# EVB72035

## *868/915MHz FSK/ASK Transmitter Evaluation Board Description*

## *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
- ❒ 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
- ❒ FSK deviation and center frequency independently adjustable
- ❒ Adjustable output power range from -12 dBm to +9.5 dBm (at connector board)
- ❒ Adjustable effective radiated power (ERP) range from -27 dBm to -6 dBm (at antenna board)
- ❒ Adjustable current consumption from 3.9 mA to 13.4 mA
- ❒ Conforms to EN 300 220 and similar standards

## *Ordering Information*

### *Part No. (see paragraph 6)*

| | |
|---|---|
| EVB72035-868-FSK-A | EVB72035-868-FSK-C (on request) |
| EVB72035-915-FSK-A | EVB72035-915-FSK-C (on request) |

**Note 1:** EVB default population is FSK, ASK modifications according to section 3.1 and 4.1.
**Note 2:** EVB72035 is applicable for devices TH72035, TH72031 and TH72032.

## *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

## *Evaluation Board Example*




## *General Description*

The TH72035 evaluation board is designed to demonstrate the performance of the transmitter IC with an on-board loop antenna. This board allows the user to setup an RF transmitter very easily. Alternatively a 50 Ohm connector board can be requested.

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# 1 Theory of Operation

## 1.1 General

As depicted in Fig.1, the TH72035 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

