FUJITSU SEMICONDUCTOR
DATA SHEET

DS501-00010-6v0-E

Memory FRAM

16 K (2 K × 8) Bit I²C

MB85RC16V

■ DESCRIPTION

The MB85RC16V is an FRAM (Ferroelectric Random Access Memory) chip in a configuration of 2,048 words × 8 bits, using the ferroelectric process and silicon gate CMOS process technologies for forming the nonvolatile memory cells.

Unlike SRAM, the MB85RC16V is able to retain data without using a data backup battery.

The memory cells used in the MB85RC16V have at least 10^{12} Read/Write operation endurance per byte, which is a significant improvement over the number of read and write operations supported by other non-volatile memory products.

The MB85RC16V can provide writing in one byte units because the long writing time is not required unlike Flash memory and E²PROM. Therefore, the writing completion waiting sequence like a write busy state is not required.

■ FEATURES

- Bit configuration : 2,048 words × 8 bits
- Two-wire serial interface : Fully controllable by two ports: serial clock (SCL) and serial data (SDA).
- Operating frequency : 1 MHz (Max)
- Read/Write endurance : 10^{12} times / byte
- Data retention : 10 years (+ 85 °C), 95 years (+ 55 °C), over 200 years (+ 35 °C)
- Operating power supply voltage : 3.0 V to 5.5 V
- Low power consumption : Operating power supply current 90 μA (Typ @1 MHz)
  Standby current 5 μA (Typ)
- Operation ambient temperature range: − 40 °C to + 85 °C
- Package : 8-pin plastic SOP (FPT-8P-M02)
  RoHS compliant

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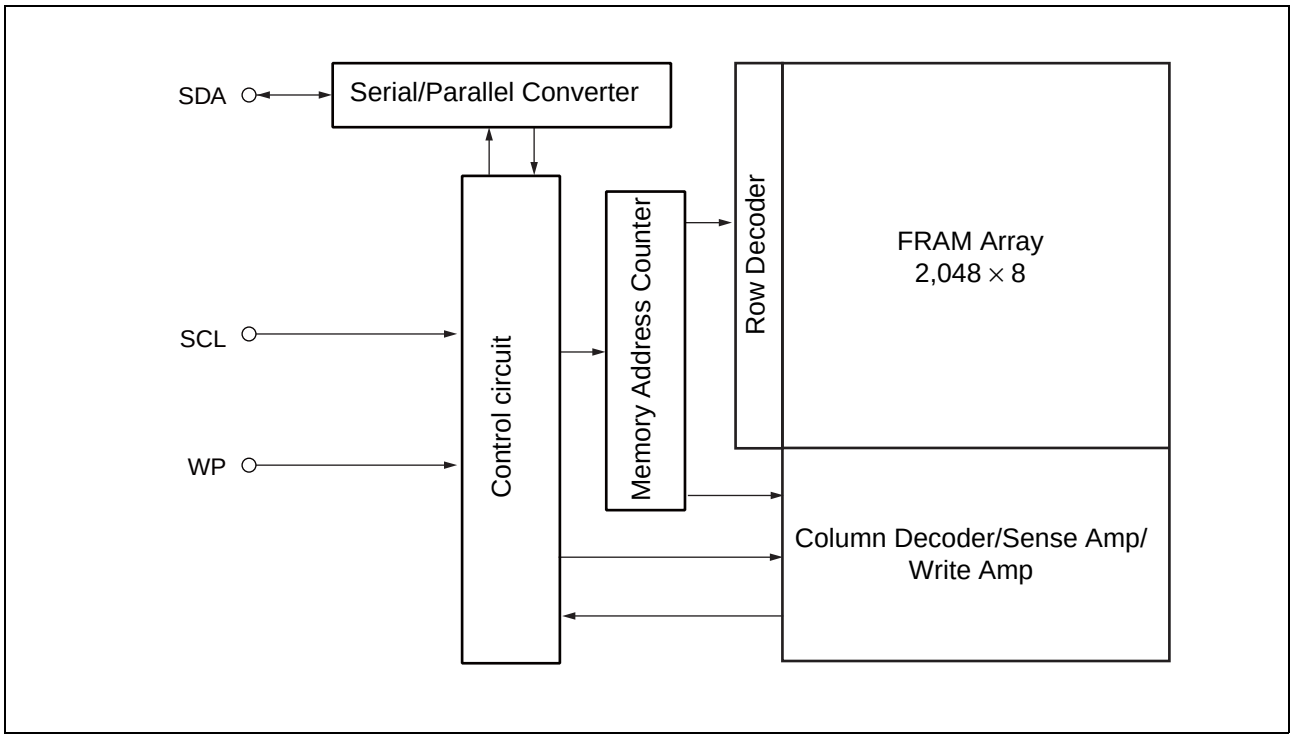
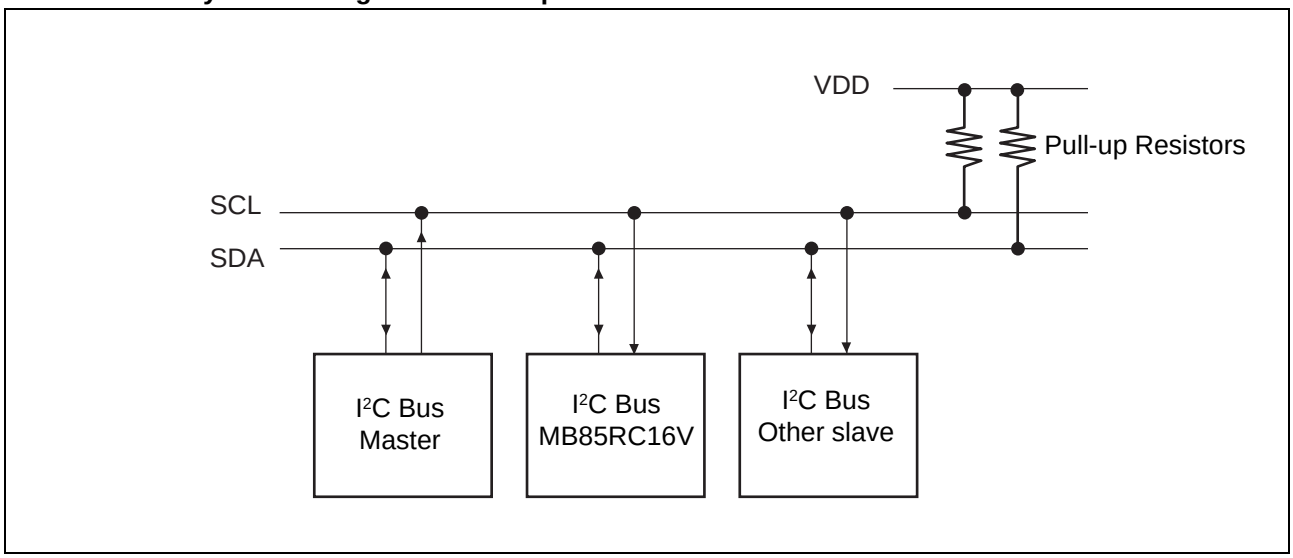
■ BLOCK DIAGRAM



■ I²C (Inter-Integrated Circuit)

The MB85RC16V has the two-wire serial interface; the I²C bus,and operates as a slave device.
The I²C bus defines communication roles of “master” and “slave” devices, with the master side holding the authority to initiate control. Furthermore, an I²C bus connection is possible where a single master device is connected to multiple slave devices in a party-line configuration.

• I²C Interface System Configuration Example



■ I²C COMMUNICATION PROTOCOL

The I²C bus provides communication by two wires only, therefore, the SDA input should change while SCL is the “L” level. However, when starting and stopping the communication sequence, SDA is allowed to change while SCL is the “H” level.

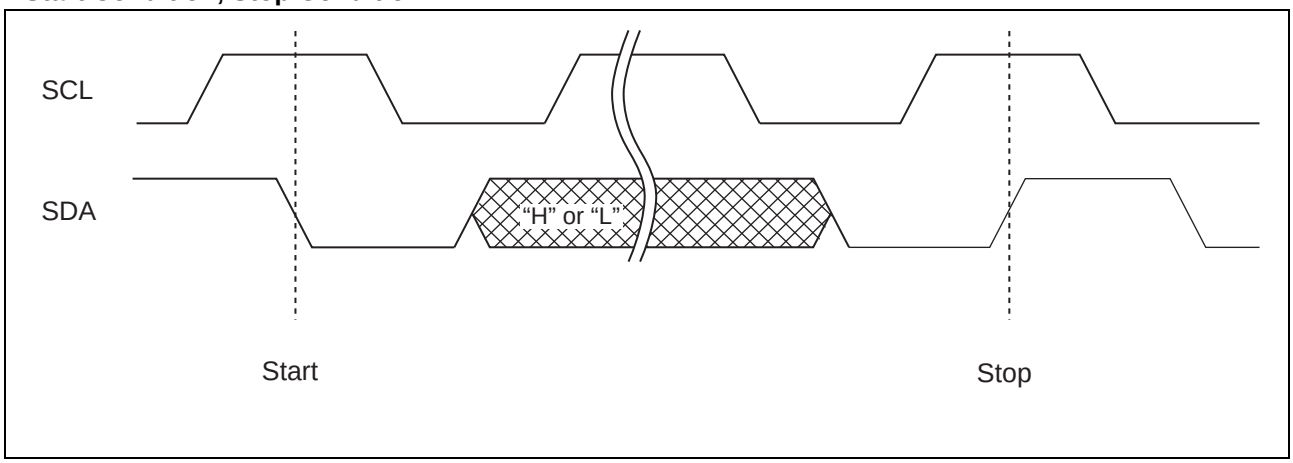
- Start Condition

To start read or write operations by the I²C bus, change the SDA input from the “H” level to the “L” level while the SCL input is in the “H” level.

- Stop Condition

To stop the I²C bus communication, change the SDA input from the “L” level to the “H” level while the SCL input is in the “H” level. In the reading operation, inputting the stop condition finishes reading and enters the standby state. In the writing operation, inputting the stop condition finishes inputting the rewrite data and enters the standby state.

• Start Condition, Stop Condition



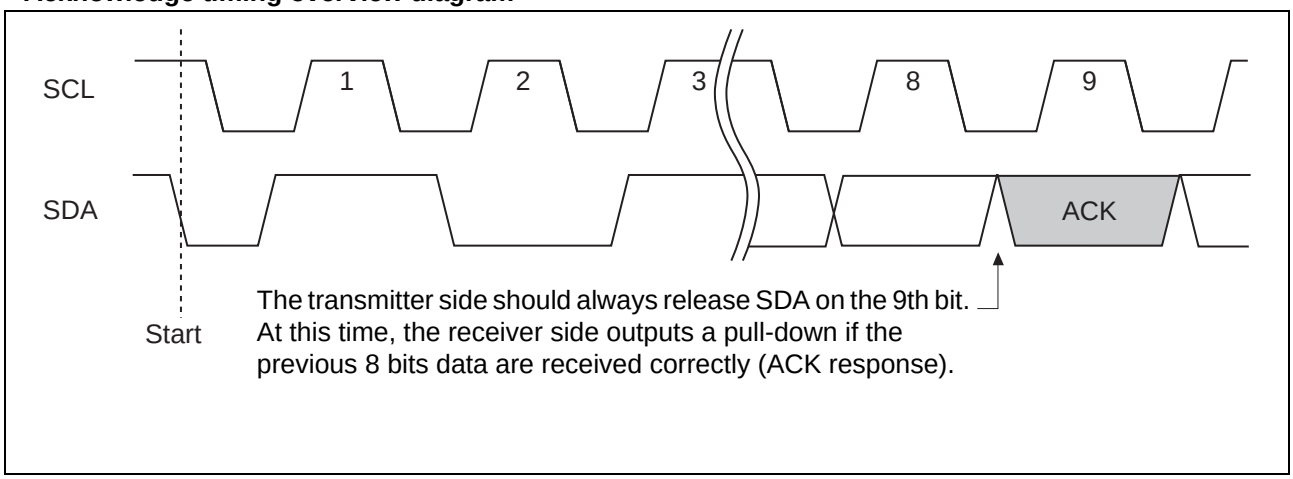
Note : At the write operation, the FRAM device does not need the programming wait time (t_{WC}) after issuing the Stop Condition.

