

Document Title

128M x 8 Bit NAND Flash Memory

Revision History

| <u>Revision No</u> | <u>History</u> | <u>Draft Date</u> | <u>Remark</u> |
|--------------------|---|-------------------|---------------|
| 0.0 | 1. Initial issue | Aug. 24. 2003 | Advance |
| 0.1 | 1. The tADL(Address to Data Loading Time) is added. - tADL Minimum 100ns (Page 11, 23~26) - tADL is the time from the WE rising edge of final address cycle to the WE rising edge of first data cycle at program operation. | Jan. 27. 2004 | Preliminary |
| | 2. Added Addressing method for program operation | | |
| 0.2 | 1. Add the Protrusion/Burr value in WSOP1 PKG Diagram. | Apr. 23. 2004 | Preliminary |
| 0.3 | 1. PKG(TSOP1, WSOP1) Dimension Change | May. 19. 2004 | |

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

128M x 8 Bit NAND Flash Memory

PRODUCT LIST

| Part Number | Vcc Range | Organization | PKG Type |
|----------------|--------------|--------------|-----------------------|
| K9F1G08Q0A | 1.70 ~ 1.95V | X8 | Only available in MCP |
| K9F1G08U0A-Y,P | 2.7 ~ 3.6V | | TSOP1 |
| K9F1G08U0A-V,F | | | WSOP1 |

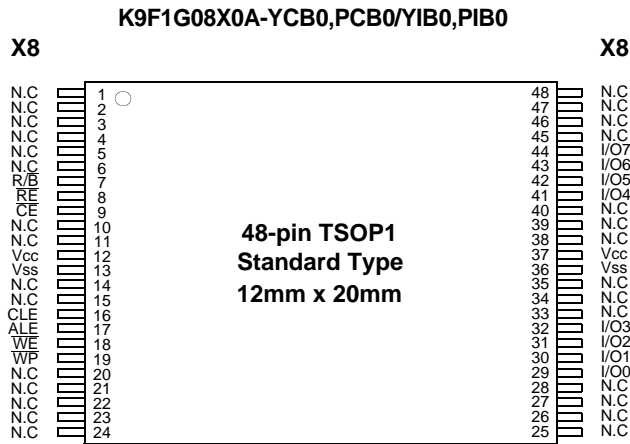
FEATURES

- Voltage Supply
 - 1.8V device(K9F1G08Q0A): 1.70V~1.95V
 - 3.3V device(K9F1G08U0A): 2.7 V ~3.6 V
- Organization
 - Memory Cell Array : (128M + 4,096K)bit x 8bit
 - Data Register : (2K + 64)bit x8bit
 - Cache Register : (2K + 64)bit x8bit
- Automatic Program and Erase
 - Page Program : (2K + 64)Byte
 - Block Erase : (128K + 4K)Byte
- Page Read Operation
 - Page Size : 2K-Byte
 - Random Read : 25µs(Max.)
 - Serial Access : 30ns(Min.) : (K9F1G08U0A)
50ns(Min.) : (K9F1G08Q0A)
- Fast Write Cycle Time
 - Program time : 300µs(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
- Cache Program Operation for High Performance Program
- Intelligent Copy-Back Operation
- Unique ID for Copyright Protection
- Package :
 - K9F1G08U0A-YCB0/YIB0
48 - Pin TSOP I (12 x 20 / 0.5 mm pitch)
 - K9F1G08U0A-VIB0
48 - Pin WSOP I (12X17X0.7mm)
 - K9F1G08U0A-PCB0/PIB0
48 - Pin TSOP I (12 x 20 / 0.5 mm pitch)- Pb-free Package
 - K9F1G08U0A-FIB0
48 - Pin WSOP I (12X17X0.7mm)- Pb-free Package
 - * K9F1G08U0A-V,F(WSOPI) is the same device as K9F1G08U0A-Y,P(TSOP1) except package type.

GENERAL DESCRIPTION

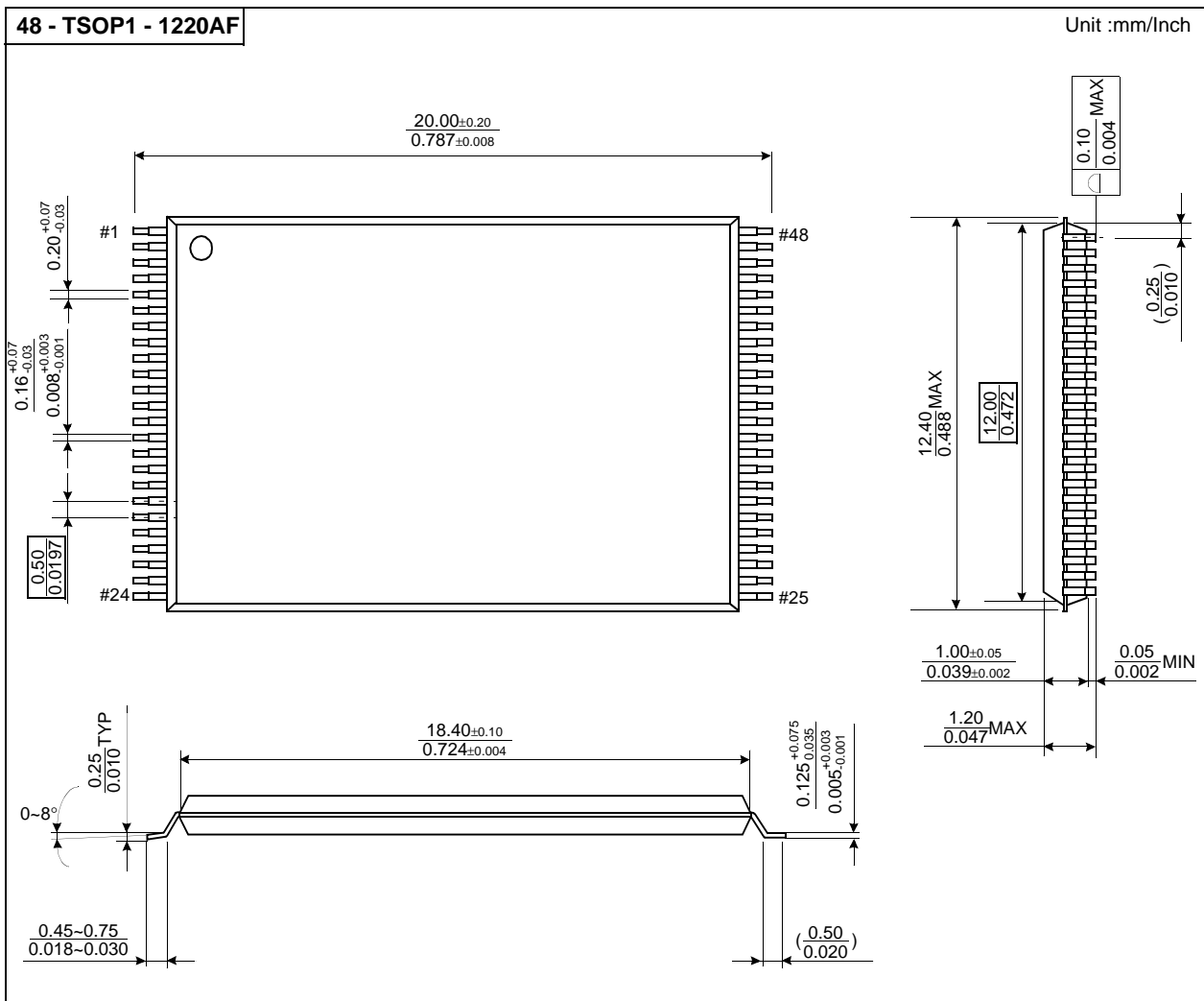
Offered in 128Mx8bit the K9F1G08X0A is 1G bit with spare 32M bit capacity. Its NAND cell provides the most cost-effective solution for the solid state mass storage market. A program operation can be performed in typical 300µs on the 2112-byte page and an erase operation can be performed in typical 2ms on a 128K-byte block. Data in the data page can be read out at 50ns (30ns, K9F1G08U0A) cycle time per byte. The I/O pins serve as the ports for address and data input/output as well as command input. The on-chip write controller automates all program and erase functions including pulse repetition, where required, and internal verification and margining of data. Even the write-intensive systems can take advantage of the K9F1G08X0A's extended reliability of 100K program/erase cycles by providing ECC(Error Correcting Code) with real time mapping-out algorithm. The K9F1G08X0A 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)



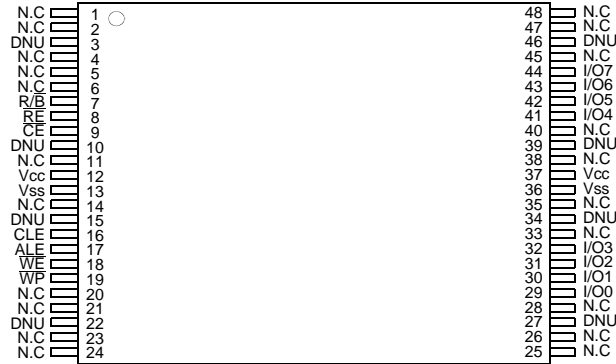
PACKAGE DIMENSIONS

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



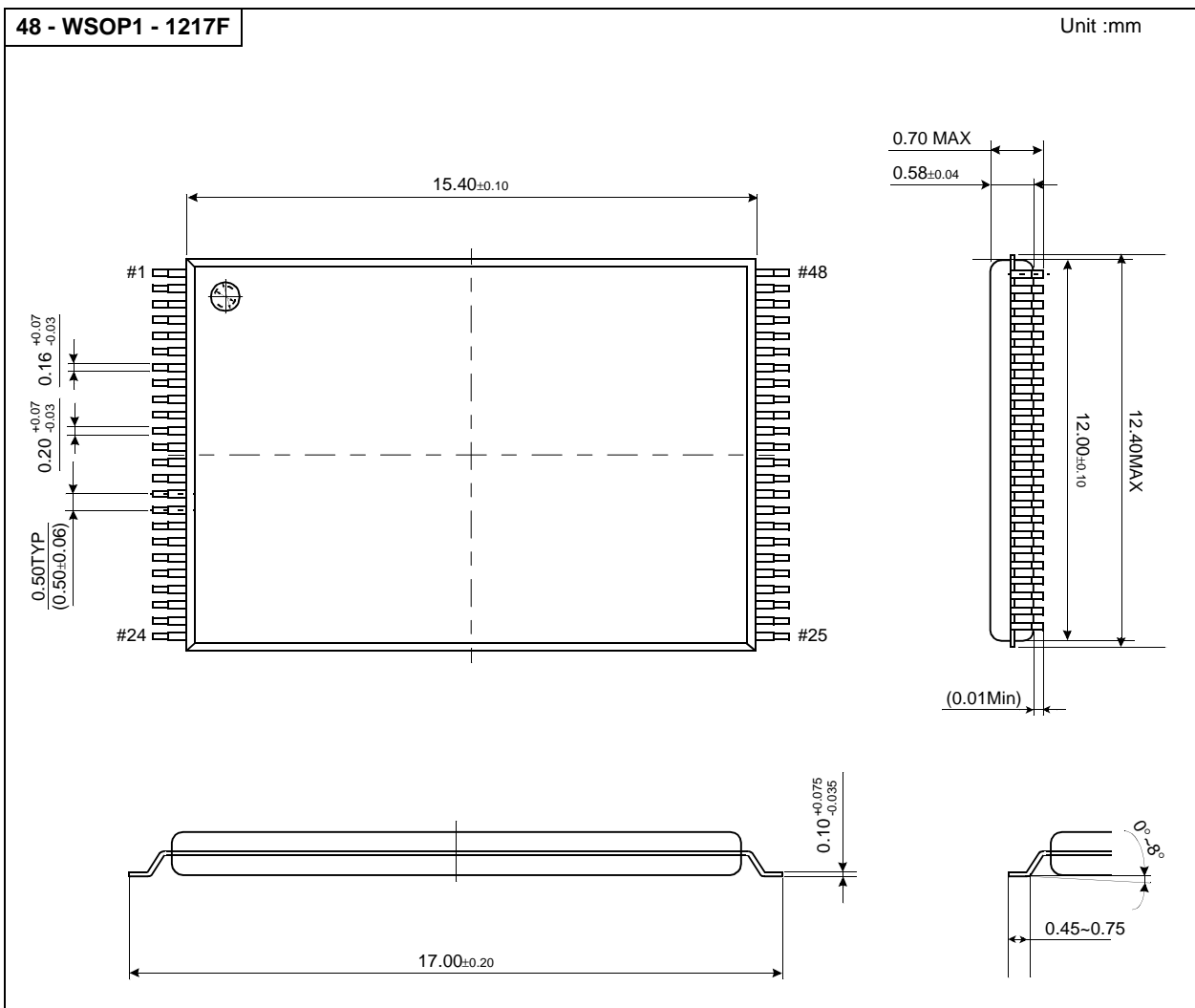
PIN CONFIGURATION (WSOP1)

K9F1G08U0A-VIB0,FIB0



PACKAGE DIMENSIONS

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



PIN DESCRIPTION

| Pin Name | Pin Function |
|-------------------------------------|---|
| I/O ₀ ~ I/O ₇ | 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. |
| 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 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 WE with ALE high. |
| $\overline{\text{CE}}$ | CHIP ENABLE The CE input is the device selection control. When the device is in the Busy state, $\overline{\text{CE}}$ high is ignored, and the device does not return to standby mode. |
| $\overline{\text{RE}}$ | READ ENABLE The $\overline{\text{RE}}$ 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. |
| $\overline{\text{WE}}$ | WRITE ENABLE The $\overline{\text{WE}}$ input controls writes to the I/O port. Commands, address and data are latched on the rising edge of the WE pulse. |
| $\overline{\text{WP}}$ | WRITE PROTECT The WP pin provides inadvertent write/erase protection during power transitions. The internal high voltage generator is reset when the WP pin is active low. |
| R/B | READY/BUSY OUTPUT The R/B output indicates the status of the device operation. When low, it indicates that a program, erase or random read operation is in process and returns to high state upon completion. It is an open drain output and does not float to high-z condition when the chip is deselected or when outputs are disabled. |
| Vcc | POWER Vcc is the power supply for device. |
| Vss | GROUND |
| N.C | NO CONNECTION Lead is not internally connected. |

NOTE : Connect all Vcc and Vss pins of each device to common power supply outputs.
Do not leave Vcc or Vss disconnected.

