

# TDA 5220

ASK/FSK Single Conversion Receiver

Version 1.1

Wireless Control  
Components



Never stop thinking.

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V 1.1

Previous Version: none

| Page | Subjects (major changes since last revision) |
|------|----------------------------------------------|
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# 1 Product Description

## 1.1 Overview

The IC is a very low power consumption single chip FSK/ASK Superheterodyne Receiver (SHR) for the frequency bands 810 to 870 MHz and 400 to 440 MHz. The IC offers a high level of integration and needs only a few external components. The device contains a low noise amplifier (LNA), a double balanced mixer, a fully integrated VCO, a PLL synthesiser, a crystal oscillator, a limiter with RSSI generator, a PLL FSK demodulator, a data filter, an advanced data comparator (slicer) with selection between two threshold modes and a peak detector. Additionally there is a power down feature to save current and extend battery life, and two selectable alternatives of generating the data slicer threshold.

## 1.2 Features

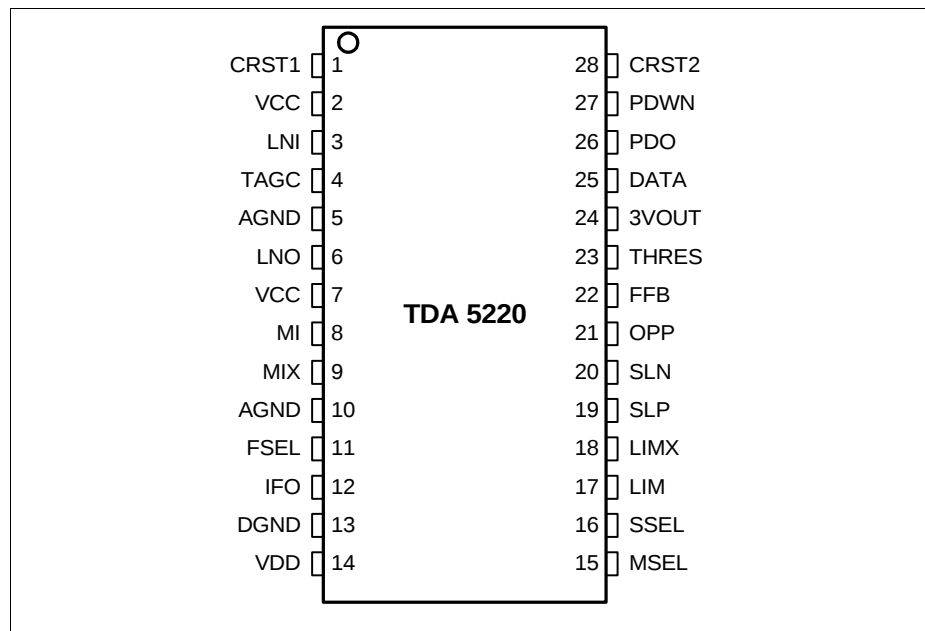
- Low supply current ( $I_s = 5.7/5.9$  mA typ. in FSK mode,  $I_s = 5.0/5.2$  mA typ. in ASK mode for 434/868 MHz)
- Supply voltage range  $5V \pm 10\%$
- Power down mode with very low supply current (50nA typ.)
- FSK and ASK demodulation capability
- Fully integrated VCO and PLL Synthesiser
- ASK sensitivity better than -106 dBm over specified temperature range (- 40 to +105°C)
- FSK sensitivity better than -100 dBm over specified temperature range (- 40 to +105°C)
- Selectable frequency ranges 810-870 MHz and 400-440 MHz
- Limiter with RSSI generation, operating at 10.7MHz
- 2nd order low pass data filter with external capacitors
- Data slicer with selection between two threshold modes (see [Section 2.4.8](#))

## 1.3 Application

- Keyless Entry Systems
- Remote Control Systems
- Alarm Systems
- Low Bitrate Communication Systems

## 2 Functional Description

### 2.1 Pin Configuration

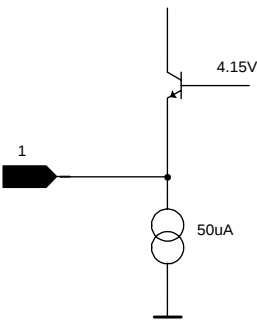
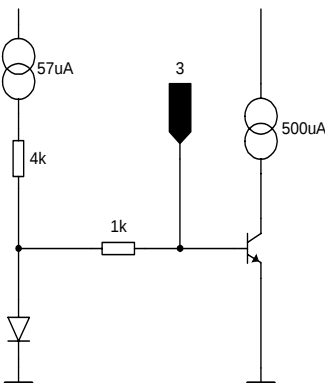


**Figure 1 Pin Configuration**

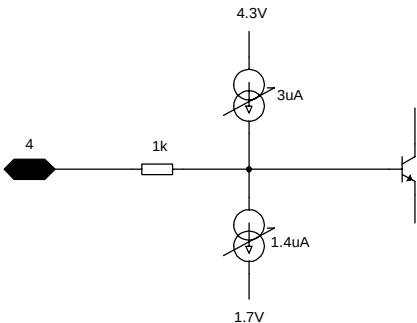
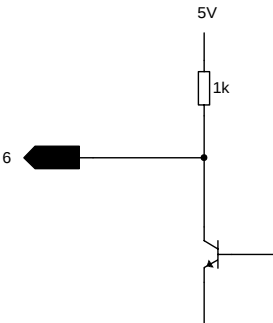
## Functional Description

### 2.2 Pin Definition and Functions

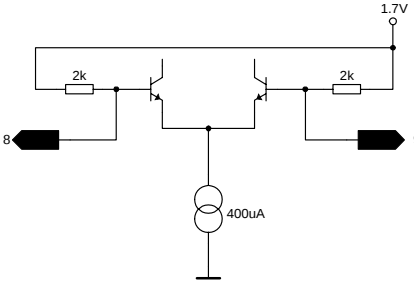
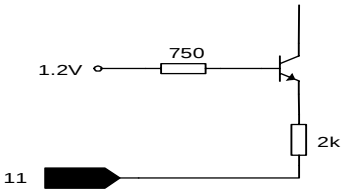
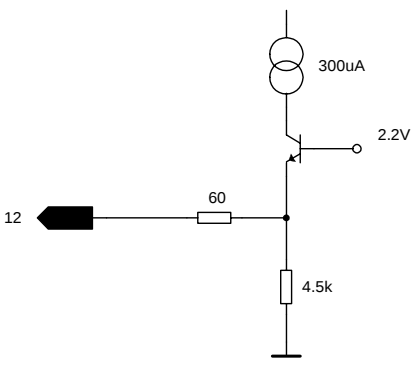
**Table 1 Pin Defintion and Function**

| Pin No. | Symbol | Equivalent I/O Schematic                                                           | Function                     |
|---------|--------|------------------------------------------------------------------------------------|------------------------------|
| 1       | CRST1  |   | External Crystal Connector 1 |
| 2       | VCC    |                                                                                    | 5V Supply                    |
| 3       | LNI    |  | LNA Input                    |

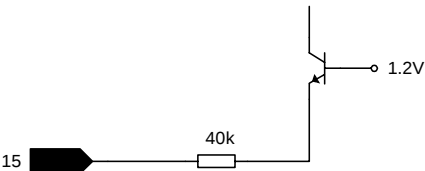
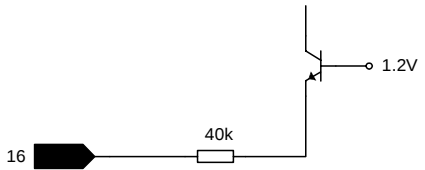
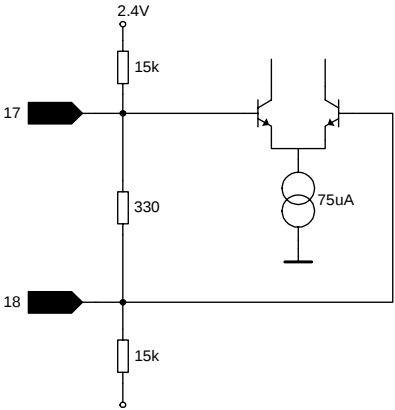
# Functional Description

| Pin No. | Symbol | Equivalent I/O Schematic                                                           | Function                  |
|---------|--------|------------------------------------------------------------------------------------|---------------------------|
| 4       | TAGC   |   | AGC Time Constant Control |
| 5       | AGND   |                                                                                    | Analogue Ground Return    |
| 6       | LNO    |  | LNA Output                |
| 7       | VCC    |                                                                                    | 5V Supply                 |

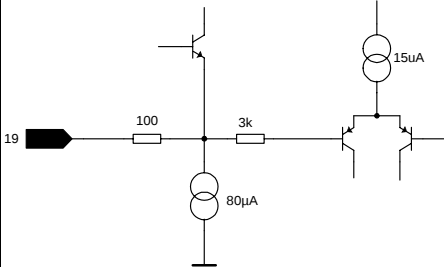
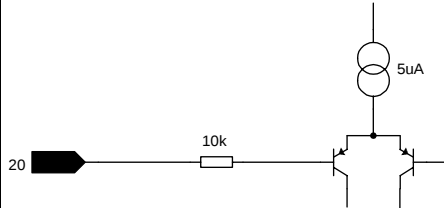
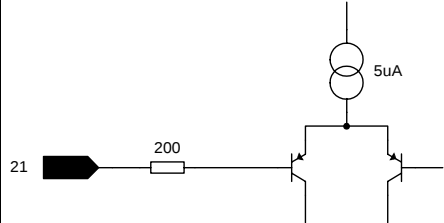
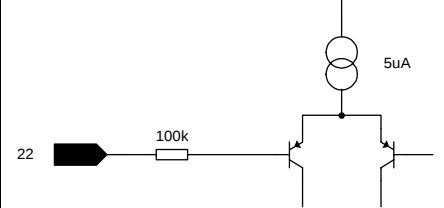
**Functional Description**

| Pin No. | Symbol | Equivalent I/O Schematic                                                           | Function                                 |
|---------|--------|------------------------------------------------------------------------------------|------------------------------------------|
| 8       | MI     |   | Mixer Input                              |
| 9       | MIX    |                                                                                    | Complementary Mixer Input                |
| 10      | AGND   |                                                                                    | Analogue Ground Return                   |
| 11      | FSEL   |   | 868/434 MHz Operating Frequency Selector |
| 12      | IFO    |  | 10.7 MHz IF Mixer Output                 |
| 13      | DGND   |                                                                                    | Digital Ground Return                    |

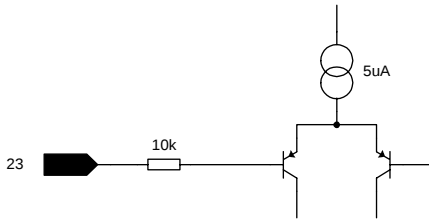
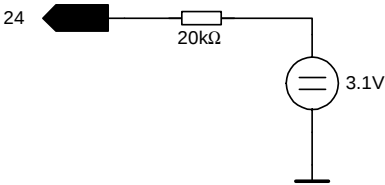
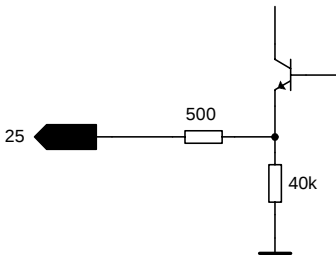
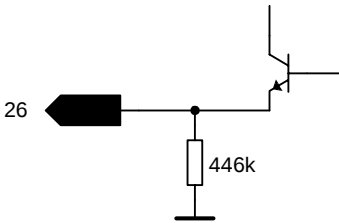
**Functional Description**

| Pin No. | Symbol | Equivalent I/O Schematic                                                           | Function                           |
|---------|--------|------------------------------------------------------------------------------------|------------------------------------|
| 14      | VDD    |                                                                                    | 5V Supply (PLL Counter Circuitry)  |
| 15      | MSEL   |   | ASK/FSK Modulation Format Sector   |
| 16      | SSEL   |   | Data Slicer Reference Level Sector |
| 17      | LIM    |  | Limiter Input                      |
| 18      | LIMX   |                                                                                    | Complementary Limiter Input        |

