3D Flash Memory
Toggle DDR2.0
Technical Data Sheet

Rev. 1.1
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Toshiba Memory
Memory Division

CONTENTS

LIST of FIGURES

LIST of TABLES

1. INTRODUCTION

1.1. General Description

Toggle DDR is a Flash Memory interface for high performance applications which support data read and write operations using bidirectional DQS.

Toggle DDR Flash Memory has implemented 'Double Data Rate' without a clock. It is compatible with functions and command which have been supported in conventional type Flash Memory(i.e. SDR Flash Memory) while providing high data transfer rate based on the high-speed Toggle DDR Interface and saving power with separated DQ voltage. For applications that require high capacity and high performance Flash Memory, Toggle DDR Flash Memory is the most appropriate.

Toggle DDR2.0 Flash Memory supports the interface speed of up to 200 MHz (400 Mbps), which is more than 10 times faster than the data transfer rate offered by SDR Flash Memory (40 Mbps). Toggle DDR Flash Memory transfers data at high speed using DQS signal that behaves as a clock, and DQS shall be used only when data is transferred for optimal power consumption.

1.2. Definitions and Abbreviations

DDR
Acronym for double data rate.

Address
The address is comprised of a column address with 2 cycles and a row address with 3 cycles. The row address identifies the WL, block and LUN to be accessed. The column address identifies the byte within a page to access. The least significant bit of the column address shall always be zero.

Column
The byte location within the page register.

Row
Refer to the block and WL to be accessed.

Page
The smallest addressable unit for the Read operation.

WL
The smallest addressable unit for the Program operation.

Block
Consists of multiple pages and is the smallest addressable unit for the Erase operation.

Plane
The unit that consists of a number of blocks. There are one or more Planes per LUN. This unit is also regarded as Physical Plane.

Page register
Register used to transfer data to and from the Flash Array.

Cache register
Register used to transfer data to and from the Host.

Defect area
The defect area is where factory defects are marked by the manufacturer. Refer to the section 3.2.

Device
The packaged Flash Memory unit. A device may contain more than a target.

LUN (Logical Unit Number)
The minimum unit that can independently execute commands and report status. There are one or more LUNs per $\overline{CE}$.

Target
An independent Flash Memory component with its own $\overline{CE}$ signal.

SR[x] (Status Read)
SR refers to the status register contained within a particular LUN. SR[x] refers to bit x in the status register for the associated LUN. Refer to 5.2.9 for the definition of bit meanings within the status register.

Differential signaling
A method of transmitting information by means of two complementary signals. The opposite technique is called single-ended signaling.

Single-ended signaling
A method of transmitting information by means of one signal. The opposite technique is called differential signaling.

FSP (Full Sequence Program)
FSP is the abbreviation which stands for Full Sequence Program

Flash Memory
Flash Memory in this document means three dimensional type of flash memory.

1.3. Features

- **Organization**

Table 1 Product Organization

Parameter	TH58TFG9V23BA4C	TH58TFT0V23BA8C	TH58TFT1V23BA8H
Part number (T_{OPER}: 0~70°C)	TH58TFG9V23BA4C	TH58TFT0V23BA8C	TH58TFT1V23BA8H
Device capacity	18336×768×2956×8 ×2 bits	18336×768×2956×8 ×4 bits	18336×768×2956×8 ×8 bits
Page size	18336 Bytes	18336 Bytes	18336 Bytes
Block size	14082048 Bytes	14082048 Bytes	14082048 Bytes
Plane size	20,813,266,944 Bytes	20,813,266,944 Bytes	20,813,266,944 Bytes
Plane per one LUN	2 Planes	2 Planes	2 Planes
LUN per one target	1 LUN	1 LUN	2 LUN
Target per one device	2 targets	4 targets	4 targets
Number of valid blocks per a device (Min.)	5548	11096	22192
Number of valid blocks per a device (Max.)	5912	11824	23648
Package weight (Typ.)	0.40 g	0.40 g	0.47 g

NOTE:

1) The device occasionally contains unusable blocks.
2) The first block of LUN0 in each Target is guaranteed to be a valid block at the time of shipment.
3) The specification for the minimum number of valid blocks is applicable over the device lifetime.
4) The number of valid blocks includes extended blocks.

- **Modes**

Basic Operation

Page Read Operation (with Random Data Output), Data Out After Status Read, Random Cache Read Operation, Full Sequence Program Operation(with Random Data Input),Cache Full Sequence Program Operation, Block Erase Operation,
Set Feature Operation, Get Feature Operation, Read ID Operation, Read Status Operation, Reset Operation, Reset LUN Operation

Extend Operation

Multi Plane Read Operation, Multi Plane Random Cache Read Operation, Multi Plane Full Sequence Program Operation, Multi Plane Cache Full Sequence Program Operation, Multi Block Erase Operation,
Device Identification Table Read Operation, Read Status Enhanced Operation, Read LUN #N Status Operation

Interleaving Operation

Interleaving Full Sequence Program, Interleaving Page Read, Interleaving Block Erase, Interleaving Multi Plane Full Sequence Program, Interleaving Multi Plane Read, Interleaving Multi Block Erase,Interleaving Full Seqeuence Program to Read

Table 2 Supported Operation Modes

Operation Mode	TH58TFG9V23BA4C	TH58TFT0V23BA8C	TH58TFT1V23BA8H
Basic Operation	Supported	Supported	Supported
Extended Operation	Supported	Supported	Supported
Interleaving Operation	Not supported	Not supported	Supported

NOTE :

Read LUN #N Status Operation is supported only if the Target has more than 2 LUNs.

- **Mode control**
  Serial input/output
  Command control

- **Power supply**
  V_{CC} = 2.35 V to 3.6 V
  $V_{CC}Q$ = 2.7 V to 3.6 V / 1.7 V to 1.95V

- **Access time**
  Cell array to register 100 µs max.
  67 µs typ.
  Maximum Data Transfer Rate 200MHz

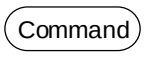
- **Program/Erase time**
  Full Sequnece Program 3.1 ms/WL typ.
  Block Erase 10 ms/block typ.

- **Operating current**
  Read 50 mA max. (per 1 chip)
  Program (avg.) 50 mA max. (per 1 chip)
  Erase (avg.) 50 mA max. (per 1 chip)
  Standby 50 µA max. (per 1 chip)

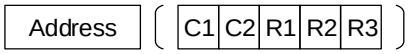
- **Reliability**
  Refer to APPLICATION NOTES AND COMMENTS.

1.4. Diagram Legend

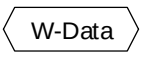
Diagrams in the datasheet use the following legend:



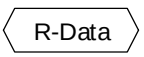
This legend shows the command data. Refer to the Table 31 for more information about the command data.



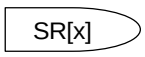
This legend shows the Address data. The addresses are comprised of 2 cycles column address and 3 cycles row address.
C1: Column address 1
C2: Column address 2
R1: Row address 1
R2: Row address 2
R3: Row address 3



This legend shows Host writing data (data input) to the device.



This legend shows Host reading data (data output) from the device.



This legend shows Host reading the status register within a particular LUN.

2. PHYSICAL INTERFACE

2.1. Package Introduction

2.1.1. 132-BGA Introduction

Figure 1 and Figure 2 defines the ball assignments for devices using Flash Memory Dual Channel(x8) BGA.

N.C indicates mechanical support balls that are not internally connected.
N.U balls at four corner areas indicate mechanical support balls that may be internally connected. Therefore, N.U balls landing pad shall not be used for users' purposes.
Any of the support ball locations may or may not be populated with a ball depending upon the Flash Memory Vendor's actual package size. Therefore it's recommended to consider landing pad location for all possible support balls based upon maximum package size allowed in the application.

2.1.1.1. Pin Configuration<TOP VIEW>(TH58TFG9V23BA4C)

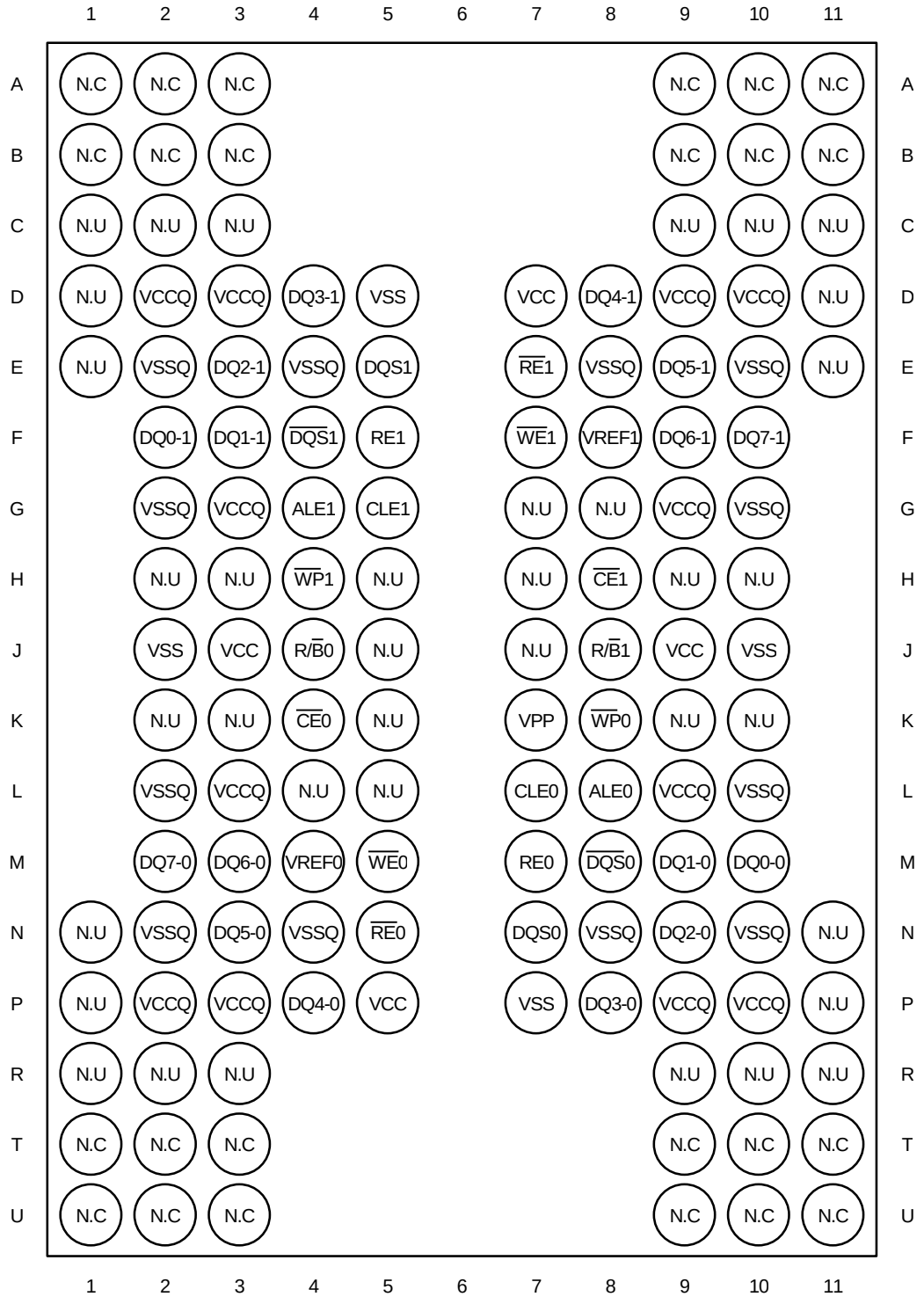


Figure 1. Ball assignment for dual 8-bit data access for 132-BGA (TH58TFG9V23BA4C)

2.1.1.2. Pin Configuration<TOP VIEW>(TH58TFT0V23BA8C, TH58TFT1V23BA8H)

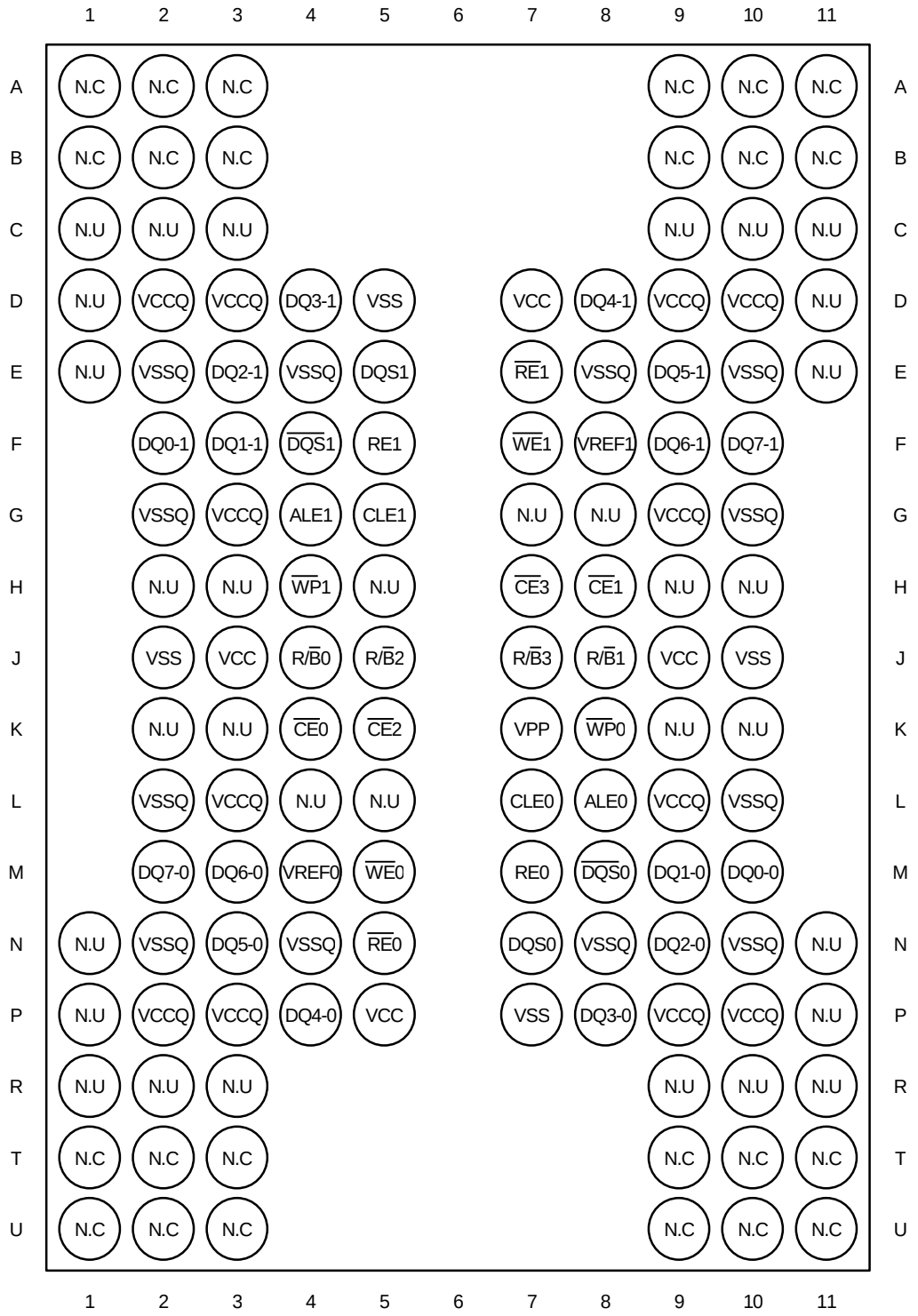


Figure 2. Ball assignment for dual 8-bit data access for 132-BGA (TH58TFT0V23BA8C, TH58TFT1V23BA8H)

2.2. Pin Descriptions

Table 3 Pin Descriptions

Pin Name	Pin Function
DQ[7:0]	**DATA INPUTS/OUTPUTS** The DQ pins are used to input command, address and data and to output data during read operations. The DQ 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 DQ 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.
$\overline{RE}$, (RE)	**READ ENABLE** The $\overline{RE}$ input is the serial data-out control, and when active, drives the data onto the DQ bus. Data is valid after t_{DQSRE} of rising edge & falling edge of $\overline{RE}$ which also increments the internal column address counter by each one. The Read Enable $\overline{RE}$ is paired with differential signal RE to provide differential pair signaling to the system during reads.
$\overline{WE}$	**WRITE ENABLE** The $\overline{WE}$ input controls writes to the DQ port. Commands, addresses are latched on the rising edge of the $\overline{WE}$ pulse.
$\overline{WP}$	**WRITE PROTECT** The $\overline{WP}$ pin provides inadvertent program/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.
DQS, ($\overline{DQS}$)	**DATA STROBE** Output with read data, input with write data. Edge-aligned with read data, centered in write data. The data strobe DQS is paired with differential signal $\overline{DQS}$ to provide differential pair signaling to the system during reads and writes.
Vcc	**POWER** Vcc is the power supply for device.
VccQ	**DQ POWER** The VccQ is the power supply for input and/or output signals.
Vss	**GROUND**
VssQ	**DQ GROUND** The VssQ is the power supply ground.
V_{REF}	**REFERENCE VOLTAGE**
V_{PP}	**External V_{PP}** The V_{PP} signal is an optional external high voltage power supply to the device. This high voltage power supply may be used to enhance Erase and Program operations (e.g., improved power efficiency).
N.C	**NO CONNECTION** Lead is not internally connected.
N.U	**NOT USE** Nothing should be connected with it.

NOTE:

1) Connect all Vcc and Vss pins of each device to common power supply outputs.
2) Do not leave all Vcc, VccQ and Vss and VssQ disconnected.

2.3. BLOCK DIAGRAM

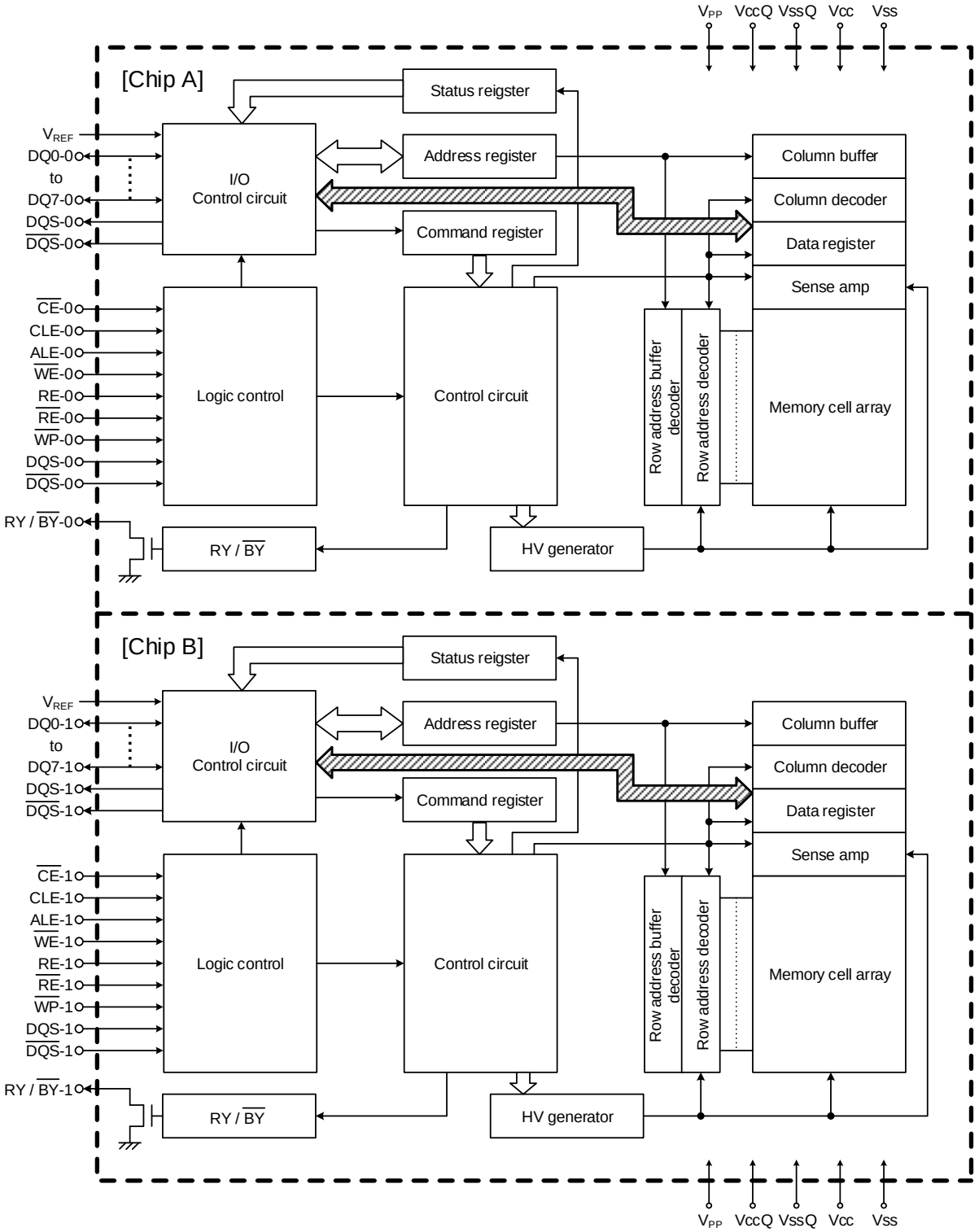


Figure 3. Block Diagram (TH58TFG9V23BA4C)

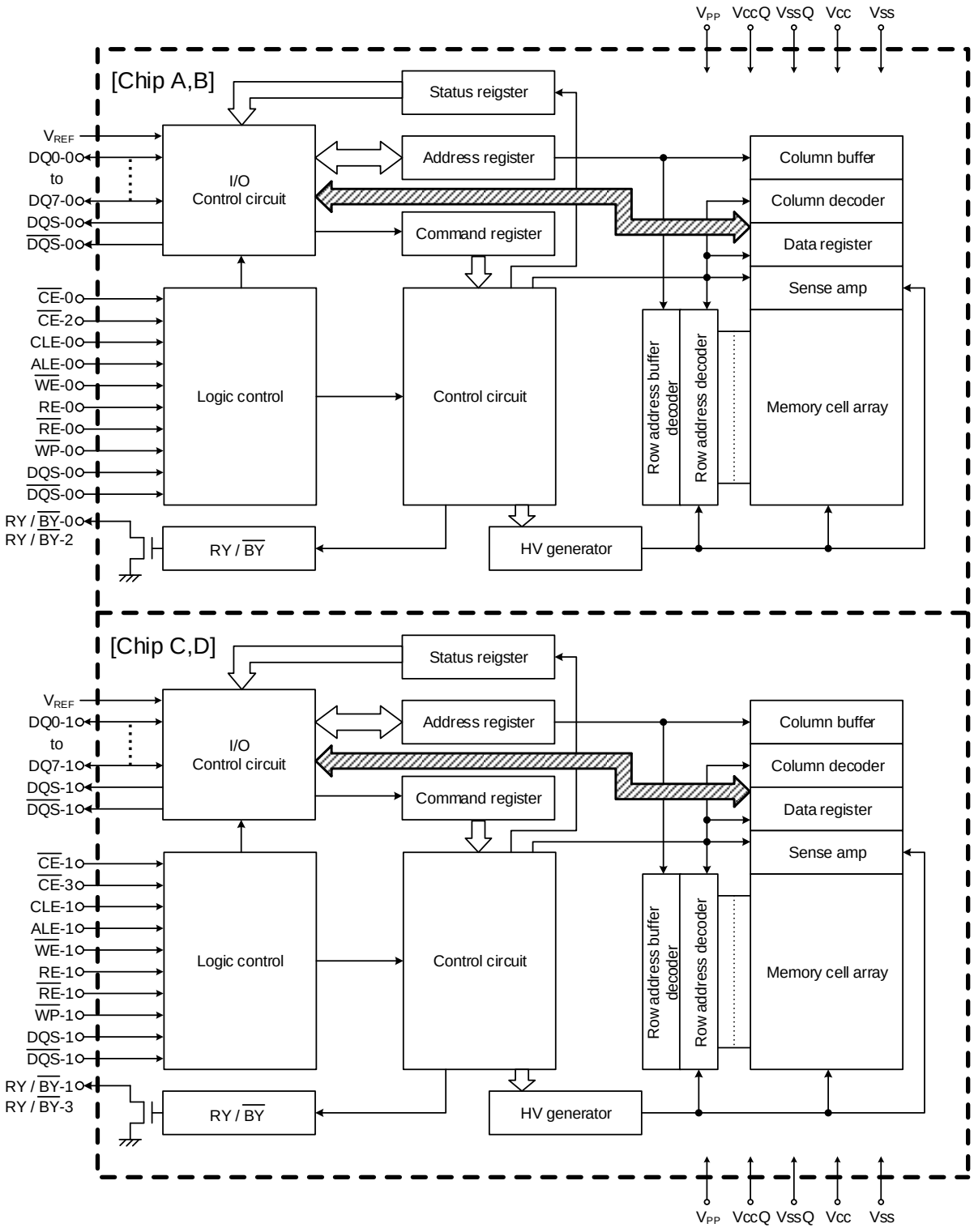


Figure 4. Block Diagram (TH58TFT0V23BA8C)

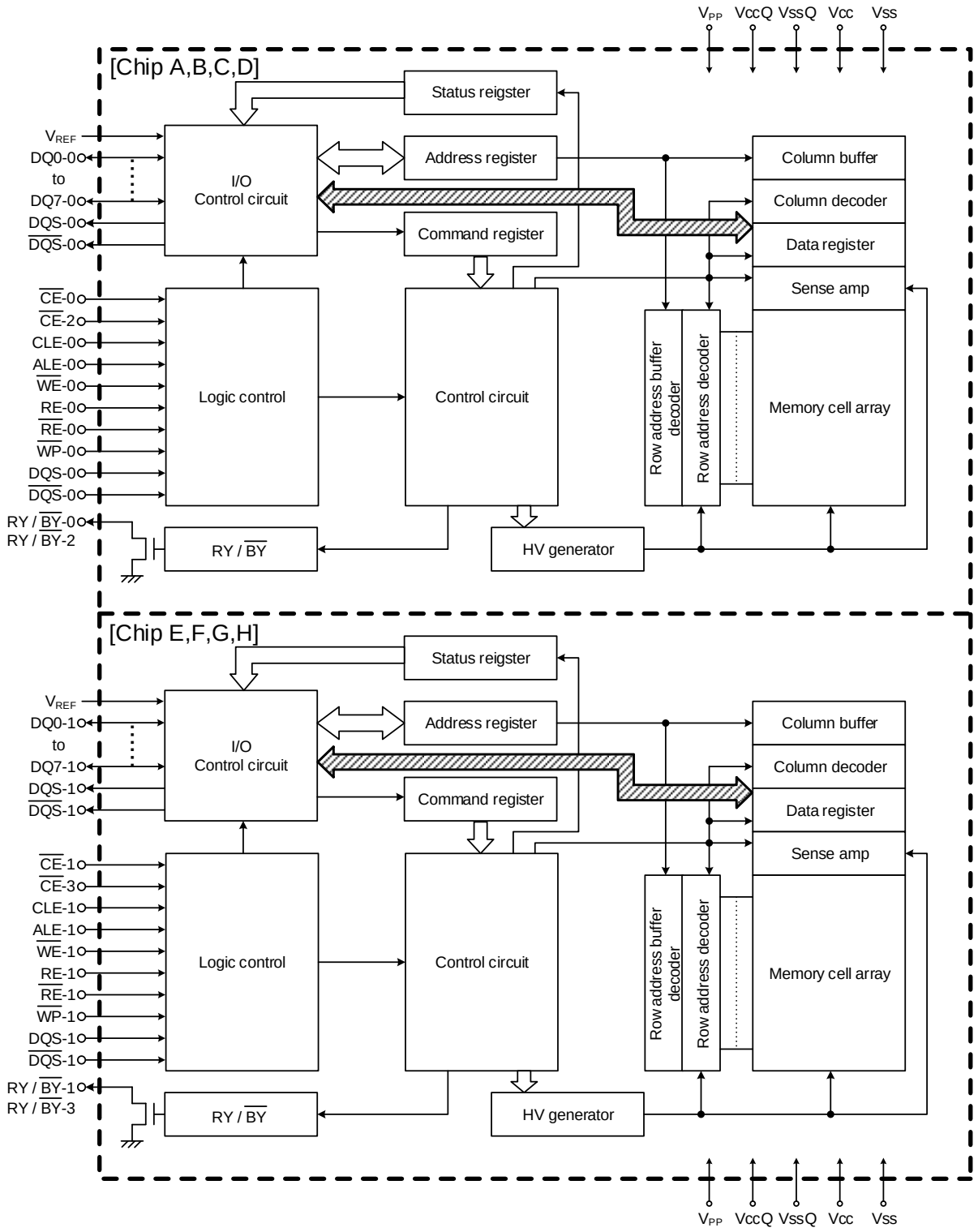


Figure 5. Block Diagram (TH58TFT1V23BA8H)

2.4. Independent Data Buses

There may be two independent 8-bit data buses in some packages, with two or four $\overline{CE}$ signals. If the device supports two independent data buses, then $\overline{CE}1$ and $\overline{CE}3$ (if connected) shall use the second data bus. $\overline{CE}0$ and $\overline{CE}2$ shall always use the first data bus pins. Note that all $\overline{CE}$s may use the first data bus and the first set of control signals ($\overline{RE}0$, CLE0, ALE0, $\overline{WE}0$, and $\overline{WP}0$) if the device does not support independent data buses. Table 4 defines the control signal to $\overline{CE}$ signal mapping when there are two independent x8 data buses.

Table 4 Dual Channel(x8) Data Bus Signal to $\overline{CE}$ mapping

Signal Name	CE
R/$\overline{B}$0	$\overline{CE}$0
R/$\overline{B}$1	$\overline{CE}$1
R/$\overline{B}$2	$\overline{CE}$2
R/$\overline{B}$3	$\overline{CE}$3
$\overline{RE}$0 / RE0	$\overline{CE}$0, $\overline{CE}$2
$\overline{RE}$1 / RE1	$\overline{CE}$1, $\overline{CE}$3
CLE0	$\overline{CE}$0, $\overline{CE}$2
CLE1	$\overline{CE}$1, $\overline{CE}$3
ALE0	$\overline{CE}$0, $\overline{CE}$2
ALE1	$\overline{CE}$1, $\overline{CE}$3
$\overline{WE}$0	$\overline{CE}$0, $\overline{CE}$2
$\overline{WE}$1	$\overline{CE}$1, $\overline{CE}$3
$\overline{WP}$0	$\overline{CE}$0, $\overline{CE}$2
$\overline{WP}$1	$\overline{CE}$1, $\overline{CE}$3
DQS0 / $\overline{DQS}$0	$\overline{CE}$0, $\overline{CE}$2
DQS1 / $\overline{DQS}$1	$\overline{CE}$1, $\overline{CE}$3

Implementations may tie the data lines and control signals ($\overline{RE}$, CLE, ALE, $\overline{WE}$, $\overline{WP}$, and DQS) together for the two independent 8-bit data buses externally to the device.

2.5. Absolute Maximum Rating

Stresses greater than those listing in Table 5 may cause permanent damage to the device. This is a stress rating only. Operation beyond the operating conditions specified in Table 6 is not recommended. Extended exposure beyond these conditions may affect device reliability.

Table 5 Absolute Maximum Rating

Parameter	Symbol		Rating	Unit
Voltage on any pin relative to Vss	Vcc		-0.6 to +4.6	V
	VccQ		-0.6 to +4.6	
	VIN	VccQ(3.3V)	-0.6 to +4.6	
		VccQ(1.8V)	-0.2 to +2.4	
	VI/O	VccQ(3.3V)	-0.6 to +4.6	
		VccQ(1.8V)	-0.2 to +2.4	
	V_{PP}		-0.6 to 16.0	
Soldering Temperature (10 s)	T_{SOLDER}		260	°C
Storage Temperature	T_{STG}		-40～+85	°C

NOTE:
3.3V VccQ is not supported for the case where transfer rate is greater than 100MHz.

2.6. Operating Temperature Condition

Table 6 Operating Temperature Condition

Symbol	Parameter	Part Number	Rating	Unit
T_{OPER}	Operating Temperature Range for Commercial	TH58TFG9V23BA4C	0～70	°C
		TH58TFT0V23BA8C	0～70	
		TH58TFT1V23BA8H	0～70	

NOTE:

1) Operating Temperature (T_{OPER}) is the case surface temperature on the center/top side of the Flash Memory.
2) Operating Temperature Range specifies the temperatures where all Flash Memory specifications will be supported. During operation, the Flash Memory case temperature must be maintained between the range specified in the table under all operating conditions.

2.7. Recommended Operating Conditions

Table 7 Recommended Operating Condition

Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply Voltage	Vcc	2.35	3.3	3.6	V
Ground Voltage	Vss	0	0	0	V
Supply Voltage for 1.8V I/O signaling	VccQ	1.7	1.8	1.95	V
Supply Voltage for 3.3V I/O signaling	VccQ	2.7	3.3	3.6	V
Ground Voltage for I/O signaling	VssQ	0	0	0	V

VccQ and Vcc may be distinct and unique voltages. If Vcc Supply is less than 2.7V, VccQ supply shall be 1.8V range. The device shall support one of the following VccQ/Vcc combinations,

Vcc = 3.3V, VccQ = 3.3V
Vcc = 3.3V, VccQ = 1.8V

All parameters, timing modes and other characteristics are related to the supported voltage combination.

2.8. AC Overshoot/Undershoot Requirements

The device may have AC overshoot or undershoot from VccQ and VssQ levels. Table 8 defines the maximum values that the AC overshoot or undershoot may attain. These values apply for both 3.3V and 1.8V VccQ levels.

Table 8 AC Overshoot/Undershoot Specification

Parameter	Maximum Value							Unit
	~50MHz	51~ 66MHz	67~ 83MHz	84~ 100MHz	101~ 133MHz	134~ 166MHz	167~ 200MHz	
Max. peak amplitude allowed for overshoot area	1	1	1	1	1	1	1	V
Max. peak amplitude allowed for undershoot area	1	1	1	1	1	1	1	V
Max. overshoot area above VccQ	3	2.25	1.8	1.5	1.13	0.9	0.75	V-ns
Max. undershoot area above Vss	3	2.25	1.8	1.5	1.13	0.9	0.75	V-ns

NOTE:
This specification is intended for devices with no clamp protection and is guaranteed by design.

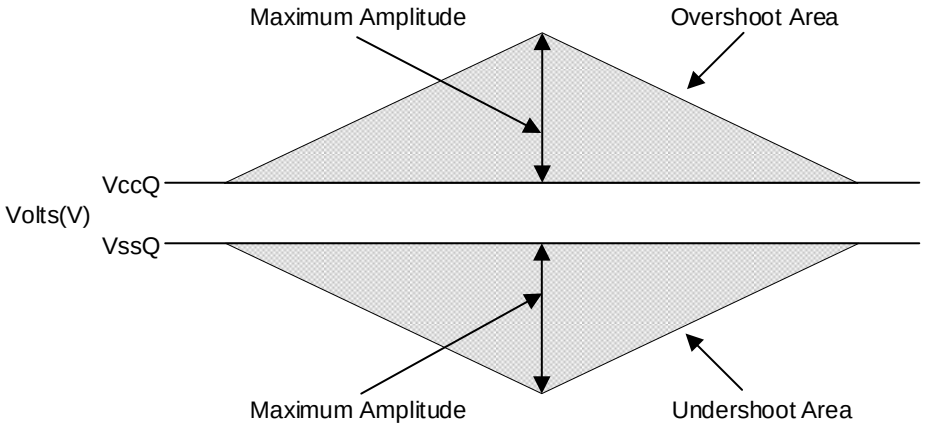


Figure 6. Overshoot/Undershoot Diagram

2.9. DC Operating Characteristics

Table 9 DC & Operating Characteristics for VccQ=3.3V

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Read Operation Current	I_{CC1}	-	-	-	50	mA
Program Operation Current	I_{CC2}	-	-	-	50	
Erase Operation Current	I_{CC3}	-	-	-	50	
DQ Burst Read Current for Vcc	I_{CC4R}	t_{RC}= t_{RC}(min.) Half data switching	-	-	80	
DQ Burst Write Current for Vcc	I_{CC4W}	t_{DSC} = t_{DSC} (min.) Half data switching	-	-	80	
DQ Burst Write Current for VccQ	I_{CCQ4W}	t_{DSC} = t_{DSC} (min.) Half data switching w/o ODT	-	-	10	
Bus Idle Current	I_{CC5}	-	-	-	10	
Stand-by Current(CMOS)	I_{SB}	$\overline{CE}$=VccQ-0.2, $\overline{WP}$=0V/VccQ	-	-	NOTE 5)	µA
Input Leakage Current	I_{LI}	V_{IN}=0 to VccQ(max.)	-	-	±10	
Output Leakage Current	I_{LO}	V_{OUT}=0 to VccQ(max.)	-	-	NOTE 7)	
V_{PP} Current	I_{PP}	V_{PP} is enabled	-	-	5	mA
AC Input High Voltage	V_{IH} (AC)	-	0.8 xVccQ	-	NOTE 8)	V
DC Input High Voltage	V_{IH} (DC)	-	0.7 xVccQ	-	VccQ +0.3	
AC Input Low Voltage	V_{IL} (AC)	-	NOTE 8)	-	0.2 xVccQ	
DC Input Low Voltage	V_{IL} (DC)	-	-0.3	-	0.3 xVccQ	
AC Input High Voltage (Small Swing1)	V_{IH} (AC)	-	V_{REF} + 0.30	-	NOTE 8)	
DC Input High Voltage (Small Swing1)	V_{IH} (DC)	-	V_{REF} + 0.15	-	VccQ +0.3	
AC Input Low Voltage (Small Swing1)	V_{IL} (AC)	-	NOTE 8)	-	V_{REF} - 0.30	
DC Input Low Voltage (Small Swing1)	V_{IL} (DC)	-	-0.3	-	V_{REF} - 0.15	
AC Input High Voltage (Small Swing2)	V_{IH} (AC)	-	VccQ/2+0.30	-	NOTE 8)	
DC Input High Voltage (Small Swing2)	V_{IH} (DC)	-	VccQ/2+0.15	-	VccQ +0.3	
AC Input Low Voltage (Small Swing2)	V_{IL} (AC)	-	NOTE 8)	-	VccQ/2-0.30	
DC Input Low Voltage (Small Swing2)	V_{IL} (DC)	-	-0.3	-	VccQ/2-0.15	
Output High Voltage Level	V_{OH}	I_{OH}= -400µA	2.4	-	-	
Output Low Voltage Level	V_{OL}	I_{OL}= 2.1mA	-	-	0.4	
Reference Voltage	V_{REF}	-	0.49 xVccQ	0.50 xVccQ	0.51 xVccQ	
External V_{PP}	V_{PP}	-	10.8	12	13.2	
Output Low Current(R/$\overline{B}$)	I_{OL}(R/$\overline{B}$)	V_{OL}=0.4V	8	10	-	mA

NOTE: The values in this table are subject to change.

1) Typical value is measured at Vcc=3.3V, T_{OPER} =25°C. Not 100% tested.
2) V_{OH} and V_{OL} should be available on these two conditions; Output Strength is nominal and VccQ=3.3V, Rpd/Rpu are all VccQx0.5. If the drive strength settings are supported, Table 13 shall be used to derive the output driver impedance values.
3) $I_{CC1,2}$ are without data cache.
4) $I_{CC1/2/3}$, I_{CC4R}, I_{CC4W}, I_{CCQ4W}, I_{CC5} and I_{PP} are the value of one active logical unit.
5) TH58TFG9V23BA4C = 150µA, TH58TFT0V23BA8C = 200µA, TH58TFT1V23BA8H = 400µA
6) DQ, DQS, $\overline{DQS}$, $\overline{RE}$ and RE apply I_{LO} characteristic. Other pins apply I_{LI} characteristic.
7) TH58TFG9V23BA4C = ±10µA, TH58TFT0V23BA8C = ±20µA, TH58TFT1V23BA8H = ±40µA
8) Refer to AC Overshoot and Undershoot requirements.
9) Small Swing 1 is defined as the small amplitude with utilizing reference voltage signal (V_{REF}). Small Swing 1 characteristics above shall be applied to DQ, DQS, $\overline{DQS}$, $\overline{RE}$ and RE.
10) Small Swing 2 is defined as the small amplitude with utilizing differential signaling. Small Swing 2 characteristics above shall be applied to each individual component of a differential signal.
11) V_{REF} in the above table is the linear average of V_{REF}(t) over a long period of time (e.g. 1sec.). V_{REF}(t) may temporarily deviate from V_{REF} by no more than +/- 1% VccQ, while the average shall meet the min./max. requirements in above table.

Table 10 DC & Operating Characteristics for VccQ=1.8V

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Read Operation Current	I_{CC1}	-	-	-	50	mA
Program Operation Current	I_{CC2}	-	-	-	50	
Erase Operation Current	I_{CC3}	-	-	-	50	
DQ Burst Read Current for Vcc	I_{CC4R}	t_{RC}= t_{RC}(min.) Half data switching	-	-	80	
DQ Burst Write Current for Vcc	I_{CC4W}	t_{DSC} = t_{DSC} (min.) Half data switching	-	-	80	
DQ Burst Write Current for VccQ	I_{CCQ4W}	t_{DSC} = t_{DSC} (min.) Half data switching w/o ODT	-	-	10	
Bus Idle Current	I_{CC5}	-	-	-	10	
Stand-by Current(CMOS)	I_{SB}	$\overline{CE}$=VccQ-0.2, $\overline{WP}$=0V/VccQ	-	-	NOTE 5)	µA
Input Leakage Current	I_{LI}	V_{IN}=0 to VccQ(max.)	-	-	±10	
Output Leakage Current	I_{LO}	V_{OUT}=0 to VccQ(max.)	-	-	NOTE 7)	
V_{PP} Current	I_{PP}	V_{PP} is enabled	-	-	5	mA
AC Input High Voltage	V_{IH} (AC)	-	0.8 xVccQ	-	NOTE 8)	V
DC Input High Voltage	V_{IH} (DC)	-	0.7 xVccQ	-	VccQ +0.3	
AC Input Low Voltage	V_{IL} (AC)	-	NOTE 8)	-	0.2 xVccQ	
DC Input Low Voltage	V_{IL} (DC)	-	-0.3	-	0.3 xVccQ	
AC Input High Voltage (Small Swing1)	V_{IH} (AC)	-	V_{REF} + 0.30	-	NOTE 8)	
DC Input High Voltage (Small Swing1)	V_{IH} (DC)	-	V_{REF} + 0.15	-	VccQ +0.3	
AC Input Low Voltage (Small Swing1)	V_{IL} (AC)	-	NOTE 8)	-	V_{REF} - 0.30	
DC Input Low Voltage (Small Swing1)	V_{IL} (DC)	-	-0.3	-	V_{REF} - 0.15	
AC Input High Voltage (Small Swing2)	V_{IH} (AC)	-	VccQ/2+0.30	-	NOTE 8)	
DC Input High Voltage (Small Swing2)	V_{IH} (DC)	-	VccQ/2+0.15	-	VccQ +0.3	
AC Input Low Voltage (Small Swing2)	V_{IL} (AC)	-	NOTE 8)	-	VccQ/2-0.30	
DC Input Low Voltage (Small Swing2)	V_{IL} (DC)	-	-0.3	-	VccQ/2-0.15	
Output High Voltage Level	V_{OH}	I_{OH}= -100µA	VccQ-0.1	-	-	
Output Low Voltage Level	V_{OL}	I_{OL}= 100µA	-	-	0.1	
Reference Voltage	V_{REF}	-	0.49 xVccQ	0.50 xVccQ	0.51 xVccQ	
External V_{PP}	V_{PP}	-	10.8	12	13.2	
Output Low Current(R/$\overline{B}$)	I_{OL}(R/$\overline{B}$)	V_{OL}=0.2V	3	4	-	mA

NOTE: The values in this table are subject to change.

