AN4146
Application note

STSmartVoice demonstration board STEVAL-MKI126Vx

Introduction

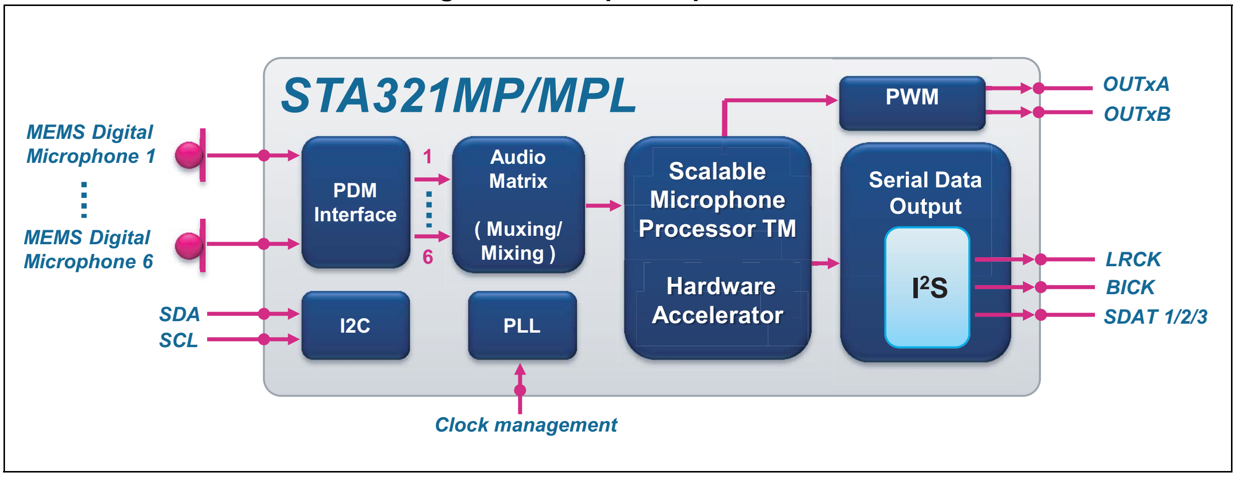
This application note describes the STSmartVoice demonstration board STEVAL-MKI126Vx. The connections and setup of the programming and interface boards are also detailed as well as other versions of the main board hosting the different microphones.

The STA321MP/MPL (package option respectively VFQFPN56 and TQFP64) has been designed to decode the pulse-density modulation (PDM) signal coming from the microphones and convert it into the most common digital audio format: I^2S. The device is also able to provide pulse-width modulation (PWM) outputs, one per channel, suitable to support an analog interface. The processor also includes a digital block, the hardware accelerator, composed of a chain of biquads (see *Figure 1*).

The STEVAL-MKI126Vx board can connect up to six microphones using the sockets provided or through a dedicated six-microphone array. The digital interface of the device allows interfacing the MIC output to the most widely used audio receivers and digital amplifiers or simply evaluating the MIC using generic audio measurement equipment. The filtered PWM signals allow the connection of a headset to listen to the audio received through the microphones.

The fully digital path ensures a high level of processing with sound preconditioning, filtering and voice enhancement. The pre- and post-mixing of the signals coming from the microphones, in combination with the frequency equalization block, allow the implementation of acoustic algorithms such as beam forming.

Figure 1. Microphone processor



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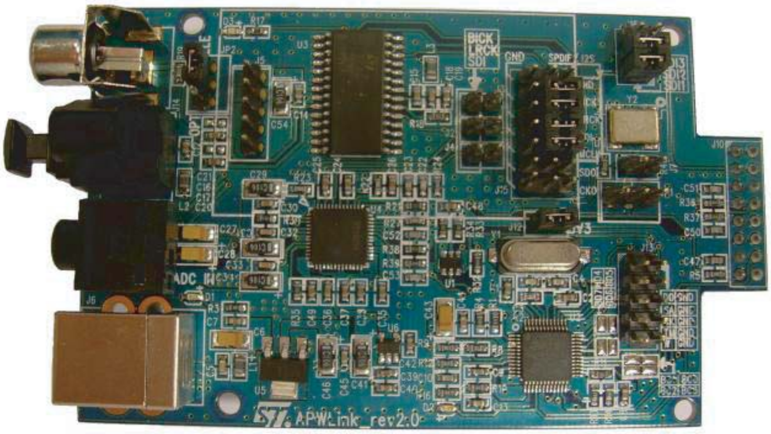
1 Demonstration board and accessories

The STSmartVoice board STEVAL-MKI126Vx requires a dedicated interface board, STEVAL-CCA035V1 (APWLink) or STEVAL-MKI138V1 (ST audio hub), for programming the device. Additional boards hosting the microphones are compatible with the board using suitable connectors placed onboard. These boards are listed and shown in the following sections and figures.

1.1 Interface

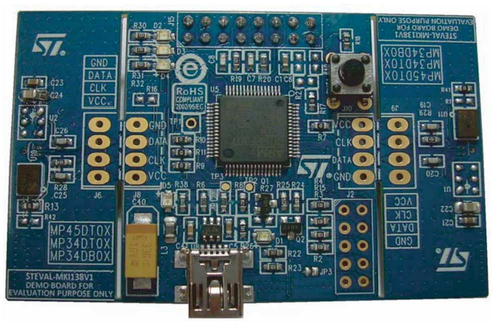
The STEVAL-CCA035V1 works as a programming board since it manages writing to the I^2C. The microphone processor is a digital device set using the I^2C commands. In addition, the STEVAL-CCA035V1 also serves as an interface board since the I^2S provided by the processor is routed on its connector (referred to as the APWLink connector). Finally, this board also provides on the connector the 12.288 MHz clock used by the processor in case the sampling frequency of the I^2S is 192 kHz or 48 kHz.

Figure 2. STEVAL-CCA035V1 (APWLink)



The STEVAL-MKI138V1 performs the functions listed above plus supports audio streaming via the USB cable. Basically the ST audio hub, using the STM32F107RC microcontroller, is able to program the STA321MPL device via the I^2C and decodes the I^2S into a USB stream in order for the PC to manage the sound captured by the microphones.

Figure 3. STEVAL-MKI138V1 (ST audio hub)

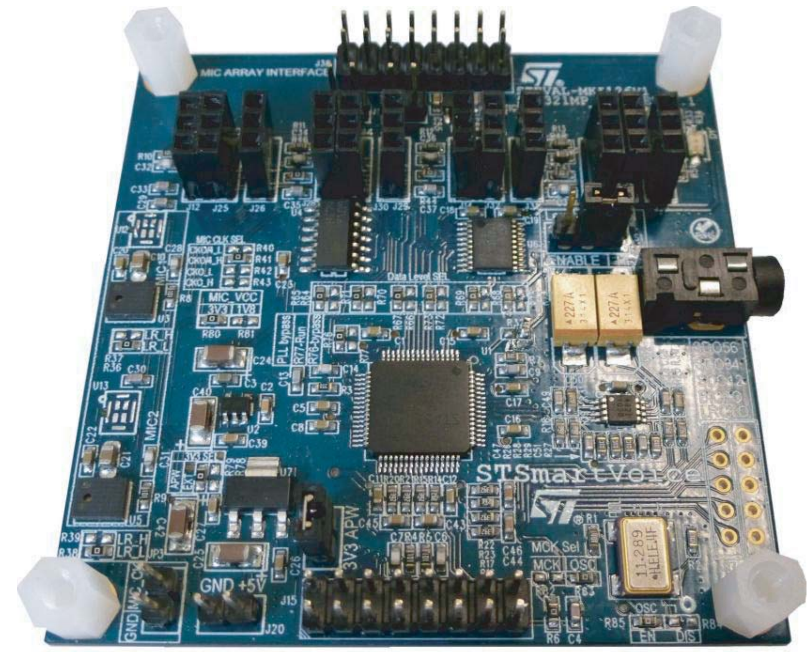


1.2 STEVAL-MKI126Vx board

The main task of the STEVAL-MKI126Vx in *Figure 4* is to convert the PDM signals provided by the microphones both into the more common I²S and PWM. The I²S signal is routed both on a general connector and APWLink connector. The PWM signals, properly filtered, provide an analog interface. There are two different versions of the board depending on the microphones soldered onboard:

- STEVAL-MKI126V1: MP45DT02 devices have been soldered
- STEVAL-MKI126V3: MP34DT01 devices have been soldered

