# TH72031

868/915MHz

FSK Transmitter

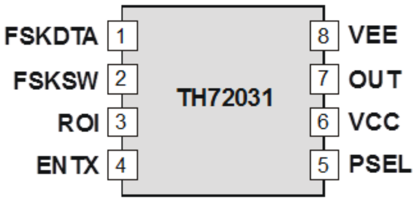
## Features

- 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 1.95 V to 5.5 V
- Very low standby current
- On-chip low voltage detector
- High over-all frequency accuracy
- FSK deviation and center frequency independently adjustable
- Adjustable output power range from
- -12 dBm to +9.5 dBm
- Adjustable current consumption from
- 5.1 mA to 13.4 mA
- Conforms to EN 300 220 and similar standards
- 8-pin Small Outline Integrated Circuit (SOIC)

## Application Examples

- General digital data transmission
- Tire Pressure Monitoring Systems (TPMS)
- Remote Keyless Entry (RKE)
- Wireless access control
- Alarm and security systems
- Garage door openers
- Remote Controls
- Home and building automation
- Low-power telemetry systems

## Pin Description



## Ordering information

| Product Code | Temperature Code | Package Code | Option Code | Packing Form Code |
|---|---|---|---|---|
| TH72031 | **K** | DC | BAA-000 | RE |
| TH72031 | **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:* | *TH72031KDC-BAA-000-TU* |

## General Description

The TH72031 FSK transmitter IC is designed for applications in the European 868 MHz 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 902 to 928 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. This is done by using a crystal with a reference frequency according to: $f_{ref} = f_c/N$, where N = 32 is the PLL feedback divider ratio.

## Contents

# 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). The RF signal power $P_{out}$ can be adjusted in four steps from $P_{out}$ = –12 dBm to +9.5 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 1.95 V to 5.5 V.

## 1.2. Block Diagram

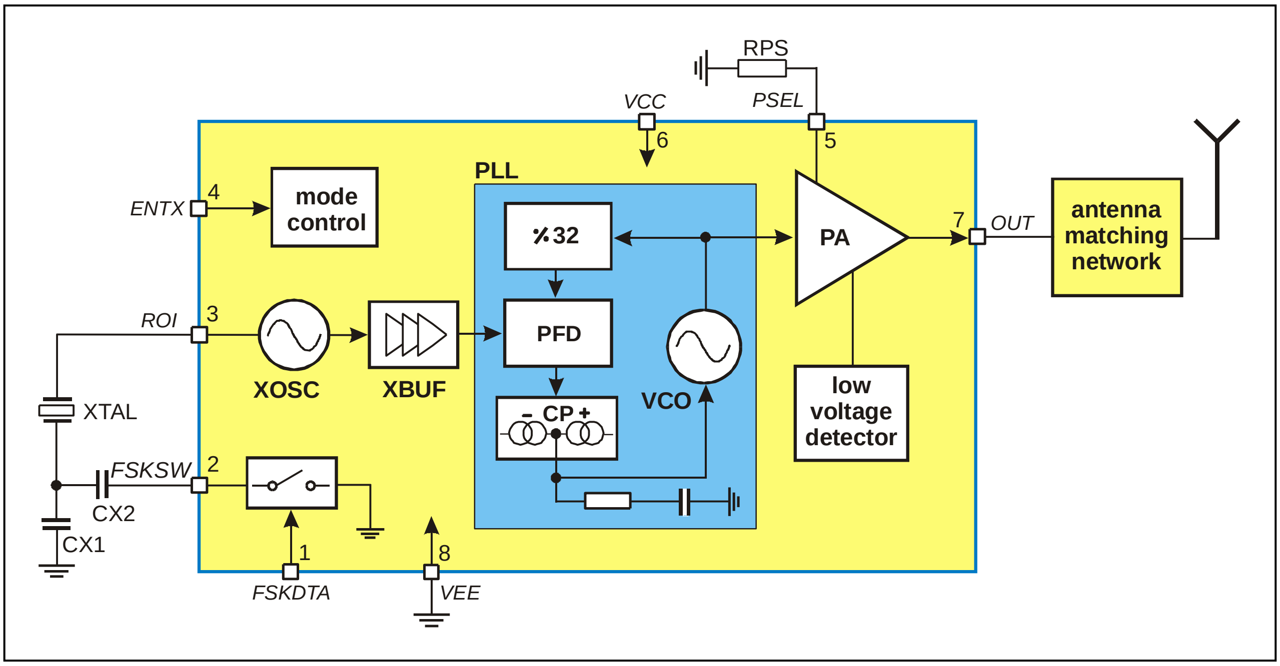


*Fig. 1: Block diagram with external components*

# 2. Functional Description

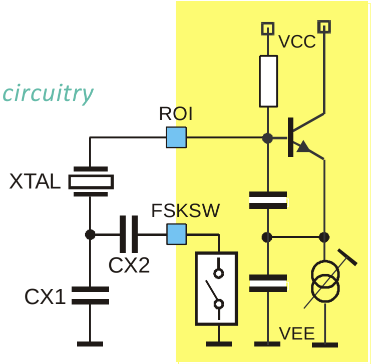
## 2.1. Crystal Oscillator

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. 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 $\Delta f$ 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.

