

Features

- Single-conversion superhet architecture for low external component count
- FSK demodulation with phase-coincidence demodulator
- Low current consumption in active mode and very low standby current
- Switchable LNA gain for improved dynamic range
- RSSI allows signal strength indication and ASK detection

Ordering Information

Part No.

EVB71111-868-FSK-C
EVB71111-868-ASK-C

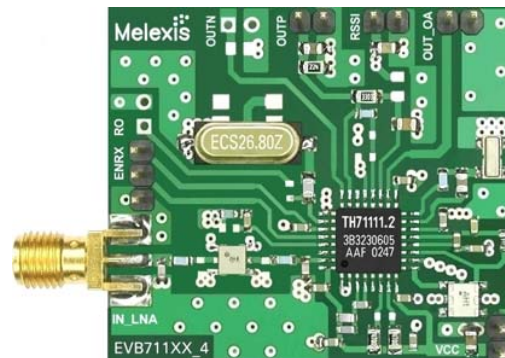
EVB71111-915-FSK-C
EVB71111-915-ASK-C

* EVB71111-XXX-YYY-C with XXX = Reception frequency (868.3MHz or 915MHz) and YYY = Modulation (FSK or ASK).
** The evaluation board is supplied with a SMA connector.

Application Examples

- 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

Evaluation Board



General Description

The TH71111 FSK/ASK single-conversion superheterodyne receiver 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 800 MHz to 930 MHz (e.g. for applications to FCC part 15).

Document Content

| | | |
|----------|--|-----------|
| 1 | Theory of Operation | 3 |
| 1.1 | General..... | 3 |
| 1.2 | EVB Technical Data Overview | 3 |
| 1.3 | Block Diagram | 4 |
| 1.4 | Mode Configurations | 4 |
| 1.5 | LNA GAIN Control | 4 |
| 1.6 | Frequency Planning..... | 4 |
| 1.6.1 | Selected Frequency Plans..... | 5 |
| 1.6.2 | Maximum Frequency Coverage..... | 5 |
| 2 | Application Circuits | 6 |
| 2.1 | FSK Application Circuit..... | 6 |
| 2.1.1 | Circuit Diagram for FSK Reception..... | 6 |
| 2.1.2 | Board Component Values for FSK | 7 |
| 2.1.3 | Component Arrangement Top Side for FSK Reception | 8 |
| 2.2 | ASK Application Circuit..... | 9 |
| 2.2.1 | Circuit Diagram for ASK Reception | 9 |
| 2.2.2 | Board Component Values for ASK..... | 10 |
| 2.2.3 | Component Arrangement Top Side for ASK Reception | 11 |
| 3 | Evaluation Board Layouts | 12 |
| 4 | Package Description | 13 |
| 4.1 | Soldering Information | 13 |
| 5 | Disclaimer | 14 |

1 Theory of Operation

1.1 General

With the TH71111 receiver chip, various circuit configurations can be arranged in order to meet a number of different customer requirements. For FSK reception the IF tank used in the phase coincidence demodulator can be constituted by an external ceramic discriminator. In ASK configuration, the RSSI signal is fed to an ASK detector, which is constituted by the operational amplifier.

A double-conversion variant, called TH71112, is also available. This receiver IC allows a higher degree of image rejection, achieved in conjunction with an RF front-end filter. Both RXICs have the same die. At the TH71112, the second mixer (MIX2) is used to down-convert the first IF (IF1) to the second IF (IF2). At the TH71111, MIX2 operates as an amplifier.

Efficient RF front-end filtering is realized by using a SAW, ceramic or helix filter in front of the LNA and by adding an LC filter at the LNA output.

The TH71111 receiver IC consists of the following building blocks:

- PLL synthesizer (PLL SYNTH) for generation of the local oscillator signal LO, parts of the PLL SYNTH are: the high-frequency VCO1, the feedback divider DIV_32, a phase-frequency detector (PFD) with charge pump (CP) and a crystal-based reference oscillator (RO)
- Low-noise amplifier (LNA) for high-sensitivity RF signal reception
- First mixer (MIX1) for down-conversion of the RF signal to the IF
- IF pre amplifier which is a mixer cell (MIX2) that operates as an amplifier
- IF amplifier (IFA) to amplify and limit the IF signal and for RSSI generation
- Phase coincidence demodulator (DEMOD) with third mixer (MIX3) to demodulate the IF signal
- Operational amplifier (OA) for data slicing, filtering and ASK detection
- Bias circuitry for bandgap biasing and circuit shutdown

