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Facultad de Ingeniería

Escuela de Ingeniería Eléctrica

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Laboratorio #4:

STM32: GPIO, ADC, comunicaciones, Iot

IE0624 Laboratorio de Microcontroladores

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Grupo 01

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Resumen

En esta práctica de laboratorio se ha desarrollado un sistema para simular un sismógrafo digital. para registrar y estudiar la vibración en el edificio de la escuela de ingeniería eléctrica. Él Los sismógrafos actuales funcionan con baterías (recargadas por paneles solares) y tienen una respuesta de frecuencia estrecha. correa de transmisión de datos. Por lo tanto, la placa STM32F429 utilizada en el registrador sísmico desarrollado. La suite Discovery y la biblioteca libopencm3 leen los ejes x, y y z del giroscopio contenido en El STM32F429 Discovery establece y muestra esos valores en la pantalla LCD; Esto también incluye cambiar para habilitar y deshabilitar la comunicación USART-USB; gire cuando la batería cerca del límite inferior, el LED parpadeará para indicar el estado de la batería. Finalmente, este sismógrafo se conecta vía MQTT a la plataforma de instrumentos IoT Internet para mostrar las lecturas de una manera fácil de usar. diseño del planeta prototipo; solo se utilizan los componentes integrados en el STM32F429 Discovery conjunto de física No se realiza la simulación. El proyecto se ha completado con éxito.

1 Nota Teórica

1.1 Información general del MCU

STM32 es una familia de circuitos integrado de microcontroladores desarrollada por STMicroelectronics. Los chips STM32 están agrupados en series relacionadas que están basadas todas en el mismo núcleo de procesador ARM de 32-Bits. A continuación un resumen de los procesadores y las series mencionadas:

STM32 series	ARM CPU Core
L5, U5	Cortex-M33F
F7, H7	Cortex M7F
F7, F4, G4, L4, L4+, WB	Cortex M4F
WL	Cortex-M4
F1, F2, L1	Cortex-M3
G0, L0	Cortex-M0+
F0	Cortex-M0

En este laboratorio se utilizará la serie F4; es la primera basada en el Cortex M4F. Además es el primer MCU de toda la familia STM32 en tener DSP e instrucciones de punto flotante.

- Procesador Core: ARM 32 bits Cortex-M4 con FPU (RISC).
- Operación: 180MHz.
- Memoria: $2MB$ flash, $256KBSRAM$.
- Controlador LCD-TFT para la pantalla LCD.
- Posibilidad de operar a baja potencia (1.8 a 3.6 voltios).
- Posee convertidores Analógico-Digital 3x12bit.
- Posee 2x12bit convertidores Digital-Analógico.
- Posee 17 Timers: 12 timers de 16 bits, 2 de 32bits de hasta 180MHz, cada timer con 4IC/OC/PWM.
- Funciones para depuración: SWD y JTAG.
- 168 I/O para realizar interrupciones.
- Posee 21 interfaces de comunicaciones (entre estas I2C, USART, SPI, SAN, CAN)..
- Posee conectividad avanzada USB 2.0.
- Posee interfaz de cámara.
- Unidad para generar n´umeros aleatorios True NRG (Random Number Generator).
- Posee una unidad para poder hacer CRC.
- Posee controladores DMA.

Este posee las siguientes características:

Symbol	Ratings	Min	Max	Unit
V_{DD}–V_{SS}	External main supply voltage (including V_{DDA}, V_{DD} and VBAT)(1)	− 0.3	4.0	V
V_{IN}	Input voltage on FT pins(2)	V_{SS} − 0.3	V_{DD}+4.0	
	Input voltage on TTa pins	V_{SS} − 0.3	4.0	
	Input voltage on any other pin	V_{SS} − 0.3	4.0	
	Input voltage on BOOT0 pin	V_{SS}	9.0	
$\|\Delta V_{DDx}\|$	Variations between different V_{DD} power pins	-	50	mV
$\|V_{SSX} - V_{SS}\|$	Variations between all the different ground pins including V_{REF-}	-	50	
$V_{ESD(HBM)}$	Electrostatic discharge voltage (human body model)	see *Section 6.3.15: Absolute maximum ratings (electrical sensitivity)*		

Figura 1: Características de voltaje.

Symbol	Ratings	Max.	Unit
ΣI_{VDD}	Total current into sum of all V_{DD_x} power lines (source)(1)	270	mA
ΣI_{VSS}	Total current out of sum of all V_{SS_x} ground lines (sink)(1)	− 270	
I_{VDD}	Maximum current into each V_{DD_x} power line (source)(1)	100	
I_{VSS}	Maximum current out of each V_{SS_x} ground line (sink)(1)	− 100	
I_{IO}	Output current sunk by any I/O and control pin	25	
	Output current sourced by any I/Os and control pin	− 25	
ΣI_{IO}	Total output current sunk by sum of all I/O and control pins (2)	120	
	Total output current sourced by sum of all I/Os and control pins(2)	− 120	
$I_{INJ(PIN)}$ (3)	Injected current on FT pins (4)	− 5/+0	
	Injected current on NRST and BOOT0 pins (4)		
	Injected current on TTa pins(5)	±5	
$\Sigma I_{INJ(PIN)}$(5)	Total injected current (sum of all I/O and control pins)(6)	±25	

Figura 2: Características de corriente.

En la figura – se muesta el diagrama de pines y en la figura 5 la arquitectura del STM32 F4. En este caso el STM32F429 incluye Cortex M4F - LQFP144.

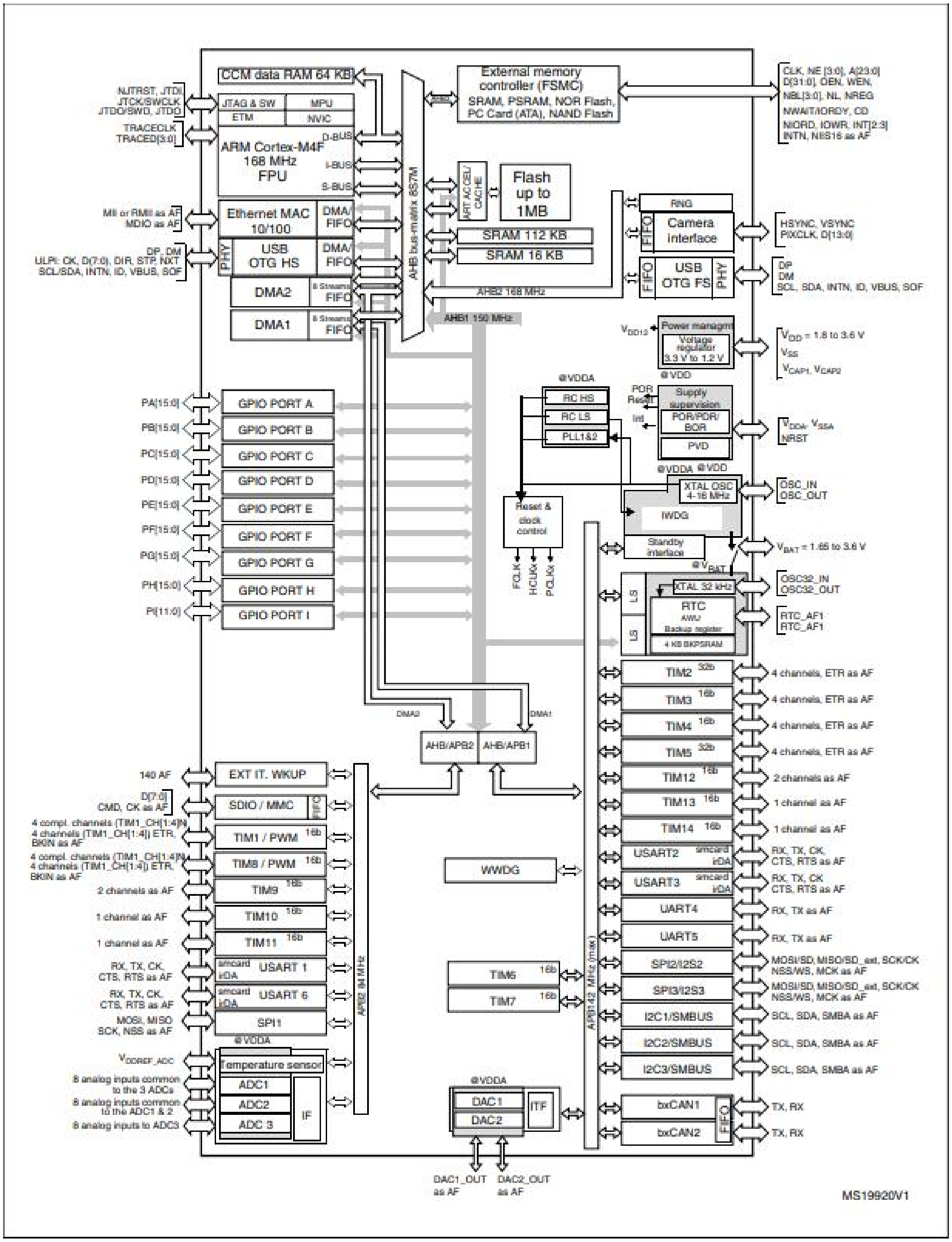


Figura 3: Diagrama de bloques.

1.2 Sobre el STM32F429 Discovery kit

Es una placa de desarrollo que incluye el microcontrolador en cuestión entre otras herramientas complementarias. Cuenta con 6 leds, un giroscopio, dos botones; uno de reset y uno de user, un puerto USB micro-AB, una pantalla LCD, entre otras características muy útiles e interesantes.

1.2.1 Giroscopio

El sensor de movimiento se trata del L3GD20 ST MEMS. Con 3 ejes de precisión. El L3GD20 es un sensor de velocidad angular de tres ejes ultra-compacto y de bajo consumo. posee elemento de detección y una interfaz IC con la capacidad de brindar una tasa angular a través de la interfaz serial I2C/SPI. Posee escalas completas dinámicamente elegibles por el usuario de ±250dps/500dps/2000dps.

1.2.2 Pantalla LCD

Se trata de una pantalla LCD TFT (Thin-film-transistor liquid-crystal display) 2.4", 262K colores RGB, 240 x 320 puntos de resolución. Es impulsada directamente por el mcu usando el protocolo RGB. Usa el controlador ILI9341 LCD y opera con un voltaje de 2.8 ± 0.3V . El MCU mcu controla esta pantalla a través de la interfaz spi.

1.3 Registros de interés

Tanto el micrcontrolador, como el giroscopio, como el módulo de la pantalla, tienen registros independientes. Del microncotrolador se ingresaron específicamente los periféricos. Entre los utilizados más importantes, los cuales se utilizaron para habilitar lecturas de otros registros, leer variables del giroscopio, ajustar variables físicas, entre otros:

- CTRL_REG1
- CTRL_REG4
- GYR_OUT_X_L
- GYR_OUT_X_H
- GYR_OUT_Y_L
- GYR_OUT_Y_H
- GYR_OUT_Z_L
- GYR_OUT_Z_H

Registros de interés del giroscopio:

Bus	Boundary address	Peripheral
	0x4008 0000- 0x4FFF FFFF	Reserved
AHB1	0x4004 0000 - 0x4007 FFFF	USB OTG HS
	0x4002 BC00- 0x4003 FFFF	Reserved
	0x4002 B000 - 0x4002 BBFF	DMA2D
	0x4002 9400 - 0x4002 AFFF	Reserved
	0x4002 9000 - 0x4002 93FF	ETHERNET MAC
	0x4002 8C00 - 0x4002 8FFF	
	0x4002 8800 - 0x4002 8BFF	
	0x4002 8400 - 0x4002 87FF	
	0x4002 8000 - 0x4002 83FF	
	0x4002 6800 - 0x4002 7FFF	Reserved
	0x4002 6400 - 0x4002 67FF	DMA2
	0x4002 6000 - 0x4002 63FF	DMA1
	0X4002 5000 - 0X4002 5FFF	Reserved
	0x4002 4000 - 0x4002 4FFF	BKPSRAM
	0x4002 3C00 - 0x4002 3FFF	Flash interface register
	0x4002 3800 - 0x4002 3BFF	RCC
	0X4002 3400 - 0X4002 37FF	Reserved
	0x4002 3000 - 0x4002 33FF	CRC
	0x4002 2C00 - 0x4002 2FFF	Reserved
	0x4002 2800 - 0x4002 2BFF	GPIOK
	0x4002 2400 - 0x4002 27FF	GPIOJ
	0x4002 2000 - 0x4002 23FF	GPIOI
	0x4002 1C00 - 0x4002 1FFF	GPIOH
	0x4002 1800 - 0x4002 1BFF	GPIOG
	0x4002 1400 - 0x4002 17FF	GPIOF
	0x4002 1000 - 0x4002 13FF	GPIOE
	0X4002 0C00 - 0x4002 0FFF	GPIOD
	0x4002 0800 - 0x4002 0BFF	GPIOC
	0x4002 0400 - 0x4002 07FF	GPIOB
	0x4002 0000 - 0x4002 03FF	GPIOA

Figura 4: Mapeo de registros el giroscopio utilizado.

Por parte del microcontrolador:

Bus	Boundary address	Peripheral
	0x4008 0000- 0x4FFF FFFF	Reserved
AHB1	0x4004 0000 - 0x4007 FFFF	USB OTG HS
	0x4002 BC00- 0x4003 FFFF	Reserved
	0x4002 B000 - 0x4002 BBFF	DMA2D
	0x4002 9400 - 0x4002 AFFF	Reserved
	0x4002 9000 - 0x4002 93FF	ETHERNET MAC
	0x4002 8C00 - 0x4002 8FFF	
	0x4002 8800 - 0x4002 8BFF	
	0x4002 8400 - 0x4002 87FF	
	0x4002 8000 - 0x4002 83FF	
	0x4002 6800 - 0x4002 7FFF	Reserved
	0x4002 6400 - 0x4002 67FF	DMA2
	0x4002 6000 - 0x4002 63FF	DMA1
	0X4002 5000 - 0X4002 5FFF	Reserved
	0x4002 4000 - 0x4002 4FFF	BKPSRAM
	0x4002 3C00 - 0x4002 3FFF	Flash interface register
	0x4002 3800 - 0x4002 3BFF	RCC
	0X4002 3400 - 0X4002 37FF	Reserved
	0x4002 3000 - 0x4002 33FF	CRC
	0x4002 2C00 - 0x4002 2FFF	Reserved
	0x4002 2800 - 0x4002 2BFF	GPIOK
	0x4002 2400 - 0x4002 27FF	GPIOJ
	0x4002 2000 - 0x4002 23FF	GPIOI
	0x4002 1C00 - 0x4002 1FFF	GPIOH
	0x4002 1800 - 0x4002 1BFF	GPIOG
	0x4002 1400 - 0x4002 17FF	GPIOF
	0x4002 1000 - 0x4002 13FF	GPIOE
	0X4002 0C00 - 0x4002 0FFF	GPIOD
	0x4002 0800 - 0x4002 0BFF	GPIOC
	0x4002 0400 - 0x4002 07FF	GPIOB
	0x4002 0000 - 0x4002 03FF	GPIOA

Figura 5: Mapeo de registros del giroscopio utilizado.

