Low Power 32 kHz Circuit for Analog Quartz Watches

Description

The EM1537 is an integrated circuit in a low power CMOS technology for battery operated wristwatches with bipolar stepping motors. Time base is a 32 kHz crystal oscillator. It has a very low current consumption of typ. 100 nA in a wide voltage range of 1.2 to 3.6 Volt.

The IC is available in two voltage ranges - 1.2 to 1.8 Volt and 1.8 to 3.6 V.

Motor pulse width is programmable from 0.098 ms to 14.65 ms in steps of 0.98 ms by metal mask.

Motor period is programmable from 2 x 1s to 2 x 60 s in steps of 1 s selectable by metal mask.

Motor pulse chopping is programmable from 1/8 to 8/8 in steps of 1/8 with chopping frequencies of 1024 Hz or 2048 Hz selectable by metal mask.

Motor period in Motor test mode is selectable 2 x 31.25 ms or 2 x 62.5 ms by metal mask

Input and output capacitors are integrated on chip and also programmable by metal mask.

With a fully debounced RESET pad the motor can be stopped.

A multi-functional bidirectional pad MTEST acts as output for a 32 Hz or 512 Hz for frequency tuning - if open, or – if connected to Vp – accelerates the motor period by a factor of 16 or 32.

Features

- Low power 32 kHz Quartz oscillator
- Operating voltage ranges 1.55V and 3 Volt.
- Very low current consumption typ. 100 nA at 1.5V.
- Motor pulse width motor period and motor pulse chopping is programmable in a wide range by metal mask and don't require additional bonds.
- Fully debounced RESET input for accurate time setting and power saving during shelf life.
- Integrated capacitors, mask selectable is steps of 1 pF up to 35 pF.
- Operation temperature range: -10°C to +60°C
- Available in chip form, SO8 package

Applications

- Analog watches
- Driver for bipolar stepping motors

Functional Diagram

Operating range of Trimmer Capacitance:
$3pF \leq C_{TR} \leq 30\ pF$
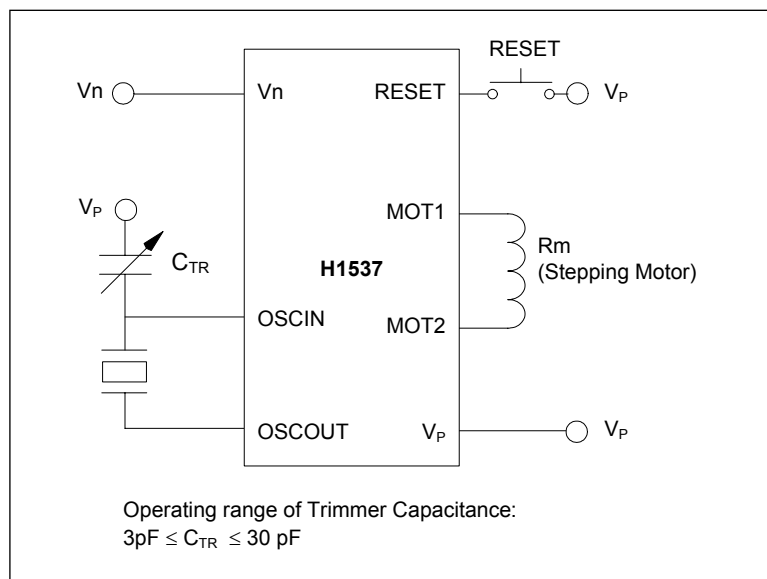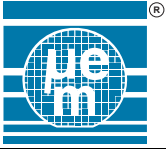
Current Versions

Version		Motor output						Integrated Capa		Test	Pad options	
	Supply voltage (V)	Period (s)	Pulse width (ms)	Chop. ratio	Chop. freqy (Hz)	Fast mode (ms)		Cin (pF)	Cout (pF)	Fast test (Hz)	Pad 2	Pad 8
016	1.55	2 x 1	5.859	8/8	0	2 x 62.5		2	14	512	MTEST	RESET
017	1.55	2x5	5.859	8/8	0	2 x 62.5		4	14	512	MTEST	RESET
020	1.55	2 x 20	5.859	8/8	0	2 x 62.5		2	14	512	MTEST	RESET
021	1.55	2 x 1	4.883	8/8	0	2 x 62.5		2	14	512	MTEST	RESET
026	1.55	2x20	6.836	8/8	0	2 x 31.25		4	14	512	MTEST	RESET
058	1.55	2 x 10	4.883	8/8	0	2 x 31.25		2	25	512	RESET	MTEST

