MUSICR1: 8 channel Multiple Use IC for SiPM anode readout

PCB Board description

Issue:	Second Version
Revision:	2.1
Reference:	MUSICR1
Created:	15th June 2016
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Prepared By:	SiUB

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1. Summary

The MUSIC board provides 8 individual analog and digital single ended outputs and two summation channels in differential model for readout of SiPMs. This document describes the main characteristics and the configuration of the MUSIC board. Moreover, the connectors that can be used in the board are detailed. Currently, we have the first version of the ASIC.

Besides the different output possibilities, this ASIC also has several configuration parameters. All outputs present two different gain configurations. The ASIC contains a tunable Pole-Zero cancellation providing output signals with less than 10ns FWHM. Note that the PZ can be also bypassed if the shaping is not needed. All channels, blocks and also the SiPMs can be power-off. Lastly, it is important to highlight that the digital signal shares the same PAD as the analog single ended output, thus the digital or analog signal must be switch off with a specific configuration parameter via SPI.

2. Board description

2.1. Block diagram

The block diagram of the board is here detailed in Figure 1. The board is prepared to admit several SiPM models, as detailed in the following sections and besides it contains a SiPM connector so a custom injection board can be employed to connect other sensors. This SiPM connector could be employed with an Arbitrary Waveform Generator which emulates electrically the pulse shape of different SiPMs, as depicted in Figure 2. Moreover, the amplitude of the signal can be controlled with a high precision logarithmic attenuator. Note that the external injection board must be carefully designed to properly adapt the input impedance of the ASIC and the Waveform Generator.

The A/D single channels and the summation can be directly red out using a pin connector in the board or they can be read using an additional external board with SMA connection. Moreover, a trigger signal is generated by performing an OR between the different digital channels and it is provided as SMA output connection.

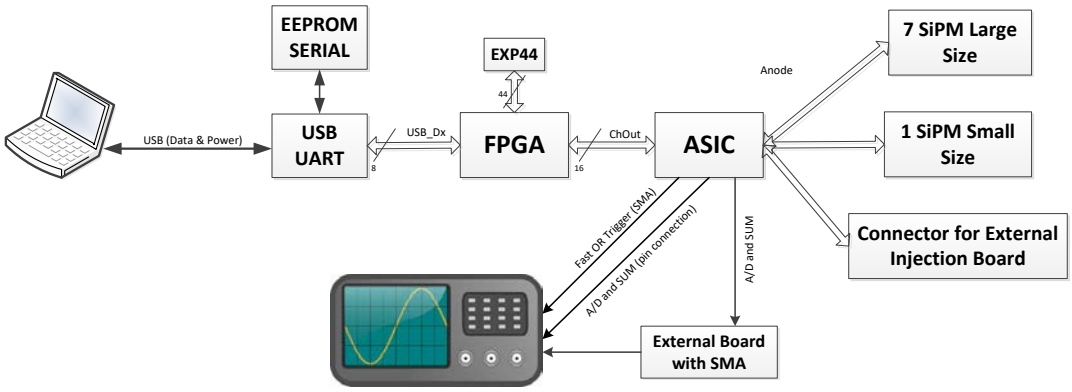


Figure 1: Block diagram of the functional flow.

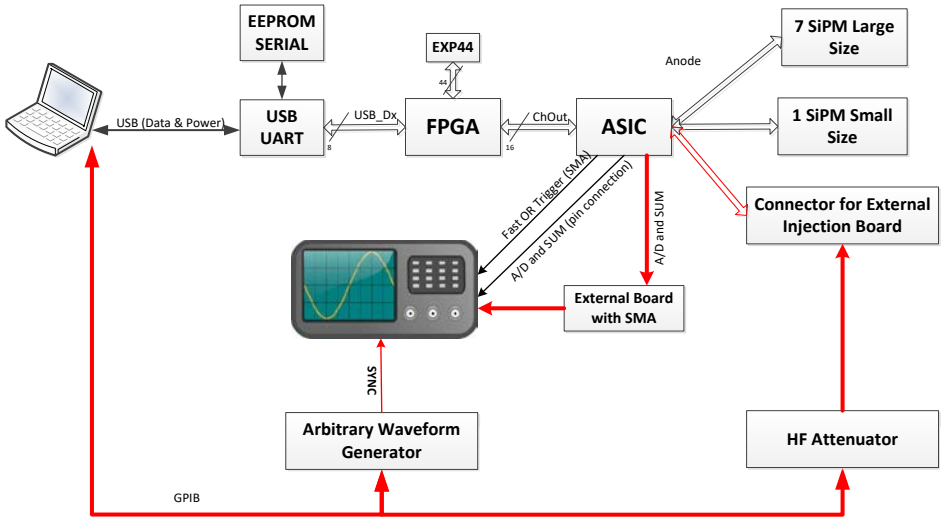


Figure 2: Block diagram of the functional flow using an attenuator and an electrical waveform generator.

