

ASSP SmartCard

Microcontroller for Multiapplication SmartCard

HIFERRON Series

MB94R215B

■ DESCRIPTION

MB94R215B is a one-chip micro-controller for IC cards, with a combination of contact/contactless functions. Based around the FR65E core, it includes in built functions such as a timer, FRAM, DES, RSA, contact interface, contactless RF interface, etc.

The MB94R215B is optimized for contact/contactless IC card applications.

■ FEATURE

- FR CPU
 - 32-bit RISC, load/store architecture with a five-stage pipeline
 - 16 - bit fixed length instructions (basic instructions), 1 instruction per cycle
 - Instruction set optimized for embedded applications : Memory-to-memory transfer, bit manipulation, barrel shift etc.
 - Instructions adapted for high - level languages : Function entry/exit instructions, multiple - register load/store instructions
 - Register interlock functions : Facilitating coding in assemblers
 - Built-in multiplier with instruction-level support
 - 32-bit multiplication with sign : 5 cycles
 - 16-bit multiplication with sign : 3 cycles
 - Interrupt (PC and PS save) : 6 cycles, 16 priority levels
 - Harvard architecture allowing program access and data access to be executed simultaneously
 - Instruction compatible with FR family

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- Contactless IC card I/F
 - Operating magnetic field strength : 4.0 to 7.5 A/m (in recommended antenna pattern)
 - Load modulation strength (Min) : $30/H^{1.2}$ (mVpeak) (in recommended antenna pattern)
 - Antenna input pin capacity : 75 pF
 - Communication protocol : ISO 14443 TypeB T = CL 106 Kbps, 212 Kbps Input clock frequency = 13.56 MHz
 - Receive data demodulation and send data modulation for contactless I/F
 - Variety of error detection function (frame, overrun, exceeding ISO regulation time)

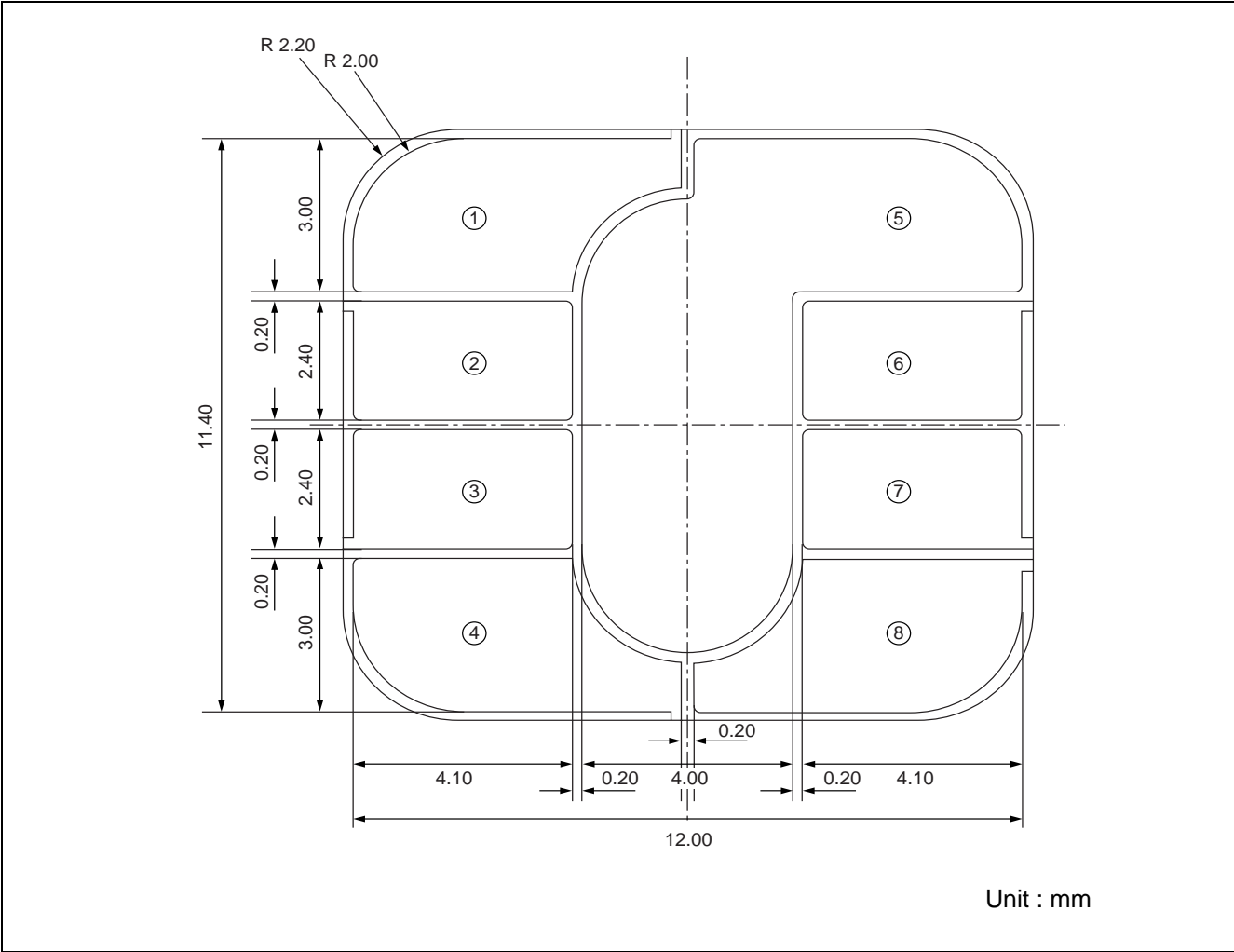
- Contact IC card I/F (5 V I/F)
 - Support for power supply voltage = $5\text{ V} \pm 0.5\text{ V}$ and input clock frequency = 1 MHz to 5 MHz (ISO 7816 Class-A)
 - Communication protocol : ISO 7816/T = 0, 1
Operation is confirmed for $F_i = 372$ with $D_i = 1, 2, 4, 8$, and for $F_i = 512$ with $D_i = 1, 2, 4, 8, 16$.