1.2 EVB Technical Data Overview

- Input frequency range: 800 MHz to 930 MHz
- Power supply range: 2.3 V to 5.5 V @ ASK
2.7 V to 5.5 V @ FSK
- Temperature range: -40 °C to +85 °C
- Standby current: 50 nA
- Operating current: 7.5 mA @ low gain mode
9.2 mA @ high gain mode
- Sensitivity: -109 dBm @ ASK 1)
-103 dBm @ FSK 2)
- Range of IF: 400 kHz to 22 MHz
- Maximum input level: -10 dBm @ ASK
0 dBm @ FSK
- Image rejection: > 45 dB (e.g. with 868.3 MHz SAW front-end filter and at 10.7 MHz IF)
- Spurious emission: < -70 dBm
- Input frequency acceptance range: up to ±100 kHz
- RSSI range: 70 dB
- FSK deviation range: ±2.5 kHz to ±80 kHz

- 1) at 4 kbps NRZ, BER = $3 \cdot 10^{-3}$, 180 kHz IF filter BW, incl. 3 dB SAW front-end-filter loss
- 2) at 4 kbps NRZ, BER = $3 \cdot 10^{-3}$, ± 20 kHz FSK deviation, 180 kHz IF filter BW, incl. 3 dB SAW front-end-filter loss

For more detailed information, please refer to the latest TH71111 data sheet revision

1.3 Block Diagram

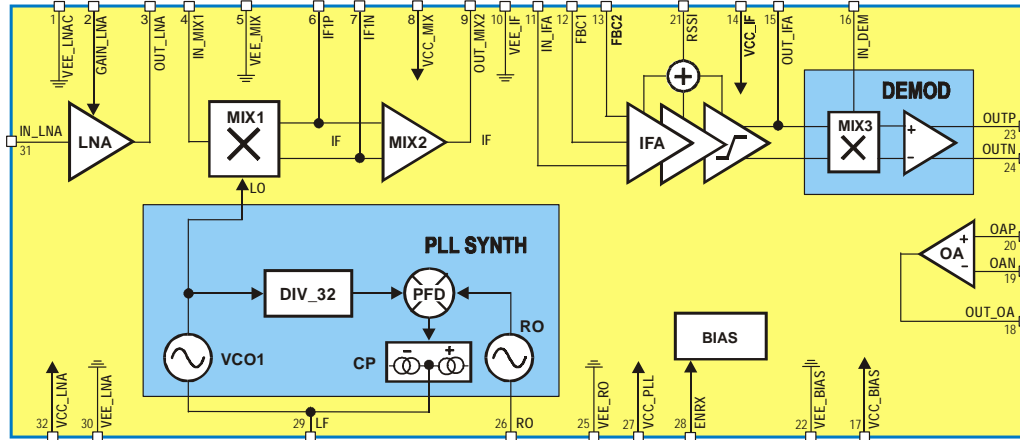


Fig. 1: TH71111 block diagram

1.4 Mode Configurations

| ENRX | Mode | Description |
|------|------------|-------------|
| 0 | RX standby | RX disabled |
| 1 | RX active | RX enable |

Note: ENRX are pulled down internally

1.5 LNA GAIN Control

| V_{GAIN_LNA} | Mode | Description |
|-----------------|-----------|----------------------|
| < 0.8 V | HIGH GAIN | LNA set to high gain |
| > 1.4 V | LOW GAIN | LNA set to low gain |

Note: hysteresis between gain modes to ensure stability

1.6 Frequency Planning

Frequency planning is straightforward for single-conversion applications because there is only one IF that can be chosen, and then the only possible choice is low-side or high-side injection of the LO signal (which is now the one and only LO signal in the receiver).

The receiver's single-conversion architecture requires careful frequency planning. Besides the desired RF input signal, there are a number of spurious signals that may cause an undesired response at the output. Among them is the image of the RF signal that must be suppressed by the RF front-end filter.

By using the internal PLL synthesizer of the TH71111 with the fixed feedback divider ratio of $N = 32$ (DIV_32), two types of down-conversion are possible: low-side injection of LO and high-side injection of LO. The following table summarizes some equations that are useful to calculate the crystal reference frequency (REF) and the LO frequency, for a given RF and IF.

| Injection type | low | high |
|----------------|----------------|----------------|
| REF | $(RF - IF)/32$ | $(RF + IF)/32$ |
| LO | $32 \cdot REF$ | $32 \cdot REF$ |
| IF | $RF - LO$ | $LO - RF$ |
| RF image | $RF - 2IF$ | $RF + 2IF$ |

1.6.1 Selected Frequency Plans

The following table depicts crystal, LO and image signals considering the examples of 868.3 MHz and 915 MHz RF reception at IF = 10.7 MHz.

