PROGRAMMING THE CL2400

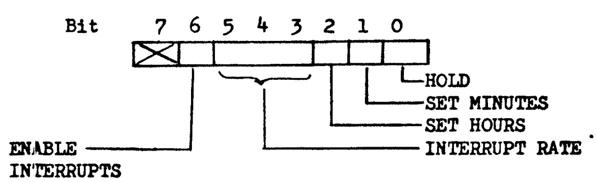
The CL2400 uses 8 successive I/O ports, starting at the base address determined by jumpers on the board. Relative addressing of CL2400 inputs and outputs is as follows:

	OUTPUT	INPUT
Base Address	Interrupt Acknowledge	Interrupt Status
Base Address +1	Control Register	Minutes (0-9)
Base Address +2	-	Tens of Seconds (0-5)
Base Address +3	-	Seconds (0-9)
Base Address +4	-	-
Base Address +5	-	Tens of Minutes (0-5)
Base Address +6	-	Hours (0-9)
Base Address +7	-	Tens of Hours (0-5)

The following sections assume standard CL2400 addressing of 250-257, Octal (A8-AF, Hex).

CONTROL REGISTER OUTPUT

The CL2400 control register is loaded by outputting to peripheral address 251 octal (169 decimal). The control register responds to an 8 bit control output as follows:



HOLD: (bit 0) A '1' in this bit causes the clock to cease updating the time and hold the last reading. The clock resumes operation when a '0' is output.

SET MINUTES: (bit 1) A'1' in this bit causes the clock to run at 60 times the normal rate. This causes the minutes counter to change every second, allowing any count to be reached in less than one minute. A '0' resumes normal operating speed.

SET HOURS: (bit 2) A '1' in this bit causes the minutes counter to change 60 times per second. This causes the hours counter to change every second, allowing any count to be reached in 24 seconds or less. A '0' resumes normal operating speed.

INTERRUPT RATE: (bits 3-5)
This 3 bit field determines the rate at which the CL2400 generates an internal interrupt signal. The rates are as follows:

Bit 5	Bit 4	Bit 3	Interrupt Rate
1	0	0	Once each second
1	0	1	Once each 10 seconds
1	1	0	Once each minute
0	1	0	Once each 10 minutes
0	0	1	Once each hour
0	0	0	Twice each day (10:00 and 20:00)

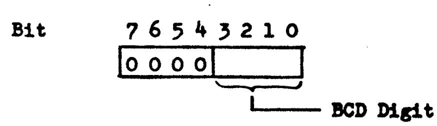
If the CL2400 is placed in the SET MINUTES mode, the following rates are available:

Bit 5	Bit 4	Bit 3	Interrupt Rate
1	0	0	Once each 16.7 ms
1	0	1	Once each 167 ms

INTERRUPT ENABLE: (bit 6)
A '1' in this bit enables the CL2400 internal interrupt signal to assert a processor bus line. If the processor's internal interrupt enable is set (accomplished by a previous EI instruction), an interrupt will occur at the end of the present instruction. A '0' inhibits the CL2400 from generating any interrupts.

DATA INPUT

A single BCD digit can be input from each of 6 addresses. The data is returned in the following format:



Each input address returns a different digit of the present time. The addresses are:

ADDRESS		
OCTAL	DECIMAL	DIGIT
251	169	Minutes (0-9)
252	170	Tens of seconds (0-5)
253	171	Seconds (0-9)
255	173	Tens of minutes (0-5)
256	174	Hours (0-9)
257	175	Tens of hours (0-2)

INTERRUPT STATUS INPUT

Octal address 250 (168 decimal) returns two status bits. Bit 6 indicates the present state of the CL2400 interrupt enable flip-flop. Bit 7 indicates the present state of the interrupt flip-flop.

INTERRUPT ACKNOWLEDGE OUTPUT

Once the CL2400 interrupt flip-flop is set, it must be acknowledged by the processor before it will be reset. Any output to octal address 250 (168 decimal) is accepted by the CL2400 as an interrupt acknowledge, and the interrupt signal is reset.

Figure 1

```
10 DIM T(10)
20 OUT 169,0
30 PRINT
40 PRINT "ENTER 0 TO READ OR 1 TO SET";: INPUT X
50 IF X=0 GOTO 80
60 IF X=1 GOTO 150
70 GOTO 40
80 REM  INPUT AND PRINT TIME
90 FOR I=0 TO 7: LET T(I)=INP(168 +I): NEXT I
100 LET H=10*T(7)+T(6)
110 LET M=10*T(5)+T(1)
120 LET S=10*T(2)+T(3)
130 PRINT "TIME --" H ":" M ":" S
140 GOTO 20
150 REM  SET CLOCK BY FAST RUNNING
160 PRINT "PRESENT TIME (4 DIGITS SEPARATED BY COMMAS)";
170 INPUT H9,H,M9,M
180 OUT 169 ,4
190 IF INP(175 )=H9 THEN IF INP( 174)=H THEN OUT 169, 0: GOTO 210
200 GOTO 190
210 OUT 169,2
220 IF INP(173 )=M9 THEN IF INP( 169)=M THEN OUT 169,0: GOTO 80
230 GOTO 220
OK

RUN

ENTER 0 TO READ OR 1 TO SET? 0
TIME -- 14 : 18 : 33

ENTER 0 TO READ OR 1 TO SET? 0
TIME -- 14 : 18 : 39

ENTER 0 TO READ OR 1 TO SET? 0
TIME -- 14 : 18 : 46

ENTER 0 TO READ OR 1 TO SET? 1
PRESENT TIME (4 DIGITS SEPARATED BY COMMAS)? 0,9,1,5
TIME -- 9 : 15 : 1

ENTER 0 TO READ OR 1 TO SET? 0
TIME -- 9 : 15 : 22

ENTER 0 TO READ OR 1 TO SET? 0
TIME -- 9 : 15 : 32

ENTER 0 TO READ OR 1 TO SET? 1
PRESENT TIME (4 DIGITS SEPARATED BY COMMAS)? 1,4,2,0
TIME -- 14 : 20 : 1

ENTER 0 TO READ OR 1 TO SET? 0
TIME -- 14 : 21 : 34

ENTER 0 TO READ OR 1 TO SET?
```

PROGRAMMING IN HIGHER LEVEL LANGUAGES

Figure 1 shows a sample program written in ALTAIR^{tm} 8k BASIC. This program can be used to set and read the present time. Its operation is as follows:

STATEMENT(S)	DESCRIPTION
20	Places clock in normal mode
40-70	Determines whether to set or read clock, and jumps to appropriate routine
80-140	Read and print time routine
90	Inputs from peripheral addresses 168-175 and stores digits in T(0)-T(7)
100-120	Assembles hours, minutes, seconds numbers
130	Prints hours, minutes, seconds separated by colons
150-230	Set time routine
160-170	Inputs present time from terminal as tens of hours (H9), hours (H), tens of minutes (M9), and minutes (M)
180	Places clock in set hours mode
190-200	Stays in set hours mode until clock hours digits advance to present time. Returns clock to normal mode, jumps to set minutes routine
210	Places clock in set minutes mode
220-230	Stays in set minutes mode until clock minutes digits advance to present time. Returns clock to normal mode, jumps to input and print routine.

NOTES:

Most BASIC interpreters require addresses and data to be in decimal. Notice that in figure 1, CL2400 addresses are decimal 168-175, and that output data are the decimal equivalent of binary data required by the CL2400 control register.

The clock set routine can require up to 23 seconds to set the hours counter, and up to 59 seconds to set the minutes counter, for a worst case, total of 1 minute, 22 seconds. If absolute time accuracy is required, set the clock to 2 minutes past the present time, and exit with a HOLD command output. Release the HOLD mode when the actual time advances to the time set into the CL2400.

