
TRACER-E

RUGGEDIZED PC/104 Digital I/O

Revision: June 23, 2009



Apex Embedded Systems

Reference Manual

TRACER-E Reference Manual

Apex Embedded Systems
116 Owen Road
Monona, WI 53716
Phone 608.256.0767 • Fax 608.256.0765

Copyright Notice:

Copyright © 2009 by Apex Embedded Systems. All rights reserved.

Legal Notice:

Apex Embedded Systems' sole obligation for products that prove to be defective within 1 year from date of purchase will be for replacement or refund. Apex Embedded Systems gives no warranty, either expressed or implied, and specifically disclaims all other warranties, including warranties for merchantability and fitness. In no event shall Apex Embedded Systems' liability exceed the buyer's purchase price, nor shall Apex Embedded Systems be liable for any indirect or consequential damages.

This warranty does not apply to products which have been subject to misuse (including static discharge), neglect, accident or modification, or which have been soldered or altered during assembly and are not capable of being tested.

DO NOT USE PRODUCTS SOLD BY APEX EMBEDDED SYSTEMS AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS!

Products sold by Apex Embedded Systems are not authorized for use as critical components in life support devices or systems. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

Table of Contents

TABLE OF CONTENTS	II
SUPPORT POLICY	IV
GENERAL SUPPORT POLICY	IV
RECOMMENDED SEQUENCE IN OBTAINING CUSTOMER SUPPORT.....	IV
NEED CUSTOM MODIFICATIONS?	IV
WELCOME.....	V
BENEFITS AND FEATURES.....	1
EXECUTIVE SUMMARY.....	1
PHOTO.....	3
BLOCK DIAGRAM.....	4
HARDWARE CONFIGURATION	5
BASE ADDRESS AND CONFIGURATION	5
EXAMPLE BASE ADDRESS	5
BASE ADDRESS TABLE.....	6
REGISTER SET	7
REGISTER SET SUMMARY	7
8255 DEVICE #1 REGISTERS.....	8
DIGITAL I/O CONNECTOR J12, 8255 #1.	9
EXTERNAL IRQ SOURCE 0 (IRQ_IN0) J5	9
8255 DEVICE #2 REGISTERS.....	10
DIGITAL I/O CONNECTOR J9, 8255 #2.	11
EXTERNAL IRQ SOURCE 1 (IRQ_IN1) J7	11
8254 COUNTER/TIMER REGISTERS.....	13
COUNTER/TIMER SETUP REGISTER	14
GENERAL CONFIGURATION REGISTER	16
CONNECTOR SUMMARY	18
DIGITAL I/O CONNECTOR J12, 8255 #1.	19
EXTERNAL IRQ SOURCE 0 (IRQ_IN0) J5	19
DIGITAL I/O CONNECTOR J9, 8255 #2.	20
EXTERNAL IRQ SOURCE 1 (IRQ_IN1) J7	20
PC/104 IRQ SOURCE A CONNECTOR J10	21
PC/104 IRQ SOURCE B CONNECTOR J8.....	21
PC/104 IRQ SOURCE C CONNECTOR J6.....	21

COUNTER/TIMER CONNECTOR J13.....	22
SPECIFICATION.....	23
GENERAL	23
COUNTER/TIMER.....	23
DIGITAL I/O CIRCUITRY.....	23
INTERRUPT CONTROL.....	23
APPLICATION NOTES	24
QUADRATURE DECODER	24
LIMITED WARRANTY	25

Support Policy

General Support Policy.

We support all hardware products for a period of 3 months from time of delivery. See limited warranty terms.

Recommended sequence in obtaining customer support

Review user manuals for additional information not found in demo software.

Go to our website at www.apexembeddedsystems.com/support.html.

Contact us via email at help@apexembeddedsystems.com. Technical support related inquiry answered typically within a 24-hour period.

Need custom modifications?

Contact us for customization or modifications to our standard product. If you need large quantities we can generally save you money through optimizing card designs to meet your exact needs.

Welcome

Dear Valued Customer:

Thank you for your interest in our products and services.

Apex Embedded Systems "Continuous improvement" policy utilizes customer feedback to improve existing products and create new product offerings based on needs of our customers.

Continued Success,

Apex Embedded Systems

Benefits and Features

The TRACER-E is the toughest PC/104 module on the market today!

