

Document Title

64MB & 128MB SmartMedia™ Card

Revision History

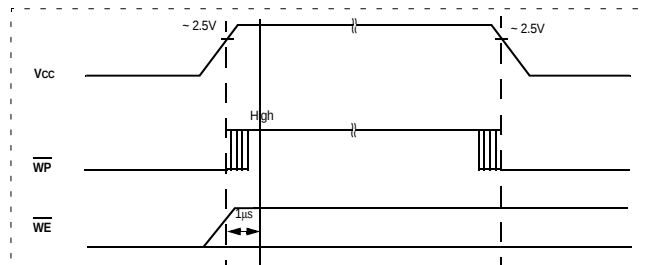
Revision No	History	Draft Date	Remark
0.0	Initial issue	Mar. 30th 2001	Preliminary
0.1	1. Changed DC characteristics	Apr. 7th 2001	

Parameter	Min	Typ	Max	Unit
Operating Current	Sequential Read	-	10	20->30
	Program	-	10	20->30
	Erase	-	10	20->30

- Added t_{DBSY} parameter
- Removed Copy-Back program command
- Changed AC characteristics

Parameter	Symbol	Min	Max	Unit
ALE to $\overline{RE}$ Delay (ID read)	t_{AR1}	100->10	-	ns

- | | | |
|-----|--|---------------|
| 0.2 | <p>1. Powerup sequence is added</p> <p>Recovery time of minimum $1\mu s$ is required before internal circuit gets ready for any command sequences</p> | Sep. 7th 2001 |
|-----|--|---------------|



- AC parameter t_{CLR} (CLE to $\overline{RE}$ Delay, min 50ns) is added.
- Changed AC characteristics

(Before)

Parameter	Symbol	Min	Max	Unit
ALE to $\overline{RE}$ Delay (ID read)	t_{AR1}	100	-	ns
ALE to $\overline{RE}$ Delay (Read)	t_{AR2}	100	-	
$\overline{RE}$ Low to Status Output	t_{RSTO}	-	35	
$\overline{CE}$ Low to Status Output	t_{CSTO}	-	45	
$\overline{RE}$ access time (Read ID)	t_{READID}	-	35	

Note : For more detailed features and specifications including FAQ, please refer to Samsung's Flash web site.
<http://www.samsung.com/Products/Semiconductor/Flash/TechnicalInfo/datasheets>.

The attached data sheets are prepared and approved by SAMSUNG Electronics. SAMSUNG Electronics CO., LTD. reserve the right to change the specifications. SAMSUNG Electronics will evaluate and reply to your requests and questions about device. If you have any questions, please contact the SAMSUNG branch office near your office.

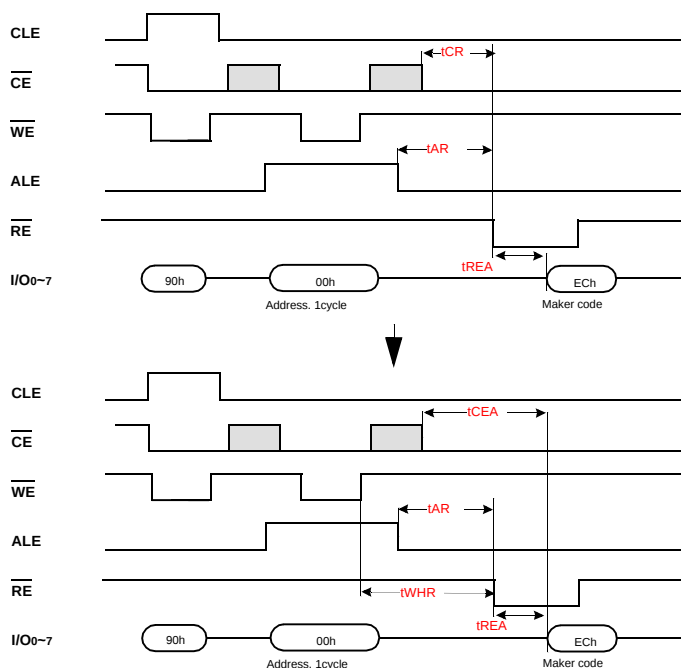
Revision History

Revision No	History	Draft Date	Remark
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- AC characteristics (After)
. Deleted tRSTO, tCSTO and tREADID / Added tCLR, tCEA

Sep. 7th 2001 Final

Parameter	Symbol	Min	Max	Unit
ALE to RE Delay (ID read)	tAR1	50	-	ns
ALE to RE Delay (Read cycle)	tAR2	50	-	
CLE to RE Delay	tCLR	10		
CE Access Time	tCEA	-	45	

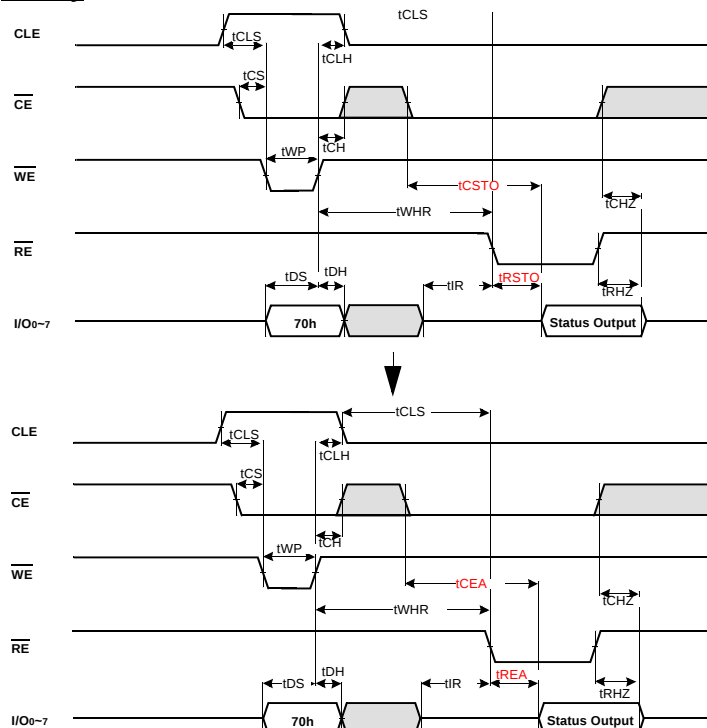


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Revision History

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- 0.3 1. Eliminated the duplicated AC parameter.
- AC characteristics (Before)
. Replaced tAR1,tAR2 with tAR

Feb. 9th 2002 Final

Parameter	Symbol	Min	Max	Unit
ALE to $\overline{\text{RE}}$ Delay (ID read)	tAR1	50	-	ns
ALE to $\overline{\text{RE}}$ Delay (Read cycle)	tAR2	50	-	
CLE to $\overline{\text{RE}}$ Delay	tCLR	10		
CE Access Time	tCEA	-	45	

- AC characteristics (After)

Parameter	Symbol	Min	Max	Unit
ALE to $\overline{\text{RE}}$ Delay	tAR	10	-	ns
CLE to $\overline{\text{RE}}$ Delay	tCLR	10		
CE Access Time	tCEA	-	45	

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64MB & 128MB SmartMedia™ Card

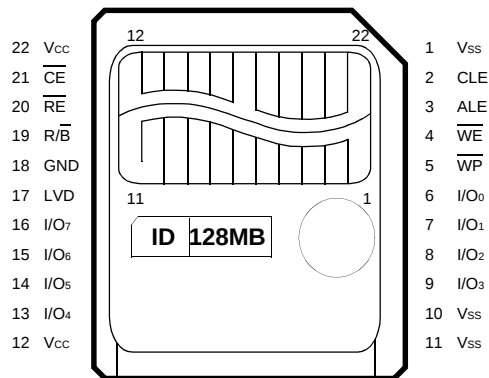
FEATURES

- Single 2.7V~3.6V Supply
- Organization
 - Memory Cell Array :
 - K9S1208V0X: (64M + 2,048K)bit x 8bit
 - K9D1G08V0X: (128M + 4,096K)bit x 8bit
 - Data Register : (512 + 16)bit x 8bit
- Automatic Program and Erase
 - Page Program : (512 + 16)Byte
 - * Multi Page Program : 2K Bytes
 - Block Erase : (16K + 512)Byte
- 528-Byte Page Read Operation
 - Random Access : 12μs(Max.)
 - Serial Page Access : 50ns(Min.)
- Fast Write Cycle Time
 - Program Time : 200μs(Typ.)
 - Block Erase Time : 2ms(Typ.)
- Command/Address/Data Multiplexed I/O Port
- Hardware Data Protection
 - Program/Erase Lockout During Power Transitions
- Reliable CMOS Floating-Gate Technology
 - Endurance : 100K Program/Erase Cycles
 - Data Retention : 10 Years
- Command Register Operation
- 22pad SmartMedia™(SSFDC)
- Unique ID for Copyright Protection

GENERAL DESCRIPTION

Using Nand flash memory, SmartMedia provides the most cost-effective solution for the solid state mass storage market. A program operation is implemented by the single page of 528 bytes in typical 200μs and an erase operation is done by the single block of 16K bytes in typical 2ms. Data in the page can be read out at 50ns cycle time per byte. The I/O pins serve as the ports for address and data input/output as well as command inputs. The on-chip write controller automates all program and erase functions including pulse repetition, where required, and internal verification and margining of data. Even the write-intensive systems can take advantage of the K9D1G08V0X, K9S1208V0X's extended reliability of 100K program/erase cycles by providing ECC(Error Correcting Code) with real time mapping-out algorithm. SmartMedia is an optimum solution for large nonvolatile storage applications such as solid state file storage, digital voice recorder, digital still camera and other portable applications requiring non-volatility.

SmartMedia™ CARD(SSFDC)



22 PAD SmartMedia™

PIN DESCRIPTION

Pin Name	Pin Function
I/O0 ~ I/O7	Data Input/Outputs
CLE	Command Latch Enable
ALE	Address Latch Enable
CE	Chip Enable
RE	Read Enable
WE	Write Enable
WP	Write Protect
LVD	Low Voltage Detect
GND	Ground
R/B	Ready/Busy output
Vcc	Power
Vss	Ground
N.C	No Connection

NOTE : Connect all Vcc and Vss pins of each device to common power supply outputs and do not leave Vcc or Vss disconnected. The pin 17(LVD) is used to detect 5V or 3.3V product electrically. Please, refer to the SmartMedia Application note for detail.

Figure 1. FUNCTIONAL BLOCK DIAGRAM

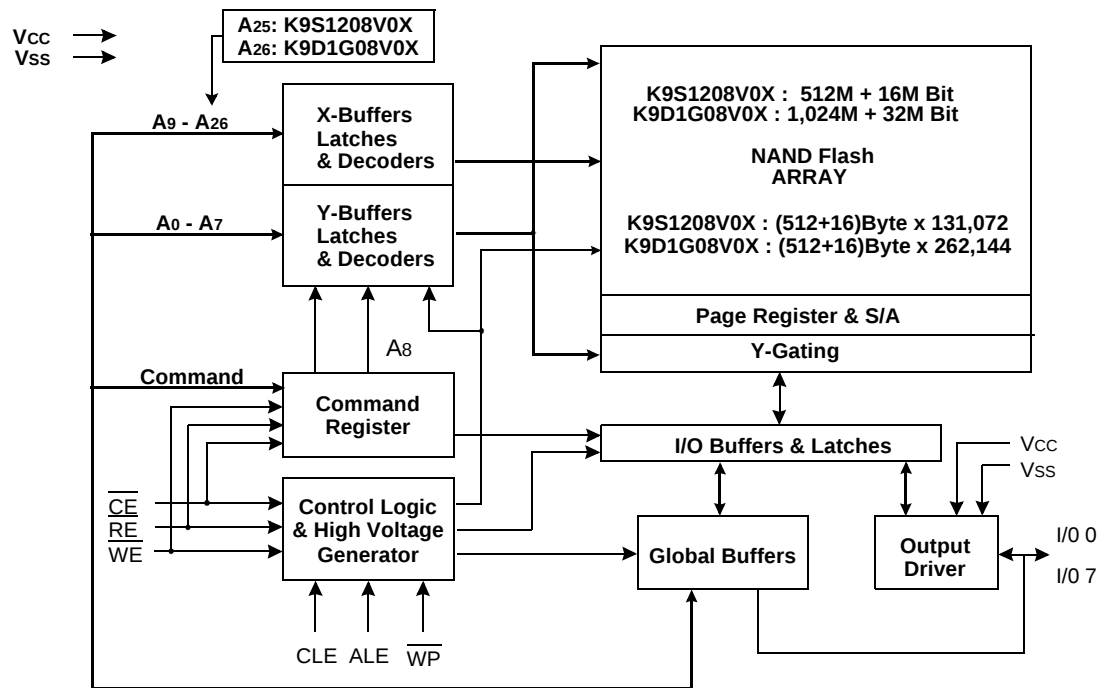
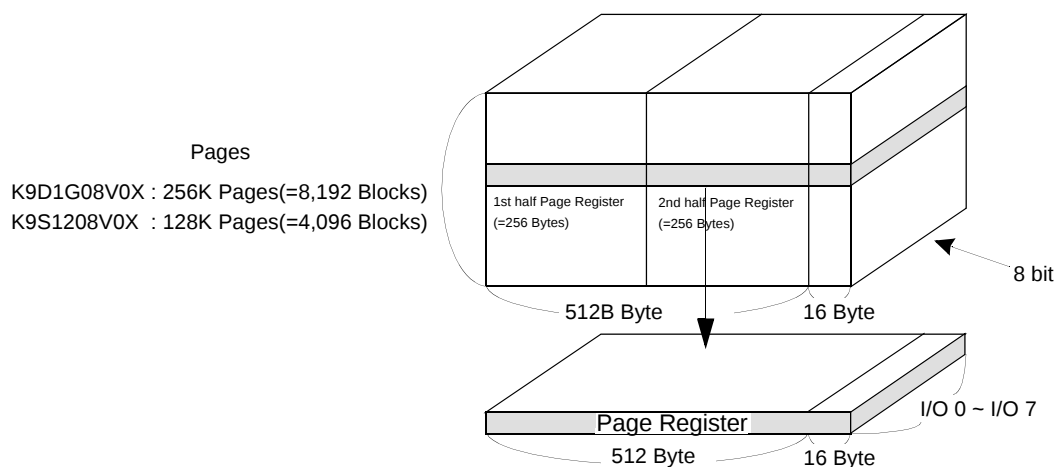


Figure 2. ARRAY ORGANIZATION



ARRAY ORGANIZATION

	1 Page	1 Block	1 Device
K9D1G08V0X	528 Byte	528 Byte x 32 Pages	528Byte x 32Pages x 8,192 Blocks
K9S1208V0X	528 Byte	528 Byte x 32 Pages	528Byte x 32Pages x 4,096 Blocks

NOTE : Column Address : Starting Address of the Register.

	I/O 0	I/O 1	I/O 2	I/O 3	I/O 4	I/O 5	I/O 6	I/O 7	
1st Cycle	A0	A1	A2	A3	A4	A5	A6	A7	Column Address
2nd Cycle	A9	A10	A11	A12	A13	A14	A15	A16	Row Address
3rd Cycle	A17	A18	A19	A20	A21	A22	A23	A24	(Page Address)
4th Cycle	A25	A26	*L	*L	*L	*L	*L	*L	

00h Command (Read) : Defines the starting address of the 1st half of the register.

01h Command (Read) : Defines the starting address of the 2nd half of the register.

A25: K9S1208V0X should be designated up to A25, address A26 must be set to "Low".

A26: K9D1G08V0X should be designated up to A26.

* A8 is set to "Low" or "High" by the 00h or 01h Command.

* "L" must be set to "Low".

* The device ignores any additional input of address cycles than required.

Product Introduction

The SmartMedia has the memory organization as following Table1. Spare sixteen columns are located from column address of 512 to 527. A 528-byte data register is connected to memory cell arrays and is accommodating data-transfer between the I/O buffers and memory cell arrays during page read and page program operations. The memory array is made up of 16 cells that are serially connected to form a NAND structure. Each of the 16 cells resides in a different page. A block consists of the 32 pages formed by two 16 cell memory array. The array organization is shown in Figure 2. The program and the read operations are executed on a page basis, while the erase operation is executed on a block basis.

The SmartMedia has addresses multiplexed into 8 I/O's. This scheme dramatically reduces pin counts and allows system upgrade to future densities by maintaining consistency in system board design. Command, address and data are all written through I/O's by bringing WE to low while CE is low. Data is latched on the rising edge of WE. Command Latch Enable(CLE) and Address Latch Enable(ALE) are used to multiplex command and address respectively, via the I/O pins. The 128M byte and 64M byte physical space requires 26 and 25 addresses, thereby requiring four cycles for byte-level addressing; column address, row address, in that order. Page Read and Page Program need the same four address cycles following the required command input. In Block Erase operation, however, only the three row address cycles are used. Device operations are selected by writing specific commands into the command register. Table 2 defines the specific commands of the SmartMedia.

The device provides simultaneous program/erase capability up to four pages/blocks. By dividing the memory array into eight 128Mbit separate planes, simultaneous multi-plane operation dramatically increases program/erase performance by 4X while still maintaining the conventional 512 byte structure.

The extended pass/fail status for multi-plane program/erase allows system software to quickly identify the failing page/block out of selected multiple pages/blocks. Usage of multi-plane operations will be described further throughout this document.

