AN4041
Application note

APWLink+ microphone USB demonstration boards based on the MP34DT01, MP45DT02, or MP34DB01

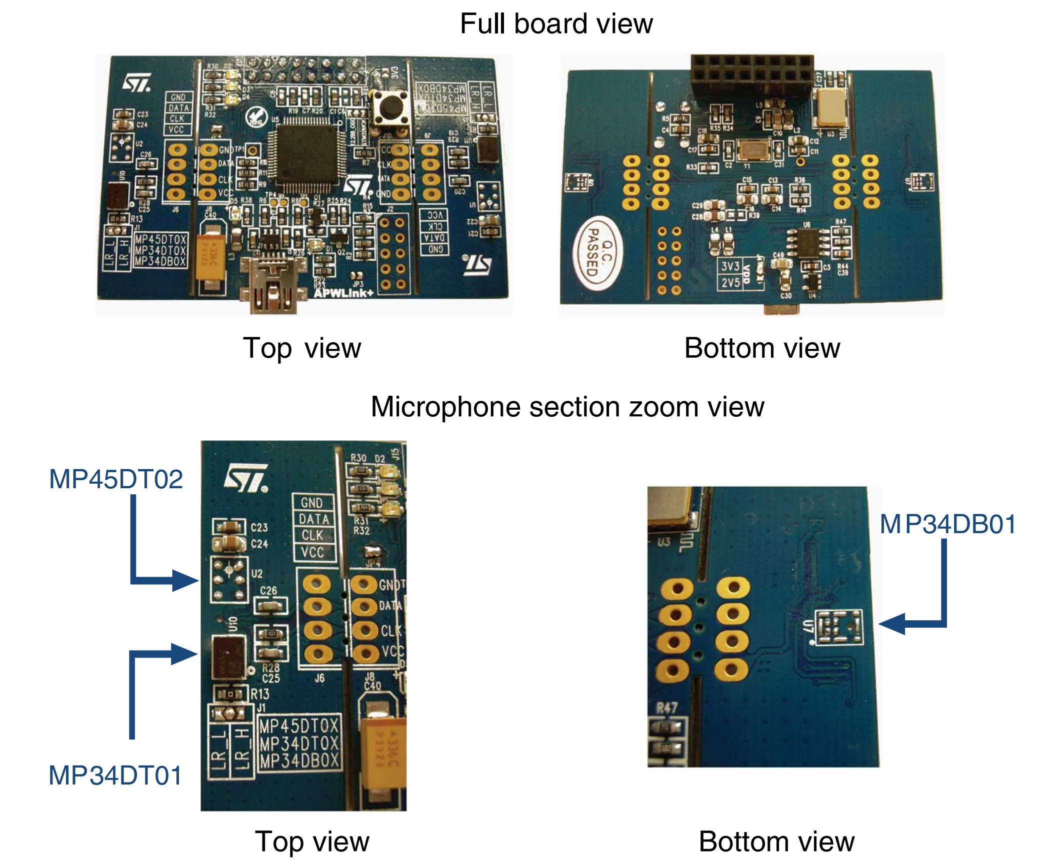
Introduction

The purpose of this application note is to give a brief description of the APWLink+ microphone USB demonstration boards from STMicroelectronics. These boards host the microcontroller STM32F107RC and either the MP45DT02, MP34DT01 (top-port digital microphones) or the MP34DB01 (bottom-port digital microphone). *Figure 1* shows the capability of the board to host these microphones.

These microphones are analog-to-digital transducers, in other words, they are able to sense sound pressure and convert this signal to a digital signal using the pulse-density modulation (PDM) technique. The STM32 microcontroller decodes the PDM signal coming from the microphones and streams the audio via the USB.

This document will provide a brief description of the software that decodes the PDM signal and also information about the hardware as well as simple steps to use the boards. Ordering information for these boards can be found in *Appendix C on page 12*.

