

Problems with the Voltage and Current measurements in the ELMB Test Box

In the ELMB test box the voltages and the currents of the tested ELMB card are measured with help of a second ELMB (called the monitoring ELMB with ID=62). The monitoring ELMB is mounted in a standard motherboard [1]. This is equipped with differential attenuators made with 160 and 10 kohms resistors given the ratio 1:17. The voltages of the ELMB under test can therefore be measured directly while the currents are measured with the help of series resistors with the value of 110 ohms. In total eleven parameters are measured for each of the tested ELMB. In the first applications of the Test Box in the 2004 production problems were discovered with these measurements: Occasionally an ELMB board would fail in these tests even though the board was shown to be OK in a second measurement. This is unacceptable in a production test. Therefore comprehensive tests have been made to investigate the problem. The method used is to measure repeatedly every 2 sec the voltages and currents of an ELMB under test. The results obtained for the Test Box 3 are shown in Table 1 and example of the noise seen on the Vref is shown in Figure 1 for 1300 measurements. As seen there are about 10% of the measurements which are outside the nominal error of $\pm 0.5\%$ for the Vref voltage, with some measurement as much as +7% and -11%.

Table 1 Result of measurements on the Test Box 3 DC Voltages and Currents

	Dig V	Dig I	Ana V	Ana I	CAN V	CAN I	3.3V DIG	5V CAN	5V ANA	5V NEG	Vref
Noise (V RMS)	0.024	0.034	0.024	0.025	0.034	0.024	0.026	0.024	0.026	0.028	0.025
Mean value (V)	10.572	1.405	11.151	0.940	9.849	2.092	3.282	4.950	4.950	4.926	2.487
Noise in % of Mean	0.2	2.4	0.2	2.6	0.3	1.2	0.8	0.5	0.5	0.6	1.0
Min value in % of Mean	-4.0	-60.7	-3.0	-19.6	-3.6	-14.6	-8.4	-5.6	-5.6	-6.0	-11.1
Max value in % of Mean	1.8	18.3	1.6	27.8	6.1	8.0	7.1	5.7	4.5	4.4	6.9
Min	10.149	0.552	10.811	0.756	9.491	1.786	3.005	4.673	4.673	4.631	2.211
Max	10.766	1.662	11.333	1.201	10.445	2.259	3.516	5.231	5.171	5.143	2.659

