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Chapter 2 Technical Notes

Highlights of the DATAshuttle

Maximum Resolution

DATAshuttle-16: *16 Bits (.0015%)*

DATAshuttle-12: *12 Bits   (.024%)*

Maximum Speed

DATAshuttle-16: *2   kHz*

DATAshuttle-12: *5   kHz*

All DATA*shuttles* Feature

8 Differential analog input channels · Dynamic resolution · 8 Digital I/O lines, user configurable, with provision for digital isolation modules · Six voltage input ranges, and Autoranging · Wide acceptance of sensor devices · High noise rejection integrating converter · Software linearization for RTDs and Thermocouples · Input protection to 50 Volts continuous · On-unit counter/timer · Two optional analog output channels · Parallel passthrough port for multiple DATAshuttles or printer on same port · Factory guaranteed accuracy for two years from date of purchase

Chapter 1: Introduction & Installation of the DATAshuttle

Thank you for selecting the DATA*shuttle* for your project!

Our primary objective is to provide you with data acquisition systems that are easy to install, operate, and maintain. We also strive to furnish the performance you need at the lowest overall cost. The benefits for you are increased productivity, data you can count on, and, of course, meeting your budget.

We manufacture the DATA*shuttle* as an enhancement product that readily plugs into the parallel port of an IBM, or compatible, desktop or portable computer.

The product's high noise rejection, input protection to withstand as much as 50 Volts, and guaranteed long term stability make it ideal both for the laboratory and for harsh industrial environments. With its parallel port interface, built-in terminal panel, and compact, light size, the DATA*shuttle* is also completely portable, providing for a quick and easy set-up in both in-house labs and remote test sites.

Using the DATA*shuttle* together with our graphical interface application software (such as WorkBench PC™ for Windows or DOS, or QuickLog™ PC), you can easily and very quickly implement a broad spectrum of research and commercial tasks, in a wide variety of settings. You can, for example,

- **Display, and log data** *to disk for later analysis,*
- **Measure temperature, pressure, flow** *and most other analog inputs from sensors and instruments,*
- **Capture maximums, minimums, averages, or differences** *of measurements,*
- **Monitor and control processes***,*
- **Set alarm limits** *on any input,*
- **Control devices at preset levels** *(fans, pumps, heaters, etc.),*
- **Control devices from digital input** *(from switches or TTL signals), and*
- **Gather data unattended***.*

You can use the system interactively, operating controls or modifying your set-up while the system is running.

DEVELOPMENT SYSTEM People who decide, on the other hand, to write their own software (rather than using an off-the-shelf application) can employ the Analog Connection Development System™ hardware driver to address all features of the unit from within a program they design and code for their specific purpose.

EXPANDABILITY All DATA*shuttle*s have eight differential analog input channels and 8 digital input/output lines; and you can add one DATA*shuttle* at a time to your computer, for as many as 15 units with a total of 120 analog input channels and 120 digital I/Os!

RANGES/ UNITS OF MEASURE The six input ranges of the DATA*shuttle* span from 50 milliVolts through 10 Volts DC, making it capable of accepting data from almost any sensor. You can, as well, install a resistor, making the DATA*shuttle* capable of DC current measurements.

Its high accuracy makes the DATA*shuttle* ideal for precise evaluations in the laboratory or field.

The DATA*shuttle* together with our software – such as WorkBench PC for Windows or DOS and QuickLog PC – make it easy to specify engineering units (degrees, volts, milliAmperes, etc.) for measurements, as well as which ranges to use.

(You can measure temperature, for example, by selecting from among 11 different thermocouple types, or from a wide variety of resistance temperature devices – RTDs. With the application software, the process simply consists of selecting the type of sensing device from a menu – the driver itself automatically handles cold junction compensation and linearization.)

DATA PRESENTATION The combination of OMEGA hardware and application software (WorkBench PC for Windows or DOS or QuickLog PC) enables both the display of data on the screen, and the logging of data to disk for later analysis.

The system is capable of showing data on the monitor in a variety of formats. On-screen meters can provide accurate readings of any parameter on any channel. Chart displays can indicate trends for comparison of actual measurements on several channels, or for setting data points or alarms.

DYNAMIC RESOLUTION All DATA*shuttle*s incorporate "Dynamic Resolution," which improves the unit's accuracy.

With this feature, resolution is greater at the lower (negative) end of any range than at the higher end. As your readings approach the low end of any given range, the resolution becomes finer (that is, the increments of the signal you can distinguish become smaller).

Dynamic resolution improvement is most noticeable when the signal remains below a 10% of full scale threshold (approximately). Our products, consequently, are the best available for taking accurate measurements of low-level signals, as you would using a thermocouple sensor.

Dynamic resolution is always best toward the negative end of any range:

Figure 1. Dynamic Resolution for Dissimilar Ranges –
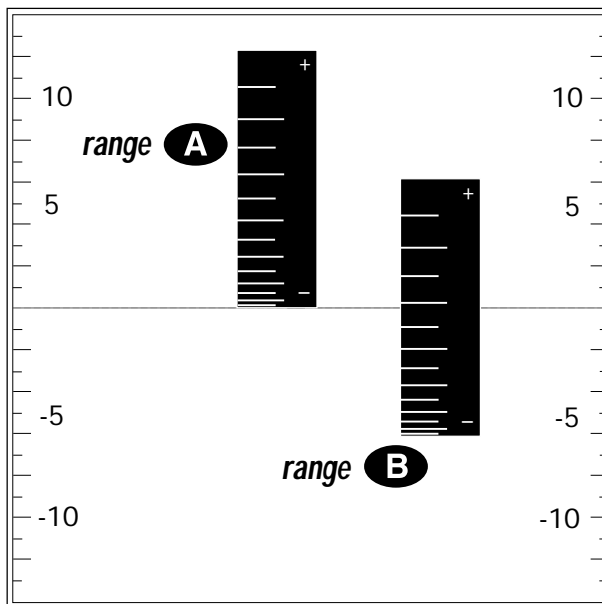
Two vertical black "rulers" (range **A** and range **B**) portray the impact of Dynamic Resolution. Their graduations – representing their ability to resolve – are always finer at the lower (more negative) ends of their ranges, regardless of the spectrum of values the ranges are measuring.

Features and Configurations

The DATA*shuttle*-12 is capable of attaining 12 bit resolution (that is, .024% of signal), while the DATA*shuttle*-16 can achieve 16 bit resolution (.0015% of signal). The units possess these features:

ANALOG INPUT CHANNELS Both the DATA*shuttle*-12 and the DATA*shuttle*-16 have eight differential analog input channels.

RESOLUTION SELECTIONS The resolution of the DATA*shuttle*s is selectable in software. For the DATA*shuttle*-12, resolution ranges from 9 through 12 bits. With the DATA*shuttle*-16, it extends from 12 through 16 bits.

(These products also feature advanced "dynamic resolution." See page 1 – 3 for further explanation.)

DATA ACQUISITION SPEED The data acquisition rate for the DATA*shuttle*-12 reaches as high as 5 kHz at 9 bits, in burst mode, while the maximum rate for the DATA*shuttle*-16 is 2.0 kHz at 12 bit resolution.

RANGES DATA*shuttle*-12 and DATA*shuttle*-16 products have six voltage ranges, all selectable individually for each analog input channel.

NOISE REJECTION All DATA*shuttle*-12 and DATA*shuttle*-16 models feature a high noise rejection integrating converter (in "low noise mode" it helps reject 50/60 Hz AC power line interference).

SENSORS The DATA*shuttle* supports accurate cold junction compensation and linearization for thermocouple devices, and signal conditioning for resistance temperature devices (RTDs).

ACCURACY We guarantee the factory calibration of the DATA*shuttle* for a period of two years from the date of purchase. Calibration constants are stored in non-volatile memory on each DATA*shuttle*.