■ ACKNOWLEDGE (ACK)

In the I²C bus, serial data including memory address or memory information is sent and received in units of 8 bits. The acknowledge signal indicates that every 8 bits of the data is successfully sent and received. The receiver side usually outputs the “L” level every time on the 9th SCL clock after each 8 bits are successfully transmitted and received. On the transmitter side, the bus is temporarily released to Hi-Z every time on this 9th clock to allow the acknowledge signal to be received and checked. During this Hi-Z released period, the receiver side pulls the SDA line down to indicate the “L” level that the previous 8 bits communication is successfully received.

In case the slave side receives Stop condition before sending or receiving the ACK “L” level, the slave side stops the operation and enters to the standby state. On the other hand, the slave side releases the bus state after sending or receiving the NACK “H” level. The master side generates Stop condition or Start condition in this released bus state.

• Acknowledge timing overview diagram



■ MEMORY ADDRESS STRUCTURE

The MB85RC16V has the memory address buffer to store the 11-bit information for the memory address.

As for byte write, page write and random read commands, the complete 11-bit memory address is configured by inputting the memory upper address (3 bits) and the memory lower address (8 bits), and saved to the memory address buffer. Then access to the memory is performed.

As for a current address read command, the complete 11-bit memory address is configured and saved to the memory address buffer, by inputting the memory upper address (3 bits) and the memory lower address (8 bits) which has saved in the memory address buffer. Then access to the memory is performed.

■ DEVICE ADDRESS WORD

Following the start condition, the 8 bit device address word is input. Inputting the device address word decides whether writing or reading operation. However, the clock is always driven by the master. The device address word (8 bits) consists of a device Type code (4 bits), memory upper address code (3 bits), and a Read/Write code (1 bit).

- Device Type Code (4 bits)

The upper 4 bits of the device address word are a device type code that identifies the device type, and are fixed at “1010” for the MB85RC16V.

- Memory Upper Address Code (3 bits)

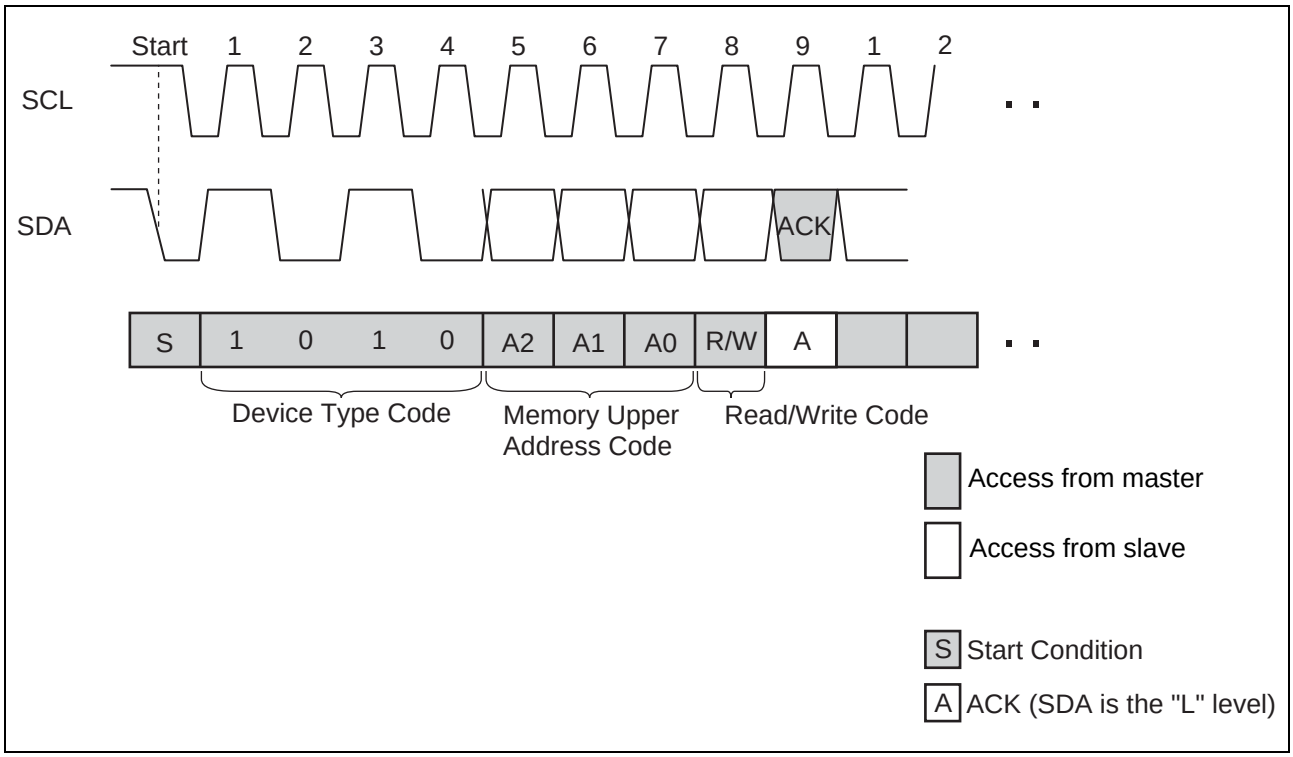
Following the device type code, the 3 bits of the memory upper address code are input.

The slave address selection is not performed by the external pin setting on this device. These 3 bits are not the setting bits for the slave address, but the upper 3-bit setting bits for the memory address.

- Read/Write Code (1 bit)

The 8th bit of the device address word is the R/W (Read/Write) code. When the R/W code is “0” input, a write operation is enabled, and the R/W code is “1” input, a read operation is enabled for the MB85RC16V. If the device code is not “1010”, the Read/Write operation is not performed and the standby state is chosen.

• Device Address Word



■ DATA STRUCTURE

The master inputs the device address word (8 bits) following the start condition, and then the slave outputs the Acknowledge “L” level on the 9th bit. After confirming the Acknowledge response, the sequential 8-bit memory lower address is input, to the byte write, page write and random read commands.

As for the current address read command, inputting the memory lower address is not performed, and the address buffer lower 8-bit is used as the memory lower address.

When inputting the memory lower address finishes, the slave outputs the Acknowledge “L” level on the 9th bit again.

Afterwards, the input and the output data continue in 8-bit units, and then the Acknowledge “L” level is output for every 8-bit data.

■ FRAM ACKNOWLEDGE -- POLLING NOT REQUIRED

The MB85RC16V performs the high speed write operations, so any waiting time for an ACK* by the acknowledge polling does not occur.

*: In E^2PROM, the Acknowledge Polling is performed as a progress check whether rewriting is executed or not. It is normal to judge by the 9th bit of Acknowledge whether rewriting is performed or not after inputting the start condition and then the device address word (8 bits) during rewriting.

■ WRITE PROTECT (WP)

The entire memory array can be write protected by setting the WP pin to the “H” level. When the WP pin is set to the “L” level, the entire memory array will be rewritten. Reading is allowed regardless of the WP pin's “H” level or “L” level.

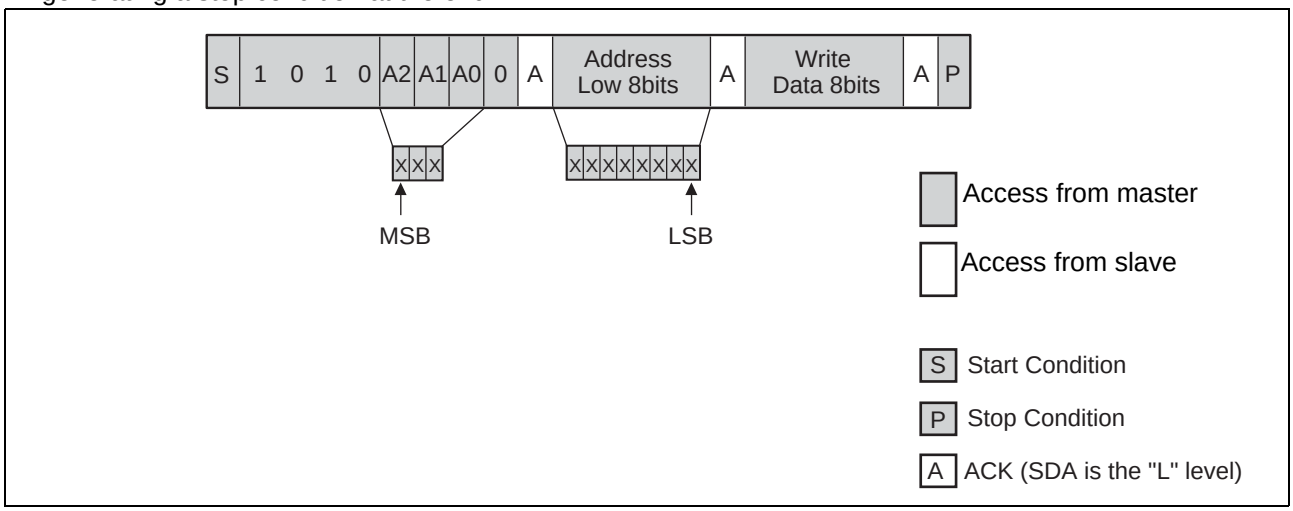
Do not change the WP signal level during the communication period from the start condition to the stop condition.

Note : The WP pin is pulled down internally to the VSS pin, therefore if the WP pin is open, the pin status is recognized as the “L” level (write enabled).

■ COMMAND

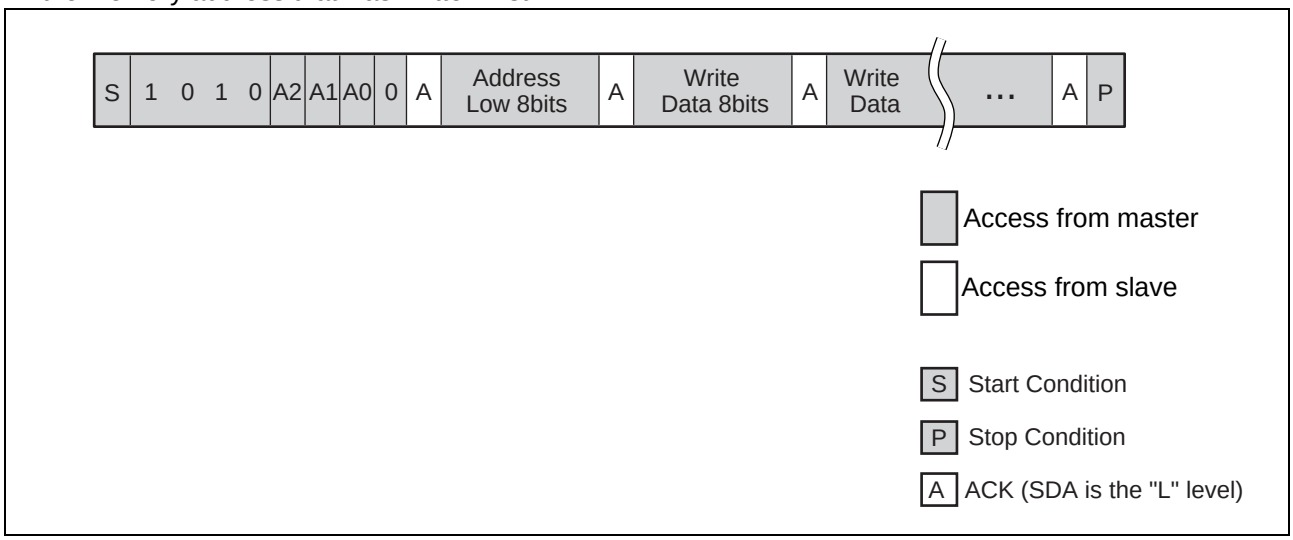
• Byte Write

If the device address word (R/W “0” input) is sent after the start condition, the slave responds with an ACK. After this ACK, write memory addresses and write data are sent in the same way, and the write ends by generating a stop condition at the end.



