AN98487

Programmer's Guide for the Cypress 65 nm GL-S MirrorBit® Eclipse™ Flash Family

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Associated Part Family: S29GL-S, S29GL-N,S29GL-P

AN98487 describes the new features of the Cypress S29GL-S Flash device family and software considerations for migrating from the S29GL-N and S29GL-P families.

Contents

1 Introduction

The MirrorBit 65 nm GL-S is a family of 3.0-volt, page access, NOR flash memory products. This guide discusses new features of the S29GL-S and software considerations the designer should make when migrating from the S29GL-N or S29GL-P memory family. In this document, S29GL-S and GL-S refer to the 128 Mb, 256 Mb, 512 Mb, 1 Gb, and 2 Gb (dual die) densities only.

2 Feature Comparisons Summary

Consider the following items when adapting software from S29GL-N or S29GL-P to S29GL-S:

- S29GL-S supports programming in address aligned 512-byte write buffers
- S29GL-S provides a Status Register in addition to the Data Polling feature
- S29GL-S includes updates to CFI and ID (Autoselect)
- S29GL-S has updated timing for various embedded operations
- S29GL-S provides an updated Secure Silicon Region
- S29GL-S has command set changes
  - Improved Suspend and Resume commands
  - New Blank Check command
  - Advanced Sector Protection updates
  - Unlock Bypass command removed
  - Sector Erase command no longer supports multi-sector erase

Table 1. Feature Comparisons

Key Features	GL-N	GL-P	GL-S
Technology	MirrorBit	MirrorBit	MirrorBit Eclipse
Process Node	110 nm	90 nm	65 nm
Densities	128 Mb to 512 Mb	128 Mb to 2 Gb (3)	128 Mb to 2 Gb (3)
Data Bus Width	8-bit or 16-bit	8-bit or 16-bit	16-bit only
Sector Erase Architecture	128 kB	128 kB	128 kB
Read Page	16 bytes	16 bytes	32 bytes
Write Buffer	32 bytes	64 bytes	512 bytes
Single-Word Programming	Yes	Yes	Yes
Accelerated Programming	Yes	Yes	No
Unlock Bypass	Yes	Yes	No
Data Polling Status	Yes	Yes	Yes (2)
Status Register	No	No	Yes
Program Suspend / Resume	Yes	Yes	Yes (1)
Erase Suspend / Resume	Yes	Yes	Yes
Sector Erase Queuing	Yes	Yes	No
Software Sector Protection	Advanced Sector Protection	Advanced Sector Protection	Advanced Sector Protection
Secure Silicon Region	256 bytes	256 bytes	2 x 512 bytes
Program-Erase Endurance (typical)	100,000 cycles per sector	100,000 cycles per sector	100,000 cycles per sector
PPB Bit Endurance (typical)	100,000 cycles	100,000 cycles	1,000 cycles
Data Retention (typical)	20-year	20-year	20-year

Notes:

1. *GL-S Program Suspend / Resume is backward compatible, but the new Program Suspend / Resume commands are recommended for new designs.*
2. *Data Polling Status may not be supported in future generations of the S29GL family; best practice is to use the Status Register.*
3. *The 2 Gb is a dual die solution.*

3 Data Alignment and Granularity

Many applications store data in multiples of 512 bytes. The S29GL-S devices have a 256-word (512-byte) write buffer aligned on 512-byte boundaries. Programming data to the flash is most efficient when writing in full Page Program Buffers. Although smaller writes are allowed, software should be modified to program data in full, address aligned, write buffer increments.

For smaller or misaligned data writes, it is important to note that the embedded program operation happens in address aligned pages of 16 words (32 bytes). For optimal flash performance and reliability, data should be programmed in multiples of full 32-byte aligned pages. While multiple program operations within a 32 byte page are not best practice for S29GL-S devices, they are allowed for backwards compatibility with the S29GL-N and S29GL-P devices.

For example, a simple flash file system might write two 512-byte file sectors, each with 30 bytes of metadata. Programming this data sequentially would cause several misalignments.

