

# TDA7110F

434 MHz ASK/FSK Transmitter in 10-pin  
Package

Version 1.0

Wireless Control  
Components



Never stop thinking.

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V 1.0

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

## 1.1 Overview

The TDA7110F is a single chip ASK/FSK transmitter for operation in the frequency band 433 ... 435 MHz. The IC offers a high level of integration and needs only a few external components. The device contains a fully integrated PLL synthesizer and a high efficiency power amplifier to drive a loop antenna. A special circuit design and an unique power amplifier design are used to save current consumption and therefore to save battery life. Additional features are a power down mode and a divided clock output.

## 1.2 Features

- fully integrated frequency synthesizer
- VCO without external components
- ASK and FSK modulation
- frequency range 433 ... 435 MHz
- high efficiency power amplifier (typically 10 dBm)
- low supply current
- voltage supply range 2.1 ... 4 V
- temperature range  $-40 \dots +85^{\circ}\text{C}$
- power down mode
- crystal oscillator 13.56 MHz
- FSK-switch
- divided clock output for  $\mu\text{C}$
- low external component count

## 1.3 Application

- Keyless entry systems
- Remote control systems
- Alarm systems
- Communication systems

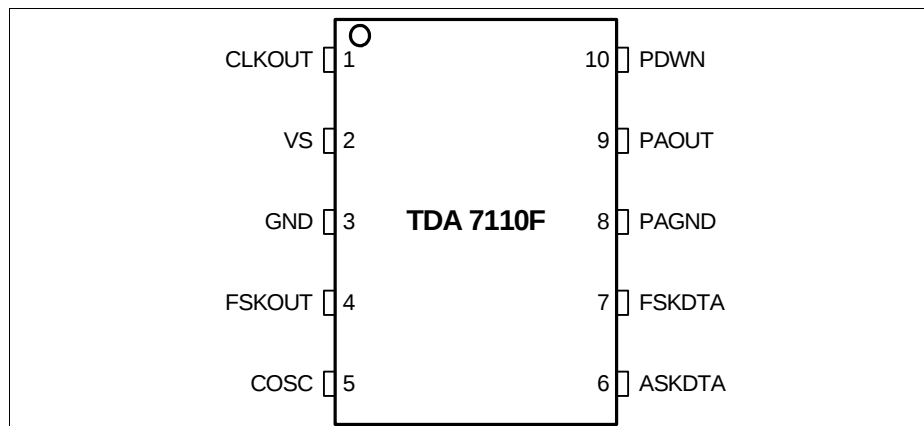
## 1.4 Order Information

**Table 1**      **Order Information**

| Type                       | Ordering Code | Package     |
|----------------------------|---------------|-------------|
| TDA7110F                   | SP000611108   | PG-TSSOP-10 |
| available on tape and reel |               |             |

## 2 Functional Description

### 2.1 Pin Configuration



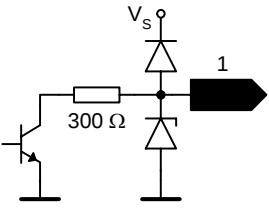
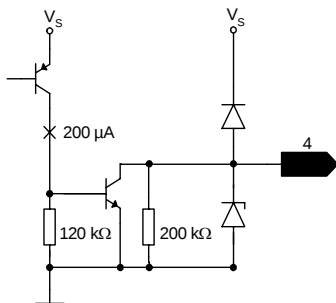
**Figure 1 IC Pin Configuration**

### 2.2 Pin Definition and Functions

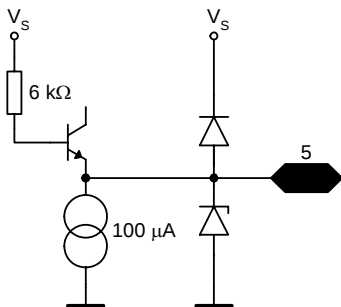
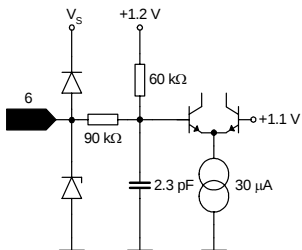
**Table 2 Pin Definition and Functions - Overview**

| Pin No. | Symbol | Function                             |
|---------|--------|--------------------------------------|
| 1       | CLKOUT | Clock Driver Output (847.5 kHz)      |
| 2       | VS     | Voltage Supply                       |
| 3       | GND    | Ground                               |
| 4       | FSKOUT | Frequency Shift Keying Switch Output |
| 5       | COSC   | Crystal Oscillator Input (13.56 MHz) |
| 6       | ASKDTA | Amplitude Shift Keying Data Input    |
| 7       | FSKDTA | Frequency Shift Keying Data Input    |
| 8       | PAGND  | Power Amplifier Ground               |
| 9       | PAOUT  | Power Amplifier Output (434 MHz)     |
| 10      | PDWN   | Power Down Mode Control              |

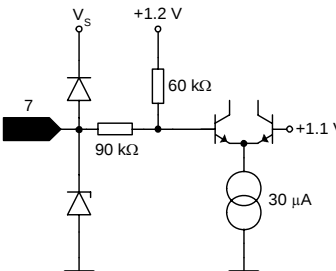
**Table 3 Pin Definition and Function<sup>1</sup>**

| Pin No. | Symbol | Interface Schematic                                                                | Function                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------|--------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | CLKOUT |   | <p>Clock output to supply an external device.</p> <p>An external pull-up resistor has to be added in accordance to the driving requirements of the external device.</p> <p>The clock frequency is 847.5 kHz.</p>                                                                                                                                                                                                                                     |
| 2       | VS     |                                                                                    | <p>This pin is the positive supply of the transmitter electronics.</p> <p>An RF bypass capacitor should be connected directly to this pin and returned to GND (pin 3) as short as possible.</p>                                                                                                                                                                                                                                                      |
| 3       | GND    |                                                                                    | General ground connection.                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 4       | FSKOUT |  | <p>This pin is connected to a switch to GND (pin 3).</p> <p>The switch is closed when the signal at FSKDTA (pin 7) is in a logic low state.</p> <p>The switch is open when the signal at FSKDTA (pin 7) is in a logic high state.</p> <p>FSKOUT can switch an additional capacitor to the reference crystal network to pull the crystal frequency by an amount resulting in the desired FSK frequency shift of the transmitter output frequency.</p> |

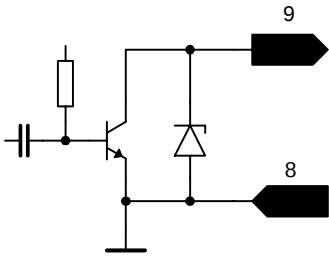
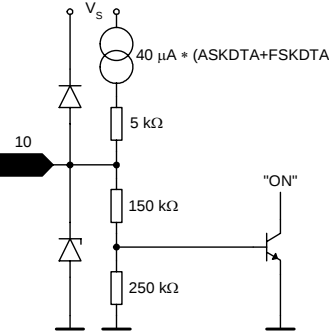
**Functional Description**

| Pin No. | Symbol | Interface Schematic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Function                                                                                                                                                                                                                                       |
|---------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5       | COSC   |  <p>The schematic for Pin 5 (COSC) shows a reference oscillator circuit. A supply voltage <math>V_S</math> is connected to a <math>6\text{ k}\Omega</math> resistor, which is in series with a transistor. The transistor's emitter is grounded, and its collector is connected to a diode. The other end of the diode is connected to Pin 5. A current source of <math>100\text{ }\mu\text{A}</math> is connected to the junction between the resistor and the transistor. Another diode is connected in series with the first one, also leading to Pin 5. The second diode's emitter is grounded.</p>                                                                                                                                   | <p>This pin is connected to the reference oscillator circuit. The reference oscillator is working as a negative impedance converter. It presents a negative resistance in series to an inductance at the COSC pin.</p>                         |
| 6       | ASKDTA |  <p>The schematic for Pin 6 (ASKDTA) shows a digital amplitude modulation control circuit. Pin 6 is connected to a diode, which is in series with a <math>90\text{ k}\Omega</math> resistor. The other end of the resistor is connected to a junction. This junction is also connected to a <math>60\text{ k}\Omega</math> resistor, which is connected to a <math>+1.2\text{ V}</math> supply. The junction is also connected to a <math>2.3\text{ pF}</math> capacitor and a <math>30\text{ }\mu\text{A}</math> current source. The output of the current source is connected to a transistor, which is in series with another transistor. The output of the second transistor is connected to a <math>+1.1\text{ V}</math> supply.</p> | <p>Digital amplitude modulation can be imparted to the Power Amplifier through this pin.</p> <p>A logic high (ASKDTA &gt; 1.5 V or open) enables the Power Amplifier.</p> <p>A logic low (ASKDTA &lt; 0.5 V) disables the Power Amplifier.</p> |