Figure 1. APWLink+ demonstration board



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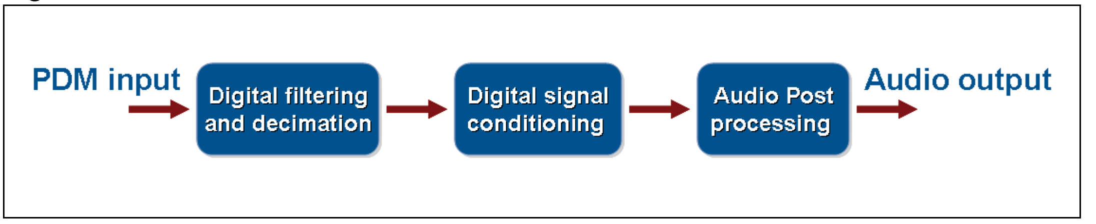
1 Software description

The digital signal processing (DSP) consists of the simple flow depicted in the figure below.

Figure 2. DSP



The PDM signal from the microphone is filtered and decimated in order to obtain a sound signal at the required frequency and resolution. The loaded firmware implements a filter pipeline that has been designed as two filtering-decimation stages.

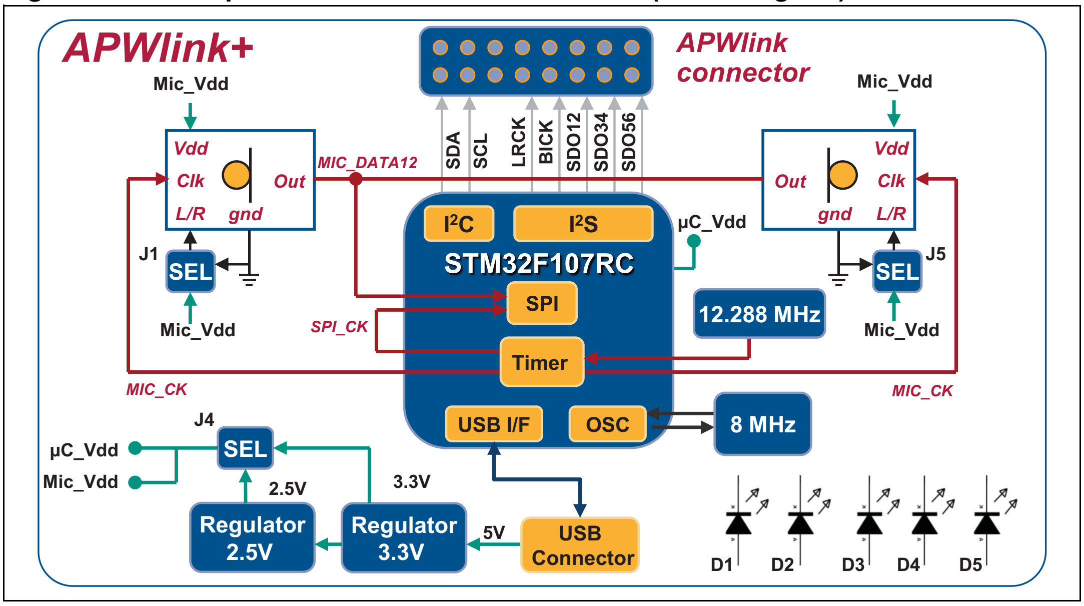
Assuming an input frequency of 3.072 MHz and a desired output frequency of 48 kHz, the filter stages are configured to implement a decimation factor of 64. The final gain of the pipeline is therefore $G_1 = 7.8125$. As a result, the output of the filter pipeline is a 16-bit pulse-code modulated (PCM) signal.

For further information, please refer to application note AN3998, “PDM audio software decoding on STM32 microcontrollers” available on *www.st.com*.

2 Hardware description

The board is a sound card automatically recognized by the PC as an audio device. The connection is done through the USB cable which also supplies the board and then streams the audio collected from the microphones to the PC.

Figure 3. Microphone USB demonstration board (block diagram)



Supply section

The supply section of the board is made up of two voltage regulators that step down the 5 V of the USB connection to 3.3 V and 2.5 V. The solder jumper J4 gives the user the possibility to choose the desired supply voltage.The digital microphone voltage ranges are given in the following table.

Table 1. Microphone supply voltage range

Part number	Min.	Typ.	Max.	Unit
MP45DT02	1.64	1.8	3.6	V
MP34DB01	1.64	1.8	3.6	V
MP34DT01	1.64	1.8	3.6	V

We recommend using 2.5 V to avoid supplying the microphone with a voltage that is too high. For instance, the MP34DT01 cannot support a supply voltage of 3.3 V.

