effect, over operating temperature range
- (3) Output noise, maximum, DC to 50Hz

Specification subject to change without notice

MotionPak[®] II Specifications (3g version)

DUAL SUPPLY OPERATION

(HIGH, LOW & RS232 OUTPUTS)

INPUT POWER =====	DUAL SUPPLY (BIPOLAR) =====
Input Voltage	±14 Vdc ± 2 Vdc (±15 Vdc Nominal)
Input Current	Plus Supply <125 milliamps Minus Supply <35 milliamps

PERFORMANCE ===== RATE SENSOR ACCELEROMETERS=====

Ranges	± 75°/sec	±2.7g
Full Range HIGH Analog Output	±10 Vdc	±9.0 Vdc
Full Range LOW Analog Output	+0.5/+4.5 Vdc	
Scale Factor HIGH , nominal	0.133 V/°/sec	-3.33 V/g
Scale Factor LOW , nominal	-0.027 V/°/sec	0.75V/g
Scale Factor Error, maximum (1)	±6%	±5%
Bias HIGH Analog, nominal	0 Vdc	
Bias LOW Analog, nominal	2.5 Vdc	
Bias Error, maximum (2)	±5.0°/sec	±200mg
Input Axis Alignment	1° typical	
Output noise HIGH Analog (3)	28mV RMS	
Output noise LOW Analog (3)	6mV RMS	5mV RMS
Star-up Time, maximum	1.0 second	
Bandwidth, flat ±3dB	DC to >30Hz	DC to >250Hz
Non-linearity (% of Full Scale)	3% maximum	

ENVIRONMENTS =====

Operating/ storage temperature	-40 to + 85°C
Vibration survival	4g RMS (20-2KHz)
Shock	200g PK 2 mSec ½ sine pulse

RS232 FEATURE =====

Data Transfer Rate: 32 Hz maximum (measuring all seven (7) "12Bit" WORDS)
LSB = 1.2 mVdc (Least Significant Bit)
8 Data Bits, 1 Start Bit, 1 Stop Bit, No Parity
Baud Rate Range: 1200-9600 Autodetect

TEMPERATURE SENSOR =====

LM335 – internally mounted	-40°C (233.15°K) = +2.33 Vdc
10 mVdc/°K; ± 4°K	+85°C (358.15°K) = +3.58 Vdc

- (2) Sum of factory setting and non-linearity, over operating temperature range
- (2) Sum of factory setting and temperature effect, over operating temperature range
- (3) Output noise, maximum, DC to 50Hz

Specification subject to change without notice

RS-232 Data Acquisition Software

Document Scope

This document provides operating instructions and software description for the RS-232 Data Acquisition software provided with the MotionPak® II.

A technical description of the RS-232 data format is also provided for customers developing their own data acquisition software.

System Requirements

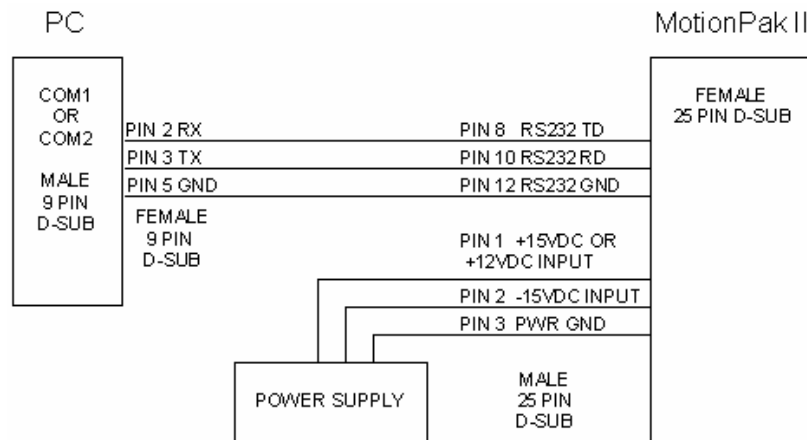
The following are required for running the MotionPak Data Acquisition software.

