MUSICR1: 8 channel Multiple Use IC for SiPM anode readout

PCB Board description

Issue:	Third Version
Revision:	3.1
Reference:	MUSICR1
Created:	15th June 2016
Last modified:	12th February 2017
Prepared By:	SiUB

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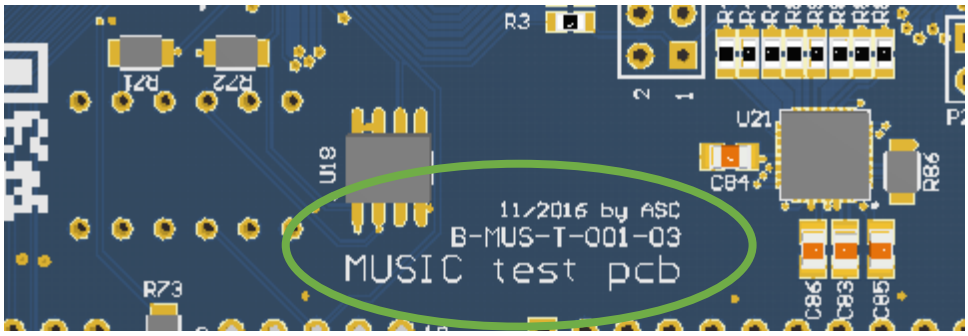
1. Summary

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.

This manual is based on the version 3 of the MUSIC board.



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.

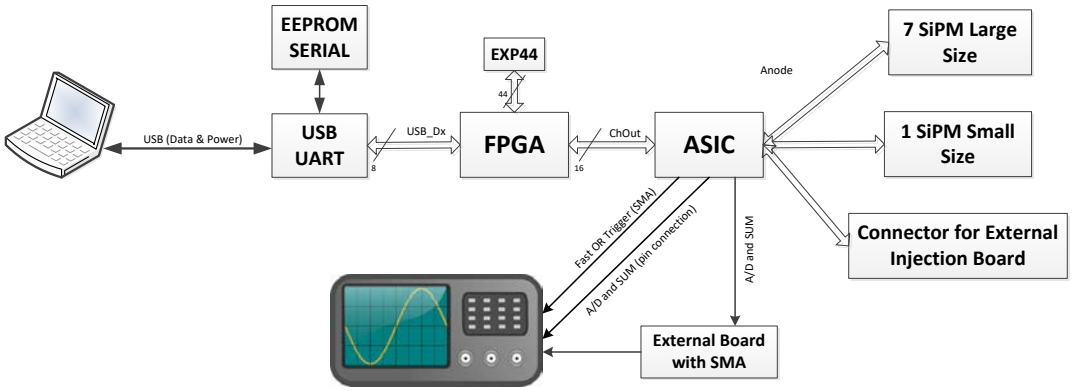


Figure 1: Block diagram of the functional flow.

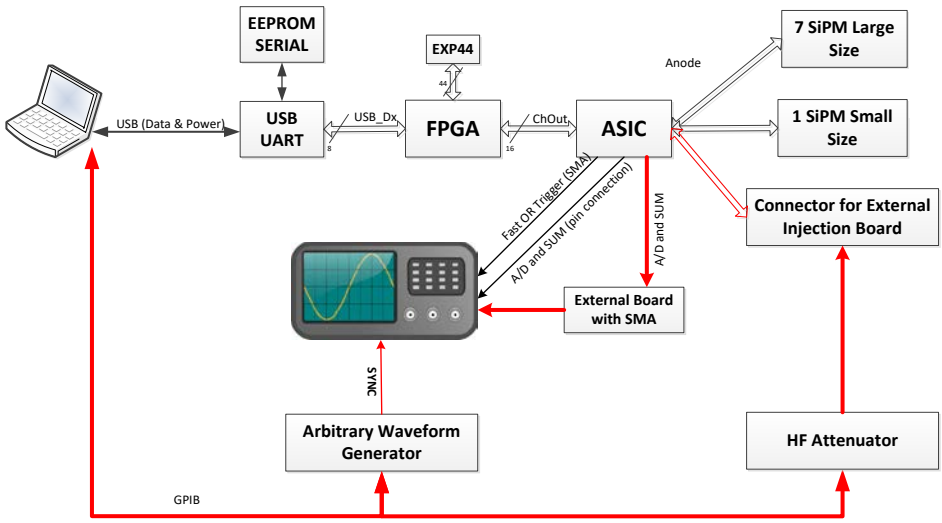


Figure 2: Block diagram of the functional flow using an attenuator and an electrical waveform generator.

