RTC31 & RTC52
8031 & 8052
REALTIME CONTROLLER

Technical Manual
Rev 1.0

Micromint, Inc

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Release 1.0
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MICROCONTROLLER EVOLUTION

The majority of 8031 and 8052 controller boards are designed as general purpose controllers with external-board expandable I/O. This in not a new revelation, just an observation. If you want an A/D, you add an A/D board. Want more parallel I/O? Then add a parallel I/O board.

The benefit of this architecture is that such a system can be expanded in many directions to incorporate massive amounts of I/O. Where the system fails, however, is that the features which offer easy expandability and onboard software development in large configurations are usually unnecessary in minimum-configuration minimum-control applications. Often we don't need the 48 I/O lines afforded through an expansion I/O card but only 2 or perhaps 3 inputs. Similarily, we may not need microsecond-speed infinite-accuracy analog conversions but only a simple 8-bit A/D for temperature measurements. What's needed is a plain-brown-wrapper 8031/8052 controller that is optimized for these minimal-configuration applications.

The RTC31 and RTC52 meets this criteria. Optimized both for single-use drop-in solutions as well as volume OEM applications, this new Real Time Controller, designated as the RTC31 (8031 processor) or RTC52 (80C52-BASIC processor), is designed to be small and cost effective.

The RTC 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. Ssytem expansion is through a pair of vertical-stacking headers, which eliminates the need for an expensive backplane.

One expansion board, the RTC-IO board, contains 3 parallel TTL I/O ports, an 8-channel 8-bit A/D, 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 second expansion, RTC-Proto board, is just that - a prototyping board. It permits the user to add his or her own special I/O circuits.

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.

8031 vs. 8052

The 8031 family of high-performance control-oriented CPUs was first introduced by Intel in the early 1980s. Since that time, many companies including AMD, Fujitsu, GE/Intersil, OKI, Matra Harris, Siemens, and Signetics have second-sourced one or more devices in this family. This kind of competition shows the 8031 family as a dominating faction in the embedded-controller industry. Two popular versions in this family are the 8031 and the 8052. The internal differences are as follow:

Differences	**8031**	**8052**
RAM		
Internal	128 x 8 bits	256 x 8 bits
External	64K x 8 bits	64K x 8 bits
ROM		
Internal	none	8K x 8 bits
External	64K x 8 bits	56K x 8 bits (64K x 8 bits) (when not using internal ROM)
TIMER/COUNTERS	2 x 16 bits	3 x 16 bits
INTERRUPTS		
Internal	3	4
External	2	2

They also have many features in common, as seen below:

Comparable	**8031**	**8052**
PORTS	4 x 8 bits	4 x 8 bits
SERIAL CHANNELS	1 Full Duplex	1 Full Duplex auto baud
Execution Time @12 MHz clock		
INSTRUCTION		
1 byte	1 Microsecond	1 Microsecond
2 bytes	2 Microseconds	2 Microseconds
4 bytes	4 Microseconds	4 Microseconds

The instruction set of the 8031 family of microcontrollers is similar to the 8048 family, with the addition of:

Non paged Jumps
Direct Addressing
Four 8-register Banks
Stack Depth Up to 128 Bytes
Multiply, Divide, Subtract, and Compare

8031 FAMILY PIN DESCRIPTION

Port 0	pins 39-32	8-bit open drain bidirectional I/O (multiplexed low-order data/address for external memory)
Port 1	pins 1-8	8-bit quasi-bidirectional I/O
Port 2	pins 21-28	8-bit quasi-bidirectional I/O (high-order address for ext. memory)
Port 3	pins 10-17	8-bit quasi-bidirectional I/O (secondary functions as follows: **RXD/data** Serial Channel's receiver **TXD/data** Serial Channel's transmitter ***INT0** Interrupt 0/counter gate 0 input ***INT1** Interrupt 1/counter gate 1 input **T0** Counter 0 input **T1** Counter 1 input ***WR** write for external data memory ***RD** read for external data memory
ALE	pin 30	Address latch enable
***PSEN**	pin 29	read for external program memory
***EA**	pin 31	tied to logic high for executing code masked within the 8x5x series processors with internal ROM or tied to logic low to disable internal ROM and fetches all instructions from external program memory

RTC31 & RTC52 EXTERNAL ADDRESSING SPACE

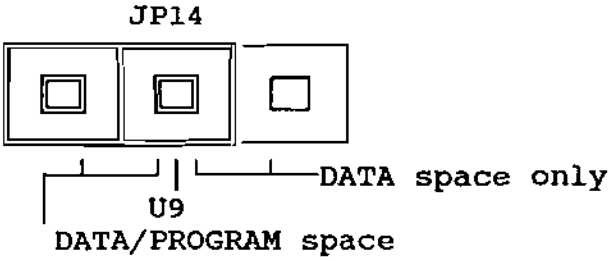
The 8031 family of microcontrollers can directly address 128K of external memory. That is, 64K of DATA memory and 64K of PROGRAM memory. The *RD and *WR lines control DATA memory (READ/WRITE and I/O) and the *PSEN line controls PROGRAM memory (READ-only memory). By ORing the *RD and *PSEN lines, a combined DATA/PROGRAM space can be created containing one 64K space (each of the two 64K spaces are combined for an "anything goes here" space). This combined DATA/PROGRAM space (64K) is half the total possible external address space (128K), but it simplifies use by not having to keep track of which space is which. Separated space is available for the experienced programmer.

Many combinations of 8K and 32K RAMs and EPROMs are possible on the RTC board. **When using the RTC31, code (your EPROM) starts execution at 0000H (PROGRAM space). When using the RTC52 (masked with BASIC in the internal ROM), RAM must be at 0000H (DATA space).** The following chart shows conventional addressing for the memories used on the RTC31 and RTC52:

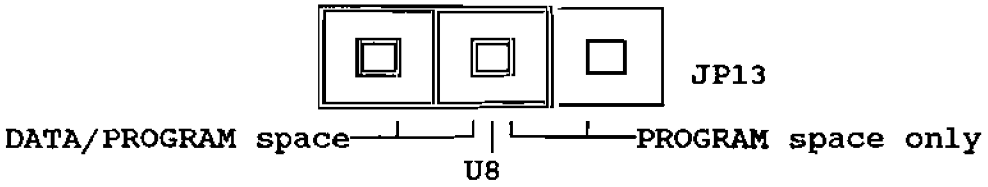
Separated DATA/PROGRAM space		Combined DATA/PROGRAM space	
Memory #1 DATA	Memory #2 PROGRAM	Memory #1 DATA/PROGRAM	Memory #2 DATA/PROGRAM
8K at 0000H and	8K at 0000H	8K at 0000H and	8K at 2000H
or		or	
8K at 0000H and	32K at 0000H	8K at 0000H and	32K at 2000H
or		or	
32K at 0000H and	8K at 0000H	32K at 0000H and	8K at 8000H
or		or	
32K at 0000H and	32K at 0000H	32K at 0000H and	32K at 8000H

ADDRESS SPACE SELECTION

Two memory sockets are provided on the RTC board (U9 & U8). Each memory socket has a jumper used in selecting the type of address space assigned to the socket. JP14 selects the space for U9 and JP13 selects the space for U8. The selection made determines which line *RD (for DATA space only), *PSEN (for PROGRAM space only), or *GET (for combined DATA/PROGRAM space [*GET = *RD or *PSEN]) is used for an *OE (output enable) on the memory.



