

F20 64Gb MLC NAND Flash Memory Legacy LGA52

Document Title

64Gbit(8192M x 8bit) NAND Flash Memory

Revision History

Revision No.	History	Draft Date	Remark
0.0	Initial Draft	Mar.07.2011	Preliminary
0.1	Modified some numbers	Mar.18.2011	Preliminary
0.2	Revised errata	Sep.22.2011	Preliminary
0.3	Add paired page address table	Oct.12.2011	Preliminary
1.0	1.0 Released	Oct.21.2011	
1.1	CLE, ALE Hold Time Changed	Nov.18.2011	
1.2	Correct No. of Valid Blocks	Jun.21.2012	

Product Feature

■ Multi Level Cell (MLC) Technology

■ Power Supply Voltage

- VCC / VCCq= 2.7V ~ 3.6V

■ Organization

- Page Size : 16,384 + 1,280(Spare) bytes
- Block Size : 4M + 320K bytes, 256pages
- Plane Size : 1024 + 42(Extended) blocks
- Device Size : 2048 + 84(Extended) blocks

■ Page Read Time

- Random Read Time (tR) : TBD
- Sequential Access (tRC/tWC) : 16ns(Min.)

■ Page Write Time

- Page Program Time : 1500 (Typ.)

■ Block Erase Time

- Block Erase Time : 5.0ms(Typ.)

■ Hardware Data Protection

- Program/Erase locked during power transitions

■ Package

- Package type : VLGA
- Chip count : SDP
- Pin(Ball) count : 52 ball
- Size : 14mm x 18mm x 1mm

■ Electronic Signature

- 1st cycle : Manufacturer code
- 2nd cycle : Device code
- 3rd cycle : Internal chip number, Cell type,
Number of simultaneously programmed pages
- 4th cycle : Page size, Block size, Organization,
Spare size
- 5th cycle : Multi-plane information
- 6th cycle : Technology, EDO, Interface

■ Reliability

- TBD

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1. Summary Description

The product part No. H27UCG8T2BYR-BC is a single 3.3V 64Gbit NAND flash memory. The Device contains 2 planes in a single die. Each plane is made up of the 1066 blocks. Each block consists of 256 programmable pages. Each page contains 17,664 bytes. The pages are subdivided into an 16,384 byte main data storage area with a spare 1,280 byte district.

Page program operation can be performed in typical 1500us, and a single block can be erased in typical 5ms.

1.1. Product List

PART NUMBER	ORGANIZATION	OPERATING RANGE	PACKAGE
H27UCG8T2BYR-BC	X8	2.7 to 3.6V	52-LGA

Table 1 : List of supported versions / packages

1.2. Pin Descriptions

Pin Name	Description
I/O 0— I/O 7	DATA INPUTS/OUTPUTS The I/O pins is used to COMMAND LATCH cycle, ADDRESS INPUT cycle, and DATA in-out cycles during read / write operations. The I/O pins float to High-Z when the device is deselected or the outputs are disabled.
CLE	COMMAND LATCH ENABLE This input activates the latching of the I/O inputs inside the Command Register on the Rising edge of Write Enable (WE#).
ALE	ADDRESS LATCH ENABLE This input activates the latching of the I/O inputs inside the Address Register on the Rising edge of Write Enable (WE#).
CE#	CHIP ENABLE This input controls the selection of the device. When the device is busy, CE# low does not deselect the memory. The device goes into Stand-by mode when CE# goes High during the device is in Ready state. The CE# signal is ignored when device is in Busy state, and will not enter Standby mode even if the CE# goes high.
WE#	WRITE ENABLE This input acts as clock to latch Command, Address and Data. The I/O inputs are latched on the rise edge of WE#.
RE#	READ ENABLE The RE# input is the serial data-out control, and when active drives the data onto the I/O bus. Data is valid tREA after the falling edge of RE# which also increments the internal column address counter by one.
WP#	WRITE PROTECT The WP# pin, when Low, provides a hardware protection against undesired write operations. Hardware Write Protection is activated when the Write Protect pin is low. In this condition modify operation do not start and the content of the memory is not altered. Write Protect pin is not latched by Write Enable to ensure the protection even during the power up phases.
R/B#	READY / BUSY The Ready/Busy output is an Open Drain pin that signals the state of the memory.
V_{CC}Q	SUPPLY VOLTAGE FOR I/O BUFFER
V_{SS}Q	GROUND FOR I/O BUFFER
V_{CC}	SUPPLY VOLTAGE The VCC supplies the power for all the operations. (Read, Write, and Erase).
V_{SS}	GROUND
NC	NO CONNECTED

Table 2 : Signal descriptions

NOTE: A 0.1uF capacitor should be connected between the Vcc (Supply Voltage) pin and the Vss (Ground) pin to decouple the current surges from the power supply. The PCB track widths must be sufficient to carry the currents required during program and erase operations.

1.3. Pin Diagram

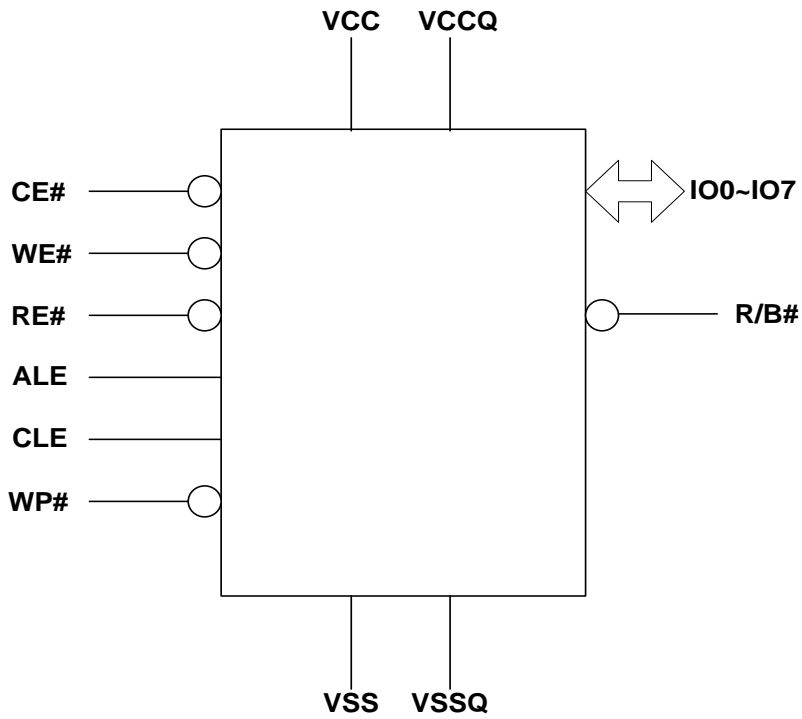


Figure 1 : Pin diagram(SDP)

1.4. Pin Assignments

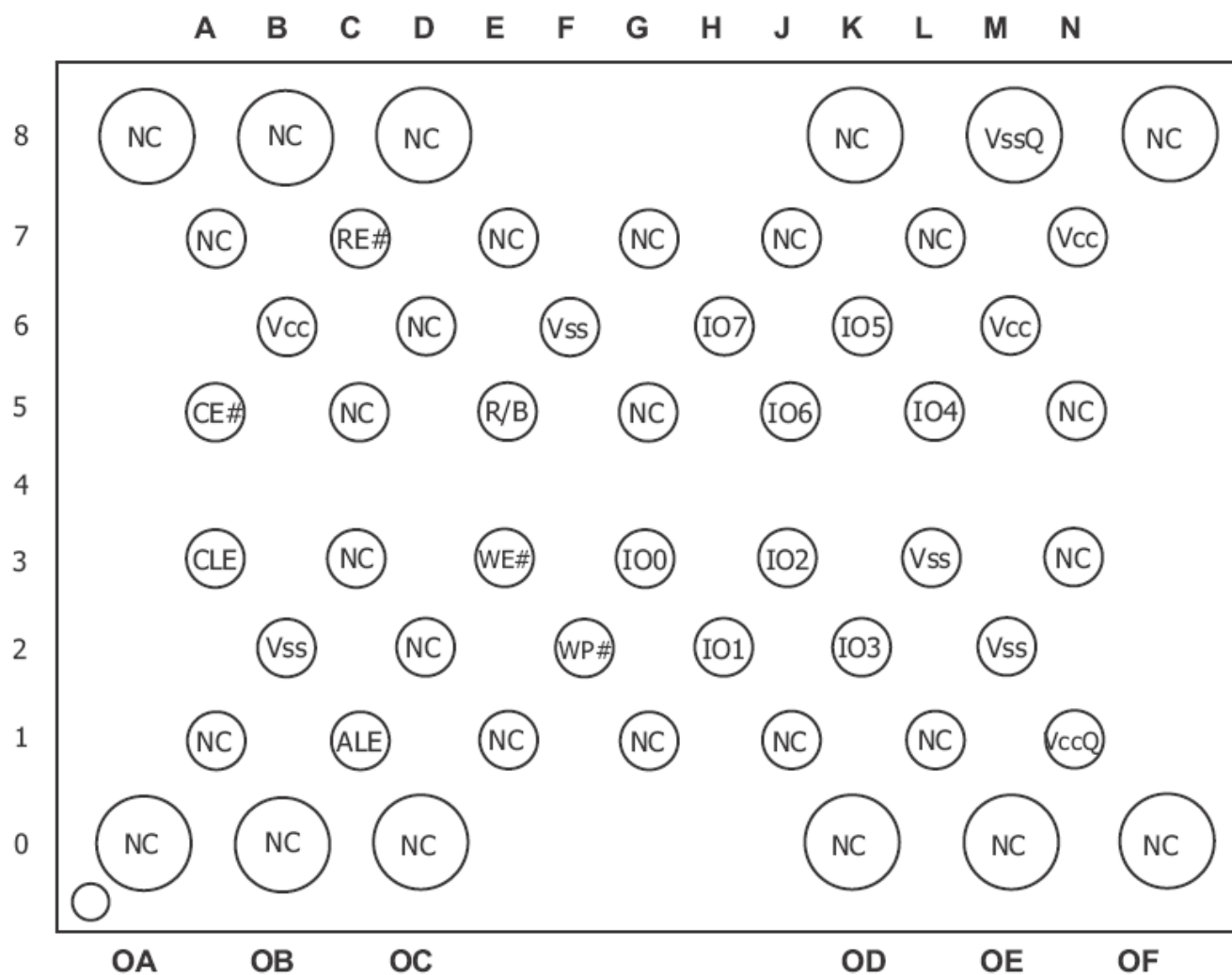


Figure 2 : 52-VLGA

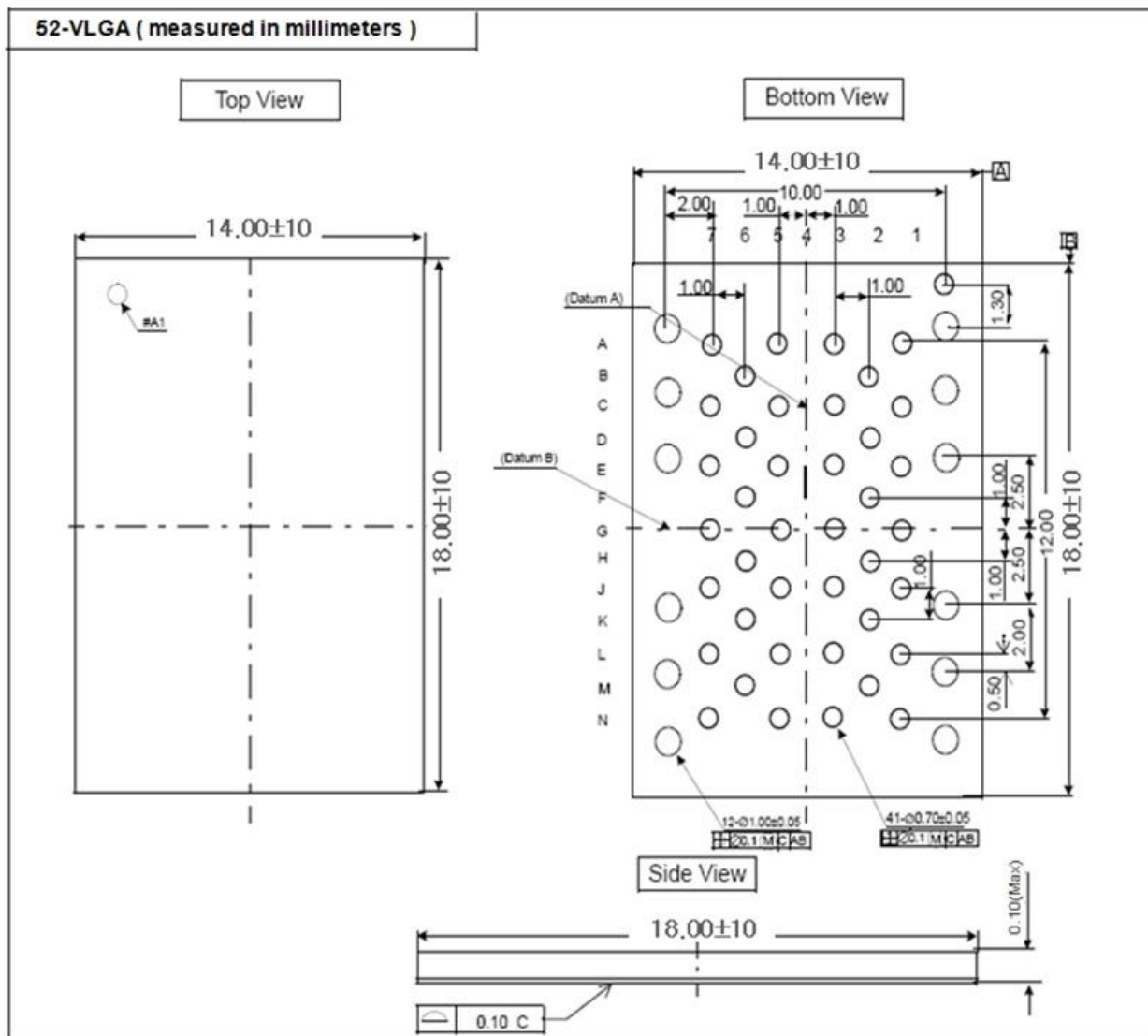


Figure 3 : Package Mechanical Data

1.5. Block Diagram

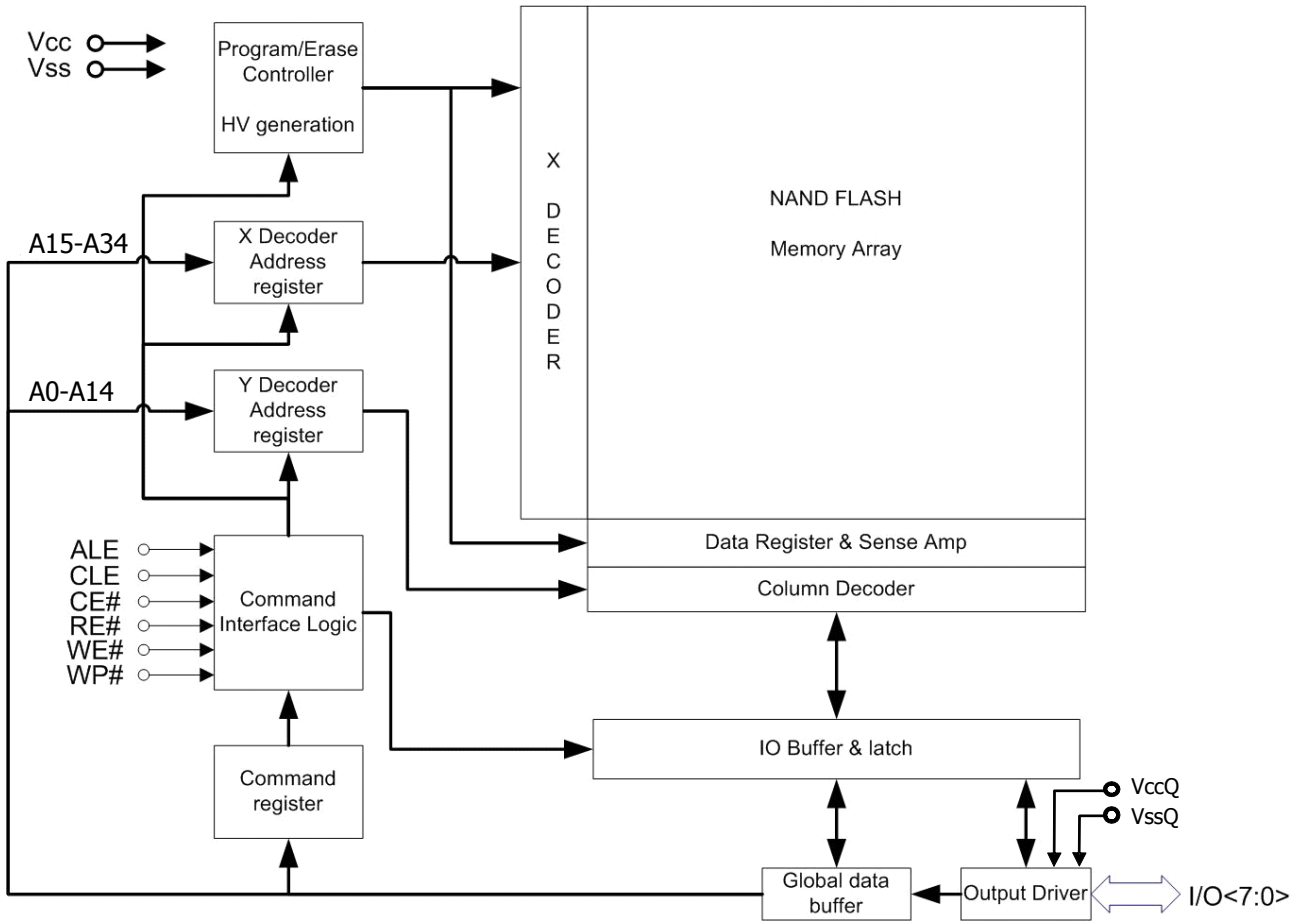


Figure 3 : Block diagram(SDP)

1.6. Array Organization

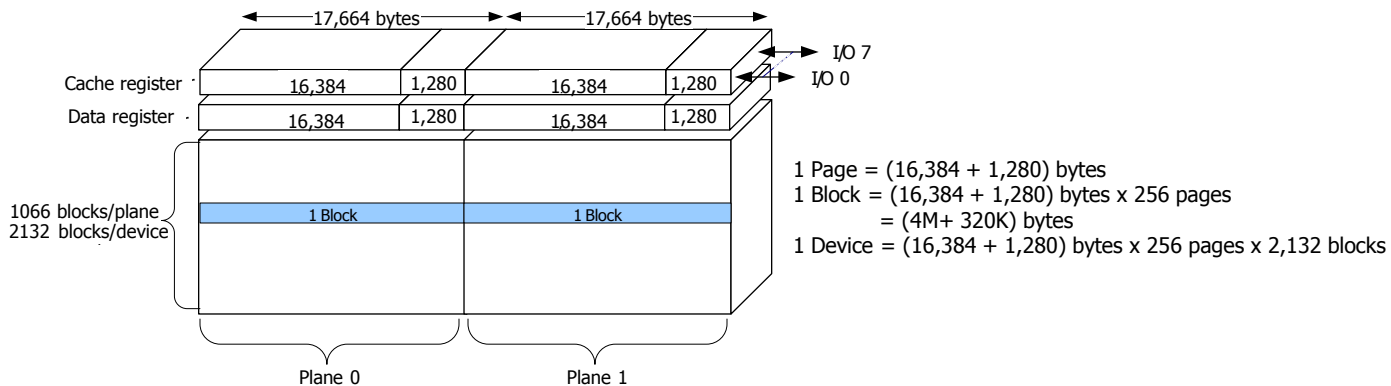


Figure 4 : Array organization

1.7. Addressing

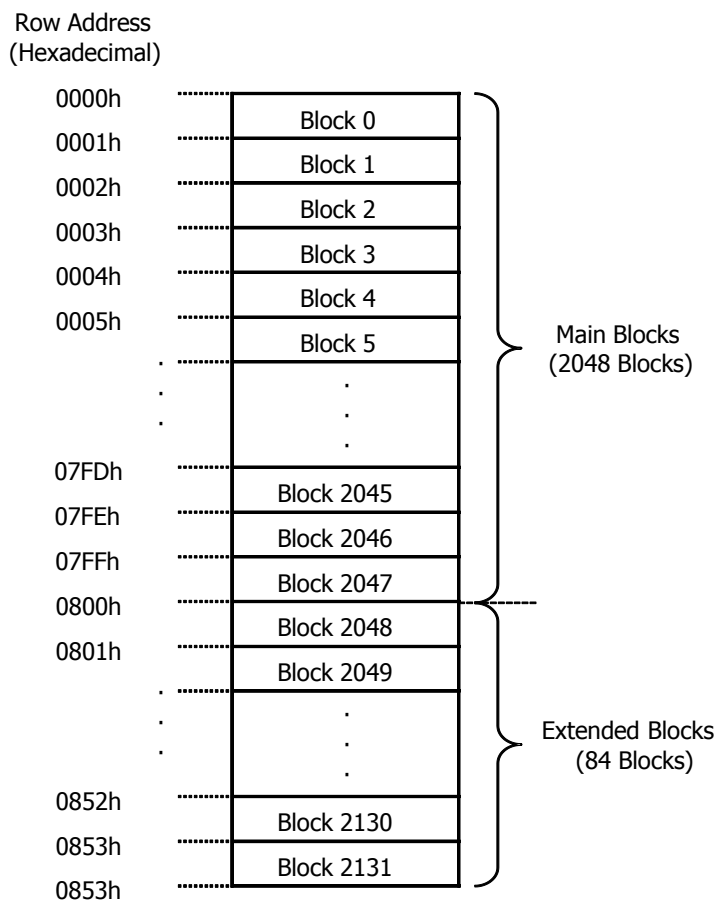
Bus cycle	I/O0	I/O1	I/O2	I/O3	I/O4	I/O5	I/O6	I/O7
1 st Cycle	A0	A1	A2	A3	A4	A5	A6	A7
2 nd Cycle	A8	A9	A10	A11	A12	A13	A14	L ⁽¹⁾
3 rd Cycle	A15	A16	A17	A17	A19	A20	A21	A22
4 th Cycle	A23	A24	A25	A26	A27	A28	A29	A30
5 th Cycle	A31	A32	A33	A34	L ⁽¹⁾	L ⁽¹⁾	L ⁽¹⁾	L ⁽¹⁾

Notes:

1. L must be set to Low.
2. The device ignores any additional address input cycle than required.
3. The Address consists of column address (A0~A14), page address (A15 ~ A22), plane address (A23), and block address (A24 ~ the last address).