Figure 4. STEVAL-MKI126Vx



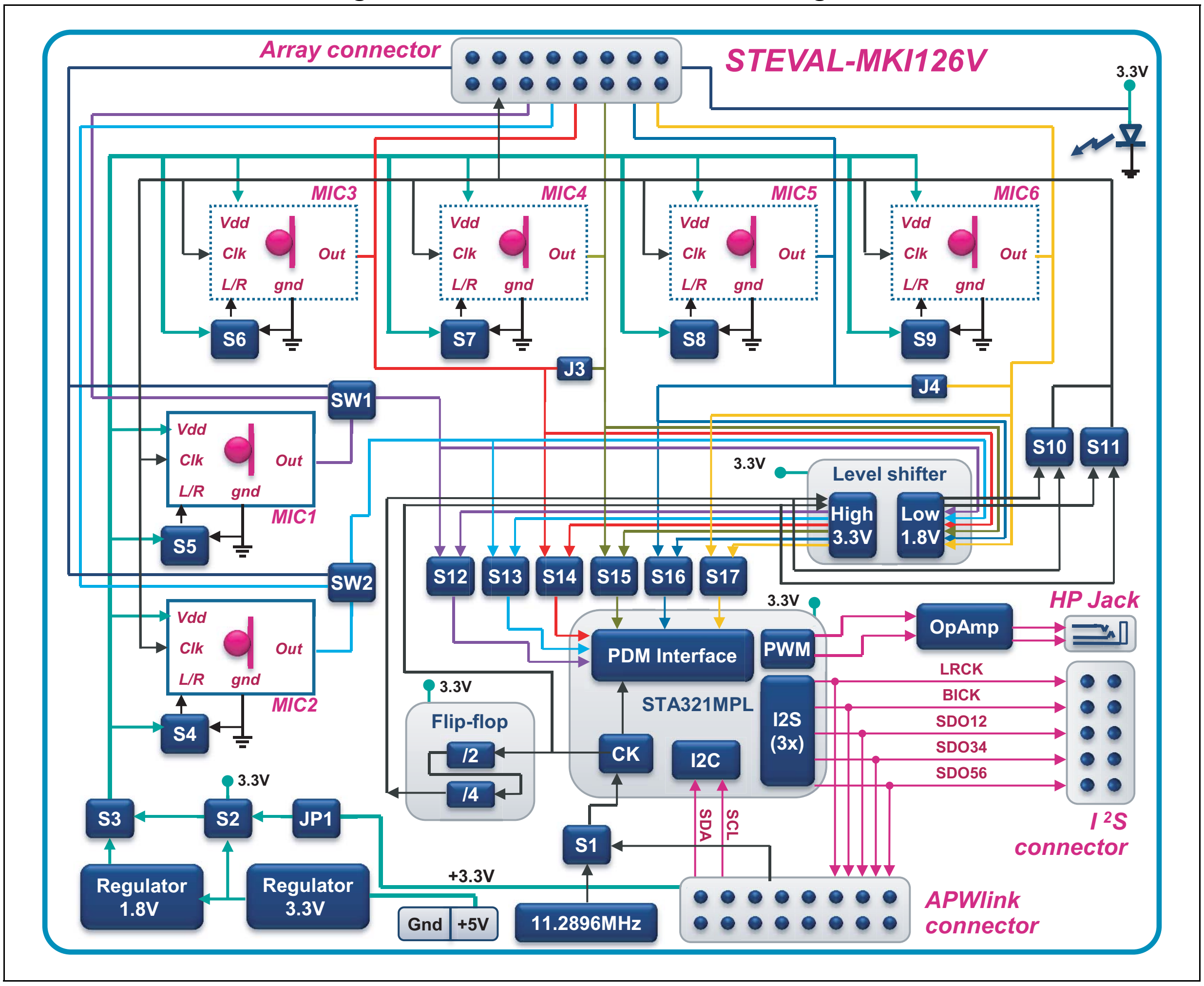
1.3 Microphone adapters

Microphone adapters are small circular PCBs with a single soldered MEMS microphone. There are three different ordering codes for each board corresponding to the different type of mounted digital microphone (STEVAL-MKI129V1 for the MP34DT02, STEVAL-MKI129V2 for the MP34DB01, and STEVAL-MKI129V3 for the MP34DT01. Please refer to AN4184 “Microphone coupon boards STEVAL-MKI129Vx based on the MP45DT02, MP34DB01, and MP34DT01” for further details.

Figure 5. MP34DT01 microphone adapter board

1.4 STEVAL-MKI126Vx overview

Figure 6. STEVAL-MKI126Vx - block diagram



The board hosts the homonymous microphone processor ***STA321MP*** or ***MPL*** according to the package.

It also includes two ***voltage regulators*** in order to provide the required voltages. One regulator generates 3.3 V for supplying both the processor and the microphone and the other one generates 1.8 V in case the user desires to supply the microphones at this voltage.

For the reason above, there is also a voltage ***level shifter*** that must be used if the microphones and the processor are fed with different voltages.

Another important section is represented by the clock. The board hosts an ***oscillator*** in order to provide the clock to the processor. The device is able to generate the clock for the microphones (default clock-out value / 4), but a ***flip-flop*** has been introduced for dividing the STA321MP clock out for a debugging purposes; the flip-flop during normal use is bypassed.

The input section is represented by the two ***soldered microphones***, the four microphone ***sockets*** and the ***8x2 header connector*** for the microphone array. The board has been designed for automatically switching from the microphones onboard to the microphones on the array thanks to two voltage-controlled switches ***SW1*** and ***SW2***.

The output section is represented by an ***I²S connector*** that exports the I^2S bus and a headphone amplifier, ***TS482***, which also allows a digital-to-analog path. These two paths allow interfacing the microphones to, respectively, a generic audio processor or measurement equipment or to interface the MEMS to a PC.

A further component is the ***APWLink connector*** that allows the control of the processor via I^2C. This connector also provides a 3.3 V source line and I^2S signals.

All selectors have their own name on the board serigraphy and are composed of two resistors where only one is soldered according to the desired functionality.

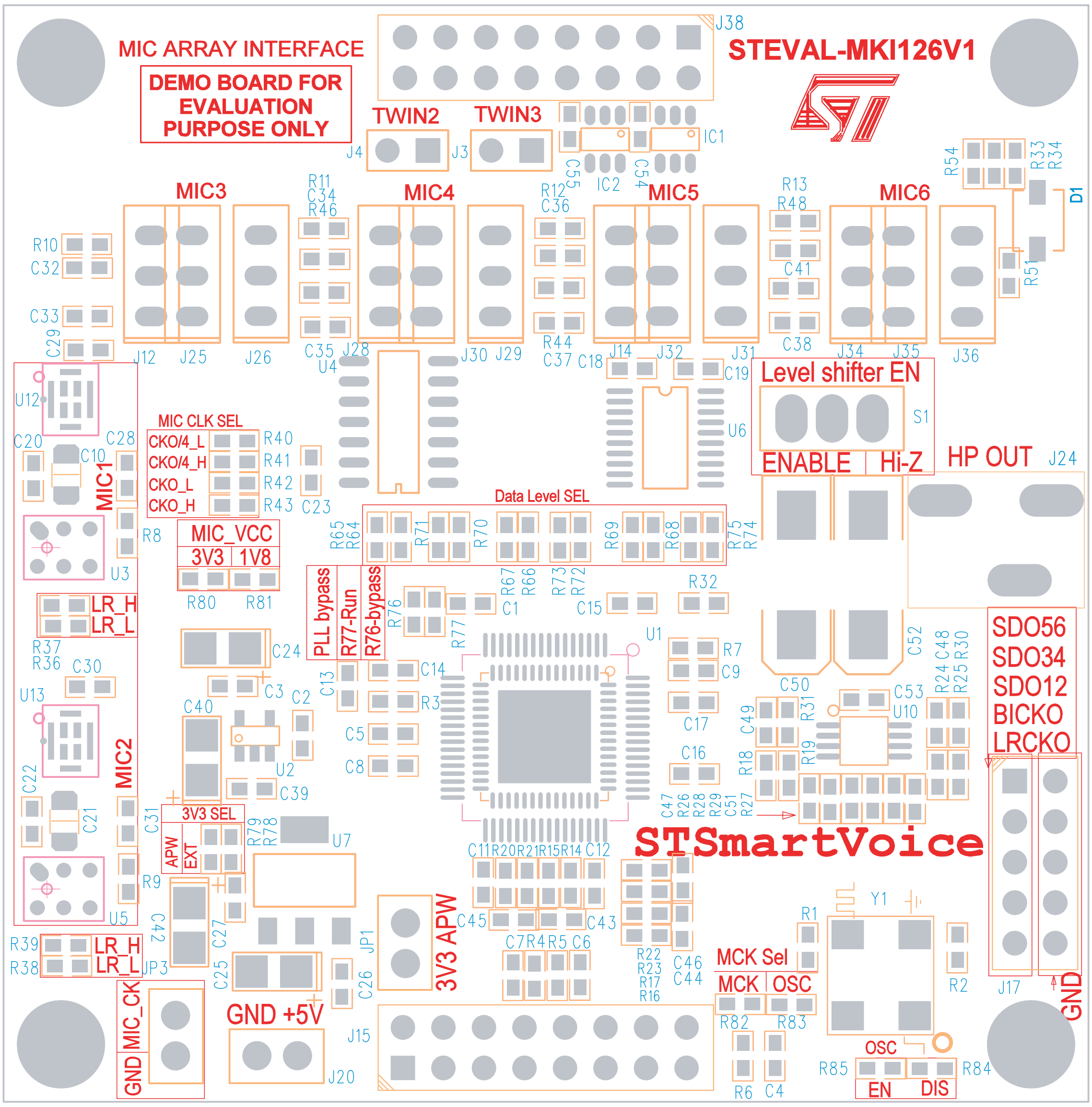
Figure 6 depicts all the components listed and the different colored traces represent the following sections of the board:

- Power supply (green trace)
- Clock management (black trace)
- PDM interface (rainbow traces)
- Output sections
  - Headphone out (fuchsia trace)
  - I^2S signals (fuchsia trace)

1.5 STEVAL-MIKI126Vx connections and setup

The figure below represents the placement of the component and the selectors, made up of resistors, which manage all the possible configurations and signals paths supported by the demonstration board.

