

FCM7001 FCM7002 FCM7003 FCM7004

DIGITAL CLOCK/CALENDAR CIRCUITS

CONSUMER PRODUCTS

GENERAL DESCRIPTION - The FCM7001, FCM7002, FCM7003 and FCM7004 are versatile MOS/LSI Digital Clock/Calendar Circuits. Decoded 7-segment outputs or BCD outputs are available.

- FCM7001/7004 FOR LED DISPLAYS
- FCM7002 FOR BCD OUTPUT
- FCM7003 FOR GAS DISCHARGE DISPLAYS
- 4-YEAR CALENDAR (FCM7004 IS EUROPEAN FORMAT)
- 12/24 HOUR CLOCK
- 24-HOUR ALARM CYCLE
- 4/6 DIGIT DISPLAY
- ON-CHIP BACK-UP OSCILLATOR
- CLOCK RADIO FEATURES
- SIMPLE SETTING OF ALL REGISTERS
- OUTPUTS MAY BE WIRED-OR TO SHARE DISPLAY
- 9-HOUR, 59-MINUTE TIMER
- 10-MINUTE DOZE
- LOW VOLTAGE INDICATION
- 50/60 Hz OPERATION

PIN NAMES

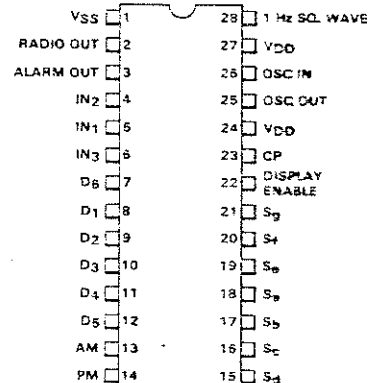
D ₁ - D ₆	Digit Outputs
S _a - S _g	Segment Outputs (FCM7001, FCM7003, FCM7004)
IN ₁ - IN ₃	Setting and Control Inputs
Radio Output	Active HIGH dc Output
Alarm Output	Active HIGH dc Output
CP	50/60 Hz Sine Wave Input
Display Enable	Active HIGH Input
Q ₀ - Q ₃	Active HIGH BCD Outputs (FCM7002)
Time	Data Outputs other than Time of Day, Active HIGH (FCM7002)
DS	Data Strobe, Active LOW Output (FCM7002)
OSC IN	External Timebase Input
OSC OUT	Oscillator Feedback Output

ABSOLUTE MAXIMUM RATINGS (above which the useful life may be impaired)

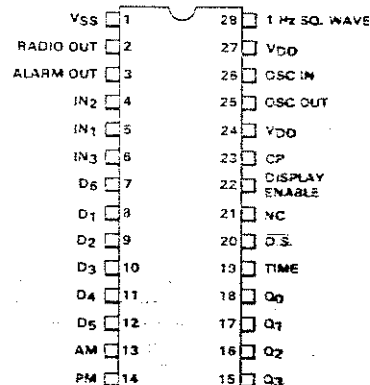
Voltage on any pin relative to V _{SS} (Except S _a to S _g)	+0.3 V to -20 V
1 Hz Sq. Wave, D ₁ to D ₆ , AM, PM	
Voltage on S _a to S _g , 1 Hz Sq. Wave, D ₁ to D ₆ , AM, PM relative to V _{SS}	+0.3 V to V _{DD} -25 V
Operating Temperature (Ambient)	0°C to 70°C
Storage Temperature (Ambient)	-55°C to 150°C

CONNECTION DIAGRAMS (TOP VIEW)

