CMOS Car Clock Circuit

Features

- 4.19 MHz quartz oscillator
- Frequency is programmable via a 5 bit E^2PROM (no trimming capacitor required)
- LCD drive voltage adjustable via 5 bit E^2PROM for best contrast and largest viewing angle
- Temperature compensated LCD drive voltage for best contrast and largest viewing angle
- 12 hour or 24 hour display mode selectable via MODE input
- Colon flash option selectable via FLASH input
- Operating ambient temperature range: −40 to +85°C
- 28 lead mini package (SO28)
- Auto-increment mask programmable to 1 Hz, 2 Hz or 4 Hz
- DATA and V_{PP} are normal logical inputs
- Excellent immunity from electromagnetic radiation

Description

The H 5050 is a 4.19 MHz CMOS car clock circuit providing hours and minutes display. It is designed to drive a 3¾ digit, 2:1 multiplexed 7 segment clock display with AM and PM functions (e.g. Philips LTD133 liquid crystal display).
Time setting functions are accomplished via 2 inputs S1 and S2. Oscillator frequency and LCD drive voltage are programmable via on-chip E^2PROM.

Applications

- Car clocks

Typical Operating Configuration

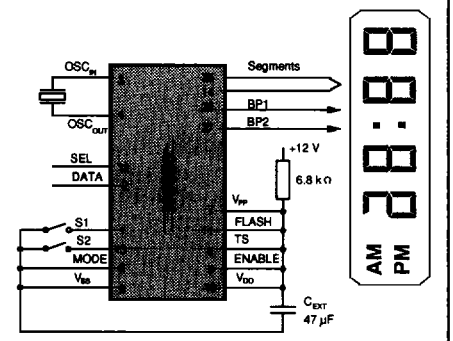

Fig. 1

Pin Assignment

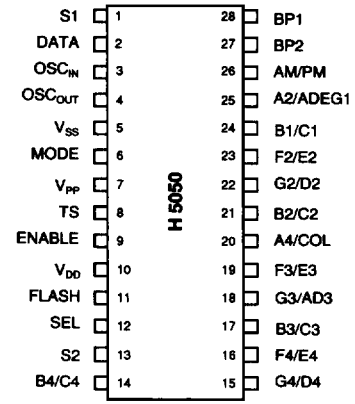

Fig. 2

Absolute Maximum Ratings

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Supply voltage	V_{DD}	with relation to V_{SS}	-		8	V
Supply current	I_{DD}		-		3	mA
Voltage applied to input pins	V_I	with relation to V_{SS}	−0.3		V_{DD}+0.3	V
Storage temperature	T_{STO}		−65		+150	°C
Operating temperature range	T_A		−40		+85	°C

Table 1

Stresses above these listed maximum ratings may cause permanent damage to the device. Exposure beyond specified operating conditions may affect device reliability or cause malfunction.

Electrical Characteristics

V_{DD} = 3 ÷ 6 V, T_A = −40 to +85°C, quartz: frequency = 4.194304 MHz, max. frequency tolerance = ± 30*10^{-6}, R_S = 50 Ω, C_L = 12 pF, unless otherwise specified

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Supply						
Supply voltage	V_{DD}	Programmable	3	-	6	V
Supply voltage variation	ΔV_{DD}	S1 or S2 closed	-	-	50	mV
Supply voltage variation due	TC	V_{DD} = 4.5 V	-	−0.35	-	%/°K
to temperature			-	−16	-	mV/°K
Supply current	I_{DD}	Note [1]	500		2000	µA
Capacitance	C_{EXT}	External capacitor	22	47	-	µF
Oscillator						
Start time	t_{OSC}		-	-	200	ms
Frequency stability	$\Delta f/f \cdot \Delta V_{DD}$	ΔV_{DD} = 100 mV	-	-	1	ppm/V
Input capacitance	C_I		-	16	-	pF
Output capacitance	C_O			16		pF
Feedback resistance	R_{fb}		300	1000	3000	kΩ
Inputs						
Pull-up resistance	R_{Pu}	S1, S2, TS, SEL, DATA and V_{PP}	45	90	180	kΩ
Pull-up/down resistance	$R_{Pu/d}$	MODE	100	300	1000	kΩ
Debounce time	t_{Deb}	S1 and S2 only	78	-	110	ms
Backplane						
Output resistance	R_{BP}	High/low level ± 100 µA	-	-	3	kΩ
Segments						
Output resistance	R_{SEG}	± 100 µA	-	-	5	kΩ
DC offset voltage	V_{dc}	200 kΩ/1 nF	-	-	50	mV

[1] A suitable external resistor R must be selected:
Example: V_{DD} = 5 V, R_{min} = (12 V − 5 V) / 2000 µA = 3.5 kΩ

