INTERSIL

ICM7223
4-Digit LCD Clock Circuit with Snooze Alarm

FEATURES

- **3-1/2 or 4 digit display with AM/PM and alarm flags**
- **12/24 hour user selectable formats**
- **Direct alarm drive @ 3V p-p, with complex (cricket) alarm tone**
- **8 minute snooze (Dice programmable from 2 to 14 minutes in two minute increments)**
- **Single battery operation (1.5V)**
- **Low current — 6 μA maximum**
- **On-chip fixed oscillator input capacitor**
- **32 kHz oscillator requires only quartz crystal and trimming capacitor**
- **Voltage tripler for large displays**

ORDERING INFORMATION

PART NUMBER	TEMPERATURE RANGE	PACKAGE
ICM7223IPL	-20°C to +70°C	40 Pin Plastic DIP
ICM7223D/D	-20°C to +70°C	DICE

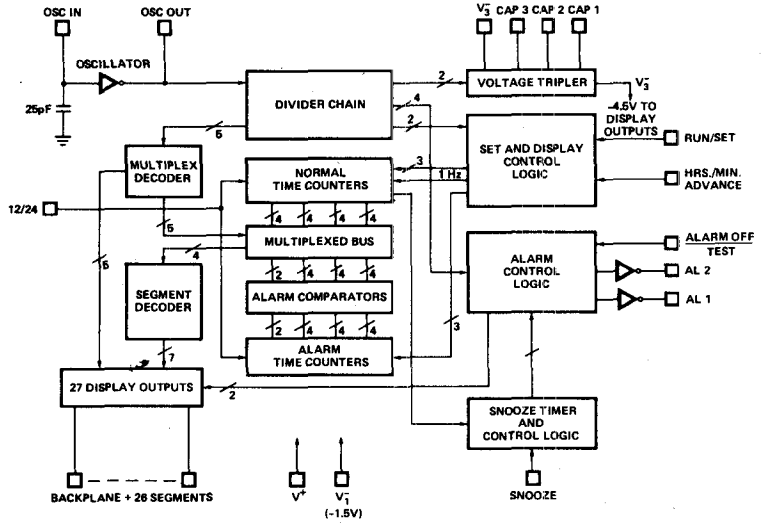
GENERAL DESCRIPTION

The ICM7223 is a fully integrated 4-digit LCD clock circuit with 24 hour alarm and 8 minute snooze timer. For high accuracy and low power consumption a 32.768 KHz quartz watch crystal is used as the time base, and the number of external components has been reduced to a minimum.

The time keeping and alarm time counters are split during setting, allowing hours and minutes to be set independently, each at a 2 Hz rate. A 'time hold' mode is entered when setting minutes; seconds are automatically reset to zero. The clock starts when the RUN mode is entered, thereby permitting synchronization of the clock to the nearest second. Seconds are not displayed.

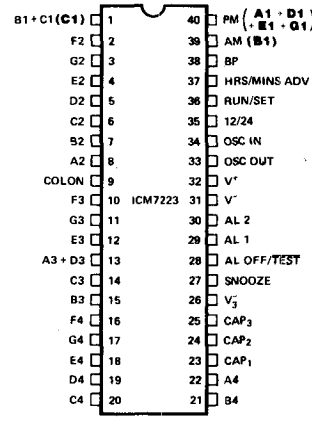
The ICM7223 is fabricated using Intersil's low threshold metal gate CMOS process for minimum cost and long battery life.

BLOCK DIAGRAM



PIN CONFIGURATION

(OUTLINE DRAWING PL)



PARENTHESES AND **BOLD TYPE** INDICATE 24 HOUR OPERATION

ABSOLUTE MAXIMUM RATINGS

Storage Temperature ..... -55°C to +125°C
Operating Temperature ..... -10°C to +60°C
Power Dissipation[1] ..... 100 mW
Supply Voltage[2]
$V^+ - V_1^-$ 2.0V
$V^+ - V_3^-$ 5.5V
Input Voltage (Osc. In, Test, Set, Display) ..... $V^- \le V_{IN} \le V^+$
Output Voltage (Osc. Out, 512) ..... $V_1^- \le V_{OUT} \le V^+$
(All Other Pins) ..... $V_3^- \le V_{OUT} \le V^+$

NOTE: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent device failure. These are stress ratings only and functional operation of the devices at these or any other conditions above those indicated in the operation sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may cause device failures.