| Signal type | RF = 868.3 MHz | RF = 868.3 MHz | RF = 915 MHz | RF = 915 MHz |
|----------------|-----------------|----------------|-----------------|--------------|
| Injection type | low | high | low | high |
| REF / MHz | 26.80000 | 27.46875 | 28.25938 | 28.92813 |
| LO / MHz | 857.6 | 879.0 | 904.3 | 925.7 |
| RF image / MHz | 846.9 | 889.7 | 893.6 | 936.4 |

The selection of the reference crystal frequency is based on some assumptions. As for example: the image frequency should not be in a radio band where strong interfering signals might occur (because they could represent parasitic receiving signals), the LO signal should be in the range of 800 MHz to 930 MHz (because this is the optimum frequency range of the VCO1). Furthermore the IF should be as high as possible to achieve highest RF image rejection. The columns in bold depict the selected frequency plans to receive at 868.3 MHz and 915 MHz, respectively.

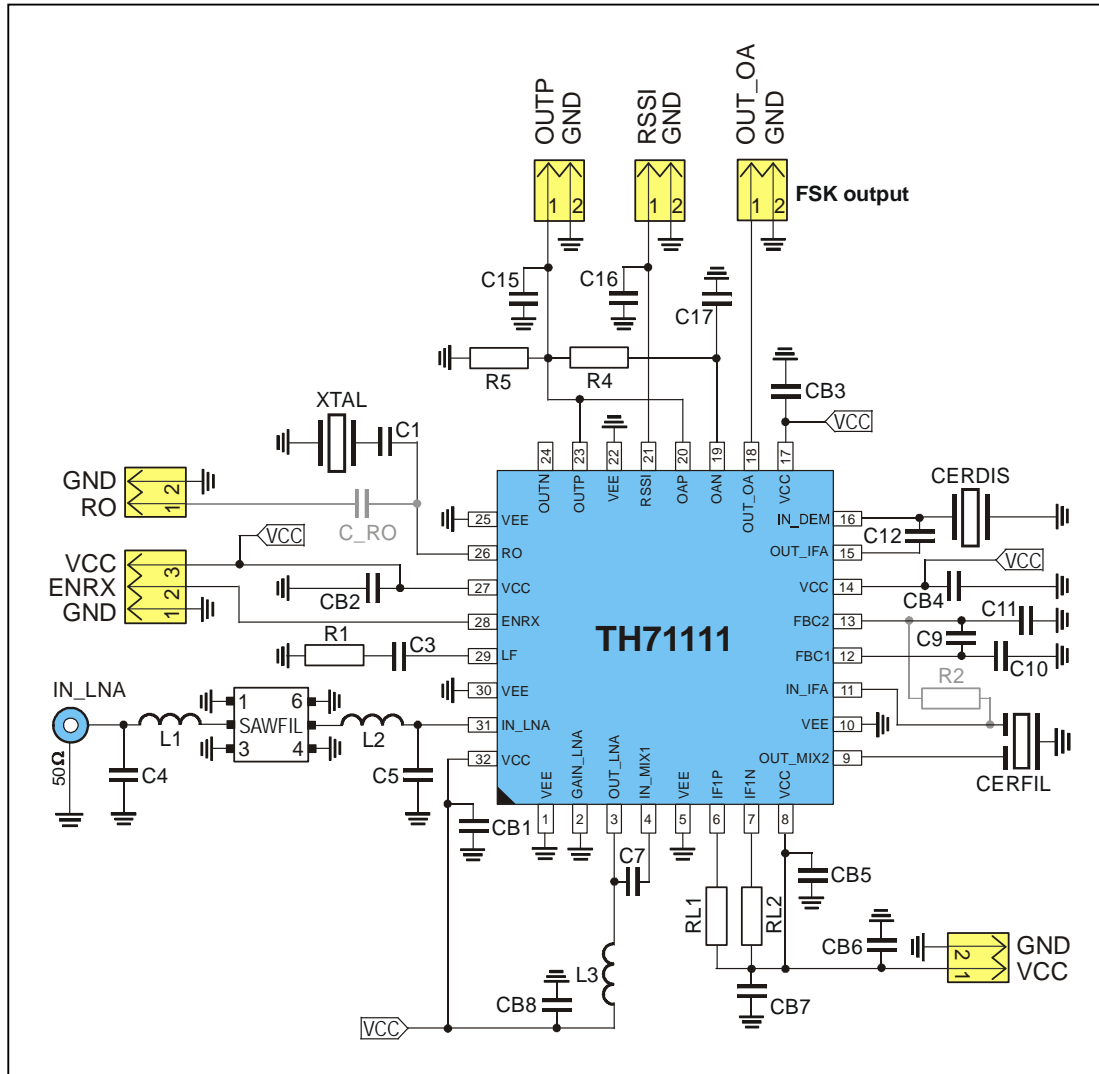
1.6.2 Maximum Frequency Coverage

| Parameter | f_{min} | f_{max} |
|----------------|-----------|-----------|
| Injection type | high | low |
| RF / MHz | 789.3 | 940.7 |
| REF / MHz | 25.0 | 29.0625 |
| LO / MHz | 800 | 930 |
| IF / MHz | 10.7 | 10.7 |