Table 2

Pin Description

Pin	Name	Function
1	S1	Hour adjustment input
2	DATA	E^2PROM data input
3	OSC_{IN}	Oscillator input
4	OSC_{OUT}	Oscillator output
5	V_{SS}	Negative supply voltage
6	MODE	12/24 hour mode select input
7	V_{PP}	Programming input
8	TS	Test speed-up mode input
9	ENABLE	Enable input for S1 and S2
10	V_{DD}	Positive supply voltage
11	FLASH	Colon option input
12	SEL	E^2PROM select input
13	S2	Minute adjustment input
14	B4/C4	Segment driver
15	G4/D4	Segment driver
16	F4/E4	Segment driver
17	B3/C3	Segment driver
18	G3/AD3	Segment driver
19	F3/E3	Segment driver
20	A4/COL	Segment driver
21	B2/C2	Segment driver
22	G2/D2	Segment driver
23	F2/E2	Segment driver
24	B1/C1	Segment driver
25	A2/ADEG1	Segment driver
26	AM/PM	Segment driver
27	BP2	Backplane 2
28	BP1	Backplane 1

Table 3

Segment designation of LCD display

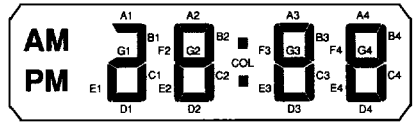

Fig.3

Functional Description

Outputs

The circuit presents LCD data at pins 14 to 26. Two way (1:2) multiplex driving is used in order to save circuit pins. The backplane signals appear at pin 27 and 28 respectively. In Fig. 3 the corresponding waveforms are shown.

Backplane and Segment Waveforms

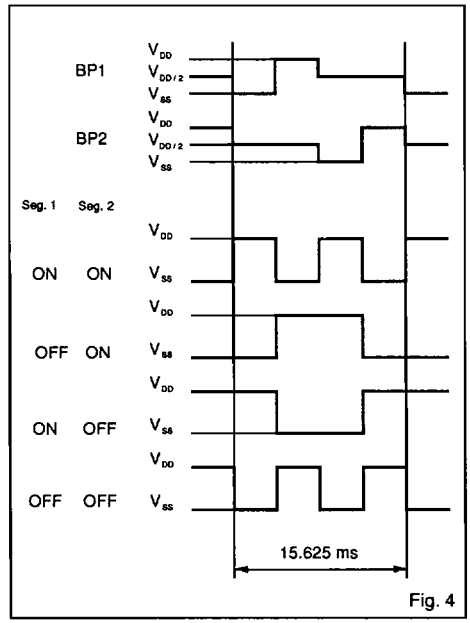

Fig. 4

The average voltages across the segments have the following values:

$V_{ON(ms)} = 0.79\ V_{DD}$

$V_{OFF(ms)} = 0.35\ V_{DD}$

LCD Driving Voltage

The on-chip shunt regulator controls the value of supply voltage according to ambient temperature and the content of the 5 bit voltage E^2PROM. This guarantees best contrast and largest viewing angle for the whole temperature range (see section "LCD Voltage Programming").

12/24 Hour Mode

Operation of 12 hour or 24 hour mode is selected via MODE input. If MODE input is floating and a reset occurs (see section "Segment Test and Reset"), the mode will change from 12 hour to 24 hour or vice versa.

Power-Up

After power-up the actual mode and LCD display is set according to connection of the mode input:

1 : 00 AM 12 hour mode when MODE input is connected to V_{DD}

1 : 00 24 hour mode when MODE input is floating or connected to V_{SS}.

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Colon
If FLASH input is held at V_{DD} colon will flash at 1 Hz (duty cycle 50%). Connecting FLASH to V_{SS} displays a stable colon.

Time Setting
Time setting is accomplished via the two inputs S1 and S2. These two inputs are pulled to V_{DD} via on-chip resistors of about 90 kΩ. This in conjunction with debouncer circuitry (debouncing time 78 ÷ 110 ms), allows the use of simple single-throw switches.

Set Enable
Connecting ENABLE to V_{DD} enables inputs S1 and S2, connecting ENABLE to V_{SS} makes S1 and S2 inactive.

Hours Setting
When S1 is pulled to V_{SS} the hours counter is incremented by 1 immediately (after debounce time). If S1 is held at V_{SS}, after a pause of 1 ÷ 1.25 s, the hours counter is auto-incremented at a rate of 1, 2 or 4 Hz (depending on metal mask version) until S1 is released again. In hours setting mode the carry from minutes counter is not propagated.

Minutes Setting
When S2 is pulled to V_{SS} the minutes counter is incremented by 1 immediately (after debounce time). If S2 is held at V_{SS}, after a pause of 1 ÷ 1.25 s, the minutes counter is auto-incremented at a rate of 1, 2 or 4 Hz (depending on metal version) until S2 is released again. In minutes setting mode the carry is not propagated to the hours counter. In addition to minutes setting, the seconds counter is reset to zero.

