UM2631

User manual

Getting started with the digital MEMS microphone expansion board based on MP34DT06J for STM32 Nucleo

Introduction

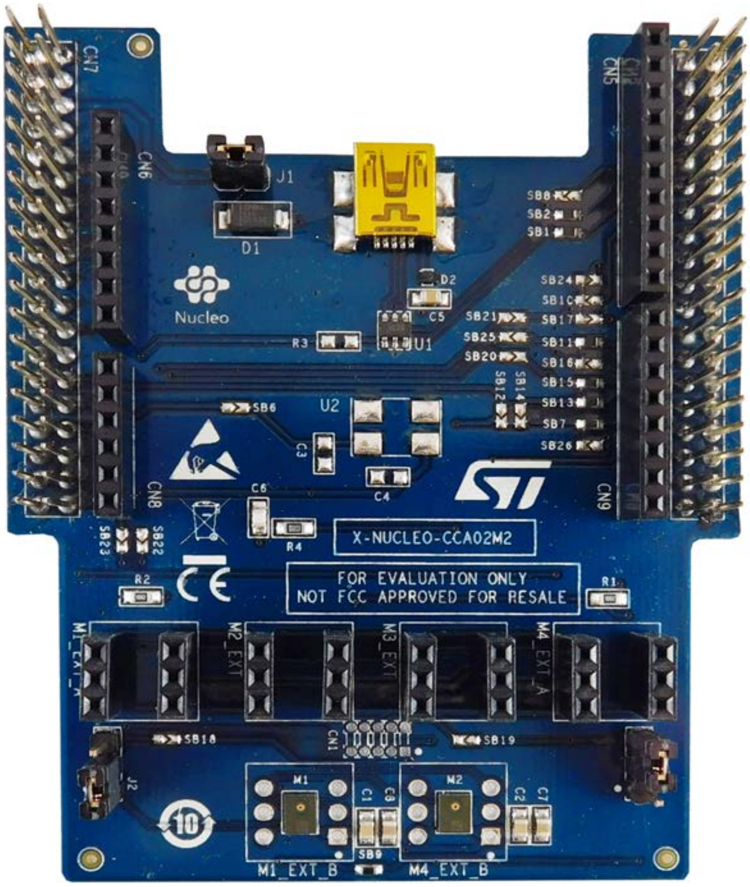
The X-NUCLEO-CCA02M2 expansion board has been designed around MP34DT06J digital MEMS microphone.

It is compatible with the ST morpho connector layout and with digital microphone coupon boards such as STEVAL-MIC001V1, STEVAL-MIC002V1 and STEVAL-MIC003V1.

The X-NUCLEO-CCA02M2 embeds two MP34DT06J microphones and allows synchronized acquisition and streaming of up to 4 microphones through I²S, SPI, DFSDM or SAI peripherals.

It represents a quick and easy solution for the development of microphone-based applications as well as a starting point for audio algorithm implementation.

