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DATA TRANSLATION®

UM-10546-E

DT2802
User Manual

Chromatography Board for the
IBM® Personal Computer AT and Compatibles

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Fifth Edition
April, 1992

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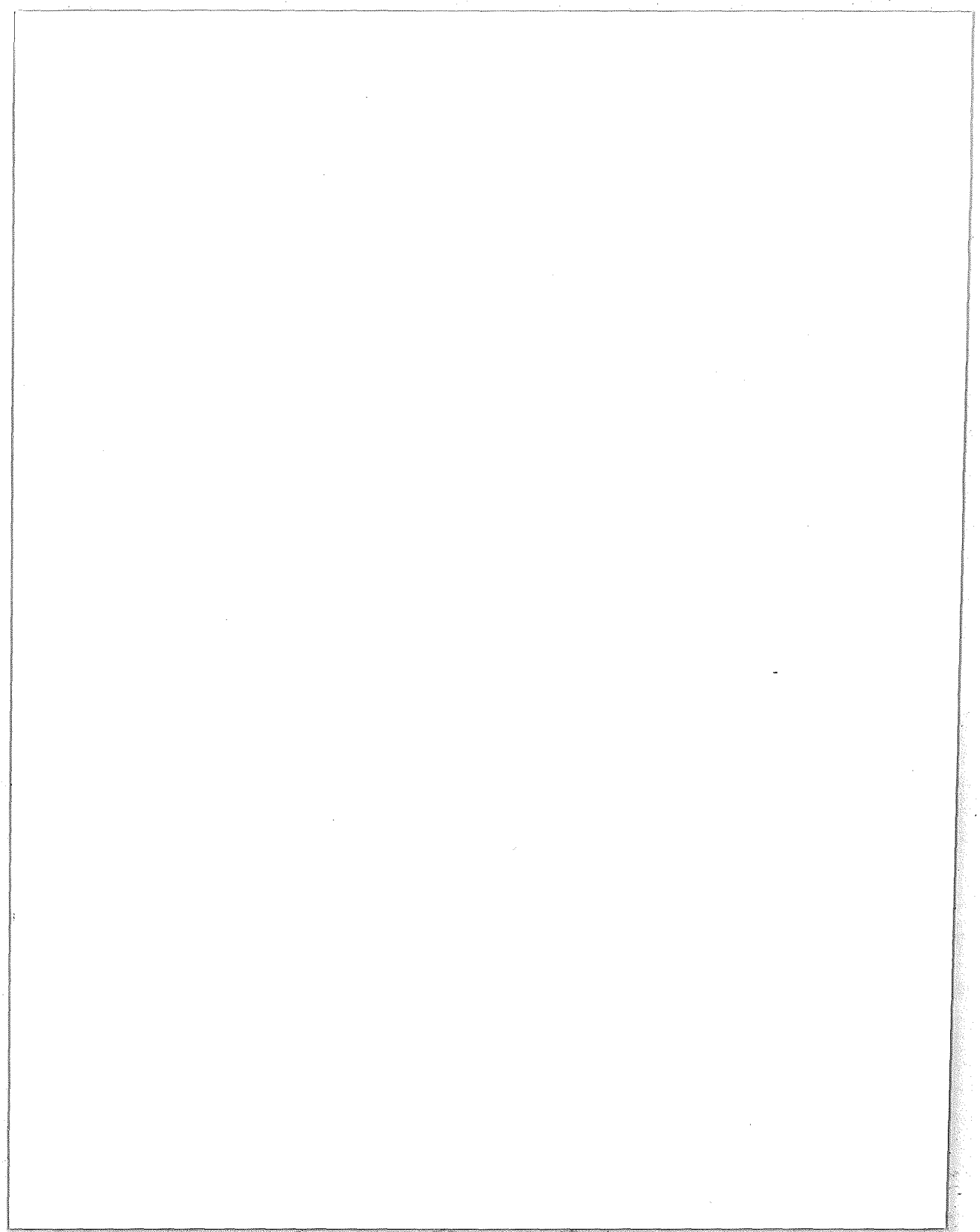
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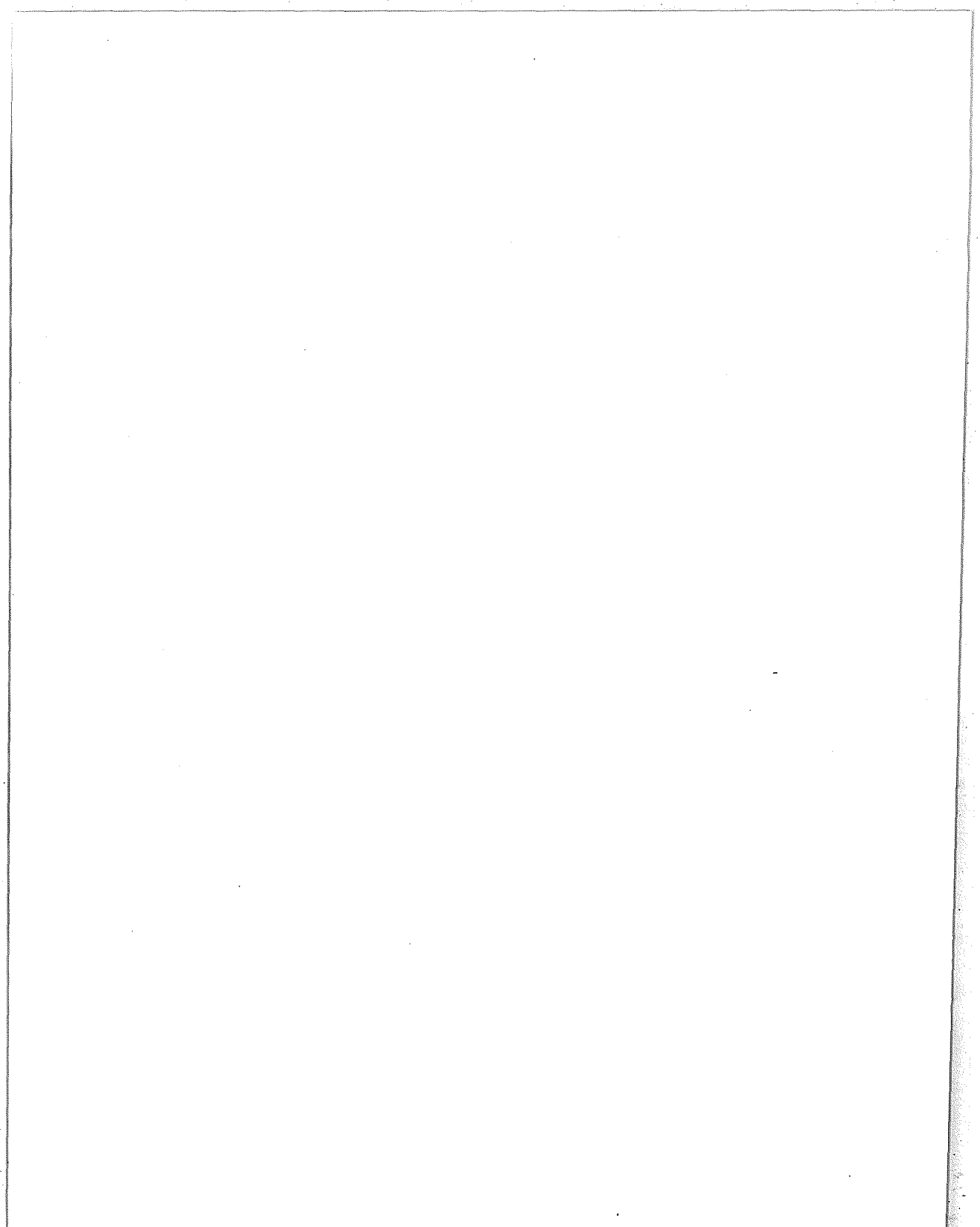
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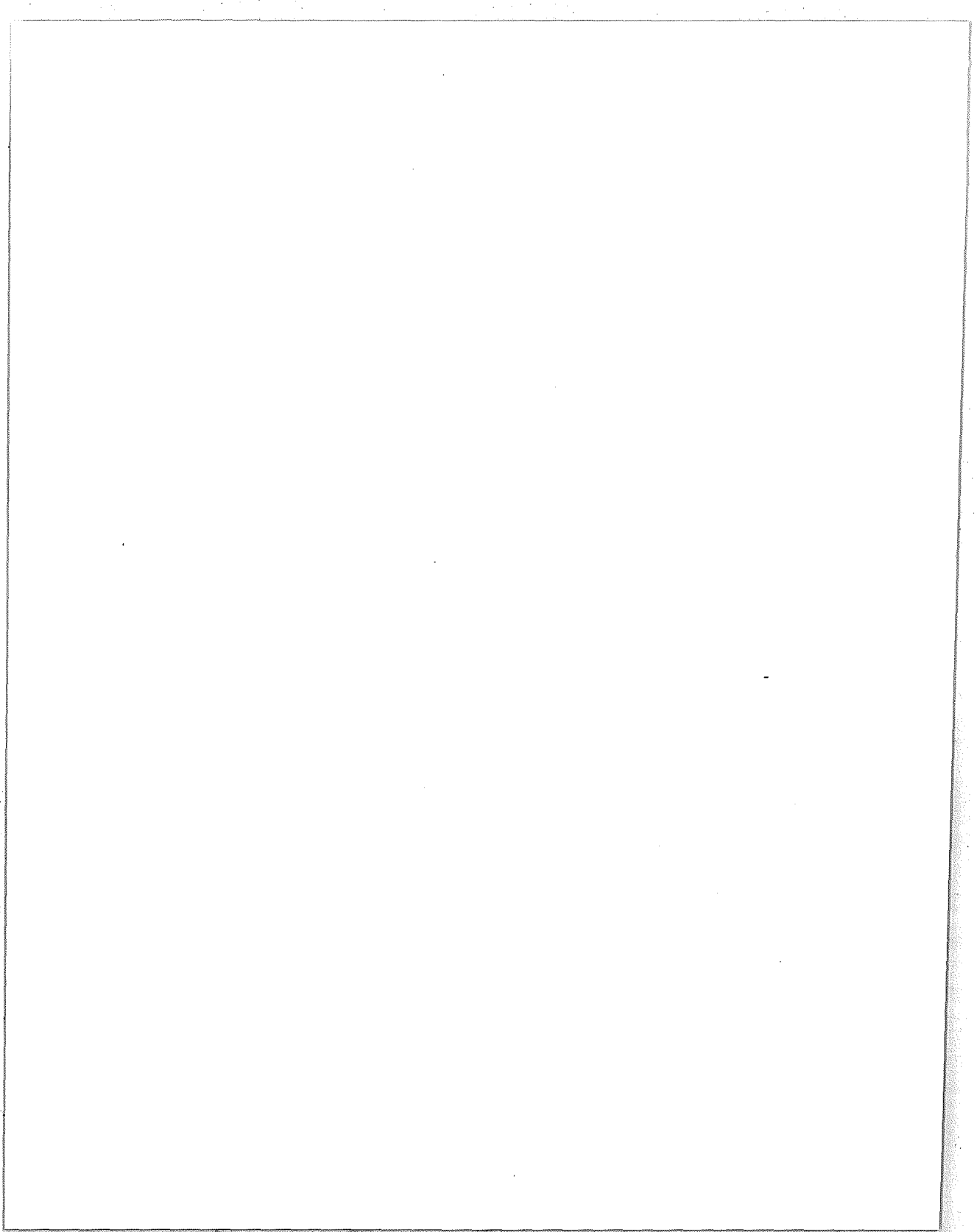
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How to Use This Manual

This manual describes the high resolution DT2802 data acquisition board for chromatography applications on the IBM Personal Computer AT and compatibles.

To use the DT2802, it is assumed you have a general understanding of data acquisition and chromatography concepts, and that you possess enough proficiency in software to write your own application and diagnostic programs.

Listed below is an overview of the information presented in this manual.

Installing and Using

Chapter 1, "**Introduction**," presents the major features of the DT2802 board and describes compatible Data Translation products.

Chapter 2, "**Installing the DT2802**," describes how to install the DT2802 in an IBM Personal Computer AT or compatible and how to connect external devices to the board.

Chapter 3, "**Hardware Overview**," discusses the main subsystems of the DT2802 board and the I/O registers for communicating with the board.

Chapter 4, "**Firmware**," describes the firmware commands for performing the board's operations.

Chapter 5, "**Programming Sequences**," lists the sequence of steps necessary for doing commonly-performed board operations.

Hardware Reference

Reference 1, "**Jumper Configuration**," shows you how to change the base address, interrupt priority level, and operating mode of your board.

Reference 2, "**Board Calibration**," describes the auto-calibration feature of the board.

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Reference 3, "**Board Connectors**," describes the DT2802 board connectors and lists their pinouts.

Reference 4, "**Detector Connections**," discusses the sources of noise in a measurement. It shows you how to connect your detector output to the DT2802 for low noise, high resolution measurements.

Reference 5, "**Specifications**," provides the electrical and mechanical specifications for the DT2802 board.

Firmware Reference

Reference 6, "**Remote Control Protocol**," describes how to communicate and operate the DT2802 board via its RS232 port.

Reference 7, "**Error Codes**," lists the DT2802 error codes.

Reference 8, "**Firmware Command Summary**," provides a numerical and alphabetical summary of the firmware commands and references their location in this manual.

Reference 9, "**Product Support**," explains what to do if you are having difficulty using the DT2802 board.

The **Glossary** defines data acquisition and chromatography terms used in this manual.

Related Documents

DT2802 Software User Manual, Document Number UM-10548, Data Translation, Inc.

DT777 User Manual, Document Number UM-10710, Data Translation, Inc.

IBM Technical Reference, International Business Machines Corporation

Note *Requests for copies of this manual should be made to your authorized IBM Personal Computer dealer.*

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Conventions Used in This Manual

Throughout this manual, the term "DT2802" refers to both the DT2802-2 and DT2802-4 boards. Information applying to a particular model only will indicate that board by model number.

The following symbol is used beside a firmware command to indicate that command does not apply to the DT2802-2 board:



Unless otherwise noted, all features referenced in this manual can be used with both the DT2802-2 and DT2802-4 boards.

The following symbol is used beside a firmware command to indicate that command is not valid in the stand-alone mode of operation:

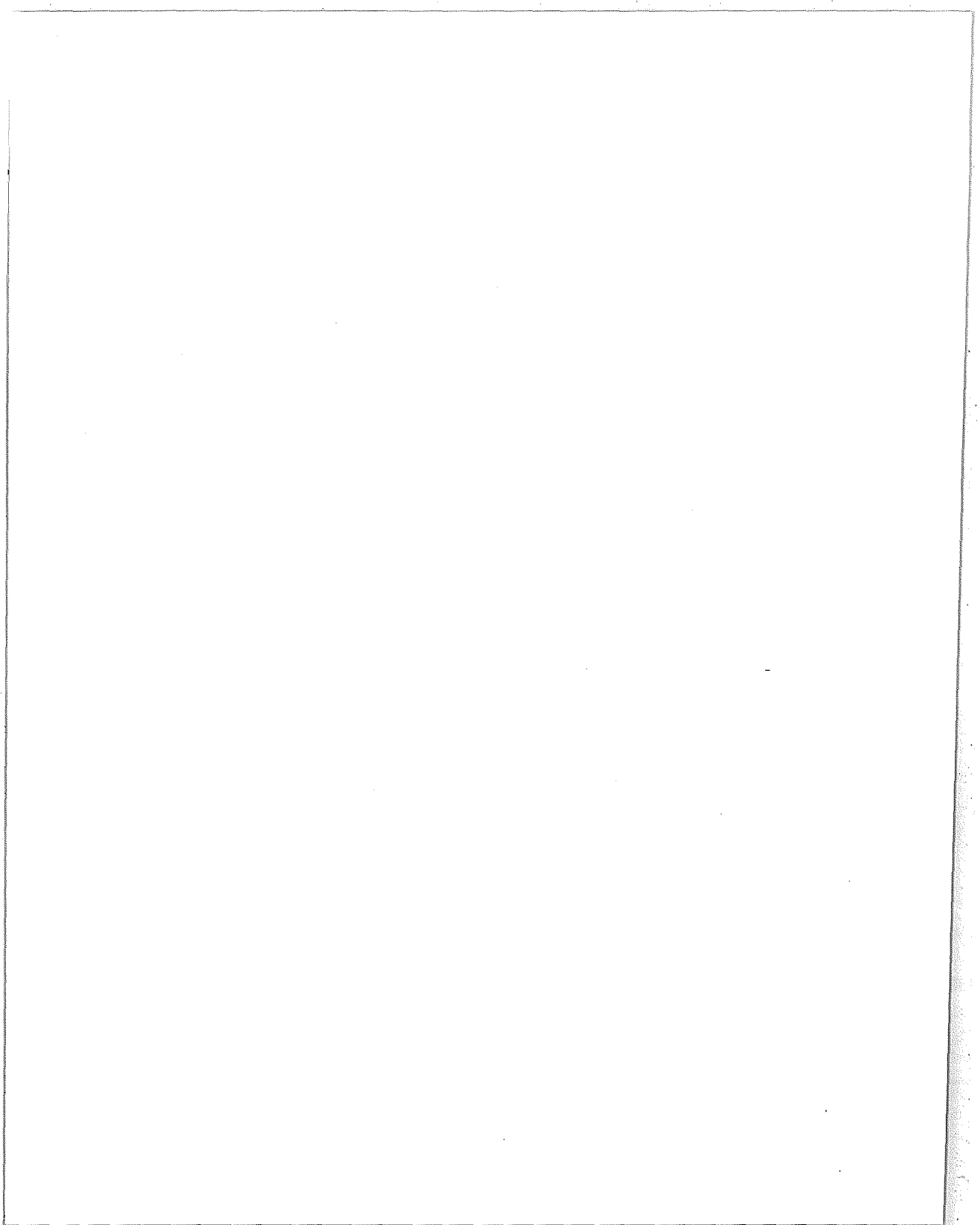


Unless otherwise noted, all features referenced in this manual apply in both the normal ISA bus mode and the stand-alone mode of operation.

Where to Get Help

If you have difficulty installing or using your DT2802 board, see Reference 9, "Product Support."

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Chapter 1



Introduction

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*Chapter 1, "**Introduction**," introduces you to the main features of the DT2802 board. It also describes Data Translation software packages and hardware accessories. This chapter is organized as follows:*

- *The DT2802 Board*
- *System Requirements*
- *Accessories*

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The DT2802 Board

The DT2802 is a high resolution (18-bit to 24-bit) microprocessor-controlled data acquisition board for liquid and gas chromatography applications. It is designed for use in the IBM Personal Computer AT and compatible computer systems.

The DT2802 board provides the following features:

- One (DT2802-2 board) or two (DT2802-4 board) high resolution time-base independent integrators each having two differential input channels
- Background data acquisition
- Four input switch detectors to sense contact closures or TTL or CMOS levels
- Four optically isolated output switches
- Onboard memory buffers for storing up to 2048 samples per integrator
- Auto-calibration function
- Command driven operation
- RS232 interface for communicating with a chromatograph, auto-sampler, or other RS232-based device; or for operating remotely from the host system
- Software-selectable board configuration settings

See Chapter 3, "Hardware Overview," for a complete discussion of these features.

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System Requirements

The minimum system requirements for the DT2802 board are as follows:

- IBM Personal Computer AT (or 100% compatible)
- PC-DOS operating system (version 3.30 or higher)

Up to four DT2802 boards can be installed in a single system.

To acquire sample data, you will need the following:

- Chromatography system including a detector having an output range between -0.2V and +2.0V

  Note *Other voltage input ranges may be used if attenuated properly.*

- DT777 screw terminal panel and EP777 cable or similar device to connect the detector output to the DT2802 board

The minimum system requirements listed above are necessary for using the DT2802 to acquire chromatography data. Addition of the following components will significantly enhance the functionality of the DT2802 operating environment:

- A hard disk or an additional floppy diskette drive
- 640 Kbytes of free system RAM

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Accessories

This section describes the Data Translation hardware and software accessories and industry-standard chromatography software compatible with the DT2802 board. Contact Data Translation for the most current information on the accessories available for the DT2802.

DT777 Screw Terminal Panel

The DT777 is a screw terminal panel that accommodates all user connections (detector and external device) to the DT2802 board. It provides facilities for installing a resistor network to attenuate the detector inputs, which effectively extend the analog input range of the DT2802 board. It also provides transient overvoltage protection on the switch inputs and output switches.

The DT777 requires the EP777 cable assembly (available from Data Translation) to connect to the DT2802 board. The EP777 cable assembly consists of individually shielded twisted pairs housed in a 6-foot flexible cable. This cable assembly has a D-shell connector at each end.

The EP246 shielded enclosure (available from Data Translation) helps preserve the integrity of analog signals by shielding the DT777 from electrical noise and from ambient airflow. Data Translation recommends using the EP246 enclosure with the DT777 for best performance.

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DT2802 Device Driver and Subroutine Library

All DT2802 boards ship with the DT2802 Device Driver and Subroutine Library (SP0802). This software package contains an MS-DOS device driver and a set of subroutines which interface to the device driver and take full advantage of the board's functionality. The *DT2802 Software User Manual* describes this software tool in detail.

