

TDA7200

ASK/FSK Single Conversion Receiver

Version 1.0

Wireless Control
Components



Never stop thinking.

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Table of Contents	Page
1 Product Description	6
1.1 Overview	6
1.2 Features	6
1.3 Application	6
2 Functional Description	7
2.1 Pin Configuration	7
2.2 Pin Definition and Functions	8
2.3 Functional Block Diagram	15
2.4 Functional Block Description	15
2.4.1 Low Noise Amplifier (LNA)	15
2.4.2 Mixer	16
2.4.3 PLL Synthesizer	16
2.4.4 Crystal Oscillator	16
2.4.5 Limiter	16
2.4.6 FSK Demodulator	17
2.4.7 Data Filter	17
2.4.8 Data Slicer	18
2.4.9 Peak Detector	18
2.4.10 Bandgap Reference Circuitry	18
3 Applications	19
3.1 Application Circuit	19
3.2 Data Filter Design	21
3.3 Crystal Load Capacitance Calculation	22
3.4 Crystal Frequency Calculation	22
3.5 Data Slicer Threshold Generation	23
3.6 ASK/FSK-Data Path Functional Description	25
3.7 FSK Mode	26
3.8 ASK Mode	28
3.9 Principle of the Precharge Circuit	28
4 Reference	32
4.1 Electrical Data	32
4.1.1 Absolute Maximum Ratings	32
4.1.2 Operating Range	32
4.1.3 AC/DC Characteristics at $T_{AMB} = 25^{\circ}\text{C}$	33
4.1.4 AC/DC Characteristics at $T_{AMB} = -20^{\circ}\text{C} \dots +70^{\circ}\text{C}$	38
4.2 Test Circuit	42
4.3 Test Board Layouts	43
4.4 Bill of Materials	44
5 Package Outlines	46

1 Product Description

1.1 Overview

The IC is a very low power consumption single chip FSK/ASK Superheterodyne Receiver (SHR) for the frequency band 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 ($I_s = 5.7$ mA typ. in FSK mode, $I_s = 5.0$ mA typ. in ASK mode)
- 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 (-20 to +70°C)
- FSK sensitivity better than -100 dBm over specified temperature range (-20 to +70°C)
- 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

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

Table 1 Order Information

Type	Ordering Code	Package
TDA7200	SP000296473	PG-TSSOP-28

2 Functional Description

2.1 Pin Configuration

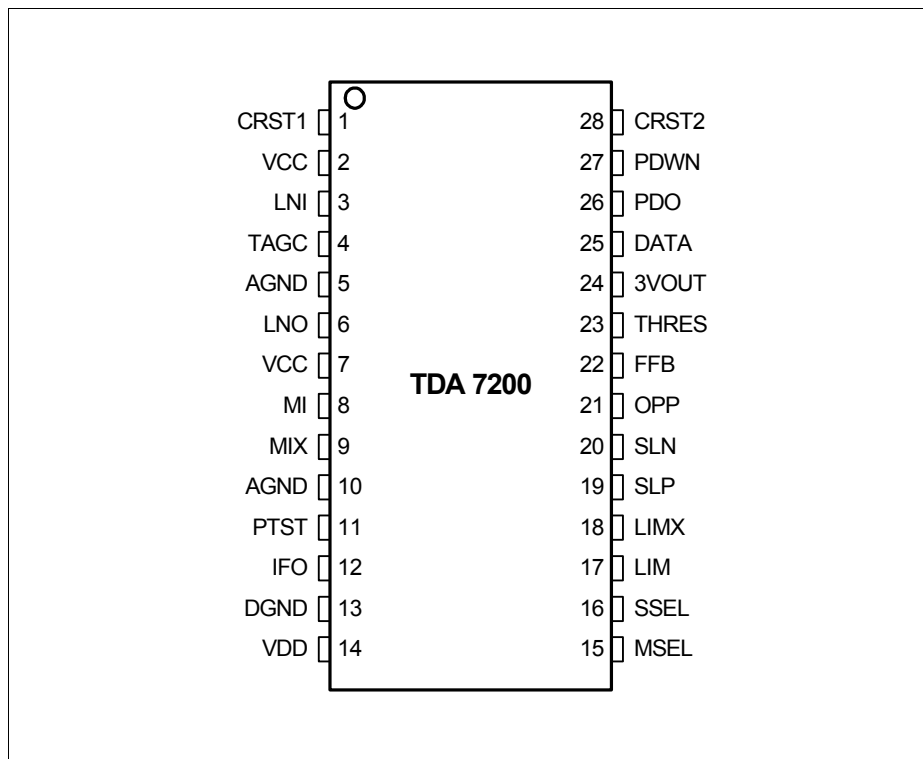
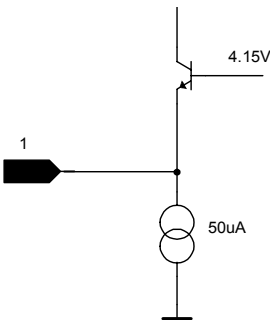
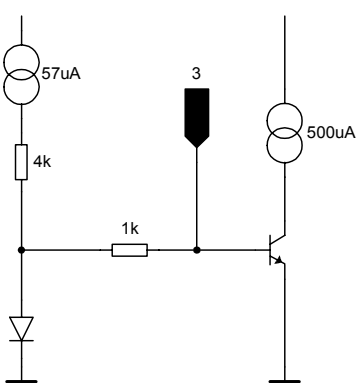


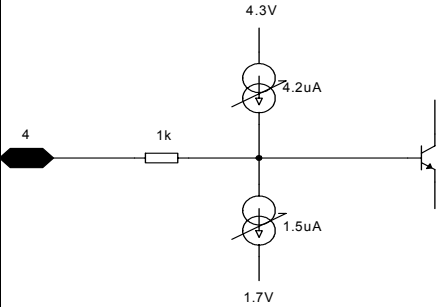
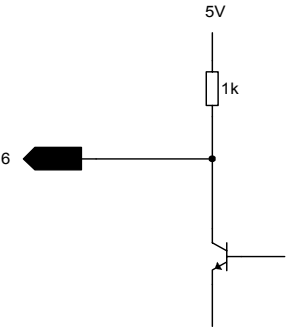
Figure 1 Pin Configuration

