Watches

Part Number	Circuit Description	Typical Current at 1.55 VDC
ICM1424C	3½-Digit 5-Function LCD watch circuit. Features Hours:Minutes, Month-Date, Seconds. Rapid advance setting. Mounts on top of the watch substrate.	1.5μA
ICM1424MC	Same as ICM1424C above, except mounts on backside of the substrate.	1.5μA
ICM7210 ICM7210C	4-Digit 6-Function LCD watch circuit. Features Hours:Minutes, Month-Date, Alpha Day, Seconds. ICM7210 mounts on top of substrate, has AM/PM flags.	1.5μA
ICM7210M ICM7210MC	Same as ICM7210 and ICM7210C above, except backside mount.	1.5μA
ICM7214A	4-Digit 6-Function LED watch circuit. Features Hours:Minutes, Alpha Day, Month-Date, Seconds. Direct drive of LED digits and segments.	4.0μA @ 3.1 V
ICM7220A ICM7220FA	6-Digit 6-Function LCD watch circuit with direct drive Cricket alarm. Features Hours:Minutes, Month-Date, Alpha Day (ICM7220A) or Day-of-Week flags (ICM7220FA), Seconds. Backside mount.	2.5μA
ICM7220MA ICM7220MA	Same as ICM7220A and ICM7220FA above, except top mount.	2.5μA
ICM7245B/D/E/F ICM7245U	Analog quartz watch/clock circuit. ICM7245B/D/E/F for bipolar stepper motors, ICM7245U for unipolar stepper motors. Ultra high accuracy: 0.1 ppm.	0.4μA
ICM7270	4-Digit 6-Function Duplex LCD watch circuit. Features Hours:Minutes, Day-of-Week flags, Month-Date, Seconds. Bond option for 24 hour, date-month reversal. Top mount. Ultra high accuracy 0.1 ppm	0.9μA
ICM7271	4-Digit 6-Function Duplex LCD watch circuit with direct Cricket alarm and Snooze. Features Hours:Minutes, Day-of-Week flags, Month-Date, Seconds. Bond option for 24 hour, date-month reversal. 5 minute repeatable snooze. Top mount. Ultra high accuracy 0.1 ppm	0.9μA
ICM7272	4-Digit 6-Function Duplex LCD watch circuit with Chronograph. Features Hours:Minutes, Day-of-Week flags, Month-Date, Seconds. Bond option for 24 hour, date-month reversal. 30 minute Chronograph with auto rollover, bargraph for tenths of seconds resolution. Top mount. Ultra high accuracy 0.1 ppm	0.9μA
ICM7273	4-Digit 6-Function LCD watch circuit with direct drive Cricket alarm. Features Hours:Minutes, Day-of-Week flags, Month-Date, Seconds. Bond option for 24 hour, date-month reversal. Top mount.	2.5μA

Notes: All Intersil watch circuits are designed for use with a 32.768Hz quartz crystal. All provide a rapid advance setting.

Watch circuits are normally sold in die form. The ICM1424C is also available in a 40 pin plastic DIP, and the ICM7245B/D/E/F and ICM7245U are available in either an 8 pin plastic DIP or mini-flatpack as well as dice.

All Intersil watch circuits have a fixed on-chip oscillator capacitor. The above circuits show typical current at 1.55 Volts (3.1 for the ICM7214A) LCD units in doubler mode.

Clocks

Part Number	Circuit Description	Typical Operating Voltage	Package
ICM1115	Analog quartz clock circuit with simple alarm. For bipolar stepper motors; 1 Hz square wave output.	1.5V	8 pin DIP
ICM1115A	Analog quartz clock circuit with simple alarm. For bipolar stepper motors; 1 Hz square wave output.		
ICM1115B	Analog quartz clock circuit with simple alarm. For bipolar stepper motors; 1 Hz square wave output.		
ITS9064-1	Analog quartz clock with complex alarm. For bipolar stepper motors. 1Hz square wave output.		
ICM7038A	Analog quartz clock circuit with simple alarm. For synchronous motors.	3.0V	8 pin DIP
ICM7038C	ICM7038A is a 16 stage divider. 7038C is a 17 stage divider, and 7038F is an 18 stage divider.		
ICM7038F	All have a square wave output.		
ICM7038B	Analog quartz clock circuit with simple alarm. For synchronous motors.	1.5V	8 pin DIP
ICM7038D	ICM7038B is a 16 stage divider. 7038D is a 17 stage. 7038E is an 18 stage. and 7038G is a 19 stage.		
ICM7038E	All have a square wave output.		
ICM7038G			
ICM7049A	Analog quartz clock circuit with complex alarm. For unipolar stepper motors. 31 ms pulse width. 1Hz rate.	1.5V	8 pin DIP
ICM7050	Analog quartz clock circuit with complex alarm. For bipolar stepper motors. 47 ms pulse width. 1Hz rate	1.5V	8 pin DIP
ITS9063	Analog quartz clock circuit with complex alarm. For bipolar stepper motors. 31 ms pulse width. 1Hz rate		
ICM7051A	Analog quartz clock circuit for automotive applications—synchronous motors. 64 Hz square wave.	12.0V	8 pin DIP
ICM7051B	Analog quartz clock circuit for automotive applications—bipolar stepper motors. 31 ms pulse width. 1Hz rate		
ICM7052	Analog quartz clock circuit with complex alarm and Snooze. For bipolar stepper motors. 31 ms pulse width. 1Hz rate.	1.5V	14 pin DIP
ICM7223	4 Digit LCD Alarm Clock with Snooze.	1.5V	40 pin DIP
ICM7223D	Direct drive Cricket alarm. 24 hour format by bond option. For 32.768 kHz quartz crystal.		
ICM7223A	4 Digit LCD Clock Radio circuit with Sleep Timer. Snooze and Alarm. Low battery indicator. Radio Enable. For 32.768 kHz quartz crystal.	9.0V	40 pin DIP
ICM7223VF	4 Digit Vacuum Fluorescent Clock Radio/Auto Clock circuit with Sleep Timer. Alarm. Snooze. and Radio Enable. For 32.768 kHz quartz crystal.	12.0V	40 pin DIP

Notes: All Analog clock circuits are designed for use with a 4.19 MHz quartz crystal. with the exception of the ICM7223 series which uses a 32.768 kHz crystal.
Clock circuits are normally purchased in package form; each is also available as dice.
All Analog clock circuits are mask programmable for oscillator frequency. output frequency and pulse width. and alarm frequency. Consult the factory for details.

Stopwatches

Part Number	Circuit Description	Crystal Frequency	Package
ICM7045	8 Digit 4 Function LED stopwatch circuit. Features Hours:Minutes:Seconds:100ths. Provides Time Out. Taylor. Split and Rally modes. Direct drive for LEDs. May be used as 24-hour clock.	6.55 MHz	28 pin DIP
ICM7045A	8 Digit 4 Function LED industrial stopwatch circuit. precision decade timer. Counts seconds. minutes or hours by selection of suitable quartz crystal.	Seconds: 1.31MHz Minutes: 2.18 MHz Hours: 3.64 MHz	28 pin DIP
ICM7205	6 Digit 2 Function LED stopwatch circuit. Features Minutes:Seconds:100ths. Provides Taylor and Split modes. Direct drive for LEDs.	3.28 MHz	24 pin DIP
ICM7215	6 Digit 4 Function LED stopwatch circuit. Features Minutes:Seconds:100ths. Provides Time out. Taylor and Split modes. Direct drive for LEDs.	3.28 MHz	24 pin DIP

Notes: All stopwatches may be purchased as an Evaluation Kit (EV KIT) which includes the IC and the appropriate quartz crystal. All operate at 2.5 to 4.5 volts. and source 15 mA current to the segments of the LEDs.

INTERSIL

CMOS
ANALOG QUARTZ CLOCK(1)
SELECTION GUIDE

PRODUCT NUMBER	INTERSIL MASK VARIANT	CRYSTAL FREQUENCY (MHz)	MOTOR DRIVE OUTPUT	OUTPUT PULSE CHARACTERISTICS Width (ms)	Freq. (pulses per sec)	ALARM FREQUENCY (Hz)	NOMINAL VOLTAGE (V)	TYPICAL CURRENT (I^+) (μA)	PACKAGE(4)
ICM7038A	—	4.19	Synchronous	7.8 (1)	64	512	3.0	90	8-pin DIP
ICM7038B	—	4.19	Synchronous	7.8 (1)	64	512	1.5	40	8-pin DIP
ICM7038C	—	4.19	Synchronous	15.6 (1)	32	512	3.0	90	8-pin DIP
ICM7038D	—	4.19	Synchronous	15.6 (1)	32	512	1.5	40	8-pin DIP
ICM7038E	—	4.19	Synchronous	31.2 (1)	16	512	1.5	40	8-pin DIP
ICM7038F	—	4.19	Synchronous	31.2 (1)	16	512	3.0	90	8-pin DIP
ICM7038G	—	4.19	Synchronous	62.5 (1)	8	512	1.5	40	8-pin DIP
ICM7049	ITS9026	4.19	Unipolar	7.8	1	1024+16+2	1.5	40	14-pin DIP
ICM7049	ITS9026	4.19	Unipolar	31.2 (1)	16				
ICM7049	ITS9026	4.19	Unipolar	125	1 per min				
ICM7049A	—	4.19	Unipolar	31.2	1	2048+8+1	1.5	40	8-pin DIP
ICM7049A	ITS9044-1	4.19	Unipolar	15.6	1	1024	1.5	40	8-pin DIP
ICM7049A	ITS9068	4.19	Unipolar	7.8	1	2048+8+1	1.5	40	8-pin DIP
ICM7050	—	4.19	Bipolar	46.9	1	2048+8+1	1.5	40	8-pin DIP
ICM7050	ITS9063	4.19	Bipolar	31.2	1	2048+8+1	1.5	40	8-pin DIP
ICM7050	ITS9064-1	4.19	Bipolar	500 (1)	1	2048+8+1	1.5	40	8-pin DIP
ICM7051A	ITS9042-1	4.19	Bipolar	7.8(1)	64	—	13.5(2)	500	8-pin DIP
ICM7051B	—	4.19	Bipolar	31.2	1	—	13.5(2)	500	8-pin DIP
ICM7052	—	4.19	Bipolar	31.2 or 500	1	4096+32+2+1 (3)	1.5	40	14-pin DIP
ICM1115A	—	4.19	Bipolar	500 (1)	1	64	1.5	80	8-pin DIP
ICM1115B	—	4.19	Bipolar	500 (1)	1	64	1.5	40	8-pin DIP
ICM7307	ITS9088	4.19	Unipolar	7.8	1	0.25	1.5	35	8-pin DIP
ICM7307	ITS9090	4.19	Unipolar	7.8	1	0.25(3)	1.5	35	8-pin DIP

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All Intersil analog quartz products are mask programmable. Options include:

- Crystal frequency (32 kHz, 1 MHz, etc.)
- Pulse width (500 msec to 3.9 msec)
- Pulse frequency (64 Hz to 0.5 Hz)
- Alarm frequency (64 Hz to 4096 Hz, including complex)
- Motor drive characteristics
- Oscillator characteristics, including fixed capacitors (ICM7049A, ICM7050)

Notes: (1) Square wave
(2) For automotive service
(3) Includes snooze
(4) All Intersil analog quartz products may be ordered in die form.

