DRIVER AND LIBRARY GUIDE

SPI Flash

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Content

1.1 SPI Flash library structures

1.1.1 SPI_Flash_TypeDef

Data Fields

- **GPIO_Type CS_GPIO_Port**
- **uint32_t CS_GPIO_Pin**
- **uint32_t JedecID**
- **SPI_Flash_IDTypeDef ID**
- **uint8_t *UniqID**
- **uint16_t PageSize**
- **uint32_t NumberOfPage**
- **uint32_t SectorSize**
- **uint32_t NumberOfSector**
- **uint32_t BlockSize**
- **uint32_t NumberOfBlocks**
- **uint32_t Capacity**
- **uint8_t StatusRegister1**
- **uint8_t StatusRegister2**
- **uint8_t StatusRegister3**
- **uint8_t WaitToComplete**

Field Documentation

- ***GPIO_Type SPI_Flash_TypeDef:: CS_GPIO_Port***

  Specifies the GPIO Port of CS pin
- ***uint32_t SPI_Flash_TypeDef:: CS_GPIO_Pin***

  Specifies the GPIO Pin of CS pin
- ***uint32_t SPI_Flash_TypeDef:: JedecID***

  The JedecID of flash memory
- ***SPI_Flash_IDTypeDef SPI_Flash_TypeDef::ID***

  The specific device ID of flash memory
- ***uint8_t SPI_Flash_TypeDef::*UniqID***

  The specific UniqID of flash memory
- ***uint16_t SPI_Flash_TypeDef::PageSize***

  The page size of flash memory (B)
- ***uint32_t SPI_Flash_TypeDef::NumberOfPage***

  The number of flash page
- ***uint32_t SPI_Flash_TypeDef::SectorSize***

  The sector size of Flash

- ***uint32_t SPI_Flash_TypeDef::NumberOfSector***

  The number of flash sector
- ***uint32_t SPI_Flash_TypeDef::BlockSize***

  The block size of Flash
- ***uint32_t SPI_Flash_TypeDef::NumberOfBlocks***

  The number of flash block
- ***uint32_t SPI_Flash_TypeDef::Capacity***

  The capacity of flash (KB)
- ***uint8_t SPI_Flash_TypeDef::StatusRegister1***

  Specifies the register value of flash
- ***uint8_t SPI_Flash_TypeDef::StatusRegister2***

  Specifies the register value of flash
- ***uint8_t SPI_Flash_TypeDef::StatusRegister3***

  Specifies the register value of flash
- ***uint8_t SPI_Flash_TypeDef::WaitToComplete***

  The write status of flash for use in ISR and RTOS

1.2 SPI Flash library API description

1.2.1 How to use this library

This library can be used as follows:

1. Config MCU SPI and initialize it
2. Add library Header and Source file in your project
3. Config the flash memory in ***"spi_flash_conf.h"***
4. Create flash memory object with ***SPI_Flash_TypeDef*** type and set specific GPIO
5. Initialize flash memory with ***SPI_Flash_Init***
6. Use flash memory operation functions

1.2.2 Initialization and de-initialization functions

This section provides functions allowing to:

- Initialize and configure the flash memory

This section contains the following APIs:

- *SPI_Flash_Init()*

1.2.3 Operation functions

This section contains the following APIs:

- *SPI_Flash_GetID()*

- *SPI_Flash_GetUniqID()*
- *SPI_Flash_WriteEnable()*
- *SPI_Flash_WriteDisable()*
- *SPI_Flash_ReadStatusRegister()*
- *SPI_Flash_WriteStatusRegister()*
- *SPI_Flash_WaitForWriteEnd()*
- *SPI_Flash_ChipErase()*
- *SPI_Flash_SectorErase()*
- *SPI_Flash_BlockErase()*
- *SPI_Flash_Write()*
- *SPI_Flash_PageWrite()*
- *SPI_Flash_SectorWrite()*
- *SPI_Flash_BlockWrite()*
- *SPI_Flash_BurstWrite()*
- *SPI_Flash_Read()*
- *SPI_Flash_PageRead()*
- *SPI_Flash_SectorRead()*
- *SPI_Flash_BlockRead()*
- *SPI_Flash_BurstRead()*