Metal options

Parameter	Min	Max	Resolution	Unit	Description
Supply voltage	(1.2 to 1.8) or (1.8 – 3.6)			V	
Motor pulse period	2 x 1	2 x 60	2 x 1	s	
Motor pulse width	0.977	14.65	0.977	ms	
Chopping ratio	1/8	8/8	1/8	1	
Chopping frequency	1024 or 2048			Hz	
Fast mode period	2 x 31.25 or 2 x 62.5			ms	Motor period in Test mode
Cin	2	35 - Cout	1	pF	Internal capacitor on OSCIN
Cout	2	35 - Cin	1	pF	Internal capacitor on OSCOUT
Fast test	32 or 512			Hz	Test frequency on MTEST
Pad 2	MTEST or RESET				
Pad 8	RESET or MTEST				

Block Diagram

EM1537
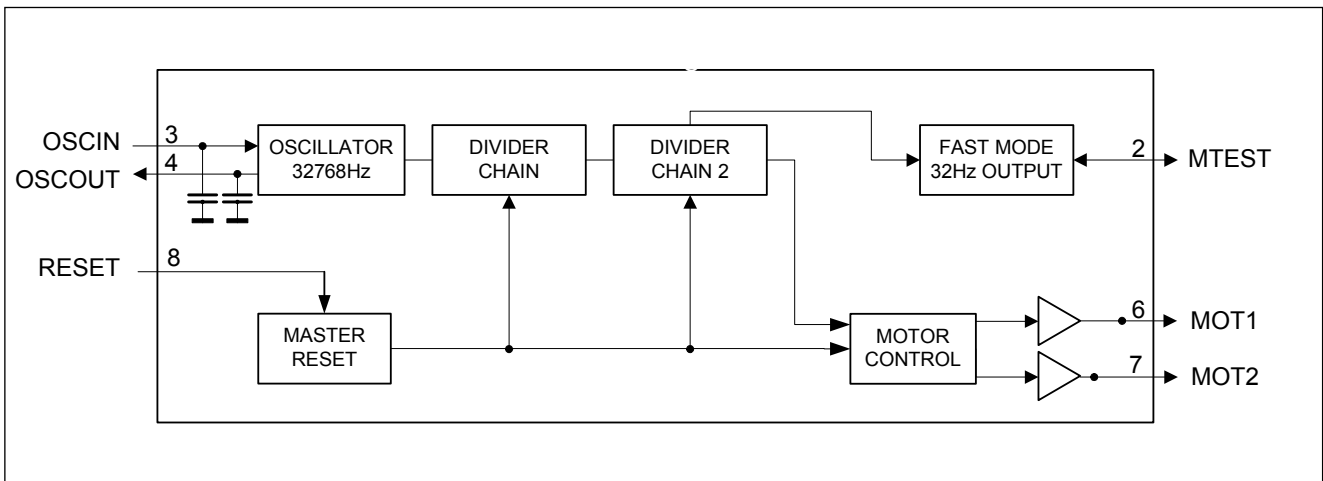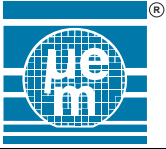
Absolute Maximum Ratings

Parameter	Symbol	Conditions
Voltage at V_{DD} to GND	V_p	- 0.3 to + 4.0 V
Voltage on other terminals		Vn-0.3 V to Vp+0.3 V
Operating temperature	Top	- 10 to + 60 °C
Storage Temperature Range	T_{stg}	- 55 to + 150 °C
Quartz serial resistor	Rq	50 kΩ

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

Handling Procedures

This device has built-in protection against high static voltages or electric fields; however, anti-static precautions must be taken as for any other CMOS component. Unless otherwise specified, proper operation can only occur when all terminal voltages are kept within the voltage range. Unused inputs must always be tied to a defined logic voltage level.

