STM32-based camera with ZigBee® connectivity

Introduction

This user manual describes the function of hardware boards on the "STM32 based camera with ZigBee® connectivity" system (henceforth the system). The system is designed as two separate hardware units. One of the hardware units (called the "camera unit") consists of a camera and ZigBee module interfaced with an STM32 microcontroller, while the other unit (called the "monitoring unit") consists of a TFT and ZigBee module interfaced with an STM32 for viewing/monitoring jpeg images.

The STM32 microcontroller in the camera unit captures jpeg images from the camera (using DMA) and transfers them onto the ZigBee network using an SPI controlled SN260 module. The images are transferred into jpeg format which helps to save transfer time on the ZigBee network. The camera unit can also record these images in the onboard memory (microSD card) using a FAT file system. The user can record these images at the click of a button or the present system can be expanded to record the images once motion is detected by the camera (using a PIR sensor).

The monitoring unit scans for jpeg images on the ZigBee network. Once the images are available on the network they are captured. These jpeg images are then converted into bmp format for display on the onboard TFT. Both units can be powered either by battery or through a USB. The system can be configured to go into standby mode as per user configuration. This feature helps in reducing the power consumption of the system. With these features, the system is useful for applications where certain areas need to be monitored wirelessly, e.g. door intercoms and baby monitoring systems.

Contents

List of figures

1 Getting started

1.1 Package

The STM32-based camera with a ZigBee connectivity package (STEVAL-IFV001V1) includes the following items:

● Hardware content
  – Demonstration board fitted with camera, micro SD card, and ZigBee module (also called camera unit).
● Firmware
  – Programmed in the system
  – Object files of the firmware
● Documentation
  – User manual (this document)

Note: The other hardware board (the monitoring unit) is available with the order code: STEVAL-CCM003V1

1.2 Hardware setup

1. Power the camera unit first
2. Then wait for 2 to 3 seconds
3. Then power the monitoring unit.

1.2.1 Setting the camera unit

The camera unit is shown in *Figure 1*. This unit can be powered up either through a USB or from a battery. The slider switch (SW3) present on the board is used for selecting the power source. Before powering up the system, set this switch to the appropriate position, as per *Table 1*:

Table 1. Power source setting

Switch (SW3) position	Power source
1-2	USB
2-3	Battery

Figure 1. Camera unit

AM06378v1
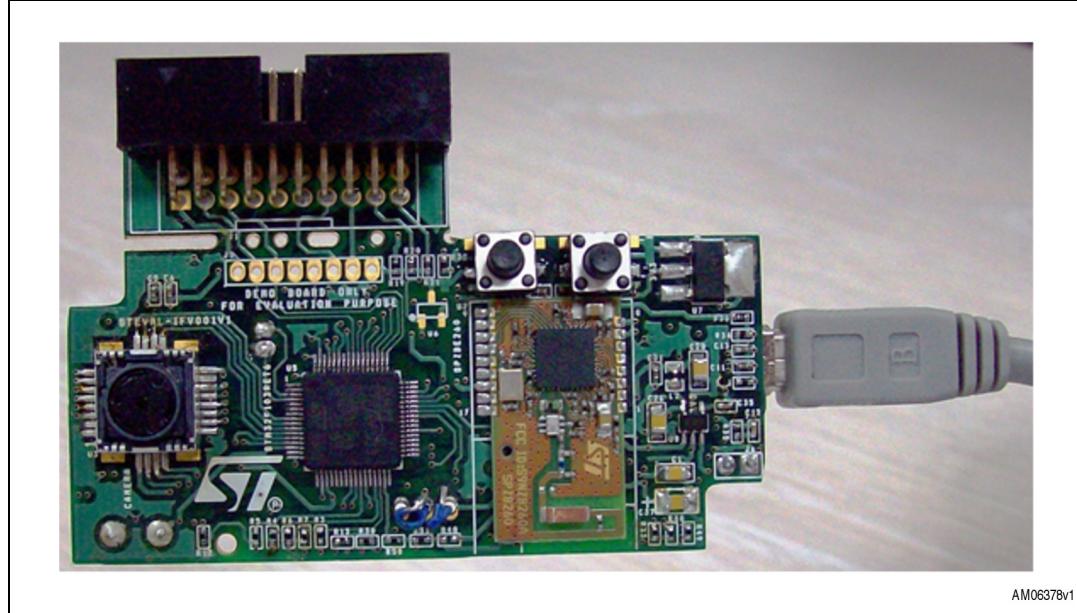
1.2.2 Setting the monitoring unit

The monitoring unit is shown in *Figure 2* below. This unit is fitted with the ZigBee module and TFT. The unit can be powered from a battery or from a USB supply. To select the power source no hardware changes need to be made for this board. This unit needs to be powered up after powering the camera unit (as the camera unit acts as the ZigBee coordinator).

Figure 2. Monitoring unit

AM06379v1
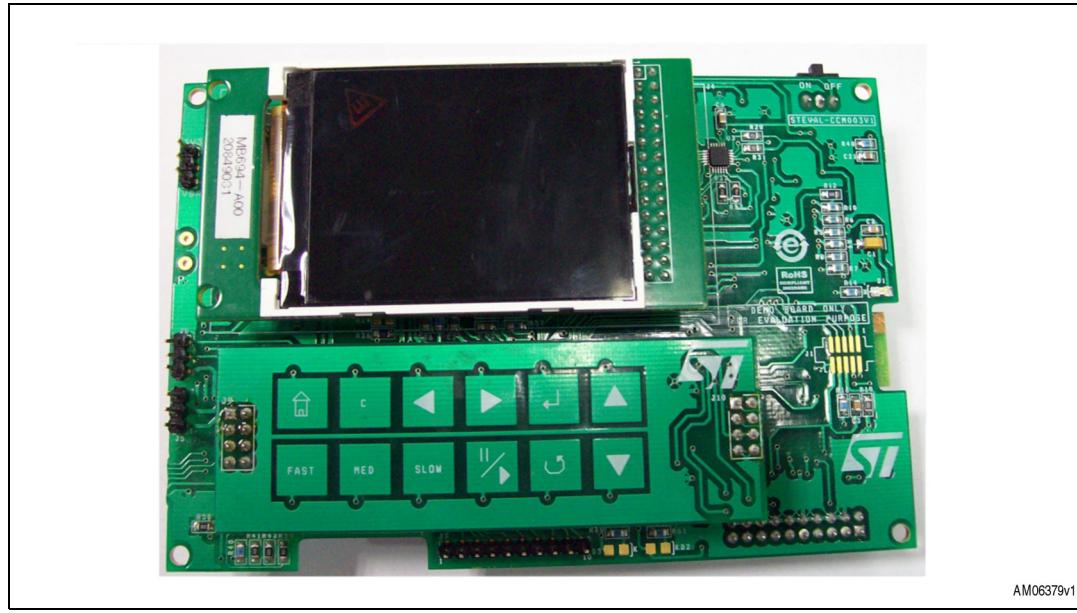
1.2.3 Hardware layout

The system is built around STMicroelectronics' cortex-based STM32F103RET6 in the 64-pin LQFP64 package. The hardware layout of the camera unit is shown in *Figure 3*. For the layout of the monitoring unit, please refer to the UM0874 user manual.

Figure 3. **STEVAL-IFV001V1 front view**
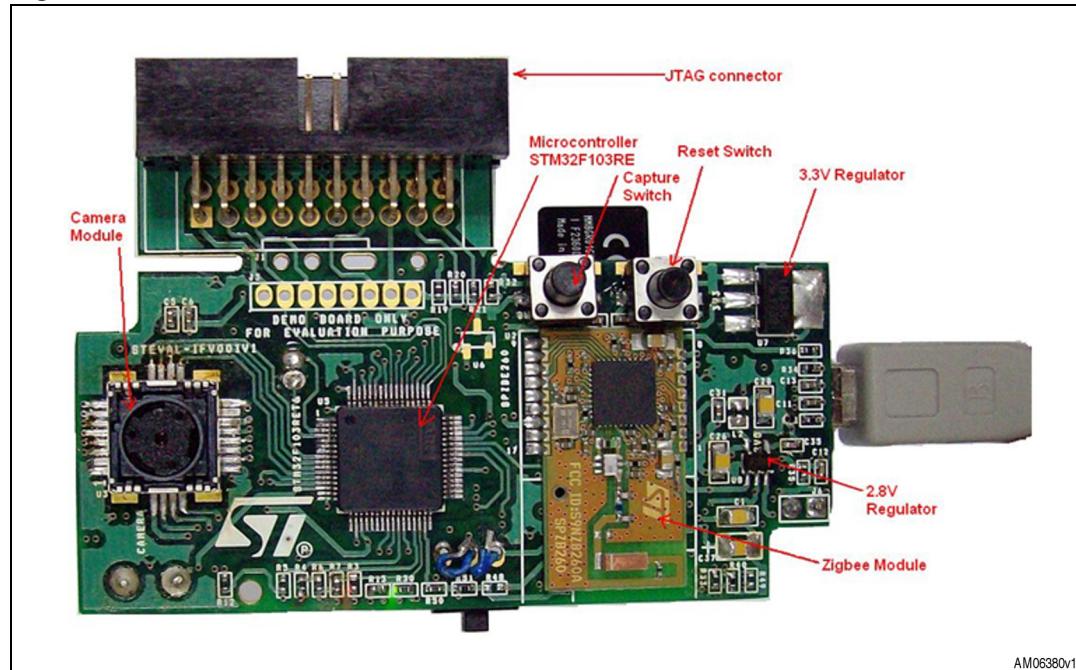
Figure 4. **STEVAL-IFV001V1 rear view**

