

Technical Note

Comparing 128Mb P5Q Serial PCM and NOR Flash SPI Memory

Introduction

The purpose of this technical note is to compare features of the 128Mb P5Q serial PCM and NOR Flash SPI memory devices. Features compared include memory architecture, package options, signal descriptions, command sets, electrical specifications, and device identification, software, and performance.

Features of Phase Change Memory

Bit Alterability

Phase change memory (PCM) has bit alterability, which is the ability to change each memory bit independently from 0 to 1 or 1 to 0 without an intervening BLOCK ERASE operation. Bit alterability enables software to write to the nonvolatile memory in the same way that writing to RAM or EEPROM eliminates the overhead of erasing blocks prior to write. Bit-alterable WRITES use the same command sequences as a traditional SPI page program sequence.

P5Q serial PCM memory has a set of bit-alterable WRITE commands that uses the same sequences as page program sequences. The primary difference with the bit-alterable commands in P5Q serial PCM devices is that when the device start executing, the data written to the buffer is directly overwritten into the P5Q serial PCM device, unlike Flash memory, which can only go from 1 to 0 before an erase of the entire block.

For highest program performance, the P5Q serial PCM product has a bit-alterable program on all 1s commands that enables the device to program at a higher performance when the locations in the addressed page have previously been set (1s).

Unlike floating gate Flash, P5Q serial PCM does not require a high-voltage BLOCK ERASE operation to change all the bits in a block to 1. As a bit-alterable technology, each bit is capable of independently being changed from a 0 to a 1 and from a 1 to a 0. To maintain compatibility with legacy Flash system software, P5Q serial PCM mimics or emulates a Flash erase by writing each bit within a block to 1.

The advantage of bit alterability is that no block erase is needed prior to writing a block. This minimizes system overhead for software management of data and ultimately improves latency and determinism and reduces power consumption. Storing counter variables can be easily handled using PCM memory because a 0 can change to a 1 or a 1 can change to a 0.

Endurance

P5Q serial PCM is capable of more than 1,000,000 WRITE cycles, demonstrating better endurance than NAND or NOR Flash devices. PCM endurance is different than traditional nonvolatile memory because a PCM WRITE cycle is defined as any time a bit changes within a 32-byte page.

Performance

P5Q serial PCM delivers better performance from system memory because it provides faster programming and erase speeds than traditional NOR Flash SPI technology. The P5Q serial PCM device accomplishes this while also maintaining compatibility with legacy Flash system software by emulating Flash ERASE.

Memory Array Architecture

Table 1: Memory Array Architecture

P5Q Serial PCM	NOR Flash SPI Memory
Program 1 to 64 bytes	Program 1 to 256 bytes
Sector erase (128KB0)	Sector erase (32KB and 64KB)
N/A	Subsector erase (4KB)

Package Configurations

Table 2: Package Configurations

Package Option	P5Q Serial PCM	Nor Flash SPI
MLP8 (4 x 3)	No	Yes
MLP8 (6 x 5)	No	Yes
MLP8 (6 x 8)	No	Yes
S08N	No	Yes
S08W	No	Yes
S016W	Yes	Yes
TBGA	No	Yes

1. Refer to the P5Q serial PCM data sheets for package details.

Signal Descriptions

Signal compatibility between P5Q serial PCM and NOR Flash SPI devices is shown in the Signal Description table. Note that P5Q serial PCM devices do not support enhanced program supply voltage signals (V_{pp}).

Table 3: Signal Descriptions

P5Q Serial PCM Signal	NOR Flash SPI Signal	Description
C	C	Serial clock
DQ0	DQ0	Serial data input/I/O
DQ1	DQ1	Serial data input/I/O
S#	S#	Chip select
W/DQ2	W/ V_{pp} /DQ2	Write protect/enhanced program voltage/I/O
HOLD#/DQ3	HOLD#/DQ3	Hold/I/O
V_{CC}	V_{CC}	Supply voltage
V_{SS}	V_{SS}	Ground

Commands

Some NOR Flash SPI devices have READ/PROGRAM/ERASE, DEEP POWER DOWN, PROGRAM/ERASE, and SUSPEND/RESUME commands that are not available on P5Q serial PCM devices. Refer to the P5Q serial PCM data sheets for a complete list of supported commands for that device.