Operating Conditions

Parameter	Symbol	Min	Max	Unit
Supply voltage	V_{DD}	1.2	3.6	V
Operating Temperature	T_A	- 10	+ 60	°C

Electrical Characteristics 1.55 Volt

Vp = 1.55 V; Vss = 0 V; Ta = 25 °C; fq = 32768 Hz; Quartz crystal Rs = 30 kΩ; Motor coil resistance Rm = 2 kΩ; Supply source resistor Ri = 10 Ω; unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Supply						
Supply voltage range	Vp		1.2	1.55	1.8	V
Supply voltage drop during Motorpulse	dVp				0.7	V
Mean dynamic current	Idyn	Without motor and quartz 32 kHz 900mVpp sinus wave, forced on OSCIN/OSCOUT, TEST open		90	150	nA
Mean current consumption	In	With quartz, without motor, MTEST open, Ctr = 12 pF		250	350	nA
Mean current consumption in variation with Rq of quartz	dIn/dRq			2.6		nA/kΩ
Oscillator						
Transconductance	Gm	Vp = 1.2 V, Vpp = 300 mV sinus	2.5	15		umho
Starting voltage	Vst	Within 10 seconds		0.75		V
Starting time	Tst			1	2	sec
Stability df/f*dVp		Between 1.4 V and 1.6 V		1.5	5	ppm/V
Input capacitance	Cin	C = nominal value		C +/- (0.1C + 0.5)		pF
Output capacitance	Cout	C = nominal value		C +/- (0.1C + 0.5)		pF
Trimmer capacitance	Ctr		3		30	pF
Motordrivers						
Voltage across Motor	Vmot	Vp = 1.55 V, Rm = 2 kΩ	1.35	1.4		V
		Vp = 1.25 V, Rm = 2 kΩ	1.00	1.1		V
		Ri = 300 Ω, Rm = 2 kΩ, T = - 10 to + 60 °C	1.00	1.2		V
Short circuit impedance	Rsc	Between motor pulses 100 mV applied between MOT1 and MOT2	150	300		Ω
Rise and Fall time		From 90% Vp to 10% Vn		40	200	ns
MTEST Input/Output						
Debounce delay	Ttst		31.25		62.5	ms
Amplitude	Vtst	30 pF // 1 MΩ load	1.55			Vpp
Mean current	Itst	Pulled to Vpp, ftst = 512 Hz		70	250	nA
RESET Input						
Debounce delay	Ts		7.81		23.43	ms
Input current after delay Ts	Is	Pulled to Vp		10	50	nA

