

Features

- Programmable PLL synthesizer
- 8-channel preconfigured or fully programmable SPI mode
- Double super-heterodyne receiver architecture with 2nd mixer as image rejection mixer
- Reception of FSK, FM and ASK modulated signals
- Low shut-down and operating currents
- AGC – automatic gain control
- On-chip IF filter
- Fully integrated FSK/FM demodulator
- RSSI for level indication and ASK detection
- 2nd order low-pass data filter
- Positive and negative peak detectors
- Data slicer (with averaging or peak-detector adaptive threshold)
- 32-pin Quad Flat No-Lead Package (QFN)
- EVB programming software is available on Melexis web site

Ordering Information

EVB71122-315-C
EVB71122-433-C

EVB71122-868-C
EVB71122-915-C

**SPI mode is default population*

***EVB71122-XXX-C with XXX = Reception frequency (315 or 433.92 or 868.3 or 915MHz).*

****The evaluation board is supplied with an SMA connector.*

Application Examples

- General digital and analog RF receivers at 300 to 930MHz
- Tire pressure monitoring systems (TPMS)
- Remote keyless entry (RKE)
- Low power telemetry systems
- Alarm and security systems
- Active RFID tags
- Remote controls
- Garage door openers
- Home and building automation

Evaluation Board Example



General Description

The MLX71122 is a multi-channel RF receiver IC based on a double-conversion super-heterodyne architecture. It is designed to receive FSK and ASK modulated RF signals either in 8 predefined frequency channels or frequency programmable via a 3-wire serial programming interface (SPI).

The IC is designed for a variety of applications, for example in the European bands at 433MHz and 868MHz or for the use in North America or Asia, e.g. at 315MHz, 447MHz or 915MHz.

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1 Theory of Operation

1.1 General

The MLX71122 receiver architecture is based on a double-conversion super-heterodyne approach. The two LO signals are derived from an on-chip integer-N PLL frequency synthesizer. The PLL reference frequency is derived from a crystal (XTAL). The PLL synthesizer consists of an integrated voltage-controlled oscillator with external inductor, a programmable feedback divider chain, a programmable reference divider, a phase-frequency detector with a charge pump and an external loop filter.

In the receiver's down-conversion chain, two mixers MIX1 and MIX2 are driven by the internal local oscillator signals LO1 and LO2, respectively. The second mixer MIX2 is an image-reject mixer. As the first intermediate frequency (IF1) is very high (typically above 100 MHz), a reasonably high degree of image rejection is provided even without using an RF front-end filter. At applications asking for very high image rejections, cost-efficient RF front-end filtering can be realized by using a SAW filter in front of the LNA.

The receiver signal chain is set up by a low noise amplifier (LNA), two down-conversion mixers (MIX1 and MIX2), an on-chip IF filter (IFF) as well as an IF amplifier (IFA). By choosing the required modulation via an FSK/ASK switch (at pin MODSEL), either the on-chip FSK demodulator (FSK DEMOD) or the RSSI-based ASK detector is selected. A second order data filter (OA1) and a data slicer (OA2) follow the demodulator. The data slicer threshold can be generated from the mean-value of the data stream or by means of the positive and negative peak detectors (PKDET+/-).

In general the MLX71122 can be set to shut-down mode, where all receiver functions are completely turned off, and to several other operating modes. There are two global operating modes that are selectable via the logic level at pin SPISEL:

- 8-channel preconfigured mode (**ABC mode**)
- fully programmable mode (**SPI mode**).

In ABC mode the number of frequency channels is limited to eight but no microcontroller programming is required. In this case the three lines of the serial programming interface (SPI) are used to select one of the eight predefined frequency channels via simple 3-bit parallel programming. Pins ENRX and MODSEL are used to enable/disable the receiver and to select FSK or ASK demodulation, respectively.

SPI mode is recommended for full programming flexibility. In this case the three lines of the SPI are configured as a standard 3-wire bus (SDEN, SDTA and SCLK). This allows changing many parameters of the receiver, for example more operating modes, channels, frequency resolutions, gains, demodulation types, data slicer settings and more. The pin MODSEL has no effect in this mode.

1.2 EVB Data Overview

- | | |
|--|--|
| <ul style="list-style-type: none"> <input type="checkbox"/> Input frequency ranges: 300 to 930MHz <input type="checkbox"/> Power supply range: 3.0 to 5.5V <input type="checkbox"/> Temperature range: -40 to +105°C <input type="checkbox"/> Shutdown current: 50nA <input type="checkbox"/> Operating current: 12mA (typ.) <input type="checkbox"/> Internal IF2: 2MHz with 230kHz 3dB bandwidth <input type="checkbox"/> Maximum data rate: 100kbps NRZ code, 50kbps bi-phase code <input type="checkbox"/> Minimum frequency resolution: 10kHz | <ul style="list-style-type: none"> <input type="checkbox"/> Total image rejection: > 65dB (with external RF front-end filter) <input type="checkbox"/> FSK/FM deviation range: ±2 to ±50kHz <input type="checkbox"/> Spurious emission: < -70dBm <input type="checkbox"/> Linear RSSI range: > 50dB <input type="checkbox"/> FSK input frequency acceptance range: 180kHz (3dB) <input type="checkbox"/> Crystal reference frequency: 10MHz |
|--|--|

| <input type="checkbox"/> Input Sensitivity: at 4 kbps NRZ, BER = $3 \cdot 10^{-3}$ | | | | |
|--|---------|------------|-----------|---------|
| Frequency | 315 MHz | 433.92 MHz | 868.3 MHz | 915 MHz |
| FSK: ±20 kHz deviation | -106dBm | -104dBm | -101dBm | -101dBm |
| ASK | -108dBm | -108dBm | -106dBm | -106dBm |

1.3 Block Diagram

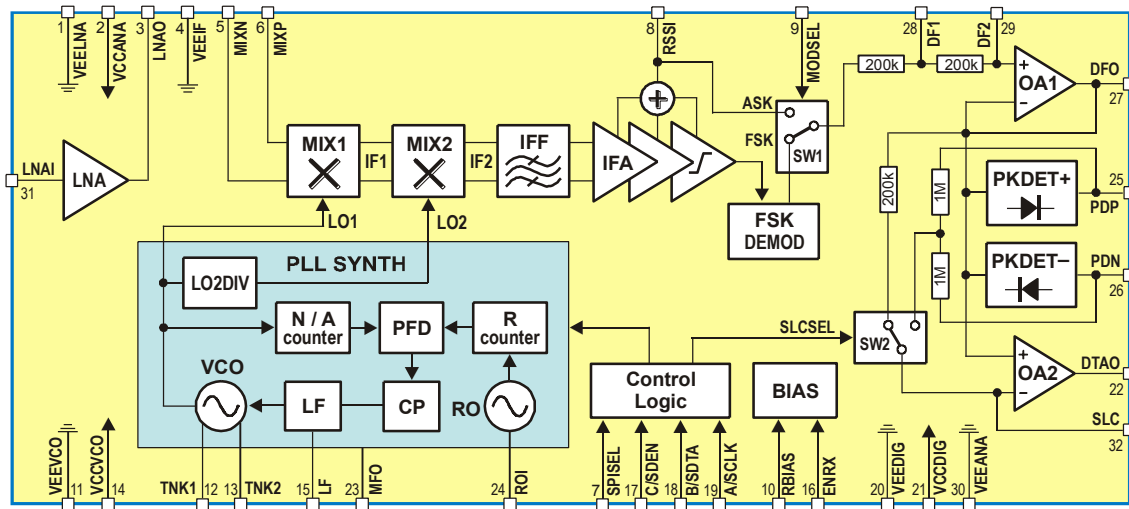


Fig. 1: MLX71122 block diagram

The MLX71122 receiver IC consists of the following building blocks:

- PLL synthesizer (PLL SYNTH) to generate the first and second local oscillator signals LO1 and LO2, parts of the PLL SYNTH are the voltage-controlled oscillator (VCO), the feedback dividers N/A and R, the phase-frequency detector (PFD), the charge pump (CP) and the 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 first IF (intermediate frequency)
- Second mixer (MIX2) with image rejection for down-conversion from the first to the second IF
- IF Filter (IFF) with a 2MHz center frequency and a 230kHz 3dB bandwidth
- IF amplifier (IFA) to provide a large amount of voltage gain and an RSSI signal output
- FSK demodulator (FSK DEMOD)
- Operational amplifiers OA1 and OA2 for low-pass filtering and data slicing, respectively
- Positive (PKDET+) and negative (PKDET-) peak detectors
- Switches SW1 to select between FSK and ASK as well as SW2 to chose between averaging or peak detector data slicer
- Control logic with 3-wire bus serial programming interface (SPI)
- Biasing circuit with modes control

For more detailed information, please refer to the latest MLX71122 data sheet revision.

