F303 Shield A Reference

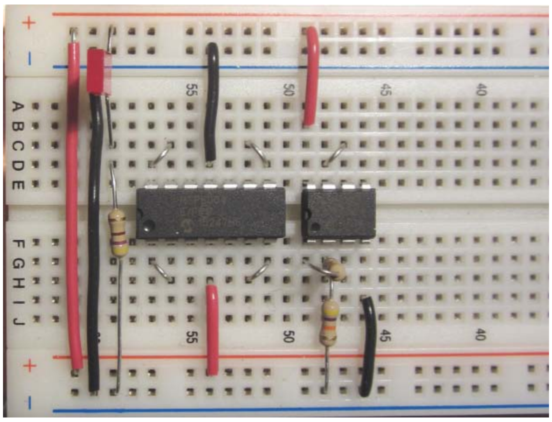
This document is the reference for the F303 Shield A that can be used to interface the Nucleo F303RE and Nucleo L152RE boards.

Index

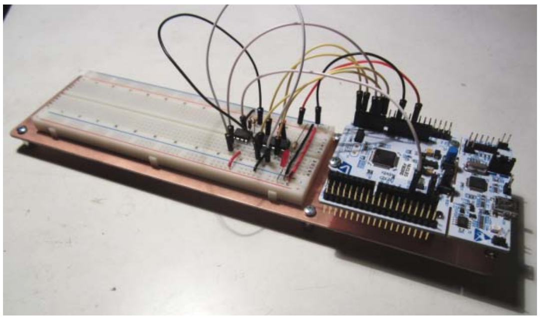
Introduction

The SLab System requires a hardware board in order to interface the SLab Python module with a circuit under test. One of the official implementations of the hardware board is based on the use of a Nucleo64 F303RE demonstration board.

The ADCs and DACs in this board require the use of operational amplifier followers in order to guarantee that we don't have loading effects in our measurements. The easiest way to implement the buffering is by building the circuit on a breadboard as shown in the following figure.

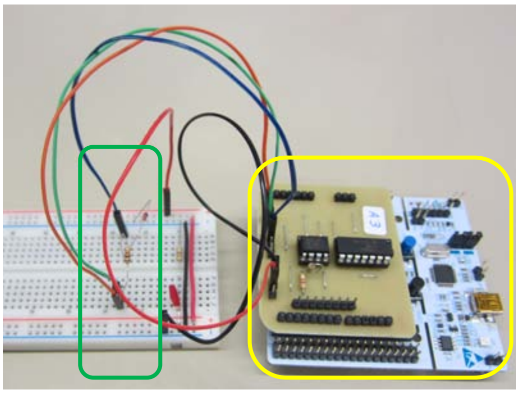


This solution, although easy, has three main drawbacks: First, it occupies part of the breadboard space, reducing the space available for the circuit under test (CUT). Second, the connections in a solderless breadboard are not as reliable as soldered connections. And third, we need to use at least eight jumper wires to connect the hardware board to the driver circuit in the breadboard. That makes the system less portable.



This document describes the F303 Shield "A". This is small board that can be connected over the F303RE board to provide the needed buffering. As the F152RE board features the same pinout, it is also compatible with this board.
The shield includes the "A" letter because, in the future, there could be an improved "B" version with different components or connections.

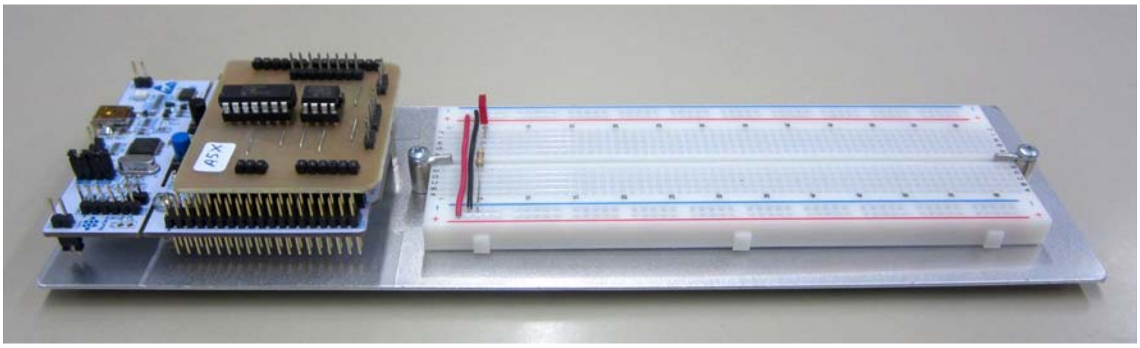
The following figure shows the Nucleo64 F303RE board fitted with the shield, implemented on a custom made PCB, and connected to a Circuit Under Test (CUT) that is built on a solderless breadboard.



