

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 1.95 V to 5.5 V
- Very low standby current
- On-chip low voltage detector
- High over-all frequency accuracy
- Adjustable output power range from -12 dBm to +10 dBm
- Adjustable current consumption from 3.4 mA to 10.6 mA
- Conforms to EN 300 220 and similar standards
- 8-pin Small Outline Integrated Circuit (SOIC)

Ordering Code

| Product Code | Temperature Code | Package Code | Option Code | Packing Form Code |
|--------------|------------------|--------------|-------------|-------------------|
| TH72012 | K | DC | BAA-000 | RE |
| TH72012 | K | DC | BAA-000 | TU |

Legend:

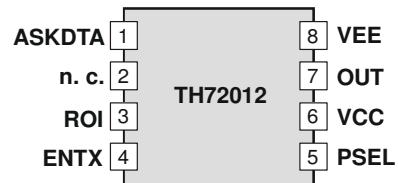
Temperature Code: K for Temperature Range -40°C to 125°C
 Package Code: DC for SOIC
 Packing Form: RE for Reel, TU for Tube

Ordering example: TH72012KDC-BAA-000-RE

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



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.

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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 $+10$ 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 50Ω load. Bandgap biasing ensures stable operation of the IC at a power supply range of 1.95 V to 5.5 V.

1.2 Block Diagram

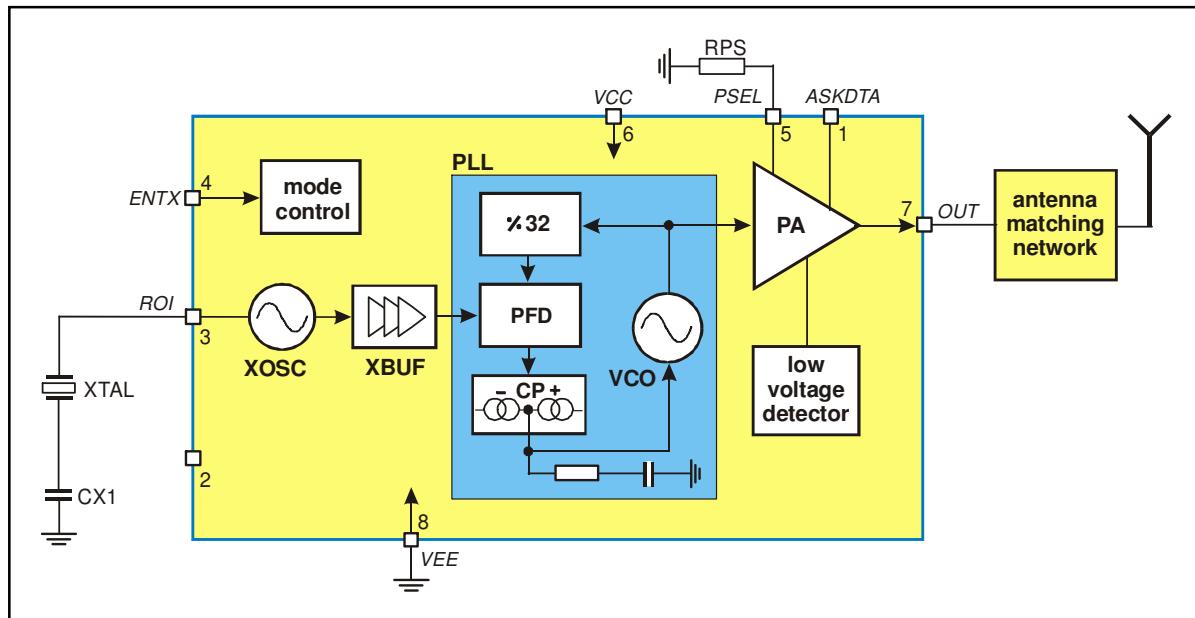


Fig. 1: Block diagram with external components

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.

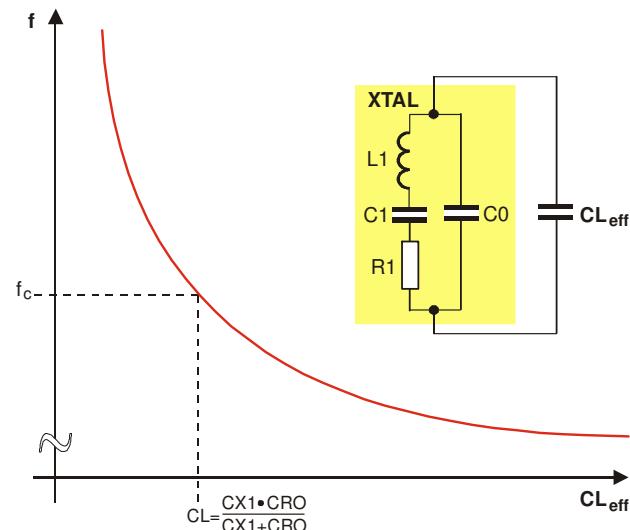


Fig. 2: Crystal pulling characteristic

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 μ A. 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.

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.

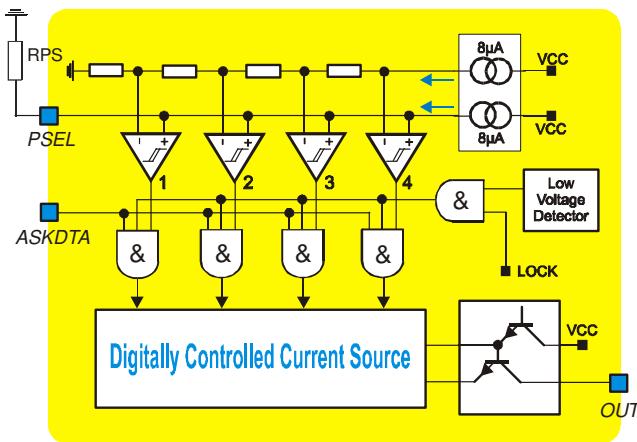


Fig. 3: Block diagram of output power control circuitry

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.