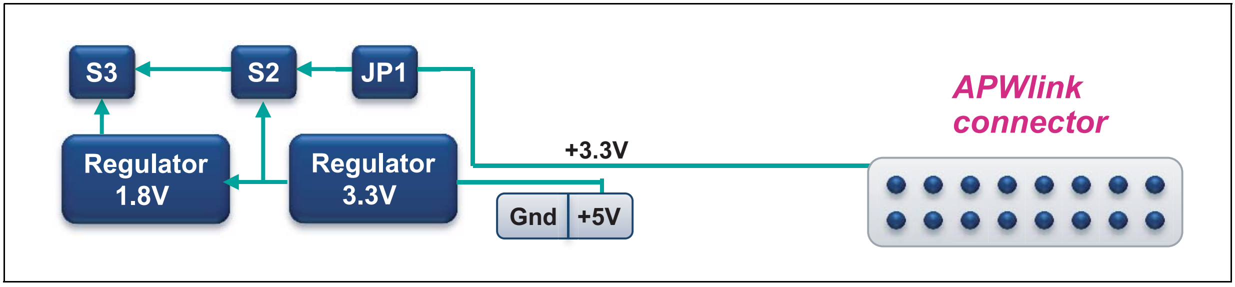
Figure 7. STEVAL-MIKI126Vx placement and serigraphy



1.5.1 Power supply

The STA321MP processor needs 3.3 V as a supply voltage while the operative voltage range of the microphones is 1.64 V - 3.6 V where the typical value is 1.8 V. For this reason there are two voltage regulators onboard. One regulator is used to generate the 3.3 V from an external 5 V supply (J20) while the other one generates the 1.8 V from the 3.3 V. The 3.3 V can also be provided from the APWLink connector on pin 11 and enabled on the board by closing JP1. In spite of the fact that the STEVAL-CCA035V1 board is always connected (for the I^2C communication) and so 3.3 V is always provided to the STEVAL-MKI126Vx, the demonstration board also hosts the 3.3 V regulator (scaled by an external 5 V supply) to allow better noise immunity. The following diagram depicts the supply lines scheme: S2 (R78-R79) selects the 3.3 V source while S3 (R80-R81) selects either 1.8 V or 3.3 V as the microphone supply voltage. These selectors are indicated on the board with the serigraphy 3V3 SEL and MIC_VCC, respectively.

Figure 8. Power supply - block diagram subsection

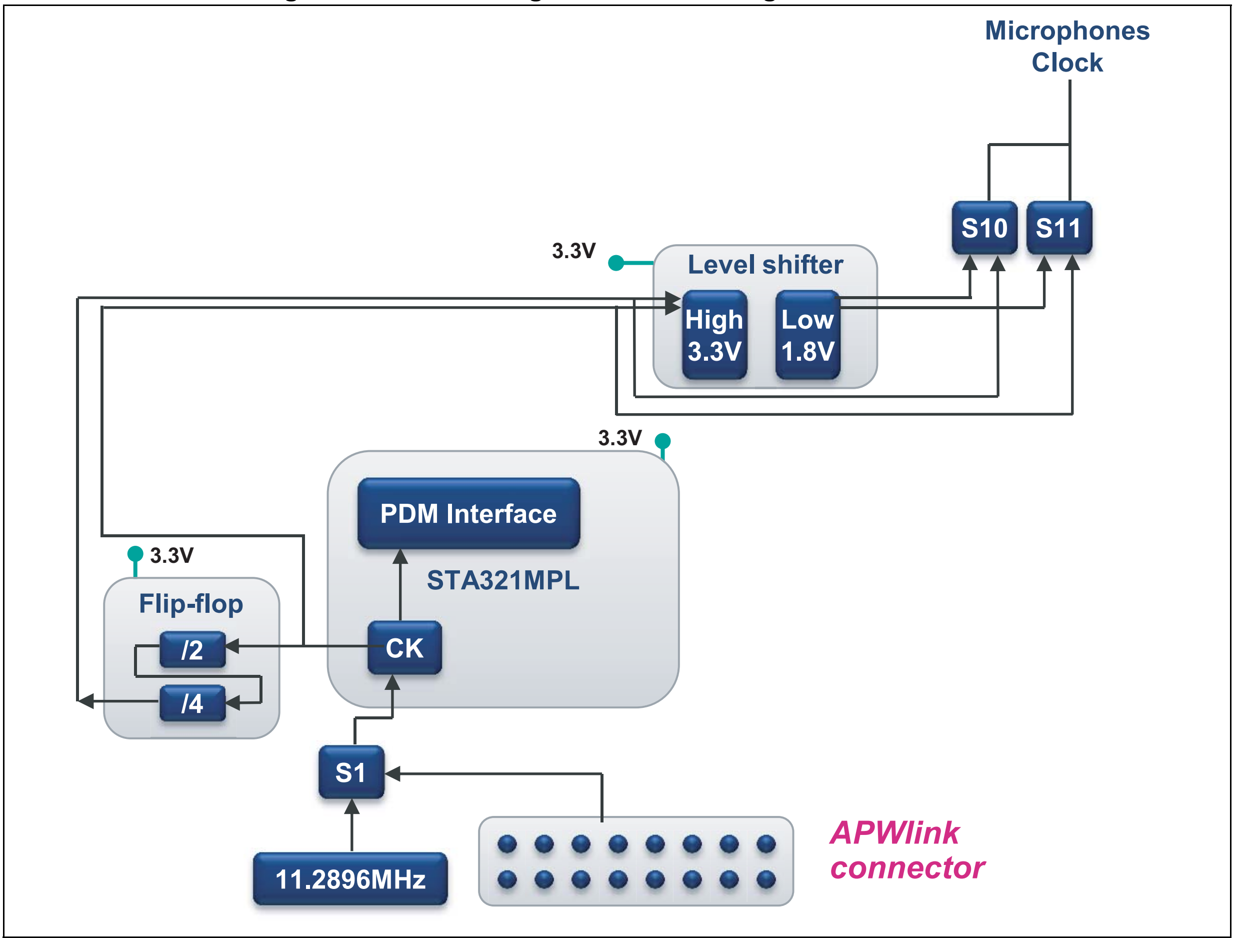


Once the 3.3 V voltage supply has been chosen, the devices that are fed with this voltage are the STA321MP, the flip-flop, the level shifter and the opamp. Regarding the microphones section, the selector S3 offers the possibility to choose their supply level.

1.5.2 Clock management

Clock management is an important topic since all of the devices involved have their own clock.

Figure 9. Clock management - block diagram subsection



The processor device needs two clocks: one for its digital core and one for the PDM (a register bit allows selecting the ratio between the two clocks). The microphones and the PDM interface need the same clock while the processor core clock is fed with a quadruple of such clock. The core clock can be provided to the processor through the STEVAL-CCA035V1, 12.288 MHz on pin 15, or thanks to an onboard 11.2896 MHz oscillator, the selector S1 (R82-R83) is used to select one of these two clocks. The choice of the frequency value depends on the desired output sampling frequency of the I^2S:

- 12.288 MHz: Fs = 12.288/64 = 192 kHz → Fs = 48 kHz enabling I^2S decimator
- 11.2896 MHz: Fs = 11.2896/64 = 176.4 kHz → Fs =44.1 kHz enabling I^2S decimator

The clock for the microphones and PDM interface is generated thanks to the PLL enabling the device microphone mode (refer to the STA321MP datasheet) and exported thanks to the clock-out (pin 25). The PDM interface is internally clocked by enabling one bit of a dedicated device register. If the microphone mode is not enabled, the external flip-flop is used as a frequency divider of the clock-out; this is for a debugging purposes only. For this reason, the I/F_CLK pin stays open by not soldering it to R32.The clock routing is managed by the two selectors S10, S11 called MIC_CLK_SEL on the board serigraphy. In microphone mode, the clock-out works exactly as the microphone clock, so it must be provided to the microphone pins. This is done by closing the resistor R43 of the selector S11 (R42-R43). In the case of supplying the microphones at 1.8 V, the clock provided to the microphones must be reduced from 3.3 V to 1.8 V. The level shifter provides this scaled clock, if needed. When the user wants to feed the microphones at 1.8 V, the resistor R42 of the selector S11 must be soldered instead of R43 (R42-R43).The selector S10 (R40-R41) is used when the microphone mode is not enabled, thus, for debugging purposes only. For this reason, both of its resistors are not soldered.

1.5.3 MEMS microphones, PDM interface and level shifter

Table 1. L/R channel selection

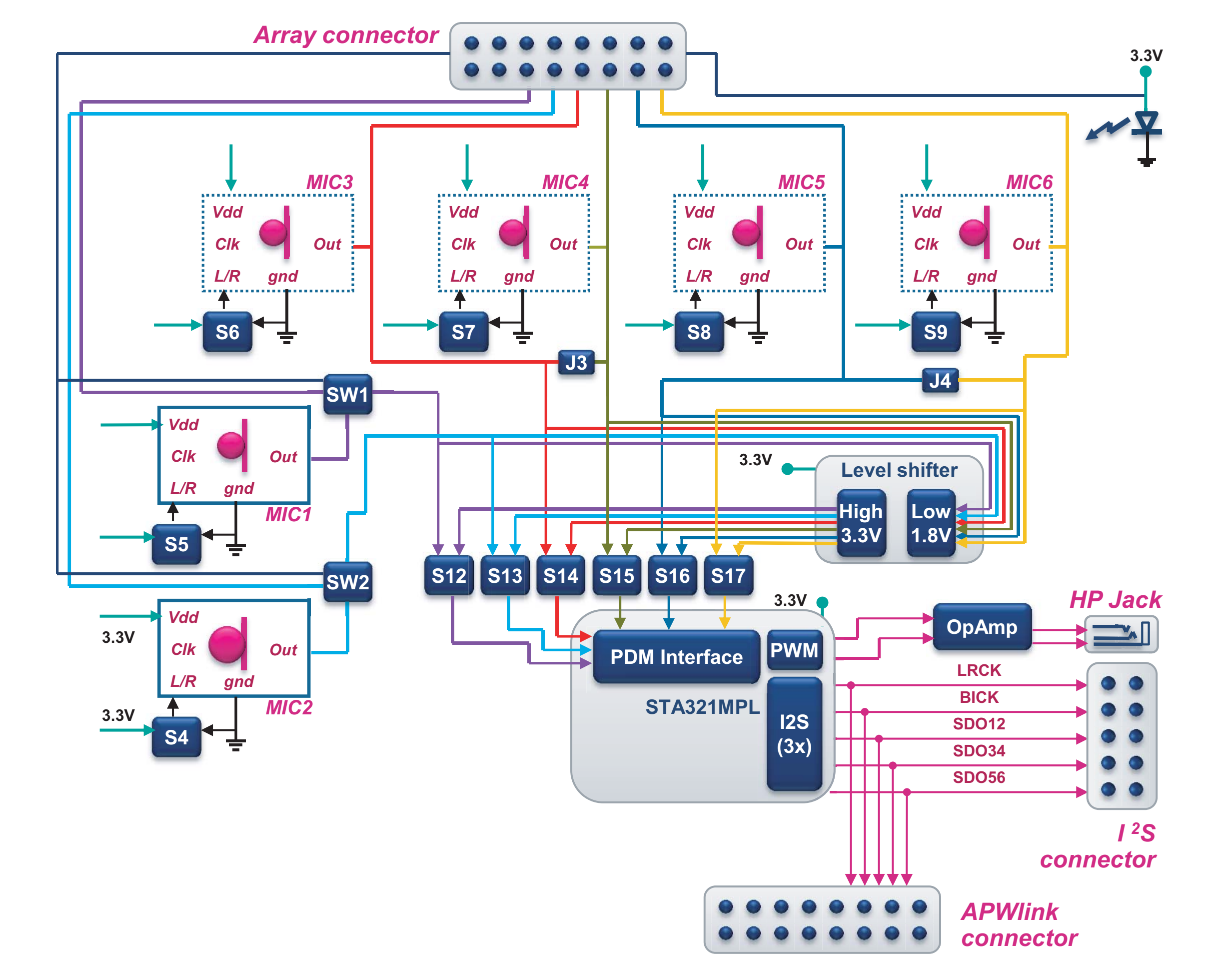
L/R	Clock low	Clock high
GND	Data valid	High impedance
VDD	High impedance	Data valid

