DIGITAL ALARM CLOCK CIRCUIT

EA 5316
CONSUMER PRODUCTS

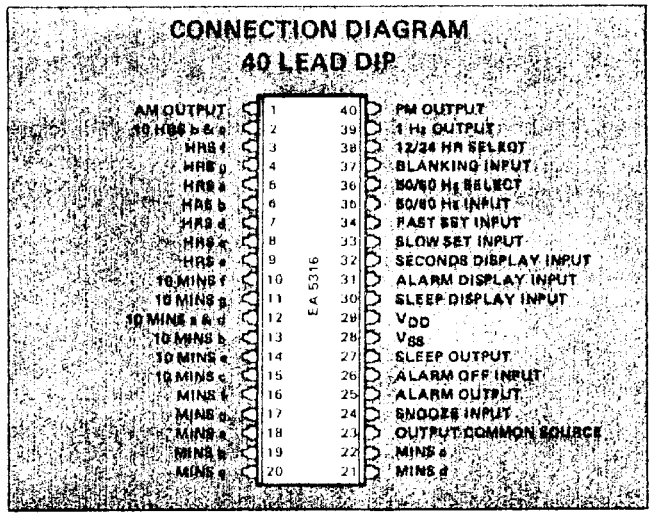
SEPTEMBER 1975

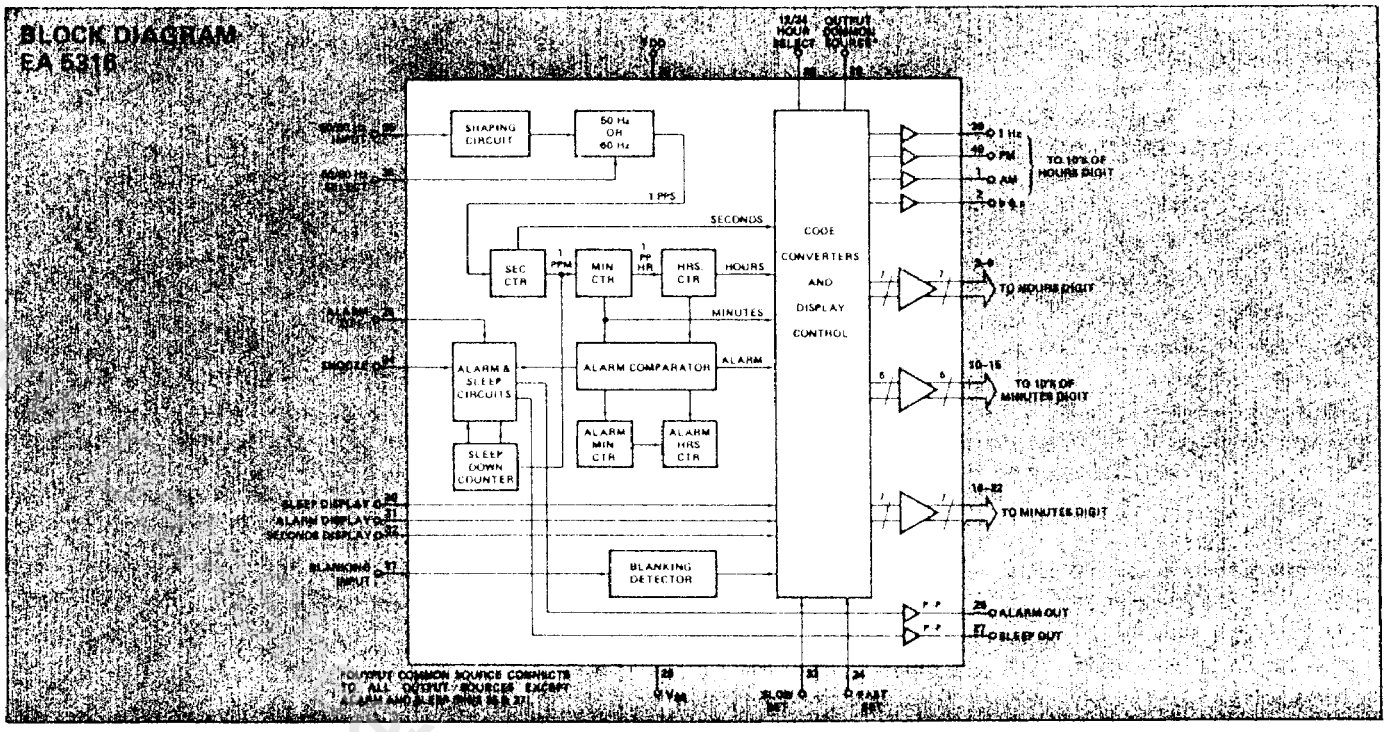
GENERAL DESCRIPTION

The EA5316 is a monolithic digital alarm clock circuit utilizing low voltage MOS P-channel enhancement mode and ion-implanted integrated circuit technology. The EA5316 utilizes line frequency (50 or 60 Hz) as its timing base, and provides a variety of timing functions suitable for a digital alarm clock, digital clock radio, and other applications. Four display modes are provided (hours and minutes, minutes and seconds, alarm, and sleep). The EA5316 drives seven segment clock displays and provides either a 12-hour or 24-hour format. Outputs consist of display drive, sleep (timed radio or event turn-off), and alarm enable. The EA5316 requires only a single unregulated power supply (–7 to –30 volts) and incorporates a power failure indication.