There is always a certain amount of software response delay associated with statements such as those at 190 and 220 in Figure 1. This is the time that it takes the program to realize that the clock has advanced to the present time, and then respond with program branching. This is a function of system memory speed and interpreter design. At statement 190, the minutes counter is advancing at 60Hz, and often advances to a count of 01 or 02 before the set minutes routine at 210 is reached. If a minutes count of 00 is desired, the clock will advance to the next hours before the routine exits, and a setting error of 1 hours will be observed. Depending upon a specific system's speed, times between an even hour and 2 or 3 minutes after the hour should not be used when setting the clock with this routine.

A simple BASIC timing program to ring the terminal bell and print a message at 6:30 could be written as follows:

```
10  IF INP (174) < 6 GO TO 10
20  IF INP (173) < 3 GO TO 20
30  PRINT "(Bell)"
40  PRINT "(Message)"
50  STOP
```

PROGRAMMING IN ASSEMBLY LANGUAGE

Figure 2 shows a typical routine for displaying the present time on a CRT display. Each time this "TIME" routine is called, the six time digits and two ":" will be placed into memory locations on a video display board. For automatic time update, the "TIME" routine can be used as an interrupt handler by placing a jump to "TIME" in memory locations assigned to an interrupt vector. Figure 2 shows the "TIME" routine as a level 7 interrupt handler - that is, each time a level 7 interrupt occurs, the "TIME" routine will automatically be called. Program operation is as follows:

Line(s)	
510-530	Save processor registers
540-560	Calculate absolute address of 50th character in top line of display. The "CLNA" routine is dependent upon the type of display used, and places the address of character "B" of line "A" into the HL register.
570	Places an ASCII "0" in B, and an ASCII ":" in C.
580-610	Read a time digit from the CI2400, set the appropriate bits to make it a valid ASCII CODE, store it in video display memory, and increment the address pointer to

Figure 2

```
3DD8                *
3DD8                *
3DD8                *         MOVE PRESENT TIME FROM
3DD8                *          CL2400 TO VIDEO RAM
3DD8                *
3DD8 F5             TIME   DB    0F5H     PUSH PSW
3DD9 E5                    PUSH  H        SAVE HL
3DDA C5                    PUSH  B        SAVE BC
3DDB 06 32                 MVI   B,50     50TH CHAR IN
3DDD AF                    XRA   A        LINE NO 0
3DDE CD 32 3D              CALL  CLNA     GET ABS ADDRESS
3DE1 01 3A 30              LXI   B,303AH  ":" TO C, "0" TO B
3DE4 DB AF                 IN    0AFH     GET TENS HOURS
3DE6 B0                    ORA   B        BDC TO ASCII
3DE7 77                    MOV   M,A      STORE IN VDM RAM
3DE8 23                    INX   H        NEXT LOC
3DE9 DB AE                 IN    0AEH     GET HOURS
3DEB B0                    ORA   B        BCD TO ASCII
3DEC 77                    MOV   M,A      TO VDM RAM
3DED 23                    INX   H        NEXT LOC
3DEE 71                    MOV   M,C      STORE ":"
3DEF 23                    INX   H        NEXT LOC
3DF0 DB AD                 IN    0ADH     GET TENS MINUTES
3DF2 B0                    ORA   B        BCD TO ASCII
3DF3 77                    MOV   M,A      TO VDM RAM
3DF4 23                    INX   H        NEXT LOC
3DF5 DB A9                 IN    0A9H     GET MINUTES
3DF7 B0                    ORA   B        BCD TO ASCII
3DF8 77                    MOV   M,A      TO VDM RAM
3DF9 23                    INX   H        NEXT LOC
3DFA 71                    MOV   M,C      STORE ":"
3DFB 23                    INX   H        NEXT LOC
3DFC DB AA                 IN    0AAH     GET TENS SECONDS
3DFE B0                    ORA   B        BCD TO ASCII
3DFF 77                    MOV   M,A      TO VDM RAM
3E00 23                    INX   H        NEXT LOC
3E01 DB AB                 IN    0ABH     GET SECONDS
3E03 B0                    ORA   B        BCD TO ASCII
3E04 77                    MOV   M,A      TO VDM RAM
3E05 C1                    POP   B        RESTORE BC
3E06 E1                    POP   H        RESTORE HL
3E07 F1                    DB    0F1H     POP PSW
3E08 D3 A8                 OUT   0A8H     CLEAR CL2400 INTR
3E0A FB                    EI             ENABLE INTERRUPTS
3E0B C9                    RET            GO AWAY
3E0C                *
3E0C                *         RESTART 7 VECTOR
3E0C                *
3E0C                       ORG   38H
0038 C3 D8 3D              JMP   TIME     DISPLAY TIME
003B                *
003B                *
003B                *
003B                CLNA   EQU   3D32H    CALC CHAR ADDR
```

Figure 3

```
3F32              0010 *
3F32              0020 *          CL2400 SET TIME ROUTINE
3F32              0030 *
3F32              0040        ORG   3F32H
3F32  21 F0 3E    0050 STIME  LXI   H,ZERO     POINT TO ZERO
3F35  CD 58 3F    0060        CALL  SSEC       SET SECONDS TO 00
3F38  3E 04       0070        MVI   A,4        SET HOURS CODE
3F3A  D3 A9       0080        OUT   0A9H       OUT TO CL2400
3F3C  DB AF       0090 LOOP1  IN    0AFH       GET TENS HOURS
3F3E  BE          0100        CMP   M          DESIRED?
3F3F  C2 3C 3F    0110        JNZ   LOOP1      NO, LOOK AGAIN
3F42  23          0120        INX   H          POINT TO HOURS
3F43  DB AE       0130        IN    0AEH       GET HOURS
3F45  BE          0140        CMP   M          DESIRED?
3F46  C2 43 3F    0150        JNZ   LOOP2      NO, LOOK AGAIN
3F49  23          0160        INX   H          POINT TO TENS MINUTES
3F4A  DB AD       0170 LOOP3  IN    0ADH       GET TENS MINUTES
3F4C  BE          0180        CMP   M          DESIRED?
3F4D  C2 4A 3F    0190        JNZ   LOOP3      NO, LOOK AGAIN
3F50  23          0200        INX   H          POINT TO MINUTES
3F51  DB A9       0210 LOOP4  IN    0A9H       GET MINUTES
3F53  BE          0220        CMP   M          DESIRED?
3F54  C2 51 3F    0230        JNZ   LOOP4      NO, LOOK AGAIN
3F57  23          0240        INX   H          POINT TO TENS SECONDS
3F58  3E 02       0250 SSEC   MVI   A,Z        SET MINUTES CODE
3F5A  D3 A9       0260        OUT   0A9H       OUT TO CL2400
3F5C  DB AA       0270 LOOP5  IN    0AAH       GET TENS SECONDS
3F5E  BE          0280        CMP   M          DESIRED?
3F5F  C2 5C 3F    0290        JNZ   LOOP5      NO, LOOK AGAIN
3F62  23          0300        INX   H          POINT TO SECONDS
3F63  DB AB       0310 LOOP6  IN    0ABH       GET SECONDS
3F65  BE          0320        CMP   M          DESIRED?
3F66  C2 63 3F    0330        JNZ   LOOP6      NO, LOOK AGAIN
3F69  23          0340        INX   H          POINT TO NEXT
3F6A  3E 00       0350        MVI   A, 0       NORMAL RUN CODE
3F6C  D3 A9       0360        OUT   0A9H       OUT TO CL2400
3F6E  C9          0370        RET              DONE
3F6E              0380 *
3F66              0390 *        FOLLOWING ARE TWO ZEROS AND
3F66              0400 *        6 LOCATIONS USED TO PASS
3F66              0410 *        THE PRESENT TIME TO THE
3F66              0420 *        STIME ROUTINE
3F66              0430 *
3F66              0440        ORG   3EF0H
3EF0  00          0450 ZERO   DB    0
3EF1  00          0460        DB    0
3EF2              0470 H10    DS    1          TENS HOURS
3EF3              0480 HRS    DS    1          HOURS
3EF4              0490 M10    DS    1          TENS MINUTES
3EF5              0500 MINS   DS    1          MINUTES
3EF6              0510 S10    DS    1          TENS SECONDS
3EF7              0520 SECS   DS    1          SECONDS
```