• Page Write

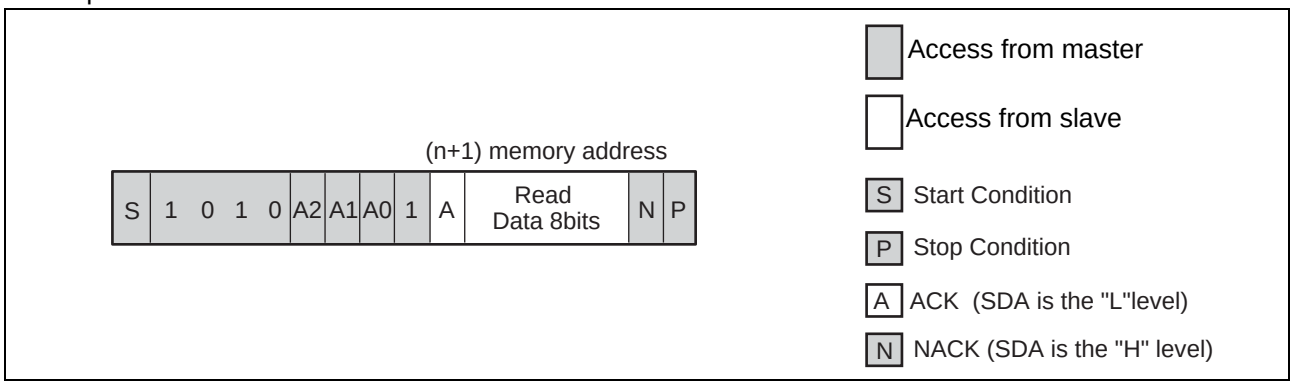
If additional 8 bits are continuously sent after the same command (except stop condition) as Byte Write, a page write is performed. The memory address rolls over to first memory address (000_H) at the end of the address. Therefore, if more than 2 Kbytes are sent, the data is overwritten in order starting from the start of the memory address that was written first.



• Current Address Read

If the last write or read operation finishes successfully up to the end of stop condition, the memory address that was accessed last remains in the memory address buffer (the length is 11 bits).

When sending this command without turning the power off, it is possible to read from the memory address n+1 which adds 1 to the total 11-bit memory address n, which consists of the memory upper address 3-bit from the device address word input and the lower 8-bit of the memory address buffer. If the memory address n is the last address, it is possible to read with rolling over to the head of the memory address (000_H). The current address (address that the memory address buffer indicates) is undefined immediately after turning the power on.

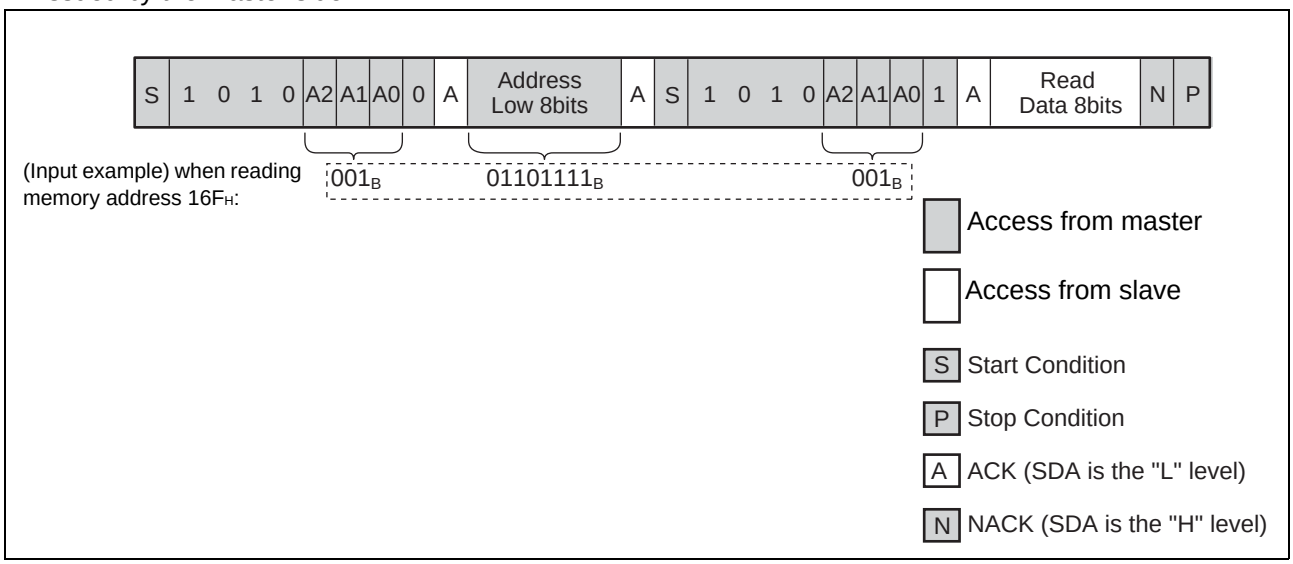


• Random Read

The one byte of data from the memory address saved in the memory address buffer can be read out synchronously to SCL by specifying the address in the same way as for a write, and then issuing another start condition and sending the Device Address Word (R/W “1” input).

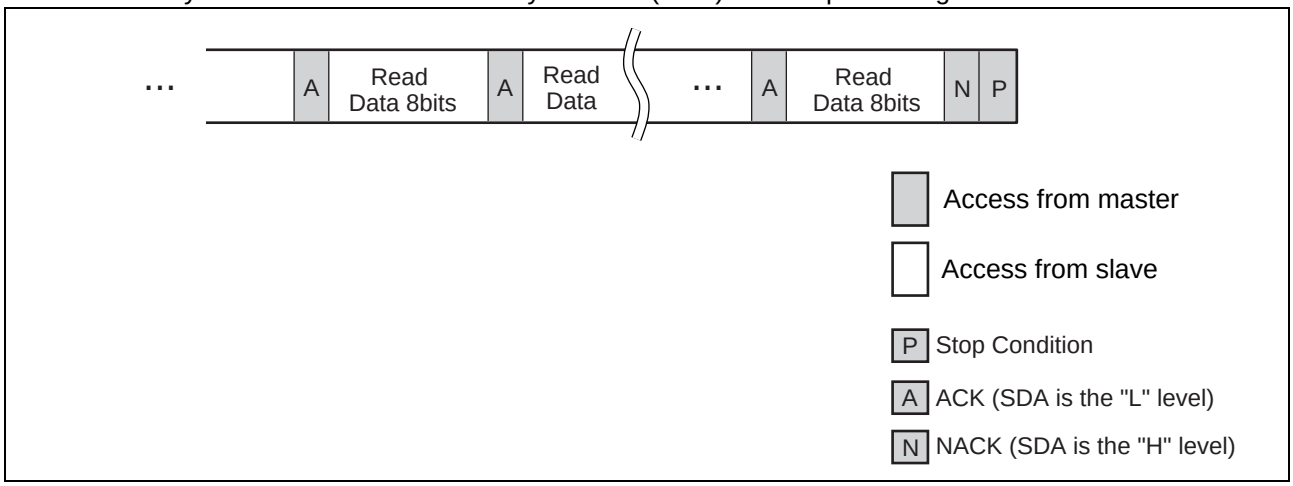
Setting values for the first and the second memory upper address codes should be the same (an example is shown in below).

The final NACK (SDA is the “H” level) is issued by the receiver that receives the data. In this case, this bit is issued by the master side.



• Sequential Read

Data can be received continuously following the Device address word (R/W “1” input) after specifying the address in the same way as for Random Read. If the read reaches the end of address, the read address automatically rolls over to the first memory address (000_H) and keeps reading.

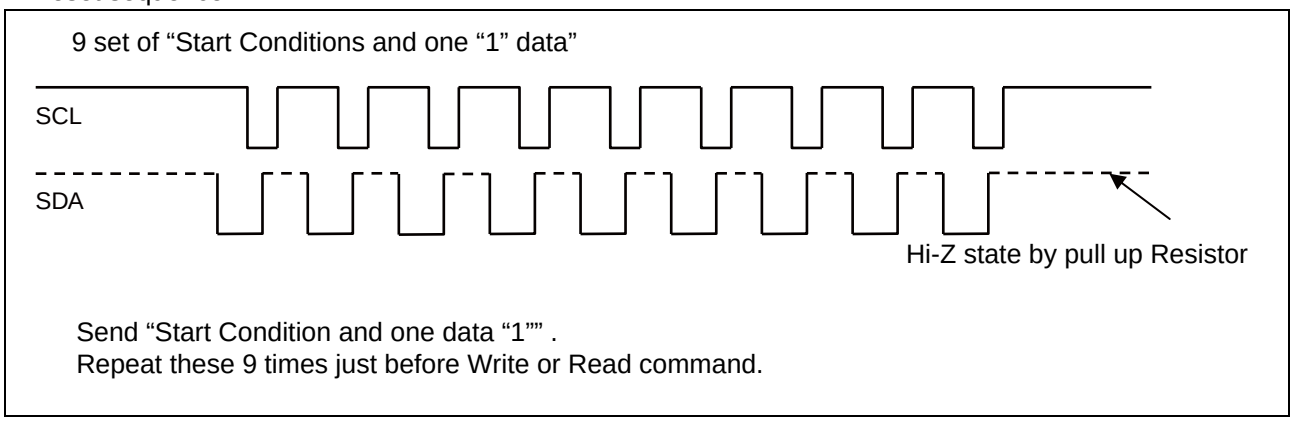


■ SOFTWARE RESET SEQUENCE OR COMMAND RETRY

In case the malfunction has occurred after power on, the master side stopped the I²C communication during processing, or unexpected malfunction has occurred, execute the following (1) software recovery sequence just before each command, or (2) retry command just after failure of each command.

(1) Software Reset Sequence

Since the slave side may be outputting “L” level, do not force to drive “H” level, when the master side drives the SDA port. This is for preventing a bus conflict. The additional hardware is not necessary for this software reset sequence.



(2) Command Retry

Command retry is useful to recover from failure response during I²C communication.

■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating		Unit
		Min	Max	
Power supply voltage*	V_{DD}	− 0.5	+ 6.0	V
Input voltage*	V_{IN}	− 0.5	V_{DD} + 0.5 (≤ 6.0)	V
Output voltage*	V_{OUT}	− 0.5	V_{DD} + 0.5 (≤ 6.0)	V
Operation ambient temperature	T_A	− 40	+ 85	°C
Storage temperature	T_{STG}	− 55	+ 125	°C

*: These parameters are based on the condition that Vss is 0 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_{DD}	3.0	—	5.5	V
“H” level input voltage*	V_{IH}	$V_{DD} \times 0.8$	—	5.5	V
“L” level input voltage*	V_{IL}	V_{SS}	—	$V_{DD} \times 0.2$	V
Operation ambient temperature	T_A	− 40	—	+ 85	°C

*: These parameters are based on the condition that Vss is 0 V.

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 representatives beforehand.