- Built-in memory
 - MASK ROM of 128 KB
 - DATA RAM (SRAM) of 8 KB
 - FRAM (Nonvolatile memory) of 32 KB

- Cryptosystem coprocessor
 - DES coprocessor
 - ECB mode corresponding (The CBC mode corresponds by XOR and transfer instruction.)
 - Operating at 20 coproclocks

- RSA coprocessor
 - Maximum key length 1024 bits
 - High-speed Montgomery multiplication surplus (REDC) calculations using 32-bit data processing
 - ECC (Prime Finite Fields) : Maximum key length 224 bits

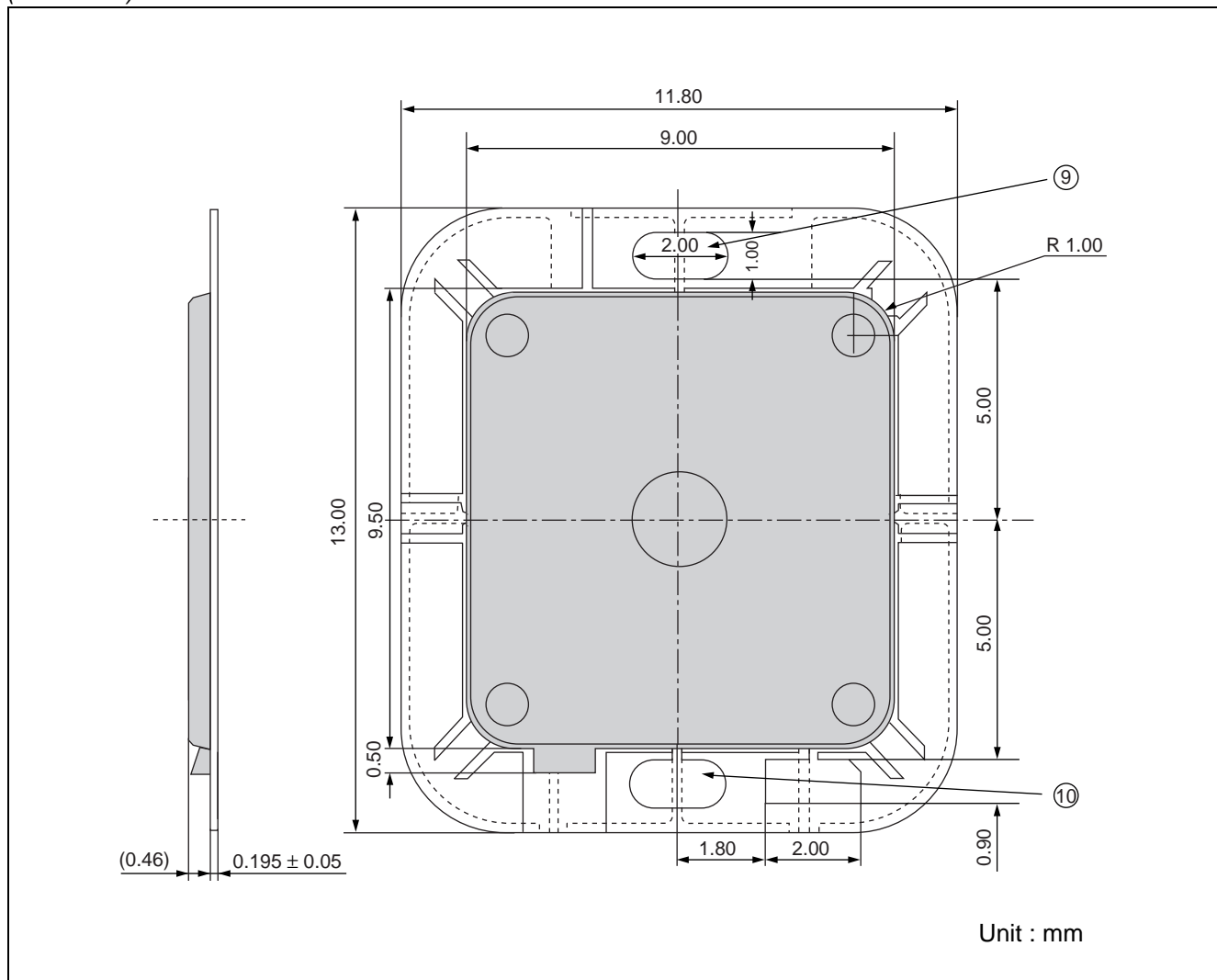
■ PIN ASSIGNMENT



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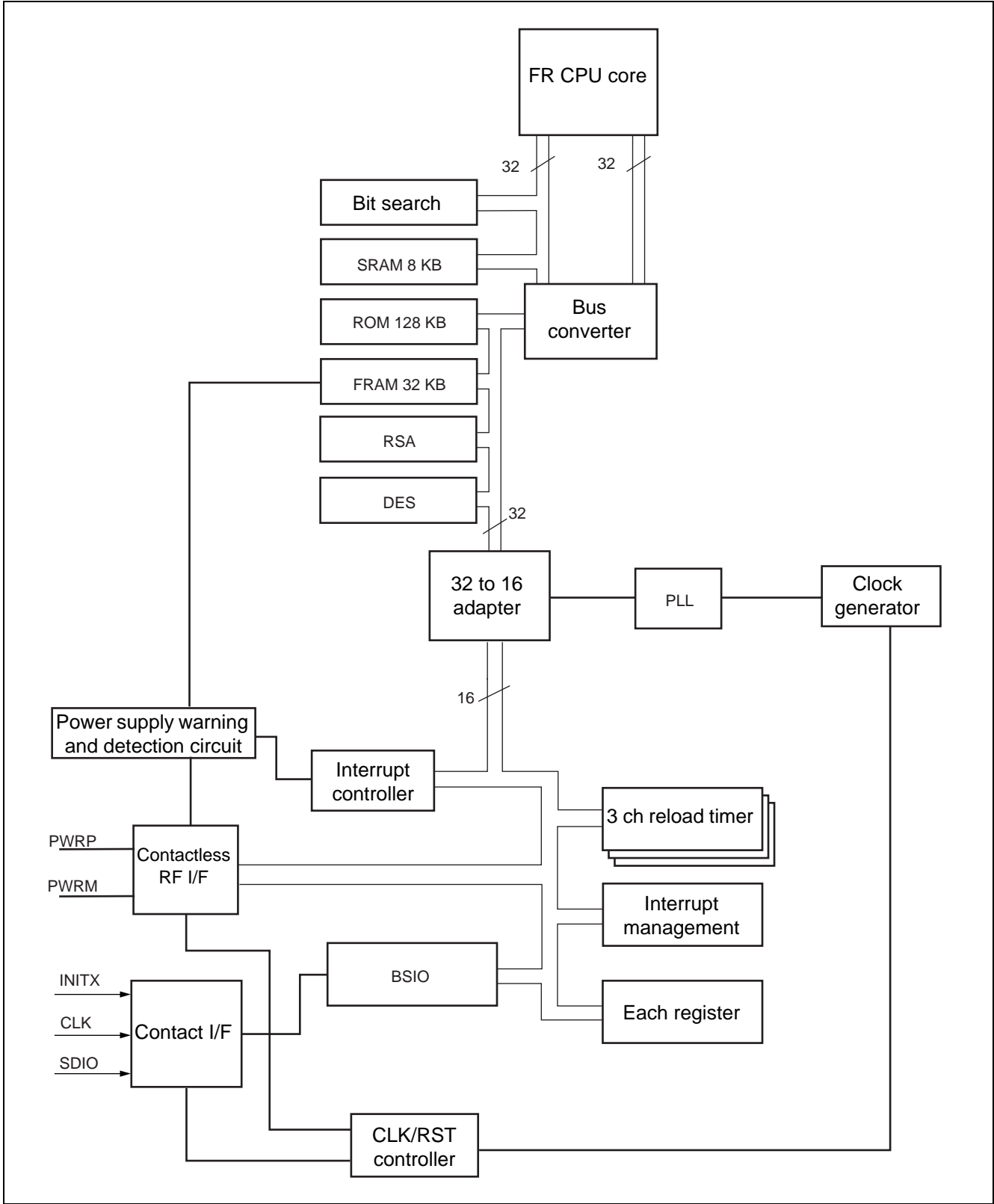
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Pin No.	Pin Name	Chip Correspondence	Function
1	VCC	EXT5V	Power supply pin*
2	RST	INITX	Reset input*
3	CLK	CLK	Clock input*
4	RFU	N.C.	Empty pin*
5	GND	VSS	Ground pin*
6	VPP	N.C.	Program power supply (not used in this module) *
7	I/O	SDIO	Data input/output*
8	RFU	N.C.	Empty pin*
9	PWRP	PWRP	Antenna pin for contactless. Located on rear of module
10	PWRM	PWRM	Antenna pin for contactless. Located on rear of module

* : Refer to ISO/IEC7816-2.

■ BLOCK DIAGRAM



■ HANDLING DEVICES

1. Preventing Latchup

Latch-up may occur in a CMOS IC if a voltage greater than V_{CC} or less than V_{SS} is applied to an input or output pin, or if an above-rating voltage is applied between V_{CC} and V_{SS} . A latchup, if it occurs, significantly increases the power supply current and may cause thermal destruction of an element. When you use a CMOS IC, be very careful not to exceed the absolute maximum rating.

