# The ELMB128 2002 production

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## *1.0 Introduction*

The production of the ELMB128 was done during November 2002 by the firm FUTURCOM SRL, Bologna, Italy on a contract negotiated by the CERN EST-DEM group. Two versions were made. One complete with a 16-bit ADC with 64 differential inputs ELMB128-A [1] and one simplified version called ELMB128-D [2] without the ADC. The cards were tested as part of the manufacturing process with an automatic ELMB128 test system [3] controlled by special developed test software [4] running on a PC supplied by CERN. The tests consisted of readout of the serial number (bar code) of the card, DC measurements, the programming of the microcontroller ATMEGA128L and the calibration of the on-board ADC for the ELMB128-A. The test program decided if a card a passed the test or not. The result of the test was written on the hard disk of the PC for each card. Different formats were used for failed respectively good cards. Also the number of times a card has been tested was indicated in the file name. It is therefore possible to analyse in detail the production of the ELMB128 and draw conclusion for the future productions.

## *2.0 DC measurements*

### 2.1 ELMB128-A

Measurements were made on the following critical voltages of the ELMB128-A. The total number of devices tested was 471.

Table 1 Voltage reference and power supply regulators

| Function | Device | Mean value (V) | Stdev (V) | Stdev (%) |
|---|---|---|---|---|
| Vref | AD680JR | 2.490 | 0.002 | 0.07 |
| 3.3V DIG | MIC5203-3.3BM4 | 3.284 | 0.013 | 0.40 |
| 5VA NEG | MAX871EUK | -4.957 | 0.020 | 0.40 |
| 5VA POS | MIC5203-5BM4 | 4.968 | 0.020 | 0.40 |
| 5V CAN | MIC5203-5BM4 | 4.986 | 0.023 | 0.46 |

Table 2 Power supply currents of the ELMB128-A

| Function | Mean value (mA) | Stdev (mA) | Stdev (%) |
|---|---|---|---|
| Analog current | 10.55 | 0.11 | 1.03 |
| Digital current | 12.56 | 0.21 | 1.69 |
| CAN current | 19.32 | 0.25 | 1.32 |

