DRIVER AND LIBRARY GUIDE

SPI Flash Extension

Prepared for:

Sharif University of Technology Branch – Optic Center

Prepared by:

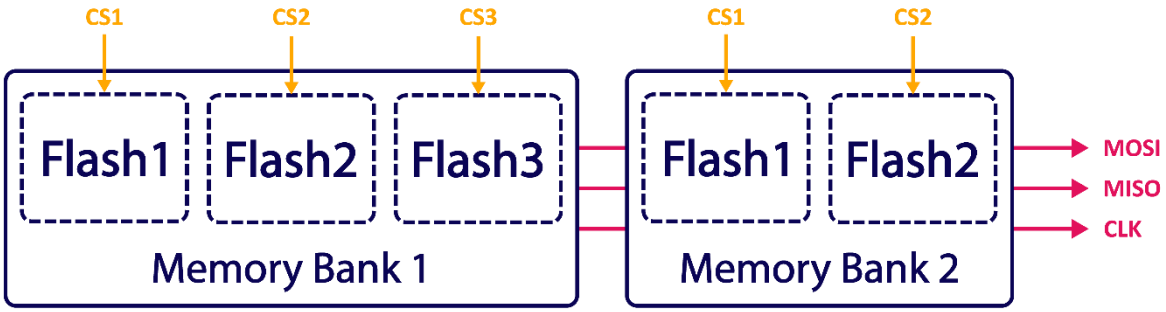
Majid Derhambakhsh

September 23, 2021

Content

1 What does this library do?

This library merges a collection of flash memories as a memory bank:



Notes

- All the flash memories use the common MOSI, MISO, and CLK pin.
- Each flash memory uses a separately cs pin.
- The control of each collection is managed by the library.
- Each memory bank capacity consists of the sum of the flash memory capacity of that set

2.1 SPI Flash Extension library structures

2.1.1 SPI_Flash_BankTypeDef

Data Fields

- **SPI_Flash_TypeDef *FlashList**
- **uint32_t TotalNumberOfPages**
- **uint32_t TotalNumberOfSectors**
- **uint32_t TotalNumberOfBlocks**
- **uint32_t TotalCapacity**
- **uint8_t NumberOfChip**
- **uint32_t LastWriteAddress**

Field Documentation

- ***SPI_Flash_TypeDef SPI_Flash_BankTypeDef::*FlashList***

  The list of flash for merge
- ***uint32_t SPI_Flash_BankTypeDef::TotalNumberOfPages***

  The sum of merged flash pages
- ***uint32_t SPI_Flash_BankTypeDef::TotalNumberOfSectors***

  The sum of merged flash sectors
- ***uint32_t SPI_Flash_BankTypeDef::TotalNumberOfBlocks***

  The sum of merged flash blocks
- ***uint32_t SPI_Flash_BankTypeDef::TotalCapacity***

  The total capacity of merged flash's (KB)
- ***uint8_t SPI_Flash_BankTypeDef::NumberOfChip***

  The number of merged flash chips
- ***uint32_t SPI_Flash_BankTypeDef::LastWriteAddress***

  The Last address written (B)

  This value is equal to: last address + 1

2.2 SPI Flash Extension library API description

2.2.1 How to use this library

This library can be used as follows:

1. Add SPI Flash library as a base library and config it
2. Add SPI Flash Extension library Header and Source file in your project
3. Config the library in ***"spi_flash_ex_conf.h"***
4. Create array of flash memory object with ***SPI_Flash_TypeDef*** type and set specific GPIO
5. Create flash memory bank object with ***SPI_Flash_BankTypeDef*** type and set FlashList, NumberOfChip

6. Initialize memory bank with ***SPI_FlashEx_Init***
7. Use flash memory operation functions

2.2.2 Initialization and de-initialization functions

This section provides functions allowing to:

- Initialize and configure the flash memory

This section contains the following APIs:

- *SPI_FlashEx_Init()*

2.2.3 Operation functions

This section contains the following APIs:

- *SPI_FlashEx_ChipErase()*
- *SPI_FlashEx_SectorErase()*
- *SPI_FlashEx_BlockErase()*
- *SPI_FlashEx_Write()*
- *SPI_FlashEx_PageWrite()*
- *SPI_FlashEx_SectorWrite()*
- *SPI_FlashEx_BlockWrite()*
- *SPI_FlashEx_BurstWrite()*
- *SPI_FlashEx_Read()*
- *SPI_FlashEx_PageRead()*
- *SPI_FlashEx_SectorRead()*
- *SPI_FlashEx_BlockRead()*
- *SPI_FlashEx_BurstRead()*

2.2.4 Detailed description of functions

SPI_FlashEx_Init

Function name	**uint8_t SPI_FlashEx_Init (SPI_Flash_BankTypeDef *_flashBank)**
Function description	This function is used to initialize memory bank
Parameters	• **_flashBank:** pointer to flash bank struct
Return values	• **SPI:** status of SPI peripheral

