CMOS Circuit for Analog Quartz Watches

Features

- 32kHz quartz oscillator
- Operating voltage range −2.2 V to −3.6 V
- High oscillator stability
- Integrated capacitors, mask selectable
- Mask options for pad designation, motor period, fast mode period, motor pulse width, motor pulse chopping and two chopping frequencies
- Shorted motor coil between motor pulses
- Fast motor test function
- 32 Hz 50% duty cycle frequency or bidirectional MTEST pad for quartz frequency measurement
- Fully debounced RESET input and MTEST input

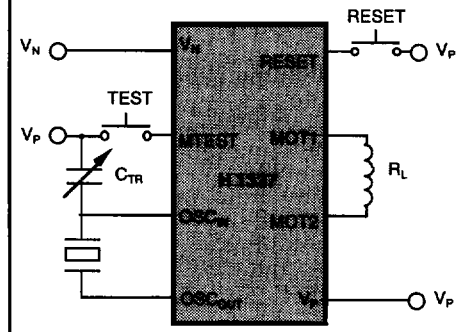
Description

The H 1337 is a low power 32 kHz analog watch chip designed to drive a stepping motor. Motor pulse width is programmable from 0.9765 to 14.65 milliseconds in steps of 0.9765 milliseconds. Motor pulse chopping is programmable from 1/8 to 8/8 steps of 1/8 with two programmable chopping frequencies 1024 Hz or 2048 Hz. Motor pulse period is programmable from 2 x 1 to 2 x 60 seconds in steps of 1 second. Fast mode period is selectable between 62.5 milliseconds and 125 milliseconds. Input and output capacitors are integrated on the chip. Their values are metal mask selectable. The selection of width, chopping, period, fast mode and capacitance are metal options and do not require additional bonds.

Application

- Analog watches

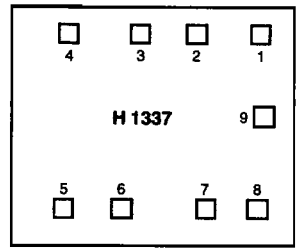
Functional Diagram



Operating range of trimmer capacitance: 3pF ≤ C ≤ 30 pF

Fig. 1

Pin Assignment



Pad	Function	Pad Locations
V_N	Negative supply voltage	1
MTEST	Test input/output	2 or 8
OSC_{IN}	Oscillator input	3
OSC_{OUT}	Oscillator output	4
V_P	Positive supply voltage	5
MOT_1	Motor drive output 1	6
MOT_2	Motor drive output 2	7
RESET	Reset input	8 or 2
EMTEST	Manufacturer test pad	9

Fig. 2

Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Units
Supply voltage	V_N	−4.0		+3.0	V
Voltage applied to other terminals		V_N−0.3		V_P+0.3	V
Storage temperature	T_{STOR}	−55		+150	°C

Table 1

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

Handling Procedures

This device contains circuitry to protect the terminals against damage due to high static voltages or electrical fields. However, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this circuit.

Recommended Operating Conditions

Parameter	Symbol	Value	Units
Ambient temperature	T_A	25	°C
Quartz frequency	f_Q	32768	Hz
Quartz serial resistance	R_Q	30	kΩ
Motor coil resistance	R_M	2.0	kΩ
Positive supply	V_P	0	V
Negative supply	V_N	−3.00	V
Supply source resistance	R_I	10	Ω

Table 2

Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units
Operating temperature	T_{OPR}	−10		+60	°C
Quartz series resistance			30	50	kΩ
Trimmer capacitance	C_{TR}	3		30	pF

