TH72012
433MHz
ASK Transmitter

Melexis
Microelectronic Integrated Systems

Features

- Fully integrated PLL-stabilized VCO
- Frequency range from 380 MHz to 450 MHz
- Single-ended RF output
- ASK achieved by on/off keying of internal power amplifier up to 40 kbit/s
- Wide power supply range from 1.9 V to 5.5 V
- Very low standby current
- Low voltage detector

- High over-all frequency accuracy
- Adjustable output power range from -12 dBm to +8.5 dBm
- Adjustable current consumption from 3.5 mA to 10.7 mA
- Conforms to EN 300 220 and similar standards
- 8-pin Small Outline Integrated Circuit (SOIC)

Ordering Information

Part No.	Temperature Code	Package Code
TH72012	K (-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

Pin Description

Pin			Pin
ASKDTA	1	8	VEE
n. c.	2	7	OUT
ROI	3	6	VCC
ENTX	4	5	PSEL
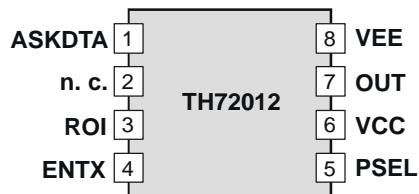
TH72012

General Description

The TH72012 ASK transmitter IC is designed for applications in the European 433 MHz industrial-scientific-medical (ISM) band, according to the EN 300 220 telecommunications standard; but it can also be used in any other country with similar frequency bands.

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 380 MHz to 450 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 TH72012 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). The RF signal power P_{out} can be adjusted in four steps from $P_{out} = -12$ dBm to +8.5 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
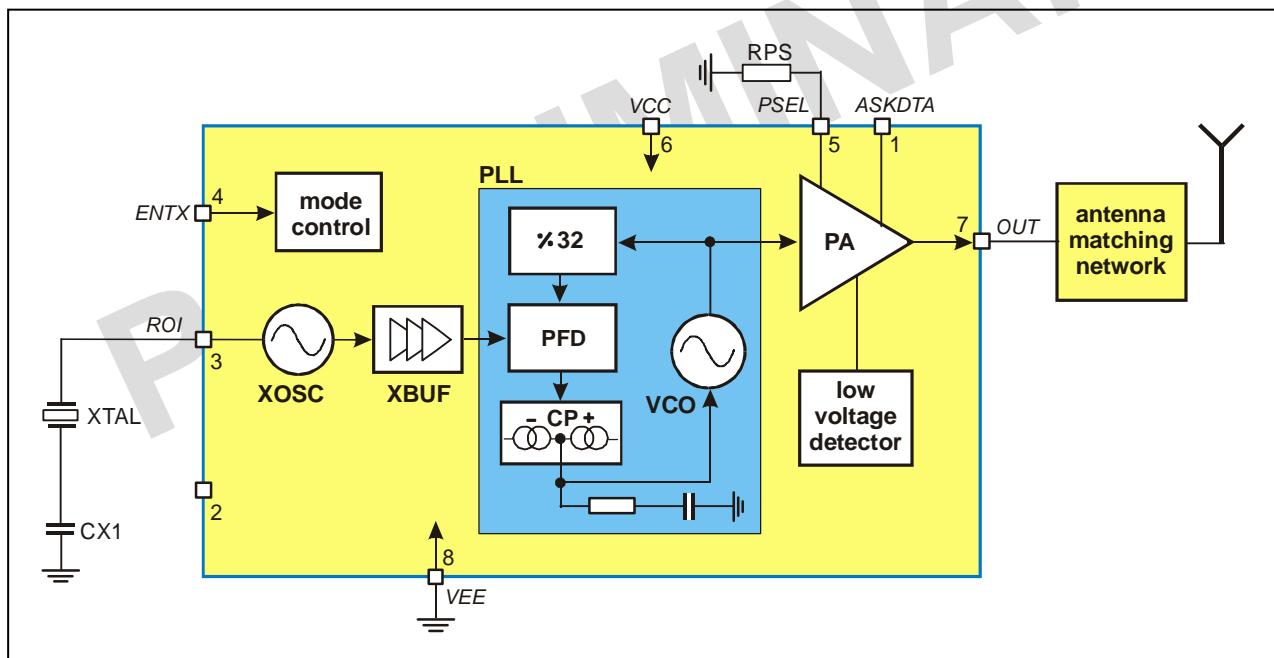
Fig. 1:   Block diagram with external components

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 ASK Modulation

The PLL transmitter can be ASK-modulated by applying a data stream directly at the pin ASKDTA. This turns the internal current sources of the power amplifier on and off and therefore leads to an ASK signal at the output.