2.2 Pin Definition and Functions

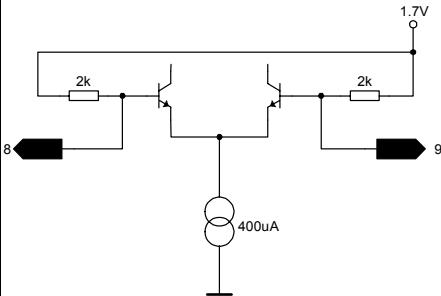
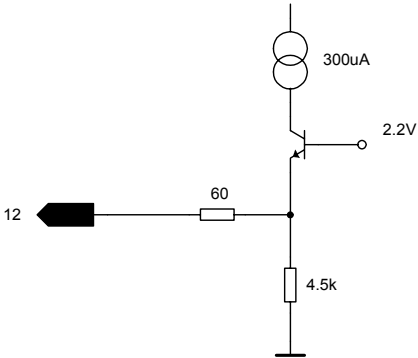
Table 2 Pin Defintion and Function

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

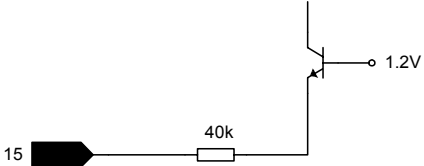
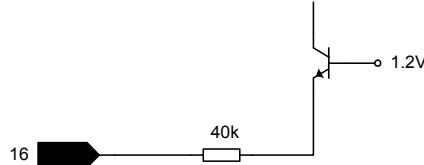
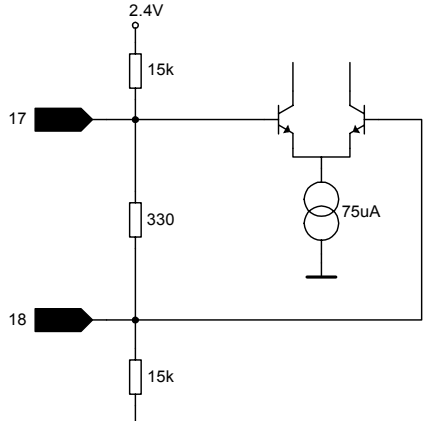
Functional Description

Pin No.	Symbol	Equivalent I/O Schematic	Function
4	TAGC	 <p>The schematic for Pin 4 (TAGC) shows a connection to a 4.3V supply through a 1k resistor. The pin is also connected to a 1.7V supply through a 1.5uA current source and to a 4.2uA current source. The pin is also connected to a transistor base.</p>	AGC Time Constant Control
5	AGND		Analogue Ground Return
6	LNO	 <p>The schematic for Pin 6 (LNO) shows a connection to a 5V supply through a 1k resistor. The pin is also connected to a transistor base.</p>	LNA Output
7	VCC		5V Supply

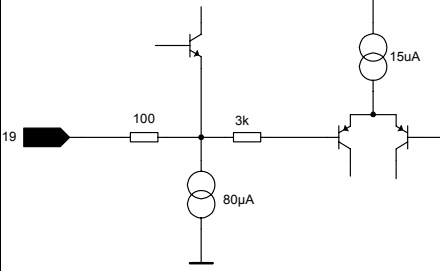
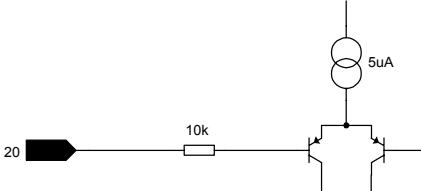
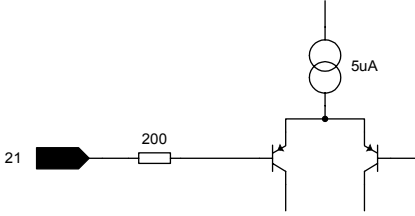
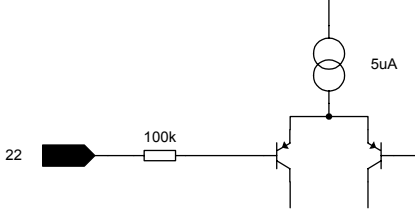
Functional Description

Pin No.	Symbol	Equivalent I/O Schematic	Function
8	MI		Mixer Input
9	MIX		Complementary Mixer Input
10	AGND		Analogue Ground Return
11	PTST		has to be left open
12	IFO		10.7 MHz IF Mixer Output
13	DGND		Digital Ground Return
14	VDD		5V Supply (PLL Counter Circuitry)

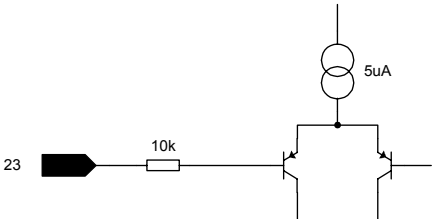
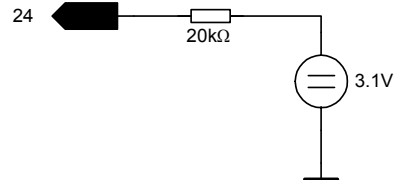
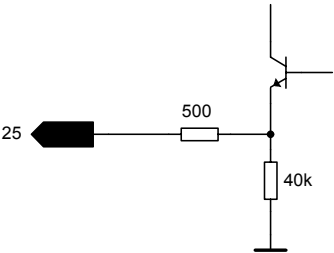
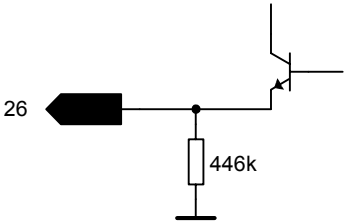
Functional Description

Pin No.	Symbol	Equivalent I/O Schematic	Function
15	MSEL		ASK/FSK Modulation Format Sector
16	SSEL		Data Slicer Reference Level Sector
17	LIM		Limiter Input
18	LIMX		Complementary Limiter Input

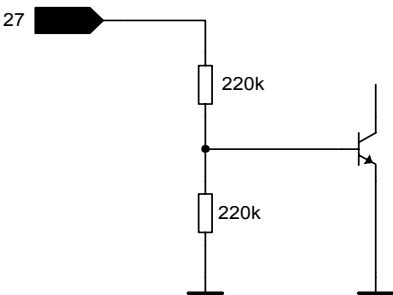
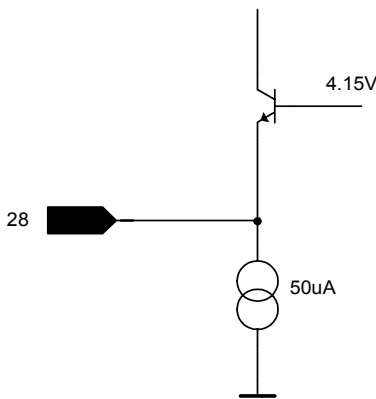
Functional Description