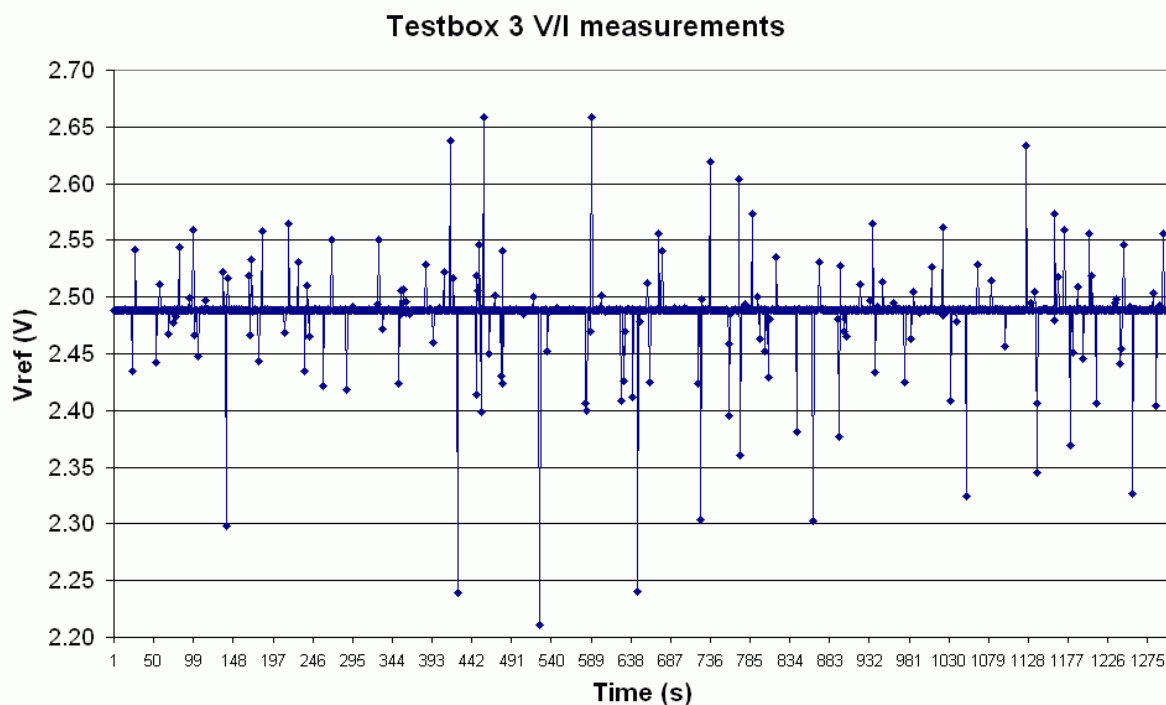


Figure 1 Test box 3 Vref noise = 1.0 % RMS

Check of other Test Boxes

Measurements on all the five Test Boxes showed that three of them have the same type of problem as shown above for the Test Box 3. As an example of a very good performance is shown in Figure 2. The noise corresponds to ± 1 LSB of the ADC reading. By exchanging the motherboards of the monitoring ELMB's it was possible to achieve the similar performance on all of the Test Boxes as shown in Figure 2. Hence the cause for the noise is the ELMB standard motherboard.

