Document Title

16M x 8 Bit , 8M x 16 Bit NAND Flash Memory

Revision History

Revision No.	History	Draft Date	Remark
0.0	Initial issue.	Apr. 15th 2002	Advance
1.0	TBGA PKG Dimension Change 48-Ball, 6.0mm x 8.5mm --> 63-Ball, 9.0mm x 11.0mm	Sep. 5th 2002	Advance
2.0	1.A3 Pin assignment of TBGA Package is changed.(Page 4) (before) NC --> (after) Vss 2. Add the Rp vs tr ,tf & Rp vs ibusy graph for 1.8V device (Page 32) 3. Add the data protection Vcc guidence for 1.8V device - below about 1.1V. (Page 33)	Dec.10th 2002	Preliminary
2.1	The min. Vcc value 1.8V devices is changed. K9F28XXQ0C : Vcc 1.65V~1.95V --> 1.70V~1.95V	Mar. 6th 2003	
2.2	Pb-free Package is added. K9F2808U0C-FCB0,FIB0 K9F2808Q0C-HCB0,HIB0 K9F2816U0C-HCB0,HIB0 K9F2816U0C-PCB0,PIB0 K9F2816Q0C-HCB0,HIB0 K9F2808U0C-HCB0,HIB0 K9F2808U0C-PCB0,PIB0	Mar. 13rd 2003	
2.3	Some AC parameters are changed(K9F28XXQ0C). tWC tWH tWP tRC tREH tRP tREA tCEA Before 45 15 25 50 15 25 30 45 After 60 20 40 60 20 40 40 55	Mar. 26th 2003	
2.4	1. New definition of the number of invalid blocks is added. (Minimum 502 valid blocks are guaranteed for each contiguous 64Mb memory space) 2. Note is added. (VIL can undershoot to -0.4V and VIH can overshoot to VCC +0.4V for durations of 20 ns or less.)	May. 24th 2003 Oct. 10th 2003	
2.5	1. K9F2808U(Q)0C-DC(I)B0,K9F2816U(Q)0C-DC(I)B0 is deleted. 2. tWC is changed. 45ns(Before) ---> 50ns(After) 3. Minimum valid block number is changed. 1004(Before) --> 1009(After)		

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.htm

16M x 8 Bit / 8M x 16 Bit NAND Flash Memory

PRODUCT LIST

Part Number	Vcc Range	Organization	PKG Type
K9F2808U0C-Y,P	2.7 ~ 3.6V	X8	TSOP1
K9F2808U0C-V,F			WSOP1
K9F2816U0C-Y,P		X16	TSOP1

FEATURES

- Voltage Supply : 2.7 ~ 3.6 V
- Organization
  - Memory Cell Array
    - X8 device(K9F2808U0C) : (16M + 512K)bit x 8bit
    - X16 device(K9F2816U0C) : (8M + 256K)bit x 16bit
  - Data Register
    - X8 device(K9F2808U0C) : (512 + 16)bit x 8bit
    - X16 device(K9F2816U0C) : (256 + 8)bit x16bit
- Automatic Program and Erase
  - Page Program
    - X8 device(K9F2808U0C) : (512 + 16)Byte
    - X16 device(K9F2816U0C) : (256 + 8)Word
  - Block Erase :
    - X8 device(K9F2808U0C) : (16K + 512)Byte
    - X16 device(K9F2816U0C) : (8K + 256)Word
- Page Read Operation
  - Page Size
    - X8 device(K9F2808U0C) : (512 + 16)Byte
    - X16 device(K9F2816U0C) : (256 + 8)Word
  - Random Access : 10µs(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
- Unique ID for Copyright Protection
- Package
  - K9F28XXU0C-YCB0/YIB0

48 - Pin TSOP I (12 x 20 / 0.5 mm pitch)

  - K9F28XXU0C-PCB0/PIB0

48 - Pin TSOP I (12 x 20 / 0.5 mm pitch) - Pb-free Package

  - K9F2808U0C-VCB0/VIB0

48 - Pin WSOP I (12X17X0.7mm)

  - K9F2808U0C-FCB0/FIB0

48 - Pin WSOP I (12X17X0.7mm) - Pb-free Package

* K9F2808U0C-V/F(WSOPI) is the same device as K9F2808U0C-Y/P(TSOP1) except package type.

GENERAL DESCRIPTION

Offered in 16Mx8bit or 8Mx16bit, the K9F28XXU0C is 128M bit with spare 4M bit capacity. The device is offered in 3.3V Vcc. Its NAND cell provides the most cost-effective solutIon for the solid state mass storage market. A program operation can be performed in typical 200µs on the 528-byte(X8 device) or 264-word(X16 device) page and an erase operation can be performed in typical 2ms on a 16K-byte(X8 device) or 8K-word(X16 device) block. Data in the page can be read out at 50ns cycle time per word(X8 device) or word(X16 device). The I/O pins serve as the ports for address and data input/output as well as command input. The on-chip write control 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 K9F28XXU0C' s extended reliability of 100K program/erase cycles by providing ECC(Error Correcting Code) with real time mapping-out algorithm.
The K9F28XXU0C is an optimum solution for large nonvolatile storage applications such as solid state file storage and other portable applications requiring non-volatility.

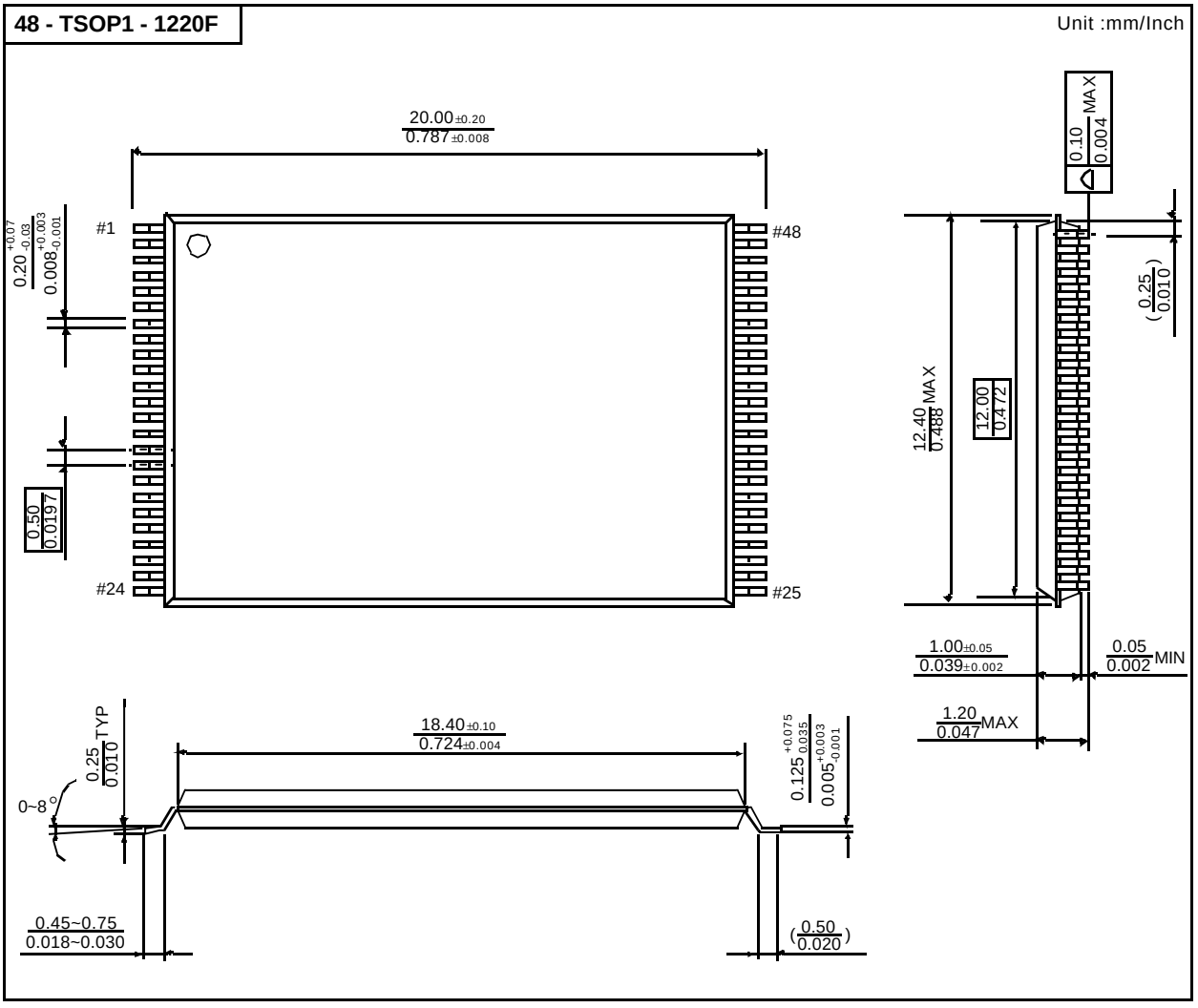
PIN CONFIGURATION (TSOP1)

K9F28XXU0C-YCB0,PCB0/YIB0,PIB0

X16	X8		X8	X16
N.C	N.C	1	N.C	Vss
N.C	N.C	2	N.C	I/O15
N.C	N.C	3	N.C	I/O7
N.C	N.C	4	N.C	I/O14
N.C	N.C	5	I/O7	I/O6
GND	GND	6	I/O6	I/O13
R/B	R/B	7	I/O5	I/O5
RE	RE	8	I/O4	I/O12
CE	CE	9	N.C	I/O4
N.C	N.C	10	N.C	N.C
N.C	N.C	11	N.C	N.C
Vcc	Vcc	12	Vcc	Vcc
Vss	Vss	13	Vss	N.C
N.C	N.C	14	N.C	N.C
N.C	N.C	15	N.C	N.C
CLE	CLE	16	N.C	I/O11
ALE	ALE	17	I/O3	I/O3
WE	WE	18	I/O2	I/O10
WP	WP	19	I/O1	I/O2
N.C	N.C	20	I/O0	I/O9
N.C	N.C	21	N.C	I/O1
N.C	N.C	22	N.C	I/O8
N.C	N.C	23	N.C	I/O0
N.C	N.C	24	N.C	Vss

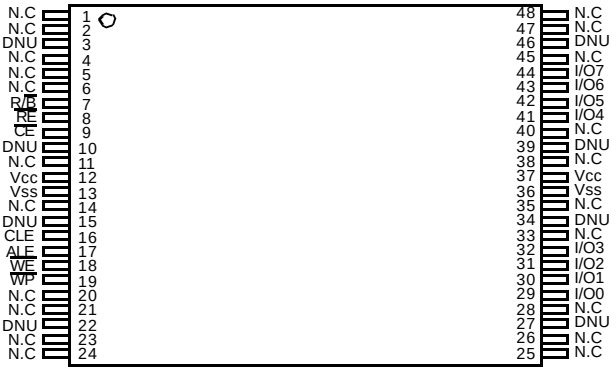
PACKAGE DIMENSIONS

48-PIN LEAD/LEAD FREE PLASTIC THIN SMALL OUT-LINE PACKAGE TYPE(I)



PIN CONFIGURATION (WSOP1)

K9F2808U0C-VCB0,FCB0/VIB0,FIB0

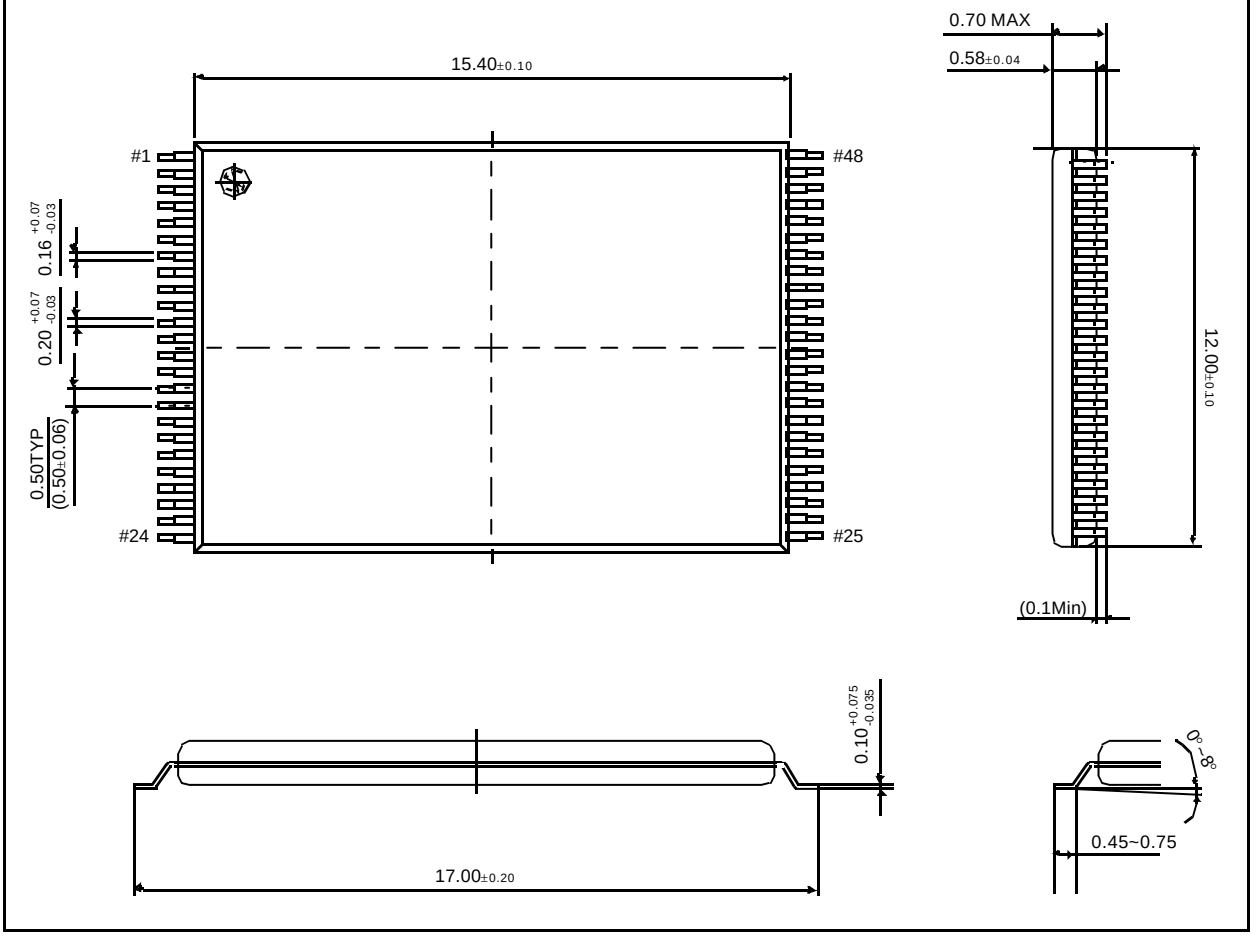


PACKAGE DIMENSIONS

48-PIN LEAD/LEAD FREE PLASTIC VERY VERY THIN SMALL OUT-LINE PACKAGE TYPE (I)

