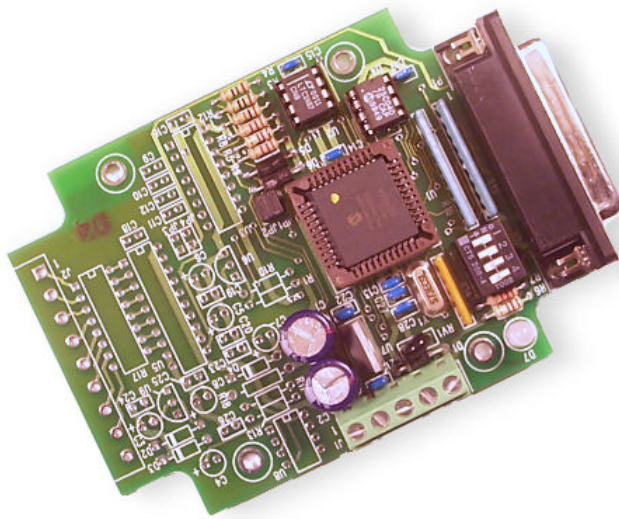
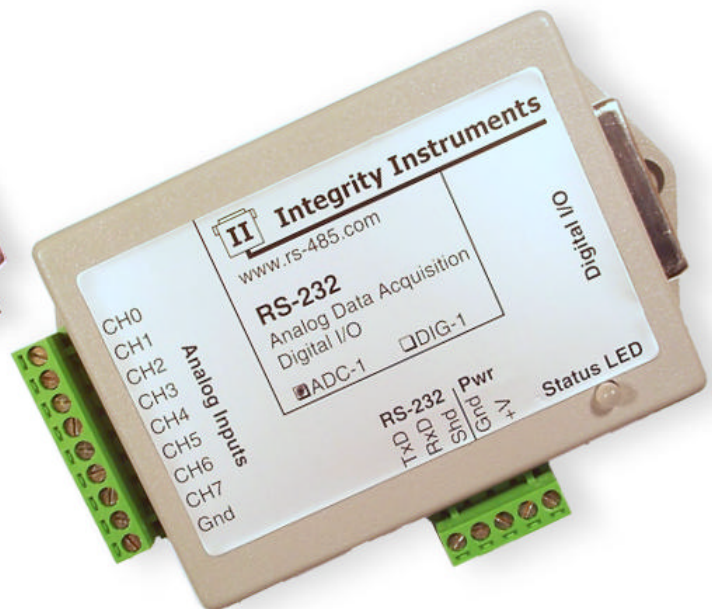


# Model: ADC-x/DIG-x

## RS-485 / RS-232 Data Acquisition Digital I/O v2.2 Firmware



RS-485 DIG Model: DIG-3



RS-232 ADC Model: ADC-1



# Integrity Instruments

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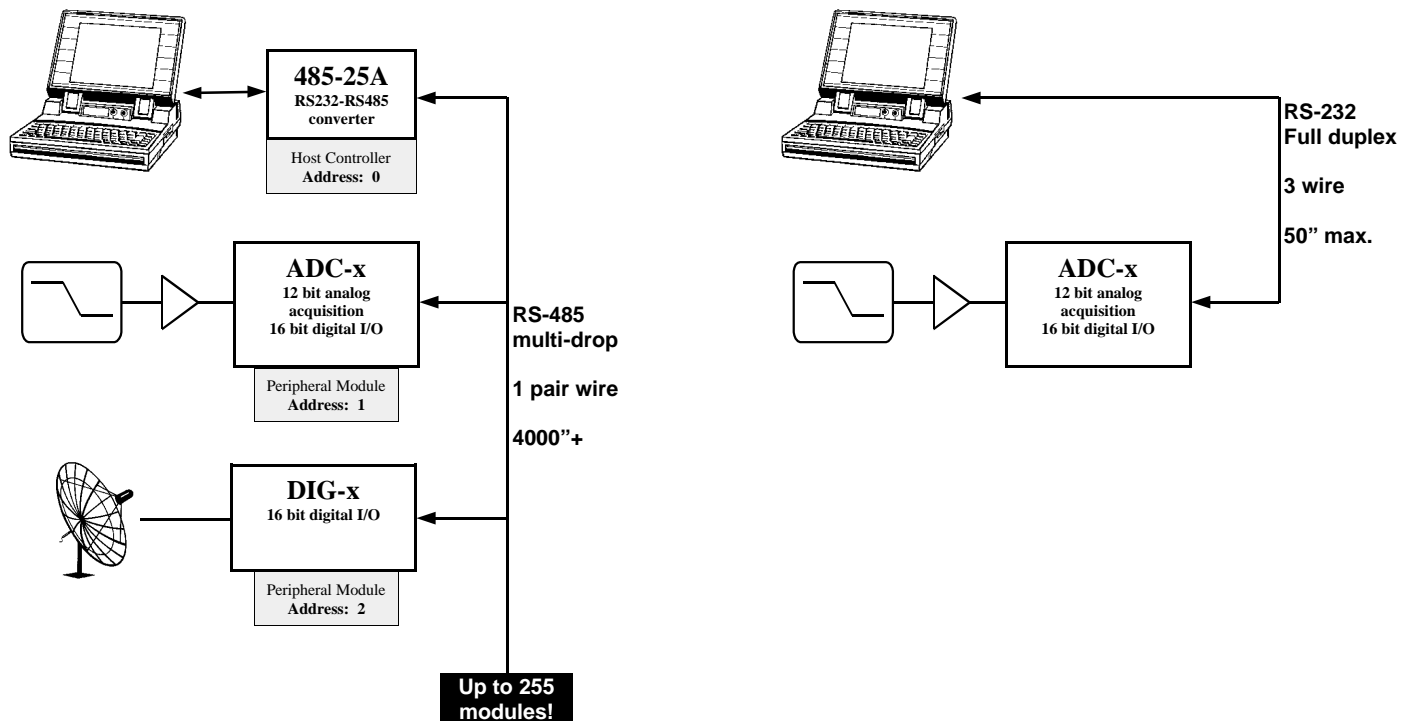
# Introduction - Features

Welcome to the wonderful world of Integrity Instruments I/O modules. We offer two different I/O module lines: **ADC-x** and **DIG-x**. Each module is available with two different serial interface types: RS-232 and RS-485.

All modules use exactly the same PCB populated with different ICs dependent on the interface and Analog Input requirements.

## I/O Module features:

MPU:	Microchip PIC16C65
EEPROM:	Microchip 25C040
MPU Clock:	7.3728 Mhz
Interface:	RS-485 (multidrop up to 255 nodes) or RS-232 (single ended)
Baud:	9600, 19200, 57600, 115200 (DIP switch selectable)
LED:	Bicolor diagnostic LED
Watchdog:	MPU has built-in watchdog timer
POR:	MPU contains timed Power On Reset circuitry
Brownout:	MPU brownout detection circuitry built-in
Temperature:	0°-70°C (32°-158°F) <b>Extended temperature version available</b>
PCB:	FR4
Power:	7.5Vdc - 30.0Vdc, approx. 50 ma.(see "Charge Pump Resistor page 23)
Transient:	ZNR surge suppression on +V power input TransZorb protection on RS-485 data lines



# Quick Start

So, you're in a hurry? Let's see if we can help.

## You need the following:

- Hypterminal program (Windows 95/98 or Windows NT)
- An open COMPORT on your PC
- Power supply (we suggest a +9Vdc wall wart)
- A cable to connect your PC to your I/O Module (See **PCB Details** section for pinout)
- If you have an RS-485 interface, you need a **485-25E** converter.

