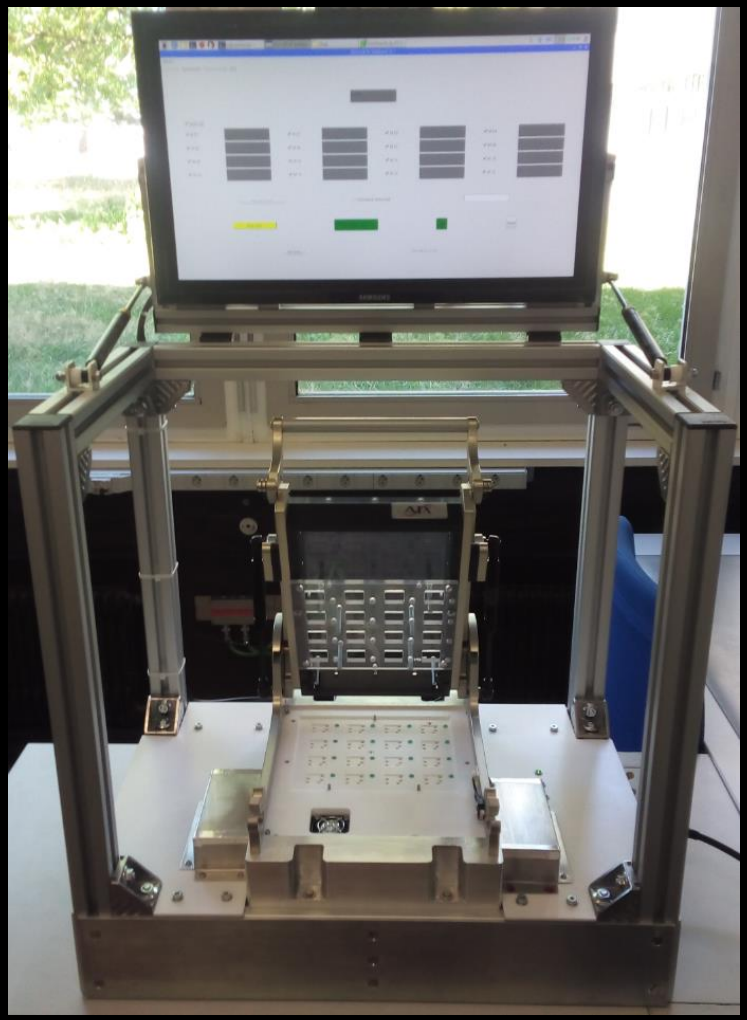

Automatic test bench for power supply modules
BI Seminar

CERN,
14th June 2019

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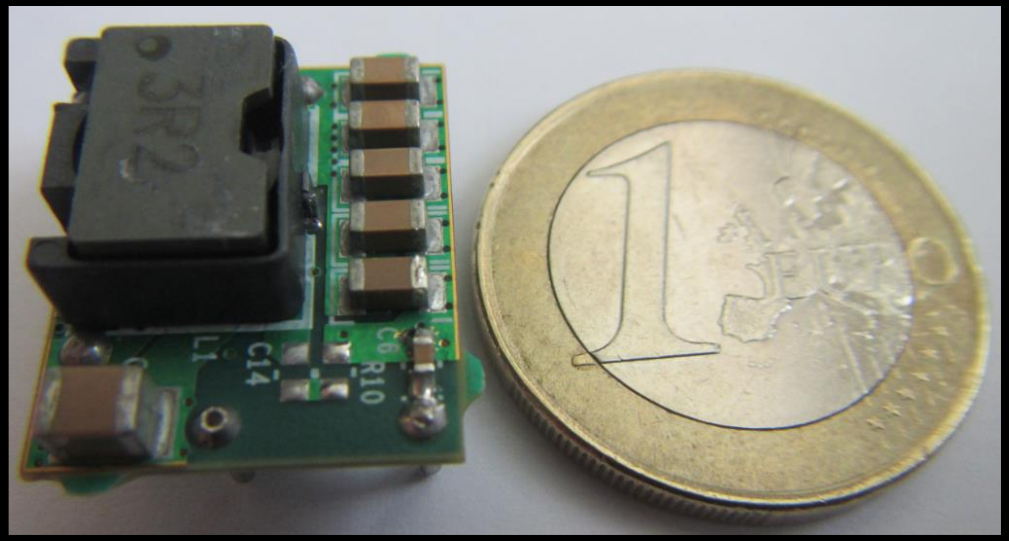
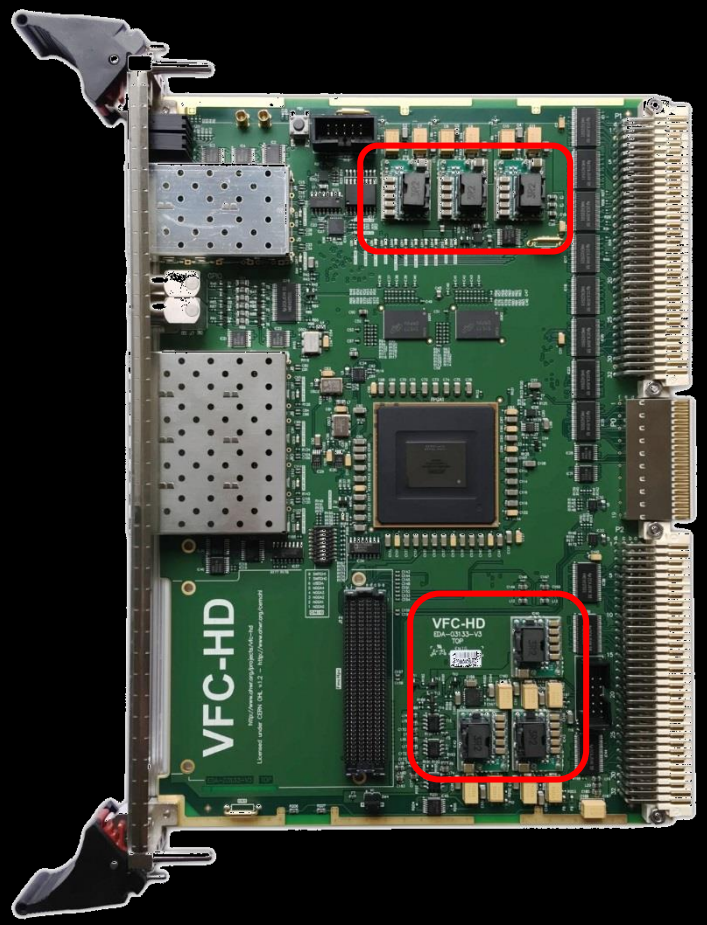
Power supply under test: **Hi-Rel DC/DC**

- Hi-Rel DC/DC converter module for electronic boards equipped with FPGA.
- Designed in according with the Military/Aerospace derating rules.
- Designed for long life requirements.

