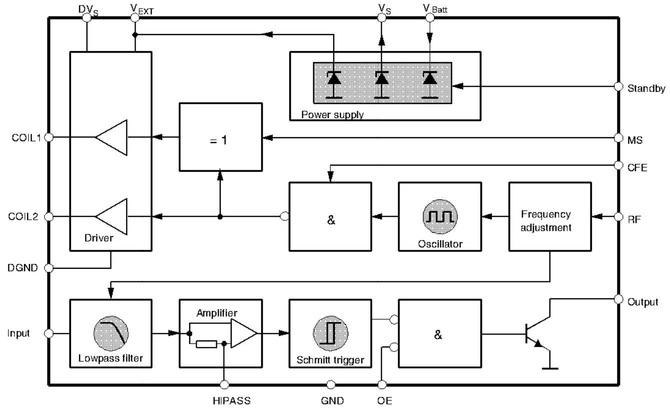
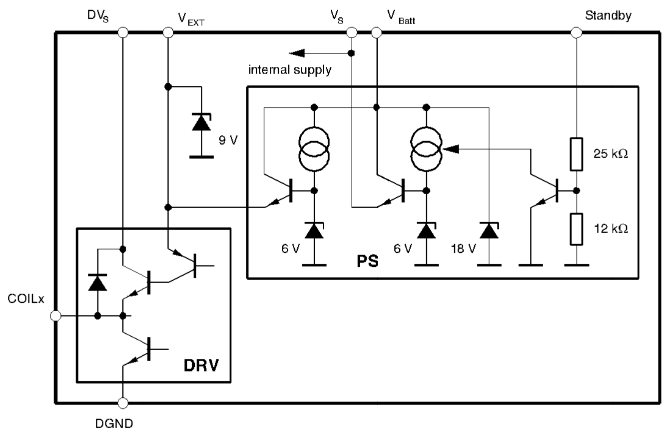
Block Diagram



Functional Description

Power Supply (PS)

Figure 2. Equivalent Circuit of Power Supply and Antenna Driver



The U2270B can be operated with one external supply voltage or with two externally-stabilized supply voltages for an extended driver output voltage or from the 12-V battery voltage of a vehicle. The 12-V supply capability is achieved via the on-chip power supply (see Figure 2). The power supply provides two different output voltages, V_S and V_{EXT}.

V_S is the internal power supply voltage except for the driver circuit. Pin V_S is used to connect a block capacitor. V_S can be switched off by Standby pin. In standby mode, the chip's power consumption is very low. V_{EXT} is the supply voltage of the antenna's pre-driver. This voltage can also be used to operate external circuits, like a microcontroller. In conjunction with an external NPN transistor it also establishes the supply voltage of the antenna coil driver, DVS.

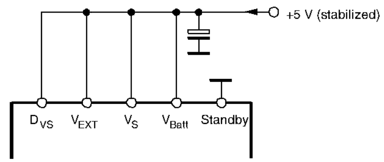
Operation Modes to Power the U2270B

The following section explains the 3 different operation modes to power the U2270B.

One-rail Operation

All internal circuits are operated from one 5-V power rail (see Figure 3). In this case, V_S, V_{EXT} and D_{VS} serve as inputs. V_{Batt} is not used but should also be connected to that supply rail.

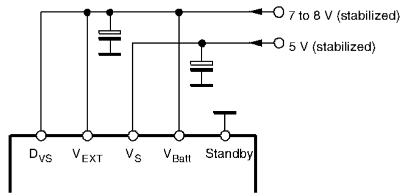
Figure 3. One Rail Operation Supply



Two-rail Operation

In this application, the driver voltage, D_{VS}, and the pre-driver supply, V_{EXT}, are operated at a higher voltage than the rest of the circuitry to obtain a higher driver-output swing and thus a higher magnetic field (see Figure 4). V_S is connected to a 5-V supply, whereas the driver voltages can be as high as 8 V. This operation mode is intended to be used in situations where an extended communication distance is required.

Figure 4. Two Rail Operation Supply



Battery-voltage Operation

Using this operation mode, V_S and V_{EXT} are generated by the internal power supply (see Figure 5). For this mode, an external voltage regulator is not needed. The IC can be switched off via the Standby pin. V_{EXT} supplies the base of an external NPN transistor and external circuits, like a microcontroller (even in Standby mode).

Pin V_{EXT} and V_{Batt} are overvoltage protected via internal Zener diodes (see Figure 2).The maximum current into the pins is determined by the maximum power dissipation and the maximum junction temperature of the IC.

Figure 5. Battery Operation

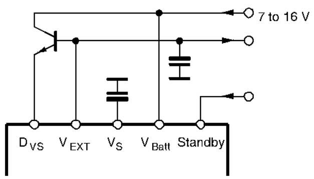


Table 1. Characteristics of the Various Operation Modes

Operation Mode	External Components Required	Supply-voltage Range	Driver Output Voltage Swing	Standby Mode Available
One-rail operation	1 Voltage regulator 1 Capacitor	5 V ±10%	≈ 4 V	No
Two-rail operation	2 Voltage regulators 2 Capacitors	5 V ±10% 7 V to 8 V	6 V to 7 V	No
Battery-voltage operation	1 Transistor 2 Capacitors Optional for load dump protection: 1 Resistor 1 Capacitor	6 V to 16 V	≈ 4 V	Yes

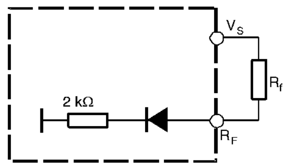
Oscillator (Osc)

The frequency of the on-chip oscillator is controlled by a current fed into the R_F input. An integrated compensation circuit ensures a wide temperature range and a supply-voltage-independent frequency which is selected by a fixed resistor between R_F (pin 15) and V_S (pin 14). For 125 kHz, a resistor value of 110 kΩ is defined. For other frequencies, use the following formula:

$$R_t[k\Omega] = \frac{14375}{f_0[kHz]} - 5$$

This input can be used to adjust the frequency close to the resonance of the antenna. For more details refer to the section “Applicatons” and to the application note ANT019.

Figure 6. Equivalent Circuit of Pin R_F



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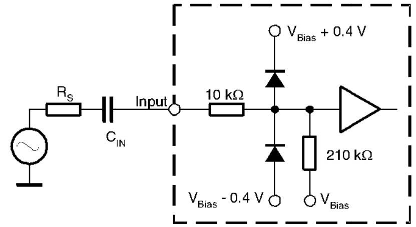
Filter (LPF)

The fully-integrated lowpass filter (4th-order butterworth) removes the remaining carrier signal and high-frequency disturbances after demodulation. The upper cut-off frequency of the LPF depends on the selected oscillator frequency. The typical value is $f_{Osc}/18$. That means that data rates up to $f_{Osc}/25$ are possible if Bi-phase or Manchester encoding is used.

A highpass characteristic results from the capacitive coupling at the input pin 4 as shown in Figure 7. The input voltage swing is limited to 2 V_{pp}. For frequency response calculation, the impedances of the signal source and LPF input (typical 220 kΩ) have to be considered. The recommended values of the input capacitor for selected data rates are given in the section “Applications”.

Note: After switching on the carrier, the DC voltage of the coupling capacitor changes rapidly. When the antenna voltage is stable, the LPF needs approximately 2 ms to recover full sensitivity.

Figure 7. Equivalent Circuit of Pin Input



Amplifier (AMP)

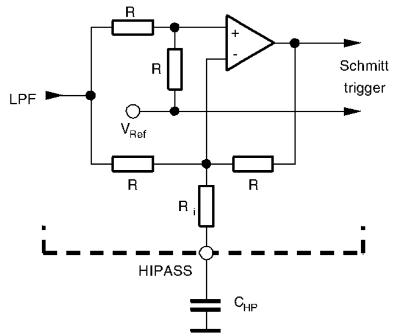
The differential amplifier has a fixed gain, typically 30. The HIPASS pin is used for dc decoupling. The lower cut-off frequency of the decoupling circuit can be calculated as follows:

$$f_{cut} = \frac{1}{2 \times \pi \times C_{HP} \times R_i}$$

The value of the internal resistor R_i can be assumed to be 2.5 kΩ.