■ ELECTRICAL CHARACTERISTICS

1. DC Characteristics

(within recommended operating conditions)

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
Input leakage current*1	$\|I_{LI}\|$	V_{IN} = 0 V to V_{DD}	—	—	1	µA
Output leakage current*2	$\|I_{LO}\|$	V_{OUT} = 0 V to V_{DD}	—	—	1	µA
Operating power supply current	I_{DD}	SCL = 400 kHz	—	40	80	µA
		SCL = 1000 kHz	—	90	130	µA
Standby current	I_{SB}	SCL, SDA = V_{DD} WP = 0 V or V_{DD} or OPEN T_A = + 25 °C in stop condition	—	5	10	µA
“L” level output voltage	V_{OL}	I_{OL} = 3 mA	—	—	0.4	V
Input resistance for WP pin	R_{IN}	V_{IN} = V_{IL} (Max)	50	—	—	kΩ
		V_{IN} = V_{IH} (Min)	1	—	—	MΩ

*1: Applicable pin: SCL,SDA

*2: Applicable pin: SDA

2. AC Characteristics

Parameter	Symbol	Value						Unit
		STANDARD MODE		FAST MODE		FAST MODE PLUS		
		Min	Max	Min	Max	Min	Max	
SCL clock frequency	FSCL	0	100	0	400	0	1000	kHz
Clock high time	T_{HIGH}	4000	—	600	—	400	—	ns
Clock low time	T_{LOW}	4700	—	1300	—	600	—	ns
SCL/SDA rising time	T_r	—	1000	—	300	—	300	ns
SCL/SDA falling time	T_f	—	300	—	300	—	100	ns
Start condition hold	$T_{HD:STA}$	4000	—	600	—	250	—	ns
Start condition setup	$T_{SU:STA}$	4700	—	600	—	250	—	ns
SDA input hold	$T_{HD:DAT}$	20	—	20	—	20	—	ns
SDA input setup	$T_{SU:DAT}$	250	—	100	—	100	—	ns
SDA output hold	$T_{DH:DAT}$	0	—	0	—	0	—	ns
Stop condition setup	$T_{SU:STO}$	4000	—	600	—	250	—	ns
SDA output access after SCL falling	T_{AA}	—	3000	—	900	—	550	ns
Pre-charge time	T_{BUF}	4700	—	1300	—	500	—	ns
Noise suppression time (SCL and SDA)	T_{SP}	—	50	—	50	—	50	ns

AC characteristics were measured under the following measurement conditions.

Power supply voltage : STANDARD MODE and FAST MODE 3.0 V to 5.5 V
: FAST MODE PLUS 4.5 V to 5.5 V

Operation ambient temperature: – 40 °C to + 85 °C

Input voltage amplitude: $V_{DD} \times 0.2$ to $V_{DD} \times 0.8$

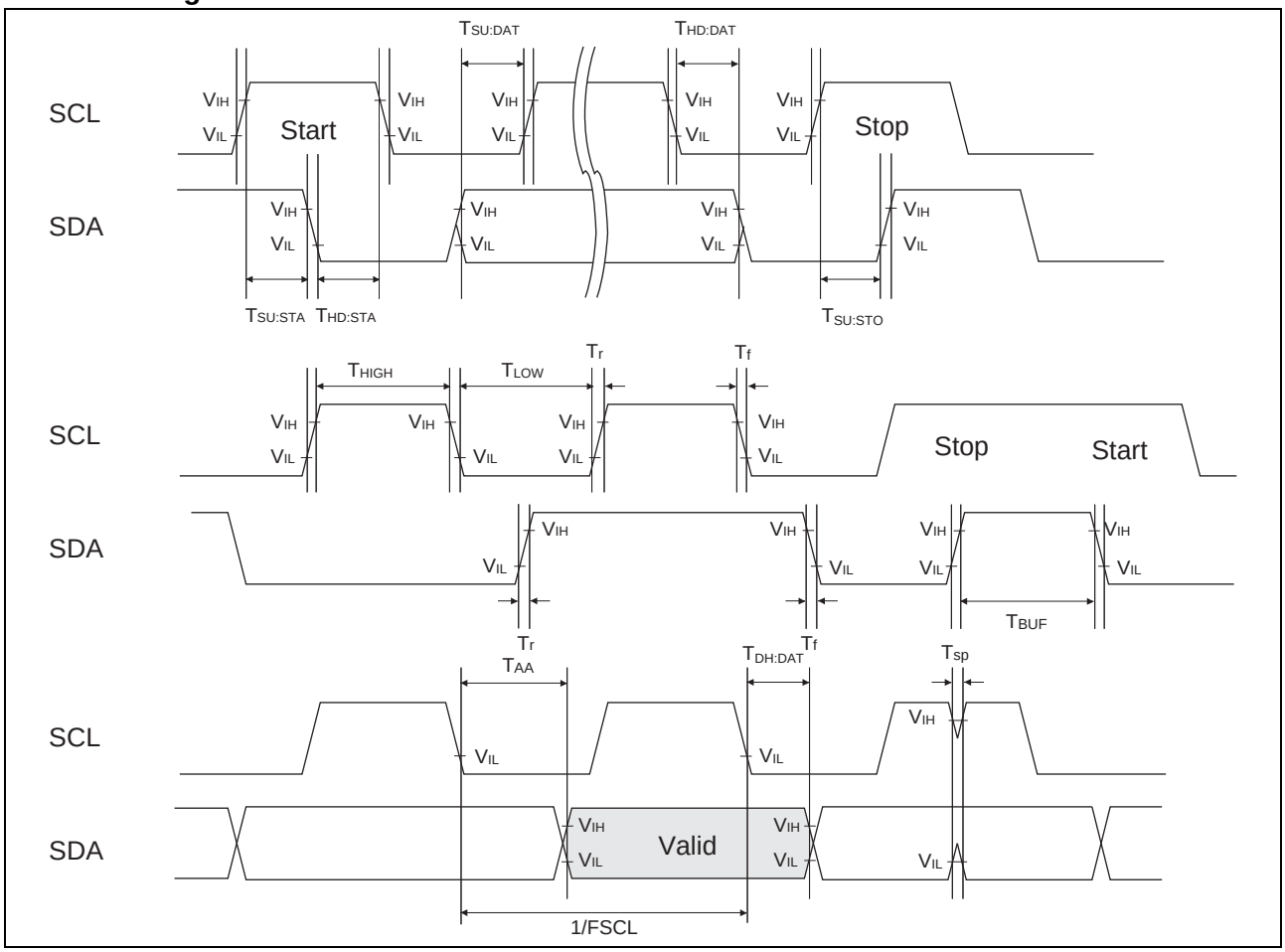
Input rising time : 5 ns

Input falling time : 5 ns

Input judge level : $V_{DD}/2$

Output judge level : $V_{DD}/2$

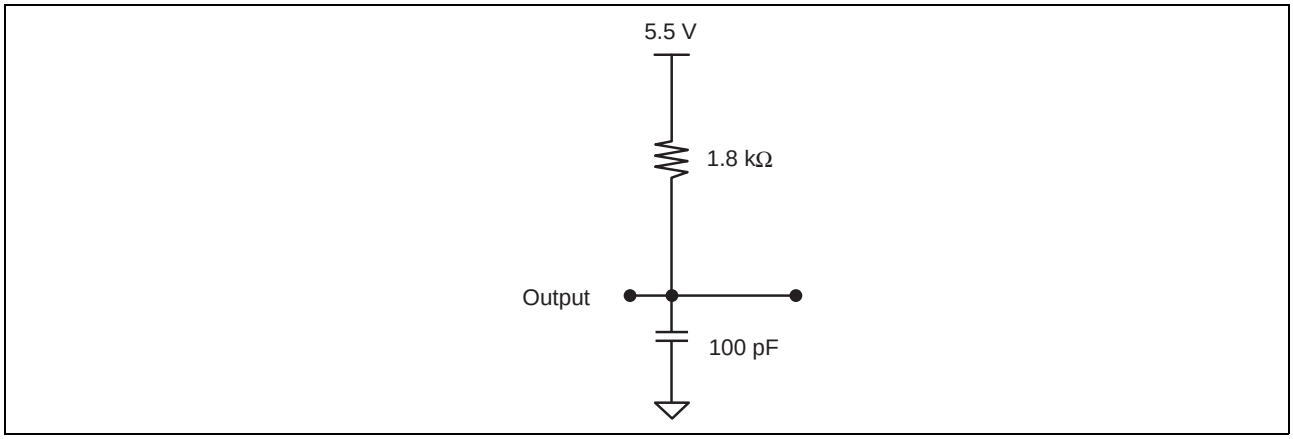
3. AC Timing Definitions



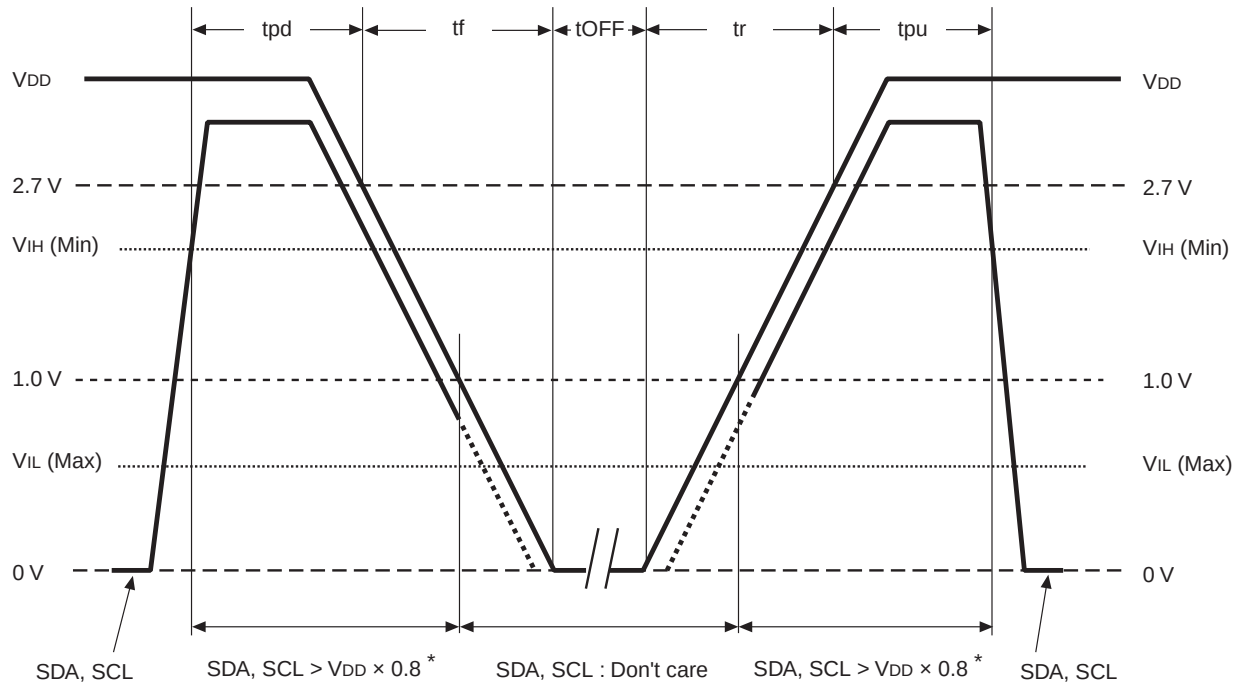
4. Pin capacitance

Parameter	Symbol	Conditions	Value			Unit
			Min	Typ	Max	
I/O capacitance	$C_{I/O}$	$V_{DD} = V_{IN} = V_{OUT} = 0V$, f = 1 MHz, T_A = + 25 °C	—	—	15	pF
Input capacitance	C_{IN}		—	—	15	pF

5. AC Test Load Circuit



■ POWER ON/OFF SEQUENCE



* : SDA, SCL (Max) < V_{DD} + 0.5 V

Parameter	Symbol	Value		Unit
		Min	Max	
SDA, SCL level hold time during power down	tpd	85	—	ns
SDA, SCL level hold time during power up	tpu	85	—	ns
Power supply rising time	tr	0.5	50	ms
Power supply falling time	tf	0.01	50	ms
Power off time	tOFF	50	—	ms

If the device does not operate within the specified conditions of read cycle, write cycle or power on/off sequence, memory data can not be guaranteed.