Table 2. Misaligned Data Storage

Order	1st	2nd	3rd	4th
Size	512 bytes	30 bytes	512 bytes	30 bytes
Byte Offset	0	512	542	1054

Data Written	Initial 512 bytes			30 bytes	512 bytes				30 bytes	Not Written
Internal Pages	Page 0	…	Page 15	Page 16	Page 17	…	Page 31	Page 32	Page 33	Page 34

Instead, the writes should be rearranged to maximize programming performance. In Table 3, sector data is written from the bottom of flash, and metadata is written from the top. The S indicates two bytes that are skipped and left unused. Page N is the last page in the device. M is the size of the flash device in bytes.

Table 3. Aligned Data Storage

Order	1st	2nd	3rd	4th
Size	512 bytes	30 bytes	512 bytes	30 bytes
Byte Offset	0	M - 32	512	M - 64

Data Written	Initial 512 bytes			512 bytes			Not Written	30 bytes	S	30 bytes	S
Internal Pages	Page 0	…	Page 15	Page 16	…	Page 31	…	Page N - 1		Page N	

4 Status Register and Data Polling

The S29GL-S devices are backward compatible with the Data Polling Status (toggle bits) feature from previous generations.

The S29GL-S devices also offer a Status Register for software to check the status of an embedded operation. After issuing the Status Register Read command, the Status Register values are available for one read access, anywhere in the selected sector.

Table 4. Status Register Bits

Bit #	15:8	7	6	5	4	3	2	1	0
Name		DRB	ESSB	ESB	PSB	WBASB	PSSB	SLSB	
Description	Reserved	Device Ready or Busy	Erase Suspend Status	Erase Status	Program Status	Write Buffer Abort Status	Program Suspend Status	Sector Lock Status	Reserved
Busy Value	Invalid	0	Invalid	Invalid	Invalid	Invalid	Invalid	Invalid	Invalid
When DRB Indicates Ready, Value 1 in Bit 6 through Bit 1 Indicates	Reserved	1	Erase Suspended	Erase Error or Not Erased (Blank Check)	Program Error or Password Unlock Error	Abort During Write Buffer Program	Program Suspended	Sector Locked Error	Reserved
When DRB Indicates Ready, Value 0 in Bit 6 through Bit 1 Indicates	Reserved	1	No Erase Suspend	No Erase Error or Erased (Blank Check)	No Program nor Password Unlock Error	No Abort Error	No Program Suspend	No Lock Error	Reserved
Reset Value	X	1	0	0	0	0	0	0	0

While the device is busy (DRB = 0), the remaining bits are invalid. Once the device is ready (DRB = 1), the remaining bits can be interpreted for device status. The Error bits (ESB, PSB, WBASB, and SLSB) can be cleared by issuing the Clear Status Register command or the Reset command or the Write-to-Buffer-Abort Reset command.

Table 5. Status Register Commands

Command Sequence	Cycles	First		Second		Third	
		Word Address	Data	Word Address	Data	Word Address	Data
Read Status Register	2	555h	70h	X	RD		
Clear Status Register	1	555h	71h				
Reset (1)	1	X	F0h				
Write-to-Buffer-Abort Reset	3	555h	AAh	2AAh	55h	555h	F0h