Table 3

Electrical and Switching Characteristics

at recommended operating conditions unless otherwise specified

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Supply voltage range	V_N		−3.6	−3	−2.2	V
Supply voltage drop during motor pulse	ΔV_N				0.7	V
Mean dynamic current	I_{DYN}	Without motor and quartz, 32 kHz + $\overline{32\ kHz}$ square wave forced at OSC_{IN} and OSC_{OUT}, TEST open		120	250	nA
Mean current consumption	I_N	With quartz, without motor, MTEST open, C_{TR} = 12pF		200	350	nA
In variation with R_Q	$\Delta I_N/\Delta R_Q$			2.6		nA/KΩ
Oscillator						
Transconductance	Gm	V_N = −2.2 V, V_{PP} = 300 mV sinus	2.5	15		µmho
Starting voltage	V_{ST}	Within 10 seconds			−1.9	V
Starting time	T_{ST}	General conditions (−2.2 to +3.6 V)		1	2	s
Stability df/f*dV_N		Between −2.9 V and −3.1 V		1.5	5	ppm/V
Motor Drivers						
Voltage across motor	V_{MOT}	V_N = −3.00 V, R_M = 2 kΩ	2.69	2.84		V
		V_N = −2.20 V, R_M = 2 kΩ	1.97	2.08		V
		R_I = 300 Ω, T_{OPR} range, R_M = 2 kΩ	2.35	2.40		V
		V_N = −3.00 V, R_M = 640 Ω	2.21	2.56		V
		V_N = −2.20 V, R_M = 640 Ω	1.62	1.87		V
		R_I = 300 Ω, T_{OPR} range, R_M = 640 Ω	1.64	1.80		V
Short circuit impedance	R_{CC}	Between motor pulses, 100mV applied			215	Ω
Fall Time	t_F	From V_P to V_N (10% to 90%)			100	µs
MTEST Input / Output						
Debounce delay	T_{TST}		31.25		62.5	ms
Amplitude	V_{TST}	30 pF // 1 MΩ load	2.6			V_{PP}
Mean current	I_{TST}	Pulled to V_P		10	50	nA
RESET Input						
Debounce delay	T_S		7.81		23.43	ms
Input current after debounce delay*	I_S	Pulled to V_P		10	50	nA

