Read/Write Crypto Transponder for Short Cycle Time

TK5561A-PP

Features

- 65 ms Cycle Time for Crypto Algorithm Programming
- Encryption Time < 10 ms, < 30 ms Optional
- Identification Transponder in Plastic Cube
- Contactless Read/Write Data Transmission
- High-security Crypto Algorithm Optional
- Inductive Coupled Power Supply at 125 kHz
- Basic Component R/W e5561 IDIC®
- Built-in Coil and Capacitor for Circuit Antenna
- Starts with Cyclical Data Read Out
- Self-adapting Resonance Frequency (Optional)
- 128-bit User-programmable EEPROM
- Typical < 50 ms to Write and Verify a Block
- Read/Write Protection by Lock Bits
- Options Set by EEPROM:
  - Bit Rate (Bit/s): Rf/32, Rf/64
  - Modulaton: Manchester, Biphase

Application

- Car Immobilizers with Higher Security Level
- High-security Identification Systems

Description

The TK5561A-PP is a complete transponder integrating all important functions for immobilizer and identification systems. It consists of a plastic cube which accommodates the crypto IDIC e5561A and the antenna realized as tuned LC-circuit. The TK5561A-PP is a R/W crypto transponder for applications which demand higher security levels than those which standard R/W transponders can fulfil. For this reason, the TK5561A-PP has an additional encryption algorithm block which enables a base station to authenticate the transponder. Any attempt to fake the base station with a wrong transponder will be recognized immediately. For authentication, the base station transmits a challenge to the TK5561A-PP. This challenge is encrypted by both the IC and the base station. Both should possess the same secret key. Only then can the results be expected to be equal.

For detailed technical information about functions, configurations etc., please refer to the e5561 data sheet.

Rev. 4682A–RFID–02/03

Figure 1. Transponder and Base Station

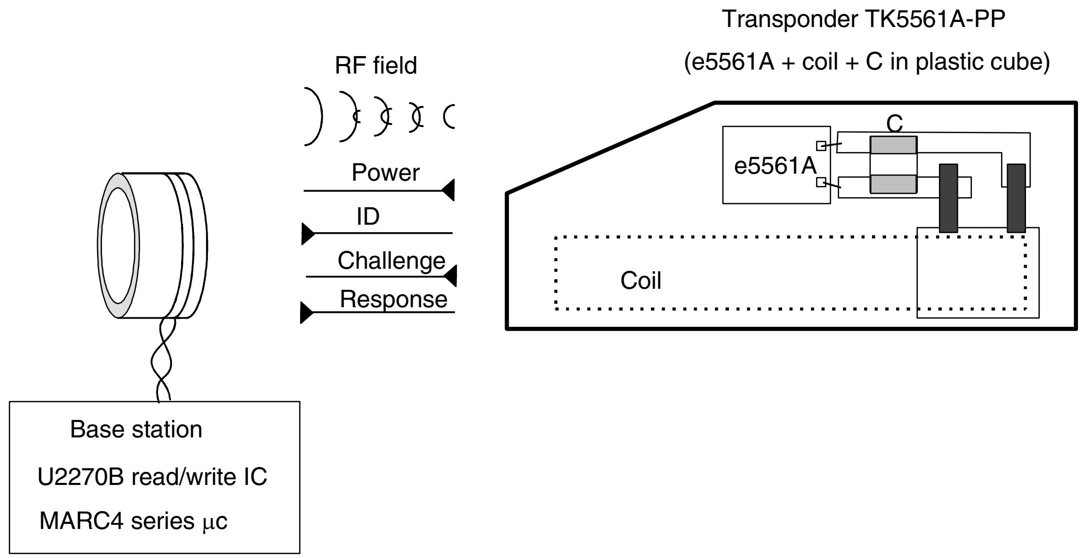
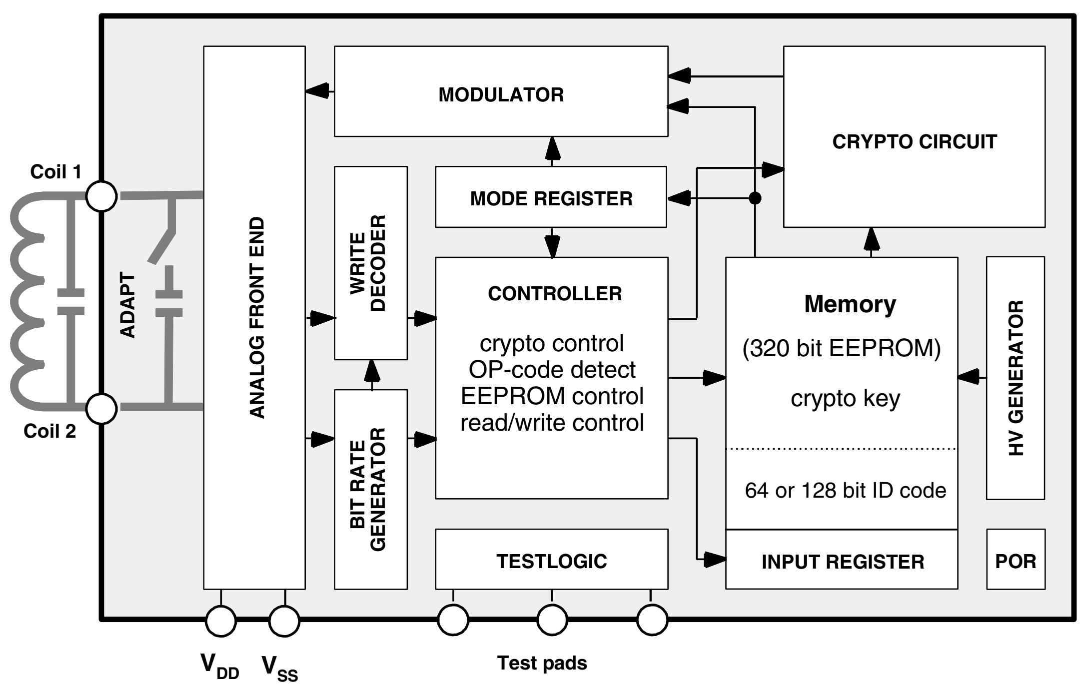