## Make these DIP switch settings

**SW1:** OFF

**SW2:** ON RS-232 or OFF RS-485

**SW3:** ON

**SW4:** ON

These are factory default (115,200 Baud)

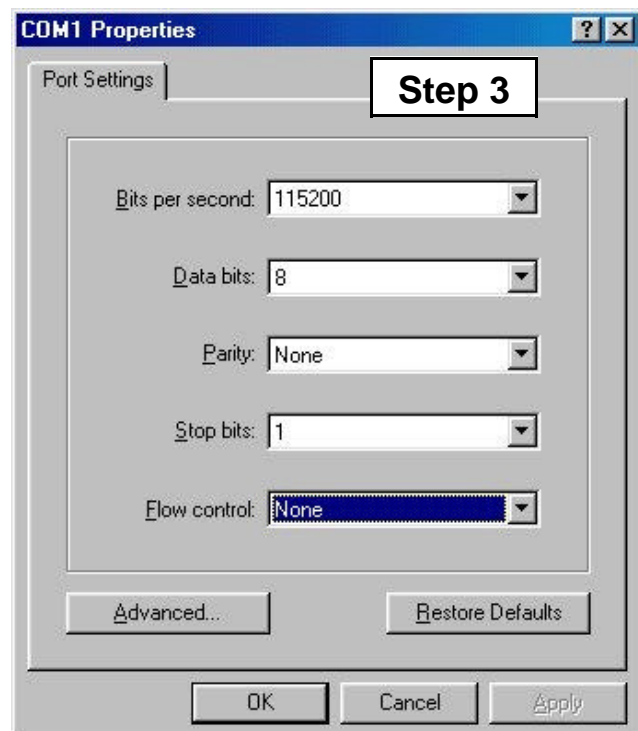
See page 11

## Launch the Hyperterminal program

The Hyperterminal program is found under the **Programs - Accessories** folder. Double click on the **Hypertm.exe** icon to launch the program.

## Hypterminal program configuration

- 1) Create a new connection named "*Integrity*"
- 2) Select your Comport (COM2 in the example)
- 3) Set COM Properties: 115,200 baud, 8 data bits, No parity, 1 stop bit, Flow control None



## Hyperterminal program configuration cont.

- 4) Under the **File** menu, select **Properties**, click on the **Settings** tab, and adjust the **ASCII Setup** settings for “*Echo typed characters locally*” and “*Append line feeds to incoming line ends*”

## Your First Command

Now that you have a Hyperterminal session running, you can start typing. After your first command, see **Commands and Responses** section for more commands.

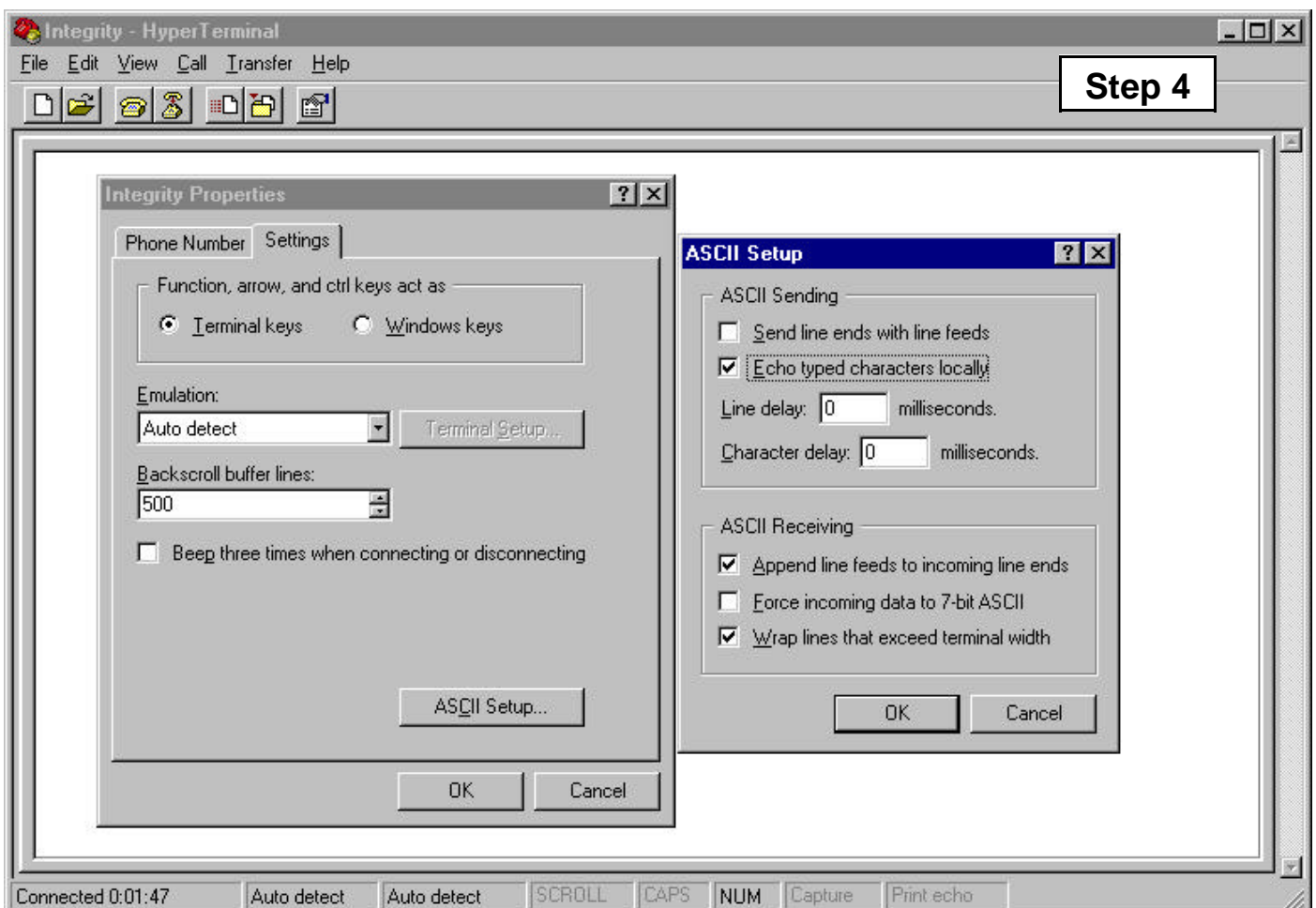
### RS-232

- Type letter **V** and the **Enter Key**
- You should see V22 on the screen

### RS485

- Type letters **0100V** and the **Enter Key**
- You should see 0001V22 on the screen

**NOTE:** Make sure to type **CAPITAL V**, not lowercase v!

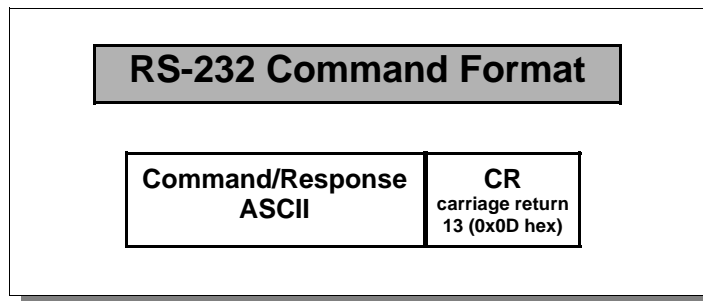


# Communications

The Integrity Instruments models **ADC-x** and **DIG-x** support both RS-232 and RS-485 communications interfaces. Each interface type uses simple **ASCII** commands. A carriage return (**decimal code 13 or Hex code 0x0D**) marks the end of a data packet.

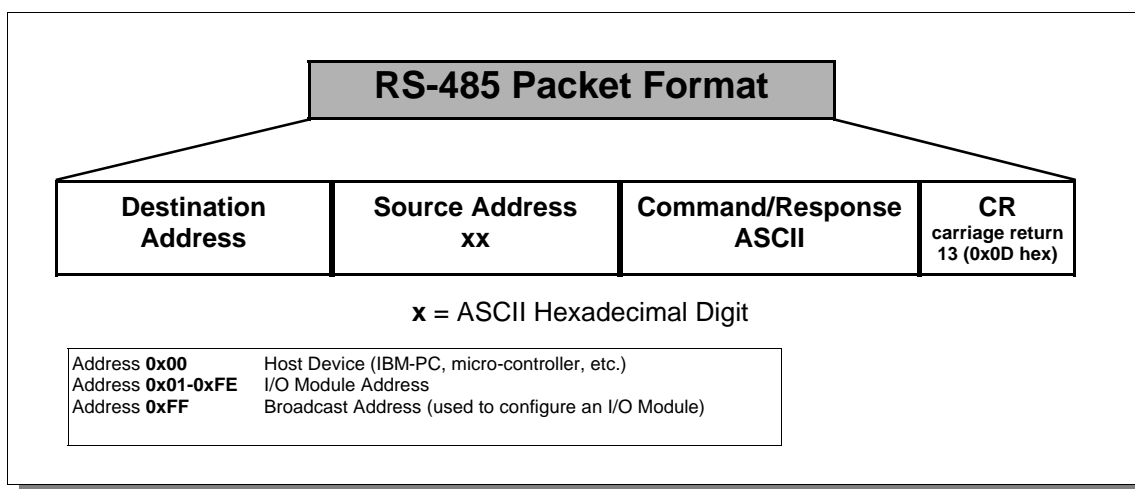
## RS-232 Interface:

- RS-232 operates Full Duplex
- RS-232 modules can enter **Continuous mode** whereby the module is configured via EEPROM settings to continuously communicate with the host computer to output its current Digital, Counter or Analog readings.