FEATURES

- 12 or 24 hour display format
- 24 hour alarm setting
- 9 minute snooze alarm
- Presettable 59 minute sleep timer
- AM/PM outputs (12 hr. format)
- Leading zero blanking (12 hr. format)
- Flashing colon for seconds indication
- Fast and slow set controls
- All counters resettable
- Elimination of illegal time display at turn-on
- Blanking/brightness control capability
- Power failure indication
- Direct interface to fluorescent tubes or liquid crystal displays. Also operates with LED's
- 50 or 60 Hz operation
- Single unregulated power supply
- Low power dissipation (32 mW @ 7V)
- Low input impedance for high noise margins
- Push-pull outputs on sleep and alarm buffers
- Alternate to NSC 5316 or AMI 1998





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ABSOLUTE MAXIMUM RATINGS

Voltage at any Pin	+0.3V to -31V
Operating Temperature Range (Ambient)	0°C to +70°C
Storage Temperature	-55°C to +150°C

Stresses more severe than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and operation of the device at any condition above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

STANDARD TEST CONDITIONS

The characteristics below apply for the following standard test conditions unless otherwise noted. All voltages are referenced with respect to V_{SS}.

$-30V \leq V_{DD} \leq -7V$ $0°C \leq T_A \leq +70°C$ $V_{SS} = 0V$ Common Sources = 0V

ELECTRICAL DRIVE CHARACTERISTICS

Parameter	Condition	Min.	Typ.	Max.	Units
Power Supply Voltage V_{DD}	V_{SS} = 0V	-30		-7	Volts
Power Supply Current, I_{DD}	V_{SS} = 0V. No loads.				
	V_{DD} = -7V	2		4	mA
	V_{DD} = -30V	3		5	mA
50/60 Hz Inputs:			50 or 60		
Frequency		DC		15K	Hz
Voltage	(Note 1)				
V_{IH} Logical High Level		V_{SS} - 1		V_{SS}	Volts
V_{IL} Logical Low Level		V_{DD}		V_{DD} + 1	Volts
Blanking Input Voltage:	(Note 1)				
V_{IH} Logical High Level		V_{SS} - 2		V_{SS}	Volts
V_{IL} Logical Low Level		V_{DD}		V_{SS} - 4	Volts
All Other Input Voltages:	With active pulldown (Note 2).				
V_{IH} Logical High Level		V_{SS} - 1		V_{SS}	Volts
V_{IL} Logical Low Level		V_{DD}		V_{DD} + 2	Volts

ELECTRICAL CHARACTERISTICS

Parameter	Condition	Min.	Typ.	Max.	Units
Input Capacitance	Except 50/60 Input			6	pF
50/60 Hz Input Capacitance	0 Volt Bias			7.5	pF
Output Currents:	T_A = +25°C				
1 Hz Display Outputs					
Logical High Level	@ $V_{OH} = V_{SS}$ - 2V	1500			µA
Logical Low Level	@ $V_{OL} = V_{DD}$ = -30V			1	µA
10's of Hours (b and c), 10's of Minutes (a and d) Outputs					
Logical High Level	@ $V_{OH} = V_{SS}$ - 2V	1000			µA
Logical Low Level	@ $V_{OL} = V_{DD}$ = -30V			1	µA
Alarm and Sleep Outputs:					
Logical High Level	@ $V_{OH} = V_{SS}$ - 2V	3500			µA
Logical Low Level	@ $V_{OL} = V_{DD}$ + 0.6V			10	µA
All Other Display Outputs:					
Logical High Level	@ $V_{OH} = V_{SS}$ - 2V	500			µA
Logical Low Level	@ $V_{OL} = V_{DD}$ = -30V			1	µA
Power Fail Detect Voltage	A.M. or P.M. flash	-20		-8	Volts

Note 1: Standard MOS input with leakage current of 1µA max. at V_{IN} = - 30 volts, all other pins at GND, and T_A = +25°C. Input also contains Schmitt trigger circuit to provide hysteresis. (See Figure 1.)