Line(s)	
	point to the next character position.
620-840	Duplication of the above for the remaining 5 digits. Also places ":" in the proper locations.
850-870	Restore processor registers.
875	Clear the CL2400 interrupt flip-flops. This is required if the "TIME" routine is used as an interrupt handler.
880	Re-enable interrupts. Only required if "TIME" is used as an interrupt handler.
890	Return to calling program, or return from interrupt.
940	Sets up "TIME" to be run each time a level 7 interrupt occurs.

NOTES:

1. For hard-copy output, the 8 MOV M,A instructions can be replaced with CALL PRINT instructions, where the PRINT routine outputs the accumulator to a hard-copy device.
2. Video displays with dynamic relationships between character and memory locations, such as where a character in a given memory location is not always displayed in the same screen position, can require additional software to keep the time displayed.

Figure 3 shows an assembly language set routine for the CL2400. The desired time is passed to the "STIME" routine in locations H10, HR, M10, S10, and SEC. The routine operates as follows:

Line(s)	
50-60	Points to two successive zero bytes and clears the seconds digits.
70-80	Places clock in SET HOURS mode (minutes change 60 times per second).
90-120	Loop tests if first digit is desired digit passed to routine in H10 location.
130-240	3 more loops to test next 3 digits until equal to desired values.
250-260	Places clock in SET MINUTES mode (seconds change 60 times per second).
270-340	Last 2 loops to test seconds digit until equal to desired values.
350-370	Places clock in normal run mode and returns to calling program.

Line(s)	
450-460	Defines two zero bytes used to clear seconds digits.
470-520	Storage locations for 6 digits of time. Calling program places desired tine in these 6 locations.

THEORY OF OPERATION

The CL2400 circuitry can be roughly divided into four sections: 1) address decoding and control register, 2) time-keeping circuitry, 3) input data circuitry, and 4) interrupt circuitry. Refer to the schematic at the end of this manual to follow the circuitry descriptions.

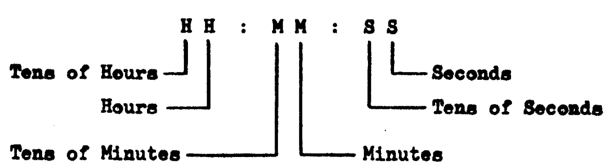
ADDRESS DECODING AND CONTROL REGISTER

Bus address lines A11 through A15 are presented to I.C.'s A12 and A13 through the 5 address jumpers. CL2400 ADDR (A13 pin 1) goes high whenever address lines A15 through A8 contain an address that satisfies the 3 high and 2 low requirements of the jumpers and A12 and A13. Gate A7 "ANDS" the SINP bus signal to create a READ (A7 pin 3) signal. READ enables the A16 & A11 input data drivers whenever the computer inputs from a peripheral address within the block of 8 CL2400 addresses. Additional sections of A12 and A13 "AND" SOUT and PWR signals to establish a WRITE (A8 pin 6) signal. If the computer outputs data to CL2400 base address +1, +2, +3, +5, +6, or +7 (+0 and +4 are eliminated by gate A7 pin 11), a seven bit register consisting of A15 (data out bits DO0-DO5) and one half of A10 (DO6) is strobed by A7 pin 8. Latched data bits 0-2 from A15 are presented to the mode control inputs of A1. Bits 3-5 determine the interrupt rate, and bit 6 (stored in A10) serves as the interrupt enable signal.

Bus address lines A8, A9 and A10 are presented to the digit select inputs of A1 through sections of A14 and A11 I.C.'s whenever the computer reads the clock. Transistors contained in A6 convert TTL signal levels to the 12 volts required by A1.

TIME-KEEPING CIRCUITRY

The MM5318 I.C., A1, contains all counters required to take a 60Hz input and keep the present time in 6 digit hours, minutes, seconds, (BCD) format as follows:



This requires digit select logic for selection of the digit to be read. The MM5318's digit select codes (pin 26, 27, and 28) are as follows:

Z Pin 28	Y Pin 27	Z Pin 26	Digit
12 v	12 v	12 v	Tens of hours
12 v	12 v	GND	Hours
12 v	GND	12 v	Tens of minutes
12 v	GND	GND	---------
GND	12 v	12 v	Seconds
GND	12 v	GND	Tens of seconds
GND	GND	12 v	Minutes
GND	GND	GND	---------

Control over the MM5318 counters is obtained with the HOLD (pin 16), SET MINUTES (pin 17), and SET HOURS (pin 18) signals from the control register. HOLD inhibits advancing of the counters, SET MINUTES advances the seconds counter at a 60Hz rate, and SET HOURS advances the minutes counter at a 60Hz rate.

The 60Hz input to the MM5318 is derived from the coumpter's +16 volt supply transformer. A 60 Hz signal from the transformer is routed from bus pin 64 to a half-wave rectifier consisting of D2, D3, and R1. R3, R4, C3, and C4 then filter line transients from the signal before it is presented to A1 pin 19. D4 ensures that the input 60Hz signal does not exceed the 12 volt supply created by R2, D1, and C2.

INPUT DATA CIRCUITRY

The BCD digit selected by address lines A8, A9, and A10 is available on pins 2-5 of A1, after a delay required for internal decoding. To allow for this delay, one-shot A4 is triggered each time a clock digit is read. Pin 13 of A4 causes a 3 - 4 microsecond pulse that enables a section of A11 to pull down the processor XRDY line. The XRDY signal is synchronized with the ∅2 clock externally (on the processor board).

The BCD digit is inverted by A2 and enabled onto bits DI0-DI3 when the READ signal is active. Bits DI4 and DI5 are always forced to 0, and bits DI6 and DI7 are forced to 0 by A8 pin 2 and A7 pin 11, respectively, unless address 310 or 314 is being read. Since CL2400 base address and base address +4 do not return a BCD digit from the MM5318, they are used to return interrupt enable status in bit DI6 and interrupt pending status in bit DI7.

INTERRUPT CIRCUITRY

When the clock is not being read, I.C. A5 gates the interrupt rate code from the control register (A15 pins 12, 7, and 10) to the digit select inputs of A1. This selects one of the six time digits to appear at the MM5318 BCD output. The least significant bit (LSB) of this digit is clocked by the PSYNC signal into I.C. A9. A3 then makes a comparison between the present state of the LSB, and the previous state stored in A9 pin 12. If a change occurs, A3 pin 3 makes a low to high transition, which clocks pin 3 of A10 to set the interrupt flip-flop, I.C. 10 pin 5. If INTERRUPT ENABLE (A10 pin 9) is active, A17 pin 11 pulls down the selected bus interrupt line.

To guard against erroneous setting of the interrupt flip-flop, the interrupt circuitry is disabled each time the clock is read. The READ signal from A8 pin 4 fires one-shot A4, causing pin 12 to go low for 16 microseconds. This disables the PSYN signal from changing the stored LSB, and disables the change signal from setting the interrupt flip-flop.