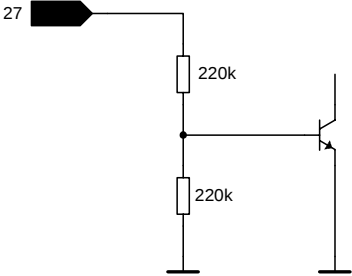
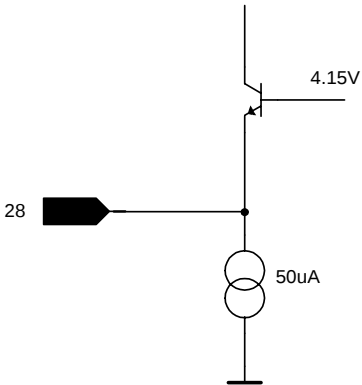
## Functional Description

| Pin No. | Symbol | Equivalent I/O Schematic                                                            | Function                   |
|---------|--------|-------------------------------------------------------------------------------------|----------------------------|
| 19      | SLP    |    | Data Slicer Positive Input |
| 20      | SLN    |    | Data Slicer Negative Input |
| 21      | OPP    |   | OpAmp Noninverting Input   |
| 22      | FFB    |  | Data Filter Feedback Pin   |

# Functional Description

| Pin No. | Symbol | Equivalent I/O Schematic                                                            | Function             |
|---------|--------|-------------------------------------------------------------------------------------|----------------------|
| 23      | THRES  |    | AGC Threshold Input  |
| 24      | 3VOUT  |    | 3V Reference Output  |
| 25      | DATA   |   | Data Output          |
| 26      | PDO    |  | Peak Detector Output |

**Functional Description**

| Pin No. | Symbol | Equivalent I/O Schematic                                                           | Function                     |
|---------|--------|------------------------------------------------------------------------------------|------------------------------|
| 27      | PDWN   |   | Power Down Input             |
| 28      | CRST2  |  | External Crystal Connector 2 |



**Functional Description**
**2.4.2 Mixer**

The Double Balanced Mixer downconverts the input frequency (RF) in the range of 400-440MHz/810-870MHz to the intermediate frequency (IF) at 10.7MHz with a voltage gain of approximately 21dB by utilising either high- or low-side injection of the local oscillator signal. In case the mixer is interfaced only single-ended, the unused mixer input has to be tied to ground via a capacitor. The mixer is followed by a low pass filter with a corner frequency of 20MHz in order to suppress RF signals to appear at the IF output (**IFO** pin). The IF output is internally consisting of an emitter follower that has a source impedance of approximately 330 $\Omega$  to facilitate interfacing the pin directly to a standard 10.7MHz ceramic filter without additional matching circuitry.

**2.4.3 PLL Synthesizer**

The Phase Locked Loop synthesizer consists of a VCO, an asynchronous divider chain, a phase detector with charge pump and a loop filter and is fully implemented on-chip. The VCO is including spiral inductors and varactor diodes. The tuning range of the VCO guarantee over production spread and the specified temperature range is 820 and 860MHz. The oscillator signal is fed both to the synthesiser divider chain and to the downconverting mixer. In case of operation in the 400 to 440MHz range the signal is divided by two before it is fed to the Mixer. Depending on whether high- or low-side injection of the local oscillator is used, the receiving frequency ranges are 810 to 840MHz and 840 to 870MHz or 400 to 420MHz and 420 to 440MHz - see also Section 3.4. To be able to switch between two different frequency channels a divider ratio of either 32 or 32.25 can be selected via the FSEL-Pin.

**Table 2 FSEL-Pin Operating States**

| <b>FSEL</b> | <b>RF</b>  |
|-------------|------------|
| Open        | 400-440MHz |
| GND         | 810-870MHz |

**2.4.4 Crystal Oscillator**

The calculation of the value of the necessary crystal load capacitance is shown in Section 3.3, the crystal frequency calculation is explained in Section 3.4.

**2.4.5 Limiter**

The Limiter is an AC coupled multistage amplifier with a cumulative gain of approximately 80 dB that has a bandpass-characteristic centred around 10.7 MHz. It has a typical input impedance of 330  $\Omega$  to allow for easy interfacing to a 10.7 MHz ceramic IF filter. The limiter circuit also acts as a Receive Signal Strength Indicator (RSSI) generator which produces a DC voltage that is directly proportional to the input

## Functional Description

signal level as can be seen in Figure 4. This signal is used to demodulate ASK-modulated receive signals in the subsequent baseband circuitry. The RSSI output is applied to the modulation format switch, to the Peak Detector input and to the AGC circuitry.

In order to demodulate ASK signals the MSEL pin has to be in its 'High'-state as described in the next chapter.

### 2.4.6 FSK Demodulator

To demodulate frequency shift keyed (FSK) signals a PLL circuit is used that is contained fully on chip. The Limiter output differential signal is fed to the linear phase detector as is the output of the 10.7 MHz center frequency VCO. The demodulator gain is typically 200 $\mu$ V/kHz. The passive loop filter output that is comprised fully on chip is fed to both the VCO and the modulation format switch described in more detail below. This signal is representing the demodulated signal with low frequencies applied to the demodulator demodulated to logic zero and high frequencies demodulated to logic ones. However this is only valid in case the local oscillator is low-side injected to the mixer which is applicable to receive frequencies above 840 or 420MHz. In case of receive frequencies below 840 or 420MHz high frequencies are demodulated as logical zeroes due to a sign inversion in the downconversion mixing process as the LO is high-side injected to the mixer. See also Section 3.4.

The modulation format switch is actually a switchable amplifier with an AC gain of 11 that is controlled by the **MSEL** pin (Pin 15) as shown in the following table. This gain was chosen to facilitate detection in the subsequent circuits. The DC gain is 1 in order not to saturate the subsequent Data Filter with the DC offset produced by the demodulator in case of large frequency offsets of the IF signal. The resulting frequency characteristic and details on the principle of operation of the switch are described in Section 3.6.

**Table 3 MSEL Pin Operating States**

| MSEL              | Modulation Format |
|-------------------|-------------------|
| Open              | ASK               |
| Shorted to ground | FSK               |

The demodulator circuit is switched off in case of reception of ASK signals.

### 2.4.7 Data Filter

The data filter comprises an OP-Amp with a bandwidth of 100kHz used as a voltage follower and two 100k $\Omega$  on-chip resistors. Along with two external capacitors a 2nd order

## Functional Description

Sallen-Key low pass filter is formed. The selection of the capacitor values is described in Section 3.2.

### 2.4.8 Data Slicer

The data slicer is a fast comparator with a bandwidth of 100 kHz. This allows for a maximum receive data rate of up to 100kBaud. The maximum achievable data rate also depends on the IF Filter bandwidth and the local oscillator tolerance values. Both inputs are accessible. The output delivers a digital data signal (CMOS-like levels) for subsequent circuits. A self-adjusting slicer-threshold on pin 20 is generated by a RC-term. In ASK-mode alternatively a scaled value of the voltage at the PDO-output (approx. 87%) can be used as the slicer-threshold as shown in Table 4. The data slicer threshold generation alternatives are described in more detail in Section 3.5.

**Table 4 SSEL Pin Operating States**

| SSEL | MSEL | Selected Slicing Level (SL)           |
|------|------|---------------------------------------|
| X    | Low  | external SL on Pin 20 (RC-term, e.g.) |
| High | High | external SL on Pin 20 (RC-term, e.g.) |
| Low  | High | 87% of PDO-output (approx.)           |

### 2.4.9 Peak Detector

The peak detector generates a DC voltage which is proportional to the peak value of the receive data signal. A capacitor is necessary. The input is connected to the output of the RSSI-output of the Limiter, the output is connected to the **PDO** pin (Pin 26). This output can be used as an indicator for the received signal strength to use in wake-up circuits and as a reference for the data slicer in ASK mode. Note that the RSSI level is also output in case of FSK mode.

### 2.4.10 Bandgap Reference Circuitry

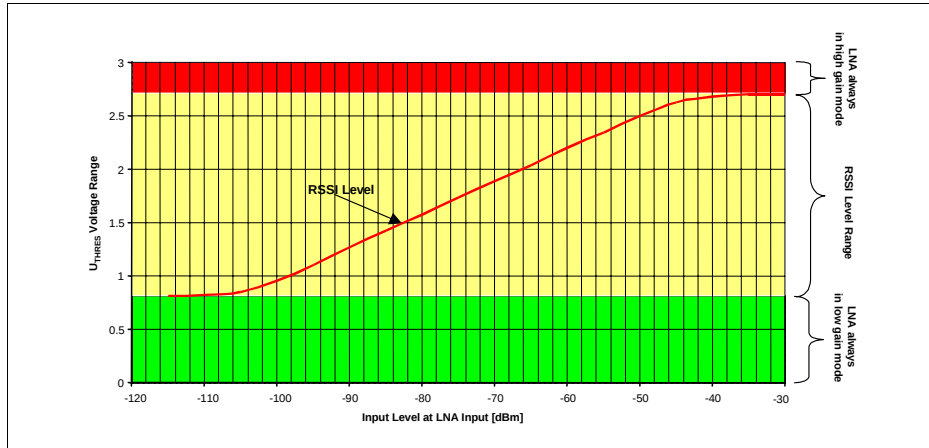
A Bandgap Reference Circuit provides a temperature stable reference voltage for the device. A power down mode is available to switch off all subcircuits which is controlled by the PWDN pin (Pin 27) as shown in the following table. The supply current drawn in this case is typically 50nA.

**Table 5 PWDN Pin Operating States**

| PWDN                   | Operating State |
|------------------------|-----------------|
| Open or tied to ground | Powerdown Mode  |
| Tied to Vs             | Receiver On     |



AGC and are used to charge an external capacitor which finally generates the LNA gain control voltage.



**Figure 4** RSSI Level and Permissible AGC Threshold Levels

The switching point should be chosen according to the intended operating scenario. The determination of the optimum point is described in the accompanying Application Note, a threshold voltage level of 1.8V is apparently a viable choice. It should be noted that the output of the **3VOUT** pin is capable of driving up to 50 $\mu$ A, but that the **THRES** pin input current is only in the region of 40nA. As the current drawn out of the **3VOUT** pin is directly related to the receiver power consumption, the power divider resistors should have high impedance values. The sum of R1 and R2 has to be 600k $\Omega$  in order to yield 3V at the **3VOUT** pin. R1 can thus be chosen as 240k $\Omega$ , R2 as 360k $\Omega$  to yield an overall **3VOUT** output current of 5 $\mu$ A<sup>1)</sup> and a threshold voltage of 1.8V

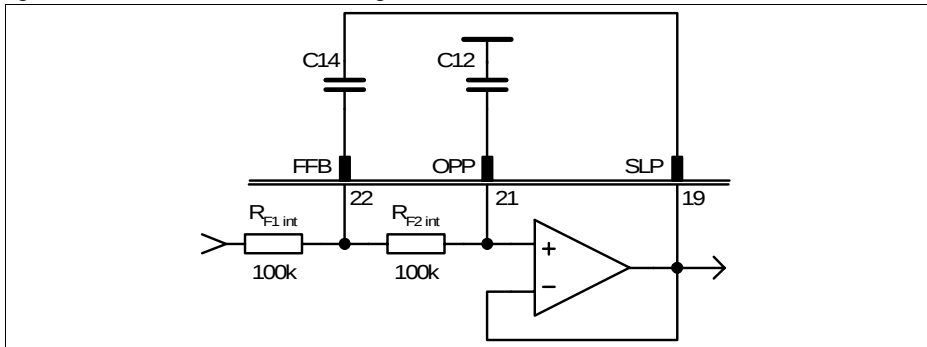
**Note:** If the LNA gain shall be kept in either high or low gain mode this has to be accomplished by tying the **THRES** pin to a fixed voltage. In order to achieve high gain mode operation, a voltage higher than 2.8V shall be applied to the **THRES** pin, such as a short to the **3VOLT** pin. In order to achieve low gain mode operation **THRES** has to be connected to GND.

