

# DATA SHEET

**HT2 MOA3 S20**

**HITAG<sup>TM</sup>2 Chip Module**

Preliminary Specification  
Revision 1.1

August 1997



**PHILIPS**

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# 1 Definitions

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## 1.1 Objective of the Specifications

This specification lists the parameters to be fulfilled by the HITAG 2 chip module HT2 MOA3 S20 for contactless smart cards or similar transponders (as e.g. discs).

## 1.2 Definition of the Chip Module

A chip module is an electronically packaged chip covered with a globe top cap. The HT2 MOA3 S20 is above all used as card module, i.e. for further lamination into contactless smart cards according to ISO 10536.1.

So the HITAG 2 chip module HT2 MOA3 S20 is best suited for customers that do not want to spend time with micro assembly and therefore start - e.g. ISO card production - with the HITAG 2 chip module.

## 1.3 Use of the Modules

The HITAG 2 modules are designed to be connected to a coil and then to be further processed by packaging into a transponder (e.g. lamination into an ISO smart card). Specific processing information for the coil-module connection and packaging is given in the specification.

For production of contactless chip cards it is recommended to prepunch card foils to create a recess for the chip module in the card body.

## 2 Specifications

### 2.1 Mechanical Properties

Width (Proposed Punching Outline)	7.55 mm	see also drawing in chapter 3
Length (Proposed Punching Outline)	11.75 mm	
Overall Thickness	0.45 mm $\pm$ 0.03 mm	
Film Thickness	0.16 mm $\pm$ 0.005 mm	
Bondpad Size for Transponder Coil / Module Interconnection	1.9 x 3.5 mm	Suitable for Welding/Soldering/ Conductive Gluing

### 2.2 Materials

Tape	110 $\mu$ m	Glass epoxy
Copper Plating	35 $\mu$ m	ED copper
Bond Plating	Ni / Au	Suitable for Al and Au wire bonding
Backside Plating	Ni / Au	
Glob Top	Filled Epoxy	Thermal curing

### 2.3 Temperature Range

Operating	-25°C to +85°C	For packed transponder, depending on type of package
Processing	150°C for 30 minutes	at a standard lamination pressure for contactless smart card plastic materials (e.g. PVC, PET, ...)
Welding Parameters	max. 25 ms @ 500 °C	on bond pads
Soldering Parameters	max. 3 s @ 390 °C	on bond pads

## 2.4 Storage Conditions

Temperature	15 - 30 °C	
Relative Humidity	40 - 70 %	
Duration	1 year	

## 2.5 Delivery Conditions

Delivery Identification	Date of ready for shipment, reel numbers, total quantity of good modules with the detail of good modules per reel, order number, product type, no supplier identification on reels, bags and boxes.	
Types of Delivery	Chip modules on reel  single chip modules (bulk goods)	approx. 15.000 to 20.000 pcs. per reel, tape width super 35 mm, pitch 9,5 mm, 2 rows  500 pcs . per bag
Packing and Transport	According to documentation "Packing Method Modules (reel)" "Packing Method Modules (singulated)"	Order-No. 3322 845 04881
Bad Module Marking	All bad modules (mechanical and electrical faults) must be punched by reject hole for customer  Bad positions (reel): <20%	see drawings chapter 3
Splicing Specifications	Tape material: adhes. tape 15,5 +/- 0,7 mm, thermal resistance at <190°C by < 100 cN tractive power and < 30 sec. duration.	see drawings chapter 3
Labeling	Identification label on the reel and on carton bag: - Product type - Number of the reel - Total number of positions - Number of good positions - Date of sealing (to be checked) - Two batches per reel only - Batch number indication (only coded, to be checked)	

## 2.6 Electrical Specifications

	Symbol	min	typ	max	Comment / Conditions
<b>Absolute Maximum Ratings</b>					
Junction Temperature	$T_J$	-55°C		140°C	
Input Peak Current	$I_{INpeak}$			30 mA	
Latch up Current		100 mA			MIL-STD 883D, Method 3023
ESD		2 kV			MIL-STD 883D, Method 3015.7, Human Body
<b>Operating Range</b>					
Temperature	$T_A$	-40°C		85°C	$R_{ThJunctionAmbient} \leq 30 \text{ K/W} @ I_{INpeak} = 30 \text{ mA}$
Input Read Only Threshold Voltage <sup>1) 3)</sup>	$V_{IN,RO}$		2,8 V <sub>p</sub>	3,9 V <sub>p</sub>	start modulation in read only modes
Input Threshold Voltage <sup>1) 3)</sup>	$V_{IN,TH}$		3,1 V <sub>p</sub>	4,2 V <sub>p</sub>	start modulation after SETCC
Input Read Voltage <sup>1) 3)</sup>	$V_{IN,RD}$		3,5 V <sub>p</sub>	4,5 V <sub>p</sub>	read E <sup>2</sup> PROM
Input Write Voltage <sup>1) 3)</sup>	$V_{IN,WR}$		3,7 V <sub>p</sub>	4,7 V <sub>p</sub>	write E <sup>2</sup> PROM
<b>Demodulator</b>					
Range <sup>3)</sup>	$V_{DEM,R}$	2,0 V <sub>p</sub>		4,0 V <sub>p</sub>	$V_{INHigh} - V_{INLow} @ V_{INHigh} = 5,0 \text{ V}_p$ $T_0 = 8 \mu\text{s}, T_{MOD} = 6 * T_0$ <sup>2)</sup>
<b>Modulator</b>					
R_MOD linear <sup>3)</sup>	$R_{MODL}$			4,5 kΩ	$V_{INLow} \leq 2,0 \text{ V}_p$
R_MOD nonlinear <sup>3)</sup>	$R_{MODNL}$			3,6 kΩ	$V_{INLow} \geq 2,0 \text{ V}_p$
<b>Resonance Capacitor<sup>3)</sup></b>					
	$C_{ResInit}$	189 pF	210 pF	231 pF	$V_{IN} = 4,0 \text{ V}_p$

