HD38991

DIGITAL CLOCK WITH INTERNAL LED DISPLAY DRIVER

General description

The HD38991 is an E/D MOS LSI utilizing P-channel Si-gate, enhancement mode and ion-implanted depletion mode devices. It provides all the functions to build several types of clock and timers.

The static operation allows circuit optimization in clock radio circuits to minimize any possible R.F.I..

The HD38991 is designed to drive light emitting diode (LED) display directly. Four display modes (Time, Alarm, Sleep and Second) are provided and they can be set independently.

The HD38991 has time display formats of 12 hours (AM/PM indication) and 24 hours. Time keeping function operates on either 50Hz or 60Hz input with colons flashing at 1Hz rate and leading zero blanking.

Output consists of display drivers, sleep and alarm.

The HD38991 has especial zero-adjusting modes which helps to adjust time within 30 minutes deviation.

Power failure indication consists of alternate flashing of AM 12:00 indication and all blanked indication in case of 12 hours display format, and flashing of 0:00 indication and all blanked indication in turn in case of 24 hours display format, at 1Hz rate.

The HD38991 operates over a power supply range ($-V_{DD}$) of 8V to 29V.

■ FEATURES
- Direct interface to LED display
- One power source and low power dissipation
- 50Hz or 60Hz operation
- 12 hours or 24 hours display formats
- Colon flashing at 1Hz rate
- Leading zero blanking
- 24 hour alarm setting
- Presettable sleep timer (max. 59 minutes)
- Fast and slow set controls and one touch zero adjusting
- Power failure indication
- Brightness control capability
- 9 minutes snooze alarm
- Pin compatible with MM5387 and S1998A

■ APPLICATIONS
- Alarm clocks
- Desk clocks
- Radio clocks
- Stopwatches
- Various types timer

(DP-40)

■ PIN ARRANGEMENT

AM	1		40	PM
10HRS	2		39	1Hz Output
HRS-F	3		38	12/24 HR Select
HRS-G	4		37	Zero Adjust Input
HRS-A	5		36	50/60 Hz Select
HRS-B	6		35	50/60 Hz Input
HRS-D	7		34	Fast Set Input
HRS-C	8		33	Slow Set Input
HRS-E	9		32	Seconds Display Input
10 Mins-F	10		31	Alarm Display Input
10 Mins-G	11		30	Sleep Display Input
10 Mins-A&D	12		29	V_{DD}
10 Mins-B	13		28	V_{SS}
10 Mins-E	14		27	Sleep Output
10 Mins-C	15		26	Alarm Off Input
Mins-F	16		25	Alarm Output
Mins-G	17		24	Snooze Input
Mins-A	18		23	Output Common Source
Mins-B	19		22	Mins-C
Mins-E	20		21	Mins-D

(Top View)

■ ABSOLUTE MAXIMUM RATINGS

Voltage at Any Pin Except Segment Outputs and Output Common Source .... **VSS + 0.3 to VSS − 29V**

Voltage at Segment Outputs and Output Common Source .... **VSS + 0.3 to VSS − 14 V**