Table 1. MEMORY ORGANIZATION

	Memory Organization	Number of rows(Pages)	Number of columns
K9S1208V0X	528Mbit (553,648,218 bit)	131,072 rows	528 columns
K9D1G08V0X	1,056M bit (1,107,296,436 bit)	262,144 rows	528 columns

Table2. Command Sets

Function	1st. Cycle	2nd. Cycle	3rd. Cycle	Acceptable Command during
Read 1	00h/01h ⁽¹⁾	-	-	
Read 2	50h	-	-	
Read ID	90h	-	-	
Reset	FFh	-	-	O
Page Program (True)	80h	10h	-	
Page Program (Dummy)	80h	11h	-	
Page Program (Multi Block Program)	80h	15h	-	
Block Erase	60h	D0h	-	
Multi-Plane Block Erase	60h---60h	D0h	-	
Read Status	70h	-	-	O
Read Multi-Plane Status	71h ⁽²⁾	-	-	O

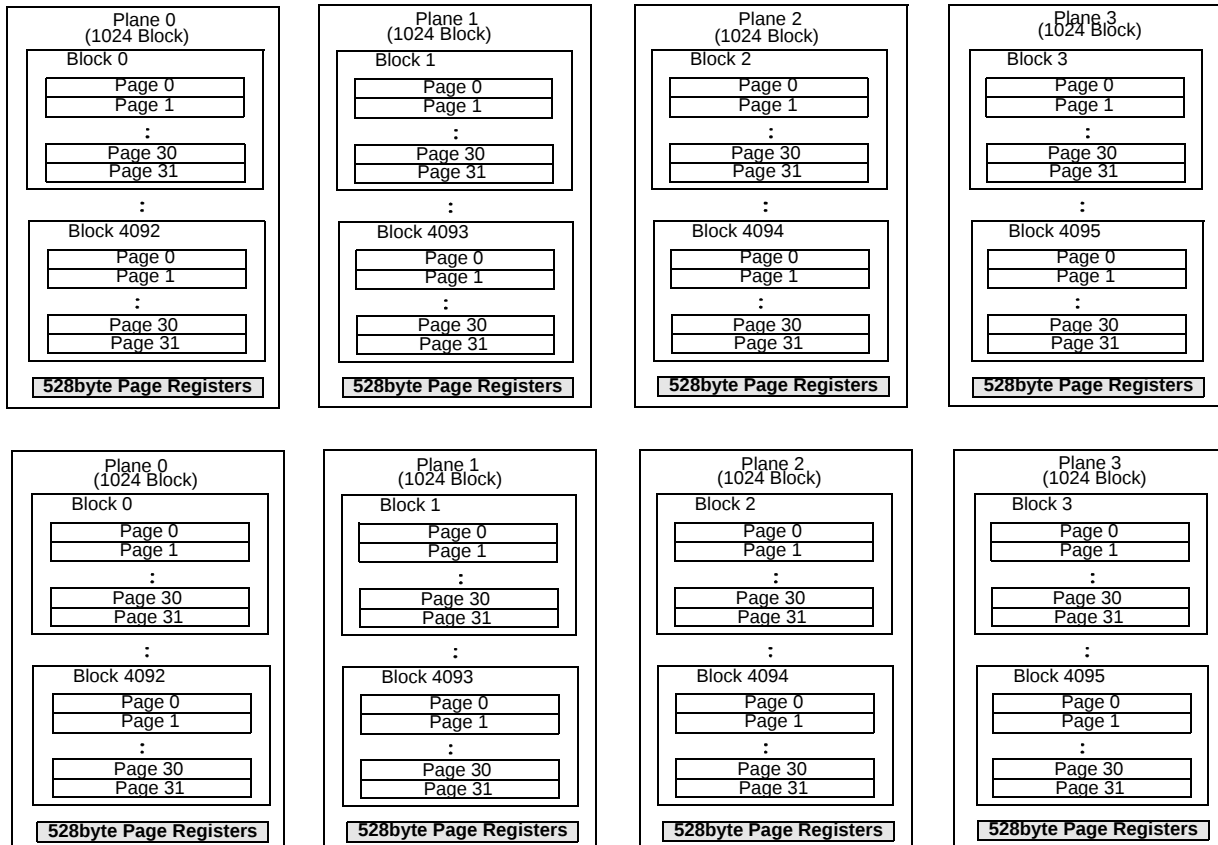
NOTE : 1. The 00h command defines starting address of the 1st half of registers. The 01h command defines starting address of the 2nd half of registers. After data access on the 2nd half of register by the 01h command, the address pointer is automatically moved to the 1st half register(00h) on the next cycle.

2. Any undefind commands are prohibited, which are not mentioned above command set table.

Figure 3. Memory Array Map

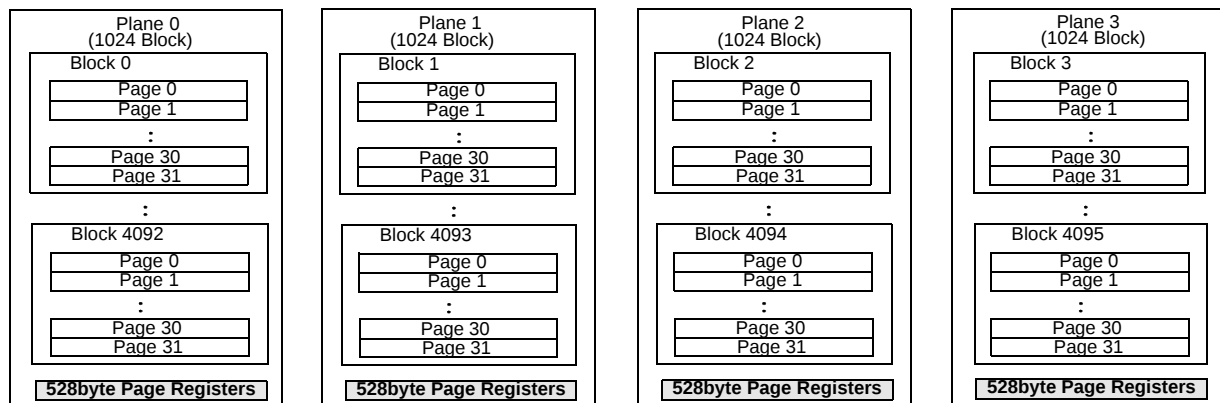
K9D1G08V0X-SSB0

The device is arranged in eight 128Mbit memory planes. Each plane contains 1,024 blocks and 528 byte page registers. This allows it to perform simultaneous page program and block erase by selecting one page or block from each plane. The block address map is configured so that multi-plane program/erase operations can be executed for every four sequential blocks by dividing the memory array into plane 0~3 or plane 4~7 separately. For example, multi-plane program/erase operations into plane 2,3,4 and 5 are prohibited.



*** K9S1208V0X-SSB0**

The device is arranged in four 128Mbit memory planes. Each plane contains 1,024 blocks and 528 byte page registers. This allows it to perform simultaneous page program and block erase by selecting one page or block from each plane. The block address map is configured so that multi-plane program/erase operations can be executed for every four sequential blocks.



PIN DESCRIPTION

Command Latch Enable(CLE)

The CLE input controls the path activation for commands sent to the command register. When active high, commands are latched into the command register through the I/O ports on the rising edge of the WE signal.

Address Latch Enable(ALE)

The ALE input controls the activating path for address to the internal address registers. Addresses are latched on the rising edge of WE with ALE high.

Chip Enable($\overline{\text{CE}}$)

The $\overline{\text{CE}}$ input is the device selection control. When $\overline{\text{CE}}$ goes high during a read operation the device is returned to standby mode. However, when the device is in the busy state during program or erase, $\overline{\text{CE}}$ high is ignored and does not return the device to standby mode.

Write Enable($\overline{\text{WE}}$)

The $\overline{\text{WE}}$ input controls writing to the I/O port. Commands, address and data are latched on the rising edge of the $\overline{\text{WE}}$ pulse.

Read Enable($\overline{\text{RE}}$)

The $\overline{\text{RE}}$ input is the serial data-out control, and when active drives the data onto the I/O bus.

I/O Port : I/O 0 ~ I/O 7

The I/O pins are used to input command, address and data, and to output data during read operations. The I/O pins float to high-z when the chip is deselected or when the outputs are disabled.

Write Protect($\overline{\text{WP}}$)

The $\overline{\text{WP}}$ pin provides inadvertent write/erase protection during power transitions. The internal high voltage generator is reset when the $\overline{\text{WP}}$ pin is active low.

Ready/Busy($\overline{\text{R/B}}$)

The $\overline{\text{R/B}}$ output indicates the status of the device operation. When low, it indicates that a program, erase or random read operation is in process and returns to high state upon completion. It is an open drain output and does not float to high-z condition when the chip is deselected or when outputs are disabled.

Low Voltage Detect(LVD)

The LVD is used to detect the proper supply voltage electrically. By connecting this pin to Vss through a pull-down resistor, it is possible to distinguish 3.3V product from 5V product. When 3.3V is applied as Vcc to pins 12 and 22, a 'High' level can be detected on the system side if the device is a 3.3V product, and 'Low' level for 5V product.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Voltage on any pin relative to Vss	V _{IN}	-0.6 to + 4.6	V
	V _{CC}	-0.6 to + 4.6	
Temperature Under Bias	T _{BIAS}	-10 to +65	°C
Storage Temperature	T _{STG}	-20 to +65	°C

NOTE :

1. Minimum DC voltage is -0.3V on input/output pins. During transitions, this level may undershoot to -2.0V for periods <30ns.
Maximum DC voltage on input/output pins is V_{CC}+0.3V which, during transitions, may overshoot to V_{CC}+2.0V for periods <20ns.
2. Permanent device damage may occur if ABSOLUTE MAXIMUM RATINGS are exceeded. Functional operation should be restricted to the conditions as detailed in the operational sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

RECOMMENDED OPERATING CONDITIONS

(Voltage reference to GND, T_A=0 to 55°C)

Parameter	Symbol	Min	Typ.	Max	Unit
Supply Voltage	V _{CC}	2.7	3.3	3.6	V
Supply Voltage	V _{SS}	0	0	0	V

DC AND OPERATING CHARACTERISTICS(Recommended operating conditions otherwise noted.)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Operating Current	Sequential Read	I _{CC1}	t _{RC} =50ns, $\overline{CE}=V_{IL}$, I _{OUT} =0mA	-	10	30	mA
	Program	I _{CC2}	-	-	10	30	
	Erase	I _{CC3}	-	-	10	30	
Stand-by Current(TTL)		I _{SB1}	$\overline{CE}=V_{IH}$, $\overline{WP}=0V/V_{CC}$	-	-	1	μA
Stand-by Current(CMOS)		I _{SB2}	$\overline{CE}=V_{CC}-0.2$, $\overline{WP}=0V/V_{CC}$	-	10	50	
Input Leakage Current		I _{LI}	V _{IN} =0 to 3.6V	-	-	±10	
Output Leakage Current		I _{LO}	V _{OUT} =0 to 3.6V	-	-	±10	
Input High Voltage, All inputs		V _{IH}	-	2.0	-	V _{CC} +0.3	V
Input Low Voltage, All inputs		V _{IL}	-	-0.3	-	0.8	
Output High Voltage Level		V _{OH}	I _{OH} =-400μA	2.4	-	-	
Output Low Voltage Level		V _{OL}	I _{OL} =2.1mA	-	-	0.4	
Output Low Current(R/B)		I _{OL} (R/B)	V _{OL} =0.4V	8	10	-	mA

VALID BLOCK

Parameter		Symbol	Min	Typ.	Max	Unit
Valid Block Number	K9D1G08V0X	NvB	8,052	-	8,192	Blocks
	K9S1208V0X	NvB	4,026	-	4,096	Blocks

1. The K9D1G08V0X, K9S1208V0X may include invalid blocks when first shipped. Additional invalid blocks may develop while being used. The number of valid blocks is presented with both cases of invalid blocks considered. Invalid blocks are defined as blocks that contain one or more bad bits. Do not erase or program factory-market bad blocks. Refer to the attached technical notes for an appropriate management of invalid blocks.
2. Per the specification of the physical format version 1.2 by SSFDC forum, minimum 1,000 valid blocks are guaranteed for each 16MB memory space.

AC TEST CONDITION

(TA=0 to 55°C, VCC=2.7V~3.6V unless otherwise noted)

Parameter	Value
Input Pulse Levels	0.4V to 2.4V
Input Rise and Fall Times	5ns
Input and Output Timing Levels	1.5V
Output Load (3.0V +/-10%)	1 TTL GATE and CL=50pF
Output Load (3.3V +/-10%)	1 TTL GATE and CL=100pF

CAPACITANCE(TA=25°C, VCC=3.3V, f=1.0MHz)

Item	Symbol	Test Condition	Min	Max		Unit
				K9D1G08V0X	K9S1208V0X	
Input/Output Capacitance	C _{I/O}	V _{IL} =0V	-	20	10	pF
Input Capacitance	C _{IN}	V _{IN} =0V	-	20	10	pF

NOTE : Capacitance is periodically sampled and not 100% tested.

MODE SELECTION

CLE	ALE	CE	WE	RE	WP	Mode	
H	L	L		H	X	Read Mode	Command Input
L	H	L		H	X		Address Input(4clock)
H	L	L		H	H	Write Mode	Command Input
L	H	L		H	H		Address Input(4clock)
L	L	L		H	H	Data Input	
L	L	L	H		X	sequential Read & Data Output	
X	X	L	X	X	X	During Read(Busy)	
X	X	X	X	X	H	During Program(Busy)	
X	X	X	X	X	H	During Erase(Busy)	
X	X ⁽¹⁾	X	X	X	L	Write Protect	
X	X	H	X	X	0V/VCC ⁽²⁾	Stand-by	

NOTE : 1. X can be V_{IL} or V_{IH}.

2. WP should be biased to CMOS high or CMOS low for standby.

Program / Erase Characteristics

Parameter	Symbol	Min	Typ	Max	Unit
Program Time	t _{PROG}	-	200	500	μs
Dummy Busy Time for Multi Plane Program	t _{DBSY}		1	10	μs
Number of Partial Program Cycles in the Same Page	Main Array	-	-	1	cycle
	Spare Array	-	-	2	cycles
Block Erase Time	t _{BERS}	-	2	3	ms

AC Timing Characteristics for Command / Address / Data Input

Parameter	Symbol	Min	Max	Unit
CLE setup Time	t _{CLS}	0	-	ns
CLE Hold Time	t _{CLH}	10	-	ns
$\overline{\text{CE}}$ setup Time	t _{CS}	0	-	ns
$\overline{\text{CE}}$ Hold Time	t _{CH}	10	-	ns
$\overline{\text{WE}}$ Pulse Width	t _{WP}	25 ⁽¹⁾	-	ns
ALE setup Time	t _{ALS}	0	-	ns
ALE Hold Time	t _{ALH}	10	-	ns
Data setup Time	t _{DS}	20	-	ns
Data Hold Time	t _{DH}	10	-	ns
Write Cycle Time	t _{WC}	50	-	ns
$\overline{\text{WE}}$ High Hold Time	t _{WH}	15	-	ns

NOTE : 1. If t_{CS} is set less than 10ns, t_{WP} must be minimum 35ns, otherwise, t_{WP} may be minimum 25ns.

AC Characteristics for Operation

Parameter	Symbol	Min	Max	Unit
Data Transfer from Cell to Register	t _R	-	10	μs
CLE to $\overline{\text{RE}}$ Delay	t _{CLR}	10	-	ns
ALE to $\overline{\text{RE}}$ Delay	t _{AR}	10	-	ns
Ready to $\overline{\text{RE}}$ Low	t _{RR}	20	-	ns
$\overline{\text{RE}}$ Pulse Width	t _{RP}	30	-	ns
$\overline{\text{WE}}$ High to Busy	t _{WB}	-	100	ns
Read Cycle Time	t _{RC}	50	-	ns
$\overline{\text{RE}}$ Access Time	t _{REA}	-	35	ns
$\overline{\text{RE}}$ High to Output Hi-Z	t _{RHZ}	15	30	ns
$\overline{\text{CE}}$ High to Output Hi-Z	t _{CHZ}	-	20	ns
$\overline{\text{RE}}$ High Hold Time	t _{REH}	15	-	ns
Output Hi-Z to $\overline{\text{RE}}$ Low	t _{IR}	0	-	ns
Last $\overline{\text{RE}}$ High to Busy(at sequential read)	t _{RB}	-	100	ns
$\overline{\text{CE}}$ High to Ready(in case of interception by $\overline{\text{CE}}$ at read)	t _{CRY}	-	50 + t _r (R/ $\overline{\text{B}}$) ⁽¹⁾	ns
$\overline{\text{CE}}$ High Hold Time(at the last serial read) ⁽²⁾	t _{CEH}	100	-	ns
$\overline{\text{WE}}$ High to $\overline{\text{RE}}$ Low	t _{WHR}	60	-	ns
Device Resetting Time(Read/Program/Erase)	t _{RST}	-	5/10/500 ⁽³⁾	μs

NOTE : 1. The time to Ready depends on the value of the pull-up resistor tied R/ $\overline{\text{B}}$ pin.
2. To break the sequential read cycle, $\overline{\text{CE}}$ must be held high for longer time than t_{CEH}.
3. If reset command(FFh) is written at Ready state, the device goes into Busy for maximum 5us.

SmartMedia Technical Notes

Invalid Block(s)

Invalid blocks are defined as blocks that contain one or more invalid bits whose reliability is not guaranteed by Samsung. The information regarding the invalid block(s) is so called as the invalid block information. An invalid block(s) does not affect the performance of valid block(s) because it is isolated from the bit line and the common source line by a select transistor. The system design must be able to mask out the invalid block(s) via address mapping.