Figure 1-1. K9F1G08X0A (X8) Functional Block Diagram

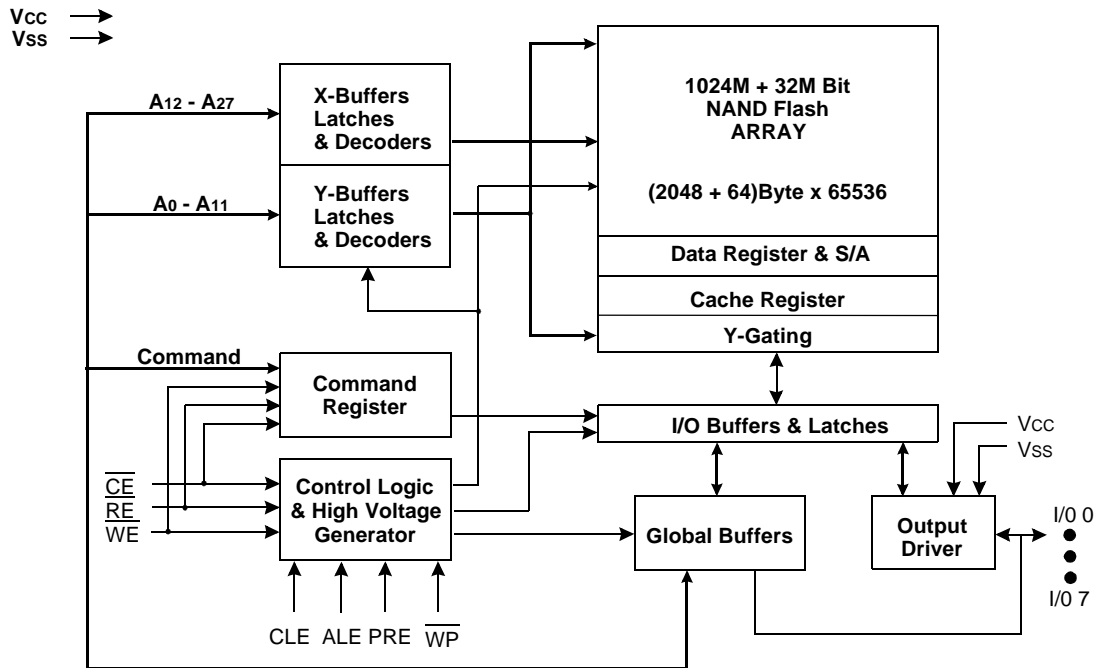
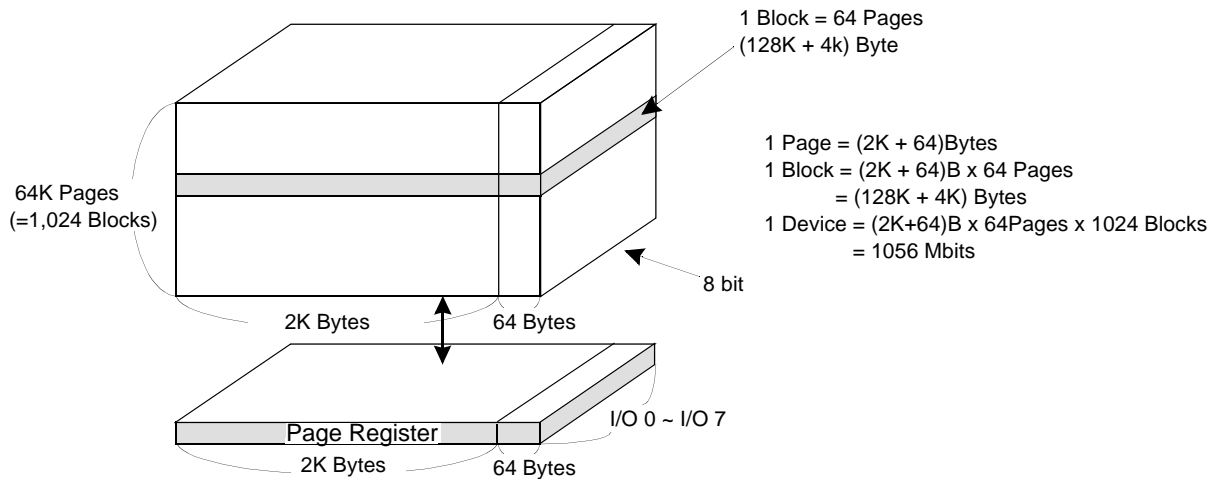


Figure 2-1. K9F1G08X0A (X8) Array Organization



| | 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 | A ₀ | A ₁ | A ₂ | A ₃ | A ₄ | A ₅ | A ₆ | A ₇ |
| 2nd Cycle | A ₈ | A ₉ | A ₁₀ | A ₁₁ | *L | *L | *L | *L |
| 3rd Cycle | A ₁₂ | A ₁₃ | A ₁₄ | A ₁₅ | A ₁₆ | A ₁₇ | A ₁₈ | A ₁₉ |
| 4th Cycle | A ₂₀ | A ₂₁ | A ₂₂ | A ₂₃ | A ₂₄ | A ₂₅ | A ₂₆ | A ₂₇ |

Column Address
Column Address
Row Address
Row Address

NOTE : Column Address : Starting Address of the Register.

* L must be set to "Low".

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

Product Introduction

The K9F1G08X0A is a 1056Mbit(1,107,296,256 bit) memory organized as 65,536 rows(pages) by 2112x8 columns. Spare 64 columns are located from column address of 2048~2111. A 2112-byte data register and a 2112-byte cache register are serially connected to each other. Those serially connected registers are connected to memory cell arrays for accommodating data transfer between the I/O buffers and memory cells during page read and page program operations. The memory array is made up of 32 cells that are serially connected to form a NAND structure. Each of the 32 cells resides in a different page. A block consists of two NAND structured strings. A NAND structure consists of 32 cells. Total 1081344 NAND cells reside in a block. 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 128K-byte blocks. It indicates that the bit by bit erase operation is prohibited on the K9F1G08X0A.

The K9F1G08X0A has addresses multiplexed into 8 I/Os. This scheme dramatically reduces pin counts and allows system upgrades to future densities by maintaining consistency in system board design. Command, address and data are all written through I/O's by bringing WE to low while CE is low. Those are latched on the rising edge of WE. Command Latch Enable(CLE) and Address Latch Enable(ALE) are used to multiplex command and address respectively, via the I/O pins. Some commands require one bus cycle. For example, Reset Command, Status Read Command, etc require just one cycle bus. Some other commands, like page read and block erase and page program, require two cycles: one cycle for setup and the other cycle for execution. The 128M byte physical space requires 28 addresses, thereby requiring four cycles for addressing: 2 cycles of column address, 2 cycles of row address, in that order. Page Read and Page Program need the same four address cycles following the required command input. In Block Erase operation, however, only the 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 K9F1G08X0A.

The device provides cache program in a block. It is possible to write data into the cache registers while data stored in data registers are being programmed into memory cells in cache program mode. The program performance may be dramatically improved by cache program when there are lots of pages of data to be programmed.

In addition to the enhanced architecture and interface, the device incorporates copy-back program feature from one page to another page without need for transporting the data to and from the external buffer memory. Since the time-consuming serial access and data-input cycles are removed, system performance for solid-state disk application is significantly increased.

Table 1. Command Sets

| Function | 1st. Cycle | 2nd. Cycle | Acceptable Command during Busy |
|---------------------|------------|------------|--------------------------------|
| Read | 00h | 30h | |
| Read for Copy Back | 00h | 35h | |
| Read ID | 90h | - | |
| Reset | FFh | - | O |
| Page Program | 80h | 10h | |
| Cache Program | 80h | 15h | |
| Copy-Back Program | 85h | 10h | |
| Block Erase | 60h | D0h | |
| Random Data Input* | 85h | - | |
| Random Data Output* | 05h | E0h | |
| Read Status | 70h | | O |

- NOTE :** 1. Random Data Input/Output can be executed in a page.
2. Command not specified in command sets table is not permitted to be entered to the device, which can raise erroneous operation.

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

ABSOLUTE MAXIMUM RATINGS

| Parameter | | Symbol | Rating | | Unit |
|------------------------------------|-----------------|---------|----------------|-------------------|------|
| | | | 1.8V DEVICE | 3.3V/2.65V DEVICE | |
| Voltage on any pin relative to Vss | | VIN/OUT | -0.6 to + 2.45 | -0.6 to + 4.6 | V |
| | | Vcc | -0.2 to + 2.45 | -0.6 to + 4.6 | |
| Temperature Under Bias | K9F1G08X0A-XCB0 | TBIAS | -10 to +125 | | °C |
| | K9F1G08X0A-XIB0 | | -40 to +125 | | |
| Storage Temperature | K9F1G08X0A-XCB0 | TSTG | -65 to +150 | | °C |
| | K9F1G08X0A-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 Vcc+0.3V which, during transitions, may overshoot to Vcc+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, K9F1G08X0A-XCB0 :TA=0 to 70°C, K9F1G08X0A-XIB0:TA=-40 to 85°C)

| Parameter | Symbol | K9F1G08Q0A(1.8V) | | | K9F1G08U0A(3.3V) | | | Unit |
|----------------|--------|------------------|------|------|------------------|------|-----|------|
| | | Min | Typ. | Max | Min | Typ. | Max | |
| Supply Voltage | Vcc | 1.70 | 1.8 | 1.95 | 2.7 | 3.3 | 3.6 | V |
| Supply Voltage | Vss | 0 | 0 | 0 | 0 | 0 | 0 | V |

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

| Parameter | | Symbol | Test Conditions | K9F1G08Q0A | | | K9F1G08U0A | | | Unit |
|---------------------------------------|------------------------------|-------------------------------------|--|----------------------|-----|----------------------|---------------------|-----|----------------------|------|
| | | | | 1.8V | | | 3.3V | | | |
| | | | | Min | Typ | Max | Min | Typ | Max | |
| Operating Current | Page Read with Serial Access | I _{CC1} | t _{RC} =50ns, $\overline{CE}=V_{IL}$ I _{OUT} =0mA | - | 10 | 20 | - | 15 | 30 | mA |
| | Program | I _{CC2} | - | - | 10 | 20 | - | 15 | 30 | |
| | Erase | I _{CC3} | - | - | 10 | 20 | - | 15 | 30 | |
| Stand-by Current(TTL) | | I _{SB1} | $\overline{CE}=V_{IH}$, $\overline{WP}=0V/V_{CC}$ | - | - | 1 | - | - | 1 | |
| Stand-by Current(CMOS) | | I _{SB2} | $\overline{CE}=V_{CC}-0.2$, $\overline{WP}=0V/V_{CC}$ | - | 10 | 50 | - | 10 | 50 | μA |
| Input Leakage Current | | I _{LI} | V _{IN} =0 to V _{CC} (max) | - | - | ±10 | - | - | ±10 | μA |
| Output Leakage Current | | I _{LO} | V _{OUT} =0 to V _{CC} (max) | - | - | ±10 | - | - | ±10 | |
| Input High Voltage | | V _{IH} * | - | 0.8xV _{CC} | - | V _{CC} +0.3 | 0.8xV _{CC} | - | V _{CC} +0.3 | V |
| Input Low Voltage, All inputs | | V _{IL} * | - | -0.3 | - | 0.2xV _{CC} | -0.3 | - | 0.2xV _{CC} | |
| Output High Voltage Level | | V _{OH} | K9F1G08Q0A :I _{OH} =-100μA K9F1G08U0A :I _{OH} =-400μA | V _{CC} -0.1 | - | - | 2.4 | - | - | |
| Output Low Voltage Level | | V _{OL} | K9F1G08Q0A :I _{OL} =100uA K9F1G08U0A :I _{OL} =2.1mA | - | - | 0.1 | - | - | 0.4 | |
| Output Low Current(R \overline{B}) | | I _{OL} (R \overline{B}) | K9F1G08Q0A :V _{OL} =0.1V K9F1G08U0A :V _{OL} =0.4V | 3 | 4 | - | 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 | NvB | 1004 | - | 1024 | Blocks |

NOTE :

1. The K9F1G08X0A 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 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.

AC TEST CONDITION

(K9F1G08X0A-XCB0 :TA=0 to 70°C, K9F1G08X0A-XIB0:TA=-40 to 85°C

K9F1G08Q0A : Vcc=1.70V~1.95V, K9F1G08U0A : Vcc=2.7V~3.6V unless otherwise noted)

| Parameter | K9F1G08Q0A | K9F1G08U0A |
|--------------------------------|------------------------|------------------------|
| Input Pulse Levels | 0V to Vcc | 0V to Vcc |
| Input Rise and Fall Times | 5ns | 5ns |
| Input and Output Timing Levels | Vcc/2 | Vcc/2 |
| Output Load | 1 TTL GATE and CL=30pF | 1 TTL GATE and CL=50pF |

CAPACITANCE(TA=25°C, VCC=1.8V/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 | CE | WE | RE | WP | Mode | |
|-----|------------------|----|----|----|-----------------------|----------------------|-----------------------|
| H | L | L | | H | X | Read Mode | Command Input |
| L | H | L | | H | X | | Address Input(4clock) |
| H | L | L | | H | H | Write Mode | Command Input |
| L | H | L | | H | H | | Address Input(4clock) |
| L | L | L | | H | H | Data Input | |
| L | L | L | H | | X | Data Output | |
| X | X | X | X | H | X | During Read(Busy) | |
| X | X | X | X | X | H | During Program(Busy) | |
| X | X | X | X | X | H | During Erase(Busy) | |
| X | X ⁽¹⁾ | X | X | X | L | Write Protect | |
| X | X | H | X | X | 0V/Vcc ⁽²⁾ | Stand-by | |

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

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

Program / Erase Characteristics

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|-------------|-----|-----|-----|--------|
| Program Time | tPROG | - | 300 | 700 | μs |
| Dummy Busy Time for Cache Program | tCBSY | | 3 | 700 | μs |
| Number of Partial Program Cycles in the Same Page | Main Array | - | - | 4 | cycles |
| | Spare Array | - | - | 4 | cycles |
| Block Erase Time | tBERS | - | 2 | 3 | ms |

NOTE : 1. Max. time of tCBSY depends on timing between internal program completion and data in

AC Timing Characteristics for Command / Address / Data Input

| Parameter | Symbol | Min | | Max | | Unit |
|---------------------------------------|--------|--------------------|--------------------|------------|------------|------|
| | | K9F1G08Q0A | K9F1G08U0A | K9F1G08Q0A | K9F1G08U0A | |
| CLE setup Time | tCLS | 25 | 10 | - | - | ns |
| CLE Hold Time | tCLH | 10 | 5 | - | - | ns |
| $\overline{\text{CE}}$ setup Time | tCS | 35 | 15 | - | - | ns |
| $\overline{\text{CE}}$ Hold Time | tCH | 10 | 5 | - | - | ns |
| $\overline{\text{WE}}$ Pulse Width | tWP | 25 | 15 | - | - | ns |
| ALE setup Time | tALS | 25 | 10 | - | - | ns |
| ALE Hold Time | tALH | 10 | 5 | - | - | ns |
| Data setup Time | tDS | 20 | 10 | - | - | ns |
| Data Hold Time | tDH | 10 | 5 | - | - | ns |
| Write Cycle Time | tWC | 45 | 30 | - | - | ns |
| $\overline{\text{WE}}$ High Hold Time | tWH | 15 | 10 | - | - | ns |
| ALE to Data Loading Time | tADL | 100 ⁽¹⁾ | 100 ⁽¹⁾ | - | - | ns |

NOTE : 1. tADL is the time from the $\overline{\text{WE}}$ rising edge of final address cycle to the $\overline{\text{WE}}$ rising edge of first data cycle.