1. IBM compatible PC
2. Available RS-232 port
3. Windows 95, 98, 98SE, ME, 2000, XP, NT 4.0 or compatible operating system¹
4. Internet Explorer 4.0 or later (for Software Kit Demonstration)
5. Excel 97 or later (for the sample spreadsheet)
6. Visual Basic 6.0 (for recompiling the source code)

Operating Instructions

A. Installation

1. Install the software by running the accompanied SETUP.EXE program.
2. Make the RS-232 and Power Supply connections as shown in the following diagram. Your Power Supply can be either a Dual Output +/-15 VDC supply, or a Single Output +12 VDC supply. For Single Power Supply Mode operation, ground pin 2.



¹ Windows 95, 98, 98SE, ME, 2000, XP and NT, Internet Explorer, Excel 97 and Visual Basic are trademarks of the Microsoft Corporation.

3. Run either the Software Kit Demonstration or RS-232 Data Acquisition programs according to the following instructions. On first use of the software, the "MotionPak Data Acquisition Configuration" dialog box will pop up. From the "Comm. Port Number" drop-down list, select the Communications Port your MotionPak is connected to. From the "Connected MotionPak" drop-down list, select the Part Number (MP2K-CCC-666-100 or MP2K-CCC-777-100) of your MotionPak.² Click on **OK** to begin using your MotionPak.

B. Software Kit Demonstration

1. On the Start menu, open Programs, open Systron Donner MotionPak, and then Software Kit Demonstration. Internet Explorer will show the demonstration software in web page (HTML) format. Your internet connection is not used.
2. On the web page menu bar, click on Data Acquisition Demonstration. Here is where the configuration dialog box will pop up on first use of the data acquisition software. If everything is working, the animated graphics will respond to any movement of the MotionPak. To reset the Angle Integration graph, right-click with the mouse to pop-up the graph's menu.
3. On the web page menu bar, click on Log Data to Spreadsheet. See the instructions on the web page for how to run the Excel macro.

C. Log Data to Spreadsheet

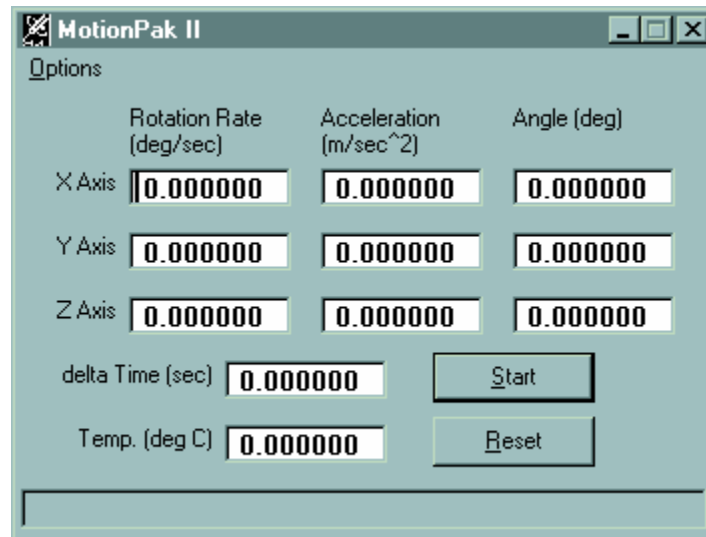
1. Open the BOOK1.XLS spreadsheet file.
2. When Excel starts up, enable macros if prompted.
3. Click the **Run Macro** button on the spreadsheet.
4. Enter the sheet name and number of samples into the dialog box, and click the **Get Data** button.
5. To modify the macro, press **Alt+F11** to show the Visual Basic editor. The macro code is contained in UserForm1 and Module1. See the "Sample Spreadsheet Macro Code" section in this document for a detailed description of the code.