Identifying Invalid Block(s)

SSFDC Forum specifies the logical format and physical format to ensure compatibility of SmartMedia. Samsung pre-formats SmartMedia in the Forum-compliant format prior to shipping. The physical format standard by SSFDC Forum specifies that invalid block information is written at the 6th byte of spare area in invalid blocks with two or more "0" bits, while valid blocks are erased(FFh). Since the invalid block information is also erasable in most cases, it is impossible to recover the information once it has been erased. Therefore, the system must be able to recognize the invalid block(s) based on the original invalid block information and create the invalid block table via the following suggested flow chart(Figure 4). Any intentional erasure of the original invalid block information is prohibited.

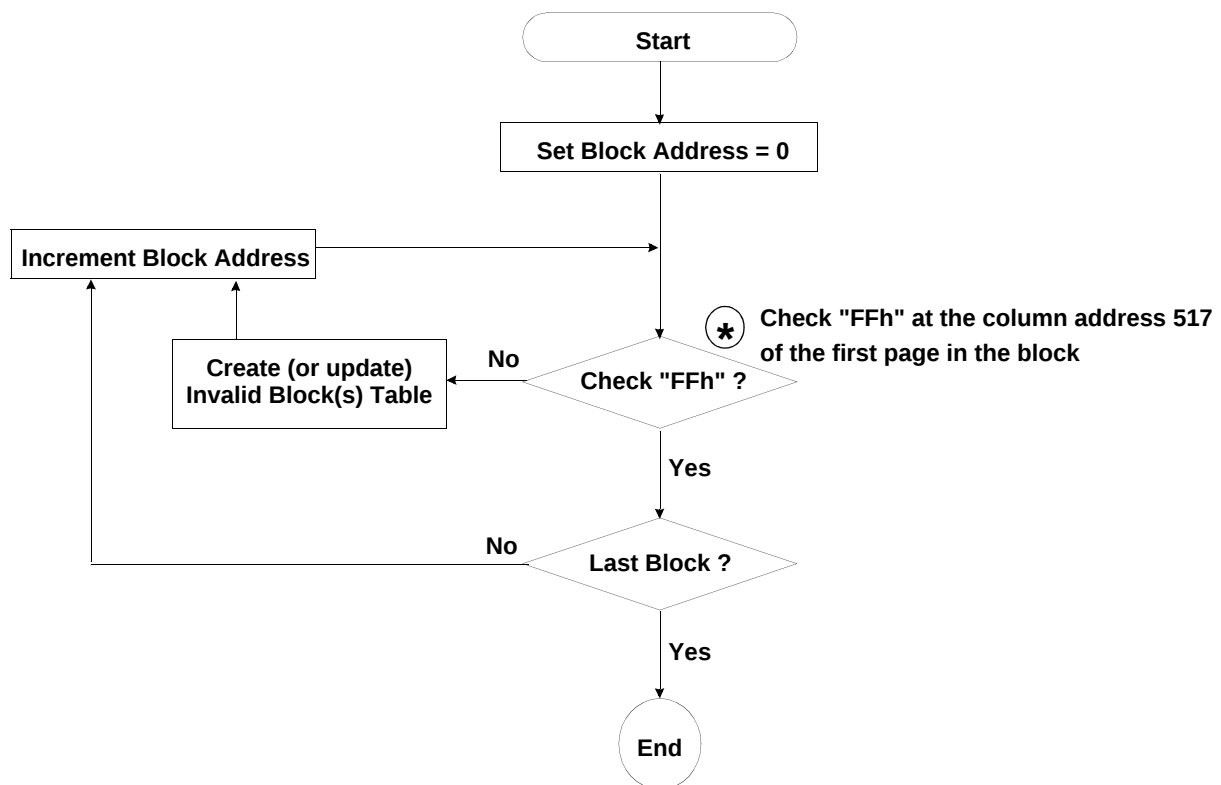


Figure 4. Flow chart to create invalid block table.

SmartMedia Technical Notes (Continued)

Error in write or read operation

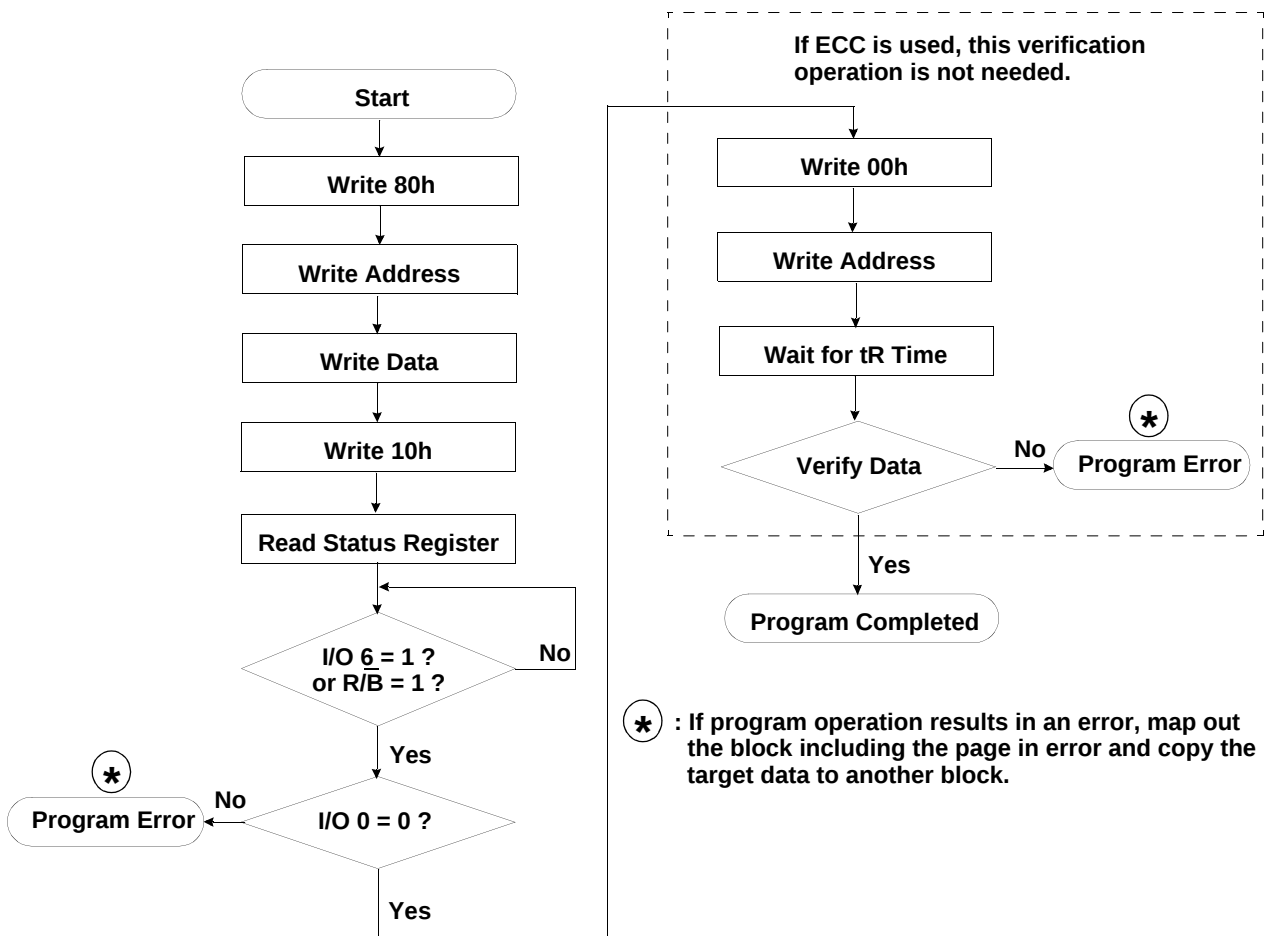
Over its life time, the additional invalid blocks may develop with NAND Flash memory. Refer to the qualification report for the actual data. The following possible failure modes should be considered to implement a highly reliable system. In the case of status read failure after erase or program, block replacement should be done. Because program status fail during a page program does not affect the data of the other pages in the same block, block replacement can be executed with a page-sized buffer by finding an erased empty block and reprogramming the current target data and copying the rest of the replaced block. To improve the efficiency of memory space, it is recommended that the read or verification failure due to single bit error be reclaimed by ECC without any block replacement. The said additional block failure rate does not include those reclaimed blocks.

Failure Mode		Detection and Countermeasure sequence
Write	Erase Failure	Status Read after Erase --> Block Replacement
	Program Failure	Status Read after Program --> Block Replacement Read back (Verify after Program) --> Block Replacement or ECC Correction
Read	Single Bit Failure	Verify ECC -> ECC Correction

ECC

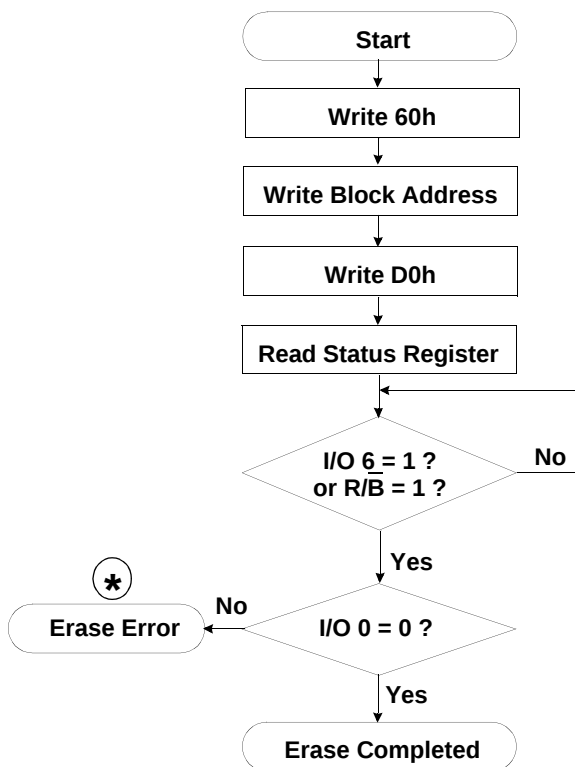
: Error Correcting Code --> Hamming Code etc.
Example) 1bit correction & 2bit detection

Program Flow Chart

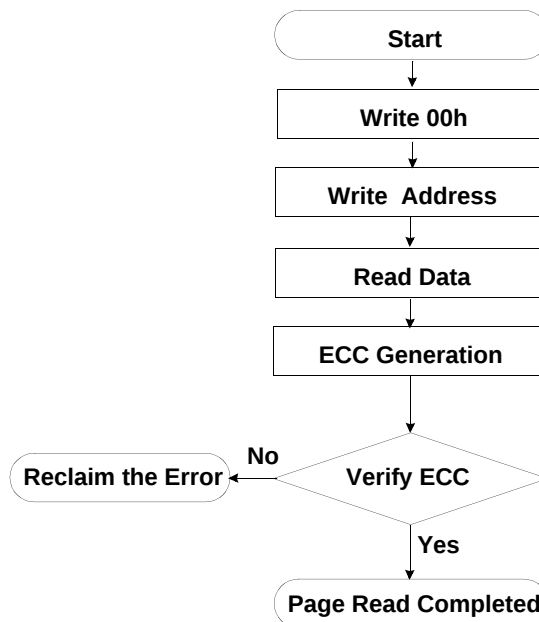


SmartMedia Technical Notes (Continued)

Erase Flow Chart

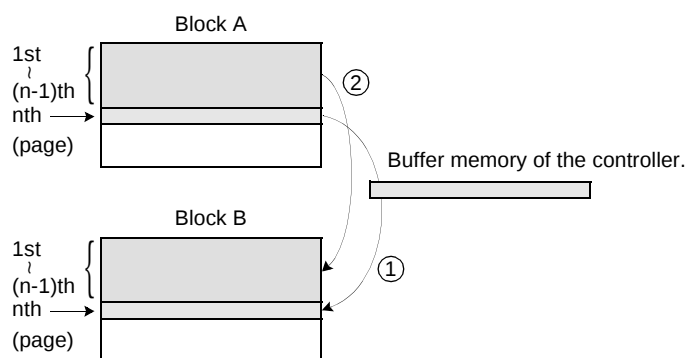


Read Flow Chart



* : If erase operation results in an error, map out the failing block and replace it with another block.

Block Replacement



* Step1

When an error happens in the nth page of the Block 'A' during the program operation.

* Step2

Copy the nth page data of the Block 'A' in the buffer memory to the nth page of another free block. (Block 'B')

* Step3

Then, copy the data in the 1st ~ (n-1)th page of the Block 'A' to the same location of the Block 'B'.

* Step4

Do not erase or program to Block 'A' by creating an 'invalid Block' table or using other appropriate scheme.

Pointer Operation of K9D1G08V0X, K9S1208V0X

Samsung NAND Flash has three address pointer commands as a substitute for the two most significant column addresses. '00h' command sets the pointer to 'A' area(0~255byte), '01h' command sets the pointer to 'B' area(256~511byte), and '50h' command sets the pointer to 'C' area(512~527byte). With these commands, the starting column address can be set to any of a whole page(0~527byte). '00h' or '50h' is sustained until another address pointer command is inputted. '01h' command, however, is effective only for one operation. After any operation of Read, Program, Erase, Reset, Power_Up is executed once with '01h' command, the address pointer returns to 'A' area by itself. To program data starting from 'A' or 'C' area, '00h' or '50h' command must be inputted before '80h' command is written. A complete read operation prior to '80h' command is not necessary. To program data starting from 'B' area, '01h' command must be inputted right before '80h' command is written.

Destination of the pointer

Command	Pointer position	Area
00h	0 ~ 255 byte	1st half array(A)
01h	256 ~ 511 byte	2nd half array(B)
50h	512 ~ 527 byte	spare array(C)

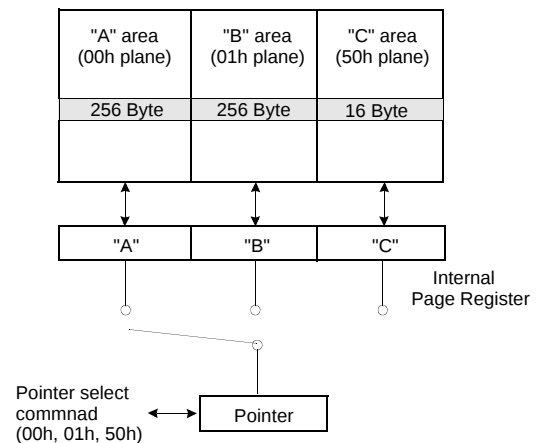
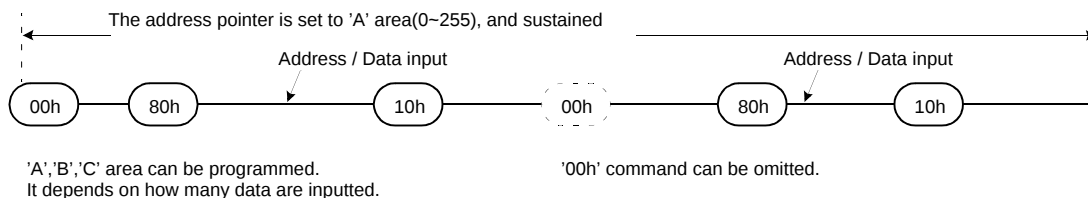
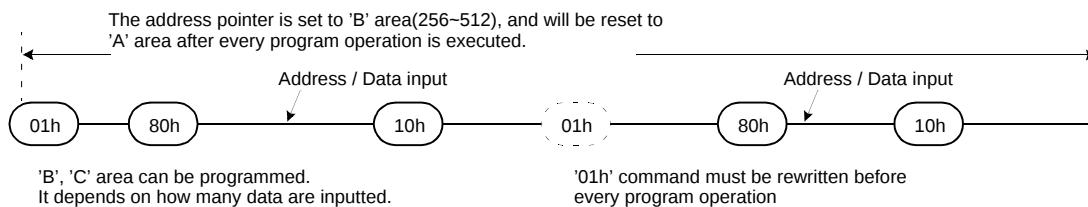


Figure 5. Block Diagram of Pointer Operation

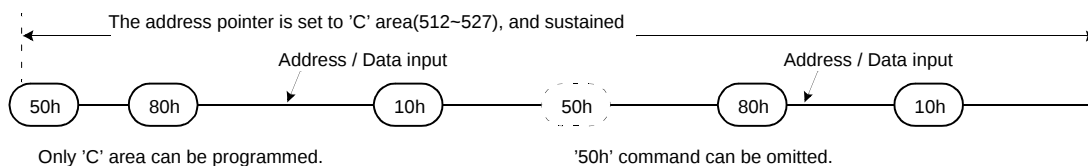
(1) Command input sequence for programming 'A' area



(2) Command input sequence for programming 'B' area



(3) Command input sequence for programming 'C' area



System Interface Using $\overline{\text{CE}}$ don't-care.

For an easier system interface, $\overline{\text{CE}}$ may be inactive during the data-loading or sequential read as shown below. The internal 528byte page registers are utilized as separate buffers for this operation and the system design gets more flexible. In addition, for voice or audio applications which use slow cycle time on the order of u-seconds, de-activating $\overline{\text{CE}}$ during the data-loading and reading would provide significant savings in power consumption.

Figure 6. Program Operation with $\overline{\text{CE}}$ don't-care.