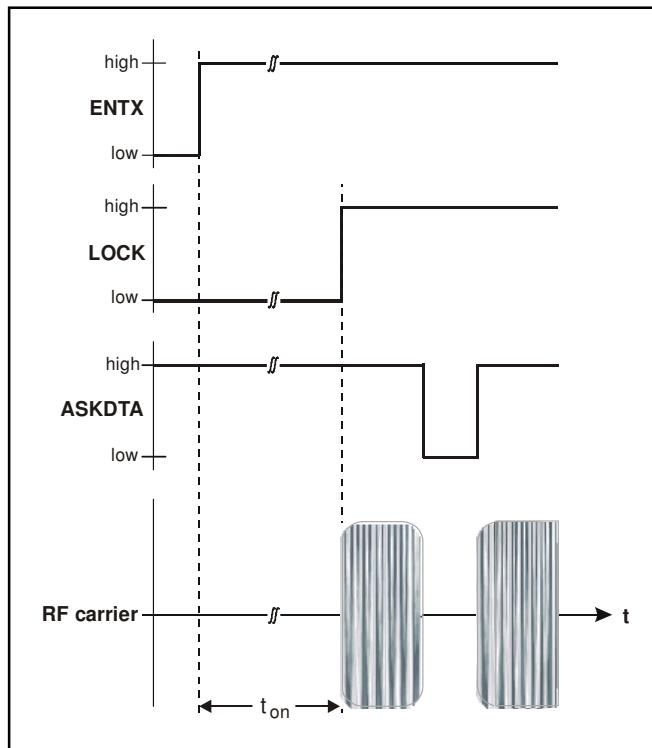
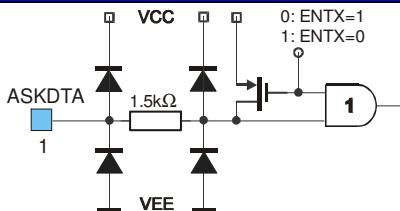
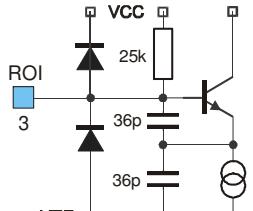
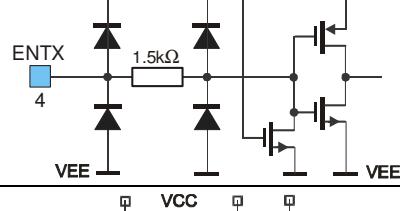
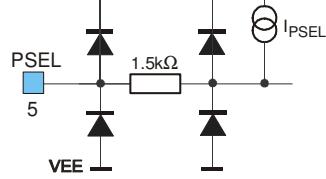
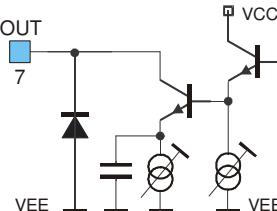


Fig. 4: Timing diagram for ASK modulation

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 = 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 | 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_{ESD} | human body model (HBM) according to CDF-AEC-Q100-002 | ±2.0 | | kV |

4.2 Normal Operating Conditions

| Parameter | Symbol | Condition | Min | Max | Unit |
|-------------------------|-----------|----------------------------|--------------|--------------|--------|
| Supply voltage | V_{CC} | | 1.95 | 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 $T_A = 23^\circ\text{C}$ and $V_{CC} = 3\text{ V}$

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|--------------|---------------------------------|--------------|------|--------------|---------------|
| Operating Currents | | | | | | |
| Standby current | I_{SBY} | $ENTX=0, T_A=85^\circ\text{C}$ | | 0.2 | 200 | nA |
| | | $ENTX=0, T_A=125^\circ\text{C}$ | | | 4 | μA |
| Supply current in power step 0 | I_{CC0} | $ENTX=1$ | 1.5 | 2.5 | 3.8 | mA |
| Supply current in power step 1 | I_{CC1} | $ENTX=1$ | 2.1 | 3.4 | 4.9 | mA |
| Supply current in power step 2 | I_{CC2} | $ENTX=1$ | 3.0 | 4.6 | 6.2 | mA |
| Supply current in power step 3 | I_{CC3} | $ENTX=1$ | 4.5 | 6.5 | 8.5 | mA |
| Supply current in power step 4 | I_{CC4} | $ENTX=1$ | 7.3 | 10.6 | 13.3 | 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} | $ENTX=1$ | 7.0 | 8.6 | 9.9 | μA |
| Power select voltage step 0 | V_{PS0} | $ENTX=1$ | | | 0.035 | V |
| Power select voltage step 1 | V_{PS1} | $ENTX=1$ | 0.14 | | 0.24 | V |
| Power select voltage step 2 | V_{PS2} | $ENTX=1$ | 0.37 | | 0.60 | V |
| Power select voltage step 3 | V_{PS3} | $ENTX=1$ | 0.78 | | 1.29 | V |
| Power select voltage step 4 | V_{PS4} | $ENTX=1$ | 1.55 | | | V |
| Low Voltage Detection Characteristic | | | | | | |
| Low voltage detect threshold | V_{LVD} | $ENTX=1$ | 1.75 | 1.85 | 1.95 | V |