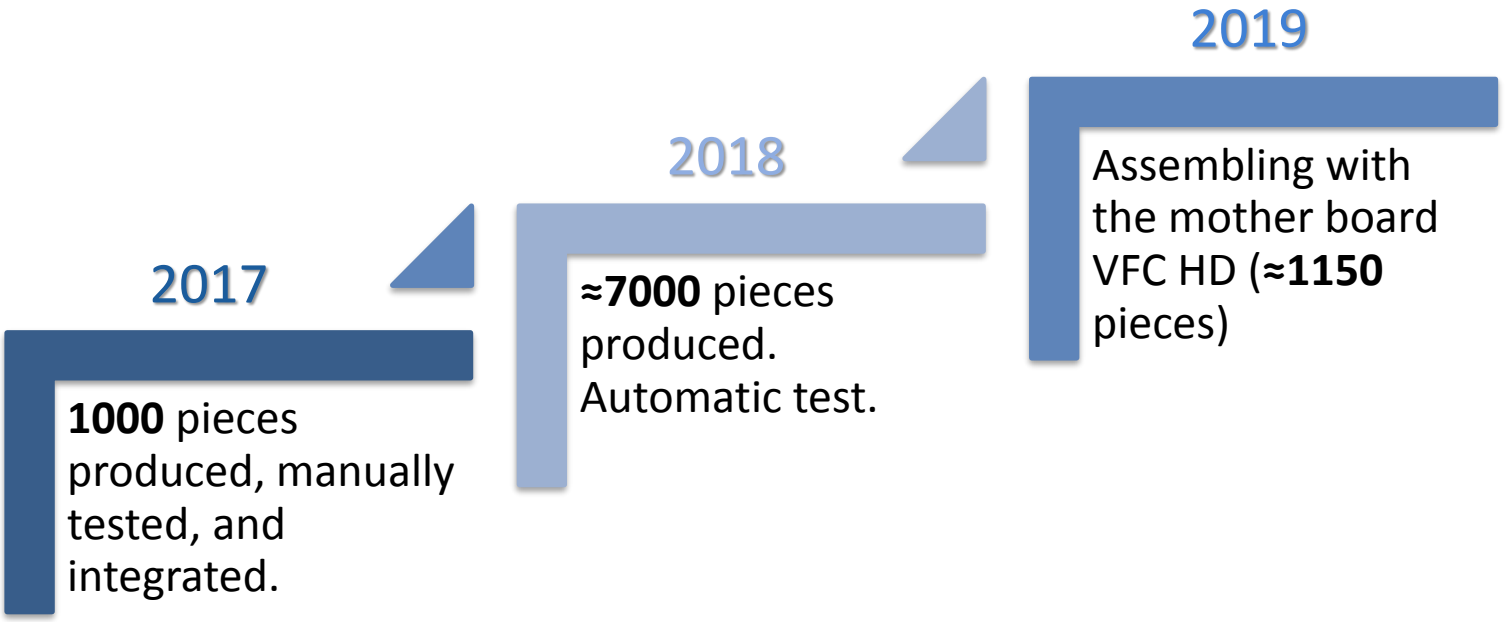


EDMS number: EDA-02878-V3-1

- Used on the VFC HD board
- 6 modules for each board



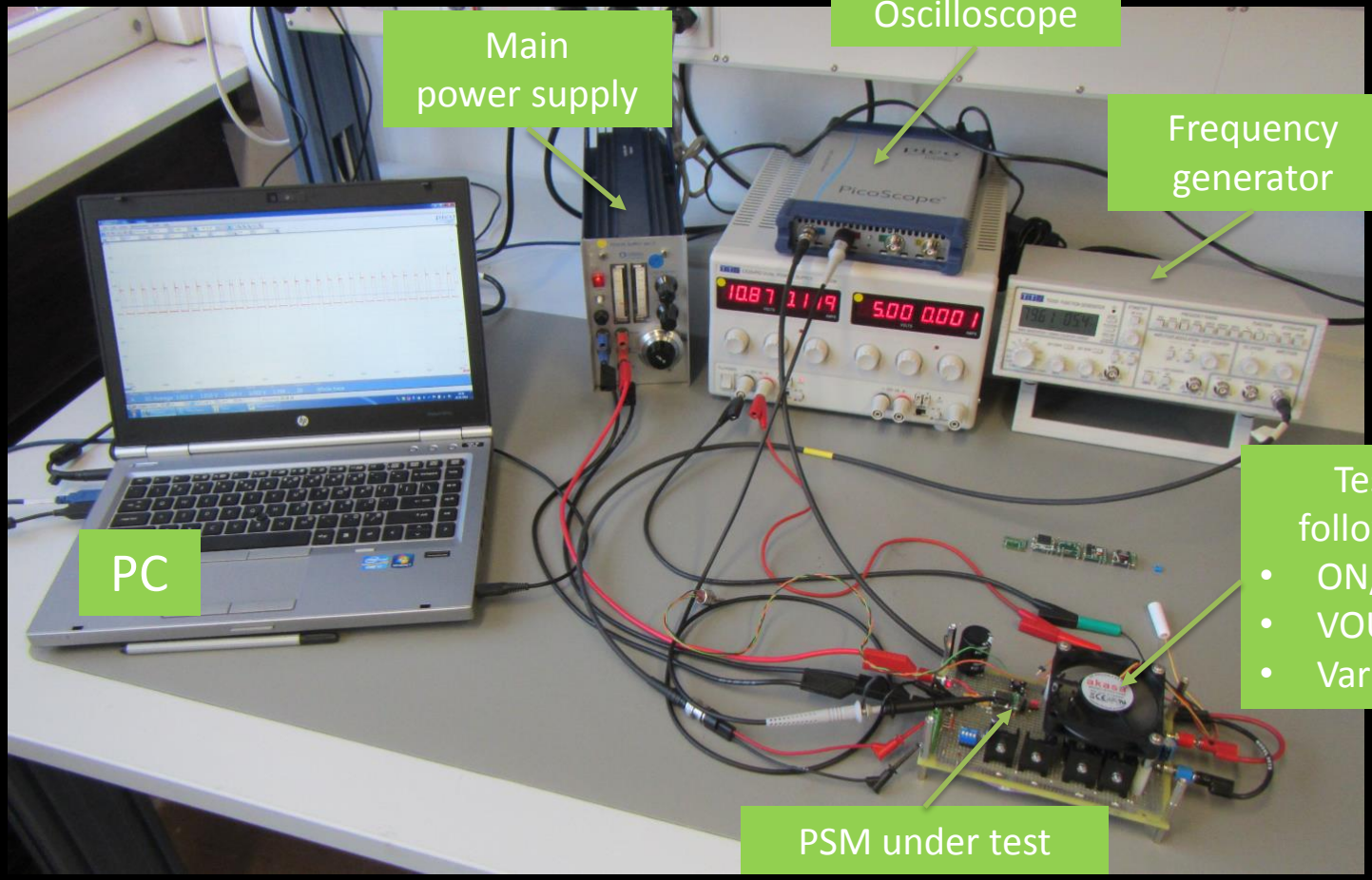
Production history



- The same company which produced the VFC HD also produced the Power Supply Module (PSM).
- Before the integration onto the VFC HD it was mandatory to test each module to prevent failure of the complete board.
- The test was executed at the manufacturing company.

Manual test equipment

- The first 1000 pieces have been manually tested one by one in the laboratory by means of a simple test bench.