1.2.4 Detailed description of functions

SPI_Flash_Init

Function name **uint8_t SPI_Flash_Init (SPI_Flash_TypeDef *_flash)**

Function description This function is used to initialize flash memory

Parameters

- **_flash:** pointer to flash struct

Return values

- **SPI:** status of SPI peripheral

SPI_Flash_GetID

Function name **uint8_t SPI_Flash_GetID (SPI_Flash_TypeDef *_flash)**

Function description This function is used to get flash memory ID

Parameters

- **_flash:** pointer to flash struct

Return values

- **SPI:** status of SPI peripheral

Notes

- The flash ID is stored in the flash struct

SPI_Flash_GetUinqID

Function name **uint8_t SPI_Flash_GetUniqID (SPI_Flash_TypeDef *_flash)**

Function description This function is used to get Unique ID of flash memory

Parameters

- **_flash:** pointer to flash struct

Return values

- **SPI:** status of SPI peripheral

Notes

- The flash Unique ID is stored in the flash struct

SPI_Flash_WriteEnable

Function name **uint8_t SPI_Flash_WriteEnable (SPI_Flash_TypeDef *_flash)**

Function description This function is used to enable write mode of flash memory

Parameters

- **_flash:** pointer to flash struct

Return values

- **SPI:** status of SPI peripheral

SPI_Flash_WriteDisable

Function name **uint8_t SPI_Flash_WriteDisable (SPI_Flash_TypeDef *_flash)**

Function description This function is used to disable write mode of flash memory

Parameters

- **_flash:** pointer to flash struct

Return values

- **SPI:** status of SPI peripheral

SPI_Flash_ReadStatusRegister

Function name **uint8_t SPI_Flash_ReadStatusRegister (SPI_Flash_TypeDef *_flash, SPI_Flash_RegTypeDef _register)**

Function description This function is used to read status registers of flash memory

Parameters

- **_flash:** pointer to flash struct
- **_register:** register number of flash memory

Return values

- **SPI:** status of SPI peripheral

Notes

- The registers value is stored in the flash struct

SPI_Flash_WriteStatusRegister

Function name	**uint8_t SPI_Flash_WriteStatusRegister (SPI_Flash_TypeDef *_flash, SPI_Flash_RegTypeDef _register)**
Function description	This function is used to write status registers of flash memory

Parameters

- **_flash:** pointer to flash struct
- **_register:** register number of flash memory

Return values

- **SPI:** status of SPI peripheral

Notes

- The registers value is stored in the flash struct and flash memory

SPI_Flash_WaitForWriteEnd

Function name	**uint8_t SPI_Flash_WaitForWriteEnd (SPI_Flash_TypeDef *_flash)**
Function description	This function is used to check write status and wait for end of it

Parameters

- **_flash:** pointer to flash struct

Return values

- **SPI:** status of SPI peripheral

SPI_Flash_ChipErase

Function name	**uint8_t SPI_Flash_ChipErase (SPI_Flash_TypeDef *_flash)**
Function description	This function is used to erase flash memory

Parameters

- **_flash:** pointer to flash struct

Return values

- **SPI:** status of SPI peripheral

Notes

- This function clears the memory completely

SPI_Flash_SectorErase

Function name **uint8_t SPI_Flash_SectorErase (SPI_Flash_TypeDef *_flash, uint32_t _sector)**

Function description This function is used to erase special sector of flash memory

Parameters

- **_flash:** pointer to flash struct
- **_sector:** sector number to erase

Return values

- **SPI:** status of SPI peripheral

SPI_Flash_BlockErase

Function name **uint8_t SPI_Flash_BlockErase (SPI_Flash_TypeDef *_flash, uint32_t _block)**

Function description This function is used to erase special block of flash memory

Parameters

- **_flash:** pointer to flash struct
- **_block:** block number to erase

Return values

- **SPI:** status of SPI peripheral

SPI_Flash_Write

Function name **uint8_t SPI_Flash_Write (SPI_Flash_TypeDef *_flash, uint8_t _data, uint32_t _address)**

Function description This function is used to write a byte of data in flash memory

Parameters

- **_flash:** pointer to flash struct
- **_data:** data to write
- **_address:** address to write data

Return values

- **SPI:** status of SPI peripheral

Notes

- This function writes a single byte in memory, you can use other functions to write many bytes in memory

SPI_Flash_PageWrite

Function name **uint8_t SPI_Flash_PageWrite (SPI_Flash_TypeDef *_flash, uint8_t *_pData, uint32_t _page, uint32_t _offset, uint32_t _size)**