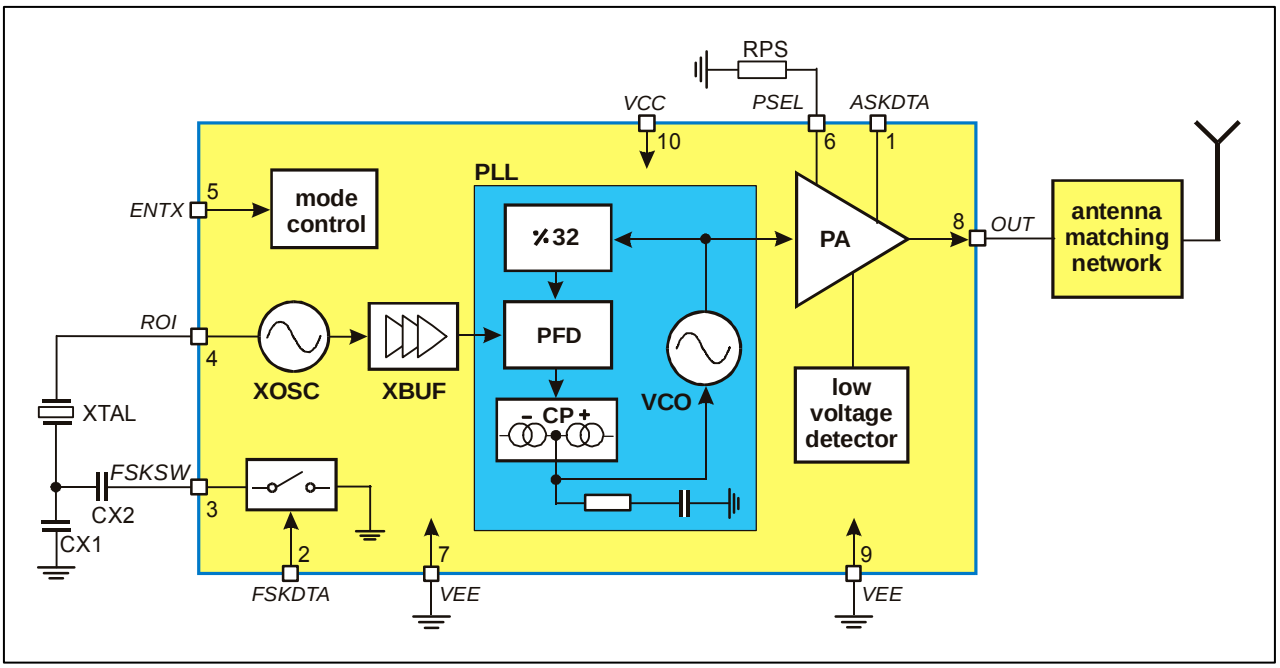



Fig. 1: Block diagram with external components

# 2 Functional Description

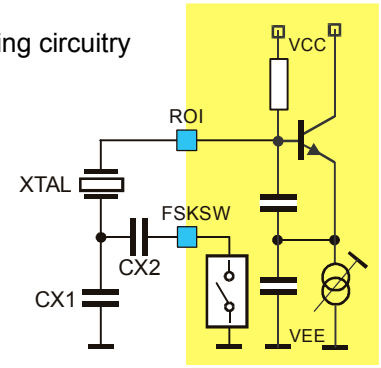
## 2.1 Crystal Oscillator

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.

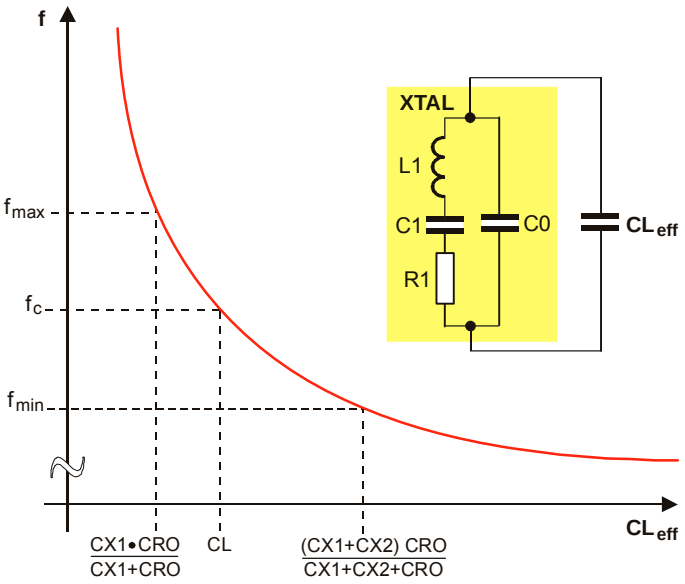



Fig. 3: Crystal pulling characteristic

For ASK applications CX2 can be omitted. Then CX1 has to be adjusted for center frequency.

## 2.4 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) |

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

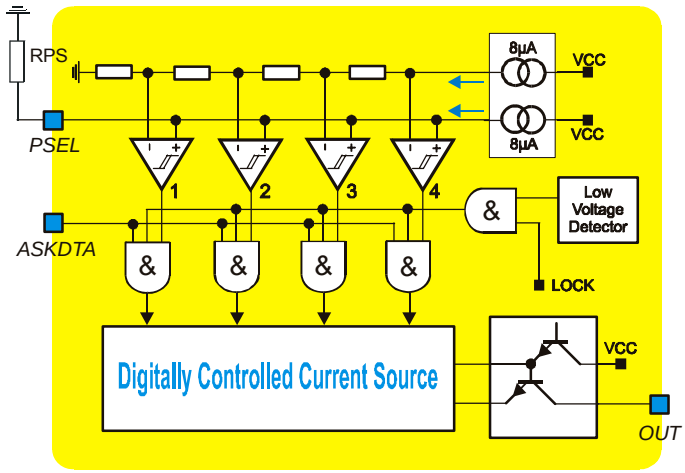



Fig. 4: Block diagram of output power control circuitry

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.

