SERMA
PRODUCTIVITY ENGINEERING

Datasheet

PE3001

Table of Content

1 Revision History

Version	Date	Changes	Page
Initial Version V1.0	09/2009		
V1.1	07/2010	General Layout Change	
V1.2	02/2011	Minor adjustments for grammar and better understanding	
V1.3	03/2012	Removed TEST_EPC in Section 10	24

2 Introduction

PE3001 is a UHF RFID Tag IC with an integrated data monitoring system.
It includes the following properties:

- Passive transponder chip according to EPC Class 1 Generation 2 UHF RFID version 1.0.9
- Temperature measurement and storage including a time stamp in the integrated non-volatile EEPROM
- Energy provided for communication through the RF field, energy for the data monitoring provided through a battery
- Intelligent power management for the different power domains
- 8kBit EEPROM can be written and read through the RF field and the data monitor
- Fully integrated system without any need of external devices (antenna and battery only)
- Extra signal output for “out-of-limits” temperature detection
- Continuous battery control and automatic shut down
- Extended battery supply voltage range for single or dual cell supply
- Password protection for monitoring data according to EPC Gen 2 Protocol
- Additional functionality possible through SPI interface (µC, external Sensors)

3 External References

- EPC™ Radio-Frequency Identity Protocols Class-1 Generation-2 UHF RFID Protocol for Communications at 860 MHz – 960 MHz, Version 1.0.9

4 PE3001 Overview

The PE3001 is an integrated circuit for tracking and controlling logistics. It monitors certain temperature and related time data everywhere the adjacent goods are located during transport or storage. While not in an RFID reader field and so not being supplied through the reader the systems draws the required energy from the battery. While in a UHF reader field the system is supplied by the reader's field energy and communicates to the reader based on standard protocol. Besides standard EPC communication additional EPC functionality to read out temperature or other data is implemented. The integrated SPI interface allows communication with other external devices like a micro controller that can provide additional sensor functionality like for MEMS sensors.
The IC contains the following main functional blocks:

- RFID Frontend for extraction of field energy and bidirectional communication
- Real Time Clock to provide an accurate clock signal of 8.738 kHz
- Temperature sensor
- Digital controller to manage all internal mechanisms
- Digital controller to manage reader communication
- Digital controller to manage access to the integrated 8kBit EEPROM
- SPI interface for external wired communication
- Power manager to control and switch between the different power domains within the IC