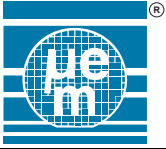* average input current (modulated by a frequency of 64 Hz)
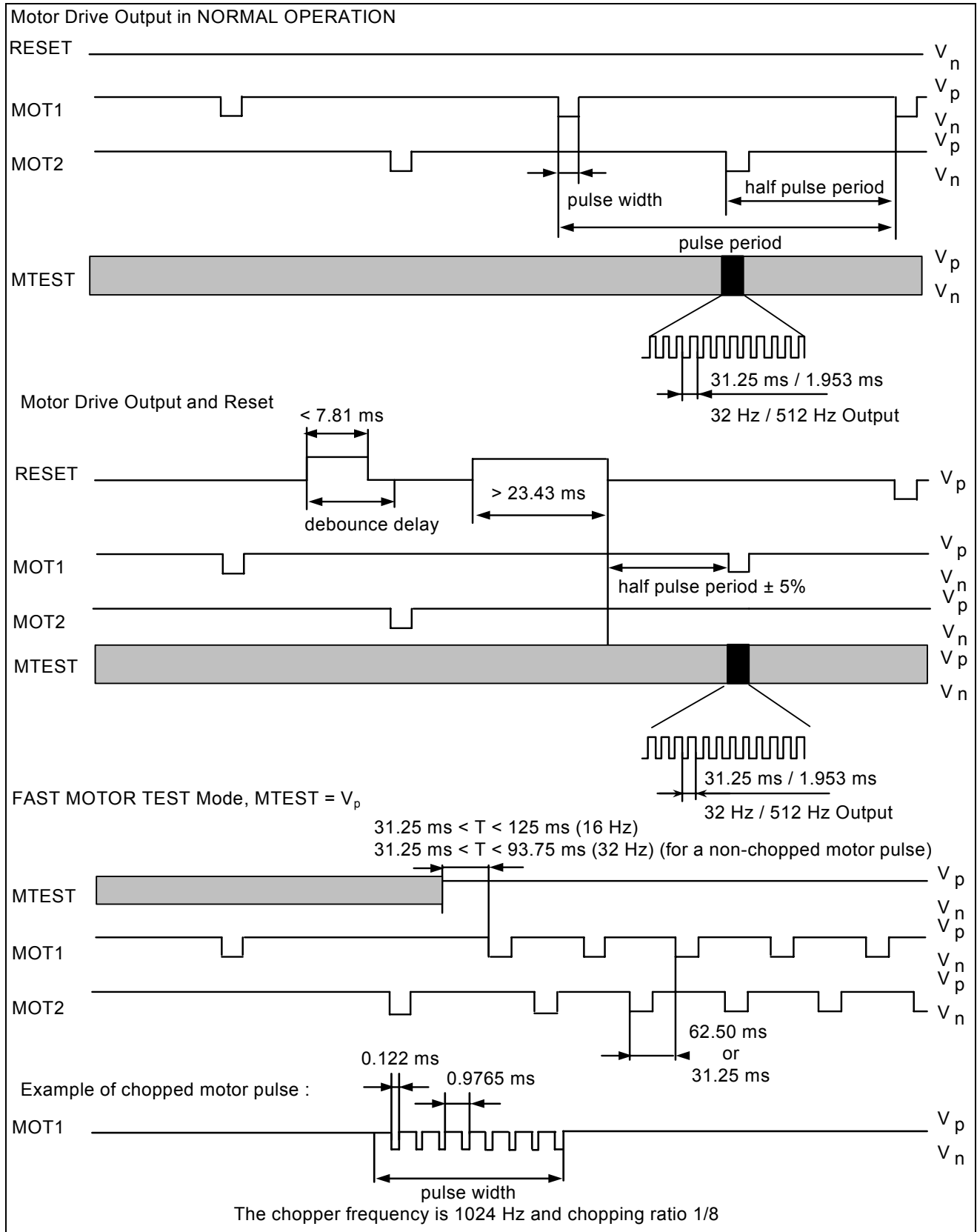
Electrical Characteristics 3.0 Volt

Vp = 3.0 V; Vss = 0 V; Ta = 25 °C; fq = 32768 Hz; Quartz crystal Rs = 30 kΩ; Motor coil resistance Rm = 2 kΩ; Supply source resistor Ri = 10 Ω; unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Supply						
Supply voltage range	Vp		1.8	3.0	3.6	V
Supply voltage drop during Motorpulse	dVp				0.7	V
Mean dynamic current	Idyn	Without motor and quartz 32 kHz 900mVpp sinus wave, forced on OSCIN/OSCOUT, TEST open		120	250	nA
Mean current consumption	In	With quartz, without motor, MTEST open, Ctr = 12 pF		200	350	nA
Mean current consumption in variation with Rq of quartz	dIn/dRq			2.6		nA/kΩ
Oscillator						
Transconductance	Gm	Vp = 1.2 V, Vpp = 300 mV sinus	2.5	15		umho
Starting voltage	Vst	Within 10 seconds	1.8			V
Starting time	Tst			1	2	sec
Stability df/f*dVp		Between 1.4 V and 1.6 V		1.5	5	ppm/V
Input capacitance	Cin	C = nominal value	C +/- (0.1C + 0.5)			pF
Output capacitance	Cout	C = nominal value	C +/- (0.1C + 0.5)			pF
Trimmer capacitance	Ctr		3		30	pF
Motordrivers						
Voltage across Motor	Vmot	Vp = 3.0 V, Rm = 2 kΩ	2.69	2.84		V
		Vp = 2.2 V, Rm = 2 kΩ	1.97	2.08		V
		Ri = 300 Ω, Rm = 2 kΩ, T = - 10 to + 60 °C	2.35	2.40		V
		Vp = 3.0 V, Rm = 640 Ω	2.21	2.56		
		Vp = 2.2 V, Rm = 640 Ω	1.62	1.87		V
		Ri = 300 Ω, Rm = 640 Ω, T = - 10 to + 60 °C	1.64	1.80		V
Short circuit impedance	Rsc	Between motor pulses 100 mV applied between MOT1 and MOT2			215	Ω
Rise and Fall time		From 90% Vp to 10% Vn		40	200	ns
MTEST Input/Output						
Debounce delay	Ttst		31.25		62.5	ms
Amplitude	Vtst	30 pF // 1 MΩ load	2.6			Vpp
Mean current	Itst	Pulled to Vpp, ftst = 512 Hz		70	250	nA
RESET Input						
Debounce delay	Ts		7.81		23.43	ms
Input current after delay Ts *	Is	Pulled to Vp		10	50	nA

