RTCIO

TTL, A/D, D/A & Clock
I/O Expansion
for the RTC Series
Microcontrollers

Technical Manual

Release 1.1
5/15/89

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REV. 1/89

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REAL-TIME CONTROLLER SERIES

The Real-Time Controller series system measures only 3.5 inches square and uses vertical-stacking connectors for I/O expansion. The RTC processor board contains the processor, EPROM and RAM memory, address decoding, buffering, parallel I/O with screw terminals, and an RS-232/RS-485 serial port. System expansion is through a pair of vertical-stacking headers, which eliminates the need for an expensive backplane.

The RTCIO board, the first in a series of I/O boards for the RTC series microcontrollers, contains three parallel TTL I/O ports and an 8-channel 8-bit A/D. Optional upgrades add a 4-channel 8-bit D/A, a battery-backed Real-Time Clock, and a DC-to-DC converter which allows complete 5-volt-only system operation.

A stacked-board arrangement has certain benefits besides eliminating costly gold-contact backplanes (motherboards). It allows configuration of either a basic system for experimentation or an expanded system for black-box applications yet still retains its low profile. Each vertically stacked board only increases the height by 5/8 inch. Additional cost can be saved by populating only the I/O necessary for the application.

VERTICAL-STACKING I/O EXPANSION

The vertical-stacking connectors pass all the necessary I/O control, address, and data signals to each expansion board added to the system. The buffered address/data bus (AD0-AD7), the latched address bus (A0-A7), and the upper four decoded address blocks (8000H, A000H, C000H & E000H) are grouped together. Control lines are bundled separately on a second vertical connector. These two connectors alone provide adequate mechanical stability for the stacking arrangement, but corner mounting holes are provided for #4 x 9/16" spacers.

JP16

	26	25	
Buffered D4			Buffered A3
Buffered D5			Buffered A2
Buffered D6			Buffered A1
Buffered D7			Buffered D0
+5 volts			+5 volts
Latched A4			Latched A3
Latched A5			Latched A2
Latched A6			Latched A1
Latched A7			Latched A0
+5 volts			+5 volts
0C000H			0A000H
0E000H			8000H
+12 volts			*GET
	2	1	

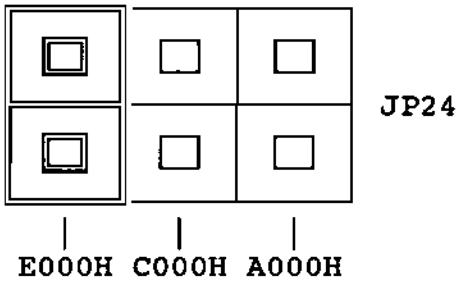
JP15

	26	25	
-12 volts			GND
ALE			GND
*DS			GND
*WR			GND
*RD			GND
*PSEN			GND
T1			*INT1
T0			*INT0
RESET			GND
P1.4			P1.3
P1.5			P1.2
P1.6			P1.1
P1.7			P1.0
	2	1	

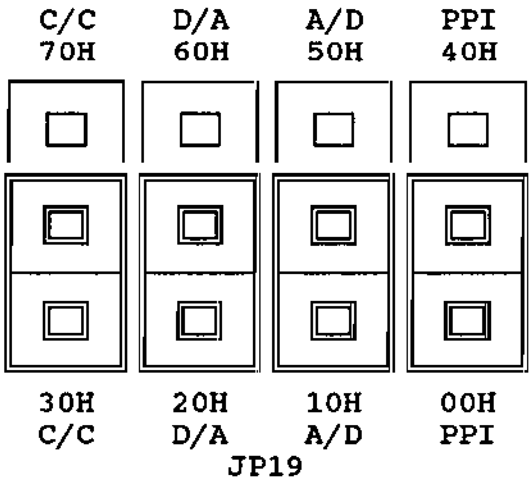
JP16 and JP15 bring the expansion bus up to I/O boards which mate atop the RTC series microcontrollers

SELECTING THE I/O ADDRESS SPACE

The RTC processor board decodes the address space into 8k blocks. The top three blocks (A000H-BFFFH, C000H-DFFFH, and E000H-FFFFH) are available for base address selection. U1, a 74HCT138 3-to-8 decoder, divides the selected base plus BAD7 intoo eight separate chip selects (xx0x-xx7x).