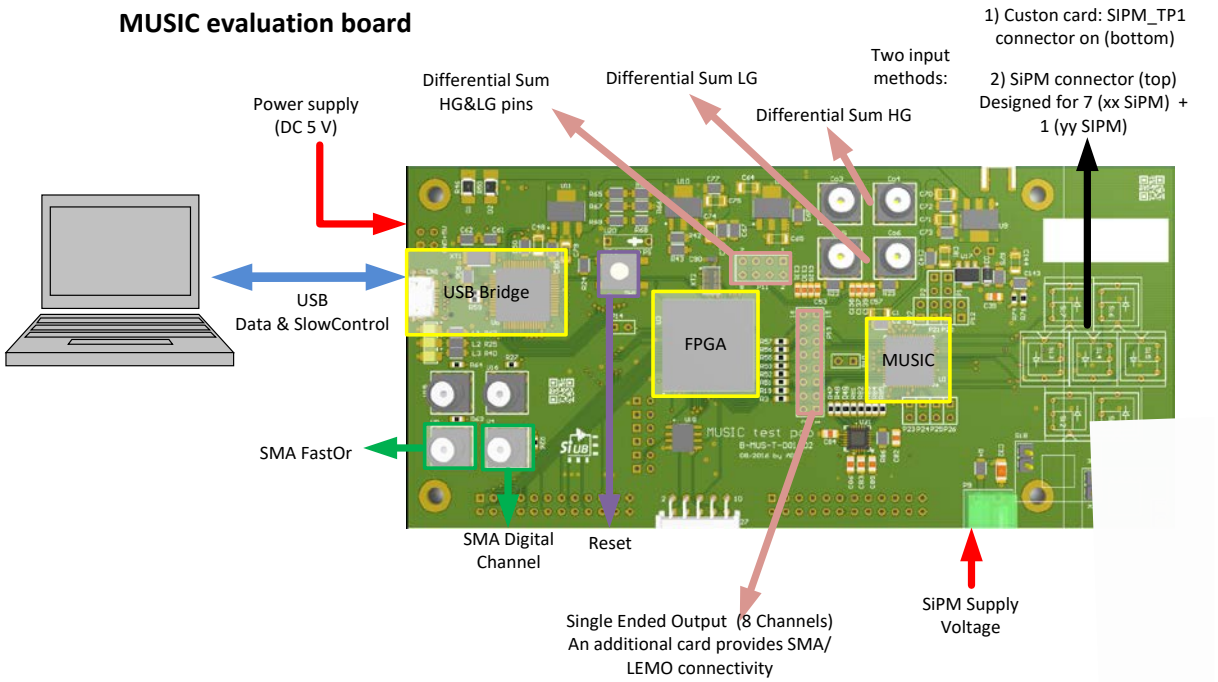


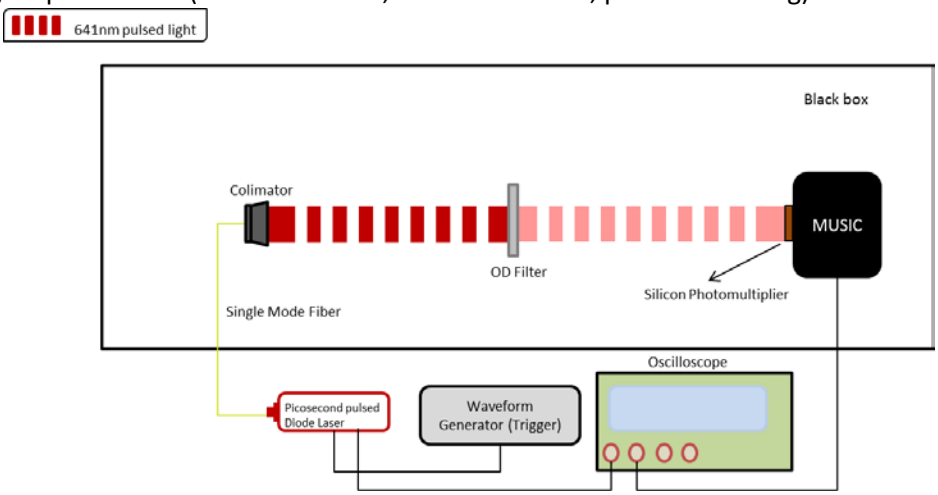
Figure 3: Overview of the different components of the PCB board.

<u>It is important to highlight that you should wear an anti-static bracelet when manipulating the board or when plugin the SiPMs.</u>

2.2. Example of Optical Test bench

The Optical test bench here employed to evaluate the performance of the MUSIC ASIC contains the following elements:

1. **Temperature controlled black box.** Temperature is stabilized at 20 degrees using a temperature controller Device.
2. **Light source** is provided by a 600 nm laser with 50 ps FWHM. The light system also includes: an attenuator + collimators + filters.
3. A **digital phosphor oscilloscope** (DPO) of 4 GHz bandwidth and 20 GS/s is employed to obtain analog parameters (amplitude, pulse, charge, etc).
4. A **computer** analyzes the data processed at the FPGA in the MUSIC board in order to provide digital parameters (threshold scans, dark count rates, photon counting).