1.4 Enable/Disable in ABC Mode

| ENRX | Description |
|------|---------------|
| 0 | Shutdown mode |
| 1 | Receive mode |

Pin ENRX is pulled down internally. Device is in shutdown by default, after power supply on.
 If ENRX = 0 and SPISEL = 1 then operating modes according to OPMODE bit (refer to control word R0).
 If ENRX = 1 then OPMODE bit has no effect (hardwired receive mode).

1.5 Demodulation Selection in ABC Mode

| MODSEL | Description |
|--------|------------------|
| 0 | FSK demodulation |
| 1 | ASK demodulation |

Pin MODSEL has no effect in SPI mode (SPISEL = 1). We recommend connecting it to ground to avoid a floating CMOS gate.

1.6 Programming Modes

| SPISEL | Description |
|--------|---------------------------------------|
| 0 | ABC mode (8 channels preconfigured) |
| 1 | SPI mode (programming via 3-wire bus) |

1.7 Preconfigured Frequencies in ABC Mode

| A | B | C | Receive Frequency |
|---|---|---|-------------------|
| 0 | 0 | 0 | FSK1: 369.5 MHz |
| 0 | 1 | 0 | FSK5: 388.3 MHz |
| 1 | 0 | 0 | FSK2: 371.1 MHz |
| 1 | 1 | 0 | FSK4: 376.9 MHz |
| 0 | 0 | 1 | FSK3: 375.3 MHz |
| 0 | 1 | 1 | FSK7: 394.3 MHz |
| 1 | 0 | 1 | FSK6: 391.5 MHz |
| 1 | 1 | 1 | FSK8: 395.9 MHz |

As all pins, pins A, B, and C are equipped with ESD protection diodes that are tied to VCC and to VEE. Therefore these pins should not be directly connected to positive supply (a logic "1") before the supply voltage is applied to the IC. Otherwise the IC will be supplied through these control lines and it may enter into an unpredictable mode. In case the user wants to apply a positive supply voltage to these pins before the supply voltage is applied to the IC, a protection resistor should be inserted in each control line.

2 Functional Description

2.1 Frequency Planning

Because of the double conversion architecture that employs two mixers and two IF signals, there are four different combinations for injecting the LO1 and LO2 signals:

- LO1 high side and LO2 high side: receiving at $f_{RF}(\text{high-high})$
- LO1 high side and LO2 low side: receiving at $f_{RF}(\text{high-low})$
- LO1 low side and LO2 high side: receiving at $f_{RF}(\text{low-high})$
- LO1 low side and LO2 low side: receiving at $f_{RF}(\text{low-low})$

As a result, four different radio frequencies (RFs) could yield one and the same second IF (IF2). Fig. 2 shows this for the case of receiving at $f_{RF}(\text{high-high})$. In the example of Fig. 2, the image signals at $f_{RF}(\text{low-high})$ and $f_{RF}(\text{low-low})$ are suppressed by the bandpass characteristic provided by the RF front-end. The bandpass shape can be achieved either with a SAW filter (featuring just a couple of MHz bandwidth), or by the tank circuits at the LNA input and output (this typically yields 30 to 60MHz bandwidth). In any case, the high value of the first IF (IF1) helps to suppress the image signals at $f_{RF}(\text{low-high})$ and $f_{RF}(\text{low-low})$.

The two remaining signals at IF1 resulting from $f_{RF}(\text{high-high})$ and $f_{RF}(\text{high-low})$ are entering the second mixer MIX2. This mixer features image rejection with so-called single-sideband (SSB) selection. This means either the upper or lower sideband of IF1 can be selected. In the example of Fig. 2, LO2 high-side injection has been chosen to select the IF2 signal resulting from $f_{RF}(\text{high-high})$.

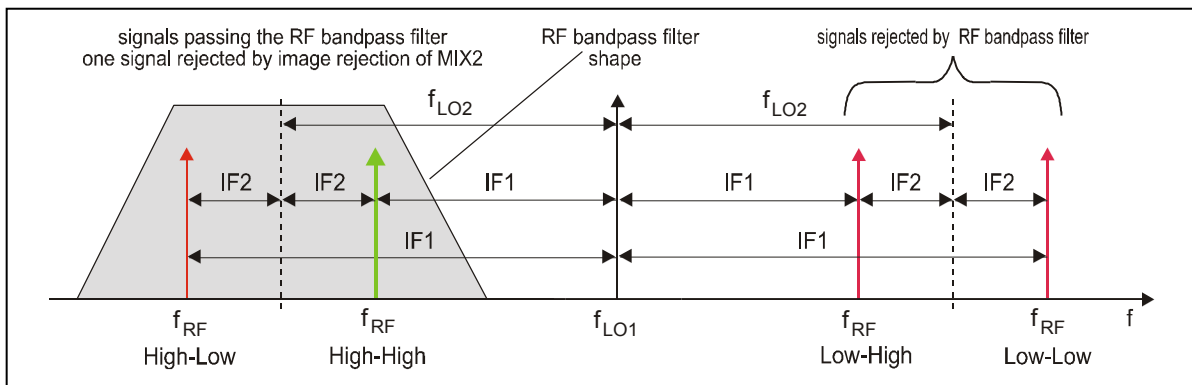


Fig. 2: The four receiving frequencies in a double conversion superhet receiver

It can be seen from the block diagram of Fig. 1 that there is a fixed relationship between the LO1 signal frequency f_{LO1} and the LO2 signal frequency f_{LO2} .

$$LO2DIV = N_{LO2} = \frac{f_{LO1}}{f_{LO2}} \quad (1)$$

The LO1 signal frequency f_{LO1} is directly synthesized from the crystal reference oscillator frequency f_{RO} by means of an integer-N PLL synthesizer. The PLL consists of a dual-modulus prescaler (P/P+1), a program counter N and a swallow counter A.

$$f_{LO1} = \frac{f_{RO}}{R} (N \cdot P + A) = f_{PFD} (N \cdot P + A) = f_{PFD} \cdot N_{tot} \quad (2)$$

Due to the double superhet receiver architecture, the channel frequency step size f_{CH} is not equal to the phase-frequency detector (PFD) frequency f_{PFD} . For high-side injection, the channel step size f_{CH} is given by:

$$f_{CH} = \frac{f_{RO}}{R} \frac{N_{LO2} - 1}{N_{LO2}} = f_{PFD} \frac{N_{LO2} - 1}{N_{LO2}} \quad (3)$$

While the following equation is valid for low-side injection:

$$f_{CH} = \frac{f_{RO}}{R} \frac{N_{LO2} + 1}{N_{LO2}} = f_{PFD} \frac{N_{LO2} + 1}{N_{LO2}} \quad (4)$$

2.2 Calculation of Counter Settings

Frequency planning and the selection of the MLX71122's PLL counter settings are straightforward and can be laid out on the following procedure.

Usually the receive frequency f_{RF} and the channel step size f_{CH} are given by system requirements. The N and A counter settings can be derived from N_{tot} or f_{LO1} and f_{PFD} by using the following equations.

$$N = \text{floor}\left(\frac{N_{tot}}{P}\right) = \text{floor}\left(\frac{N_{tot}}{32}\right); A = N_{tot} - N \cdot P = N_{tot} - N \cdot 32 \quad (5)$$

2.2.1 Calculation of LO1 and IF1 frequency for Low Frequency Bands

High-high injection must be used for the low frequency bands. First of all choose a PFD frequency f_{PFD} according to below table. The R counter values are valid for a 10MHz crystal reference frequency f_{RO} . The PFD frequency is given by $f_{PFD} = f_{RO} / R$.

| Injection Type | f_{CH} [kHz] | f_{PFD} [kHz] | R |
|----------------|----------------|-----------------|-----|
| h-h | 10 | 13.3 | 750 |
| h-h | 12.5 | 16.7 | 600 |
| h-h | 20 | 26.7 | 375 |
| h-h | 25 | 33.3 | 300 |
| h-h | 50 | 66.7 | 150 |
| h-h | 100 | 133.3 | 75 |
| h-h | 250 | 333.3 | 30 |

The second step is to calculate the missing parameters f_{LO1} , f_{IF1} , N_{tot} , N and A. While the second IF (f_{IF2}), the N_{LO2} divider ratio and the prescaler divider ratio P are bound to $f_{IF2} = 2\text{MHz}$, $N_{LO2} = 4$ (or 8) and $P = 32$.

$$f_{LO1} = \frac{N_{LO2}}{N_{LO2} - 1} (f_{RF} - f_{IF2}) \quad f_{LO1} = \frac{4}{3} (f_{RF} - 2\text{MHz}) \quad (6)$$

$$f_{IF1} = \frac{f_{RF} - N_{LO2} f_{IF2}}{N_{LO2} - 1} \quad f_{IF1} = \frac{f_{RF} - 8\text{MHz}}{3} \quad (7)$$

Finally N and A can be calculated with formula (5).