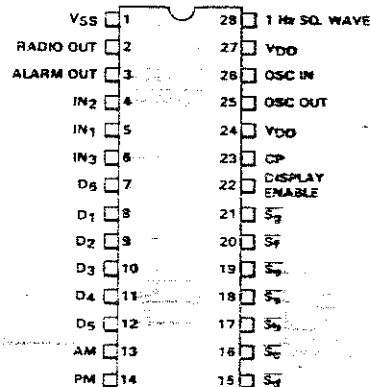
FCM7001/FCM7004



FCM7002

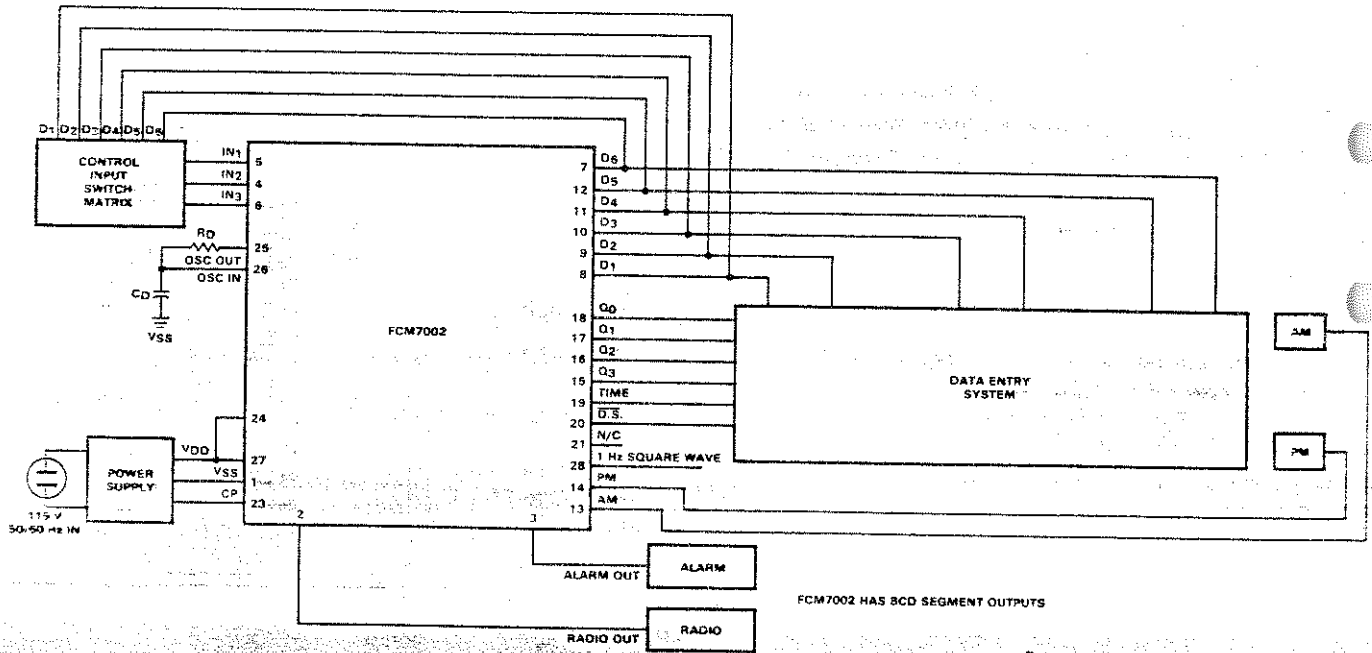
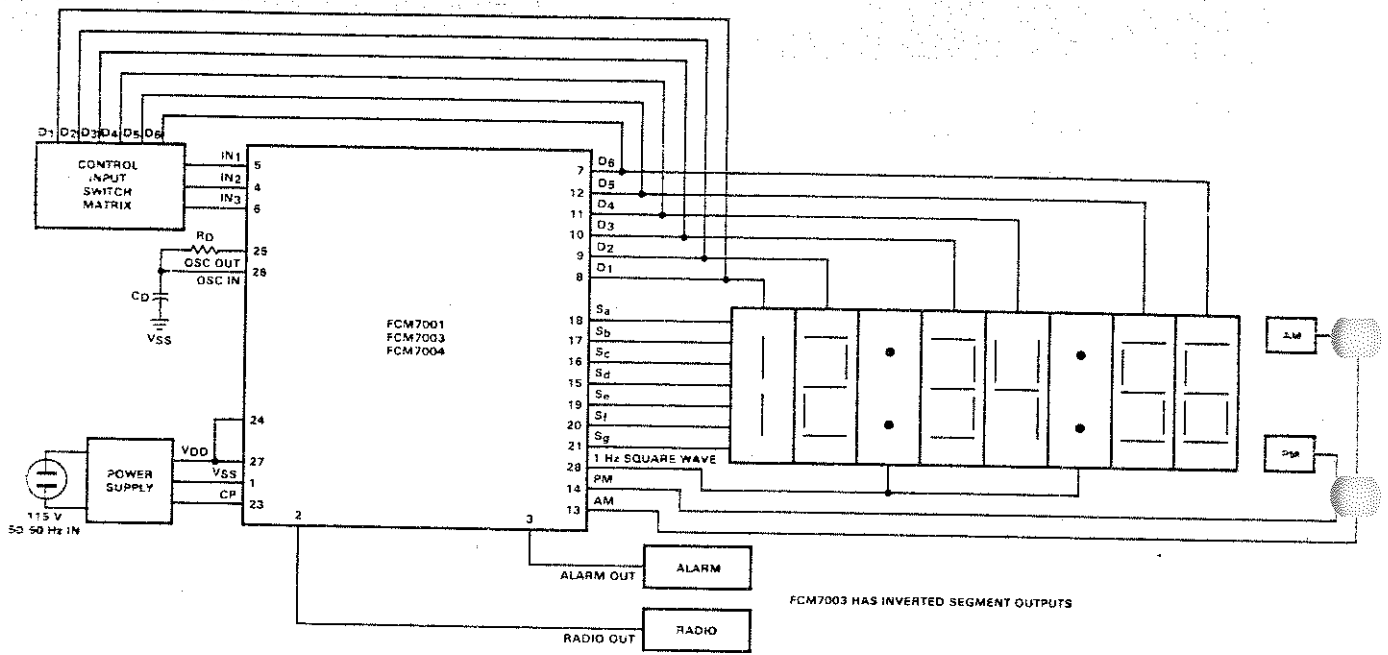


FCM7003



FCM7001 • FCM7002 • FCM7003 • FCM7004 DIGITAL CLOCK/CALENDAR CIRCUITS - CONSUMER PRODUCTS

TYPICAL SYSTEM BLOCK DIAGRAMS



FAIRCHILD • FCM7001 • FCM7002 • FCM7003 • FCM7004

FUNCTIONAL DESCRIPTION – The FCM7001 through FCM7004 accommodates either four or six 7-segment displays. The outputs may be wired OR to share the display with other logic devices or blanked through use of the Display-Enable pin. The circuits incorporate a backup oscillator to maintain timing in the absence of the line frequency.

CLOCK: 12-hour display with AM/PM indication or 24-hour display is user selectable. The FCM7001 and FCM7004 have 7-segment decoded outputs suitable for driving LEDs with 75491A segment drivers and 75492 digit drivers. The FCM7003 has active LOW 7-segment decoded outputs which withstands +.3 V to $V_{DD} - 25$ V, making it suitable for driving Gas discharge displays. The FCM7002 has BCD segment output information for interface in industrial timer applications. Continuous clock, continuous calendar, or alternating display is user selectable. A 24-hour alarm cycle with a 10-minute doze feature is provided. A programmable timer with 9-hour, 59-minute capacity allows "sleep to music" and/or "wake to music" for the preset period in clock radio configuration.

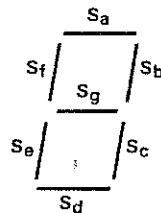
CALENDAR: A four year calendar which displays month and date is included. The FCM7004 is identical to the FCM7001 with the exception that calendar data is presented in European format, *i.e.*, day, month, *e.g.*, 27 07 for July 27.

SETTING: The register to be set is selected by the set clock/alarm/calendar/sleep timer inputs, which cause the contents of the applicable register to appear at the display outputs. The digits to be set are selected by the set hours/minutes inputs. When the setting input is activated the selected digits are advanced at a 1 Hz rate. Contents of unselected registers and digits are not disturbed by the setting operation. The seconds counter is reset to zero when the set clock and the set minutes inputs are activated. When set clock is deactivated, the seconds counters resume counting at a 1 Hz rate.

BCD OUTPUTS: Data is encoded per Table A. Pin 19 is HIGH at digit 6 time when data other than time of day is being displayed.