<b>EEPROM</b>					
Write Current <sup>4)</sup>	$I_W$			25 μA	$V_{DD} = 2,8 \text{ V}$
Read Current <sup>4)</sup>	$I_R$			9 μA	$V_{DD} = 2,8 \text{ V}$
Data Retention	Years	10			@ 55°C
Write Endurance	Cycles	100.000			

1)  $|V_{IN}| = |V_{IN1} - V_{IN2}|$  ... voltage between connection pads

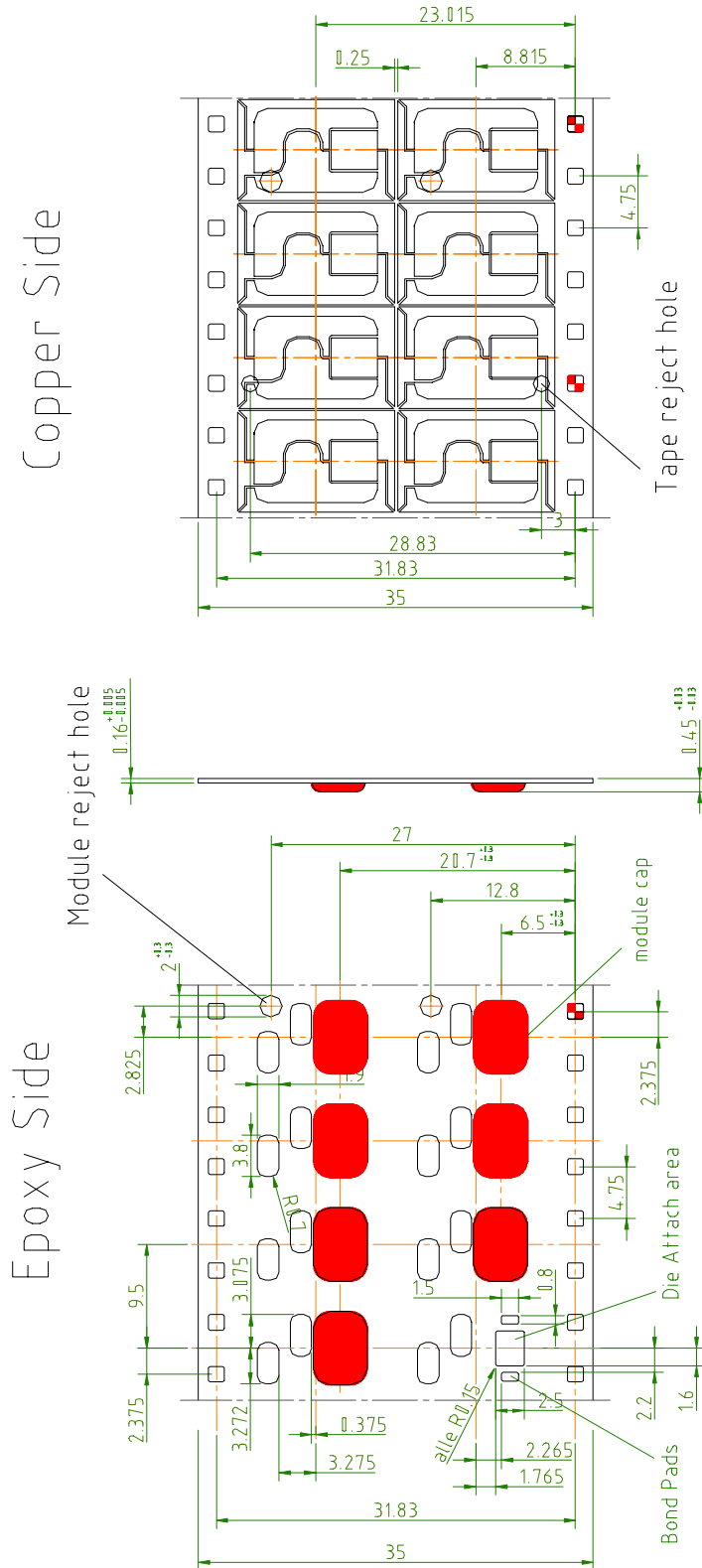
2)  $V_{INHigh}$  input voltage before modulation  
 $V_{INLow}$  input voltage during modulation  
 $T_{MOD}$  duration of the modulation

