

TDK5116F

868 MHz ASK/FSK Transmitter in 10-pin
Package

Version 1.1

Wireless Control
Components



Never stop thinking.

Edition 2006-09-15

**Published by Infineon Technologies AG,
Am Campeon 1-12
85579 Neubiberg, Germany**

**© Infineon Technologies AG 2006.
All Rights Reserved.**

Attention please!

The information herein is given to describe certain components and shall not be considered as a guarantee of characteristics.

Terms of delivery and rights to technical change reserved.

We hereby disclaim any and all warranties, including but not limited to warranties of non-infringement, regarding circuits, descriptions and charts stated herein.

Information

For further information on technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies Office in Germany or the Infineon Technologies Companies and our Infineon Technologies Representatives worldwide (www.infineon.com).

Warnings

Due to technical requirements components may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies Office.

Infineon Technologies Components may only be used in life-support devices or systems with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system, or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body, or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.

TDK5116F

868 MHz ASK/FSK Transmitter in 10-pin
Package

Version 1.1

Wireless Control
Components



Never stop thinking.

Revision History: 2006-09-15

V 1.1

Previous Version: V 1.0

| Page | Subjects (major changes since last revision) |
|--------|---|
| 27 | ESD-values increased to +/- 2.5kV |
| 28, 30 | Current consumption complemented by max. values |
| 29, 32 | Power amplifier output complemented by min., typ. and max. values |
| 32 | Values for enhanced f_{VCO} range added |
| 32 | Values of output power and tolerance at 2.1V, 3V and 4V added |

We Listen to Your Comments

Any information within this document that you feel is wrong, unclear or missing at all? Your feedback will help us to continuously improve the quality of this document. Please send your proposal (including a reference to this document) to:

sensors@infineon.com

| 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 | 7 |
| 2.3 | Functional Block Diagram | 12 |
| 2.4 | Functional Block Description | 13 |
| 2.4.1 | PLL Synthesizer | 13 |
| 2.4.2 | Crystal Oscillator | 13 |
| 2.4.3 | Power Amplifier | 13 |
| 2.4.4 | Power Modes | 14 |
| 2.4.4.1 | Power Down Mode | 14 |
| 2.4.4.2 | PLL Enable Mode | 14 |
| 2.4.4.3 | Transmit Mode | 15 |
| 2.4.4.4 | Power mode control | 15 |
| 2.4.5 | Recommended Timing Diagrams for ASK- and FSK-Modulation | 17 |
| 3 | Applications | 19 |
| 3.1 | 50 Ohm-Output Testboard Schematic | 19 |
| 3.2 | 50 Ohm-Output Testboard Layout | 20 |
| 3.3 | Bill of Material (50 Ohm-Output Evalboard) | 21 |
| 3.4 | Application Hints on the Crystal Oscillator | 22 |
| 3.5 | Design Hints on the Clock Output (CLKOUT) | 24 |
| 3.6 | Application Hints on the Power-Amplifier | 25 |
| 4 | Reference | 27 |
| 4.1 | Electrical Data | 27 |
| 4.1.1 | Absolute Maximum Ratings | 27 |
| 4.2 | Operating Ratings | 28 |
| 4.3 | AC/DC Characteristics | 28 |
| 4.3.1 | AC/DC Characteristic at 3V, 25°C | 28 |
| 4.3.2 | AC/DC Characteristic at 2.1V ...4.0 V, -40°C ...+125°C | 30 |
| 5 | Package Outlines | 33 |

1 Product Description

1.1 Overview

The TDK5116F is a single chip ASK/FSK transmitter for operation in the frequency band 866 ... 870 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 866 ... 870 MHz
- high efficiency power amplifier (typically 10 dBm)
- low supply current
- voltage supply range 2.1 ... 4 V
- temperature range $-40 \dots +125^{\circ}\text{C}$
- power down mode
- crystal oscillator 13.56 MHz
- FSK-switch
- divided clock output for μC
- low external component count

1.3 Application

- Tire pressure monitoring systems
- Keyless entry systems
- Remote control systems
- Alarm systems
- Communication systems

2 Functional Description

2.1 Pin Configuration

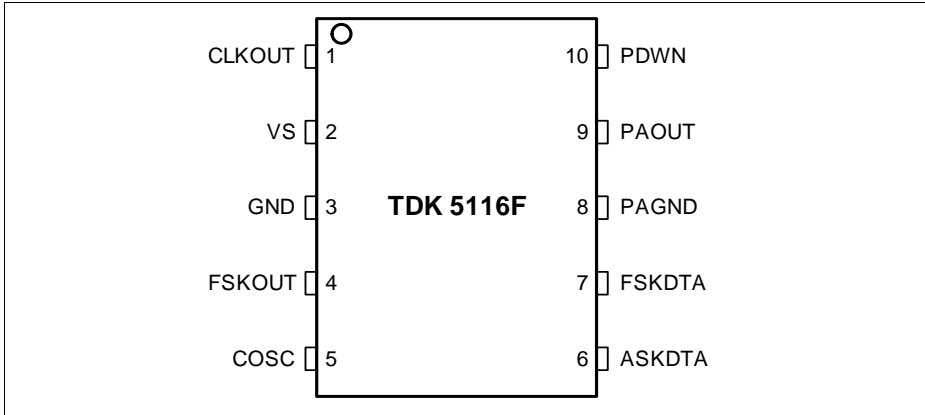


Figure 1 IC Pin Configuration

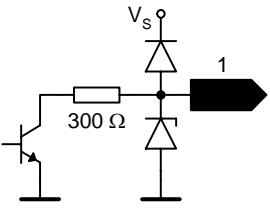
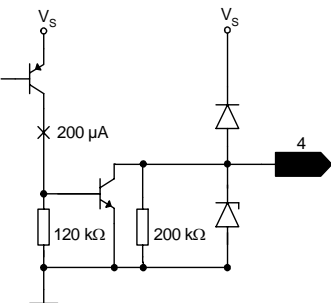
2.2 Pin Definition and Functions