JP14 shows combined DATA/PROGRAM space selected for U9

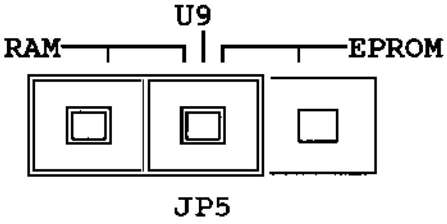


JP13 shows combined DATA/PROGRAM space selected for U8

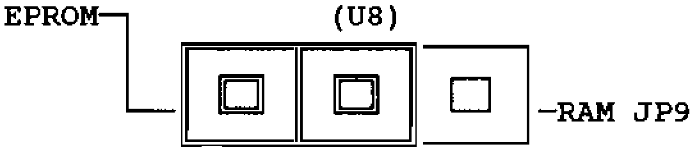
MEMORY DEVICE TYPE SELECTION

Pin 1 on RAM is A14 (on an 8K RAM it's a "don't care"), while the same pin on an EPROM must be at Vcc (Vpp for programming). Jumpers JP5 (for U9) and JP9 (for U8) route the proper signal depending on the type of memory device being used.

The following configuration is typical for the RTC52 which requires RAM at address 0000H.



JP5 shows RAM memory selected for U9

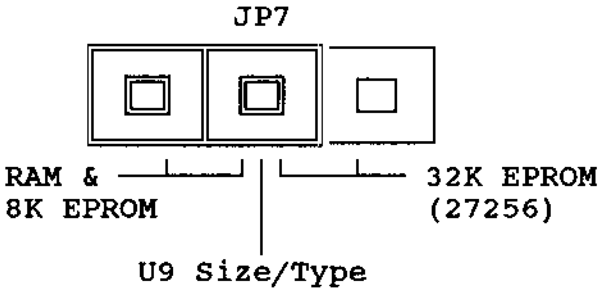


JP9 shows EPROM memory selected for U8

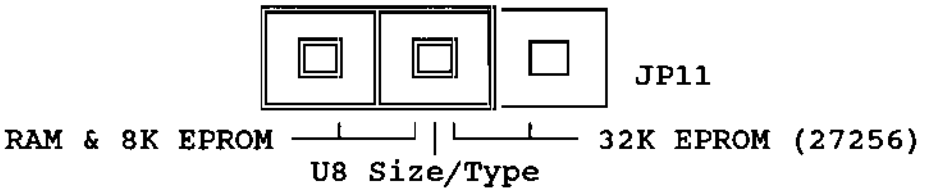
MEMORY DEVICE SIZE/TYPE SELECTION

Pin 27, on a RAM device, requires the *WR line to write to the RAM. The same pin on a 32K EPROM, is designated as A14, the high address line. An 8K EPROM does not use this pin as an address line but requires a logic high to enable it. Since it is possible for the A14 line to be logic low during an access to an 8K EPROM, it must be configured here as a RAM device. In this case the *WR line will be logic high and satisfy the condition. Jumpers JP7 (for U9) and JP11 (for U8) route the proper signal depending on the type of memory device being used.

The following configuration is typical for an RTC31 or RTC52 using 8K memory devices.



JP7 shows RAM or 8K EPROM selected for U9

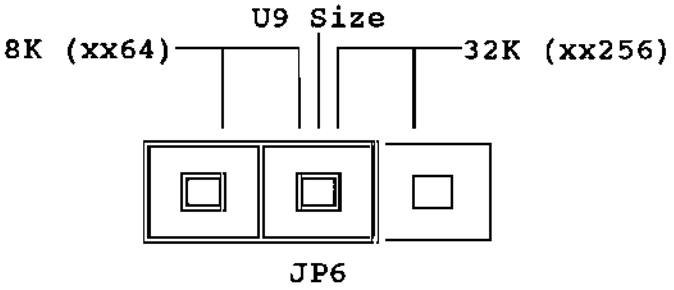


JP11 shows RAM or 8K EPROM selected for U8

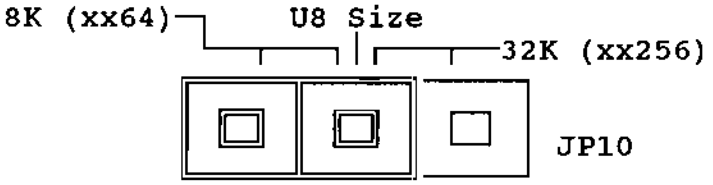
MEMORY DEVICE SIZE SELECTION

8K RAMs require a logic high enable for pin 26 (CS). On an 8K EPROM this pin is a "don't care". The 32K devices use this pin for A13, an address line. JP6 routes the proper signal to pin 26 of the memory device used in U9, and JP10 routes to pin 26 of U8.

The following configuration is typical for an RTC31 or RTC52 using 8K memory devices.