Since the STA321MP processor manages the channels separately, there is no need to set the microphone in stereo configuration in this demonstration board. The L/R pins can be set to either GND or VDD through the selectors S4, S5, S6, S7, S8 and S9 (respectively the couples R38-R39, R36-R37, R46-R47, R44-R45, R48-R49 and R50-R51). By default, all the L/R pins are connected to GND, in other words R36, R38, R44, R46, R48 and R51 are soldered.

The processor STA321MP samples the microphone data according to the PDM interface clock. The sampling edge can be set to both rising and falling since, in microphone mode, the processor provides an internal PDM interface clock shifted 90º with respect to the clock-out. Refer to the STA321MP/MPL datasheet for details.

The data output is a digital signal carrying the audio information with a PDM encoding. The processor STA321MP is able to decode these signals and convert them into the more common I^2S and PWM. The I^2S signal is routed both on a general connector and APWLink connector; the PWM signals, suitably filtered, provide an analog interface (fuchsia traces in *Figure 10 on page 13*).

Figure 10. Microphones and I/O interfaces - block diagram subsection



The inputs of the PDM interface depend on the group of selectors S12, S13, S14, S15, S16 and S17 called Data Level SEL (respectively the couples R64-R65, R70-R71, R66-R67, R72-R73, R68-R69 and R74-R75). These selectors are set if the PDM inputs come from the microphones or from the level shifter.

The level shifter (enabled through the level shifter EN) is used when the microphones supply voltage is set to 1.8 V. Under this condition the sensors are a 1.8 V section while the decoder is still a 3.3 V section. In order to match these two board portions, a level shifter is needed to increase the PDM data output level before providing it to the processor.

In a default configuration the PDM inputs are directly connected to the microphones data, in other words R65, R67, R69, R71, R73 and R75 are soldered.

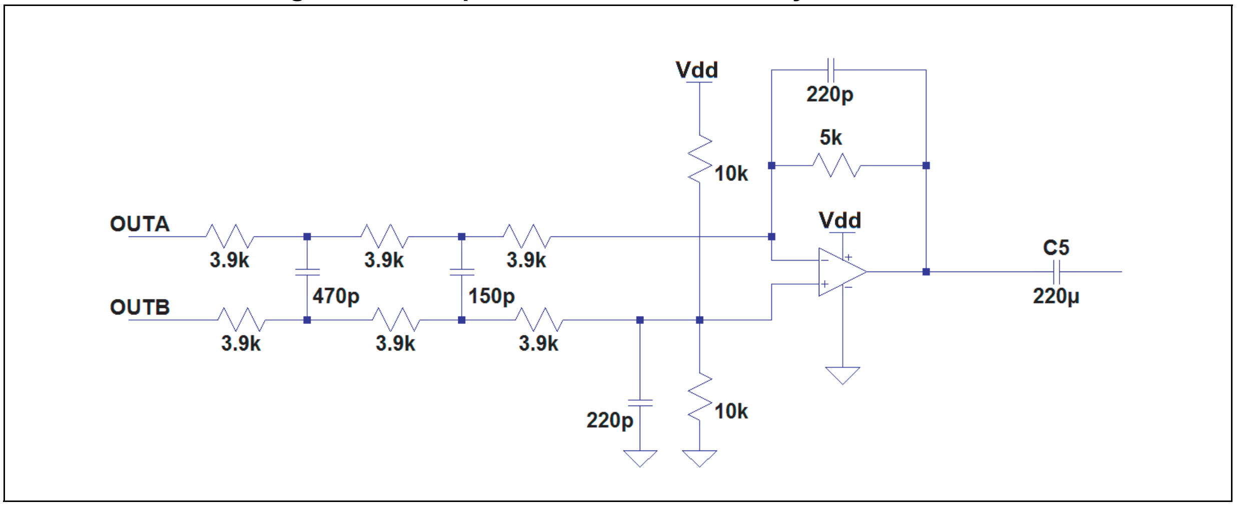
Microphones 1 and 2 are always connected since they are soldered on the board[a], the other four inputs depend on the connection of the microphone adapter boards. If the user wants to use the external microphone array, the microphone adapter boards must be unplugged and then the user must connect the array to the array connector with the dedicated cable. When the array is plugged in, pin 2 of the array connector is forced to

a. Regarding MIC1 and MIC2, the board can host every type of ST digital microphone since it supports all the footprints ground (due to the array board schematic) and this trace is used to switch off the LED D1 and to control the voltage-controlled switches SW1 and SW2 (IC1 and IC2 on the STEVAL-MKI126Vx board). The LED switching off indicates that the array is connected and the switches commutate the PDM input 1 and 2 from the data of the microphones onboard to the data of the microphones on the array.

1.5.4 Output section

The output section is simply represented by a connector that exports the I^2S bus (J17) and an operational amplifier used as the headphone driver. The STA321MP includes a PWM modulator so it possible to export this signal and after a suitable filtering (refer to *Figure 11*) an analog signal is obtained. This dual output option allows interfacing the microphones to both a digital processor (through the I^2S interface) and to analog systems like the PC line in (filtered output).

Figure 11. Headphone out schematic - only one channel



2 Selectors, jumpers and connectors

2.1 Selectors and jumpers

Table 2. Selectors and jumpers

Name on block diagram	Serigraphy	Function
S1	MCK_Sel	Core clock selection: R82: Coming from APWLink connector R83: Coming from on-board oscillator
S2	3V3 SEL	3.3 V selection: R78: External supply needed R79: Coming from APWLink connector
S3	MIC_VCC	Microphone supply voltage: R80: 3.3 V R81: 1.8 V
S4	LR_H/L	Microphone 2 L/R: R38: GND R39: Vdd
S5	LR_H/L	Microphone 1 L/R: R36: GND R37: Vdd
S6		Microphone 3 L/R: R46: GND R47: Vdd
S7		Microphone 4 L/R: R44: GND R45: Vdd
S8		Microphone 5 L/R: R48: GND R49: Vdd
S9		Microphone 6 L/R: R50: Vdd R51: GND
S10	MIC CLK SEL	Microphone clock voltage level: R42: 1.8 V R43: 3.3 V
S11 DEBUGGING PURPOSES ONLY	MIC CLK SEL	Microphone clock voltage level: R40: 1.8 V R41: 3.3 V
S12	Data Level SEL	PDM1 selection: R64: when microphones are 1.8 V supplied R65: when microphones are 3.3 V supplied

Table 2. Selectors and jumpers (continued)

Name on block diagram	Serigraphy	Function
S13	Data Level SEL	PDM2 selection: R70: when microphones are 1.8 V supplied R71: when microphones are 3.3 V supplied
S14	Data Level SEL	PDM3 selection: R66: when microphones are 3.3 V supplied R67: when microphones are 3.3 V supplied
S15	Data Level SEL	PDM4 selection: R72: when microphones are 1.8 V supplied R73: when microphones are 3.3 V supplied
S16	Data Level SEL	PDM5 selection: R68: when microphones are 1.8 V supplied R69: when microphones are 3.3 V supplied
S17	Data Level SEL	PDM6 selection: R74: when microphones are 1.8 V supplied R75: when microphones are 3.3 V supplied

Table 3. Jumpers and further options - summary table

Name on block diagram	Serigraphy	Function
JP1	3V3 APW	3V3 from APWLink board enable: Closed: 3V3 from APWLink Open: line open
J3-J4	TWIN3-TWIN2	Reserved
	Level shifter EN	Level shifter enable: Pin 1: GND device is disabled Pin 3: 1.8 V device is enabled
	PLL_Bypass	PLL bypass or not: R76: PLL is bypassed R77: PLL not bypassed

2.2 Microphone audio adapter connections

Connecting the microphone audio adapter boards is very simple. The STEVAL-MKI126Vx board hosts four groups of three female headers like those depicted in the figure below. The J12, J25 and J26 group can host one of the three different types of microphone audio adapters