Table 1 Pin Definition and Functions - Overview

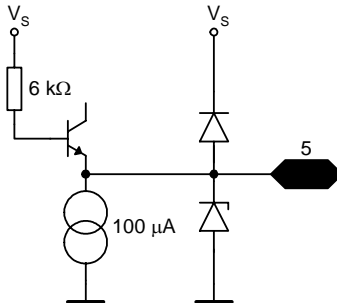
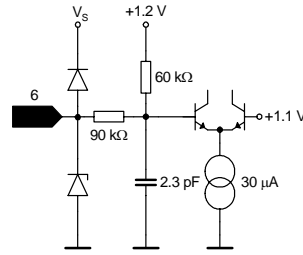
| Pin No. | Symbol | Function |
|---------|--------|--------------------------------------|
| 1 | CLKOUT | Clock Driver Output (847.5 kHz) |
| 2 | VS | Voltage Supply |
| 3 | GND | Ground |
| 4 | FSKOUT | Frequency Shift Keying Switch Output |
| 5 | COSC | Crystal Oscillator Input (13.56 MHz) |
| 6 | ASKDTA | Amplitude Shift Keying Data Input |
| 7 | FSKDTA | Frequency Shift Keying Data Input |
| 8 | PAGND | Power Amplifier Ground |
| 9 | PAOUT | Power Amplifier Output (868 MHz) |
| 10 | PDWN | Power Down Mode Control |

Functional Description

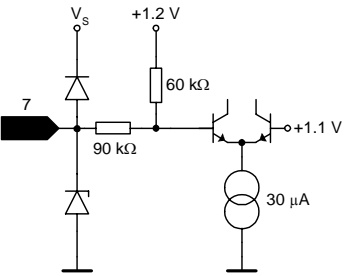
Table 2 Pin Definition and Function¹

| 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 | | <p>General ground connection.</p> |
| 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> |

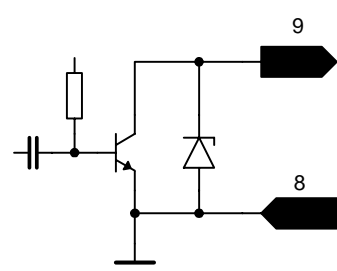
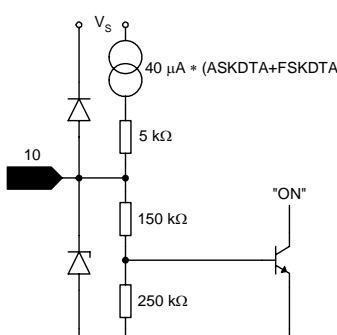
Functional Description

| Pin No. | Symbol | Interface Schematic | Function |
|---------|--------|---|--|
| 5 | COSC |  | <p>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>Digital amplitude modulation can be imparted to the Power Amplifier through this pin.</p> <p>A logic high (ASKDTA > 1.5 V or open) enables the Power Amplifier.</p> <p>A logic low (ASKDTA < 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 > 1.5V or open) sets the FSK switch to a high impedance state.</p> <p>A logic low (FSKDTA < 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>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>Disable pin for the complete transmitter circuit.</p> <p>A logic low (PDWN < 0.7 V) turns off all transmitter functions.</p> <p>A logic high (PDWN > 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