Note 2: Inputs contain active pulldown resistor. $30K\Omega \leq R_{IN} \leq 150K\Omega$, @ $V_{IN} = V_{SS}$.

FUNCTIONAL DESCRIPTION

A block diagram of the EA 5316 digital alarm clock is shown on page 1. The various display modes provided by this clock are listed in Table 1. The functions of setting controls are listed in Table 2. The following discussions are based on the Block Diagram.

50 or 60 Hz Input (pin 35): A shaping circuit is provided to square the 50 or 60 Hz input (see Figure 1). This circuit allows use of a filtered sinewave input. The circuit is a Schmitt trigger that is designed to provide about 6V of hystersis. A simple RC filter should be used to remove possible line-voltage transients that could either cause the clock to gain time or damage the device. The input should swing between V_{SS} and V_{DD}. The shaper output drives a counter chain which performs the timekeeping function.

50 or 60 Hz Select Input (pin 36): A programmable prescale counter divides the input line frequency by either 50 or 60 to obtain a 1-pps time base. This counter is programmed to divide by 60 simply by leaving pin 36 unconnected; pull-down to V_{DD} is provided by an internal 150KΩ resistor. Operation at 50 Hz is programmed by connecting pin 36 to V_{SS}.

Display Mode Select Inputs (pins 30 through 32): In the absence of any of these three inputs, the display drivers present time-of-day information to the appropriate display digits. Internal 150KΩ pull-down resistors allow use of simple SPST switches to select the display mode. If more than one mode is selected, the priorities are as noted in Table 1. Alternate display modes are selected by applying V_{SS} to the appropriate pin. As shown in the Block Diagram, the code converters receive time, seconds, alarm and sleep information from appropriate points in the clock circuitry. The display mode select inputs control the gating of the desired data to the code converter inputs and ultimately (via output drivers) to the display digits.

Time Setting Inputs (pins 33 and 34): Both fast and slow setting inputs are provided. These inputs are applied either singly or in combination to obtain the control functions listed in Table 2. Again, internal 150KΩ pull-down resistors are provided; application of V_{SS} to these pins effects the control functions. Note that the control functions proper are dependent on the selected display mode. For example, a hold-time control function is obtained by selecting seconds display and actuating the slow set input. As another example, the clock time may be reset to 12:00:00 A.M., in the 12-hour format (00:00:00 in the 24-hour format), by selecting seconds display and actuating both slow and fast set inputs.

Blanking Control Input (pin 37): Connecting this Schmitt trigger input to V_{DD} places all display drivers in a non-conducting, high-impedance state, thereby inhibiting the display. (See Figure 1.) Conversely, V_{SS} applied to this input enables the display.

Output Common Source Connection (pin 23): All display output drivers are open-drain devices with all sources common to pin 23 (Figures 4, 5 and 6). When using fluorescent tube displays, V_{SS} or a display brightness control voltage is permanently connected to this pin. Since the brightness of a fluorescent tube display is dependent on the anode (segment) voltage, applying a variable voltage to pin 23 results in a display brightness control. This control is shown in Figure 9. However, when using liquid crystal displays, the lifetime of the display device is optimized when AC drive voltages are provided. The common source connection of the EA 5316 output drivers facilitates generating AC drive voltages. An interface circuit for driving liquid crystal displays is shown in Figure 7.

When using low current LED displays, the EA 5316 is connected as shown in Figure 10 to provide direct drive to the display. The 20V supply insures low output ON resistance. The zener diode provides a 12V drop across output drivers which limits internal power dissipation to less than 60 mW per driver.

12 or 24 Hour Select Input (pin 38): By leaving this pin unconnected, the outputs for the most-significant display digit (10's of hours) are programmed to provide a 12-hour display format. An internal 150KΩ pull-down resistor is again provided. Connecting this pin to V_{SS} programs the 24-hour display format. Also, the output connections (pins 1, 2, 39 and 40) are different for each format. Figure 8 illustrates these differences. In addition to displaying 10's of hours, this digit provides an A.M./P.M. indication (12-hour format only) and the power failure indication. In the 12-hour format, A.M. indication is provided by segment "f"; P.M. indication by segment "e." The power failure indication consists of a flashing of the A.M. or P.M. indicator at a 1 Hz rate. A fast or slow set input resets an internal power failure latch and returns the display to normal. In the 24-hour format, the power failure indication consists of flashing segments "c" and "f" for times less than 10 hours, and of a flashing segment "c" for times equal to or greater than 10 hours but less than 20 hours; and a flashing segment "g" for times equal to or greater than 20 hours.