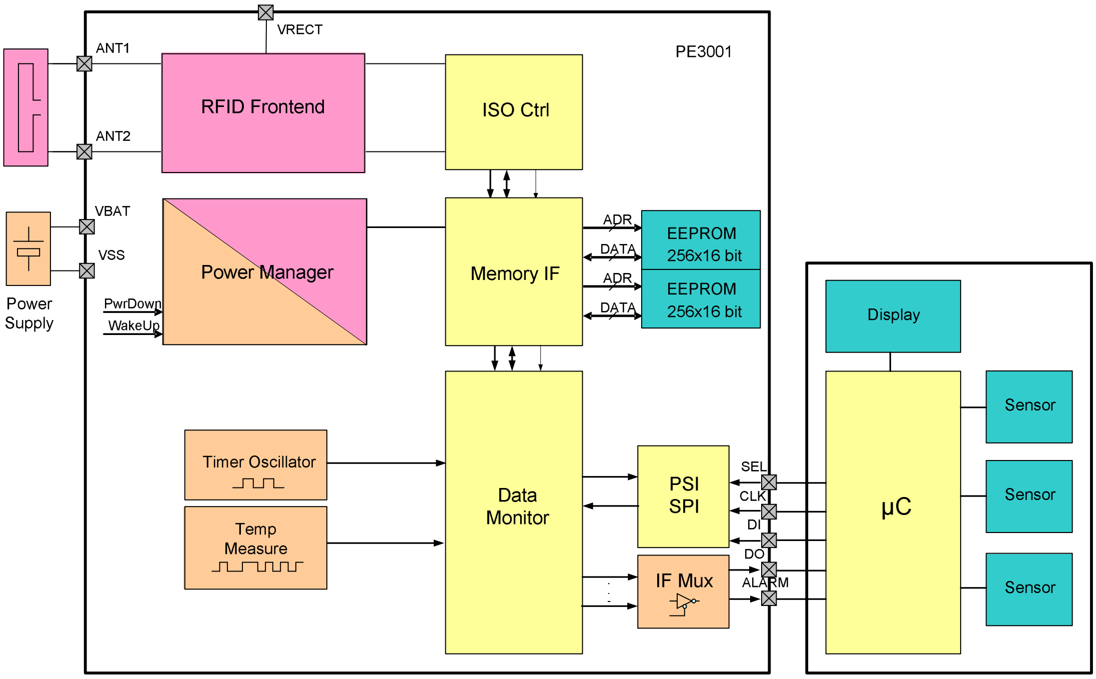

Figure 1 – PE3001 block circuit diagram

5 Typical Application

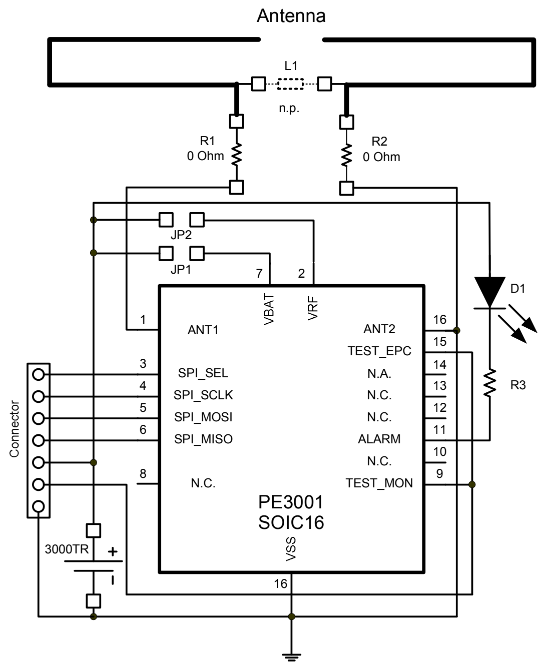

Figure 2 – Typical application circuitry SOIC16

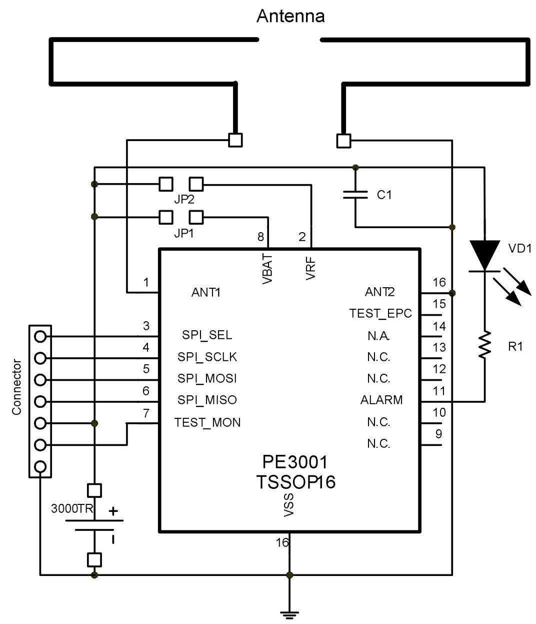

Figure 3 – Typical application circuitry TSSOP16

6 Pin Assignment / Package

The PE3001 comes in a TSSOP16 or SOIC16 (some early samples) package. For high volume production the chip is also available as bare dice.

Table 1 – Pin assignment

SOIC16 ES Pin No.	TSSOP16 ES Pin No.	Pin Name	I/O	Function
1	1	ANT1	input	RFID antenna
2	2	VRF	power	RFID rectifier voltage
3	3	SPI_SEL	input (PD)	SPI select signal
4	4	SPI_SCLK	input (PD)	SPI clock signal
5	5	SPI_MOSI	input (PD)	SPI data signal input
6	6	SPI_MISO	output	SPI data signal output
7	8	VBAT	power	Battery (+)
9	7	TEST_MON	input (PD)	Test function on
11	11	ALARM	output (OD)	Alarm port connects to VSS
15	15	TEST_EPC	input (PD)	Test function on
16	16	ANT2 / VSS	power	RFID antenna Connected to VSS / Battery (-)
8,10,12,13,14	9,10,12,13,14	-	-	Not connected