1.4 Diseño

Las capacidades del Discovery Kit STM32F429 y su perfecta integración se han reutilizado para evitar la necesidad de adaptar la electrónica al diseño. La pantalla LCD, los LED y los interruptores ya están integrados en la placa del chasis, por lo que no se requiere un diseño eléctrico de estos componentes para la creación de prototipos. Estos componentes ya están configurados y operativos en sus puntos de operación en coordinación con el microcontrolador, y el diseño posterior será para el modelo de trabajo, no para el prototipo. Lo único que hay que ajustar es medir el valor de la tensión analógica, de la que teóricamente se debe alimentar la comunicación USB. Por lo tanto, debe diseñarse con una batería de 9V. Dado que el voltaje máximo de las I/O utilizadas es de 5V, el divisor de voltaje está diseñado para que el voltaje leído en el pin cuando la batería esté en 9V sea:

$$V_{\text{out}} = \frac{R_2}{R_1 + R_2} \times V_{bat} = \frac{5K\Omega}{4K\Omega + 5K\Omega} \times 9 \text{ V} = 5 \text{ V} \tag{1}$$

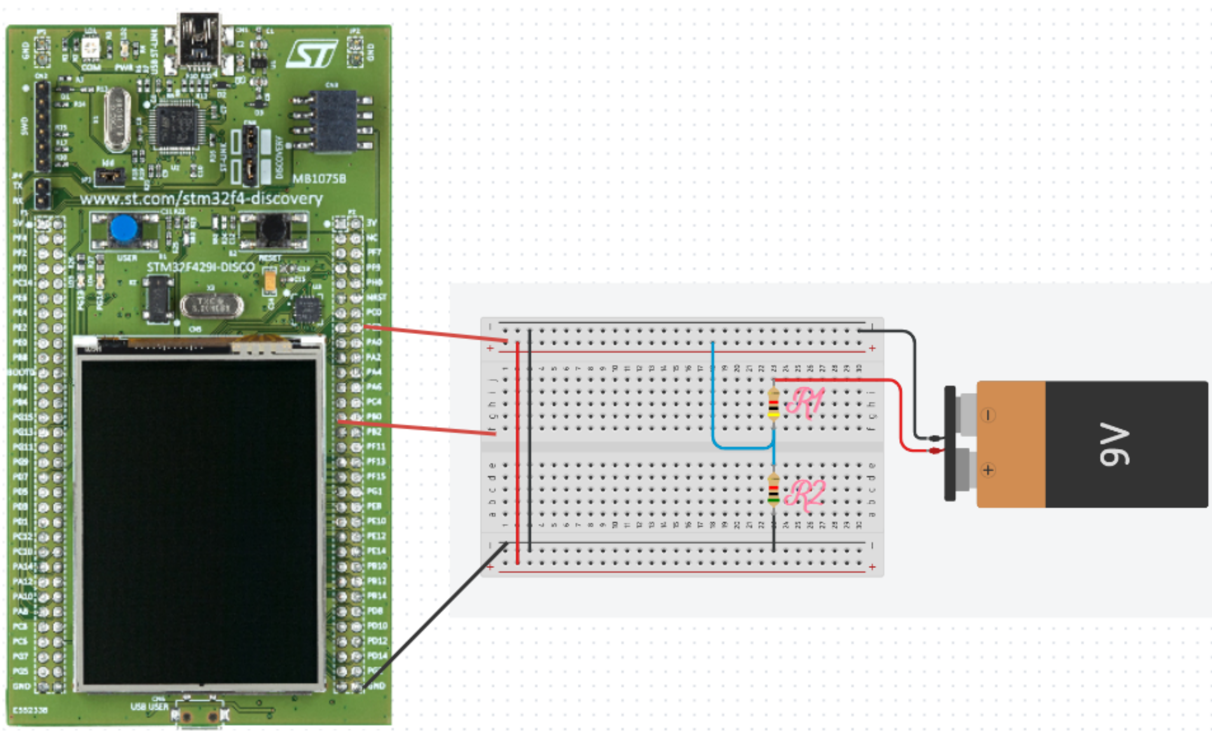


Figura 6: Esquemático final (Autoría propia).

1.5 Componentes complementarios

El proyecto se trata de un prototipo por lo que en su mayoría se utilizaron los componentes integrados en el STM32F429 Discovery kit. Es decir, el switch, la pantalla, y el led del proyecto son solamente ejemplos de cómo podría funcionar el sismógrafo completamente. Adicional a esto se conecto una batería externa para simular el comportamiento que tendría en el circuito y por lo mismo fue necesario utilizar resistores.

Componente	**Cantidad**	**Precio (USD)**
Resistores 1KΩ	10	1.6
Batería 9V	1	Batería 9V 1
STM32F429 Discovery kit	1	98.6
Total		**102.2**

Tabla 1: Lista de cantidad y precios de los componentes (Autoría propia).

1.6 Conceptos

1.6.1 IoT

Según las siglas inglesas ”Internet of Things”, Internet de las Cosas, si se puede incluir de alguna manera en la definición, incluyendo la conexión de objetos a través de una red, generalmente inalámbrica, donde interactúan sin el necesario humano. Intervención. ¡Pueden ser sensores, zapatos, ropa e incluso un lápiz! Esta idea implica la comunicación entre dos máquinas o M2M (máquina a máquina) y, por lo tanto, el aprendizaje automático. Utilice un microcontrolador conectado a Internet y cuando haya un estímulo de movimiento, como un terremoto, envíe sus aceleraciones reales como datos a Internet para que otro dispositivo las vea en cualquier parte del mundo, aprovechando la Internet de las cosas.

2 Desarrollo

2.1 Análisis de SW

2.1.1 Firmware

Para el desarrollo del firmware de este laboratorio, primeramente fue necesario configurar los pines del protocolo SPI que conectan microcontrolador STM32F429 con el giroscopio L3GD20 que trae integrado el Discovery kit. Para realizar esta configuración se tomaron como referencia las conexiones descritas en la figura 9.

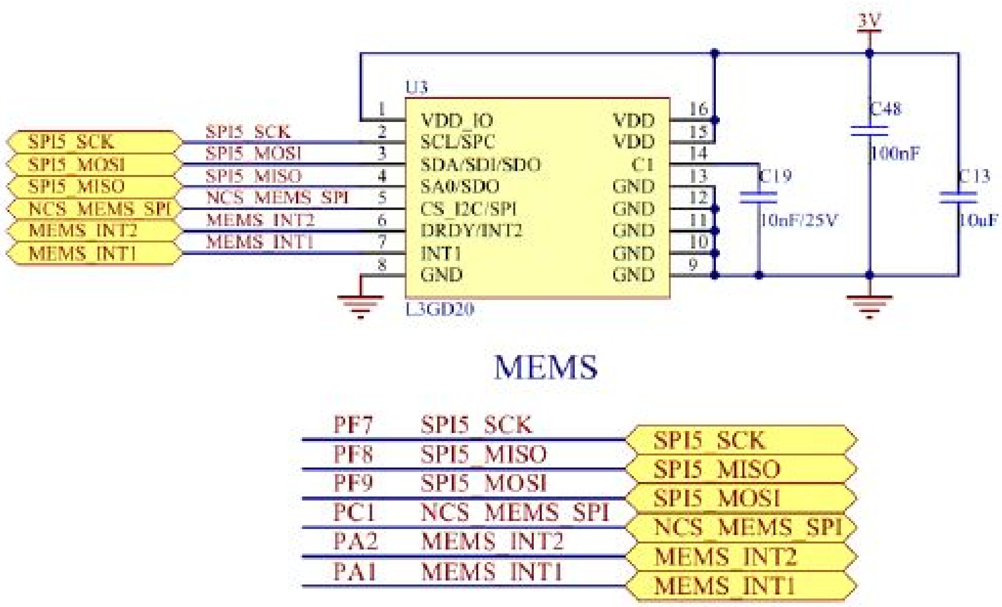


Figura 7: Conexión de pines entre el STM32F429 y el L3GD20.

En la figura anterior se puede ver que los pines SPI del giroscopio corresponden a los pines SPI5 del microcontrolador. También puede ver que la entrada CS del giroscopio está conectada al pin PC1, la entrada SCL al pin PF7 y las señales MOSI y MISO están conectadas a los pines PF8 y PF9 respectivamente. Al mismo tiempo, para establecer comunicación SPI entre el microcontrolador y el giroscopio, además de SPI5, se deben habilitar los pines de los puertos PC y PF. Para ello se utilizó la función de habilitación del reloj periférico rcc(). Por otro lado, el pin PC1 (CS) necesita ser controlado por el microcontrolador, en este caso el pin principal, por lo que se ha habilitado este pin como salida con el siguiente comando:

```
{gpio_mode_setup(GPIOC, GPIO_MODE_OUTPUT, GPIO_PUPD_NONE, GPIO1);
```

Por el contrario, los pines PF7 (SCK), PF8 (MISO) y PF9 (MOSI) son utilizados tanto por el giroscopio como el microcontrolador. Así que se habilitan en modo alternate function (AF) de la siguiente forma:

```
gpio_mode_setup(GPIOF, GPIO_MODE_AF, GPIO_PUPD_NONE, GPIO7 | GPIO8 | GPIO9);
```

Después de hacer esto, simplemente escriba CTRL REG1 y CTRL REG4 en los registros para habilitar la lectura de los registros que capturan cambios en los ejes individuales del giroscopio. Para establecer estos registros, se utiliza la función gpio clear() para establecer el estado en el pin PC1 (CS) y la dirección del registro se determina mediante la función spi send(). La respuesta se lee con spi read(), para después escribir los datos deseados de estos registros con otro spi send(), seguido de un spi read() para leer la respuesta. Este proceso termina al poner el pin PC1 (CS) en alto con gpio set(). Para leer los registros del giroscopio, primero configure el pin PC1 (CS) bajo usando la función gpio clear(). La dirección del registro que se va a leer se envía mediante spi send() y la respuesta se recibe mediante spi read(). Luego se envía cero usando spi send() y spi read() recibe la respuesta. La respuesta dada corresponde al valor de 8 bits del registro de lectura. Finalmente, el pin PC1 (CS) se restablece alto usando la función gpio set () Por ejemplo, aquí está el código para leer el registro bajo del giroscopio para el eje X (GYR OUT XL):

```
gpio_clear(GPIOC, GPIO1);
spi_send(SPI5, GYR_OUT_X_L | GYR_RNW);
spi_read(SPI5);
spi_send(SPI5, 0);
gyr_x=spi_read(SPI5);
gpio_set(GPIOC, GPIO1);
```

Luego, el valor inicial del eje del giroscopio se multiplica por la sensibilidad para obtener un valor de 500 dps. Finalmente, los valores leídos de cada eje se envían a través del puerto USB, a través del USART1 del microcontrolador, a través de la función print decimal(). Para habilitar y deshabilitar el envío de datos, se ha modificado la función decimal print() para bloquear el USUARIO (PA0) provocando permutaciones en el estado de comunicación. Esto significa que si se habilita la conexión y se presiona el botón especificado durante al menos un segundo, se interrumpirá el envío de datos. De lo contrario, si el envío de datos está deshabilitado y se presiona el botón, se restablecerá la conexión. Finalmente, se crea el método adc update() para medir el voltaje proporcionado por la batería, use la función read adc naiive() para leer la salida PA1:

```
void adc\_update(void){
battery = read_adc_naiive(1)*9/4095;
}
```

Como se puede observar en la porción de código anterior, la lectura devuelta por read adc naiive se multiplica por 9 y se divide entre 4095 para obtener el valor de tensión asociado. La función adc update se llama en cada ciclo de ejecuci´on para dar un valor actualizado de la batería. Además, si dicho valor es igual o menor a 7 se enciende el LED PG14 y se 1.

2.2 Análisis de HW

Ahora se analiza el circuito y sus elementos sensores para verificar su desempeño. Nuevamente, el funcionamiento del LED, el interruptor y la pantalla LCD depende del diseño del firmware, por lo que esta operación no se considera en el análisis del hardware. Por otro lado, la parte eléctrica a controlar debe actuar de la siguiente manera. Cuando la batería está a 7 voltios, se aplicarán 3,11 voltios al pin, que es un voltaje bajo cercano al límite mínimo de funcionamiento de la MCU. Durante este tiempo, el prototipo se quedará sin batería, el LED parpadeará y se enviará una notificación de batería baja a ThingsBoard. Los datos del giroscopio, los LED que se encienden para habilitar o deshabilitar la comunicación USART, los LED de advertencia de batería baja, los botones de alternancia y la pantalla LCD funcionan correctamente y no se encontraron fallas obvias en el laboratorio.

3 Git

GIT: https://github.com/OzmenCR/Laboratorio_microcontroladores/tree/main/Lab4/src/spi-gyro

4 Conclusiones y recomendaciones

- En esta práctica de laboratorio, los profesionales demostraron que el microcontrolador stm32 aplicado ofrece un alto rendimiento para aplicaciones exigentes. El resultado es una herramienta que puede ser extremadamente útil en aplicaciones de sistemas integrados del mundo real. Es lo suficientemente potente para aplicaciones del "mundo real", no solo académicas.

- El consumo de energía durante el funcionamiento es extremadamente bajo. En aplicaciones donde el consumo de energía es importante, este procesador es útil. Los practicantes llegaron a esta conclusión gracias a la aplicación recibida por la batería de energía.

- El laboratorio se concluyó con éxito. Cuando se trata de aplicaciones de IoT este microprocesador resulta una excelente opción. Se ha verificado su funcionamiento mediante la plataforma ThingsBoard, y el microcontrolador utilizado ha demostrado su eficacia independientemente de la influencia de factores humanos sobre estímulos externos, como terremotos.