1.8. Extended Blocks Arrangement

The device offers 84 extended blocks to increase valid blocks. These blocks can be accessed when the block address A34 is 'High'.



1.9. Command Set

FUNCTION	1 st Cycle	Number of Address cycles	Data Input cycles	2 nd Cycle	Number of Address cycles	Data input cycles	3 rd Cycle	Acceptable command During busy
PAGE READ	00h	5	-	30h	-	-	-	No
READ FOR COPY-BACK	00h	5	-	35h	-	-	-	No
RANDOM DATA OUTPUT ¹⁾	05h	2	-	E0h	-	-	-	No
SINGLE/MULTI-PLANE CACHE READ ⁵⁾	31h	-	-	-	-	-	-	No
SINGLE/MULTI-PLANE CACHE READ END ⁵⁾	3Fh	-	-	-	-	-	-	No
READ ID	90h	1	-	-	-	-	-	No
READ STATUS REGISTER	70h	-	-	-	-	-	-	Yes
PAGE PGM (start)/ CACHE PGM ⁵⁾ (end)	80h	5	Yes	10h	-	-	-	No
RANDOM DATA INPUT ¹⁾	85h	2	Yes	-	-	-	-	No
COPY-BACK PGM	85h	5	option	10h	-	-	-	No
CACHE PGM (start) ⁵⁾	80h	5	Yes	15h	-	-	-	No
BLOCK ERASE	60h	3	-	D0h	-	-	-	No
RESET	FFh	-	-	-	-	-	-	Yes
MULTI-PLANE PAGE READ	60h	3	-	60h	3	-	30h	No
MULTI-PLANE CACHE READ START ^{5) 6)}	60h	3	-	60h	3	-	33h	No
MULTI-PLANE READ FOR COPY-BACK	60h	3	-	60h	3	-	35h	No
MULTI-PLANE BLOCK ERASE	60h	3	-	60h	3	-	D0h	No
MULTI-PLANE RANDOM DATA OUTPUT ^{1) 3)}	00h	5	-	05h	2	-	E0h	No
MULTI-PLANE READ STATUS REGISTER	78h	3	-	-	-	-	-	Yes
MULTI-PLANE READ STATUS REGISTER (legacy)	75h	-	-	-	-	-	-	Yes
MULTI-PLANE PAGE PGM/ MULTI-PLANE CACHE PGM (end)	80h	5	Yes	11h-81h ²⁾	5	Yes	10h	No
MULTI-PLANE COPY-BACK PGM	85h	5	option	11h-81h ²⁾	5	option	10h	No
MULTI-PLANE CACHE PGM (start) ⁵⁾	80h	5	Yes	11h-81h ²⁾	5	Yes	15h	No
CACHE READ ENHANCED	00h	5	-	31h	-	-	-	No
MULTI-PLANE CACHE READ ENHANCED	60h	3	-	60h	3	-	31h	No

Notes:

1. Random Data Input/Output must be performed in a selected page.
2. Any command between 11h and 81h is prohibited except 70h, 78h, 75h and FFh.
3. Multi-plane Random data-out must be used after multi-plane read operations (Multi-plane Page Read, Multi-plane Cache Read and Multi-plane Read for Copy Back).
4. Do not change plane address order when using all multi-plane operations.
5. All cache operation (cache program, cache read) is available only within a block.
6. It's possible to confirm the multi-plane cache read first step using both 30h and 33h.

Caution:

1. Any undefined command inputs are prohibited except for above command set.
2. Multi-plane page read, multi-plane cache read, and multi-plane read for copy-back must be used after multi-plane programmed page, multi-plane cache program, and multi-plane copy-back program.

1.10. 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 (5 Cycles)
H	L	L		H	H	Write Mode	Command Input
L	H ¹⁾	L		H	H		Address Input (5 Cycles)
L	L	L		H	H	Data Input	
L	L ¹⁾	L	H		X	Sequential Read and Data Output	
X	X	X	H ³⁾	H ³⁾	X	During Read (Busy)	
X	X ¹⁾	X	X	X	H	During Program (Busy)	
X	X	X	X	X	H	During Erase (Busy)	
X	X	X	X	X	L	Write Protect	
X	X	H	X	X	0V/V _{cc} ²⁾	Stand-By	

Notes:

1. X can be V_{IL} or V_{IH}. H = Logic level "High". L = Logic level "Low".
2. WP# should be biased to CMOS high or CMOS low for stand-by mode.
3. WE# and RE# during Read Busy must be keep on high to prevent unplanned command/address/data input or to avert unintended data out. In this time, only Reset, Read Status, and Multi-plane Read Status can be inputted to the device.

1.11. Bad Block Management

Devices with Bad Blocks have the same quality level and the same AC and DC characteristics as devices where all the blocks are valid. A Bad Block does not affect the performance of valid blocks because it is isolated from the bit line and common source line by a select transistor. The devices are supplied with all the locations inside valid blocks erased (FFh). The Bad Block Information is written prior to shipping. Any block where the 1st Byte in the spare area of the first and last page does not contain FFh is a Bad Block. The Bad Block Information must be read before any erase is attempted as the Bad Block Information may be erased. For the system to be able to recognize the Bad Blocks based on the original information it is recommended to create a Bad Block table following the flowchart shown in Figure 5. The 1st block, which is placed on 00h block address, is guaranteed to be a valid block at the time of shipment.

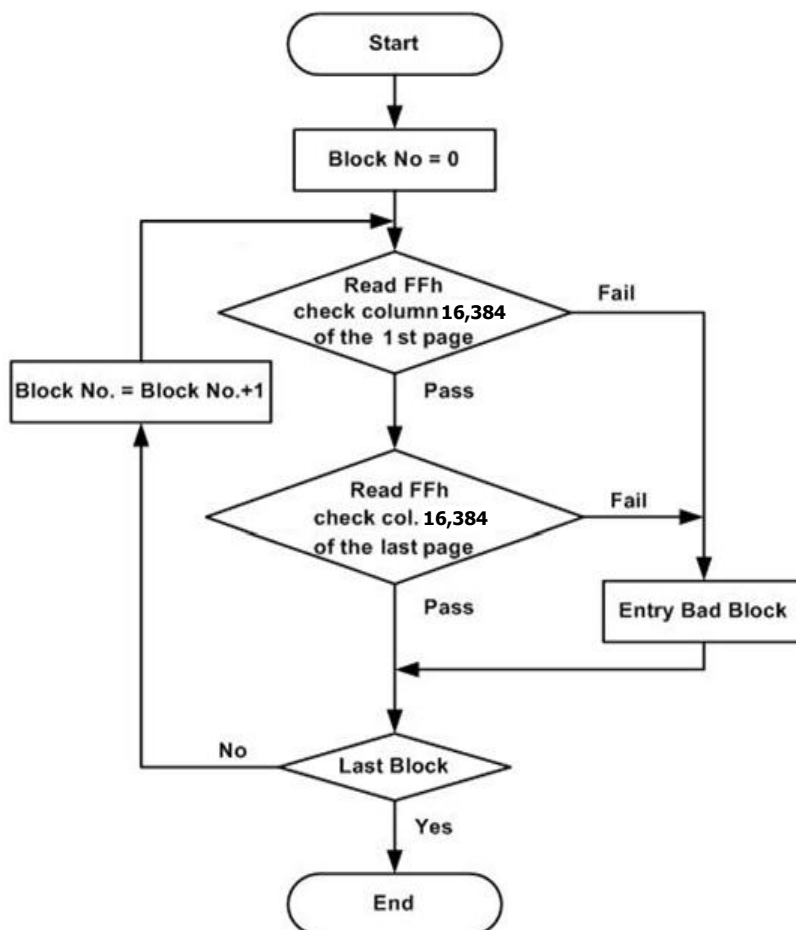


Figure 5 : Bad block management flow chart

Notes:

1. Do not try to erase the detected bad blocks, because the bad block information will be lost.
2. Do not perform program and erase operation in invalid block, it is impossible to guarantee the input data and to ensure that the function is normal.

1.12. Bad Block Replacement

This device may have the invalid blocks when shipped from factory. An invalid block is one that contains one or more bad bits. Over the lifetime of the device additional Bad Blocks may develop. In this case, the block has to be replaced by copying the data to a valid block. These additional Bad Blocks can be identified as attempts to program or erase them will give errors in the Status Register.

The failure of a page program operation does not affect the data in other pages in the same block. Bad block can be replaced by re-programming the current data and copying the rest of the replaced block to an available valid block. Refer to Table 4 and Figure 6 for the recommended procedure to follow if an error occurs during an operation.

Operation	Recommended Procedure
Erase	Block Replacement
Program	Block Replacement
Read	ECC

Table 4 : Block failure

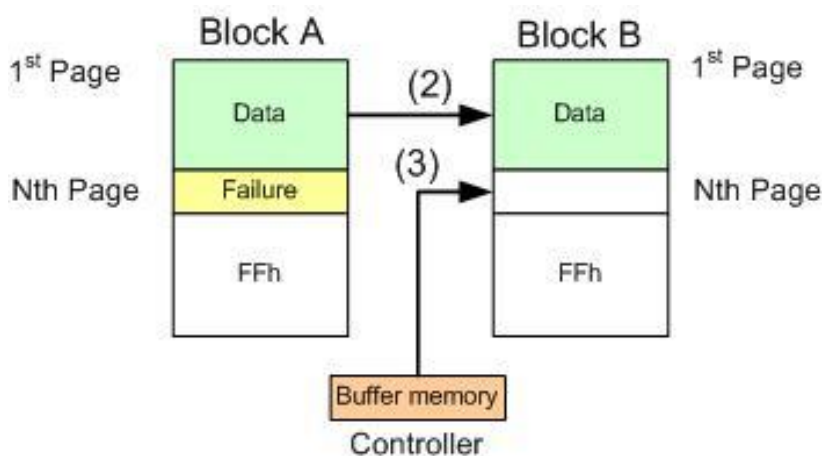


Figure 6 : Block replacement

Notes:

1. An error occurs on nth page of the Block A during Program or Erase operation.
2. Data in Block A is copied to same location in Block B which is valid block.
3. Nth page of block A which is in controller buffer memory is copied into nth page of Block B
4. Bad block table should be updated to prevent from erasing or programming Block A.

2. Electrical Characteristics

2.1. Valid Blocks

	Symbol	Min	Typ	Max	Unit
Valid Block Number	N_{VB}	2046		2132	Blocks

Notes:

1. The 1st block is guaranteed to be a valid block at the time of shipment.
2. This single device has a maximum of 86 invalid blocks.
3. Invalid blocks are one that contains one or more bad bits. The device may contain bad blocks on shipment.

2.2. Absolute Maximum Rating

Symbol	Parameter	Value	Unit
		Min	
T_A	Ambient Operating Temperature (Commercial Temperature Range)	0 to 70	°C
	Ambient Operating Temperature (Extended Temperature Range)	-25 to 85	°C
	Ambient Operating Temperature (Industrial Temperature Range)	-40 to 85	°C
T_{BIAS}	Temperature Under Bias	-50 to 125	°C
T_{STG}	Storage Temperature	-65 to 150	°C
V_{IO}	Input or Output Voltage	-0.6 to 4.6	V
V_{CC}	Supply Voltage	-0.6 to 4.6	V

Notes:

1. Except for the rating "Operating Temperature Range", stresses above those listed in the Table "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the Operating sections of this specification is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.
Refer also to the SK hynix SURE Program and other relevant quality documents.
2. Minimum voltage may undershoot to -2V during transition and for less than 20ns during transitions.
Maximum voltage may overshoot to $V_{CC}+2V$ during transition and for less than 20ns during transitions.

2.3. DC and Operating Characteristics

Parameter		Symbol	Test Conditions	3.3V			Units
				Min	Typ	Max	
Power on reset current		I_{CC0}	FFh command input after power on	-	-	50 per device	mA
Operating Current	Read	I_{CC1}	$t_{RC} = t_{RC}(\text{min})$, $CE\# = V_{IL}$, $I_{OUT} = 0$ mA	-	-	50	mA
	Program	I_{CC2}		-	-	50	mA
	Erase	I_{CC3}		-	-	50	mA
Stand-by Current (TTL)		I_{CC4}	$CE\# = V_{IH}$, $WP\# = 0V/V_{CC}$	-	-	1	mA
Stand-by Current (CMOS)		I_{CC5}	$CE\# = V_{CC} - 0.2$, $WP\# = 0V/V_{CC}$	-	10	50	uA
Input Leakage Current			$V_{IN} = 0$ to $V_{CC}(\text{MAX})$	-	-	± 10	uA
Output Leakage Current		I_{LO}	$V_{OUT} = 0$ to $V_{CC}(\text{MAX})$	-	-	± 10	uA
Input High Voltage		V_{IH}	-	$V_{CC} \times 0.8$	-	$V_{CC} + 0.3$	V
Input Low Voltage		V_{IL}	-	-0.3	-	$0.2 \times V_{CC}$	V
Output High Voltage Level		V_{OH}	$I_{OH} = -400$ μ A	2.4	-	-	V
Output Low Voltage Level		V_{OL}	$I_{OL} = 2.1$ mA	-	-	0.4	V
Output Low Current (R/B#)		$I_{OL} (R/B\#)$	$V_{OL} = 0.4V$	8	10	-	mA

2.4. AC Test Conditions

Parameter	Value
	$2.7V \leq V_{CCQ} \leq 3.6V$
Input Pulse Levels	0 V to V_{CC}
Input Rise and Fall Times	5 ns
Input and Output Timing Levels	$V_{CC} / 2$
Output Load (2.7V-3.6V)	1 TTL GATE and $CL = 50$ pF

Note:

These parameters are verified device characterization and are not 100% tested.

2.5. Pin Capacitance ($T_A=25^\circ\text{C}$, $F=1.0\text{MHz}$)

Symbol	Parameter	Test Condition	Min	Max	Unit
C_{IN}	Input Capacitance	$V_{IN} = 0V$	-	10	pF
$C_{I/O}$	Input/Output Capacitance	$V_{IL} = 0V$	-	10	pF

2.6. Program/ Read / Erase Characteristics

Parameter	Symbol	Min	Typ	Max	Unit
Program (following 10h)	t_{PROG}	-	1500	4000	us
Cache Program (following 15h)	t_{CBSYW}	-	-	4000	us
Multi-plane Program / Multi-plane Cache Program / Multi-plane Copy-back Program (following 11h)	t_{DBSY}	-	0.5	3	us
Cache Read / Multi-plane Cache Read (following 31h/3Fh)	t_{CBSYR}		3	90	us
Block Erase / Multi-plane Block Erase	t_{BERS}	-	5	10	ms
Number of partial Program Cycles in the same page	NOP	-	-	1	cycles

Notes:

Typical value is measured at $V_{CC}=3.3V$, $T_A=25^\circ\text{C}$. Not 100% tested.

2.7. AC Timing Characteristics

Parameter	Symbol	3.3V		Unit
		Min	Max	
CLE setup time	t_{CLS}	6		ns
CLE Hold time	t_{CLH}	3		ns
CE# setup time	t_{CS}	20		ns
CE# hold time	t_{CH}	5		ns
WE# pulse width	t_{Wp}	8		ns
ALE setup time	t_{ALS}	6		ns
ALE hold time	t_{ALH}	3		ns
Data setup time	t_{DS}	6		ns
Data hold time	t_{DH}	2		ns
Write cycle time	t_{WC}	16		ns
WE# high hold time	t_{WH}	6		ns
Data transfer from cell to register	t_R		90	us
ALE to RE# delay	t_{AR}	10		ns
CLE to RE# delay	t_{CLR}	10		ns
Ready to RE# low	t_{RR}	20		ns
RE# pulse width	t_{RP}	8		ns
WE# high to busy	t_{WB}		100	ns
Read cycle time	t_{RC}	16		ns
RE# access time	t_{REA}		16	ns
RE# high to output high Z	t_{RHZ}		100	ns
CE# high to output high Z	t_{CHZ}		50	ns
RE# high to output hold	t_{RHOH}	15		ns
RE# low to output hold	t_{RLOH}	5		ns
RE# or CE# high to output hold	t_{COH}	15		ns
RE# high hold time	t_{REH}	6		ns
WE# high to RE# low	t_{WHR}	80		ns
WE# high to RE# low for Random data out	t_{WHR2}	200		ns
RE# high to WE# low	t_{RHW}	100		ns
Output high Z to RE# low	t_{IR}	0		ns
CE# low to RE# low	t_{CR}	10		ns
Address to data loading time	t_{ADL}	200		ns
Device resetting time (Read/Program/Erase)	t_{RST}		20/30/500	us
Write protection time	t_{WW}	100		ns

Notes:

1. If Reset Command (FFh) is written at Ready state, the device goes into Busy for maximum 5us.
2. Program / Erase Enable Operation: WP# high to WE# High.
Program / Erase Disable Operation: WP# Low to WE# High.
3. The transition of the corresponding control pins must occur only while WE# is held low.
4. t_{ADL} is the time from the WE# rising edge of final address cycle to the WE# rising edge of first data cycle.

