Melexis
Microelectronic Integrated Systems

TH72031
868/915MHz
FSK Transmitter

Features

- Fully integrated PLL-stabilized VCO
- Frequency range from 850 MHz to 930 MHz
- Single-ended RF output
- FSK through crystal pulling allows modulation from DC to 40 kbit/s
- High FSK deviation possible for wideband data transmission
- Wide power supply range from 1.9 V to 5.5 V
- Low voltage detector
- High over-all frequency accuracy
- FSK deviation and center frequency independently adjustable
- Very low standby current
- Adjustable output power range from -15 dBm to +6 dBm
- Adjustable current consumption from 4.0 mA to 14.0 mA
- Conforms to EN 300 220 and similar standards

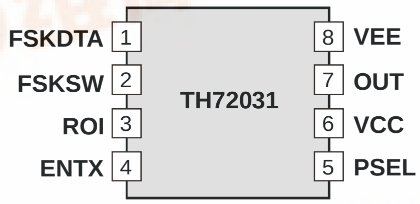
Ordering Information

Part No.	***Temperature Code***	***Package Code***
TH72031	E (-40 C° to 125 °C)	DC (SOIC8)

Application Examples

- General digital data transmission
- Tire Pressure Monitoring System(TPMS)
- Remote Keyless Entry (RKE)
- Low-power telemetry
- Alarm and security systems
- Garage door openers
- Home automation
- Remote controls
- Local oscillator signal generation

Pin Description



General Description

The TH72031 FSK transmitter IC is designed for applications in the European 868MHz industrial-scientific-medical (ISM) band, according to the EN 300 220 telecommunications standard. It can also be used for any other system with carrier frequencies ranging from 850 MHz to 930 MHz (e.g. for applications in the US 915 MHz ISM band).
The transmitter's carrier frequency f_c is determined by the frequency of the reference crystal f_{ref}. The integrated PLL synthesizer ensures that each RF value, ranging from 850 MHz to 930 MHz, can be achieved by using a crystal with a reference frequency according to: $f_{ref} = f_c/N$, where N = 32 is the PLL feedback divider ratio.

Document Content

1 Theory of Operation

1.1 General

As depicted in Fig.1, the TH72031 transmitter consists of a fully integrated voltage-controlled oscillator (VCO), a divide-by-32 divider (div32), a phase-frequency detector (PFD) and a charge pump (CP). An internal loop filter determines the dynamic behavior of the PLL and suppresses reference spurious signals. A Colpitts crystal oscillator (XOSC) is used as the reference oscillator of a phase-locked loop (PLL) synthesizer. The VCO's output signal feeds the power amplifier (PA). RF signal power P_{out} can be adjusted in four steps from P_{out} = –15 dBm to +6 dBm, either by changing the value of resistor RPS or by varying the voltage V_{PS} at pin PSEL. The open-collector output (OUT) can be used either to directly drive a loop antenna or to be matched to a 50Ohm load. Bandgap biasing ensures stable operation of the IC at a power supply range of 1.9 V to 5.5 V.