AC Characteristics for Operation

| Parameter | Symbol | Min | | Max | | Unit |
|--|------------------|------------|------------|-------------------------|-------------------------|------|
| | | K9F1G08Q0A | K9F1G08U0A | K9F1G08Q0A | K9F1G08U0A | |
| Data Transfer from Cell to Register | t _{TR} | - | - | 25 | 25 | μs |
| ALE to $\overline{\text{RE}}$ Delay | t _{TAR} | 10 | 10 | - | - | ns |
| CLE to $\overline{\text{RE}}$ Delay | t _{CLR} | 10 | 10 | - | - | ns |
| Ready to $\overline{\text{RE}}$ Low | t _{RR} | 20 | 20 | - | - | ns |
| RE Pulse Width | t _{RP} | 25 | 15 | - | - | ns |
| WE High to Busy | t _{WB} | - | - | 100 | 100 | ns |
| Read Cycle Time | t _{RC} | 50 | 30 | - | - | ns |
| $\overline{\text{RE}}$ Access Time | t _{REA} | - | - | 30 | 18 | ns |
| $\overline{\text{CE}}$ Access Time | t _{CEA} | - | - | 45 | 23 | ns |
| $\overline{\text{RE}}$ High to Output Hi-Z | t _{RHZ} | - | - | 30 | 30 | ns |
| $\overline{\text{CE}}$ High to Output Hi-Z | t _{CHZ} | - | - | 20 | 20 | ns |
| $\overline{\text{RE}}$ or $\overline{\text{CE}}$ High to Output hold | t _{OH} | 15 | 15 | - | - | ns |
| $\overline{\text{RE}}$ High Hold Time | t _{REH} | 15 | 10 | - | - | ns |
| Output Hi-Z to $\overline{\text{RE}}$ Low | t _{IR} | 0 | 0 | - | - | ns |
| WE High to $\overline{\text{RE}}$ Low | t _{WHR} | 60 | 60 | - | - | ns |
| Device Resetting Time (Read/Program/Erase) | t _{RST} | - | - | 5/10/500 ⁽¹⁾ | 5/10/500 ⁽¹⁾ | μs |

NOTE: 1. If reset command(FFh) is written at Ready state, the device goes into Busy for maximum 5us.

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 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 1st byte in the spare area. Samsung makes sure that either the 1st or 2nd page of every invalid block has non-FFh data at the column address of 2048. 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.

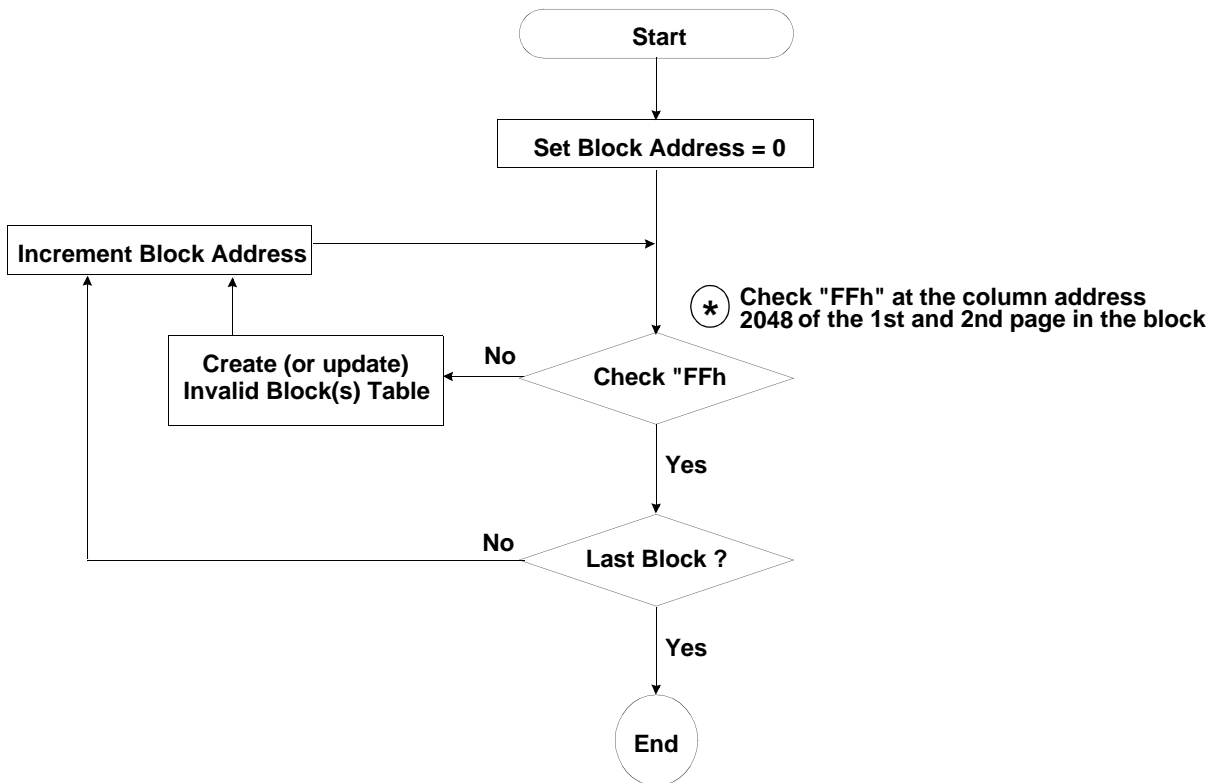


Figure 3. Flow chart to create invalid block table.

NAND Flash Technical Notes (Continued)

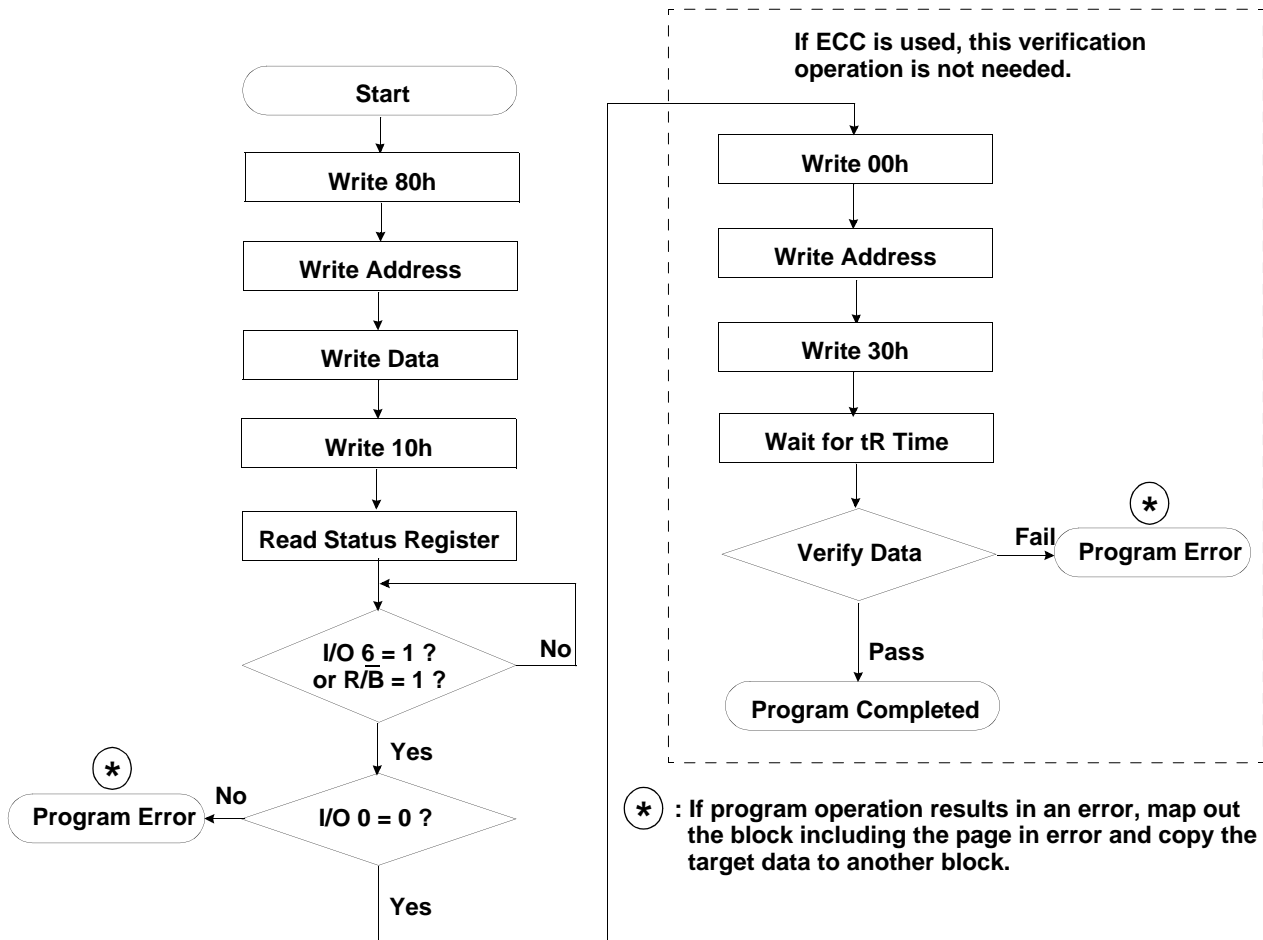
Error in write or read operation

Within its life time, 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 |

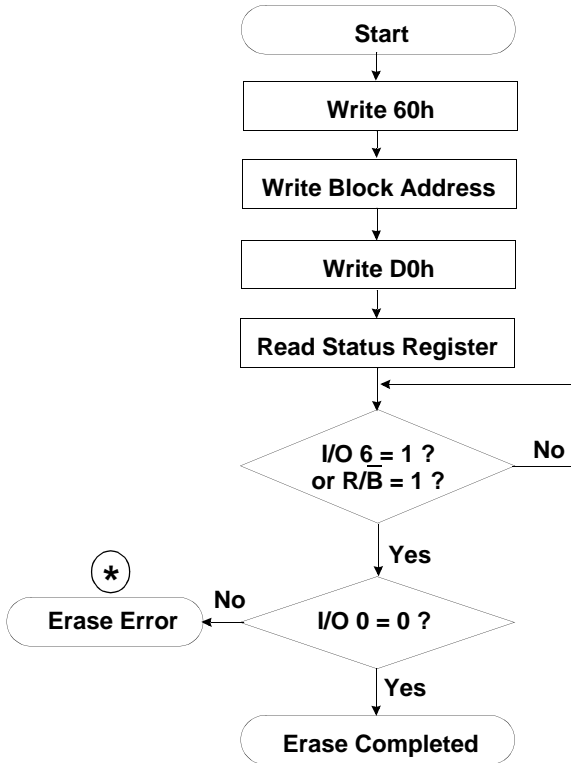
ECC : Error Correcting Code --> Hamming Code etc.
Example) 1bit correction & 2bit detection

Program Flow Chart

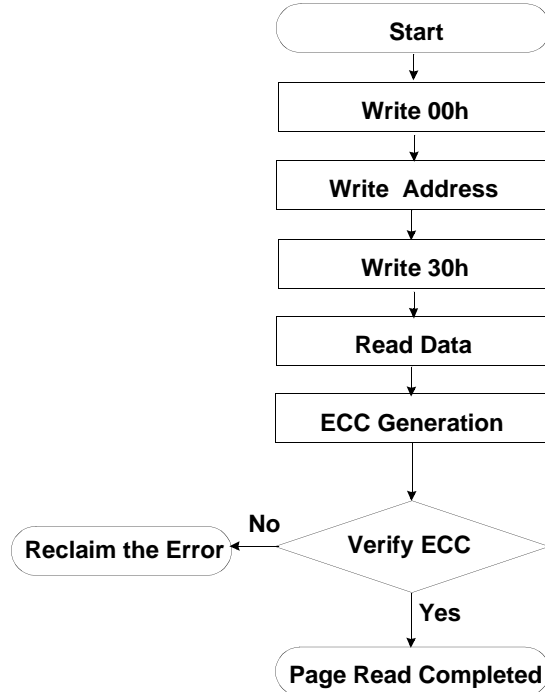


NAND Flash Technical Notes (Continued)

Erase Flow Chart

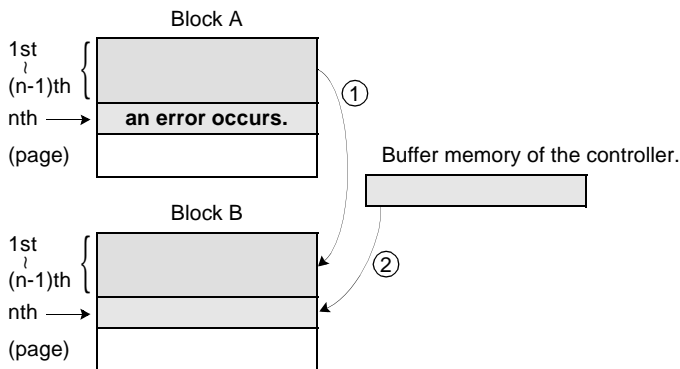


Read Flow Chart



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

Block Replacement

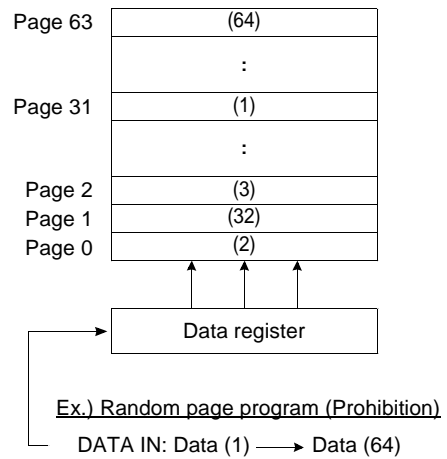
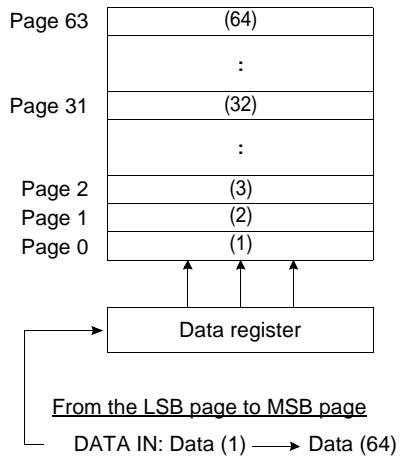


- * Step1
When an error happens in the nth page of the Block 'A' during erase or program operation.
- * Step2
Copy the data in the 1st ~ (n-1)th page to the same location of another free block. (Block 'B')
- * Step3
Then, copy the nth page data of the Block 'A' in the buffer memory to the nth page of the Block 'B'.
- * Step4
Do not erase or program to Block 'A' by creating an 'invalid Block' table or other appropriate scheme.