As stated above the capacitor connected to the **TAGC** pin is generating the gain control voltage of the LNA due to the charging and discharging currents of the OTA and thus is also responsible for the AGC time constant. As the charging and discharging currents are not equal two different time constants will result. The time constant corresponding to the charging process of the capacitor shall be chosen according to the data rate. According to measurements performed at Infineon the capacitor value should be greater than 47nF.

1) note the 20k $\Omega$  resistor in series with the 3.1V internal voltage source

### 3.2 Data Filter Design

Utilising the on-board voltage follower and the two 100kΩ on-chip resistors a 2nd order Sallen-Key low pass data filter can be constructed by adding 2 external capacitors between pins 19 (SLP) and 22 (FFB) and to pin 21 (OPP) as depicted in the following figure and described in the following formulas<sup>1)</sup>.



**Figure 5 Data Filter Design**

with  $R_{F1.int} = R_{F2.int} = R$

$$C14 = \frac{2Q\sqrt{b}}{R2\pi f_{3dB}} \quad C12 = \frac{\sqrt{b}}{4QR\pi f_{3dB}}$$

with

$$Q = \frac{\sqrt{b}}{a}$$

Q is the quality factor of the poles where, in case of a Bessel filter  $a=1.3617$ ,  $b=0.618$  and thus  $Q=0.577$

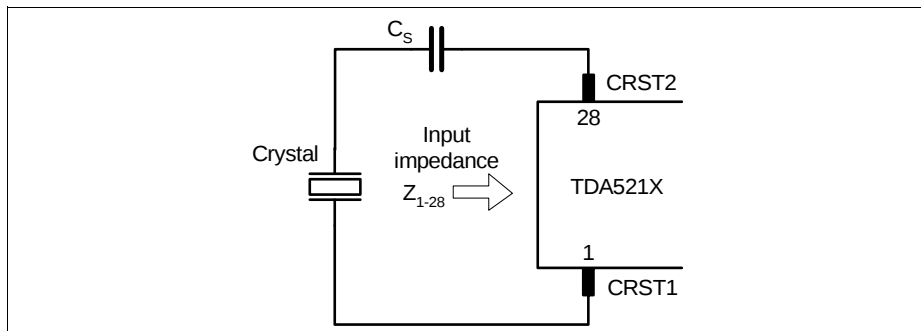
and in case of a Butter worth filter  $a=1.414$ ,  $b=1$  and thus  $Q=0.71$

Example: Butter worth filter with  $f_{3dB}=5\text{kHz}$  and  $R=100\text{k}\Omega$ :  
 $C14=450\text{pF}$ ,  $C12=225\text{pF}$

<sup>1)</sup> taken from Tietze/Schenk: Halbleiterschaltungstechnik, Springer Berlin, 1999

### 3.3 Crystal Load Capacitance Calculation

The value of the capacitor necessary to achieve that the crystal oscillator is operating at the intended frequency is determined by the reactive part of the negative resistance of the oscillator circuit as shown in Section 4.1.3 and by the crystal specifications given by the crystal manufacturer.



**Figure 6 Determination of Series Capacitance Vale for the Quartz Oscillator**

The required series capacitor for a crystal with specified load capacitance  $C_L$  can be calculated as

$$C_S = \frac{1}{\frac{1}{C_L} + 2\pi f X_L}$$

$C_L$  is the nominal load capacitance specified by the crystal manufacturer.

Example:

$$13.4 \text{ MHz: } C_L = 12 \text{ pF} \quad X_L = 1010 \Omega \quad C_S = 5.9 \text{ pF}$$

This value may be obtained by putting two capacitors in series to the crystal, such as 22pF and 8.2pF for 13.4MHz.

But please note that the calculated  $C_S$ -value includes all parasitic.

### 3.4 Crystal Frequency Calculation

As described in Section 2.4.3 the operating range of the on-chip VCO is wide enough to guarantee a receive frequency range between 810 and 870MHz or between 400 and 440MHz. The VCO signal is divided by 2 before applied to the mixer in case of operation at 434MHz. This local oscillator signal can be used to downconvert the RF signals both

## Applications

with high- or low-side injection at the mixer. High-side injection of the local oscillator has to be used for receive frequencies between 810 and 840MHz or between 400 and 420MHz. In this case the local oscillator frequency is calculated by adding the IF frequency (10.7 MHz) to the RF frequency. Thus the higher frequency of a FSK-modulated signal is demodulated as a logical zero (low).

Low-side injection has to be used for receive frequencies above 840 MHz or above 420 MHz. The local oscillator frequency is calculated by subtracting the IF frequency (10.7 MHz) from the RF frequency then. In this case no sign-inversion occurs and the higher frequency of a FSK-modulated signal is demodulated as a logical one (high). The overall division ratios in the PLL are 32 or 64 depending on whether the FSEL-pin is left open or tied to ground.

Therefore the crystal frequency may be calculated by using the following formula:

$$f_{QU} = \frac{f_{RF} \pm 10.7}{r}$$

with  $f_{RF}$  receive frequency  
 $f_{LO}$  local oscillator (PLL) frequency ( $f_{RF} \pm 10.7$ )  
 $f_{QU}$  quartz crystal oscillator frequency  
 r ratio of local oscillator (PLL) frequency and crystal frequency as shown in the subsequent table

**Table 6 Dependence of PLL Overall Division Ratio on FSEL**

| FSEL | Ratio $r=(f_{LO}/f_{QU})$ |
|------|---------------------------|
| open | 32                        |
| GND  | 64                        |

This yields the following examples:

FSEL is „Low“:

$$f_{QU} = \frac{868.4MHz - 10.7MHz}{64} = 13.4015625 \text{ MHz}$$

FSEL is „High“:

$$f_{QU} = \frac{434.2MHz - 10.7MHz}{32} = 13.234375 \text{ MHz}$$

### 3.5 Data Slicer Threshold Generation

The threshold of the data slicer can be generated using an external R-C integrator as shown in Figure 7.

The time constant  $T_A$  of this circuit including also the internal resistors  $R_{F3int}$  and  $R_{F4int}$  (see Figure 9) has to be significantly larger than the longest period of no signal change  $T_L$  within the data sequence.

In order to keep distortion low, the minimum value for R is 20k $\Omega$ .

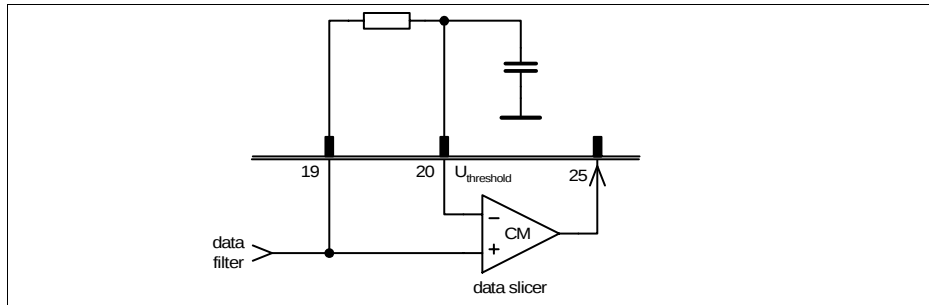
$T_A$  has to be calculated as

$$T_A = \frac{R1 \cdot (R_{F3int} + R_{F4int})}{R1 + R_{F3int} + R_{F4int}} \cdot C13 = R1II(R_{F3int} + R_{F4int}) \cdot C13 \quad \dots \text{for ASK}$$

and

$$T_A = \frac{R1 \cdot R_{F4int}}{R1 + R_{F3int} + R_{F4int}} \cdot C13 = \frac{R1II(R_{F3int} + R_{F4int})}{V} \cdot C13 \quad \dots \text{for FSK}$$

R1,  $R_{F3int}$ ,  $R_{F4int}$  and C13 see also Figure 7 and .Figure 9



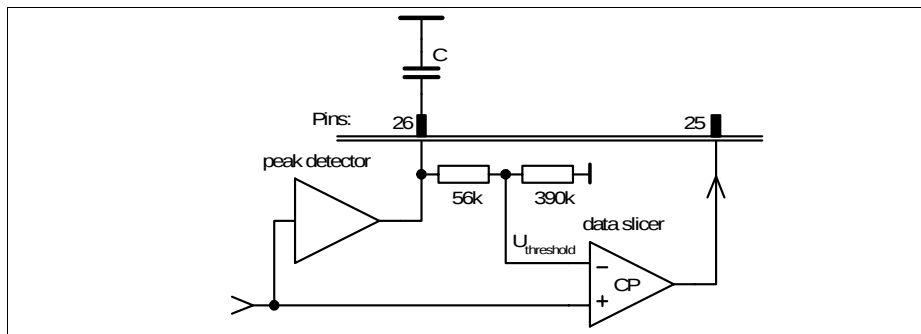
**Figure 7 Data Slicer Threshold Generation with External R-C Integrator**

In case of ASK operation another possibility for threshold generation is to use the peak detector in connection with an internal resistive divider and one capacitor as shown in the following Figure 8. For selecting the peak detector as reference for the slicing level a logic low as to be applied on the SSEL pin.

In case of MSEL is high (or open), which means that ASK-Mode is selected, a logic low on the SSEL pin yields a logic high on the AND-output and thus the peak-detector is selected (see Figure 9).

In case of FSK the MSEL-pin and furthermore the one input of the AND-gate is low, so the peak detector can not be selected.

The capacitor value is depending on the coding scheme and the protocol used.



**Figure 8 Data Slicer Threshold Generation Utilising the Peak Detector**

### 3.6 ASK/FSK-Data Path Functional Description

The TDA5220 is containing an ASK/FSK switch which can be controlled via Pin 15 (MSEL). This switch is actually consisting of 2 operational amplifiers that are having a gain of 1 in case of the ASK amplifier and a gain of 11 in case of the FSK amplifier in order to achieve an appropriate demodulation gain characteristic. In order to compensate for the DC-offset generated especially in case of the FSK PLL demodulator there is a feedback connection between the threshold voltage of the bit slicer comparator (Pin 20) to the negative input of the FSK switch amplifier.

In ASK-mode alternatively to the voltage at Pin 20 (SLN) a value of approx. 87% of the peak-detector output-voltage at Pin 26 (PDO) can be used as the slicer-reference level. The slicing reference level is generated by an internal voltage divider ( $R_{T1int}$ ,  $R_{T2int}$ ), which is applied on the peak detector output.