1.2 Block Diagram

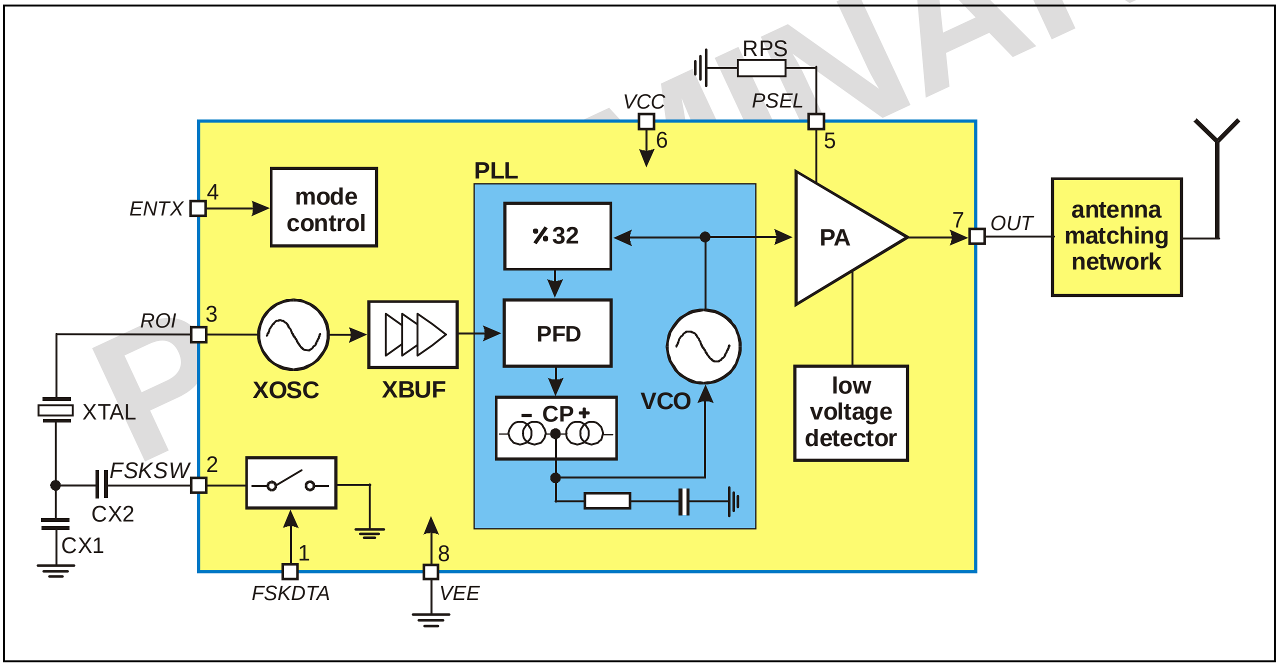


Fig. 1: Block diagram with external components

2 Functional Description

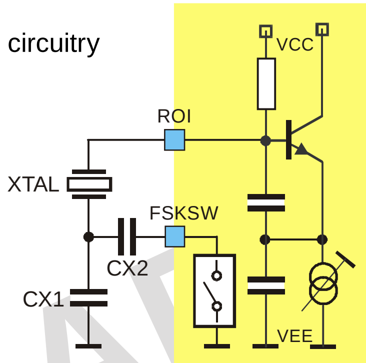
2.1 Crystal Oscillator

A Colpitts crystal oscillator with integrated functional capacitors is used as the reference oscillator for the PLL synthesizer. The equivalent input capacitance CRO offered by the crystal oscillator input pin ROI is about 18pF. The crystal oscillator is provided with an amplitude control loop in order to have a very stable frequency over the specified supply voltage and temperature range in combination with a short start-up time.

2.2 FSK Modulation

FSK modulation can be achieved by pulling the crystal oscillator frequency. A CMOS-compatible data stream applied at the pin FSKDTA digitally modulates the XOSC via an integrated NMOS switch. Two external pulling capacitors CX1 and CX2 allow the FSK deviation Δf and the center frequency f_c to be adjusted independently. At FSKDTA = 0, CX2 is connected in parallel to CX1 leading to the low-frequency component of the FSK spectrum (f_{min}); while at FSKDTA = 1, CX2 is deactivated and the XOSC is set to its high frequency f_{max}.
An external reference signal can be directly AC-coupled to the reference oscillator input pin ROI. Then the transmitter is used without a crystal. Now the reference signal sets the carrier frequency and may also contain the FSK (or FM) modulation.