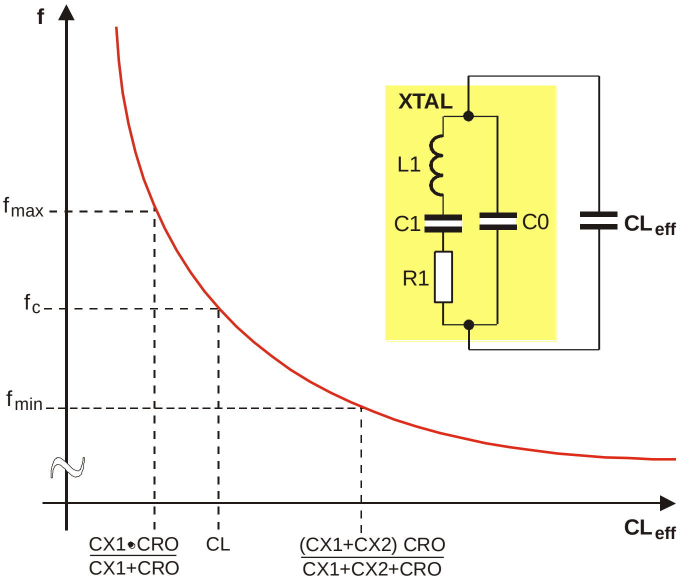


*Fig. 3: Crystal pulling characteristic*

## 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.

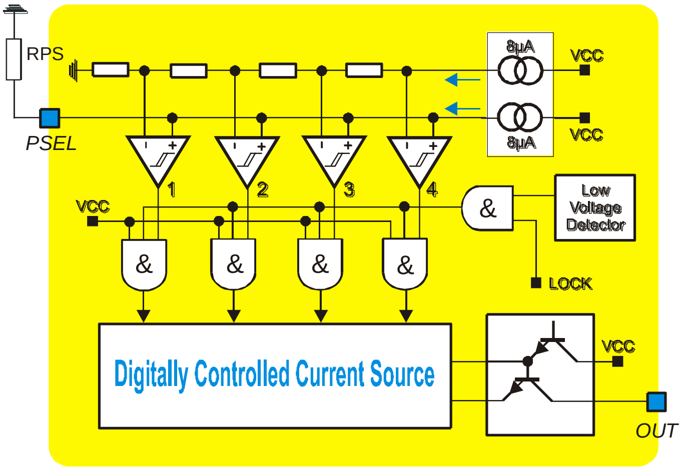


*Fig. 4: Block diagram of output power control circuitry*

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.

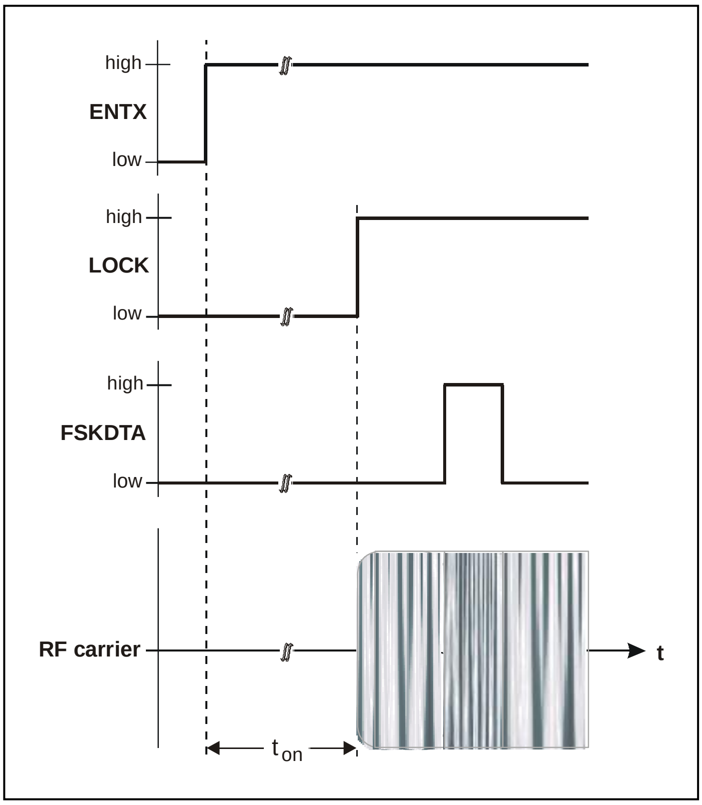
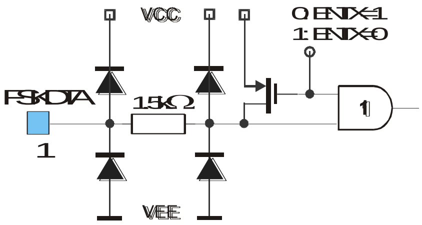
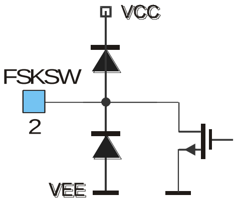
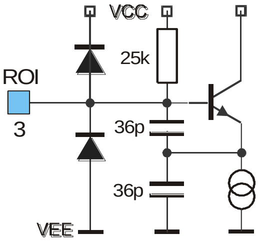
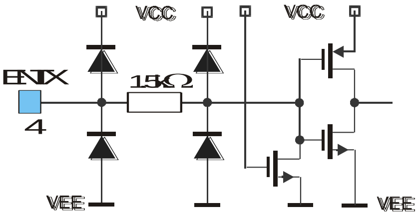
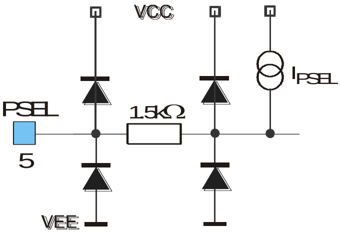
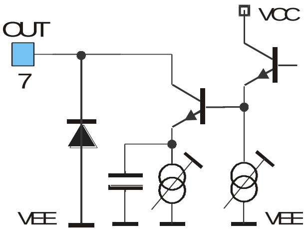


*Fig. 5: Timing diagram for FSK modulation*

## 3. Pin Definition and Description

| Pin No. | Name | I/O Type | Functional Schematic | Description |
|---|---|---|---|---|
| 1 | FSKDTA | input |  | FSK data input,<br>CMOS compatible with operation mode dependent pull-up circuit<br>TX standby: no pull-up<br>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<br>TX standby: $I_{PSEL} = 0$<br>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 | $V_{ESD}$ | 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, 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 | $\Delta f$ | depending on CX1, CX2 and crystal parameters | ±2.5 | ±60 | kHz |
| Data rate | R | NRZ | | 40 | kbit/s |