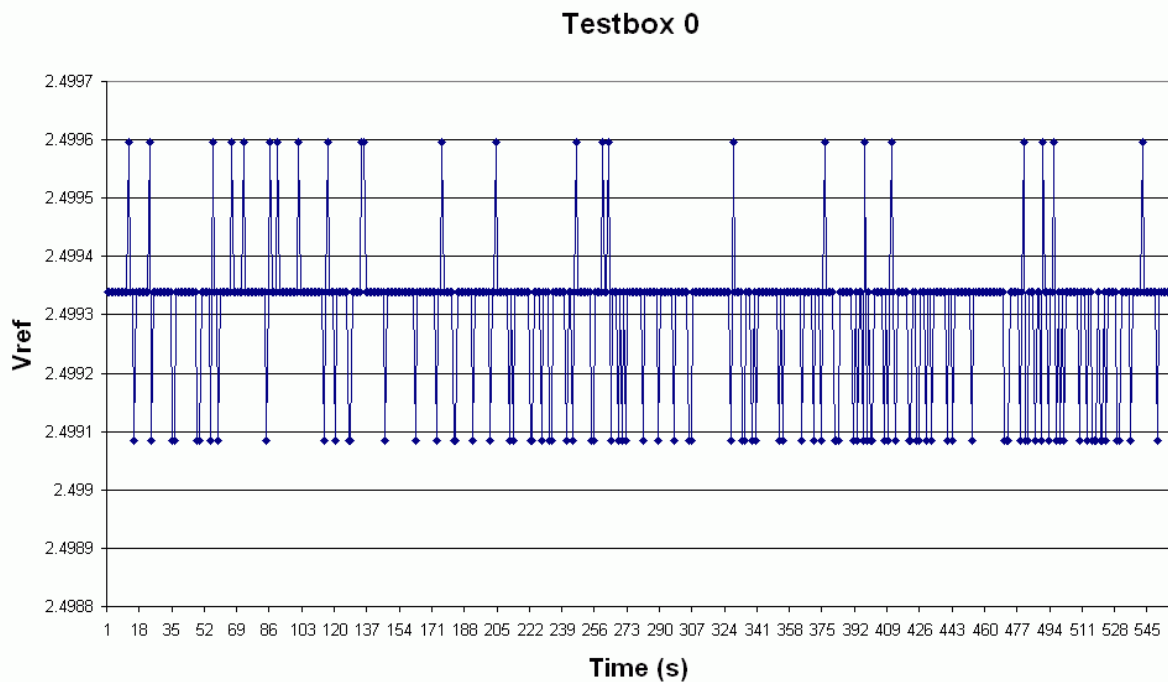


Figure 2 Test Box 0 noise level = 0.0045% of mean value of Vref

Measurements on a few motherboards

In order to see how common the noise problem is a series of measurements was made on 8 motherboards using the same ELMB and identical conditions. The parameter Vref is taken as reference for all the boards and the results are shown in Figures 3 to 10. This voltage is measured at the output of a buffer amplifier and nominally be $2.5V \pm 12mV$. Three boards had acceptable performances; see Figure 3, 4 and 5. One of the boards the MB0155 had very serious problems of intermittent type, see Figure 6. There are four boards MB0583, MB0626, MB0630 and MB0656 showing the characteristic noise pattern, see Figure 7 to 10.

