UM0701
User manual

Getting started with the STEVAL-MKI032V1, STM32-MEMS demonstration board

1 Introduction

This user manual describes the STEVAL-MKI032V1, STM32-MEMS demonstration board which serves as interface between the STM32™ demonstration board (STMicroelectronics™ STM3210B-EVAL, STM3210E-EVAL, IAR KickStart Kit™ for STM32) and the MEMS demonstration board (any STEVAL-MKI0xxVx compatible with DIL24 socket).

The STM32-MEMS demonstration board comes with a development kit: a firmware package for the STM32 microcontroller family, which includes a library, examples, demonstration applications and application hints. The aim of this development kit is to provide a simple interface to analog and digital MEMS accelerometers together with demonstration applications that utilize this interface.

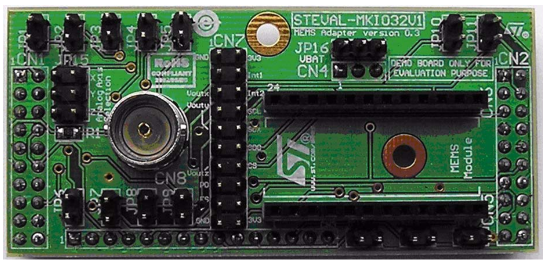
The STM32 family of 32-bit Flash microcontrollers is based on the breakthrough ARM® Cortex™-M3, a core specifically developed for embedded applications. The STM32 family benefits from the Cortex-M3 architectural enhancements including the Thumb-2® instruction set to deliver improved performance with better code density, significantly faster response to interrupts, all combined with industry-leading power consumption.

The STM32 family is built to offer new degrees of freedom to MCU users. It offers a complete 32-bit product range that combines high-performance, real-time, low-power and low-voltage operation, while maintaining full integration and ease of development. Compatibility of pin-assignments, peripherals and software across all STM32 devices is a core technical feature throughout this family of microcontrollers.

The STM32 family of microcontrollers is supported by a complete range of high-end and low-cost demonstration, software, debugging and programming tools. This complete line includes third-party solutions that come complete with an integrated development environment and in-circuit debugger/programmer featuring a JTAG application interface. Developers who are new to this family and the Cortex core can also benefit from the range of starter kits that are specially designed to help developers evaluate device features and start their own applications.

Sensors based on MEMS (micro electro-mechanical systems) technology are conquering many market segments, ranging from mobile communication and computing to consumer electronics, healthcare and industrial. ST offers a portfolio of MEMS-based linear accelerometers able to sense acceleration or vibration in one, two and even three axes. Leveraging on proprietary MEMS technology and worldwide recognized success on acceleration sensors, ST introduces new high-performance MEMS gyroscope sensors.

Figure 1. STEVAL-MKI032V1, STM32-MEMS demonstration board, top view



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2 Key features of the board

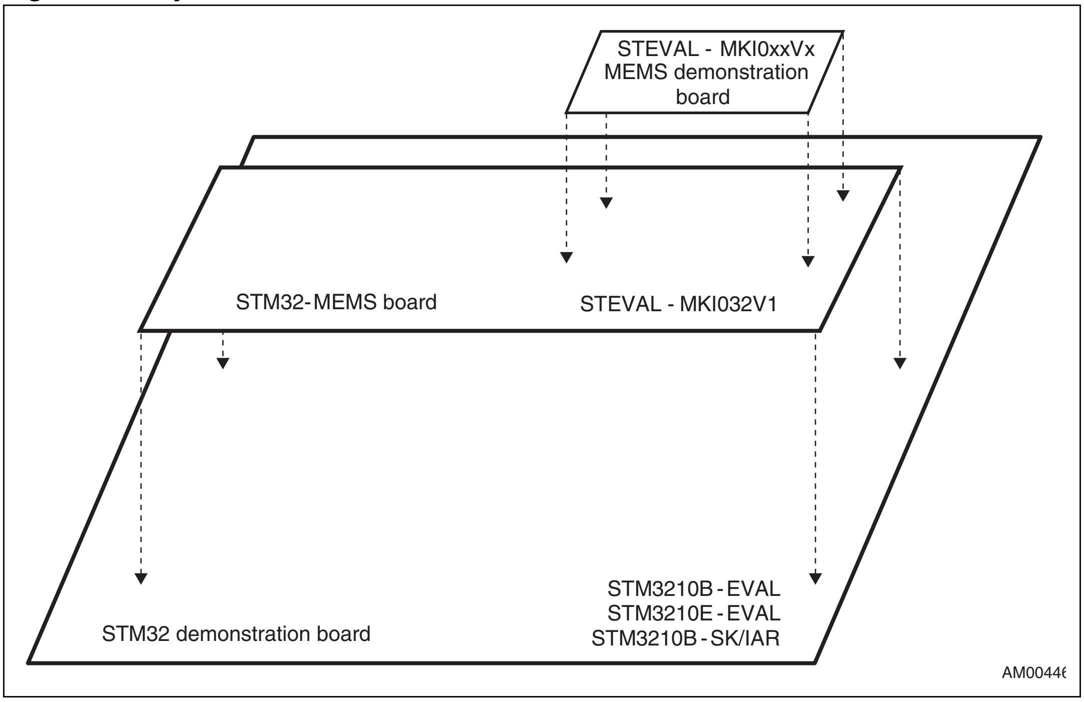
- Compatible with the following demonstration boards.
  - ST STM3210B-EVAL - ST demonstration board implementing the complete range of peripherals and features for the STM32F10xxB (128 KB) medium-density devices.
  - ST STM3210E-EVAL - ST demonstration board implementing the complete range of peripherals and features for the STM32F10xxE (512 KB) high-density devices.
  - IAR KickStart Kit™ for STM32 (STM3210B-SK/IAR) - full-featured demonstration board with STM32F103B microcontroller, standalone J-Link debugger/programmer, IAR Embedded Workbench® for ARM (EWARM) development environment, IAR C/C++ compiler.
- Compatible with all STEVAL-MKI0xxVx MEMS accelerometer demonstration boards suitable for DIL24 sockets. Recommended boards are:
  - digital MEMS accelerometers: STEVAL-MKI013V1 (LIS302DL), STEVAL-MKI009V1 (LIS3LV02DL),
  - analog MEMS accelerometers: STEVAL-MKI015V1 (LIS344ALH), STEVAL-MKI018V1 (LIS244AL), STEVAL-MKI020V1 (LIS302SG),
- Options for remote connection using two STM32-MEMS demonstration boards.
  - Standard 20-pin ribbon cable with 2.54 mm pitch connectors with all signals
  - Coax cable with standard BNC connector for connection of one analog signal - MEMS axis selectable by jumper
- STM32-MEMS development kit firmware package for STM32 included.
  - MEMS Library: set of functions, data structures and constants used to manage a MEMS sensor. Examples of usage of the MEMS Library.
  - Demonstration applications that utilize the MEMS Library showing how to acquire data from a sensor and send them to a PC over USB or how to display the data using an LCD. Several demonstration applications show utilization of interrupts generated by digital MEMS.
  - Application hints on inclination measurements.

3 General system description

The STM32-MEMS demonstration board serves to connect data and control signals of a MEMS sensor to pins of the STM32 microcontroller.
The STM32-MEMS board is designed to fit on particular connectors of compatible STM32 demonstration boards. The compatible boards are: STM3210B-EVAL board (with medium-density STM32 MCU), STM3210E-EVAL board (with high-density STM32 MCU) and STM3210B-SK/IAR (for medium-density STM32 MCU).
The STM32-MEMS board has a DIL24 socket to connect any STEVAL-MKI0xxVx MEMS demonstration board compatible with the socket. The recommended boards are: digital MEMS accelerometers STEVAL-MKI013V1 (LIS302DL) and STEVAL-MKI009V1 (LIS3LV02DL), and analog MEMS accelerometers STEVAL-MKI015V1 (LIS344ALH), STEVAL-MKI018V1 (LIS244AL) and STEVAL-MKI020V1 (LIS302SG).

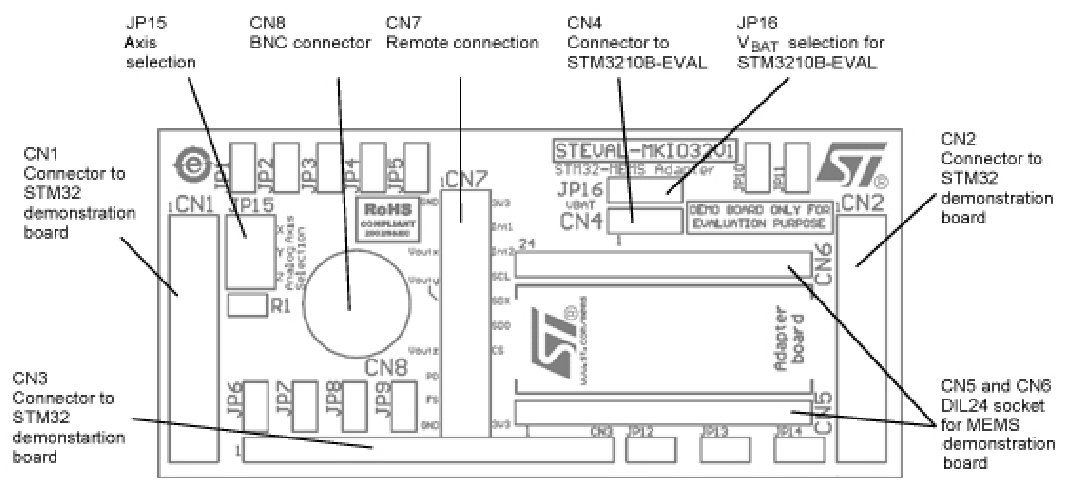
The system with STM32-MEMS board offers full control over the MEMS sensor. For analog sensors all axes, power-down and full-scale signals are available. For digital sensors both SPI and I^2C interfaces are usable as well as interrupt lines.
To run the system, the STM32-MEMS board must be connected on one side to an STM32 demonstration board, and on the other side to a MEMS demonstration board. The jumpers on the STM32-MEMS demonstration board have to be fitted properly. In some cases, minor changes may have to be made to the STM32 demonstration board. All system settings are described in detail in the following chapters.

