Read/Write Transponder

Description
The TK5550 is a complete programmable R/W transponder, which implements all important functions for identification systems. It allows the contactless reading and writing of data, which are transmitted bidirectionally between a read/write basestation and the transponder. It is a plastic-cube device, which accommodates the IDIC® *) e5550 and also the antenna realized as an LC-circuit. No additional external power supply is necessary for the transponder, because it receives power from the RF field generated by the basestation. Data are transmitted by modulating the amplitude of the RF field. The TK5550 can be used to adjust and modify the ID-code or any other stored data, e.g. rolling code systems. The on-chip 264-Bit EEPROM (8 blocks, 33 bits per block) can be read and written blockwise from the basestation. The blocks can be protected against overwriting. One block is reserved for setting the operation modes of the IC. Another block can obtain a password to prevent unauthorized writing.

Features
- Identification transponder in plastic cube
- Contactless read/write data transmission
- Inductive coupled power supply at 125 kHz
- Basic component: R/W IDIC® e5550
- Built-in coil and capacitor for circuit antenna
- Starts with cyclical data read out
- 224 bit EEPROM user programmable in 32-bit blocks
- Typical < 50 ms to write and verify a block
- Write protection by lock bits
- Malprogramming protection
- Options set by EEPROM:
  - Bitrate [bit/s]: RF/8, RF/16, RF/32, RF/40, RF/50, RF/64, RF/100, RF/128
  - Modulation: BIN, FSK, PSK, Manchester, Biphase

Application
- Access control
- Rechargeable cash card
- Process control and automation
- Other identification systems

Figure 1. Transponder and base station

*) IDIC® stands for IDentification Integrated Circuit and is a trademark of TEMIC.
Ordering Information

<table>
<thead>
<tr>
<th>Extended Type Number</th>
<th>Package</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| TK5550F–PP           | Plastic cube | All kind of modulation; RF/8, RF/16, RF/32, RF/40, RF/50, RF/64, RF/100 and RF/128. *)
|                      |              | Default programmed: Manchester Modulation, RF/32, MAXBLK = 2           |

*) see datasheet e5550 page 4

General

The transponder is the mobile part of the closed coupled identification system (see figure 1 on page 1), whereas the read/write base station is basing on the U2270B or on discrete solutions, and the read/write transponder is basing on the IDIC® e5550.

The transponder is a plastic-cube device consisting of following parts:
- The transponder antenna, realized as tuned LC-circuit
- Read/write IDIC® (e5550) with EEPROM

The 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 for improving the distance of read, write and programming operations.

The Read/Write IDIC® e5550

The read/write IDIC® e5550 is part of the transponder TK5550. The data are transmitted bidirectionally between the base station and the transponder. The transponder receives power via a single coil from the RF signal generated by the base station. The single coil is connected to the chip and also serves as the IC’s bidirectional communication interface.

Data are transmitted by modulating the amplitude of the RF signal. Reading occurs by damping the coil by an internal load. Writing occurs by interrupting the RF field in a specific way. The TK5550 transponder operates at a nominal frequency of 125 kHz. There are different bit rates and encoding schemes.

The on-chip 264-bit EEPROM (8 block, 33 bits each) can be read and written blockwise from the base station. The blocks can be protected against overwriting by using lock bits. One block is reserved for setting the operation modes of the IC. Another block contains a password to prevent unauthorized writing.

See e5550 data sheet for more detailed information of IDIC®.

Figure 2. Block diagram e5550
Electrical Characteristics

Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature range</td>
<td>$T_{amb}$</td>
<td>–40 to +85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature range</td>
<td>$T_{stg}$</td>
<td>–40 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>Maximum assembly temperature, $t &lt; 5$ min.</td>
<td>$T_{ass}$</td>
<td>170</td>
<td>°C</td>
</tr>
<tr>
<td>Magnetic field strength at 125 kHz</td>
<td>$H_{pp}$</td>
<td>1000</td>
<td>A/m</td>
</tr>
</tbody>
</table>

Operating Characteristics Transponder

$T_{amb} = 25°C$, $f = 125$ kHz if not otherwise noted

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inductance</td>
<td></td>
<td>$L$</td>
<td>3.8</td>
<td></td>
<td></td>
<td>mH</td>
</tr>
<tr>
<td>LC circuit, $H_{pp} = 20$ A/m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resonance frequency</td>
<td>Room temperature</td>
<td>$f_r$</td>
<td>120</td>
<td>125</td>
<td>130</td>
<td>kHz</td>
</tr>
<tr>
<td>Quality factor</td>
<td></td>
<td>$Q_{LC}$</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Magnetic field strength (H)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. field strength where tag does not modulate</td>
<td>No influence to other tags in the field</td>
<td>$H_{pp\ not}$</td>
<td>4</td>
<td></td>
<td></td>
<td>A/m</td>
</tr>
</tbody>
</table>