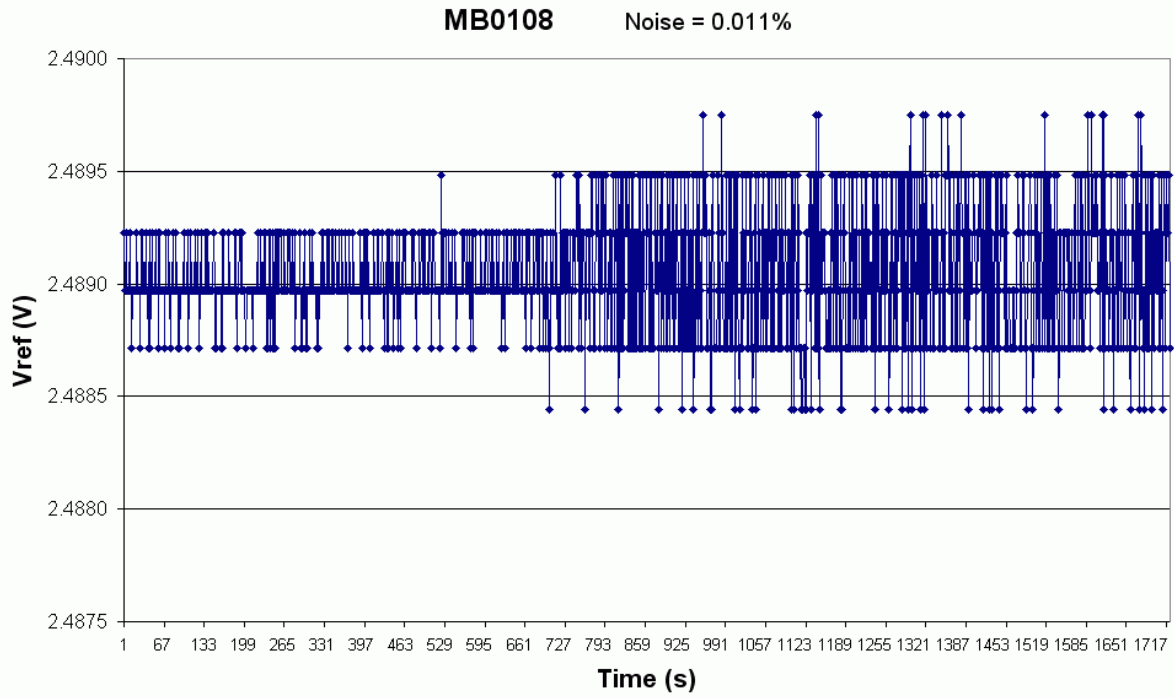


Figure 3 Motherboard MB0108 showing a RMS noise = 0.011% of the mean value

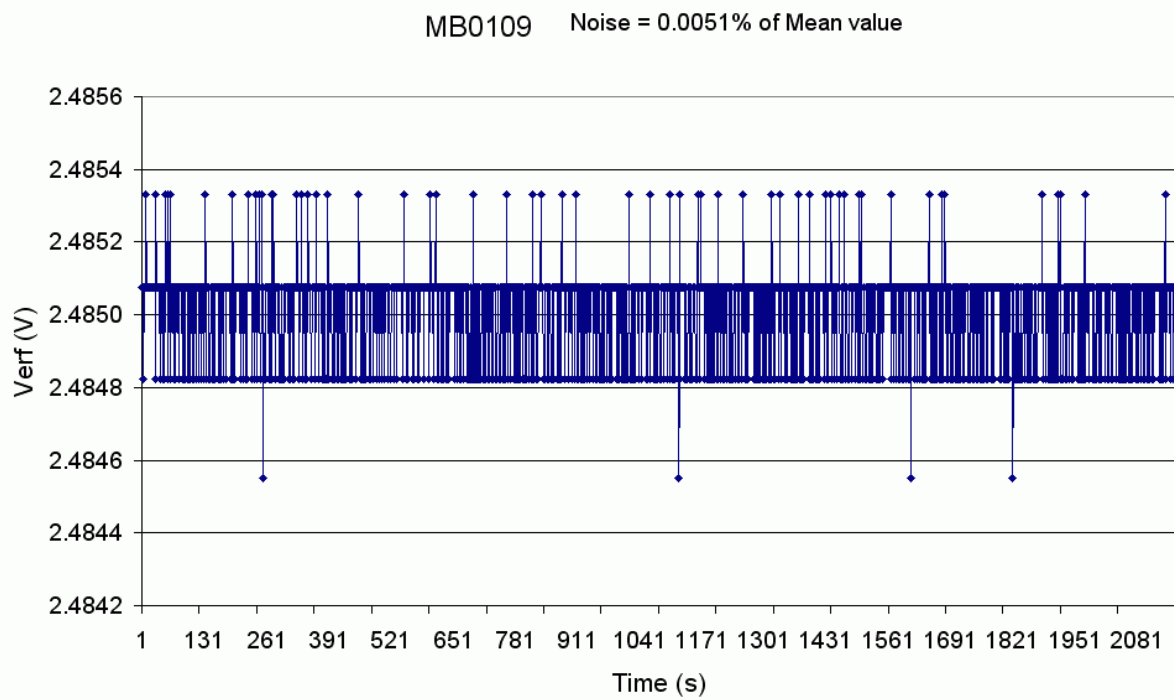


Figure 4 Motherboard MB0109 showing a RMS noise = 0.0051% of the mean value

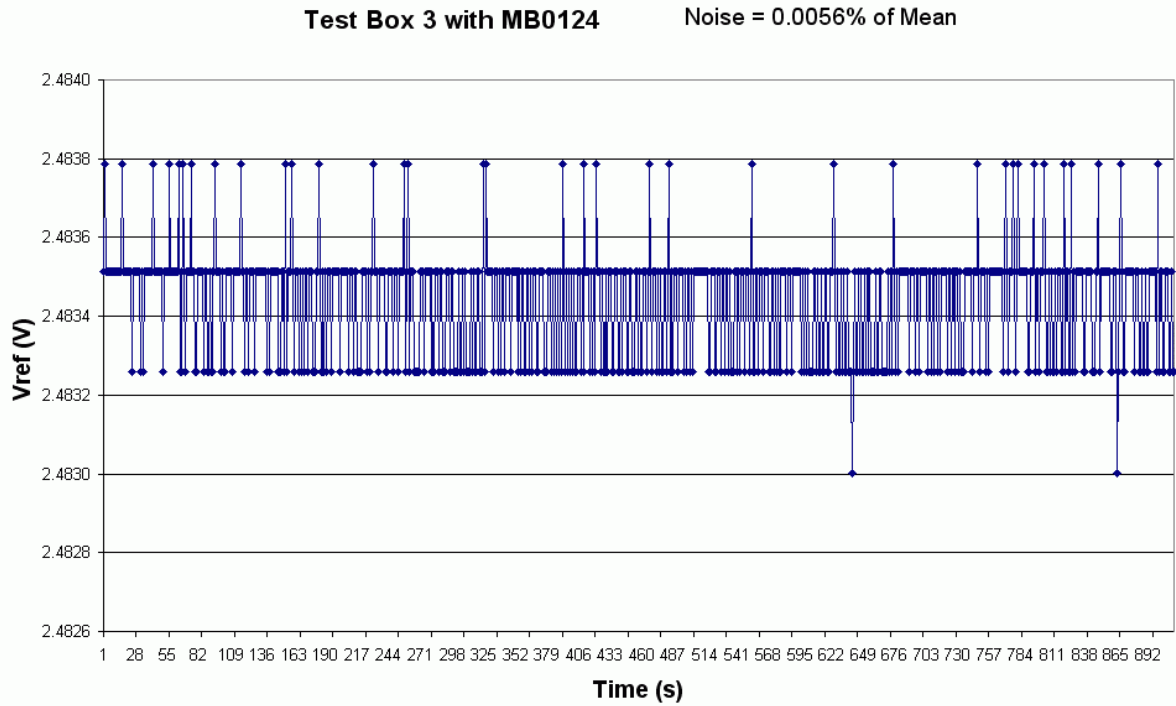