OPERATING CHARACTERISTICS

TEST CONDITIONS: V^+-V^- = 1.55V, voltage tripler connected, T_A = 25°C, Test Circuit, unless otherwise specified, voltages and currents are shown as absolute values.

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Supply Voltage	V^+	V^- = 0V -10°C < T_A < 60°C	1.2		1.8	Volts
Supply Current	I^+	Display Disconnected		4	6	μA
Tripler Output Voltage	V_3^-	I_3 = 0.0 μA	4.2			V
		I_3 = 1.0 μA	4.1			
Segment Drive Current	I_{SEG}	V_{SAT} = 0.2V (Both Directions)	5			μA
Backplane Drive Current	I_{BP}	V_{SAT} = 0.1V (Both Directions)	20			μA
Switch Actuation Current	I_{SW}	$V_{SW} = V^+$ or $V_{SW} = V_3^-$		3	5	μA
Alarm Saturation Resistance	$R_{AL(ON)}$	P-CH at 1 mA P-CH		350	500	Ω
		N-CH at 0.5 mA N-CH		1500	1800	
Oscillator Stability	f_{STAB}	V^- = 0V, 1.20V ≤ V^+ ≤ 1.55V, C_{OUT} = 25 pF		2		PPM
Oscillator Input Current[3]	I_{OSCI}	'OSC IN' Connected to V^+ 'OSC OUT' Open Circuit		0.2		μA
Oscillator Input Capacitance	C_{IN}		20	25	30	pF
Oscillator Transconductance	g_m		10	15		μmho

Notes:
1. The ICM7223 is fully short circuit protected on all inputs and outputs. However, if by forward biasing an input or output the device is put into a latchup condition, power dissipation must be limited to 100 mW to prevent destruction of the device.
2. The ICM7223 is intended for use with two power supplies, one of which is derived from an external battery V_1^- and the other is generated internally by the voltage multiplier (V_3^- The common point of the two supplies is the most positive, V+. If desired the circuit can be supplied with an external V_3^- by disconnecting the multiplier capacitors, or V_3^- and V_1^- can be tied together (for a 1.5 volt display for instance).
3. The integrated oscillator biasing components have a nonlinear characteristic depending on the instantaneous values of the input and output voltages of the oscillator and the supply. Under oscillator startup conditions this component has a maximum value.

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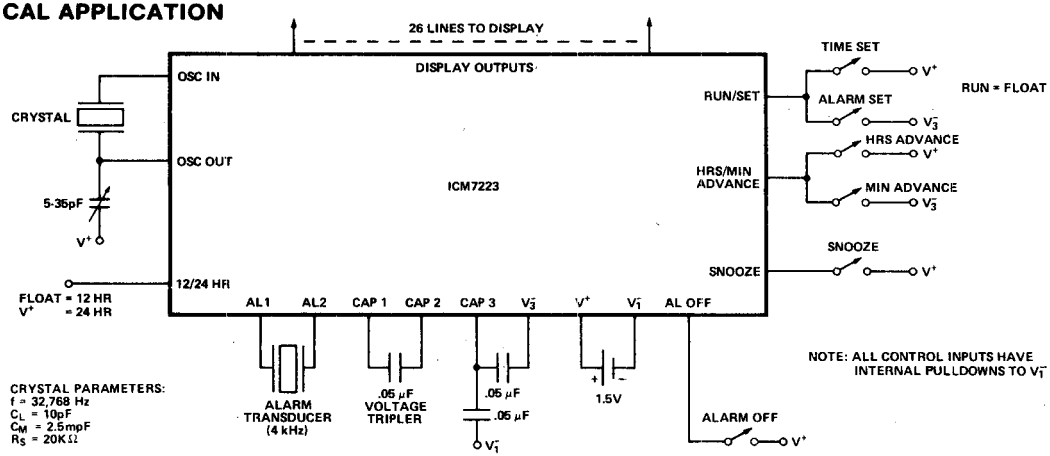
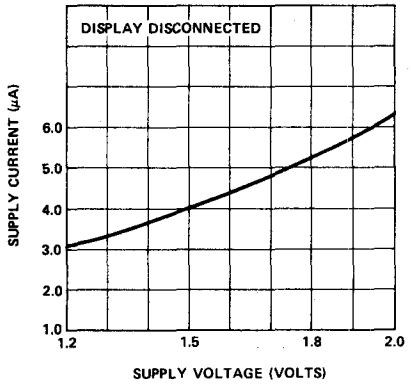
TYPICAL APPLICATION