# Functional Description

| Pin No. | Symbol | Interface Schematic                                                               | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------|--------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7       | FSKDTA |  | <p>Digital frequency modulation can be imparted to the Xtal Oscillator by this pin. The VCO-frequency varies in accordance to the frequency of the reference oscillator.</p> <p>A logic high (FSKDTA &gt; 1.5V or open) sets the FSK switch to a high impedance state.</p> <p>A logic low (FSKDTA &lt; 0.5 V) closes the FSK switch from FSKOUT (pin 4) to GND (pin 3). A capacitor can be switched to the reference crystal network this way. The Xtal Oscillator frequency will be shifted giving the designed FSK frequency deviation.</p> |

**Functional Description**

| Pin No. | Symbol | Interface Schematic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Function                                                                                                                                                                                                                                                                                                                              |
|---------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8       | PAGND  |  <p>The diagram shows a power amplifier output stage. Pin 9 (PAOUT) is connected to the output of the power amplifier. Pin 8 (PAGND) is connected to the ground of the power amplifier. A DC path to the positive supply VS is supplied by the antenna matching network.</p>                                                                                                                                             | <p>Ground connection of the power amplifier.</p> <p>The RF ground return path of the power amplifier output PAOUT (pin 9) has to be concentrated to this pin.</p>                                                                                                                                                                     |
| 9       | PAOUT  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <p>RF output pin of the transmitter.</p> <p>A DC path to the positive supply VS has to be supplied by the antenna matching network.</p>                                                                                                                                                                                               |
| 10      | PDWN   |  <p>The diagram shows the PDWN input circuit. Pin 10 is connected to a network of resistors and a diode. The network includes a 5 kΩ resistor, a 150 kΩ resistor, and a 250 kΩ resistor. A diode is connected to the positive supply VS. The current through the diode is 40 μA * (ASKDTA + FSKDTA). The PDWN input will be pulled up by 40 μA internally by either setting FSKDTA or ASKDTA to a logic high-state.</p> | <p>Disable pin for the complete transmitter circuit.</p> <p>A logic low (PDWN &lt; 0.7 V) turns off all transmitter functions.</p> <p>A logic high (PDWN &gt; 1.5 V) gives access to all transmitter functions.</p> <p>PDWN input will be pulled up by 40 μA internally by either setting FSKDTA or ASKDTA to a logic high-state.</p> |

- 1) Indicated voltages and currents apply for PLL Enable Mode and Transmit Mode.  
In Power Down Mode, the values are zero or high-ohmic.

## 2.3 Functional Block Diagram

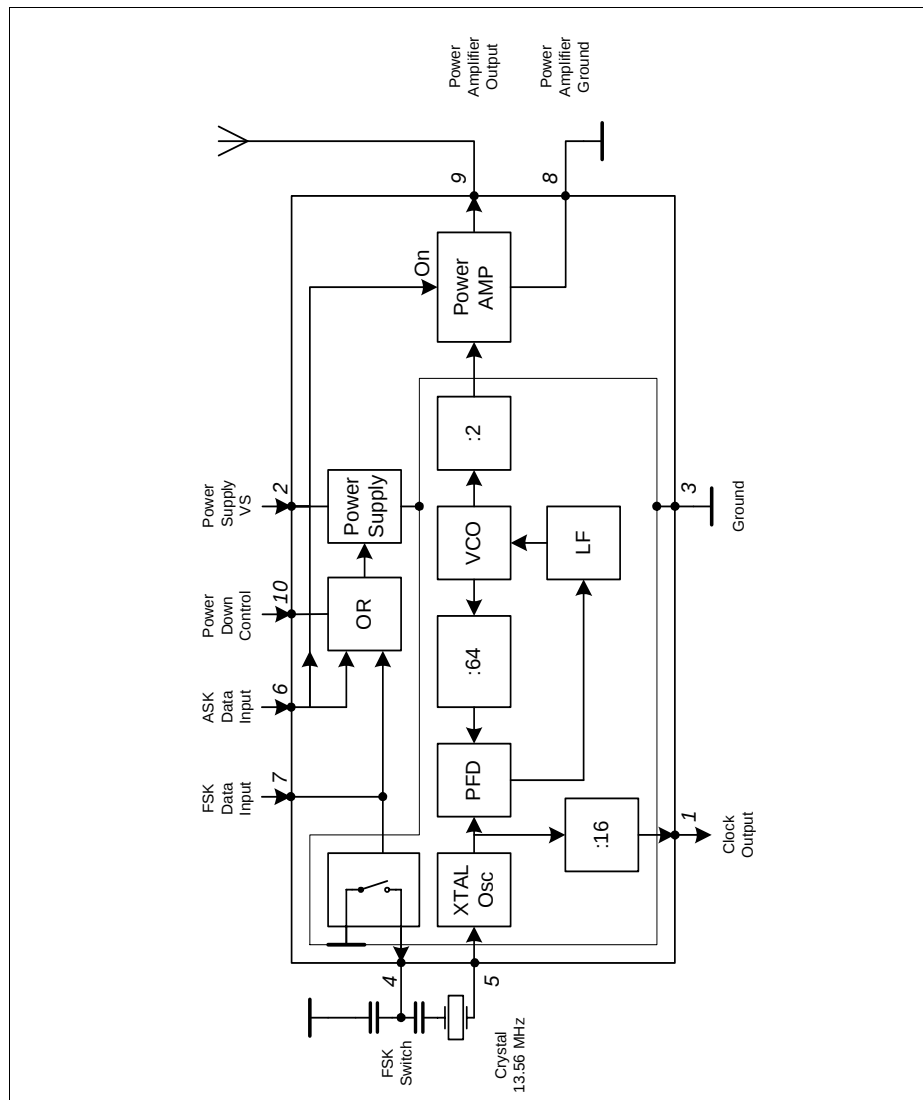


Figure 2 Functional Block Diagram

## Functional Description

### 2.4 Functional Block Description

#### 2.4.1 PLL Synthesizer

The Phase Locked Loop synthesizer consists of a Voltage Controlled Oscillator (VCO), an asynchronous divider chain, a phase detector, a charge pump and a loop filter. It is fully implemented on chip. The tuning circuit of the VCO consisting of spiral inductors and varactor diodes is on chip, too. Therefore no additional external components are necessary. The nominal center frequency of the VCO is 868 MHz. The oscillator signal is fed both, to the synthesizer divider chain and to the power amplifier. The overall division ratio of the asynchronous divider chain is 64. The phase detector is a Type IV PD with charge pump. The passive loop filter is realized on chip.

#### 2.4.2 Crystal Oscillator

The crystal oscillator operates at 13.56 MHz.

The crystal frequency is divided by 16. The resulting 847.5 kHz are available at the clock output CLKOUT (pin1) to drive the clock input of a micro controller.

To achieve FSK transmission, the oscillator frequency can be detuned by a fixed amount by switching an external capacitor via FSKOUT (pin 4).

The condition of the switch is controlled by the signal at FSKDTA (pin 7).

**Table 4 FSKDTA - FSK Switch**

| FSKDTA (pin7)                           | FSK Switch |
|-----------------------------------------|------------|
| Low <sup>1)</sup>                       | CLOSED     |
| Open <sup>2)</sup> , High <sup>3)</sup> | OPEN       |

1) Low: Voltage at pin < 0.5V

2) Open: Pin open

3) High: Voltage at pin > 1.5V

#### 2.4.3 Power Amplifier

The VCO frequency is divided by 2 and fed to the Power Amplifier.

The Power Amplifier can be switched on and off by the signal at ASKDTA (pin 6).