48 - WSOP1 - 1217F

Unit :mm



PIN DESCRIPTION

Pin Name	Pin Function
$I/O_0 \sim I/O_7$ (K9F2808U0C) $I/O_0 \sim I/O_{15}$ (K9F2816U0C)	**DATA INPUTS/OUTPUTS** 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. I/O8 ~ I/O15 are used only in X16 organization device. Since command input and address input are x8 operation, I/O8 ~ I/O15 are not used to input command & address. I/O8 ~ I/O15 are used only for data input and output.
CLE	**COMMAND LATCH ENABLE** The CLE input controls the activating path 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 $\overline{WE}$ signal.
ALE	**ADDRESS LATCH ENABLE** The ALE input controls the activating path for address to the internal address registers. Addresses are latched on the rising edge of $\overline{WE}$ with ALE high.
$\overline{CE}$	**CHIP ENABLE** The $\overline{CE}$ input is the device selection control. When the device is in the Busy state, $\overline{CE}$ high is ignored, and the device does not return to standby mode in program or erase operation. Regarding $\overline{CE}$ control during read operation, refer to ' Page read' section of Device operation .
$\overline{RE}$	**READ ENABLE** The $\overline{RE}$ 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 $\overline{RE}$ which also increments the internal column address counter by one.
$\overline{WE}$	**WRITE ENABLE** The $\overline{WE}$ input controls writes to the I/O port. Commands, address and data are latched on the rising edge of the $\overline{WE}$ pulse.
$\overline{WP}$	**WRITE PROTECT** The $\overline{WP}$ pin provides inadvertent write/erase protection during power transitions. The internal high voltage generator is reset when the $\overline{WP}$ pin is active low.
R/$\overline{B}$	**READY/BUSY OUTPUT** The R/$\overline{B}$ 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.
V_{CCQ}	**OUTPUT BUFFER POWER** V_{CCQ} is the power supply for Output Buffer. V_{CCQ} is internally connected to Vcc, thus should be biased to Vcc.
Vcc	**POWER** V_{CC} is the power supply for device.
Vss	**GROUND**
N.C	**NO CONNECTION** Lead is not internally connected.
GND	**GND INPUT FOR ENABLING SPARE AREA** To do sequential read mode including spare area , connect this input pin to Vss or set to static low state or to do sequential read mode excluding spare area , connect this input pin to Vcc or set to static high state.
DNU	**DO NOT USE** Leave it disconnected.

NOTE :
Connect all V_{CC} and V_{SS} pins of each device to common power supply outputs.
Do not leave V_{CC} or V_{SS} disconnected.

Figure 1-1. K9F2808U0C (X8) FUNCTIONAL BLOCK DIAGRAM

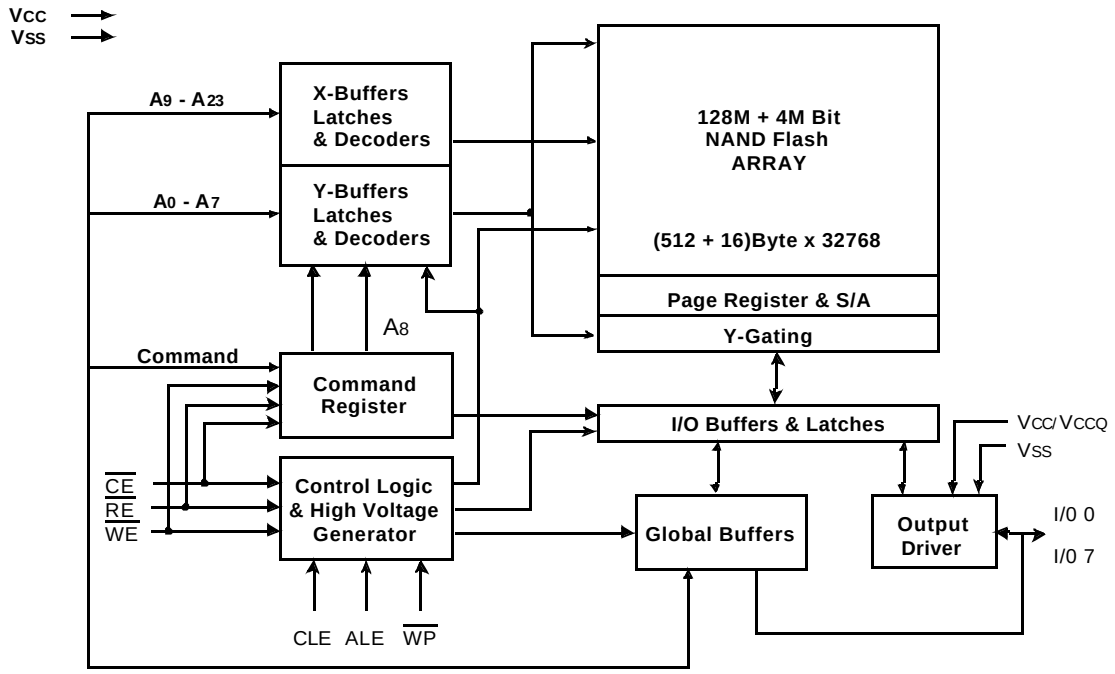
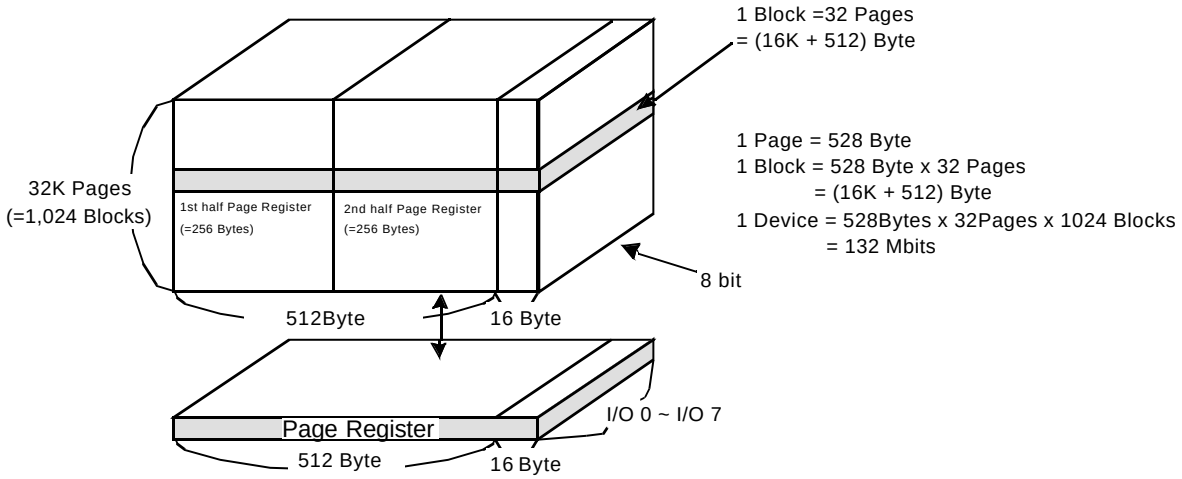


Figure 2-1. K9F2808U0C (X8) ARRAY ORGANIZATION



	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 (Page Address)
3rd Cycle	A17	A18	A19	A20	A21	A22	A23	L*	

NOTE : Column Address : Starting Address of the Register.

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.

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

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

* L must be set to "Low".

Figure 1-2. K9F2816U0C (X16) FUNCTIONAL BLOCK DIAGRAM

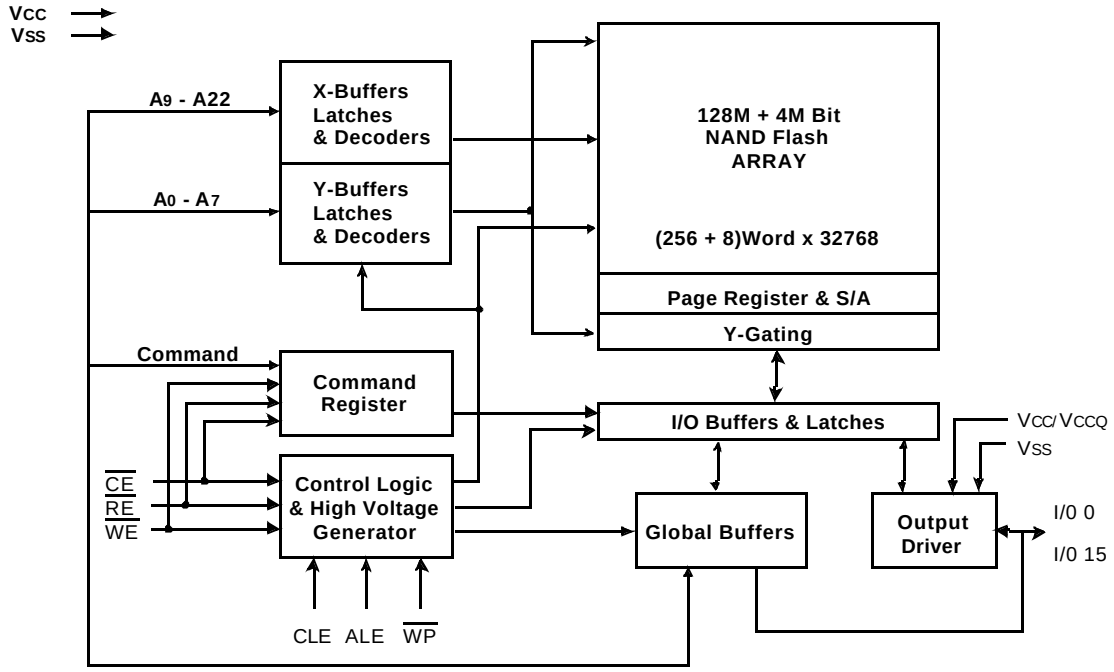
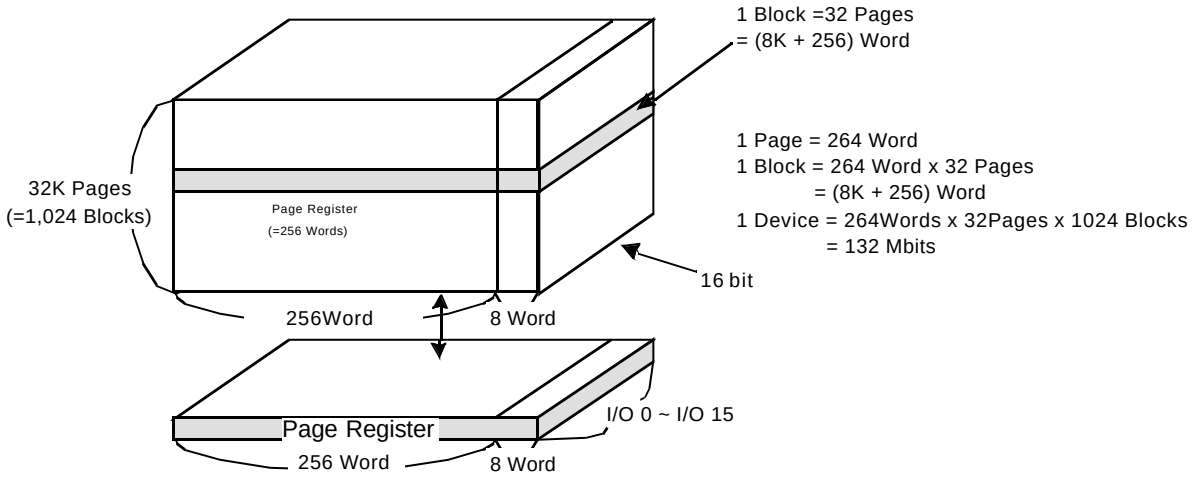


Figure 2-2. K9F2816U0C (X16) ARRAY ORGANIZATION



	I/O 0	I/O 1	I/O 2	I/O 3	I/O 4	I/O 5	I/O 6	I/O 7	I/O8 to 15	
1st Cycle	A0	A1	A2	A3	A4	A5	A6	A7	L*	Column Address
2nd Cycle	A9	A10	A11	A12	A13	A14	A15	A16	L*	Row Address (Page Address)
3rd Cycle	A17	A18	A19	A20	A21	A22	L*	L*	L*	

NOTE: Column Address : Starting Address of the Register.

* L must be set to "Low".

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

PRODUCT INTRODUCTION

The K9F28XXU0C is a 132Mbit(138,412,032 bit) memory organized as 32,768 rows(pages) by 528(X8 device) or 264(X16 device) columns. Spare eight columns are located from column address of 512~527(X8 device) or 256~263(X16 device). A 528-byte(X8 device) or 264-word(X16 device) data register is connected to memory cell arrays accommodating data transfer between the I/O buffers and memory 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 two NAND structured strings. A NAND structure consists of 16 cells. Total 135168 NAND cells reside in a block. The array organization is shown in Figure 2-1,2-2. The program and read operations are executed on a page basis, while the erase operation is executed on a block basis. The memory array consists of 1024 separately erasable 16K-Byte(X8 device) or 8K-Word(X16 device) blocks. It indicates that the bit by bit erase operation is prohibited on the K9F28XXU0C.

The K9F28XXU0C has addresses multiplexed into 8 I/Os(X16 device case : lower 8 I/Os). K9F2816U0C allows sixteen bit wide data transport into and out of page registers. This scheme dramatically reduces pin counts while providing high performance and allows systems upgrades to future densities by maintaining consistency in system board design. Command, address and data are all written through I/O' s by bringing $\overline{WE}$ to low while $\overline{CE}$ is low. Data is latched on the rising edge of $\overline{WE}$. Command Latch Enable(CLE) and Address Latch Enable(ALE) are used to multiplex command and address respectively, via the I/O pins. Some commands require one bus cycle. For example, Reset command, Read command, Status Read command, etc require just one cycle bus. Some other commands like Page Program and Block Erase, require two cycles: one cycle for setup and the other cycle for execution. The 16K-byte(X8 device) or 32K-word(X16 device) physical space requires 24 addresses(X8 device) or 23 addresses(X16 device), thereby requiring three cycles for word-level addressing: column address, low row address and high row address, in that order. Page Read and Page Program need the same three address cycles following the required command input. In Block Erase operation, however, only the two row address cycles are used. Device operations are selected by writing specific commands into the command register. Table 1 defines the specific commands of the K9F28XXU0C.

The device includes one block sized OTP(One Time Programmable), which can be used to increase system security or to provide identification capabilities. Detailed information can be obtained by contact with Samsung.

Table 1. COMMAND SETS

Function	1st. Cycle	2nd. Cycle	Acceptable Command during Busy
Read 1	00h/01h (1)	-	
Read 2	50h	-	
Read ID	90h	-	
Reset	FFh	-	O
Page Program	80h	10h	
Block Erase	60h	D0h	
Read Status	70h	-	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 2nd half of register by the 01h command, start pointer is automatically moved to 1st half register(00h) on the next cycle.