PU = Pull Up, PD = Pull Down, OD = Open Drain

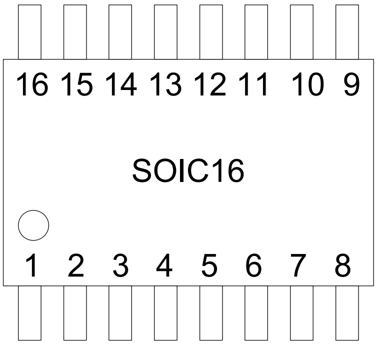

Figure 4 – SOIC16 package

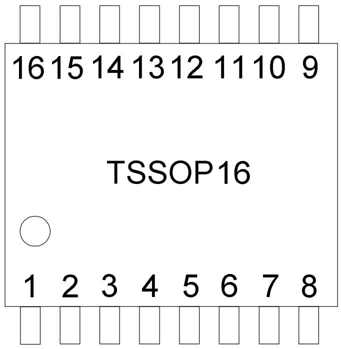

Figure 5 – TSSOP16 package

6.1 SOIC16 Package Dimensions

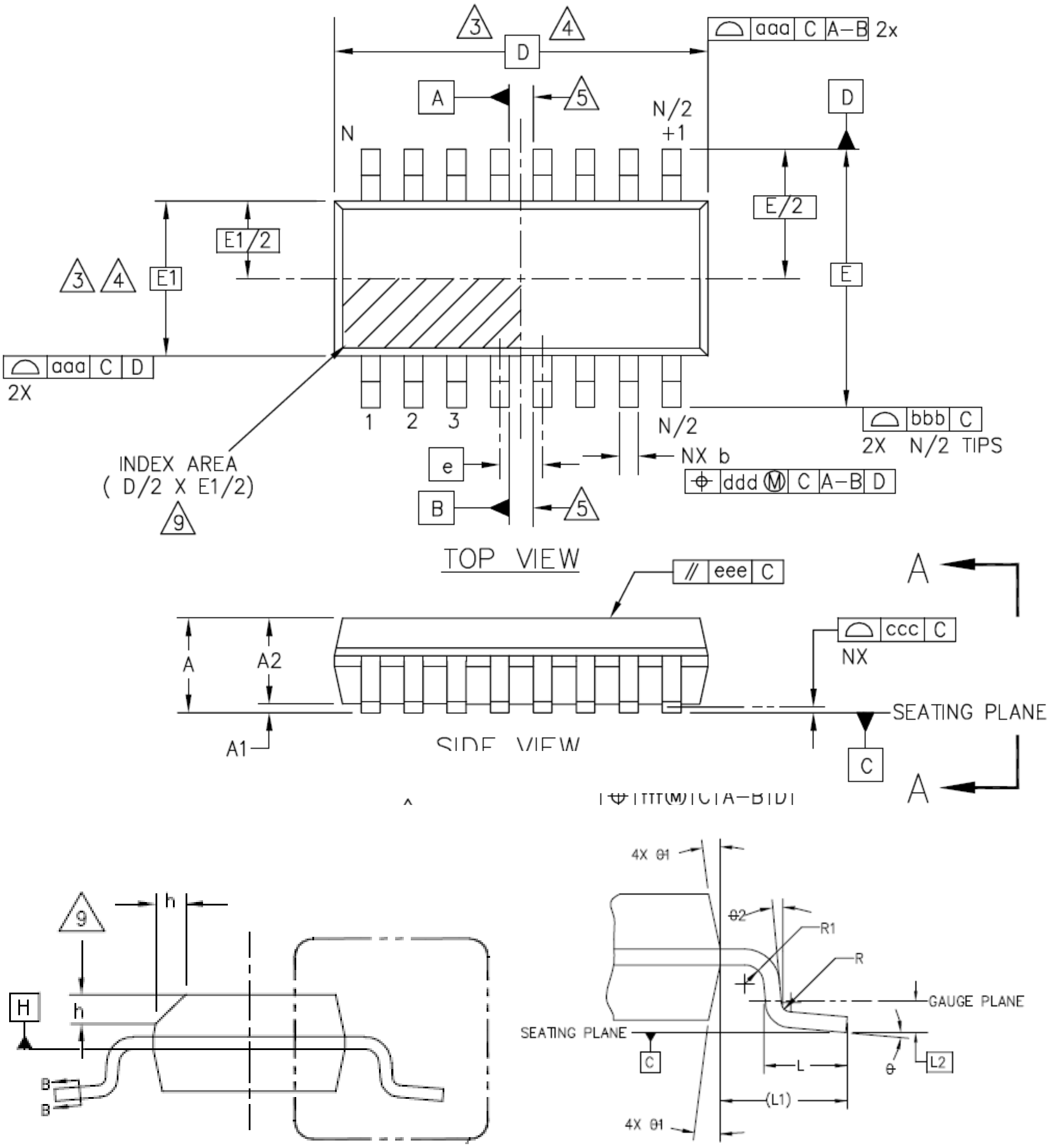

Figure 6 – SOIC16 package dimensions

Table 2 – SOIC16 package dimensions

SYMBOL	COMMON DIMENSIONS		
	MIN	NOM	MAX
A	-	-	1,75
A1	0.1	-	0.25
A2	1.25	-	-
D BSC		9.90	
N		16	
b	0.31	-	0.51
b1	0.28	-	0.48
c	0.17	-	0.25
c1	0.17		0.23
E	6.00 BSC		
E1	3.90 BSC		
e	1.27 BSC		
L	0.40	-	1.27
L1	1.04 REF		
L2	0.25 BSC		
R	0.07	-	-
R1	0.07	-	-
h	0.25	-	0.50
Θ	0°	-	8°
Θ1	5°	-	15°
Θ2	0°	-	-
SYMBOL	**TOLERANCES OF FORM AND POSITION**		
aaa	0.10		
bbb	0.20		
ccc	0.10		
ddd	0.25		
eee	0.10		
fff	0.15		