CUT

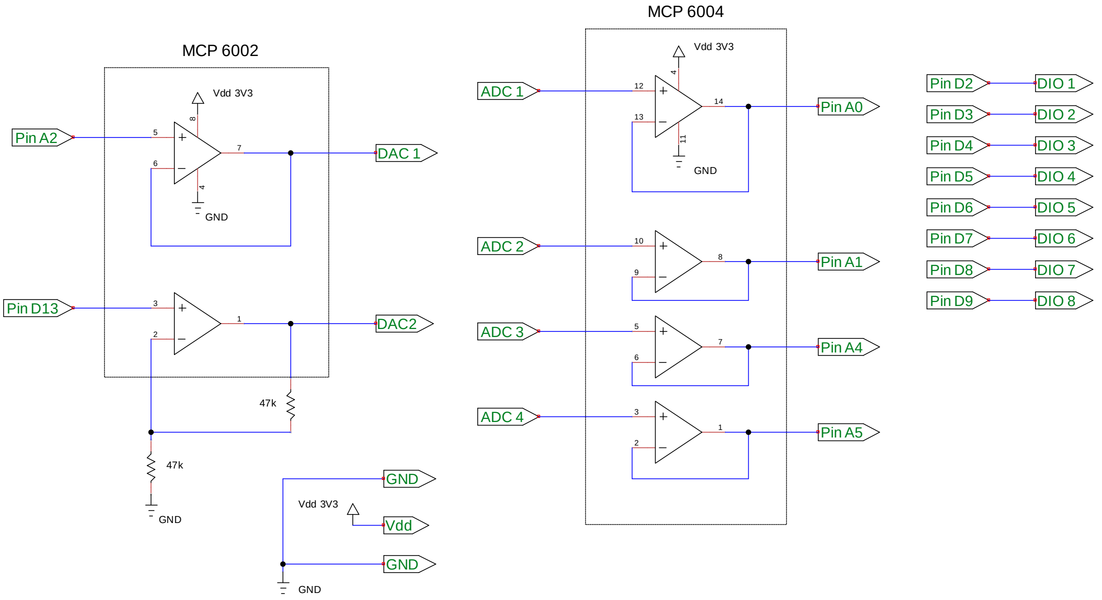
Nucleo Board
and Driver Shield

Finally the following figure shows the ***SLab longboard*** that includes all the needed SLab elements in a rigid support plate that is easier to use and transport.



Board Schematic

The following figure shows the schematic for this board.



It is basically the same schematic shown for the F303RE buffering circuit in the SLab Main reference document, with the LED removed and with the DIO lines added.

The shield use through hole opamp ICs on sockets so that they can be changed if we burn them by the use of improper connections.