2 Application Circuits

2.1 FSK Application Circuit

2.1.1 Circuit Diagram for FSK Reception



Circuit Features

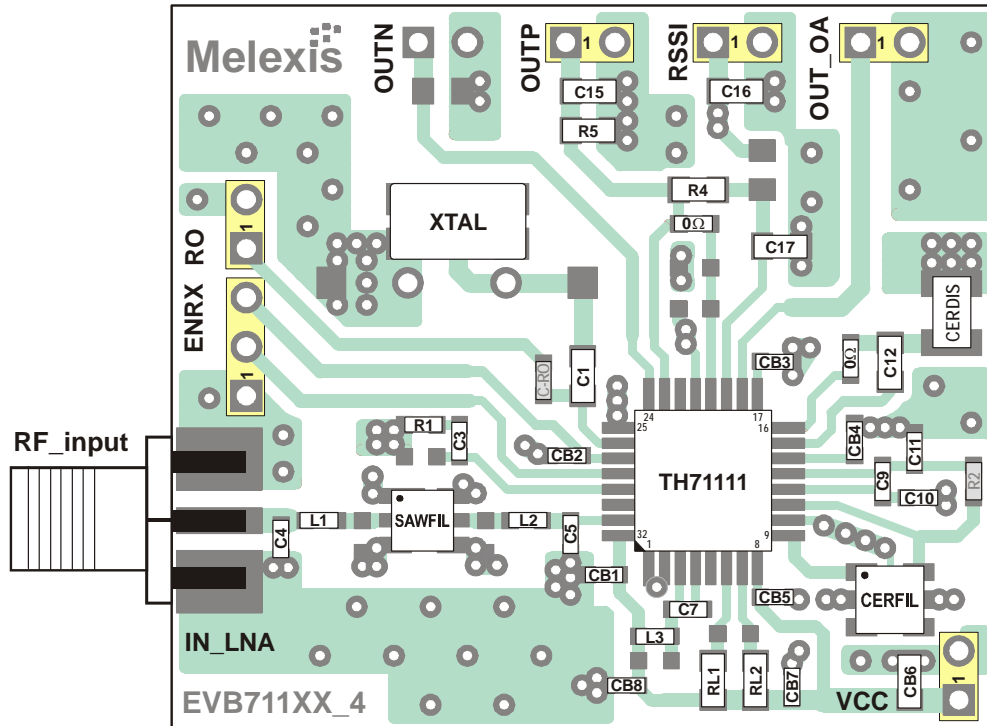
- Tolerates input frequency variations
- Well-suited for NRZ, Manchester and similar codes