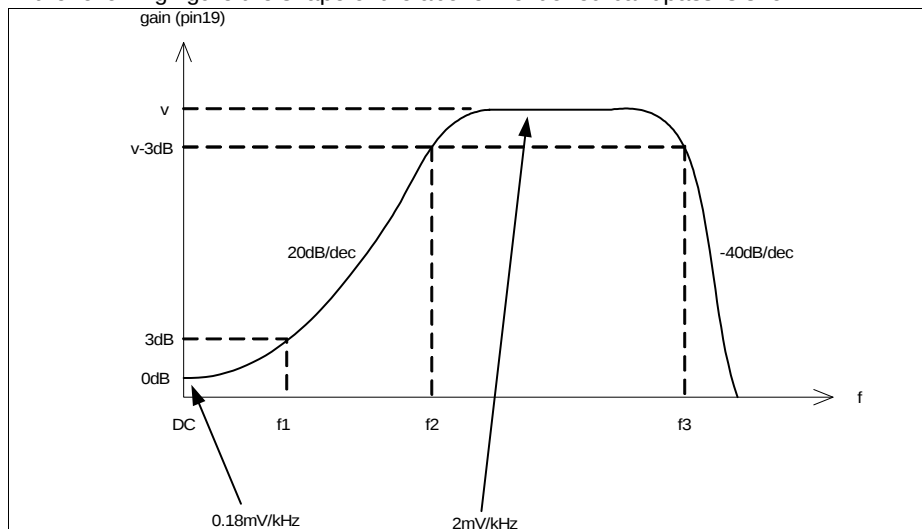
The selection between these modes is controlled by Pin 16 (SSEL), as described in Section 3.5.

This is shown in the following Figure 9.



asymmetrical offset for the demodulation of long zeros the lower of the two FSK frequencies should be chosen in the transmitter as the zero-symbol frequency.

In the following figure the shape of the above mentioned bandpass is shown.



**Figure 10 Frequency characteristic in case of FSK mode**

The cutoff frequencies are calculated with the following formulas:

$$f_1 = \frac{1}{2\pi \frac{R1 \times 330k\Omega}{R1 + 330k\Omega} \times C13}$$

$$f_2 = v \times f_1 = 11 \times f_1$$

$$f_3 = f_{3dB}$$

$f_3$  is the 3dB cutoff frequency of the data filter - see Section 3.2.

Example:

$R1 = 100k\Omega$ ,  $C13 = 47nF$

This leads to  $f_1 = 44Hz$  and  $f_2 = 485Hz$

### 3.8 ASK Mode

In case the receiver is operated in ASK mode the datapath frequency characteristic is dominated by the data filter alone, thus it is lowpass shaped. The cutoff frequency is determined by the external capacitors  $C_{12}$  and  $C_{14}$  and the internal 100k resistors as described in Section 3.2

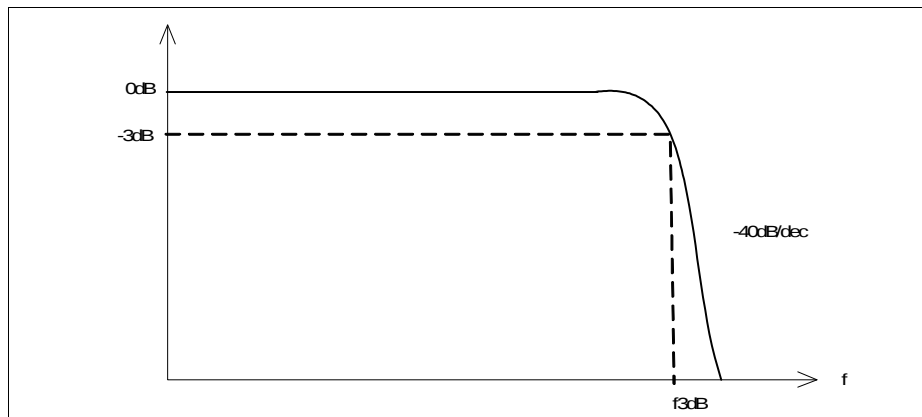


Figure 11 Frequency characteristic in case of ASK mode

### 3.9 Principle of the Precharge Circuit

In case the data slicer threshold shall be generated with an external RC network as described in Section 3.5 it is necessary to use large values for the capacitor C attached to the **SLN** pin (pin 20) in order to achieve long time constants. This results also from the fact that the choice of the value for R1 connected between the **SLP** and **SLN** pins (pins 19 and 20) is limited by the 330k $\Omega$  resistor appearing in parallel to R1 as can be seen in Figure 9. Apart from this a resistor value of 100k $\Omega$  leads to a voltage offset of 1mV at the comparator input. The resulting startup time constant  $\tau_1$  can be calculated with:

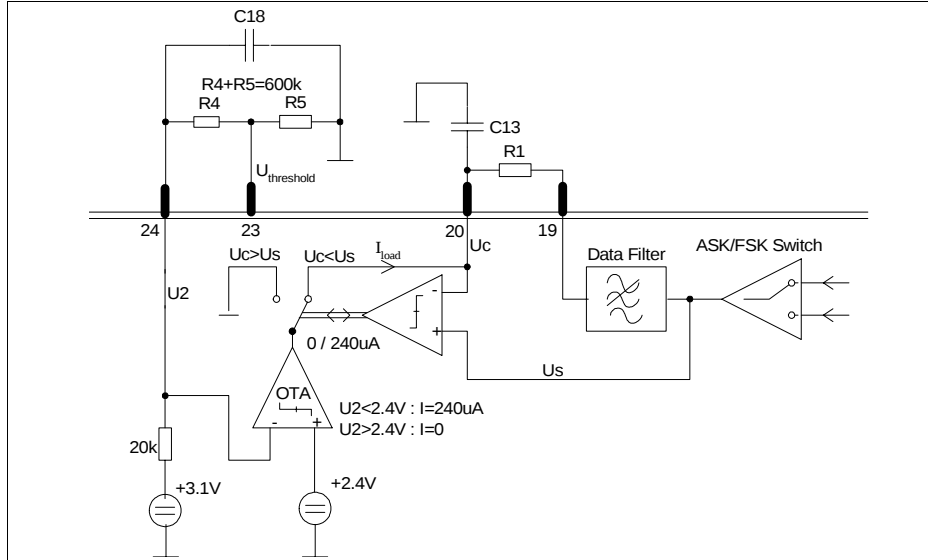
$$\tau_1 = (R1 \parallel 330k\Omega) \times C13$$

In case R1 is chosen to be 100k $\Omega$  and C13 is chosen as 47nF this leads to

$$\tau_1 = (100k\Omega \parallel 330k\Omega) \times 47nF = 77k\Omega \times 47nF = 3.6ms$$

When the device is turned on this time constant dominates the time necessary for the device to be able to demodulate data properly. In the powerdown mode the capacitor is only discharged by leakage currents.

In order to reduce the turn-on time in the presence of large values of C a precharge circuit was included in the TDA5220 as shown in the following figure.



**Figure 12 Principle of the precharge circuit**

This circuit charges the capacitor C13 with an inrush current  $I_{load}$  of typically  $220\mu A$  for a duration of  $T_2$  until the voltage  $U_c$  appearing on the capacitor is equal to the voltage  $U_s$  at the input of the data filter. This voltage is limited to 2.5V. As soon as these voltages are equal or the duration  $T_2$  is exceeded the precharge circuit is disabled.

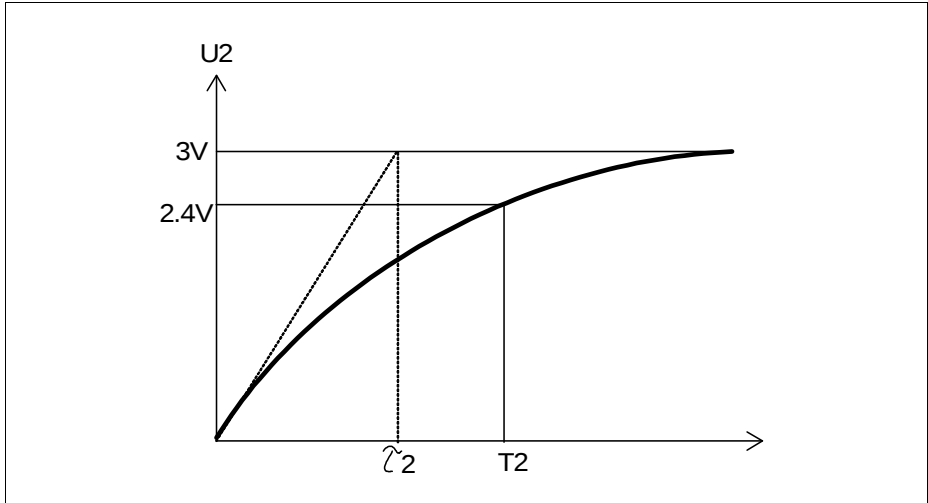
$\tau_2$  is the time constant of the charging process of C18 which can be calculated as

$$\tau_2 \approx 20k\Omega \times C2$$

as the sum of R4 and R5 is sufficiently large and thus can be neglected.  $T_2$  can then be calculated according to the following formula:

$$T_2 = \tau_2 \ln \left( \frac{1}{1 - \frac{2.4V}{3V}} \right) \approx \tau_2 \times 1.6$$

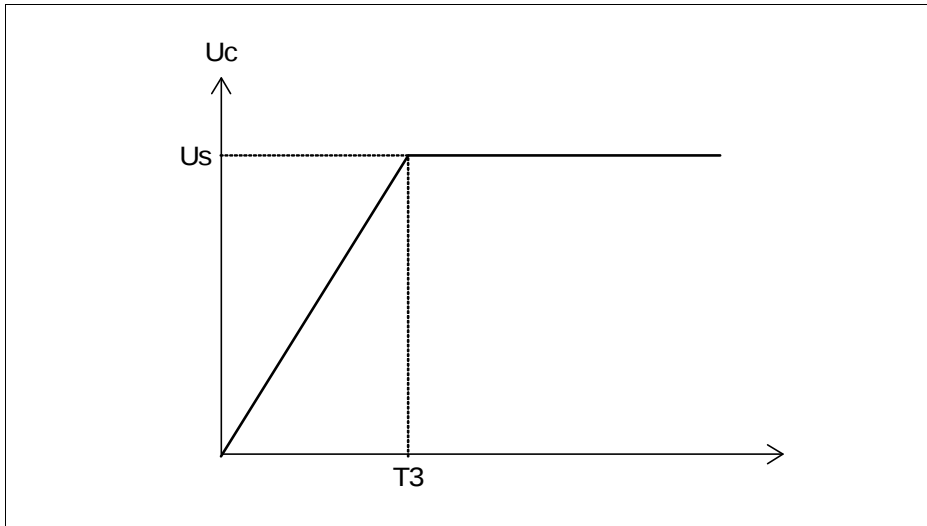
The voltage transient during the charging of  $C_2$  is shown in the following figure:



**Figure 13 Voltage appearing on C18 during precharging process**

The voltage appearing on the capacitor  $C13$  connected to pin 20 is shown in the following figure. It can be seen that due to the fact that it is charged by a constant current source it exhibits a linear increase in voltage which is limited to  $U_{Smax} = 2.5V$  which is also the approximate operating point of the data filter input. The time constant appearing in this case can be denoted as  $T_3$ , which can be calculated with:

$$T_3 = \frac{U_{Smax} \times C13}{220\mu A} = \frac{2.5V}{220\mu A} \times C13$$



**Figure 14 Voltage transient on capacitor C13 attached to pin 20**

As an example the choice of  $C18 = 22\text{nF}$  and  $C13 = 47\text{nF}$  yields

$$\tau_2 = 0.44\text{ms}$$

$$T_2 = 0.71\text{ms}$$

$$T_3 = 0.53\text{ms}$$

This means that in this case the inrush current could flow for a duration of  $0.64\text{ms}$  but stops already after  $0.49\text{ms}$  when the  $U_{S\text{max}}$  limit has been reached.  $T_3$  should always be chosen to be shorter than  $T_2$ .