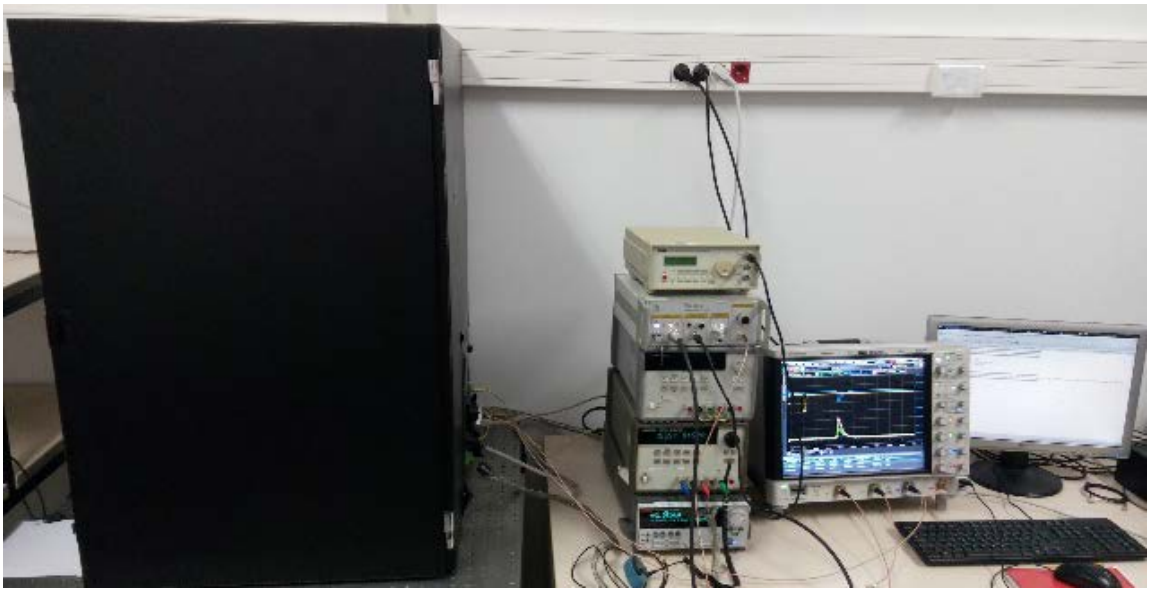


Figure 4: optical test bench example

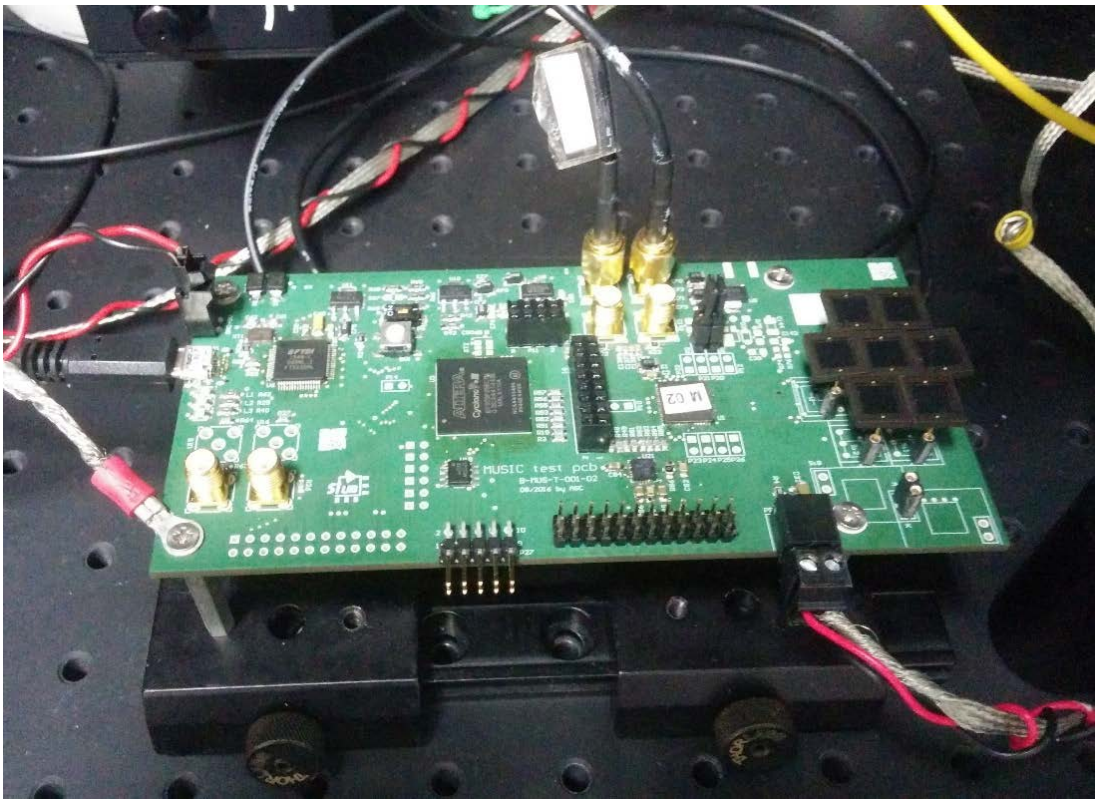


Figure 5: 7 SIPM matrix using the MUSIC board