Once the interrupt flip-flop is set, it must be cleared by a program statement. Any output to CL2400 base address or base address +4 is decoded by A8 pin 2, which is ANDED with the WRITE signal by A17. Pin 3 of A17 clears the interrupt flip-flop.

TROUBLESHOOTING

NOTE: Routines in this section assume standard CL2400 addressing. Change port numbers as required if CL2400 is not set for 250-257, octal.

To check CL2400 address decoding and input buffer operating, load the following program:

(OCTAL) ADDRESS	(OCTAL) DATA	INSTRUCTION	PURPOSE
000	076	MVI A, 0	Move a zero to A
001	000		
002	323	OUT 251	Set clock to normal mode
003	251		
004	333	IN 253	Read seconds
005	253		

1. Examine 000000.
2. Single step 7 times to execution of IN instruction.
3. Data lights D4-D7 should be off, indicating that the CL2400 has decoded its address properly.
4. Data lights D0-D3 should be counting from 0 to 9 in binary at a one second rate.

To check the SET MINUTES mode of operation, change the data in address 001 of the above program from 000 to 002. After 7 single steps, D0-D3 should be counting at a 60Hz rate.

To check the SET HOURS mode of operation, change the data in address 001 of the above program from 000 to 004, and the data in address 005 from 253 to 251. After 7 single steps, D0-D3 should be counting at a 60Hz rate.

If the CL2400 operation appears to be faulty, refer to the theory of operation section and the schematic, and check the following:

NO RESPONSE FROM CL2400 ON INPUT INSTRUCTION

Single step the instruction IN 253 and stop when the 'INPUT' light is on. Check for a logic high at A13-1 (CL2400 ADDR) and A8-4 (READ). If not correct, check back through A12 and A13 to address bus signals. Check for a logic low at A16-1, A16-15, and A11-15. Ensure that the A16, A11 output buffers are transferring the correct logic level from the input to the output of each stage.

TIME DOES NOT CHANGE

Check for +12 VDC at A1-16 (HOLD). Output 000 to address 251. Single step the instruction IN 353 and stop when the 'INPUT' status light is on. Check all A1 voltages for the following:

Pin No.	Voltage (DC)
1	0
13	12
14	0
15	12
16	12
17	12
18	12
26	12
27	12
28	0

Check the 60Hz input at the anode of D3 for greater than 11 volts AC. Check A1-19 for an AC voltage of approximately 4.5 - 6 volts. This reading will vary according to the meter used, as it is a half wave rectified AC signal.

SECONDS CHANGE AND BOARD RESPONDS TO INPUT INSTRUCTION IN SINGLE STEP, BUT RUNNING PROGRAMS INPUT INCORRECT TIMES

Enter the following program:

(OCTAL) ADDRESS	(OCTAL) DATA	INSTRUCTION
000	333	IN 253
001	253	
002	303	JMP 0
003	000	
004	000	

The WAIT status LED should be on dimly as this program runs to indicate that the CL2400 is being given enough time to decode the digit select. If not, check A4-13 with an oscilloscope. A positive-going 3-4 microsecond pulse should be observed. Check A4-2 for a negative going trigger pulse. Check XRDY for negative going pulse.

NO INTERRUPTS CAN BE GENERATED

Ensure that the interrupt enable status signal from the processer is active (Excute an EI instruction). Output 140 octal to address 253. Check A1 pins 26, 27, and 28 for OV, 12V and 12V respectively. Check A2-3 for a logic level change every second. Check for an unchanging logic level on A9-12, and for a changing level on A3-3. A10-5 should go high if A3-11 is changing and A10-1 is high. Check that the logic low at A17-11 is jumpered to an interrupt bus line.

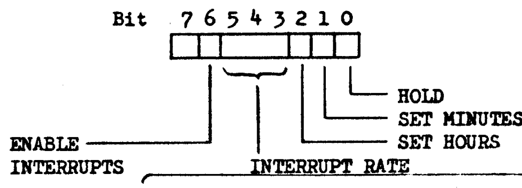
INTERRUPTS OCCUR WHEN CLOCK IS READ

Enter a program that executes an IN 253, 12 NOP's, and jumps back to repeat this sequence. Start the program and check A4-12 with an oscilloscope. A negative-going pulse of approximately 16 usec should be observed. Check A9-1 for a series of PSYNC pulses followed by a low level for approximately 16 usec.

CL2400 PROGRAMMING FORMAT

CONTROL REGISTER OUTPUT

Standard Address: 251 Octal
169 Decimal
A9 Hex

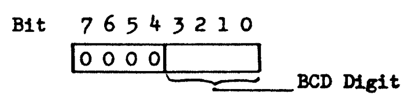


000 - 2/day (10:00 & 20:00)
001 - 1/hour
010 - 1/ten minutes
011 - none
100 - 1/second
101 - 1/ten secon[d]
110 - 1/minute
111 - none

OUTPUT DATA	DECIMAL OUTPUT
NORMAL	0
HOLD	1
SET MINUTES	2
SET HOURS	4
1/minute rate	48
1/ten seconds rate	40
1/second rate	32
1/ten minutes rate	16
1/hour rate	8
2/day rate	0
ENABLE INTERRUPTS	64

Correct decimal output is sum of desired control values listed above.

DATA INPUT



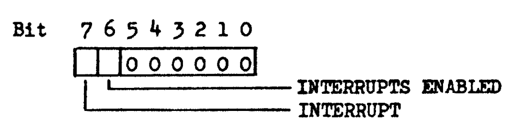
Standard Address:

Octal	Decimal	Hex	Digit
251	169	A9	Minutes
252	170	AA	Tens of seconds
253	171	AB	Seconds
255	173	AD	Tens of minutes
256	174	AE	Hours
257	175	AF	Tens of hours

INTERRUPT ACKNOWLEDGE (RESET) OUTPUT - Any output to address 250 octal, 168 168 decimal, A8 hex.