Microphone section

Regarding the microphone section, the MEMS outputs are a PDM signal, which is a high-frequency stream (1 to 3.25 MHz) of 1-bit digital samples. According to the application hints given in the datasheets (available on *www.st.com*), the microphone can be used in single-channel configuration or stereo configuration by setting the LR pin. This pin sets the validity of the output data on the high level of the clock or on the low level, refer to the following table.

Table 2. L/R channel selection

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

On this board the microphones are used in stereo configuration, so the two digital outputs are shorted (Mic_DATA12, refer to the schematic) and the two MEMS LR pins must be set one to GND and the other one to VDD. On the board, the resistors R1 and R13 have already set the LR pin of the microphones. In order to change the MEMS polarity, the user must unsolder these resistors and manually set the LR pin using the solder jumper J1 and J5. Note that the PCB section mounting the MEMS microphones is detachable. This option has been implemented in order to let the user put the microphones in the desired position (i.e. for display applications in which the microphones are placed at the edges of the display).

Microcontroller

The STM32F107RC microcontroller simultaneously works as a PDM interface and also supports the USB audio streaming. The board hosts two external clocks, the 12.288 MHz and 8 MHz. The first one serves to clock an internal timer for generating both MIC_CK and SPI_CK. The 8 MHz is the microcontroller’s external clock connected to the OSC_IN OSC_OUT pins.

The STM32 samples the microphone’s output data by using the synchronous serial port (SPI1). The microphone signal MIC_DATA12 is a stereophonic signal and the SPI must be able to sample both channels. Since MIC_DATA12 is synchronous with its clock, SPI_CK must be doubled. Summarizing, the timer generates:

-MIC_CK = 3.072 MHz

-SPI_CK = 6.144 MHz

Finally, the USB interface allows streaming the audio on the USB peripheral making this demonstration board compatible with any laptop or desktop. This streaming capability allows using any acoustic tool for the sound acquisition done by STMicroelectronics’ MEMS microphones. The demonstration board also has the possibility to manage the microcontroller registers using the I^2C bus. Another important STM32 peripheral that is used is the I^2S which allows exporting the audio in the most commonly used digital format. This allows the user to test the signal using audio testing equipment such as Audio Precision. All these signals can be monitored on the APWLink connector.

LEDs D1-D5

The status of the board is indicated by the following LEDs:

- D1 on: USB enumeration successful
- D2 on: Firmware correctly downloaded
- D3 off: Firmware correctly downloaded
- D4: not soldered
- D5 on: Board supplied