Figure 2. System with STM32-MEMS demonstration board



4 Board layout

Figure 3. STM32-MEMS demonstration board layout



5 System setup

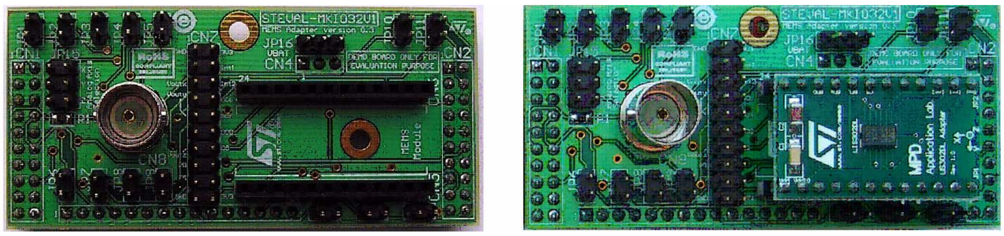
The system consists of three boards: the STM32 demonstration board, the STM32-MEMS demonstration board and the MEMS demonstration board. The set-up of the system can be split into three main steps.

1. Set-up of the STM32 demonstration board. In some cases, minor changes may have to be made to the board.
2. Set-up of the jumpers on the STM32-MEMS board.
3. Connection of the STM32-MEMS board to the STM32 demonstration board.
4. Connection of the MEMS demonstration board to the STM32-MEMS board.

Steps 1 to 3 vary according to the type of STM32 demonstration board and MEMS demonstration board used. They are described in the following chapters.

Regarding step 4: all MEMS demonstration boards compatible with the DIL24 socket can be connected to the STM32-MEMS board. The correct orientation of the board is depicted in *Figure 4* by the ST logo printed on the top side of the STM32-MEMS board.

Figure 4. Connecting MEMS demonstration board to STM32-MEMS board



5.1 System setup with STM3210B-EVAL board

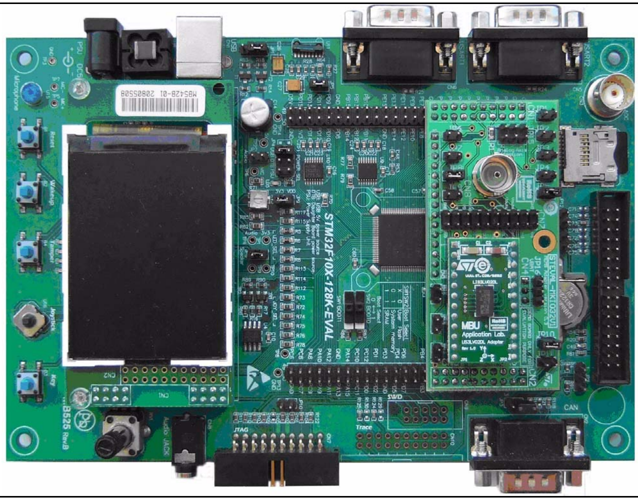
5.1.1 Connecting the STM32-MEMS board

Table 1. Connecting the STM32-MEMS board to the STM3210B-EVAL board

Pin of STM32-MEMS board	Connected to pin of STM3210B-EVAL
CN1-1	CN12-1
CN2-1	CN13-1
CN4-1	JP11-1

Note: The CN4 connector of the STM32-MEMS board is connected to the JP11 jumper of the STM3210B-EVAL board in order to distribute V_{CC} to the MEMS sensor. In this setup, the JP16 jumper of the STM32-MEMS board takes over the V_{BAT} selection functionality of the JP11 jumper of the STM3210B-EVAL board.

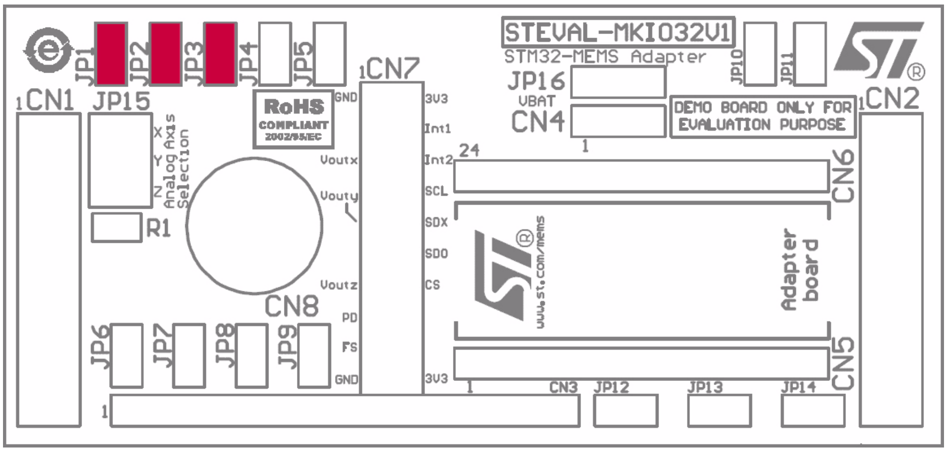
Figure 5. STM3210B-EVAL board with STM32-MEMS board connected



5.1.2 Setup for analog MEMS

Position the JP1, JP2 and JP3 jumpers on the STM32-MEMS board. No modification is needed on the STM3210B-EVAL board.

Figure 6. Setup for analog MEMS



5.1.3 Setup for digital MEMS - SPI interface

Position the JP7 jumper on the STM32-MEMS board.

If Int1 signal is used

Position the JP10 jumper on the STM32-MEMS board.

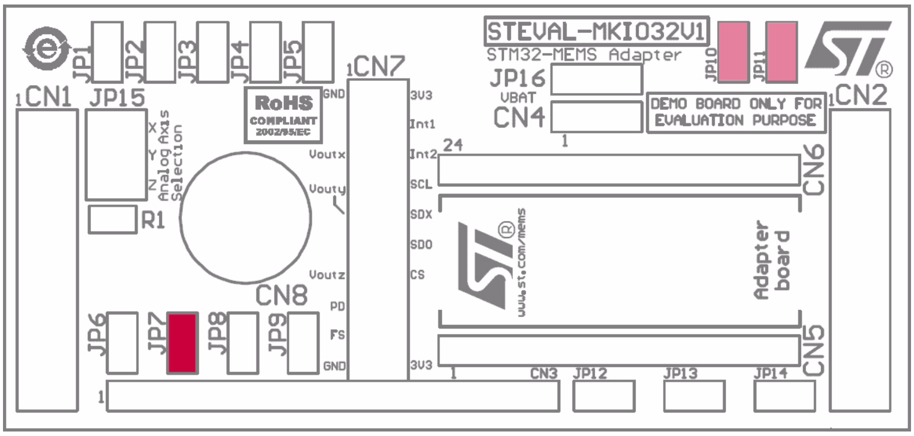
The CN13-14 pin of the STM3210B-EVAL is also used by the right joystick. If the joystick is required, remove R75 from the STM3210B-EVAL board.

If Int2 signal is used

Position the JP11 jumper on the STM32-MEMS board.

The CN13-4-pin of the STM3210B-EVAL is also used by the Tamper button. The Tamper button cannot be used when using the Int2 signal.

Figure 7. Setup for digital MEMS - SPI interface



5.1.4 Setup for digital MEMS - I²C interface

Position the JP7 and JP12 jumpers on the STM32-MEMS board.

If Int1 signal is used

Position the JP10 jumper on the STM32-MEMS board.

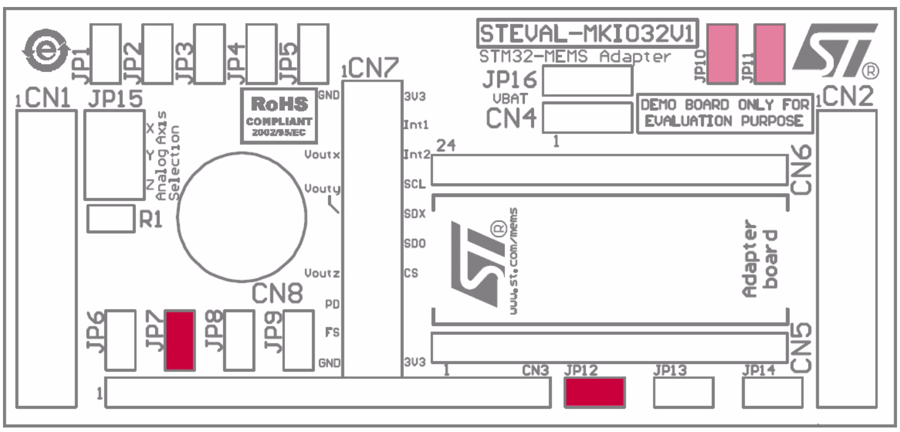
The CN13-14-pin of the STM3210B-EVAL is also used by the right joystick. If the joystick is required, remove R75 from the STM3210B-EVAL board.

If Int2 signal is used

Position the JP11 jumper on the STM32-MEMS board.

The CN13-4-pin of the STM3210B-EVAL is also used by the Tamper button. The Tamper button cannot be used when using the Int2 signal.