JP6 shows 8K RAM or EPROM selected for U9

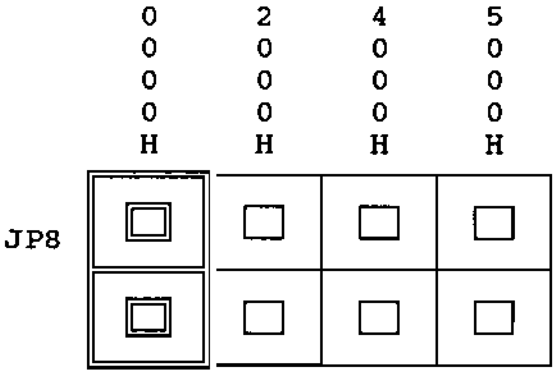


JP10 shows 8K RAM or EPROM selected for U8

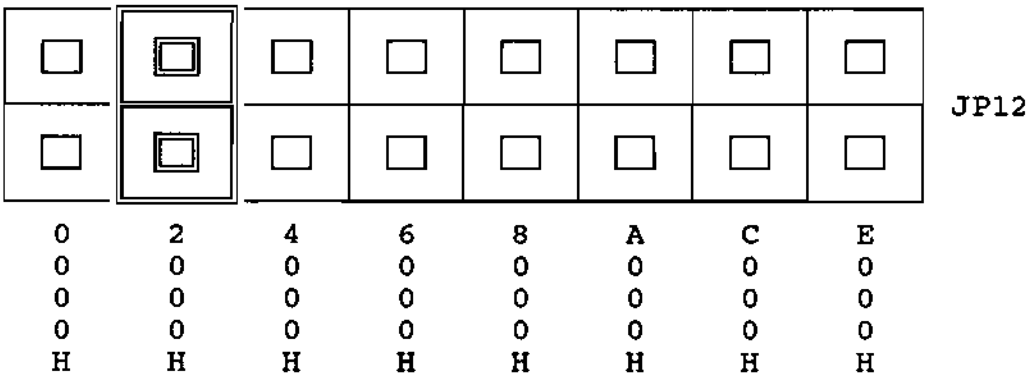
MEMORY DEVICE ADDRESS SELECTION

U3, a 74LS156, decodes the top three address lines from the processor, producing eight 8K blocks. Memory devices U9 and U8 require one or more 8K blocks depending on the size of the memory device. An 8K memory device requires one block. A 32K memory device requires four 8K blocks (4 times 8K = 32K.) The '156 is an open-collector decoder which allows its outputs to be wire-ORed. **Once any outputs are combined on JP8 or JP12 they will appear ORed to the whole system. Therefore, when using a system with separate DATA and PROGRAM spaces, any memory devices sharing any address block must be of the same size. To reduce confusion, unless necessary for the application, combined DATA/PROGRAM space should be used!** Selection of each 8K block determines the location of the memory device within the 0-64K address space. The memory device used in U9 can be addressed at 0000H-1FFFH, 2000H-3FFFH, 4000H-5FFFH, and/or 6000H-7FFFH. The memory device used in U8 can be addressed at same four blocks as U9 and an aditional four: 8000H-9FFFH, A000H-BFFFH, C000H-DFFFH, and/or E000H-FFFFH.

U9 Address Selection



JP8 shows an 8K block starting at address 0000H selected for the 8K memory device in U9

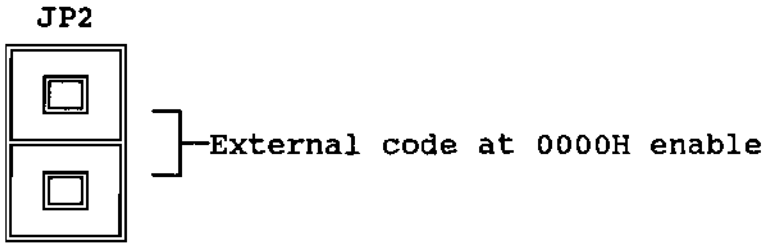


U8 Address Selection

JP12 shows an 8K block starting at address 2000H selected for the 8K memory device in U8

EXTERNAL CODE SELECTION

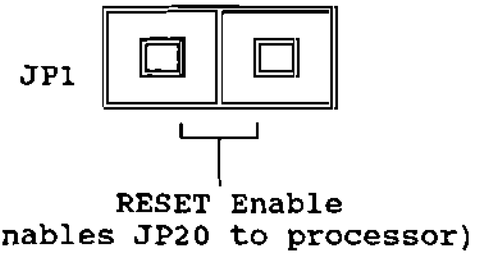
The 8031 microcontroller requires *EA (pin 31 on the microcontroller) to be pulled down to a logic low level. This instructs the processor to start executing machine language code starting at address 0000H (PROGRAM space). The 8052 is masked with BASIC and will run internal code (BASIC interpreter) if *EA is pulled up to a logic high. Pulling *EA low on an 8052 will disable BASIC and execute code starting at 0000H (similar to an 8032).



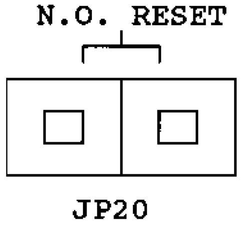
JP2 shows the microcontroller enabled for external code execution

RESETTING THE RTC31 & RTC52

Reset of the RTC board occurs when a normally open push button switch is attached to JP20 and momentarily pressed. A logic high is applied to the system RESET line and held momentarily high by an R/C circuit. The DDT-51, Digital Debugging Tool for the 80xx family of microcontrollers, must control the RESET line to the processor. JP1 can isolate the system RESET line from the processors RST pin. This enables the DDT-51 to reset the 80xx without resetting any peripheral on the RTC system Bus.



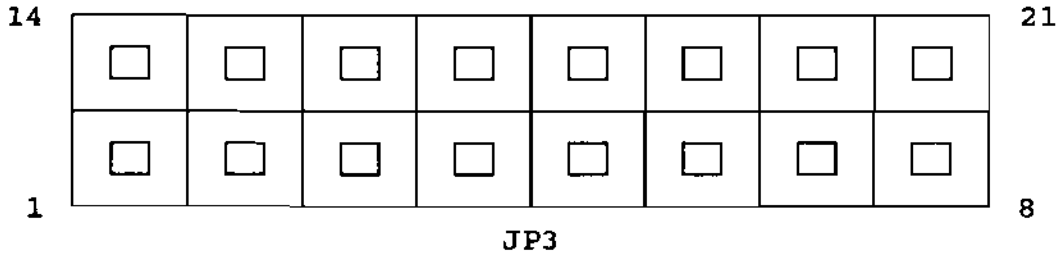
JP1 jumper must be installed when not using the DDT-51



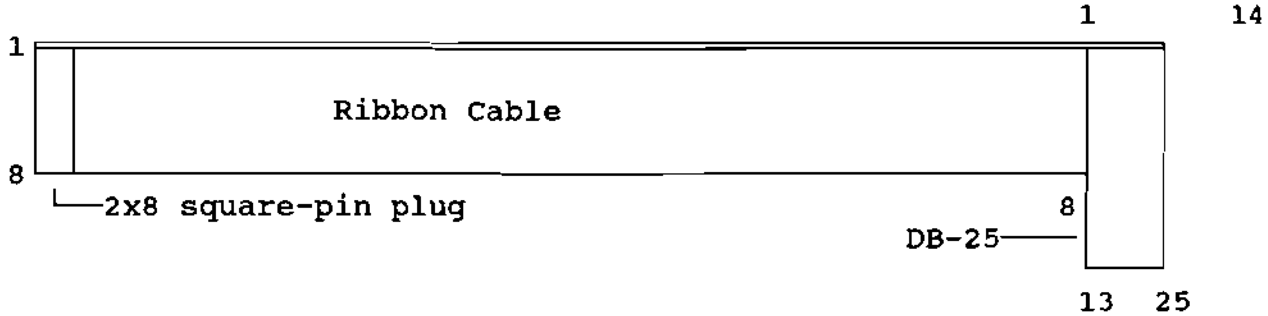
Use JP20 for connecting a normally open push button switch as an external system RESET

RS-232 COMMUNICATIONS

The 8031/8052 family contains a full-duplex serial channel. TTL-level serial signals are converted to ±10-volt RS-232-compatible signals by U6, the MAX232 device. A 16-lead flat ribbon cable made with a DB-25 at one end (for connection to DTE terminal device and a 16-pin plug (for connection to JP3) will permit serial communication with a dumb terminal or computer.