Table 4: Supported Command Set

Command Name	Command Code P5Q Serial PCM	Command Code NOR Flash SPI	Notes
READ⁴			
READ	03h	03h	
FAST READ	0Bh	0Bh	
DUAL OUPT FAST READ	38h	38h	
QUAD OUPT FAST READ	68h	68h	
READ DEVICE ID	9Fh	9Fh	
PROGRAM			
PAGE PROGRAM	02h	02h	
BIT ALTERABLE PAGE PROGRAM	22h	N/A	1
BIT ALTERABLE PAGE PROGRAM (on all 1s)	D1h	N/A	1
DUAL INPUT FAST PROGRAM	A2h	A2h	
BIT ALTERABLE DUAL INPUT PAGE PROGRAM	D3h	N/A	1
BIT ALTERABLE DUAL INPUT PAGE PROGRAM (on all 1s)	D5h	N/A	1
QUAD INPUT FAST PROGRAM	32h	32h	
BIT ALTERABLE QUAD INPUT PAGE PROGRAM	D7h	N/A	1

Table 4: Supported Command Set (continued)

Command Name	Command Code P5Q Serial PCM	Command Code NOR Flash SPI	Notes
BIT ALTERABLE QUAD INPUT PAGE PROGRAM (on all 1s)	D9h	N/A	1
ERASE			
BLOCK ERASE	C7h	C7h	
SECTOR ERASE (64KB)	D8h	D8h	3
SUBSECTOR ERASE (4KN)	N/A	20h	2
SUSPEND			
WRITE SUSPEND	B0h	B0h	
ERASE SUSPEND	B0h	B0h	
SUSPEND RESUME	D0h	D0h	
BLOCK LOCKING			
LOCK SETUP	60h	60h	
LOCK BLOCK	01h	01h	
UNLOCK BLOCK	D0h	D0h	
LOCK DOWN	2Fh	2Fh	

- Notes:
1. Not supported on NOR Flash SPI devices.
 2. Not supported on P5Q serial PCM devices.
 3. P5Q serial PCM sectors are 128KB.
 4. P5Q serial PCM devices follow the standard 3-address byte address protocol.

PROGRAM Commands

P5Q serial PCM has a set of BIT ALTERABLE WRITE commands, which have the same sequences as the PAGE PROGRAM command sequences. The primary difference among the bit-alterable commands in P5Q serial PCM is that when the write state machine starts executing, the data written to the buffer will be directly overwritten into the PCM memory, unlike Flash memory, which can only go from 1 to 0 before erasing the entire block.

P5Q serial PCM has a bit-alterable buffered program on all 1s command (DEh) that enables the device to program at a higher performance when the locations in the addressed page have previously been set (1s).

ERASE Commands

Unlike floating gate Flash memory, P5Q serial PCM does not require a high-voltage block erase operation to change all the bits in a block to 1. Because PCM is a bit-alterable technology, each bit is capable of being independently changed from a 0 to a 1 and from a 1 to a 0.

To maintain compatibility with legacy Flash system software, P5Q serial PCM mimics or emulates a Flash erase by writing each bit within a block to 1.

Electrical Characteristics

Stresses greater than those listed may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions outside those indicated in each device's data sheet is not implied. Exposure to operating conditions for extended periods may adversely affect reliability.

Operating Conditions

Table 5: Operating Conditions

Parameter	Symbol	P5Q Serial PCM		NOR Flash SPI		Unit
		Min	Max	Min	Max	
Operating temperature ¹	T _A	-40	85	-40	85	°C
Supply voltage	V _{CC}	2.7	3.6	2.7	3.6	V
V _{PP} supply voltage	V _{PPH}	N/A	N/A	8.5	9.5	V
Main block	WRITE cycles	1,000,000 ³	-	100,000 ²	-	Cycles

- Notes:
1. Ambient temperature.
 2. NOR Flash WRITE cycle is defined as program/erase of a block.
 3. P5Q serial PCM WRITE cycle is defined as any time that a bit changes within a 32-byte page.

DC Specifications

Table 6: DC Current Specifications

Refer to product data sheets for a complete list of AC/DC specifications.