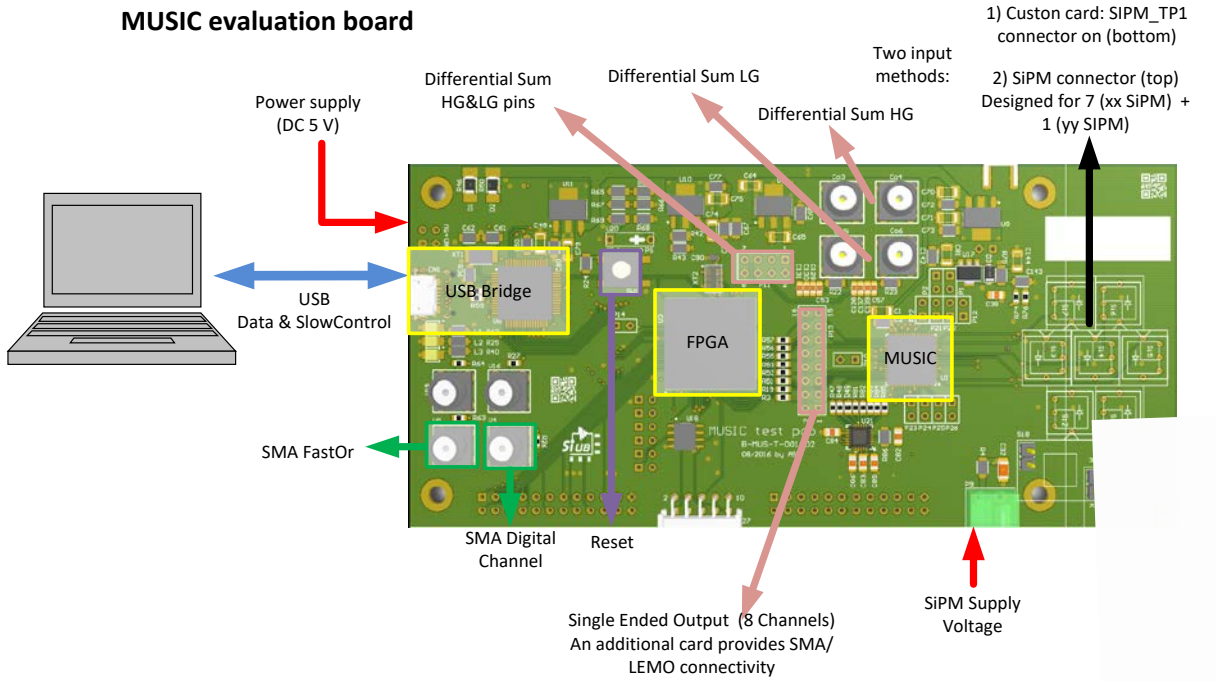


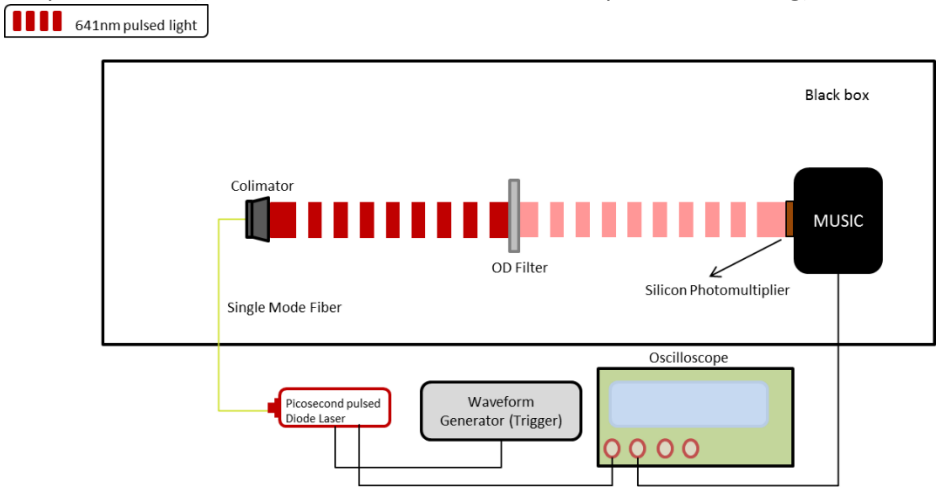
Figure 3: Overview of the different components of the PCB board.

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

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).