Use JP3 for RS-232 communications

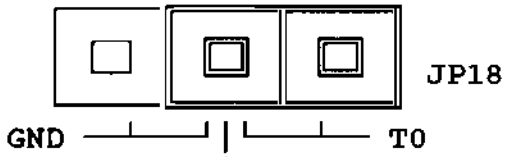


Cable required for RS-232 communications

To eliminate unwanted noise on the RX input to the processor, remove the unused line driver chip. (U4 or U6)

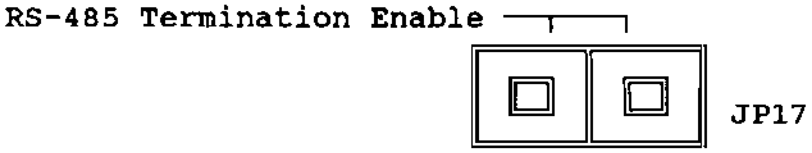
RS-485 COMMUNICATIONS

RS-485 communications over a single twisted pair can include multiple (up to 32) devices. Since each device can transmit and receive, certain protocols must be adhered to to prevent message collision. The simplest being "listen to the line and transmit only if free". (The protocol you use will depend on the application and is beyond the scope of this manual.) JP17 enables a termination resister across the twisted pair and should be installed only on the microcontrollers located at the extremes of the twisted pair (one at each end.) JP18 selects the control of the RS-485 receiver. Two options are available for control of the receiver: always enabled and only enabled when the transmitter is disabled (to prevent receiving what is being sent). U4, the 75176 RS-485 device, draws as much current as the rest of the RTC board. If low power operation is of great concern and the RS-485 is not being used, current consumption can be reduced by removing the 75176.



RS-485 Receive Control

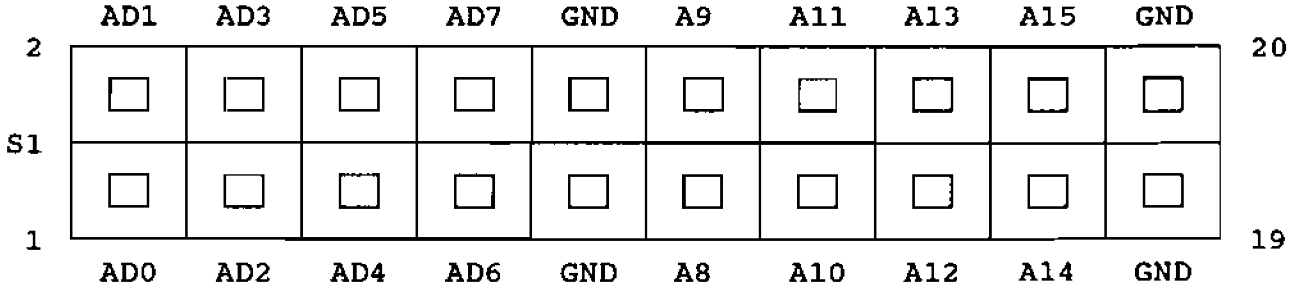
JP18 shows the receiver of the RS-485 device controlled by T0, the same line that controls the receiver. The transmit control is active high and the receiver is active low, so the transmitter and receiver are alternately enabled by the logic level of T0.



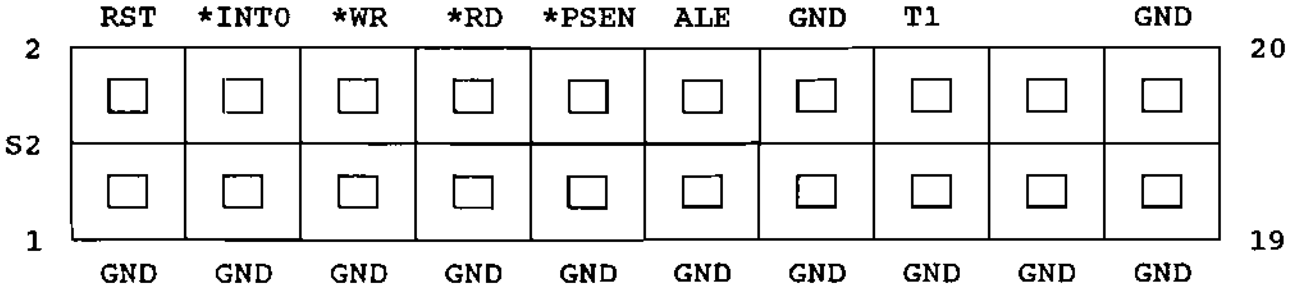
JP17 shows termination of the RS-485 lines enabled

DDT-51 CONNECTIONS

The DDT-51 is another product which was introduced to give users an inexpensive debugging tool for the 8031/52 family of microcontrollers. It is attached to a target system through two 20-pin conectors on the DDT-51 board. A 40-pin DIP clip is wired to the connectors and is attached to the target microcontroller. In an attempt to make using the DDT-51 as easy and clean as possible, a matching set of connectors was added to the RTC31 & RTC52 boards which ellininates the need for the DIP clip. Two short 4-inch 20-lead ribbon cables with 20-pin plugs at each end will make all connections necessary to the DDT-51. **For more information on the DDT-51 call Circuit Cellar Inc. (203) 875-2751.**



S1 carries all the address and data lines from the microcontroller



S2 carries all the control lines from the microcontroller

VERTICAL-STACKING EXPANSION HEADER

The small size of the RTC31 and RTC52 mirocontroller boards, less than four inches square, is not sacrificed by the expansion of its I/O capabilities. The footprint remains the same as each I/O board only adds 9/16 of an inch to the height of the system. I/O expansion is obtained through a vertical header system making a backplane unnecessary. The data bus and latched low-order address bus passed are through the expansion header along with control lines and power. In place of the upper address bus, the upper four 8K block decodes are passed through the expansion header making I/O decoding a snap.

JP16

	26	25	
Buffered D4	☐	☐	Buffered D3
Buffered D5	☐	☐	Buffered D2
Buffered D6	☐	☐	Buffered D1
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	