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

2.3 Functional Block Diagram

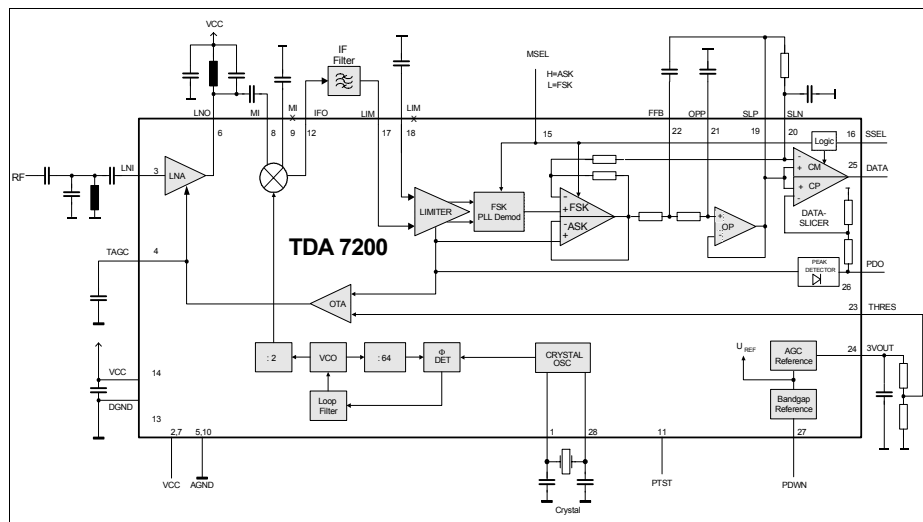


Figure 2 Block Diagram

2.4 Functional Block Description

2.4.1 Low Noise Amplifier (LNA)

The LNA is an on-chip cascode amplifier with a voltage gain of 15 to 20dB. The gain figure is determined by the external matching networks situated ahead of LNA and between the LNA output **LNO** (Pin 6) and the Mixer Inputs **MI** and **MIX** (Pins 8 and 9). The noise figure of the LNA is approximately 3dB, the current consumption is 500μA. The gain can be reduced by approximately 18dB. The switching point of this AGC action can be determined externally by applying a threshold voltage at the **THRES** pin (Pin 23). This voltage is compared internally with the received signal (RSSI) level generated by the limiter circuitry. In case that the RSSI level is higher than the threshold voltage the LNA gain is reduced and vice versa. The threshold voltage can be generated by attaching a voltage divider between the **3VOUT** pin (Pin 24) which provides a temperature stable 3V output generated from the internal bandgap voltage and the **THRES** pin as described in [Section 3.1](#). The time constant of the AGC action can be determined by connecting a capacitor to the **TAGC** pin (Pin 4) and should be chosen along with the appropriate threshold voltage according to the intended operating case and interference scenario to be expected during operation. The optimum choice of AGC time constant and the threshold voltage is described in [Section 3.1](#).

Functional Description**2.4.2 Mixer**

The Double Balanced Mixer downconverts the input frequency (RF) in the range of 400-440MHz 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 Ω 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 frequency range of the VCO guaranteed over production spread and the specified temperature range is 820 to 860MHz. The oscillator signal is fed both to the synthesiser divider chain and to the downconverting mixer. The VCO 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 range is 400 to 420MHz and 420 to 440MHz - see also [Section 3.4](#).

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 Ω 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 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.

Functional Description

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 μ 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 420MHz. In case of receive frequencies below 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 Ω on-chip resistors. Along with two external capacitors a 2nd order Sallen-Key low pass filter is formed. The selection of the capacitor values is described in [Section 3.2](#).

Functional Description
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 PDWN Pin Operating States

PDWN	Operating State
Open or tied to ground	Powerdown Mode
Tied to Vs	Receiver On

3 Applications

3.1 Application Circuit

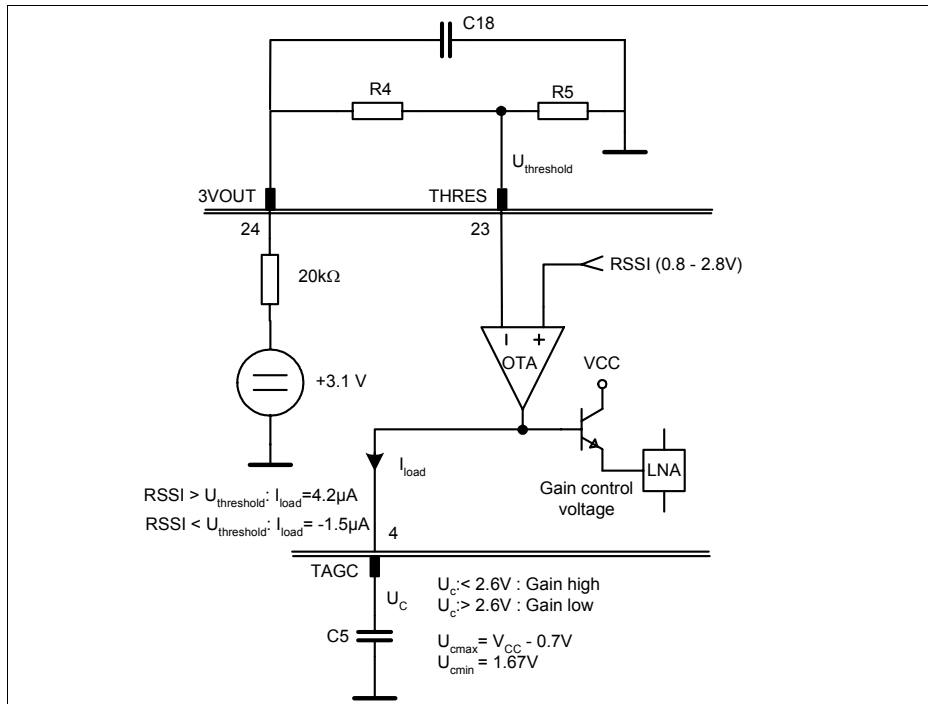


Figure 3 LNA Automatic Gain Control Circuitry

The LNA automatic gain control circuitry consists of an operational transimpedance amplifier that is used to compare the received signal strength signal (RSSI) generated by the Limiter with an externally provided threshold voltage U_{thres} . As shown in the following figure the threshold voltage can have any value between approximately 0.8 and 2.8V to provide a switching point within the receive signal dynamic range.