1) Typical value is measured at Vcc=3.3V, VccQ=1.8V, T_{OPER}=25°C. Not 100% tested.
2) V_{OH} and V_{OL} should be available on these two conditions; Output Strength is nominal and VccQ=1.8V, Rpd/Rpu are all VccQx0.5. If the drive strength settings are supported, Table 13 shall be used to derive the output driver impedance values.
3) $I_{CC1,2}$ are without data cache.
4) $I_{CC1/2/3}$, I_{CC4R}, I_{CC4W}, I_{CCQ4W}, I_{CC5} and I_{PP} are the value of one active logical unit.
5) TH58TFG9V23BA4C = 150µA, TH58TFT0V23BA8C = 200µA, TH58TFT1V23BA8H = 400µA
6) DQ, DQS, $\overline{DQS}$, $\overline{RE}$ and RE apply I_{LO} characteristic. Other pins apply I_{LI} characteristic.
7) TH58TFG9V23BA4C = ±10µA, TH58TFT0V23BA8C = ±20µA, TH58TFT1V23BA8H = ±40µA
8) Refer to AC Overshoot and Undershoot requirements.
9) Small Swing 1 is defined as the small amplitude with utilizing reference voltage signal (V_{REF}). Small Swing 1 characteristics above shall be applied to DQ, DQS, $\overline{DQS}$, $\overline{RE}$ and RE.
10) Small Swing 2 is defined as the small amplitude with utilizing differential signaling. Small Swing 2 characteristics above shall be applied to each individual component of a differential signal.
11) V_{REF} in the above table is the linear average of V_{REF}(t) over a long period of time (e.g. 1sec.). V_{REF}(t) may temporarily deviate from V_{REF} by no more than +/- 1% VccQ, while the average shall meet the min./max. requirements in above table.

2.10. Differential Input AC Characteristics

The differential AC input characteristics are described in Figure 7 V_{TR} is the "true" input signal and V_{CP} is the "complementary" input signal. V_{IX} (AC) indicates the voltage at which differential input signals shall cross. The typical value of V_{IX} (AC) is expected to be about VccQ/2. V_{IX} (AC) is expected to track variations in VccQ/2. V_{IX} (AC) shall meet the requirements in Table 11.
Note that each individual component of a differential signal shall meet the operating conditions such as V_{IH} (AC) / V_{IL} (AC) specified in Table 9 and Table 10.

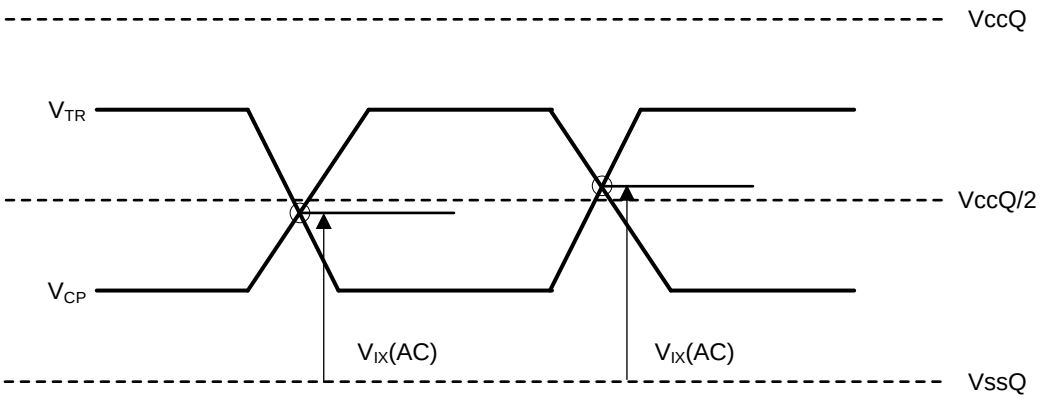


Figure 7. Differential Input Signal

Table 11 AC Characteristics for Differential Input Signal

Parameter	Symbol	Min.	Max.	Unit
AC differential cross point voltage	V_{IX} (AC)	VccQ/2 – 0.175	VccQ/2 + 0.175	V

2.11. Input/Output Capacitance (T_{OPER} =25°C, f=1MHz, VccQ=1.8V)

Table 12 Input/ Output capacitance

Item	Symbol	Test Condition	Max.			Unit
			TH58TFG9V23BA4C	TH58TFT0V23BA8C	TH58TFT1V23BA8H	
DQ, DQS, $\overline{DQS}$, $\overline{RE}$ and RE	C_{DQ}	V_{IN}=0V	6.5	10	17	pF
ALE, CLE, $\overline{WE}$ and $\overline{WP}$	C_{IN}	V_{IN}=0V	5.5	7	10	pF
$\overline{CE}$	C_{OTHER}	V_{IN}=0V	4.5	4.5	6	pF

NOTE :

1) Capacitance is periodically sampled and not 100% tested.
2) The capacitance is measured at a package level.

2.12. DQ Driver Strength

The device may be configured with multiple driver strengths with 'SET FEATURE' command. There are Underdrive, Nominal, Overdrive 1 options. The Toggle DDR supports all three driver strength settings. Devices that support driver strength settings shall comply with the output driver requirements in this section. A device is only required to meet driver strength values for either 3.3V VccQ or 1.8V VccQ, and is not required to meet driver strength values for both 3.3V VccQ and 1.8V VccQ.

Table 13 DQ Drive Strength Settings

Setting	Driver Strength	VccQ
Overdrive 1	1.4x = 25 Ohms	3.3 V
Nominal	1.0x = 35 Ohms	
Underdrive	0.7x = 50 Ohms	
Overdrive 1	1.4x = 25 Ohms	1.8 V
Nominal	1.0x = 35 Ohms	
Underdrive	0.7x = 50 Ohms	

The impedance values corresponding to several different VccQ values are defined in Table 15 for 3.3V and 1.8V VccQ. The test conditions that shall be used to verify the impedance values are specified in Table 14. The terms T_{OPER}(Min.) and T_{OPER}(Max.) are in reference to the minimum and maximum operating temperature defined for the device.

Table 14 Testing Conditions for Impedance Values

Condition	Temperature	VccQ (3.3V)	VccQ (1.8V)	Process
Minimum Impedance	T_{OPER} (Min.) degrees Celsius	3.6 V	1.95 V	Fast - Fast
Nominal Impedance	25 degrees Celsius	3.3 V	1.8 V	Typical
Maximum Impedance	T_{OPER} (Max.) degrees Celsius	2.7 V	1.7 V	Slow - Slow

Table 15 Output Drive Strength Impedance Values

Output Strength	Rpd/Rpu	V_{OUT} to Vss	Minimum		Nominal		Maximum		Unit
			VccQ(3.3V)	VccQ(1.8V)	VccQ(3.3V)	VccQ(1.8V)	VccQ(3.3V)	VccQ(1.8V)	
Overdrive1	Rpd	VccQ x 0.2	8.0	10.5	15.0	19.0	30.0	44.0	ohms
		VccQ x 0.5	15.0	13.0	25.0	25.0	45.0	47.0	ohms
		VccQ x 0.8	20.0	16.0	35.0	32.5	65.0	61.5	ohms
	Rpu	VccQ x 0.2	20.0	16.0	35.0	32.5	65.0	61.5	ohms
		VccQ x 0.5	15.0	13.0	25.0	25.0	45.0	47.0	ohms
		VccQ x 0.8	8.0	10.5	15.0	19.0	30.0	44.0	ohms
Nominal	Rpd	VccQ x 0.2	12.0	15.0	22.0	27.0	40.0	62.5	ohms
		VccQ x 0.5	20.0	18.0	35.0	35.0	65.0	66.5	ohms
		VccQ x 0.8	25.0	22.0	50.0	52.0	100.0	88.0	ohms
	Rpu	VccQ x 0.2	25.0	22.0	50.0	52.0	100.0	88.0	ohms
		VccQ x 0.5	20.0	18.0	35.0	35.0	65.0	66.5	ohms
		VccQ x 0.8	12.0	15.0	22.0	27.0	40.0	62.5	ohms
Underdrive	Rpd	VccQ x 0.2	18.0	21.5	32.0	39.0	55.0	90.0	ohms
		VccQ x 0.5	29.0	26.0	50.0	50.0	100.0	95.0	ohms
		VccQ x 0.8	40.0	31.5	75.0	66.5	150.0	126.5	ohms
	Rpu	VccQ x 0.2	40.0	31.5	75.0	66.5	150.0	126.5	ohms
		VccQ x 0.5	29.0	26.0	50.0	50.0	100.0	95.0	ohms
		VccQ x 0.8	18.0	21.5	32.0	39.0	55.0	90.0	ohms

Table 16 Pull-up and Pull-down Output Impedance Mismatch

Drive Strength	Minimum	Maximum	Unit
Overdrive 1	0.0	8.8	ohms
Nominal	0.0	12.3	ohms
Underdrive	0.0	17.5	ohms

NOTE:

1) Mismatch is the absolute value between pull-up and pull-down impedances. Both are measured at the same temperature and voltage.
2) Test conditions: VccQ = VccQ(min.), Vout = VccQ×0.5

2.13. Operating condition on transfer rate

The operating condition on the transfer rate is described in Table 17.

Table 17 Operating condition on the transfer rate

Feature	Conditions	
	Up to 100 MHz	Over 100 MHz and up to 200 MHz
Differential signaling	Optional	Required
Reference voltage (V_{REF})	Optional	Required
VccQ condition	3.3 V or 1.8 V	1.8 V
On die termination	Optional	Optional

NOTE:

Toggle 2.0 specific settings are disabled after power-up. The required features shall be enabled by Set Feature command for the transfer rate over 100 MHz.

2.14. Input/Output Slew rate

The input slew rate requirements that the device shall comply with are defined in Table 18, Table 19 and Table 20. The output slew rate requirements that the device shall comply with are defined in Table 22. The testing conditions that shall be used to verify the input slew rate and output slew rate are listed in Table 21 and Table 23 respectively.

Table 18 Derating factor (Differential signaling)

Input slew rate	Up to 100MHz				Over 100MHz and up to 200MHz				Unit
	V_{REF} not used		V_{REF} used		V_{REF} not used		V_{REF} used		
	3.3VccQ	1.8VccQ	3.3VccQ	1.8VccQ	3.3VccQ	1.8VccQ	3.3VccQ	1.8VccQ	
1.0V/ns	0	0	0	0	N/A	N/A	N/A	0	ps
0.8V/ns	166	90	50	50	N/A	N/A	N/A	50	
0.6V/ns	442	241	134	134	N/A	N/A	N/A	134	

NOTE:
Derating factor listed in this table shall be applied to data setup time (t_{DS}) and data hold time (t_{DH}) as additional value if the slew rate is less than the minimum value defined in Table 20.

Table 19 Derating factor (Single-ended signaling)

Input slew rate	Up to 100MHz				Over 100MHz and up to 200MHz				Unit
	V_{REF} not used		V_{REF} used		V_{REF} not used		V_{REF} used		
	3.3VccQ	1.8VccQ	3.3VccQ	1.8VccQ	3.3VccQ	1.8VccQ	3.3VccQ	1.8VccQ	
1.0V/ns	0	0	0	0	N/A	N/A	N/A	N/A	ps
0.8V/ns	332	180	100	100	N/A	N/A	N/A	N/A	
0.6V/ns	884	482	268	268	N/A	N/A	N/A	N/A	

NOTE:
Derating factor listed in this table shall be applied to data setup time (t_{DS}) and data hold time (t_{DH}) as additional value if the slew rate is less than the minimum value defined in Table 20.

Table 20 Input Slew Rate

VccQ	Minimum slew rate	
	Up to 100MHz	Over 100MHz and up to 200MHz
3.3V	1.0V/ns	N/A
1.8V	1.0V/ns	1.0V/ns

Table 21 Testing Conditions for Input Slew Rate

Parameter	Value
Positive Input Transition	V_{IL} (DC) to V_{IH} (AC)
Negative Input Transition	V_{IH} (DC) to V_{IL} (AC)

Table 22 Output Slew Rate Requirements

Parameter	VccQ=3.3V		VccQ=1.8V		Unit
	Minimum	Maximum	Minimum	Maximum	
Overdrive 1	1.5	9.0	0.85	5.0	V/ns
Nominal	1.2	7.0	0.75	4.0	V/ns
Underdrive	1.0	5.5	0.60	4.0	V/ns

NOTE :
1) Measured with a test load of 5pF connected to Vss.
2) The ratio of pull-up slew rate to pull-down slew rate is specified for the same temperature and voltage, over the entire temperature and voltage range. For a given output, it represents the maximum difference between pull-up and pull-down drivers due to process variation.

Table 23 Testing Conditions for Output Slew Rate

Parameter	Value
V_{OL} (DC)	0.3 * VccQ
V_{OH} (DC)	0.7 * VccQ
V_{OL} (AC)	0.2 * VccQ
V_{OH} (AC)	0.8 * VccQ
Positive Output Transition	V_{OL} (DC) to V_{OH} (AC)
Negative Output Transition	V_{OH} (DC) to V_{OL} (AC)
t_{RISE}(1)	Time during Rising Edge from V_{OL} (DC) to V_{OH} (AC)
t_{FALL}(1)	Time during Falling Edge from V_{OH} (DC) to V_{OL} (AC)
Output Slew Rate Rising Edge	(V_{OH} (AC) - V_{OL} (DC)) / t_{RISE}
Output Slew Rate Falling Edge	(V_{OH} (DC) - V_{OL} (AC)) / t_{FALL}
Output Load	50 Ohms to Vtt (Vtt=0.5*VccQ)

NOTE :

1) Refer to Figure 8.
2) Output slew rate is verified by design and characterization. It may not be subject to production test.
3) The minimum slew rate is the minimum of the rising edge and the falling edge slew rate. The maximum slew rate is the maximum of the rising edge and the falling edge slew rate.

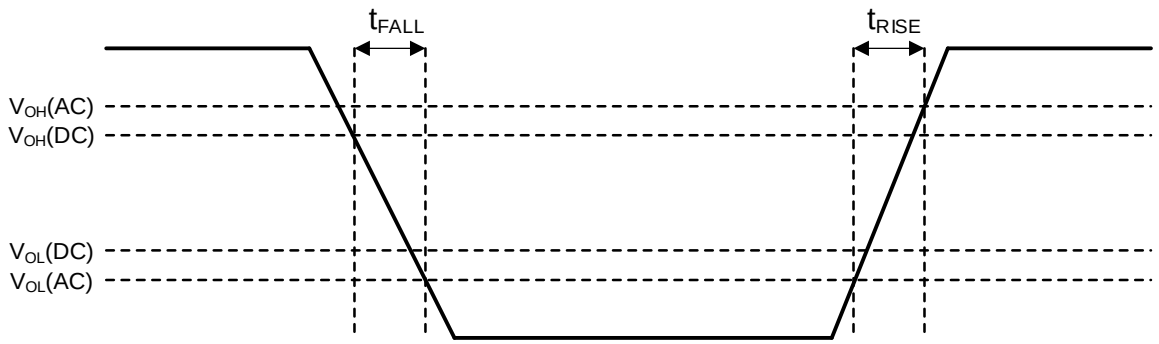


Figure 8. t_{RISE} and t_{FALL} Definition for Output Slew Rate

2.15. High Speed Toggle DDR with ODT

2.15.1. ODT (On die termination)

On Die Termination (ODT) is a feature that allows a Flash Memory device to turn on/off termination resistance of each DQ and DQS / $\overline{DQS}$ for Data Input and RE / $\overline{RE}$ for Data Output. The ODT feature is designed to improve signal integrity of the memory channel by allowing the Flash Memory controller to independently turn on/off termination resistance for a selected target.

2.15.2. ODT setting

ODT setting is configured by 'SET FEATURE' operation. Refer to 5.2.6 for the further information. Figure 9 defines an ODT setting sequence.

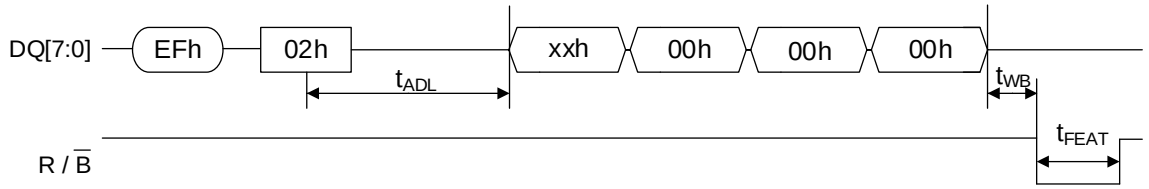


Figure 9. ODT setting through 'SET FEATURE'

2.15.3. ODT behavior during Read operation

ODT is enabled within Read pre-amble period after $\overline{RE}$ falling, and disabled on $\overline{CE}$ rising or one of CLE and ALE rising while $\overline{CE}$ is low. Figure 10 defines ODT enable/disable behavior and timings during data output.

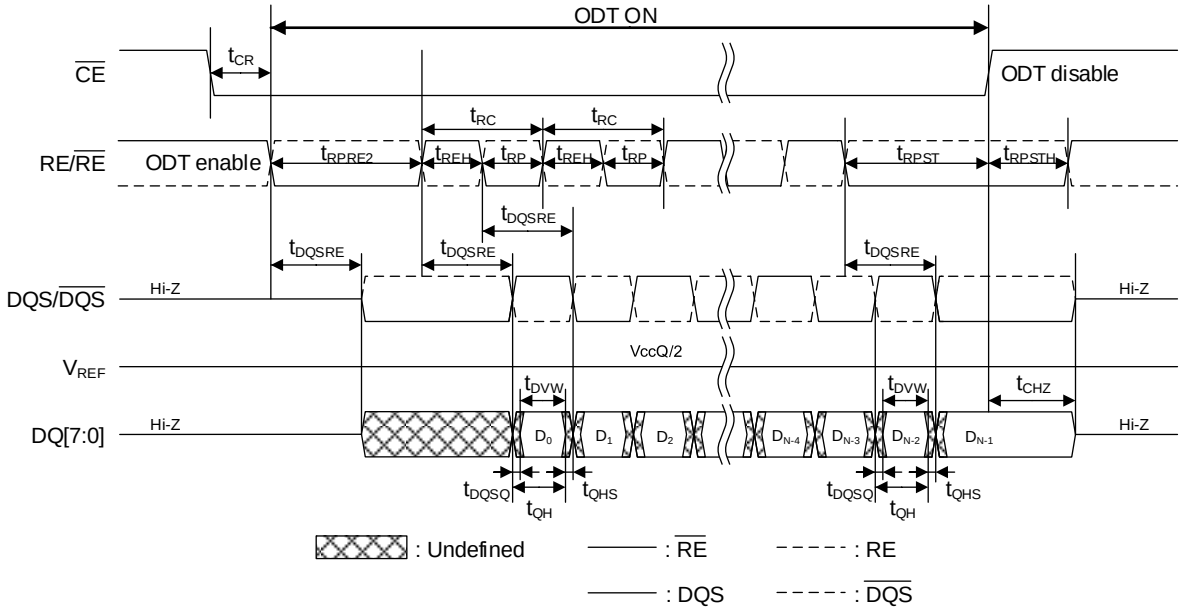


Figure 10. ODT enable/disable during Read

2.15.4. ODT behavior during Write operation

ODT is enabled within Write pre-amble period while ALE, CLE and DQS is low and disabled on $\overline{CE}$ rising or one of CLE and ALE rising while $\overline{CE}$ is low. Figure 11 defines ODT enable/disable behavior and timings during data input.

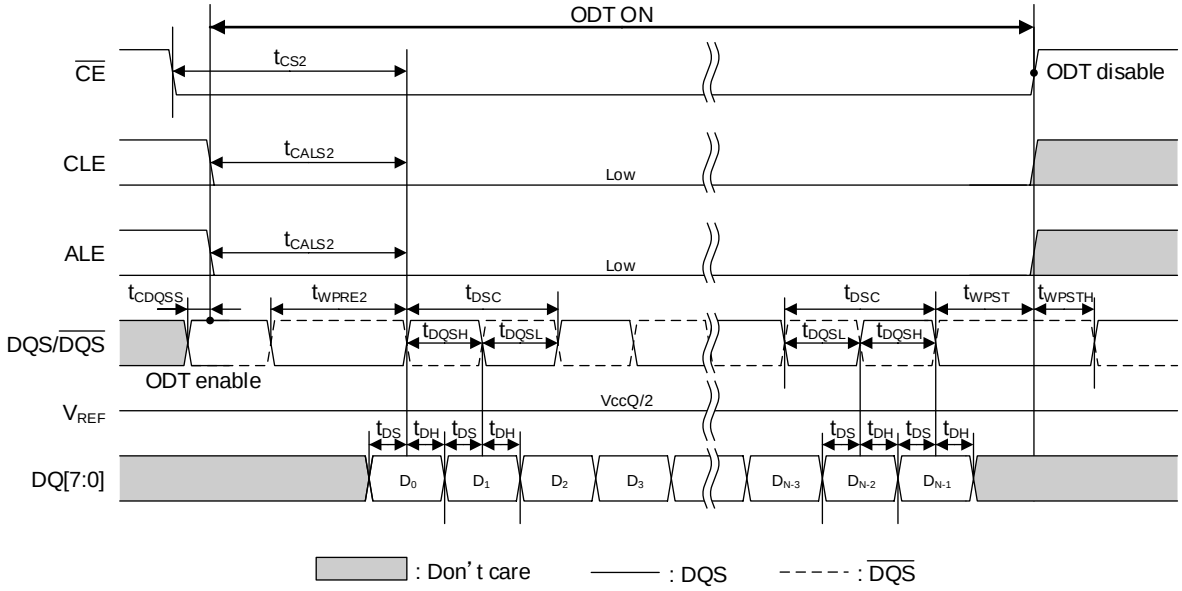


Figure 11. ODT enable/disable during Write

2.15.5. Functional Representation of ODT

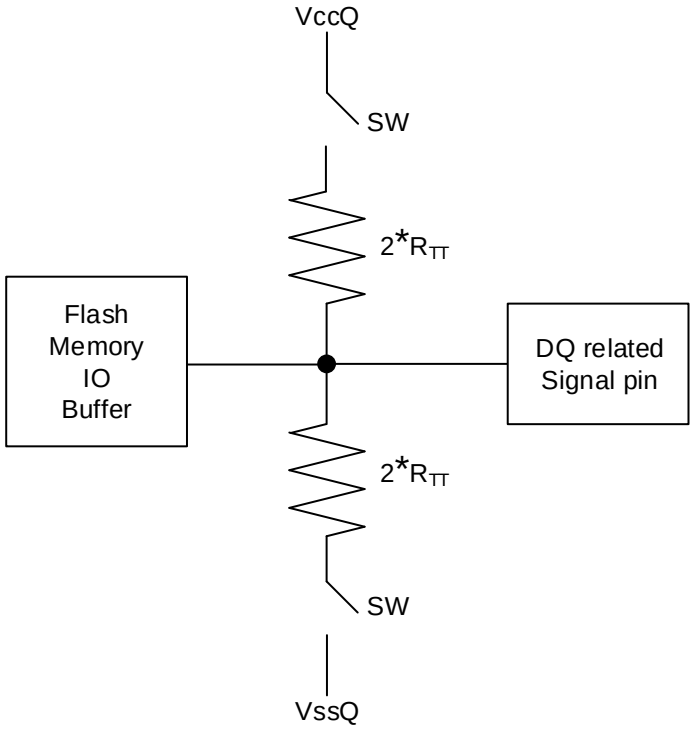


Figure 12. Functional Representation of ODT

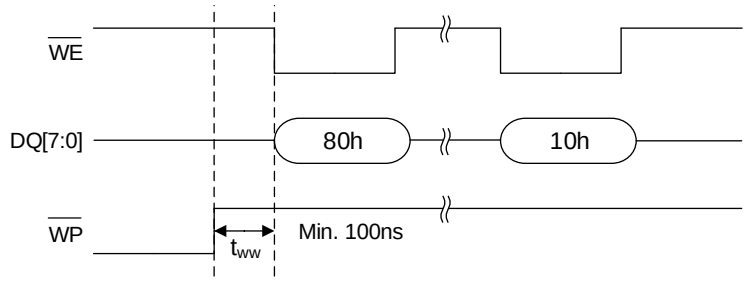
2.16. R/$\overline{B}$ and SR[6] Relationship

R/$\overline{B}$ represents the status of the selected target. R/$\overline{B}$ goes busy when one or more of its die (LUNs) are busy. R/$\overline{B}$ goes ready when all of its die (LUNs) are ready.

2.17. Write Protect

When $\overline{WP}$ is active low, Flash array is blocked from any program and erase operations. This signal shall only be transitioned when a target is idle. The host shall be allowed to issue a new command after tWW once $\overline{WP}$ is active low. Figure 13 describes the tWW timing requirement, Figure 14 shown with the start of a Program command. And shows with the start of a Erase command.
Note that following requirements shall be applied to the other Programming and Erase sequences, e.g. Program Operation with Random Data Input, Multi Plane Full Sequence Program Operation, Multi Block Erase Operation and etc.

Enable Programming



Disable Programing

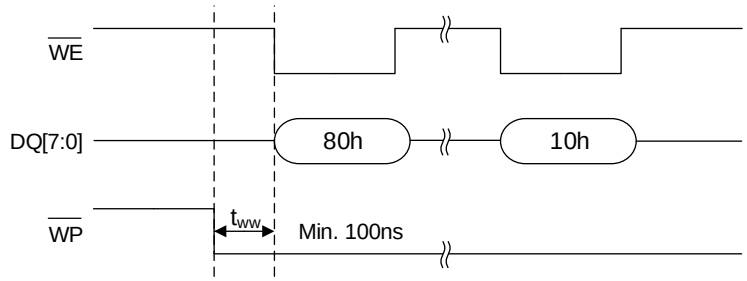
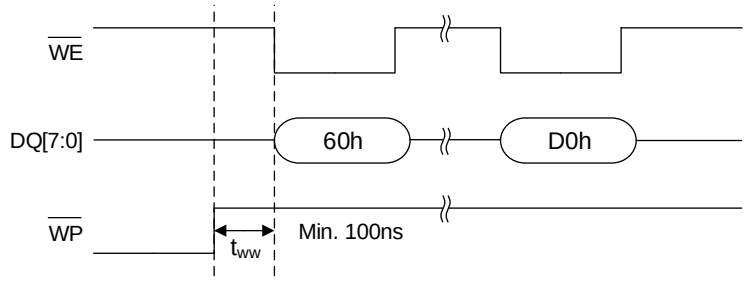


Figure 13. Write Protect timing requirements of the Program operation

Enable Erase



Disable Erase

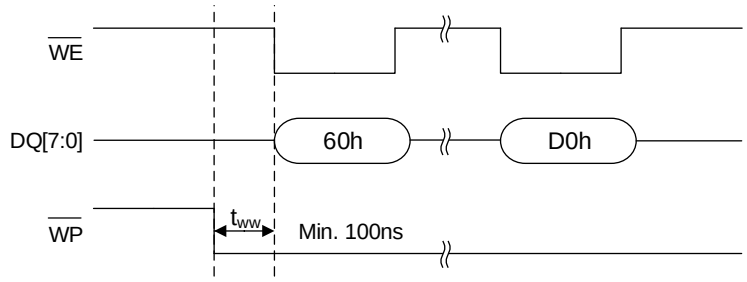


Figure 14. Write Protect timing requirements of the Erase operation

3. MEMORY ORGANIZATION

A device contains one or more targets. A target is controlled by one $\overline{CE}$ signal. A target is organized into one or more logical units (LUNs).

A logical unit (LUN) is the minimum unit that can independently execute commands and report status. Specifically, separate LUNs may operate on arbitrary command sequences in parallel. For example, it is permissible to start a program operation on LUN 0 and then prior to the operation's completion to start a Read command on LUN 1. A LUN contains at least one page register and a Flash array. The number of page registers is dependent on the number of plane operations supported for the LUN. The Flash array contains a number of blocks.

A block is the smallest erasable unit of data within the Flash array of a LUN. A block contains a number of WLs and pages. A WL is the smallest addressable unit for Program operation. A page is the smallest addressable unit for Read operation. A WL contains 3 pages.

Each LUN shall have at least one page register. A page register is used for the temporary storage of data before it is moved to a page within the Flash array or after it is moved from a page within the Flash array.

The byte location within the page register is referred to as the column.

There are several mechanisms to achieve parallelism within this architecture. There may be multiple commands outstanding to different LUNs at the same time. To get further parallelism within a LUN, plane addressing may be used to execute additional dependent operations in parallel. Additionally, parallel page operations within a plane may be used if its functionality is supported by the device. Each of above operations shall be executed in accordance with the requirements dependent on the memory organization of the device.

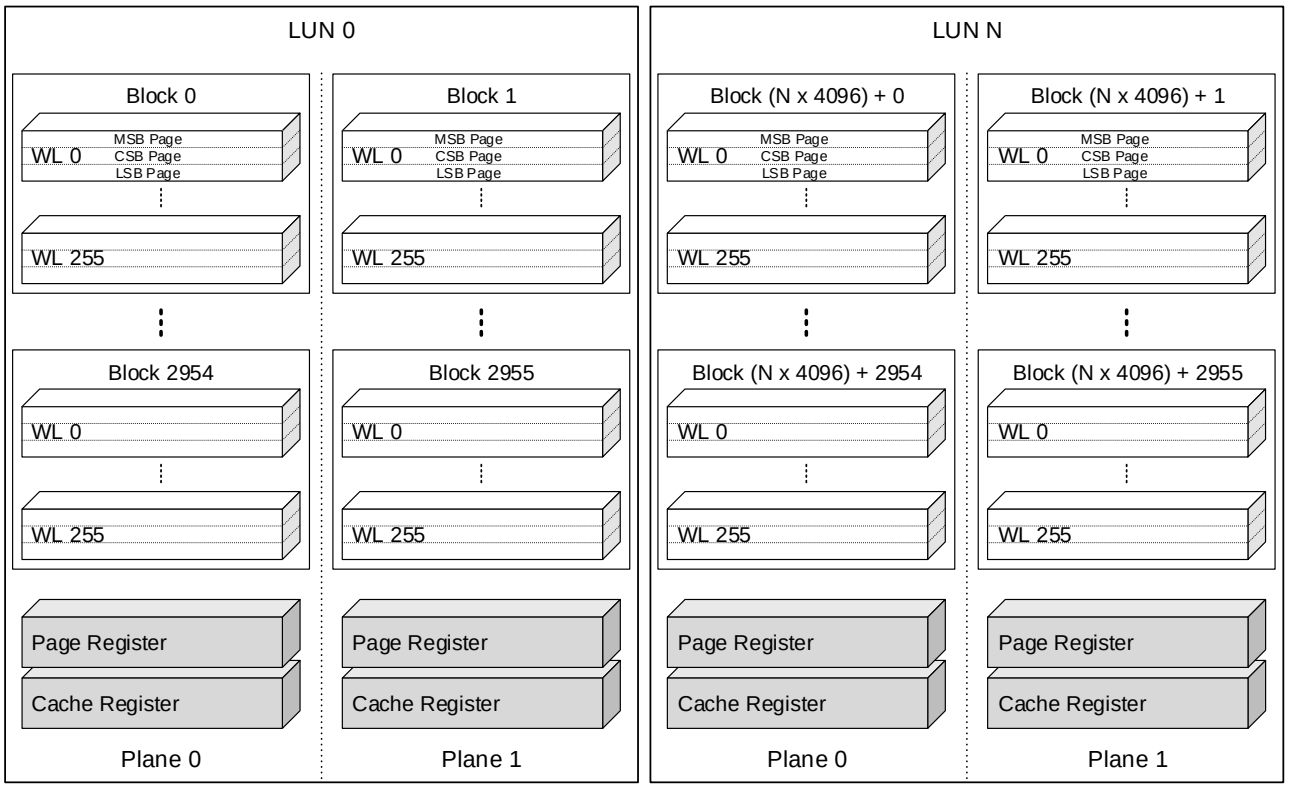


Figure 15. Target Organization

3.1. Addressing

There are two address types used: the column address and the row address. The column address is used to access bytes within a page, i.e. the column address is the byte offset into the page. The least significant bit of the column address shall always be zero for a DDR interface, i.e. an even number of bytes is always transferred. The row address is used to address WLs, blocks, and LUNs. When both the column and row addresses are required to be issued, the column address is always issued first in one or more 8-bit address cycles. The row addresses follow in one or more 8-bit address cycles. There are some functions that may require only row addresses, such as Block Erase. In this case, the column addresses are not issued. For both column and row addresses, the first address cycle always contains the least significant address bits and the last address cycle always contains the most significant address bits. If there are bits in the most significant cycles of the column and row addresses that are not used then they are required to be cleared to zero. The row address structure is shown in Figure 16 with the least significant row address bit to the right and the most significant row address bit to the left.

Figure 16. Row Address Layout

The WL address is set by the least significant row address bits, and the LUN address is set by the most significant row address bit(s). The block address is between a WL address and a LUN address. A host shall not access an address of a page or block beyond maximum WL address or block address. The addressing of this device is shown in Table 24.

Table 24 The addressing of this device.

	DQ7	DQ6	DQ5	DQ4	DQ3	DQ2	DQ1	DQ0
First cycle (Column address 1)	C1-7	C1-6	C1-5	C1-4	C1-3	C1-2	C1-1	C1-0
Second cycle (Column address 2)	L	C2-6	C2-5	C2-4	C2-3	C2-2	C2-1	C2-0
Third cycle (Row address 1)	R1-7	R1-6	R1-5	R1-4	R1-3	R1-2	R1-1	R1-0
Fourth cycle (Row address 2)	R2-7	R2-6	R2-5	R2-4	R2-3	R2-2	R2-1	R2-0
Fifth cycle (Row address 3)	L	L	L	R3-4	R3-3	R3-2	R3-1	R3-0

R1-0 to R1-7: WL address
R2-0 to R3-3: Block address
R3-4: LUN address (Note)

NOTE :

1) The least significant bit of Block address is also regarded as Plane Address bit. Refer to 3.1.1.
2) If the target of the device has only one LUN, no LUN Address bit is assigned.
3) LUN address in the above table is only for the device having multiple LUNs per a target. The LUN address is L for the device having single LUN per a target.

3.1.1. Plane Addressing

The plane address comprises the lowest order bits of the block address as shown in Figure 17. The plane address is used when performing a multi-plane operation on a particular LUN. Regarding the restriction of address setting sequences for multi-plane operation, refer to section 5.3.2.

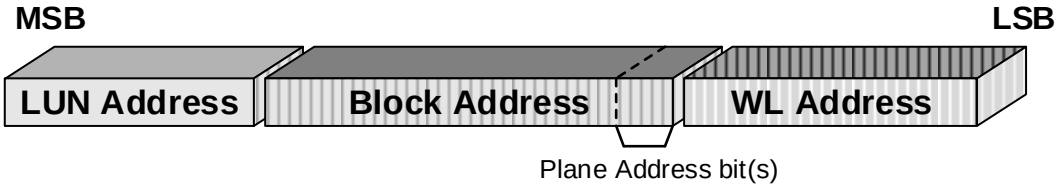


Figure 17. Position of Plane Address

3.1.2. Extended Blocks Arrangement

The device has 112 extended blocks per plane (Extended Blocks) to increase valid blocks. Extended Blocks can be accessed by the following addressing.

Table 25 Extended Blocks Arrangement for LUN #N

Row Address	Block Assignment	
(Nx100000h) + 000000h	Block (Nx4096)+0(Plane 0)	LUN #(0+N) Main Blocks (2732blocks)
(Nx100000h) + 000100h	Block (Nx4096)+1(Plane 1)	
(Nx100000h) + 000200h	Block (Nx4096)+2(Plane 0)	
(Nx100000h) + 000300h	Block (Nx4096)+3(Plane 1)	
(Nx100000h) + 000400h	Block (Nx4096)+4(Plane 0)	
(Nx100000h) + 000500h	Block (Nx4096)+5(Plane 1)	
|	|	
(Nx100000h) + 0AAA00h	Block (Nx4096)+2730(Plane 0)	
(Nx100000h) + 0AAB00h	Block (Nx4096)+2731(Plane 1)	
(Nx100000h) + 0AAC00h	Block (Nx4096)+2732(Plane 0)	LUN #(0+N) Extended Blocks (112x2 blocks)
(Nx100000h) + 0AAD00h	Block (Nx4096)+2733(Plane 1)	
|	|	
(Nx100000h) + 0B8A00h	Block (Nx4096)+2954(Plane 0)	
(Nx100000h) + 0B8B00h	Block (Nx4096)+2955(Plane 1)	
(Nx100000h) + 0B8C00h – (Nx100000h) + 0FFFFFh	**Address Gap**	

NOTE :

1) Table 25 is only for the device having multiple LUNs per a target and shall be ignored for the device having single LUN per a target.
2) N=0 to 1(Up to LUN number per a target)

3.2. Factory Defect Mapping

The Flash array is not presumed to be pristine, and a number of defects that makes the blocks unusable may be present. Invalid blocks shall be sorted out from normal blocks by software.

3.2.1. Device Requirements

If a block is defective, the manufacturer shall mark the block as defective by setting the Defective Block Marking, as shown in Figure 18, of the first LSB page or the last MSB page of the defective block to a value of non-FFh. The Defective Block Marking is located on the first byte of user data area or the first byte of spare data area in the pages within a block.

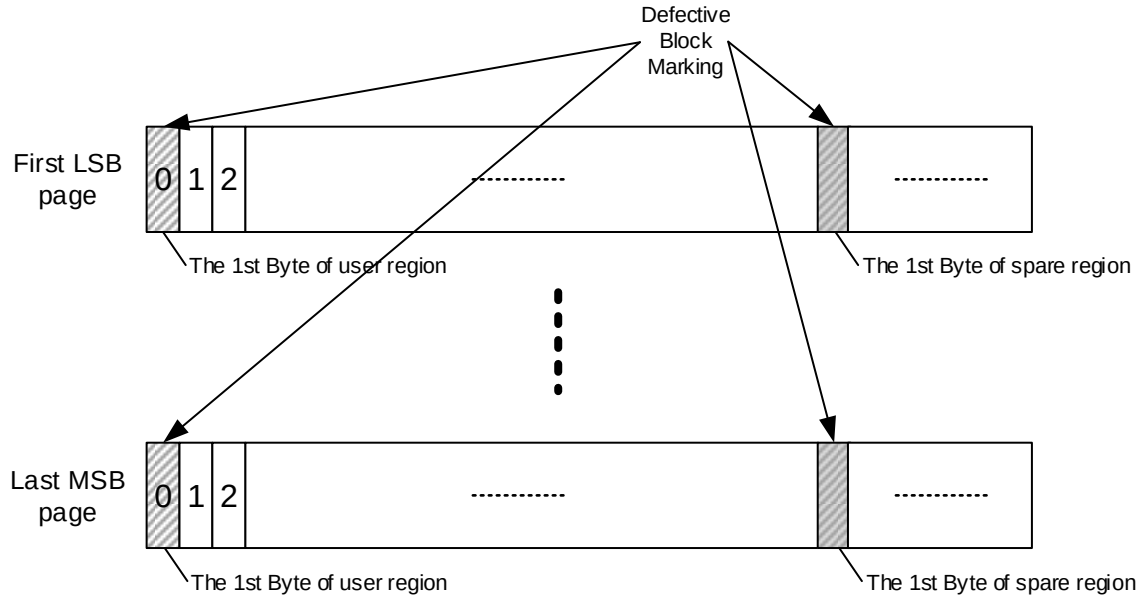


Figure 18. Area marked in the first LSB page or the last MSB page of block indicating defect

3.2.2. Host Requirements

The host shall not erase or program blocks marked as defective by the manufacturer, and any attempt to do so yields indeterminate results.

Figure 19 outlines the flow chart how to create an initial invalid block table. It should be performed by the host to create the initial bad block table prior to performing any erase or programming operations on the target. All pages in non-defective blocks are erased as the majority of bits being read as FFh. A defective block is indicated by the majority of bits being read as 00h in the Defective Block Marking location of either the first LSB page or the last MSB page of the block. The host shall check the Defective Block Marking location of both the first LSB page or the last MSB page of each block to verify the block is valid prior to any erase or program operations on that block. When Host encounters the data neither FFh nor 00h, Host should select either FFh or 00h which has closer Hamming distance to the data.

NOTE :
Over the lifetime use of a Flash Memory device, the Defective Block Marking of defective blocks may encounter read disturbs that cause bit changes. The initial defect marks by the manufacturer may change value over the lifetime of the device, and are expected to be read by the host and used to create a bad block table during initial use of the part.

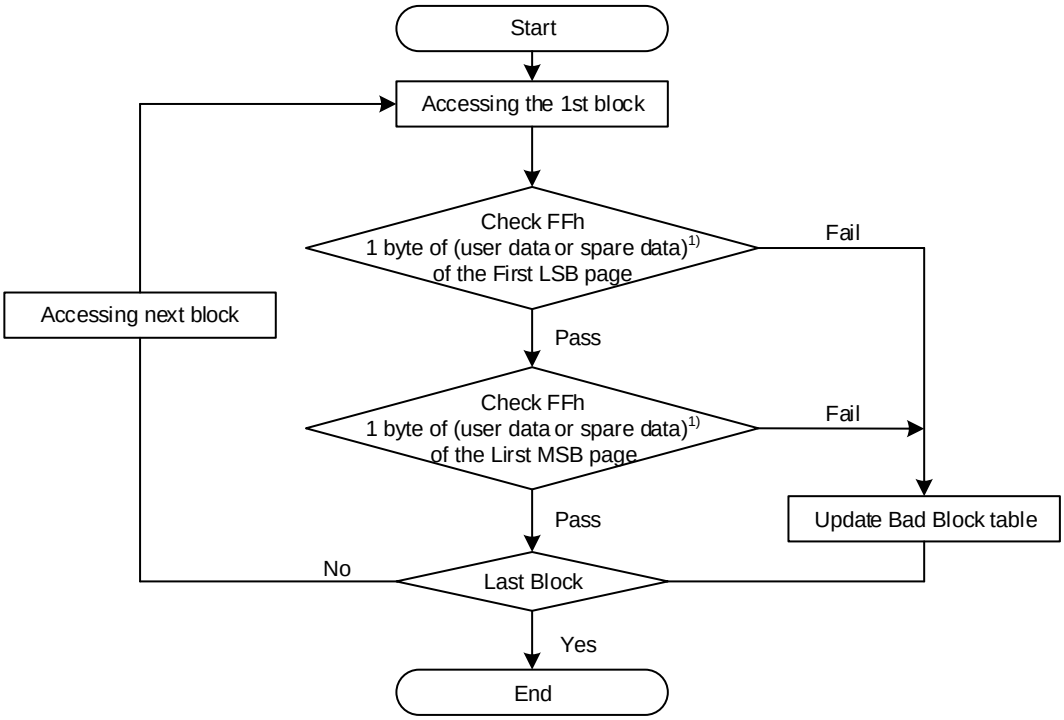


Figure 19. Flow chart to create initial invalid block table

NOTE :
1) The location for the initial invalid block may vary depending on vendors

4. FUNCTION DESCRIPTION

4.1. Discovery and Initialization

4.1.1. Power-on/off sequence

Power-on/off sequences are necessary to follow the timing sequence shown in the figure below. The device internal initialization starts with FFh command after the power supply reaches an appropriate level and wait 100us. During the initialization, the device RY/$\overline{BY}$ signal indicates the Busy state and the device consumes power-on initialize current which is defined on DC characteristics table. The acceptable command is 70h during this period. The $\overline{WP}$ signal is useful for protecting against data corruption at power-on/off.
During Power-off sequence, when Vcc level is less than 2.15V, Vcc must set below 0.5V and stay 1ms at least.