## RS-485 Interface:

- RS-485 operates Half Duplex
- Each module (node) on the bus has a unique Address 1 to 254 (0x01-0xFE hex)
- We use the latest Linear Technologies RS-485 bus drivers (LTC1487) allowing up to **255 nodes** on the RS-485 multi-drop bus
- Address 0 (0x00 hex) is reserved for the Host controller
- Address 255 (0xFF hex) is reserved for Broadcast messages - **accepted by all modules on the RS-485 bus.**



# Firmware v2.2 Commands/Responses

## Command and Response

The following table illustrates the Integrity Instruments I/O module commands and responses.

### NOTE

- \* All numeric data is represent as ASCII Hexadecimal integers (value **x/y** in the table)
- \* If a module receives an illegal or improperly formatted command, Error Response is sent.
- \* All ASCII characters are **CASE SENSITIVE** (use all capital letters!)

Command Sent by Host	Response Sent by I/O Module	Description
V	Vxy	Firmware version x.y
I	Ixyy	Input digital port status xx = PORT1 (PORTB) yy = PORT2 (PORTD) <i>Also returns current output port status</i>
Oxyy	O	Output digital port: xx = PORT1 (PORTB) yy = PORT2 (PORTD)
Txyy	T	Set digital direction: xx = PORT1 (PORTB) yy = PORT2 (PORTD) bit set(1) = Input, bit clear(0) = Output
G	Gxyy	Get current digital direction: xx = PORT1 (PORTB) yy = PORT2 (PORTD) bit set(1) = Input, bit clear(0) = Output
N	Nxxxx	Get Pulse Counter (xxxx 16 bit counter value)
M	M	Clear Pulse Counter
Qy	Qyxxx	Bipolar sample analog (y control nibble , xxx analog value)
Uy	Uyxxx	Unipolar sample analog (y control nibble, xxx analog value)
K	Kxx	Get receive error count (xx current count)
J	J	Clear receive error count
Pxyyy	P	PWM (xx = PWM frequency, yyy = PWM duty)
Wyyxx	W	Write EEPROM (yy address, xx value)
Ryy	Rxx	Read EEPROM (yy address in command, xx value in reponse)
S	S	Start stream continuous mode
H	H	Halt stream continuous mode
Z	Z	Reset CPU
	X	Command error response

# Command/Response RS-232 Interface

## RS-232 Interface Example Commands

The following table illustrates actual command and response data for an RS-232 interface.

### NOTE

\* All numeric data is represent as ASCII Hexadecimal integers

\* The symbol ↵ equates to a carriage return (decimal 13, hex 0x0D)

Command Sent by Host	Response Sent by I/O Module	Description
V↵	V20↵	Module Firmware version 2.0
I↵	IFF00↵	Input digital port [PORT1 bits0-7 ON] [PORT2 bits0-7 OFF] <b>Note:</b> this command also returns the current digital output
O007F↵	O↵	Output digital port [PORT1 bits 0-7 OFF] [PORT2 bit 7 OFF, bits 0-6 ON]
TFF80↵	T↵	Set digital direction [PORT1 bits 0-7 INPUT] [PORT2 bit 7 INPUT, bits 0-6 OUTPUT]
G↵	GFF80↵	Get current digital direction [PORT1 bits 0-7 INPUT] [PORT2 bit 7 INPUT, bits 0-6 OUTPUT]
N↵	N0003↵	Get pulse counter: Current count = 3
M↵	M↵	Clear pusle counter: Current count = 0
Q1↵	Q100F↵	Bipolar analog control nibble = 0x1 Analog reading = 0x00F
U8↵	U840F↵	Unipolar analog control nibble = 0x8 Analog reading = 0x40F
K↵	K00↵	Current receive errors = 0
J↵	J↵	Clear receive error count: Current receive errors = 0
P08004↵	P↵	PWM freq = 51200 Hz, PWM duty = 12.5%
W0410↵	W↵	Write EEPROM Address 0x04 with value 0x10
R04↵	R10↵	Read EEPROM Adress 0x04 (value is 0x10)
S↵	S↵ IFF00↵ Q100F↵ IFF00↵ Q100F↵ ...	<b>START</b> stream continuous mode <b>See Modes of Operation section</b>  This example illustrates stream mode configured to continuously update with <b>Input Digital Port</b> command and <b>Query Analog</b> command with control 0x1. <b>The module continues until a command H↵ is received.</b>
H↵	H↵	<b>HALT</b> stream continuous mode
Z↵	Z↵	Reset CPU (forces a watchdog timeout)



# Command/Response RS-485 Interface

## RS-485 Interface Example Commands

The following table illustrates actual command and response data for an RS-485 interface.

### NOTE

- \* All numeric data is represent as ASCII Hexadecimal integers
- \* Example Host Address = 0x00 and Module Address = 0x13
- \* The symbol ↵ equates to a carriage return (decimal 13, hex 0x0D)

Command Sent by Host	Response Sent by I/O Module	Description
1300V↵	0013V20↵	Module Firmware version 2.0
1300I↵	0013IFF00↵	Input digital port [PORT1 bits0-7 ON] [PORT2 bits0-7 OFF] <b>Note:</b> this command also returns the current digital output
1300O007F↵	0013O↵	Output digital port [PORT1 bits 0-7 OFF] [PORT2 bit 7 OFF, bits 0-6 ON]
1300TFF80↵	0013T↵	Set digital direction [PORT1 bits 0-7 INPUT] [PORT2 bit 7 INPUT, bits 0-6 OUTPUT]
1300G↵	0013GFF80↵	Get current digital direction [PORT1 bits 0-7 INPUT] [PORT2 bit 7 INPUT, bits 0-6 OUTPUT]
1300N↵	0013N0003↵	Get pulse counter: Current count = 3
1300M↵	0013M↵	Clear pulse counter: Current count = 0
1300Q1↵	0013Q100F↵	Bipolar analog control nibble = 0x1 Analog reading = 0x00F
1300U8↵	0013U840F↵	Unipolar analog control nibble = 0x8 Analog reading = 0x40F
1300K↵	0013K00↵	Current receive errors = 0
1300J↵	0013J↵	Clear receive error count: Current receive errors = 0
1300P08004↵	0013P↵	PWM freq = 51200 Hz, PWM duty = 12.5%
1300W0410↵	0013W↵	Write EEPROM Address 0x04 with value 0x10
1300R04↵	0013R10↵	Read EEPROM Adress 0x04 (value is 0x10)
1300S↵	0013X↵	<b>START</b> stream continuous mode <b>Illegal in RS-485 Mode</b>
1300H↵	0013X↵	<b>HALT</b> stream continuous mode <b>Illegal in RS-485 Mode</b>
1300Z↵	0013Z↵	Reset CPU (forces a watchdog timeout after Z↵ response sent to Host)

**NOTE:** A command addressed to Module address 0xFF is accepted by all Modules

# Analog Control Nibble

## Analog Control Nibble and Example

The **ADC-x** module utilizes the Linear Technologies LTC1296 analog to digital conversion chip. In the process of performing a data sample, the user sends a control nibble to the **ADC-x** module. The **ADC-x** module in turn performs a data conversion using the control nibble and transmits a response data sample back. The following table lists each of the 16 possible analog configurations.