Recommended values of C_{HP} for selected data rates can be found in the section “Applications”.

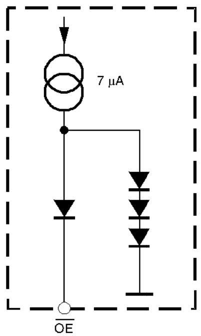
Figure 8. Equivalent Circuit of Pin HIPASS



Schmitt Trigger

The signal is processed by a Schmitt trigger to suppress possible noise and to make the signal microcontroller compatible. The hysteresis level is 100 mV symmetrically to the DC operation point. The open-collector output is enabled by a low level at OE (pin 3).

Figure 9. Equivalent Circuit of Pin OE



Driver (DRV)

The driver supplies the antenna coil with the appropriate energy. The circuit consists of two independent output stages. These output stages can be operated in two different modes. In common mode, the outputs of the stages are in phase. In this mode, the outputs can be interconnected to achieve a high-current output capability. Using the differential mode, the output voltages are in anti-phase. Thus, the antenna coil is driven with a higher voltage. For a specific magnetic field, the antenna coil impedance is higher for the differential mode. As a higher coil impedance results in a better system sensitivity, the differential mode should be preferred.

The CFE input is intended to be used for writing data into a read/write or a crypto transponder. This is achieved by interrupting the RF field with short gaps. The various functions are controlled by the inputs MS and CFE (refer to the function table). The equivalent circuit of the driver is shown in Figure 2.

Figure 10. Equivalent Circuit of Pin MS

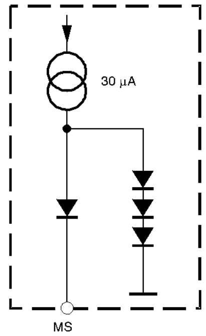
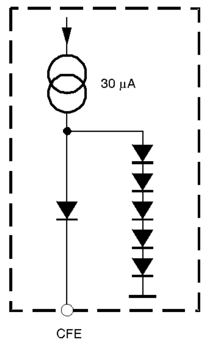


Figure 11. Equivalent Circuit of Pin CFE



Function Table

CFE	MS	COIL1	COIL2
Low	Low	High	High
Low	High	Low	High
High	Low	_⎍_	_⎍_
High	High	‾⊔‾	_⎍_

OE	Output
Low	Enabled
High	Disabled

Standby	U2270B
Low	Standby mode
High	Active

Applications

To achieve the system performance, consider the power-supply environment and the magnetic-coupling situation.

The selection of the appropriate power-supply operation mode depends on the quality of supply voltage. If an unregulated supply voltage in the range of V = 7 V to 16 V is available, the internal power supply of the U2270B can be used. In this case, standby mode can be used and an external low-current microcontroller can be supplied.

If a 5-V supply rail is available, it can be used to power the U2270B. In this case, please check that the voltage is noise-free. An external power transistor is not necessary.

The application depends also on the magnetic-coupling situation. The coupling factor mainly depends on the transmission distance and the antenna coils. The following table lists the appropriate application for a given coupling factor. The magnetic coupling factor can be determined using Atmels test transponder coil.

Table 2. Magnetic Coupling

Magnetic Coupling Factor	Appropriate Application
k > 3%	Free-running oscillator
k > 1%	Diode feedback
k > 0.5%	Diode feedback plus frequency altering
k > 0.3%	Diode feedback plus fine frequency tuning

The maximum transmission distance is also influenced by the accuracy of the antenna's resonance. Therefore, the recommendations given above are proposals only. A good compromise for the resonance accuracy of the antenna is a value in the range of f_{res} = 125 kHz ±3%. Further details concerning the adequate application and the antenna design is provided in the section "Antenna Design Hints".

The application of the U2270B includes the two capacitors C_{IN} and C_{HP} whose values are linearly dependend on the transponder's data rate. The following table gives the appropriate values for the most common data rates. The values are valid for Manchester- and Bi-phase-code.

Table 3. Recommended Cap Values

Data Rate f = 125 kHz	Input Capacitor (C_{IN})	Decoupling Capacitor (C_{HP})
f/32 = 3.9 kbit/s	680 pF	100 nF
f/64 = 1.95 kbit/s	1.2 nF	220 nF

The following applications are typical examples. The values of C_{IN} and C_{HP} correspond to the transponder's data rate only. The arrangement to fit the magnetic-coupling situation is also independent from other design issues except for one constellation. This constellation, consisting of diode feedback plus fine frequency tuning together with the two-rail power supply, should be used if the transmission distance of is d ≈ 10 cm.

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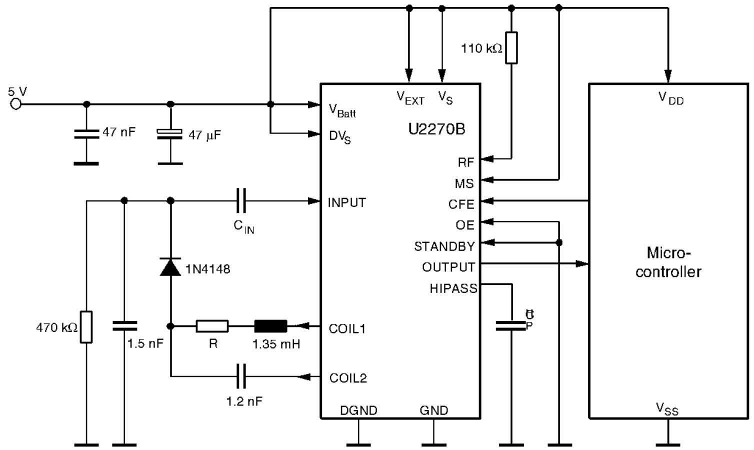
Application 1

Application using few external components. This application is for intense magnetic coupling only.

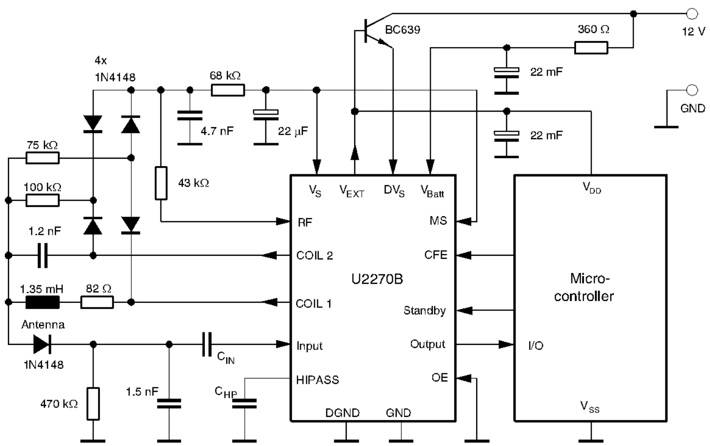
Figure 12. Application Circuit 1



Application 2

Basic application using diode feedback. This application allows higher communication distances than application 1

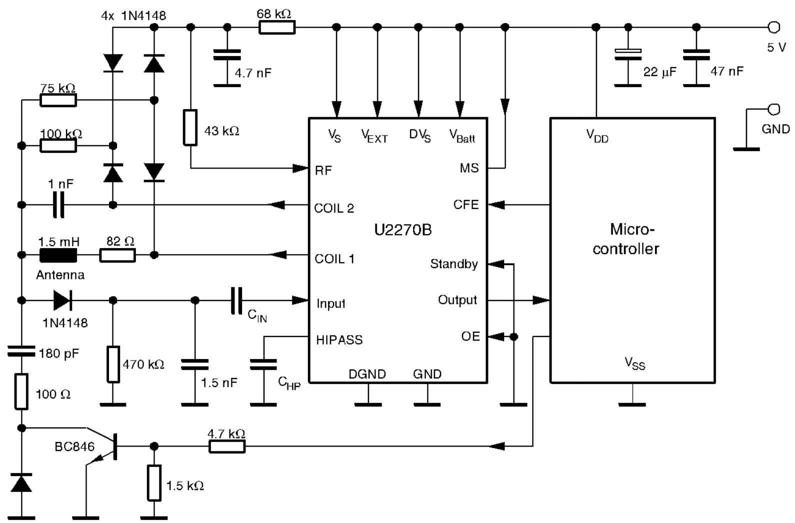
Figure 13. Application Circuit 2



Application 3

This application is comparable to application 2 but alters the operating frequency. This allows higher antenna resonance tolerances and/or higher communication distances. This application is preferred if the detecting microcontroller is close to the U2270B as an additional microcontroller signal controls the adequate operating frequency.