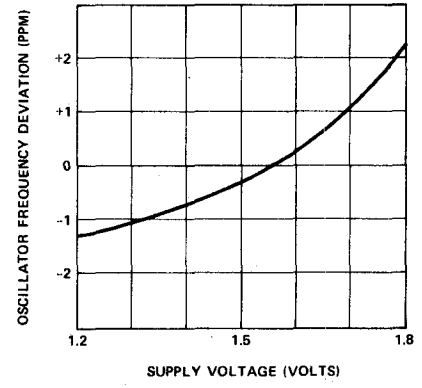


TYPICAL PERFORMANCE CHARACTERISTICS

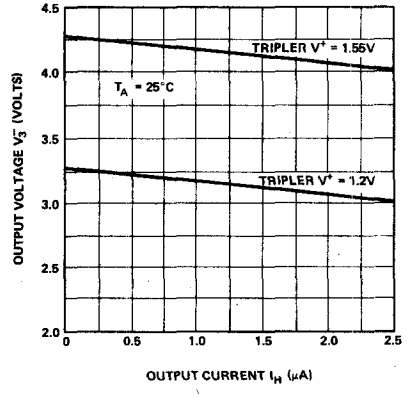
SUPPLY CURRENT VS. SUPPLY VOLTAGE



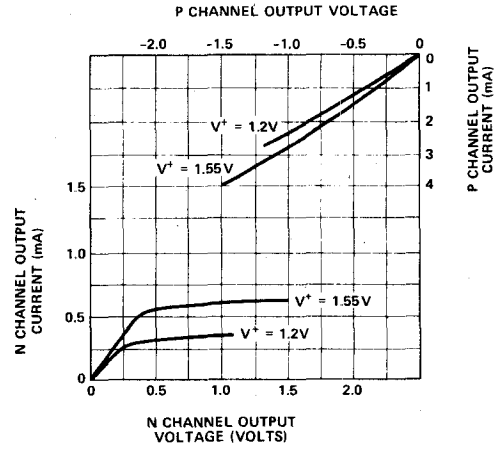
OSCILLATOR STABILITY VS. SUPPLY VOLTAGE



VOLTAGE MULTIPLIER OUTPUT VOLTAGE VS. OUTPUT CURRENT



ALARM DRIVER OUTPUT CURRENT VS. OUTPUT VOLTAGE



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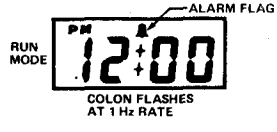
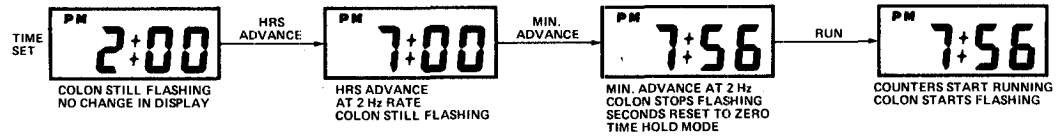
NORMAL CLOCK OPERATION



In normal operation, hours and minutes are displayed with the colon flashing at a 1 Hz rate. An AM and a PM indicator flag is provided in the 12 hour mode, while in the 24 hour mode, the pads used for the AM/PM flags are utilized to drive the segments which produce the numeral "2" in the tens of hours digit. The alarm flag will be on if the alarm is enabled, and off if the alarm is not enabled; (Alarm Off input at V^+).

TIME SETTING

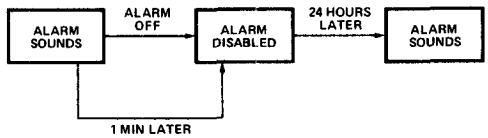


NOTE: When the HRS/MIN Advance input is activated there will be a pause of less than one second before the counters start advancing at a 2 Hz rate.

TIME SETTING

To set the time, the RUN/SET switch is placed in the Time Set position, and the HRS/MIN advance input is used to advance the hours or minutes. The seconds are reset to zero and counting is stopped whenever the minutes are set. The clock will start when the RUN/SET switch is put back into the RUN position, and while in the RUN position, inputs from the HRS/MIN advance switch are disabled to prevent accidental setting.