INTERSIL

ICM7038B/D/E/G CMOS Analog Quartz Clock Circuit

Synchronous Motor Applications

FEATURES

- **Single battery operation: 1.2 to 1.8 volt operation**
- **Very low power: 30μA typical**
- **High output current drive: 1 mA minimum**
- **Zero output bridge DC component (50% duty cycle square wave)**
- **All inputs fully protected — no special handling precautions required**
- **Wide temperature range: -20° C to +70° C**

GENERAL DESCRIPTION

The ICM7038 family of synchronous motor drivers is designed to operate from a 1.5V battery, and performs the functions of oscillator, frequency divider and output driver. In addition a power driver is tapped off from the thirteenth divider for use as an alarm driver.

Specifically the ICM7038 family uses an inverter oscillator having all biasing components on chip. Binary dividers permit frequency division from 4 MHz down to 64 Hz (ICM7038B). The output from the divider network drives a bridge output circuit which provides a 50% duty cycle AC square wave having virtually zero DC component for driving a synchronous single phase motor. The total output driver saturation is typically 200 ohms providing efficient operation of synchronous motors. The alarm output will drive a transducer (piezoelectric or speaker).

TABLE OF OPTIONS

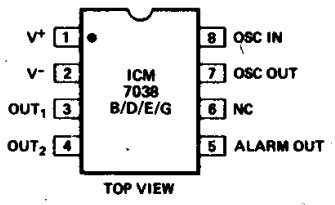
The ICM7038 may be modified with alternative metal masks to provide any number of binary divider stages up to a maximum of 19 together with various output options. Consult your Intersil representative or the factory for further information. The alarm output can be tapped off from any of the latter divider stages.

(See table for standard options).

Part Number	Binary Dividers	Output Frequency (50% Duty Cycle Square Wave)
ICM7038B	16	64 Hz
ICM7038D	17	32 Hz
ICM7038E	18	16 Hz
ICM7038G	19	8 Hz

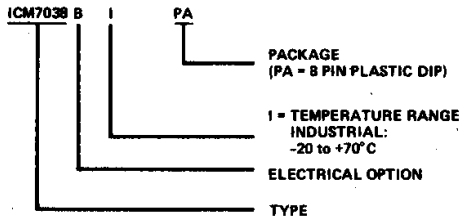
PIN CONFIGURATION

(OUTLINE DRAWING PA)



PIN 1 IS DESIGNATED BY EITHER A DOT OR A NOTCH.

ORDERING INFORMATION



ORDER DEVICES BY FOLLOWING PART NUMBER–
ICM7038B I PA

ORDER DICE BY FOLLOWING PART NUMBER–
ICM7038C/D

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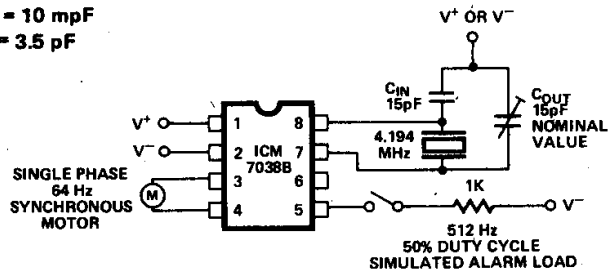
ABSOLUTE MAXIMUM RATINGS

Power Dissipation Output Short Circuit[1] ... 300mW
Supply Voltage 3V
Output Voltage[2] 3V
Input Voltage[2] 3V
Storage Temperature ..... -30°C to +125°C
Operating Temperature ..... -20°C to +70°C

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.

TEST CIRCUIT

QUARTZ CRYSTAL PARAMETERS
f = 4,194,304 Hz
R_S = 35Ω
C_m = 10 mpF
C_0 = 3.5 pF



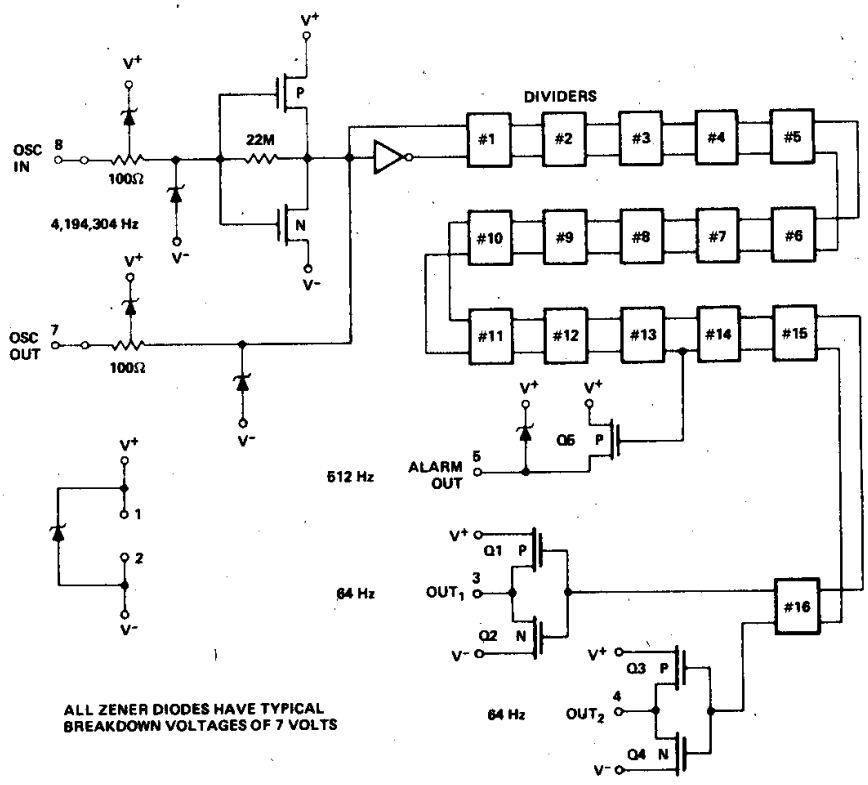
NOTES:
1. This value of power dissipation refers to that of the package and will not be obtained under normal operating conditions.
2. Except for instantaneous static discharges all terminals may exceed the supply voltage (2.0V max) by ±0.5 volt provided that the currents in these terminals are limited to 2 mA each.

TYPICAL OPERATING CHARACTERISTICS

(V^+ = 1.5V, f_{osc} = 4,194,304 Hz test circuit 1, T_A = 25°C, unless otherwise specified)

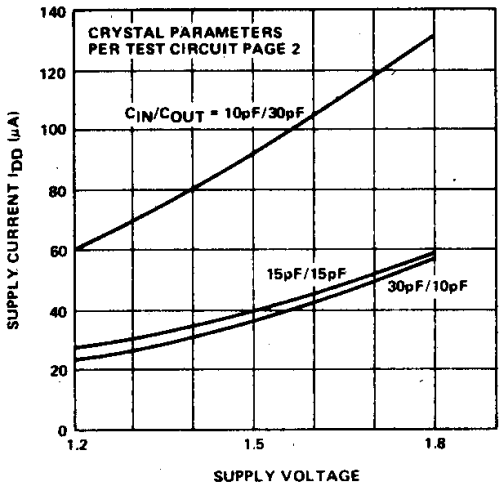
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Current	I^+			30	60	μA
Guaranteed Operating Voltage Range	V^+	-20°C ≤ to ≤ 70°C	1.2		1.8	V
Total Output Saturation Resistance	R_{SAT}	p+n Output Transistors, I_{OUT} = 0.5mA		200	700	Ω
Alarm Output Saturation Resistance	R_{AL}	I_{OUT} = 1mA		300	800	Ω
Oscillator Stability	f_{STAB}	1.2V < V^+ < 1.6V C_{IN} = C_{OUT} = 15pF		1		ppm
Oscillator Start-Up Time	t_{start}	V^+ = 1.2V			1.0	sec

SCHEMATIC DIAGRAM (ICM7038B)