NAND Flash Technical Notes (Continued)

Addressing for program operation

Within a block, the pages must be programmed consecutively from the LSB (least significant bit) page of the block to MSB (most significant bit) pages of the block. Random page address programming is prohibited.



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

For an easier system interface, $\overline{\text{CE}}$ may be inactive during the data-loading or serial access as shown below. The internal 2112byte data registers are utilized as separate buffers for this operation and the system design gets more flexible. In addition, for voice or audio applications which use slow cycle time on the order of u-seconds, de-activating $\overline{\text{CE}}$ during the data-loading and serial access would provide significant savings in power consumption.

Figure 4. Program Operation with $\overline{\text{CE}}$ don't-care.

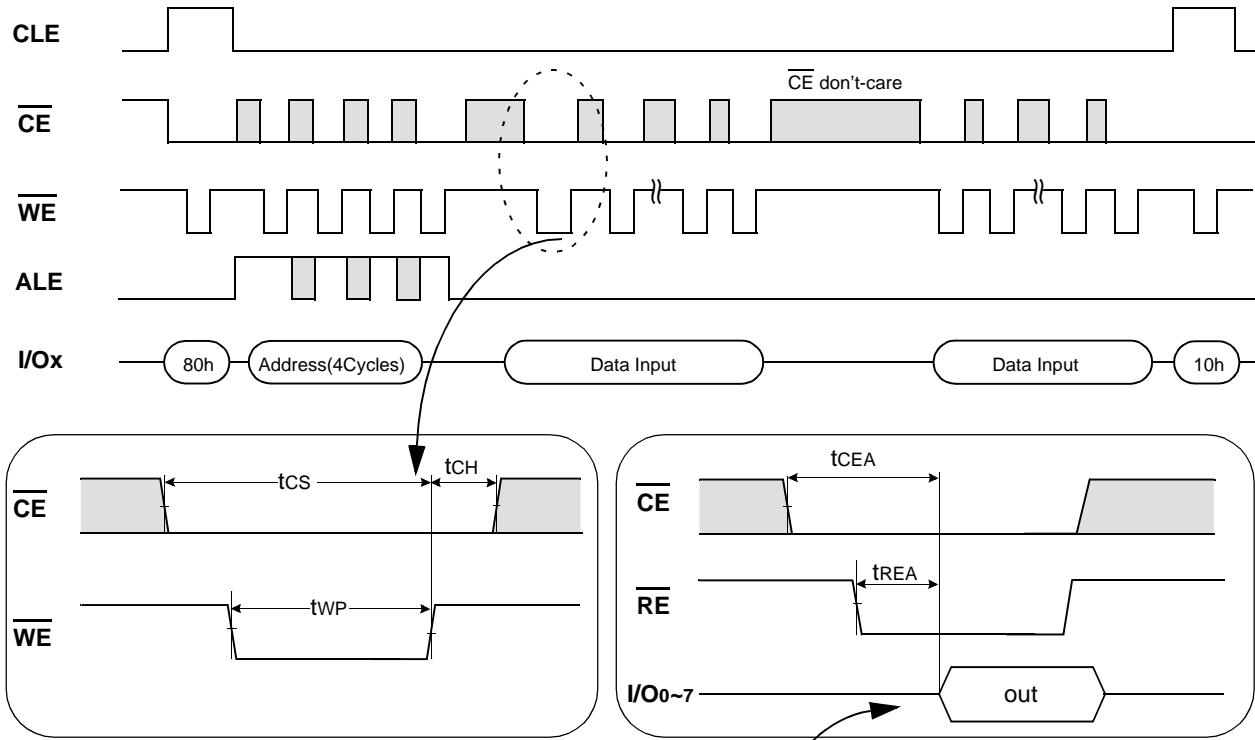
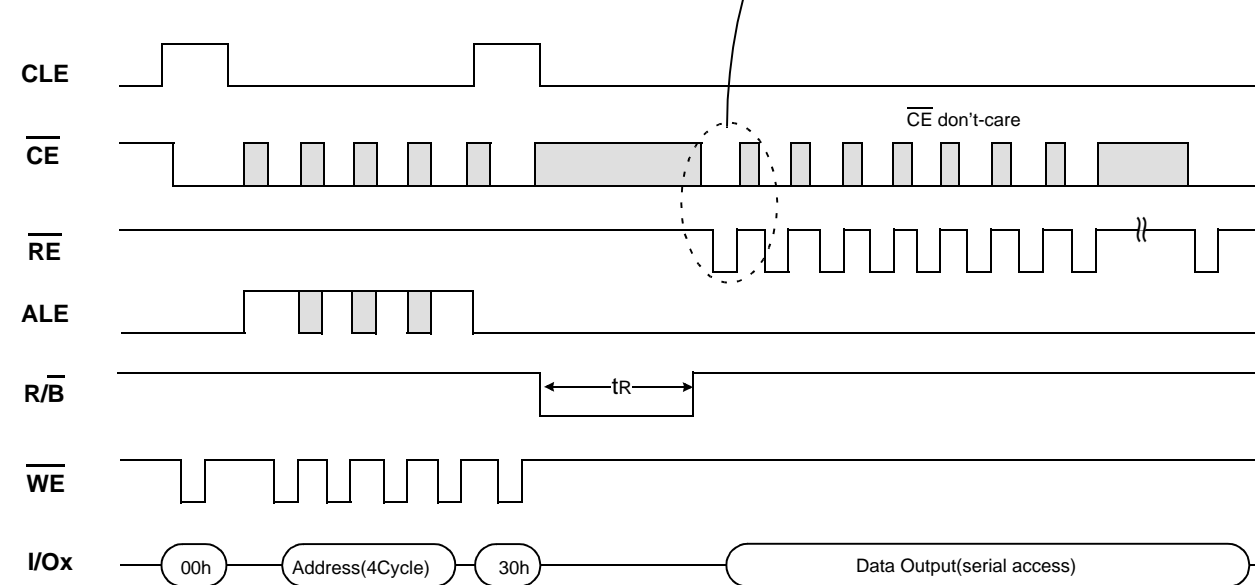


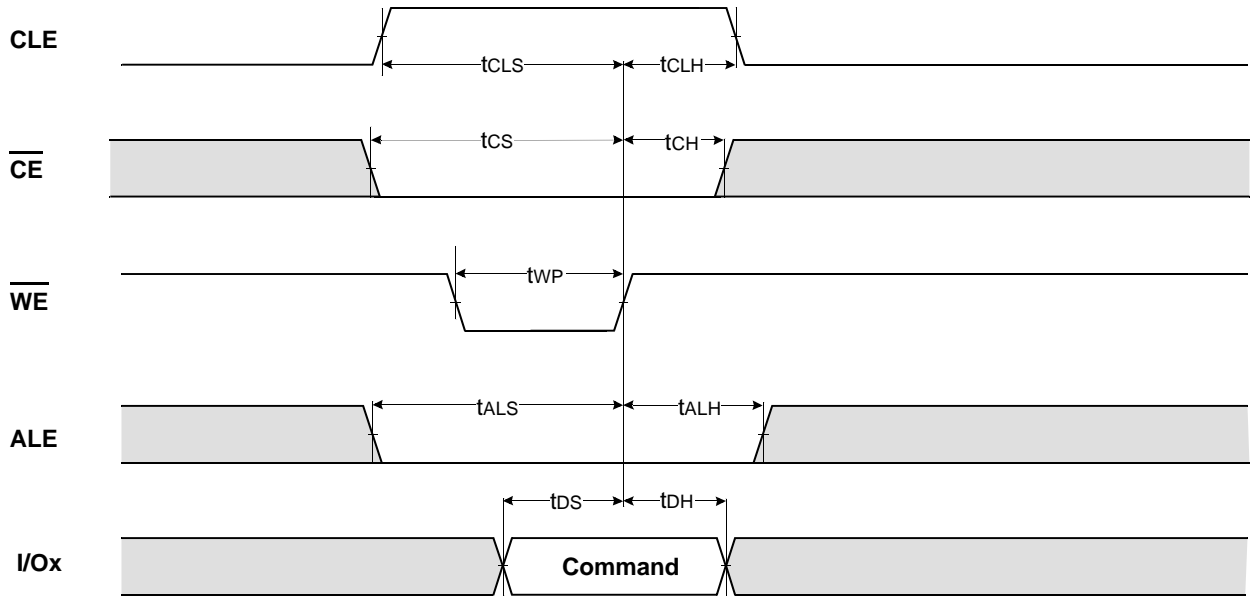
Figure 5. Read Operation with $\overline{\text{CE}}$ don't-care.



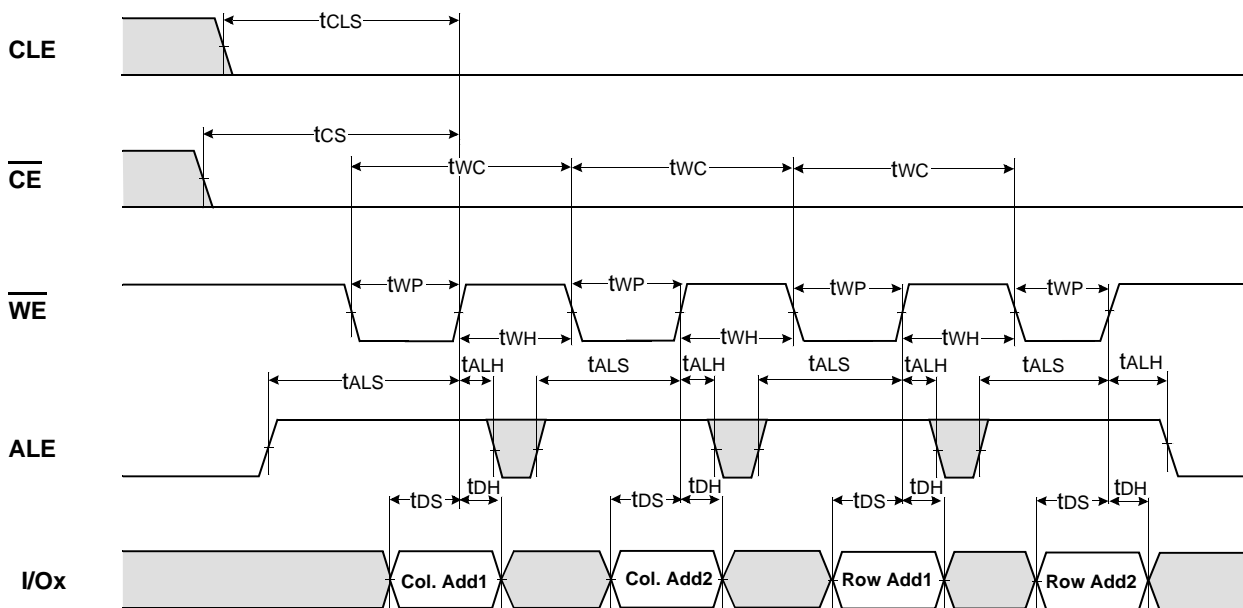
NOTE

| Device | I/O | DATA | ADDRESS | | | |
|------------|---------------|-------------|-----------|-----------|----------|----------|
| | I/Ox | Data In/Out | Col. Add1 | Col. Add2 | Row Add1 | Row Add2 |
| K9F1G08X0A | I/O 0 ~ I/O 7 | ~2112byte | A0~A7 | A8~A11 | A12~A19 | A20~A27 |