2.2.2 Calculation of LO1 and IF1 frequency for High Frequency Bands

Typical ISM band operating frequencies like 868.3 and 915MHz can be covered without changing the crystal nor the VCO inductor.

Low-low injection should be used for the high frequency bands. First of all choose a PFD frequency f_{PFD} according to below table. The R counter values are valid for a 10MHz crystal reference. The PFD frequency is given by $f_{PFD} = f_{RO} / R$.

| Injection Type | f_{CH} [kHz] | f_{PFD} [kHz] | R |
|----------------|----------------|-----------------|-----|
| I-I | 20 | 16 | 625 |
| I-I | 25 | 20 | 500 |
| I-I | 50 | 40 | 250 |
| I-I | 100 | 80 | 125 |
| I-I | 250 | 200 | 50 |
| I-I | 500 | 400 | 25 |

The second step is to calculate the missing parameters f_{LO1} , f_{IF1} , N_{tot} , N and A. While the second IF (f_{IF2}), the N_{LO2} divider ratio and the prescaler divider ratio P are bound to $f_{IF2} = 2\text{MHz}$, $N_{LO2} = 4$ (or 8) and $P = 32$.

$$f_{LO1} = \frac{N_{LO2}}{N_{LO2} + 1} (f_{RF} - f_{IF2}) \quad f_{LO1} = \frac{4}{5} (f_{RF} - 2\text{MHz}) \quad (8)$$

$$f_{IF1} = \frac{f_{RF} + N_{LO2} f_{IF2}}{N_{LO2} + 1} \quad f_{IF1} = \frac{f_{RF} + 8\text{MHz}}{5} \quad (9)$$

Finally N and A can be calculated with formula (5).

2.2.3 Counter Setting Examples for SPI Mode

To provide some examples, the following table shows some counter settings for the reception of the well-known ISM and SRD frequency bands. The channel spacing is assumed to be $f_{CH} = 100\text{kHz}$. In below table all frequency units are in MHz.

| Inj | f_{RF} | f_{IF1} | f_{LO1} | N_{tot} | N | P | A | f_{PFD} | R | f_{REF} | f_{LO2} | f_{IF2} |
|-----|----------|-----------|-----------|-----------|-----|----|----|-----------|-----|-----------|-----------|-----------|
| h-h | 300 | 97.3 | 397.3 | 2980 | 93 | 32 | 4 | 0.133 | 75 | 10 | 99.3 | 2 |
| h-h | 315 | 102.3 | 417.3 | 3130 | 97 | 32 | 26 | 0.133 | 75 | 10 | 104.3 | 2 |
| h-h | 434 | 142 | 576 | 4320 | 135 | 32 | 0 | 0.133 | 75 | 10 | 144 | 2 |
| h-h | 470 | 154 | 624 | 4680 | 146 | 32 | 8 | 0.133 | 75 | 10 | 156 | 2 |
| I-I | 850 | 171.6 | 678.4 | 8480 | 256 | 32 | 0 | 0.08 | 125 | 10 | 169.6 | 2 |
| I-I | 868 | 175.2 | 692.8 | 8660 | 270 | 32 | 20 | 0.08 | 125 | 10 | 173.2 | 2 |
| I-I | 915 | 184.6 | 730.4 | 9130 | 285 | 32 | 10 | 0.08 | 125 | 10 | 182.6 | 2 |
| I-I | 930 | 187.6 | 742.4 | 9280 | 290 | 32 | 0 | 0.08 | 125 | 10 | 185.6 | 2 |

2.2.4 Counter Settings in ABC Mode – 8+1 Preconfigured Channels

In ABC mode (SPISEL=0), the counter settings are hard-wired. In below table all frequency units are in MHz.

| CH | Inj | f _{RF} | f _{IF1} | f _{LO1} | N _{tot} | N | P | A | f _{PFD} | R | f _{REF} | f _{LO2} | f _{IF2} |
|----|-----|-----------------|------------------|------------------|------------------|-----|----|----|------------------|----|------------------|------------------|------------------|
| 1 | h-l | 369.5 | 125.8 | 495.3 | 3715 | 116 | 32 | 3 | 0.133 | 75 | 10 | 123.8 | 2 |
| 2 | h-l | 371.1 | 126.4 | 497.5 | 3731 | 116 | 32 | 19 | 0.133 | 75 | 10 | 124.4 | 2 |
| 3 | h-l | 375.3 | 127.8 | 503.1 | 3773 | 117 | 32 | 29 | 0.133 | 75 | 10 | 125.8 | 2 |
| 4 | h-l | 376.9 | 128.3 | 505.2 | 3789 | 118 | 32 | 13 | 0.133 | 75 | 10 | 126.3 | 2 |
| 5 | h-l | 384.0 | 130.7 | 514.7 | 3860 | 120 | 32 | 20 | 0.133 | 75 | 10 | 128.7 | 2 |
| 6 | h-l | 388.3 | 132.1 | 520.4 | 3903 | 121 | 32 | 31 | 0.133 | 75 | 10 | 130.1 | 2 |
| 7 | h-l | 391.5 | 133.2 | 524.7 | 3935 | 122 | 32 | 31 | 0.133 | 75 | 10 | 131.2 | 2 |
| 8 | h-l | 394.3 | 134.1 | 528.4 | 3963 | 123 | 32 | 27 | 0.133 | 75 | 10 | 132.1 | 2 |
| 9 | h-l | 395.9 | 134.6 | 530.5 | 3979 | 124 | 32 | 11 | 0.133 | 75 | 10 | 132.6 | 2 |

| List of Mathematical Acronyms | |
|-------------------------------|--|
| A | divider ratio of the swallow counter (part of feedback divider) |
| f _{FB} | frequency at the feedback divider output |
| floor (x) | The floor function gives the largest integer less than or equal to x. For example, floor(5.4) gives 5, floor(-6.3) gives -7. |
| f _{PFD} | PFD frequency in locked state |
| $\frac{f_{RO}}{R} = f_R$ | reference frequency of the PLL |
| f _{RO} | frequency of the crystal reference oscillator |
| f _{VCO} | frequency of the VCO (equals the LO1 signal of the first mixer) |
| N _{tot} = N · P + A | total divider ratio of the PLL feedback path |
| N | divider ratio of the program counter (part of feedback divider) |
| N _{LO2} | LO2DIV divider ratio, to derive the LO2 signal from LO1 (N ₁ = 4 or 8) |
| P | divider ratio of the prescaler (part of feedback divider) |
| R | divider ratio of the reference divider R |

2.2.5 PLL Counter Ranges

In order to cover the frequency range of about 300 to 930MHz the following counter values are implemented in the receiver:

| PLL Counter Ranges | | | |
|--------------------|-------------------|-------------------|----|
| A | N | R | P |
| 0 to 31 (5bit) | 3 to 2047 (11bit) | 3 to 2047 (11bit) | 32 |

Therefore the minimum and maximum divider ratios of the PLL feedback divider are given by:

$$N_{\text{totmin}} = 32 \cdot 32 = 1024 \quad N_{\text{totmax}} = 2047 \cdot 32 + 31 = 65535$$

2.3 SPI Description

2.3.1 General

Serial programming interface (SPI) mode can be activated by choosing SPISEL = 1 (e.g. at positive supply voltage V_{CC}). In this mode, the input pins 17, 18 and 19 are used as a 3-wire unidirectional serial bus interface (SDEN, SDTA, SCLK). The internal latches contain all user programmable variables including counter settings, mode bits etc.

In addition the MFO pin can be programmed as an output (see section 3.1.4) in order to read data from the internal latches and it can be used as an output for different test modes as well.

At each rising edge of the SCLK signal, the logic value at the SDTA terminal is written into a shift register. The programming information is taken over into internal latches with the rising edge of SDEN. Additional leading bits are ignored, only the last bits are serially clocked into the shift register. A normal write operation shifts 16 bits into the SPI, a normal read operation shifts 4 bits into the SPI and reads additional 12 bits from the MFO pin. If less than 12 data bits are shifted into SDTA during the write operation then the control register may contain invalid information.

In general a control word has the following format. Bit 0 is the Read/Write bit that determines whether it is a read (R/W = 1) or a write (R/W = 0) sequence. The R/W bit is preceding the latch address and the corresponding data bits.

| Control Word Format | | | | | | | | | | | | | | | | |
|---------------------|-----|----|----|----|----|----|----|----|----|----|----|----------------------|-----|-------------|-----|-------|
| MSB | | | | | | | | | | | | LSB | MSB | | LSB | Bit 0 |
| Data | | | | | | | | | | | | Latch Address | | Mode | | |
| D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | A2 | A2 | A0 | R/W | |

There are two control word formats for read and for write operation. Data bits are only needed in write mode. Read operations require only a latch address and a R/W bit.

Due to the static CMOS design, the serial interface consumes virtually no current. The SPI is a fully separate building block and can therefore be programmed in every operational mode.