Figure 1. **X-NUCLEO-CCA02M2 expansion board**



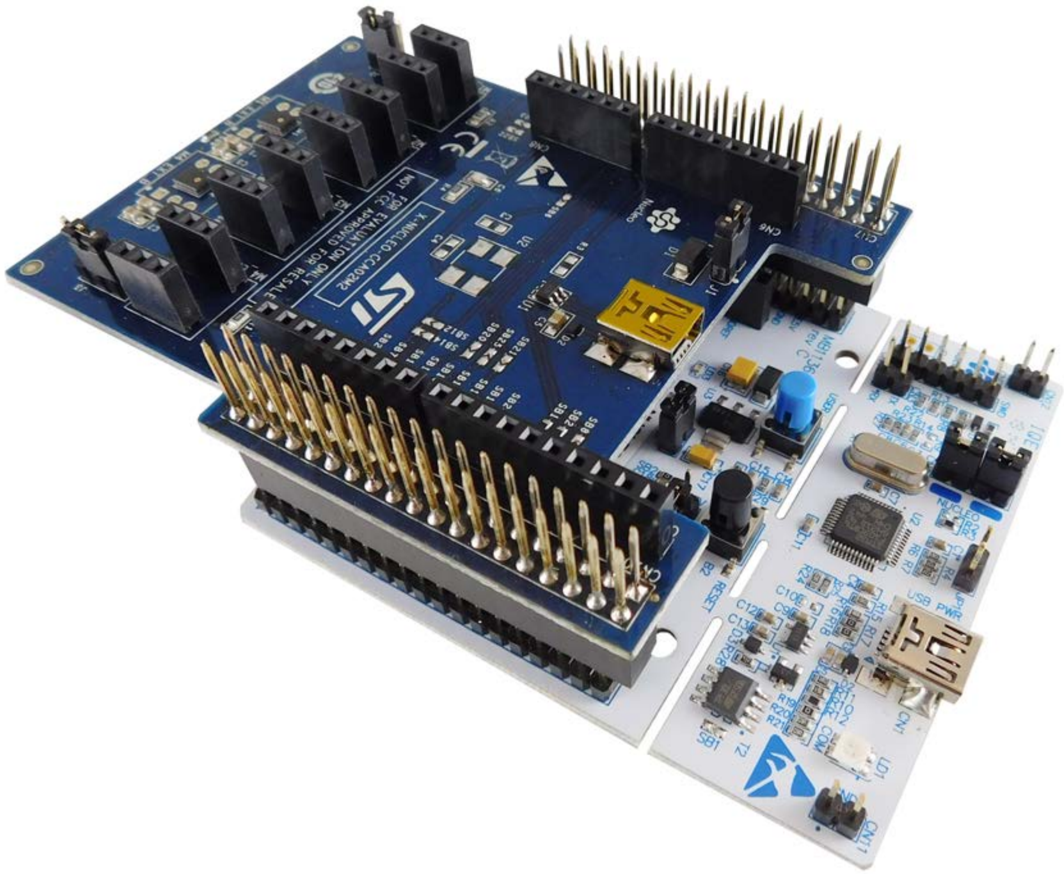
1 Getting started

1.1 Hardware requirements

The X-NUCLEO-CCA02M2 expansion board can be connected to any STM32 Nucleo board.

However, the related firmware, X-CUBE-MEMSMIC1, offers an out-of-the-box package for some STM32 Nucleo boards (for further details, refer to the firmware documentation on www.st.com).

Figure 2. X-NUCLEO-CCA02M2 on STM32 Nucleo board



When mounting the X-NUCLEO-CCA02M2 on the STM32 Nucleo, align all the pins with their corresponding connector.

Note: Handle the boards carefully during this operation and implement ESD prevention measures to avoid damaging (or bending) the male/female pins, connectors and the expansion board components.

1.2 System requirements

To use the X-NUCLEO-CCA02M2 expansion board you need the same hardware and software resources of STM32 Nucleo boards (for details, refer to UM1724 on www.st.com) as well as 40 MB of free space on your hard disk and at least 128 MB of RAM to run the related X-CUBE-MEMSMIC1 firmware package.

2 Hardware description

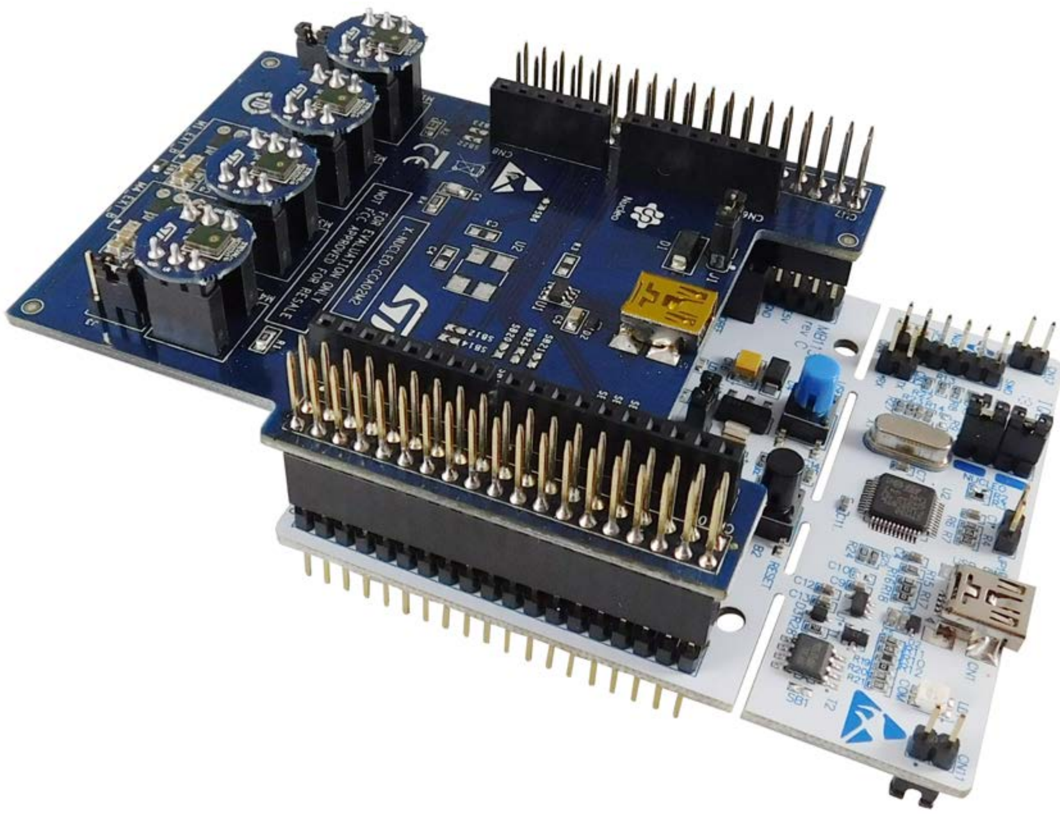
The X-NUCLEO-CCA02M2 allows testing STMicroelectronics digital MEMS microphones: two MP34DT06J microphones are mounted on the board and 6 headers (4 mounted with 2 additional footprints) are available for connecting additional microphones by connecting digital microphone coupon boards (STEVAL-MIC001V1, STEVAL-MIC002V1 and STEVAL-MIC003V1).