■ FRAM CHARACTERISTICS

Item	Min	Max	Unit	Parameter
Read/Write Endurance*1	10^{12}	—	Times/byte	Operation Ambient Temperature T_A = + 85 °C
Data Retention*2	10	—	Years	Operation Ambient Temperature T_A = + 85 °C
	95	—		Operation Ambient Temperature T_A = + 55 °C
	≥ 200	—		Operation Ambient Temperature T_A = + 35 °C

*1 : Total number of reading and writing defines the minimum value of endurance, as an FRAM memory operates with destructive readout mechanism.

*2 : Minimun values define retention time of the first reading/writing data right after shipment, and these values are calculated by qualification results.

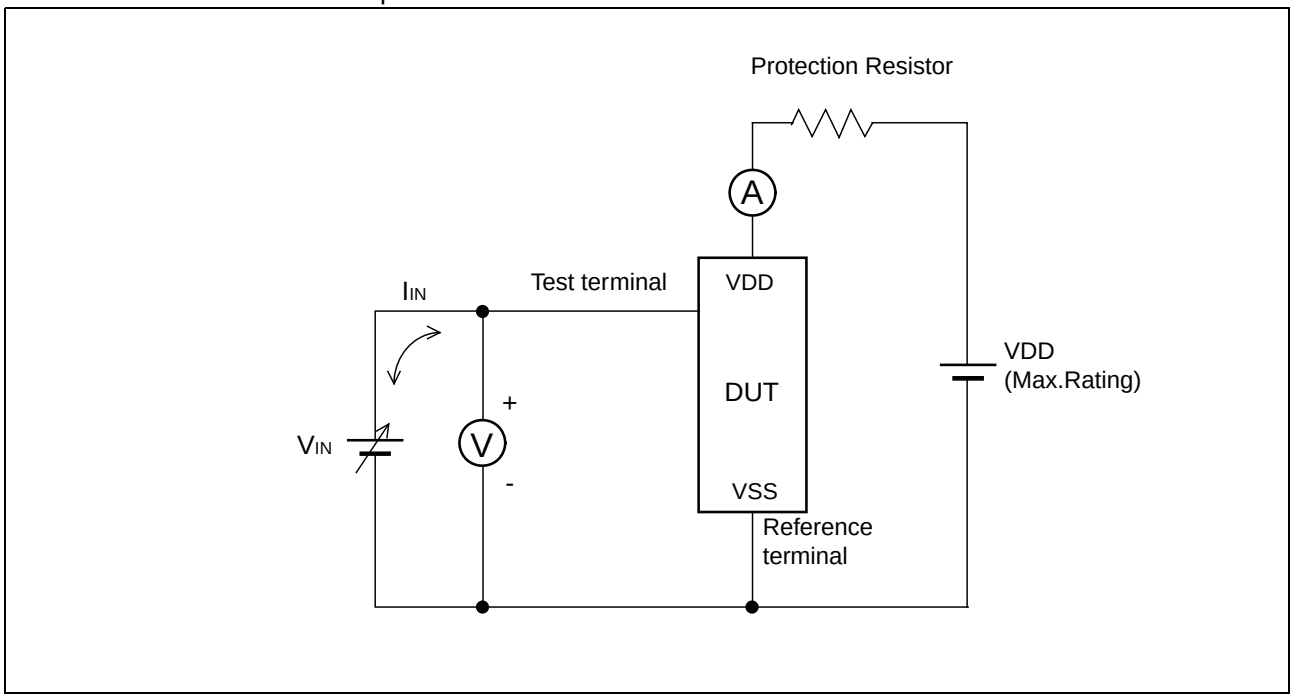
■ NOTE ON USE

Data written before performing IR reflow is not guaranteed after IR reflow.

■ ESD AND LATCH-UP

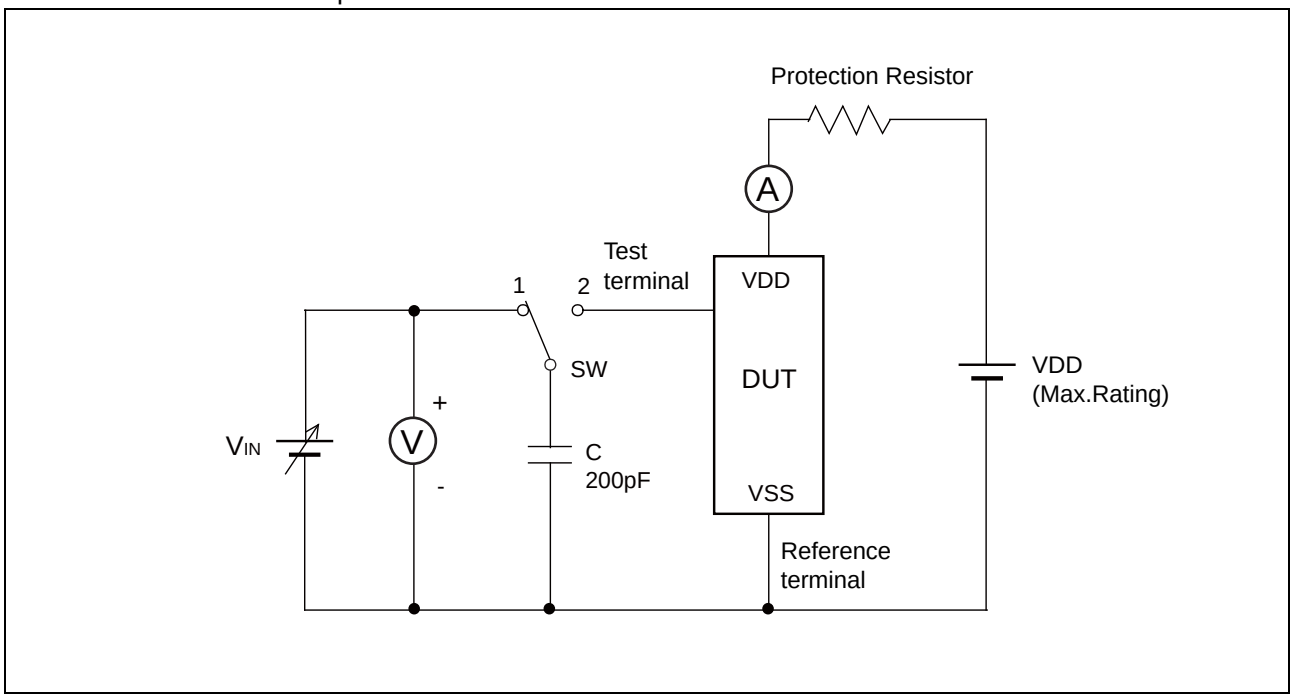
Test	DUT	Value
ESD HBM (Human Body Model) JESD22-A114 compliant	MB85RC16VPNF-G-JNE1	≥ |2000 V|
ESD MM (Machine Model) JESD22-A115 compliant		≥ |200 V|
ESD CDM (Charged Device Model) JESD22-C101 compliant		≥ |1000 V|
Latch-Up (I-test) JESD78 compliant		—
Latch-Up (V_{supply} overvoltage test) JESD78 compliant		—
Latch-Up (Current Method) Proprietary method		≥ |300 mA|
Latch-Up (C-V Method) Proprietary method		—

- Current method of Latch-Up Resistance Test



Note : The voltage V_{IN} is increased gradually and the current I_{IN} of 300 mA at maximum shall flow.
Confirm the latch up does not occur under $I_{IN} = \pm 300$ mA.
In case the specific requirement is specified for I/O and I_{IN} cannot be 300 mA, the voltage shall be increased to the level that meets the specific requirement.

• C-V method of Latch-Up Resistance Test



Note : Charge voltage alternately switching 1 and 2 approximately 2 sec interval. This switching process is considered as one cycle.
Repeat this process 5 times. However, if the latch-up condition occurs before completing 5 times, this test must be stopped immediately.

■ RESTRICTED SUBSTANCES

This product complies with the regulations below (Based on current knowledge as of November 2011).

- EU RoHS Directive (2002/95/EC)
- China RoHS (Administration on the Control of Pollution Caused by Electronic Information Products (电子信息产品污染控制管理办法))
- Vietnam RoHS (30/2011/TT-BCT)

Restricted substances in each regulation are as follows.

Substances	Threshold	Contain status*
Lead and its compounds	1,000 ppm	❍
Mercury and its compounds	1,000 ppm	❍
Cadmium and its compounds	100 ppm	❍
Hexavalent chromium compound	1,000 ppm	❍
Polybrominated biphenyls (PBB)	1,000 ppm	❍
Polybrominated diphenyl ethers (PBDE)	1,000 ppm	❍

* : The mark of "❍" shows below a threshold value.

■ ORDERING INFORMATION

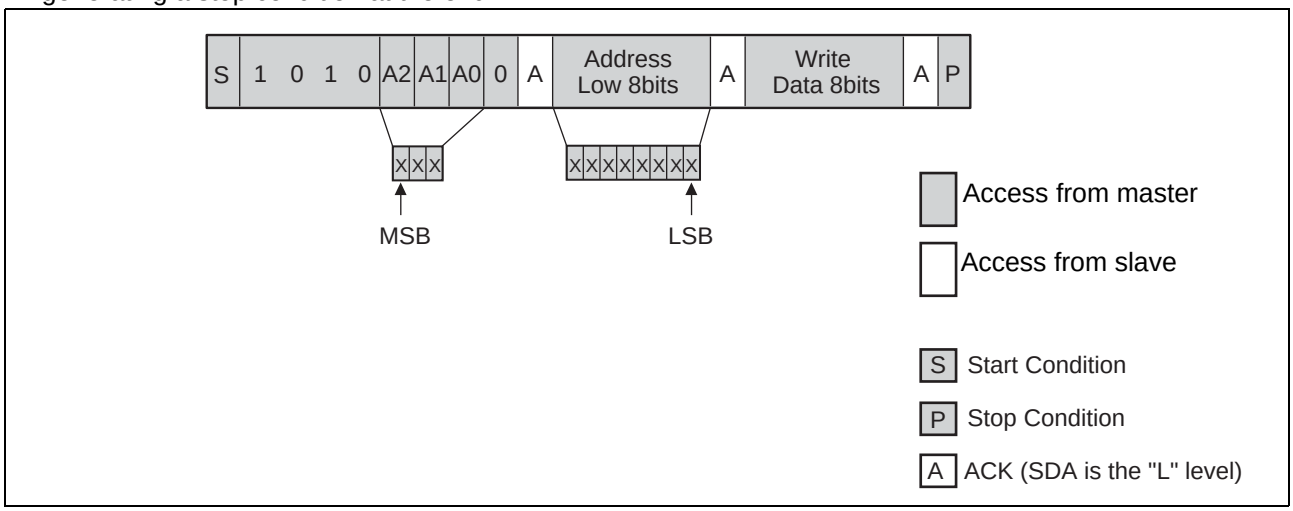
Part number	Package	Shipping form	Minimum shipping quantity
MB85RC16VPNF-G-JNE1*	8-pin, plastic SOP (FPT-8P-M02)	Tube	1
MB85RC16VPNF-G-JNERE1*	8-pin, plastic SOP (FPT-8P-M02)	Embossed Carrier tape	1500
MB85RC16VPNF-G-JNN1E1	8-pin, plastic SOP (FPT-8P-M02)	Tube	1
MB85RC16VPNF-G-JNN1ERE1	8-pin, plastic SOP (FPT-8P-M02)	Embossed Carrier tape	1500

* : These part numbers are not recommended to use for new design.