Anexos

Anexo A

.1 STM Funcionando

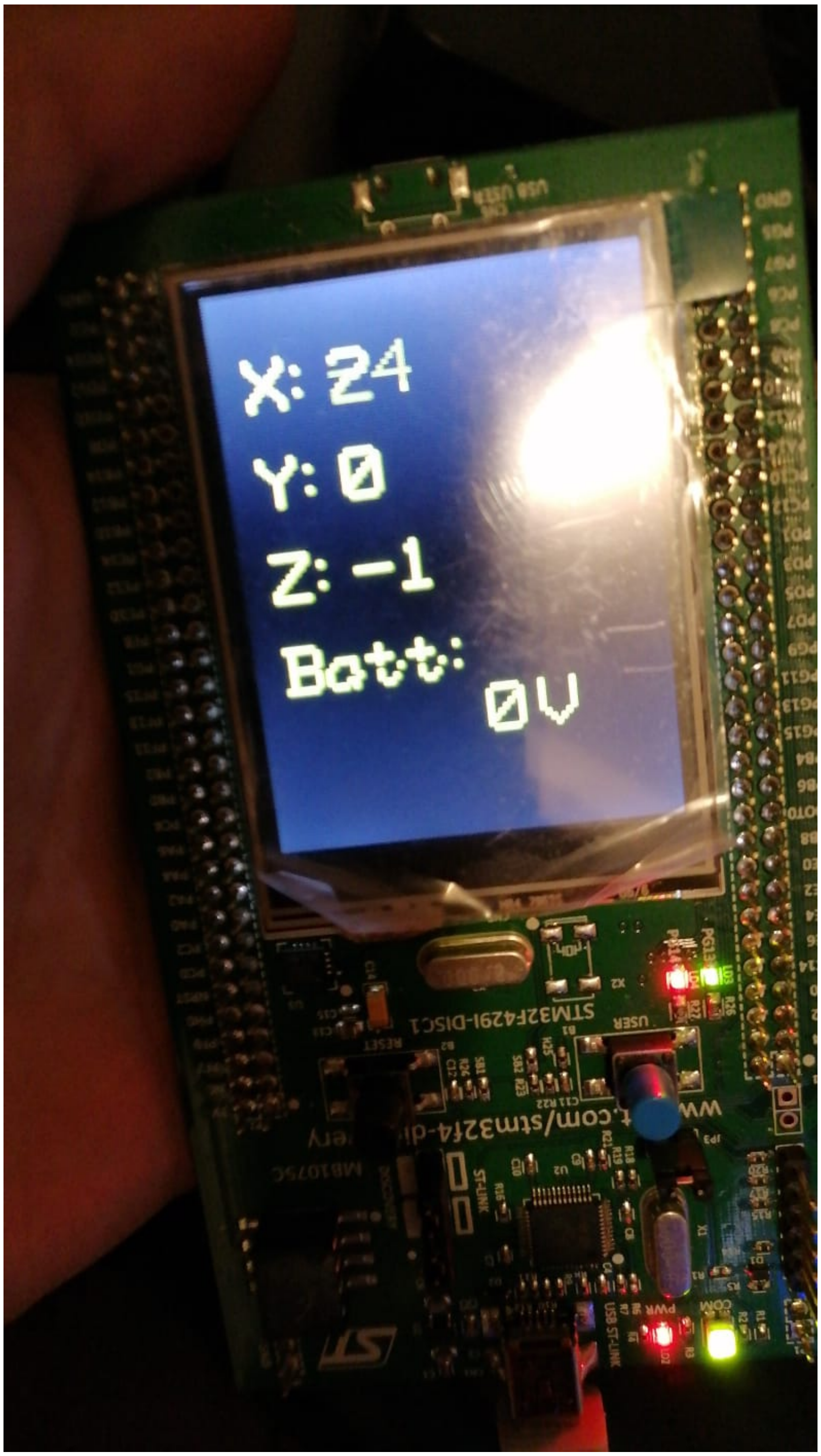


Figura 8: STM funcionando

Anexo B

.2 STM Funcionando

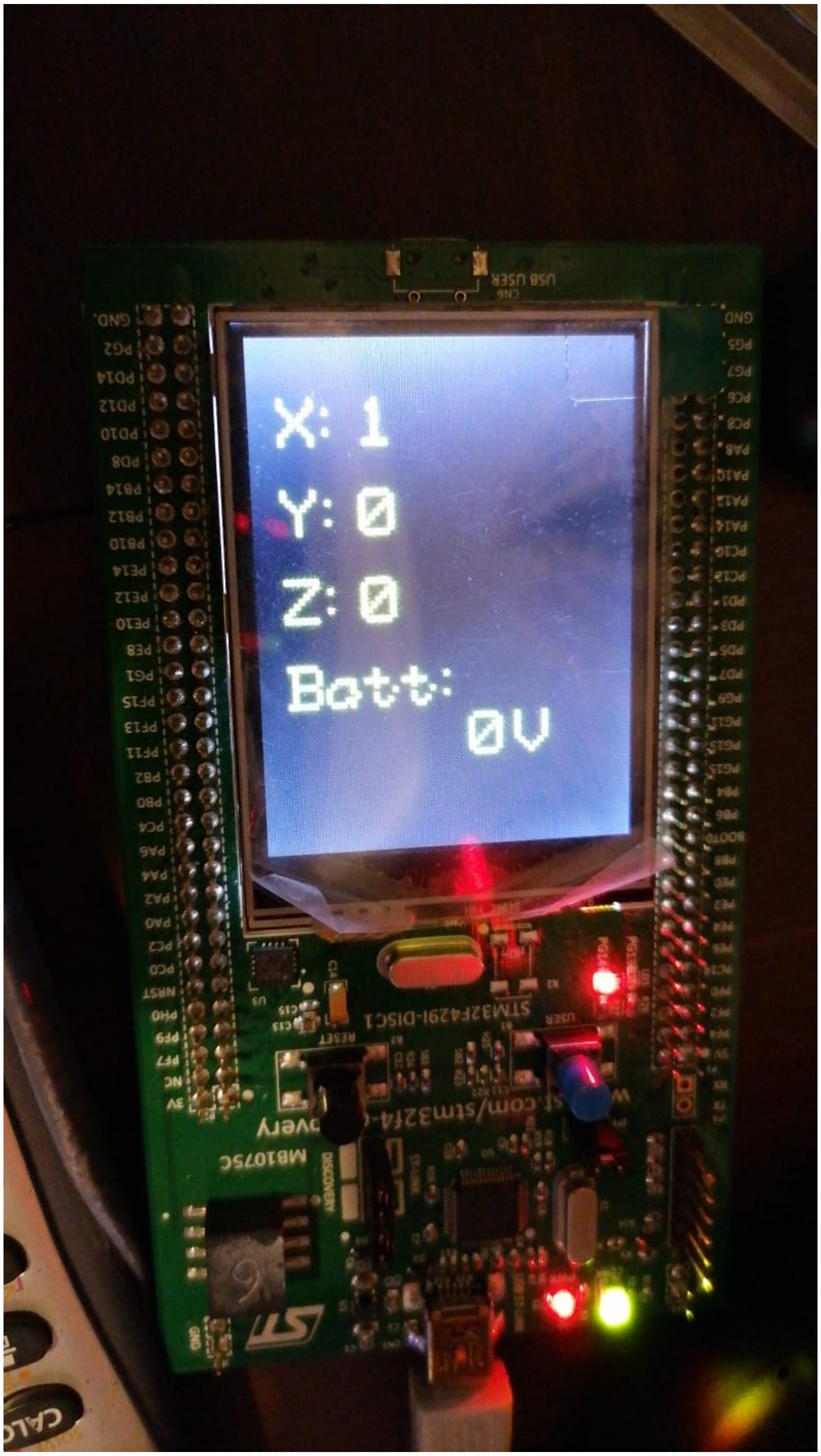


Figura 9: STM funcionando

Anexo C

Hoja de dato

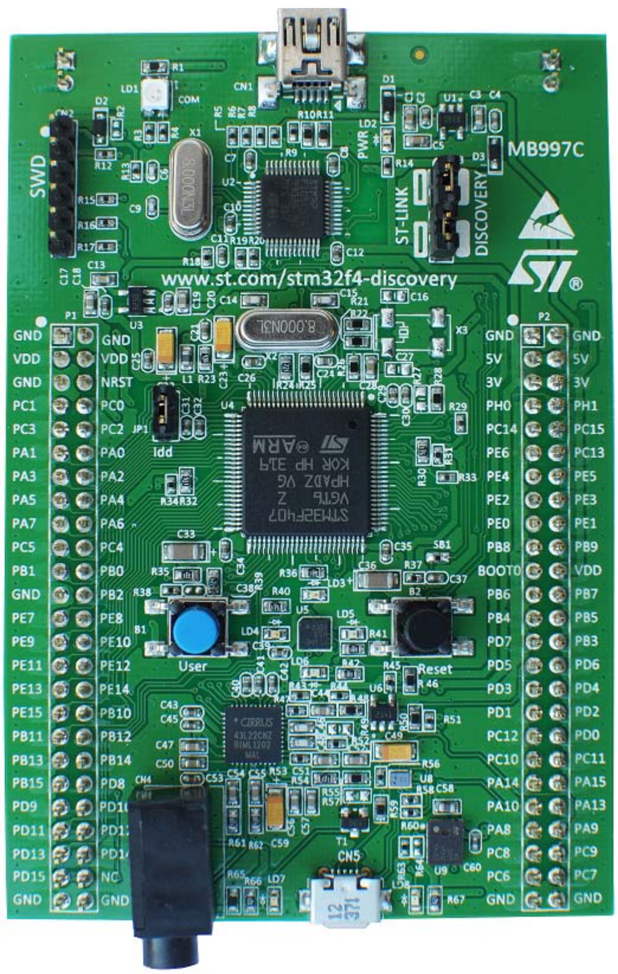
UM1472
User manual

Discovery kit for STM32F407/417 lines

Introduction

The STM32F4DISCOVERY helps you to discover the STM32F407 & STM32F417 lines' high-performance features and to develop your applications.
It is based on an STM32F407VGT6 and includes an ST-LINK/V2 embedded debug tool interface, ST MEMS digital accelerometer, ST MEMS digital microphone, audio DAC with integrated class D speaker driver, LEDs, pushbuttons and a USB OTG micro-AB connector.

Figure 1. STM32F4DISCOVERY



1. Picture not contractual

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1 Conventions

Table 1 provides the definition of some conventions used in the present document.

Table 1. ON/OFF conventions

Convention	Definition
Jumper JP1 ON	Jumper fitted
Jumper JP1 OFF	Jumper not fitted
Solder bridge SBx ON	SBx connections closed by solder
Solder bridge SBx OFF	SBx connections left open

2 Quick start

The STM32F4DISCOVERY is a low-cost and easy-to-use development kit to quickly evaluate and start a development with an STM32F4 high-performance microcontroller.

Before installing and using the product, please accept the Evaluation Product License Agreement from www.st.com/stm32f4-discovery.

For more information on the STM32F4DISCOVERY and for demonstration software, visit www.st.com/stm32f4-discovery.

2.1 Getting started

Follow the sequence below to configure the STM32F4DISCOVERY board and launch the DISCOVER application:

1. Check jumper position on the board, JP1 on, CN3 on (DISCOVERY selected).
2. Connect the STM32F4DISCOVERY board to a PC with a USB cable ‘type A to mini-B’ through USB connector CN1 to power the board. Red LED LD2 (PWR) then lights up.
3. Four LEDs between B1 and B2 buttons are blinking.
4. Press user button B1 to enable the ST MEMS sensor, move the board and observe the four LEDs blinking according to the motion direction and speed. (If you connect a second USB cable ‘type A to micro-B’ between PC and CN5 connector then the board is recognized as standard mouse and its motion will also control the PC cursor).
5. To study or modify the DISCOVER project related to this demo, visit www.st.com/stm32f4-discovery and follow the tutorial.
6. Discover the STM32F4 features, download and execute programs proposed in the list of projects.
7. Develop your own application using available examples.

2.2 System requirements

- Windows PC (XP, Vista, 7)
- USB type A to Mini-B USB cable

2.3 Development toolchain supporting the STM32F4DISCOVERY

- Altium, TASKING™ VX-Toolset
- Atollic TrueSTUDIO®
- IAR Embedded Workbench® for ARM (EWARM)
- Keil™, MDK-ARM

2.4 Order code

To order the STM32F4 high-performance discovery board, use the order code STM32F4DISCOVERY.

3 Features

The STM32F4DISCOVERY offers the following features:

- STM32F407VGT6 microcontroller featuring 1 MB of Flash memory, 192 KB of RAM in an LQFP100 package
- On-board ST-LINK/V2 with selection mode switch to use the kit as a standalone ST-LINK/V2 (with SWD connector for programming and debugging)
- Board power supply: through USB bus or from an external 5V supply voltage
- External application power supply: 3V and 5V
- LIS302DL or LIS3DSH, ST MEMS motion sensor, 3-axis digital output accelerometer
- MP45DT02, ST MEMS audio sensor, omnidirectional digital microphone
- CS43L22, audio DAC with integrated class D speaker driver
- Eight LEDs:
  - LD1 (red/green) for USB communication
  - LD2 (red) for 3.3V power on
  - Four user LEDs, LD3 (orange), LD4 (green), LD5 (red) and LD6 (blue)
  - 2 USB OTG LEDs LD7 (green) VBus and LD8 (red) over-current
- Two pushbuttons (user and reset)
- USB OTG with micro-AB connector
- Extension header for LQFP100 I/Os for quick connection to prototyping board and easy probing

4 Hardware and layout

The STM32F4DISCOVERY is designed around the STM32F407VGT6 microcontroller in a 100-pin LQFP package.

Figure 2 illustrates the connections between the STM32F407VGT6 and its peripherals (ST-LINK/V2, pushbutton, LED, Audio DAC, USB, ST MEMS accelerometer, ST MEMS microphone, and connectors).

Figure 3 and *Figure 4* help you to locate these features on the STM32F4DISCOVERY.