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Chapter 2

Installing the DT2802

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*Chapter 2, "**Installing the DT2802**," describes how to install the DT2802 board in your computer and how to connect detectors to the input channels, external devices to the input switch detector and output switch terminals, and peripherals to the serial I/O port. This chapter is organized as follows:*

- *Unpacking*
- *Installation Procedure*
- *Powering Up the System*

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Unpacking

If you purchased your DT2802 from Data Translation, make sure that you have received the following items before installing the board:

- DT2802 board
- *DT2802 User Manual*
- *DT2802 Software User Manual*
- Two 5-1/4-inch diskettes:
  SP0802: DT2802 software and Demonstration program
  SP0172: C, QuickBASIC examples
- Warranty and Service policy

If you purchased your DT2802 as part of a complete chromatography data system, the contents of your DT2802 package will vary. Instead of the above items, you will receive application specific software and documentation provided by your vendor.

If an item is missing or damaged, call Data Translation's **Customer Service Department** at **(508) 481-3700**. They will guide you through the appropriate steps for replacing missing or damaged items.

If you are located outside the USA, call your local distributor. The name and telephone number of your nearest distributor are listed in your Data Translation catalog.

Note *Save the original packing material in the unlikely event your board requires servicing in the future.*

Keep the DT2802 board in its protective anti-static bag until you are ready to install it. When you remove the board from the bag, hold it by the edges and do not touch the components.

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Installation Procedure

Install the DT2802 board and connect any external devices following the steps below. These steps are described in detail on the following pages.

Step 1: Check the jumper selections

Step 2: Install the board

Step 3: Connect RS232-based devices

Step 4: Connect the screw terminal panel (if used)

Step 5: Connect the detector(s)

Step 6: Connect the external devices

Note *Be sure to read the directions in each step carefully before attempting it. Follow the steps in the order given.*

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Step 1: Check the Jumper Selections

The DT2802 board ships with a base address of 300H and interrupt priority level of 5. It is configured for installation in the host computer system (ISA bus mode). In most instances you can use these factory-configured settings. To select an alternative setting for a parameter, see Reference 1, "Jumper Configuration," for instructions.

Note *Make sure your jumper settings are suitable BEFORE installing the board. No other peripheral in your system can use these values. Mismatched settings can result in unpredictable behavior and inaccurate results!*

Other board configuration settings, such as interrupt source(s), conversion rate, resolution, integration channel, trigger mode, serial data mode, stream data packet size, and serial port baud rate, are software-configurable. See Chapter 4, "Firmware," and Chapter 5, "Programming Sequences," for more information on these configuration parameters.

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Step 2: Install the Board

Follow the instructions below to install the DT2802 board in any available fully-bussed expansion slot in your computer. If you are remotely operating the DT2802 board (stand-alone operation), skip the instructions in this step and install the DT2802 board in your peripheral device.

1. Turn off the computer.

2. Turn off all accessories connected to the computer.

3. Unplug the computer and all accessories.

4. Note the location of all cables, and disconnect them from the rear of the computer.

5. Remove the computer's cover.

   The DT2802 board may be installed in any fully-bussed expansion slot. Figure 1 illustrates the expansion slots in the IBM Personal Computer AT.

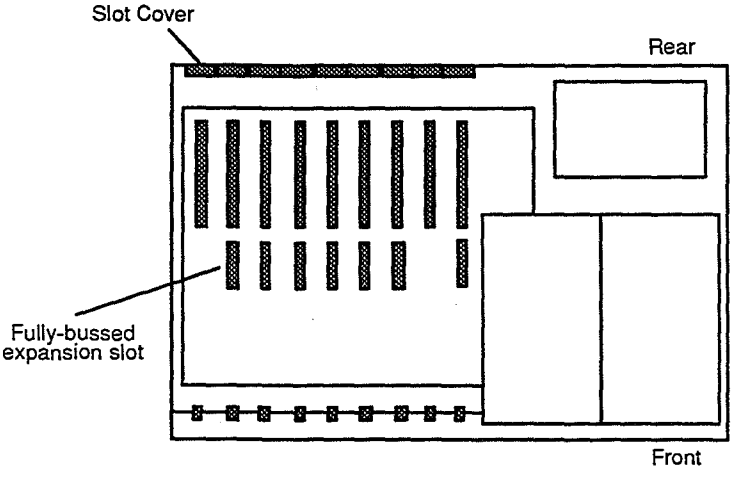


Figure 1: IBM Personal Computer AT – top view

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6. Remove the slot cover from the selected expansion slot.

7. Before handling the board, discharge any static buildup by touching the metal case of the computer.

8. Remove the board from its anti-static bag. Holding the board by its edges, position it so that the rear panel connector (J1) faces the rear of the computer, as shown in Figure 2.

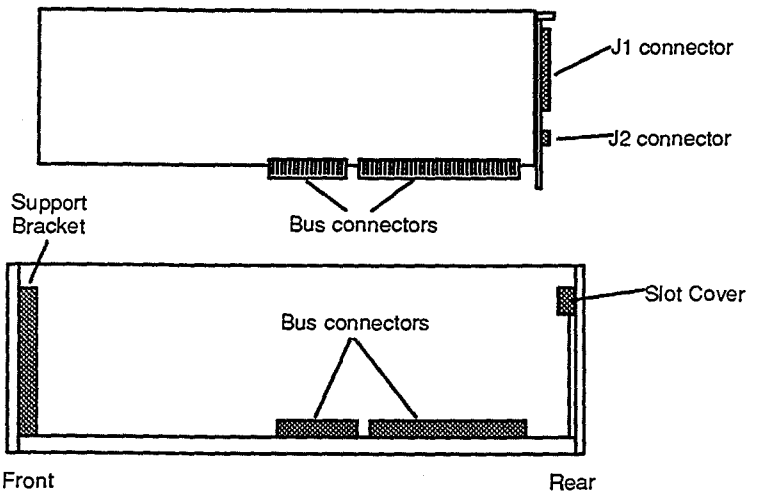


Figure 2: Installing the Board

9. Carefully lower the board into the expansion slot using the groove in the card cage to properly align the board in the slot. When the bottom of the board contacts the bus connector, gently press down on the board until it clicks into place.

   Caution *Do not force the board into place. If you encounter resistance when inserting the board, pull it out and try again. Do not wiggle the board from side to side during installation as this may damage the bus connector.*

10. Gently lift the board to determine if it is properly connected.

    If the board stays in place, it is installed correctly. If it exhibits no resistance, press down firmly on the board to seat it in its connector.

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11. Secure the board to the rear panel of the chassis using the screw removed from the slot cover.

12. Replace the computer's cover.

13. Reconnect all cables to the rear of the computer.

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Step 3: Connect RS232-based Devices

The RS232 port may be used to communicate with RS232-based devices to provide, for example, start/stop type of control. The RS232 port may also be used to pass commands and data to operate the DT2802 board remotely from the host system.

This port has a programmable baud rate. It has 1 start bit, 1 stop bit, 8 data bits, and no parity.

The RS232 port has an RD (receive data), TD (transmit data), and RS232 control signal. Table 1 lists the location of these signal lines at the J2 connector.

Table 1: RS232 Signal Lines

Description	Pin		Description
Not connected	1	2	RS232 signal (control signal)
Signal ground	3	4	RS232-TD (transmit data)
RS232-RD (receive data)	5	6	Not connected

Note *For information on various RS232 connectors, see Reference 3, "Board Connectors."*

To connect to the RS232 port:

1. Plug one end of the RS232 cable to the J2 connector on the rear of the DT2802 board.

2. Plug the other end of the RS232 cable to the RS232 connector on the communicating device.

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Step 4: Connect the Screw Terminal Panel

If you are using the Data Translation DT777 screw terminal panel, follow the instructions below for connecting it to the DT2802 board.

1. Position the computer (or peripheral device) so you can easily access the board's rear panel connector (J1).

2. Plug the 37-pin connector on the screw terminal panel cable into the mating connector (J1) on the rear of the DT2802 board, as shown in Figure 3.

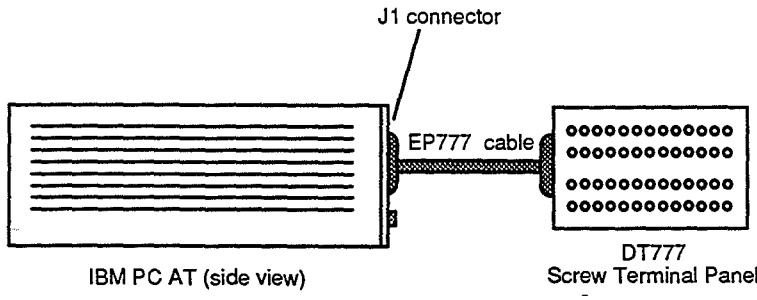


Figure 3: Connecting a Screw Terminal Panel

Note *For the remainder of this chapter, refer to the user manual provided with your screw terminal panel for the screw terminal assignments. If you are connecting external devices via another cable, refer to Table 2 for the DT2802 board's J1 pin assignments.*

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Table 2: J1 Pin Assignments

Description	Pin		Description
Digital Ground	1		
Switch 4 High	2	20	Switch 4 Low
Switch 3 High	3	21	Switch 3 Low
Switch 2 High	4	22	Switch 2 Low
Switch 1 High	5	23	Switch 1 Low
Input 4 High	6	24	Input 4 Low
Input 3 High	7	25	Input 3 Low
Input 2 High	8	26	Input 2 Low
Input 1 High	9	27	Input 1 Low
+12V [1]	10	28	–12V [1]
Digital Ground	11	29	Digital Ground
Analog Ground	12	30	Analog Ground
Channel 4 High	13	31	Channel 4 Low
Analog Ground	14	32	Analog Ground
Channel 3 High	15	33	Channel 3 Low
Voltage Reference High	16	34	Voltage Reference Low
Channel 2 High	17	35	Channel 2 Low
Analog Ground	18	36	Analog Ground
Channel 1 High	19	37	Channel 1 Low

[1] *No more than 10 mA should be drawn from the ±12V terminals (pins 10 and 28). The return for the ±12V is Digital Ground.*

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Step 5: Connect the Detector(s)

The DT2802-2 board provides two differential input channels for one or two detectors and the DT2802-4 board provides four differential input channels for up to four detectors.

The DT2802 is capable of converting analog voltage ranges from -0.200V to +2.000V. The detector need not have a voltage output that ranges to 2V. If your detector's output exceeds 2V, however, you must reduce the voltage using a resistor divider circuit. The DT777 screw terminal panel can accommodate 5V and 10V detector outputs. Refer to the *DT777 User Manual* for information on these connections.

The DT2802-2 has one integrator (integrator A) and the DT2802-4 has two integrators (integrators A and B). Each integrator connects to two input channels. Integrator A connects to input channels 1 and 2 and integrator B connects to input channels 3 and 4. Each integrator has its own programmable time base. Therefore, the two channels associated with an integrator will have the same sampling rate and resolution.

1. Connect the high level voltage output from the detector to the desired channel Hi terminal on the screw terminal panel or to the corresponding pin on the J1 connector (see Figure 4).

2. Connect the low side of the detector output to the corresponding Low terminal or pin for that channel.

   Note *For information on how to make connections for high resolution inputs, see Reference 4, "Detector Connections."*

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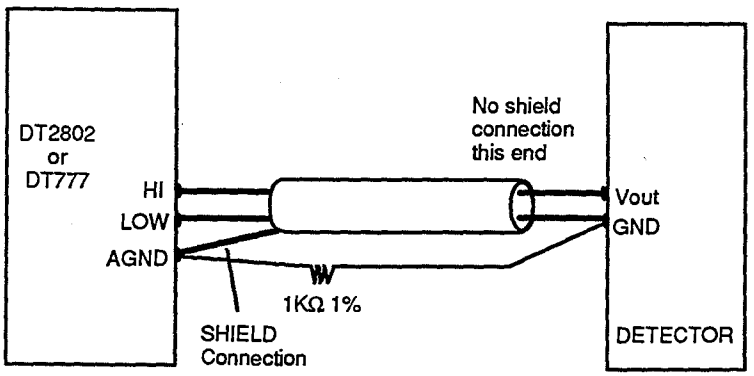


Figure 4: Detector Connections

Analog Ground on the DT2802 must be connected to the detector ground to provide a return path for the DT5705 input bias current. The 1kΩ resistor serves to limit the current if the grounds are not at the same potential. Only one connection of this type is necessary per detector.

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Step 6: Connect the External Devices

The DT2802 has four switch inputs and four output switches. The inputs can detect switch closures or can be driven by TTL compatible logic. The output switches are optically isolated switch closures.

Switch Input Connections

Many injectors and autosamplers output a signal when they make an injection. You can connect this signal output to one of the switch inputs and program the DT2802 to signal the host when it senses the change in signal.

To connect an input signal to the DT2802:

1. Connect the high side of the input line to the desired Input terminal on the DT2802 (see Figure 5).

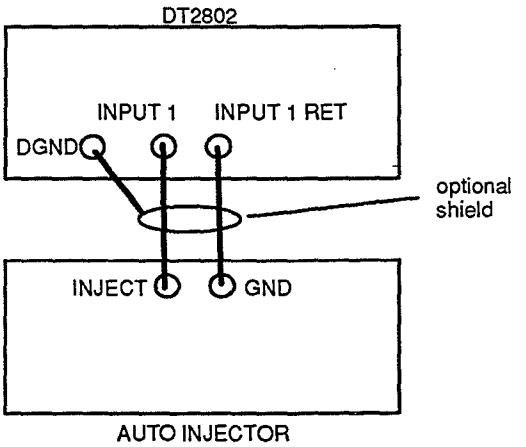


Figure 5: External Device Input Connections

Note *Use a shielded cable for minimum noise on the input signal to the detectors.*

2. Connect the low side of the input line to the corresponding Input Low terminal on the DT2802.

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Output Switch Connections

To connect an output switch to an external device:

1. Connect one lead from the cable between the device and the DT2802 to the desired Switch Low terminal. Connect the corresponding lead on the other end of the cable to a ground terminal on the device (see Figure 6).

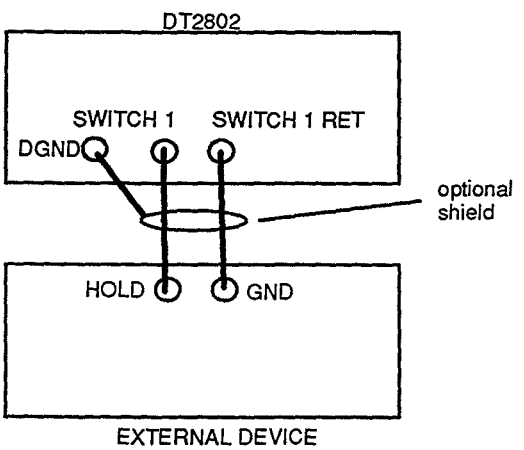


Figure 6: Output Switch Connection

Note *Use a shielded cable for minimum noise on the input signal to the detectors.*

2. Connect the other leads on the cable to the corresponding output switch terminal and the input terminal on the device.

Note *The output switches do not supply power to the circuit.*

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Powering Up the System

Once you are satisfied that all connections are secure and made properly, you can power up your system. Plug the computer and all accessories into their power outlets.

1. Power up all accessories.

2. Power up the computer.

Upon powerup, the DT2802 automatically executes self-diagnostics. Once it determines it is operational, it loads its configuration and calibration table, and signals the host that it is ready for operation.

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Chapter 3

Hardware Overview

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*Chapter 3, "**Hardware Overview**," describes the major features of the DT2802 board. This chapter is organized as follows:*

- *Overview*
- *Data Acquisition Subsystem*
- *DT2802 Microprocessor*
- *Inputs and Outputs*
- *Serial Port*
- *Bus Interface*

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Overview

The DT2802 board is a data acquisition system for liquid and gas chromatography systems in an IBM Personal Computer AT or compatible computer system environment. The DT2802 can perform data acquisition as a background task to the host and is capable of RS232 serial I/O, communication with external devices through I/O switches, and data buffering.

Built-in firmware commands manage all DT2802 operations. These firmware commands eliminate the extensive register programming required to perform an operation, thereby simplifying programming. You perform board operations or monitor the board's status by writing commands and parameters to or reading the status or data from four registers. Chapter 4, "Firmware," describes the firmware commands in detail.

Figure 7 provides a block diagram of the DT2802-4 board. Refer to this diagram for help in following the discussions throughout this chapter. (The DT2802-2 is identical to the DT2802-4 board except that the DT5705 portion of integrator B is not present.)

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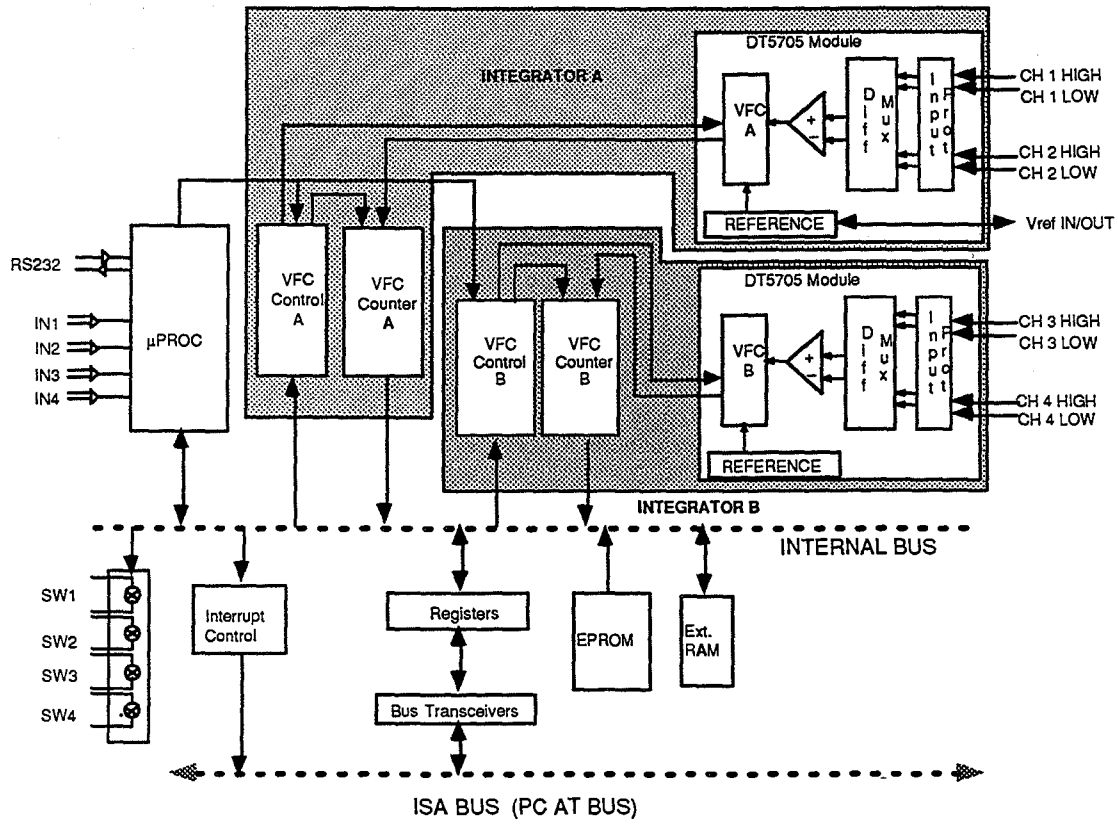


Figure 7: DT2802-4 Functional Block Diagram

The DT2802-2 has one integrator and the DT2802-4 has two integrators. An integrator consists of a DT5705 module which contains a high resolution voltage-to-frequency (VFC) converter, a VFC controller, and a VFC counter. The integrator has two differential input channels. The integrator has programmable channel selection, resolution, and sampling rate.

The microprocessor controls the operation of the DT2802. It sets the board configuration, and controls the integrators and all I/O tasks. It also calibrates the integrators on command.

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There are three types of memories onboard the DT2802:

- EPROM – programmed at the factory with the code executed by the microprocessor to control DT2802 operations.
- EEROM – resides in the microprocessor. It contains the last saved board configuration and calibration tables.
- External RAM – 32 Kbytes – part of which is used as a data buffer. The DT2802 places the digital code from each conversion into the buffer. It is subsequently transferred to the host system from this buffer.

The serial I/O port is part of the microprocessor. It provides an RS232 port with a programmable baud rate. It permits the DT2802 to communicate with other RS232-based peripherals or operate as a stand-alone peripheral. In the stand-alone mode, the host sends commands and arguments to and receives data and board status from the board over the RS232 port.

There are four input switch detectors that accept contact closure or TTL-compatible logic signals from external devices such as injectors and fraction collectors The inputs can be programmed to signal the host on a rising edge, falling edge, or both.

There are four optically isolated output switches. Each output is written directly, individually or as a group.

The host bus interface provides the communication between the DT2802 and the host in the normal ISA bus mode of operation. It has a command/status register at the board's base address and a data I/O register at the base+1 address. The host writes firmware commands and arguments to or reads the board status or data from these registers.

The DT2802-2 has eight event/interrupt sources and the DT2802-4 has nine event/interrupt sources that are software-enabled or disabled. If the master interrupt is enabled, any enabled interrupt source can cause the DT2802 to interrupt the host when that condition occurs. The host can also poll the event/interrupt source list to determine the board state whether interrupts are enabled or disabled.

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The following sections describe these board subsystems in more detail:

- Data acquisition
- DT2802 onboard microprocessor
- Digital inputs and outputs
- Serial I/O port
- Bus interface

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Data Acquisition Subsystem

The data acquisition subsystem (see Figure 8) consists of one (DT2802-2) or two (DT2802-4) integrators. Each integrator has a DT5705 module containing a voltage-to-frequency (VFC) converter, a VFC controller, and a VFC counter.