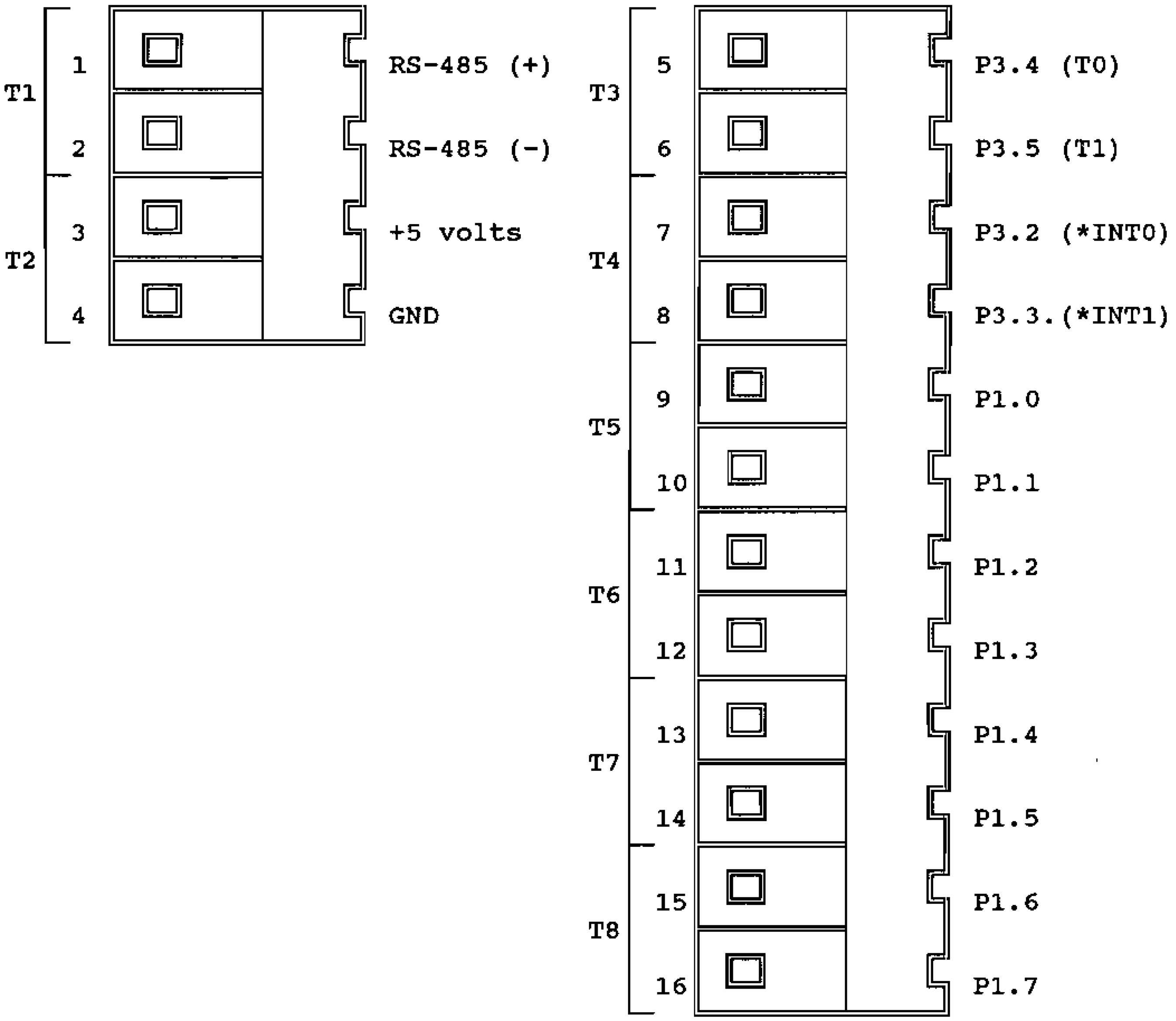
JP15

	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	

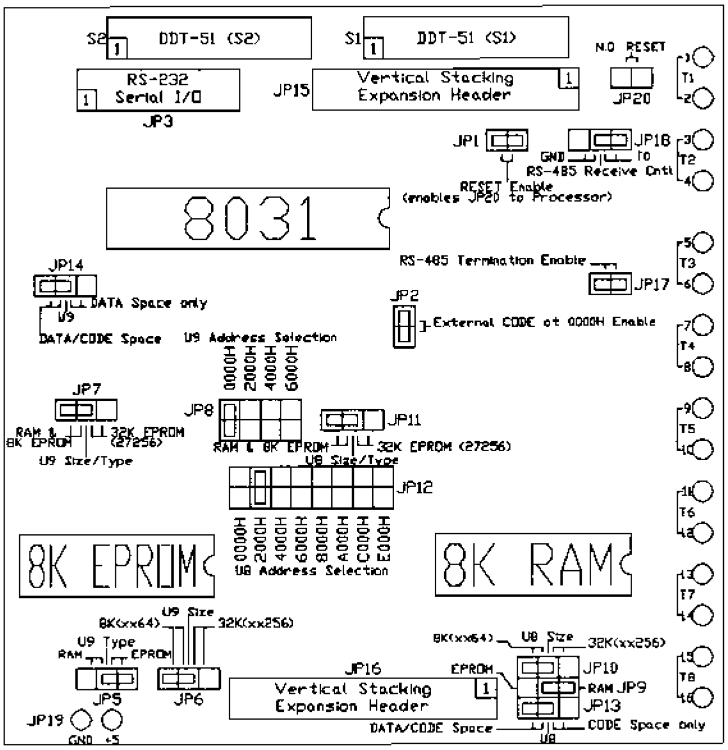
JP16 and JP15 bring the expansion bus up to I/O boards which mate atop the RTC31 and RTC52

STAND-ALONE I/O CONNECTIONS

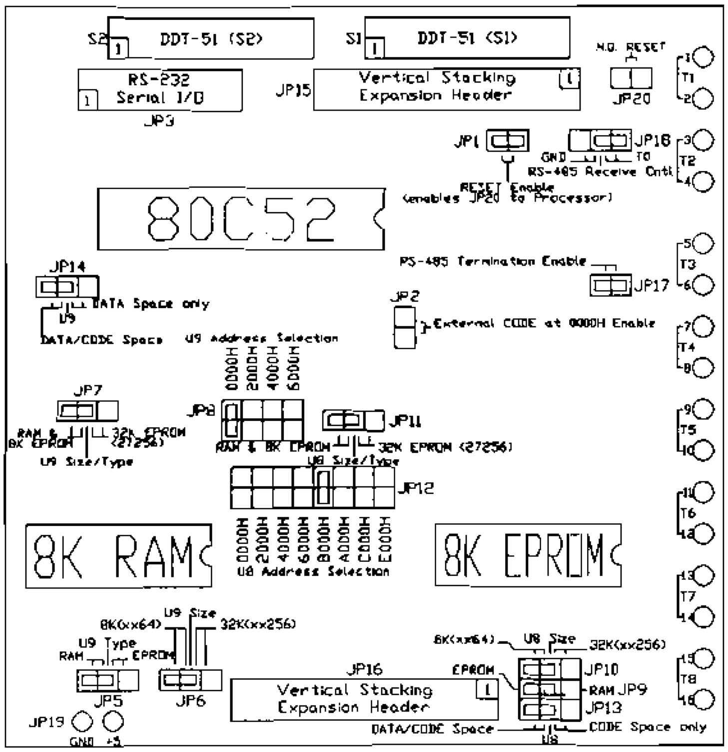
Sixteen user connections make the RTC31 and RTC52 a perfect stand-alone microcontroller. Provisions are made on the board for using optional screw terminal blocks for each of these connections. Two connections for RS-485 twisted-pair communications, a pair for power (+5 volts and ground), eight connections for quasi-bidirectional port 1 from the processor, and four additional control lines off the processor (T0, T1, *INT0, and *INT1).