Function description This function is used to write many bytes of data in a special page of flash memory

Parameters

- **_flash:** pointer to flash struct
- **_pData:** pointer to data to write
- **_page:** page number to write data
- **_offset:** offset of data in page (Range: 0B ~ 255B)
- **_size:** size of data to write (Range: 1B ~ 256B)

Return values

- **SPI:** status of SPI peripheral

SPI_Flash_SectorWrite

Function name **uint8_t SPI_Flash_SectorWrite (SPI_Flash_TypeDef *_flash, uint8_t *_pData, uint32_t _sector, uint32_t _offset, uint32_t _size)**

Function description This function is used to write many bytes of data in a special sector of flash memory

Parameters

- **_flash:** pointer to flash struct
- **_pData:** pointer to data to write
- **_sector:** sector number to write data
- **_offset:** offset of data in sector (Range: 0B ~ 4095B)
- **_size:** size of data to write (Range: 1B ~ 4096B)

Return values

- **SPI:** status of SPI peripheral

SPI_Flash_BlockWrite

Function name **uint8_t SPI_Flash_BlockWrite (SPI_Flash_TypeDef *_flash, uint8_t *_pData, uint32_t _block, uint32_t _offset, uint32_t _size)**

Function description This function is used to write many bytes of data in a special block of flash memory

Parameters

- **_flash:** pointer to flash struct
- **_pData:** pointer to data to write
- **_block:** block number to write data
- **_offset:** offset of data in block (Range: 0B ~ 65535B)
- **_size:** size of data to write (Range: 1B ~ 65536B)

Return values

- **SPI:** status of SPI peripheral

SPI_Flash_BurstWrite

Function name **uint8_t SPI_Flash_BurstWrite (SPI_Flash_TypeDef *_flash, uint8_t *_pData, uint32_t _address, uint32_t _size)**

Function description This function is used to write many bytes of data in flash memory

Parameters

- **_flash:** pointer to flash struct
- **_pData:** pointer to data to write
- **_address:** start of address to write data
- **_size:** size of data to write (Range: 1B ~ Flash Capacity)

Return values

- **SPI:** status of SPI peripheral

Notes

- This function has don't any limitations for size of data
- Maximum address to write is: Flash Capacity - 1B

SPI_Flash_Read

Function name **uint8_t SPI_Flash_Read (SPI_Flash_TypeDef *_flash, uint8_t *_data, uint32_t _address)**

Function description This function is used to read a byte of data from flash memory

Parameters

- **_flash:** pointer to flash struct
- **_data:** pointer to data to read
- **_address:** address to read data

Return values

- **SPI:** status of SPI peripheral

Notes

- This function read a single byte from memory; you can use other functions to read many bytes from memory

SPI_Flash_PageRead

Function name **uint8_t SPI_Flash_PageRead (SPI_Flash_TypeDef *_flash, uint8_t *_pData, uint32_t _page, uint32_t _offset, uint32_t _size)**

Function description This function is used to read many bytes of data from a special page of flash memory

Parameters

- **_flash:** pointer to flash struct
- **_pData:** pointer to data to read
- **_page:** page number to read data

- **_offset:** offset of data in page (Range: 0B ~ 255B)
- **_size:** size of data to read (Range: 1B ~ 256B)

Return values

- **SPI:** status of SPI peripheral

SPI_Flash_SectorRead

Function name **uint8_t SPI_Flash_SectorRead (SPI_Flash_TypeDef *_flash, uint8_t *_pData, uint32_t _sector, uint32_t _offset, uint32_t _size)**

Function description This function is used to read many bytes of data from a special sector of flash memory

Parameters

- **_flash:** pointer to flash struct
- **_pData:** pointer to data to read
- **_sector:** sector number to read data
- **_offset:** offset of data in sector (Range: 0B ~ 4095B)
- **_size:** size of data to read (Range: 1B ~ 4096B)

Return values

- **SPI:** status of SPI peripheral

SPI_Flash_BlockRead

Function name **uint8_t SPI_Flash_BlockRead (SPI_Flash_TypeDef *_flash, uint8_t *_pData, uint32_t _block, uint32_t _offset, uint32_t _size)**

Function description This function is used to read many bytes of data from a special block of flash memory

Parameters

- **_flash:** pointer to flash struct
- **_pData:** pointer to data to read
- **_block:** block number to read data
- **_offset:** offset of data in block (Range: 0B ~ 65535B)
- **_size:** size of data to read (Range: 1B ~ 65536B)