Figure 8. Setup for digital MEMS - I²C interface



5.1.5 Analog MEMS signals connected to STM32 pins

Table 2. Analog MEMS signals connected to STM32 pins

Analog MEMS signal	STM32 pin
FS	PE3
PD	PE2
V_{OUTX}	PC0
V_{OUTY}	PC1
V_{OUTZ}	PC3

5.1.6 Digital MEMS signals connected to STM32 pins

Table 3. System setup with STM3210E-EVAL board

	Digital MEMS signal	STM32 pin
Common signals	CS	PE6
	Int1	PE0
	Int2	PC13
SPI signals	SCK	PA5
	SDI	PA7
	SDO	PA6
I^2C signals	SCL	PB6
	SDA	PB7

Note: Some digital MEMS use SDO as the LSB of their I^2C address.

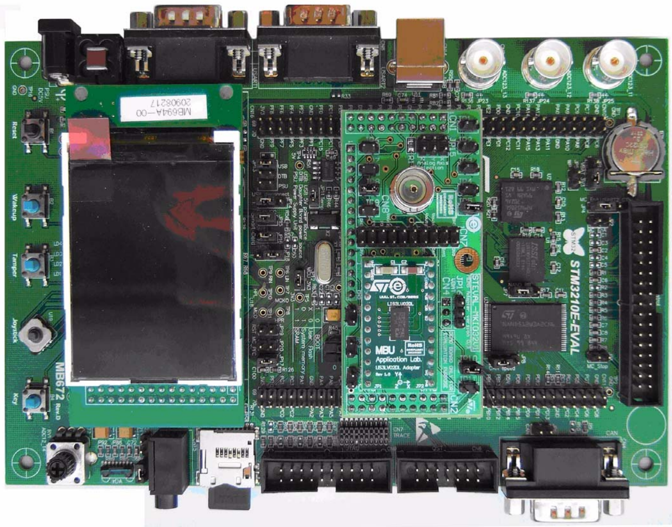
5.2 System setup with STM3210E-EVAL board

5.2.1 Connecting the STM32-MEMS board

Table 4. Connecting STM32-MEMS board to STM3210E-EVAL board

Pin of STM32-MEMS board	Connected to pin of STM3210E-EVAL
CN1-1	CN10-33
CN2-1	CN11-33

Figure 9. STM3210E-EVAL board with STM32-MEMS board connected

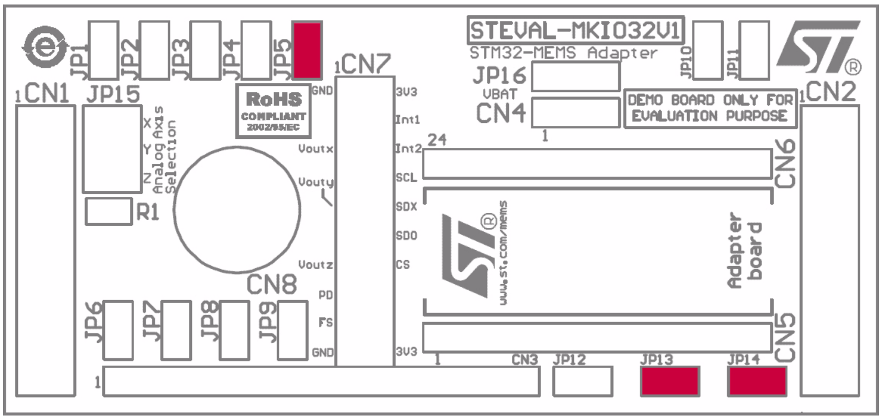


5.2.2 Setup for analog MEMS

Position the JP5, JP13 and JP14 jumpers on the STM32-MEMS board.

No modification is needed on the STM3210E-EVAL board.

Figure 10. Setup for analog MEMS



5.2.3 Setup for digital MEMS - SPI interface

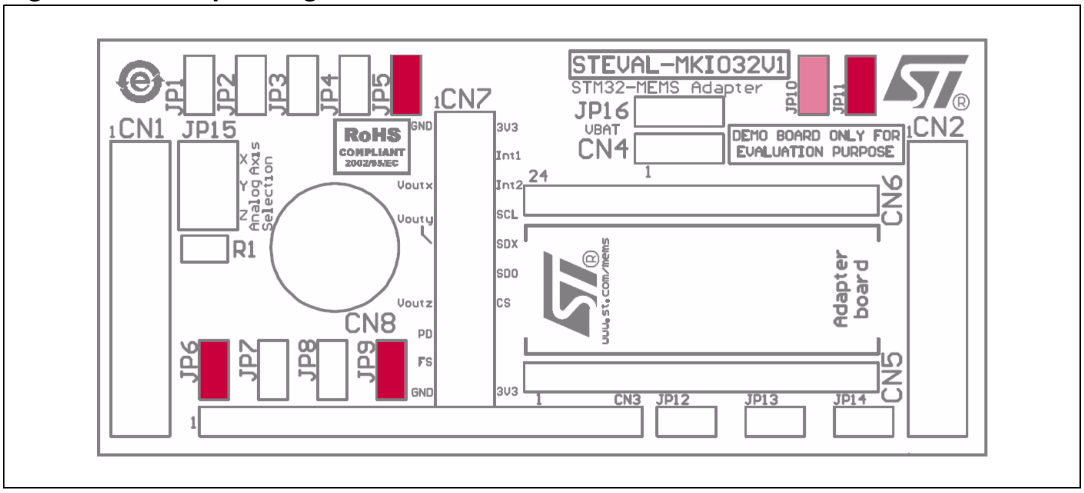
Position the JP5, JP6, JP9 and JP11 jumpers on the STM32-MEMS board.

If Int1 signal is used

Position the JP10 jumper on the STM32-MEMS board.

Remove the SD card from the CN13 card socket on the STM3210E-EVAL board.

Figure 11. Setup for digital MEMS - SPI interface



5.2.4 Setup for digital MEMS - I^{2}C interface

Position the JP5, JP8, JP9 and JP11 jumpers on the STM32-MEMS board.

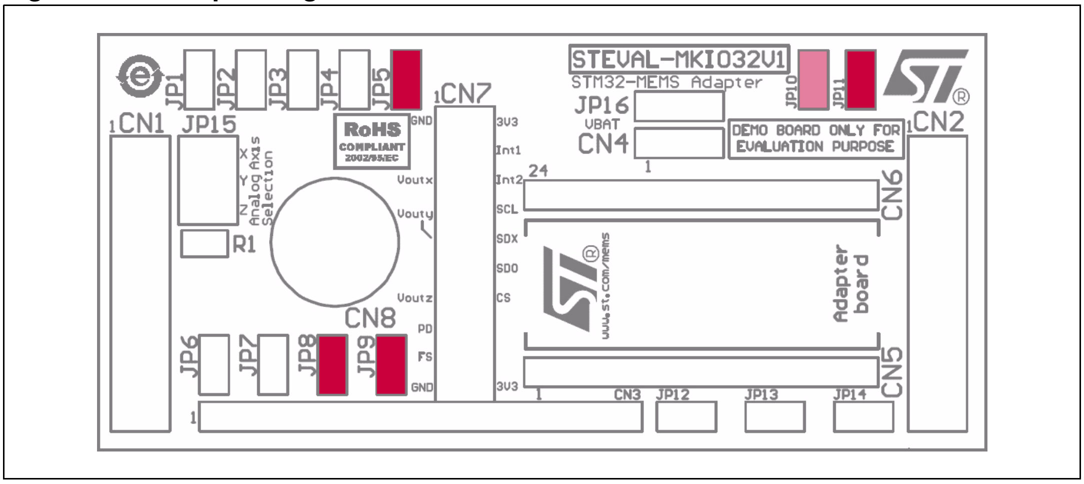
Remove R32 from the STM3210E-EVAL board.

If Int1 signal is used

Position the JP10 jumper on the STM32-MEMS board.

Remove the SD card from the CN13 card socket on the STM3210E-EVAL board.

Figure 12. Setup for digital MEMS - I^{2}C interface



5.2.5 Analog MEMS signals connected to STM32 pins

Table 5. Analog MEMS signals connected to STM32 pins

Analog MEMS signal	STM32 pin
FS	PG0
PD	PF13
V_{OUTX}	PB0
V_{OUTY}	PC5
V_{OUTZ}	PB1

5.2.6 Digital MEMS signals connected to STM32 pins

Table 6. Digital MEMS signals connected to STM32 pins

Digital MEMS signal	STM32 pin	
Common signals	CS	PG1
	Int1	PF11
	Int2	PE8
SPI signals	SCK	PB3
	SDI	PB5
	SDO	PB4
I^2C signals	SCL	PB8
	SDA	PB9

Note: Some digital MEMS use the SDO as the LSB of their I^2C address.