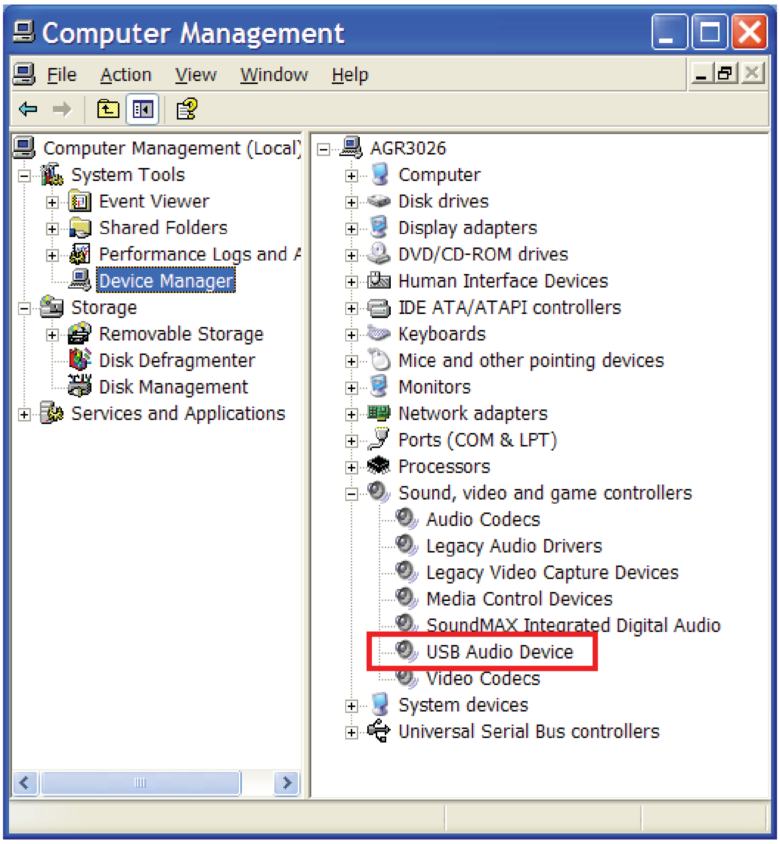
3 Getting started

The demonstration board is very user-friendly and is ready to use. After connecting the micro USB cable to the laptop or desktop, the message shown in *Figure 4* below appears. This is possible since the firmware loaded into the STM microcontroller allows the operating system to recognize the peripheral as an audio device. The version (in this case v1.0) indicates the firmware loaded. The version v1.0 refers to a software decimator of 48 kHz as the sampling frequency and 64 as the decimator index.

Figure 4. Windows message

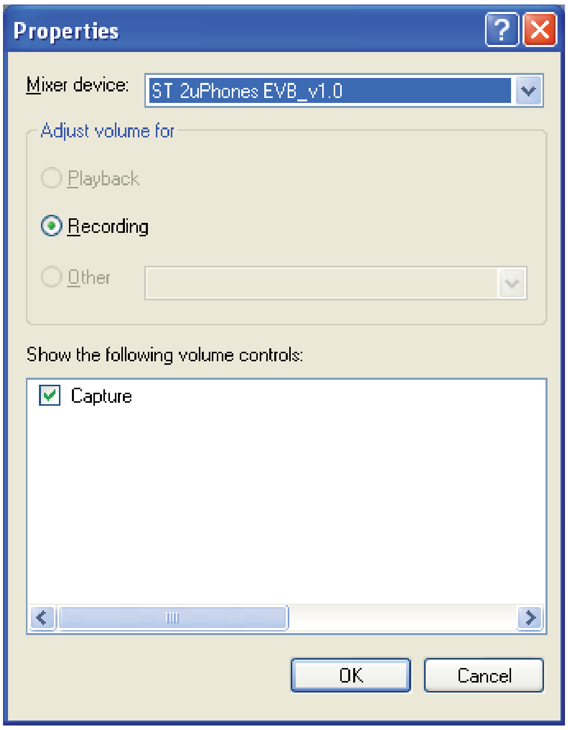
The user can also check if the USB demonstration board is recognized as an audio device by accessing the computer management and then clicking on the device manager. The demonstration board appears as a USB audio device in the list below.