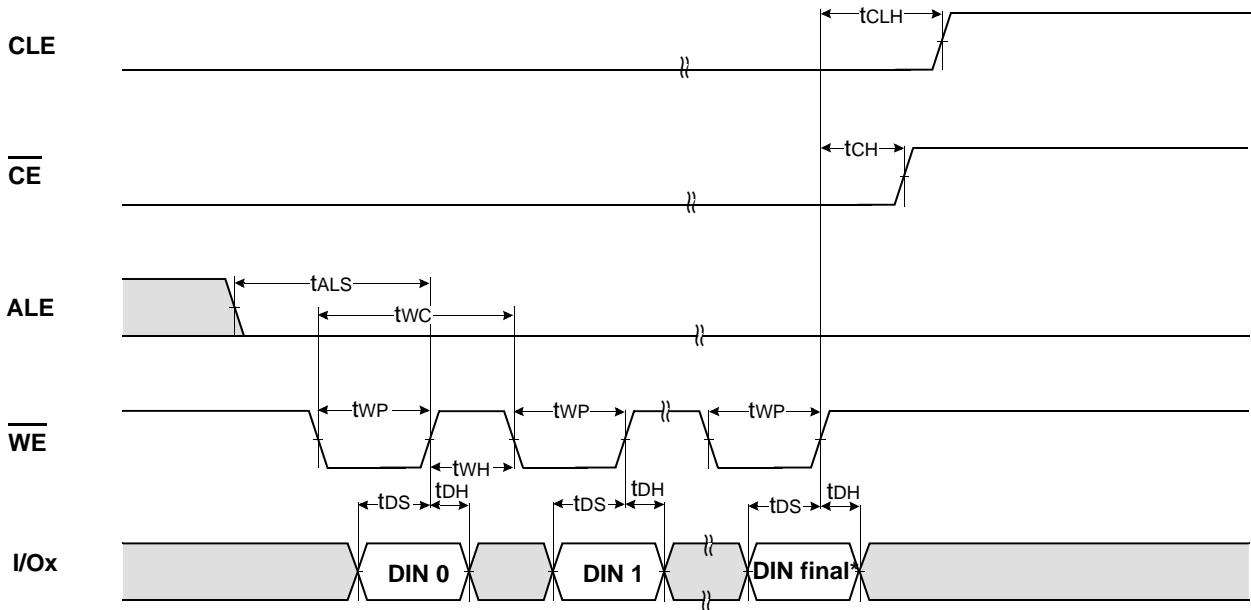
Command Latch Cycle



Address Latch Cycle

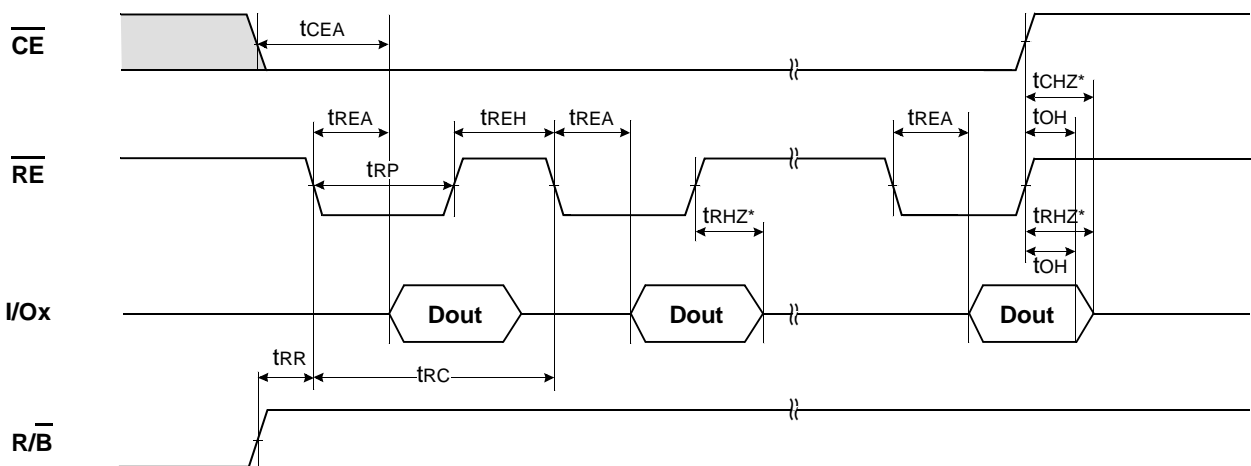


Input Data Latch Cycle



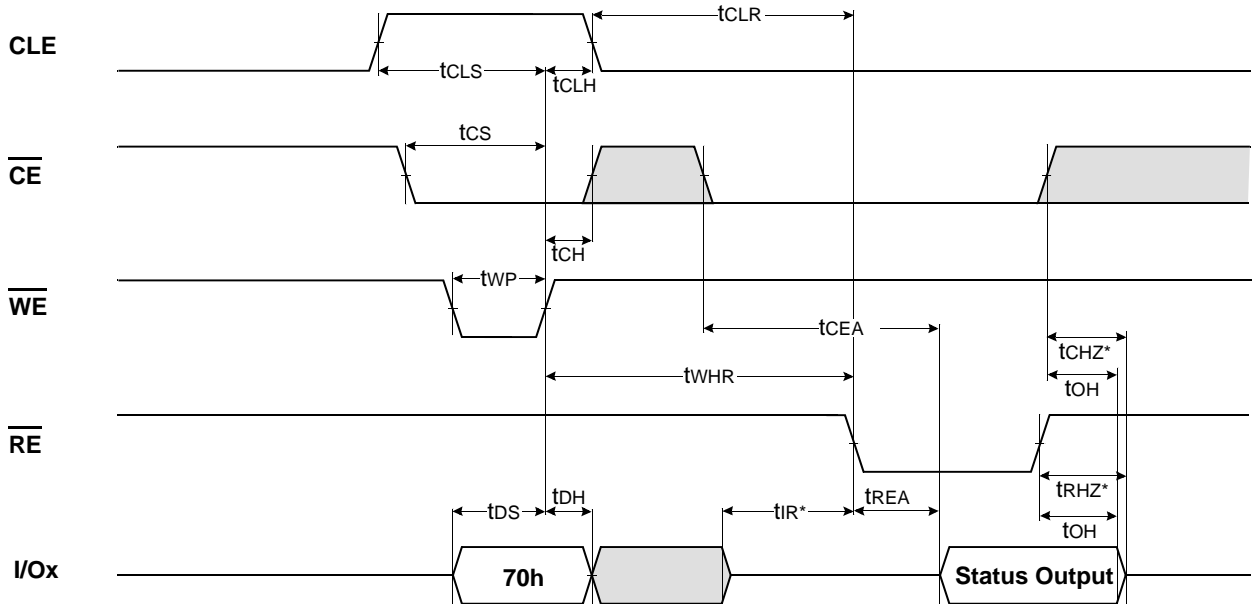
NOTES : DIN final means 2112

Serial Access Cycle after Read (CLE=L, WE=H, ALE=L)

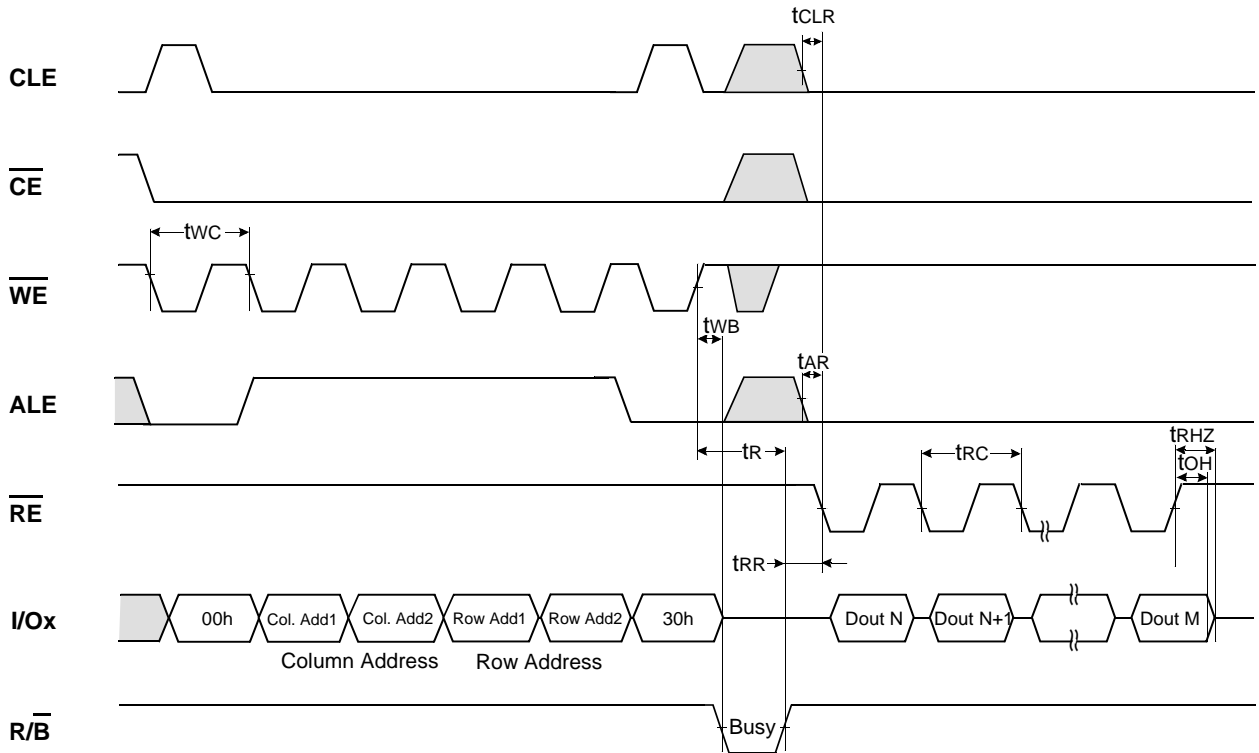


NOTES : Transition is measured $\pm 200\text{mV}$ from steady state voltage with load.
This parameter is sampled and not 100% tested.