TABLE A DECODING OF SEGMENT DRIVER OUTPUTS

FCM7001/FCM7003/FCM7004



FCM7002

Q ₃	Q ₂	Q ₁	Q ₀	DATA
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9

ELECTRICAL CHARACTERISTICS: $T_A = 25^\circ\text{C}$. Voltages are referenced to $V_{SS} = 0$ V

CHARACTERISTIC	MIN	MAX	UNITS	NOTES
V_{DD} , Supply Voltage	-17.0	-10.0	V	
I_{DD} , Supply Current at -10.0 V		10	mA	
INPUTS: IN ₁ , IN ₂ , IN ₃				
V_{IN} "1" level	-5.0	+0.3	V	3
V_{IN} "0" level		$V_{DD} + 0.5$	V	
CP, OSC IN, Display Enable				
V_{IN} "1" level	-1.0	+0.3	V	
V_{IN} "0" level		$V_{DD} + 0.5$	V	
All Inputs at $V_{IN} = -17$ V		25	μA	2, 4
OUTPUTS: Radio Out, Alarm Out				
I_{OUT} "1" level at $V_{OUT} = -1.0$ V	0.5		mA	1
I_{OUT} "0" level at $V_{OUT} = V_{DD}$		25	μA	
D ₁ to D ₆ ; S _a to S _g ; 1 Hz Sq. Wave, AM, PM				
I_{OUT} "1" level at $V_{OUT} = -4.0$ V	5.0		mA	1
I_{OUT} "1" level at $V_{OUT} = -1.0$ V	1.0		mA	
I_{OUT} "0" level at $V_{OUT} = -35.0$ V		25	μA	
OSC Out				
I_{OUT} "1" level at $V_{OUT} = -1.0$ V	0.4		mA	
I_{OUT} "0" level at $V_{OUT} = V_{DD} + 1.0$ V	40.0		μA	

NOTES:

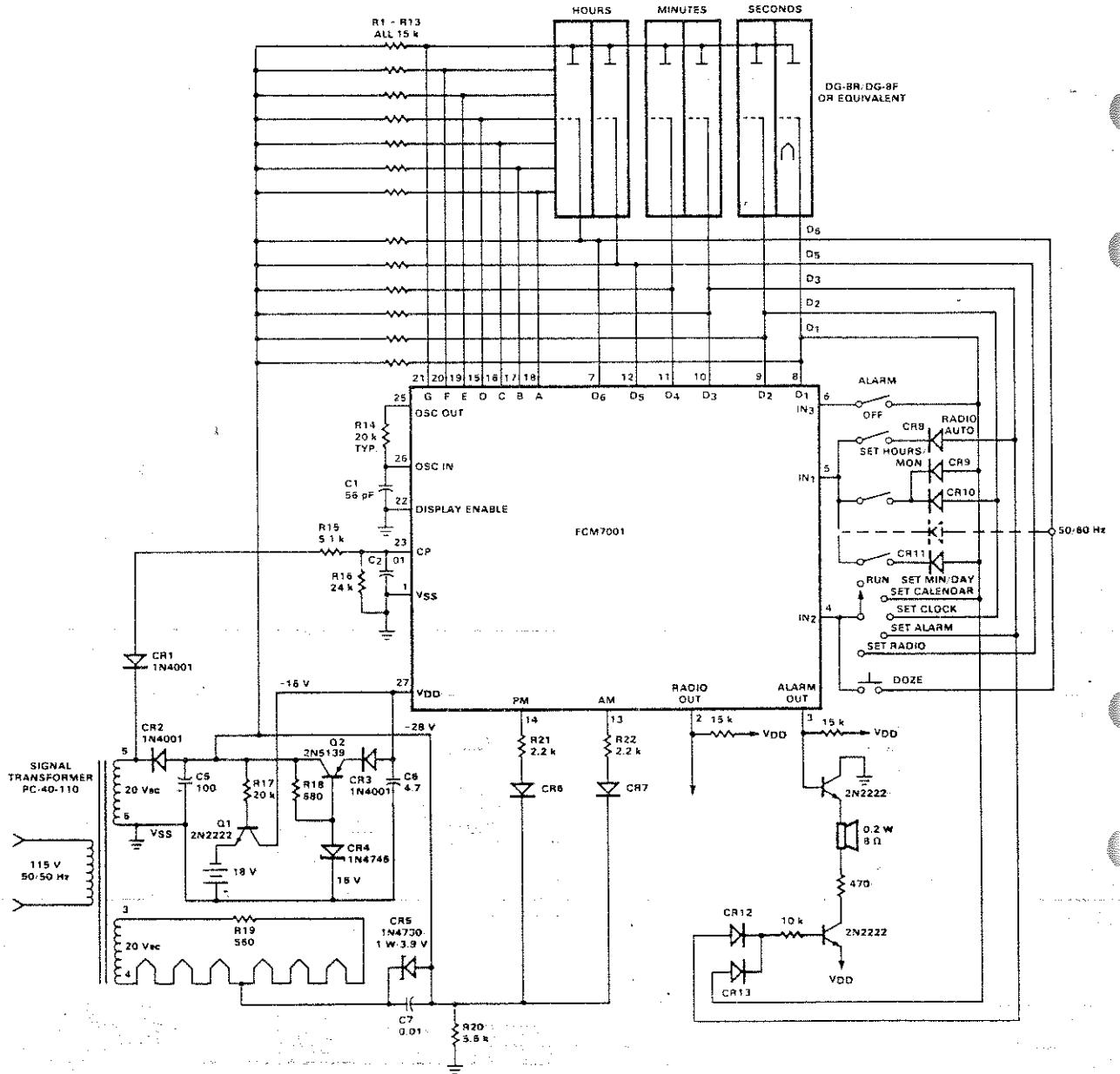
1. Open Drain Output – external pull-down resistors to V_{DD} required.
2. Voltage swing on CP should be $V_{SS} - 1$ V min. to $V_{DD} - 6 \pm 4$ V, with a max of -20 V, not to be exceeded.
3. On inputs IN₁, IN₂, IN₃, an internal 125 k Ω (typ) resistor to V_{DD} is provided.
4. $V_{DD} = -17$ V and $V_{SS} = 0$ V.

DIGITAL CLOCK/CALENDAR CIRCUITS

DISPLAYS

The FCM7001 accommodates either four or six standard 7-segment displays. The circuit direct drives fluorescent common-anode display tubes (see Figure 1). The FCM7001 can also be used to drive common-cathode LEDs. When the display-Enable input (pin 22) is connected to V_{DD}, the segment, digit, AM/PM, and 1 Hz outputs float (open drain) and the IN₁, IN₂ and IN₃ conditioning and setting inputs are disabled. This allows circuit segment and digit outputs to be wired-OR to share a common display with another chip, such as a calculator.