■ COMMAND

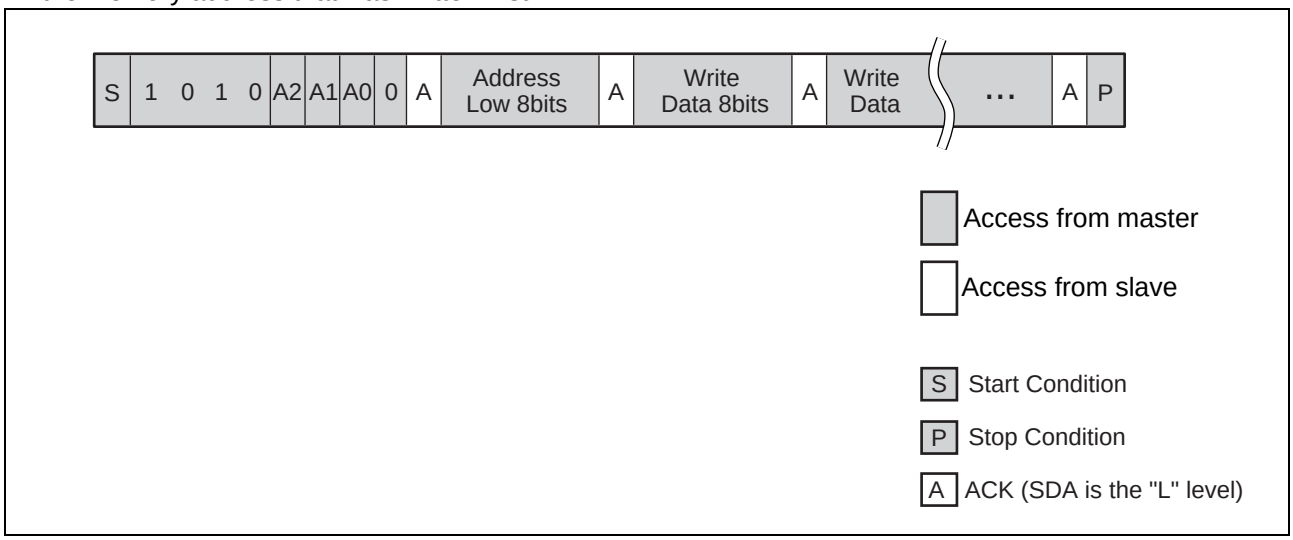
• Byte Write

If the device address word (R/W “0” input) is sent after the start condition, the slave responds with an ACK. After this ACK, write memory addresses and write data are sent in the same way, and the write ends by generating a stop condition at the end.



• Page Write

If additional 8 bits are continuously sent after the same command (except stop condition) as Byte Write, a page write is performed. The memory address rolls over to first memory address (000_H) at the end of the address. Therefore, if more than 2 Kbytes are sent, the data is overwritten in order starting from the start of the memory address that was written first.



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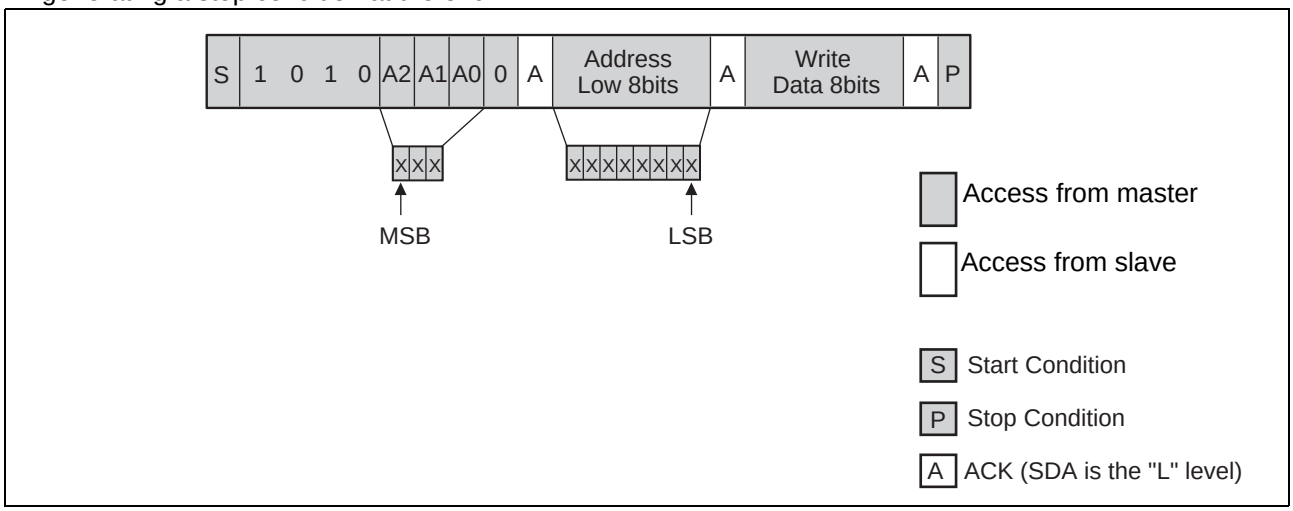

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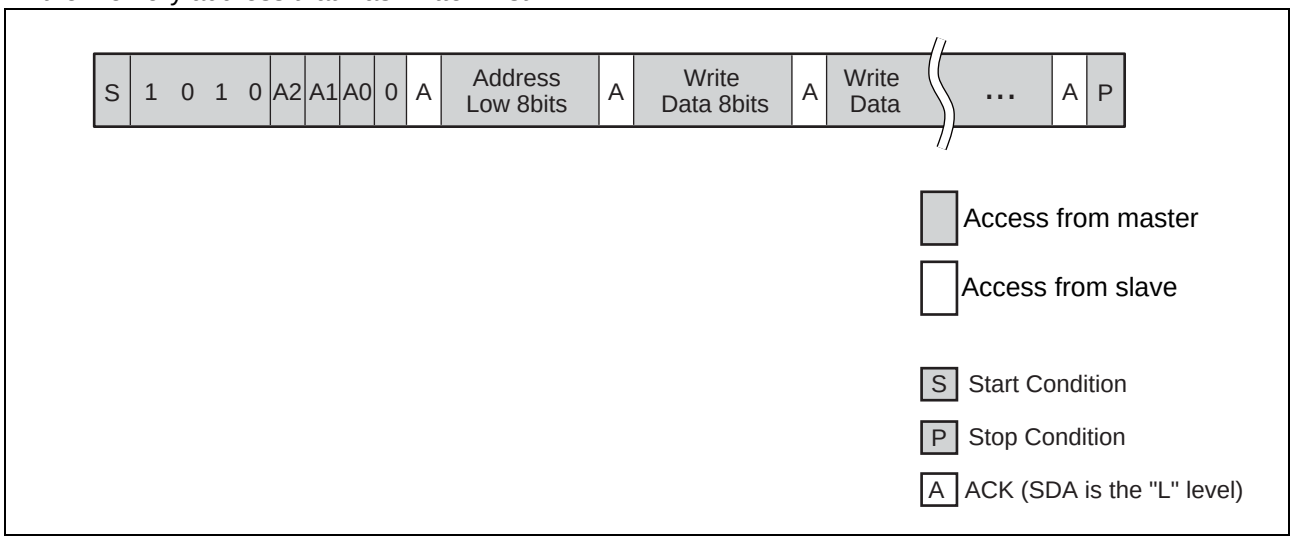

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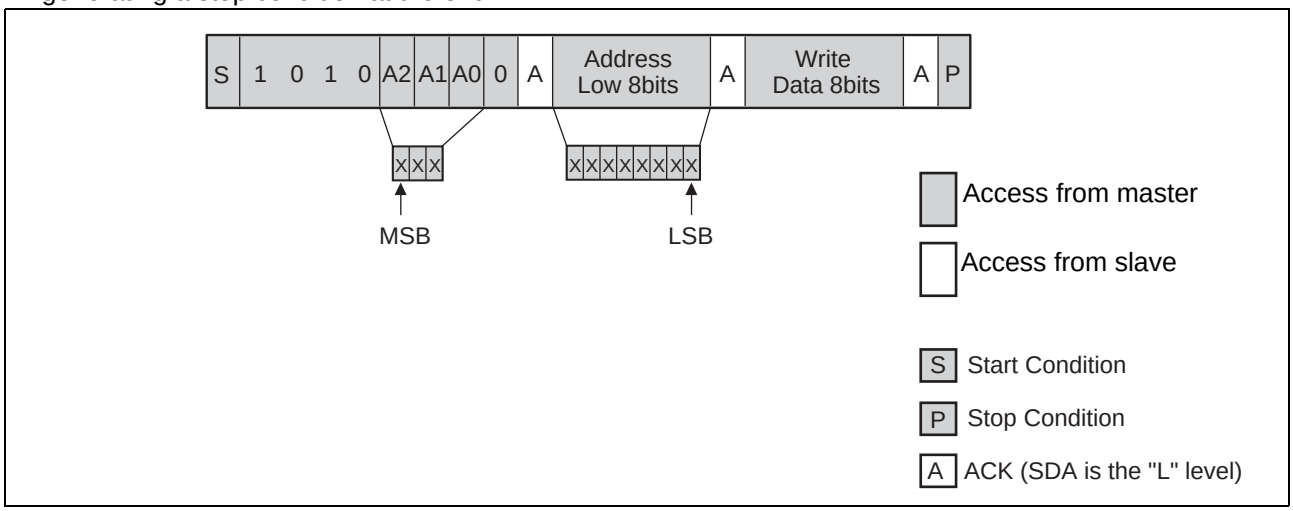

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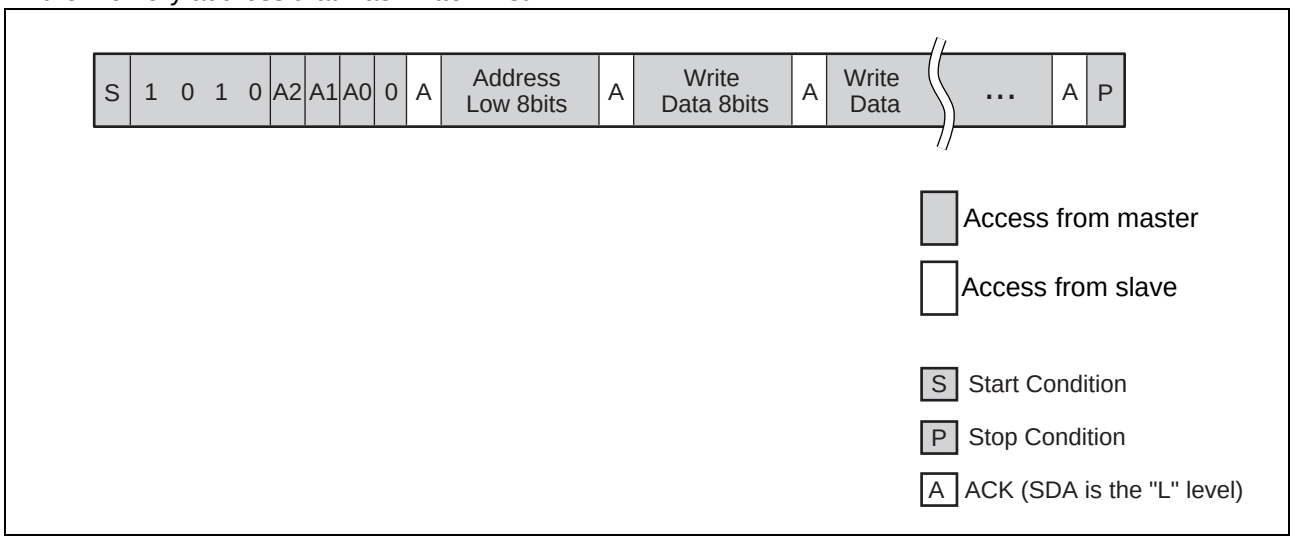