## 2.6 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.

## 2.7 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.

## 2.8 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 |

## 2.9 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 or ASK modulated.

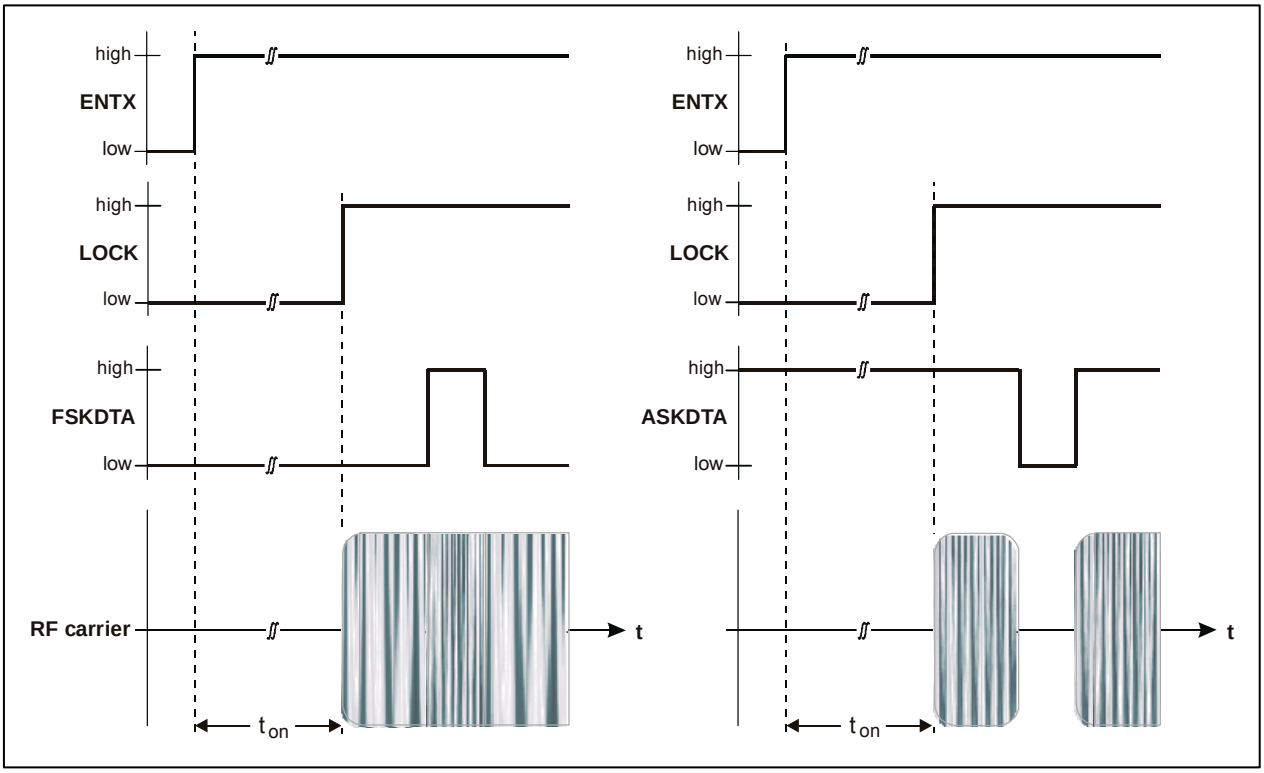



Fig. 5: Timing diagrams for FSK and ASK modulation

**For more detailed information, please refer to the latest TH72035 data sheet revision.**

# 3 Antenna Board Circuit Diagram

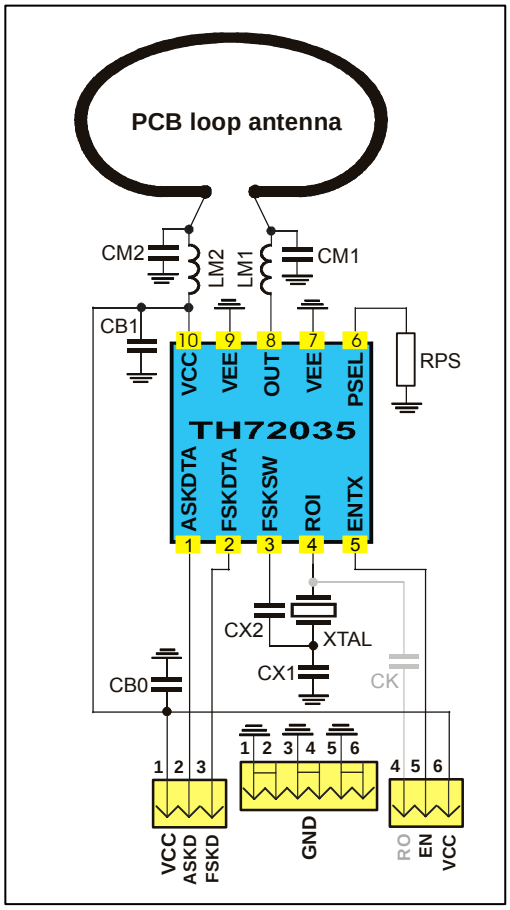


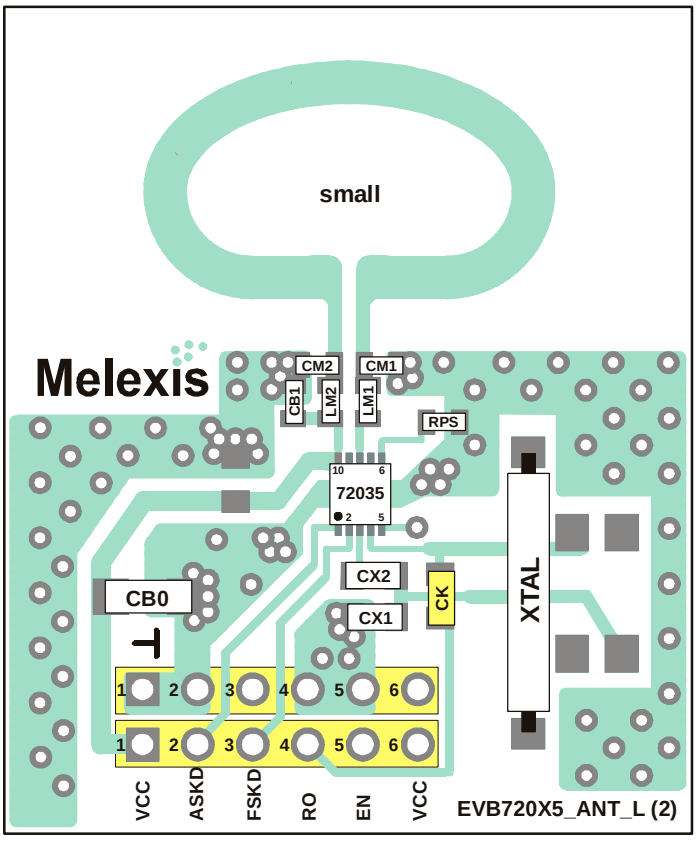

Fig. 6: Circuit diagram with loop antenna matching network

## 3.1 Board Component Values to Fig. 6

| Part | Size | Value @ 868.3 MHz | Value @ 915 MHz | Toler-ance | Description |
|---|---|---|---|---|---|
| CM1 | 0603 | 4.7 pF | 3.9 pF | ±5% | impedance matching capacitor |
| CM2 | 0603 | 3.3 pF | 3.3 pF | ±5% | impedance matching capacitor |