FCM7001 FLUORESCENT DISPLAY INTERFACE



NOTE: All resistors are 1/4 W in ohms.
All capacitor values are in microfarads.

Fig. 1

DIGITAL CLOCK/CALENDAR CIRCUITS (Cont'd)

Options. There are three normal display options. Refer to scanned input options Table B and Figure 3.

1. With no connection between IN₃ and D₃ or D₄, the display presents time in hours and minutes during units seconds (D₆) counts "0" through "7". During units seconds counts "8" and "9", the display will present the month and date.
2. Connecting IN₃ and D₄ causes the calendar to be displayed continuously.
3. Connecting IN₃ and D₃ causes the clock to be displayed continuously. Both AM and PM are active only during the clock and alarm (12-hour display) display presentations. See Figure 4 for FCM7002 TIME (pin 19) output conditions during other than clock display.

TABLE B
SCANNED INPUT OPTIONS

INPUT PIN	SCAN TIME	INPUT NAME	DEFINITION, CONNECTION	DEFINITION, NO CONNECTION
IN ₁	D ₁	Set	Advance Selected Counter	Advance Selected Counter Disabled
IN ₁	D ₂	Set Hour/Minute	Select Set Hour or Month Digits	Select Set Minute or Day Digits
IN ₁	D ₃	Clock Radio Switch	Clock Radio Switch - On	Clock Radio Switch - Off
IN ₁	D ₄	Mode A	Mode A - Off	Mode A - On
IN ₁	D ₅	Mode B	Mode B - On	Mode B - Off
IN ₁	D ₆	50/60 Hz	50 Hz Input	60 Hz Input
IN ₂	D ₁	Set Calendar	Set Calendar Counter	Set Calendar Disabled
IN ₂	D ₂	Set Clock	Set Clock Counter	Set Clock Counter Disabled
IN ₂	D ₃	Set Alarm	Set Alarm Counter	Set Alarm Counter Disabled
IN ₂	D ₅	Set Clock Radio	Set Clock Radio Counter	Set Clock Radio Counter Disabled
IN ₂	D ₆	Doze Switch	Doze Switch - On	Doze Switch - Off
IN ₃	D ₁	Alarm Switch	Alarm Switch - On	Alarm Switch - Off
IN ₃	D ₂	12/24 Hour	24-Hour Operation	12-Hour Operation
IN ₃	D ₃	C1	View Clock	Alternating Display Mode
IN ₃	D ₄	C2	View Calendar	Alternating Display Mode

NOTE:

For FCM7004, IN₁ connected to D₂ selects set hour or date digits.

IN₁ not connected to D₂ selects set minutes or month digits.

SCANNING INPUT CONNECTION SCHEME

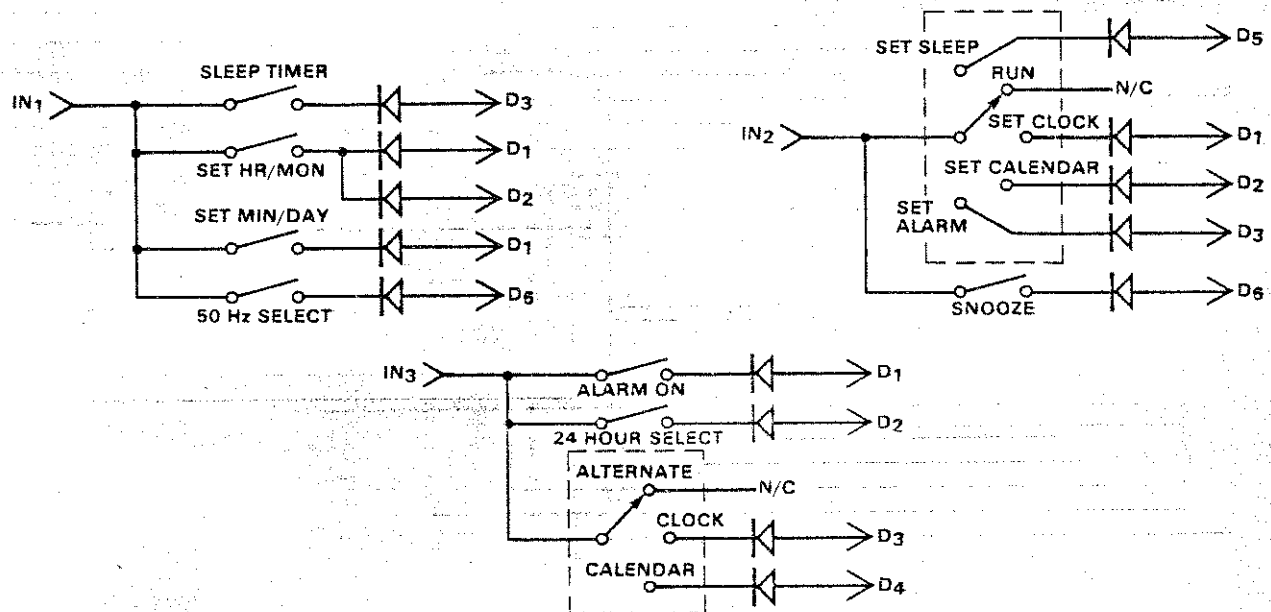


Fig. 3

NOTE: Depending on the functions utilized and the physical configuration of the switches in the clock system, it may be necessary to use diodes in the digit scan lines to the conditioning inputs. The diodes prevent shorting between digits when multiple digit times are connected to the same input simultaneously.

DIGITAL CLOCK/CALENDAR CIRCUITS (Cont'd)

BCD OUTPUT TIMING 100.8 kHz OSCILLATOR FREQ. (FCM7002 Only)

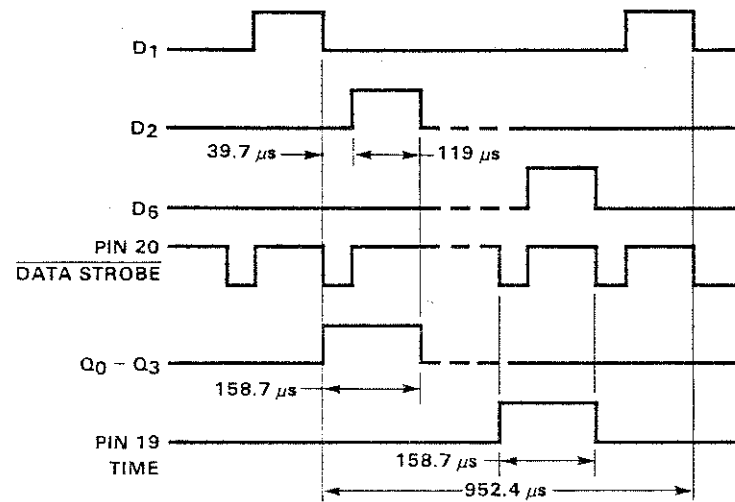


Fig. 4

DIGIT TIMING 100.8 kHz OSCILLATOR FREQ.