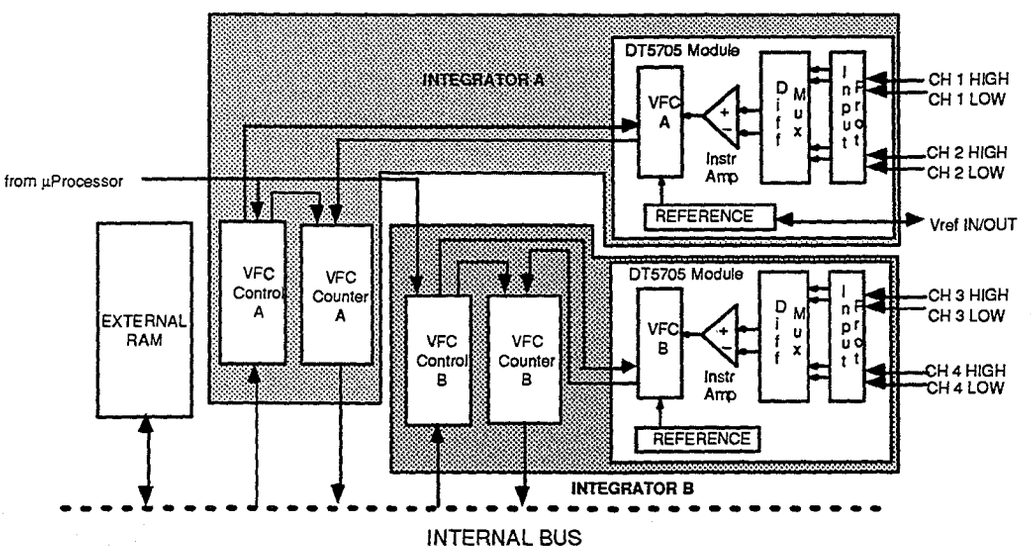


Figure 8: Data Acquisition Subsystem (DT2802-4)

DT5705 Module The DT5705 module contains a high resolution VFC. The VFC converts the analog voltage signal from one or two detectors to an output which the DT2802 accumulates and converts to a digital code during each sampling interval.

VFC Controller The VFC controller is a state machine which controls the VFC counter and the DT5705 multiplexer. The state machine has inputs from the onboard microprocessor and crystal clock. It produces integration start and end times at the precision of the crystal clock.

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The state machine sequencer saves the count value in a register. The controller clears and restarts the counter in less than 500 nsec. This allows the DT2802 to make "back-to-back" measurements.

The microprocessor uses the user-specified resolution, sampling rate, and trigger to set up the VFC controller. These are the user-configurable integrator values. The DT2802 stores these settings in EEROM and loads the last saved values on power up or reset into the microprocessor RAM. You can change the configuration in RAM without affecting the settings you saved to EEROM. When integration is triggered, the DT2802 uses the latest values from RAM.

VFC Counter

The VFC counter accumulates the raw VFC output during the integration interval. The DT2802 then converts this value to a digital code that represents the input voltage. The digital output codes are listed in Table 3 below. All digital codes are expressed in hex.

Table 3: Digital Output Codes

Voltage	24 Bits	23 Bits	22 Bits	21 Bits	20 Bits	19 Bits	18 Bits
+2.000V (+FS)	FFFFFF	7FFFFF	3FFFFF	1FFFFF	0FFFFF	07FFFF	03FFFF
0V	180000	0C0000	060000	030000	018000	00C000	006000
–0.207V (–FS)	000000	000000	000000	000000	000000	000000	000000

The following formulas calculate the voltage from the digital code at each resolution:

Voltage = (2.0V/E7FFFFH) * (Code – 180000H) *(24-bit resolution)*

Voltage = (2.0V/73FFFFH) * (Code – 0C0000H) *(23-bit resolution)*

Voltage = (2.0V/39FFFFH) * (Code – 060000H) *(22-bit resolution)*

Voltage = (2.0V/1CFFFFH) * (Code – 030000H) *(21-bit resolution)*

Voltage = (2.0V/0E7FFFH) * (Code – 018000H) *(20-bit resolution)*

Voltage = (2.0V/073FFFH) * (Code – 00C000H) *(19-bit resolution)*

Voltage = (2.0V/039FFFH) * (Code – 006000H) *(18-bit resolution)*

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This digital code is three bytes in length. Since each digital value may be a data point from any of the four input channels, the DT2802 adds a "tag" byte to each digital code to identify it, making it a 4 byte word. It then stores these four bytes as a data point in the onboard memory buffer for that integrator until transferred to the host. The Data Buffer Management section (see page 121) of Chapter 4, "Firmware," describes the data format and its transfer to the host system.

Input Characteristics

The DT5705 module, the VFC controller, and the VFC counter represent a complete integrator. (See Figure 8 on page 29.) The DT5705 has one high-resolution VFC with two detector input channels. You can configure each integrator separately to suit the needs of the chromatography system.

Input Type

The DT5705 has two differential input channels and one VFC. The VFC sees the following voltage from its two input channels:

$$\text{Input Voltage} = V_{\text{chan high}} - V_{\text{chan low}}$$

Differential inputs are relatively insensitive to electrical noise since the VFC sees only the difference in voltage between the high and low sides of the input channel connections. See page 18 for these connections.

Input range

The *input range* is the range of voltage levels the VFC can measure. The VFC can measure a detector signal between -0.207V and +2.000V.

Channel selection

You can configure the DT2802 to integrate the signal at either channel or to automatically switch between the two channels (automux) for each conversion. See Chapter 4, "Firmware," for more information on this feature.

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Resolution

Resolution refers to the number of bits the DT2802 uses to represent the detector output signal. As the resolution increases, more digits are used to represent the same input range, allowing each code to represent a smaller signal. Table 4 shows the smallest measurable signal as 1 LSB and in nV-sec at each resolution.

Table 4: Resolution vs. LSB and nV-sec

Resolution	1 LSB	nV-sec @ 60Hz	nV-sec @ 50Hz
18 bits	8392.3 nV	69.936 nV-sec	83.923 nV-sec
19 bits	4196.2 nV	69.936 nV-sec	83.923 nV-sec
20 bits	2098.1 nV	69.936 nV-sec	83.923 nV-sec
21 bits	1049.0 nV	69.936 nV-sec	83.923 nV-sec
22 bits	524.52 nV	69.936 nV-sec	73.433 nV-sec
23 bits	262.26 nV	69.936 nV-sec	68.188 nV-sec
24 bits	131.13 nV	69.936 nV-sec	65.565 nV-sec

All values in this table are rounded to 5 decimal digits.

The integrator converts the input voltage from the detector to output pulses which it counts over the sampling interval. The DT2802 then converts these counts to a digital code. At the maximum sampling rate of 120 or 100 measurements per second (depending on the line frequency configuration value), the DT2802 is able to count 18-bit values. At longer sampling intervals, the DT2802 can accumulate more counts allowing for higher resolution.

You can configure each integrator for a resolution of 18 to 24 bits. The resolution you choose determines the maximum sampling rate. The DT2802 takes 8.333 msec (1/120 second) to perform a conversion at 18 bits. The DT2802 takes 500 msec (60/120 second) to perform a conversion at 24 bits. Table 5 lists the maximum sampling rate at each resolution. The minimum sampling rate is approximately 1 sample every 9 minutes.

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Table 5: Resolution vs. Sampling Rate (Single Channel)

	Number of Line Cycles		Maximum Sampling Rate*	
Resolution	**60Hz**	**50Hz**	**60Hz**	**50Hz**
18 bits	0.5	0.5	120	100
19 bits	1.0	1.0	60	50
20 bits	2.0	2.0	30	25
21 bits	4.0	4.0	15	12.5
22 bits	8.0	7.0	7.5	7.143**
23 bits	16.0	13.0	3.75	3.846**
24 bits	30.0	25.0	2.0	2.0

** Maximum sampling rate is in measurements per second*

*** These throughput rates are rounded to three decimal places*

Sampling rate

The *sampling rate* is the maximum speed at which the DT2802 can acquire data and maintain the specified accuracy. The DT2802 bases its integration timing on the local line frequency selected for the board (60Hz or 50Hz). The smallest measurable unit is 1/2 line cycle or 1/120 second (for 60Hz line frequency) or 1/100 second (for 50Hz line frequency). This results in the fastest sampling rate of 120 (or 100) samples per second. With the exception of 18-bit resolution, all integration times are an integral number of power line cycles. This allows the DT2802 to reject the crosstalk from the power lines to the detector inputs. See "Resolution" above for the effect of resolution on the sampling rate.

To take measurements less frequently than the maximum sampling rates shown in Table 5 above, specify an interval (delay) time between conversions. This interval time is specified in 0.5 line cycle increments. Refer to the discussion on the Time Interval command on pages 56 to 61 for further information about this delay time.

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VFC Operation

The VFC is always running when the DT2802 is powered up. That is, it constantly produces output pulses representing the voltage of the selected input. During data acquisition, the DT2802 counts these pulses over the integration interval and calculates a digital code representing the input voltage.

When you switch inputs to the VFC (either manually or in the automux mode), the VFC requires a settling time to stabilize its output. The length of this settling time depends on the resolution you select for the integrator. Table 6 shows the settling time (in number of power line cycles) at each resolution at the two local line frequencies.

Table 6: VFC Settling Time

Resolution	Settling Time (number of line cycles)	
	60Hz	50Hz
18 bits	0.5	0.5
19 bits	0.5	0.5
20 bits	0.5	0.5
21 bits	1.0	1.0
22 bits	2.0	2.0
23 bits	3.0	3.0
24 bits	3.0	3.0

Table 7 shows the effect of resolution on throughput in the automux mode.

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Table 7: Resolution vs. Throughput (Automux Mode)

Resolution	Throughput per Channel	
	60Hz	50Hz
18 bits	30.0	25.0
19 bits	20.0	16.6667*
20 bits	12.0	10.0
21 bits	6.0	5.0
22 bits	3.0	2.7778*
23 bits	1.5789*	1.5625
24 bits	0.9091*	0.8929*

** These throughput rates are rounded to 4 decimal places.*

The firmware always waits the settling time before taking a measurement when you switch the input channel or operate in the automux mode.

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DT2802 Microprocessor

The DT2802 microprocessor, a Motorola 68HC11, controls all inputs and outputs with the host and the data acquisition subsystem. This microprocessor (Figure 9) provides 512 bytes of RAM, 512 bytes of EEROM, one serial I/O port, a baud rate generator, and a timer. An EPROM and external RAM complete the microprocessor subsystem.

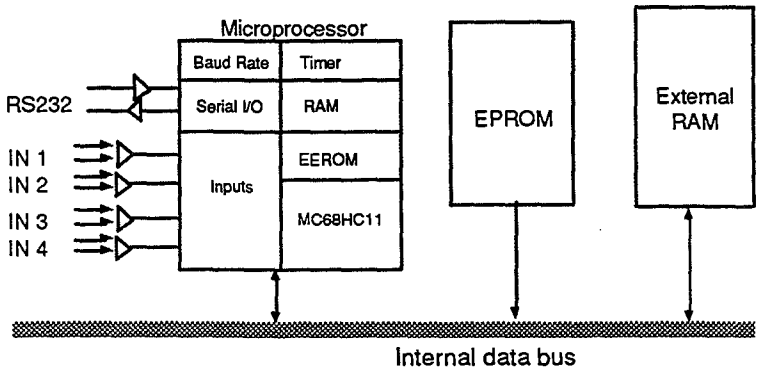


Figure 9: DT2802 Microprocessor

Baud Rate Generator Generates the baud rate specified for the serial port. This rate is one of the board configuration settings.

Serial Port This is an RS232 port that permits serial communication with an RS232-based peripheral. It also allows the DT2802 to operate remotely from the host system. See Reference 6, "Remote Control Protocol," for information on passing firmware commands and data over the RS232 port.

Timer The timer's frequency is set to two times the local line frequency selected for the board. The timer interrupts the processor. All integrator actions take place on ticks of this timer.

The timer hardware also produces an output pulse to control the VFC counters.

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RAM The RAM contains the "working" board configuration settings. At power up or reset, the microprocessor loads the settings from EEROM to RAM. These settings can be modified (with the exception of line frequency) and will remain in effect until a reset occurs.

EEROM The EEROM stores the board configuration settings. These settings represent the last saved configuration. At power up or reset, the DT2802 loads these values into RAM to become the working values. The calibration constants are also stored in EEROM. See Chapter 4, "Firmware," for more information on the configuration parameters.

EPROM The EPROM is 32 Kbytes in size and contains the code executed by the 68HC11 microprocessor to control DT2802 operations.

External RAM The DT2802 places the digital code from each conversion into this 32 Kbyte RAM for its subsequent transfer to a user buffer in the host system.

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Inputs and Outputs

The DT2802 supplies four switch inputs and four output switches. A "1" indicates a switch input is high or an output switch is open. A "0" indicates a switch input is low or an output switch is closed.

Inputs

The four inputs have pullup resistors and can accept a TTL, CMOS, or contact closure signal from devices in the chromatography system. This signal can be the inject signal from a manual or auto-injector, or the abort signal from a controller. You can configure each input to sense a low-to-high transition, high-to-low transition, or either type of transition. Each input can interrupt the host or trigger integration when it senses the selected change in signal. You can set the input mode to normal or debounce. (Use the debounce mode when the input is a contact closure.) See Chapter 4, "Firmware," for information on selecting the active edge and configuring an input as an interrupt or trigger source.

Output Switches

The output switches are optically isolated switch closures. The host writes each output value individually or as a group to provide external device control. You can connect these outputs to devices to provide a chart mark output at the start of integration, a hold signal in the event of an abort input, an alarm signal, etc.

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Serial Port

The serial I/O port provides an RS232 port that permits serial communication with other RS232-based peripherals. This port is intended to pass CTS (clear to send) signals to RS232-based chromatographic equipment or to provide other RS232-compatible on/off controls.

The DT2802 can be remotely controlled by firmware commands received over its RS232 port. This stand-alone mode of operation is jumper-selectable. Reference 6, "Remote Control Protocol," describes the communications protocol for this mode of operation.

The serial I/O port has an RD (receive data), TD (transmit data), and RS232 control signal. This serial I/O port is part of the DT2802 microprocessor.

Since the microprocessor controls the data acquisition tasks, you should limit serial communication during data acquisition.

The serial port parameters have the following values:

- Baud rate 9600 *(factory-configuration)*
- Data 8 bits/character
- Stop bits 1
- Start bits 1
- Parity None

The baud rate is software-configurable for rates of 300, 1200, 2400, 4800, 9600, 19200, and 38400. The port may also interrupt the host when data is available. See Chapter 4, "Firmware," for information on configuring this port.

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Bus Interface

The DT2802 board provides four 8-bit registers that occupy two I/O addresses. In the ISA bus mode, all communications between the host and the DT2802 occur via these registers. In the stand-alone mode, all communications between the host and the DT2802 occur via the RS232 port.

The Command and Status registers are located at the base address. The host writes commands to the Command register and reads the board status from the Status register. The Data In and Data Out registers are located at the base+1 address. The host writes the command arguments to the Data In register and reads integration and other board information from the Data Out register.

The host can read the Status register at any time. It can write to the Command or Data In registers, or read from the Data Out register, only when the Port Ready bit in the Status register is set (high). Any host action with these registers when the Port Ready bit is clear causes an error condition.

Table 8 summarizes the DT2802 registers, their functions, and addresses.

Table 8: DT2802 Registers

Register	Function	Address	Access
Status	Provides board status information	Base + 0	Read
Command	Specifies the firmware command to execute	Base + 0	Write
Data Out	Provides integration results and other board information	Base + 1	Read
Data In	Supplies the arguments for the firmware command	Base + 1	Write

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Conventions

Each register has a two character abbreviation listed beside its name on the following pages. The Status register bits also have a two or three character abbreviation. (This is not done with the other register bits since they do not have individual functions.)

It may be necessary from time to time in this manual to refer to the state of a particular bit or bits. Rather than spell out the register and bit name, this manual will use its abbreviations as follows: **REGISTER:BIT**. For example, SR:PR represents the Status register, Port Ready bit.

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Status Register [SR]

Address: Base Address ***Access: READ***

The Status register returns the status of the DT2802 board. Figure 10 shows the bit functions of the Status register.

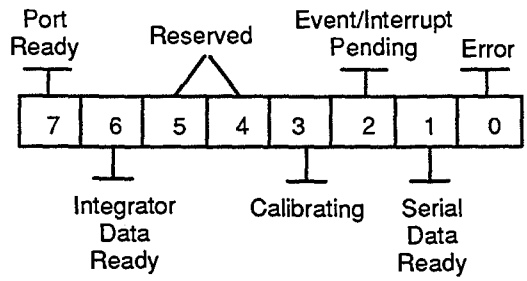


Figure 10: Status Register Bit Functions

Bit 7: Port Ready (PR)

This bit is set when the host can access the Command register and Data In/Out registers. This bit is clear when the DT2802 is not ready for commands or data. A write to the Command or Data In register, or a read of the Data Out register when this bit is clear causes an error.

READ: 0 = DT2802 not ready
1 = DT2802 ready

Bit 6: Integrator Data Ready (IDR)

This bit sets when the number of data points specified for either integrator is in the data buffer. This bit is clear when there are fewer data points in the data buffer than the Threshold value for either integrator. Reading enough data values from the data buffer to bring the number of data points in the buffer for that integrator below its threshold value clears this bit.

READ: 0 = Integration data not available
1 = Integration data available for reading

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Bits 5 and 4: Reserved

These bits are reserved and always return "00."

Bit 3: Calibrating (CAL)

This bit sets while the board is calibrating the integrators. It clears when the calibration sequence completes. (SR:PR will be clear during calibration indicating to the host the board is in a "not ready" state.)

READ: 0 = board is not in calibration sequence
1 = calibration in progress

Bit 2: Event/Interrupt Pending (IP)

This bit sets when any event/interrupt source that has been enabled becomes active. If the Master Interrupt is enabled, the DT2802 also interrupts the host when this bit sets.

The DT2802 has the following event/interrupt sources:

- Data ready integrator A
- Data ready integrator B *(not used by the DT2802-2)*
- Digital input 1 active
- Digital input 2 active
- Digital input 3 active
- Digital input 4 active
- Serial port data ready
- Serial output port ready
- Error

To determine the source of an interrupt or which event has occurred, use the Interrupt Pending command. This command returns a 2-byte event/interrupt mask in which each bit represents a particular event/interrupt source. Figure 11 shows the event/interrupt mask.

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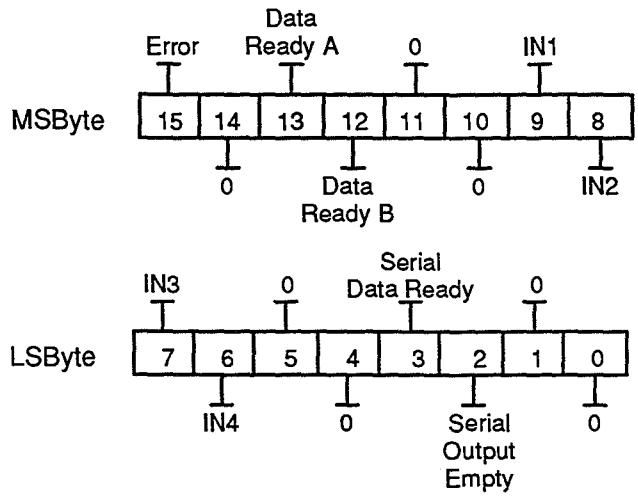


Figure 11: Event/Interrupt Source Mask

READ: 0 = no interrupt conditions have occurred
1 = interrupt condition has occurred

Bit 1: Serial Data Ready (SDR)

This bit sets when there is a data byte in the serial input buffer. SR:IP also sets when this bit sets if the Serial Port Data Ready event/interrupt source is enabled.

READ: 0 = serial data buffer empty
1 = serial data available

Bit 0: Error (ERR)

This bit sets when an error occurs. This error may be an illegal command, an improper number of arguments, etc. To determine which error occurred, and to clear the error bit, use the READ SYSTEM ERROR command. If more than one error occurred, this bit remains set after the first error is read. Continue executing the READ SYSTEM ERROR command until this bit clears. See Reference 7, "Error Codes," for a list of the possible errors.

READ: 0 = no error
1 = error exists

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Command Register [CR]

Address: Base Address ***Access: WRITE***

The host writes the firmware command to execute to the Command register. Figure 12 shows the bit functions of the Command register.

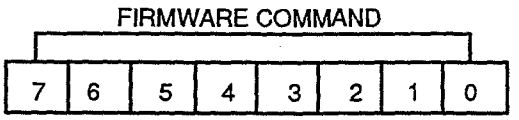


Figure 12: Command Register Bit Functions

Bits 7–0: Firmware Command

A write to this register provides the firmware command for the DT2802 to execute. This register can only be written to when SR:PR is set. Writing to this register when SR:PR is clear causes an error. Most commands have a fixed number of arguments or data bytes that must be written to or read from the Data In/Out registers. Some commands have no arguments, while other commands have one, two, or more arguments. Failure to write the appropriate number of arguments or read the appropriate number of data bytes following a command causes an error.

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Data Out Register [DO]

Address: Base Address + 1 ***Access: READ***

The host reads the data associated with a read command from the Data Out register. Figure 13 shows the bit functions of the Data Out register.