Figure 14. Application Circuit 3



Note: Application examples have not been examined for series use or reliability, and no worst case scenarios have been developed. Customers who adapt any of these proposals must carry out their own testing and be convinced that no negative consequences arise from the proposals.

Absolute Maximum Ratings

All voltages are referred to GND (Pins 1 and 7)

Parameter	Pin	Symbol	Min.	Max.	Unit
Operating voltage	12	V_{Batt}	V_S	16	V
Operating voltage	8, 9, 10, 11, 14	V_S, V_{EXT}, DV_S, Coil 1, Coil 2	-0.3	8	V
Range of input and output voltages	3, 4, 5, 6, 15 16 2 and 13	V_{IN}, V_{OUT}	-0.3 -0.3	V_S + 0.3 V_{Batt}	V
Output current	10	I_{EXT}		10	mA
Output current	2	I_{OUT}		10	mA
Driver output current	8 and 9	I_{Coil}		200	mA
Power dissipation SO16		P_{tot}		380	mW
Junction temperature		T_j		150	°C
Storage temperature		T_{stg}	-55	125	°C
Ambient temperature		T_{amb}	-40	105	°C

Thermal Resistance

Parameter	Symbol	Value	Unit
Thermal resistance SO16	R_{thJA}	120	K/W

Operating Range

All voltages are referred to GND (Pins 1 and 7)

Parameter		Symbol	Value	Unit
Operating voltage	Pin 12	V_{Batt}	7 to 16	V
Operating voltage	Pin 14	V_S	4.5 to 6.3	V
Operating voltage	Pins 10, 11	V_{EXT}, DV_S	4.5 to 8	V
Carrier frequency			100 to 150	kHz

Electrical Characteristics

All voltages are referred to GND (Pins 1 and 7)

Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit
Data output - Collector emitter - Saturation voltage	I_{out} = 5 mA	2	V_{CEsat}			400	mV
Data output enable - Low-level input voltage - High-level input voltage		3	V_{il} V_{ih}	 2.4		0.5	V V
Data input - Clamping level low - Clamping level high - Input resistance - Input sensitivity	f = 3 kHz (squarewave) gain capacitor = 100 nF	4	V_{il} V_{ih} R_{in} S_{IN}	 10	2 3.8 220		V V kΩ mV_{pp}
Driver polarity mode - Low-evel input voltage - High-level input voltage		5	V_{il} V_{ih}	 2.4		0.2	V V
Carrier frequency enable - Low-level input voltage - High-level input voltage		6	V_{il} V_{ih}	 3.0		0.8	V V
Operating current	5-V application without load connected to the coil driver	10, 11,12 and 14	I_S		4.5	9	mA
Standby current	12-V application	12	I_{St}		30	70	µA
V_S - Supply voltage - Supply voltage drift - Output current		14	V_S dV_s/dT I_S	4.6 1.8	5.4 4.2 3.5	6.3	V mV/K mA
Driver output voltage - One-rail operation - Battery-voltage.........operation	I_L = ±100 mA V_S, V_{EXT}, V_{Batt}, DV_S = 5 V V_{Batt} = 12 V	8, 9	V_{DRV} V_{DRV}	2.9 3.1	3.6 4.0	4.3 4.7	V_{PP} V_{PP}
Vext - Output voltage - Supply voltage drift - Output current - Standby output current	 IC active standby mode	10	V_{EXT} dV_{EXT}/dT I_{EXT} I_{EXT}	4.6 3.5 0.4	5.4 4.2	6.3	V mV/K mA mA
Standby input - Low-level input voltage - High-level input voltage		13	V_{il} V_{ih}	 3.1		0.8	V V
Oscillator - Carrier frequency	RF resistor = 110 kΩ (application 2), REM 1(1)		f_0	121	125	129	kHz
Lowpass filter - Cut-off frequency	Carrier freq. = 125 kHz		f_{cut}		7		kHz
Amplifier - Gain	C_{HP} = 100 nF				30		

Note: 1. REM1: In application 1 where the oscillator operates in free-runing mode, the IC must be soldered free from destortion. Otherwise, the oscillator may be out of bounds.

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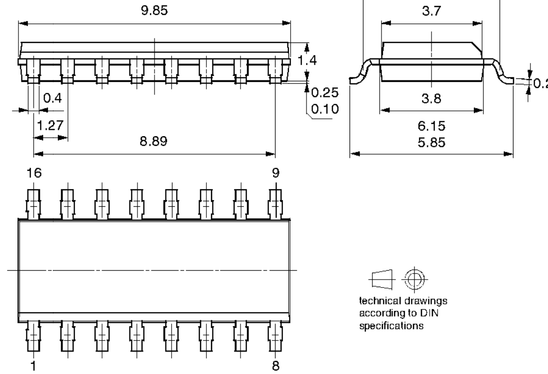
Ordering Information

Extended Type Number	Package	Remarks
U2270B-FP	SO16	

Package Information

Package SO16
Dimensions in mm



Features

- Contactless Power Supply and Communication Interface
- Up to 10 kbaud Data Rate (R/O)
- Power Management for Contactless and Battery Power Supply
- Frequency Range 100 kHz to 150 kHz
- 32 x 16-bit EEPROM
- Two-wire Serial Interface
- Shift Register Supported Bi-phase and Manchester Modulator Stage
- Reset I/O Line
- Field Clock Extractor
- Field and Gap Detection Output for Wake-up and Data Reception
- Field Modulator with Energy-saving Damping Stage

Pb Lead Free

Applications

- Main Areas
  - Access Control
  - Telemetry
  - Wireless Sensors
- Examples:
  - Wireless Passive Access and Active Alarm Control for Protection of Valuables
  - Contactless Position Sensors for Alignments of Machines
  - Contactless Status Verification and/or Data Readout from Sensors

Transponder Interface for Microcontroller

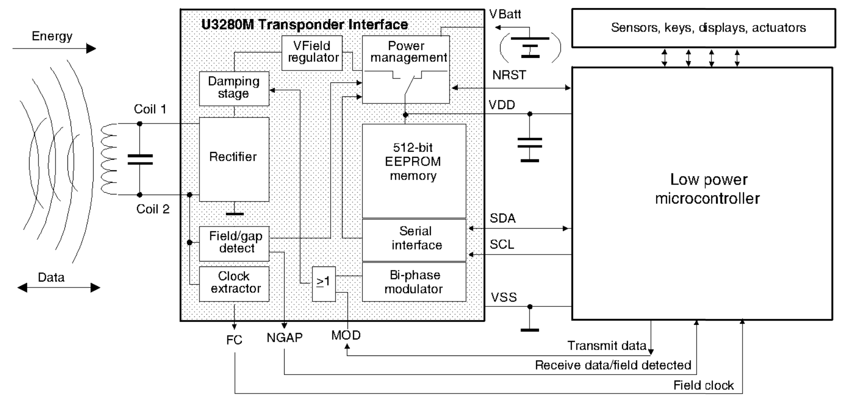
U3280M

Rev. 4688C–RFID–09/05

1. Description

The U3280M is a transponder interface for use in contactless ID systems, remote control systems, tag and sensor applications. It supplies the microcontroller with power from an RF field via an LC-resonant circuit and it enables contactless bi-directional data communication via this RF field. It includes power management that handles switching between the magnetic field and a battery power supply. To store permanent data like an identifier code and configuration data, the U3280M includes a 512-bit EEPROM with a serial interface.