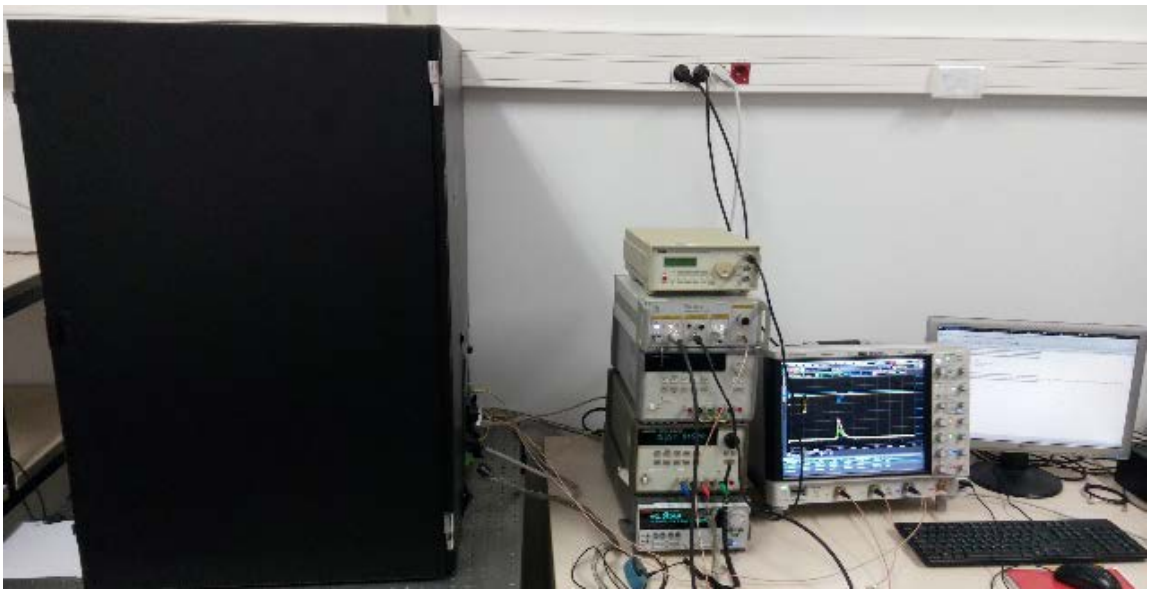


Figure 4: optical test bench example

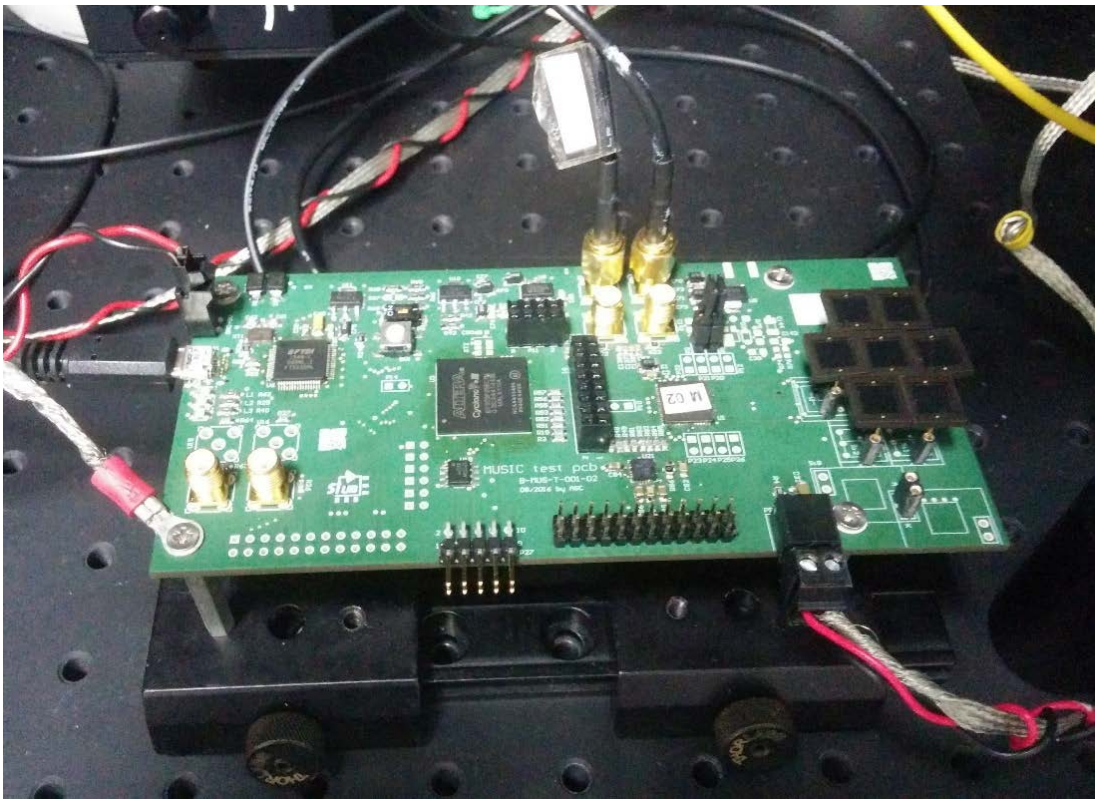


Figure 5: 7 SIPM matrix using the MUSIC board

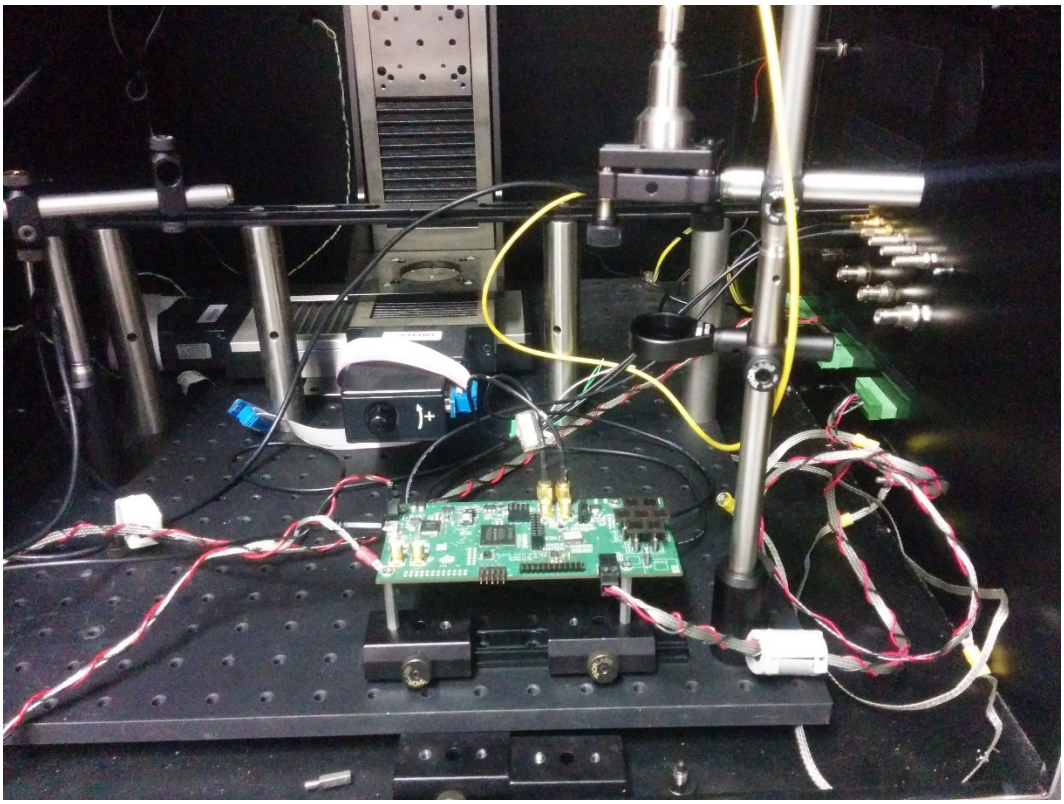


Figure 6: Board, Laser, attenuator ND (Neutral density Filter) and diffusor (expands the laser beam to the whole matrix).