The X-NUCLEO-CCA02M2 interfaces with the STM32 Nucleo microcontrollers via the I²S, SPI, DFSDM or SAI peripherals for the synchronized acquisition of up to 4 microphones.

The board also provides USB streaming using the STM32 Nucleo microcontroller USB peripheral: a USB connector is available together with the footprint to mount a dedicated oscillator that can be used to feed the host MCU through the OSC_IN pin.

Solder bridges allows choosing from different options, depending on the number of microphones and the MCU peripherals involved.

Figure 3. Microphone coupon board connected to X-NUCLEO-CCA02M2



2.1 USB connector and power source

The on-board USB connector supports audio streaming to the host PC and can also be used to power the whole system up, including the STM32 Nucleo board, by:

- closing Jumper J1 on the X-NUCLEO-CCA02M2 expansion board
- placing JP5 in position E5 on the STM32 Nucleo board

2.2 Audio acquisition strategy

A digital MEMS microphone can be acquired via different peripherals (SPI, I²S, GPIO, SAI or DFSDM). It requires an input clock to output a PDM stream at the same frequency of the input clock.

The PDM stream is further filtered and decimated for conversion into PCM standard for audio transmission.

Two different digital MEMS microphones can be connected on the same data line, configuring the first one to generate valid data on the rising edge of the clock and the other one on the falling edge, by setting the L/R pin of each microphone accordingly.

On the X-NUCLEO-CCA02M2 expansion board two microphones share the same data line. Depending on the peripherals available on the host MCU, different acquisition methods can be implemented to get microphone data as further detailed in the following paragraphs.

2.2.1 DFSDM microphone acquisition

The DFSDM peripheral generates the clock needed by the microphones and reads the data on the rising and falling edges of each PDM line.

The acquired signals become an input to DSFDM filters for hardware filtering and decimation to generate standard PCM streams.

An additional software high pass filtering stage removes any DC offset in the output stream. DMA is used to reduce MCU load.

2.2.2 I²S and SPI microphone acquisition

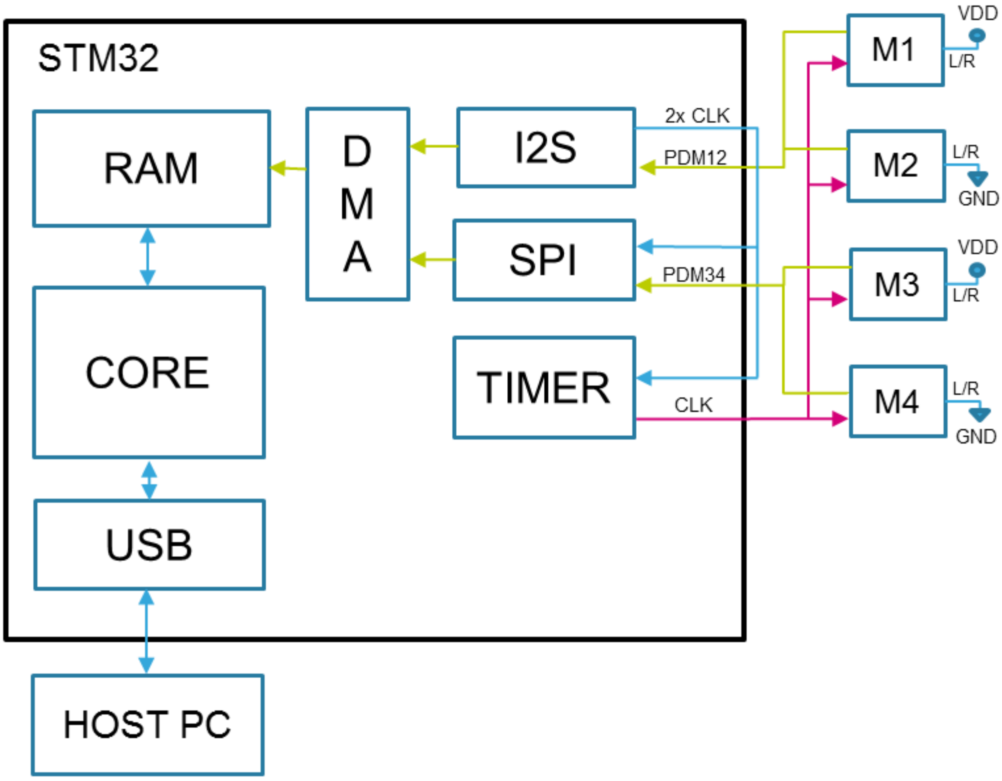
In this scenario, I²S peripheral is used for the first and second microphone, while SPI is adopted for the third and fourth one.