2.3.2 Read / Write Sequences

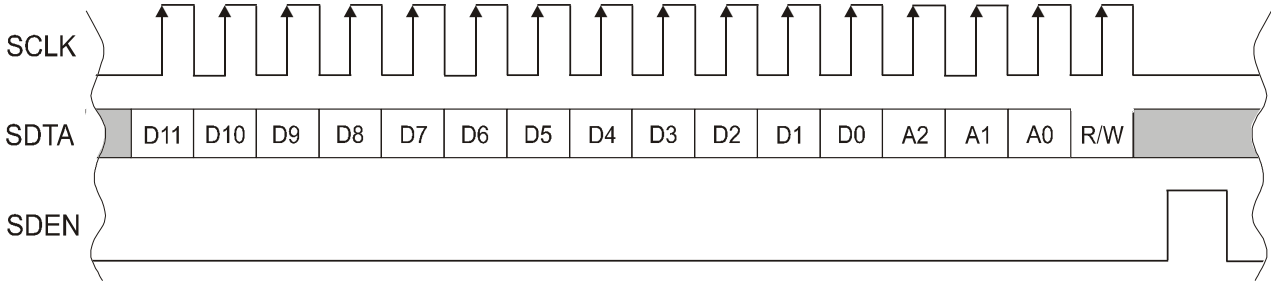


Fig. 6 Typical write sequence diagram

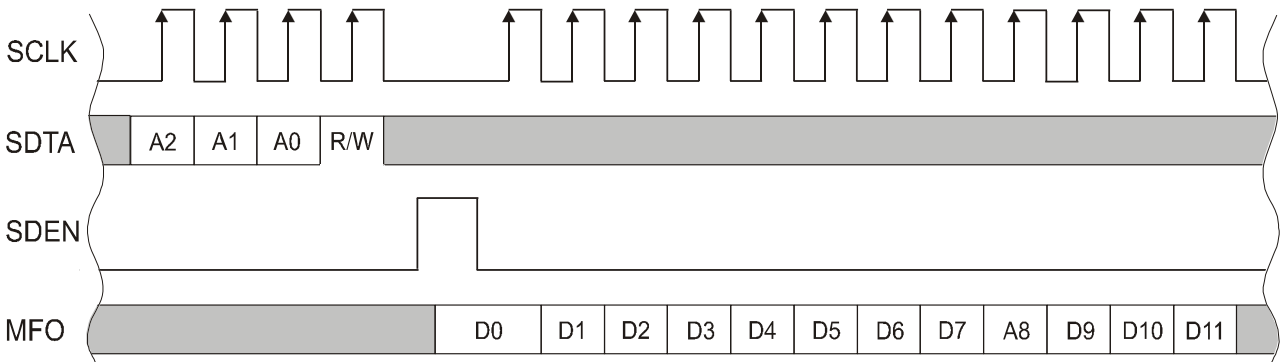


Fig. 7 Typical read sequence diagram

2.3.3 Serial Programming Interface Timing

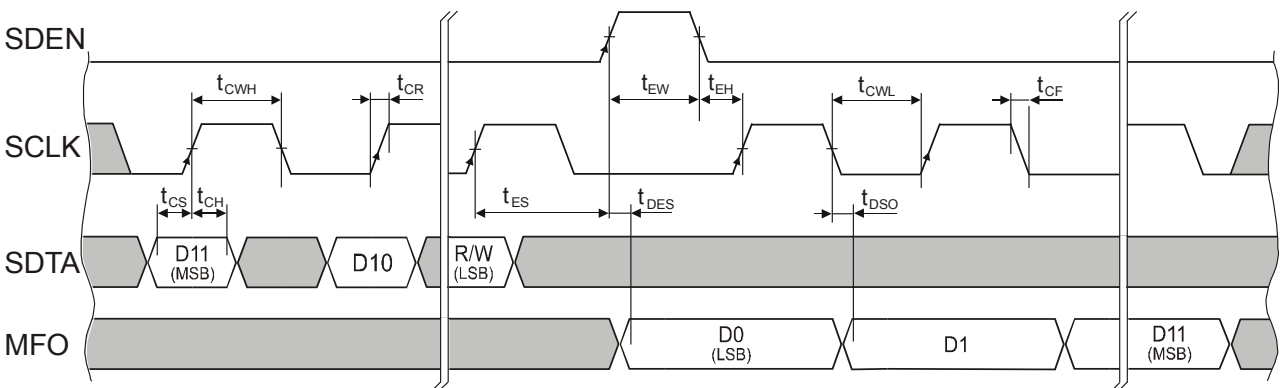


Fig. 8 SPI timing diagram

3 Register Description

The following tables are to describe the functionality of the registers.

Sec. 3.1 provides a register overview with all the control words R0 to R7. The subsequent sections. 3.1.1 to 3.1.8 show the content of the control words in more detail.

Programming the registers requires SPI mode (SPISEL = 1). Default settings are for ABC mode.

3.1 Register Overview

| CONTROL WORD | DATA | | | | | | | | | | | | LATCH ADDRESS | | |
|--------------|-----------|---------|--------|---------|---------------|----------|--------------|----------|---------------|--------|--------------|-----|---------------|------------|--|
| | MSB | | | | | | | | | | | LSB | MSB | LSB | |
| Bit No. | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | MSB | LSB | |
| default | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | |
| R0 | DTAPOL | SLCSEL | SSBSEL | DEMGAIN | IFFGAIN [1:0] | | MIX2GAIN | MIX1GAIN | LNAGAIN [1:0] | | OPMODE [1:0] | | read/write | | |
| Bit No. | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | MSB | LSB | |
| default | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | |
| R1 | SHOWLD | PRESCUR | VCOBUF | VCOCUR | VCORANGE | RSSIGAIN | LDTIME [1:0] | | LDERR | PFDPOL | CPCUR [1:0] | | read/write | | |
| Bit No. | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | MSB | LSB | |
| default | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | |
| R2 | N [6:0] | | | | | | A [4:0] | | | | | | read/write | | |
| Bit No. | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | MSB | LSB | |
| default | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| R3 | MFO [3:0] | | | | AGCDEL [1:0] | | AGCEN | LO2DIV | N [10:7] | | | | | read/write | |
| Bit No. | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | MSB | LSB | |
| default | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |

| CONTROL WORD | DATA | | | | | | | | | | | | LATCH ADDRESS | | |
|--------------|----------------|----------------|-------------------|------------------|---|---|---|---|---|---|---|-----|----------------|---|-----|
| | MSB | | | | | | | | | | | LSB | MSB | | LSB |
| Bit No. | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | MSB | | LSB |
| default | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| R4 | AGCMODE | R [10:0] | | | | | | | | | | | read/ write | | |
| Bit No. | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | MSB | | LSB |
| default | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| R5 | MODSEL | RIFF [10:0] | | | | | | | | | | | read/ write | | |
| Bit No. | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | MSB | | LSB |
| default | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| R6 | ROCUR [1:0] | IFFTUNE | IFFHLT | IFFPRES [7:0] | | | | | | | | | read/ write | | |
| Bit No. | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | MSB | | LSB |
| default | | | | | | | | | | | | | 1 | 1 | 1 |
| R7 | RSSIH | LDRSSIL* | IFFSTATE [1:0] | IFFVAL [7:0] | | | | | | | | | read- only | | |

Note: * depends on bit 11 in R4, 0 = RSSIL, 1 = LD

3.1.1 Control Word R0

| Name | Bits | Description | |
|----------|-------|---|--|
| OPMODE | [1:0] | operation mode | |
| | | 00 | shutdown #default |
| | | 01 | receive mode |
| | | 10 | reference oscillator & BIAS only |
| | | 11 | synthesizer only |
| LNAGAIN | [3:2] | LNA gain | |
| | | 00 | lowest gain (default – 20dB) |
| | | 01 | low gain (default – 6dB) |
| | | 10 | high gain (default – 2dB) |
| | | 11 | highest gain (default – 0dB) #default |
| | | gain values are relative to gain at default | |
| MIX1GAIN | [4] | 1 st Mixer gain | |
| | | 0 | high gain (14dB) #default |
| | | 1 | low gain (0dB) |
| MIX2GAIN | [5] | 2 nd Mixer gain | |
| | | 0 | high gain (9dB) #default |
| | | 1 | low gain (-2dB) |
| IFFGAIN | [7:6] | intermediate frequency filter gain | |
| | | 00 | lowest gain (-14dB) |
| | | 01 | low gain (-6dB) |
| | | 10 | high gain (0dB) #default |
| | | 11 | highest gain (+6dB) |
| DEMGAIN | [8] | demodulator gain | |
| | | 0 | low gain (~ 12mV/kHz) #default |
| | | 1 | high gain (~ 14.5mV/kHz) |
| SSBSEL | [9] | single side band selection | |
| | | 0 | upper side band LO2 low-side inj. (IF1 = LO2 + IF2) #default |
| | | 1 | lower side band LO2 high-side inj. (IF1 = LO2 – IF2) |
| | | Internal IF2 = 2MHz | |
| SLCSEL | [10] | slicer mode select | |
| | | 0 | averaging Data Slicer mode #default |
| | | 1 | peak detector Data Slicer mode |
| DTAPOL | [11] | data output polarity OA2 | |
| | | 0 | inverted #default |
| | | '1' for space at ASK or f _{min} at FSK, '0' for mark at ASK or f _{max} at FSK | |
| | | 1 | normal |
| | | '0' for space at ASK or f _{min} at FSK, '1' for mark at ASK or f _{max} at FSK | |