ALARM OPERATION



The alarm comparator provides a 24 hour alarm in both 12 and 24 hour modes. When the time of day and alarm times are equal, the alarm outputs are enabled, providing that the ALARM OFF input is at V_T^-. If the ALARM OFF input is at V^+, the alarm outputs will not be enabled. The alarm outputs provide a push-pull, or bridge, configuration for direct drive of a piezoelectric transducer, and if increased drive (loudness) is desired, a coil and external NPN transistor may be used. The external transistor should be driven by the ALARM 1 output. The coil DC resistance should be 100Ω or greater, to limit the peak current to less than 13 mA.

The alarm signal is a complex waveform that generates the Intersil Cricket sound. The alarm output will automatically stop after one minute unless either the ALARM OFF or the SNOOZE input is used. The alarm transducer should be selected to provide maximum output (loudness) at 4 kHz, that is, it should be resonant at 4 kHz.

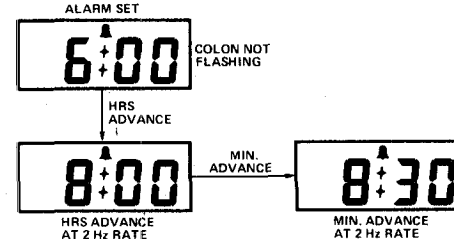
SNOOZE OPERATION

A momentary closure of the SNOOZE switch to V^+ will silence the alarm and start the snooze timer. The Snooze input must be activated during the one minute the alarm is sounding in order to start a Snooze cycle. After 8 minutes the alarm will again sound, and will continue for 2 minutes and stop unless ALARM OFF is used or another Snooze cycle is activated. The Snooze may be repeated as many times as desired.

NOTE: In die form, all the SNOOZE input pads are available, allowing the manufacturer or user to select snooze times from 2 to 14 minutes in 2 minute steps. These pads are identified as SN1, SN2 and SN3. See the following table for the selection of Snooze times:

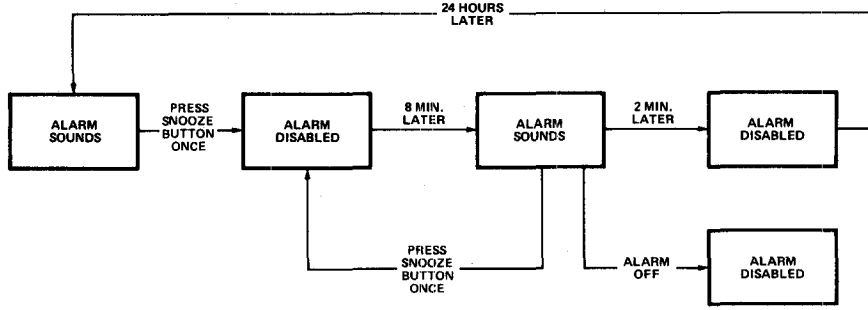
INPUT CODE (1 = V^+)			SNOOZE
SN3	SN2	SN1	TIME
0	0	0	None
0	0	1	2 minutes
0	1	0	4 minutes
0	1	1	6 minutes
1	0	0	8 minutes
1	0	1	10 minutes
1	1	0	12 minutes
1	1	1	14 minutes

ALARM SETTING



The alarm time is set by switching to Alarm Set, then using the HRS/MIN ADVANCE input to set hours and minutes. The alarm time is displayed only when the RUN/SET switch is in the Alarm Set position.

SNOOZE OPERATION



NOTE: IF ALARM OFF IS LEFT AT V^+ THE ALARM WILL NOT SOUND 24 HOURS LATER.

APPLICATION NOTES

ALARM DRIVE

The ICM7223 alarm output transistors are capable of directly driving a piezoelectric ceramic transducer at 3 volts peak-to-peak. Any transducer that does not require more than 1 mA of peak current may also be used. The transducer should generate maximum output at 4 kHz. If a louder sound is desired, buffering (using an NPN transistor and 5 mho coil) or sound enhancement techniques such as a resonant cavity or diaphragm will be required. See Application Bulletin A031 for details.

TEST MODE

The high speed test mode for automatic testing is entered by pulling the ALARM OFF/TEST Input to -7 volts referenced to V_T. In this state the HRS/MIN ADVANCE input will advance the appropriate counters at the rate that the input is toggled. The colon will appear to stop flashing as it is changing state more rapidly than the display can respond. In the run mode the minutes will change at a 4.27 Hz rate, as the clock has been speeded up by a factor of 256 Hz. The backplane frequency will be 512 Hz. The voltage tripler drive frequencies remain the same as in normal modes.

ALARM AND DISPLAY TEST

If the ALARM OFF and SNOOZE buttons are pushed simultaneously, all segments of the display will be turned on and the alarm will sound, while none of the time counter contents are disturbed.