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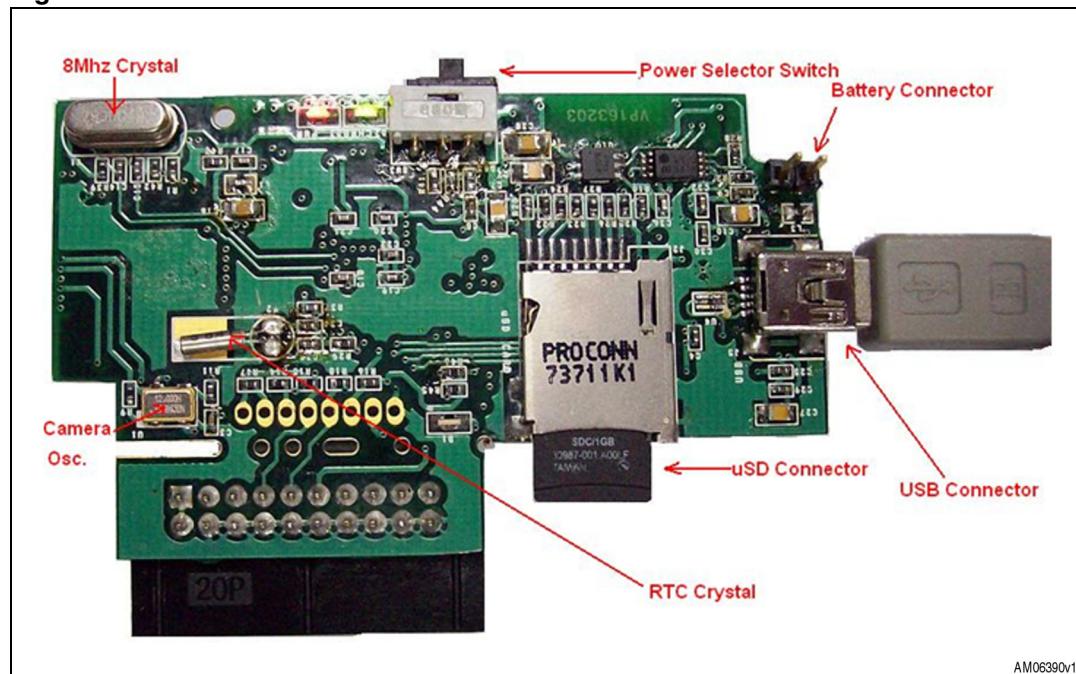
2   System overview

2.1   System architecture description

The architecture of the system is shown in *Figure 5* below. The system works as a wireless camera using ZigBee communication. The system has two units; one is the "camera unit" while the other is the "monitoring unit". Both units are based on the STM32 microcontroller.

Figure 5.   System architecture
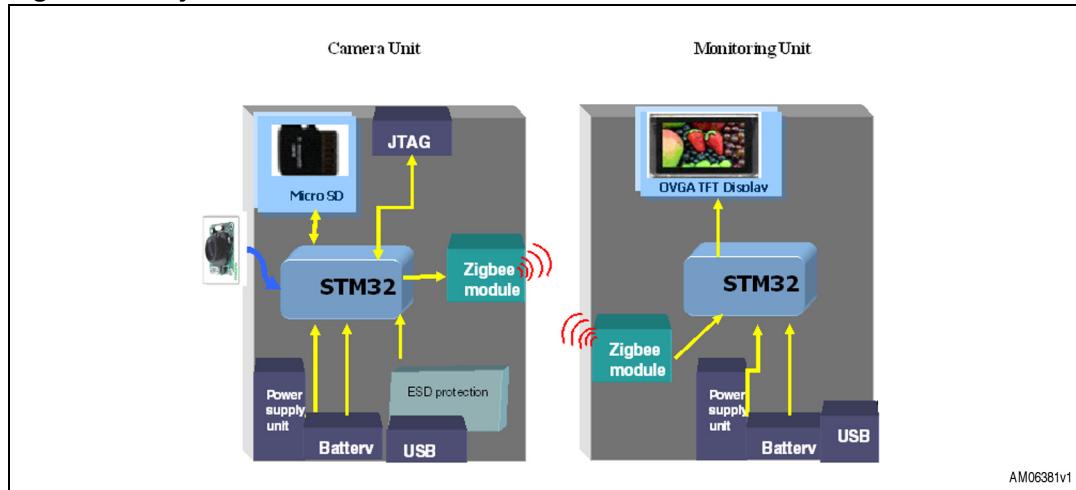
In the camera unit, the STM32 microcontroller is interfaced to the camera through GPIOs. Through these GPIOs, the microcontroller takes data from the industry standard ITU 8-bit interface of the camera. On powering up, the camera module is initialized through an I^2C interface for the streaming of jpeg images. During this Initialization appropriate registers in the camera module are updated to get images as per requirements. In this unit, the camera module is programmed for streaming jpeg images rather than bmp format, as this helps in reducing the image transfer time on the ZigBee network.

Furthermore, this unit fully utilizes the advantages of the STM32 built-in DMA controller to capture images from the camera module, therefore keeping the microcontroller free for other purposes. The DMA controller is triggered through the STM32 timer which receives interrupt on the rising edge of the PCLK signal. The DMA unit transfers the whole image in the microcontroller's RAM from where it is sent onto the ZigBee network by the microcontroller through the SPI based ZigBee module. During the time the image is transferred onto the ZigBee network the DMA stays in STOP mode. Once the whole image is transferred onto the ZigBee network the DMA captures another frame from the camera and the process is repeated. In a case where there is no monitoring unit present in the system the camera unit discards the present frame and captures the new frame.

In this system, the ZigBee network is established using the SN260 module which works on channel 20. The camera unit acts as a coordinator and the monitoring unit acts as a node. This camera unit is also capable of storing images in the uSD card available on the unit. The images are stored using the FAT file system and therefore they can be easily viewed on a PC using a card reader. The system can be triggered to capture images through a trigger switch, or an external PIR sensor can be interfaced for this purpose. This unit is capable of working both on USB power supplies and battery.

The other unit in the system, called the monitoring unit, is capable of capturing images from the ZigBee network using the SN260 module. The STM32 microcontroller in this unit runs a jpeg decompression algorithm which converts the captured jpeg images into raw bmp format. After this conversion, the raw bmp image is displayed on TFT.

The principle parts of the system are described below:

● STM32 microcontroller

The system is based on an STM32F104RET6 microcontroller. The STM32 family of 32-bit Flash Microcontrollers is based on the breakthrough ARM Cortex™-M3 core - 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 and a significantly faster response to interrupts, all combined with industry leading power consumption. For more details refer to the stm32 literature available at st.com.

● Camera module - VS6724

The VS6724 is a CMOS color digital camera featuring low size and low power consumption for mobile applications (PDA, mobile phones). Manufactured using ST 0.13 µm CMOS imaging process, it integrates a high-sensitivity pixel array, a digital image processor, and camera control functions.

The VS6724 is capable of streaming UXGA video up to 30 fps, with ITU-R BT.656-4 YUV 4:2:2 frame format, and M-jpeg compression. The VS6724 also supports the output of uncompressed video data at UXGA resolution at up to 15 fps. It supports1.8 V/2.8 V interface and requires a 2.4 V to 3.0 V analog power supply. If required, the VS6724 can operate as a 2.8 V single supply camera. The integrated PLL allows for low frequency system clock and flexibility.

● ZigBee module unit (SPZB260)

The SPZB260 is a low power consumption ZigBee module optimized for embedded applications. It enables OEMs to easily add wireless capability to electronic devices. It has an Integrated 2.4 GHz, IEEE 802,15,4-complaint transceiver. For more details refer to the ZigBee literature available at st.com.

● USB

The system supports USB 2.0 compliant full speed communication via a mini USB type-B connector. An ESD protection device (USBLC6) is also mounted to protect the USB bus.

3   Running the system

3.1   Powering up

The system is powered up in the following manner:

1.   Powering up the camera unit

This unit needs to be powered up first. It can be powered from either a battery or USB. Various states of the board are indicated by the corresponding LEDs. On powering up the system using a USB, LED D3 lights up, which indicates the availability of 5 V on this unit from the USB. Moreover, if a battery is not connected or uncharged, the LED D2 also lights up (as shown in *Figure 3* and *4*).

The activity on this board is indicated by LED D1. If the system initializes well, the D1 LED stays ON, otherwise it remains OFF, which indicates a problem on the board. On the other hand, if the system is powered up using a battery then LED D2 & D3 remain OFF (to reduce power consumption from the battery). However, LED D1 works as an activity LED, as explained earlier.

Note: *The availability of a micro SD card on the board does not disturb the system initialization. Though in this case the recording feature does not function.*

2.   Powering up the monitoring unit

This unit should be powered up after powering the camera unit. Once this unit is powered on, it tries to establish a connection with the ZigBee coordinator as the unit is acting as a ZigBee node. Once the connection is established, the activity LED D1 on the camera unit starts blinking as the camera unit starts transferring the image to the ZigBee network.

The monitoring unit displays the captured images on the TFT after decoding them from jpeg format to bmp format.

3.   Capturing images

To use the recording feature, make sure the micro SDcard is plugged into the system before powering it up. To capture a picture at a particular moment, press the capture switch button (SW1). At one click of the button, one jpeg image is saved onto the micro SDcard using the FAT file system which can be seen on the desktop machine using a card reader. This feature is useful for applications where a picture needs to be captured and saved in local memory at some external trigger (e.g. trigger from PIR sensor).