This voltage U_{thres} is applied to the **THRES** pin (Pin 23). The threshold voltage can be generated by attaching a voltage divider between the **3VOUT** pin (Pin 24) which provides a temperature stable 3V output generated from the internal bandgap voltage and the **THRES** pin. If the RSSI level generated by the Limiter is higher than U_{thres} , the OTA generates a positive current I_{load} . This yields a voltage rise on the **TAGC** pin (Pin 4). Otherwise, the OTA generates a negative current. These currents do not have the same values in order to achieve a fast-attack and slow-release action of the

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

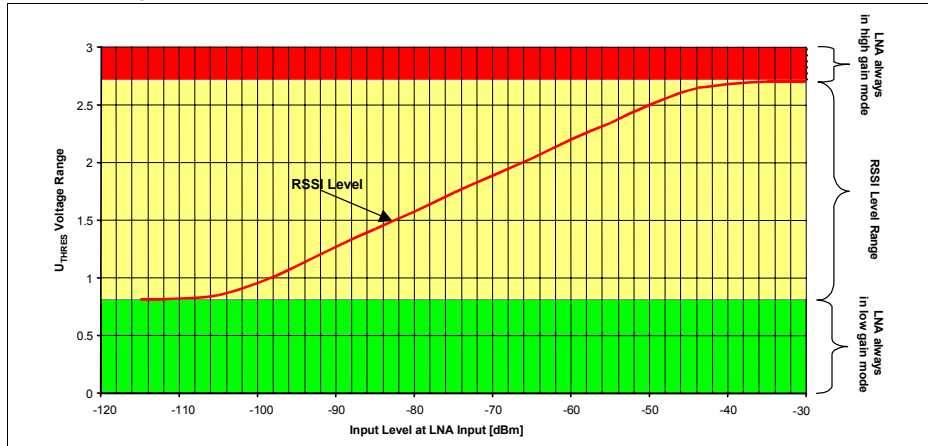


Figure 4 RSSI Level and Permissible AGC Threshold Levels

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 μ 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 Ω in order to yield 3V at the **3VOUT** pin. R1 can thus be chosen as 240k Ω , R2 as 360k Ω to yield an overall **3VOUT** output current of 5 μ A¹⁾ 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 Ω 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 formulas¹⁾.

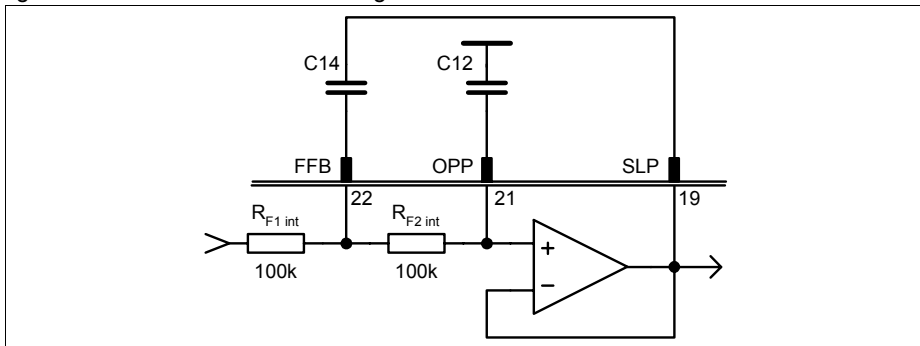


Figure 5 Data Filter Design

with $R_{F1int} = R_{F2int} = R$

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

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 $R=100\text{k}\Omega$:
 $C14=450\text{pF}$, $C12=225\text{pF}$

¹⁾ 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.

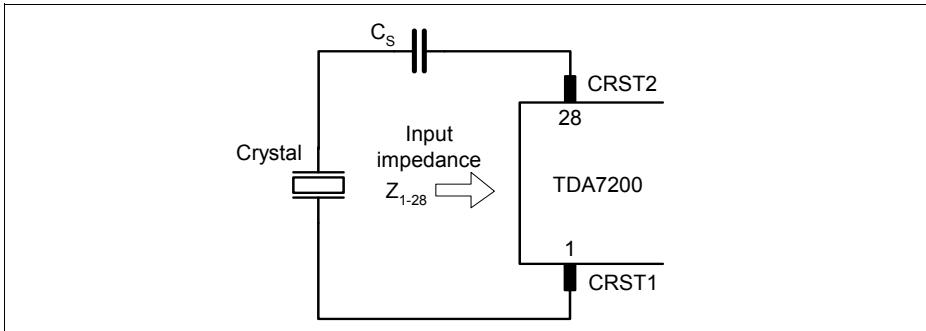


Figure 6 Determination of Series Capacitance Vale for the Quartz Oscillator

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

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 400 and 440MHz. The VCO signal is divided by 2 before applied to the mixer. This local oscillator signal can be used to downconvert the RF signals both with high- or low-side injection at the mixer. High-side

injection of the local oscillator has to be used for receive frequencies 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 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 ratio in the PLL is 32.

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

$$f_{QU} = \frac{f_{RF} \pm 10.7}{32}$$

with f_{RF} receive frequency
 f_{LO} local oscillator (PLL) frequency ($f_{RF} \pm 10.7$)
 f_{QU} quartz crystal oscillator frequency
 32 ratio of local oscillator (PLL) frequency and crystal frequency.

This yields the following example:

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

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 20kΩ.

T_A has to be calculated as

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

and

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

$R1$, R_{F3int} , R_{F4int} and $C13$ see also [Figure 7](#) and [Figure 9](#)

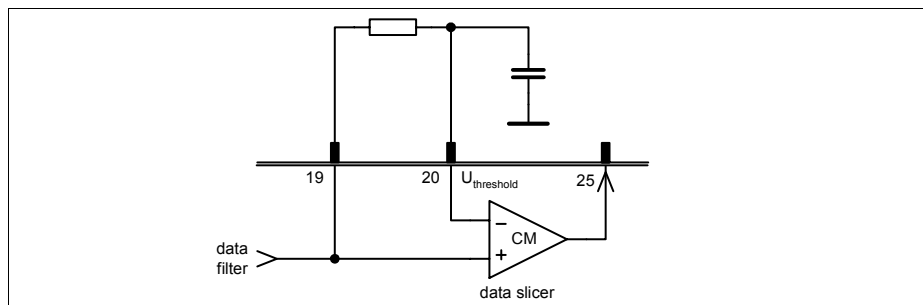


Figure 7 Data Slicer Threshold Generation with External R-C Integrator

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 [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.

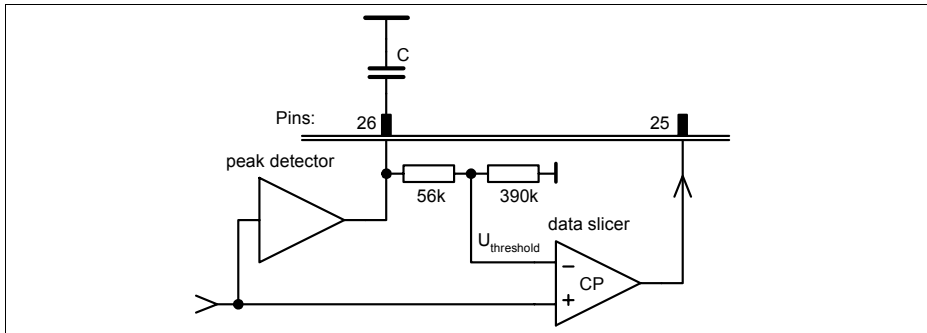


Figure 8 Data Slicer Threshold Generation Utilising the Peak Detector

3.6 ASK/FSK-Data Path Functional Description

The TDA7200 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 [Figure 9](#).