3. Board connections

3.1. Board detailed view

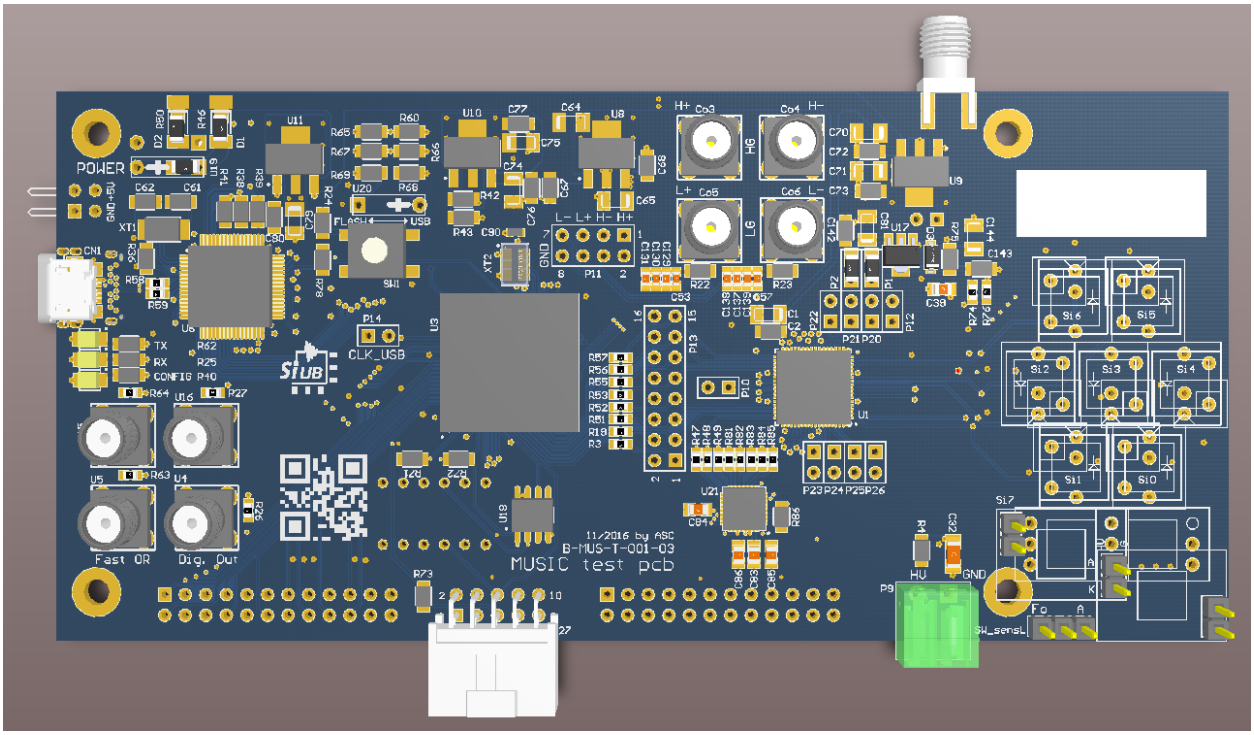


Figure 7: Board top view.