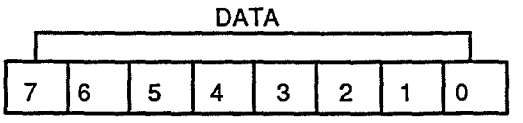


Figure 13: Data Out Register Bit Functions

Bits 7–0: Data

A read of this register returns one byte of data associated with the read command written earlier to the Command register. If multiple bytes are associated with the read command, the first read returns the most significant byte. The next read returns the second most significant byte, and so on. The last read returns the least significant byte. This register can only be read when SR:PR is set. Reading this register when SR:PR is clear causes an error. A read of this register following a write command also causes an error.

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Data In Register [DI]

Address: Base Address + 1 ***Access: WRITE***

The host writes the arguments associated with a command to the Data In register. Figure 14 shows the bit functions of the Data In register.

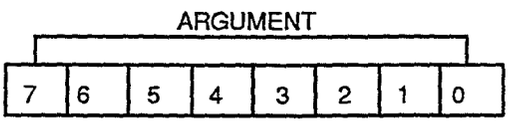
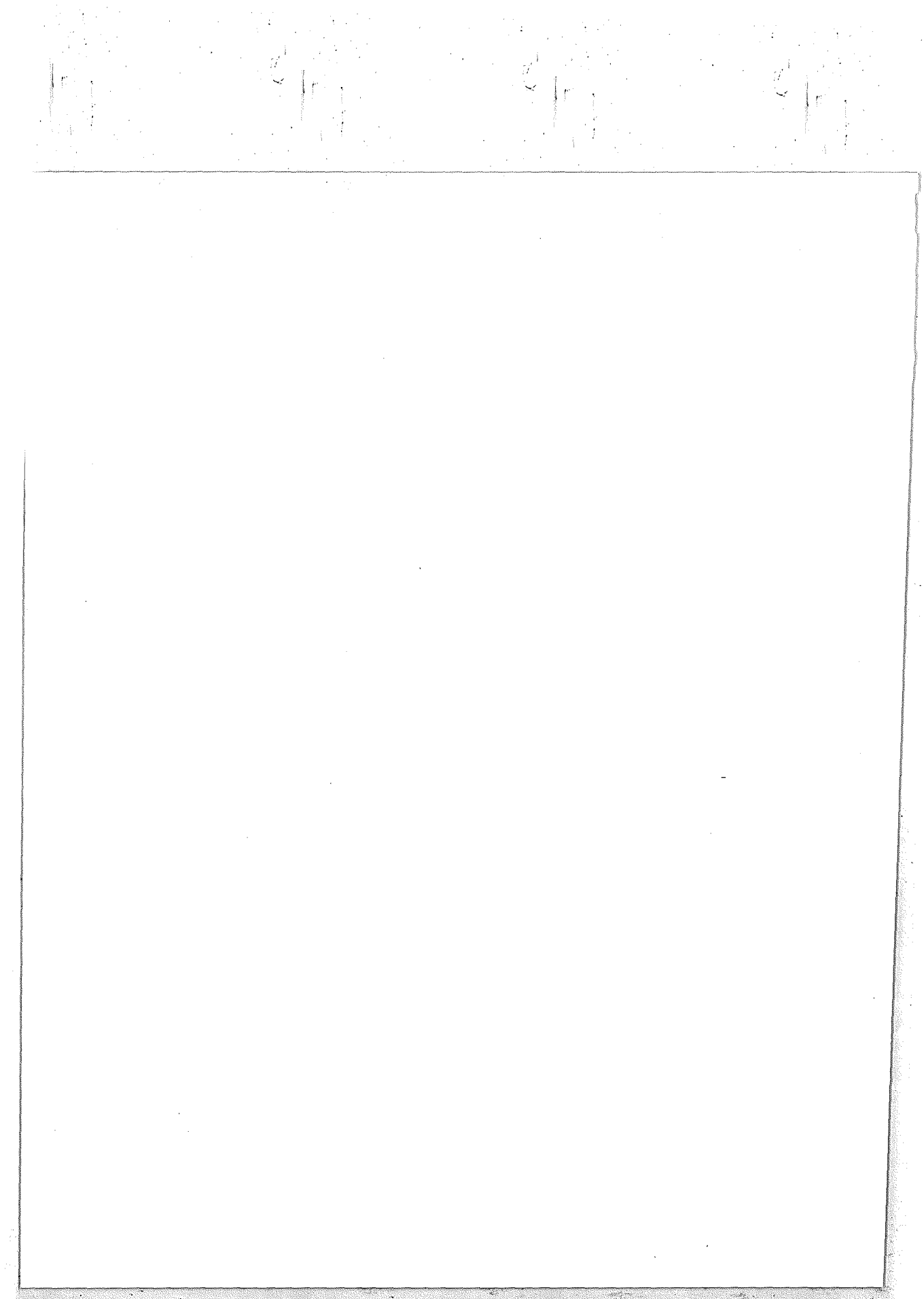


Figure 14: Data In Register Bit Functions

Bits 7–0: Argument

A write to this register provides an argument associated with the firmware command written earlier to the Command register. If multiple arguments are associated with the command, the arguments are written in order of most significant byte to least significant byte. This register can only be written to when SR:PR is set. Writing to this register when SR:PR is clear causes an error. A write to this register following a read command also causes an error.

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Chapter 4

Firmware

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*Chapter 4, "**Firmware**," describes the firmware commands that the host writes to the DT2802 to perform operations. This chapter is organized as follows:*

- *Overview*
- *DT2802 System Operation*
- *Command Summary*
- *Firmware Commands*

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Overview

The onboard microprocessor controls and services the DT5705 module, the serial port, input and output switches, the command and data registers, and internal timers.

The DT2802 performs an operation when it receives a firmware command from the host. The onboard EPROM contains the code executed by the microprocessor. This code is preprogrammed at the factory and performs all the board functions. You do not write code for the microprocessor. You operate the board by writing firmware commands that the microprocessor uses to perform specific board functions.

Powerup/Reset

At powerup or reset, the microprocessor sets up and performs diagnostics on the EPROM, data buffer, and its internal RAM. Once these diagnostics complete, the microprocessor loads the EEROM configuration into its RAM. Finally, the microprocessor tests the integrators by performing one conversion on each integrator at the configured resolution.

Note *This conversion affects the length of the powerup or reset operation. If the last saved resolution was 18 bits, the conversion occurs in 8.333 msec (or 1/120 seconds @ 60Hz line frequency). If the last saved resolution was 24 bits, the conversion requires 500 msec (or 1/2 second @ 60Hz line frequency).*

If all tasks in this sequence are successful, the Port Ready bit (bit 7) in the Status register (SR:PR) sets, indicating to the host that the DT2802 is ready for operation. If any tasks in this sequence fail, the Error bit (bit 0) in the Status register (SR:ERR) sets.

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Command Processing

Once powered up or reset, the DT2802 board is idle until the host writes a firmware command to the board. While in this state the Port Ready bit (SR:PR) is set. (See pages 40 to 47 in Chapter 3, "Hardware Overview," for the DT2802 register descriptions.)

When the DT2802 receives a command byte, the microprocessor determines if any arguments are required. If no arguments are associated with the command, the DT2802 executes the command. If arguments are required by the command, the DT2802 waits for the host to send the arguments (via the Data In register). In the stand-alone mode, the host sends the arguments with the command in a packet. When the DT2802 has received all arguments, it executes the command.

When the command completes, the DT2802 becomes ready for another command. The DT2802 can execute firmware read commands while the integrators are acquiring data (online state).

The following commands can only execute when no data acquisition is occurring (the DT2802 is in the offline state):

- CALIBRATE INTEGRATORS
- SAVE CONFIGURATION IN EEROM
- SET LINE FREQUENCY

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DT2802 System Operation

The DT2802 has several subsystems: one or two independent integrators, four output switches, four switch inputs, a serial I/O port, an Event/Interrupt control section, and a data management system. Each subsystem has its own set of configuration and operation commands. This section provides the details of each subsystem's operation.

Integrators

The DT2802-2 has one and the DT2802-4 has two time-base independent integrators. Each integrator has its own configuration parameters and data buffer. You can set and read the parameters listed below for each integrator installed on your board. You need to configure your integrator parameters once for your application and then save the values. The integrators will retain these values (even after powering off your system) until you change them.

Integrator Enable *(see page 81)*

You can turn off one of the integrators to prevent crosstalk between integrators. Crosstalk is the effect one input signal can have on another. For example, if one detector is tracking a large peak and the other detector is at baseline, some small amount of the peak could show up in the baseline trace.

The DT2802 always powers up or resets with both integrators enabled. The integrator enable/disable state is not saved in EEROM.

You can configure an integrator in either the enabled or disabled state. However, attempting to issue a start command to a disabled integrator will result in an "integrator not enabled" error.

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Trigger Source *(see page 82)*

The trigger source is the specific action required to *trigger* the integrator to start conversions. The trigger source may be a change in state at any of the four switch inputs or a software command.

Acquisition Type *(see page 84)*

The acquisition type can be either *single* or *continuous*. When the acquisition type is "single," the integrator performs one conversion for each trigger. When the acquisition type is "continuous," a trigger starts the integrator which then converts the detector signal continuously (at a rate determined by the RESOLUTION and TIME INTERVAL commands) until the DT2802 receives a STOP command or the data buffer for that integrator overflows.

Integrator Mode *(see page 85)*

The integrator mode can be either *single channel* or *automux*. When the integrator mode is "single channel," the integrator acquires data from only the channel selected via the SET CHANNEL command. When the integrator mode is "automux," the integrator performs a conversion on one input channel, the next conversion on the other input channel, the next conversion on the first input channel, and so on, alternating conversions between the two channels.

Note *In the "automux" mode, integrator A automatically begins with channel 1 and integrator B with channel 3. If you wish to begin automux conversions on channel 2 (integrator A) or channel 4 (integrator B), issue the SET INTEGRATOR INPUT CHANNEL command after setting the mode to "automux."*

When you set the acquisition type to "single" and select "automux," each trigger causes the integrator to perform one conversion on the current channel (for example, channel 1) and then switch to the other channel (for example, channel 2). The next trigger causes the integrator to perform one conversion on that channel (channel 2) and then switch to the other channel (channel 1).

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Note *Whenever the DT2802 switches channels, the integrator must settle before it can take another measurement. The length of this settling time depends on the resolution value for the integrator (see Table 9 below). As a result, in the automux mode, the maximum throughput per channel is slightly less than one-half the throughput in the single channel mode.*

Table 9: Resolution vs. Throughput

	Single Channel Mode		Automux Mode	
Resolution	**60Hz**	**50Hz**	**60Hz**	**50Hz**
18 bits	120	100	30.0	25.0
19 bits	60	50	20.0	16.6667*
20 bits	30	25	12.0	10.0
21 bits	15	12.5	6.0	5.0
22 bits	7.5	7.1429*	3.0	2.7778*
23 bits	3.75	3.8462*	1.5789*	1.5625
24 bits	2.0	2.0	0.9091*	0.8929*

** These throughput rates are rounded to four decimal places.*

Integrator Input Channel *(see pages 87–88)*

Each integrator has two input channels. The input channels for integrator A are channels 1 and 2. The input channels for integrator B are channels 3 and 4. This parameter selects the channel to be used for conversions on that integrator.

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Integrator Resolution *(see pages 89–92)*

You can set each integrator independently for a resolution of 18 to 24 bits. The higher the resolution you select, the smaller the change in signal the integrator can measure. As you increase the resolution, you increase the time the integrator requires to convert the detector signal. For example, at 18-bit resolution, the integrator requires 8.333 msec or 1/120 second (at 60Hz line frequency) to perform a conversion. At 19-bit resolution, the integrator requires 16.667 msec (1/60 second) to perform a conversion. At 24-bit resolution, the integrator requires 500 msec (1/2 second) to perform a conversion. Table 10 lists the minimum measurable voltage and conversion time at each resolution.

Table 10: Resolution vs. Conversion Time

		Minimum Conversion Time (number of power line cycles)	
Resolution	**1 LSB**	**60Hz**	**50Hz**
18 bits	8392.3 nV	0.5	0.5
19 bits	4196.2 nV	1.0	1.0
20 bits	2098.1 nV	2.0	2.0
21 bits	1049.0 nV	4.0	4.0
22 bits	524.42 nV	8.0	7.0
23 bits	262.26 nV	16.0	13.0
24 bits	131.13 nV	30.0	25.0

Time Interval *(see page 94)*

The DT2802 bases its integration times on the user-specified power line frequency. With the exception of 18-bit resolution, all measurements are an integral number of power line cycles. This allows the DT2802 to reject the crosstalk from the power lines to the detector inputs.

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To take measurements less frequently than the maximum sampling rates shown in Table 11, you must specify a time interval (delay) between conversions. This time interval is specified in 0.5 line cycle increments. Using a fractional number for the time interval will not adversely affect rejection of the power line crosstalk.

Note *In the automux mode, the integrator will delay the time interval between measurements rather than the settling time when after switching channels if the specified time interval exceeds the settling time. However, if the settling time is longer than the specified time interval, the integrator will wait the settling time before taking a measurement on the new channel.*

Table 11: Resolution vs. Sampling Rate (Single Channel)

Resolution	Maximum Sampling Rate*	
	60Hz	50Hz
18 bits	120	100
19 bits	60	50
20 bits	30	25
21 bits	15	12.5
22 bits	7.5	7.1429**
23 bits	3.75	3.8462**
24 bits	2.0	2.0

** Maximum sampling rate is in measurements per second*

*** These throughput rates are rounded to four decimal places*

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The equation to compute the sampling rate is:

$$\textbf{Sampling Rate} = \frac{\textbf{1.0}}{\textbf{Conversion Time + Time Interval}}$$

where:

$$\text{Conversion Time} = \frac{\text{Min Conv Time in number of line cycles}}{\text{Line Frequency}}$$

$$\text{Time Interval} = \frac{\text{Time Interval in number of line cycles}}{\text{Line Frequency}}$$

To compute the time interval value, follow the steps below. (Refer to pages 60 and 61 for examples of this calculation.)

1. Determine the *Number of Line Cycles per Conversion* at your desired sampling rate.

   For 60Hz boards:

   $$\text{Number of Line Cycles per Conversion} = \frac{60}{\text{Desired Sampling Rate}}$$

   For 50Hz boards:

   $$\text{Number of Line Cycles per Conversion} = \frac{50}{\text{Desired Sampling Rate}}$$

   The *Number of Line Cycles per Conversion* is in units of 0.5 line cycles.

2. Determine the resolution you need from Table 12 below. Table 12 gives the smallest measurable signal at each resolution.

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Table 12: Resolution vs. LSB and nV-sec

Resolution	1 LSB	nV-sec @ 60Hz	nV-sec @ 50Hz
18 bits	8392.3 nV	69.936 nV-sec	83.923 nV-sec
19 bits	4196.2 nV	69.936 nV-sec	83.923 nV-sec
20 bits	2098.1 nV	69.936 nV-sec	83.923 nV-sec
21 bits	1049.0 nV	69.936 nV-sec	83.923 nV-sec
22 bits	524.52 nV	69.936 nV-sec	73.433 nV-sec
23 bits	262.26 nV	69.936 nV-sec	68.188 nV-sec
24 bits	131.13 nV	65.565 nV-sec	65.565 nV-sec

All values in this table are rounded to five decimal digits.

3. Using Table 10 on page 56, determine the number of line cycles required to make a measurement at your selected resolution. This value is the *Minimum Number of Line Cycles per Conversion.*

4. Compare the *Number of Line Cycles per Conversion* (from step 1) with the *Minimum Number of Line Cycles per Conversion* (from step 3).

   The *Number of Line Cycles per Conversion* must be equal to or greater than the *Minimum Number of Line Cycles per Conversion.*

   If the *Number of Line Cycles per Conversion* is less than the *Minimum Number of Line Cycles per Conversion*, you are attempting to exceed the maximum sampling rate of the system.

5. If the *Number of Line Cycles per Conversion* is greater than the *Minimum Number of Line Cycles per Conversion*, determine the *Time Interval* in number of line cycles.

   Time Interval = Number of Line Cycles per Conversion –
   Minimum Number of Line Cycles per Conversion

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6. Calculate the argument value for the SET INTERVAL TIME command. (This argument has an increment of 1/2 line cycle.)

   Argument value = Time Interval * 2

   Convert the argument value to hex.

Example 1 A 20Hz sampling rate is desired at 18-bit resolution with a 60Hz line frequency.

- Sampling Rate = 20Hz
- *Number of Line Cycles per Conversion* is 60/20 = 3.0.
- Using Table 10, the *Minimum Number of Line Cycles per Conversion* = 0.5.
- The *Time Interval* is 3.0 – 0.5 = 2.5.
- The argument value for the SET INTERVAL TIME command is 2 * 2.5 = 5 (decimal) = 05 (hex)

Example 2 A 5Hz sampling rate is desired at 20-bit resolution with a 60Hz line frequency.

- Sampling Rate = 5Hz
- *Number of Line Cycles per Conversion* is 60/5 = 12.0.
- Using Table 10, the *Minimum Number of Line Cycles per Conversion* = 2.0.
- The *Time Interval* is 12.0 – 2.0 = 10.0.
- The argument value for the SET INTERVAL TIME command is 2 * 10 = 20 (decimal) = 14 (hex)

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Example 3 A 5Hz sampling rate is desired at 20-bit resolution with a 50Hz line frequency.

- Sampling Rate = 5Hz
- *Number of Line Cycles per Conversion* is 50/5 = 10.0.
- Using Table 10, the *Minimum Number of Line Cycles per Conversion* = 2.0.
- The *Time Interval* is 10.0 – 2.0 = 8.0.
- The argument value for the SET INTERVAL TIME command is 2 * 8.0 = 16.0 (decimal) = 10 (hex)

Additional Configuration

In addition to these configuration parameters for the integrators, there are several commands and parameters associated with interrupt and polled I/O operation (see pages 115 to 118) as well as buffer management (see pages 119 to 121) during conversions. These commands provide the interface from the DT2802 to the host PC.

Starting Conversions *(see page 97)*

After you have configured the integrator(s), you initiate conversions with a trigger.

To use a software trigger, select the software command as the trigger source (see page 54) using the SET TRIGGER SOURCE command and issue the START CONVERSIONS command to begin conversions. The conversions begin immediately.

To use a hardware trigger, select one of the switch inputs as the trigger source using the SET TRIGGER SOURCE command, specify its active edge with the SET ACTIVE EDGE command, and enable the switch input using the SET INPUT ENABLE command. The DT2802 begins conversions when the DT2802 senses the specified change in state at that switch input. For the DT2802 to recognize another hardware trigger at that switch input, the host must acknowledge the event before beginning another set of conversions.

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The DT2802 behaves differently in the single acquisition and continuous conversion modes.

Single Acquisition Mode

Each START CONVERSIONS command initiates the integrator to perform a single conversion. The DT2802 places the data in the data buffer and becomes ready for the next trigger.

Continuous Conversion Mode

The START CONVERSIONS command resets/clears the data buffer for the integrator and then initiates the integrator to begin conversions. When conversions begin, the DT2802 places the result of each conversion in the data buffer for the integrator. The conversions occur automatically at the defined interval. The DT2802 sets the Integrator Data Ready bit in the Status register (SR:IDR) when the number of data points in the buffer reaches the preset threshold.

Stopping Conversions *(see page 97)*

The conversions stop when the DT2802 receives the STOP command from the host or the data buffer overflows. You should read the contents of the data buffer (if the data is valid) whenever conversions stop, or you will lose that data when you issue another START CONVERSIONS command. This command stops conversions *immediately*. A conversion in progress (on that VFC) is lost.

Read Integrator Status *(see page 96)*

You can determine whether an integrator is idle or converting data by using the READ INTEGRATOR STATUS commands.

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Output Switches

The DT2802 has four output switches that you can open and close individually or together. The DT2802 opens all output switches on powerup or reset. See Reference 5, "Specifications," for the input and output switch interface specifications.

Open/Close Switches *(see page 103)*

You can open or close each output switch separately or simultaneously using the SET OUTPUT SWITCHES command.

Switch Inputs

The DT2802 has four switch inputs. You can configure the active edge for each switch input, the debounce state, and enable/disable recognition of an input signal. The firmware commands for the switch inputs include:

Set Active Edge *(see pages 98–100)*

You can specify the active edge for each input as a low-to-high transition, high-to-low transition, or either type of transition.

Debounce Input Mode *(see page 101)*

Relays or contact closures connected to the inputs may have some bounce (oscillation between high and low states) when they close. The debounce input mode can be *debounce* or *no debounce*. When the input mode is "debounce," the DT2802 looks for a stable state following a transition to determine whether an event occurred at the input. When the input mode is "no debounce," the DT2802 recognizes the selected active edge as an event at that input.

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Input Enable *(see page 102)*

The DT2802 disables all switch inputs at powerup or reset. That is, it does not recognize a change of state at any of these inputs until they are "enabled." This allows you to connect devices to the inputs before or after powering on without spurious edge detection occurring. You must "enable" the detection circuit with this command to recognize an input signal at any of the inputs.

Read/Acknowledge Active Inputs *(see pages 105–106)*

Any active edge that occurs on an enabled input event/interrupt source causes the Event/Interrupt Pending bit in the Status register (SR:IP) to set. (Inputs must be enabled with the INPUT ENABLE command for the DT2802 to recognize a change in signal.) The READ/ACK INPUT command returns the edge that caused the event and clears the event/interrupt so the DT2802 can detect another edge on that input.

Note *The DT2802 cannot detect another event at that input until the previous event is cleared. (That is, the corresponding bit in the Event/Interrupt Pending mask must be clear.)*

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Serial I/O

The DT2802 has a serial I/O port for communicating with RS232-based devices (in the ISA bus mode) or for operating remotely (stand-alone mode).