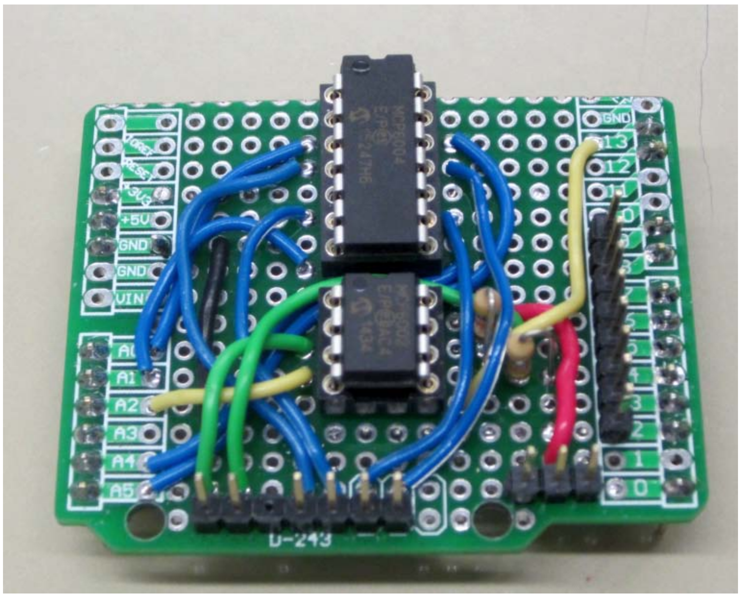
The board connects, using male pins, to the Nucleo64 F303RE board on the bottom side. In particular it connects with pins: 3V3, GND, A0, A1, A2, A4, A5, D2 to D9 and D13.

On the top component side, the board provides male pins for all the signals the shield provides:

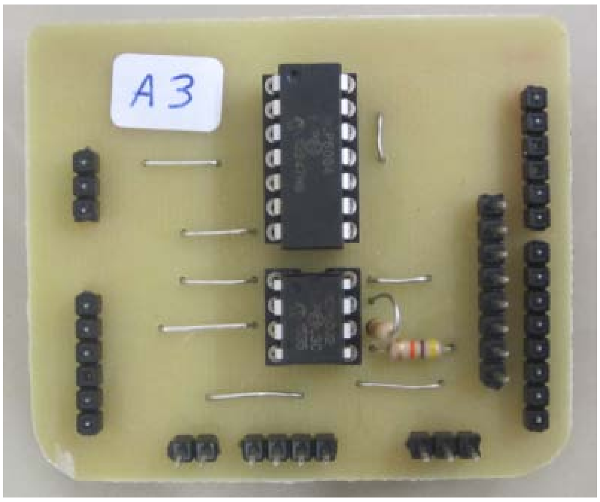
Power : Vdd and GND (2 pins for GND)
Analog output: DAC1 and DAC2
Analog input: ADC1, ADC2, ADC3 and ADC4
Digital I/O: DIO1 to DIO8 (8 lines)

Shield implementation

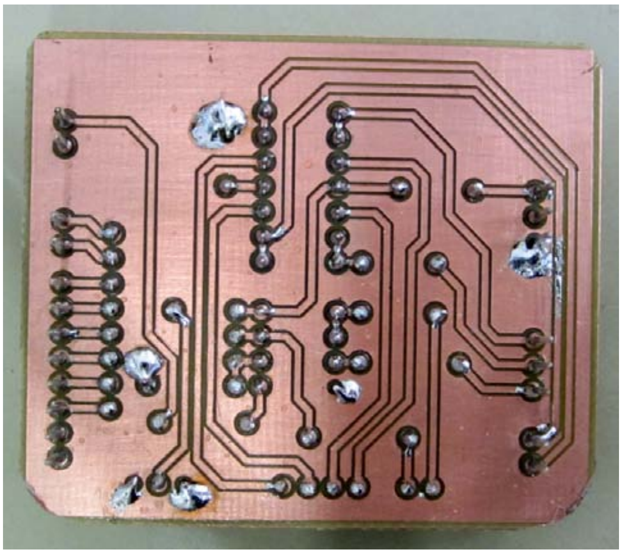
The shield can be implemented on an Arduino UNO compatible prototyping shield as seen on the following figure. Note that the board has been cut over D13 to reduce the board size and to prevent blocking the F303RE board push buttons.