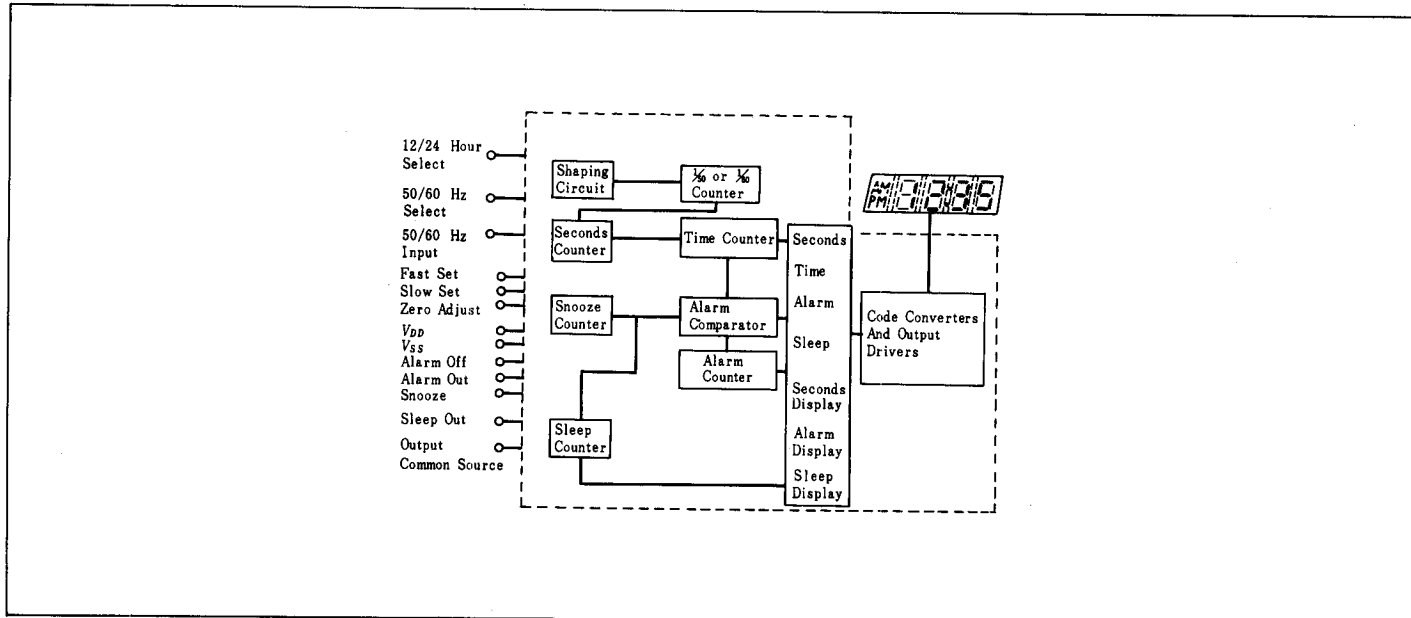Current at Segment Outputs Except PM(24HR mode), 1Hz, 10HRS(12HR mode) and 10' sM-a&d .... **11 mA**
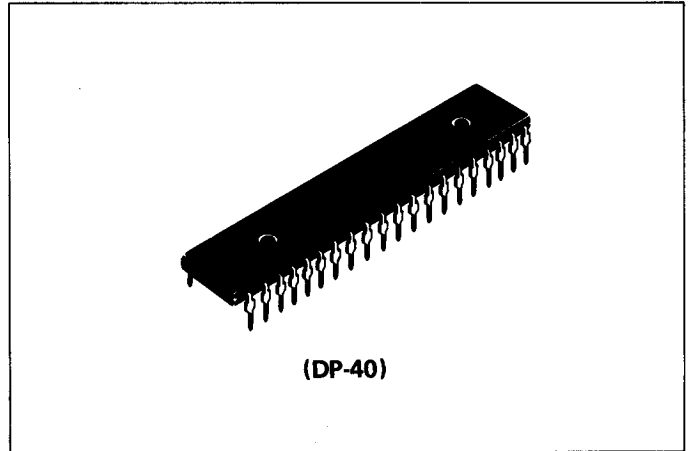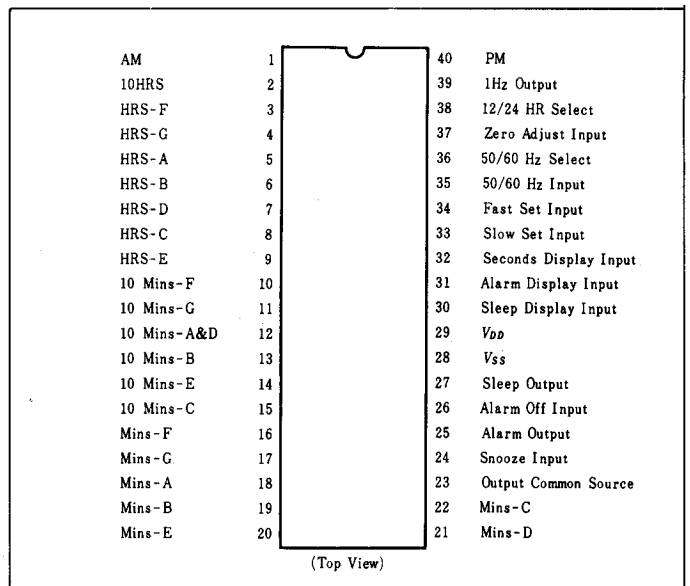
Current at Segment Outputs for 1Hz, 10HRS (12HR mode) and 10'sM-a&d .... **22 mA**

Current at Segment Output for PM .... **44 mA**

Current at Output Common Source .... **286 mA**

Operating Temperature .... **−20°C to +75°C**

Storage Temperature .... **−55°C to +125°C**

■ FUNCTIONAL BLOCK DIAGRAM

■ ELECTRICAL CHARACTERISTICS (To within operting range, $-V_{DD}=18V\pm5V$, $V_{ss}=0V$, unless otherwise specified)