In the ISA bus mode, the serial I/O port is intended to pass start/stop type of control signals. It has a 255-byte input buffer. The following commands are valid in this mode:

- SET/READ SERIAL INPUT CONTROL
- SELECT/READ BAUD RATE
- WRITE SERIAL DATA BYTE
- READ SERIAL DATA BYTE
- READ NUMBER OF BYTES
- SET/CLEAR RS232CONTROL SIGNAL
- READ RS232 CONTROL SIGNAL

In the stand-alone mode, all communication with the host (firmware commands and data) occurs over the serial port. The following commands are valid in this mode:

- SELECT/READ BAUD RATE
- READ NUMBER OF DATA BYTES
- SET/READ SIO DATA MODE
- SET/READ STREAM DATA SIZE

Serial Input Enable *(see page 108)*

The serial input port of the DT2802 is disabled at powerup or reset. To receive serial data from an external device, you must enable the input port using the SET SERIAL INPUT CONTROL command.

Note *Enabling the serial input port clears the serial input buffer. You must read any data in the input buffer using the READ SERIAL DATA command before you enable the port, or the data will be lost.*

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Set Serial Baud Rate *(see page 109)*

The serial port has a software-configurable baud rate that can optionally be saved to EEROM. The selectable baud rate values are: 300, 1200, 2400, 4800, 9600, 19200, and 38400. The serial port receiver and transmitter use the same baud rate.

The other communications parameters are fixed at 8 data bits, 1 stop bit, 1 start bit, and no parity.

You must disable the serial input port before issuing this command or the DT2802 reports a "Serial Input in Process" error. Also, if you wrote a byte of serial data to the port, you must allow it to complete transmission before issuing this command or the DT2802 reports a "Serial Output in Process" error.



Read/Write Serial Data *(see page 111)*

The DT2802 sends or receives data through the serial port one (1) byte at a time.

Serial Input Buffer *(see page 111)*

The DT2802 has a 255-byte input buffer for data received from an external device connected to the serial port. You can use the READ NUMBER OF BYTES command to determine how many bytes are in the input buffer. If the buffer is full (255 bytes) and the DT2802 receives another byte, the DT2802 reports a "Serial Input Buffer Overflow Error," and the new data is lost.



Set/Clear RS232 Control Signal *(see page 112)*

The RS232 port has a control signal line that you can set or clear. You can use the READ RS232 CONTROL SIGNAL command to determine the state of this signal line.

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Set/Read SIO Mode *(see page 113)*

The DT2802 has two modes for transmitting data to the host when in the stand-alone mode: Normal Data and Stream Data. In the Normal Data mode, the DT2802 sends the data to the host, one data point (four bytes) at a time. In the Stream Data mode, the DT2802 sends packets of data to the host in a continuous stream. You can use the READ SIO MODE command to determine the data transfer mode.

Set/Read Stream Data Size *(see page 114)*

You can specify the number of data points the DT2802 includes in the data packet it sends to the host in the Stream Data mode. The data packet size can range between 1 and 64 four-byte data points, inclusive.

The throughput of the DT2802 is affected by the stream data packet size, the baud rate, the VFC resolution, and the operating environment. If you choose a large packet size, the DT2802 may have to send the packet multiple times in a noisy environment, or the VFC buffers may overflow at faster resolutions (18 or 19 bits) at slower baud rates.

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Event/Interrupt Control

The Event/Interrupt Control section presents the current status of the major subsystems within the DT2802. The two-byte Event/Interrupt Pending mask provides this status. Each bit in the mask corresponds to a specific event within the DT2802's normal operation.

Your application can use this event/interrupt pending mask in two modes: polled I/O and interrupt driven operation.

Polled I/O

see page 117 You can use the READ/EVENT INTERRUPT PENDING MASK command to determine the state of all subsystems at any time.

see page 116 You can use the SET EVENT/INTERRUPT MASK command to enable a specific subsystem as an event source. Each bit in the Event/Interrupt mask corresponds to the same bit in the Event/Interrupt Pending mask. If a bit in the Event/Interrupt Pending mask is set, and the same bit is set in the Event/Interrupt mask, the DT2802 sets the Interrupt Pending bit (bit 2) in the Status register (SR:IP). By polling SR:IP, you can determine when the DT2802 is ready to be serviced.

Interrupt Driven I/O

see page 118 In addition to using the SET EVENT/INTERRUPT MASK command to enable a specific subsystem as an interrupt source (as described above for Polled I/O), you would enable the Master Interrupt using the SET MASTER INTERRUPT command. With interrupts enabled, the DT2802 issues an interrupt to the host whenever SR:IP sets.

Use the READ EVENT/INTERRUPT PENDING command to determine the source of the interrupt. Once you know the source, service the interrupt, clear it, and re-enable the Master interrupt.

Notes *When an interrupt occurs, the DT2802 disables further interrupts until you re-enable the Master Interrupt. In addition, the DT2802 will not recognize another interrupt from that source until you acknowledge that interrupt.*

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In order to minimize the number of times your application must service interrupts, service all events that have occurred before you re-enable the Master Interrupt.

You must acknowledge each event/interrupt individually using the appropriate READ/ACK command. Table 13 lists the events that can occur and the command that clears the interrupt.

Table 13: Acknowledging Events/Interrupts

Event	Acknowledge Command	Page
System Error	READ SYSTEM ERROR	79
Data Ready A	READ NEXT CONVERSION INTEGRATOR A	121
Data Ready B	READ NEXT CONVERSION INTEGRATOR B	121
Serial Data Ready	READ SERIAL DATA BYTE	111
Serial Transmit Buffer Empty	WRITE SERIAL DATA BYTE	111
Input 1	READ INPUT 1	105
Input 2	READ INPUT 2	105
Input 3	READ INPUT 3	105
Input 4	READ INPUT 4	105

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Data Management

Each integrator on the board has its own 2048-sample data buffer. The DT2802 provides a series of commands for easy manipulation of these buffers. These commands include:

Reset Buffer *(see page 119)*

This command erases the contents of the integrator's data buffer. *All data is lost.*

Buffer Threshold *(see page 120)*

The buffer threshold determines the number of samples to collect before the DT2802 signals that data from that integrator is available for transfer. The DT2802 sets the Integrator Data Ready bit in the Status register (SR:IDR) at that time.

Read the Current Number of Samples *(see page 120)*

This command returns the number of samples currently in the integrator's data buffer. The number of samples increments each time the DT2802 adds a data point from a conversion and decrements each time the DT2802 transfers a value to the host.

You use this command to determine when an integrator is ready for another trigger when it is configured for the *single acquisition mode* as follows:

Before you issue a trigger, you read the number of samples in the buffer. You then issue the trigger and read the number of samples in the buffer until it increments by 1. The integrator is ready for another trigger at that time.

Read the Next Conversion *(see page 121)*

This command transfers a data point in the integrator's data buffer to the host PC.

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Command Summary

This section summarizes the types of firmware commands for the DT2802 board. These commands are described in detail in "Firmware Commands," beginning on page 75.

These commands have been grouped according to the following functions:

- **System Operation**

  These commands set the line frequency, save the board configuration, calibrate the integrators, abort a command, and return/clear an error status.

- **Integrator Configuration/Operation**

  These commands affect how an integrator performs conversions. They set or return sampling rate, resolution, and acquisition mode, select the input channel, and start/stop integration.

- **I/O Switch Configuration**

  These commands set or return the active edge for the input switches, enable the input, acknowledge an input interrupt, and set or return the output switch states.

- **Serial Port Configuration/Operation**

  These commands set or return the serial port baud rate and transfer data and commands to/from the serial port.

- **Event/Interrupt Control**

  These commands set or return the state of the master interrupt and set or return the event/interrupt source mask.

- **Data Buffer Management**

  These commands set or return the threshold for an integrator's data buffer.

- **Other**

  These are additional DT2802 commands.

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Command Structure

In the ISA bus mode, the host writes the DT2802 firmware commands to the Command register when the Port Ready bit (SR:PR) is set. Some command require the host to write one or more *arguments* to the Data In register before the DT2802 executes that command. Other commands require the host to read one or more *data values* from the Data Out register to complete execution of that command. Each command has a specific number of bytes associated with it. The host must send or read that number of bytes from the appropriate data register before sending another command or an error occurs.

In the stand-alone mode, the host sends a packet containing the firmware command and any arguments to the DT2802 when the status byte returned by the DT2802 indicates it is ready for another command.

Most arguments have specific values. That is, each argument value has a particular meaning to that command.

The DT2802 returns values associated with a command most significant byte first, followed by the next most significant byte, and so on. The last data byte associated with a multi-byte command is the least significant byte. For commands requiring arguments, you must send the most significant byte first and the least significant byte last.

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To Send a Command

In order to send a command to the DT2802 in the ISA bus mode, you must follow these basic steps. If the DT2802 is in the stand-alone mode, see Reference 6, "Remote Control Protocol," for information on sending commands to the DT2802.

Note *See pages 40 to 47 in Chapter 3, "Hardware Overview," for a description of the DT2802 registers.*

1. Read the Status register [SR] until the Port Ready bit (PR) sets.

2. Write the command byte to the Command register [CR].

3. Read the SR until PR sets.

   - If the command has no arguments associated with it, the DT2802 executes the command (PR is clear during command execution) and the host can send another command as soon as PR sets.

   - If the command has arguments associated with it, continue with step 4.

4. Write the first argument to the Data In register [DI].

5. Read the SR until PR sets.

6. If there are additional arguments associated with that command, write the next argument to the DI register.

7. Read the SR until PR sets.

8. Repeat steps 6 and 7 until all arguments associated with that command have been written to the DT2802. The DT2802 will execute the command after it receives all arguments.

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To Read Data from the DT2802

In order to read data from the DT2802 in the ISA bus mode, you must follow these basic steps. If the DT2802 is in the stand-alone mode, see Reference 6, "Remote Control Protocol," for information on transferring data to the host.

Note *See pages 40 to 47 in Chapter 3, "Hardware Overview," for a description of the DT2802 registers.*

1. Read the Status register [SR] until the Port Ready bit (PR) sets.
2. Write the command byte to the Command register [CR].
3. Read the SR until PR sets.
4. Read the first data byte from the Data Out register [DO].
5. Read the SR until PR sets.
6. If there are additional data bytes associated with that command, read the next byte from the DO register.
7. Read the SR until PR sets.
8. Repeat steps 6 and 7 until all data associated with that command has been read from the DT2802.

Note *The DT2802 always sends the most significant byte first, followed by the next most significant byte, and so on. It sends the least significant byte last.*

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Firmware Commands

This section describes the firmware commands for the DT2802 board. Some commands have arguments associated with them. Some arguments have specific settings. Other commands require you to read several bytes of data. All of these conditions are noted.

The commands are presented by function as described in the previous section. The format for each command is as follows:

Command Name

Command description

Hex Code	ARG1	ARG2	ARG3...	DESCRIPTION

for set or select commands

or

Hex Code	DATA1	DATA2	DATA3...	DESCRIPTION

for read command

See Reference 8, "Firmware Command Summary," for a list of commands in alphabetical and numerical order.

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System Operation

The commands described in this section perform specific board functions.

SET LINE FREQUENCY

This command sets the DT2802 board to the local line frequency. All integration timing is based on this selection. Both integrators must be idle to execute this command.

Note *If you change this setting, you must reset the board for the new value to take effect. If you set and then read this value without resetting the board, the DT2802 returns the previous value. This is because this command changes the line frequency value in EEROM. When you reset the board, the DT2802 writes this value to its working configuration table.*

CMD	ARG1	DESCRIPTION
28	01	Select 60Hz line frequency
28	02	Select 50Hz line frequency

READ LINE FREQUENCY

This command returns a value indicating to which line frequency the DT2802 board is set.

CMD	DATA1	DESCRIPTION
38	01	Line frequency set to 60Hz
38	02	Line frequency set to 50Hz

Note: *All commands and arguments are in hex unless otherwise noted.*

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RESET

This command performs a hardware reset of the board when the argument written to the Data In register is 01. When the argument is 02, the DT2802 saves the factory configuration values in EEROM and resets the board. *The previously saved user configuration is lost!* At reset (and powerup), the Master Interrupt is disabled, the four output switches are open, the switch inputs are disabled, and serial input is disabled.

In the stand-alone mode, the DT2802 responds to this command with the ACK|STATUS message at the current baud rate. It then sets the baud rate to the value stored in EEROM if the argument value is 01, and to 9600 baud if the argument value is 02. Bacause there is a slight delay before the baud rate actually changes, the host should not try to access the DT2802 at the new baud rate for at least 10 ms after sending this command. In addition, the host serial port must also be set to the new baud rate before communication is possible with the DT2802. If the DT2802 detects an error when the host sends this command, the DT2802 responds with the ACK|STATUS message. The error bit in the status byte will be set and the reset does not occur.

CMD	ARG1	DESCRIPTION
29	01	Reset the board and restore the last saved settings from EEROM
29	02	Restore factory configuration to EEROM and reset the board

SAVE CONFIGURATION IN EEROM

This command saves the current configuration table to EEROM. This save operation takes 100 ms to perform and can only be done while the integrators are idle (DT2802 is in an offline state). If you send this command while the DT2802 is acquiring data, an error occurs.

This command requires you to write four data values in sequence to the Data In register for the save to take place. (The Port Ready bit in the Status register [SR:PR] must set before you write each argument or an error occurs.)

Note: *All commands and arguments are in hex unless otherwise noted.*

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CMD	ARG1	ARG2	ARG3	ARG4	DESCRIPTION
2C	01	02	03	04	Save current configuration to EEROM

The parameters stored in EEROM are the event/interrupt sources, local line frequency, serial port baud rate, serial I/O data mode, stream packet size, trigger source, acquisition type, buffer threshold, resolution, and input channel for each integrator, input mode, and active edge for each input.

CALIBRATE INTEGRATORS

This command electronically calibrates the integrators. This operation takes approximately 1 minute to perform. Both integrators must be idle (DT2802 is in an offline state) to send this command. If you send this command while the DT2802 is acquiring data, an error occurs.

This command requires you to write four data values in sequence to the Data In register for calibration to occur. (The Port Ready bit in the Status register [SR:PR] must set before you write each argument or an error occurs.) For more information on the calibration sequence, see Reference 2, "Board Calibration."

In the stand-alone mode, no communication with the DT2802 is possible while this command executes. The DT2802 returns the ACK|STATUS message approximately 1 minute after the host sends this command. If the DT2802 detects an error with this command, it returns the ACK|STATUS message immediately.

CMD	ARG1	ARG2	ARG3	ARG4	DESCRIPTION
2D	01	02	03	04	Calibrate the integrators and reset the board

Note: *All commands and arguments are in hex unless otherwise noted.*

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ABORT COMMAND

This command terminates the current command without causing a system error. You can only abort a command prior to sending the final argument for the command. If you have already sent all arguments when you write this command, the command executes and does not abort. You cannot abort a command with no arguments.

CMD	DESCRIPTION
2E	Terminate the current command without causing an error or executing the command

READ SYSTEM ERROR

This command returns 2 bytes indicating the source of the error. By executing this command, you clear the error. If more than one error has occurred, the Error bit in the Status register (SR:ERR) remains set until you have read all the errors.

When SR:ERR sets, a system error has occurred. The DT2802 will not allow further command processing until you clear this error. Some conditions that can cause an error include:

- Command written to Command register [CR] when DT2802 was expecting arguments (except ABORT command).
- Command, Data In, or Data Out register was accessed when SR:PR was clear
- Data In or Data Out register was accessed out of sequence
- Buffer overflow occurred

See Reference 7, "Error Codes," for a complete list of the error codes and their meaning.

CMD	DATA1	DATA2	DESCRIPTION
39	MSB	LSB	Error code

Note: *All commands and arguments are in hex unless otherwise noted.*

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Integrator Configuration/Operation

The commands described in this section represent the parameters affecting data conversion. The DT2802 provides separate commands for each integrator.

Note *Commands for integrator B are not used on a DT2802-2. These commands are flagged with a special symbol in this document. If you attempt to execute a command for integrator B on a DT2802-2 board, the DT2802-2 returns an "Integrator B not installed" error.*

The DT2802 loads the settings for Trigger Source, Acquisition Type, Sampling Rate, Channel, and Resolution for each integrator at powerup or reset. You can change the settings any time the board is not actively acquiring data and optionally store the new settings in EEROM. See Chapter 5, "Programming Sequences," for instructions on changing the board configuration.

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET INTEGRATOR ENABLE

This command allows you to turn off one of the integrators to prevent crosstalk between the integrators.

Both integrators are enabled at powerup or reset. You can configure an integrator while it is enabled or disabled. However, you cannot trigger integration on a disabled integrator or an "Integrator not enabled" error occurs.

CMD	ARG1	DESCRIPTION
2F	01	Enable integrator A and disable integrator B
2F	02	Disable integrator A and enable integrator B
2F	03	Enable both integrators

READ INTEGRATOR ENABLE

This command returns a value to the Data Out [DO] register indicating the enable/disable state of the two integrators. You can send this command while the integrators are busy or idle.

CMD	DATA1	DESCRIPTION
3F	01	Integrator A enabled and integrator B disabled
3F	02	Integrator A disabled and integrator B enabled
3F	03	Both integrators are enabled

Note: *All commands and arguments are in hex unless otherwise noted.*

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SELECT TRIGGER SOURCE

This command chooses the signal that will start integration on an integrator. This trigger source can be any of the switch inputs or a software command. You can only send this command for a particular integrator while that integrator is idle. If you send this command while that integrator is acquiring data, an error occurs.

CMD	ARG1	DESCRIPTION
04	01	Select switch input 1 as trigger source for integrator A
04	02	Select switch input 2 as trigger source for integrator A
04	03	Select switch input 3 as trigger source for integrator A
04	04	Select switch input 4 as trigger source for integrator A
04	05	Select software command as trigger source for integrator A
05	01	Select switch input 1 as trigger source for integrator B
05	02	Select switch input 2 as trigger source for integrator B
05	03	Select switch input 3 as trigger source for integrator B
05	04	Select switch input 4 as trigger source for integrator B
05	05	Select software command as trigger source for integrator B

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ TRIGGER SOURCE

This command returns a value to the Data Out [DO] register indicating the type of signal that will start integration on that integrator. You can send this command while the integrators are busy or idle.

CMD	DATA1	DESCRIPTION
14	01	Trigger source for integrator A is switch input 1
14	02	Trigger source for integrator A is switch input 2
14	03	Trigger source for integrator A is switch input 3
14	04	Trigger source for integrator A is switch input 4
14	05	Trigger source for integrator A is a software command
15	01	Trigger source for integrator B is switch input 1
15	02	Trigger source for integrator B is switch input 2
15	03	Trigger source for integrator B is switch input 3
15	04	Trigger source for integrator B is switch input 4
15	05	Trigger source for integrator B is a software command

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET ACQUISITION TYPE

When the argument is 01, this command causes an integrator to perform a single conversion each time the START INTEGRATION command executes.

When the argument is 02, this command causes an integrator to continuously convert the detector signal at the specified sampling rate when the START INTEGRATION command executes. Conversions do not stop until the STOP CONVERSIONS command executes.

You can change the acquisition type for a particular integrator only while that integrator is idle. If you send this command while that integrator is acquiring data, an error occurs.

CMD	ARG1	DESCRIPTION
06	01	Select single acquisition mode for integrator A
06	02	Select continuous acquisitions for integrator A
07	01	Select single acquisition mode for integrator B
07	02	Select continuous acquisitions for integrator B

READ ACQUISITION TYPE

This command returns a value to the Data Out [DO] register indicating whether the integrator performs a single conversion (01) or continuous conversions (02) once integration starts. You can send this command while the integrators are busy or idle.

CMD	DATA1	DESCRIPTION
16	01	Integrator A performs a single conversion
16	02	Integrator A performs continuous conversions
17	01	Integrator B performs a single conversion
17	02	Integrator B performs continuous conversions

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET INTEGRATOR MODE

This command chooses whether the input to an integrator will be from a single channel or alternate between the two input channels. Use the SET INTEGRATOR INPUT CHANNEL command to select the input channel for an integrator when the integrator mode is single or to select the other channel as the starting channel in the automux mode.

Note *Whenever the DT2802 switches channels, the integrator must settle before it can take another measurement. The length of this settling time depends on the resolution value for the integrator (see Table 16 under the READ SETTLING TIME command). As a result, in the automux mode, the maximum throughput is half the throughput in the single channel mode. Use the READ SETTLING TIME command to determine the settling time for the integrator.*

You can change the input mode for a particular integrator only while that integrator is idle. If you send this command while that integrator is acquiring data, an error occurs.

CMD	ARG1	DESCRIPTION
80	01	Select single channel mode for integrator A
80	02	Select automux input mode for integrator A
81	01	Select single channel mode for integrator B
81	02	Select automux input mode for integrator B

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ INTEGRATOR MODE

This command returns a value that represents the input mode selected for an integrator to the Data Out [DO] register. You can send this command while the integrators are busy or idle.

CMD	DATA1	DESCRIPTION
90	01	The input mode for integrator A is single channel
90	02	The input mode for integrator A is automux
91	01	The input mode for integrator B is single channel
91	02	The input mode for integrator B is automux

Note: *All commands and arguments are in hex unless otherwise noted.*

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SELECT INTEGRATOR INPUT CHANNEL

This command chooses the input channel to the integrator when the integrator mode is single channel. (See SET INTEGRATOR MODE command.) This command selects the starting input channel when you send it after you set the automux mode.