Figure 1-1. Block Diagram



4688C–RFID–09/05

2. Pin Configuration

Figure 2-1. Pinning

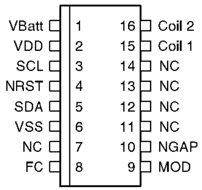


Table 2-1. Pin Description

Pin	Symbol	Function
1	VBatt	Power supply voltage input to connect a battery
2	VDD	Power supply voltage for the microcontroller and EEPROM. At this pin a buffer capacitor (0.5 to 10 µF) must be connected to buffer the voltage during field supply and to block the VDD of the microcontroller.
3	SCL	Serial clock line
4	NRST	Reset line bi-directional
5	SDA	Serial data line
6	VSS	Circuit ground
7	NC	Not connected
8	FC	Field clock output of the front-end clock extractor
9	MOD	Modulation input
10	NGAP	Gap and field detect output
11	NC	Not connected
12	NC	Not connected
13	NC	Not connected
14	NC	Not connected
15	Coil 1	Coil input 1. Use pin to connect a resonant circuitry for communication and field supply
16	Coil 2	Coil input 2. Use pin to connect a resonant circuitry for communication and field supply

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3. Functional Description

3.1 Transponder Interface

The U3280M is a transponder interface IC that can operate microcontrollers using wireless technology and battery independently. Wireless data communication and the power supply are handled via an electromagnetic field and the coil antenna of the transponder interface. The U3280M consists of a rectifier stage for the antenna, power management to handle field and battery power supplies, a damping modulator, and a field-gap detection stage for contactless data communication. Furthermore, a field clock extraction and an EEPROM are on-chip.

The internal rectifier stage rectifies the AC from the LC-resonant circuit at the coil inputs and supplies the U3280M device and an additional microcontroller device with power. It is also possible to supply the device via the V_{Batt} input with DC from a battery. The power management handles switching between battery supply (V_{Batt} pin) and field supply automatically. It switches to field supply if a field is applied at the coil, and it switches back to battery if the field is removed. The voltage from the coil or the V_{Batt} pin is output at the V_{DD} pin to supply the microcontroller or any other suited device. At the V_{DD} pin a capacitor must be connected to smooth and buffer the supply voltage. This capacitor is also necessary to buffer the supply voltage during communication (damping and gaps in the field).

For communication, the chip contains a damping stage and gap-detect circuitry. By means of the damping stage the coil voltage can be modulated to transmit data via the field. It can be controlled with the modulator input (MOD pin) via the microcontroller. The gap-detection circuitry detects gaps in the field and outputs the gap/field signal at the gap-detect output (Pin NGAP).

To store data like keycodes, identifiers and configuration bits, a 512-bit EEPROM is available on-chip. It can be read and written by the microcontroller via a two-wire serial interface.

The serial interface, the EEPROM and the microcontroller are supplied with the voltage at the V_{DD} pin. That means the microcontroller can read and write the EEPROM if the supply voltage at V_{DD} is in the operating range of the IC.

The U3280M has built-in operating modes to support a wide range of applications. These modes can be activated via the serial interface with special mode control bytes.

To support applications with battery supply only, power management can be switched off by software to disable the automatic switching to field supply.

An on-chip Bi-phase and Manchester modulator can be activated and controlled by the serial interface. If this modulator is used, it modulates the serial data stream at the serial inputs SDA and SCL into a Bi-phase or Manchester-coded signal for the damping stage.

3.2 Modulation

The transponder interface can modulate the magnetic field by its damping stage to transmit data to a base station. It modulates the coil voltage by varying the coil's load. The modulator can be controlled via the MOD pin. A high level ("1") increases the current into the coil and damps the coil voltage. A low level ("0") decreases the current and increases the coil voltage. The modulator generates a voltage stroke of about 2 V_{pp} at the coil. A high level at the MOD pin makes the maximum of the field energy available at V_{DD}. During reset mode, a high level at the MOD pin causes optimum conditions for starting the device and charging the capacitor at V_{DD} after the field has been applied at the coil.

3.2.1 Digital Input to Control the Damping Stage (MOD)

MOD = 0: coil not damped

$V_{coil\text{-}peak} = V_{DD} \times \sqrt{2} + V_{CMS} = V_{CU}$

MOD = 1: coil damped

$V_{coil\text{-}peak} = V_{DD} \times \sqrt{2} = V_{CD}$

$V_{CMS} = V_{CID}$: modulation voltage stroke at coil inputs

Note: If the automatic power management is disabled, the internal front-end V_{DD} is limited at V_{DDC}. In this case the value V_{DDC} must be used in the above formula.

3.3 Field Clock

The field clock extractor of the interface makes the field clock available for the microcontroller. It can be used to supply timer inputs to synchronize modulation and demodulation with the field clock.

3.4 Gap Detect

The transponder interface can also receive data. The base station modulates the data with short gaps in the field. The gap-detection circuit detects these gaps in the magnetic field and outputs the NGAP/field signal at the NGAP pin. A high level indicates that a field is applied at the coil and a low level indicates a gap or that the field is off. The microcontroller must demodulate the incoming data stream at one of its inputs.

4. U3280M Signals and Timing

Figure 4-1. Modulation

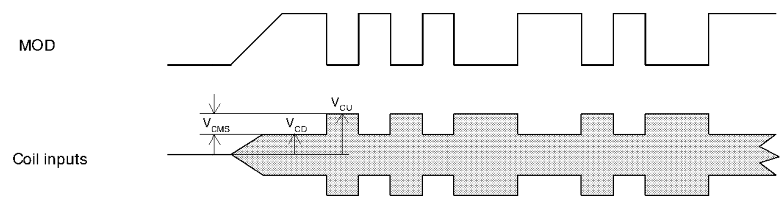
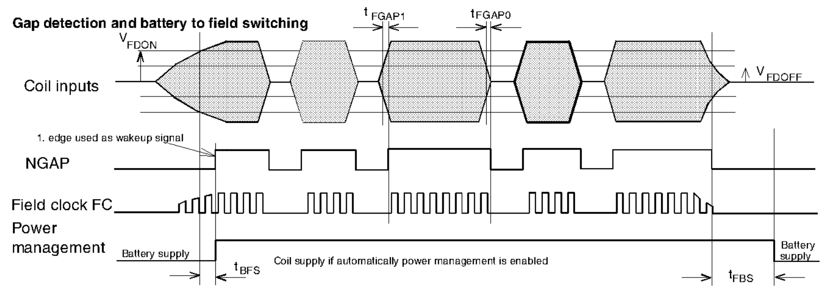


Figure 4-2. GAP and Modulation Timing



4.1 Digital Output of the Gap-detection Stage (NGAP)

NGAP = 0: gap detected/no field $V_{coil\text{-}peak} = V_{FDoff}$

NGAP = 1: field detected $V_{coil\text{-}peak} = V_{FDon}$

Note: No amplifier is used in the gap-detection stage. A digital Schmitt trigger evaluates the rectified and smoothed coil voltage.

4.2 Wake-up Signal

If a field is applied at the coil of the transponder interface, the microcontroller can be woken up with the wake-up signal at the NGAP pin. For that purpose, the NGAP pin must be connected to an interrupt input of the microcontroller. A high level at the NGAP output indicates an applied field and can be used as a wake-up signal for the microcontroller via an interrupt. The wake-up signal is generated if power management switches to field supply. The field-detection stage of the power management has lowpass characteristics to avoid generating wake-up signals and unnecessary switching between battery and field supply in case of interferences at the coil inputs.

4.3 Power Supply

The U3280M has a power management that handles two power supply sources. Normally, the IC is supplied by a battery at the V_{Batt} pin. If a magnetic field is applied at the LC-resonant circuit of the device, the field detection circuit switches automatically from V_{Batt} to field supply.

The V_{DD} pin is used to connect a capacitor to smooth the voltage from the rectifier and to buffer the power while the field is modulated by gaps and damping. The EEPROM and the connected controller always operate with the voltage at the V_{DD} pin.

Note: During field supply the maximum energy from the field is used if a high level is applied at the MOD input.

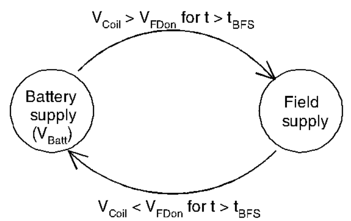
4.3.1 Automatic Power Management

There are different conditions that cause a switch from the battery to field and back from field to the battery.

