

Initial setup for the CMS testboard BA120.3

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1 Visual inspection

The purpose of the visual inspection is to find obvious flaws in the assembly of the board. Since the printed circuit board (PCB) itself is known to be working, the components placed on it may still be mounted wrongly. The main considerations when inspecting the testboard is are

- any parts that look obviously wrong.
- the polarity of the electrolytic capacitors, because they tend to explode if they are connected in the wrong way.
- the orientation of the microchips, especially the FPGA and the ADCs, because they are expensive and difficult to replace.

The best way to do this is to compare the new testboard to one which is known to be working.

2 First electric test

When supplying power to the testboard for the first time one should use a laboratory power supply and connect the lab cables to the black and red sockets. The voltage must be set to 6 V and the current should be limited to 2 A. Before switching on the power, a multimeter should be connected to measure the core voltage of the FPGA. One can access this voltage near the output of the voltage regulator U2 (near the heat exchanger) where there is a little hole.

If one turns on the power and if nothing is wrong one should find 1.5 V for the FPGA core voltage, the power LED D1 should be on and the LEDs near the FPGA (D4-D7) should be dimly lit. It is normal that the two ADCs (IC12, IC16) will be warm. If one of the following conditions occur, power should be immediately disconnected:

- Explosion, smoke, fire
- Volatage of the FPGA core exceeds 1.6 V (the FPGA is probably dead then)
- The voltages measurable at X8 are different from -4 V (-5 V ?), 3.3 V, 5.0 V by more than 5 %

Measure the voltage of the oscillator IC1 (3.3 V), the ADCs IC12, IC16 (5.0 V). To measure the voltage at the FTDI USB interface socket X10, a 0Ω resistor (SMD 0603) should first be paced at J5 (board backside) where the track leads away from the socket. The volatage of 5 V should the be found on one of pins of the USB interface socket.

3 Programming test

To see whether the FPGA is programmable, a programming cable must be connected to the JTAG socket X13. Observe correct orientation of the connector. With the board under power and the programming cable connected to both testboard and computer the Altera Quartus II software should be started and the project for the firmware of the testboard opened and compiled. Using the programmer function of the software, the firmware can be downloaded into the RAM of the FPGA on the testboard. If everything goes well, there are

no error messages and upon completion of the programming cycle the 4 LEDs (D4-D7) are no longer dimly lit, but are off. With this test, it is not yet clear, whether the FPGA receives a clock or not.

After having successfully downloaded the firmware into RAM the NIOS II CPU is now running on the testboard. This is required to download the firmware and the software for the NIOS II CPU into the flash memory on the testboard. To do this the 'flash' script must be executed. The script consists of the following few lines:

```
#!/bin/bash

sof2flash --epcs --input=../../atb/atb.sof --output=atb.flash
elf2flash --epcs --after=atb.flash --input=../atb_expert/Release/atb_expert.elf --output=atb_expert.flash
nios2-flash-programmer --cable='USB-Blaster [USB-0]' --epcs --base=0x4000000 atb.flash
nios2-flash-programmer --cable='USB-Blaster [USB-0]' --epcs --base=0x4000000 --go atb_expert.flash
```

After loading the flash memory the program is running on the NIOS II CPU. This may show on the testboard by blinking LEDs (implementation dependent). If nothing happens, either the program does not implement any visible start sequence or the FPGA receives no clock.

4 USB test and NIOS II software test

First, the USB interface module has to be put into the socket X10 and a USB connection established to a computer. The computer should recognise the device only if the testboard is powered. If the board is recognised the psi46test software must be started. In the program execute the command `scan` to detect the testboard and receive its identification string. If this scan is successful it shows not only the identification string but also the firmware version and the testboard ID. This means that the software on the FPGA is running. One can then open the connection to the testboard by typing `open <idstring>`. After this type `welcome` to see the LEDs flashing (implementation dependent).

5 Digital and analog voltage

Still having a USB connection to the testboard one can type `pon` in psi46test to turn on digital and analog voltages which are meant to power modules. One can measure the voltage at J3 and J2.

6 Module test

To complete the test of the testboard one can attach a module adaptor board and a module to the testboard (while power is off). One can also attach a single ROC. With the psi46test program and an open connection to the testboard one can type `test 1` to make a basic test of the module/ROC. It returns 0 when successful. Jumpers must be placed on J2 and J3 to do this test.

7 Trimming

There are two supplies on a testboard to power the attached pixel module, one for analog and the other for digital voltage. The two supplies are identical and completely independent from each other. Each power supply can be adjusted in voltage and a current limit can be set using two DACs. Additionally voltage and current can be read back again through ADCs.

The voltage measurement is made using a simple voltage divider to accommodate the voltage range of the DAC. This voltage divider is made with 1 % precision resistors and has to be further adjusted for the DAC to read the correct value. The potentiometer R149 (R153) is used to adjust the voltage divider of the digital (analog) power supply.

The current measurement is made using a shunt resistor of 1 Ω and a differential amplifier. The measurement is then again made with a voltage divider that can be adjusted using the resistor R150 (R154) for the digital (analog) power supply. However, the differential amplifier has a small common mode gain which also needs to be adjusted. This is done using the resistor R148 (R152) for the digital (analog) power supply.

To adjust the power supplies the following steps have to be performed:

1. A 40-pin DIN connector must be attached to the testboard with leads to ground, digital, and analog voltage. For each of these contacts two leads must be attached, to be able to measure the voltage at the connector (without voltage drop in the cables).