Executive Summary

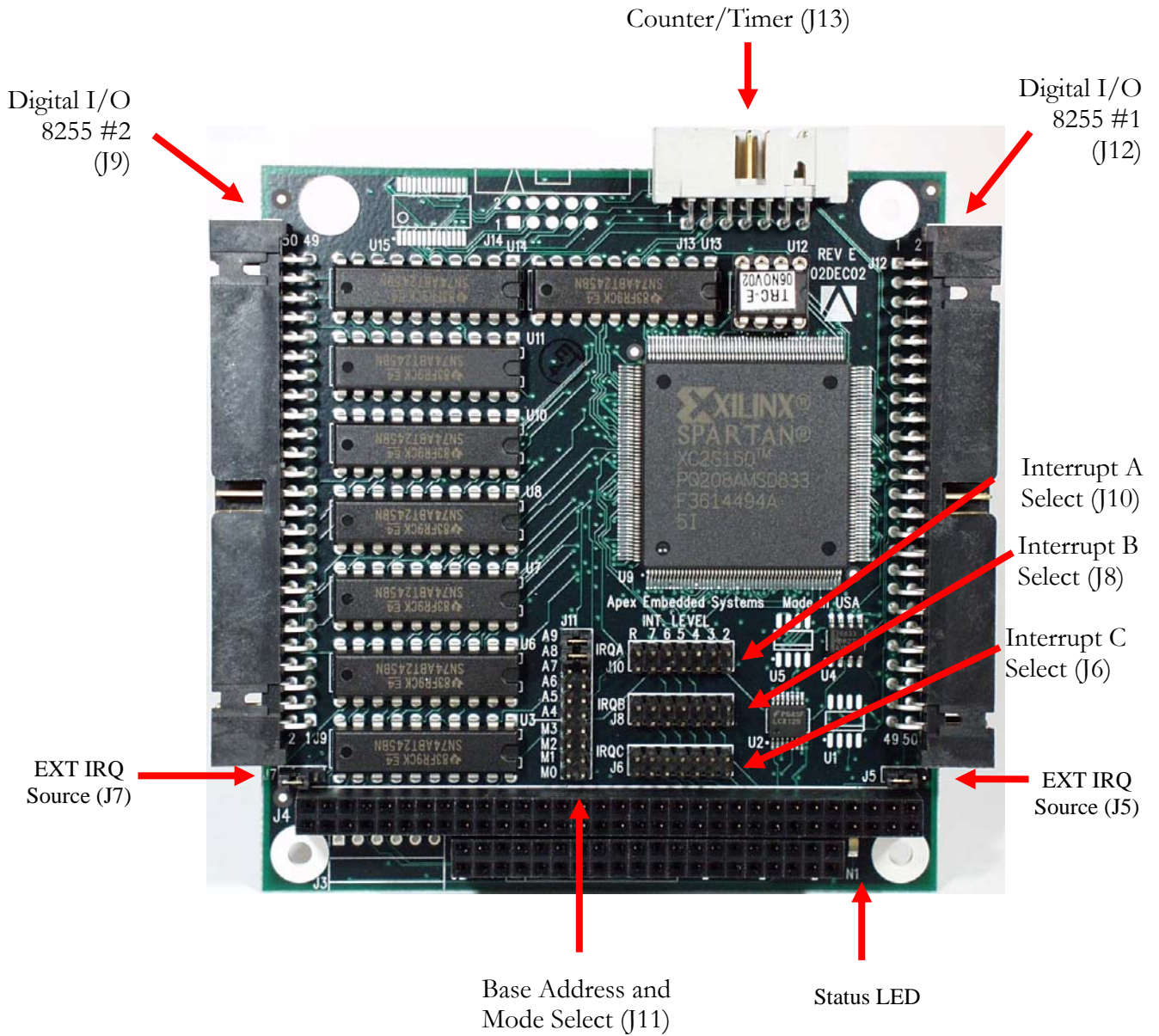
What is the TRACER-E? The TRACER-E is a high current PC/104 digital I/O and counter/timer module. It is designed for use in systems where high reliability is of utmost importance while operating in harsh environments. The board provides 48 lines of 8255 compatible GPIO and three 16-bit 8254 compatible counter/timers.

What are the Benefits to using the TRACER-E?

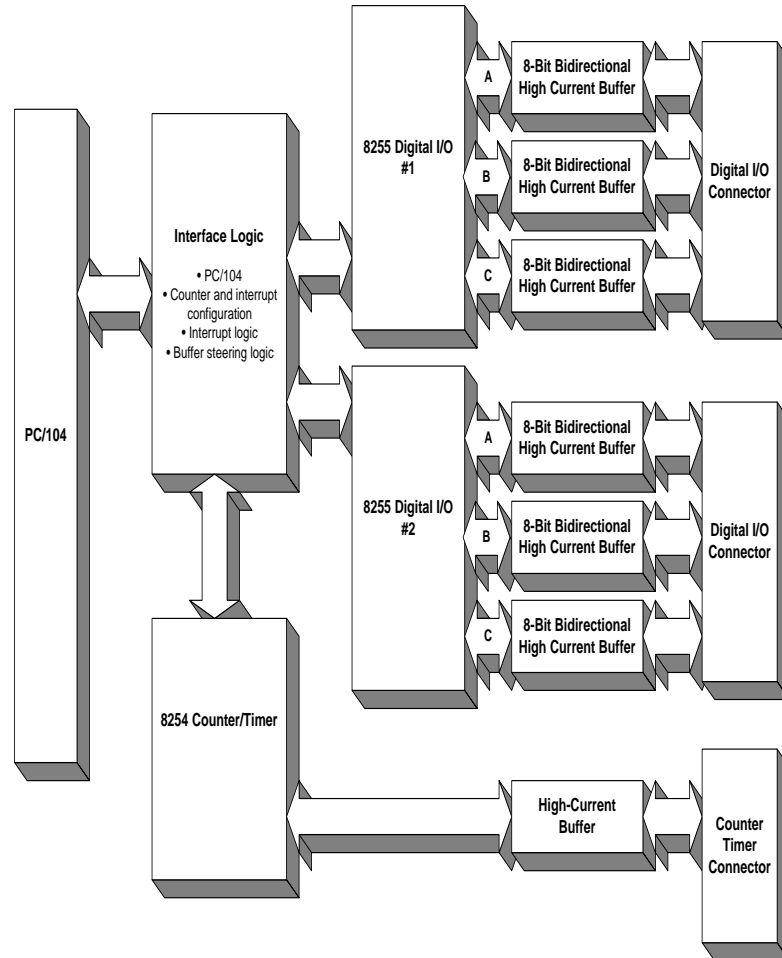
- Designed for operation in harsh environments. All components and materials used in our products are designed to operate in the extended temperature range, under high shock and vibration. The TRACER-E is designed to insure the greatest MTBF for mission critical applications.
- Operating Temperature from -40 to 85°C
- High-current outputs 64mA sink, 18mA source. This is true even while operating at high temperatures.
- Input currents +/-20uA. **Improved feature!**
- Lower quiescent power at just under 500mW. **Improved feature!**
- LED Status indicator. Useful in determining general status and in system debugging. A wide variety of signals can be routed to the LED via software selection.
- 8255 Software compatible interface structure. The hardware provides two 8255 compatible I/O ports that provide 48 lines of general purpose I/O.
- Digital I/O connectors organized to allow direct connection to OPTO-22's isolated I/O racks that use the standard G4 series of I/O modules from them, the PB16-H, PB16-J, PB16-K, PB16-L, PB8H and the PB24HQ.