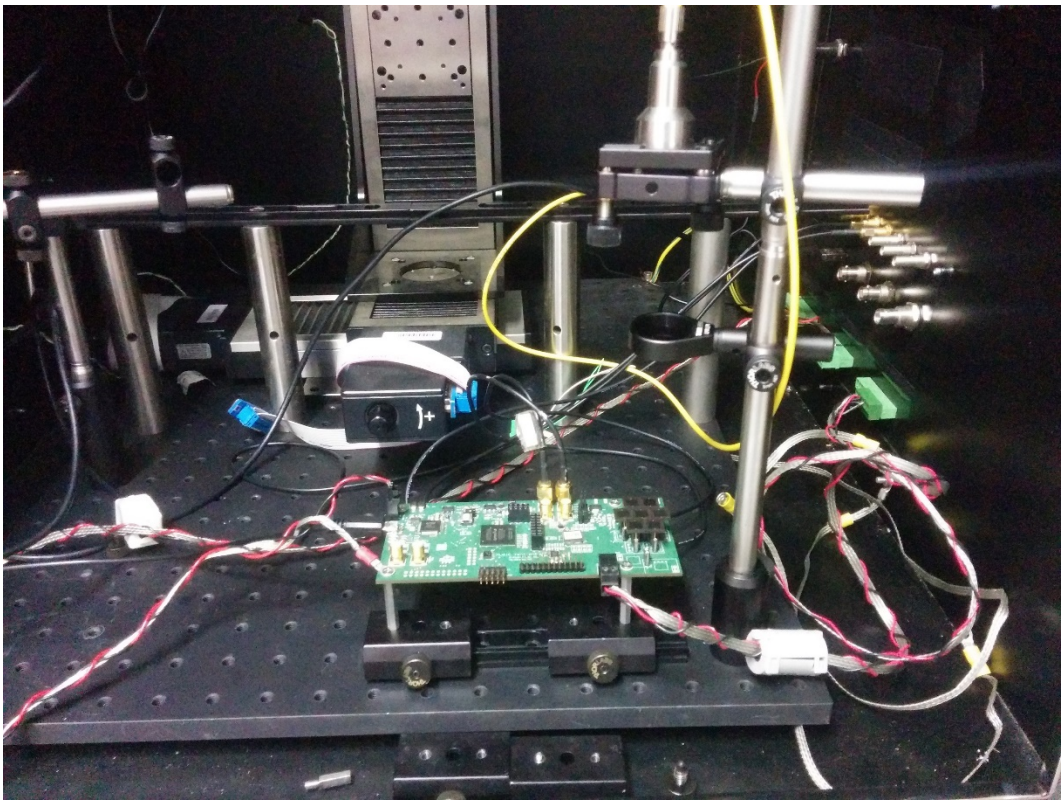


Figure 6: Board, Laser, attenuator ND (Neutral density Filter) and diffusor (expands the laser beam to the whole matrix).