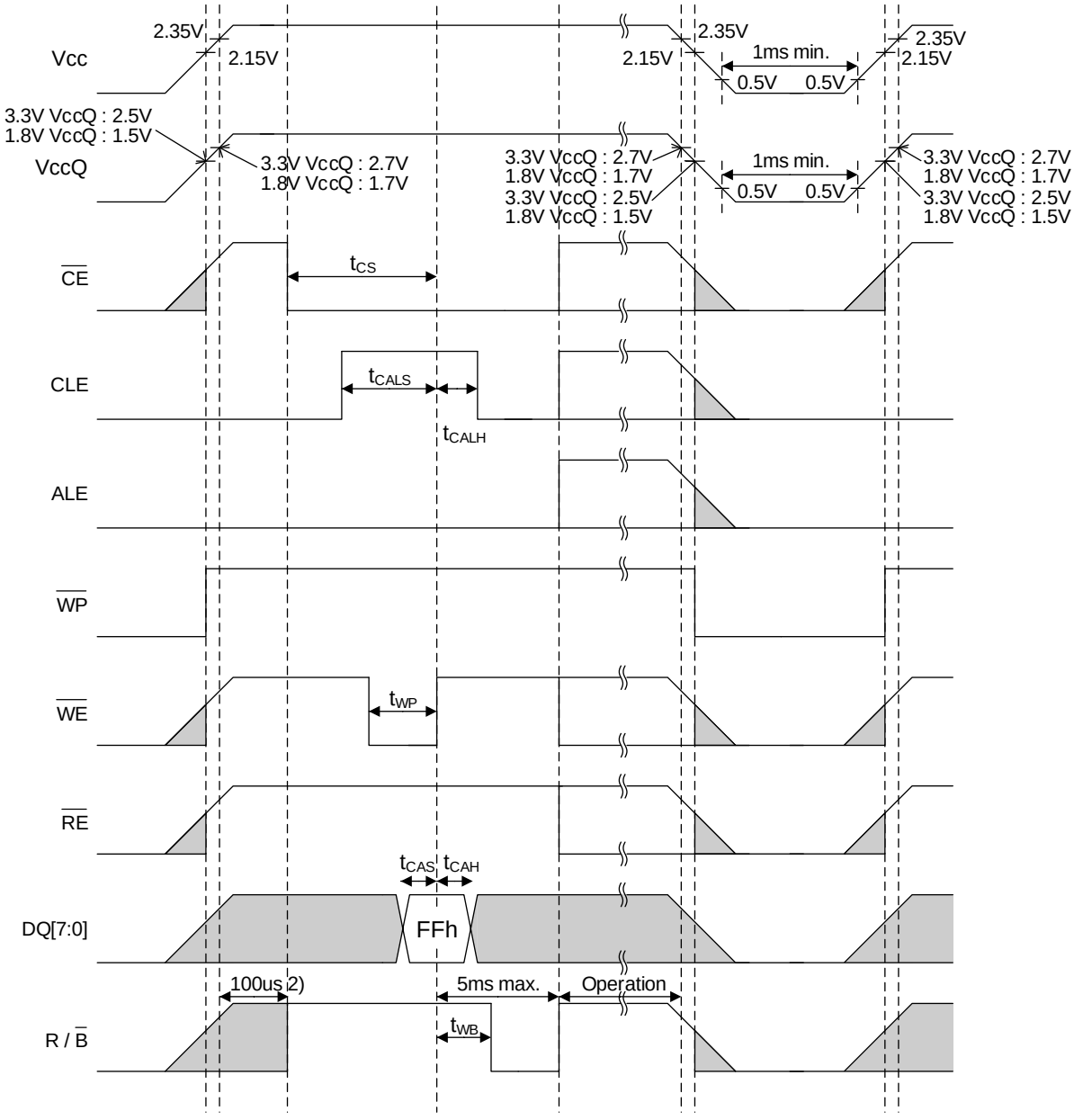


Figure 20. Initialization Timing

NOTE:
1) During the initialization, the device consumes a maximum current of Icc1.
2) The R/$\overline{B}$ signal becomes valid after 100us since Vcc reaches 2.35V and VccQ reaches 2.7V (1.7V for 1.8V VccQ).

4.1.2. V_{PP} Initialization

To enable V_{PP}, following conditions shall be satisfied:

- Vcc must be successfully ramped prior to the start of ramping V_{PP}.
- V_{PP} shall be ramped to meet its valid range prior to issuing the SET FEATURES (EFh) command to enable the V_{PP} functionality. The valid range is specified in Table 9 and Table 10.
- The SET FEATURES (EFh) command shall be issued after the device is successfully powered-on.
- Once V_{PP} is enabled, V_{PP} shall be maintained to keep the valid range.

Regarding power-down when V_{PP} is enabled, following conditions shall be satisfied:

- V_{PP} must go down to 0V before Vcc ramping down.
- The device shall not be turned to power-down during busy period.

4.1.3. Single Channel Discovery

Host shall set to 'Low' the $\overline{CE}$ which is to enable the target if connected, while all other $\overline{CE}$ are set to 'High'. Host shall then issue the Reset command (FFh) to the target. Following the reset, the host should then issue the Read ID command to the target. If the Host read out 6 cycles data by the Read ID command with address 00h, then the corresponding target is connected. If the ID values are not returned or any error is encountered within the sequence, then the corresponding target may not be connected properly and no further use of the target shall be done.

4.1.4. Dual Channel Discovery

If there are dual channel in a package, host should issue the Reset command (FFh) to both channels to initialize all LUNs. Note that the relationships are described between several $\overline{CE}$ and dual channels. See the Table 4 for further information.

The sequence of initialization is the same as the sequence for single channel discovery. Host shall set to 'Low' the $\overline{CE}$ which is to enable the target if connected, while all other $\overline{CE}$ are set to 'High'. Host shall then issue the Reset command (FFh) to the target. Following the reset, the host should then issue a Read ID command to the target. If the Host read out 6 cycles data by the Read ID command with address 00h, then the corresponding target is connected. If the ID values are not returned or any error is encountered within the sequence, then the corresponding target may not be connected properly and no further use of the target shall be done.

4.2. Mode Selection

Table 26 describes the bus state for the Toggle DDR. Command and address are all written through DQ's by bringing $\overline{WE}$ to low while $\overline{CE}$ is low. Those are 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 DQ pins. Host reads or writes data to the device using DQS signal. And data are latched on both falling and rising edges of DQS on data input.

Table 26 Mode Selection

CLE	ALE	$\overline{CE}$	$\overline{WE}$	$\overline{RE}$	DQS	$\overline{WP}$	Mode	
H	L	L	↑	H	X	X	Read Mode	Command Input
L	H	L	↑	H	X	X		Address Input(5 cycles)
H	L	L	↑	H	X	H	Write Mode	Command Input
L	H	L	↑	H	X	H		Address Input(5 cycles)
L	L	L	H	H	↓↑	H	Data Input	
L	L	L	H	↓↑	↓↑	X	Data Output	
X	X	X	X	H	X	X	During Read(Busy)	
X	X	X	X	X	X	H	During Program(Busy)	
X	X	X	X	X	X	H	During Erase(Busy)	
X	X	X	X	X	X	L	Write Protect	
X	X	H	X	X	X	H/L[3)]	Stand-by	
L	L	L	H	H	H/L	H	Bus Idle	

NOTE:

1) H indicates V_{IH}, and L indicates V_{IL}.
2) X can be V_{IL} or V_{IH}.
3) $\overline{WP}$ should be biased to CMOS high or CMOS low for standby.
4) $\overline{WP}$ shall be kept high if the sequence including 60h command is performed as specified in the relevant sections.

4.3. General Timing

4.3.1. Command Latch Cycle

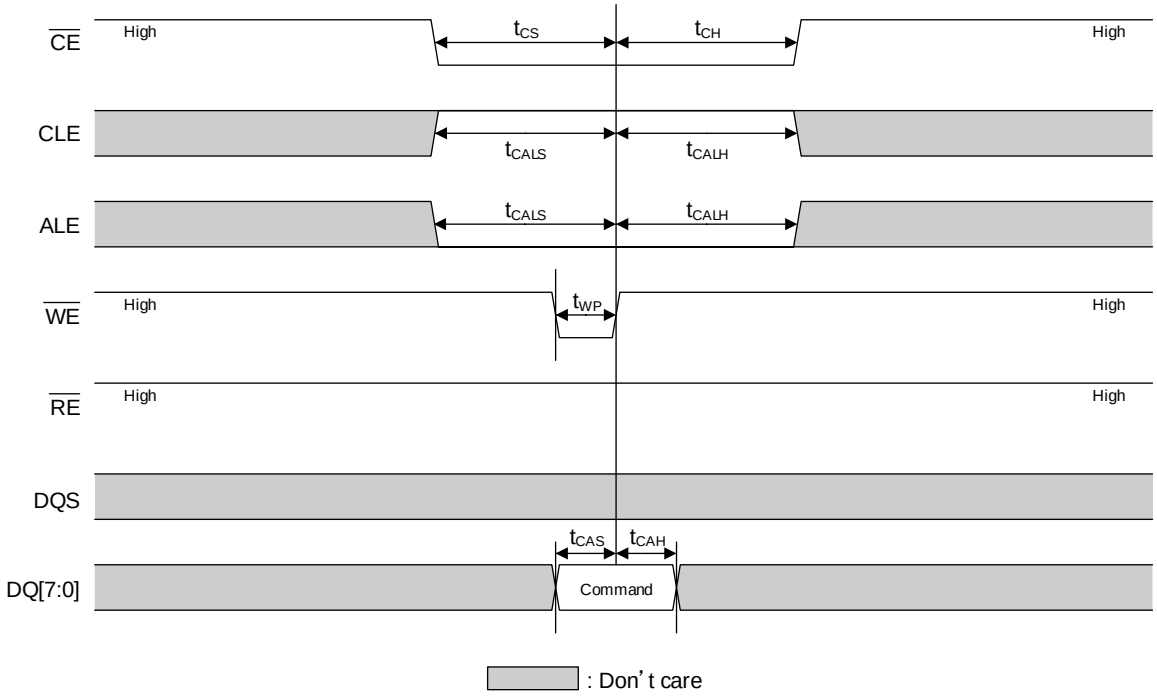


Figure 21. Command Latch Cycle Timing

NOTE :
Command Information is latched by $\overline{WE}$ going 'High', when $\overline{CE}$ is 'Low', CLE is 'High', and ALE is 'Low'.

4.3.2. Address Latch Cycle

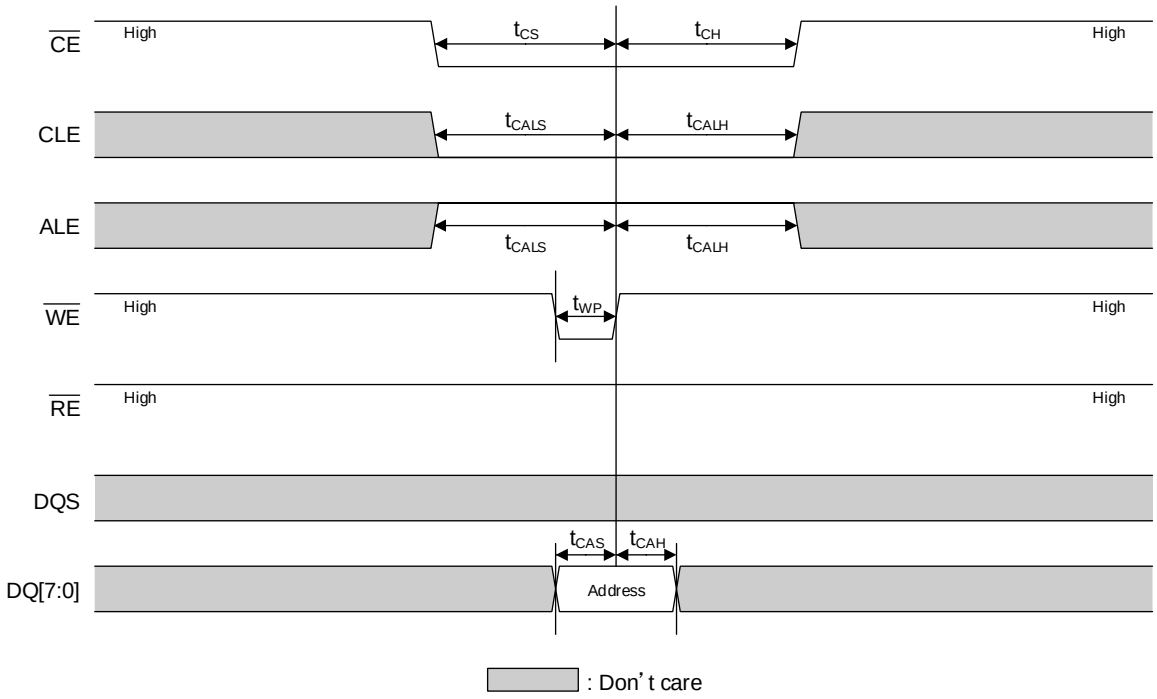


Figure 22. Address Latch Cycle Timing

NOTE :
Address Information is latched by $\overline{WE}$ going 'High', when $\overline{CE}$ is 'Low', CLE is 'Low', and ALE is 'High'.

4.3.3. Basic Data Input Timing

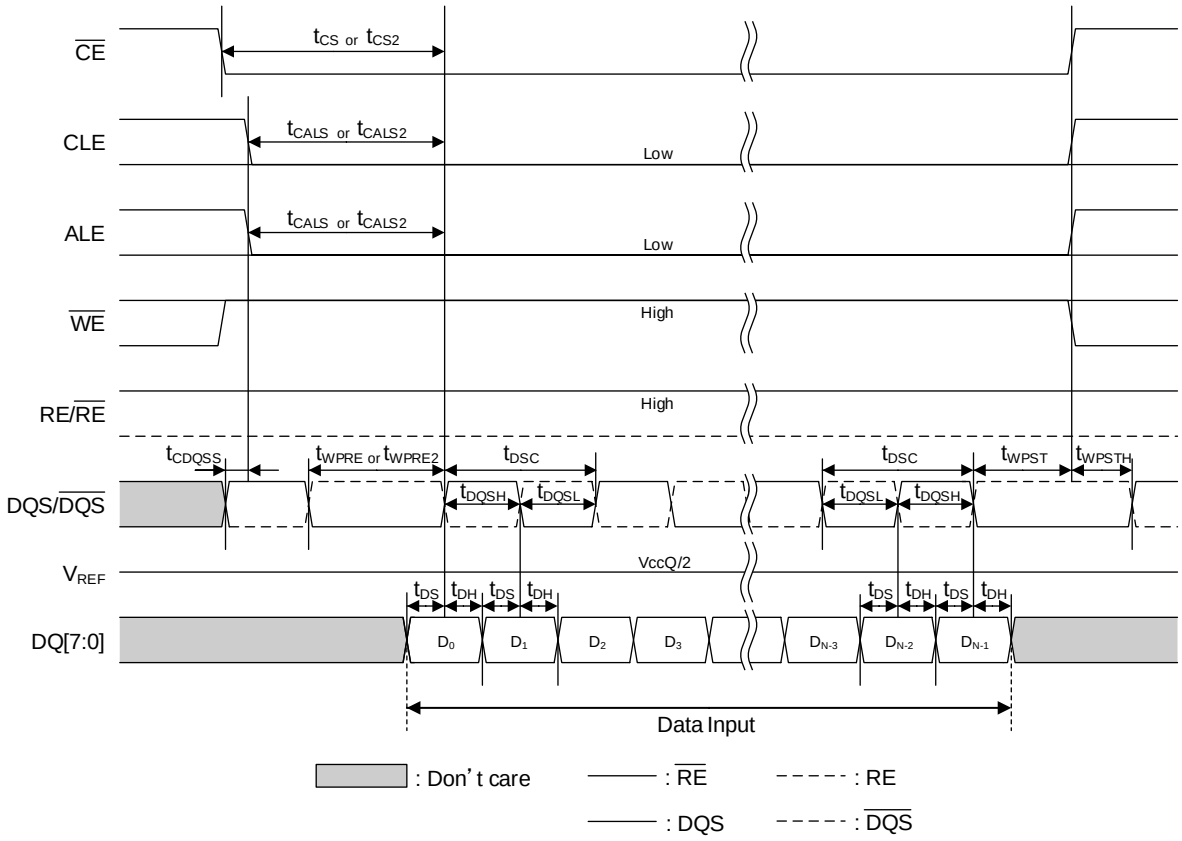


Figure 23. Basic Data Input Timing

NOTE:

1) DQS, $\overline{DQS}$ and Data input buffers are turned-on when $\overline{CE}$ and DQS goes 'Low' and Data inputs begin with DQS, $\overline{DQS}$ toggling simultaneously.
2) ALE and CLE should not toggle during t_{WPRE} period regardless of t_{CALS}.
3) DQS and Data input buffers are turned-off if either CLE or $\overline{CE}$ goes 'High'.
4) The least significant bit of the column address shall always be zero.
5) DQS shall be set to High before 80h command data-input condition is set.
6) DQS shall be set to High or Low before these commands(85h,10h or 15h) are input.

4.3.4. Basic Data Output Timing

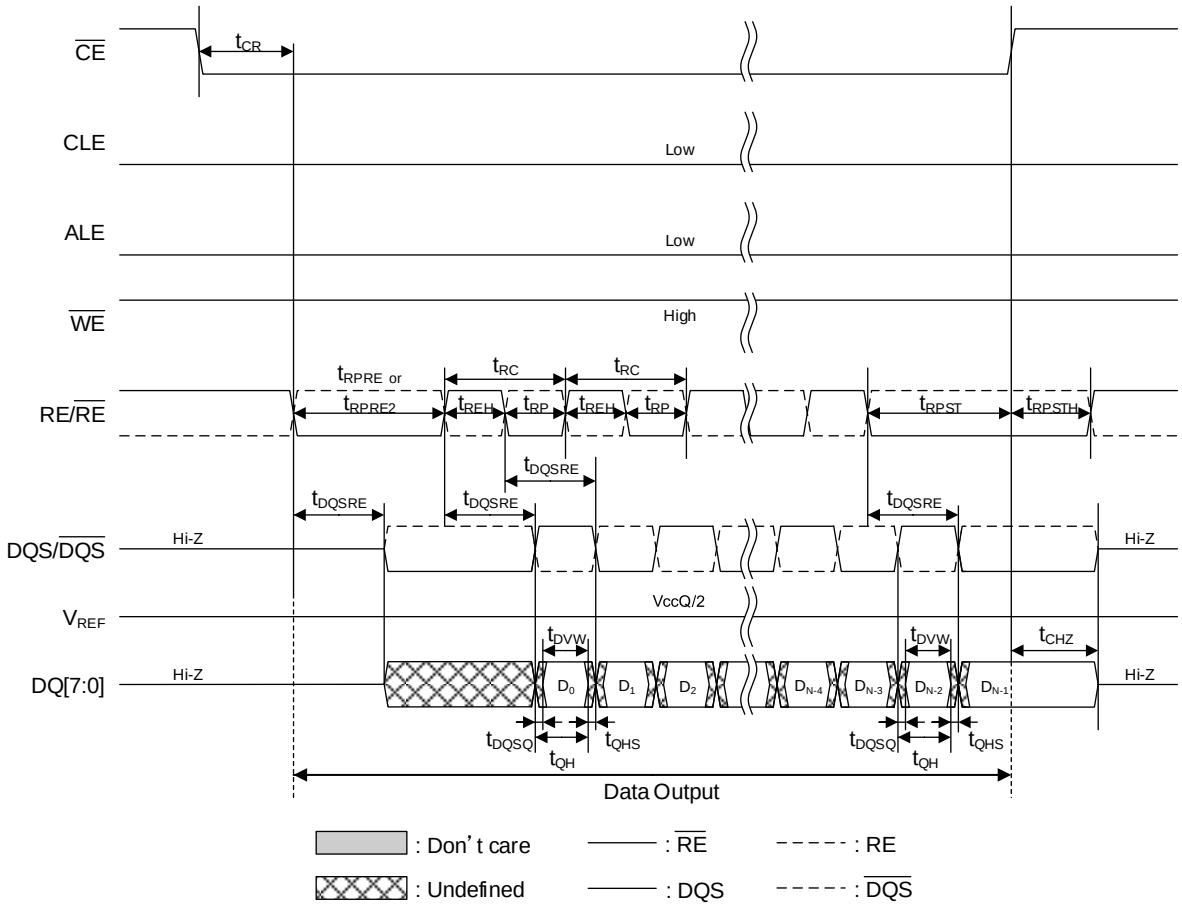


Figure 24. Basic Data Output Timing

NOTE:

1) DQS,DQS and DQ drivers are turned-on when CE and RE goes Low for data out operation.
2) ALE and CLE should not toggle during t_{RPRE} period regardless of t_{CALS}.
3) DQS and DQ drivers turn from valid to high-z if either CLE or CE goes high.
4) The least significant bit of the column address shall always be zero.

4.3.5. Bus Driving

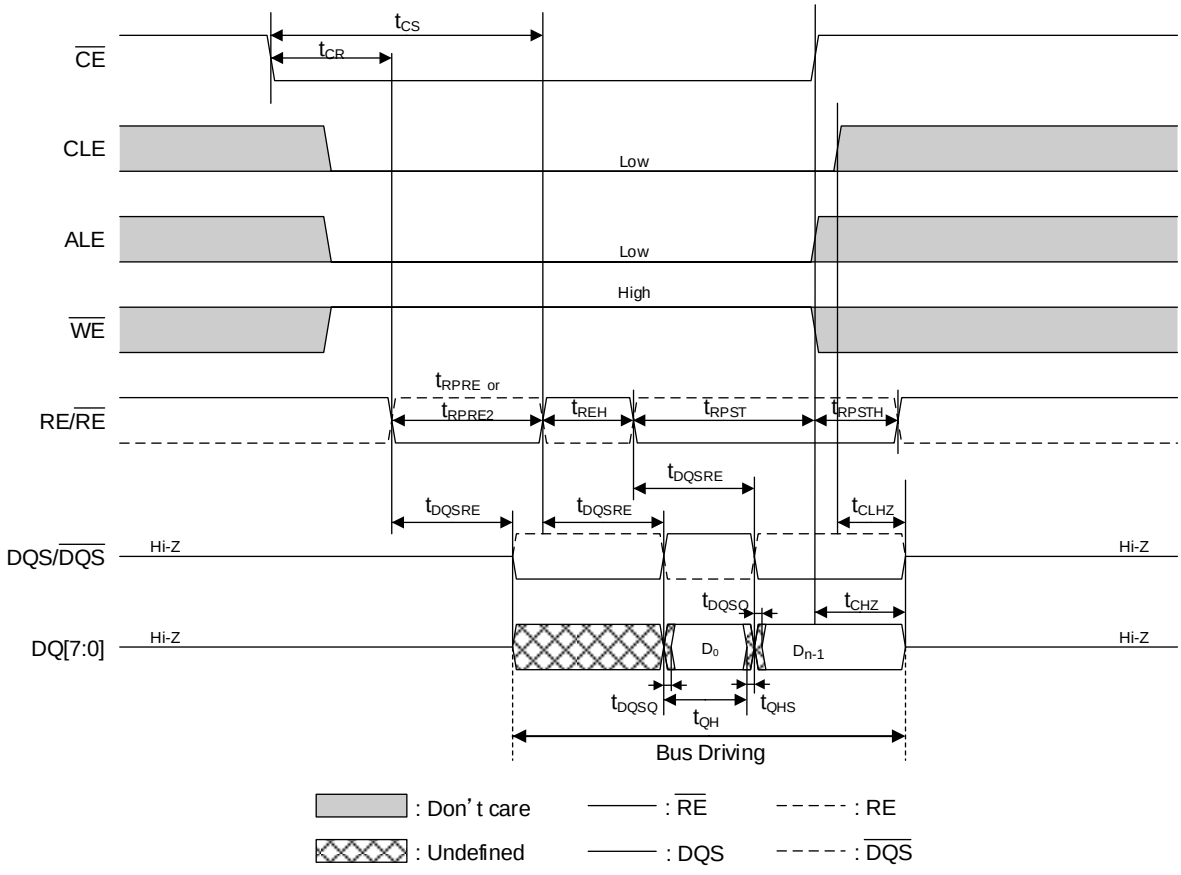


Figure 25. Bus Driving Timing

4.3.6. Read ID Operations

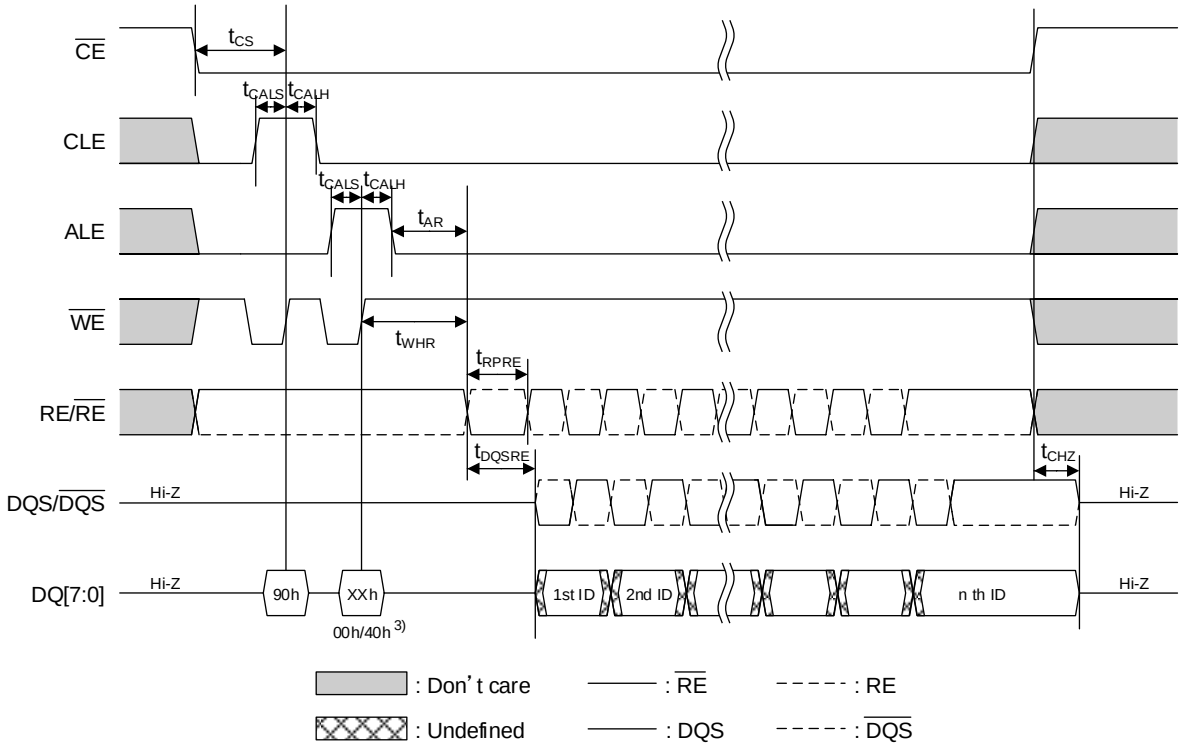


Figure 26. Read ID Operation Timing

NOTE:

1) Even though toggle-mode Flash Memory uses both low- and high-going edges of DQS for reads, READ ID operation repeats each data byte twice, so that READ ID timing becomes identical to that conventional Flash Memory
2) DQS and DQ drivers turn from valid to high-z when CE or CLE goes high.
3) Address 00h is for Toshiba conventional Flash Memory and 40h is for new JEDEC ID information.

4.3.7. Status Read Cycle

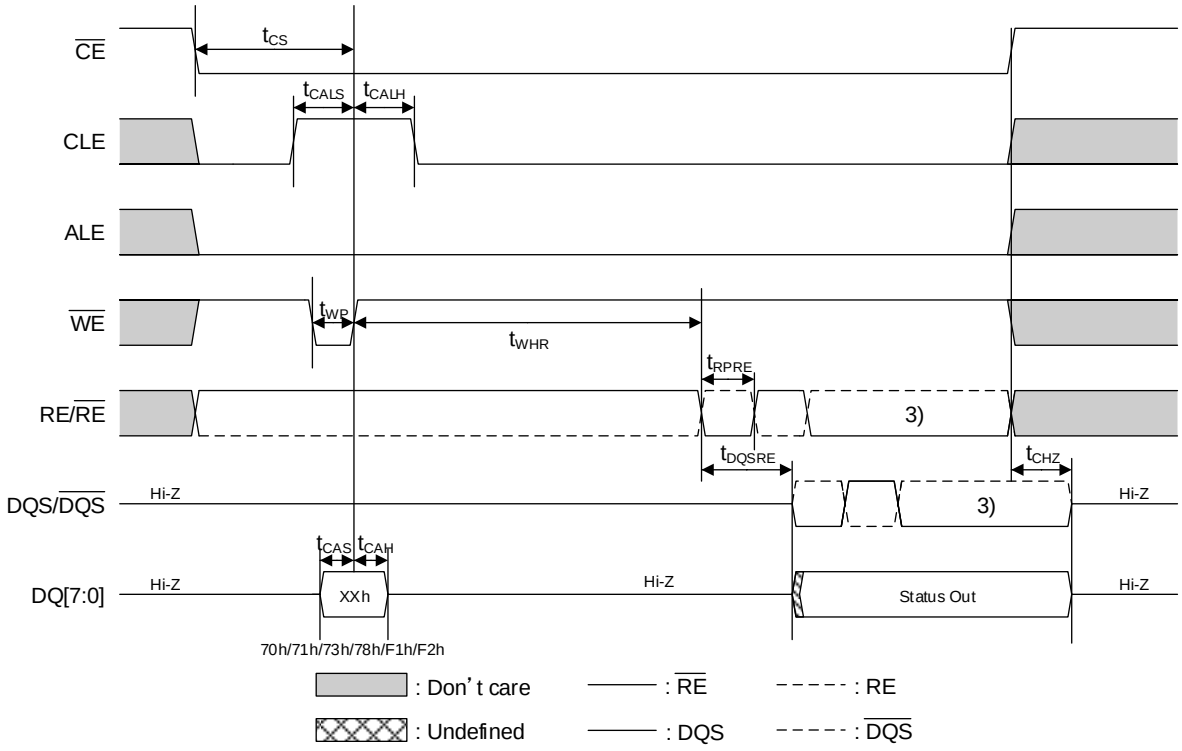


Figure 27. Status Read Cycle Timing

NOTE:

1) It is required that "Status read" outputs are read by using low- or high-going edges of DQS, although the output would repeat same value if the device internal status doesn't change.
2) DQS and Data out buffers turn from valid value to high-z when $\overline{CE}$ or $\overline{CLE}$ goes high.
3) $\overline{RE}$ can toggle more than once.
4) Read Status Enhanced command (78h) requires row address setting steps before reading status value although it is omitted in the above figure. tWHR is defined by /WE High to /RE Low after row address setting.

Status read cycle before toggle mode setting at power up sequence is below.

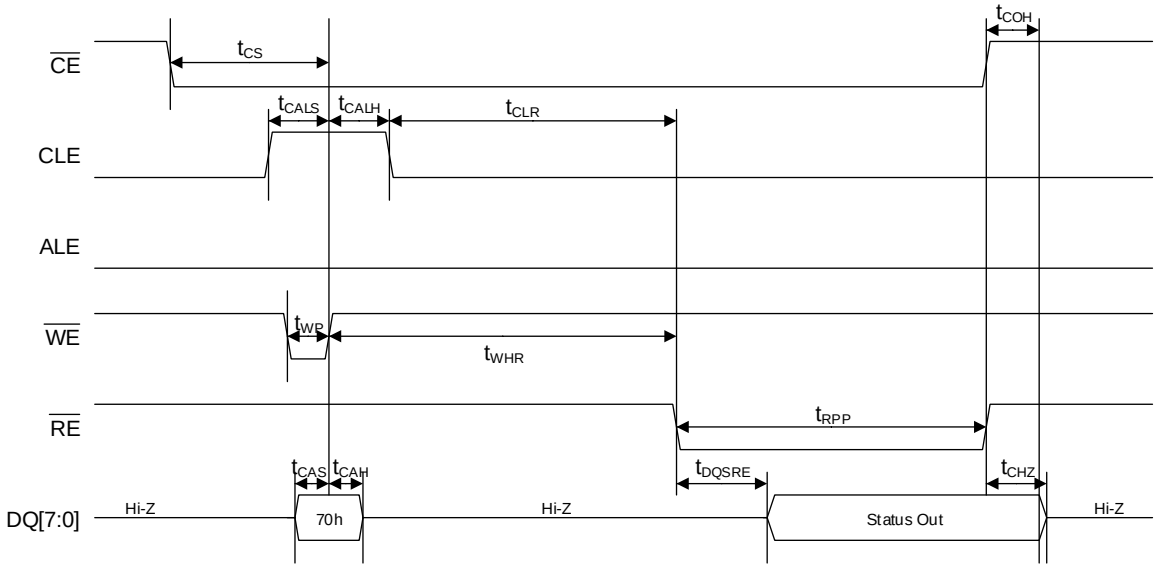


Figure 28. Status Read Cycle Timing before toggle mode setting at power up sequence.

4.3.8. Set Feature

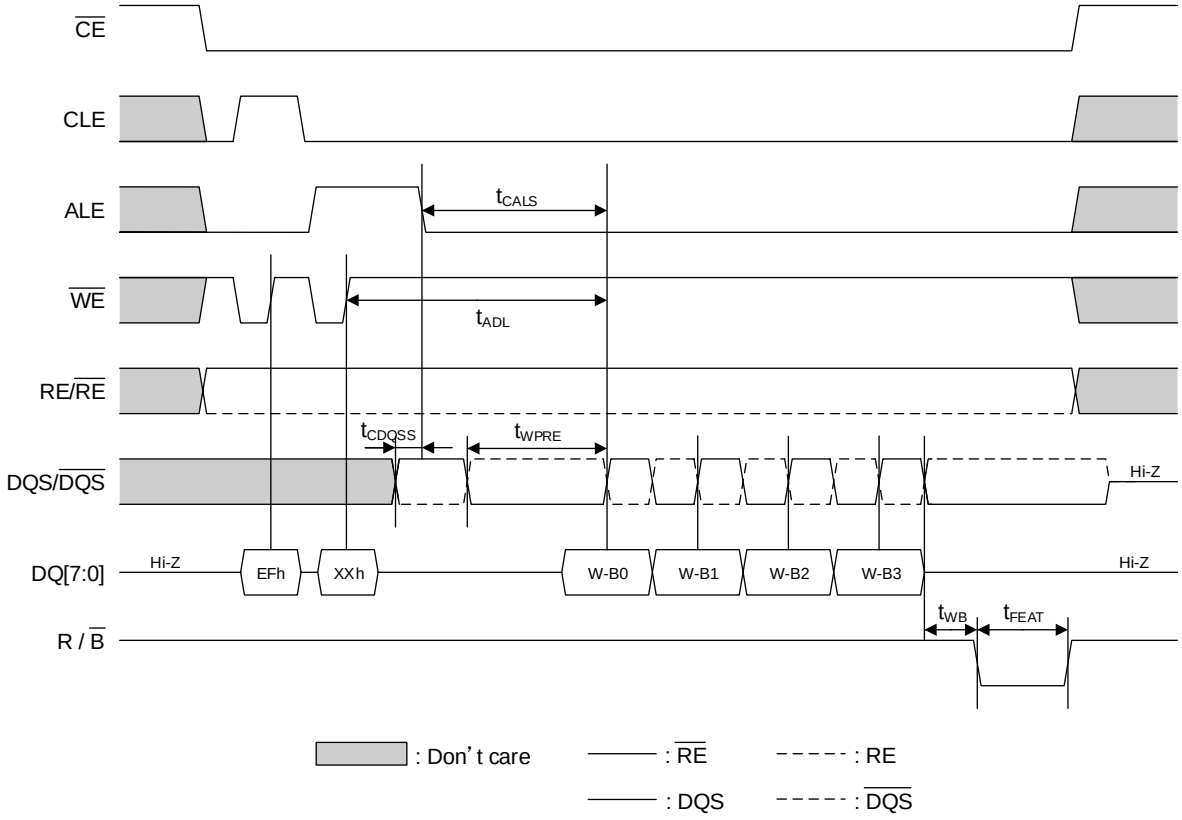


Figure 29. Set Feature Timing.

NOTE:
After Set Feature command is issued, $\overline{CE}$ shall be kept Low until the device becomes busy state.

4.3.9. Get Feature

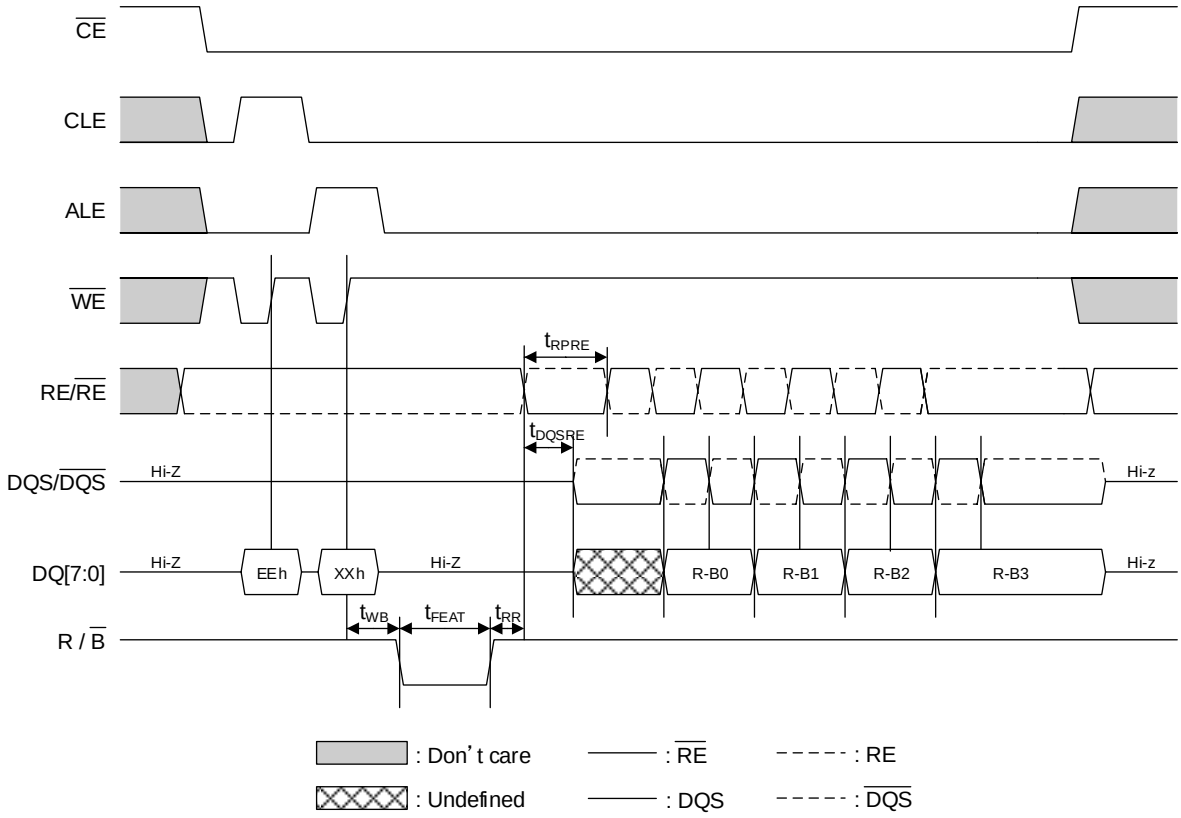


Figure 30. Get Feature Timing.

4.3.10. Page Read Operation

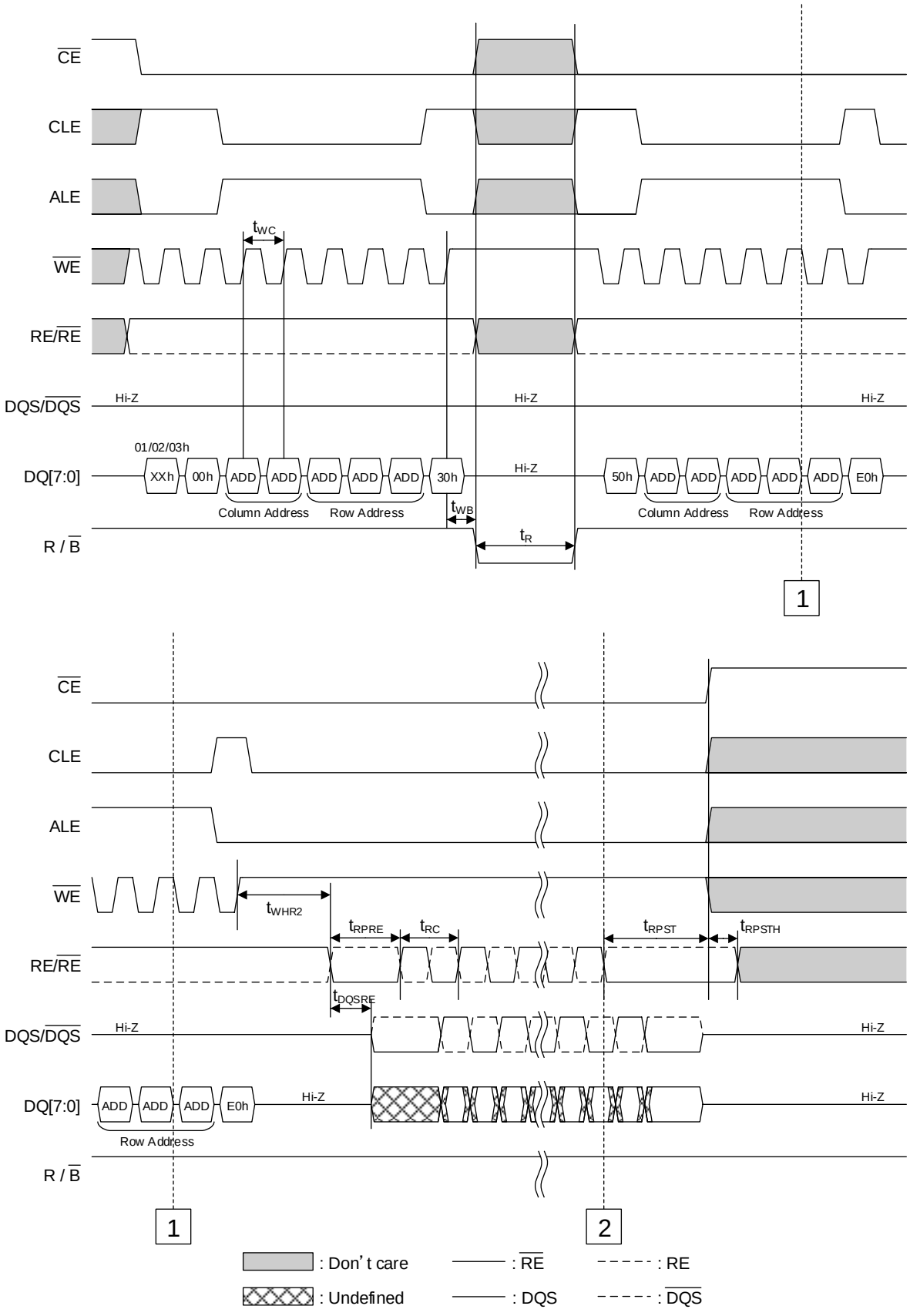


Figure 31. Page Read Operation Timing.