The power management switches from battery to field if the rectified voltage (V_{coil}) from the coil inputs becomes higher than the field-on-detection voltage (V_{FDon}), even if no battery voltage is available ($0 < V_{Batt} < 1.8V$). It switches back to battery if the coil voltage becomes lower than the field-off-detection voltage (V_{FDoff}).

The field detection stage of the power management has low pass characteristics to suppress noise. An applied field needs a time delay t_{BFS} (battery-to-field switch delay) to change the power supply. If the field is removed from the coil, the power management will generate a reset that can be connected to the microcontroller.

Figure 4-3. Switch Conditions for Power Management



Note: The rectified supply voltage from the coil is limited to V_{DDC} (2.9V). During field supply, the battery is switched off and V_{DD} changes to V_{DDC}.

4.3.2 Controlling Power Management via the Serial Interface

The automatic mode of the power management can be switched off and on by a command from the microcontroller. If the automatic mode is switched off, the IC is always supplied by the battery up to the next power-on reset or to a switch-on command. The power management's on and off command must be transferred via the serial interface.

If the power management is switched off and the device is supplied from the battery, it can communicate via the field without loading the field. This mode can be used to realize applications with battery supply if the field is too weak to supply the IC with power.

4.3.3 Buffer Capacitor C_B

The buffer capacitor connected at V_{DD} is used to buffer the supply voltage for the microcontroller and the EEPROM during field supply. It smoothes the rectified AC from the coil and buffers the supply voltage during modulation and gaps in the field. The size of this capacitor depends on the application. It must be of a dimension so that during modulation and gaps the ripple on the supply voltage is in the range of 100 mV to 300 mV. During gaps and damping the capacitor is used to supply the device, which means the size of the capacitor depends on the length of the gaps and damping cycles.

Table 4-1. Example for a 350 µA Supply Current, 200 mV Ripple at V_{DD}

No Field Supply During	Necessary C_B
250 µs	470 nF
500 µs	1000 nF

4.4 Serial Interface

The transponder interface has a serial interface to the microcontroller for read and write access to the EEPROM. In a special mode, the serial interface can also be used to control the Bi-phase/Manchester modulator or the power management of the U3280M.

The serial interface of the U3280M device must be controlled by a master device (normally the microcontroller) which generates the serial clock and controls the access via the SCL and SDA lines. SCL is used to clock the data in and out of the device. SDA is a bi-directional line and used to transfer data into and out of the device. The following protocol is used for the data transfers.

4.4.1 Serial Protocol

- Data states on the SDA line change only when SCL is low.
- Changes in the SDA line while SCL is high will be interpreted as a START or STOP condition.
- A STOP condition is defined as a high-to-low transition on the SDA line while the SCL line is high.
- Each data transfer must be initialized with a START condition and terminated with a STOP condition. The START condition awakens the device from standby mode, and the STOP condition returns the device to standby mode.
- A receiving device generates an acknowledge (A) after the reception of each byte. For that purpose the master device must generate an extra clock pulse. If the reception was successful, the receiving master or slave device pulls down the SDA line during that clock cycle. If an acknowledge has not been detected (N) by the interface in transmit mode, it will terminate further data transmissions and switch to receive mode. A master device must finish its read operation by a not acknowledge and then issue a STOP condition to switch the device to a known state.

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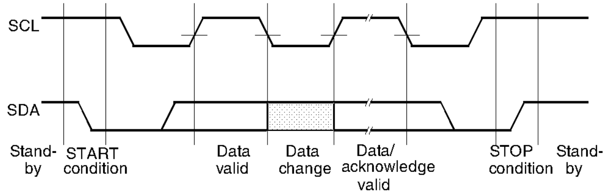
Figure 4-4. Serial Protocol



Control Byte Format

	EEPROM address					Mode control bits		Read/ NWrite	
START	A4	A3	A2	A1	A0	C1	C0	R/NW	Ackn

The control byte follows the START condition and consists of the 5-bit row address, 2 mode control bits and the read/not-write bit.

Data Transfer Sequence

START	Control byte	Ackn	Data byte	Ackn	Data byte	Ackn	STOP

- After the STOP condition and before the START condition the device is in standby mode and the SDA line is switched to an input with the pull-up resistor.
- The START condition follows a control byte that determines the following operation. Bit 0 of the control byte is used to control the following transfer direction. A "0" defines a write access and a "1" defines a read access.

5. EEPROM

The EEPROM has a size of 512 bits and is organized as a 32 × 16-bit matrix. To read and write data to and from the EEPROM, the serial interface must be used. The interface supports one and two-byte write access and one to n-byte read access to the EEPROM.

5.1 EEPROM Operating Modes

The operating modes of the EEPROM are defined by the control byte. The control byte contains the row address, the mode control bits and the read/not-write bit that is used to control the direction of the following transfer. A "0" defines the write access and a "1" defines a read access. The five address bits select one of the 32 rows of EEPROM memory to be accessed. For complete access the complete 16-bit word of the selected row is loaded into a buffer. The buffer must be read or overwritten via the serial interface. The two mode control bits C1 and C2 define in which order the access to the buffer is performed: high byte – low byte or low byte – high byte. The EEPROM also supports auto-increment and auto-decrement read operations. After sending the START address with the corresponding mode, consecutive memory cells can be read row by row without transmission of the row addresses.

Two special control bytes allow the initialization of the complete EEPROM with "0" or with "1".

5.2 Write Operations

The EEPROM allows for 8-bit and 16-bit write operations. A write access starts with the START condition followed by writing a write control byte and one or two data bytes from the master. It is completed with the STOP condition from the master after the acknowledge cycle.

When the EEPROM receives the control byte, it loads the addressed memory cell into a 16-bit read/write buffer. The following data bytes overwrite the buffer. The internal EEPROM programming cycle is started by a STOP condition after the first or second data byte. During the programming cycle, the addressed EEPROM cells are cleared and the contents of the buffer is written back to the EEPROM cells. The complete erase-write cycle takes about 10 ms.

5.2.1 Acknowledge Polling

If the EEPROM is busy with an internal write cycle, all inputs are disabled and the EEPROM will not acknowledge until the write cycle is finished. This can be used to determine when the write cycle is complete. The master must perform acknowledge polling by sending a START condition followed by the control byte. If the device is still busy with the write cycle, it will not return an acknowledge and the master has to generate a STOP condition or perform further acknowledge polling sequences.

If the cycle is complete, the device returns an acknowledge and the master can proceed with the next read or write cycle.

5.2.1.1 Write One Data Byte

START	Control byte	A	Data byte 1	A	STOP

5.2.1.2 Write Two Data Bytes

START	Control byte	A	Data byte 1	A	Data byte 2	A	STOP

5.2.1.3 Write Control Byte Only

START	Control byte	A	STOP
A →acknowledge			

5.2.1.4 Write Control Bytes

Write Low Byte First

MSB							LSB
A4	A3	A2	A1	A0	C1	C0	R/NW
Row address					0	1	0

Byte Order

LB(R)	HB(R)

Write High Byte First

MSB							LSB
A4	A3	A2	A1	A0	C1	C0	R/NW
Row address					1	0	0

Byte Order

HB(R)	LB(R)

HB: high byte; LB: low byte; R: row address

5.2.2 Read Operations

The EEPROM allows byte-, word- and current address read operations. The read operations are initiated in the same way as write operations. Each read access is initiated by sending the START condition followed by the control byte which contains the address and the read mode. When the device has received a read command, it returns an acknowledge, loads the addressed word into the read/write buffer and sends the selected data byte to the master. The master has to acknowledge the received byte to proceed with the read operation. If two bytes are read out from the buffer, the device automatically increments or decrements the word address and loads the buffer with the next word. The read mode bit determines if the low or high byte is read first from the buffer and if the word address is incremented or decremented for the next read access. When the memory address limit has been reached, the data word address will "roll over" and the sequential read will continue. The master can terminate the read operation after every byte by not responding with an acknowledge (N) and by issuing a STOP condition.