Figure 5 Motherboard MB0124 showing a RMS noise = 0.0056% of the mean value

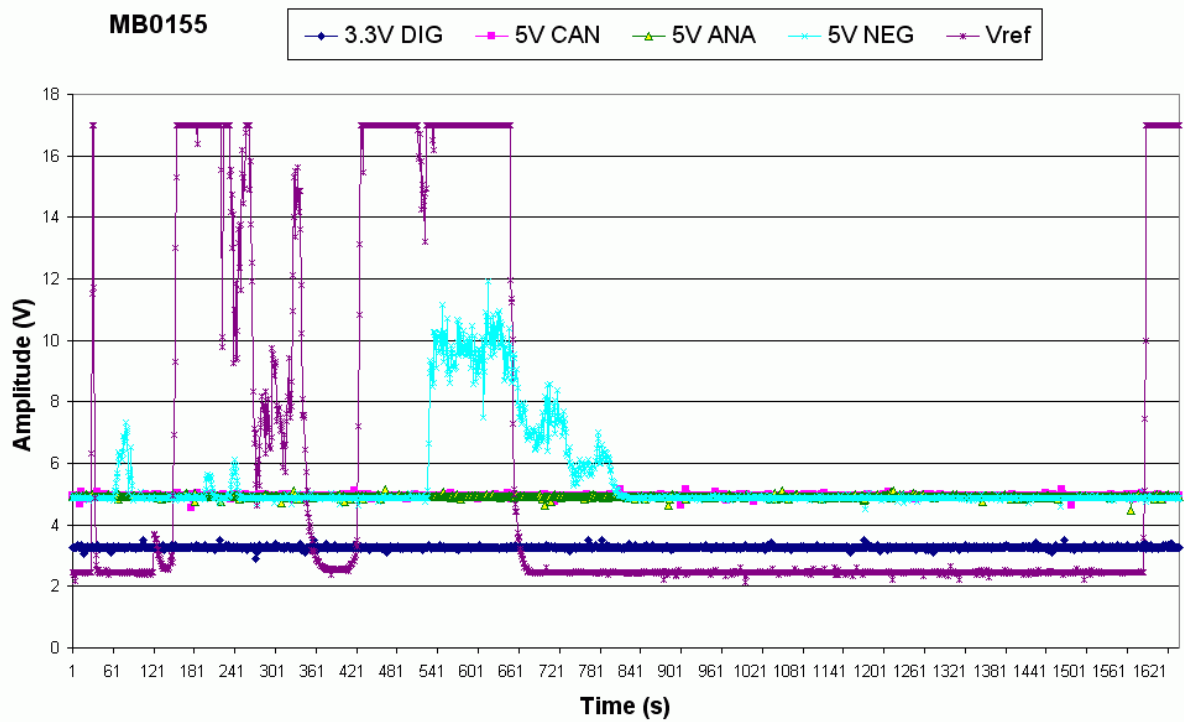


Figure 6 Motherboard MB0155 showing very much noise and intermittent problems

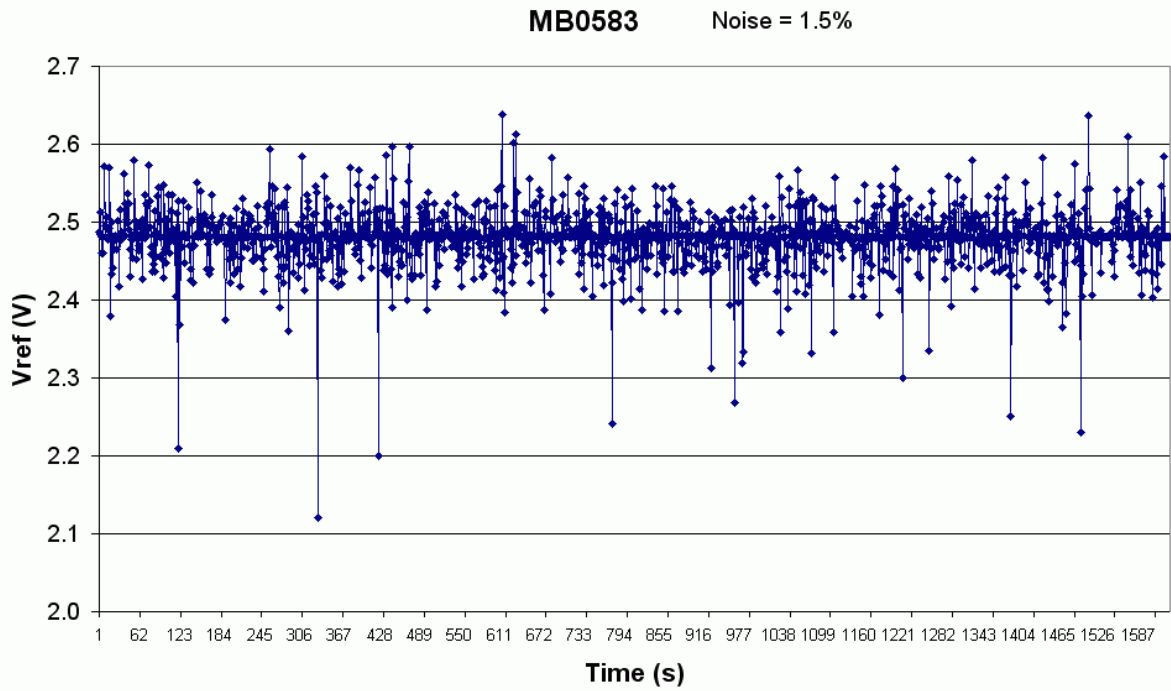


Figure 7 Motherboard MB0583 showing a RMS noise level of 1.5% of the mean value

