MM5385, MM5386, MM5396, MM5397 digital alarm clocks

general description

The MM5385, MM5386, MM5396 and MM5397 digital alarm clocks are monolithic MOS integrated circuits utilizing P-channel low-threshold, enhancement mode and ion-implanted depletion mode devices. MM5385 or MM5396 and MM5386 or MM5397 have display formats of 12 hours and 24 hours respectively, with 24-hour alarm display capability. They provide all the logic required to build several types of clocks and timers. Four display modes (time, seconds, alarm and sleep) are provided to optimize circuit utility. The circuit interfaces directly with 7-segment light emitting diodes and requires two power supplies. The timekeeping function operates from either a 50 or 60 Hz input. MM5385 or MM5396 displays 12 hours with colon flashing at a one second rate and a PM indication. MM5386 or MM5397 displays 24 hours with leading zero blanking. Outputs consist of display drives, sleep (e.g., timed radio turn off), and alarm enable. Power failure indication is provided to inform the user that incorrect time is being displayed. The power failure indication consists of flashing of all the "ON" digits at a 1 Hz rate. Setting the time cancels this indication. The device operates over a power supply range of 18–26V and LED supply voltage of 4–7V.

The MM5396 and MM5397 are reverse lead-bend versions (mirror image) of the MM5385, MM5386 (respectively) ideally suited to facilitate PC board layouts when designing an "L" shaped clock "module" (vertical display, horizontal component board); the MM5385, MM5386 are better suited for applications where the display and IC are mounted on a PC board in the same plane. All four versions are supplied in a 40-lead dual-in-line package.

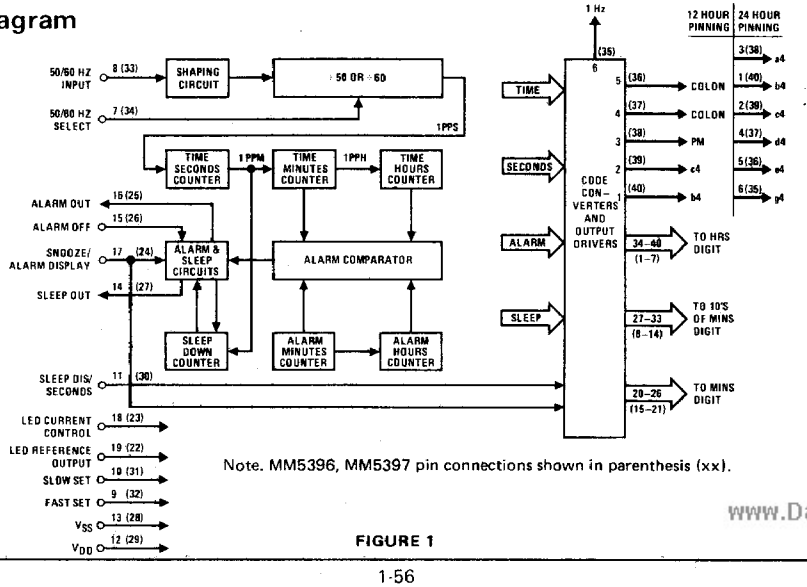
features

- 50 or 60 Hz operation
- Low power dissipation
- PM outputs in 12-hour format with a colon flashing at a one second rate ((MM5385 and MM5396 only)
- Leading zero blanking
- 24-hour alarm setting
- All counters are resettable
- Fast and slow set controls
- Power failure indication
- Blanking/brightness control capability
- Direct interface to light emitting diode (LED) with forward current of 3–15 mA
- Individual drivers for each segment of each digit
- 9-minute snooze alarm
- Presettable 59-minute sleep timer
- Radio frequency interference eliminating slow up circuitry at the outputs
- Available in standard (MM5385, MM5386) or reverse lead-bend version (MM5396, MM5397)

applications

- Alarm clocks
- Desk clocks
- Clock radios
- Stopwatches
- Industrial clocks
- Portable clocks
- Photography timers
- Industrial timers
- Appliance timers
- Sequential controllers

block diagram



Note. MM5396, MM5397 pin connections shown in parenthesis (xx).