It has to be noted finally that during the turn-on duration  $T_2$  the overall device power consumption is increased by the  $220\mu\text{A}$  needed to charge C13.

The precharge circuit may be disabled if C18 is not equipped. This yields a  $T_2$  close to zero. Note that the sum of  $R_4$  and  $R_5$  has to be  $600\text{k}\Omega$  in order to produce  $3\text{V}$  at the THRES pin as this voltage is internally used also as the reference for the FSK demodulator.

## 4 Reference

### 4.1 Electrical Data

#### 4.1.1 Absolute Maximum Ratings

**Attention:** *The maximum ratings may not be exceeded under any circumstances, not even momentarily and individually, as permanent damage to the IC may result. The AC/DC characteristic limits are not guaranteed.*

**Table 7** Absolute Maximum Ratings,  $T_{amb} = -40\text{ °C} \dots +105\text{ °C}$

| # | Parameter                                                                    | Symbol     | Limit Values |                | Unit         | Remarks                                      |
|---|------------------------------------------------------------------------------|------------|--------------|----------------|--------------|----------------------------------------------|
|   |                                                                              |            | min.         | max.           |              |                                              |
| 1 | Supply Voltage                                                               | $V_s$      | -0.3         | 5.5            | V            |                                              |
| 2 | Junction Temperature                                                         | $T_j$      | -40          | +125           | °C           |                                              |
| 3 | Storage Temperature                                                          | $T_s$      | -40          | +150           | °C           |                                              |
| 4 | Thermal Resistance                                                           | $R_{thJA}$ |              | 114            | K/W          |                                              |
| 5 | ESD integrity, all pins excl. Pins 1,3, 6, 28<br>ESD integrity Pins 1,3,6,28 | $V_{ESD}$  |              | +2<br><br>+1.5 | kV<br><br>kV | HBM according to MIL STD 883D, method 3015.7 |

#### 4.1.2 Operating Range

Within the operational range the IC operates as explained in the circuit description. Currents flowing into the device are denoted as positive currents and vice versa. The device parameters with ■ are not part of the production test, but either verified by design or measured in the Infineon Evalboard as described in Section 4.2.

Supply voltage:  $V_{CC} = 4.5V \dots 5.5V$

**Table 8 Operating Range,  $T_{amb} = -40\text{ °C} \dots +105\text{ °C}$** 

| # | Parameter                                                          | Symbol                                                   | Limit Values             |                          | Unit                 | Test Conditions/<br>Notes                                                                                                                        | L |
|---|--------------------------------------------------------------------|----------------------------------------------------------|--------------------------|--------------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|---|
|   |                                                                    |                                                          | min.                     | max.                     |                      |                                                                                                                                                  |   |
| 1 | Supply Current                                                     | $I_{SF868}$<br>$I_{SF434}$<br>$I_{SA868}$<br>$I_{SA434}$ | 3.9<br>3.7<br>3.2<br>3.0 | 7.9<br>7.7<br>7.2<br>7.0 | mA<br>mA<br>mA<br>mA | $f_{RF}=868\text{MHz}$ , FSK Mode<br>$f_{RF}=434\text{MHz}$ , FSK Mode<br>$f_{RF}=868\text{MHz}$ , ASK Mode<br>$f_{RF}=434\text{MHz}$ , ASK Mode |   |
| 2 | Receiver Input Level<br>ASK<br>FSK, frequ. dev. $\pm 50\text{kHz}$ | $RF_{in}$                                                | -106<br>-100             | -13<br>-13               | dBm<br>dBm           | @source impedance<br>50 $\Omega$<br>BER 2E-3, average<br>power level, Manchester<br>encoded datarate 4kBit,<br>280KHz IF Bandwidth               | ■ |
| 3 | LNI Input Frequency                                                | $f_{RF}$                                                 | 400/810                  | 440/870                  | MHz                  |                                                                                                                                                  |   |
| 4 | MI/X Input Frequency                                               | $f_{MI}$                                                 | 400/810                  | 440/870                  | MHz                  |                                                                                                                                                  |   |
| 5 | 3dB IF Frequency Range<br>ASK<br>FSK                               | $f_{IF-3dB}$                                             | 5<br>10.4                | 23<br>11                 | MHz                  |                                                                                                                                                  | ■ |
| 6 | Powerdown Mode On                                                  | $PWDN_{ON}$                                              | 2                        | $V_S$                    | V                    |                                                                                                                                                  |   |
| 7 | Powerdown Mode Off                                                 | $PWDN_{OFF}$                                             | 0                        | 0.8                      | V                    |                                                                                                                                                  |   |
| 8 | Gain Control Voltage,<br>LNA high gain state                       | $V_{THRES}$                                              | 2.8                      | $V_S$                    | V                    |                                                                                                                                                  |   |
| 9 | Gain Control Voltage,<br>LNA low gain state                        | $V_{THRES}$                                              | 0                        | 0.7                      | V                    |                                                                                                                                                  |   |

■ Not part of the production test - either verified by design or measured in the Infineon Evalboard as described in Section 4.2.

#### 4.1.3 AC/DC Characteristics at $T_{AMB} = 25\text{ °C}$

AC/DC characteristics involve the spread of values guaranteed within the specified voltage and ambient temperature range. Typical characteristics are the median of the production. Currents flowing into the device are denoted as po-sitive currents and vice versa. The device performance parameters marked with ■ are not part of the production test - either verified by design or measured in the Infineon Evalboard as described in Section 4.2.

**Table 9 AC/DC Characteristics with  $T_A$  25°C,  $V_{VCC}=4.5 \dots 5.5$  V**

| # | Parameter | Symbol | Limit Values |      |      | Unit | Test Conditions/<br>Notes | L |
|---|-----------|--------|--------------|------|------|------|---------------------------|---|
|   |           |        | min.         | typ. | max. |      |                           |   |

**SUPPLY**
**Supply Current**

|   |                                                             |               |     |     |     |    |                                                      |  |
|---|-------------------------------------------------------------|---------------|-----|-----|-----|----|------------------------------------------------------|--|
| 1 | Supply current, standby mode                                | $I_{S\ PDWN}$ |     | 50  | 100 | nA | Pin 27 (PDWN) open or tied to 0 V                    |  |
| 2 | Supply current, device operating in 868 MHz range, FSK mode | $I_{SF\ 868}$ | 5.1 | 5.9 | 6.7 | mA | Pin 11 (FSEL) tied to GND, Pin 15 (MSEL) tied to GND |  |
| 3 | Supply current, device operating in 434 MHz range, FSK mode | $I_{SA\ 434}$ | 4.9 | 5.7 | 6.5 | mA | Pin 11 (FSEL) open, Pin 15 (MSEL) tied to GND        |  |
| 4 | Supply current, device operating in 868 MHz range, ASK mode | $I_{SA\ 868}$ | 4.4 | 5.2 | 6   | mA | Pin 11 (FSEL) tied to GND, Pin 15 (MSEL) open        |  |
| 5 | Supply current, device operating in 434 MHz range, ASK mode | $I_{SA\ 434}$ | 4.2 | 5.  | 5.8 | mA | Pin 11 (FSEL) open, Pin 15 (MSEL) open               |  |

**LNA**
**Signal Input LNI (PIN 3),  $V_{THRES} > 2.8V$ , high gain mode**

|   |                                                     |               |                   |      |  |     |                                                                         |   |
|---|-----------------------------------------------------|---------------|-------------------|------|--|-----|-------------------------------------------------------------------------|---|
| 1 | Average Power Level at BER = 2E-3 (Sensitivity)     | $RF_{in}$     |                   | -110 |  | dBm | Manchester encoded datarate 4kBit, 280kHz IF Bandwidth                  | ■ |
| 2 | Average Power Level at BER = 2E-3 (Sensitivity) FSK | $RF_{in}$     |                   | -103 |  | dBm | Manchester enc. datarate 4kBit, 280kHz IF Bandw., $\pm 50$ kHz pk. dev. | ■ |
| 3 | Input impedance, $f_{RF} = 434$ MHz                 | $S_{11\ LNA}$ | 0.873 / -34.7 deg |      |  |     |                                                                         | ■ |
| 4 | Input impedance, $f_{RF} = 869$ MHz                 | $S_{11\ LNA}$ | 0.738 / -73.5 deg |      |  |     |                                                                         | ■ |
| 5 | Input level @ 1dB compression                       | $P1dB_{LNA}$  |                   | -15  |  | dBm |                                                                         | ■ |

| # | Parameter                                                      | Symbol              | Limit Values |      |      | Unit | Test Conditions/<br>Notes | L |
|---|----------------------------------------------------------------|---------------------|--------------|------|------|------|---------------------------|---|
|   |                                                                |                     | min.         | typ. | max. |      |                           |   |
| 6 | Input 3 <sup>rd</sup> order intercept point $f_{RF} = 434$ MHz | IIP3 <sub>LNA</sub> |              | -10  |      | dBm  | matched input             | ■ |
| 7 | Input 3 <sup>rd</sup> order intercept point $f_{RF} = 869$ MHz | IIP3 <sub>LNA</sub> |              | -14  |      | dBm  | matched input             | ■ |
| 8 | LO signal feedthrough at antenna port                          | LO <sub>LNI</sub>   |              |      | -73  | dBm  |                           | ■ |

**Signal Output LNO (PIN 6),  $V_{THRES} > 2.8V$ , high gain mode**

|   |                                               |               |                   |    |  |    |  |   |
|---|-----------------------------------------------|---------------|-------------------|----|--|----|--|---|
| 1 | Gain $f_{RF} = 434$ MHz                       | $S_{21\ LNA}$ | 1.509/ 138.2 deg  |    |  |    |  | ■ |
| 2 | Gain $f_{RF} = 869$ MHz                       | $S_{21\ LNA}$ | 1.419/ 101.7 deg  |    |  |    |  | ■ |
| 3 | Output impedance, $f_{RF} = 434$ MHz          | $S_{22\ LNA}$ | 0.886 / -12.9 deg |    |  |    |  | ■ |
| 4 | Output impedance, $f_{RF} = 869$ MHz          | $S_{22\ LNA}$ | 0.866 / -24.2 deg |    |  |    |  | ■ |
| 5 | Voltage Gain Antenna to MI $f_{RF} = 434$ MHz | $G_{AntMI}$   |                   | 42 |  | dB |  |   |
| 6 | Voltage Gain Antenna to MI $f_{RF} = 869$ MHz | $G_{AntMI}$   |                   | 40 |  | dB |  |   |

**Signal Input LNI,  $V_{THRES} = GND$ , two gain mode**

|   |                                                                |                     |                   |     |  |     |               |   |
|---|----------------------------------------------------------------|---------------------|-------------------|-----|--|-----|---------------|---|
| 1 | Input impedance, $f_{RF} = 434$ MHz                            | $S_{11\ LNA}$       | 0.873 / -34.7 deg |     |  |     |               | ■ |
| 2 | Input impedance, $f_{RF} = 869$ MHz                            | $S_{11\ LNA}$       | 0.738 / -73.5 deg |     |  |     |               | ■ |
| 3 | Input level @ 1dB C. P. $f_{RF} = 434$ MHz                     | P1dB <sub>LNA</sub> |                   | -18 |  | dBm | matched input | ■ |
| 4 | Input level @ 1dB C. P. $f_{RF} = 869$ MHz                     | P1dB <sub>LNA</sub> |                   | -6  |  | dBm | matched input | ■ |
| 5 | Input 3 <sup>rd</sup> order intercept point $f_{RF} = 434$ MHz | IIP3 <sub>LNA</sub> |                   | -10 |  | dBm | matched input | ■ |
| 6 | Input 3 <sup>rd</sup> order intercept point $f_{RF} = 869$ MHz | IIP3 <sub>LNA</sub> |                   | -5  |  | dBm | matched input | ■ |