INPUT PROTECTION Built-in circuitry assures protection of analog input channels for ±50 Volts continuous.

DIGITAL I/O All DATA*shuttle*s feature eight digital input/output channels that the user can configure individually to be input or output.

COUNTER/TIMER Every DATA*shuttle* includes a counter/timer for precise timing (for counting pulses or other events) which you can also use as a pulse output.

ANALOG OUTPUT CHANNELS All DATA*shuttle*-AO models feature two optional 12-bit analog output channels with one current (4-20mA) and six voltage ranges, software selectable.

FOR MORE INFORMATION　For more information about the capabilities of your DATA*shuttle*, please see the "Product Specifications" in Chapter 2.

For instructions on controlling the unit with our interface software (such as WorkBench PC for DOS or Windows or QuickLog PC), refer to that particular software manual.

To learn more about data acquisition and process control in general, and how to use the Analog Connection systems together to accomplish everyday tasks, consult our *Applications* manual.

And, last but not least, if you're creating your own program to address the unit for a custom purpose, please see the *Analog Connection Development System* manual.

SYSTEM REQUIREMENTS　Before installing the DATA*shuttle*, make sure the computer system fulfills these minimum requirements:

Hardware –

- **IBM PC AT (or higher) or -compatible**, *with at least 640k system RAM,*

- **Floppy disk drive** *and a hard drive.*

Software Environment –

- **DOS 3.0** *(or higher, depending on the application software),*

- **Application software** *(WorkBench PC for DOS or Windows, QuickLog PC, the Analog Connection Development System, or other compatible proprietary software; please see your software manual for directions for using it with the DATAshuttle).*

PACKAGE CONTENTS　Your DATA*shuttle* package should include:

- *One DATAshuttle*

- *One 6V 1A AC Adapter (for U.S. market; may differ for international markets)*

- *One parallel cable (DB-25 M-F)*

- *This manual, including DATAshuttle, QuickLog PC, Applications, and AC Development System*

- *One QuickLog PC Disk*

- *One AC Development Disk*

DATAshuttle Model Variations

The DATA*shuttle* family line offers 3 basic model variations, each available with either 12- or 16-bit resolution and 2 optional analog outputs, for a total of 12 model types.

DATA*shuttle*-GP The DS-12-8-GP and DS-16-8-GP are general purpose units designed for all types of inputs. The DATA*shuttle*-GP features terminals for 8 differential analog inputs and 8 digital I/O lines, with room for up to 8 high-power optically isolated modules.

DATA*shuttle*-RTD The DS-12-8-RTD and DS-16-8-RTD are specifically designed for high accuracy RTD measurements. The DATA*shuttle*-RTD has signal conditioning set resistors pre-installed at the factory for use with two or three wire RTDs. This model also features terminals for 8 digital I/O lines, with room for up to 8 optically isolated modules.

The DATA*shuttle*-RTD can also measure non-RTD inputs. For channels that are required to measure other signals, remove the pre-installed resistors at R3 and R4. See example in the Analog Auxiliary Components section of Chapter 2 for a more detailed illustration.

Figure 2. Illustration of the DATAshuttle-GP and DATAshuttle-RTD –
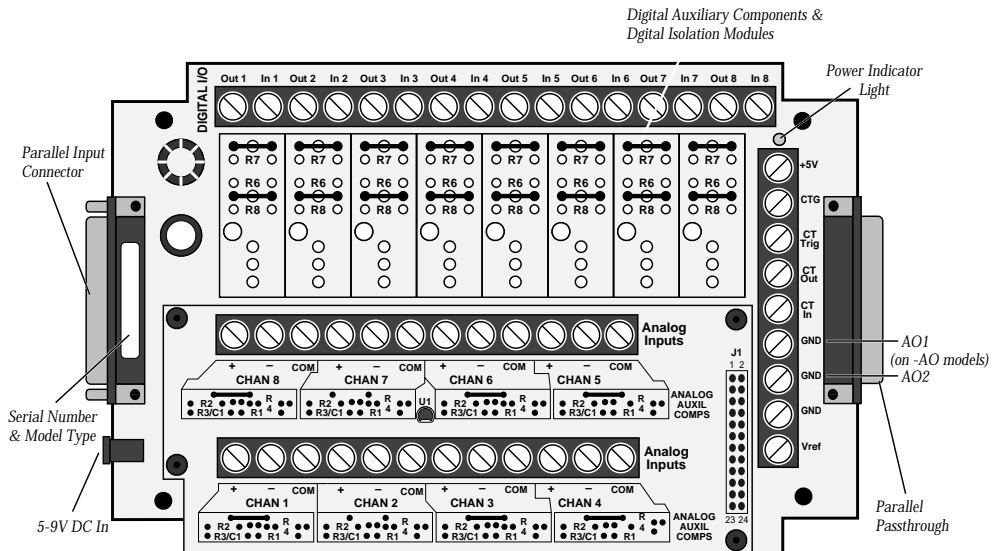
DATA*shuttle*-TC The DS-12-8-TC and DS-16-8-TC are the best models for thermocouple measurement. The DATA*shuttle*-TC has a large aluminum isothermal plate with screw terminals for 8 analog inputs. This isothermal plate improves accuracy by attenuating temperature differences at the cold junction connector. Without this plate, the connectors can vary in temperature by 5˚C or more, causing a similar error in the reading reported by the DATA*shuttle*.

The plate, however, does not prevent measurement of other signals, such as voltage or current. In addition, the DATA*shuttle*-TC features 8 digital I/O lines, with room for up to 8 optically isolated modules.

Figure 3. Illustration of the DATAshuttle-TC –
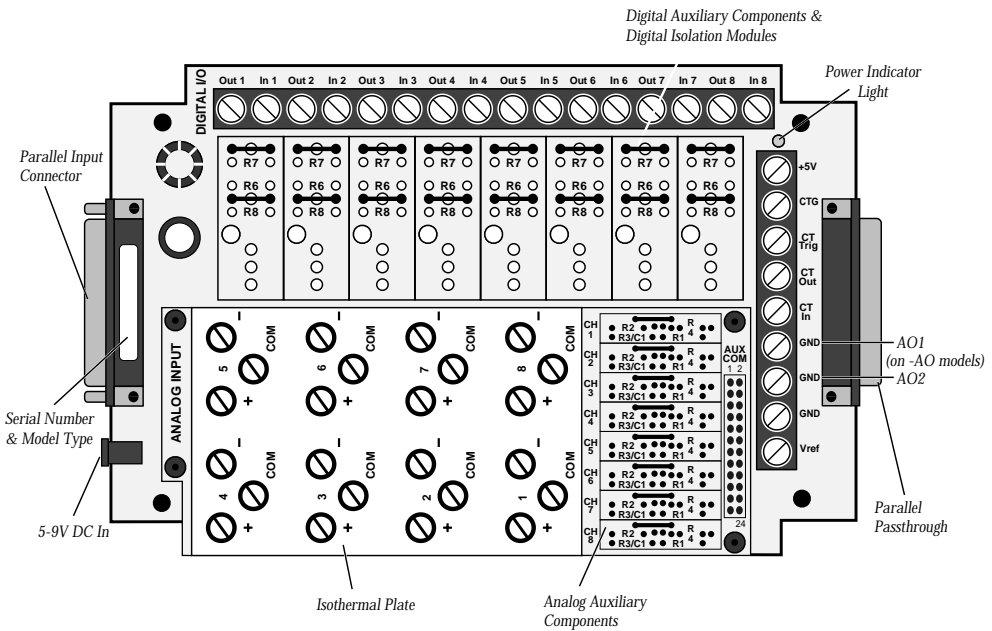
Installing Your DATAshuttle

Getting your DATA*shuttle* up and running is a straightfoward process; you only need to:

· **Connect the DATAshuttle to the parallel port** *of a computer, and*

· **Connect power to the DATAshuttle**.