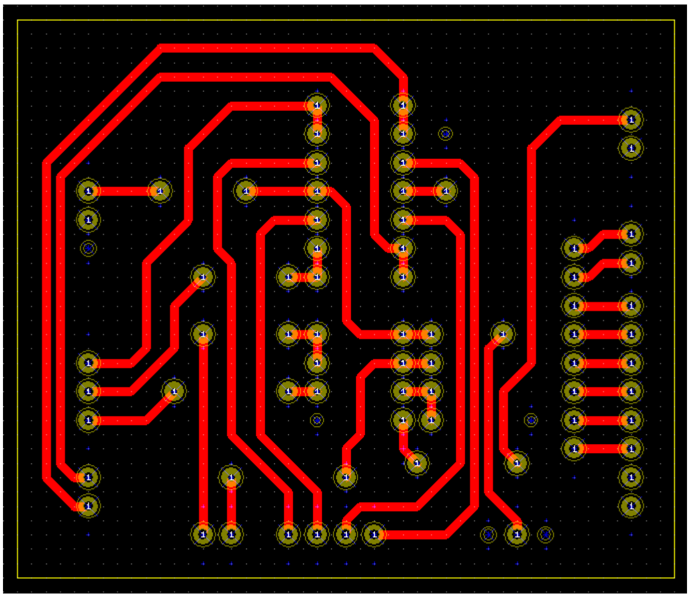
The shield can also be implemented on a custom PCB like the one seen below. In this case it is a single side board to ease its fabrication.



The solder side of the board can be seen on the following figure. Note the six connections to the ground plane. They would be better if using thermal relief pads but no design is perfect. Note also that, as this is a one layer design, the pins that connect to the F303RE board need to be soldered at the connecting side.



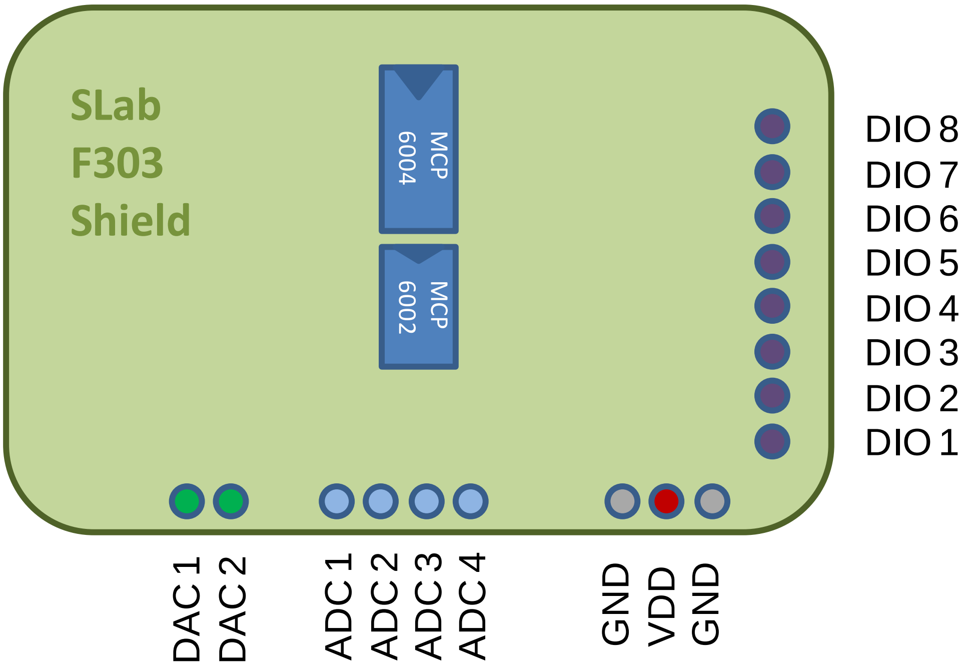
The following figure shows the routing of the custom PCB shield on a 50 mil grid.



This shield has been developed using KiCad and the design and Gerber files can be located on the "Hardware" folder of the SLab distribution. The board includes two hole sizes: 40 mil holes for the male pin connectors and 30 mil holes for the other components. The board has been fabricated by milling the track shapes so there is copper between tracks in the entire bottom board surface that acts as the ground node. This node is accessed at 6 drill holes. If you fabricate the board using other methods you would probably need to add the copper pour.
Note that, as the design is simple, it has been directly drawn on the Pcbnew editor without the usual step of drawing the schematic or generating the netlist.