2. Treatment of N.C. pins

Be sure to use NC pins in open state.

3. Rising time for power supply voltage

Ensure that the power supply rise time is 100 μ s or less when using contact mode operation but, which may cause misoperation resulting in the corruption of FRAM data.

4. Power supply off time

Ensure that the power supply off time is 1ms or longer when using contact mode operation.

5. Magnetic field strength rise time

See the “■ RF INTERFACE in CONTACTLESS OPERATION” section for points to note regarding contactless operation.

6. When using both contact and contactless operation

When operating in contact mode, ensure there is no RF input from the antenna. When operating in contactless mode, ensure that the contact terminals are open circuit.

■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating		Unit
		Min	Max	
Power supply voltage	V_{CC}	- 0.5	6.0	V
Input voltage	V_{IN}	- 0.5	$V_{CC} + 0.5$	V
Output voltage	V_{OUT}	- 0.5	$V_{CC} + 0.5$	V
Operating temperature	T_A	- 20	+ 80	°C
Storage temperature	T_{STG}	- 40	+ 85	°C
Voltage between antenna pins (Peak-Peak voltage)	V_{ANT}	—	20	V

WARNING: Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

■ RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Power supply voltage	V_{CC}	4.5	5.0	5.5	V
"H" level input voltage	V_{IN}	—	—	$V_{CC} + 0.5$	V
"L" level input voltage	V_{OUT}	- 0.5	—	+ 0.6	V
Operating temperature	T_A	- 20	—	+ 80	°C
Operating magnetic field strength*	—	4.0	—	7.5	A/m
Load modulation level	—	30	—	—	$1/H^{1.2}$ (mVpeak)
Voltage between antenna pins (Peak-Peak voltage)	V_{ANT}	—	—	20	V

* : In reference antenna pattern

WARNING: The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated within these ranges.

Always use semiconductor devices within their recommended operating condition ranges. Operation outside these ranges may adversely affect reliability and could result in device failure.

No warranty is made with respect to uses, operating conditions, or combinations not represented on the data sheet. Users considering application outside the listed conditions are advised to contact their FUJITSU representatives beforehand.

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■ ELECTRICAL CHARACTERISTICS

1. DC Characteristics

(1) Power supply voltage and current

Parameter	Symbol	Conditions	Value			Unit
			Min	Typ	Max	
Operating power supply current	I_{CC}	*1	—	—	8.0	mA
Standby current	I_{CS}	*2	—	—	2.0	mA

*1 : $4.5\text{ V} < V_{CC} < 5.5\text{ V}$, CLK input = 3.57 MHz, no PLL using, at Java Card OS operating

*2 : $4.5\text{ V} < V_{CC} < 5.5\text{ V}$, CLK stop

(2) I/O pin

Parameter	Symbol	Conditions	Value			Unit
			Min	Typ	Max	
"H" level input voltage	V_{IH}	—	$0.7 \times V_{CC}$	—	V_{CC}	V
"L" level input voltage	V_{IL}	—	0.0	—	$0.15 \times V_{CC}$	V
"H" level input current	I_{IH}	*1	- 10	—	+ 10	μA
"L" level input current	I_{IL}	*1	- 200	—	+ 10	μA
"H" level output voltage	V_{OH}	*2	$0.7 \times V_{CC}$	—	V_{CC}	V
"L" level output voltage	V_{OL}	*3	0.0	—	$0.15 \times V_{CC}$	V
"H" level output current	I_{OH}	*4	- 1000	—	+ 10	μA
"L" level output current	I_{OL}	*5	- 0.01	—	+ 8.0	mA

*1 : $V_{CC} = 5.5\text{ V}$

*2 : Chip external pull-up resistance : 20 k Ω

*3 : $I_{OL} = 1\text{ mA}$

*4 : $V_{OH} = 0.7 \times V_{CC}$

*5 : $V_{OL} = 0.15 \times V_{CC}$

(3) CLK pin

Parameter	Symbol	Conditions	Value			Unit
			Min	Typ	Max	
"H" level input voltage	V_{IH}	—	$0.7 \times V_{CC}$	—	V_{CC}	V
"L" level input voltage	V_{IL}	—	0.0	—	0.5	V
"H" level input current	I_{IH}	*	- 10	—	+ 10	μA
"L" level input current	I_{IL}	*	- 100	—	+ 10	μA

* : $V_{CC} = 5.5\text{ V}$

(4) RST pin

Parameter	Symbol	Conditions	Value			Unit
			Min	Typ	Max	
"H" level input voltage	V_{IH}	—	$0.8 \times V_{CC}$	—	V_{CC}	V
"L" level input voltage	V_{IL}	—	0.0	—	$0.12 \times V_{CC}$	V
"H" level input current	I_{IH}	*	- 10	—	+ 10	μA
"L" level input current	I_{IL}	*	- 200	—	+ 10	μA