Figure 2. Hardware block diagram

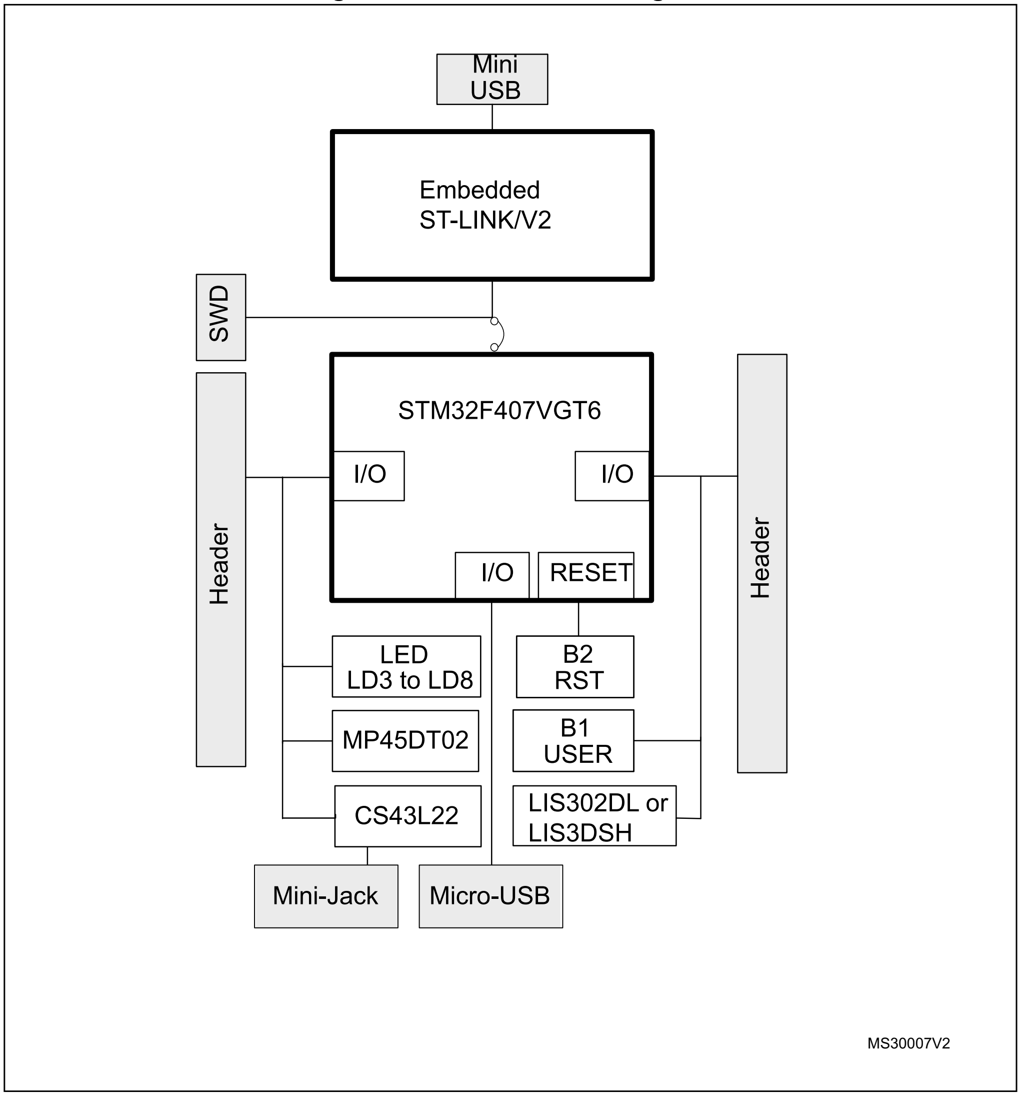
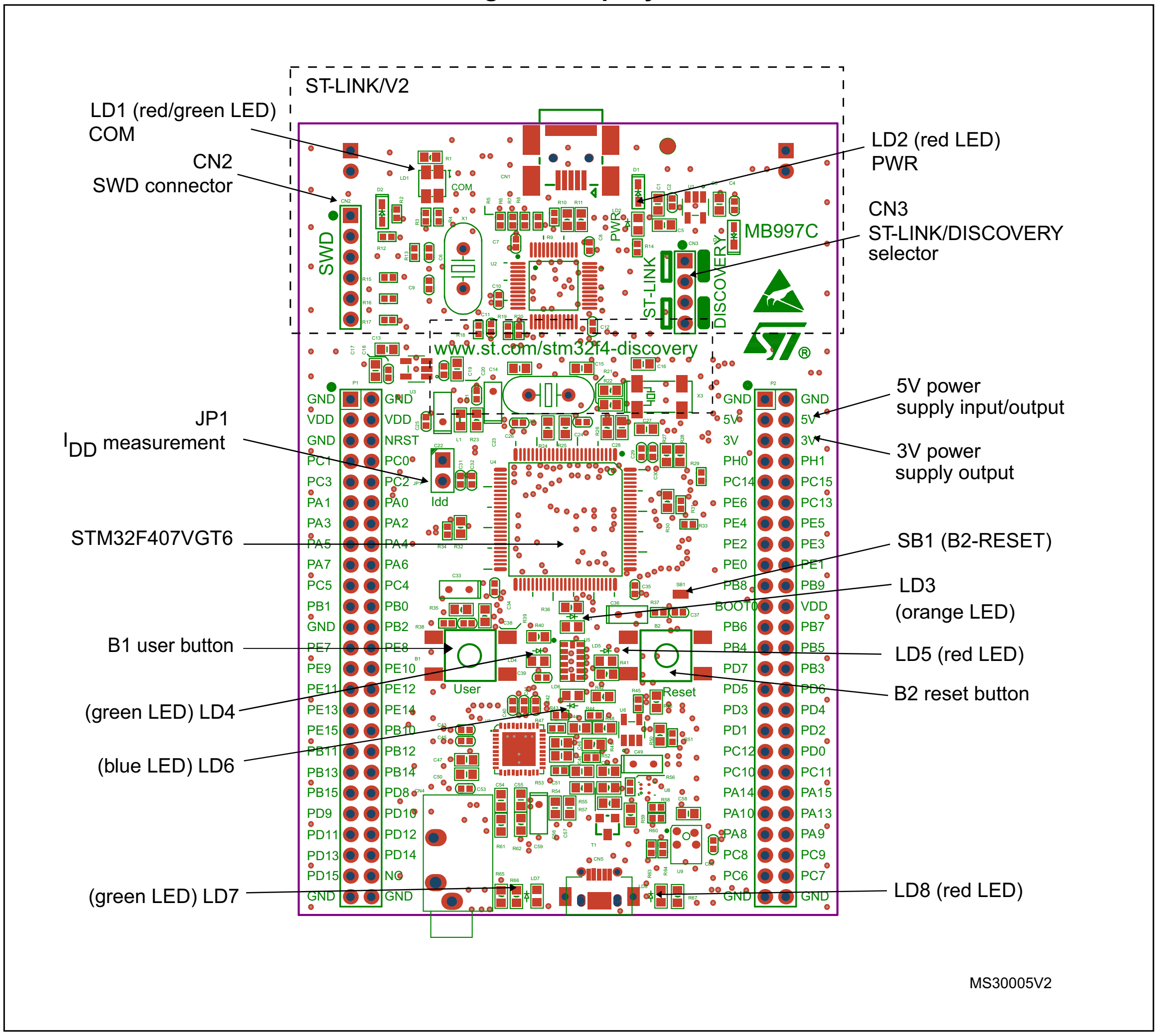
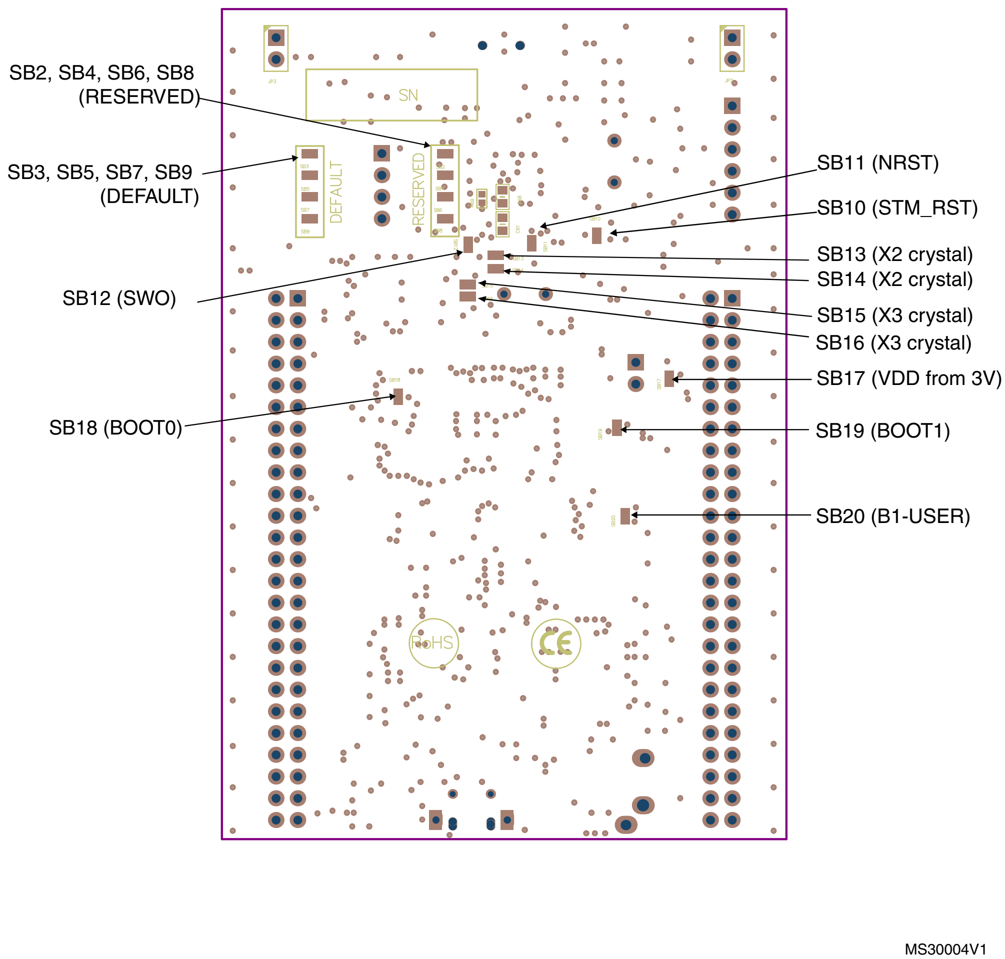


Figure 3. Top layout



Note: *Pin 1 of CN2, CN3, JP1, P1 and P2 connectors are identified by a square.*

Figure 4. Bottom layout



4.1 STM32F407VGT6 microcontroller

This ARM Cortex-M4 32-bit MCU with FPU has 210 DMIPS, up to 1 MB Flash/192+4 KB RAM, USB OTG HS/FS, Ethernet, 17 TIMs, 3 ADCs, 15 comm. interfaces and a camera.

Figure 5. STM32F407VGT6 package

STM32F407VGT6

1 Mbyte of Flash memory
192 Kbytes of RAM

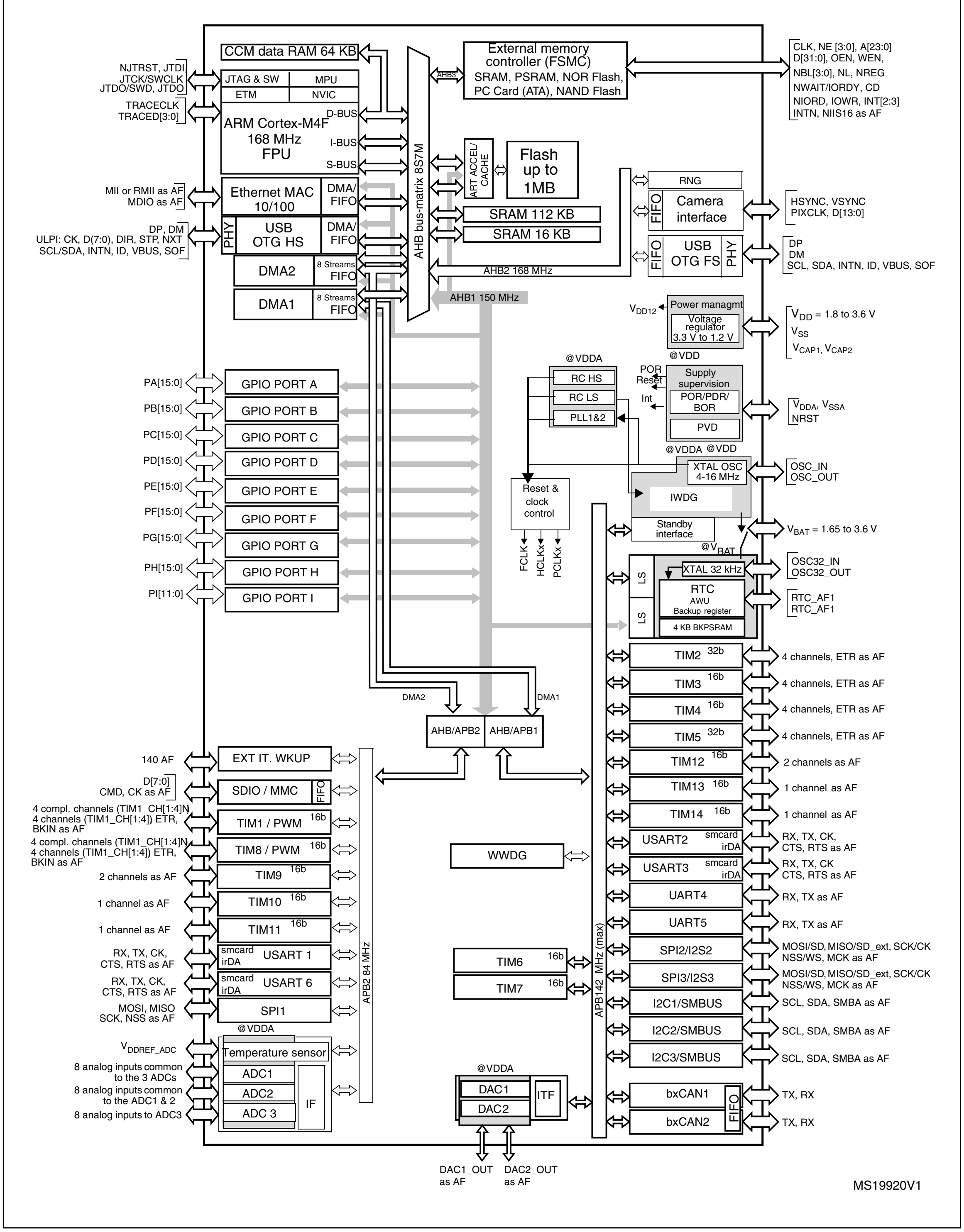
LQFP100 14 x 14 mm

MS30003V1

This device provides the following benefits.

- 168 MHz/210 DMIPS Cortex-M4 with single cycle DSP MAC and floating point unit providing:
  Boosted execution of control algorithms
  More features possible for your applications
  Ease of use
  Better code efficiency
  Faster time to market
  Elimination of scaling and saturation
  Easier support for meta-language tools
- Designed for high performance and ultra fast data transfers; ART Accelerator, 32-bit, 7-layer AHB bus matrix with 7 masters and 8 slaves including 2 blocks of SRAM, Multi DMA controllers: 2 general purpose, 1 for USB HS, 1 for Ethernet, One SRAM block dedicated to the core, providing performance equivalent to 0-wait execution from Flash Concurrent execution and data transfers and simplified resource allocation
- Outstanding power efficiency; Ultra-low dynamic power, RTC <1 µA typical in VBAT mode, 3.6 V down to 1.7 V VDD, Voltage regulator with power scaling capability, providing extra flexibility to reduce power consumption for applications requiring both high processing and low power performance when running at low voltage or on a rechargeable battery
- Maximum integration: Up to 1 Mbyte of on-chip Flash memory, 192 Kbytes of SRAM, reset circuit, internal RCs, PLLs, WLCSP package available, providing more features in space constrained applications
- Superior and innovative peripherals providing new possibilities to connect and communicate high speed data and more precision due to high resolution
- Extensive tools and software solutions providing a wide choice within the STM32 ecosystem to develop your applications.

Figure 6. STM32F407VGT6 block diagram



4.2 Embedded ST-LINK/V2

The ST-LINK/V2 programming and debugging tool is integrated on the STM32F4DISCOVERY. The embedded ST-LINK/V2 can be used in 2 different ways according to the jumper states (see *Table 2*):

- Program/debug the MCU on board,
- Program/debug an MCU in an external application board using a cable connected to SWD connector CN2.

The embedded ST-LINK/V2 supports only SWD for STM32 devices. For information about debugging and programming features refer to user manual UM1075 (*ST-LINK/V2 in-circuit debugger/programmer for STM8 and STM32*) which describes in detail all the ST-LINK/V2 features.

Figure 7. Typical configuration

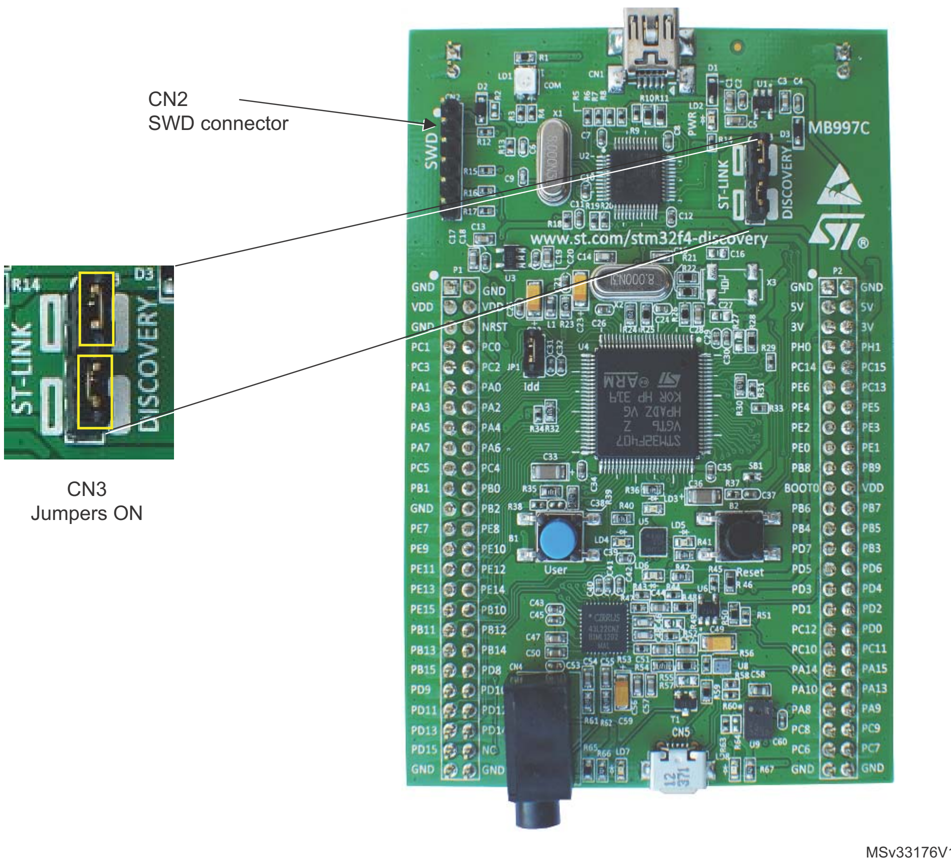
Table 2. Jumper states

Jumper state	Description
Both CN3 jumpers ON	ST-LINK/V2 functions enabled for on board programming (default)
Both CN3 jumpers OFF	ST-LINK/V2 functions enabled for application through external CN2 connector (SWD supported)

4.2.1 Using ST-LINK/V2 to program/debug the STM32F4 on board

To program the STM32F4 on board, simply plug in the two jumpers on CN3, as shown in *Figure 8* in red, but do not use the CN2 connector as that could disturb communication with the STM32F407VGT6 of the STM32F4DISCOVERY.