Caution : Any undefined command inputs are prohibited except for above command set of Table 1.

ABSOLUTE MAXIMUM RATINGS

Parameter		Symbol	Rating	Unit
Voltage on any pin relative to V_{SS}		$V_{IN/OUT}$	-0.6 to + 4.6	V
		V_{CC}	-0.6 to + 4.6	
		V_{CCQ}	-0.6 to + 4.6	
Temperature Under Bias	K9F28XXU0C-XCB0	T_{BIAS}	-10 to +125	°C
	K9F28XXU0C-XIB0		-40 to +125	
Storage Temperature	K9F28XXU0C-XCB0	T_{STG}	-65 to +150	°C
	K9F28XXU0C-XIB0			
Short Circuit Current		Ios	5	mA

NOTE :
1. Minimum DC voltage is -0.6V 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, K9F28XXU0C-XCB0 :T_A=0 to 70°C, K9F28XXU0C-XIB0:T_A=-40 to 85°C)

Parameter	Symbol	K9F28XXU0C(3.3V)			Unit
		Min	Typ.	Max	
Supply Voltage	V_{CC}	2.7	3.3	3.6	V
Supply Voltage	V_{CCQ}	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}	tRC=50ns, $\overline{CE}$=V_{IL}, I_{OUT}=0mA	-	10	20	mA
	Program	I_{CC2}	-	-	10	20	
	Erase	I_{CC3}	-	-	10	20	
Stand-by Current(TTL)		I_{SB1}	$\overline{CE}$=V_{IH}, $\overline{WP}$=0V/V_{CC}	-	-	1	
Stand-by Current(CMOS)		I_{SB2}	$\overline{CE}$=V_{CC}-0.2, $\overline{WP}$=0V/V_{CC}	-	10	50	µA
Input Leakage Current		I_{LI}	V_{IN}=0 to Vcc(max)	-	-	±10	
Output Leakage Current		I_{LO}	V_{OUT}=0 to Vcc(max)	-	-	±10	
Input High Voltage		V_{IH}*	I/O pins	2.0	-	V_{CCQ}+0.3	V
			Except I/O pins	2.0	-	V_{CC}+0.3	
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/$\overline{B}$)		I_{OL}(R/$\overline{B}$)	V_{OL}=0.4V	8	10	-	mA

NOTE : V_{IL} can undershoot to -0.4V and V_{IH} can overshoot to V_{CC} +0.4V for durations of 20 ns or less.

VALID BLOCK

Parameter	Symbol	Min	Typ.	Max	Unit
Valid Block Number	N_{VB}	1004	-	1024	Blocks

NOTE :
1. The device 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-marked bad blocks. Refer to the attached technical notes for a appropriate management of invalid blocks.
2. The 1st block, which is placed on 00h block address, is guaranteed to be a valid block, does not require Error Correction up to 1K program/erase cycles.
3. Minimum 502 valid blocks are guaranteed for each contiguous 64Mb memory space.

AC TEST CONDITION

(K9F28XXU0C-XCB0 :TA=0 to 70°C, K9F28XXU0C-XIB0:TA=-40 to 85°C
K9F28XXU0C : Vcc=2.7V~3.6V unless otherwise noted)

Parameter	K9F28XXU0C
Input Pulse Levels	0.4V to 2.4V
Input Rise and Fall Times	5ns
Input and Output Timing Levels	1.5V
Output Load (V_{CCQ}:3.0V +/-10%)	1 TTL GATE and CL=50pF
Output Load (V_{CCQ}:3.3V +/-10%)	1 TTL GATE and CL=100pF

CAPACITANCE(T_A=25°C, V_{CC}=3.3V, f=1.0MHz)

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

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

MODE SELECTION

CLE	ALE	$\overline{CE}$	$\overline{WE}$	$\overline{RE}$	GND	$\overline{WP}$	Mode	
H	L	L	⎍	H	X	X	Read Mode	Command Input
L	H	L	⎍	H	X	X		Address Input(3clock)
H	L	L	⎍	H	X	H	Write Mode	Command Input
L	H	L	⎍	H	X	H		Address Input(3clock)
L	L	L	⎍	H	L	H	Data Input	
L	L	L	H	⎎	L	X	Data Output	
L	L	L	H	H	L	X	During Read(Busy) on K9F2808U0C_Y,P or K9F2808U0C_V,F	
X	X	X	X	H	L	X	During Read(Busy) on the devices except K9F2808U0C_Y,P and K9F2808U0C_V,F	
X	X	X	X	X	L	H	During Program(Busy)	
X	X	X	X	X	X	H	During Erase(Busy)	
X	X(1)	X	X	X	X	L	Write Protect	
X	X	H	X	X	0V	0V/V_{CC}(2)	Stand-by	

NOTE : 1. X can be V_{IL} or V_{IH}.
2. $\overline{WP}$ 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
Number of Partial Program Cycles in the Same Page	Main Array	Nop	-	-	2	cycles
	Spare Array		-	-	3	cycles
Block Erase Time		t_{BERS}	-	2	3	ms

AC Timing Characteristics for Command / Address / Data Input

Parameter	Symbol	K9F2808U0C		Unit
CLE Set-up Time	t_{CLS}	0	-	ns
CLE Hold Time	t_{CLH}	10	-	ns
$\overline{CE}$ Setup Time	t_{CS}	0	-	ns
$\overline{CE}$ Hold Time	t_{CH}	10	-	ns
$\overline{WE}$ Pulse Width	t_{WP}	25	-	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
$\overline{WE}$ High Hold Time	t_{WH}	15	-	ns

NOTE : 1. If tCS is set less than 10ns, tWP must be minimum 35ns, otherwise, tWP may be minimum 25ns.

AC Characteristics for Operation

Parameter		Symbol	K9F2808U0C		Unit
Data Transfer from Cell to Register		t_R	-	10	µs
ALE to $\overline{RE}$ Delay		t_{AR}	10	-	ns
CLE to $\overline{RE}$ Delay		t_{CLR}	10	-	ns
Ready to $\overline{RE}$ Low		t_{RR}	20	-	ns
$\overline{RE}$ Pulse Width		t_{RP}	25	-	ns
$\overline{WE}$ High to Busy		t_{WB}	-	100	ns
Read Cycle Time		t_{RC}	50	-	ns
$\overline{CE}$ Access Time		t_{CEA}	-	45	ns
$\overline{RE}$ Access Time		t_{REA}	-	30	ns
$\overline{RE}$ High to Output Hi-Z		t_{RHZ}	-	30	ns
$\overline{CE}$ High to Output Hi-Z		t_{CHZ}	-	20	ns
$\overline{RE}$ or $\overline{CE}$ High to Output hold		t_{OH}	15	-	ns
$\overline{RE}$ High Hold Time		t_{REH}	15	-	ns
Output Hi-Z to $\overline{RE}$ Low		t_{IR}	0	-	ns
$\overline{WE}$ High to $\overline{RE}$ Low		t_{WHR}	60	-	ns
Device Resetting Time(Read/Program/Erase)		t_{RST}	-	5/10/500(1)	µs
K9F2808U0C-Y,P,V,F only	Last RE High to Busy (at sequential read)	t_{RB}	-	100	ns
	$\overline{CE}$ High to Ready(in case of inter-ception by $\overline{CE}$ at read)	t_{CRY}	-	50 +tr(R/$\overline{B}$)(3)	ns
	$\overline{CE}$ High Hold Time(at the last serial read)(2)	t_{CEH}	100	-	ns

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

NAND Flash 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. Devices with invalid block(s) have the same quality level as devices with all valid blocks and have the same AC and DC characteristics. 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. The 1st block, which is placed on 00h block address, is fully guaranteed to be a valid block, does not require Error Correction up to 1K program/erase cycles.

Identifying Invalid Block(s)

All device locations are erased(FFh) except locations where the invalid block(s) information is written prior to shipping. The invalid block(s) status is defined by the 6th byte(X8 device) or 1st & 6th word(X16 device) in the spare area. Samsung makes sure that either the 1st or 2nd page of every invalid block has non-FFh(X8 device) or non-FFFFh(X16 device) data at the column address of 517(X8 device) or 256 and 261(X16 device). 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 3). Any intentional erasure of the original invalid block information is prohibited.

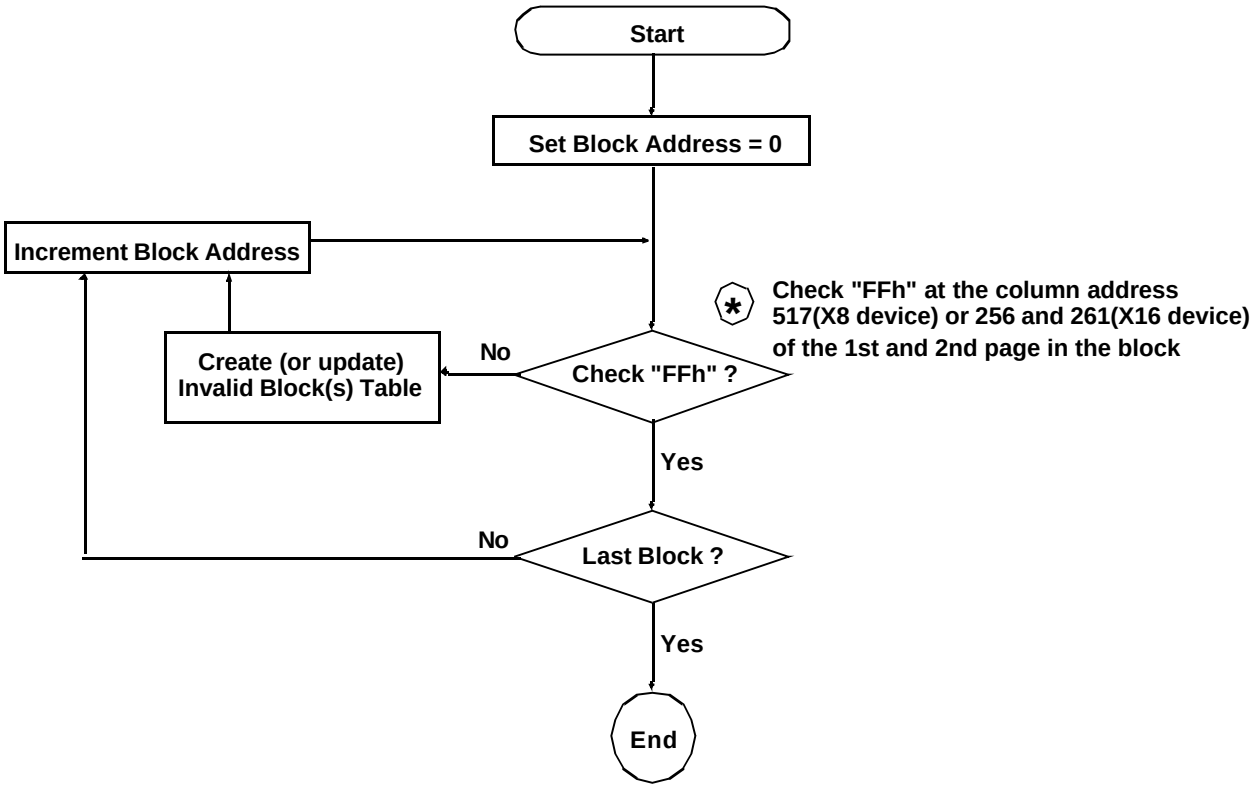


Figure 3. Flow chart to create invalid block table.

NAND Flash Technical Notes *(Continued)*

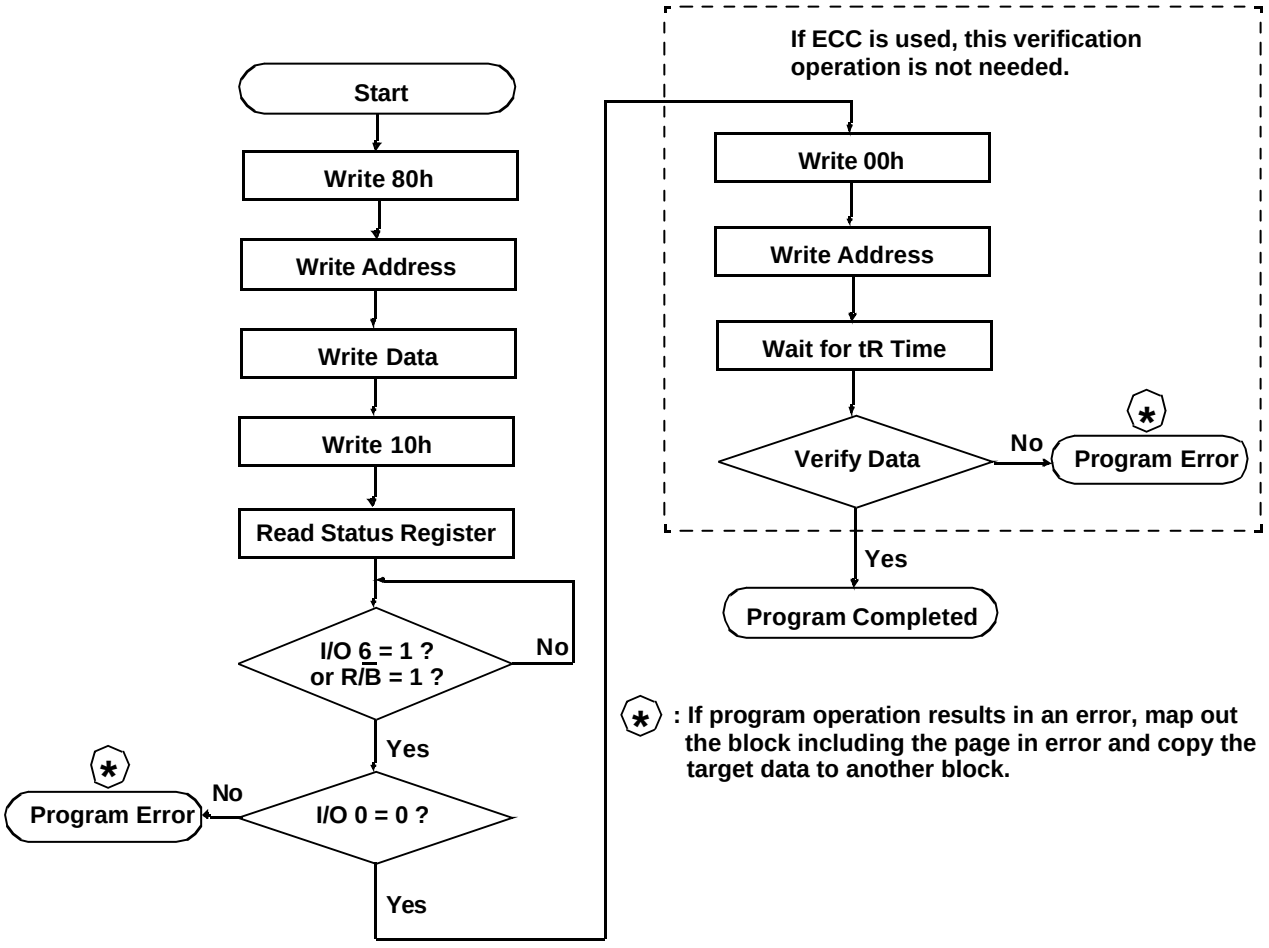
Error in write or read operation

Within 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

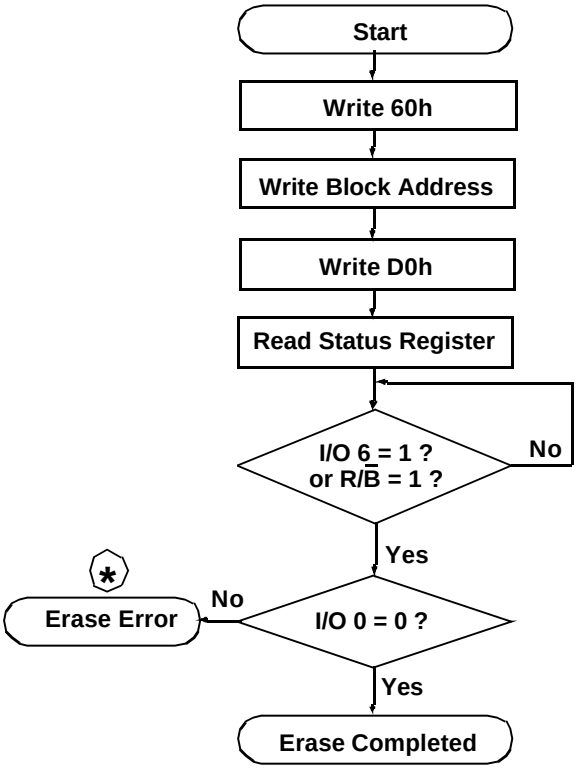
ECC : Error Correcting Code --> Hamming Code etc.
Example) 1bit correction & 2bit detection