INTERRUPT STATUS INPUT

Standard Address: 250 Octal
168 Decimal
A8 Hex



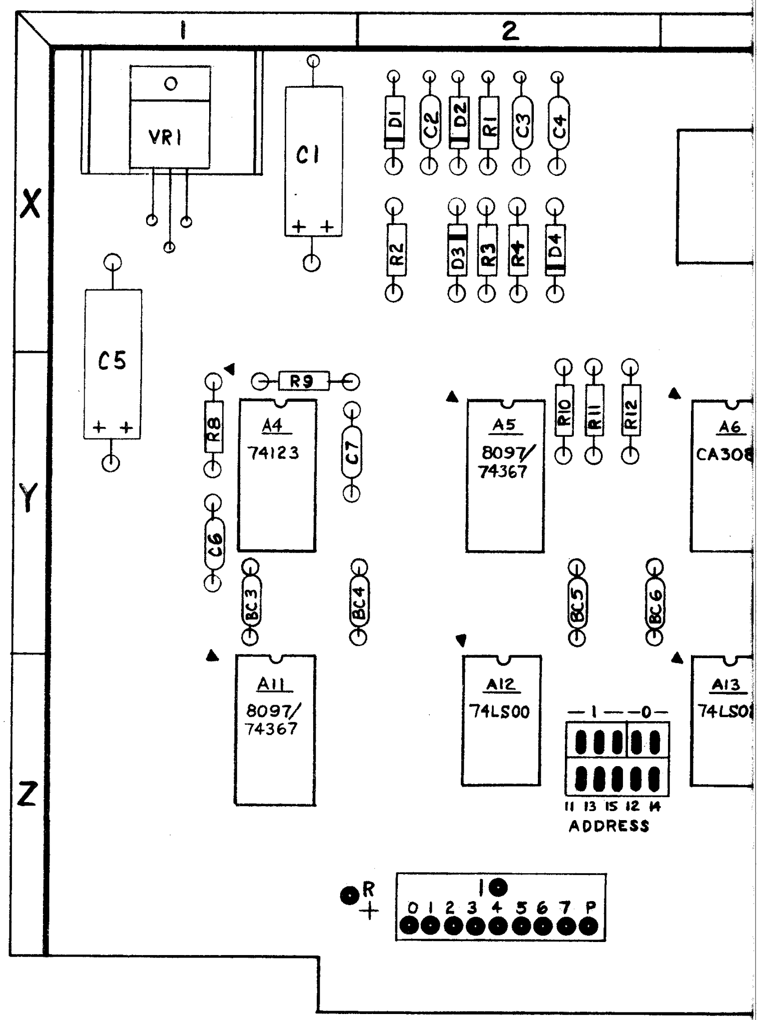
PARTS LIST - CONT'D

Quantity	Number	Description	Substitution
2	250103	.01uf DISC	______
2	253047	47uf, 25V	______
Sockets			
10	800014	14 Pin	______
6	800016	16 Pin	______
1	800028	28 Pin	______
Hardware			
8'	750000	Solder	______
4"	751000	#24 Bare Wire	______
3'	751001	#24 Wire	______
1	800100	Heat Sink	______
1	806005	5/16" 6-32 Screw	______
1	806098	6-32 Nut	______
1	806099	#6 Lockwasher	______
Circuit Board			
1	CB2400	CL2400 Circuit Board	______

NAME	VALUE	LOCATION
R1	2.2K	X2
R2	120	X2
R3	56K	X2
R4	56K	X2
R5	4.7K	X4
R6	4.7K	X4
R7	4.7K	X4
R8	10K	Y1
R9	10K	Y1

NAME	VALUE	LOCATION
R10	2.2K	Y2
R11	2.2K	Y2
R12	2.2K	Y2
R13	2.2K	Y3
R14	2.2K	Y3
R15	2.2K	Y3

NAME
C1
C2
C3
C4
C5
C6
C7
BC1-2
BC3-12



...E	LOCATION
'	X1
7	X2
	X2
	X2
	Y1
17	Y1
1	Y1
7	X4-X5
7	Y1-Y6

NAME	TYPE	LOCATION
D1	1N4742	X2
D2	1N4001	X2
D3	1N4001	X2
D4	1N4001	X2
VR1	7805	X1

CL2400 ASSEMBLY		
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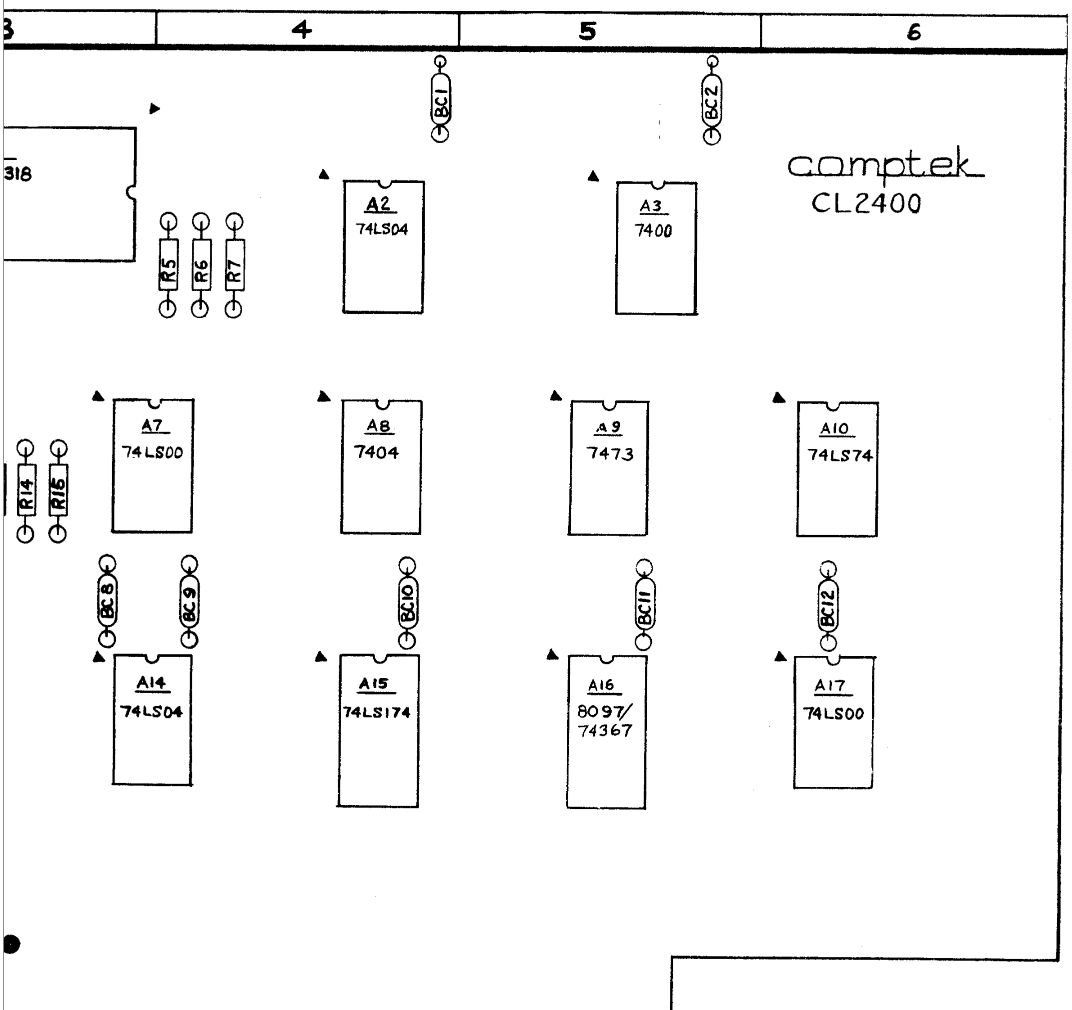
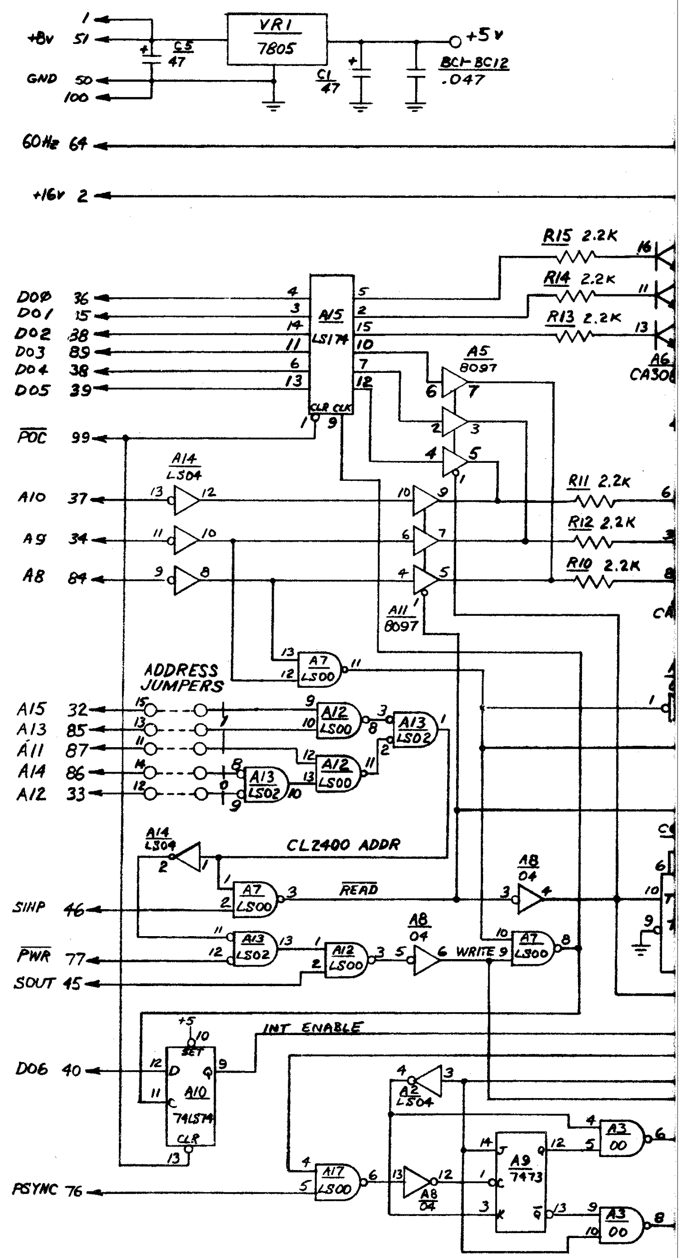
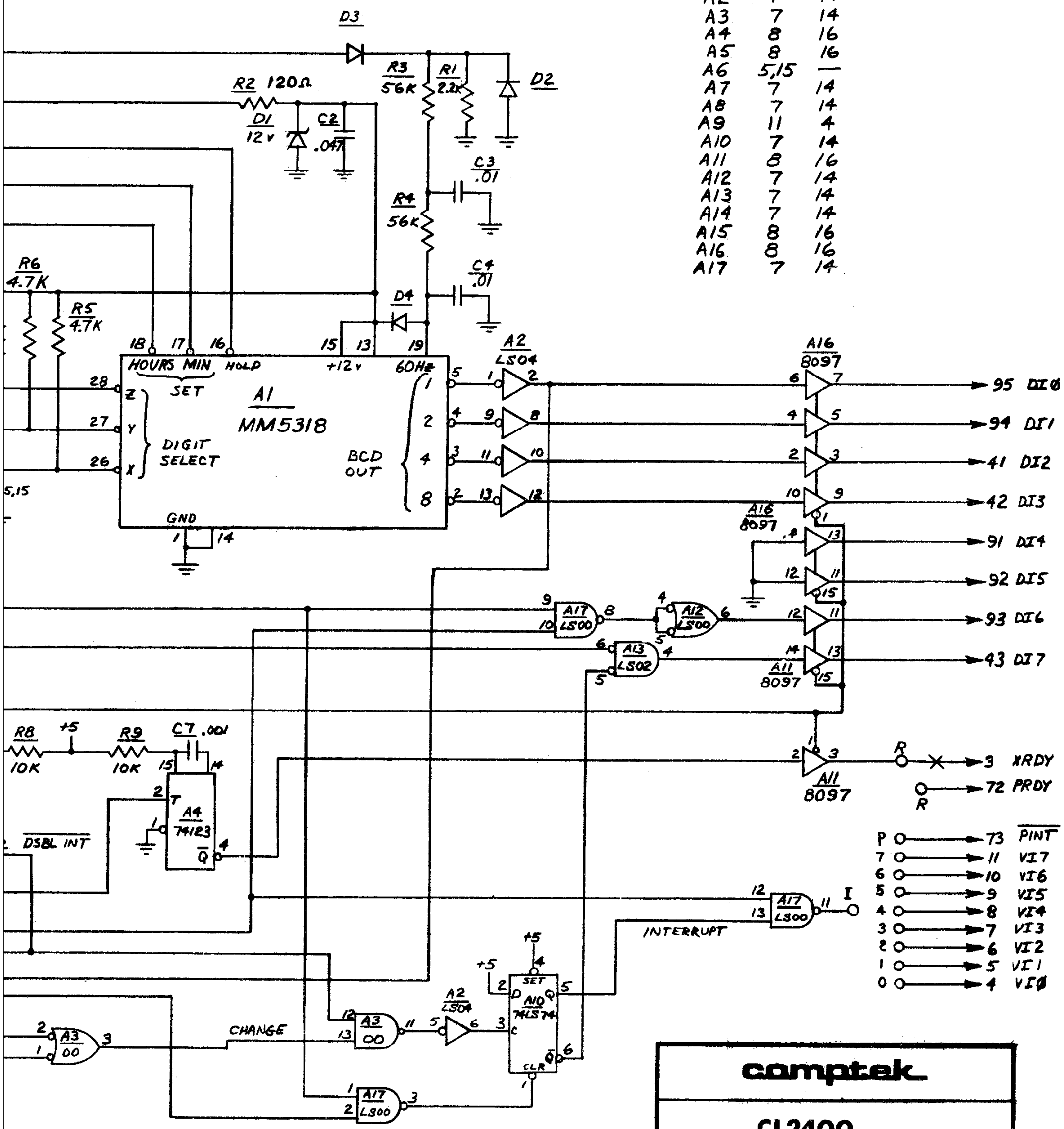