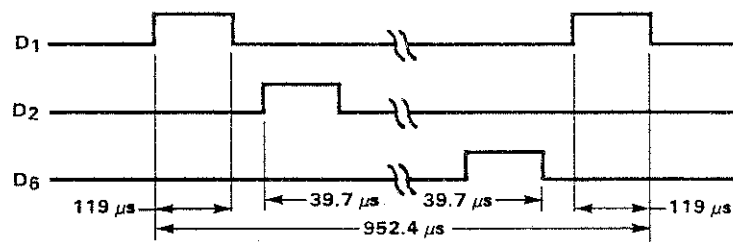


Fig. 5

SEGMENT TIMING 100.8 kHz OSCILLATOR FREQ.

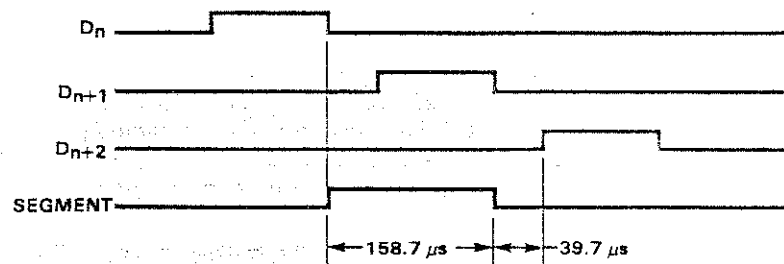


Fig. 6

DIGITAL CLOCK/CALENDAR CIRCUITS (Cont'd)

Clock Options. The two 24-hour options are:

1. 12 hours with AM or PM (01:00 00 to 12:59 59).
2. 24 hours (00:00 00 to 23:59 59).

These options are selected with the 12/24 hour conditioning input. For the 24-hour option, IN₃ is connected with a diode to D₂. See Figure 3 and Table B. The FCM7001, FCM7002, FCM7003 and FCM7004 clock displays hours, minutes and seconds. To economize display costs, only hours and minutes (month and date) display elements may be used. See Figure 7.

FCM7001/FCM7003/FCM7004 CIRCUIT BLOCK DIAGRAM

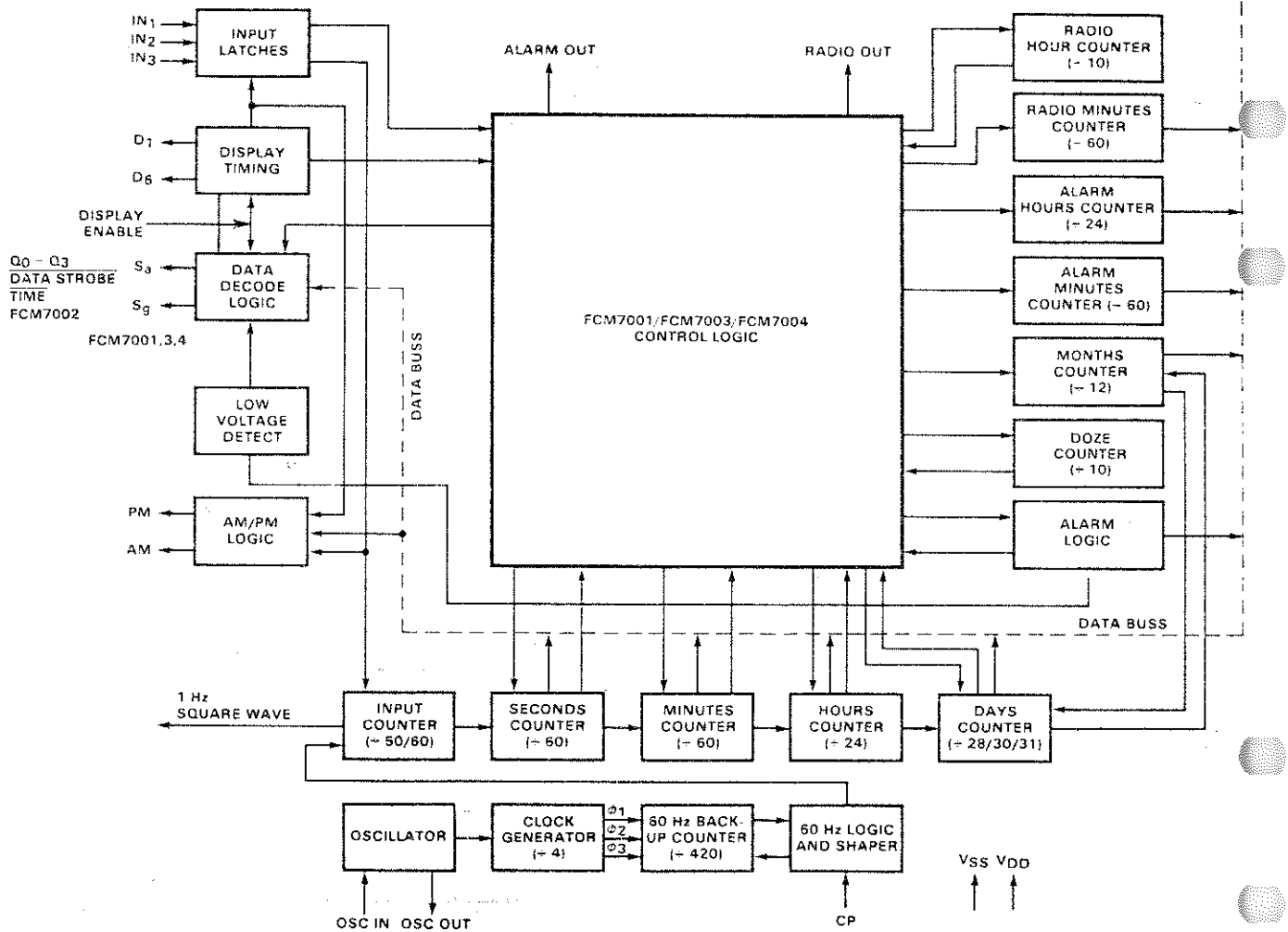


Fig. 7

Four Year Calendar. The calendar displays month and date. The date counter counts the correct number of days for each month. The normal count for February is 28 days. February 29 must be manually set. The calendar automatically counts from February 29 to March 1. Refer to digit multiplexing Table C for calendar information presentation on the display. FCM7004 is electrically identical to FCM7001 except that the calendar information for the FCM7004 is European format. The months and date for the FCM7004 are reversed in the calendar column of digit multiplexing Table C.