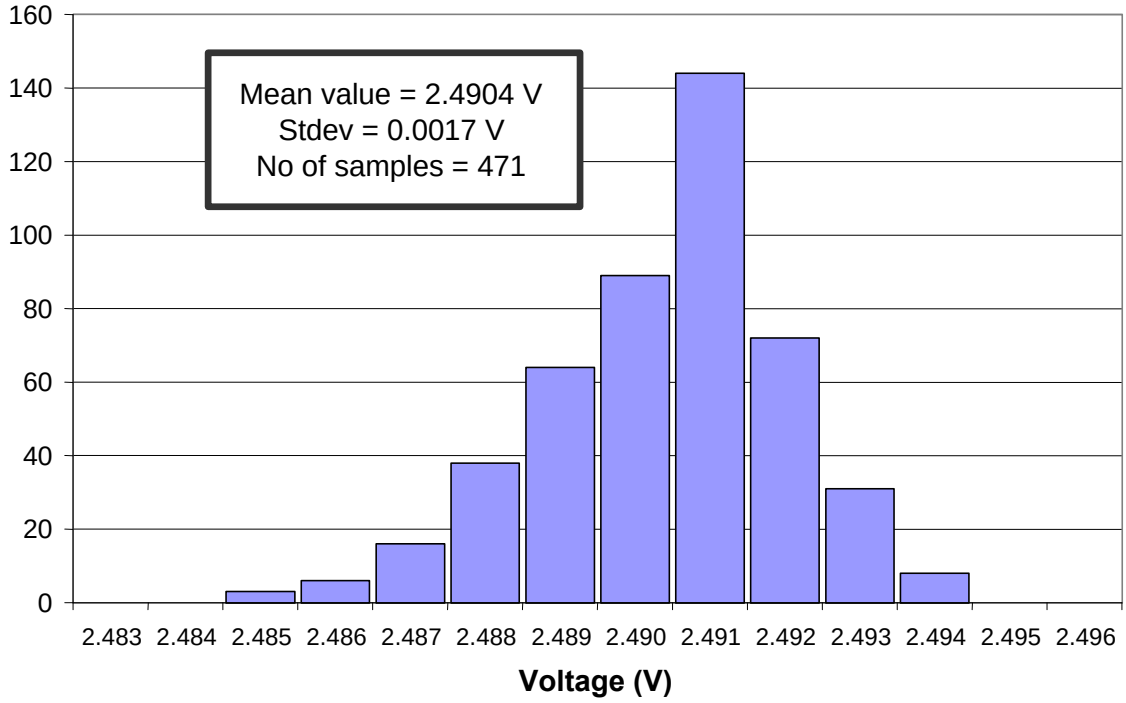


Figure 1 Result of the production test of the voltage reference Analog Devices AD680JR

## 2.2 ELMB128-D

Measurements were made on the following critical voltages of the ELMB128-D. The total number of devices tested was 186.

Table 3 Voltage regulators

| Function | Device | Mean value (V) | Stdev (V) | Stdev (%) |
|---|---|---|---|---|
| Digital 3.3V | MIC5203-3.3BM4 | 3.285 | 0.013 | 0.40 |
| CAN 5V | MIC5203-5BM4 | 4.988 | 0.020 | 0.40 |

Table 4 Power supply currents

| Function | Mean value (mA) | Stdev (mA) | Stdev (%) |
|---|---|---|---|
| Digital current | 12.033 | 0.219 | 1.82 |
| CAN current | 19.321 | 0.216 | 1.12 |

The standard deviations shown in Table 1 to 4 are much better than what could be expected from the data sheet of the manufactures. The MICREL MIC5203 has a specified output voltage accuracy of ±3% and ANALOG DEVICES AD680JR ±0.4%. All the semiconductor components for the ELMB128 2002 production were specified and purchased as devices from the same manufacturing lot.

### *2.0 Calibration of the ELMB128-A*

The 16-bit ADC of the Crystal Semiconductor type CS5523 used on the ELMB128-A can be calibrated using the built-in circuitry of the CS5523. The ELMBio v4.1 embedded software [4] developed specially for the present ELMB128 production support this feature. The test box used for the production of the ELMB128-A contains an ADC test circuit. This is used for the calibration of the 6 gain ranges of the CS5523. The test software stores the calibration constants in the EEPROM of the ELMB128-A. The embedded software will always use these gain factors stored in EEPROM, whether the read-out is in volts or ADC-counts.
The aim of the production calibration was to perform the calibration in less than 30 sec and with a precision of about 0.1%. The precision is limited by the hardware of the present test box. Table 5 shows the average values of the gain as measured in the test box during the production of the ELMB128-A. The number of samples is 471.

Table 5 Gain of the different ADC ranges before calibration

| Range | Average Gain | Stdev in % | Est. Absolute Error in % |
|---|---|---|---|
| 25 mV | 0.995 | 0.85 | -0.47 |
| 55 mV | 1.043 | 1.54 | 4.34 |
| 100 mV | 1.005 | 0.57 | 0.52 |
| 1 V | 0.985 | 0.36 | -1.52 |
| 2.5 V | 0.998 | 0.098 | -0.19 |
| 5 V | 0.841 | 0.97 | -15.9 |

As be seen from Table 5 the best range of the ADC is the 2.5V because this uses the external voltage reference as full-scale voltage. The absolute gain error of the 5V range before calibration is about -16 % due to the inherent design of the CS5525. This will be improved by a factor 100 after the calibration.

### *3.0 Analysis of the test files generated by production*

The test box software generates two kinds of test files for each of the two versions of the ELMB128. One complete, which indicates that an ELMB128 card, has passed all tests and another indicating the type of failure. If a card is re-tested a new file is made with a new version number. It is therefore possible to determine how many times a card has been tested. As also the timestamp is generated for each file it is possible to estimate the total test time. More than 900 files were generated during the testing by the manufacturer of the ELMB128.