VR1
7805
+5V
+8V 51
GND 50
100
C5 47
C1 47
BC1-BC12 .047
60Hz 64
+16V 2
R15 2.2K
R14 2.2K
R13 2.2K
A6 CA30
DO0 36
DO1 15
DO2 38
DO3 89
DO4 38
DO5 39
A15 LS174
A5 8097
POC 99
A14 LS04
A10 37
A9 34
A8 84
R11 2.2K
R12 2.2K
R10 2.2K
A11 8097
A7 LS00
ADDRESS JUMPERS
A15 32
A13 85
A11 87
A14 86
A12 33
A12 LS00
A13 LS02
CL2400 ADDR
READ
A8 04
SINP 46
PWR 77
SOUT 45
WRITE
INT ENABLE
DO6 40
A10 74LS74
SET
CLR
A2 LS04
A3 00
A9 7473
A17 LS00
PSYNC 76



IC	GND	+5	+12
A1	14	—	15
A2	7	14	
A3	7	14	
A4	8	16	
A5	8	16	
A6	5,15	—	
A7	7	14	
A8	7	14	
A9	11	4	
A10	7	14	
A11	8	16	
A12	7	14	
A13	7	14	
A14	7	14	
A15	8	16	
A16	8	16	
A17	7	14	

comptek

CL2400
REAL TIME CLOCK

3-28-77	JKF	REVISION — A —

BEFORE STARTING

- - - - - MOS HANDLING PRECAUTIONS - - - - -

The MM5318 I.C. used on the CL2400 is an MOS circuit. This type of circuit is sensitive to static electricity build up. Leave the MM5318 in its special shipping foam and do not handle until directed to install it. Handle it only by the plastic case, and touch the circuit board with your hand before the MM5318 makes contact.

Be careful when soldering components onto the circuit board that no excess solder unintentionally connects adjacent circuit traces.

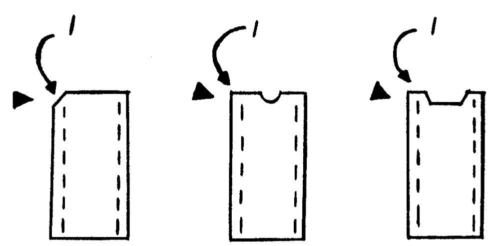
Check the contents of the six bags of parts against the parts list found in the REFERENCE MANUAL appendix. If any component substitutions were made, they are noted on the parts list. These substitutions will have to be referred to when the instructions call for a part for which there has been a substitution.