D. RS-232 Data Acquisition

On the Start menu, open Programs, open Systron Donner MotionPak, and then RS-232 Data Acquisition. This launches the MOPAK.EXE program which provides a numeric readout of the acquired data. The data acquisition and angle integration are controlled by the Start, Stop and Reset buttons. At the bottom of the form, any Data Fail Flags are displayed in hexadecimal.

² If the list does not have your MotionPak's Part Number, you can create a new MotionPak model definition. See the instructions for the MotionPak Tab of the Configuration Dialog Box.

MotionPak Program



The following functions are available through the Options menu.

- | | |
|------------------------|--|
| Comm. Port | Selects the connected Communications Port, which is initially the Default Port Number. Enter a valid Port Number for your PC into the pop-up box. |
| Sample Interval | Sets the Sample Interval, which is initially the Default Sample Interval. Enter the number of milliseconds, or enter the number 0 to have the acquisition occur as fast as possible. |
| About | Shows the software's "About" box. It displays the software version, the connected Communications Port, the Sample Interval, and any RS-232 communication errors. |
| Configuration | Shows the Configuration Dialog Box. |

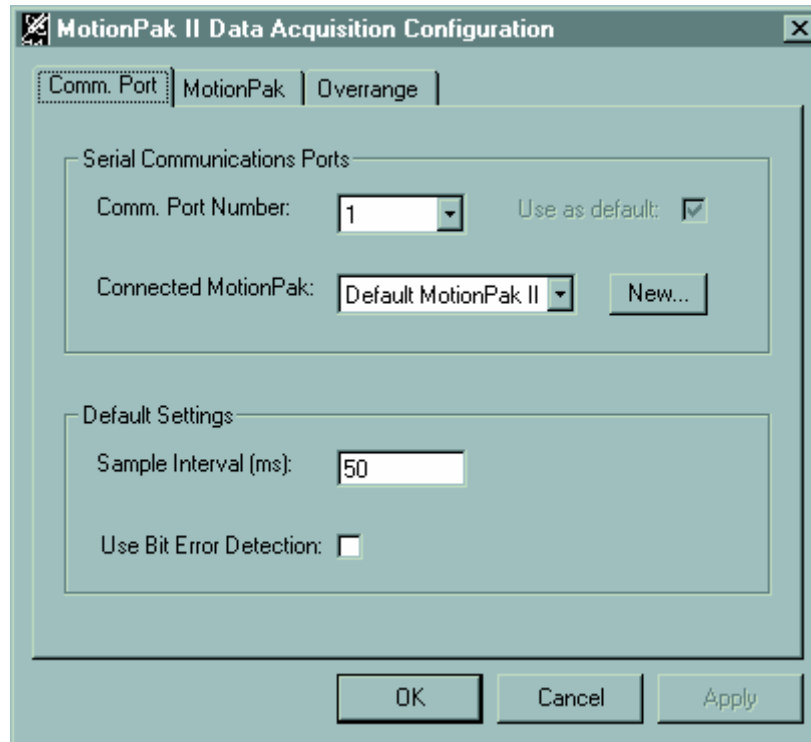
E. Configuration Dialog Box

Overview

The MotionPak Data Acquisition Configuration is stored in the MOPAKDAQ.INI file. The configuration dialog box provides a means of editing this file, and interactively changing the configuration and calibration parameters while the software is running. The functions of the buttons are as follows:

- | | |
|---------------|--|
| OK | Saves and applies the changes to the configuration, and closes the dialog box. |
| Cancel | Closes the dialog box without saving the changes. |
| Apply | This button is only enabled when a change is made to the configuration. It saves and applies the new configuration without closing the dialog box. |

Comm. Port Tab



The "Serial Communications Ports" group of settings has the "Comm. Port Number" drop-down list. Scroll through the list to view the identifier of the "Connected MotionPak" and whether the port is the Default Port Number.