| LM1 | 0603 | 27 nH | 27 nH | ±5% | impedance matching inductor |
| LM2 | 0603 | 12 nH | 10 nH | ±5% | impedance matching inductor |
| $CX1_{_FSK}$ | 0805 | 18 pF | 18 pF | ±5% | XOSC FSK capacitor (Δf = ±20 kHz), note 1 |
| $CX1_{_ASK}$ | 0805 | 27 pF | 27 pF | ±5% | XOSC ASK capacitor, trimmed to $f_C$, note 1 |
| CX2 | 0805 | 10 pF | 10 pF | ±5% | XOSC capacitor (Δf = ±20 kHz), note 1, only needed for FSK |
| RPS | 0603 | NIP | | ±5% | power-select resistor, see data sheet section 4.6 |
| CB0 | 1206 | 220 nF | | ±10% | de-coupling capacitor |
| CB1 | 0603 | 330 pF | | ±10% | de-coupling capacitor |
| XTAL | HC49/S | 27.13438 MHz | 28.59375 MHz | | fundamental wave crystal, $C_L$ = 12 pF, $C_{0,\,max}$ = 7 pF, $R_1$ = 40 Ω |
| | | ±30ppm cal.; ±30ppm temp. | | | |
| CK | 0805 | 1 nF | | ±10% | ROI coupling capacitor, only required for external reference frequency input |