A precise clock signal is generated by the I²S peripheral while the SPI is configured in slave mode and is fed by the same timing signal generated by I²S. This clock is then halved by a timer and input to the microphones. The SPI and I²S peripherals operate at twice the microphone frequency to read the data on both the rising and falling edges of the microphone clock, thus reading the bits of two microphones each.

A software demuxing step separates the signal from the two microphones and allows further software processing; typically PDM to PCM conversion is performed to transform PDM signals in the widely adopted and easy to manage PCM format.

For further information regarding MEMS microphones acquisition and PDM to PCM decimation, refer to AN5027 and UM2372 on www.st.com.

Figure 4. General acquisition strategy using I²S and SPI



For single microphone acquisition, the microphone precise clock is generated directly by I²S and one single microphone data line is read by the same peripheral.

2.2.3 SAI microphone acquisition

Like DFSDM, the SAI peripheral with PDM interface is able to generate the precise clock needed by the microphones and can read the data on the rising and falling edges of each PDM line.

Unlike DFSDM, however, SAI cannot convert PDM to PCM in hardware, thus a software step for the conversion is needed after data acquisition.

2.3 Solder bridge configurations

Several board configurations are possible, depending on the use case.

MEMS microphones can be plugged into ST morpho pins, and thus to MCU peripherals, with appropriate solder bridges.

Clock routing can also be changed according to specific needs.

2.3.1 Solder bridge functions

Table 1. Solder bridge functions with respect to audio acquisition strategies

Solder bridge	Function
SB1	Connects USB DM pin from connector to MCU
SB2	Connects USB DP pin from connector to MCU
SB6	Routes on-board oscillator output to OSC_IN MCU pin
SB7	Connects MEMS clock to MCU timer output channel
SB8	Routes I²S clock to SPI clock
SB9	Merges on-board microphone PDMs to be acquired with one interface
SB10	Connects MIC34 PDM to MCU SPI
SB11	Connects MIC12 PDM to MCU I2S
SB12	Clock from the DFSDM peripheral
SB13	I²S clock from MCU
SB14	Connects I²S clock directly to MIC clock without passing through timer
SB15	Connects I²S clock to MCU timer input channel
SB16	Connects MIC12 PDM to MCU DFSDM
SB17	Connects MIC34 PDM to MCU DFSDM
SB24	Connects MIC34 PDM to MCU SAI
SB25	Connects MIC12 PDM to MCU SAI
SB26	Clock from the SAI peripheral

2.3.1.1 Sample use cases

In this section, we analyze specific use cases together with the corresponding solder bridge configurations based on the acquisition peripherals involved. Custom setups are also possible for ad-hoc functions.

Note: SB1, SB2, SB6 are reserved for the USB or oscillator pins and are not involved in the audio acquisition process.

2.3.1.1.1 Jumper settings for DFSDM-based systems

1 or 2 microphone acquisition

The clock is generated by DFSDM peripheral and the PDM line of the first and second microphone is routed to the MCU.

Table 2. **Solder bridge configuration for 1 or 2 microphone acquisition**

Solder bridge	Status
SB7	Open
SB8	Open
SB9	Open/closed
SB10	Open
SB11	Open
SB12	Close
SB13	Open
SB14	Open
SB15	Open
SB16	Close
SB17	Open
SB18	Open
SB19	Open
SB20	Open
SB21	Open
SB24	Open
SB25	Open
SB26	Open

Note: *J2 must be placed in position 1-2 for on-board microphone acquisition or 2-3 when using an external microphone while J3 must be left open. When acquiring on-board microphones, close SB9 to acquire both of them.*

4 microphone acquisition

The PDM line of the third and fourth microphone is also routed to the MCU.

Table 3. **Solder bridge configuration for 4 microphone acquisition**

Solder bridge	Status
SB7	Open
SB8	Open
SB9	Open
SB10	Open
SB11	Open
SB12	Close
SB13	Open
SB14	Open
SB15	Open
SB16	Close
SB17	Close

Solder bridge	Status
SB18	Open
SB19	Open
SB20	Open
SB21	Open
SB24	Open
SB25	Open
SB26	Open

Note: J2 and J3 must be placed in position 2-3 for external microphone acquisition.

2.3.1.1.2 Jumper settings for I²S-plus-SPI-based systems

1 microphone acquisition

The I²S peripheral is used directly to give the right clock to the microphone and to acquire the same microphone.