Figure 5. Computer management



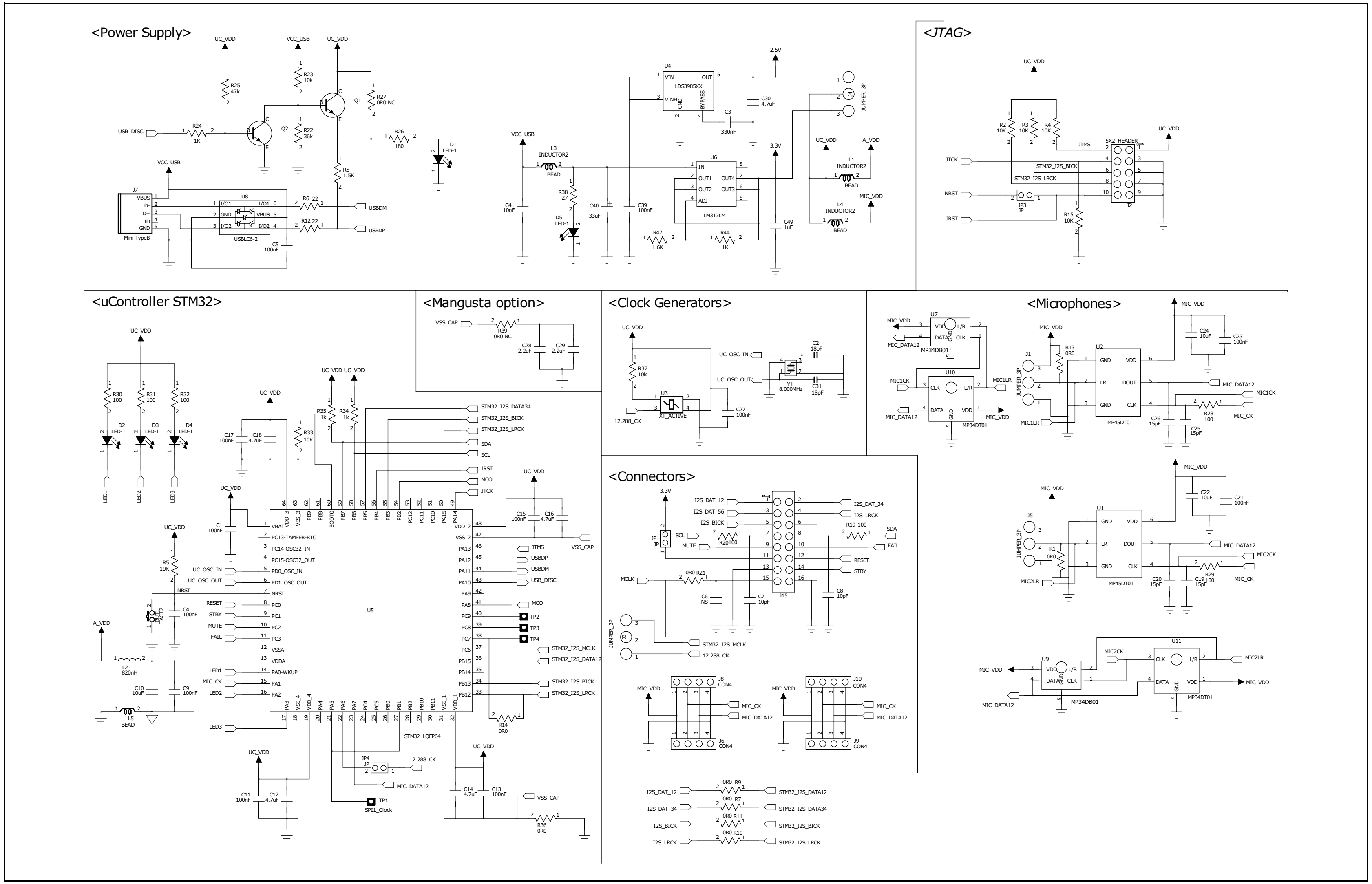
Since the firmware is able to let the operating system recognize the peripheral as an audio device, it is possible to set the "ST 2uPhones EVB_v1.0" evaluation board as the recording device. In this configuration, the demonstration board can be used to record the input of general-purpose acoustic tools.