Figure 2. Block Diagram



General

The transponder is the mobile part of the closed coupled identification system (see Figure 1), whereas the read/write base station is based on the U2270B or on discrete solutions, and the read/write transponder is based on the e5561A IDIC.

The transponder is a plastic-cube device consisting of the following parts:

- The transponder antenna, with a tuned LC-circuit
- Read/write IDIC (e5561A) with EEPROM

Transponder Antenna

The antenna consists of a coil and a capacitor for tuning the circuit to the nominal carrier frequency of 125 kHz. The coil has a ferrite core to improve the read, write and programming operation distances.

Read/Write Crypto Identification

The e5561A is a member of the Atmel's contactless **ID**entification **IC** (IDIC) family, which are used in applications where information has to be transmitted without contacts. The IDIC is connected to a tuned LC circuit for power supply and bidirectional data communication (**R**ead/**W**rite) to a base station.

The on-chip non-volatile memory of the 320-bit EEPROM (10 blocks, 32 bits each) can be read and written blockwise by a read/write base station, e.g. based on the U2270B. Up to four blocks consisting of the user programmable ID code, the crypto key and configurations are stored in six blocks. The crypto key and the ID code can be individually protected against overwriting.

The typical operational frequency of the TK5561A-PP is 125 kHz. Two data bit rates are programmable: Rf/32 and Rf/64. During the reading operation the incoming RF field is dampened bit-wise by an on-chip load. This AM-modulation is detected by the field generating base station unit. Data transmission starts after power-up with the transmission of the ID code and continues as long as the TK5561A-PP is powered.

Writing is carried out by means of Atmel's patented writing method. To transmit data to the TK5561A-PP the read/write base station has to interrupt the RF field for a short time to create a field gap. The information is encoded in the number of clock cycles between two subsequent gaps.

See the e5561A data sheet for detailed information of the IDIC.

