

Migrating to Cypress S25FL-L Serial NOR Flash from Winbond W25Q-JV/FV, Micron N25Q-A, and Macronix M25L-F Devices

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AN202471 discusses the key differences to consider when migrating to Cypress S25FL-L devices from Winbond W25Q-JV/FV, Micron N25Q-A, and Macronix M25L-F devices.

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1 Introduction

Cypress S25FL-L Family devices are 3.0-V Flash nonvolatile memory products fabricated with the 65-nm Floating Gate process technology. Their high performance and standard features make the FL-L devices excellent replacements for many competing devices. This application note describes the key differences to consider when migrating to a Cypress S25FL-L device from Winbond W25Q-JV/FV, Micron N25Q-A, and Macronix M25L-F devices.

2 Feature and Performance Comparison

Winbond W25Q-JV/FV, Micron N25Q-A, and Macronix M25L-F devices are well suited for migration to Cypress S25FL-L family products. Moreover, the S25FL-L family of products are drop-in replacements for the Winbond W25Q-JV/FV family of products. The Cypress, Winbond, Micron, and Macronix serial NOR Flash products feature compatible pinouts, packages, standard command sets, and 4-kB/64-kB sector/block architecture. Cypress S25FL-L family products provide high-performance read commands, extended temperature ranges, and AEC-Q100 qualification for automotive applications. These benefits make the Cypress S25FL-L family an advantageous choice for migration from Winbond W25Q-JV/FV, Micron N25Q-A, and Macronix M25L-F devices.

Some differences exist among all serial NOR Flash devices such as timing specifications, current consumption, and one-time protection (OTP) region architecture. Migration from Winbond W25Q-JV/FV, Micron N25Q-A, and Macronix M25L-F devices to Cypress S25FL-L products may require software changes to accommodate differences between devices. System designers should also note differences in current consumption as it alters the power used by a system. The following sections provide additional information regarding differences between devices when migrating.

2.1 Comparison of 64-Mb Devices

Table 1 provides a detailed comparison of packages, features, and performance of 64-Mb serial NOR Flash devices.

Table 1. Detailed Comparison of 64-Mb Serial NOR Flash Devices

Parameter ¹		Device				
		Cypress S25FL064L	Winbond W25Q64JV	Winbond W25Q64FV	Micron N25Q064A	Macronix MX25L6433F
Package/Pinout	8-pin SOIC 208 mil	Yes	Yes	Yes	Yes	Yes
	USON 4 × 4 mm	Yes	Yes	Yes	No	No
	BGA 24 (6 Ball × 4 Ball) 6 × 8 mm	Yes	Yes	Yes	Yes	Yes
	BGA 24 (5 Ball × 5 Ball) 6 × 8 mm	Yes	Yes	Yes	Yes	No
Temperature Range	Industrial (-40°C to 85°C)	Yes	Yes	Yes	Yes	Yes
	Industrial Plus (-40°C to 105°C)	Yes	No	No	No	No
	Extended (-40°C to 125°C)	Yes	No	No	Yes	No
	AEC-Q100 Grade 3 (-40°C to +85°C)	Yes	No	No	Yes	No
	AEC-Q100 Grade 2 (-40°C to +105°C)	Yes	No	No	No	No
	AEC-Q100 Grade 1 (-40°C to +125°C)	Yes	No	No	Yes	No
Operating Voltage Range		2.7 V to 3.6 V	2.7 V to 3.6 V	2.7 V to 3.6 V	2.7 V to 3.6 V	2.7 V to 3.6 V
Standby Current ²	Typical	20 µA ³	10 µA	10 µA	–	10 µA
	Max	30 µA ⁴	50 µA	50 µA	100 µA ⁵	50 µA
Deep Power Down Current ²	Typical	2 µA	1 µA	1 µA	–	3 µA
	Max	20 µA ⁶	15 µA	25 µA	–	20 µA
Serial SDR Read Data Current ²	Typical	15 mA @ 50 MHz	–	–	–	2.5 mA @ 50 MHz
	Max	20 mA @ 50 MHz	15 mA @ 50 MHz	15 mA @ 50 MHz	6 mA @ 54 MHz	5 mA @ 50 MHz
	Max	30 mA @ 108 MHz	20 mA @ 104 MHz	20 mA @ 104 MHz	15 mA @ 108 MHz	–
Quad Output Read Current ²	Typical	25 mA @ 108 MHz ⁷	–	–	–	10 mA @ 133 MHz
	Max	30 mA @ 108 MHz	18 mA @ 80 MHz	18 mA @ 80 MHz	20 mA @ 108 MHz	17 mA @ 133 MHz
Page Program Current ²	Typical	40 mA	20 mA	20 mA	–	10 mA
	Max	50 mA	25 mA	25 mA	20 mA	15 mA
Write Status Register Current	Typical	40 mA	20 mA	8 mA	–	10 mA
	Max	50 mA	25 mA	12 mA	20 mA	15 mA
Erase Current	Typical	40 mA	20 mA	20 mA	–	10 mA

¹ Reference the appropriate product datasheet for information regarding the test conditions applicable to the parameters listed in this table