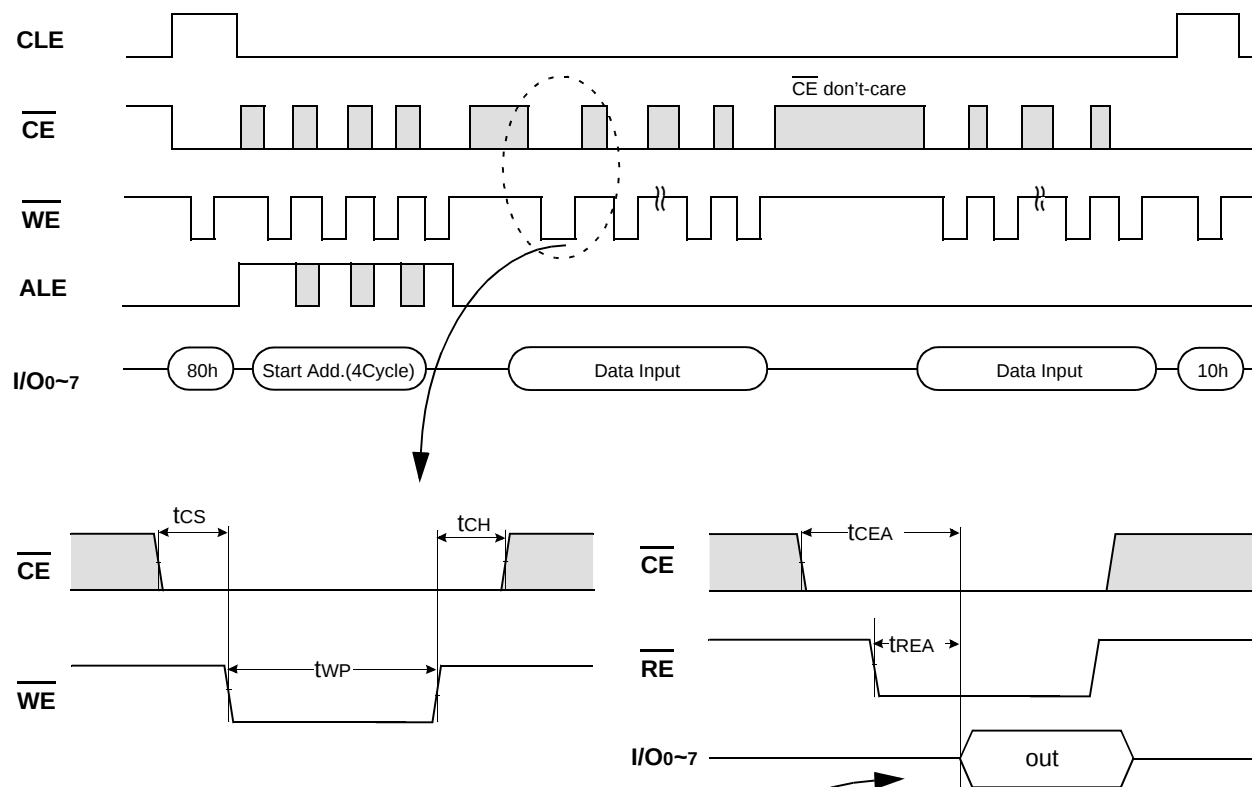
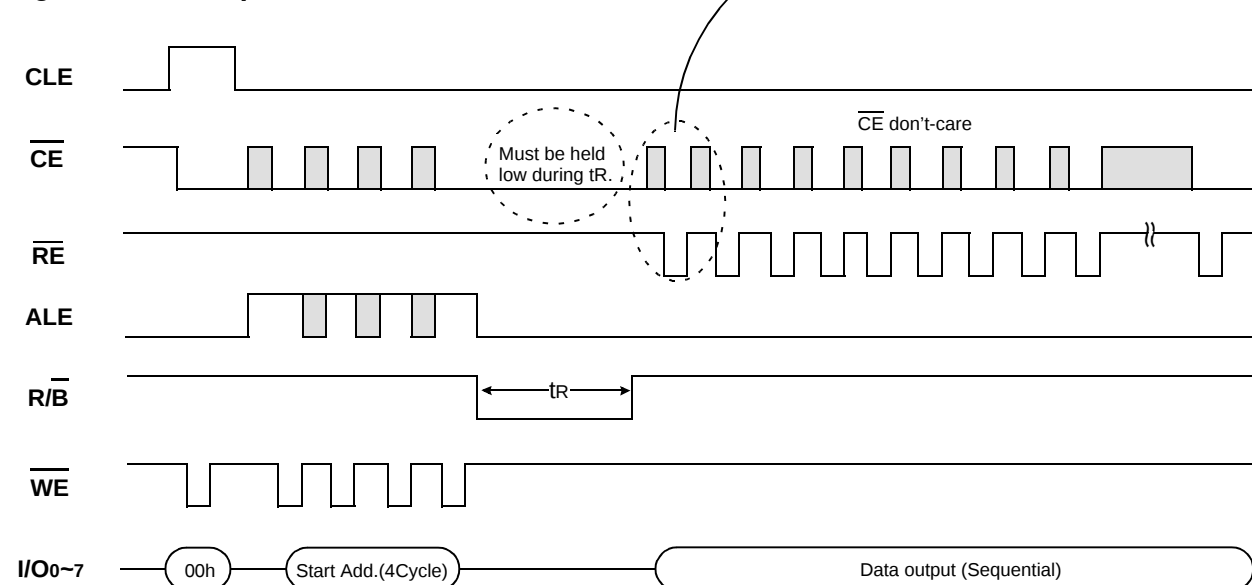
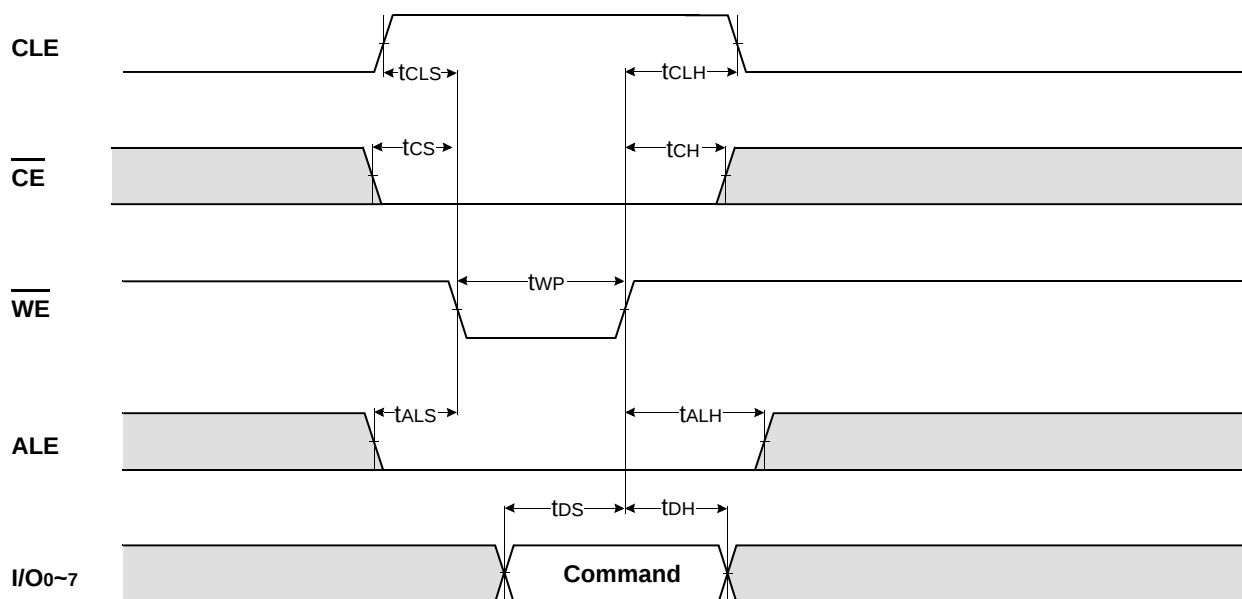


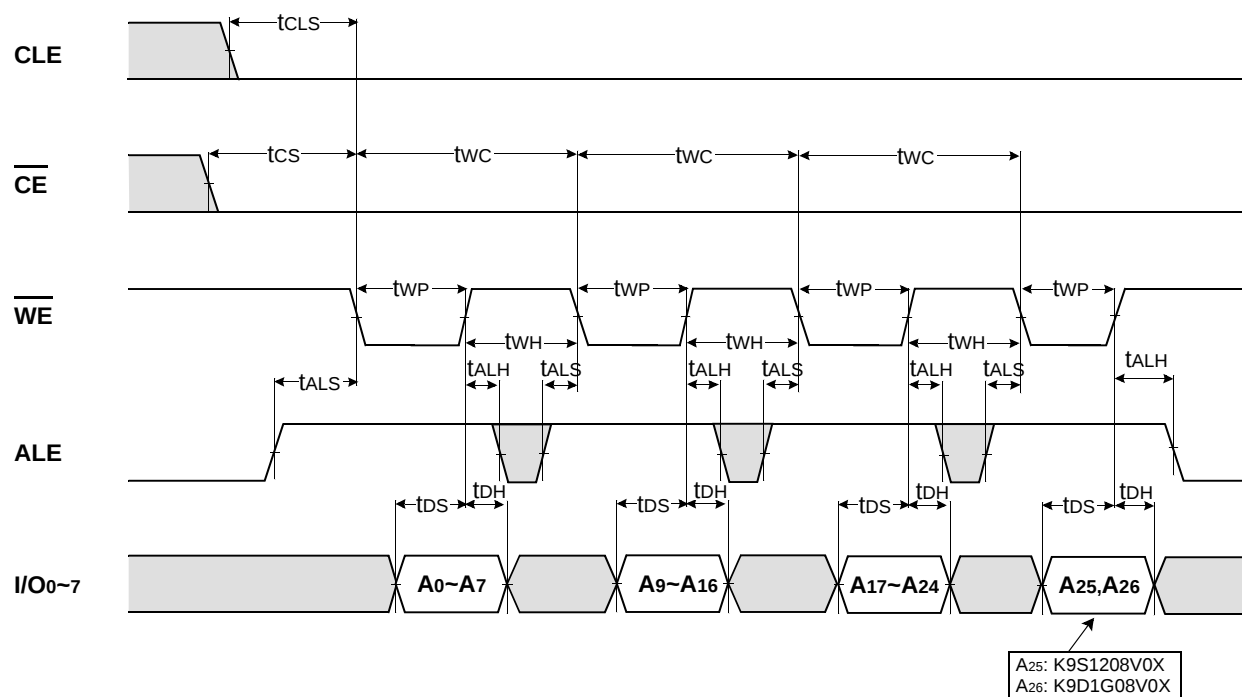
Figure 7. Read Operation with $\overline{\text{CE}}$ don't-care.



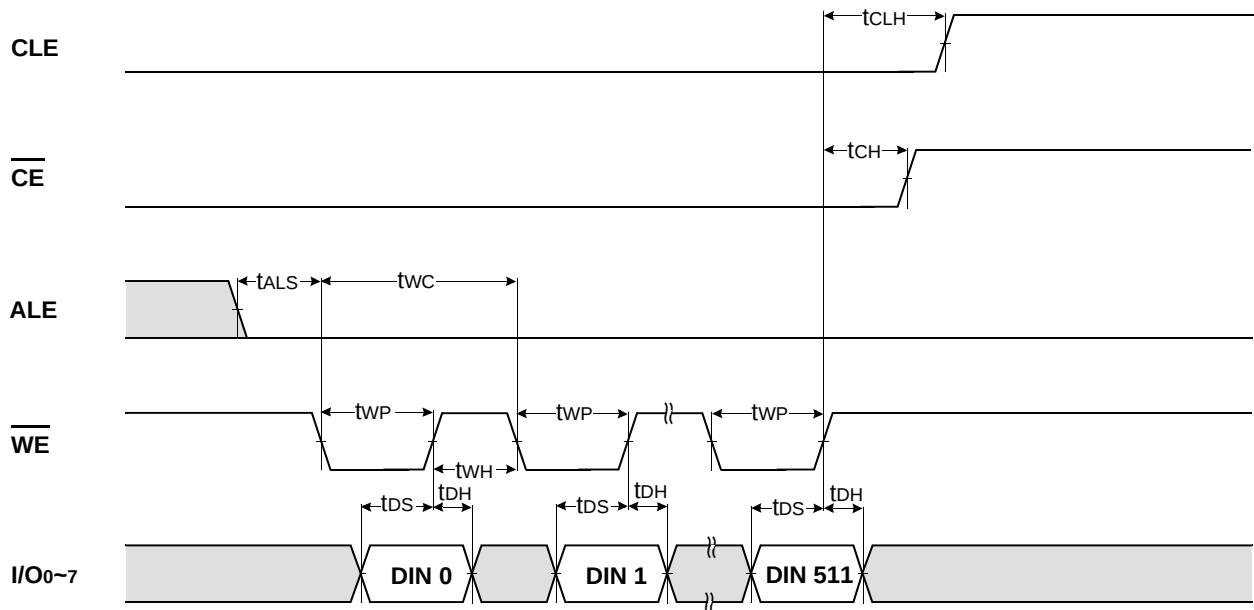
Command Latch Cycle



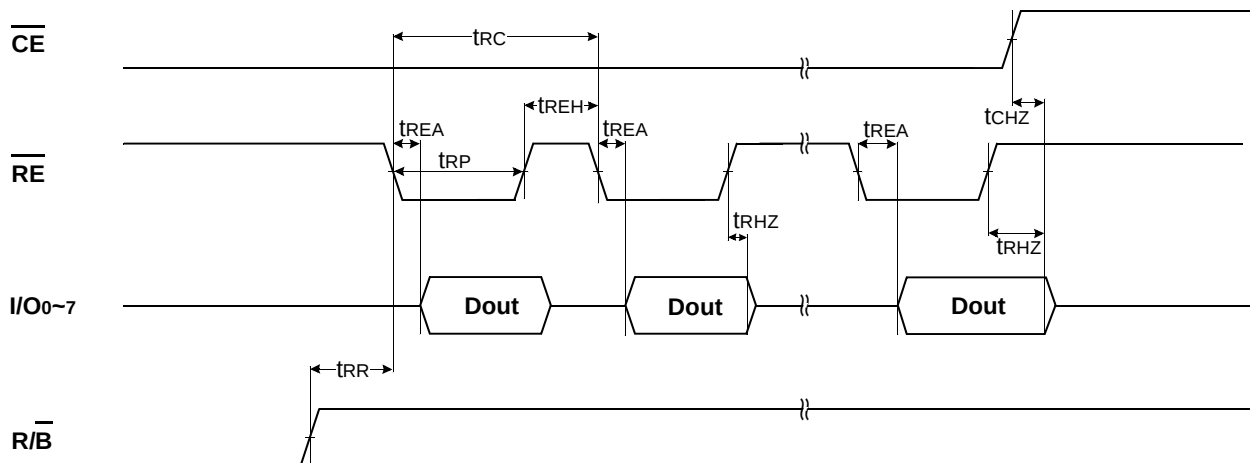
Address Latch Cycle



Input Data Latch Cycle

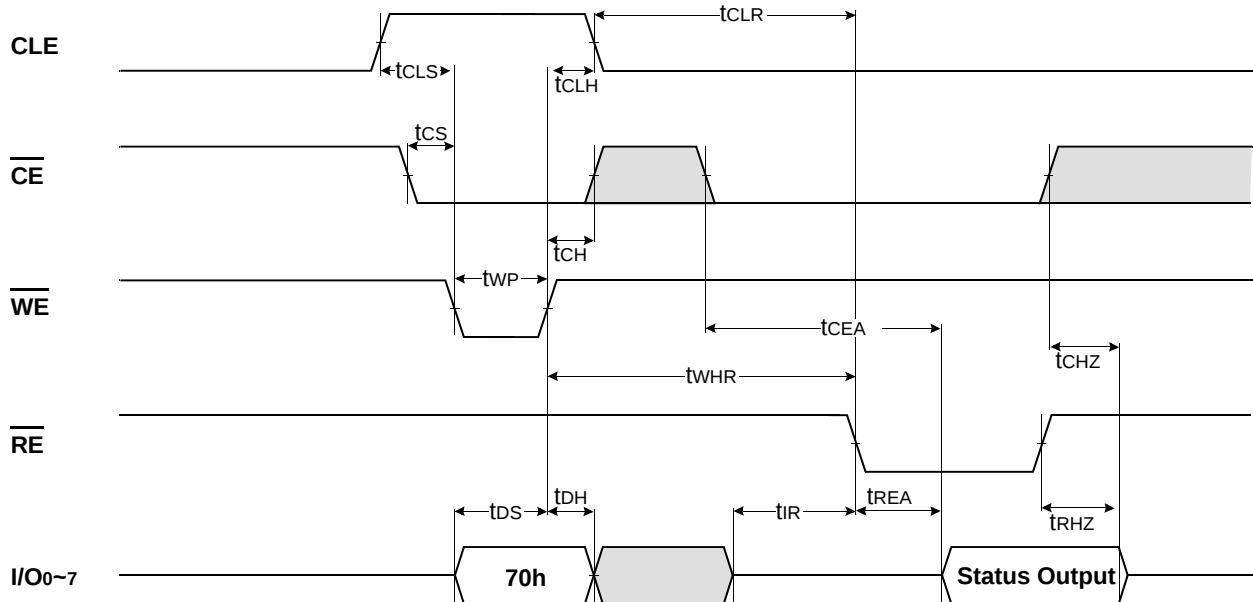


Serial Access Cycle after Read (CLE=L, $\overline{WE}$ =H, ALE=L)