4.5 AC Characteristics

all parameters under normal operating conditions, unless otherwise stated;
typical values at $T_A = 23^\circ\text{C}$ and $V_{CC} = 3\text{ V}$; test circuit shown in Fig. 18, $f_c = 433.92\text{ MHz}$

| 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 | -13 | -12 | $-10^{1)}$ | dBm |
| Output power in step 2 | P_2 | ENTX=1 | -3.5 | -3 | $-1.5^{1)}$ | dBm |
| Output power in step 3 | P_3 | ENTX=1 | 2 | 3 | $4.5^{1)}$ | dBm |
| Output power in step 4 | P_4 | ENTX=1 | 4.5 | 8 | $10^{1)}$ | dBm |
| Phase noise | $L(f_m)$ | @ 200kHz offset | | -88 | -83 | dBc/Hz |
| Spurious emissions according to EN 300 220-1 (2000.09) table 13 | P_{spur} | 47MHz < $f < 74\text{MHz}$ | | | -54 | dBm |
| | | 87.5MHz < $f < 118\text{MHz}$ | | | | |
| | | 174MHz < $f < 230\text{MHz}$ | | | | |
| | | 470MHz < $f < 862\text{MHz}$ | | | | |
| | | $B=100\text{kHz}$ | | | | |
| | | $f < 1\text{GHz}, B=100\text{kHz}$ | | | -36 | dBm |
| | | $f > 1\text{GHz}, B=1\text{MHz}$ | | | -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 |

1) output matching network tuned for 5V supply

4.6 Output Power Steps

| Power step | 0 | 1 | 2 | 3 | 4 |
|------------------------|-----|----|----|-----|---------------|
| RPS / $\text{k}\Omega$ | < 3 | 22 | 56 | 120 | not connected |