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Operating temperature range	T_{amb}	-40 to +85	°C
Storage temperature range	T_{stg}	-40 to +125	°C
Maximum assembly temperature, t < 5 min	T_{ass}	170	°C
Magnetic field strength at 125 kHz	H_{pp}	1000	A/m

Operating Characteristics Transponder

T_{amb} = 25°C, f = 125 kHz unless otherwise specified

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit
Inductance		L		4.2		mH
LC circuit, H_{pp} = 20 A/m						
Resonance frequency	T_{amb} = -40 to +85°C	f_r	121	125	129	kHz
Quality factor		Q_{LC}	5	8	11	
Magnetic Field Strength (H)						
Max. field strength where transponder does not modulate	No influence to other transponders in the field	$H_{pp\ not}$		5		A/m
Minimum Field Strength (H)						
Read mode	T_{amb} = -40°C	$H_{pp\ -40}$			24	A/m
	T_{amb} = 25°C	$H_{pp\ 25}$			18	A/m
	T_{amb} = 85°C	$H_{pp\ 85}$			15	A/m
Programming mode	T_{amb} = -40°C	$H_{pp\ -40}$			30	A/m
	T_{amb} = 25°C	$H_{pp\ 25}$			35	A/m
	T_{amb} = 85°C	$H_{pp\ 85}$			40	A/m
Lowest adapt frequency		f_{LA}	118	121	124.5	kHz
Highest adapt frequency		f_{HA}	125	128	131.5	kHz
Data retention EEPROM	T = 25°C	$t_{retention}$	10			Years
Programming cycles EEPROM			100,000			
Programming time/block	RF = 125 kHz	t_p		16		ms
Maximum field strength		$H_{pp\ max}$			600	A/m

Figure 3. Typical Curve for Degree of Modulation

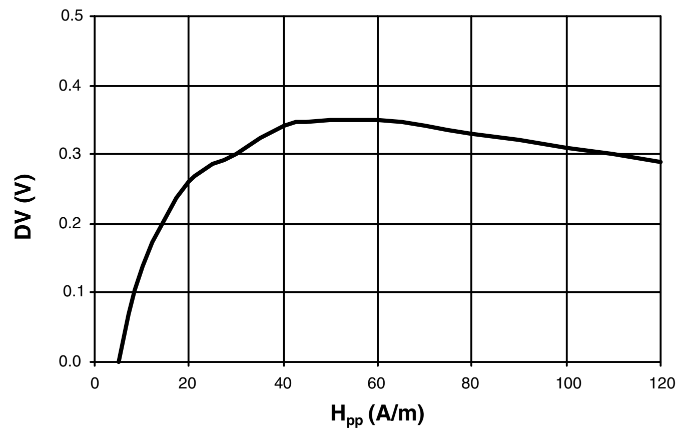
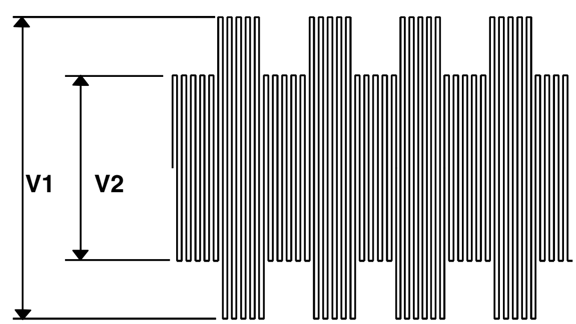


Figure 4. Measurement of the Degree of Modulation



$$m = \frac{V1 - V2}{V1 + V2}$$

Measurement Assembly

All parameters are measured in a Helmholtz-arrangement, which generates a homogenous magnetic field (see Figure 5 and Figure 6). A function generator drives the field generating coils, so the magnetic field can be varied in frequency and field strength.