FIGURE 1

absolute maximum ratings

Voltage at Any Pin	V_{SS} + 0.3 to V_{SS} − 28V
Voltage at Any Output Pin	V_{SS} + 0.3 to V_{SS} − 7.5V
Operating Temperature	−25°C to +70°C
Storage Temperature	−65°C to +150°C
Power Dissipation	1W
Lead Temperature (Soldering, 10 seconds)	300°C

electrical characteristics

T_A within operating range, V_{SS} = 18V to 26V, V_{DD} = 0V, unless otherwise specified.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Power Supply Voltage (V_{SS})	Output Driving Display	18		26	V
	Functional Clock	8		26	V
Power Supply Current	No Output Loads, V_{SS} = 26V			5	mA
50/60 Hz Input Frequency Voltage		dc	50 or 60	10k	Hz
Logical High Level		V_{SS}−1		V_{SS}	V
Logical Low Level		V_{DD}		V_{DD}+1	V
All Other Input Voltages	(Note 2)				
Except Sleep/Seconds Display					
Logical High Level		V_{SS}−1		V_{SS}	V
Logical Low Level	Internal Depletion Device to V_{DD}	V_{DD}		V_{DD}+7	V
Power Failure Detect Voltage	(V_{SS} Voltage) (Note 1)	1		7.5	V
Output Currents	V_{SS} = 18V to 26V, V_{DD} = 0V. Current Measured in Individual Segment Driver with 0 Current in Remaining Segment Driver. LED Current Control Connected to V_{DD}				
All Segment Drivers					
Logical High Level	$V_{OH} = V_{SS} - 2$	15			mA
Logical Low Level	$V_{OL} = V_{SS} - 6$			10	μA
Alarm and Sleep Outputs					
Logical High Level	$V_{OH} = V_{SS} - 2V$	500			μA
Logical Low Level	$V_{OL} = V_{DD} + 2$			1	μA
LED Reference Output	LED Current Control Connected to V_{DD}, V_{SS} = 18V, All Segment Driver 0 Current				
Logical High Level	$V_{OH} = V_{SS} - 2$	15			mA
Logical Low Level	$V_{OL} = V_{SS} - 6$			10	μA

Note 1: The power-fail detect voltage is 0.5V or more above the hold count voltage. The power-fail latch trips into the power-fail mode at least 0.5V above the voltage at which data stored in the time latch is lost.

Note 2: Sleep/seconds display (pin 11 on MM5385 and MM5386, pin 30 on MM5396 and MM5397). Connect pin to V_{SS} for Sleep display. Connect pin to V_{DD} for Seconds display. Leave pin open for normal time display.

functional description

A block diagram of the MM5385, MM5386, MM5396 and MM5397 digital alarm clock is shown in *Figure 1*. The various display/setting modes are listed in Table I and Table II shows the setting control functions. The following description is based on *Figure 1*; for simplification, pin numbers in the text are shown only for the MM5385 and MM5386, but pin connections for the MM5396 and MM5397 may be cross-referenced from the diagrams in *Figure 2*.

50 or 60 Hz Input (pin 8): A shaping circuit *(Figure 3)* is provided to square the 50 or 60 Hz input. This circuit allows use of a filtered sinewave input. The circuit is a Schmitt Trigger that is designed to provide about 6V of hysteresis. A simple RC filter, such as shown in *Figure 7*, 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.