² Values shown for -40°C to 85°C

³ RESET#, CS#=VDD; SI, SCK = VDD or VSS: SPI, Dual I/O and Quad I/O Modes

⁴ 110 µA for -40°C to 105°C and 150 µA for -40°C to 125°C

⁵ 150 µA for -40°C to 125°C

⁶ 30 µA for -40°C to 105°C and 50 µA for -40°C to 125°C

⁷ For DDR Typical 30 mA and Max 35 mA @ 54 MHz

Parameter ¹		Device				
		Cypress S25FL064L	Winbond W25Q64JV	Winbond W25Q64FV	Micron N25Q064A	Macronix MX25L6433F
	Max	50 mA	25 mA	25 mA	20 mA	15 mA
Data Retention		20-year data retention minimum	20-year data retention minimum	20-year data retention minimum	20-year data retention minimum	20-year data retention
Endurance (Program/Erase Cycles)		100k erase/program cycles minimum	100k erase/program cycles minimum	100k erase/program cycles minimum	100k erase/program cycles minimum	100k erase/program cycles typical
Burst Wrap Lengths		8, 16, 32, 64 bytes	8, 16, 32, 64 bytes	8, 16, 32, 64 bytes	16, 32, 64 bytes	8, 16, 32, 64 bytes
Write Status Register Time	Typical	220 ms	10 ms	15 ms	1.3 ms	–
	Max	1200 ms	15 ms	20 ms	8 ms	40 ms
Page Buffer Size		256 bytes	256 bytes	256 bytes	256 bytes	256 bytes
Page Program Time	Typical	450 µs	800 µs	450 µs	500 µs	330 µs
	Max	1.35 ms	3.00 ms	3.00 ms	5.00 ms	1.20 ms
Sector Erase Time (4 KB)	Typical	65 ms	45 ms	45 ms ^B	250 ms	25 ms
	Max	270 ms	400 ms	400 ms	800 ms	200 ms
Block Erase Time (64 KB)	Typical	450 ms	150 ms	150 ms	700 ms	250 ms
	Max	1150 ms	2000 ms	2000 ms	3000 ms	1000 ms
Chip Erase Time	Typical	55 s	20 s	20 s	60 s	20 s
	Max	150 s	100 s	100 s	120 s	60 s
Program/Erase Suspend/Resume		Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes
Security Regions / OTP		4 x 256 bytes Security Regions	3 x 256 bytes Security Regions	3 x 256 bytes Security Regions	64-Byte OTP	1024-Byte OTP

^B For W25Q64FVxxIG Typical = 60 ms

2.2 Comparison of 128-Mb Devices

Table 2 provides a detailed comparison of packages, features, and performance of 128-Mb serial NOR Flash devices.

Table 2. Detailed Comparison of 128-Mb Serial NOR Flash Devices

Parameter ⁹		Device			
		Cypress S25FL128L	Winbond W25Q128FV	Micron N25Q128A	Macronix MX25L12845G
Package/Pinout	8-pin SOIC 208 mil	Yes	Yes	Yes	Yes
	WSON 5 x 6 mm	Yes	Yes	Yes	Yes
	BGA 24 (6 Ball x 4 Ball) 6 x 8 mm	Yes	Yes	No	Yes
	BGA 24 (5 Ball x 5 Ball) 6 x 8 mm	Yes	Yes	Yes	Yes
Temperature Range	Industrial (-40°C to 85°C)	Yes	Yes	Yes	Yes
	Industrial Plus (-40°C to 105°C)	Yes	No	No	No
	Extended (-40°C to 125°C)	Yes	No	Yes	No
	AEC-Q100 Grade 3 (-40°C to +85°C)	Yes	No	Yes	No
	AEC-Q100 Grade 2 (-40°C to +105°C)	Yes	No	No	Yes
	AEC-Q100 Grade 1 (-40°C to +125°C)	Yes	No	Yes	No
Operating Voltage Range		2.7 V to 3.6 V	2.7 V to 3.6 V	2.7 V to 3.6 V	2.7 V to 3.6 V
Standby Current ¹⁰	Typical	20 µA ¹¹	10 µA	–	20 µA
	Max	100 µA ¹²	50 µA	100 µA ¹³	100 µA
Deep Power Down Current ¹⁰	Typical	2 µA	1 µA	–	2 µA
	Max	20 µA ¹⁴	20 µA	–	20 µA
Serial SDR Read Data Current ¹⁰	Typical	15 mA @ 50 MHz	–	–	12 mA @ 84 MHz
	Max	20 mA @ 50 MHz	15 mA @ 50 MHz	6 mA @ 54 MHz	–
	Max	30 mA @ 133 MHz	20 mA @ 104 MHz	15 mA @ 108 MHz	15 mA @ 84 MHz
Quad Output Read Current ¹⁰	Typical	25 mA @ 108 MHz ¹⁵	–	–	12 mA @ 104 MHz
	Max	35 mA @ 108 MHz	18 mA @ 80 MHz	–	20 mA @ 104 MHz
	Max	40 mA @ 133 MHz	20 mA @ 104 MHz	20 mA @ 108 MHz	25 mA @ 133 MHz
Page Program Current ¹⁰	Typical	40 mA	20 mA	–	12 mA
	Max	50 mA	25 mA	20 mA	20 mA
Write Status Register	Typical	40 mA	8 mA	–	10 mA

⁹ Reference the appropriate product datasheet for information regarding the test conditions applicable to the parameters listed in this table

¹⁰ Values shown for -40°C to 85°C

¹¹ RESET#, CS#=VDD; SI, SCK = VDD or VSS; SPI, Dual I/O and Quad I/O Modes. 60 µA RESET#, CS#=VDD; SI, SCK = VDD or VSS; QPI Mode

¹² 110 µA for -40°C to 105°C and 150 µA for -40°C to 125°C

¹³ 150 µA for -40°C to 125°C

¹⁴ 30 µA for -40°C to 105°C and 50 µA for -40°C to 125°C

¹⁵ For DDR Typical 30 mA and Max 40 mA @ 66 MHz

Parameter ⁹		Device			
		Cypress S25FL128L	Winbond W25Q128FV	Micron N25Q128A	Macronix MX25L12845G
Current	Max	50 mA	12 mA	20 mA	12 mA
Erase Current	Typical	40 mA	20 mA	–	10 mA
	Max	50 mA	25 mA	20 mA	25 mA
Data Retention		20-year data retention minimum	20-year data retention minimum	20-year data retention minimum	20-year data retention
Endurance (Program/Erase Cycles)		100k erase/program cycles minimum	100k erase/program cycles minimum	100k erase/program cycles minimum	100k erase/program cycles typical
Burst Wrap Lengths		8, 16, 32, 64 bytes	8, 16, 32, 64 bytes	16, 32, 64 bytes	8, 16, 32, 64 bytes
Write Status Register Time	Typical	145 ms	10 ms	1.3 ms	–
	Max	750 ms	15 ms	8 ms	40 ms
Page Buffer Size		256 bytes	256 bytes	256 bytes	256 bytes
Page Program Time	Typical	300 µs	700 µs	500 µs ¹⁶	250 µs
	Max	1.2 ms	3.0 ms	5.0 ms	1.5 ms
Sector Erase Time (4 KB)	Typical	50 ms	45 ms ¹⁷	250 ms ¹⁸	30 ms
	Max	200 ms	400 ms	800 ms	400 ms
Block Erase Time (64 KB)	Typical	270 ms	150 ms	700 ms ¹⁹	380 ms
	Max	725 ms	2000 ms	3000 ms	2000 ms
Chip Erase Time	Typical	70 s	40 s	170 s ²⁰	55 s
	Max	180 s	200 s	250 s	200 s
Program/Erase Suspend/Resume		Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes
Security Regions / OTP		4 x 256 bytes Security Regions	3 x 256 bytes Security Regions	64-Byte OTP	512-Byte OTP