Fig. 2: Crystal pulling circuitry



FSKDTA	Description
0	$f_{min} = f_c - \Delta f$ (FSK switch is closed)
1	$f_{max} = f_c + \Delta f$ (FSK switch is open)

2.3 Crystal Pulling

A crystal is tuned by the manufacturer to the required oscillation frequency f_0 at a given load capacitance CL and within the specified calibration tolerance. The only way to pull the oscillation frequency is to vary the effective load capacitance CL_{eff} seen by the crystal.
Figure 3 shows the oscillation frequency of a crystal as a function of the effective load capacitance. This capacitance changes in accordance with the logic level of FSKDTA around the specified load capacitance. The figure illustrates the relationship between the external pulling capacitors and the frequency deviation.
It can also be seen that the pulling sensitivity increases with the reduction of CL. Therefore, applications with a high frequency deviation require a low load capacitance. For narrow band FSK applications, a higher load capacitance could be chosen in order to reduce the frequency drift caused by the tolerances of the chip and the external pulling capacitors.

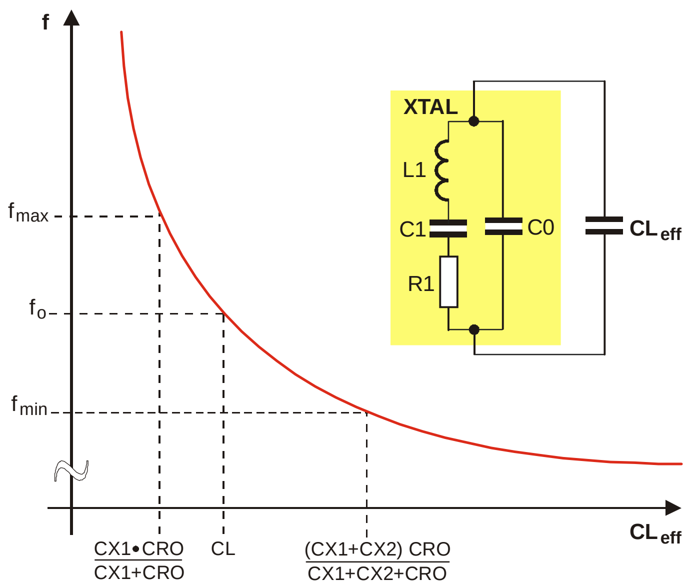


Fig. 3: Crystal pulling characteristic

2.4 Output Power Selection

The transmitter is provided with an output power selection feature. There are four predefined output power steps and one off-step accessible via the power selection pin PSEL. A digital power step adjustment was chosen because of its high accuracy and stability. The number of steps and the step sizes as well as the corresponding power levels are selected to cover a wide spectrum of different applications.

The implementation of the output power control logic is shown in figure 4. There are two matched current sources with an amount of about 8 µA. One current source is directly applied to the PSEL pin. The other current source is used for the generation of reference voltages with a resistor ladder. These reference voltages are defining the thresholds between the power steps. The four comparators deliver thermometer-coded control signals depending on the voltage level at the pin PSEL. In order to have a certain amount of ripple tolerance in a noisy environment the comparators are provided with a little hysteresis of about 20 mV. With these control signals, weighted current sources of the power amplifier are switched on or off to set the desired output power level (Digitally Controlled Current Source). The LOCK signal and the output of the low voltage detector are gating this current source.