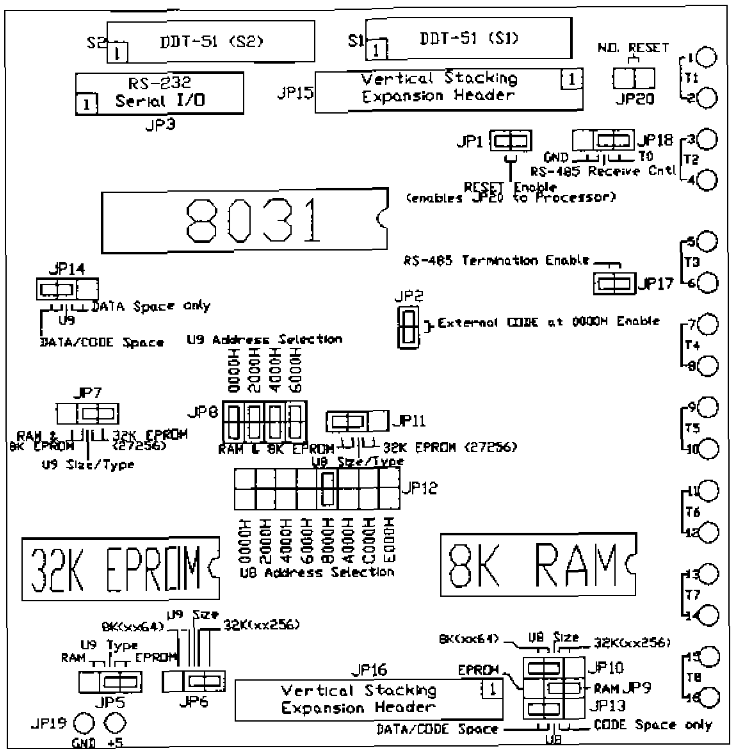
Optional screw terminal blocks make connections to external I/O easy



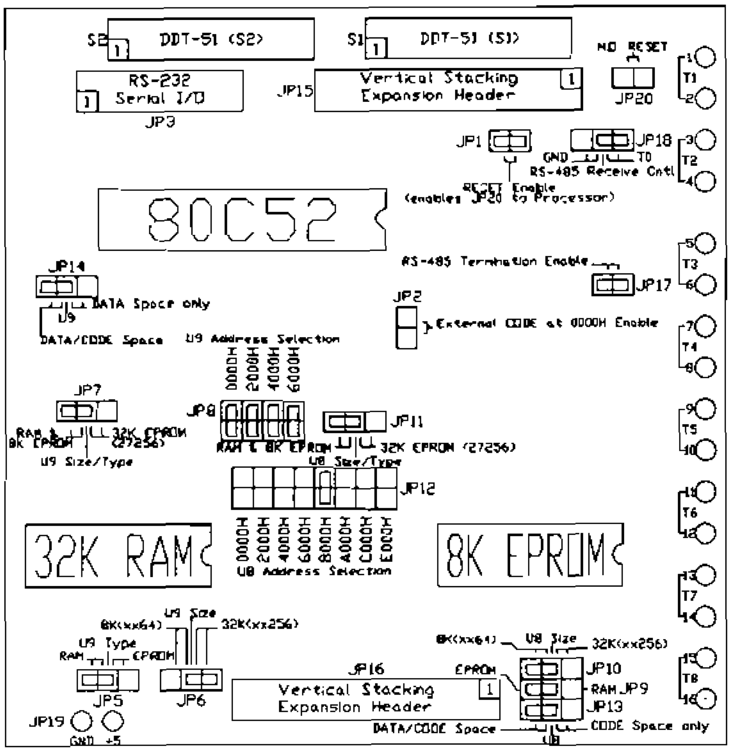
Suggested jumper configurations for combined DATA/PROGRAM(CODE) space using an 8k EPROM @ 0000H and an 8k RAM @ 2000H on an RTC31



Suggested jumper configurations for combined DATA/PROGRAM(CODE) space using an 8k RAM @ 0000H and an 8k EPROM @ 8000H on an RTC52



Suggested jumper configurations for combined DATA/PROGRAM(CODE) space using a 32k EPROM @ 0000H and an 8k RAM @ 8000H on an RTC31



Suggested jumper configurations for combined DATA/PROGRAM(CODE) space using a 32k RAM @ 0000H and an 8k EPROM @ 8000H on an RTC52

To eliminate unwanted noise on the RX input to the processor, remove the unused line driver chip. (U4 or U6)

GETTING STARTED

RTC52

The RTC52, with internal BASIC, will communicate with the user on power-up if correct connection to a dumb terminal or computer (running communication software) is made. **After pressing the space bar** the RTC52 will inspect the serial transmission and select the correct baud rate (transmission must be 8 bits, no parity, and 1 stop bit). The RTC52 will respond with a sign-on message and command prompt ">". Type in the short program below to verify BASIC is operating correctly. This should toggle the P1.0 line on the microcontroller. If you connect a piece of wire from the P1.0 I/O output (T5 #9) to the T0 I/O pin (T3 #5), the LED controlled by P3.4 should blink about once per second. Since BASIC cannot directly address port 0, 2, or 3, Port 1 is used to drive the T0 line by use of the wire.

```
10 PORT1 = PORT1 .AND. 0FEH
20 GOSUB 60
30 PORT1 = PORT1 .OR. 01H
40 GOSUB 60
50 GOTO 10
60 FOR X = 1 TO 100
70 NEXT X
80 RETURN
```

NOTE: When using an RTC52 with a terminal or computer, press the space bar to start the systems' auto-baud rate sequence. A sign-on message will be displayed after it is correctly received.