Alarm Operation and Output (pin 25): The alarm comparator senses coincidence between the alarm counter (the alarm setting) and the time counters (real time). The comparator output is used to set a latch in the alarm and sleep circuits. The latch output enables the alarm output driver (Figure 3), the EA 5316 output that is used to control the external alarm sound generator. The alarm latch remains set for 59 minutes, during which the alarm will therefore sound if the latch output is not temporarily inhibited by another latch set by the snooze alarm input (pin 24) or reset by the alarm off input (pin 26). Note in Figure 3 that this and the sleep output are push-pull outputs that can supply 3.5 mA minimum of output current.

Snooze Alarm Input (pin 24): Momentarily connecting pin 24 to V_{SS} inhibits the alarm output for between 8 and 9 minutes, after which the alarm will again be sounded. This input is pulled-down to V_{DD} by an internal 150KΩ resistor. The snooze alarm feature may be repeatedly used during the 59 minutes in which the alarm latch remains set.

Alarm Off Input (pin 26): Momentarily connecting pin 26 to V_{SS} resets the alarm latch and thereby silences the alarm. This input is also returned to V_{DD} by an internal 150KΩ resistor. The momentary alarm off input also readies the alarm latch for the next comparator output, and the alarm will automatically sound again in 24 hours (or at a new alarm setting). If it is desired to silence the alarm for a day or more, the alarm off input should remain at V_{SS}.

Sleep Timer and Output (pin 27): The sleep output at pin 27 can be used to turn off a radio after a desired time interval of up to 59 minutes. The time interval is chosen by selecting the sleep display mode (Table 1) and setting the desired time interval (Table 2). This automatically results in a current-source output via pin 27, which can be used to turn on a radio (or other appliance). When the sleep counter, which counts downwards, reaches 00 minutes, a latch is reset and the sleep output current drive is removed, thereby turning off the radio. This turn-off may also be manually controlled (at any time in the countdown) by momentary V_{SS} connection to the snooze input (pin 24). The output circuitry is the same as the alarm output (Figure 3), which is push-pull in order to supply a minimum of 3.5 mA of output current.

Table 1. EA 5316 Display Modes

*Selected Display Mode	Digit No. 1	Digit No. 2	Digit No. 3	Digit No. 4
Time Display	10's of Hours & AM/PM	Hours	10's of Minutes	Minutes
Seconds Display	Blanked	Minutes	10's of Seconds	Seconds
Alarm Display	10's of Hours & AM/PM	Hours	10's of Minutes	Minutes
Sleep Display	Blanked	Blanked	10's of Minutes	Minutes

*If more than one display mode input is applied, the display priorities are in the order of Sleep (overrides all others), Alarm, Seconds, Time (no other mode selected).

Table 2. EA 5316 Setting Control Functions

Selected Display Mode	Control Input	Control Function
*Time	Slow	Minutes advance at 2 Hz rate.
	Fast	Minutes advance at 60 Hz rate.
	Both	Minutes advance at 60 Hz rate.
Alarm	Slow	Alarm minutes advance at 2 Hz rate.
	Fast	Alarm minutes advance at 60 Hz rate.
	Both	Alarm resets to 12:00 A.M. (12-hour format).
	Both	Alarm resets to 00:00 (24-hour format).
Seconds	Slow	Input to entire time counter is inhibited (Hold).
	Fast	Seconds and 10's of seconds reset to zero without a carry to minutes.
	Both	Time resets to 12:00:00 A.M. (12-hour format).
	Both	Time resets to 00:00:00 (24-hour format).
Sleep	Slow	Subtracts count at 2 Hz.
	Fast	Subtracts count at 60 Hz.
	Both	Subtracts count at 60 Hz.

*When setting time sleep, minutes will decrement at rate of time counter, until the sleep counter reaches 00 minutes (sleep counter will not recycle).

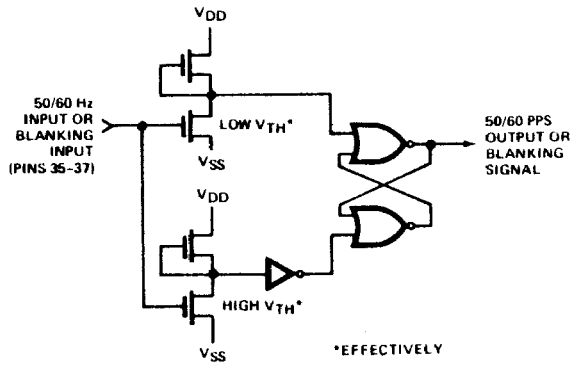


Figure 1. 50/60 Hz or Blanking Input Shaping Circuits

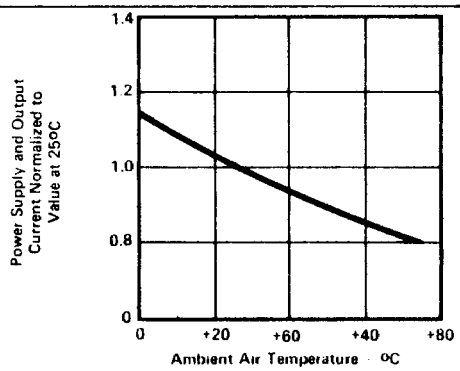
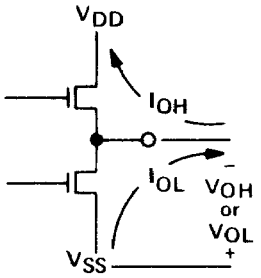