### NOTE

- \* All numeric data is represent as ASCII Hexadecimal integers
- \* The symbol ↵ equates to a carriage return (decimal 13, hex 0x0D)
- \* See **ADC Technical Info** section for sample to volts conversion

Control Nibble Sent by Host	Analog Sample
0	Differential: CH0+ CH1-
1	Differential: CH2+ CH3-
2	Differential: CH4+ CH5-
3	Differential: CH6+ CH7-
4	Differential: CH0- CH1+
5	Differential: CH2- CH3+
6	Differential: CH4- CH5+
7	Differential: CH6- CH7+
8	Single Point: CH0
9	Single Point: CH2
A	Single Point: CH4
B	Single Point: CH6
C	Single Point: CH1
D	Single Point: CH3
E	Single Point: CH5
F	Single Point: CH7

Command Sent by Host	Response Sent by I/O Module	Description
Q0↵	Q000F↵	Bipolar sample differential CH0+ CH1- (Control = 1) Analog sample = 0x00F (decimal 15)
UA↵	UA123↵	Unipolar sample CH4 (Control = A ) Analog sample = 0x123 (decimal 291)

# Module DIP Switch & Jumper Configuration

## DIP switch settings:

1	2	3	4	DIP switch position
		OFF	OFF	9600 baud
		ON	OFF	19200 baud
		OFF	ON	57600 baud
		ON *	ON *	115200 baud
	ON			RS-232 packet <b>No packet addressing</b>
	OFF			RS-485 packet <b>Packet addressing used</b>
ON				RS-485 Fast response
OFF *				RS-485 Delayed response* <b>Wait approx. 2 ms. to send response</b>

\*

## Factory default settings:

**RS-232** SW1-OFF, SW2-ON, SW3-ON, SW4-ON (115,200 baud)

**RS-485** SW1-OFF, SW2-OFF, SW3-ON, SW-4 ON (115,200 baud)

**\*NOTE:** Use RS-485 delayed response when using the **485-25E** protocol converter (SW1-OFF)

## Jumper settings:

JP1	JP2	Jumper
ON *	ON *	RS-485 active bus termination
OFF	OFF	<b>No</b> RS-485 bus termination

\*

## Factory default setting

JP1-ON JP2-ON

# EEPROM Map - Module Configuration

Address	Description
0x00	Module Address (RS-485 address) [factory default = 0x01]
0x01	Timed/Async Destination Address [factory default = 0x00]
0x02	Data Direction Port 1 (PIC16C65 PORTB) Bit set (1) = Input Bit clear (0) = Output [factory default = 0xFF]
0x03	Data Direction Port 2 (PIC16C65 PORTD) Bit set (1) = Input Bit clear (0) = Output [factory default = 0xFF]
0x04	Timed/Async Update Configuration 0x00= No Timed/Async updates 0x01= Change Update on Digital Input or Counter change 0x02...0xFF = Timed Update (Time = Value * 100 milliseconds) [factory default = 0x00]
0x05 ... 0x0E	Reserved
0x0F	Analog offset calibration (2's complement integer offset to be added to analog bipolar sample)
0x10	Continuous Analog configuration count 0x00 = No analog stream readings 0x01..0x08 = Number of analog queries <b>See Modes of Operation Stream Continuous for locations 0x10...0x1A</b>
0x11	Analog Query 1 - control byte - <b>analog control nibble</b>
0x12	Analog Query 2 - control byte - <b>analog control nibble</b>
0x13	Analog Query 3 - control byte - <b>analog control nibble</b>
0x14	Analog Query 4 - control byte - <b>analog control nibble</b>
0x15	Analog Query 5 - control byte - <b>analog control nibble</b>
0x16	Analog Query 6 - control byte - <b>analog control nibble</b>
0x17	Analog Query 7 - control byte - <b>analog control nibble</b>
0x18	Analog Query 8 - control byte - <b>analog control nibble</b>
0x19	Continuous Digital Input configuration 0x00 = Digital Input status OFF 0x01 = Digital Input status ON
0x1A	Continuous Pulse Counter configuration 0x00 = Pulse Counter status OFF 0x01 = Pulse Counter status ON
0x1B ... 0xFF	Available to User

# Modes of Operation

## General

The Integrity Instruments I/O modules can operate in three communications modes: Polled, Timed/Async, and Continuous. **These modes of operation can be used singularly or together in combination.**

Mode	Interface
Polled	RS-485 and RS-232
Timed/Async	RS-485 and RS-232
Continuous	RS-232

## Polled Mode

By far, the Polled Mode is the most common usage of the ADC-x and DIG-x I/O modules. In this mode the Host computer sends a command to the I/O Modules which in turn sends an associated response back to the Host computer.



## Timed/Async Mode

Timed/Async Mode refers to the I/O Module sending data **without** the Host sending a command to poll the I/O Module. This can be viewed as the I/O Module sending a Response without the Host first sending a Command. Async mode reduces communicationsbus traffic.

**NOTE:** Timed/Async mode is configured using EEPROM location 0x04.

Analog Sample Rate Chart - - samples per second per analog channel theoretical maximum				
Baud Rate	RS-232 Polled	RS-232 Streamed	RS-485 Polled	RS-485 Streamed
115,200	1,280	1,920	677	N/A
57,600	640	960	338	N/A
19,200	213	320	113	N/A
9600	106	160	56	N/A

Numbers are single channel in samples per second. To calculate take table of values and divide by number of channels being used. Example: 8 channels RS-232 Polled would be 1,280/8=160 per second. 8 channels RS-232 streamed would be 1,920/8=240 samples per second.

Value at EEPROM Location 0x04	
0x00	Timed/Async Mode disabled
0x01	<b>Change Update</b> Digital Input or Pulse Counter change
0x02-0xFF (decimal 2-255)	<b>Timed Update</b> Time = Value * .1 second Range = .2 second - 25.5 seconds

# Modes of Operation

## Timed/Async Mode — Change Update

When EEPROM location 0x04 = 0x01, the ADC/DIG I/O module enters an asynchronous update mode whereby any detected change on the Digital Input port or the Counter Capture port causes the I/O module to transmit data to the host.

Status Change	Data Sent by I/O Module
Digital Input port change	Ixxxx
Counter Capture change	Nxxxx



## Timer/Async Mode — Timed Update

When EEPROM location 0x04 = 0x02...0xFF, the ADC/DIG I/O module enters a timed update mode whereby the I/O module will send data to the host after the specified time period has elapsed.

$$\text{Time Period} = \text{Value (EEPROM location 0x04)} * .1 \text{ second}$$

When using Async Timed Update, the I/O module uses the **Continuous Mode** configuration to determine the data sent to the host.

## Continuous Mode

The final mode of operation is Continuous mode. This mode constantly sends or **streams** data to the host until the host halts the mode. Since the I/O module sends data continuously in this mode, **only the RS-232 interface can be configured for Continuous mode.** (*RS-485 is half duplex and there would be no way to halt the stream of data coming from the I/O module!*) In brief, the I/O Module can send 0 thru 8 analog samples, digital input status, and the counter capture status.

The I/O module uses parameters found in EEPROM locations 0x10 thru 0x1A to configure the continuous mode. Therefore, the EEPROM must be configured before engaging the Continuous mode.

## Continuous mode setup steps

- 1 - Configure EEPROM locations 0x10 thru 0x1A
- 2 - Begin Continuous mode by sending command 'S' to the I/O Module
- 3 - Halt Continuous mode by sending command 'H' to the I/O Module

# Modes of Operation

## Continuous Mode Configuration — EEPROM Locations

All parameters configuring the Stream Continuous mode are stored in EEPROM. See the following table for a description of the locations and the parameters. Use command 'W' to update EEPROM values.