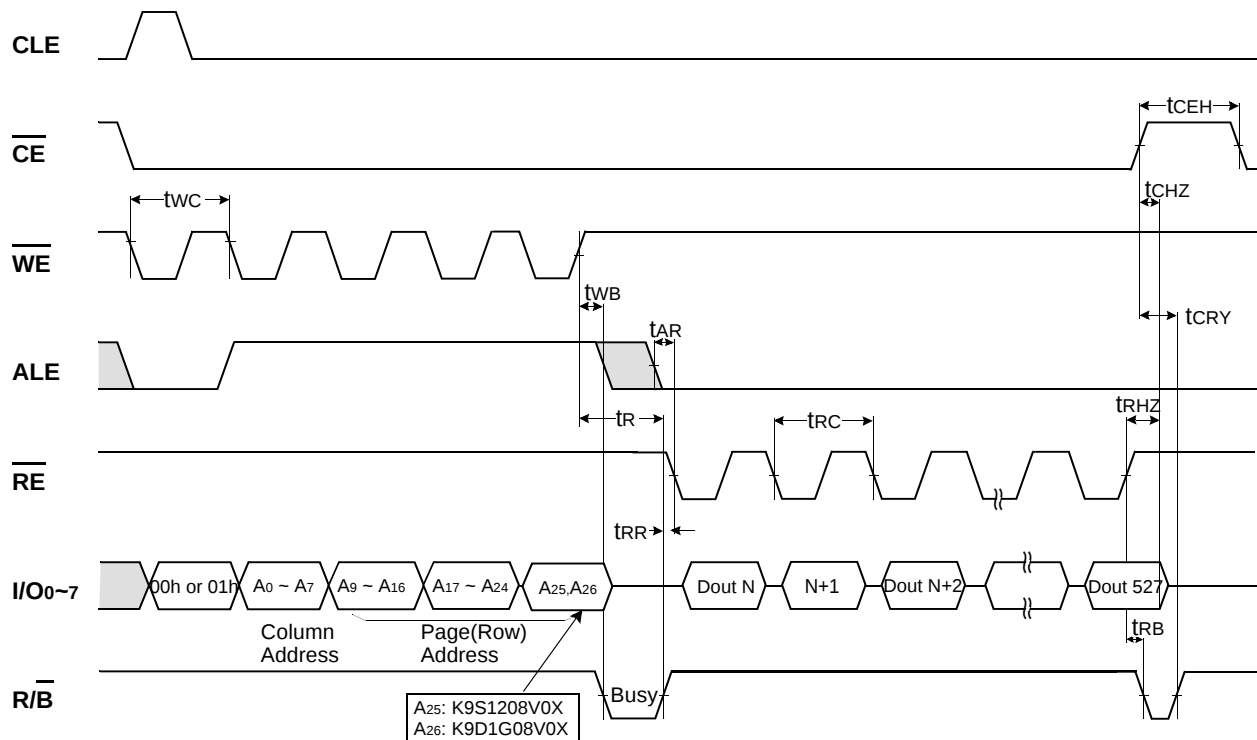


NOTES : Transition is measured $\pm 200\text{mV}$ from steady state voltage with load.
This parameter is sampled and not 100% tested.

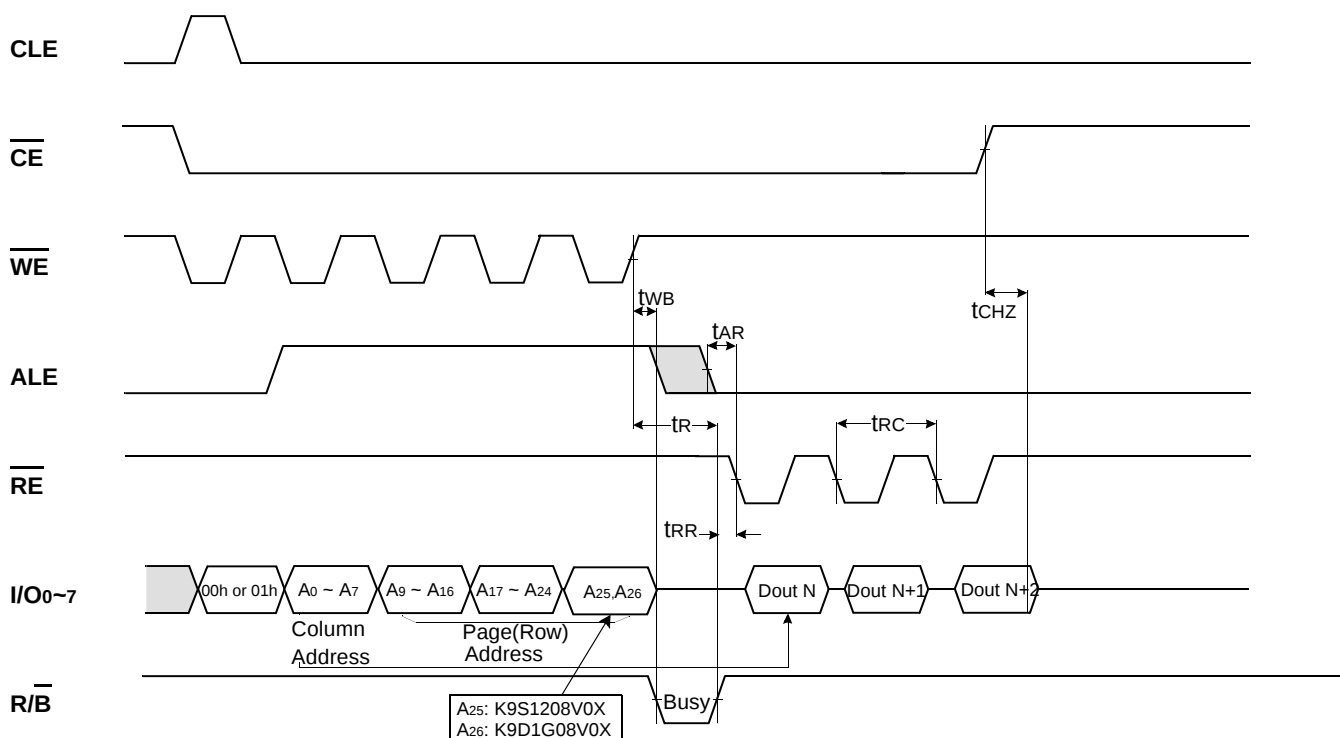
Status Read Cycle



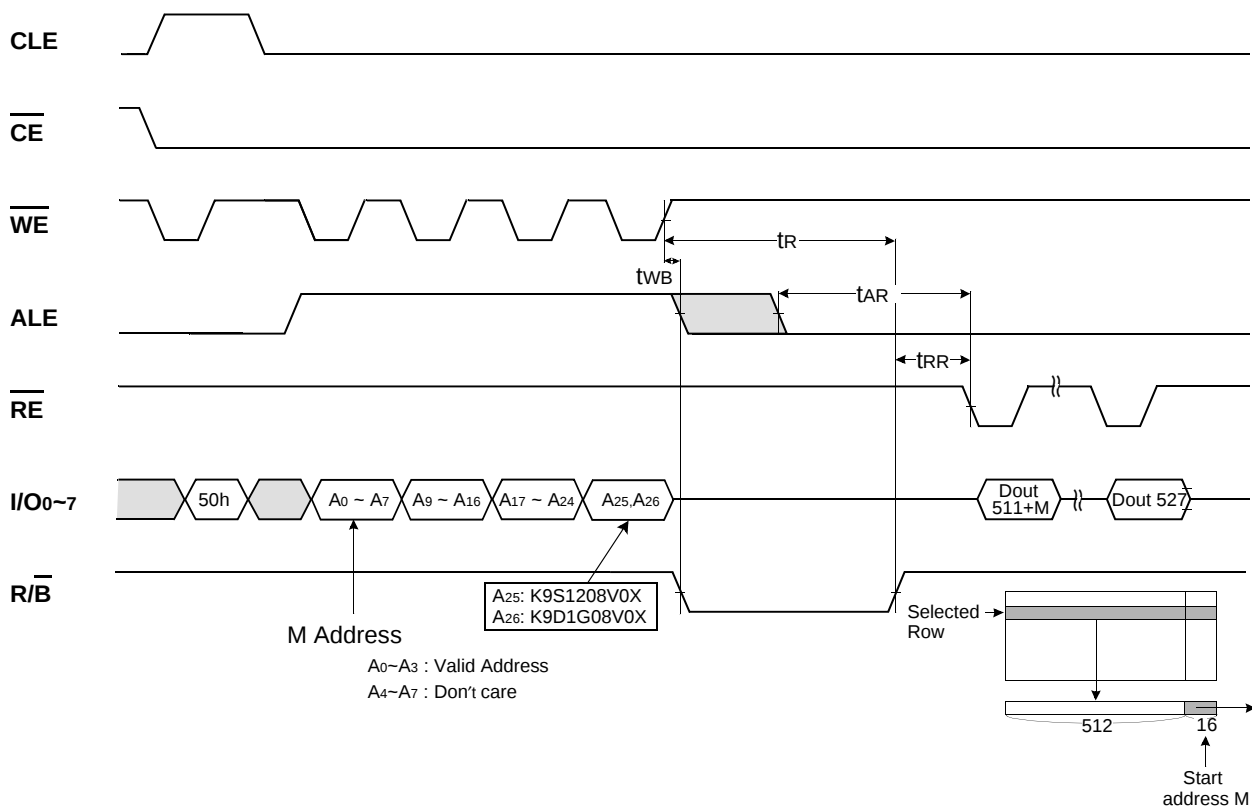
READ1 OPERATION(READ ONE PAGE)



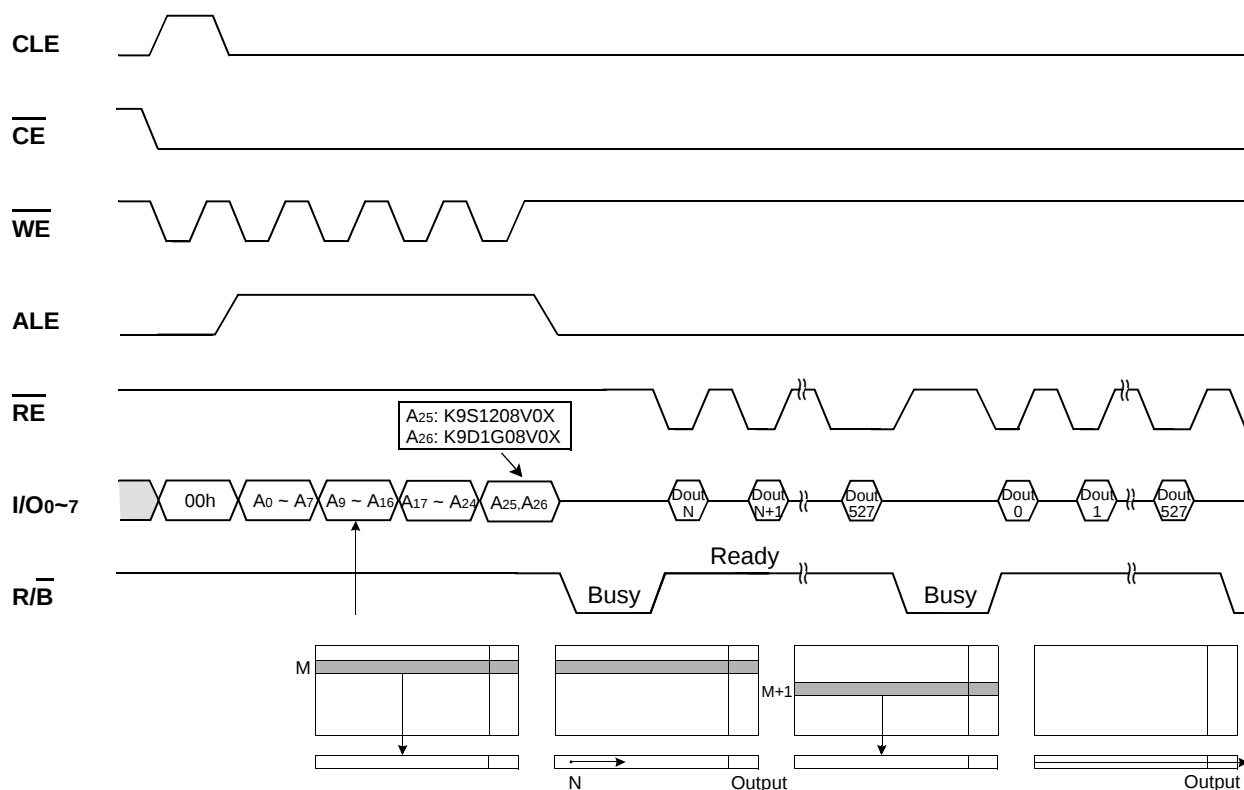
READ1 OPERATION (INTERCEPTED BY $\overline{\text{CE}}$)



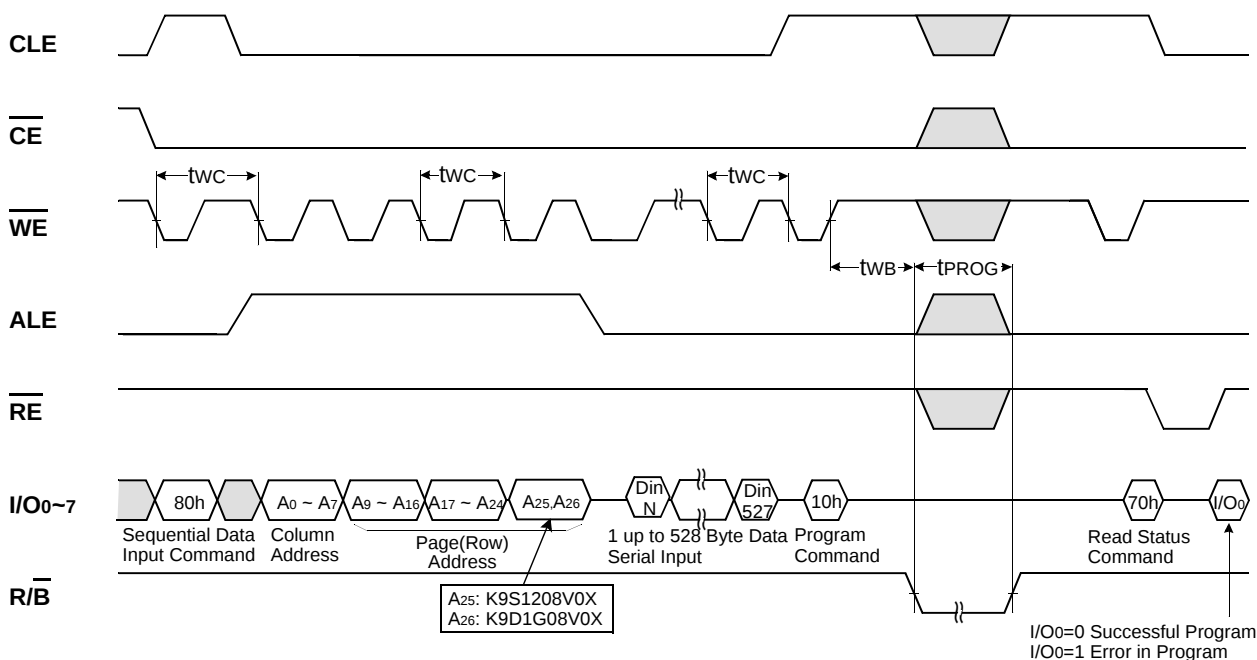
READ2 OPERATION (READ ONE PAGE)



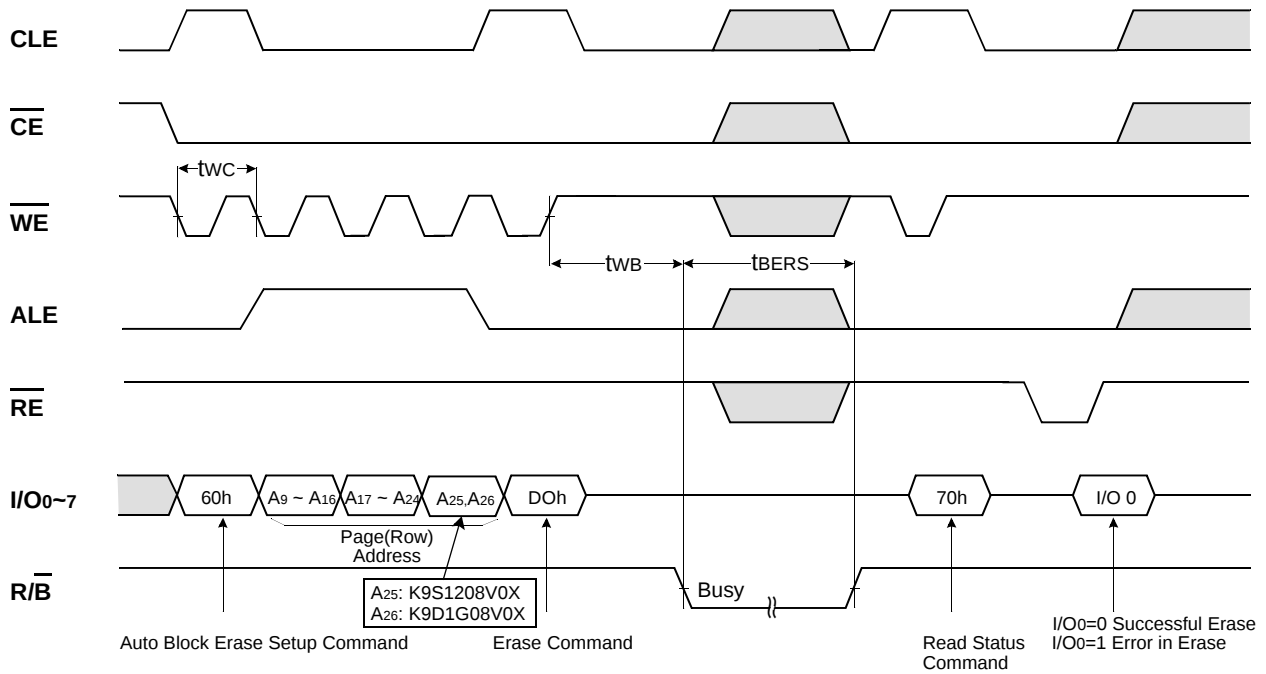
SEQUENTIAL ROW READ OPERATION (WITHIN A BLOCK)