Figure 2. Temperature Coefficient

Pins 25 and 27
Temperature – 25°C
Curve 1 Minimum I_{OL} current for V_{DD} = –7V
Curve 2 Maximum I_{OL} current for V_{DD} = –30V
Curve 3 Minimum I_{OH} current for V_{DD} = –7V
Curve 4 Maximum I_{OH} current for V_{DD} = –30V



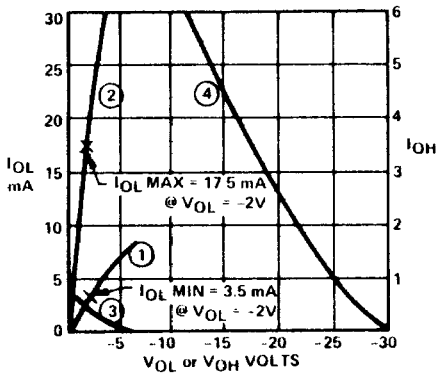
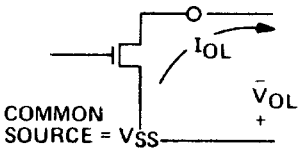


Figure 3. Alarm and Sleep Output Buffers

Pins 1, 3-11, 13-22 and 40
Temperature – 25°C
Curve 1 Minimum I_{OL} current for V_{DD} = –7V
Curve 2 Minimum I_{OL} current for V_{DD} = –21V
Curve 3 Maximum I_{OL} current for V_{DD} = –30V



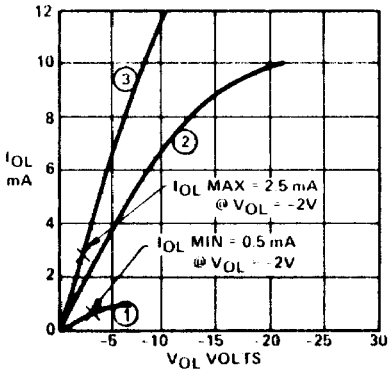
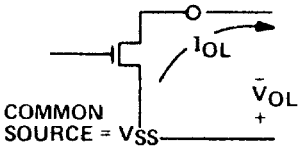


Figure 4. Single Segment Output Buffers

Pin 2 – 10 HRS b and c
Pin 12 – 10 MINS a and d
Temperature – 25°C
Curve 1 Minimum I_{OL} current for V_{DD} = –7V
Curve 2 Minimum I_{OL} current for V_{DD} = –21V
Curve 3 Maximum I_{OL} current for V_{DD} = –30V



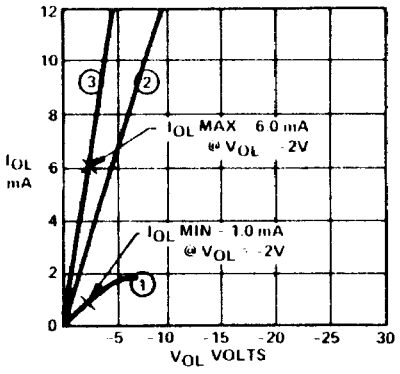
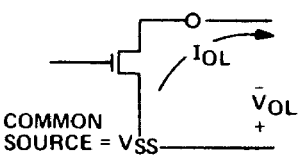


Figure 5. Double Segment Output Buffers

Pin 39 – 1 Hz Output
Temperature – 25°C
Curve 1 Minimum I_{OL} current for V_{DD} = –7V
Curve 2 Minimum I_{OL} current for V_{DD} = –21V
Curve 3 Maximum I_{OL} current for V_{DD} = –30V