RTC31

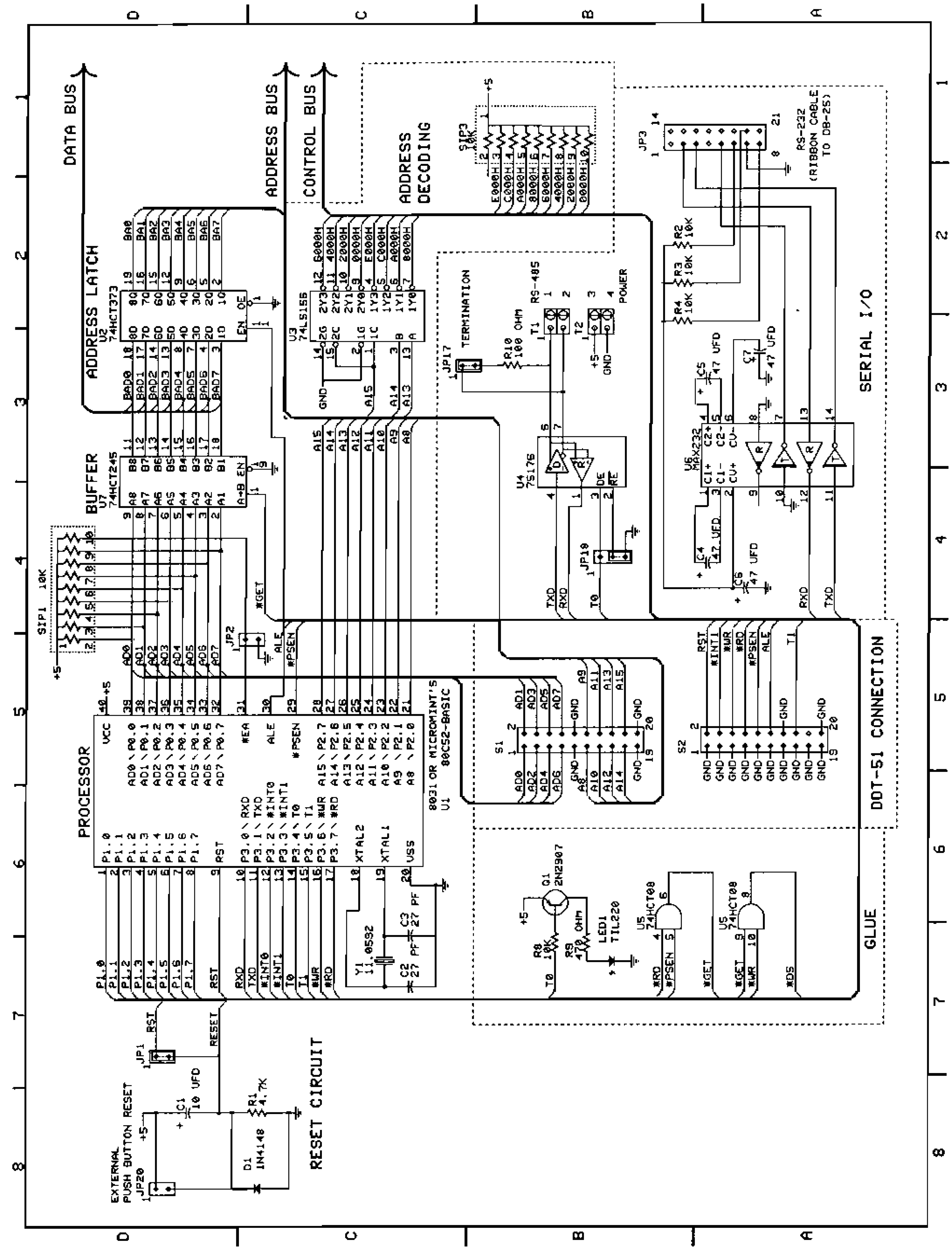
The RTC31 does not have any internal program, so the user must program an EPROM with machine language code which will start execution at 0000H. The following code can be programmed into a blank EPROM and will turn the LED on and off about once per second, verifying the ability to execute code. T0 is directly addressable, so no wire is necessary as was with the above BASIC program. Refer to Intel's EMBEDDED CONTROLLER HANDBOOK for additional information on the 8031/8052 microcontroller functions.

```
0000H  15H  F0H            ;DEC  B
0002H  D5H  F0H  F5H       ;DJNZ B,0000H
0005H  14H                 ;DEC  A
0006H  70H  F8H            ;JNZ  0000H
0008H  B2H  B4H            ;CPL  T0
000AH  01H  00H            ;AJMP 0000H
```

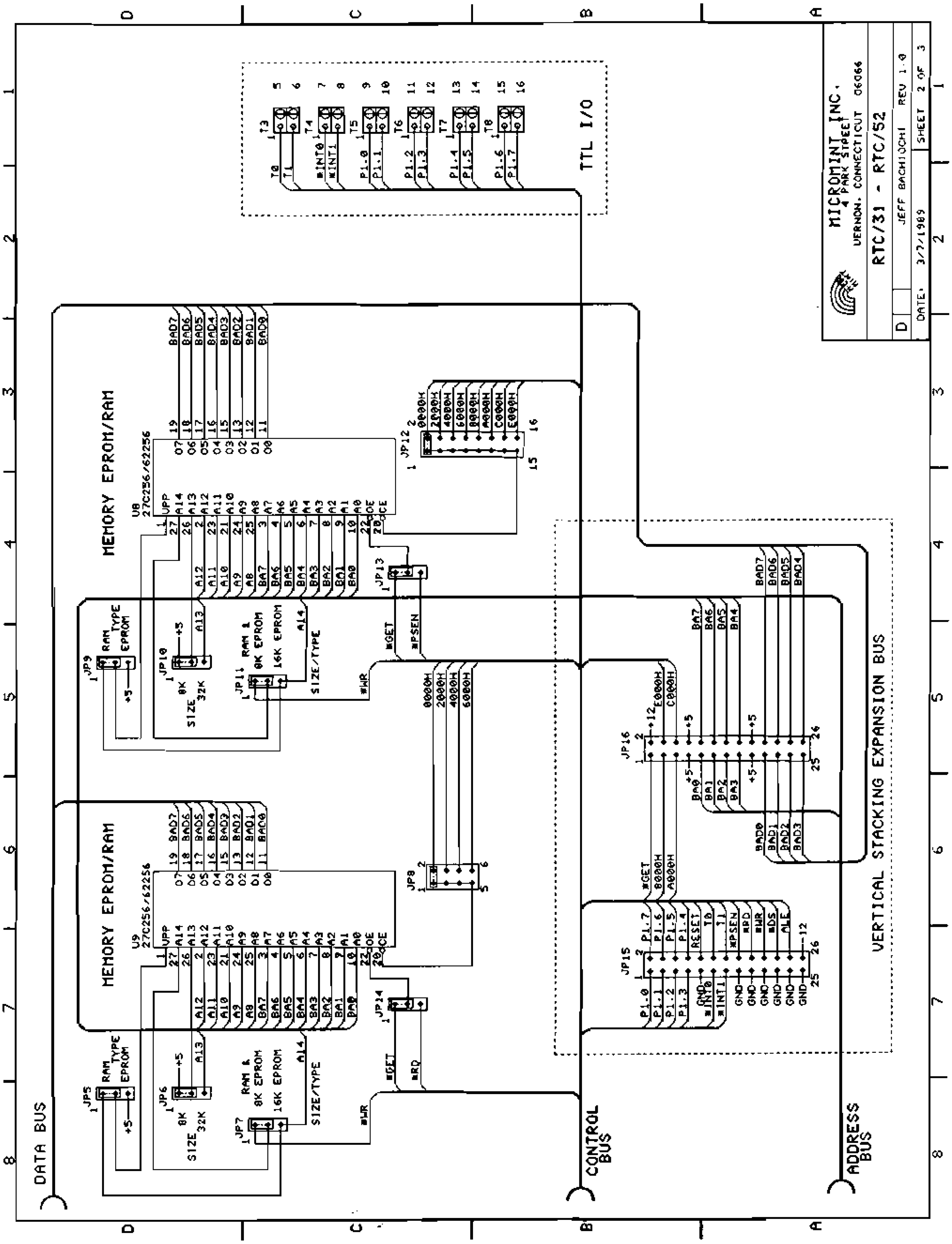
GETTING YOUR CODE INTO AN EPROM

Neither the RCT31 nor the RTC52 have a built in EPROM programmer. For the most part, development and EPROM programming can be easily done on the BCC52C (2764/27128) or the BCC52CX (27256). Alternately, you can use the Micromint Serial Eprom Programmer.