EEPROM Location	Value	Description
0x10	0x00...0x08	<b>Analog Configuration</b> 0x00 = No analog samples 0x01...0x08 = Number of analog samples
0x11 <i>Sample 1</i>	0x0y ... 0x0y 0x8y ... 0x8y	Bipolar Analog: y = analog control nibble Unipolar Analog: y = analog control nibble
0x12 <i>Sample 2</i>	0x0y ... 0x0y 0x8y ... 0x8y	Bipolar Analog: y = analog control nibble Unipolar Analog: y = analog control nibble
0x13 <i>Sample 3</i>	0x0y ... 0x0y 0x8y ... 0x8y	Bipolar Analog: y = analog control nibble Unipolar Analog: y = analog control nibble
0x14 <i>Sample 4</i>	0x0y ... 0x0y 0x8y ... 0x8y	Bipolar Analog: y = analog control nibble Unipolar Analog: y = analog control nibble
0x15 <i>Sample 5</i>	0x0y ... 0x0y 0x8y ... 0x8y	Bipolar Analog: y = analog control nibble Unipolar Analog: y = analog control nibble
0x16 <i>Sample 6</i>	0x0y ... 0x0y 0x8y ... 0x8y	Bipolar Analog: y = analog control nibble Unipolar Analog: y = analog control nibble
0x17 <i>Sample 7</i>	0x0y ... 0x0y 0x8y ... 0x8y	Bipolar Analog: y = analog control nibble Unipolar Analog: y = analog control nibble
0x18 <i>Sample 8</i>	0x0y ... 0x0y 0x8y ... 0x8y	Bipolar Analog: y = analog control nibble Unipolar Analog: y = analog control nibble
0x19	0x00 0x01 ... 0xFF	Digital Input status <b>disabled</b> Digital Input status <b>enabled</b>
0x1A	0x00 0x01 ... 0xFF	Pulse Counter status <b>disabled</b> Pulse Counter status <b>enabled</b>

## Continuous Mode Example

In this example, the I/O module EEPROM is configured to take 2 Analog samples and update the Counter status.

EEPROM Location 0x10	0x02	<i>Take 2 Analog samples</i>
EEPROM Location 0x11	0x08	<i>Sample 1 - Bipolar sample CH0</i>
EEPROM Location 0x12	0x89	<i>Sample 2 - Unipolar sample CH2</i>
EEPROM Location 0x1A	0x01	<i>Pulse Counter Status enabled</i>

# Modes of Operation

## Stream Mode Example cont.

The following table illustrates the Host Command and I/O Module responses for the stream continuous example configuration and usage.

EEPROM Location 0x10	0x02	<i>Take 2 Analog samples</i>
EEPROM Location 0x11	0x08	<i>Sample 1 - Bipolar sample CH0</i>
EEPROM Location 0x12	0x89	<i>Sample 2 - Unipolar sample CH1</i>
EEPROM Location 0x1A	0x01	<i>Counter Status enabled</i>

## NOTE

- \* All numeric data is represent as ASCII Hexadecimal integers
- \* The symbol ↵ equates to a carriage return (decimal 13, hex 0x0D)

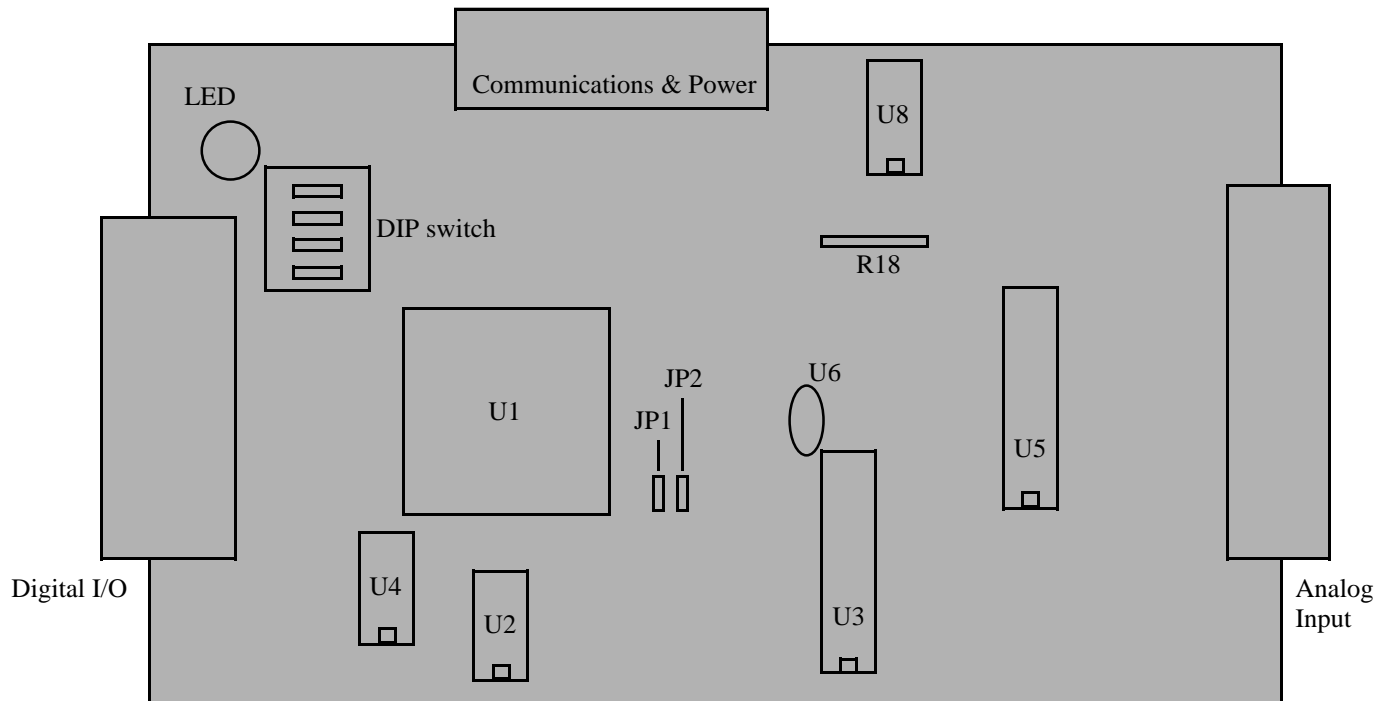
Host Sends	I/O Module Sends
W1002↵	W↵
W1108↵	W↵
W1289↵	W↵
W1A01↵	W↵
S↵	S↵ <i>Continuous mode started</i>
	Q8023↵
	U9823↵
	N0044↵
	Q8024↵
	U9823↵
	N0044↵
	.... repeats continually
H↵	H↵ <i>Continuous mode halted</i>

The HOST may send any command during the Continuous mode and it will be accepted and processed by the I/O Module as in normal operation.

**NOTE:** Engaging the Continuous mode at a high baud rate (115.2K baud) may overwhelm certain Host computer systems due to the high volume of data transmitted on the RS-232 link. The is especially true of slower 386 or 486 based systems running Windows 95 with limited memory resources.



# PCB Details



## IC Description

U1	PIC16C65 MPU [44 pin PLCC]
U2*	LTC1487 RS-485 driver [8 pin DIP]
U3*	MAX202 RS-232 driver [16 pin DIP]
U4	25C040 EEPROM [8 pin DIP]
U5	LTC1296 [20 pin DIP]
U6	LM4040 Voltage Reference
U8	LMC555 Timer charge pump [8 pin DIP]
R18	Charge pump power supply resistor

**NOTE\*:** U2 and U3 are mutually exclusive.

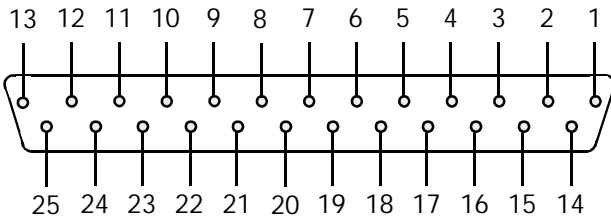
## LED Operation

Blinking Green	[1 per Second]	Unit functioning correctly
Blinking Green	[Rapid or Steady]	Unit receiving serial data
Blinking Red	[Rapid or Steady]	Unit transmitting serial data
No LED		Unit is not functioning

## Jumpers

JP1-JP2	Installed	RS-485 active termination at unit
---------	-----------	-----------------------------------