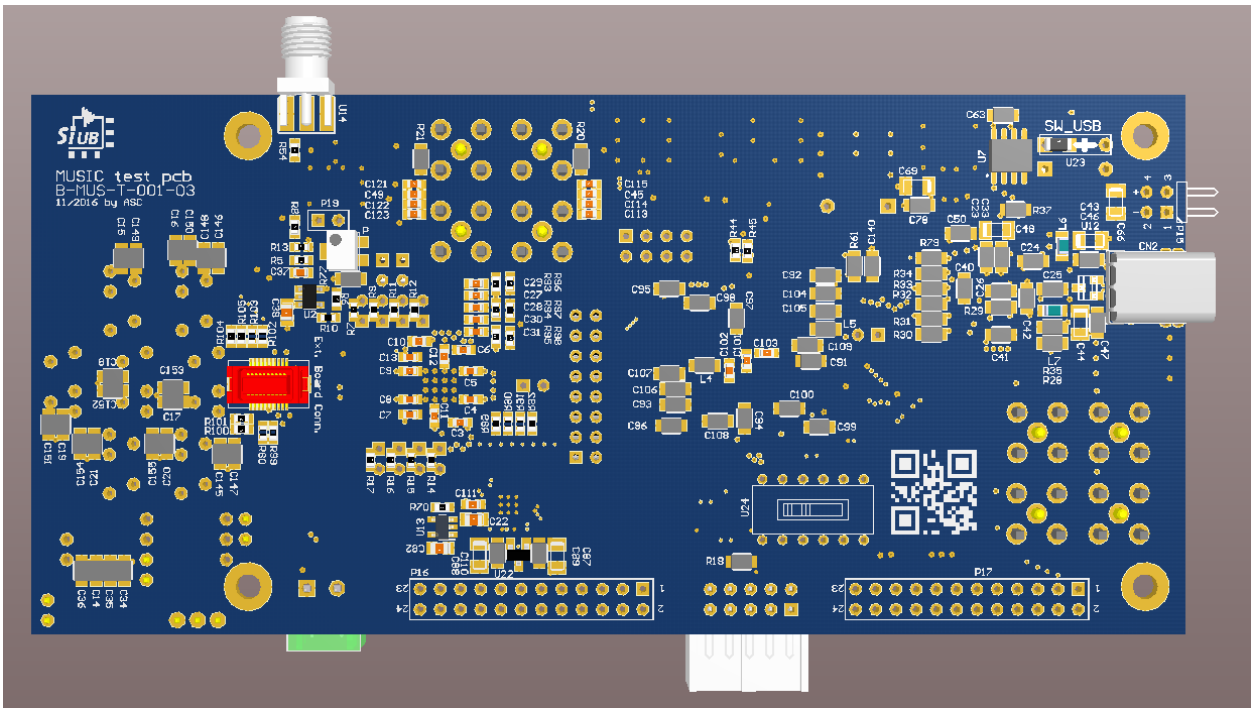


Figure 8: Board bottom view.

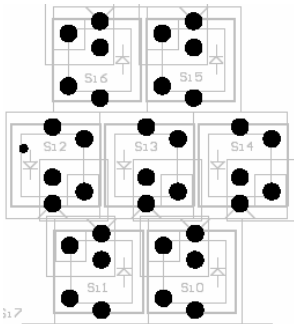
3.2. SiPM connectors

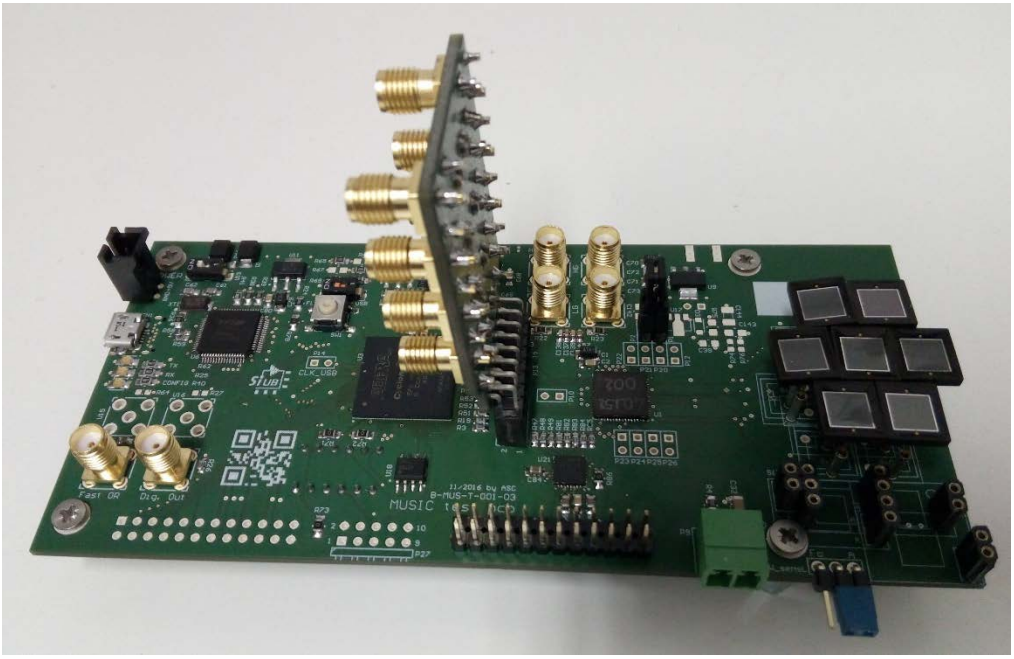
Different options are available for SiPM connection as detailed below:

1. 7 large size connectors for SiPMs can be connected in Si0-Si6. 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. Observe that the SiPm symbol shows the anode and cathode connection of each SiPM connector.

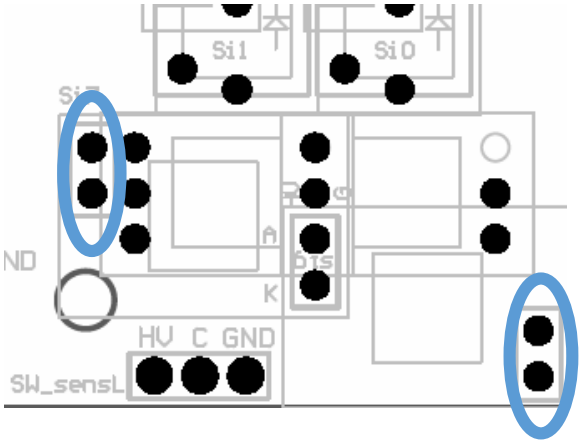
Table 1: Large Size connection for SiPMs.

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





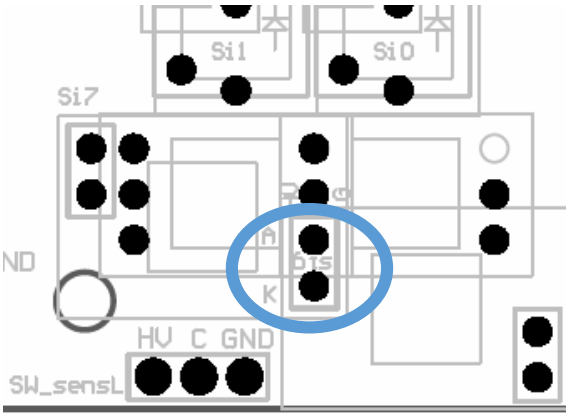
2. 1 small size connector for a SiPM can be connected in Si7 and it is routed to the channel 8 of the ASIC. This connector is intended for different SiPMs:
   2.1. An AdvanSiD ASD-NUV4S-P model (spaced 2.54mm), but it could be also used for a 3x3 Hamamatsu SiPM.