Paraimter	Symbol	Conditions	min	typ	max	Unit
Power Supply Voltage	$-V_{DD}$		8	18	29	V
Power Supply Current	$-I_{DD}$	$-V_{DD}=18V$, No Output Loads	—	—	5	mA
50/60Hz Input						
Frequency	f_{-clock}		DC	50/60	*10k	Hz
Logical High Level	$-V_{IH1}$	*at $Ta=25°C$	0	—	1.0	V
Logical Low Level	$-V_{IL1}$		$-V_{DD}-1$	—	$-V_{DD}$	V
Input Leakage	$-I_{IL1}$		—	—	10	μA
All Other Input						
Logical High Level	$-V_{IH2}$		0	—	1.0	V
Logical Low Level	$-V_{IL2}$		$-V_{DD}-6$	—	$-V_{DD}$	V
Input Leakage	$-I_{IL2}$		—	—	10	μA
Power Failure Detect Voltage	$-PFDV$	$-V_{DD}$ voltage	—	—	8	V
Output Current Levels		$-V_{DD}=18V$, Output Common Source$=0V$	—	—	—	
PM out (24HR mode)						
Logical High Level	$-I_{OH1}$		—	—	44	mA
Logical Low Level	$-I_{OL1}$	$-V_{OL}=14V$	—	—	10	μA
1Hz, 10HRS(12HR mode) 10'sM-a & d						
Logical High Level	$-I_{OH2}$		—	—	22	mA
Logical Low Level	$-I_{OL2}$	$-V_{OL}=14V$	—	—	10	μA
All Other Display out 10HRS (24HR mode), PM(12HR mode)						
Logical High Level	$-I_{OH3}$		—	—	11	mA
Logical Low Level	$-I_{OL3}$	$-V_{OL}=14V$	—	—	10	μA
Alarm and Sleep Out						
Logical High Level	$-I_{OH4}$	$-V_{OH}=2V$	2	—	—	mA
Logical Low Level	$-I_{OL4}$	$-V_{OL}=14V$	—	—	10	μA
Input Pull Down Resistor						
50/60Hz, 12/24HR SELECT	R_{IN1}	$-V_{DD}=18V$, $Ta=25°C$	—	1	—	$M\Omega$
All Other Input	R_{IN2}	$-V_{DD}=18V$, $Ta=25°C$, Note 1	—	50	—	$k\Omega$
Display Voltage	$-V_{DISP}$	Note 2	—	—	14	V

Note: 1) Except 50/60Hz INPUT Terminal Pin
      2) Don't supply this voltage to output without current limitter.

■ SETTING CONTROL

1. Power On

When the power voltage to the LSI is supplied, or a momentary AC power failure and possible loss of clock occured, indicator will flash at 1Hz rate. In the 12-HOUR format, flashing is 4 digits at AM 12:00 indication. In the 24-HOUR format, flashing is 3 digits at 0:00 indication. A fast or slow set input resets an internal power failure latch and returns the display to normal. The various display modes on normal operation are shown in Fig.2.

2. Time-of-Day Setting

Opening all display mode select inputs, the display presents time-of-day information. Time-of-day setting is performed by operation of Fast or Slow/Fast & Slow set input.

3. Alarm Setting/Alarm Operation and Output

Alarm Setting is performed as the following procedure.

1) To connect alarm display input to V_{SS}
2) To set the time of alarm with Fast or Slow set input
3) To leave alarm diaplay input open

If the alarm comparator senses coincidence between the alarm counter (the alarm setting) and the time counter (real time), the comparator output sets the latch of the alarm circuit. The latch output enables the alarm output. The alarm output remains set for 59 minutes.

4. Sleep Setting/Sleep Operation and Output

As the following procedure, sleep time setting is performed.

1) To connect sleep display input to V_{SS}
2) To set the time of sleep with Fast or Slow / Fast & Slow set input
3) To leave sleep display input open

The sleep output is turned on by above setting. When the sleep counter which counts downwards, reaches 00 minutes, sleep output is turned off.

5. Second Setting/Adjusting

As the following procedure, second setting / adjusting is performed.

1) To connect seconds display input to V_{SS}
2) To set to the standard second time with Fast or Slow set input
3) To leave seconds display input open

6. Zero Adjusting

Adjusting to the standard time signal of every hours will easily be performed by using zero adjust input operation. Within ±30 minutes, one touch zero-adjust input operation can set the time just to the standard time (HOURS, MINUTES, SECONDS simultaneously).