5 Typical Operating Characteristics

5.1 DC Characteristics

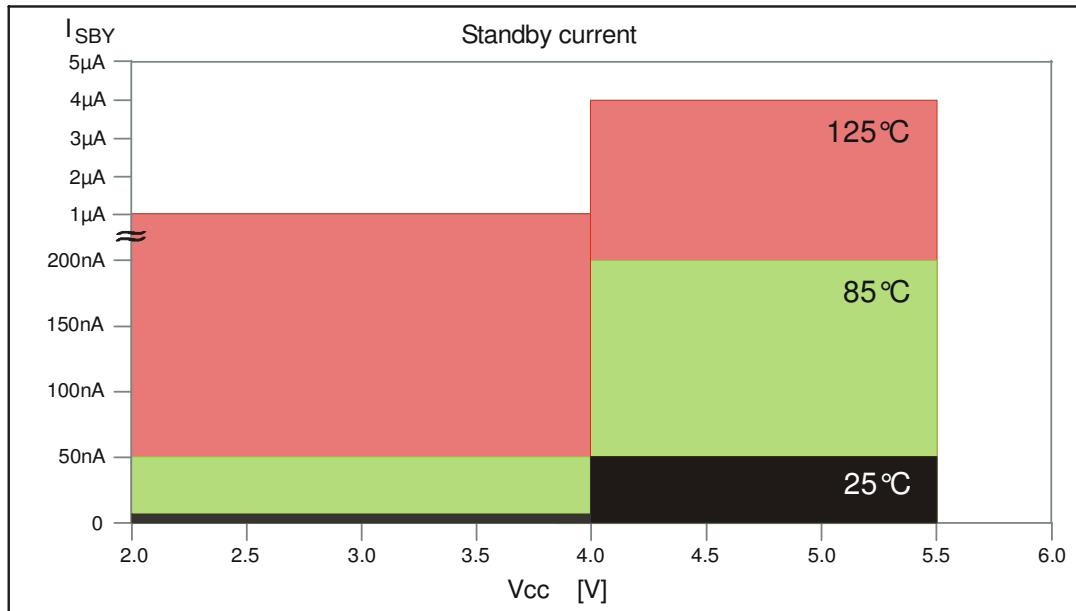


Fig. 5: Standby current limits

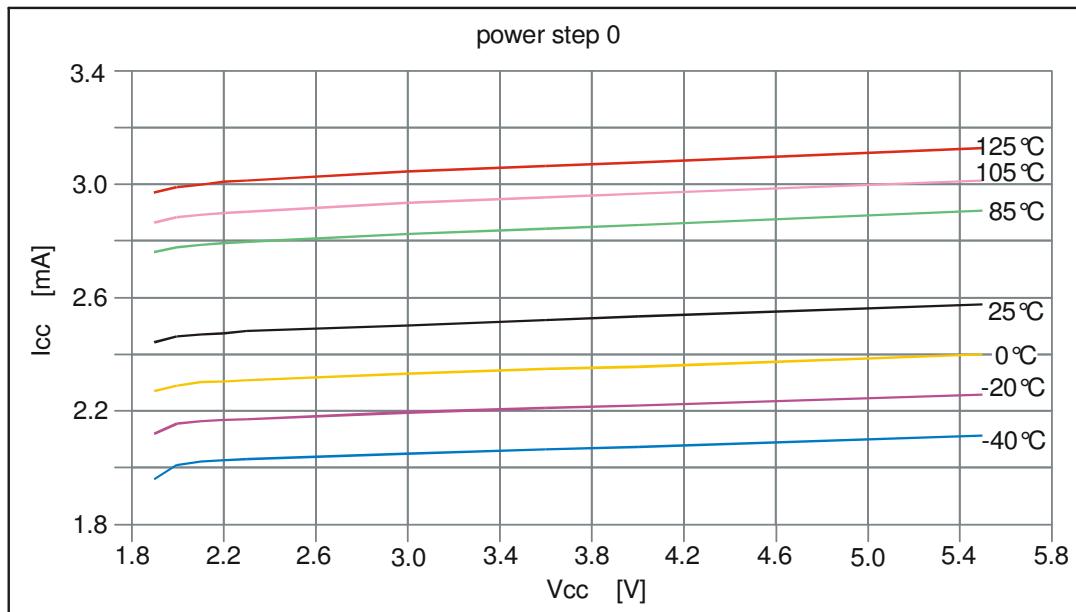


Fig. 6: Supply current in power step 0

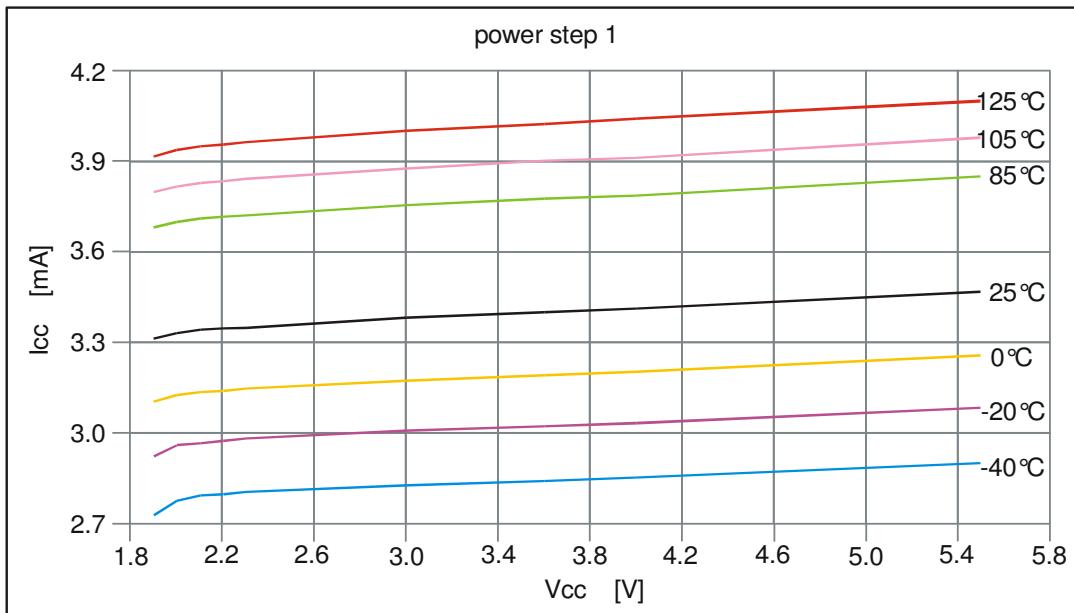


Fig. 7: Supply current in power step 1

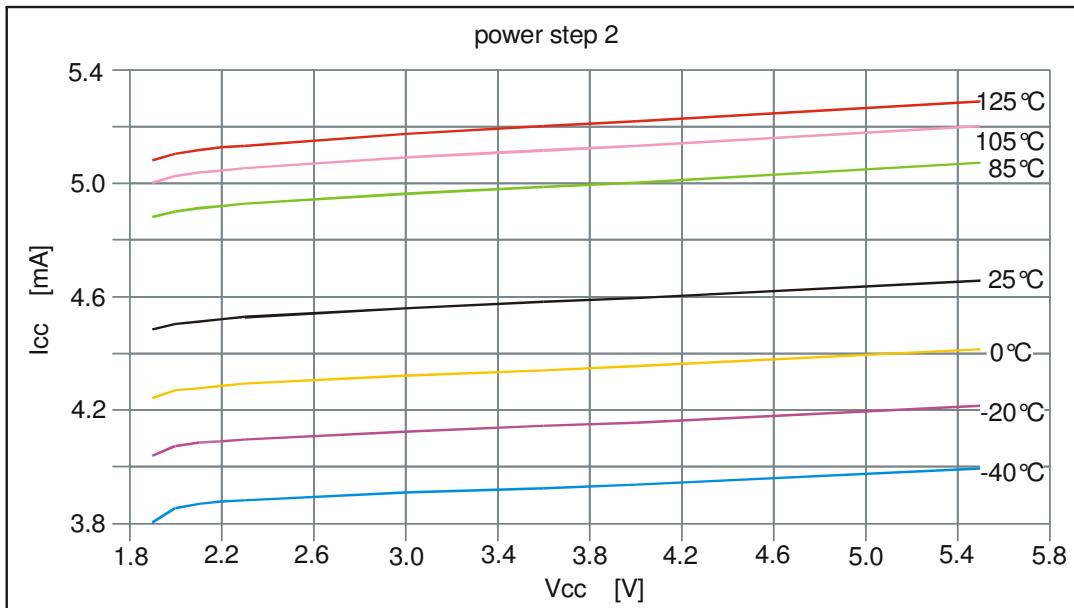


Fig. 8: Supply current in power step 2

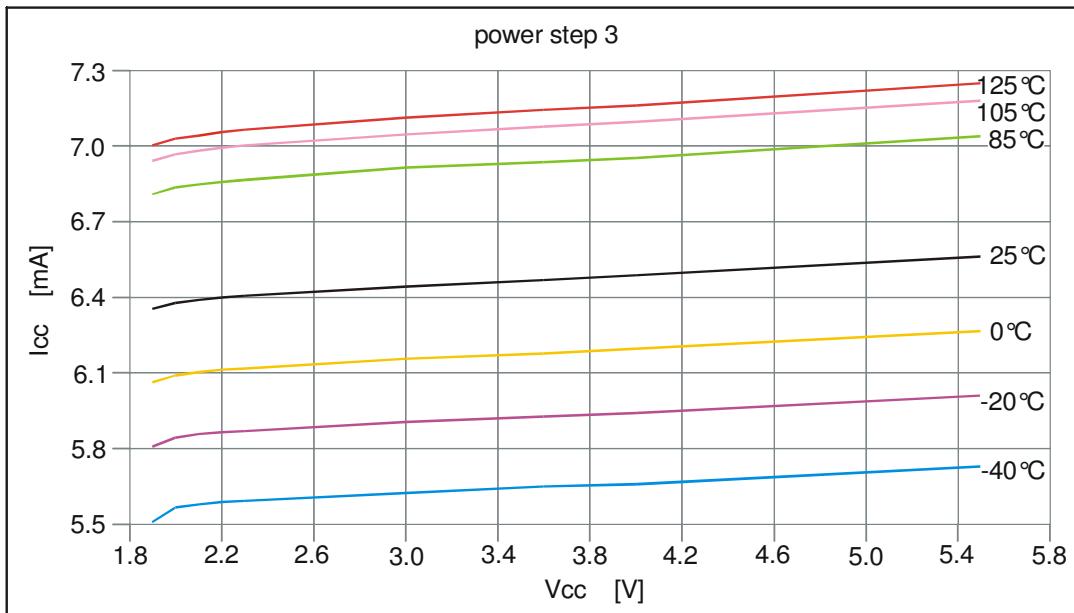


Fig. 9: Supply current in power step 3

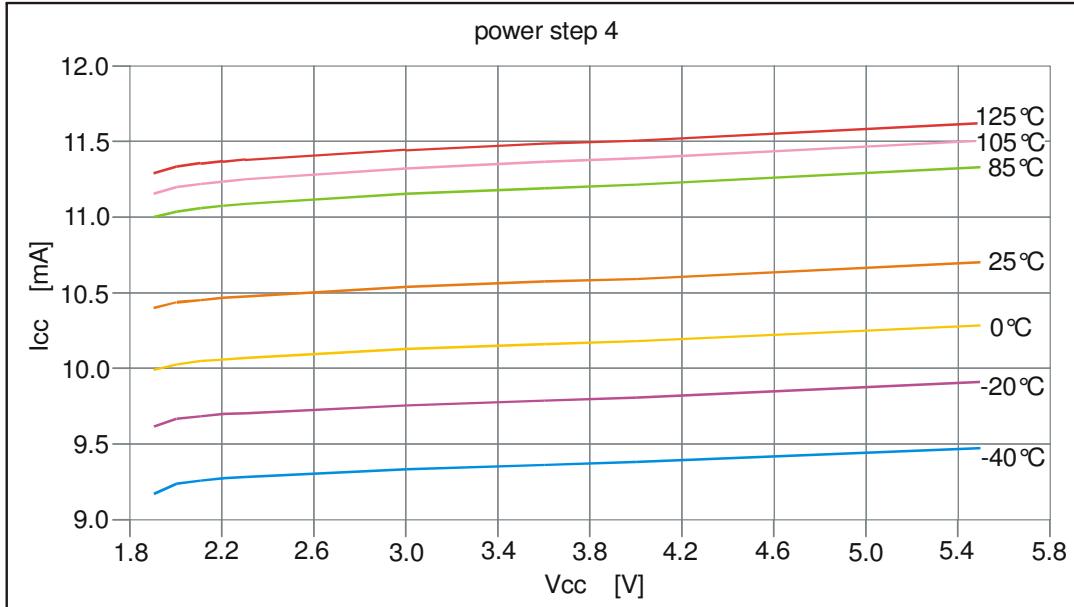


Fig. 10: Supply current in power step 4

5.2 AC Characteristics

- Data according to test circuit in Fig. 17

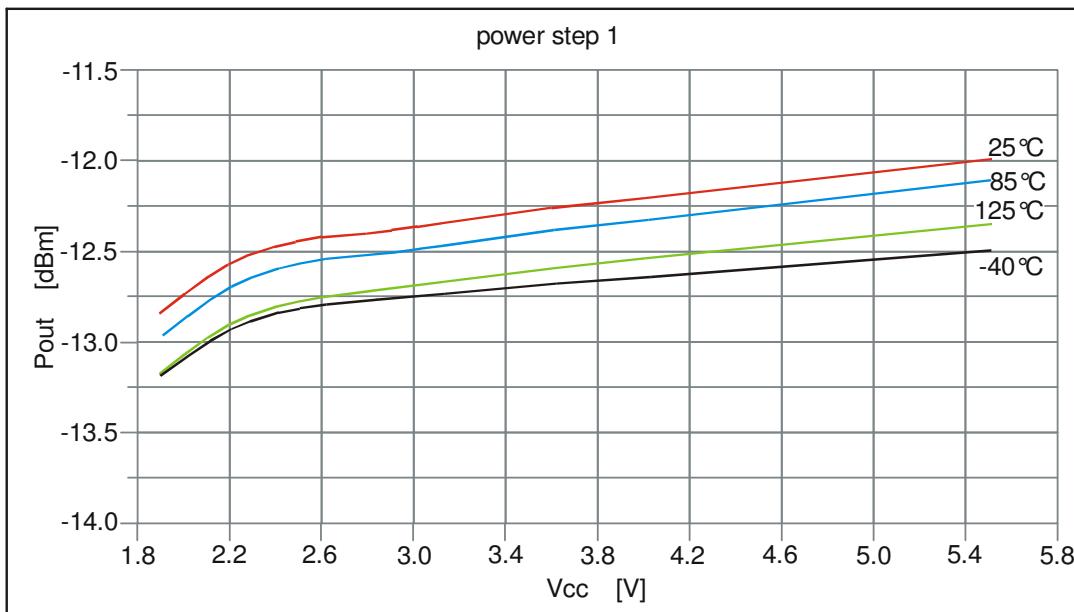


Fig. 11: Output power in step 1

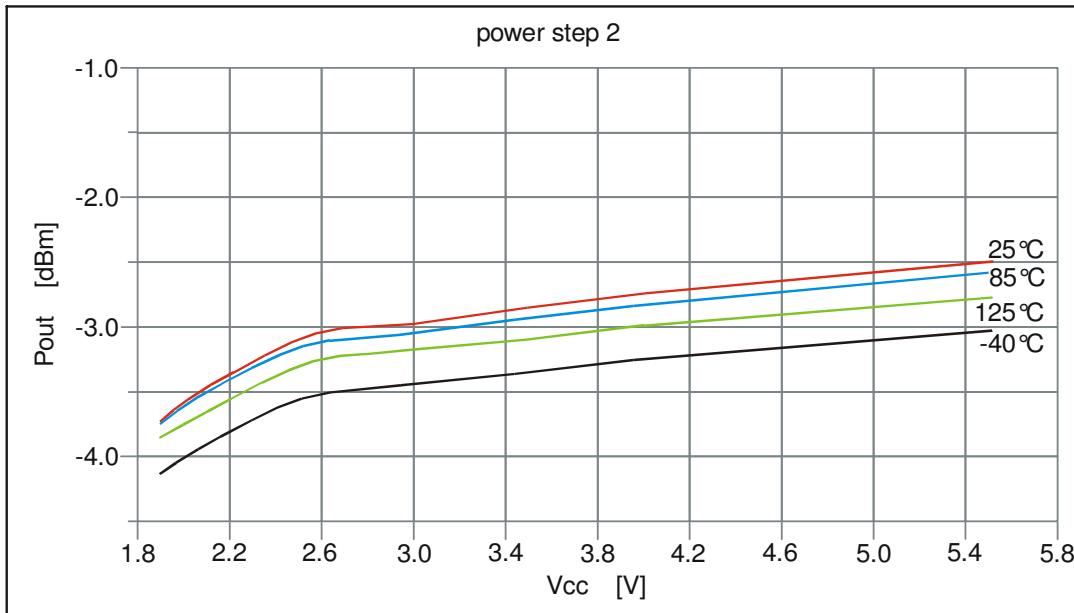


Fig. 12: Output power in step 2

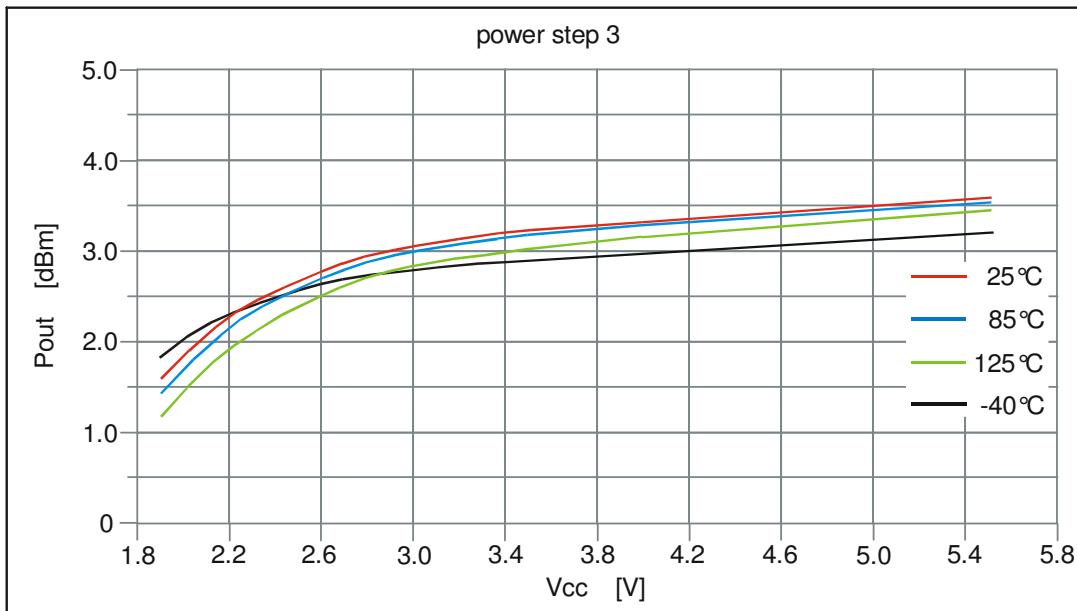


Fig. 13: Output power in step 3