5.3 System setup with STM3210B-SK/IAR board

5.3.1 Connecting the STM32-MEMS board

Figure 13. Connecting the STM32-MEMS board to the STM3210B-SK/IAR board

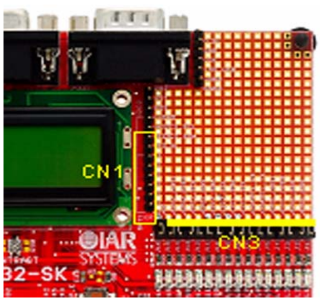
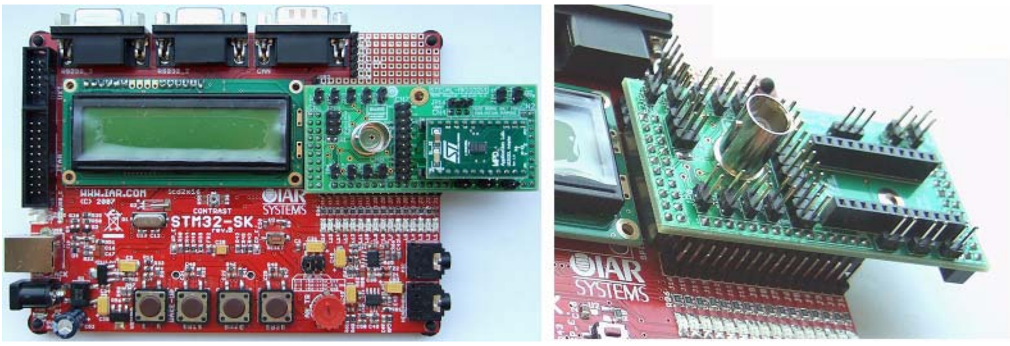


Table 7. Connecting the STM32-MEMS board to the STM3210B-SK/IAR board

Pin of STM32-MEMS board	Connected to pin of STM3210B-SK/IAR
CN1-2	I^2C2_SDA pin on 13-pin single row header next to LCD display
CN3-1	WP pin on 32-pin dual row header next to LEDs

Figure 14. STM3210B-SK/IAR board with STM32-MEMS board connected

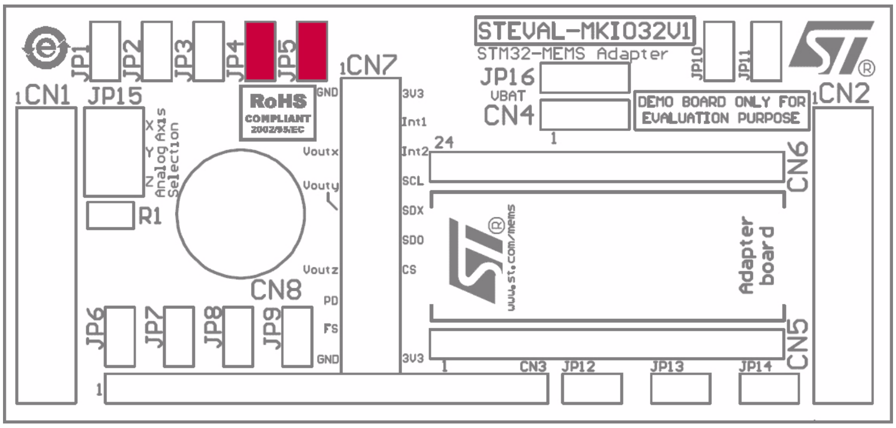


5.3.2 Setup for all MEMS

Position the JP4 and JP5 jumpers on the STM32-MEMS board.

To use the analog MEMS, remove R36, R37 and R59 from the STM3210B-SK/IAR board.

Figure 15. Setup for all MEMS



5.3.3 Analog MEMS signals connected to STM32 pins

Table 8. Analog MEMS signals connected to STM32 pins

Analog MEMS signal	STM32 pin
FS	PA9
PD	PA10
V_{OUTX}	PA5
V_{OUTY}	PA6
V_{OUTZ}	PA7

5.3.4 Digital MEMS signals connected to STM32 pins

Table 9. Digital MEMS signals connected to STM32 pins

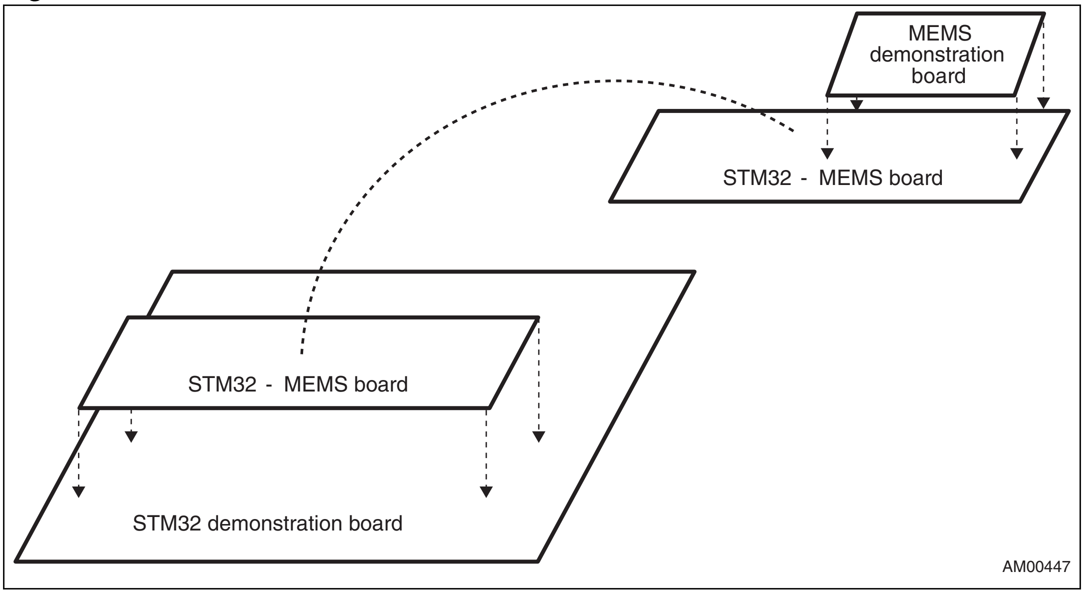
	Digital MEMS signal	STM32 pin
Common signals	CS	PB12
	Int1	PB11
	Int2	PB10
SPI signals	SCK	PB13
	SDI	PB15
	SDO	PB14
I^2C signals	SCL	PB6
	SDA	PB7

Note: Some digital MEMS use the SDO as the LSB of their I^2C address.

6 Remote connection option

The remote connection option can be used when the MEMS sensor needs to be placed in a position where the STM32 demonstration board does not fit, for example for motor vibration measurement applications. Two STM32-MEMS demonstration boards are needed to use the remote connection option. One of the boards is connected to the STM32 demonstration board, while the other is connected to the MEMS demonstration board. The two STM32-MEMS boards are interconnected using a 20-pin ribbon cable with 10 x 2 2.54 mm pitch sockets connected to the CN7 connectors. It is possible to improve the transition of one analog axis by using a coax cable connected to the CN8 BNC connectors. The JP15 jumper selects the analog axis that is connected to the CN8 BNC connector.

Figure 16. Remote connection



6.1 Remote connection connector CN7

This connector allows two STM32-MEMS boards to be connected together.

Figure 17. Remote connection connector CN7

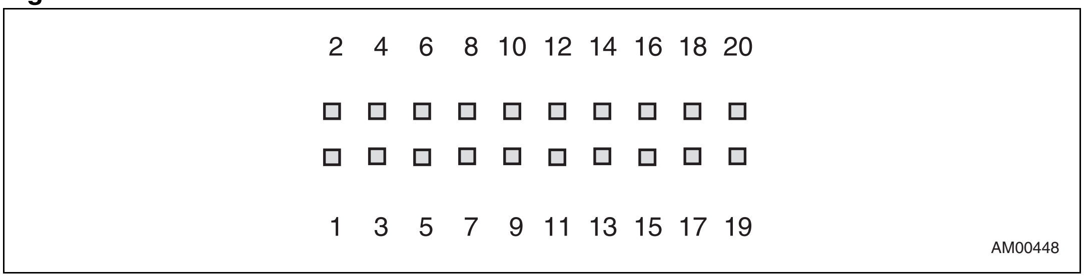


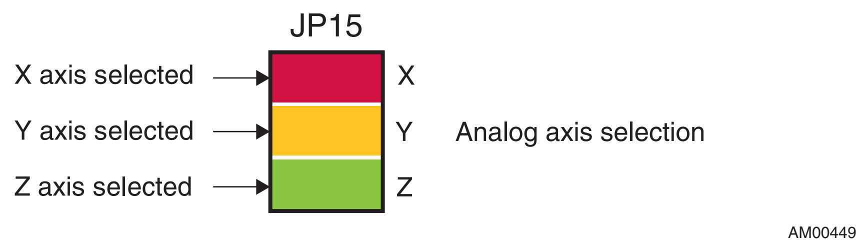
Table 10. CN7 connector pinout

Pin	Signal	Pin	Signal
1	GND	2	3.3 V DC
3	NC	4	Int1
5	V_{OUTX}	6	Int2
7	NC	8	SCL
9	V_{OUTY}	10	SDx
11	NC	12	SDO
13	V_{OUTZ}	14	CS
15	PD	16	NC
17	FS	18	NC
19	GND	20	3.3 V DC

6.2 Analog axis selection - JP15 jumper

This jumper is used to select which analog axis is connected to the CN8 BNC connector.

Figure 18. Analog axis selection using the JP15 jumper



7 STM32-MEMS development kit

The STM32-MEMS development kit provides a simple programming interface between the STM32 microcontroller and analog or digital MEMS accelerometers together with demonstration applications that utilize this interface.

The following sections describe all the components that make up the STM32-MEMS development kit, including:

- the MEMS Library,
- examples of MEMS Library usage,
- the STM32-MEMS USB demonstration application,
- the STM32-MEMS LCD demonstration applications,
- application tips on inclination measurements.

7.1 MEMS Library

This section describes the firmware interface (called MEMS Library) used to manage the MEMS sensor attached to the STEVAL-MKI032V1, STM32-MEMS demonstration board by the STM32 microcontroller.

The main purpose of this firmware library is to provide resources to ease the development of applications using a MEMS sensor. The MEMS Library is designed to be used with the STM32-MEMS demonstration board. However, it is parameterized and therefore can be easily adapted to any other hardware configuration.