Figure 5. Testing Application

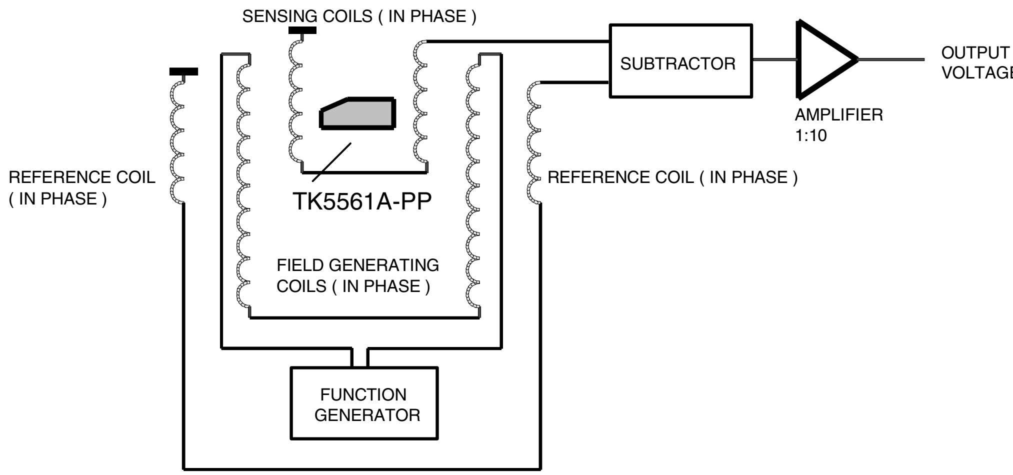
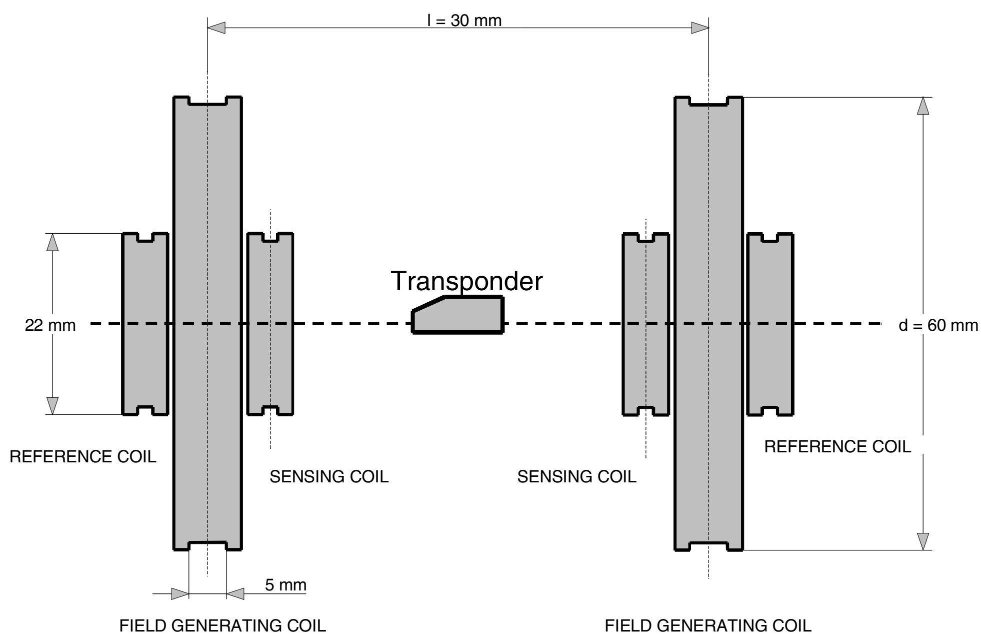


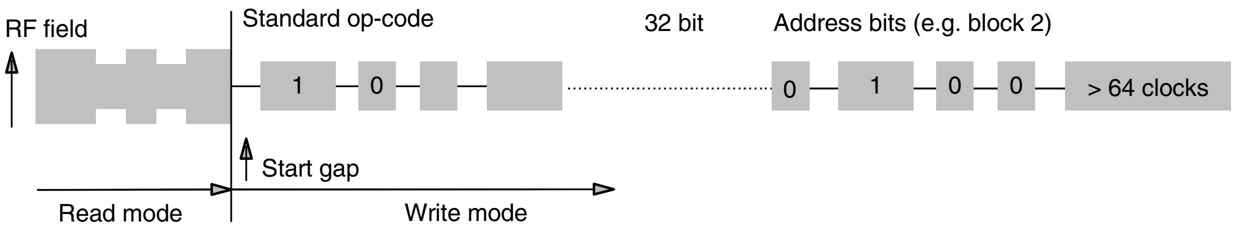
Figure 6. Testing Geometry



Writing Data into the TK5561A-PP

A write sequence of the TK5561A-PP is shown in Figure 7. Writing data into the transponder occurs by interrupting the RF field with short gaps. After the start gap the write op-code (10) is transmitted. The next 32 bits contain the actual data. The last 4 bits denote the destination block address. If the correct number of bits have been received, the actual data is programmed into the specified memory block.