2.8. Status Register Coding
2.8.1. Status Register Coding For 70h/78h command

I/O	Page Program	Block Erase	Read	Cache Read	Cache Program	Coding
						70h / 78h
0	Pass / Fail	Pass / Fail	N/A	N/A	Pass / Fail (N)	N page Pass : '0' Fail : '1'
1	N/A	N/A	N/A	N/A	Pass / Fail (N-1)	N -1 page Pass : '0' Fail : '1'
2	N/A	N/A	N/A	N/A	N/A	'0'
3	N/A	N/A	N/A	N/A	N/A	'0'
4	N/A	N/A	N/A	N/A	N/A	'0'
5	N/A	N/A	N/A	Ready / Busy	Ready / Busy	Ready / Busy Busy : '0' Ready : '1'
6	Ready / Busy	Ready / Busy	Ready / Busy	Ready / Busy	Ready / Busy	Data Cache Ready / Busy Busy : '0' Ready : '1'
7	Write Protect	Write Protect	Write Protect	Write Protect	Write Protect	Protected : '0' Not Protected : '1'

Notes:

1. I/O0 : This bit is only valid for Program and Erase operations. During Cache Program operations, this bit is only valid when I/O5 is set to one.
2. I/O1 : This bit is only valid for cache program operations. This bit is not valid until after the second 15h command or the 10h command has been transferred in a Cache program sequence. When Cache program is not supported, this bit is not used.
3. I/O5 : If set to one, then there is no array operation in progress. If cleared to zero, then there is a command being processed (I/O6 is cleared to zero) or an array operation in progress. When overlapped interleaved operations or cache commands are not supported, this bit is not used.
4. I/O6 : If set to one, then the device or interleaved address is ready for another command and all other bits in the status value are valid. If cleared to zero, then the last command issued is not yet complete and Status Register bits<5:0> are invalid value. When cache operations are in use, then this bit indicates whether another command can be accepted, and I/O5 indicates whether the last operation is complete.

2.8.2. Status Register Coding For 75h command

I/O	Page Program	Block Erase	Read	Cache Read	Cache Program	Coding
						75h
0	/ Fail	/ Fail	N/A	N/A	Chip Pass / Fail (N)	N page Pass : '0' Fail : '1'
1	Plane 0 Pass / Fail	Plane 0 Pass / Fail	N/A	N/A	Plane 0 Pass / Fail (N)	N page Pass : '0' Fail : '1'
2	Plane 1 Pass / Fail	Plane 1 Pass / Fail	N/A	N/A	Plane 1 Pass / Fail (N)	N page Pass : '0' Fail : '1'
3	N/A	N/A	N/A	N/A	Plane 0 Pass / Fail (N-1)	N -1 page Pass : '0' Fail : '1'
4	N/A	N/A	N/A	N/A	Plane 1 Pass / Fail (N-1)	N -1 page Pass : '0' Fail : '1'
5	N/A	N/A	N/A	Ready / Busy	Ready / Busy	Ready / Busy Busy : '0' Ready : '1'
6	Ready / Busy	Ready / Busy	Ready / Busy	Ready / Busy	Ready / Busy	Data Cache Ready / Busy Busy : '0' Ready : '1'
7	Write Protect	Write Protect	Write Protect	Write Protect	Write Protect	Protected : '0' Not Protected : '1'

2.9. Device Identifier Coding

Parameter	Symbol
Device Identifier Byte	Description
1 st	Manufacturer Code
2 nd	Device Identifier
3 rd	Internal chip number, cell Type, Number of Simultaneously Programmed Pages, Interleaved Program, Write Cache.
4 th	Page size, Block size, Redundant area size
5 th	Plane Number, ECC Level
6 th	Technology (Design Rule), EDO, Interface

2.10. Read ID Data Table

Part Number	Voltage	Bus Width	Manufacture Code	Device Code	3 rd	4 th	5 th	6 th
H27UCG8T2B	3.3V	X8	ADh	DEh	94h	EBh	74h	44h

2.10.1. 3rd Byte of Device Identifier Description

3 rd cycle	Description	I/07	I/06	I/05	I/04	I/03	I/02	I/01	I/00
Internal Chip Number / CE	1							0	0
	2							0	1
	4							1	0
	8							1	1
Cell Type	2 Level Cell					0	0		
	4 Level Cell					0	1		
	8 Level Cell					1	0		
	16 Level Cell					1	1		
Number of Simultaneously Programmed Pages	1			0	0				
	2			0	1				
	4			1	0				
	8			1	1				
Interleaved Program Between Multiple die	Not Supported		0						
	Supported		1						
Write Cache	Not Supported	0							
	Supported	1							

2.10.2. 4th Byte of Device Identifier Description

4 th cycle	Description	I/07	I/06	I/05	I/04	I/03	I/02	I/01	I/00
Page Size (Without Spare Area)	2KB							0	0
	4KB							0	1
	8KB							1	0
	16KB							1	1
Block Size (Without Spare area)	128KB	0		0	0				
	256KB	0		0	1				
	512KB	0		1	0				
	768KB	0		1	1				
	1MB	1		0	0				
	2MB	1		0	1				
	4MB	1		1	0				
	Reserved	1		1	1				
Redundant Area Size / 8KB	640Bytes		1			1	0		
	448Bytes		0			1	0		
	224Bytes		0			0	1		
	128Bytes		0			0	0		
	64Byte		0			1	1		
	32Byte		1			0	0		
	16Byte		1			0	1		
	Reserved		1			1	1		

2.10.3. 5th Byte of Device Identifier Description

5 th cycle	Description	I/O7	I/O6	I/O5	I/O4	I/O3	I/O2	I/O1	I/O0
Plane Number / CE	16					0	0		
	2					0	1		
	4					1	0		
	8					1	1		
ECC Level	None		0	0	0				
	1bit/512Bytes		0	0	1				
	2bit/512Bytes		0	1	0				
	4bit/512Bytes		0	1	1				
	8bit/512Bytes		1	0	0				
	24bit/1KBytes		1	0	1				
	32bit/1KBytes		1	1	0				
	40bit/1KBytes		1	1	1				
Reserved		0						0	0

2.10.4. 6th Byte of Device Identifier Description

6 th cycle	Description	I/O7	I/O6	I/O5	I/O4	I/O3	I/O2	I/O1	I/O0
NAND Technology	48nm						0	0	0
	41nm						0	0	1
	32nm						0	1	0
	26nm						0	1	1
	20nm						1	0	0
	Reserved						1	0	1
	Reserved						1	1	0
	Reserved						1	1	1
EDO Support	Not Support		0						
	Support		1						
NAND Interface	Async. Only								
	Async. & Sync. Interface								
Reserved		0		0	0	0			

3. Timing Diagram

Bus Operation

There are six standard bus operations that control the device. These are Command Input, Address Input, Data Input, Data Output, Write Protect, and Standby.

3.1. Command Latch Cycle Timings

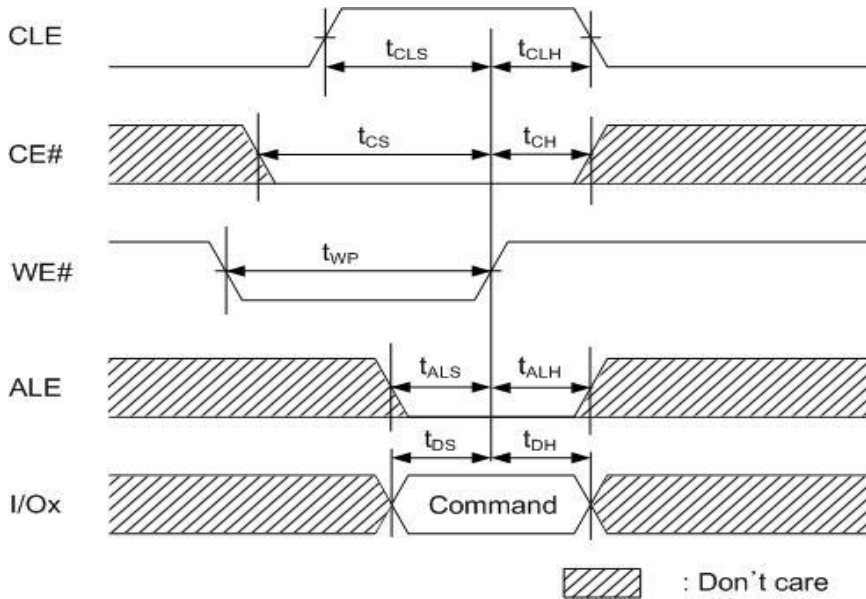


Figure 7 : Command latch timings

Note:

All command except Reset, Read Status, and Multi-plane Read Status is issued to command register on the rising edge of WE#, when CLE is high, CE# and ALE is low, and device is not busy state.

3.2. Address Latch Cycle Timings

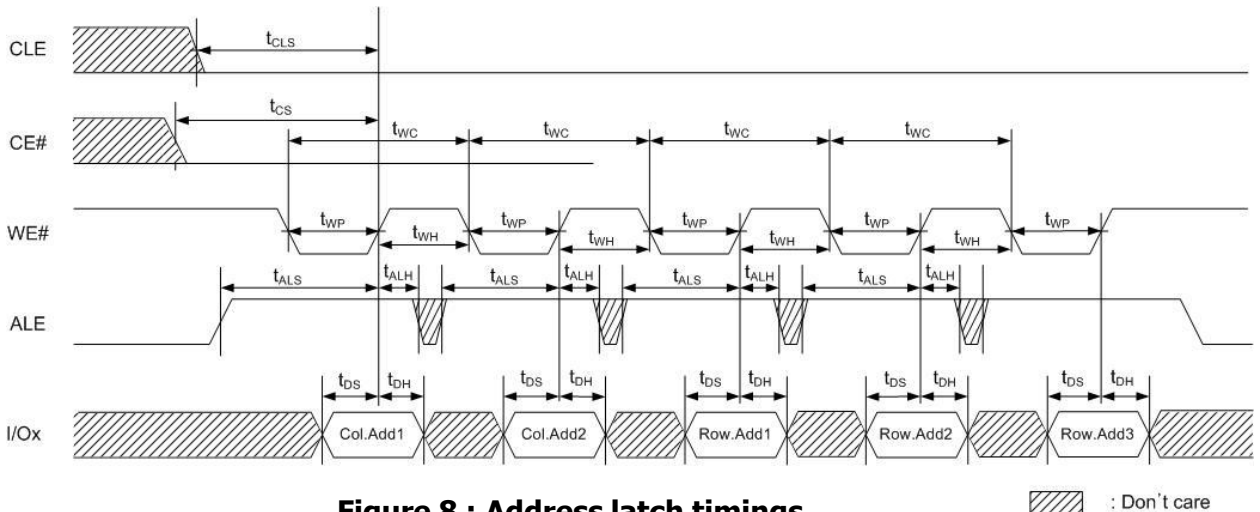


Figure 8 : Address latch timings

3.3. Input Data Latch Cycle Timings

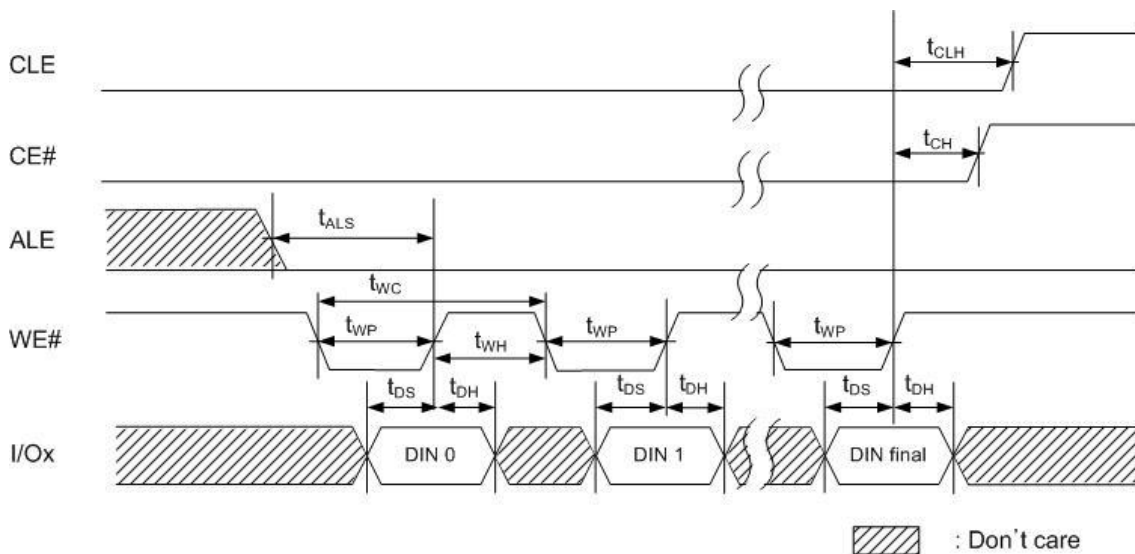


Figure 9 : Input data cycle timings

Note:

Data Input cycle is accepted to data register on the rising edge of WE#, when CLE and CE# and ALE are low, and device is not Busy state.

3.4. Data Output Cycle Timings (CLE=L, WE#=H, ALE=L, WP#=H)

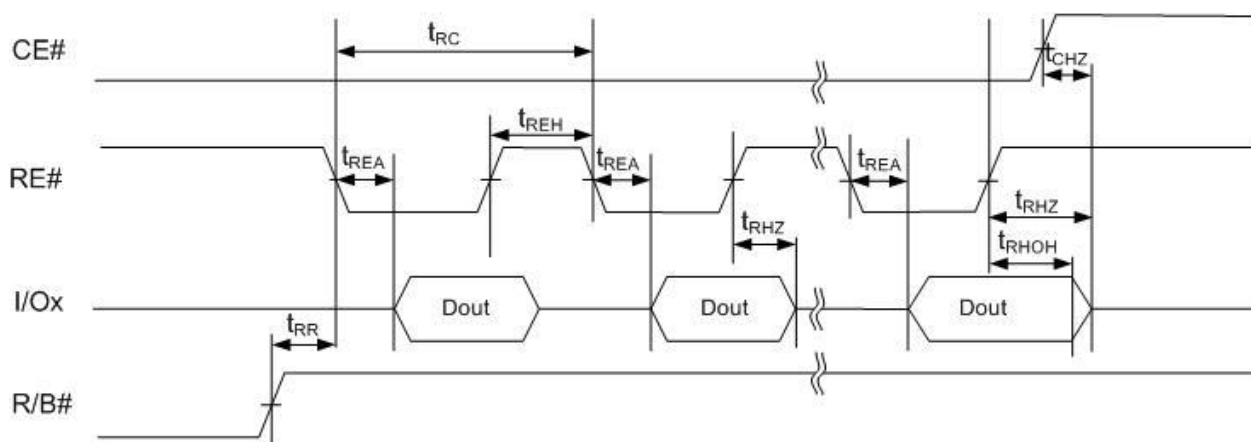


Figure 10 : Data output cycle timings

Notes:

1. Transition is measured +/-200mV from steady state voltage with load. This parameter is sampled and not 100% tested. (t_{CHZ} , t_{RHZ})
2. t_{RLOH} is valid when frequency is higher than 10 MHz .
 t_{RHOH} starts to be valid when frequency is lower than 10 MHz.

3.5. Data Output Cycle Timings (EDO type, CLE=L, WE#=H, ALE=L)

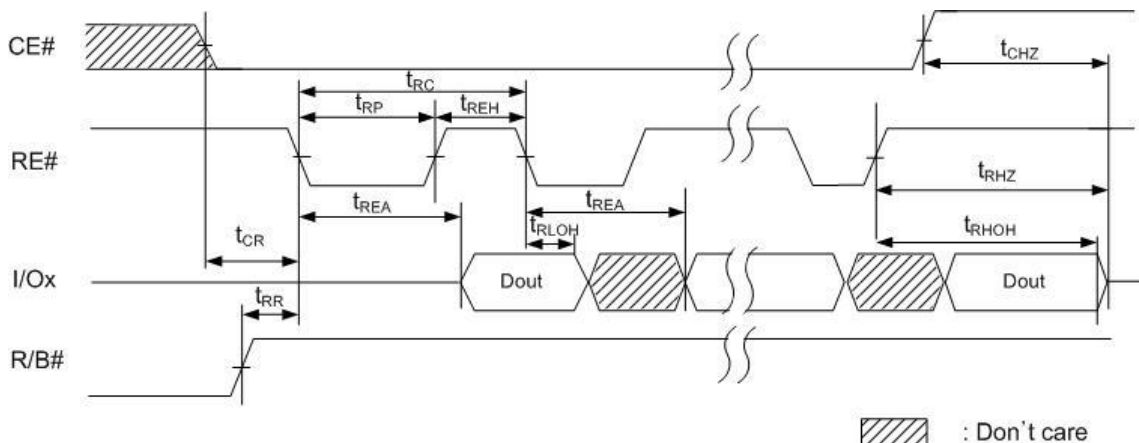


Figure 11 : Data output cycle timings (EDO)

Notes:

1. Transition is measured +/-200mV from steady state voltage with load.
 This parameter is sampled and not 100% tested. (t_{CHZ} , t_{RHZ})
2. t_{RLOH} is valid when frequency is higher than 10 MHz.
 t_{RHOH} starts to be valid when frequency is lower than 10 MHz.