Figure 12. Female headers on STEVAL-MKI126Vx board

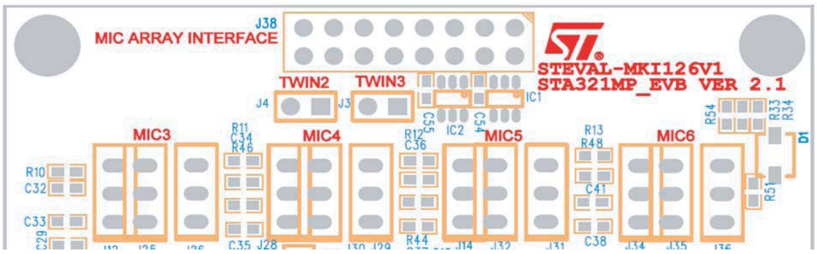
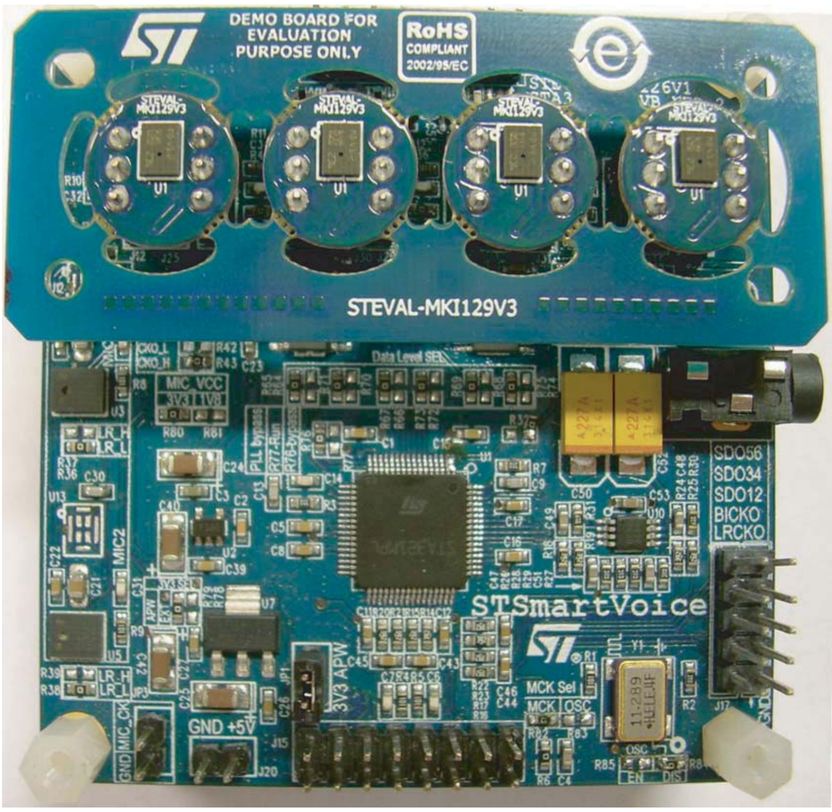


Figure 13 shows the connection of the audio adapter board for the MP34DT01. It's also possible to cut one of the microphones and use a single small circular PCB, allowing the evaluation of a different type of digital microphone at the same time.

Figure 13. Microphone audio adapter board plugged into STEVAL-MKI126 (STSmartVoice demonstration board)



3 Software settings

The demonstration board is programmed using the PC interface board STEVAL-CCA035V1 (APWLink) or STEVAL-MKI138Vx (ST audio hub). The figure below shows the connection using the APWLink connector (J15).

Figure 14. Interface board connection

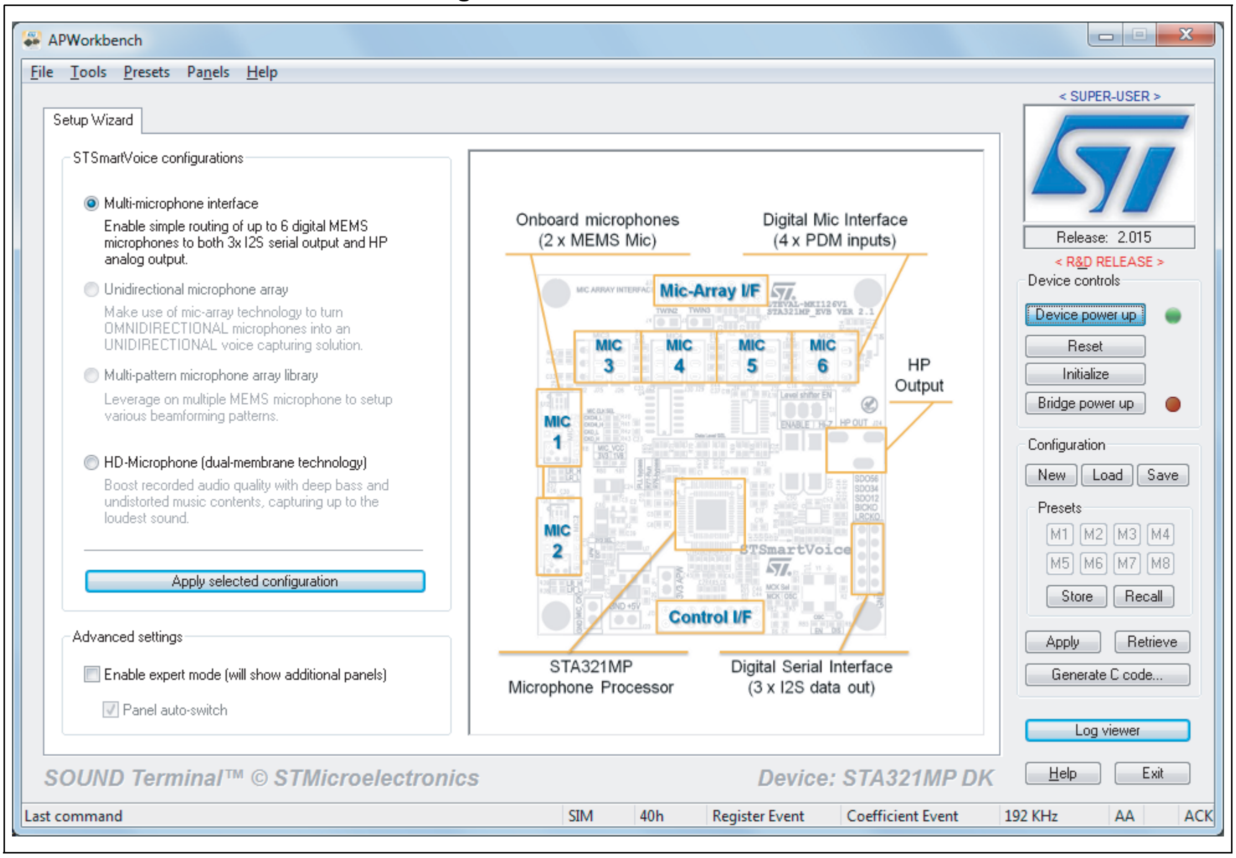
To program the microphone processor STA321MP/MPL, the APWorkbench tool is needed. Follow these steps to correctly set up the device:

1. Run the tool
2. Click on the "MEMS Microphones Demo Kit" button
3. Select “STSmartVoice Demo Kit” in the “Microphone Kit Selection” box
4. Click on the "Run selected application…" button

Figure 15. APWorkbench launch wizard

The selection of the application allows the user to access all supported configurations of the STSmartVoice board. The kit will work as a microphone onboard manager by selecting the "Multi-microphone interface" choice. Then the user must confirm by clicking on the "Apply selected configuration" button.

Figure 16. APWorkbench tool



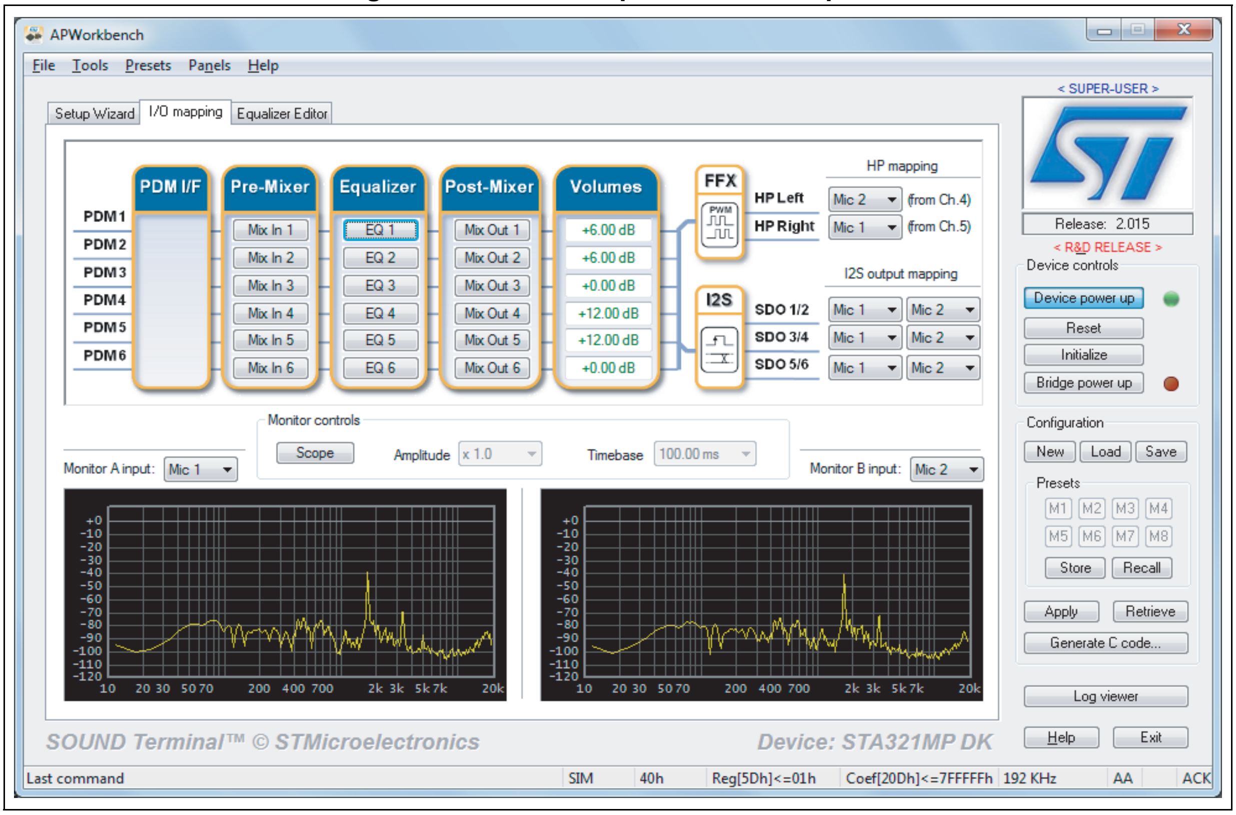
The selection of the kit as a "Multi-microphone interface" will perform the I^2C writes given in the table below.