Reasons for an automatic test

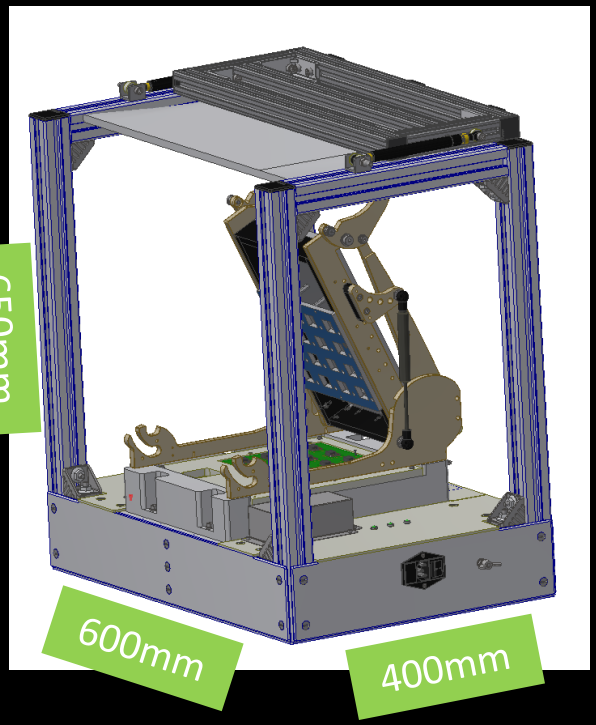
- The manual test bench requires about 5 min (best case) to test a PSM, which includes:
  Picking-up the PSM -> Plugging in the socket pins -> Running the test -> Writing the report -> Unplugging the PSM -> Storing the PSM -> coffee breaks…

- Performing the manual test on 7000 PSM would take a minimum of 583 working hours. With a working hour cost of about 52CHF/h, a manual test would cost at least **30K CHF**.

- In addition, performing a manual test has the following disadvantages:
  - Difficult to track faults because the PSM are too small to be equipped with a bar code (the panel is equipped with bar code).
  - Mechanical damage.
  - Quality of the data logging depends on the operator.
  - Difficulties in the post fault analysis.
  - ESD issues.

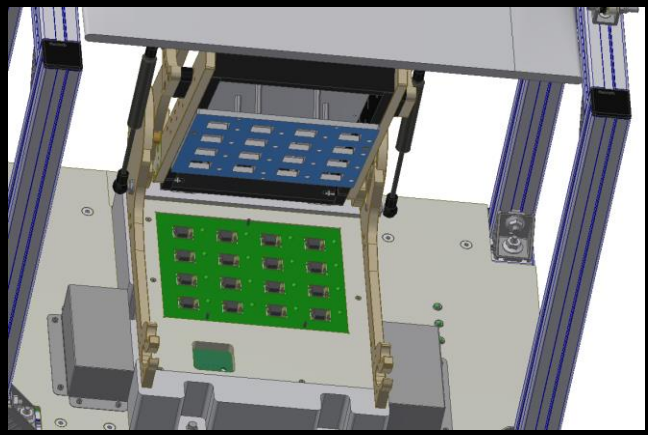
Strategic decisions for the automatic test

1. The test equipment should be portable, robust, easy to transport and use.
2. The human interface should be simple and quick to use.
3. Short test duration.
4. The test equipment must be able to test a complete PCB panel with several PSM.
5. A pre Burn-In has to be executed by stressing each PSM with high current output.
6. A test report should be automatically created and saved on the test bench, and sent to CERN after the manufacturing.