   2.2. It could be also used for a 3x3 Hamamatsu SiPM.

Table 2: Hamamatsu 3x3 SiPms SiPMs.

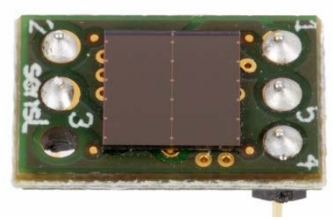
Pin	Signal
A	IN9Ch (ASIC)
K	HV (High Voltage)



2.3. Channel 7 can be also used with Sensl SiPMs. You can connect the MicroFJ-SMTPA-60035 Board to this input. The MUSIC ASIC can process the standard output by connecting pin 1 of this board to pin A in the MUSIC board. Note that the fast output can not be seen with the actual configuration of the board, please contact us for further information on how to process the fast output with the current ASIC. Place a jumper on the switch "SW_sensl" to select the standard input, as detailed below.

Table 3: Sensl SiPm.

Pin	Signal
1	Standard out (Anode)
2	Fast Out
3	Cathode
4	Ground
5	No connect



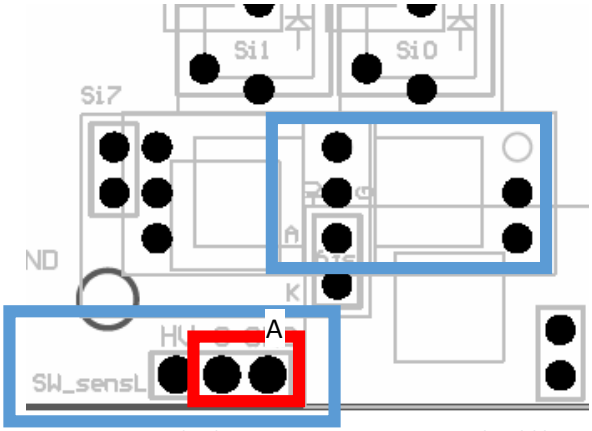


Figure 10: Standard Output Connection. Pin 1 should be connected to pin A.

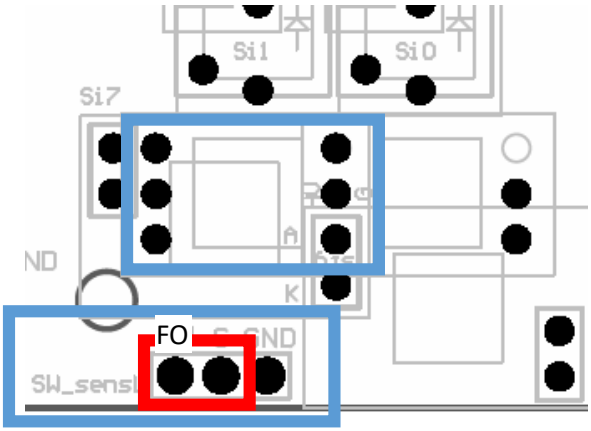
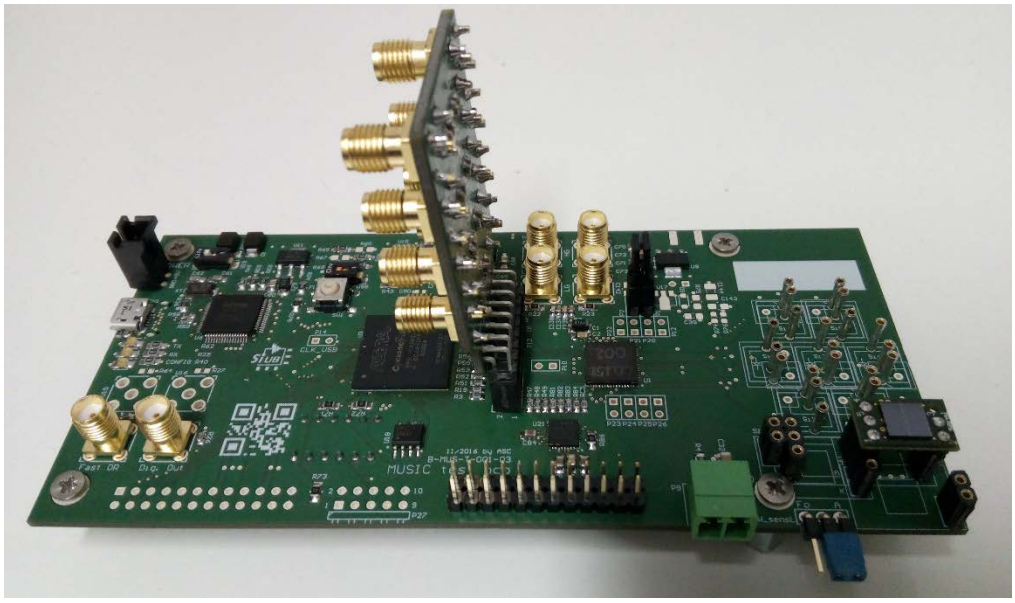


Figure 9: Fast Output Connection. Pin 2 should be connected to pin A.