Return values

- **SPI:** status of SPI peripheral

SPI_Flash_BurstRead

Function name **uint8_t SPI_Flash_BurstRead (SPI_Flash_TypeDef *_flash, uint8_t *_pData, uint32_t _address, uint32_t _size)**

Function description This function is used to read many bytes of data from flash memory

Parameters

- **_flash:** pointer to flash struct

- **_pData:** pointer to data to read
- **_address:** start of address to read data
- **_size:** size of data to read (Range: 1B ~ Flash Capacity)

Return values

- **SPI:** status of SPI peripheral

Notes

- This function has don't any limitations for size of data
- Maximum address to read is: Flash Capacity - 1B

1.3 SPI Flash library defines

1.3.1 SPI Flash

SPI Flash Page Size

_SPI_FLASH_PAGE_SIZE

SPI Flash Sector Size

_SPI_FLASH_SECTOR_SIZE

SPI Flash Sector Per Block

_SPI_FLASH_SECTOR_PER_BLOCK

SPI Flash Status Registers

_SPI_FLASH_STATUS_REGISTER_1

_SPI_FLASH_STATUS_REGISTER_2

_SPI_FLASH_STATUS_REGISTER_3

SPI Flash ID

_SPI_FLASH_25Q10

_SPI_FLASH_25Q20

_SPI_FLASH_25Q40

_SPI_FLASH_25Q80

_SPI_FLASH_25Q16

_SPI_FLASH_25Q32

_SPI_FLASH_25Q64

_SPI_FLASH_25Q128

_SPI_FLASH_25Q256

_SPI_FLASH_25Q512

_SPI_FLASH_25Q01

SPI Flash Exported Macros

__CONVERT_BYTE_TO_KBYTE

__CONVERT_KBYTE_TO_BYTE

__CONVERT_PAGE_TO_SECTOR

__CONVERT_PAGE_TO_BLOCK

__CONVERT_SECTOR_TO_PAGE

__CONVERT_SECTOR_TO_BLOCK

__CONVERT_BLOCK_TO_PAGE

__CONVERT_BLOCK_TO_SECTOR

__CONVERT_ADDRESS_TO_PAGE

1.4 SPI Flash Library Configuration

Open "spi_flash_conf.h" to configure library

- Set MCU in controller series section, for example:

  + in this section, you should define the microcontroller of your project

```
/* ---------- Controller Series --------- */
#define _MCU_SERIES
```

  + _MCU_SERIES: microcontroller series

    • _LPC17XX for LPC17 series

- Add requirement driver / libraries, for example:

  + in this section, you should include the required libraries of the spi_flash library

```
/* ------ Required Driver.Library ------- */
#include "spi_library.h"
#include "gpio_library.h"
```

  + lpc_spi_ex.h and lpc_gpio_ex.h for LPC17 series

- Set MUC SPI in configuration section, for example:

  + in this section, you should set the SPI peripheral and its 'time out'

```
/* ............ SPI ............ */
#define _SPI_FLASH_PERIPHERAL SPIx
#define _SPI_FLASH_TIMEOUT    Time
```

  + SPIx: the SPI struct or its identifier

    - LPC_SPI for LPC17 series

  + Time: the SPI time out (Range: 1 ~ x)

- Set RTOS mode in configuration section, for example:

  + in this section, you should set the ROTS mode

```
/* ............ RTOS ........... */
#define _SPI_FLASH_USE_RTOS    Mode
```

  + Mode: RTOS mode

    - 0: Disabled

    - 1: Enabled

- Set flash manufacturer, for example:

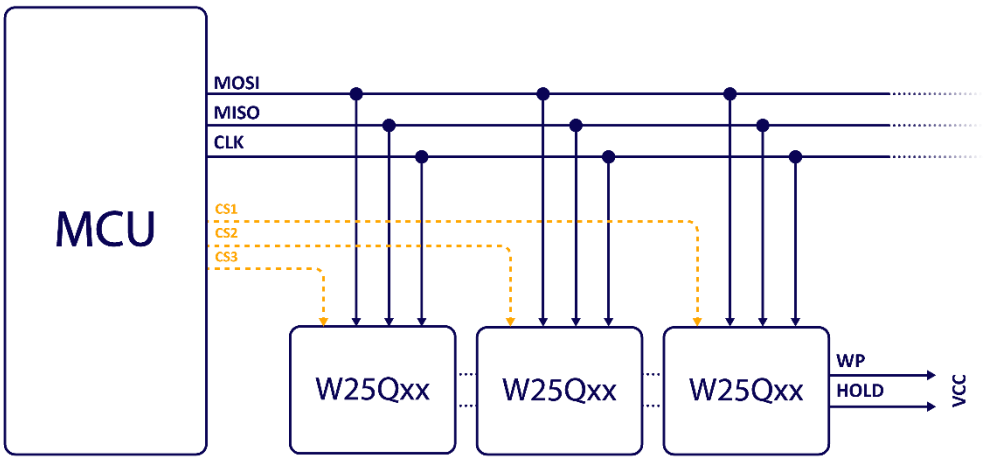
  + in this section, you should define the microcontroller of your project

```
/* ..... Flash manufacturer .... */
#define _SPI_FLASH_x
```

  + _SPI_FLASH_x: flash manufacturer

    - _SPI_FLASH_WINBOND for Winbond company

2. Circuit Design



3. Examples

- Example 1: Initialize and use external flash memory with LPC1768

```
#include "lpc17xx.h"
#include "lpc17xx_gpio.h"
#include "lpc17xx_spi.h"
#include "lpc17xx_libcfg.h"
#include "lpc17xx_pinsel.h"

#include "lpc_spi_ex.h"
#include "spi_flash.h"

SPI_CFG_Type SPI_ConfigStruct;

uint8_t textData[44] = "Hello from master!, this is a test program!\n";
uint8_t Rx_Buf[50];

int main()
{

	/* ---------- Setup GPIO --------- */
	PINSEL_CFG_Type PinCfg;

	/*
	* Initialize SPI pin connect
	* P0.15 - SCK;
	* P0.0 / P0.1 - SSEL - used as GPIO
	* P0.17 - MISO
	* P0.18 - MOSI
	*/

	PinCfg.Funcnum   = 3;
	PinCfg.OpenDrain = 0;
	PinCfg.Pinmode   = 0;
	PinCfg.Portnum   = 0;
	PinCfg.Pinnum    = 15;
	PINSEL_ConfigPin(&PinCfg);

	PinCfg.Pinnum    = 17;
	PINSEL_ConfigPin(&PinCfg);

	PinCfg.Pinnum    = 18;
	PINSEL_ConfigPin(&PinCfg);

	PinCfg.Funcnum   = 3;
	PinCfg.OpenDrain = 0;
	PinCfg.Pinmode   = 0;
	PinCfg.Portnum   = 0;
	PinCfg.Pinnum    = 15;
	PINSEL_ConfigPin(&PinCfg);

	PinCfg.Pinnum    = 17;
	PINSEL_ConfigPin(&PinCfg);

	PinCfg.Pinnum    = 18;
	PINSEL_ConfigPin(&PinCfg);

	/* Set GPIO Direction */
	GPIO_SetDir(0, (1 << 16), 1);
	GPIO_SetDir(0, (1 << 19), 1);
	GPIO_SetDir(0, (1 << 7), 1);

	GPIO_SetValue(0, (1 << 16));
	GPIO_SetValue(0, (1 << 19));
	GPIO_SetValue(0, (1 << 7));
```

```
    /* ---------- Setup SPI ---------- */
    SPI_ConfigStruct.CPHA      = SPI_CPHA_FIRST;
    SPI_ConfigStruct.CPOL      = SPI_CPOL_HI;
    SPI_ConfigStruct.ClockRate = 300000;
    SPI_ConfigStruct.DataOrder = SPI_DATA_MSB_FIRST;
    SPI_ConfigStruct.Databit   = SPI_DATABIT_8;
    SPI_ConfigStruct.Mode      = SPI_MASTER_MODE;

    SPI_Init(LPC_SPI, &SPI_ConfigStruct);

    /* --------- Wait to init --------- */
    SPI_Delay(1);

    /* ~~~~~~~~~~~~~~~~~~ Flash Example ~~~~~~~~~~~~~~~~~~ */
    /* --------- Setup Flash ---------- */
    SPI_Flash_TypeDef     Flash1;
    SPI_Flash_TypeDef     Flash2;
    SPI_Flash_TypeDef     Flash3;

    Flash1.CS_GPIO_Port = 0;
    Flash1.CS_GPIO_Pin  = (1 << 16);

    Flash2.CS_GPIO_Port = 0;
    Flash2.CS_GPIO_Pin  = (1 << 19);

    Flash3.CS_GPIO_Port = 0;
    Flash3.CS_GPIO_Pin  = (1 << 7);

    /* ----------- Commands ----------- */
    SPI_Flash_Init(&Flash1);
    SPI_Flash_Init(&Flash2);
    SPI_Flash_Init(&Flash3);

    SPI_Flash_ChipErase(&Flash1);
    SPI_Flash_ChipErase(&Flash2);
    SPI_Flash_ChipErase(&Flash3);

    SPI_Flash_SectorWrite(&Flash2, textData, 0, 10, 44);
    SPI_Flash_SectorRead(&Flash2, Rx_Buf, 0, 10, 44);

    while(1)
    {

    }
    /* Loop forever */

}
```