3) @  $R_i = 10 \text{ k}\Omega$  resistance of measurement equipment

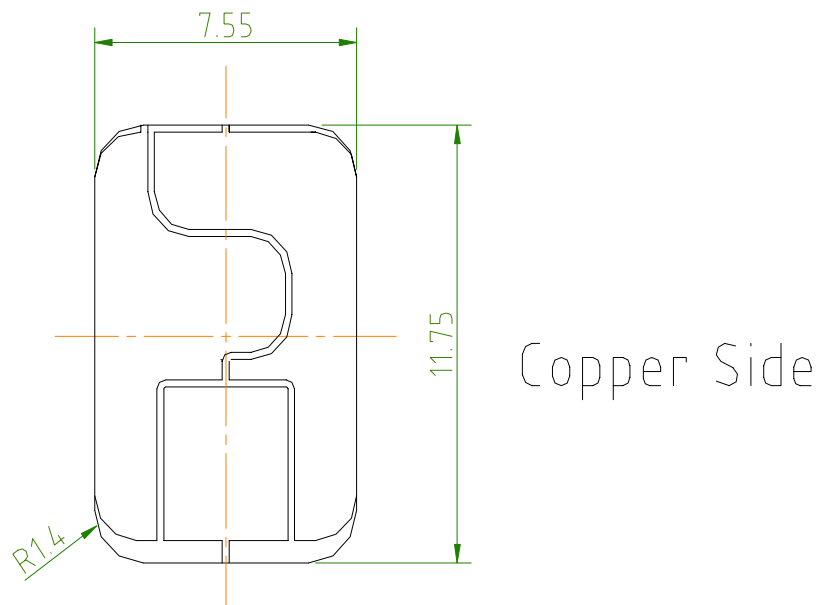
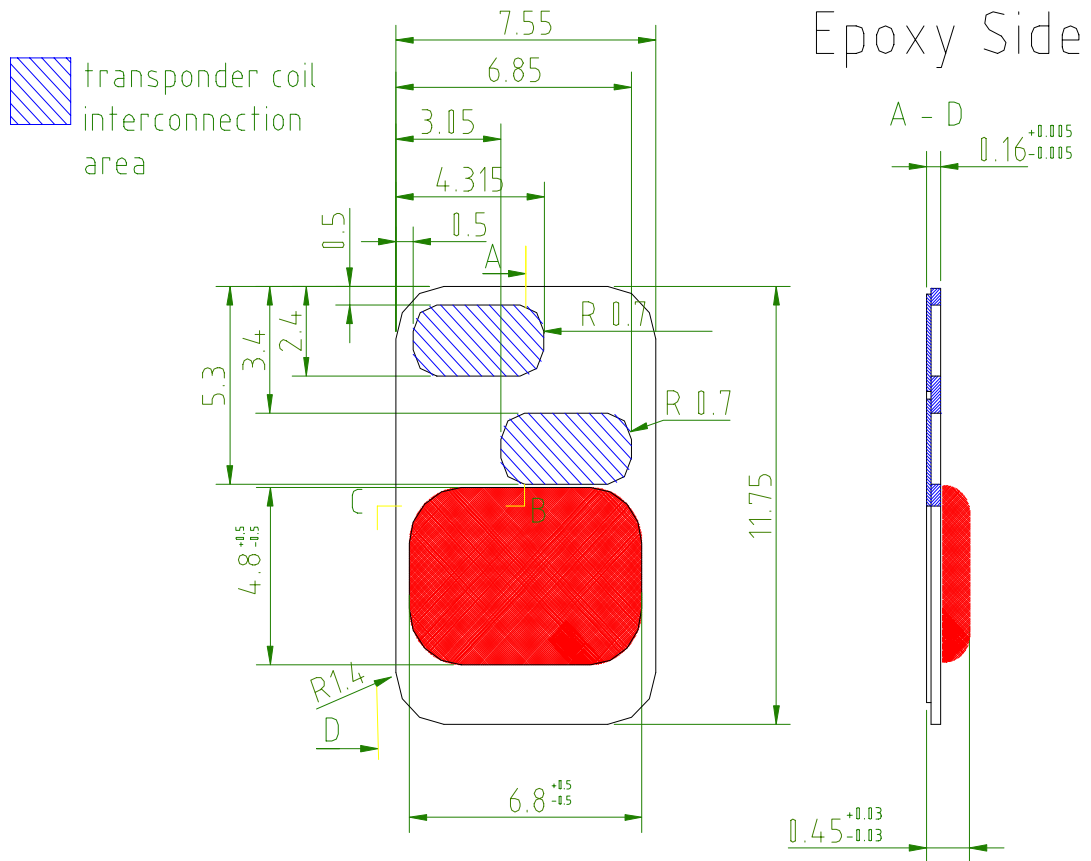
4) tested on silicon level