3. Board connections

3.1. Board detailed view

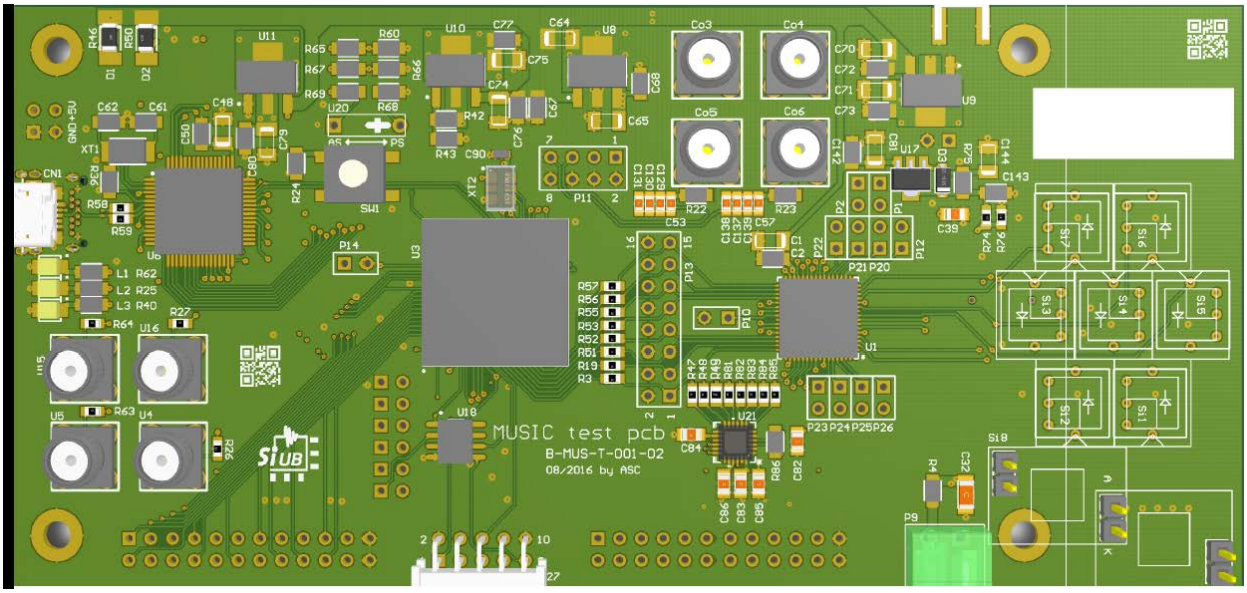


Figure 7: Board top view.

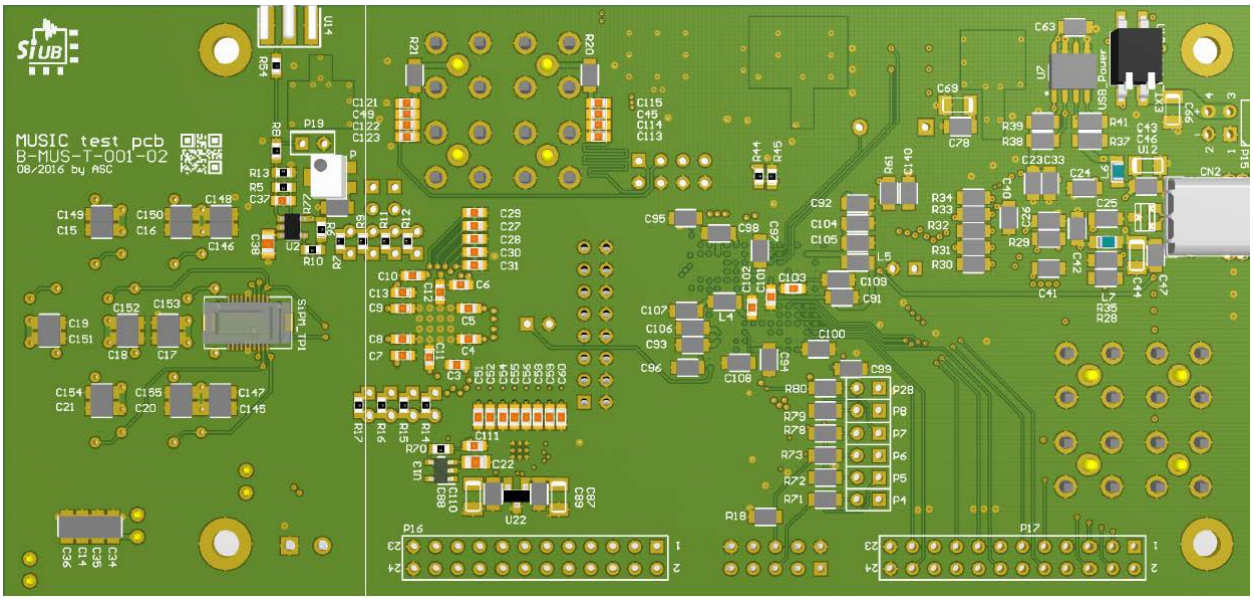


Figure 8: Board bottom view.

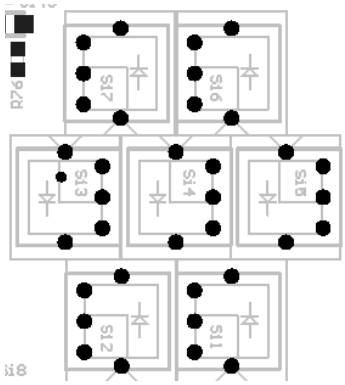
3.2. SiPM connectors

Different options are available for SiPM connection as detailed below:

1. 7 large size connectors for SiPMs can be connected in Si1-Si7. This connector is intended for Hamamatsu S13360-6050CS (pins in the center, spaced 7.4mm) or an Excelitas C30742-66-50-C (pins on a side, spaced 5.06mm).
   The images below show the pin location for the Hamamatsu S13360-6050CS SiPM, however the SiPM orientation is not correct and the real position of the anode and cathode is the opposite. Moreover, the small triangle drawn in one of the sides of each SiPM does not corresponds to the triangle or mark on the right side of the picture of the SiPM. Thus place the SiPM oppositely as shown in the PCB board.