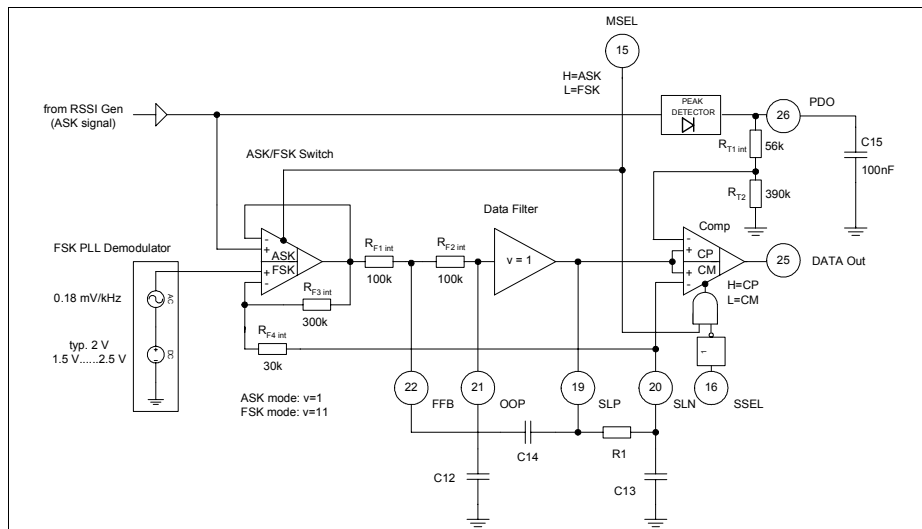


Figure 9 ASK/FSK mode datapath

3.7 FSK Mode

The FSK datapath has a bandpass characterisctic due to the feedback shown above (highpass) and the data filter (lowpass). The lower cutoff frequency f_2 is determined by the external RC-combination. The upper cutoff frequency f_3 is determined by the data filter bandwidth.

The demodulation gain of the FSK PLL demodulator is $200\mu\text{V/kHz}$. This gain is increased by the gain v of the FSK switch, which is 11. Therefore the resulting dynamic gain of this circuit is 2.2mV/kHz within the bandpass. The gain for the DC content of FSK signal remains at $200\mu\text{V/kHz}$. The cut-off frequencies of the bandpass have to be chosen such that the spectrum of the data signal is influenced in an acceptable amount.

In case that the user data is containing long sequences of logical zeroes the effect of the drift-off of the bit slicer threshold voltage can be lowered if the offset voltage inherent at the negative input of the slicer comparator (Pin20) is used. The comparator has no hysteresis built in.

This offset voltage is generated by the bias current of the negative input of the comparator (i.e. 20nA) running over the external resistor R . This voltage raises the voltage appearing at pin 20 (e.g. 1mV with $R = 100\text{k}\Omega$). In order to obtain benefit of this

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.

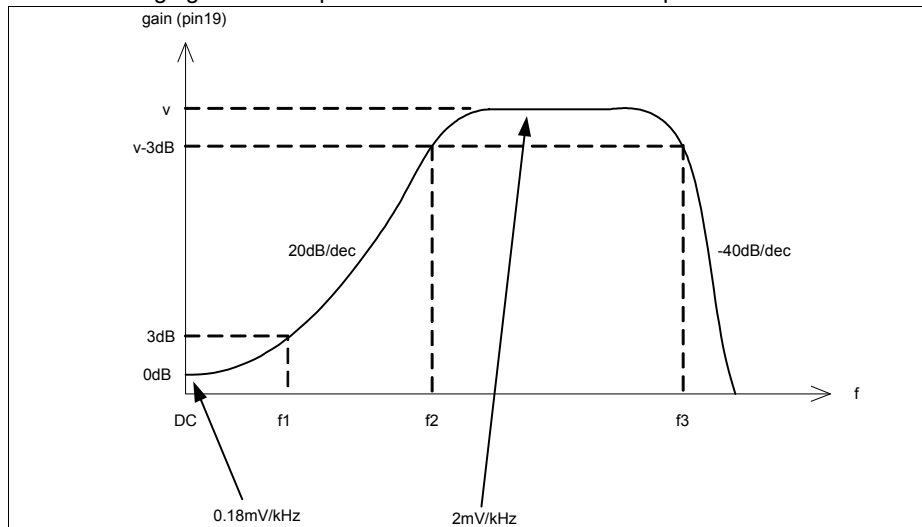


Figure 10 Frequency characteristic in case of FSK mode

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](#)

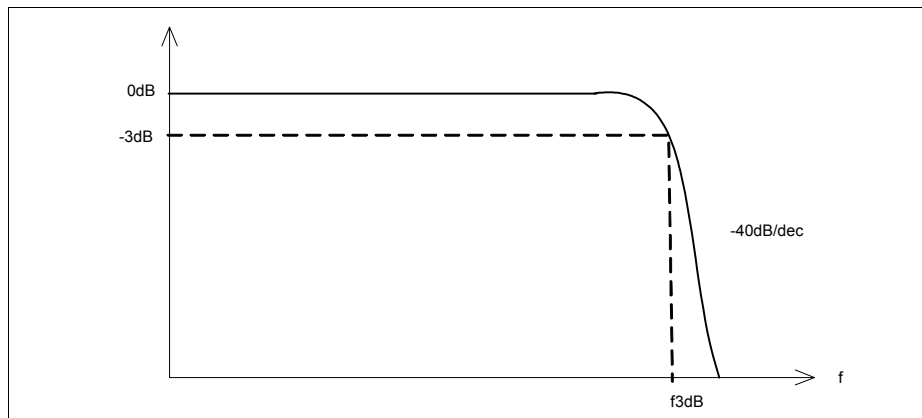


Figure 11 Frequency characteristic in case of ASK mode

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 Ω resistor appearing in parallel to R1 as can be seen in [Figure 9](#). Apart from this a resistor value of 100k Ω leads to a voltage offset of 1mV at the comparator input. The resulting startup time constant τ_1 can be calculated with:

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

In case R1 is chosen to be 100k Ω 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.