5.2.2.1 Read One Data Byte

START	Control byte	A	Data byte 1	N	STOP

5.2.2.2 Read Two Data Bytes

START	Control byte	A	Data byte 1	A	Data byte 2	N	STOP

5.2.2.3 Read n Data Bytes

START	Control byte	A	Data byte 1	A	Data byte 2	A	- - - - - -	Data byte n	N	STOP

A →acknowledge, N →no acknowledge

5.2.2.4 Read Control Bytes

Read Low Byte First, Address Increment

MSB							LSB
A4	A3	A2	A1	A0	C1	C0	R/NW
Row address					0	1	1

Byte Order

LB(R)	HB(R)	LB(R+1)	HB(R+1)	- - - -	LB(R+n)	HB(R+n)

Read High Byte First, Address Decrement

MSB							LSB
A4	A3	A2	A1	A0	C1	C0	R/NW
Row address					1	0	1

Byte Order

HB(R)	LB(R)	HB(R-1)	LB(R-1)	- - - -	HB(R-n)	LB(R-n)
HB: high byte; LB: low byte; R: row address						

5.2.3 Initialization after a Reset Condition

The EEPROM with the serial interface has reset circuitry on-chip. In systems with microcontrollers that have their own reset circuitry for power-on reset, watchdog reset or brown-out reset, it may be necessary to bring the U3280M into a known state independently of the internal reset. This is performed by reading one byte without acknowledging and then generating a STOP condition.

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5.2.4 Special Modes

Table 5-1. Control Byte Description

Control Byte	Description
1100x111b	Bi-phase modulation
1101x111b	Manchester modulation
11xx0111b	Switch power management off →disables switching from battery to field supply
11xx1111b	Switch power management on →enables automatic switching between battery and field supply
xxxxx110b	Reserved

Data Transfer Sequence for Bi-phase and Manchester Modulation

START	Control byte	Ackn	Bit 1	Bit 2	Bit 3	- - - - - - - - - - -	Bit n	STOP

By using special control bytes, the serial interface can control the modulator stage or the power management. The EEPROM access and the serial interface are disabled in these modes until the next STOP condition. If no START or STOP condition is generated, the SCL and SDA lines can be used for the modulator stage. SCL is used for the modulator clock and SDA is used for the data. In this mode, the same conditions for clock and data changing, as in normal mode, are valid. The SCL and SDA lines can be used for continuous bit transfers, an acknowledge cycle after 8 bits must not be generated.

Note: After a reset of the microcontroller it is not assured that the transponder interface has been reset as well. It could still be in a receive or transmit cycle. To switch the device's serial interface to a known state, the microcontroller should read one byte from the device without acknowledge and then generate a STOP condition.

5.2.5 Power-on Reset, NRST

The U3280M transponder front end starts working with the applied field. For the digital circuits like the EEPROM serial interface and registers there is reset circuitry. A reset is generated by a power-on condition at V_{DD}, by switching back from field to battery supply and if a low signal is applied at the NRST-pin.

The NRST-pin is a bi-directional pin and can also be used as a reset output to generate a reset for the microcontroller if the circuit switches over from field to battery supply. This sets the microcontroller in a well-defined state after the uncertain power supply condition during switching.

5.2.6 Antenna

For the transponder interface a coil must be used as an antenna. Air and ferrite cored coils can be used. The achievable working distance (passive mode, not battery assisted) depends on the minimum coupling factor of an application, the power consumption, and the size of the antennas of the IC and the base station. With a power consumption of 150 µA, a minimum magnetic coupling factor below 0.5% is within reach. For applications with a higher power consumption, the coupling factor must be increased.

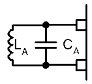
The Q-factor of the antenna coil should be in a range between 30 and 80 for read only applications and below 40 for bi-directional read-write applications.

The antenna coil must be connected with a capacitor as a parallel LC resonant circuit to the Coil 1 and Coil 2 pins of the IC. The resonance frequency f_0 of the antenna circuit should be in the range of 100 kHz to 150 kHz.

The correct LC combination can be calculated with the following formula:

$$L_A = \frac{1}{C_A \times (2 \times \pi \times f_0)^2}$$

Figure 5-1. Antenna Circuit Connection



Example: Antenna frequency: f_0 = 125 kHz, capacitor: C_A = 2.2 nF

$$L_A = \frac{1}{2.2\ nF \times (2 \times \pi \times 125\ kHz)^2} = 737\ \mu H$$

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6. Absolute Maximum Ratings

Stresses greater than those listed under absolute maximum ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at any condition beyond those indicated in the operational section of these specification is not implied. Exposure to absolute maximum rating conditions for an extended period may affect device reliability. All inputs and outputs are protected against high electrostatic voltages or electric fields. However, precautions to minimize build-up of electrostatic charges during handling are recommended. Reliability of operation is enhanced if unused inputs are connected to an appropriate logic voltage level (for example, V_{DD}).

Voltages are given relative to V_{SS}

Parameter	Symbol	Value	Unit
Supply voltage	V_{DD}, V_{Batt}	0V to +7.0V with reverse protection	V
Maximum current out of V_{SS} pin	I_{SS}	15	mA
Maximum current into V_{Batt} pin	I_{Batt}	15	mA
Input voltage (on any pin)	V_{IN}	V_{SS} –0.6 ≤ V_{IN} ≤ V_{DD} +0.6	V
Input/output clamp current (V_{SS} > Vi/Vo > V_{DD})	I_{IK}/I_{OK}	±15	mA
Min. ESD protection (100 pF through 1.5 kΩ)		±2	kV
Operating temperature range	T_{amb}	-40 to +85	°C
Storage temperature range	T_{STG}	-40 to +125	°C
Soldering temperature (t ≤ 10s)	T_{SD}	260	°C

7. Thermal Resistance

Parameter	Symbol	Value	Unit
Junction ambient	R_{thJA}	180	K/W

8. DC Characteristics

Supply voltage V_{DD} = 1.8V to 6.5V, V_{SS} = 0V, T_{amb} = –40°C to 85°C unless otherwise specified

Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit
Power Supply							
Operating voltage at V_{Batt}			V_{Batt}	2.0		6.5	V
Operating voltage at V_{DD} during battery supply			V_{DDB}		V_{Batt} – V_{SD}		V
V_{DD}-limiter voltage during coil supply			V_{DDC}	2.6	2.9	3.2	V
Operating current during field supply	V_{DD} > 2.0V		I_{Fi}		40	80	µA
Sleep current			I_{SI}			0.4	µA
EEPROM							
Operating current during erase/write cycle	V_{DD} = 2.0V V_{DD} = 6.5V		I_{WR} I_{WR}		400	500 1200	µA µA
Operating current during read cycle	V_{DD} = 2.0V V_{DD} = 6.5V Peak current during 1/4 of read cycle		I_{Rdp} I_{Rdp}			300 350	µA µA

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8. DC Characteristics (Continued)

Supply voltage V_{DD} = 1.8V to 6.5V, V_{SS} = 0V, T_{amb} = –40°C to 85°C unless otherwise specified

Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit
Power Management							
Field-on detection voltage	V_{DD} > 1.8V		V_{FDon}	2.3	2.5	2.9	V
Field-off detection voltage	V_{DD} > 1.8V		V_{FDoff}		0.8		V
Voltage drop at power-supply switch	I_S = 0.5 mA, V_{Batt} = 2 V		V_{SD}			150	mV
Coil Inputs: Coil 1 and Coil 2							
Coil input current			I_{CI}			20	mA
Input capacitance			C_{IN}	30			pF
Coil voltage stroke during modulation	V_{CU} > 5V I_{coil} = 3 to 20 mA		V_{CMS}	1.8	2.3	4.0	V
Pin MOD							
Input LOW voltage			V_{IL}	V_{IH}		0.2 × V_{DD}	V
Input LOW voltage			V_{IH}	0.8 × V_{DD}		V_{DD}	V
Input leakage current			$I_{Ileakage}$		10		nA
Pin NGAP/FC							
Output LOW current	V_{DD} = 2.0V V_{OL} = 0.2 × V_{DD}		I_{OL}	0.08	0.2	0.3	mA
Output HIGH current	V_{DD} = 2.0V V_{OH} = 0.8 × V_{DD}		I_{OH}	–0.06	–0.15	–0.25	mA
Serial Interface I/O Pins SCL and SDA							
Input LOW voltage			V_{IL}	V_{IH}		0.3 × V_{DD}	V
Input HIGH voltage			V_{IH}	0.7 × V_{DD}		V_{DD}	V
Input leakage current			$I_{Ileakage}$		10		nA
Output LOW current	V_{DD} = 2.0V V_{OL} = 0.2V_{DD} V_{DD} = 6.0V		I_{OL}	0.7 2.8	0.9 3.5	1.1 4.2	mA mA
Output HIGH current	V_{DD} = 2.0V V_{OH} = 0.8 V_{DD} V_{DD} = 6.0V		I_{OH}	–0.5 –1.8	–0.6 –2.2	–0.7 –2.6	mA mA