JP24 shows the LEFT jumper selecting the base address E000H



JP19 shows both jumpers down selecting:

```
JP24  E000H + 00H = E000H for the PPI
JP24  E000H + 10H = E010H for the A/D
JP24  E000H + 20H = E020H for the D/A
JP24  E000H + 30H = E030H for the C/C
```

The combination of these two jumpers (JP19 & JP24) makes it possible to address up to two of the RTCIO boards within the same 8K block of E000H. These default addresses (as shown above) will be adequate for most applications and the addresses used (in the examples) for the remainder of this manual.

TTL I/O

The 8255 programmable peripheral interface (PPI) is an efficient and cost-effective way to add TTL (logic level) I/O to any microcontroller system. The PPI adds 24 bits of I/O to the RTC system. The 24 bits are grouped into three 8-bit ports. Ports A & B can be independently programmed as 8-bit input or output ports. The third port, port C, is divided into two 4-bit nibbles (an upper and lower nibble). These nibbles can be programmed independently as 4-bit input or output ports.

The three ports are memory mapped. Referring to JP19 and JP24 we find the base + offset address of the PPI to be E000H + 00H (E000H). Starting with this address, the ports are addressed as follows:

8255 Port	**JP19 & JP24 address + 8255 offset address = actual address**
Port A	E000H + 00H = E000H
Port B	E000H + 01H = E001H
Port C	E000H + 02H = E002H
Mode Port	E000H + 03H = E003H

The mode port is a write-only port used to set the PPI for the appropriate configuration. Let's assume we need 12 input bits and 12 output bits. Port A and the upper nibble of port C as inputs and port B and the lower nibble of port C as outputs. Writing a value of 98H to the mode port (E003H) configures the ports. Verify this value in the following chart:

PPI configuration values

Port A	Port C (upper) (nibble)	Port B	Port C (lower) (nibble)	Value
output	output	output	output	80H
output	output	output	input	81H
output	output	input	output	82H
output	output	input	input	83H
output	input	output	output	88H
output	input	output	input	89H
output	input	input	output	8AH
output	input	input	input	8BH
input	output	output	output	80H
input	output	output	input	91H
input	output	input	output	92H
input	output	input	input	93H
input	**input**	**output**	**output**	**98H**
input	input	output	input	99H
input	input	input	output	9AH
input	input	input	input	9BH

Once the PPI is configured the appropriate ports (A, B & C) can be read from and written to. In this example, reading port A (E000H) will return a value equal to the logic levels applied to the port A pins on JP17. Reading port C (E002H) will return a value equal to the logic levels applied to the upper nibble port C pins on JP17. The value returned for the upper nibble of port C will contain erroneous data in the lower nibble and must be discarded. ANDing the value read with 'F0H' will clear the lower nibble to zero.

Writing 'FFH' to port B (E001H) will set the corresponding bit pins on JP17 to a logic '1'. Writing '00H' to port C (E002H) will clear the corresponding bit pins on JP17 to a logic '0'. In this case the upper nibble is not used and could be any value.

Upon power-up or manual reset, the PPI is configured with all three ports (A, B, & C) as inputs. Once reconfigured, if necessary, for your application, care must be taken not to change the mode. The values at each port will be lost when the mode is changed.