Guidelines for loading the software, and for starting up, depend on the application program you are going to use (such as our WorkBench PC for DOS or Windows, or QuickLog PC, or a package by a third party developer who has our authorization).

The program you are going to use with the DATA*shuttle* might even be unique and proprietary, a product of your organization. (The Analog Connection Development System is a powerful set of utilities making it possible for software engineers to design and develop their own programs to exploit the DATA*shuttle*'s many features).

In any event, please refer to the software provider's installation manual, or user guide, for specific information on how to load and run the particular program.

Troubleshooting – If you have any difficulty getting your unit to work, refer to the "Troubleshooting" section in Chapter 2.

Physical Installation

Installation very simply consists of plugging the DATA*shuttle*'s DB-25 cable into the parallel port outside your computer. The DATA*shuttle* may be used in combination with any of our data acquisition products.

SINGLE UNIT INSTALLATION

To Install a DATAshuttle–

1. **TURN THE COMPUTER OFF!** Never plug anything into the computer's parallel port without first turning its power switch to the "off" position.

2. **Connect the parallel input connector** on the left side of the DATA*shuttle* to the parallel port on your computer with the provided DB-25 cable. The parallel port on the PC has 25 pins and is often labelled "Printer" or "LPT." Computers may have up to four parallel ports; the DATA*shuttle* may be connected to any one of these.

3. **Connect the provided AC Adapter** to the 6-9V DC input just to the side of the parallel port of the DATA*shuttle*. Plug the AC Adapter into an AC power line.

4. **Connect the sensors needed for your application:** Remove the top cover of the DATA*shuttle* by removing the four screws in the corners of the unit. Connect the sensors needed for your application to the DATA*shuttle* screw terminals. Replace the cover. You may wish to refer to the *Applications Reference Manual* for examples of particular applications.
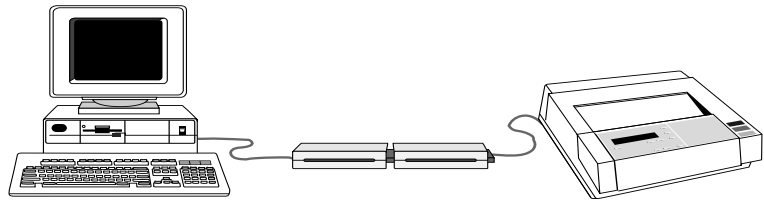
MULTIPLE UNIT INSTALLATION

To install more than one DATAshuttle– Follow the steps above to install the first DATA*shuttle*. Then for every additional DATA*shuttle* you wish to install, simply connect the parallel input port of that DATA*shuttle* to the passthrough port of the previously installed DATA*shuttle*. You may use the additional DB-25 cables to do this, or you can plug the next DATA*shuttle* directly into the previous one. If you prefer to keep the units separate, you may also connect additional DATA*shuttle*s directly to any or all of the other parallel ports on your computer.

In any of these ways, you may connect up to 15 DATA*shuttle*s to one computer.

Please note, however, that only three DATA*shuttle*s, or only two DATA*shuttle*-AO models, may be powered off the same 6V, 1 amp AC Adapter. Therefore, you must connect a new AC Adapter (see Step 3 above) to every fourth (or third) DATA*shuttle* in a series.

Figure 4. Installation with multiple DATAshuttles and printer–

A Note on Board Numbers– When you are using multiple units in your installation, each unit needs to have an identity, or "board number," for the software to recognize it as "individual."

When the software is loaded, it will conduct a search for all installed hardware, scanning first for in-system boards and then for any DATA*shuttle*s connected to the parallel ports. Any plug-in boards that you have installed will be assigned a board number first. Then the DATA*shuttle* connected at LPT1 nearest to the computer will be assigned the next available board number. Additional DATA*shuttle*s on LPT1 will be assigned sequentially higher board numbers. This process will be repeated on LPT2, LPT3, and LPT4 until all units have received a board number.

PRINTER INSTALLATION ***If you wish to use a printer on the same parallel port as a DATAshuttle–*** Connect the printer cable to the passthrough port of the last DATA*shuttle* in the series.

KEYBOARD ADAPTER INSTALLATION ***For field applications where no AC power line is available–*** The Keyboard Adapter power cable (available optionally) may be used instead of the AC Adapter. To install, simply connect one end of the cable to the keyboard port on the computer. (This connector must be the six pin mini DIN style found on IBM PS-2s and most portable computers.) Plug the other end of the cable into the DATA*shuttle*'s DC input jack. Up to three DATA*shuttle*s may be powered off of one keyboard adapter. (See the "Multiple Unit Installation" section on page 1 – 9 for instructions on installing multiple DATA*shuttle*s.)

NEXT STEPS ***Installing the Software –*** For information on loading and configuring WorkBench PC for DOS or Windows, QuickLog PC, or other software please refer to the user guide for that software package.

Chapter 2: Technical Notes

Although operations in this chapter are seldom necessary during everyday data acquisition, you might want to refer to them at certain times during operation of the DATA*shuttle.* They are:

- · **Block diagram** *(of the DATAshuttle showing on-unit processing);*
- · **Editing calibration** *numbers to accommodate changes to your installation, or to restore missing files;*
- · **Auxiliary analog and digital components**
- · **Counter/Timer**
- · **Use with AC Development System software**
- · **Troubleshooting:** *some possible problems and solutions after installing, and during operation of your unit.*
- · **Specifications** *of the different DATAshuttle models.*

Figure 5. Block Diagram of DATAshuttle-12 and DATAshuttle-16 –
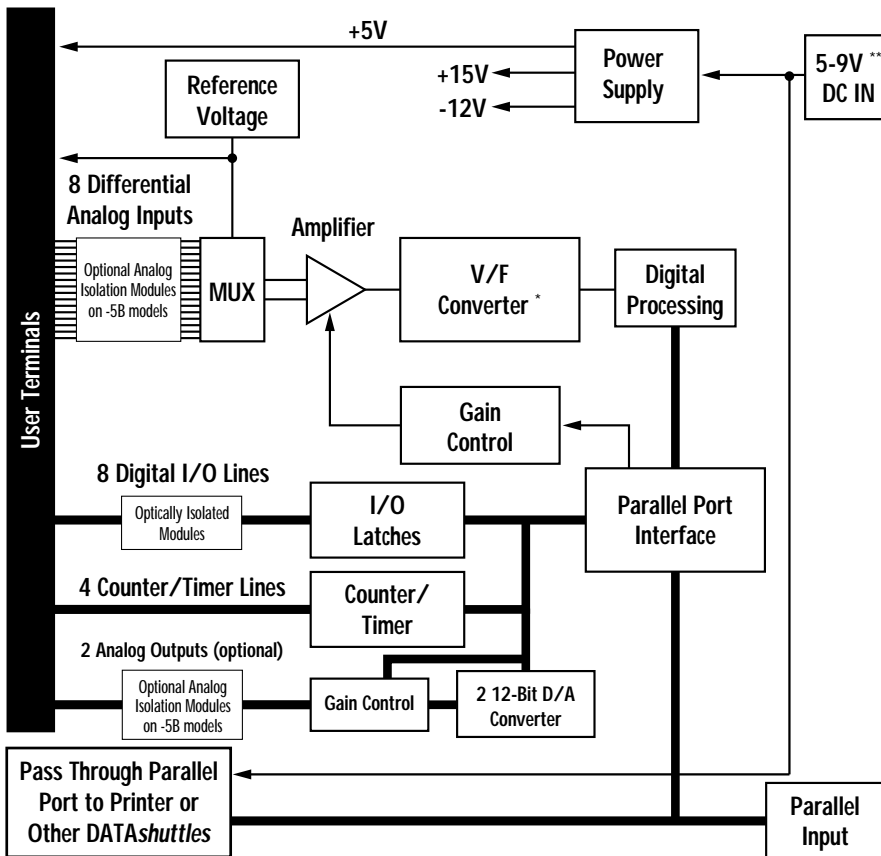
*V/F Converter: *12 bits for DATAshuttle-12; 16 bits for DATAshuttle-16*

Using EDITCAL

EDITCAL.EXE (or EDITCAL, for short) is our utility program that allows the modification of calibration numbers.