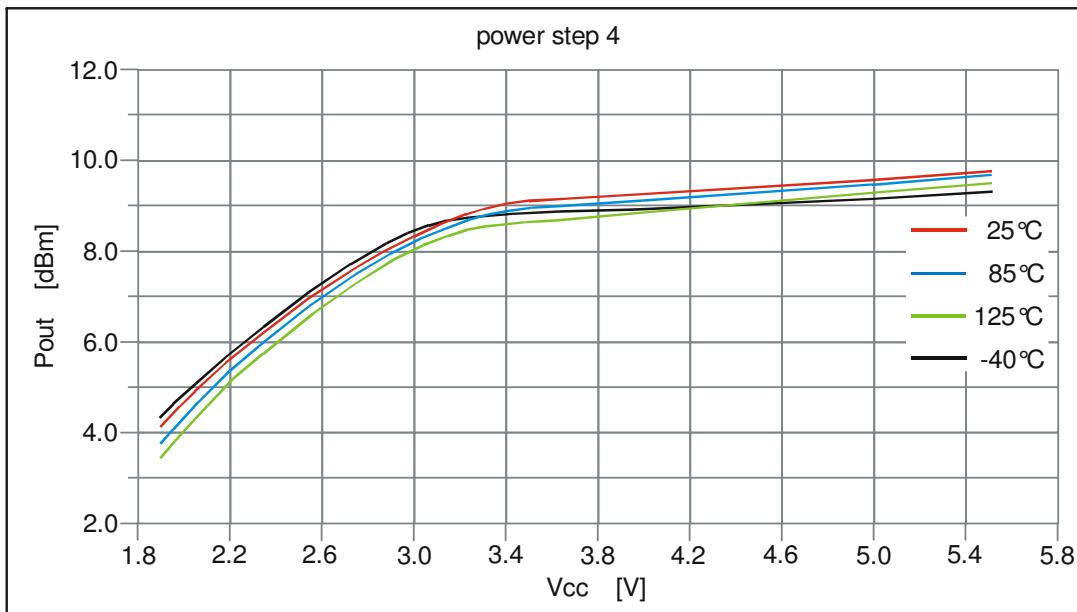


Fig. 14: Output power in step 4

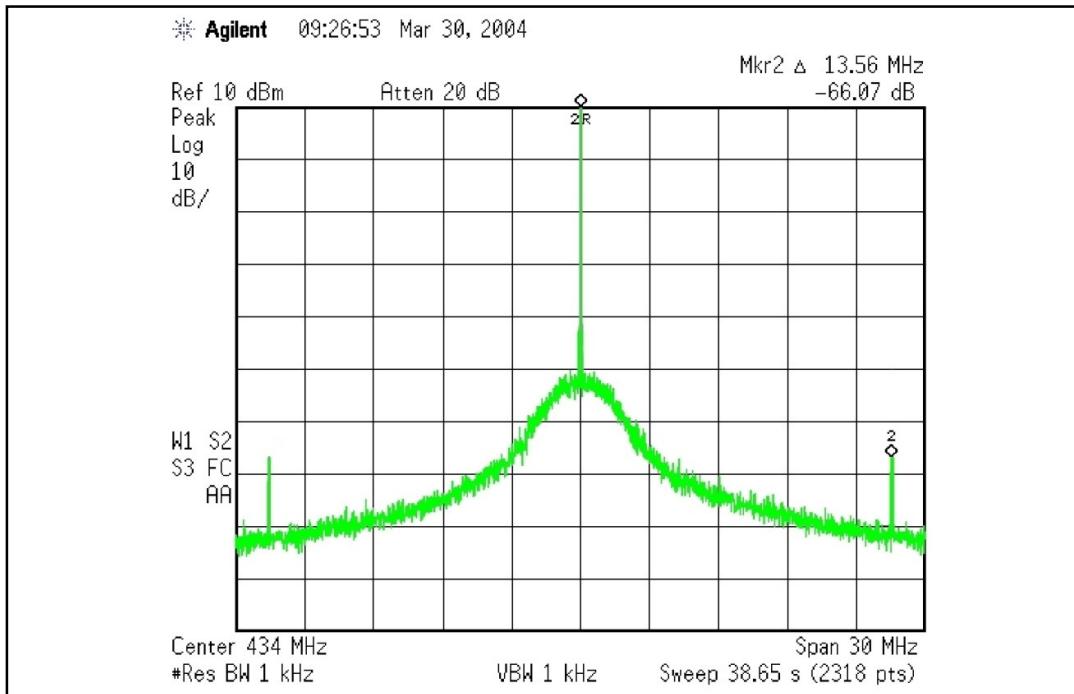


Fig. 15: RF output signal with PLL reference spurs

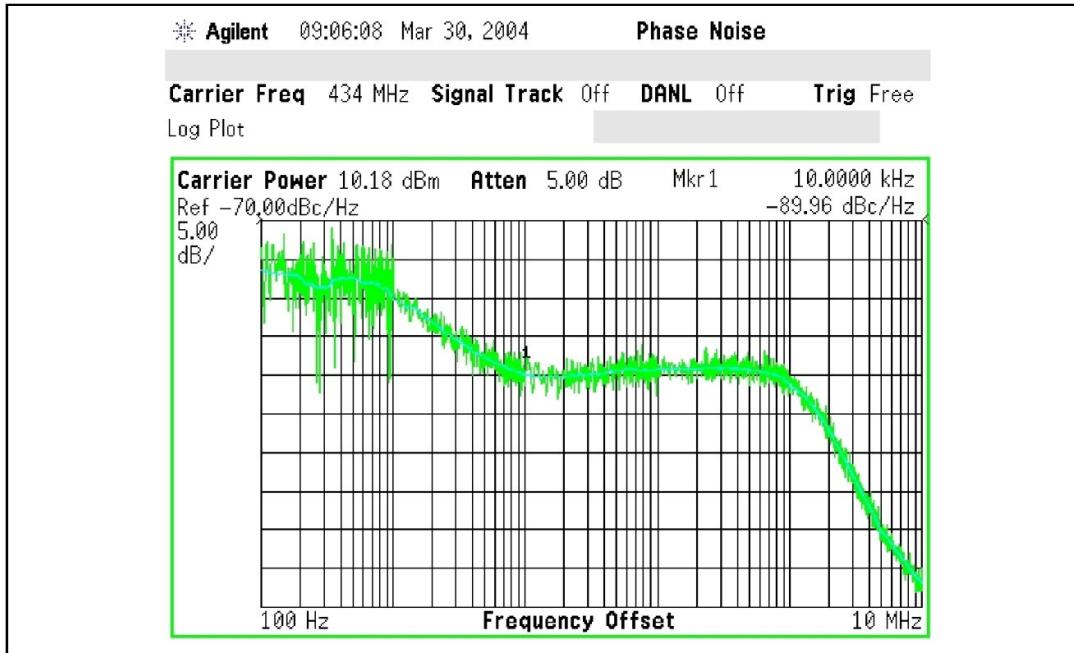


Fig. 16: Single sideband phase noise

6 Test Circuit

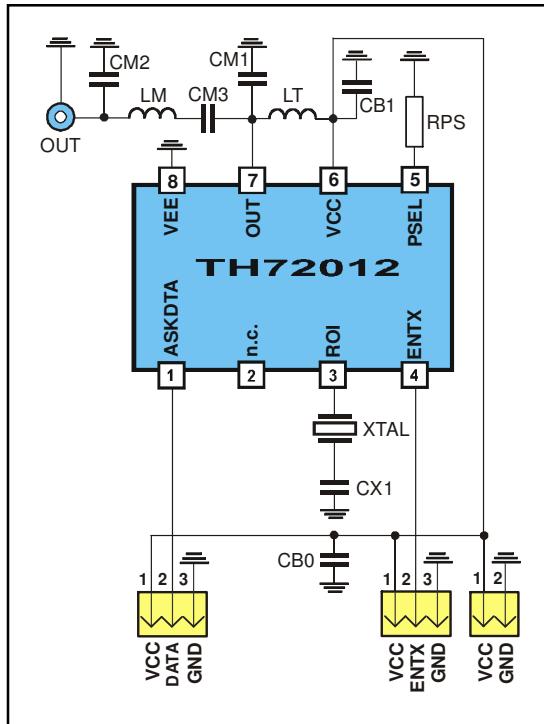


Fig. 17: Test circuit for ASK with 50Ω matching network

6.1 Test circuit component list to Fig. 17

| Part | Size | Value @ 433.92 MHz | Tolerance | Description |
|------|--------|--------------------|--|--|
| CM1 | 0805 | 5.6 pF | $\pm 5\%$ | impedance matching capacitor |
| CM2 | 0805 | 10 pF | $\pm 5\%$ | impedance matching capacitor |
| CM3 | 0805 | 82 pF | $\pm 5\%$ | impedance matching capacitor |
| LM | 0805 | 33 nH | $\pm 5\%$ | impedance matching inductor, note 2 |
| LT | 0805 | 33 nH | $\pm 5\%$ | output tank inductor, note 2 |