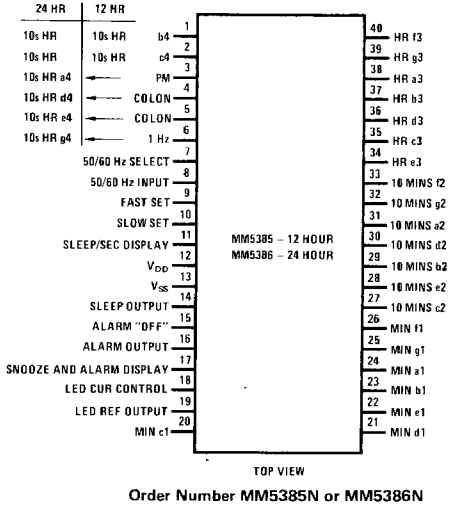
50 or 60 Hz Select Input (pin 7): A programmable prescale counter divides the input line frequency by either 50 or 60 to obtain a 1 pps time base. This counter is programmed to divide by 60 simply by leaving pin 7 unconnected; pull-down to V_{DD} is provided by an internal depletion load. Operation at 50 Hz is programmed by connecting pin 7 to V_{SS}.

Display Mode Select Inputs (pins 11 and 17): In the absence of any of these two inputs (i.e., pin open), the display drivers present time-of-day information to the appropriate display digits. Snooze/alarm display input has an internal pull-down depletion load to V_{DD}. Sleep/seconds display input has an internal voltage control which allows this input to assume three input states. The sleep time can be displayed by connecting pin 11 to V_{SS} and seconds can be displayed by connecting pin 11 to V_{DD}, and if pin 11 is left open, normal time is displayed. If more than one mode is selected, the priorities are as noted in Table I. As shown in *Figure 1* the code converters receive time, 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.

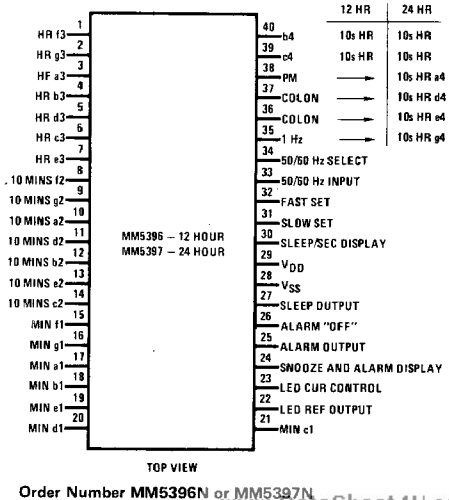
Time Setting Inputs (pins 9 and 10): Both fast and slow setting inputs are provided. These inputs are applied either singly or in combination to obtain the control functions listed in Table II. Again, internal depletion loads to V_{DD} are provided, application of V_{SS} to these pins affects the control 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 AM (midnight), in the 12-hour format (0:00:00 in the 24-hour format), by selecting seconds display and actuating both slow and fast set inputs.

Alarm Operation and Output (pin 16): The alarm comparator *(Figure 1)* senses coincidence between the alarm counters (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 open drain alarm output driver 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 17) or reset by the alarm "OFF" input (pin 15).

Snooze/Alarm Display (pin 17): Momentarily connecting pin 17 to V_{SS} inhibits the alarm output for between 8 and 9 minutes after which the alarm will again be sounded and display alarm time. This input is pulled-down to V_{DD} by an internal depletion load. The snooze alarm feature may be repeatedly used during the 59 minutes in which the alarm latch remains are set; connecting pin 17 to V_{SS} displays alarm time.



Order Number MM5385N or MM5386N
See Package 24



Order Number MM5396N or MM5397N
See Package 24

FIGURE 2

functional description (Continued)

Alarm "OFF" Input (pin 15): Momentarily connecting pin 15 to V_{SS} resets the alarm latch and thereby silences the alarm. This input is also returned to V_{DD} by an internal depletion load. 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}.

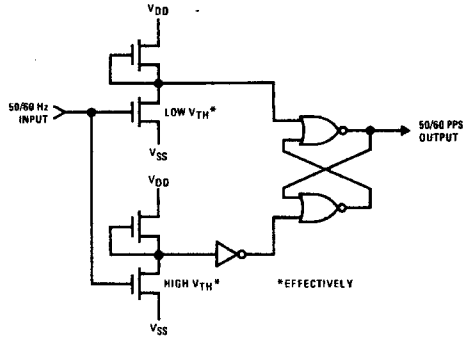


FIGURE 3. 50/60 Hz Input Shaping Circuits

Sleep Timer and Output (pin 14): The sleep output at pin 14 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 I) and setting the desired time interval (Table II). This automatically results in a current-source output via pin 14, 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 drive is removed, thereby turning off the radio. This turn off may also be manually controlled (at any time in the countdown) by a momentary V_{SS} connection to the snooze input (pin 17).