**Note 1:** depends on crystal parameters, other Δf values can be selected with other CX1, CX2 values
NIP – not in place, may be used optionally

### 3.2 Antenna Board PCB Top View




Board size is 32 mm x 38 mm

### 3.3 Board Connection

| | | | |
|---|---|---|---|
| **VCC** | Power supply (1.95 V to 5.5 V) | **RO** | External reference frequency input |
| **ASKD** | Input for ASK data (CMOS, see section 2.4) | **EN** | Mode control pin (see section 2.7) |
| **FSKD** | Input for FSK data (CMOS, see section 2.2) | ⊥ | Several ground pins |

# 4 50Ω Connector Board Circuit Diagram

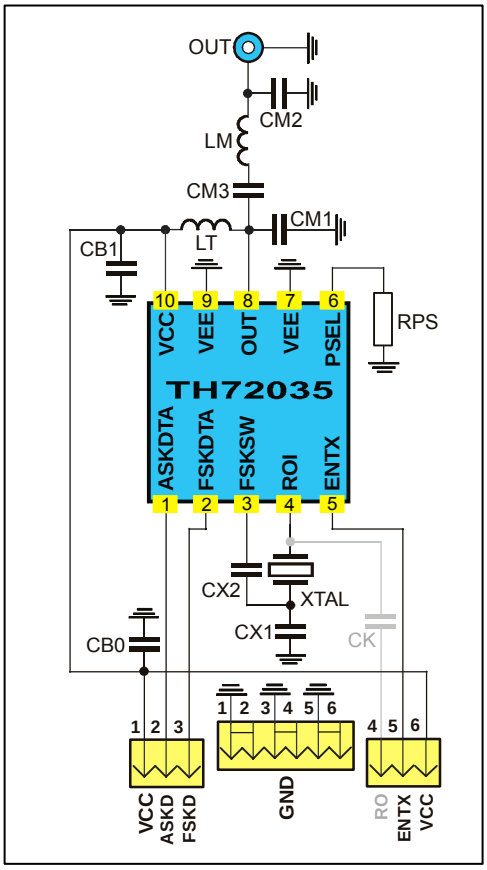


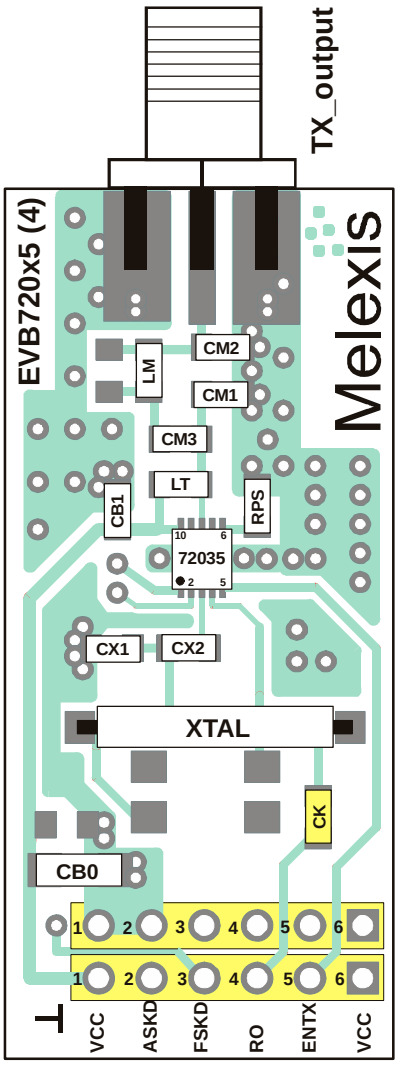

Fig. 7: Circuit diagram with 50 Ω matching network

## 4.1 Board Component Values to Fig. 7

| Part | Size | Value @ 868.3 MHz | Value @ 915 MHz | Toler-ance | 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 |
| LT | 0805 | 15 nH | 10 nH | ±5% | output tank inductor |
| $CX1_{_FSK}$ | 0805 | 18 pF | 18 pF | ±5% | XOSC FSK capacitor (Δf = ±20 kHz), note 1 |
| $CX1_{_ASK}$ | 0805 | 27 pF | 27 pF | ±5% | XOSC ASK capacitor, trimmed to $f_C$, note 1 |