4 Schematics of STEVAL-IFV001V1

4.1 Camera unit

Figure 6. Microcontroller schematic

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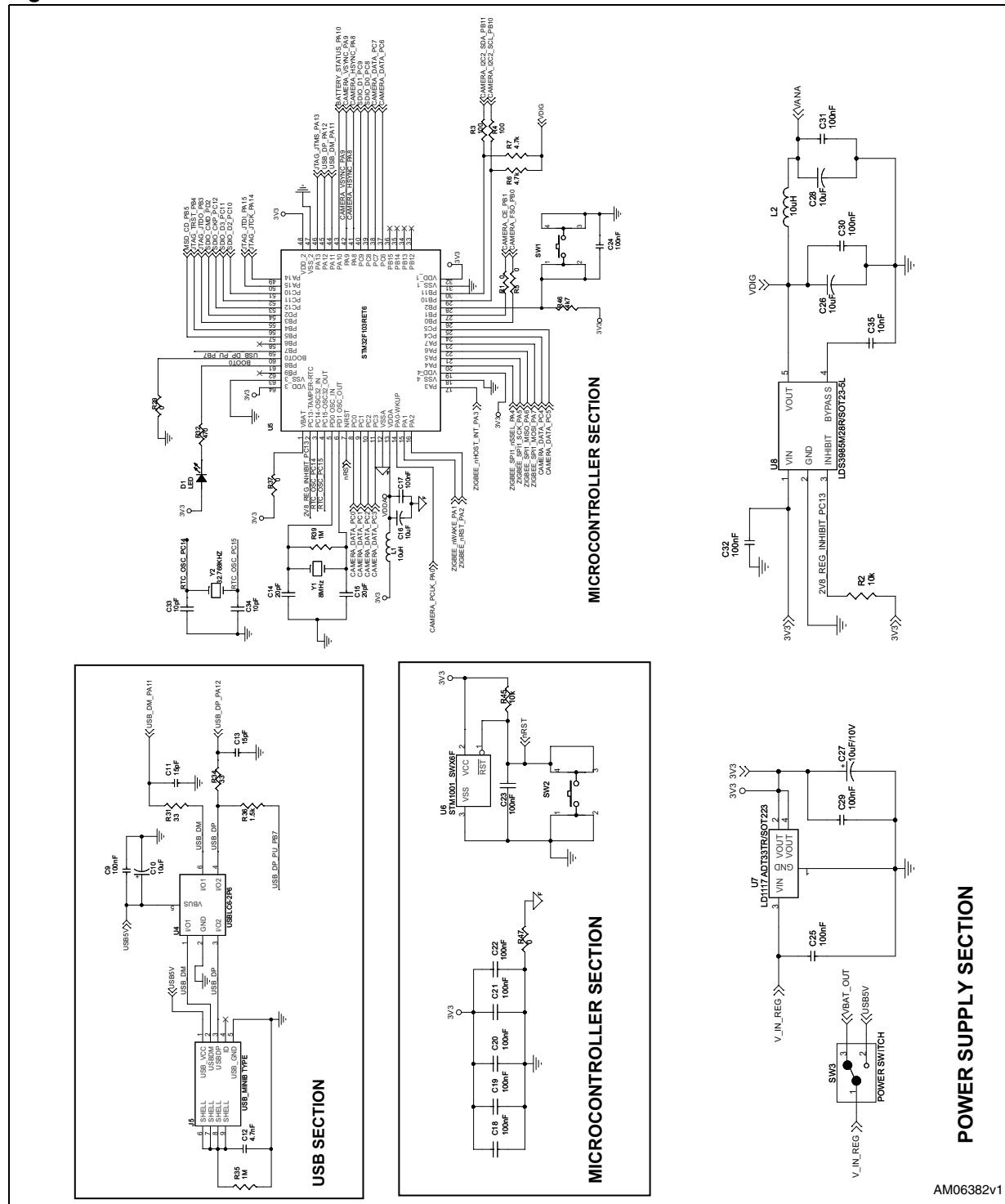
Figure 7.   Connector schematic
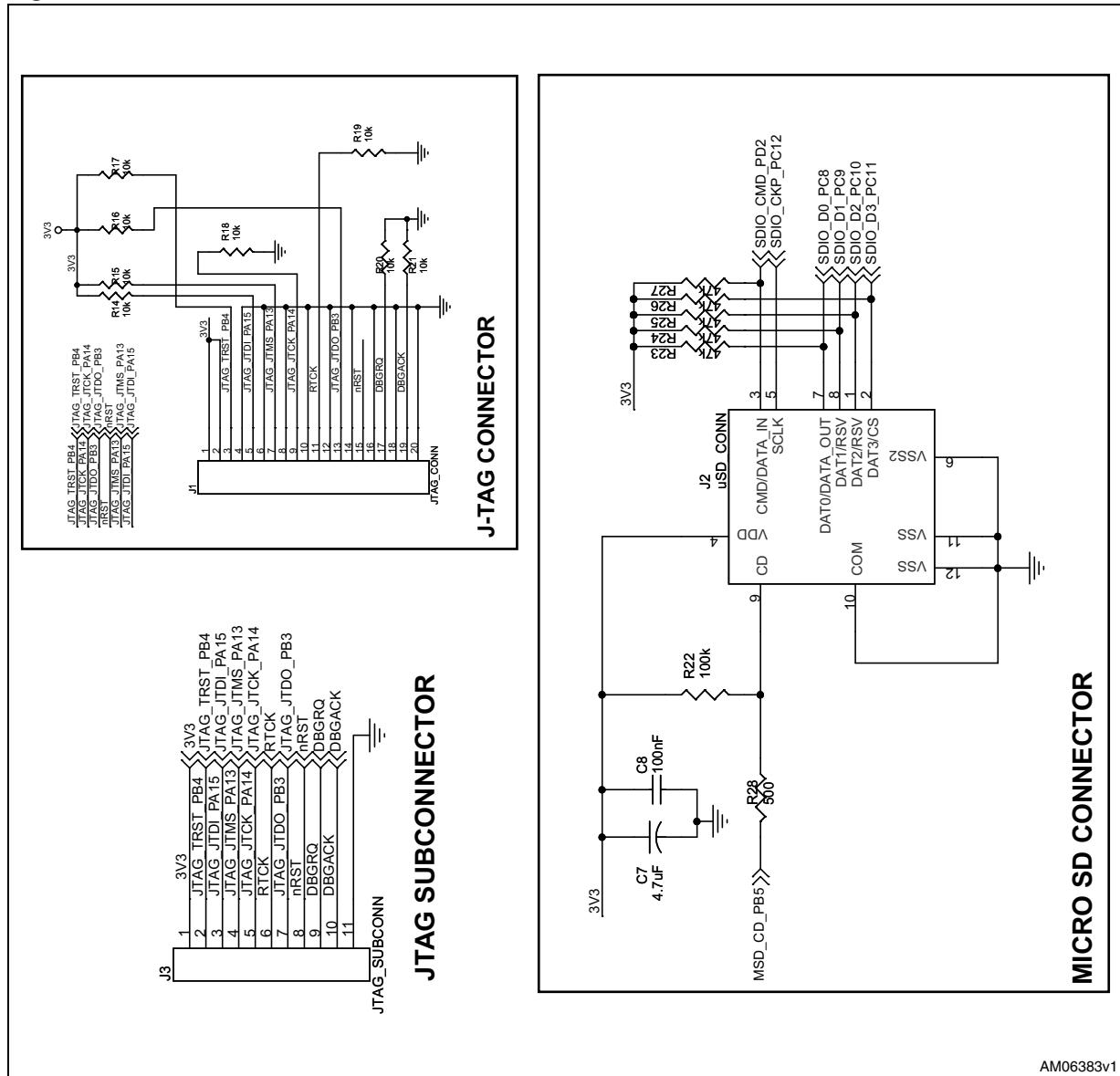
AM06383v1

Figure 8.   Camera ZigBee schematic

AM06384v1

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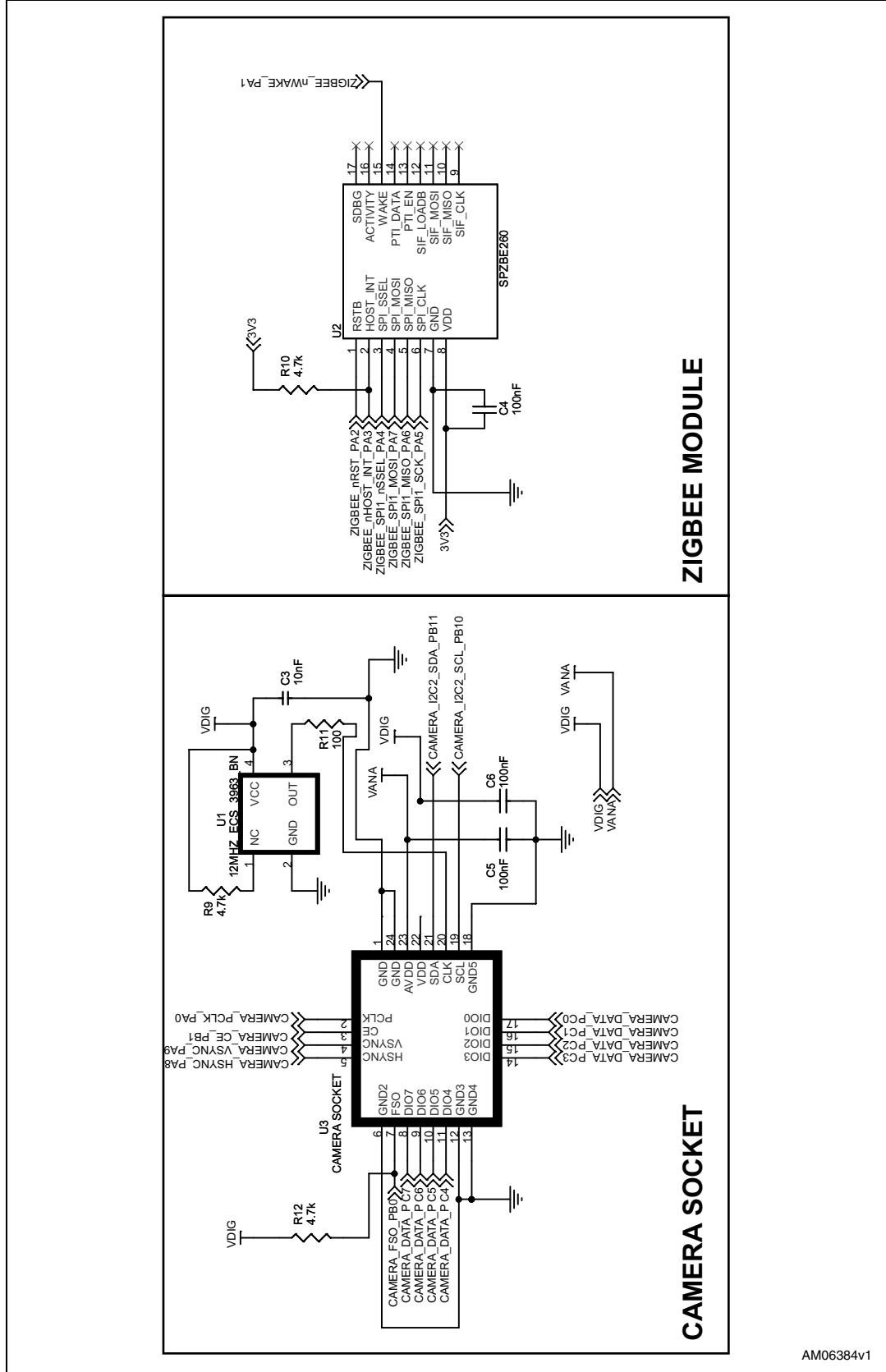
**Figure 9.	Battery schematic**