CAUTION Changing these numbers will affect the accuracy of the analog measurements.

STARTING Make sure the EDITCAL.EXE program file is in the same sub-
EDITCAL directory as the application programs.

Load the EDITCAL.EXE program from the keyboard:

To Start Up EDITCAL.EXE –

1. At the DOS prompt, enter **EDITCAL**, then press the **[ENTER]** key. (This invokes the utility.)

EDITCAL *To Select a Function –*
SELECTIONS

1. Use the arrow keys to navigate back and forth among these menu selections:

Data Files *To merge calibration files supplied from the factory into a single file for systems that have multiple units, or to update existing calibration files.*

AC EEPROM *To view or modify calibration data on Analog Connection units that have non-volatile on-unit EEPROMS.*

HS EEPROM *To view or modify calibration data on high speed units EEPROM, such as WB-WORKMATE or WB-FLASH12.*

DS EEPROM *To view/modify calibration DATAshuttle EEPROMs or perform analog recalibration*

QUIT *Ends this EDITCAL session.*

2. Move the arrow keys until DS EEPROM is flashing.

3. Press **[ENTER]**.

Continue – Proceed according to the on-screen instructions that appear after making your selection.

Help – At any time during your use of EDITCAL, press the **[F1]** key to display help about a field that is highlighted.

Auxiliary Analog and Digital Components

AUXILIARY COMPONENTS Auxiliary Components are required by some sensors, are used to protect digital signals, or are used to pull digital outputs to a set level. There are two areas (one digital and one analog) on the DATA*shuttle* for installing auxiliary components. Schematics of both Analog and Digital auxiliary components are shown in detail in Figures 6(a) and 6(b) below.

Figure 6. Schematic for Analog & Digital Auxiliary Components –

a. Analog Auxiliary Components, each channel

b. Digital Auxiliary Components, each channel
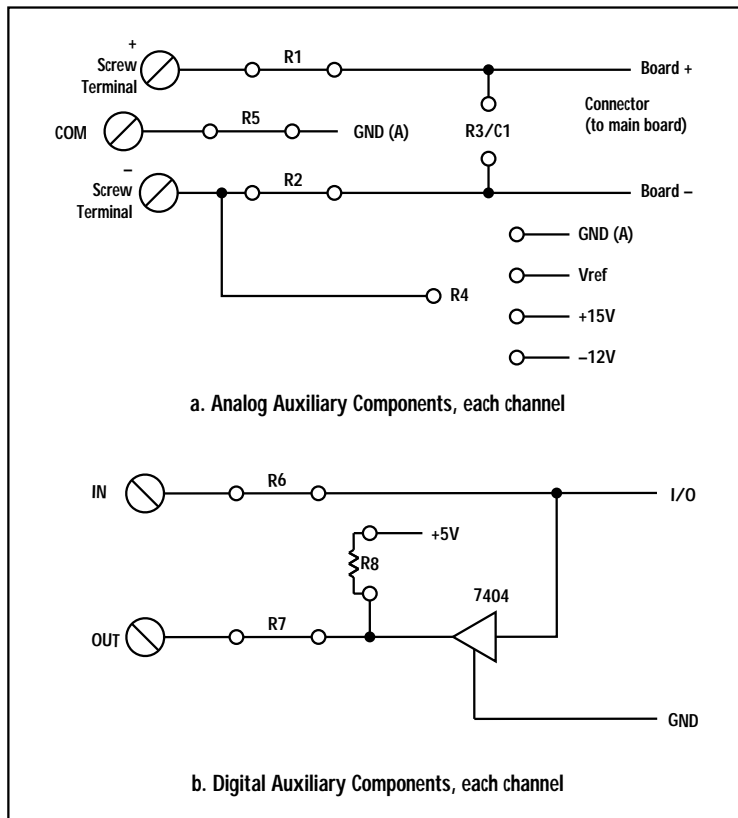
Each channel on the DATA*shuttle* has room for its own separate set of auxiliary components. Examples of their use can be found in the following pages and in the *Applications Reference Manual.*

ANALOG AUXILIARY COMPONENTS

Instructions for installing components–

Most common sensors can be connected without the use of auxiliary components. Some of the sensor installations (bridges, RTD circuits, voltage dividers and current sensors), however, require auxiliary components. These components can be installed on the DATA*shuttle* for convenience. This requires soldering and some familiarity with electronics. In the examples in the *Applications Reference Manual*, and the following, the component locations are shown but not the component values; you must calculate the values if they are not supplied with the sensor.

The first step is to remove the daughterboard from the unit, as you will need full access to it for soldering on the auxiliary components. To do this, simply remove the four screws in the corners of the daughterboard and lift it off of the DATA*shuttle*.
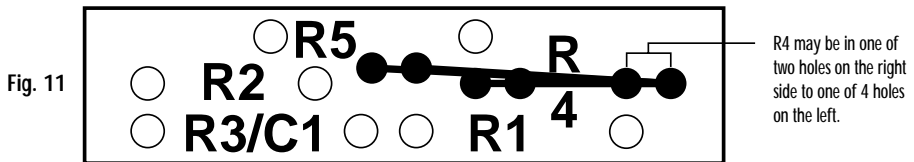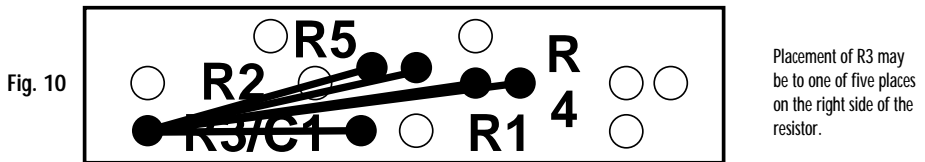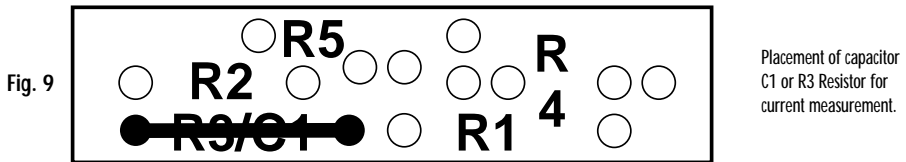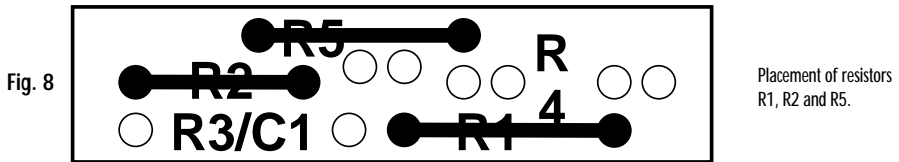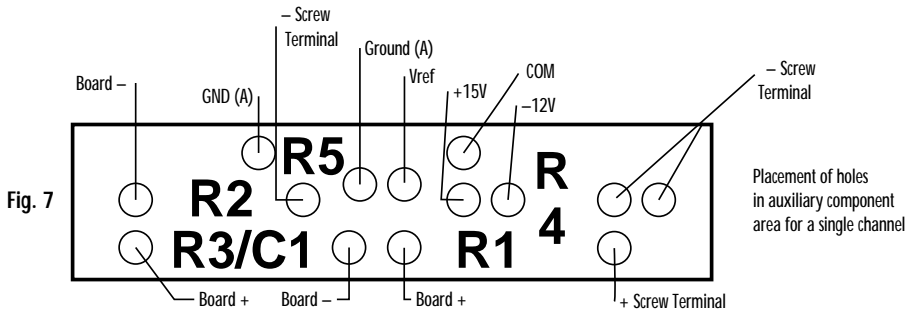
When using analog auxiliary components R1, R2, and R5 you must cut the shorting metal trace that connects the two ends of the line together before installing any of the components in these locations. Use a sharp knife to carefully slice through the trace without cutting additional traces. In the case of R5 this is a plastic covered metal wire. Diagrams of the auxiliary component area, hole functions, and connection possibilities are shown on the following page.