| CX2 | 0805 | 10 pF | 10 pF | ±5% | XOSC capacitor (Δf = ±20 kHz), note 1, only needed for FSK |
| RPS | 0805 | NIP | | ±5% | power-select resistor, see data sheet section 4.6 |
| CB0 | 1206 | 220 nF | | ±20% | de-coupling capacitor |
| CB1 | 0805 | 330 pF | | ±10% | de-coupling capacitor |
| XTAL | HC49/S | 27.13438 MHz | 28.59375 MHz | | fundamental mode crystal, $C_L$ = 12 pF, $C_{0,\,max}$ = 7 pF, $R_1$ = 40 Ω |
| | | ±30ppm cali., ±30ppm temp | | | |
| CK | 0805 | 1 nF | | ±10% | ROI coupling capacitor, only required for external reference frequency input |

**Note 1:** depends on crystal parameters, other Δf values can be selected with other CX1, CX2 values
NIP – not in place, may be used optionally

### 4.2 50Ω Connector Board PCB Top View




Board size is 19 mm x 42 mm

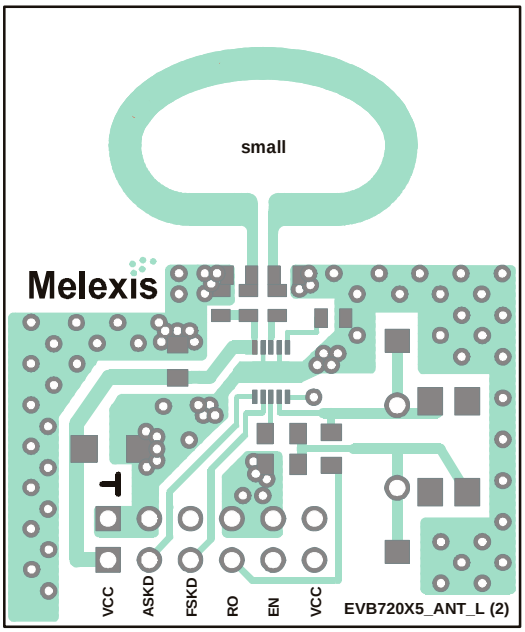
### 4.3 Board Connection

| | | | |
|---|---|---|---|
| **VCC** | Power supply (1.95 V to 5.5 V) | **RO** | External reference frequency input |
| **FSKD** | Input for ASK data (CMOS, see section 2.4) | **ENTX** | Mode control pin (see section 2.7) |
| **FSKD** | Input for FSK data (CMOS, see section 2.2) | ⊥ | Several ground pins |