2.1.2 Board Component Values for FSK

| Part | Size | Value @ 868.3 MHz | Value @ 915 MHz | Tolerance | Description |
|--------------------------|--------------|--|--|-----------------------------|--|
| C1 | 0805 | 22 pF | 22 pF | ±5% | crystal series capacitor |
| C3 | 0603 | 1 nF | 1 nF | ±10% | loop filter capacitor |
| C4 | 0603 | 4.7 pF | NIP | ±5% | capacitor to match SAW filter input |
| C5 | 0603 | 2.7 pF | NIP | ±5% | capacitor to match SAW filter output |
| C7 | 0603 | 1.0 pF | 0.68 pF | ±5% | MIX1 input matching capacitor |
| C9 | 0603 | 33 nF | 33 nF | ±10% | IFA feedback capacitor |
| C10 | 0603 | 1 nF | 1 nF | ±10% | IFA feedback capacitor |
| C11 | 0603 | 1 nF | 1 nF | ±10% | IFA feedback capacitor |
| C12 | 0805 | 10 pF | 10 pF | ±5% | DEMODO phase-shift capacitor |
| C15 | 0805 | 100 pF | 100 pF | ±5% | demodulator output low-pass capacitor, this value for data rates < 20 kbps NRZ, for higher data rates decrease the value |
| C16 | 0805 | 1.5 nF | 1.5 nF | ±10% | RSSI output low-pass capacitor |
| C17 | 0805 | 10 nF | 10 nF | ±10% | data slicer capacitor, this value for data rates > 0.8 kbps NRZ, for lower data rates increase the value |
| CB1 to CB5 CB7 to CB8 | 0603 | 330 pF | 330 pF | ±10% | de-coupling capacitor |
| CB6 | 0805 | 33 nF | 33 nF | ±10% | de-coupling capacitor |
| C_RO | 0603 | 330 pF | 330 pF | ±5% | optional capacitor, to couple external RO signal |
| R1 | 0603 | 10 kΩ | 10 kΩ | ±5% | loop filter resistor |
| R2 | 0603 | 330 Ω | 330 Ω | ±5% | optional CERFIL output matching resistor |
| R4 | 0805 | 330 kΩ | 330 kΩ | ±5% | data slicer resistor |
| R5 | 0805 | 220 kΩ | 220 kΩ | ±5% | loading resistor |
| RL1 | 0805 | 470 Ω | 470 Ω | ±5% | MIX1 bias resistor |
| RL2 | 0805 | 470 Ω | 470 Ω | ±5% | MIX1 bias resistor |
| L1 | 0603 | 22 nH | 0 Ω | ±5% | SAW filter matching inductor from Würth-Elektronik (WE-KI series), or equivalent part |
| L2 | 0603 | 22 nH | 0 Ω | ±5% | |
| L3 | 0603 | 10 nH | 10 nH | ±5% | LNA output tank inductor from Würth-Elektronik (WE-KI series), or equivalent part |
| XTAL | SMD 6x3.5 | 26.80000 MHz @ RF = 868.3 MHz | 28.25938 MHz @ RF = 915 MHz | ±25ppm cal. ±30ppm temp. | fundamental-mode crystal from Telcona/Horizon (HEX22 series) or equivalent par |
| | HC49 SMD | | | | fundamental-mode crystal, C _{load} = 10 pF to 15 pF, C _{0, max} = 7 pF, R _{1, max} = 50 Ω |
| SAWFIL | SMD 3x3 | SAFCC868MSL0X00 (f ₀ = 868.3 MHz) | SAFCH915MAL0N00 (f ₀ = 915 MHz) | B _{3dB} = 2 MHz | low-loss SAW filter from Murata or equivalent part |
| | SMD 3.8x3.8 | | | | |
| CERFIL | SMD 3.45x3.1 | SFECF10M7HA00 | | B _{3dB} = 180 kHz | ceramic filter from Murata, or equivalent part |
| CERDIS | SMD 4.5x2 | CDSCB10M7GA135 | | | ceramic discriminator from Murata, or equivalent part |

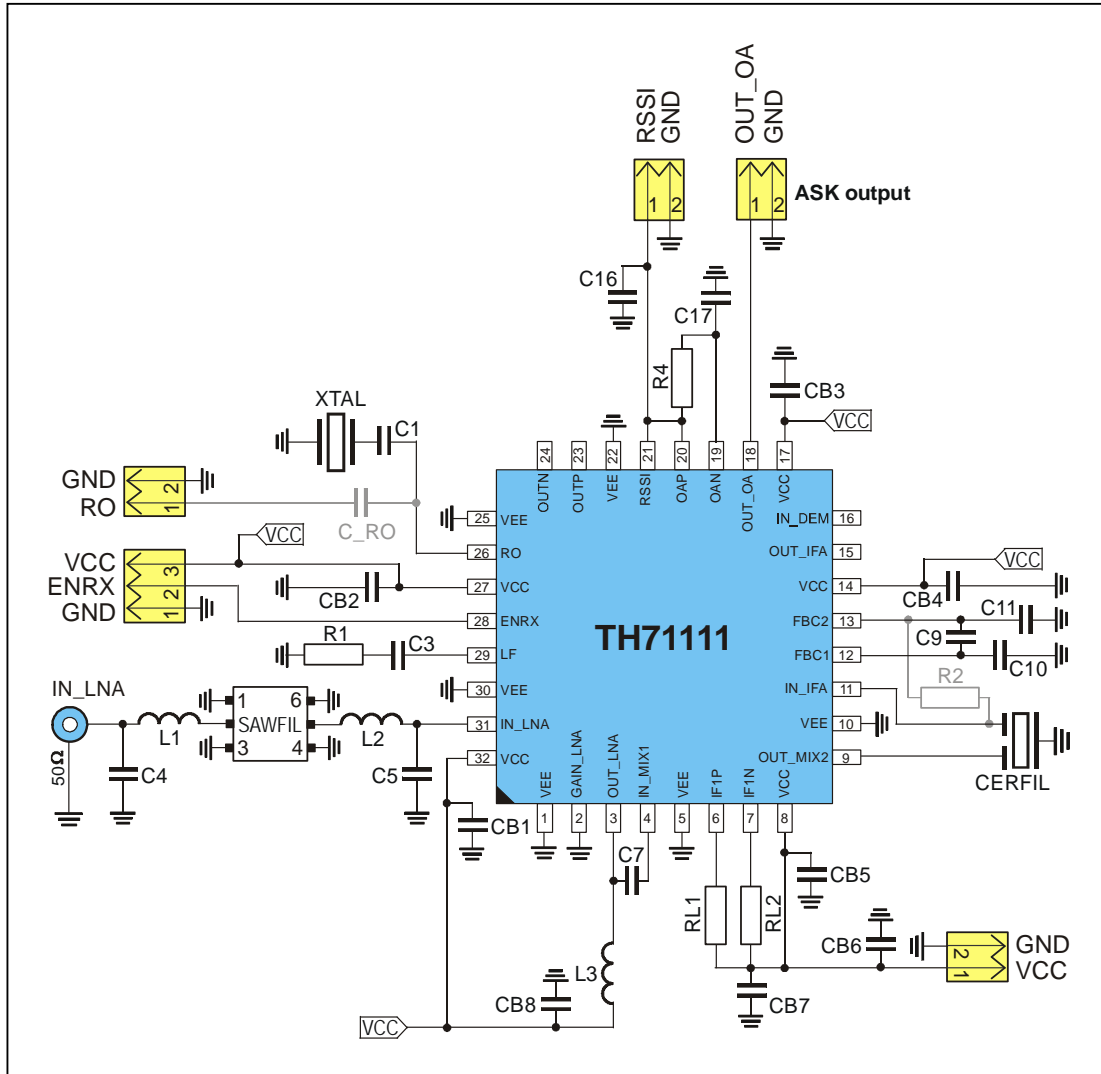
2.1.3 Component Arrangement Top Side for FSK Reception