## 4.3. Crystal Parameters

| 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 | | 10 | 4000 | nA |
| Supply current in power step 0 | $I_{CC0}$ | ENTX=1 | 2.5 | 3.9 | 5.7 | mA |
| Supply current in power step 1 | $I_{CC1}$ | ENTX=1 | 3.5 | 5.1 | 7.3 | mA |
| Supply current in power step 2 | $I_{CC2}$ | ENTX=1 | 4.5 | 6.4 | 8.8 | mA |
| Supply current in power step 3 | $I_{CC3}$ | ENTX=1 | 6.2 | 8.6 | 11.4 | mA |
| Supply current in power step 4 | $I_{CC4}$ | ENTX=1 | 9.4 | 13.4 | 17.3 | 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 | $I_{PDEN}$ | ENTX=1 | 0.2 | 2.0 | 20 | µA |
| Low level input current ENTX | $I_{INLEN}$ | ENTX=0 | | | 0.02 | µA |
| High level input current FSKDTA | $I_{INHDTA}$ | FSKDTA=1 | | | 0.02 | µA |
| Pull up current FSKDTA active | $I_{PUDTAa}$ | FSKDTA=0, ENTX=1 | 0.1 | 1.5 | 12 | µA |
| Pull up current FSKDTA standby | $I_{PUDTAs}$ | FSKDTA=0, ENTX=0 | | | 0.02 | µA |
| **FSK Switch Resistance** | | | | | | |
| MOS switch On resistance | $R_{ON}$ | FSKDTA=0<br>ENTX=1 | | 20 | 70 | Ω |
| MOS switch Off resistance | $R_{OFF}$ | FSKDTA=1<br>ENTX=1 | 1 | | | MΩ |
| **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 °C and $V_{CC}$ = 3 V; test circuit shown in Fig. 17, $f_c$ = 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 | -13 | -12 | -11 [1)] | dBm |
| Output power in step 2 | $P_2$ | ENTX=1 | -4 | -3 | -2 [1)] | dBm |
| Output power in step 3 | $P_3$ | ENTX=1 | 1 | 2.5 | 3.5 [1)] | dBm |
| Output power in step 4 | $P_4$ | ENTX=1 | 4 | 7.5 | 9.5 [1)] | dBm |
| Phase noise | $L(f_m)$ | @ 200kHz offset | | -87 | -82 | dBc/Hz |
| Spurious emissions according to EN 300 220-1 (2000.09) table 13 | $P_{spur}$ | 47MHz< f <74MHz<br>87.5MHz< f <118MHz<br>174MHz< f <230MHz<br>470MHz< f <862MHz<br>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 |
| Frequency stability vs. variation range of $C_{RO}$ | $df_{CRO}$ | | | | ±20 | ppm |

1) output matching network tuned for 5V supply

## 4.6. Output Power Steps

| **Power step** | **0** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|---|
| **RPS / kΩ** | < 3 | 22 | 56 | 120 | not connected |