Program Flow Chart

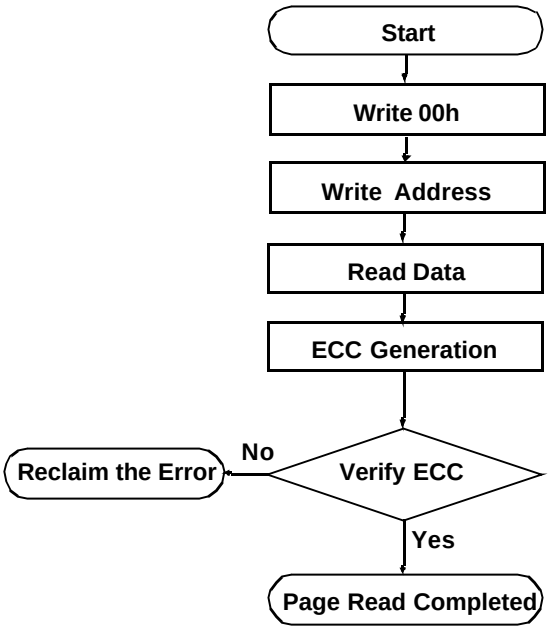


NAND Flash Technical Notes *(Continued)*

Erase Flow Chart

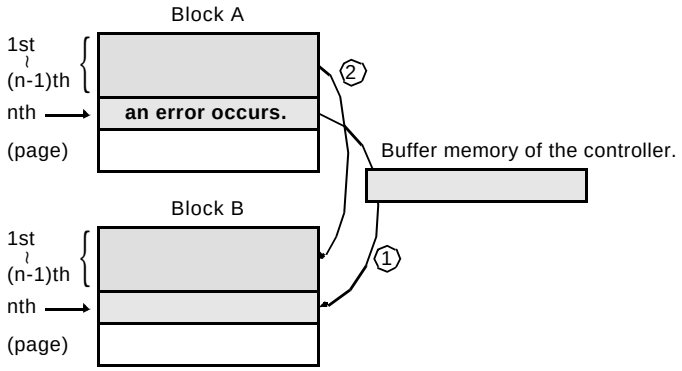


Read Flow Chart



: **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 erase or 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 to the same location of the Block ' B' .
* Step4
Do not further erase Block ' A' by creating an ' invalid Block' table or other appropriate scheme.

Pointer Operation of K9F2808U0C(X8)

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.

Table 2. 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)

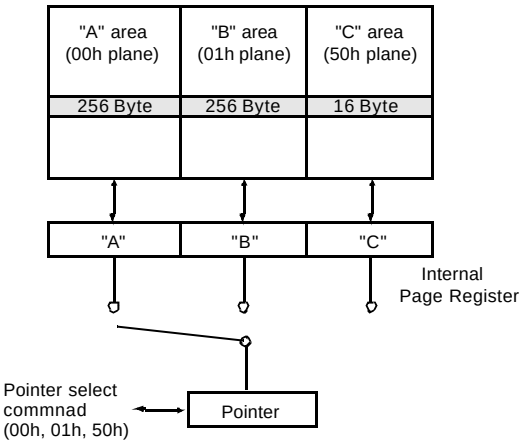
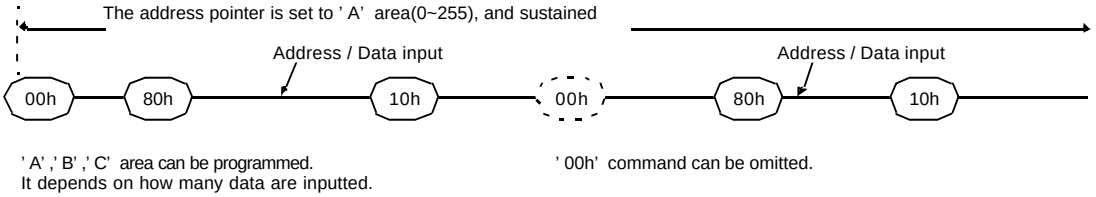


Figure 4. Block Diagram of Pointer Operation

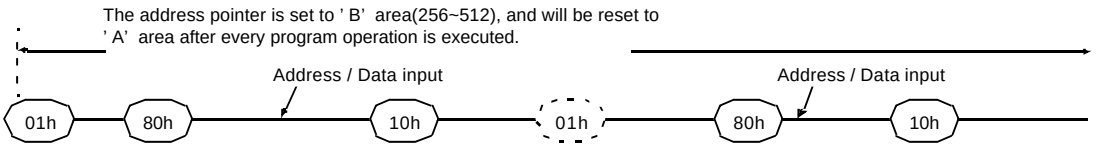
(1) Command input sequence for programming ' A' area



' A' ,' B' ,' C' area can be programmed.
It depends on how many data are inputted.

' 00h' command can be omitted.

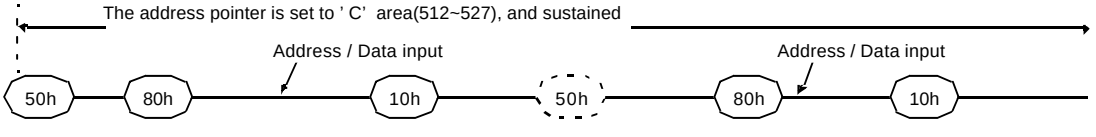
(2) Command input sequence for programming ' B' area



' B' , ' C' area can be programmed.
It depends on how many data are inputted.

' 01h' command must be rewritten before
every program operation

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



Only ' C' area can be programmed.

' 50h' command can be omitted.

Pointer Operation of K9F2816U0C(X16)

Samsung NAND Flash has two address pointer commands as a substitute for the most significant column address. ' 00h' command sets the pointer to ' A' area(0~255word), and ' 50h' command sets the pointer to ' B' area(256~263word). With these commands, the starting column address can be set to any of a whole page(0~263word). ' 00h' or ' 50h' is sustained until another address pointer command is inputted. To program data starting from ' A' or ' B' area, ' 00h' or ' 50h' command must be inputted before ' 80h' command is written. A complete read operation prior to ' 80h' command is not necessary.

Table 3. Destination of the pointer

Command	Pointer position	Area
00h	0 ~ 255 word	main array(A)
50h	256 ~ 263 word	spare array(B)

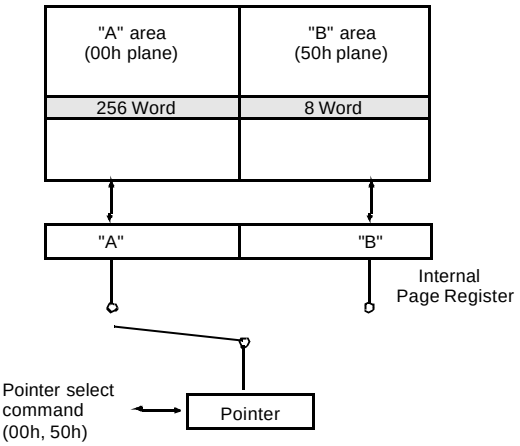
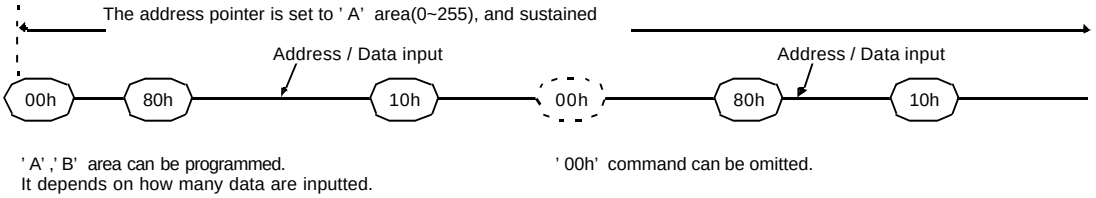


Figure 5. Block Diagram of Pointer Operation

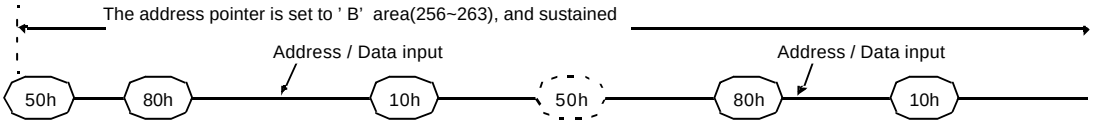
(1) Command input sequence for programming ' A' area



' A' ,' B' area can be programmed.
It depends on how many data are inputted.

' 00h' command can be omitted.

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



Only ' B' area can be programmed.

' 50h' command can be omitted.

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

For an easier system interface, $\overline{CE}$ may be inactive during the data-loading or sequential data-reading as shown below. The internal 528byte(x8 device), 264word(x16 device) page registers are utilized as seperate 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 $\overline{CE}$ during the data-loading and reading would provide significant savings in power consumption.

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

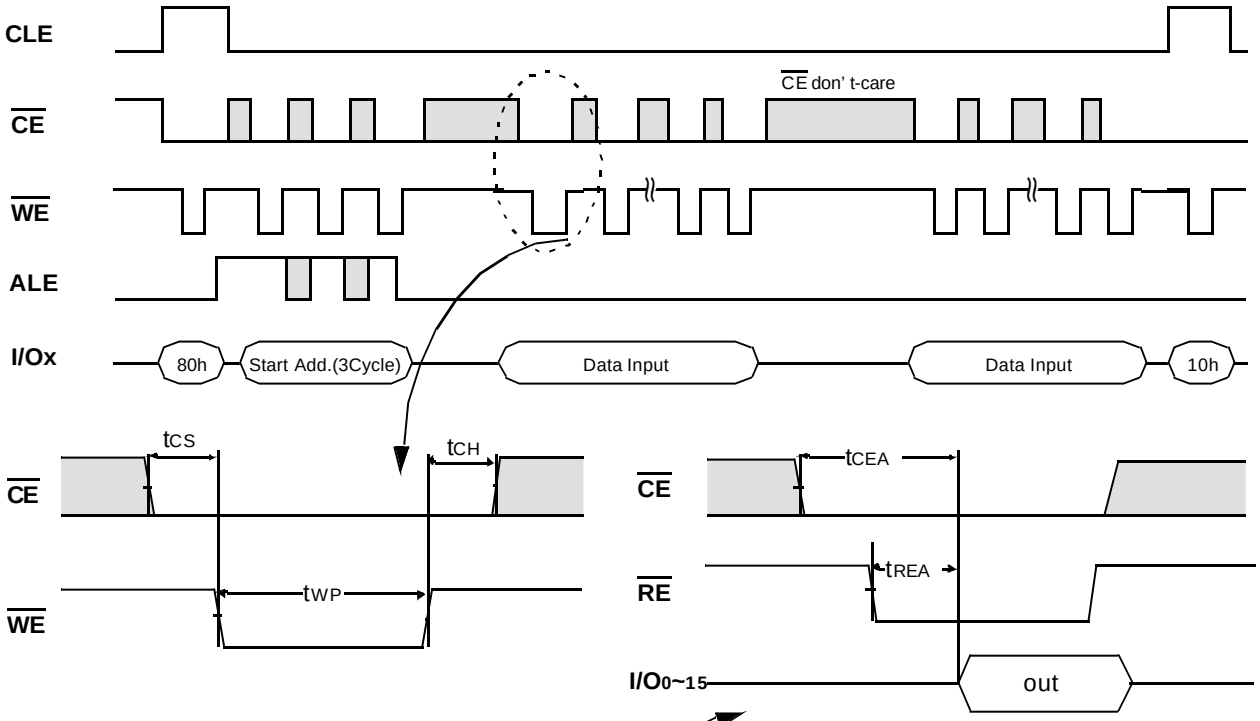
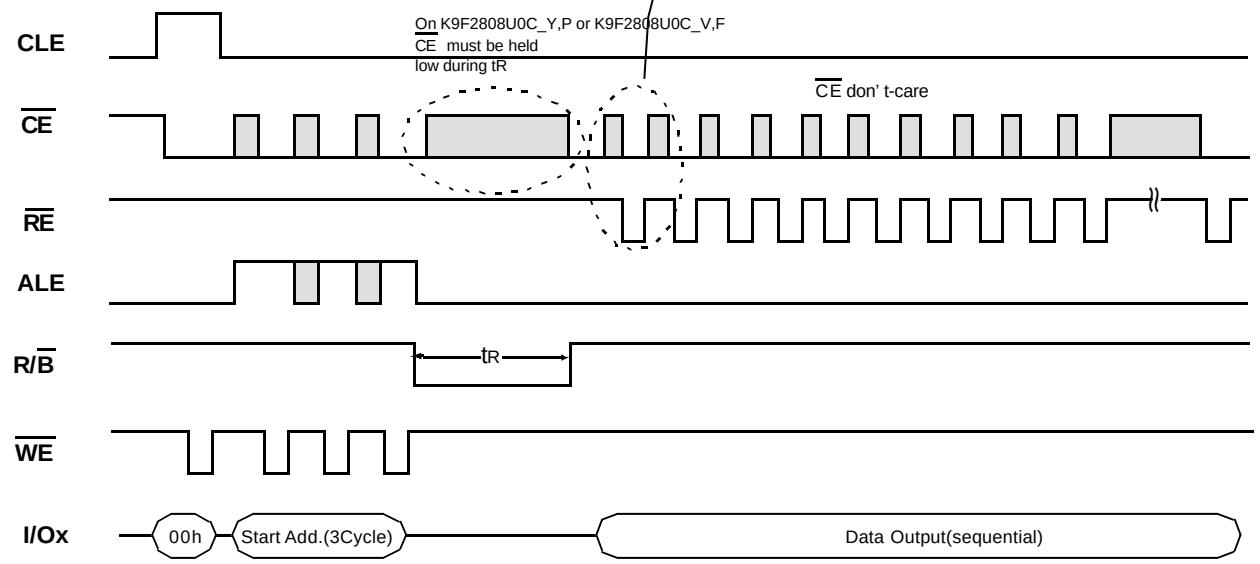