Note *Whenever the DT2802 switches channels, the integrator must settle before it can take another measurement. The length of this settling time depends on the resolution value for the integrator (see Table 16 under the READ SETTLING TIME command). As a result, in the automux mode, the maximum aggregate throughput is slightly less than half the throughput in the single channel mode. Use the READ SETTLING TIME command to determine the settling time for the integrator.*

You can send a trigger to start conversions before the integrator finishes settling without causing an error. It will perform the conversion after it settles.

You can change the input channel for a particular integrator only while that integrator is idle. If you send this command while that integrator is acquiring data, an error occurs.

CMD	ARG1	DESCRIPTION
82	01	Select channel 1 as the input channel for integrator A
82	02	Select channel 2 as the input channel for integrator A
83	01	Select channel 3 as the input channel for integrator B
83	02	Select channel 4 as the input channel for integrator B

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ INTEGRATOR INPUT CHANNEL

This command returns a value that represents the input channel selected for an integrator to the Data Out [DO] register. You can send this command while the integrators are busy or idle.

CMD	DATA1	DESCRIPTION
92	01	Channel 1 is the input channel for integrator A
92	02	Channel 2 is the input channel for integrator A
93	01	Channel 3 is the input channel for integrator B
93	02	Channel 4 is the input channel for integrator B

Note: *All commands and arguments are in hex unless otherwise noted.*

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SELECT INTEGRATOR RESOLUTION

This command chooses the resolution for an integrator. The resolution refers to the number of bits the integrator uses to represent the detector signal. The higher the resolution, the smaller the change in signal the integrator can measure. Table 14 lists the smallest measurable signal at each resolution.

Table 14: Resolution vs. Smallest Measurable Signal

Resolution	1 LSB	nV-sec @ 60Hz	nV-sec @ 50Hz
18 bits	8392.3 nV	69.936 nV-sec	83.923 nV-sec
19 bits	4196.2 nV	69.936 nV-sec	83.923 nV-sec
20 bits	2098.1 nV	69.936 nV-sec	83.923 nV-sec
21 bits	1049.0 nV	69.936 nV-sec	83.923 nV-sec
22 bits	524.52 nV	69.936 nV-sec	73.433 nV-sec
23 bits	262.26 nV	69.936 nV-sec	68.188 nV-sec
24 bits	131.13 nV	65.565 nV-sec	65.565 nV-sec

All values in this table are rounded to five decimal digits.

Increasing the resolution also increases the time the integrator needs to perform a conversion. The integrator takes 8.333 msec (1/120 second) perform a single conversion at 18-bit resolution. It takes 500 msec (1/2 second) to perform a single conversion at 24-bit resolution. Table 15 on the following page lists resolution vs. conversion time (in number of power line cycles) and maximum throughput for the single channel mode.

Note: *All commands and arguments are in hex unless otherwise noted.*

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Table 15: Resolution vs. Conversion Time and Maximum Throughput (Single Channel)

Resolution	Conversion Time (NPLC)		Maximum Throughput*	
	60Hz	50Hz	60Hz	50Hz
18 bits	0.5	0.5	120	100
19 bits	1.0	1.0	60	50
20 bits	2.0	2.0	30	25
21 bits	4.0	4.0	15	12.5
22 bits	8.0	7.0	7.5	7.143**
23 bits	16.0	13.0	3.75	3.846**
24 bits	30.0	25.0	2.0	2.0

** Maximum sampling rate is in measurements per second*

*** These throughput rates are rounded to three decimal places*

The argument value written to the Data In [DI] register determines the resolution. Use the READ INTEGRATION TIME command to determine how long it takes the integrator to perform a single conversion.

Note *The resolution affects the length of the settling time. The higher the resolution, the longer it takes the integrator to settle. Whenever you set the resolution, the integrator settles to the new rate. See Table 15 above for the settling time at each resolution.*

You can change the resolution for a particular integrator only while that integrator is idle. If you send this command while that integrator is acquiring data, an error occurs.

Note: *All commands and arguments are in hex unless otherwise noted.*

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CMD	ARG1	DESCRIPTION
84	01	Select 18 bits as the resolution for integrator A
84	02	Select 19 bits as the resolution for integrator A
84	03	Select 20 bits as the resolution for integrator A
84	04	Select 21 bits as the resolution for integrator A
84	05	Select 22 bits as the resolution for integrator A
84	06	Select 23 bits as the resolution for integrator A
84	07	Select 24 bits as the resolution for integrator A
85	01	Select 18 bits as the resolution for integrator B
85	02	Select 19 bits as the resolution for integrator B
85	03	Select 20 bits as the resolution for integrator B
85	04	Select 21 bits as the resolution for integrator B
85	05	Select 22 bits as the resolution for integrator B
85	06	Select 23 bits as the resolution for integrator B
85	07	Select 24 bits as the resolution for integrator B

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ INTEGRATOR RESOLUTION

This command returns a value that represents the resolution for an integrator to the Data Out [DO] register. You can send this command while an integrator is busy or idle.

CMD	DATA1	DESCRIPTION
94	01	Integrator A resolution is 18 bits
94	02	Integrator A resolution is 19 bits
94	03	Integrator A resolution is 20 bits
94	04	Integrator A resolution is 21 bits
94	05	Integrator A resolution is 22 bits
94	06	Integrator A resolution is 23 bits
94	07	Integrator A resolution is 24 bits
95	01	Integrator B resolution is 18 bits
95	02	Integrator B resolution is 19 bits
95	03	Integrator B resolution is 20 bits
95	04	Integrator B resolution is 21 bits
95	05	Integrator B resolution is 22 bits
95	06	Integrator B resolution is 23 bits
95	07	Integrator B resolution is 24 bits

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ SETTLING TIME

This command returns a 1 byte value that represents the number of half line cycles for the selected integrator to settle at its chosen resolution to the Data Out [DO] register. You can send this command while the integrators are busy or idle.

When you switch inputs to an integrator (either manually or in the automux mode), the VFC requires a settling time to stabilize its output. The length of this settling time depends on the resolution you have chosen for that integrator. Table 16 shows the settling time (in number of half power line cycles) at each resolution at the two local line frequencies.

Table 16: Integrator Settling Time

Resolution	Settling Time (number of half line cycles)	
	60Hz	50Hz
18 bits	1	1
19 bits	1	1
20 bits	1	1
21 bits	2	2
22 bits	4	4
23 bits	6	6
24 bits	6	6

The firmware always waits the settling time or time interval (whichever is longer) before taking a measurement when you switch the input channel or operate in the automux mode.

CMD	DATA1	DESCRIPTION
98	byte	Number of half line cycles for integrator A to settle
99	byte	Number of half line cycles for integrator B to settle

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ INTEGRATION TIME

This command returns a 1-byte value that represents the number of half line cycles *for* a conversion to occur at the selected resolution on an integrator to the Data Out [DO] register. You can send this command while the integrators are busy or idle.

CMD	DATA1	DESCRIPTION
96	byte	Number of half line cycles for a conversion to occur on integrator A
97	byte	Number of half line cycles for a conversion to occur on integrator B

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET TIME INTERVAL

This command specifies the time interval between conversions. This command has a 2-byte value that represents the number of half line cycles (in hex) *between* conversions. Use the READ INTEGRATION TIME command to determine how long it takes the integrator to perform a single conversion.

You can change the time interval between conversions for a particular integrator only while that integrator is idle. If you send this command while that integrator is acquiring data, an error occurs.

CMD	ARG1	ARG2	DESCRIPTION
08	MSB	LSB	Set the number of half line cycles between conversions for integrator A
09	MSB	LSB	Set the number of half line cycles between conversions for integrator B

READ TIME INTERVAL

This command returns a 2 byte value that represents the number of half line cycles *between* conversions for an integrator to the Data Out [DO] register. You can send this command while the integrators are busy or idle.

CMD	DATA1	DATA2	DESCRIPTION
18	MSB	LSB	Number of half line cycles between conversions for integrator A
19	MSB	LSB	Number of half line cycles between conversions for integrator B

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ INTEGRATOR STATUS

This command returns the current operating status of an integrator to the Data Out [DO] register. You can send this command while the integrators are busy or idle.

CMD	DATA1	DESCRIPTION
74	01	Integrator A is idle
74	02	Integrator A is converting data
75	01	Integrator B is idle
75	02	Integrator B is converting data

Note: *All commands and arguments are in hex unless otherwise noted.*

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START CONVERSIONS

This command initiates data acquisition when the trigger source is a software command. If the acquisition type is continuous (see the SET ACQUISITION TYPE command), the integrator, when triggered, converts data until the stop command (see STOP CONVERSIONS) executes. If you send another START CONVERSIONS command while that integrator is acquiring data, an error occurs.

If the acquisition type is single, the integrator performs one conversion when triggered. If you send another START CONVERSIONS command before the data point is in the data buffer, an error occurs. (To determine when the data is in the buffer, use the READ NUMBER OF SAMPLES IN BUFFER command. The data point is in the buffer when the value returned by the command increments by 1.)

Note *If you send this command immediately after executing the SET INTEGRATOR INPUT CHANNEL or SET INTEGRATOR RESOLUTION command when the trigger source is a software command, the first conversion will start after the integrator settles. That is, the start of integration is delayed by the settling time at that resolution.*



CMD	DESCRIPTION
88	Start conversions on integrator A only
89	Start conversions on integrator B only
8A	Start conversions on both integrators

STOP CONVERSIONS

This command stops data acquisition IMMEDIATELY. Any conversion in process (on that VFC) is lost.



CMD	DESCRIPTION
8C	Stop conversions on integrator A only
8D	Stop conversions on integrator B only
8E	Stop conversions on both integrators

Note: *All commands and arguments are in hex unless otherwise noted.*

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I/O Switch Configurations

The commands described in this section set or return the active edge and mode for the switch inputs, enable input signal recognition, acknowledge an input event, and set or return the output switch states.

The DT2802 loads the last saved active edge and input mode settings at powerup or reset. You can change these settings any time the board is not actively acquiring data and optionally store the new settings in EEROM.

SET ACTIVE EDGE

This command chooses the active edge for a switch input. This command requires you to write the value for the desired edge to the Data In [DI] register.

The switch input can be enabled as a trigger source (see the SELECT TRIGGER SOURCE command) and as an interrupt source (see the SET INTERRUPT MASK command). The switch inputs must be enabled (see the SET INPUT ENABLE command) for the DT2802 to recognize the specified change in state at any of the switch inputs. The event must be subsequently acknowledged (see the READ/ACK INPUT commands) for the DT2802 to recognize additional changes in state at the switch input.

Note: *All commands and arguments are in hex unless otherwise noted.*

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CMD	ARG1	DESCRIPTION
0A	01	Select a low-to-high transition as the active edge for input 1
0A	02	Select a high-to-low transition as the active edge for input 1
0A	03	Select either transition as the active edge for input 1
0B	01	Select a low-to-high transition as the active edge for input 2
0B	02	Select a high-to-low transition as the active edge for input 2
0B	03	Select either transition as the active edge for input 2
0C	01	Select a low-to-high transition as the active edge for input 3
0C	02	Select a high-to-low transition as the active edge for input 3
0C	03	Select either transition as the active edge for input 3
0D	01	Select a low-to-high transition as the active edge for input 4
0D	02	Select a high-to-low transition as the active edge for input 4
0D	03	Select either transition as the active edge for input 4

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ ACTIVE EDGE

This command returns the active edge for a switch input to the Data Out [DO] register.

CMD	DATA1	DESCRIPTION
1A	01	Active edge for input 1 is a low-to-high transition
1A	02	Active edge for input 1 is a high-to-low transition
1A	03	Active edge for input 1 is either transition
1B	01	Active edge for input 2 is a low-to-high transition
1B	02	Active edge for input 2 is a high-to-low transition
1B	03	Active edge for input 2 is either transition
1C	01	Active edge for input 3 is a low-to-high transition
1C	02	Active edge for input 3 is a high-to-low transition
1C	03	Active edge for input 3 is either transition
1D	01	Active edge for input 4 is a low-to-high transition
1D	02	Active edge for input 4 is a high-to-low transition
1D	03	Active edge for input 4 is either transition

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET INPUT SWITCH MODE

This command determines whether the DT2802 debounces the input signal when determining whether a change in signal occurred.

Relays or contact closures connected to any of the switch inputs may have some bounce – or oscillation between the high and low states when they close. In the debounce mode, the DT2802 looks for a stable state for 15 msec following a transition to determine a change in signal. When the DT2802 is not in the debounce mode, it recognizes the selected transition as an input signal.

The DT2802 samples the input signal to the switch inputs at 200Hz. In the debounce mode, it looks for 3 consecutive samples to have the same state following a change in signal level to detect an edge. When the DT2802 is not in the debounce mode, it detects an edge on the first sample showing a change in signal.

CMD	ARG1	DESCRIPTION
27	01	Select no debounce for the input signals
27	02	Select debounce for the input signals

READ INPUT SWITCH MODE

This command returns the input switch mode to the Data Out [DO] register.

CMD	DATA1	DESCRIPTION
37	01	No debounce state selected for inputs
37	02	Debounce state selected for inputs

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET INPUT ENABLE

This command enables the switch input logic within the firmware. This command requires you to write 02 to the Data In [DI] register for the board to recognize the specified transition at any of its four switch inputs. If a switch input has been selected as a trigger source for integration, this command enables the DT2802 to recognize a hardware trigger at that input and begin integration when the specified transition occurs.

A reset or powerup condition always disables input recognition by the board.

CMD	ARG1	DESCRIPTION
0E	01	Disable input signal recognition by the board
0E	02	Enable input signal recognition by the board

READ INPUT ENABLE

This command returns the recognition state of the switch inputs by the DT2802 to the Data Out [DO] register.

CMD	DATA1	DESCRIPTION
1E	01	Input signal not recognized by the board
1E	02	Input signal recognized by the board

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET OUTPUT SWITCHES

This command writes the switch state to individual switches or to all switches simultaneously. A "0" closes a switch. A "1" opens a switch. All switches are open at powerup or reset. This command requires you to write the desired output switch state to the Data In [DI] register.

CMD	ARG1	DESCRIPTION
26	10	Close switch 1
26	11	Open switch 1
26	20	Close switch 2
26	21	Open switch 2
26	30	Close switch 3
26	31	Open switch 3
26	40	Close switch 4
26	41	Open switch 4

You may set all four switch states simultaneously. To do this, the upper four bits (bits 7 to 4) of the argument are "0." The lower four bits each correspond to a single switch. By setting (opening) or clearing (closing) bits 3 through 0, you selectively open and close a switch. Figure 15 illustrates this argument byte's bit assignments.

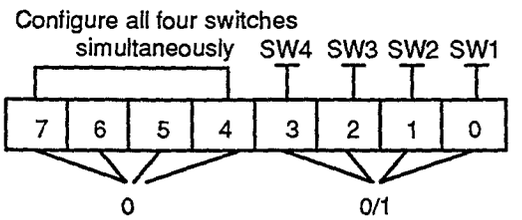


Figure 15: Set Switch States Simultaneously Byte

CMD	ARG1	DESCRIPTION
26	00	Close all switches
26	0x	Set all switches to state specified by "x"
26	0F	Open all switches

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ I/O SWITCH STATES

This command returns 1 byte that indicates the current state of both the four output switches and the four switch inputs to the Data Out [DO] register. Each bit in the byte corresponds to a switch or input as shown in Figure 16.

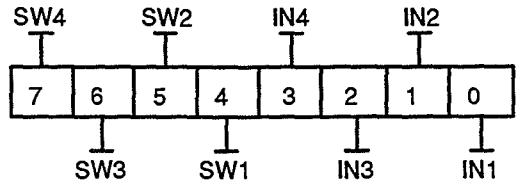


Figure 16: I/O Switch State Byte

The high four bits indicate the current state of the output switches: "0" for a bit indicates that switch is closed; "1" indicates that switch is open.

The low four bits show the most recently detected state at the switch inputs: "0" for a bit indicates that switch input state is low; "1" indicates that switch input state is high.

Note *Since the DT2802 samples the switch inputs at 200Hz, it could take 15 msec (in debounce mode) to detect a change of state.*

CMD	DATA1	DESCRIPTION
36	byte	Current state of the four input switches and four output switches

Note *All switch inputs are disabled at powerup or reset. All will read "1" (high) until you enable the input logic (using the SET INPUT ENABLE command) and the DT2802 detects a signal transition at a switch input.*

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ/ACK INPUT

This command returns the last level change sensed by the DT2802 at that switch input to the Data Out [DO] register. This command also acknowledges an input occurred at that input to trigger integration or an event pending from that event/interrupt source.

Note *Since the DT2802 samples the switch inputs at 200Hz, it could take 15 msec (in debounce mode) to detect a change of state.*

CMD	DATA1	DESCRIPTION
56	00	Most recent active edge sensed for input 1 was a high-to-low transition
56	01	Most recent active edge sensed for input 1 was a low-to-high transition
57	00	Most recent active edge sensed for input 2 was a high-to-low transition
57	01	Most recent active edge sensed for input 2 was a low-to-high transition
58	00	Most recent active edge sensed for input 3 was a high-to-low transition
58	01	Most recent active edge sensed for input 3 was a low-to-high transition
59	00	Most recent active edge sensed for input 4 was a high-to-low transition
59	01	Most recent active edge sensed for input 4 was a low-to-high transition

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ/ACK ALL INPUTS

This command returns a byte that indicates the last level change sensed by the DT2802 at each switch input to the Data Out [DO] register. This command also acknowledges an input occurred at that input to trigger integration or the event pending from these interrupt sources. Each bit in the byte corresponds to a switch input as shown in Figure 17.

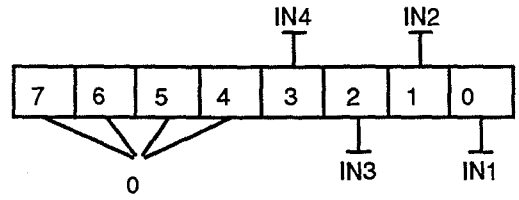


Figure 17: Input State Byte

A "0" for a bit indicates the most recent edge sensed for that switch input was a high-to-low transition. A "1" for a bit indicates the most recent edge sensed for that switch input was a low-to-high transition.

Note *Since the DT2802 samples the switch inputs at 200Hz, it could take 15 msec (in debounce mode) to detect a change of state.*

CMD	DATA1	DESCRIPTION
5A	byte	Most recent active edge sensed for each input

Note: *All commands and arguments are in hex unless otherwise noted.*

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Serial Port Configuration/Operation

The commands described in this section affect the serial port. The serial port has 1 start bit, 1 stop bit, 8 data bits, and no parity. It has a configurable baud rate. Its input data buffer is 255 bytes in length.

Note *There are several commands that are not valid when the DT2802 is jumper-configured for the stand-alone mode of operation. These commands are flagged with a special symbol in this document. If you attempt to execute one of the commands in the stand-alone mode, the DT2802 returns a "Not Valid Command" error.*

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET SERIAL INPUT CONTROL

This command enables/disables the serial input port.

A reset or powerup condition always disables serial port receiver. Enabling the serial input port clears the 255-byte serial input buffer.

CMD	ARG1	DESCRIPTION
23	01	Disable serial port receiver
23	02	Enable serial port receiver and clear serial input buffer

READ SERIAL INPUT CONTROL

This command returns a value that represents the serial input port state of the DT2802 board to the Data Out [DO] register.

CMD	DATA1	DESCRIPTION
33	01	Serial input port disabled
33	02	Serial input port enabled

Note: *All commands and arguments are in hex unless otherwise noted.*

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SELECT BAUD RATE

This command sets the baud rate for the serial port. This command requires you to write the value representing the desired baud rate to the Data In [DI] register.

The DT2802 loads the last saved baud rate setting at powerup or reset. You can change this setting only while the serial input port is disabled or a "Serial input in process" error occurs. If you send this command after writing a byte to the port and before it completes transmission, a "Serial output in process" error occurs. You can optionally store the new setting in EEROM when the integrators are idle. (See the SAVE CONFIGURATION IN EEROM command.)

In the stand-alone mode, the DT2802 responds to the command with the ACK|STATUS message at the current baud rate. It then sets its baud rate to specified value. Because there is a slight delay before the baud rate actually changes, the host should not try to access the DT2802 at the new baud rate for at least 10 ms after sending this command. In addition, the host serial port must also be set to the new baud rate before communication is possible with the DT2802. If the DT2802 detects an error when the host sends this command, the DT2802 responds with the ACK|STATUS message. The error bit in the status byte will be set and the baud rate will not change to the specified value.

Note *The stand-alone mode of operation does not support a baud rate of 38400.*

CMD	ARG1	DESCRIPTION
20	01	Select a baud rate of 300 for the serial port
20	02	Select a baud rate of 1200 for the serial port
20	03	Select a baud rate of 2400 for the serial port
20	04	Select a baud rate of 4800 for the serial port
20	05	Select a baud rate of 9600 for the serial port
20	06	Select a baud rate of 19200 for the serial port
20	07	Select a baud rate of 38400 for the serial port

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ BAUD RATE

This command returns a value to the Data Out [DO] register indicating the baud rate for the serial port.

CMD	DATA1	DESCRIPTION
30	01	Baud rate for serial port set to 300
30	02	Baud rate for serial port set to 1200
30	03	Baud rate for serial port set to 2400
30	04	Baud rate for serial port set to 4800
30	05	Baud rate for serial port set to 9600
30	06	Baud rate for serial port set to 19200
30	07	Baud rate for serial port set to 38400

Note: *All commands and arguments are in hex unless otherwise noted.*

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WRITE SERIAL DATA BYTE

This command transfers the byte written to the Data In [DI] register to an RS232-based peripheral connected to the RS232 port.