SPI_FlashEx_ChipErase

Function name **uint8_t SPI_FlashEx_ChipErase (SPI_Flash_BankTypeDef *_flashBank)**

Function description This function is used to erase memory bank

Parameters

- **_flashBank:** pointer to flash bank struct

Return values

- **SPI:** status of SPI peripheral

Notes

- This function clears the memory bank completely

SPI_FlashEx_SectorErase

Function name **uint8_t SPI_FlashEx_SectorErase (SPI_Flash_BankTypeDef *_flashBank, uint32_t _sector)**

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

Parameters

- **_flashBank:** pointer to flash bank struct
- **_sector:** sector number to erase

Return values

- **SPI:** status of SPI peripheral

SPI_FlashEx_BlockErase

Function name **uint8_t SPI_FlashEx_BlockErase (SPI_Flash_BankTypeDef *_flashBank, uint32_t _block)**

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

Parameters

- **_flashBank:** pointer to flash bank struct
- **_block:** block number to erase

Return values

- **SPI:** status of SPI peripheral

SPI_FlashEx_Write

Function name **uint8_t SPI_FlashEx_Write (SPI_Flash_BankTypeDef *_flashBank, uint8_t _data, uint32_t _address)**

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

Parameters

- **_flashBank:** pointer to flash bank 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 memories, you can use other functions to write many bytes in memories

SPI_FlashEx_PageWrite

Function name **uint8_t SPI_FlashEx_PageWrite (SPI_Flash_BankTypeDef *_flashBank, 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 memory bank

Parameters

- **_flashBank:** pointer to flash bank 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_FlashEx_SectorWrite

Function name **uint8_t SPI_FlashEx_SectorWrite (SPI_Flash_BankTypeDef *_flashBank, 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 memory bank

Parameters

- **_flashBank:** pointer to flash bank 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_FlashEx_BlockWrite

Function name **uint8_t SPI_FlashEx_BlockWrite (SPI_Flash_BankTypeDef *_flashBank, 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 memory bank

Parameters

- **_flashBank:** pointer to flash bank 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_FlashEx_BurstWrite

Function name	**uint8_t SPI_FlashEx_BurstWrite (SPI_Flash_BankTypeDef *_flashBank, uint8_t *_pData, uint32_t _address, uint32_t _size)**
Function description	This function is used to write many bytes of data in memory bank

Parameters

- **_flashBank:** pointer to flash bank struct
- **_pData:** pointer to data to write
- **_address:** start of address to write data
- **_size:** size of data to write (Range: 1B ~ Memory Bank 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: Memory Bank Capacity - 1B

SPI_FlashEx_Read

Function name	**uint8_t SPI_FlashEx_Read (SPI_Flash_BankTypeDef *_flashBank, uint8_t *_data, uint32_t _address)**
Function description	This function is used to read a byte of data from memory bank

Parameters

- **_flashBank:** pointer to flash bank 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 memories; you can use other functions to read many bytes from memories

SPI_FlashEx_PageRead

Function name **uint8_t SPI_FlashEx_PageRead (SPI_Flash_BankTypeDef *_flashBank, 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 memory bank

Parameters

- **_flashBank:** pointer to flash bank 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_FlashEx_SectorRead

Function name **uint8_t SPI_FlashEx_SectorRead (SPI_Flash_BankTypeDef *_flashBank, 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 memory bank

Parameters

- **_flashBank:** pointer to flash bank 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_FlashEx_BlockRead

Function name **uint8_t SPI_FlashEx_BlockRead (SPI_Flash_BankTypeDef *_flashBank, 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 memory bank

Parameters

- **_flashBank:** pointer to flash bank 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_FlashEx_BurstRead

Function name	**uint8_t SPI_FlashEx_BurstRead (SPI_Flash_BankTypeDef *_flashBank, uint8_t *_pData, uint32_t _address, uint32_t _size)**
Function description	This function is used to read many bytes of data from memory bank
Parameters	• **_flashBank:** pointer to flash bank struct • **_pData:** pointer to data to read • **_address:** start of address to read data • **_size:** size of data to read (Range: 1B ~ Memory Bank 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: Memory Bank Capacity - 1B

2.3 SPI Flash Extension Library Configuration

Open "spi_flash_ex_conf.h" to configure library

- Set the 'last write address' ability in the configuration section, for example:

  + in this section, you can define the "_SPI_FLASH_EX_USE_LAST_WRITE_ADD" to use this ability

```
/* ----------- Configuration ------------ */
#define _SPI_FLASH_EX_USE_LAST_WRITE_ADD
```

  + Comment this define to disable the ability

3. Examples

- Example 1: Initialize and use external flash memories as a memory bank 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_ex.h"