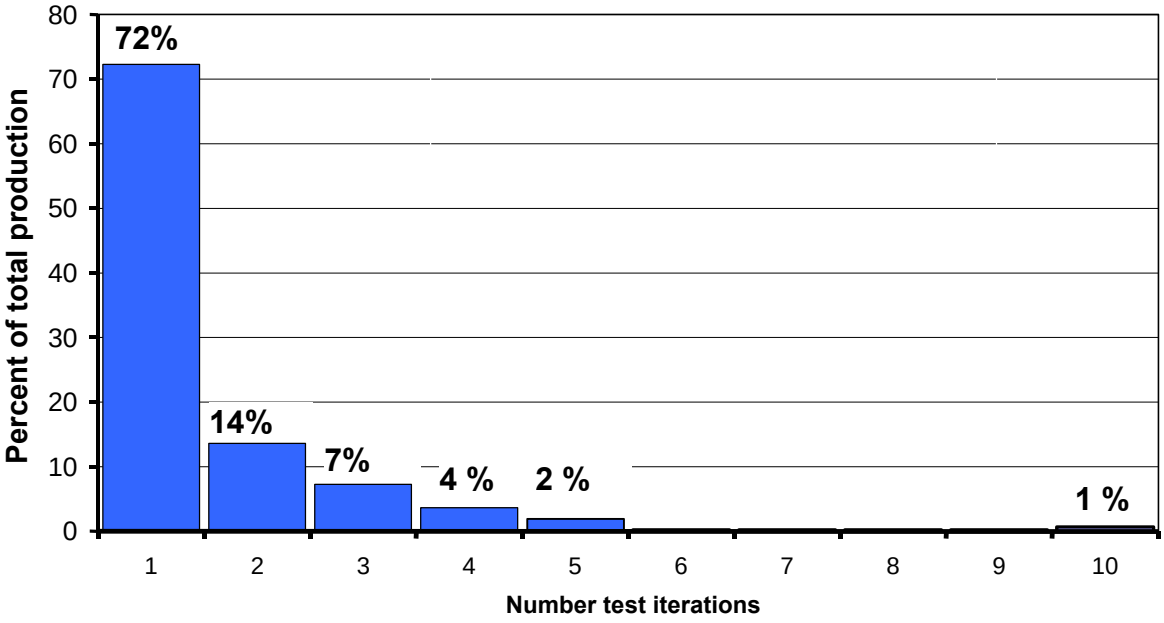


Figure 2 The number of iterations needed for the ELMB128-A to pass the all tests

### 3.1 Test results of the ELMB128-A

The total number of ELMB128-A tested at the production was 471. From Figure 2 it can be seen that 72% of them passed all tests immediately, respectively 14% passed on the second test and 7% after third test. The types of faults are indicated in Figure 3. The ADC inputs are the most common fault, while fault in the power supply currents are the second cause. All faults found during earlier productions of these cards have been soldering defects and can usually be detected by visual inspection. The total test time and repair time invested by the manufacturer