Table 1: Large Size connection for SiPMs.

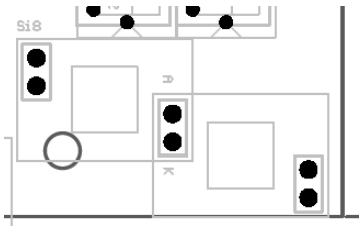
Pin	Signal
A	INCh (ASIC)
K	HV (High Voltage)



2. 1 small size connector for a SiPM can be connected in Si8 and it is routed to the channel 8 of the ASIC. This connector is intended for an AdvanSiD ASD-NUV4S-P model (spaced 2.54mm), but it could be also used for a 3x3 Hamamatsu SiPM.

Table 2: Small Size connection for SiPMs.

Pin	Signal
A	IN9Ch (ASIC)
K	HV (High Voltage)



3. A multipurpose 20 way Hirose SiPM receptacle connector. This connector is placed on the bottom side of the board. Its reference is D17(3.0)-20DS-0.5V (Hirose) or 2300343 (Farnell). Note that the SiPM2 connector mounted on the board does not have high voltage (HV) connectors. Moreover, it only employs 8 pins from the connector to be used as 8 inputs (8 SiPM inputs) in the main board.

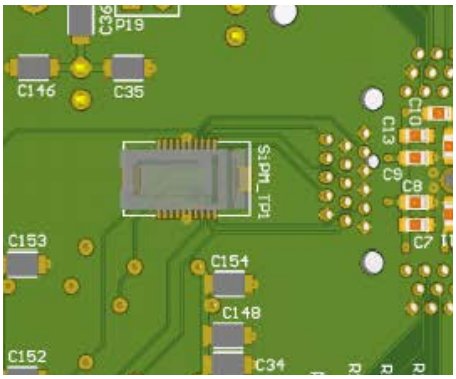
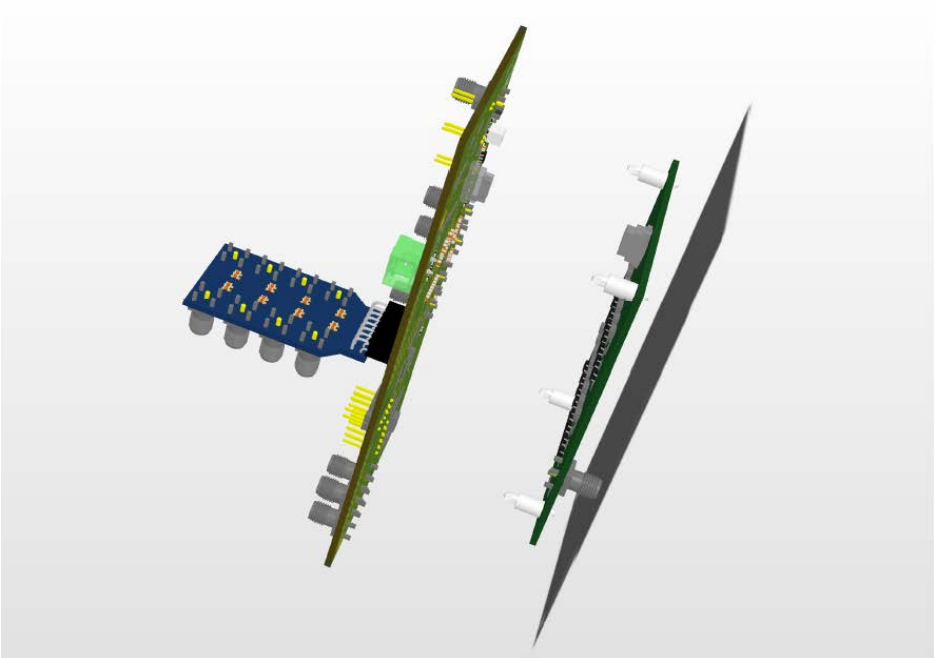


Figure 9: Multipurpose SiPM connector at the bottom side of the board.

Table 3: SiPM1 connector. Note that only 8 pins of the connector are used as inputs to the main board.

Pin	Signal	Pin	Signal
1	IN2 (ASIC)	**12**	NC (Not connected)
2	IN3 (ASIC)	**13**	NC (Not connected)
3	IN7 (ASIC)	**14**	NC (Not connected)
4	IN6 (ASIC)	**15**	GND
5	GND	**16**	GND
6	GND	**17**	IN5 (ASIC)
7	NC (Not connected)	**18**	IN4 (ASIC)
8	NC (Not connected)	**19**	IN0 (ASIC)
9	NC (Not connected)	**20**	IN1 (ASIC)
10	NC (Not connected)	**21**	NC (Not connected)
11	NC (Not connected)		



Figrue 10: Example of usage of the SiPM connector.