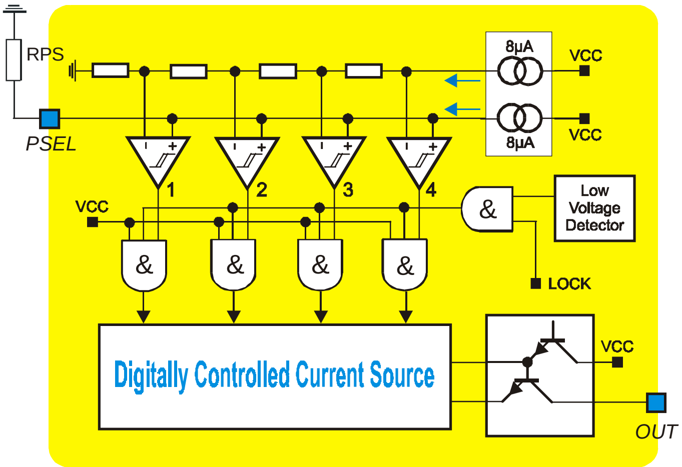


Fig. 4: Block diagram of output power control circuitry

There are two ways to select the desired output power step. First by applying a DC voltage at the pin PSEL, then this voltage directly selects the desired output power step. This kind of power selection can be used if the transmission power must be changed during operation. For a fixed-power application a resistor can be used which is connected from the PSEL pin to ground. The voltage drop across this resistor selects the desired output power level. For fixed-power applications at the highest power step this resistor can be omitted. The pin PSEL is in a high impedance state during the “TX standby” mode.

2.5 Lock Detection

The lock detection circuitry turns on the power amplifier only after PLL lock. This prevents from unwanted emission of the transmitter if the PLL is unlocked.

2.6 Low Voltage Detection

The supply voltage is sensed by a low voltage detect circuitry. The power amplifier is turned off if the supply voltage drops below a value of about 1.85 V. This is done in order to prevent unwanted emission of the transmitter if the supply voltage is too low.

2.7 Mode Control Logic

The mode control logic allows two different modes of operation as listed in the following table. The mode control pin ENTX is pulled-down internally. This guarantees that the whole circuit is shut down if this pin is left floating.

ENTX	Mode	Description
0	TX standby	TX disabled
1	TX active	TX enable

2.8 Timing Diagrams

After enabling the transmitter by the ENTX signal, the power amplifier remains inactive for the time t_{on}, the transmitter start-up time. The crystal oscillator starts oscillation and the PLL locks to the desired output frequency within the time duration t_{on}. After successful PLL lock, the LOCK signal turns on the power amplifier, and then the RF carrier can be FSK modulated.

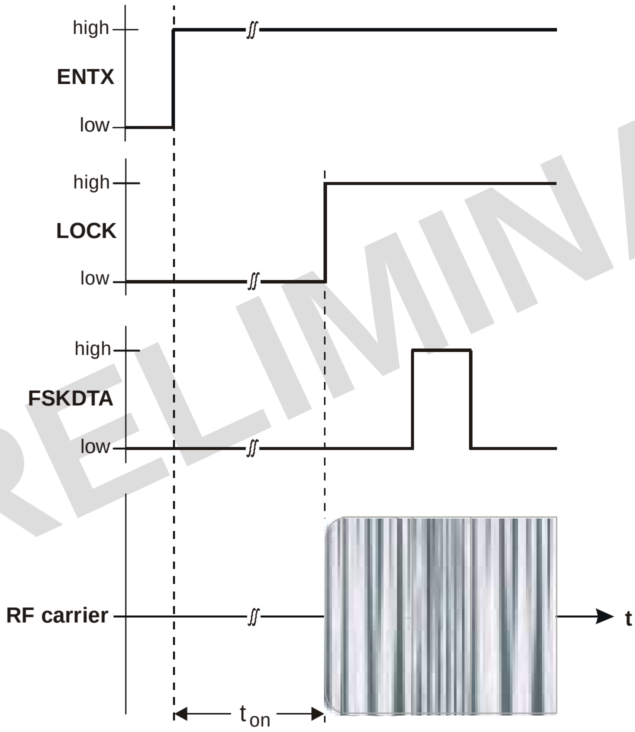
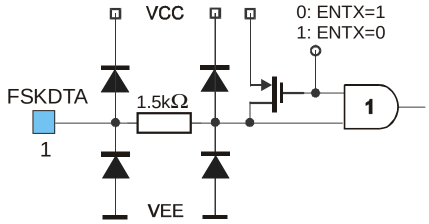
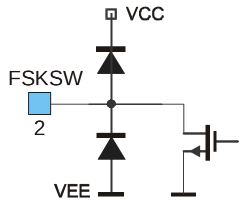
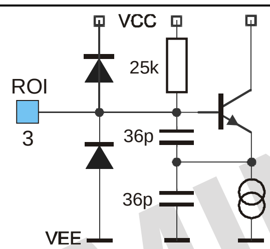
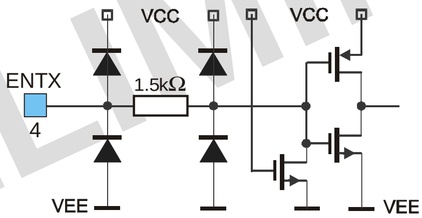
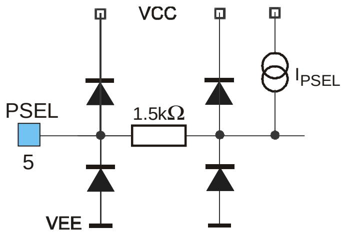
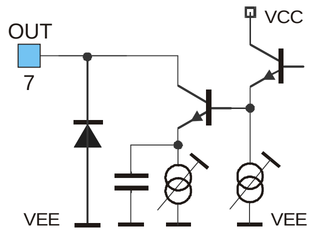