# Connector Pinout



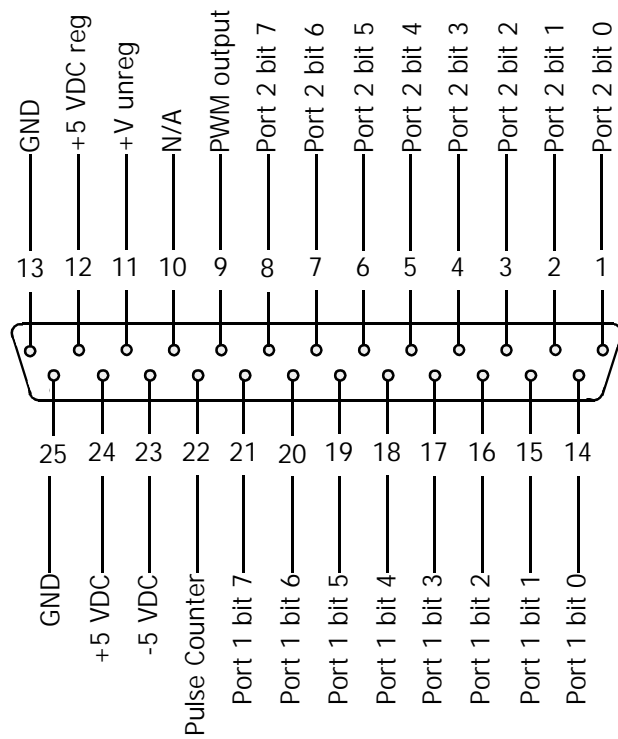
Female front view - Male rear view

(unit has female connector) (male required to mate)

## DB25 Digital I/O Port

### DB25 Female Digital Port pinout

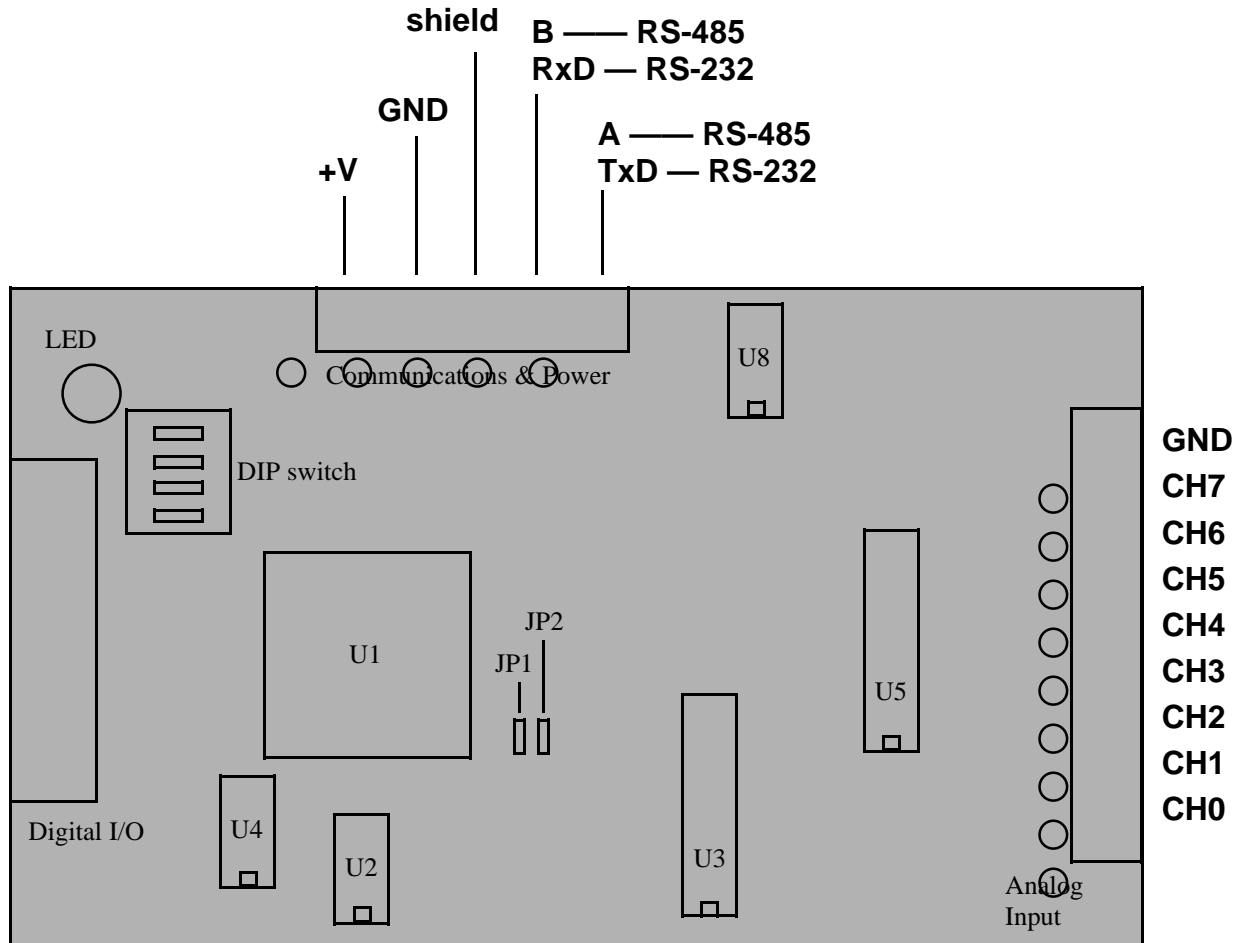
DB25 Pin	Description
1	Port 2 bit 0 (PIC PORTD 0)
2	Port 2 bit 1 (PIC PORTD 1)
3	Port 2 bit 2 (PIC PORTD 2)
4	Port 2 bit 3 (PIC PORTD 3)
5	Port 2 bit 4 (PIC PORTD 4)
6	Port 2 bit 5 (PIC PORTD 5)
7	Port 2 bit 6 (PIC PORTD 6)
8	Port 2 bit 7 (PIC PORTD 7)
9	PWM output
10	N/A
11	+V_Unreg
12	+5Vdc
13	GND
14	Port 1 bit 0 (PIC PORTB 0)
15	Port 1 bit 1 (PIC PORTB 1)
16	Port 1 bit 2 (PIC PORTB 2)
17	Port 1 bit 3 (PIC PORTB 3)
18	Port 1 bit 4 (PIC PORTB 4)
19	Port 1 bit 5 (PIC PORTB 5)
20	Port 1 bit 6 (PIC PORTB 6)
21	Port 1 bit 7 (PIC PORTB 7)
22	Pulse Counter Input
23	-5Vdc
24	+5Vdc
25	GND



Female front view - Male rear view

(unit has female connector) (male required to mate)

# Connector Pinout



## **Power Supply**

7.5-30Vdc approx. 50 ma. (we suggest a 12Vdc 250ma power supply)

**NOTE:** Voltage supplies > 17Vdc must alter R18 charge pump resistor value.

## **GND and Shield**

The GND and Shield terminals are connected on the ADC-x/DIG-x board and are therefore electrically equivalent.

## **RS-485 Cabling**

RS-485 wiring is quite simple. Connect all node **A** signals together and all node **B** signals together. Simply run a twisted pair wire to all nodes. Please note that some systems may denote signal **A** as T+/R+ and signal **B** as T-/R-.