VOLTAGE MULTIPLIER

The ICM7223 voltage multiplier may be utilized only in a tripler configuration; only four pins, and three external capacitors are required. The connection of the capacitors differs from that used in standard watch circuit type voltage multipliers, therefore close attention should be paid to substrate design to ensure the proper connection of the capacitors.

OSCILLATOR

The oscillator of the ICM7223 is designed for low frequency operation at very low currents from a 1.55 volt supply. The oscillator is of the inverter type with a nonlinear feedback resistor included on chip, which has a maximum resistance under startup conditions. The nominal load capacitance of the crystal should be less than 15 pF, typically 12 pF. In specifying the crystal, the motional capacitance, series resistance and tuning tolerance have to be compatible with the characteristics of the circuit to insure startup and operation over a wide voltage range under worst case conditions.

The following expressions can be used to arrive at a crystal specification:

Tuning range

$$\frac{\Delta f}{f} = \frac{C_m}{2\,(C_O + C_L)} \; ; \; C_L = \frac{C_{IN}\,C_{OUT}}{C_{IN} + C_{OUT}}$$

g_m required for startup

$$g_m = 4\pi^2 f^2\, C_{IN}\, C_{OUT}\, R_S \left(1 + \frac{C_O}{C_L}\right)^2$$

where

R_S = Series Resistance of Crystal
f = Frequency of the Crystal
Δf = Frequency Shift from Series Resonance Frequency
C_O = Static Capacitance of Crystal
C_{IN} = Input Capacitance
C_{OUT} = Output Capacitance
C_L = Load Capacitance of Crystal
C_m = Motional Capacitance of Crystal

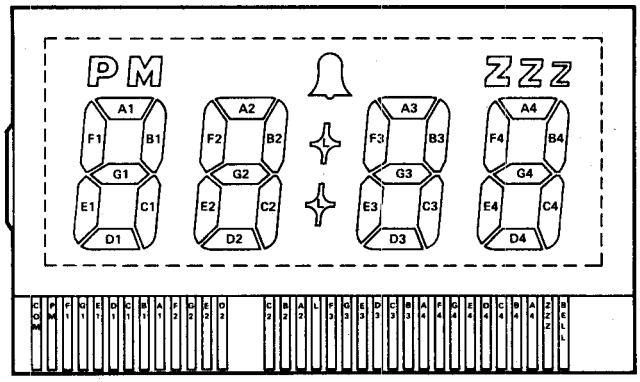
The g_m required for startup calculated should not exceed 50% of the g_m guaranteed for the device.

POWER UP RESET

An on chip circuit is provided that will reset all counters and flip-flops to a known state when power is first applied. The alarm and timekeeping counters will be reset to 1:00 am in the 12 hr. mode and 0:00 in the 24 hr. mode. This function is not tested during automatic testing, as it does not affect normal circuit operation.

DISPLAY

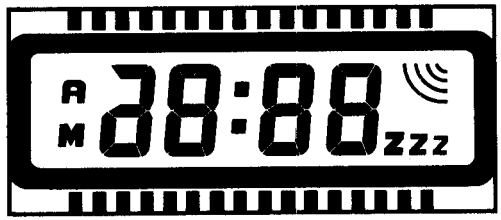
MOTOROLA	MLC406
BECKMAN	737-01
LADCOR	LAD-001
HAMLIN	3411
TIMEX	T1001
COCKROFT	CII202



DISPLAY FONT

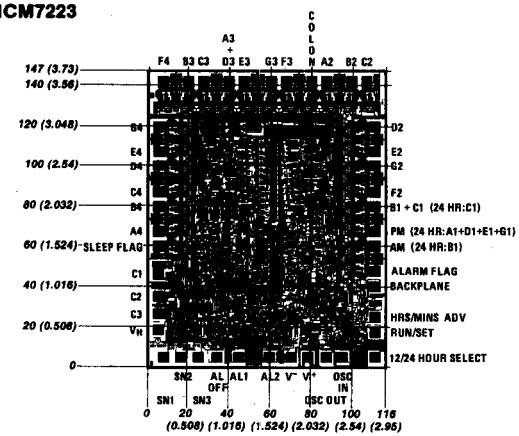
NUMBERS

COCKROFT CII201



CHIP TOPOGRAPHY

ICM7223



CHIP DIMENSIONS: 116 x 147 mils (2.95 x 3.73 mm)

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