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

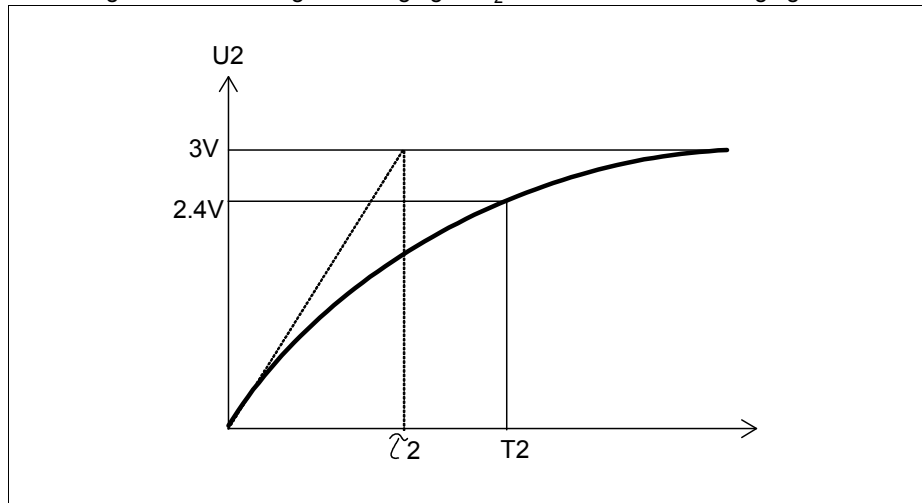


Figure 13 Voltage appearing on C18 during precharging process

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:

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

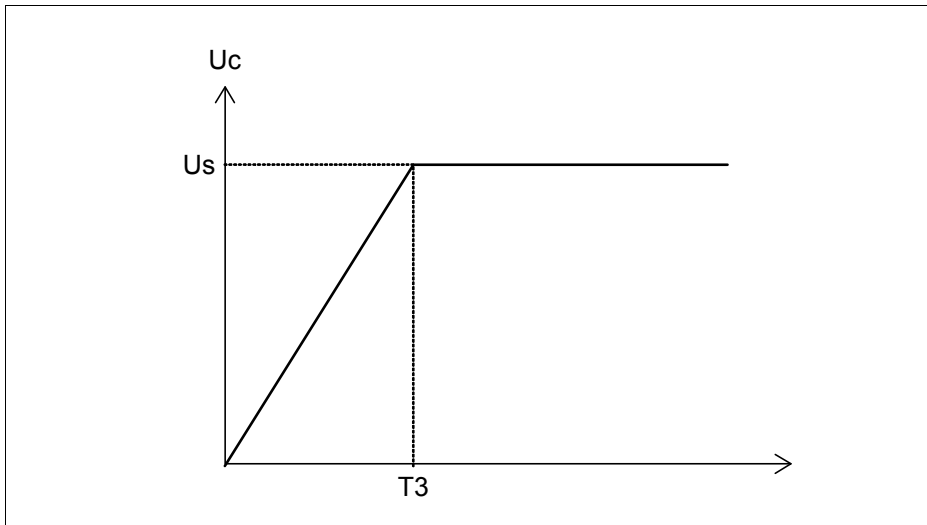


Figure 14 Voltage transient on capacitor C13 attached to pin 20

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 0.64ms but stops already after 0.49ms 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 3V 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 will result. The AC/DC characteristic limits are not guaranteed.*

Table 6 Absolute Maximum Ratings, $T_{amb} = -20\text{ °C} \dots +70\text{ °C}$

#	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 ESD integrity Pins 1,3,6,28	V_{ESD}		+2	kV	HBM according to MIL STD 883D, method 3015.7
				+1.5	kV	

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 7 **Operating Range, $T_{amb} = -20\text{ °C} \dots +70\text{ °C}$**

#	Parameter	Symbol	Limit Values		Unit	Test Conditions/ Notes	L
			min.	max.			
1	Supply Current	I_{SF} I_{SA}	3.7 3.0	7.7 7.0	mA mA	FSK Mode ASK Mode	
2	Receiver Input Level ASK FSK, frequ. dev. $\pm 50\text{kHz}$	RF_{in}	-106 -100	-13 -13	dBm dBm	@source impedance 50 Ω BER 2E-3, average power level, Manchester encoded datarate 4kBit, 280KHz IF Bandwidth	■
3	LNI Input Frequency	f_{RF}	400	440	MHz		
4	MI/X Input Frequency	f_{MI}	400	440	MHz		
5	3dB IF Frequency Range ASK FSK	$f_{IF -3dB}$	5 10.4	23 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, LNA high gain state	V_{THRES}	2.8	$V_S - 1$	V		
9	Gain Control Voltage, 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 8 AC/DC Characteristics with T_A 25°C, V_{CC} =4.5 ... 5.5 V

#	Parameter	Symbol	Limit Values			Unit	Test Conditions/ 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, FSK mode	I_{SA}	4.9	5.7	6.5	mA	Pin 15 (MSEL) tied to GND	
3	Supply current, device operating, ASK mode	I_{SA}	4.2	5	5.8	mA	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., $\pm 50kHz$ pk. dev.	■
3	Input impedance $f_{RF} = 434$ MHz	$S_{11\ LNA}$	0.873 / -34.7 deg					■
4	Input level @ 1dB compression	$P1dB_{LNA}$		-15		dBm		■
5	Input 3 rd order intercept point $f_{RF} = 434$ MHz	$IIP3_{LNA}$		-10		dBm	matched input	■
6	LO signal feedthrough at antenna port	LO_{LNI}			-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	Output impedance, $f_{RF} = 434$ MHz	$S_{22\ LNA}$	0.886 / -12.9 deg					■
3	Voltage Gain Antenna to IFO $f_{RF} = 434$ MHz	$G_{AntMixer-Out}$		42		dB		

Reference

#	Parameter	Symbol	Limit Values			Unit	Test Conditions/ Notes	L
			min.	typ.	max.			

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 level @ 1dB C. P. $f_{RF} = 434$ MHz	$P1dB_{LNA}$		-18		dBm	matched input	■
3	Input 3 rd order intercept point $f_{RF} = 434$ MHz	$IIP3_{LNA}$		-10		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	Output impedance, $f_{RF} = 434$ MHz	$S_{22\ LNA}$	0.897 / -13.6 deg					■
3	Voltage Gain Antenna to IFO $f_{RF} = 434$ MHz	$G_{AntMixer-Out}$		22		dB		

Signal 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	μA	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}	-3.6	-4.2	-5.5	μA	$RSSI > V_{THRES}$	
2	Current in, LNA high gain state	I_{TAGC_in}	1	1.5	2.2	μA	$RSSI < V_{THRES}$	

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

1	Input impedance, $f_{RF} = 434$ MHz	$S_{11\ MIX}$	0.942 / -14.4 deg					■
2	Input 3 rd order intercept point $f_{RF} = 434$ MHz	$IIP3_{MIX}$		-28		dBm		■

Reference

#	Parameter	Symbol	Limit Values			Unit	Test Conditions/ Notes	L
			min.	typ.	max.			

Signal Output IFO (PIN 12)

1	Output impedance	Z_{IFO}		330		Ω		■
2	Conversion Voltage Gain $f_{RF} = 434$ MHz	G_{MIX}		19		dB		

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

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

DATA FILTER

1	Useable bandwidth	$BW_{BB\ FILT}$			100	kHz		■
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	

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 μ A	

Slicer, Negative Input (PIN 20)

1	Precharge Current Out	I_{PCH_SLN}	-100	-220	-300	μ A	see Section 4.2 .	
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#	Parameter	Symbol	Limit Values			Unit	Test Conditions/ Notes	L
			min.	typ.	max.			