Table 4. I^2C writes of setup file

Address	Value	Note
00	9B	PDM interface enable
02	20	20: FS = XTI/256. Example: 44.1 kHz = 11.2896 MHz/256 48 kHz = 12.288 MHz/256
04	18	Ch4/5 Binary
07	7A	Remove Soft Volume
08	80	Bridge power-UP
0A	00	Master volume 0 dB
0B	54	Ch1: +6 dB
0C	54	Ch2: +6 dB
0E	48	Ch4: +12 dB
0F	48	Ch5: +12 dB
5D	01	Microphone mode
81	09	Output I^2S interface pins set as output

The selection of the kit as a "Multi-microphone interface" also lets the user access the dedicated panel given in the figure below.

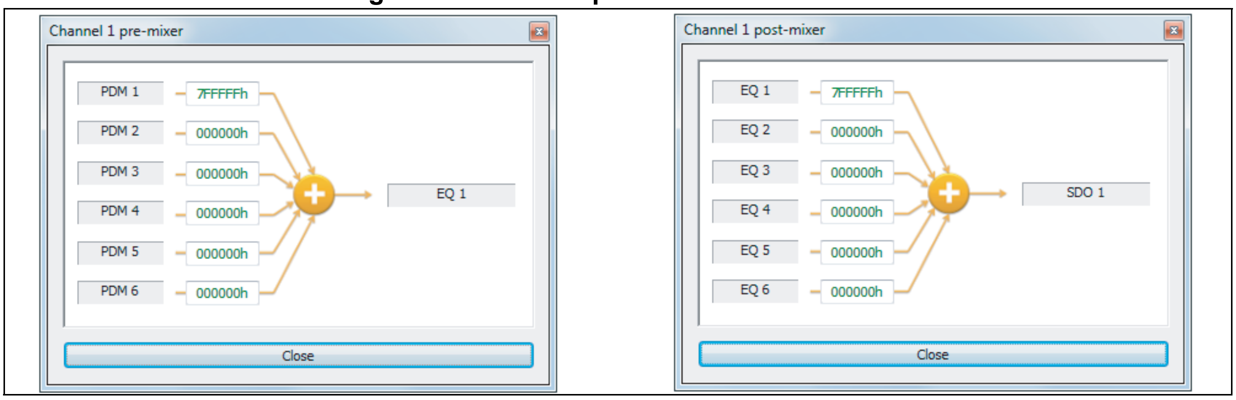
Figure 17. Multi-microphone interface panel



The user can route the signal of the desired microphone on the output interfaces (I^2S or HP out) using the mapping drop-down menus on the right side of the panel. These menus act on the pre-mixer of the respective channel. In the default configuration of the I^2S output data 1 and 2 (SDO12), the pre-mixer of channel 1 takes 100% of PDMIN_1 (MIC1) and channel 2 takes 100% of PDMIN_2 (MIC2). The user can also directly edit the mixer values at will. The post-mixer works in the same way, but takes a percentage of the outcome of the processing block.

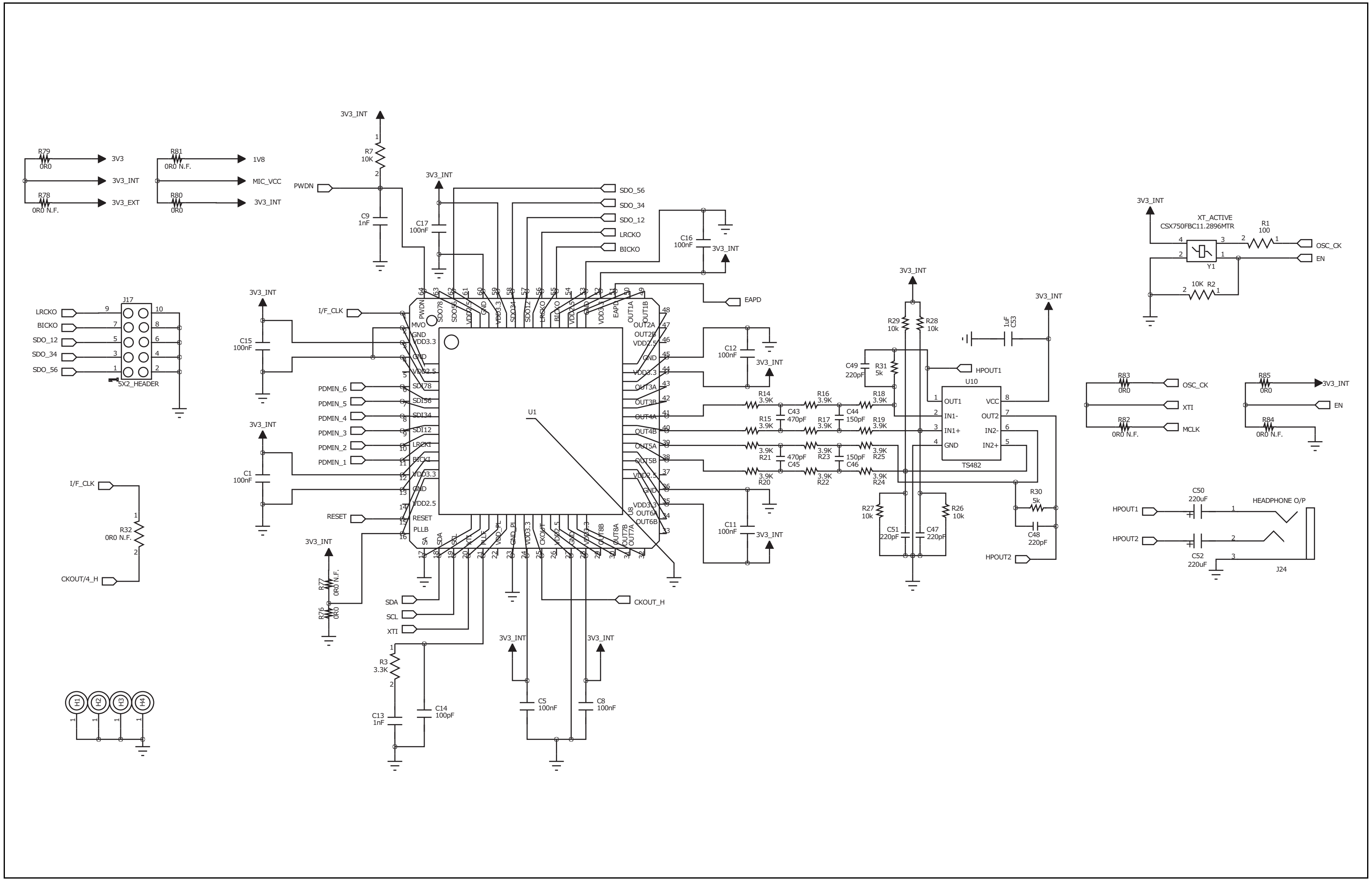
As an example, the figure below shows the layout of the pre- and post-mixer of channel1.