Read Hold Operation with $\overline{CE}$ High is below

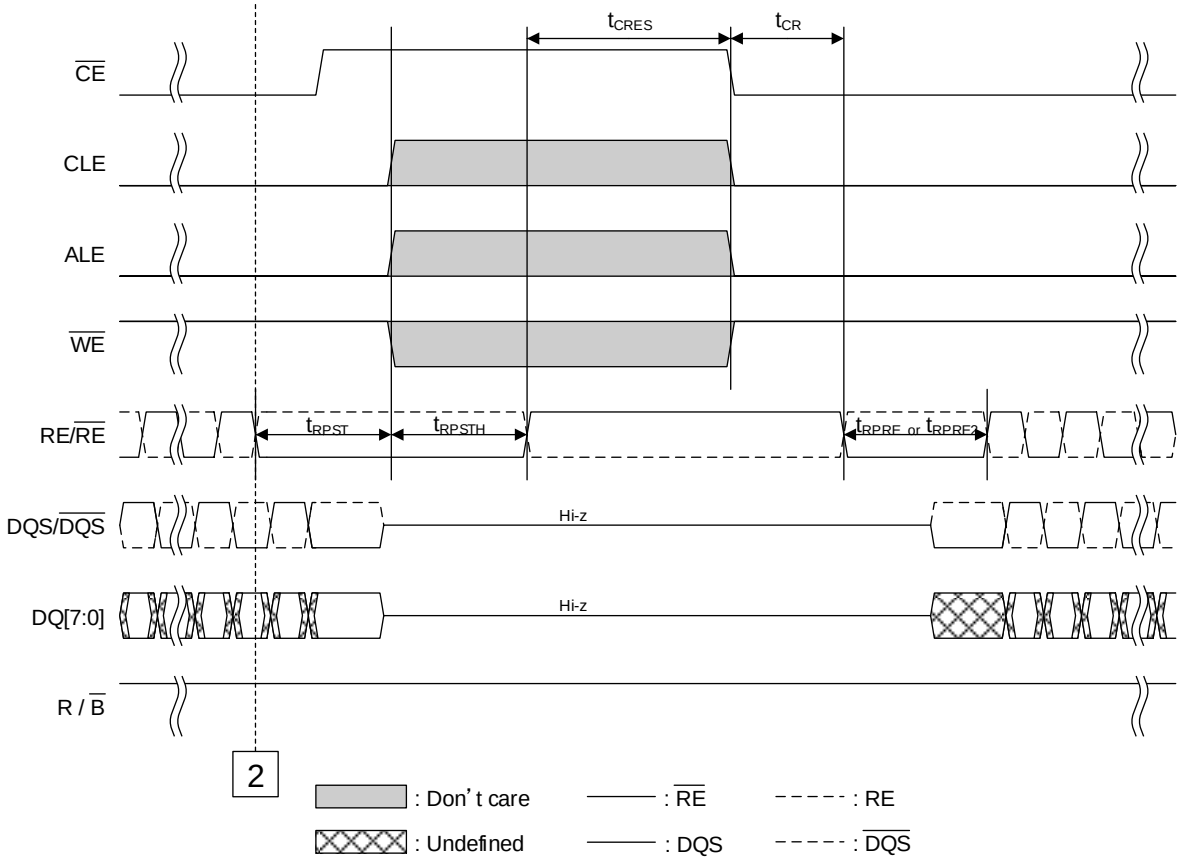
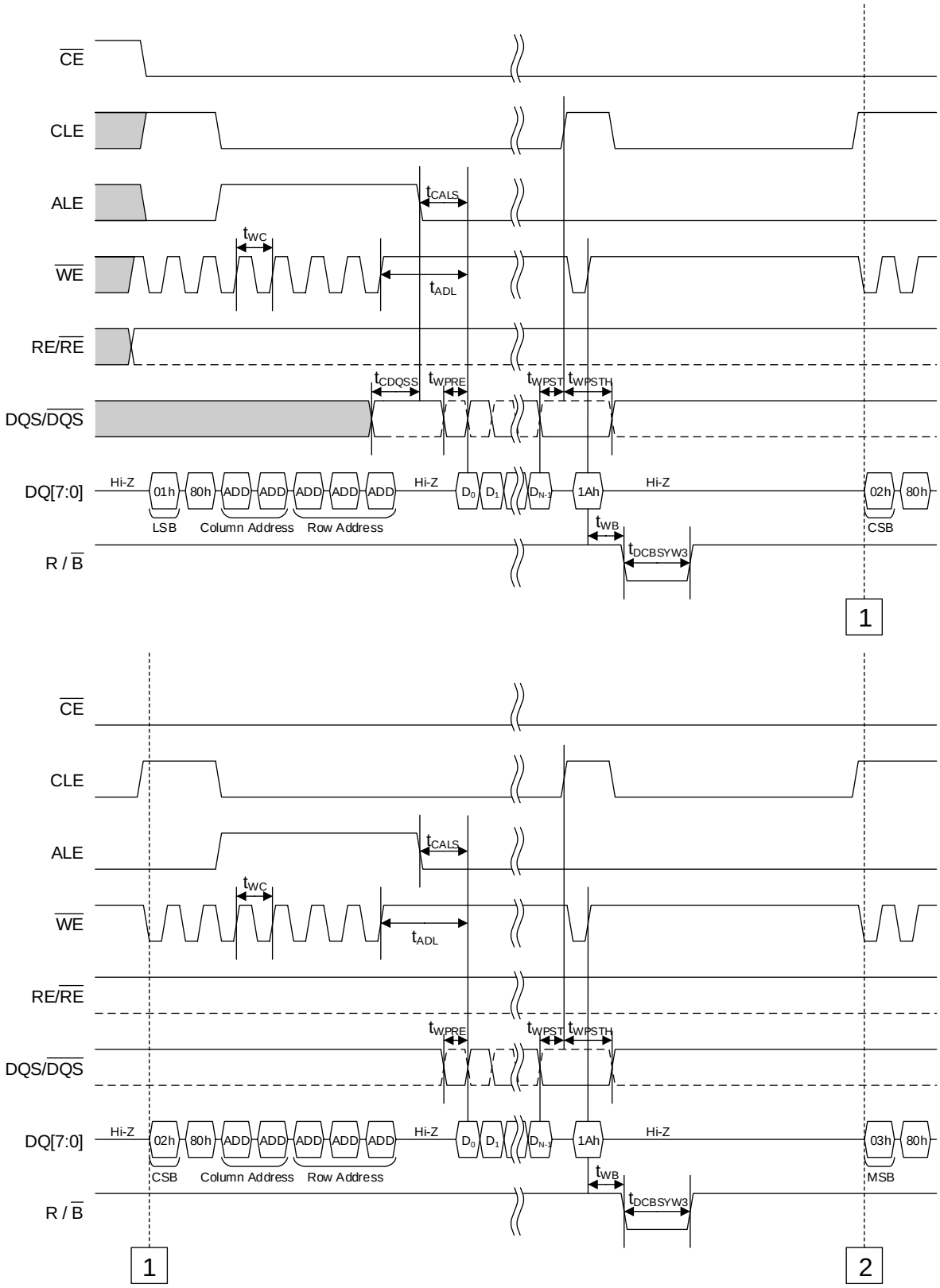


Figure 32. Read Hold Operation with $\overline{CE}$ high

4.3.11. Full Sequence Program Operation



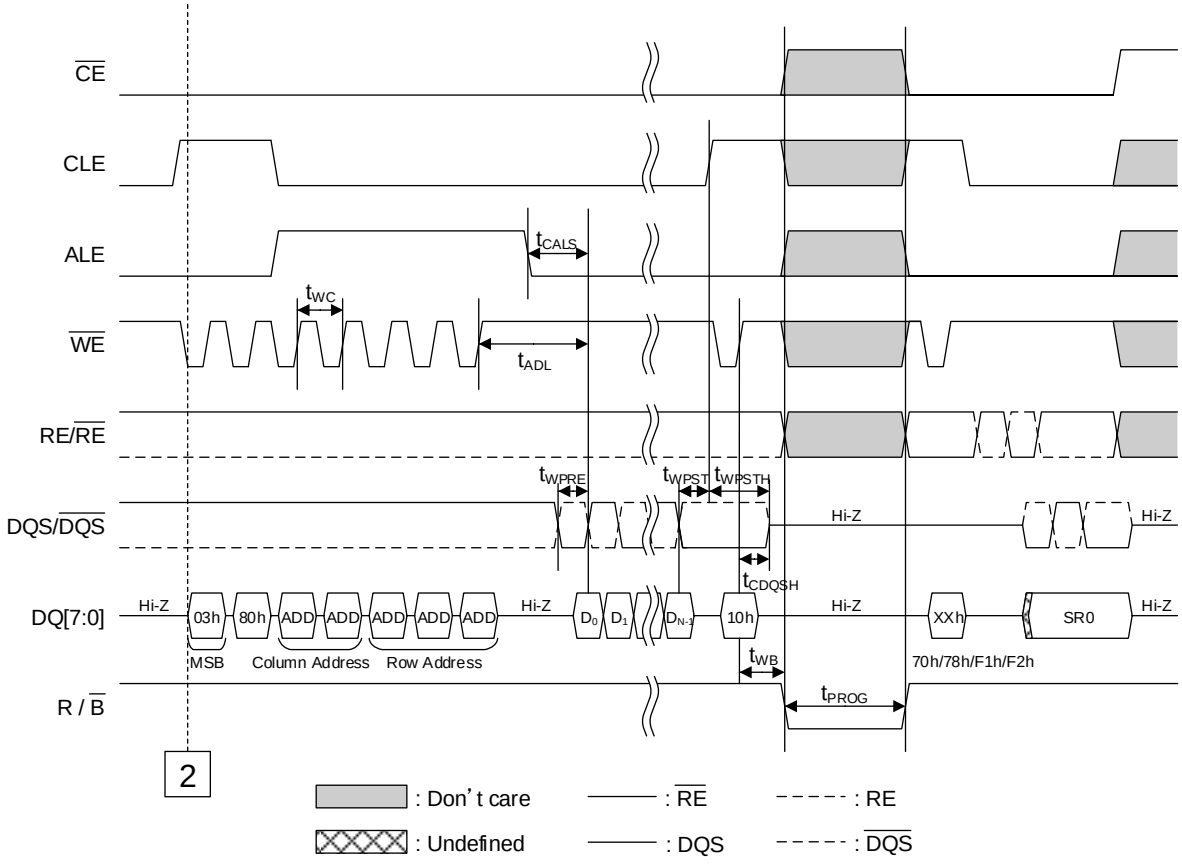
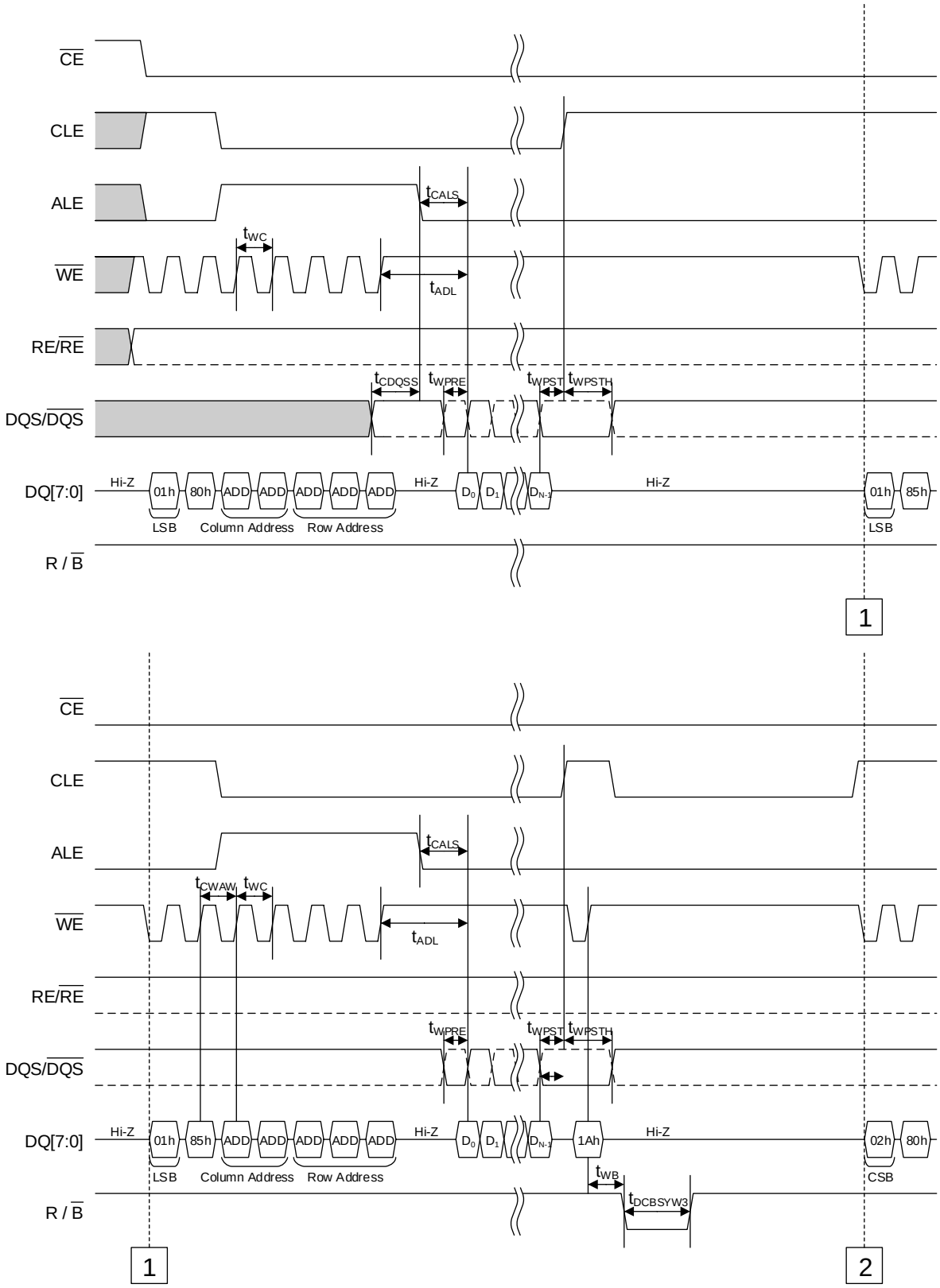


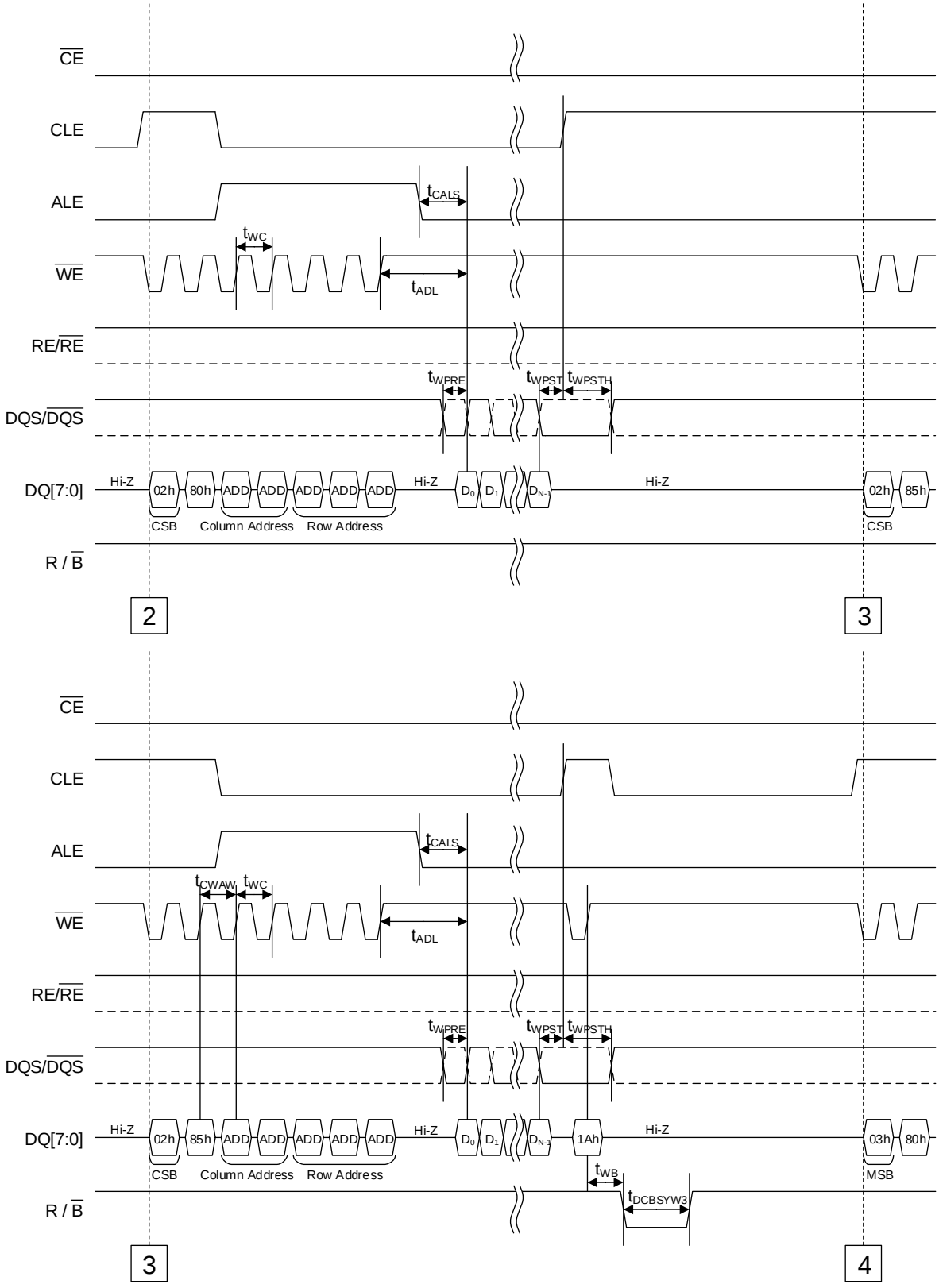
Figure 33. Full Sequence Program Operation Timing.

NOTE:

1) No address to distinguish LSB/CSB/MSB is assigned. Instead, page select command shall be issued just before 80h. 01h; LSB page, 02h; CSB page, 03h: MSB page.
2) Read Status Enhanced command (78h) requires row address setting steps before reading status value although it is omitted in the above figure.
3) DQS shall be set to High before data-input.

4.3.12. Full Sequence Program Operation with Random Data Input




CE
CLE
ALE
WE
RE/RE
DQS/DQS
DQ[7:0]
R / B
tCALS
tWC
tADL
tWPRE
tWPST
tWPSTH
Hi-Z
02h
80h
ADD
D0
D1
DN-1
85h
CSB
Column Address
Row Address
2
3
tCWAW
1Ah
03h
tWB
tDCBSYW3
MSB
4

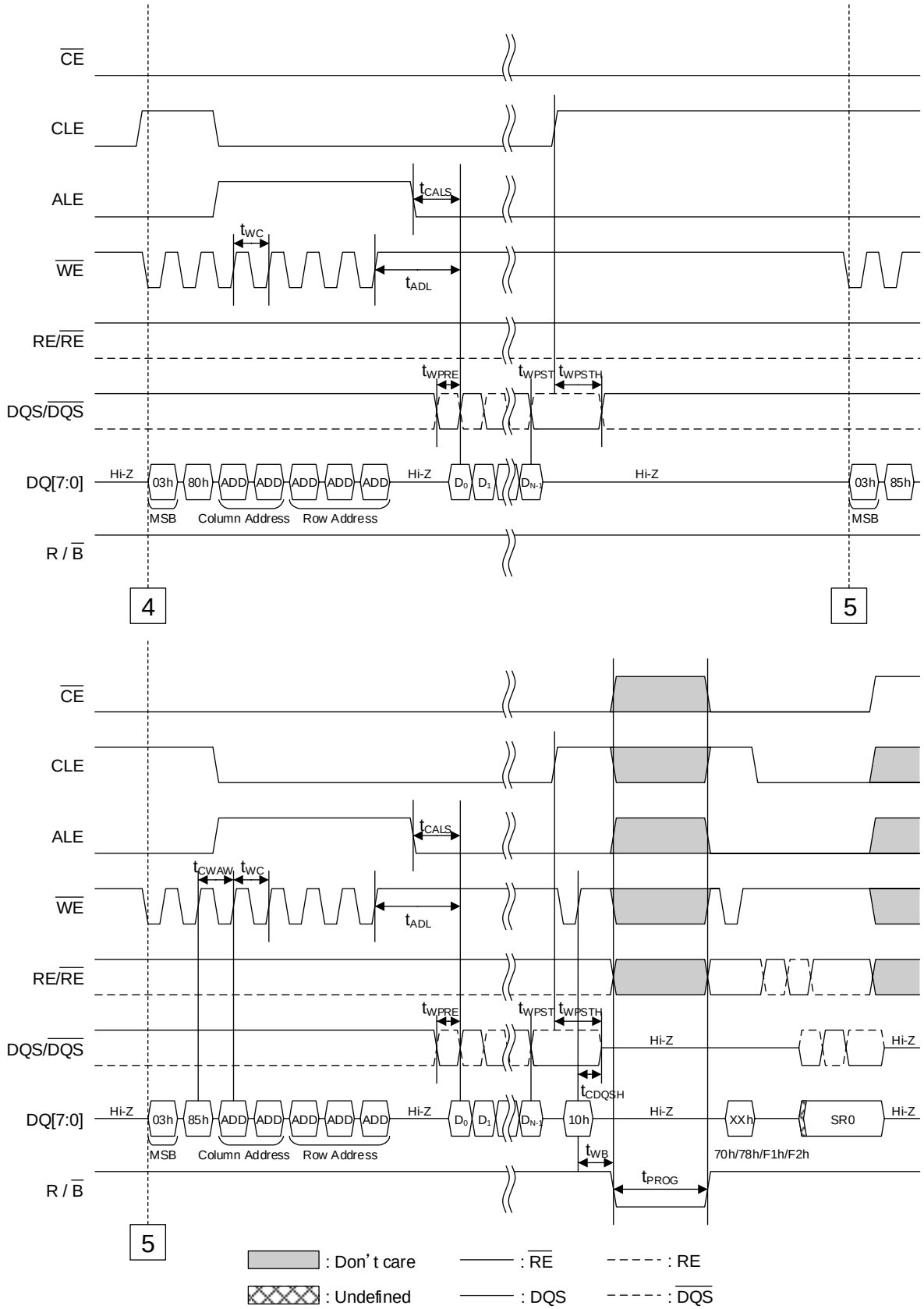


Figure 34. Full Sequence Program Operation with Random Data Input Timing.

NOTE:

1) No address to distinguish LSB/CSB/MSB is assigned. Instead, page select command shall be issued just before 80h. 01h; LSB page, 02h; CSB page, 03h: MSB page.
2) Read Status Enhanced command (78h) requires row address setting steps before reading status value although it is omitted in the above figure.
3) DQS shall be set to High before data-input.
4) DQS shall be maintained to High or Low until data-input of Random Data Input start.

4.4. AC Timing Characteristics

4.4.1. Timing Parameters Description

Table 27 Toggle DDR Timing Parameters Description

Parameter	Description
t_{R}	Data Transfer from Flash array to Register
t_{PROG}	Program Time
t_{BERASE}	Erase Time
t_{ADL}	Address to Data Loading Time
t_{AR}	ALE Low to $\overline{RE}$ Low
t_{CALH}	CLE/ALE Hold Time
t_{CALS}	CLE/ALE Setup Time
t_{CALS2}	CLE/ALE Setup Time when ODT is enabled
t_{CAH}	Command/Address Hold Time
t_{CAS}	Command/Address Setup Time
t_{CH}	$\overline{CE}$ Hold Time
t_{CDQSH}	DQS Hold Time for data input mode finish
t_{CDQSS}	DQS Setup Time for data input mode start
t_{CHZ}	$\overline{CE}$ High to Output Hi-Z
t_{CLHZ}	CLE High to Output Hi-Z
t_{CLR}	CLE to $\overline{RE}$ Low
t_{COH}	Data Hold Time after $\overline{CE}$ disable
t_{CR}	$\overline{CE}$ Low to $\overline{RE}$ Low
t_{CRES}	$\overline{RE}$ Setup Time before $\overline{CE}$ Low
t_{CS}	$\overline{CE}$ Setup Time
t_{CS2}	$\overline{CE}$ Setup Time when ODT is enabled
t_{CWAW}	Command Write Cycle to Address Write Cycle Time for Random Data Input
t_{DH}	Data Hold Time
t_{DQSH}	DQS Input High Pulse Width
t_{DQSL}	DQS Input Low Pulse Width
t_{DQSQ}	Output skew among data output and corresponding DQS
t_{DQSRE}	$\overline{RE}$ to DQS and DQ delay
t_{DSC}	Data Strobe Cycle Time
t_{DS}	Data Setup Time
t_{DVW}	Output data valid window
t_{FEAT}	Busy time for Set Feature and Get Feature
t_{QH}	Output hold time from DQS
t_{QHS}	DQS hold skew factor
t_{RC}	Read Cycle Time
t_{REH}	$\overline{RE}$ High pulse width
t_{RP}	$\overline{RE}$ Low pulse width
t_{RPP}	$\overline{RE}$ Low pulse width for Read Status at Power-up sequence
t_{RPRE}	Read Preamble
t_{RPRE2}	Read Preamble when ODT is enabled
t_{RPST}	Read Postamble
t_{RPSTH}	Read Postamble Hold Time
t_{RR}	Ready to $\overline{RE}$ Low
t_{RST}	Device Resetting Time(Read/Program/Erase)
t_{WB}	$\overline{WE}$ High to Busy
t_{WC}	Write Cycle Time
t_{WH}	$\overline{WE}$ High pulse width
t_{WHR}	$\overline{WE}$ High to $\overline{RE}$ Low
t_{WHR2}	$\overline{WE}$ High to $\overline{RE}$ Low for Random data output
t_{WP}	$\overline{WE}$ Low pulse Width

t_{WPRE}	Write Preamble
t_{WPRE2}	Write Preamble when ODT is enabled
t_{WPST}	Write Postamble
t_{WPSTH}	Write Postamble Hold Time
t_{WW}	$\overline{WP}$ High/Low to $\overline{WE}$ low
$t_{DCBSYW1}$	Data Cache Busy Time in Write Cache (following 11h or 32h)
$t_{DCBSYW2}$	Data Cache Busy Time in Write Cache (following 15h)
$t_{DCBSYW3}$	Data Cache Busy Time in Write Cache (following 1Ah)
t_{DCBSYR}	Cache Busy in Read Cache

4.4.2. Timing Parameters Table

Table 28 AC Timing Characteristics

Parameter	Symbol	100Mhz		133Mhz		166Mhz		200Mhz		Unit
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
Address to Data Loading Time	t_{ADL}	300	-	300	-	300	-	300	-	ns
ALE Low to $\overline{RE}$ Low	t_{AR}	10	-	10	-	10	-	10	-	ns
CLE/ALE Hold Time	t_{CALH}	5	-	5	-	5	-	5	-	ns
CLE/ALE Setup Time	t_{CALS}	15	-	15	-	15	-	15	-	ns
CLE/ALE Setup Time when ODT is enabled	t_{CALS2}	25	-	25	-	25	-	25	-	ns
Command/Address Hold Time	t_{CAH}	5	-	5	-	5	-	5	-	ns
Command/Address Setup Time	t_{CAS}	5	-	5	-	5	-	5	-	ns
DQS Hold Time for data input mode finish	t_{CDQSH}	100	-	100	-	100	-	100	-	ns
DQS Setup Time for data input mode start	t_{CDQSS}	100	-	100	-	100	-	100	-	ns
$\overline{CE}$ Hold Time	t_{CH}	5	-	5	-	5	-	5	-	ns
$\overline{CE}$ High to Output Hi-Z	t_{CHZ}	-	30	-	30	-	30	-	30	ns
CLE High to Output Hi-Z	t_{CLHZ}	-	30	-	30	-	30	-	30	ns
CLE to RE Low	t_{CLR}	10	-	10	-	10	-	10	-	ns
Data Hold Time after CE disable	t_{COH}	5	-	5	-	5	-	5	-	ns
$\overline{CE}$ Low to $\overline{RE}$ Low	t_{CR}	10	-	10	-	10	-	10	-	ns
$\overline{RE}$ Setup Time before $\overline{CE}$ Low	t_{CRES}	10	-	10	-	10	-	10	-	ns
$\overline{CE}$ Setup Time	t_{CS}	20	-	20	-	20	-	20	-	ns
$\overline{CE}$ Setup Time when ODT is enabled	t_{CS2}	30	-	30	-	30	-	30	-	ns
Command Write cycle to Address Write cycle Time for Random data input	t_{CWAW}	300	-	300	-	300	-	300	-	ns
Data Hold Time	t_{DH}	0.9	-	0.75	-	0.55	-	0.4	-	ns
DQS Input High Pulse Width	t_{DQSH}	0.4*t_{DSC}	-	0.4*t_{DSC}	-	0.4*t_{DSC}	-	0.4*t_{DSC}	-	ns
DQS Input Low Pulse Width	t_{DQSL}	0.4*t_{DSC}	-	0.4*t_{DSC}	-	0.4*t_{DSC}	-	0.4*t_{DSC}	-	ns
Output skew among data output and corresponding DQS	t_{DQSQ}	-	0.8	-	0.6	-	0.5	-	0.4	ns
$\overline{RE}$ to DQS and DQ delay	t_{DQSRE}	-	25	-	25	-	25	-	25	ns
Data Strobe Cycle Time	t_{DSC}	10	-	7.5	-	6	-	5	-	ns
Data Setup Time	t_{DS}	0.9	-	0.75	-	0.55	-	0.4	-	ns
Output data valid window	t_{DVW}	$t_{DVW} = t_{QH} — t_{DQSQ}$								ns
Busy time for Set Feature and Get Feature	t_{FEAT}	-	1	-	1	-	1	-	1	µs
Output hold time from DQS	t_{QH}	$t_{QH} = \min[t_{REH}, t_{RP}] — t_{QHS}$								ns
DQS hold skew factor	t_{QHS}	-	0.8	.-	0.6	-	0.5	-	0.4	ns
Read Cycle Time	t_{RC}	10	-	7.5	-	6	-	5	-	ns
$\overline{RE}$ High pulse width	t_{REH}	0.4*t_{RC}	-	0.4*t_{RC}	-	0.4*t_{RC}	-	0.4*t_{RC}	-	ns
$\overline{RE}$ Low pulse width	t_{RP}	0.4*t_{RC}	-	0.4*t_{RC}	-	0.4*t_{RC}	-	0.4*t_{RC}	-	ns
RE Low pulse width for Read Status at Power-up sequence	t_{RPP}	30	-	30	-	30	-	30	-	ns
Read Preamble	t_{RPRE}	15	-	15	-	15	-	15	-	ns
Read Preamble when ODT is enabled	t_{RPRE2}	25	-	25	-	25	-	25	-	ns
Read Postamble	t_{RPST}	t_{DQSRE} +0.5*t_{RC}	-	t_{DQSRE} +0.5*t_{RC}	-	t_{DQSRE} +0.5*t_{RC}	-	t_{DQSRE} +0.5*t_{RC}	-	ns
Read Postamble Hold Time	t_{RPSTH}	25	-	25	-	25	-	25	-	ns
Ready to $\overline{RE}$ Low	t_{RR}	5	-	5	-	5	-	5	-	ns
Device Resetting Time (Read/Program/Erase)	t_{RST}	-	10 /30 /100	-	10 /30 /100	-	10 /30 /100	-	10 /30 /100	µs
$\overline{WE}$ High to Busy	t_{WB}	-	100	-	100	-	100	-	100	ns
Write Cycle Time	t_{WC}	25	-	25	-	25	-	25	-	ns
$\overline{WE}$ High pulse width	t_{WH}	11	-	11	-	11	-	11	-	ns
$\overline{WE}$ High to $\overline{RE}$ Low	t_{WHR}	120	-	120	-	120	-	120	-	ns
$\overline{WE}$ High to $\overline{RE}$ Low for Random data output	t_{WHR2}	300	-	300	-	300	-	300	-	ns

$\overline{WE}$ Low pulse Width	t_{WP}	11	-	11	-	11	-	11	-	ns
Write Preamble	t_{WPRE}	15	-	15	-	15	-	15	-	ns
Write Preamble when ODT is enabled	t_{WPRE2}	25	-	25	-	25	-	25	-	ns
Write Postamble	t_{WPST}	6.5	-	6.5	-	6.5	-	6.5	-	ns
Write Postamble Hold Time	t_{WPSTH}	25	-	25	-	25	-	25	-	ns
$\overline{WP}$ High/Low to $\overline{WE}$ low	t_{WW}	100	-	100	-	100	-	100	-	ns

Table 29 AC Test Conditions

Parameter	Single-ended signaling	Single-ended signaling with V_{REF}	Differential signaling
Positive input transition	V_{IL}(DC) to V_{IH}(AC)	V_{IL}(DC) to V_{IH}(AC)	V_{IL}(DC) to V_{IH}(AC)
Negative input transition	V_{IH}(DC) to V_{IL}(AC)	V_{IH}(DC) to V_{IL}(AC)	V_{IL}(DC) to V_{IH}(AC)
Input Rise and Fall Times	1.0V/ns	1.0V/ns	1.0V/ns
Input and Output Timing Levels	VccQ/2	V_{REF}	crosspoint
Output Load	50 Ohms to Vtt (Vtt=0.5*VccQ)	50 Ohms to Vtt (Vtt=0.5*VccQ)	50 Ohms to Vtt (Vtt=0.5*VccQ)

NOTE :

V_{REF} and Differential signaling are used if transfer rate is greater than 100MHz.

Table 30 Read/Program/Erase Timing Characteristics

Description	Parameter	Typ.	Max.	Unit
Data Transfer from Cell to Register	t_R	67	100	µs
Programming Time	t_{PROG}	3.1	11	ms
Block Erasing Time	t_{BERASE}	10	25	ms
Data Cache Busy Time in Write Cache (following 11h or 32h)	$t_{DCBSYW1}$	0.6	1	µs
Data Cache Busy Time in Write Cache (following 15h)	$t_{DCBSYW2}$	-	8	ms
Data Cache Busy Time in Write Cache (following 1Ah, non-cache program operation)	$t_{DCBSYW3}$	-	15	µs
Data Cache Busy Time in Write Cache (following 1Ah, cache program operation)	$t_{DCBSYW3}$	-	8	ms
Cache Busy in Read Cache	t_{DCBSYR}	-	105	µs

NOTE :

1) t_{PROG} is the internal program time from a cache or page register to Flash Memory array. t_R is the internal loading time from Flash Memory array to the a cache or page register.
2) $t_{DCBSYW2}$, $t_{DCBSYW3}$ depends on the timing between internal programming time and data in time.
3) t_{PROG}, $t_{DCBSYW2}$ and $t_{DCBSYW3}$ are the average busy time in a block.

5. COMMAND DESCRIPTION AND DEVICE OPERATION

5.1. Basic Command Sets

Toggle DDR Flash Memory has addresses multiplexed into 8 I/Os. Command and address are all written through DQ [7:0] by bringing $\overline{WE}$ to low while $\overline{CE}$ is low. Those are 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 DQ[7:0] pins. Commands which apply to a specific page, WL or block typically have a second command and ones that apply to a target or a LUN have a first command only.
Table 31 below defines the basic command sets.

Table 31 Basic Command Sets

Function	Primary or Secondary	1st Set	Address Cycles	2nd Set	Acceptable while Accessed LUN is Busy	Acceptable while Other LUNs are Busy
LSB Page Select [2)]	-	01h	-	-		
CSB Page Select [2)]	-	02h	-	-		
MSB Page Select [2)]	-	03h	-	-		
Page Read	Primary	00h	5	30h		Y
Read Start for Last Page Cache Read	Primary	3Fh	-	-		
Random Cache Read	Primary	00h	5	31h		
Full Sequence Program	N/A	80h-1Ah	5	80h-10h		Y
Cache Full Sequence Program	N/A	80h-1Ah	5	80h-15h or 80h-10h		
Block Erase	Primary	60h	3	D0h		Y
Random Data Input [1)]	Primary	85h	5	-		Y
Random Data Output [1)]	Primary	05h	5	E0h		Y
Set Feature	Primary	EFh	1	-		
Get Feature	Primary	EEh	1	-		
Read ID	Primary	90h	1	-		
Read Status	Primary	70h	-	-	Y	Y
Read Status 2	Primary	71h	-	-	Y	Y
Read Status 3	Primary	73h	-	-	Y	Y
Reset	Primary	FFh	-	-	Y	Y
Reset LUN	-	FAh	3	-	Y	Y

NOTE:
1) Random Data Input/Output can be executed in a page.
2) 01/02/03h command is needed for definition of LSB/CSB/MSB page.

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

5.2. Basic Operation

5.2.1. Page Read Operation

The Page Read function reads a page of data identified by row address for the selected LUN. The page of data is made available to be read from the page register starting at the specified column address. Figure 35 defines the Page Read behavior and timings. Reading beyond the end of a page results in indeterminate values being returned to the host.

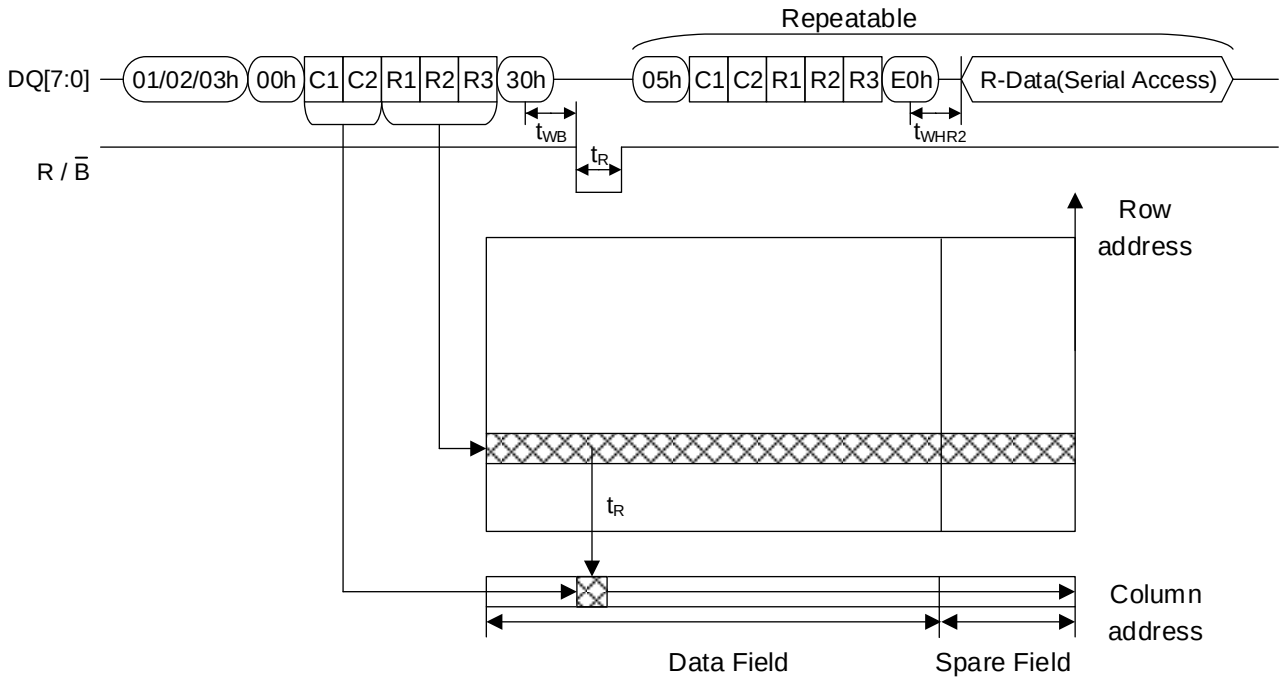


Figure 35. Page Read Timing

5.2.1.1. Page Read Operation with Random Data Output

The Random Data Output function changes the column address from which data is being read in the page register for the selected LUN. The Random Data Output command shall only be issued when the LUN is in a read idle condition. Figure 36 defines the Random Data Output behavior and timings. The host shall not read data from the LUN until t_{WHR2}(ns) after the second(i.e. E0h) is written to the LUN.

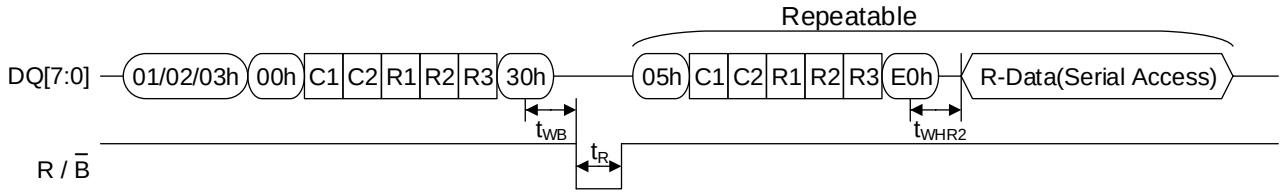


Figure 36. Page Read with Random Data Output Timing

5.2.1.2. Data Out After Status Read

While monitoring the read status to determine when the t_R (transfer from Flash array to a page register) is complete, the host shall perform the random data output sequence. Issuing the random data output sequence will cause data to be returned starting at the selected column address.

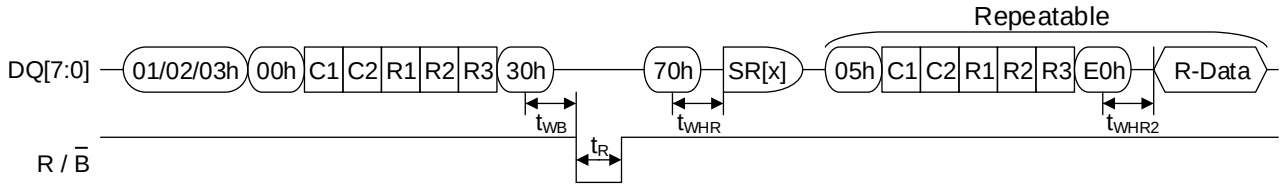


Figure 37. Data Out After Status Read Timing

5.2.2. Random Cache Read Operation

The Random Cache Read operation permits a page to be read from the page register while another page is simultaneously read from the Flash array for the selected LUN. A Read Page command shall be issued prior to the initial Random Cache Read command in a cache read sequence. A Random Cache Read command shall be issued prior to the Read Start for Last Page Cache Read command (3Fh) being issued. The page, WL and block address address can be accessed in a random manner. Figure 38 defines the Random Cache Read behavior and timings.

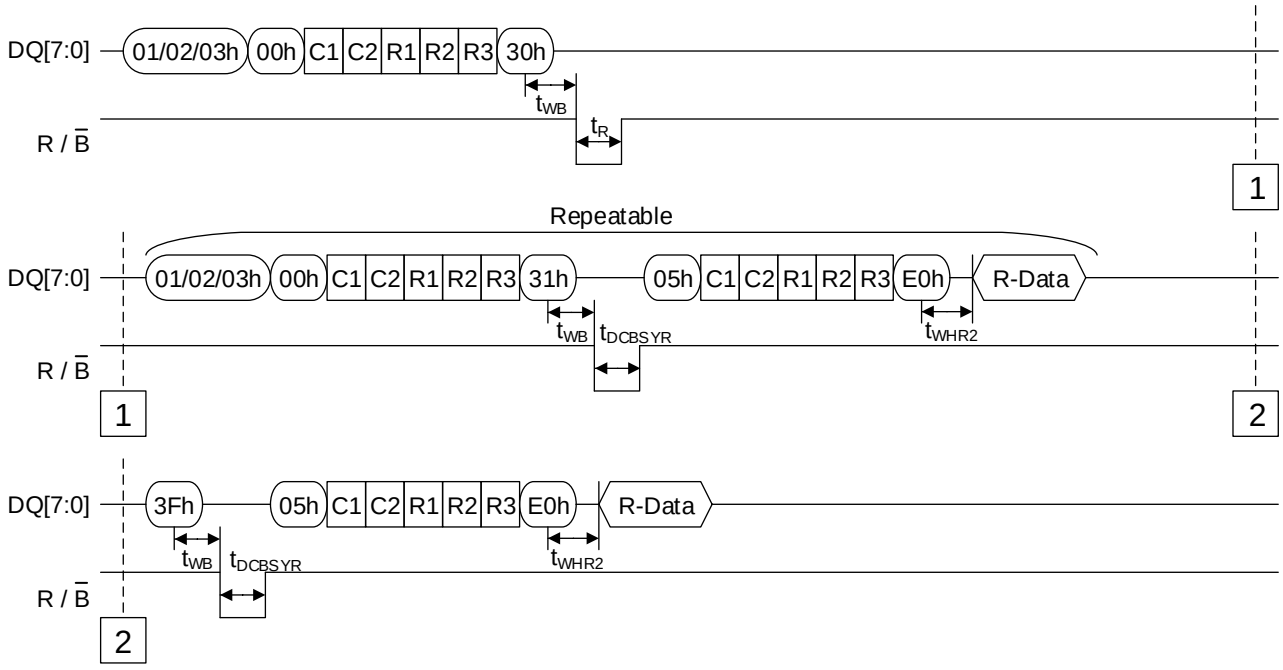


Figure 38. Random Cache Read Timing

5.2.3. Full Sequence Program Operation

The device is programmed on three-page basis, and each page shall be programmed only once before being erased. The WL address of programming shall be ascending order within a block. The contents of the page register are programmed into the Flash array specified by row address. SR[0] is valid for this command after SR[6] transitions from zero to one until the next transition of SR[6] to zero. Figure 39 defines the Full Sequence Program behavior and timings. Writing beyond the end of the page register is undefined. The Full Sequence Program is available for each FSP Set as defined in the Table 32. This operation is only for single Full Sequence Program Unit within a plane and shall not be carried out for multiple Full Sequence Program Units within a plane.