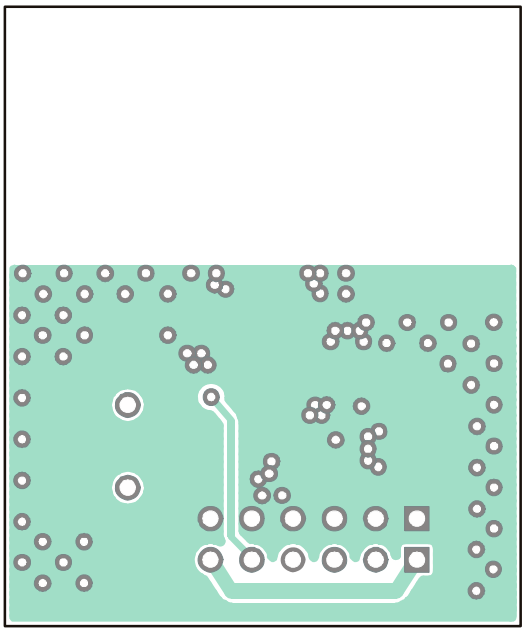
# 5 Evaluation Board Layouts

## 5.1 Antenna Board

Board layout data in Gerber format are available, board size is 32mm x 38mm x 1mm FR4.




PCB top view



PCB bottom view

## 5.2 PCB Loop Antenna Dimensions

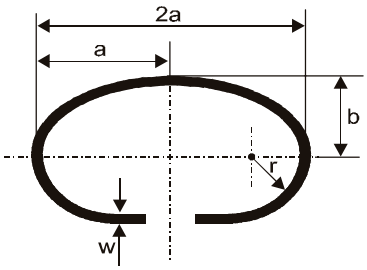



Fig. 8: Circular loop

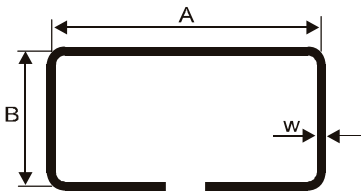
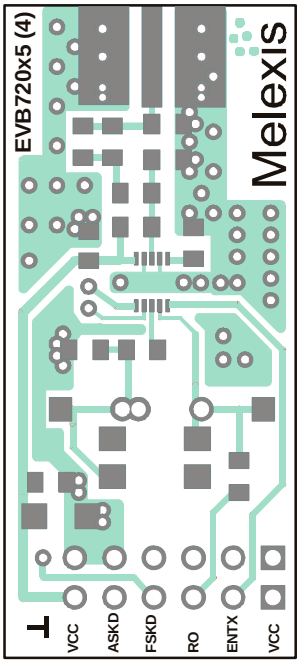



Fig. 9: Square loop equivalent

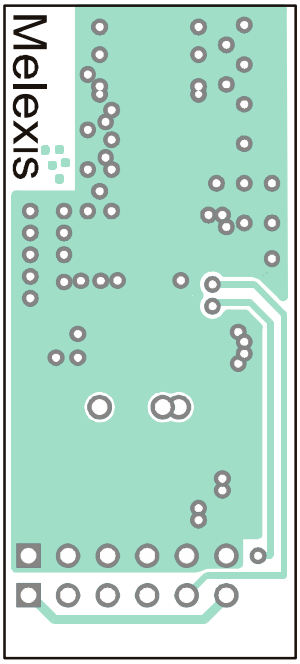
| Loop Dimension | A | B | 2a | a | b | r | w |
|---|---|---|---|---|---|---|---|
| mm | 16 | 8 | 17 | 8.5 | 5 | 4 | 2 |

### 5.3 Connector Board

Board layout data in Gerber format are available, board size is 19mm x 42mm x 1mm FR4.




PCB top view




PCB bottom view

## 6 Board Variants

| Type | Frequency/MHz | Modulation | Board Execution |
|---|---|---|---|
| EVB72035 | –315 | –FSK | –A antenna version |
| | –433 | –ASK according to section 3.1 / 4.1 | –C connector version |
| | –868 | –FM | |
| | –915 | | |

**Note:** available EVB setups

# 7 Package Description

The device TH72035 is RoHS compliant.