3.6. Read Status Cycle Timings

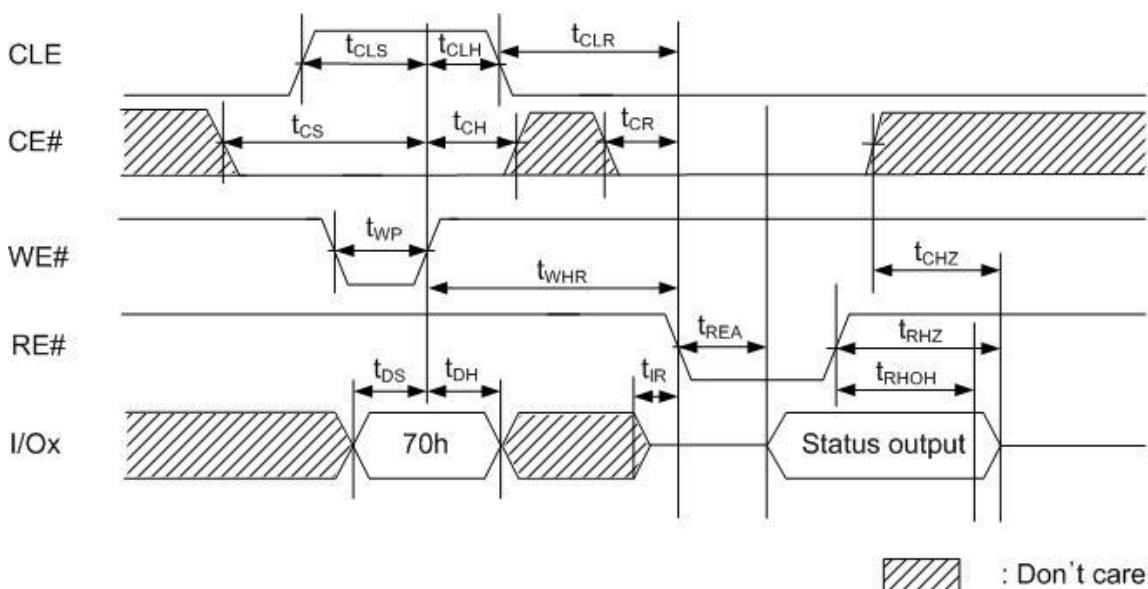


Figure 12 : Read status timings

3.7. Multi-Plane Read Status Timings

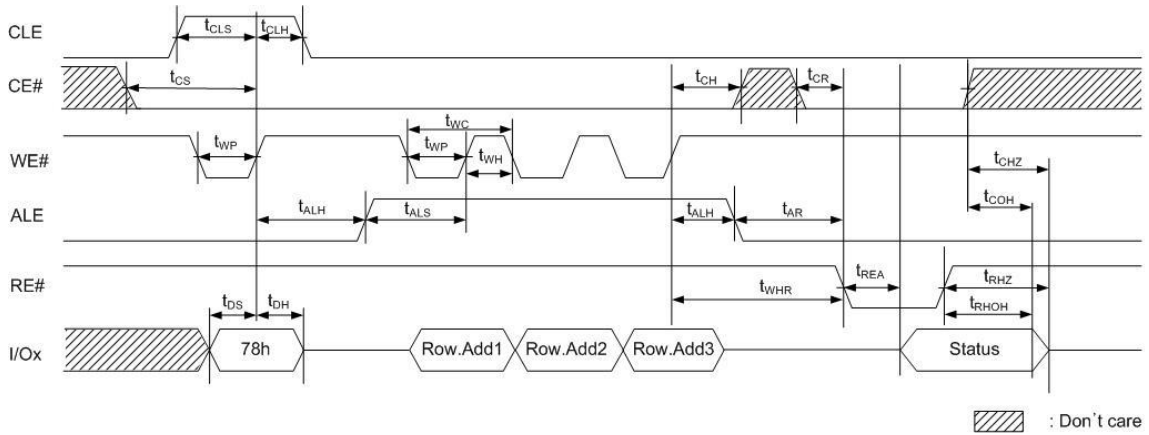


Figure 13 : Multi-plane read status timings

3.8. Page Read Operation Timings (Read One Page)

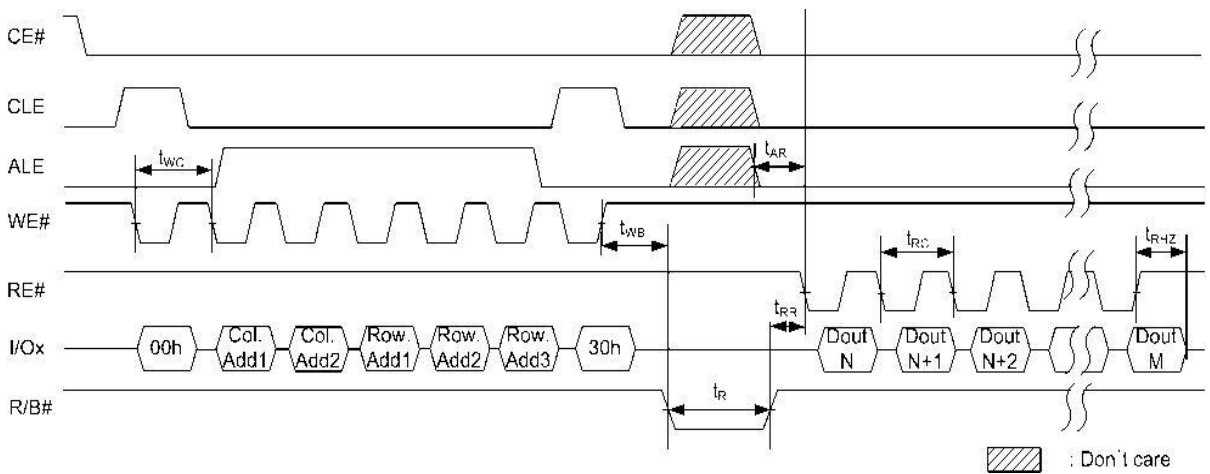


Figure 14 : Page read operation timings

3.9. Page Read Operation Timings (Intercepted by CE#)

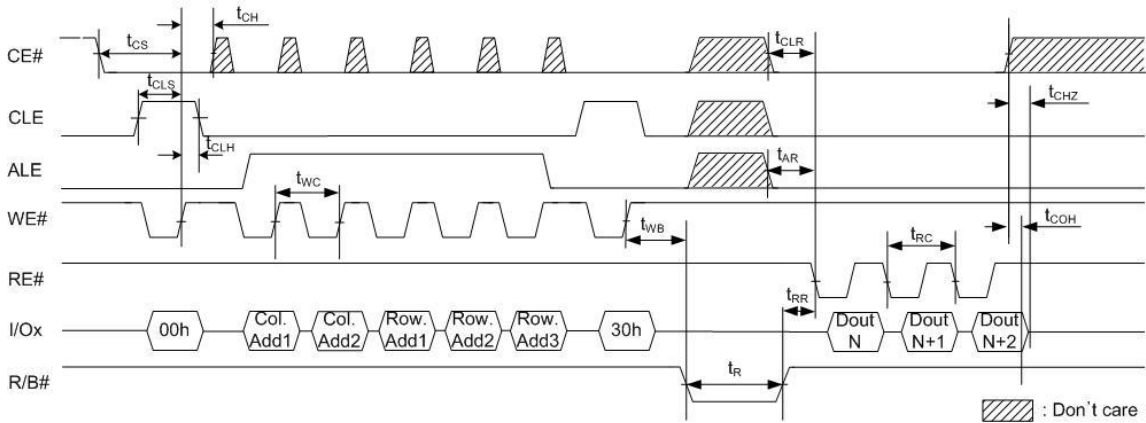


Figure 15 : Page read operation timings

3.10. Page Read Operation Timings with CE# don't care

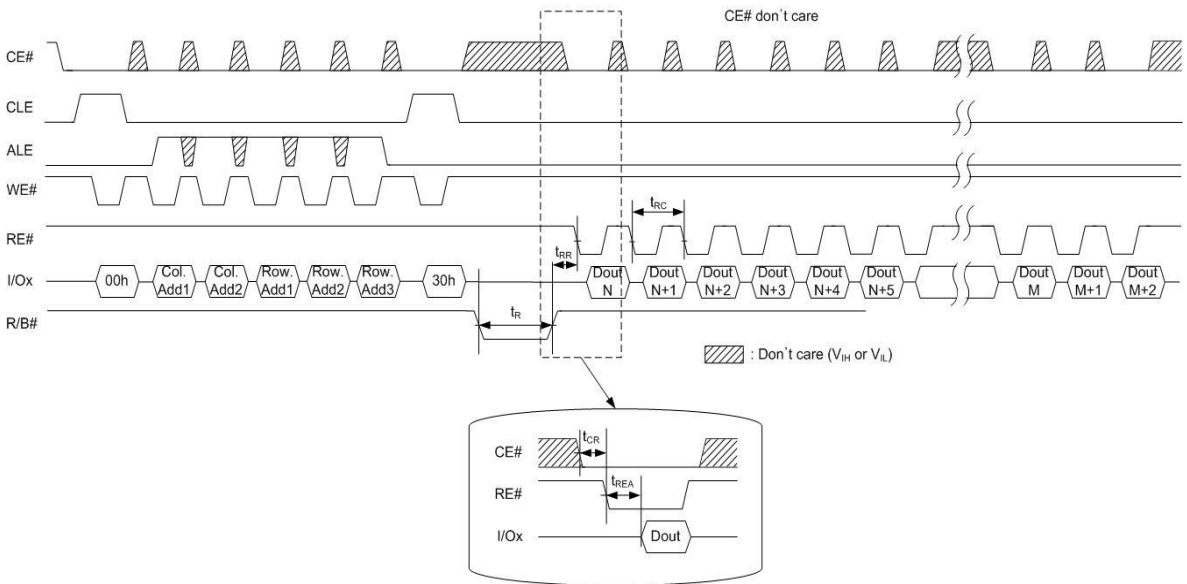


Figure 16 : Page read operation timings with CE# don't care

3.11. Random Data Output Timings

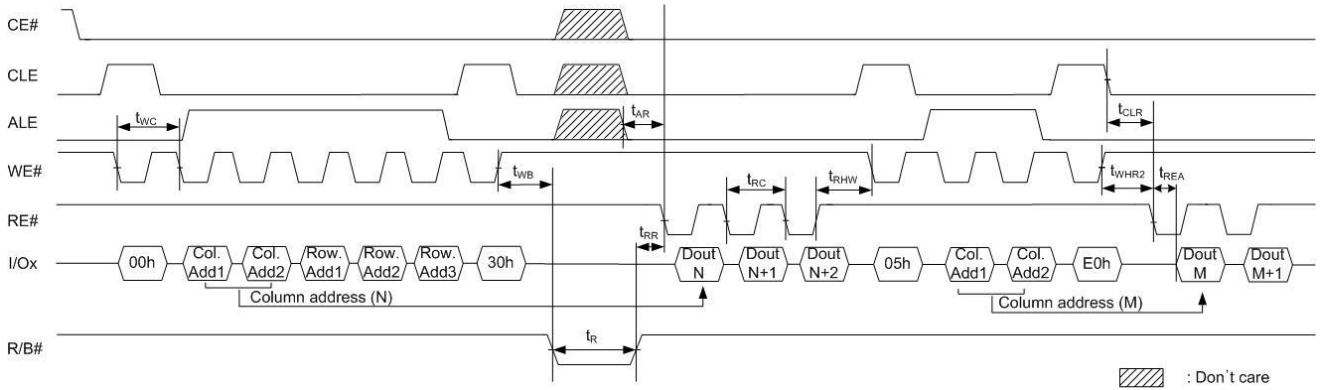


Figure 17 : Random data output timings

Notes:

Random data output is available within a page.

3.12. Multi-plane Page Read Operation with Random Data output Timings

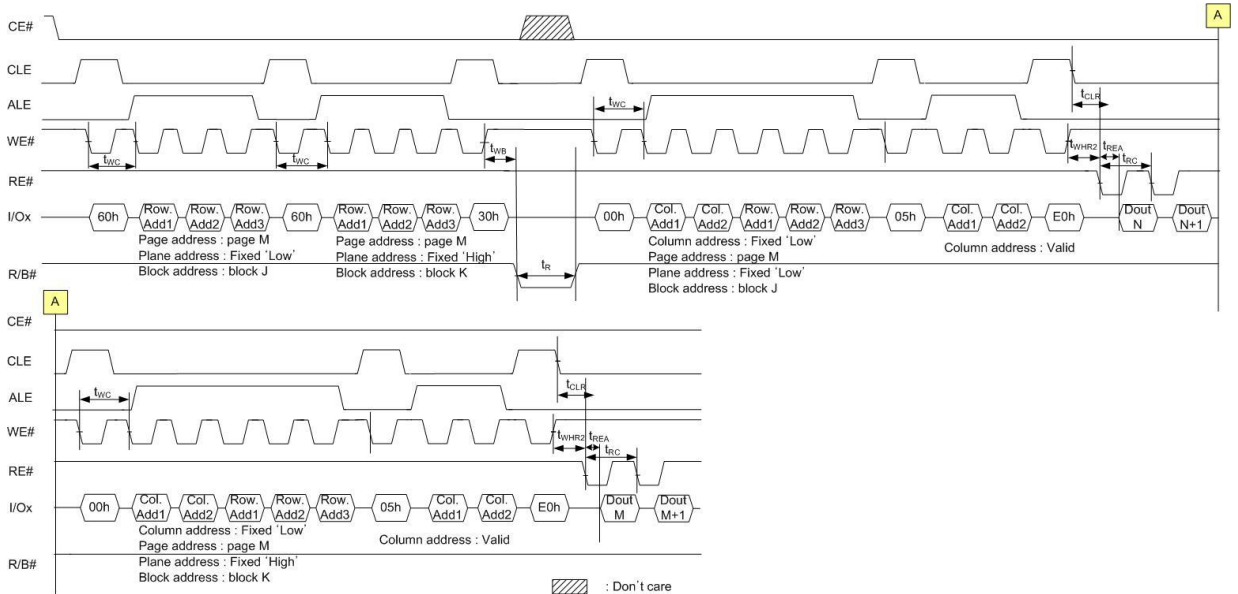


Figure 18 : Multi-plane page read operation timings with random data output

Notes:

1. Multi-plane Page addresses are required to be the same.
2. Multi-plane Random data-out must be used after multi plane read operations.
3. Multi-plane page read must be used after multi-plane programmed page, multi-plane cache program, and multi-plane copy-back program.

3.13. Cache Read Operation Timings

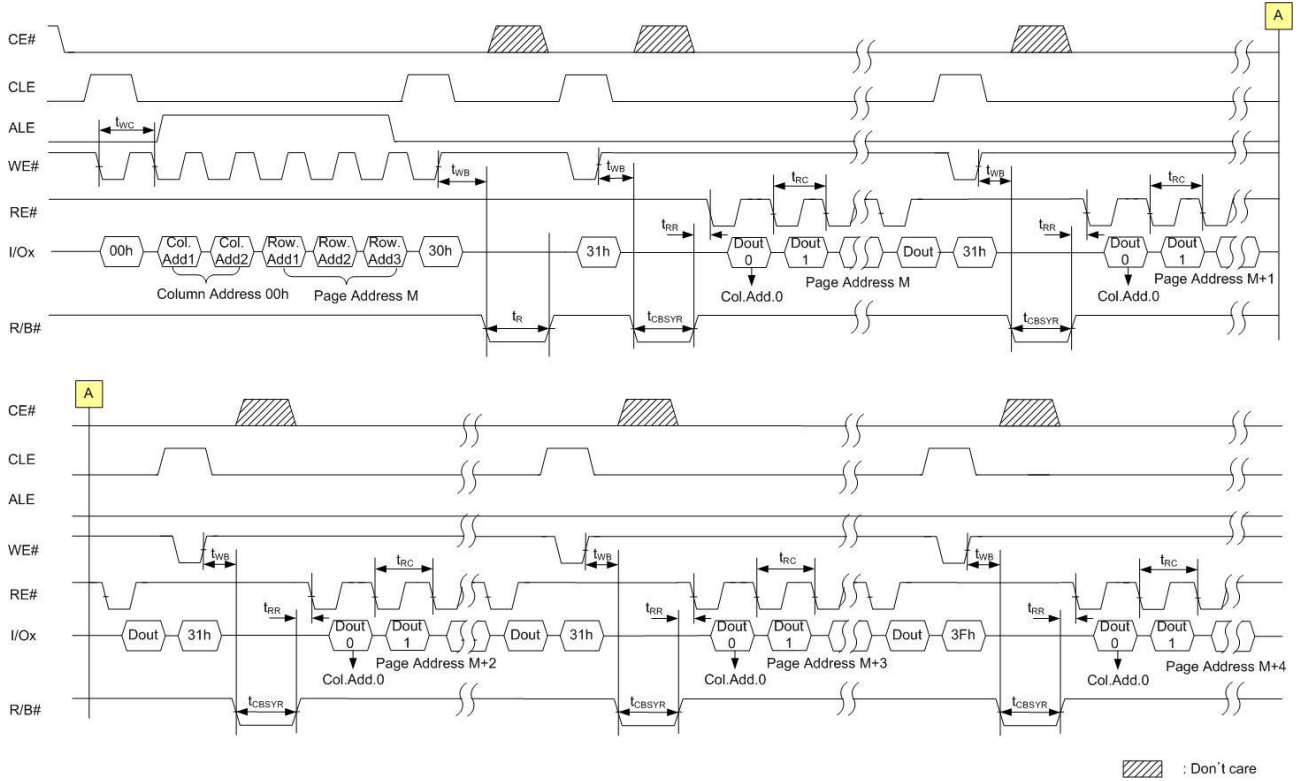


Figure 19 : Cache read operation timings

Notes:

1. The column address will be reset to 0 by the 31h/3Fh command input.
2. Cache read operation is available only within a block.

3.14. Multi Plane Cache Read Operation Timings

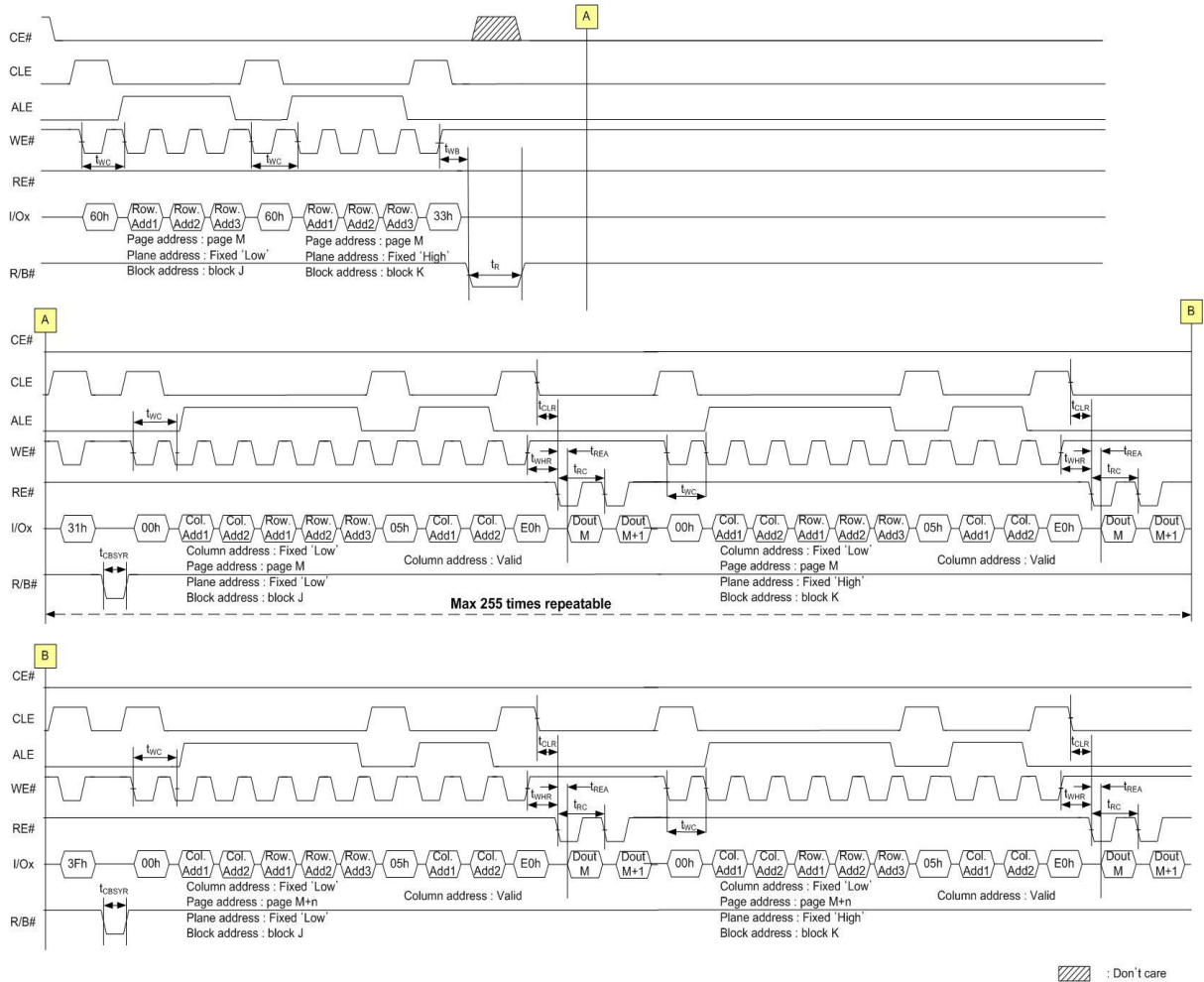


Figure 20 : Multi-plane cache read operation Timings

Notes:

1. The column address will be reset to 0 by the 31h/3Fh command input.
2. Cache read operation is available only within a block.
3. Make sure to terminate the operation with 3Fh command. If the page read operation is completed, issue FFh reset before next operation.
4. Multi-plane Page addresses are required to be the same.
5. Multi-plane cache read must be used after multi-plane programmed page, multi-plane cache program, and multi-plane copy-back program

3.15. Read ID Operation Timings

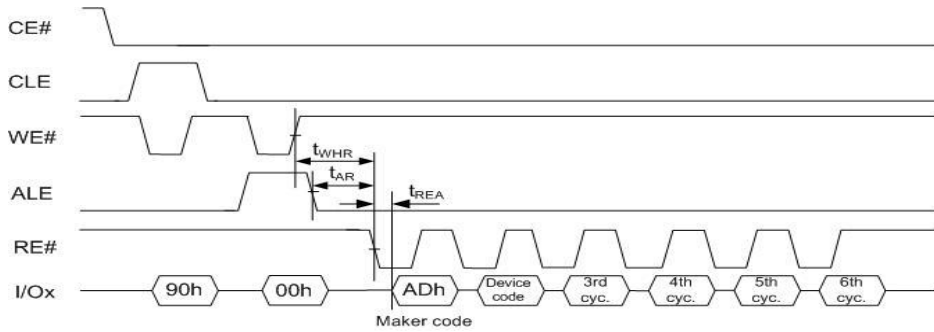


Figure 21 : Read ID operation timings

3.16. Page Program Operation Timings

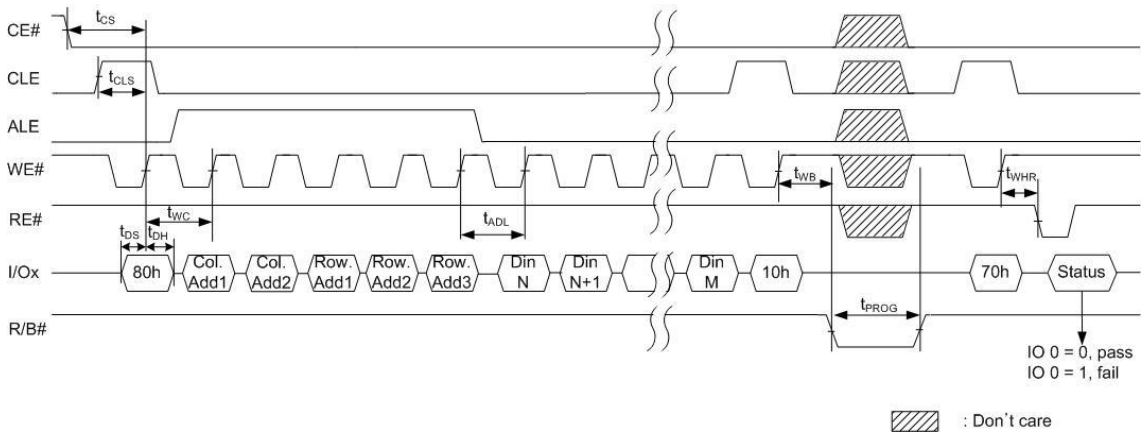


Figure 22 : Page program operation timings

Note:

t_{ADL} is the time from the WE# rising edge of final address cycle to the WE# rising edge of first data cycle.