- Polarized I/O Connectors.
- 8254 Software compatible counter/timers. Three 16-bit counter/timers are based on an 82C54. Counter/Timer operation to 40MHz.
- Broad selection of interrupt sources which are fully software configurable.
- Industry Standard Form Factor. Compliant to the PC/104 standard form factor ensuring consistent system packaging.
- No tantalum or electrolytic capacitors used in the design.
- Counter/Timer can be easily configured to support quadrature encoder signals.
- Long-Term Product Availability. Apex Embedded Systems is committed to delivering long life cycle products.
- FPGA customization available.
- Designed and manufactured in Wisconsin by Apex Embedded Systems. We will do whatever we can to assist you in designing in our products.
- Operating system drivers available: Linux, Windows XP, DOS. Please email us at customer.service@apexembeddedsystems.com for further information.
- MTBF: 600,000 hrs, ground benign, per MIL-HDBK-217F at 40°C.

Photo

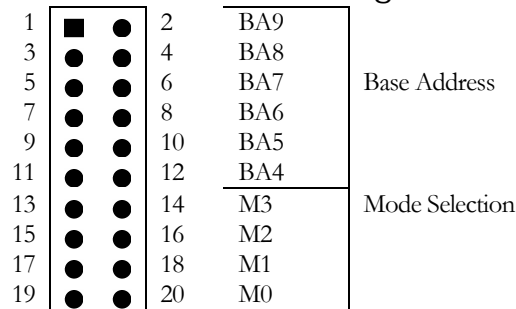


Tracer-E Block Diagram



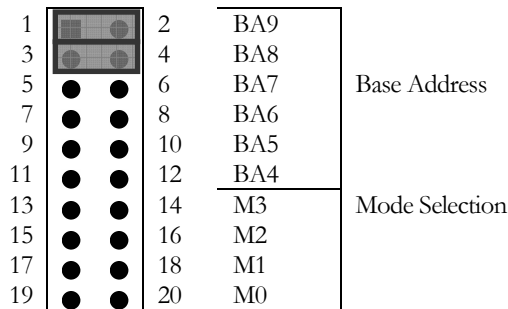
Hardware Configuration

Base Address and Configuration



Example Base Address

Base Address = 768 or 0x300 (11 0000 0000₂)



Mode	M3	M2	M1	M0
Normal, Legacy*	0	0	0	0

Note: 1 = Jumper installed, 0 = Jumper not installed.

* Factory Default

Base Address Table

Base Address	BA9	BA8	BA7	BA6	BA5	BA4
0x220	1	0	0	0	1	0
0x240	1	0	0	1	0	0
0x250	1	0	0	1	0	1
0x260	1	0	0	1	1	0
0x280	1	0	1	0	0	0
0x290	1	0	1	0	0	1
0x2A0	1	0	1	0	1	0
0x2B0	1	0	1	0	1	1
0x2C0	1	0	1	1	0	0
0x2D0	1	0	1	1	0	1
0x2E0	1	0	1	1	1	0
0x2F0	1	0	1	1	1	1
*0x300	1	1	0	0	0	0
0x310	1	1	0	0	0	1
0x320	1	1	0	0	1	0
0x330	1	1	0	0	1	1
0x340	1	1	0	1	0	0
0x350	1	1	0	1	0	1
0x360	1	1	0	1	1	0
0x370	1	1	0	1	1	1
0x380	1	1	1	0	0	0
0x390	1	1	1	0	0	1
0x3A0	1	1	1	0	1	0
0x3B0	1	1	1	0	1	1
0x3C0	1	1	1	1	0	0
0x3D0	1	1	1	1	0	1
0x3E0	1	1	1	1	1	0
0x3F0	1	1	1	1	1	1

Note: 1 = Jumper installed, 0 = Jumper not installed.