6.2 TSSOP16 Package Dimensions

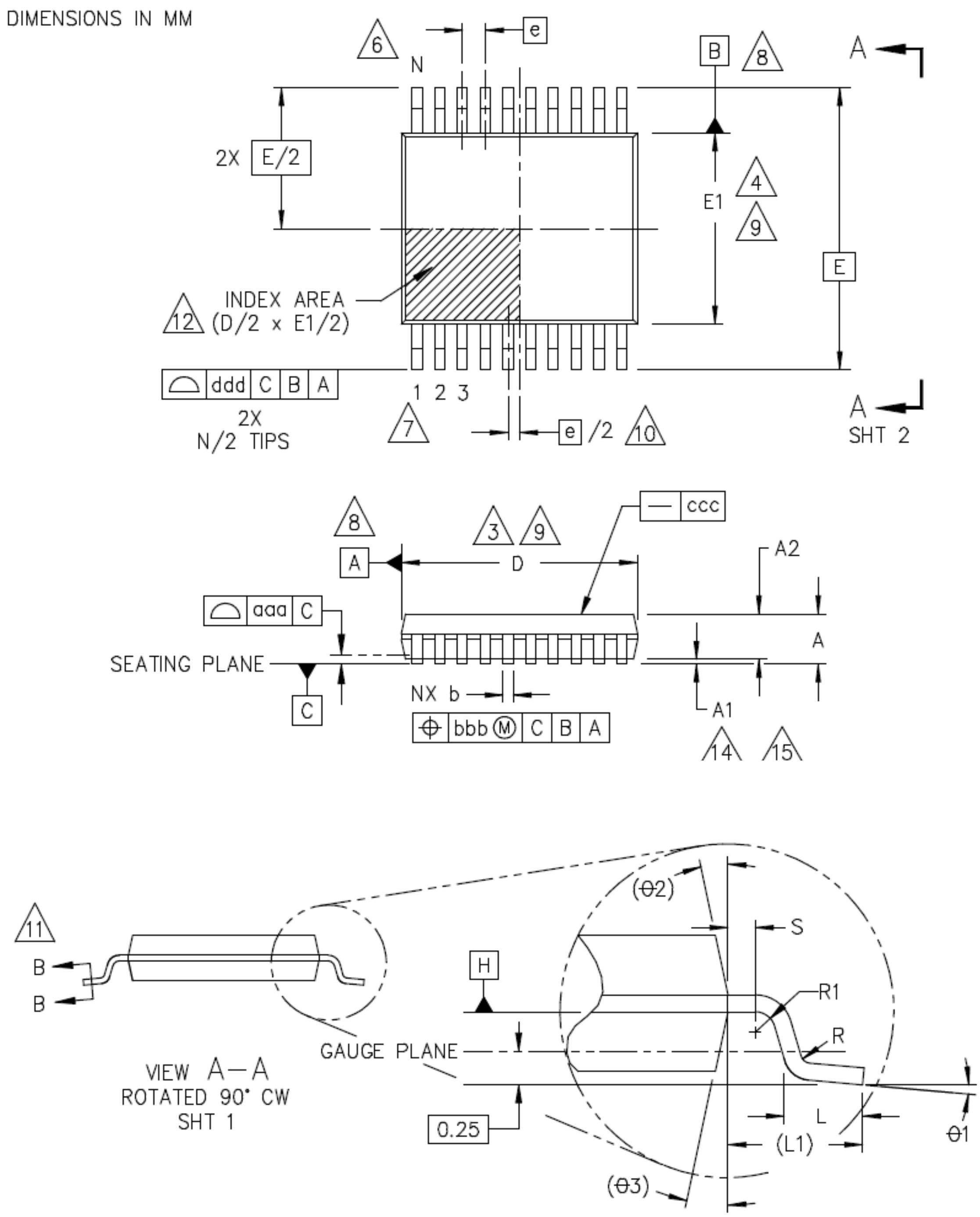

Figure 7 – TSSOP16 package dimensions

Table 3 – TSSOP16 package dimensions

SYMBOL	COMMON DIMENSIONS (Millimeters)		
	MIN	NOM	MAX
A	-	-	1,20
A1	0.05	-	0.15
A2	0.80	1.00	1.00
D	4.90	5.00	5.10
N		16	
b	0.19	-	0.30
b1	0.19	0.22	0.25
c	0.09	-	0.20
c1	0.09	-	0.16
E	6.40 BSC		
E1	4.30	4.40	4.50
e	0.65 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		
R	0.09	-	-
R1	0.09	-	-
S	0.20	-	-
Θ1	0°	-	8°
Θ2	12 REF		
Θ3	12 REF		
SYMBOL	**TOLERANCES OF FORM AND POSITION**		
aaa	0.10		
bbb	0.10		
ccc	0.05		
ddd	0.20		
REF	11-360		
ISSUE	A		

7 Electrical Parameters

7.1 Absolute Maximum Ratings

Table 4 – Absolute maximum ratings

Parameter	Symbol	Min	Typ	Max	Unit
Junction-Temperature	T_{chip}	-40		120	°C
Input voltage	V_{in}	-0.5		V_{bat}+0.5	V
Output voltage	V_{out}	-0.5		V_{bat}+0.5	V
Antenna voltage	V_{ant}	-6.0		6.0	V
Battery voltage	V_{bat}	-0.5		3.6	V
Rectifier voltage	V_{rf}	-0.5		3.6	V

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

7.2 Typical Operating Conditions

Table 5 – Typical operating conditions

Parameter	Symbol	Min	Typ	Max	Unit	Comment
Operating temperature	T_{amb}	-40	27	85	°C	
RF field frequency	f_{rf}	860		960	MHz	
Read sensitivity	P_{rd}		-6		dBm	passive tag
Write sensitivity	P_{wr}		-4		dBm	passive tag
Input impedance chip SOIC16	Z_{in}		4 – j 60		Ohm	simulated
Input impedance chip TSSOP16	Z_{in}		15 – j 74		Ohm	measured
Input power	P_{rf}			20	dBm	on antenna
Rectifier voltage	V_{rf}	2.0		3.3	V	[1]
Battery voltage data monitor	V_{bat}	1.1	1.4	1.7 (3.6)	V	[2]
Power consumption data monitor	P_{mon}			5	µW	average for log interval
EEPROM block size			512x16		Bit	
EEPROM write cycles		100.000				@ 25°C
EEPROM write cycle		10.000				@ 125°C
EEPROM data retention		10			years	@ 85°C
Accuracy data monitor		-1.00 -1.75		1.00 1.75	°C	-20°C to 30°C [2] 30°C to 50°C [2]
Measurement resolution		0.3	0.4	0.5	°C	8 bit value
Accuracy time		-3		+3	%	[2]
AlarmPort current	I_{drain}		5		mA	open drain output

[1] An external battery can be connected to pin VRF to supply the RFID block. In this case a series diode is recommended to avoid current into the battery when the antenna is in an RF field.

[2] Functional at 3.3V but no guarantee on timer and temperature measurement accuracy.

8 Functional Description

8.1 General

The PE3001 is an EPC Class 1 Generation 2 Transponder chip, implementing basic EPC functionality. Additionally it also contains a temperature measurement unit and a real time clock.

Since the primary application is meant to be in the absence of a reader field, the data monitor (temp + time) can be supplied through two pins by an external battery with a wide voltage range. RFID communication is passive. This means even if the battery is empty or not connected the communication can be conducted and stored data can be read as well as written into not protected addresses.

Memory access is granted through the UHF reader controller as well as through the data monitoring controller. Both blocks have the same priority. An already initiated memory access will not be interrupted by a request for another access. The started access will be finished first before the new access request will be acknowledged.

The EPC specified memory blocks were extended for configuration and data storage. Monitoring configuration is controlled by the TID bank. Through this EPC-ID, user data and monitoring function/setup can be protected separately for read and write access. Measured temperature data in the RESERVED bank cannot be written by the reader through the RFID field.

An external microcontroller can be connected for communication through the SPI interface. External sensors, displays, buttons and other devices can interface the PE3001 this way. A more complex wireless system can be build around the chip. Devices being hooked up to the SPI can access data being stored in the RFID chip memory. All memory address space can be accessed this way.

8.2 Memory Concept

Control of the data monitor is being conducted through the TID bank. It manages the configuration and start/stop commands. Measured data are being stored in the RESERVED bank. The variable LogSize, in the monitor configuration within the TID bank, defines the border between RESERVED and USER bank. USER bank can be used to store user specific information.