* average input current (modulated by a frequency of 64 Hz)

Timing Waveforms

Motor Drive Output in NORMAL OPERATION

RESET — V_n

MOT1 — V_p / V_n

MOT2 — V_p / V_n

pulse width

half pulse period

pulse period

MTEST — V_p / V_n

31.25 ms / 1.953 ms

32 Hz / 512 Hz Output

Motor Drive Output and Reset

< 7.81 ms

RESET — V_p

> 23.43 ms

debounce delay

MOT1 — V_p / V_n

half pulse period ± 5%

MOT2 — V_p / V_n

MTEST — V_p / V_n

31.25 ms / 1.953 ms

32 Hz / 512 Hz Output

FAST MOTOR TEST Mode, MTEST = V_p

31.25 ms < T < 125 ms (16 Hz)
31.25 ms < T < 93.75 ms (32 Hz) (for a non-chopped motor pulse)

MTEST — V_p / V_n

MOT1 — V_p / V_n

MOT2 — V_p / V_n

62.50 ms
or
31.25 ms

Example of chopped motor pulse :

0.122 ms

0.9765 ms

MOT1 — V_p / V_n

pulse width

The chopper frequency is 1024 Hz and chopping ratio 1/8

Functional Description

Oscillator (Pads OSCIN/OSCOUT)
Time-base is a 32 kHz quartz crystal. Special care was taken at design of crystal oscillator and initial divider chain to achieve very low power consumption and a wide operating voltage range.
Input and output capacitances are integrated on-chip; their values are metal mask selectable.
The oscillator frequency can be adjusted with an external trimmer (C_{TR}) connected on Pad OSCIN.

Motor Drive Output (Pads MOT1, MOT2)
The EM1537 contains two push-pull output buffers for driving a bipolar stepping motor. Between two motor pulses, the two p-channel devices are active for damping the motor. A special circuitry prevents transfer current spikes during switching.

Reset Input (Pad RESET)
The reset input is fully debounced with a debounce-delay between 7.8 ms and 23.4 ms.
Pulling the RESET input to Vp, resets the frequency dividers and disables motor pulses. Motor pulses in progress when the RESET function is applied will be completed. After releasing the RESET pad from Vp the next motor pulse appears with a delay of one half motor cycle +/- 5% on the drive output MOT1 if the last pulse appeared on MOT2 and vice-versa. The RESET input has an internal pull-down.