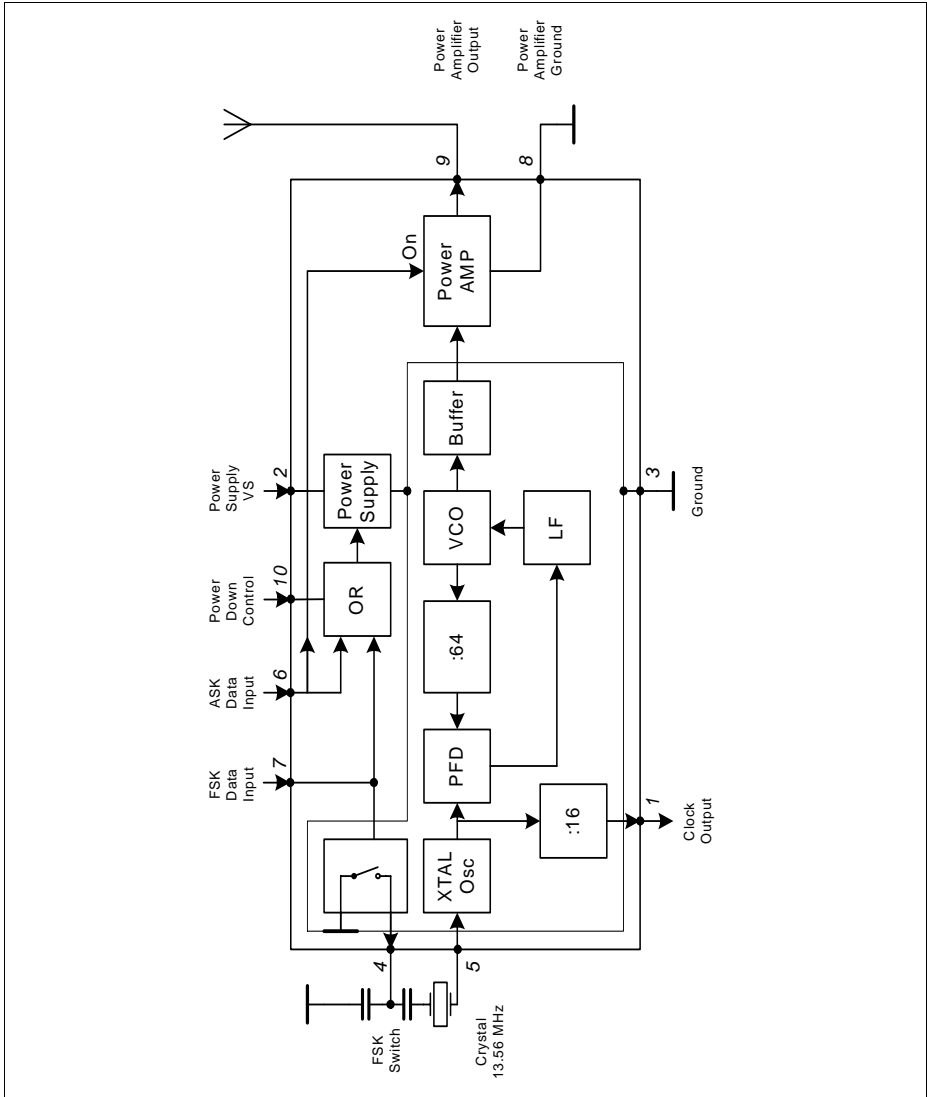


Figure 2 Functional Block Diagram

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 3 FSKDTA - FSK Switch

| FSKDTA (pin7) | FSK Switch |
|---|------------|
| Low ¹⁾ | CLOSED |
| Open ²⁾ , High ³⁾ | 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 buffered and fed to the Power Amplifier.

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

Table 4 ASKDTA - Power Amplifier

| ASKDTA (pin6) | Power Amplifier |
|---|-----------------|
| Low ¹⁾ | OFF |
| Open ²⁾ , High ³⁾ | 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 values for higher temperatures are typically 14 nA at 85°C and typically 600 nA at 125°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.

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 $V > 1.5\text{ V}$ 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

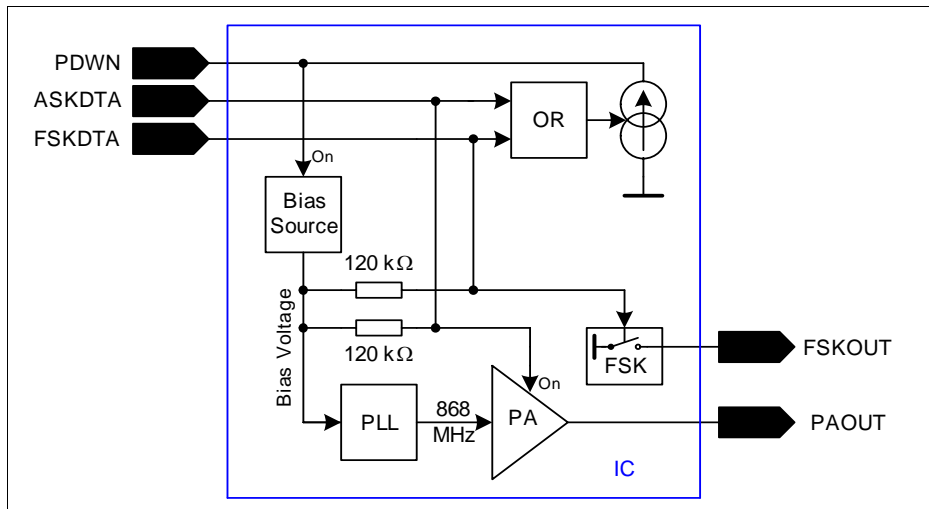


Figure 3 Power mode control circuitry

Functional Description

Table 5 provides a listing of how to get into the different power modes

Table 5 Power Modes

| PDWN | FSKDTA | ASKDTA | MODE |
|--------------------|-----------------|------------|------------|
| Low ¹⁾ | Low, Open | Low, Open | POWER DOWN |
| Open ²⁾ | Low | Low | |
| High ³⁾ | 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

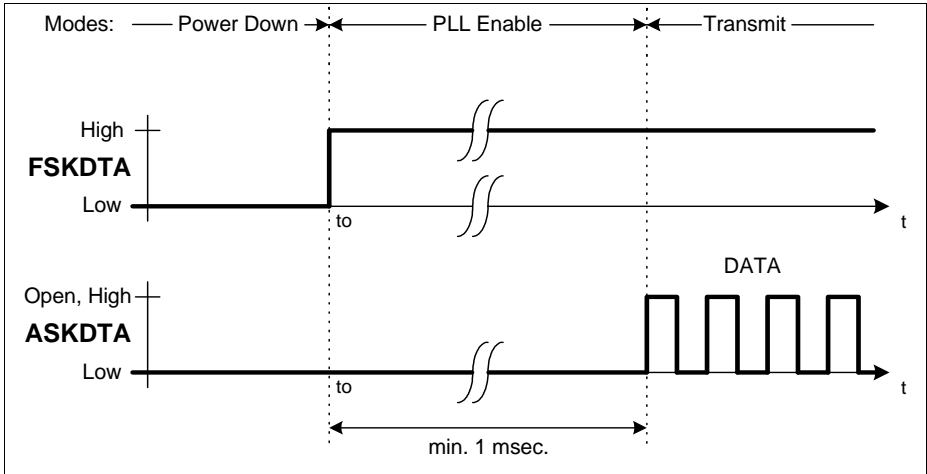


Figure 4 ASK Modulation

FSK Modulation using FSKDTA and ASKDTA, PDWN not connected.