### 3 Drawing of the Chip Module HT2 MOA3 S20

#### 3.1 Drawing of the Reel

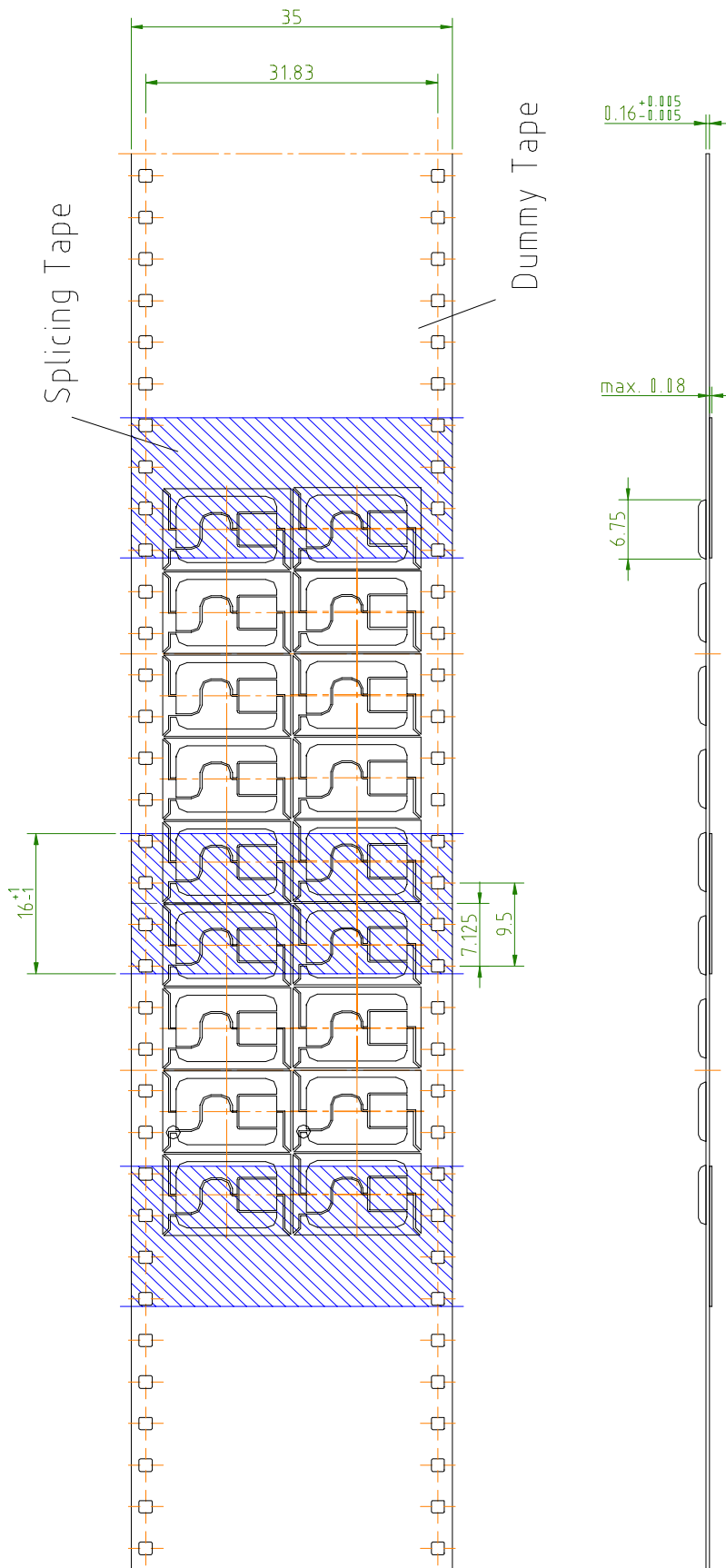


### 3.2 Module outline suggestion





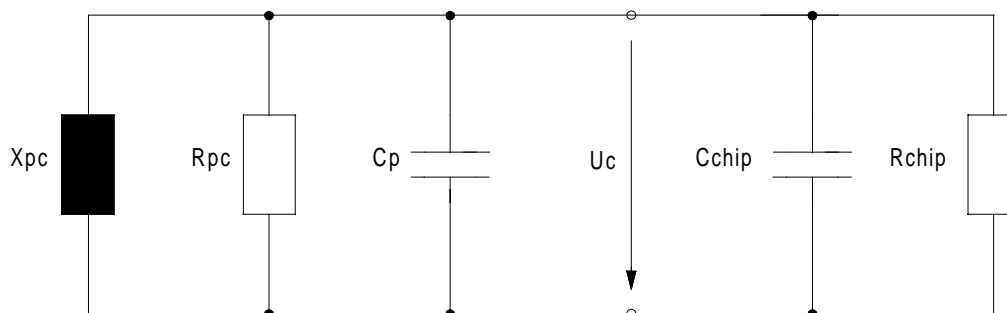
### 3.3 Splicing Specification



## 4 Coil Specifications

The HITAG 2 chip module has to be connected to a coil whose parameters are briefly described in the following.