* : $V_{CC} = 5.5 V$

(5) Antenna pin

Parameter	Symbol	Conditions	Value			Unit
			Min	Typ	Max	
Capacity between antenna pins	Cant	0.1 Vrms	60	68	75	pF
Load modulation circuit resistance	Rmod	Resistance between antenna and GND	600	750	900	Ω

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2. AC Characteristics

(1) Contact operation

Parameter	Symbol	Conditions	Value			Unit
			Min	Typ	Max	
Input CLK frequency	F _{CLK}	—	1	—	5	MHz
Communication speed	C _{RATE}	—	—	—	112	Kbps
Output signal rising	tr	*	—	—	1.0	μs
Output signal falling	tf	*	—	—	1.0	μs

* : External capacitance of I/O pins = 50 pF

(2) Contactless operation

Parameter	Symbol	Conditions	Value			Unit
			Min	Typ	Max	
Antenna input frequency	Fin	Antenna connection	13.553	13.560	13.567	MHz
Resonant frequency	Fr	Antenna connection	—	16.0	—	MHz
ASK modulation level	Vask	Antenna connection	8	—	14	%
Load modulation level	Vsub	Antenna connection 4.0 A/m (Magnetic Field Strength)	30	—	—	1/H ^{1.2} (mVpeak)
Operating magnetic field strength	H	Antenna connection	4.0	—	7.5	A/m
Communication speed	—	Antenna connection	—	106	—	Kbps

3. Pin capacity

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
I/O	C _{IH}	—	8.0	—	pF
CLK	C _{IL}	—	8.0	—	pF
RST	C _{IH}	—	8.0	—	pF

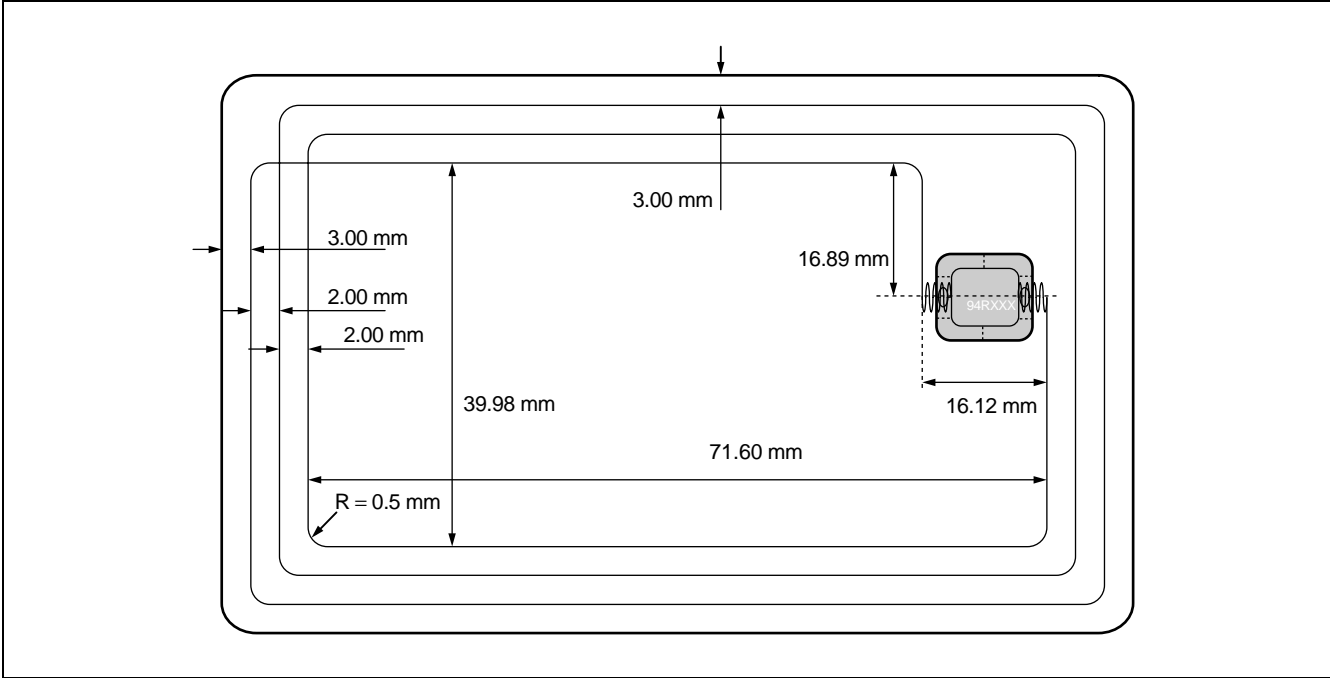
Note : Capacitance between pins and ground (measured by 0.1 Vpp and 1 MHz signal)

4. FRAM characteristics (data retaining characteristics)

Parameter	Conditions	Value			Unit
		Min	Typ	Max	
Data retaining	Ta ≤ + 55 °C	10	—	—	year
Number of writes	Ta ≤ + 55 °C	10 ¹⁰	—	—	number

■ REFERENCE ANTENNA PATTERN

The pattern below is intended for reference data when designing the antenna. When developing a card, please take note of the module characteristics when designing the antenna pattern.