9. AC Characteristics

Supply voltage V_{DD} = 1.8V to 6.5V, V_{SS} = 0V, T_{amb} = –40°C to 85°C unless otherwise specified

Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit
Serial Interface Timing							
SCL clock frequency			f_{SCL}	0		100	kHz
Clock low time			t_{LOW}	4.7			µs
Clock high time			t_{HIGH}	4.0			µs
SDA and SCL rise time			t_R			1000	ns
SDA and SCL fall time			t_F			300	ns
START condition setup time			t_{SUSTA}	4.7			µs
START condition hold time			t_{HDSTA}	4.0			µs
Data input setup time			t_{SUDAT}	250			ns
Data input hold time			t_{HDDAT}	0			ns
STOP condition setup time			t_{SUSTO}	4.7			µs
Bus free time			t_{BUF}	4.7			µs
Input filter time			t_I			100	ns
Data output hold time			t_{DH}	300		1000	ns
Coil Inputs							
Coil frequency			f_{COIL}	100	125	150	kHz
Gap Detection							
Delay field off to GAP = 0	$V_{coilGap}$ < 0.7 V_{DC}		T_{FGAP0}	10		50	µs
Delay field on to GAP = 1	$V_{coilGap}$ > 3 V_{DC}		T_{FGAP1}	1		50	µs
Power Management							
Battery to field switch delay			t_{BFS}			1000	µs
Field to battery switch delay	V_{Batt} = 6.5V		t_{FBS}	5	10	30	ms
EEPROM							
Endurance	Erase/write cycles		E_D	500000			Cycles
Data erase/write cycle time	For 16-bit access		t_{DEW}		9	12	ms
Data retention time	T_{amb} = 25° C		t_{DR}	10			years
Power up to read operation			t_{PUR}			0.2	ms
Power up to write operation			t_{PUW}			0.2	ms
Reset							
Power-on reset	V_{DDrise} = 0 to 2V		t_{rise}			10	ms
NRST	Vll < 0.2 V_{DD}		t_{res}	1			µs

Figure 9-1. Typical Reset Delay After Switching V_{DD} On

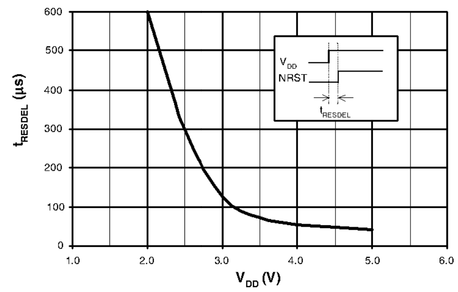


Figure 9-2. Typical Reset Delay After Switching V_{DD} On

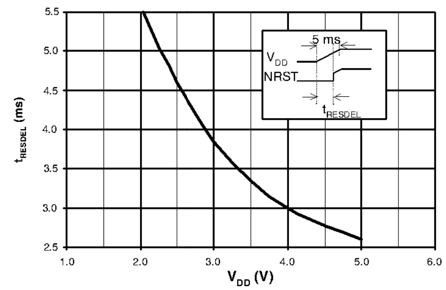
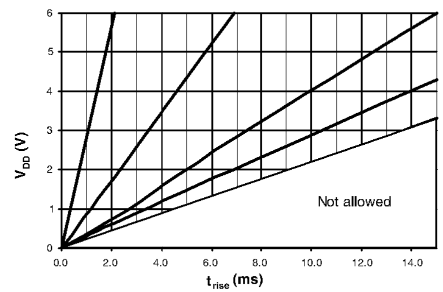


Figure 9-3. V_{DD} Rise Time to Ensure Power-on Reset



Features

- Identification Transponder in Plastic Cube
- Basic Component: e5530 IDIC®
- Includes Coil and Capacitor for Tuned Circuit Antenna
- Carrier Frequency: 125 kHz

Application

- Car Immobilizer
- Access Control
- Alarm Systems
- Other Identification Systems

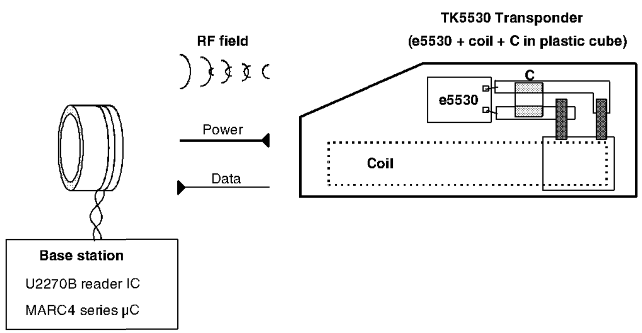
Description

The TK5530 is a complete transponder, which implements all important functions for immobilizer and identification systems. It consists of a plastic cube which accommodates the read-only **ID**entification **I**ntegral **C**ircuit (IDIC®) e5530 and the antenna is realized by a LC-circuit.

The identifying data are stored in a 128 bit PROM on the e5530, realized as an array of laser-programmable fuses. The logic block diagram for the e5530 is shown in Figure 1. The data are sent bit-serially as a code.

Any attempt to fake the base station with a wrong transponder will be recognized immediately.

System Block Diagram



Read-only Transponder

TK5530

Rev. 4683A–RFID–02/03

General

The transponder consists of a plastic cube which accommodates following components:

- Read-only IDIC® with ROM (e5530)
- Antenna realized as tuned LC-circuit

Read-Only IDIC®
with ROM (e5530)

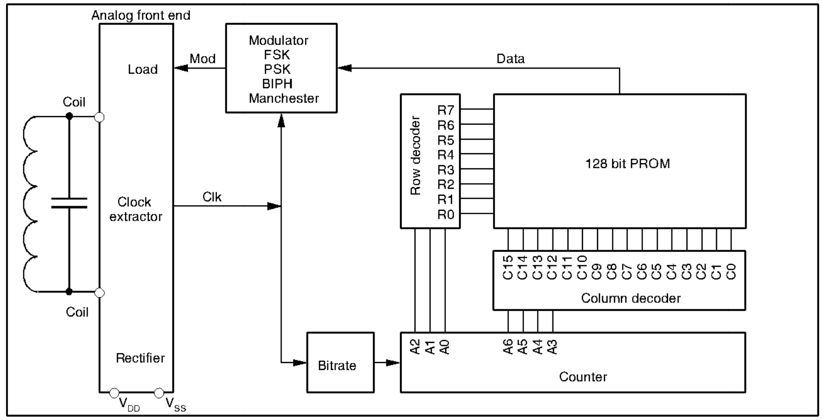
The e5530 is part of a closed coupled identification system (see 'System Block Diagram'). It receives power from a RF transmitter (reader) which is coupled inductively to the IDIC. The TK5530 transponder operates at a nominal frequency of 125 kHz. Receiving RF, the IDIC responds with a data stream by damping the incoming RF via an internal load. This damping in turn can be detected by the reader. The identifying data are stored in a 128-bit PROM on the e5530, which is factory programmed with a unique code (see specification of the e5530).

The e5530 has several possible options regarding modulation, bitrate, memory size etc.

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 readout distance.