Fig. 5: Timing diagram for FSK modulation

3 Pin Definition and Description

Pin No.	Name	I/O Type	Functional Schematic	Description
1	FSKDTA	input		FSK data input, CMOS compatible with operation mode dependent pull-up circuit TX standby: no pull-up TX active: pull-up
2	FSKSW	analog I/O		XOSC FSK pulling pin, MOS switch
3	ROI	analog I/O		XOSC connection to XTAL, Colpitts type crystal oscillator
4	ENTX	input		mode control input, CMOS-compatible with internal pull-down circuit
5	PSEL	analog I/O		power select input, high-impedance comparator logic TX standby: I_{PSEL} = 0 TX active: I_{PSEL} = 8µA
6	VCC	supply		positive power supply
7	OUT	output		power amplifier output, open collector
8	VEE	ground		negative power supply

4 Electrical Characteristics

4.1 Absolute Maximum Ratings

Parameter	Symbol	Condition	Min	Max	Unit
Supply voltage	V_{CC}		-0.3	7.0	V
Input voltage	V_{IN}		-0.3	V_{CC}+0.3	V
Storage temperature	T_{STG}		-65	165	°C
Junction temperature	T_J			150	°C
Power dissipation	P_{diss}			0.12	W
Electrostatic discharge	V_{ESD}	HBM according to MIL STD 833D method 3015.7	-1.0	+1.0	kV

4.2 Normal Operating Conditions

Parameter	Symbol	Condition	Min	Max	Unit
Supply voltage	V_{CC}		1.9	5.5	V
Operating temperature	T_A		-40	125	°C
Input low voltage CMOS	V_{IL}	ENTX, FSKDTA pins		0.3*V_{CC}	V
Input high voltage CMOS	V_{IH}	ENTX, FSKDTA pins	0.7*V_{CC}		V
XOSC frequency	f_{ref}	set by the crystal	26.6	29	MHz
VCO frequency	f_c	$f_c = 32 \bullet f_{ref}$	850	930	MHz
FSK deviation	Δf	depends on CX1, CX2 and crystal parameter	±5	±80	kHz
Data rate	R	NRZ		40	kbit/s

4.3 Crystal Parameter

Parameter	Symbol	Condition	Min	Max	Unit
Crystal frequency	f_0	fundamental mode, AT	26.6	29	MHz
Load capacitance	C_L		10	15	pF
Static capacitance	C_0			7	pF
Series resistance	R_1			50	Ω
Spurious response	a_{spur}			-10	dB