# 5. Typical Operating Characteristics

## 5.1. DC Characteristics

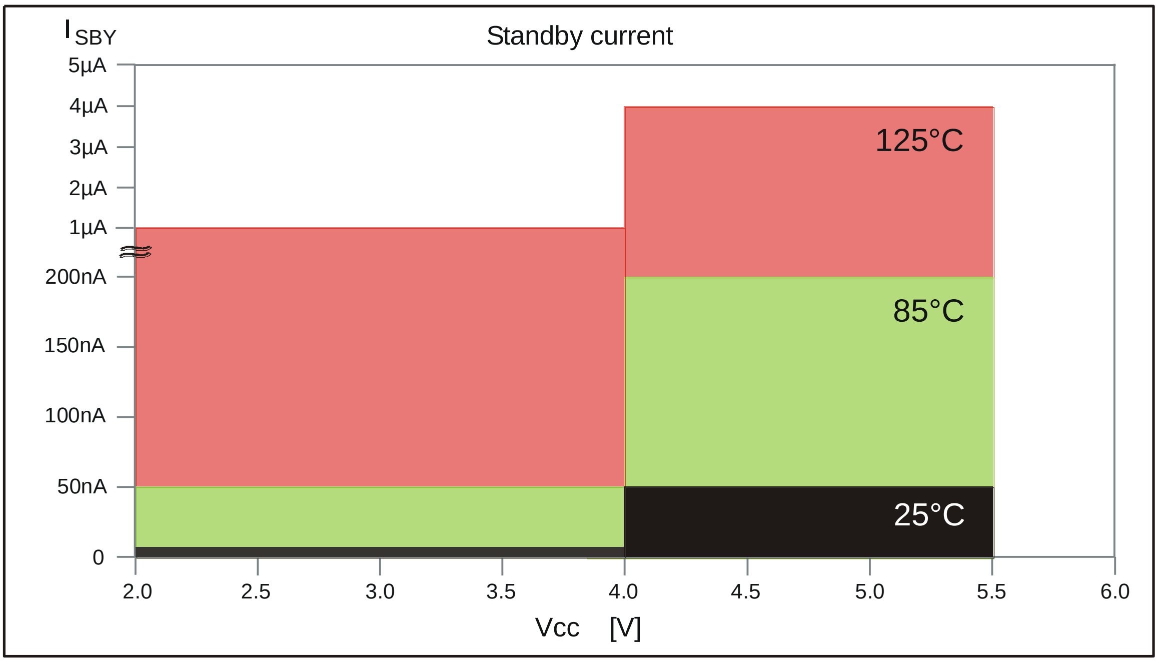


*Fig. 6: Standby current limits*

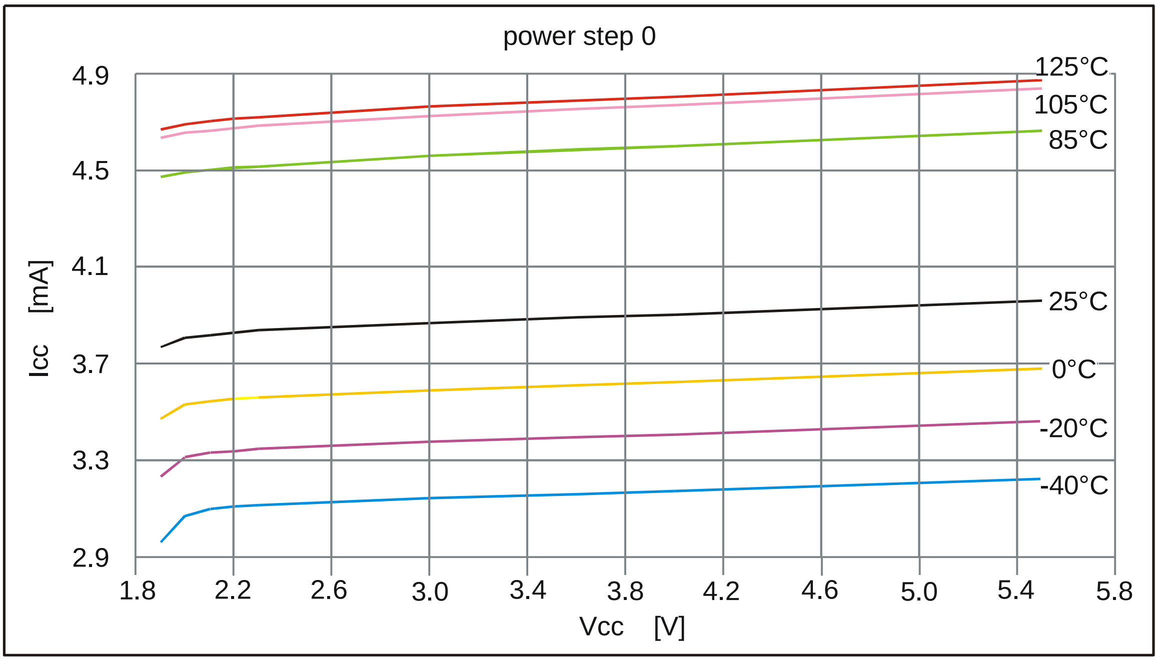


*Fig. 7: Supply current in power step 0*

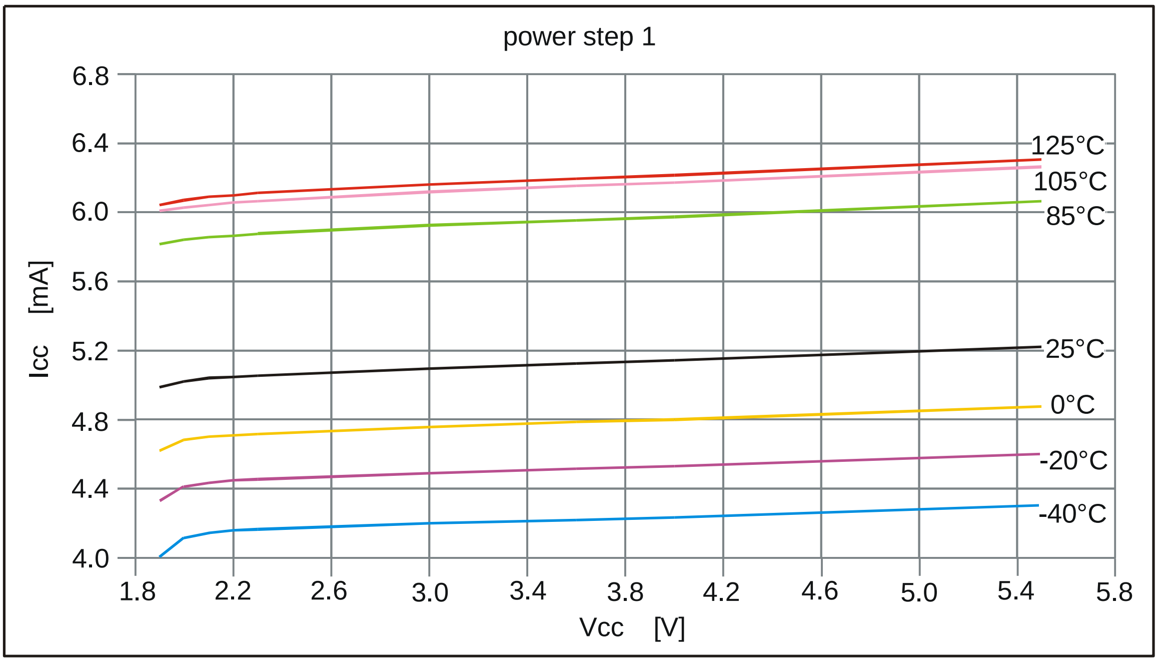


*Fig. 8: Supply current in power step 1*