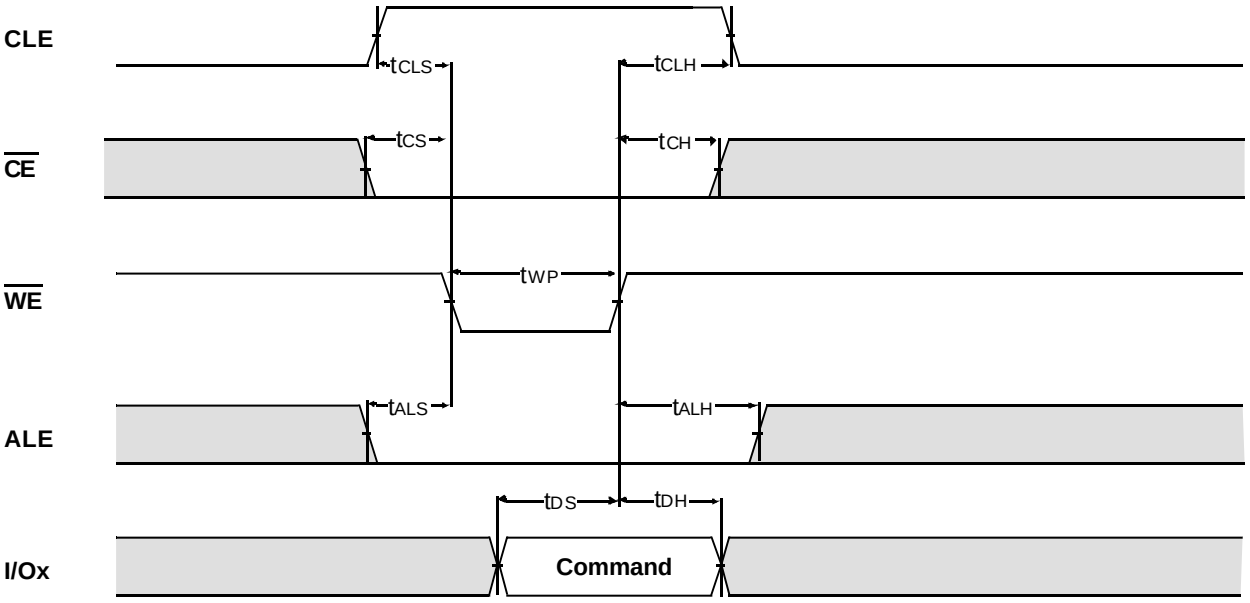
Figure 7. Read Operation with $\overline{CE}$ don' t-care.



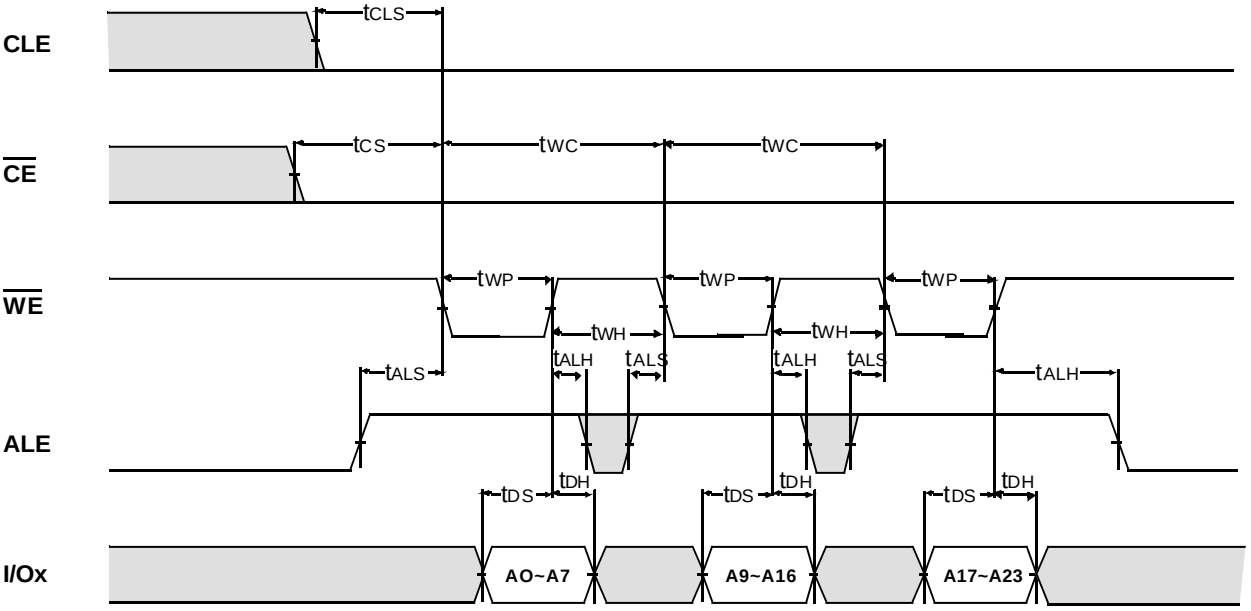
Device	I/O	DATA
	I/Ox	Data In/Out
K9F2808U0C(X8 device)	I/O 0 ~ I/O 7	~528byte
K9F2816U0C(X16 device)	I/O 0 ~ I/O 15 1)	~264word

NOTE: 1. I/O8~15 must be set to "0" during command or address input.
I/O8~15 are used only for data bus.

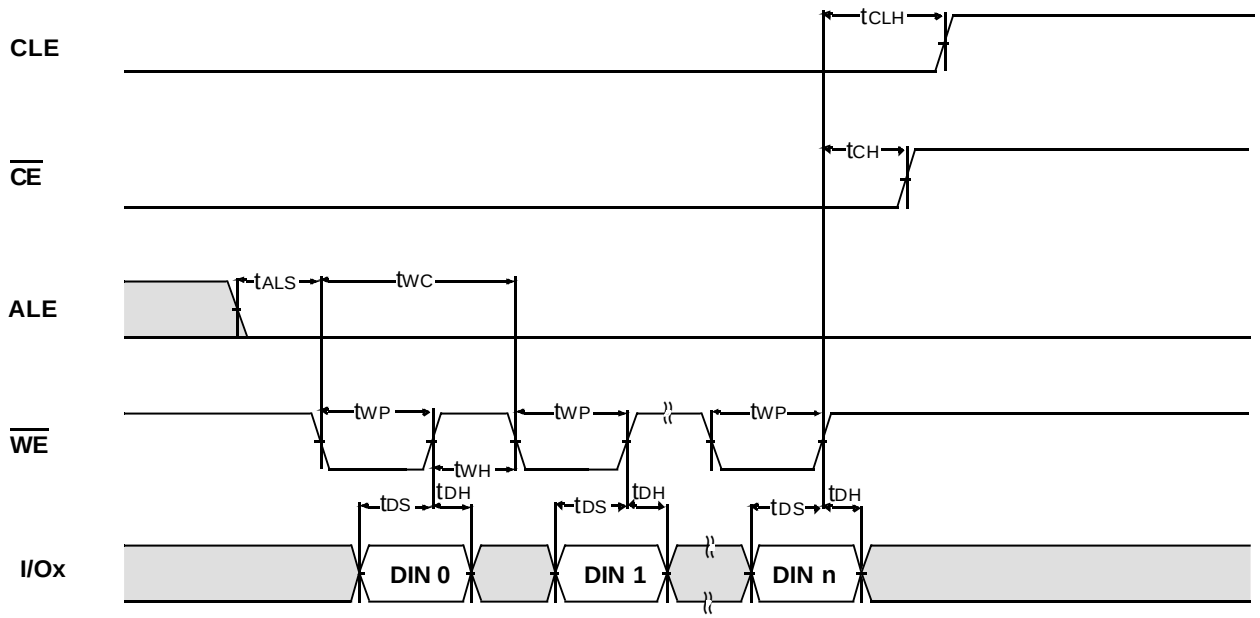
Command Latch Cycle



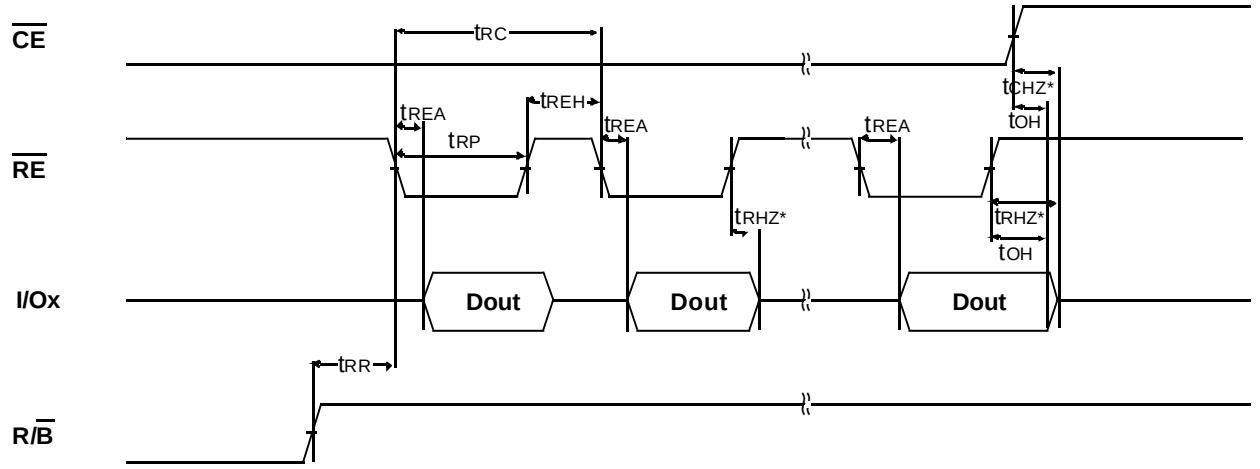
Address Latch Cycle



Input Data Latch Cycle

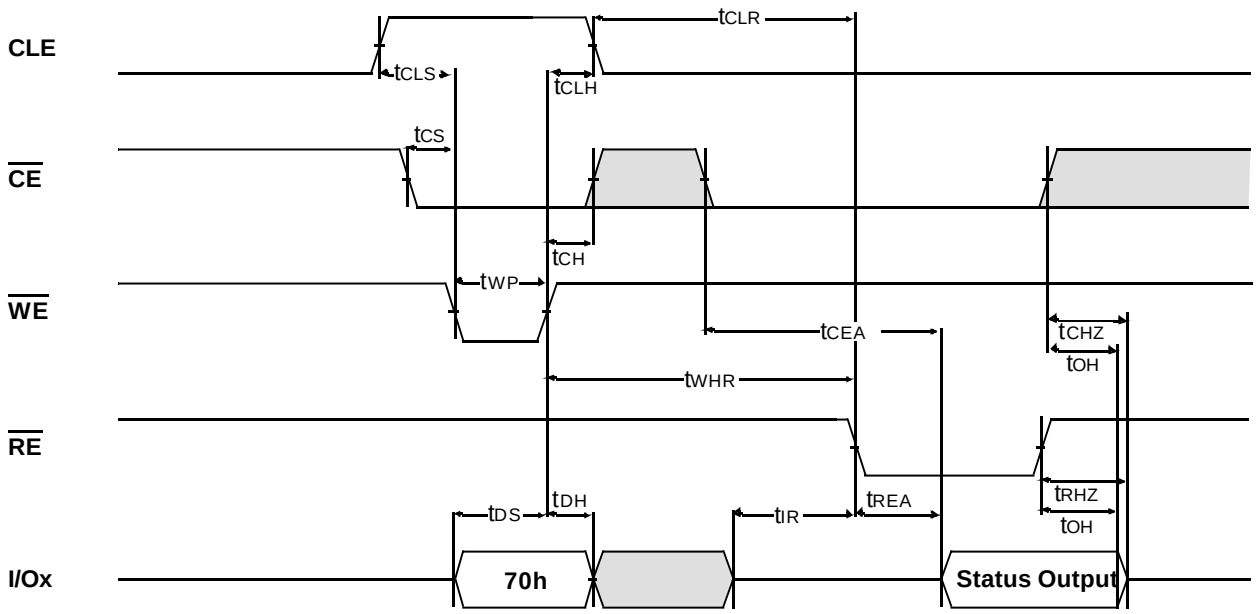


Serial access Cycle after Read (CLE=L, $\overline{WE}$=H, ALE=L)

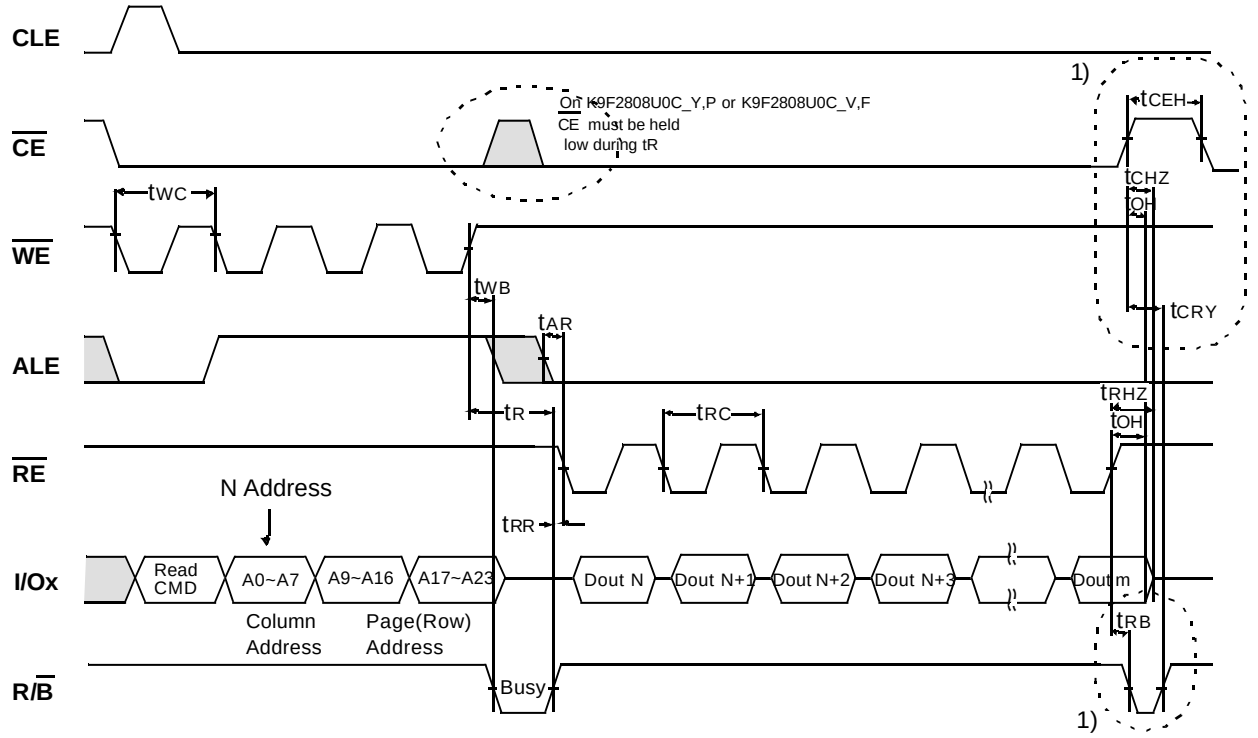


NOTES : Transition is measured ±200mV from steady state voltage with load.
This parameter is sampled and not 100% tested.