**Signal Output LNO,  $V_{THRES} = GND$ , two gain mode**

|   |                                      |               |                   |  |  |  |  |   |
|---|--------------------------------------|---------------|-------------------|--|--|--|--|---|
| 1 | Gain $f_{RF} = 434$ MHz              | $S_{21\ LNA}$ | 0.183 / 140.6 deg |  |  |  |  | ■ |
| 2 | Gain $f_{RF} = 869$ MHz              | $S_{21\ LNA}$ | 0.179 / 109.1 deg |  |  |  |  | ■ |
| 3 | Output impedance, $f_{RF} = 434$ MHz | $S_{22\ LNA}$ | 0.897 / -13.6 deg |  |  |  |  | ■ |

| # | Parameter                                                | Symbol               | Limit Values      |      |      | Unit | Test Conditions/<br>Notes | L |
|---|----------------------------------------------------------|----------------------|-------------------|------|------|------|---------------------------|---|
|   |                                                          |                      | min.              | typ. | max. |      |                           |   |
| 4 | Output impedance,<br>$f_{RF} = 869 \text{ MHz}$          | $S_{22 \text{ LNA}}$ | 0.868 / -26.3 deg |      |      |      |                           | ■ |
| 5 | Voltage Gain Antenna<br>to MI $f_{RF} = 434 \text{ MHz}$ | $G_{\text{AntMI}}$   |                   | 22   |      | dB   |                           |   |
| 6 | Voltage Gain Antenna<br>to MI $f_{RF} = 869 \text{ MHz}$ | $G_{\text{AntMI}}$   |                   | 19   |      | dB   |                           |   |

**Signal 3VOUT (PIN 24)**

|   |                |                    |     |     |     |               |                 |  |
|---|----------------|--------------------|-----|-----|-----|---------------|-----------------|--|
| 1 | Output voltage | $V_{3\text{VOUT}}$ | 2.9 | 3.1 | 3.3 | V             | 3VOUT Pin open  |  |
| 2 | Current out    | $I_{3\text{VOUT}}$ | -3  | -5  | -10 | $\mu\text{A}$ | see Section 4.1 |  |

**Signal THRES (PIN 23)**

|   |                     |                        |   |   |           |    |                      |   |
|---|---------------------|------------------------|---|---|-----------|----|----------------------|---|
| 1 | Input Voltage range | $V_{\text{THRES}}$     | 0 |   | $V_S - 1$ | V  | see Section 4.1      |   |
| 2 | LNA low gain mode   | $V_{\text{THRES}}$     |   |   | 0         | V  |                      |   |
| 3 | LNA high gain mode  | $V_{\text{THRES}}$     | 3 |   | $V_S - 1$ | V  | or shorted to Pin 24 |   |
| 4 | Current in          | $I_{\text{THRES\_in}}$ |   | 5 |           | nA |                      | ■ |

**Signal TAGC (PIN 4)**

|   |                                    |                        |      |      |      |               |                                  |  |
|---|------------------------------------|------------------------|------|------|------|---------------|----------------------------------|--|
| 1 | Current out,<br>LNA low gain state | $I_{\text{TAGC\_out}}$ | -3.6 | -4.2 | -5.5 | $\mu\text{A}$ | $\text{RSSI} > V_{\text{THRES}}$ |  |
| 2 | Current in,<br>LNA high gain state | $I_{\text{TAGC\_in}}$  | 1    | 1.6  | 2.2  | $\mu\text{A}$ | $\text{RSSI} < V_{\text{THRES}}$ |  |

**MIXER**
**Signal Input MI/MIX (PINS 8/9)**

|   |                                                                           |                            |                   |     |  |     |  |   |
|---|---------------------------------------------------------------------------|----------------------------|-------------------|-----|--|-----|--|---|
| 1 | Input impedance,<br>$f_{RF} = 434 \text{ MHz}$                            | $S_{11 \text{ MIX}}$       | 0.942 / -14.4 deg |     |  |     |  | ■ |
| 2 | Input impedance,<br>$f_{RF} = 869 \text{ MHz}$                            | $S_{11 \text{ MIX}}$       | 0.918 / -28.1 deg |     |  |     |  | ■ |
| 3 | Input 3 <sup>rd</sup> order intercept<br>point $f_{RF} = 434 \text{ MHz}$ | $\text{IIP3}_{\text{MIX}}$ |                   | -28 |  | dBm |  | ■ |
| 4 | Input 3 <sup>rd</sup> order intercept<br>point $f_{RF} = 869 \text{ MHz}$ | $\text{IIP3}_{\text{MIX}}$ |                   | -26 |  | dBm |  | ■ |

**Signal Output IFO (PIN 12)**

|   |                                                       |                  |  |     |  |          |  |   |
|---|-------------------------------------------------------|------------------|--|-----|--|----------|--|---|
| 1 | Output impedance                                      | $Z_{\text{IFO}}$ |  | 330 |  | $\Omega$ |  | ■ |
| 2 | Conversion Voltage<br>Gain $f_{RF} = 434 \text{ MHz}$ | $G_{\text{MIX}}$ |  | 19  |  | dB       |  |   |

## Reference

| # | Parameter                                          | Symbol    | Limit Values |      |      | Unit | Test Conditions/<br>Notes | L |
|---|----------------------------------------------------|-----------|--------------|------|------|------|---------------------------|---|
|   |                                                    |           | min.         | typ. | max. |      |                           |   |
| 3 | Conversion Voltage Gain $f_{RF} = 869 \text{ MHz}$ | $G_{MIX}$ |              | 18   |      | dB   |                           |   |

## LIMITER

## Signal Input LIM/X (PINS 17/18)

|   |                                  |              |     |         |     |          |  |   |
|---|----------------------------------|--------------|-----|---------|-----|----------|--|---|
| 1 | Input Impedance                  | $Z_{LIM}$    | 264 | 330     | 396 | $\Omega$ |  | ■ |
| 2 | RSSI dynamic range               | $DR_{RSSI}$  |     | 70      |     | dB       |  |   |
| 3 | RSSI linearity                   | $LIN_{RSSI}$ |     | $\pm 1$ |     | dB       |  | ■ |
| 4 | Operating frequency (3dB points) | $f_{LIM}$    | 5   | 10.7    | 23  | MHz      |  | ■ |

## DATA FILTER

|   |                                                                    |                     |  |      |     |     |                                  |   |
|---|--------------------------------------------------------------------|---------------------|--|------|-----|-----|----------------------------------|---|
| 1 | Useable bandwidth                                                  | $BW_{BB}$<br>$FILT$ |  |      | 100 | kHz |                                  | ■ |
| 2 | RSSI Level at Data Filter Output SLP, $RF_{IN} = -103 \text{ dBm}$ | $RSSI_{low}$        |  | 1.1  |     | V   | LNA in high gain mode at 868 MHz |   |
| 3 | RSSI Level at Data Filter Output SLP, $RF_{IN} = -30 \text{ dBm}$  | $RSSI_{high}$       |  | 2.65 |     | V   | LNA in high gain mode at 868 MHz |   |

## SLICER

## Signal Output DATA (PIN 25)

|   |                     |               |             |           |             |      |                              |   |
|---|---------------------|---------------|-------------|-----------|-------------|------|------------------------------|---|
| 1 | Maximum Datarate    | $DR_{max}$    |             |           | 100         | kBps | NRZ, 20pF capacitive loading | ■ |
| 2 | LOW output voltage  | $V_{SLIC\_L}$ | 0           |           | 0.1         | V    |                              |   |
| 3 | HIGH output voltage | $V_{SLIC\_H}$ | $V_S - 1.3$ | $V_S - 1$ | $V_S - 0.7$ | V    | output current = 200 $\mu A$ |   |

## Slicer, Negative Input (PIN 20)

|   |                       |                |      |      |      |         |                  |  |
|---|-----------------------|----------------|------|------|------|---------|------------------|--|
| 1 | Precharge Current Out | $I_{PCH\_SLN}$ | -100 | -220 | -300 | $\mu A$ | see Section 4.2. |  |
|---|-----------------------|----------------|------|------|------|---------|------------------|--|

## Reference

| # | Parameter | Symbol | Limit Values |      |      | Unit | Test Conditions/<br>Notes | L |
|---|-----------|--------|--------------|------|------|------|---------------------------|---|
|   |           |        | min.         | typ. | max. |      |                           |   |

## PEAK DETECTOR

### Signal Output PDO (PIN 26)

|   |                         |            |      |     |     |            |                                                  |  |
|---|-------------------------|------------|------|-----|-----|------------|--------------------------------------------------|--|
| 1 | Load current            | $I_{load}$ | -500 |     |     | $\mu A$    | static load current must not exceed -500 $\mu A$ |  |
| 2 | Internal resistive load | R          | 357  | 446 | 535 | k $\Omega$ |                                                  |  |

## CRYSTAL OSCILLATOR

### Signals CRSTL 1, CRSTL 2 (PINS 1/28)

|   |                          |              |   |               |     |          |                                    |   |
|---|--------------------------|--------------|---|---------------|-----|----------|------------------------------------|---|
| 1 | Operating frequency      | $f_{CRSTL}$  | 6 |               | 14  | MHz      | fundamental mode, series resonance |   |
| 2 | Input Impedance @ ~13MHz | $Z_{1-28}$   |   | -600 + j 1010 |     | $\Omega$ |                                    | ■ |
| 3 | Serial Capacity @ ~13MHz | $C_{S10}=C1$ |   |               | 5.9 | pF       |                                    | ■ |

## ASK/FSK Signal Switch

### Signal MSEL (PIN 15)

|   |                         |            |     |     |     |         |                  |  |
|---|-------------------------|------------|-----|-----|-----|---------|------------------|--|
| 1 | ASK Mode                | $V_{MSEL}$ | 1.4 |     | 4   | V       | or open          |  |
| 2 | FSK Mode                | $V_{MSEL}$ | 0   |     | 0.2 | V       |                  |  |
| 3 | Input Bias Current MSEL | $I_{MSEL}$ |     | -11 | 19  | $\mu A$ | MSEL tied to GND |  |

## FSK DEMODULATOR

|   |                      |              |      |      |      |             |  |  |
|---|----------------------|--------------|------|------|------|-------------|--|--|
| 1 | Demodulation Gain    | $G_{FMDEM}$  |      | 200  |      | $\mu V/kHz$ |  |  |
| 2 | Useable IF Bandwidth | $BW_{IFPLL}$ | 10.2 | 10.7 | 11.2 | MHz         |  |  |

## POWER DOWN MODE

### Signal PDWN (PIN 27)

|   |                    |              |     |  |       |   |  |  |
|---|--------------------|--------------|-----|--|-------|---|--|--|
| 1 | Powerdown Mode On  | $PWDN_{ON}$  | 2.8 |  | $V_S$ | V |  |  |
| 2 | Powerdown Mode Off | $PWDN_{Off}$ | 0   |  | 0.8   | V |  |  |