| CX1 | 0805 | 27 pF | $\pm 5\%$ | XOSC capacitor, note 1 |
| RPS | 0805 | see para. 4.6 | $\pm 5\%$ | power-select resistor |
| CB0 | 1206 | 220 nF | $\pm 20\%$ | blocking capacitor |
| CB1 | 0805 | 330 pF | $\pm 10\%$ | blocking capacitor |
| XTAL | HC49/S | 13.56000 MHz | $\pm 30\text{ppm}$ calibr. $\pm 30\text{ppm}$ temp. | fundamental wave crystal, $C_L = 12 \text{ pF}$, $C_{0,\text{max}} = 7 \text{ pF}$, $R_1 = 60 \Omega$ |

Note 1: value depending on crystal parameters

Note 2: for high-power applications high-Q wire-wound inductors should be used

7 Package Information

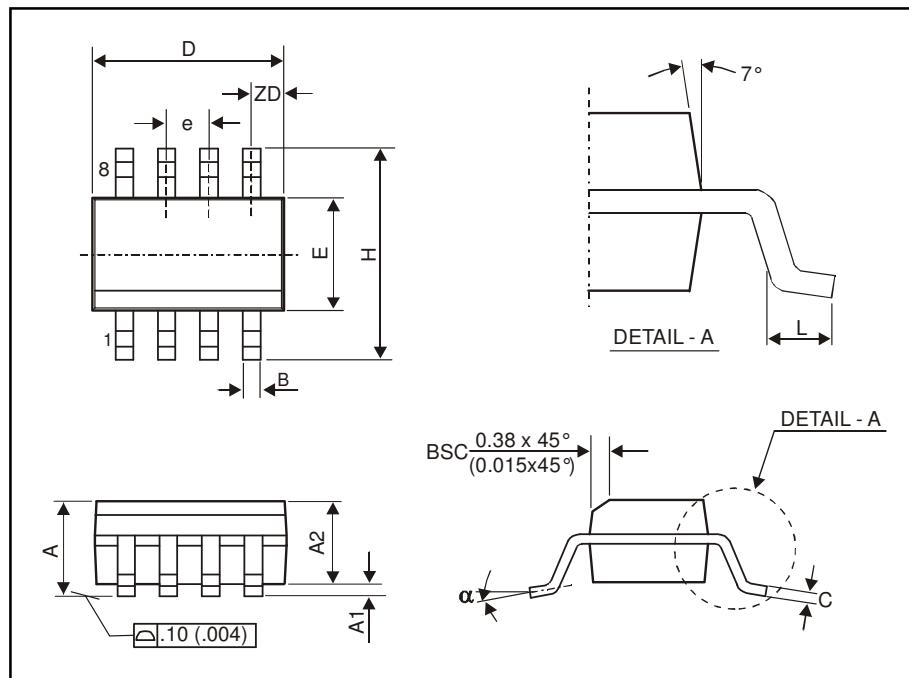


Fig. 18: SOIC8 (Small Outline Integrated Circuit)

| 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 | 0.46 | 0.25 | 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 | 0.050 | 0.018 | 0.021 | 0.098 | 0.050 | 8° |