4. Requirements

1. CMSIS driver in LPCxx series
2. lpc_gpio_ex driver in LPCxx series
3. lpc_spi_ex driver in LPCxx series

5. Important tips

1. All defines beginning with _ (underline)
2. All functions are written as CamelCase

6. Error and Warning's

- **Error's**
  - [FLASH ERROR01]Controller is not selected Or not supported: This error occurs when the MCU or its library not supported.

- **Warning's**
  - None

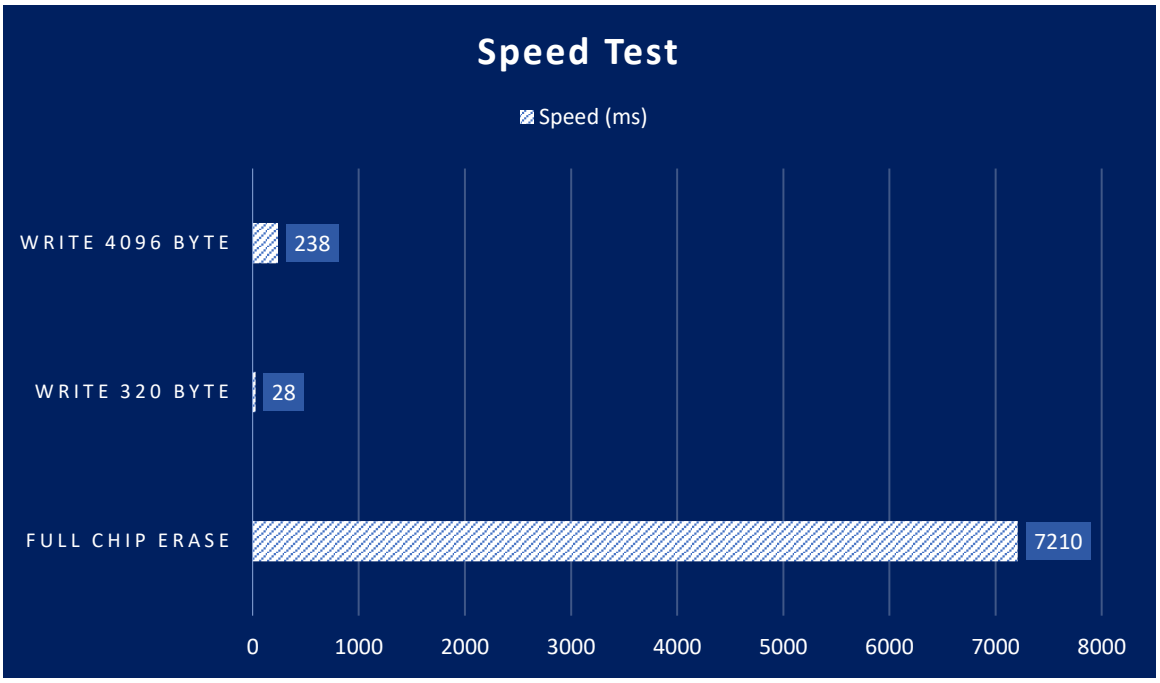
7. Supported memories

- **Winbond**

W25Q10	W25Q20	W25Q40	W25Q80	W25Q16	W25Q32	W25Q64	W25Q128	W25Q256	W25Q512
W25Q01									

8. Tests performed

- **Speed test in W25Q32**



Test Parameter :

- **Core:** STM32F469NI
- **Core Speed:** 180MHz
- **SPI Speed:** 45MBits

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