**Reference**

| # | Parameter                                       | Symbol     | Limit Values |      |      | Unit    | Test Conditions/<br>Notes   | L |
|---|-------------------------------------------------|------------|--------------|------|------|---------|-----------------------------|---|
|   |                                                 |            | min.         | typ. | max. |         |                             |   |
| 3 | Input bias current PDWN                         | $I_{PDWN}$ |              | 19   |      | $\mu A$ | Power On Mode               |   |
| 4 | Start-up Time until valid IF signal is detected | $T_{SU}$   |              | <1   |      | ms      | depends on the used crystal |   |

**VCO MULTIPLEXER**
**Signal FSEL (PIN 11)**

|   |                         |            |      |      |      |         |                  |  |
|---|-------------------------|------------|------|------|------|---------|------------------|--|
| 1 | $f_{RF}$ range 434 MHz  | $V_{FSEL}$ | 1.4  |      | 4    | V       | or open          |  |
| 2 | $f_{RF}$ range 869 MHz  | $V_{FSEL}$ | 0    |      | 0.2  | V       |                  |  |
| 3 | Input bias current FSEL | $I_{FSEL}$ | -160 | -200 | -240 | $\mu A$ | FSEL tied to GND |  |

**DATA-SLICER REFERENCE-LEVEL**
**Signal SSEL (PIN 16), ASK-Mode**

|   |                                                                |            |     |     |     |         |                  |  |
|---|----------------------------------------------------------------|------------|-----|-----|-----|---------|------------------|--|
| 1 | Slicer-Reference is voltage at Pin 20 (SLN)                    | $V_{SSEL}$ | 1.4 |     | 4   | V       | or open          |  |
| 2 | Slicer-Reference is approx. 87% of the voltage at Pin 26 (PDO) | $V_{SSEL}$ | 0   |     | 0.2 | V       |                  |  |
| 3 | Input bias current SSEL                                        | $I_{SSEL}$ |     | -10 | -19 | $\mu A$ | SSEL tied to GND |  |

■ Not part of the production test - either verified by design or measured in the Infineon Evalboard as described in Section 4.2.

#### 4.1.4 AC/DC Characteristics at $T_{AMB} = -40$ to $105^{\circ}\text{C}$

Currents flowing into the device are denoted as positive currents and vice versa.

**Table 10 AC/DC Characteristics with  $T_{AMB} = -40^{\circ}\text{C} \dots +105^{\circ}\text{C}$ ,  $V_{VCC} = 4.5 \dots 5.5 \text{ V}$**

| # | Parameter | Symbol | Limit Values |      |      | Unit | Test Conditions/<br>Notes | ■ |
|---|-----------|--------|--------------|------|------|------|---------------------------|---|
|   |           |        | min.         | typ. | max. |      |                           |   |

#### SUPPLY

##### Supply Current

|   |                                                             |               |     |     |     |    |                                                      |  |
|---|-------------------------------------------------------------|---------------|-----|-----|-----|----|------------------------------------------------------|--|
| 1 | Supply current, standby mode                                | $I_{S\ PDWN}$ |     | 50  | 400 | nA | Pin 27 (PDWN) open or tied to 0 V                    |  |
| 2 | Supply current, device operating in 868 MHz range, FSK mode | $I_{SF\ 868}$ | 3.9 | 5.9 | 7.9 | mA | Pin 11 (FSEL) tied to GND, Pin 15 (MSEL) tied to GND |  |
| 3 | Supply current, device operating in 434 MHz range, FSK mode | $I_{SA\ 434}$ | 3.7 | 5.7 | 7.7 | mA | Pin 11 (FSEL) open, Pin 15 (MSEL) tied to GND        |  |
| 4 | Supply current, device operating in 868 MHz range, ASK mode | $I_{SA\ 868}$ | 3.2 | 5.2 | 7.2 | mA | Pin 11 (FSEL) tied to GND, Pin 15 (MSEL) open        |  |
| 5 | Supply current, device operating in 434 MHz range, ASK mode | $I_{SA\ 434}$ | 3   | 5   | 7   | mA | Pin 11 (FSEL) open, Pin 15 (MSEL) open               |  |

##### Signal Input 3VOUT (PIN 24)

|   |                |             |     |     |     |               |                 |  |
|---|----------------|-------------|-----|-----|-----|---------------|-----------------|--|
| 1 | Output voltage | $V_{3VOUT}$ | 2.9 | 3.1 | 3.3 | V             | 3VOUT Pin open  |  |
| 2 | Current out    | $I_{3VOUT}$ | -3  | -5  | -10 | $\mu\text{A}$ | see Section 4.1 |  |

##### Signal THRES (PIN 23)

|   |                     |                 |   |   |           |    |                      |   |
|---|---------------------|-----------------|---|---|-----------|----|----------------------|---|
| 1 | Input Voltage range | $V_{THRES}$     | 0 |   | $V_S - 1$ | V  | see Section 4.1      |   |
| 2 | LNA low gain mode   | $V_{THRES}$     |   |   | 0         | V  |                      |   |
| 3 | LNA high gain mode  | $V_{THRES}$     | 3 |   | $V_S - 1$ | V  | or shorted to Pin 24 |   |
| 4 | Current in          | $I_{THRES\_in}$ |   | 5 |           | nA |                      | ■ |

##### Signal TAGC (PIN 4)

|   |                                 |                 |    |      |    |               |                    |  |
|---|---------------------------------|-----------------|----|------|----|---------------|--------------------|--|
| 1 | Current out, LNA low gain state | $I_{TAGC\_out}$ | -1 | -4.2 | -8 | $\mu\text{A}$ | RSSI > $V_{THRES}$ |  |
|---|---------------------------------|-----------------|----|------|----|---------------|--------------------|--|

## Reference

| # | Parameter                       | Symbol         | Limit Values |      |      | Unit    | Test Conditions/<br>Notes | ■ |
|---|---------------------------------|----------------|--------------|------|------|---------|---------------------------|---|
|   |                                 |                | min.         | typ. | max. |         |                           |   |
| 2 | Current in, LNA high gain state | $V_{TAGC\_in}$ | 0.5          | 1.5  | 5    | $\mu A$ | $RSSI < V_{THRES}$        |   |

## MIXER

|   |                                            |           |  |     |  |    |  |  |
|---|--------------------------------------------|-----------|--|-----|--|----|--|--|
| 1 | Conversion Voltage Gain $f_{RF} = 434$ MHz | $G_{MIX}$ |  | +19 |  | dB |  |  |
| 2 | Conversion Voltage Gain $f_{RF} = 868$ MHz | $G_{MIX}$ |  | +18 |  | dB |  |  |

## LIMITER

## Signal Input LIM/X (PINS 17/18)

|   |                                                            |               |  |      |  |    |                                  |  |
|---|------------------------------------------------------------|---------------|--|------|--|----|----------------------------------|--|
| 1 | RSSI dynamic range                                         | $DR_{RSSI}$   |  | 70   |  | dB |                                  |  |
| 2 | RSSI Level at Data Filter Output SLP, $RF_{IN} = -103$ dBm | $RSSI_{low}$  |  | 1.1  |  | V  | LNA in high gain mode at 868 MHz |  |
| 3 | RSSI Level at Data Filter Output SLP, $RF_{IN} = -30$ dBm  | $RSSI_{high}$ |  | 2.65 |  | V  | LNA in high gain mode at 868 MHz |  |

## DATA FILTER

## Slicer, Signal Output DATA (PIN 25)

|   |                     |               |             |           |             |      |                              |   |
|---|---------------------|---------------|-------------|-----------|-------------|------|------------------------------|---|
| 1 | Maximum Datarate    | $DR_{max}$    |             |           | 100         | kBps | NRZ, 20pF capacitive loading | ■ |
| 2 | LOW output voltage  | $V_{SLIC\_L}$ | 0           |           | 0.1         | V    |                              |   |
| 3 | HIGH output voltage | $V_{SLIC\_H}$ | $V_S - 1.5$ | $V_S - 1$ | $V_S - 0.5$ | V    | output current=200 $\mu A$   |   |

## Slicer, Negative Input (PIN 20)

|   |                       |                |      |      |      |         |                 |  |
|---|-----------------------|----------------|------|------|------|---------|-----------------|--|
| 1 | Precharge Current Out | $I_{PCH\_SLN}$ | -100 | -220 | -300 | $\mu A$ | see Section 4.2 |  |
|---|-----------------------|----------------|------|------|------|---------|-----------------|--|

| # | Parameter | Symbol | Limit Values |      |      | Unit | Test Conditions/<br>Notes | ■ |
|---|-----------|--------|--------------|------|------|------|---------------------------|---|
|   |           |        | min.         | typ. | max. |      |                           |   |

## PEAK DETECTOR

### Signal Output PDO (PIN 26)

|   |                         |            |      |     |     |            |                                                  |  |
|---|-------------------------|------------|------|-----|-----|------------|--------------------------------------------------|--|
| 1 | Load current            | $I_{load}$ | -400 |     |     | $\mu A$    | static load current must not exceed -500 $\mu A$ |  |
| 2 | Internal resistive load | R          | 356  | 446 | 575 | k $\Omega$ |                                                  |  |

## CRYSTAL OSCILLATOR

### Signals CRSTL 1, CRSTL 2 (PINS 1/28)

|   |                     |             |   |  |    |     |                                    |  |
|---|---------------------|-------------|---|--|----|-----|------------------------------------|--|
| 1 | Operating frequency | $f_{CRSTL}$ | 6 |  | 14 | MHz | fundamental mode, series resonance |  |
|---|---------------------|-------------|---|--|----|-----|------------------------------------|--|

## ASK/FSK Signal Switch

### Signal MSEL (PIN 15)

|   |                         |            |     |     |     |         |                  |  |
|---|-------------------------|------------|-----|-----|-----|---------|------------------|--|
| 1 | ASK Mode                | $V_{MSEL}$ | 1.4 |     | 4   | V       | or open          |  |
| 2 | FSK Mode                | $V_{MSEL}$ | 0   |     | 0.2 | V       |                  |  |
| 3 | Input bias current MSEL | $I_{MSEL}$ |     | -11 | -20 | $\mu A$ | MSEL tied to GND |  |

## FSK DEMODULATOR

|   |                      |              |      |      |      |             |  |  |
|---|----------------------|--------------|------|------|------|-------------|--|--|
| 1 | Demodulation Gain    | $G_{FMDEM}$  |      | 200  |      | $\mu V/kHz$ |  |  |
| 2 | Useable IF Bandwidth | $BW_{IFPLL}$ | 10.2 | 10.7 | 11.2 | MHz         |  |  |

## POWER DOWN MODE

### Signal PDWN (PIN 27)

|   |                    |              |     |  |       |   |  |  |
|---|--------------------|--------------|-----|--|-------|---|--|--|
| 1 | Powerdown Mode On  | $PWDN_{ON}$  | 2.8 |  | $V_S$ | V |  |  |
| 2 | Powerdown Mode Off | $PWDN_{Off}$ | 0   |  | 0.8   | V |  |  |

## Reference

| # | Parameter                                          | Symbol   | Limit Values |      |      | Unit | Test Conditions/<br>Notes   | ■ |
|---|----------------------------------------------------|----------|--------------|------|------|------|-----------------------------|---|
|   |                                                    |          | min.         | typ. | max. |      |                             |   |
| 3 | Start-up Time until valid signal is detected at IF | $T_{SU}$ |              | <1   |      | ms   | depends on the used crystal |   |