7. Snooze Alarm Operation

Momentary connecting snooze to V_{SS} inhibits the alarm output for between 8 and 9 minutes, after which the alarm output is "on". The snooze alarm feature may be repeatedly used during the 59 minutes in which the alarm latch remains set. This input may also use to reset sleep output.

8. Alarm Off Operation

Momentary connecting alarm off to V_{SS} resets the alarm output. The alarm operation will automatically enable again after 24 hours.

9. Summary of Setting Control

Summary of setting control is listed in Table 1.

10. Functional description of the other pins

1) 50/60Hz Input

A shaping circuit is provided to square the 50 or 60Hz input. This circuit allows use of a filtered sinewave input. 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.

2) 50/60Hz Select Input

Operation at 50Hz is programmed by connecting this input to V_{SS}. Operation at 60Hz by leaving this pin open, or by connecting to V_{DD}, which is better to minimize out-coming noise.

3) 12/24 Hours Select Input

Operation at 24 Hour formats is programmed by connecting this input to V_{SS}. Operation at 12 Hour formats by leaving this pin to open.

4) Output Common Source

All display output drivers are open-drain devices with all sources common to this pin. It is normally connected to V_{SS}.
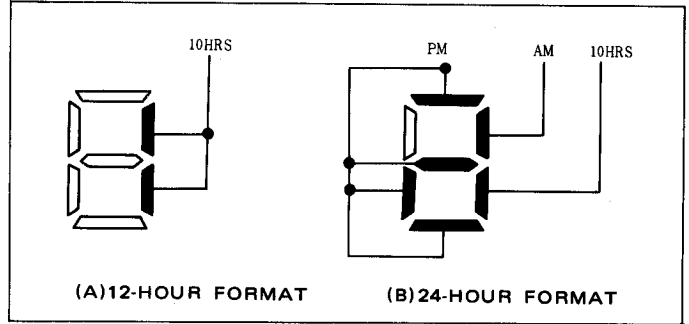
■ Table 1. SETTING CONTROL

Display Mode	Display Control	None	Fast Set	Slow Set	Both
TIME	NONE	Time-of-Day Display (10H, 1H, 10M, 1M)	Time Set Advance at 50/60Hz rate	Time Set Advance at 2Hz rate	Same as FAST SET
SECONDS	SECONDS DISPLAY	Seconds Display (1M, 10S, 10M, 1M)	Seconds Reset to 00 without a Carry to Minutes	Time Count Inhibited (Hold Mode)	Time Reset 12:00:00 AM (12HR) 0:00:00 (24HR)
ALARM	ALARM DISPLAY	Alarm Disply (10H, 1H, 10M, 1M)	Alarm Set Advance at 50/60Hz rate	Alarm Set Advance at 2Hz rate	Alarm Reset 12:00 AM (12HR) 0:00 (24HR)
SLEEP	SLEEP DISPLAY	Sleep Display (10M, 1M)	Sleep Countdown Set at 50/60Hz rate	Sleep Countdown Set at 2Hz rate	Same as FAST SET