¹⁶ For N25Q128A13Exx4xx from week code 13 2014 onwards Typical = 0.2 ms Max = 0.4 ms

¹⁷ W25Q128FVx1G Typical time = 100 ms

¹⁸ For N25Q128A13Exx4xx from week code 13 2014 onwards Typical = 60 ms Max = 200 ms

¹⁹ For N25Q128A13Exx4xx from week code 13 2014 onwards Typical = 300 ms Max = 1000 ms

²⁰ For N25Q128A13Exx4xx from week code 13 2014 onwards Typical = 46 s Max = 250 s

2.3 Comparison of 256-Mb Devices

Table 3 provides a detailed comparison of the packages, features, and performance of 256-Mb serial NOR Flash devices.

Table 3. Detailed Comparison of 256-Mb Serial NOR Flash Devices

Parameter ²¹		Device				
		Cypress S25FL256L	Winbond W25Q256JV	Winbond W25Q256FV	Micron N25Q256A	Macronix MX25L25645G
	WSO6 6 x 8 mm	Yes	Yes	Yes	Yes	Yes
	16-pin SOIC 300 mil	Yes	Yes	Yes	Yes	Yes
	BGA 24 (6 x 4) 6 x 8 mm	Yes	Yes	Yes	No	Yes
	BGA 24 (5 x 5) 6 x 8 mm	Yes	Yes	Yes	Yes	Yes
Temperature Range	Industrial (-40°C to 85°C)	Yes	Yes	Yes	Yes	Yes
	Industrial Plus (-40°C to 105°C)	Yes	No	No	No	No
	Enhanced (-40°C to 125°C)	Yes	No	No	Yes	No
	AEC-Q100 Grade 3 (-40°C to +85°C)	Yes	Yes	Yes	Yes	No
	AEC-Q100 Grade 2 (-40°C to +105°C)	Yes	Yes	No	No	Yes
	AEC-Q100 Grade 1 (-40°C to +125°C)	Yes	No	Yes	Yes	No
Operating Voltage Range		2.7 V to 3.6 V	2.7 V to 3.6 V	2.7 V to 3.6 V	2.7 V to 3.6 V	2.7 V to 3.6 V
Standby Current ²²	Typical	20 µA ²³	10 µA	10 µA	–	15 µA
	Max	100 µA ²⁴	60 µA	50 µA	100 µA ²⁵	50 µA
Deep Power Down Current ²²	Typical	2 µA	1 µA	1 µA	–	3 µA
	Max	20 µA ²⁶	20 µA	25 µA	–	20 µA
Serial SDR Read Data Current ²²	Typical	15 mA @ 50 MHz	–	–	–	12 mA @ 84 MHz
	Max	20 mA @ 50 MHz	15 mA @ 50 MHz	15 mA @ 50 MHz	6 mA @ 54 MHz	–
	Max	35 mA @ 133 MHz	20 mA @ 104 MHz	20 mA @ 104 MHz	15 mA @ 108 MHz	15 mA @ 84 MHz
Quad Output Read Current ²²	Typical	25 mA @ 108 MHz ²⁷	–	–	–	12 mA @ 104 MHz
	Max	35 mA @ 108 MHz	–	18 mA @ 80 MHz	–	20 mA @ 104 MHz
	Max	40 mA @ 133 MHz	20 mA @ 104 MHz	20 mA @ 104 MHz	20 mA @ 108 MHz	25 mA @ 133 MHz
Page Program Current ²²	Typical	40 mA	20 mA	20 mA	–	12 mA
	Max	50 mA	25 mA	25 mA	20 mA	20 mA

²¹ Reference the appropriate product datasheet for information regarding the test conditions applicable to the parameters listed in this table.

²² Values shown for -40°C to 85°C

²³ RESET#, CS#=VDD; SI, SCK = VDD or VSS; SPI, Dual I/O and Quad I/O Modes. 60 µA RESET#, CS#=VDD; SI, SCK = VDD or VSS; QPI Mode

²⁴ 100 µA for -40°C to 105°C and 150 µA for -40°C to 125°C

²⁵ 250 µA for -40°C to 125°C

²⁶ 30 µA for -40°C to 105°C and 50 µA for -40°C to 125°C

²⁷ For DDR Typical 30 mA and Max 40 mA @ 66 MHz

Parameter ²¹		Device				
		Cypress S25FL256L	Winbond W25Q256JV	Winbond W25Q256FV	Micron N25Q256A	Macronix MX25L25645G
Write Status Register Current	Typical	40 mA	20 mA	8 mA	–	10 mA
	Max	50 mA	25 mA	12 mA	20 mA	12 mA
Erase Current	Typical	40 mA	20 mA	20 mA	–	10 mA
	Max	50 mA	25 mA	25 mA	20 mA	25 mA
Data Retention		20-year data retention minimum	20-year data retention minimum	20-year data retention minimum	20-year data retention minimum	20-year data retention
Endurance (Program/Erase Cycles)		100k erase/program cycles minimum	100k erase/program cycles minimum	100k erase/program cycles minimum	100k erase/program cycles minimum	100k erase/program cycles typical
Burst Wrap Lengths		8, 16, 32, 64 bytes	8, 16, 32, 64 bytes	8, 16, 32, 64 bytes	16, 32, 64 bytes	8, 16, 32, 64 bytes
Write Status Register Time	Typical	145 ms	10 ms	10 ms	1.3 ms	40 ms
	Max	750 ms	15 ms	15 ms	8 ms	–
Page Buffer Size		256 bytes	256 bytes	256 bytes	256 bytes	256 bytes
Page Program Time	Typical	300 µs	700 µs	700 µs	500 µs	250 µs
	Max	1.2 ms	3.0 ms	3.0 ms	5.0 ms	1.5 ms
Sector Erase Time (4 KB)	Typical	50 ms	50 ms	45 ms ²⁸	250 ms	30 ms
	Max	200 ms	400 ms	400 ms	800 ms	400 ms
Block Erase Time (64 KB)	Typical	270 ms	150 ms	150 ms	700 ms	280 ms
	Max	725 ms	2000 ms	2000 ms	3000 ms	2000 ms
Chip Erase Time	Typical	140 s	80 s	80 s	240 s	150 s
	Max	360 s	400 s	400 s	480 s	400 s
Program/Erase Suspend/Resume		Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes
Security Regions / OTP		4 × 256 bytes Security Regions	3 × 256 bytes Security Regions	3 × 256 bytes Security Regions	64-byte OTP	512-byte OTP