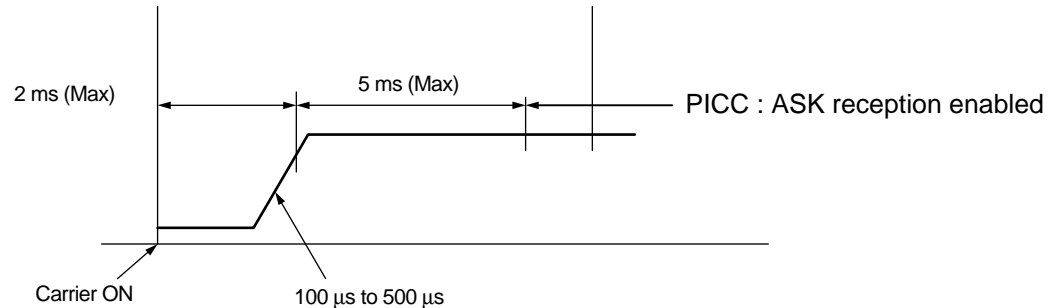
■ RF INTERFACE in CONTACTLESS OPERATION

1. Flow at carrier ON

Communications between PICC (card) and PCD (R/W) is based on a "PCD Talk First" protocol in accordance with the procedure described below.

- (1) RF power is supplied to PICC by the magnetic field generated by PCD.
- (2) PICC is able to receive within 5 ms of RF power on.
- (3) PICC waits with no response until receiving a command from PCD (receive standby state).
- (4) PCD sends a command to PICC (sent approx. 10 ms after RF power on).
- (5) PICC executes the operation specified by the PCD instruction and sends a response to PCD on completion.

• Time standard at carrier ON



2. Power supply

- (1) Carrier frequency f_c : 13.56 MHz \pm 7 kHz
- (2) PICC operating magnetic field strength (when not modulated) : 4.0 A/m to 7.5 A/m

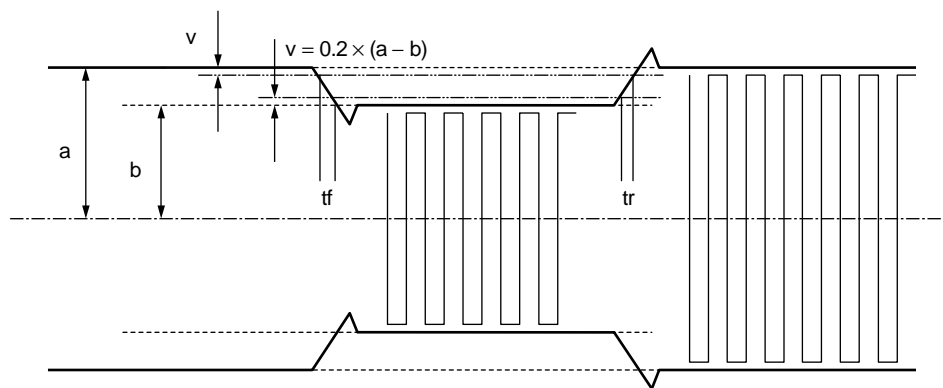
3. Interface of signal

(1) Data transmission from PCD to PICC

- Communication speed f_b : 105.9375 Kbps / 211.8750 Kbps
- Method of modulation type : ASK
- Modulation level m :
 - PICC : 8.0% to 14.0%
 - PCD : $30/H^{1.2}$ (mVpeak)
- Bit coding
 - Logic "1" : High magnetic field amplitude (with no modulation)
 - Logic "0" : Low magnetic field amplitude

The modulation level m is defined by the formula $m = (a - b) / (a + b)$ as shown in the figure below. Here, a and b are the maximum and minimum amplitudes of the magnetic field strength generated by PCD. The rising and falling edges of these amplitude changes are monotonic. The transition times are $1 \mu\text{s}$ or less.

• Definition of modulation level



(2) Data transmission from PICC to PCD

- Communication speed f_b : 105.9375 Kbps ($f_c/128$)
- Method of data transmission : Load Modulation
 - PCD always sends logic "1" during data transfer from PICC.
- Load modulation sub-carrier frequency f_s : 847.5 kHz ($f_c/16$)
- Method of sub-carrier modulation : BPSK
 - Phase changes occur at valid timings on the sub-carrier rise and fall.
 - The sub-carrier f_s is modulated by the data using BPSK modulation. The carrier f_c is further amplitude modulated by the phase-changed sub-carrier.
- Bit coding : NRZ-L
- Load Modulation load resistance : Modulation circuit resistance 150Ω