ASSEMBLY INSTRUCTIONS

Assembly of the CL2400 consists of soldering I.C. sockets and discrete components to the circuit boards, and adding a single wire to the computer motherboard. The assembly drawing located in the REFERENCE MANUAL appendix shows the correct location for each component. The component side of the circuit board has component outlines printed on it. Position the circuit board as shown on the assembly drawing, and mount the following components:

SOCKETS

Mount ten 14 pin I.C. sockets in locations A2, A3, A7, A8, A9, A10, A12, A13, A14, and A17. An arrow on the circuit board points to pin 1 of each I.C. Pin 1 of the socket is adjacent to the notched end as follows:



Insert a socket into the circuit board so that pin 1 on the socket is pointed to by the arrow. Turn the board over and solder all 14 pins to the pads on the opposite side of the board (tape may be used to temporarily hold the sockets in place while the board is turned over).

( ) A2 ( ) A8 ( ) A12 ( ) A17

( ) A3 ( ) A9 ( ) A13

( ) A7 ( ) A10 ( ) A14

Mount six 16 pin sockets in locations A4, A5, A6, A11, A15, and A16. Use the same procedure as above for the 14 pin sockets.

( ) A4 ( ) A6 ( ) A15

( ) A5 ( ) A11 ( ) A16

Mount the 28 pin socket in location A1 using the procedure described above.

( ) A1

RESISTORS

Install the 15 resistors by selecting the proper value, bending both leads 90° then inserting the resistor into the location shown on the assembly drawing. Turn board over and solder both leads to pads, then cut off excess leads. Resistors nos. R1, R10, R11, R12, R13, R14, and R15 are 2.2k, 1/4W (red-red-red).

( ) R1 ( ) R11 ( ) R13 ( ) R15

( ) R10 ( ) R12 ( ) R14

Resistor R2 is 120 OHM, 1/4W (brown-red-brown).

( ) R2

Resistors R3 and R4 are 56K, 1/4W (green-blue-orange).

( ) R3 ( ) R4

Resistors R5, R6, and R7 are 4.7K, 1/4W (yellow-violet-red).

( ) R5 ( ) R6 ( ) R7

Resistors R8 and R9 are 10.0K and have 10.0K or 1002 printed on them.

( ) R8 ( ) R9

CAPACITORS

Install the 19 capacitors, using the same procedure as the resisters above. Refer to the assembly drawing locations. Capacitors C1 and C5 are 47 uf electrolytics. The (+) side of these capacitors must be oriented exactly as shown on the assembly drawing. The (+) lead is marked on the body of the capacitor, and also on the circuit board.

( ) C1 ( ) C5

Capaciter C2 is a .047uf disc ceramic.

( ) C2

Capaciters C3 and C4 are .01 disc ceramics.

( ) C3 ( ) C4

Capaciter C6 is a .0047 uf disc ceramic (may be labled 4700pf).

( ) C6

Capaciter C7 is a .001 uf disc ceramic (may be labled 1000pf).

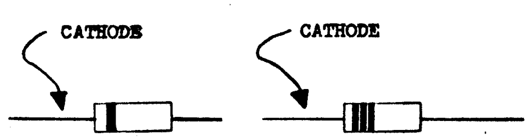
( ) C7

Bypass capacitors BC1-BC12 are .047 uf disc ceramics and are connected across the +5v and ground buses in 12 places as shown.

( ) BC1 - BC12

DIODES

Install the 4 diodes in the locations shown on the assembly drawing. The cathode (bar end) of each diode must be oriented exactly as shown on the drawing. The cathode end is always marked with one or more bands as follows:



Diode D1 is a 1N4742 12 volt zener.

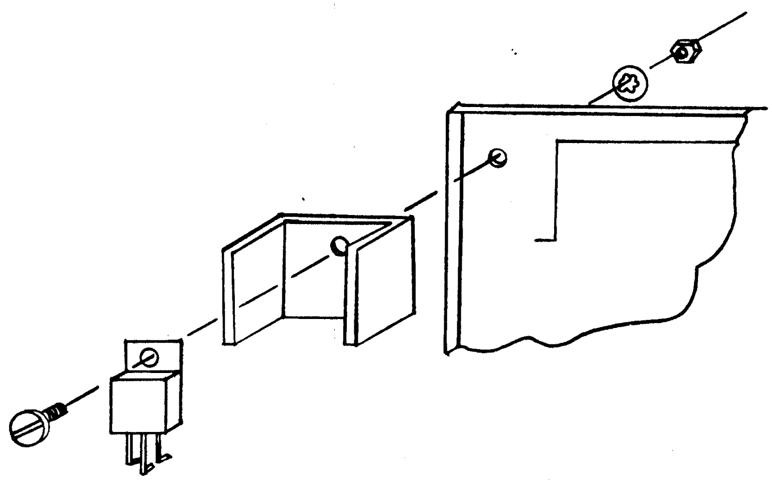
( ) D1

Diodes D2, D3, and D4 are 1N4001.

( ) D2 ( ) D3 ( ) D4

VOLTAGE REGULATOR

Align the mounting hole in the 7805 regulator with the hole in the circuit board. Determine the points at which to bend the 3 regulator leads so that they will go through the proper 3 holes on the board. Bend the leads 90° at these points. Mount the regulator and heat sink, using the 6-32 x 5/16" screw, #6 lockwasher, and #6 nut as shown:



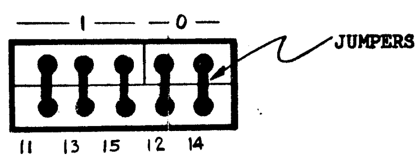
Turn board over and solder 3 leads to pads. Cut off any excess leads.

( ) Voltage regulator

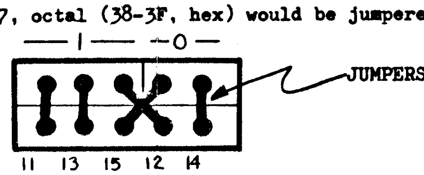
ADDRESS JUMPERS

The CI2400 uses 8 sequential I/O ports for communication with the CPU. There are 5 address selection jumpers located between I.C.'s A12 and A13 which are used to select between 10 possible starting addresses for the CL2400. The jumpers are associated with bus address lines A11, A12, A13, A14, and A15, as printed on the circuit board below the address selection jumpers. Of these 5 address lines, the CL2400 requires that 3 be set to a high state, and the remaining 2 set to a low state. In addition to the 5 pads for the address are 3 lines marked '1' and 2 lines marked '0' for selecting which address lines will be required to be high (1) and low (0) for the CL2400 to recognize its own block of addresses.

Standard CL2400 addressing uses I/O ports 250-257, octal (A8-AF, hex), which is accomplished by installing 5 bare wire jumpers as shown:



For other addressing, check the following list to see which address lines must be high (1) and which must be low (0), and install jumpers accordingly. Be sure to use the insulated wire for any jumpers that cross each other. For example, addresses 70-77, octal (38-3F, hex) would be jumpered as follows:



ADDRESSES USED			
Octal	Hex	ADDRESS LINES HIGH (1)	ADDRESS LINES LOW (0)
070-077	38-3F	11, 12, 13	14, 15
130-137	58-5F	11, 12, 14	13, 15
150-157	68-6F	11, 13, 14	12, 15
160-167	70-77	12, 13, 14	11, 15
230-237	98-9F	11, 12, 15	13, 14
250-257	A8-AF	11, 13, 15	12, 14

ADDRESSES USED		ADDRESS LINES HIGH (1)	ADDRESS LINES LOW (0)
Octal	Hex		
260-267	B0-B7	12, 13, 15	11, 14
310-317	C8-CF	11, 14, 15	12, 13
320-327	D0-D7	12, 14, 15	11, 13
340-347	E0-E7	13, 14, 15	11, 12

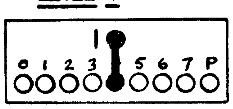
( ) Address Jumper

INTERRUPT LEVEL JUMPER

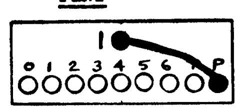
The interrupt level jumper is optional, and is only needed if the CL2400 interrupt capabilities are to be used. The interrupt level jumper is located in the lower left corner of the CL2400. If the system in which the CL2400 is to be installed has priority interrupt hardware, the CL2400 interrupt output 'I' can be jumpered to any priority level (0-7). This is done by connecting a bare wire jumper between the 'I' pad and any one of the eight priority level pads 0-7. If no priority interrupt hardware exists, the $\overline{\text{PINT}}$ bus line must be used. To use $\overline{\text{PINT}}$, connect a bare wire jumper from the 'I' pad to the 'P' pad located immediately to the right of the level 7 pad.