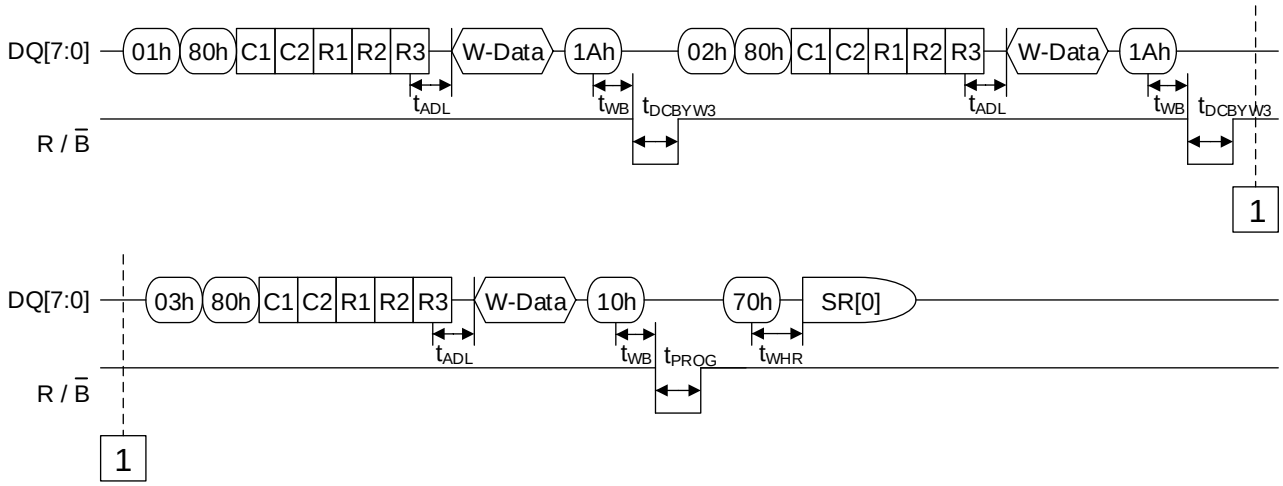


Figure 39. Full Sequence Program Timing

Table 32 Full Sequence Program Unit(FSP Unit)

	WL Address for each Full Sequence Program Unit		
FSP Unit Number	LSB Page (01h)	CSB Page (02h)	MSB Page (03h)
1	0	0	0
2	1	1	1
3	2	2	2
4	3	3	3
5	4	4	4
6	5	5	5
7	6	6	6
8	7	7	7
9	8	8	8
10	9	9	9
11	10	10	10
12	11	11	11
13	12	12	12
14	13	13	13
15	14	14	14
⋮	⋮	⋮	⋮

	WL Address for each Full Sequence Program Unit		
FSP Unit Number	LSB Page (01h)	CSB Page (02h)	MSB Page (03h)
⋮	⋮	⋮	⋮
242	241	241	241
243	242	242	242
244	243	243	243
245	244	244	244
246	245	245	245
247	246	246	246
248	247	247	247
249	248	248	248
250	249	249	249
251	250	250	250
252	251	251	251
253	252	252	252
254	253	253	253
255	254	254	254
256	255	255	255

Note:
LSB,CSB and MSB of each FSP Unit shall be be configured by the same row address.

5.2.3.1. Full Sequence Program Operation with Random Data Input

The device supports random data input in a page. The column address for the next data, which will be written, may be changed to the address using Random data input command (i.e. 85h). Random data input may be operated multiple times without limitation. The address indicated by 85h shall be the column address for the LSB Page in the FSP Unit beforethe first 1Ah command is issued. After the first 1Ah command and before the second 1Ah is issued, the address indicated by 85h shall be the column address for the CSB Page in the FSP Unit. After second 1Ah command is issued, the address indicated by 85h shall be the column address for the MSB Page in the FSP Unit.

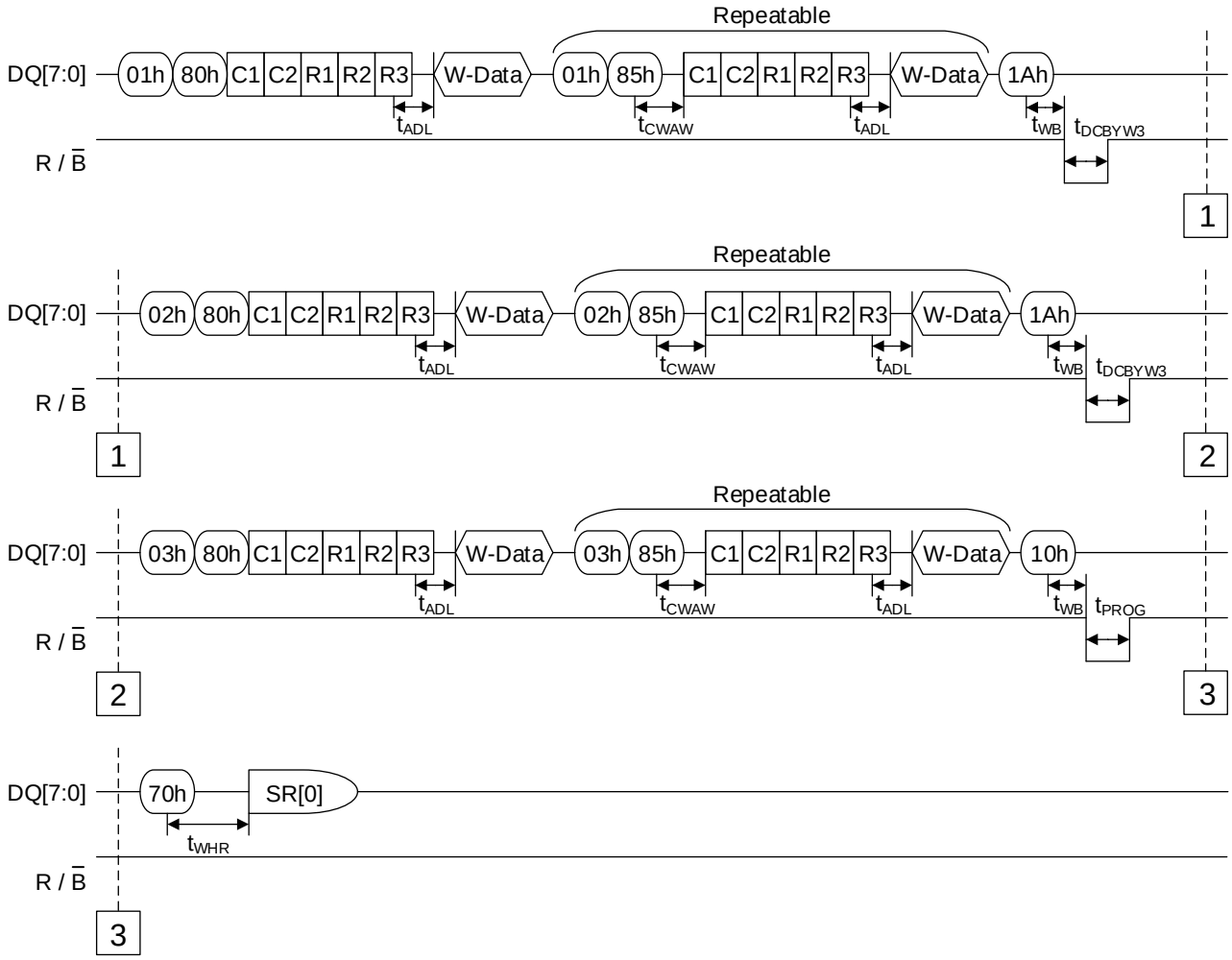


Figure 40. Full Sequence Program operation with Random Data Input Timing

5.2.4. Cache Full Sequence Program Operation

The Cache Full Sequence Program function allows the host to input the next data for another page to the page register while a WL of data is programming to the Flash array for the selected LUN. When command 1Ah/15h is issued, R/B returns high (i.e. ready) when a cache register is ready to be written after data in the cache register is transferred to a page register. However, when command 10h is issued for the final MSB page, R/$\overline{B}$ turns to high after outstanding program operation performed by previous Cache Full Sequence Program command and the Full Sequence program operation for the final WL is completed. SR[0] is valid for this command after SR[5] transitions from zero to one until the next transition. SR[1] is valid for this command after SR[6] transitions from zero to one, and it is invalid after the first Cache Full Sequence Program Command completion since there is no previous Cache Full Sequence Program operation. Cache Full Sequence Program operation shall work only within a block.Figure 41 defines the Cache Full Sequence Program behavior and timings. Note that t_{PROG} at the end of the caching operation may be longer than typical as this time also includes completing the programming operation for the previous WL. Writing beyond the end of the page register is undefined.

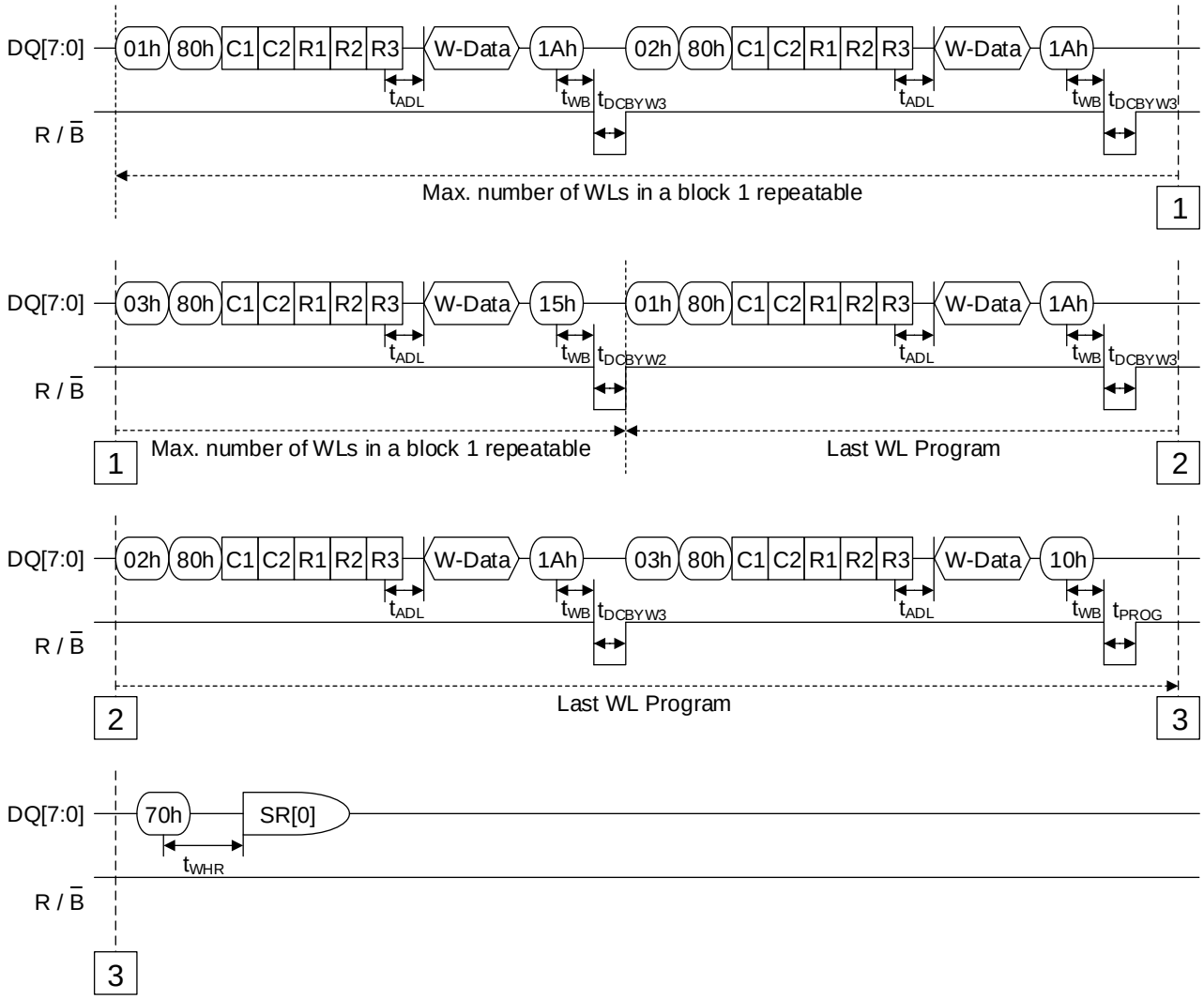


Figure 41. Cache Full Sequence Program Timing

5.2.5. Block Erase Operation

The Block Erase operation is done on a block basis. Only three cycles of row addresses are required for Block Erase operation and a WL address within the cycles is ignored while plane and block address are valid. After Block Erase operation passes, all bits in the block shall be set to one. SR[0] is valid for this command after SR[6] transitions from zero to one(i.e. the selected LUN is ready) until the LUN goes in busy state by a next command. Figure 42 defines the Block Erase behavior and timings.

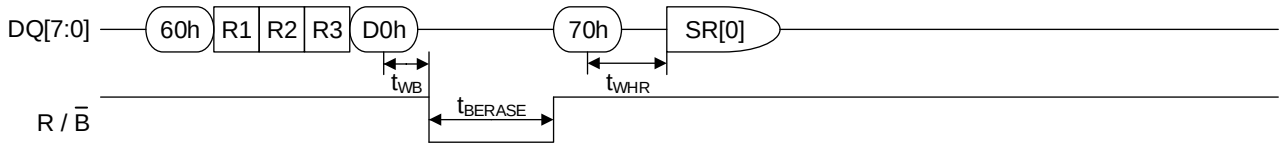


Figure 42. Block Erase Timing

5.2.6. Set Feature Operation

Users may set particular features using 'Set Feature' operation. Figure 43 defines the Set Features behavior and timings and Table 33 defines features that users can change. Once Set Feature operation begins, the operation shall be completed without any disturbance and interruption such as Reset operation.

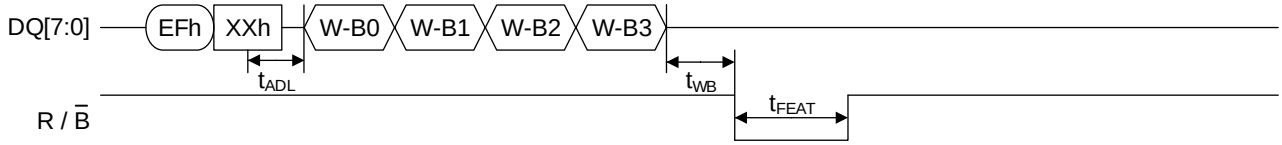


Figure 43. Set Feature Timing

NOTE:
The feature-setting shall work on equal to or lower than 133MHz, which means that t_{DSC} shall be equal to or larger than 7.5ns.

Table 33 Set feature addresses

1st Cycle	2nd Cycle	Description
EFh	02h	Toggle 2.0 specific setting
	10h	Driver strength setting
	30h	External V_{PP} Setting

5.2.6.1. Toggle 2.0 specific setting (02h)

This setting is required in order to use reference voltage and complementary signal, and ODT. DQS latency cycle can also be configured by this 'Set Feature' operation to read the first valid data correctly.

Table 34 Toggle 2.0 Specific Setting Data

	DQ7	DQ6	DQ5	DQ4	DQ3	DQ2	DQ1	DQ0
B0	ODT (with Rtt value)				Reserved	RE	$\overline{DQS}$	V_{REF}
B1	# of Latency DQS cycle for WRITE(Optional)				# of Latency DQS cycle for READ			

NOTE :
B2 and B3 are reserved and shall be written with 00h.

Table 35 Toggle 2.0 Specific Setting Data Definition

	Description
V_{REF}	0 : Disabled (default) 1 : Enabled
$\overline{DQS}$	0 : Disabled (default) 1 : Enabled
RE	0 : Disabled (default) 1 : Enabled
ODT	0000 : Disabled (default) 0001 : Enabled with 150ohm 0010 : Enabled with 100ohm 0011 : Enabled with 75ohm 0100 : Enabled with 50ohm
# of Latency DQS Cycle (READ / WRITE / READ DEVICE ID TABLE)	0000 : No latency DQS cycle (default) 0001 : One latency DQS cycle 0010 : Two latency DQS cycle 0011 : Four latency DQS cycle

NOTE:
V_{REF} shall meet its valid range prior to the Set Feature that enables V_{REF}.

5.2.6.2. Driver strength setting (10h)

Driver strength is configured according to the B0 value.

Table 36 Driver Strength Setting Data

B0 Value	Description
00h ~ 01h	Reserved
02h	Driver Multiplier : Underdrive
03h	Reserved
04h	Driver Multiplier : 1 (default)
05h	Reserved
06h	Driver Multiplier : Overdrive 1
07h	Reserved
08h	Reserved
09h ~ FFh	Reserved

NOTE:
B1, B2 and B3 are reserved and shall be written with 00h.

5.2.6.3. External V_{PP}(30h)

This setting controls whether external V_{PP} is enabled. External V_{PP} is configured according to the B0 value. V_{PP} must be validly supplied prior to the Set Feature that enables V_{PP}.

Table 37 External V_{PP} Setting Data

	DQ7	DQ6	DQ5	DQ4	DQ3	DQ2	DQ1	DQ0
B0	Reserved							V_{PP}

Table 38 External V_{PP} Setting Data Definition

	Description
V_{PP}	0 : Disabled (default) 1 : Enabled

NOTE:
B1, B2 and B3 are reserved and shall be written with 00h.

5.2.7. Get Feature Operation

Users find how the target is set through 'Get Feature' command. The function shall return the current setting information. If a host starts to read the first byte of data (i.e. B0 value), the host shall complete reading all four bytes of data before issuing another command (including Read Status or Read Status Enhanced). Figure 44 defines the Get Features behavior and timings. If Read Status (or Read Status Enhanced) is used to monitor whether the t_{FEAT} time is complete, the host shall issue Read command (i.e. 00h) to read B0-B1-B2-B3.

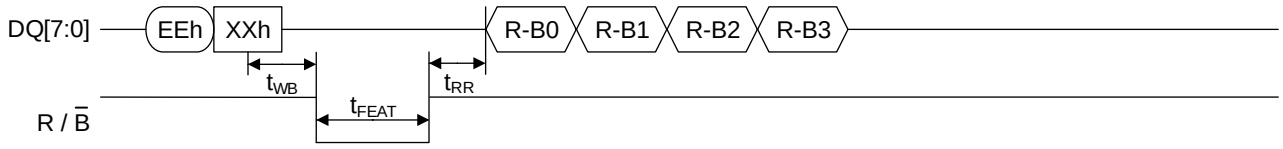


Figure 44. Get Feature Timing

NOTE:
The feature-getting shall work on equal to or lower than 133MHz, which means that tRC shall be equal to or larger than 7.5ns.

5.2.8. Read ID Operation

The ID of a target is read by command 90h followed by 00h or 40h address. Figure 45 defines Read ID operation behavior and timings. Once Read ID operation begins, the operation shall be completed without any disturbance and interruption such as Reset operation.

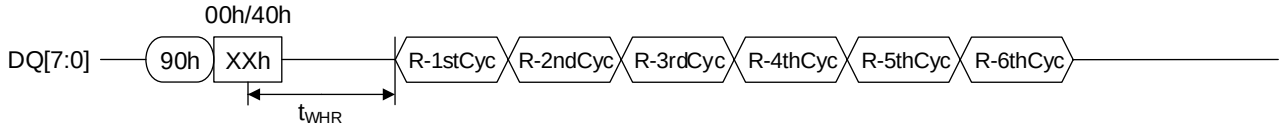


Figure 45. Read ID Timing

5.2.8.1. 00h Address ID Definition

Users can read six bytes of ID containing manufacturer code, device code and architecture information of the target by command 90h followed by 00h address. The command register remains in Read ID mode until another command is issued.

Table 39 00h Address ID Definition Table

Cycle	Description	Hex Data		
		TH58TFG9V23BA4C	TH58TFT0V23BA8C	TH58TFT1V23BA8H
1st Data	Maker Code	98h	98h	98h
2nd Data	Device Code	3Ch	3Ch	3Eh
3rd Data	Number of LUN per Target, Cell Type, Etc.	98h	98h	99h
4th Data	Page Size, Block Size,etc.	B3h	B3h	B3h
5th Data	Plane Number,etc.	76h	76h	7Ah
6th Data	Technology Code	F2h	F2h	F2h

Table 40 2nd ID Data

	Description	DQ7	DQ6	DQ5	DQ4	DQ3	DQ2	DQ1	DQ0	Hex Data
Memory Density per Target	8 Gbits	1	1	0	1	0	0	1	1	D3h
	16 Gbits	1	1	0	1	0	1	0	1	D5h
	32 Gbits	1	1	0	1	0	1	1	1	D7h
	64 Gbits	1	1	0	1	1	1	1	0	DEh
	128 Gbits	0	0	1	1	1	0	1	0	3Ah
	256 Gbits	0	0	1	1	1	1	0	0	3Ch
	512 Gbits	0	0	1	1	1	1	1	0	3Eh
	1024 Gbits	0	1	0	0	1	0	0	0	48h

Table 41 3rd ID Data

	Description	DQ7	DQ6	DQ5	DQ4	DQ3	DQ2	DQ1	DQ0
Number of LUN per Target	1							0	0
	2							0	1
	4							1	0
	8							1	1
Cell Type	2 Level Cell					0	0		
	4 Level Cell					0	1		
	8 Level Cell					1	0		
	16 Level Cell					1	1		

Table 42 4th ID Data

	Description	DQ7	DQ6	DQ5	DQ4	DQ3	DQ2	DQ1	DQ0
Page Size (w/o redundant area)	2KB							0	0
	4KB							0	1
	8KB							1	0
	16KB							1	1
Block Size (w/o redundant area)	128KB	0		0	0				
	256KB	0		0	1				
	512KB	0		1	0				
	1MB	0		1	1				
	2MB	1		0	0				
	4MB	1		0	1				
	6MB	1		1	0				
	Others	1		1	1				
	Reserved	1		X	X				

*X : either 0 or 1

Table 43 5th ID Data

	Description	DQ7	DQ6	DQ5	DQ4	DQ3	DQ2	DQ1	DQ0
Number of Plane per Target	1					0	0		
	2					0	1		
	4					1	0		
	8					1	1		

Table 44 6th ID Data

	Description	DQ7	DQ6	DQ5	DQ4	DQ3	DQ2	DQ1	DQ0
Technology Code	1st Gen						0	0	0
	2nd Gen						0	0	1
	3rd Gen						0	1	0
	Reserved						0	1	1
	Reserved						1	0	0
	Reserved						1	0	1
	Reserved						1	1	0
	Reserved						1	1	1
Interface	Conventional	0							
	Toggle Mode	1							

5.2.8.2. 40h Address ID Definition

Toggle DDR Flash Memory also provides six bytes of JEDEC standard signature ID. Users can read the ID by command 90h followed by 40h address. Any data returned after the six bytes of JEDEC standard signature is considered reserved for future use.

Table 45 40h Address ID Cycle

1st Cycle	2nd Cycle	3rd Cycle	4th Cycle	5th Cycle	6th Cycle
4Ah	45h	44h	45h	43h	02h

Table 46 40h Address ID Definition

Cycle	Description	DQ7	DQ6	DQ5	DQ4	DQ3	DQ2	DQ1	DQ0
1st	J	0	1	0	0	1	0	1	0
2nd	E	0	1	0	0	0	1	0	1
3rd	D	0	1	0	0	0	1	0	0
4th	E	0	1	0	0	0	1	0	1
5th	C	0	1	0	0	0	0	1	1
6th	Conventional Asynchronous SDR	0	0	0	0	0	0	0	1
	Toggle DDR					0	0	1	0
	Synchronous DDR					0	1	0	0

5.2.9. Read Status Operation

In the case of non-multi-plane operations, the 70h Read Status function retrieves a status value for the last operation issued. If multi-plane operations are in progress on a single LUN, then 70h Read Status returns the composite status value. Specifically, 70h Read Status shall return the combined status value of the independent status register bits according to Table 47. On the other hands, 71h Read Status returns statuses of current page in two planes on a single LUN according to Table 48. 73h Read Status returns statues of previous page in two planes on a single LUN accoriding to Table 49. Figure 46 defines the Read Status behavior and timings.

Table 47 Read Status Definition for 70h

	DQ 0	DQ 1	DQ 2	DQ 3	DQ 4	DQ 5	DQ 6	DQ 7
Definition of value	Pass : "0" Fail : "1"	Pass : "0" Fail : "1"	Reserved	Reserved	Reserved	Busy : "0" Ready : "1"	Busy : "0" Ready : "1"	Protected : "0" Not Protected :"1"
Block Erase	Pass/Fail	Not Use	Not Use	Not Use	Not Use	Not Use	Busy/Ready	Write Protect
Full Sequence Program	Pass/Fail	Not Use	Not Use	Not Use	Not Use	Not Use	Busy/Ready	Write Protect
Cache FSP	Pass/Fail for the current program	Pass/Fail for the previous program	Not Use	Not Use	Not Use	Busy/Ready for Flash array	Busy/Ready for Host	Write Protect
Read	Not Use	Not Use	Not Use	Not Use	Not Use	Not Use	Busy/Ready	Write Protect
Cache Read	Not Use	Not Use	Not Use	Not Use	Not Use	Busy/Ready for Flash array	Busy/Ready for Host	Write Protect

NOTE:

1) Pass/Fail for the program operation is the result of not page but FSP Unit basis.
2) During Block Erase or Full Sequence Program, DQ 0 is only valid when DQ 6 shows the Ready state.
3) During Cache FSP operation, DQ 0 is only valid when DQ 5 shows the Ready state, and DQ 1 is only valid when DQ 6 shows the Ready state.

Table 48 Read Status Definition for 71h

	DQ 0	DQ 1	DQ 2	DQ 3	DQ 4	DQ 5	DQ 6	DQ 7
Definition of value	Pass : "0" Fail : "1"	Pass : "0" Fail : "1"	Pass : "0" Fail : "1"	Reserved	Reserved	Busy : "0" Ready : "1"	Busy : "0" Ready : "1"	Protected : "0" Not Protected :"1"
Block Erase	Pass/Fail	Pass/Fail for Plane#0	Pass/Fail for Plane#1	Not Use	Not Use	Not Use	Busy/Ready	Write Protect
Full Sequence Program	Pass/Fail	Pass/Fail for Plane#0	Pass/Fail for Plane#1	Not Use	Not Use	Not Use	Busy/Ready	Write Protect
Cache FSP	Pass/Fail for the current program	Pass/Fail for Plane#0 current program	Pass/Fail for Plane#1 current program	Not Use	Not Use	Busy/Ready for Flash array	Busy/Ready for Host	Write Protect
Read	Not Use	Not Use	Not Use	Not Use	Not Use	Not Use	Busy/Ready	Write Protect
Cache Read	Not Use	Not Use	Not Use	Not Use	Not Use	Busy/Ready for Flash array	Busy/Ready for Host	Write Protect

NOTE:

1) Pass/Fail for the program operation is the result of not page but FSP Unit basis.
2) During Block Erase or Full Sequence Program operation, DQ 0, DQ 1 and DQ 2 are only valid when DQ 6 shows the Ready state.
3) During Cache FSP operation, DQ 0, DQ 1 and DQ 2 are only valid when DQ 5 shows the Ready state.
4) If either Plane#0 or #1 is not selected as a target of Multi Plane Operation, the bit for non-selected Plane shall be invalid. If both Plane#0 and #1 are not selected as a target of Multi Plane Operation, the Status of this command shall be invalid.

Table 49 Read Status Definition for 73h

	DQ 0	DQ 1	DQ 2	DQ 3	DQ 4	DQ 5	DQ 6	DQ 7
Definition of value	Pass : "0" Fail : "1"	Pass : "0" Fail : "1"	Pass : "0" Fail : "1"	Reserved	Reserved	Busy : "0" Ready : "1"	Busy : "0" Ready : "1"	Protected : "0" Not Protected :"1"
Block Erase	Not Use	Not Use	Not Use	Not Use	Not Use	Not Use	Busy/Ready	Write Protect
Full Sequence Program	Pass/Fail for previous program	Pass/Fail for Plane#0 previous program	Pass/Fail for Plane#1 previous program	Not Use	Not Use	Not Use	Busy/Ready	Write Protect
Cache FSP	Pass/Fail for previous program	Pass/Fail for Plane#0 previous program	Pass/Fail for Plane#1 previous program	Not Use	Not Use	Busy/Ready for Flash array	Busy/Ready for Host	Write Protect
Read	Not Use	Not Use	Not Use	Not Use	Not Use	Not Use	Busy/Ready	Write Protect
Cache Read	Not Use	Not Use	Not Use	Not Use	Not Use	Busy/Ready for Flash array	Busy/Ready for Host	Write Protect

NOTE:

1) Pass/Fail for the program operation is the result of not page but FSP Unit basis.
2) During Block Erase or Full Sequence Program operation, DQ 0, DQ 1 and DQ 2 are only valid when DQ 6 shows the Ready state.
3) During Cache FSP operation, DQ 0, DQ 1 and DQ 2 are only valid when DQ 5 shows the Ready state.
4) If either Plane#0 or #1 is not selected as a target of Multi Plane Operation, the bit for non-selected Plane shall be invalid. If both Plane#0 and #1 are not selected as a target of Multi Plane Operation, the Status of this command shall be invalid.

Figure 46. Read Status Timing

5.2.10. Reset Operation

Toggle DDR Flash Memory offers a reset function by command FFh. When the device is in 'Busy' state during any operation, the Reset operation will abort these operations. The contents of memory cells being programmed are no longer valid, as the data will be partially programmed or erased. Reset during the operation with a cache register (e.g. Cache FSP operation) may not just stop the most recent WL operation but it may also stop the previous WL operation depending on when the FF reset is input. Although the device is already in process of reset operation, a new reset command will be accepted. Figure 47. Reset timing defines the Reset behavior and timings.

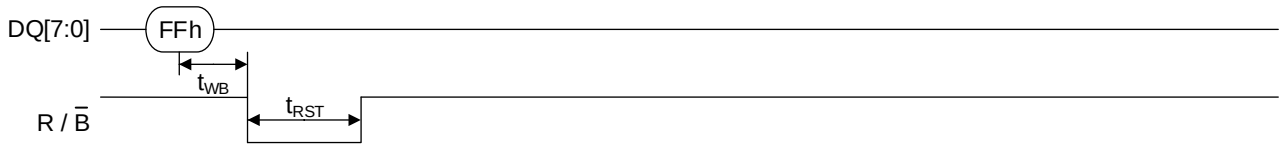


Figure 47. Reset timing

When Reset (FFh) command is input during Program operation

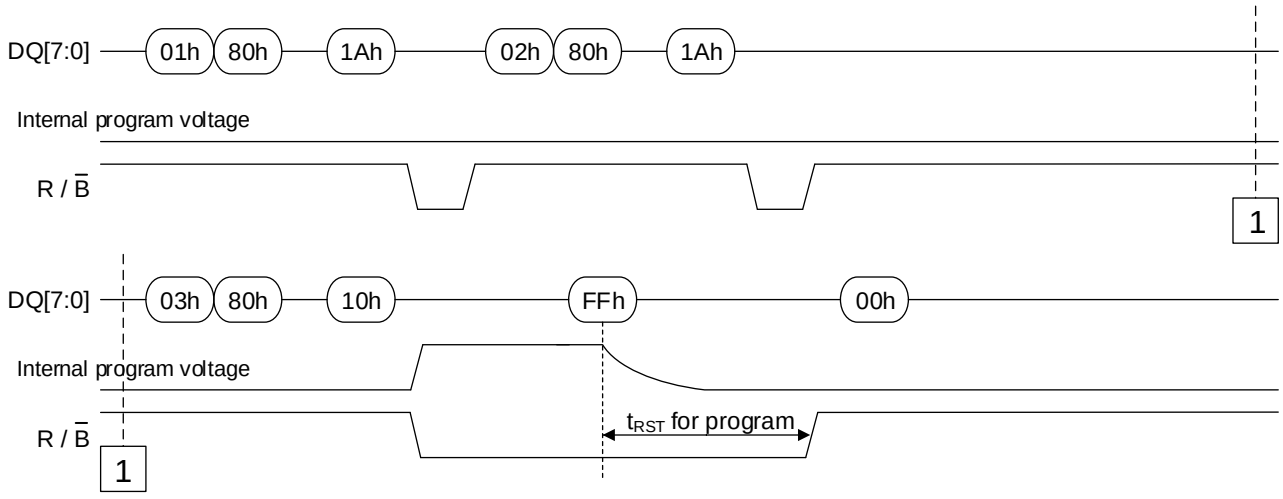


Figure 48. Reset timing during Program Operation

When Reset (FFh) command is input during Erase operation

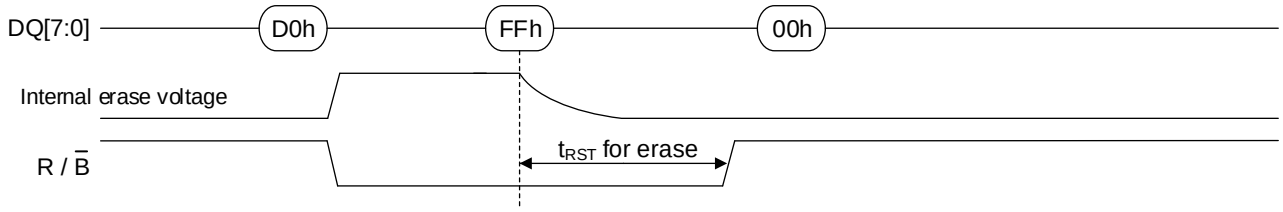


Figure 49. Reset timing during Erase Operation

When Reset (FFh) command is input during Read operation

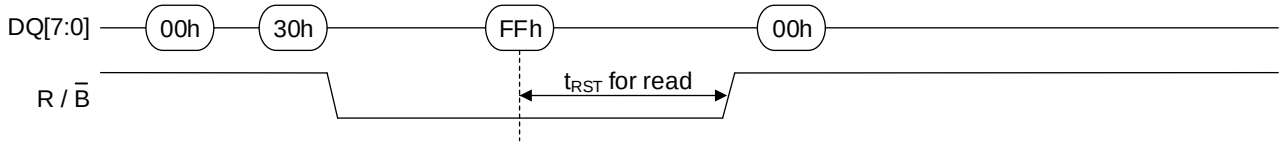


Figure 50. Reset timing during Read Operation

When Read Status command (70h) is input after Reset operation

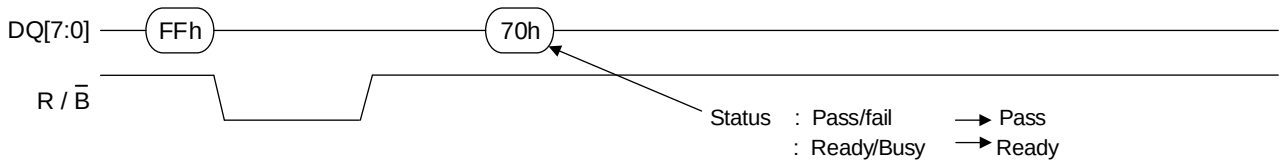


Figure 51. Status Read after Reset operation

When two or more Reset commands are input in succession

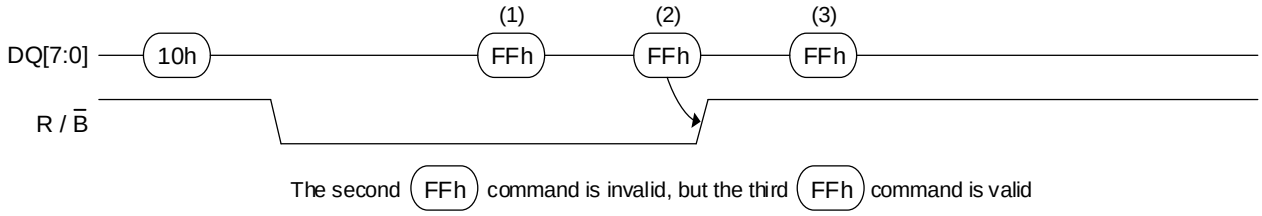


Figure 52. Successive Reset operation

5.2.11. Reset LUN Operation

A certain LUN within a target can be reset by command FAh followed by row addresses. Row addresses are required to set a LUN to be reset. Figure 53 defines the Reset LUN behavior and timings.

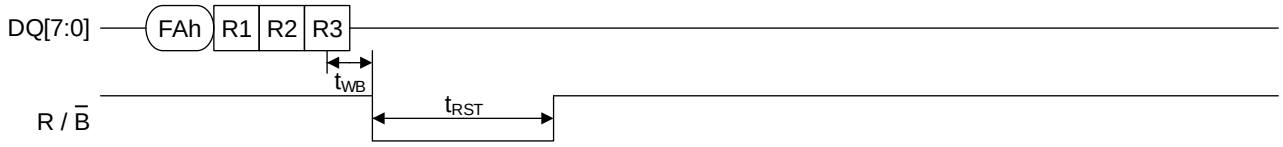


Figure 53. Single LUN Reset Timing

NOTE :
If there are multiple LUNs on a target, R/$\overline{B}$ is also affected by the rest of LUN(s) on the same target.

5.3. Extended Operation

5.3.1. Extended Command Sets

Table 50 defines the Extended Command Sets. Primary and Secondary Commands are also categorized in the table. Primary commands are recommended to use when a particular function is implemented, while Secondary commands are for alternative implementation for backward compatibility.

Table 50 Extended Command Sets

Function	Primary or secondary	1st Set	Address Cycles for 1st Set	2nd Set	Address Cycles for 2nd Set
Multi Plane Read / Multi Plane Cache Read	Primary	00h-32h	5	00h-30h	5
Multi Plane Read	Secondary	60h	3	30h	-
Multi Plane Random Cache Read	Primary	00h-32h	5	00h-31h	5
Multi Plane Random Data Output	Primary	05h	5	E0h	-
Multi Plane Full Sequence Program	N/A	80h-11h	5	80h-1Ah or 80h-10h	5
Multi Plane Cache Full Sequence Program	N/A	80h-11h	5	80h-1Ah or 80h-15h or 80h-10h	5
Multi Block Erase	Primary	60h	3	D0h	-
Device Identification Table Read	Primary	ECh	1	-	-
Read status enhanced	Primary	78h	3	-	-
Read LUN #N Status [4)]	Secondary	Fnh	-	-	-

NOTE:

1) Multi Plane Random Data output must be used after Multi Plane Read or Multi Plane Cache Read operation.
2) Any command between 11h and 80h/81h/85h is prohibited except 70h/71h/73h/78h/Fnh and FFh
3) Read LUN #N Status command is only for the device having two LUNs per a target.
4) "n" of Fnh shall be either of 1 or 2, where the number specifies each LUN. The number shall be the LUN address + 1(n = N +1). For example, F1h is used to check the status of LUN #0.

5.3.2. Address Input Restrictions for Multi Plane Operation / Multi Block Operation

Multi Plane/ multi block operation requires specific address input restrictions described as below.
For read and program operation, multiple WL addresses may be set over multiple planes. When setting WL address of each plane, the WL addresses shall be identical although block addresses may differ. The same plane address shall not be set twice or more within a set of address setting sequence. The number of planes which are set for this operation shall be even.
For erase operation, multiple block addresses may be set over multiple planes. The same plane address shall not be set twice or more within a set of address setting sequence. The number of planes which are set for this operation shall be even. Multi block operation is also regarded as multi-plane operation.

5.3.3. Multi Plane Read Operation

The Multi Plane Read operation is an extension of the Page Read operation. The device supporting Multi Plane Read operation also allows multiple Random data-output from each page (i.e. Multi Plane Random Data Output) once multi-plane are loaded to page registers. With the primary command, R/$\overline{B}$ returns to ready in a short time (i.e. $t_{DCBSYW1}$) after the first command 32h since it does not load data from a selected page and the selected page data are transferred to the cache registers via page registers in less than t_R after command 30h. Note that the Multi Plane addresses shall be set through 1st Set and 2nd Set of command with the Address Input Restrictions for Multi Plane Operation specified in section 5.3.2. Once the data are loaded into the cache registers, the data on the first page can be read out by issuing the Multi Plane Random Data Output command. The data on other pages can be also read out using the identical command sequences. Figure 54 and Figure 55 define Multi Plane Read and Multi Plane Random Data Output behavior and timings. In the case of secondary command, make sure $\overline{WP}$ is held to High level when Multi Plane Read operation is performed. Within the repeatable sequence in the following figure, the Page Select command (i.e 01h/02h/03h) shall be identical between planes.

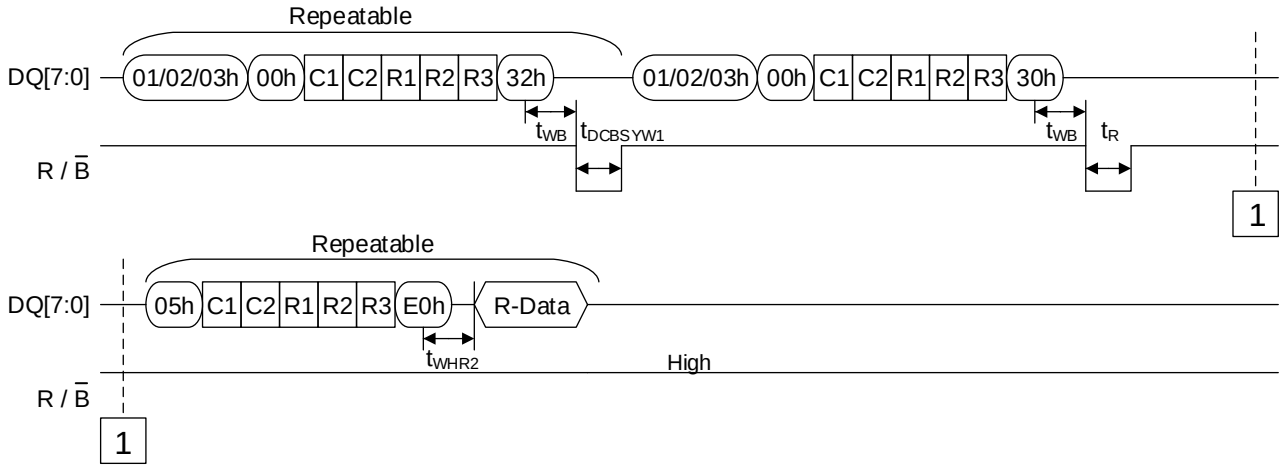


Figure 54. Example Timing with Multi Plane Read (Primary)

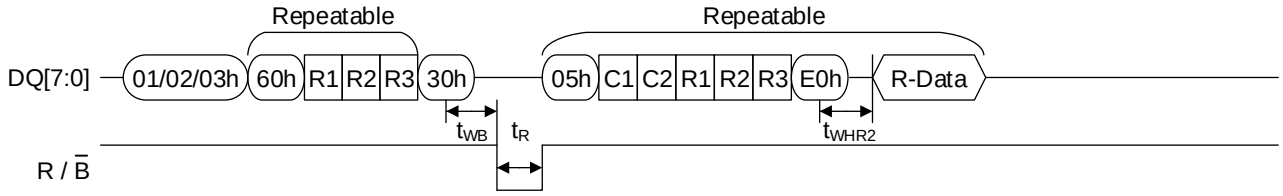


Figure 55. Example Timing with Multi Plane Read (Secondary)

5.3.4. Multi Plane Random Cache Read Operation

Multi Plane Random Cache Read function requires multiple address settings ahead of command 31h to load data of particular pages. Since the selected pages are loaded to page register while a host read data from cache register where previous data are loaded, R/$\overline{B}$ returns high (i.e. ready) in a short time unless the previous data are still being loaded. Note that the Multi Plane addresses shall be set through 1st Set and 2nd Set of command with the Address Input Restrictions for Multi Plane Operation specified in section 5.3.2. The activated planes for the first Multi Plane Random Cache Read shall be kept using in the next address sequence until the Multi Plane Random Cache operation is completed by command 3Fh. Figure 56 defines Multi Plane Random Cache Read behavior and timings. Within the repeatable sequence in the following figure, the Page Select command (i.e 01h/02h/03h) shall be identical between planes.