ASKDTA	Description
0	Power amplifier is turned off
1	Power amplifier is turned on (according to the selected output power step)

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 2 shows the oscillation frequency of a crystal as a function of the effective load capacitance. This figure also illustrates the relationship between the external pulling capacitor and the center frequency.

It can be seen that the pulling sensitivity increases with the reduction of CL. For high-accuracy ASK applications, a higher load capacitance should be chosen in order to reduce the frequency drift caused by the tolerances of the chip and the external pulling capacitor.

$$CL = \frac{CX1 \cdot CRO}{CX1 + CRO}$$
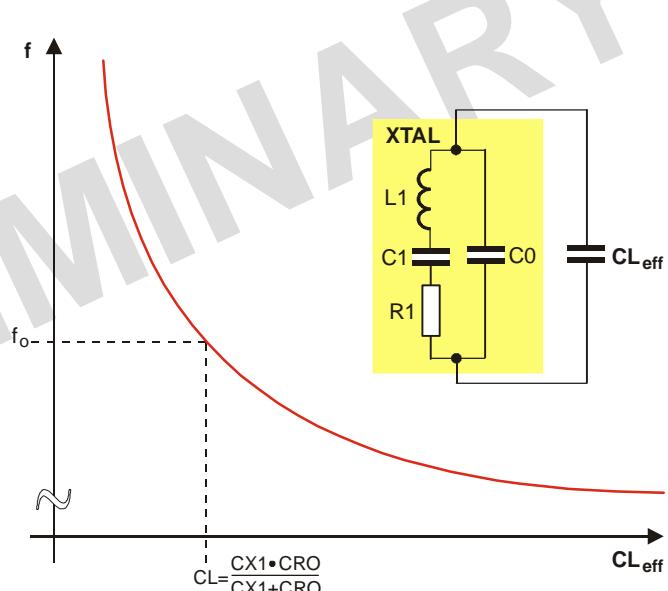
Fig. 2: Crystal pulling characteristic

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 3. 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, ASK signal and the output of the low voltage detector are gating this current source.


Fig. 3:   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 ASK modulated.
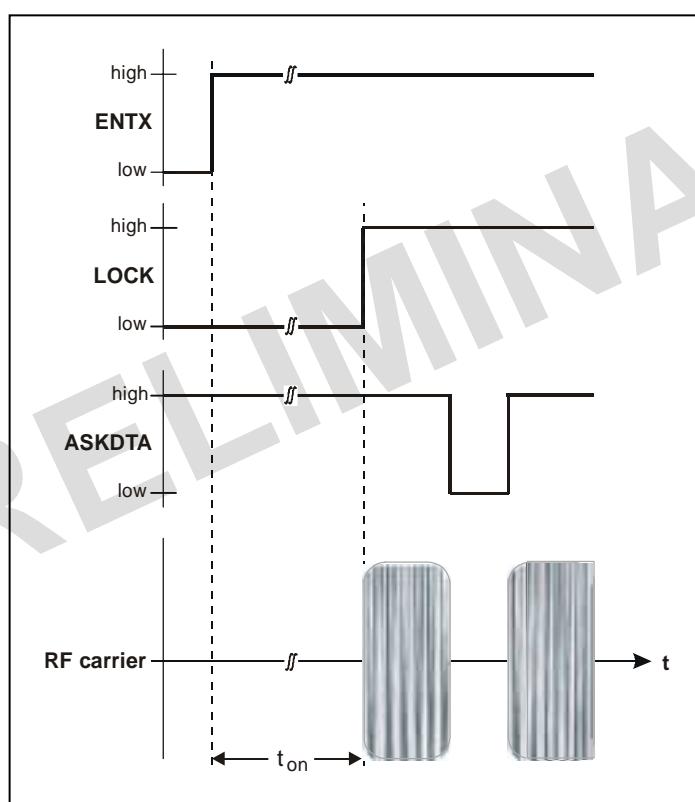
Fig. 4:   Timing diagram for ASK modulation