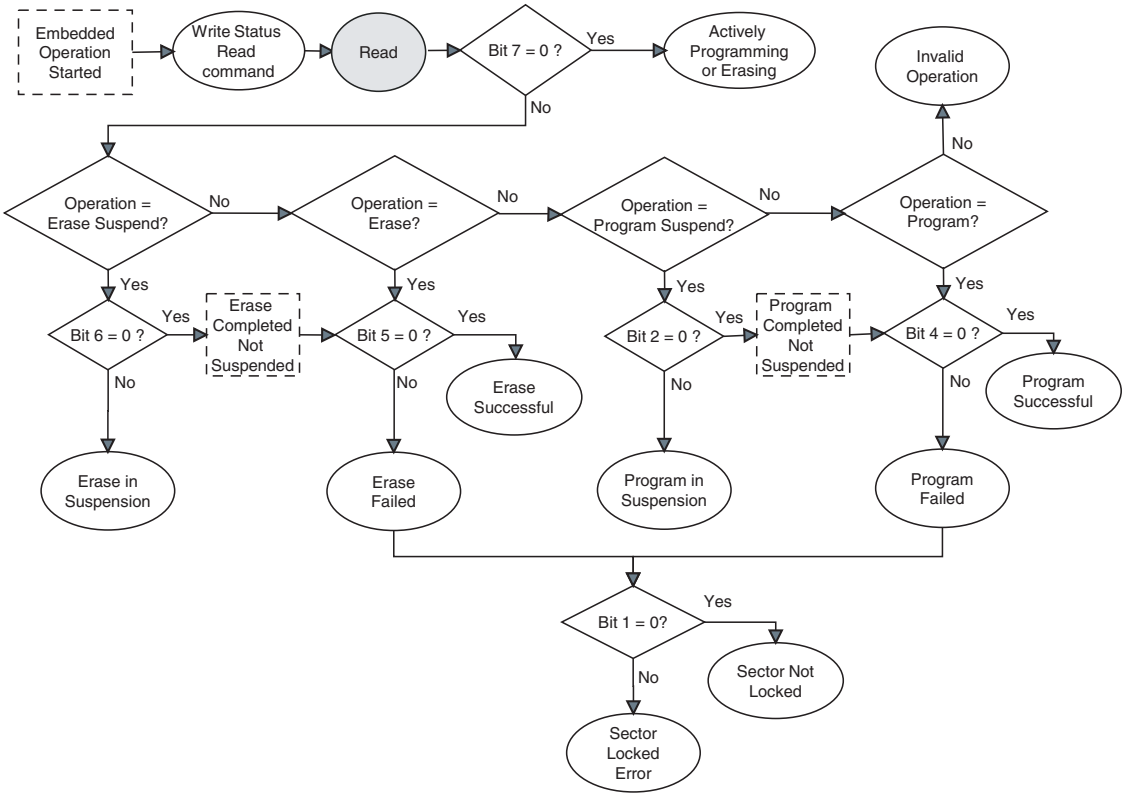
Legend:
RD = Read Data *X = Any flash address*

Note:
1. *The Reset command clears error bits in the Status Register.*

Software can be simplified by using the Status Register to check device status because a single status read can be used to determine device status. The legacy Data Polling method requires comparison of multiple reads to determine device status. The Cypress Low Level Driver (LLD) provides software examples for both Data Polling and Status Register polling. The LLD can be downloaded from the Cypress website (www.cypress.com).

Figure 1 is one example of logic for Status Register Polling. Software only needs to read the register once to interpret the flash status.

Figure 1. Status Register Usage Flow Diagram



5 Device Identification and CFI

The S29GL-S devices have combined Device Identification (ID), formerly called Autoselect, and Common Flash Interface (CFI) address spaces. Both Device ID and CFI access commands are backward compatible with previous generations of flash, but now either command can be used to access the same information. The ID-CFI information is available at the same offsets defined for S29GL-N and S29GL-P families, but data may have changed at some locations.

Table 6. ID-CFI Commands

Command Sequence	Cycles	First		Second		Third	
		Word Address	Data	Word Address	Data	Word Address	Data
ID Entry (Autoselect)	3	555h	AAh	2AAh	55h	SA + 555h	90h
CFI Entry	1	SA + 55h	98h				
ID-CFI Read	1	RA	RD				
Reset/ASO Exit	1	X	F0h				

Legend:
SA = Sector Address
X = Any flash address
RA = Read Address
RD = Read Data
ASO = Address Space Overlay

The S29GL-S devices have Device ID codes that are backward compatible with GL-N and GL-P devices of the same density. Most features are backward compatible, but as described subsequently there are some differences that systems designers should consider. Software that only reads the ID (Autoselect) code to identify a device may attempt operations that are not compatible with the specific S29GL-S device.