Table 4. Solder bridge configuration for 1 microphone acquisition

Solder bridge	Status
SB7	Open
SB8	Open
SB9	Open
SB10	Open
SB11	Closed
SB12	Open
SB13	Closed
SB14	Closed
SB15	Open
SB16	Open
SB17	Open
SB18	Open
SB19	Open
SB20	Open
SB21	Open
SB24	Open
SB25	Open
SB26	Open

Note: J2 must be placed in position 1-2 for on-board microphone acquisition or 2-3 when using an external microphone, while J3 must be left open. If using external microphones, do not plug anything in `M2_EXT` header.

2 microphone acquisition

The I²S peripheral is used to generate twice the frequency needed by the microphones. In this scenario, the clock is then halved by the timer and routed to the microphones to give them the right clock. I²S therefore reads values from both edges of the merged PDM lines.

Table 5. Solder bridge configuration for 2 microphone acquisition

Solder bridge	Status
SB7	Closed
SB8	Open
SB9	Open /closed
SB10	Open
SB11	Closed
SB12	Open
SB13	Closed
SB14	Open
SB15	Closed
SB16	Open
SB17	Open
SB18	Open
SB19	Open
SB20	Open
SB21	Open
SB24	Open
SB25	Open
SB26	Open

Note: J2 must be placed in position 1-2 for on-board microphone acquisition or 2-3 when using external microphones, while J3 must be left open. When acquiring on-board microphones, close SB9 to acquire both of them.

4 external microphone acquisition

The I²S peripheral is used to generate a clock frequency that is twice the frequency needed by the microphones, and SPI is configured in slave mode to use such timing. As in the previous case, the clock is then halved by the timer and routed to the microphones to give the right clock. I²S and SPI read values from both the edges of the merged PDM lines.

Table 6. Solder bridge configuration for 4 microphone acquisition

Solder bridges	Status
SB7	Closed
SB8	Closed
SB9	Open
SB10	Closed
SB11	Closed
SB12	Open

Solder bridges	Status
SB13	Closed
SB14	Open
SB15	Closed
SB16	Open
SB17	Open
SB18	Open
SB19	Open
SB20	Open
SB21	Open
SB24	Open
SB25	Open
SB26	Open

Note: J2 and J3 must be placed in position 2-3 for external microphone acquisition.

Note: Other configurations are available, based on the MCU used.

Note: When acquiring 4 microphones using a NUCLEO-F746ZG development board, JP6 jumper on the board must be opened.

2.3.1.1.3 Jumper settings for SAI-based systems

1 or 2 microphone acquisition

The clock is generated by SAI peripheral and the PDM line of the first and second microphone is routed to the MCU.

Table 7. Solder bridge configuration for 1 or 2 microphone acquisition

Solder bridge	Status
SB7	Open
SB8	Open
SB9	Open/closed
SB10	Open
SB11	Open
SB12	Open
SB13	Open
SB14	Open
SB15	Open
SB16	Open
SB17	Open
SB18	Open
SB19	Open
SB20	Open
SB21	Open

Solder bridge	Status
SB24	Open
SB25	Closed
SB26	Closed

Note: J2 must be placed in position 1-2 for on-board microphone acquisition or 2-3 when using an external microphone while J3 must be left open. When acquiring on-board microphones, close SB9 to acquire both of them.

4 microphone acquisition

The PDM line of the third and fourth microphone is also routed to the MCU.

Table 8. Solder bridge configuration for 4 microphone acquisition

Solder bridge	Status
SB7	Open
SB8	Open
SB9	Open/closed
SB10	Open
SB11	Open
SB12	Open
SB13	Open
SB14	Open
SB15	Open
SB16	Open
SB17	Open
SB18	Open
SB19	Open
SB20	Open
SB21	Open
SB24	Closed
SB25	Closed
SB26	Closed

Note: J2 and J3 must be placed in position 2-3 for external microphone acquisition.

3 NUCLEO-F746ZG support

To connect an X-NUCLEO-CCA02M2 expansion board to a NUCLEO-F746ZG development board, morpho header connectors must be soldered on the relevant footprint available on the STM32 Nucleo.

Note: For the expansion board, you do not need to solder the whole 2 x 80 pin header but only a pair of 2 x 38 pin stripline connectors.

4 Connectors

The pin assignments for the Arduino UNO R3 and the ST morpho connectors are shown in Table 9. ST morpho connectors and Table 10. Arduino connectors respectively.