3 Package Comparison

Cypress S25FL-L Family devices are pin-to-pin compatible with competitor devices of the same package. S25FL-L devices offer additional functionality that is unavailable on some of the serial NOR Flash competitor devices of interest, such as the RESET# signal. Optional signals, such as RESET#, WP#/IO2, and IO3/RESET#, have internal pull-up resistors to allow the signal to remain unconnected if not used by the host system.

²⁸ W25Q256FVxIG Typical time = 100 ms

4 Capacitance Comparison

The input and output capacitance of the Cypress FL-L family devices and competitor serial NOR Flash devices are compared in Table 4. See product datasheets for additional information regarding capacitance values. System designers should note differences in input/output capacitance, and investigate how differences may affect the timing of the system.

Table 4. Comparison of Input and Output Capacitance

Manufacturer	Device	Input Capacitance (C _{IN})			Output Capacitance (C _{OUT})		
		Minimum	Maximum	Test Conditions	Minimum	Maximum	Test Conditions
Cypress ²⁹	S25FL064L	–	8 pF	T _A = 25°C, 1 MHz V _{IN} = 0V	–	8 pF	T _A = 25°C, 1 MHz V _{OUT} = 0V
	S25FL128L	–	8 pF	T _A = 25°C, 1 MHz V _{IN} = 0V	–	8 pF	T _A = 25°C, 1 MHz V _{OUT} = 0V
	S25FL256L	–	8 pF	T _A = 25°C, 1 MHz V _{IN} = 0V	–	8 pF	T _A = 25°C, 1 MHz V _{OUT} = 0V
Winbond	W25Q64JV	–	6 pF	T _A = 25°C, V _{IN} = 0V	–	8 pF	T _A = 25°C, V _{OUT} = 0V
	W25Q256JV	–	6 pF	T _A = 25°C, V _{IN} = 0V	–	8 pF	T _A = 25°C, V _{OUT} = 0V
	W25Q64FV	–	6 pF	T _A = 25°C, V _{IN} = 0V	–	8 pF	T _A = 25°C, V _{OUT} = 0V
	W25Q128FV	–	6 pF	T _A = 25°C, V _{IN} = 0V	–	8 pF	T _A = 25°C, V _{OUT} = 0V
	W25Q256FV	–	6 pF	T _A = 25°C, V _{IN} = 0V	–	8 pF	T _A = 25°C, V _{OUT} = 0V
Micron ³⁰	N25Q064A	–	6 pF	T _A = 25°C, 54 MHz, V _{IN} = 0V	–	8 pF	T _A = 25°C, 54 MHz, V _{OUT} = 0V
	N25Q128A	–	6 pF	T _A = 25°C, 54 MHz, V _{IN} = 0V	–	8 pF	T _A = 25°C, 54 MHz, V _{OUT} = 0V
	N25Q256A	–	6 pF	T _A = 25°C, 54 MHz, V _{IN} = 0V	–	8 pF	T _A = 25°C, 54 MHz, V _{OUT} = 0V
Macronix	MX25L6433F	–	6 pF	T _A = 25°C, 1 MHz	–	8 pF	T _A = 25°C, 1 MHz
	MX25L12845G	–	6 pF	T _A = 25°C, 1 MHz	–	8 pF	T _A = 25°C, 1 MHz
	MX25L25645G	–	6 pF	T _A = 25°C, 1 MHz	–	8 pF	T _A = 25°C, 1 MHz

²⁹ C_{IN} applies to SCK, CS#, RESET#, and IO3/RESET#; C_{OUT} applies to all I/Os.

³⁰ C_{IN} applies to all pins besides DQ0, DQ1, DQ2, and DQ3; C_{OUT} applies to DQ0, DQ1, DQ2, and DQ3.

5 AC Characteristics

A comparison of AC characteristics is necessary to ensure desired timing when migrating from a competitor device to the Cypress FL-L family. Timing differences exist between devices from all manufacturers. Modifications to the host system software that controls the serial NOR Flash device may be necessary to accommodate differences in timing when migrating. Table 5 provides the most pertinent AC characteristics for the serial NOR devices of interest.

Table 5. Comparison of AC Characteristics

Characteristic ³¹	Unit	Device															
		Cypress			Winbond					Micron			Macronix				
		S25FL064L	S25FL128L	S25FL256L	W25Q64JV	W25Q256JV	W25Q64FV	W25Q128FV	W25Q256FV	N25Q064A	N25Q128A	N25Q256A	MX25L6433F	MX25L12845G	MX25L25645G		
SDR Read Clock Rate ($F_{SCK,R}$)	Max	MHz	50	50	50	50	50	50	50	50	50	54	54	54	50	50	50
SDR Dual I/O and Quad I/O Read Clock Rate ($F_{SCK,C}$)	Max	MHz	108	133	133	133	133	104	104	104	108	108	108	133	80	80	
DDR Quad I/O Read Clock Rate ($F_{SCK,R}$)	Max	MHz	54	66	66	–	–	–	–	–	–	–	–	54	–	54	84 ³²
CS# High Time Read (t_{CS})	Min	ns	20	20	20	10	10	10	10	10	20	20	20	15	15	15	
	Max	ns	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CS# High Time Non-Read (t_{CS})	Min	ns	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
	Max	ns	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CS# Active Setup Time (t_{CSS}) ³³	Min	ns	3	3	3	5	5	5	5	5	4	4	4	4	4	4	4
	Max	ns	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CS# Active Hold Time (t_{CSS}) ³⁵	Min	ns	5	5	5	5	5	5	3	3	4	4	4	4	4	4	4
	Max	ns	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Data in Setup Time (t_{SU})	Min	ns	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2
	Max	ns	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Data in Hold Time (t_{HD})	Min	ns	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
	Max	ns	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Clock Low to Output Valid (t_V)	Min	ns	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Max	ns	8 ³⁴ 6 ³⁵	8 ³⁴ 6 ³⁵	8 ³⁴ 6 ³⁵	6 ³⁶	6 ³⁶	7 ³⁶	7 ³⁶	7 ³⁶	7 ³⁶	7 ³⁶ 5 ³⁷	7 ³⁶ 5 ³⁷	7 ³⁶ 5 ³⁷	8 ³⁴ 6 ³⁵	8 ³⁴ 6 ³⁵	8 ³⁴ 6 ³⁵
Output Hold Time (t_{HO})	Min	ns	1	1	1	1.5	1.5	0	2	2	1	1	1	1	1	1	1
	Max	ns	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