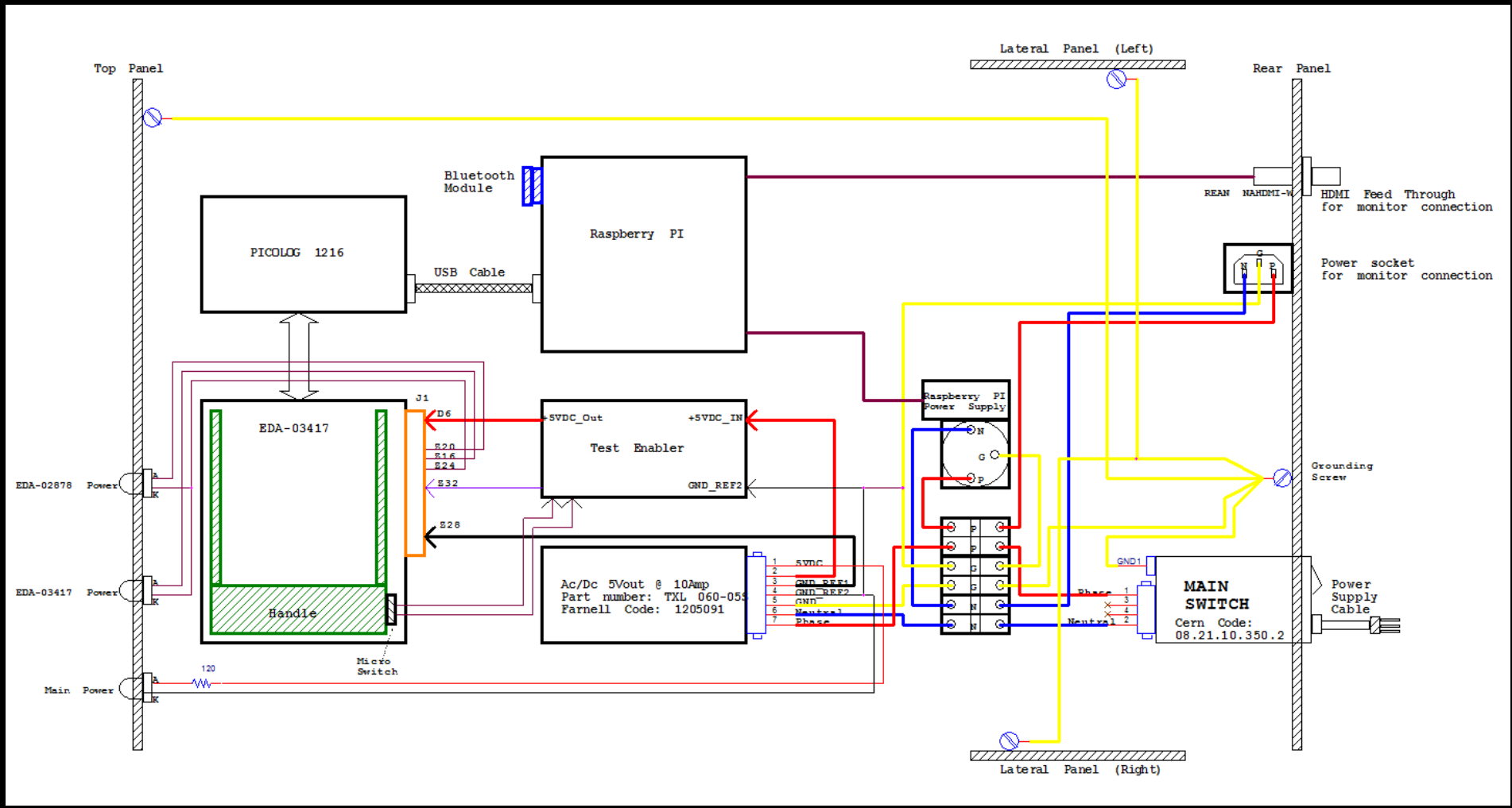


Implemented solutions for the automatic test

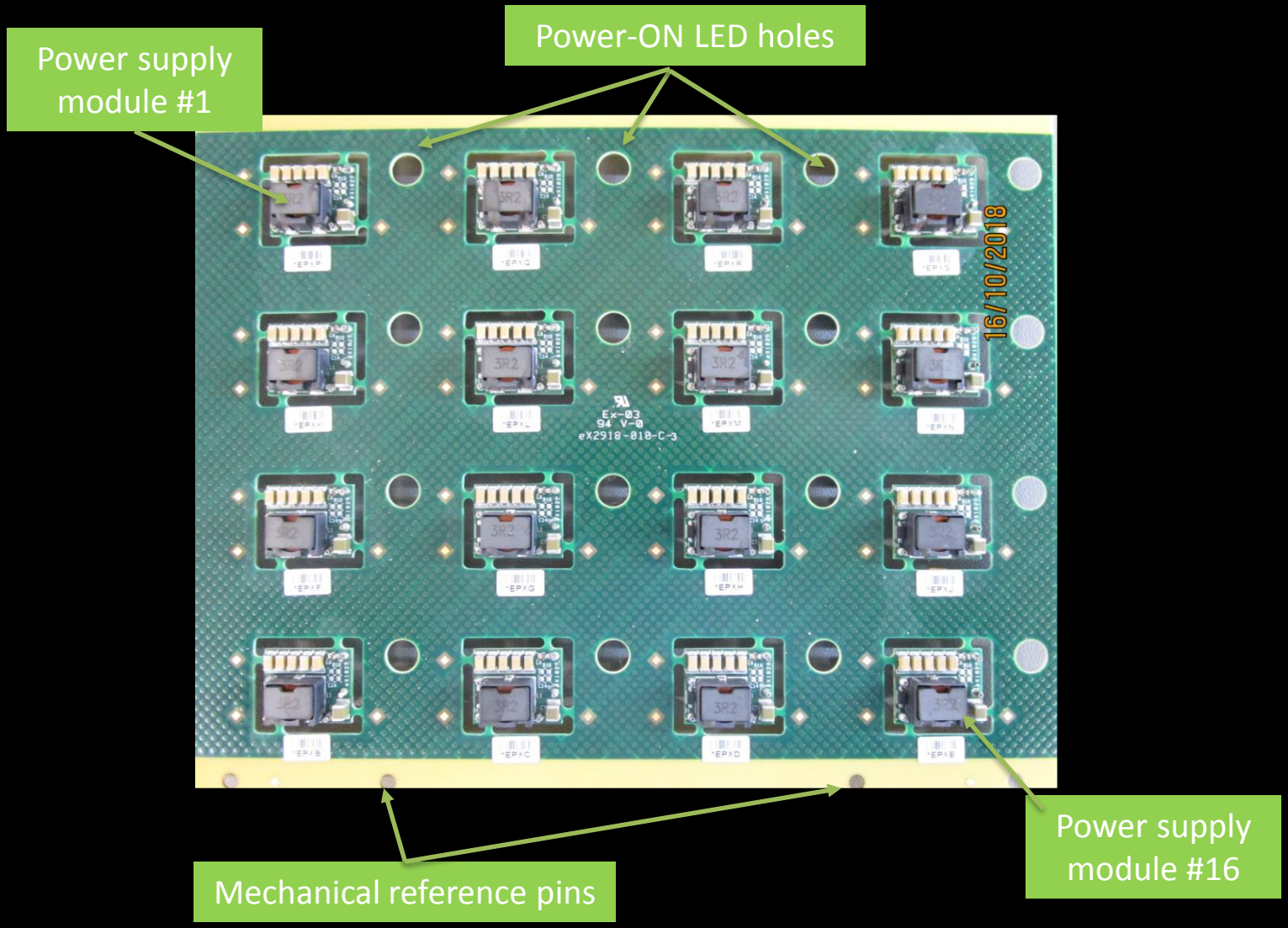
1. To ensure the best mechanical compatibility, the test equipment was design in parallel with the PCB.
2. To simplify operation of the test equipment a single switch is used to power-on the system.
3. The test is automatically activated when the operator pull down the “handle”.
4. A panel of 16 PSMs requires 3 seconds to be tested.
5. Each PSM is tested sequentially.
6. Test results are download over a Wi-Fi connection.
7. Mechanical frame built with Bosch-Rexroth profiles.