**Table 5 ASKDTA - Power Amplifier**

| <b>ASKDTA (pin6)</b>                    | <b>Power Amplifier</b> |
|-----------------------------------------|------------------------|
| Low <sup>1)</sup>                       | OFF                    |
| Open <sup>2)</sup> , High <sup>3)</sup> | ON                     |

- 1) Low: Voltage at pin < 0.5V  
 2) Open: Pin open  
 3) High: Voltage at pin > 1.5V

The Power Amplifier has an Open Collector output at PAOUT (pin 9) and requires an external pull-up coil to provide bias. The coil is part of the tuning and matching LC circuitry to get best performance with the external loop antenna. To achieve the best power amplifier efficiency, the high frequency voltage swing at PAOUT (pin 9) should be twice the supply voltage.

The power amplifier has its own ground pin PAGND (pin 8) in order to reduce the amount of coupling to the other circuits.

## **2.4.4 Power Modes**

The IC provides three power modes, the POWER DOWN MODE, the PLL ENABLE MODE and the TRANSMIT MODE.

### **2.4.4.1 Power Down Mode**

In the POWER DOWN MODE the complete chip is switched off.

The current consumption is typically 0.3 nA at 3 V 25°C.

This current doubles every 8°C. The value for higher temperature is typically 14 nA at 85°C.

### **2.4.4.2 PLL Enable Mode**

In the PLL ENABLE MODE the PLL is switched on but the power amplifier is turned off to avoid undesired power radiation during the time the PLL needs to settle. The turn on time of the PLL is determined mainly by the turn on time of the crystal oscillator and is less than 1 msec when the specified crystal is used.

The current consumption is typically 4mA.

## Functional Description

### 2.4.4.3 Transmit Mode

In the TRANSMIT MODE the PLL is switched on and the power amplifier is turned on too. The current consumption of the IC is typically 14.2 mA when using a proper transforming network at PAOUT, see Figure 8.

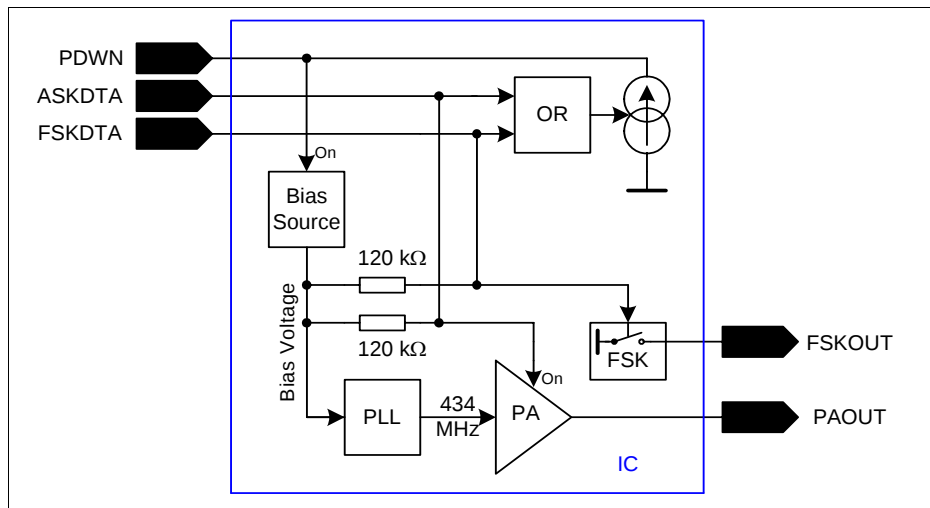
### 2.4.4.4 Power mode control

The bias circuitry is powered up via a voltage  $V > 1.5$  V at the pin PDWN (pin10). When the bias circuitry is powered up, the pins ASKDTA and FSKDTA are pulled up internally.

Forcing the voltage at the pins low overrides the internally set state.

Alternatively, if the voltage at ASKDTA or FSKDTA is forced high externally, the PDWN pin is pulled up internally via a current source. In this case, it is not necessary to connect the PDWN pin, it is recommended to leave it open.

The principle schematic of the power mode control circuitry is shown in Figure 3



**Figure 3** Power mode control circuitry

**Functional Description**

Table 6 provides a listing of how to get into the different power modes

**Table 6      Power Modes**

| <b>PDWN</b>        | <b>FSKDTA</b>   | <b>ASKDTA</b> | <b>MODE</b> |
|--------------------|-----------------|---------------|-------------|
| Low <sup>1)</sup>  | Low, Open       | Low, Open     | POWER DOWN  |
| Open <sup>2)</sup> | Low             | Low           |             |
| High <sup>3)</sup> | Low, Open, High | Low           | PLL ENABLE  |
| Open               | High            | Low           |             |
| High               | Low, Open, High | Open, High    | TRANSMIT    |
| Open               | High            | Open, High    |             |
| Open               | Low, Open, High | High          |             |

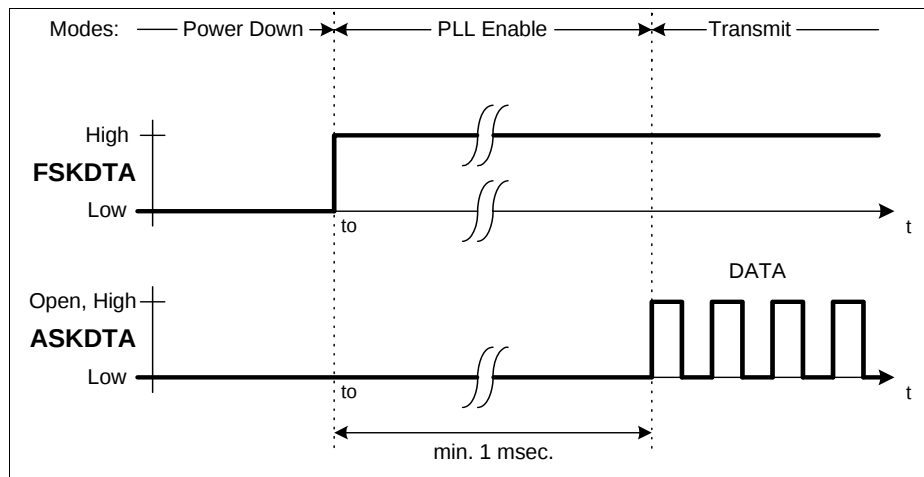
- 1) Low:                      Voltage at pin < 0.7V (PDWN)  
                                     Voltage at pin < 0.5V (FSKDTA, ASKDTA)
- 2) Open:                    Pin open
- 3) High:                    Voltage at pin > 1.5V

Other combinations of the control pins PDWN, FSKDTA and ASKDTA are not recommended.

## Functional Description

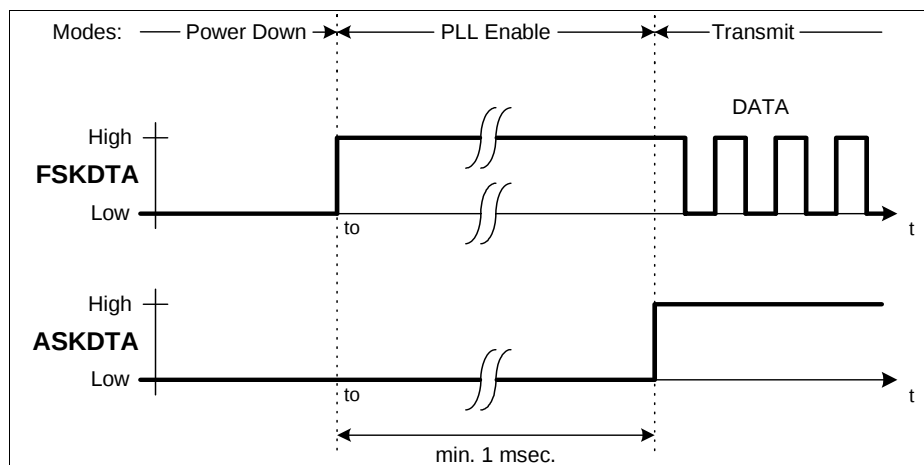
### 2.4.5 Recommended Timing Diagrams for ASK- and FSK-Modulation