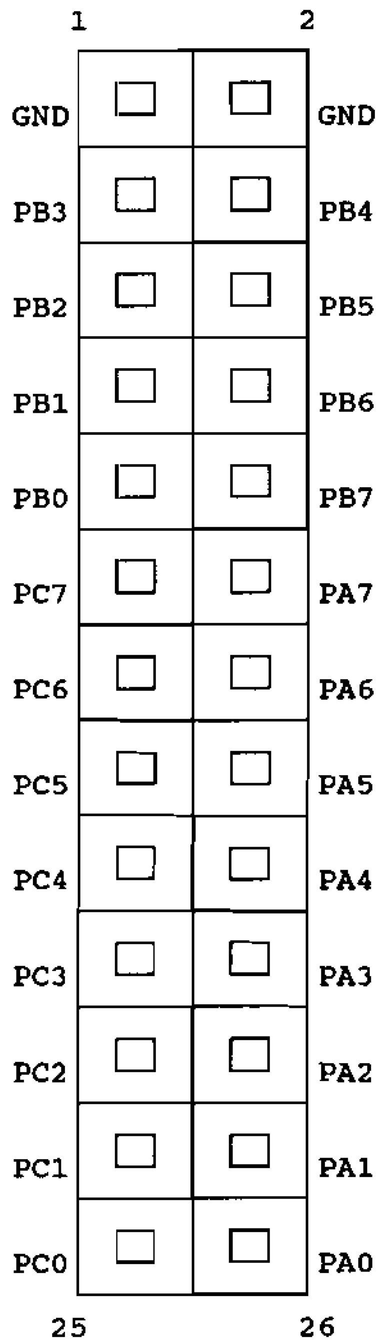
The 8255's port pins are brought out to connector JP17. JP17 is normally populated with a 2 x 13 right-angle square-pin header. These port pins can be brought directly up to the RTC-PROTO (prototyping) board by replacing the right-angle connector with a 2 x 13 straight pin header. This will simplify the wiring when DIP relays or opto-isolators are needed on the TTL I/O lines.

The following program, written for the RTC52, will allow easy configuration of the I/O ports and testing of your TTL I/O pins on JP17.

```
10      STRING 33,7
20     $(0)="OUTPUT" : $(1)="INPUT" : $(2)="WRITE" : $(3)="READ"
30     A=1 : B=1 : C=1
40     M=9BH : P=0E000H
50     PRINT
60     PRINT "Hit MENU Selection #"
70     PRINT "1 - Set Port A from ",$(A)," to ",$(ABS(A-1))
80     PRINT "2 - ",$(A+2)," PORT A"
90     PRINT "3 - Set Port B from ",$(B)," to ",$(ABS(B-1))
100     PRINT "4 - ",$(B+2)," PORT B"
110     PRINT "5 - Set Port C from ",$(C)," to ",$(ABS(C-1))
120     PRINT "6 - ",$(C+2)," PORT C"
130     PRINT "7 - END"
140   G=GET
150   G=GET
160    IF G=0 THEN 150
170   G=G-30H
180    IF ((G<1).OR.(G>7)) THEN 150
190    IF G=7 THEN  END
200    ON G-1 GOTO 1000,4000,2000,5000,3000,6000
```

```
999 REM ************************* Adjust Mode Port Value for Port A
1000    IF A=1 THEN 1050
1010   A=1
1020   M=M.OR.10H
1030    GOSUB 7000
1040    GOTO 50
1050   A=0
1060   M=M.AND.8FH
1070    GOSUB 7000
1080    GOTO 50
1999 REM ************************* Adjust Mode Port Value for Port B
2000    IF B=1 THEN 2050
2010   B=1
2020   M=M.OR.02H
2030    GOSUB 7000
2040    GOTO 50
2050   B=0
2060   M=M.AND.0FDH
2070    GOSUB 7000
2080    GOTO 50
2999 REM ************************* Adjust Mode Port Value for Port C
3000    IF C=1 THEN 3050
3010   C=1
3020   M=M.OR.09H
3030    GOSUB 7000
3040    GOTO 50
3050   C=0
3060   M=M.AND.0F6H
3070    GOSUB 7000
3080    GOTO 50
3999 REM ************************* Read/Write Port A
4000    IF A=1 THEN 4040
4010    INPUT "Enter Value"V
4020   XBY(P)=V
4030    GOTO 50
4040    PHO. XBY(P)
4050    GOTO 50
4999 REM ************************* Read/Write Port B
5000    IF B=1 THEN 5040
5010    INPUT "Enter Value"V
5020   XBY(P+1)=V
5030    GOTO 50
5040    PHO. XBY(P+1)
5050    GOTO 50
5999 REM ************************* Read/Write Port C
6000    IF C=1 THEN 6040
6010    INPUT "Enter Value"V
6020   XBY(P+2)=V
6030    GOTO 50
6040    PHO. XBY(P+2)
6050    GOTO 50
6999 REM ************************* Write Mode Port Value
7000  XBY(P+3)=M
7010   RETURN
```