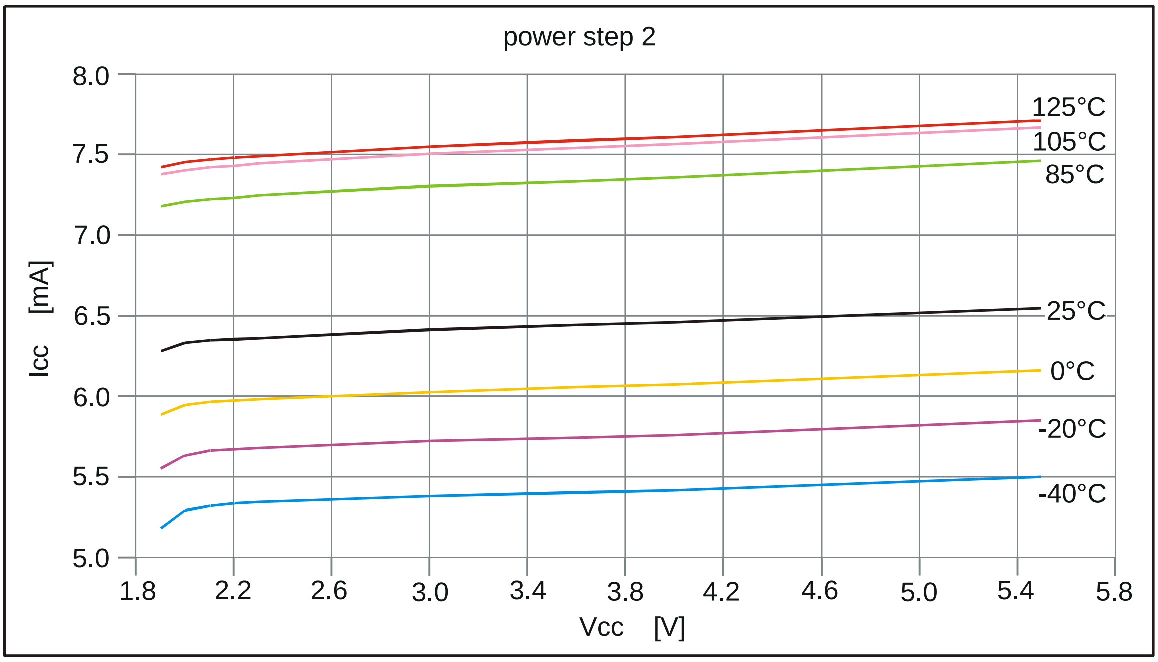


*Fig. 9: Supply current in power step 2*

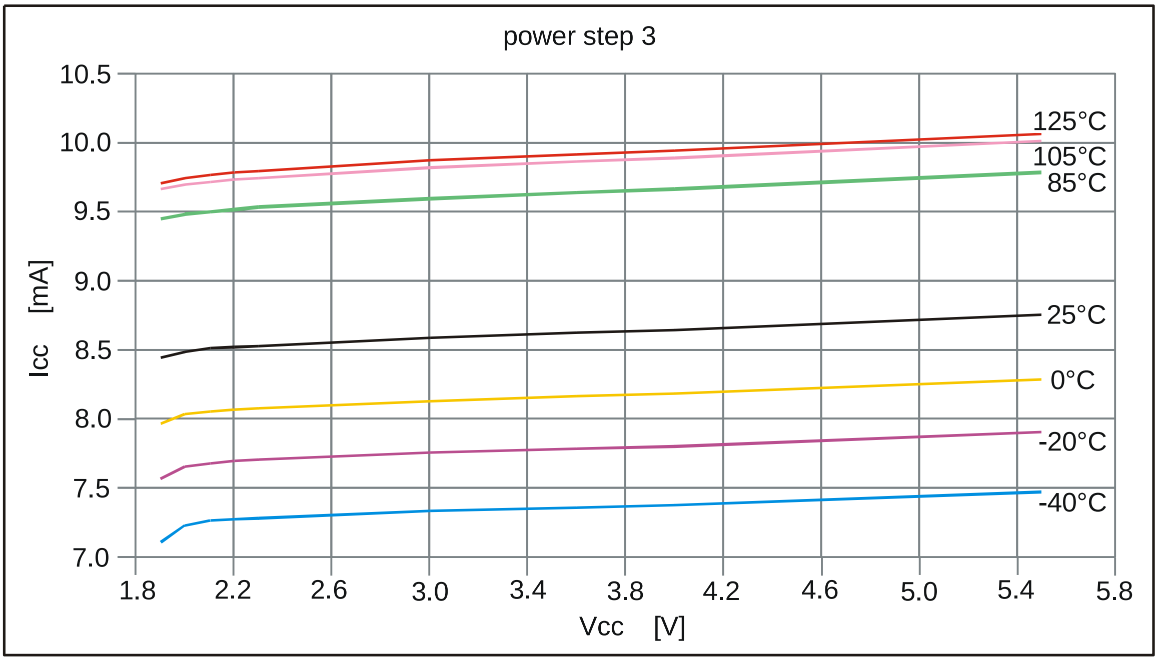


*Fig. 10: Supply current in power step 3*

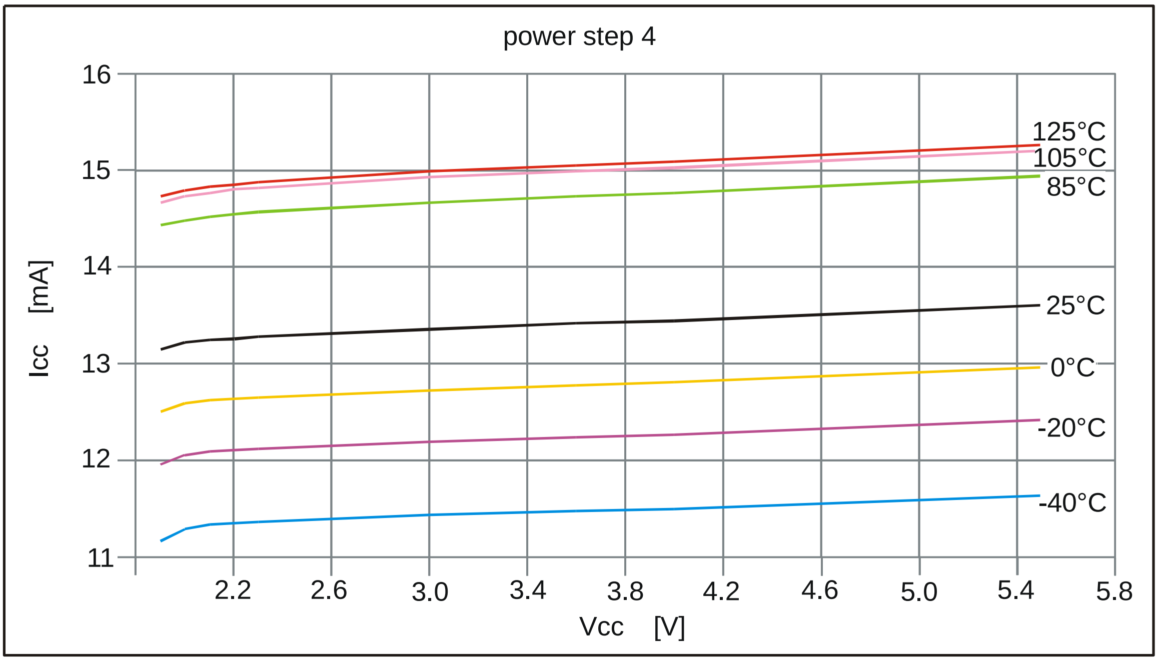


*Fig. 11: Supply current in power step 4*

## 5.2. AC Characteristics

- Data according to test circuit in Fig. 18 (868.3MHz)