Segment Outputs (pins 1–6 and 20–40): All segment outputs are open drain devices with all sources connected to V_{SS}. Each segment output may source direct current of 15 mA at 2V on the output device. *Figure 5(b)* shows the output resistance (R_{ON}) of segment driver with respect to V_{DD}.

Power Failure Indications: Power failure indication is shown by the flashing of all "ON" digits at 1 Hz rate. A fast or slow set input resets an internal power failure latch and returns the display to normal. The power failure latch trips into the power failure mode prior to the loss of data stored in the time latches. When powered up, alarm and sleep outputs will be in the "OFF" state. In order to assure guaranteed power fail indication, power supply rise time should not exceed 10 V/ms.

LED CURRENT CONTROL INPUT AND REFERENCE OUTPUT (PINS 19 AND 18)

Pin 18 controls the gate voltage at all the display outputs and the reference device. The output drivers can be disabled by connecting pin 18 to V_{SS}. This wire-OR capability allows the display to be used for other functions (e.g., temperature, radio frequency wavelength).

TABLE I. MM5385, MM5386, MM5396, MM5397 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 II. MM5385, MM5386, MM5396, MM5397 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 AM (Midnight) (MM5385, MM5396)
	Both	Alarm Resets to 0:00 (MM5386, MM5397)
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 AM (Midnight) (MM5385, MM5396)
	Both	Time Resets to 0:00:00 (MM5386, MM5397)
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).

functional description (Continued)

The output current can be controlled two ways: 1) driving the output in saturated mode; 2) driving the output in linear mode. (Refer to *Figures 4 and 5)*.

1) The reference device (pins 18 and 19) is connected as a diode, and an external resistor is used to set the desired current in this diode (see *Figure 4*). The segment drivers of all digits are connected as current mirrors. The drain voltage V1 of the segment drivers is selected such that these devices operate in saturation mode. Since the drain current variation in saturation mode operation of the MOS device is relatively constant, the segment drive current does not vary significantly, even though V1 is increased considerably. However, as the voltage across the output buffers increases, average power dissipation also increases linearly. This technique of current control is recommended to be used only with low current LEDs (1–7 mA).

2) The high current drive requirement of large LED displays can be accomplished by operating the segment drivers in the linear mode. The circuit for high current LED drivers is shown in *Figure 5*. The reference output device is used in series with a reference LED, diode and current setting resistor. A high beta PNP transistor provides the current drive for all the segments. A reference voltage V3 is developed which compensates for variations in MOS process parameter and the variations in the voltage drop across the LED. The resistor sets the current in the reference LED which sets the reference voltage V3. This in turn sets the current in the LEDs equal to resistor current less the base current of the transistor. Variation in second supply voltage does not vary the LED currents so long as the PNP transistor is kept operating in the linear mode. Full wave rectified power supply without any filtering can be used as a second supply voltage V2. The LED brightness can be varied by using a variable resistor.

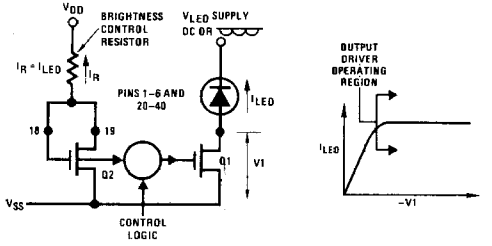


FIGURE 4(a). Low Current LED Drive Control Circuit (1–7 mA)

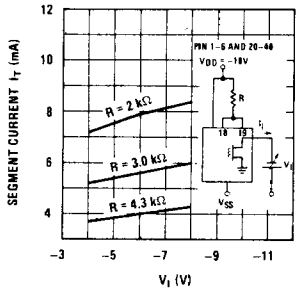


FIGURE 4(b). Segment Current vs V_I (V_{DD} at –18V) (Typical Output Characteristics)