AM06385v1
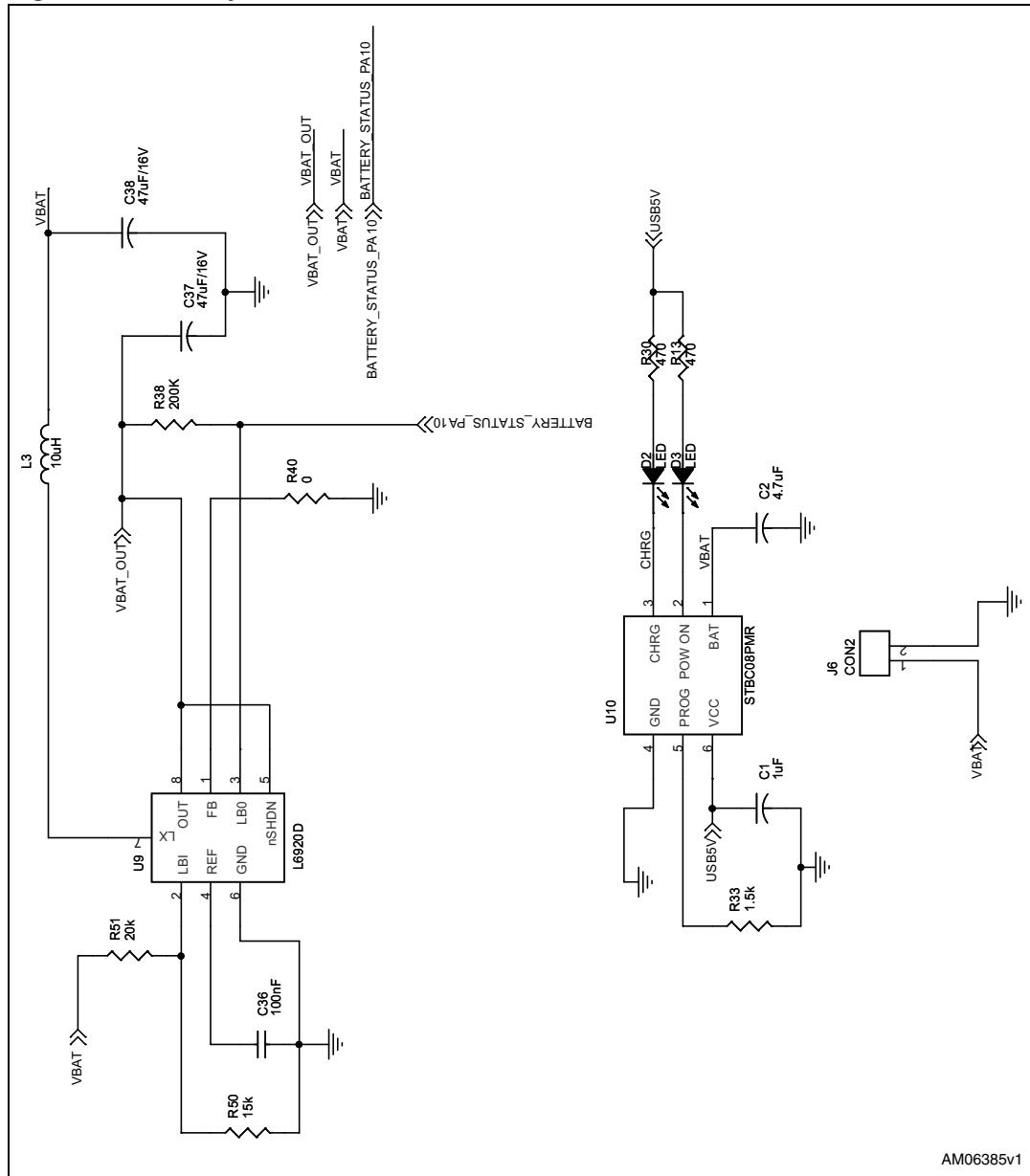
5   Bill of material of STEVAL-IFV001V1

Table 2.   BOM

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code or equivalent
ST devices	U4	USB protection IC	SOT666	STMicroelectronics	USBLC6-2P6	STMicroelectronics	USBLC6-2P6
	U6	Reset supervisor IC	SOT23-3	STMicroelectronics	STM1001MWX6F	STMicroelectronics	STM1001MWX6F
	U5	STM32 Performance Line 64-pin, 32 K Flash, 20 K RAM	LQFP64	STMicroelectronics	STM32F103RET6	STMicroelectronics	STM32F103RET6
	U7	3.3 V voltage regulator	SOT223	STMicroelectronics	LD1117ADT33TR	STMicroelectronics	LD1117ADT33TR
	U8	2.8 V regulator	SOT23-5L	STMicroelectronics	LDS3985M28R	STMicroelectronics	LDS3985M28R
	U9	DC-DC boost IC	TSSOP8	STMicroelectronics	L6920D	STMicroelectronics	L6920D
	U10	Battery charger IC	QFN6 (3 mm x 3 mm)	STMicroelectronics	STBC08PMR	STMicroelectronics	STBC08PMR
	U3	Camera	SmOP2 8.0 x 8.0 x 5.5 mm	STMicroelectronics	VS6724Q0FB		
	U2	SN260 module	ZigBee Module 12-Pin Interface	STMicroelectronics	SPZB260	STMicroelectronics	SPZB260
	R1, R5, R29, R37, R40, R47	0 Ω resistance 1/10 W	0402 SMD	Panasonic - ECG (VA) V	ERJ-2GE0R00X	Digi-Key	P0.0JCT-ND

Table 2. **BOM (continued)**

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code or equivalent
Resistance	R31, R34	33 Ω resistance 1/10 W	0402 SMD	Panasonic - ECG (VA) V	ERJ-2GEJ330X	Digi-Key	P33JCT-ND
	R3, R4, R11	100 Ω resistance 1/10 W	0402 SMD	Panasonic - ECG (VA) V	ERJ-2GEJ101X	Digi-Key	P100JCT-ND
	R13, R28, R30, R32	470 Ω resistance 1/10 W	0402 SMD	Panasonic - ECG (VA) V	ERJ-2GEJ471X	Digi-Key	P470JCT-ND
Resistance	R33, R36	1.5 kΩ resistance 1/10 W	0402 SMD	Panasonic - ECG (VA) V	ERJ-2GEJ152X	Digi-Key	P1.5KJCT-ND
	R6, R7, R9, R10, R12, R46	4.7 kΩ resistance 1/10 W	0402 SMD	Panasonic - ECG (VA) V	ERJ-2GEJ472X	Digi-Key	P4.7KJCT-ND
	R2, R14, R15, R16, R17, R18, R19, R20, R21, R45	10 kΩ resistance 1/10 W	0402 SMD	Panasonic - ECG (VA) V	ERJ-2GEJ103X	Digi-Key	P10KJCT-ND
	R50	15 kΩ resistance 1/10 W	403 SMD	Panasonic - ECG (VA) V	ERJ-2GEJ153X	Digi-Key	P15KJCT-ND
	R51	20 kΩ resistance 1/10 W	0402 SMD	Panasonic - ECG (VA) V	ERJ-2GEJ203X	Digi-Key	P20KJCT-ND
	R23, R24, R25, R26, R27	47 kΩ resistance 1/10 W	403 SMD	Panasonic - ECG (VA) V	ERJ-2GEJ473X	Digi-Key	P47KJCT-ND
	R22	100 kΩ resistance 1/10 W	0402 SMD	Panasonic - ECG (VA) V	ERJ-2GEJ104X	Digi-Key	P100KJCT-ND
	R38	200 kΩ resistance 1/10 W	403 SMD	Panasonic - ECG (VA) V	ERJ-2GEJ204X	Digi-Key	P200KJCT-ND
	R35,R39	1 MΩ resistance 1/10 W	0402 SMD	Panasonic - ECG (VA) V	ERJ-2GEJ105X	Digi-Key	P1.0MJCT-ND