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.

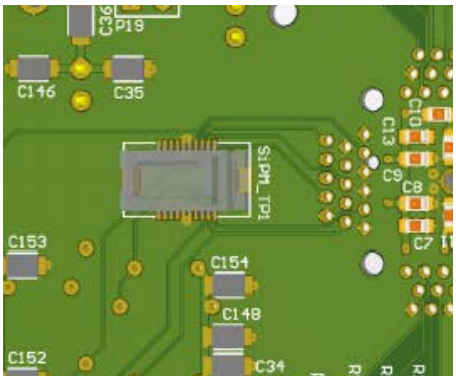
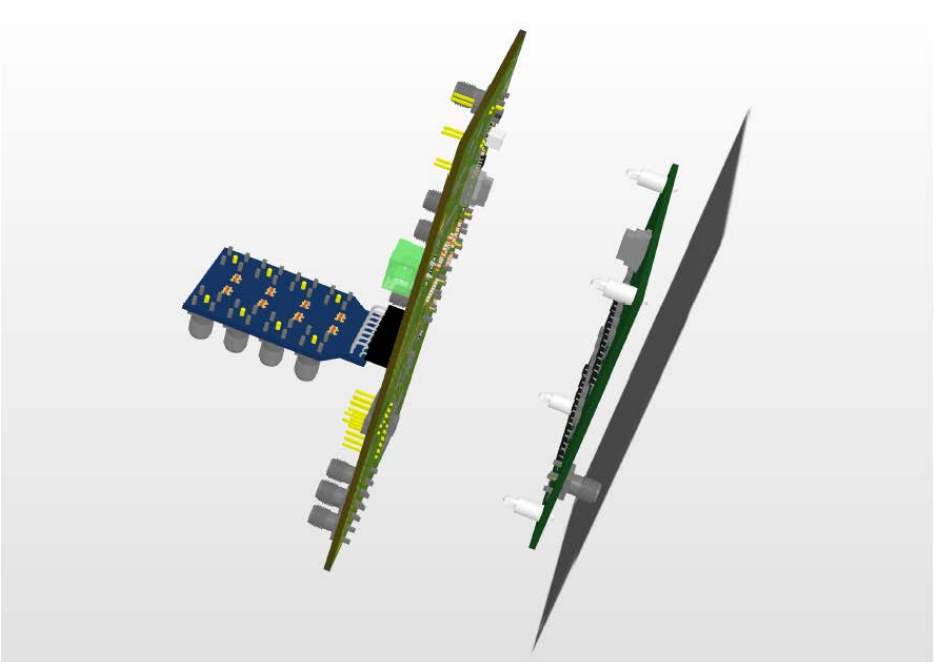


Figure 11: Multipurpose SiPM connector at the bottom side of the board.

Table 2: 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**	GND
2	IN3 (ASIC)	**13**	HV
3	IN7 (ASIC)	**14**	HV
4	IN6 (ASIC)	**15**	GND
5	GND	**16**	GND
6	GND	**17**	IN5 (ASIC)
7	AUX0	**18**	IN4 (ASIC)
8	AUX1	**19**	IN0 (ASIC)
9	AUX3	**20**	IN1 (ASIC)
10	AUX2	**21**	GND
11	GND		



Figrue 12: Example of usage of the SiPM connector.

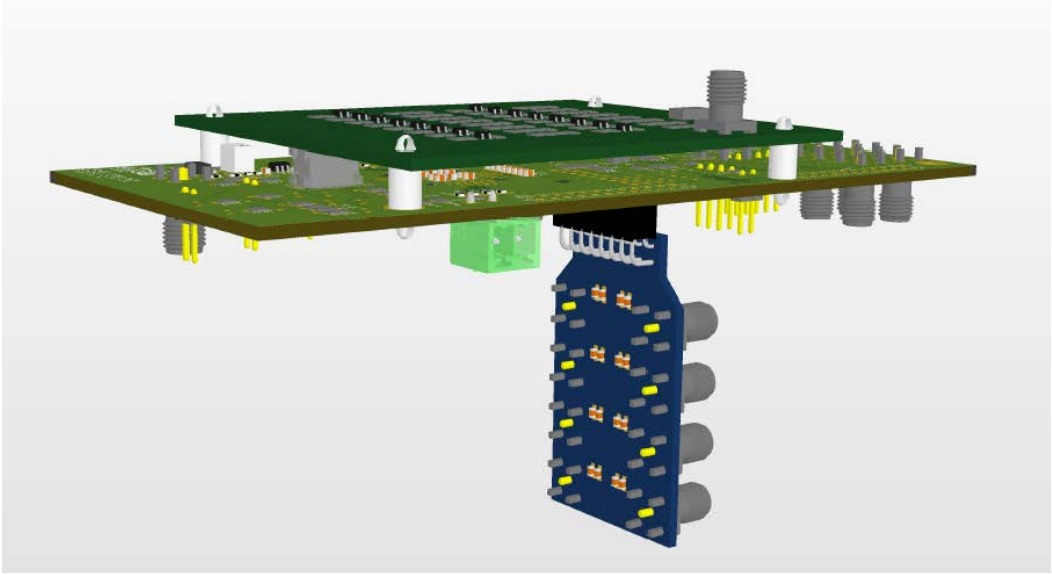


Figure 13: Example of usage of the SiPM connector

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

The main power supply can be enabled with a POWER switch is on top-left of the board. Note that the board contains led that will be illuminated once the board is switch on. Lastly, note that there is an alternative power supply coming from the USB. 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.