3 Pin Definition and Description

Pin No.	Name	I/O Type	Functional Schematic	Description
1	ASKDTA	input		ASK data input, CMOS compatible with operation mode dependent pull-up circuit TX standby: no pull-up TX active: pull-up
2	n. c.			no connection
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: $I_{PSEL} = 8\mu A$
6	VCC	supply		positive power supply
7	OUT	output		power amplifier output, open collector
8	VEE	ground		negative power supply
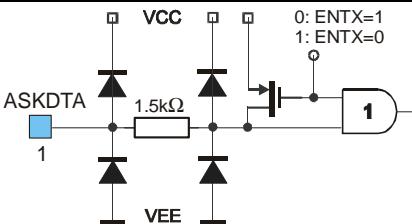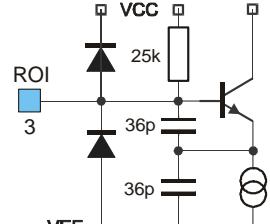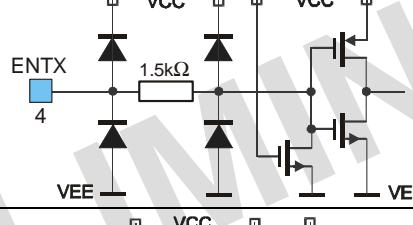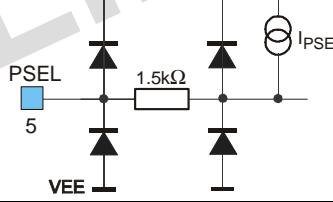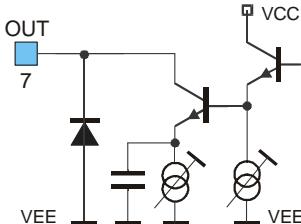
4 Electrical Characteristics

4.1 Absolute Maximum Ratings

Parameter	Symbol	Condition	Min	Max	Unit
Supply voltage	V_{CC}		0	7.0	V
Input voltage	V_{IN}		-0.3	V_{CC}+0.3	V
Storage temperature	T_{STG}		-65	150	°C
Junction temperature	T_J			150	°C
Thermal Resistance	R_{thJA}			163	K/W
Power dissipation	P_{diss}			0.12	W
Electrostatic discharge	V_{ESD1}	human body model, 1)	-2.0	+2.0	kV
	V_{ESD2}	human body model, 2)	-2.0	+0.75	

1) all pins except OUT

2) pin OUT versus VCC

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, ASKDTA pins		$0.3*V_{CC}$	V
Input high voltage CMOS	V_{IH}	ENTX, ASKDTA pins	$0.7*V_{CC}$		V
XOSC frequency	f_{ref}	set by the crystal	11.9	14	MHz
VCO frequency	f_c	$f_c = 32 \bullet f_{ref}$	380	450	MHz
Data rate	R	NRZ		40	kbit/s

4.3 Crystal Parameters

Parameter	Symbol	Condition	Min	Max	Unit
Crystal frequency	f_0	fundamental mode, AT	11.9	14	MHz
Load capacitance	C_L		10	15	pF
Static capacitance	C_0			7	pF
Series resistance	R_1			70	Ω

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	2.0	2.7	5.0	mA
Supply current in power step 1	I_{CC1}	ENTX=1	2.9	3.5	7.0	mA
Supply current in power step 2	I_{CC2}	ENTX=1	3.2	4.7	7.9	mA
Supply current in power step 3	I_{CC3}	ENTX=1	4.5	6.5	11	mA
Supply current in power step 4	I_{CC4}	ENTX=1	7.0	10.7	16	mA
Digital Pin Characteristics						
Input low voltage CMOS	V_{IL}	ENTX, ASKDTA pins	-0.3		$0.3*V_{cc}$	V
Input high voltage CMOS	V_{IH}	ENTX, ASKDTA pins	$0.7*V_{CC}$		V_{CC}+0.3	V
Pull down current ENTX pin	I_{PDEN}	ENTX=1	0.2	2.0	20	µA
Low level input current ENTX pin	I_{INLEN}	ENTX=0			0.02	µA
High level input current ASKDTA pin	I_{INHDTA}	ASKDTA=1			0.02	µA
Pull up current ASKDTA pin active	I_{PUDTAa}	ASKDTA=0 ENTX=1	0.1	1.5	12	µA
Pull up current ASKDTA pin standby	I_{PUDTAs}	ASKDTA=0 ENTX=0			0.02	µA
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. 5, f_c = 433.92 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		-12		dBm
Output power in step 2	P_2	ENTX=1		-4		dBm
Output power in step 3	P_3	ENTX=1, V_{CC} @ 2.0V		2		dBm
Output power in step 4	P_4	ENTX=1, V_{CC} @ 2.0V		4		dBm
		ENTX=1, V_{CC} @ 3.0V		7.5		
		ENTX=1, V_{CC} @ 4.0V		8.5	9.5	
		ENTX=1, V_{CC} @ 5.0V		9.0	10.5	
Phase noise	$L(f_m)$	@ 200kHz offset		-86		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		0.8	1.2	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} @ 4 V
ENTX = 1, f_c = 433.92 MHz, test circuit shown in Fig. 5