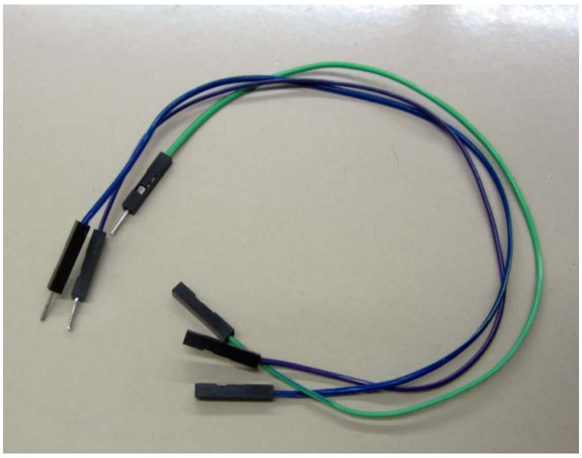
Shield pins

In any case, the layout of the board is always the same and features 17 male pins on the top side:

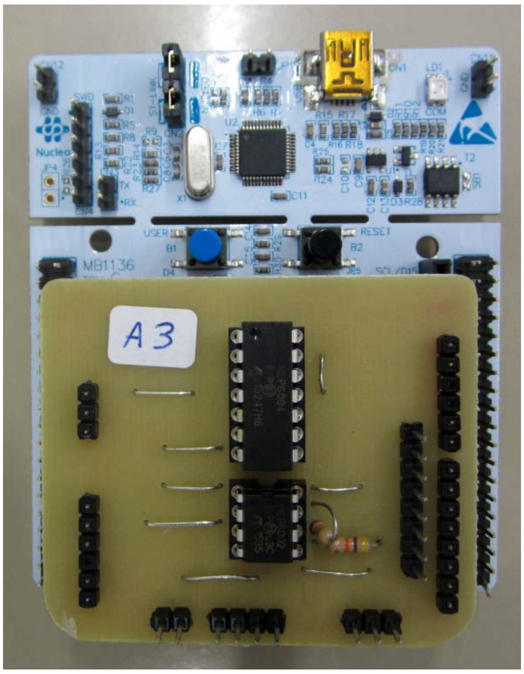


We have the two operational amplifier chips: Quad AO MCP6004 for the ADCs and dual AO MCP6002 for the DACs. All the board signals are on male pins.

The best way to interface the shield with a circuit under test is by using jumper wires with a female connector on the shield side and a male connector in the breadboard side.



The following figure shows the custom made PCB shield connected on top of a Nucleo F303RE board.



We will keep the red LED diode and its companion 470Ω resistor on the breadboard. That way we always know when the board is powered.

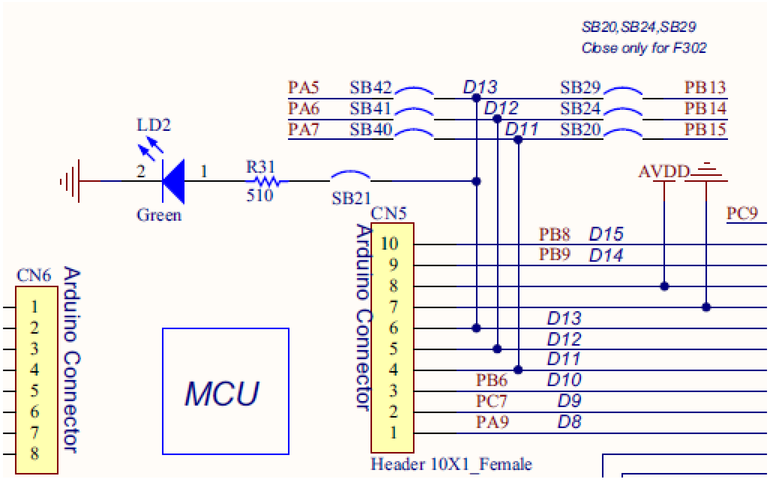
Remember that the system calibration depends both on the Nucleo Board and the Driver circuit. You will need to recalibrate is you modify any of them and that includes adding a new shield.