4.4 DC Characteristics

all parameters under normal operating conditions, unless otherwise stated;
typical values at T_A = 23 °C and V_{CC} = 3 V

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Operating Currents						
Standby current	I_{SBY}	ENTX=0		0.05	0.1	µA
Supply current in power step 0	I_{CC0}	ENTX=1		4.0		mA
Supply current in power step 1	I_{CC1}	ENTX=1		5.3		mA
Supply current in power step 2	I_{CC2}	ENTX=1		6.7		mA
Supply current in power step 3	I_{CC3}	ENTX=1		9.0		mA
Supply current in power step 4	I_{CC4}	ENTX=1		14.0		mA
Digital Pin Characteristics						
Input low voltage CMOS	V_{IL}	ENTX, FSKDTA pins	-0.3		0.3*V_{cc}	V
Input high voltage CMOS	V_{IH}	ENTX, FSKDTA pins	0.7*V_{CC}		V_{CC}+0.3	V
Pull down current ENTX pin	I_{PDEN}	ENTX=1		2.0		µA
Low level input current ENTX pin	I_{INLEN}	ENTX=0			0.02	µA
High level input current FSKDTA pin	I_{INHDTA}	FSKDTA=1			0.02	µA
Pull up current FSKDTA pin active	I_{PUDTAa}	FSKDTA=0 ENTX=1		1.5		µA
Pull up current FSKDTA pin standby	I_{PUDTAs}	FSKDTA=0 ENTX=0			0.02	µA
FSK Switch Resistance						
MOS switch On resistance	R_{ON}	FSKDTA=0 ENTX=1		20	60	Ω
MOS switch Off resistance	R_{OFF}	FSKDTA=1 ENTX=1	1			MΩ
Power Select Characteristics						
Power select current	I_{PSEL}	ENTX=1	6	8	11	µA
Power select voltage step 0	V_{PS0}	ENTX=1			0.1	V
Power select voltage step 1	V_{PS1}	ENTX=1	0.14		0.24	V
Power select voltage step 2	V_{PS2}	ENTX=1	0.28		0.51	V
Power select voltage step 3	V_{PS3}	ENTX=1	0.57		1.18	V
Power select voltage step 4	V_{PS4}	ENTX=1	1.23			V
Low Voltage Detection Characteristic						
Low voltage detect threshold	V_{LVD}	ENTX=1	1.8	1.85	1.9	V

4.5 AC Characteristics

all parameters under normal operating conditions, unless otherwise stated;
typical values at T_A = 23 °C and V_{CC} = 3 V; test circuit shown in Fig. 6, f_c = 868.3 MHz

Parameter	Symbol	Condition	Min	Typ	Max	Unit
CW Spectrum Characteristics						
Output power in step 0 (Isolation in off-state)	P_{off}	ENTX=1			-70	dBm
Output power in step 1	P_1	ENTX=1		-15		dBm
Output power in step 2	P_2	ENTX=1		-6		dBm
Output power in step 3	P_3	ENTX=1, V_{CC}>2.5V		0		dBm
Output power in step 4	P_4	ENTX=1, V_{CC}>3.0V		5		dBm
		ENTX=1, V_{CC}>4.0V		6		
Phase noise, integrated	PN	B=100kHz, @ 200kHz offset			-36	dBm
Phase noise	$L(f_m)$	@ 200kHz offset		-92		dBc/Hz
Spurious emissions according to EN 300 220-1 (2000.09) table 13	P_{spur}	47MHz< f <74MHz 87.5MHz< f <118MHz 174MHz< f <230MHz 470MHz< f <862MHz B=100kHz			-54	dBm
		f < 1GHz, B=100kHz			-36	dBm
		f > 1GHz, B=1MHz			-30	dBm
Start-up Parameters						
Start-up time	t_{on}	from standby to transmit mode		0.6	1	ms
Frequency Stability						
Frequency stability vs. supply voltage	df_{VCC}				±3	ppm
Frequency stability vs. temperature	df_{TA}	crystal at constant temperature			±10	ppm