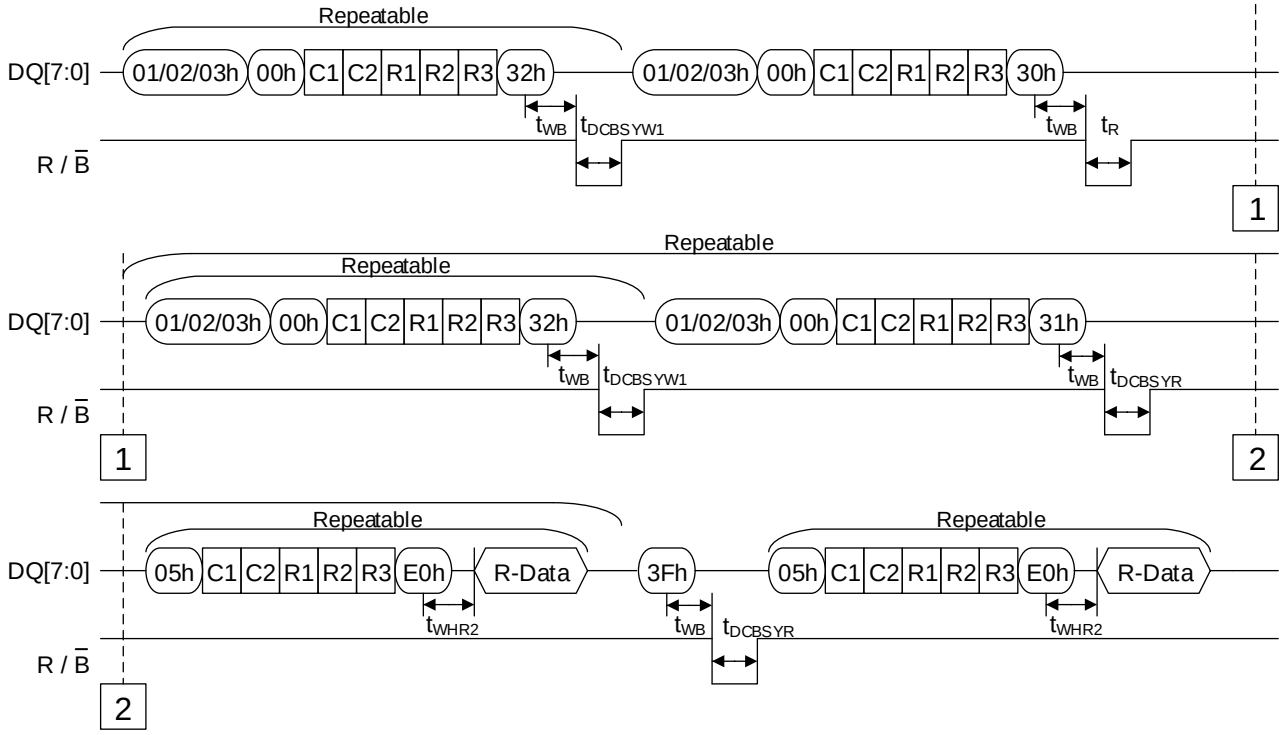


Figure 56. Example Timing with Multi Plane Cache Read (Primary)

5.3.5. Multi Plane Full Sequence Program Operation

Multi Plane Full Sequence Program function extends an effective programmable size using multiple planes. After data loading for the first plane, command 11h for the second command is used. After command 11h is issued, R/B pin goes busy state in a short period since it is not actual programming operation(i.e. $t_{DCBSYW1}$). At the last MSB page of the Multi plane data loading, command 10h is issued, then all loaded data in each plane starts to be programmed to Flash array simultaneously. Note that the Multi Plane addresses shall be set through 1st Set and 2nd Set of command with the Address Input Restrictions for Multi Plane Operation specified in section 5.3.2. Figure 57 define s Multi Plane Full Sequence Program behavior and timings.

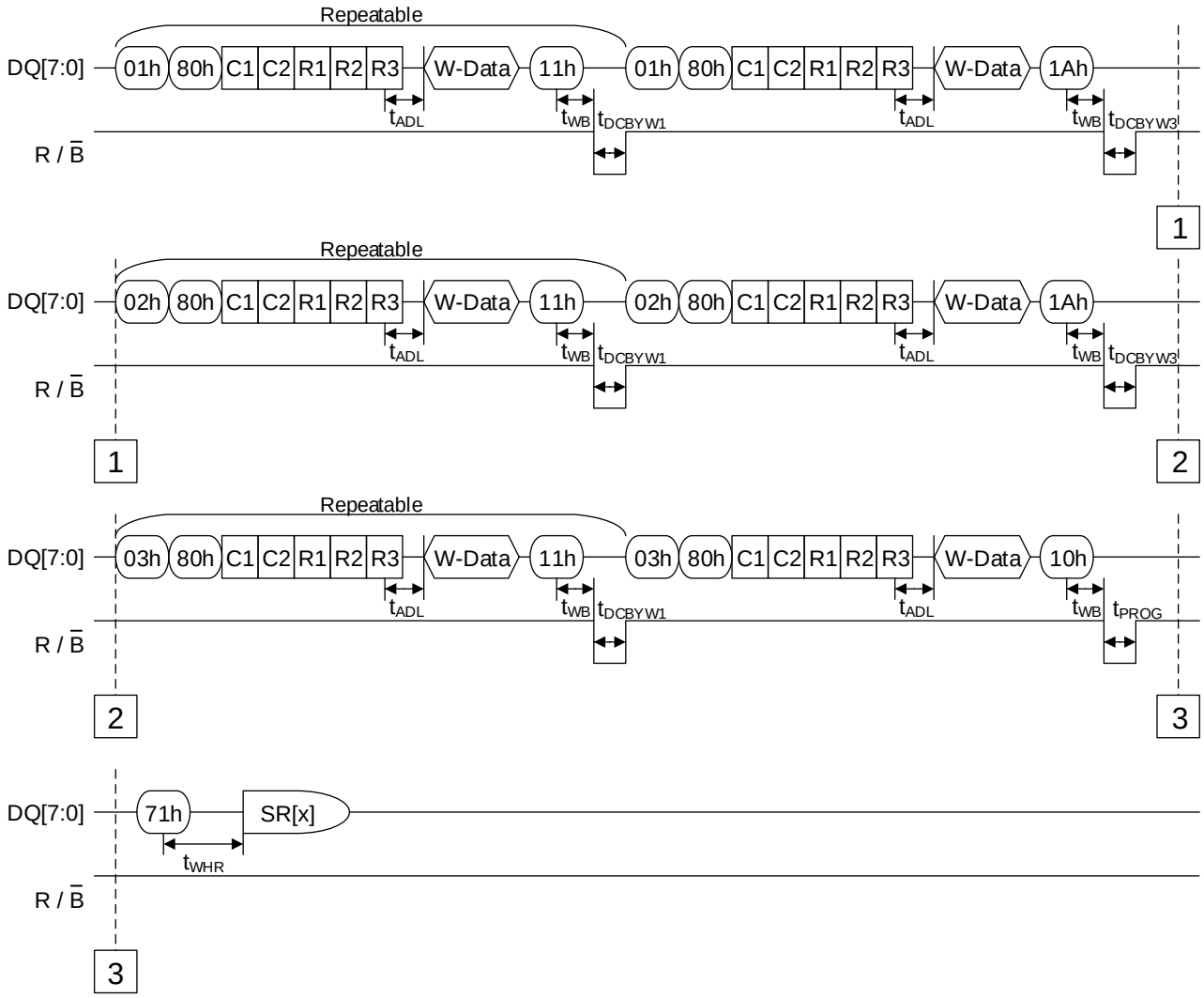
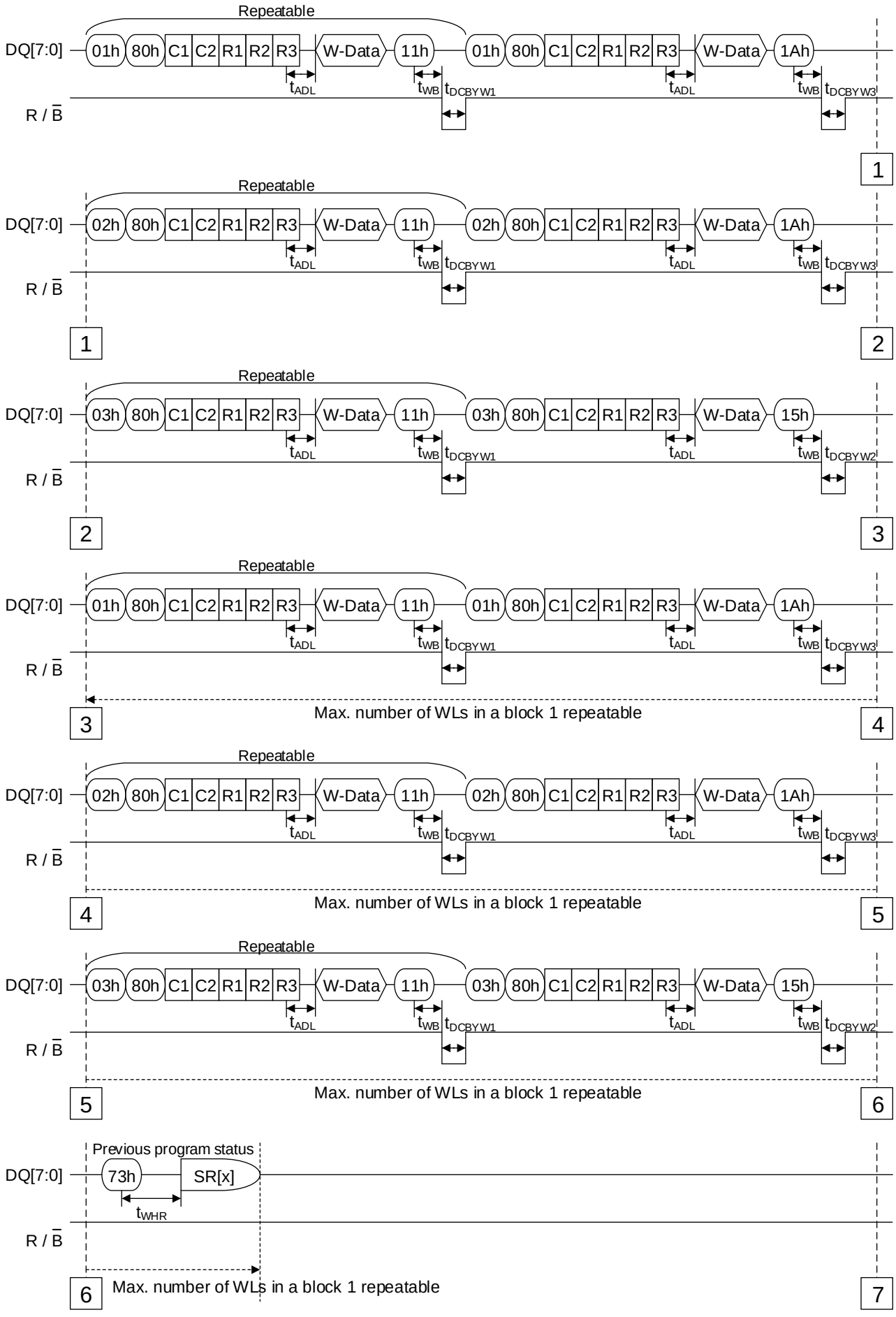


Figure 57. Example Timing with Multi Plane Full Sequence Program

5.3.6. Multi Plane Cache Full Sequence Program Operation

The Multi Plane Cache Full Sequence Program is an extension of the Cache Full Sequence Program. After loading pages for Multi Plane Cache Full Sequence Program, command 15h is issued. After command 15h, R/$\overline{B}$ returns high once transferring data from cache register to page register is completed. Internal program operation is in progress after R/$\overline{B}$ returns while other pages are loaded by a host. At the last page loading for the entire Multi Plane Cache Full Sequence Program, command 10h is required to finalize the operation and R/$\overline{B}$ stays busy as long as t_{PROG}. Multi Plane Cache Full Sequence Program operation shall work only within a block of each plane and shall not be continued over the boundary of plane. Note that the Multi Plane addresses shall be set through 1st Set and 2nd Set of command with the Address Input Restrictions for Multi Plane Operation specified in section 5.3.2. The activated planes for the first Multi Plane Cache Full Sequence Program shall be kept using in the next address sequence until the Multi Plane Cache Full Seqeuence Program operation is completed by command 10h. Figure 58 defines Multi Plane Cache Full Seqeuence Program behavior and timings.


Repeatable
DQ[7:0]
01h 80h C1 C2 R1 R2 R3 W-Data 11h 01h 80h C1 C2 R1 R2 R3 W-Data 1Ah
R / B
tADL tWB tDCBYW1 tADL tWB tDCBYW3
1
Repeatable
DQ[7:0]
02h 80h C1 C2 R1 R2 R3 W-Data 11h 02h 80h C1 C2 R1 R2 R3 W-Data 1Ah
R / B
tADL tWB tDCBYW1 tADL tWB tDCBYW3
1
2
Repeatable
DQ[7:0]
03h 80h C1 C2 R1 R2 R3 W-Data 11h 03h 80h C1 C2 R1 R2 R3 W-Data 15h
R / B
tADL tWB tDCBYW1 tADL tWB tDCBYW2
2
3
Repeatable
DQ[7:0]
01h 80h C1 C2 R1 R2 R3 W-Data 11h 01h 80h C1 C2 R1 R2 R3 W-Data 1Ah
R / B
tADL tWB tDCBYW1 tADL tWB tDCBYW3
3
Max. number of WLs in a block 1 repeatable
4
Repeatable
DQ[7:0]
02h 80h C1 C2 R1 R2 R3 W-Data 11h 02h 80h C1 C2 R1 R2 R3 W-Data 1Ah
R / B
tADL tWB tDCBYW1 tADL tWB tDCBYW3
4
Max. number of WLs in a block 1 repeatable
5
Repeatable
DQ[7:0]
03h 80h C1 C2 R1 R2 R3 W-Data 11h 03h 80h C1 C2 R1 R2 R3 W-Data 15h
R / B
tADL tWB tDCBYW1 tADL tWB tDCBYW2
5
Max. number of WLs in a block 1 repeatable
6
Previous program status
DQ[7:0]
73h SR[x]
tWHR
R / B
6
Max. number of WLs in a block 1 repeatable
7

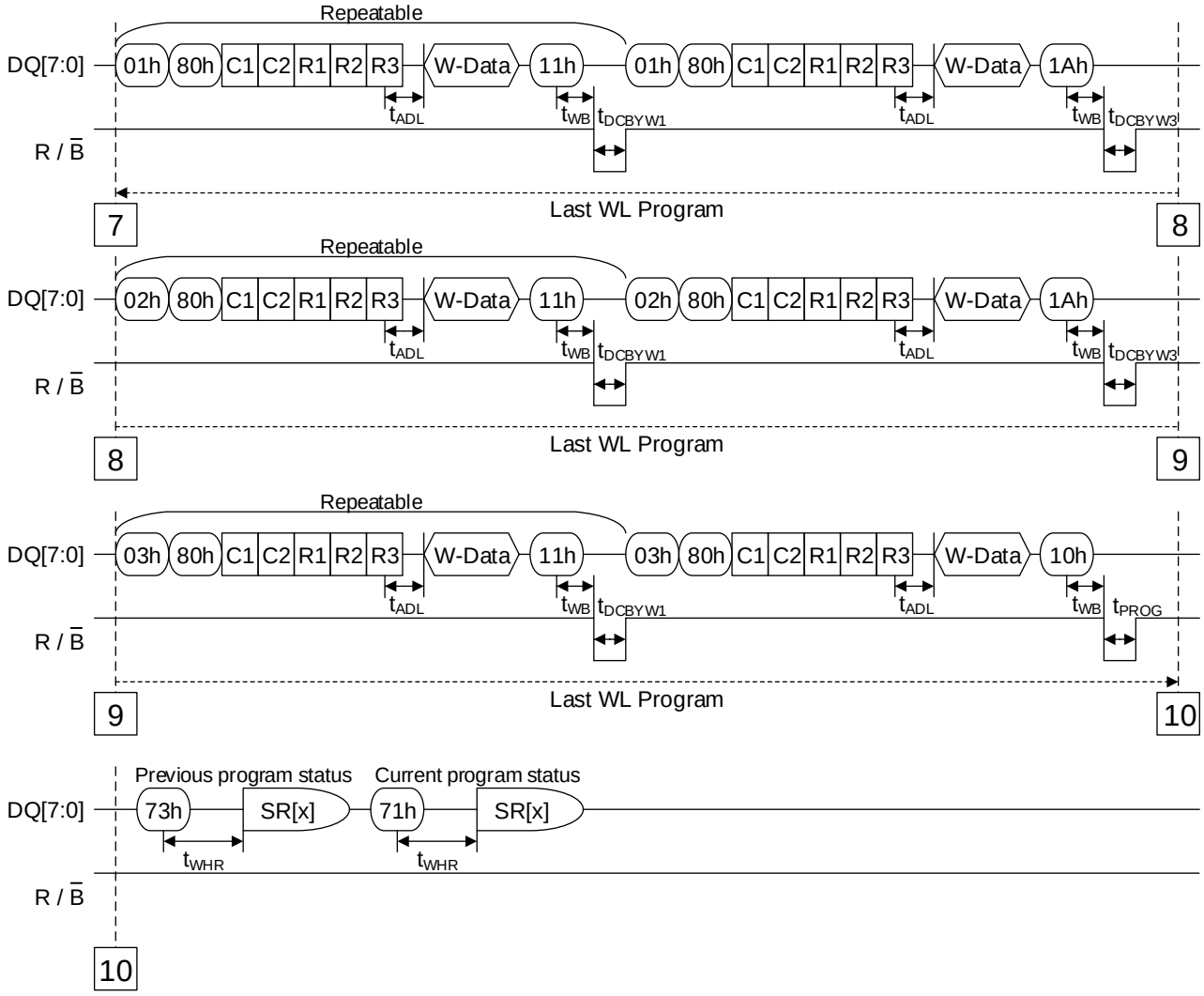


Figure 58. Example Timing with Multi Plane Cache Full Sequence Program

5.3.7. Multi Block Erase Operation

Multi Block Erase allows users to erase multiple blocks comprising a block of each plane simultaneously.
The same plane address shall not be set twice within a set of address setting sequence for the Multi Block Erase Operation. Figure 59 defines Multi Block Erase behavior and timings.

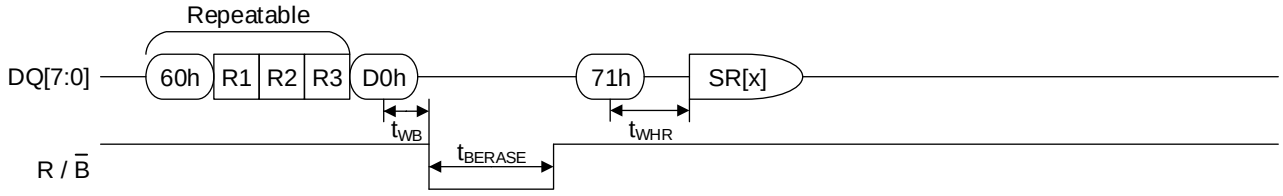


Figure 59. Example Timing with Multi Block Erase

5.3.8. Device Identification Table Read Operation

The device returns a JEDEC standard formatted parameter page during the data out phase of the READ PARAMETER PAGE command when address 40h is inputted. The READ PARAMETER PAGE command is a ECh value for the command cycle and a 40h value for the address cycle, and the bytes of the parameter page are returned in the data output (DOUT) cycles. After the command Ech address 40h is received by the Flash Memory device, it will go busy for a period of time (t_R in the figure) after which, the parameter page can be read from the device. The length and contents of the parameter page is defined in section 5.3.9. The timing associated with the bus cycles for the READ PARAMETER PAGE command is defined elsewhere in the JEDEC standard. The READ ID command is used by the controller to identify the device that is attached. This command is used by the controller to gather information about the target flash device. Figure 60 defines the behavior and timings. If Read Status (or Read Status Enhanced) is used to monitor whether the tR time is complete, the host shall issue Random Data Output command with applying 00h for all 5 cycles of address to read the Parameter Page.

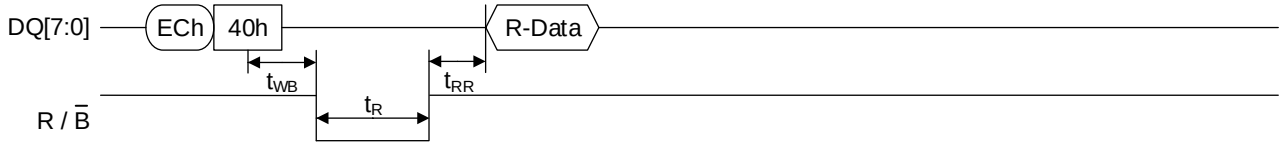


Figure 60. Device Identification Table Read Timing

5.3.9. Parameter Page Definition

Table 51 defines the parameter page data structure. For parameters that span multiple bytes, the least significant byte of the parameter corresponds to the first byte.
Values are reported in the parameter page in units of bytes when referring to items related to the size of data access (as in an 8-bit data access device). For example, the target will return how many data bytes are in a page. All optional parameters that are not implemented shall be cleared to 00h by the target.

When the information is read from the device, the host shall calculate CRC to check the data prior to taking action on that data. If the CRC of the first Parameter Page read is not valid, the host shall read redundant Parameter Page copies. The host shall then check the CRC of that redundant Parameter Page.
If the CRC is correct, the host may take action based on the contents of that redundant Parameter Page. If the CRC is incorrect, then the host shall attempt to read the next redundant Parameter Page by the same procedure.
There may be a case where the number of error exceeds the error detectability of CRC. In this case, the retrieved data with valid CRC may contain errors. To be prepared for this case, the host should compare two or more sets of the retrieved data to check equality.
All Parameter Pages returned by the Target may have invalid CRC values; however, bit-wise majority or other ECC techniques may be used to recover the contents of the Parameter Page by the host.
If necessary, the data successfully read should be safely kept by the host in its own manner for further protection.

If there are any discrepancies between the content in Parameter Page and the content in this or the other documents separately provided, the latter shall take precedence.

Table 51 Parameter Page Definitions

Byte	O/M	Description	Value
Revision information and features block			
0-3	M	Parameter page signature Byte 0: “J” (= 4Ah) Byte 1: “E” (= 45h) Byte 2: “S” (= 53h) Byte 3: “D” (= 44h)	4Ah, 45h, 53h, 44h
4-5	M	Revision number 3-15: Reserved (0) 2: 1 = supports Parameter Page revision 1.0 and standard revision 1.0 1: 1 = supports vendor specific Parameter Page 0: Reserved (0)	04h, 00h
6-7	M	Features supported 9-15 Reserved (0) 8: 1 = supports program page register clear enhancement 7 : 1 = supports external V_{PP} 6 : 1 = supports Toggle Mode DDR 5: 1 = supports Synchronous DDR 4: 1 = supports multi-plane read operations 3: 1 = supports multi-plane program and erase operations 2: 1 = supports non-sequential page programming 1: 1 = supports multiple LUN operations 0: 1 = supports 16-bit data bus width	D8h, 01h (TH58TFG9V23BA4C, TH58TFT0V23BA8C) DAh, 01h (TH58TFT1V23BA8H)
8-10	M	Optional commands supported 11-23: Reserved (0) 10: 1 = supports Synchronous Reset 9: 1 = supports Reset LUN (Primary) 8: 1 = supports Small Data Move 7: 1 = supports Multi-plane Copyback Program (Primary) 6: 1 = supports Random Data Output (Primary) 5: 1 = supports Read Unique ID 4: 1 = supports Copyback 3: 1 = supports Read Status Enhanced (Primary) 2: 1 = supports Get Features and Set Features 1: 1 = supports Read Cache commands	4Dh, 02h, 00h

		0 : 1 = supports Page Cache Program command	
11-12	O	Secondary commands supported 8-15: Reserved (0) 7: 1 = supports secondary Read Status Enhanced 6: 1 = supports secondary Multi-plane Block Erase 5: 1 = supports secondary Multi-plane Copyback Program 4: 1 = supports secondary Multi-plane Program 3: 1 = supports secondary Random Data Output 2: 1 = supports secondary Multi-plane Copyback Read 1: 1 = supports secondary Multi-plane Read Cache Random 0: 1 = supports secondary Multi-plane Read	81h, 00h
13	O	Number of Parameter Pages	20h
14-31		Reserved (0)	All 00h
Manufacturer information block			
32-43	M	Device manufacturer (12 ASCII characters) TOSHIBA	54h, 4Fh, 53h, 48h 49h, 42h, 41h, 20h 20h, 20h, 20h, 20h
44-63	M	Device model (20 ASCII characters)	54h, 48h, 35h, 38h, 54h, 46h, 47h, 39h 56h, 32h, 33h, 42h, 41h, 34h, 43h, 20h 20h, 20h, 20h, 20h(TH58TFG9V23BA4C)
			54h, 48h, 35h, 38h, 54h, 46h, 54h, 30h 56h, 32h, 33h, 42h, 41h, 38h, 43h, 20h 20h, 20h, 20h, 20h (TH58TFT0V23BA8C)
			54h, 48h, 35h, 38h, 54h, 46h, 54h, 31h 56h, 32h, 33h, 42h, 41h, 38h, 48h, 20h 20h, 20h, 20h, 20h (TH58TFT1V23BA8H)
64-69	M	JEDEC manufacturer ID (6 bytes)	98h, 00h, 00h, 00h, 00h, 00h
70-79		Reserved (0)	All 00h
Memory organization block			
80-83	M	Number of data bytes per page	00h, 40h, 00h, 00h
84-85	M	Number of spare bytes per page	A0h, 07h
86-91		Reserved (0)	All 00h
92-95	M	Number of pages per block	00h, 03h, 00h, 00h
96-99	M	Number of blocks per logical unit (LUN)	8Ch, 0Bh, 00h, 00h
100	M	Number of logical units (LUNs)	01h (TH58TFG9V23BA4C, TH58TFT0V23BA8C) 02h (TH58TFT1V23BA8H)
Memory organization block			
101	M	Number of address cycles 4-7: Column address cycles 0-3: Row address cycles	23h
102	M	Number of bits per cell	03h
103	M	Number of programs per page	01h
104	M	Multi-plane addressing 4-7: Reserved (0) 0-3: Number of plane address bits	01h
105	M	Multi-plane operation attributes 3-7: Reserved (0) 2: 1= read cache supported 1: 1= program cache supported 0: 1= No multi-plane block address restrictions	07h
106-143		Reserved (0)	All 00h
Electrical parameters block			
144-145	O	Asynchronous SDR speed grade 6-15: Reserved (0) 5: 1 = supports 20 ns speed grade (50 MHz) 4: 1 = supports 25 ns speed grade (40 MHz) 3: 1 = supports 30 ns speed grade (~33 MHz) 2: 1 = supports 35 ns speed grade (~28 MHz) 1: 1 = supports 50 ns speed grade (20 MHz)	00h, 00h

		0: 1 = supports 100 ns speed grade (10 MHz)	
146-147	O	Toggle DDR speed grade 8-15: Reserved (0) 7: 1 = supports 5 ns speed grade (~200 MHz) 6: 1 = supports 6 ns speed grade (~166 MHz) 5: 1 = supports 7.5 ns speed grade (~133 MHz) 4: 1 = supports 10 ns speed grade (~100 MHz) 3: 1 = supports 12 ns speed grade (~83 MHz) 2: 1 = supports 15 ns speed grade (~66 MHz) 1: 1 = supports 25 ns speed grade (40 MHz) 0: 1 = supports 30 ns speed grade (~33 MHz)	FFh, 00h
148-149	O	Synchronous DDR speed grade 6-15: Reserved (0) 5: 1 = supports 10 ns speed grade (100 MHz) 4: 1 = supports 12 ns speed grade (~83 MHz) 3: 1 = supports 15 ns speed grade (~66 MHz) 2: 1 = supports 20 ns speed grade (50 MHz) 1: 1 = supports 30 ns speed grade (~33 MHz) 0: 1 = supports 50 ns speed grade (20 MHz)	00h, 00h
150	O	Asynchronous SDR features 0-7: Reserved (0)	00h
151	O	Toggle-mode DDR features 0-7: Reserved (0)	00h
152	O	Synchronous DDR features 0-7: Reserved (0)	00h
153-154	M	tPROG Maximum page program time (µs)	F8h, 2Ah
155-156	M	tBERS Maximum block erase time (µs)	A8h, 61h
157-158	M	tR Maximum page read time (µs)	64h, 00h
159-160	O	tR Maximum multi-plane page read time (µs)	00h, 00h
161-162	O	tCCS Minimum change column setup time (ns)	00h, 00h
163-164	M	I/O pin capacitance, typical or maximum	41h (TH58TFG9V23BA4C) 64h (TH58TFT0V23BA8C) AAh (TH58TFT1V23BA8H)
165-166	M	Input pin capacitance, typical or maximum	37h (TH58TFG9V23BA4C) 46h (TH58TFT0V23BA8C) 64h (TH58TFT1V23BA8H)
167-168	O	CK pin capacitance, typical or maximum	00h, 00h
169	M	Driver strength support 3-7: Reserved (0) 2: 1 = supports 18 ohm drive strength 1: 1 = supports 25 ohm drive strength 0: 1 = supports 35ohm/50ohm drive strength	03h
170-171	O	tADL Program page register clear enhancement tADL value (ns)	00h, 00h
172-207		Reserved (0)	All 00h
ECC and endurance block			
208	O	Guaranteed valid blocks of target	00h
209-210	O	Block endurance for guaranteed valid blocks	00h, 00h
211-218	M	ECC and endurance information block 0 Byte 211: Number of bits ECC correctability Byte 212: Codeword size Byte 213-214: Maximum value of average bad blocks per LUN Byte 215-216: Block endurance Byte 217-218: Reserved (0)	78h, 0Ah, B6h, 00h, 00h, 00h, 00h, 00h
219-226	O	ECC and endurance information block 1 Byte 219: Number of bits ECC correctability Byte 220: Codeword size Byte 221-222: Maximum value of average bad blocks per LUN Byte 223-224: Block endurance	All 00h

		Byte 225-226: Reserved (0)	
227-234	O	ECC and endurance information block 2 Byte 227: Number of bits ECC correctability Byte 228: Codeword size Byte 229-230: Maximum value of average bad blocks per LUN Byte 231-232: Block endurance Byte 233-234: Reserved (0)	All 00h
235-242	O	ECC and endurance information block 3 Byte 235: Number of bits ECC correctability Byte 236: Codeword size Byte 237-238: Maximum value of average bad blocks per LUN Byte 239-240: Block endurance Byte 241-242: Reserved (0)	All 00h
243-419		Reserved (0)	All 00h
Vendor specific block			
420-421	M	Vendorr Specific Revision Number	Vendor specific
422-509		Vendor specific	Vendor specific
CRC for Parameter Page			
510-511	M	Integrity CRC	CRC Value
Redundant Parameter Pages			
512-1023		Value of bytes 0-511	Value of bytes 0-511
1024-1535		Value of bytes 0-511	Value of bytes 0-511
…			
15872-16383		Value of bytes 0-511	Value of bytes 0-511

Note:
This field may contain invalid data as far as the value of the field is not fixed. Once it's fixed, the field of the Parameter Page table in this document designates valid value. The value will be reflected into the succeeding devices and there may be lag time for the reflection.

Byte 0-3: Parameter page signature
This field contains the Parameter Page signature. When two or more bytes of the signature are valid, then it denotes that a valid copy of the Parameter Page is present.

Byte 0 shall be set to 4Ah.
Byte 1 shall be set to 45h.
Byte 2 shall be set to 53h.
Byte 3 shall be set to 44h.

Byte 4-5: Revision number
This field indicates the revisions of the Parameter Page and standard that the target complies to. The target may support multiple revisions of the standard. This is a bit field where each defined bit corresponds to a particular specification revision that the target may support.

Bit 0 shall be cleared to zero.
Bit 1 when set to one indicates that the target supports vendor specific Parameter Page.
Bit 2 when set to one indicates that the target supports Parameter Page revision 1.0 and standard revision 1.0.
Bits 3-15 are reserved and shall be cleared to zero.

Byte 6-7: Features supported
This field indicates the optional features that the target supports.

Bit 0 when set to one indicates that the target's data bus width is 16-bits. Bit 0 when cleared to zero indicates that the target's data bus width is 8-bits. The host shall use the indicated data bus width for all commands that are defined to be transferred at the bus width (x8 or x16). Note that some commands, like Read ID, always transfer data as 8-bit only.

Bit 1 when set to one indicates that the target supports multiple LUN operations. If bit 1 is cleared to zero, then the host shall not issue commands to a LUN unless all other LUNs on the target are idle (i.e. R/B_n is set to one).

Bit 2 when set to one indicates that the target supports non-sequential page programming operations, such that the host may program pages within a block in arbitrary order. Bit 2 when cleared to zero indicates that the target does not support non-sequential page programming operations. If bit 2 is cleared to zero, the host shall program all pages within a block in order starting with page 0.

Bit 3 when set to one indicates that the target supports multi-plane program and erase operations.

Bit 4 when set to one indicates that the target supports multi-plane read operations.

Bit 5 when set to one indicates that the Synchronous DDR data interface is supported by the target. If bit 5 is set to one, then the target shall indicate the Synchronous DDR timing modes supported in the Synchronous DDR timing mode support field. Bit 5 when cleared to zero indicates that the Synchronous DDR data interface is not supported by the target.

Bit 6 when set to one indicates that the Toggle Mode DDR data interface is supported by the target. If bit 6 is set to one, then the target shall indicate the Toggle Mode DDR timing modes supported in the Toggle Mode DDR timing mode support field. Bit 6 when cleared to zero indicates that the Toggle Mode DDR data interface is not supported by the target.

Bit 7 when set to one indicates that the target supports external V_{PP}. If bit 7 is cleared to zero, then the target does not support external V_{PP}.

Bit 8 when set to one indicates that the target supports clearing only the page register for the LUN addressed with the Program (80h) command. If bit 8 is cleared to zero, then a Program (80h) command clears the page register for each LUN that is part of the target. At power-on, the device clears the page register for each LUN that is part of the target.

Bits 9-15 are reserved and shall be cleared to zero.

Byte 8-10: Optional commands supported

This field indicates the optional commands that the target supports.

Bit 0 when set to one indicates that the target supports the Page Cache Program command. If bit 0 is cleared to zero, the host shall not issue the Page Cache Program command to the target.

Bit 1 when set to one indicates that the target supports the Read Cache Random, Read Cache Sequential, and Read Cache End commands. If bit 1 is cleared to zero, the host shall not issue the Read Cache Sequential, Read Cache Random, or Read Cache End commands to the target.

Bit 2 when set to one indicates that the target supports the Get Features and Set Features commands. If bit 2 is cleared to zero, the host shall not issue the Get Features or Set Features commands to the target.

Bit 3 when set to one indicates that the target supports the Read Status Enhanced command. If bit 3 is cleared to zero, the host shall not issue the Read Status Enhanced command to the target. Read Status Enhanced shall be supported if the target has multiple LUNs or supports multi-plane operations.

Bit 4 when set to one indicates that the target supports the Copyback Program and Copyback Read commands. If bit 4 is cleared to zero, the host shall not issue the Copyback Program or Copyback Read commands to the target.

Bit 5 when set to one indicates that the target supports the Read Unique ID command. If bit 5 is cleared to zero, the host shall not issue the Read Unique ID command to the target.

Bit 6 when set to one indicates that the target supports the Random Data Output command. If bit 6 is cleared to zero, the host shall not issue the Random Data Output command to the target.

Bit 7 when set to one indicates that the target supports the Multi-plane Copyback Program command. If bit 7 is cleared to zero, the host shall not issue the Multi-plane Copyback Program command to the target.

Bit 8 when set to one indicates that the target supports the Small Data Move command for both Program and Copyback operations. If bit 8 is cleared to zero, the target does not support the Small Data Move command for

Program or Copyback operations. The Small Data Move command is mutually exclusive with overlapped multi-plane support. When bit 8 is set to one, the device shall support the 11h command to flush any internal data pipeline regardless of whether multi-plane operations are supported.

Bit 9 when set to one indicates that the target supports the Reset LUN command. If bit 9 is cleared to zero, the host shall not issue the Reset LUN command.

Bit 10 when set to one indicates that the target supports the Synchronous Reset command. If bit 10 is cleared to zero, the host shall not issue the Synchronous Reset command.

Bits 11-23 are reserved and shall be cleared to zero.

Byte 11-12: Secondary commands supported
This field indicates the secondary commands that the target supports.

Bit 0 when set to one indicates that the target supports the secondary Multi-plane Read command. If bit 0 is cleared to zero, the host shall not issue the secondary Multi-plane Read command to the target.

Bit 1 when set to one indicates that the target supports the secondary Multi-plane Read Cache Random command. If bit 1 is cleared to zero, the host shall not issue the secondary Multi-plane Read Cache Random command to the target.

Bit 2 when set to one indicates that the target supports the secondary Multi-plane Copyback Read command. If bit 2 is cleared to zero, the host shall not issue the secondary Multi-plane Copyback Read command to the target.

Bit 3 when set to one indicates that the target supports the secondary Random Data Output command. If bit 3 is cleared to zero, the host shall not issue the secondary Random Data Output command to the target.

Bit 4 when set to one indicates that the target supports the secondary Multi-plane Program command. If bit 4 is cleared to zero, the host shall not issue the secondary Multi-plane Program command to the target.

Bit 5 when set to one indicates that the target supports the secondary Multi-plane Copyback Program command. If bit 5 is cleared to zero, the host shall not issue the secondary Multi-plane Copyback Program command to the target.

Bit 6 when set to one indicates that the target supports the secondary Multi-plane Block Erase command. If bit 6 is cleared to zero, the host shall not issue the secondary Multi-plane Block Erase command to the target.

Bit 7 when set to one indicates that the target supports the secondary Read Status Enhanced command. If bit 7 is cleared to zero, the host shall not issue the secondary Read Status Enhanced command to the target.

Bits 8-15 are reserved and shall be cleared to zero.

Byte 13: Number of Parameter Pages
This field specifies the number of Parameter Pages present, including the original and the subsequent redundant versions.

Byte 32-43: Device manufacturer
This field contains the manufacturer of the device. The content of this field is an ASCII character string of twelve bytes. The device shall pad the character string with spaces (20h), if necessary, to ensure that the string is the proper length.

There is no standard for how the manufacturer represents their name in the ASCII string. If the host requires use of a standard manufacturer ID, it should use the JEDEC manufacturer ID.

Byte 44-63: Device model
This field contains the model number of the device. The content of this field is an ASCII character string of twenty bytes. The device shall pad the character string with spaces (20h), if necessary, to ensure that the string is the proper length.

Byte 64-69: JEDEC manufacturer ID
This field contains the JEDEC manufacturer ID for the manufacturer of the device.

Byte 80-83: Number of data bytes per page
This field contains the number of data bytes per page. The value reported in this field shall be a power of two. The minimum value that shall be reported is 512 bytes.

Byte 84-85: Number of spare bytes per page
This field contains the number of spare bytes per page. There are no restrictions on the value.

Byte 92-95: Number of pages per block
This field contains the number of pages per block.

Byte 96-99: Number of blocks per logical unit
This field contains the number of blocks per logical unit. There are no restrictions on this value.

Byte 100: Number of logical units (LUNs)
This field indicates the number of logical units the target supports. Logical unit numbers are sequential, beginning with a LUN address of zero. This field shall be greater than zero.

Byte 101: Number of Address Cycles
This field indicates the number of address cycles used for row and column addresses. The reported number of address cycles shall be used by the host in operations that require row and/or column addresses (e.g. Page Program).

Bits 0-3 indicate the number of address cycles used for the row address. This field shall be greater than zero.
Bits 4-7 indicate the number of address cycles used for the column address. This field shall be greater than zero.

NOTE :
Throughout these standard examples are shown with 2-byte column addresses and 3-byte row addresses. However, the host is responsible for providing the number of column and row address cycles in each of these sequences based on the values in this field.

Byte 102: Number of bits per cell
This field indicates the number of bits per cell in the Flash array. This field shall be greater than zero. The value reported in this field shall be a power of two.

Byte 103: Number of programs per page
This field indicates the maximum number of times a portion of a page may be programmed without an erase operation. After the number of programming operations specified have been performed, the host shall issue an erase operation to that block before further program operations to the affected page. This field shall be greater than zero.

Byte 104: Multi-plane addressing
This field describes parameters for multi-plane addressing.

Bits 0-3 indicate the number of bits that are used for plane addresses. This value shall be greater than 0h when multi-plane operations are supported.

Bits 4-7 are reserved.

Byte 105: Multi-plane operation attributes
This field describes attributes for multi-plane operations. This byte is mandatory when multi-plane operations are supported as indicated in the Features supported field.

Bit 0 indicates that there are no block address restrictions for the multi-plane operation. If set to one all block address bits may be different between multi-plane operations. If cleared to zero, there are block address restrictions.

Bit 1 indicates whether program cache is supported with multi-plane programs. If set to one then program cache is supported for multi-plane program operations. If cleared to zero then program cache is not supported for multi-plane program operations. Note that program cache shall not be used with multi-plane copyback program operations.

Bit 2 indicates whether read cache is supported with multi-plane reads. If set to one then read cache is supported for multi-plane read operations. If cleared to zero then read cache is not supported for multiplane read operations. Note that read cache shall not be used with multi-plane copyback read operations.

Bits 3-7 are reserved.

Byte 144-145: Asynchronous SDR speed grade
This field indicates the asynchronous SDR speed grades supported.

Bit 0 when set to one indicates that the target supports the 100 ns speed grade (10 MHz).
Bit 1 when set to one indicates that the target supports the 50 ns speed grade (20 MHz).
Bit 2 when set to one indicates that the target supports the 35 ns speed grade (~28 MHz).
Bit 3 when set to one indicates that the target supports the 30 ns speed grade (~33 MHz).
Bit 4 when set to one indicates that the target supports the 25 ns speed grade (40 MHz).
Bit 5 when set to one indicates that the target supports the 20 ns speed grade (50 MHz).
Bits 6-15 are reserved and shall be cleared to zero.

Byte 146-147: Toggle DDR speed grade
This field indicates the Toggle DDR speed grades supported. The target shall support an inclusive range of speed grades.

Bit 0 when set to one indicates that the target supports the 30 ns speed grade (~33 MHz).
Bit 1 when set to one indicates that the target supports the 25 ns speed grade (40 MHz).
Bit 2 when set to one indicates that the target supports the 15 ns speed grade (~66 MHz).
Bit 3 when set to one indicates that the target supports the 12 ns speed grade (~83 MHz).
Bit 4 when set to one indicates that the target supports the 10 ns speed grade (~100 MHz).
Bit 5 when set to one indicates that the target supports the 7.5 ns speed grade (~133 MHz).
Bit 6 when set to one indicates that the target supports the 6 ns speed grade (~166 MHz).
Bit 7 when set to one indicates that the target supports the 5 ns speed grade (~200 MHz).
Bits 8-15 are reserved and shall be cleared to zero.

Byte 148-149: Synchronous DDR speed grade
This field indicates the synchronous DDR speed grades supported. The target shall support an inclusive range of speed grades.
Bit 0 when set to one indicates that the target supports the 50 ns speed grade (20 MHz).
Bit 1 when set to one indicates that the target supports the 30 ns speed grade (~33 MHz).
Bit 2 when set to one indicates that the target supports the 20 ns speed grade (50 MHz).
Bit 3 when set to one indicates that the target supports the 15 ns speed grade (~66 MHz).
Bit 4 when set to one indicates that the target supports the 12 ns speed grade (~83 MHz).
Bit 5 when set to one indicates that the target supports the 10 ns speed grade (100 MHz).
Bits 6-15 are reserved and shall be cleared to zero.

Byte 150: Asynchronous SDR features
This field describes features and attributes for asynchronous SDR operation. This byte is mandatory when the asynchronous SDR data interface is supported.
Bits 0-7 are reserved.