3.1.2 Control Word R1

| Name | Bits | Description | |
|----------|-------|---|--------------------------------|
| CPCUR | [1:0] | charge pump current setting | |
| | | 00 | 100µA #default |
| | | 01 | 400µA |
| | | 10 | 400µA static down |
| | | 11 | 400µA static up |
| PFDPOL | [2] | PFD output polarity | |
| | | 0 | negative #default |
| | | 1 | positive |
| LDERR | [3] | lock detector time error | |
| | | 0 | 15ns #default |
| | | 1 | 30ns |
| LDTIME | [5:4] | lock detection time | |
| | | 00 | 2/f _R #default |
| | | 01 | 4/f _R |
| | | 10 | 8/f _R |
| | | 11 | 16/f _R |
| | | minimum time span before lock in f _R is the reference oscillator frequency f _{RO} divided by R, see section 3.1.5 (R4) | |
| RSSIGAIN | [6] | sensitivity of RSSI voltage | |
| | | 0 | low gain (~39mV/dB) #default |
| | | 1 | high gain (~51mV/dB) |
| VCORANGE | [7] | VCO range | |
| | | 0 | 3V supply #default |
| | | 1 | 5V supply |
| | | VCO range setting for different VCCs. | |
| VCOCUR | [8] | VCO core current | |
| | | 0 | 450µA #default |
| | | 1 | 520µA |
| VCOBUF | [9] | VCO buffer current | |
| | | 0 | 900µA #default |
| | | 1 | 1040µA |
| PRESCUR | [10] | prescaler 32/33 reference current | |
| | | 0 | 20µA #default |
| | | 1 | 30µA |
| | | 30µA may be used for f _{RF} = 868/915MHz | |
| SHOWLD | [11] | function of LDRSSIL bit | |
| | | 0 | RSSIL (RSSI low flag) #default |
| | | 1 | LD (lock detection flag) |
| | | select output data of LDRSSIL, see section 3.1.8 (R7) | |

3.1.3 Control Word R2

| Name | Bits | Description | |
|----------|--------|------------------------------------|---|
| A | [4:0] | swallow counter value | |
| | | 10100 | value is 20 #default swallow counter range: 0 to 31 |
| N | [11:5] | program counter value (bits 0 – 6) | |
| | | 000 0111 1000 | N value is 120 #default N counter range: 3 to 2047 |

3.1.4 Control Word R3

| | | | |
|---------------|--------|---|---|
| N | [3:0] | program counter range (bits 7 – 10) | |
| | | 000 0111 1000 | N value is 120 #default N counter range: 3 to 2047 |
| LO2DIV | [4] | LO2 divider ratio | |
| | | 0 1 | divide by 4 divide by 8 #default |
| AGCEN | [5] | AGC enable mode | |
| | | 0 1 | disabled enabled #default |
| AGCDEL | [7:6] | AGC delay settings | |
| | | 00 01 10 11 | no delay 3/f_{IFF} 15/f_{IFF} 31/f_{IFF} #default <small>f_{IFF} is the reference oscillator frequency f_{RO} divided by RIFF, see section 3.1.6 (R6)</small> |
| MFO | [11:8] | multi functional output | |
| | | 0000 0001 0010 0011 0100 0101 1000 | MFO is in Z state MFO is SPI read-out #default MFO = 0 MFO = 1 MFO is analog RO output MFO is IFF output MFO is lock detector output |

3.1.5 Control Word R4

| Name | Bits | Description | |
|--|--------|-------------------------|--|
| R | [10:0] | reference divider range | |
| | | 000 0100 1011 | value is 75 #default R counter range: 3 to 2047 |
| AGCMODE | [11] | AGC delay mode | |
| | | 0 | gain decrease and increase with delay #default |
| | | 1 | gain decrease without delay, gain increase with delay |
| selects AGC delay mode in combination with AGCDEL bits, see section 3.1.4 (R3) | | | |

3.1.6 Control Word R5

| Name | Bits | Description | |
|--|--------|--|--|
| RIFF | [10:0] | reference divider value for IFF adjustment | |
| | | 010 1010 1100 | value is 684 #default IFF counter range: 4 to 2047 |
| MODSEL | [11] | demodulation selection | |
| | | 0 | FSK demodulation #default |
| | | 1 | ASK demodulation |
| selects modulation type when chip is controlled via SPI mode | | | |

3.1.7 Control Word R6

| Name | Bits | Description | |
|-------------------------------|------------------------|-----------------------------------|--|
| IFFPRES | [7:0] | IFF preset value | |
| | | 0101 1011 | value is 91 #default IFF DAC preset at start of automatic tuning |
| IFFHLT | [8] | IFF halt | |
| | | 0 | auto tuning running #default |
| | | 1 | auto tuning halted |
| suspends IFF automatic tuning | | | |
| IFFTUNE | [9] | IFF tuning | |
| | | 0 | disable and load DAC with IFFPRES |
| 1 | enable #default | | |
| ROCUR | [11:10] | reference Oscillator core current | |
| | | 00 | 85µA |
| | | 01 | 170µA |
| | | 10 | 270µA |
| | | 11 | 355µA |
| #default | | | |

3.1.8 Control Word R7 (Read-only Register)

| Name | Bits | Description |
|----------|-------|--|
| IFFVAL | [7:0] | IFF adjustment value |
| | | see also IFFPRES in section 3.1.7 (R6) |
| IFFSTATE | [9:8] | IFF automatic tuning state |
| | | 00 filter tuned or auto-tuning disabled |
| | | 01 tuning up the filter frequency |
| | | 10 tuning down the filter frequency |
| | | 11 master oscillator of filter does not work |
| LDRSSIL | [10] | lock detector or RSSI low flag |
| | | 0 PLL not locked or RSSI value in lower region |
| | | 1 PLL locked or RSSI value above lower region |
| | | depends on SHOWLD in section 3.1.2 (R1) |
| RSSIH | [11] | RSSI high flag |
| | | 0 RSSI value below upper region |
| | | 1 RSSI value in upper region |