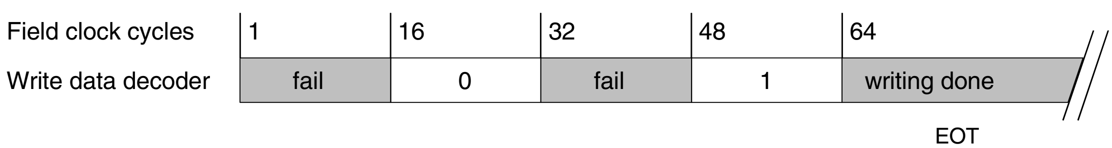
Figure 7. Write Protocol to Program the EEPROM



Writing Data Decoding

The time elapsing between two detected gaps is used to encode the information. As soon as a gap is detected, a counter starts counting the number of field clock cycles until the next gap is detected. Depending on how many field clocks elapse, the data is regarded as 0 or 1. The required number of field clocks is shown in Figure 8. A valid 0 is assumed if the number of counted clock periods is between 16 and 31, for a valid 1 it is 48 or 63 respectively. Any other value being detected results in an error and the device exits write mode and returns to read mode.

Figure 8. Write Data Decoding Scheme



Actual Device Behavior

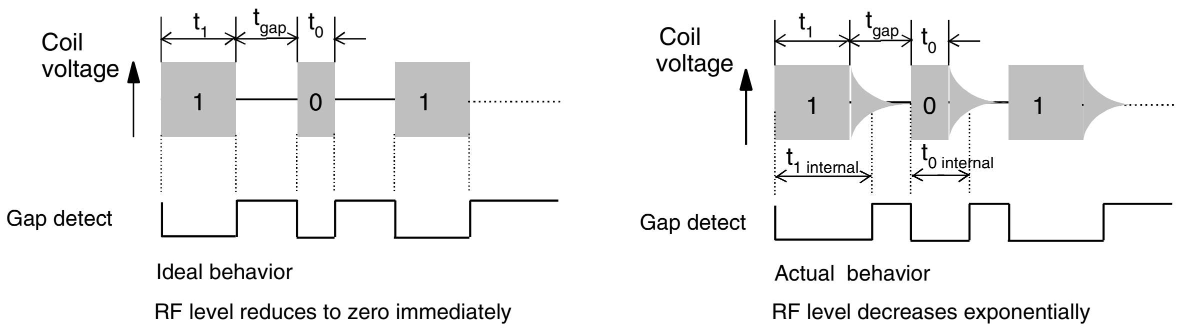
The TK5561A-PP detects a gap if the voltage across the coils decreases below a peak-to-peak value of about 800 mV. Until then, the clock pulses are counted. The number given for a valid 0 or 1 (see Figure 8) refers to the actual clock pulses counted by the device. However, there are always more clock pulses being counted than were applied by the base station. The reason for this is the fact that an RF field cannot be switched off immediately. The coil voltage decreases exponentially. So although the RF field coming from the base station is switched off, it takes some time until the voltage across the coils reaches the threshold peak-to-peak value of about 800 mV and the device detects the gap. Referring to the following diagram Figure 9, this means that the device uses the times t_0 internal and t_1 internal. The exact times for t_0 and t_1 are dependent on the application (e.g., field strength, etc.)

Typical time frames are:

t_0 = 60 to 140 µs
t_1 = 300 to 400 µs
t_{gap} = 150 to 400 µs

Antennas with a high Q-factor require longer times for t_{gap} and shorter time values for t_0 and t_1.