* Factory Default

Apex offers factory configured hard-coded jumper settings for high vibration requirements. Resistors are soldered to the board in place of jumpers to insure successful operation in high vibration conditions.

Register Set

Register Set Summary

Offset Address	Direction	Function
0	Read/Write	8255 Device #1 Port A Register
1	Read/Write	8255 Device #1 Port B Register
2	Read/Write	8255 Device #1 Port C Register
3	Write	8255 Device #1 Configuration Register
4	Read/Write	8255 Device #2 Port A Register
5	Read/Write	8255 Device #2 Port B Register
6	Read/Write	8255 Device #2 Port C Register
7	Write	8255 Device #2 Configuration Register
8	Read/Write	8254 Counter/Timer 0 Data
9	Read/Write	8254 Counter/Timer 1 Data
10	Read/Write	8254 Counter/Timer 2 Data
11	Write	8254 Counter/Timer Mode Configuration Register
12	Read/Write	8254 Counter/Timer Input Setup Low Byte Register
13	Read/Write	8254 Counter/Timer Input Setup High Byte Register
14	Read/Write	General Setup Low Byte Register
15	Read/Write	General Setup High Byte Register

8255 Device #1
Registers

Detailed register information for 8255 device #1. Both bit names and associated connector placement are shown where applicable (i.e. ref. pin #).

Base + 0							8255 Device #1 Port A Register		Read/Write
D7	D6	D5	D4	D3	D2	D1	D0		
1A7	1A6	1A5	1A4	1A3	1A2	1A1	1A0		
Associated Connector Pins:									
J12.1	J12.3	J12.5	J12.7	J12.9	J12.11	J12.13	J12.15		

Base + 1							8255 Device #1 Port B Register		Read/Write
D7	D6	D5	D4	D3	D2	D1	D0		
1B7	1B6	1B5	1B4	1B3	1B2	1B1	1B0		
Associated Connector Pins:									
J12.33	J12.35	J12.37	J12.39	J12.41	J12.43	J12.45	J12.47		

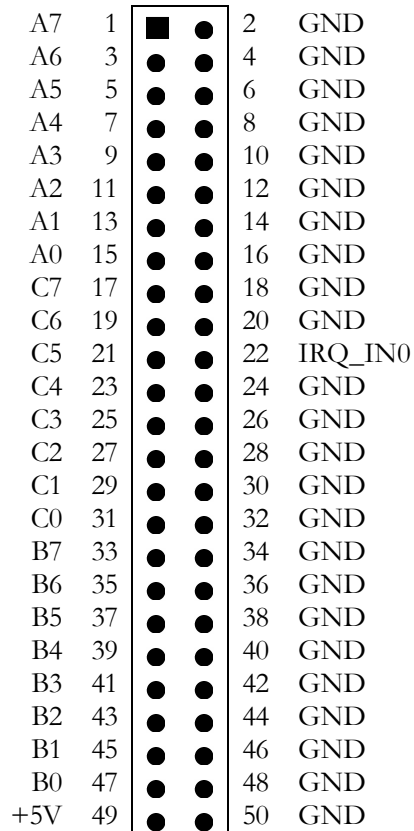
Base + 2							8255 Device #1 Port C Register		Read/Write
D7	D6	D5	D4	D3	D2	D1	D0		
1C7	1C6	1C5	1C4	1C3	1C2	1C1	1C0		
Associated Connector Pins:									
J12.17	J12.19	J12.21	J12.23	J12.25	J12.27	J12.29	J12.31		

Base + 3							8255 Device #1 Configuration Register		Write
D7	D6	D5	D4	D3	D2	D1	D0		
Mode Set	Group A				Group B				
	M3	M2	A	CU	M1	B	CL		

8255 Configuration codes valid for the Tracer. Only Mode 0 is supported.

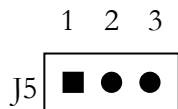
Port Direction					Hex Value	Decimal Value
A	CH	CL	B			
IN	IN	IN	IN		0x9B	155
IN	IN	IN	OUT		0x99	153
IN	OUT	OUT	IN		0x92	146
IN	OUT	OUT	OUT		0x90	144
OUT	IN	IN	IN		0x8B	139
OUT	IN	IN	OUT		0x89	137
OUT	OUT	OUT	IN		0x82	130
OUT	OUT	OUT	OUT		0x80	128

Digital I/O Connector J12, 8255 #1.



J12

External IRQ Source 0 (IRQ_IN0) J5



Jumper Position	Function
1-2*	External Interrupt source 0 input at J12 pin 22 (J12.22)
2-3	J12 pin 22 grounded (for OPTO 22 rack compatibility) External Interrupt Source 0 not available.

* FACTORY CONFIGURATION

8255 Device #2
Registers

Detailed register information for 8255 device #2. Both bit names and associated connector placement are shown where applicable (i.e. ref. pin#).