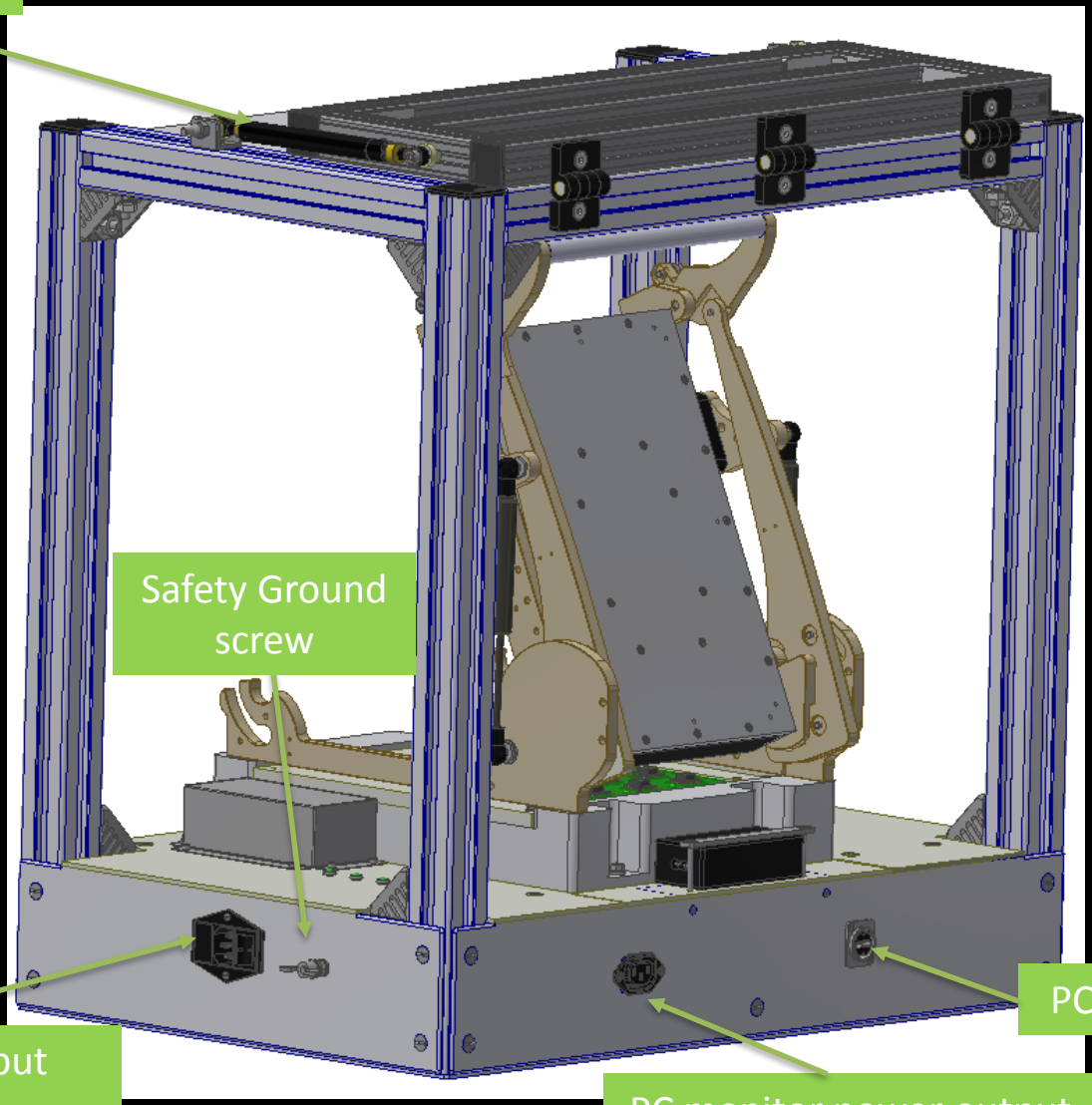
Automatic test bench - block diagram



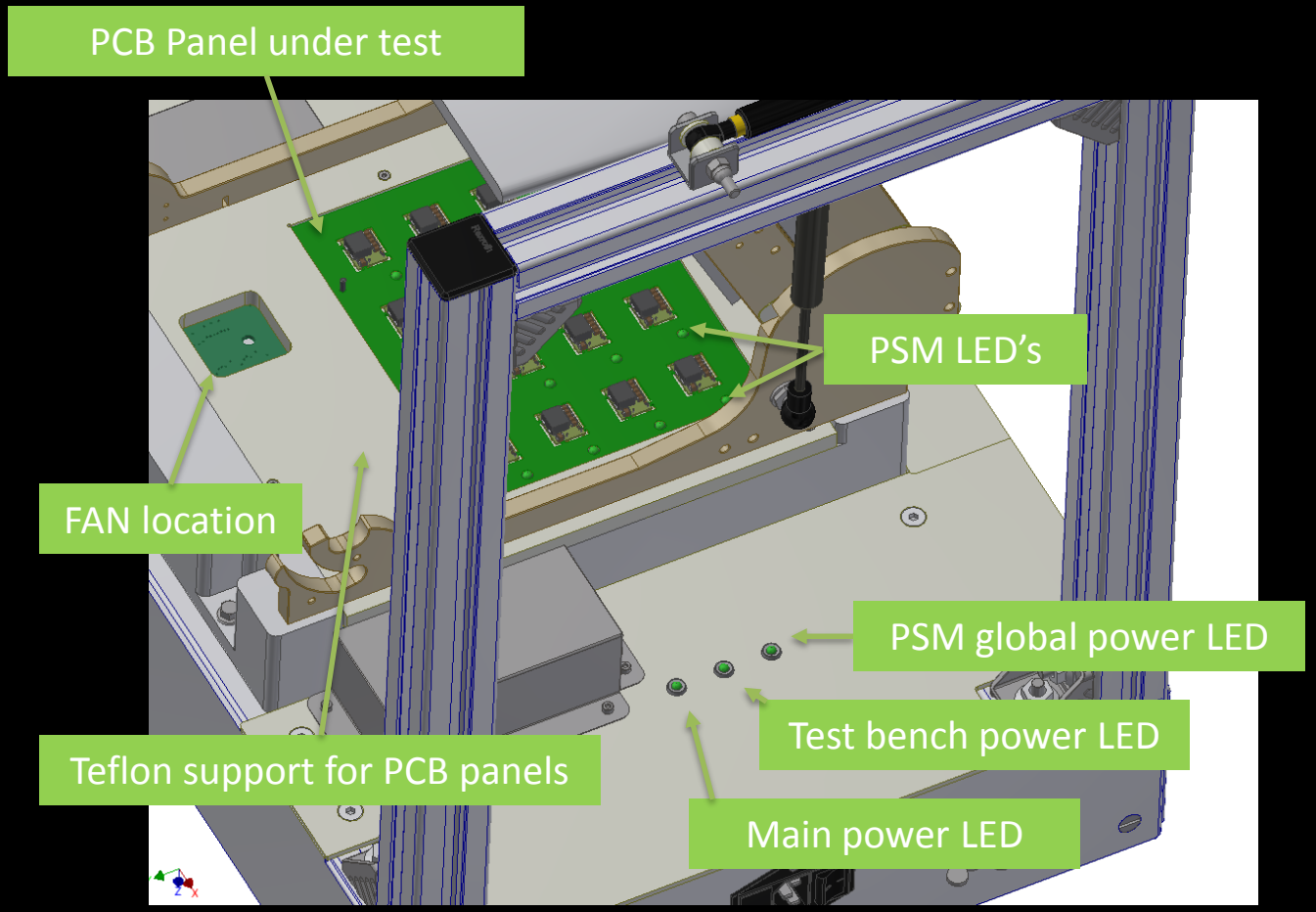
PCB paneling



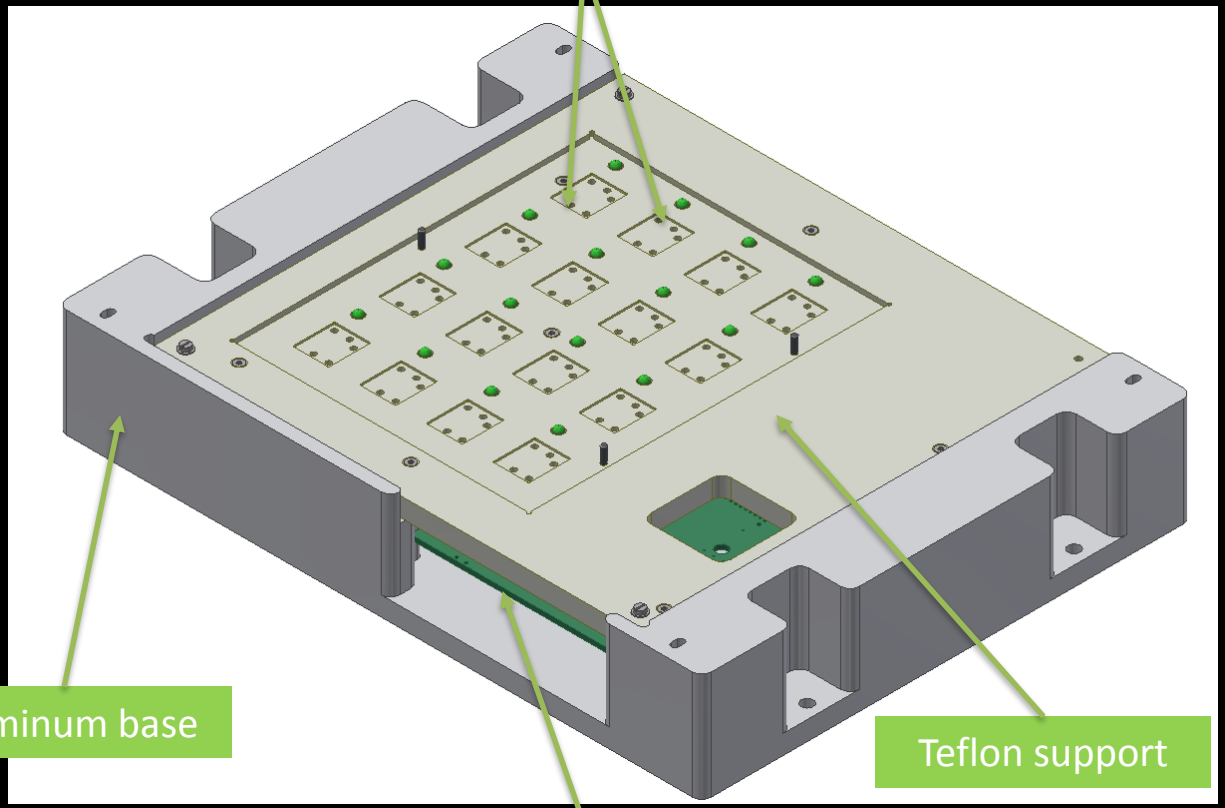
Test equipment overview



Test equipment overview

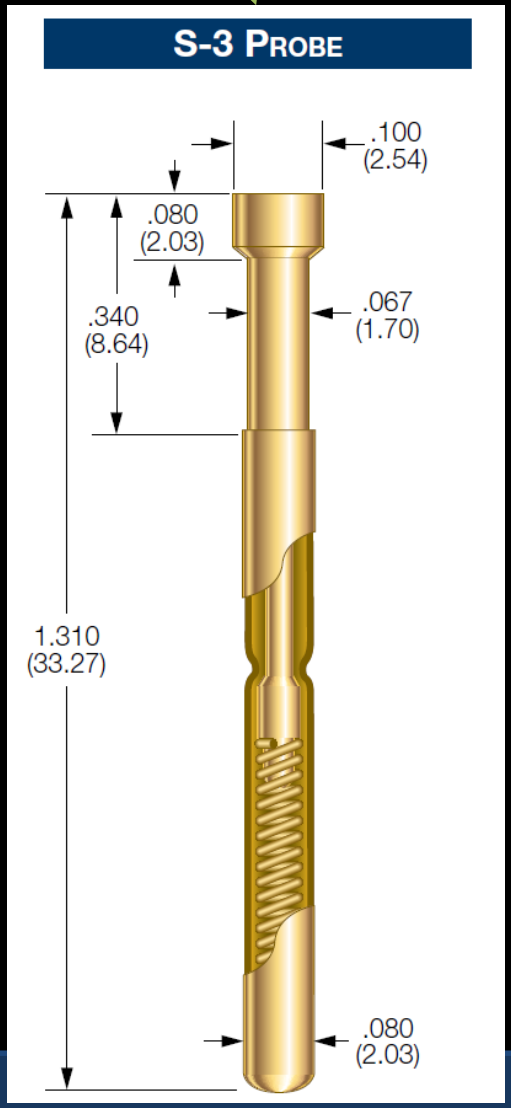


PCB panel interface