3.17. Page Program Operation Timings with CE# don't care

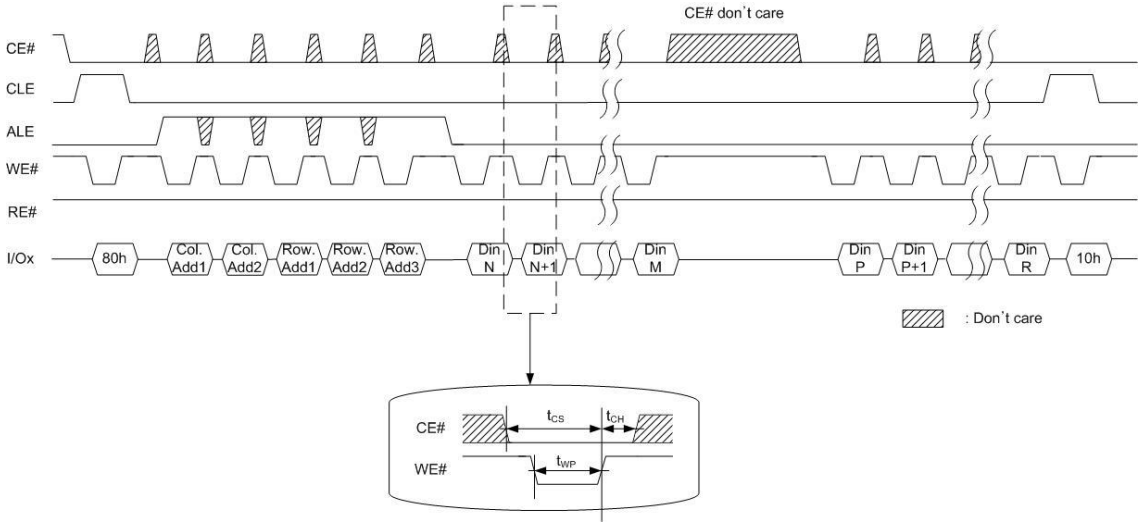


Figure 23 : Page program operation timings with CE# don't care

Note:

t_{ADL} is the time from the WE# rising edge of final address cycle to the WE# rising edge of first data cycle.

3.18. Random Data Input Timings

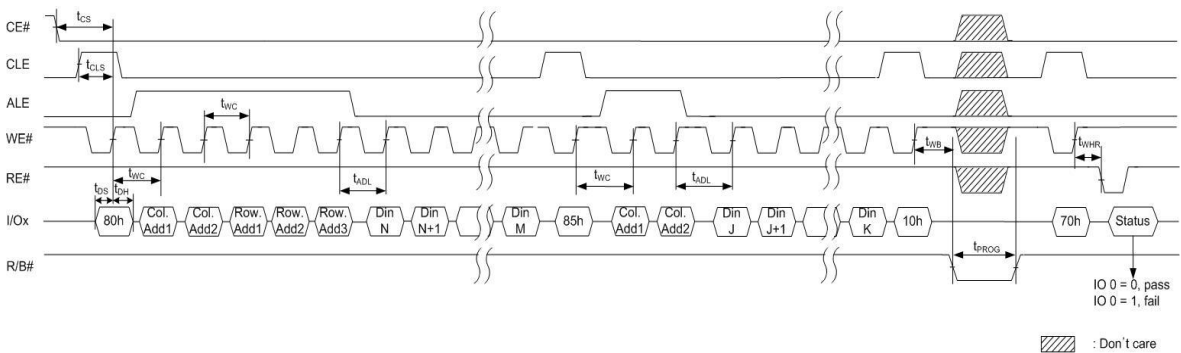


Figure 24 : Random data input timings

Notes:

1. t_{ADL} is the time from the WE# rising edge of final address cycle to the WE# rising edge of first data cycle.
2. Random data input can be performed in a page.

IO 0 = 0, pass
 IO 0 = 1, fail

3.19. Multi-Plane Page Program Operation Timings

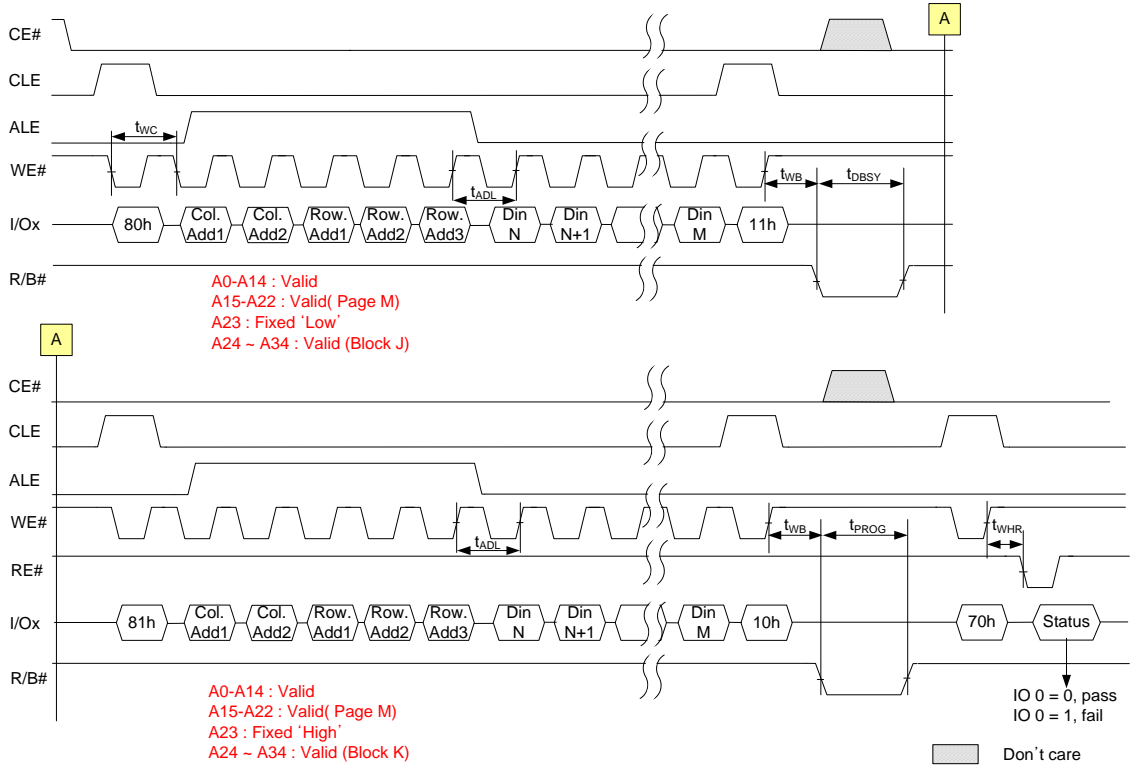


Figure 25 : Multi-plane page program operation timing

Notes:

1. Any command between 11h and 81h is prohibited except 70h, 78h, 75h and FFh
2. t_{ADL} is the time from the WE# rising edge of final address cycle to the WE# rising edge of first data cycle.
3. Multi-plane Page addresses are required to be the same.

3.20. Copy-Back Program Operation Timings with Random Date Input

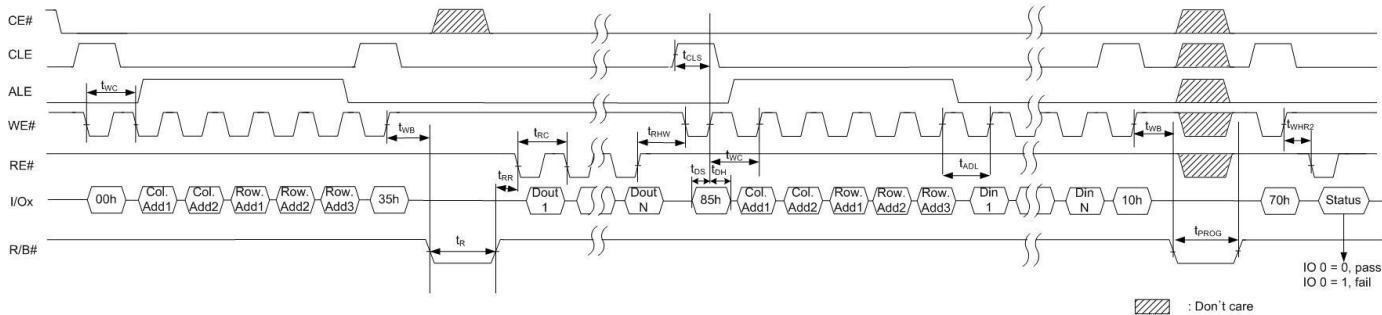


Figure 26 : Copy-back program operation timing with random data input

Note:

Copy-back operation is allowed only within the same memory plane.

3.21. Cache Program Operation Timings

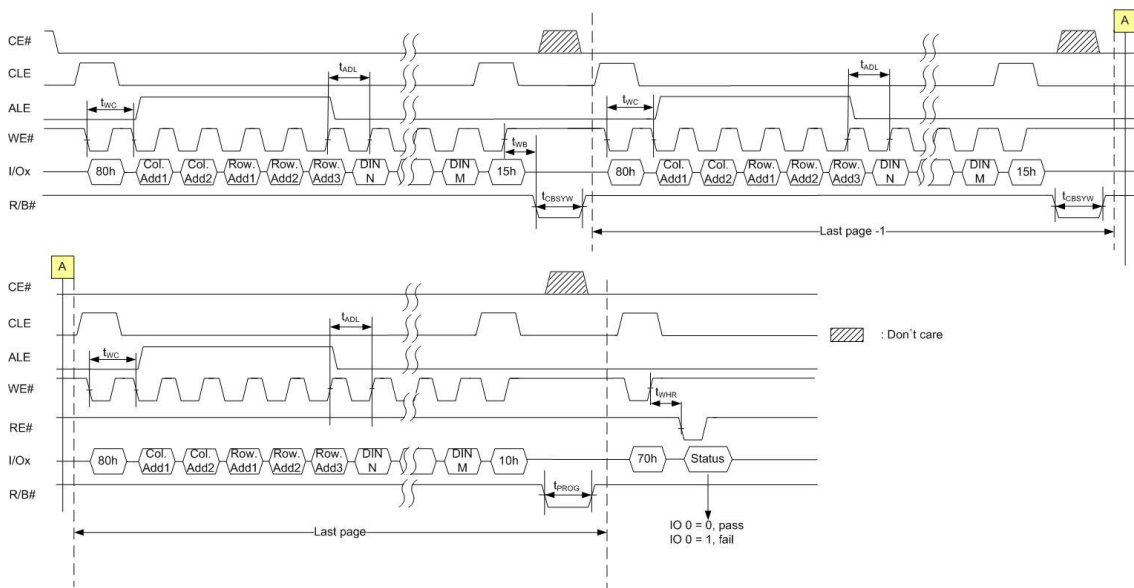


Figure 27 : Cache program operation timings

Note:

t_{PROG} = Program time for the last page + Program time for the (last -1)th page
 - (command input cycle time + address input cycle time + Last page data loading time)

3.22. Multi-Plane Cache Program Operation Timings

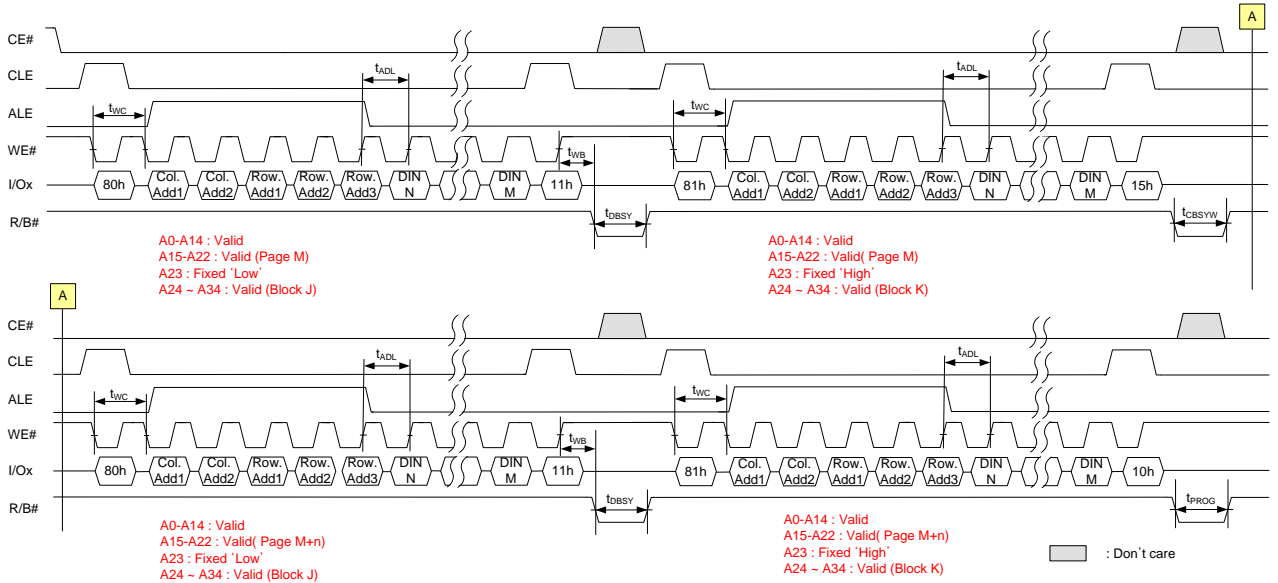


Figure 28 : Multi-plane cache program operation timings

Notes:

- t_{PROG} = Program time for the last page + Program time for the (last -1)th page – (command input cycle time + address input cycle time + Last page data loading time)
- Make sure to terminate the operation with 80h-10h- command sequence. If the operation is terminated by 80h-15h command sequences, monitor I/O5 (Ready/Busy) and I/O6 (Data Cache Ready/Busy) by issuing Read Status Command (70h) and make sure the previous and current Cache Page Program operation is completed. If the page program operation is completed, issue FFh reset before next operation.
- Selected Page address except A23 within two blocks must be same.

3.23. Block Erase Operation Timings

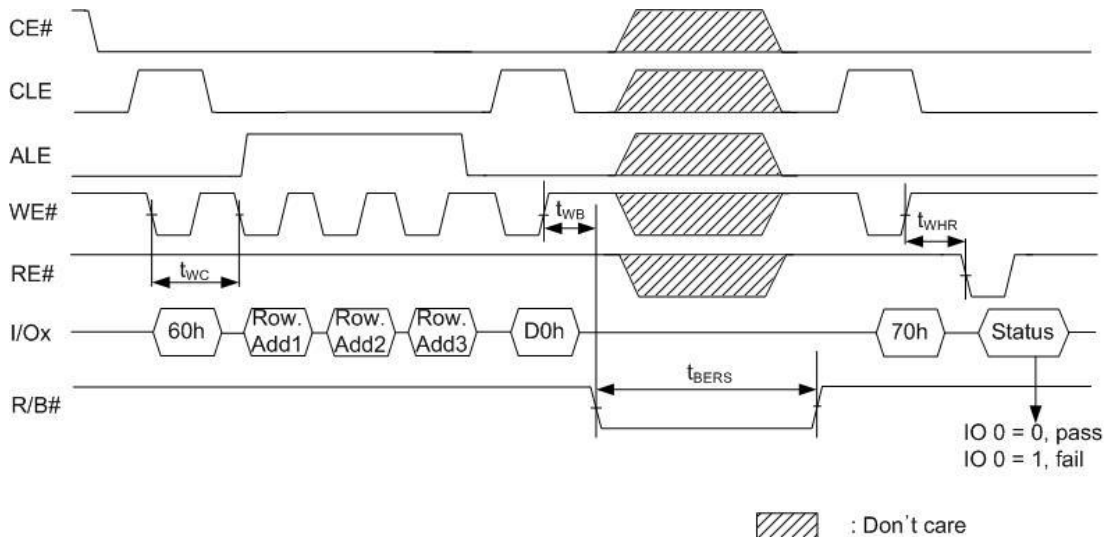


Figure 29 : Block erase operation timings

3.24. Multi-Plane Erase Operation Timings

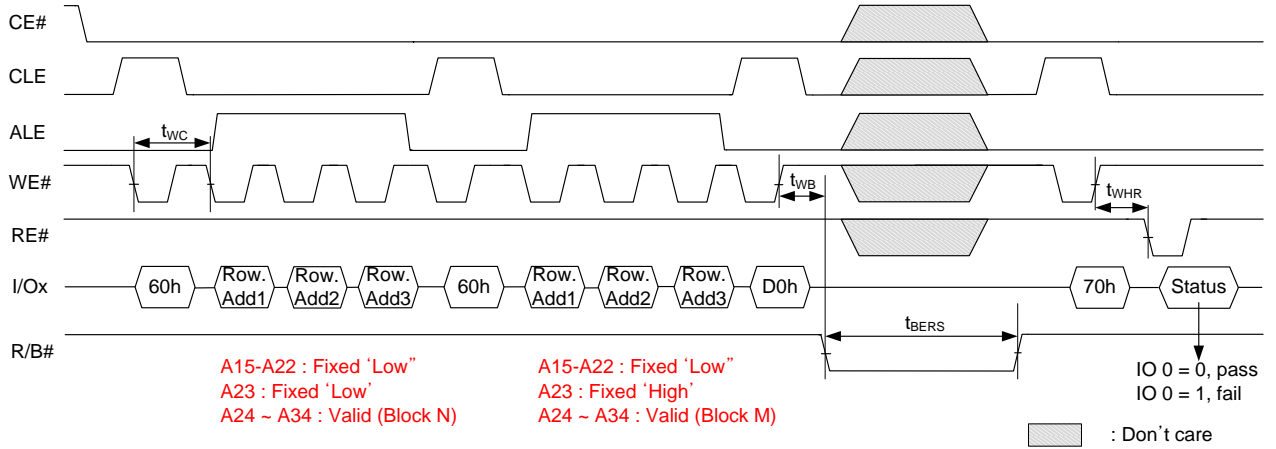


Figure 30 : Multi-plane erase operation timings

3.25. Reset Timings

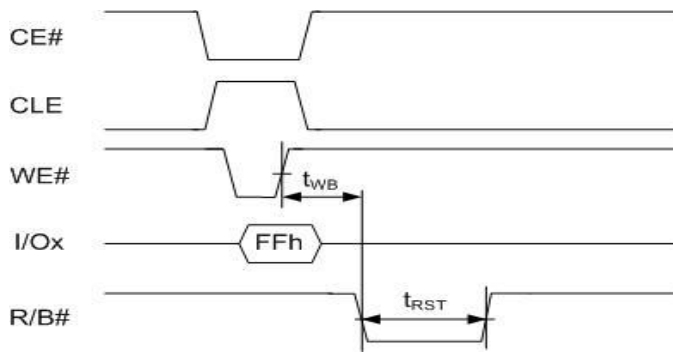


Figure 31 : Reset timings

4. Device Operation

4.1. Page Read

This operation is initialized by 00h-30h to the command register along with followed by five address input cycles. The 17,664 bytes of data within the selected page are transferred to the data registers in less than t_R . The system controller may 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 data registers, they may be read out in 20ns cycle time by sequentially pulsing RE#. The repetitive high to low transitions of the RE# clock make the device output the data starting from the selected column address up to the last column address.