POWER SUPPLIES

A Note on Power Supplies – The DATA*shuttle* supplies the following voltages to power transducers, strain gauges, etc. The currents available to the user are limited as follows:

Voltage	Tolerance	Maximum Current (mA)	Output Impedance (ohms)
Vref(6.9V)	±5%	10	<1
+5V	4.5 to 5.0V	100	<50
+15V	±3%	10	100
-12V	±3%	10	100

Users of the open collector digital outputs and buffer amplifiers should be careful not to exceed these limits. Any power used from these supplies will add to the specified supply current used by the DATA*shuttle*.

Analog Auxiliary Component Area on the DATAshuttle –

Fig. 7

Board –   GND (A)   – Screw Terminal   Ground (A)   Vref   +15V   COM   –12V   – Screw Terminal

R5   R2   R3/C1   R4   R1

Board +   Board –   Board +   + Screw Terminal

Placement of holes in auxiliary component area for a single channel

Fig. 8

R5   R2   R3/C1   R4   R1

Placement of resistors R1, R2 and R5.

Fig. 9

R5   R2   R3/C1   R4   R1

Placement of capacitor C1 or R3 Resistor for current measurement.

Fig. 10

R5   R2   R3/C1   R4   R1

Placement of R3 may be to one of five places on the right side of the resistor.

Fig. 11

R5   R2   R3/C1   R4   R1

R4 may be in one of two holes on the right side to one of 4 holes on the left.

EXAMPLES *Example 1: Current sense resistor*

The DATA*shuttle* can measure currents up to 50 mA directly. A 24.9 Ohm precision resistor needs to be installed in the auxiliary component area to do so. This connection for current measurement is shown below. (To see how this connection adds to the circuit, refer to Figure 6(a).) R3 is used as a shunt resistor across the positive and negative lines of the channel in use.

To install this resistor, push the resistor ends through the holes for R3 (from the terminal side) until the resistor lies flat with the panel surface. On the back side, solder the wires to the holes, and then clip off the extra wire with pliers. This connection does not require any additional traces to be cut.

Be sure to select current measurement in the software package that you are using. This installation allows the measurement of voltage across the resistor and the conversion of this measurement to current using the equation V=IR. Observe the power rating of the resistor you install at R3. Space is provided for a 1/4 Watt resistor.
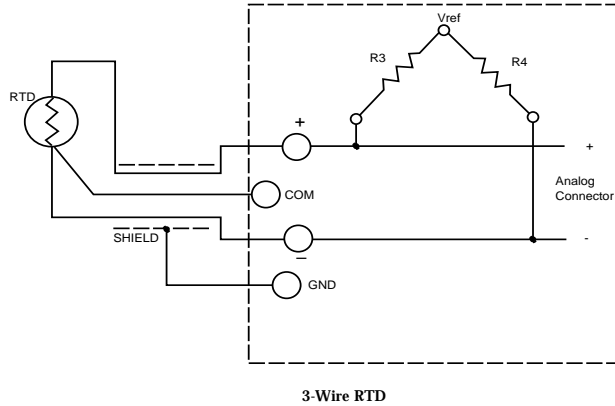
Figure 12. Current Measurement Connection –
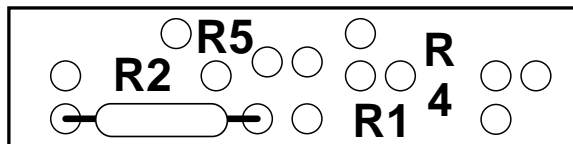
Example 2: 3-Wire RTD components

The most popular connection for RTDs is the three wire type. This sensor requires the installation of resistors R3 and R4. Both resistors are already installed in the DATA*shuttle*-RTD model.

Figure 13. 3-Wire RTD Components

3-Wire RTD

However, if you need to install these resistors yourself then do the following: Figure 10 and Figure 11 show the possible locations of R3 and R4. Figure 7 will show you that R3 and R4 need to be connected as in Figure 14. R5 is already in place and should not be removed. To install these resistors push the resistor ends through the holes for R3 and R4 as shown in Figure 10 (from the terminal side) until the resistor lies flat with the panel surface. If two wires cannot fit into the Vref hole then one wire may be soldered to another that is already inserted. On the back side solder the wires to the holes. Then clip off the extra wire with pliers. The auxiliary component area in question will now look like Figure 14. This connection does not require any additional traces to be cut.

Figure 14. 3-Wire RTD Connection –
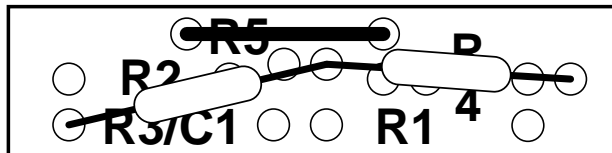
Example 3: Ground loops

Occasionally there is an installation where the ground connection is made at the sensor, but it is not reliable. The solution to this "intermittent" ground is to replace the COM to GND(A) jumper wire at R5 (Figure 6(a)) with a 10 Megohm, 5%, 1/4 Watt resistor. This provides a ground reference for the analog inputs in question, but allows very little ground current to flow. In very noisy environments with intermittent grounds, a smaller resistor may be used if the readings are erratic.

To install this resistor the wire at R5 must first be removed. After R5 has been removed push the resistor ends through the holes for R5 (from the terminal side) until the resistor lies flat with the panel surface. On the back side, solder the wires to the holes. Then clip off the extra wire with pliers. The auxiliary component area in question will now look like Figure 15. This connection does not require any additional traces to be cut.

Figure 15. Ground Loop Connection –
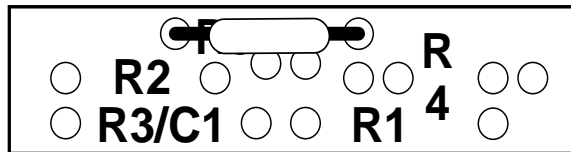
DIGITAL
AUXILIARY
COMPONENTS

Installing Digital Modules –

Modules are available to safely connect the digital I/O lines to high voltage AC and DC sources. There are four basic types:

· *AC output: to switch AC power (relay)*

· *DC output: to switch DC power (relay)*

· *AC input: to sense AC voltage*

· *DC input: to sense DC voltage*

The output types are used to switch loads on and off. The input types are used to sense the high/low status of a signal. All of the modules provide optical isolation between the high voltage and terminations.

These modules may be installed on any DATA*shuttle*. You may have had modules installed at the factory. If not, you may do the installation yourself. First, remove the jumpers labeled R6 and R7. This disconnects the digital I/Os from the terminals. The module will not fit into the panel until these jumpers are removed. Then, simply insert the module and fasten the retention screw.

The terminals for that I/O have now changed their function from low voltage I/O to high voltage isolated I/O. The two terminals become one input channel (high and low lines), or one output channel (like relay contacts), depending on the type of module you have installed.

CAUTION When using these terminals as input lines, be sure to connect the positive line to the old OUT terminal and the negative line to the old IN terminal. Failure to do this will result in the module not switching.

Installing Pull-up Resistors –

As noted in the *Applications Reference Manual* and previously in this manual, the digital outputs are open collector and must have a power source connected in order to drive loads. Merely connecting the output terminal through a load (such as a bulb) and then to digital ground will not work. In this case, a pull-up resistor connecting the output terminal to a power supply will complete the circuit.