8.3 Security Concept

All access mechanisms can be used as specified in the EPC standard. For this reason the data to be stored are separated like this:

Table 6 – Security concept

EPC Bank	Data	Access Rights
EPC	Electronic Product Code	read & write, when EPC bank is not locked
TID	Transponder ID	read only
	Monitor configuration	read & write, when TID bank is not locked (write stops the monitor and resets Status / Logcounter)
	Command interface	read & write, when TID bank is not locked
RESERVED	Access and Kill Password	no read, write through EPC Lock access only
	Chip UID	read only
	Temp data	read only
USER	User data	read & write, when USER bank is not locked

9 Memory Organization

9.1 EPC Bank

The EPC bank is organized as specified in the EPC specification. The CRC16 is implemented as RAM register and is not written in the EEPROM.

Table 7 – EPC bank

EPC Bank	Bit 15..12	Bit 11..8	Bit 7..4	Bit 3..0
00h	CRC16 (EPC Specification)			
01h	PC (EPC Specification)			
02h	EPC (EPC Specification)			
03h				
04h				
05h				
06h				
07h				

9.2 TID Bank

The TID bank contains information about the manufacturer of the tag and the tag version. All necessary information about the data monitoring configuration is also being stored in the TID bank. The last two addresses in the TID bank are used for a command interface and are being shadowed as a register in the RAM. Start and stop of the data monitor takes place through this interface.

Table 8 – TID bank

TID Bank	Bit 15..12	Bit 11..8	Bit 7..4	Bit 3..0
00h	TID (EPC Specification)			
01h				
02h	Status Flags (7 Bit)		Log Counter (9 Bit)	
03h	Temperature Scaling Offset		Temperature Scaling Slope	
04h	Calibration Temperature 2		Calibration Temperature 1	
05h			UHF Frequency Trimming	
06h	RTC Frequency Trimming		RTC Temperature Trimming	
07h	BattChkOff (1 Bit) Algeb. Sign (1 Bit)	Temperature Offset		
08h	Temperature Trimming Osc2		Temperature Trimming Osc1	
09h		AlarmLogCount		
0Ah	MeanValueNumber	LogSize		
0Bh	Wait-Till-Log-Start			
0Ch	Interval Length			
0Dh	TempHiLimit		TempLoLimit	
0Eh	Command	Parameter		
0Fh	Response	Parameter		

TID

Table 9 – TID register

TID Register 00h – 01h	Bit 31..24	Bit 23..12	Bit 11..4	Bit 3..0
Transponder ID	Tag ACI E2h	Tag MDID 013h	Tag Version	Tag Revision

STATUS FLAGS

Bit 6: Initializing, monitor started
Bit 5: Monitoring active
Bit 4: Memory overflow
Bit 3: Watchdog error
Bit 2: Battery error
Bit 1: AlarmPort enabled
Bit 0: Outband mode

LOG COUNTER

Log counter defines how many measured samples can be written into the EEPROM. It increments after every memory write access. Write access to TID bank address 03h to 0Dh erases status flags and Log counter. The data monitor stops.
Since the memory is not being deleted after a restart of the data monitor, it can be recognized up to which address valid data have been written by reading the complete memory. The log counter equals the number of written 16bit blocks.

TEMPERATURE SCALING

This scaling provides all factors to calculate real temperature values from whole-numbered temperature values. The temperature can be calculated according to this formula:

$$T\ [°C] = \frac{Slope}{100} \cdot Value - Offset$$

Values Slope and Offset are set in IC production.

CALIBRATION TEMPERATURE

The calibration temperature contains the calibration points (value times 10) of the two-point calibration.
This value is set in IC production.

UHF FREQUENCY TRIMMING

Value for trimming the tag oscillator frequency.
This value is set in IC production.

RTC TRIMMING

Value for trimming the 8kHz oscillator in the data monitor. This oscillator accounts for the accuracy and deviation of the minute interval (RealTimeClock).
This value is set in IC production.

TEMPERATURE OFFSET

Value of the offset counter for temperature measurements. The algebraic sign (pos/neg) of the offset counter can be set in bit 12. Logic ‘1’ accounts for a positive sign.
This value is set in IC production.

TEMPERATURE TRIMMING

Calibration value for temperature measurement.
This value is set in IC production.

ALARMLOGCOUNT

If the log counter (number of logged data blocks) is larger than ALARMLOGCOUNT, the alarm port will be switched to VSS. In combination with the OUTBAND MODE the alarm port can be used for signalling when the tag was below or above a certain programmed temperature value.
The related AlarmPort will go back to its original state (“high z“) after the monitor has been turned off, battery low-signal has been detected or the memory is full, even though the information is still in ALARMNLOGCOUNT. For this reason it is recommended to use chemical visual displays that change the colour only once when power is applied. The use of an external or partially external S&H circuit is possible as well (bi-stable multivibrator) but also looses information after battery has been removed.

MEANVALUENUMBER

MEANVALUENUMBER defines the calculation of a mean value. This value is always calculated 2 over MEANVALUENUMBER measured values. That means that 2 over x measured values are being used to build the mean value. This mean value is than stored as a single temperature and the next mean value calculation starts.

LOGSIZE

LogSize defines the size of the memory to store measured temperature values. When reducing the LogSize, the spare memory will be added to the USER data area. LogSize can be between 000h – 1DDh. If a value larger than 1DDh is being programmed LogSize will be set to 1DDh.
Note: USER bank is physically organized in the opposite order. When the USER data are being decreased, logged data values from the lower end will be cut off.

WAIT-TILL-LOG-START

Through this the system can be given a wait time before the data logging system starts with the first data storage. Duration is defined by WAIT-TILL-LOG-START x 1min.

INTERVAL LENGTH

Defines the duration of a measurement interval in minutes. INTERVAL LENGTH of 0 logs data continuously without interrupts until the reserved memory is full. It is useful for test and development purposes only.