The device may output random data in a page instead of the consecutive sequential data by writing random data output command. The column address of next data, which is going to be out, may be changed to the address, which follows random data output command. Random data output can be operated multiple times, regardless of how many times it is done in a page.

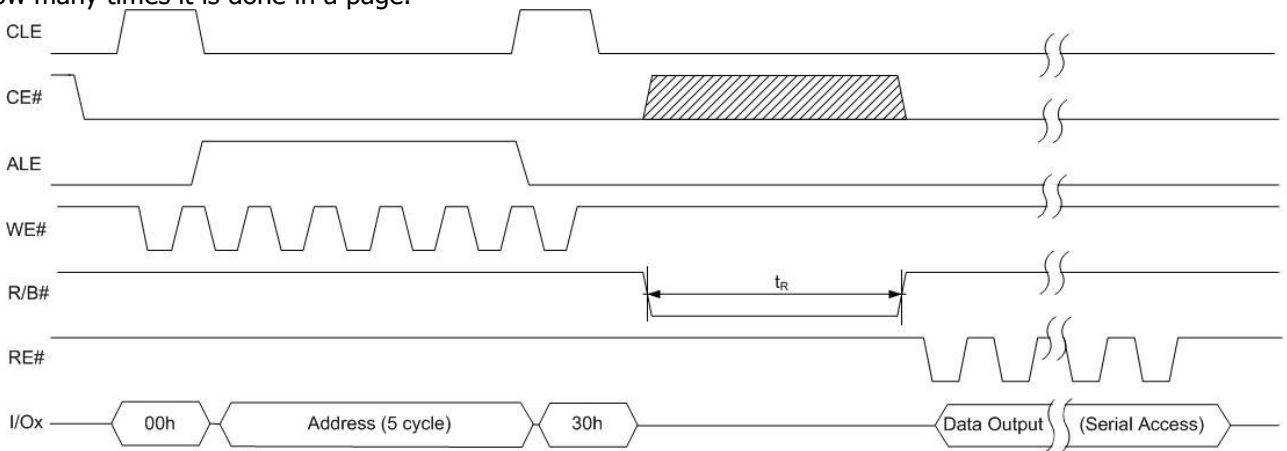


Figure 32 : Page read

Random data output

Random data output operation changes the column address from which data is being read in the page register. Random data output only is issued in Ready state. Refer to Figure 33.

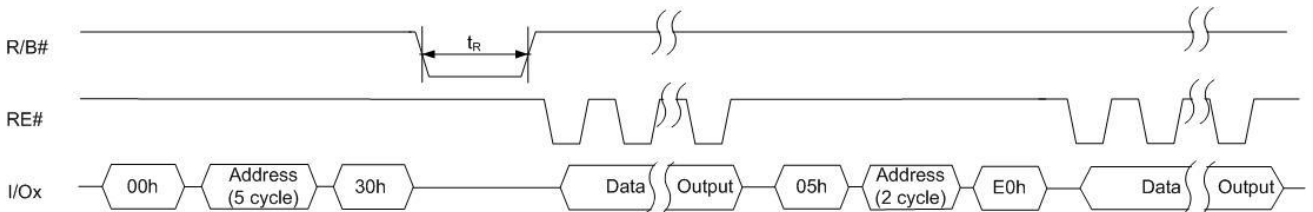


Figure 33 : Random data output

4.2. Cache Read (available only within a block)

To improve page read throughput, cache read operation is used within a block. First step is same as normal page read, issuing a page read sequence (00-30h). After random access (R/B# returns to high), 31h command is latched into the command register. Data is being transferred from the data register to the cache register. While cache register data is outputted, next page is transferred from memory cell to data register. R/B# will stay low during present page random accessing and previous page transferring to cache register. Because it is not necessary to output a whole page data before issuing another 31h command, if serial data output time exceeds random access time (t_R), the random access time can be hidden. The subsequent pages are issued additional 31h commands. To terminate cache read, 3Fh command should be issued. This command transfer data from data register to the cache register without issuing next page read. During the Cache Read Operation, device doesn't allow any other command except Cache Read command (31h), Read Status (70h, 78h, 75h), Read (00h), and Reset (FFh). To carry out other operations after cache operation, cache read must be ended by 3Fh command or issue reset (FFh) before next operation.

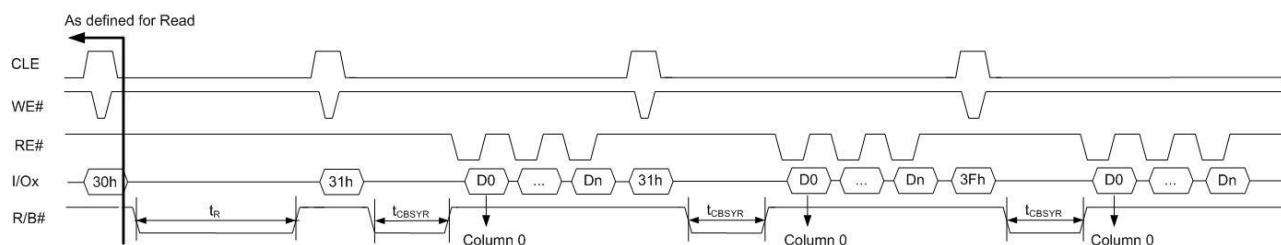


Figure 34 : Cache read

4.3. Cache Read Enhanced (available only within a block)

This command extends the Cache Read command. While, by issuing a Cache Read command, the next page address of the next page is automatically incremented by 1, the next page address of the next page is given arbitrarily by the user. The Cache Read Enhanced command sequence consists of a 00h command, five address cycles and a 31h command, which replaces the single 31h command of the Cache Read command sequence.

4.4. Multi Plane Page Read

Multi-Plane Page Read is an extension of Page Read, for a single plane with 17,664byte page registers. Since the device is equipped with two memory planes, activating the two sets of 17,664byte page registers enables a random read of two pages. Multi-Plane Page Read is initiated by repeating command 60h followed by three address cycles twice. In this case, only same page of each block can be selected from each plane.

After Read Confirm command (30h) the 17,664bytes of data within the selected two pages are transferred to the data registers in less than t_R . The system controller can detect the completion of data transfer (t_R) by monitoring the output of R/B# pin.

Once the data is read into the data registers, the data output of first plane can be read out by issuing command 00h with Five Address Cycles, command 05h with two column address and finally E0h. The data output of second plane can be read out using the identical command sequences. The restrictions for Multi-Plane Page Read are shown in Figure 35. Multi-Plane Page Read must be used in the block which has been programmed with Multi-Plane Page Program.

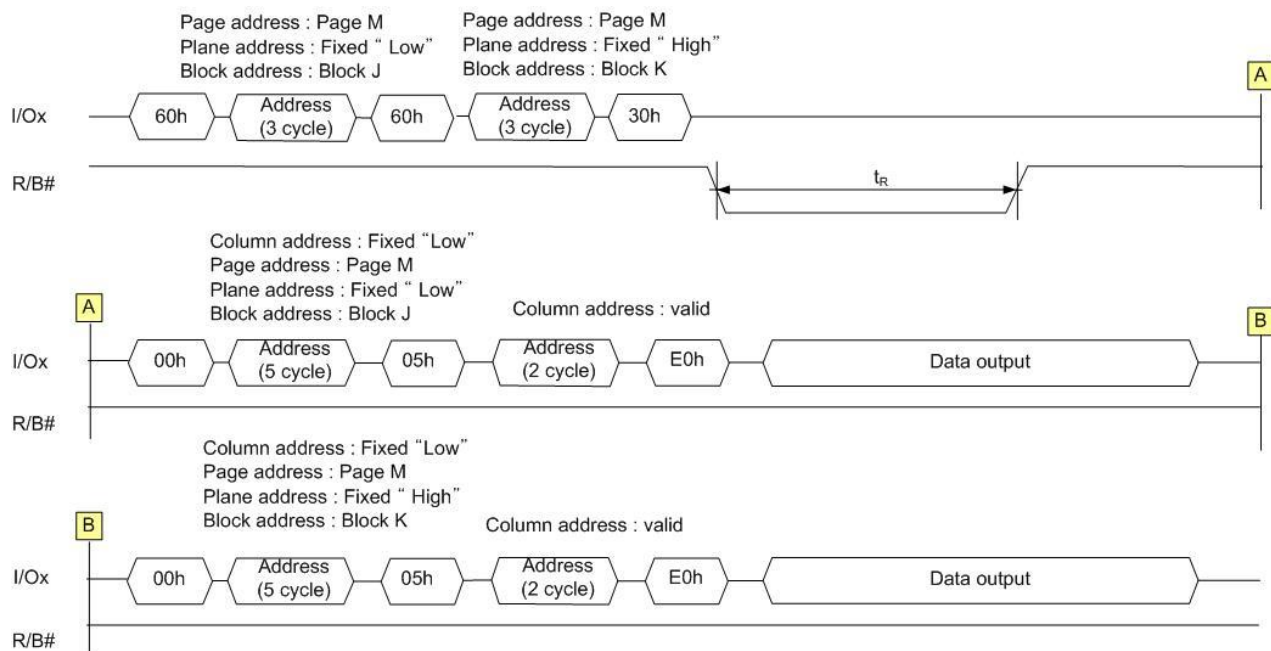


Figure 35 : Multi plane page read

4.5. Multi Plane Cache Read (available only within a block)

The device supports multi-plane cache read, which enables high read throughput by reading two pages in parallel. Figure 36 shows the command sequence for the multi-plane cache read operation. Both confirm commands, 30h and 33h, are valid for the first page read sequence.

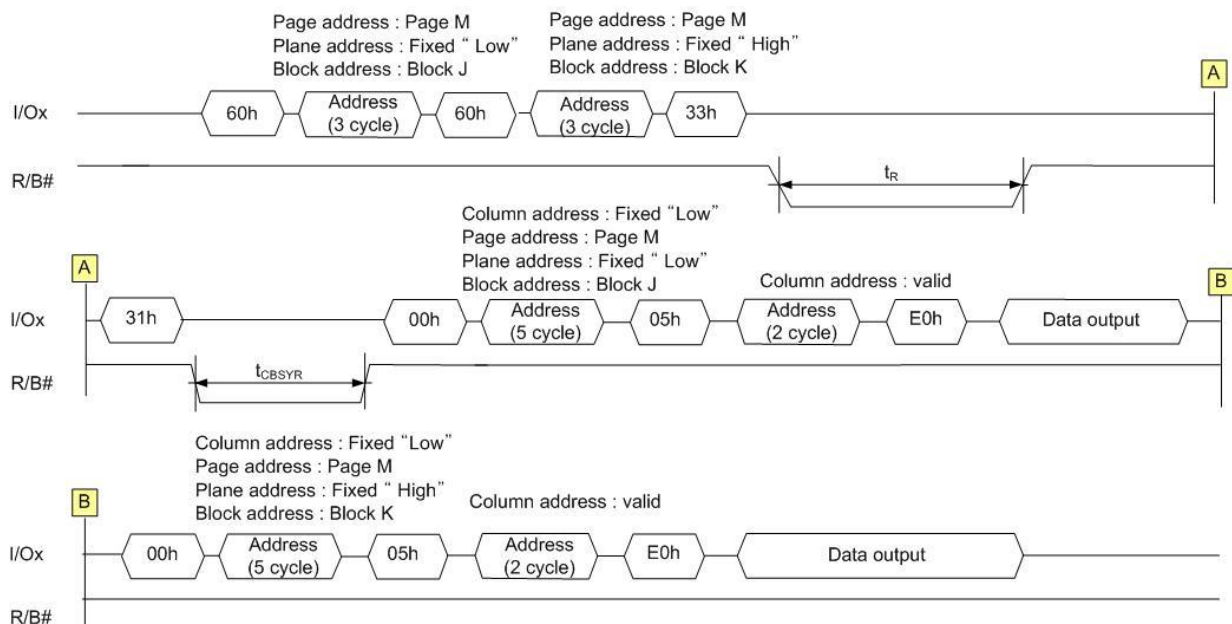


Figure 36 : Multi plane cache read

Notes:

1. plane 0 and plane 1 should be selected within the same chip
2. Only one block should be selected from the each plane.
3. Multi plane cache read is available only within a block per plane.
4. Selected Page address except A23 within two blocks must be same.
5. The operation has to be terminated with "3Fh" command.
6. It's possible to confirm the multi-plane cache read first step using both 30h and 33h.

4.6. Multi Plane Cache Read Enhanced (available only within a block)

This command is a multi-plane extension of the Cache Read Enhanced command.

4.7. Read ID

The device contains a product identification mode, initiated by writing 90h to the command register, followed by an address input of 00h. Six read cycles sequentially output the manufacturer code (ADh), and the device code and 3rd, 4th, 5th, 6th cycle ID, respectively. The command register remains in Read ID mode until further commands are issued to it. Figure 37 shows the operation sequence, while 2.10 READ ID data tables explain the byte meaning.

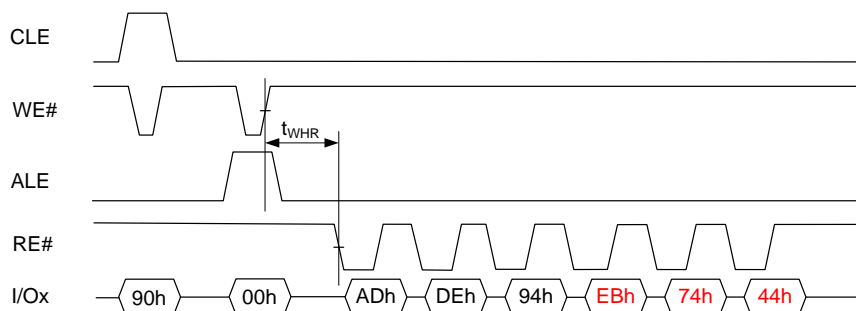


Figure 37 : Read ID

4.8. Read Status Register

The device contains a Status Register which may be read to find out whether read, program or erase operation is completed, and whether the program or erase operation is completed successfully. After writing Read Status (70h) or Multi Plane Read Status (78h,75h) command to the command register, a read cycle outputs the content of the Status Register to the I/O pins only if CE# and RE# are low, 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. Refer to 2.8. STATUS REGISTER CODINGS for specific Status Register definitions and Figure 38, Figure 39 for Read Status. The command register remains in Read Status mode until further commands are issued to it. Therefore, if the status register is read during a random read cycle, the read command (00h) should be given before starting read cycles.

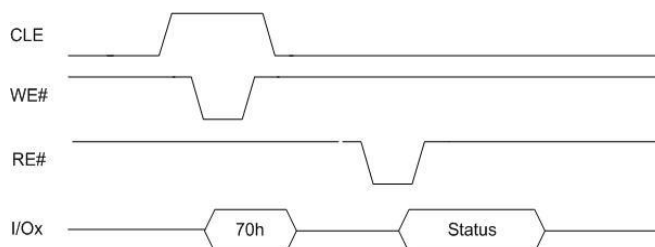


Figure 38 : Read status

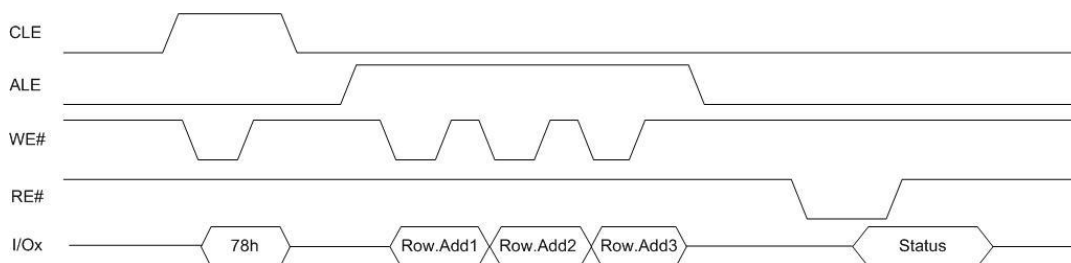


Figure 39 : Multi plane read status

4.9. Page Program

The device is programmed as a page unit. The number of consecutive partial page programming operation within the same page without an intervening erase operation must not exceed 1 times. The program addressing should be done in sequential order in a block. A page program cycle consists of a serial data loading period in which up to 17,664 bytes of data may be loaded into the data register, followed by a non-volatile programming period where the loaded data is programmed into the appropriate cell. The serial data-loading period begins by inputting the Serial Data Input command (80h), followed by the five cycle address inputs and then serial data. The words other than those to be programmed do not need to be loaded. The device supports random data input in a page. The column address of next data, which will be entered, may be changed to the address which follows random data input command (85h). Random data input may be operated multiple times, regardless of how many times it is done in a page. 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 to read the status register.

The system controller can detect the completion of a program cycle by monitoring the 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. The Write Status Bit (I/O 0) is valid, when all internal operations are complete (status bit I/O 6 = high).

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 40 and Figure 41 details the sequence.