Equivalent circuit of the transponder



$U_c$	...	voltage at the connection pads
$f_{res}$	...	resonant frequency of the transponder
$X_{pc}$	...	parallel reactance of the coil ( $f = 125$ kHz)
$R_{pc}$	...	parallel resistance of the coil ( $f = 125$ kHz)
$C_p$	...	parasitic capacitance of the package
$C_{chip}$	...	capacitance of the chip ( $U_c > 4$ Vpp)
$R_{chip}$	...	resistance of the chip
$f_{resc}$	...	self resonant frequency of the coil
$L_{pc}$	=	$X_{pc}/2\pi f$ ( $f = 125$ kHz)
$L_{pc}$	=	$7.72$ mH $\pm$ x % ( $C_p = 0$ , x depends on the coil production process)
$C_{chip}$	=	$210$ pF $\pm$ 10 %
$R_{pc}$	>	$45$ k $\Omega$
$f_{resc}$	>	$750$ kHz

Note: The parasitic capacitance of the package ( $C_p$ ) must be considered.

$$f_{res} = \frac{1}{2\pi\sqrt{(C_{chip} + C_p) \cdot L_{pc}}} = 125 \text{ kHz} \Rightarrow L_{pc} = \frac{1}{(2\pi f_{res})^2 (C_{chip} + C_p)}$$

### Typical values for $C_p$

hot laminated cards:  $C_p = 1.5$  pF

moulded tags:  $C_p = 6.0$  pF

For a rough estimation ( $\pm 10\%$ ) of the number of coil windings following formula can be used. It is assumed that the winding is done in circular form.

$$N = \sqrt[1.85]{\frac{L}{2 U \ln\left(\frac{u}{d}\right)}}$$

- N ... number of windings  
L ... inductance [nH]  
U ... average coil circumference [cm]  
d ... copper diameter [mm]  
u ... average coil circumference [mm]

For fine tuning a measurement of the inductance and an according adjustment of the number of windings is necessary. This process always needs some iterations.

## 5 Functional Description of HITAG 2

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### 5.1 Memory Organization

The memory of the transponder consists of 256 bits EEPROM memory and is organized in 8 pages with 32 bits each.

Depending on the operation mode the EEPROM is organized as described in the following.

#### Crypto Mode:

Page	Content
0	Serial Number
1	32 bit "KEY LOW"
2	16 bit " KEY HIGH", 16 bit reserved
3	8 bit Configuration, 24 Bit Password TAG
4	read/write page
5	read/write page
6	read/write page
7	read/write page

#### Password Mode:

Page	Content
0	Serial Number
1	Password RWD
2	reserved
3	8 bit Configuration, 24 bit Password TAG
4	read/write page
5	read/write page
6	read/write page
7	read/write page

## 5.2 Operation Modes and Configuration

With the Configuration Byte the operation mode and the access rights to the memory can be selected. During Power-Up of the transponder the Configuration Byte is read from the transponder's EEPROM.

**If you change the configuration, keys or passwords, you have to place the transponder directly on the antenna or hold it directly to it (0-distance)! In order to avoid any errors do not move the transponder during this write process and be sure that you are in a safe environment without electrical noise.**

### 5.2.1 Modes of Operation

The HITAG 2 can be operated in several modes.

#### **Crypto Mode:**

Mode for writing or reading the transponder with encrypted data transmission.

#### **Password Mode:**

Mode for writing or reading the transponder with plain data transmission.  
A password check is performed.

#### **Public Mode A (Manchester):**

Read only mode emulating Philips Semiconductors' MIRO transponders resp.  $\mu$ EM H400x transponders.  
The 64 bits of the user Pages 4 and 5 are cyclically transmitted to the read/write device.

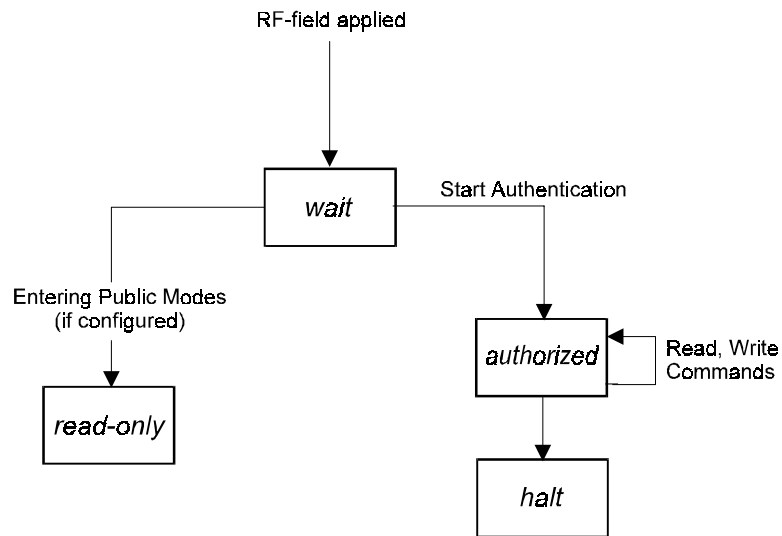
#### **Public Mode B (Biphase):**

Read only mode according to ISO standards 11784 and 11785 for animal identification.  
The 128 bits of the user Pages 4 to 7 are cyclically transmitted to the read/write device.