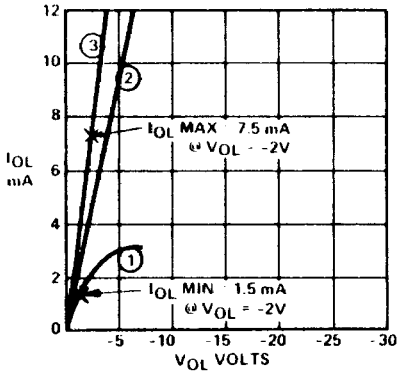
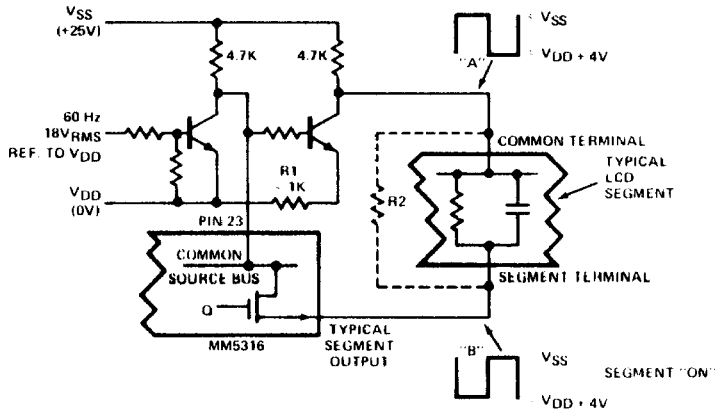


Figure 6. Double Segment Output Buffers



Note 1: R1 should be chosen for equal peak to peak swings at points "A" and "B," so there is no DC component placed on the segment.

Note 2: R2 may or may not be required, depending on the display used and the parasitic circuit capacitance associated with the segment output. This resistor should be just small enough to assure that off segments are not visible.