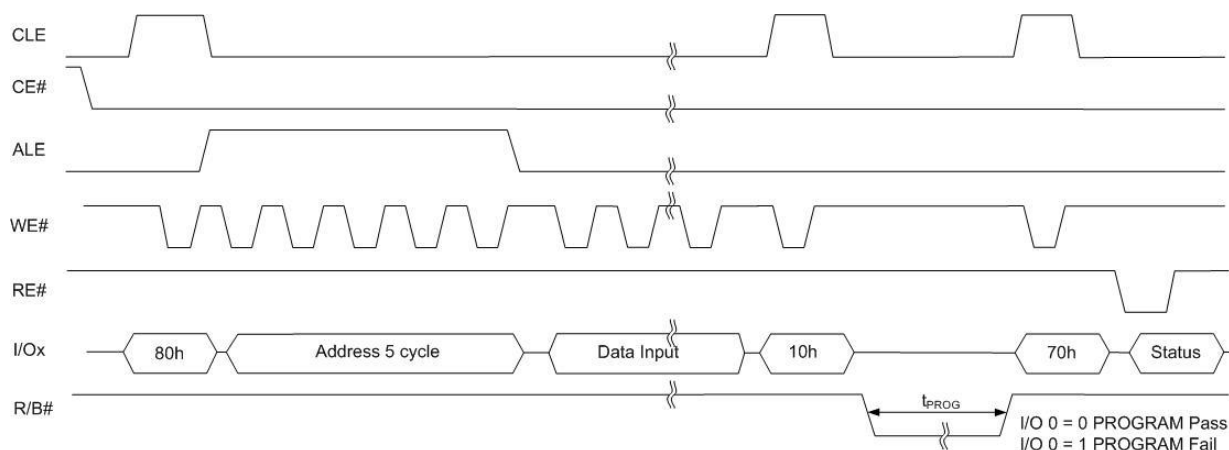


Figure 40 : Page Program

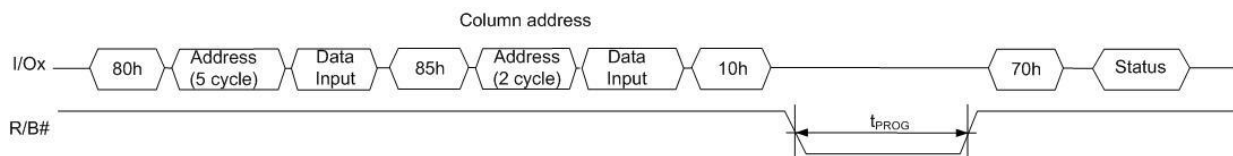


Figure 41 : Random data input

4.10. Multi Plane Program

Device supports multiple plane program. It is possible to program in parallel 2 pages, one per each plane. A multiple plane program cycle consists of a double serial data loading period in which up to 17,664bytes of data may be loaded into the data register, followed by a non-volatile programming period where the loaded data is programmed into the appropriate cell. The serial data loading period begins by inputting the Serial Data Input command (80h), followed by the five cycle address inputs and then serial data for the 1st page. Address for this page must be within first plane ($A<23>=0$). The data of first page other than those to be programmed do not need to be loaded. The device supports random data input exactly like page program operation. The Dummy Page Program Confirm command (11h) stops 1st page data input and the device becomes busy for a short time (t_{DBSY}). Once it has become ready again, 81h command must be issued, followed by second page address (5 cycles) and its serial data input. Address for this page must be within second plane ($A<23>=1$). The data of second page other than those to be programmed do not need to be loaded. Program Confirm command (10h) makes parallel programming of both pages start. User can check operation status by R/B# pin or read status register command, as if it were a normal page program; status register command is also available during Dummy Busy time (t_{DBSY}). In case of fail in first plane or second plane page program, fail bit of status register will be set: Pass/Fail status of each plane can be checked by Multi Plane Read Status. Figure 42 details the sequence.

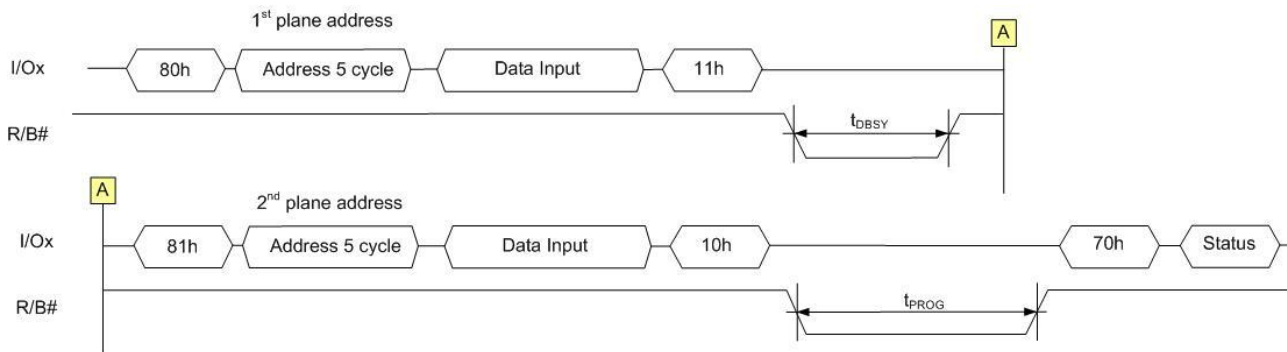


Figure 42 : Multi plane page program

Notes:

1. plane 0 and plane 1 should be selected within the same chip.
2. Only one block should be selected from the each plane.
3. Selected Page address except A23 within two blocks must be same.
4. Any command between 11h and 81h is prohibited except 70h/78h/75h and FFh.
5. Read Status command can be 70h or 78h or 75h.

4.11. Cache Program (available only within a block)

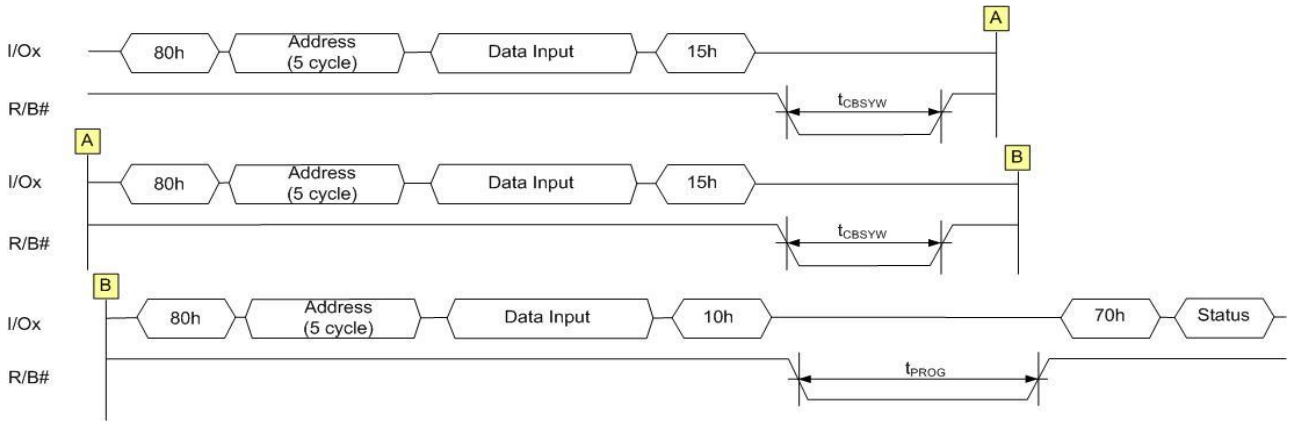
Cache Program is an extension of the standard page program, which is executed with 17,664 bytes cache registers and same bytes data register. After the serial data input command (80h) is loaded to the command register, followed by 5 cycles of address, a full or partial page of data is latched into the cache register, and then the cache write command (15h) is loaded to the command register. After that sequence, the data in the cache register is transferred into the data register for cell programming. At this time, the device remains in busy state. After all data of the cache register is transferred into the data register, the device goes to the Ready state to load the next data into the cache register by issuing another cache program command sequence (80h-15h). There are some restrictions for cache program operation.

1. The cache program command is available only within a block.
2. User must give address and data after 80h command.

The Busy time of first sequence equals the time it takes to transfer the data of cache register to the data register. Cell programming of the data of data register and loading of the next data into the cache register is consequently processed as a pipeline method. On the second and cascading sequence, transfer from the cache register to the data register is held off until cell programming of current data register contents has been done.

Read Status command (70h) may be issued to find out when the cache register is ready by polling the Cache-Busy status bit (I/O 6). In addition, the status bit (I/O 5) can be used to determine when the cell programming of the current data register contents is complete. Pass/fail status of only the previous page (I/O 1) is available upon the return to Ready state.

If the system monitors the progress of programming only with R/B#, the last page of the target programming sequence must be programmed with actual Page Program command (10h). If the Cache Program command (15h) is used instead, status bit (I/O5) must be polled to find out when the last programming is actually finished before starting other operations such as read. Pass/fail status is available in two steps. I/O 1 returns with the status of the previous page upon Ready or I/O6 status bit changing to "1", and later I/O 0 with the status of current page upon true Ready (returning from internal programming) or I/O 5 status bit changing to "1". I/O 1 may be read together when I/O 0 is checked. Refer to 2.8. Status Register Coding and Figure 43 for more details.



Pass/Fail status for each page programmed by the Cache Program operation can be detected by the Read Status operation.

- I/O 0 : Pass/Fail of the current page program operation.
- I/O 1 : Pass/Fail of the previous page program operation.

The Pass/Fail status on I/O 0 and I/O 1 are valid under the following conditions.

- Status on I/O 0 : Ready/Busy is Ready state.

The Ready/Busy is output on I/O 5 by Read Status operation or R/B pin after the 10h command.

- Status on I/O 1 : Data Cache Ready /Busy is Ready State.

The Data Cache Ready/Busy is output on I/O 6 by Read Status operation or R/B pin after the 15h command.

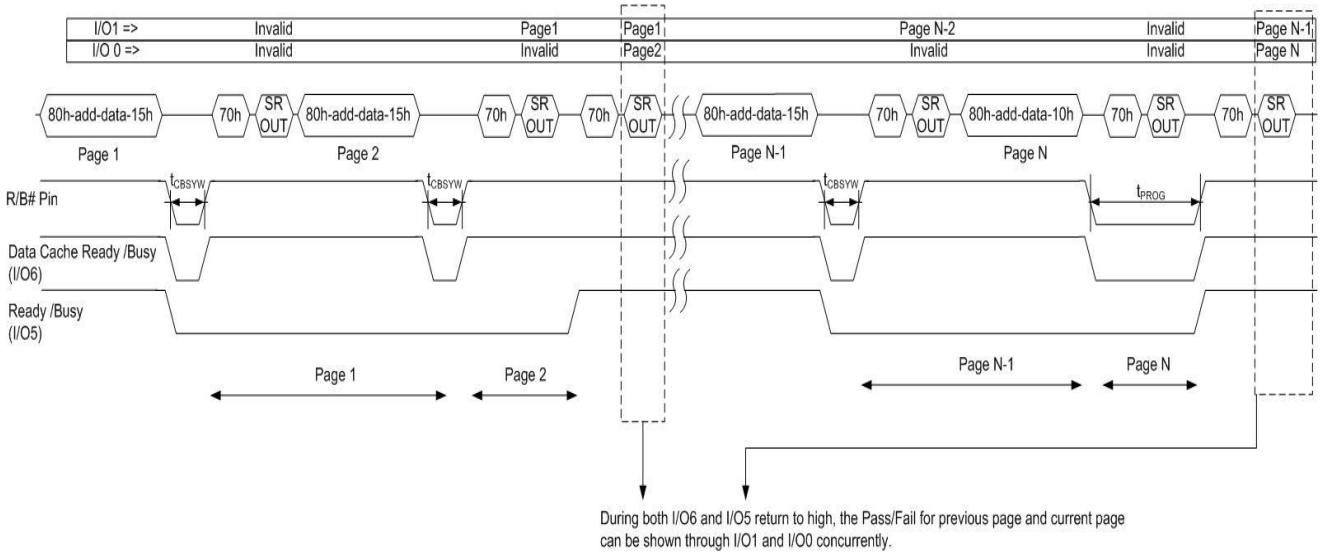


Figure 43 : Cache program

4.12. Multi Plane Cache Program (available only within a block)

The device supports multi-plane cache program, which enables high program throughput by programming two pages. The serial data-loading period begins by inputting the Serial Data Input command (80h), followed by the five cycle address inputs and then serial data for the first page. Address for this page must be within first plane ($A<23>=0$). The data of first page other than those to be programmed do not need to be loaded. The device supports random data input exactly like page program operation. The Dummy Page Program Confirm command (11h) stops 1st page data input and the device becomes busy for a short time (t_{DBSY}). Once it has become ready again, 81h command must be issued, followed by 2nd page address (5 cycles) and its serial data input. Address for this page must be within second plane ($A<23>=1$). The data of second page other than those to be programmed do not need to be loaded. Cache Program Confirm command (15h) makes parallel programming of both pages start. And last page inputs Program confirm command (10h). Figure 44 shows the command sequence for Multi Plane Cache Program operation. After the "15h" or "10h" command, the result per plane of the operation is shown through the "78h" Multi Plane Read Status command.

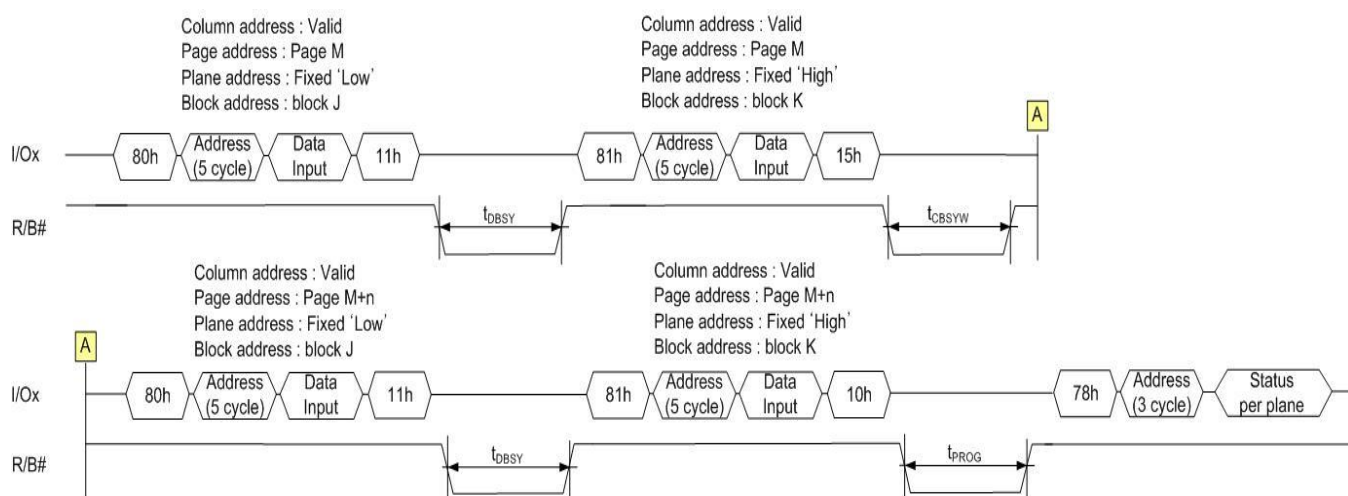


Figure 44 : Multi plane cache program

Notes:

1. plane 0 and plane 1 should be selected within the same chip
2. Only one block should be selected from the each plane.
3. Multi plane cache program is available only within a block per plane.
4. Selected Page address except A23 within two blocks must be same.
5. The operation has to be terminated with "10h" command.
6. Any command between 11h and 81h is prohibited except 70h/78h/75h and FFh.
7. Read Status command can be 70h or 78h or 75h. Reading the Status per plane is available only 78h.

4.13. Copy-Back Program

Copy-Back program with Read for Copy-Back is configured to quickly and efficiently rewrite data stored in one page without data reloading when the bit error is not in data stored. Since the time-consuming re-loading cycles are removed, the system performance is improved. The benefit is especially obvious when a portion of a block is updated and the rest of the block needs to be copied to the newly assigned free block. Copy-Back operation is a sequential execution of Read for Copy-Back and of copy-back program with the destination page address. A read operation with "35h" command and the address of the source page moves the whole 17,664byte data into the internal data buffer. A bit error is checked by sequential reading the data output. In the case where there is no bit error, the data do not need to be reloaded. Therefore, Copy-Back program operation is initiated by issuing Page-Copy Data-Input command (85h) with destination page address. Actual programming operation begins after Program Confirm command (10h) is issued. Once the program process starts, the Read Status Register command (70h) may be entered to read the status register. The system controller can detect the completion of a program cycle by monitoring the R/B# output, or the Status bit (I/O 6) of the Status Register. When the Copy-Back Program is complete, the Write Status Bit (I/O 0) may be checked. The command register remains in Read Status command mode until another valid command is written to the command register. During copy-back program, data modification is possible using random data input command (85h) as shown in Figure 45.

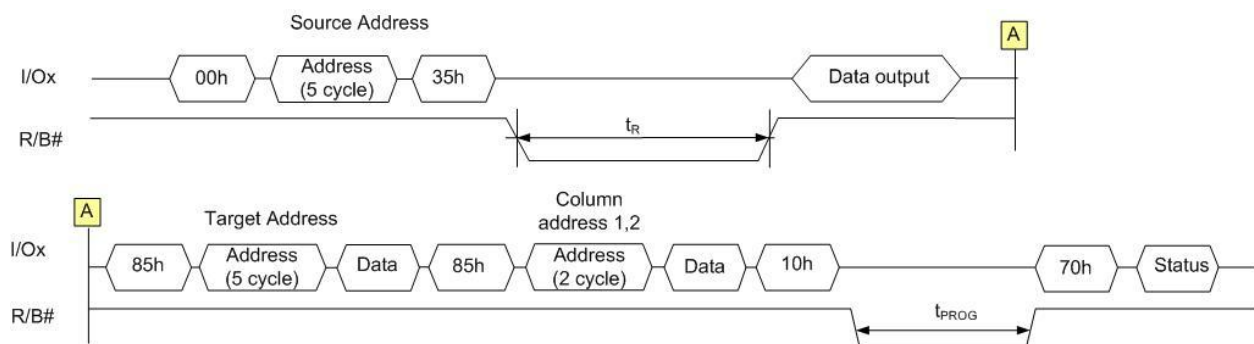


Figure 45 : Copy-back program

4.14. Multi-Plane Copy-Back Program

Multi-Plane Copy-Back Program is an extension of Copy-Back Program, for a single plane with 17,664byte page registers. Since the device is equipped with two memory planes, activating the two sets of 17,664byte page registers enables a simultaneous programming of two pages. Figure 46 and Figure 47 show command sequence for the multi-plane copy-back operation. First case, Figure 46, shows random data input of two planes that started right after finishing random data output of previous two planes. Second case, Figure 47, shows the random data input of each plane which started right after finishing the random data output of each plane