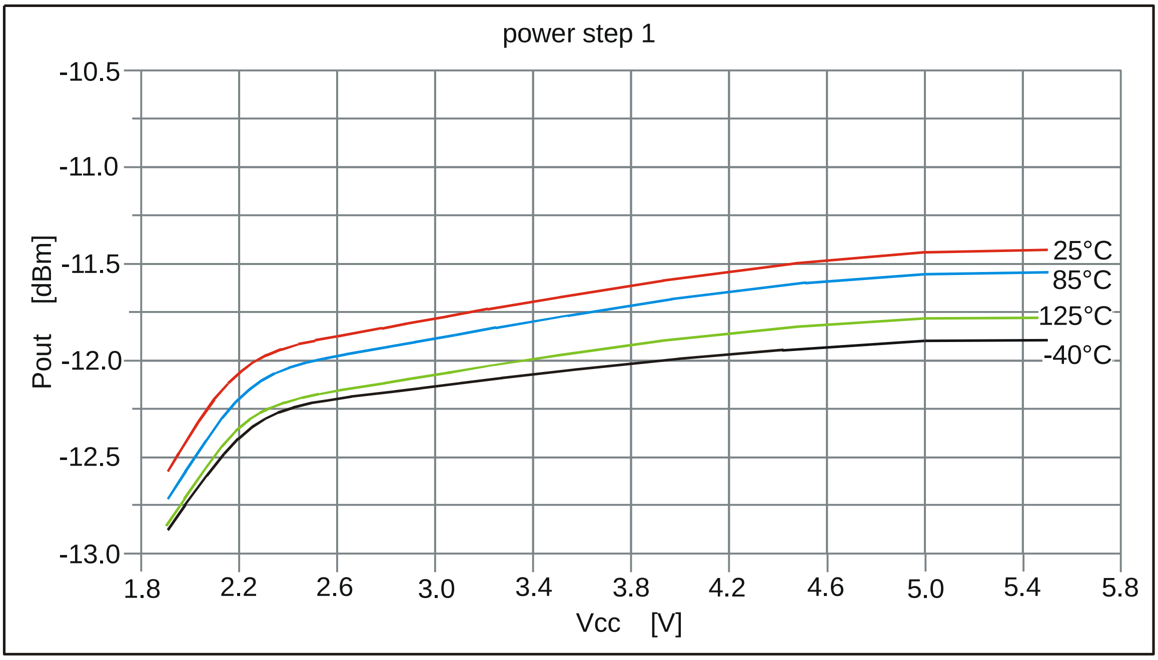


*Fig. 12: Output power in step 1*

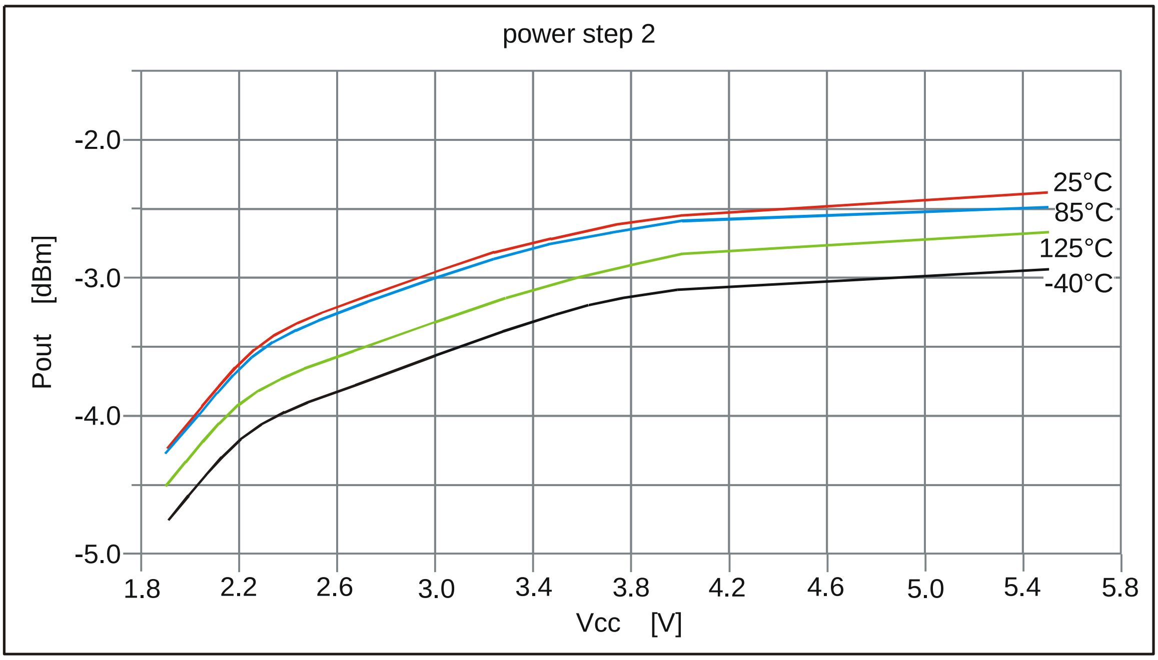


*Fig. 13: Output power in step 2*

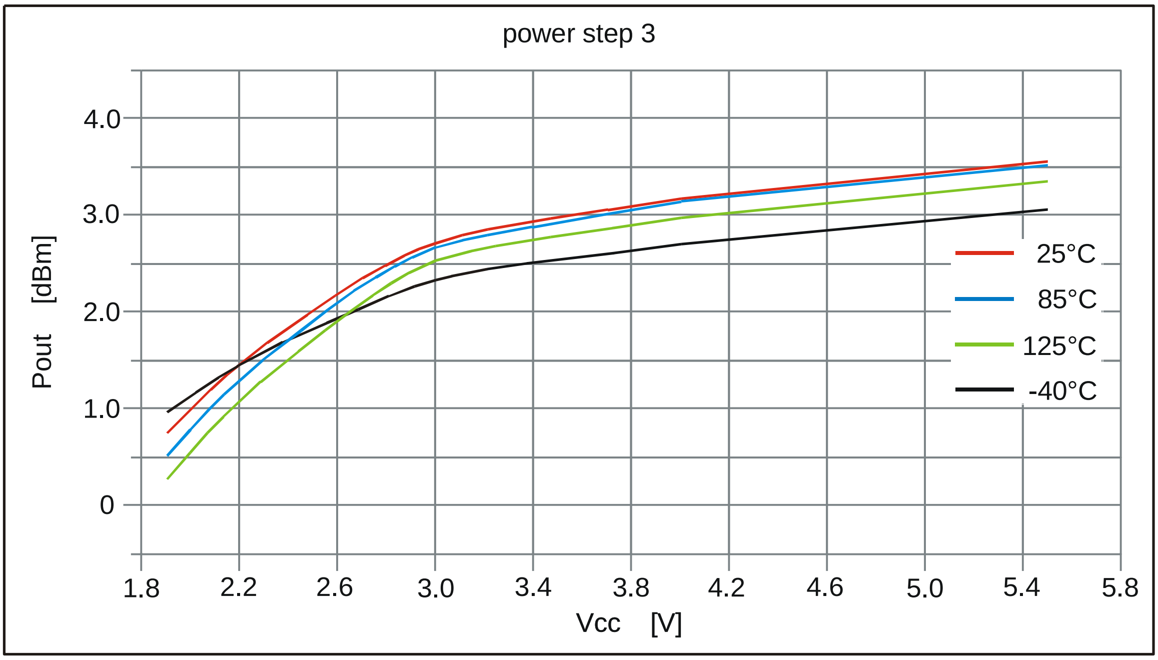


*Fig. 14: Output power in step 3*

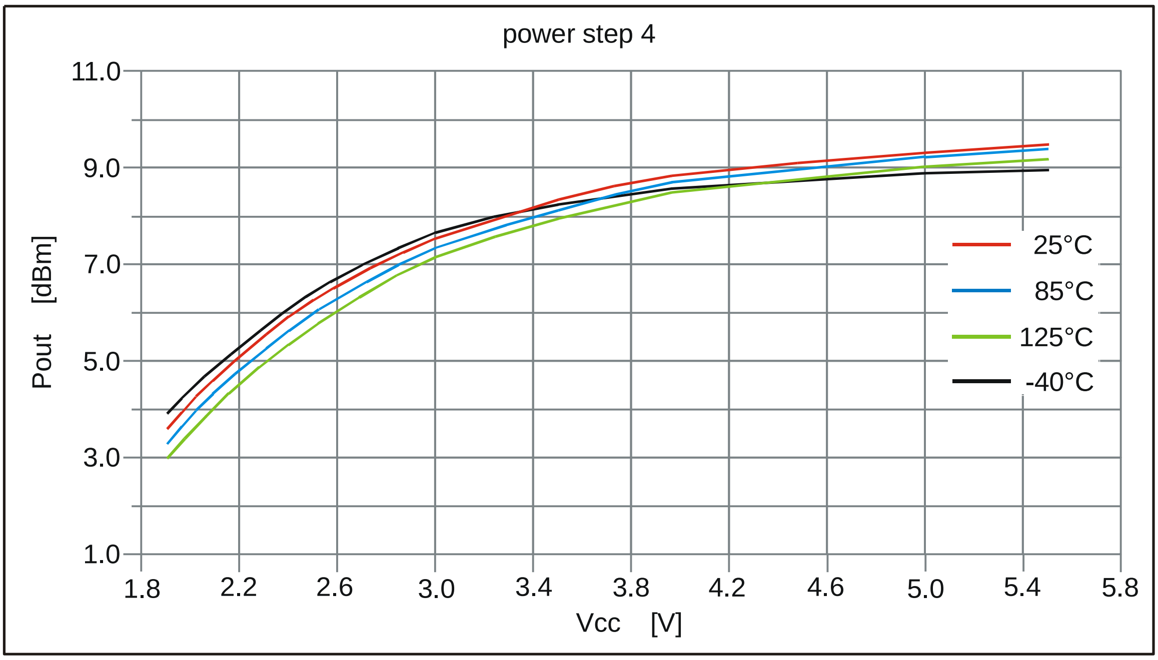


*Fig. 15: Output power in step 4*

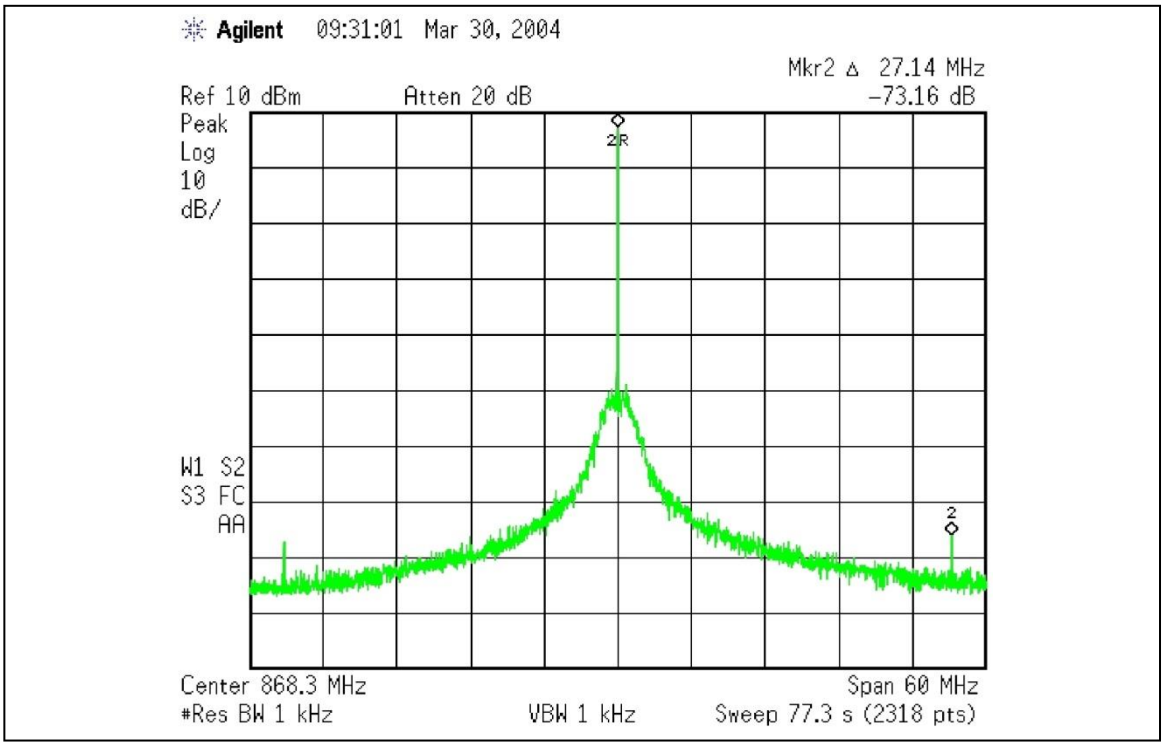


*Fig.16: RF output signal with PLL reference spurs*

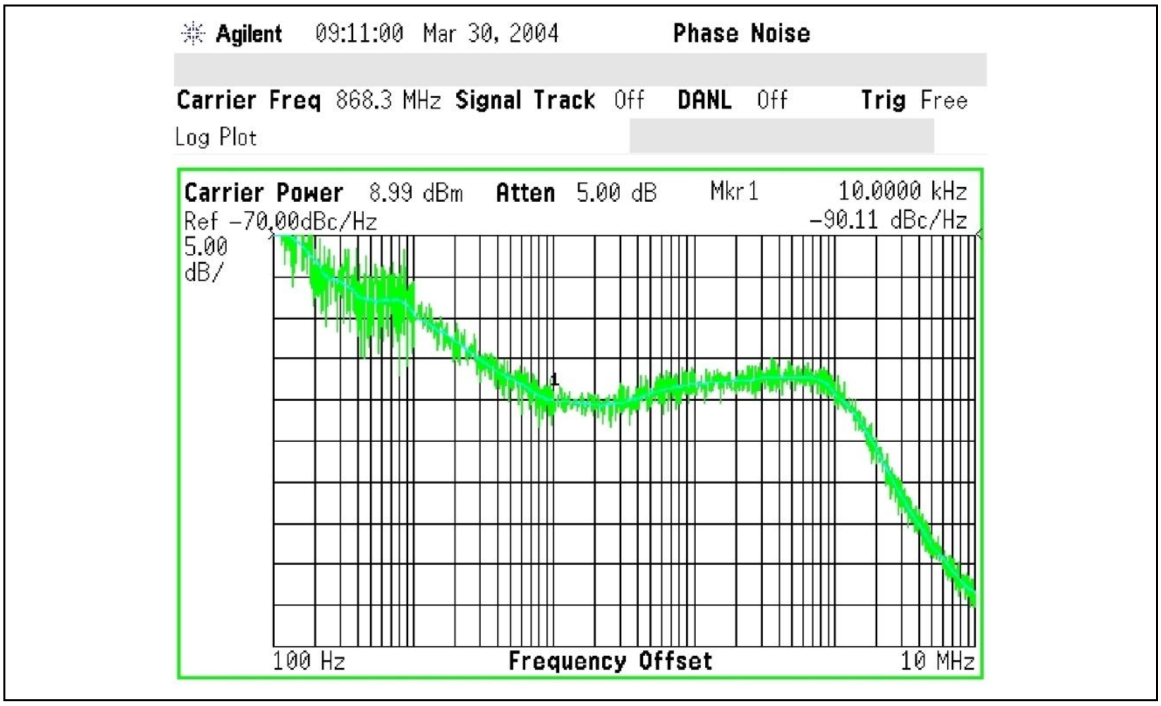


*Fig.17: Single sideband phase noise*

## 6. Test Circuit

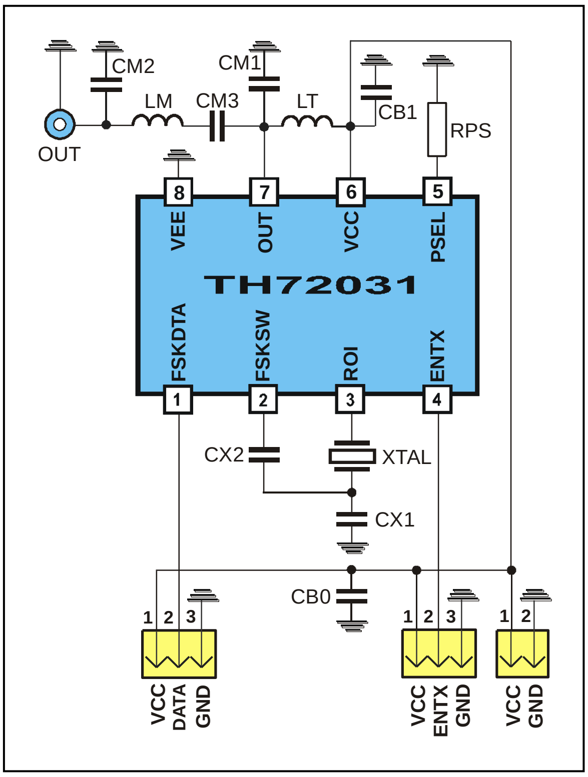


*Fig.18: Test circuit for FSK with 50 Ω matching network*

### 6.1. Test circuit component list to Fig. 18

| Part | Size | Value @ 868.3 MHz | Value @ 915 MHz | Tolerance | Description |
|---|---|---|---|---|---|
| CM1 | 0805 | 1.8 pF | 2.2 pF | ±5% | impedance matching capacitor |