Table 9. **ST morpho connectors**

Connector	Pin	Signal	Remarks
CN7	1	MIC_CLKx2	If SB20 is closed
	3	MIC_PDM34	If SB20 is closed
	6	E5V	
	12	3V3	
	16	3V3	
	18	5V	
	20	GND	
	22	GND	
	24	V_IN	
	29	OSC_CLK_OUT	If SB6 is closed
	35	MIC_CLK_NUCLEO	If SB12 is closed
CN10	11	MIC_CLKx2	If SB8 is closed
	12	OTG_FS_DP_NUCLEO	If SB1 is closed
	14	OTG_FS_DM_NUCLEO	If SB2 is closed
	15	MIC_PDM34	If SB10 is closed
	19	MIC_PDM34	If SB24 is closed
	24	MIC_CLK_NUCLEO	If SB26 is closed
	25	MIC_PDM34	If SB17 is closed
	26	MIC_PDM12	If SB11 is closed
	27	MIC_CLKx2	If SB15 is closed
	28	MIC_PDM12	If SB16 is closed
	29	MIC_CLK_NUCLEO	If SB7 is closed
	30	MIC_CLKx2	If SB13 is closed
	31	MIC_PDM12	If SB25 is closed

Table 10. Arduino connectors

Connector	Pin	Signal	Remarks
CN6	2	3V3	
	4	3V3	
	5	5V	
	6	GND	
	7	GND	
	8	V_IN	
CN5	6	MIC_CLKx2	If SB8 is closed
	4	MIC_PDM34	If SB10 is closed
	2	MIC_PDM34	If SB24 is closed
CN9	7	MIC_PDM34	If SB17 is closed
	7	MIC_CLK_NUCLEO	If SB26 is closed
	6	MIC_CLKx2	If SB15 is closed
	5	MIC_CLK_NUCLEO	If SB7 is closed
	4	MIC_PDM12	If SB25 is closed