2. Connect a multimeter to the digital (analog) voltage contact and ground contact.
3. Connect a dummy load of $x \Omega$ to the second lead of the digital (analog) voltage contact and ground contact.
4. Connect an ammeter in series with the dummy load.
5. Set a voltage of 2.5 V for the digital (analog) power supply using the software psi46test.
6. Read back the voltage using the software and compare it to the multimeter value.
7. Adjust the potentiometer R149 (R153) to get the correct reading in the software by repeatedly reading the voltage.
8. Set the voltage of 1.0 V for the digital (analog) power supply using the software psi46test.
9. Read back the value of the voltage using the software. The values should agree.
10. Reset the voltage to 2.5 V.
11. Disconnect the dummy load. Current should now be 0 A.
12. Read back the current using the software.
13. Adjust the potentiometer R148 (R152) to minimise the current reading. Because the current cannot be negative in this setup, the point has to be found where the read back current reaches the minimum.
14. Connect the dummy load.
15. Read back the current using the software and compare it to the reading from the ammeter.
16. Adjust the potentiometer R150 (R154) to read the correct current value by repeatedly reading the current at different adjustment settings.
17. Set the voltage to 1.0 V.
18. Check the current reading using the software and compare it to the reading from the ammeter.
19. If the current readings do not agree, iterate with R148 and R150 (R152 and R154) at different voltages to get the correct current reading.

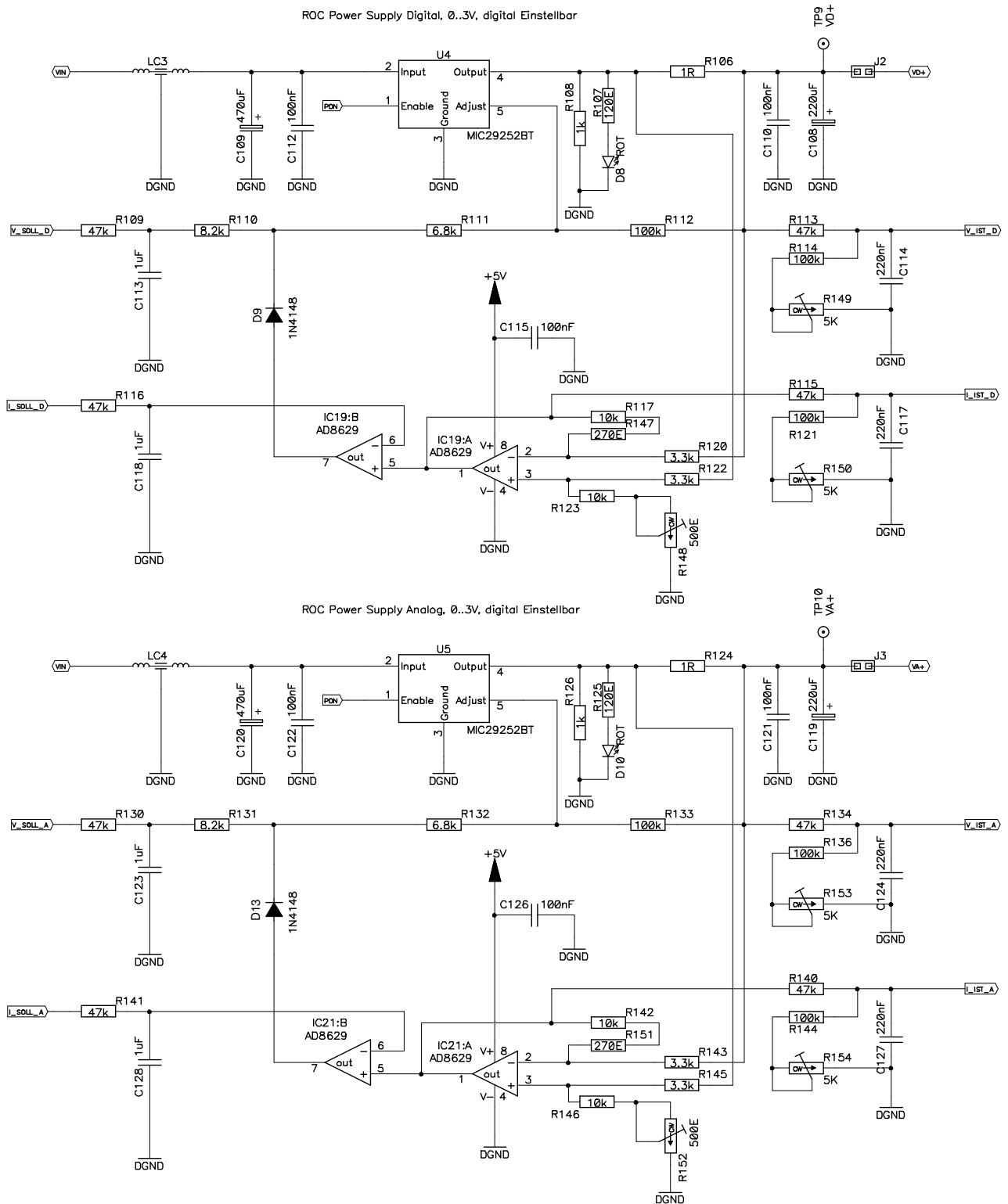


Figure 1: Schematic of the digital and analog power supplies for the pixel module in BA120.3. The potentiometers used for trimming are R148, R149, R150, R152, R153, R154.