## VCO MULTIPLEXER

### Signal FSEL (PIN 11)

|   |                         |            |      |      |      |         |                  |  |
|---|-------------------------|------------|------|------|------|---------|------------------|--|
| 1 | $f_{RF}$ range 434 MHz  | $V_{FSEL}$ | 1.4  |      | 4    | V       | or open          |  |
| 2 | $f_{RF}$ range 869 MHz  | $V_{FSEL}$ | 0    |      | 0.2  | V       |                  |  |
| 3 | Input bias current FSEL | $I_{FSEL}$ | -110 | -200 | -340 | $\mu A$ | FSEL tied to GND |  |

## DATA-SLICER REFERENCE-LEVEL

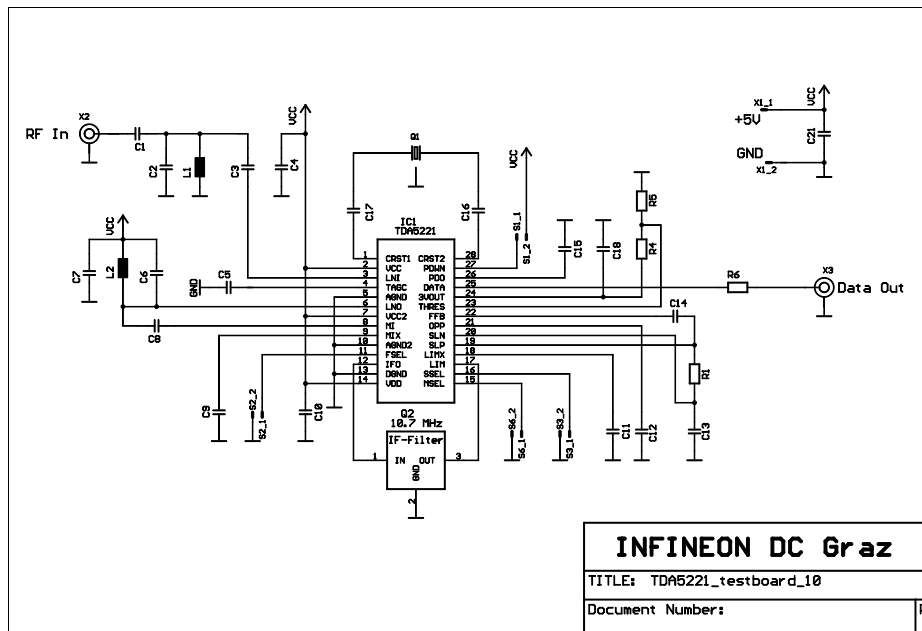
### Signal SSEL (PIN 16), ASK-Mode

|   |                                                                |            |     |     |     |         |                  |  |
|---|----------------------------------------------------------------|------------|-----|-----|-----|---------|------------------|--|
| 1 | Slicer-Reference is voltage at Pin 20 (SLN)                    | $V_{SSEL}$ | 1.4 |     | 4   | V       | or open          |  |
| 2 | Slicer-Reference is approx. 87% of the voltage at Pin 26 (PDO) | $V_{SSEL}$ | 0   |     | 0.2 | V       |                  |  |
| 3 | Input bias current SSEL                                        | $I_{SSEL}$ |     | -11 | -20 | $\mu A$ | SSEL tied to GND |  |

■ Not part of the production test - either verified by design or measured in the Infineon Evalboard as described in Section 4.2.

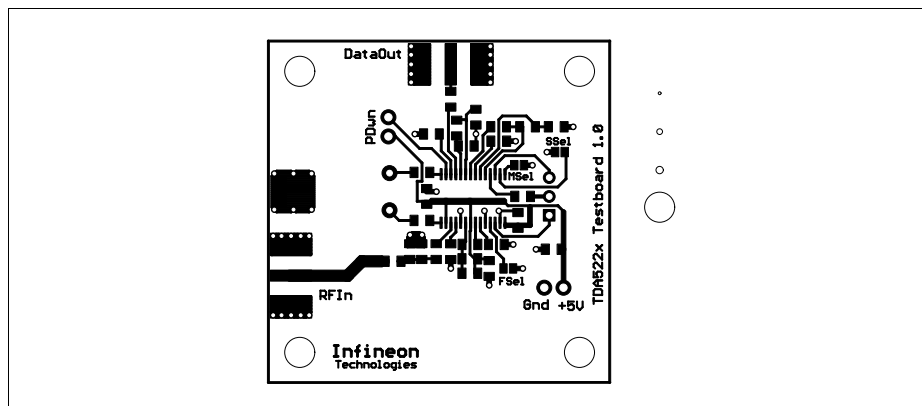
## 4.2 Test Circuit

The device performance parameters marked with ■ in **Section 4.1** were either verified by design or measured on an Infineon evaluation board. This evaluation board can be obtained together with evaluation boards of the accompanying transmitter device TDK5110 in an evaluation kit that may be ordered on the INFINEON Webpage [www.infineon.com/Products](http://www.infineon.com/Products). More information on the kit is available on request.

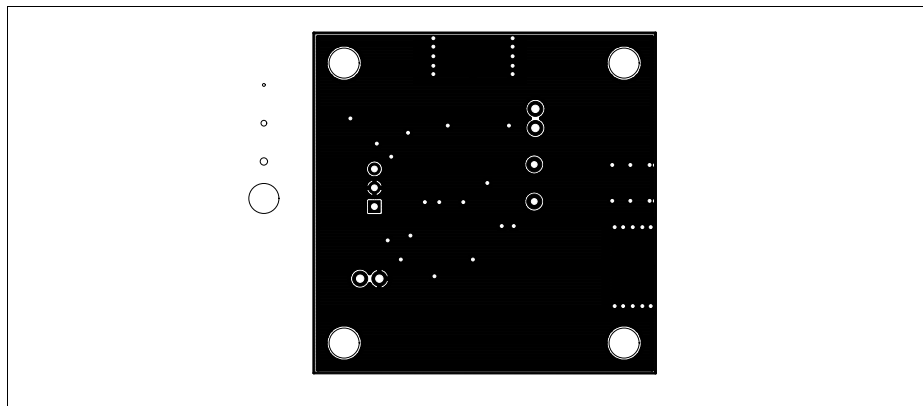


**Figure 15 Schematic of the Evaluation Board**

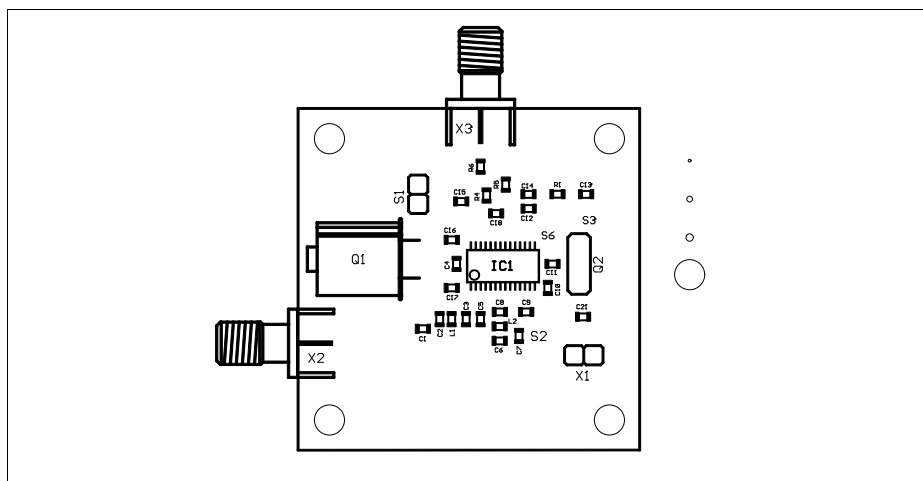
### 4.3 Test Board Layouts



**Figure 16**      **Top Side of the Evaluation Board**



**Figure 17** Bottom Side of the Evaluation Board



**Figure 18** Component Placement on the Evaluation Board

## 4.4 Bill of Materials

The following components are necessary for evaluation of the TDA5220.

**Table 11 Bill of Materials (cont'd)**

| Ref. | Value 434MHz  | Value 868MHz   | Specification        |
|------|---------------|----------------|----------------------|
| C1   | 1pF           | 1pF            | 0805, COG, +/-0.1pF  |
| C2   | 4.7pF         | 3.9pF          | 0805, COG, +/-0.1pF  |
| C3   | 6.8pF         | 5.6pF          | 0805, COG, +/-0.1pF  |
| C4   | 100pF         | 100pF          | 0805, COG, +/-5%     |
| C5   | 47nF          | 47nF           | 1206, X7R, +/-10%    |
| C6   | 10nH          | 3.9pF          | Toko, PTL2012-F10N0G |
| C7   | 100pF         | 100pF          | 0805, COG, +/-5%     |
| C8   | 33pF          | 22pF           | 0805, COG, +/-5%     |
| C9   | 100pF         | 100pF          | 0805, COG, +/-5%     |
| C10  | 10nF          | 10nF           | 0805, X7R, +/-10%    |
| C11  | 10nF          | 10nF           | 0805, X7R, +/-10%    |
| C12  | 220pF         | 220pF          | 0805, COG, +/-5%     |
| C13  | 47nF          | 47nF           | 0805, X7R, +/-10%    |
| C14  | 470pF         | 470pF          | 0805, COG, +/-5%     |
| C15  | 47nF          | 47nF           | 0805, COG, +/-5%     |
| C16  | 8.2pF         | 8.2pF          | 0805, COG, +/-0.1pF  |
| C17  | 18pF          | 18pF           | 0805, COG, +/-1%     |
| C18  | 22nF          | 22nF           | 0805, X7R, +/-5%     |
| C21  | 100nF         | 100nF          | 1206, X7R, +/-10%    |
| IC1  | TDA5220       | TDA5220        | Infineon             |
| L1   | 15nH          | 3.3nH          | Toko, PTL2012-F15N0G |
| L2   | 8.2pF         | 3.9pF          | 0805, COG, +/-0.1pF  |
| Q1   | 13.234375 MHz | 13.4015625 MHz | 1053-922             |
| Q2   | SFE_10.7MA5-A | SFE_10.7MA5-A  | Murata               |
| R1   | 100kΩ         | 100kΩ          | 0805, +/-5%          |
| R4   | 240kΩ         | 240kΩ          | 0805, +/-5%          |
| R5   | 360kΩ         | 360kΩ          | 0805, +/-5%          |

**Reference**

| <b>Ref.</b> | <b>Value 434MHz</b>              | <b>Value 868MHz</b>              | <b>Specification</b>            |
|-------------|----------------------------------|----------------------------------|---------------------------------|
| R6          | 10k $\Omega$                     | 10k $\Omega$                     | 0805, +/-5%                     |
| S1          | STL_2POL                         | STL_2POL                         | 2-pole pin connector            |
| S2          | SOL_JUMP                         | SOL_JUMP                         | SOL_JUMP                        |
| S3          | SOL_JUMP                         | SOL_JUMP                         | SOL_JUMP                        |
| S6          | SOL_JUMP                         | SOL_JUMP                         | SOL_JUMP                        |
| X1          | STL_2POL                         | STL_2POL                         | 2-pole pin connector            |
| X2          | A107-900A (1.6mm<br>gold plated) | A107-900A (1.6mm<br>gold plated) | INPUT OUTPUT<br>ENTERPRISE CORP |
| X3          | A107-900A (1.6mm<br>gold plated) | A107-900A (1.6mm<br>gold plated) | INPUT OUTPUT<br>ENTERPRISE CORP |

Please note that in case of operation at 434MHz a capacitor has to be soldered in place L2 and an inductor in place C6.



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