Table 2. **BOM (continued)**

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code or equivalent
Resistance	C33, C34	10 pF 50 V ceramic	0402 SMD	Panasonic - ECG (VA) V	ECJ-0EC1H100D	Digi-Key	PCC100CQCT-ND
	C11, C13	15 pF 50 V ceramic	0402 SMD	Panasonic - ECG (VA) V	ECJ-0EC1H150J	Digi-Key	PCC150CQCT-ND
Capacitors	C14, C15	20 pF 50 V ceramic	0402 SMD	MURATA ELECTRONICS (VA) V	GRM1555C1H200 JZ01D	Digi-Key	490-1282-1-ND
	C12	4700 pF / 4.7 nF 25 V ceramic	0402 SMD	Panasonic - ECG	ECJ-0EB1E472K	Digi-Key	PCC472BQCT-ND
	C3, C35	10000 pF/ 10 nF 16 V ceramic	0402 SMD	Panasonic - ECG (VA) V	ECJ-0EB1C103K	Digi-Key	PCC103BQCT-ND
	C4, C5, C6, C8, C9, C17, C18, C19, C20, C21, C22, C23, C24, C25, C29, C30, C31, C32, C36	1 µF/ 100 nF 10 V ceramic	0402 SMD	Panasonic - ECG (VA) V	ECJ-0EB1A104K	Digi-Key	PCC2146CT-ND
	C1	1 µF 6.3 V ceramic	0402 SMD	Panasonic - ECG (VA) V	ECJ-0EB0J105K	Digi-Key	PCC2393CT-ND
	C2, C7	Tantalum capacitors 4.7 µF 6.3 V 20 % R	0805 SMD	Rohm semiconductor	TCP0J475M8R	Digi-Key	511-1443-1-ND
	C10, C16, C26, C27, C28	Tantalum capacitors 10 µF 6.3 V 20 % R	0805 SMD	Rohm semiconductor	TCP0J106M8R	Digi-Key	511-1447-1-ND

Table 2. BOM (continued)

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code or equivalent
Capacitors	C37, C38	Tantalum capacitors 47 µF 6.3 V 20 % R	0805 SMD	Nichicon	F980J476MSA	Digi-Key	493-2877-1-ND
	L1, L2, L3	Ferrite bead 600 Ω	0402 SMD	TAIYO YUDEN (VA) V	BK1005HS601-T	Digi-Key	587-1846-1-ND
	D1, D2	LED RT angle green CLR	0805 SMD	LITE-ON INC (VA) V	LTST-S220GKT	Digi-Key	160-1218-1-ND
	D3	LED RT angle red CLR	0805 SMD	LITE-ON INC (VA) V	LTST-S220EKT	Digi-Key	160-1220-1-ND
Beads	U1	OSC 12.00 MHZ 3.0 V	SMD	ECS INC (VA) V	ECS-3963-120-BN-TR	Digi-Key	XC1031CT-ND
	Y1	8 MHz low profile	HC49US	ECS	ECS-80-18-4X	Digi-Key	300-8483-ND
LEDs	Y2	32.768 khz Tuning fork	Cylinder		CMR200T32.768K DZF-UT	Digi-Key	300-8340-1-ND
	SW1, SW2	Switch, micro detect right angle	SMD	MCFTE-2C-V	MULTICOMP	Farnell	1316984
	SW3	Slide switch, SPDT, horizontal	DIP	EAO	01-10290-01	Farnell	674357
Crystals and oscillators	J1	JTAG CONN	Box header, right angle, 20 way, 2x10 pin, 2.54 mm x 2.54 mm Pitch	Molex	70246-1001	Mouser	538-70246-1001

Table 2. **BOM (continued)**

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number or equivalent	Supplier	Supplier ordering code or equivalent
Crystals and oscillators	J2	Micro SD push type, gold flash lead free plating	uSD connector	Proconn technology Co., Ltd	MSPN09-D0-1002	Proconn technology Co., Ltd	MSPN09-D0-1002
	J3	JTAG_SUBCONN 050" 50POS PCB GOLD	Through hole	Sullins connector solutions	GRPB501VWVN-RC	Digi-Key	S9014E-50-ND
	J5	USB mini-B type connector	SMD USB Mini-B type connector	SAMTEC	MUSB-05-S-B-SM-A		
Switches	J6	2-pin battery connector	CONN Header 2POS, 2.54 mm pitch	SAMTEC	TSW-106-07-T-S	Digi-Key	SAM1035-06-ND
	U3 (Socket)	Camera socket	SMD	SMK corporation	CLE9124-1501FSZ		

6   Schematics of the STEVAL-CCM003V1

Figure 10.   Microcontroller schematic

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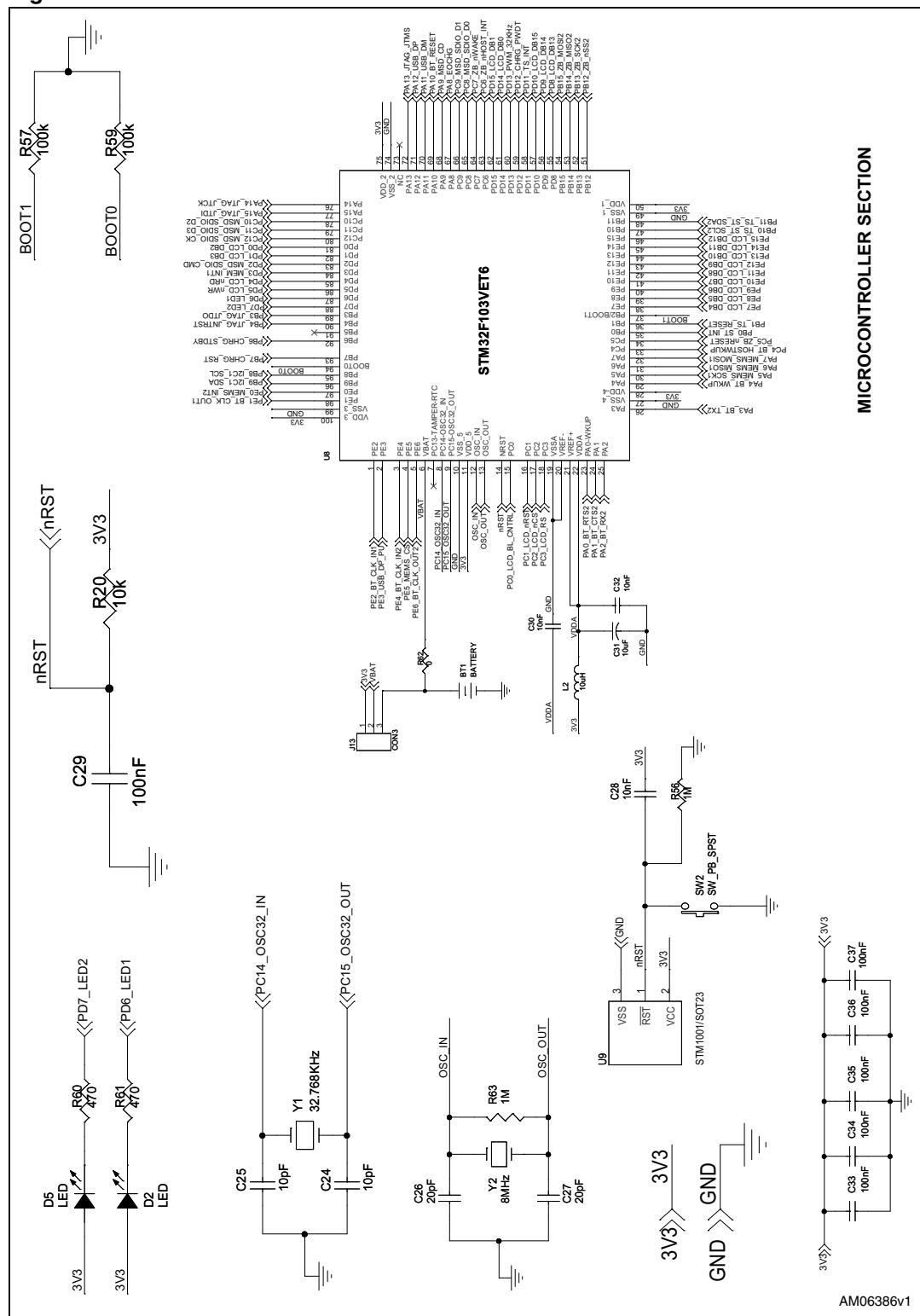
Figure 11.   Bluetooth schematic