* Is the average input current modulated by a frequency of 64 Hz

Table 4

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Timing Waveforms

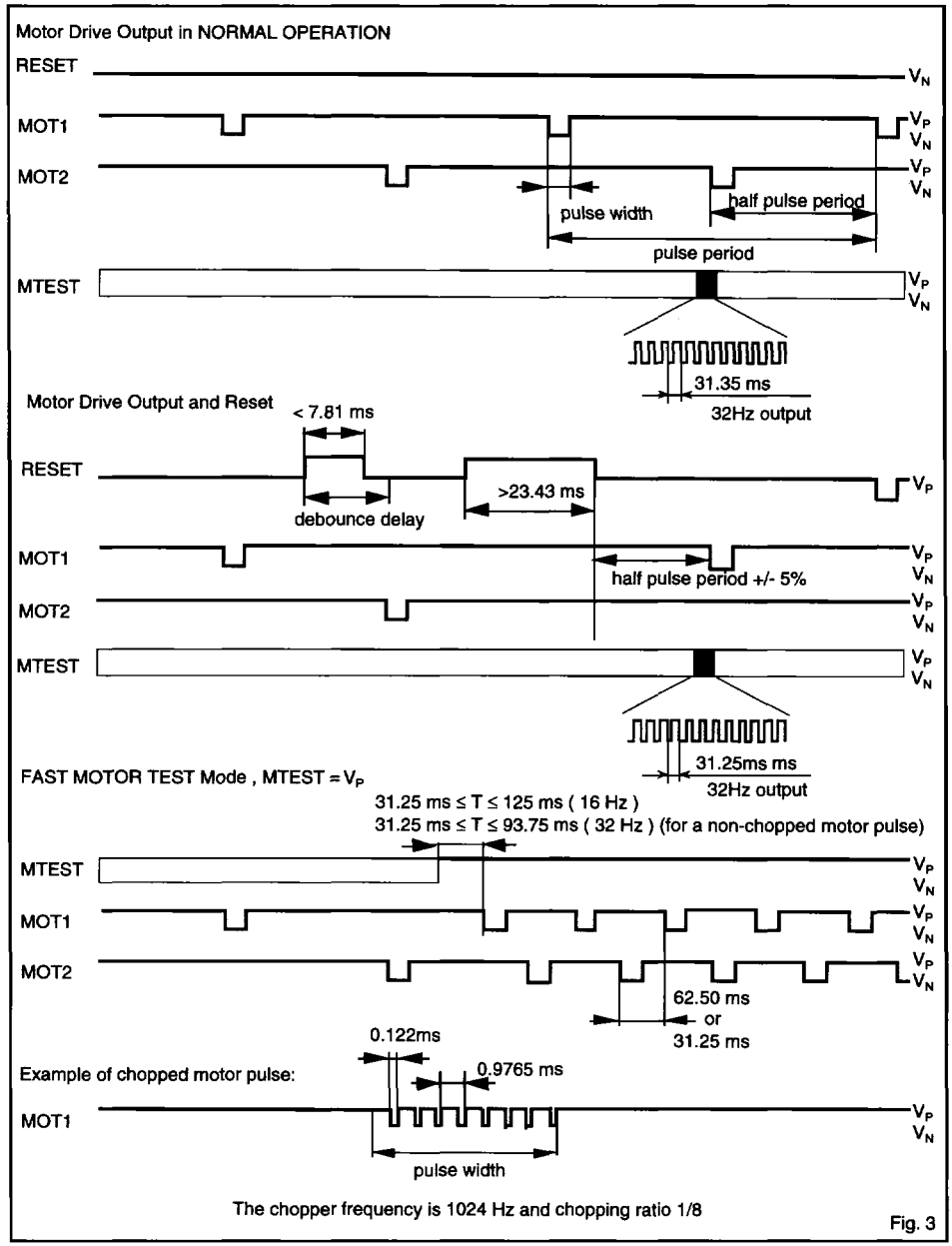


Fig. 3

Block Diagram

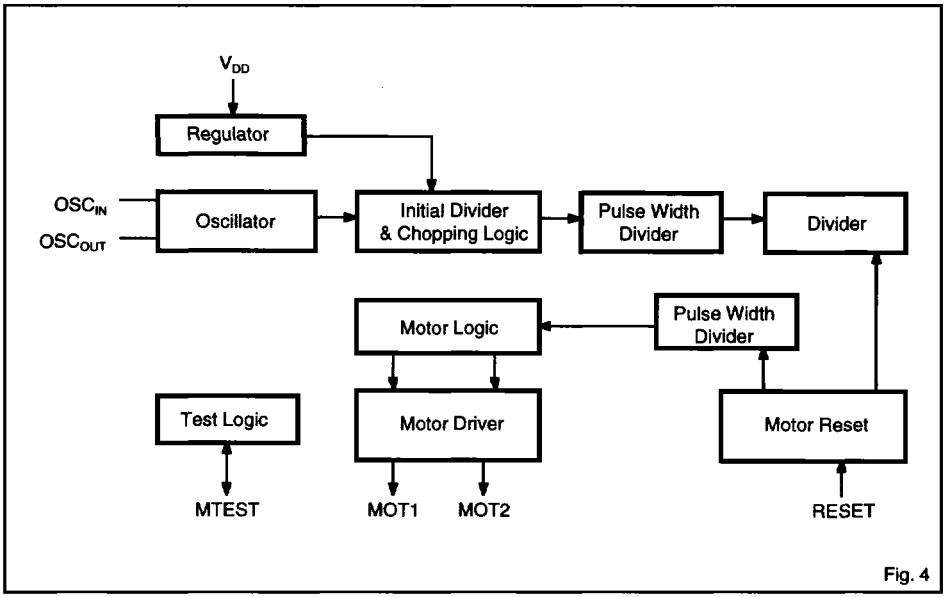


Fig. 4

Pin Description

Name	Function
V_N	Negative supply voltage
MTEST	Test input / output
OSC_{IN}	Oscillator input
OSC_{OUT}	Oscillator output
V_P	Positive supply voltage
MOT_1	Motor drive output 1
MOT_2	Motor drive output 2
RESET	Reset input
EMTEST	Test input / output

Table 5

Functional Description

Oscillator
The 32'768Hz clock frequency is generated by a crystal oscillator. Input and output capacitances are integrated in the chip. Their values are metal mask selectable.