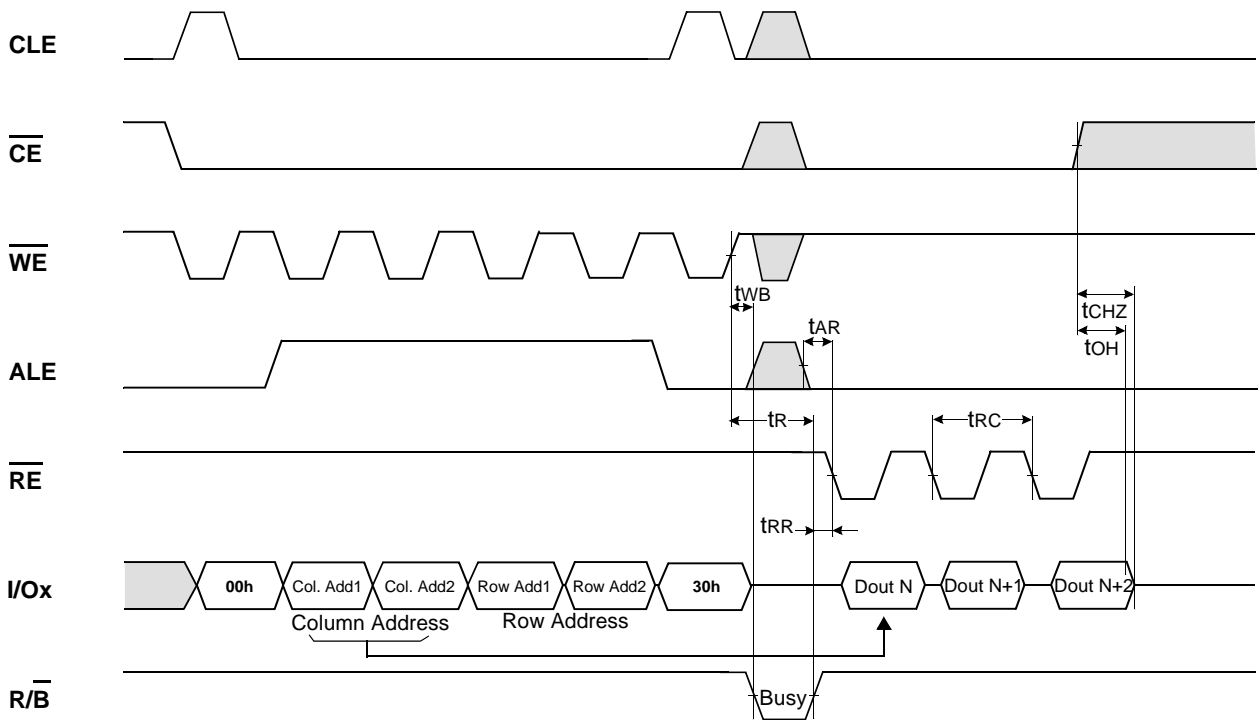
Status Read Cycle



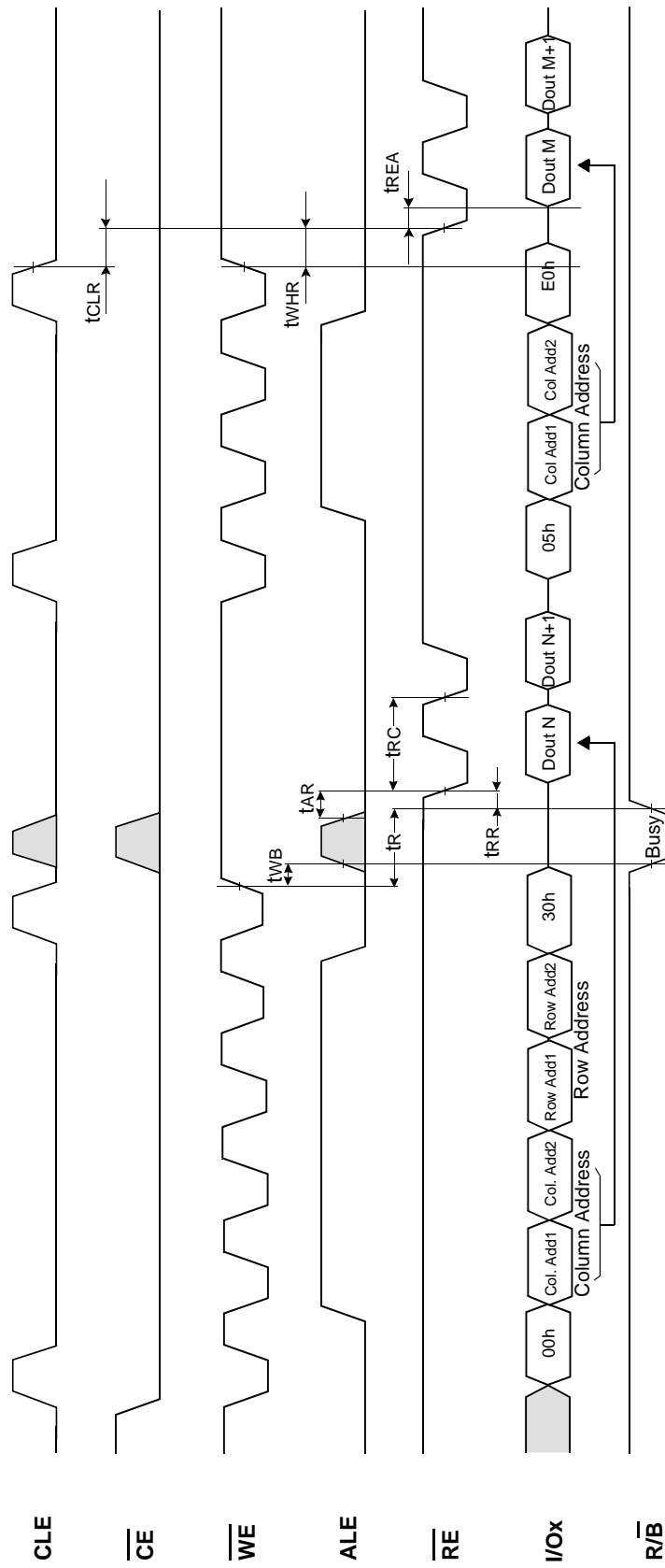
Read Operation



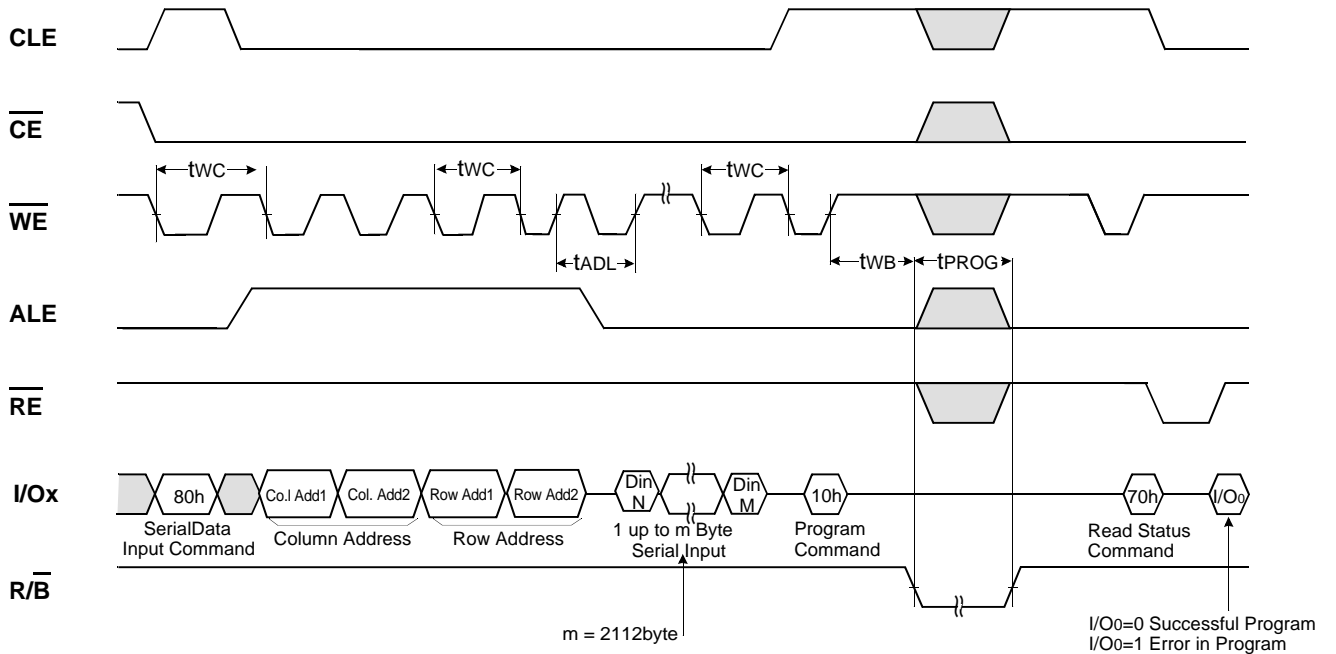
Read Operation (Intercepted by \overline{CE})



Random Data Output In a Page

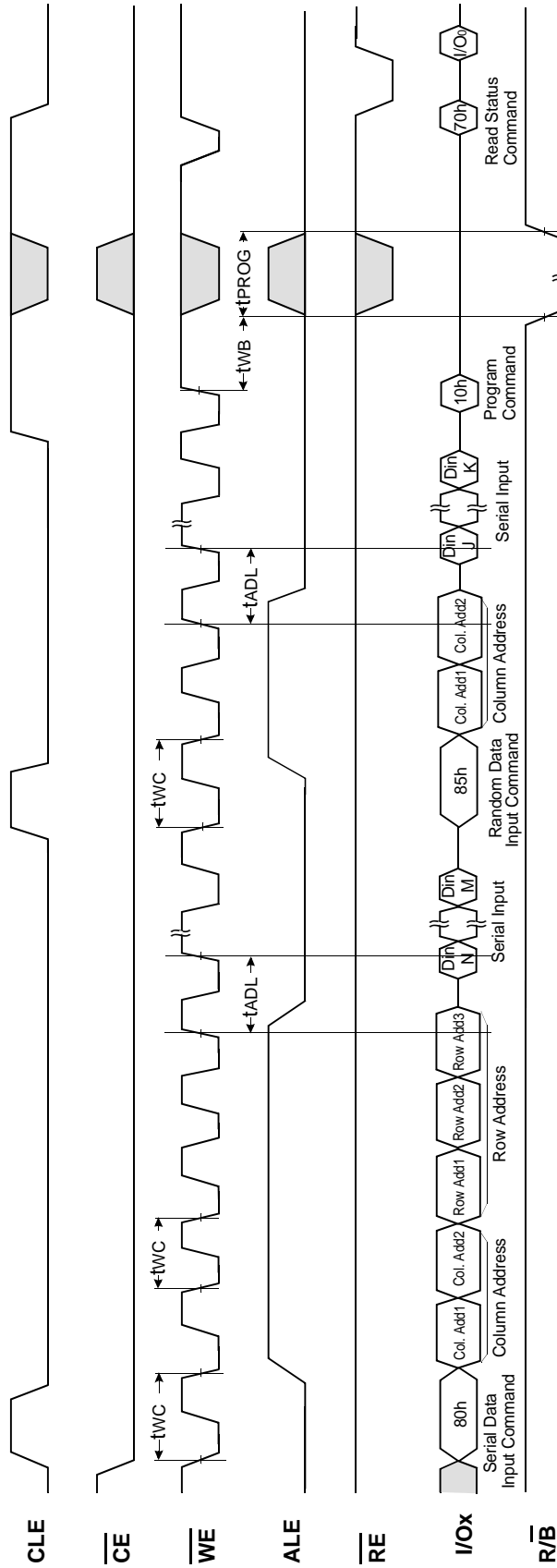


Page Program Operation



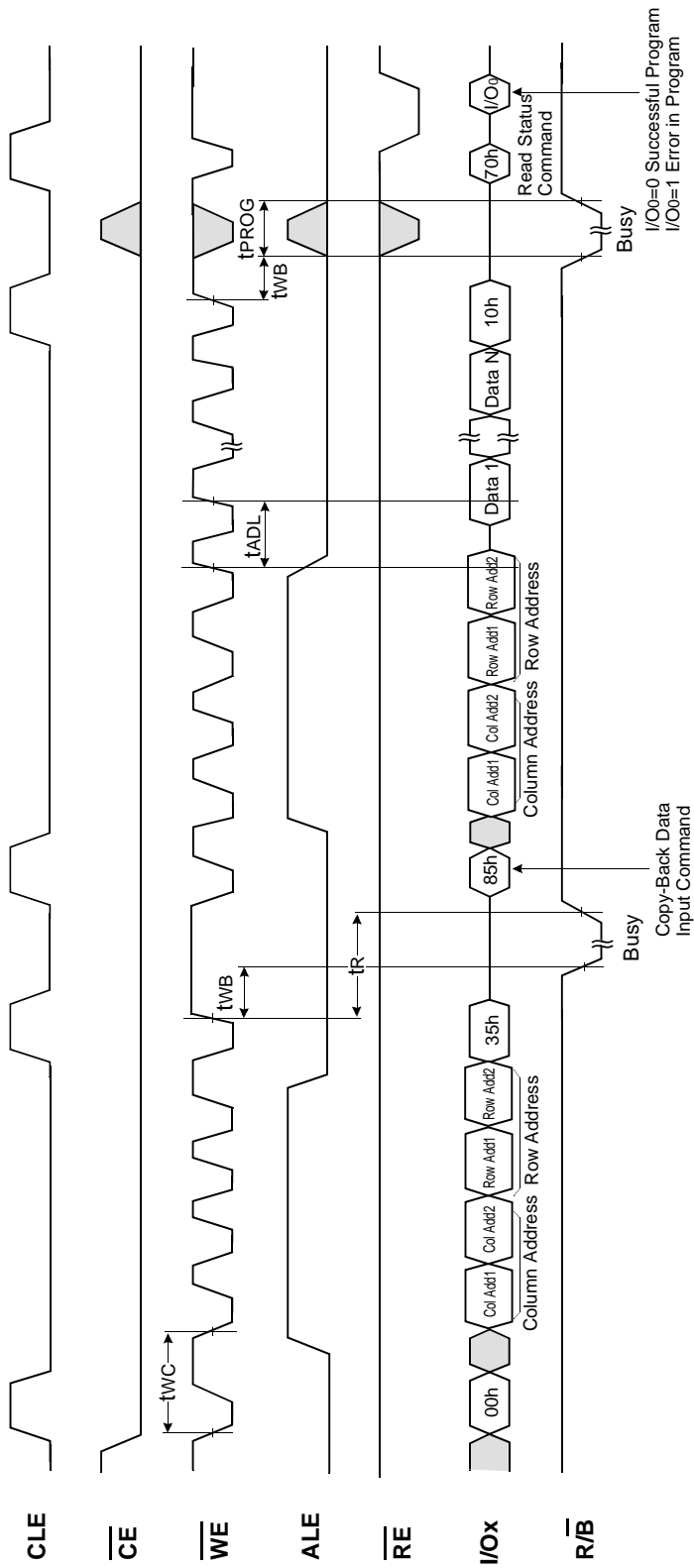
NOTES : t_{ADL} is the time from the \overline{WE} rising edge of final address cycle to the \overline{WE} rising edge of first data cycle.

Page Program Operation with Random Data Input



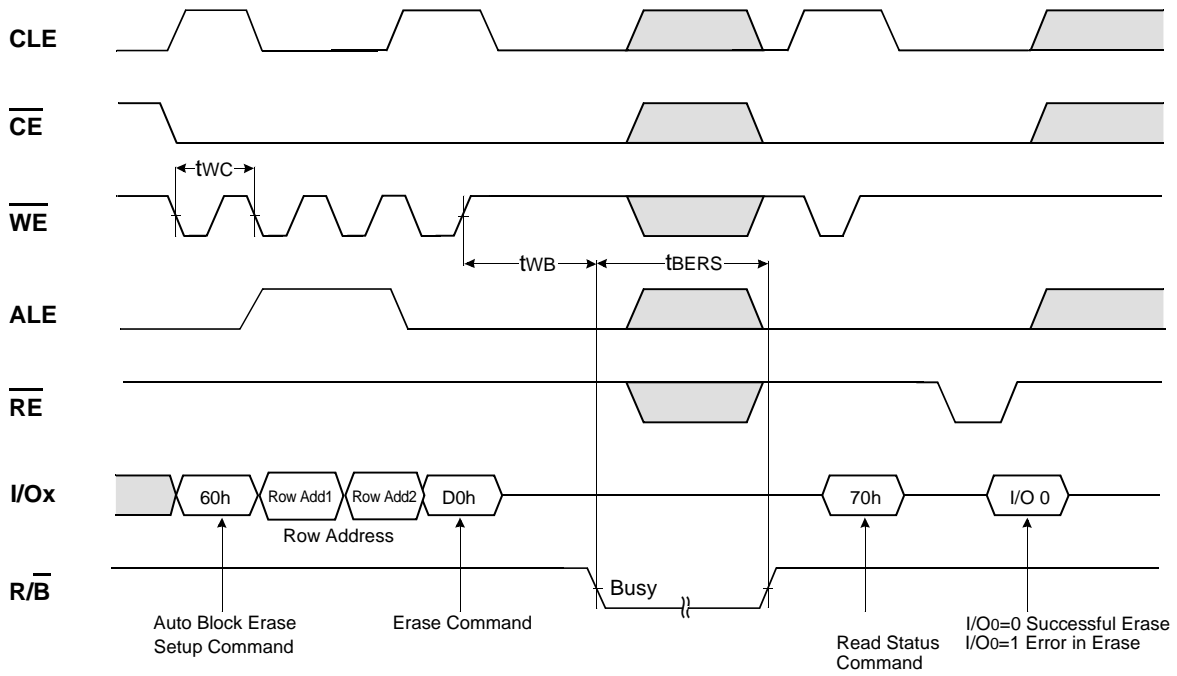
NOTES : tADL is the time from the WE rising edge of final address cycle to the WE rising edge of first data cycle.

Copy-Back Program Operation with Random Data Input

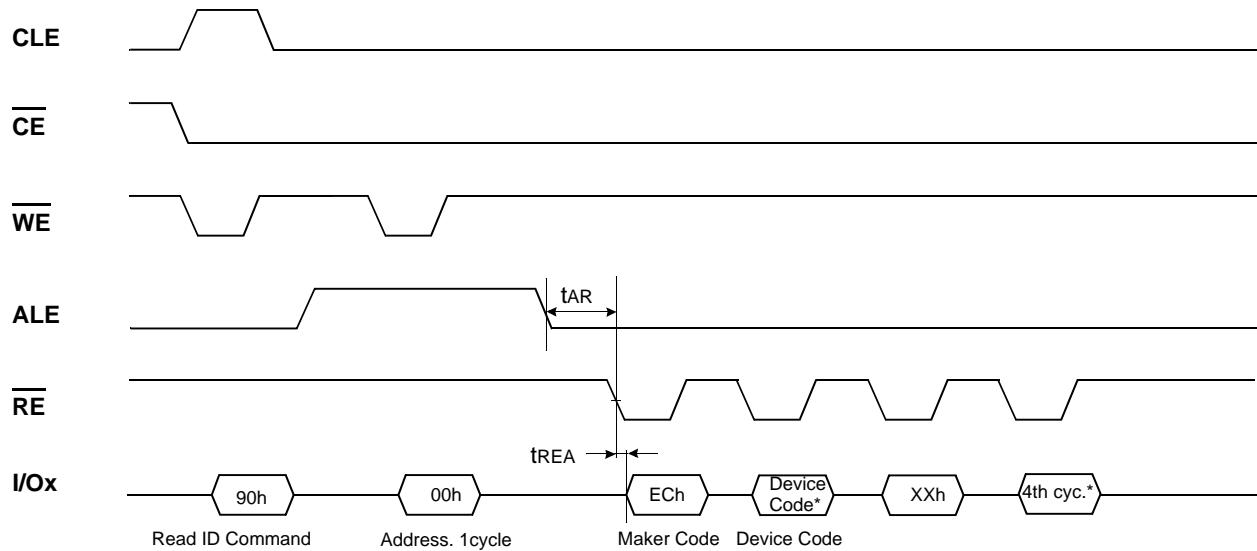


NOTES : t_{ADL} is the time from the \overline{WE} rising edge of final address cycle to the \overline{WE} rising edge of first data cycle.