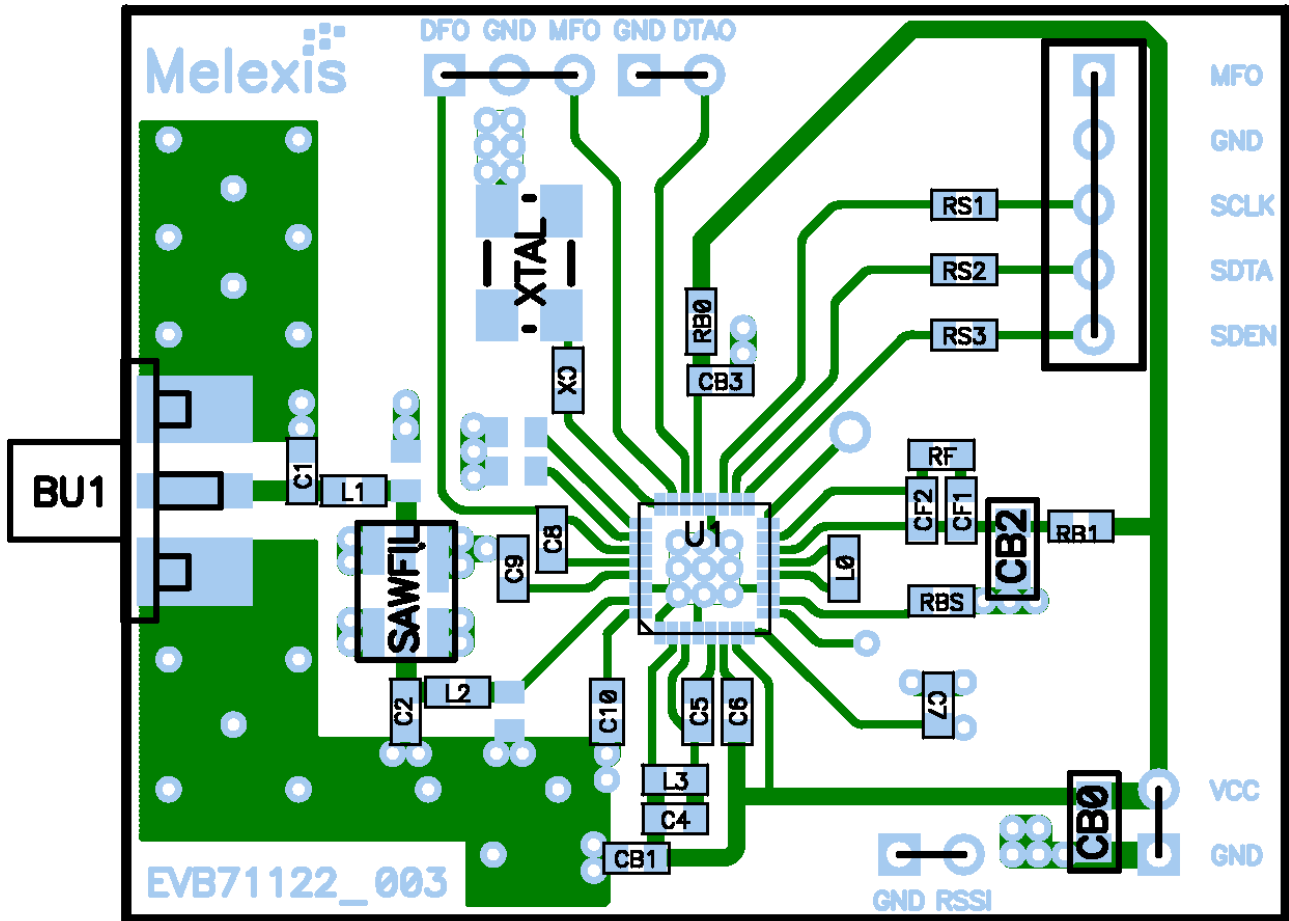


Fig. 7: PCB Top-side view (averaging data slicer option)

4.2 Peak Detector Data Slicer Configured for NRZ Codes

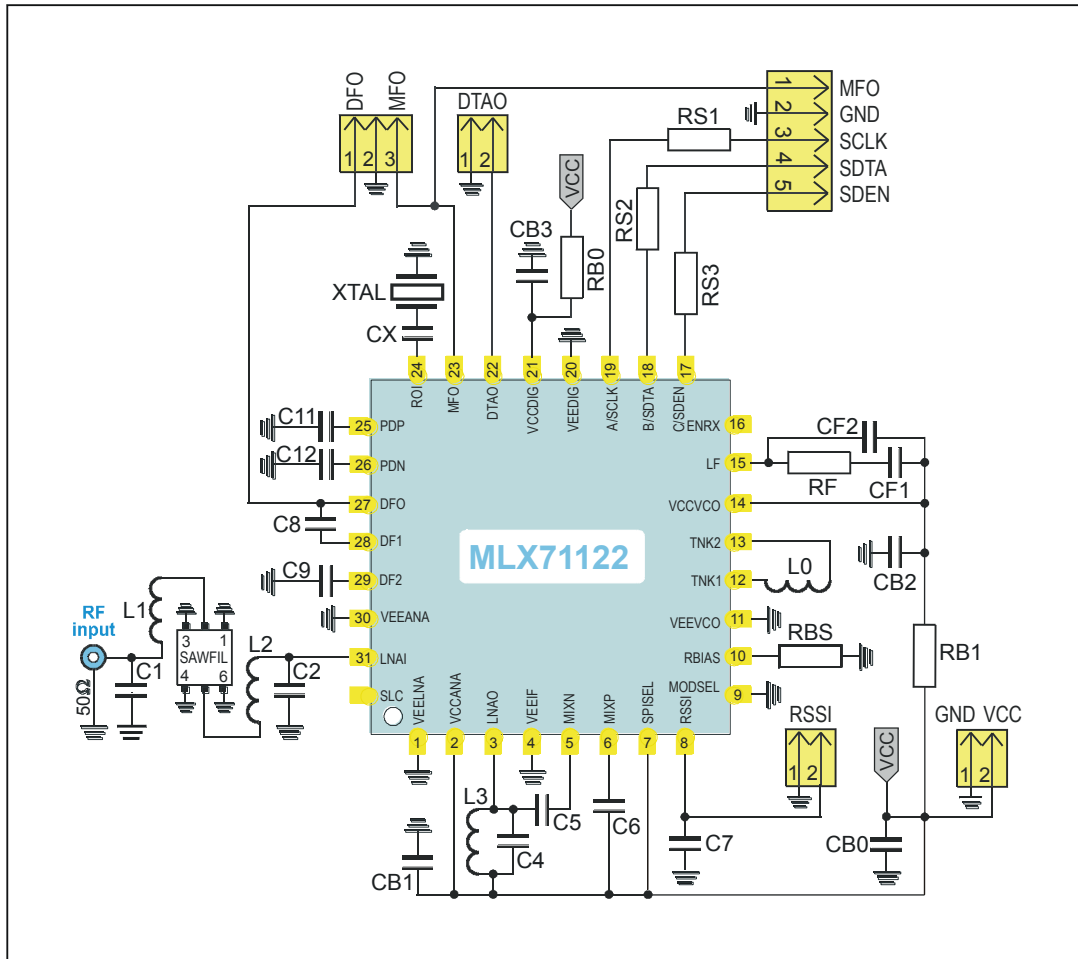


Fig. 8: Application circuit for SPI Mode (peak detector option)

Note

- EVB71122 default population is SPI mode

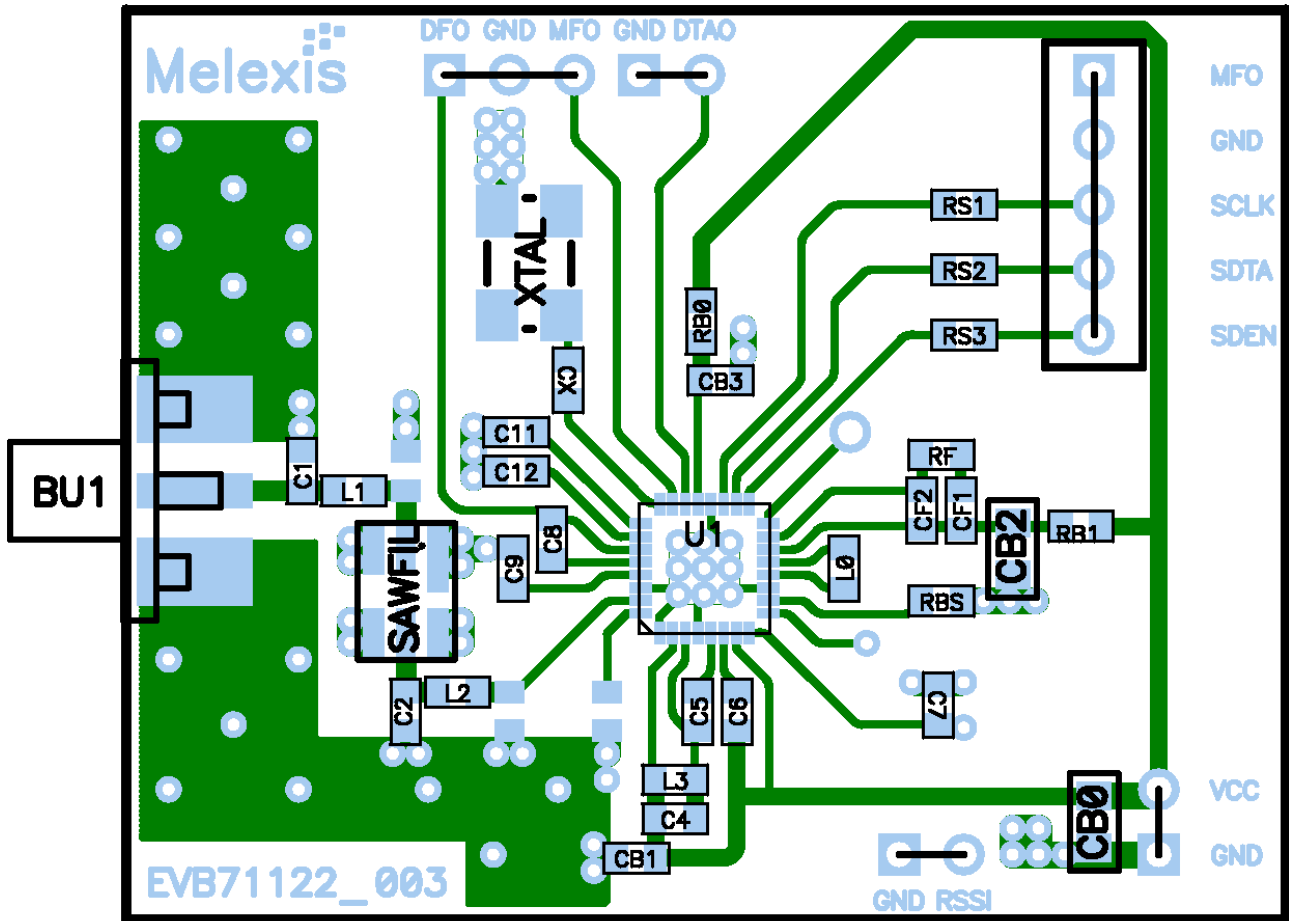


Fig. 9: PCB Top-side view (peak detector option)