ASK Modulation using FSKDTA and ASKDTA, PDWN not connected



**Figure 4 ASK Modulation**

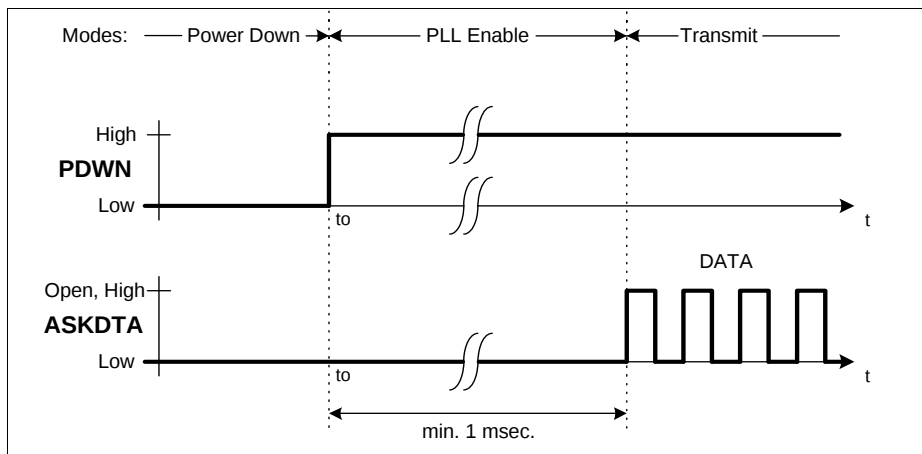
FSK Modulation using FSKDTA and ASKDTA, PDWN not connected.



**Figure 5 FSK Modulation**

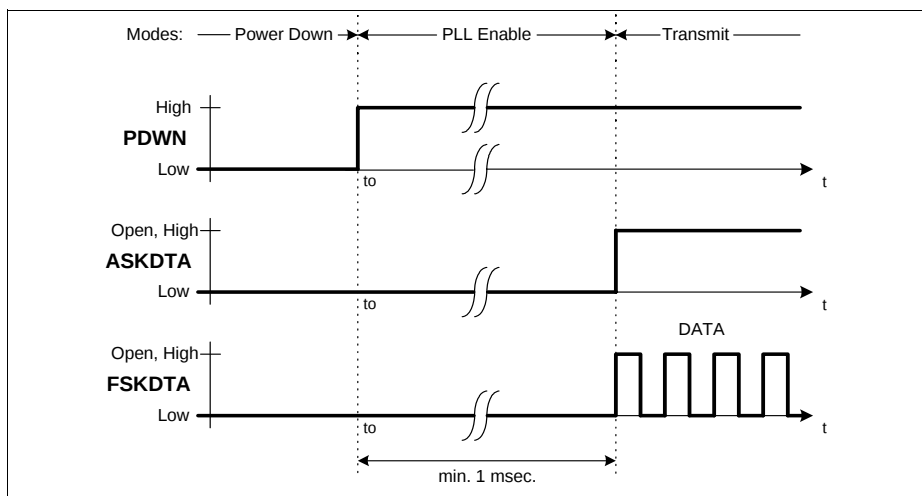
## Functional Description

Alternative ASK Modulation, FSKDTA not connected.



**Figure 6 Alternative ASK Modulation**

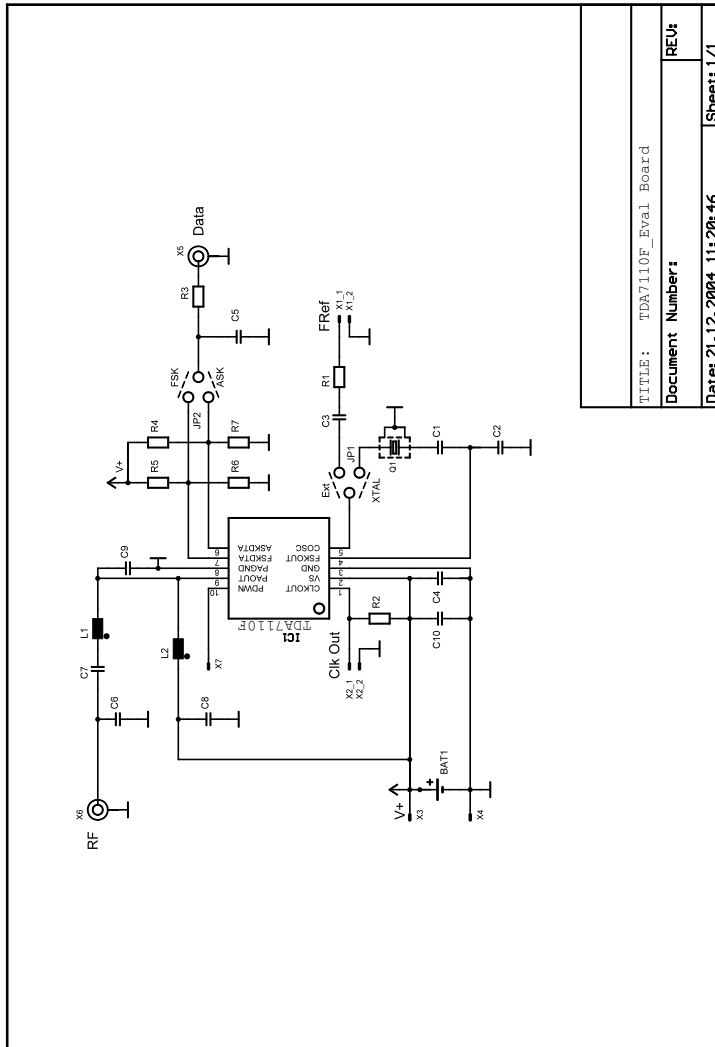
Alternative FSK Modulation



**Figure 7 Alternative FSK Modulation**

### 3 Applications

### 3.1 50 Ohm-Output Testboard Schematic



**Figure 8**      **50 Ohm-output testboard schematic**

### 3.2 50 Ohm-Output Testboard Layout

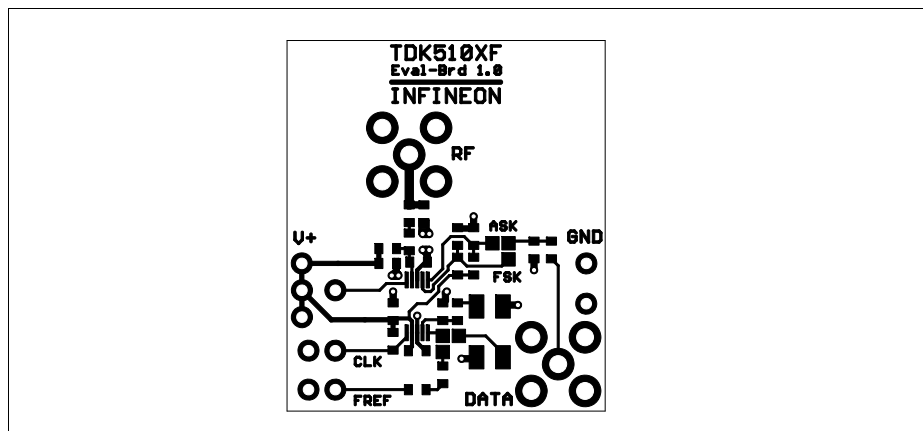


Figure 9 Top Side of TDA7110F-Testboard<sup>1)</sup> with 50 Ohm-Output

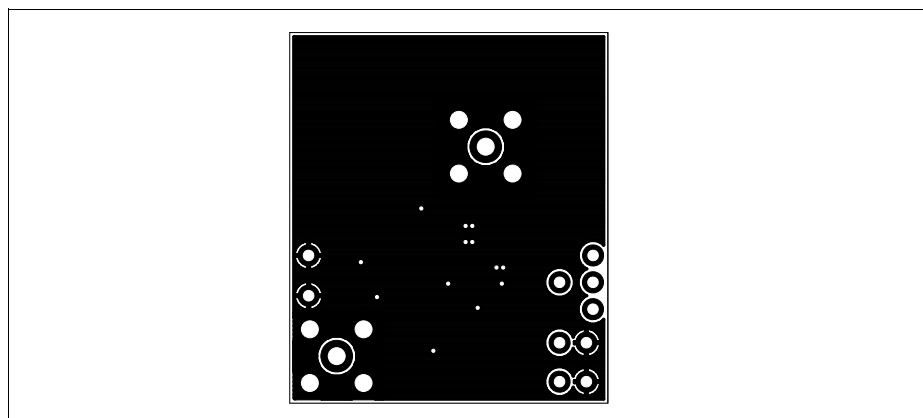


Figure 10 Bottom Side of TDA7110F-Testboard<sup>1)</sup> with 50 Ohm-Output

1) Name and labeling of the PCB itself is TDK510xF

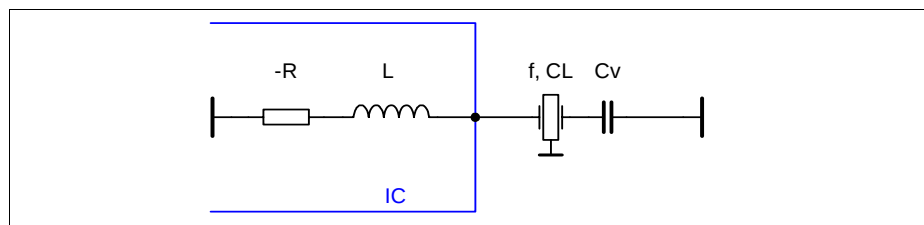
### 3.3 Bill of Material (50 Ohm-Output Evalboard)