BLOCK ERASE OPERATION



Read ID Operation



| Device | Device Code*(2nd Cycle) | 4th Cycle* |
|------------|-------------------------|------------|
| K9F1G08Q0A | A1h | 15h |
| K9F1G08U0A | F1h | 15h |

ID Definition Table

90 ID : Access command = 90H

| | Description |
|----------------------|--|
| 1 st Byte | Maker Code |
| 2 nd Byte | Device Code |
| 3 rd Byte | Don't care |
| 4 th Byte | Page Size, Block Size, Spare Size, Organization, Serial access minimum |

4th ID Data

| ITEM | Description | I/O7 | I/O6 | I/O5 | I/O4 | I/O3 | I/O2 | I/O1 | I/O0 |
|--|-------------|------|------|------|------|------|------|------|------|
| Page Size (w/o redundant area) | 1KB | | | | | | | 0 | 0 |
| | 2KB | | | | | | | 0 | 1 |
| | Reserved | | | | | | | 1 | 0 |
| | Reserved | | | | | | | 1 | 1 |
| Block Size (w/o redundant area) | 64KB | | | 0 | 0 | | | | |
| | 128KB | | | 0 | 1 | | | | |
| | 256KB | | | 1 | 0 | | | | |
| | Reserved | | | 1 | 1 | | | | |
| Redundant Area Size (byte/512byte) | 8 | | | | | | 0 | | |
| | 16 | | | | | | 1 | | |
| Organization | x8 | | 0 | | | | | | |
| | x16 | | 1 | | | | | | |
| Serial Access minimum | 50ns | 0 | | | | 0 | | | |
| | 25ns | 1 | | | | 0 | | | |
| | Reserved | 0 | | | | 1 | | | |
| | Reserved | 1 | | | | 1 | | | |

Device Operation

PAGE READ

Page read is initiated by writing 00h-30h to the command register along with five address cycles. After initial power up, 00h command is latched. Therefore only five address cycles and 30h command initiates that operation after initial power up.

The 2112 bytes of data within the selected page are transferred to the data registers in less than $25\mu s(t_R)$. The system controller can detect the completion of this data transfer(t_R) by analyzing the output of R/B pin. Once the data in a page is loaded into the data registers, they may be read out in 50ns (30ns, K9F1G08U0A) 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 6. Read Operation

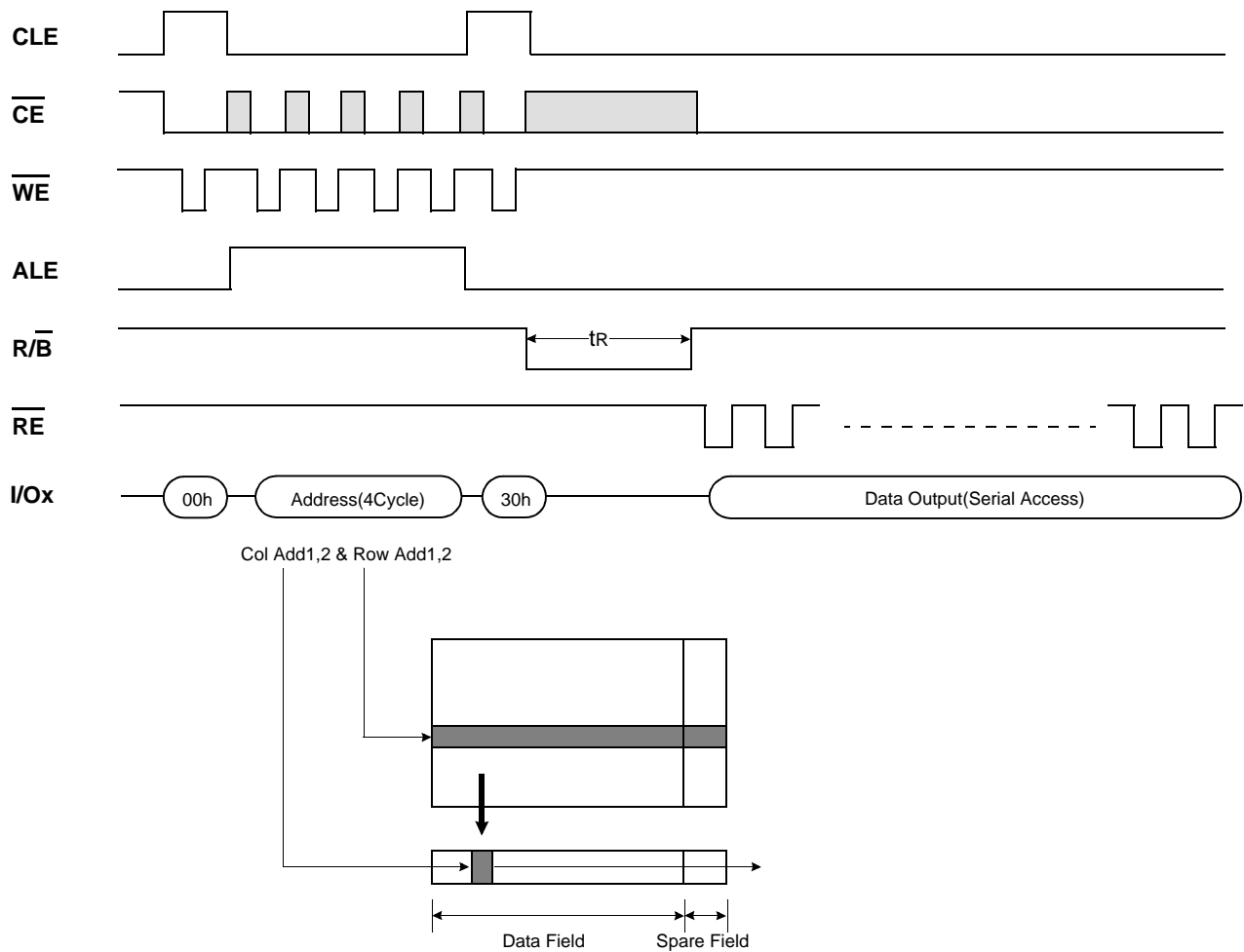
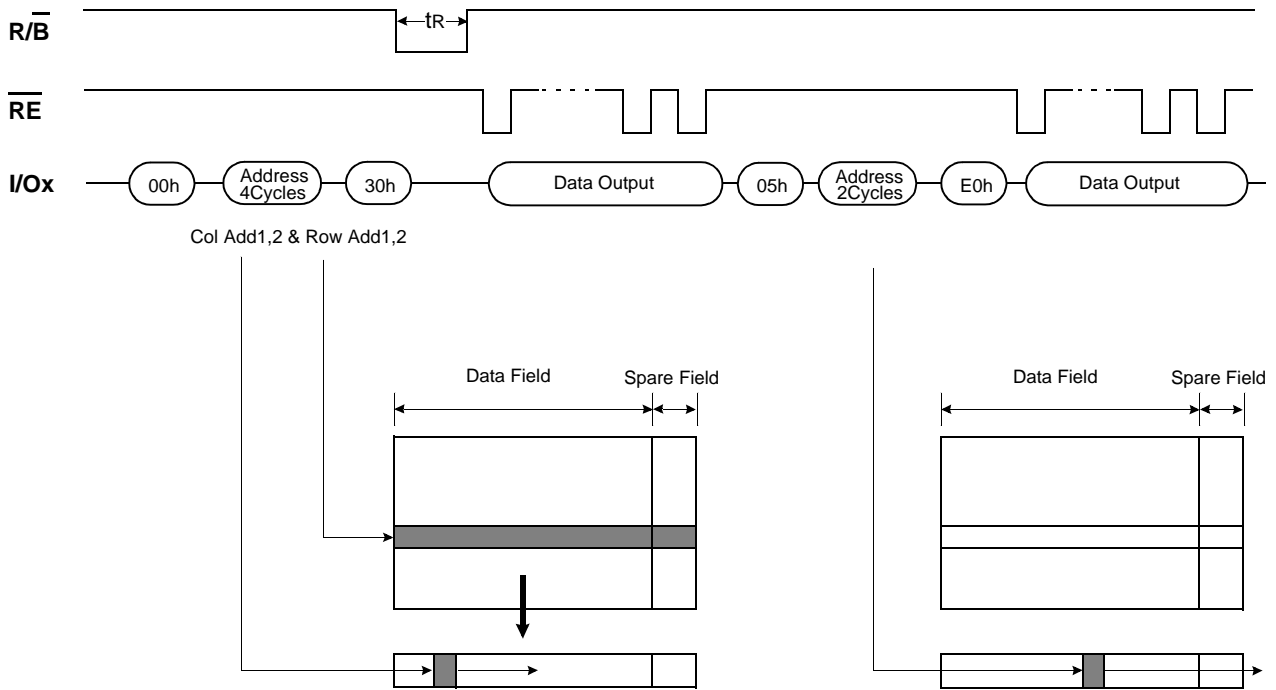


Figure 7. Random Data Output In a Page



PAGE PROGRAM

The device is programmed basically on a page basis, but it does allow multiple partial page programming of a word or consecutive bytes up to 2112, in a single page program cycle. The number of consecutive partial page programming operation within the same page without an intervening erase operation must not exceed 4 times for main array(1time/512byte) and 4 times for spare array(1time/16byte). The 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 2112bytes 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 four cycle address inputs and then serial data loading. 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. When the Page Program is complete, the Write Status Bit(I/O 0) may be checked(Figure 8). 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 8. Program & Read Status Operation

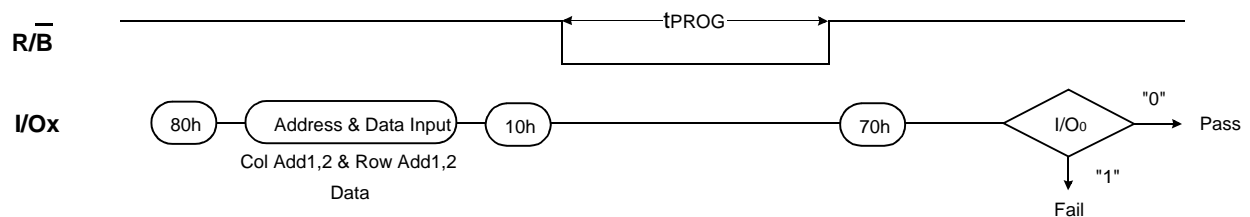
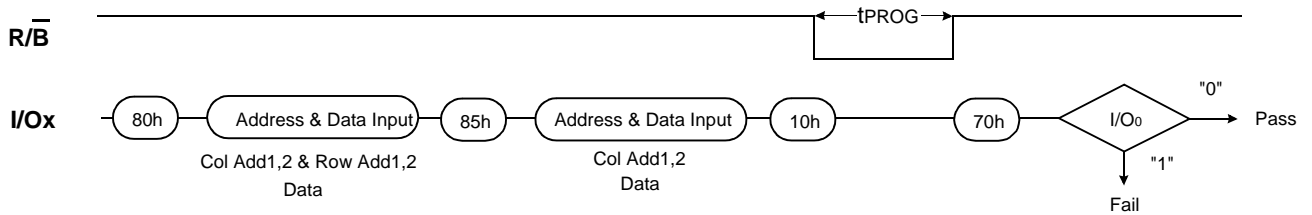


Figure 9. Random Data Input In a Page

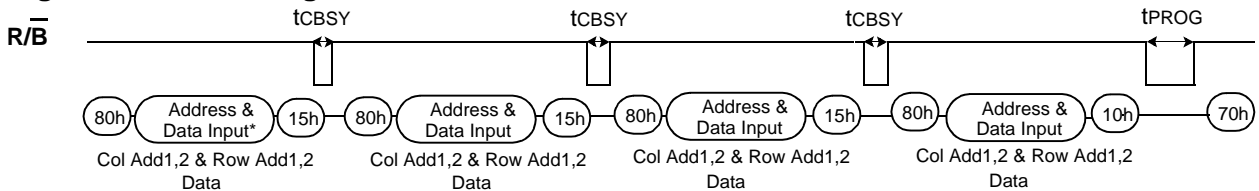


Cache Program

Cache Program is an extension of Page Program, which is executed with 2112byte data registers, and is available only within a block. Since the device has 1 page of cache memory, serial data input may be executed while data stored in data register are programmed into memory cell.

After writing the first set of data up to 2112byte into the selected cache registers, Cache Program command (15h) instead of actual Page Program (10h) is inputted to make cache registers free and to start internal program operation. To transfer data from cache registers to data registers, the device remains in Busy state for a short period of time(tCBSY) and has its cache registers ready for the next data-input while the internal programming gets started with the data loaded into data registers. Read Status command (70h) may be issued to find out when cache registers become ready by polling the Cache-Busy status bit(I/O 6). Pass/fail status of only the previous page is available upon the return to Ready state. When the next set of data is inputted with the Cache Program command, tCBSY is affected by the progress of pending internal programming. The programming of the cache registers is initiated only when the pending program cycle is finished and the data registers are available for the transfer of data from cache registers. The status bit(I/O5) for internal Ready/Busy may be polled to identify the completion of internal programming. 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).

Figure 10. Cache Program (available only within a block)



NOTE : Since programming the last page does not employ caching, the program time has to be that of Page Program. However, if the previous program cycle with the cache data has not finished, the actual program cycle of the last page is initiated only after completion of the previous cycle, which can be expressed as the following formula.

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

Copy-Back Program

The copy-back program is configured to quickly and efficiently rewrite data stored in one page without utilizing an external memory. Since the time-consuming cycles of serial access and 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 also need to be copied to the newly assigned free block. The operation for performing a copy-back program is a sequential execution of page-read without serial access and copying-program with the address of destination page. A read operation with "35h" command and the address of the source page moves the whole 2112byte data into the internal data buffer. As soon as the device returns to Ready state, Page-Copy Data-input command (85h) with the address cycles of destination page followed may be written. The Program Confirm command (10h) is required to actually begin the programming operation. Data input cycle for modifying a portion or multiple distant portions of the source page is allowed as shown in Figure 12. "When there is a program-failure at Copy-Back operation, error is reported by pass/fail status. But if the source page has a bit error for charge loss, accumulated copy-back operations could also accumulate bit errors. For this reason, two bit ECC is recommended for copy-back operation."