Figure 8. STM32F4DISCOVERY connections image



4.2.2 Using ST-LINK/V2 to program/debug an external STM32 application

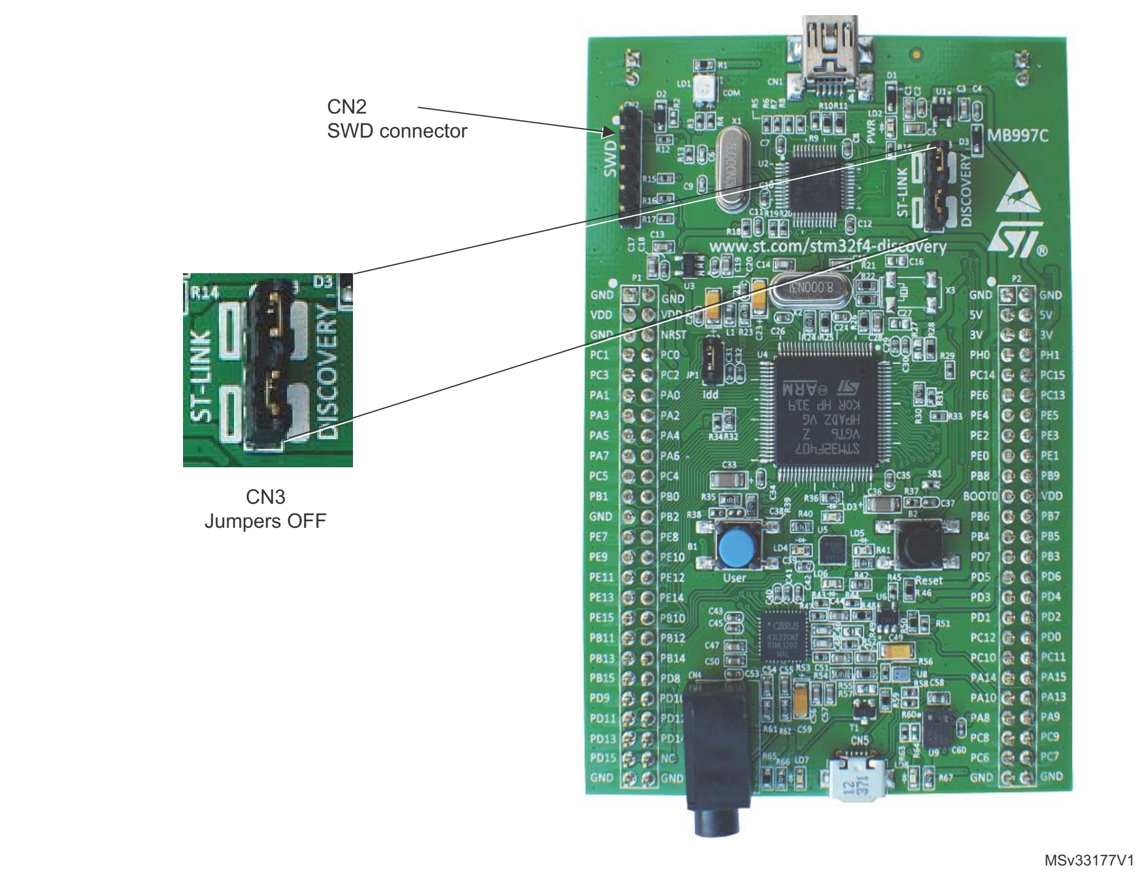
It is very easy to use the ST-LINK/V2 to program the STM32 on an external application. Simply remove the 2 jumpers from CN3 as shown in *Figure 9*, and connect your application to the CN2 debug connector according to *Table 3*.

Note: SB11 must be OFF if you use CN2 pin 5 in your external application.

Table 3. Debug connector CN2 (SWD)

Pin	CN2	Designation
1	VDD_TARGET	VDD from application
2	SWCLK	SWD clock
3	GND	Ground
4	SWDIO	SWD data input/output
5	NRST	RESET of target MCU
6	SWO	Reserved

Figure 9. ST-Link connections image



4.3 Power supply and power selection

The power supply is provided either by the host PC through the USB cable, or by an external 5V power supply.

The D1 and D2 diodes protect the 5V and 3V pins from external power supplies:

- 5V and 3V can be used as output power supplies when another application board is connected to pins P1 and P2.
  In this case, the 5V and 3V pins deliver a 5V or 3V power supply and power consumption must be lower than 100 mA.
- 5V can also be used as input power supplies e.g. when the USB connector is not connected to the PC.
  In this case, the STM32F4DISCOVERY board must be powered by a power supply unit or by auxiliary equipment complying with standard EN-60950-1: 2006+A11/2009, and must be Safety Extra Low Voltage (SELV) with limited power capability.

4.4 LEDs

- LD1 COM: LD1 default status is red. LD1 turns to green to indicate that communications are in progress between the PC and the ST-LINK/V2.
- LD2 PWR: red LED indicates that the board is powered.
- User LD3: orange LED is a user LED connected to the I/O PD13 of the STM32F407VGT6.
- User LD4: green LED is a user LED connected to the I/O PD12 of the STM32F407VGT6.
- User LD5: red LED is a user LED connected to the I/O PD14 of the STM32F407VGT6.
- User LD6: blue LED is a user LED connected to the I/O PD15 of the STM32F407VGT6.
- USB LD7: green LED indicates when VBUS is present on CN5 and is connected to PA9 of the STM32F407VGT6.
- USB LD8: red LED indicates an overcurrent from VBUS of CN5 and is connected to the I/O PD5 of the STM32F407VGT6.

4.5 Pushbuttons

- B1 USER: User and Wake-Up button connected to the I/O PA0 of the STM32F407VGT6.
- B2 RESET: Pushbutton connected to NRST is used to RESET the STM32F407VGT6.

4.6 On board audio capability

The STM32F4 uses an audio DAC (CS43L22) to output sounds through the audio mini jack connector.

The STM32F4 controls the audio DAC through the I2C interface and processes digital signals through I2S connection or analog input signal.

- The sound can come independently from different inputs:
  - ST MEMS microphone (MP45DT02): digital using PDM protocol or analog when using the low pass filter.
  - USB connector: from external mass storage such as a USB key, USB HDD, and so on.
  - Internal memory of the STM32F4.
- The sound can be output in different ways through audio DAC:
  - Using I2S protocol
  - Using the STM32F4 DAC to analog input AIN1x of the CS43L22
  - Using the microphone output directly via a low pass filter to analog input AIN4x of the CS43L22

4.7 USB OTG supported

The STM32F4 is used to drive only USB OTG full speed on this board. The USB micro-AB connector (CN5) allows the user to connect a host or device component, such as a USB key, mouse, and so on.

Two LEDs are dedicated to this module:

- LD7 (green LED) indicates when VBUS is active
- LD8 (red LED) indicates an overcurrent from connected device

4.8 Motion sensor (ST MEMS LIS302DL or LIS3DSH)

Two different versions of motion sensor (U5 in schematic) are available on the board depending the PCB version. The LIS302DL is present on board MB997B (PCB revision B) and the LIS3DSH is present on board MB997C (PCB rev C).

The LIS302DL or LIS3DSH are both an ultra compact low-power three-axis linear accelerometer.

It includes a sensing element and an IC interface able to provide the measured acceleration to the external world through I2C/SPI serial interface.

The LIS302DL has dynamically user selectable full scales of +-2g/+-8g and it is capable of measuring acceleration with an output rate of 100Hz to 400Hz.

The LIS3DSH has ±2g/±4g/±6g/±8g/±16g dynamically selectable full-scale and it is capable of measuring acceleration with an output data rate of 3.125 Hz to 1.6 kHz.

The STM32F4 controls this motion sensor through the SPI interface.

4.9 JP1 (Idd)

Jumper JP1, labeled Idd, allows the consumption of STM32F407VGT6 to be measured by removing the jumper and connecting an ammeter.

- Jumper on: STM32F407VGT6 is powered (default).
- Jumper off: an ammeter must be connected to measure the STM32F407VGT6 current, (if there is no ammeter, the STM32F407VGT6 is not powered).

4.10 OSC clock

4.10.1 OSC clock supply

If PH0 and PH1 are only used as GPIOs instead of as a clock, then SB13 and SB14 are closed and R24, R25 and R68 are removed.

- **MCO from ST-LINK**. From MCO of the STM32F103. This frequency cannot be changed, it is fixed at 8 MHz and connected to PH0-OSC_IN of the STM32F407VGT6. Configuration needed:
  - SB13, SB14 OPEN
  - R25[a] removed
  - R68[a] soldered
- **Oscillator onboard**. From X2 crystal. For typical frequencies and its capacitors and resistors, please refer to the STM32F407VGT6 Datasheet. Configuration needed:
  - SB13, SB14 OPEN
  - R25[a] soldered
  - R68[a] removed
- **Oscillator from external PH0**. From external oscillator through pin 7 of the P2 connector. Configuration needed:
  - SB13 closed
  - SB14 closed
  - R25 and R68 removed

4.10.2 OSC 32 KHz clock supply

If PC14 and PC15 are only used as GPIOs instead of as a clock, then SB15 and SB16 are closed, and R21 and R22 are removed.

- **Oscillator onboard**. From X1 Crystal (not provided). Configuration needed:
  - SB15, SB16 OPEN
  - C16, C27, R21 and R22 soldered.
- **Oscillator from external PC14**. From external oscillator trough the pin 9 of P2 connector. Configuration needed:
  - SB16 closed
  - SB15 closed
  - R21 and R22 removed

a. As the frequency supplied by X2 is the same as MCO (8 MHz) R25 and R68 are soldered.

4.11 Solder bridges

Table 4. Solder bridges

Bridge	State(1)	Description
SB13,14 (X2 crystal)(2)	**OFF**	X2, C14, C15, R24 and R25 provide a clock. PH0, PH1 are disconnected from P2.
	ON	PH0, PH1 are connected to P2 (R24, R25 and R68 must not be fitted).
SB3,5,7,9 (Default)	**ON**	Reserved, do not modify.
SB2,4,6,8 (Reserved)	**OFF**	Reserved, do not modify.
SB15,16 (X3 crystal)	**OFF**	X3, C16, C27, R21 and R22 deliver a 32 KHz clock. PC14, PC15 are not connected to P2.
	ON	PC14, PC15 are only connected to P2. Remove only R21, R22
SB1 (B2-RESET)	**ON**	B2 pushbutton is connected to the NRST pin of the STM32F407VGT6 MCU.
	OFF	B2 pushbutton is not connected the NRST pin of the STM32F407VGT6 MCU.
SB20 (B1-USER)	**ON**	B1 pushbutton is connected to PA0.
	OFF	B1 pushbutton is not connected to PA0.
SB17 (VDD powered from 3V)	**OFF**	VDD is not powered from 3V, depends on JP1 jumper.
	ON	VDD is permanently powered from 3V, JP1 jumper has no effect.
SB11 (NRST)	**ON**	NRST signal of the CN2 connector is connected to the NRST pin of the STM32F407VGT6 MCU.
	OFF	NRST signal of the CN2 connector is not connected to the NRST pin of the STM32F407VGT6 MCU.
SB12 (SWO)	**ON**	SWO signal of the CN2 connector is connected to PB3.
	OFF	SWO signal is not connected.
SB10 (STM_RST)	**OFF**	No incidence on STM32F103C8T6 (ST-LINK/V2) NRST signal.
	ON	STM32F103C8T6 (ST-LINK/V2) NRST signal is connected to GND.
SB18 (BOOT0)	**ON**	BOOT0 signal of the STM32F407VGT6 MCU is held low through a 510 ohm pull-down resistor.
	OFF	BOOT0 signal of the STM32F407VGT6 MCU is held high through a 10 Kohm pull-up resistor.
SB19 (BOOT1)	**OFF**	The BOOT1 signal of the STM32F407VGT6 MCU is held high through a 10 Kohm pull-up resistor.
	ON	The BOOT1 signal of the STM32F407VGT6 MCU is held low through a 510 ohm pull-down resistor.

1. Default SBx state is shown in bold.
2. SB13 and SB14 are OFF to allow the user to choose between MCO and X2 crystal for clock source.

4.12 Extension connectors

The male headers P1 and P2 can connect the STM32F4DISCOVERY to a standard prototyping/wrapping board. STM32F407VGT6 GPI/Os are available on these connectors. P1 and P2 can also be probed by an oscilloscope, logical analyzer or voltmeter.

Table 5. MCU pin description versus board function

MCU pin			Board function														
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
BOOT0	VPP	94	-	-	-	-	-	-	-	-	-	-	-	-	-	21
NRST	-	14	-	-	-	RESET	-	NRST	-	-	-	-	-	5	6	-
PA0-WKUP	USART2_CTS/ USART4_TX/ ETH_MII_CRS/ TIM2_CH1_ETR/ TIM5_CH1/ TIM8_ETR/ ADC123_IN0/ WKUP	23	-	-	-	USER	-	-	-	-	-	-	-	-	12	-
PA1	USART2_RTS/ USART4_RX/ ETH_RMII_REF_CLK/ ETH_MII_RX_CLK/ TIM5_CH2/ TIMM2_CH2/ ADC123_IN1	24	-	-	-	-	-	-	-	-	-	-	-	-	11	-
PA2	USART2_TX/ TIM5_CH3/ TIM9_CH1/ TIM2_CH3/ ETH_MDIO/ ADC123_IN2	25	-	-	-	-	-	-	-	-	-	-	-	-	14	-

Table 5. MCU pin description versus board function (continued)

MCU pin			Board function														
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
PA3	USART2_RX/ TIM5_CH4/ TIM9_CH2/ TIM2_CH4/ OTG_HS_ULPI_D0/ ETH_MII_COL/ ADC123_IN3	26	-	-	-	-	-	-	-	-	-	-	-	-	13	-
PA4	SPI1_NSS/ SPI3_NSS/ USART2_CK/ DCMI_HSYNC/ OTG_HS_SOF/ I2S3_WS/ ADC12_IN4/ DAC1_OUT	29	LRCK/AIN1x	-	-	-	-	-	-	-	-	-	-	-	16	-
PA5	SPI1_SCK/ OTG_HS_ULPI_CK/ TIM2_CH1_ETR/ TIM8_CHIN/ ADC12_IN5/ DAC2_OUT	30	-	-	SCL/SPC	-	-	-	-	-	-	-	-	-	15	-
PA6	SPI1_MISO/ TIM8_BKIN/ TIM13_CH1/ DCMI_PIXCLK/ TIM3_CH1/ TIM1_BKIN/ ADC12_IN6	31	-	-	SDO	-	-	-	-	-	-	-	-	-	18	-
PA7	SPI1_MOSI/ TIM8_CH1N/ TIM14_CH1TIM3_CH2/ ETH_MII_RX_DV/ TIM1_CH1N/ RMII_CRS_DV/ ADC12_IN7	32	-	-	SDA/SDI/SDO	-	-	-	-	-	-	-	-	-	17	-

Table 5. MCU pin description versus board function (continued)