#### **Public Mode C (Biphase):**

Read only mode emulating the read operation of the PCF793X (with a slightly different Program Mode Check).  
In the Public Mode C the 128 bits of the user Pages 4 to 7 are cyclically transmitted to the read/write device.

## 5.2.2 Status Flow



After entering the RF-field the transponder waits for a command to start the authentication.

After issuing this command the mutual authentication takes place, followed by read- and write commands.

In password mode the data transfer occurs plain, in crypto mode data are encrypted.

The halt mode can be entered for muting a transponder.

If the transponder is configured in one of the public modes, these modes are entered automatically after a certain waiting time and data pages are sent cyclically to the read/write device.

By issuing the command to start the authentication during the waiting time also public mode transponders can be brought into the authorized state.

## 5.2.3 Configuration

The Configuration Byte is represented by the first 8 bits of Page 3 of the transponder memory.

### Configuration Byte:

7	6	5	4	3	2	1	0
0: Manchester Code 1: Biphase Code							
Bit 2		Bit 1		Version		Coding	Coding in HITAG 2-Operation
0		0		Public Mode B		biphase	depending on bit 0
0		1		Public Mode A		manchester	depending on bit 0
1		0		Public Mode C		biphase	depending on bit 0
1		1		HITAG 2		depending on bit 0	depending on bit 0
0: password mode 1: crypto mode							
0: PAGE 6 and 7 read/write 1: PAGE 6 and 7 read only							
0: PAGE 4 and 5 read/write 1: PAGE 4 and 5 read only							
THE SETTING OF THIS BIT IS <b>OTP !</b> 0: PAGE 3 read/write 1: PAGE 3 read only; Configuration Byte and Password TAG <b>fixed</b>							
THE SETTING OF THIS BIT IS <b>OTP !</b> 0: PAGE 1 and 2 read/write 1: PAGE 1 no read/no write PAGE 2 read only (when transponder is in password mode) PAGE 2 no read/no write (when transponder is in crypto mode)							

### Configuration Byte / Bit 6:

Bit 6 = '0': Page 3 is read/write.

Bit 6 = '1': Page 3 can only be read. This process is irreversible !

**ATTENTION: Do not set Bit 6 of the Configuration Byte to '1' before having written the final data into Page 3 (including the Configuration Byte and Password TAG) of the transponder.**

### Configuration Byte / Bit 7:

Bit 7 = '0': Pages 1 and 2 are read/write.

Bit 7 = '1': Pages 1 and 2 are locked against writing. This process is irreversible !

**ATTENTION: Do not set Bit 7 of the Configuration Byte to '1' before having written the final data into Pages 1 and 2 of the transponder.**

### Standard values for the Configuration Byte:

Password Mode:	0x06
Crypto Mode:	0x0E
Public Mode A:	0x02
Public Mode B:	0x00
Public Mode C:	0x04

## 5.3 Configuration of Delivered HITAG 2 Transponders

HITAG 2 transponders are delivered with the following configuration by Philips Semiconductors:

### Unique Serial Number:

Serial Number:	Read Only	-	fixed
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### Configuration Byte:

0x06:	Password Mode (Manchester Code)	-	can be changed
	Page 6 and 7 read/write	-	can be changed
	Page 4 and 5 read/write	-	can be changed
	Page 3 read/write	-	can be changed
	Page 1 and 2 read/write	-	can be changed

### Values for Transport Passwords, Transport Keys:

Password RWD:	0x4D494B52	(= "MIKR")
Password TAG:	0xAA4854	
Key Low:	0x4D494B52	(= "MIKR")
Key High:	0x4F4E	(= "ON")

### RECOMMENDATION:

Before delivering transponders to end users, Pages 1 to 3 should be locked (set Configuration Byte / Bit 6 to '1' for Page 3 and set Configuration Byte / Bit 7 to '1' for Pages 1 and 2).



## 5.4 Definition of Passwords and Keys

Keys are cryptographic codes, which determine data encryption during data transfer between read/write device and transponder. They are used to select a HITAG 2 transponder in Crypto Mode. The 16 bit KEY HIGH and 32 bit KEY LOW form one 48 bit key which has to be identical on both the transponder and the read/write device.

Passwords are needed to select a HITAG 2 transponder in Password Mode. There is one pair of passwords (Password TAG, Password RWD) which has to be identical both on the transponder and the read/write device.

**Password TAG:** Password that the transponder sends to the read/write device and which may be verified by the latter (depending on the configuration of the read/write device).

**Password RWD:** Password that the read/write device sends to the transponder and which is checked for identity by the latter.

It is important that the following values are in accordance with each other, i.e. the respective data on the read/write device and on the transponder have to be identical pairs.

### HITAG 2 in Password mode:

on the read/write device		on the transponder
Password RWD	↔	Password RWD

as an option (depending on the configuration of the read/write device):

Password TAG	↔	Password TAG
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### HITAG 2 in Crypto mode:

on the read/write device		on the transponder
KEY LOW	↔	KEY LOW
KEY HIGH	↔	KEY HIGH

as an option (depending on the configuration of the read/write device):

Password TAG	↔	Password TAG
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The passwords and keys are predefined by Philips Semiconductors by means of defined Transport Passwords and a Transport Key. They can be written to, which means that they can be changed (see also Chapter “Configuration of Delivered HITAG 2 Transponders“).