Connector JP17 - PPI Port Pin Designation



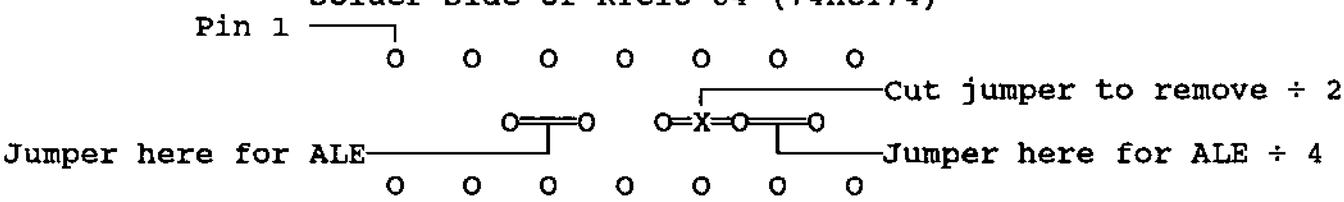
A/D INPUT

Control of a function often requires knowing more than whether it is off (logic 0) or it is on (logic 1). The ADC0808 A-to-D converter will provide this knowledge for eight separate input channels. The A/D requires only 5 volts for operation, although the 5.0-volt reference for the converter is regulated from +12V. The +12 volts must be provided by the user or by the optional on-board DC-to-DC converter. Trim-pot1 adjusts the 5.0-volt reference. The voltage range for all eight inputs is 0V-Vref (5.0V). Vref divided by the resolution of the A/D (8 bits, 255 steps) equals 19.6 millivolts/step.

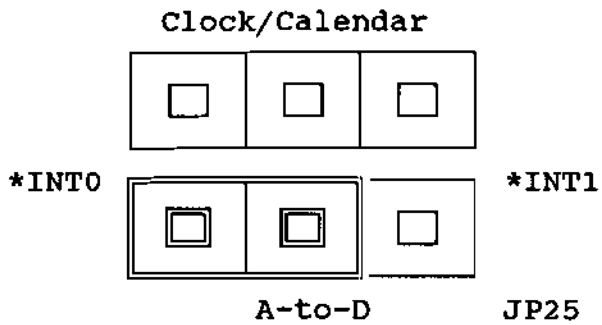
NOTE: the A/D section requires +5V and +12V or +5V and the DC/DC option

The ALE line on the expansion bus is used to drive the clock input of the ADC0808. For example, on the RTC31/52 with an 11.0592-MHz crystal, the ALE line clocks at 1.8432 MHz. This exceeds the maximum input clock frequency of 1.28 MHz for the ADC0808. The RTCIO board provides a 74HCT74 (U4) used as a divide-by-two and -four. The divide-by-two output (921.6 kHz) is hard wired as clock input for the ADC0808. ALE and ALE divided by four are available for other RTC series microcontrollers to adjust maximum clock speed. This adjustment is accomplished by breaking the present connection and soldering a piece of wire appropriately as shown below:

Solder Side of RTCIO U4 (74HCT74)



The stock RTCIO using the default ALE divided by two, clocks the ADC0808 at 921.6 kHz. A conversion time of about 80 microseconds. End-of-conversion (EOC) is recognized in one of three ways. First, if using interpreted BASIC, the time it takes the system to start conversion and read back the results exceeds the EOC time, therefore EOC can be disregarded. Second, if using a compiled BASIC or machine language, a software loop of sufficient length can be inserted between the start of conversion and the read back to ensure the conversion is completed. Third, *INT0 or *INT1 can be used (JP25) to signal the RTC microcontroller of EOC. This produces the fastest response time. The EOC signal is inverted by Q2 and supplies a BUSY falling edge indicating an EOC.