MCU pin			Board function														
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
PA8	MCO1/ USART1_CK/ TIM1_CH1/ I2C3_SCL/ OTG_FS_SOF	67	-	-	-	-	-	-	-	-	-	-	-	-	-	43
PA9	USART1_TX/ TIM1_CH2/ I2C3_SMBA/ DCMI_D0/ OTG_FS_VBUS	68	-	-	-	-	GREEN	-	VBUS	-	-	-	1	-	-	44
PA10	USART1_RX/ TIM1_CH3/ OTG_FS_ID/ DCMI_D1	69	-	-	-	-	-	-	ID	-	-	-	4	-	-	41
PA11	USART1_CTS/ CAN1_RX/ TIM1_CH4/ OTG_FS_DM	70	-	-	-	-	-	-	DM	-	-	-	2	-	-	-
PA12	USART1_RTS/ CAN1_TX/ TIM1_ETR/ OTG_FS_DP	71	-	-	-	-	-	-	DP	-	-	-	3	-	-	-
PA13	JTMS-SWDIO	72	-	-	-	-	-	SWDIO	-	-	-	-	-	4	-	42
PA14	JTCK-SWCLK	76	-	-	-	-	-	SWCLK	-	-	-	-	-	2	-	39
PA15	JTDI/ SPI3_NSS/ I2S3_WS/ TIM2_CH1_ETR/ SPI1_NSS	77	-	-	-	-	-	-	-	-	-	-	-	-	-	40

Table 5. MCU pin description versus board function (continued)

MCU pin			Board function													
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
PB0	TIM3_CH3/ TIM8_CH2N/ OTG_HS_ULPI_D1/ ETH_MII_RXD2/ TIM1_CH2N/ ADC12_IN8	35	-	-	-	-	-	-	-	-	-	-	-	-	22	-
PB1	TIM3_CH4/ TIM8_CH3N/ OTG_HS_ULPI_D2/ ETH_MII_RXD3/ OTG_HS_INTN/ TIM1_CH3N/ ADC12_IN9	36	-	-	-	-	-	-	-	-	-	-	-	-	21	-
PB2	-	37	-	-	-	-	-	-	-	-	-	-	-	-	24	-
PB3	JTDO/ TRACESWO/ SPI3_SCK/ I2S3_CK/ TIM2_CH2/ SPI1_SCK	89	-	-	-	-	-	SWO	-	-	-	-	-	6		28
PB4	NJTRST/ SPI3_MISO/ TIM3_CH1/ SPI1_MISO/ I2S3ext_SD	90	-	-	-	-	-	-	-	-	-	-	-	-	-	25
PB5	I2C1_SMBA/ CAN2_RX/ OTG_HS_ULPI_D7/ ETH_PPS_OUT/ TIM3_CH2/ SPI1_MOSI/ SPI3_MOSI/ DCMI_D10/ I2S3_SD	91	-	-	-	-	-	-	-	-	-	-	-	-	-	26

Table 5. MCU pin description versus board function (continued)

MCU pin			Board function													
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
PB6	I2C1_SCL/ TIM4_CH1/ CAN2_TX/ OTG_FS_INTN/ DCMI_D5/ USART1_TX	92	SCL	-	-	-	-	-	-	-	-	-	-	-	-	23
PB7	I2C1_SDA/ FSMC_NL/ DCMI_VSYNC/ USART1_RX/ TIM4_CH2	93	-	-	-	-	-	-	-	-	-	-	-	-		24
PB8	TIM4_CH3/ SDIO_D4/ TIM10_CH1/ DCMI_D6/ OTG_FS_SCL/ ETH_MII_TXD3/ I2C1_SCL/ CAN1_RX	95	-	-	-	-	-	-	-	-	-	-	-	-	-	19
PB9	SPI2_NSS/ I2S2_WS/ TIM4_CH4/ TIM11_CH1/ OTG_FS_SDA/ SDIO_D5/ DCMI_D7/ I2C1_SDA/ CAN1_TX	96	SDA	-	-	-	-	-	-	-	-	-	-	-	-	20
PB10	SPI2_SCK/ I2S2_CK/ I2C2_SCL/ USART3_TX/ OTG_HS_ULPI_D3/ ETH_MII_RX_ER/ OTG_HS_SCL/ TIM2_CH3	47	-	CLK	-	-	-	-	-	-	-	-	-	-	34	-

Table 5. MCU pin description versus board function (continued)

MCU pin			Board function														
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
PB11	I2C2_SDA/ USART3_RX/ OTG_HS_ULPI_D4/ ETH_RMII_TX_EN/ ETH_MII_TX_EN/ OTG_HS_SDA/ TIM2_CH4	48	-	-	-	-	-	-	-	-	-	-	-	-	35	-
PB12	SPI2_NSS/ I2S2_WS/ I2C2_SMBA/ USART3_CK/ TIM1_BKIN/ CAN2_RX/ OTG_HS_ULPI_D5/ ETH_RMII_TXD0/ ETH_MII_TXD0/ OTG_HS_ID	51	-	-	-	-	-	-	-	-	-	-	-	-	36	-
PB13	SPI2_SCK/ I2S2_CK/ USART3_CTS/ TIM1_CH1N/ CAN2_TX/ OTG_HS_ULPI_D6/ ETH_RMII_TXD1/ ETH_MII_TXD1/ OTG_HS_VBUS	52	-	-	-	-	-	-	-	-	-	-	-	-	37	-
PB14	SPI2_MISO/ TIM1_CH2N/ TIM12_CH1/ OTG_HS_DMUSART3 _RTS/ TIM8_CH2N/ I2S2ext_SD	53	-	-	-	-	-	-	-	-	-	-	-	-	38	-

Table 5. MCU pin description versus board function (continued)

MCU pin			Board function														
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
PB15	SPI2_MOSI/ I2S2_SD/ TIM1_CH3N/ TIM8_CH3N/ TIM12_CH2/ OTG_HS_DP	54	-	-	-	-	-	-	-	-	-	-	-	-	39	-
PC0	OTG_HS_ULPI_STP/ ADC123_IN10	15	-	-	-	-	-	-	PowerOn	-	-	-	-	-	8	-
PC1	ETH_MDC/ ADC123_IN11	16	-	-	-	-	-	-	-	-	-	-	-	-	7	-
PC2	SPI2_MISO/ OTG_HS_ULPI_DIR/ TH_MII_TXD2/ I2S2ext_SD/ ADC123_IN12	17	-	-	-	-	-	-	-	-	-	-	-	-	10	-
PC3	SPI2_MOSI/ I2S2_SD/ OTG_HS_ULPI_NXT/ ETH_MII_TX_CLK/ ADC123_IN13	18	-	DOUT/AIN4x	-	-	-	-	-	-	-	-	-	-	9	-
PC4	ETH_RMII_RX_D0/ ETH_MII_RX_D0/ ADC12_IN14	33	-	-	-	-	-	-	-	-	-	-	-	-	20	-
PC5	ETH_RMII_RX_D1/ ETH_MII_RX_D1/ ADC12_IN15	34	-	-	-	-	-	-	-	-	-	-	-	-	19	-
PC6	I2S2_MCK/ TIM8_CH1/ SDIO_D6/ USART6_TX/ DCMI_D0/ TIM3_CH1	63	-	-	-	-	-	-	-	-	-	-	-	-	-	47

Table 5. MCU pin description versus board function (continued)

MCU pin			Board function														
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
PC7	I2S3_MCK/ TIM8_CH2/ SDIO_D7/ USART6_RX/ DCMI_D1/ TIM3_CH2	64	MCLK	-	-	-	-	-	-	-	-	-	-	-	-	48
PC8	TIM8_CH3/ SDIO_D0/ TIM3_CH3/ USART6_CK/ DCMI_D2	65	-	-	-	-	-	-	-	-	-	-	-	-	-	45
PC9	I2S_CKIN/ MCO2/ TIM8_CH4/ SDIO_D1/ I2C3_SDA/ DCMI_D3/ TIM3_CH4	66	-	-	-	-	-	-	-	-	-	-	-	-	-	46
PC10	SPI3_SCK/ I2S3_CK/ UART4_TX/ SDIO_D2/ DCMI_D8/ USART3_TX	78	SCLK	-	-	-	-	-	-	-	-	-	-	-	-	37
PC11	UART4_RX/ SPI3_MISO/ SDIO_D3/ DCMI_D4/ USART3_RX/ I2S3ext_SD	79	-	-	-	-	-	-	-	-	-	-	-	-	-	38
PC12	UART5_TX/ SDIO_CK/ DCMI_D9/ SPI3_MOSI/ I2S3_SD/ USART3_CK	80	SDIN	-	-	-	-	-	-	-	-	-	-	-	-	35

Table 5. MCU pin description versus board function (continued)

MCU pin			Board function													
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
PC13	RTC_AF1	7	-	-	-	-	-	-	-	-	-	-	-	-	-	12
PC14	OSC32_IN	8	-	-	-	-	-	-	-	OSC32_IN	-	-	-	-	-	9
PC15	OSC32_OUT	9	-	-	-	-	-	-	-	OSC32_OUT	-	-	-	-	-	10
PD0	FSMC_D2/ CAN1_RX	81	-	-	-	-	-	-	-	-		-	-	-	-	36
PD1	FSMC_D3/ CAN1_TX	82	-	-	-	-	-	-	-	-	-	-	-	-	-	33
PD2	TIM3_ETR/ UART5_RXSDIO_CMD / DCMI_D11	83	-	-	-	-	-	-	-	-	-	-	-	-	-	34
PD3	FSMC_CLK/ USART2_CTS	84	-	-	-	-	-	-	-	-	-	-	-	-	-	31
PD4	FSMC_NOE/ USART2_RTS	85	RESET	-	-	-	-	-	-	-	-	-	-	-	-	32
PD5	FSMC_NWE/ USART2_TX	86	-	-	-	-	RED	-	OverCurrent	-	-	-	-	-	-	29
PD6	FSMC_NWAIT/ USART2_RX	87	-	-	-	-	-	-	-	-	-	-	-	-	-	30
PD7	USART2_CK/ FSMC_NE1/ FSMC_NCE2	88	-	-	-	-	-	-	-	-	-	-	-	-	-	27

Table 5. MCU pin description versus board function (continued)

MCU pin			Board function													
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
PD8	FSMC_D13/ USART3_TX	55	-	-	-	-	-	-	-	-	-	-	-	-	40	-
PD9	FSMC_D14/ USART3_RX	56	-	-	-	-	-	-	-	-	-	-	-	-	41	-
PD10	FSMC_D15/ USART3_CK	57	-	-	-	-	-	-	-	-	-	-	-	-	42	-
PD11	FSMC_A16/ USART3_CTS	58	-	-	-	-	-	-	-	-	-	-	-	-	43	-
PD12	FSMC_A17/ TIM4_CH1/ USART3_RTS	59	-	-	-	-	GREEN	-	-	-	-	-	-	-	44	-
PD13	FSMC_A18/ TIM4_CH2	60	-	-	-	-	ORANGE	-	-	-	-	-	-	-	45	-
PD14	FSMC_D0/ TIM4_CH3	61	-	-	-	-	RED	-	-	-	-	-	-	-	46	-
PD15	FSMC_D1/ TIM4_CH4	62	-	-	-	-	BLUE	-	-	-	-	-	-	-	47	-
PE0	TIM4_ETR/ FSMC_NBL0/ DCMI_D2	97	-	-	INT1	-	-	-	-	-	-	-	-	-	-	17
PE1	FSMC_NBL1/ DCMI_D3	98	-	-	INT2	-	-	-	-	-	-	-	-	-	-	18
PE2	TRACECLK/ FSMC_A23/ ETH_MII_TXD3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	15
PE3	TRACED0/ FSMC_A19	2	-	-	CS_I2C/SPI	-	-	-	-	-	-	-	-	-	-	16

Table 5. MCU pin description versus board function (continued)

MCU pin			Board function														
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
PE4	TRACED1/ FSMC_A20/ DCMI_D4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	13
PE5	TRACED2/ FSMC_A21/ TIM9_CH1/ DCMI_D6	4	-	-	-	-	-	-	-	-	-	-	-	-	-	14
PE6	TRACED3/ FSMC_A22/ TIM9_CH2/ DCMI_D7	5	-	-	-	-	-	-	-	-	-	-	-	-	-	11
PE7	FSMC_D4/ TIM1_ETR	38	-	-	-	-	-	-	-	-	-	-	-	-	25	-
PE8	FSMC_D5/ TIM1_CH1N	39	-	-	-	-	-	-	-	-	-	-	-	-	26	-
PE9	FSMC_D6/ TIM1_CH1	40	-	-	-	-	-	-	-	-	-	-	-	-	27	-
PE10	FSMC_D7/ TIM1_CH2N	41	-	-	-	-	-	-	-	-	-	-	-	-	28	-
PE11	FSMC_D8/ TIM1_CH2	42	-	-	-	-	-	-	-	-	-	-	-	-	29	-
PE12	FSMC_D9/ TIM1_CH3N	43	-	-	-	-	-	-	-	-	-	-	-	-	30	-
PE13	FSMC_D10/ TIM1_CH3	44	-	-	-	-	-	-	-	-	-	-	-	-	31	-
PE14	FSMC_D11/ TIM1_CH4	45	-	-	-	-	-	-	-	-	-	-	-	-	32	-
PE15	FSMC_D12/ TIM1_BKIN	46	-	-	-	-	-	-	-	-	-	-	-	-	33	-
PH0	OSC_IN	12	-	-	-	-	-	-	-	OSC_IN	-	-	-	-	-	7

Table 5. MCU pin description versus board function (continued)

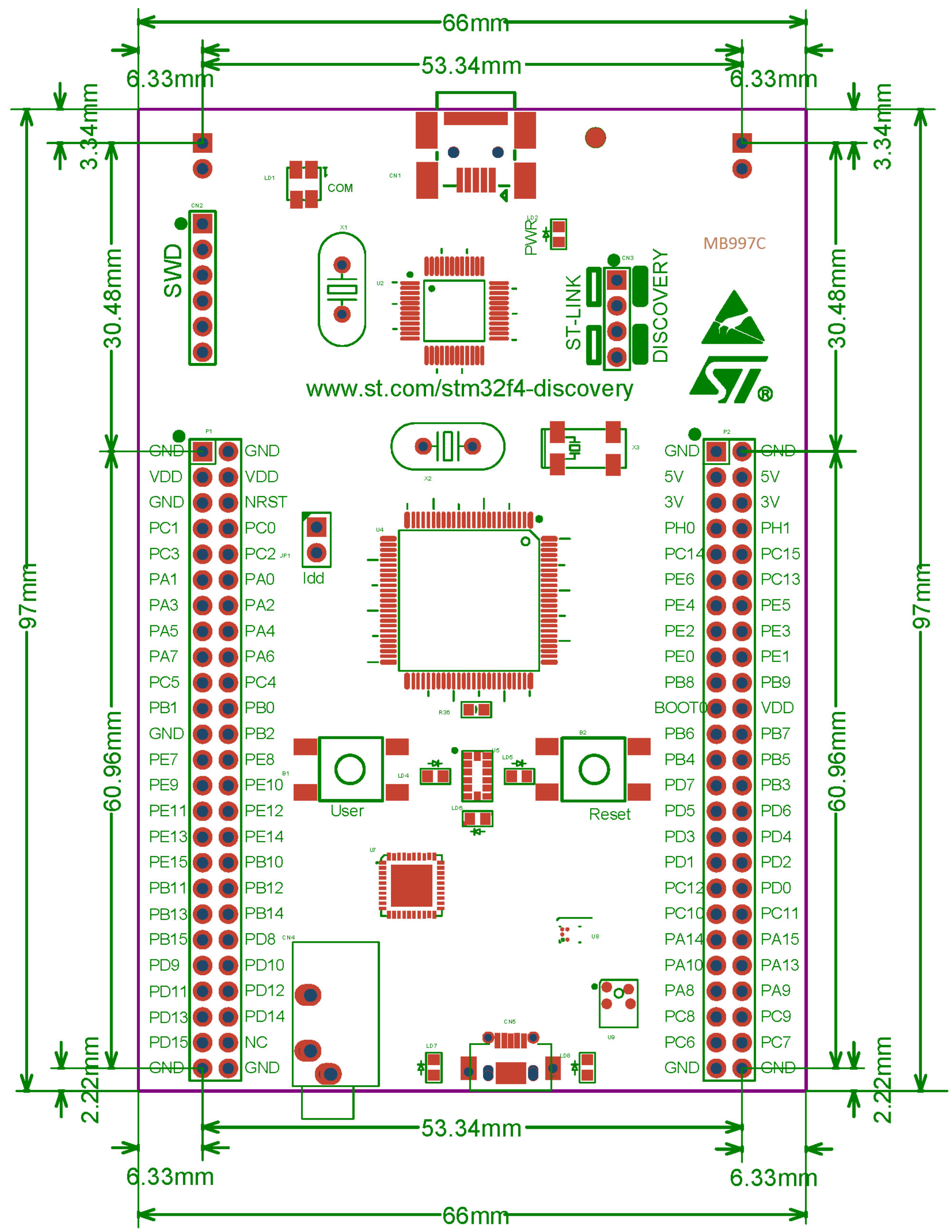
MCU pin			Board function													
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
PH1	OSC_OUT	13	-	-	-	-	-	-	-	OSC_OUT	-	-	-	-	-	8
-	-	-	-	-	-	-	-	-	-	-	-	5V	-	-	-	3
-	-	-	-	-	-	-	-	-	-	-	-	5V	-	-	-	4
-	-	-	-	-	-	-	-	-	-	-	-	3V	-	-	-	5
-	-	-	-	-	-	-	-	-	-	-	-	3V	-	-	-	6
-	-	-	-	-	-	-	-	-	-	-	-	VDD	-	-	3	-
-	-	-	-	-	-	-	-	-	-	-	-	VDD	-	-	4	-
-	-	-	-	-	-	-	-	-	-	-	-	VDD	-	-	-	22
-	-	-	-	-	-	-	-	GND	GND	-	-	GND	5	3	1	-
-	-	-	-	-	-	-	-	-	-	-	-	GND	-	-	2	-
-	-	-	-	-	-	-	-	-	-	-	-	GND	-	-	5	-
-	-	-	-	-	-	-	-	-	-	-	-	GND	-	-	23	-
-	-	-	-	-	-	-	-	-	-	-	-	GND	-	-	49	-
-	-	-	-	-	-	-	-	-	-	-	-	GND	-	-	50	-
-	-	-	-	-	-	-	-	-	-	-	-	GND	-	-	-	1
-	-	-	-	-	-	-	-	-	-	-	-	GND	-	-	-	2