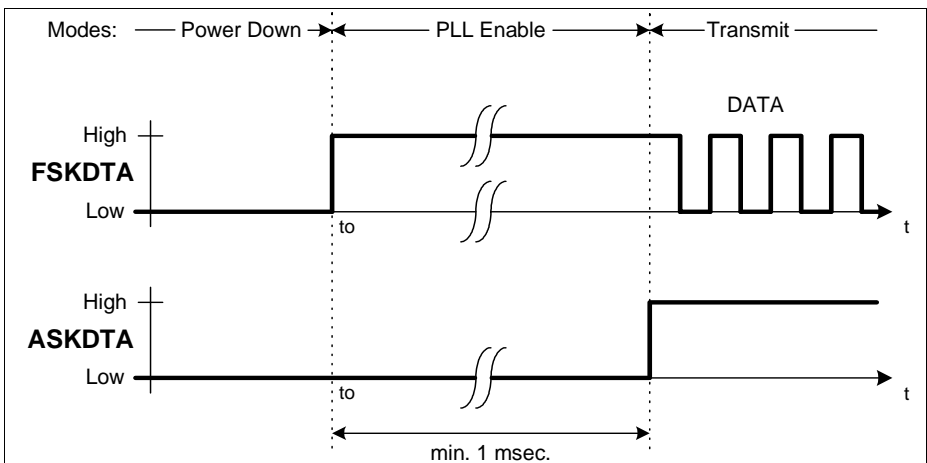


Figure 5 FSK Modulation

Functional Description

Alternative ASK Modulation, FSKDTA not connected.