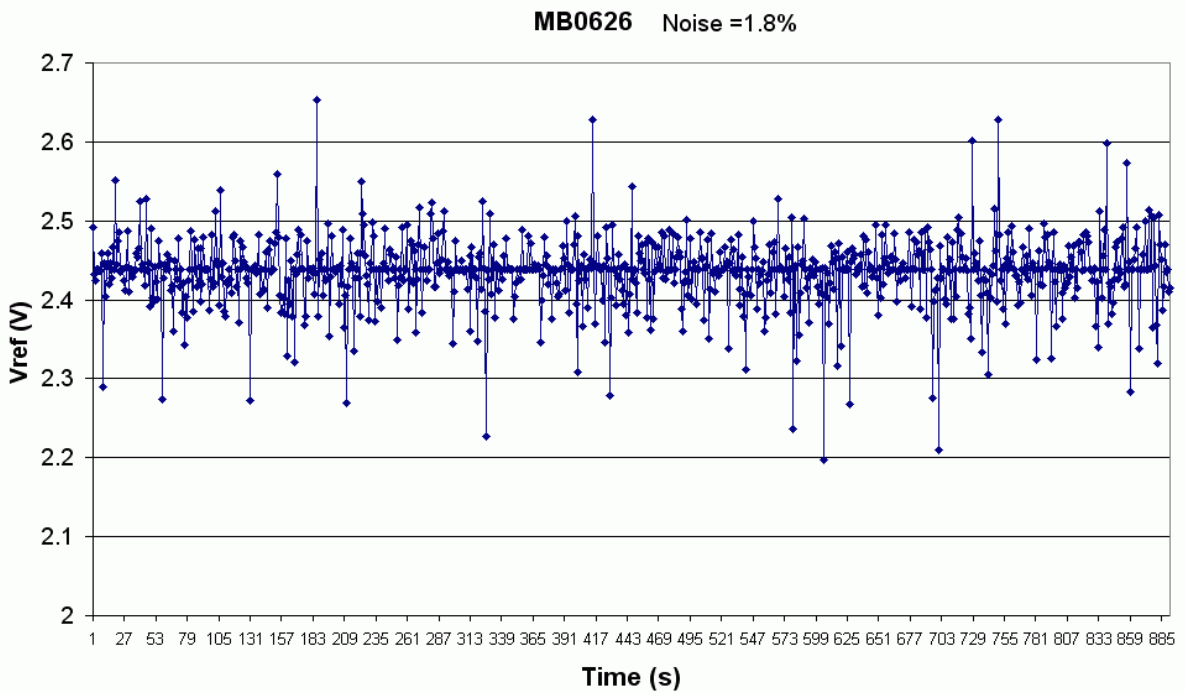


Figure 8 Motherboard MB0626 showing a RMS noise level of 1.8% of the mean value

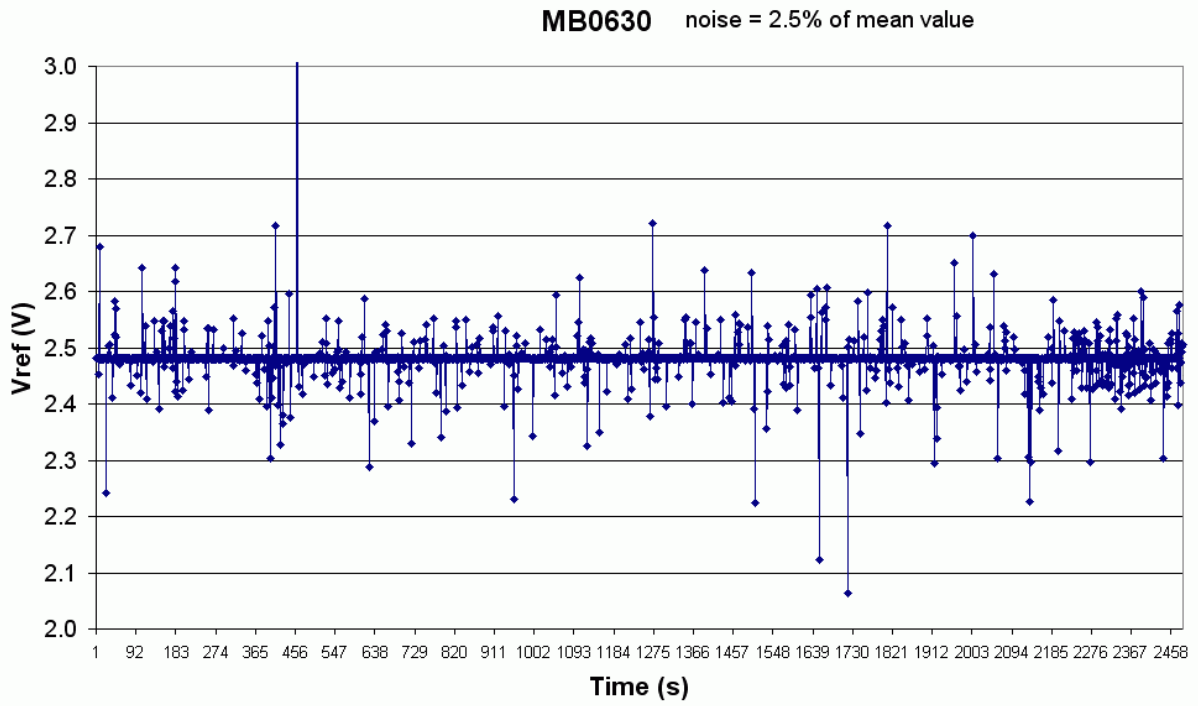


Figure 9 Motherboard MB0630 showing a RMS noise level of 2.5% of the mean value