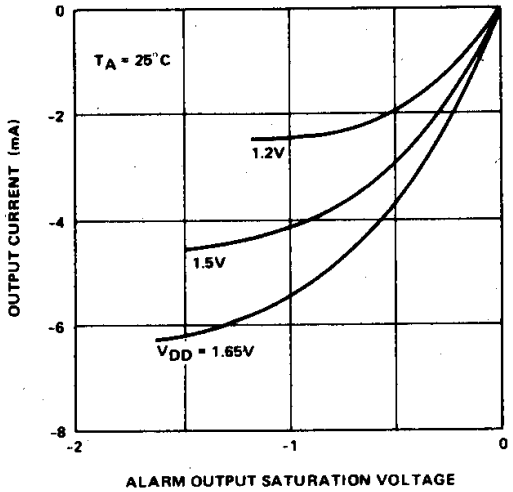


TYPICAL OPERATING CHARACTERISTICS

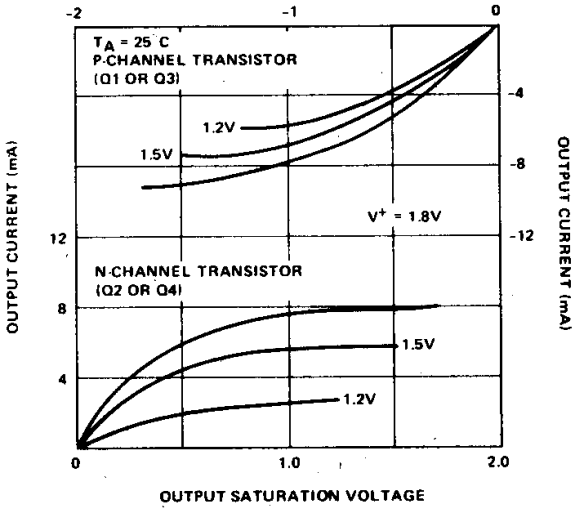
SUPPLY CURRENT VS. SUPPLY VOLTAGE



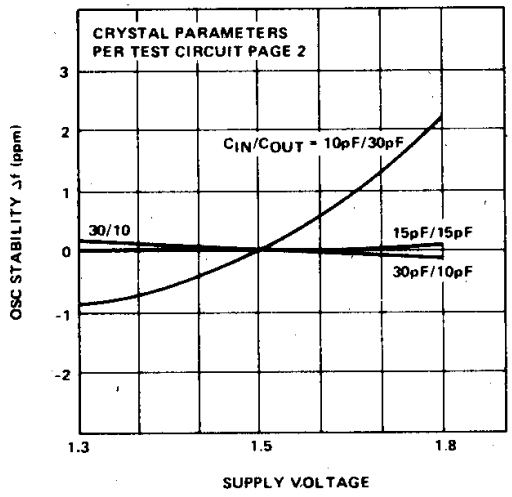
ALARM OUTPUT CURRENT (SOURCE) VS. OUTPUT SATURATION VOLTAGE



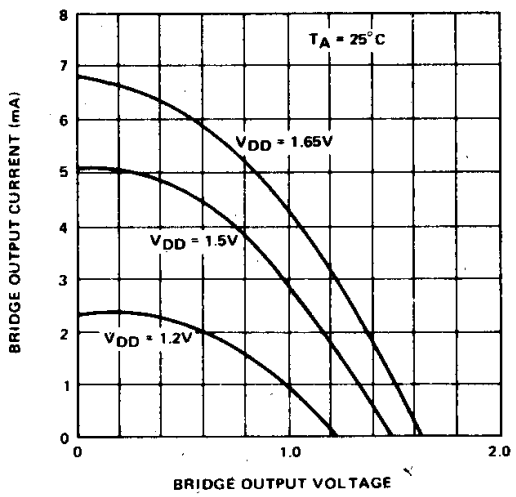
OUTPUT CURRENT (SOURCE) VS. OUTPUT SATURATION VOLTAGE



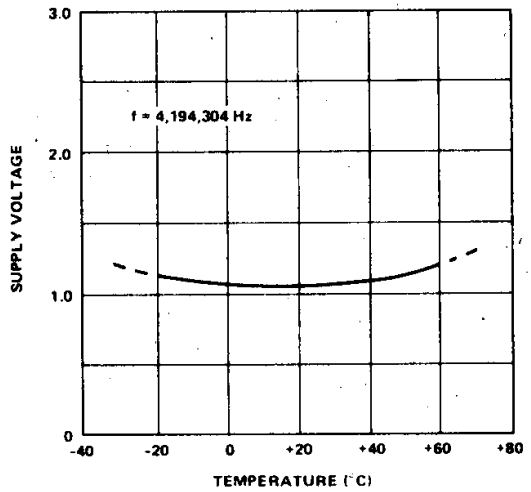
OSCILLATOR STABILITY VS. SUPPLY VOLTAGE



BRIDGE OUTPUT CURRENT VS. BRIDGE OUTPUT VOLTAGE



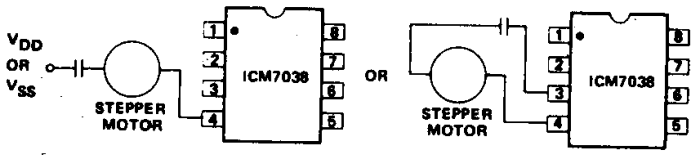
MINIMUM OPERATING SUPPLY VOLTAGE VS. TEMPERATURE



APPLICATION NOTES

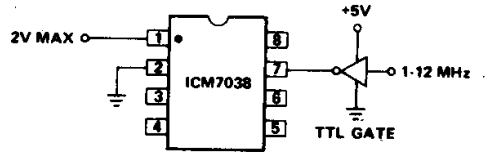
GENERAL DESCRIPTION

The ICM7038 Family has been designed primarily for quartz clock and timer applications using oscillator frequencies between 2.0 and 10 MHz. The design objectives were exceptional oscillator frequency stability, very low power, wide supply voltage range and wide temperature range. The oscillator contains all components except the tuning components and quartz crystal. Three outputs are provided. The two principal outputs are intended to be used to drive a single phase synchronous motor in a bridge configuration. As such, because of the matching of the transistors in the two outputs, the output DC component is extremely small. Stepper motors may also be used by placing a capacitor in series with the motor and using either a single output or the bridge output.



Alternatively outputs 3 and 4 may be used to drive TTL logic directly for timer applications.

The alarm output is taken from the output of the thirteenth divider and can source 1 mA at a low saturation voltage.



The ICM7038 may be used as a straight divider by driving directly into the oscillator output (pin no. 7) with a low impedance square wave drive. As such it may be used over the frequency range 1 MHz to 10 MHz.

OSCILLATOR CONSIDERATIONS

The oscillator of the ICM7038 is designed to operate with crystals having a load capacitance of 10 to 12 pF. This allows nominal capacitor values of 15/15 pF or 20/20 pF. Increasing the load capacitance of the crystal requires larger oscillator device sizes, which causes the supply current to increase. Modifications to the oscillator can be made on a custom basis. The tuning range can be increased by using crystals with lower load capacitances, however, the stability may decrease somewhat. This can be counteracted by reducing the motional capacitance of the crystal. A non-linear feedback resistor is provided on chip, which has a maximum value at start up. Oscillator tuning should be done at the oscillator output.

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

Tuning Range

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

g_m required for startup

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

R_S = series resistance of the crystal
f = frequency of the crystal
Δf = frequency shift from series resonance frequency
C_O = static capacitance of the crystal
C_{IN} = input capacitance
C_{OUT} = output capacitance
C_L = load capacitance
C_m = motional capacitance
$\omega = 2\pi f$

The resulting g_m should not exceed 50 μmhos

INTERSIL

ICM7050
CMOS Quartz Clock Circuit
Bipolar Stepper Motor Applications

FEATURES

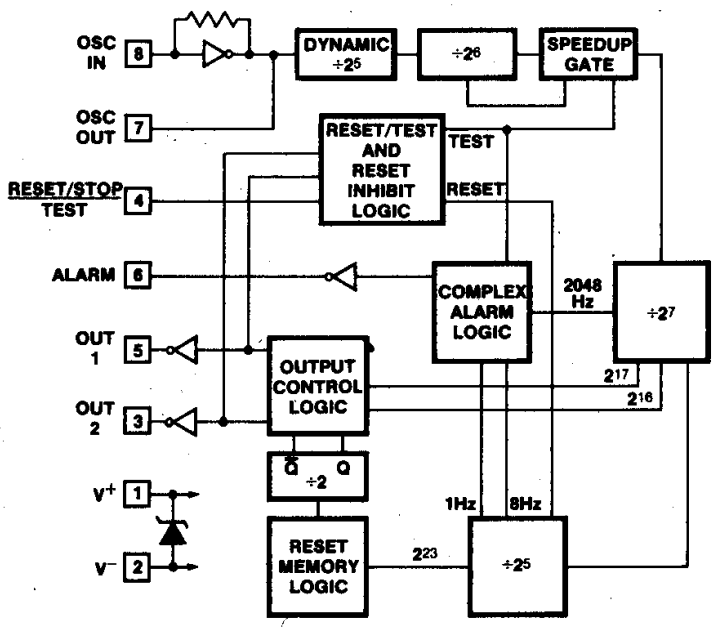
- **Single battery operation**
- **Very low current - typically 30μA at 4.19MHz**
- **Reset or stop function, inhibited during output**
- **Excellent drive with extremely low output saturation resistance: less than 100 ohms**
- **Complex direct drive alarm: 1Hz + 8Hz + 2048Hz**
- **Output pulse width 47ms at 1 Hz rate**
- **Custom options available***

*Two customized versions of the ICM7050 are available as standard factory options. They are:
ITS9063 — Output pulse width is 31 ms at 1Hz rate.
ITS9064-1 — Output pulse is a 1Hz square wave.

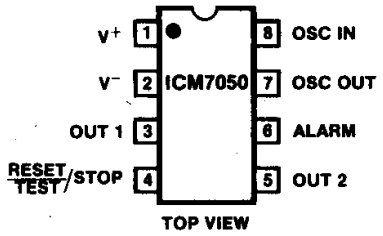
GENERAL DESCRIPTION

The ICM7050 is a single battery analog quartz clock circuit intended for use with bipolar stepper motors, and fabricated using Intersil's low voltage metal gate C-MOS process. The circuit consists of an oscillator, a divider chain, an output oneshot, and output buffers. The oscillator, when using the specified 4.19MHz crystal and capacitors, provides excellent stability. The high frequency portion of the divider chain consists of dynamic dividers, while the remainder are static. The dynamic dividers provide for low power consumption and low operating voltage, but limit low frequency operation. The 2^{23} divider chain is tapped at the 2^{11}, 2^{19}, and 2^{22} points to provide a complex alarm of 1Hz, 8Hz, and 2048Hz driving an output inverter. The oneshot generates the 46.875 millisecond pulse width and the large output inverters provide the low impedance necessary to drive the motor. A reset inhibit function is provided so that if the RESET occurs during an output pulse resetting will not take place until the pulse is completed. RESET may also be used as a stop for synchronization to a time signal or tester.