| Reference | Value                 | Specification                                         |
|-----------|-----------------------|-------------------------------------------------------|
| R1        | open                  |                                                       |
| R2        | open                  |                                                       |
| R3        | 4k7                   | 0603, +/-5%                                           |
| R4        | 12k                   | 0603, +/-5%                                           |
| R5        | open                  |                                                       |
| R6        | 15k                   | 0603, +/-5%                                           |
| R7        | open                  |                                                       |
| C1        | 10p                   | 0603, C0G, +/-1%                                      |
| C2        | 6p8                   | 0603, C0G, +/-0.1p                                    |
| C3        | open                  |                                                       |
| C4        | open                  |                                                       |
| C5        | 100p                  | 0603, X7R, +/-10%                                     |
| C6        | 10p                   | 0603, C0G, +/-1%                                      |
| C7        | 39p                   | 0603, C0G, +/-1%                                      |
| C8        | 1n                    | 0603, C0G, +/-5%                                      |
| C9        | 3p9                   | 0603, C0G, +/-0.1p                                    |
| C10       | 47n                   | 0603, X7R, +/-10%                                     |
| L1        | 39n                   | EPCOS SIMID 0603-C, +/-2%                             |
| L2        | 100n                  | EPCOS SIMID 0603-C, +/-2%                             |
| X1        | n.e.                  |                                                       |
| X2        | n.e.                  |                                                       |
| X3        | Pin                   | single-pole connector, 2.54 mm                        |
| X4        | Pin                   | single-pole connector, 2.54 mm                        |
| X5        | SMA-connector         |                                                       |
| X6        | SMA-connector         |                                                       |
| X7        | n.e.                  |                                                       |
| JP1       | solder bridge         | in position "XTAL"                                    |
| JP2       | solder bridge         | in position "FSK"                                     |
| Q1        | 13.56875 MHz, CL=12pF | Tokyo Denpa TSS-3B 13.56875 MHz<br>Spec. No. 10-50205 |
| IC1       | TDA7110F              |                                                       |

### 3.4 Application Hints on the Crystal Oscillator

#### Application Hints on the crystal oscillator

The crystal oscillator achieves a turn on time less than 1 msec when the specified crystal is used. To achieve this, a NIC oscillator type is implemented in the TDA7110F. The input impedance of this oscillator is a negative resistance in series to an inductance. Therefore the load capacitance of the crystal  $C_L$  (specified by the crystal supplier) is transformed to the capacitance  $C_v$ .



**Figure 11 Application Hints**

Formula 1:

$$C_v = \frac{1}{\frac{1}{C_L} + \omega^2 L}$$

- CL: crystal load capacitance for nominal frequency  
 $\omega$ : angular frequency  
 L: inductance of the crystal oscillator

#### Example for the ASK-Mode:

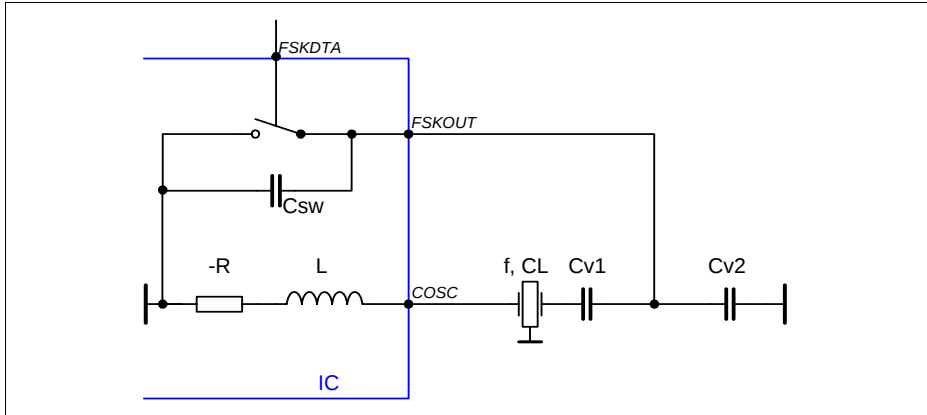
Referring to the application circuit, in ASK-Mode the capacitance  $C_2$  is replaced by a short to ground. Assume a crystal frequency of 13.56MHz and a crystal load capacitance of  $C_L = 12$  pF. The inductance  $L$  at 13.56MHz is about 4.6  $\mu$ H. Therefore  $C_1$  is calculated to 10 pF.

But please note that the calculated  $C_v$  value includes all parasitic. So the value of the capacitor (except the parasitic) is a bit smaller depending on the parasitic.

$$C_v = \frac{1}{\frac{1}{C_L} + \omega^2 L} = C_1$$

### Example for the FSK-Mode:

FSK modulation is achieved by switching the load capacitance of the crystal as shown below.



**Figure 12 FSK Mode**

The frequency deviation of the crystal oscillator is multiplied with the divider factor N of the Phase Locked Loop to the output of the power amplifier. In case of small frequency deviations (up to +/- 1000 ppm), the two desired load capacitances can be calculated with the formula below.

$$CL_{\pm} = \frac{CL \mp C_0 \frac{\Delta f}{N * f_1} \left(1 + \frac{2(C_0 + CL)}{C_1}\right)}{1 \pm \frac{\Delta f}{N * f_1} \left(1 + \frac{2(C_0 + CL)}{C_1}\right)}$$

$C_L$ : crystal load capacitance for nominal frequency

$C_0$ : shunt capacitance of the crystal

f: frequency

$\omega$ :  $\omega = 2\pi f$ : angular frequency

N: division ratio of the PLL

df: peak frequency deviation

Because of the inductive part of the TDA7110F, these values must be corrected by Formula 1 on the preceding page. The value of  $C_{v\pm}$  can be calculated.

$$C_{V\pm} = \frac{1}{\frac{1}{CL\pm} + \omega^2 L}$$

If the FSK switch is closed,  $C_{V\pm}$  is equal to  $C_{V1}$  ( $C1$  in the application diagram). If the FSK switch is open,  $C_{V2}$  ( $C2$  in the application diagram) can be calculated.

$$C_{V2} = C2 = \frac{C_{sw} * C_{V1} - (C_{V+}) * (C_{V1} + C_{sw})}{(C_{V+}) - C_{V1}}$$

$C_{sw}$ : parallel capacitance of the FSK switch (3 pF incl. layout parasitics)

Remark: These calculations are only approximations. The necessary values depend on the parasitic and thus on the layout also and must be adapted for the specific application board.