Board size is 42.7mm x 37.5mm



2.2 ASK Application Circuit

2.2.1 Circuit Diagram for ASK Reception

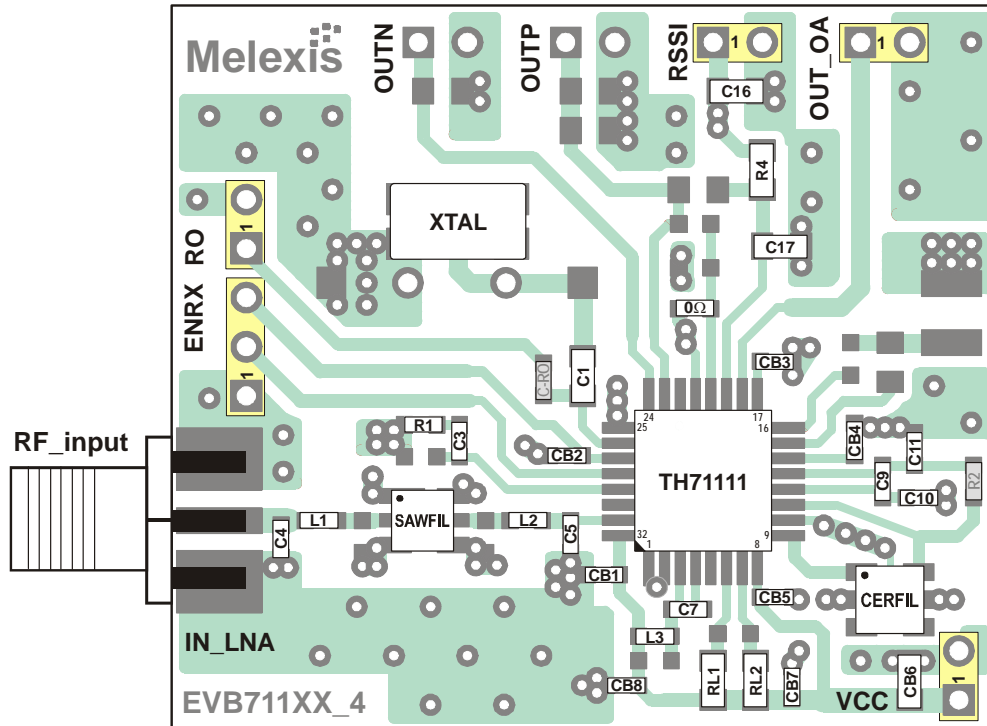


2.2.2 Board Component Values for ASK

| Part | Size | Value @ 868.3 MHz | Value @ 915 MHz | Tolerance | Description |
|--------------------------|--------------|--|--|-----------------------------|--|
| C1 | 0805 | 22 pF | 22 pF | ±5% | crystal series capacitor |
| C3 | 0603 | 1 nF | 1 nF | ±10% | loop filter capacitor |
| C4 | 0603 | 4.7 pF | NIP | ±5% | capacitor to match SAW filter input |
| C5 | 0603 | 2.7 pF | NIP | ±5% | capacitor to match SAW filter output |
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| C9 | 0603 | 33 nF | 33 nF | ±10% | IFA feedback capacitor |
| C10 | 0603 | 1 nF | 1 nF | ±10% | IFA feedback capacitor |
| C11 | 0603 | 1 nF | 1 nF | ±10% | IFA feedback capacitor |
| C16 | 0805 | 1.5 nF | 1.5 nF | ±10% | RSSI output low-pass capacitor, this value for data rates < 10 kbps NRZ, for higher data rates decrease the value |
| C17 | 0805 | 10 nF | 10 nF | ±10% | data slicer capacitor, this value for data rates > 0.8 kbps NRZ, for lower data rates increase the value |
| CB1 to CB5 CB7 to CB8 | 0603 | 330 pF | 330 pF | ±10% | de-coupling capacitor |
| CB6 | 0805 | 33 nF | 33 nF | ±10% | de-coupling capacitor |
| C_RO | 0603 | 330 pF | 330 pF | ±5% | optional capacitor, to couple external RO signal |
| R1 | 0603 | 10 kΩ | 10 kΩ | ±5% | loop filter resistor |