The "Default Settings" group has the "Default Sample Interval" and the "Use Bit Error Detection" option. To detect RS-232 communication errors, the Bit Error Detection option causes each data byte to be sent twice: normally and the byte's complement. If any pair of bytes miscompares, the corresponding sensor's Data Fail Flag is set.

Note that the Default Port Number, Default Sample Interval and "Use Bit Error Detection" options are only applied when a RS-232 connection is made. This happens during startup of the Data Acquisition Module, and when selecting another Comm. Port. To effect a change in these settings, it may be necessary to exit all running applications that are using the Data Acquisition Module or desired Comm. Port to break the RS-232 connection.

MotionPak Tab

The MotionPak Tab provides the creation and editing of model definitions for MotionPak Part Numbers, and of calibration parameters of individual sensors. The software as installed provides parameters for several Part Numbers, and for scaling the sensor readings in volts. Scroll through the drop-down list to view the parameters for each MotionPak. Note that the parameters for the "Default MotionPak II" can not be modified, but many other definitions may be created, edited and stored.

To enter a new model definition, click on **New**. Enter the Part Number in the pop-up input box, and click on **OK**. The default parameters will appear. Change the Scale Factors to the values listed for LOW Analog Outputs on the specification sheet. The default Bias and Temp. Sensor parameters should be the correct for any model.

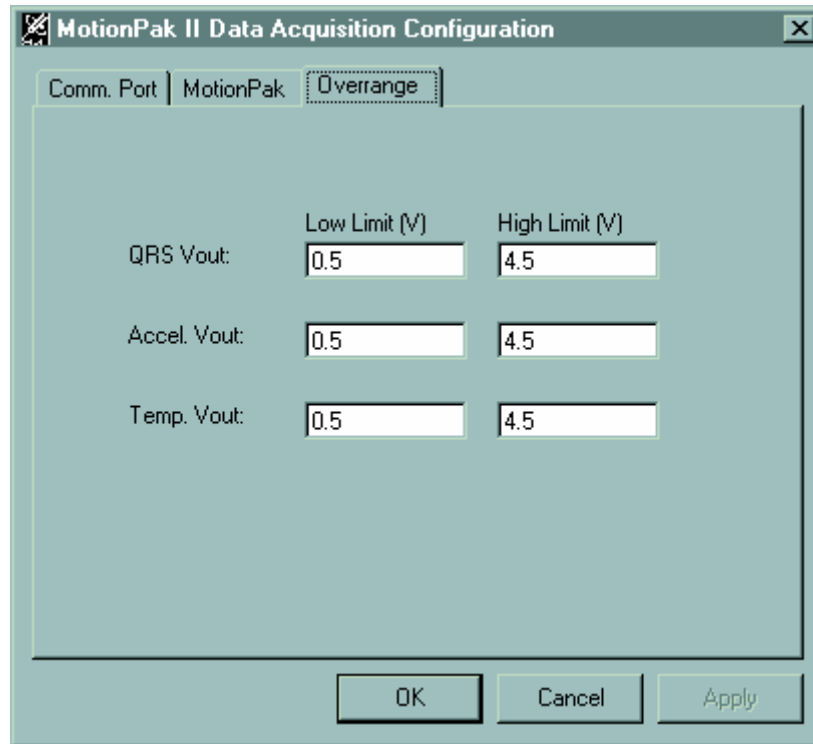
To enter calibration parameters for a particular MotionPak, click on **New**, and enter the MotionPak's Serial Number, or other unique identifier in the pop-up input box. Edit the parameters to the values determined by the calibration.

After editing any parameter, click on **OK** or **Apply** to save the new definition, or **Cancel** to undo the changes. If the saved parameters are for the "Connected MotionPak", the parameters take effect immediately.

The calibration parameters are defined as follows.