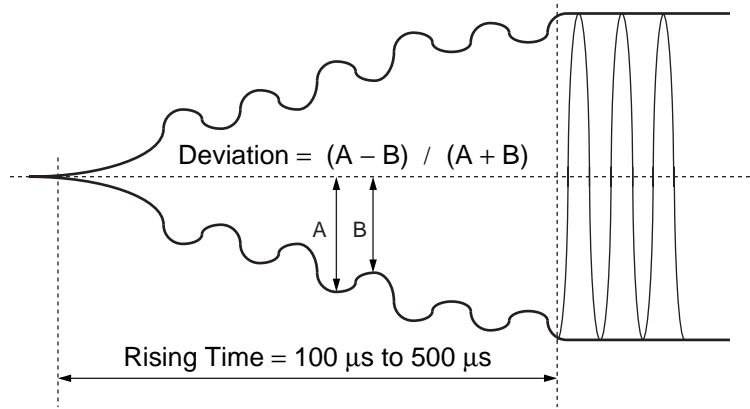
4. Notes on carrier

When handling the device for the contactless IC cards, observe the following to prevent the improper operation or damage to the device. Keep in mind, however, that the transmission characteristics are dependent on the antenna design and reader/writer characteristics, so the values below are only for reference and the values below are not intended to guarantee the finished card characteristics. Ensure that operation and transmission characteristics have no problems in the environments where you use a card.

(1) Rising of carrier

Ensure that the carrier rise time is in the range 100 μ s to 500 μ s and that the carrier rises continuously with a deviation of $\pm 2.4\%$ or less.

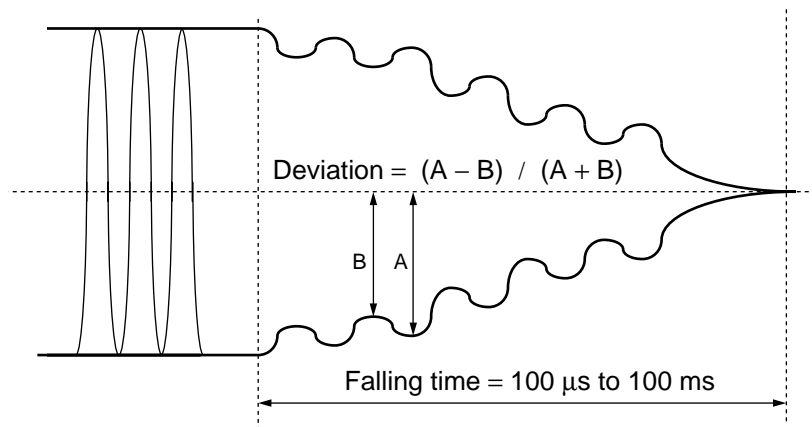
- Rising waveform of carrier



(2) Falling of carrier

Ensure that the carrier fall time is in the range 100 μ s to 100 ms and that the carrier falls continuously with a deviation of $\pm 2.4\%$ or less.

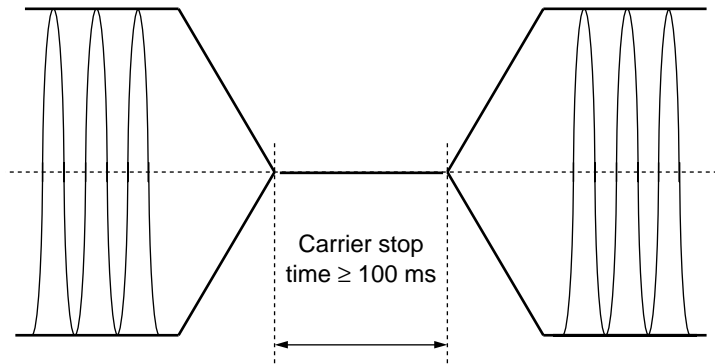
- Falling waveform of carrier



(3) Stop of carrier

The MB94R215B has internal capacitance to smooth the power supply and similar. Accordingly, always provide a gap of 100 ms or longer between halting and restarting the carrier to allow the internal state to stabilize.

- Stop time of carrier

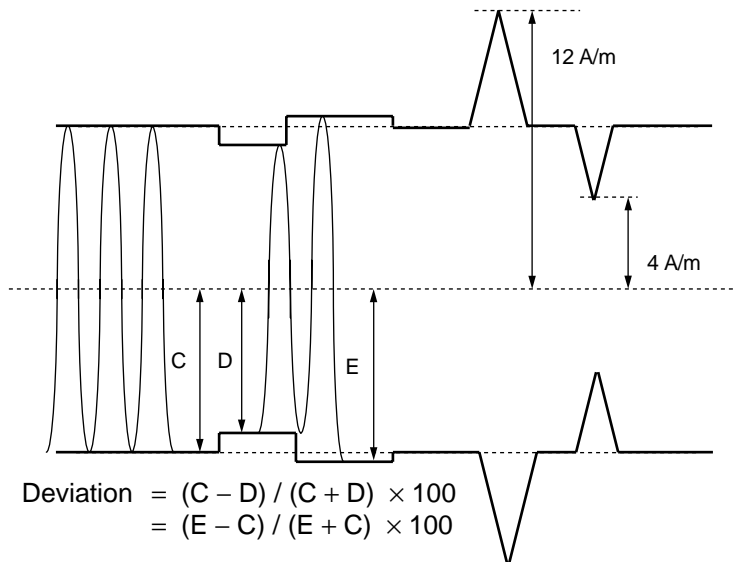


(4) Carrier deviation (noise, momentary stop, etc.)

Ensure that the deviation when not modulated is $\pm 2.4\%$ or less. The following problems may occur if variation (noise) in excess of this limit occurs.