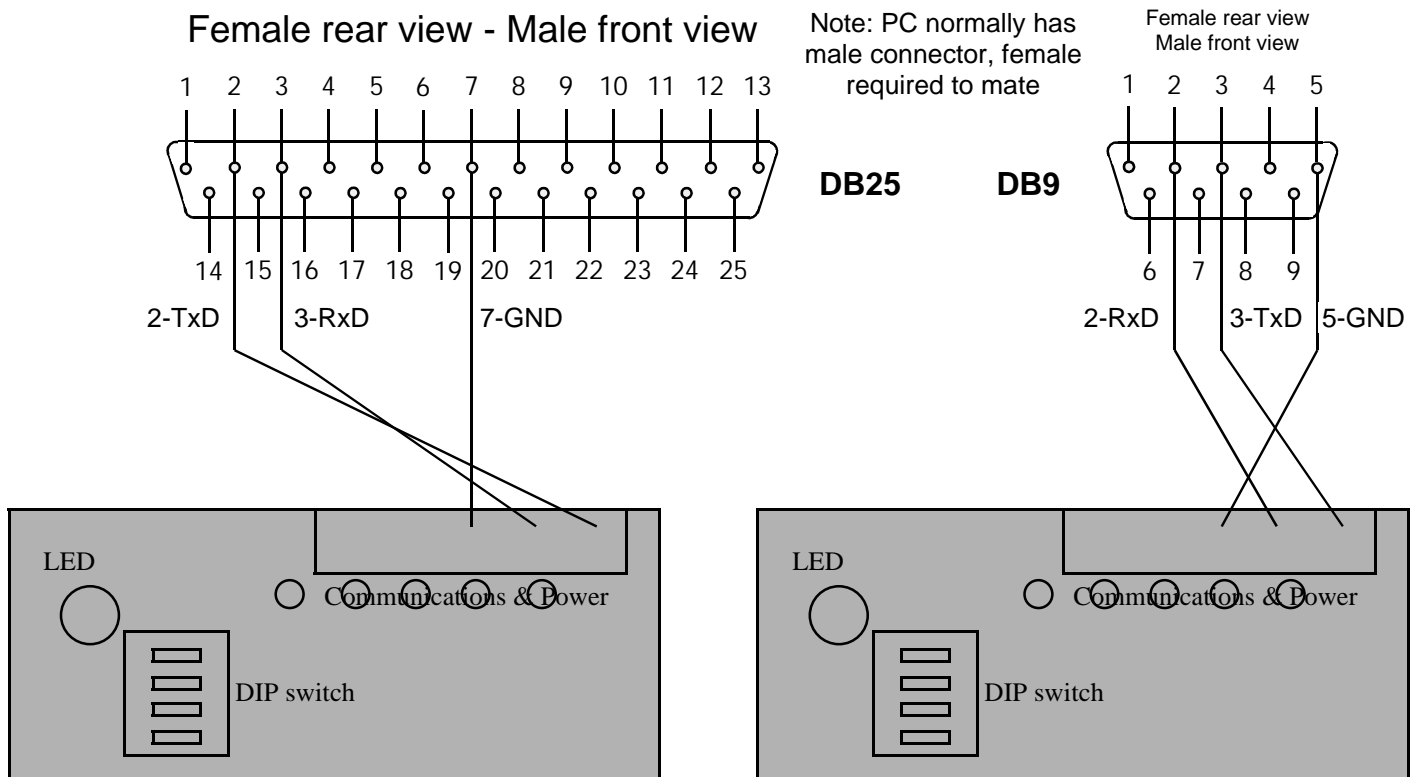
## **RS-485 Termination**

The two nodes (units) at the extreme ends of the cable must be terminated: JP1 & JP2 installed. Ensure that only two nodes maximum are terminated.

# Connector Pinout

## RS-232 Cabling

The RS-232 interface uses a “**3 wire**” RS-232 connection. That is to say only three wires are connected between the I/O Module and the Host PC: **TxD**, **RxD** and **GND**.



## RS-232 Hardware Flow Control

Some RS-232 interfaces may require certain control signals to be wired **loopback** in order to support various Hardware Flow control schemes.

If your Host PC or Controller is using **Hardware Flow** control for serial communications, then use the following chart to loopback the control signals.

**RTS-CTS**  
**DSR-DTR-CD**

**DB25:** pins 5-4 wired together  
**DB25:** pins 20-8-6 wired together

**DB9:** pins 8-7 wired together  
**DB9:** pins 6-4-1 wired together

## RS-232 Software Flow Control - Xon/Xoff

The Integrity Instruments ADC-x/DIG-x I/O modules **do not support Xon/Xoff flow control**.

# Digital I/O Technical Information

## Digital I/O Characteristics

The following chart lists the Digital I/O characteristics and values.

Characteristic	Value
Digital I/O Current	I/O line source & sink 25 ma Total current PORT1 200 ma
Digital I/O Voltage Levels	Input Off (0) = 0V - 0.8V Input On (1) = 2.0V - 5.0V Output Off (0) = 0.6V max.
Pulse Counter Input	1 Mhz max. input rate 16 bit counter capture <b>Counter increments on high-low transition</b>

## Digital Port Configuration Example

Any Digital I/O configuration changes made to the I/O Module using the 'T' command are stored in EEPROM locations 0x02 and 0x03.

EEPROM Location 0x02 Port 1 I/O Configuration  
EEPROM Location 0x03 Port 2 I/O Configuration

When using either the 'T' command or directly writing to EEPROM using the 'W' command, a binary 1 at a bit location puts the I/O line into Input mode, while a binary 0 at a bit location puts the I/O line into Output mode.

Digital Sample Rate Chart - - samples per second (all 16 bits of I/O) theoretical maximum				
Baud Rate	RS-232 Polled	RS-232 Streamed	RS-485 Polled	RS-485 Streamed
115,200	1,440	1,920	720	N/A
57,600	720	960	360	N/A
19,200	240	320	120	N/A
9,600	120	160	60	N/A

## NOTE

- \* All numeric data is represent as ASCII Hexadecimal integers
- \* The symbol  $\backslash$  equates to a carriage return (decimal 13, hex 0x0D)

Host Command	Module Response	Action
T0000 $\backslash$	T $\backslash$	All I/O lines are configured as Outputs
TFFFF $\backslash$	T $\backslash$	All I/O lines are configured as Inputs
TFF00 $\backslash$	T $\backslash$	Port 1 bits 0-7 Inputs Port 2 bits 0-7 Outputs
T00FF $\backslash$	T $\backslash$	Port 1 bits 0-7 Outputs Port 2 bits 0-7 inputs
T1234 $\backslash$	T $\backslash$	Port 1 bits 4,1 Inputs Port 1 bits 7,6,5,3,2,0 Outputs Port 2 bits 4,5,2 Inputs Port 2 bits 7,6,3,1,0 Outputs

# Digital I/O Technical Information

## Pulse Width Modulation (PWM)

The ADC-x and DIG-x I/O modules have a configurable PWM output. There are two settings to configure for proper PWM operation: PWM frequency and PWM duty cycle. The current capability of the PWM output is the same as a Digital I/O line (source & sink 25 ma.)

## PWM — Command

Pxxyyy      xx = Pwm\_Divisor    yyy = Pwm\_Duty (10 bits max.)

Pwm\_Divisor = 0x00 ... 0xFF

Pwm\_Duty = 0x000 ... 0x3FF      **Pwm\_Duty = 0, PWM output is disabled (output 0)**

## PWM — Control

Fpwm = Frequency of PWM output in Hz

Pwm\_Duty\_Percentage = PWM duty cycle (output % on for period Fpwm)

$F_{pwm} = 460800 \text{ Hz} / (Pwm\_Divisor + 1)$

$Duty\_Resolution = \log(1843200/F_{pwm}) / \log(2)$

$Pwm\_Duty\_Percentage = Pwm\_Duty / 2^{Duty\_Resolution}$

Pwm_Divisor	Fpwm	Duty_Resolution
0xFF	1800 Hz	10 bits*
0xFE	1807 Hz	10 bits
0x08	51200 Hz	5 bits
0x00	460800 Hz	2 bits

If (Pwm\_Duty > Duty\_Resolution), then  
Pwm\_Duty\_Percentage = 100%

**\*Note:** Pwm\_Divisor 0xFF cannot achieve complete 100% duty cycle. Use Pwm\_Divisor 0xFE if 100% duty cycle is required.