TEMPERATURE LIMITS

The system manages two temperature limits (TempHiLimit, TempLoLimit) in OUTBAND MODE. When these upper and lower limits are exceeded, the temperature value and time stamp will be stored in the EEPROM. As long as all measured values are within limits nothing will be stored.

COMMAND INTERFACE

Blocks ‘Command’ and ‘Response’ in the TID bank serve as command interfaces to start and stop the data monitor. Those blocks are registers in the RAM. The command is written into ’Command’. Bits 15..12 are reserved for the command and Bits 11..0 are reserved for the parameters. The data monitor sets the block ’Response’ to FFFFh, executes the command and returns the result in ‘Response’. Every write access to the EEPROM from the data monitor sets the ‘Response’ Register to FFFFh at the same time.

Table 10 – Command register

Command (Bits 15..12)	Name	Parameter	Description
0001b	START	Bit8: Outband Mode	Starts the data monitor, deletes the log counter
0010b	STOP		Stops the data monitor

Table 11 – Response register

Response (Bits 15..12)	Name	Parameter	Description
0001b	START	Bit8: Outband Mode	Monitor started
0010b	STOP		Monitor stopped

When starting the monitor the log counter will be reset. Additionally the status flags will be updated at start and stop of the monitor. After writing the last empty block the monitor will be stopped.
Before every new temperature measurement the system measures the battery voltage to ensure a complete measurement and storage cycle can be conducted. When the battery voltage is to low at this time the monitor will be stopped and the BATTERY ERROR FLAG will be set to ‘1’. This safety feature can be overridden by setting the BattChkOff register to ‘1’.
The data monitor will be stopped and the logstatus and logcounter will be reset after each successful write cycle (no locked TID bank) in the address space from 03h to 0Dh.

Note: PE GmbH delivers samples and production volume ICs in calibrated condition (RTC, TMS). The nature of the chip allows everybody to access AND change these values at any time as long as the TID bank is not locked. If the TID bank will be locked the data monitoring setup cannot be changed any more. The values are trimmed in the test process during manufacturing and are guaranteed to be within specified limits.

9.3 RESERVED Bank

Blocks 04h through 09h + LogSize in the RESERVED bank can only is read through the RFID interface, independent of the lock information. Data monitor has always full access to these blocks. The UID allows the tag to be identified and traced back at any time.

Table 12 – RESERVED bank

RESERVED Bank	Bit 15..12	Bit 11..8	Bit 7..4	Bit 3..0
00h	KILL Password (EPC Specification)			
01h				
02h	ACCESS Password (EPC Specification)			
03h				
04h	Chip UID			
05h				
06h				
07h				
08h	Operation Cycle Counter (total number of measurement intervals, never erased)			
09h … 09h + LogSize	Log Data			

Chip UID

Table 13 – UID register 1

RESERVED Register 04h – 07h	Bit 63..56	Bit 55..48	Bit 47..44	Bit 43..40
Chip UID	UID Header E2h	UID MFC 13h	Chip Version	Chip Revis.

Table 14 – UID register 2

RESERVED Register 04h – 07h	Bit 39..21	Bit 20..16	Bit 15..8	Bit 7..0
Chip UID	Lot	Wafer	X-Position	Y-Position

OPERATION CYCLE COUNTER

The operation cycle counter will be increased at any temperature measurement. It can not be erased. At overflow the counter will stop at FFFFh. The system remains operational.

LOG DATA

Measured values are stored in Block 09h through 09h + LogSize. Depending on the mode two or one values are stored per EEPROM block. The logcounter indicates how many valid 16bit blocks are stored in the EEPROM.

Table 15 – Log Data in continuous mode

Mode = All Values	Bit 15..8	Bit 7..0
	measurement n + 1	measurement n

Table 16 – Log Data in outband mode

Mode = Outband	Bit 15..8	Bit 7..0
	Interval counter measurement n	measurement n

The interval counter is not stored in the EEPROM. It counts the number of executed monitoring intervals in an 8 bit counter since the start of the monitor. This counter serves also as time base, therefore it will also be incremented when no measurement value will be stored in the EEPROM.
Note: In Outband Mode the interval counter will write in bits 15..8. When the interval counter overflows a measurement value will be stored at interval count = ’0’ even if the measured value will be within limits of the defined outband mode. By counting the measured and stored values with interval count = ’0’ all measured values can be explicitly identified.

POWER ON RESET

At POR (battery on) the log counter and all status flags and the AlarmPort will be set to ’0’.

9.4 USER Bank

Available EEPROM memory is divided into RESERVED and USER. Size of RESERVED bank and USER bank is defined by parameter LogSize in TID. Content of USER bank has to be defined by the user.

Table 17 – USER bank

USER Bank	Bit 15..12	Bit 11..8	Bit 7..4	Bit 3..0
000h … 1DDh – LogSize	User data			

9.5 Physical Memory Organization

Table 18 – Physical memory organization 1

EPC Bank (01b)					
Addr.	**EEP Addr.**	**Bit**	**Data**	**Mode**	**Description**
00h	**000h**	**15-0**	**CRC16**	**r**	**CRC of PC and EPC Data from addr. 01h to max. 07h**
01h	**001h**	**15-0**	**PC**	**r/w**	**Protocol Control bits**
		15-11	Length		Length of PC+EPC in words 00000b: one word (addresses 001h in EPC memory) 00001b: two words (addresses 001h to 002h in EPC memory) 00010b: three words (addresses 001h to 003h in EPC memory) ... 00101b: 7 words (addresses 001h to 007h in EPC memory)
		10-9	RFU		Reserved for Future Use
		8-0	NSI		Number System Identifier
02h	**002h**	**15-0**	**EPC [95:80]**	**r/w**	**Electronic Product Code**
03h	**003h**	**15-0**	**EPC [79:64]**	**r/w**	
04h	**004h**	**15-0**	**EPC [63:48]**	**r/w**	
05h	**005h**	**15-0**	**EPC [47:32]**	**r/w**	
06h	**006h**	**15-0**	**EPC [31:16]**	**r/w**	
07h	**007h**	**15-0**	**EPC [15:0]**	**r/w**	