BLOCK DIAGRAM



PIN CONFIGURATION (OUTLINE DRAWING PA)



TOP VIEW

ORDERING INFORMATION

ICM7050 I PA

- PA = Package: 8 pin plastic DIP
- I = Temperature Range: Industrial -20°C to 70°C
- ICM7050 = Type

Order Devices by Following Part Number — ICM7050IPA
Order Dice by Following Part Number — ICM7050/D
Order Options by Following Part Numbers —
ICM7050 IPA/ITS 9063
ICM7050 IPA/ITS 9064-1

ABSOLUTE MAXIMUM RATINGS

Power Dissipation Output Short Circuit (Note 1) 300mW
Supply Voltage 3V
Output Voltage (Note 2) ..... Equal to but never
Input Voltage (Note 2) ..... exceeding the supply voltage
Storage Temperature ..... -30°C to +125°C
Operating Temperature ..... -20°C to +70°C
Lead Temperature (soldering, 10s) ..... 300°C

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

NOTE 1: This value of power dissipation refers to that of the package and will not normally be obtained under normal operating conditions.
NOTE 2: Due to the inherent SCR structure of junction isolated CMOS devices, the circuit can be put in a latchup mode if large currents are injected into device inputs or outputs. For this reason special care should be taken in a system with multiple power supplies to prevent voltages being applied to inputs and/or outputs before power is applied. If only inputs are affected, latchup can also be prevented by limiting the current into the input terminal to less than 1mA.

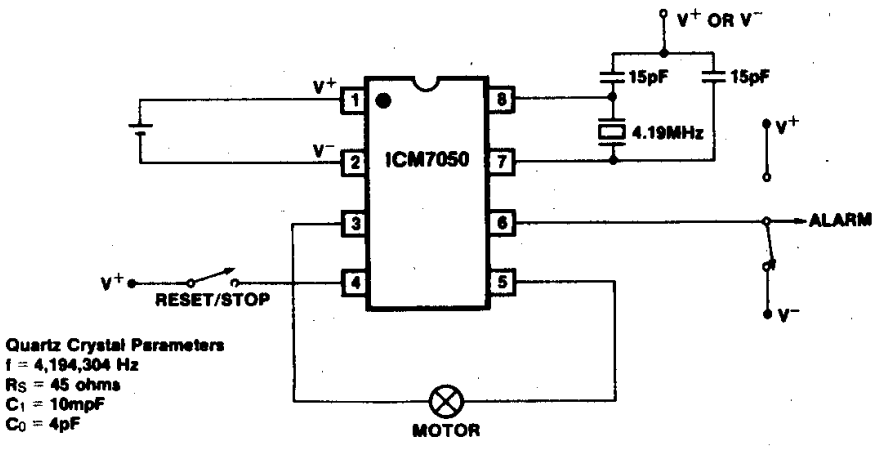
ELECTRICAL CHARACTERISTICS

($V+ = 1.5V$, $f_{osc} = 4{,}194{,}304Hz$ test circuit, $T_A = 25°C$, unless otherwise specified)

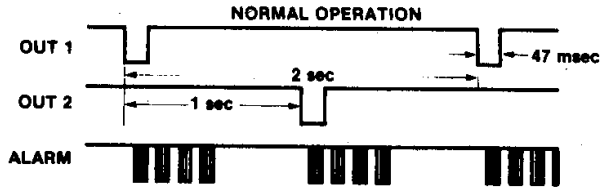
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current	I^+	No Load		30	60	μA
Operating Voltage	V^+	$-20°C < T_A < 70°C$	1.2		1.8	V
Total Output Saturation Resistance	R_{OUT}	$I_L = 3mA$		70	100	Ω
Alarm Saturation Resistance	$R_{AL(on)}$	P, $I_L = 1mA$		400	700	Ω
		N, $I_L = 2mA$		100	400	Ω
Oscillator Stability	f_{stab}	$1.2 \leq V^+ \leq 1.6$		1		ppm
Oscillator Start-up Time	t_{start}	$V^+ = 1.2V$			1.0	sec

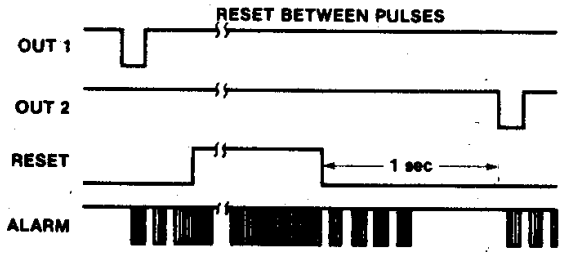
7

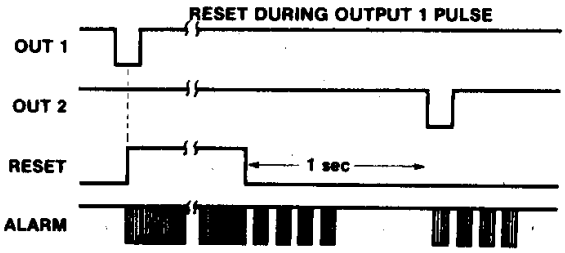
CLOCK CIRCUIT

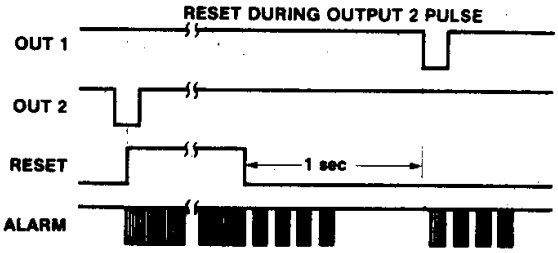


OUTPUT WAVEFORMS



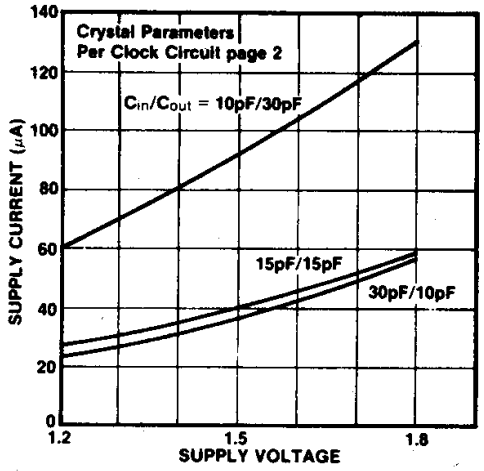




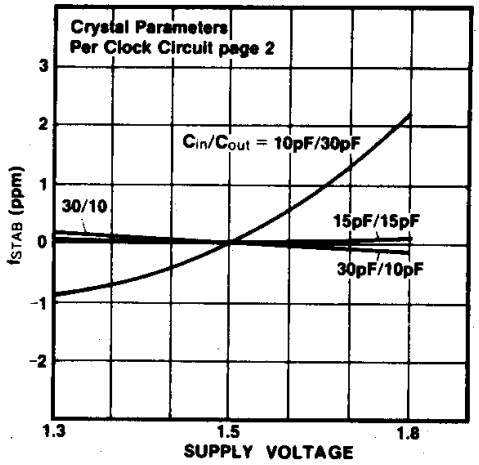


TYPICAL OPERATION CHARACTERISTICS

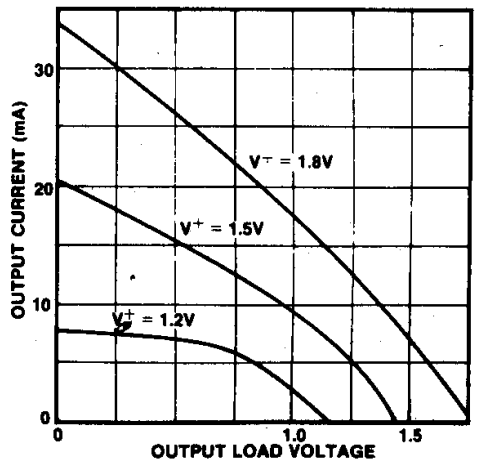
SUPPLY CURRENT vs SUPPLY VOLTAGE



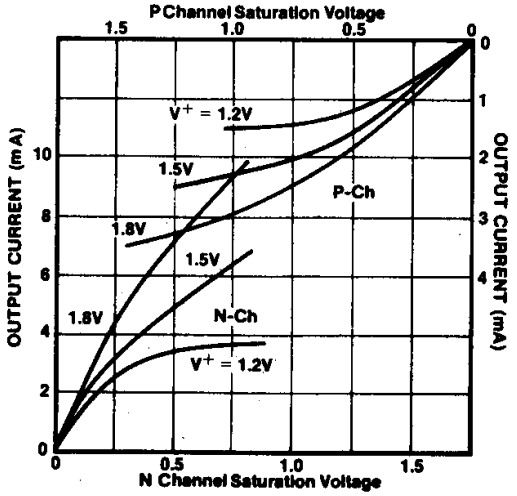
OSCILLATOR STABILITY vs. SUPPLY VOLTAGE



OUTPUT CURRENT vs OUTPUT LOAD VOLTAGE



ALARM OUTPUT CURRENT vs SATURATION VOLTAGE



CUSTOM OPTIONS

All Intersil analog quartz dock circuits are mask programmable for a variety of input and output configurations. The ICM7050 may be customized by varying the following. Parameters specified apply to an input frequency of 32kHz.

- On chip oscillator capacitor — up to 50pF at Cosci or Cosco
- Output pulse width — from 7.8ms to 50% of output period
- Output pulse frequency — from 0.5Hz to 64Hz
- Alarm frequency — Any combination of three binary frequencies up to and including 2048Hz.

A mask programming charge and a minimum order are required for custom options. Consult factory for details.