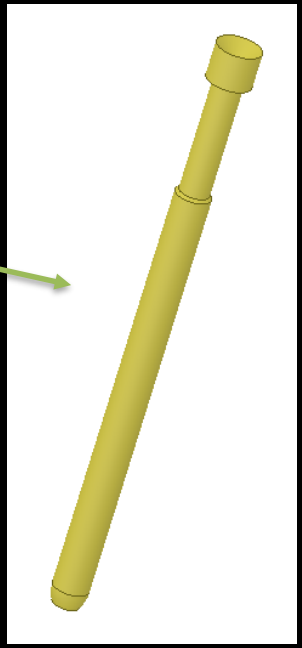
Contact pins

Spring loaded pin

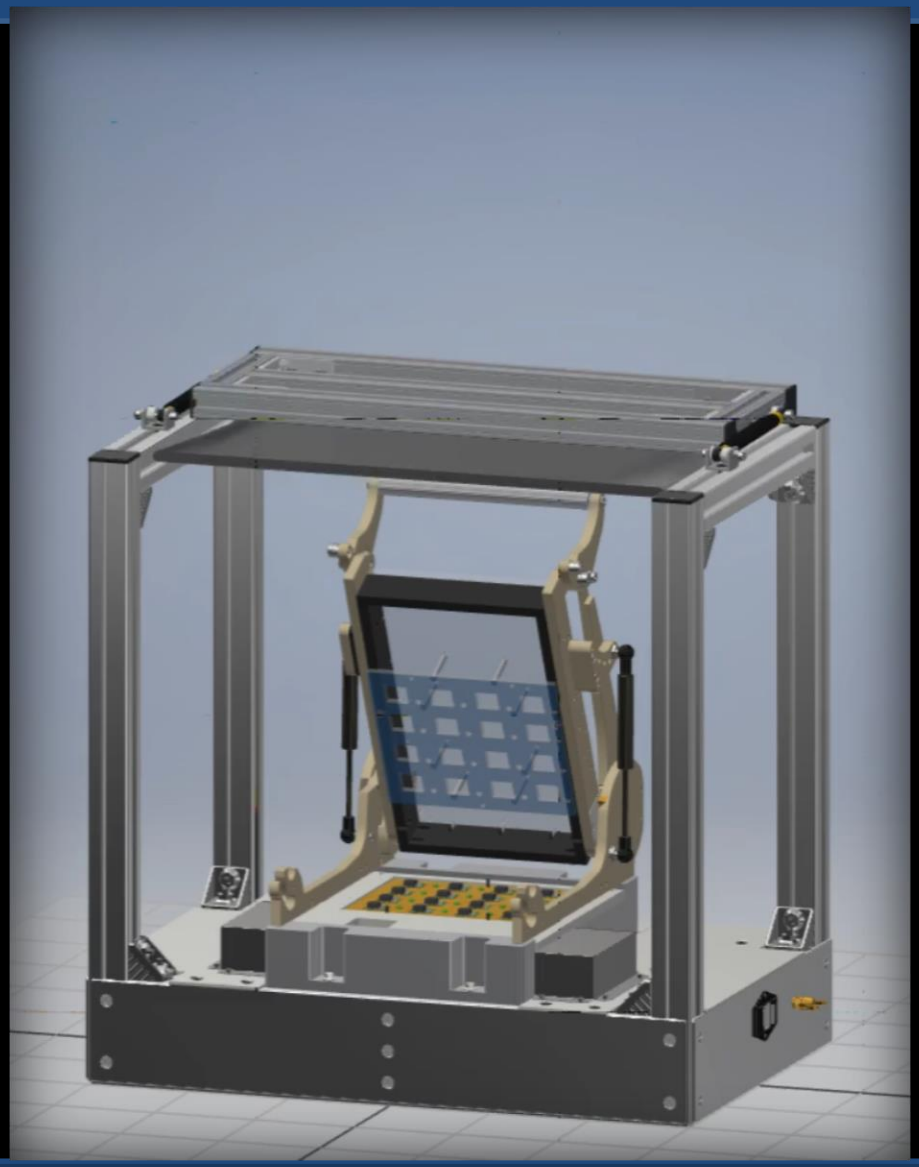


Manufacturer:	IDI
Part number:	S-3-A-4-G
Current Rating:	5 amps continuous
Spring Force:	4.0 @ 4.32mm travel
Typical Resistance:	< 20 mΩ
Maximum Travel:	6.35mm
Working Travel:	4.32mm