Table 19 – Physical memory organization 2

TID Bank (10b)					
Addr.	**EEP Addr.**	**Bit**	**Data**	**Mode**	**Description**
00h	**008h**	**15-0**	**TID [31:16]**	**r**	**Transponder ID bit 31-16**
		15-8	Tag ACI		Application Class ID: E2h
		7-0	Tag MDID [11:4]		MDID defined for PE GmbH: 01h
01h	**009h**	**15-0**	**TID [15:0]**	**r**	**Transponder ID bit 15-0**
		15-12	Tag MDID [3:0]		MDID defined for PE GmbH: 3h
		11-4	Tag Version		Version of Tag
		3-0	Tag Revision		Revision of Tag
02h	**00Ah**	**15-0**	**LogCount**	**r/w**	**Statusflags, Logcounter erased on write to TID 03h - 0Dh**
		15	Monitor Started		Flag Monitor started (0 = not started, 1 = started)
		14	Monitor Active		Flag Monitor active (0 = not activated, 1 = activated)
		13	Overflow		Flag Memory overflow (0 = no overflow, 1 = overflow detected)
		12	WDT Error		Flag Watchdog error (0 = Watchdog ok, 1 = Watchdog overflow)
		11	Battery Error		Flag Battery error (0 = Battery ok, 1 = Battery error)
		10	Alarm Port		Flag Alarm Port enabled (0 = no Alarm, 1 = Alarm)
		9	Outband		Flag Outband Mode enabled (0 = Normal mode, 1 = Outband mode)
		8-0	LogCount		Log Counter

Table 20 – Physical memory organization 3

TID Bank (10b)					
Addr.	**EEP Addr.**	**Bit**	**Data**	**Mode**	**Description**
03h	**00Bh**	**15-0**	**TempScaling**	**r/w**	**Temperature scaling to calculate temperature values**
		15-8	TOffset		Offset for temperature scaling
		7-0	TSlope		Slope for temperature scaling
04h	**00Ch**	**15-0**	**CalTemp**	**r/w**	**Calibration temperature (Set in IC production.)**
		15-8	TTrimB		Second calibration temperature
		7-0	TTrimA		First calibration temperature
05h	**00Dh**	**6-0**	**TagFrequ**	**r/w**	**UHF frequency trimming value (Set in IC production.)**
06h	**00Eh**	**15-0**	**RTCTrim**	**r/w**	**RTC frequency trimming (Set in IC production.)**
		15-8	RTCFreq		RTC frequency trimming
		7-0	RTCTemp		RTC temperature trimming
07h	**00Fh**	**15-0**	**TempOffset**	**r/w**	**Temperature offset and BattCheckOff (Set in IC production.)**
		15-14	RFU		Reserved for Future Use
		13	BattChk		BatteryCheckOff (0 = check battery, 1 = don't check battery)
		12	Sign		Algebraic sign of the offset counter (1 = pos, 0 = neg)
		11-0	TempOffs		Offset counter for temperature measurement
08h	**010h**	**15-0**	**TempTrim**	**r/w**	**Frequency trimming of OSC1/2 (Set in IC production.)**
		15-8	OSC2		Trimming value for Osc2
		7-0	OSC1		Trimming value for Osc1

Table 21 – Physical memory organization 4

TID Bank (10b)					
Addr.	**EEP Addr.**	**Bit**	**Data**	**Mode**	**Description**
09h	**011h**	**8-0**	**AlarmLogCnt**	**r/w**	**Alarm log counter value (AlarmPort = Low, if LogCount > AlarmLogCnt)**
0Ah	**012h**	**15-0**	**MWLog**	**r/w**	**Mean value and Log size**
		15-12	MW		Mean value for measured data (2^MW)
		11-9	RFU		Reserved for Future Use
		8-0	LogSize		Size of memory to store measured data
0Bh	**013h**	**15-0**	**WTLS**	**r/w**	**Wait-Till-Log-Start, wait time before monitoring starts**
0Ch	**014h**	**15-0**	**IntLength**	**r/w**	**Interval Length, duration of a measurement interval**
0Dh	**015h**	**15-0**	**TempLimit**	**r/w**	**Temperature limits for outband mode**
		15-8	TempLimHi		Constraint of high measured value
		7-0	TempLimLo		Constraint of low measured value
0Eh	**016h**	**15-0**	**CMD**	**r/w**	**Command interface**
		15-12	CMD		Command interface 0001b: Starts the data monitor, deletes the log counter 0010b: Stops the data monitor
		8	Outband		Outband mode (0 = Normal mode, 1 = Outband mode)
0Fh	**017h**	**15-0**	**RSP**	**r/w**	**Response data**
		15-12	RSP		Response data 0001b: Monitor started 0010b: Monitor stopped
		8	Outband		Outband mode (0 = Normal mode, 1 = Outband mode)