Table 5. MCU pin description versus board function (continued)

MCU pin			Board function														
Main function	Alternate functions	LQFP100	CS43L22	MP45DT02	LIS302DL or LIS3DSH	Pushbutton	LED	SWD	USB	OSC	Free I/O	Power supply	CN5	CN2	P1	P2
-	-	-	-	-	-	-	-	-	-	-	-	GND	-	-	-	49
-	-	-	-	-	-	-	-	-	-	-	-	GND	-	-	-	50

5 Mechanical drawing

Figure 10. STM32F4DISCOVERY mechanical drawing



6 Electrical schematics

Figure 11. STM32F4DISCOVERY

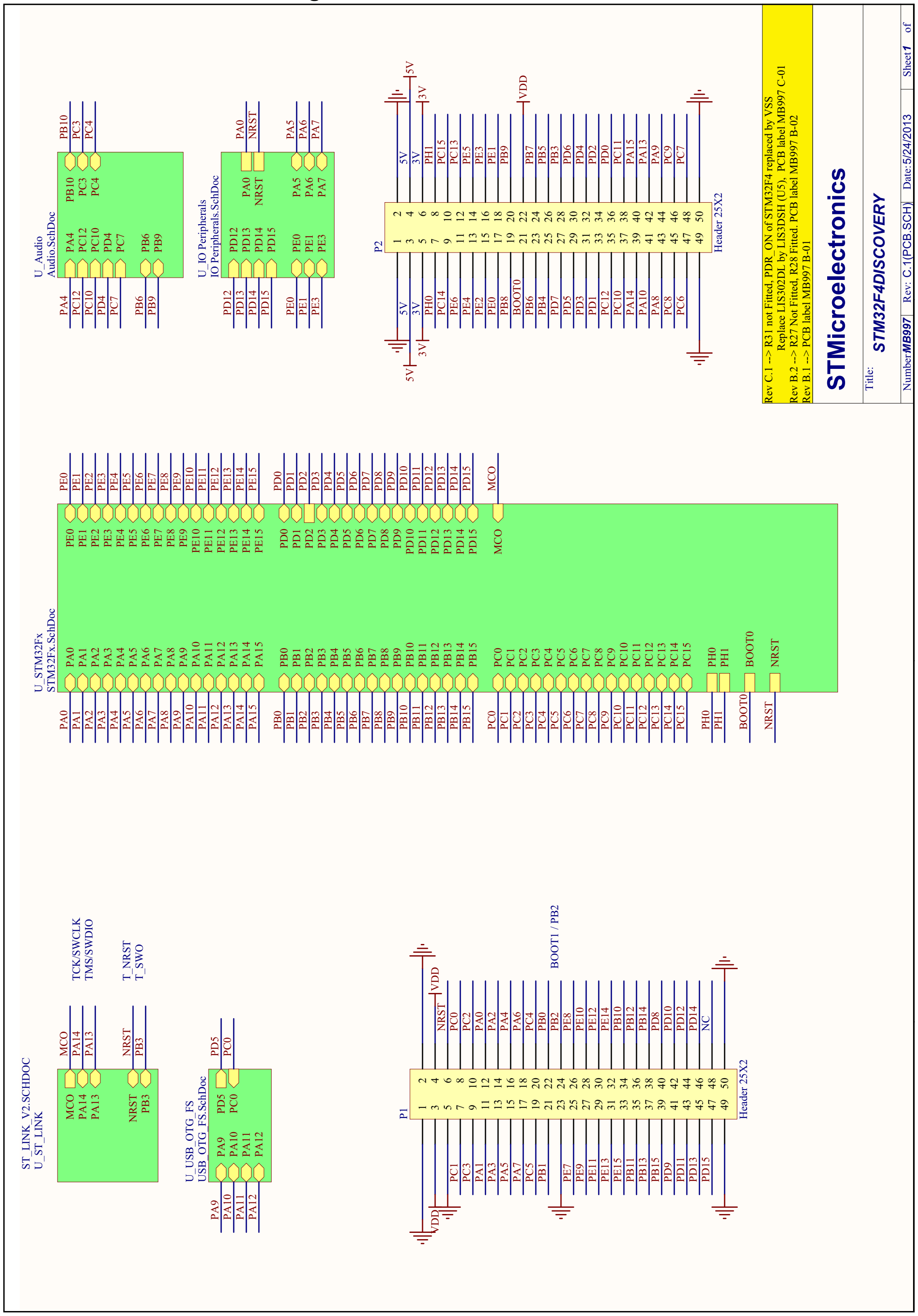


Figure 12. ST-LINK/V2 (SWD only)