Base + 4							8255 Device #2 Port A Register		Read/Write
D7	D6	D5	D4	D3	D2	D1	D0		
2A7	2A6	2A5	2A4	2A3	2A2	2A1	2A0		
Associated Connector Pins:									
J9.1	J9.3	J9.5	J9.7	J9.9	J9.11	J9.13	J9.15		

Base + 5							8255 Device #2 Port B Register		Read/Write
D7	D6	D5	D4	D3	D2	D1	D0		
2B7	2B6	2B5	2B4	2B3	2B2	2B1	2B0		
Associated Connector Pins:									
J9.33	J9.35	J9.37	J9.39	J9.41	J9.43	J9.45	J9.47		

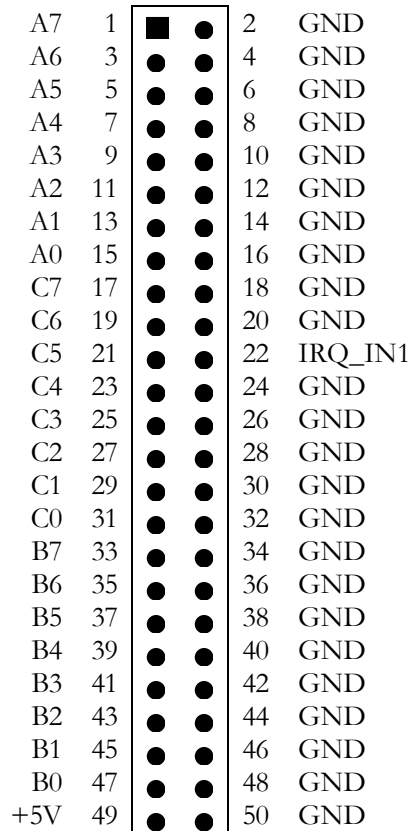
Base + 6							8255 Device #2 Port C Register		Read/Write
D7	D6	D5	D4	D3	D2	D1	D0		
2C7	2C6	2C5	2C4	2C3	2C2	2C1	2C0		
Associated Connector Pins:									
J9.17	J9.19	J9.21	J9.23	J9.25	J9.27	J9.29	J9.31		

Base + 7							8255 Device #2 Configuration Register		Write
D7	D6	D5	D4	D3	D2	D1	D0		
Mode Set	Group A				Group B				
	M3	M2	A	CU	M1	B	CL		

8255 Configuration codes valid for the Tracer. Only Mode 0 is supported.

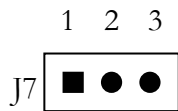
Port Direction				Hex Value	Decimal Value
A	CH	CL	B		
IN	IN	IN	IN	0x9B	155
IN	IN	IN	OUT	0x99	153
IN	OUT	OUT	IN	0x92	146
IN	OUT	OUT	OUT	0x90	144
OUT	IN	IN	IN	0x8B	139
OUT	IN	IN	OUT	0x89	137
OUT	OUT	OUT	IN	0x82	130
OUT	OUT	OUT	OUT	0x80	128

Digital I/O Connector J9, 8255 #2.



J9

External IRQ Source 1 (IRQ_IN1) J7



Jumper Position	Function
1-2*	External Interrupt source 1 input at J9 pin 22 (J9.22)
2-3	J9 pin 22 grounded (for OPTO 22 rack compatibility) External Interrupt Source 1 not available.

* FACTORY CONFIGURATION

- Blank -

8254
Counter/Timer
Registers

Data registers to/from the each of the three counter/timers.

Base + 8		8254 Counter/Timer 0 Data					Read/Write	
D7	D6	D5	D4	D3	D2	D1	D0	
D7	D7	D5	D4	D3	D2	D1	D0	

Base + 9		8254 Counter/Timer 1 Data					Read/Write	
D7	D6	D5	D4	D3	D2	D1	D0	
D7	D7	D5	D4	D3	D2	D1	D0	

Base + 10		8254 Counter/Timer 2 Data					Read/Write	
D7	D6	D5	D4	D3	D2	D1	D0	
D7	D7	D5	D4	D3	D2	D1	D0	

Counter/Timer configuration register.

Base + 11		8254 Counter/Timer Mode Configuration Register					Write	
D7	D6	D5	D4	D3	D2	D1	D0	
SC1	SC0	RW1	RW0	M2	M1	M0	BCD	

BCD = Binary Coded Decimal (BCD) Counter (4 decades) if set to one, otherwise 16-bit binary counter.

M[2:0] = Counter/Timer Mode Select:
 000 = Mode 0, Interrupt on terminal count
 001 = Mode 1, Hardware retriggerable one-shot
 X10 = Mode 2, Rate generator
 X11 = Mode 3, Square wave generator
 100 = Mode 4, Software triggered strobe
 101 = Mode 5, Hardware triggered strobe (retriggerable)

RW[1:0] = Read/Write:
 00 = Counter latch command
 01 = Read/Write least significant byte only
 10 = Read/Write most significant byte only
 11 = Read/Write least significant byte first, then most significant byte.

SC[1:0] = Select Counter:
 00 = Select Counter 0
 01 = Select Counter 1
 10 = Select Counter 2
 11 = Read-Back Command (see read operations)

Counter/Timer
Setup Register

The counter/timer setup register is used to route the desired signals to the counter/timer clock inputs. In addition, the polarity of the gate inputs can be selected as well.