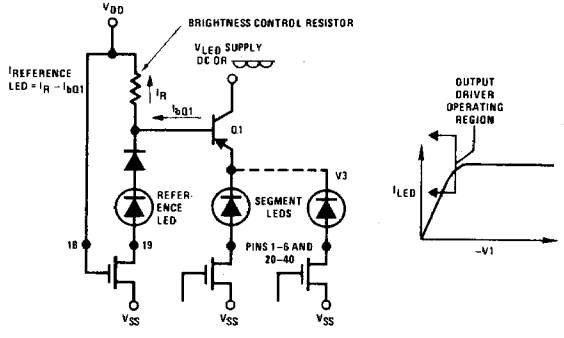


FIGURE 5(a). High Current LED Drive Control Circuit (7–15 mA)

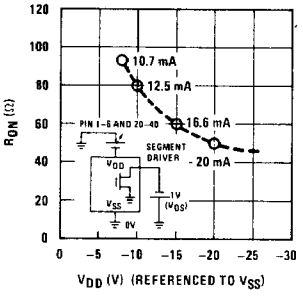


FIGURE 5(b). R_{ON} vs V_{DD} (V_{DS} at –1V) (Typical Output Characteristics)

functional description (Continued)

Figure 6 shows a LED drive circuit which uses a single resistor. The resistor controls the total current flowing through all the segments. Brightness shall vary depending on number of segments that are on at that time.

Radio Frequency Interference: All display outputs include circuitry to slow up the switching transition time to minimize radio frequency interference.

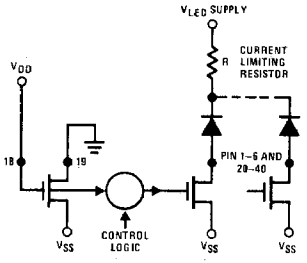


FIGURE 6. Simple LED Drive Circuit

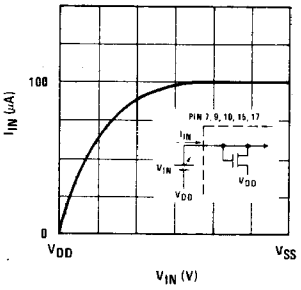


FIGURE 7. I_{IN} vs V_{IN} (Typical Input Depletion Load Characteristics)

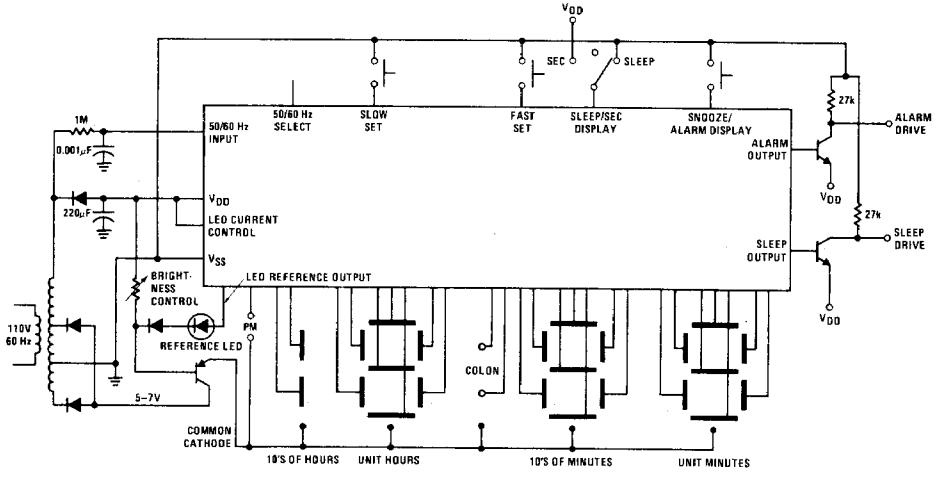


FIGURE 8. General Purpose Alarm Clock Using the MM5385 or MM5396 and LED Display