Figure 7. Liquid Crystal Display Interface

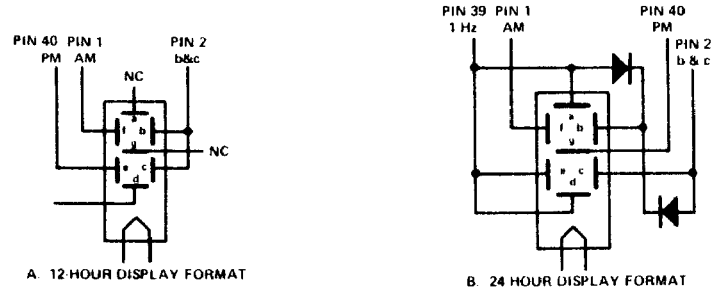


Figure 8. Wiring Ten's-of-Hours Digit

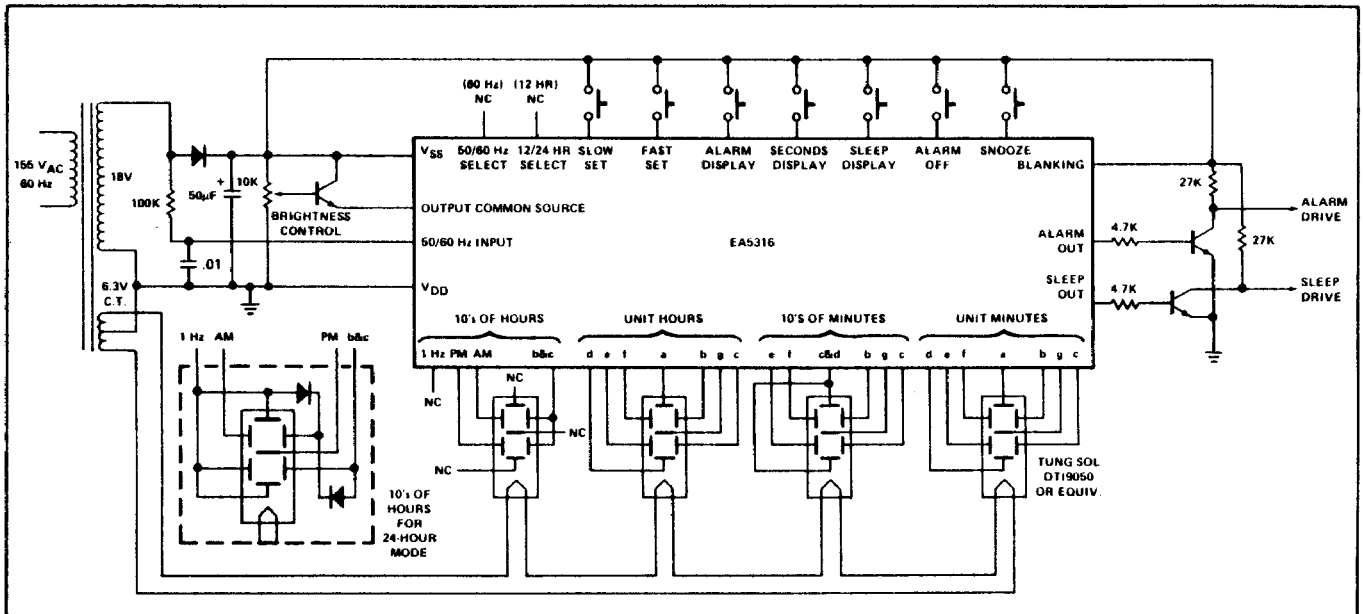


Figure 9. Fluorescent Tube Display Clock

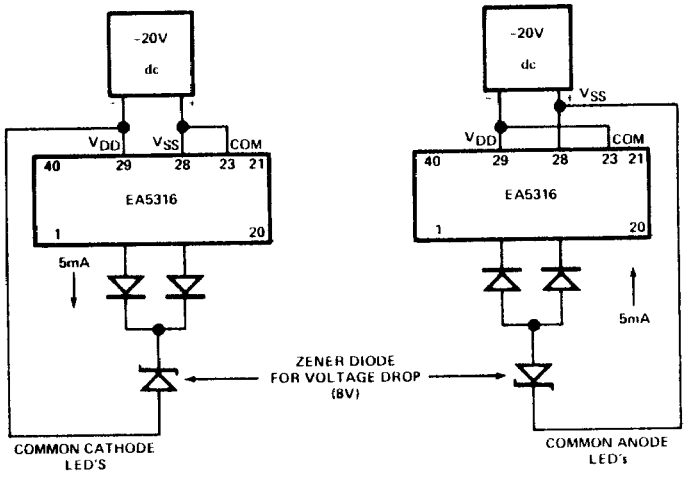


Figure 10. LED Interface