Note: When using the MEMS Library on the STM3210E_EVAL board, some JTAG signals of the STM32 MCU can be remapped to the GPIO functionality by the library functions MEMS_SPI_Setup and MEMS_I2C_Setup. This means that after the program startup, debugging or flashing the MCU via the JTAG will not be possible. In order to be able to re-flash the MCU via the JTAG, you have to power-up the board with BOOT0 and BOOT1 switches set to position 1 and then flash the MCU. Finally, to run the program from the Flash, power-up the board with switches BOOT0 and BOOT1 set to position 0.

Table 11 presents the MEMS Library structure.

Table 11. MEMS Library structure

File	Description
stm32_mems.h	Constants and types related to MEMS sensors.
stm32_mems_adapter.h	Constants for configuration and utilization of STM32 peripherals related to the MEMS sensor attached to the STM32-MEMS demonstration board.
stm32_mems_adapter.c	Functions for configuration and utilization of STM32 peripherals related to the MEMS sensor attached to the STM32-MEMS demonstration board.

stm32_mems.h

This file provides constants containing the I^2C address, register addresses and *who_am_i* value related to several digital MEMS sensors (LIS302DL, LIS3LV02DL). It also defines a type used to store data from the axis of a MEMS accelerometer.

stm32_mems_adapter.h

This file provides constants for configuration and utilization of STM32 peripherals related to the MEMS sensor attached to the STM32-MEMS demonstration board. The constants correspond to pins and peripherals of the STM32 microcontroller connected to the MEMS sensor.

There are three sets of constants. Each set contains the same constants but for different STM32 demonstration boards. To choose a particular set, one of the three `#define` statements at the beginning of the file must be uncommented. The `#define` statements are:

```
#define STM3210B_EVAL

#define STM3210E_EVAL

#define STM3210B_SK_IAR
```

For example, the correct definition to choose a set of constants for the ST STM3210B-EVAL demonstration board is:

```
#define STM3210B_EVAL

// #define STM3210E_EVAL

// #define STM3210B_SK_IAR
```

stm32_mems_adapter.c

This file provides functions for configuration and utilization of STM32 peripherals related to the MEMS sensor attached to the STM32-MEMS demonstration board.

7.2 MEMS Library functions reference

Table 12 lists the MEMS Library functions.

Table 12. MEMS Library functions

Function name	Description
MEMS_ANL_Setup	Sets-up all peripherals related to the analog MEMS.
MEMS_ANL_Drive_FS	Drives the FS pin of the analog MEMS.
MEMS_ANL_Drive_PD	Drives the PD pin of the analog MEMS.
MEMS_ANL_ADC_Restart	Restarts the ADC and DMA.
MEMS_ANL_Get_Axis	Gets values of all MEMS axes.
MEMS_DIG_Setup_Int1	Enables or disables EXTI for the Int1 interrupt signal.
MEMS_DIG_Setup_Int2	Enables or disables EXTI for the Int2 interrupt signal.
MEMS_SPI_Setup	Sets-up all peripherals related to the digital MEMS connected over the SPI.

Table 12. MEMS Library functions

Function name	Description
MEMS_SPI_WriteReg	Writes data to the MEMS register over the SPI.
MEMS_SPI_ReadReg	Reads data to the MEMS register over the SPI.
MEMS_SPI_SendFrame	Sends one frame over the SPI.
MEMS_SPI_ReceiveFrame	Receives one frame over the SPI.
MEMS_I2C_Setup	Sets-up all peripherals related to the digital MEMS connected over the I^2C.
MEMS_I2C_Set_Address	Sets the address of the MEMS for I^2C communication.
MEMS_I2C_WriteReg	Writes data to the MEMS register over the I^2C.
MEMS_I2C_ReadReg	Reads data from the MEMS register over the I^2C.
MEMS_I2C_SendFrame	Sends one frame over the I^2C.
MEMS_I2C_ReceiveFrame	Receives one frame over the I^2C.

7.2.1 MEMS_ANL_Setup function

Table 13 describes the MEMS_ANL_Setup function.

Table 13. MEMS_ANL_Setup function

Function name	MEMS_ANL_Setup
Function prototype	`void MEMS_ANL_Setup (void)`
Description	Sets-up all peripherals related to the analog MEMS.
Input parameter	None
Output parameter	None
Return parameter	None

7.2.2 MEMS_ANL_Drive_FS function

Table 14 describes the MEMS_ANL_Drive_FS function.

Table 14. MEMS_ANL_Drive_FS function

Function name	MEMS_ANL_Drive_FS
Function prototype	`void MEMS_ANL_Drive_FS (BitAction BitVal)`
Description	Drives the FS pin of the analog MEMS.
Input parameter	`BitVal`: new value of the FS pin `BitVal` must be one of the `BitAction` enum values: – `Bit_RESET`: clears the port pin – `Bit_SET`: sets the port pin
Output parameter	None
Return parameter	None

7.2.3 MEMS_ANL_Drive_PD function

Table 15 describes the MEMS_ANL_Drive_PD function.

Table 15. MEMS_ANL_Drive_PD function

Function name	MEMS_ANL_Drive_PD
Function prototype	`void MEMS_ANL_Drive_PD (BitAction BitVal)`
Description	Drives the PD pin of the analog MEMS.
Input parameter	`BitVal`: new value of the PD pin `BitVal` must be one of the `BitAction` enum values: – `Bit_RESET`: clears the port pin – `Bit_SET`: sets the port pin
Output parameter	None
Return parameter	None

7.2.4 MEMS_ANL_ADC_Restart function

Table 16 describes the MEMS_ANL_ADC_Restart function.

Table 16. MEMS_ANL_ADC_Restart function

Function name	MEMS_ANL_ADC_Restart
Function prototype	`void MEMS_ANL_ADC_Restart(void)`
Description	Restarts the ADC and DMA.
Input parameter	None
Output parameter	None
Return parameter	None

7.2.5 MEMS_ANL_Get_Axis function

Table 17 describes the MEMS_ANL_Get_Axis function.

Table 17. MEMS_ANL_Get_Axis function

Function name	MEMS_ANL_Get_Axis
Function prototype	`void MEMS_ANL_Get_Axis(s16 *x, s16 *y, s16 *z)`
Description	Gets values of all MEMS axes.
Input parameter	None
Output parameter1	`x`: value of x axis
Output parameter2	`y`: value of y axis
Output parameter3	`z`: value of z axis
Return parameter	None

7.2.6 MEMS_DIG_Setup_Int1 function

Table 18 describes the MEMS_DIG_Setup_Int1 function.

Table 18. MEMS_DIG_Setup_Int1 function

Function name	MEMS_DIG_Setup_Int1
Function prototype	`void MEMS_DIG_Setup_Int1 (FunctionalState NewState)`
Description	Enables or disables EXTI for the Int1 interrupt signal.
Input parameter	`NewState`: new state of the interrupt. This parameter can be ENABLE or DISABLE
Output parameter	None
Return parameter	None

7.2.7 MEMS_DIG_Setup_Int2 function

Table 19 describes the MEMS_DIG_Setup_Int2 function.

Table 19. MEMS_DIG_Setup_Int2 function

Function name	MEMS_DIG_Setup_Int2
Function prototype	`void MEMS_DIG_Setup_Int2 (FunctionalState NewState)`
Description	Enables or disables EXTI for the Int2 interrupt signal.
Input parameter	`NewState`: new state of the interrupt. This parameter can be ENABLE or DISABLE
Output parameter	None
Return parameter	None

7.2.8 MEMS_SPI_Setup function

Table 20 describes the MEMS_SPI_Setup function.

Table 20. MEMS_SPI_Setup function

Function name	MEMS_SPI_Setup
Function prototype	`void MEMS_SPI_Setup (void)`
Description	Sets-up all peripherals related to the digital MEMS connected over SPI.
Input parameter	None
Output parameter	None
Return parameter	None

7.2.9 MEMS_SPI_WriteReg function

Table 21 describes the MEMS_SPI_WriteReg function.

Table 21. MEMS_SPI_WriteReg function

Function name	MEMS_SPI_WriteReg
Function prototype	`ErrorStatus MEMS_SPI_WriteReg (u8 RegAddress, u8 Data)`
Description	Writes data to the MEMS register over SPI.
Input parameter1	`RegAddress`: address of register
Input parameter2	`Data`: data to be written
Output parameter	None
Return parameter	An `ErrorStatus` enumeration value: – `SUCCESS`: register written – `ERROR`: register not written

7.2.10 MEMS_SPI_ReadReg function

Table 22 describes the MEMS_SPI_ReadReg function.

Table 22. MEMS_SPI_ReadReg function

Function name	MEMS_SPI_ReadReg
Function prototype	`ErrorStatus MEMS_SPI_ReadReg (u8 RegAddress, u8 *Data)`
Description	Reads data to the MEMS register over SPI.
Input parameter	`RegAddress`: address of register
Output parameter	`Data`: data read
Return parameter	An `ErrorStatus` enumeration value: – `SUCCESS`: register written – `ERROR`: register not written

7.2.11 MEMS_SPI_SendFrame function

Table 23 describes the MEMS_SPI_SendFrame function.

Table 23. MEMS_SPI_SendFrame function

Function name	MEMS_SPI_SendFrame
Function prototype	`ErrorStatus MEMS_SPI_SendFrame (u8 RegAddress, u8 *pBuffer, u8 NoOfBytes)`
Description	Sends one frame over SPI.
Input parameter1	`RegAddress`: address of register
Input parameter2	`pBuffer`: pointer to buffer with data
Input parameter3	`NoOfBytes`: number of bytes to be sent
Output parameter	None
Return parameter	An `ErrorStatus` enumeration value: – `SUCCESS`: register written – `ERROR`: register not written

7.2.12 MEMS_SPI_ReceiveFrame function

Table 24 describes the MEMS_SPI_ReceiveFrame function.