3D model



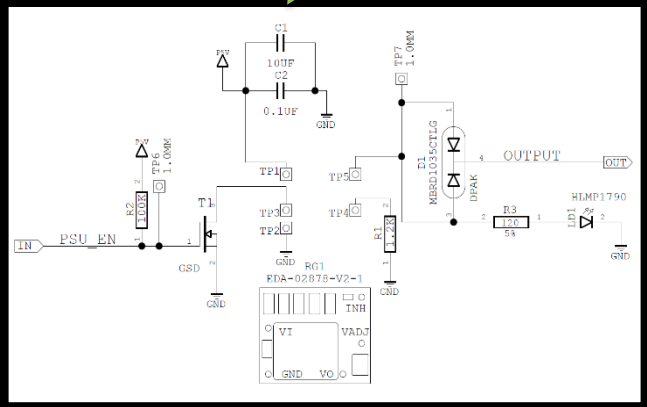
Test bench 3D functionality



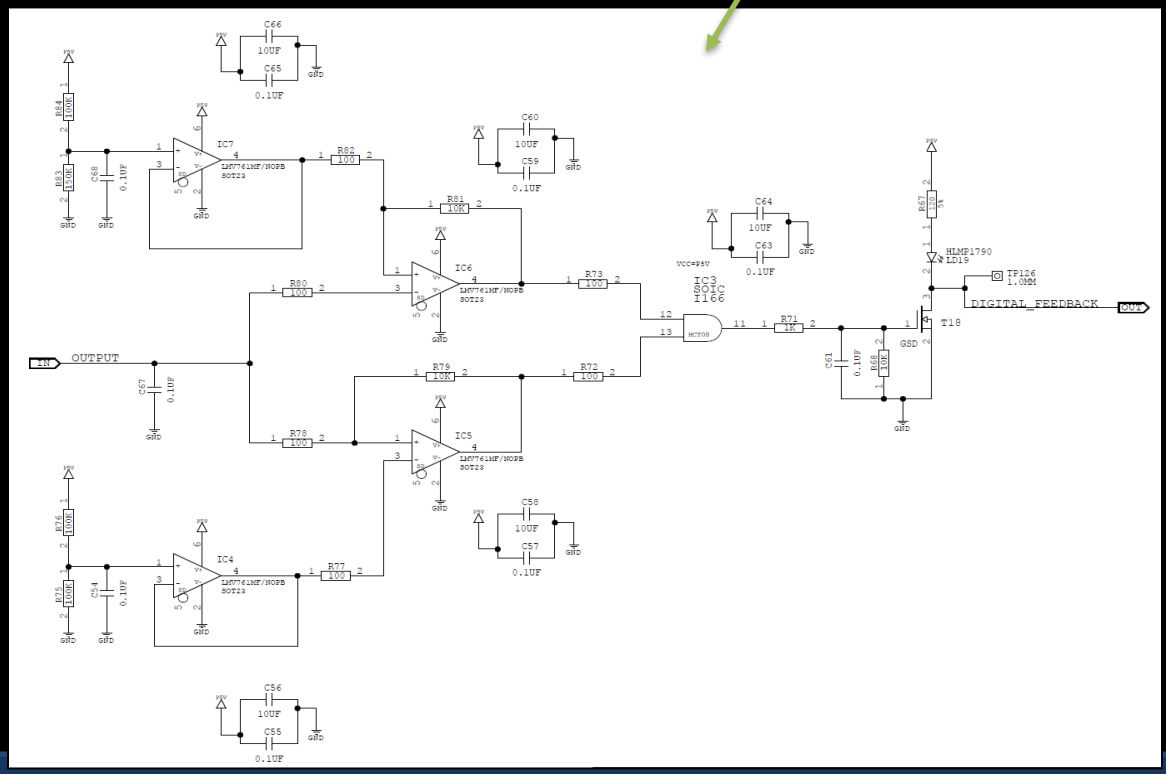
Acceptance test criteria

- The output voltage of the PSMs (settable with an external resistor) was set to 3.3V, and all PSM's connected by an OR diode circuitry on the load.
- The PSM output voltage has been checked against an analog comparator where thresholds were set between 2.4V and 3.2V

PSM connections

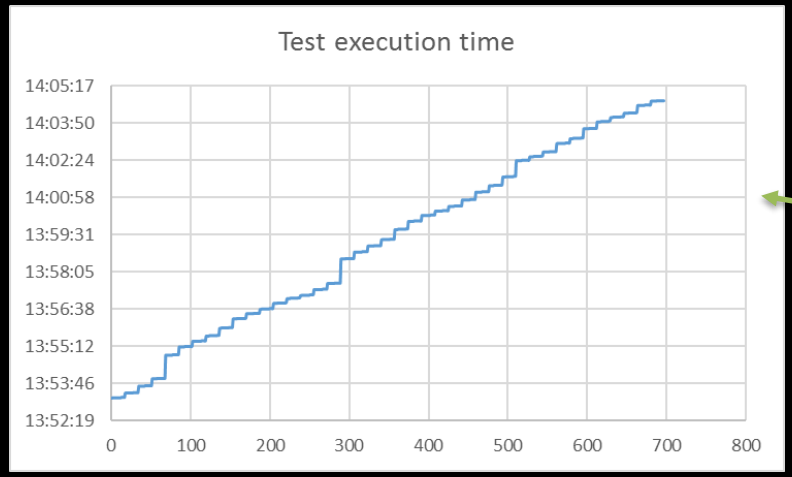


Analog comparator



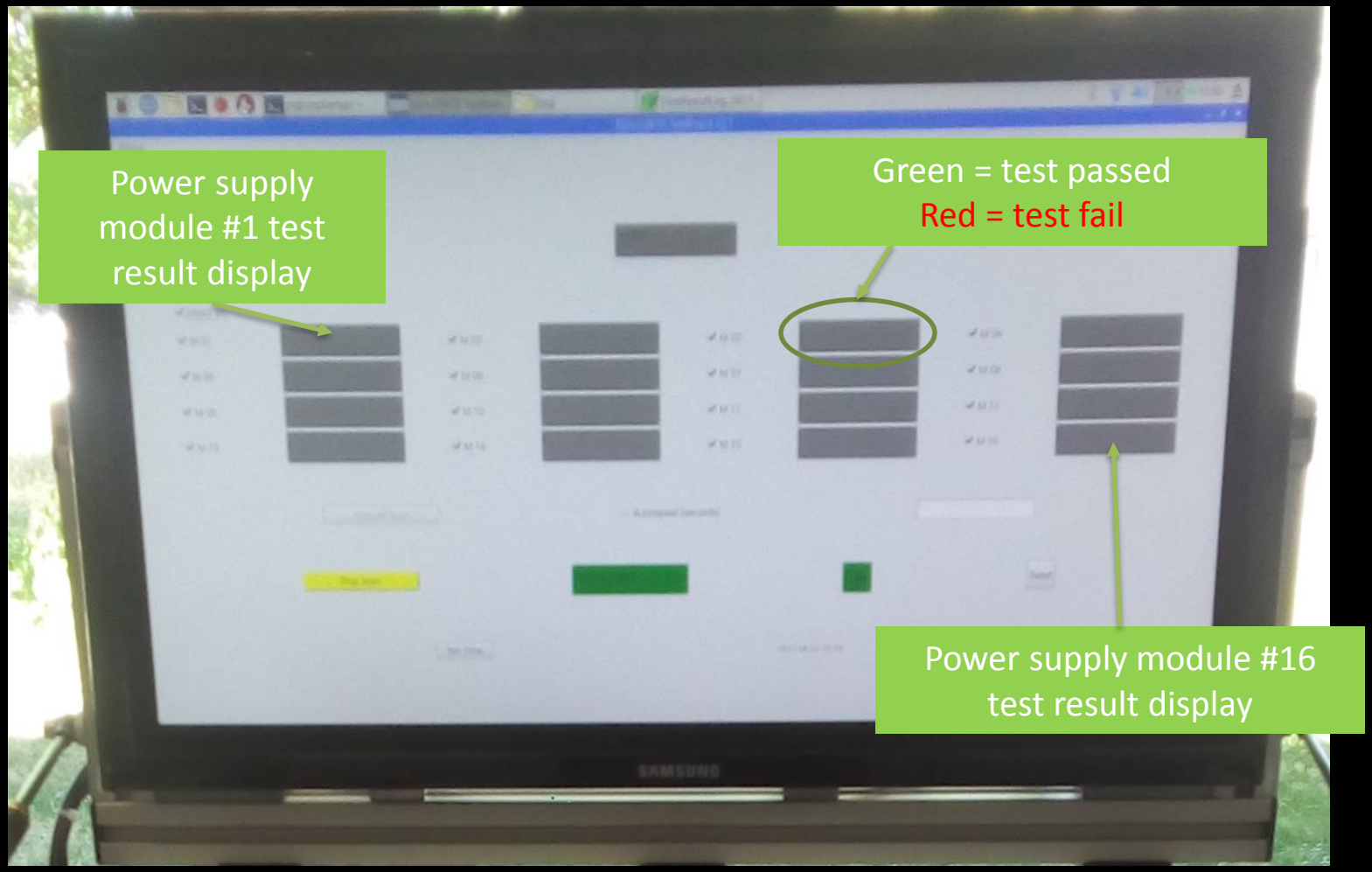
Test results

- 6944 PSMs produced by Norcott (UK) equal to 434 PCB panels.
- The test equipment has been delivered to Norcott with a sample PCB panels to verify the functionality.
- Including operator pauses and PCB panel swapping, the average test time has been = 17 sec per panel.