Table 22 – Physical memory organization 5

RESERVED Bank (00b)					
Addr.	**EEP Addr.**	**Bit**	**Data**	**Mode**	**Description**
00h	**18h**	**15-0**	**KillPwd [31:16]**		**Kill Password [31:16]**
01h	**19h**	**15-0**	**KillPwd [15:0]**		**Kill Password [15:0]**
02h	**1Ah**	**15-0**	**AccessPwd [31:16]**		**Access Password [31:16]**
03h	**1Bh**	**15-0**	**AccessPwd [15:0]**		**Access Password [15:0]**
04h	**1Ch**	**15-0**	**UID [63:48]**	**r**	**Chip UID**
		15-8	UIDHead		UID Header: E2h
		7-0	UIDMFC		Manufacturer Code: 13h
05h	**1Dh**	**15-0**	**UID [47:32]**	**r**	**Chip UID**
		15-12	ChipVer		Chip Version
		11-8	ChipRev		Chip Revision
		7-0	Lot[18:11]		Lot
06h	**1Eh**	**15-0**	**UID [31:16]**	**r**	**Chip UID**
		15-5	Lot[10:0]		Lot
		4-0	Wafer		Wafer
07h	**1Fh**	**15-0**	**UID [15:0]**	**r**	**Chip UID**
		15-8	XPos		X-Position
		7-0	YPos		Y-Position
08h	**20h**	**15-0**	**CycCount**	**r**	**Operation cycle counter (total number of measurement)**
09h	**21h**	**15-0**	**LogData**	**r**	**Log data**
0Ah	**22h**	**15-0**	**LogData**	**r**	**Log data**
0Bh	**…**		**…**	**r**	**…**
0Ch	**21h + LogSize**		**LogData**	**r**	**Log data**

Table 23 – Physical memory organization 6

USER Bank (11b)						
Addr.	**EEP Addr.**	**Bit**	**Data**	**Mode**		**Description**
1DDh - LogSize		**22h + LogSize**	**15-0**	**UserData**	**r/w**	**User data**
01h		**1FEh**	**15-0**	**UserData**	**r/w**	**…**
00h		**1FFh**	**15-0**	**UserData**	**r/w**	**User data**

10 Serial Interface

The EEPROM can be accessed through a standard serial interface with SPI protocol. External sensor data can be stored in the internal EEPROM this way and can so be read through the RFID field. Clock frequency for this interface is limited to 1MHz. Transmission of address and data is executed with MSB first. When the data word is shorter than 16 bit the leading bits have to be filled with ’0’.

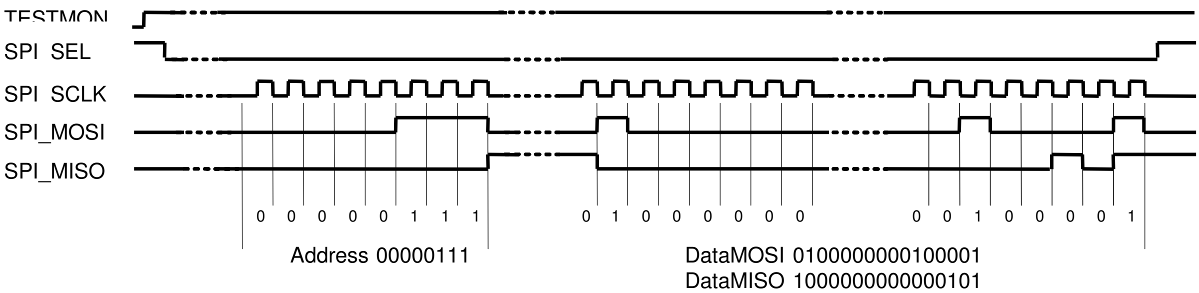

Figure 8 – SPI Interface

TESTMON	Activate Test Mode (pull down input)
SPI_SEL	Activate SPI Transfer (low active, pull down input)
SPI_SCLK	SPI-Clock (pull down input)
SPI_MOSI	Serial Data Input (pull down input)
SPI_MISO	Serial Data Output

All input pins of the interface have pull down resistors. If no idle current into the pins is wanted, the pins must be set to high z or tied to ground. In this case the chip is in the normal operating state and the interface is not active.
The interface will be activated by setting the test signal “TESTMON” to high. At this time the internal state machine for monitoring is halted.
The SPI_SEL is low active, as in most SPI standards, and defines begin and end of a data transfer (frame: address8, data16).
The data input (MOSI) will be latched with the rising clock edge into the chip. The data output (MISO) can be read by a µC during the clock line is high.

It is important to have a low clock line when SPI_SEL is switched to low – otherwise a rising clock pulse will be generated at this transition.
A combination of low test signals and low SPI_SEL resets all internal register in PE3001.

10.1 SPI Addresses

For programming and reading of the EEPROM certain command sequences have to be obeyed. Follow the sequences described in the tables below. At the beginning an initialization has to be executed. Afterwards addresses can be accessed.
An 'ERASE' has to be conducted before a memory cell can be written. The wait time between 'ERASE' and 'WRITE' has to be at least 4ms.

Table 24 – Serial interface – initialize EEPROM access

SPI-Address	Data	Command
0x06	0x8000	Set Wakeup
0x06	0x0000	Clear Wakeup
0x20	0x0018	Set Sleep, Reset
0x01	0x0000	Clear EEPROM CTRL
0x02	0x0000	Clear EEPROM Address
0x03	0x0000	Clear EEPROM DATA
0x3A	0x0080	Enable Chargepump
		wait for 10ms

Table 25 – Serial interface – disable EEPROM access

SPI-Address	Data	Command
0x3A	0x0000	Disable Chargepump
0x20	0x0018	Set Sleep, Reset
0x06	0x4000	Set Power down
0x06	0x0000	Clear Power down

Table 26 – Serial interface – write EEPROM

SPI-Address	Data	Command
0x01	0x00C0	Set Mem, Set EEPROM
0x02	address	Set Address
0x03	data	Set Data
0x01	0x00C8	Set Erase
		wait for 4ms
0x01	0x00C0	Clear Erase
0x01	0x00C2	Set Write
		wait for 4ms
0x01	0x00C0	Clear Write

Table 27 – Serial interface – read EEPROM

SPI-Address	Data	Command
0x01	0x00C0	Set Mem, Set EEPROM
0x02	address	Set Address
0x01	0x00C1	Set Read
0x03	0x0000	Read Data the memory data will be received at the MISO pin
0x01	0x00C0	Clear Read

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