This pull-up resistor is installed in position R8, as shown in Figure 6(b), which connects the output to the unit's +5 volt power supply.

Figures 2 and 3 in Chapter 1 show the physical location of R8 on the DATA*shuttle.* Note that R8 must be installed manually between the +5 volt supply and the output terminal in question.

To install this resistor, push the resistor ends through the holes for R8 (from the terminal side) until the resistor lies flat with the panel surface. On the back side, solder the wires to the holes. Clip off the extra wire with pliers. This connection does not require any additional traces to be cut.

Installing Current Limiting Resistors –

To limit the current in the digital input line, install a resistor in the R6 position (remove the corresponding jumper first).

Install a resistor in the R7 position (after removing the jumper) to limit the current in the digital output line.

Counter/Timer

The DATA*shuttle* features one 16 bit counter/timer that may be used to count up to 2^{16} (65,535) events. The maximum rate of pulses it can measure is 3MHz. The counter/timer is connected to an internal 2MHz clock, allowing it 0.5µS resolution.

There are four dedicated terminals for the counter/timer:

Counter/Timers lines available on the DATAshuttle –

Label	Name	Function
CTG	Gate	Input/output functions may operate when this line is high and stop when it is low
CT Trig	Trigger	Initiate input or output functions on rising edge
CT Out	Output	Output pulses or square waves
CT In	Input	Measure frequency of pulses, count pulses, or time events

All of these lines are TTL compatible. Please note that they may not be optically isolated with modules.

For more information and examples about the uses of the counter/timer please see the *Applications Reference* or *QuickLog* manuals.

Use With the AC Development System

The DATA*shuttle* was developed using the framework of our WB-AAI/FAI family of plug-in data acquisition boards. As a result, the DATA*shuttle* responds to the same commands in our AC Development System software as these boards. Should you wish to use the AC Development System with the DATA*shuttle,* you should treat the DATA*shuttle-12* as an WB-FAI and the DATA*shuttle-16* as an WB-AAI. Please note, however, that there are two significant differences between the DATA*shuttle* and WB-AAI/FAI boards:

1. The DATAshuttle contains its calibration numbers in onboard nonvolatile RAM (ACAL, BCAL, DCAL and CCAL) instead of in a calibration file. CALIB.DAT is not necessary.

2. The DATAshuttle has different minimum sample periods (set by the J or j commands) than the WB-AAI/FAI boards. They are as follows:

Minimum sample period for DATAshuttle-12[†] –

Resolution	Sample Period (Single Channel)	Sample Period (Multiple Channels)
9 bits	167 μS	250 μS
10 bits	200 μS	294 μS
11 bits	333 μS	357 μS
12 bits	455μS	500 μS
18 bits	*	*

Minimum sample period for DATAshuttle-16[†] –

Resolution	Sample Period (Single Channel)	Sample Period (Multiple Channels)
12 bits	455 μS	455 μS
13 bits	833 μS	909 μS
14 bits	1,250 μS	1,333 μS
15 bits	2,381 μS	2,500 μS
16 bits	4,545 μS	4,545 μS
18 bits	*	*

* Low noise mode; 16,667 if power line frequency is 60 Hz; 20,000 if 50 Hz

[†] Rates describe a 33MHz IBM 386DX. Minimums are somewhat lower in faster computers.

Troubleshooting: Installation

If you experience difficulty in getting your DATA*shuttle* up and running, please check to see that the installation is according to the descriptions in Chapter 1.

If the software reports a unit failure, or that it cannot find a DATA*shuttle*, then try these remedies:

1. ***Make sure the cable is securely connected*** from the DATA*shuttle* input connector to the parallel port on the computer.

2. ***Make sure the DATAshuttle is connected to a power source***, either an AC Adapter or Keyboard Adapter. A red light on the board will indicate that power is present.

3. ***Verify that the software is up to date*** (a version compatible with the unit you are using). Contact us, or your software provider.

4. ***Disconnect additional DATAshuttles*** and printers in your setup.

5. ***Connect the DATAshuttle to another parallel port.***

6. ***Remove any additional data acquisition cards*** from the computer.

7. ***If possible, install the DATAshuttle with another computer*** to verify its correct operation.

8. ***Remove other terminate and stay resident (TSR)*** programs from your system's AUTOEXEC.BAT file, temporarily. Also REM out any AUTOEXEC.BAT and CONFIG.SYS lines that relate to a PCMCIA port, such as device drivers, as these have been known to cause conflicts.

9. ***Make sure that you plug the DATAshuttle in and that power is connected*** before starting your computer. Many laptops will deactivate the parallel port at the start-up if nothing is attached to it.

10. ***Make sure that the Print Manager is not active in the Windows environment*** when attempting to start the DATA*shuttle*. Some computers automatically load the Print Manager at startup, and it can interfere with WorkBench PC *for Windows*' ability to communicate with the hardware. Printing is possible while using the DATA*shuttle* but not during the initial loading of the Work-Bench PC *for Windows* software.

(Please call our Technical Support line before returning a DATAshuttle – we hope to assist you with your problem via telephone.)

Troubleshooting: Operation

HINTS It's essential to have exactly one ground reference per channel. This single connection to ground makes sure you don't exceed the common mode range of input.

(More than one connection per channel can lead to ground loops, causing errors or erratic readings. Connecting the – to the Com terminal provides a single ground. Your sensor might also provide another ground. If you're not sure that your sensor is grounded, try connecting the – to Com, and not, and see which works best.)

Remember that if speed is not critical, selecting the "low noise mode" in software always provides the best accuracy and resolution with your data acquisition unit.

OPERATING Qs AND As Here are mini "case studies" of difficulties, along with some easy solutions:

Problem: **My unit reads analog inputs wrong.**

Action: Make sure the calibration numbers in the non-volatile memory are non-zero (run EDITCAL to check this). If the figures are correct, try shorting + to – to Com: the unit should return a reading around 0V.

Problem: **My unit reads the thermocouple as a very negative temperature.**

Action: Verify the connections are secure. Opens read as negative temperature.

Problem: **My readings are noisy.**

Action: Try using the low noise mode (see your software manual for more information).

Problem: **I can't measure any voltage change with my voltmeter on my digital output.**

Action: With nothing but a voltmeter connected, this is normal. The digital outputs are termed "open collector." These kind of outputs do not supply any voltage; it must be supplied from another source. This allows the flexibility to use any supply voltage up to 30V. The easiest way to see the state of any output terminal is to check the state of the input terminal with a voltmeter.

Problem: **My digital inputs are "high" with nothing connected to them.**

Action: This is normal. The digital inputs are pulled up to about 1.5 volts by leakage from the LS7407 chips. This is enough to read logic high. You can pull them low with a 470 ohm resistor to ground.

Problem: **Can I get any output signal from the digital input terminals?**

Action: Yes, you can use an input terminal to drive light loads such as a TTL input.

Problem: **What should I do with the jumpers connecting the analog input to COM?**

Action: In general, it is best to leave them connected as shipped.

Problem: **My 5V terminal reads only 4.6V.**

Action: This is normal. Tolerance is 4.5 to 5V.

Problem: **My analog output accuracy is poor.**

Action: From the DOS command line, or in GO.BAT, run GFIND -C. This calibrates analog outputs. Note, however, that calibration sends full scale outputs, so it may be necessary to remove any instruments connected to the outputs.

BEFORE CALLING CUSTOMER SUPPORT *Check the following key areas to validate whether or not the DATAshuttle is operational:*

1. Make sure the AC Adapter is not damaged. To do this, detach the adapter from the DATA*shuttle*, while leaving it plugged in to the wall outlet. Then measure the voltage between the inside and outside surfaces of the cylindrical connector. In this no-load condition, the voltage should measure approximately 9V. If this is not the case, it is likely that the AC Adapter will need to be replaced.