³¹ All characteristics apply to single data rate (SDR) operations aside from the DDR Quad I/O Read Clock Rate

³² 100 MHz for the restricted voltage range 3.0 - 3.6 V

³³ Relative to SCK

³⁴ Full V_{DD} range and $CL = 30$ pF

³⁵ Full V_{DD} range and $CL = 15$ pF

³⁶ For CL under 30 pF

³⁷ For CL under 10 pF

6 Command Sets

6.1 Addressing

Legacy SPI Flash command sets support 24-bit addressing, which allows addressing of memory arrays up to 16 MB (128 Mb). With the advent of 32 MB (256 Mb) and larger devices, additional address bits are required to access higher address spaces. SPI Flash manufacturers have developed the following methods for dealing with this issue:

- New commands which only accept 4-byte addressing
- Commands to enter and exit the 4-byte addressing mode
- A Bank Address register to supply the extra high-order address bits for legacy software

Table 6 illustrates whether the device can accept 4-byte commands, whether there are commands to enter and exit 4-byte addressing, and whether the device has a bank address register. Note that competitor devices refer to the bank address register as the extended address register. All manufacturers provide a means to use 4-byte addressing on their 256-Mb devices.

Table 6. Comparison of 4-Byte Addressing

Manufacturer	Device	4-Byte Commands	Commands to Enter/Exit 4-Byte Addressing	Extended Address Register
Cypress	S25FL064L	Yes	Yes	Yes
	S25FL128L	Yes	Yes	Yes
	S25FL256L	Yes	Yes	Yes
Winbond	W25Q64JV	No	No	No
	W25Q256JV	Yes	Yes	Yes
	W25Q64FV	No	No	No
	W25Q128FV	No	No	No
	W25Q256FV	Yes	Yes	Yes
Micron	N25Q064A	No	No	No
	N25Q128A	No	No	No
	N25Q256A	Yes	Yes	Yes
Macronix	MX25L6433F	No	No	No
	MX25L12845G	Yes ³⁸	No	No
	MX25L25645G	Yes	Yes	Yes

³⁸ Only Advanced Sector Protection commands have 4-byte addresses.

6.2 Read Device ID

When supported, the 'Read JEDEC Serial Flash Discoverable Parameters (SFDP) 5Ah' command allows the host system to read the device identification, feature, and configuration information in accordance with the JEDEC JESS216 standard. If the device does not support this, the 'Read ID (RDID) 9Fh' command allows access to the manufacturer identification, device identification, and Common Flash Interface (CFI) information.

Winbond and Macronix also offer additional, legacy means to determine the ID information such as the Device ID ABh command and the Read Manufacturer Device ID 90h, 92h, and 94h commands. The Read SFDP and Read ID commands provide the same information as these legacy commands. Cypress recommends using the Read SFDP 5Ah command in place of the Device ID ABh command, and the Read Manufacturer Device ID 90h, 92h, and 94h commands, which may require changes to the host system software. [Table 7](#) provides the commands used by serial NOR Flash devices of interest to access the Device ID information.

Table 7. Comparison of Read Device ID Command Support

Manufacturer	Device	Read SFDP (5A)	READ ID (9F)	READ QUAD ID (AF)	Read Unique ID (4B)	Device ID (AB)	Read Manufacturer Device ID (90, 92, 94) ³⁹
Cypress	S25FL064L	Yes	Yes	Yes	Yes	No	No
	S25FL128L	Yes	Yes	Yes	Yes	No	No
	S25FL256L	Yes	Yes	Yes	Yes	No	No
Winbond	W25Q64JV	Yes	Yes	No	Yes	Yes	Yes
	W25Q256JV	Yes	Yes	No	Yes	Yes	Yes
	W25Q64FV	Yes	Yes	No	Yes	Yes	Yes
	W25Q128FV	Yes	Yes	No	Yes	Yes	Yes
	W25Q256FV	Yes	Yes	No	Yes	Yes	Yes
Micron	N25Q064A	Yes	Yes	Yes	No	No	No
	N25Q128A	Yes	Yes	Yes	No	No	No
	N25Q256A	Yes	Yes	Yes	No	No	No
Macronix	MX25L6433F	Yes	Yes	No	No	Yes	90 only
	MX25L12845G	Yes	Yes	No	No	Yes	90 only
	MX25L25645G	Yes	Yes	No	No	Yes	90 only

³⁹ 90 single-bit output, 92 2-bit output, 94 4-bit output

6.3 Read Flash Array

All manufacturers support multiple commands to read the Flash array. The different commands define what modes the host and device use to transfer the address of the data and the data itself. Table 8 summarizes the various read commands used by serial NOR Flash devices of interest. Note that some Winbond devices feature Word Program commands, which other manufacturers do not. Changes to the host system software are necessary when migrating if the software implemented these commands.