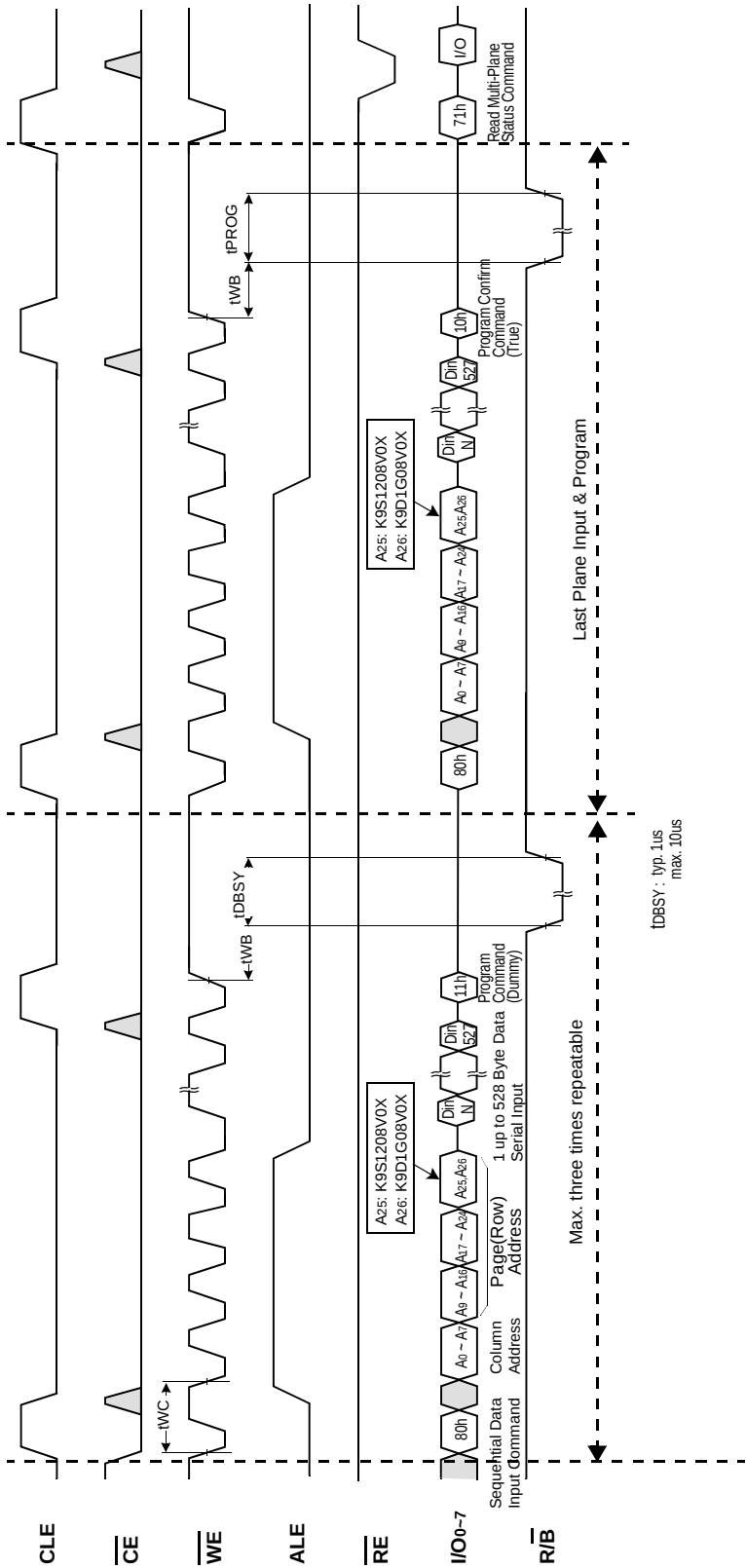
PAGE PROGRAM OPERATION



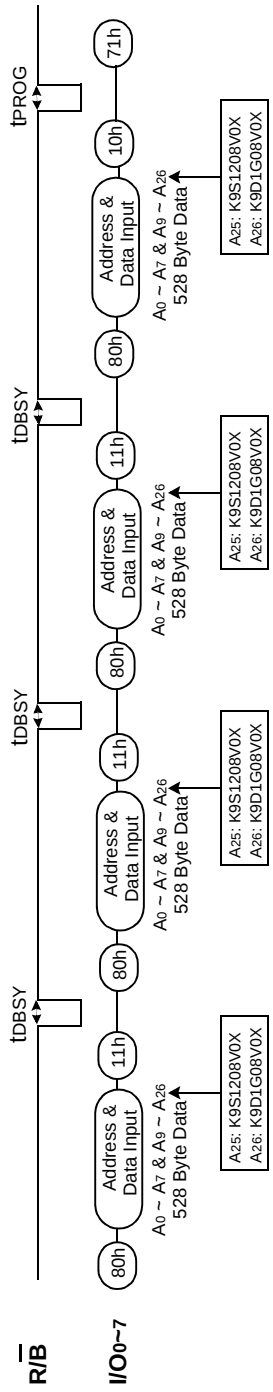
BLOCK ERASE OPERATION (ERASE ONE BLOCK)



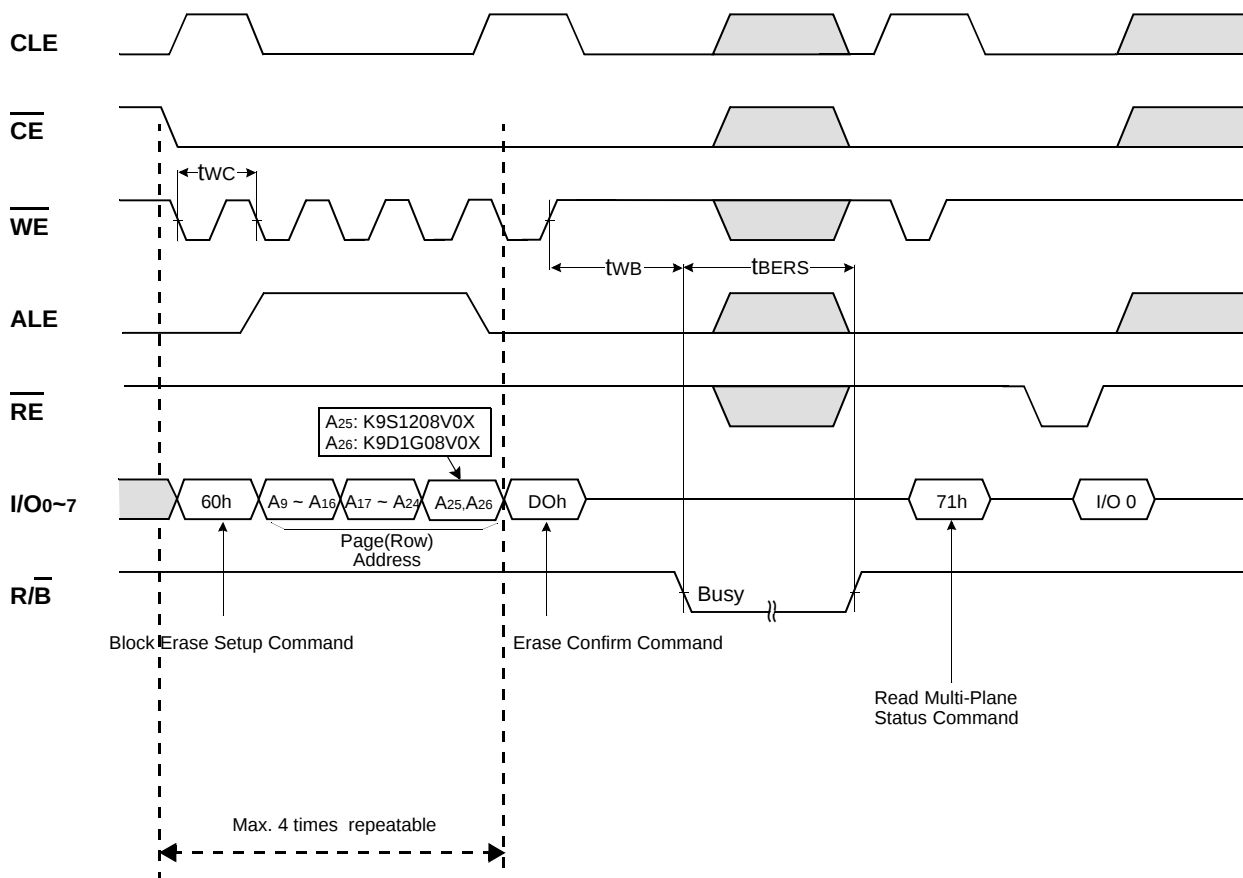
Multi-Plane Page Program Operation



Ex.) Four-Plane Page Program



Multi-Plane Block Erase Operation



* For Multi-Plane Erase operation, Block address to be erased should be repeated before "D0H" command.

Ex.) Four-Plane Block Erase Operation

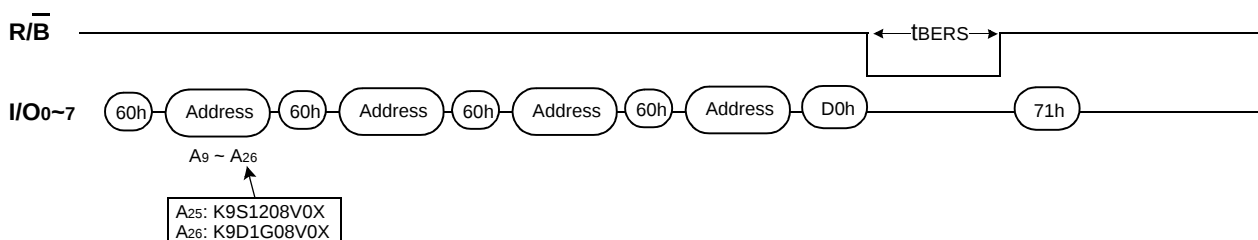
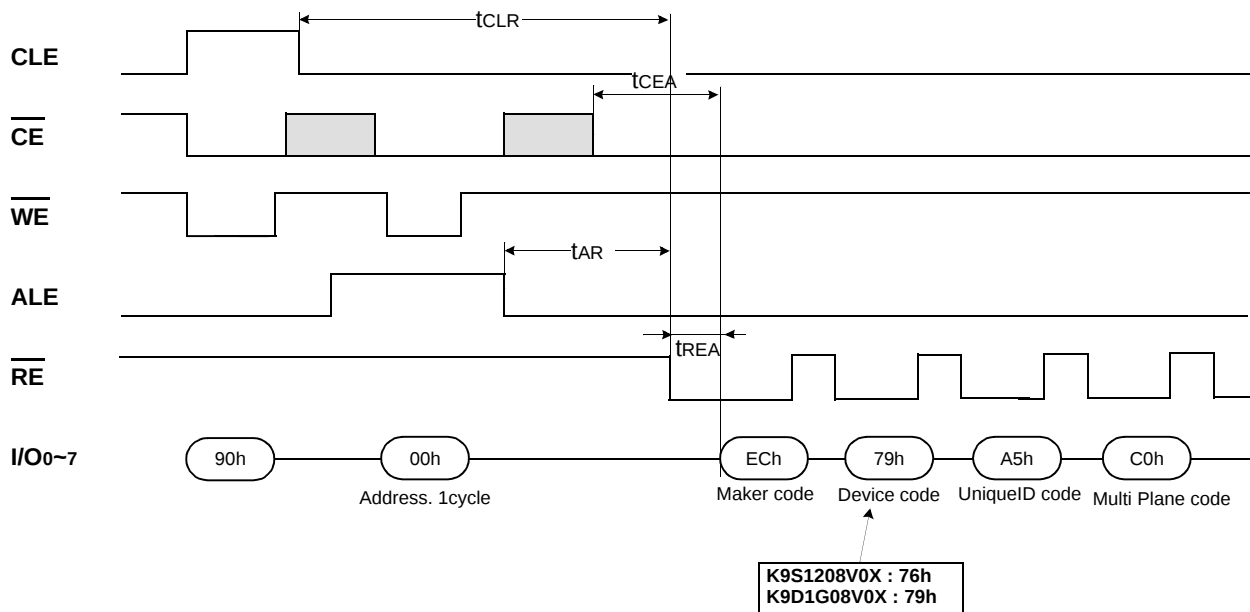


Figure 8. Read ID Operation



90 ID : Access command = 90H

READ ID (1)	Value	Description
1 st Byte	ECh	Maker Code
2 nd Byte	76h/79h	Device Code
3 rd Byte	A5h	Unique1D code
4 th Byte	C0h	Multiplane Support

NOTE :
Device Code : K9S1208VOX(76h), KD1G08VOX(79h)

Device Operation

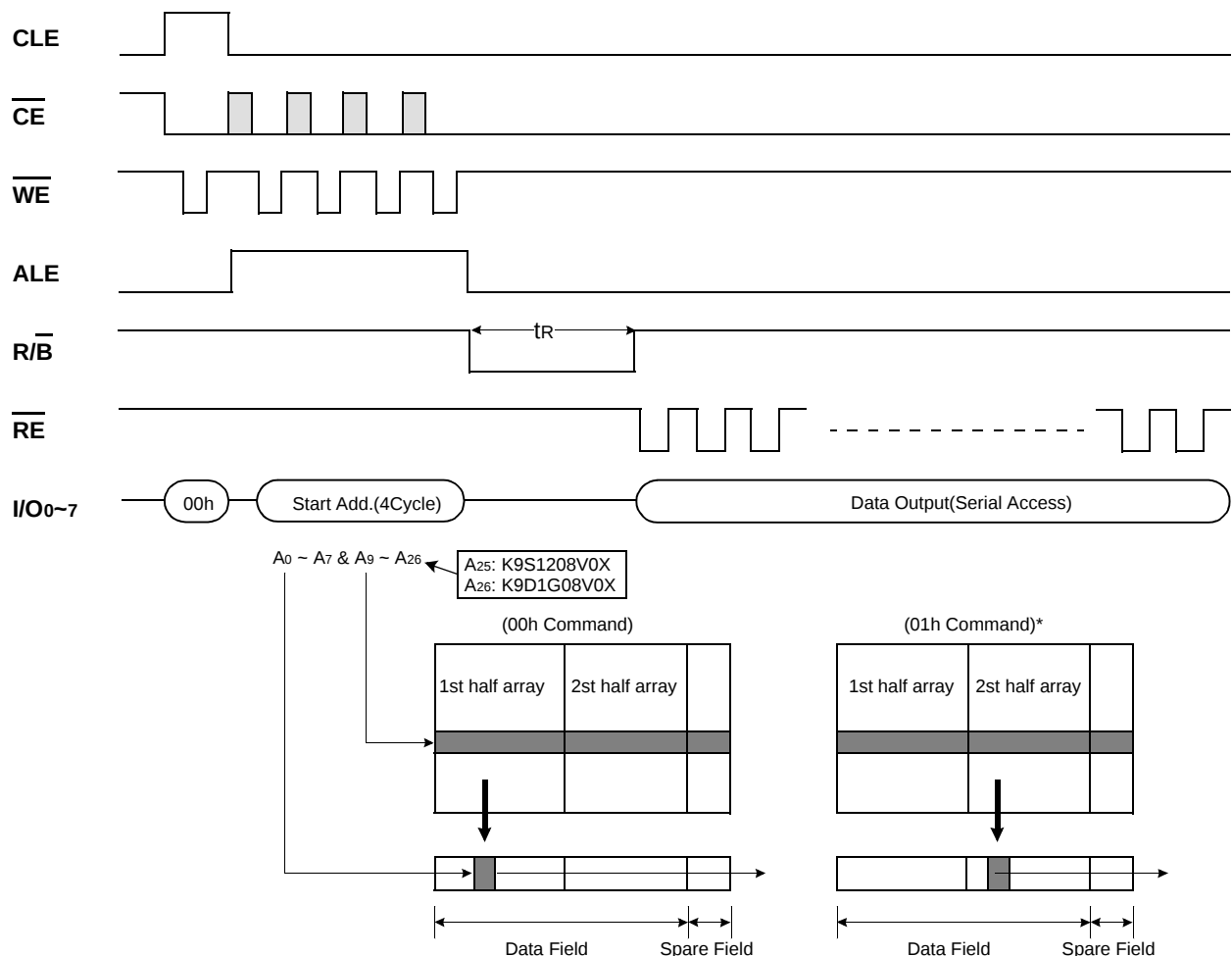
PAGE READ

Upon initial device power up, the device defaults to Read1 mode. This operation is also initiated by writing 00h to the command register along with four address cycles. Once the command is latched, it does not need to be written for the following page read operation. Three types of operations are available : random read, sequential read and sequential row read.

The random read mode is enabled when the page address is changed. The 528 bytes of data within the selected page are transferred to the data registers in less than 12μs(t_R). The system controller can detect the completion of this data transfer(t_R) by analyzing the output of R/B pin. Once the data in a page is loaded into the registers, they may be read out in 50ns cycle time by pulsing RE sequentially. High to low transitions of the RE clock output the data starting from the selected column address up to the last column address. After the data of last column address is clocked out, the next page is automatically selected for sequential row read.