### 3.5 Design Hints on the Clock Output (CLKOUT)

The CLKOUT pin is an open collector output. An external pull up resistor ( $R_L$ ) should be connected between this pin and the positive supply voltage. The value of  $R_L$  is depending on the clock frequency and the load capacitance  $CLD$  (PCB board plus input capacitance of the microcontroller).  $R_L$  can be calculated to:

$$R_L = \frac{1}{f_{CLKOUT} * 8 * CLD}$$

**Table 7 Clock Output**

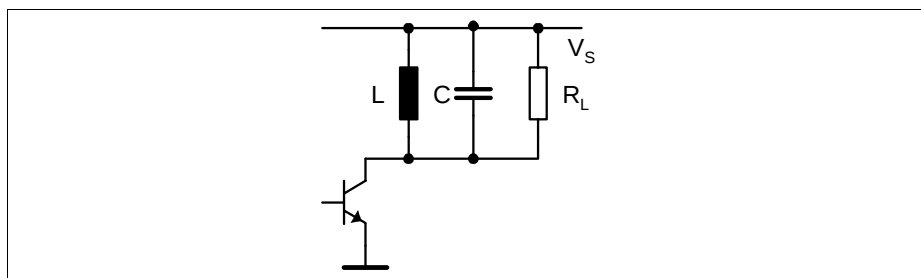
| <b>fCLKOUT=847.5 kHz</b> |                 |
|--------------------------|-----------------|
| <b>CL[pF]</b>            | <b>RL[kOhm]</b> |
| 5                        | 27              |
| 10                       | 12              |
| 20                       | 6.8             |

Remark: To achieve a low current consumption and a low spurious radiation, the largest possible  $R_L$  should be chosen.

Even harmonics of the signal at CLKOUT can interact with the crystal oscillator input COSC preventing the start-up of oscillation. Care must be taken in layout by sufficient separation of the signal lines to ensure sufficiently small coupling.

### 3.6 Application Hints on the Power-Amplifier

The power amplifier operates in a high efficient class C mode. This mode is characterized by a pulsed operation of the power amplifier transistor at a current flow angle of  $\theta \ll \pi$ . A frequency selective network at the amplifier output passes the fundamental frequency component of the pulse spectrum of the collector current to the load. The load and its resonance transformation to the collector of the power amplifier can be generalized by the equivalent circuit of Figure 13. The tank circuit  $L/C//R_L$  in parallel to the output impedance of the transistor should be in resonance at the operating frequency of the transmitter.



**Figure 13** Equivalent power amplifier tank circuit

The optimum load at the collector of the power amplifier for “critical” operation under idealized conditions at resonance is:

$$R_{LC} = \frac{V_S^2}{2 * P_O}$$

The theoretical value of  $R_{LC}$  for an RF output power of  $P_O = 10\text{dBm}$  (10mW) is:

$$R_{LC} = \frac{3^2}{2 * 0.01} = 450\Omega$$

“Critical” operation is characterized by the RF peak voltage swing at the collector of the PA transistor to just reach the supply voltage  $V_S$ .

The high degree of efficiency under “critical” operating conditions can be explained by the low power losses at the transistor. During the conducting phase of the transistor, its collector voltage is very small. This way the power loss of the transistor, equal to  $i_C * u_{CE}$  is minimized. This is particularly true for small current flow angles of  $\theta \ll \pi$ .

## Applications

In practice the RF-saturation voltage of the PA transistor and other parasitics reduce the “critical”  $R_{LC}$ .

The output power  $P_o$  is reduced by operating in an “overcritical” mode characterised by  $R_L > R_{LC}$ .

The power efficiency (and the bandwidth) increase when operating at a slightly higher  $R_L$ , as shown in Figure 14.

The collector efficiency  $E$  is defined as

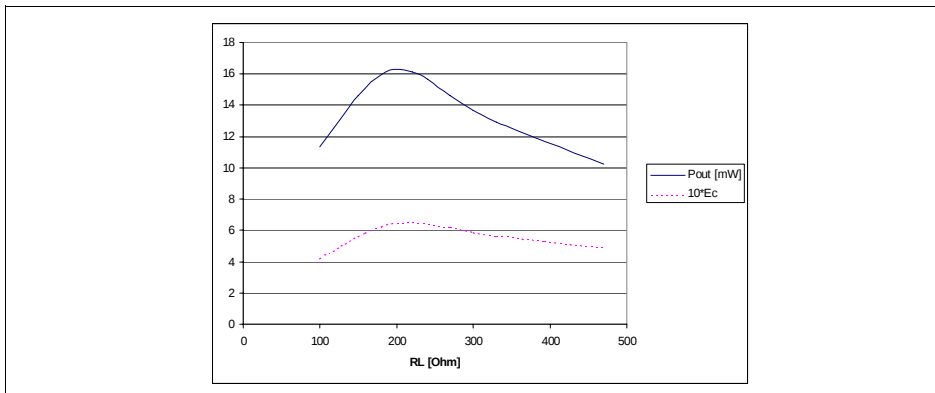
$$E = \frac{P_o}{V_s I_C}$$

The diagram of Figure 14 was measured directly at the PA-output at  $V_s = 3\text{ V}$ . Losses in the matching circuitry decrease the output power by about 1.5 dB. As can be seen from the diagram,  $250\ \Omega$  is the optimum impedance for operation at 3 V. For an approximation of  $R_{OPT}$  and  $P_{OUT}$  at other supply voltages those two formulas can be used:

$$R_{OPT} \sim V_s$$

and

$$P_{OUT} \sim R_{OPT}$$



**Figure 14** Output power  $P_o$  (mW) and collector efficiency  $E$  vs. load resistor  $R_L$ .

The DC collector current  $I_c$  of the power amplifier and the RF output power  $P_o$  vary with the load resistor  $R_L$ . This is typical for overcritical operation of class C amplifiers. The collector current will show a characteristic dip at the resonance frequency for this type of “overcritical” operation. The depth of this dip will increase with higher values of  $R_L$ .

## 4 Reference

### 4.1 Electrical Data

#### 4.1.1 Absolute Maximum Ratings

**Attention:** *The maximum ratings must not be exceeded under any circumstances, not even momentarily and individually, as permanent damage to the IC will result.*

**Table 8** Absolute Maximum Ratings,  $T_{amb} = -40\text{ °C} \dots +85\text{ °C}$

| Parameter                               | Symbol     | Limit Values |             | Unit | Remarks                      |
|-----------------------------------------|------------|--------------|-------------|------|------------------------------|
|                                         |            | min.         | max.        |      |                              |
| Junction Temperature                    | $T_J$      | -40          | +150        | °C   |                              |
| Storage Temperature                     | $T_s$      | -40          | +125        | °C   |                              |
| Thermal Resistance                      | $R_{thJA}$ |              | 220         | K/W  |                              |
| Supply voltage                          | $V_S$      | -0.3         | +4.0        | V    |                              |
| Voltage at any pin excluding pin 9      | $V_{pins}$ | -0.3         | $V_S + 0.3$ | V    |                              |
| Voltage at pin 9                        | $V_{pin9}$ | -0.3         | $2 * V_S$   | V    | No ESD-Diode to $V_S$        |
| ESD integrity, all pins                 | $V_{ESD}$  | -1           | +1          | kV   | JEDEC Standard JESD22-A114-B |
| ESD integrity, all pins excluding pin 9 | $V_{ESD}$  | -2.5         | +2.5        | kV   | JEDEC Standard JESD22-A114-B |

Ambient Temperature under bias:  $T_A = -40\text{ °C}$  to  $+85\text{ °C}$

Note: All voltages referred to ground (pins) unless stated otherwise.

Pins 3 and 8 are grounded.

## 4.2 Operating Ratings

Within the operational range the IC operates as described in the circuit description.

**Table 9 Operating Ratings**

| Parameter           | Symbol | Limit Values |      | Unit | Test Conditions |
|---------------------|--------|--------------|------|------|-----------------|
|                     |        | min.         | max. |      |                 |
| Supply voltage      | $V_S$  | 2.1          | 4.0  | V    |                 |
| Ambient temperature | $T_A$  | -40          | 85   | °C   |                 |

## 4.3 AC/DC Characteristics

AC/DC characteristics involve the spread of values guaranteed within the specified supply voltage and ambient temperature. Typical characteristics are the median of the production.