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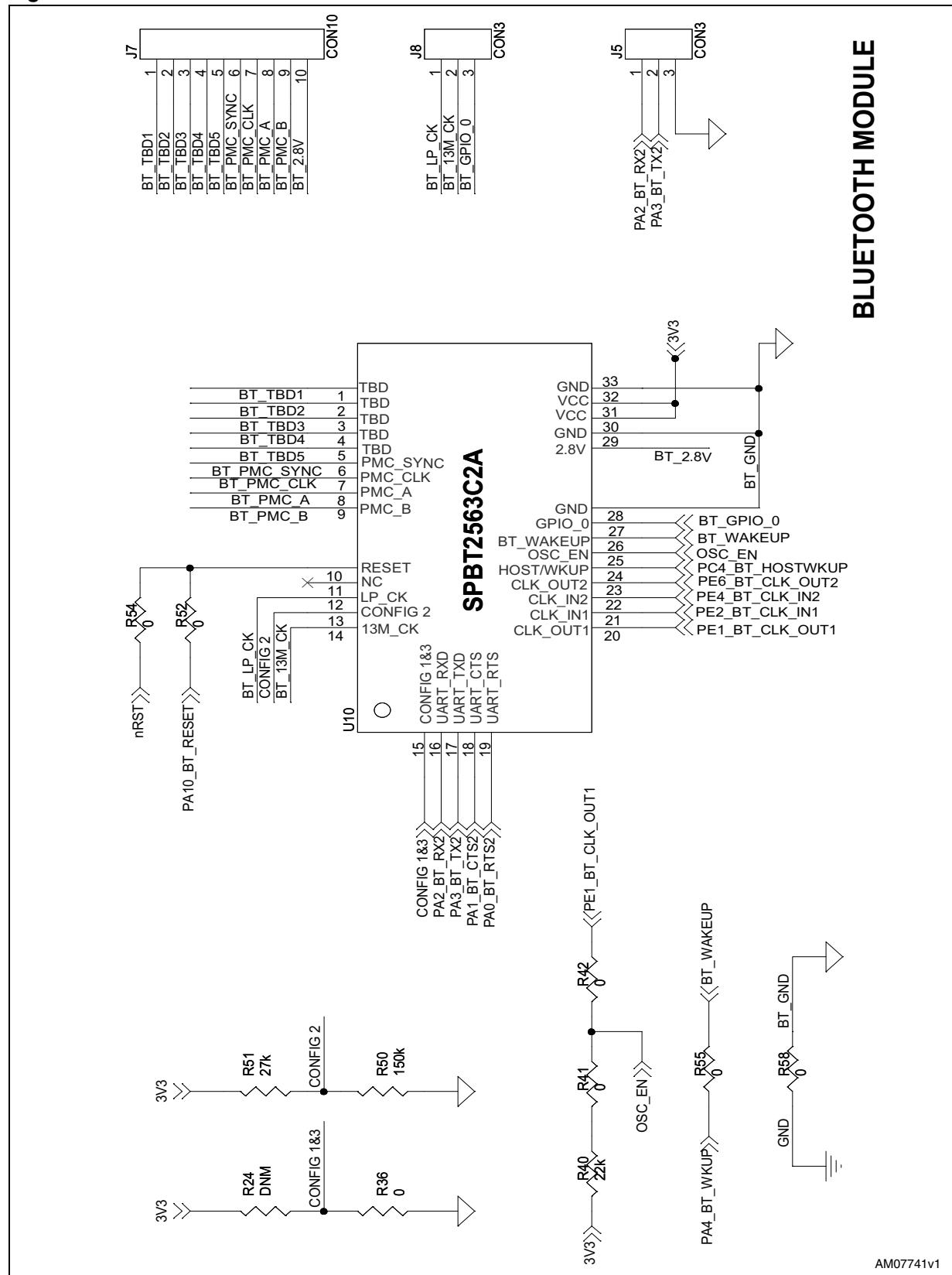
Figure 12.   TFT, touch, temperature and JTAG schematics

AM07742v1
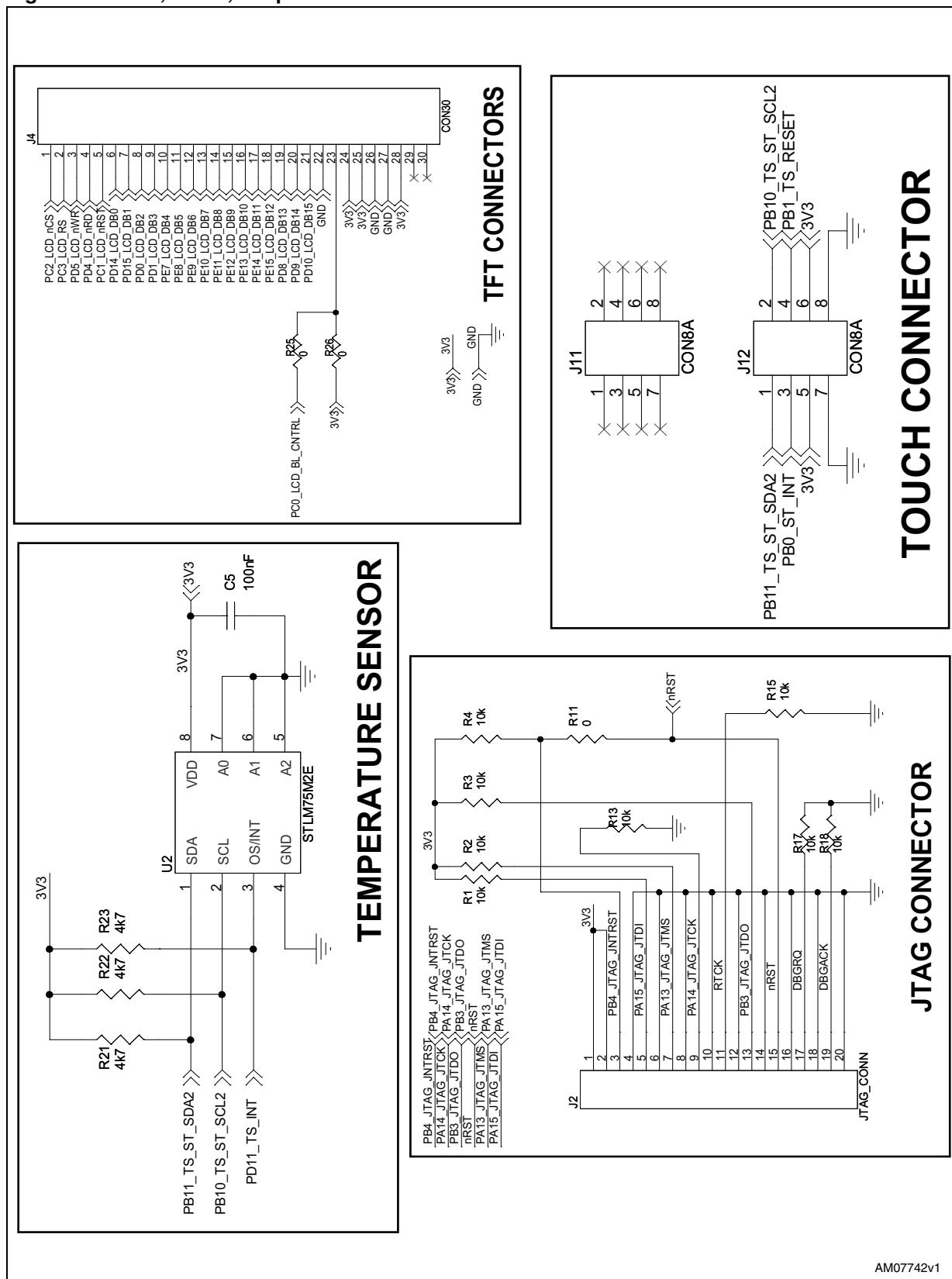
Figure 13. Micro SD and ZigBee schematics