APPLICATION NOTES

OSCILLATOR CONSIDERATIONS

The oscillator of the ICM7050 has been designed to operate with crystals having a load capacitance of 10 to 12pF. This allows nominal capacitor values of 15/15pF or 20/20pF. Increasing the load capacitance of the crystal requires larger oscillator device sizes, which causes the supply current to increase. Modifications to the oscillator can be made on a custom basis. The tuning range can be increased by using crystals with lower load capacitances, however the stability may decrease somewhat. This can be counteracted by reducing the motional capacitance of the crystal. A non-linear feedback resistor having a maximum value at start up is provided on chip. Oscillator tuning should be done at the oscillator output.

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

Tuning Range

$$\frac{\Delta f}{f} = \frac{C_m}{2(C_o + C_L)} \qquad C_L = \frac{C_{in}C_{out}}{C_{in} + C_{out}}$$

g_m required for startup

$$g_m = \omega^2 C_{in}C_{out}R_S \left(1 + \frac{C_o}{C_L}\right)^2$$

R_S = series resistance of the crystal
f = frequency of the crystal
Δf = frequency shift from series resonance frequency
C_o = static capacitance of the crystal
C_{in} = input capacitance
C_{out} = output capacitance
C_L = motional capacitance
$\omega = 2\pi f$

The resulting g_m should not exceed 50μmhos.

OSCILLATOR TUNING METHODS

When tuning the oscillator two methods can be used. The first method would be to monitor the output pulse at either OUT 1 or OUT 2 with a counter set to measure the period. The oscillator trimmer would then be adjusted for a reading of 2.000000 secs. A second method would be to put the device in the reset mode by pulling the reset pin to V^+ and then monitor the ALARM output with a counter set to measure average period. The ALARM output is a continuous 2048Hz when in the reset mode, which gives a period of 488.2815μs.

The trimmer capacitor used for tuning should be connected to the oscillator output. Otherwise, if tuned at the input, the stability will vary with tuning, and the current drain may become excessive when the input capacitance is much less than the output capacitance. Refer to the I^+ vs V^+ and OSCILLATOR STABILITY vs V^+ characteristic curves on the preceding page.

TEST MODE OPERATION

Pulling the RESET/TEST input to −7V switches the device into the test mode to speedup automatic testing. When in the test mode the output rate is increased 16 times, from 1Hz to 16Hz, with a corresponding reduction in pulse width. The ALARM output changes to a composite waveform of 16Hz and 128Hz. The circuit can be reset while in the test mode by shorting the ALARM output to V^-.

ALARM CONSIDERATIONS

The ALARM output inverter is large enough to directly drive transducers requiring up to 2mA of current. If more current is needed than a buffer should be used*. A slight fluctuation in the supply current of 0.5μA to 1.0μA will be seen; this is a result of 2048Hz driving the relatively large gate capacitance of the alarm output transistors.

*See Intersil Application Bulletin A031 for details.

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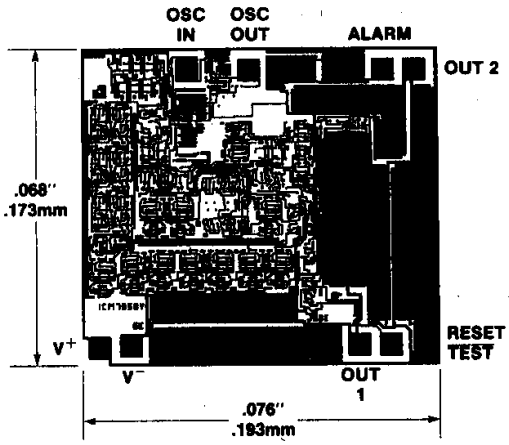
CHIP TOPOGRAPHY



INTERSIL

ICM7245 Quartz Analog Watch Circuit

FEATURES

- **Very low current consumption: 0.4μA at 1.55 volt typical**
- **32 kHz oscillator requires only quartz crystal and trimming capacitor**
- **Bipolar stepper drive with low output ON resistance: 200 ohms maximum (7245 A/B/D/E/F)**
- **Unipolar stepper drive with very low output ON resistance: 50 ohms maximum (7245U)**
- **Extremely accurate: oscillator stability typically 0.1 ppm**
- **STOP function for easy time synchronization**
- **TEST input for highspeed testing**
- **Wide temperature range: -20° C to +70° C**
- **On chip fixed oscillator capacitor: 20pF ±20%**

TABLE OF OPTIONS

Device Number	Bipolar/ Unipolar	Pulse Width (ms)	Pulse Frequency	Oscillator Capacitor
ICM7245A	B	9.7	1Hz	COUT
ICM7245B	B	7.8	1Hz	CIN
ICM7245D	B	7.8	0.1Hz (1 pulse/ 10 seconds)	COUT
ICM7245E	B	7.8	0.0833Hz (1 pulse/ 12 seconds)	CIN
ICM7245F	B	7.8	0.05Hz (1 pulse/ 20 seconds)	CIN
ICM7245U	U	3.9	1Hz	CIN

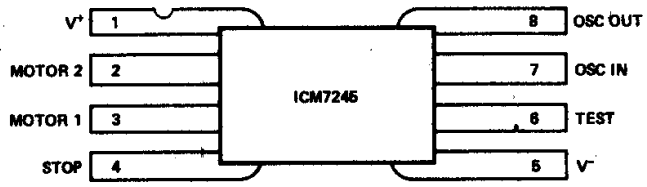
GENERAL DESCRIPTION

The ICM7245 is a very low current, low voltage microcircuit for use in analog watches. It consists of an oscillator, dividers, logic and drivers necessary to provide either bipolar or unipolar drive for minimum-component count watches. The oscillator is extremely stable over wide ranges of voltage and temperature, and thus combines high accuracy with low system power. The ICM7245 is fabricated using Intersil's low threshold metal-gate CMOS process.

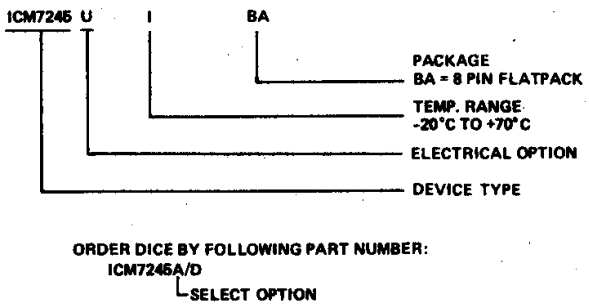
The inverter oscillator contains all components on-chip except for the tuning capacitor and quartz crystal. The binary divider consists of 15 stages, the last 5 of which may be reset. If a reset (stop) occurs during an output pulse, the duration of the pulse is not affected. When the reset is released, the first output occurs approximately 1 second later. For the bipolar version, memory reset logic is included to make sure the first pulse after a "stop" occurs on the opposite output from the one just before the "stop".

The bipolar bridge output consists of two large inverters, normally high. The output ON resistance of the P and N channel devices in series is 200Ω maximum @ 1 mA. In unipolar operation, the output is made up of a single normally high inverter. The ON resistance of the N-channel device is 50Ω maximum @ 3 mA.

PIN CONFIGURATION (OUTLINE DRAWING BA)



ORDERING INFORMATION



ORDER DICE BY FOLLOWING PART NUMBER:
ICM7246A/D
└SELECT OPTION

ABSOLUTE MAXIMUM RATINGS

Storage Temperature ..... -40°C to +125°C
Operating Temperature ..... -20°C to +70°C
Power Dissipation (Note 1) ..... 25 mW
Supply Voltage ($V^+ - V^-$) ..... 3.0 volts
Lead Temperature (Soldering, 10 sec) ..... 300°C
Input Voltages ..... $V^- - 0.3 < V_{IN} < V^+ + 0.3$

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.

Note 1.: This value of power dissipation refers to that of the package and will not normally be obtained under normal operating conditions.

TYPICAL OPERATING CHARACTERISTICS

$V^+ - V^- = 1.55V$, $f_{osc} = 32{,}768$ Hz, circuit in Figure 1, $T_A = 25°C$, unless otherwise stated.
Numbers are in absolute values.

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS
Supply Current	I^+	No Load		0.4	0.8	μA
Operating Voltage	$V^+ - V^-$	$0°C < T_A < 50°C$	1.2		1.8	V
Oscillator Transconductance	g_m	Start-up	15			μmho
Oscillator Capacitance	C_{OSC}		16	20	24	pF
STOP Input Current	I_{STOP}				0.3	μA
TEST Input Current	I_{TEST}				10	μA
Oscillator Stability	f_{STAB}	$\Delta(V^+ - V^-) = 0.6V$		0.1		ppm
Supply Current During Stop	I^+	'STOP' Connected to V^+			1.0	μA
Output Saturation Resistance	R_O	Bipolar (N-CH. + P-CH) $I_L = 1$ mA			200	Ω
Output Saturation Resistance P-CH	R_{O-P}	Unipolar $I_L = 3$ mA			200	Ω
Output Saturation Resistance N-CH	R_{O-N}	Unipolar $I_L = 3$ mA			50	Ω