| R2 | 0603 | 330 Ω | 330 Ω | ±5% | optional CERFIL output matching resistor |
| R4 | 0805 | 330 kΩ | 330 kΩ | ±5% | data slicer resistor |
| RL1 | 0805 | 470 Ω | 470 Ω | ±5% | MIX1 bias resistor |
| RL2 | 0805 | 470 Ω | 470 Ω | ±5% | MIX1 bias resistor |
| L1 | 0603 | 22 nH | 0 Ω | ±5% | SAW filter matching inductor from Würth-Elektronik (WE-KI series), or equivalent part |
| L2 | 0603 | 22 nH | 0 Ω | ±5% | |
| L3 | 0603 | 10 nH | 10 nH | ±5% | LNA output tank inductor from Würth-Elektronik (WE-KI series), or equivalent part |
| XTAL | SMD 6x3.5 | 26.80000 MHz @ RF = 868.3 MHz | 28.25938 MHz @ RF = 915 MHz | ±25ppm cal. ±30ppm temp. | fundamental-mode crystal from Telcona/Horizon (HEX22 series) or equivalent par |
| | HC49 SMD | | | | fundamental-mode crystal, C _{load} = 10 pF to 15 pF, C _{0, max} = 7 pF, R _{1, max} = 50 Ω |
| SAWFIL | SMD 3x3 | SAFCC868MSL0X00 (f ₀ = 868.3 MHz) | SAFCH915MALON00 (f ₀ = 915 MHz) | B _{3dB} = 2 MHz | low-loss SAW filters from Murata or equivalent part |
| | SMD 3.8x3.8 | | | | |
| CERFIL | SMD 3.45x3.1 | SFECF10M7HA00 | | B _{3dB} = 180 kHz | ceramic filter from Murata, or equivalent part |

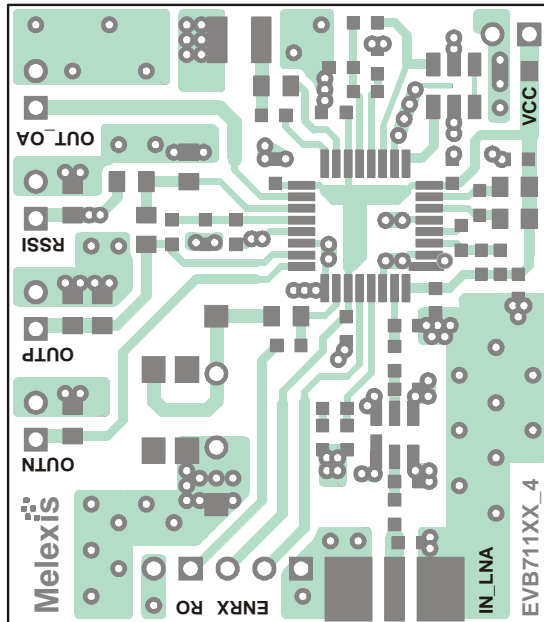
2.2.3 Component Arrangement Top Side for ASK Reception

Board size is 42.7mm x 37.5mm

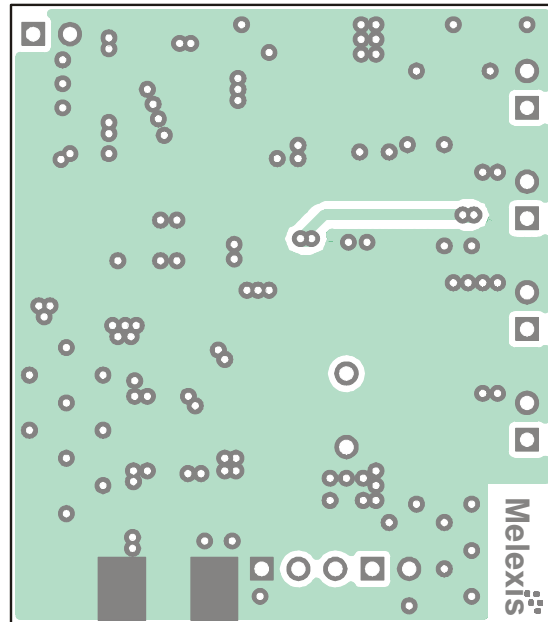


3 Evaluation Board Layouts

Board layout data in Gerber format is available, board size is 37.5mm x 42.7mm.