Power step	0	1	2	3	4
P_{out} / dBm	< -70	-12	-4	2	8.5
RPS / kΩ	< 10	22	47	100	> 220

5 Test Circuit
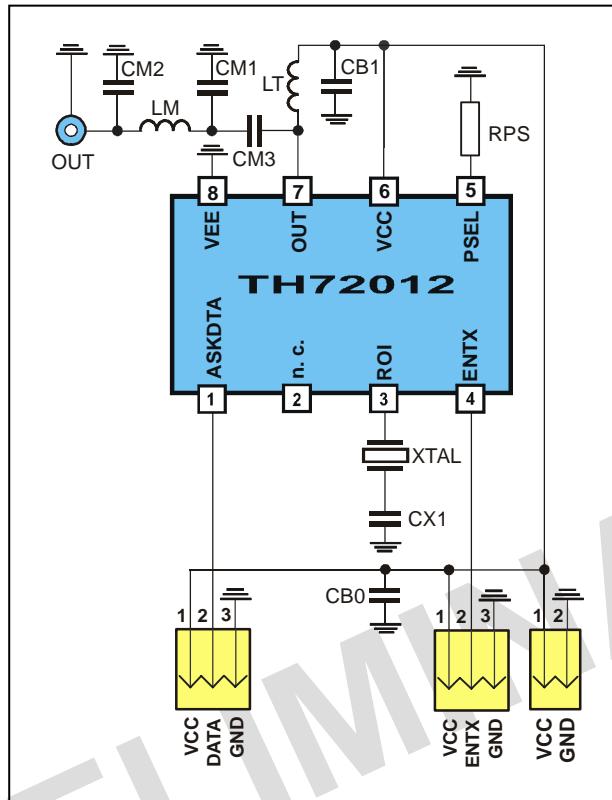
Fig. 5: Test circuit for ASK with 50 Ω matching network

5.1 Test circuit component list to Fig. 5

Part	Size	Value @ 433.92 MHz	Tolerance	Description
CX1	0805	27 pF	±5%	XOSC capacitor, **note 1**
CM1	0805	5.6 pF	±5%	impedance matching capacitor
CM2	0805	10 pF	±5%	impedance matching capacitor
CM3	0805	82 pF	±5%	impedance matching capacitor
CB0	0805	220 nF	±10%	output tank inductor, **note 2**
CB1	0805	330 pF	±10%	impedance matching inductor, **note 2**
LT	0805	33 nH	±5%	power-select resistor
LM	0805	33 nH	±5%	blocking capacitor
RPS	0805	see para. 4.6	±10%	blocking capacitor
XTAL	HC49/S	13.56000 MHz fundamental wave	±30ppm calibration ±30ppm temp.	crystal, C_L = 12 pF, $C_{0, max}$ = 7 pF, R_1 = 60 Ω

Note 1: value depends on crystal parameters
Note 2: for high-power applications high-Q wire-wound inductors should be used