Table 7. Device IDs

Density	GL-N	GL-P	GL-S
128 Mb	227Eh / 2221h / 2201h	227Eh / 2221h / 2201h	227Eh / 2221h / 2201h
256 Mb	227Eh / 2222h / 2201h	227Eh / 2222h / 2201h	227Eh / 2222h / 2201h
512 Mb	227Eh / 2223h / 2201h	227Eh / 2223h / 2201h	227Eh / 2223h / 2201h
1 Gb		227Eh / 2228h / 2201h	227Eh / 2228h / 2201h
2 Gb		227Eh / 2248h / 2201h	227Eh / 2248h / 2201h

Note:
1. *Data are read from addresses 01h, 0Eh, and 0Fh within the Device ID ASO.*

Since the device IDs are the same across the different lithographies, software should use the CFI information to detect device features and use the flash devices appropriately. Below are differences in CFI information between S29GL-S and previous generations.

Table 8. CFI Register Differences (Sheet 1 of 2)

CFI Register	Word Offset	GL-N	GL-P	GL-S
Typical timeout for single-word write = 2^N µs	1Fh	0007h	0006h	0008h
Typical timeout for maximum multi-byte program = 2^N µs	20h	0007h	0009h	0009h
Typical timeout for individual block erase = 2^N ms	21h	000Ah	0009h	0008h
Typical timeout for full chip erase = 2^N ms 0000h = Not Supported	22h	0000h	0013h (1 Gb) 0012h (512 Mb) 0011h (256 Mb) 0010h (128 Mb)	0013h (2 Gb) 0012h (1 Gb) 0011h (512 Mb) 0010h (256 Mb) 000Fh (128 Mb)
Maximum timeout for single-word = 2^N times typical	23h	0003h	0003h	0001h
Maximum timeout for maximum multi-byte program = 2^N times typical	24h	0005h	0005h	0002h
Maximum timeout for individual block erase = 2^N times typical	25h	0004h	0003h	0003h

Table 8. CFI Register Differences (Sheet 2 of 2)

CFI Register	Word Offset	GL-N	GL-P	GL-S
Maximum timeout for full chip erase = 2^N times typical 0000h = Not Supported	26h	0000h	0002h	0003h
Flash Device Interface Description 0000h = x8-only, 0001h = x16-only, 0002h = x8/x16 capable	28h	0002h	0002h	0001h
Maximum number of bytes in multi-byte write = 2^N	2Ah	0005h	0006h	0009h
Minor version number, ASCII	44h	0033h	0033h	0035h
Process Technology (Bits 5-2) 0100b = 110 nm MirrorBit, 0101b = 90 nm MirrorBit, 0111b = 65 nm MirrorBit Eclipse Address Sensitive Unlock (Bits 1-0) 00b = Required, 01b = Not Required	45h	0010h	0014h	001Ch
Page Mode Type 0002h = 8-word Page, 0003h = 16-word Page	4Ch	0002h	0002h	0003h
ACC (Acceleration) Supply Minimum 0000h = Not Supported, D[7:4] = V, D[3:0] = 100 mV	4Dh	00B5h	00B5h	0000h
ACC (Acceleration) Supply Maximum 0000h = Not Supported, D[7:4] = V, D[3:0] = 100 mV	4Eh	00C5h	00C5h	0000h
Unlock Bypass 0000h = Not Supported, 0001h = Supported	51h	–	–	0000h
Secure Silicon Sector (Customer OTP Area) Size = 2^N bytes	52h	–	–	0009h
Software Features	53h	–	–	008Fh
Read Page Size = 2^N bytes	54h	–	–	0005h
Erase Suspend Timeout Maximum < 2^N µs	55h	–	–	0006h
Program Suspend Timeout Maximum < 2^N µs	56h	–	–	0006h
Embedded Hardware Reset Timeout Maximum < 2^N µs	78h	–	–	0006h
Non-embedded Hardware Reset Timeout Maximum < 2^N µs	79h	–	–	0009h

There are no CFI entries for unlock bypass, status register, and sector erase queuing that are supported by some of these devices. However, software can use the minor version number to determine which set of these features is supported.

```
if ((minor_version == 0x33)&&(major_version == 0x31))
{
    polling_method = DATA_POLLING;
    sector_erase = QUEUE_MULTIPLE_SECTORS;
    word_program = USE_UNLOCK_BYPASS;
}
else if ((minor_version >= 0x35)&&(major_version == 0x31))
{
    polling_method = STATUS_REGISTER_POLLING;
    sector_erase = SINGLE_SECTOR;
    word_program = NO_UNLOCK_BYPASS;
}
else
{
    // Handle error for invalid CFI version
}
```