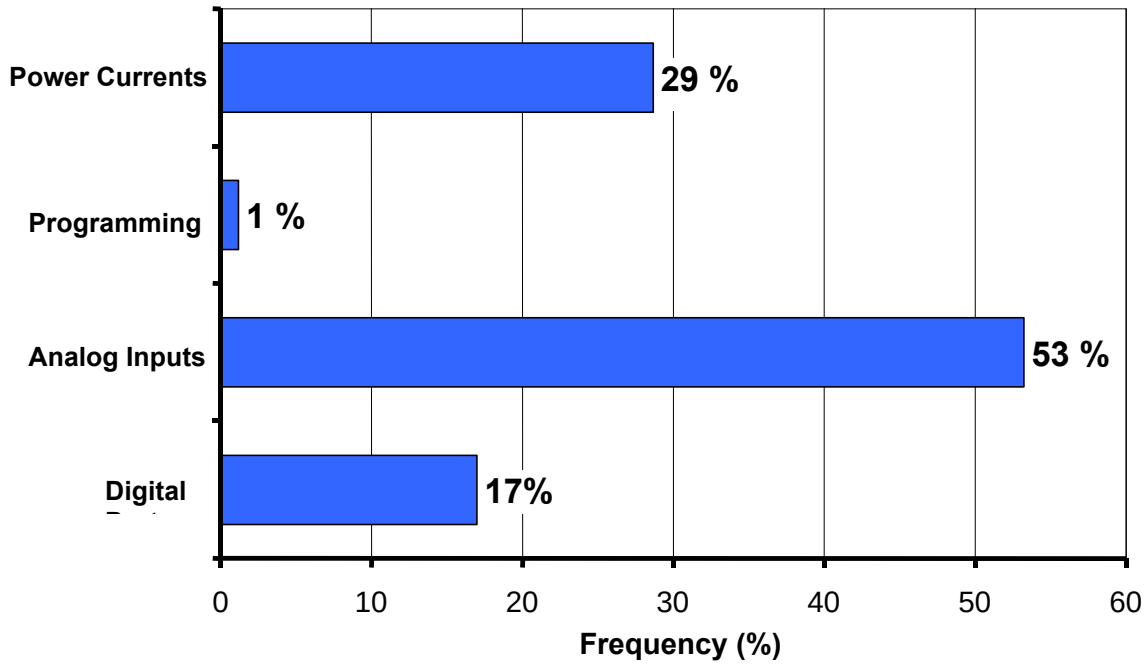


Figure 3 The type failure of the ELMB128-A found by the test program

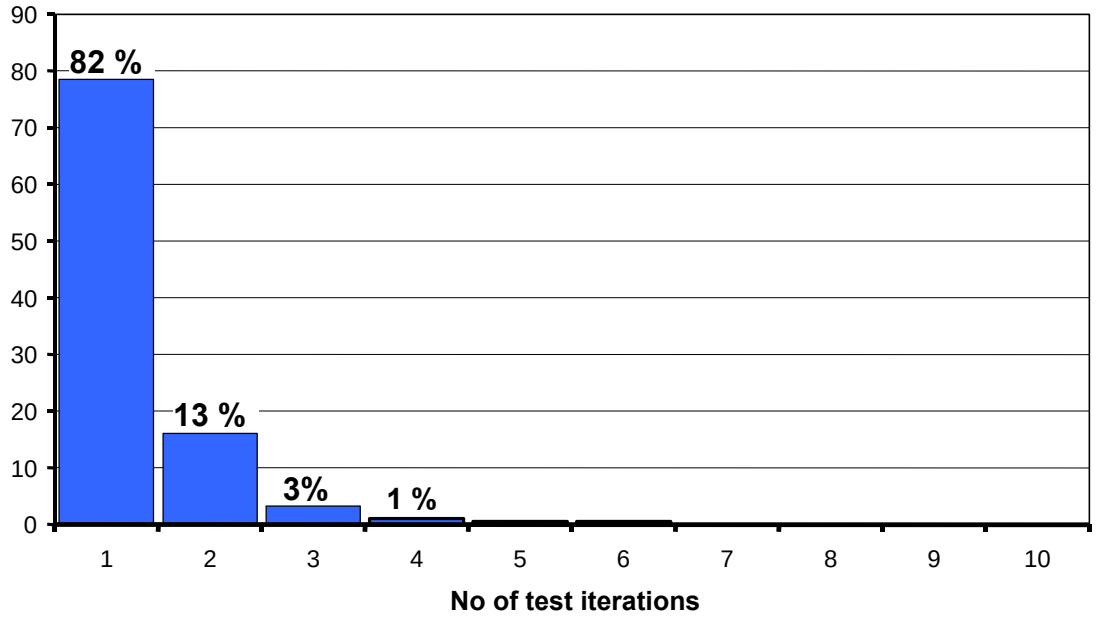


Figure 4 The number of ELMB128-D, which passed the tests

was 1140 min or 2.4 min per card. The number of cards produced and could not repaired by the manufacturer within a reasonable time was 4. This corresponds to a manufacturing yield of >99%.