Improving DAC 2

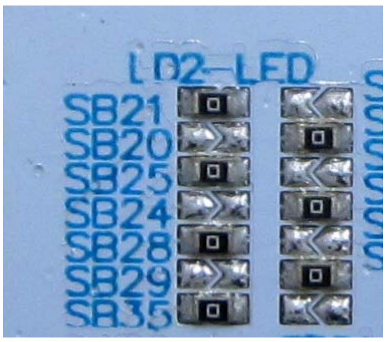
As explained before, DAC 2 driver uses a 2x gain amplifier to prevent turning ON the LED that is connected on D13 on the Nucleo Board. This solution gives us a full GND to Vdd range on the DAC 2 line at the price of a worse resolution when compared with DAC 1.

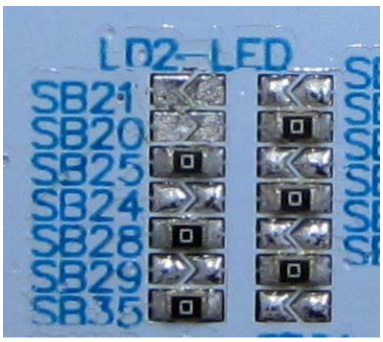
You can obtain a better DAC 2 response if you remove the connection between D13 and the user LED LD2 on the Nucleo Board. Fortunately, this board modification is straightforward thanks to the intensive use of solder bridges on the board. You need to deal, however, with desoldering a very small SMD component. If you are not sure to be capable to do the modification, don't try as you can ruin the Nucleo Board.

The following figure shows a section of the Nucleo board schematics. You can see that solder bridge SB21 connects the D13 line with the user LED LD2.



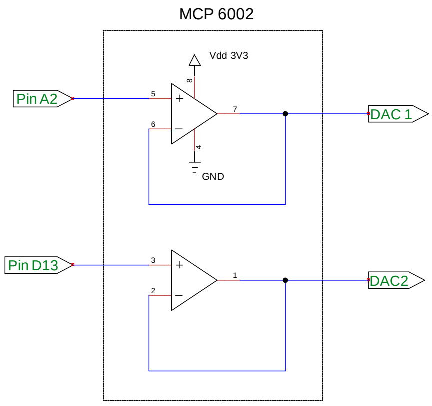
You can find SB21 at the back side of the Nucleo board as a SMD 0 Ω resistor. Just remove it from the board and all the problems associated to LD2 are gone. Obviously this solution makes also the LED inaccessible.



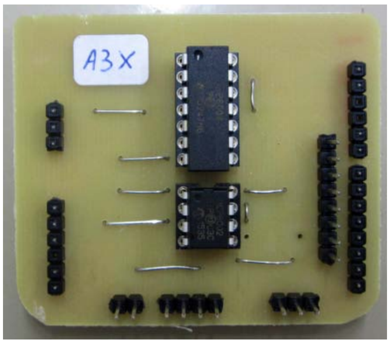


The above figures show the solder bridges. On the left we see the original board with SB21 soldered as a 0 Ω resistor. On the right we see the board with SB21 removed. Desoldering wick and flux have been used to remove all the solder from SB21. After desoldering, bridges have been cleaned with isopropyl alcohol.

With this modification you can use the same circuit for both DACS, as shown in the following schematic, and you don't need to use the 47 kΩ resistors on DAC2 anymore.



In the following figure we show the custom PCB shield board modified to use the new circuit. We call it the improved "X" version of the shield. Both 47 kΩ resistors have been removed, and the feedback one that was in vertical position, has been substituted by a jumper wire.



The modification invalidates the calibration so you will need to recalibrate the system.

References

SLab Python References

Those are the reference documents for the SLab Python modules. They describe the commands that can be carried out after importing each module.
They should be available in the **SLab/Doc** folder.

STM32 Nucleo Page

http://www.st.com/en/evaluation-tools/stm32-mcu-nucleo.html

TinyCad

https://sourceforge.net/projects/tinycad/
Circuit images on this document have been drawn using the free software TinyCad

KiCad

http://kicad-pcb.org/
The KiCad EDA Suite has been used to generate the Gerber files of the custom PCB shield.