EXAMPLES:

LEVEL 4



$\overline{\text{PINT}}$



( ) Interrupt Jumper

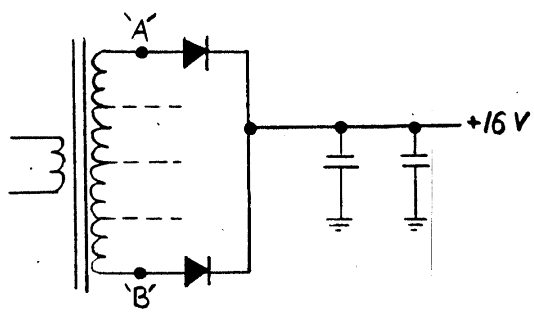
READY SIGNAL

NOTE: The following is required only if the CL2400 is to be used in a modified ALTAIR™ 8800.

The CL2400 uses the XRDY bus line to allow access time for the MOS clock I.C. Early ALTAIR™ machines have a logic conflict on the PRDY bus line caused by front panel logic gate X. If the system in which the CL2400 is to be used has been modified to move this conflict to the XRDY line, the CL2400 can be modified to use the PRDY line by cutting the circuit trace going to bus pin 3 (XRDY). This is marked with a '+' in the lower left corned of the circuit board. An insulated jumper must then be added between the two pads marked 'R'.

60Hz CLOCK INPUT

The CL2400 requires a 60Hz signal derived from the computer's +16V power supply. Strip 1/4" from one end of the enclosed jumper wire, and connect it to the motherboard bus line running between pin 64 of all circuit board connectors. Neatly route the wire along the side of the computer chassis to the power supply section. The jumper connection at the power supply end depends on the computer model. On the power supply schematic for the computer being used, locate the +16 volt supply. There will be two diodes connected to the transformer windings and capacitor (s) as follows:



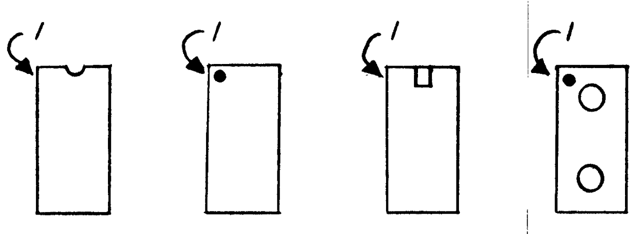
Connect the second end of the jumper from motherboard pin 64 to either point "A" or point "B" above. This is to the anode side of one of the diodes, signified as the end of the diode without the bands marked on it.

( ) 60Hz signal

INSTALLATION OF I.C.'s

Carefully install I.C.'s A2 through A17 (A1 will be installed later) by locating pin 1 on the I.C., and inserting the I.C. into the associated socket

so that the arrow on the circuit board points to pin 1. After installing each I.C., check that no pins have been bent under, shorted to adjacent pins, or bent out so as not to make contact with the socket. Pin 1 can be located as follows:



( ) **A2 and A14 are** 74LS04

( ) **A3 is** 7400

( ) **A4 is** 74123

( ) **A5, A11, and A16 are** 8097

( ) **A6 is** CA3081

( ) **A7, A12, and A17 are** 74LS00

( ) **A8 is** 7404

( ) **A9 is** 7473

( ) **A10 is** 74LS74

( ) **A13 is** 74LS02

( ) **A15 is** 74LS174

The CL2400 is now ready for checkout.

CHECKOUT

The following procedures assume that the CL2400 uses standard addresses (250-257, octal). Changes for non-standard addressing follow each program. With the computer power turned off, plug the CL2400 into a connector on the computer motherboard. Turn on the computer and load the following program:

(OCTAL) ADDRESS	(OCTAL) DATA	INSTRUCTION	PURPOSE
000	006	MVI B, 250	First input from 250
001	250		
002	170	MOV A, B	Get next input address
003	062	STA 007	Put address in address 007
004	007		
005	000		
006	333	IN (XXX)	Read Clock
007	000		Clock input address
010	004	INR B	Add 1 to address
011	303	JMP 002	Do again
012	002		
013	000		

Non-standard addressing changes: Change location 001 to the base address of the CL2400.

This routine will cause the computer to input from peripherals 250-257. To run:

1. Examine address 000000.
2. Single step 9 times (to execution in "IN" instruction). INP status light should now be on, and A7-A0 lights should read 250. Data lights should be off. Lights D6 & D7 can be off or on.
3. Single step 12 more times (back to same "IN" instruction). A7-A0 should read 251, D7-D0 should be off.
4. Repeat step 3 six more times to input all peripheral addresses from 250-257. D7-D0 should be off for all addresses except 250 and 254, where D6 or D7 may be lit.

Correct operation of the above program indicates proper address decoding and output buffer operation. If program execution was in error, refer to the theory and troubleshooting sections.

With a DC voltmeter, check the +12 V supply at pin 15 of the socket for I.C. A1. The reading should be between 11.0 and 13.0 V. Turn off power to the computer and remove the CL2400.

Reread the MOS handling precaustions in the "BEFORE STARTING" section.

( ) Install the MM5318 I.C. in location A1 making sure the arrow on the circuit board points to pin 1 of the I.C.

Re-install the CL2400 in the computer and apply power. Load the following program:

(OCTAL) ADDRESS	(OCTAL) DATA	INSTRUCTION	PURPOSE
000	076	MVI A, 0	0= Normal operation
001	000		
002	323	OUT 251	Output to clock control
003	251		
004	333	IN 253	Read "seconds" digit
005	253		
006	076	MVI A, 2	2 = Fast Seconds
007	002		
010	323	OUT 251	Output to clock control
011	251		
012	333	IN 253	Read seconds digit
013	253		
014	076	MVI A, 4	4 = Fast minutes
015	004		
016	323	OUT 251	Output to clock control
017	251		
020	333	IN 251	Read minutes digit
021	251		

Non-standard addressing changes: Change the following locations to the CL2400 (base address + 1): 003, 011, 017, 021. Change the following locations to the CL2400 (base address + 3): 005, 013.

This routine will check 3 operating modes of the CL2400. To run:

1. Examine address 000000.
2. Single step 7 times (to execution of "IN" instruction). INP status light should be on and A7-A0 lights should read 253. D3-D0 data lights should be continuously counting in binary from 0 to 9 at a one second rate (seconds digit is being displayed).
3. Single step 8 more times. D3-D0 data lights should be counting from 0 to 9 at a rate of 60 counts per second.

4. **Single step 8 more times. D3-DO should act as in step 3 above. A7-AO reads 251 to indicate minutes being displayed instead of seconds.**

Your CL2400 REAL TIME CLOCK is now ready to be used as a self contained clock.