### 4.3.1 AC/DC Characteristic at 3V, 25°C

**Table 10 Supply Voltage  $V_S=3V$ , Ambient temperature  $T_{amb}=25^\circ C$**

| Parameter                                 | Symbol                | Limit Values |       |      | Unit | Test Conditions                           |
|-------------------------------------------|-----------------------|--------------|-------|------|------|-------------------------------------------|
|                                           |                       | min.         | typ.  | max. |      |                                           |
| Current consumption                       |                       |              |       |      |      |                                           |
| Power Down mode                           | I <sub>S PDWN</sub>   |              | 0.3   | 100  | nA   | V (Pins 10, 6 and 7)<br>< 0.2 V           |
| PLL Enable mode                           | I <sub>S PLL_EN</sub> |              | 4     | 5.5  | mA   |                                           |
| Transmit mode<br>434 MHz                  | I <sub>S TRANSM</sub> |              | 14.2  | 18   | mA   |                                           |
| Output frequency                          |                       |              |       |      |      |                                           |
| Output frequency                          | f <sub>OUT</sub>      | 427          | 434.5 | 442  | MHz  | f <sub>OUT</sub> = 32 * f <sub>COSC</sub> |
| Clock Driver Output (Pin 1)               |                       |              |       |      |      |                                           |
| Output current (High)                     | I <sub>CLKOUT</sub>   |              |       | 5    | μA   | V <sub>CLKOUT</sub> = V <sub>S</sub>      |
| Saturation Voltage<br>(Low) <sup>1)</sup> | V <sub>SATL</sub>     |              |       | 0.56 | V    | I <sub>CLKOUT</sub> = 1 mA                |

**Table 10**      **Supply Voltage  $V_S=3V$ , Ambient temperature  $T_{amb}=25^{\circ}C$  (cont'd)**

| Parameter                                                   | Symbol        | Limit Values |      |       | Unit          | Test Conditions           |
|-------------------------------------------------------------|---------------|--------------|------|-------|---------------|---------------------------|
|                                                             |               | min.         | typ. | max.  |               |                           |
| FSK Switch Output (Pin 4)                                   |               |              |      |       |               |                           |
| On resistance                                               | $R_{FSKOUT}$  |              |      | 250   | $\Omega$      | $V_{FSKDTA} = 0\text{ V}$ |
| On capacitance                                              | $C_{FSKOUT}$  |              |      | 6     | pF            | $V_{FSKDTA} = 0\text{ V}$ |
| Off resistance                                              | $R_{FSKOUT}$  | 10           |      |       | k $\Omega$    | $V_{FSKDTA} = V_S$        |
| Off capacitance                                             | $C_{FSKOUT}$  |              |      | 1.5   | pF            | $V_{FSKDTA} = V_S$        |
| Crystal Oscillator Input (Pin 5)                            |               |              |      |       |               |                           |
| Load capacitance                                            | $C_{COSCmax}$ |              |      | 5     | pF            |                           |
| Serial Resistance of the crystal                            |               |              |      | 100   | $\Omega$      | $f = 13.56\text{ MHz}$    |
| Input inductance of the COSC pin                            |               |              | 4.6  |       | $\mu\text{H}$ | $f = 13.56\text{ MHz}$    |
| ASK Modulation Data Input (Pin 6)                           |               |              |      |       |               |                           |
| ASK Transmit disabled                                       | $V_{ASKDTA}$  | 0            |      | 0.5   | V             |                           |
| ASK Transmit enabled                                        | $V_{ASKDTA}$  | 1.5          |      | $V_S$ | V             |                           |
| Input bias current ASKDTA                                   | $I_{ASKDTA}$  |              |      | 30    | $\mu\text{A}$ | $V_{ASKDTA} = V_S$        |
| Input bias current ASKDTA                                   | $I_{ASKDTA}$  | -20          |      |       | $\mu\text{A}$ | $V_{ASKDTA} = 0\text{ V}$ |
| ASK data rate                                               | $f_{ASKDTA}$  |              |      | 20    | kHz           |                           |
| FSK Modulation Data Input (Pin 7)                           |               |              |      |       |               |                           |
| FSK Switch on                                               | $V_{FSKDTA}$  | 0            |      | 0.5   | V             |                           |
| FSK Switch off                                              | $V_{FSKDTA}$  | 1.5          |      | $V_S$ | V             |                           |
| Input bias current FSKDTA                                   | $I_{FSKDTA}$  |              |      | 30    | $\mu\text{A}$ | $V_{FSKDTA} = V_S$        |
| Input bias current FSKDTA                                   | $I_{FSKDTA}$  | -20          |      |       | $\mu\text{A}$ | $V_{FSKDTA} = 0\text{ V}$ |
| FSK data rate                                               | $f_{FSKDTA}$  |              |      | 20    | kHz           |                           |
| Power Amplifier Output (Pin 9)                              |               |              |      |       |               |                           |
| Output Power <sup>2)</sup> at 434 MHz transformed to 50 Ohm | $P_{OUT434}$  | 7            | 10   | 13    | dBm           |                           |

**Table 10** Supply Voltage  $V_S=3V$ , Ambient temperature  $T_{amb}=25^{\circ}C$  (cont'd)

| Parameter                        | Symbol            | Limit Values |      |                | Unit | Test Conditions                                            |
|----------------------------------|-------------------|--------------|------|----------------|------|------------------------------------------------------------|
|                                  |                   | min.         | typ. | max.           |      |                                                            |
| Power Down Mode Control (Pin 10) |                   |              |      |                |      |                                                            |
| Power Down mode                  | V <sub>PDWN</sub> | 0            |      | 0.7            | V    | V <sub>ASKDTA</sub> < 0.2 V<br>V <sub>FSKDTA</sub> < 0.2 V |
| PLL Enable mode                  | V <sub>PDWN</sub> | 1.5          |      | V <sub>S</sub> | V    | V <sub>ASKDTA</sub> < 0.5 V                                |
| Transmit mode                    | V <sub>PDWN</sub> | 1.5          |      | V <sub>S</sub> | V    | V <sub>ASKDTA</sub> > 1.5 V                                |
| Input bias current PDWN          | I <sub>PDWN</sub> |              |      | 30             | μA   | V <sub>PDWN</sub> = V <sub>S</sub>                         |

- Derating linearly to a saturation voltage of max. 140 mV at  $I_{CLKOUT} = 0$  mA
- Power amplifier in overcritical C-operation  
Matching circuitry as used in the 50 Ohm-Output Testboard at the specified frequency.  
Tolerances of the passive elements not taken into account.

#### 4.3.2 AC/DC Characteristic at 2.1V ... 4.0 V, $-40^{\circ}C$ ... $+85^{\circ}C$

**Table 11** Supply Voltage  $V_S=2.1V$  ... 4.0V,  $T_{amb}=-40^{\circ}C$  ...  $+85^{\circ}C$ 

| Parameter                              | Symbol                | Limit Values |       |      | Unit | Test Conditions                           |
|----------------------------------------|-----------------------|--------------|-------|------|------|-------------------------------------------|
|                                        |                       | min.         | typ.  | max. |      |                                           |
| Current consumption                    |                       |              |       |      |      |                                           |
| Power Down mode                        | I <sub>S PDWN</sub>   |              |       | 4    | μA   | V (Pins 10, 6 and 7) < 0.2 V              |
| PLL Enable mode                        | I <sub>S PLL_EN</sub> | 2.5          | 4     | 6    | mA   |                                           |
| Transmit mode                          | I <sub>S TRANSM</sub> |              | 11    | 15.5 | mA   | V <sub>S</sub> = 2.1 V                    |
| Load tank see Figure 8 and 9           | I <sub>S TRANSM</sub> |              | 14.2  | 18   | mA   | V <sub>S</sub> = 3.0 V                    |
|                                        | I <sub>S TRANSM</sub> |              | 16.2  | 21   | mA   | V <sub>S</sub> = 4.0 V                    |
| Output frequency                       |                       |              |       |      |      |                                           |
| Output frequency <sup>1)</sup>         | f <sub>OUT</sub>      | 432          | 434.5 | 437  | MHz  | f <sub>OUT</sub> = 32 * f <sub>COSC</sub> |
| Clock Driver Output (Pin 1)            |                       |              |       |      |      |                                           |
| Output current (High)                  | I <sub>CLKOUT</sub>   |              |       | 5    | μA   | V <sub>CLKOUT</sub> = V <sub>S</sub>      |
| Saturation Voltage (Low) <sup>2)</sup> | V <sub>SATL</sub>     |              |       | 0.5  | V    | I <sub>CLKOUT</sub> = 0.6 mA              |