CMD	ARG1	DESCRIPTION
22	byte	Send byte to the serial data port for output

READ SERIAL DATA BYTE

This command transfers a byte from the serial input buffer to the Data Out register.

CMD	DATA1	DESCRIPTION
32	byte	Data byte from RS232-based peripheral connected to the RS232 port

READ NUMBER OF BYTES

This command returns the number of bytes currently in the serial input buffer to the Data Out [DO] register. (The serial input buffer can hold up to 255 bytes. If the buffer is full, the next byte written to the port from an external device causes an overrun error.)

CMD	DATA1	DESCRIPTION
34	byte	Number of data bytes in the serial input buffer

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET/CLEAR RS232 CONTROL SIGNAL

This command sets or clears the control signal on the RS232 port. This command requires you to write the value representing the action to the Data In [DI] register. The RS232 Control signal is high on powerup or reset.

CMD	ARG1	DESCRIPTION
25	01	Set control signal at RS232 port
25	02	Clear control signal at RS232 port

READ RS232 CONTROL SIGNAL

This command returns a value to the Data Out [DO] register indicating the RS232 control signal state.

CMD	DATA1	DESCRIPTION
35	01	RS232 control signal is set
35	02	RS232 control signal is clear

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET SIO DATA MODE

This command sets the data transfer mode for the stand-alone mode of operation.

The DT2802 has two modes for transmitting data to the host when in the stand-alone mode: Normal Data and Stream Data. In the Normal Data mode, the DT2802 sends the data to the host, one data point (four bytes) at a time. In the Stream Data mode, the DT2802 sends packets of data to the host in a continuous stream.

The DT2802 loads the last saved data transfer mode at powerup or reset. You can change this setting only while the integrators are idle. You can optionally store the new setting in EEROM when the integrators are idle. (See the SAVE CONFIGURATION IN EEROM command.)

Note *You can change this setting while operating in the ISA bus mode with no affect on operation. If you also save the new setting to EEROM, it will be in effect when you rejumper the DT2802 for the stand-alone mode.*

CMD	ARG1	DESCRIPTION
21	01	Set Normal Data transfer mode
21	02	Set Stream Data transfer mode

READ SIO DATA MODE

This command returns a value to the Data Out [DO] register indicating the data transfer mode for the stand-alone mode of operation.

CMD	DATA1	DESCRIPTION
31	01	Normal Data transfer mode enabled
31	02	Stream Data transfer mode enabled

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET STREAM DATA SIZE

This command specifies the number of four-byte data points contained in a data packet in the Stream Data transfer mode. The data packet size can range between 1 and 64, inclusive.

The throughput of the DT2802 is affected by the stream data packet size, the baud rate, the VFC resolution, and the error tendency of the operating environment. If you choose a large packet size, the DT2802 may have to send the packet multiple times in a noisy environment, or the VFC buffers may overflow at faster resolutions (18 or 19 bits) at slower baud rates.

The DT2802 loads the last saved data packet size at powerup or reset. You can change this setting only while the integrators are idle. You can optionally store the new setting in EEROM when the integrators are idle. (See the SAVE CONFIGURATION IN EEROM command.)

Note *You can change this setting while operating in the ISA bus mode with no affect on operation. If you also save the new setting to EEROM, it will be in effect when you rejumper the DT2802 for the stand-alone mode.*

CMD	ARG1	DESCRIPTION
24	byte	Number of data points in data packet

READ STREAM DATA SIZE

This command returns a byte to the Data Out [DO] register indicating the number of four-byte data points included in a data packet.

CMD	DATA1	DESCRIPTION
13	byte	Number of data points sent in a data packet

Note: *All commands and arguments are in hex unless otherwise noted.*

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Event/Interrupt Control

The commands described in this section present the current status of the major subsystems within the DT2802.

The DT2802 uses two bytes to represent the event/interrupt sources. Each bit in these bytes represents a specific source. Figure 18 illustrates the bit assignment in the event/interrupt source mask.

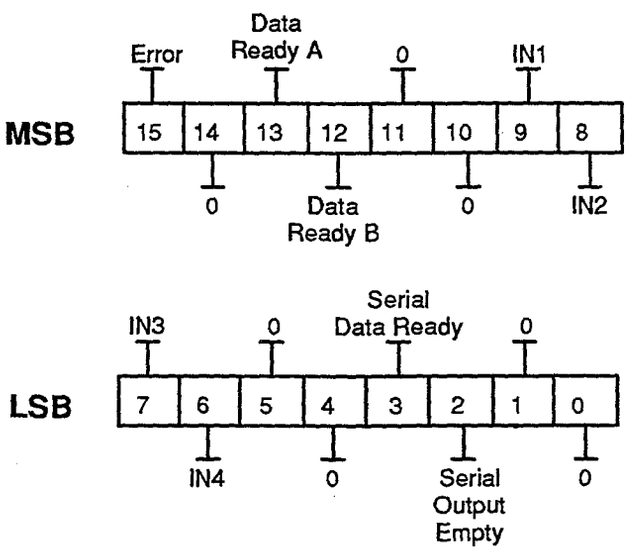


Figure 18: Event/Interrupt Source Mask

Note *The DT2802-2 board does not use the Data Ready B event/interrupt source.*

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET EVENT/INTERRUPT MASK

This command determines which of the possible event/interrupt sources can signal an event has occurred. Setting a bit in the event/interrupt mask enables that source. Clearing a bit in the mask disables that source.

The DT2802 loads the last saved event/interrupt source list at powerup or reset. You can change these settings any time the board is not actively acquiring data. You can optionally store the new settings in EEROM.

When the Interrupt Pending bit in the Status register (SR:IP) sets, one of the enabled event/interrupt source conditions has occurred. To determine which board event occurred, use the EVENT/INTERRUPT PENDING command. The EVENT/INTERRUPT PENDING command returns two bytes whose bits indicate the source condition. The bits are in the same order as the Event/Interrupt Mask (see Figure 18).

CMD	ARG1	ARG2	DESCRIPTION
42	MSB	LSB	Enable/disable event/interrupt sources

READ EVENT/INTERRUPT MASK

This command returns the two byte event/interrupt mask shown earlier in Figure 18 to the Data Out register. The value of each bit indicates whether that event/interrupt source is enabled or disabled. A "0" indicates that source is disabled. A "1" indicates that source is enabled.

CMD	DATA1	DATA2	DESCRIPTION
52	MSB	LSB	Event/interrupt source list

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ EVENT/INTERRUPT PENDING MASK

This command returns the two byte event/interrupt pending mask (the bit assignment is the same as that shown in Figure 18) to the Data Out register. A "1" for a bit indicates that event occurred.

CMD	DATA1	DATA2	DESCRIPTION
54	MSB	LSB	Source of the event or interrupt

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET MASTER INTERRUPT

This command enables the master interrupt when 02 is written to the Data In [DI] register.

The master interrupt determines whether the board will interrupt the host when a specific condition occurs. A reset or powerup condition always disables the master interrupt. The event/interrupt source list (see SET EVENT/INTERRUPT MASK) determines which board conditions can cause an interrupt.

Each interrupt disables the Master Interrupt when it occurs. To recognize additional interrupts, you must re-enable the Master Interrupt as part of your interrupt servicing routine.

CMD	ARG1	DESCRIPTION
40	01	Disable master interrupt
40	02	Enable master interrupt

READ MASTER INTERRUPT

This command returns the state of the master interrupt to the Data Out [DO] register.

CMD	DATA1	DESCRIPTION
50	01	Master interrupt disabled
50	02	Master interrupt enabled

Note: *All commands and arguments are in hex unless otherwise noted.*

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Data Buffer Management

The Buffer Management commands set the thresholds for the number of data points to store in the onboard buffer for each integrator. (There is a separate buffer for each integrator.) The buffer for each integrator holds 2048 data points. However, the maximum threshold value is 2000. This prevents an overrun error by allowing the integrator to continue converting data while the buffer contents are transferred to the host.

The Integrator Data Ready bit sets in the Status register (SR:IDR) when the number of data points in a buffer reach the threshold value set for that integrator. SR:IDR clears when you read enough data points from the buffer for that integrator so that the number of data points in the buffer is less than the threshold value.

RESET/CLEAR BUFFER

This command erases the contents of the selected buffer. All data in that buffer is lost.

CMD	ARG1	DESCRIPTION
62	01	Reset/clear buffer A
62	02	Reset/clear buffer B

Note: *All commands and arguments are in hex unless otherwise noted.*

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SET THRESHOLD

This command sets the number of data points to store in an integrator's data buffer before signalling that data is ready to be read. This command requires you to write a 2-byte value to the Data In [DI] register.

The maximum threshold is 2000 (decimal).

CMD	ARG1	ARG2	DESCRIPTION
60	MSB	LSB	Set threshold value for buffer A
61	MSB	LSB	Set threshold value for buffer B

READ THRESHOLD

This command returns a 2-byte value representing the threshold value for a buffer to the Data Out [DO] register.

CMD	DATA1	DATA2	DESCRIPTION
70	MSB	LSB	Threshold value for buffer A
71	MSB	LSB	Threshold value for buffer B

READ NUMBER OF SAMPLES

This command returns a 2-byte value representing the number of data points currently in a buffer to the Data Out [DO] register.

CMD	DATA1	DATA2	DESCRIPTION
72	MSB	LSB	Number of data points in buffer A
73	MSB	LSB	Number of data points in buffer B

Note: *All commands and arguments are in hex unless otherwise noted.*

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READ NEXT CONVERSION

This command returns a 4-byte data value representing a single conversion to the Data Out [DO] register.

The DT2802 converts each data point to a digital code and stores it in the onboard memory buffer. Each digital code is four bytes in length. The first byte is a "tag" byte that the DT2802 adds to identify the source of the data point, its resolution, etc. The second byte returned is the most significant byte of the data value. The third byte is the second byte of the data value. The fourth byte is the least significant byte of the data value.

The tag byte has the format shown in Figure 19.

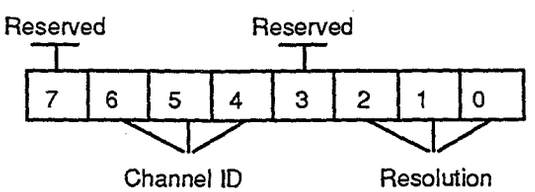


Figure 19: Tag Byte Format

Bit 7: Reserved

This bit is reserved and always returns "0."

Bits 6 through 4: Channel ID

These bits indicate on which channel the data was acquired.

READ:
001 = channel 1
010 = channel 2
011 = channel 3
100 = channel 4

Note: *All commands and arguments are in hex unless otherwise noted.*

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Bit 3: Reserved

This bit is reserved and always returns "0."

Bits 2 through 0: Resolution

These bits represent the resolution of the data value.

READ:
001 = 18 bits
010 = 19 bits
011 = 20 bits
100 = 21 bits
101 = 22 bits
110 = 23 bits
111 = 24 bits

CMD	DATA1	DATA2	DATA3	DATA4	DESCRIPTION
9E	tag byte	MSB	middle byte	LSB	First data point for integrator A in data buffer A
9F	tag byte	MSB	middle byte	LSB	First data point for integrator B in data buffer B

Note: *All commands and arguments are in hex unless otherwise noted.*

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Other

These commands report board revision information.

READ BOARD ID

This command returns a NULL-terminated ASCII string (10 bytes) representing the board identification to the Data Out [DO] register.

CMD	DATA1...	DATA10	DESCRIPTION
3C	MSB	LSB	Board identification: "DT2802-4" or "DT2802-2"

READ FIRMWARE LEVEL

This command returns a NULL-terminated ASCII string (8 bytes) representing the firmware revision level to the Data Out [DO] register.

CMD	DATA1...	DATA8	DESCRIPTION
3D	MSB	LSB	Firmware revision level

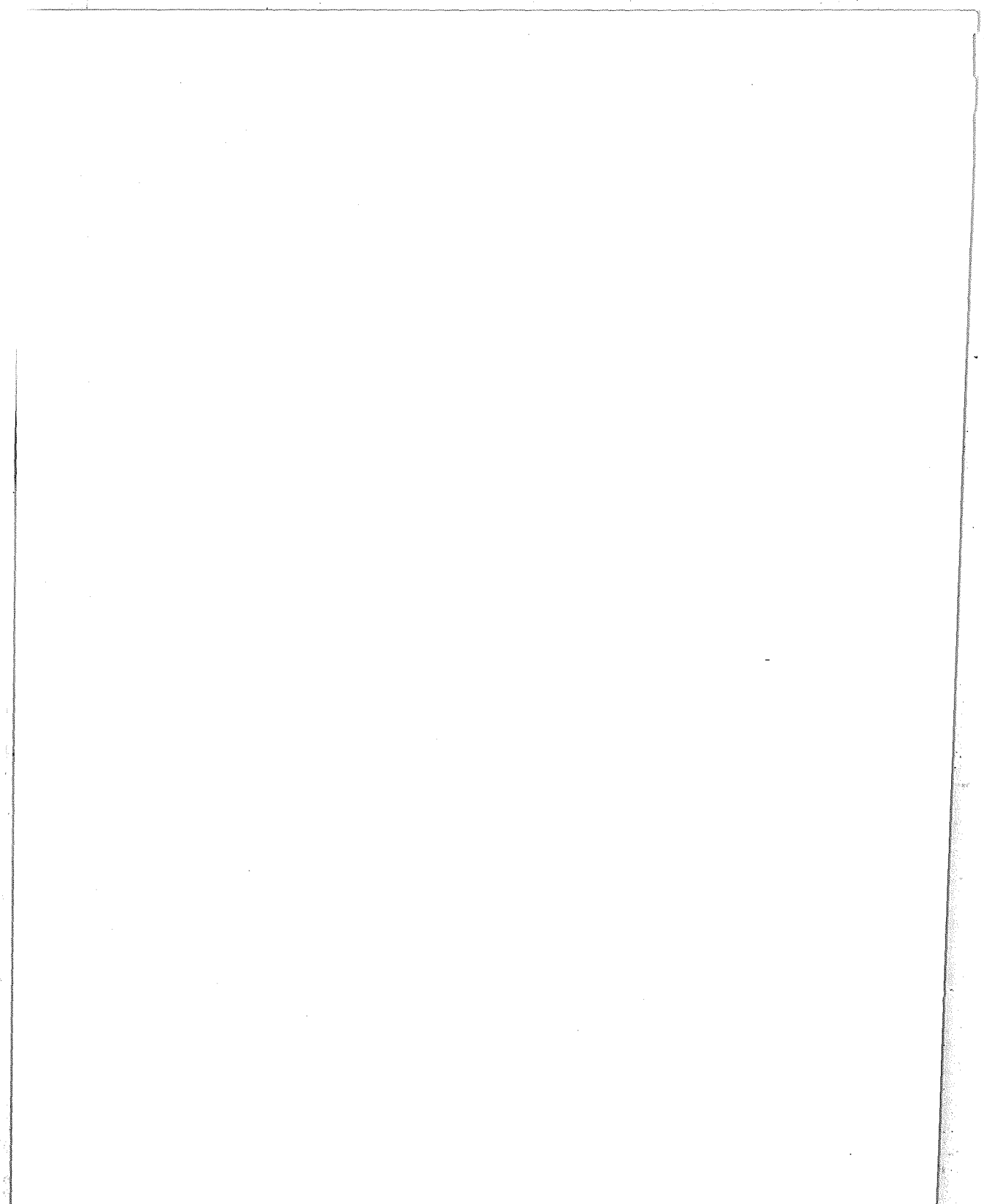
READ BOARD REVISION

This command returns a value representing the board revision level to the Data Out [DO] register.

CMD	DATA1	DESCRIPTION
3E	byte	Board revision level

Note: *All commands and arguments are in hex unless otherwise noted.*

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Chapter 5

Programming Sequences

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*Chapter 5, "**Programming Sequences**," lists the steps for performing various operations with the DT2802 board. This chapter is organized as follows:*

- *Configuring the Board*
- *Acquiring Data: Polled I/O*
- *Acquiring Data: Modified Polled I/O*
- *Acquiring Data: Interrupt Operation*
- *I/O Switch Operation*

See the Bus Interface section in Chapter 3, "Hardware Overview," for a complete description of the DT2802 registers and their bit functions.

See Reference 6, "Remote Control Protocol," for information on how to transfer commands and data over the RS232 port when the DT2802 is jumper-configured for the stand-alone mode of operation.

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Introduction

This chapter describes the sequence of steps necessary for configuring the DT2802 or for performing various data acquisition or I/O switch operations.

In addition to the programming sequences presented in this chapter, you will find several example programs in the \C directory on the diskette labeled SP0802, that ships with the board. These programs demonstrate the use of the DT2802 firmware commands to program the DT2802 board. These programs do not and are not intended to perform any particular "real-life" chromatography application. They merely illustrate the steps to take to setup the DT2802 board to operate. These example programs are as follows:

SAMP1.C	Single conversion – polled I/O
SAMP2.C	Continuous conversions – polled I/O
SAMP3.C	Switch output – polled I/O
SAMP4.C	Switch input – polled I/O
SAMP5.C	Serial I/O – polled I/O
SAMP6.C	Continuous conversions – interrupt driven
SAMP7.C	Switch input – interrupt driven
SAMP8.C	Serial I/O – interrupt driven
SAMP9.C	Stand-alone operation

Note *The example programs require Microsoft C version 6.0 to run.*

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Configuring the Board

The DT2802 board has configuration settings that you can change to suit your application needs. With the exception of the base address, interrupt priority level, and board mode selection, all DT2802 configuration settings are software-selectable. These settings are stored in EEROM. Once set, these settings remain in effect until you change them.

The DT2802 ships with the factory configuration settings outlined in Table 17 on the following page.

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Table 17: Factory Configuration Settings

	Function	Setting
Hardware	Base address	300H (jumper-selectable)
	Interrupt priority level	5 (jumper-selectable)
	Board mode of operation	ISA bus mode
Software	Local line frequency	60hz
	Event/interrupt source	all disabled
	Serial port baud rate	9600
	Integrator A configuration trigger source acquisition type buffer threshold resolution channel data mode	 convert on command continuous acquisition 1 20 bits 1 normal
	Integrator B configuration trigger source acquisition type buffer threshold resolution channel data mode	 convert on command continuous acquisition 1 20 bits 1 normal
	Switch input configuration Mode Input 1 Input 2 Input 3 Input 4	 no debounce either edge either edge either edge either edge
	Serial data mode	Normal Data
	Stream data packet size	1

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Table 18 outlines the board state on powerup or reset.

Table 18: Board State on Powerup or Reset

Function	Setting
Master interrupt	disabled
Switch inputs	disabled
Output switches	all open
Serial port	disabled
RS232 control signal	high

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To Restore the Factory Configuration

To reload the software factory settings listed in Table 17 on page 129:

1. Poll the Status register until the Port Ready bit (SR:PR) sets.
2. Write **29** (Reset command) to the Command register [CR].
3. Poll the SR until PR sets.
4. Write **02** (Return to Factory Configuration) to the Data In [DI] register.
5. Poll the SR until PR sets.

The DT2802 writes the factory configuration settings to the EEROM and resets the board.

To Change the Configuration

On powerup or reset, the DT2802 loads the last saved configuration settings into its working configuration table. You can modify these settings while the integrators are idle. The new settings are in effect until you power down or reset the board. You can optionally save the new settings to EEROM.

To change the configuration:

1. Poll the Status register until the Port Ready bit (SR:PR) sets.
2. Write the command for the parameter you are changing to the Command register [CR].
3. Poll the SR until PR sets.

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4. Write the arguments for that command to the Data In [DI] register. (If there is more than one argument or byte associated with that command, poll the SR until PR sets between each argument.)

5. *Optional:* Save the new configuration to EEROM as described below.

Saving the Configuration to EEROM

Note *You can perform this operation only when the integrators are idle.*

To save the current configuration settings to EEROM:

1. Poll the Status register until the Port Ready bit (SR:PR) sets.

2. Write **2C** (Save Configuration in EEROM) to the Command register [CR].

3. Poll the SR until PR sets.

4. Write **01**, **02**, **03,** and **04** to the Data In [DI] register, polling the SR until PR sets between each value.

The DT2802 saves the working configuration table to EEROM and restores these settings at powerup or reset.

The parameters stored in EEROM are the event/interrupt sources, local line frequency, serial port baud rate, trigger source, acquisition type, buffer threshold, resolution, and input channel for each integrator, input mode, and active edge for each input.

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Acquiring Data: Polled I/O

The programming sequences in this section summarize the steps for programming the DT2802 to acquire data in the single conversion and continuous conversion modes. These sequences poll the Status register to determine when data is available for transfer to the host.

Note *These sequences assume no errors occurred during the operation. You should, however, monitor the Error bit in the Status register routinely to make sure no errors have occurred.*

Single Conversion Mode

Perform the steps diagrammed in Figure 20 for single conversions in the polled I/O mode on integrator A. If you are using integrator B, substitute the appropriate commands. If you are using a switch input as the trigger source, incorporate the steps for input detection setup (see page 157) into your program.