Motor Drive Output
The H 1337 contains two push-pull output buffers for driving bipolar stepping motors (see Fig. 3). Between two pulses, the two P-channel devices are active for motor damping.

Reset
Pulling the RESET input to V_P resets the frequency dividers and disables the motor pulses. Motor pulses in progress when the RESET function is applied will be completed. After releasing the RESET pad from V_P, the next motor pulse appears with a delay of one half motor cycle ± 5% on the drive output MOT_1 if the last pulse appeared on MOT_2 and vice-versa.

MTEST Mode
The MTEST pad fulfils two functions:

a) For normal operation, the MTEST pad is left open. The circuit outputs a square wave signal of 32 Hz which can be used for tuning the oscillator.
b) If the MTEST pad is connected to V_P, the period for motor pulses changes either 2 x 31.25 ms or 2 x 62.5 ms (mask option) while the motor pulse width and chopping remains unchanged (fast motor test).

Test

MTEST Pad	Function	Description
Connected to V_P	Fast motor test	Increase the frequency for the motor pulses to 16 Hz (32 Hz)
Open	Normal operation	Output of square wave signal (32 Hz)

Table 6

Metal Mask Option Possibilities

Motor Pulse and Capacitance

Symbol	Description	Range min.	Range max.	Range resolut.
TM	Motor pulse period	2 x 1.00 s	2 x 60.00 s	1.00 s
TM	Fast motor TEST	2 x 31.25 ms	2 x 62.50 ms	
tm	Motor pulse width	0.9765 ms	14.65 ms	0.9765 ms
tmc	Motor pulse chopping ratio	1/8	8/8	1/8
f_{CHOP}	Chopping freq.	1024 Hz	2048 Hz	
C_{IN}	Oscillator input cap.	2 to 5 pF	$C_{IN} - C_{OUT}$ = 35 pF	2 pF
C_{OUT}	Oscillator output cap.	2 to 5 pF		2 pF

Table 7

Pad Options

Symbol	Description	Pad Layout 1	Pad Layout 2
RESET	Pad RESET	Pad 2	Pad 8
MTEST	Pad MTEST	Pad 8	Pad 2

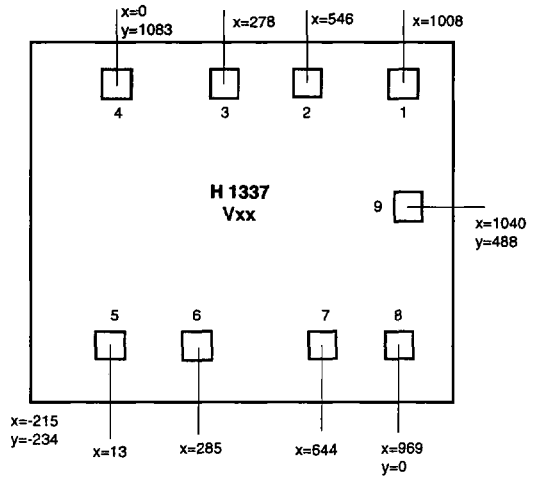
Table 8

Available Versions

Versions	Motor output					Integrated cap.		Pad Options	
	Period s	Pulse width ms	Chop ratio	Chop freq. Hz	Fast mode ms	OSC_{IN} pF	OSC_{OUT} pF	Pad 2	Pad 8
H 1337 V01	2 x 1	3.906	4/8	2048	125	4	16	MTEST	RESET

Table 9

Chip Information



Chip size is x = 1422, y = 1549 (56 by 61 mils)
The origin is the lower left coordinate of the center pads. The lower left corner of the chip shows distances to origin.
All dimensions in microns

Fig. 5