Parameter	Symbol	P5Q Serial PCM		NOR Flash SPI ¹		Unit
		Min	Max	Min	Max	
Standby current	I _{CCS1}	-	200	-	25-100	μA
Operating current (FAST READ QUAD I/O)	I _{CC3}	-	16	-	18-40	mA
Operating current (PAGE PROGRAM)	I _{CC4}	-	50	-	20-26	mA
Operating current (WRITE STATUS REGISTER)	I _{CC5}	-	50	-	12-26	mA
Operating current (ERASE)	I _{CC6}	-	50	-	20-25	mA
Input low voltage	V _{IL}	-0.5	0.3 V _{CC}	-0.5 or -0.3	0.8	V
Input high voltage	V _{IH}	0.7 V _{CC}	V _{CC} + 0.4	0.7 V _{CC}	V _{CC} + 0.4 or V _{CC} + 0.5	V
Output low voltage	V _{OL}	-	0.4	-	0.2 or 0.4	V
Output high voltage	V _{OH}	V _{CC} - 0.2	-	V _{CC} - 0.2 or V _{CC} - 0.6	-	V

- Notes:
1. NOR Flash SPI memory values represent a range from different SPI vendors.

AC Specifications

AC specifications compare the fastest versions available at the full voltage range (2.7V to 3.6V). For the full list of AC specifications, refer to the product data sheets.

Table 7: AC Specifications

Parameter	Symbol	Alt	P5Q Serial PCM		NOR Flash SPI		Unit
			Min	Max	Min	Max	
Clock frequency (FAST READ) (0°C to 70°C)	f_C	f_C	–	66	–	80–108	MHz
Clock frequency (DUAL OUTPUT FAST READ and QUAD OUTPUT FAST READ) (0°C to 70°C)	f_R	f_R	–	50	–	70–80	MHz
Clock frequency (READ) (0°C to 70°C)	f_R	f_R	–	33	–	40–54	MHz
Clock frequency for all instructions (–40°C to 85°C)	f_C/f_R		–	33	–	40–108	MHz
S active setup time	t_{SLCH}	t_{CSS}	5	–	3–8	–	ns
Data-in setup time	t_{DVCH}	t_{DSU}	2	–	2–5	–	ns
Data-in hold time	t_{CHDX}	t_{DH}	5	–	2–5	–	ns
S deselects time after incorrect READ or different instructions (ERASE or PROGRAM to READ)	t_{SHSL}	t_{CSH}	80	–	50	–	ns
Output disable time	t_{SHOZ}	t_{DIS}	–	8	–	7–10	ns
Clock LOW to output valid (30pF)	t_{CLOV}	t_V	–	9	–	7–15	ns
Output hold time	t_{CLOX}	t_{HO}	0	–	0–2	–	ns
HOLD to output Low-Z	t_{HHQX}	t_{LZ}	–	10	–	7–8	ns
HOLD to output High-Z	t_{HLOZ}	t_{LHZ}	–	10	–	8–12	ns

Program and Erase Specifications

Table 8: Program and Erase Specifications

Parameter	P5Q Serial PCM		NOR Flash SPI		Unit
	Typ	Max	Typ	Max	
PAGE PROGRAM ¹	0.12	0.36	0.7–1.5	3–5	ms
PAGE PROGRAM (all1s, 64 bytes)	0.07	0.28	N/A	N/A	ms
SECTOR ERASE ²	0.4	0.8	0.15–0.7	1–3	s
BULK ERASE (128Mb)	50	100	0.5–170	40–256	s

- Notes:
1. P5Q serial PCM page program size is 64 bytes, and NOR Flash page program size is 256 bytes.
 2. P5Q serial PCM sector erase size is 128KB, and NOR Flash sector erase size is 64KB.

Device Identification

Manufacturer identification is assigned by JEDEC. As a result, the P5Q serial PCM and NOR Flash SPI memory devices have different manufacturer ID and memory type codes. The memory capacity code (18h) for a 128Mb device will be identical among all vendors. Both the P5Q serial PCM and NOR Flash SPI devices use command 9Fh to read these codes.

Table 9: P5Q Serial PCM Read Identification Summary

Parameter	P5Q Serial PCM Code
Manufacturer	20h
Memory type	DAh
Memory capacity	18h

Conclusion

Comparing the features of the 128Mb P5Q serial PCM and NOR Flash SPI memory devices enables users to migrate applications from NOR Flash memory to P5Q serial PCM memory.