Rate Bias	The rate sensor's output with zero rate input in volts.
Rate SF	The rate sensor's scale factor in volts per "degrees per second".
Accel. Bias	The accelerometer's output when orthogonal to earth's gravity in volts.
Accel. SF	The change in the accelerometer's output when rotated from orthogonal to parallel to earth's gravity in volts per "G".
Temp. Sensor SF	The temperature sensor's gain in volts per degrees Kelvin.
Temp. Sensor Offset	The offset used to convert degrees Kelvin to degrees Celsius.

Overrange Tab

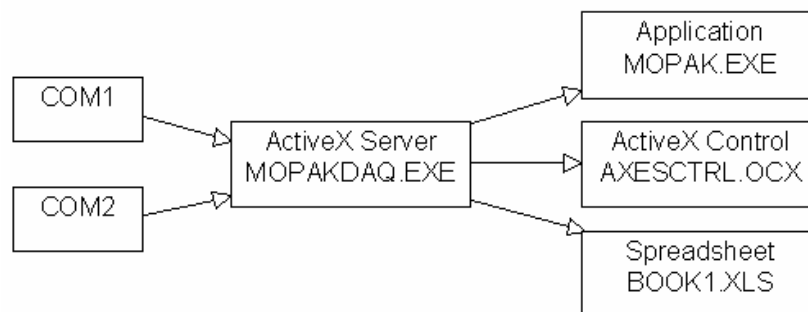


The Overrange Limits provide an additional means of setting the Data Fail Flags. Enter the voltage limits for each type of sensor: QRS (rate), acceleration or temperature. These limits will apply to any MotionPak connected to any Communications Port. To disable this feature, enter a Low Limit of 0 and a High Limit of 5.

F. Software Description

Overview

The following diagram shows the data flow from the RS-232 ports to the various applications provided by this software. Only one instance of the ActiveX Server runs for any number of ports and client applications. The same data from a single port can be sent to several applications in real time.



The ActiveX Server is described in the following "ActiveX Object Model" and "Data Acquisition Source Code" sections. The MOPAK.EXE application is described in the "Data Display Source Code" section. The ActiveX Control file provides the animated graphics seen on the "Data

Acquisition Demonstration" web page. A simple example of Visual Basic code to connect to the ActiveX Server is given in "Sample Spreadsheet Macro Code" section.

G. ActiveX Object Model

In a Visual Basic environment, a reference to the MoPakDaq object library makes available the MotionPak Data Acquisition programming interface. Use Visual Basic's Object Browser to examine the provided objects, constants, properties, methods and events. A detailed description of these items follows.

ConfigDialog	Global method that shows the Configuration Dialog Box described in the Operating Instructions.
DataFailFlags	Enumerated constants for testing binary bits in the dff parameter returned by the DataFrame event. A "1" bit means the corresponding data value is invalid, and the value returned is the last valid value from a previous DataFrame event.
Inertial	Object that provides the data acquisition function.
CommPort	Inertial object property that selects the RS-232 port. The value must be a port number between 1 and 16 that is valid for your system.
DataFrame	Event raised by the Inertial object that returns the acquired data in real time. The data includes measurements of the six inertial sensors, the temperature sensor, and the time interval between measurements. The Start property enables and disables this event.
Interval	Inertial object property that sets the data acquisition sample interval. The value must be a number in milliseconds between 0 and 32000. Note that other applications receiving data from the same RS-232 port are affected by changing this property.
ShowAbout	Inertial object property that shows or hides the About Box described in the Operating Instructions. The value is True or False.
Start	Inertial object property that enables or disables the DataFrame event. The value is True or False. Note that other applications receiving data from the same RS-232 port are not affected by changing this property.

H. Data Acquisition Source Code

MOPAKDAQ.VBP

The Visual Basic project file for the MOPAKDAQ.EXE ActiveX component.

CONFIG.CLS

This class module provides the nodes in the configuration data structure. This module's instancing is Private.