PCB top view



PCB bottom view

4 Package Description

 The device TH71111 is RoHS compliant.

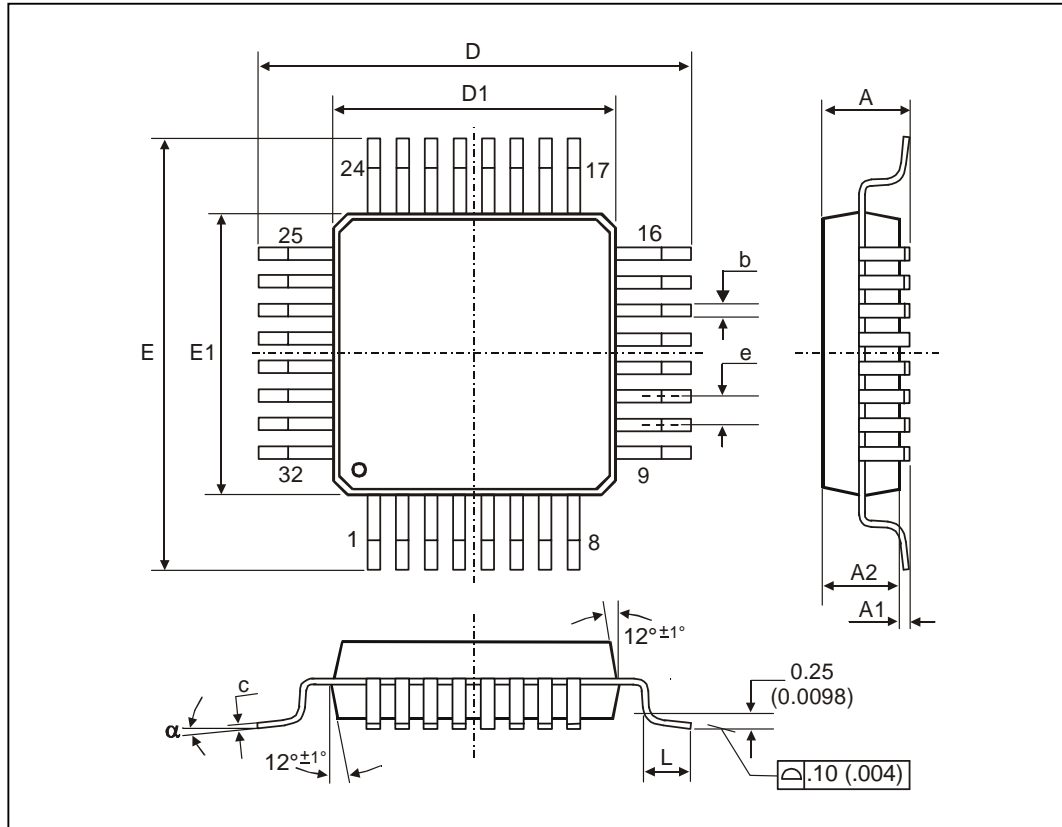


Fig. 2: LQFP32 (Low profile Quad Flat Package)

| All Dimension in mm, coplanarity < 0.1mm | | | | | | | | | | |
|---|--------|-------|-------|-------|-------|-------|-------|--------|-------|----------|
| | E1, D1 | E, D | A | A1 | A2 | e | b | c | L | α |
| min | 7.00 | 9.00 | 1.40 | 0.05 | 1.35 | 0.8 | 0.30 | 0.09 | 0.45 | 0° |
| max | | | 1.60 | 0.15 | 1.45 | | 0.45 | 0.20 | 0.75 | 7° |
| All Dimension in inch, coplanarity < 0.004" | | | | | | | | | | |
| min | 0.276 | 0.354 | 0.055 | 0.002 | 0.053 | 0.031 | 0.012 | 0.0035 | 0.018 | 0° |
| max | | | 0.063 | 0.006 | 0.057 | | 0.018 | 0.0079 | 0.030 | 7° |

4.1 Soldering Information

- The device TH71111 is qualified for MSL3 with soldering peak temperature 260 deg C according to JEDEC J-STD-2.

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