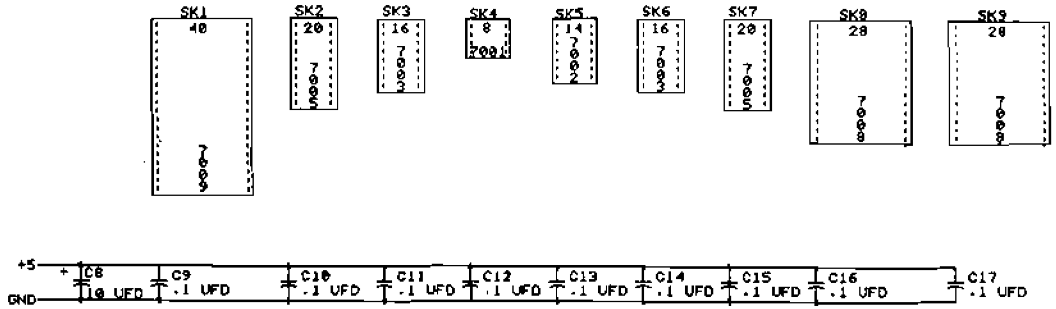
An optional battery backed RAM can be used (a typical part is the Dallas DS1225AB). Code within an 8k non-volatile RAM can be read by an EPROM programmer without having to create an Intel HEX file.



RTC31/52 SCHEMATICS (1 of 3)



RTC31/52 SCHEMATICS (2 of 3)



NOTE 80C52-BASIC PROCESSOR USER

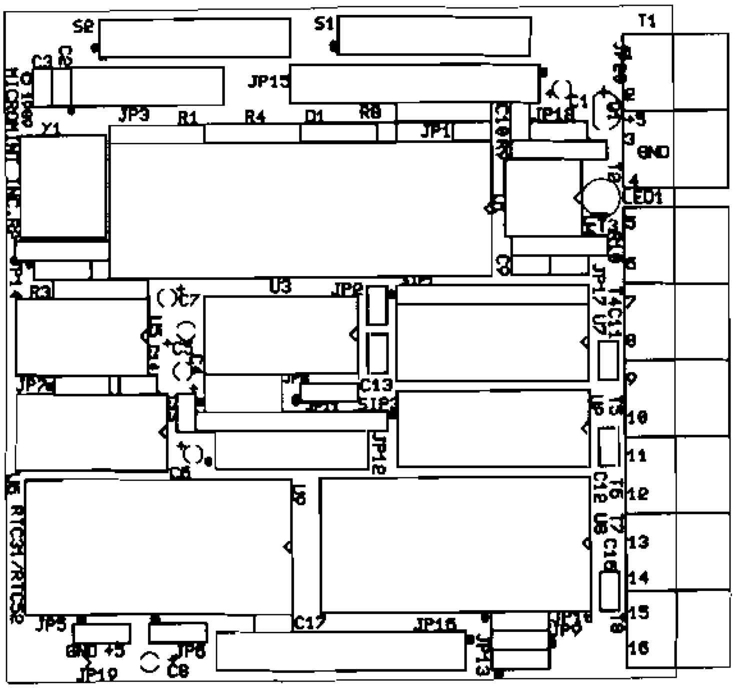
PORT1 1/O PINS ARE INITIALLY DEFINED AS:

P 1.0 T2 (TIMER 2 TRIGGER)
P 1.1 T2EX (TIMER 2 EXTERNAL INPUT)
P 1.2 PWM (PULSE WIDTH MODULATION OUTPUT)
P 1.3 *DIS (ALE DISABLE)
P 1.4 *PP (EPROM PROGRAMMING PULSE)
P 1.5 *PE (EPROM PROGRAMMING ENABLE)
P 1.6 *DMA ACK (DMA ACKNOWLEDGE)
P 1.7 ASO (AUXILIARY SERIAL OUTPUT - PRINTER)

MICROMINT INC.
4 PARK STREET
VERNON, CONNECTICUT 06066

RTC/31 - RTC/52

D | JEFF BACHIOCHI REV 1.0
DATE: 3/7/1989 SHEET 3 OF 3



RTC31/52 Silkscreen

RTC31 PARTS LIST

DESIGNATION	PART#	DESCRIPTION
Printed Circuit Board		
PCB1		RTC31/52 Printed Circuit Board
Integrated Circuits		
U1	8031	Microcontroller
U2	74HCT373	Octal Transparent Latch
U3	74LS156	Dual 2-to-4 Decoder w/OC Outputs
U4	75176	Differential Bus Transceiver
U5	74HCT08	Quad 2-Input AND Gate
U6	MAX232	5V RS-232 Dual Receiver/Xmitter
U7	74HCT245	Octal Bus Transceiver
U8	----	optional (EPROM/RAM)
U9	----	optional (EPROM/RAM)
Resistors		
R1	4.7K	1/4 watt 5% (yel-vio-red)
R2-R4,R8	10K	1/4 watt 5% (brn-blk-org)
R5-R7	-	not used
R9	470 ohm	1/4 watt 5% (yel-vio-brn)
R10	100 ohm	1/4 watt 5% (brn-blk-brn)
SIP1,SIP3	10K	10-lead, 9-resistor, pin 1 common
SIP2	-	not used
Capacitors		
C1,C4-C8	10 ufd	Tantalum
C2,C3	27 pfd	Monolithic
C9-C17	0.1 ufd	Monolithic
Semiconductors		
D1	1N4148	Small-Signal Diode
LED1	TIL220	Light-Emitting Diode
Q1	PN2907	PNP transistor
Connectors		
JP1,JP2, JP17,JP20	1 X 2	Square-Pin Header
JP3,JP12	2 X 8	Square-Pin Header
JP4	-	not used
JP5-JP7, JP9-JP11, JP13,JP14,JP18	1 X 3	Square-Pin Header
JP8	2 x 4	Square-Pin Header
JP16,JP16	2 X 13	Square-Pin Header
S1,S2	-	optional 2 X 10 right-angle square-pin headers for use with the DDT-51

DESIGNATION	PART#	DESCRIPTION
Sockets		
SK1	40-Pin	I C Socket
SK2,SK7	20-Pin	I C Socket
SK3,SK6	16-Pin	I C Socket
SK4	8-Pin	I C Socket
SK5	14-Pin	I C Socket
SK8,SK9	28-Pin	I C Socket
Miscellaneous		
Y1	11.0592 MHz	Crystal
T1-T8		optional Screw Terminal Block
SJ1-SJ20		Shorting Jumpers

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Miscellaneous		
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T1-T8		optional Screw Terminal Block
SJ1-SJ20		Shorting Jumpers

RTC31/52 Board Dimensions

DIM	Inches	Notes
A	0.15	From edge of board to center of mount hole.
B	2.9	From edge of board to center of mount hole.
C	0.75	From edge of the board to center of first closest pin of JP15.
D	0.45	From edge of board to center of mount hole.
E	0.15	From edge of board to center of mount hole.
F	3.2	From center of mount hole to center of mount hole.
G	0.15	From edge of board to center of mount hole.
H	1.15	From edge of the board to center of first closest pin of JP16.
I	0.1	From edge of the board to center of first closest pin of JP16.
K	0.35	From edge of the board to center of first closest pin of JP15.