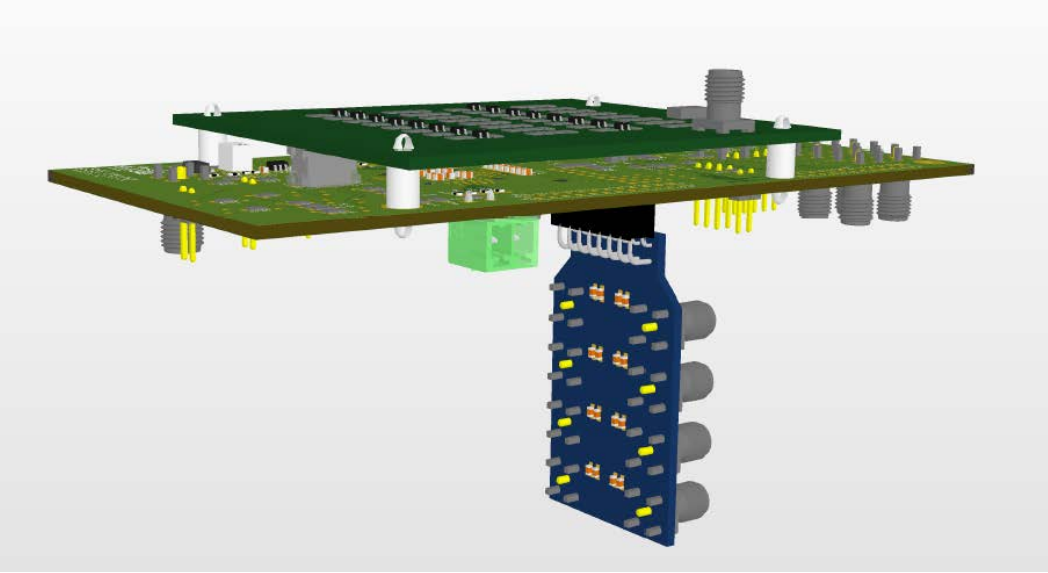


Figure 11: Example of usage of the SiPM connector

3.3. Connectors

A list of connectors and its placement on the board are detailed next.

1. Board power supply at 5V (Pin P15).

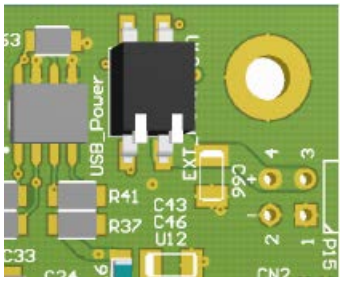
Table 4: Power Supply Connector

Pin	Signal
1	GND
2	GND
3	+5V
4	+5V

2. **Interface Connection:** A micro-usb connection is used to communicate with the ASIC via the FPGA. Note that the power supply can also come from the usb. The power supply mode can be selected using the following switch.

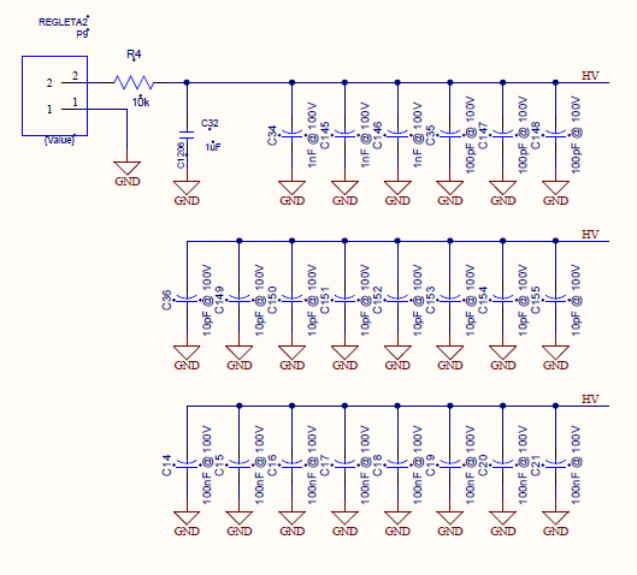
Table 5: Switch for external or USB power supply.

Pin	Signal
1 (Top)	5V external supply
2 (Bottom)	USB power suppply



NOTE: Connect the power supply and the usb connection. Note that the board can be configured using only the power supply coming from the USB connection, although some USB cables/computer might not provide enough current to the board to properly feed the ASIC. Hence, use always a power supply source besides of the usb cable.

3. **P9**: High voltage connector. The high voltage depends on the SiPM device employed. The circuit is shown next. Note that for this board we added: 1 Cap of 100nF, 1 Cap of 10nF, 3 Caps of 1nF, 3 Caps of 100pF, 8 Caps of 10pF.