Table 24. MEMS_SPI_ReceiveFrame function

Function name	MEMS_SPI_ReceiveFrame
Function prototype	`ErrorStatus MEMS_SPI_ReceiveFrame (u8 RegAddress, u8 *pBuffer, u8 NoOfBytes)`
Description	Receives one frame over SPI.
Input parameter1	`RegAddress`: address of source register
Input parameter2	`NoOfBytes`: number of bytes to be received
Output parameter	`pBuffer`: pointer to output buffer
Return parameter	An `ErrorStatus` enumeration value: – `SUCCESS`: register written – `ERROR`: register not written

7.2.13 MEMS_I2C_Setup function

Table 25 describes the MEMS_I2C_Setup function.

Table 25. MEMS_I2C_Setup function

Function name	MEMS_I2C_Setup
Function prototype	`void MEMS_I2C_Setup (u8 MEMS_I2C_Address)`
Description	Sets up all peripherals related to digital MEMS connected over I^2C.
Input parameter	`MEMS_I2C_Address`: I^2C address of MEMS
Output parameter	None
Return parameter	None

7.2.14 MEMS_I2C_Set_Address function

Table 26 describes the MEMS_I2C_Set_Address function.

Table 26. MEMS_I2C_Set_Address function

Function name	MEMS_I2C_Set_Address
Function prototype	`void MEMS_I2C_Set_Address (u8 MEMS_I2C_Address)`
Description	Sets MEMS address for I^2C communication.
Input parameter	`MEMS_I2C_Address`: I^2C address of MEMS
Output parameter	None
Return parameter	None

7.2.15 MEMS_I2C_WriteReg function

Table 27 describes the MEMS_I2C_WriteReg function.

Table 27. MEMS_I2C_WriteReg function

Function name	MEMS_I2C_WriteReg
Function prototype	`ErrorStatus MEMS_I2C_WriteReg (u8 RegAddress, u8 Data)`
Description	Writes data to the MEMS register over I^2C.
Input parameter1	`RegAddress`: address of register
Input parameter2	`Data`: data to be written
Output parameter	None
Return parameter	An `ErrorStatus` enumeration value: – `SUCCESS`: register written – `ERROR`: register not written

7.2.16 MEMS_I2C_ReadReg function

Table 28 describes the MEMS_I2C_ReadReg function.

Table 28. MEMS_I2C_ReadReg function

Function name	MEMS_I2C_ReadReg
Function prototype	`ErrorStatus MEMS_I2C_ReadReg (u8 RegAddress, u8 *Data)`
Description	Reads data to the MEMS register over I^2C.
Input parameter	`RegAddress`: address of register
Output parameter	`Data`: data read
Return parameter	An `ErrorStatus` enumeration value: – `SUCCESS`: register written – `ERROR`: register not written

7.2.17 MEMS_I2C_SendFrame function

Table 29 describes the MEMS_I2C_SendFrame function.

Table 29. MEMS_I2C_SendFrame function

Function name	MEMS_I2C_SendFrame
Function prototype	`ErrorStatus MEMS_I2C_SendFrame (u8 RegAddress, u8 *pBuffer, u8 NoOfBytes)`
Description	Sends one frame over I^2C.
Input parameter1	`RegAddress`: address of register
Input parameter2	`pBuffer`: pointer to buffer with data
Input parameter3	`NoOfBytes`: number of bytes to be sent
Output parameter	None
Return parameter	An `ErrorStatus` enumeration value: – `SUCCESS`: register written – `ERROR`: register not written

7.2.18 MEMS_I2C_ReceiveFrame function

Table 30 describes the MEMS_I2C_ReceiveFrame function.

Table 30. MEMS_I2C_ReceiveFrame function

Function name	MEMS_I2C_ReceiveFrame
Function prototype	`ErrorStatus MEMS_I2C_ReceiveFrame (u8 RegAddress, u8 *pBuffer, u8 NoOfBytes)`
Description	Receives one frame over I^2C.
Input parameter1	`RegAddress`: address of source register
Input parameter2	`NoOfBytes`: number of bytes to be received
Output parameter	`pBuffer`: pointer to output buffer
Return parameter	An `ErrorStatus` enumeration value: – `SUCCESS`: register written – `ERROR`: register not written

7.3 Example of MEMS Library usage: analog MEMS

This section shows an example of a main function to set-up and read data from an analog MEMS. Do not forget to set-up the defines in the *stm32_mems_adapter.h* file according to the STM32 demonstration board used.

```
/* This main function sets up and reads data from any analog MEMS */
int main (void)
{
  s16 ADC_DataValue[3];

  /* Setup STM32 system clock and other peripherals here */
  /* … */

  /* Setup all peripherals related to analog MEMS */
  MEMS_ANL_Setup();

  /* Wait 40ms after reset to let the MEMS turn on from power down*/
  Delay(40);

  /* Restart ADC and DMA */
  MEMS_ANL_ADC_Restart();

  while (1)
  {
      /* Read all analog MEMS axis */
MEMS_ANL_Get_Axis(&ADC_DataValue[0],&ADC_DataValue[1],&ADC_DataValu
e[2]);

    /* Use the data */
    /* … */
  }

  return 0;
}
```

7.4 Example of MEMS Library usage: digital MEMS over I²C

This section shows an example of the main function to set-up and read data from a digital MEMS over the I²C. Minor modifications (mainly replacing I²C in names of functions with SPI) would make this example work over an SPI interface. Do not forget to set-up the defines in the *stm32_mems_adapter.h* file according to the STM32 demonstration board used.

```
/* This main function sets-up and reads data from LIS302DL digital
MEMS */
int main(void)
{
  u8 i;
  u8 i2c_buffer[6];
  t_mems_data MEMS_Data={0, 0, 0, 0, 0, 0};

  /* Setup STM32 system clock and other peripherals here */
  /* … */

  /* Setup all peripherals related to digital MEMS */
  MEMS_I2C_Setup(LIS302DL_I2C_ADDR);

  /* Wait 40ms after reset to let the MEMS turn on from power down*/
  Delay(40);

  /* Check who_am_i value */
  MEMS_I2C_ReadReg(LIS302DL_WHO_AM_I, &i);
  if (i != LIS302DL_WHO_AM_I_VALUE) return 1;

  /* Initialize registers of LIS302DL */
  /* IMPORTANT NOTE: These settings differ for different MEMS part
numbers! */
  /* Following are settings for LIS302DL. */
  /* CTRL_REG1 Register - Data rate 400Hz, power up, enable all axes
*/
  MEMS_I2C_WriteReg (LIS302DL_CTRL_REG1, 0x47);

  while (1)
  {
```

```
        /* Read all MEMS axis */
        MEMS_I2C_ReceiveFrame (LIS302DL_OUTX, i2c_buffer, 6);

        MEMS_Data->outx_h = 0;
        MEMS_Data->outx_l = i2c_buffer[0];

        MEMS_Data->outy_h = 0;
        MEMS_Data->outy_l = i2c_buffer[2];

        MEMS_Data->outz_h = 0;
        MEMS_Data->outz_l = i2c_buffer[4];

        /* Use the data */
        /* … */

    }
    return 0;
}
```

7.5 STM32-MEMS demonstration applications

The STM32-MEMS development kit contains four demonstration applications.

- STM32-MEMS USB demonstration application (STM32_MEMS_USB) for STM3210B_EVAL, STM3210E_EVAL and STM3210B_SK_IAR boards.
- STM32-MEMS LCD demonstration application (STM32_MEMS_LCD_B) for the STM3210B_EVAL board.
- STM32-MEMS LCD demonstration application (STM32_MEMS_LCD_E) for the STM3210E_EVAL board.
- STM32-MEMS LCD demonstration application (STM32_MEMS_LCD_IAR) for the STM3210B_SK_IAR board.

All demonstration applications are designed and tested to be used with the STEVAL-MKI032V1, STM32-MEMS demonstration board as a bridge between the STM32 demonstration board and the MEMS demonstration board.

These demonstration applications have been tested with the following MEMS demonstration boards.

- DIGITAL MEMS accelerometers: STEVAL-MKI013V1 (LIS302DL), STEVAL-MKI009V1 (LIS3LV02DL)
- ANALOG MEMS accelerometers: STEVAL-MKI015V1 (LIS344ALH), STEVALMKI018V1 (LIS244AL), STEVAL-MKI020V1 (LIS302SG)

7.5.1 STM32-MEMS USB demonstration application

The STM32-MEMS USB demonstration application reads data from the MEMS sensor and sends it over USB to a PC. On the PC side runs the MEMS USB Reader (Windows GUI application), which use an HID class of USB interface to receive data sent by the demonstration application.

It is possible to use any of the compatible MEMS demonstration boards (see list in previous section) without changing the firmware. However, do not forget to change the jumper settings on the STM32-MEMS demonstration board if needed (for example, when changing from an analog MEMS to a digital one).