2. Check the power section of the DATAshuttle. After plugging the AC Adapter back into the DATA*shuttle*, check to make sure the LED is functioning. If the LED is not lighting up, then there is likely a problem with the power section of the unit. Contact technical support for further assistance.

3. Check the DATAshuttle's internal power supply. To do this, it is necessary to measure four voltage terminals on the unit itself: the +5V and Vref(6.9V) terminals, found at opposite ends of the terminal strip next to the passthrough connector, and the

+15V and the -12V terminals, which can be found on the raised section of the DATA*shuttle* called the terminal board. *(Please consult the diagrams on pages 1–6 and 1–7 if you are unable to locate these terminals.)*

If you have been installing resistors or capacitors on the analog input auxiliary section, then it is necessary to remove the terminal board and re-check the +5V and Vref voltages. If, after removal, these voltages return to normal, it is likely that there is a short-to-ground on the terminal board. Check the resistor/capacitor installations for such a short and reinstall the board.

If removal does not fix the +5 and -12 voltages, then there is a problem with the DATA*shuttle*'s internal power supply. Contact technical support for further assistance.

IF YOU NEED CUSTOMER SUPPORT

To help us serve you better, please have the following information ready:

1. Have the part number of your DATA*shuttle* ready.

2. Have the type and version number of the software you're using.

3. Have your computer's type, model, and the version of the operating system.

Product Specifications

ACCURACY *DATAshuttle-12 ACCURACY & RESOLUTION–*

	Range	Typical Resolution at Full Scale	Absolute Accuracy, the larger of	
			% of Range:	% of Reading:
VOLTAGE	*-5 to +50 mV*	*12 µV*	*0.08%*	*–*
	-25 to +25mV	*12 µV*	*0.16%*	*–*
	-50 to +500mV	*120 µV*	*0.05%*	*0.2%*
	-250 to +250 mV	*120 µV*	*0.05%*	*0.2%*
	-1 to +10 V	*2.4 mV*	*0.05%*	*0.2%*
	-5 to +5 V	*2.4 mV*	*0.05%*	*0.3%*

DATAshuttle-16 ACCURACY & RESOLUTION–

	Range	Typical Resolution at Full Scale	Absolute Accuracy, the larger of	
			% of Range:	% of Reading:
VOLTAGE	*-5 to +50 mV*	*0.8 µV*	*0.04%*	*–*
	-25 to +25mV	*0.8 µV*	*0.08%*	*–*
	-50 to +500mV	*8 µV*	*0.01%*	*0.05%*
	-250 to +250 mV	*8 µV*	*0.01%*	*0.05%*
	-1 to +10 V	*150 µV*	*0.01%*	*0.05%*
	-5 to +5 V	*150 µV*	*0.01%*	*0.10%*

General Conditions – From 15 to 35 degrees C, ambient at the interface unit, source resistance less than 1k Ohms. Includes linearity, drift, offset, resolution, and calibration error. In this table 12 bit (0.024%) resolution in use for the DATA*shuttle*-12, while 16 bit is in use for the DATA*shuttle*-16 (0.0015%).

DATAshuttle-12 THERMOCOUPLE ACCURACY –

Type	Range (°C.)	Resolution (°C.)	Accuracy (°C.)
J	-210 to -100	0.1 – 0.3	± 2.3
	-100 to 0	0.05	± 1.2
	0 to 880	0.05 – 0.2	± 1
K	-250 to -75	0.15 – 1.0	± 8
	-75 to 1260	0.07 – 0.3	± 1.4
	0 to 900	0.06 – 0.2	± 1.2
E	-250 to -70	0.1 – 0.5	± 4
	-70 to 100	0.04	± 1
	100 to 680	0.04 – 0.15	± 0.8
T	-250 to -50	0.15 – 0.8	± 6
	-50 to 10	0.02 – 0.8	± 1.4
	10 to 150	0.06	± 1.2
	150 to 400	0.06 – 0.1	± 1
S	-50 to 120	0.4	± 10
	120 to 380	0.3	± 5
	380 to 1770	0.2 – 0.6	± 4
R	-50 to 250	0.2 – 0.4	± 10
	250 to 800	0.2	± 4
	800 to 1770	0.2 – 0.4	± 3
B	200 to 300	0.7 – 1	± 20
	300 to 500	0.4 – 0.7	± 13
	500 to 1000	0.2 – 0.4	± 8
	1000 to 1820	0.2 – 0.4	± 4
G	25 to 200	0.2 – 1	± 15
	200 to 2315	0.15 – 0.8	± 4
D	-20 to 2315	0.2 – 1	± 4
	150 to 2000	0.15 – 0.6	± 3
C	-20 to 2315	0.15 – 1	± 4
	100 to 1500	0.15 – 0.4	± 3
N	-200 to -100	0.7 – 1.4	± 5
	-100 to 1300	0.4 – 0.7	± 3

DATA*shuttle*-16 *THERMOCOUPLE ACCURACY –*

Type	Range (°C.)	Resolution (°C.)	Accuracy (°C.)
	-210 to -100	0.02 – 0.04	± 1.2
J	-100 to 100	0.02	± 0.7
	100 to 880	0.01	± 0.5
	-250 to -150	0.03 – 0.15	± 4
K	-150 to -50	0.03	± 1
	-50 to 1260	0.02	± 0.7
	-250 to -100	0.08 – 0.01	± 2
E	-100 to 200	0.01	± 0.6
	200 to 680	0.01	± 0.4
	-250 to -120	0.03 – 0.1	± 3
T	-120 to -25	0.02 – 0.03	± 0.9
	-25 to 200	0.01 – 0.02	± 0.7
	200 to 400	0.01	± 0.5
	-50 to 50	0.1 – 0.2	± 5
S	50 to 300	0.1	± 3
	300 to 1770	0.08	± 2
	-50 to 25	0.1 – 0.2	± 5
R	25 to 200	0.1	± 3
	200 to 1770	0.08	± 2
	200 to 300	0.25 – 0.4	± 10
B	300 to 500	0.15 – 0.25	± 6
	500 to 1000	0.08 – 0.15	± 4
	1000 to 1820	0.08	± 2
G	25 to 200	0.08 – 0.3	± 8
	200 to 2315	0.08	± 2
D	-20 to 2315	0.04 – 0.08	± 2
	300 to 1500	0.04	± 1.3
C	-20 to 2315	0.04 – 0.08	± 2
	100 to 1500	0.05	± 1.5
N	-200 to -100	0.05 – 0.1	± 3
	-100 to 1300	0.02 – 0.05	± 1.5

Thermocouple Conditions – Same as General Conditions. Does not include the accuracy of the thermocouple itself (cold junction error must be added in; cold junction compensation with DATA*shuttle*-TCs only). Resolution assumes 12 bit resolution in use for DATA*shuttle*-12, 16 bit resolution for DATA*shuttle*-16; it is approximate as resolution varies with temperature measured.

Thermocouples use the 50 mV range. For inputs below -5 mV (below approximately -100 degrees C), use the +/-25 mV range.

Cold Junction Compensation Error – For the best resolution while using the DATA*shuttle*-TCs, use the 50 mV range above -5 mV. Cold Junction Compensation Error (degrees C) at terminal temperature of:

Type	25˚C	15˚ & 35˚C	5˚ & 45˚C
J	0	< 0.25	< 0.6
K	0	< 0.3	< 0.7
E	0	< 0.3	< 0.8
T	0	< 0.4	< 1.2
S	0	< 0.6	< 1.3
R	0	< 0.4	< 1.6
B	0	< 1.0	< 2.0
G	0	< 0.7	< 1.7
C	0	< 0.5	< 1.2
D	0	< 0.6	< 1.8
N	0	< 0.6	< 1.2

Cold junction compensation error is in reference to the temperature of the terminals. For types B and G the above error applies for measured temperatures above 200 degrees C only. The cold junction sensor can be recalibrated at any temperature from 0 to 50 degrees to improve the accuracy if it will not be used at 25 degrees.