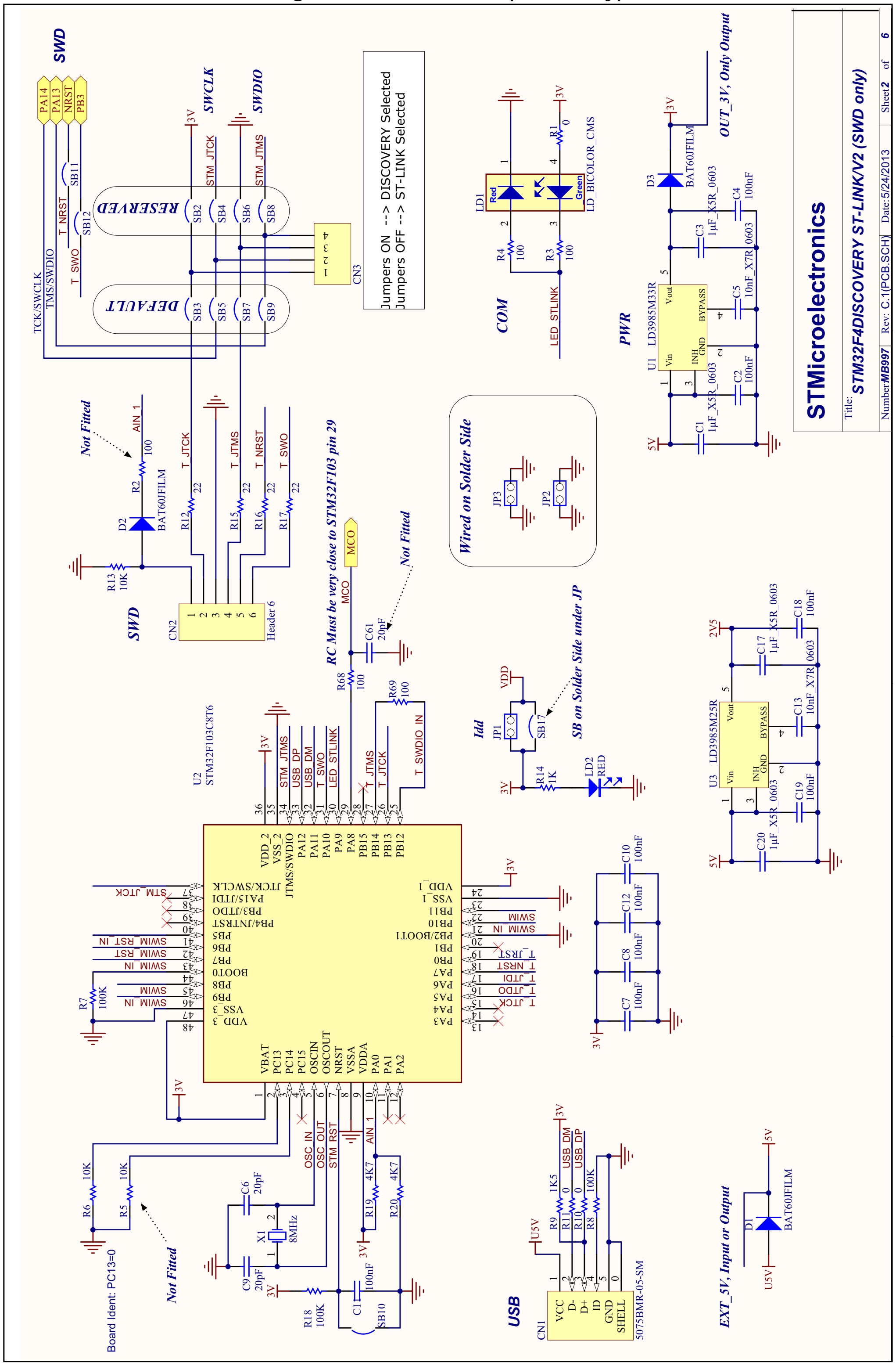


Figure 13. MCU

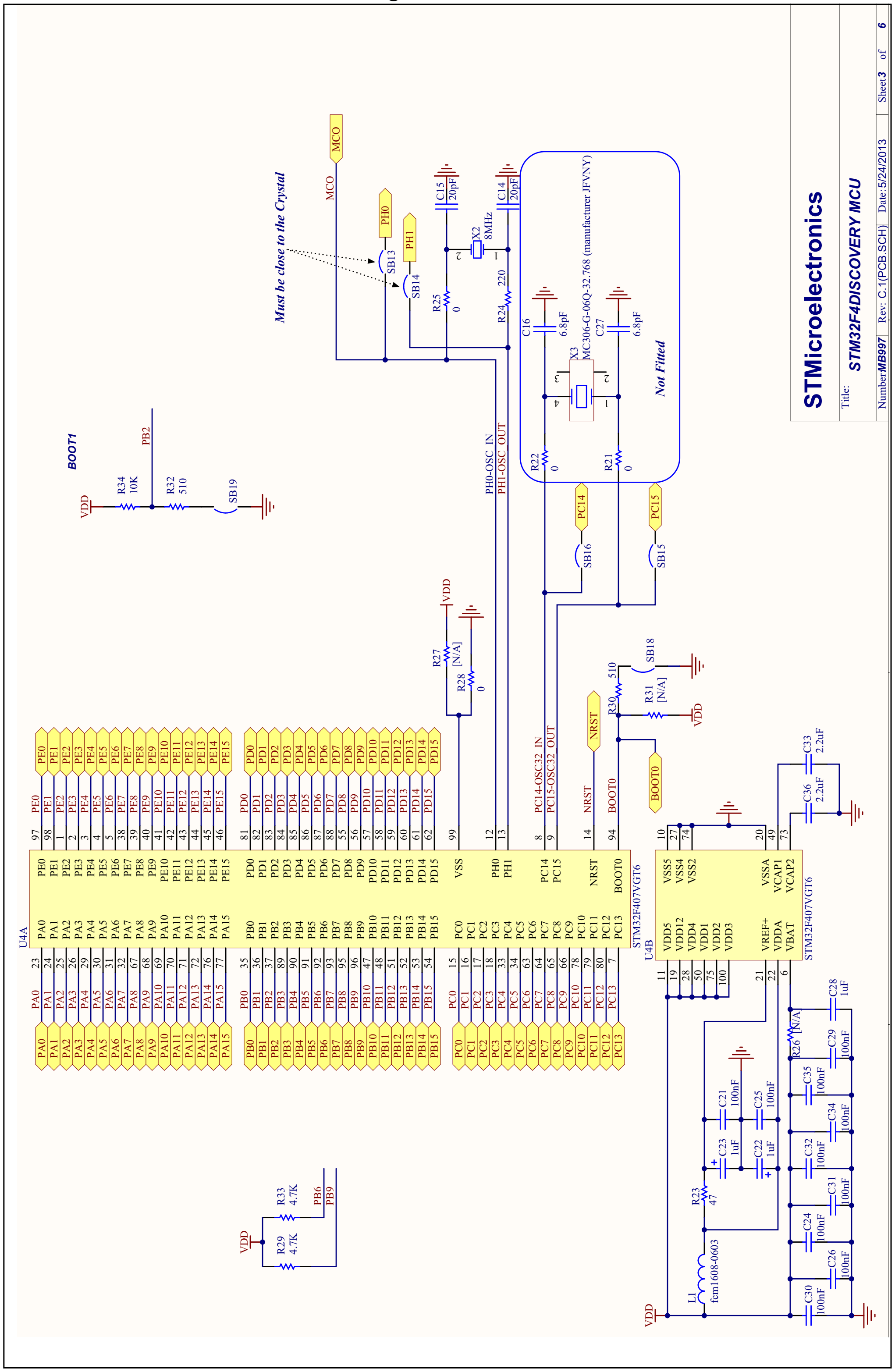


Figure 14. Audio

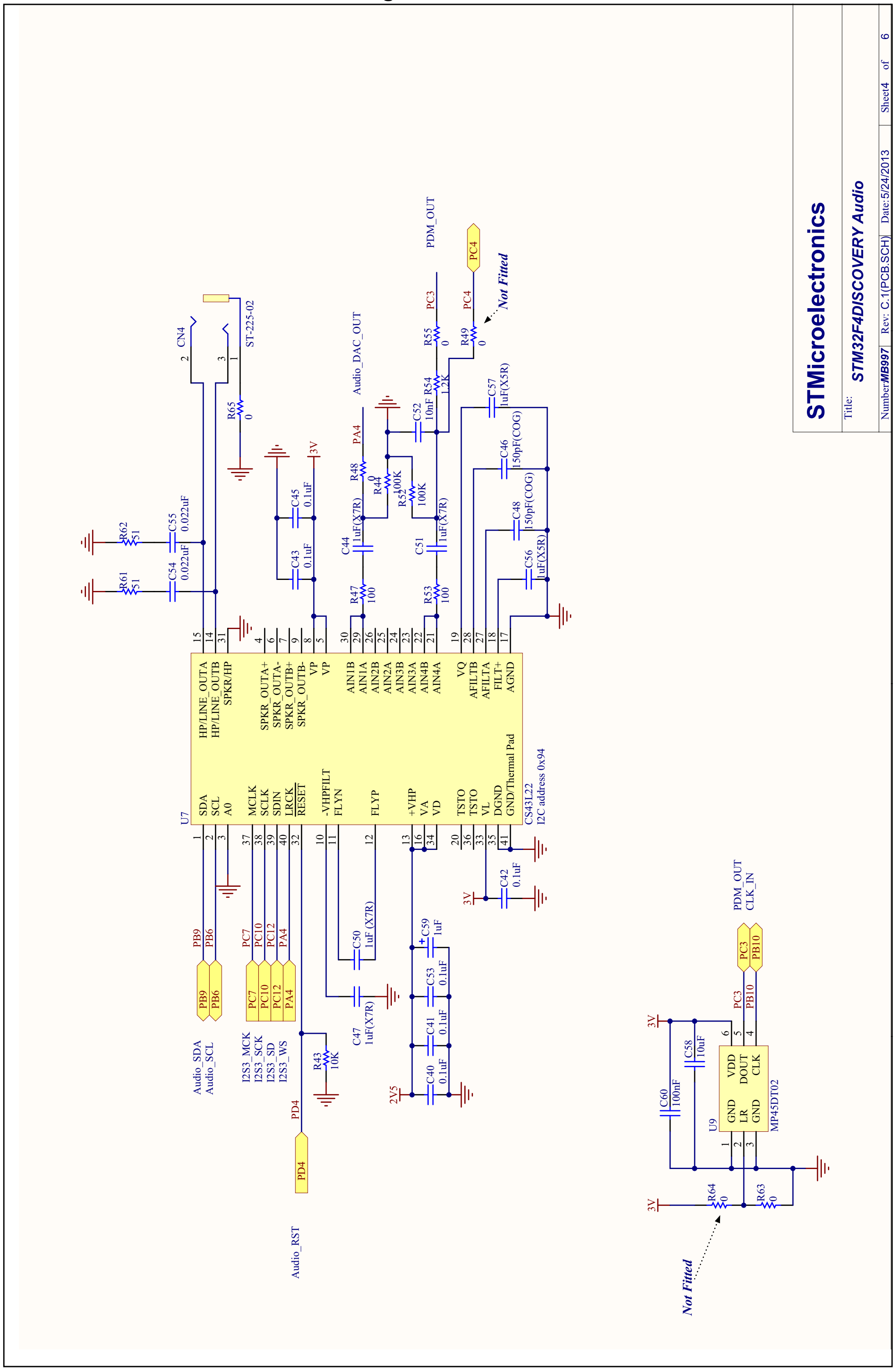


Figure 15. USB_OTG_FS

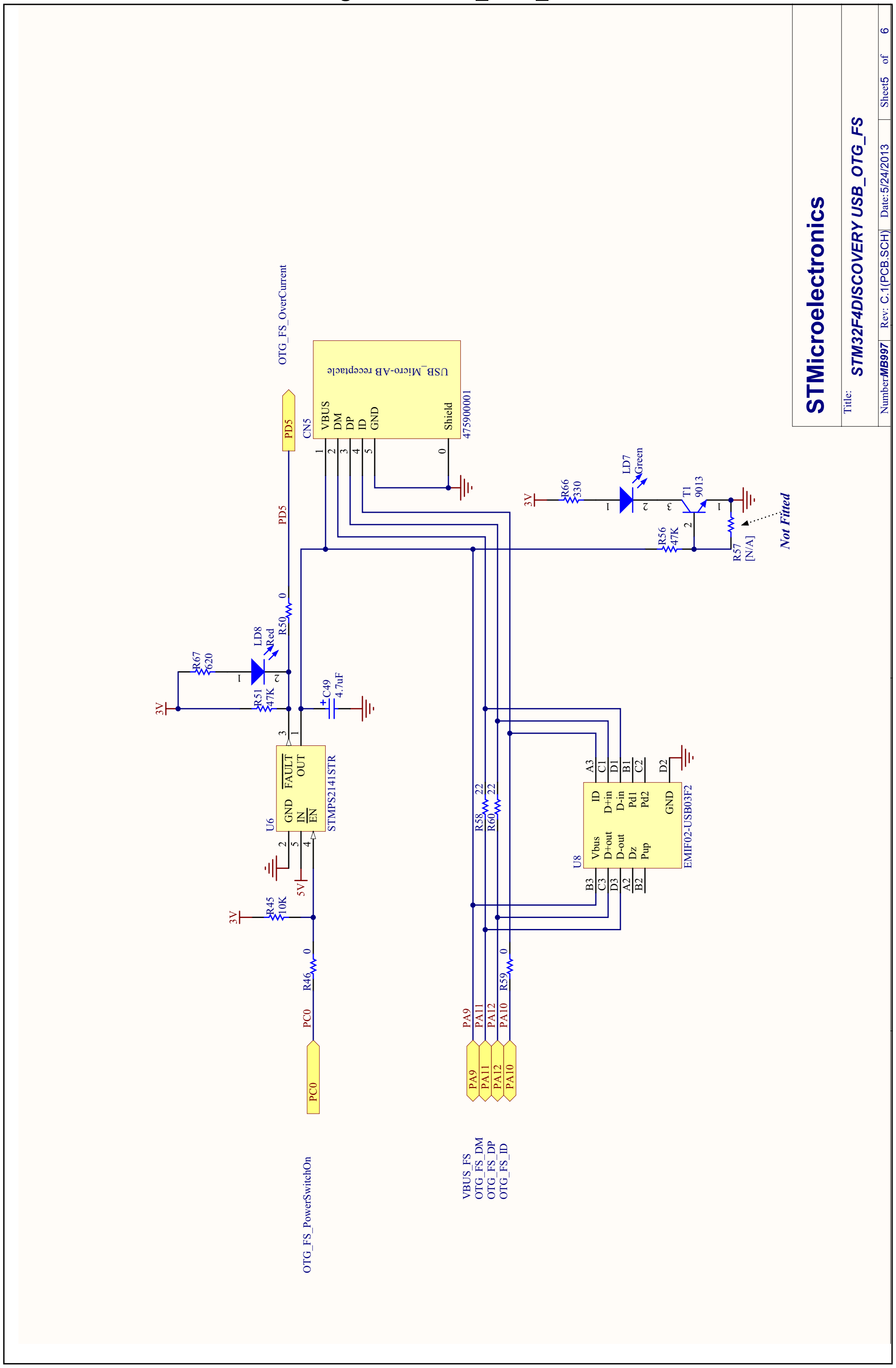
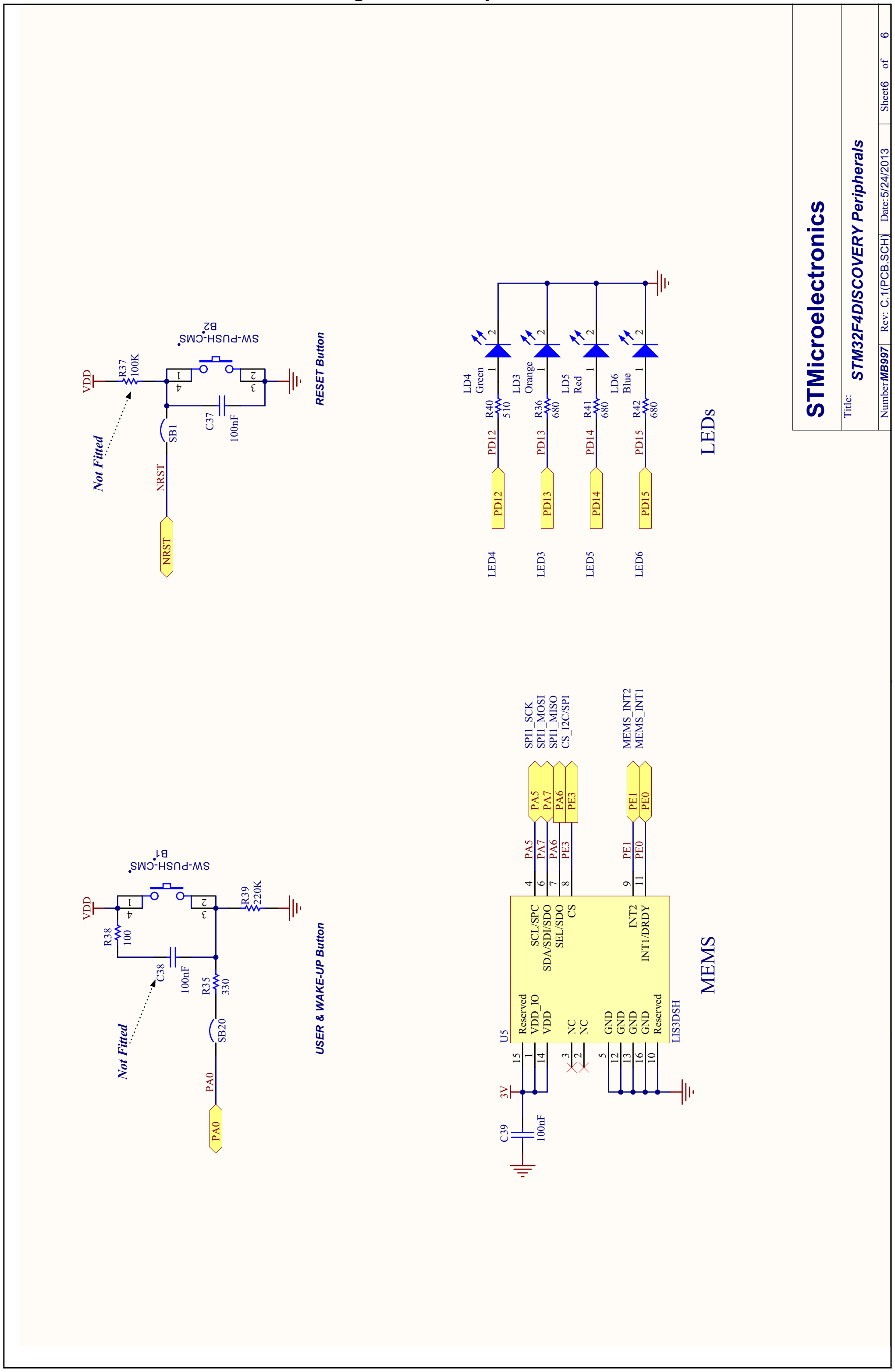


Figure 16. Peripherals



7 Revision history

Table 6. Document revision history

Date	Revision	Changes
27-Sept-2011	1	Initial release.
30-Jan-2012	2	Added *Section 4.1: STM32F407VGT6 microcontroller* corrected *Figure 3* MCU name, modified *Figure 2* and *Chapter 6: Electrical schematics*. Modified *Table 5* PE2 and PE3 entries.
28-Nov-2013	3	Updated for board rev. C. Modified title. Modified *Section 4.8: Motion sensor (ST MEMS LIS302DL or LIS3DSH)* Updated *Chapter 6: Electrical schematics*
29-Jan-2014	4	Modified *Chapter 3: Features*, *Figure 2*, *Chapter 4.8: Motion sensor (ST MEMS LIS302DL or LIS3DSH)* , *Table 5* adding ST MEMS LIS302DL reference.

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www.st.com

Anexo D

Hoja de datos

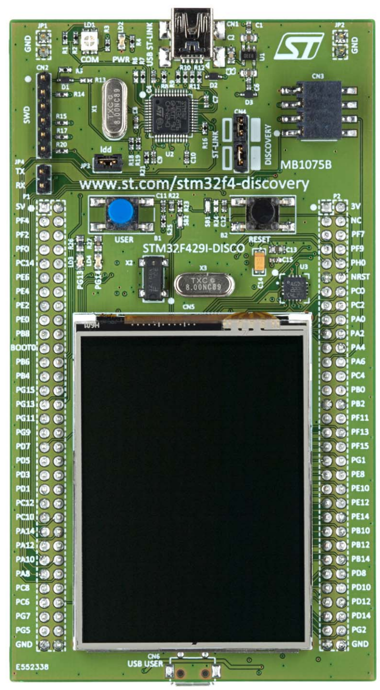
32F429IDISCOVERY

Discovery kit with STM32F429ZI MCU

Data brief

Features

- STM32F429ZIT6 microcontroller featuring 2 Mbytes of Flash memory, 256 Kbytes of RAM in an LQFP144 package
- On-board ST-LINK/V2 on STM32F429I-DISCO (old order code) or ST-LINK/V2-B on STM32F429I-DISC1 (new order code)
- mbed™-enabled (see http://mbed.org) with the new order code only
- USB functions:
  – Debug port
  – Virtual COM port (with new order code only)
  – Mass storage (with new order code only)
- Board power supply: through the USB bus or from an external 3 V or 5 V supply voltage
- 2.4" QVGA TFT LCD
- 64-Mbit SDRAM
- L3GD20, ST-MEMS motion sensor 3-axis digital output gyroscope
- Six LEDs:
  – LD1 (red/green) for USB communication
  – LD2 (red) for 3.3 V power-on
  – Two user LEDs: LD3 (green), LD4 (red)
  – Two USB OTG LEDs: LD5 (green) VBUS and LD6 (red) OC (over-current)
- Two push-buttons (user and reset)
- USB OTG with micro-AB connector
- Extension header for LQFP144 I/Os for a quick connection to the prototyping board and an easy probing
- Comprehensive free software including a variety of examples, part of STM32CubeF4 package or STSW-STM32138, for using legacy standard libraries



1. Picture is not contractual.

Description

The 32F429IDISCOVERY kit leverages the capabilities of the STM32F429 high-performance microcontrollers, to allow users to easily develop rich applications with advanced Graphic User interfaces.

With the latest board enhancement, the new STM32F429I-DISC1 order code has replaced the old STM32F429I-DISCO order code.

System requirements

- Windows® OS (XP, 7, 8)
- USB Type-A to Mini-B cable

Development toolchains

- IAR® EWARM (IAR Embedded Workbench®)
- Keil® MDK-ARM™
- GCC-based IDEs (free AC6: SW4STM32, Atollic® TrueSTUDIO®,...)
- ARM® mbed™ online

Demonstration software

The demonstration software is preloaded in the MCU Flash memory. It displays on the screen icons to run different applications: clock/calendar, a game, a video player and an image browser, performance monitoring and system information.

The latest versions of the demonstration source code and associated documentation can be downloaded from the www.st.com/stm32f4-discovery webpage.

Product marking

Tools marked as "ES" or "E" are not yet qualified and as such, they may be used only for evaluation purposes. ST shall not be liable for any consequences related with other ways of use of such non-qualified tools, for example, as reference design or for production.

Examples of location of "E" or "ES" marking:

- on target STM32 microcontroller part mounted on the board (for illustration, refer to section “Package information” of a STM32 datasheet at *www.st.com*)
- next to the evaluation tool ordering part number, as a label stuck or a silk-screen printed on the board

Ordering information

To order the Discovery kit for the STM32F429 line of microcontrollers, refer to *Table 1*.

Table 1. List of the order codes

Order code	ST-LINK version
STM32F429I-DISCO	ST-LINK/V2
STM32F429I-DISC1	ST-LINK/V2-B

Revision history

Table 2. Document revision history

Date	Revision	Changes
06-Sep-2013	1	Initial version.
29-Sep-2014	2	Updated *Section : Features* and *Section : Description* to introduce STM32cubeF4 and STSW-STM32138. Updated ST MEMS feature. Updated *Section : System requirements* and *Section : Development toolchains*.
23-Oct-2015	3	Updated *Section : Features*, *Section : Description*, *Section : Product marking*.
28-Oct-2016	4	Updated *Section : Features* and *Section : Description* to inform that the new STM32F429I-DISC1 order code has replaced the old STM32F429I-DISCO order code.