PEAK DETECTOR

Signal Output PDO (PIN 26)

1	Load current	I_{load}	-500			μA	static load current must not exceed -500 μA	
2	Internal resistive load	R	357	446	535	k Ω		

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		Ω		■
3	Load Capacitance @ ~13MHz	$C_{CRSTmax} = C1$			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	μA	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		

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

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	μA	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 $T_{AMB} = -20^{\circ}C \dots +70^{\circ}C$

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

Table 9 AC/DC Characteristics with $T_{AMB} = -20^{\circ}C \dots +70^{\circ}C$, $V_{CC} = 4.5 \dots 5.5 V$

#	Parameter	Symbol	Limit Values			Unit	Test Conditions/ 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 FSK mode	I_{SA}	3.7	5.7	7.7	mA	Pin 15 (MSEL) tied to GND	

#	Parameter	Symbol	Limit Values			Unit	Test Conditions/ Notes	■
			min.	typ.	max.			
5	Supply current, device operating in ASK mode	I_{SA}	3	5	7	mA	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	μA	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	μA	$RSSI > V_{THRES}$	
2	Current in, LNA high gain state	I_{TAGC_in}	0.5	1.5	5	μA	$RSSI < V_{THRES}$	

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		
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DATA FILTER

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

#	Parameter	Symbol	Limit Values			Unit	Test Conditions/ Notes	■
			min.	typ.	max.			

SLICER

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=200μA	

Slicer, Negative Input (PIN 20)

1	Precharge Current Out	I_{PCH_SLN}	-100	-220	-300	μA	see Section 4.2	
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PEAK DETECTOR

Signal Output PDO (PIN 26)

1	Load current	I_{load}	-400			μA	static load current must not exceed -500μA	
2	Internal resistive load	R	356	446	575	kΩ		

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	μA	MSEL tied to GND	

Reference

#	Parameter	Symbol	Limit Values			Unit	Test Conditions/ Notes	■
			min.	typ.	max.			

FSK DEMODULATOR

1	Demodulation Gain	G_{FMDEM}		200		$\mu\text{V}/\text{kHz}$		
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		
3	Start-up Time until valid signal is detected at IF	T_{SU}		<1		ms	depends on the used crystal	

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	μA	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 TDA7100 in an evaluation kit that may be ordered on the INFINEON Webpage www.infineon.com/Products. More information on the kit is available on request.