Figure 1. Block Diagram



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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
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		3.95		mH
LC circuit, $H_{pp = 20 A/m}$						
Resonance frequency	Room temperature	f_r	121.4	125	129.2	kHz
Resonance frequency	T_{amb} = -40 to +85°C	f_r	120.0		131.0	kHz
Quality factor		Q_{LC}		13		
Magnetic Field Strength (H)						
Max. field strength where tag does not modulate	No influence to other tags in the field	$H_{pp\ not}$		2		A/m
Field strength for operation	T_{amb} = -40°C	$H_{pp\ -40}$		30		A/m
Field strength for operation	T_{amb} = 25°C	$H_{pp\ 25}$		18		A/m
Field strength for operation	T_{amb} = 85°C	$H_{pp\ 85}$		17		A/m
Maximun field strength		$H_{pp\ max}$			600	A/m
Modulation Range (see also H-DV curve)						
Modulation range	H_{pp} = 20 A/m H_{pp} = 30 A/m H_{pp} = 50 A/m H_{pp} = 100 A/m	DV		4.0 6.0 8.0 8.0		V

Figure 2. Typical T_K-range of Resonance Frequency

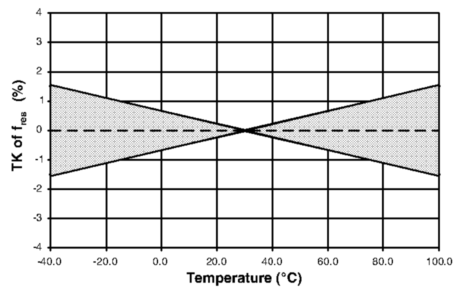


Figure 3. Typical H-DV Curve

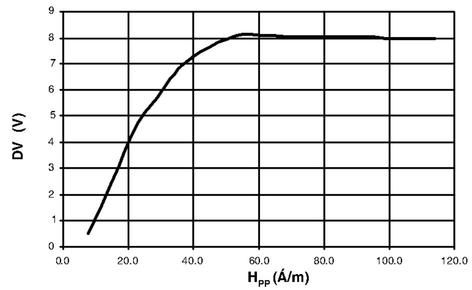
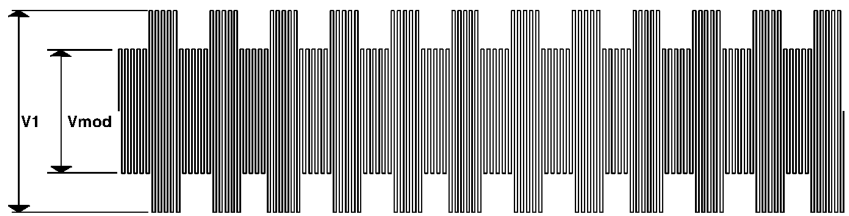


Figure 4. Measurement of the Modulation Range DV

Output voltage of the testing application (see figure 6 and 7)



DV = V1-Vmod

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

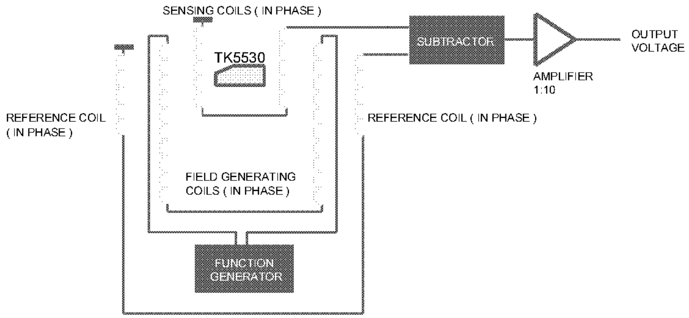
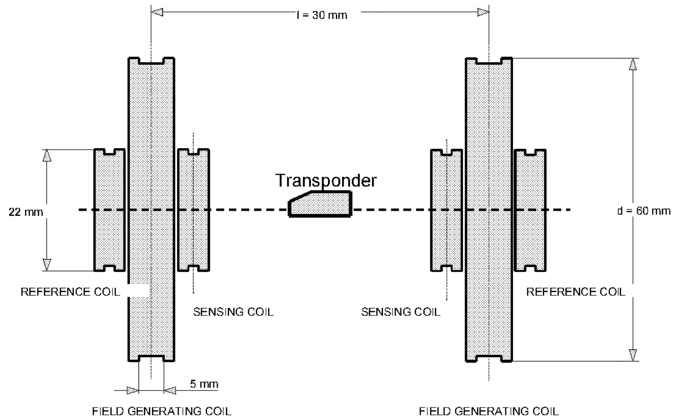


Figure 6. Testing Geometry



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IDIC® (Reference Data Sheet e5530)

Memory size maximum	128 Bit (details see “Coding”)
Memory type	ROM
Programming	Laser cutting
Data rate	RF/32 - RF/64
Encoding	Manchester or Bi-phase
Modulation	AM
Maximum coil voltage (internally limited) V_{pp} (I = 5 mA)	16 V

Coding

The memory of the TK5530 can be selected to be a 64- or 128-bit rolling code. In the non-standard version, the first 8 bits are a customer-specific pattern. This can be selected by the customer, provided that Atmel agrees to the customer’s proposal. This pattern is unique within the serial rolling code data stream. The ID code and further bit informations following the 8-bit header can also be defined within the customer’s specification.

The set-up of a suitable coding scheme can be provided on customer’s request.

Read Distance

The maximum distance between the base station and the TK5530 mainly depends 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 Atmel 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 TK5530 being integrated into the specific application.

Ordering Information

Extended Type Number	Modul.	Data Rate	Con-figuration	Check-sum	Header	ID Code	SPQ (Minimum Volume)	Minimum Order Volume
TK5530HM-232-PP	Manch.	RF/32	64 bit	no check-sum	E6	fixed and unique code	10 kpcs	>1 kpcs (per order, from stock)
TK5530HM-zzz-PP	defined by customer							> 300 kpcs p.a.

Note:
1) Definition of customized part number basing on orders for first year volume (300 kpcs)
2) Definition of header, ID code, checksum etc. according to customers data base
3) 8.000 US$ initial cost for metal mask
4) Lead time 5 month
5) Low volume customized application can be covered by TK5550F-PP programming, for identical application, as TK5530H-zzz-PP.

Ordering Number for Standard Version

TK5530HM-232-PP

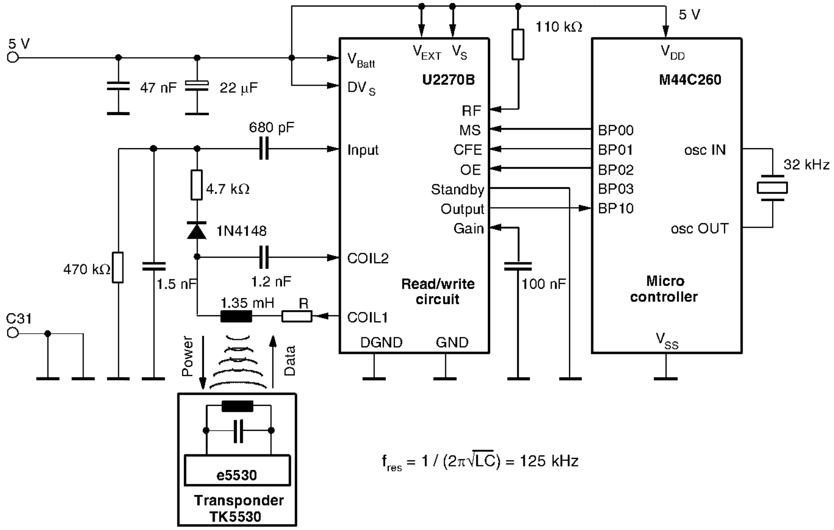
Ordering Number for Customized Version

TK5530xy-zzz-PP

- PP: Plastic package
- zzz: Custom code
- y: Modulation
  - M -> Manchester code
  - B -> Biphase code
- x: Mask version of die

Application

Figure 7. Complete Transponder System with the Read/Write Base-station IC U2270B



$f_{res} = 1 / (2\pi\sqrt{LC}) = 125$ kHz

Package Information

Dimensions in mm