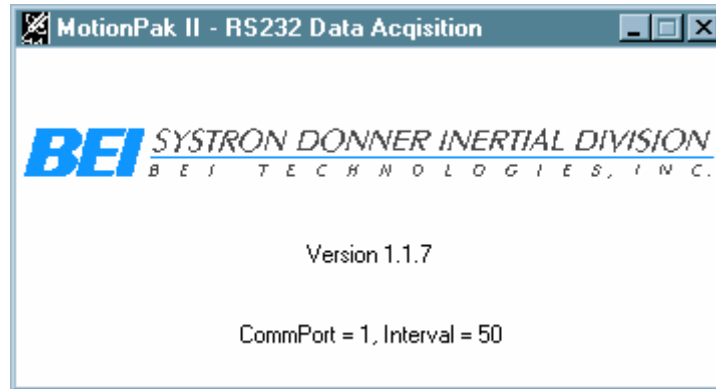
MYTIMER.CLS

This class module provides the time interval measurement functions using the highest resolution available on your system. This module's instancing is Private.

CONFIG.FRM

The Configuration Dialog Box described in the "Operating Instructions" section of this document.

MOPAKDAQ.FRM



The About Box described in the "Operating Instructions" section of this document. This form is the container for the MSComm ActiveX control which provides the serial communications functions. One instance of this form exists for each RS-232 port used by the Data Acquisition software.

In the MSComm1_OnComm event subroutine, the following functions are performed:

1. The Analog to Digital conversion is triggered.
2. The time interval measurement is taken.
3. Data is received from the RS-232 port.
4. Data is validated to determine the Data Fail Flags.
5. The voltage measurements are converted to inertial units.
6. The DataFrame event is raised for each application.

GLOBAL.CLS

This class module provides the ConfigDialog global method. This module's instancing is GlobalMultiUse.

INERTIAL.CLS

The Inertial object described in the "ActiveX Object Model" section of this document. This module's instancing is MultiUse.

GLOBAL.BAS

This module provides the configuration data and the configuration editing functions. When MOPAKDAQ.EXE starts up, the Main subroutine runs and initializes the configuration data.

I. Data Display Source Code

MOPAK.VBP

The Visual Basic project file for the MOPAK.EXE application.

INTEG.CLS

This class module provides the angle integration function.

MOPAK.FRM

This is the form described in the "RS-232 Data Acquisition" section of this document.

J. Sample Spreadsheet Macro Code

See the "Log Data to Spreadsheet" instructions in this document for how to view the macro code. The Run Macro push button on the spreadsheet is assigned the InertialDataAcq subroutine provided by Module1. The subroutine simply shows the UserForm1 dialog box. The macro code contained in UserForm1 is explained in the following.

```
Dim WithEvents DataAcq As MoPakDaq.Inertial
```

This is the declaration of the Inertial object described in the "ActiveX Object Model" section of this document. Note the WithEvents keyword is essential because it makes the DataFrame event available.

```
Private Sub UserForm_Initialize()  
    Set DataAcq = New MoPakDaq.Inertial  
End Sub
```

This is the form's initialization subroutine. Note the New keyword must be used to create the Inertial object.

```
Private Sub ToggleButton1_Click()  
    If ToggleButton1 Then  
        ...  
        DataAcq.Start = True  
    End If  
End Sub
```

This is the Get Data push button's action subroutine. If the button is depressed, the Start property of the Inertial object enables the DataFrame event.

```
Private Sub DataAcq_DataFrame(Omgx As Variant, _  
    Omgz As Variant, Omgz As Variant, Accx As Variant, _  
    Accy As Variant, Accz As Variant, Temp As Variant, _  
    dt As Variant, dff As Variant)  
  
    r = r + 1  
    DataSheet.Cells(r, cOmgx).Value = Omgx  
    ...  
End Sub
```

The DataFrame event subroutine receives the data in real time. The portion of code shown is storing the rotation rate Omgx into the spreadsheet cell located at row r and column cOmgx.

```
Private Sub UserForm_Terminate()  
    DataAcq.Start = False  
End Sub
```

This is the form's termination subroutine. Note that the DataFrame event must be disabled here otherwise the MOPAKDAQ.EXE ActiveX component will continue sending events to the nonexistent form, resulting in a pop-up error message.