MICRO SD CONNECTOR

**ZIGBEE MODULE CONNECTOR**

AM07743v1

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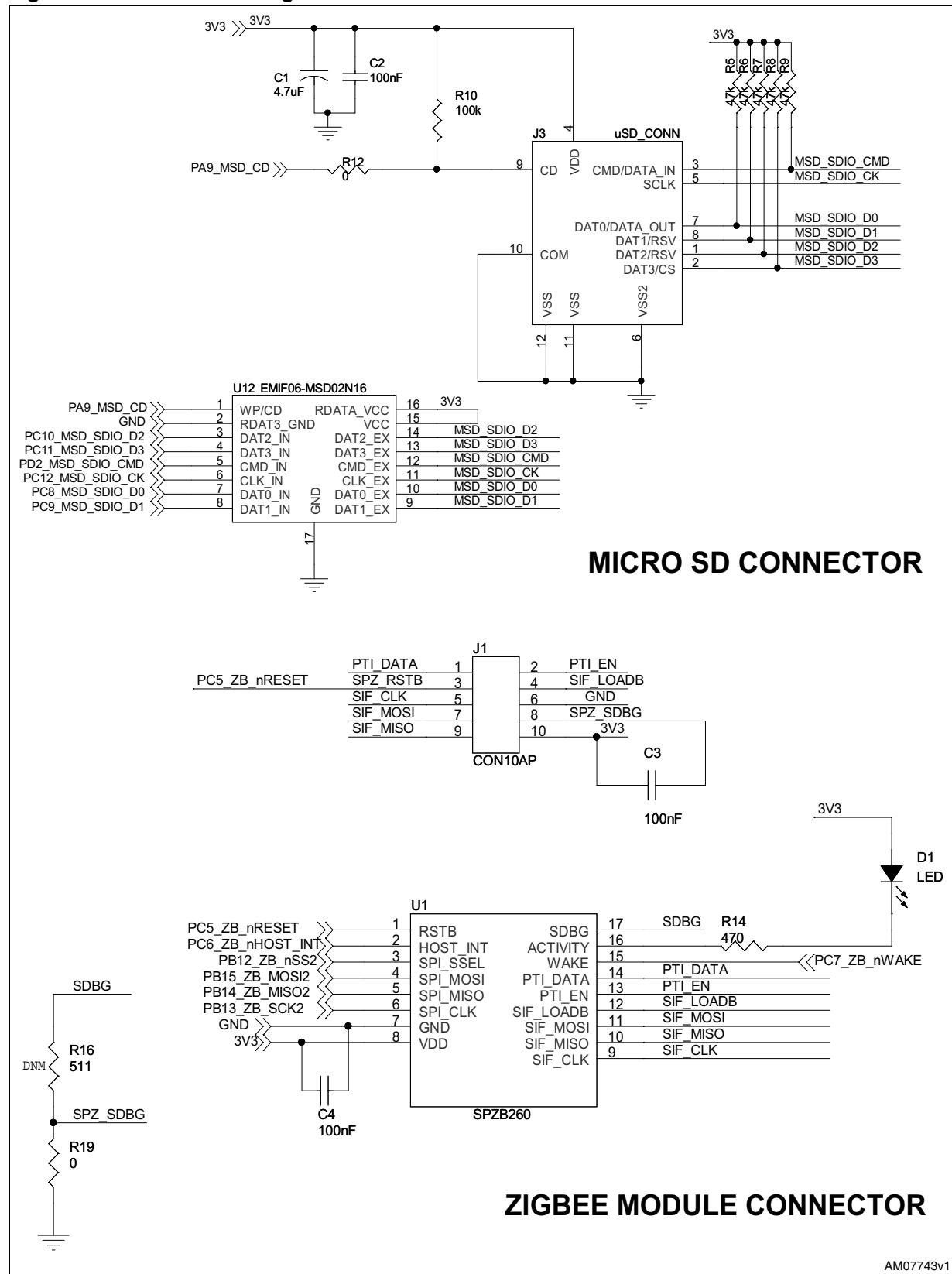
Figure 14. Power schematic
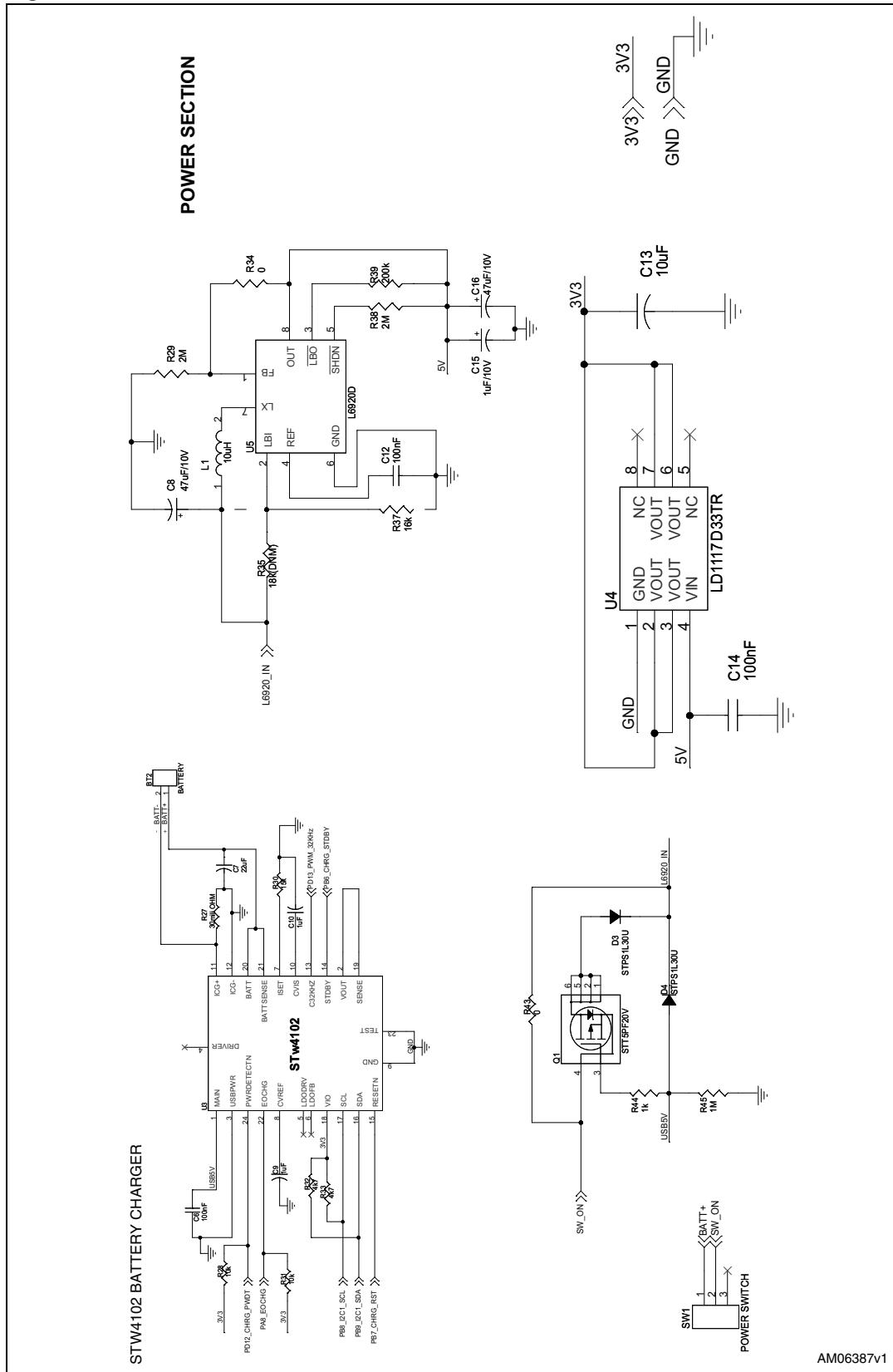
AM06387v1