Segment Test and Reset
If S1 and S2 are pulled to V_{SS} together, all LCD segments are turned ON. Releasing both switches resets the clock and the display is set according to *MODE* input:

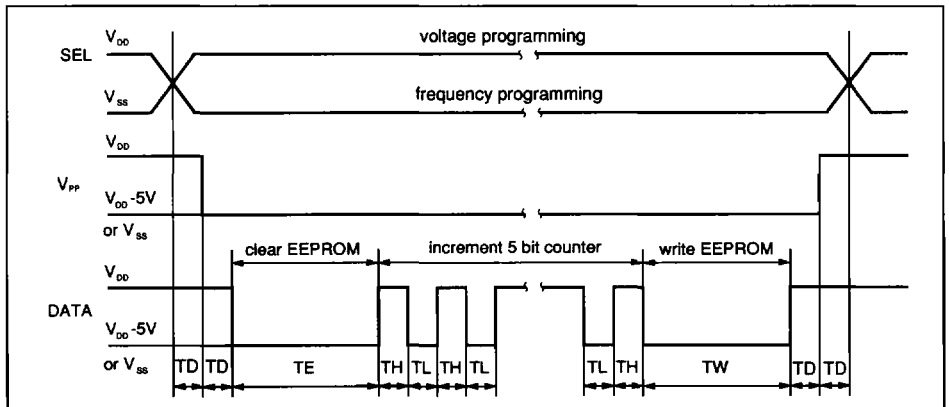
1 : 00 AM if MODE input is connected to V_{DD}
0 : 00 if MODE input is connected to V_{SS}

Display mode changes if MODE input is floating.
If DATA input is hold low during segment test, no reset occurs.

Test Mode
In normal operating mode TS input must be connected to V_{DD}. Connecting TS to V_{SS} allows quick testing of the display via the inputs S1 and S2. Debounce time and auto-increment rate are 64 times faster than normally. Additionally the carry to the seconds counter is inhibited. TS has an internal pull-up resistor, however for safety reasons it should be connected to V_{DD}.

E^2PROM Programming
The inputs DATA, SEL and V_{PP} are used to program the voltage and frequency E^2PROMs. SEL input is used to select between voltage E^2PROM (SEL high or floating) and frequency E^2PROM (SEL low). When pulled to V_{SS} or −5 V in reference to V_{DD}, V_{PP} enables E^2PROM programming sequence. DATA input serves for two purposes: any negative pulse (V_{SS} or −5 V in reference to V_{DD}) increments a 5 bit programming counter by 1 (on the *positive edge), if the pulse width is between 4 to 6 ms the* selected E^2PROM is erased (first long pulse after V_{PP} has gone low) or programmed with the content of the programming counter (second long pulse after V_{PP} has gone low). If the programming counter has reached its maximum value and an additional pulse is applied, the programming counter is reset to 0 again.
During programming sequence (V_{PP} low) the content of the programming counter, instead of the E^2PROM, defines the value of LCD voltage if SEL is high or floating, or the oscillator frequency if SEL is low. This allows the control and interactive adjustment of the appropriate parameter. E^2PROM programming must be done at ambient temperature.

E^2PROM Programming Sequence



TH ≥ 1 µs
TL > 0.5, < 1.5 µs
TE, TW = 4 to 6 ms
TD ≥ 10 µs
Time between 2 consecutive programming cycles: min. 16 ms

Fig. 5

Programming Interconnections

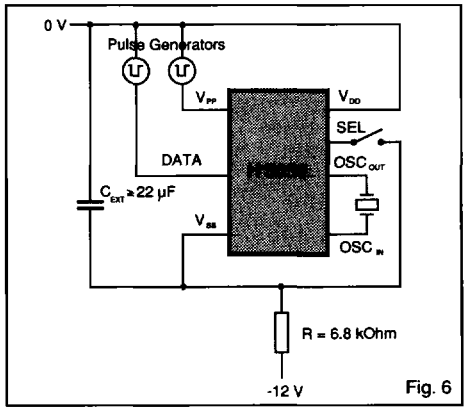
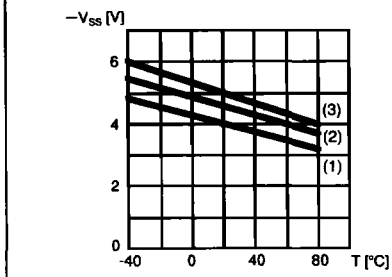


Fig. 6

Programming Inputs
The inputs DATA, SEL and V_{PP} have internal pull-up resistors, but for safety reasons V_{PP} should be connected to V_{DD}.