Table 8. Comparison of Read Array Commands

Command Description	Device													
	Cypress			Winbond					Micron			Macronix		
	S25FL064L	S25FL128L	S25FL256L	W25Q064JV	W25Q256JV	W25Q064FV	W25Q128FV	W25Q256FV	N25Q064A	N25Q128A	N25Q256A	MX25L6433F	MX25L12845G	MX25L25645G
Read	03h	03h	03h	03h	03h	03h	03h	03h	03h	03h	03h	03h	03h	03h
Fast Read	0Bh	0Bh	0Bh	0Bh	0Bh	0Bh	0Bh	0Bh	0Bh	0Bh	0Bh	0Bh	0Bh	0Bh
Read Dual Out	3Bh	3Bh	3Bh	3Bh	3Bh	3Bh	3Bh	3Bh	3Bh	3Bh	3Bh	3Bh	3Bh	3Bh
Read Quad Out	6Bh	6Bh	6Bh	6Bh	6Bh	6Bh	6Bh	6Bh	6Bh	6Bh	6Bh	6Bh	6Bh	6Bh
Dual I/O Read	BBh	BBh	BBh	BBh	BBh	BBh	BBh	BBh	BBh	BBh	BBh	BBh	BBh	BBh
Quad I/O Read	EBh	EBh	EBh	EBh	EBh	EBh	EBh	EBh	EBh	EBh	EBh	EBh	EBh	EBh
DDR Fast Read	-	-	-	-	-	-	-	-	-	-	0Dh	-	-	-
DDR Dual I/O Read	-	-	-	-	-	-	-	-	-	-	3Dh	-	-	-
DDR Quad I/O Read	EDh	EDh	EDh	-	-	-	-	-	-	-	EDh	-	EDh	EDh
Read (4-Byte Address)	13h	13h	13h	-	13h	-	-	13h	-	-	13h	-	-	13h
Fast Read (4-Byte Address)	0Ch	0Ch	0Ch	-	0Ch	-	-	0Ch	-	-	0Ch	-	-	0Ch
Read Dual Out (4-Byte Address)	3Ch	3Ch	3Ch	-	3Ch	-	-	3Ch	-	-	3Ch	-	-	3Ch
Read Quad Out (4-Byte Address)	6Ch	6Ch	6Ch	-	6Ch	-	-	6Ch	-	-	6Ch	-	-	6Ch
Dual I/O Read (4-Byte Address)	BCh	BCh	BCh	-	BCh	-	-	BCh	-	-	BCh	-	-	BCh
Quad I/O Read (4-Byte Address)	ECh	ECh	ECh	-	ECh	-	-	ECh	-	-	ECh	-	-	ECh
DDR Quad I/O Read (4-Byte Address)	EEh	EEh	EEh	-	-	-	-	-	-	-	-	-	-	EEh
Word Read Quad I/O	-	-	-	-	-	E7h	E7h	E7h	-	-	-	-	-	-
Octal Word Read Quad I/O	-	-	-	-	-	E3h	E3h	E3h	-	-	-	-	-	-

6.4 Program Flash Array

All devices of interest support Page Program and Quad Page Program commands to program the main memory array. Macronix devices use a Quad Page Program instruction code different from Cypress, Winbond, and Micron. All Cypress devices, Winbond W25Q256JV devices, and Micron N25Q256A devices support specific 4-byte address program commands. All these devices support suspending and resuming program operations. [Table 9](#) summarizes the program commands used by the serial NOR Flash devices of interest. Note that Micron devices feature Fast Program commands, for use with external programmers, which other manufacturers do not. Changes to the host system software are necessary when migrating if the software implemented these commands.

Table 9. Comparison of Program Array Commands

Command Description	Devices														
	Cypress			Winbond					Micron			Macronix			
	S25FL064L	S25FL128L	S25FL256L	W25Q64JV	W25Q256JV	W25Q64FV	W25Q128FV	W25Q256FV	N25Q064A	N25Q128A	N25Q256A	MX25L6433F	MX25L12845G	MX25L25645G	
Page Program	02h	02h	02h	02h	02h	02h	02h	02h	02h	02h	02h	02h	02h	02h	
Page Program (4-Byte Address)	12h	12h	12h	-	12h	-	-	-	-	-	12h	-	-	-	
Dual Input Fast Program	-	-	-	-	-	-	-	-	A2h	A2h	A2h	-	-	-	
Extended Dual Input Fast Program	-	-	-	-	-	-	-	-	D2h	D2h	D2h	-	-	-	
Quad Page Program	32h	32h	32h	32h	32h	32h	32h	32h	32h	32h	32h	38h	38h	38h	
Quad Input Fast Program	-	-	-	-	-	-	-	-	32h	32h	32h	-	-	-	
Extended Quad Input Fast Program	-	-	-	-	-	-	-	-	12h	12h	12h/38h	-	-	-	
Quad Page Program (4-Byte Address)	34h	34h	34h	-	34h	-	-	-	-	34h	34h	-	-	-	
Program Suspend	75h	75h	75h	75h	75h	75h	75h	75h	75h	75h	75h	75h	75h	75h	
Program Resume	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	

6.5 Erase Flash Array

All devices support erasing 4-KB sectors or sub-sectors and 64-KB blocks or sectors. All of these devices, except Micron devices, support erasing a 32-KB half block. In addition, all of the devices support both 60h and C7h commands for chip erase except Micron devices, which only support C7h. All Cypress devices, Winbond W25Q256JV devices, Micron 256-Mb, and Macronix 256-Mb devices support specific 4-byte address erase commands although they are not the same. All devices support suspending and resuming erase operations.

Table 10 provides a summary of the erase commands used by the serial NOR Flash devices of interest.

Table 10. Comparison of Erase Array Commands

Command Description	Device													
	Cypress			Winbond					Micron			Macronix		
	S25FL064L	S25FL128L	S25FL256L	W25Q64JV	W25Q256JV	W25Q64FV	W25Q128FV	W25Q256FV	N25Q064A	N25Q128A	N25Q256A	MX25L6433F	MX25L12845G	MX25L25645G
Sector Erase	20h	20h	20h	20h	20h	20h	20h	20h	20h	20h	20h	20h	20h	20h
Half Block Erase	52h	52h	52h	52h	52h	52h	52h	52h	-	-	-	52h	52h	52h
Block Erase	D8h	D8h	D8h	D8h	D8h	D8h	D8h	D8h	D8h	D8h	D8h	D8h	D8h	D8h
Chip Erase	60h/ C7h	60h/ C7h	60h/ C7h	60h/ C7h	60h/ C7h	60h/ C7h	60h/ C7h	60h/ /C7h	C7h	C7h	C7h	60h/ C7h	60h/ C7h	60h/ C7h
Sector Erase (4-Byte Address)	21h	21h	21h	-	21h	-	-	-	-	-	21h	-	-	21h
Half Block Erase (4-Byte Address)	53h	53h	53h	-	-	-	-	-	-	-	-	-	-	5Ch
Block Erase (4-Byte Address)	DCh	DCh	DCh	-	DCh	-	-	-	-	-	DCh	-	-	DCh
Erase Suspend	75h	75h	75h	75h	75h	75h	75h	75h	75h	75h	75h	75h	75h	75h
Erase Resume	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah	7Ah

6.6 Register Access

All manufacturers support the following Write and Register Access commands: Write Enable 06h, Write Disable 04h, Read Status Register 05h, and Write Register 01h.