Alarm. The alarm is a true 24-hour alarm. To enable the alarm, connect a diode between IN₃ and D₁, see Figure 3 and Table B. The alarm out (pin 3) goes HIGH when the time is coincident with the preset alarm time register. To terminate the alarm the IN₃ to D₁ connection must be opened for approximately one minute beyond alarm time.

Doze Alarm. When alarm out (pin 3) is HIGH, the 10-minute doze alarm feature may be activated. This is accomplished by momentarily connecting IN₂ to D₆. The doze alarm feature may be activated as many times as desired until the alarm out is disabled by opening the IN₃ to D₁ connection.

DIGITAL CLOCK/CALENDAR CIRCUITS (Cont'd)

Clock Radio Options. There is a 9-hour and 59-minutes counter, settable in 1-minute increments, that is associated with the alarm and clock radio logic. This counter can be used to turn on the clock radio for the preset period of time. If the FCM7001 is not used in a clock radio application, this counter can be used as an auxiliary appliance timer or for any other timing operation. Refer to Table B and Figure 3.

Clock Radio Outputs

- A. The Radio-Out output (pin 2) will go HIGH for the preset timer setting period by closing the clock radio switch and can be terminated prematurely by opening the clock radio switch. Mode A and Mode B inputs must be off for this condition. See Table D.
- B. Radio-Out will go HIGH for the preset time period and also go HIGH at the alarm time. This condition is initiated by closing the clock radio switch and having Mode A input on and Mode B input off.
- C. The Radio-Out will be HIGH for the preset time starting at the alarm time if the clock radio switch is closed and Mode A and Mode B inputs are on. See Table D.

Setting Counters. There are four independently settable counters: clock, calendar, alarm and clock radio. First, select the counter to be set (see Table B and Figure 3). This results in the display showing the contents of the selected register. The digits to be set, either hours/months or minutes/date, are selected with the set hour/minute conditioning inputs (for FCM7004, the digits set are either hours/date or minutes/month).

Connecting IN₁ to D₁ and D₂ with diodes selects and advances the hour/month digits at 1 Hz rate. Connecting only IN₁ to D₁ with a diode selects and advances the minute/date digits at a 1 Hz rate.

The contents of the seconds counter are frozen when the clock register is selected for setting. Resetting of the seconds counter to "00" occurs when the clock register is selected for setting and either hours or minutes are advanced. The seconds counter begins counting when the chip is released from set clock.

TABLE C
DIGIT MULTIPLEXING

DIGIT TIME	TIME	CALENDAR	DIGIT TIME	TIME	CALENDAR
D ₁ - Pin 8	10 Hours	10 Months	D ₄ - Pin 11	1 Minute	1 Date
D ₂ - Pin 9	1 Hour	1 Month	D ₅ - Pin 12	10 Seconds	
D ₃ - Pin 10	10 Minutes	10 Date	D ₆ - Pin 7	1 Second	

NOTE: For FCM7004 months and date are reversed in the calendar column.

TABLE D

	Mode A	Mode B	Clock/Radio Switch	Radio-Out, Pin 2
A	IN ₁ = D ₄	IN ₁ ≠ D ₅	IN ₁ = D ₃	HIGH for preset timer setting
	IN ₁ = D ₄	IN ₁ ≠ D ₅	IN ₁ ≠ D ₃	Terminates Radio-Out prematurely
B	IN ₁ ≠ D ₄	IN ₁ ≠ D ₅	IN ₁ = D ₃	HIGH for preset timer setting and HIGH at alarm time
C	IN ₁ ≠ D ₄	IN ₁ = D ₅	IN ₁ = D ₃	HIGH for preset timer time starting at alarm time

NOTE: "=" Signifies connection required.
"≠" signifies no connection.

DIGITAL CLOCK/CALENDAR CIRCUITS (Cont'd)