Test Mode (Pad MTEST)
The Pad MTEST is a bidirectional port. In its input mode it is fully debounced with a debounce-delay between 31.25 ms and 62.5 ms.
The MTEST pad fulfils two functions:
- For normal operation the MTEST pad is left open. The circuit outputs a square wave signal of 32 Hz or 512 Hz (ftst) which can be used for tuning the oscillator frequency.
- If the MTEST pad is connected to Vp the period of motor pulses changes either to 2x31.25 ms or 2x62.5 ms (mask option) while the motor pulse width and chopping remains unchanged (fast motor test).
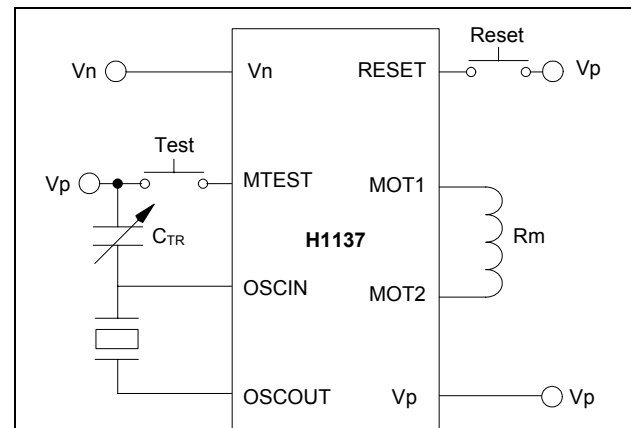
Factory Test (Pad TEST):
Test pad for Wafer sorting at the EM-Microelectronic. It has a pull-up transistor.
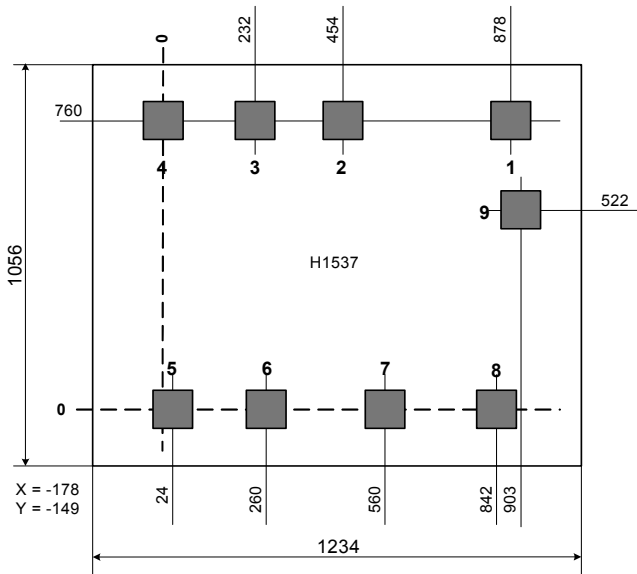
Typical Operating Characteristics
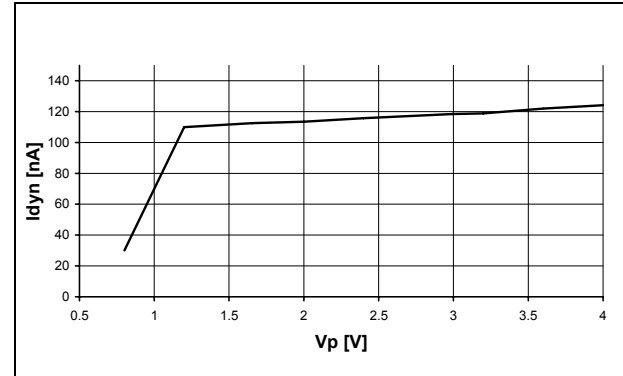
Test Configuration

Padout

Pad N°	Pad Name
1	Vn
2	MTEST or RESET
3	OSCIN
4	OSCOUT
5	Vp
6	MOT2
7	MOT1
8	RESET or MTEST
9	EMTEST (manufacturer testpad)

RESET and MTEST can be changed between pads 2 and 8 by metal mask

Pad opening 90µm x 90 µm typical.

Chip size is x=1234 µm y=1056 µm

The X origin is the most left coordinate and the Y origin is the lower coordinates of the center pads.
The lower left corner of the chip shows distances to origin.

Ordering Information

EM1537 WW 11 - %%%

Customer Version:
customer-specific number
given by EM Microelectronic

Thickness:
11 = 11 mils (280um)
10 = 10 mils (250um)
(for other thickness, contact EM)

Die form:
WW = Wafer
WS = Sawn Wafer/Frame
WP = Waffle Pack

Example:

Part number	Package	Delivery form /Thickness
EM1537WS11-%%%	Sawn wafer	11 mils
EM1537WP10-%%%	Die in waffle pack	10 mils

Please make sure to give the complete part number when ordering, including the 3-digit customer version. The customer version is made 3 digits %%% (e.g. 016, 021, etc.)
Please contact EM- Microelectronic for other packages or Bumps.