If more than one Display Control is connected to Vss simultaneously, the display priorities are in the order of SLEEP, ALARM, SECONDS, TIME.
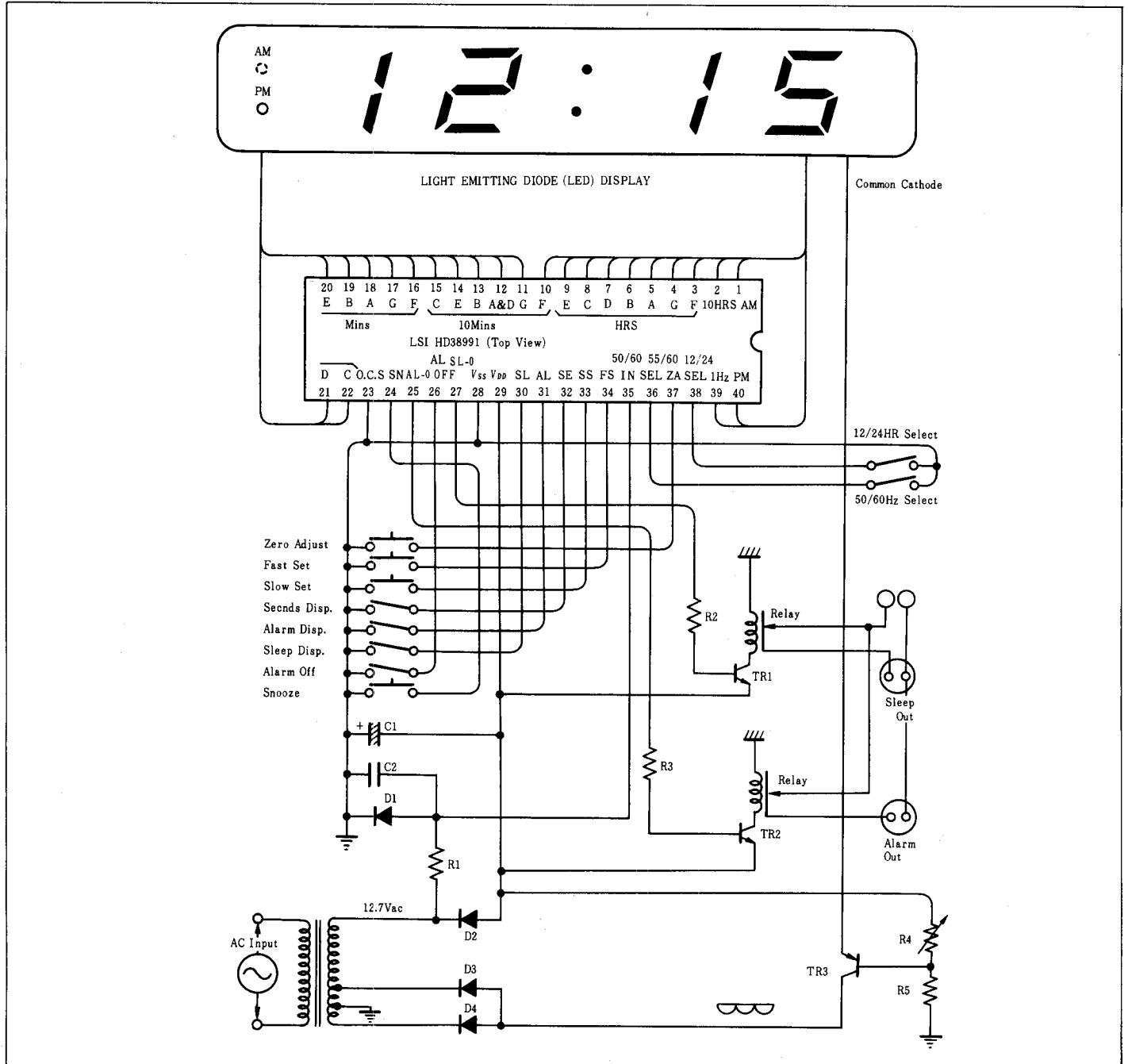① ② ③ ④

	12 Hour Format	24 Hour Format
Time	PM 10:15	22:15
Seconds	5:38	5:38
Alarm	AM 11:50	11:50
Sleep	:30	:30

Fig. 2. WIRING TEN'S OF HOURS DIGIT

(A)12-HOUR FORMAT   (B)24-HOUR FORMAT

■ TYPICAL APPLICATIONS

AM
PM

LIGHT EMITTING DIODE (LED) DISPLAY

Common Cathode

| 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| E | B | A | G | F | C | E | B | A&D | G | F | E | C | D | B | A | G | F | 10HRS | AM |

Mins   10Mins   HRS

LSI HD38991 (Top View)

AL SL-0   50/60 55/60 12/24
D   C O.C.S SN AL-0 OFF Vss Vdd SL AL SE SS FS IN SEL ZA SEL 1Hz PM
21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

12/24HR Select

50/60Hz Select

Zero Adjust
Fast Set
Slow Set
Secnds Disp.
Alarm Disp.
Sleep Disp.
Alarm Off
Snooze

R2   Relay
TR1

Sleep Out

+ C1
C2
D1

R3   Relay
TR2

Alarm Out

R1

12.7Vac
D2

AC Input

D3

D4

TR3

R4

R5

■ **PARTS LIST**

PARTS NO.	NAME	PCS	NOTE
LSI	HD38991	1	HITACHI
DISPLAY		1	
	PRINTED CIRCUIT BOARD	1	
TR1	2SC1213	1	HITACHI
TR2	2SC1213	1	HITACHI
TR3	2SA743	1	HITACHI
D1	1S2076	1	HITACHI
D2	W06A	1	HITACHI
D3	W06A	1	HITACHI
D4	W06A	1	HITACHI
R1	100kΩ	1	
R2	20kΩ	1	
R3	20kΩ	1	
R4	10kΩ	1	
R5	1kΩ	1	
C1	100μF/25V	1	
C2	0.01μF	1	
——	TRANSFORMER	1	
——	SWITCH	8	
——	SWITCH (SELECT)	2	
——	RELAY	2	