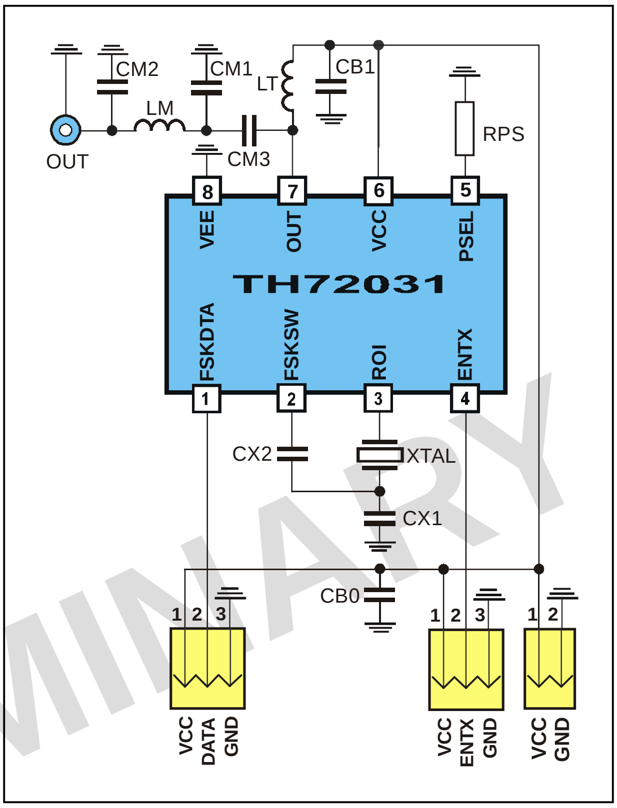
4.6 Output Power Steps

typical values at T_A = 23 °C and $V_{CC} \geq$ 4 V
ENTX = 1, f_c = 868.3 MHz, test circuit shown in Fig. 6

Power step	0	1	2	3	4
P_{out} / dBm	< -70	-15	-6	0	6
RPS / kΩ	< 10	22	47	100	> 220

5 Test Circuit

Fig. 6: Test circuit for FSK
with 50 Ω matching network



Test circuit component list to Fig. 6

Part	Size	Value @ 868.3 MHz	Value @ 915 MHz	Tolerance	Description
***CX1**	0805	33 pF	33 pF	±5%	XOSC capacitor (Δf = ±20 kHz)
***CX2**	0805	39 pF	39 pF	±5%	XOSC capacitor (Δf = ±20 kHz)
CM1	0805	3.9 pF	2.7 pF	±5%	impedance matching capacitor
CM2	0805	6.8 pF	5.6 pF	±5%	impedance matching capacitor
CM3	0603	680 pF	680 pF	±5%	impedance matching capacitor
CB0	0805	1 nF	1 nF	±10%	blocking capacitor
CB1	0603	330 pF	330 pF	±10%	blocking capacitor
LT	0603	10 nH	10 nH	±5%	output tank inductor
LM	0603	10 nH	10 nH	±5%	impedance matching inductor
RPS	0805	see para. 4.6	see para. 4.6	±10%	power-select resistor
XTAL	HC49/S	27.1344 MHz fundamental wave	28.5938 MHz fundamental wave	±30ppm calibration ±30ppm temp.	crystal, C_L = 12 pF, $C_{0,\,max}$ = 7 pF, R_1 = 40 Ω