Figure 15. MEMS and USB schematics

MEMS SECTION

USB SECTION

AM07723v1
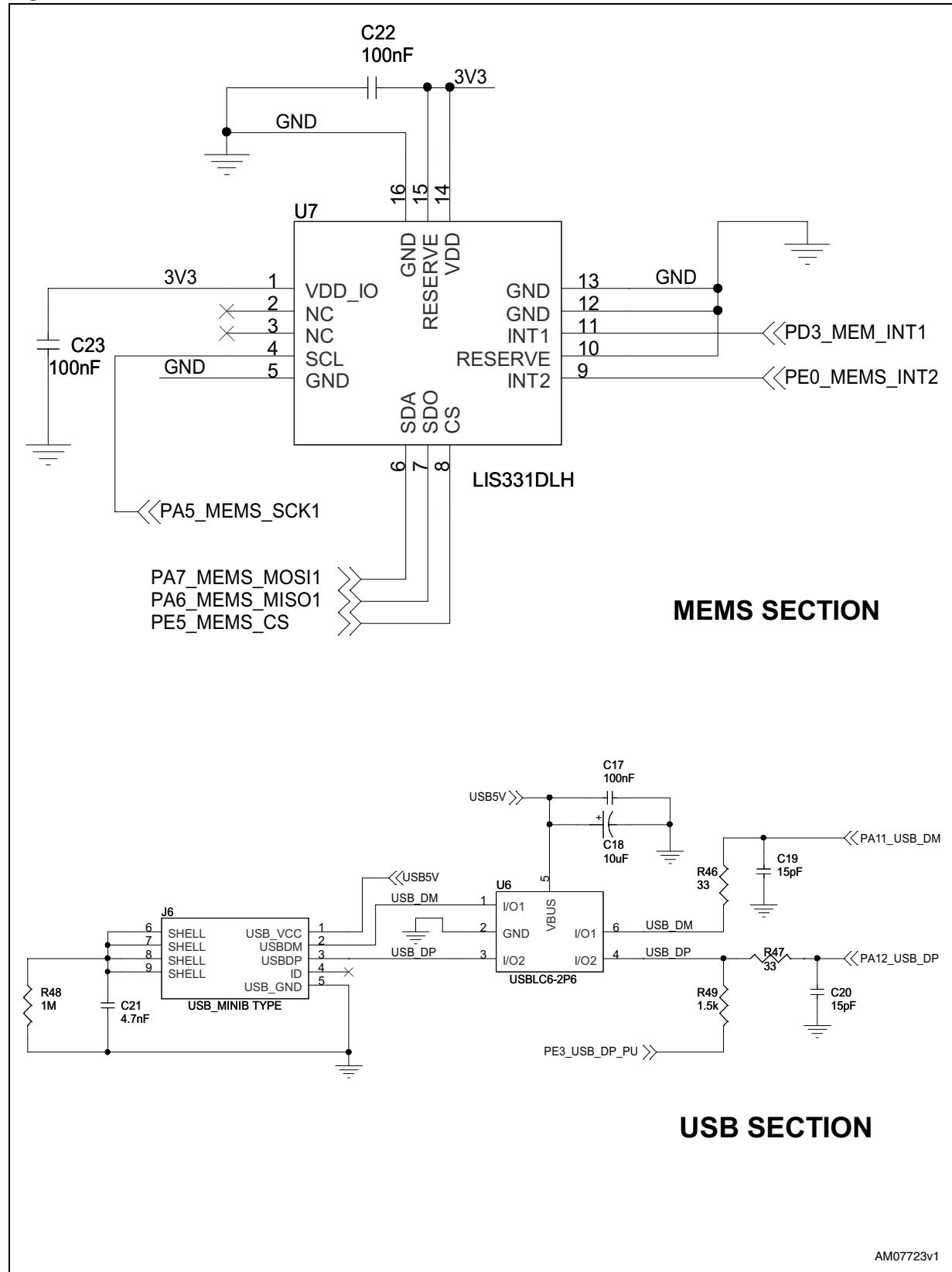
Figure 16. Touch schematic

AM06388v1
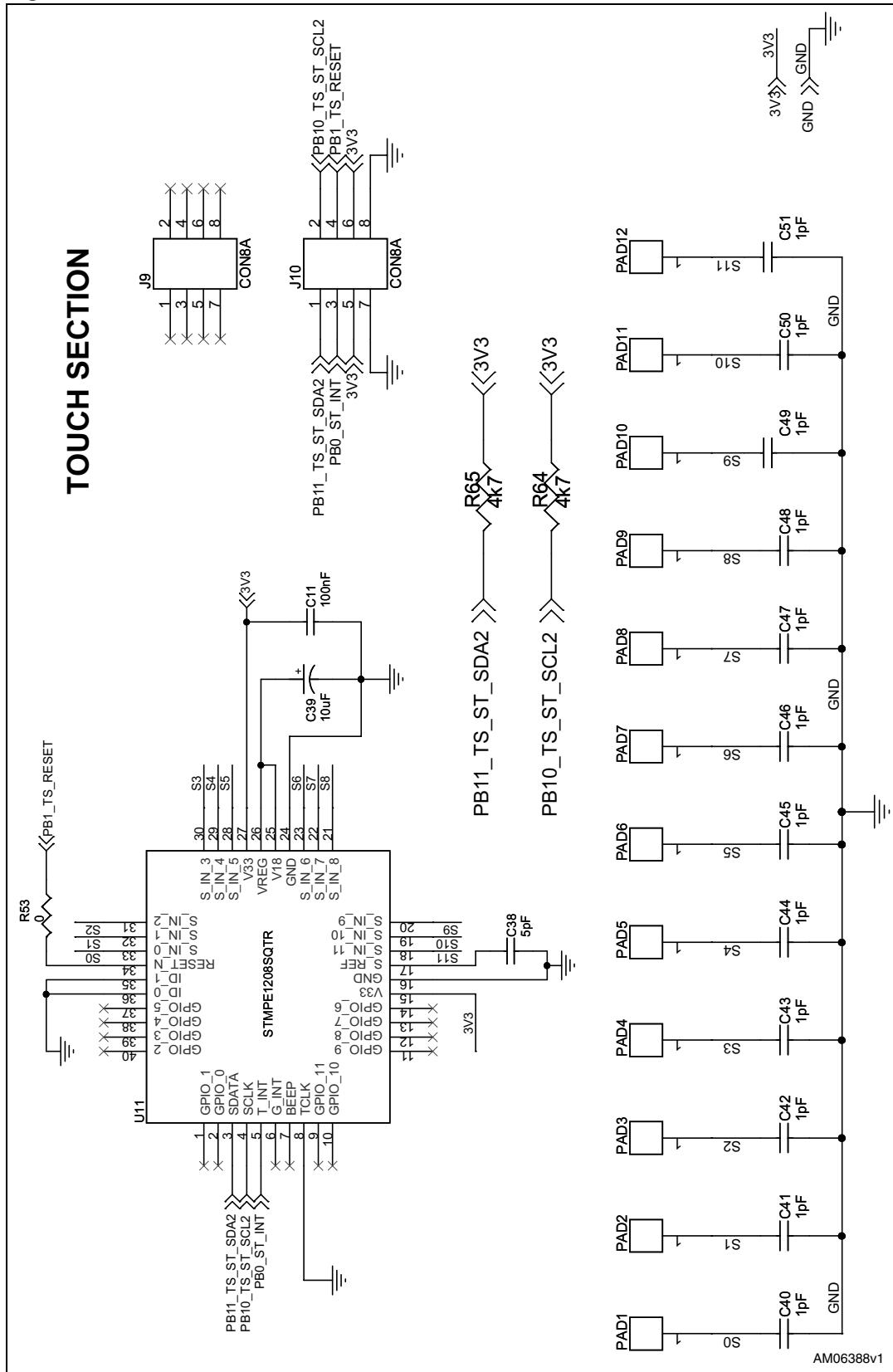
7 Bill of material of the STEVAL-CCM003V1

Table 3. **BOM**

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number	Supplier	Supplier ordering code
ST devices	U1	ZigBee module	12-pin SMD	STMicroelectronics	SPZB260		
	U2	Temperature sensor	SO-8	STMicroelectronics	STLM75M2E		
	U3	Dual USB/wall adapter Li-ion battery charger with gas gauge STw4102	QFN24	STMicroelectronics	STW4102IQT		
	U4	Low drop 3.3 V positive voltage regulators	SO-8	STMicroelectronics	LD1117D33TR		
	U5	Step-up converter	TSSOP8	STMicroelectronics	L6920D		
	U6	USBLC6_2P6 very low capacitance ESD protection for USB	SOT23-6L	STMicroelectronics	USBLC6-2P6		
	U7	3-axis MEMS	LGA16 (3x3x1)	STMicroelectronics	LIS331DLH		
	U8	Microcontroller, ARM 32-bit Cortex™-M3 CPU, 512 K flash, 64 K RAM	100-pin LQPF	STMicroelectronics	STM32F103VET6		
	U9 (not mounted)	Reset Supervisor	SOT23	STMicroelectronics	STM1001SWX6F		
	U10 (not mounted)	Footprint for other modules					
	U11	S-Touch,	QFN40	STMicroelectronics	STMPE1208SQTR		
	U12	ESD protection for µSD card	Micro QFN 16L	STMicroelectronics	EMIF06-MSD02N16		
	Q1	Power MOSFET	SOT23-6L	STMicroelectronics	STT5PF20V		
	D3, D4	Power Schottky rectifier	SMD	STMicroelectronics	STPS1L30U		

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Table 3. **BOM (continued)**

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number	Supplier	Supplier ordering code
Crystal and Oscillator	Y1	Tuning fork crystal 32 kHz	2.0 mm x 6.0 mm	Jauch	Q 0,032768-MMTF32-12,5-20		
	Y2	Quartz crystal 8 MHz	11.35 mm x 4.35 mm, SS4	Jauch	Q 8.0-SS4-22-30/30		
Connectors jumpers and switches	SW1	Power switch: slide switch: SPDT-CO, right angle	3-pin, 2.54 mm pitch through hole	EAO	09-10290-01	Farnell	674357
	SW2	Reset switch, pushbutton switch	(6 mm X 6 mm) pushbutton, through hole	TYCO ELECTRONICS	FSM2JH	Farnell	Part# 1555981
	J1(not mounted)	Connector 10-pin for ZigBee upgrade	SMT	SAMTEC	FTSH-105-01-F-DV-K		
	J2	JTAG connector	Box header, straight 20way, 2x10pin, 2.54 mm x 2.54 mm pitch, through hole	Protectron	P9603-20-15-1		
	J3	µSD connector	SMD	Proconn technology	MSPN09-D0-1002		

Table 3. **BOM (continued)**

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number	Supplier	Supplier ordering code
Connectors jumpers and switches	J4	LCD-TFT connector	Socket, 2x15 pin, 2.54 mm x 2.54 mm Pitch, through hole	Any			
	J5,J8,J13	3 pin jumpers/connectors	3-pin header,2.5 mm pitch, through hole	Any			
	J6	USB MINI-B connector	SMD	Samtec	MUSB-05-S-B-SM-A		
	J7 (not mounted)	CON10	10-pin header,2.5mm pitch, through hole	Any			
	J9,J10	CON8A	Header, 2x4pin, 2.54 mm x 2.54 mm pitch, through hole	Any			
	J11,J12	Touch-keys PCB connector	Socket, 2x4pin, 2.54 mm x 2.54 mm pitch, through hole	Any			
	BT1	Battery CR2032 holder	Through hole	Renata	HU2032-LF	Mouser	614-HU2032-LF
	BT2	Li-Ion 2-pin battery conn	2 pin header,2.5 mm pitch, through hole	Any			
LEDs	D1	LED for ZigBee	SMD	Any			
	D2,D5	LED for test purpose	SMD	Any			
Capacitors	C44,C47	1 pF	SMD0805				
	C38	6 pF	SMD0805	Any			
	C24,C25	10 pF	SMD0805	Any			
	C19,C20	15 pF	SMD0805	Any			

Table 3.   BOM (continued)

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number	Supplier	Supplier ordering code
Capacitors	C26,C27	20 pF	SMD0805	Any			
	C21	4.7 nF	SMD0805	Any			
	C28,C30,C32	10 nF	SMD0805	Any			
	C2,C3,C4,C5,C6, C11,C12,C14, C17,C22,C23, C29,C33,C34, C35,C36,C37	100 nF	SMD0805	Any			
	C9,C10, C15	1 µF	EIA 3528-21/ size A	Any			
	C1	4.7 µF	EIA 3528-21/ size A	Any			
	C13,C18,C31, C39	10 µF	EIA 3528-21/ size B	Any			
	C7	22 µF	EIA 3528-21/ size B	Any			
	C8,C16	47 µF	EIA 3528-21/ size B	Any			
	C40,C41,C42, C43,C45,C46, C48, C49,C50,C51	(Not mounted)	SMD0805				
Inductors	L1,L2	10 µH	SMD0805	Any			
Resistors	R1,R2,R3,R4, R13,R15,R17, R18,R20,R28, R31	10 kΩ	SMD0805	Any			
	R5,R6,R7,R8,R9	47 kΩ	SMD0805	Any			
	R10,R57,R59	100 kΩ	SMD0805	Any			

Table 3.   BOM (continued)

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number	Supplier	Supplier ordering code
Resistors	R11,R12,R19, R25,R26,R34, R36,R41,R42, R43,R52,R53, R54,R55,R58, R62	0	SMD0805	Any			
	R14,R60,R61	470 Ω	SMD0805	Any			
	R16	511 Ω	SMD0805	Any			
	R21,R22,R23, R32,R33,R64,R65	4.7 kΩ	SMD0805	Any			
	R24	DNM	SMD0805	Any			
	R27	Resistor, metal STRIP, 0.03 OHM 1 % 0.125 W	SMD0805	VISHAY DALE	WSL-0805 .03 1 % EB E3	Farnell	Part# 1107335
	R29,R38	2 MΩ	SMD0805	Any			
	R30	15 kΩ	SMD0805	Any			
	R35	18 k(DNM)	SMD0805	Any			
	R37	16 kΩ	SMD0805	Any			
	R39	200 kΩ	SMD0805	Any			
	R40	22 kΩ	SMD0805	Any			
	R44	1 kΩ	SMD0805	Any			
	R45,R48,R56, R63	1 MΩ	SMD0805	Any			
	R46,R47	33 Ω	SMD0805	Any			
	R49	1.5 kΩ	SMD0805	Any			
	R50	150 kΩ	SMD0805	Any			

Table 3.   BOM (continued)

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number	Supplier	Supplier ordering code
Resistors	R52	200 kΩ	SMD0805	Any			
Others	TFT	TFT: 320 x 240	Module: MB694				MB694
	MicroSD card	MicroSD card		Any			

8 Revision history

Table 4. Document revision history

Date	Revision	Changes
12-Jul-2010	1	Initial release.

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