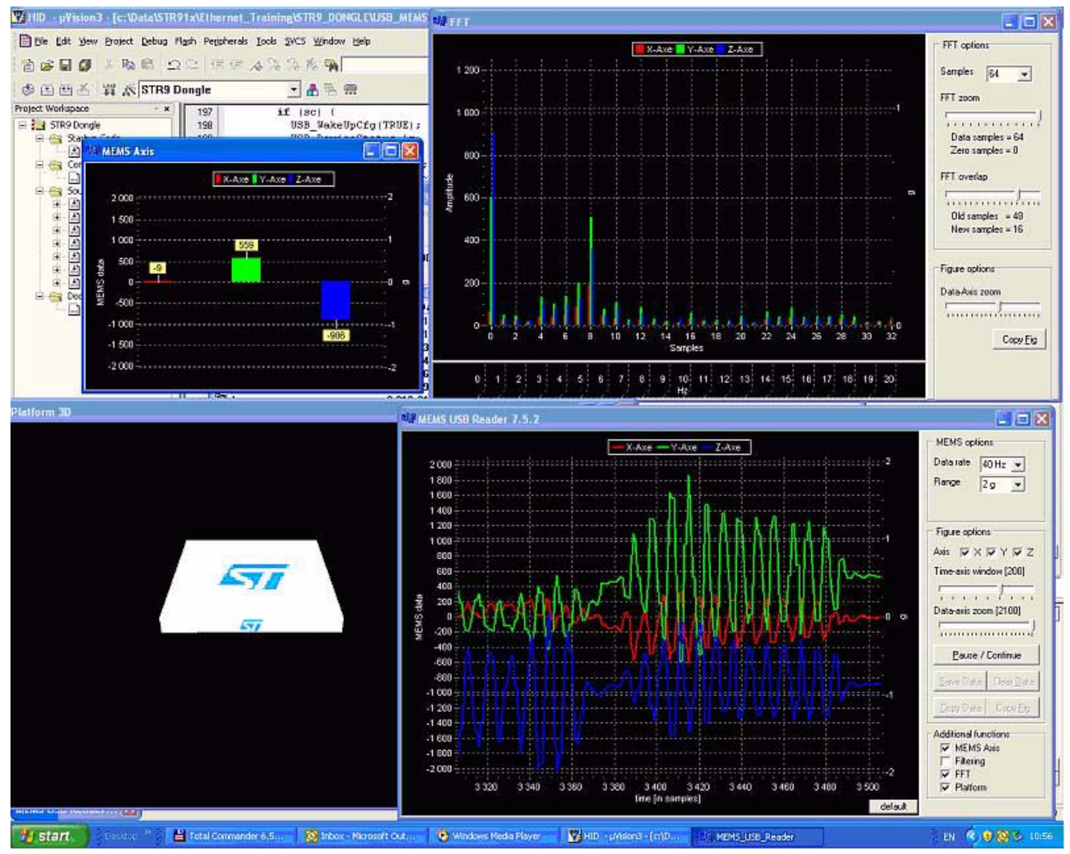
Follow these steps to run the demonstration application.

1. Mount the STM32-MEMS demonstration board onto the STM32 demonstration board and mount the MEMS demonstration board onto the STM32-MEMS demonstration board.
2. Correctly set-up the jumpers on the STM32-MEMS demonstration board.
3. Go to the IAR EWARM IDE in *Project/Options/General Options* and select the device corresponding to the one used on your STM32 demonstration board (either ST STM32F10xxB or ST STM32F10xxE).
4. In the *stm32_mems_adapter.h* file uncomment one line corresponding to the STM32 demonstration board used.
5. Compile, flash and run the project.
6. Run the MEMS USB Reader on the PC.

Note: In most cases it is necessary to power-down and power-up the system after flashing the STM32 MCU before plugging it to a PC.

Figure 19 shows the MEMS USB Reader Windows GUI application.

Figure 19. MEMS USB Reader Windows GUI application



7.5.2 STM32-MEMS LCD demonstration applications

The STM32-MEMS LCD demonstration applications read data from the MEMS sensor and display it on the LCD mounted on the STM32 demonstration board. When a digital MEMS with double-click detection is attached (for example, LIS302DL) the demonstration applications utilize an interrupt generated by the MEMS and show a message on the LCD when the double-click event occurs.

It is possible to use any of the compatible MEMS demonstration boards (see list in previous section) without changing the firmware. However, do not forget to change the jumper settings on the STM32-MEMS demonstration board if needed (for example, when changing from an analog MEMS to a digital one).

Follow these steps to run the demonstration application.

1. Mount the STM32-MEMS demonstration board onto the STM32 demonstration board and mount the MEMS demonstration board onto the STM32-MEMS demonstration board.
2. Correctly set-up the jumpers on the STM32-MEMS demonstration board. Do not forget to position the JP10 jumper and set-up the board for use with the INT1 signal if needed.
3. Compile, flash and run the project corresponding to your STM32 demonstration board.

Figure 20. STM32-MEMS LCD demonstration application running on STM3210B_EVAL (left) and STM3210B_SK_IAR (right)

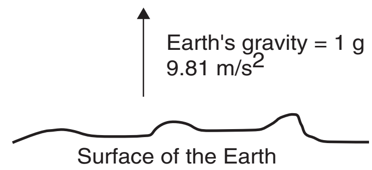
7.6 Application tips: inclination measurement

In this application, the acceleration is used to measure an inclination. This inclination is related to the angle achieved by the gravity's direction. Thus, if the device is put horizontally, the gravity will induce a 1 g value on the z axis and the acceleration measured on the other two axes will be equal to 0, meaning no angle (0°), no inclination.

7.6.1 Description

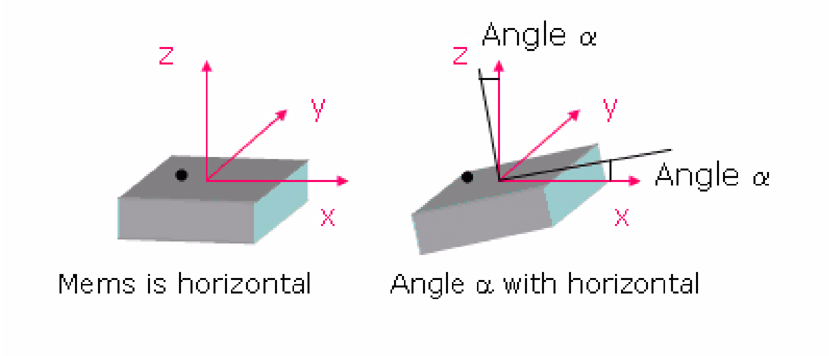
When there is no movement, the acceleration by default is called gravity and is always present. On the surface of the earth, the gravity is around 9.81 m/s^2 (1 g).

Figure 21. Earth's gravity



If the device starts to move from the horizontal position, the gravity will no longer be equal to 1 on the z axis and a value on the x or y axis will be different to 0.

Figure 22. Inclination measurement



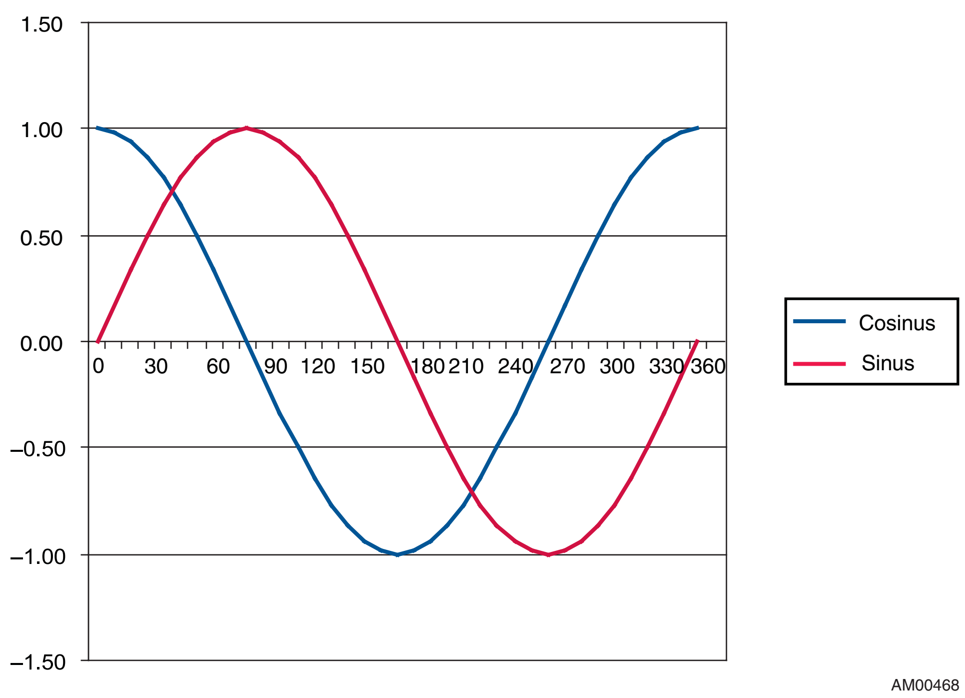
In this example, the device has an α angle with a horizontal position.

The y axis is not affected and the acceleration measured will remain equal to 0.

However, for the x axis, the acceleration measured will move from 0 and will be equal to 1g*sin(α).

For the z axis, the acceleration measured will be 1g*cos(α).

Figure 23. Sinus and Cosinus functions



7.6.2 Chip selection

Depending on the type of architecture, the user has to select either an analog or digital MEMS device. After, depending on the precision needed, the user will choose either the LIS344ALH or LIS3LV02DL, if small-angle detection is required. If such a level of precision is not needed, one can use the LIS302SG or LIS302DL. If the z axis is not affected (the device is supposed to tilt around the z axis), a 2-axis accelerometer could be used.

Example 1

In the case of the LIS3LV02DL, the resolution is 1 mg per lsb. Thus, for an acceleration variation of 1 mg, the angle measured on the z axis will be $\cos^{-1}(1-10^{-3}) = 2.5°$. For the x axis, the angle detection will be $\sin^{-1}(10^{-3}) = 0.057°$. The smallest angle variation measurable is therefore **0.057**°. This difference between the x and z axis is explained by the behavior of the sine/cosine function.