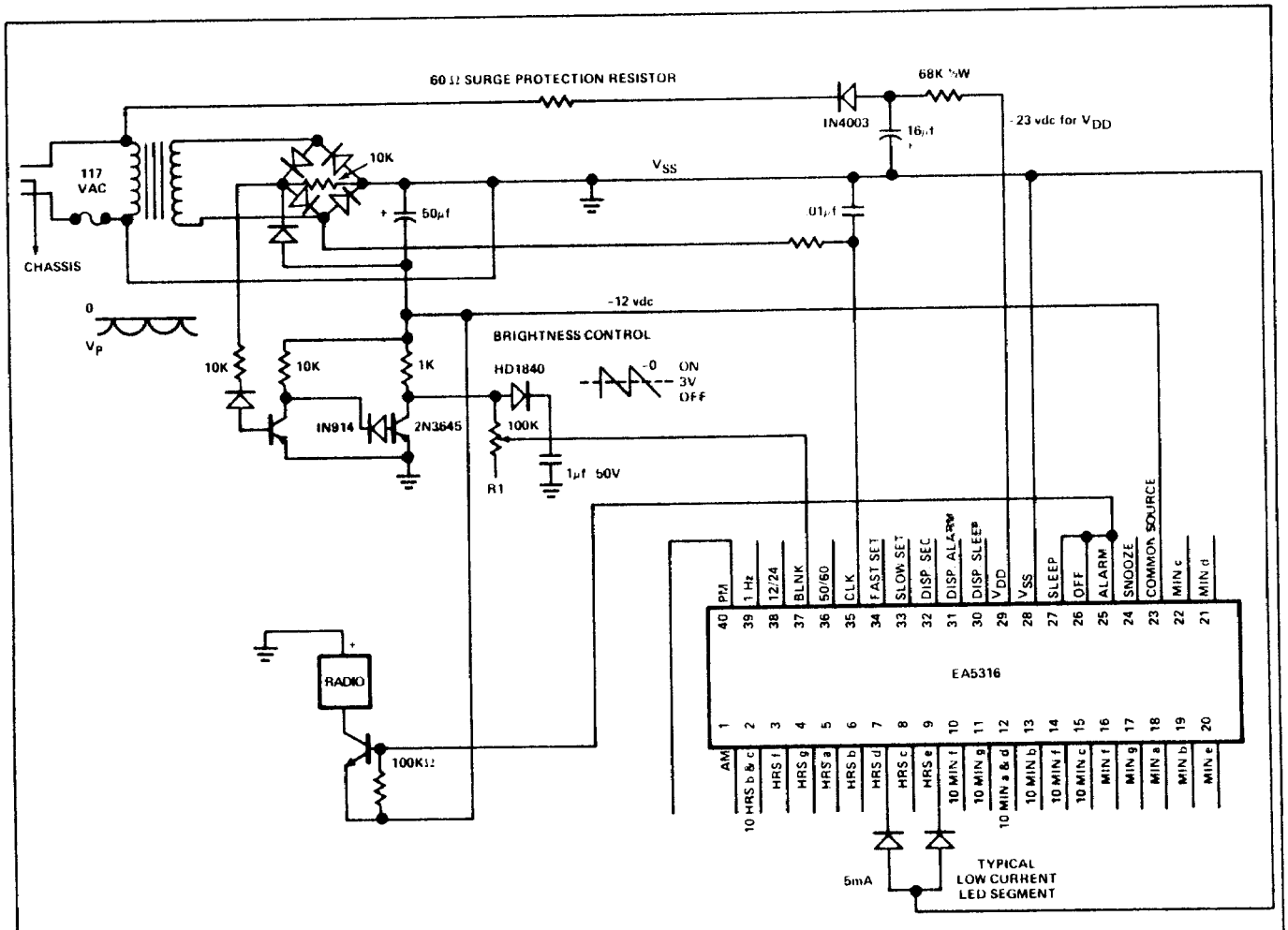


Figure 11. LED Clock with Brightness Control

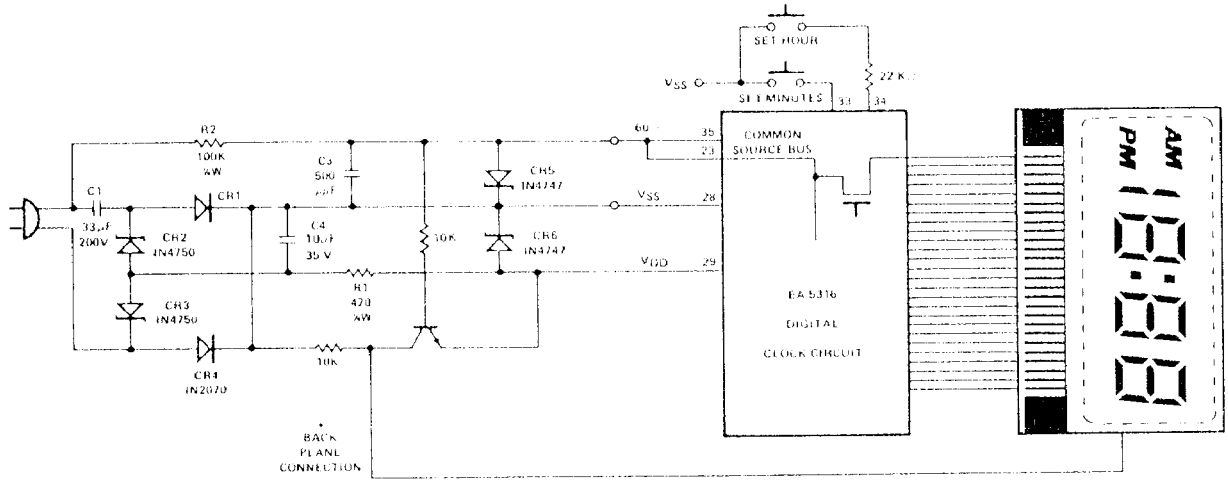
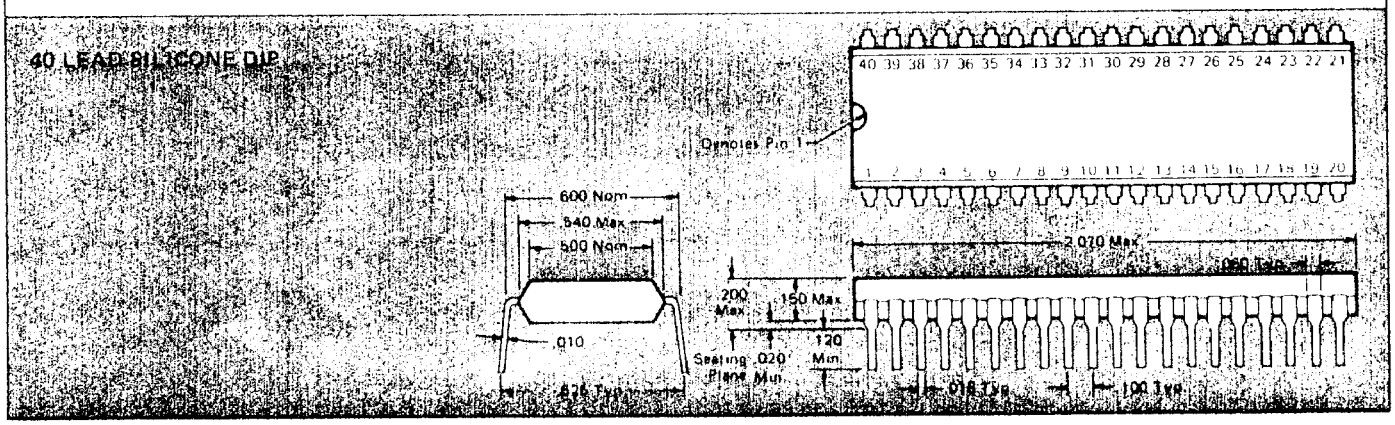


Figure 12. Liquid Crystal Display Clock

PHYSICAL DIMENSIONS



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