TYPICAL WATCH CIRCUIT

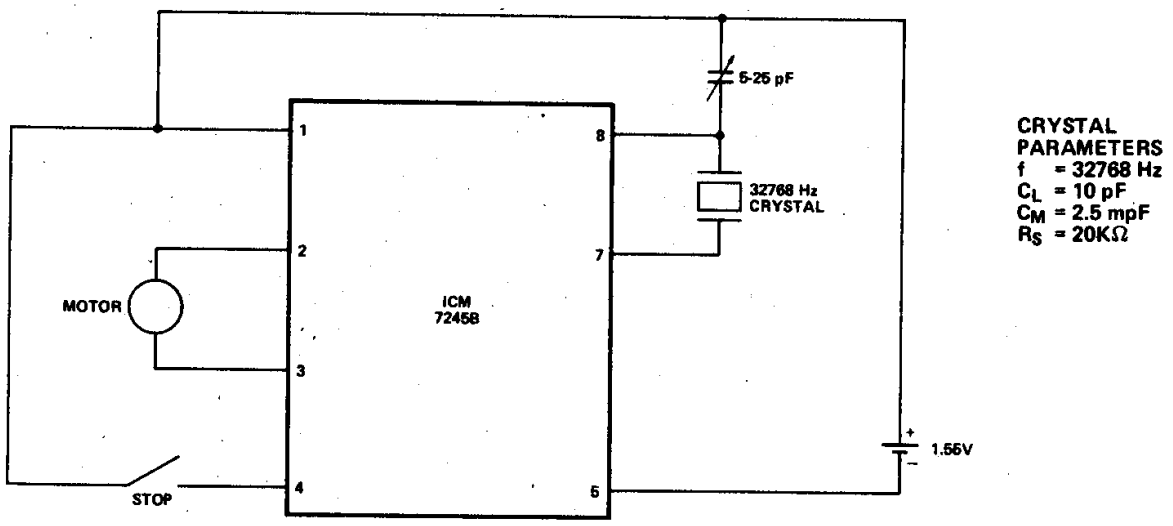
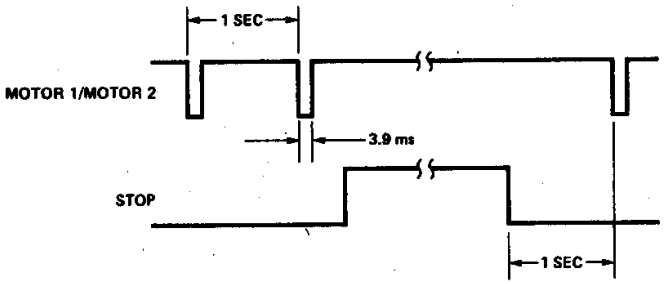


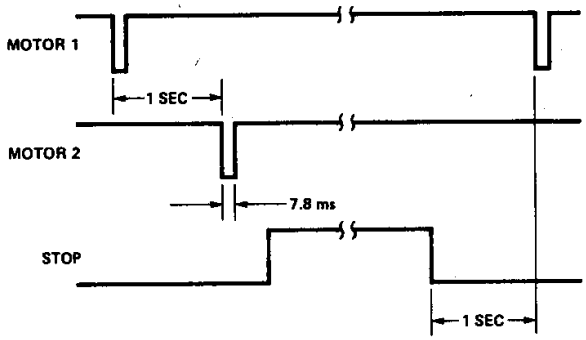
Figure 1.

WAVEFORMS

(ICM7245U)

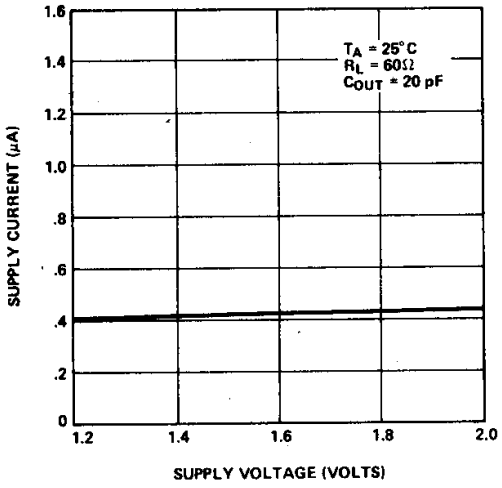


(ICM7245B)

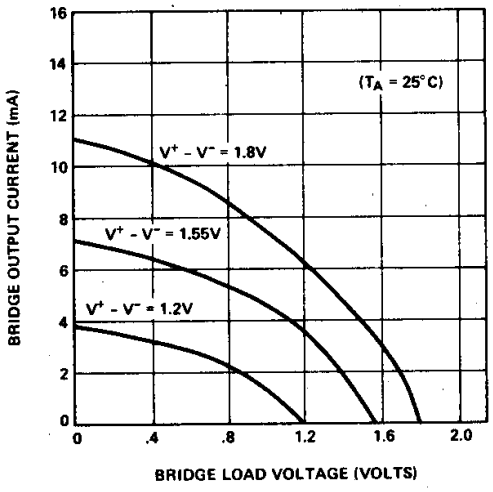


TYPICAL OPERATING CHARACTERISTICS

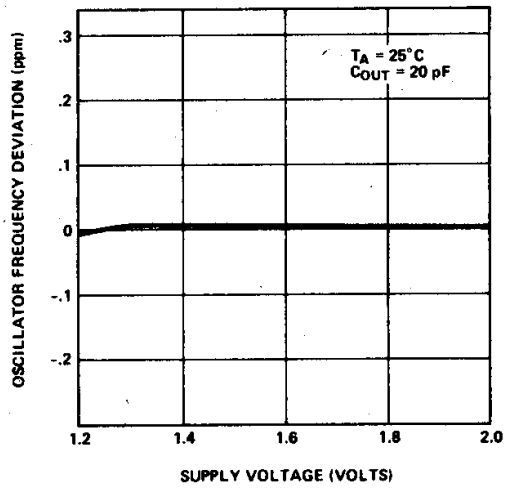
SUPPLY CURRENT AS A FUNCTION OF SUPPLY VOLTAGE



BRIDGE OUTPUT CURRENT AS A FUNCTION OF LOAD VOLTAGE



OSCILLATOR STABILITY AS A FUNCTION OF SUPPLY VOLTAGE



7

APPLICATION NOTES

OSCILLATOR

The oscillator of the ICM7245 is designed for low frequency operation at very low current from a 1.55 volt supply. The oscillator is of the inverter type, using a non-linear feedback resistor having maximum resistance under start-up conditions. The nominal load capacitance of the crystal should be less than 12 pF, with a preferred range of 7-10 pF. In specifying the crystal, the motional capacitance, series resistance and tuning tolerance must be compatible with the characteristics of the circuit to insure start-up 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 start-up

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

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
C_m = Motional Capacitance of Crystal

The g_m required for start-up calculated should not exceed 50% of the g_m guaranteed for the device.

TEST POINT

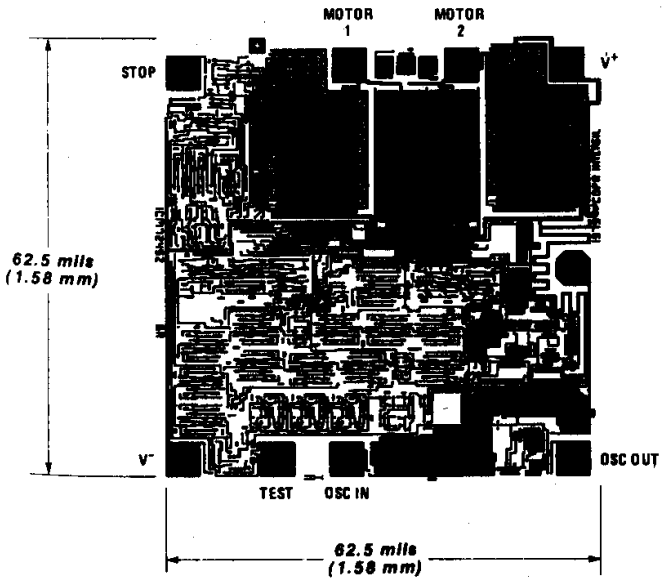
The TEST input, when connected to V^-, causes the ICM7245B/U to speed-up the outputs by 16 times. On long period output versions (12, 20, 60 sec) the speed-up factor will be larger. This allows easy testing of the finished watch module. The pulse width is not affected by the speed-up of the pulse frequency.

CUSTOM VERSIONS

The ICM7245 may be modified with alternative metal masks to provide different number of dividers, various pulse widths, and different output configurations.

In addition, MOS capacitors on-chip up to a total of 50 pF may be connected to either the input and/or the output of the oscillator. Consult your Intersil representative or the factory for further information.

CHIP TOPOGRAPHY



DIE SIZE = 62.5 x 62.5 MILS (1.58 x 1.58 mm)
BOND PAD SIZE = 5x5 MILS (.127 x .127 mm)

7

National Semiconductor

MM5368 CMOS Oscillator Divider Circuit

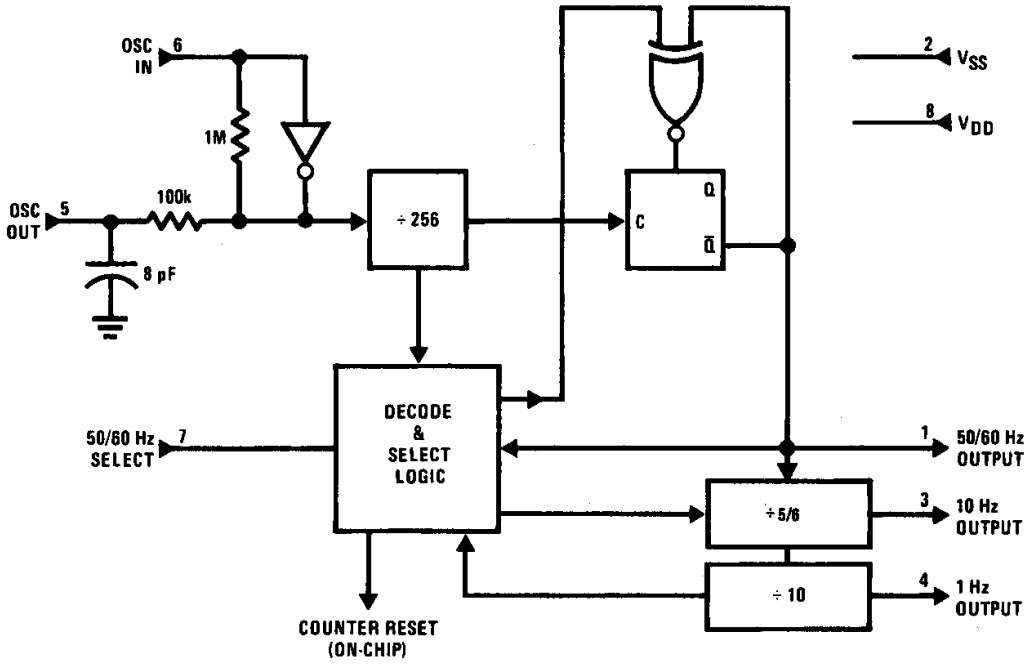
General Description

The MM5368 is a CMOS integrated circuit generating 50 or 60 Hz, 10 Hz, and 1 Hz outputs from a 32 kHz crystal (32,768 Hz). For the 60 Hz selected output the input time base is divided by 546.133, for the 50 Hz mode it is divided by 655.36. The 50/60 Hz output is then divided by 5 or 6 to obtain a 10 Hz output which is further divided to obtain a 1 Hz output. The 50/60 Hz select input can be floated for a counter reset.