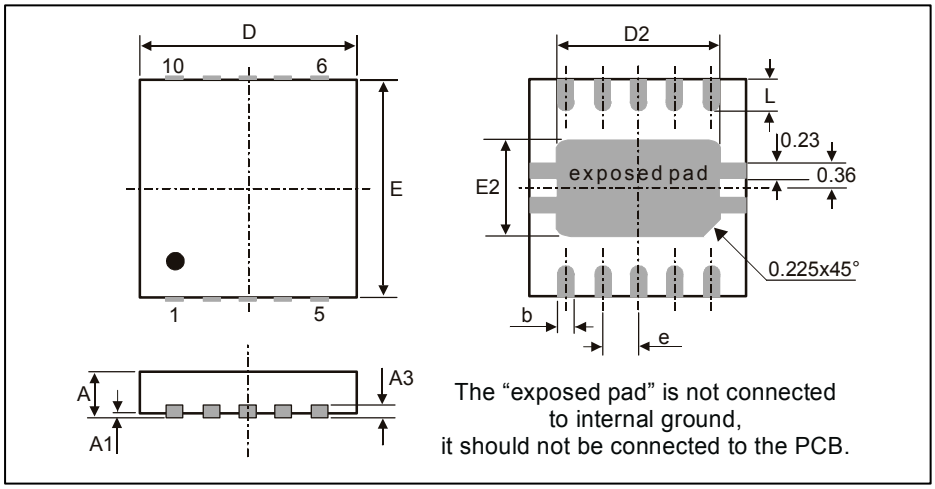


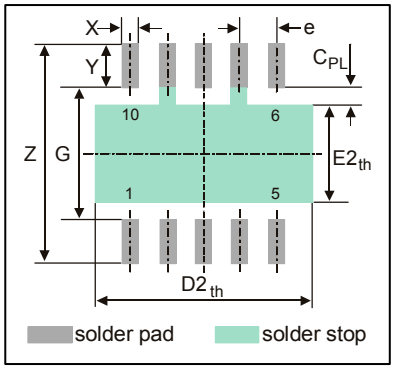

Fig. 10: 10L QFN 3x3 Dual

| all Dimensions in mm | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **D** | **E** | **D2** | **E2** | **A** | **A1** | **A3** | **L** | **e** | **b** |
| min | 2.85 | 2.85 | 2.23 | 1.49 | 0.80 | 0 | 0.20 | 0.3 | 0.50 | 0.18 |
| max | 3.15 | 3.15 | 2.48 | 1.74 | 1.00 | 0.05 | | 0.5 | | 0.30 |
| all Dimensions in inch | | | | | | | | | | |
| min | 0.112 | 0.112 | 0.0878 | 0.051 | 0.0315 | 0 | 0.0079 | 0.0118 | 0.0197 | 0.0071 |
| max | 0.124 | 0.124 | 0.0976 | 0.055 | 0.0393 | 0.002 | | 0.0197 | | 0.0118 |

## 7.1 Soldering Information

- The device TH72035 is qualified for MSL3 with soldering peak temperature 260 deg C according to JEDEC J-STD-20.

## 7.2 Recommended PCB Footprints




| all Dimensions in mm | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Z** | **G** | **D2$_{th}$** | **E2$_{th}$** | **X** | **Y** | **C$_{PL}$** | **e** |
| min | 3.55 | 1.9 | 3.2 | 1.3 | 0.25 | 0.7 | 0.3 | 0.5 |
| max | 3.90 | 2.3 | 3.6 | 1.7 | 0.30 | 1.0 | 0.5 | |
| all Dimensions in inch | | | | | | | | |
| min | 0.1398 | 0.0748 | 0.1260 | 0.0512 | 0.0098 | 0.0276 | 0.0591 | 0.0197 |
| max | 0.1535 | 0.0906 | 0.1417 | 0.0669 | 0.0118 | 0.0394 | 0.0197 | |

Fig. 11: PCB land pattern style

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