Figure 18. Pre- and post-mixer of channel 1



Appendix A STEVAL-MKI126Vx schematics, layout and BOM

Figure 19. STEVAL-MKI126Vx schematic - page 1



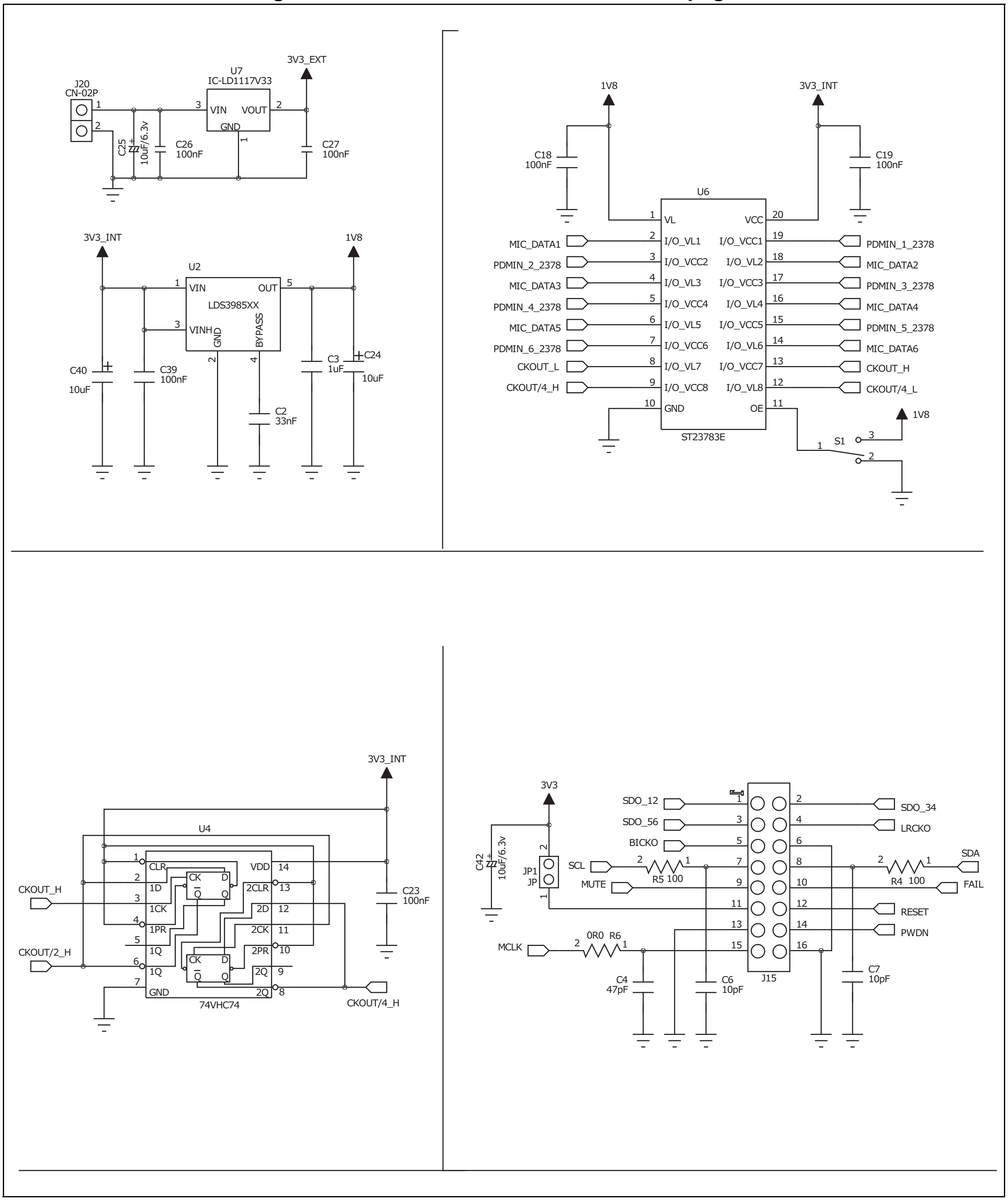


Figure 20. STEVAL-MKI126Vx schematic - page 2

Figure 21. STEVAL-MKI126Vx schematic - page 3

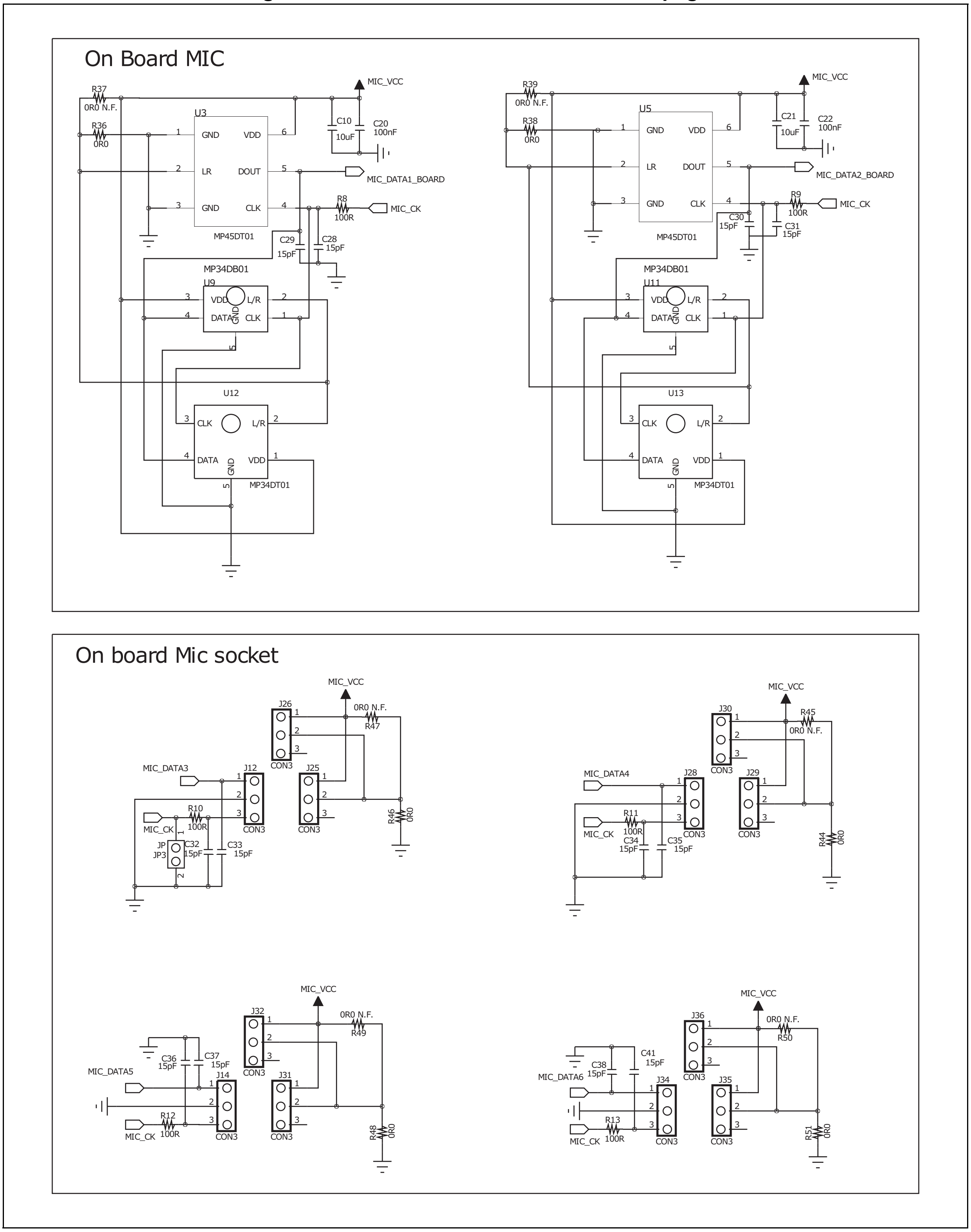


Figure 22. STEVAL-MKI126Vx schematic - page 4

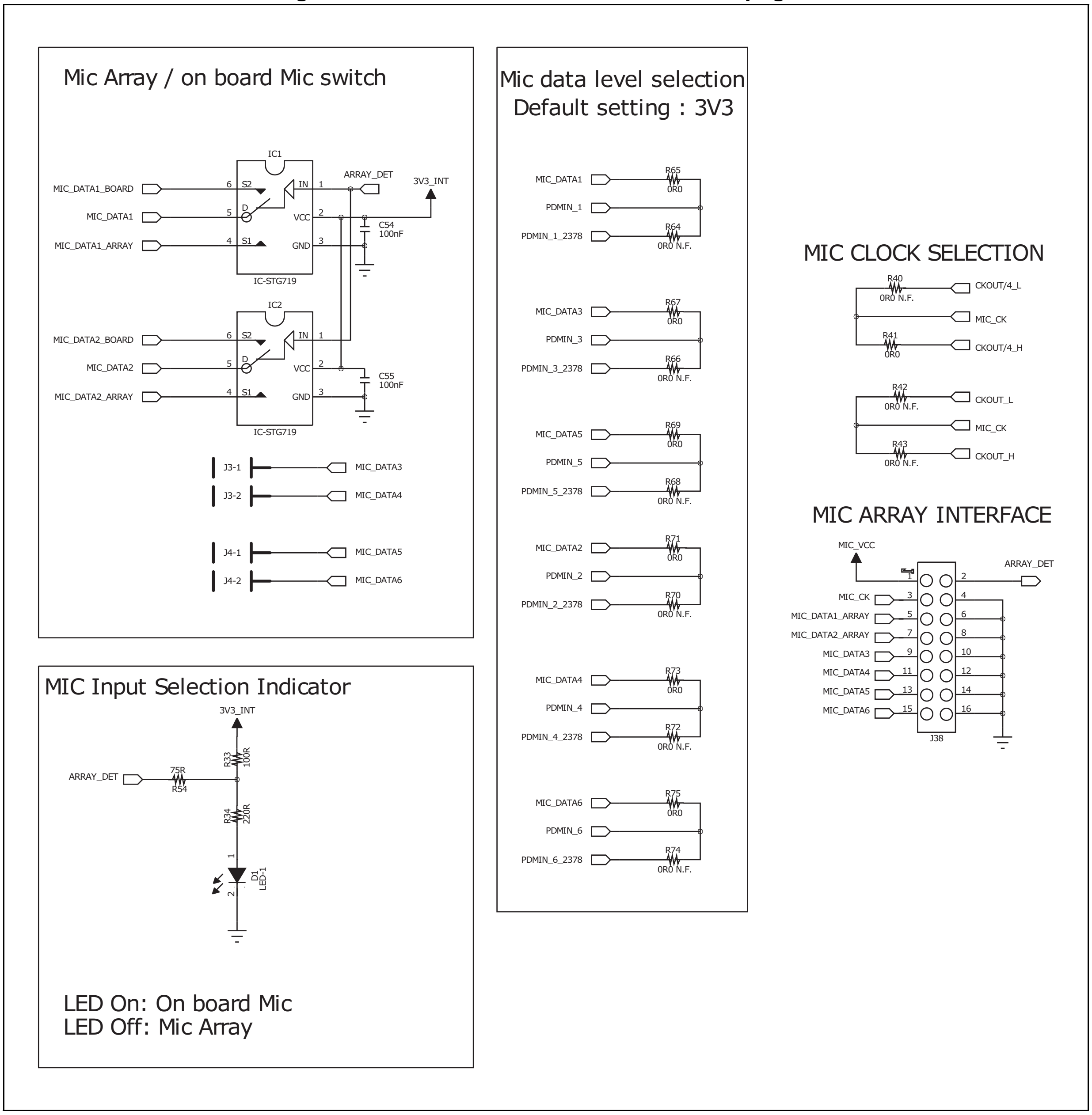


Figure 23. STEVAL-MKI126Vx layout - top view

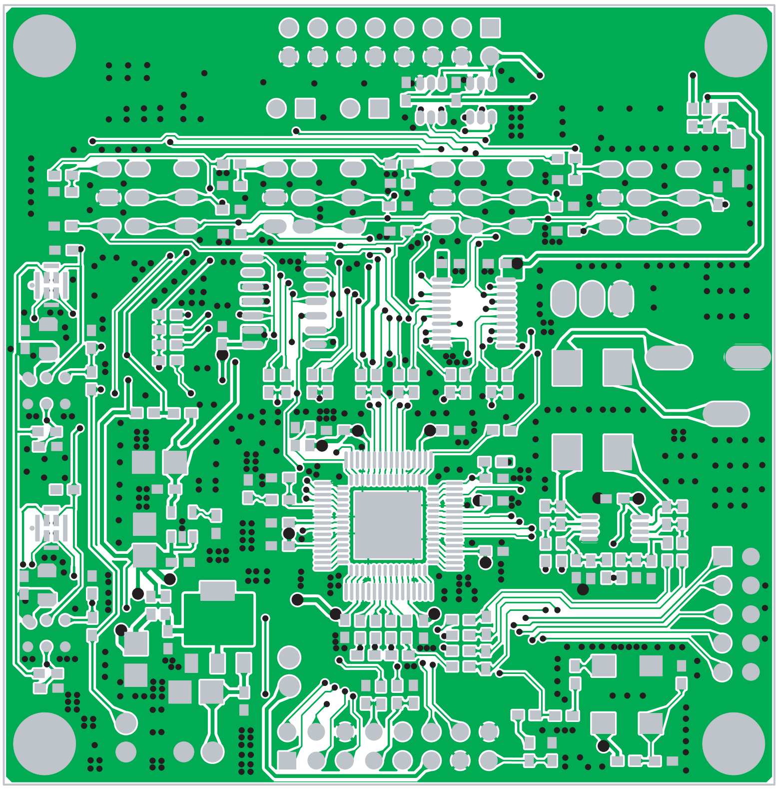


Figure 24. STEVAL-MKI126Vx layout - bottom view

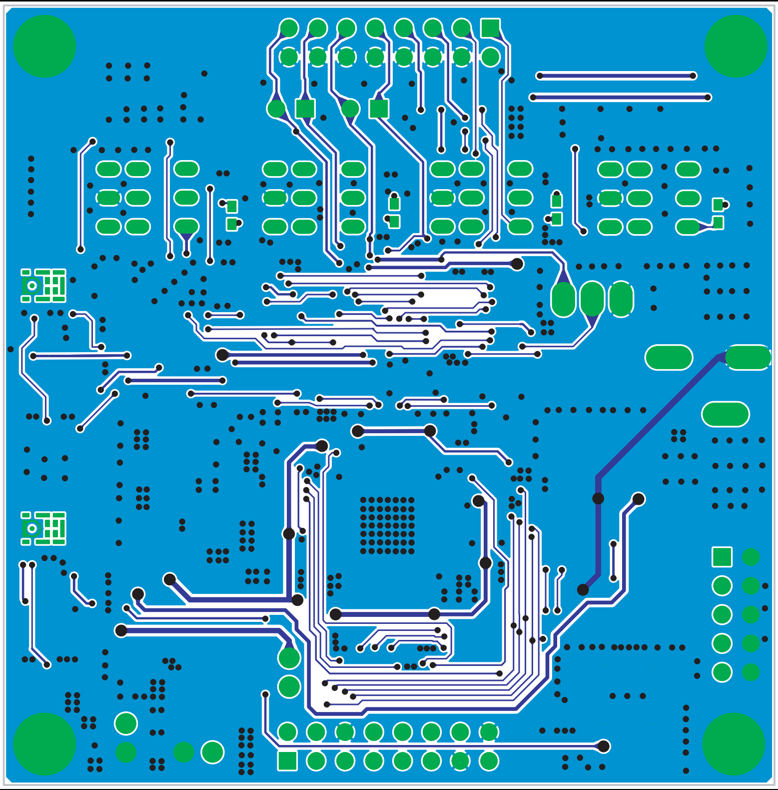


Table 5. STEVAL-MK126Vx bill of material

Type	Package	Description	Qty	Reference	Manufacturer	Remark
CCAP	CC0603	100 nF +/-10% X7R 50 V	18	C1 C5 C8 C11 C12 C15 C16 C17 C18 C19 C20 C22 C26 C27 C54 C55 C23 C39		
CCAP	CC0805	10 uF +/-10% X7R 10 V	2	C10 C21	Murata	
CCAP	CC0603	15 pF +/-10% NPO 50 V	12	C28 C29 C30 C31 C32 C33 C34 C35 C36 C37 C38 C41	Murata	
CCAP	CC0603	220 pF +/-10% NPO 50 V	4	C47-49 C51	Murata	
CCAP	CC1206	10 uF +/-10% X7R 10 V	4	C24 C25 C40 C42	Murata	
CCAP	CC0603	1 nF +/-5% X7R 50 V	2	C9 C13	Murata	
CCAP	CC0603	1 uF +/-10% X7R 10 V	2	C3 C53	Murata	
CCAP	CC0603	100 pF +/-10% NPO 50 V	1	C14	Murata	
CCAP	CC0603	10 pF +/-10% NPO 50 V	2	C6 C7	Murata	
CCAP	CC0603	47 pF +/-10% NPO 50 V	1	C4	Murata	
CCAP	CC0603	470 pF +/-10% NPO 50 V	2	C43 C45	Murata	
CCAP	CC0603	150 pF +/-10% NPO 50 V	2	C44 C46	Murata	
CCAP	CC0603	33nF +/-5% X7R 50V	1	C2	Murata	
TCAP	C7343	220 uf 10 V +/-10% 125°C tanatalum	2	C50 C52	AVX	
RES	R0603	0 ohm +/-10% 1/8W	19	R6 R36 R38 R43 R44 R46 R48 R51 R65 R67 R69 R71 R73 R75 R76 R79 R80 R82 R84	Murata	
RES	R0603	0 ohm +/-10% 1/8W	20	R32 R37 R39 R40 R41 R42 R45 R47 R49 R50 R64 R66 R68 R70 R72 R74 R77 R78 R81 R83 R85	Murata	Do not solder
RES	R0603	100 ohm +/-10% 1/8W	10	R1 R4 R5 R8 R9 R10 R11 R12 R13 R33	Murata	
RES	R0603	220 ohm +/-10% 1/8W	1	R34	Murata	
RES	R0603	75 ohm +/-10% 1/8W	1	R54	Murata	
RES	R0603	10K ohm +/-10% 1/8W	6	R2 R7 R26 R27 R28 R29	Murata	
RES	R0603	3.3 k ohm +/-10% 1/8W	1	R3	Murata	