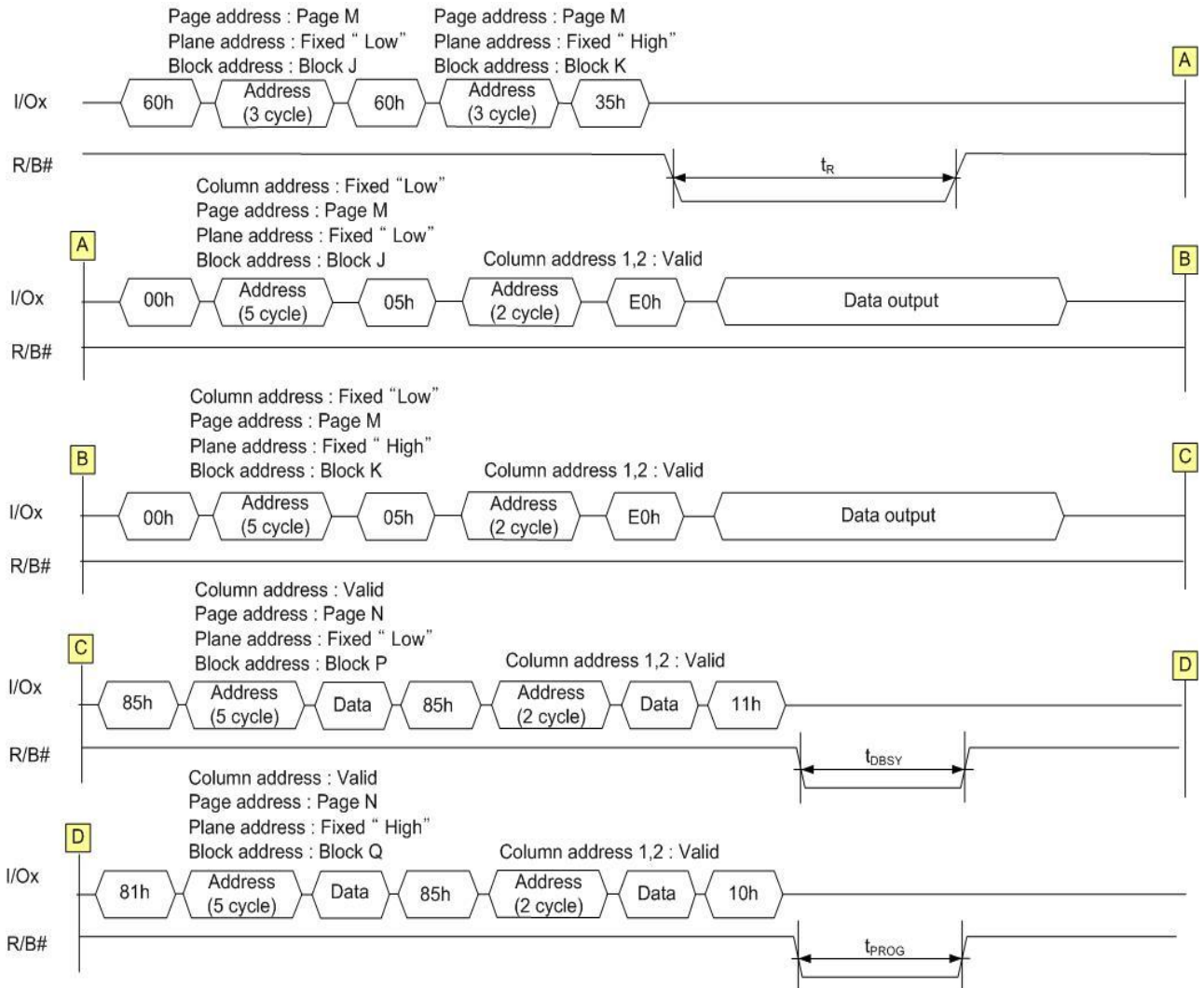


Figure 46 : Multi plane Copy-back program

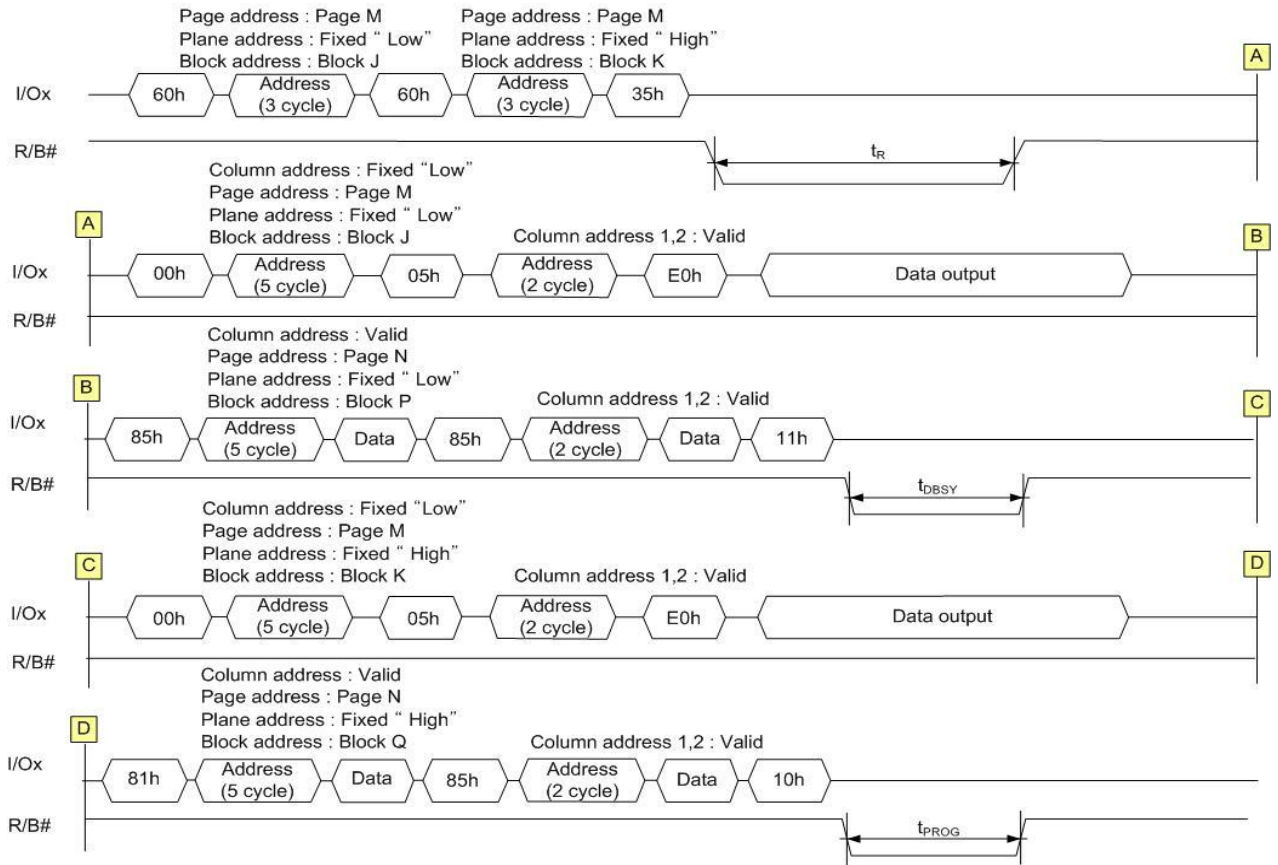


Figure 47 : Multi plane Copy-back program

4.15. Block Erase

The Erase operation is done on a block basis. Block address loading is accomplished in two cycles initiated by an Erase Setup command (60h). Only address A23 to A34 is valid while A15 to A22 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.

Once the erase process starts, the Read Status Register command may be entered to read the status register.

The system controller can detect the completion of an erase by monitoring the 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 erasing is in progress. When the erase operation is completed, the Write Status Bit (I/O 0) may be checked. [Figure 46](#) details the sequence.

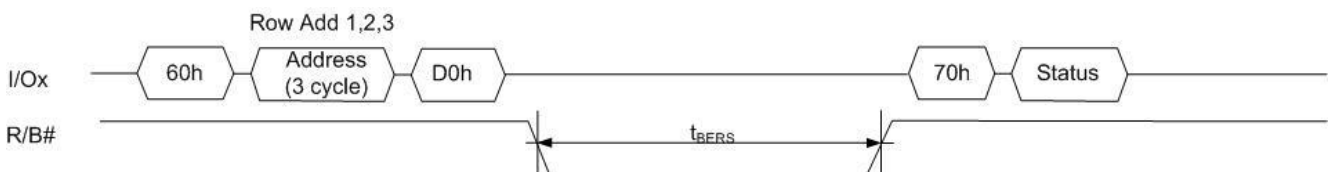


Figure 48 : Block Erase

4.16. Multi Plane Block Erase

Multiple plane erase, allows parallel erase of two blocks, one per each memory plane.
Block erase setup command (60h) must be repeated two times, each time followed by first block and second block address respectively (3 cycles each). As for block erase, D0h command makes embedded operation start. Multi plane erase does not need any Dummy Busy Time between first and second block address insertion. Address limitation required for Multiple Plane Program applies also to multiple plane erase, as well as operation progress can be checked like for Multiple Plane Program. Refer to the detail sequence as shown below.

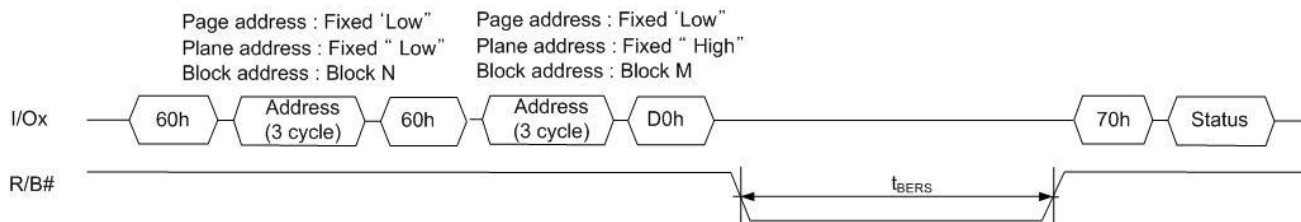


Figure 49 : Multi plane Block Erase

4.17. 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 E0h when WP# is high. Refer to 2.8. Status Register Coding for device status after reset operation. If the device is already in reset state, the command register will not accept a new reset command. The R/B# pin goes low for t_{RST} after the Reset command is written. Refer to Figure 50.

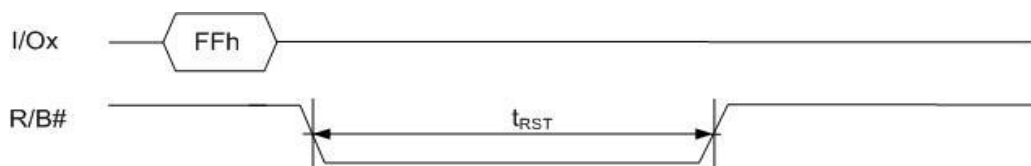


Figure 50 : Reset

5. Other Features

5.1. Data Protection & Power on/off Sequence

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 2.0V (3.3V device). WP# pin provides hardware protection and is recommended to be kept at V_{IL} during power-up and power-down. The reset command (FFh) must be issued to all dies as the first command after device is power up. Each R/B# will be busy for maximum of 2ms after reset command is issued. In this time, the acceptable command is 70h or 75h.

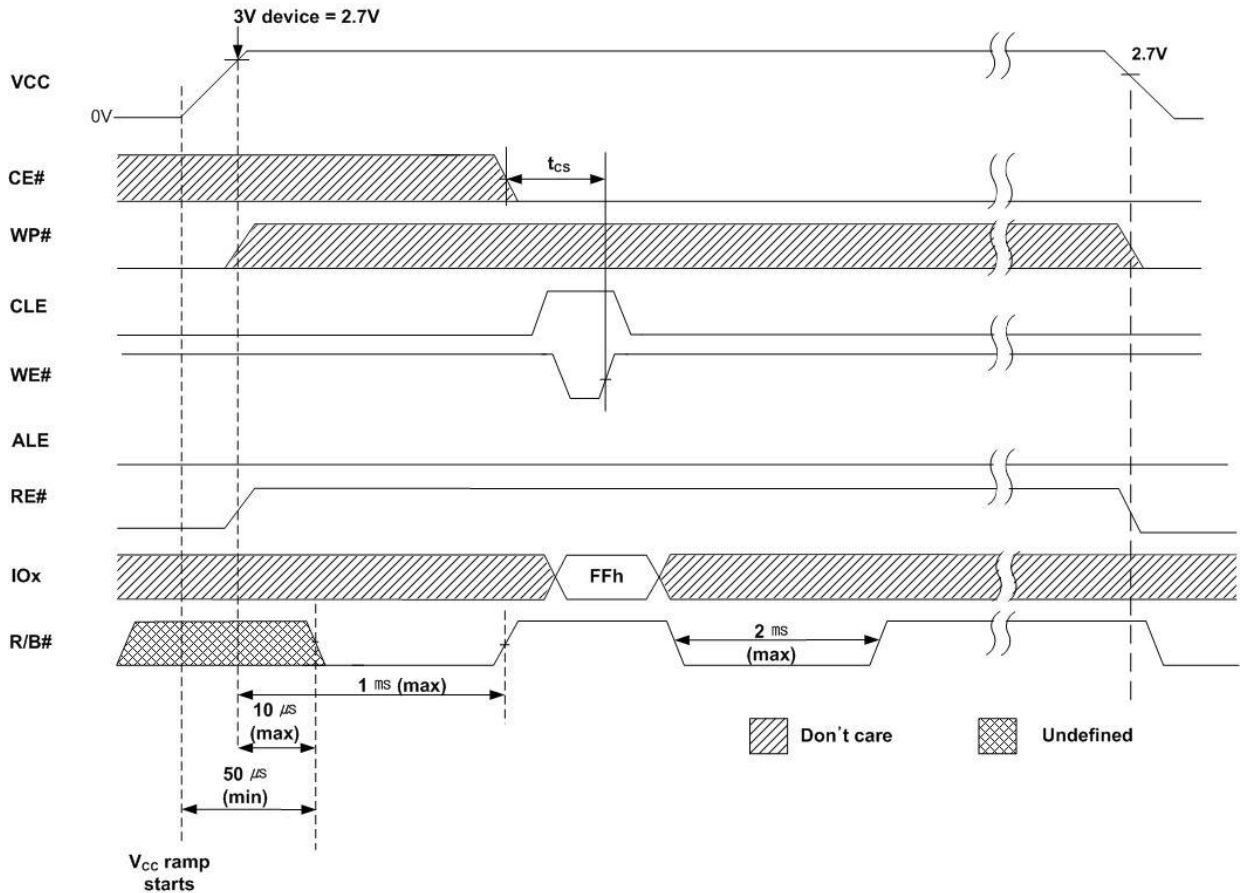


Figure 51 : Data protection and power on / off

5.2. Ready / Busy

The device has a Ready/Busy output that provides method of indicating the completion of a page program, erase, copy-back and random read completion. The R/B# pin is normally high and goes to low when the device is busy (after a reset, read, program, and erase operation). 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 (Figure 52). Its value can be determined by the following guidance.

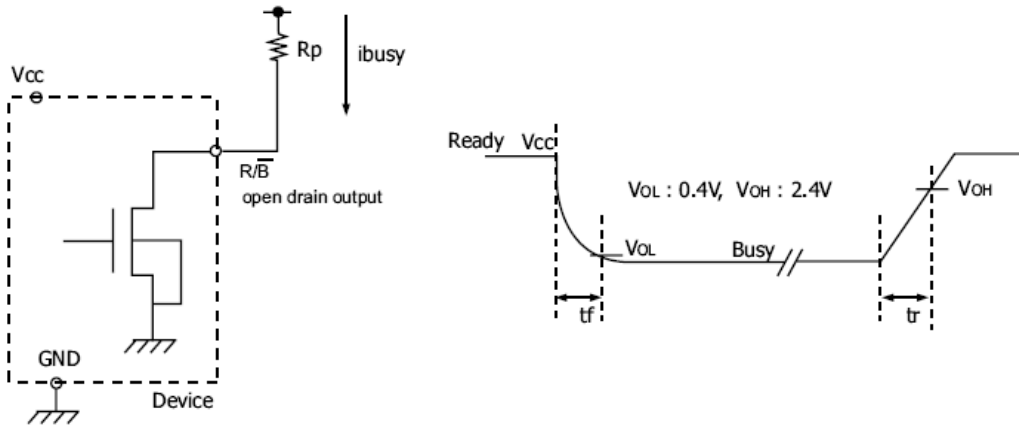
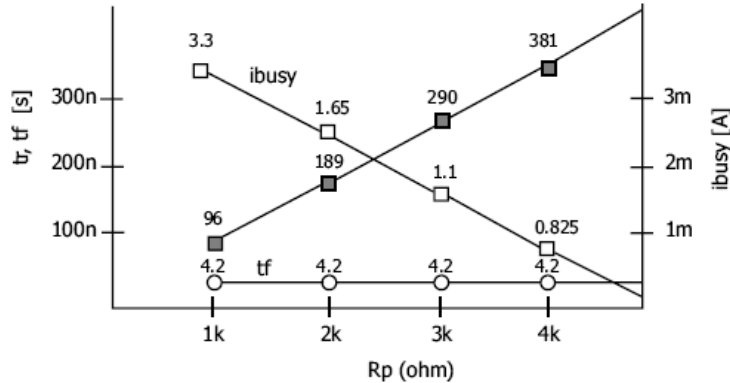


Fig. Rp vs tr, tf & Rp vs ibusy
 @ Vcc = 3.3V, Ta = 25°C, CL=50pF



Rp value guidance

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

where I_{L} is the sum of the input currents of all devices tied to the $\overline{\text{R/B}}$ pin.

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

Figure 52 : Ready / Busy

5.3. Write Protect Operation

The Erase and Program Operations are automatically reset when WP# goes Low ($t_{WW} = 100\text{ns}$, min). The operations are enabled and disabled as follows (Figure 53 ~ 56).

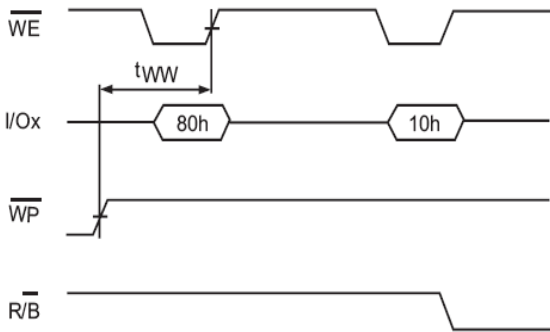


Figure 53 : Enable Programming

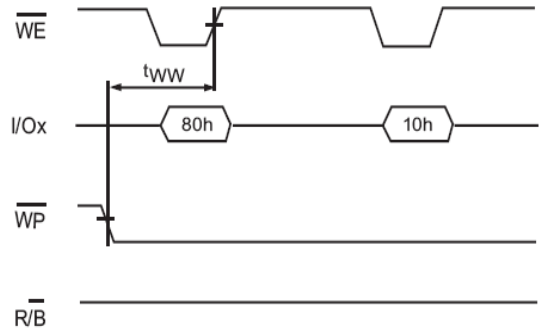


Figure 54 : Disable Programming

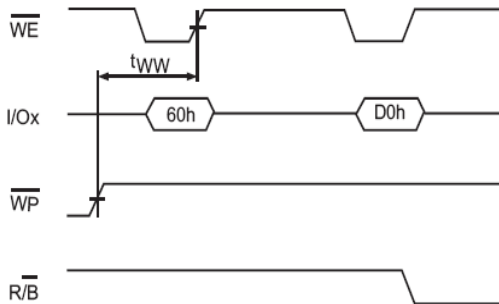


Figure 55 : Enable Erasing

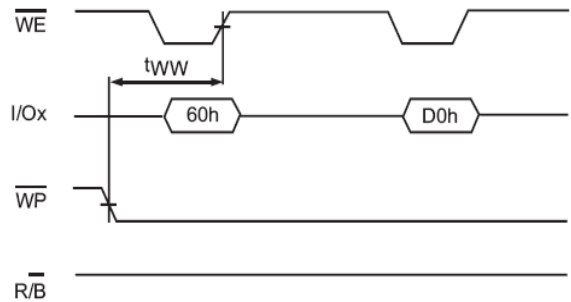


Figure 56 : Disable Erasing

6. Application Notes and Comments

6.1. Paired Page Address Information

Paired page in "1st Group" must has been programmed before page in "2nd Group" program execution.

Paired Page address (Hex code)		Paired Page address (Hex code)	
1 st Group	2 nd Group	1 st Group	2 nd Group
00	04	01	05
02	08	03	09
06	0C	07	0D
0A	10	0B	11
0E	14	0F	15
12	18	13	19
16	1C	17	1D
1A	20	1B	21
1E	24	1F	25
22	28	23	29
26	2C	27	2D
2A	30	2B	31
2E	34	2F	35
32	38	33	39
36	3C	37	3D
3A	40	3B	41
3E	44	3F	45
42	48	43	49
46	4C	47	4D
4A	50	4B	51
4E	54	4F	55
52	58	53	59
56	5C	57	5D
5A	60	5B	61
5E	64	5F	65
62	68	63	69
66	6C	67	6D
6A	70	6B	71
6E	74	6F	75
72	78	73	79
76	7C	77	7D
7A	80	7B	81
7E	84	7F	85

Paired Page address (Hex code)		Paired Page address (Hex code)	
1 st Group	2 nd Group	1 st Group	2 nd Group
82	88	83	89
86	8C	87	8D
8A	90	8B	91
8E	94	8F	95
92	98	93	99
96	9C	97	9D
8A	A0	9B	A1
9E	A4	9F	A5
A2	A8	A3	A9
A6	AC	A7	AD
AA	B0	AB	B1
AE	B4	AF	B5
B2	B8	B3	B9
B6	BC	B7	BD
BA	C0	BB	C1
BE	C4	BF	C5
C2	C8	C3	C9
C6	CC	C7	CD
CA	D0	CB	D1
CE	D4	CF	D5
D2	D8	D3	D9
D6	DC	D7	DD
DA	E0	DB	E1
DE	E4	DF	E5
E2	E8	E3	E9
E6	EC	E7	ED
EA	F0	EB	F1
EE	F4	EF	F5
F2	F8	F3	F9
F6	FC	F7	FD
FA	FE	FB	FF

When program operation is abnormally aborted (ex. sudden power-off, reset), not only page data under program but also a coupled row paired page data may be corrupted. For example, during Page Program operation of page address 05h is aborted by reset or power down, the data of 01h and 05h page address may be spoiled.