Status Read Cycle



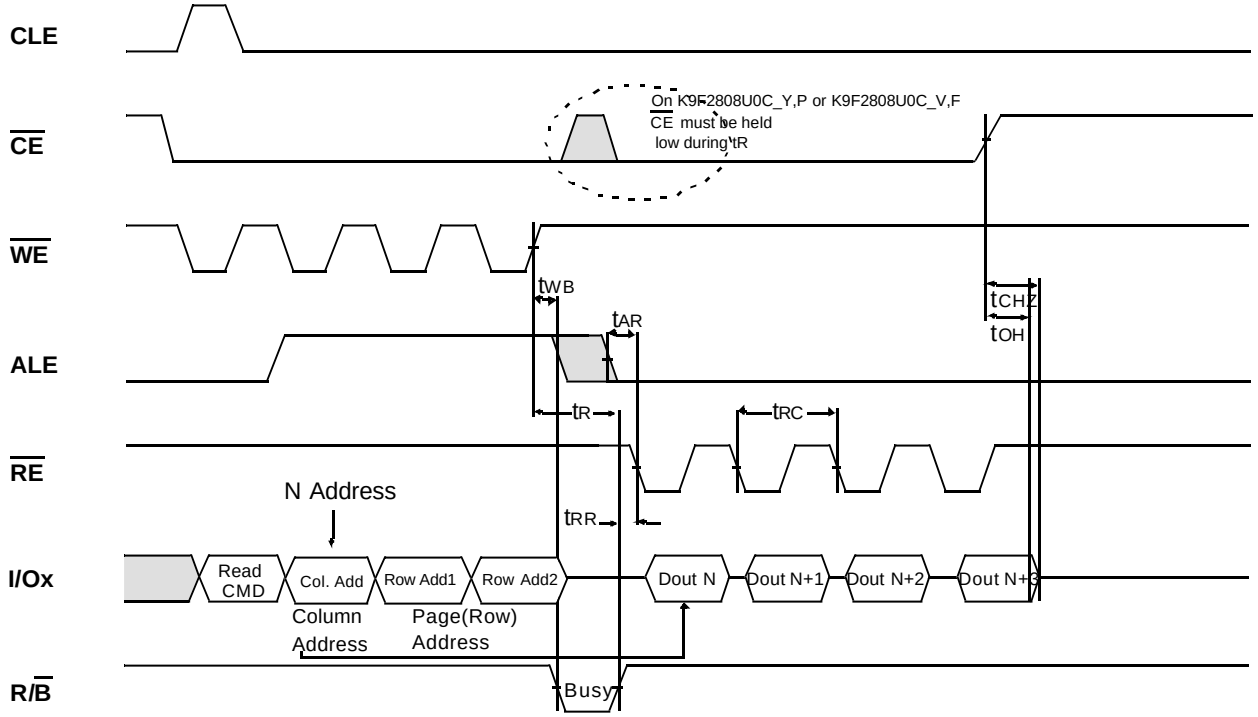
READ1 OPERATION (READ ONE PAGE)



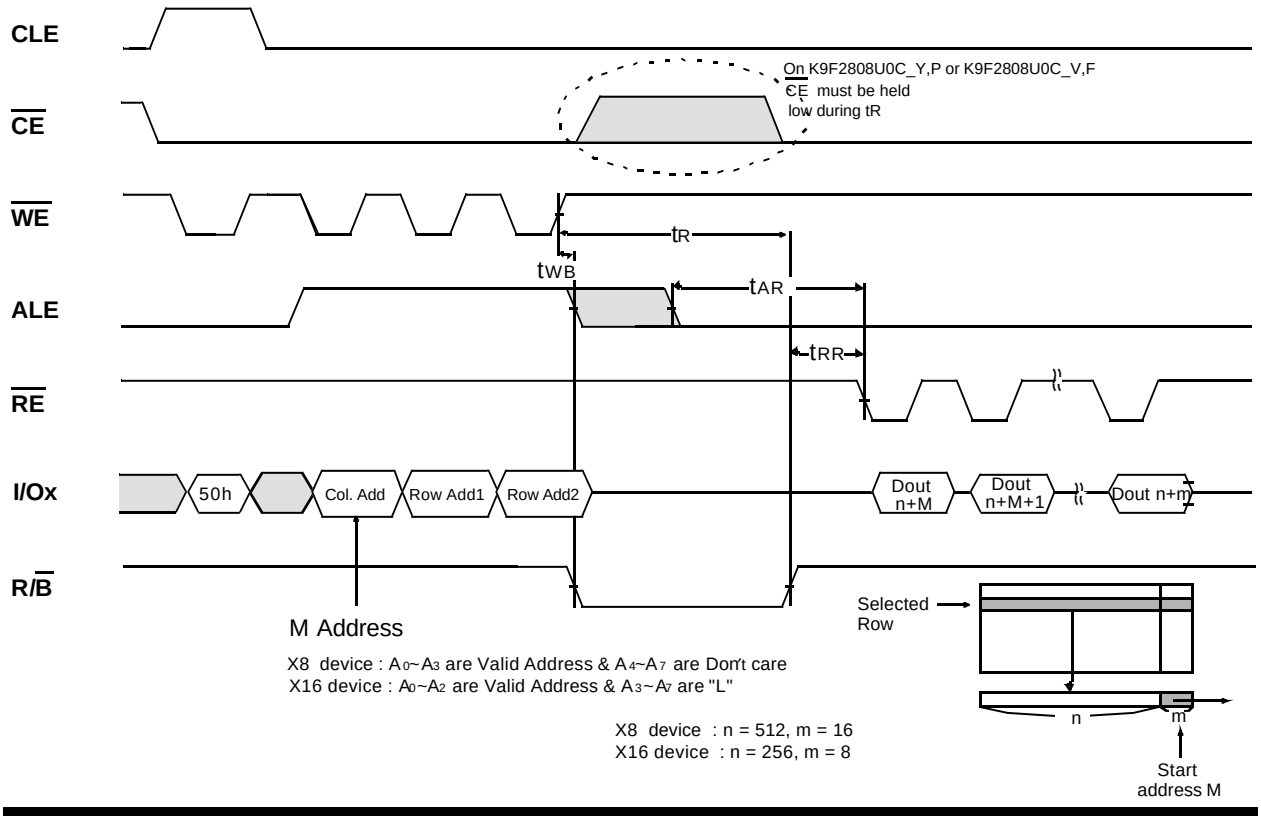
X8 device : m = 528 , Read CMD = 00h or 01h
X16 device : m = 264 , Read CMD = 00h

NOTES : 1) is only valid on K9F2808U0C_Y,P or K9F2808U0C_V,F

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



READ2 OPERATION (READ ONE PAGE)

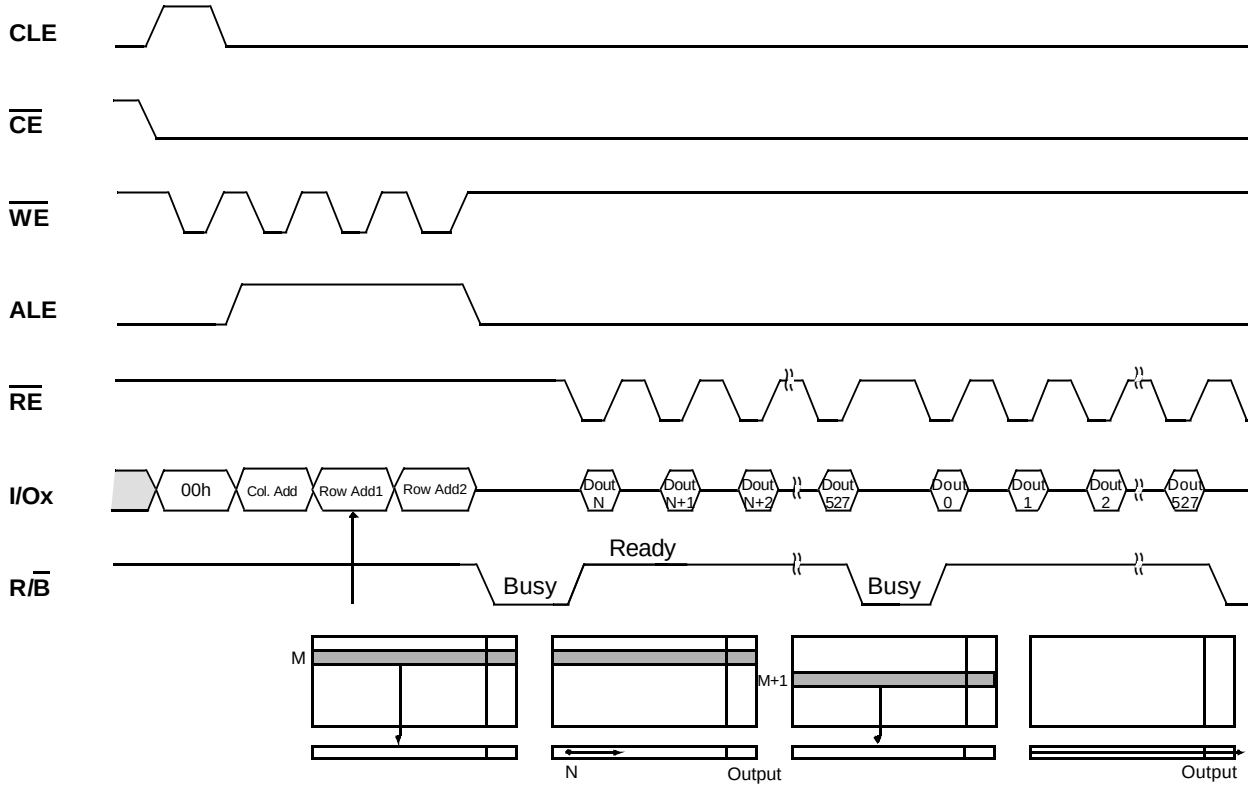


X8 device : A_0~A_3 are Valid Address & A_4~A_7 are Don't care
X16 device : A_0~A_2 are Valid Address & A_3~A_7 are "L"

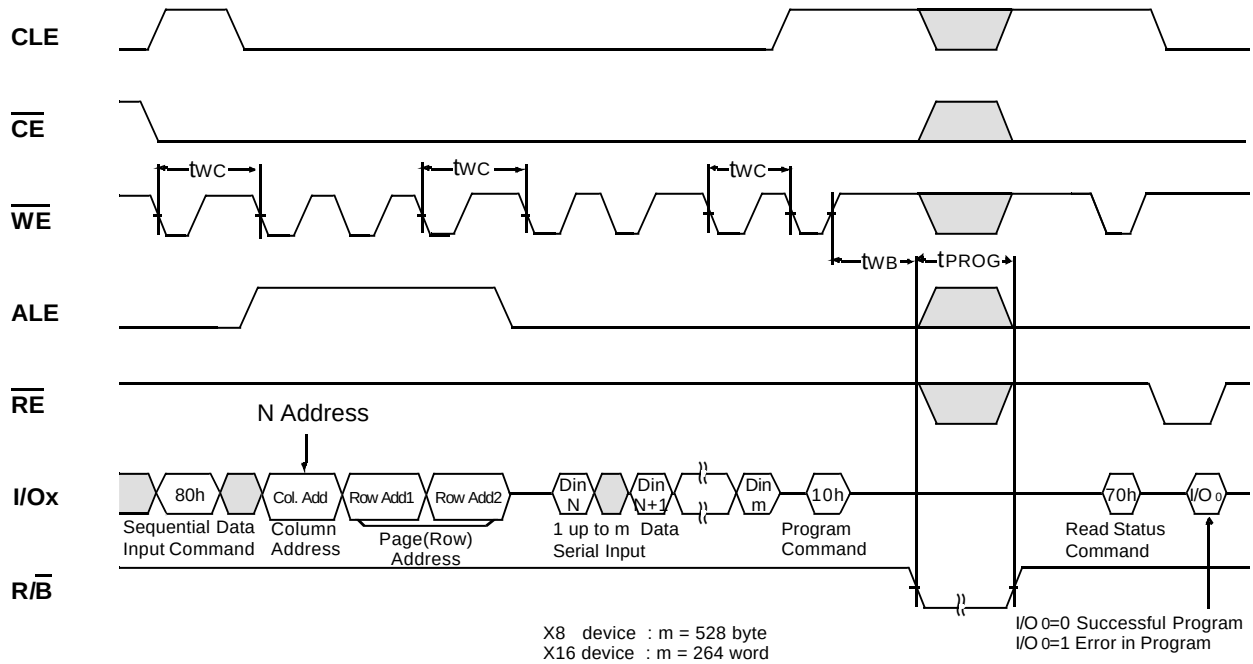
X8 device : n = 512, m = 16
X16 device : n = 256, m = 8