**Table 11**      **Supply Voltage  $V_S=2.1V \dots 4.0V$ ,  $T_{amb}=-40^\circ C \dots +85^\circ C$  (cont'd)**

| Parameter                         | Symbol               | Limit Values |      |                | Unit | Test Conditions                      |
|-----------------------------------|----------------------|--------------|------|----------------|------|--------------------------------------|
|                                   |                      | min.         | typ. | max.           |      |                                      |
| FSK Switch Output (Pin 4)         |                      |              |      |                |      |                                      |
| On resistance                     | R <sub>FSKOUT</sub>  |              |      | 280            | Ω    | V <sub>FSKDTA</sub> = 0 V            |
| On capacitance                    | C <sub>FSKOUT</sub>  |              |      | 6              | pF   | V <sub>FSKDTA</sub> = 0 V            |
| Off resistance                    | R <sub>FSKOUT</sub>  | 10           |      |                | kΩ   | V <sub>FSKDTA</sub> = V <sub>S</sub> |
| Off capacitance                   | C <sub>FSKOUT</sub>  |              |      | 1.5            | pF   | V <sub>FSKDTA</sub> = V <sub>S</sub> |
| Crystal Oscillator Input (Pin 5)  |                      |              |      |                |      |                                      |
| Load capacitance                  | C <sub>COSCmax</sub> |              |      | 5              | pF   |                                      |
| Serial Resistance of the crystal  |                      |              |      | 100            | Ω    | f = 13.56 MHz                        |
| Input inductance of the COSC pin  |                      |              | 4.6  |                | μH   | f = 13.56 MHz                        |
| ASK Modulation Data Input (Pin 6) |                      |              |      |                |      |                                      |
| ASK Transmit disabled             | V <sub>ASKDTA</sub>  | 0            |      | 0.5            | V    |                                      |
| ASK Transmit enabled              | V <sub>ASKDTA</sub>  | 1.5          |      | V <sub>S</sub> | V    |                                      |
| Input bias current ASKDTA         | I <sub>ASKDTA</sub>  |              |      | 33             | μA   | V <sub>ASKDTA</sub> = V <sub>S</sub> |
| Input bias current ASKDTA         | I <sub>ASKDTA</sub>  | -20          |      |                | μA   | V <sub>ASKDTA</sub> = 0 V            |
| ASK data rate                     | f <sub>ASKDTA</sub>  |              |      | 20             | kHz  |                                      |
| FSK Modulation Data Input (Pin 7) |                      |              |      |                |      |                                      |
| FSK Switch on                     | V <sub>FSKDTA</sub>  | 0            |      | 0.5            | V    |                                      |
| FSK Switch off                    | V <sub>FSKDTA</sub>  | 1.5          |      | V <sub>S</sub> | V    |                                      |
| Input bias current FSKDTA         | I <sub>FSKDTA</sub>  |              |      | 33             | μA   | V <sub>FSKDTA</sub> = V <sub>S</sub> |
| Input bias current FSKDTA         | I <sub>FSKDTA</sub>  | -20          |      |                | μA   | V <sub>FSKDTA</sub> = 0 V            |
| FSK data rate                     | f <sub>FSKDTA</sub>  |              |      | 20             | kHz  |                                      |

**Table 11 Supply Voltage  $V_S = 2.1\text{V} \dots 4.0\text{V}$ ,  $T_{\text{amb}} = -40^\circ\text{C} \dots +85^\circ\text{C}$  (cont'd)**

| Parameter                                                    | Symbol                | Limit Values |      |                | Unit | Test Conditions                                            |
|--------------------------------------------------------------|-----------------------|--------------|------|----------------|------|------------------------------------------------------------|
|                                                              |                       | min.         | typ. | max.           |      |                                                            |
| Power Amplifier Output (Pin 9)                               |                       |              |      |                |      |                                                            |
| Output Power <sup>3)</sup> at 434 MHz transformed to 50 Ohm. | P <sub>OUT, 434</sub> | 4            | 6.5  | 9.5            | dBm  | V <sub>S</sub> = 2.1 V                                     |
|                                                              | P <sub>OUT, 434</sub> | 6            | 10   | 13             | dBm  | V <sub>S</sub> = 3.0 V                                     |
|                                                              | P <sub>OUT, 434</sub> | 6.5          | 11.5 | 16             | dBm  | V <sub>S</sub> = 4.0 V                                     |
| Power Down Mode Control (Pin 10)                             |                       |              |      |                |      |                                                            |
| Power Down mode                                              | V <sub>PDWN</sub>     | 0            |      | 0.5            | V    | V <sub>ASKDTA</sub> < 0.2 V<br>V <sub>FSKDTA</sub> < 0.2 V |
| PLL Enable mode                                              | V <sub>PDWN</sub>     | 1.5          |      | V <sub>S</sub> | V    | V <sub>ASKDTA</sub> < 0.5 V                                |
| Transmit mode                                                | V <sub>PDWN</sub>     | 1.5          |      | V <sub>S</sub> | V    | V <sub>ASKDTA</sub> > 1.5 V                                |
| Input bias current PDWN                                      | I <sub>PDWN</sub>     |              |      | 38             | μA   | V <sub>PDWN</sub> = V <sub>S</sub>                         |

- 1) a) When the minimum  $T_A$  is increased by  $5^\circ\text{C}$ , the minimum  $f_{\text{VCO}}$  decreases by 1 MHz.  
b) When the maximum  $T_A$  is decreased by  $5^\circ\text{C}$ , the maximum  $f_{\text{VCO}}$  increases by 1 MHz.  
c) When the minimum  $V_S$  is increased by 25 mV, the maximum  $f_{\text{VCO}}$  increases by 1 MHz.  
Restriction of c): The maximum  $f_{\text{VCO}}$  must not be increased by more than 40 MHz by increasing  $V_S$ .

Please note that  $f_{\text{VCO}}$  is twice the Output Frequency.

All three measures can be taken independently and additive.

- 2) Derating linearly to a saturation voltage of max. 140 mV at  $I_{\text{CLKOUT}} = 0\text{ mA}$

- 3) Matching circuitry as used in the 50 Ohm-Output Testboard.

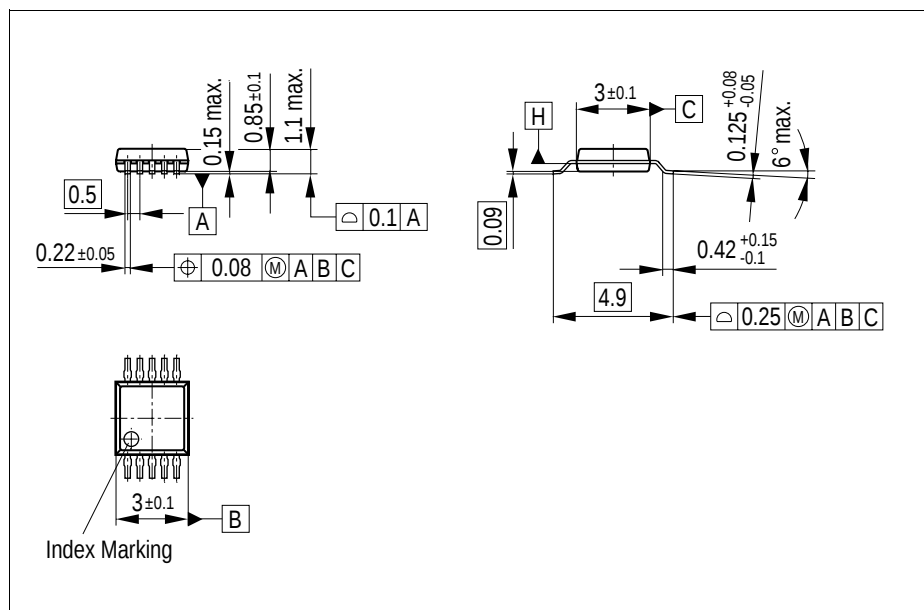
Tolerances of the passive elements not taken into account.

Range @ 2.1 V,  $+25^\circ\text{C}$ : 6.5 dBm +/- 2 dBm

Range @ 3.0 V,  $+25^\circ\text{C}$ : 10 dBm +/- 3 dBm

Range @ 4.0 V,  $+25^\circ\text{C}$ : 11.5 dBm +4.5/-3.5 dBm

## 5 Package Outlines



**Figure 15 PG-TSSOP-10**

You can find all of our packages, sorts of packing and others in our Infineon Internet Page “Products”: <http://www.infineon.com/products>.

SMD = Surface Mounted Device

Dimensions in mm

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