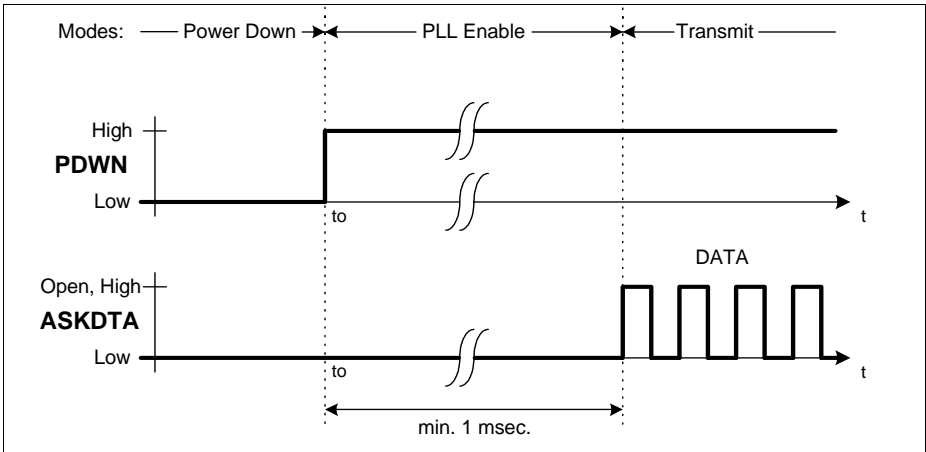


Figure 6 Alternative ASK Modulation

Alternative FSK Modulation

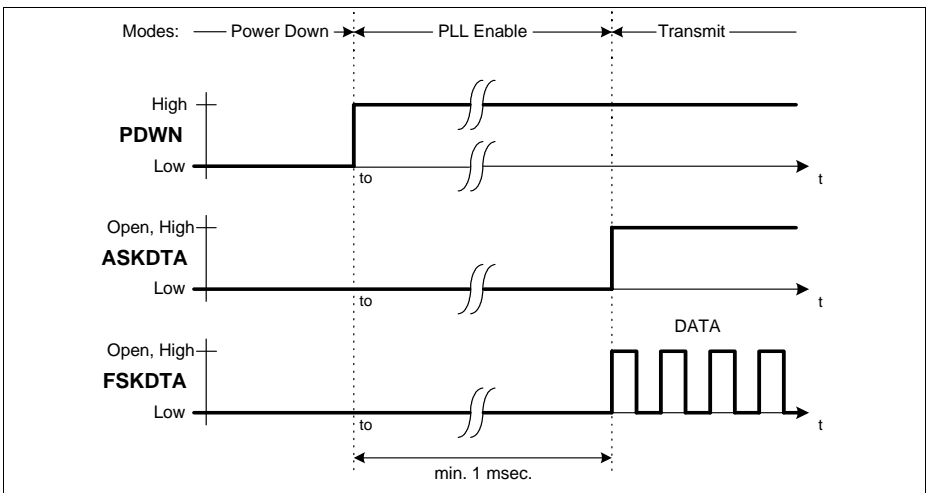


Figure 7 Alternative FSK Modulation

3 Applications

3.1 50 Ohm-Output Testboard Schematic

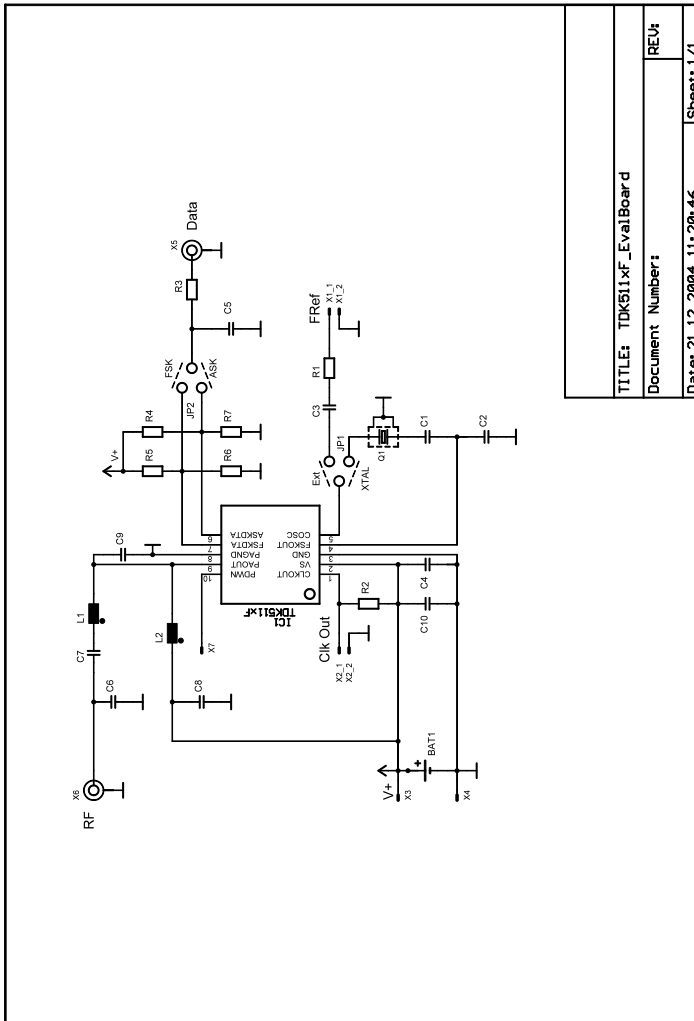


Figure 8 50 Ohm-output testboard schematic

3.2 50 Ohm-Output Testboard Layout

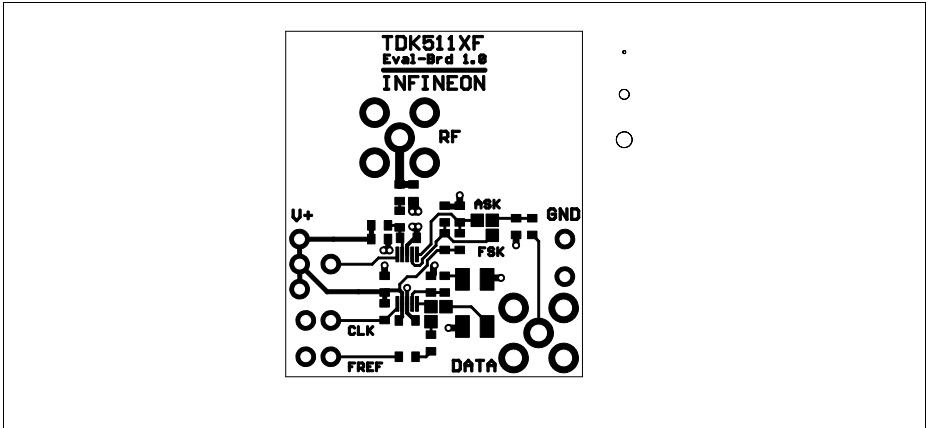


Figure 9 Top Side of TDK5116F-Testboard with 50 Ohm-Output

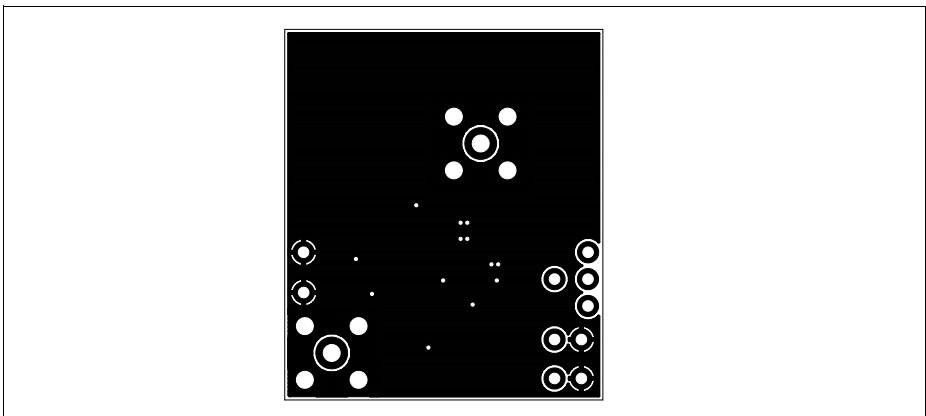


Figure 10 Bottom Side of TDK5116F-Testboard with 50 Ohm-Output

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 | 8p2 | 0603, C0G, +/-1% |
| C2 | 15p | 0603, C0G, +/-0.1p |
| C3 | open | |
| C4 | 47n | 0603, X7R, +/-10% |
| C5 | 100p | 0603, X7R, +/-10% |
| C6 | 6p8 | 0603, C0G, +/-1% |
| C7 | 47p | 0603, C0G, +/-1% |
| C8 | 47p | 0603, C0G, +/-5% |
| C9 | 2p7 | 0603, C0G, +/-0,1p |
| C10 | 47n | 0603, X7R, +/-10% |
| L1 | 10n | EPCOS SIMID 0603-C, +/-2% |
| L2 | 82n | EPCOS SIMID 0603-C, +/-2% |
| X1 | n.e. | |
| X2 | n.e. | |
| X3 | Pin | single-pole connector, 2.54mm |
| X4 | Pin | single-pole connector, 2.54mm |
| 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, Spec.No. 10-50205 |
| IC1 | TDK5116F | |
| | | |
| PCB | TDK5116F V1.0 | Manufacturer: PIU Printex in Vienna |

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 TDK5116F. 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 .