5 Schematic diagrams

Figure 5. **X-NUCLEO-CCA02M2 circuit schematic (1 of 3)**

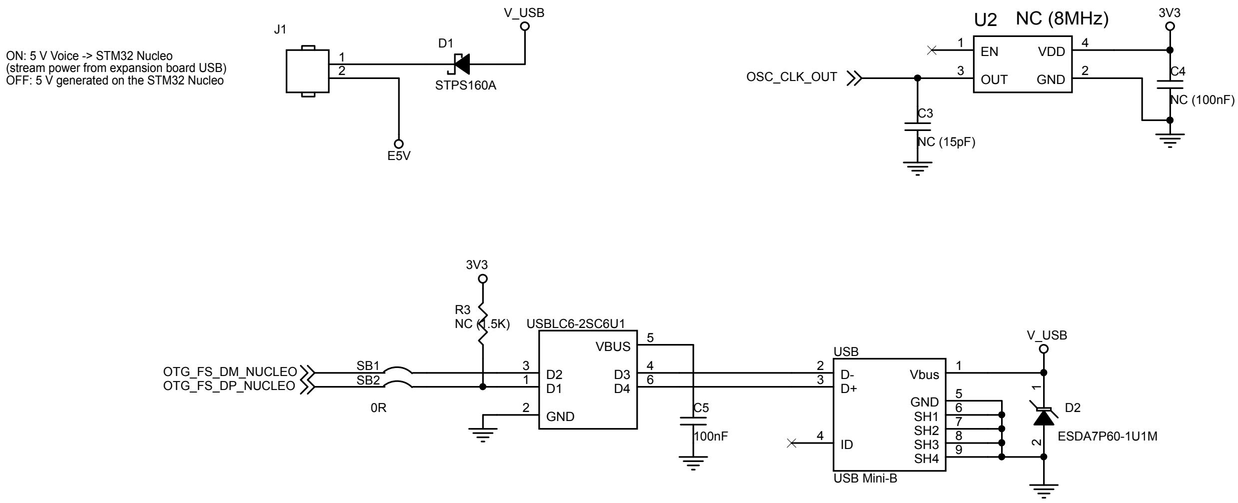


Figure 6. **X-NUCLEO-CCA02M2 circuit schematic (2 of 3)**

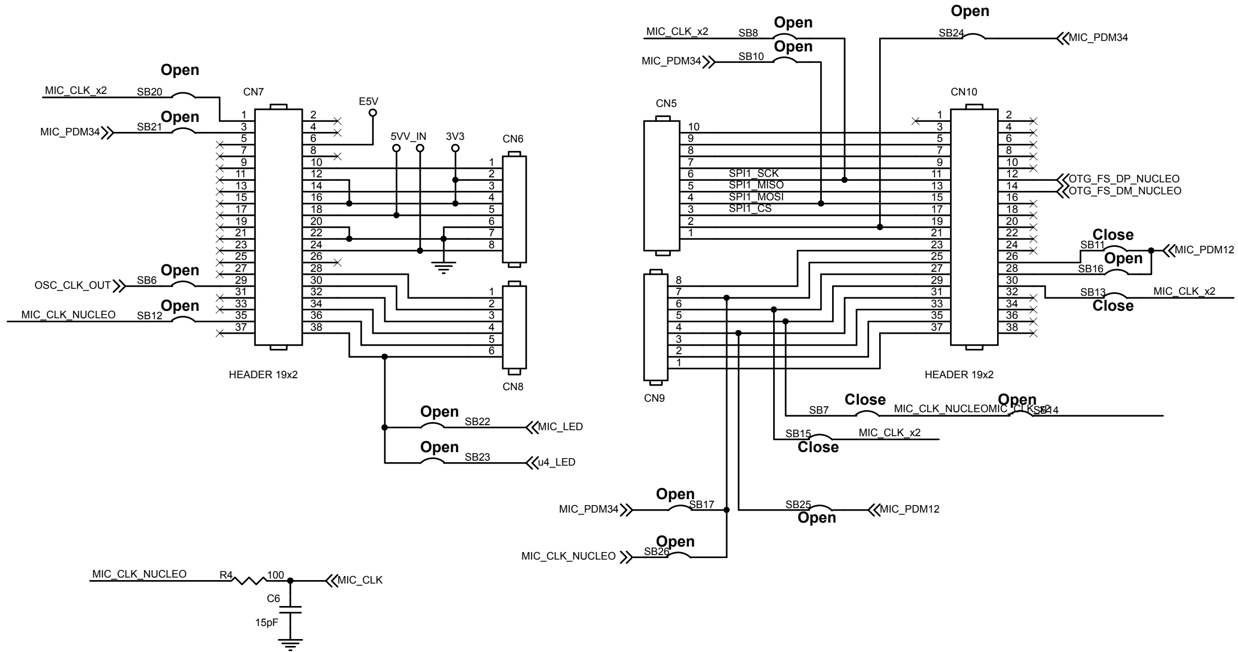
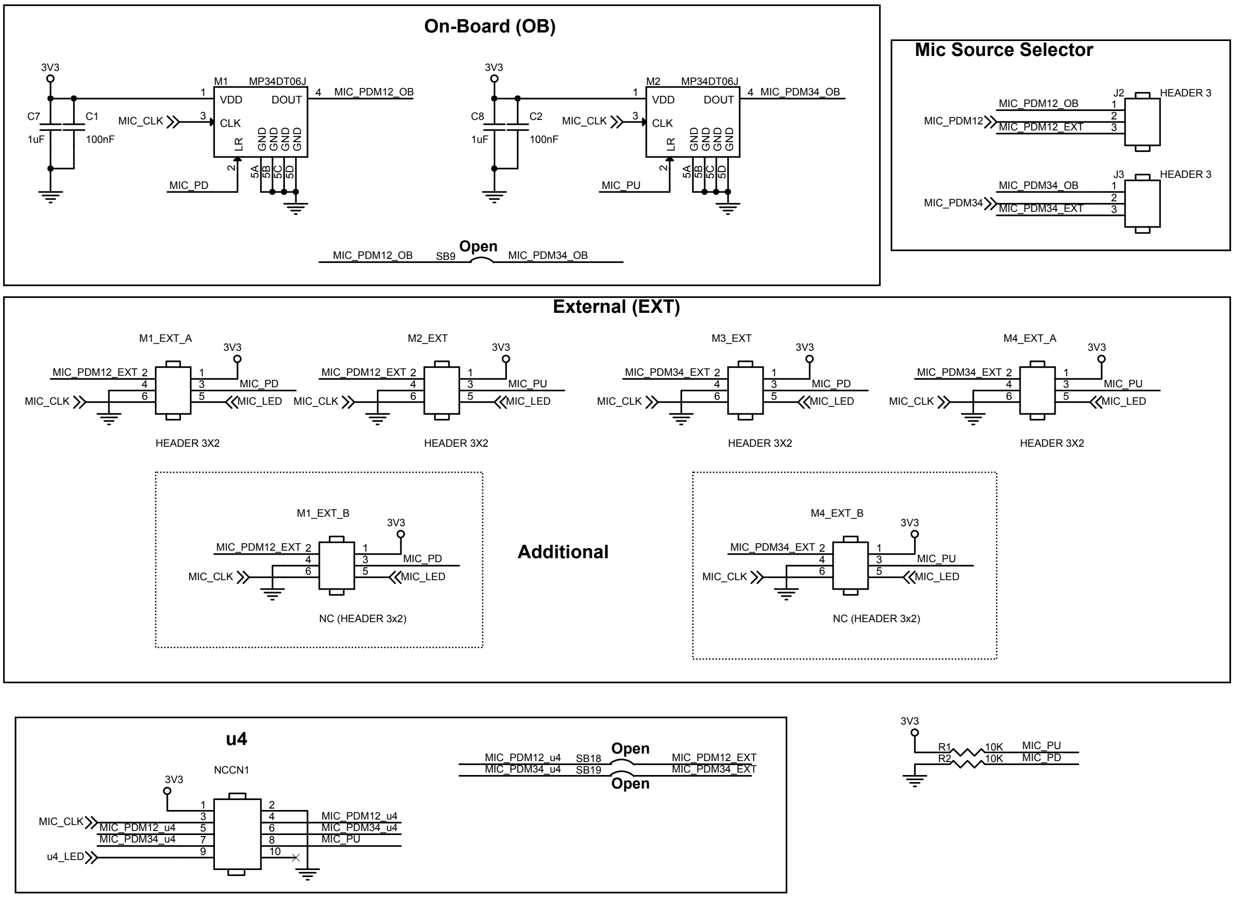