6 Package Information
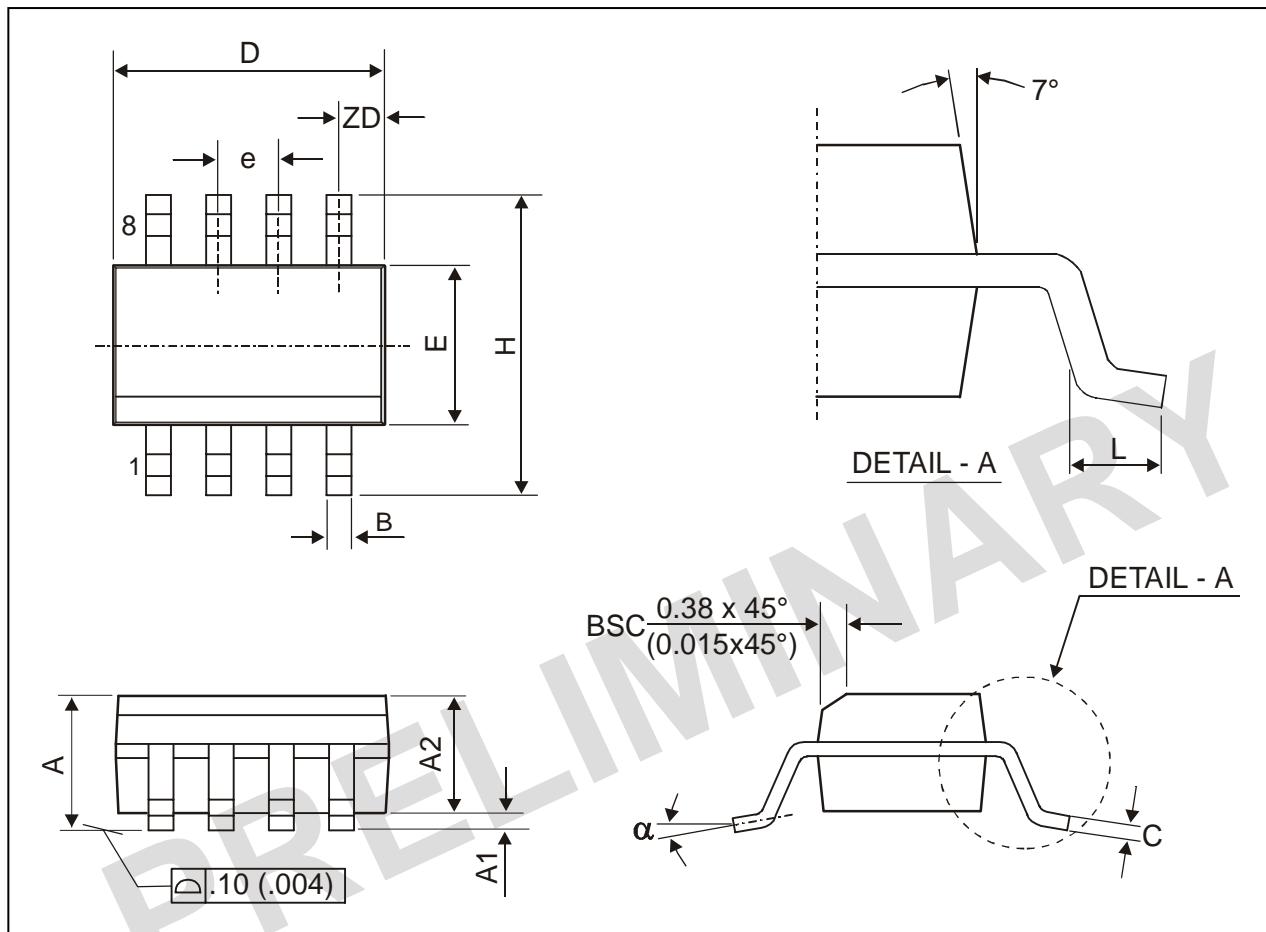
Fig. 6: SOIC8 (Small Outline Integrated Circuit)

all Dimension in mm, coplanarity < 0.1mm											
	D	**E**	**H**	**A**	**A1**	**A2**	**e**	**B**	**ZD**	**C**	**L**	**α**
min	4.80	3.81	5.80	1.52	0.10	1.37	1.27	0.36	0.53	0.19	0.41	0°
max	4.98	3.99	6.20	1.72	0.25	1.57		0.46		0.25	1.27	8°
all Dimension in inch, coplanarity < 0.004"											
min	0.189	0.150	0.2284	0.060	0.0040	0.054	0.050	0.014	0.021	0.075	0.016	0°
max	0.196	0.157	0.2440	0.068	0.0098	0.062		0.018		0.098	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

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