Waiting 12μs again allows reading the selected page. The sequential row read operation is terminated by bringing CE high. The way the Read1 and Read2 commands work is like a pointer set to either the main area or the spare area. The spare area of bytes 512 to 527 may be selectively accessed by writing the Read2 command. Addresses A0 to A3 set the starting address of the spare area while addresses A4 to A7 are ignored. Unless the operation is aborted, the page address is automatically incremented for sequential row read as in Read1 operation and spare sixteen bytes of each page may be sequentially read. The Read1 command(00h/01h) is needed to move the pointer back to the main area. Figures 9 to 12 show typical sequence and timings for each read operation.

Figure 9. Read1 Operation



* After data access on 2nd half array by 01h command, the start pointer is automatically moved to 1st half array (00h) at next cycle.

Figure 10. Read2 Operation

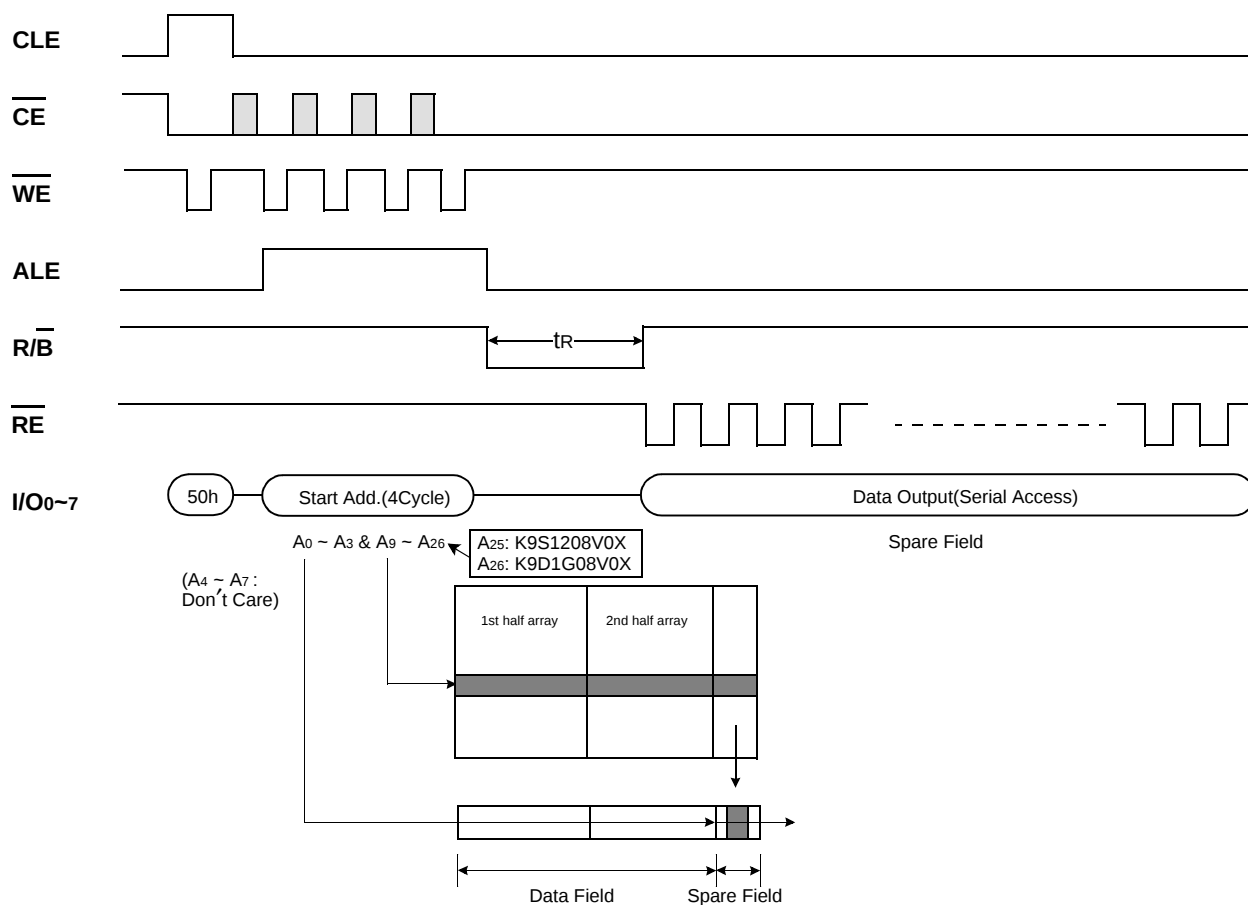
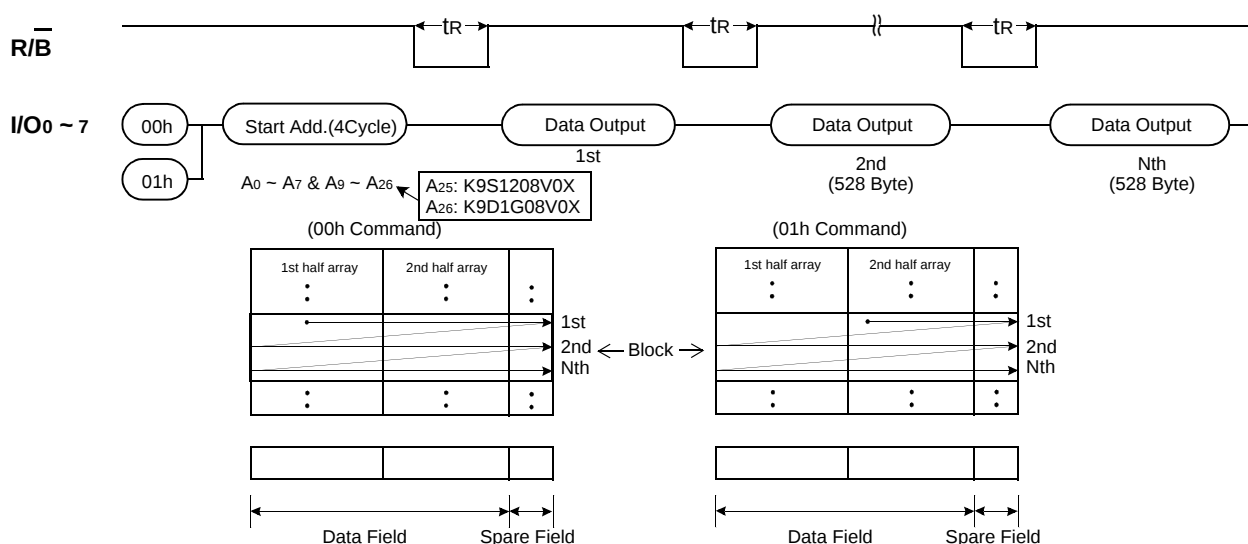
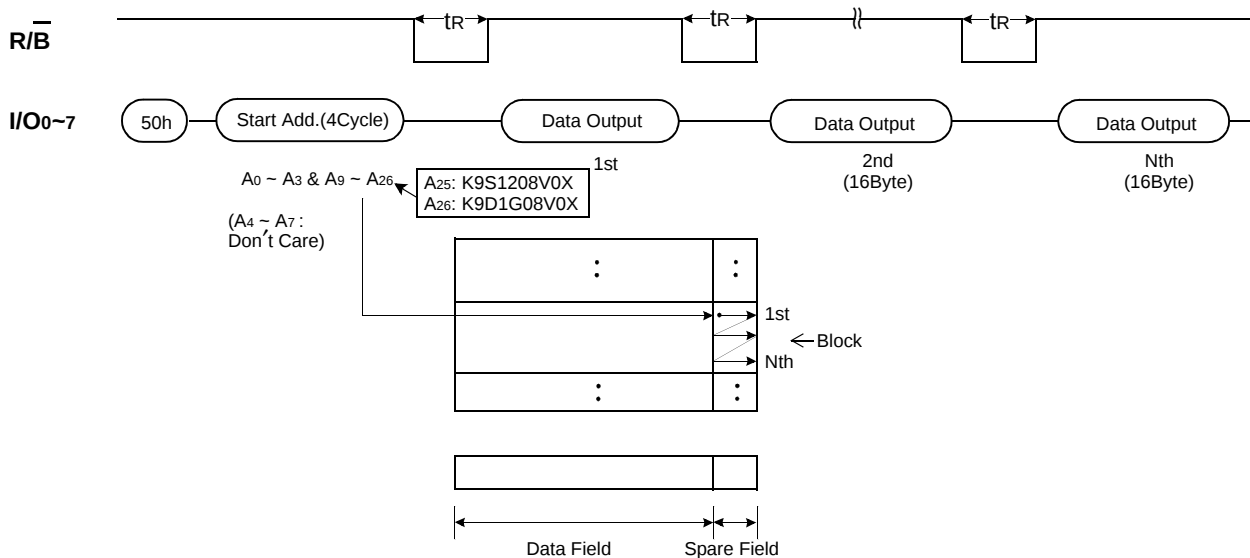


Figure 11. Sequential Row Read1 Operation



The Sequential Read 1 and Read 2 operations are allowed only within a block and after the last page of a block is readout, the sequential read operation must be terminated by bringing CE high. When the page address moves onto the next block, read command and address must be given.

Figure 12. Sequential Row Read2 Operation



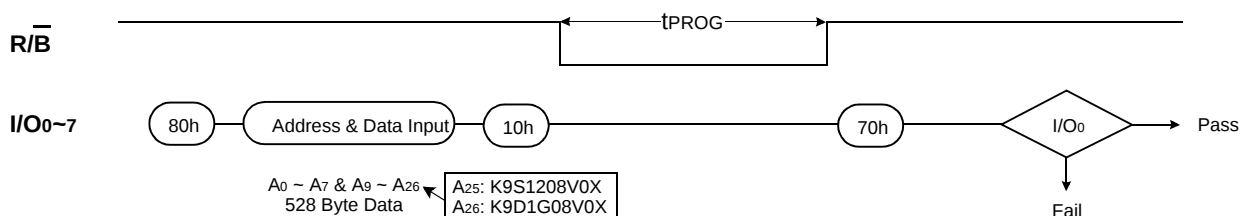
PAGE PROGRAM

The device is programmed basically on a page basis, but it does allow multiple partial page programming of a byte or consecutive bytes up to 528, in a single page program cycle. The number of consecutive partial page programming operation within the same page without an intervening erase operation must not exceed 1 for main array and 2 for spare array. However, it is advisable not to program more often than recommend. It might cause failures due to disturbance when it exceeds its limits. The failure mode could be that the data "1" of the erased cell might be changed into data "0" of the programmed cell.

The addressing may be done in any random order in a block. A page program cycle consists of a serial data loading period in which up to 528 bytes of data may be loaded into the page register, followed by a non-volatile programming period where the loaded data is programmed into the appropriate cell. Serial data loading can be started from 2nd half array by moving pointer. About the pointer operation, please refer to the attached technical notes.

The serial data loading period begins by inputting the Serial Data Input command(80h), followed by the four cycle address input and then serial data loading. The bytes other than those to be programmed do not need to be loaded. The Page Program confirm command(10h) initiates the programming process. Writing 10h alone without previously entering the serial data will not initiate the programming process. The internal write-state controller automatically executes the algorithms and timings necessary for program and verify, thereby freeing the system controller for other tasks. Once the program process starts, the Read Status Register command may be entered, with $\overline{RE}$ and $\overline{CE}$ low, to read the status register. The system controller can detect the completion of a program cycle by monitoring the $\overline{R/B}$ output, or the Status bit(I/O_6) of the Status Register. Only the Read Status command and Reset command are valid while programming is in progress. When the Page Program is complete, the Write Status Bit(I/O_0) may be checked(Figure 13). The internal write verify detects only errors for "1"s that are not successfully programmed to "0"s. The command register remains in Read Status command mode until another valid command is written to the command register.

Figure 13. Program & Read Status Operation

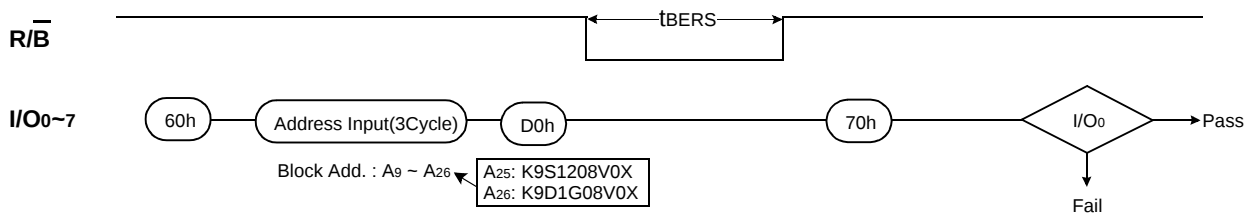


BLOCK ERASE

The Erase operation is done on a block(16K Byte) basis. Block address loading is accomplished in three cycles initiated by an Erase Setup command(60h). Only address A₁₄ to (A₂₅: K9S1208V0X, A₂₆: K9D1G08V0X), is valid while A₉ to A₁₃ is ignored. The Erase Confirm command(D0h) following the block address loading initiates the internal erasing process. This two-step sequence of setup followed by execution command ensures that memory contents are not accidentally erased due to external noise conditions.

At the rising edge of WE after the erase confirm command input, the internal write controller handles erase and erase-verify. When the erase operation is completed, the Write Status Bit(I/O 0) may be checked. Figure 14 details the sequence.

Figure 14. Block Erase Operation

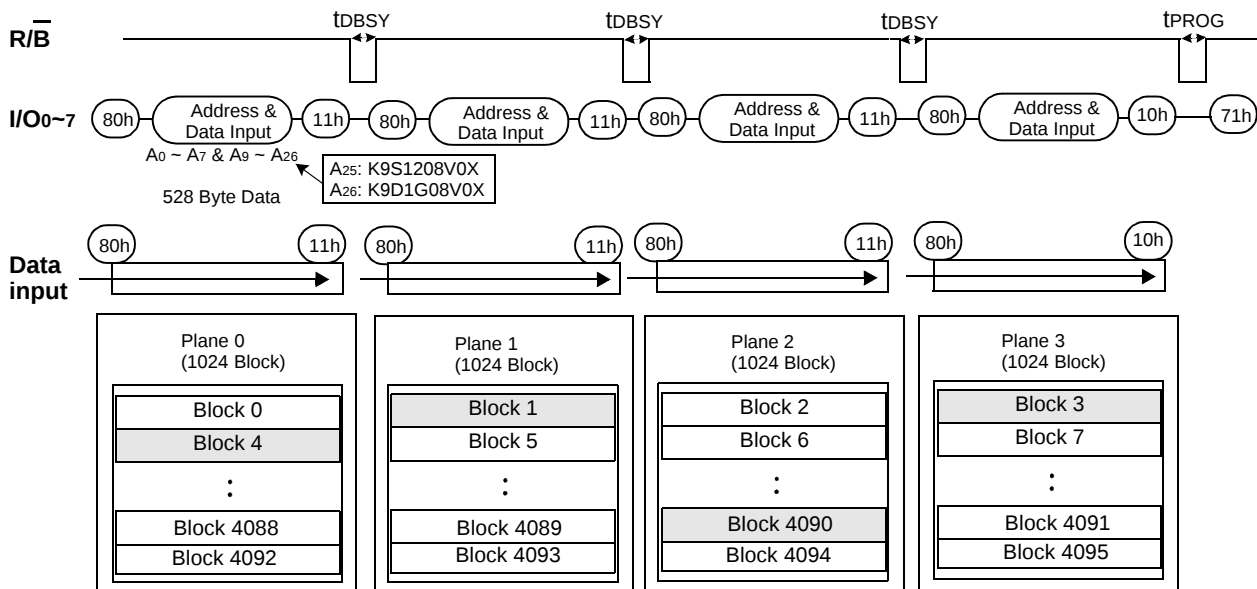


MULTI-PLANE PAGE PROGRAM INTO PLANE 0~3 OR PLANE 4~7

Multi-Plane Page Program is an extension of Page Program which is executed for a single plane with 528 byte page registers. Since the device is equipped with eight memory planes, activating the four sets of 528 byte page registers into plane 0~3 or plane 4~7 enables a simultaneous programming of four pages. Partial activation of four planes is also permitted.

After writing the first set of data up to 528 byte into the selected page register, Dummy Page Program command (11h) instead of actual Page Program (10h) is inputted to finish data-loading of the current plane and move to the next plane. Since no programming process is involved, R/B remains in Busy state for a short period of time(tDBSY). Read Status command (standard 70h or alternate 71h) may be issued to find out when the device returns to Ready state by polling the Ready/Busy status bit(I/O 6). Then the next set of data for one of the other planes is inputted with the same command and address sequences. After inputting data for the last plane, actual True Page Program (10h) instead of dummy Page Program command (11h) must be followed to start the programming process. The operation of R/B and Read Status is the same as that of Page Program. Since maximum four pages are programmed simultaneously, pass/fail status is available for each page when the program operation completes. The extended status bits (I/O1 through I/O 4) are checked by inputting the Read Multi-Plane Status Register. Status bit of I/O 0 is set to "1" when any of the pages fails. Multi-Plane page Program with "01h" pointer is not supported, thus prohibited.

Figure 15. Four-Plane Page Program



While any block in each plane may be addressable for Multi-Plane Page Program, the four least significant addresses(A9-A13) for the selected pages at one operation must be the same. Figure 15 shows an example where 2nd page of each addressed block is selected for four planes. However, any arbitrary sequence is allowed in addressing multiple planes as shown in Figure16.