Certain software drivers verify specific values in the CFI register to assure support for the specific flash. Linux MTD drivers verify the Major and Minor version number (ASCII) entries at CFI register word offsets 43h and 44h, respectively, to select the correct device-support code. GL-N and GL-P flash have a Major version number value of 0031h (ASCII "1") and a Minor version number value of 0033h (ASCII "3") to indicate the CFI Register follows the CFI 1.3 standard. The GL-S flash have a Major version number value of 0031h (ASCII "1") and a Minor version number value of 0035h (ASCII "5") to indicate the CFI Register follows the CFI 1.5 standard. This difference causes legacy MTD drivers to not recognize the GL-S flash. In that case, a software patch is required to update

the MTD for GL-S support. An appropriate Linux driver patch can be downloaded from www.cypress.com.

6 Embedded Operation Timing

There are timing differences between S29GL-S devices and previous generations. Table 9 highlights timings that may impact software design. Many of these values are also accessible to software via the Common Flash Interface (CFI) as described in Section 5, *Device Identification and CFI* on page 5.

Table 9. Embedded Operation Timeout Differences

Flash Operation	Typ, Min, or Max	GL-N	GL-P	GL-S	Unit
Single-word Programming	Typ	60	60	125	µs
	Max	–	–	400	µs
Write Buffer Programming (maximum size) (2)	Typ	240	480	340	µs
	Max	–	–	750	µs
Effective Write Buffer Programming per Word (maximum size)	Typ	15	15	1.33	µs
Sector Erase (128 kB)	Typ	500	500	275	ms
	Max	3500	3500	1100	ms
Erase Suspend / Erase Resume	Max	15 (1)	15	40	µs
Program Suspend / Program Resume	Max	15 (1)	15	40	µs
Erase Resume to Next Erase Suspend	Min	5000	5000	100	µs
Program Resume to Next Program Suspend	Min	1000	1000	100	µs
Blank Check	Typ	–	–	6.2	ms
	Max	–	–	8.5	ms
Hardware Reset During an Embedded Operation (t_{RPH} or t_{Ready})	Max	0.02	–	–	µs
	Min	–	35	35	µs
Hardware Reset During a Non-embedded Operation (t_{RPH} or t_{Ready})	Max	0.5	–	–	µs
	Min	–	35	35	µs

Notes:

1. *20 µs for GL032N and GL064N.*
2. *256 Words for GL-S, 32 Words for GL-P, and 16 Words for GL-N.*

7 Secure Silicon Region

The S29GL-S devices have a different organization of the Secured Silicon Region than previous generations. The Factory Locked Secure Silicon Region is larger on the GL-S, but the starting offset is still zero. The usage of this area is backwards compatible with the GL-N and GL-P. The Customer Locked Secure Silicon Region is also larger on the GL-S, but the starting offset is different. GL-N and GL-P devices ordered with the "Customer Lockable" option provide lockable memory from word offset 0 to 7Fh. GL-S devices provide lockable memory from word offset 100h to 1FFh. Please note that these differences may require updates to the configuration of programmers and/or system software. The commands to program and lock the Secure Silicon Region are similar to previous generations. Please note that the GL-S Customer Locked area is protected by programming bit 6 of the Lock Register; Bit 0 is used for this purpose in previous generations.

8 Command Set Changes

8.1 Suspend and Resume Commands

The S29GL-S family has backward compatible support for suspend and resume commands. However, when suspend status is detected using Data Polling, there is no means to determine whether an erase versus a program operation is suspended. If an erase operation is suspended in order to perform programming and the program operation is later suspended to perform a read, it is not possible to determine whether the program operation is suspended or completed. Using the single legacy resume command can unintentionally resume the suspended erase operation if the program operation is completed rather than suspended. This confusion can be avoided by using the new Program Suspend and Program Resume commands for program operations and the legacy suspend and resume commands for erase operations.