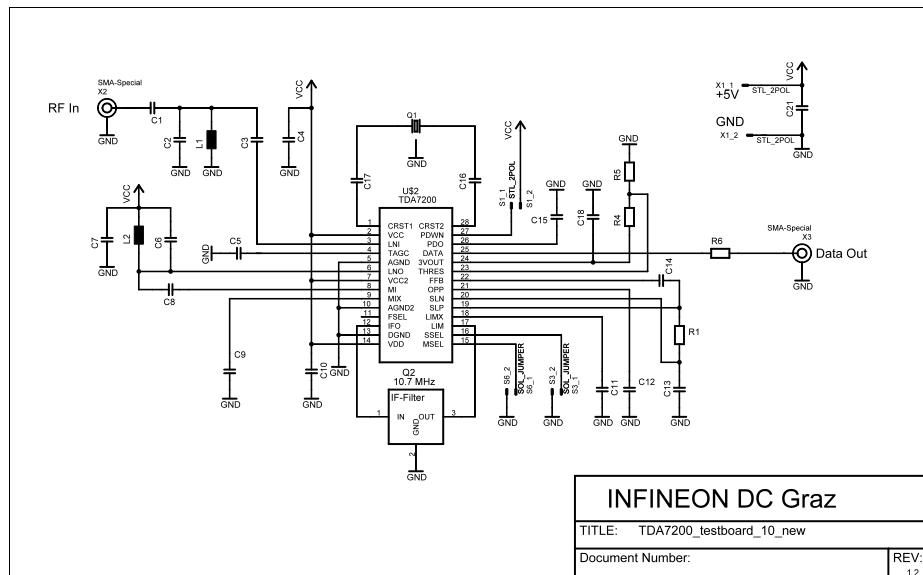


Figure 15 Schematic of the Evaluation Board

4.3 Test Board Layouts

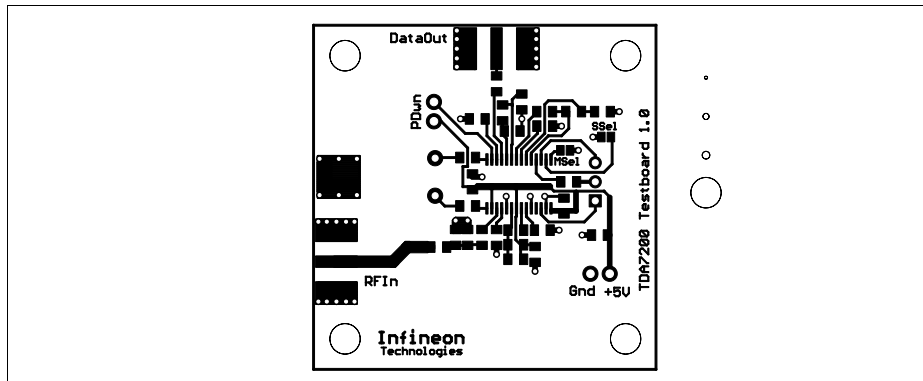


Figure 16 Top Side of the Evaluation Board

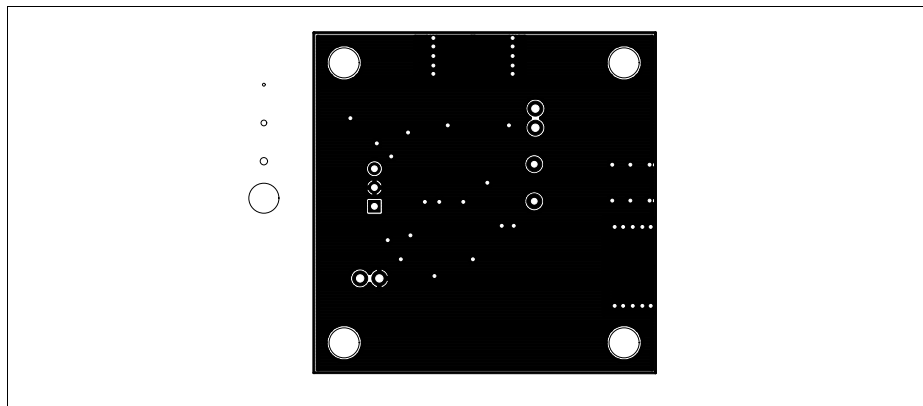


Figure 17 Bottom Side of the Evaluation Board

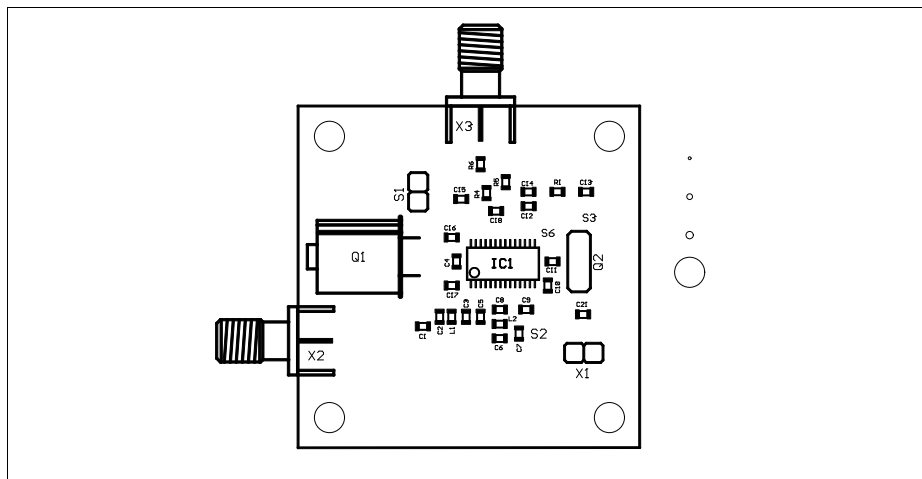


Figure 18 **Component Placement on the Evaluation Board**

4.4 **Bill of Materials**

The following components are necessary for evaluation of the TDA7200.

Table 10 **Bill of Materials (cont'd)**

Ref.	Value	Specification
C1	1pF	0805, COG, +/-0.1pF
C2	4.7pF	0805, COG, +/-0.1pF
C3	6.8pF	0805, COG, +/-0.1pF
C4	100pF	0805, COG, +/-5%
C5	47nF	1206, X7R, +/-10%
C6	10nH	Toko, PTL2012-F10N0G
C7	100pF	0805, COG, +/-5%
C8	33pF	0805, COG, +/-5%
C9	100pF	0805, COG, +/-5%
C10	10nF	0805, X7R, +/-10%
C11	10nF	0805, X7R, +/-10%

Ref.	Value	Specification
C12	220pF	0805, COG, +/-5%
C13	47nF	0805, X7R, +/-10%
C14	470pF	0805, COG, +/-5%
C15	47nF	0805, COG, +/-5%
C16	8.2pF	0805, COG, +/-0.1pF
C17	18pF	0805, COG, +/-1%
C18	22nF	0805, X7R, +/-5%
C21	100nF	1206, X7R, +/-10%
IC1	TDA7200	Infineon
L1	15nH	Toko, PTL2012-F15N0G
L2	8.2pF	0805, COG, +/-0.1pF
Q1	13.234375 MHz	1053-922
Q2	SFE_10.7MA5-A	Murata
R1	100k Ω	0805, +/-5%
R4	240k Ω	0805, +/-5%
R5	360k Ω	0805, +/-5%
R6	10k Ω	0805, +/-5%
S1	STL_2POL	2-pole pin connector
S2	SOL_JUMP	SOL_JUMP
S3	SOL_JUMP	SOL_JUMP
S6	SOL_JUMP	SOL_JUMP
X1	STL_2POL	2-pole pin connector
X2	A107-900A (1.6mm gold plated)	INPUT OUTPUT ENTERPRISE CORP
X3	A107-900A (1.6mm gold plated)	INPUT OUTPUT ENTERPRISE CORP

Please note that a capacitor has to be soldered in place L2 and an inductor in place C6.

List of Tables	Page
Table 1	Order Information. 6
Table 2	Pin Defintion and Function. 8
Table 3	MSEL Pin Operating States. 17
Table 4	SSEL Pin Operating States. 18
Table 5	PDWN Pin Operating States. 18
Table 6	Absolute Maximum Ratings, $T_{amb} = -20\text{ °C} \dots +70\text{ °C}$ 32
Table 7	Operating Range, $T_{amb} = -20\text{ °C} \dots +70\text{ °C}$ 33
Table 8	AC/DC Characteristics with $T_A\ 25\text{ °C}$, $V_{CC}=4.5 \dots 5.5\text{ V}$ 34
Table 9	AC/DC Characteristics with $T_{AMB} = -20\text{ °C} \dots +70\text{ °C}$, $V_{CC} = 4.5 \dots 5.5\text{ V}$ 38
Table 10	Bill of Materials. 44

List of Figures
Page

Figure 1	Pin Configuration	7
Figure 2	Block Diagram	15
Figure 3	LNA Automatic Gain Control Circuitry	19
Figure 4	RSSI Level and Permissive AGC Threshold Levels	20
Figure 5	Data Filter Design	21
Figure 6	Determination of Series Capacitance Vale for the Quartz Oscillator . .	22
Figure 7	Data Slicer Threshold Generation with External R-C Integrator	24
Figure 8	Data Slicer Threshold Generation Utilising the Peak Detector	25
Figure 9	ASK/FSK mode datapath	26
Figure 10	Frequency characteristic in case of FSK mode	27
Figure 11	Frequency characteristic in case of ASK mode	28
Figure 12	Principle of the precharge circuit	29
Figure 13	Voltage appearing on C18 during precharging process	30
Figure 14	Voltage transient on capacitor C13 attached to pin 20	31
Figure 15	Schematic of the Evaluation Board	42
Figure 16	Top Side of the Evaluation Board	43
Figure 17	Bottom Side of the Evaluation Board	43
Figure 18	Component Placement on the Evaluation Board	44
Figure 19	PG-TSSOP-28 package outlines	46

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