RS-232 Interface

A. Overview

The RS-232 Interface performs a 12-bit Analog to Digital conversion of the LOW Analog Outputs (+0.5 to +4.5VDC) for the six inertial sensors and one temperature sensor. The interface does not provide a time interval measurement.

The computer must transmit a command to initiate the conversion for each sample. Sending a command without waiting for the response from the previous command may produce garbled receive data.

B. Serial Port Configuration

The MotionPak's serial port has a fixed configuration that can not be changed. A baud rate of 1200 to 9600 is automatically detected. The port settings are 8 data bits, 1 stop bit and no parity.

The computer's serial port should be configured for binary data, and to generate an interrupt or event after the expected number of bytes in the response is received.

C. Transmit Data Format

The A/D conversion command comes to two formats: one provides Bit Error Detection by having the MotionPak send the complement of data bytes in the Receive Data Format, and the other provides better throughput by using less data bytes.

Table 1. Transmit Data - No Error Detection

Byte	ASCII	Decimal	Hex	Description
1	!	33	21	Start of Message
2	0	48	30	RS-485 Address (always zero)
3	R	82	52	"Read"
4	A	65	41	"Analog"
5		6	06	Highest Channel Number (0 to 6)

Table 2. Transmit Data - With Error Detection

Byte	ASCII	Decimal	Hex	Description
1	#	35	23	Start of Message (with Bit Error Detection)
2	0	48	30	RS-485 Address (always zero)
3	R	82	52	"Read"
4	A	65	41	"Analog"
5		6	06	Highest Channel Number (0 to 6)
6		249	F9	Ones Complement of Highest Channel Number

D. Receive Data Format

The A/D reading data comes in formats either having or not having Bit Error Detection according to the command used. The response format has data for the Highest Channel Number first, and data for Channel 0 (zero) last. To calculate a sensor output in volts, multiply the A/D reading by 5 volts and divide by 4095.

Table 3. Receive Data - No Error Detection

Byte	Value	Channel	Sensor	Example Value (Hex)	Convert 12-bit to Volts
1	MSB	6	Temperature	09	2.969475
2	LSB			80	
3	MSB	5	Z Accel.	0B	3.700855
4	LSB			D7	
5	MSB	4	Y Accel.	08	2.522588
6	LSB			12	
7	MSB	3	X Accel.	08	2.528693
8	LSB			17	
9	MSB	2	Z Rate	08	2.518925
10	LSB			0F	
11	MSB	1	Y Rate	07	2.499389
12	LSB			FF	
13	MSB	0	X Rate	08	2.509157
14	LSB			07	

Notes for Example Values:

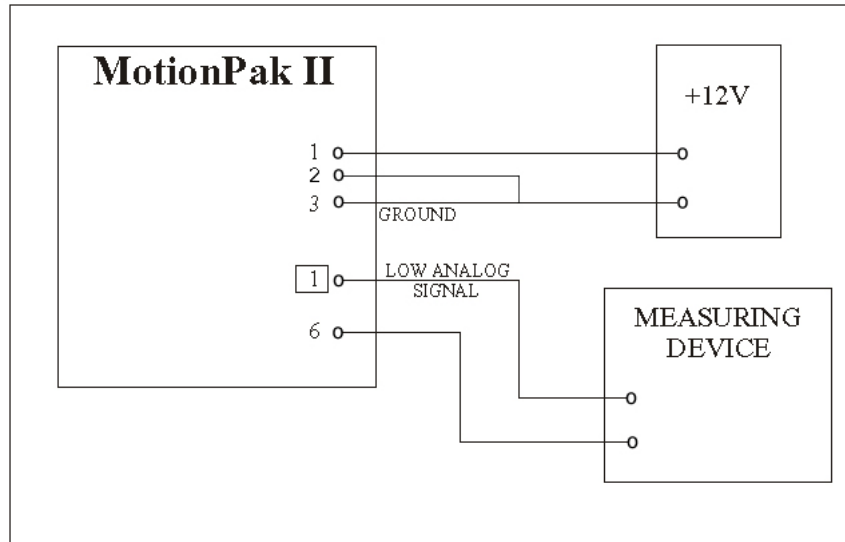
1. Nominal bias with zero inertial input is 2.5 volts
2. Z Accel has +1 g inertial input adding 1.2 volts
3. Temperature is 23.8°C

Table 4. Receive Data - With Error Detection

Byte	Value	Channel	Sensor
1	MSB	6	Temperature
2	255-MSB		
3	LSB		
4	255-LSB		
5	MSB	5	Z Accel.
6	255-MSB		
7	LSB		
8	255-LSB		
9	MSB	4	Y Accel.
10	255-MSB		
11	LSB		
12	255-LSB		
13	MSB	3	X Accel.
14	255-MSB		
15	LSB		
16	255-LSB		
17	MSB	2	Z Rate
18	255-MSB		
19	LSB		
20	255-LSB		
21	MSB	1	Y Rate
22	255-MSB		
23	LSB		
24	255-LSB		
25	MSB	0	X Rate
26	255-MSB		
27	LSB		
28	255-LSB		

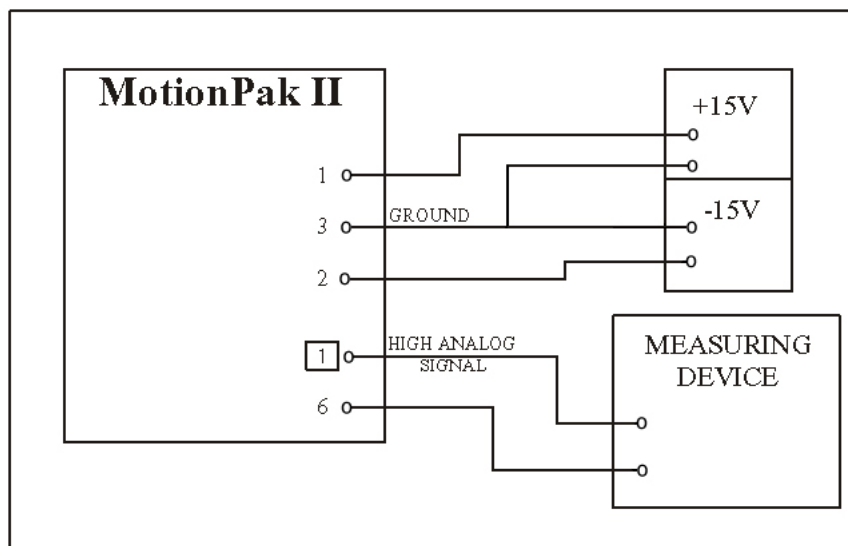
Quick set-up Diagrams

SINGLE SUPPLY OPERATION



1. Pins 18, 19, 20, 22, 23, 24 or 25 are all measured with respect to pin 6.
2. Pin 21 is used with differential inputs only.
3. Do not tie pin 21 to ground or damage may result.
4. Typically pin 6 is used for all signal returns.

DUAL SUPPLY OPERATION



1. Pins 5, 7, 9, 11, 14, or 16 are all measured with respect to pin 6.
2. Pin 21 is used with differential inputs only.
3. Do not tie pin 21 to ground or damage may result.
4. Typically pin 6 is used for all signal returns.