**ATTENTION: Passwords and Keys only can be changed if their current values are known!**

## 6 Quality Inspection

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Quality inspection is performed with statistical quality control according to ISO 2859 part 1, with AQL1.0.

Optical Properties	scratches, encapsulation failures, gold discolouration, delamination	according to the reference sample catalogue
Geometrical Properties	width	measured with gauge
	length	measured with gauge
	overall thickness	measured with micrometer at the center of the transfer mould cap
Electrical Properties	operation	basic read/write operations
Shipment Quantity		
Packing and Labeling		

## 7 Characterisation and Test of the Final Transponder

### 7.1 Characterisation of the Transponder

The parameters recommended to be characterised for the transponder are:

Parameter		Comment
Resonant frequency	$f_{res}$	Transponder does not modulate Resonant frequency @ $T_{amb} = 22^{\circ}C$ , @ $B_{TH}$
Threshold value	$B_{TH}$	Start of modulation
Threshold value for READ	$B_{RD}$	Command READ_PAGE OK
Threshold value for WRITE	$B_{WR}$	Command WRITE_PAGE OK

For the measurement of these parameters we recommend to use the test equipment available from **SCEMTEC, Marienheide-Rodt, Germany (Transponder Measurement System STM-1)**. This device also supports functional testing (besides parameter testing). Therefore it can also be used as production test equipment for the final transponder test. For further information please contact Scemtec GmbH.

### 7.2 Final Test of the Transponder

In addition to the equipment described in the previous chapter Philips Semiconductors offers a device for a final functional test of transponders, the HITAG<sup>TM</sup> Test System HT OT490. Parameter tests are not supported by this device.

#### Basic flow for production and test:

1. Assembly of transponders
2. Functional test and final test of the EEPROM

**Since the Keys and Logdata are changed during final test the Configuration and personalization must take place after the final test. The final test is disabled (not reversible) by setting the Tag-test mode bit to 0.**

**For the final test of transponders we recommend to use the HITAG<sup>TM</sup> Test System HT OT490 of Philips Semiconductors or the Transponder Measurement System STM-1 of Scemtec.**

## 8 Ordering Information

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Type Name	Description	Ordering Number
HT2 MOA3 S20/E/3	HITAG 2 S20 Chip Module, reel	9352 600 62118
HT2 MOA3 S20/E/1	HITAG 2 S20 Chip Module, bulk	9352 602 19122

## Definitions

<b>Data sheet status</b>	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
<b>Limiting values</b>	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics section of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
<b>Application information</b>	
Where application information is given, it is advisory and does not form part of the specification.	

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# Philips Semiconductors - a worldwide company

**Argentina:** see South America

**Australia:** 34 Waterloo Road, NORTHRYDE, NSW 2113,  
Tel. +612 9805 4455, Fax. +612 9805 4466

**Austria:** Computerstraße 6, A-1101 WIEN, P.O.Box 213,  
Tel. +431 60 101, Fax. +431 30 101 1210

**Belarus:** Hotel Minsk Business Centre, Bld. 3, r.1211, Volodarski Str. 6,  
220050 MINSK, Tel. +375172 200 733, Fax. +375172 200 773

**Belgium:** see The Netherlands

**Brazil:** see South America

**Bulgaria:** Philips Bulgaria Ltd., Energoproject, 15th floor,  
51 James Bourchier Blvd., 1407 SOFIA  
Tel. +3592 689 211, Fax. +3592 689 102

**Canada:** Philips Semiconductors/Components,  
Tel. +1800 234 7381

**China/Hong Kong:** 501 Hong Kong Industrial Technology Centre,  
72 Tat Chee Avenue, Kowloon Tong, HONG KONG,  
Tel. +85223 19 7888, Fax. +85223 19 7700

**Colombia:** see South America

**Czech Republic:** see Austria

**Denmark:** Prags Boulevard 80, PB 1919, DK-2300 COPENHAGEN S,  
Tel. +4532 88 2636, Fax. +4531 57 1949

**Finland:** Sinikalliontie 3, FIN-02630 ESPOO,  
Tel. +3589 61 5800, Fax. +3589 61 580/xxx

**France:** 4 Rue du Port-aux-Vins, BP 317, 92156 SURESNES Cedex,  
Tel. +331 40 99 6161, Fax. +331 40 99 6427

**Germany:** Hammerbrookstraße 69, D-20097 HAMBURG,  
Tel. +4940 23 53 60, Fax. +4940 23 536 300

**Greece:** No. 15, 25th March Street, GR 17778 TAVROS/ATHENS,  
Tel. +301 4894 339/239, Fax. +301 4814 240

**Hungary:** see Austria

**India:** Philips INDIA Ltd., Shivsagar Estate, A Block, Dr. Annie Besant Rd.  
Worli, MUMBAI 400018, Tel. +9122 4938 541, Fax. +9122 4938 722