Features

- 50/60 Hz output
- 1 Hz output
- 10 Hz output
- Low power dissipation
- Fully static operation
- Counter reset
- 3.5V–15V supply range
- On-chip oscillator—tuning and load capacitors are the only required external components besides the crystal. (For operation below 5V it may be necessary to use an ~ 1 MΩ pullup on the oscillator output to insure start-up.)

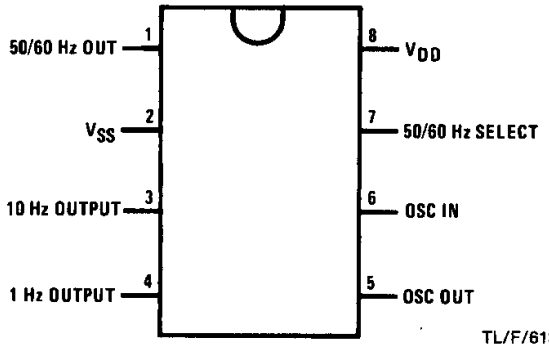
Block and Connection Diagrams



TL/F/6133–1

FIGURE 1

Dual-In-Line Package



TL/F/6133–2

Top View

FIGURE 2

Order Number MM5368N
See NS Package Number N08E

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Voltage at Any Pin	$-0.3V$ to $V_{DD} + 0.3V$
Operating Temperature	0°C to +70°C
Storage Temperature	−65°C to +150°C
Maximum V_{DD} Voltage	16V
Operating V_{DD} Range	$3.5V \leq V_{DD} \leq 15V$
Lead Temperature (Soldering, 10 sec.)	300°C

Electrical Characteristics T_A within operating range, V_{SS} = 0V

Parameter	Conditions	Min	Typ	Max	Units
Quiescent Current Drain	V_{DD} = 15V; 50/60 Select Floating			10	μA
Operating Current Drain	f_{IN} = 32 kHz, V_{DD} = 3.5V			60	μA
	f_{IN} = 32 kHz, V_{DD} = 15V			1500	μA
Maximum Input Frequency	V_{DD} = 3.5V			64	kHz
	V_{DD} = 15V			500	kHz
Output Current Levels	V_{DD} = 5V				
Logical "1", Source	$V_{OH} = V_{SS} + 2.7V$			−400	μA
Logical "0", Sink	$V_{OL} = V_{SS} + 0.4V$	400			μA
	V_{DD} = 9V				
Logical "1", Source	$V_{OH} = V_{SS} + 6.7V$			−1500	μA
Logical "0", Sink	$V_{OL} = V_{SS} + 0.4V$	1500			μA
Input Current Levels	50/60 Select Input (Note 1)				
Logical "1" (I_{IH})	$V_{DD} = 3.5V, V_{IN} \geq 0.9\ V_{DD}$			50	μA
Logical "1" (I_{IH})	$V_{DD} = 15V, V_{IN} \geq 0.9\ V_{DD}$			3	mA
Logical "0" (I_{IL})	$V_{DD} = 3.5V, V_{IN} \geq 0.1\ V_{DD}$			20	μA
Logical "0" (I_{IL})	$V_{DD} = 15V, V_{IN} \geq 0.1\ V_{DD}$			1	mA

Note 1: The input current level test is performed by first measuring the open circuit voltage at the 50/60 Hz select pin. If the voltage is "high", make the I_{IH} test. If the voltage is "low", make the I_{IL} test. The state of the 50/60 Hz select pin may be changed by applying a pulse to OSC IN (pin 6) while the 50/60 Hz pin is open circuit.

Functional Description *(Figure 1)*

The MM5368 initially divides the input time base by 256. From the resulting frequency (128 Hz for 32 kHz crystal) 8 clock periods are dropped or eliminated during 60 Hz operation and 28 clock periods are eliminated during 50 Hz operation. This frequency is then divided by 2 to obtain a 50 or 60 Hz output. This output is not periodic from cycle to cycle; however, the waveform repeats itself every second. Straight divide by 5 or 6 and 10 are used to obtain the 10 Hz output and the 1 Hz outputs.

The 60 Hz mode is obtained by tying pin 7 to V_{DD}. The 60 Hz output waveform can be seen in *Figure 3*. The 10 Hz and 1 Hz outputs have an approximate 50% duty cycle. In the 50 Hz mode the 50/60 select input is tied to V_{SS}. The 50 Hz output waveform can be seen in *Figure 3*. The 10 Hz output has an approximate 40% duty cycle and the 1 Hz output has an approximate 50% duty cycle.

For the 50/60 Hz select input floating, the counter chain is held reset, except for the initial toggle flip-flop which is needed for the reset function. A reset may also occur when the input is switched *(Figure 4)*. To insure the floating state, current sourced from the input must be limited to 1.0 μA and current sunk by the input must be limited to 1.0 μA for V_{DD} = 3.5V.

Timing Diagrams

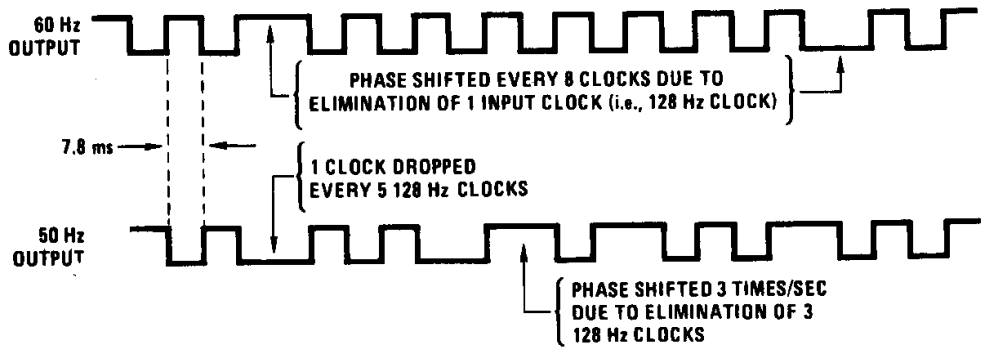
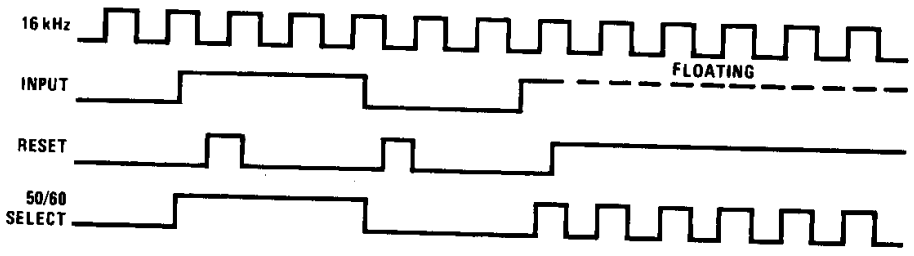
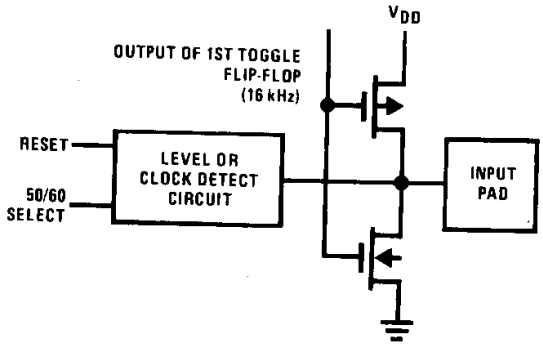


FIGURE 3. 50/60 Hz Output

Timing Diagrams (Continued)



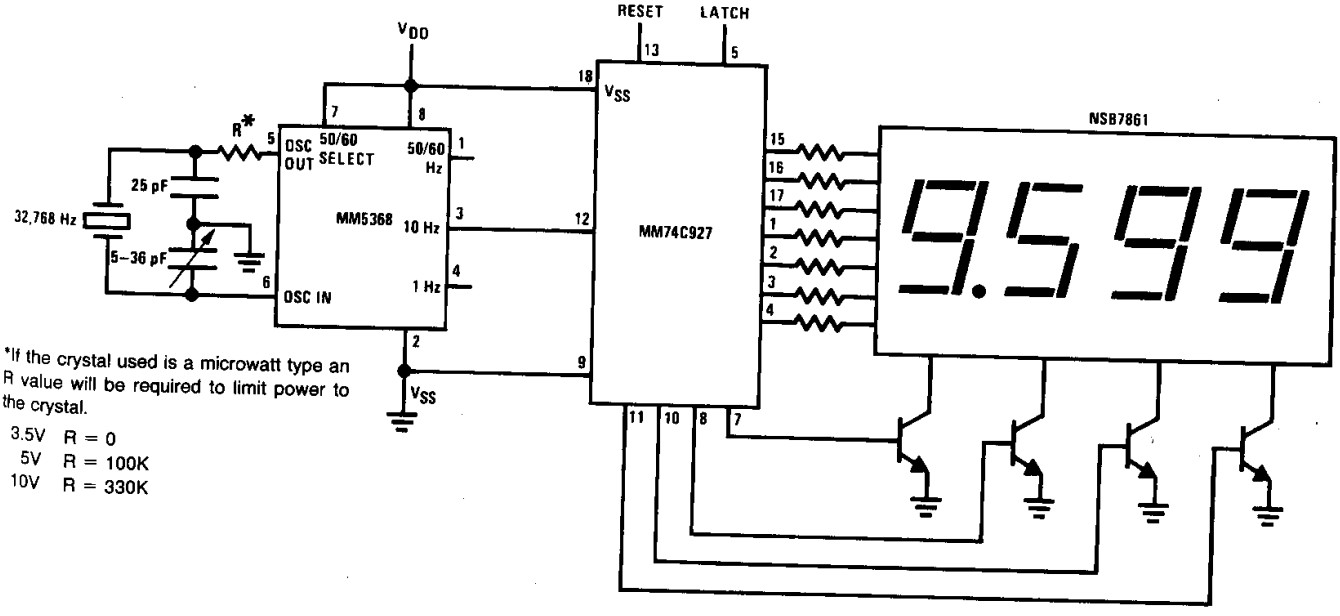
TL/F/6133–4



TL/F/6133–5

FIGURE 4. 50/60 Select and Reset

Typical Applications



*If the crystal used is a microwatt type an R value will be required to limit power to the crystal.