Figure 7. **X-NUCLEO-CCA02M2 circuit schematic (3 of 3)**



6 Bill of materials

Table 11. **X-NUCLEO-CCA02M2 bill of materials**

Item	Quantity	Reference	Part/value	Description	Manufacturer	Order code
1	1	CN1		Stripline M (not mounted)	Harwin	M52-040023W1045
2	1	CN5	HEADER 10	Stripline F	Harwin or equivalent	M20-7821046
3	2	CN6, CN9	HEADER 8	Stripline F	Harwin or equivalent	M20-7820846
4	2	CN7, CN10	HEADER 19x2	Stripline F	Samtec	ESQ-119-14-G-D
5	1	CN8	HEADER 6	Stripline F	Harwin or equivalent	M20-7820646
6	3	C1, C2, C5	100 nF X7R ±10% 0805 (2012M)	Ceramic capacitor	Murata	GCM21BR71H104KA02L
7	1	C3	15 pF C0G ±5% 0805 (2012M)	Ceramic capacitor (not mounted)	Kemet	C0805C150J5GACTU
8	1	C4	100 nF X7R ±10% 0805 (2012M)	Ceramic capacitor (not mounted)	Murata	GCM21BR71H104KA02L
9	1	C6	15 pF C0G ±5% 0805 (2012M)	Ceramic capacitor	Kemet	C0805C150J5GACTU
10	2	C7, C8	1 µF X7R ±10% 0805 (2012M)	Ceramic capacitor	Murata	GCM219R71C105KA37D
11	1	D1	60 V, 1 A	Power Schottky rectifier	ST	STPS160A
12	1	D2	ESDA7P60-1U 1M	High power transient voltage suppressor	ST	ESDA7P60-1U1M
13	1	J1	HEADER 2	Stripline TH	3M	961102-6404-AR
14	2	J2, J3	HEADER 3	Stripline M	3M	961103-6404-AR
15	4	M1_EXT_A , M2_EXT, M3_EXT, M4_EXT_A	HEADER 3X2	3x2 coupon header	Harwin	M20-7820346
16	2	M1_EXT_B , M4_EXT_B	NC (HEADER 3x2)	3x2 coupon header (not mounted)	Harwin	M20-7820346
17	2	M1, M2	MP34DT06J	MEMS audio sensor omnidirectional stereo digital microphone	ST	MP34DT06J
18	2	R1, R2	10 K 100 ppm/°C ±1% 0805 (2012M)	SMD resistors	TE Connectivity	CRG0805F10K
19	1	R3	1.5 K 100 ppm/°C ±1% 0805 (2012M)	SMD resistor (not mounted)	Vishay	CRCW08051K50FKEA

Item	Quantity	Reference	Part/value	Description	Manufacturer	Order code
20	1	R4	100 100 ppm/°C ±1% 0805 (2012M)	SMD resistor	Vishay	CRCW0805100RFKEA
21	7	SB1, SB2, SB7, SB9, SB11, SB13, SB15	0 R 100 ppm/°C ±1% 0603 (1608M)	SMD resistors	Vishay	CRCW06030000Z0EB
22	16	SB6, SB8, SB10, SB12, SB14, SB16, SB17, SB18, SB19, SB20, SB21, SB22, SB23, SB24, SB25, SB26	0 R 100 ppm/°C ±1% 0603 (1608M)	SMD resistors (not mounted)	Vishay	CRCW06030000Z0EB
23	1	USB	USB Mini-B	USB connector	Contact	MUSB-5B-2.0-S059 SERIES
24	1	U1	USBLC6-2SC6	ESD protection for high speed USB 2.0	ST	USBLC6-2SC6
25	1	U2	8 MHz 50 ppm 7 x 5 x 1.8 mm	8 MHz oscillator (not mounted)	Raltron	CO4305-8.000-EXT
26	1	J1	J1 closed	Jumper	Molex	90059-0007
27	1	J2	J2 - position 1-2	Jumper	Molex	90059-0008
28	1	J3	J3 off	Jumper	Molex	90059-0009

Revision history

Table 12. **Document revision history**

Date	Version	Changes
18-Sep-2019	1	Initial release.

Contents

List of figures

List of tables