LCD Voltage Programming
To enable LCD voltage programming, SEL is pulled to V_{DD} (or left floating). Then a negative voltage of -5 V in reference to V_{DD} is applied to V_{PP} to enable the programming sequence. A first negative pulse of 4 ÷ 6 ms is applied to the DATA input to clear the 5 bit voltage E²PROM (the lowest possible LCD voltage is now programmed, and programming counter is set to 1). Any further short pulse (0.5 ÷ 1.5 µs) on the DATA input will increment the programming counter by one and therefore increase LCD voltage by one step of 150 mV typically. When the desired voltage is reached, a second long pulse (4 ÷ 6 ms) writes the value of the programming counter into the voltage E²PROM. At the end, V_{PP} is pulled to V_{DD} again in order to leave the programming cycle.

Regulated Voltage as a Function of Temperature



(1) Programmed to 4.0 V at 25°C
(2) Programmed to 4.5 V at 25°C
(3) Programmed to 5.0 V at 25°C

Fig. 7

Frequency Programming
To enable frequency programming, SEL is pulled to V_{SS}. Then V_{SS} or -5 V in reference to V_{DD} is applied to V_{PP} to enable the programming sequence. A first negative pulse of 4 ÷ 6 ms is applied to the DATA input to clear the 5 bit frequency E²PROM (the highest possible oscillator frequency is now programmed, and programming counter is set to 1). Any further short pulse (0.5 ÷ 1.5 µs) on the DATA input will increment the programming counter by one and therefore decrease oscillator frequency by one step (see Table 3). When the desired frequency is reached a second long pulse (4 ÷ 6 ms) writes the value of the programming counter into the frequency E²PROM. At the end, the V_{PP} input has to be pulled to V_{DD} again in order to leave the programming cycle. Electronic adjustment of the oscillator frequency eliminates the requirement of an external trimming capacitor.

Frequency Programming ($\Delta t = 7.63$ µs)*

Frequency deviation $\Delta f/f$ [ppm]	Number of pulses n	Backplane period* [ms]
0	0	15.625
− 3.8	1	15.633
− 7.6	2	15.641
−11.4	3	15.648
...	...	...
...	...	...
−117.8	31	15.861

* Applies to programming cycle

Table 3

Static Protection and Handling

Static Protection
Input and output pads are protected against electrostatic discharges. The device is designed to withstand the following test:
Conditions: 2 kV pulse from 100 pF capacitor, 1.5 kΩ series resistance with reference to substrate V_{DD}. No degradation of pad characteristic or device performance is permitted. This test is an intrinsic part of the qualification procedure.

Handling
Reasonable care should be taken in handling and mounting operations to avoid the generation and discharge of electrostatic potentials.

Latch-up Protections

Inputs and outputs are protected against latch-up. The device is designed to withstand the following tests:

Static Latch-up
No latch-up triggered with ± 30 mA @ maximum power supply voltage.

Dynamic Latch-up
No latch-up triggered with ± 50 V from 220 pF, 50 Ω series resistance @ maximum power supply voltage.

These tests are an intrinsic part of the qualification procedure.

Typical Application

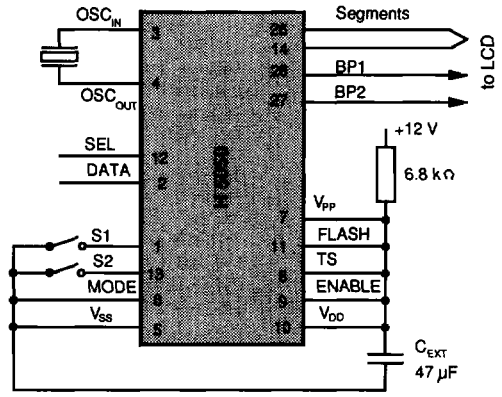


Fig. 8

Package and Ordering Information

Dimensions of SO28 Package

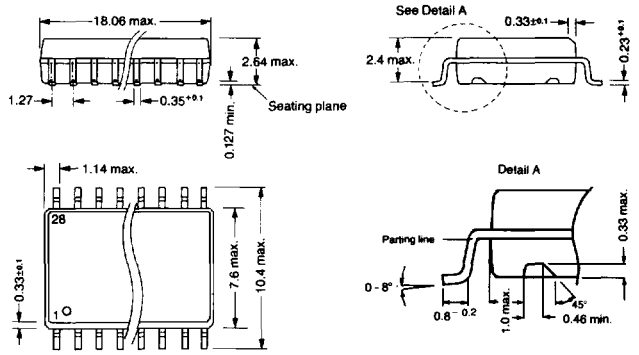


Fig. 9

Ordering Information

Option	Type	Package
1 Hz auto increment	H 5050 - 1H	SO28
2 Hz auto increment	H 5050 - 2H	SO28
4 Hz auto increment	H 5050 - 4H	SO28

Chipform and others on request.

When ordering please specify complete type and package information.