SEQUENTIAL ROW READ OPERATION

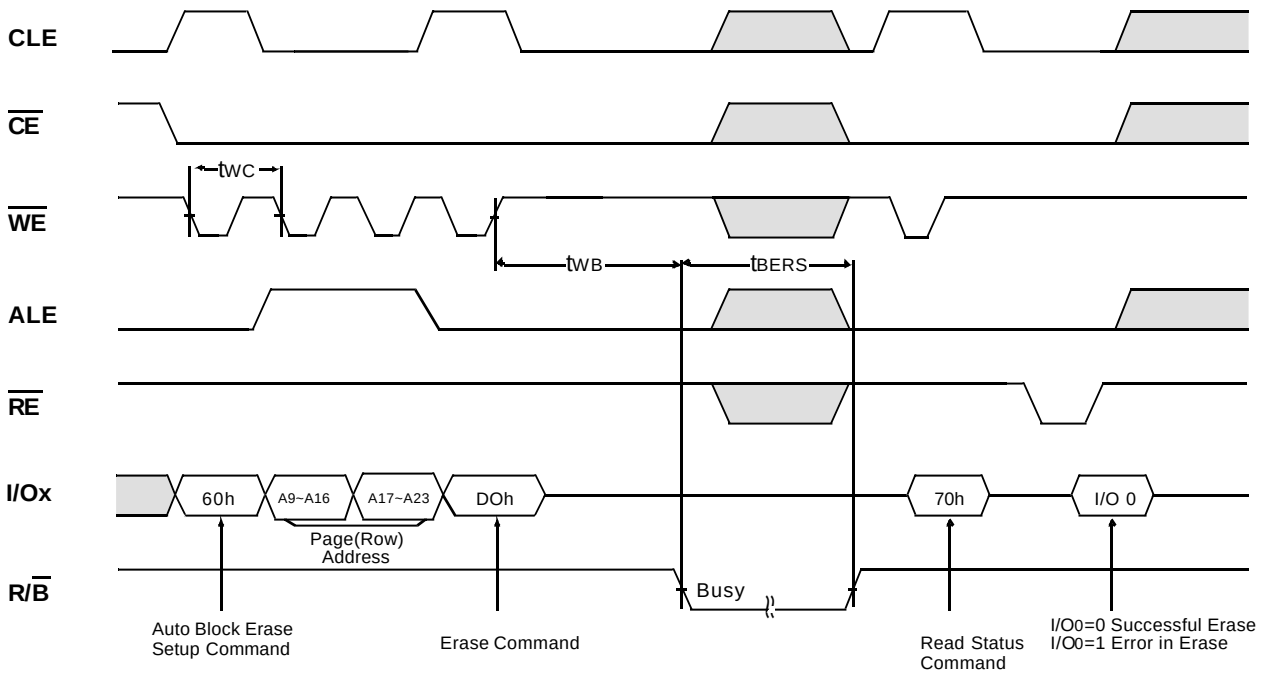
(only for K9F2808U0C-Y,P and K9F2808U0C-V,F valid wihin a block)



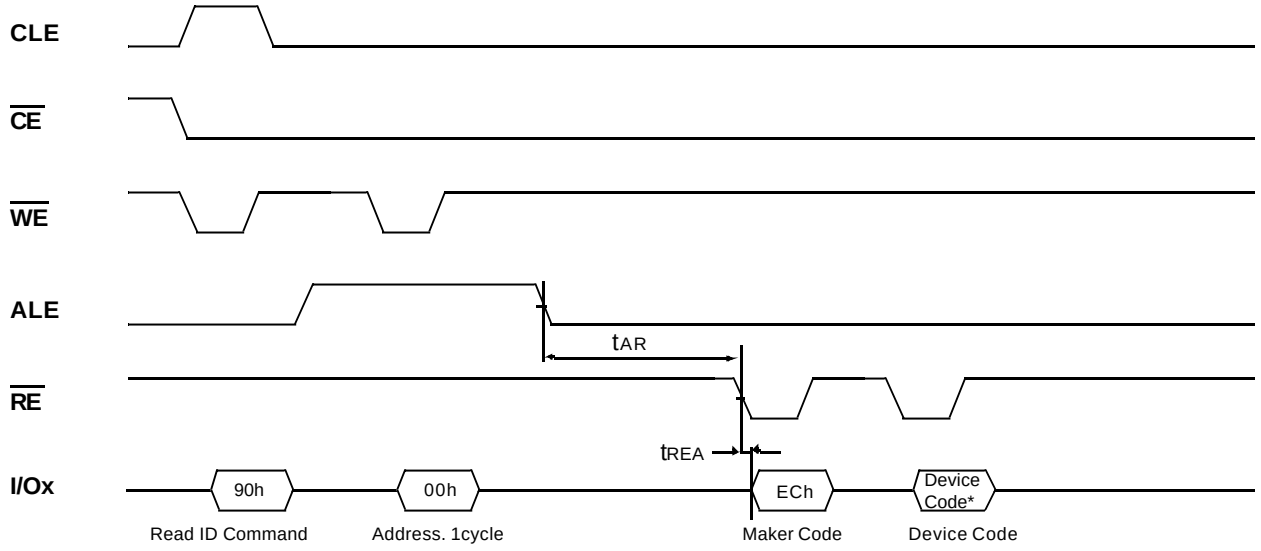
PAGE PROGRAM OPERATION



BLOCK ERASE OPERATION (ERASE ONE BLOCK)



MANUFACTURE & DEVICE ID READ OPERATION



Device	Device Code*
K9F2808U0C	73h
K9F2816U0C	XX53h

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 three address cycles. Once the command is latched, it does not need to be written for the following page read operation. Two types of operations are available : random read, serial page read.

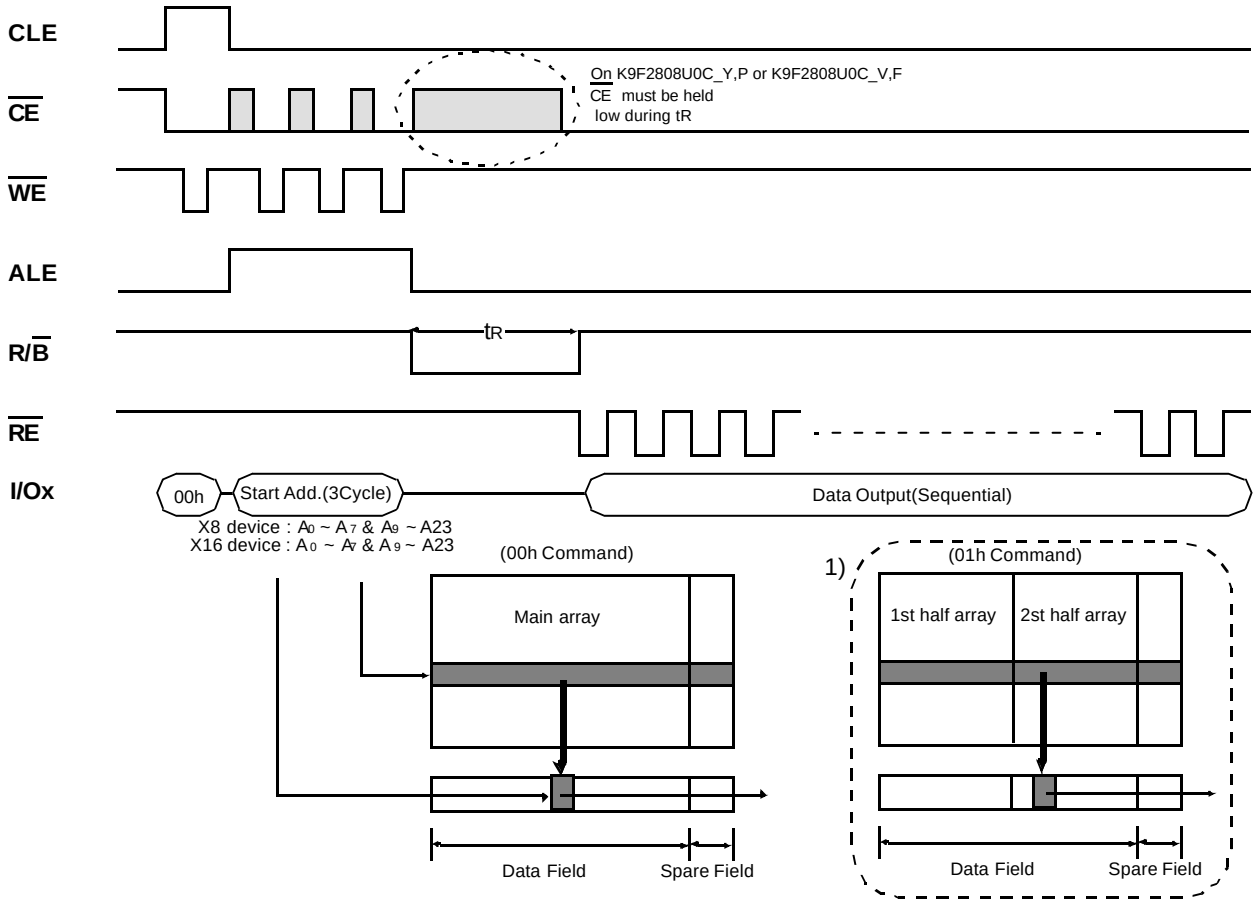
The random read mode is enabled when the page address is changed. The 528 bytes(X8 device) or 264 words(X16 device) of data within the selected page are transferred to the data registers in less than 10 μs(t_R). The system controller can detect the completion of this data transfer(tR) by analyzing the output of R/$\overline{B}$ pin. Once the data in a page is loaded into the registers, they may be read out in 50ns cycle time by sequentially pulsing $\overline{RE}$. High to low transitions of the $\overline{RE}$ clock output the data starting from the selected column address up to the last column address[column 511/ 527(X8 device) 255 /263(X16 device) depending on the state of GND input pin].

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 512 ~527 bytes(X8 device) or 256~263 words(X16 device) may be selectively accessed by writing the Read2 command with GND input pin low. Addresses A_0~A_3(X8 device) or A_0~A_2(X16 device) set the starting address of the spare area while addresses A_4~A_7 are ignored in X8 device case or A_3~A_7 must be "L" in X16 device case. The Read1 command is needed to move the pointer back to the main area. Figures 8, 9 show typical sequence and timings for each read operation.

Sequential Row Read is available only on K9F2808U0C_Y,P or K9F2808U0C_V,F :

After the data of last column address is clocked out, the next page is automatically selected for sequential row read. Waiting 10μs again allows reading the selected page. The sequential row read operation is terminated by bringing $\overline{CE}$ high. 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 Sequential Read 1 and 2 operation is allowed only within a block and after the last page of a block is readout, the sequential read operation must be terminated by bringing $\overline{CE}$ high. When the page address moves onto the next block, read command and address must be given. Figures 8-1, 9-1 show typical sequence and timings for sequential row read operation.

Figure 8. Read1 Operation



NOTE: 1) After data access on 2nd half array by 01h command, the start pointer is automatically moved to 1st half array (00h) at next cycle. 01h command is only available on X8 device(K9F2808X0C).

Figure 9. Read2 Operation

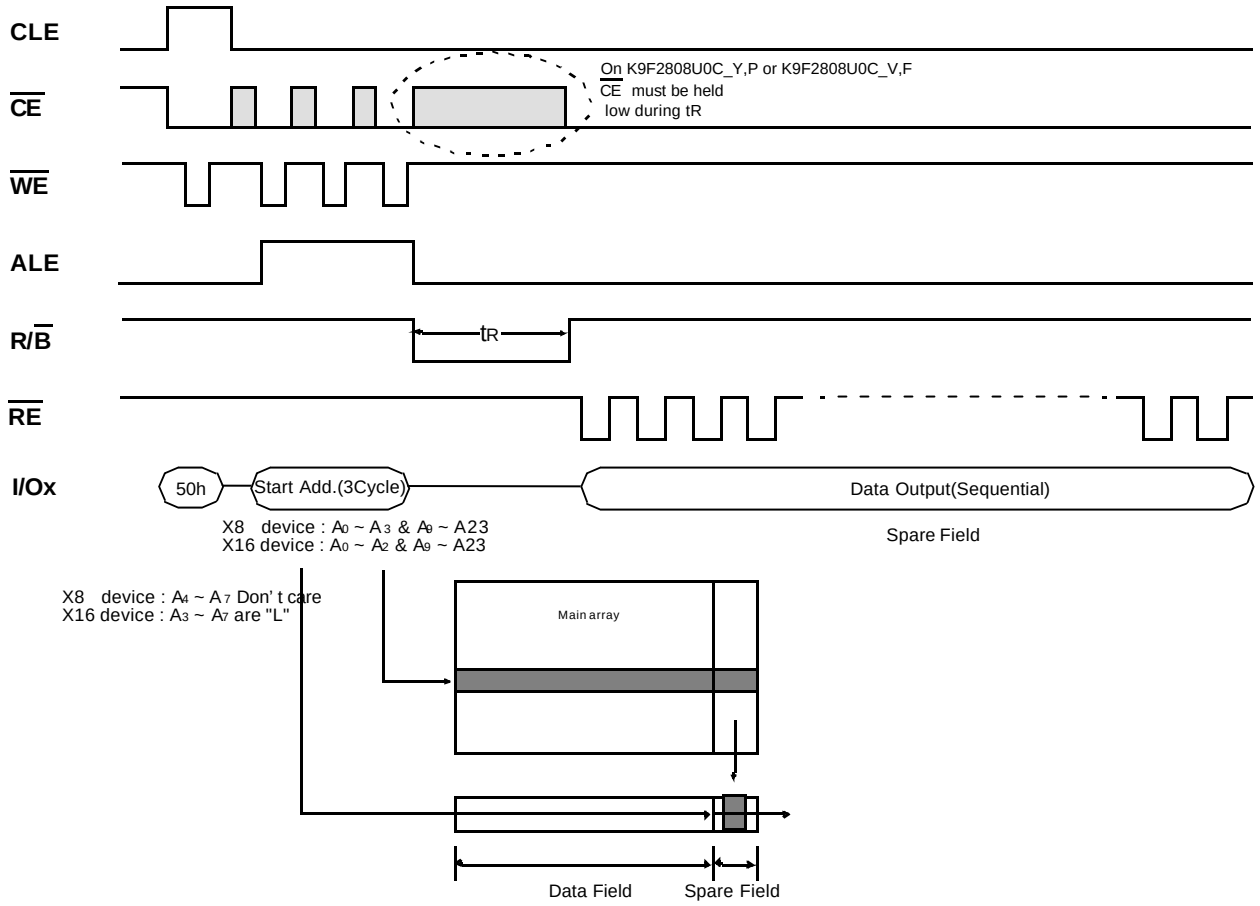


Figure 8-1. Sequential Row Read1 Operation

(only for K9F2808U0C-Y,P and K9F2808U0C-V,F valid wihin a block)