Base + 12 8254 Counter/Timer input Setup Low Byte Register							Read/Write
D7	D6	D5	D4	D3	D2	D1	D0
CLK1_INV	CLK12	CLK11	CLK10	CLK0_INV	CLK02	CLK01	CLK00

Base + 13 8254 Counter/Timer input Setup High Byte Register							Read/Write
D7	D6	D5	D4	D3	D2	D1	D0
GT0	GT2_INV	GT1_INV	GT0_INV	CLK2_INV	CLK22	CLK21	CLK20

GT2_INV = Counter #2 gate input polarity:
0 = clock input non-inverted (default)
1 = clock input inverted

CLK2_INV = Counter #2 clock input polarity:
0 = clock input non-inverted (default)
1 = clock input inverted

CLK2[2:0] = Counter #2 clock input selection:
000 = CT_IN2 (default)
001 = CT_OUT0
010 = CT_OUT1
011 = IRQ_IN2
100 = 4 MHz oscillator
101 = 10 MHz oscillator
110 = 20 MHz oscillator
111 = 40 MHz oscillator

GT1_INV = Counter #1 gate input polarity:
0 = clock input non-inverted (default)
1 = clock input inverted

CLK1_INV = Counter #1 clock input polarity:
0 = clock input non-inverted (default)
1 = clock input inverted

CLK1[2:0] = Counter #1 clock input selection:
000 = CT_IN1 (default)
001 = CT_OUT0

010 = CT_OUT2
 011 = IRQ_IN2
 100 = 4 MHz oscillator
 101 = 10 MHz oscillator
 110 = 20 MHz oscillator
 111 = 40 MHz oscillator

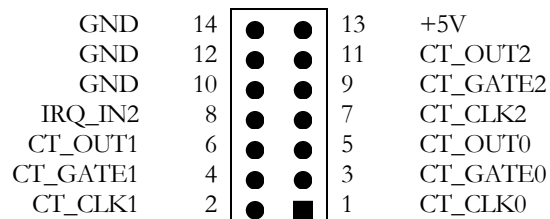
GT0_INV = Counter #0 gate input polarity:
 0 = clock input non-inverted (default)
 1 = clock input inverted

GT0 = Counter #0 gate input selection:
 0 = CT_GATE0 (default)
 1 = CT_GATE1

CLK0_INV = Counter #0 clock input polarity:
 0 = clock input non-inverted (default)
 1 = clock input inverted

CLK0[2:0] = Counter #0 clock input selection:
 000 = CT_IN0 (default)
 001 = CT_IN1
 010 = CT_OUT2
 011 = IRQ_IN2
 100 = 4 MHz oscillator
 101 = 10 MHz oscillator
 110 = 20 MHz oscillator
 111 = 40 MHz oscillator

Counter/Timer connector J13:



General Configuration Register

The general configuration register is used to route the signals to the appropriate interrupt (IRQ) output. In addition, the LED signal routing is selected.

Base + 14							General Setup Low Byte Register		Read/Write
D7	D6	D5	D4	D3	D2	D1	D0		
IEB	ISB2	ISB1	ISB0	IEA	ISA2	ISA1	ISA0		

Base + 15							General Setup High Byte Register		Read/Write
D7	D6	D5	D4	D3	D2	D1	D0		
LED3	LED2	LED1	LED0	IEC	ISC2	ISC1	ISC0		

IEA = Interrupt source A enable

IEB = Interrupt source B enable

IEC = Interrupt source C enable

ISA[2:0] = Interrupt source A (selected IRQ driven at J10):

<u>Signal Name</u>	<u>Location</u>	
000 = CT_OUT0	(J13.5)	(default)
001 = CT_OUT1	(J13.6)	
010 = CT_OUT2	(J13.11)	
011 = IRQ_IN0	(J12.22)	
100 = IRQ_IN1	(J9.22)	
101 = IRQ_IN2	(J13.8)	
110 = 8255 #1 Bit C0	(J12.31)	
111 = 8255 #2 Bit C0	(J9.31)	

ISB[2:0] = Interrupt source B (selected IRQ driven at J8):

<u>Signal Name</u>	<u>Location</u>	
000 = CT_OUT0	(J13.5)	(default)
001 = CT_OUT1	(J13.6)	
010 = CT_OUT2	(J13.11)	
011 = IRQ_IN0	(J12.22)	
100 = IRQ_IN1	(J9.22)	
101 = IRQ_IN2	(J13.8)	
110 = 8255 #1 Bit C0	(J12.31)	
111 = 8255 #2 Bit C0	(J9.31)	

ISC[2:0] = Interrupt source C (selected IRQ driven at J6):

<u>Signal Name</u>	<u>Location</u>	
000 = CT_OUT0	(J13.5)	(default)
001 = CT_OUT1	(J13.6)	
010 = CT_OUT2	(J13.11)	