Example 2

In the case of the LIS344ALH, the resolution is given by the formula *[noise density*rt(BW*correction factor)]*. BW is the bandwidth and the correction factor is linked to the low-pass filtering for the V_{OUT}. The resolution is 0.625 mg. Thus, for an acceleration variation of 0.625 mg, the angle detection on the z axis will be $\cos^{-1}(1\text{-}0.625*10^{-3}) = 2°$. For the x axis, the angle detection will be $\sin^{-1}(0.625*10^{-3})$ = **0.036**°.

Example 3

In the case of the LIS302DL, the resolution is 18 mg per lsb. Thus, for an acceleration variation of 18 mg, the angle measured on the z axis will be $\cos^{-1}(1\text{-}18^{-3}) = 10.9°$. For the x axis, the angle detection will be $\sin^{-1}(18^{-3})$ = **1**°.

Example 4

For the LIS302SG the resolution is 2.5 mg. Thus, the smallest angle variation measurable is **0.14**°.

Due to the behavior of the sine/cosine functions and the angle and precision expected, the user will have to consider the measured acceleration on one or all axes.

Appendix A Bill of materials

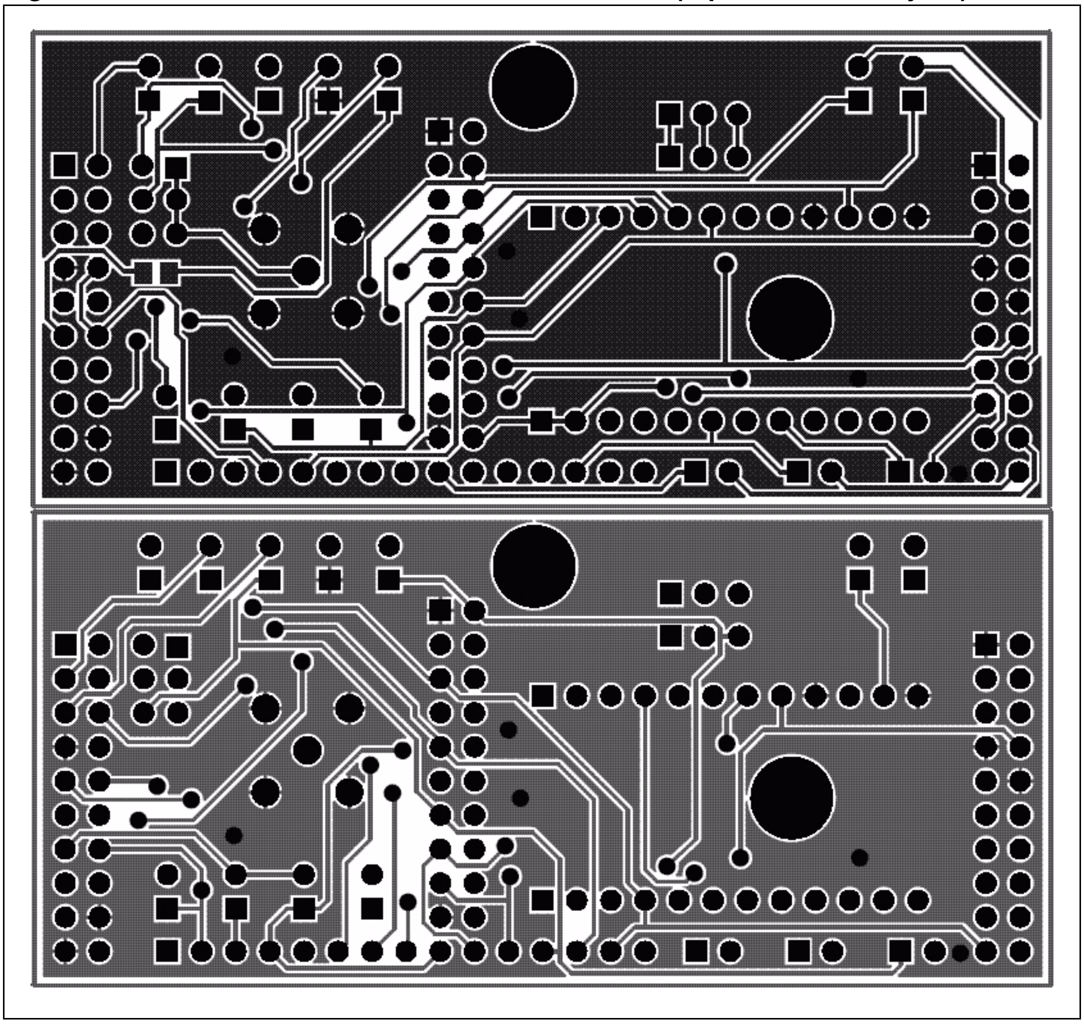
Table 31. Bill of material

Designator	Comment	Description	Footprint
CN8	BNC	BNC connector	BNC
JP1, JP2, JP3, JP4, JP5, JP6, JP7, JP8, JP9, JP10, JP11, JP12, JP13, JP14	Header 2	Header, 2-pin	HDR1X2
JP16	Header 3	Header, 3-pin	HDR1X3
CN4	Socket 3	Socket, 3-pin	HDR1X3
JP15	Header 3 x 2	Header, 3-pin, dual row	HDR2X3
CN7	Header 10 x 2	Header, 10-pin, dual row	HDR2X10
CN1, CN2	Socket 10 x 2	Socket, 10-pin, dual row	HDR2X10
CN5, CN6	Socket 12	Socket, 12-pin	HDR1X12
CN3	Socket 15	Socket, 15-pin	HDR1X15
R1	10 kΩ	Resistor	0805

Appendix B Artwork prints

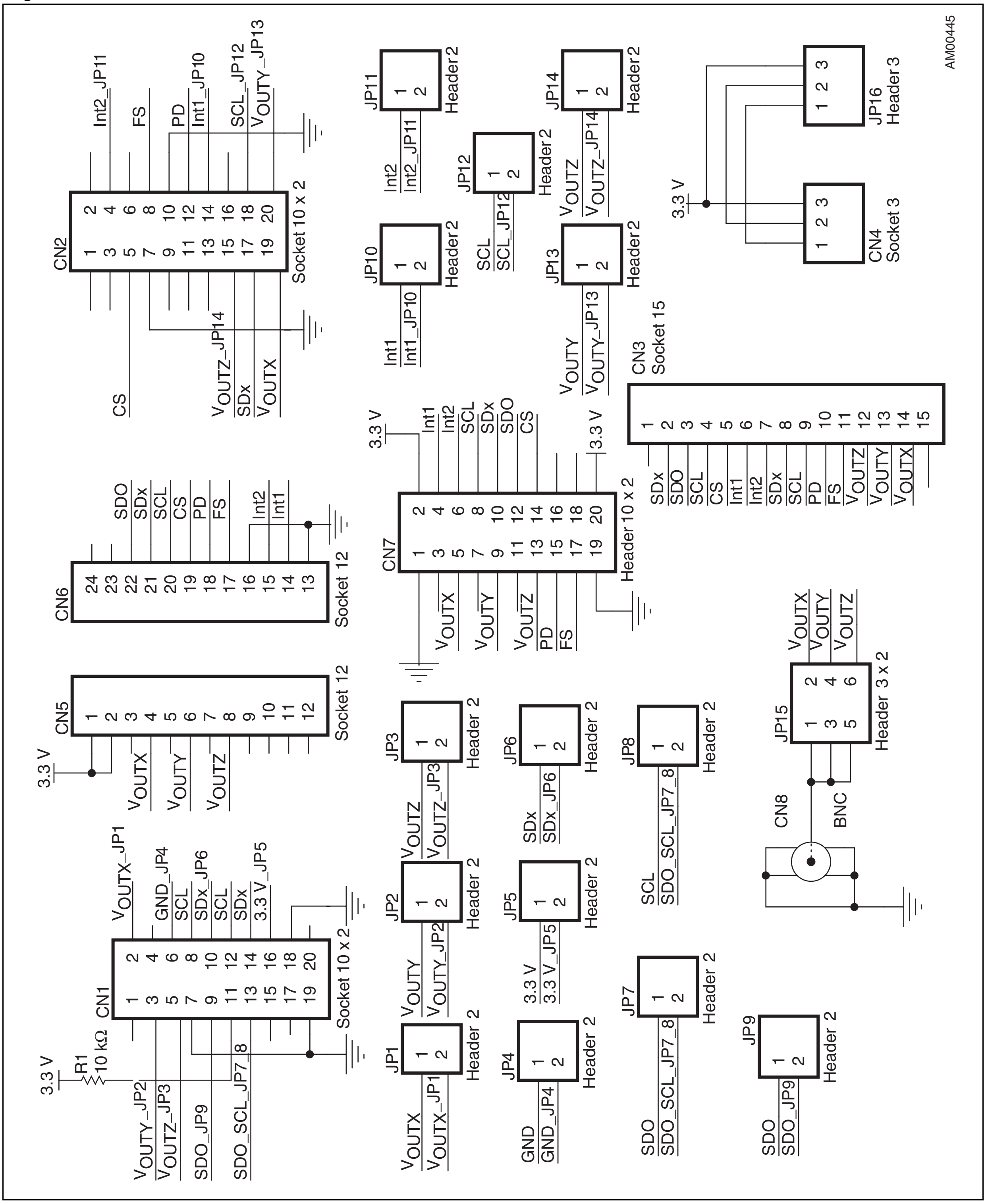
This section shows the layout of the STM32-MEMS demonstration board PCB.

Figure 24. STM32-MEMS demonstration board PCB (top and bottom layers)



Appendix C Board schematic

Figure 25. Board schematic



Revision history

Table 32. Document revision history

Date	Revision	Changes
01-Jul-2009	1	Initial release.