SPI_CFG_Type SPI_ConfigStruct;

uint8_t flashData[4096];
uint8_t sampleData[320];
uint8_t textData[44] = "Hello from master!, this is a test program!\n";
uint8_t Rx_Buf[50];
```

```c
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);

	/* 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 Bank Example ~~~~~~~~~~~~~~~~ */
	SPI_Flash_TypeDef     MainFlashList[3];
	SPI_Flash_BankTypeDef FlashBank;

	MainFlashList[0].CS_GPIO_Port = 0;
	MainFlashList[0].CS_GPIO_Pin  = (1 << 16);

	MainFlashList[1].CS_GPIO_Port = 0;
	MainFlashList[1].CS_GPIO_Pin  = (1 << 19);

	MainFlashList[2].CS_GPIO_Port = 0;
	MainFlashList[2].CS_GPIO_Pin  = (1 << 7);

	FlashBank.FlashList    = MainFlashList;
	FlashBank.NumberOfChip = 3;

	/* ----------- Commands ----------- */
	SPI_FlashEx_Init(&FlashBank);
	SPI_FlashEx_ChipErase(&FlashBank);
```

```
        SPI_FlashEx_BurstWrite(&FlashBank, flashData, FlashBank.LastWriteAddress, 10);
        SPI_FlashEx_BurstWrite(&FlashBank, sampleData, 50000, 320);
        SPI_FlashEx_BurstWrite(&FlashBank, textData, 8388586, 44);
        SPI_FlashEx_BurstWrite(&FlashBank, flashData, 12580864, 4096);

        SPI_FlashEx_PageWrite(&FlashBank, textData, 150, 0, 44);

        SPI_FlashEx_BurstRead(&FlashBank, Rx_Buf, 8388586, 44);

        while(1)
        {

        }
        /* Loop forever */

}
```

4. Requirements

1. CMSIS and SPL driver in LPCxx series
2. lpc_gpio_ex driver in LPCxx series
3. lpc_spi_ex driver in LPCxx series
4. SPI Flash library as a base library

5. Important tips

1. This library use the SPI Flash library as a base library
2. All defines beginning with _ (underline)
3. 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.

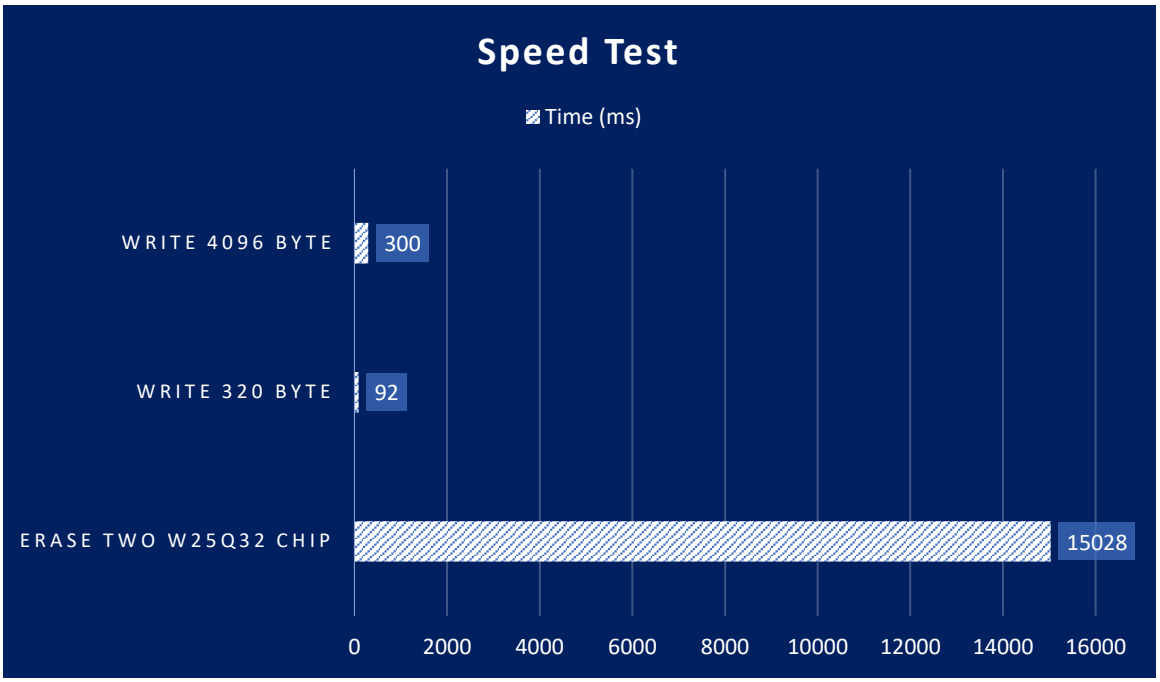
- **Warning's**
  - None

7. Supported memories

- **All supported memories by SPI Flash library**

8. Tests performed

- **Speed test in two W25Q32**



Test Parameter :

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

9. License