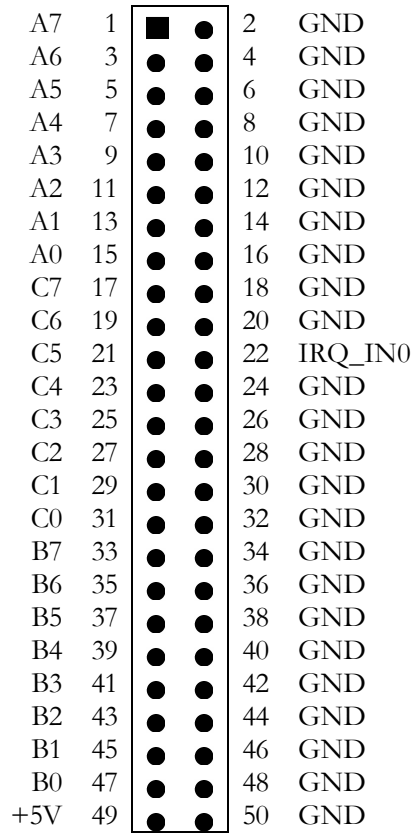
011 = IRQ_IN0 (J12.22)
100 = IRQ_IN1 (J9.22)
101 = IRQ_IN2 (J13.8)
110 = 8255 #1 Bit C0 (J12.31)
111 = 8255 #2 Bit C0 (J9.31)

LED[3:0] = LED drive source.
0000 = base address decode (default) *
0001 = Counter/Timer 0 Input (CI0)
0010 = Counter/Timer 1 Input (CI1)
0011 = Counter/Timer 2 Input (CI2)
0100 = Counter/Timer 0 Output
0101 = Counter/Timer 1 Output
0110 = Counter/Timer 2 Output
0111 = Interrupt Source A (ISA) *
1000 = IRQ_IN0
1001 = IRQ_IN1
1010 = IRQ_IN2
1011 = none
1100 = Interrupt Source B (ISB) *
1101 = Interrupt Source C (ISC) *
1110 = LED off always
1111 = LED on always

* LED minimum pulse size is approximately 0.016 seconds

Connector Summary

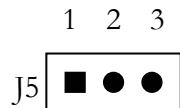
Digital I/O Connector J12, 8255 #1.



Note: # implies active low

J12

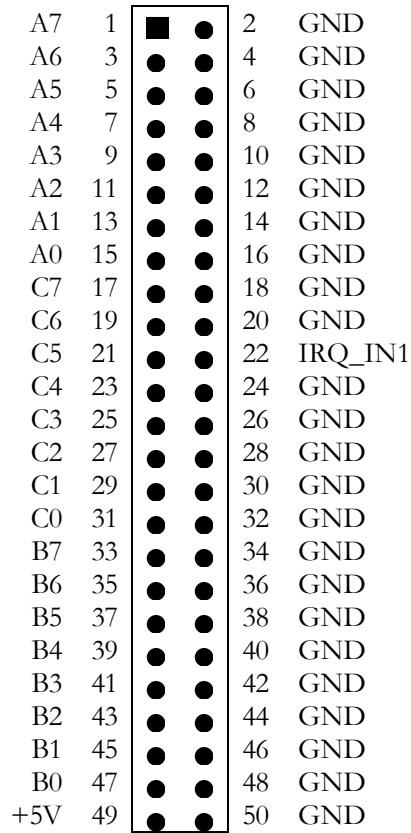
External IRQ Source 0 (IRQ_IN0) J5



Jumper Position	Function
1-2*	External Interrupt source 0 input at J12 pin 22 (J12.22)
2-3	J12 pin 22 grounded (for OPTO 22 rack compatibility) External Interrupt Source 0 not available.

* FACTORY CONFIGURATION

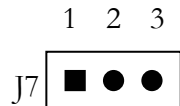
Digital I/O Connector J9, 8255 #2.



Note: # implies active low

J9

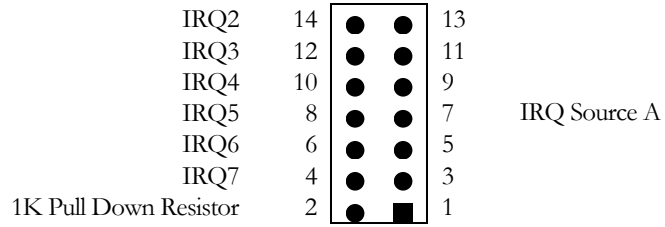
External IRQ Source 1 (IRQ_IN1) J7



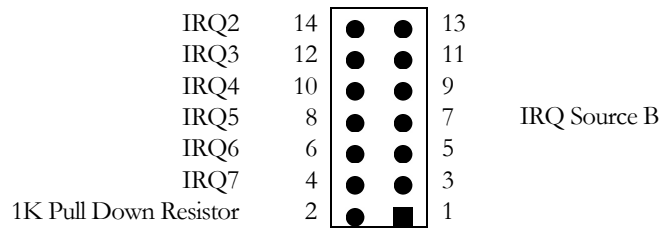
Jumper Position	Function
1-2*	External Interrupt source 1 input at J9 pin 22 (J9.22)
2-3	J9 pin 22 grounded (for OPTO 22 rack compatibility) External Interrupt Source 1 not available.