Cold Junction Temperature Differential:

For the DATA*shuttle*-TC only, the temperature gradient in the air adjacent to the cold junction plate is attenuated 15 times when AWG #22 gage or smaller thermocouple wire is used and the wires are bundled together for at least one foot from the cold junction terminals. The error is usually less than 0.1 degree C.

For the DATA*shuttle*-GPs there is no isothermal plate. The cold junction compensation error consists of the above table plus the difference between the terminal temperature and the cold junction sensor. This difference can be several degrees. The above table applies only after user calibration of the cold junction.

DATAshuttle-12 RTD ACCURACY –

Set Resistor Ω	RTD Ω	Range °C.	Resolution °C.	Accuracy °C.
10 k	50	-200 to 115	0.02 to 0.1	0.9
20 k	50	-200 to 525	0.04 to 0.2	1.2
20 k	100	-200 to 115	0.02 to 0.1	0.9
50 k	50	-200 to >850	0.1 to 0.5	2.1
50 k	100	-200 to 750	0.05 to 0.2	1.4
50 k	200	-200 to 115	0.02 to 0.1	1.0
100 k	100	-200 to >850	0.1 to 0.5	2.1
100 k	200	-200 to 750	0.05 to 0.2	1.4
100 k	500	-200 to 115	0.02 to 0.1	0.9
200 k	200	-200 to >850	0.1 to 0.5	2.1
200 k	500	-200 to 525	0.04 to 0.2	1.2
200 k	1000	-200 to 115	0.02 to 0.1	0.9
500 k	500	-200 to >850	0.1 to 0.5	2.1
500 k	1000	-200 to 750	0.05 to 0.2	1.4
1000 k	1000	-200 to >850	0.1 to 0.5	2.1

DATAshuttle-16 RTD ACCURACY –

Set Resistor Ω	RTD Ω	Range °C.	Resolution °C.	Accuracy °C.
10 k	50	-200 to 115	0.005	0.8
20 k	50	-200 to 525	0.01	0.9
20 k	100	-200 to 115	0.005	0.8
50 k	50	-200 to >850	0.03	1.4
50 k	100	-200 to 750	0.01	1.0
50 k	200	-200 to 115	0.005	0.8
100 k	100	-200 to >850	0.03	1.4
100 k	200	-200 to 750	0.01	1.0
100 k	500	-200 to 115	0.005	0.8
200 k	200	-200 to >850	0.03	1.4
200 k	500	-200 to 525	0.01	0.9
200 k	1000	-200 to 115	0.005	0.8
500 k	500	-200 to >850	0.03	1.4
500 k	1000	-200 to 750	0.01	1.0
1000 k	1000	-200 to >850	0.03	1.4

RTD Conditions – Same as General Conditions. Does not include the accuracy of the RTD sensor itself. Includes linearization and signal conditioning errors.

Assumes 12 bit resolution in use for the DATA*shuttle*-12; 16 bit resolution in use for the DATA*shuttle*-16.

RTD measurements are on the 0-50 mV range.

INPUT IMPEDANCE All analog inputs have an impedance rating of >20MΩ

NOISE REJECTION *Important:* All noise measurements are in low noise mode, with inputs shorted to COM.

CMRR – Common Mode Rejection Ratio (CMRR) is >80dB under these conditions: DC to 100 Hz, common mode input ± 7.0 Volts channel to ground. This specification applies even when one or more nonmeasured channels exceeds the operating common mode range.

DATAshuttle NOISE REJECTION –

Range	Typical Internal Noise (RMS)
50 mV	*0.5 μV*
± 25 mV	*0.5 μV*
500 mV	*4 μV*
± 250 mV	*4 μV*
10 V	*50 μV*
± 5 V	*50 μV*

COMMON MODE RANGE **Operating, channel-to-ground –** ±7 Volts

Nonoperating – ±50 Volts continuous.

INPUT PROTECTION On analog input channels: 50 Volts continuous; 150 Volts momentary.

RESOLUTION/ SCAN RATE Both resolution and scan rate are selectable in software:

DATAshuttle-12 RESOLUTION AND SCAN RATE* –

Resolution	Scan Rate (Single Channel)	Scan Rate[†] (Multiple Channels)
low noise mode: 0.024 %	*50 / 60 Hz*	*50 / 60 Hz*
12 bits: 0.024 %	*2,200 Hz*	*2,000 Hz*
11 bits: 0.05 %	*3,000 Hz*	*2,800 Hz*
10 bits: 0.1 %	*5,000 Hz*	*3,400 Hz*
9 bits: 0.2 %	*6,000 Hz*	*4,000 Hz*

DATA*shuttle*-16 *RESOLUTION AND SCAN RATE* –*

Resolution	Scan Rate (Single Channel)	Scan Rate† (Multiple Channels)
low noise mode: 0.0015%	50 / 60 Hz	50 / 60 Hz
16 bits: 0.0015%	220 Hz	220 Hz
15 bits: 0.003 %	420 Hz	400 Hz
14 bits: 0.006 %	800 Hz	750 Hz
13 bits: 0.012 %	1,200 Hz	1,100 Hz
12 bits: 0.024 %	2,200 Hz	1,800 Hz

* Rates describe an IBM PC 386DX running at 33 MHz with a math coprocessor. Rates are somewhat faster in faster computers. Please also see the discussion of "Dynamic Resolution" on page 1 – 3.

† Preliminary

Scan Rate – Scan rate is the rate in Hertz (or, samples per second) to read data into memory, including the time it takes to switch channels and ranges.

To calculate the total scan time for all channels, divide the rate by the number of channels.

(After placing a burst of data into memory, and depending on your computer and software, the system requires additional processing time before the data are available to you, or before you can collect more data).

ANALOG INPUT   *For the analog input terminals on the DATAshuttle –*

·   *Maximum voltage on any terminal: 150 volts.*

·   *Maximum current on any terminal: 1 Amp.*

DIGITAL INPUT/OUTPUT   *For the Digital Input/Output termination on the DATAshuttle –*

·   *Each line is individually selected to be an input or output.*

·   *Inputs are TTL and MOS compatible*

·   *Outputs are high voltage open collector:*
    Low Level: 50 mA max, < 0.7 volts at 40 mA (sink)
    High Level: 30 volts max, <250 μA (source)

·   *TTL outputs are available at the input terminals when an I/O is set to an output:*
    Low Level: < 0.4 volts at 2 mA (sink)
    High Level: > 2.4 volts at 100 μA (source)

COUNTER/TIMER The DATA*shuttle* has one on-unit 16 bit counter/timer with 2 MHz internal clock. It can count pulses as fast as 3 MHz.

- *Low Level: <0.4 volts at 2mA (sink)*
- *High Level: >2.4 volts at 100 µA (source)*

ANALOG OUTPUT *For the analog output terminals on the DATAshuttle-AO –*

- *Voltage compliance: will drive up to 1K load positive or negative*
- *Current compliance: 3 to 30V, sinking current only*
- *Maximum output speed: 2KHz (preliminary)*

DATAshuttle-AO RESOLUTION AND ACCURACY –

Output Range	Nominal Resolution	Accuracy
0 to 10V	2.4mV	±10mV
0 to 5V	1.2mV	±5mV
0 to 2V	0.48mV	±3mV
±5V	2.4mV	±10mV
±2.5V	1.2mV	±5mV
±1V	0.48mV	±3mV
4 to 20mA	3.9µA	±50µA

GENERAL INFORMATION *General specifications of the DATAshuttle –*

- *Analog input operating ambient temperature: 0 to 50 degrees C, 5 to 90% RH, noncondensing*
- *Input power voltage range: 5.0 to 9.0 VDC*
- *Maximum input voltage before damage: 10.0VDC*
- *Supply current consumed with no external loads: <450mA*
- *Polarity of DC input connector: Outer surface +, inner surface -*

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