8 Standard information regarding manufacturability of Melexis products with different soldering processes

Our products are classified and qualified regarding soldering technology, solderability and moisture sensitivity level according to following test methods:

Reflow Soldering SMD's (Surface Mount Devices)

- IPC/JEDEC J-STD-020
Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices (classification reflow profiles according to table 5-2)
- EIA/JEDEC JESD22-A113
Preconditioning of Nonhermetic Surface Mount Devices Prior to Reliability Testing (reflow profiles according to table 2)

Wave Soldering SMD's (Surface Mount Devices) and THD's (Through Hole Devices)

- EN60749-20
Resistance of plastic- encapsulated SMD's to combined effect of moisture and soldering heat
- EIA/JEDEC JESD22-B106 and EN60749-15
Resistance to soldering temperature for through-hole mounted devices

Iron Soldering THD's (Through Hole Devices)

- EN60749-15
Resistance to soldering temperature for through-hole mounted devices

Solderability SMD's (Surface Mount Devices) and THD's (Through Hole Devices)

- EIA/JEDEC JESD22-B102 and EN60749-21
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.

Melexis is contributing to global environmental conservation by promoting **lead free** solutions. For more information on qualifications of **RoHS** compliant products (RoHS = European directive on the Restriction Of the use of certain Hazardous Substances) please visit the quality page on our website:
<http://www.melexis.com/quality.aspx>

9 ESD Precautions

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

10 Disclaimer

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