3.5V R = 0
5V R = 100K
10V R = 330K

TL/F/6133–6

FIGURE 5. 10 Minute (9:59.9) Timer

National Semiconductor

MM5369 17 Stage Oscillator/Divider

General Description

The MM5369 is a CMOS integrated circuit with 17 binary divider stages that can be used to generate a precise reference from commonly available high frequency quartz crystals. An internal pulse is generated by mask programming the combinations of stages 1 through 4, 16 and 17 to set or reset the individual stages. The MM5369 is advanced one count on the positive transition of each clock pulse. Two buffered outputs are available: the cyrstal frequency for tuning purposes and the 17th stage output. The MM5369 is available in an 8-lead dual-in-line epoxy package.

Features

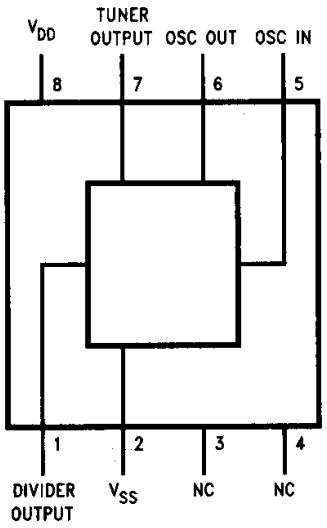
- Crystal oscillator
- Two buffered outputs
  - Output 1 crystal frequency
  - Output 2 full division
- High speed (4 MHz at V_{DD} = 10V)
- Wide supply range 3V–15V
- Low power
- Fully static operation
- 8-lead dual-in-line package
- Low Current

Option

- MM5369AA — 3.58 MHz to 60 Hz

Connection and Block Diagrams

Dual-In-Line Package



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Top View

Order Number MM5369AA/N
See NS Package Number N08E

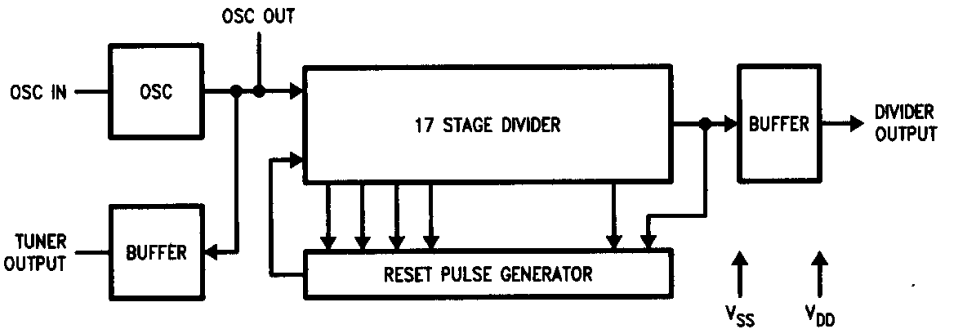

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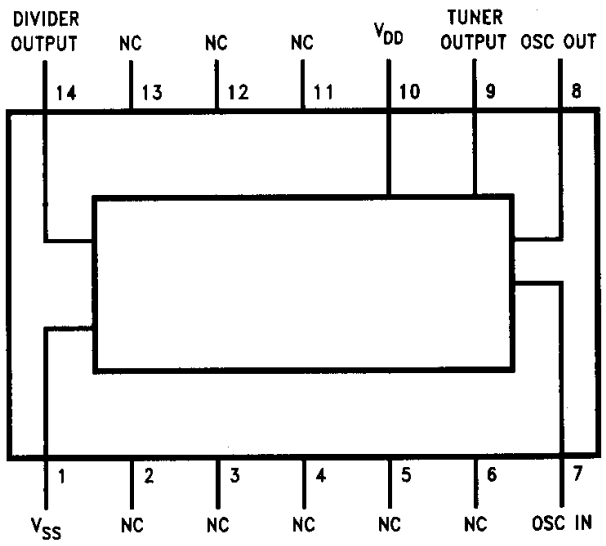
FIGURE 2



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Order Number MM5369AA/M
See NS Package Number M14A

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Voltage at Any Pin	$-0.3V$ to $V_{DD} + 0.3V$
Operating Temperature	0°C to +70°C
Storage Temperature	−65°C to +150°C
Package Dissipation	500 mW
Maximum V_{CC} Voltage	16V
Operating V_{CC} Range	3V to 15V
Lead Temperature (Soldering, 10 seconds)	300°C

Electrical Characteristics

T_A within operating temperature range, V_{SS} = GND, $3V \leq V_{DD} \leq 15V$ unless otherwise specified.

Parameter	Conditions	Min	Typ	Max	Units
Quiescent Current Drain	V_{DD} = 15V			10	μA
Operating Current Drain	V_{DD} = 10V, f_{IN} = 4.19 MHz		1.2	2.5	mA
Frequency of Oscillation	V_{DD} = 10V	DC		4.5	MHz
	V_{DD} = 6V	DC		2	MHz
Output Current Levels	V_{DD} = 10V V_O = 5V				
Logical "1" Source		500			μA
Logical "0" Sink		500			μA
Output Voltage Levels	V_{DD} = 10V I_O = 10 μA				
Logical "1"		9.0			V
Logical "0"				1.0	V

Note: For 3.58 MHz operation, V_{DD} must be ≥ 10V.

Functional Description

A connection diagram for the MM5369 is shown in *Figure 1* and a block diagram is shown in *Figure 2.*

TIME BASE

A precision time base is provided by the interconnection of a 3,579,545 Hz quartz crystal and the RC network shown in *Figure 3* together with the CMOS inverter/amplifier provided between the OSC IN and the OSC OUT terminals. Resistor R1 is necessary to bias the inverter for class A amplifier operation. Capacitors C1 and C2 in series provide the parallel load capacitance required for precise tuning of the quartz crystal.

The network shown provides > 100 ppm tuning range when used with standard crystals trimmed for C_L = 12 pF. Tuning to better than ±2 ppm is easily obtainable.

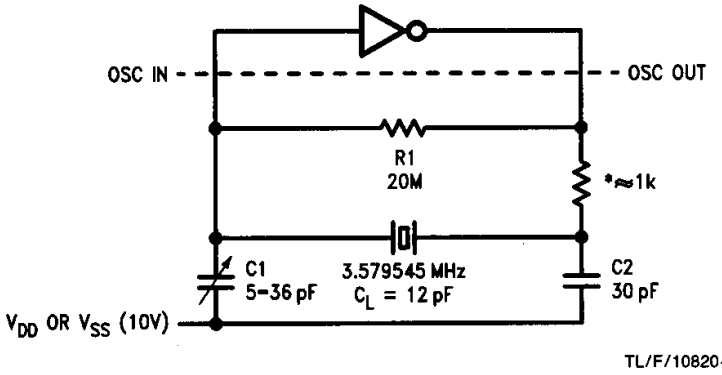
DIVIDER

A pulse is genertaed when divider stages 1 through 4, 16 and 17 are in the correct state. By mask options, this pulse is used to set or reset individual stages of the counter. *Figure 4* shows the relationship between the duty cycle and the programmed modulus.

OUTPUTS

The Tuner Output is a buffered output at the crystal oscillator frequency. This output is provided so that the crystal frequency can be obtained without disturbing the crystal oscillator. The Divide Output is the input frequency divided by the mask programmed number. Both outputs are push-pull outputs.

Functional Description (Continued)



*To be selected based on xtal used

FIGURE 3. Crystal Oscillator Network

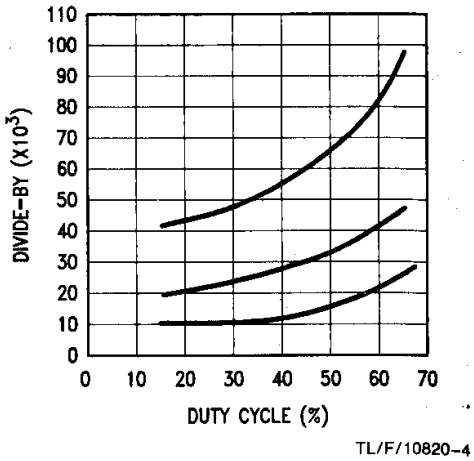


FIGURE 4. Plot of Divide-By vs Duty Cycle

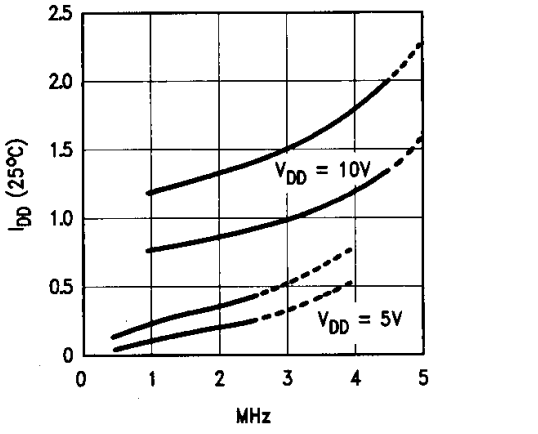


FIGURE 5. Typical Current Drain vs Oscillator Frequency

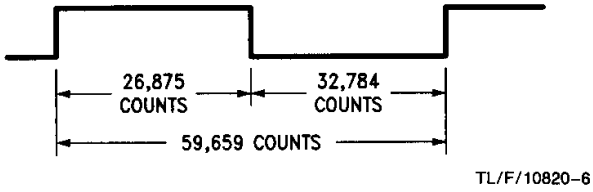


FIGURE 6. Output Waveform for the MM5369AA