### 3.2 The test result of the ELMB128-D

The digital version of the ELMB128 has about 50% of the components and solder points than the analog version. As seen from Figure 5 more than 82% of the ELMB128-D cards did pass the tests immediately. Figure 5 show that the most common error was the programming of the microcontroller. This is however in most cases caused by mechanical problems in programming connector of the test box. The total number of cards tested was 186. The total test and repair time is estimated to 320 min or 1.7 min per card. All produced ELMB128-D could be repaired thus the manufacturing yield was 100%.

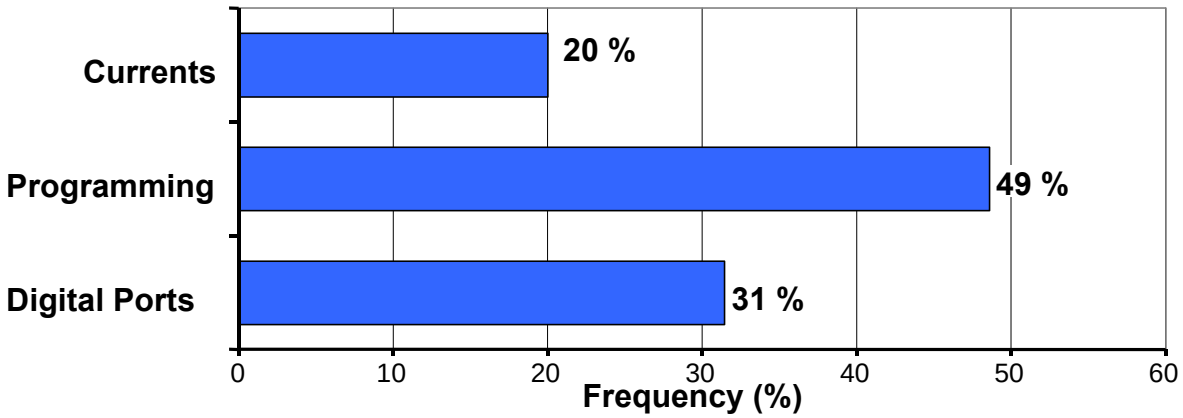


Figure 5 The type errors found by the test program for the ELMB128-D

## *4.0 Conclusions*

### 4.1 The test results

The measurements show very good results, which are consistent with the use of components from homogenous lots. This is important for the radiation qualification of the ELMB128. The calibration of the ADC improves the accuracy of the ELMB128 especially on the 5V range.

### 4.2 The production

The ELMB128 2002 production was organised in an excellent way by the CERN EST-DEM group. The ELMB128 cards were delivered fully tested and on schedule. The price per unit has been reduced to 55% of the previous production.

### 4.2 Test system

The ELMB128 test system performed satisfactory. However the mechanical construction, general robustness and the wiring must be improved before the next production. The present version of the ELMB128 test box can not check that the calibration has been done correctly i.e. that the gain factors stored in the EEPROM are correct. To do this the accuracy of the test box must be enhanced to better match that of a 16-bit ADC. The testing of the digital ports should be more complete.

## *5.0 References*

[1] ELMB128-A see https://edms.cern.ch/item/CERN-0000010235/0

[2] ELMB128-D see http://edms.cern.ch/item/CERN-0000010975/0

[3] http://atlas.web.cern.ch/Atlas/GROUPS/DAQTRIG/DCS/ELMB/elmb128.html

[4] Jim.Cook, "ELMB128 Test User Guide for Hardware and Software" ,.

[5] Henk.Boterenbrood@nikhef.nl, see
http://www.nikhef.nl/pub/departments/ct/po/html/ELMB128/ELMB128resources.html