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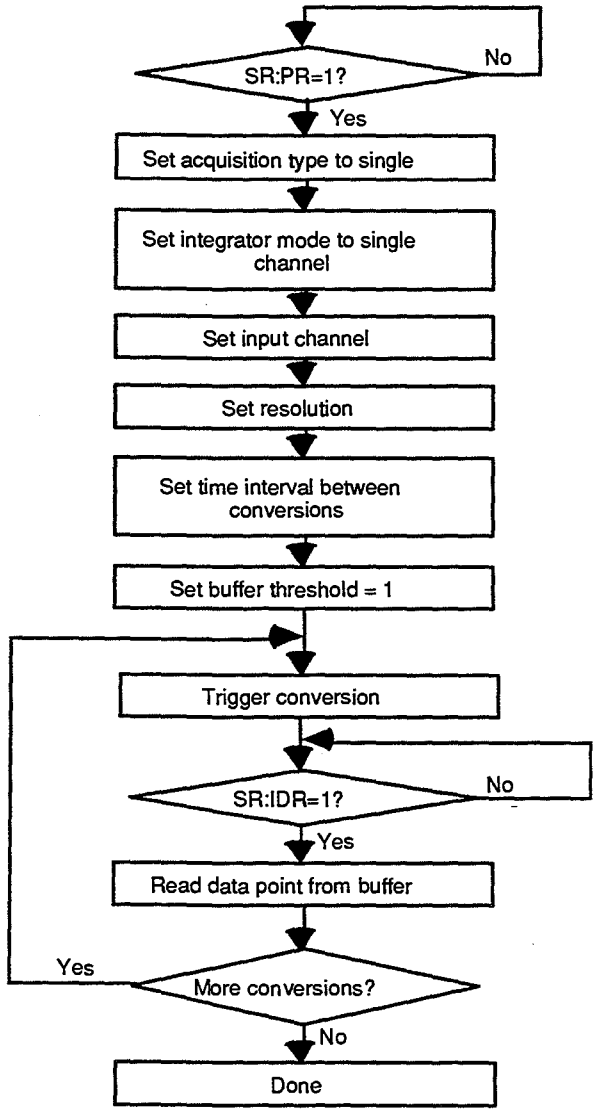


Figure 20: Single Conversion – Polled I/O

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1. Poll the Status register until the Port Ready bit (SR:PR) sets.

2. Set the acquisition type for integrator A to single conversion mode.

   - Write **06** (Set Acquisition Type Integrator A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **01** (single conversion mode) to the Data In [DI] register.
   - Poll the SR until PR sets.

3. Set the integrator mode to single channel for integrator A.

   - Write **80** (Set Integrator Mode A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **01** (single channel mode) to the Data In [DI] register.
   - Poll the SR until PR sets.

4. Select the input channel to integrator A.

   - Write **82** (Set Integrator A Input Channel) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **01** (channel 1) to the Data In [DI] register.
   - Poll the SR until PR sets.

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5. Select the resolution of integrator A.

   - Write **84** (Set Integrator A Resolution) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **xx** (desired resolution – 01H to 07H) to the Data In [DI] register.
   - Poll the SR until PR sets.

6. Specify the time between measurements.

   - Write **08** (Set Time Interval Integrator A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **xx** (MSB of number of line cycles between conversions) to the Data In [DI] register.
   - Poll the SR until PR sets.
   - Write **xx** (LSB of number of line cycles between conversions) to the Data In [DI] register.
   - Poll the SR until PR sets.

7. Set the data buffer threshold for integrator A to 1.

   - Write **60** (Set Threshold Buffer A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **00** (MSB of threshold value) to the Data In [DI] register.
   - Poll the SR until PR sets.
   - Write **01** (LSB of threshold value) to the Data In [DI] register.
   - Poll the SR until PR sets.

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8. Trigger the conversion.

   - Write **88** (Start Conversions Integrator A) to the Command register [CR].
   - Poll the SR until PR sets.

     A single conversion occurs on integrator A.

9. Poll the Status register to determine when the data point is available for reading.

   - Poll the SR until the Integrator Data Ready bit (IDR) sets.

10. Transfer the data point to the host.

    - Write **9E** (Read Next Conversion Integrator A) to the Command register [CR].
    - Poll the SR until PR sets.
    - Read the MSB from the Data Out [DO] register.
    - Poll the SR until PR sets.
    - Read the next byte from the DO register.
    - Poll the SR until PR sets.
    - Read the next byte from the DO register.
    - Poll the SR until PR sets.
    - Read the LSB from the DO register.
    - Poll the SR until PR sets.

11. Repeat steps 8 through 10 for additional conversions.

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Continuous Conversion Mode

Perform the steps diagrammed in Figure 21 for continuous conversions in the polled I/O mode on integrator A. If you are using integrator B, substitute the appropriate commands. If you are using a switch input as the trigger source, incorporate the steps for input detection setup (see page 157) into your program.

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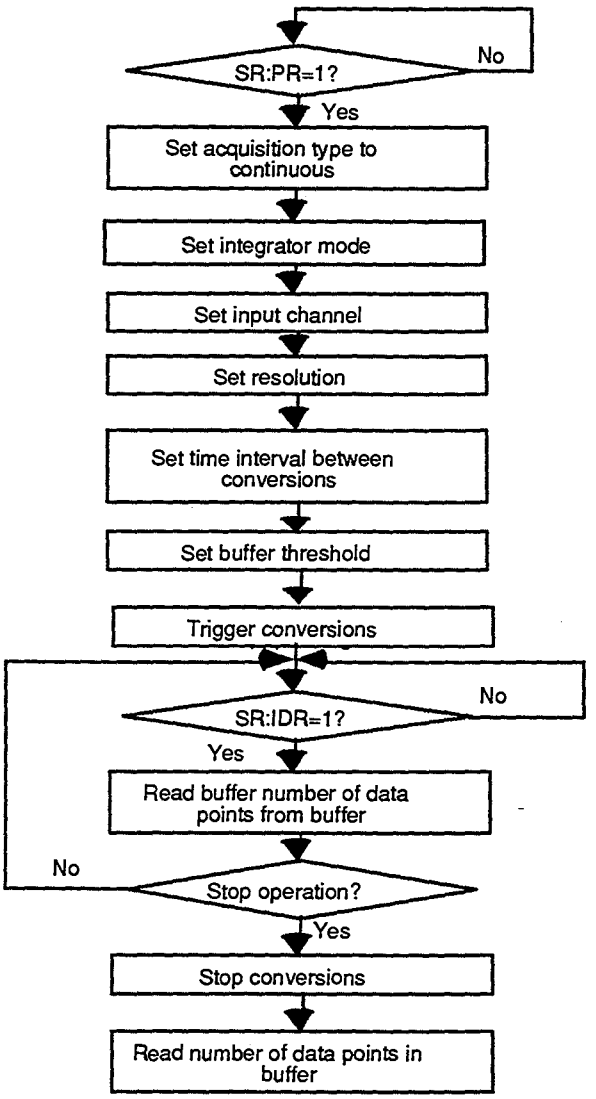


Figure 21: Continuous Conversions – Polled I/O

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1. Poll the Status register until the Port Ready bit (SR:PR) sets.

2. Set the acquisition type for integrator A to continuous conversion mode.

   - Write **06** (Set Acquisition Type Integrator A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **02** (continuous conversion mode) to the Data In [DI] register.
   - Poll the SR until PR sets.

3. Set the integrator mode to single channel for integrator A.

   - Write **80** (Set Integrator Mode A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **01** (single channel mode) to the Data In [DI] register.
   - Poll the SR until PR sets.

   If you wish to automux between the two channels, set the integrator mode to automux (02).

4. Select the input channel to integrator A.

   - Write **82** (Set Integrator A Input Channel) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **01** (channel 1) to the Data In [DI] register.
   - Poll the SR until PR sets.

   If you have set the integrator mode to automux, the input channel you specify is the starting channel.

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5. Select the resolution of integrator A.

   - Write **84** (Set Integrator A Resolution) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **xx** (desired resolution – 01H to 07H) to the Data In [DI] register.
   - Poll the SR until PR sets.

6. Specify the time between measurements.

   - Write **08** (Set Time Interval Integrator A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **xx** (MSB of number of line cycles between conversions) to the Data In [DI] register.
   - Poll the SR until PR sets.
   - Write **xx** (LSB of number of line cycles between conversions) to the Data In [DI] register.
   - Poll the SR until PR sets.

7. Set the data buffer threshold for integrator A.

   - Write **60** (Set Threshold Buffer A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **xx** (MSB of threshold value) to the Data In [DI] register.
   - Poll the SR until PR sets.
   - Write **xx** (LSB of threshold value) to the Data In [DI] register.
   - Poll the SR until PR sets.

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8. Trigger the conversion.

   - Write **88** (Start Conversions Integrator A) to the Command register [CR].
   - Poll the SR until PR sets.

   Conversions begin on integrator A.

9. Poll the Status register to determine when the threshold number of data points is available for reading.

   - Poll the SR until the Integrator Data Ready bit (IDR) sets.

10. Transfer the data to the host.

    - Write **9E** (Read Next Conversion Integrator A) to the Command register [CR].
    - Poll the SR until PR sets.
    - Read the MSB from the Data Out [DO] register.
    - Poll the SR until PR sets.
    - Read the next byte from the DO register.
    - Poll the SR until PR sets.
    - Read the next byte from the DO register.
    - Poll the SR until PR sets.
    - Read the LSB from the DO register.
    - Poll the SR until PR sets.
    - Repeat this step for the threshold number of conversions.

11. Repeat steps 9 and 10 until you are ready to stop operation.

12. To stop operation, write **8C** (Stop Conversions on Integrator A) to the Command register.

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Acquiring Data: Modified Polled I/O

Perform the steps diagrammed in Figure 22 for continuous conversions in modified polled I/O mode on integrator A. If you are using integrator B, substitute the appropriate commands. If you are using a switch input as the trigger source, incorporate the steps for input detection setup (see page 157) into your program.

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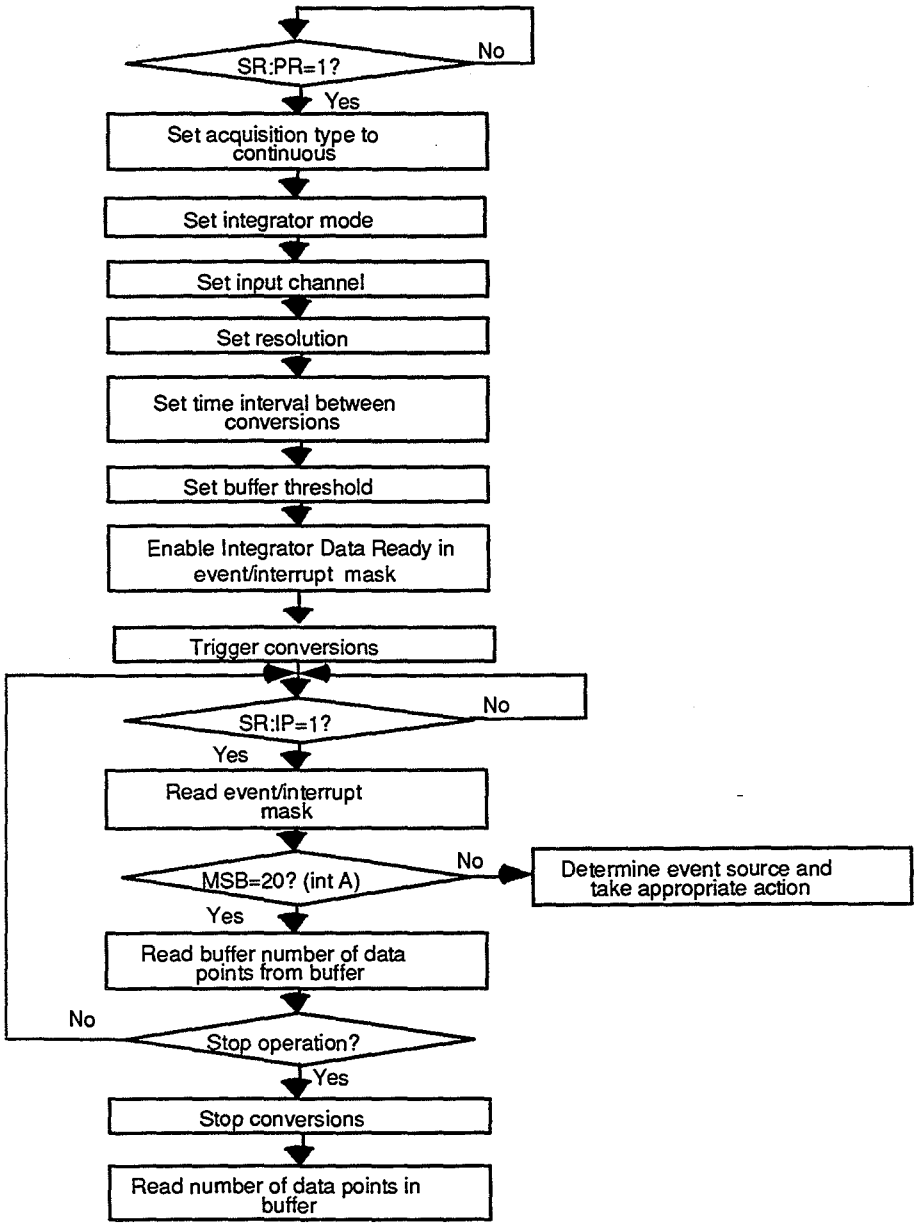


Figure 22: Continuous Conversions – Modified Polled I/O

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1. Poll the Status register until the Port Ready bit (SR:PR) sets.

2. Set the acquisition type for integrator A to continuous conversion mode.

   - Write **06** (Set Acquisition Type Integrator A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **02** (continuous conversion mode) to the Data In [DI] register.
   - Poll the SR until PR sets.

3. Set the integrator mode to single channel for integrator A.

   - Write **80** (Set Integrator Mode A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **01** (single channel mode) to the Data In [DI] register.
   - Poll the SR until PR sets.

   If you wish to automux between the two channels, set the integrator mode to automux (02).

4. Select the input channel to integrator A.

   - Write **82** (Set Integrator A Input Channel) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **01** (channel 1) to the Data In [DI] register.
   - Poll the SR until PR sets.

   If you have set the integrator mode to automux, the input channel you specify is the starting channel.

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5. Select the resolution of integrator A.

   - Write **84** (Set Integrator A Resolution) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **xx** (desired resolution – 01H to 07H) to the Data In [DI] register.
   - Poll the SR until PR sets.

6. Specify the time between measurements.

   - Write **08** (Set Time Interval Integrator A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **xx** (MSB of number of line cycles between conversions) to the Data In [DI] register.
   - Poll the SR until PR sets.
   - Write **xx** (LSB of number of line cycles between conversions) to the Data In [DI] register.
   - Poll the SR until PR sets.

7. Set the data buffer threshold for integrator A.

   - Write **60** (Set Threshold Buffer A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **xx** (MSB of threshold value) to the Data In [DI] register.
   - Poll the SR until PR sets.
   - Write **xx** (LSB of threshold value) to the Data In [DI] register.
   - Poll the SR until PR sets.

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8. Enable the Integrator A Data Ready source in the Event/Interrupt Mask.

   - Write **42** (Set Event/Interrupt Mask) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **20** (MSB of mask) to the Data In [DI] register.
   - Poll the SR until PR sets.
   - Write **00** (LSB of mask) to the Data In [DI] register.
   - Poll the SR until PR sets.

9. Trigger the conversion.

   - Write **88** (Start Conversions Integrator A) to the Command register [CR].
   - Poll the SR until PR sets.

   Conversions begin on integrator A.

10. Poll the Status register to determine when the threshold number of data points is available for reading.

    - Poll the SR until the Interrupt Pending bit (IP) sets.

11. Read the Event/Interrupt Pending mask and determine if the Data Ready A bit is set.

    - Write **54** (Event/Interrupt Pending) to the Command register.
    - Poll the SR until PR sets.
    - Read the MSB from the Data Out [DO] register.
    - Poll the SR until PR sets.

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- Read the LSB from the DO register.
- Poll the SR until PR sets.

If the MSB is "20," the Data Ready A bit is set and data is available for reading.

12. If the Data Ready A bit is set, transfer the data to the host.
    - Write **9E** (Read Next Conversion Integrator A) to the Command register [CR].
    - Poll the SR until PR sets.
    - Read the MSB from the Data Out [DO] register.
    - Poll the SR until PR sets.
    - Read the next byte from the DO register.
    - Poll the SR until PR sets.
    - Read the next byte from the DO register.
    - Poll the SR until PR sets.
    - Read the LSB from the DO register.
    - Poll the SR until PR sets.
    - Repeat this step for the threshold number of conversions.
13. Repeat steps 11 and 12 until you are ready to stop operation.
14. To stop operation, write **8C** (Stop Conversions on Integrator A) to the Command register.

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15. Read any data points still in the buffer.

    - Poll the SR until PR sets.
    - Write **72** (Read Number of Samples in Buffer A) to the Command register.
    - Poll the SR until PR sets.
    - Transfer each remaining data point to the host as described in step 12 above.

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Acquiring Data: Interrupt Operation

Perform the steps diagrammed in Figure 23 for continuous conversions on integrator A using an interrupt to signal when data is available. If you are using integrator B, substitute the appropriate commands. If you are using a switch input as the trigger source, incorporate the steps for input detection setup (see page 157) into your program.

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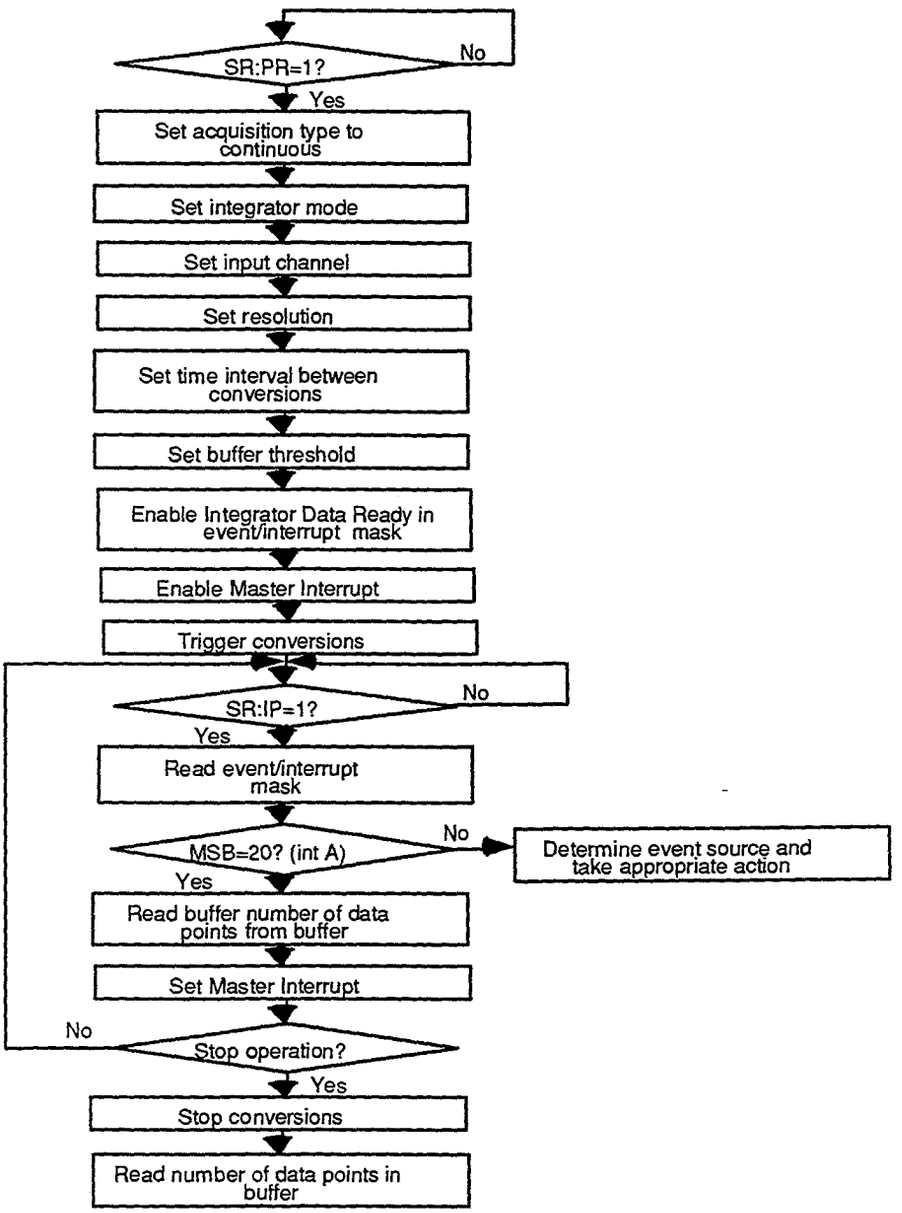


Figure 23: Continuous Conversions – Interrupt Operation

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1. Poll the Status register until the Port Ready bit (SR:PR) sets.

2. Set the acquisition type for integrator A to continuous conversion mode.

   - Write **06** (Set Acquisition Type Integrator A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **02** (continuous conversion mode) to the Data In [DI] register.
   - Poll the SR until PR sets.

3. Set the integrator mode to single channel for integrator A.

   - Write **80** (Set Integrator Mode A) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **01** (single channel mode) to the Data In [DI] register.
   - Poll the SR until PR sets.

   If you wish to automux between the two channels, set the integrator mode to automux (02).

4. Select the input channel to integrator A.

   - Write **82** (Set Integrator A Input Channel) to the Command register [CR].
   - Poll the SR until PR sets.
   - Write **01** (channel 1) to the Data In [DI] register.
   - Poll the SR until PR sets.

   If you have set the integrator mode to automux, the input channel you specify is the starting channel.

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