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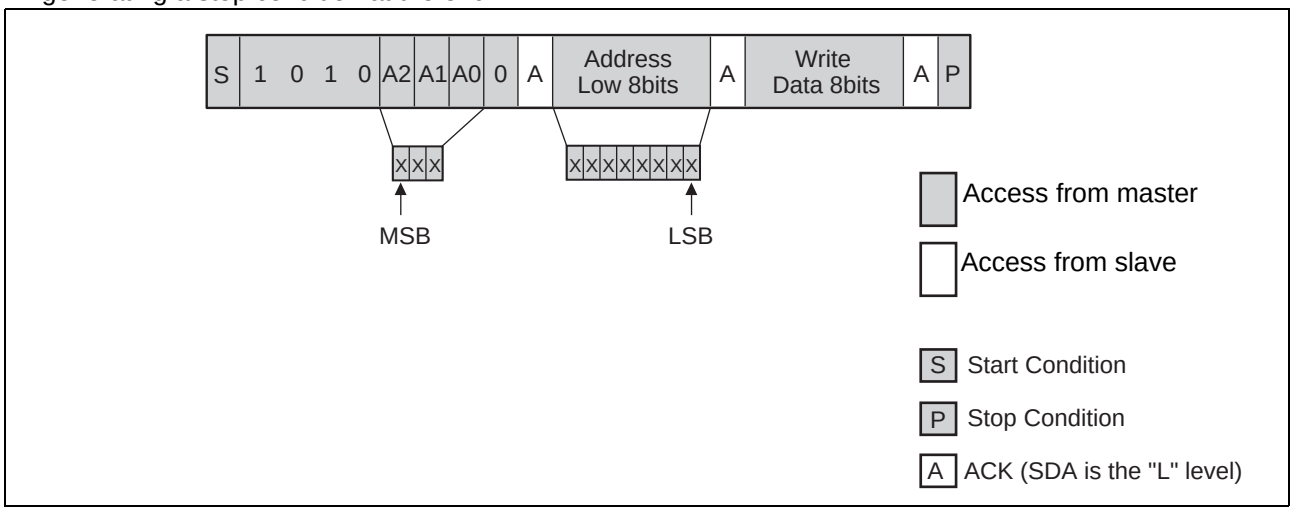

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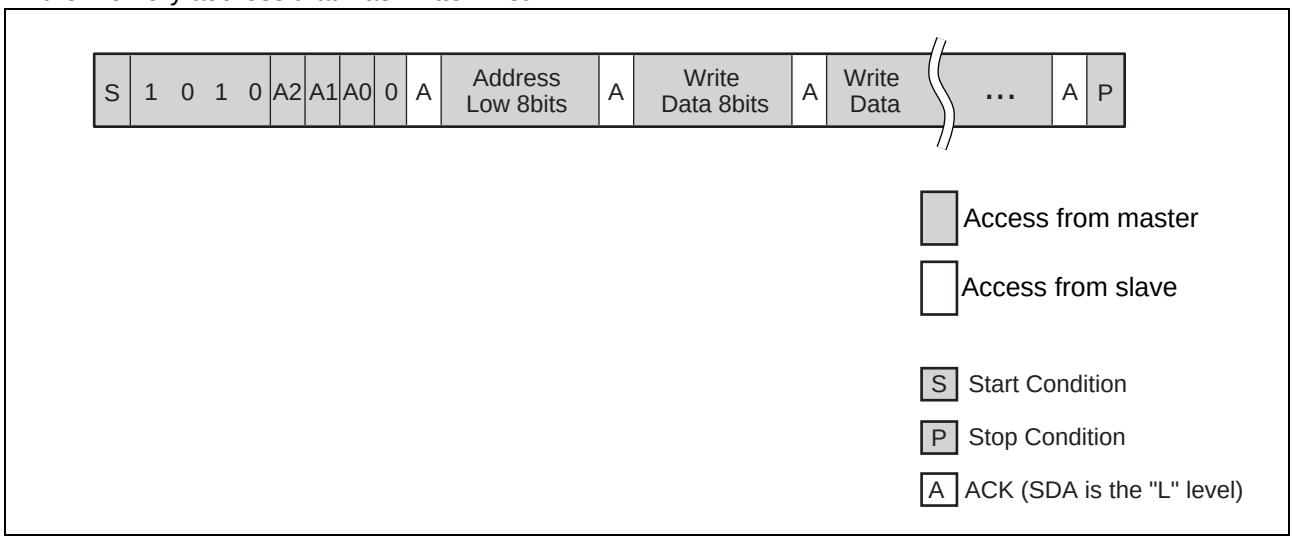

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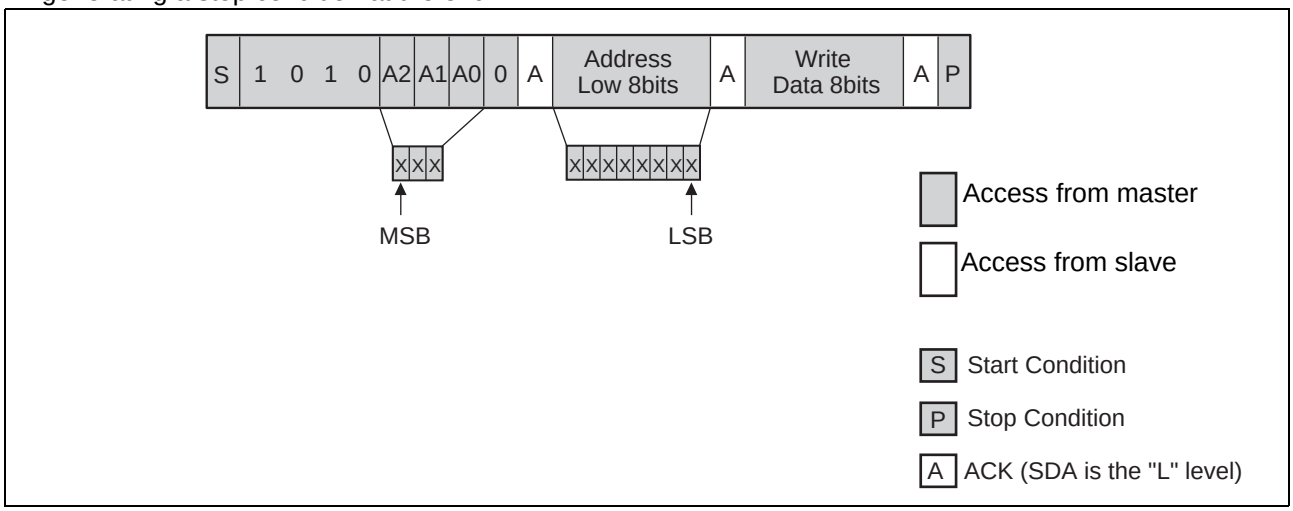

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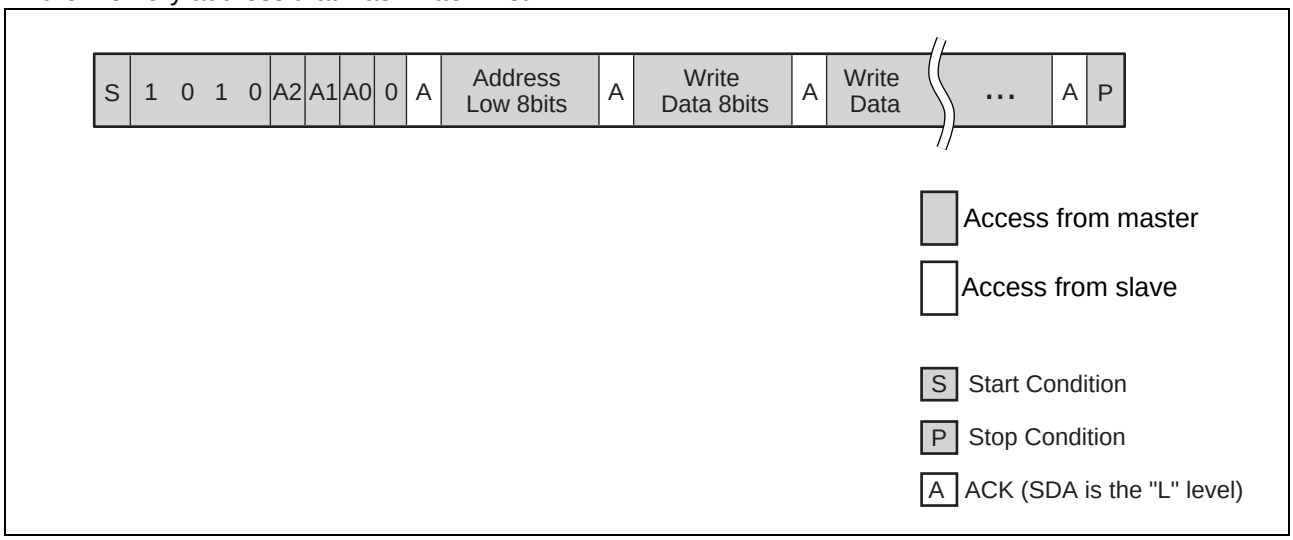

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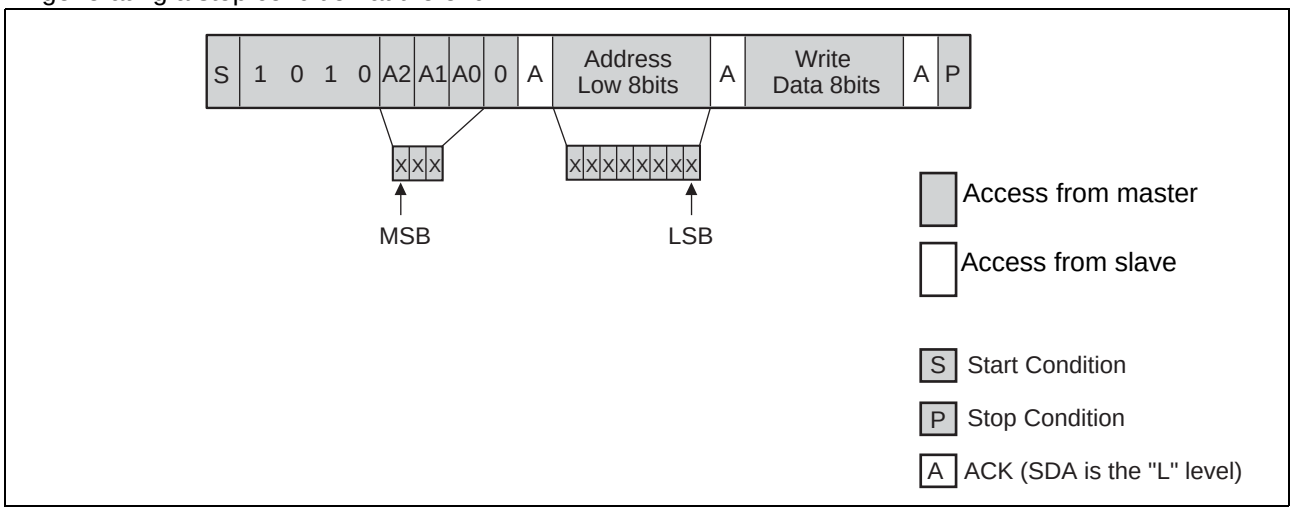

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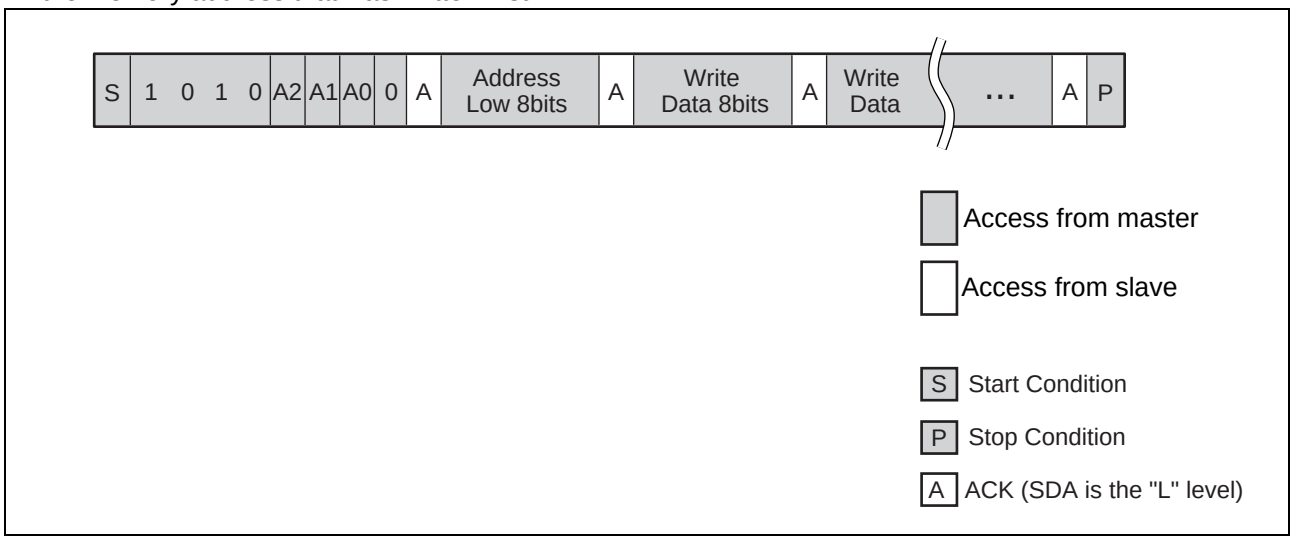