Figure 9. Ideal and Actual Signal Behavior

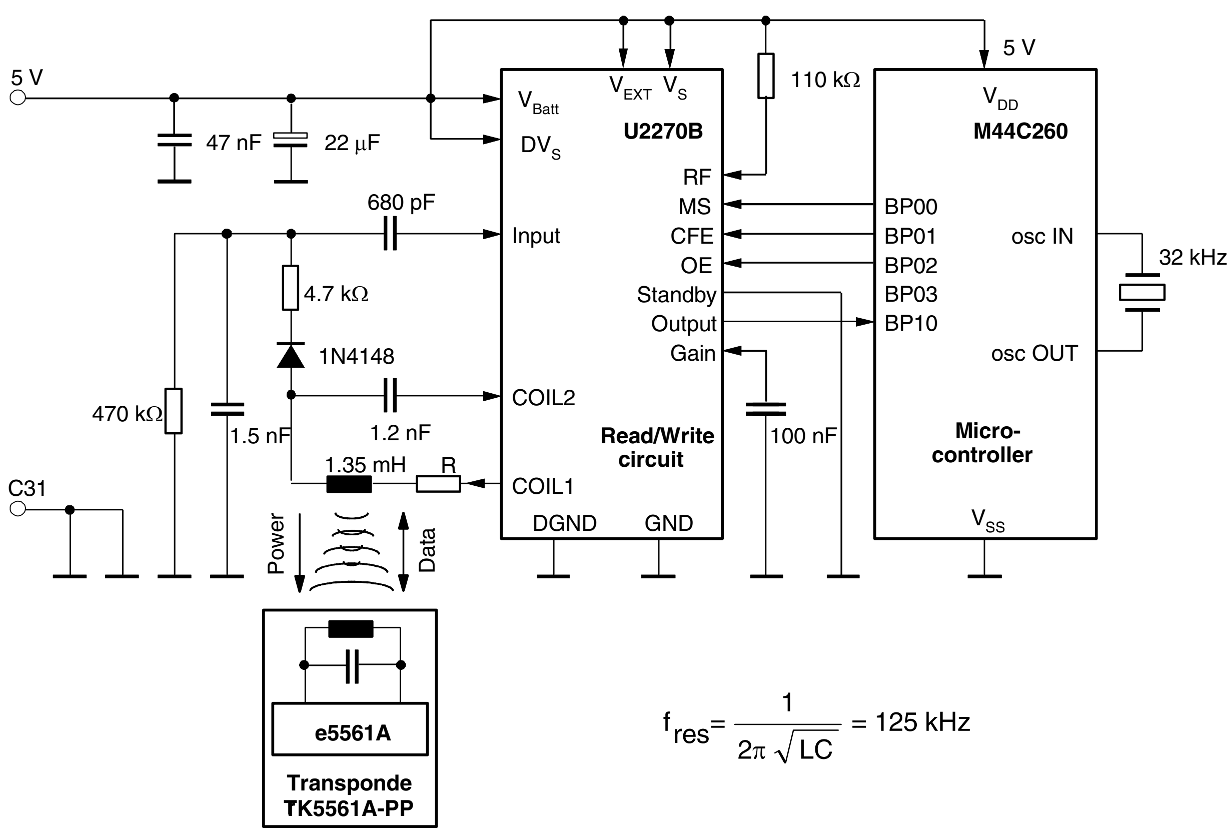


Operating Distance

The maximum distance between the base station and the TK5561A-PP depends mainly on the base station, the coil geometries and the chosen modulation options. Typical distances are 0 to 3 cm. A general maximum distance value cannot be given. A convenient way is to measure the TK5561A-PP within its environment. Rules for a correct base-station design can be provided upon request (see Antenna Design Guide).

Application

Figure 10. Complete Transponder System with the U2270B Read/Write IC

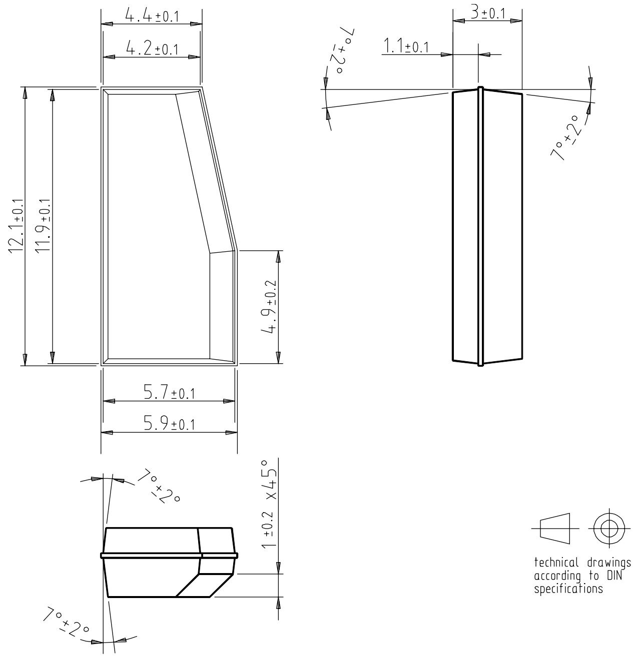


$$f_{res} = \frac{1}{2\pi\sqrt{LC}} = 125\ \text{kHz}$$

Mechanical Specification

Figure 11. Mechanical Drawing of Transponder

Dimensions in mm



Ordering Information

Extended Type Number	Package	Remarks
TK5561A-PP	–	A = Version of e5561 IDIC

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