Minimum field strength

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read mode, write mode</td>
<td>$T_{amb} = –40°C$</td>
<td>$H_{pp\ –40}$</td>
<td>30</td>
<td></td>
<td></td>
<td>A/m</td>
</tr>
<tr>
<td></td>
<td>$T_{amb} = 25°C$</td>
<td>$H_{pp\ 25}$</td>
<td>18</td>
<td></td>
<td></td>
<td>A/m</td>
</tr>
<tr>
<td></td>
<td>$T_{amb} = 85°C$</td>
<td>$H_{pp\ 85}$</td>
<td>17</td>
<td></td>
<td></td>
<td>A/m</td>
</tr>
<tr>
<td>Programming mode</td>
<td>$T_{amb} = 25°C$</td>
<td>$H_{pp}$</td>
<td>50</td>
<td></td>
<td></td>
<td>A/m</td>
</tr>
<tr>
<td>Data retention EEPROM</td>
<td>$T = 25°C$</td>
<td>$t_{retention}$</td>
<td>10</td>
<td></td>
<td></td>
<td>Years</td>
</tr>
<tr>
<td>Programming cycles EEPROM</td>
<td></td>
<td></td>
<td>100,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programming time / block</td>
<td>RF = 125 kHz</td>
<td>$t_p$</td>
<td>16</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>Maximum field strength</td>
<td></td>
<td>$H_{pp\ max}$</td>
<td>600</td>
<td></td>
<td></td>
<td>A/m</td>
</tr>
</tbody>
</table>

Modulation range (see also H–DV curve)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulation range</td>
<td>$H_{pp} = 20$ A/m</td>
<td>$DV$</td>
<td>4.0</td>
<td>6.0</td>
<td>8.0</td>
<td>V</td>
</tr>
</tbody>
</table>
Figure 3. Typical $T_K$-range of resonance frequency

Figure 4. Typical $H$–$DV$ curve

**Output voltage of the testing application**

$DV = V1 - V_{mod}$

Figure 5. Measurement of the modulation range $DV$
Measurement Assembly

All parameters are measured in a Helmholtz-arrangement, which generates a homogenous magnetic field (see figure 6 and 7). A function generator drives the field generating coils, so the magnetic field can be varied in frequency and field strength.

Figure 6. Testing application

Figure 7. Testing geometry
Writing Data into the TK5550

The write sequence of the TK5550 is shown below. Writing data into the transponder occurs by interrupting the RF field with short gaps. After the start gap the standard write OP-code (10) is followed by the lockbit. The next 32 bits contain the actual data. The last 3 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.

\[ \text{Start gap} \quad \text{Standard OP-code} \quad \text{32 bit} \quad \text{Address bits (e.g. block 4)} \]

\[ \text{RF field} \quad \text{Lock bit} \quad \text{> 64 clocks} \]

Figure 8. Write protocol

Write 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 will be 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 9. A valid '0' is assumed if the number of counted clock periods is between 16 and 32, for a valid '1' it is 48 or 64 respectively. Any other value being detected results in an error, and the device exits write mode and returns to read mode.

\[ \text{Field clock cycles} \quad 1 \quad 16 \quad 32 \quad 48 \quad 64 \]

\[ \text{Write data decoder} \quad \text{fail} \quad 0 \quad \text{fail} \quad 1 \quad \text{writing done} \]

Figure 9. Write data decoding scheme
Behavior of the Real Device

The TK5550 detects a gap if the voltage across the coils decreases below a peak-to-peak value of 800 mV. Until then, the clock pulses are counted. The number given for a valid ‘0’ or ‘1’ (see figure 9), refer to the actual clock pulses counted by the device. However, there are always more clock pulses being counted than where applied by the base station. The reason for this is the fact, that a 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 800 mV and the device detects the gap.

Referring to the following diagram (figure 10) this means that the device uses the times $t_0$ 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:

- $t_0 = 70$ to $165 \, \mu s$
- $t_1 = 330$ to $425 \, \mu s$
- $t_{gap} = 150$ to $400 \, \mu s$

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

Operating Distance

The maximum distance between the base station and the TK5550 depends mainly on the base station, the coil geometries and the modulation options chosen (see U2270B Antenna Design Hints and the U2270B data sheet). When generating an appropriate field with a suitable reader technique, a distance of 10 cm and more can be obtained. When using the TEMIC U2270B demo board, the typical distances in the range of 0 to 5 cm can be achieved. Maximum distance values which are generally valid can not be given in this data sheet. The exact measuring of the maximum distance should be carried out with the TK5550 being integrated into the specific application.
Application

![Application Diagram](image)

Figure 11. Complete transponder system with the read/write base station IC U2270B

Mechanical Specification

Dimensions in mm

![Mechanical Drawing](image)

Non tolerated dimensions: ± 0.05
∠ ± 1°

Figure 12. Mechanical drawing of transponder
Ozone Depleting Substances Policy Statement

It is the policy of TEMIC TELEFUNKEN microelectronic GmbH to

1. Meet all present and future national and international statutory requirements.

2. Regularly and continuously improve the performance of our products, processes, distribution and operating systems with respect to their impact on the health and safety of our employees and the public, as well as their impact on the environment.

It is particular concern to control or eliminate releases of those substances into the atmosphere which are known as ozone depleting substances (ODSs).

The Montreal Protocol (1987) and its London Amendments (1990) intend to severely restrict the use of ODSs and forbid their use within the next ten years. Various national and international initiatives are pressing for an earlier ban on these substances.

TEMIC TELEFUNKEN microelectronic GmbH semiconductor division has been able to use its policy of continuous improvements to eliminate the use of ODSs listed in the following documents.


2. Class I and II ozone depleting substances in the Clean Air Act Amendments of 1990 by the Environmental Protection Agency (EPA) in the USA


TEMIC can certify that our semiconductors are not manufactured with ozone depleting substances and do not contain such substances.

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