Pin	Signal
1	GND
2	HV (High Voltage)

Figure 12: Circuit used in the board for high voltage

4. **Pin output connectors.**

4.1. Single Ended: Analog or Digital pin connection.

Pin	Signal	Pin	Signal
1	VoSE0	**9**	VoSE4
2	GND	**10**	GND
3	VoSE1	**11**	VoSE5
4	GND	**12**	GND
5	VoSE2	**13**	VoSE6
6	GND	**14**	GND
7	VoSE3	**15**	VoSE7
8	GND	**16**	GND

4.2. Low Gain and High Gain summation pin configuration.

Pin	Signal	Pin	Signal
1	VoHG_P	**5**	VoLG_P
2	GND	**6**	GND
3	VoHG_N	**7**	VoLG_N
4	GND	**8**	GND

4.3. U5: Fast OR trigger SMA output.

4.4. U4: SMA digital single ended output.

5. **External board for SMA output connectors.** This external board can be employed to obtain a decoupled SMA output for the Single Ended signals, as illustrated below. Note that you can also use this external board to output the summation channels.

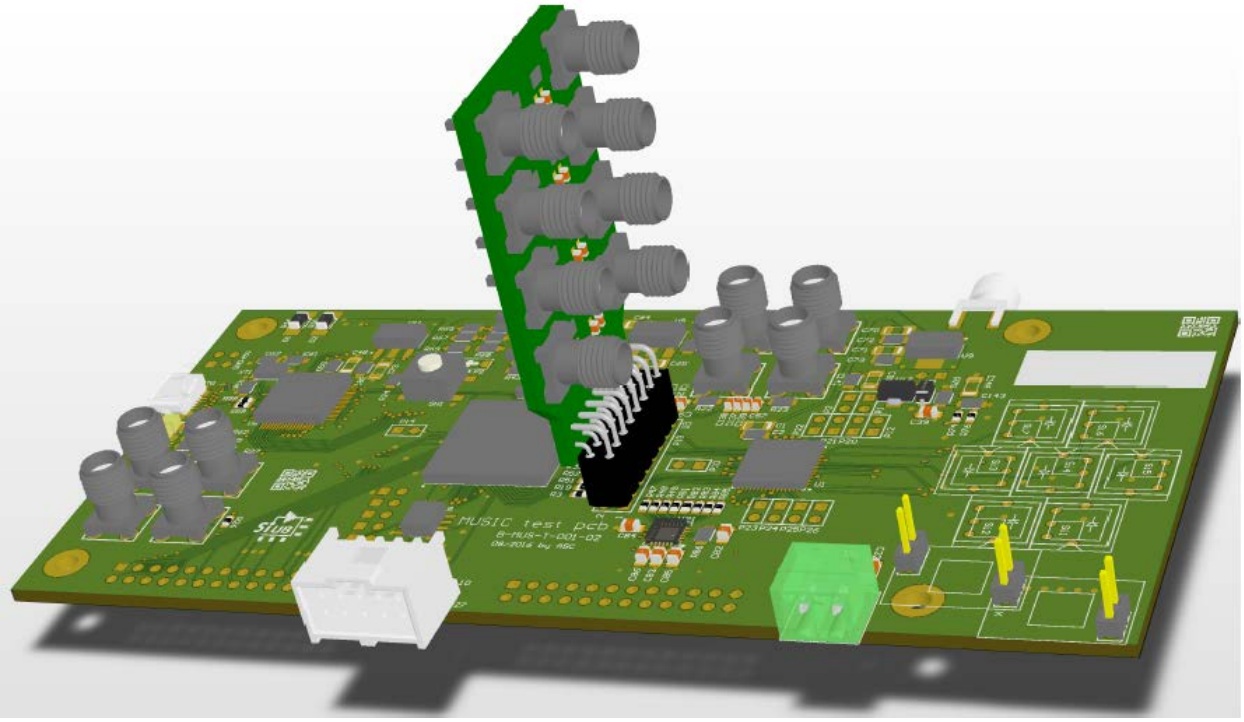


Figure 13: External board for Single-Ended SMA connection.

4. How to perform measurements

Measurements can be done following these steps.

0. Wear an anti-static bracelet to manipulate the board.
1. Connect the board power supply at 5V.
2. Connect the USB to the computer.
3. Connect the high voltage according to the SiPM employed. If you are using an external pulse for calibration you don't need to connect the high voltage.
4. Load the firmware and the configuration of the FPGA (see the software manual).
5. Configure the MUSIC ASIC with the desired configuration (see the software manual).
6. Use the oscilloscope to measure the different output signals.

5. Revision history

1. 15 – June – 2016: First version of the board manual.
2. 17 – June – 2016: Updated external board pictures.
3. 18 – July – 2016: Updated SiPM external connector description.
4. 27 – October – 2016: Updated document with new PCB board.