| CM2 | 0805 | 5.6 pF | 5.6 pF | ±5% | impedance matching capacitor |
| CM3 | 0805 | 68 pF | 68 pF | ±5% | impedance matching capacitor |
| LM | 0805 | 12 nH | 10 nH | ±5% | impedance matching inductor, note 2 |
| LT | 0805 | 15 nH | 10 nH | ±5% | output tank inductor, note 2 |
| CX1 | 0805 | 18 pF | 18 pF | ±5% | XOSC capacitor (Δf = ±20 kHz), note 1 |
| CX2 | 0805 | 10 pF | 10 pF | ±5% | XOSC capacitor (Δf = ±20 kHz), note 1 |
| RPS | 0805 | see section 4.6 | | ±5% | power-select resistor |
| CB0 | 0805 | 220 nF | | ±20% | de-coupling capacitor |
| CB1 | 0805 | 330 pF | | ±10% | de-coupling capacitor |
| XTAL | HC49/S | 27.13438 MHz | 28.59375 MHz | ±30ppm calibr.<br>±30ppm temp | fundamental wave crystal,<br>$C_L$ = 12 pF, $C_{0,\,max}$ = 7 pF, $R_1$ = 40 Ω |

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

# 7. Package Description

The device TH72031 is RoHS compliant.