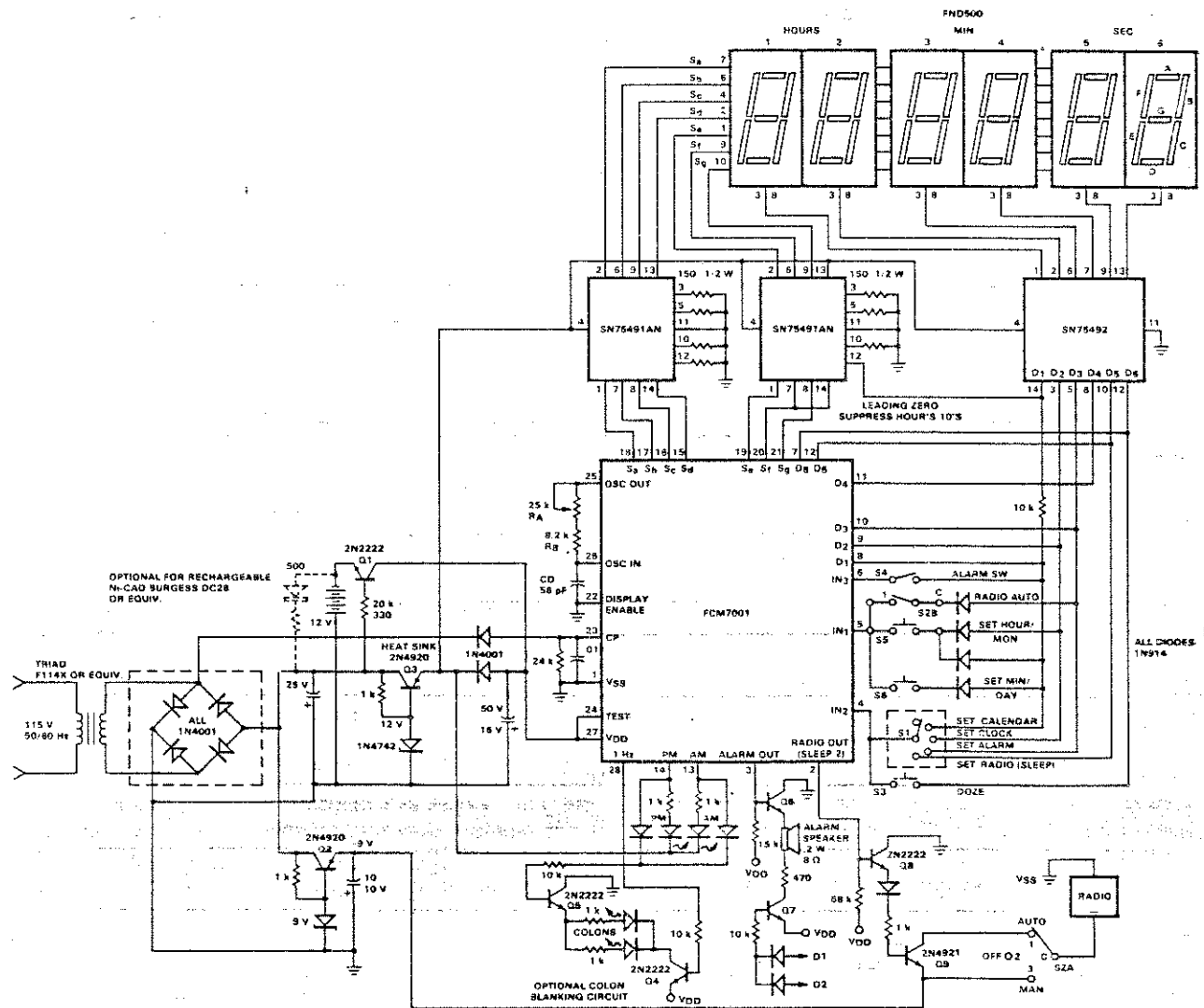
On-Chip Display Oscillator. The on-chip display oscillator drives the display multiplexing signals. Resistor R_{14} and C_1 must be connected to pin 25 and pin 26 as shown in Figure 1. Suggested values for R_{14} and C_1 are 20 k Ω and 56 pF, respectively. Without these components the circuit will not operate.

Line Operation. The circuits can operate from either a 50 Hz or 60 Hz time base. Connecting a diode between IN_1 and D_6 allows the circuit to operate from a 50 Hz clock at the clock input (pin 23), while leaving the IN_1 - D_6 connection open causes 60 Hz clock operation (Table B and Figure 3).

On-Chip 50/60 Hz Back-up Circuitry. This circuitry provides for continuous operation during an ac power failure if a battery back-up system is used. The circuitry operates in conjunction with the display oscillator. For accurate operation, R_A should be adjusted so that D_1 is 1.05 kHz for 60 Hz operation and 875 Hz for 50 Hz operation. A recommended configuration is shown in Figure 8. R_A is a 25 k Ω potentiometer, R_B is approximately 8.2 k Ω and C_D is 56 pF. For proper battery operation, C_P must be pulled to V_{SS} when the ac power is off. See R_{16} , Figure 1.

External Time Base Operation. The circuit can operate from an external time base where more accuracy is required where there is no 50/60 Hz line frequency. Condition the chip as above for 60 Hz operation, connect the clock input to V_{SS} , open the oscillator output (pin 25) and connect a 100.8 kHz signal to the oscillator input (pin 26).

SCHMATIC DIGITAL LED
CLOCK RADIO USING FCM7001



NOTE: All resistors are 1/4 W in ohms.
All capacitor values are in microfarads.

Fig. 8

DIGITAL CLOCK/CALENDAR CIRCUITS (Cont'd)

Battery Back-up. For protection from temporary ac power failures, it is advisable to connect a large filter capacitor or a rechargeable battery in parallel with the V_{DD} supply. See Figure 8 for typical circuit.

If the V_{DD} back-up voltage becomes too low for reliable circuit operation, the display will present all "8s" as a warning that the contents of the registers may be incorrect. This condition is reset by momentarily entering set hours or set minutes.

BCD OUTPUT INFORMATION - FCM7002

The FCM7002 is electrically the same as the FCM7001 but provides BCD (binary coded decimal) segment outputs in place of the standard 7-segment format. See Table A.

Pin 19 is valid during D₆ time as shown in Figure 4. This output is only present when data other than clock (calendar, alarm or clock radio) is being displayed. Pin 20 is an active LOW data strobe which is present every digit-blanking time. See Figure 4. Pin 21 is not connected. Low voltage detection is the same as the FCM7001 except the indication is A₁ and A₈ outputs are HIGH.

OPTIONAL CIRCUITS

Leading-Zero Suppression. The following external circuit may be used to zero suppress the FCM7001 clock circuit during D₁ (hours/tens) time. The display data at this time will be either 0, 1, 2 or 3. Segment F (S_f) will be on only when a zero is present. If S_f is present during D₁ time, the transistor will turn off D₁ to the display while preserving the integrity of the D₁ signal to the input matrix.

Large digit LED displays which require digit and segment drives such as SN75491, SN75492 simplify zero-suppression circuitry as shown below. One additional driver in IC₁ is used for the blanking.

ZERO SUPPRESSION-LED DISPLAYS

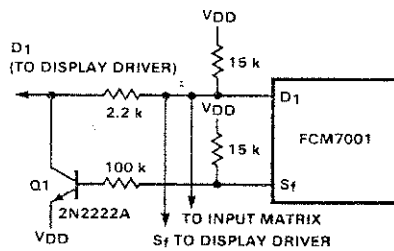


Fig. 9

ZERO SUPPRESSION-LED DISPLAYS

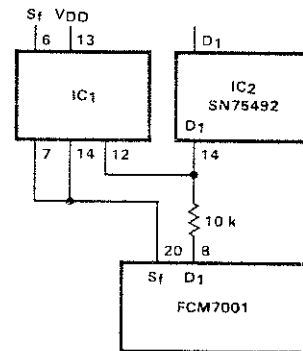


Fig. 10

The EX7001 series clock chips can use any combination of the available digit times to produce different audio sounds to a speaker. For example D₃ and D₁ outputs are used to produce an alarm tone ≈ 1 kHz. The transistors are 2N2222A, the diodes are 1N914. When pin 3 goes HIGH, it turns Q₁ on and when either D₁ or D₃ time is on, it turns Q₂ on, modulating the speaker load.