Plot extracted by the test equipment logging data

Test result display



- Additional manual settings were possible through the SW application.

Automatic test experience

- In total 16 x 5 = 80 spring loaded pins with high current flow had to be in perfect contact to allow the execution of the test.

- Due to the criticality of the contact between the PSM and the test pins, in case of test failure, the test had to be repeated 3 times to be sure it was a real fault or a false negative.

  - Theoretical time for testing 6944 PSM (434 PCB panels) = 2h04m
  - Real time spent for testing = 13h03m

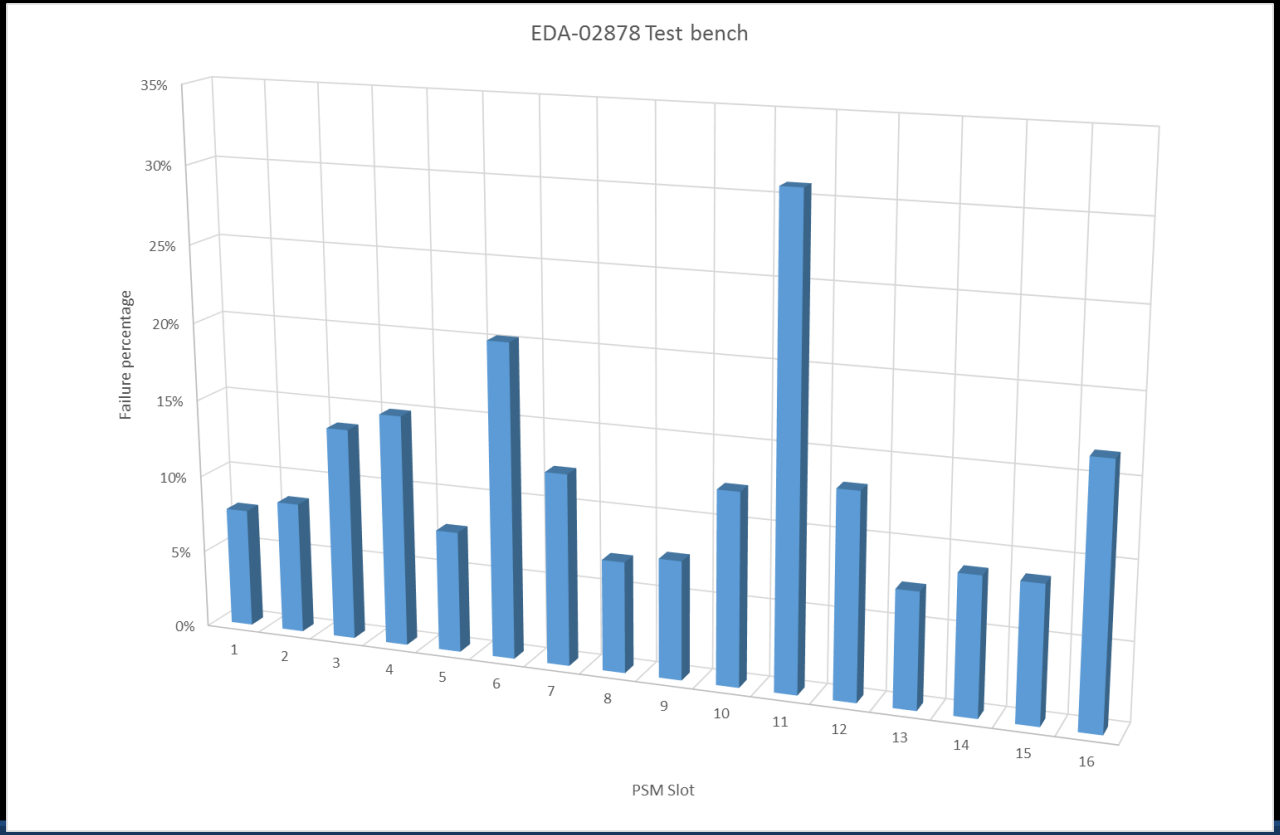
- The main cause for the difference between the theoretical testing time and the real testing time was the repetition of the test on each panel due to the false contact between the PSM and the spring loaded pins, or due to delays caused by operators.

- All “handle” actions have been recorded.

Test results (1/2)

- An analysis of the logging data allowed to identify PSM test slots “false negatives” in the test bench.
- Corrective actions to correct the test bench slots where taken by the manufacturing company after receiving our instructions.

Slot	Number of slot failures	Failure percentage per slot
1	205	8%
2	227	8%
3	367	14%
4	400	15%
5	209	8%
6	542	20%
7	330	12%
8	191	7%
9	204	8%
10	331	12%
11	825	31%
12	353	13%
13	199	7%
14	237	9%
15	235	9%
16	444	17%



Test results (2/2)

- Power supply false negative rate: 12%.
- N. of power supplies with real failures identified by the test equipment: 1 piece.
- Other faults detected by the manufacturer with SMT camera:

ID	N. of Fails	Fault reason
IC1	38	Insufficient solder
D1	11	Misaligned or missing component
L1	10	Insufficient solder or misaligned component
C4	7	Insufficient solder
C7	7	Insufficient solder
C1	6	Insufficient solder
C2	6	Insufficient solder
C3	6	Insufficient solder
C5	6	Insufficient solder
C10	5	Insufficient solder
C6	4	Misaligned component
C12	3	PCB resist/epoxy repair
R1	3	Flipped component
R3	2	Flipped component
BD1	1	Misaligned component
R6	1	Misaligned component
T1	1	Damaged component
T2	1	PCB resist/epoxy repair

Report received by the manufacturing company about the SMT camera fault detection

Conclusions –> Good practice

- It is always useful to evaluate the benefits of an automatic test bench installed directly at the manufacturing company.
- During the design of electronic units which are intended for mass production it should be mandatory to consider the effect of all component tolerances on the overall product reliability.
- Component footprints and PCB layout design should always be designed in accordance with rules (e.g. IPC-610 class 3 for manufacturing).

Conclusions -> Benefits of test benches

- In case study presented – 7000 x PSM for VFC HD – the verification and check setup at the manufacturing company + the test bench ensured zero faults after the integration of the PSM's on the VFC HD board.

- The presence of the test bench at the manufacturing company had a "psychological" effect to improve the quality of the production before the test. The company was not authorized to mount PSMs or deliver VFC HD boards if they were not passing our test benches.

Thank you for your attention!

William & Volker