## Example PWM Commands

\* All numeric data is represent as ASCII Hexadecimal integers

\* The symbol ↵ equates to a carriage return (decimal 13, hex 0x0D)

Host Command	Module Response	Action
P0000↵	P↵	PWM off
P08004↵	P↵	PWM frequency = 51200 Hz
PFE3FF↵	P↵	PWM frequency = 1807 Hz
PFE200↵	P↵	PWM frequency = 1807 Hz

# Analog Input Technical Information

## Analog Characteristics

Characteristic	Value
A/D Converter	Linear Tech LTC1296BCN $\pm .5$ LSB Linear Tech LTC1296DCN $\pm 2$ LSB
Linearity Error	Models: ADC-1/-2/-5/-6 LTC1296BCN $\pm 0.012\%$ ( $\pm .5$ LSB) Models: ADC-3/-4/-7/-8 LTC1296DCN $\pm 0.018\%$ ( $\pm .75$ LSB)
Gain Error	Models: ADC-1/-2/-5/-6 $\pm 0.012\%$ ( $\pm .5$ LSB) Models: ADC-3/-4/-7/-8 $\pm 0.39\%$ ( $\pm 4$ LSB)
Offset Error	Models: ADC-1/-2/-5/-6 $\pm 0.17\%$ Models: ADC-3/-4/-7/-8 $\pm 1.17\%$
Temperature Drift	100 ppm/ $^{\circ}$ C ( max. )
Max Input Voltage	70V over-voltage protected (R17 10K DIP) 15V over-voltage protected (R17 1K DIP)
Bandwidth	> 1500 SPS max. in continuous mode

## Voltage References

We utilize two distinct voltage references in the **ADC-x** Module: a 0.1% voltage reference and a 1.0% voltage reference. These voltage references may be changed by the user. We have included Digikey part numbers for easy ordering. (Digikey phone: 1-800-344-4539)

Voltage	Digikey Part Number
5.000V voltage range +5.0Vdc to -5.0Vdc	0.1% LM4040AIZ-5.0-ND 1.0% LM4040DIZ-5.0-ND
4.096V voltage range +4.1Vdc to -4.1Vdc	0.1% LM4040AIZ-4.1-ND 1.0% LM4040DIZ-4.1-ND
2.500V voltage range +2.5Vdc to -2.5Vdc	0.1% LM4040AIZ-2.5-ND 1.0% LM4040DIZ-2.5-ND
1.200V voltage range +1.2Vdc to -1.2Vdc	0.5% LM4041CIZ-1.2-ND

## Charge Pump Resistor

The ADC-x module contains a negative voltage supply in the form of a charge pump driven by U8, an LMC555 timer. This charge pump obtains its voltage from the unregulated power supply input. Since the LMC555 is rated only for +15Vdc, we have designed a simple zener diode power supply fed through R18 to regulate the power into the LMC555 to +12Vdc.

**If the power supply voltage > 17Vdc, R18 needs to be replaced with a 1.2K resistor.**

# Analog Input Technical Information

## Charge Pump Resistor cont.

Power supply Voltage	R18 Value
7.5Vdc to 17.0Vdc	120 ohm 1/4W (factory default)
17.1Vdc to 30Vdc	1.2K ohm 1/2W

### Sampling Analog Voltage Inputs

By far the most common configuration of the **ADC-x** is to sample voltage values. Analog voltage levels are converted to integer digital values using the Linear Technologies LTC1296 A/D (Analog/Digital) chip. The input voltage range is determined by the reference voltage.

There are two analog sample types: **Unipolar** and **Bipolar**

Both A/D sampling types result in a 12 bit binary integer value. This binary integer value is converted to a voltage depending on the sample type.

### Unipolar Analog Sampling

Unipolar analog sampling span is from ground (GND) to voltage reference (Vref). **Only positive voltages are sampled in unipolar mode.** The unipolar sample is represented as an unsigned integer as follows:

Unipolar voltages: 0V ... +Vref

The benefit of using Unipolar samples over Bipolar samples is that a 12bit binary value is spread out over less total voltage span (Vref total.)

1bit unipolar =  $V_{ref}/4096$

### Bipolar Analog Sampling

Bipolar analog sampling span is from -Vref to +Vref. Both negative and positive voltages are sampled and represented as a signed binary integer (2's complement) as follows:

Bipolar voltages: -Vref ... 0 ... +Vref

The benefit of using Bipolar sampling over Unipolar is obvious, negative voltages! The downfall of using Bipolar sampling is that a 12 bit binary value is spread out over a larger total voltage span ( $2 \times V_{ref}$  total.)

1bit bipolar =  $V_{ref}/2048$



# Analog Input Technical Information

## Voltage Conversion

The Analog conversion value obtained from the **ADC-x** module is represented as an integer value (either signed for Bipolar samples or unsigned for Unipolar sample) and is normally converted to a Real or Floating Point number for ultimate usage.

Vref = 5.000, 4.096, 2.500 or 1.200V

## Unipolar Conversion, ADC Sample is an unsigned integer value

Volts [unipolar] = ADC\_Sample \* (Vref/4096)

## Bipolar Conversion, If ADC Sample is a signed integer value

If you are fortunate enough to convert the Bipolar ASCII hexadecimal value directly to a signed integer, then conversion from ADC\_Sample to volts is very simple.

Volts [bipolar] = ADC\_Sample \* (Vref/2048) + Offset\_Calibration

## Bipolar Conversion, If ADC Sample is an unsigned integer value

Most often the ADC\_Sample value is represented as an **unsigned integer**, quite common when converting the Bipolar ASCII hexadecimal analog reading using the 'C' language scanf() function. If an unsigned integer is used, we must manually calculate a negative number.

if (ADC\_Sample >= 2048)

Volts [bipolar] = (ADC\_Sample-4097) \* (Vref/2048) + Offset\_Calibration

if (ADC\_Sample <= 2047)

Volts [bipolar] = ADC\_Sample \* (Vref/2048) + Offset\_Calibration

## Offset Calibration

The Linear Technologies LTC1296 A/D converter used in the ADC-x modules can exhibit an offset phenomenon. This offset phenomenon is unique to each LTC1296 and a calibration of the offset is required to obtain the most accurate analog readings. The offset calibration is used only with Bipolar analog samples.

## To obtain the current A/D offset use the following procedure:

- 1 - Connect analog CH0 to GND (use a jumper or clip lead)
- 2 - Take a Bipolar analog reading
- 3 - The negative (opposite sign) of this value is the offset calibration to be added to samples

At the factory an offset calibration is performed and stored in EEPROM location 0x0F as an 8 bit 2's complement number.

Offset\_Stored = 8 bit value at EEPROM location 0x0F

if (Offset\_Stored >= 128)

Offset\_Calibration = (Offset\_Stored - 256) \* (Vref/2048)

if (Offset\_Stored <= 127)

Offset\_Calibration = Offset\_Stored \* (Vref/2048)

# Analog Input Technical Information

## Sampling Current (4-20 ma) Inputs

Many devices output a current value instead of a voltage value. The secret to obtaining current readings is a 250 ohm resistor and a 5V voltage reference. Placing a 250 ohm resistor to ground on a 4-20 ma. current input will create a voltage potential of 1V to 5V.

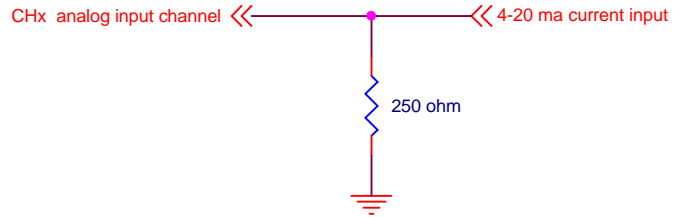
If we remember Ohm's law:

$$E = I * R$$

$$R = 250 \text{ ohms}$$

$$I = .004 \text{ to } .020 \text{ amps (4-20 ma.)}$$

$$E = 1.0V \text{ to } 5.0V$$



**NOTE:** The **PR1** package of 8 ultra precision 250 ohm .1% 1/4 watt resistors for current (4-20ma) conversions are available from Integrity Instruments. Please see catalog or website.

## Obtaining current readings is a three step process:

- 1 - Perform analog Unipolar sample (5.000V reference must be used!)
- 2 - Convert unipolar sample to volts
- 3 - Convert voltage to amps

## Current Conversion

The following formula will convert the raw analog sample reading to a current value.

$$\text{Current} = \text{ADC\_Sample} * (5.000/4096) * 250$$

## Obtaining accurate Analog samples

Please keep the following points in mind when attempting to obtain accurate samples.

- A) Watch out for UPS systems! They create loads of EMI/EMF noise.
- B) Keep the analog signal source as close to the ADC-x module as possible.
- C) Keep transformers far away from the ADC-x module.
- D) Avoid high impedance analog signal sources.
- E) Use good wiring practices, especially in regards to ground connections.
- F) RS-232 interface can generate approx. 2 mv noise.
- G) RS-485 interface offers the best noise immunity.

## Warranty

**Integrity Instruments** warranties **all** products against defective workmanship and components for the life of the unit. Integrity Instruments agrees to repair or replace, at its sole discretion, a defective product if returned to Integrity Instruments with proof of purchase.