- If the carrier falls within the ASK modulation level range (8 to 14%), this may be misinterpreted as a modulation signal. However, if the frame is determined to be invalid, the command receive block will be cleared and the device will return to the command standby state.
- If the carrier variation exceeds the ASK modulation level range in the region 0 A/m to 12 A/m, misoperation may occur and internal circuits may reset. In this case, temporarily turn off the carrier in accordance with the precautions in "(3) Stop of carrier". If the carrier is not turned off, misoperation may corrupt internal data.
- If the carrier exceeds the ASK modulation level range over 12A/m, the device may be damaged due to the increase in internal voltage.

- Carrier deviation

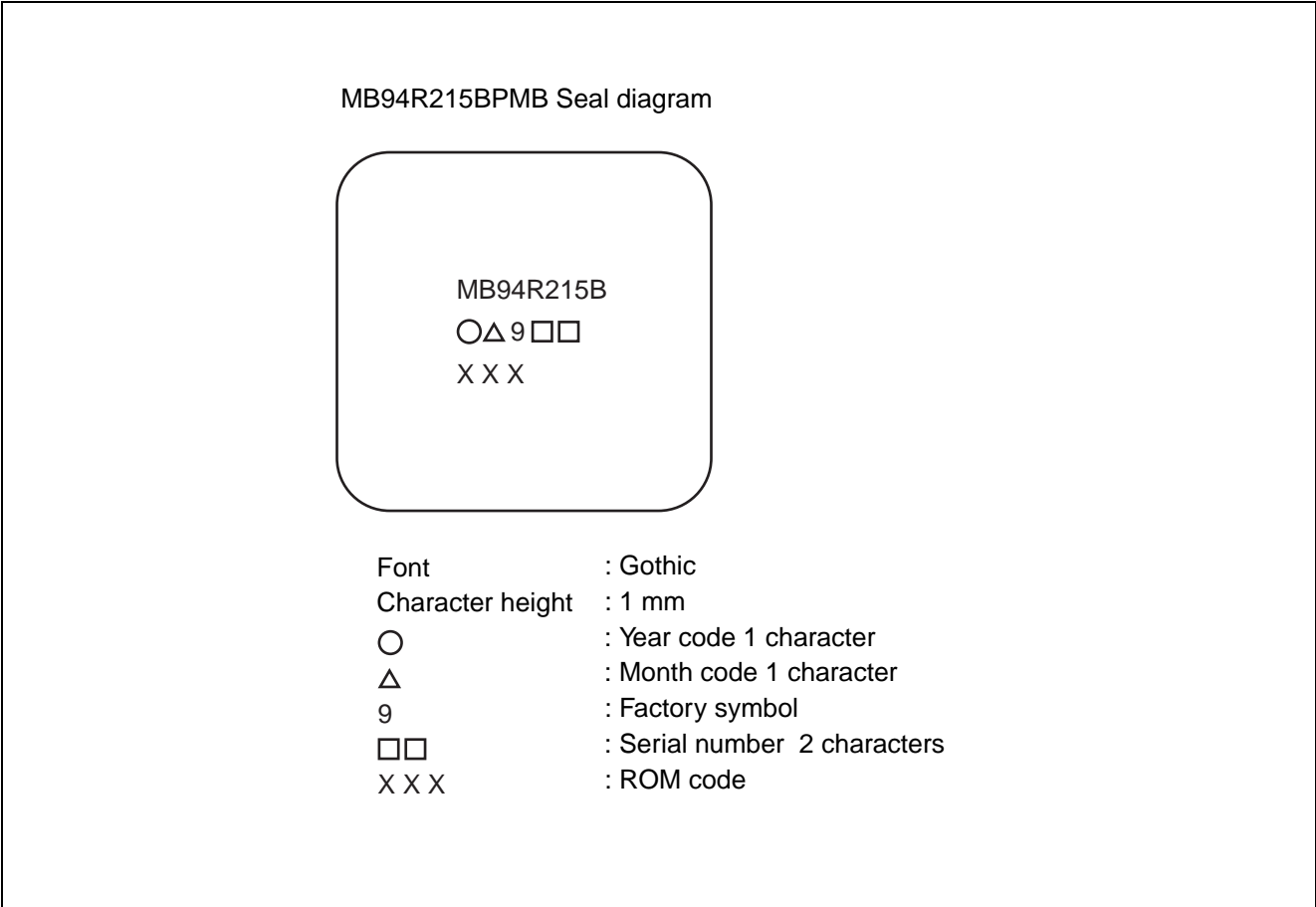


(5) Operating conditions

Contactless devices (cards) can only be used in a one-to-one communication with a reader/writer. Do not try to use the MB94R215B embedded card to a reader/writer with multiple other contactless cards. Use of multiple contactless devices may corrupt data or cause the device to misoperate.

Using the device in the presence of strong magnetic fields (12 A/m or stronger) or with reader/writers that do not match the specifications may cause data corruption.

MARKING



ORDERING INFORMATION

Part number	Package	Remarks
MB94R215BPMB	CRD-10P-M05	For Dual Interface

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