Table 5. STEVAL-MK126Vx bill of material (continued)

Type	Package	Description	Qty	Reference	Manufacturer	Remark
RES	R0603	3.9 k ohm +/-1% 1/8W	12	R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24 R25	Murata	
RES	R0603	5K ohm +/-1% 1/8W	2	R30 R31	Murata	
Diode	D1206	SMD LED diode, red,1.8 V	1	D1	any source	
OSC	SMD5X7	CSX750FBC11.2896MTR	1	Y1	Citizen	
Connector	Through-hole	1x3 2.54 mm pitch female connector	12	J12 J14 J25 J26 J28 J29 J30 J31 J32 J34 J35 J36	any source	
Connector	Through-hole	1x3 2.54 mm pitch male connector	1	S1	any source	
Connector	Through-hole	2x8 2.54 mm pitch male Connector	2	J15 J38	any source	
Connector	Through-hole	2x5 2.54 mm pitch male connector	1	J17	any source	
Connector	Through-hole	1x2 2.54 mm pitch male connector	5	J3 J4 JP1 JP3 J20	any source	
Phonejack	Through-hole	SONGCHEN CKX-3.5-06	1	J24	Song Cheng	
Plastic supportor	Through-hole	female 8 mm	4		any source	
Plastic supportor	Through-hole	male 3 mm	4		any source	
IC	TQFP64	STA321MPL	1	U1	STMicroelectronics	
IC	VQFN56	STA321MP	1	U8	STMicroelectronics	Do not solder
IC	SOT23-5	LDS3985M18R 1.8 V regulator	1	U2	STMicroelectronics	
IC	TSOP20	ST2378ETTR	1	U6	STMicroelectronics	
IC	MINISO8	TS482IST	1	U10	STMicroelectronics	
IC	SO14	74VHC74MTR	1	U4	STMicroelectronics	
IC	SOT223	LD1117S33	1	U7	STMicroelectronics	
IC	SOT23-6L	STG719STR	2	IC1 IC2	STMicroelectronics	
MEMS mic		MP34DT01	2	U12 U13	STMicroelectronics	Solder for V3
MEMS mic		MP34DB01	2	U9 U11	STMicroelectronics	Solder for V2
MEMS mic		MP45DT02	2	U3 U5	STMicroelectronics	Solder for V1

4 Revision history

Table 6. Document revision history

Date	Revision	Changes
02-Oct-2012	1	Initial release.
22-Mar-2013	2	Added audio hub demonstration board (STEVAL-MKI138V1) to application note Updated *Section 1: Demonstration board and accessories*, added *Figure 3* Updated *Section 1.3: Microphone adapters*, updated *Figure 5* Updated *Section 2.2: Microphone audio adapter connections*, added *Figure 12*, updated *Figure 13* Updated *Section 3: Software settings*, added *Figure 14*, updated *Figure 15*, *16*, *17*