Byte 151: Toggle-mode DDR features
This field describes features and attributes for Toggle-mode DDR operation. This byte is mandatory when the Toggle-mode DDR data interface is supported.
Bits 0-7 are reserved.

Byte 152: Synchronous DDR features
This field describes features and attributes for synchronous DDR operation. This byte is mandatory when the synchronous DDR data interface is supported.

Bit 0 indicates the tCAD value that shall be used by the host. If bit 0 is set to one, then the host shall use the tCADs (slow) value in synchronous DDR command, address and data transfers. If bit 0 is cleared to zero, then the host shall use the tCADf (fast) value in synchronous DDR command, address and data transfers.

Bit 1 indicates that the device supports the CK being stopped during data input. If bit 1 is set to one, then the host may optionally stop the CK during data input for power savings. If bit 1 is set to one, the host may pause data while the CK is stopped. If bit 1 is cleared to zero, then the host shall leave CK running during data input.

Bits 2-7 are reserved.

Byte 153-154: Maximum page program time
This field indicates the maximum page program time (tPROG) in microseconds.

Byte 155-156: Maximum block erase time
This field indicates the maximum block erase time (tBERS) in microseconds.

Byte 157-158: Maximum page read time
This field indicates the maximum page read time (tR) in microseconds.

Byte 159-160: Maximum multi-plane page read time
This field indicates the maximum page read time (tR) for multi-plane page reads in microseconds. Multiplane page read times may be longer than single page read times. This field shall be supported if the target supports multi-plane reads as indicated in the Features supported field.

Byte 161-162: Minimum change column setup time.
This field indicates the minimum change column setup time (tCCS) in nanoseconds. This parameter is used for the asynchronous SDR and synchronous DDR data interfaces.

After issuing a Change Read Column command, the host shall not read data until a minimum of tCCS time has elapsed. After issuing a Change Write Column command including all column address cycles, the host shall not write data until a minimum of tCCS time has elapsed. The value of tCCS shall always be longer than or equal to tWHR and tADL when the Toggle-mode DDR or Synchronous DDR data interface is supported.

Byte 163-164: I/O pin capacitance, typical or maximum
This field indicates the typical or maximum I/O pin capacitance for the target. This field is specified in 0.1 pF units. For example, a value of 31 corresponds to 3.1 pF. If vendor datasheet is specifying the maximum value, then this field is indicating the maximum capacitance value. If vendor datasheet is specifying a typical value, then this field is indicating the typical capacitance value.

Byte 165-166: Input pin capacitance, typical or maximum
This field indicates the typical or maximum input pin capacitance for the target. This value applies to all inputs except the following: CK, CK_n, CE_n and WP_n signals. This field is specified in 0.1 pF units. For example, a value of 31 corresponds to 3.1 pF. If vendor datasheet is specifying the maximum value, then this field is indicating the maximum capacitance value. If vendor datasheet is specifying a typical value, then this field is indicating the typical capacitance value.

Byte 167-168: CK input pin capacitance, typical or maximum
This field indicates the typical or maximum CK input pin capacitance for the target. This value applies to the CK and CK_n signals. This field is specified in 0.1 pF units. For example, a value of 31 corresponds to 3.1 pF. This field shall be supported if the Synchronous DDR data interface is supported. If vendor datasheet is specifying the maximum value, then this field is indicating the maximum capacitance value. If vendor datasheet is specifying a typical value, then this field is indicating the typical capacitance value.

Byte 169: Driver strength support
This field describes if the target supports configurable driver strengths and its associated features.

Bit 0 when set to one indicates that the target supports configurable driver strength settings. If this bit is set to one, then the device shall support both the Nominal and Underdrive settings. If this bit is set to one, then the device shall power-on with a driver strength at the Nominal value. If this bit is cleared to zero, then the driver strength at power-on is undefined.

Bit 1 when set to one indicates that the target supports the Overdrive 1 setting for use in the I/O Drive Strength setting.

Bit 2 when set to one indicates that the target supports the 18 ohm setting in Table 13 for use in the I/O Drive Strength setting.

Bits 3-7 are reserved.

Byte 170-171: Program page register clear enhancement tADL value

This field indicates the ALE to data loading time (tADL) in nanoseconds when the program page register clear enhancement is enabled. If the program page register clear enhancement is disabled, then the tADL value is as defined for the selected timing mode. This increased tADL value only applies to Program (80h) command sequences; it does not apply for Set Features, Copyback, or other commands.

Byte 208: Guaranteed valid blocks at beginning of target

This field indicates the number of guaranteed valid blocks starting at block address 0 of the target. The minimum value for this field is 1h. The blocks are guaranteed to be valid for the endurance specified for this area when the host follows the specified number of bits to correct in ECC information block 0.

Byte 209-210: Block endurance for guaranteed valid blocks

This field indicates the minimum number of program/erase cycles per addressable page/block in the guaranteed valid block area. This value requires that the host is using at least the minimum ECC correctability reported in ECC information block 0. This value is not encoded. If the value is 0000h, then no minimum number of cycles is specified, though the block(s) are guaranteed valid from the factory.

Byte 211-218: ECC information block 0

This block of parameters describes a set of ECC and endurance information. The parameters are related, and thus the parameters are specified as a set.

The device may report additional ECC information in the Parameter Page. The required ECC correctability is closely related to other device parameters, like the number of valid blocks and the number of program/erase cycles supported. The additional ECC information stored in the ECC information blocks allow the device to specify multiple valid methods for using the device. Bytes 211-218 provide one valid method (i.e. ECC information block 0) for using the device. Other methods can be specified in ECC information blocks 1-3 stored in Bytes 219-242

Byte 211: Number of bits ECC correctability. This field indicates the number of bits that the host should be able to correct per codeword. The codeword size is reported in byte 212. With this specified amount of error correction by the host, the target shall achieve the block endurance specified in bytes 215-216. When the specified amount of error correction is applied by the host and the block endurance is followed, then the maximum number of bad blocks specified in bytes 213-214 shall not be exceeded by the device. All used bytes in the page shall be protected by ECC including the spare bytes if the ECC requirement reported in byte 211 has a value greater than zero. When this value is cleared to zero, the target shall return valid data.

Byte 212: Codeword size. The number of bits of ECC correctability specified in byte 211 is based on a particular ECC codeword size. The ECC codeword size is specified in this field as a power of two. The minimum value that shall be reported is 512 bytes (a value of 9).

Byte 213-214: Maximum value of average bad blocks per LUN. This field contains the maximum number of average bad blocks that may be defective at manufacture and over the life of the device. The average bad blocks per LUN value can be determined by averaging the bad blocks per LUN for either the number LUNs per package or number of LUNs per target. The maximum rating assumes that the host is following the block endurance requirements and the ECC requirements reported in this ECC and endurance information block. If the value is 00h, then no maximum value of average bad blocks per LUN is specified.

Byte 215-216: Block endurance. This field indicates the maximum number of program/erase cycles per addressable page/block. This value assumes that the host is using the ECC correctability reported in byte 211. The block endurance is reported in terms of a value and a multiplier according to the following equation: value x 10multiplier. Byte 215 comprises the value. Byte 216 comprises the multiplier. For example, a block endurance of 75,000 cycles would be reported as a value of 75 and a multiplier of 3 (75 x 103). The value field shall be the smallest possible; for example 100,000 shall be reported as a value of 1 and a multiplier of 5 (1 x 105). If the value is 0000h, then no maximum number of cycles is specified.

Byte 219-226: ECC information block 1

This block of parameters describes an additional set of ECC and endurance information. The parameters are related, and thus the parameters are specified as a set. The layout is and definition for this block is equivalent to ECC information block 0. If this set of parameter is not specified, the block shall be cleared to 0h.

Byte 227-234: ECC information block 2

This block of parameters describes an additional set of ECC and endurance information. The parameters are related, and thus the parameters are specified as a set. The layout is and definition for this block is equivalent to ECC information block 0. If this set of parameter is not specified, the block shall be cleared to 0h.

Byte 235-242: ECC information block 3

This block of parameters describes an additional set of ECC and endurance information. The parameters are related, and thus the parameters are specified as a set. The layout is and definition for this block is equivalent to ECC information block 0. If this set of parameter is not specified, the block shall be cleared to 0h.

Byte 420-421: Vendor specific Revision number

This field indicates a vendor specific revision number. This field should be used by vendors to indicate the supported layout for the vendor specific Parameter Page area and the vendor specific feature addresses. The format of this field is vendor specific.

Byte 422-509: Vendor specific

This field is reserved for vendor specific use.

Byte 510-511: Integrity CRC

The Integrity CRC (Cyclic Redundancy Check) field is used to verify that the contents of the Parameter Page were transferred correctly to the host. The CRC of the Parameter Page is a word (16-bit) field. The CRC calculation covers all of data between byte 0 and byte 509 of the Parameter Page inclusive.
The CRC shall be calculated on byte (8-bit) quantities starting with byte 0 in the Parameter Page. The bits in the 8-bit quantity are processed from the most significant bit (bit 7) to the least significant bit (bit 0).

The CRC shall be calculated using the following 16-bit generator polynomial:
G(X) = X16 + X15 + X2 + 1
This polynomial in hex may be represented as 8005h.

The CRC value shall be initialized with a value of 4F4Eh before the calculation begins. There is no XOR applied to the final CRC value after it is calculated. There is no reversal of the data bytes or the CRC calculated value.

Byte 512-1023: Redundant Parameter Page 1

This field shall contain the values of bytes 0-511 of the Parameter Page. Byte 512 is the value of byte 0.

The redundant Parameter Page shall be stored in non-volatile media; the target shall not create these bytes by retransmitting the first 512 bytes.

Byte 512xN - 512xN+511(ex. 512 - 1023) : Redundant Parameter Page N (N = 1 to 31)

This field shall contain the values of bytes 0-511 of the Parameter Page. Byte 512xN is the value of byte 0.

The redundant Parameter Page shall be stored in non-volatile media; the target shall not create these bytes by retransmitting the first 512 bytes.

5.3.10. Read Status Enhanced

Read Status Enhanced function is used to check status of selected LUN and Plane specified by row address setting. Thus, the function requires row address setting steps before reading status value. Table 52 defines status values of each operation and Figure 61 defines Read Status Enhanced behavior and timings.

Table 52 Read Status Enhanced Definition for 78h

	DQ 0	DQ 1	DQ 2	DQ 3	DQ 4	DQ 5	DQ 6	DQ 7
Definition of value	Pass : “0” Fail : “1”	Pass : “0” Fail : “1”	Reserved	Reserved	Reserved	Busy : “0” Ready : “1”	Busy : “0” Ready : “1”	Protected : “0” Not Protected :“1”
Block Erase	Pass/Fail	Not Use	Not Use	Not Use	Not Use	Not Use	Ready/Busy	Write Protect
Full Sequence Program	Pass/Fail	Not Use	Not Use	Not Use	Not Use	Not Use	Ready/Busy	Write Protect
Cache FSP	Pass/Fail for the current program	Pass/Fail for the previous program	Not Use	Not Use	Not Use	Busy/Ready for Flash array	Ready/Busy for Host	Write Protect
Read	Not Use	Not Use	Not Use	Not Use	Not Use	Not Use	Ready/Busy	Write Protect
Cache Read	Not Use	Not Use	Not Use	Not Use	Not Use	Busy/Ready for Flash array	Ready/Busy for Host	Write Protect

NOTE:

1) Pass/Fail for the program operation is the result of not page but FSP Unit basis.
2) During Block Erase or Full Seqeunece Program operation, DQ 0 is only valid when DQ 6 shows the Ready state.
3) During Cache Full Sequence Program operation, DQ 0 is only valid when DQ 5 shows the Ready state, and DQ 1 is only valid when DQ 6 shows the Ready state.

Figure 61. Read Status Timing

5.3.11. Read LUN #N Status Operation

Read LUN #N Status provides status value of each LUN without address setting. The function retrieves plane0 and plane1 status only. Table 53 defines the status values and Figure 62 defines Read LUN #N Status behavior and timings. N is LUN address.

Table 53 Read LUN #N Status Definition for Fnh

	DQ 0	DQ 1	DQ 2	DQ 3	DQ 4	DQ 5	DQ 6	DQ 7
Definition of value	Pass : "0" Fail : "1"	Pass : "0" Fail : "1"	Reserved	Reserved	Reserved	Busy : "0" Ready : "1"	Busy : "0" Ready : "1"	Protected : "0" Not Protected :"1"
Block Erase	Pass/Fail for LUN #N	Not Use	Not Use	Not Use	Not Use	Not Use	Ready/Busy	Write Protect
Full Sequence Program	Pass/Fail for LUN #N	Not Use	Not Use	Not Use	Not Use	Not Use	Ready/Busy	Write Protect
Cache FSP	Pass/Fail for LUN #N current program	Pass/Fail for LUN #N previous program	Not Use	Not Use	Not Use	Busy/Ready for Flash array	Ready/Busy for Host	Write Protect
Read	Not Use	Not Use	Not Use	Not Use	Not Use	Not Use	Ready/Busy	Write Protect
Cache Read	Not Use	Not Use	Not Use	Not Use	Not Use	Busy/Ready for Flash array	Ready/Busy for Host	Write Protect

NOTE:

1) Pass/Fail for the program operation is the result of not page but FSP Unit basis.
2) During Block Erase or Full Sequence Program Operation, DQ 0 is only valid when DQ 6 shows the Ready state.
3) During Cache Full Sequence Program operation, DQ 0 and DQ 1 are only valid when DQ 5 shows the Ready state.
4) 'n' of command "Fnh" is LUN address+1, and 'n' is from 1 to 2.

Figure 62. Read LUN #N Status Timing

5.4. Interleaving Operation

When multiple LUNs share a common $\overline{CE}$, it provides interleaving operation among multiple LUNs.
At first, the host issues an operation command to one of the LUNs in the Target, say(LUN #M). The R/$\overline{B}$ pin appointed for the Target indicates that the Target goes into busy state.
During this time, the other LUN(s), say LUN #N, in the same Target is in ready state. So it can execute the operation command issued by the host.
After the execution of operation by LUN #M, it can execute another operation regardless of LUN #N.
Before that, the host shall check the status of LUN #M by issuing 78h/Fnh command.
Only when the status of LUN #M is in ready state, host can issue another operation command to the LUN #M.
If LUN #M is in busy state, the host shall wait for LUN #M to get into ready state.
Similarly, LUN #N can execute another operation after the completion of the previous operation The host can monitor the status of LUN #N by issuing 78h/Fnh command. When LUN #N goes ready state, host can issue another operation command to LUN #N.
If the number of LUNs in the Target is more than two, the interleaveing operation can be performed up to the number of LUNs in the Target with applying the same rule as described above.
See following sections for details.

NOTE :

1) During interleave operations, the following command input and operations are prohibited.
2) Command Input : 70h/71h/73h command input.
3) Operations : Random Cache Read, Multi Plane Cache Read, Multi Plane Random Cache Read, Cache Full Sequence Program and Multi Plane Cache Full Sequence Program, combination of these operations.

5.4.1. Interleaving Full Sequence Program Operation

Figure 63 defines general interleaving Full Sequence program sequence. Figure 64 defines example timing when the number of LUN is two.

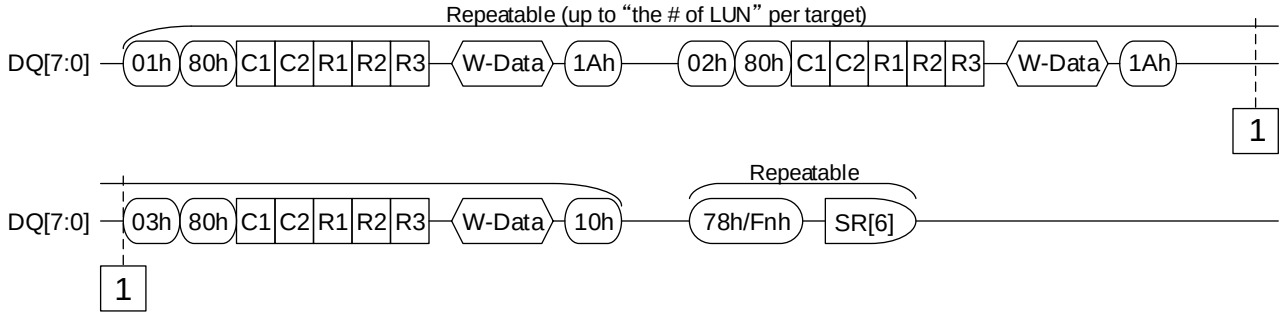


Figure 63. General Inteleaveing Full Sequence Program Sequence

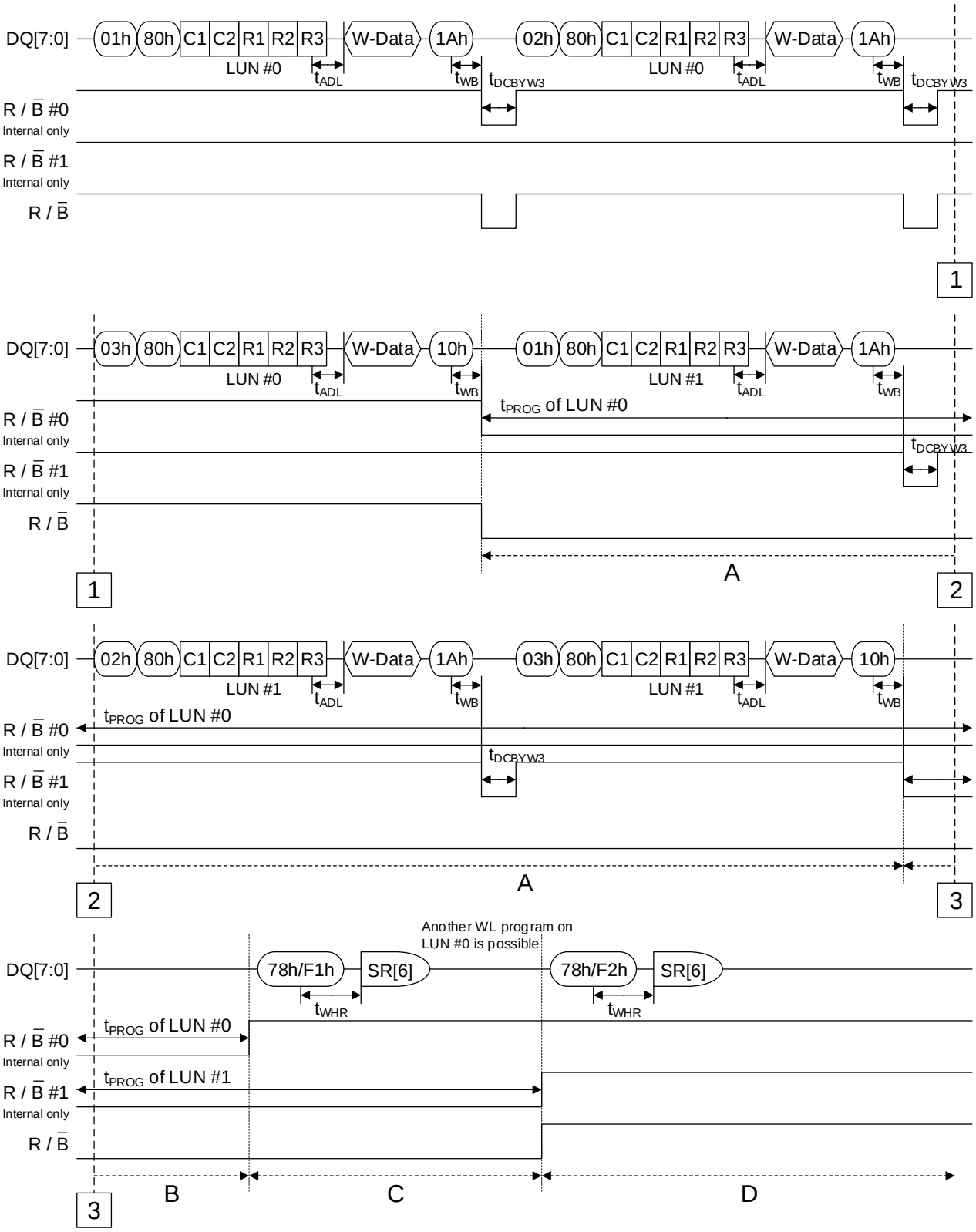


Figure 64. Example Timing with Interleaving Full Sequence Program

State A : LUN #0 is executing Full Sequence Program operation and LUN #1 is in ready state. So the host can issue page read command to LUN #1.

State B : Both LUN #0 and LUN #1 are executing Full Sequence Program operation .

State C : Full Sequence Program on LUN #0 is completed, but Full Sequence Program operation on LUN #1 is still ongoing. And the system should issue 78h/F1h command to detect the status of LUN #0. If LUN #0 is ready, status DQ 6 is "1" and the system can issue another Full Sequence Program command to LUN #0.

State D : Both of LUN #0 and LUN #1 are ready.

NOTE :

According to the above process, the system can operate Full Sequence Program on LUN #0 and LUN #1 alternately.

5.4.2. Interleaving Page Read

Figure 65 defines general interleaving page read sequence. Figure 66 defines example timing when the number of LUN is two.

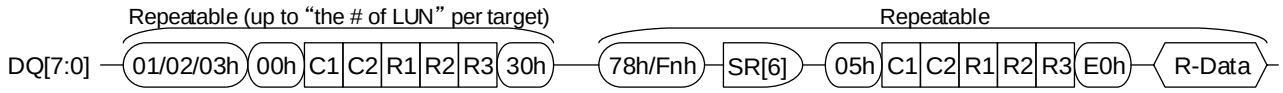


Figure 65. General Interleaving Page Read Sequence

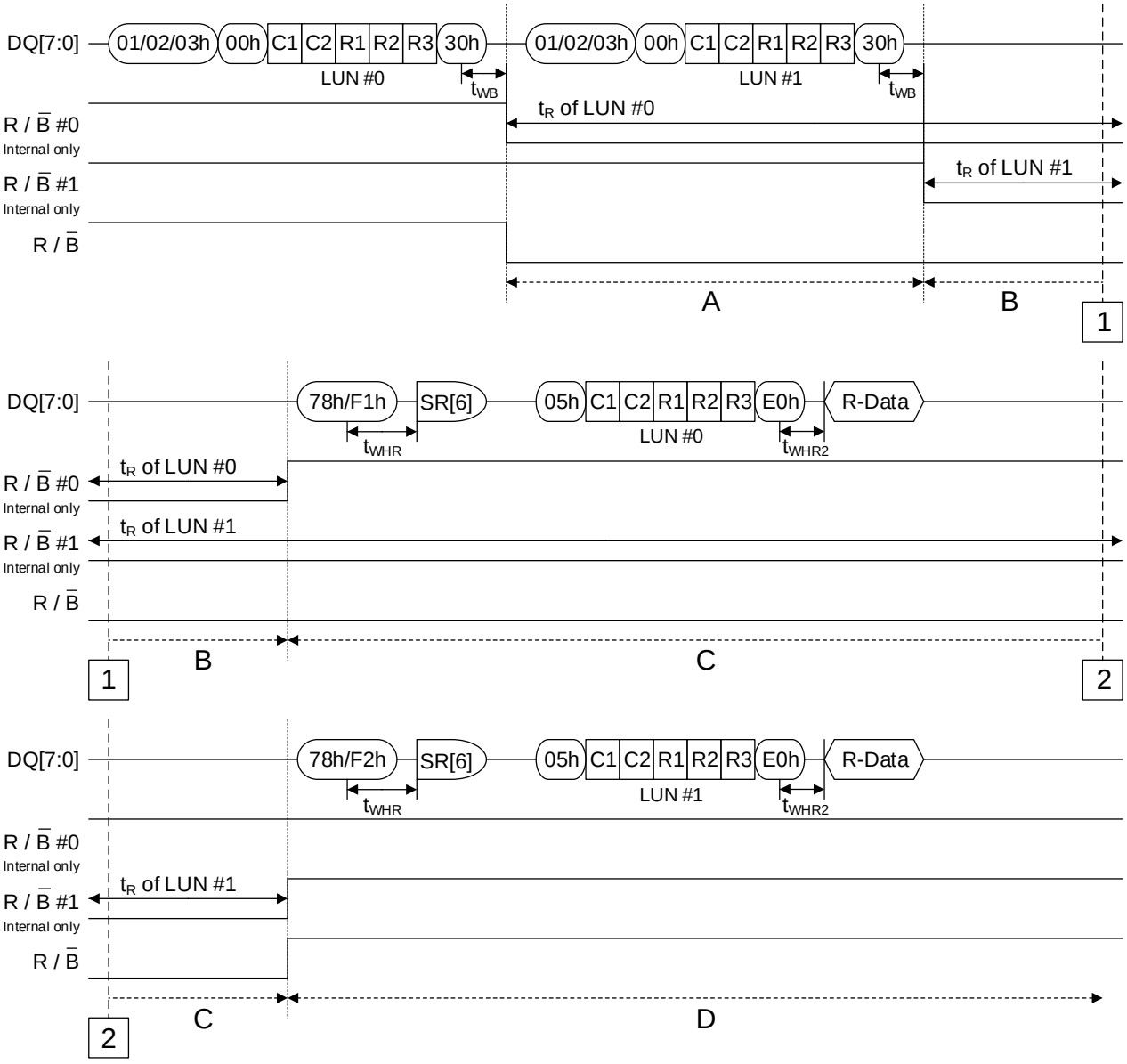


Figure 66. Example Timing with Interleaving Page Read

State A : LUN #0 is executing page read operation, and LUN #1 is in ready state. So the host can issue page read command to LUN #1.

State B : Both LUN #0 and LUN #1 are executing page read operation.

State C : Page read on LUN #0 is completed and LUN #1 is still executing page read operation. Before the host read the data, the host shall check the Ready/Busy status for LUN #0 by 78h/F1h commands. Host can read the data from the LUN #0 whose status indicates Ready state.

State D : Page read on LUN #1 is completed. Before the host read the data, the host shall check the Ready/Busy status for LUN #1 by 78h/F2h commands. Host can read the data from the LUN #1 whose status indicates Ready state.

NOTE :

78h/F1h command is required to check the status of LUN #0. 78h/F2h command is required to check the status of LUN.

5.4.3. Interleaving Block Erase

Figure 67 defines general interleaving block erase sequence. Figure 68 defines example timing when the number of LUN is two.

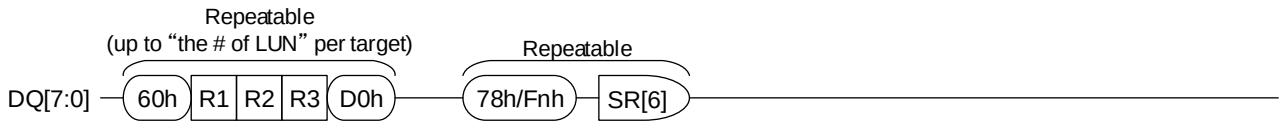


Figure 67. General Interleaving Block Erase Sequence

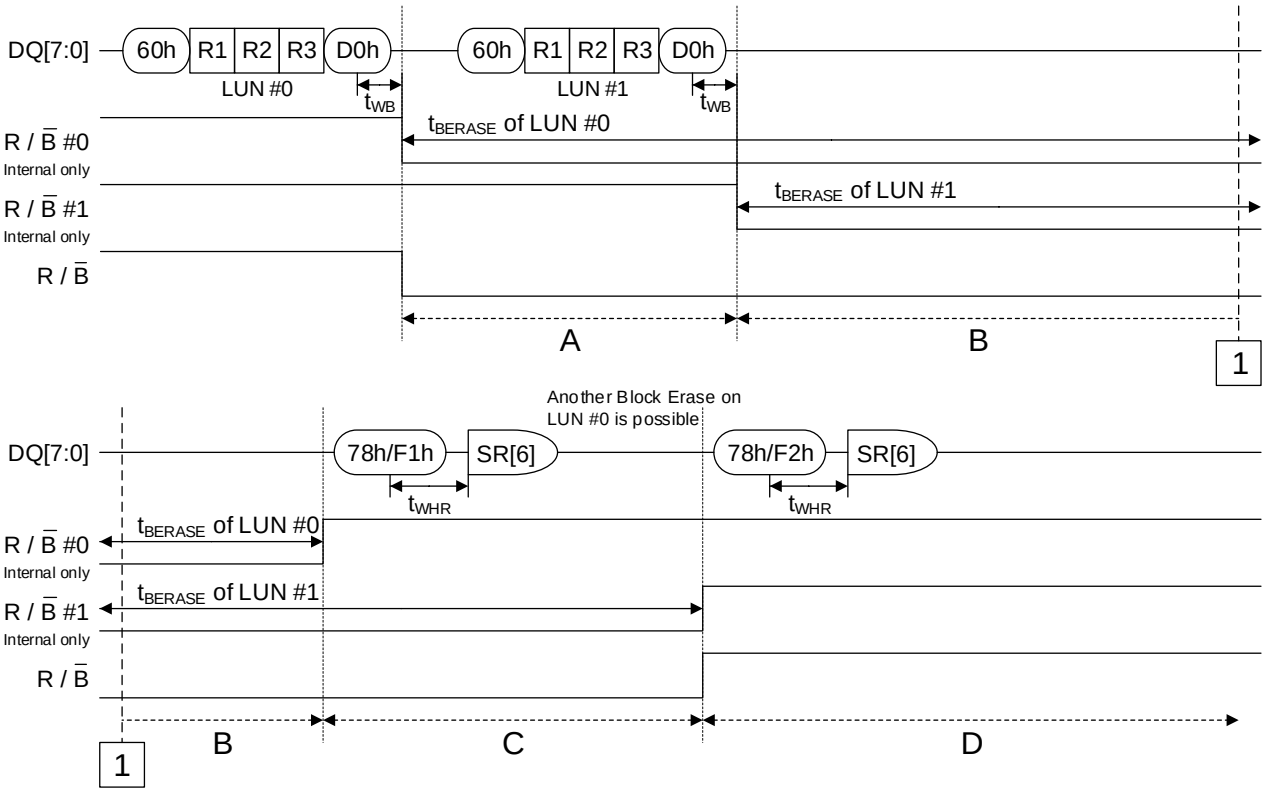


Figure 68. Example Timing with Interleaving Block Erase

State A : LUN #0 is executing block erase operation, and LUN #1 is in ready state. So the host can issue block erase command to LUN #1.

State B : Both LUN #0 and LUN #1 are executing block erase operation.

State C : Block erase on LUN #0 is completed, but block erase on LUN #1 is still operating. And the system should issue 78h/F1h command to detect the status of LUN #0. If LUN #0 is ready, status DQ 6 is "1" and the system can issue another block erase command to LUN #0.

State D : LUN #0 and LUN #1 are ready.

NOTE :

Depending on the above process, the system can operate block erase on LUN #0 and LUN #1 alternately.

5.4.4. Interleaving Multi Plane Full Sequence Program

Figure 69 defines general interleaving multi plane full sequence program. Figure 70 defines example timing when the number of LUN is two. Within the repeatable sequence in the following figure, the Page Select command (i.e 01h/02h/03h) shall be identical between planes.

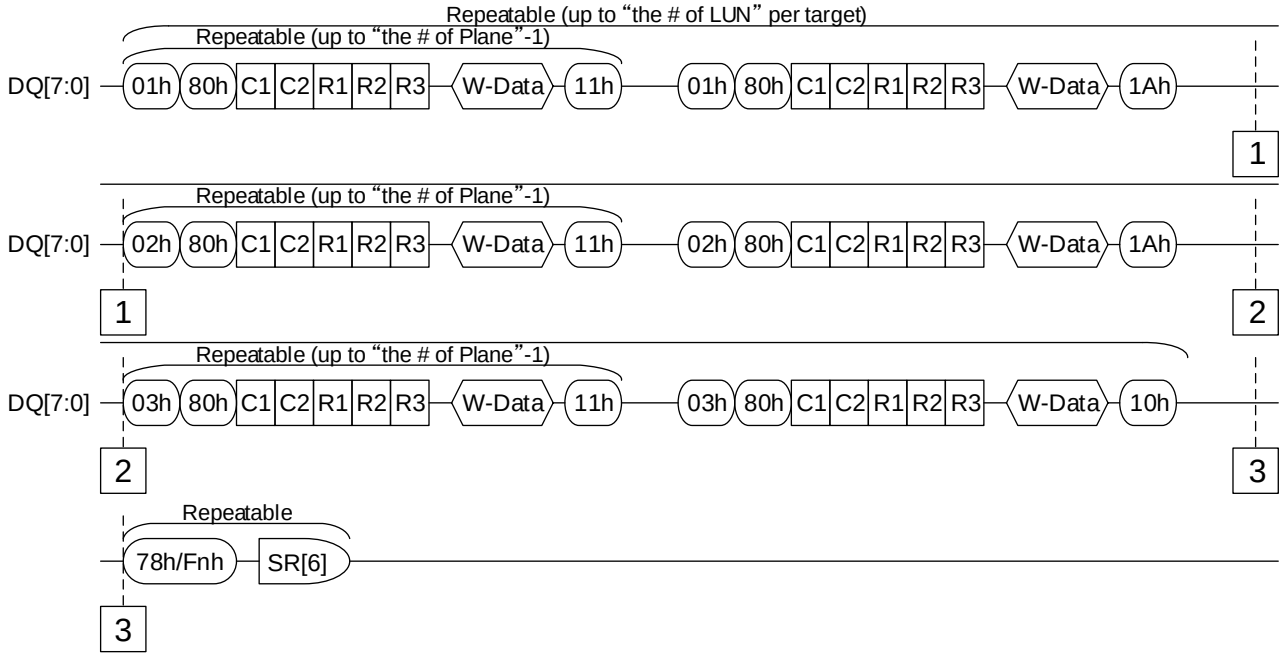
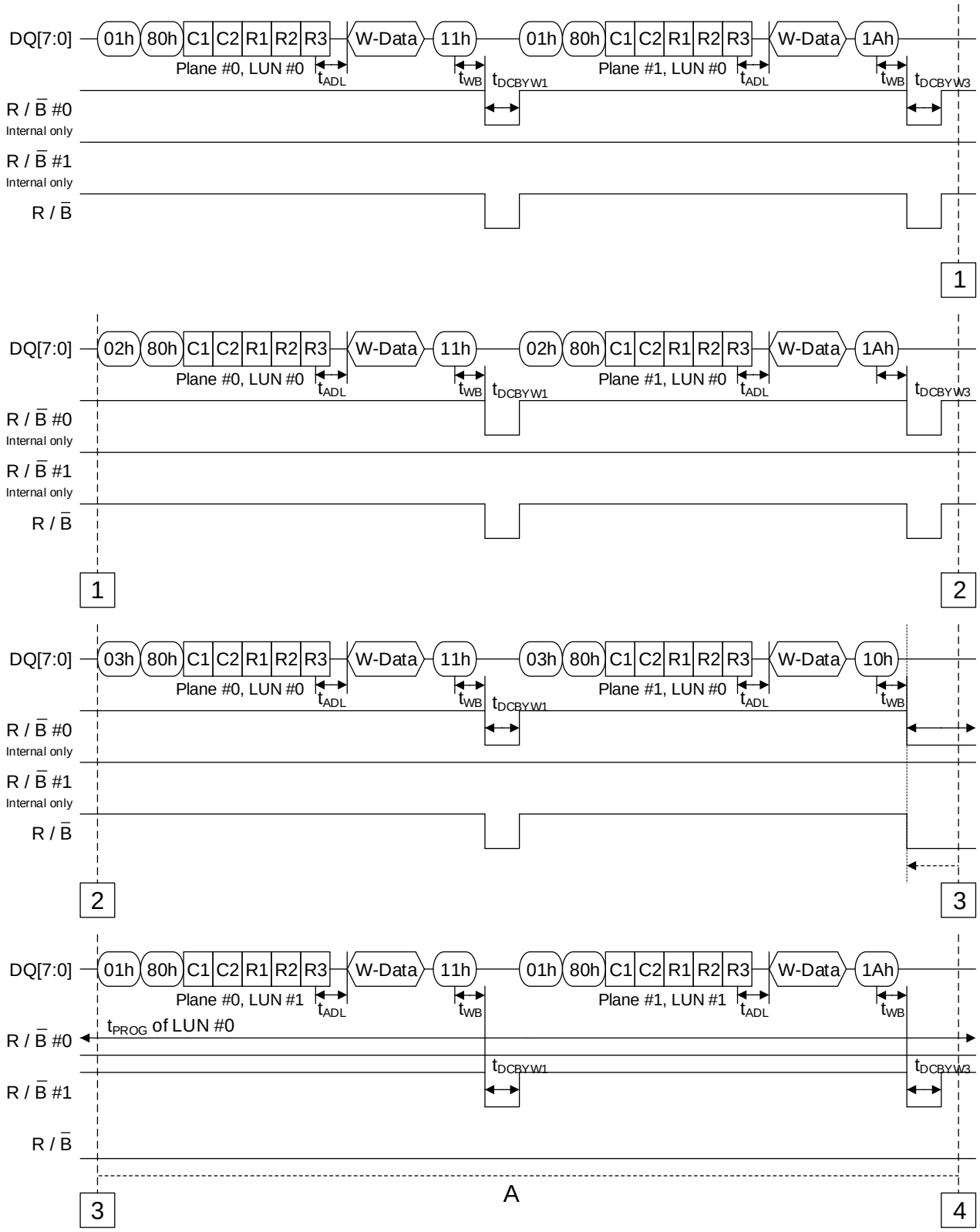


Figure 69. General Interleaving Multi plane Full Sequence Program


DQ[7:0]
01h 80h C1 C2 R1 R2 R3 W-Data 11h 01h 80h C1 C2 R1 R2 R3 W-Data 1Ah
Plane #0, LUN #0
Plane #1, LUN #0
tADL
tWB
tDCBYW1
tDCBYW3
R / B #0
Internal only
R / B #1
Internal only
R / B
1
02h 80h C1 C2 R1 R2 R3 W-Data 11h 02h 80h C1 C2 R1 R2 R3 W-Data 1Ah
2
03h 80h C1 C2 R1 R2 R3 W-Data 11h 03h 80h C1 C2 R1 R2 R3 W-Data 10h
3
01h 80h C1 C2 R1 R2 R3 W-Data 11h 01h 80h C1 C2 R1 R2 R3 W-Data 1Ah
Plane #0, LUN #1
Plane #1, LUN #1
tPROG of LUN #0
A
4

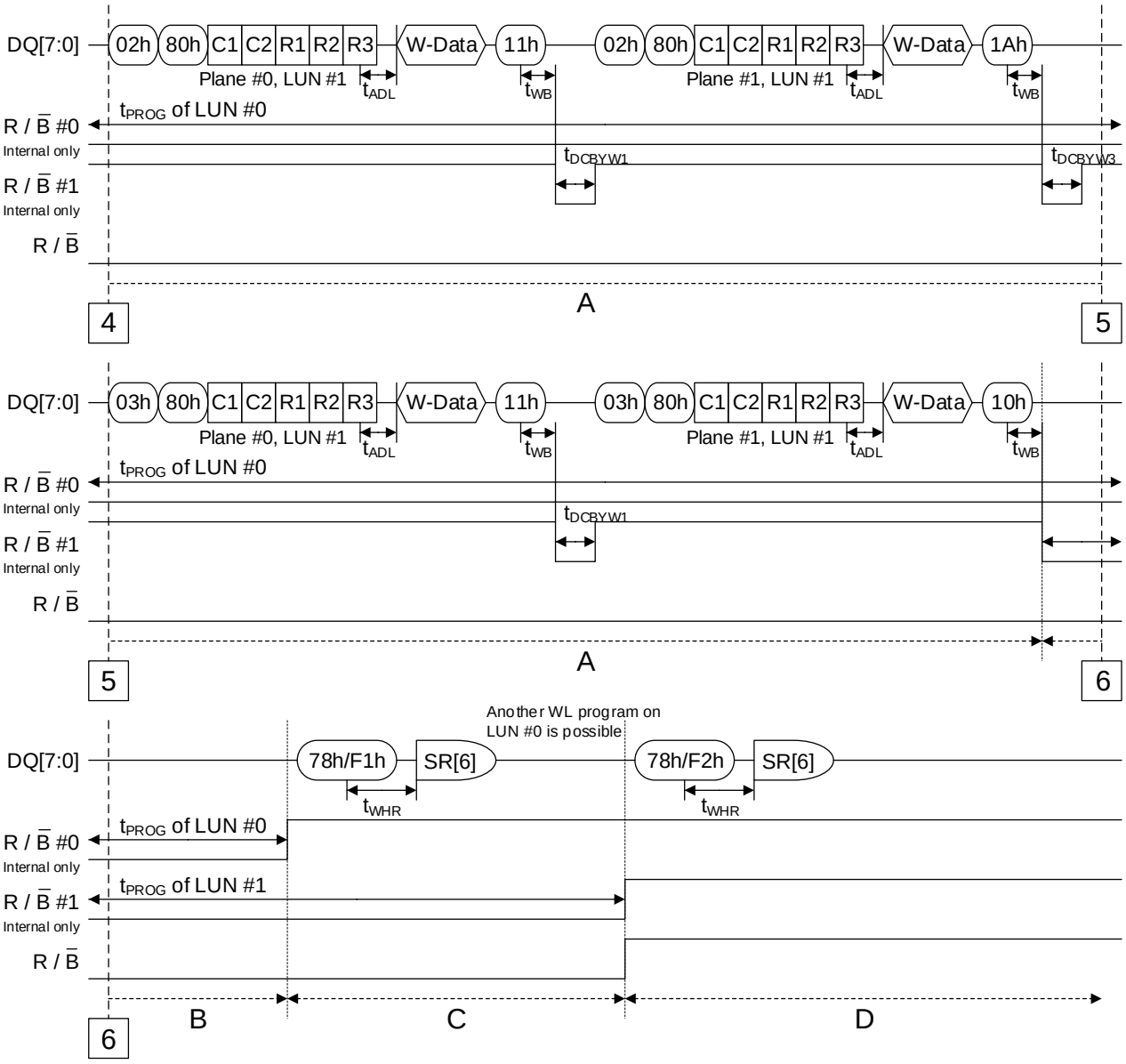


Figure 70. Example Timing with Interleaving Multi Plane Full Sequence Program

State A : LUN #0 is executing Multi Plane Full Seqeunce Program operation, and LUN #1 is in ready state. So the host can issue Multi Plane Full Sequence Program command to LUN #1.

State B : Both LUN #0 and LUN #1 are executing Multi Plane Full Seqeunce Program operation.

State C : Multi Plane Full Sequence Program on LUN #0 is completed and LUN #0 is ready for the next operation. LUN #1 is still executing Multi Plane Full Sequence Program operation.

State D : Both LUN #0 and LUN #1 are ready.

NOTE :

According to the above process, the system can operate Multi Plane Full Sequence program on LUN #0 and LUN #1 alternately.

5.4.5. Interleaving Multi Plane Read

Figure 71 defines general interleaving multi plane read sequence. Figure 72 defines exampletiming when the number of LUN is two. Within the repeatable sequence in the following figure, the Page Select command (i.e 01h/02h/03h) shall be identical between planes.