***Notes:** Value depends on crystal parameters

6 Package Information

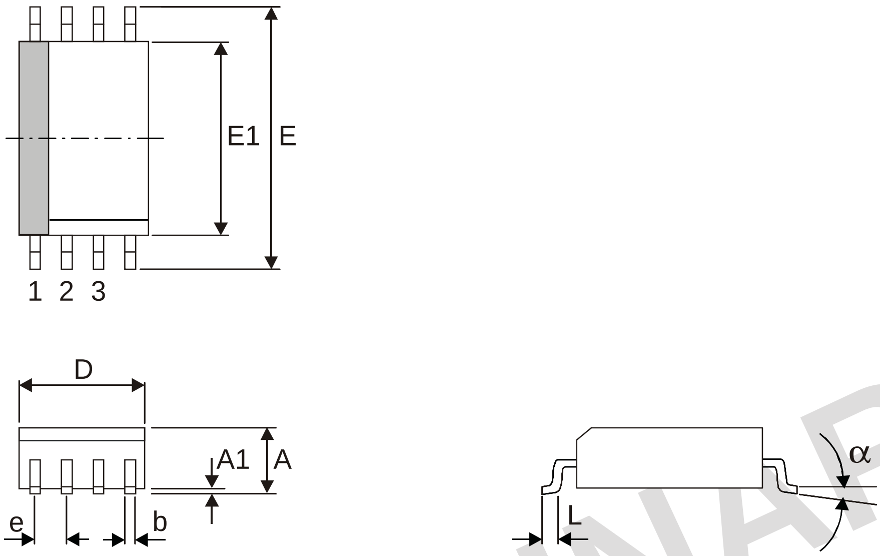


Fig. 7: SOIC8 (Small Outline Integrated Circuit)

all Dimension in mm, coplanarity < 0.1mm									
	D	E1	E	A	A1	e	b	L	α
min	4.80	3.81	5.80	1.32	0.10	1.27	0.36	0.41	0°
max	4.98	3.99	6.20	1.72	0.25		0.46	1.27	8°
all Dimension in inch, coplanarity < 0.004”									
min	0.189	0.150	0.2284	0.060	0.0040	0.05	0.014	0.016	0°
max	0.196	0.157	0.2440	0.068	0.0098		0.018	0.050	8°

7 Reliability Information

Melexis devices are classified and qualified regarding suitability for infrared, vapor phase and wave soldering with usual (63/37 SnPb-) solder (melting point at 183degC).
The following test methods are applied:

- IPC/JEDEC J-STD-020A (issue April 1999)
  Moisture/Reflow Sensitivity Classification For Nonhermetic Solid State Surface Mount Devices
- CECC00802 (issue 1994)
  Standard Method For The Specification of Surface Mounting Components (SMDs) of Assessed Quality
- MIL 883 Method 2003 / JEDEC-STD-22 Test Method B102
  Solderability

For all soldering technologies deviating from above mentioned standard conditions (regarding peak temperature, temperature gradient, temperature profile etc) additional classification and qualification tests have to be agreed upon with Melexis.

The application of Wave Soldering for SMD's is allowed only after consulting Melexis regarding assurance of adhesive strength between device and board.

For more information on manufacturability/solderability see quality page at our website:
http://www.melexis.com/

8 ESD Precautions

Electronic semiconductor products are sensitive to Electro Static Discharge (ESD).
Always observe Electro Static Discharge control procedures whenever handling semiconductor products.

Your Notes

9 Disclaimer

Devices sold by Melexis are covered by the warranty and patent indemnification provisions appearing in its Term of Sale. Melexis makes no warranty, express, statutory, implied, or by description regarding the information set forth herein or regarding the freedom of the described devices from patent infringement. Melexis reserves the right to change specifications and prices at any time and without notice. Therefore, prior to designing this product into a system, it is necessary to check with Melexis for current information. This product is intended for use in normal commercial applications. Applications requiring extended temperature range, unusual environmental requirements, or high reliability applications, such as military, medical life-support or life-sustaining equipment are specifically not recommended without additional processing by Melexis for each application.
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Europe and Japan:
Phone: +32 1367 0495
E-mail: sales_europe@melexis.com

All other locations:
Phone: +1 603 223 2362
E-mail: sales_usa@melexis.com