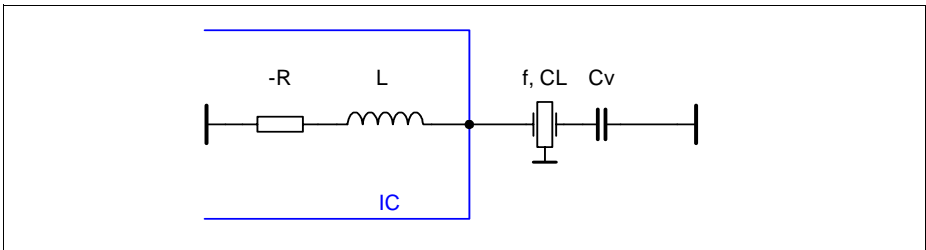


Figure 11 Application Hints

Formula 1:

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

CL: crystal load capacitance for nominal frequency

ω : 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 μ H. Therefore C_1 is calculated to 10 pF.

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

Example for the FSK-Mode:

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

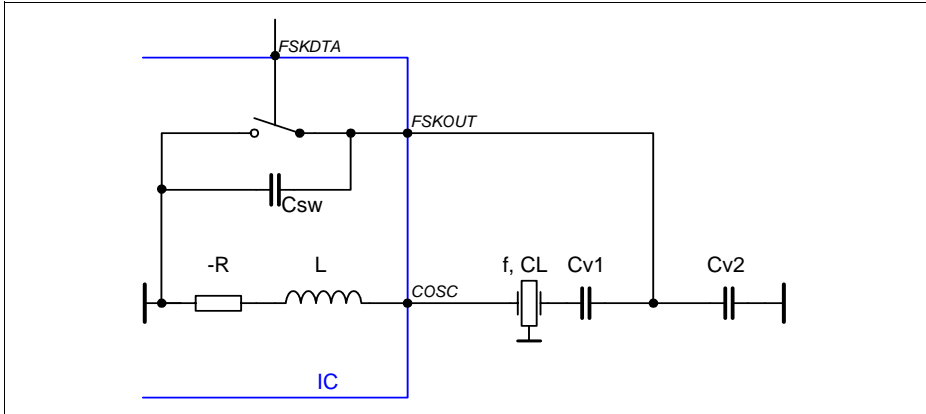


Figure 12 FSK Mode

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
- ω : $\omega = 2\pi f$: angular frequency
- N: division ratio of the PLL
- df: peak frequency deviation

Because of the inductive part of the TDK5116F, 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 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 6 Clock Output

| fCLKOUT=847.5 kHz | |
|--------------------------|----------|
| CL[pF] | RL[kOhm] |
| 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//RL in parallel to the output impedance of the transistor should be in resonance at the operating frequency of the transmitter.

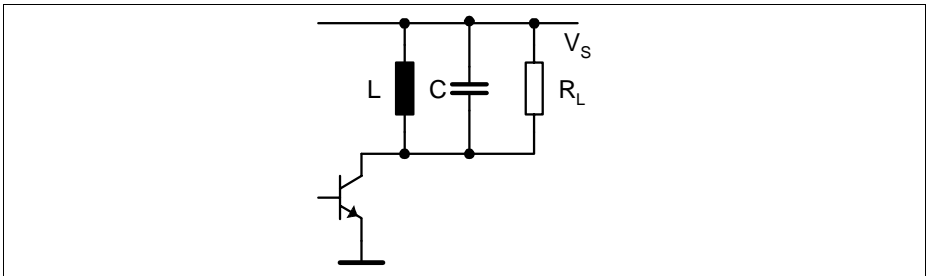


Figure 13 Equivalent power amplifier tank circuit

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

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

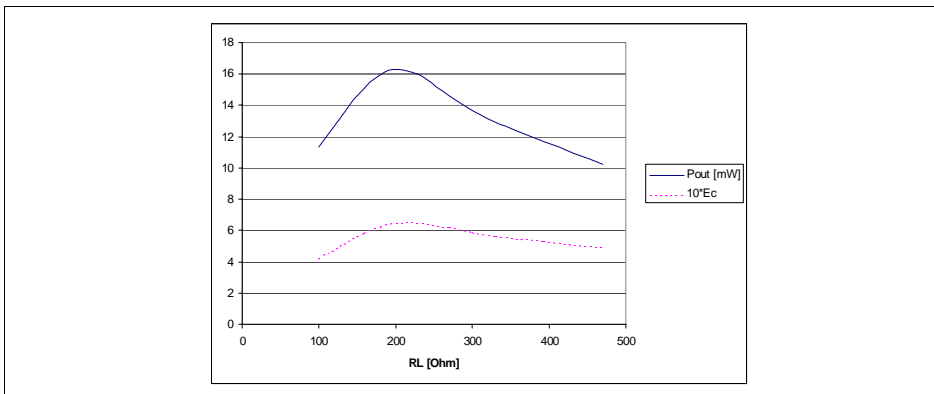


Figure 14 Output power P_o (mW) and collector efficiency E vs. load resistor R_L .

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 7 Absolute Maximum Ratings, $T_{amb} = -40\text{ °C} \dots +125\text{ °C}$

| 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: $T_{amb} = -40\text{ °C}$ to $+125\text{ °C}$

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 8 Operating Ratings

| Parameter | Symbol | Limit Values | | Unit | Test Conditions |
|---------------------|-----------|--------------|------|------|-----------------|
| | | min. | max. | | |
| Supply voltage | V_S | 2.1 | 4.0 | V | |
| Ambient temperature | T_{amb} | -40 | 125 | °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 9 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 | $I_{S\ PDWN}$ | | 0.3 | 100 | nA | V (Pins 10, 6 and 7) < 0.2 V |
| PLL Enable mode | $I_{S\ PLL_EN}$ | | 4 | 5.5 | mA | |
| Transmit mode 868 MHz | $I_{S\ TRANSM}$ | | 14 | 18 | mA | |
| Output frequency | | | | | | |
| Output frequency | f_{OUT} | 854 | 868 | 884 | MHz | $f_{OUT} = 64 * f_{COSC}$ |
| Clock Driver Output (Pin 1) | | | | | | |
| Output current (High) | I_{CLKOUT} | | | 5 | µA | $V_{CLKOUT} = V_S$ |
| Saturation Voltage (Low) ¹⁾ | V_{SATL} | | | 0.56 | V | $I_{CLKOUT} = 1\ mA$ |