The diagram illustrates the layout of data across four planes, each containing a block of 1024 pages. Each block is divided into two halves: the first half contains pages 0, 1, ..., 30, 31, and the second half contains pages 30, 31. The diagram shows the following structure:

- Plane 0 (1024 Block):** Contains Block 0, which is divided into two halves. The first half contains pages 0, 1, ..., 30, 31. The second half contains pages 30, 31.
- Plane 1 (1024 Block):** Contains Block 1, which is divided into two halves. The first half contains pages 0, 1, ..., 30, 31. The second half contains pages 30, 31.
- Plane 2 (1024 Block):** Contains Block 2, which is divided into two halves. The first half contains pages 0, 1, ..., 30, 31. The second half contains pages 30, 31.
- Plane 3 (1024 Block):** Contains Block 3, which is divided into two halves. The first half contains pages 0, 1, ..., 30, 31. The second half contains pages 30, 31.

A diagram of a 1D chain of four planes. The planes are labeled Plane 2, Plane 0, Plane 3, and Plane 1 from left to right. Between Plane 2 and Plane 0, and between Plane 0 and Plane 3, there are two hopping parameters: 11h and 80h. Between Plane 3 and Plane 1, there are two hopping parameters: 11h and 80h. The chain starts with a hopping parameter of 80h from the left, and ends with a hopping parameter of 10h to the right.

R/B

I/O0~7

Last Plane input

tPROG

80h

Address & Data Input

10h

71h

I/O

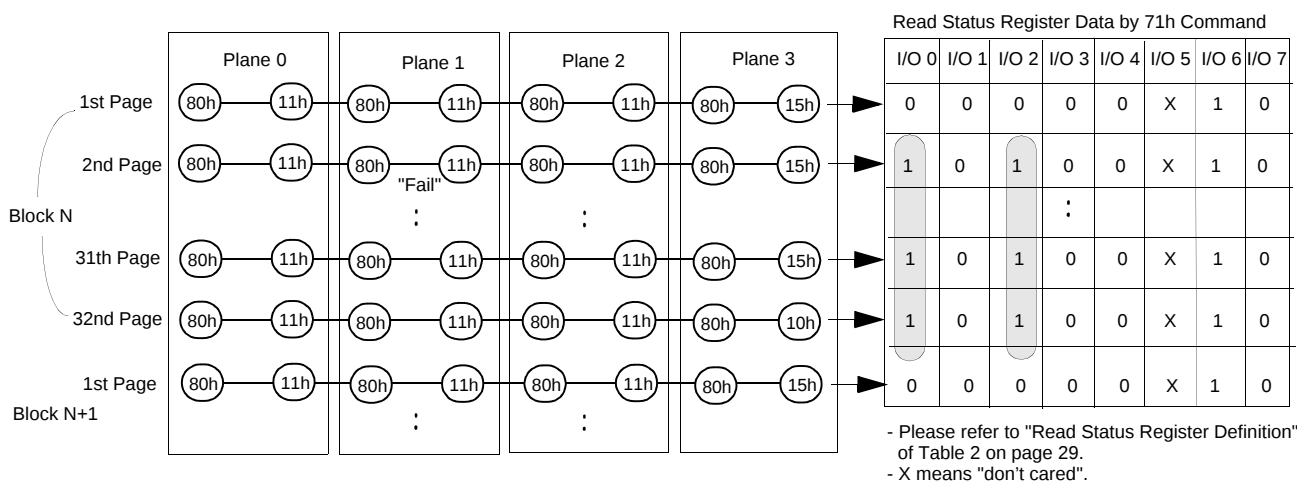
Pass

Fail

A0 ~ A7 & A9 ~ A26
528 Byte Data

A25: K9S1208V0X
A26: K9D1G08V0X

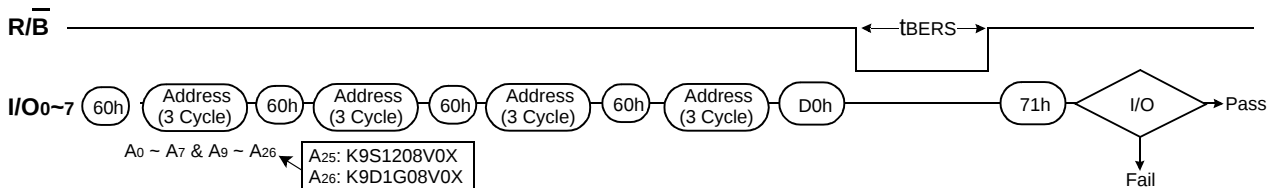
Figure 19. Multi-Plane Page Program Using 15h Command



MULTI-PLANE BLOCK ERASE INTO PLANE 0~3 OR PLANE 4~7

Basic concept of Multi-Plane Block Erase operation is identical to that of Multi-Plane Page Program. Up to four blocks, one from each plane can be simultaneously erased. Standard Block Erase command sequences (Block Erase Setup command followed by three address cycles) may be repeated up to four times for erasing up to four blocks. Only one block should be selected from each plane. The Erase Confirm command initiates the actual erasing process. The completion is detected by analyzing R/B pin or Ready/Busy status (I/O 6). Upon the erase completion, pass/fail status of each block is examined by reading extended pass/fail status (I/O 1 through I/O 4).

Figure 20. Four Block Erase Operation



READ STATUS

The device contains a Status Register which may be read to find out whether program or erase operation is completed, and whether the program or erase operation is completed successfully. After writing 70h command to the command register, a read cycle outputs the content of the Status Register to the I/O pins on the falling edge of CE or RE, whichever occurs last. This two line control allows the system to poll the progress of each device in multiple memory connections even when R/B pins are common-wired. RE or CE does not need to be toggled for updated status. Refer to Table 3 for specific Status Register definitions. The command register remains in Status Read mode until further commands are issued to it. Therefore, if the status register is read during a random read mode, a read command(00h or 50h) should be given before the sequential read cycle.

For Read Status of Multi Plane Program/Erase, the Read Multi-Plane Status command(71h) should be used to find out whether multi-plane program or erase operation is completed, and whether the program or erase operation is completed successfully. The pass/fail status data must be checked only in the Ready condition after the completion of Multi-Plane program or erase operation.

Table3. Read Status Register Definition

I/O No.	Status	Definition by 70h Command		Definition by 71h Command	
I/O 0	Total Pass/Fail	Pass : "0"	Fail : "1"	Pass : "0" ⁽¹⁾	Fail : "1"
I/O 1	Plane 0 Pass/Fail	Must be don't -cared		Pass : "0" ⁽²⁾	Fail : "1"
I/O 2	Plane 1 Pass/Fail	Must be don't -cared		Pass : "0" ⁽²⁾	Fail : "1"
I/O 3	Plane 2 Pass/Fail	Must be don't -cared		Pass : "0" ⁽²⁾	Fail : "1"
I/O 4	Plane 3 Pass/Fail	Must be don't -cared		Pass : "0" ⁽²⁾	Fail : "1"
I/O 5	Reserved	Must be don't -cared		Must be don't-cared	
I/O 6	Device Operation	Busy : "0"	Ready : "1"	Busy : "0"	Ready : "1"
I/O 7	Write Protect	Protected : "0"	Not Protected : "1"	Protected : "0"	Not Protected : "1"

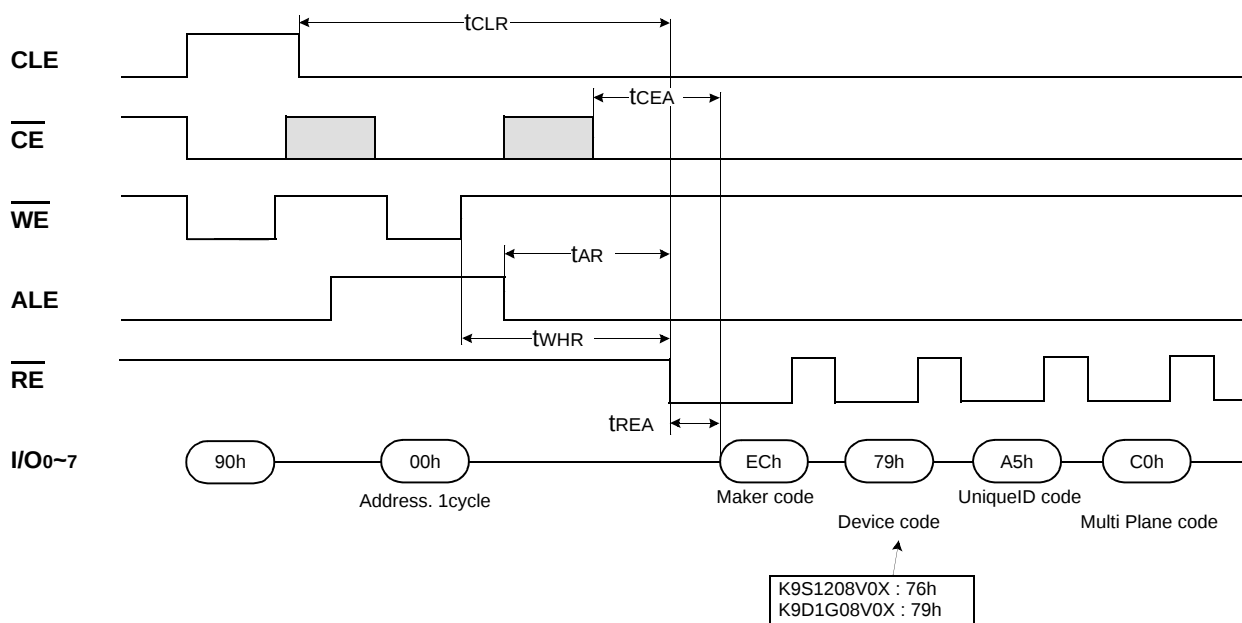
NOTE : 1. I/O 0 describes combined Pass/Fail condition for all planes. If any of the selected multiple pages/blocks fails in Program/ Erase operation, it sets "Fail" flag.

2. The pass/fail status applies only to the corresponding plane.

READ ID

The device contains a product identification mode, initiated by writing 90h and 91h to the command register, followed by an address input of 00h. Two read cycles with 90h sequentially output the manufacture code(ECh), the device code (K9S1208V0X:76h, K9D1G08V0X:79h), the UniqueID code(A5h) and the multi plane code(C0h) respectively. The command register remains in Read ID mode until further commands are issued to it. Figure 21 shows the operation sequence.

Figure 21. Read ID Operation



RESET

The device offers a reset feature, executed by writing FFh to the command register. When the device is in Busy state during random read, program or erase mode, the reset operation will abort these operations. The contents of memory cells being altered are no longer valid, as the data will be partially programmed or erased. The command register is cleared to wait for the next command, and the Status Register is cleared to value C0h when WP is high. Refer to Table 4 for device status after reset operation. If the device is already in reset state a new reset command will not be accepted by the command register. The R/B pin transitions to low for tRST after the Reset command is written. Reset command is not necessary for normal operation. Refer to Figure 23 below.

Figure 23. RESET Operation

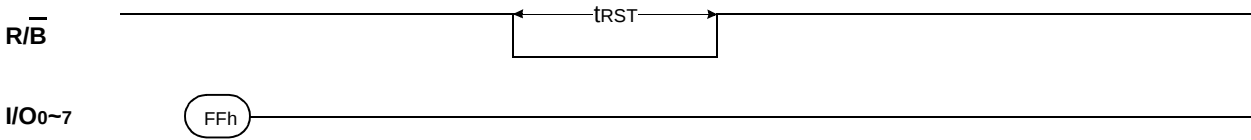


Table4. Device Status

	After Power-up	After Reset
Operation Mode	Read 1	Waiting for next command

READY/BUSY

The device has a R/B output that provides a hardware method of indicating the completion of a page program, erase and random read operations. The R/B pin is normally high but transitions to low after program or erase command is written to the command register or random read is started after address loading. It returns to high when the internal controller has finished the operation. The pin is an open-drain driver thereby allowing two or more R/B outputs to be Or-tied. Because pull-up resistor value is related to $t_r(R/B)$ and current drain during busy(i_{busy}), an appropriate value can be obtained with the following reference chart(Fig 24). Its value can be determined by the following guidance.

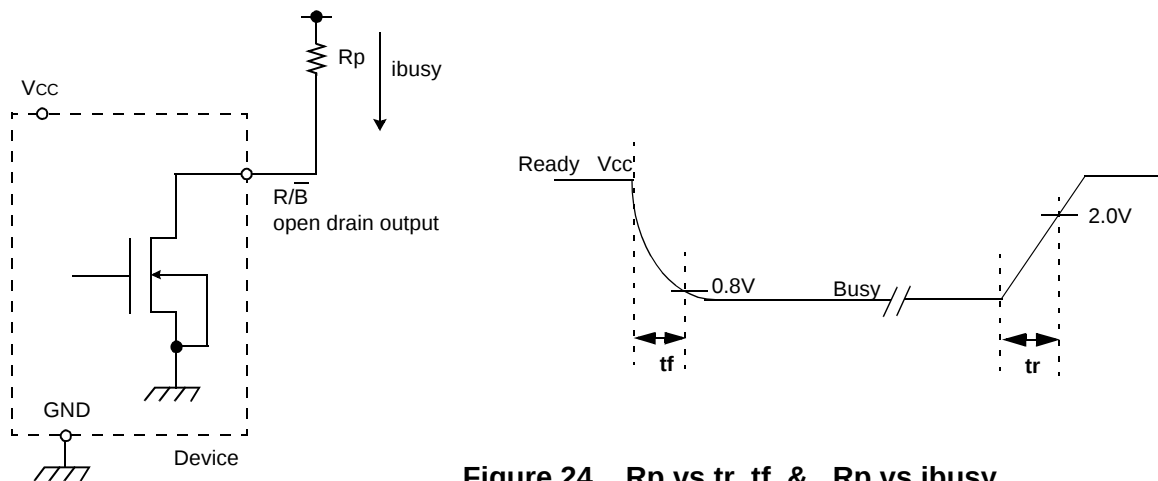
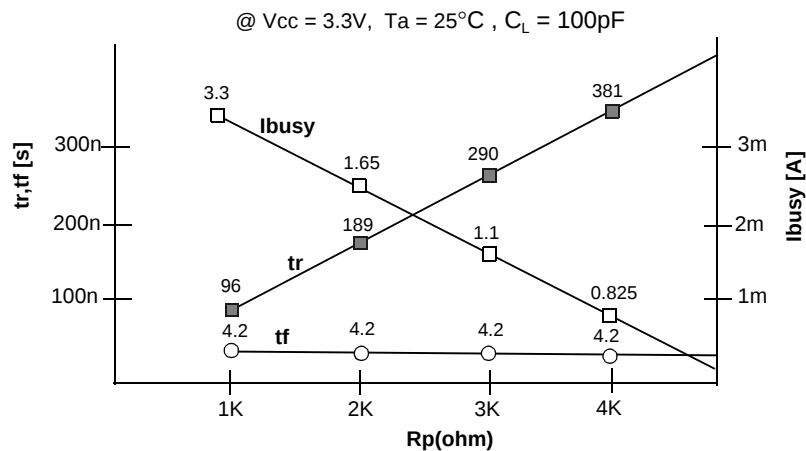


Figure 24. R_p vs t_r, t_f & R_p vs i_{busy}



R_p value guidance

$$R_p(\min) = \frac{V_{cc}(\text{Max.}) - V_{OL}(\text{Max.})}{I_{OL} + \sum I_L} = \frac{3.2V}{8mA + \sum I_L}$$

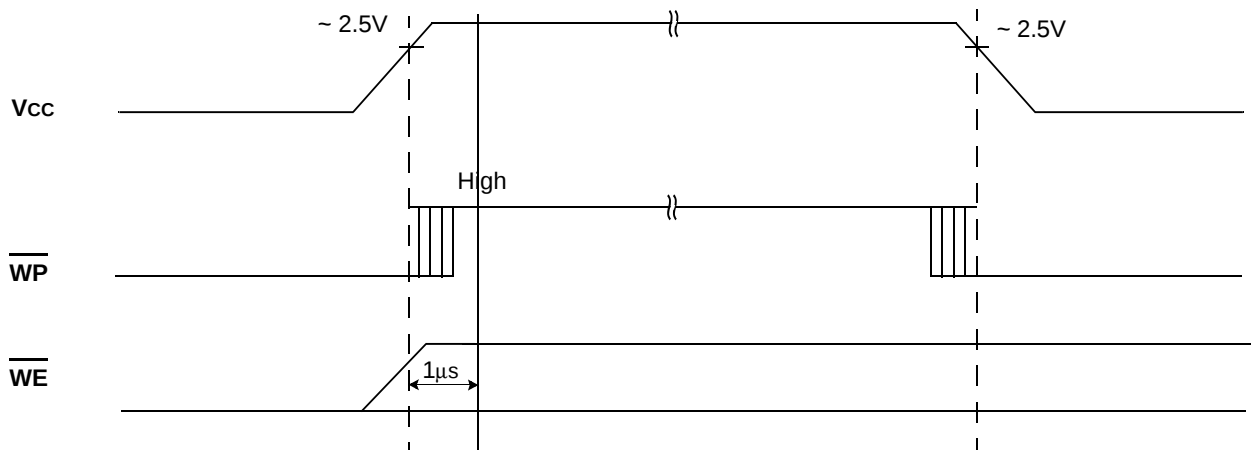
where I_L is the sum of the input currents of all devices tied to the R/B pin.

$R_p(\max)$ is determined by maximum permissible limit of t_r

DATA PROTECTION

The device is designed to offer protection from any involuntary program/erase during power-transitions. An internal voltage detector disables all functions whenever V_{CC} is below about 2V. $\overline{WP}$ pin provides hardware protection and is recommended to be kept at V_{IL} during power-up and power-down as shown in Figure 25. The two step command sequence for program/erase provides additional software protection.

Figure 25. AC Waveforms for Power Transition



DIMENSIONS

Unit:mm

22 PAD SOLID STATE FLOPPY DISK CARD (3.3V)

SOLID STATE PRODUCT OUTLINE