4.2.1 Board Component Values List (SPI mode)

Below table is for the application circuits show in Figures 6 and 8

| Part | Size | Value @ 315 MHz | Value @ 433.9 MHz | Value @ 868.3 MHz | Value @ 915 MHz | Tol. | Description |
|-----------|-----------|---|---------------------|------------------------------|----------------------------|------|--|
| C1 | 0603 | NIP | 4.7 pF | 3.3 pF | NIP | ±5% | matching capacitor |
| C2 | 0603 | NIP | NIP | NIP | NIP | ±5% | matching capacitor |
| C4 | 0603 | 4.7 pF | 3.3 pF | 2.7 pF | 2.2 pF | ±5% | LNA output tank capacitor |
| C5 | 0603 | 100 pF | 100 pF | 100 pF | 100 pF | ±5% | MIX1 negative input matching capacitor |
| C6 | 0603 | 100 pF | 100 pF | 100 pF | 100 pF | ±5% | MIX1 negative input matching capacitor |
| C7 | 0603 | 1 nF | 1 nF | 1 nF | 1 nF | ±10% | RSSI output low pass capacitor, this value for data rate of 4 kbps NRZ |
| C8 | 0603 | 220 pF | 220 pF | 220 pF | 220 pF | ±10% | data low-pass filter capacitor, this value for data rate of 4 kbps NRZ |
| C9 | 0603 | 150 pF | 150 pF | 150 pF | 150 pF | ±10% | data low-pass filter capacitor, this value for data rate of 4 kbps NRZ |
| C10 | 0603 | 33 nF | 33 nF | 33 nF | 33 nF | ±10% | data slicer capacitor, this value for data rate of 4 kbps NRZ |
| | | not required in Figure 8 | | | | | |
| C11 | 0603 | 33 nF | 33 nF | 33 nF | 33 nF | ±10% | peak detector positive filtering capacitor, this value for data rate of 4 kbps NRZ |
| | | not required in Figures 6 | | | | | |
| C12 | 0603 | 33 nF | 33 nF | 33 nF | 33 nF | ±10% | peak detector negative filtering capacitor, this value for data rate of 4 kbps NRZ |
| | | not required in Figures 6 | | | | | |
| CB0 | 0805 | 220 nF | 220 nF | 220 nF | 220 nF | ±10% | decoupling capacitor |
| CB1 | 0603 | 470 pF | 470 pF | 470 pF | 470 pF | ±10% | decoupling capacitor |
| CB2 | 0805 | 10 μF | 10 μF | 10 μF | 10 μF | ±10% | decoupling capacitor |
| CB3 | 0603 | 33 nF | 33 nF | 33 nF | 33 nF | ±10% | decoupling capacitor |
| CF1 | 0603 | 2.2 nF | 2.2 nF | 2.2 nF | 2.2 nF | ±5% | loop filter capacitor |
| CF2 | 0603 | 220 pF | 220 pF | 220 pF | 220 pF | ±5% | loop filter capacitor |
| CX | 0603 | 27 pF | 27 pF | 27 pF | 27 pF | ±5% | crystal series capacitor |
| RB0 | 0603 | 10 Ω | 10 Ω | 10 Ω | 10 Ω | ±5% | protection resistor |
| RB1 | 0603 | 270 Ω | 270 Ω | 270 Ω | 270 Ω | ±5% | protection resistor |
| RF | 0603 | 27 kΩ | 27 kΩ | 47 kΩ | 47 kΩ | ±5% | loop filter resistor |
| RBS | 0603 | 30 kΩ | 30 kΩ | 30 kΩ | 30 kΩ | ±2% | reference bias resistor |
| RS1...RS3 | 0603 | 10 kΩ | 10 kΩ | 10 kΩ | 10 kΩ | ±5% | protection resistor |
| L0 | 0603 | 33 nH | 15 nH | 8.2 nH | 8.2 nH | ±5% | VCO tank inductor |
| L1 | 0603 | 0 Ω | 47 nH | 22 nH | 0 Ω | ±5% | matching inductor |
| L2 | 0603 | 82 nH | 82 nH | 22 nH | 8.2 nH | ±5% | matching inductor |
| L3 | 0603 | 33 nH | 22 nH | 5.6 nH | 5.6 nH | ±5% | LNA output tank inductor |
| XTAL | SMD 5x3.2 | 10.00000 MHz / ±20ppm cal., ±30ppm temp. Telcon HEX24-10.000MHZ-12-50-F-H20-T2075-W2-T | | | | | fundamental-mode crystal |
| SAW FIL | SMD 3x3 | SAFDC315MS M0T00 (315 MHz) | RF3446 (433.92 MHz) | SAFCC868MS LOX00 (868.3 MHz) | SAFCH915MA LON00 (915 MHz) | | low-loss SAW filter from Murata or equivalent part |

Note: - NIP – not in place, may be used optionally

5 Hardware and Software Requirements

The PC programming software has been developed for Windows XP and has been tested for later Windows versions. The program uses TVicPort I/O driver to interface to the parallel port.

The EVB71122 can be used either with a USB-SPI converter connected to the PC's USB port or it can be directly connected to the PC's printer port (LPT). If the LPT port is used then port addresses 0x278, 0x378 and 0x3BC (hexadecimal) are supported. A programming cable with a male 25-pole SUB-D connector can be purchased together with the evaluation board EVB71122.

The following LPT ports can be connected to the corresponding IC pins:

| LPT port | Direction | IC pin | Cable pin |
|----------------|-----------|------------------------|----------------------|
| BUSY (pin11) | ← | MFO (pin 23) | Connected (1) |
| GND (pin18-25) | — | GND | Connected (2) |
| D1 (pin3) | → | A/SCLK (pin 19) | Connected (3) |
| D2 (pin4) | → | B/SDTA (pin 18) | Connected (4) |
| D0 (pin2) | → | C/SDEN (pin17) | Connected (5) |

If the PC's USB port is used, a USB-SPI converter is required (Fig. 10). It is available on request or can be purchased together with the evaluation board EVB71122.

Note that pin 7 of the MLX71122 (SPISEL) is connected to logic HIGH on the EVB71122. This is to set the receiver to SPI mode.

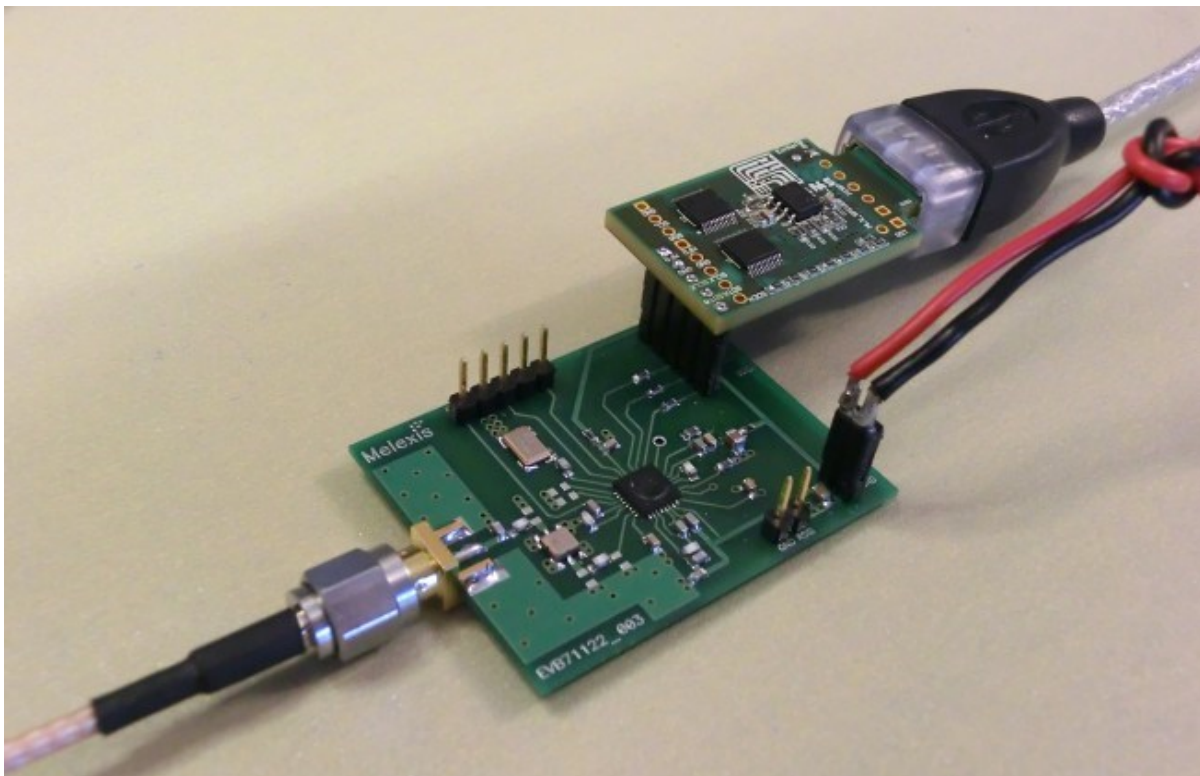


Fig. 10: How to connect the EVB71122 with the USB-SPI convertor

For further information please refer to the [Programming Software Manual for MLX71122 RF Receiver](#) .