Table 9 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 | Ω | $V_{FSKDTA} = 0 V$ |
| On capacitance | C_{FSKOUT} | | | 6 | pF | $V_{FSKDTA} = 0 V$ |
| Off resistance | R_{FSKOUT} | 10 | | | k Ω | $V_{FSKDTA} = V_S$ |
| 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 | Ω | $f = 13.56 \text{ MHz}$ |
| Input inductance of the COSC pin | | | 4.6 | | μH | $f = 13.56 \text{ MHz}$ |
| 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 | μA | $V_{ASKDTA} = V_S$ |
| Input bias current ASKDTA | I_{ASKDTA} | -20 | | | μA | $V_{ASKDTA} = 0 V$ |
| 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 | μA | $V_{FSKDTA} = V_S$ |
| Input bias current FSKDTA | I_{FSKDTA} | -20 | | | μA | $V_{FSKDTA} = 0 V$ |
| FSK data rate | f_{FSKDTA} | | | 20 | kHz | |
| Power Amplifier Output (Pin 9) | | | | | | |
| Output Power ²⁾ at 868 MHz transformed to 50 Ohm | P_{OUT868} | 7 | 10 | 13 | dBm | |

Table 9 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_{PDWN} | 0 | | 0.7 | V | $V_{ASKDTA} < 0.2 V$ $V_{FSKDTA} < 0.2 V$ |
| PLL Enable mode | V_{PDWN} | 1.5 | | V_S | V | $V_{ASKDTA} < 0.5 V$ |
| Transmit mode | V_{PDWN} | 1.5 | | V_S | V | $V_{ASKDTA} > 1.5 V$ |
| Input bias current PDWN | I_{PDWN} | | | 30 | μA | $V_{PDWN} = V_S$ |

- 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, $-40^\circ C$... $+125^\circ C$

Table 10 Supply Voltage $V_S=2.1V$... 4.0V, $T_{amb}=-40^\circ C$... $+125^\circ C$

| Parameter | Symbol | Limit Values | | | Unit | Test Conditions |
|------------------------------|-----------------|--------------|------|------|---------|--------------------------------|
| | | min. | typ. | max. | | |
| Current consumption | | | | | | |
| Power Down mode | $I_{S PDWN}$ | | | 4 | μA | V (Pins 10, 6 and 7) $< 0.2 V$ |
| PLL Enable mode | $I_{S PLL_EN}$ | 2.5 | 4 | 6 | mA | |
| Transmit mode | $I_{S TRANSM}$ | | 11 | 15.5 | mA | $V_S = 2.1 V$ |
| Load tank see Figure 8 and 9 | $I_{S TRANSM}$ | | 14 | 18 | mA | $V_S = 3.0 V$ |
| | $I_{S TRANSM}$ | | 16 | 21 | mA | $V_S = 4.0 V$ |

Output frequency

| | | | | | | |
|--------------------------------|-----------|-----|-----|-----|-----|---------------------------|
| Output frequency ¹⁾ | f_{OUT} | 864 | 868 | 874 | MHz | $f_{OUT} = 64 * f_{COSC}$ |
|--------------------------------|-----------|-----|-----|-----|-----|---------------------------|

Clock Driver Output (Pin 1)

| | | | | | | |
|--|--------------|--|--|-----|---------|-----------------------|
| Output current (High) | I_{CLKOUT} | | | 5 | μA | $V_{CLKOUT} = V_S$ |
| Saturation Voltage (Low) ²⁾ | V_{SATL} | | | 0.5 | V | $I_{CLKOUT} = 0.6$ mA |

Table 10 Supply Voltage $V_S=2.1V \dots 4.0V$, $T_{amb}=-40^\circ C \dots +125^\circ C$ (cont'd)

| Parameter | Symbol | Limit Values | | | Unit | Test Conditions |
|--|---------------|--------------|------|-------|------------|-------------------------|
| | | min. | typ. | max. | | |
| FSK Switch Output (Pin 4) | | | | | | |
| On resistance | R_{FSKOUT} | | | 280 | Ω | $V_{FSKDTA} = 0 V$ |
| On capacitance | C_{FSKOUT} | | | 6 | pF | $V_{FSKDTA} = 0 V$ |
| Off resistance | R_{FSKOUT} | 10 | | | k Ω | $V_{FSKDTA} = V_S$ |
| 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 | Ω | $f = 13.56 \text{ MHz}$ |
| Input inductance of the COSC pin | | | 4.6 | | μH | $f = 13.56 \text{ MHz}$ |
| 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} | | | 33 | μA | $V_{ASKDTA} = V_S$ |
| Input bias current ASKDTA | I_{ASKDTA} | -20 | | | μA | $V_{ASKDTA} = 0 V$ |
| 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} | | | 33 | μA | $V_{FSKDTA} = V_S$ |
| Input bias current FSKDTA | I_{FSKDTA} | -20 | | | μA | $V_{FSKDTA} = 0 V$ |
| FSK data rate | f_{FSKDTA} | | | 20 | kHz | |