JP25 shows *INT0 using the EOC signal (BUSY) as an interrupt source

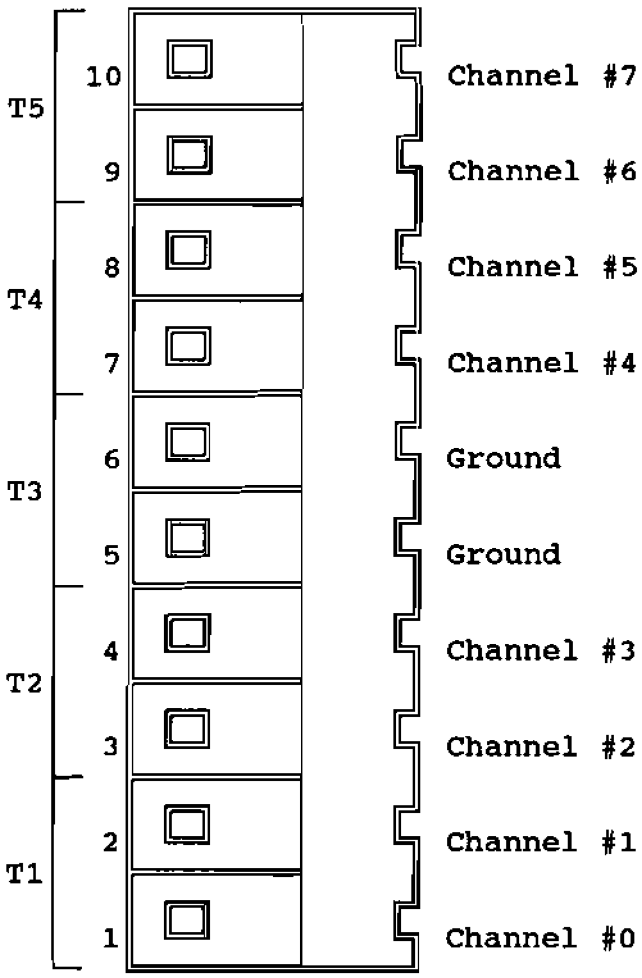
The base + offset address for the A/D as choosen earlier is E000H + 10H (E010H). The ADC0808 has eight input channels. The lower three latched address lines A0-A2 act as channel selects giving channels 0-7 the memory-mapped addresses of E010H + channel number (E010H-E017H).

The conversion is started by doing a dummy write to the address of the channel to convert. Writing 'xx' to address E013H starts a conversion for channel #3.

After EOC the converted value is read from any address within the E010H-E01FH range. Reading the value at address E010H will return the conversion value of the channel selected with the start of conversion command. To reduce confusion, it's a good idea to write to and read from the same address even though the read address can be any of the A/D's legal addresses.

Connections to the channel #0-7 inputs are made to the RTCIO board at T1-T5. Optional screw-terminal blocks make connections easily removable. Two connections, between channels #3 and #4, are at ground potential (-Vref).

NOTE: Exceeding 5V at any A/D input may permanently damage the ADC0808



Connections for A/D inputs channels #0-7 & Ground

The following program written for the RTC52 shows how easily the A/D is used. Attach inputs 0-5 volts (0-Vref) to an appropriate channel (#0-#7). Any unused channel which is not tied to ground will float and read as a good input. To avoid confusion, ground unused inputs.

```
190     PRINT "Channel      0    1    2    3    4    5    6    7"
200     PRINT "             ",
210     FOR X=0 TO 7
220    XBY(0E010H+X)=0
230     PH0. XBY(0E010H),
240     NEXT X
```

Changing line 230 to:

```
230    PRINT using(#.##),XBY(0E010H)*.0196,
```

...will display volts (0-5.00) instead of bit value (0-255)

ADJUSTMENT OF VREF

Pot1 will adjust Vref. Place the positive lead of a voltmeter on U3 pin 12 (+ref) and the negative lead on U3 pin 16 (-ref) and adjust Pot1 for 5.000 volts. Letting the circuit come to its operating temperature before making the adjustment will ensure minimum temperature drift.