Status and Configuration Registers command operations require customization due to register bit and operational differences between manufacturers. For example, Cypress, Macronix, Micron, and Winbond have the same 8-bit Status Register 1 access with the Read Status Register 05h and Write Register 01h commands, but the definition of Status Register 1 bit 6 and bit 5 are different for each manufacturer.

Cypress S25FL-L devices feature the additional Read Any Register 65h and Write Any Register 71h commands, which eliminate the need for several individual read and write register commands. Changes to the host system software may be required to use these commands.

Table 11 provides a summary of the register access commands for the serial NOR Flash devices of interest.

Table 11. Comparison of Register Access Commands.

Command Description	Device													
	Cypress			Winbond					Micron			Macronix		
	S25FL064L	S25FL128L	S25FL256L	W25Q64JV	W25Q256JV	W25Q64FV	W25Q128FV	W25Q256FV	N25Q064A	N25Q128A	N25Q256A	MX25L6433F	MX25L12845G	MX25L25645G
Read Status Register 1	05h	05h	05h	05h	05h	05h	05h	05h	05h	05h	05h	05h	05h	05h
Read Status Register 2	07h	07h	07h	35h	35h	35h	35h	35h	-	-	-	-	-	-
Read Config. Register 1	35h	35h	35h	-	-	-	-	-	-	-	-	15h	15h	15h
Read Config. Register 2	15h	15h	15h	-	-	-	-	-	-	-	-	-	-	-
Read Config. Register 3	33h	33h	33h	-	-	-	-	-	-	-	-	-	-	-
Read Any Register	65h	65h	65h	-	-	-	-	-	-	-	-	-	-	-
Write Register	01h	01h	01h	01h	01h	01h	01h	01h	01h	01h	01h	01h	01h	01h
Write Disable	04h	04h	04h	04h	04h	04h	04h	04h	04h	04h	04h	04h	04h	04h
Write Enable for Non-Volatile Data Change	06h	06h	06h	06h	06h	06h	06h	06h	06h	06h	06h	06h	06h	06h
Write Enable for Volatile Data Change	50h	50h	50h	50h	50h	50h	50h	50h	-	-	-	-	-	-
Write Any Register	71h	71h	71h	-	-	-	-	-	-	-	-	-	-	-
Clear Status Register	30h	30h	30h	-	-	-	-	-	-	-	-	-	-	-
Enter 4-Byte Address Mode	B7h	B7h	B7h	-	B7h	-	-	B7h	-	-	B7h	-	-	B7h
Exit 4-Byte Address Mode	E9h	E9h	E9h	-	E9h	-	-	E9h	-	-	E9h	-	-	E9h
Set Burst Length	77h	77h	77h	77h	77h	77h	77h	77h	-	-	-	C0h/ 77h	C0h	-
Enter QPI Mode	38h	38h	38h	-	-	38h	38h	38h	-	-	35h	-	35h	35h
Exit QPI Mode	F5h	F5h	F5h	-	-	-	-	-	-	-	F5h	-	F5h	F5h

Command Description	Device													
	Cypress			Winbond					Micron			Macronix		
	S25FL064L	S25FL128L	S25FL256L	W25Q64JV	W25Q256JV	W25Q64FV	W25Q128FV	W25Q256FV	N25Q064A	N25Q128A	N25Q256A	MX25L6433F	MX25L12845G	MX25L25645G
Read Learning Pattern Data	41h	41h	41h	-	-	-	-	-	-	-	-	-	-	-
Program non-Volatile Learning Data	43h	43h	43h	-	-	-	-	-	-	-	-	-	-	-
Write Volatile Learning Data	4Ah	4Ah	4Ah	-	-	-	-	-	-	-	-	-	-	-
Write Status Register 2	-	-	-	31h	31h	-	31h	31h	-	-	-	-	-	-
Read Status Register 3	-	-	-	15h	15h	-	15h	15h	-	-	-	-	-	-
Write Status Register 3	-	-	-	11h	11h	-	11h	11h	-	-	-	-	-	-
Set Read Parameters	-	-	-	-	-	C0h	C0h	C0h	-	-	-	-	-	-
Read Extended Address Register	-	-	-	-	C8h	-	-	C8h	-	-	C8h	-	-	C8h
Write Extended Address Register	-	-	-	-	C5h	-	-	C5h	-	-	C5h	-	-	C5h
Read Lock Register	-	-	-	-	-	E8h	-	-	E8h	E8h	E8h	-	-	-
Write Lock Register	-	-	-	-	-	E5h	-	-	E5h	E5h	E5h	-	-	-
Read Flag Status Register	-	-	-	-	-	70h	-	-	70h	70h	70h	-	-	-
Clear Flag Status Register	-	-	-	-	-	50h	-	-	50h	50h	50h	-	-	-
Read Config. Register	-	-	-	-	-	85h	-	-	85h	85h	85h	-	-	-
Write Config. Register	-	-	-	-	-	81h	-	-	81h	81h	81h	-	-	-
Read Enhanced Volatile Config. Register	-	-	-	-	-	65h	-	-	65h	65h	65h	-	-	-
Write Enhanced Volatile Config. Register	-	-	-	-	-	61h	-	-	61h	61h	61h	-	-	-

6.7 Reset

All devices support software reset enable and software reset with the same set of commands. [Table 12](#) summarizes the reset commands used by the serial NOR Flash devices of interest.