Figure 6. Recording properties



Appendix A Schematic

Figure 7. Schematic



Appendix B Layout

Figure 8. Board layout - top view

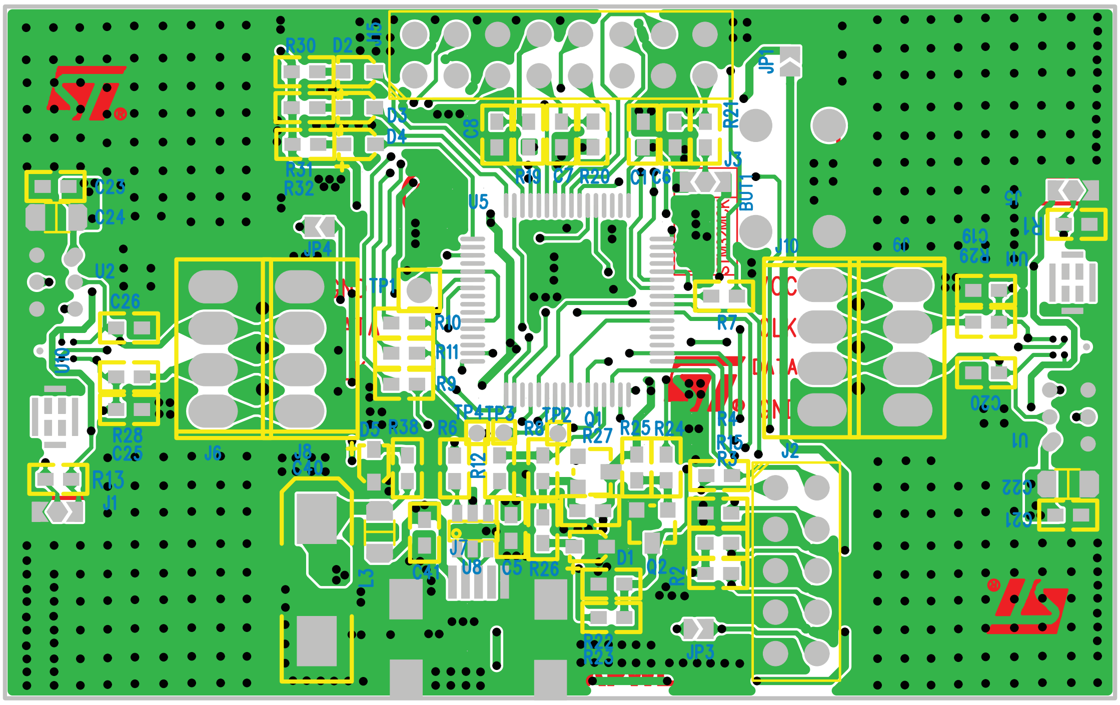
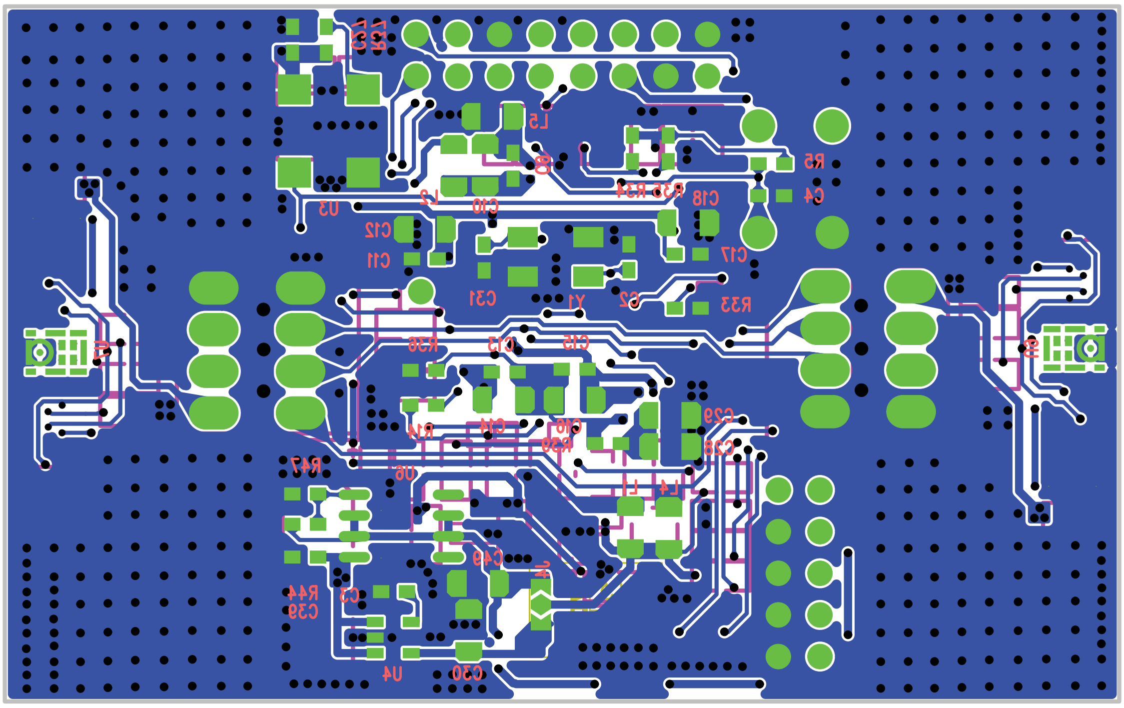


Figure 9. Board layout - bottom view



Appendix C Ordering information

The APWLink+ demonstration boards mentioned in this document are available on *www.st.com* referenced by the ordering codes listed below.

Table 3. Ordering information for demonstration boards

Order code	Board description
STEVAL-MKI116V1	MEMS microphone demonstration board based on the MP34DB01 and STM32F107RC
STEVAL-MKI117V1	MEMS microphone demonstration board based on the MP34DT01 and STM32F107RC
STEVAL-MKI117V2	MEMS microphone demonstration board based on the MP45DT02 and STM32F107RC

4 Revision history

Table 4. Document revision history

Date	Revision	Changes
30-Jan-2012	1	Initial release
06-Sep-2012	2	Updated maximum supply voltage for MP34DT01 in *Table 1* Added *Appendix C: Ordering information*