Table 10. Suspend and Resume Commands

Command Sequence	Cycles	First	
		Word Address	Data
Erase Suspend / Program Suspend	1	X	B0h
Erase Resume / Program Resume	1	X	30h
Program Suspend	1	X	51h
Program Resume	1	X	50h

Legend:
X = Any flash address

Systems designers should also consider the increased maximum latency for erase and program suspend in the GL-S device.

Table 11. Maximum Suspend Latency

Operation	GL-N	GL-P	GL-S
Erase Suspend	20 µs	20 µs	40 µs
Program Suspend	15 µs	15 µs	40 µs

8.2 Blank Check Command

The S29GL-S devices offer a new Blank Check command. This command verifies that the selected sector is fully erased. The Blank Check command is significantly faster than a sector erase operation. Overall system performance may be improved by checking if a sector is erased before performing an erase operation. The Blank Check command may or may not be slower than using the system processor to verify a sector is blank by reading, but the Blank Check command can free the processor to do other work while a Blank Check operation is in progress.

Before issuing the Blank Check command software must make sure the flash is not suspended or busy with an erase or program operation. Reading flash array data is not allowed while the Blank Check is running since the device is busy; polling data is returned instead. Software should check Status Register Bit 7 to detect completion of the Blank Check. Once complete, Status Register Bit 5 holds the result. If Bit 5 is one (1) the selected sector is erased. If Bit 5 is zero (0), the selected sector is not erased.

Table 12. Blank Check Command

Command Sequence	Cycles	First	
		Word Address	Data
Blank Check	1	SA + 555h	33h

Legend:
SA = Sector Address

8.3 Advanced Sector Protection

The S29GL-S devices offer Advanced Sector Protection that is backward compatible with previous generations of GL devices. Each flash sector can be protected by a Persistent Protection Bit (PPB) or a Dynamic Protection Bit (DYB). All PPBs are locked in the current state by clearing the PPB Lock Bit to zero (0). The Persistent Method and Password Method determine the behavior of the PPB Lock Bit. Flash devices ship with all sectors unprotected.

8.3.1 Dynamic Protection Boot Option

The S29GL-S devices can be custom ordered with each DYB cleared to zero (0; protected) after power-on reset or hardware reset. Normally, each DYB is set to one (1; unprotected) after power-up or reset. In DYB Boot Mode, sectors are initially protected by DYB, but can be unlocked.

8.3.2 Lock Register Reserved Bits

When issuing the Lock Register Program command to S29GL-S devices, all reserved bits must be masked to one (1).

8.4 Unlock Bypass Command

The S29GL-S devices do not support the Unlock Bypass command, which is available in the GL-N and GL-P families. When a series of program operations are needed in GL-N and GL-P, the Unlock Bypass feature enables software to skip the unlock cycles in subsequent program command sequences. Unlock Bypass may also be used with Sector Erase and Chip Erase operations on GL-N and GL-P. Since the Unlock Bypass feature is not available on GL-S the standard unlock cycles are required for each program or erase sequence.

The Unlock Bypass Command provided a small reduction in command cycle overhead in legacy devices where the system relies on single-word programming. The GL-S family provides a 512-byte write buffer and much faster programming speed, so the Unlock Bypass command is not needed.

8.5 Sector Erase Command

The S29GL-S devices support the Sector Erase command but only for erasing a single sector. GL-N and GL-P devices allow multiple sector address and sector erase command pairs to be written within a 50 µs timeout period after issuing the Sector Erase command sequence.

When using Data Polling Status, the DQ3 bit shows a one (1) immediately following the erase command. This tells well designed Multi-Sector Erase software that the timeout period has expired and the window for writing additional sector addresses has closed. This allows Multi-Sector Erase software to issue single sector erase commands even if the software is designed to use multi-sector erase.

9 Conclusion

The S29GL-S family offers an easy transition from GL-N and GL-P devices. Some software changes may be needed to store data efficiently. New features give system designers more options and flexibility.

10 References

- S29GL-S MirrorBit Flash Family Data Sheet
- Cypress Application Note, Migration from GL-N and GL-P to GL-S Flash

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