Table 12. Comparison of Reset Commands

Command Description	Device													
	Cypress			Winbond					Micron			Macronix		
	S25FL064L	S25FL128L	S25FL256L	W25Q64JV	W25Q256JV	W25Q64FV	W25Q128FV	W25Q256FV	N25Q064A	N25Q128A	N25Q256A	MX25L6433F	MX25L12845G	MX25L25645G
Software Reset Enable	66h	66h	66h	66h	66h	66h	66h	66h	66h	66h	66h	66h	66h	66h
Software Reset	99h	99h	99h	99h	99h	99h	99h	99h	99h	99h	99h	99h	99h	99h
Mode Bit Reset	FFh	FFh	FFh	-	-	FFFFh ⁴⁰	FFFFh ⁴³	FFFFh ⁴¹	-	-	-	-	-	-

⁴⁰ Input 1 on IO0 for 8-16 clocks depending on the command

⁴¹ Input 1 on IO0 for 8-20 clocks depending on the command

7 Array Protection

Manufacturers have implemented different mechanisms to perform the same array protection functions. It is important to understand these differences when migrating devices. There are two broad categories for protection mechanisms: legacy protection mechanisms and additional protection mechanisms. Each manufacturer provides a mechanism in both categories.

7.1 Legacy SPI Flash Protection (Block Protection Bits)

All devices provide some form of protection using Block Protection (BP) bits in the Status Register and modifying bits in the Status Register or another register. [Table 13](#) provides a summary of the legacy protection used by the serial NOR Flash devices of interest.

Table 13. Comparison of Legacy Protection

Command Description	Device													
	Cypress			Winbond					Micron			Macronix		
	S25FL064L	S25FL128L	S25FL256L	W25Q64JV	W25Q256JV	W25Q64FV	W25Q128FV	W25Q256FV	N25Q064A	N25Q128A	N25Q256A	MX25L6433F	MX25L12845G	MX25L25645G
Number of BP bits in Status Register	3	3	4	3	4	3	3	4	4	4	4	4	4	4
Protection Start (Top or Bottom)	Yes (In Status Reg. 1)	Yes (In Status Reg. 1)	Yes (In Status Reg. 1)	Yes (In Status Reg. 1)	Yes (In Status Reg. 1)	Yes (In Status Reg. 1)	Yes (In Status Reg. 1)	Yes (In Status Reg. 1)	Yes (In Status Reg.)	Yes (In Status Reg.)	Yes (In Status Reg.)	Yes (In Config Register)	Yes (In Config Register)	Yes (In Config Register)
Sector (4 KB) or Block (64 KB) Region Size Selector in Status Register	Yes	Yes	No	Yes	No	Yes	Yes	No	No	No	No	No	No	No
Compliment Bit	Yes (In Config Reg. 1)	Yes (In Config Reg. 1)	Yes (In Config Reg. 1)	No	Yes (In Status Reg. 2)	Yes (In Status Reg. 2)	Yes (In Status Reg. 2)	Yes (In Status Reg. 2)	No	No	No	No	No	No

7.2 Additional Protection Mechanisms

7.2.1 Cypress S25FL064L, S25FL128L, and S25FL256L

In addition to legacy protection mechanisms, Cypress devices provide the following:

1. Individual Block Lock (IBL) protection is a volatile mechanism to lock all the blocks (64 KB) in the array except for the top and bottom blocks, which have protection for the sectors (4 KB) that comprise them.
2. Pointer Region Protection (PRP) is a nonvolatile mechanism to lock a region containing an arbitrary number of sectors (4 KB) from 0 to the entire main memory array.
3. Individual and Region Protection is a set of independent hardware and software methods used to disable or enable programming or erase operations on Security Regions 2 and 3 and the PRP register.

7.2.2 Winbond W25Q64JV, W25Q256JV, W25Q64FV, W25Q128FV, and W25Q256FV

In addition to legacy protection mechanisms, Winbond devices provide a volatile mechanism to lock all the blocks (64 KB) in the array except for the top and bottom blocks, which have protection for the sectors (4 KB) that comprise them.

7.2.3 Micron N25Q064A, N25Q128A, and N25Q256A

In addition to legacy protection mechanisms, Micron devices provide software write protection applicable to every 64-KB sector with a volatile lock bit.

7.2.4 **Macronix MX25L6433F, MX25L12845G, and MX25L12845G**

In addition to legacy protection mechanisms, Macronix devices provide Advanced Sector Protection to protect individual 64-KB blocks in the main memory array and in the bottom and top 64 KB of memory.

8 **Summary**

AN202471 discussed the differences between the S25FL-L family devices and similar devices from several competitors. Understanding these differences enables migration from competitor serial NOR Flash devices to S25FL-L family devices.

9 **Related Documents**

Cypress Semiconductor: www.cypress.com

- Cypress S25FL064L Datasheet (Preliminary), Revision *A, dated September 26, 2016
- Cypress S25FL128L and S25FL256L Datasheet, Revision *C, dated September 26, 2016

Winbond: www.winbond.com

- Winbond W25Q64JV Datasheet, Revision D, dated August 30, 2016
- Winbond W25Q256JV Datasheet, Revision B, dated September 20, 2015
- Winbond W25Q64FV Datasheet, Revision Q, dated June 14, 2016
- Winbond W25Q128FV Datasheet, Revision M, dated May 13, 2016
- Winbond W25Q256FV Datasheet, Revision I, dated February 26, 2016

Micron: www.micron.com

- Micron N25Q064A Datasheet, Revision N, dated October 2014
- Micron N25Q128A Datasheet, Revision Q, dated November 2014
- Micron N25Q256A Datasheet, Revision V, dated May 2016

Macronix: www.macronix.com

- Macronix MX25L6433F Datasheet, Revision 1.4, dated March 10, 2016
- Macronix MX25L12845G Datasheet, Revision 1.3, dated September 02, 2016
- Macronix MX25L25645G Datasheet, Revision 1.2, dated September 08, 2016

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**	4965121	AHCL	10/15/2015	New Application Note
*A	5498794	BCHV	10/28/2016	Updated to include 64-Mb devices and the Winbond W25Q-JV family. Added Section 3 Package Comparison Added Section 4 Capacitance Comparison Added Section 5 AC Characteristics Updated template
*B	5798800	AESATMP9	07/05/2017	Updated logo and copyright.

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