Figure 11. Page Copy-Back program Operation

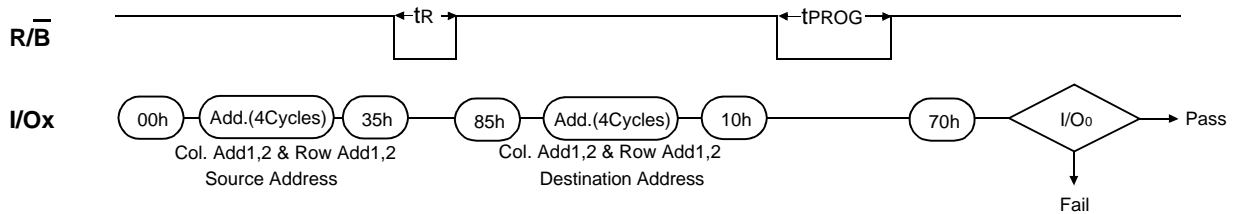
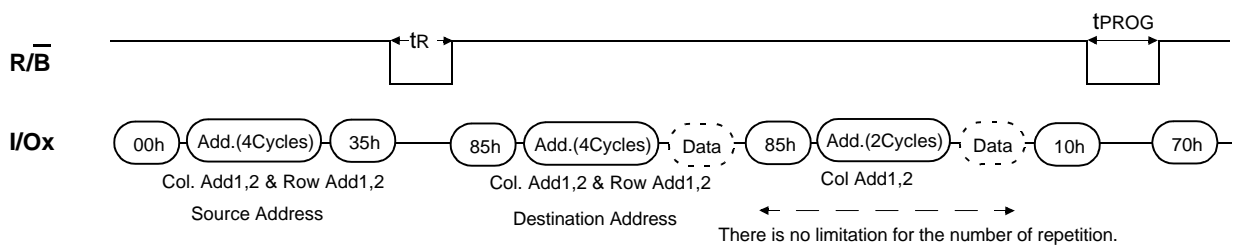


Figure 12. Page Copy-Back program Operation with Random Data Input

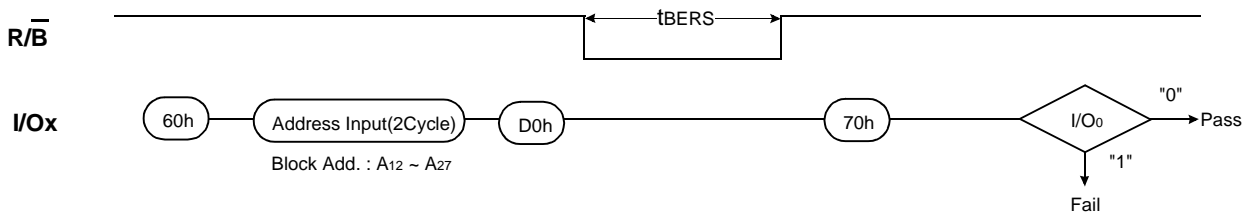


BLOCK ERASE

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 A18 to A27 is valid while A12 to A17 is ignored. The Erase Confirm command(D0h) following the block address loading initiates the internal erasing process. This two-step sequence of setup followed by execution command ensures that memory contents are not accidentally erased due to external noise conditions.

At the rising edge of WE after the erase confirm command input, the internal write controller handles erase and erase-verify. When the erase operation is completed, the Write Status Bit(I/O 0) may be checked. Figure 13 details the sequence.

Figure 13. Block Erase Operation



READ STATUS

The device contains a Status Register which may be read to find out whether program or erase operation is completed, and whether the program or erase operation is completed successfully. After writing 70h command to the command register, a read cycle outputs the content of the Status Register to the I/O pins on the falling edge of CE or RE, whichever occurs last. This two line control allows the system to poll the progress of each device in multiple memory connections even when R/B pins are common-wired. RE or CE does not need to be toggled for updated status. Refer to table 2 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, the read command(00h) should be given before starting read cycles.

Table2. Read Staus Register Definition

| I/O No. | Page Program | Block Erase | Cache Program | Read | Definition | |
|---------|---------------|---------------|-----------------|---------------|---------------|-------------------|
| I/O 0 | Pass/Fail | Pass/Fail | Pass/Fail(N) | Not use | Pass : "0" | Fail : "1" |
| I/O 1 | Not use | Not use | Pass/Fail(N-1) | Not use | Pass : "0" | Fail : "1" |
| I/O 2 | Not use | Not use | Not use | Not use | "0" | |
| I/O 3 | Not Use | Not Use | Not Use | Not Use | "0" | |
| I/O 4 | Not Use | Not Use | Not Use | Not Use | "0" | |
| I/O 5 | Ready/Busy | Ready/Busy | True Ready/Busy | Ready/Busy | Busy : "0" | Ready : "1" |
| I/O 6 | Ready/Busy | Ready/Busy | Ready/Busy | Ready/Busy | Busy : "0" | Ready : "1" |
| I/O 7 | Write Protect | Write Protect | Write Protect | Write Protect | Protected:"0" | Not Protected:"1" |

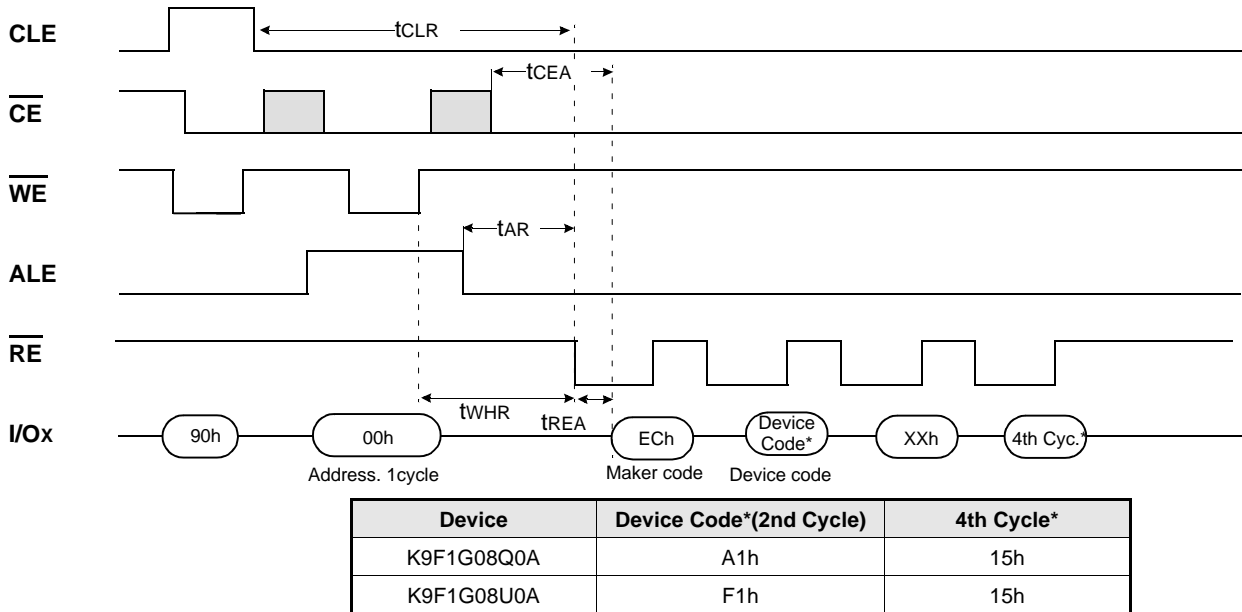
NOTE : 1. True Ready/Busy represents internal program operation status which is being executed in cache program mode.

2. I/Os defined 'Not use' are recommended to be masked out when Read Status is being executed.

Read ID

The device contains a product identification mode, initiated by writing 90h to the command register, followed by an address input of 00h. Four read cycles sequentially output the manufacturer code(ECh), and the device code and XXh, 4th cycle ID, respectively. The command register remains in Read ID mode until further commands are issued to it. Figure 14 shows the operation sequence.

Figure 14. Read ID Operation



RESET

The device offers a reset feature, executed by writing FFh to the command register. When the device is in Busy state during random read, program or erase mode, the reset operation will abort these operations. The contents of memory cells being altered are no longer valid, as the data will be partially programmed or erased. The command register is cleared to wait for the next command, and the Status Register is cleared to value C0h when WP is high. Refer to table 3 for device status after reset operation. If the device is already in reset state a new reset command will be accepted by the command register. The R/B pin transitions to low for tRST after the Reset command is written. Refer to Figure 15 below.

Figure 15. RESET Operation

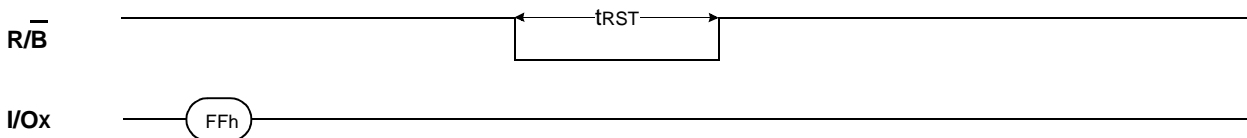


Table3. Device Status

| | After Power-up | After Reset |
|----------------|------------------------|--------------------------|
| Operation Mode | 00h command is latched | Waiting for next command |

READY/BUSY

The device has a $\overline{R/B}$ output that provides a hardware method of indicating the completion of a page program, erase and random read completion. The $\overline{R/B}$ pin is normally high but transitions to low after program or erase command is written to the command register or random read is started after address loading. It returns to high when the internal controller has finished the operation. The pin is an open-drain driver thereby allowing two or more $\overline{R/B}$ outputs to be Or-tied. Because pull-up resistor value is related to $t_r(\overline{R/B})$ and current drain during busy(i_{busy}), an appropriate value can be obtained with the following reference chart(Fig 17). Its value can be determined by the following guidance.

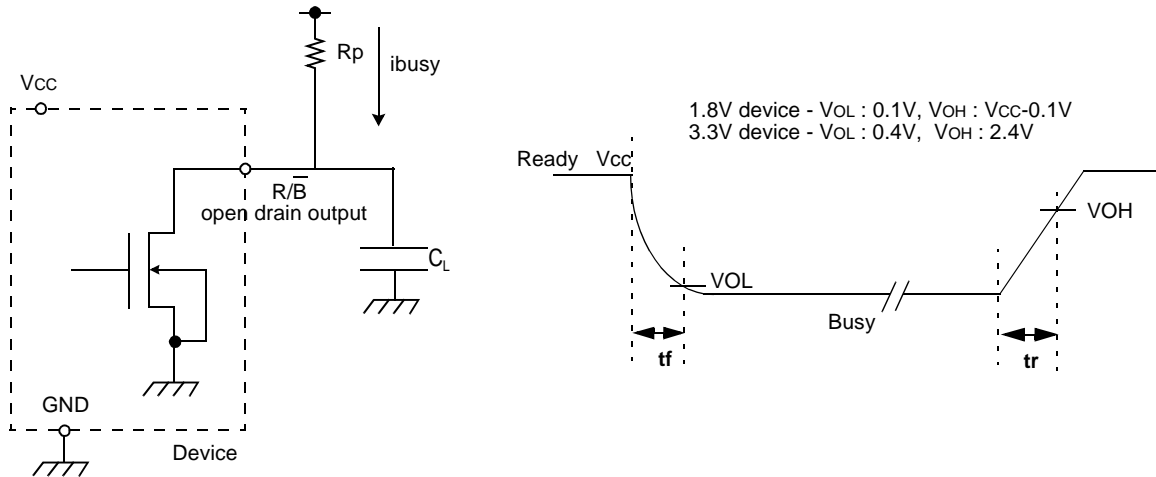
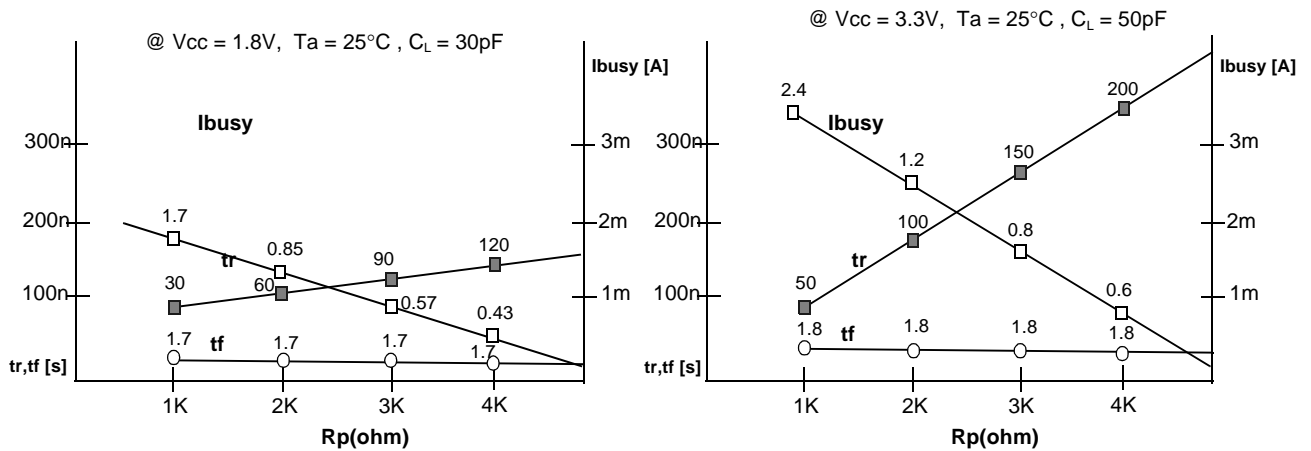


Figure 17. Rp vs tr ,tf & Rp vs i_{busy}



Rp value guidance

$$R_{p(\min, 1.8V \text{ part})} = \frac{V_{cc(\text{Max.})} - V_{OL(\text{Max.})}}{I_{OL} + \Sigma I_L} = \frac{1.85V}{3mA + \Sigma I_L}$$

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

where I_L is the sum of the input currents of all devices tied to the $\overline{R/B}$ pin.
 $R_{p(\max)}$ is determined by maximum permissible limit of t_r

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 1.1V(1.8V device), 1.8V(2.65V device), 2V(3.3V device). WP pin provides hardware protection and is recommended to be kept at VIL during power-up and power-down. A recovery time of minimum 10μs is required before internal circuit gets ready for any command sequences as shown in Figure 17. The two step command sequence for program/erase provides additional software protection.

Figure 17. AC Waveforms for Power Transition