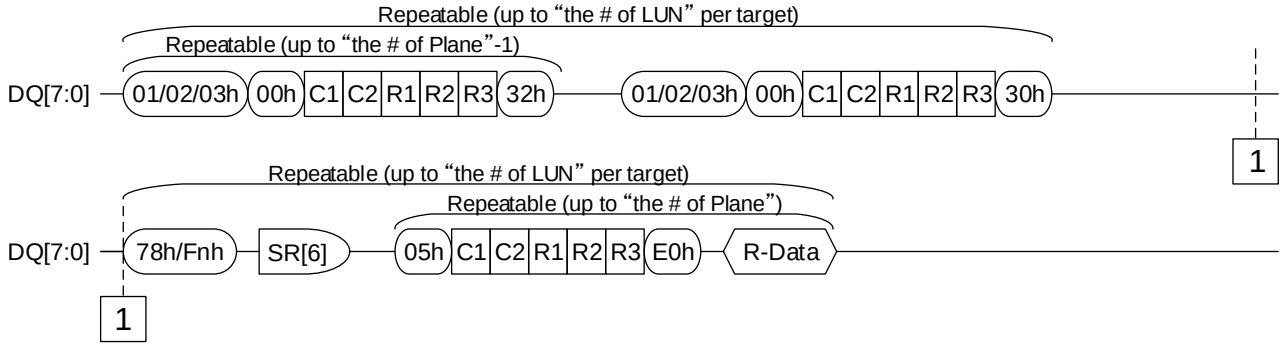


Figure 71. General Interleaving Multi Plane Read

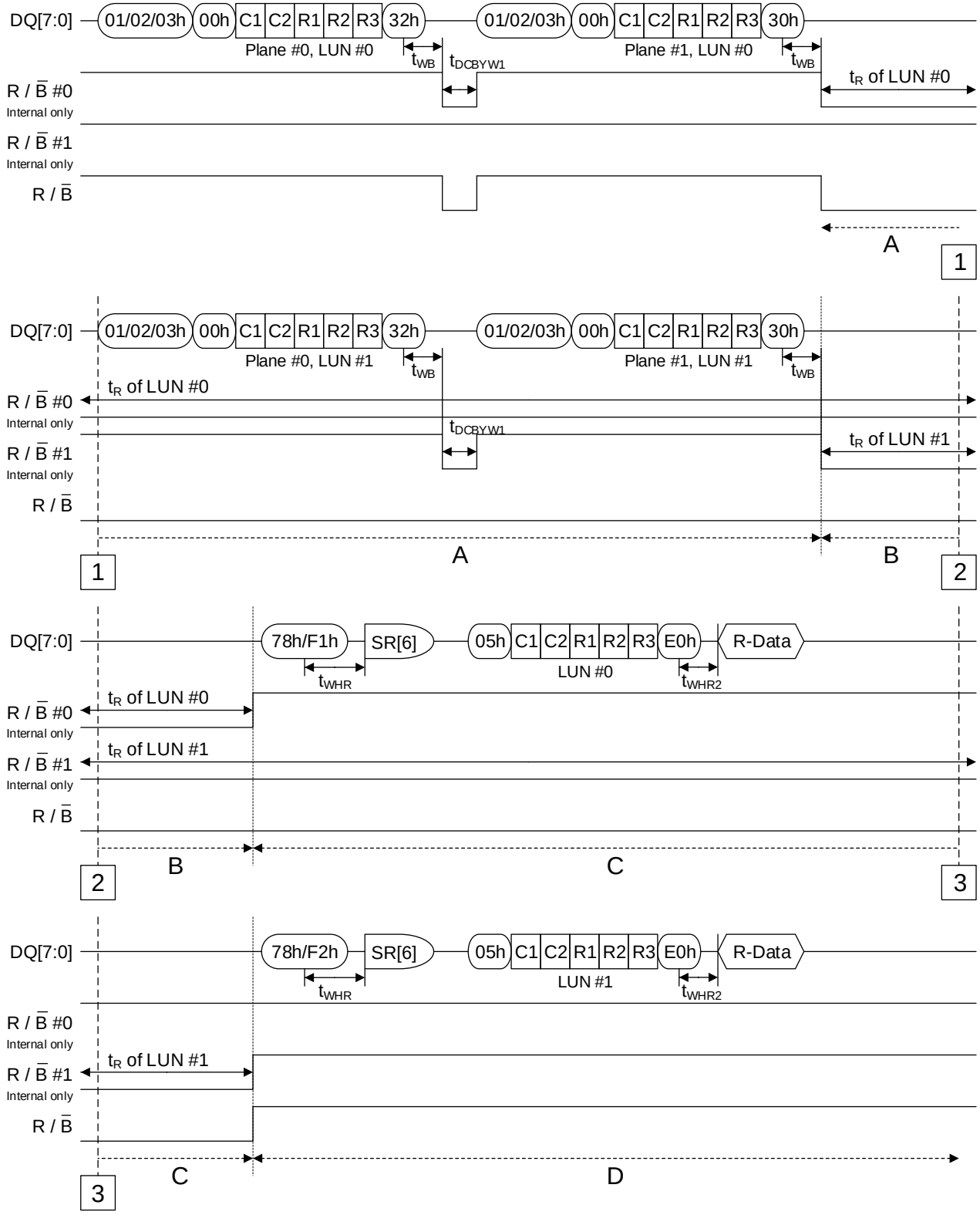


Figure 72. Example Timing with Interleaving Multi Plane Read

State A : LUN #0 is executing Two-plane page read operation, and LUN #1 is in ready state.
So the host can issue Two-plane page read command to LUN #1.

State B : Both LUN #0 and LUN #1 are executing Two-plane page read operation.

State C : Two-plane page read on LUN #0 is completed and LUN #0 is ready for the next operation.
LUN #1 is still executing Two-plane page read operation.

State D : Both LUN #0 and LUN #1 are ready.

NOTE :

1) Depending on the above process, the system can operate two-plane page read on LUN #0 and LUN #1 alternately.
2) 78h/F1h command is required to check the Read status of LUN #0.
3) 78h/F2h command is required to check the Read status of LUN #1.

5.4.6. Interleaving Multi Block Erase

Figure 73 defines general interleaving multi block erase sequence. Figure 74 defines example timing when the number of LUN is two.

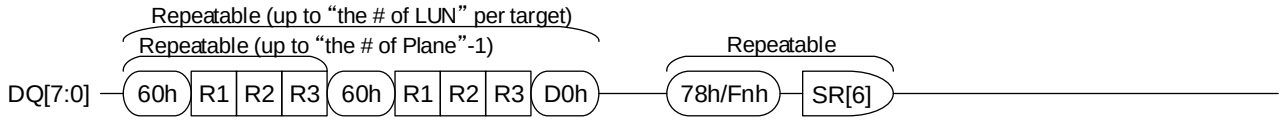


Figure 73. General Interleaving Multi Block Erase Sequence

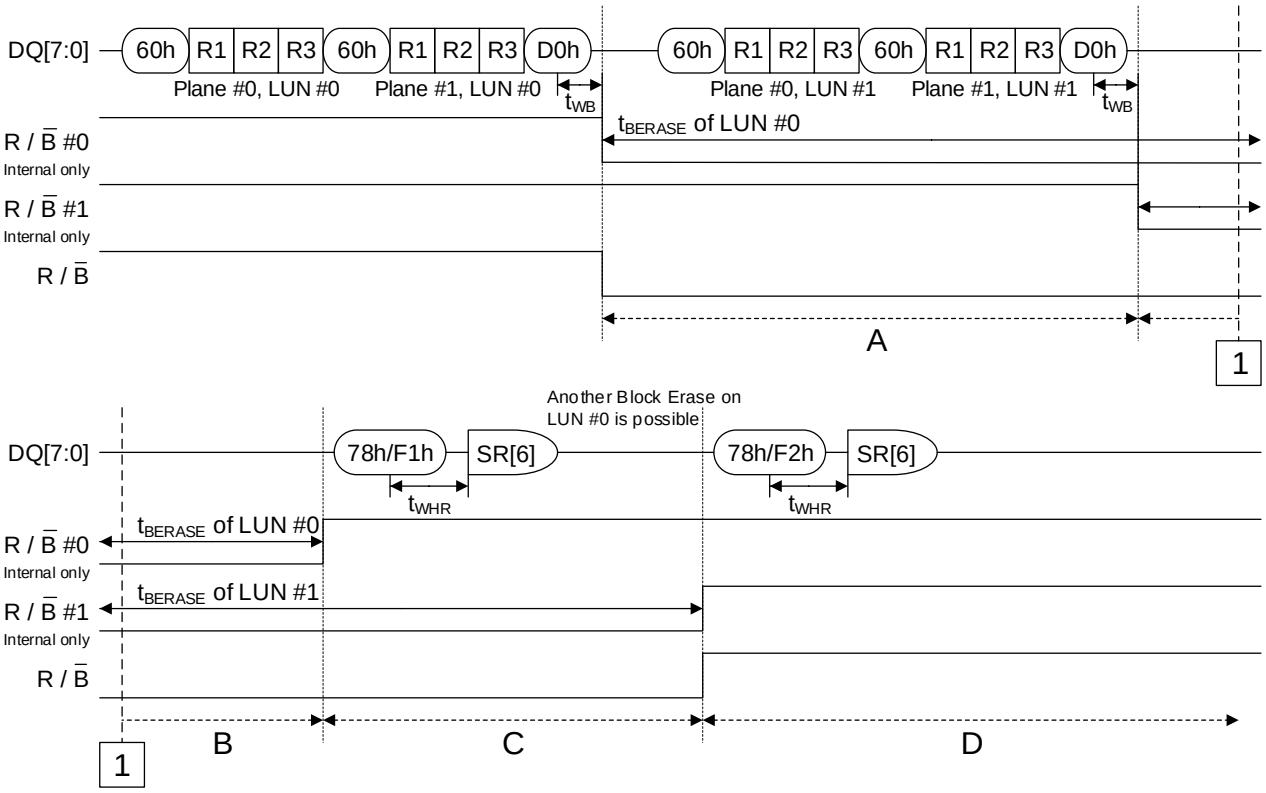


Figure 74. Example Timing with Interleaving Multi Block Erase

State A : LUN #0 is executing Multi Block Erase operation, and LUN #1 is in ready state. So the host can issue Multi Block Erase command to LUN #1.

State B : Both LUN #0 and LUN #1 are executing Multi Block Erase operation.

State C : Multi Block Erase on LUN #0 is completed and LUN #0 is ready for the next operation. LUN #1 is still executing Multi Block Erase operation.

State D : Both LUN #0 and LUN #1 are ready.

NOTE :

1) According to the above process, the system can operate multi block erase on LUN #0 and LUN #1 alternately.
2) 78h/F1h command is required to check the status of LUN #0 to issue the next block erase command to LUN #0.
3) 78h/F2h command is required to check the status of LUN #1 to issue the next block erase command to LUN #1.

5.4.7. Interleaving Full Sequence Program to Read

Figure 75 defines general interleaving full sequence program to read sequence. Figure 76 defines example timing when the number of LUN is two.

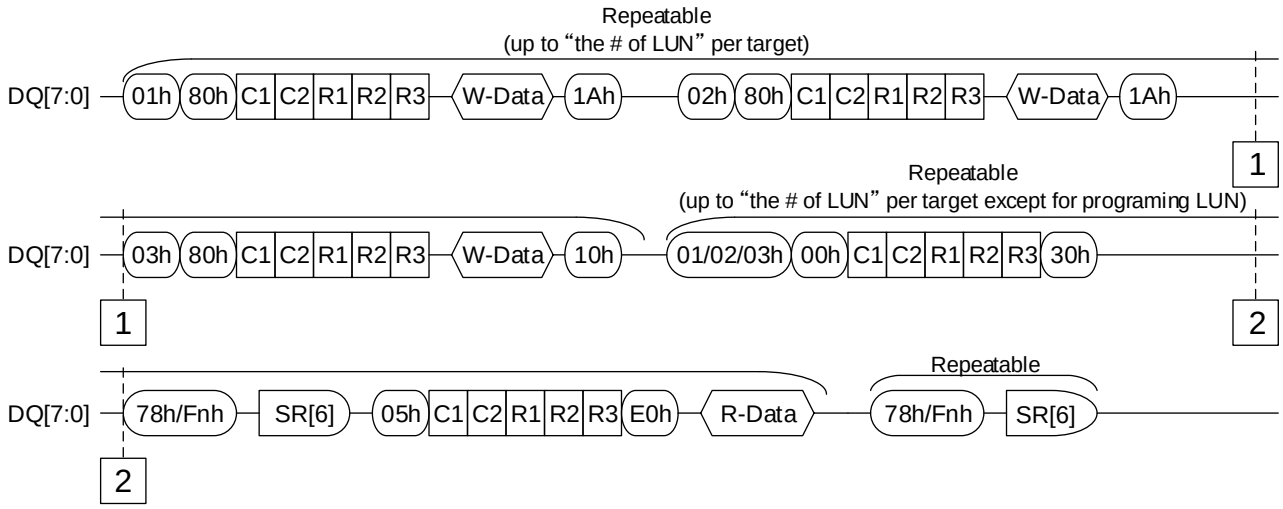


Figure 75. General Interleaving Full Sequence Program to Read

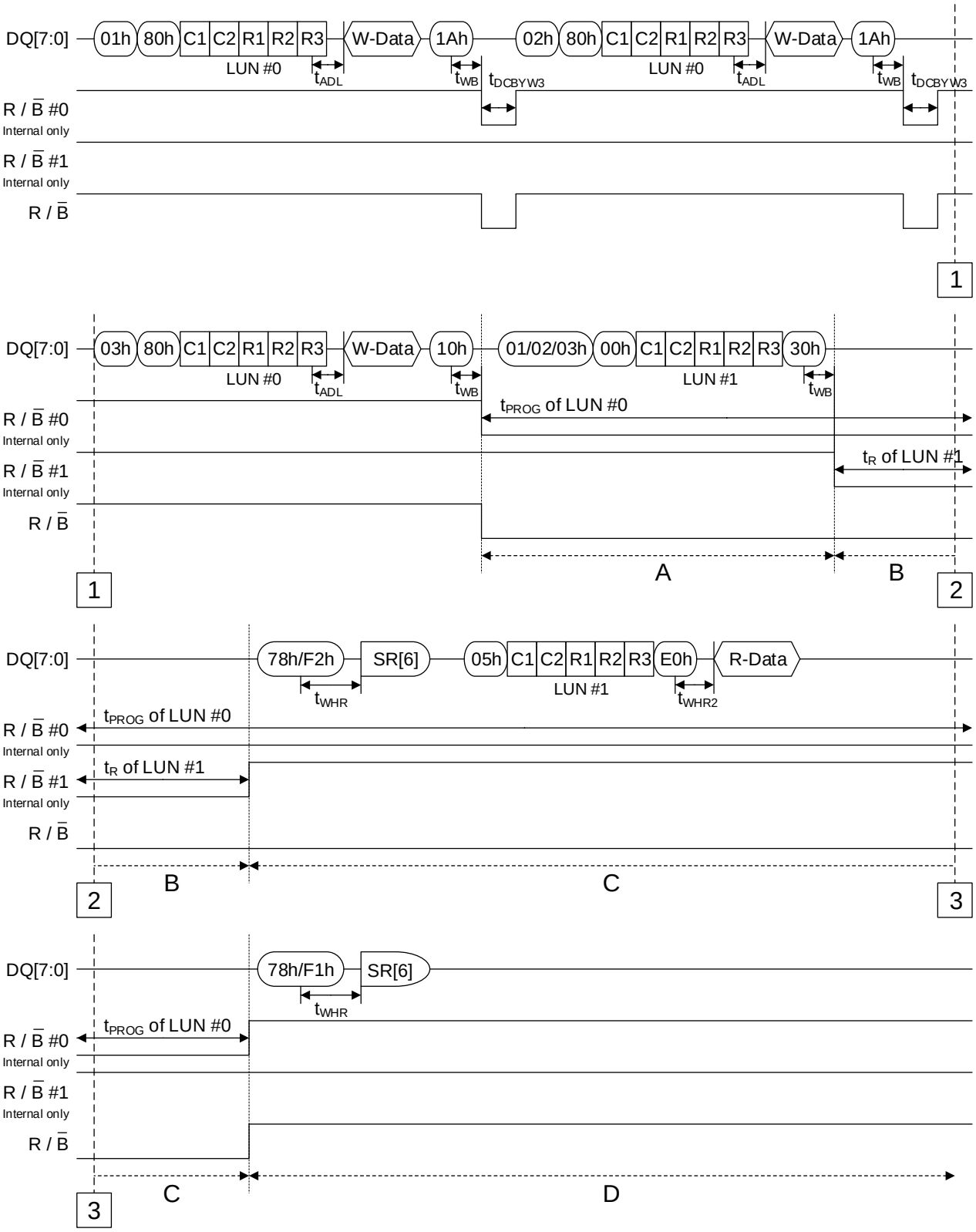


Figure 76. Example Timing with Interleaving Full Sequence Program to Read

State A : LUN #0 is executing Full Sequence Program peration, and LUN #1 is in ready state. So the host can issue read command to LUN #1.

State B : Both LUN #0 is executing Full Sequence Program operation and LUN #1 are executing read operation.

State C : Read Operation on LUN #1 is completed and LUN #1 is ready for the next operation. LUN #0 is still executing Full Sequence Program operation.

State D : Both LUN #0 and LUN #1 are ready.

NOTE :

1) According to the above process, the system can operate Full Sequence Program to read on LUN #0 and LUN #1 alternately.
2) 78h/F1h command is required to check the status of LUN #0 to issue the next block erase command to LUN #0.
3) 78h/F2h command is required to check the status of LUN #1 to issue the next block erase command to LUN #1.

6. APPLICATION NOTES AND COMMENTS

(1) Prohibition of unspecified commands

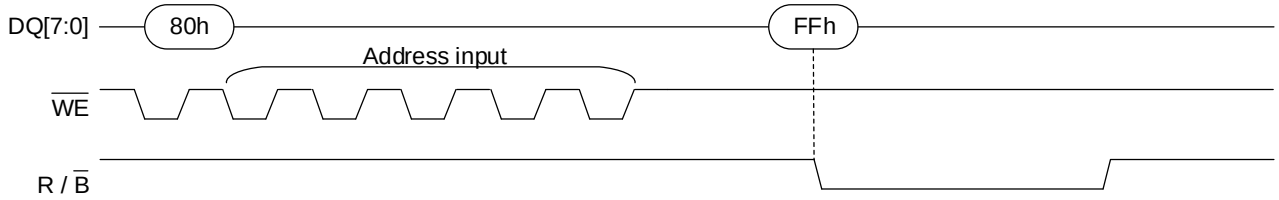
Input of a command other than those specified in this document is prohibited. Stored data may be corrupted if an unknown command is entered during the command cycle.

(2) Restriction of commands while in the Busy state

During the Busy state, do not input any command except 70h, 71h, 73h, 78h, Fnh and FFh.

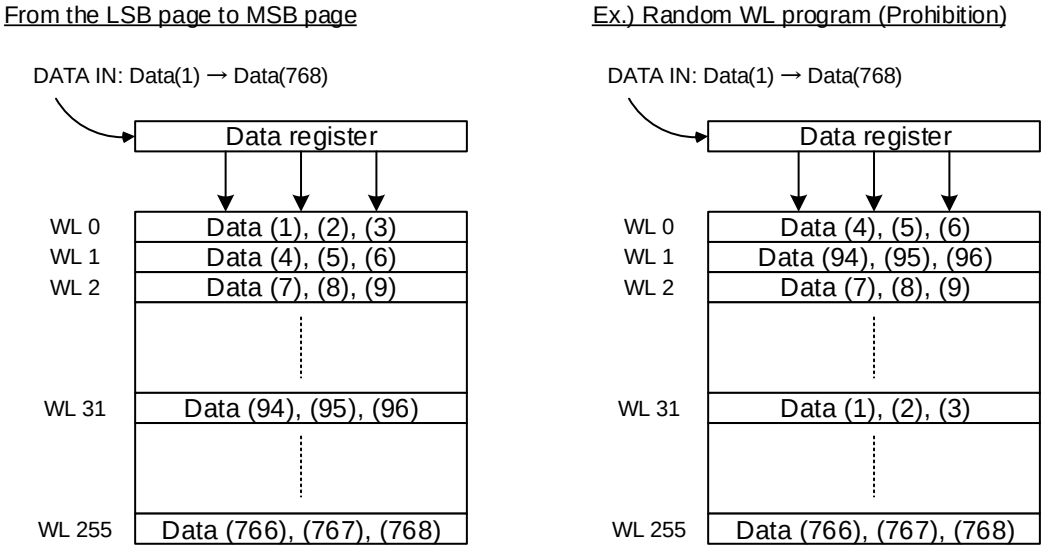
(3) Acceptable commands after Serial Input command "80h"

Once the Serial Input command "80h" has been input, do not input any command other than the Lower Page Select "01h", Middle Page Select "02h", Upper Page Select "03h", Random Data Input command "85h", Full Sequence Program command "1Ah", Multi Plane Program command "11h", Cache Program command "15h" or the Reset command "FFh" until Full Sequence Program command "10h" is input.

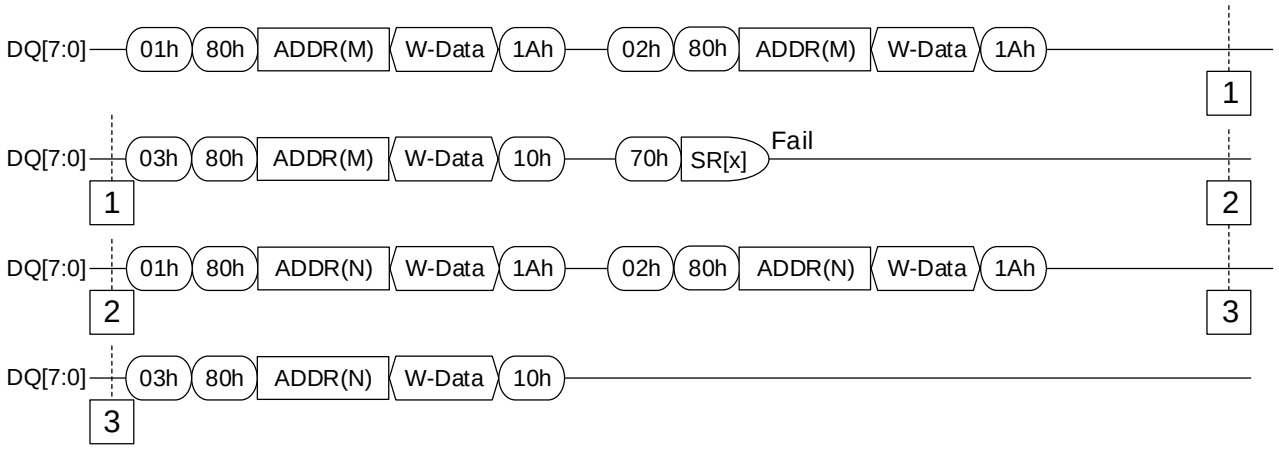


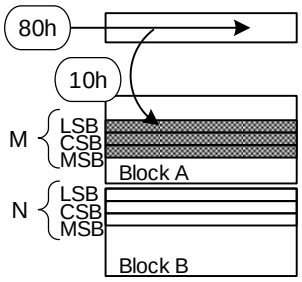
(4) Addressing for program operation

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



(5) Programming failure

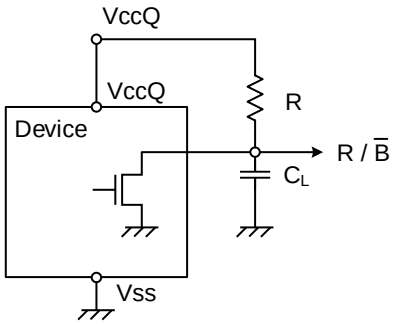




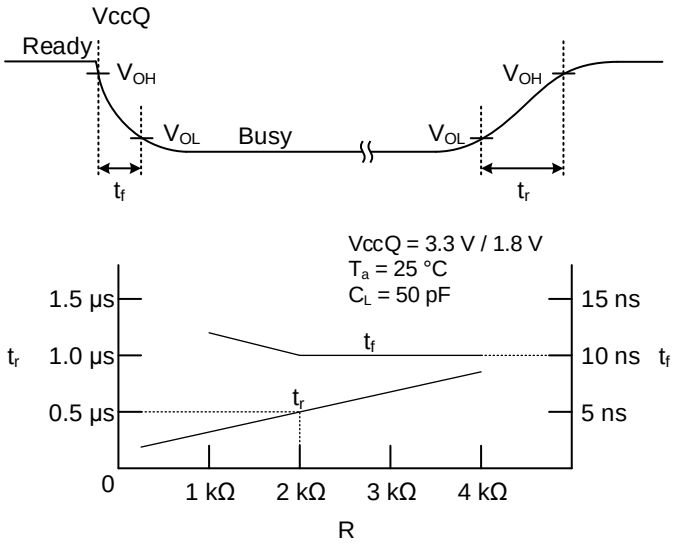
If the programming result for address M is Fail, do not try to program the pages to WL address N in another block without the data input sequence. Because the previous input data has been lost, the same input sequence of 80h command, address and data is necessary.

(6) RY/$\overline{BY}$: termination for the Ready/Busy pin (RY/$\overline{BY}$)

A pull-up resistor needs to be used for termination because the RY/$\overline{BY}$ buffer consists of an open drain circuit.



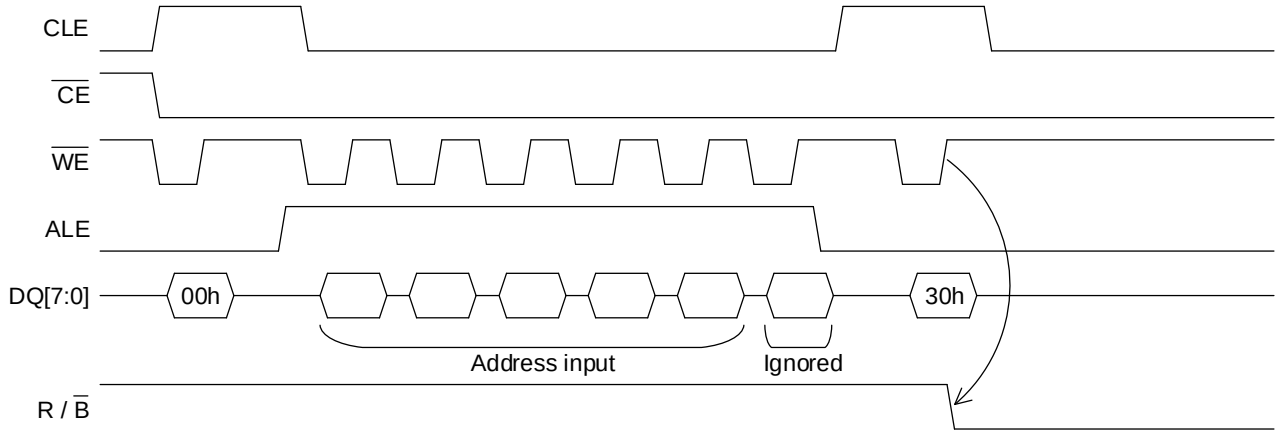
This data may vary from device to device. We recommend that you use this data as a reference when selecting a resistor value.



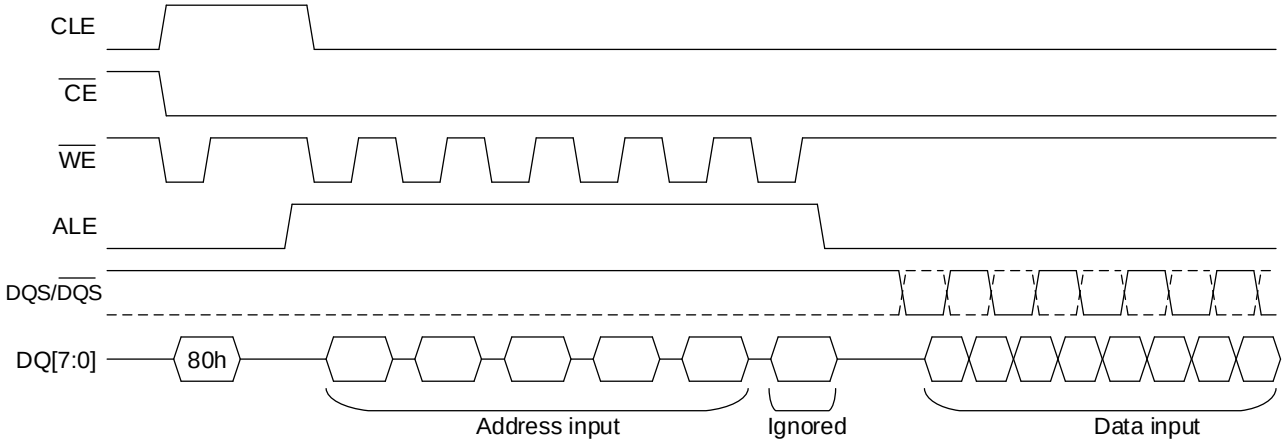
(7) When six address cycles are input

Although the device may read in a sixth address, it is ignored inside the chip.

Read operation



Program operation

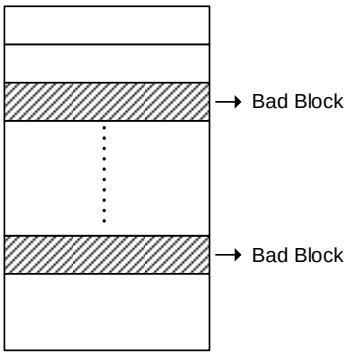


(8) Several programming cycles on the same page (Partial Page Program)

This device does not support partial page programming.

(9) Invalid blocks (bad blocks)

The device occasionally contains unusable blocks. Therefore, the following issues must be recognized:



At the time of shipment, the bad block information is marked on each bad block.

Check if the device has any bad blocks after installation into the system. Refer to the test flow for bad block detection. Bad blocks which are detected by the test flow must be managed as unusable blocks by the system.

A bad block does not affect the performance of good blocks because it is isolated from the bit lines by select gates.

Refer to section Table 1 for the number of valid blocks over the device lifetime.

(10) Failure phenomena for Erase, Program and Read operations

The device may fail during Erase, Program or Read operation. The following possible failure modes shall be considered.

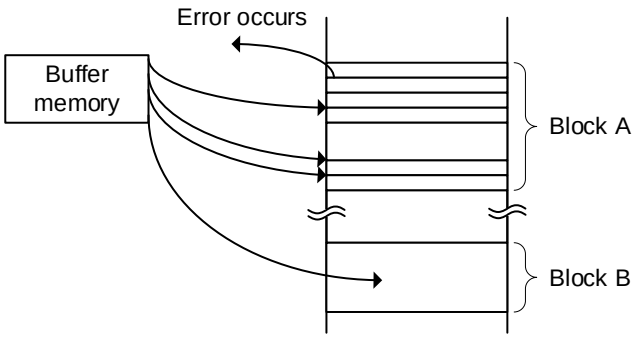
FAILURE MODE	DETECTION AND COUNTERMEASURE SEQUENCE
Erase Failure	Status Read after Erase → Block Replacement
Programming Failure	Status Read after Program → Block Replacement
Read Failure	Correctable Bit Error → ECC Uncorrectable Error → Block Replacement ECC: Error Correction Code 120 bits correction per 1024Bytes is necessary.

Erase

When an error occurs during an Erase operation, the block shall be treated as a bad block by creating a table within the system or by using another appropriate scheme. Further the bad block shall not be erased or programed.

Program

When an error occurs during an Program operation, the block shall be treated as a bad block by creating a table within the system or by using another appropriate scheme. Further the bad block shall not be erased or programed.



Read

If uncorrectable ECC error occurs, the vendor specified read shall be applied in the host system. Afterwards, if the uncorrectable ECC error still occurs, Block Replacement shall be done in the host system. For the details of the vender specified read, please refer to TOSHIBA's application note.

Others

Do not turn off the power before write/erase operation is complete. Avoid using the device when the battery is low. Power shortage and/or power failure before write/erase operation is complete will cause loss of data and/or damage to data.

(11) If FF reset command is input before completion of write operation to FSP Unit, it causes damage to data to all the pages in the FSP Unit.

	WL Address for each Full Sequence Program Unit		
FSP Unit Number	LSB Page (01h)	CSB Page (02h)	MSB Page (03h)
1	0	0	0
2	1	1	1
3	2	2	2
4	3	3	3
5	4	4	4
6	5	5	5
7	6	6	6
8	7	7	7
9	8	8	8
10	9	9	9
11	10	10	10
12	11	11	11
13	12	12	12
14	13	13	13
15	14	14	14
⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮

	WL Address for each Full Sequence Program Unit		
FSP Unit Number	LSB Page (01h)	CSB Page (02h)	MSB Page (03h)
⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮
242	241	241	241
243	242	242	242
244	243	243	243
245	244	244	244
246	245	245	245
247	246	246	246
248	247	247	247
249	248	248	248
250	249	249	249
251	250	250	250
252	251	251	251
253	252	252	252
254	253	253	253
255	254	254	254
256	255	255	255

(12) Reliability Guidance

This reliability guidance is intended to notify some guidance related to using TLC Flash Memory with 120bit ECC for each 1024bytes.
For detailed reliability data, please refer to TOSHIBA's reliability note.
Although random bit errors may occur during use, it does not necessarily mean that a block is bad.
Generally, a block should be marked as bad when a program status failure or erase status failure is detected.
The other failure modes may be recovered by a block erase.
ECC treatment for read data is mandatory due to the following Data Retention and Read Disturb failures.

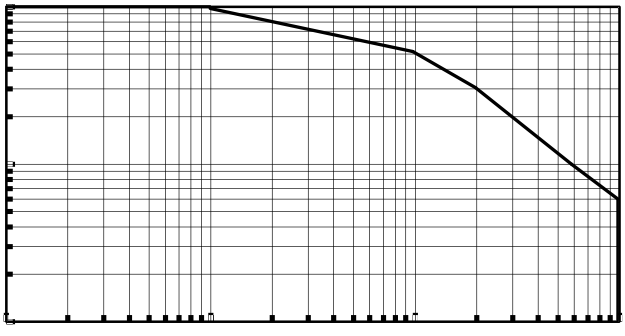
・Write/Erase Endurance

Write/Erase endurance failures may occur in a cell, page, WL or block, and are detected by doing a status read after either a program or a block erase operation. The cumulative bad block count will increase along with the number of write/erase cycles.

・Data Retention

The data in memory may change after a certain amount of storage time. This is due to charge loss or charge gain. After block erasure and reprogramming, the block may become usable again.

Here is the combined characteristics image of Write/Erase Endurance and Data Retention.



・**Read Disturb**

A read operation may disturb the data in memory. The data may change due to charge gain. Usually, bit errors occur on other pages in the block, not the page being read. After a large number of read cycles (between block erases), a tiny charge may build up and can cause a cell to be soft programmed to another state. After block erasure and reprogramming, the block may become usable again.

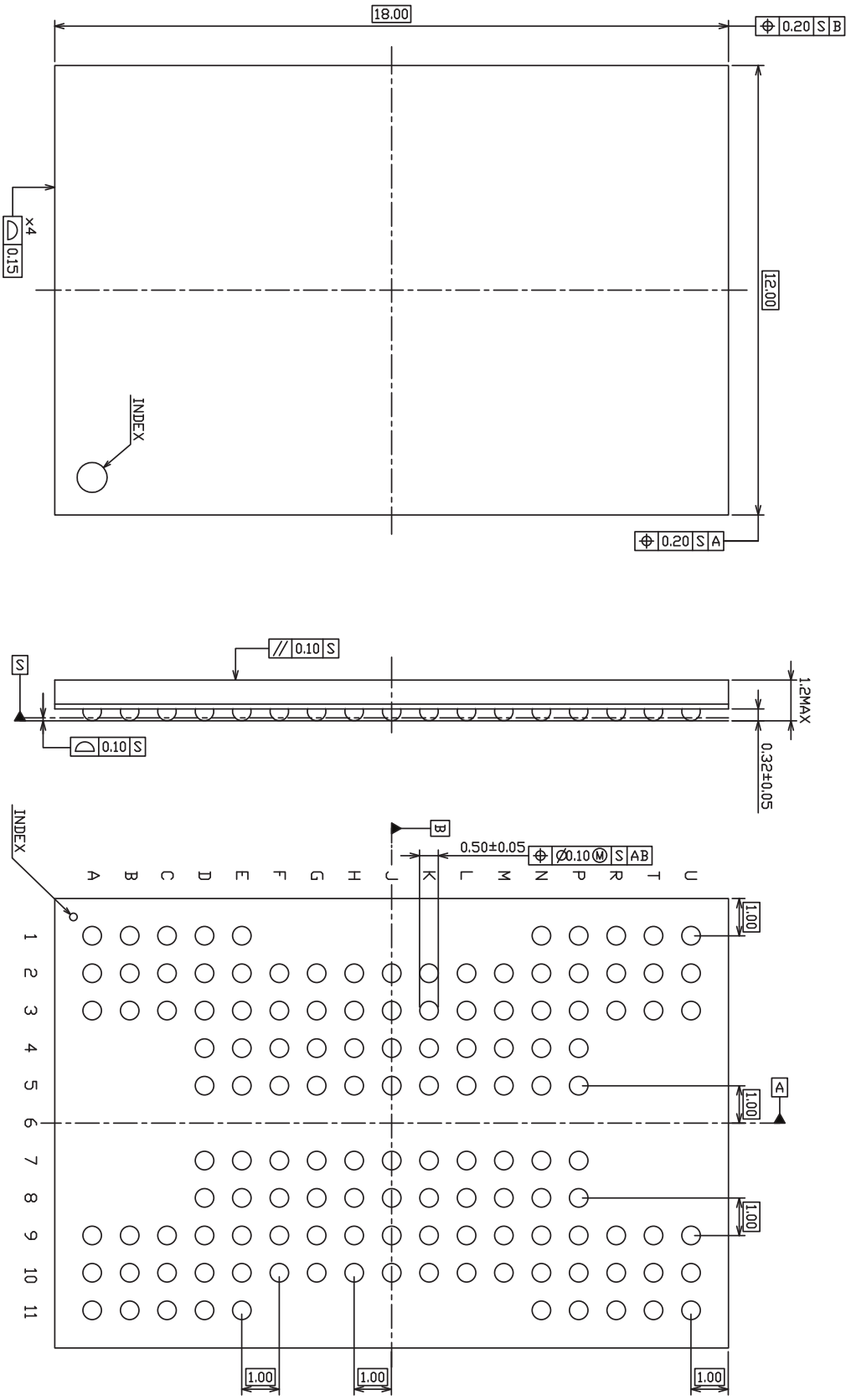
(13) Randomizing function

Controller shall employ randomizing function. All the columns within a page and across all pages within a block shall be filled with randomized data at programming. The randomized data for a block shall be differentiated by each programming and erase cycle.

7. PACKAGE DIMENSIONS

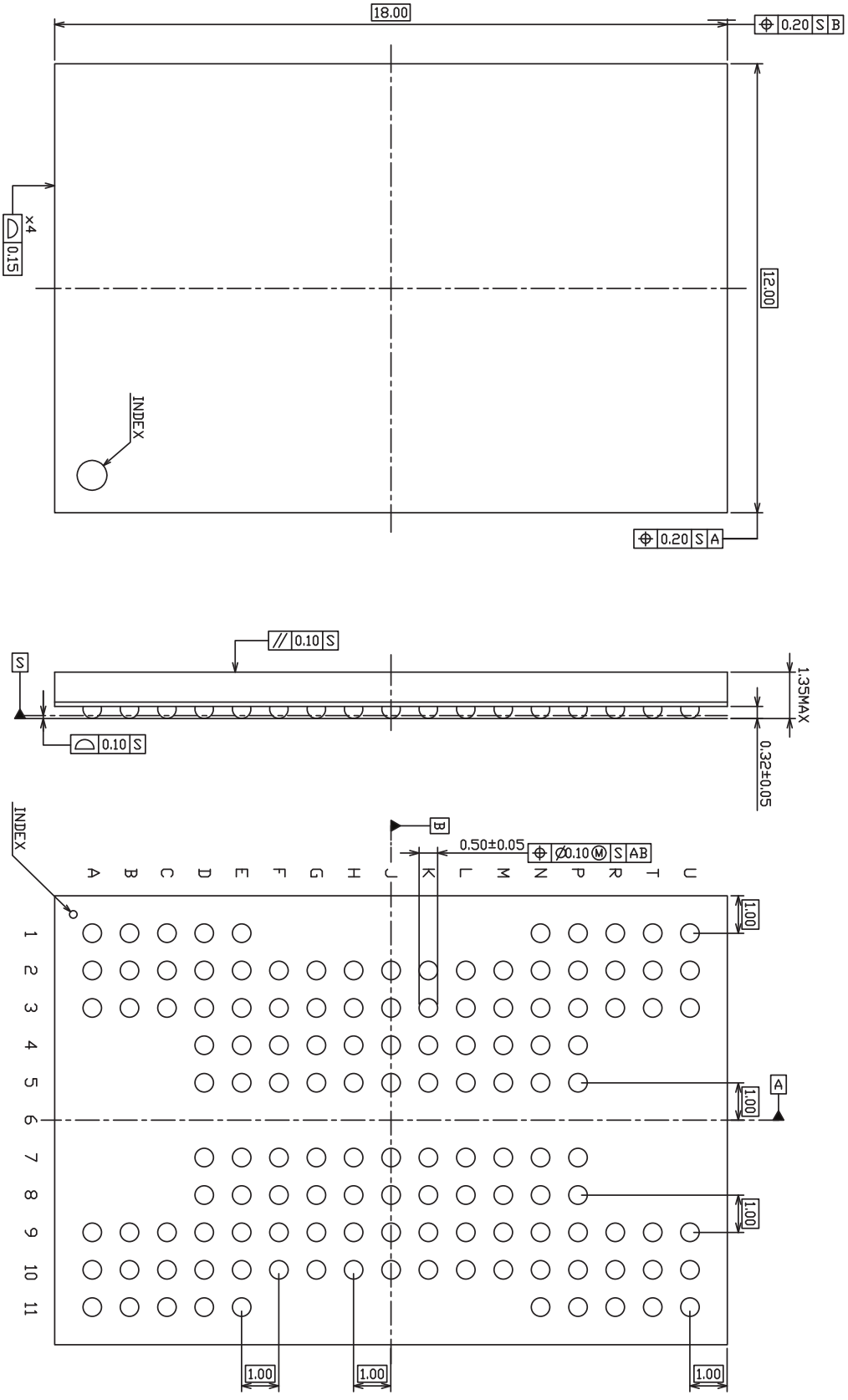
7.1. TH58TFG9V23BA4C/ TH58TFT0V23BA8C

P-TBGA132-1218-1.00-001 **Unit: mm**



7.2. TH58TFT1V23BA8H

P-BGA132-1218-1.00-003 **Unit: mm**



8. Revision history

Date	Rev.	Description
2017-01-20	0.1	Initial issue
2017-03-14	0.2	Executed miscellaneously amendments. Added WL definition and changed page definition in 1.2, as the FSP unit is WL but not page. Update is excuted in corresponding contents, Figures, Tables and Notes. Unified the line setting for all the table except Table 24 and Table 25. Unified the formatting of the pins and symbols, pins like $V_{PP,}$ Vcc, VccQ, V_{REF}, and timing symbol like Icc1/2/3, t_{PROG}, … and other symbols like V_{OH}, … Amended description of “NAND” to “Flash Memory”. Deleted the ‘Driven by NAND’ description in Figure 10, Figure 25, Figure 26, Figure 27, Figure 30. Amended the contents descriptions in 3, 4.2, 5.2.1, 5.2.4 and 5.2.5. Added 71h/73h in Figure 27. Updated Figure 58. Amended Vcc to VccQ in (6) of chapter 6.
2017-06-12	0.3	Updated ‘TOSHIBA’ to ‘TOSHIBA MEMORY’. Updated the description of the first valid block in NOTE 2) of Table 1. Updated the BGA top view in 2.1. Updated the block diagram in 2.3. Updated Figure 15 Target Organization in chapter 3. Amended the range of maximum data transfer rate in Table 8. Updated the description of maximam of I_{PP} in Table 9 and Table 10. Removed the description of one page program operation in NOTE 3) of Table 30. Added t_{CS2} and t_{RPRE2} in Figure 25. Updated the description of Cache Read in 5.2.2. Updated the description of Multi Plane Full Sequence Program Operation in 5.3.5. Updated the description of Redundant Parameter Page in 5.3.9. Amended the title of (10) of chapter 6. Updated the package dimensions in chapter 7. Typo correction.
2017-09-29	1.0	Replaced all TBD and TENTATIVE to specification values. Updated "RESTRICTIONS ON PRODUCT USE". Amended timing symbol t_{DQSQ} and t_{DQSRE} in Basic Data Output Timing. Updated Figure 31 and Figure 32 Page Read Operation. Amended Figure 33 and Figure 34 FSP Operation with adding RE/RE signals. Typo correction.
2017-12-27	1.1	Unified the formatting of all the figure. Amended Figure 55 Multi Plane Read Operation (Secondary). Amended Figure of Page Read Operation in (7) of chapter 6. Amended Toggle 2.0 specific setting data in Table 34.

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