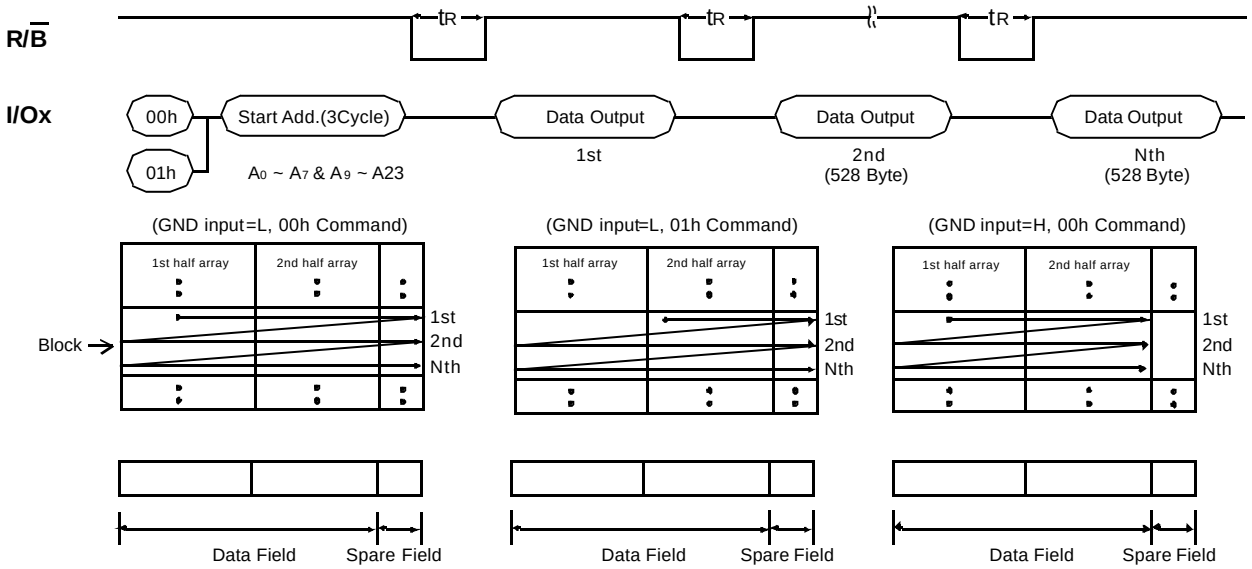
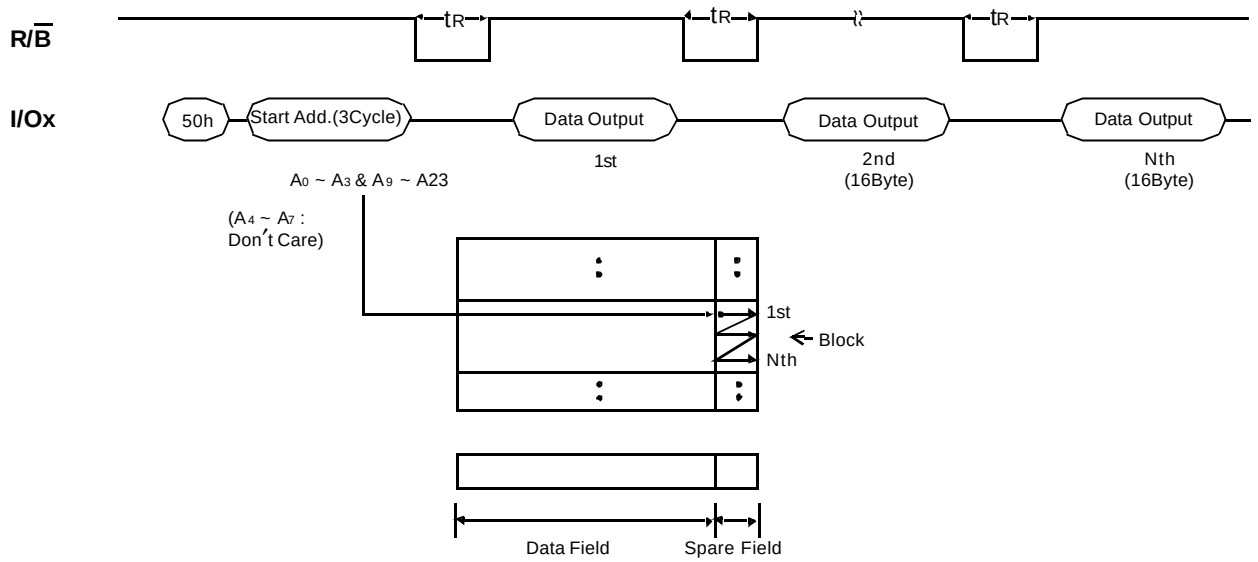


Figure 9-1. Sequential Row Read2 Operation (GND Input=Fixed Low)
(only for K9F2808U0C-Y,P and K9F2808U0C-V,F valid wihin a block)

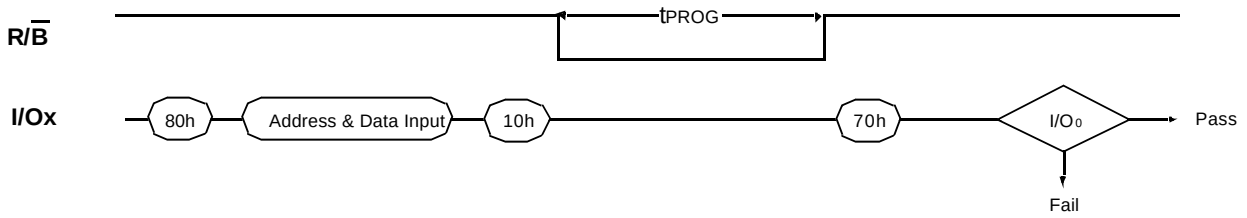


PAGE PROGRAM

The device is programmed basically on a page basis, but it does allow multiple partial page programing of a byte/word or consecutive bytes/words up to 528(X8 device) or 264(X16 device), in a single page program cycle. The number of consecutive partial page programming operation within the same page without an intervening erase operation should not exceed 2 for main array and 3 for spare array. 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 (X8 device) or 264 words (X16 device) 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. 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 three cycle address input and then serial data loading. The words 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 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 R/$\overline{B}$ 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 10). 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.

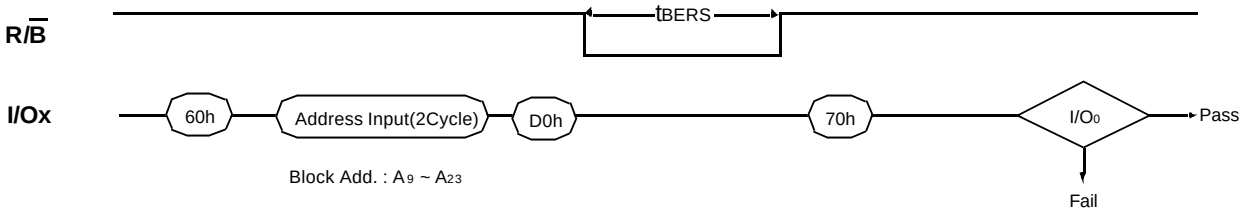
Figure 10. Program Operation



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 A_{14} to A_{23} is valid while A_9 to A_{13} 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 $\overline{WE}$ 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 11 details the sequence.

Figure 11. 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 $\overline{CE}$ or $\overline{RE}$, whichever occurs last. This two line control allows the system to poll the progress of each device in multiple memory connections even when R/$\overline{B}$ pins are common-wired. $\overline{RE}$ or $\overline{CE}$ does not need to be toggled for updated status. Refer to table 4 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 cycle, a read command(00h or 50h) should be given before sequential page read cycle.

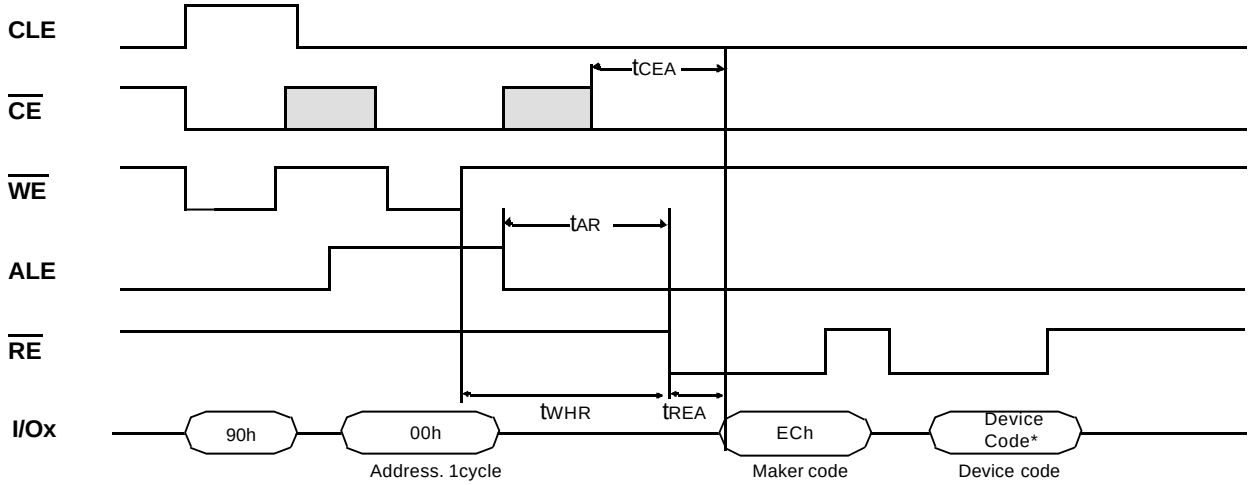
Table4. Read Status Register Definition

I/O #	Status	Definition
I/O 0	Program / Erase	"0" : Successful Program / Erase
		"1" : Error in Program / Erase
I/O 1	Reserved for Future Use	"0"
I/O 2		"0"
I/O 3		"0"
I/O 4		"0"
I/O 5		"0"
I/O 6	Device Operation	"0" : Busy "1" : Ready
I/O 7	Write Protect	"0" : Protected "1" : Not Protected
I/O 8~15	Not use	Don' t care

READ ID

The device contains a product identification mode, initiated by writing 90h to the command register, followed by an address input of 00h. Two read cycles sequentially output the manufacture code(ECh), and the device code respectively. The command register remains in Read ID mode until further commands are issued to it. Figure 12 shows the operation sequence.

Figure 12. Read ID Operation



Device	Device Code*
K9F2808U0C	73h
K9F2816U0C	XX53h

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 $\overline{WP}$ is high. Refer to table 5 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/$\overline{B}$ pin transitions to low for tRST after the Reset command is written. Refer to Figure 13 below.

Figure 13. RESET Operation

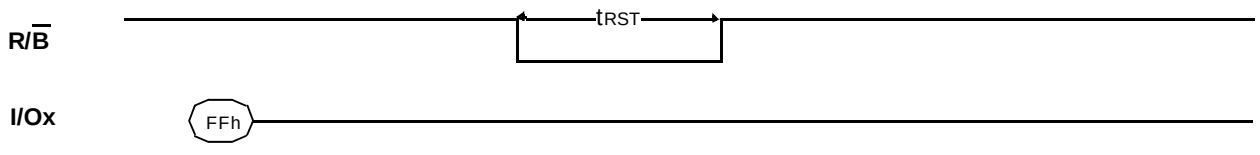


Table5. Device Status

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

READY/$\overline{BUSY}$

The device has a R/$\overline{B}$ output that provides a hardware method of indicating the completion of a page program, erase and random read completion. The R/$\overline{B}$ 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/$\overline{B}$ outputs to be Or-tied. Because pull-up resistor value is related to tr(R/$\overline{B}$) and current drain during busy(ibusy) , an appropriate value can be obtained with the following reference chart(Fig 14). Its value can be determined by the following guidance.

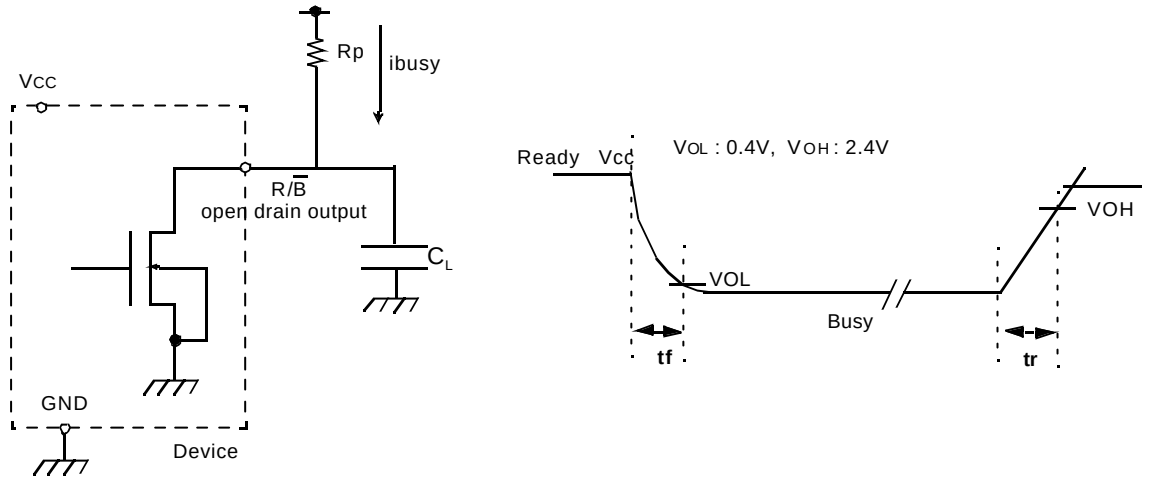
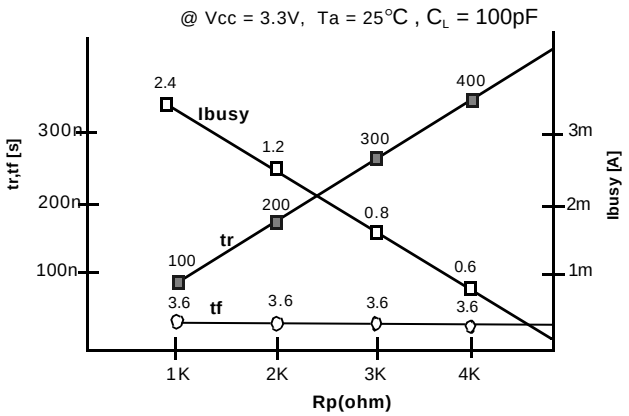


Figure 14. Rp vs tr ,tf & Rp vs ibusy



Rp value guidance

$$Rp(min, 3.3V\ part) = \frac{V_{CC}(Max.) - V_{OL}(Max.)}{I_{OL} + \Sigma I_L} = \frac{3.2V}{8mA + \Sigma I_L}$$

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

Rp(max) is determined by maximum permissible limit of tr

Data Protection & Power up sequence

The device is designed to offer protection from any involuntary program/erase during power-transitions. An internal voltage detector disables all functions whenever Vcc is below about 2V(3.3V device). $\overline{WP}$ pin provides hardware protection and is recommended to be kept at V_{IL} during power-up and power-down and recovery time of minimum 10µs is required before internal circuit gets ready for any command sequences as shown in Figure 15. The two step command sequence for program/erase provides additional software protection.

Figure 15. AC Waveforms for Power Transition