Table 10 Supply Voltage $V_S=2.1V \dots 4.0V$, $T_{amb}=-40^\circ C \dots +125^\circ C$ (cont'd)

| Parameter | Symbol | Limit Values | | | Unit | Test Conditions |
|---|----------------|--------------|------|-------|---------|--|
| | | min. | typ. | max. | | |
| Power Amplifier Output (Pin 9) | | | | | | |
| Output Power ³⁾ at 868 MHz transformed to 50 Ohm. | $P_{OUT, 868}$ | 3 | 6 | 9 | dBm | $V_S = 2.1V$ |
| | $P_{OUT, 868}$ | 6 | 10 | 14 | dBm | $V_S = 3.0V$ |
| | $P_{OUT, 868}$ | 6.5 | 11.5 | 16 | dBm | $V_S = 4.0V$ |
| Power Down Mode Control (Pin 10) | | | | | | |
| Power Down mode | V_{PDWN} | 0 | | 0.5 | V | $V_{ASKDTA} < 0.2V$ $V_{FSKDTA} < 0.2V$ |
| PLL Enable mode | V_{PDWN} | 1.5 | | V_S | V | $V_{ASKDTA} < 0.5V$ |
| Transmit mode | V_{PDWN} | 1.5 | | V_S | V | $V_{ASKDTA} > 1.5V$ |
| Input bias current PDWN | I_{PDWN} | | | 38 | μA | $V_{PDWN} = V_S$ |

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

Please note that f_{VCO} equals the Output Frequency.

All three measures can be taken independently and additive.

- 2) Derating linearly to a saturation voltage of max. 140 mV at $I_{CLKOUT} = 0$ 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, $+25^\circ C$: 6 dBm +/- 2 dBm

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

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

5 Package Outlines

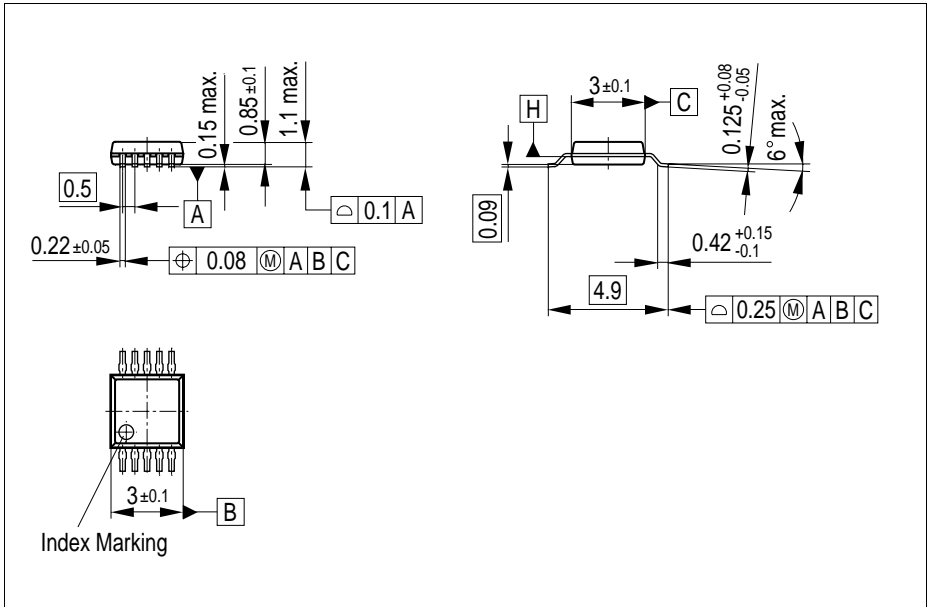


Figure 15 PG-TSSOP-10-3

Table 11 Order Information

| Type | Ordering Code | Package |
|----------------------------|---------------|---------------|
| TDK5116F | SP000056182 | PG-TSSOP-10-3 |
| available on tape and reel | | |

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

List of Tables

Page

| | | |
|----------|--|----|
| Table 1 | Pin Definition and Functions - Overview | 7 |
| Table 2 | Pin Definition and Function ¹ | 8 |
| Table 3 | FSKDTA - FSK Switch | 13 |
| Table 4 | ASKDTA - Power Amplifier | 14 |
| Table 5 | Power Modes | 16 |
| Table 6 | Clock Output | 24 |
| Table 7 | Absolute Maximum Ratings, Tamb = -40 °C ... +125 °C | 27 |
| Table 8 | Operating Ratings | 28 |
| Table 9 | Supply Voltage VS=3V, Ambient temperature Tamb=25°C | 28 |
| Table 10 | Supply Voltage VS=2.1V ... 4.0V, Tamb=-40°C ... +125°C | 30 |
| Table 11 | Order Information | 33 |

| List of Figures | | Page |
|------------------------|--|-------------|
| Figure 1 | IC Pin Configuration | 7 |
| Figure 2 | Functional Block Diagram | 12 |
| Figure 3 | Power mode control circuitry | 15 |
| Figure 4 | ASK Modulation | 17 |
| Figure 5 | FSK Modulation | 17 |
| Figure 6 | Alternative ASK Modulation | 18 |
| Figure 7 | Alternative FSK Modulation | 18 |
| Figure 8 | 50 Ohm-output testboard schematic | 19 |
| Figure 9 | Top Side of TDK5116F-Testboard with 50 Ohm-Output | 20 |
| Figure 10 | Bottom Side of TDK5116F-Testboard with 50 Ohm-Output | 20 |
| Figure 11 | Application Hints | 22 |
| Figure 12 | FSK Mode | 23 |
| Figure 13 | Equivalent power amplifier tank circuit. | 25 |
| Figure 14 | Output power P_o (mW) and collector efficiency E vs. load resistor R_L | 26 |
| Figure 15 | PG-TSSOP-10-3 | 33 |

www.infineon.com

Published by Infineon Technologies AG