Either AM or PM is HIGH during clock display which turns on Q₁. Q₂ then turns on colons at a 1 Hz rate. When calendar is displayed, AM and PM are off which disables Q₁ and turns off colons.

LOW-COST ALARM CIRCUIT

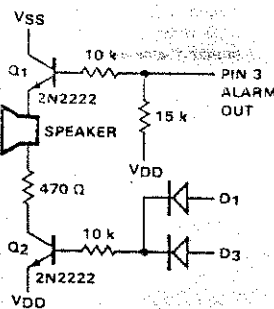


Fig. 11

COLON-BLANKING DURING CALENDAR

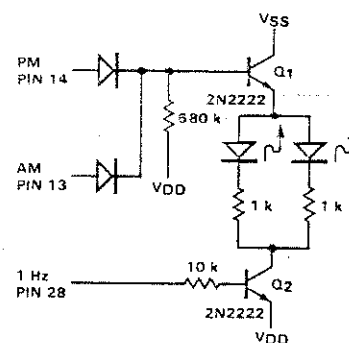


Fig. 12

FCM7002
SIMULTANEOUS DATE AND TIME DISPLAY
SUITABLE FOR μ PROC. INTERFACING

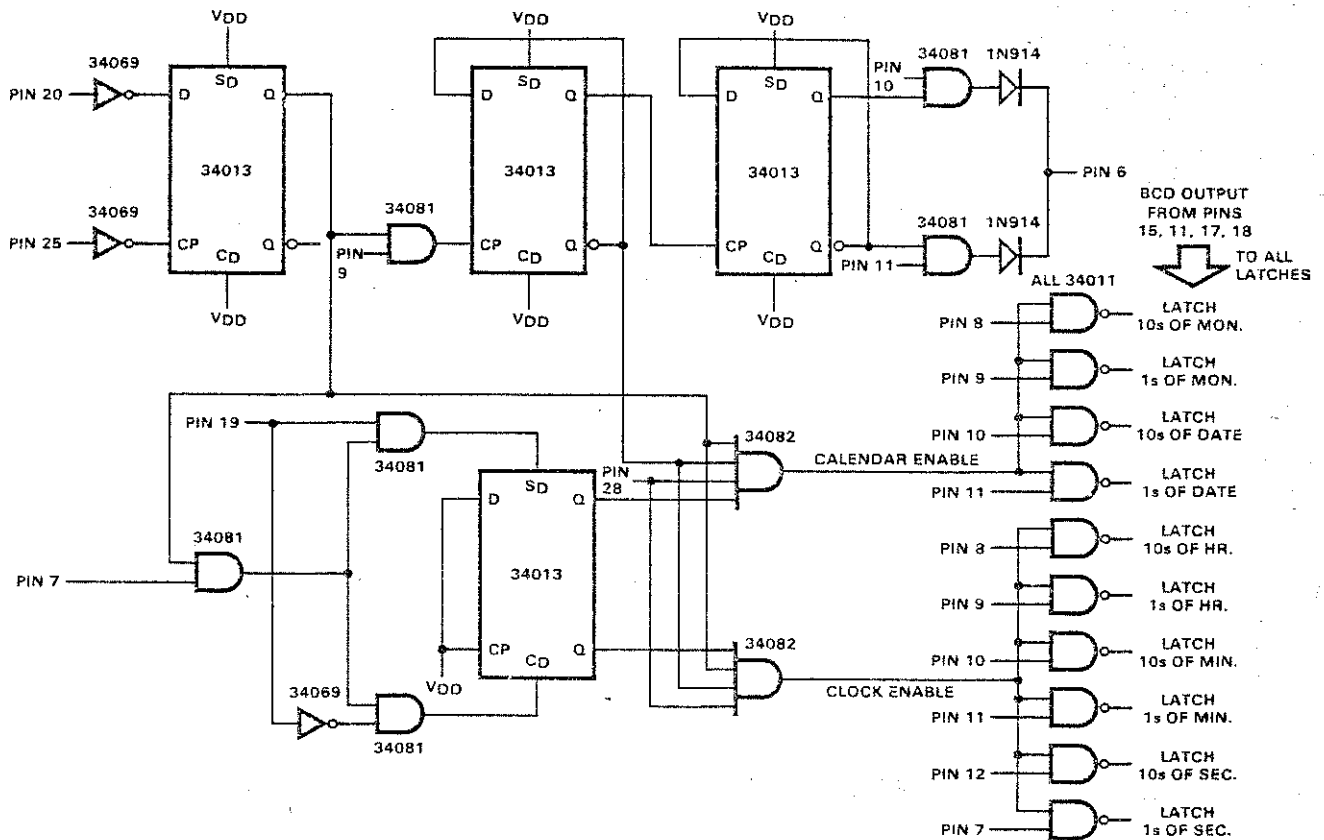
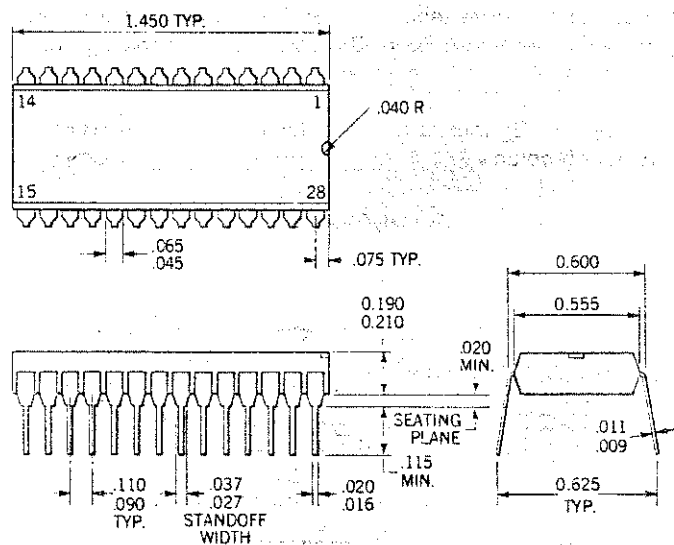


Fig. 13

PACKAGE OUTLINE

28-Pin Dual In-line



NOTES:

All dimensions in inches (bold) and millimeters (parentheses)
Package is made for PC boards with .03 holes at 0.100 center-to-center spacing with 0.600 pitch