* FACTORY CONFIGURATION

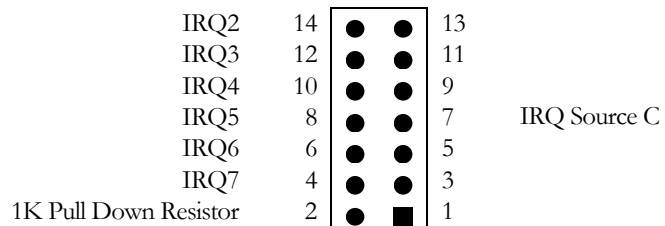
PC/104 IRQ Source A Connector J10



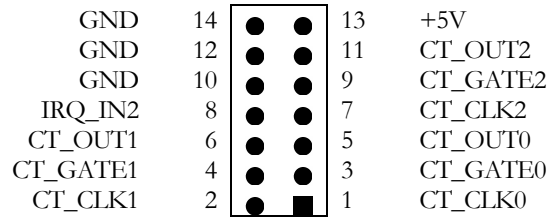
PC/104 IRQ Source B Connector J8



PC/104 IRQ Source C Connector J6



Counter/Timer Connector J13



Signal Direction

Name	Direction
CT_CLK0	Input to Tracer Board
CT_GATE0	Input to Tracer Board
CT_OUT0	Output from Tracer Board
CT_CLK1	Input to Tracer Board
CT_GATE1	Input to Tracer Board
CT_OUT1	Output from Tracer Board
CT_CLK2	Input to Tracer Board
CT_GATE2	Input to Tracer Board
CT_OUT2	Output from Tracer Board
IRQ_IN2	Additional interrupt input

Specification

General	Dimension Power Supply <i>Improved!</i> Card Type Temperature Range MTBF	PC/104 form factor 5.0 VDC \pm 10%, 100mA quiescent no-load PC/104 8-bit bus -40°C to +85°C operating -55°C to +125°C storage 600,000 hrs ground benign per MIL-HDBK-217F @ 40°C
Counter/Timer	Functionality Counter/Timers Maximum input frequency On-board oscillator Input Voltage, all inputs: Low High Current <i>Improved!</i> Output Voltage, all outputs: Low High Pull up/down resistors	Compliant to the 82C54-2 Quantity of 3, each 16-bits 40 MHz 40 MHz \pm 0.01% (100ppm) divided down to 4, 10, 20MHz TTL compatible 0V min, 0.8V max 2.0V min, 5.5V max +/- 20uA TTL compatible 0.55V max @ 64mA 2.5 V min @ -18mA 10K on all inputs and jumper selectable
Digital I/O Circuitry	Functionality Number of digital I/O lines Direction Input Voltage, all inputs: Low High Current <i>Improved!</i> Output Voltage, all outputs: Low High Pull up resistors	82C55A, quantity of two 48 All lines programmable for input or output in groups of eight TTL compatible 0V min, 0.8V max 2.0V min, 5.5V max +/- 20uA TTL compatible 0.55V max @ 64mA 2.5 V min @ -18mA 10K on all digital I/O
Interrupt Control	Number of System Interrupts Selectable interrupt levels Pull-down resistor	3 IRQ2,IRQ3,IRQ4,IRQ5,IRQ6,IRQ7 1K resistor selectable via jumper on each interrupt

Application Notes

Quadrature Decoder

Connecting a quadrature output incremental optical shaft encoder to the counter/timer input.

Wiring:	Phase A	CT_GATE1	J13.4
	Phase B	CT_CLK1	J13.2
	Common	GND	J13.14
	Power	+5V	J13.15

Counter/Timer Setup Register:

CT_GATE1 inverted	=	True
CT_CLK1 inverted	=	False
CT_CLK1 source	=	CT_IN1
CT_GATE0 inverted	=	True
CT_GATE0 source	=	CT_GATE1
CT_CLK0 inverted	=	True
CT_CLK0 source	=	CT_IN1

Base_Address + 12 <= 0000 1001

Base_Address + 13 <= 1?01 1???

where '?' is the configuration for Counter/Timer #2.

Software setup:

```
base_address = 0x300;
```

```
Counter/Timer Setup Register = 0x0000
CT0: Clock: Inverted=False, Source=CT_IN0
     Gate: Inverter=False, Source=CT_GATE1
CT1: Clock: Inverted=False, Source=CT_IN1
     Gate: Inverter=False, Source=CT_GATE1
CT2: Clock: Inverted=False, Source=CT_IN2
     Gate: Inverter=False, Source=CT_GATE2
```



Limited Warranty

Unless altered by written agreement, APEX EMBEDDED SYSTEMS (APEX) warrants to the original purchaser for a period of one year from the date of original purchase, that the products shall be free from defects in material and workmanship. APEX's obligation under this warranty is limited to replacing or repairing, at its option and its designated site, any products (except consumables) within the warranty period that are returned to APEX in the original shipping container(s) with an APEX RMA number referenced on the shipping documents.

This warranty will not apply to products that have been misused, abused, or altered. This warranty will not apply to prototypes of any kind, engineering services, software or products under pre-release status. Any returns must be supported by a Return Material Authorization (RMA) number issued by APEX. APEX reserves the right to refuse delivery of any shipment containing any shipping carton which does not have an RMA number displayed on the outside. Purchaser shall prepay transportation to APEX's location. If returned parts or products are repaired under the terms of this warranty, APEX will pay return transportation charges. Allow six (6) to eight (8) weeks for warranty repairs.

THE FOREGOING WARRANTY IS IN LIEU OF ALL WARRANTIES, EITHER EXPRESSED OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR THE PARTICULAR PURPOSE, AND OF ANY OTHER OBLIGATION ON THE PART OF APEX.

Warranty return address:

Apex Embedded Systems
Attn: Customer Service. RMA# _____
116 Owen Road
Monona, WI 53716