**Indonesia:** see Singapore

**Ireland:** Newstead, Clonskeagh, DUBLIN 14,  
Tel. +3531 7640 000, Fax. +3531 7640 200

**Israel:** RAPAC Electronics, 7 Kehilat Saloniki St., TEL AVIV 61180,  
Tel. +9723 645 0444, Fax. +9723 649 1007

**Italy:** Philips Semiconductors, Piazza IV Novembre 3,  
20124 MILANO, Tel. +392 6752 2531, Fax. +392 6752 2557

**Japan:** Philips Bldg. 13-37, Kohnan 2-chome, Minato-ku, TOKYO 108,  
Tel. +813 3740 5130, Fax. +813 3740 5077

**Korea:** Philips House, 260-199, Itaewon-dong, Yonsan-ku, SEOUL,  
Tel. +822 709 1412, Fax. +822 709 1415

**Malaysia:** No. 76 Jalan Universiti, 46200 PETALING JAYA, Selangor,  
Tel. +60 3750 5214, Fax. +603 757 4880

**Mexico:** 5900 Gateway East, Suite 200, EL PASO, Texas 79905,  
Tel. +9 5800 234 7381

**Middle East:** see Italy

**Netherlands:** Postbus 90050, 5600 PB EINDHOVEN, Bldg. VB,  
Tel. +3140 27 82785, Fax +3140 27 88399

**New Zealand:** 2 Wagener Place, C.P.O. Box 1041, AUCKLAND,  
Tel. +649 849 4160, Fax. +649 849 7811

**Norway:** Box 1, Manglerud 0612, OSLO,  
Tel. +4722 74 8000, Fax. +4722 74 8341

**Philippines:** Philips Semiconductors Philippines Inc.,  
106 Valero St. Salcedo Village, P.O.Box 2108 MCC, MAKATI,  
Metro MANILA, Tel. +632 816 6380, Fax. +632 817 3474

**Poland:** Ul. Lukiska 10, PL 04-123 WARSZWA,  
Tel. +4822 612 2831, Fax. +4822 612 2327

**Portugal:** see Spain

**Romania:** see Italy

**Russia:** Philips Russia, Ul. Usatcheva 35A, 119048 MOSCOW,  
Tel. +7095 247 9145, Fax. +7095 247 9144

**Singapore:** Lorong 1, Toa Payoh, SINGAPORE 1231,  
Tel. +65350 2538, Fax. +65251 6500

**Slovakia:** see Austria

**Slovenia:** see Italy

**South Africa:** S.A. Philips Pty Ltd., 195-215 Main Road Martindale,  
2092 JOHANNESBURG, P.O.Box 7430 Johannesburg 2000,  
Tel. +2711 470 5911, Fax. +2711 470 5494

**South America:** Al. Vicente Pinzon, 173 - 6th floor,  
04547-130 Sao Paulo, SAO PAULO - SP, Brazil,  
Tel. +5511 821 2333, Fax. +5511 829 1849

**Spain:** Balmes 22, 08007 BARCELONA,  
Tel. +343 301 6312, Fax. +343 301 4107

**Sweden:** Kottbygatan 7, Akalla, S-16485 STOCKHOLM,  
Tel. +468 632 2000, Fax. +468 632 2745

**Switzerland:** Allmendstraße 140, CH-8027 ZÜRICH,  
Tel. +411 488 2686, Fax. +411 481 7730

**Taiwan:** Philips Taiwan Ltd., 2330F, 66,  
Chung Hsiao West Road, Sec. 1, P.O.Box 22978,  
TAIPEI 100, Tel. +8862 382 4443, Fax. +8862 382 4444

**Thailand:** Philips Electronics (Thailand) Ltd.,  
209/2 Sanpavuth-Bangna Road Prakanong, BANGKOK 10260,  
Tel. +662 745 4090, Fax. +662 398 0793

**Turkey:** Talapasa Cad. No. 5, 80640 GÜLTEPE/ISTANBUL,  
Tel. +90212 279 2770, Fax. +90212 282 6707

**Ukraine:** Philips Ukraine, 4 Patrice Lumumba Str., Building B, Floor 7,  
252042 KIEV, Tel. +38044 264 2776, Fax. +38044 268 0461

**United Kingdom:** Philips Semiconductors Ltd., 276 Bath Road, Hayes,  
MIDDLESEX UM3 5BX, Tel. +44181 730 5000, Fax. +44181 754 8421

**United States:** 811 Argues Avenue, SUNNYVALE, CA94088-3409,  
Tel. +1800 234 7381

**Uruguay:** see South America

**Vietnam:** see Singapore

**Yugoslavia:** Philips, Trg N. Pasica 5/v, 11000 BEOGRAD,  
Tel. +38111 625 344, Fax. +38111 635 777

Philips Semiconductors, Mikron-Weg 1, A-8101 Gratkorn, Austria Fax: +43 / 3124 / 299 - 270

**For all other countries apply to:** Philips Semiconductors, Marketing & Sales Communications,  
Building BE-p, P.O.Box 218, 5600 MD EINDHOVEN, The Netherlands, Fax: +3140 27 24825

Internet: <http://www.semiconductors.philips.com>

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