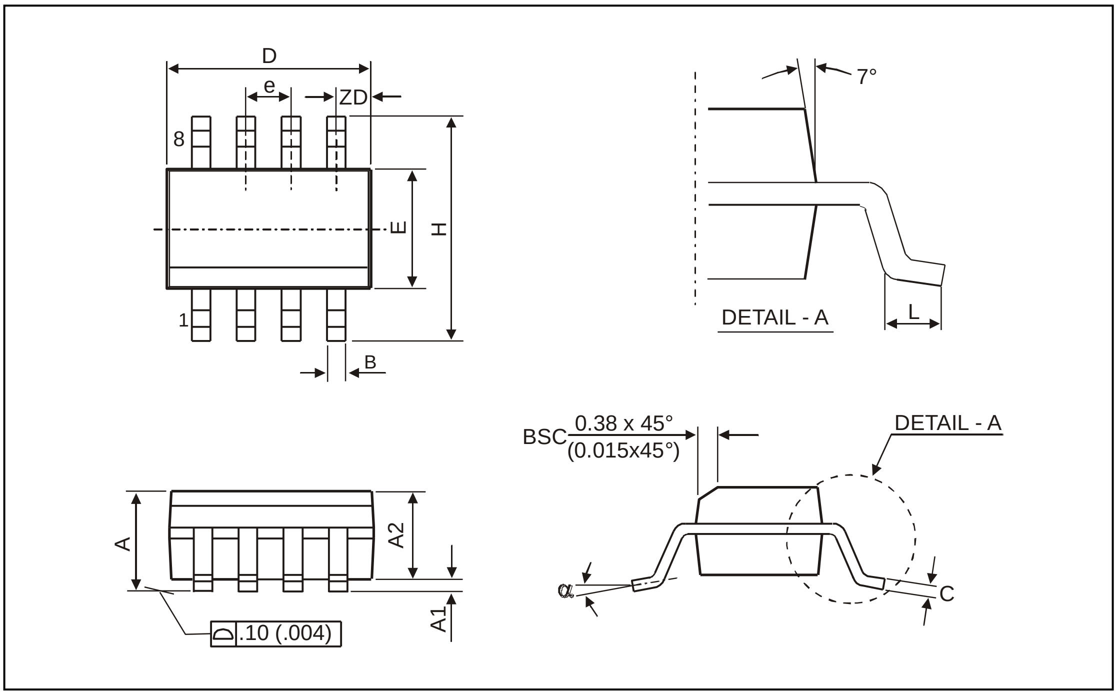


*Fig. 19: SOIC8*

| 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° |

## 7.1. Soldering Information

- The device TH72031 is qualified for MSL1 with soldering peak temperature 260 deg C according to JEDEC J-STD-20

## 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. Contact

For the latest version of this document, go to our website at [www.melexis.com.](http://www.melexis.com)

For additional information, please contact our Direct Sales team and get help for your specific needs:

| | |
|---|---|
| Europe, Africa | Telephone: +32 13 67 04 95 |
| | Email : sales_europe@melexis.com |
| Americas | Telephone: +1 603 223 2362 |
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- *Входной контроль качества.*
- *Наличие сертификата ISO.*

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