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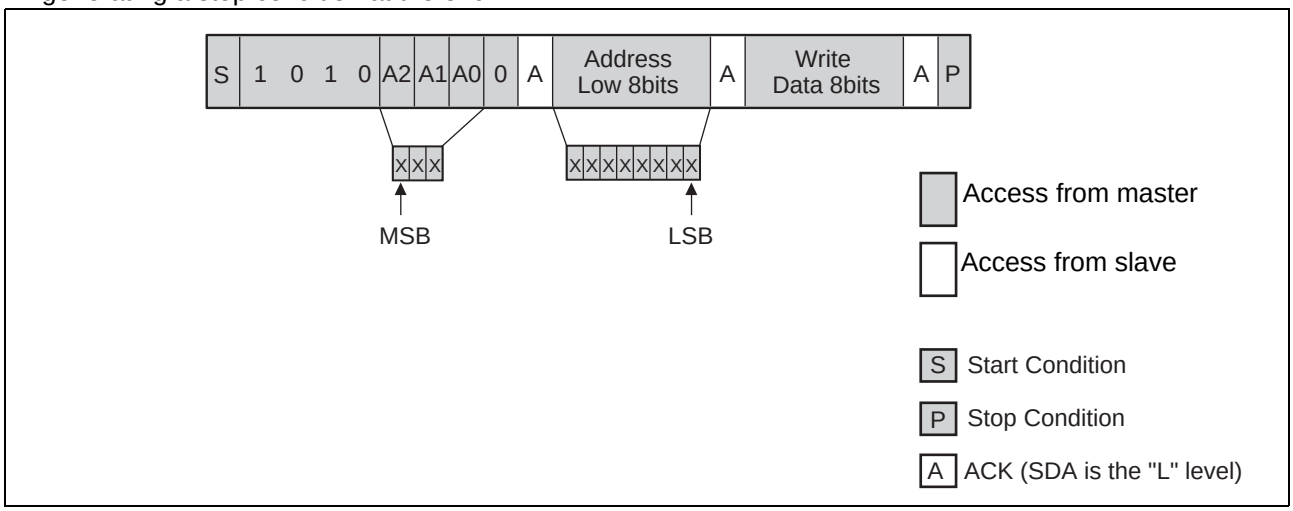

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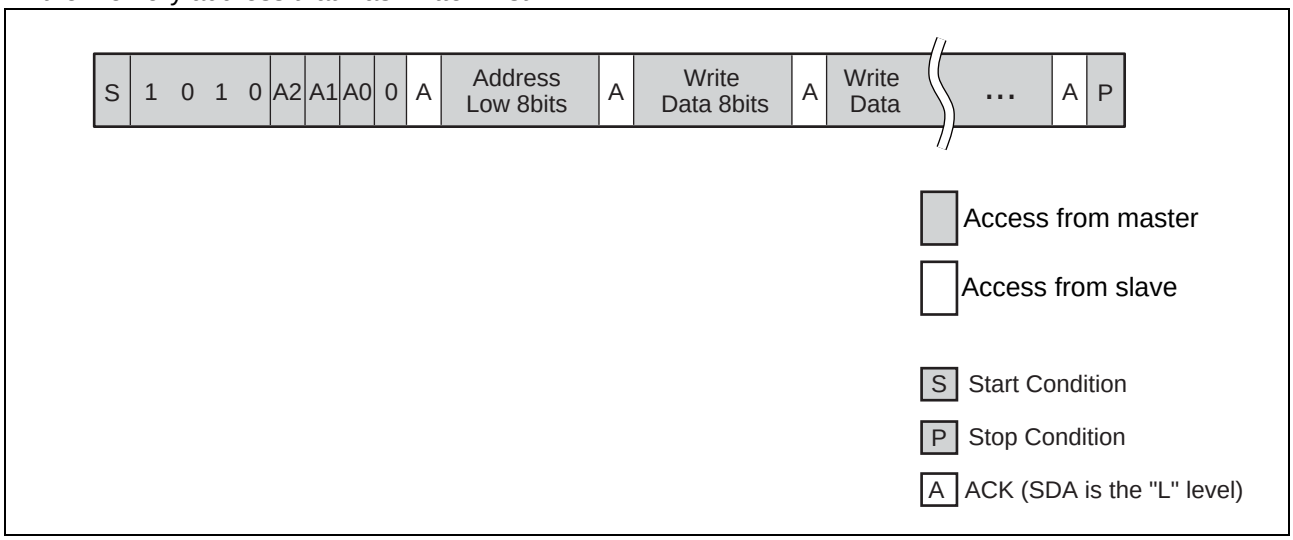

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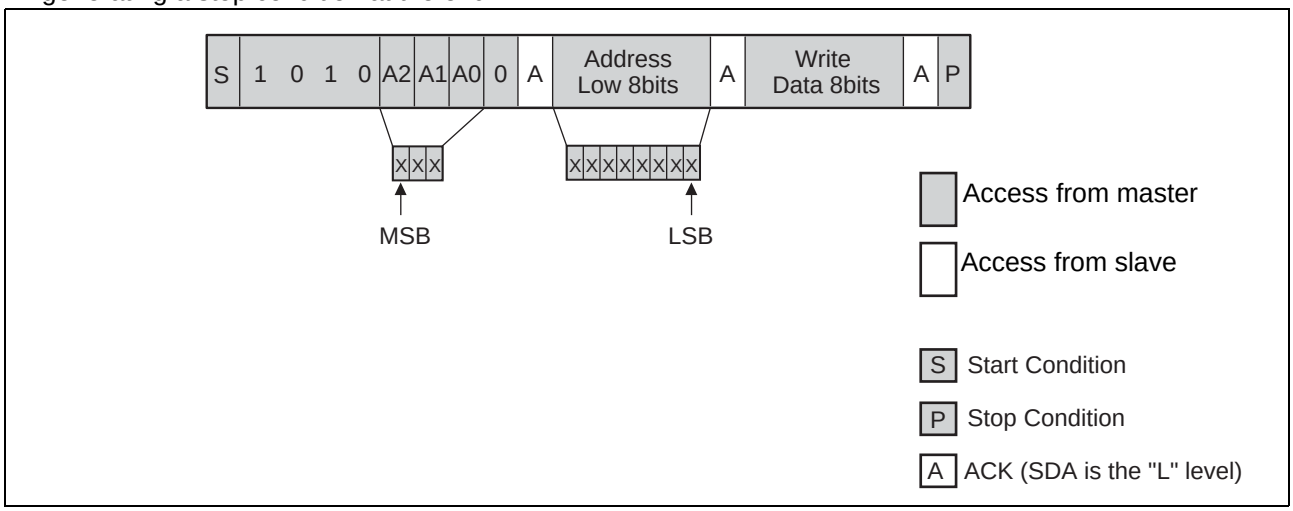

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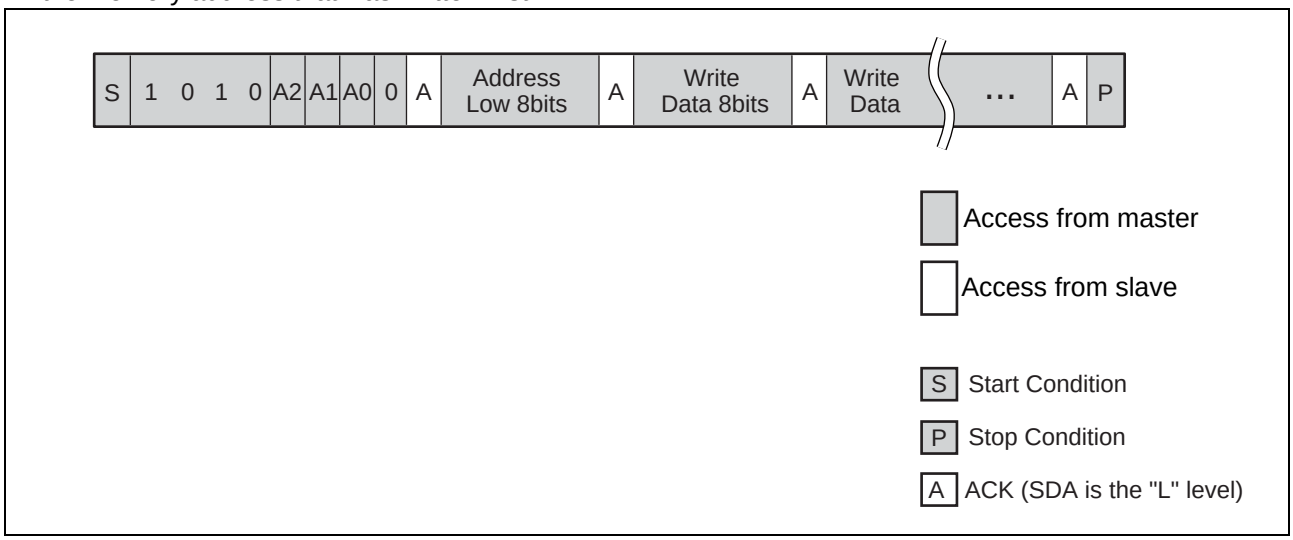
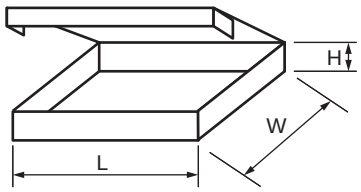


2.6 Dimensions for Containers

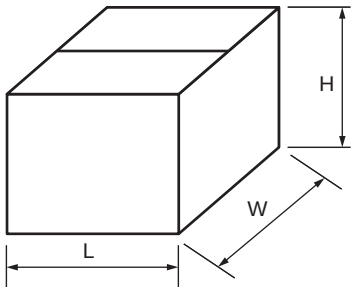
(1) Dimensions for inner box



Tape width	L	W	H
12, 16	365	345	40
24, 32			50
44			65
56			75

(Dimensions in mm)

(2) Dimensions for outer box



L	W	H
415	400	315

(Dimensions in mm)

■ MAJOR CHANGES IN THIS EDITION

A change on a page is indicated by a vertical line drawn on the left side of that page.

Page	Section	Change Results
1	■ FEATURES	Revised the Data retention 10 years (+ 85 °C) →10 years (+ 85 °C), 95 years (+ 55 °C), over 200 years (+ 35 °C)
11	■ ABSOLUTE MAXIMUM RANGES	Revised the Storage Temperature − 40 °C → − 55 °C
15	■ POWER ON/OFF SEQUENCE	Revised the following description: “POWER ON SEQUENCE” → “POWER ON/OFF SEQUENCE” Deleted the following description: “V_{DD} pin is required to be rising from 0V because turning the power-on from an intermediate level may cause malfunctions, when the power is turned on.” Added the following description: “If the device does not operate within the specified conditions of read cycle, write cycle or power on/off sequence, memory data can not be guaranteed.”
	■ FRAM CHARACTERISTICS	Revised the table and Note

MEMO

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