6 Evaluation Board Layouts

Board layout data in Gerber format is available, board size is 35.6mm x 45.3mm.

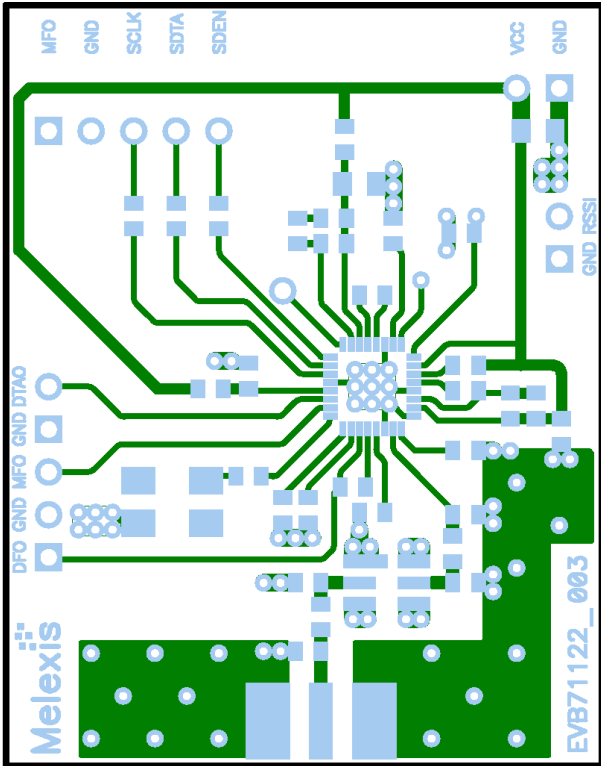


Fig. 11: PCB top view

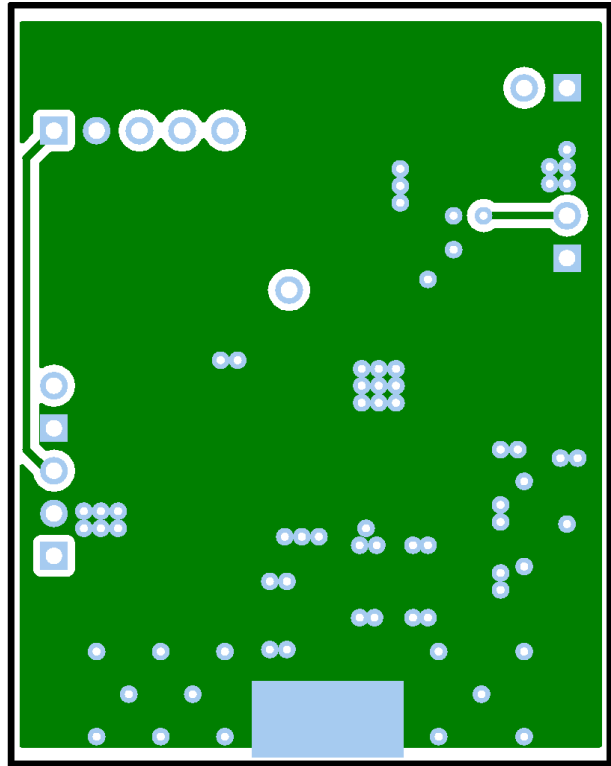



Fig. 12: PCB bottom view

7 Package Description

 The device MLX71122 is RoHS compliant.

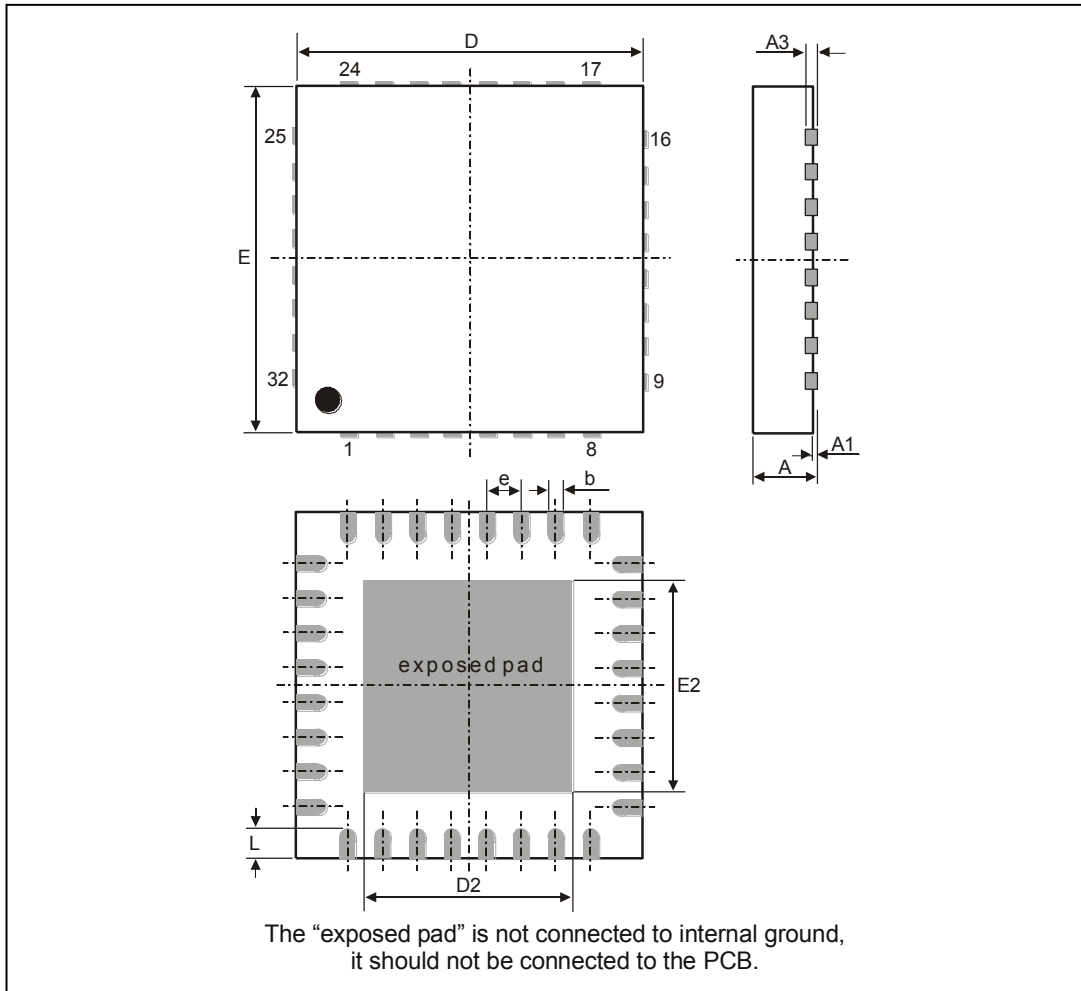


Fig 12: 32L QFN 5x5 Quad

| all Dimension in mm | | | | | | | | | | |
|-----------------------|-------|-------|-------|-------|--------|-------|--------|--------|--------|--------|
| | D | E | D2 | E2 | A | A1 | A3 | L | e | b |
| min | 4.75 | 4.75 | 3.00 | 3.00 | 0.80 | 0 | 0.20 | 0.3 | 0.50 | 0.18 |
| max | 5.25 | 5.25 | 3.25 | 3.25 | 1.00 | 0.05 | | 0.5 | | 0.30 |
| all Dimension in inch | | | | | | | | | | |
| min | 0.187 | 0.187 | 0.118 | 0.118 | 0.0315 | 0 | 0.0079 | 0.0118 | 0.0197 | 0.0071 |
| max | 0.207 | 0.207 | 0.128 | 0.128 | 0.0393 | 0.002 | | 0.0197 | | 0.0118 |

7.1 Soldering Information

The device MLX71122 is qualified for MSL3 with soldering peak temperature 260 deg C according to JEDEC J-STD-20

8 Reliability Information

This Melexis device is classified and qualified regarding soldering technology, solderability and moisture sensitivity level, as defined in this specification, 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)"

Wave Soldering SMD's (Surface Mount Devices)

- EN60749-20
"Resistance of plastic- encapsulated SMD's to combined effect of moisture and soldering heat"

Solderability SMD's (Surface Mount Devices)

- EIA/JEDEC JESD22-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.

9 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

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