Table 3: Switch for external or USB power supply.

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

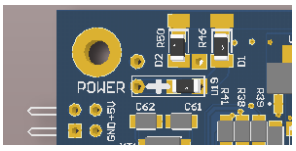


Figure 14. Power switch on the top side of the board

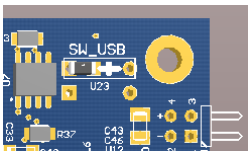
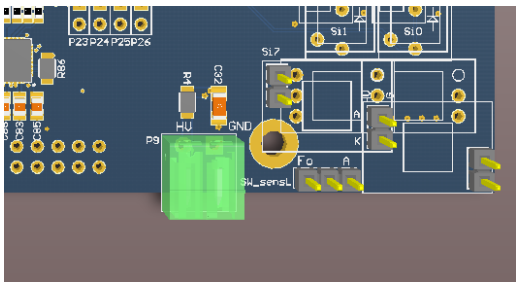
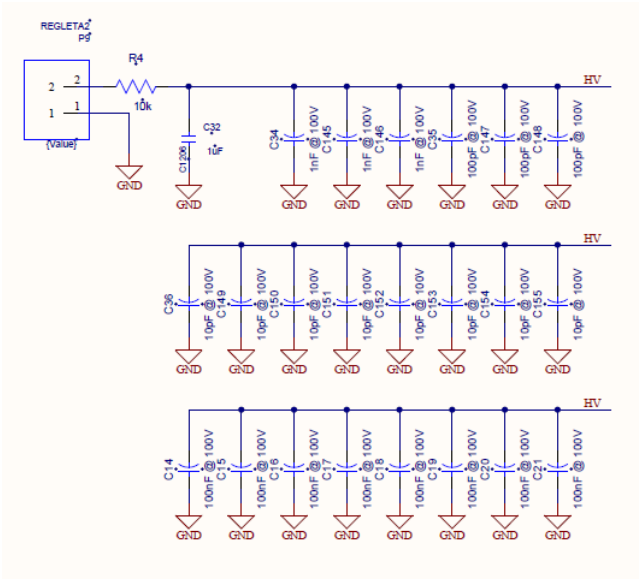


Figure 15. USB switch on the bottom side of the board

2. **Interface Connection:** A micro-usb connection is used to communicate with the ASIC via the FPGA.

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 14: 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.

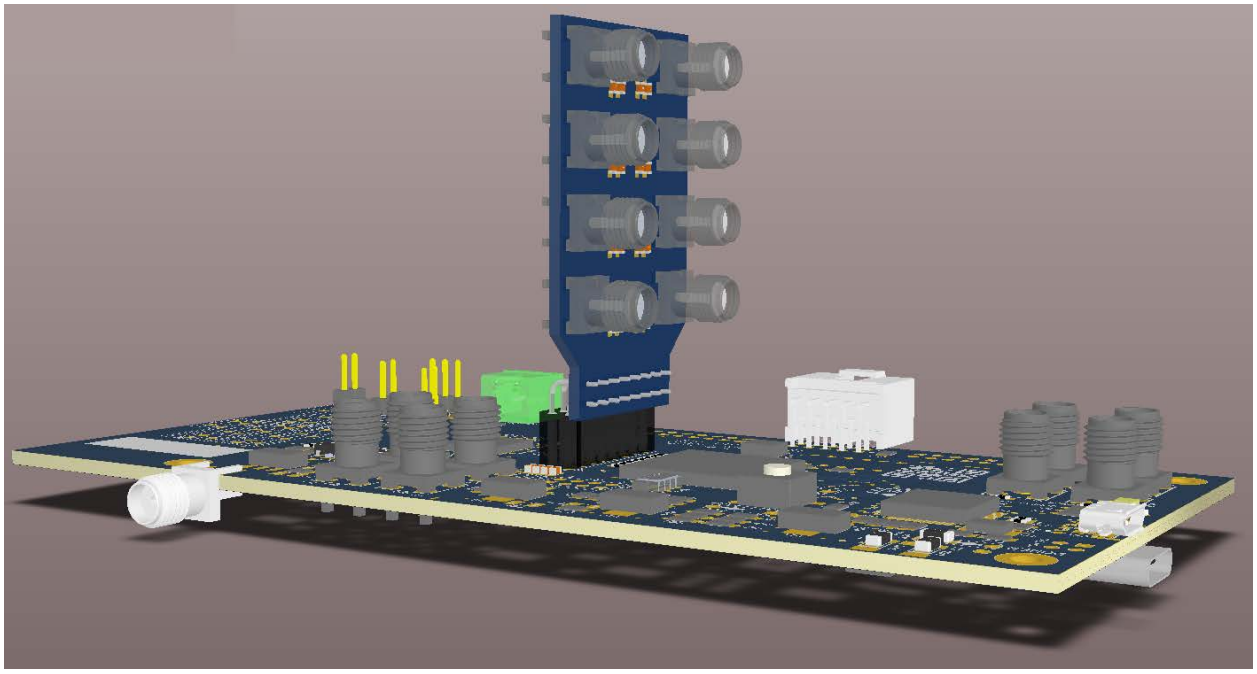


Figure 15: External board for Single-Ended SMA connection.

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.
5. 16 – December – 2016: Changed Pin 21 of the external board connector from NC to gnd.
6. 17 – January – 2017: Change Figure 13, because the external SMA board is drawn in the wrong direction.
7. 12 – February – 2017: Updated document for MUSIC board v3.