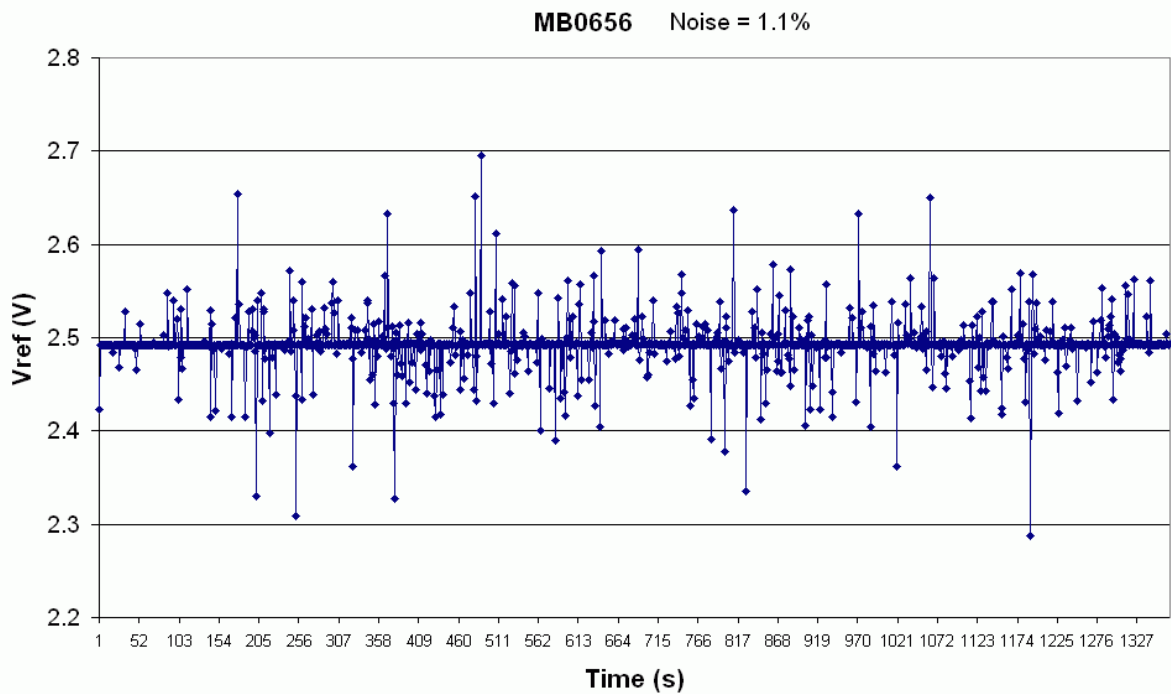


Figure 10 MB0656 showing a RMS noise level of 1.1% of the mean value

Performance of Motherboards after cleaning by TS-DEM

Four of the boards manufactured by the same firm had much solder flux all over the printed circuit board. In order to find out that this was the cause for the noise the boards with problems were given to the TS-DEM group for cleaning. The performance of the boards after the cleaning procedure is as shown in the Figures 11 to 15. All of the boards have more than a factor 100 less noise. All readings are within \pm a few LSB.

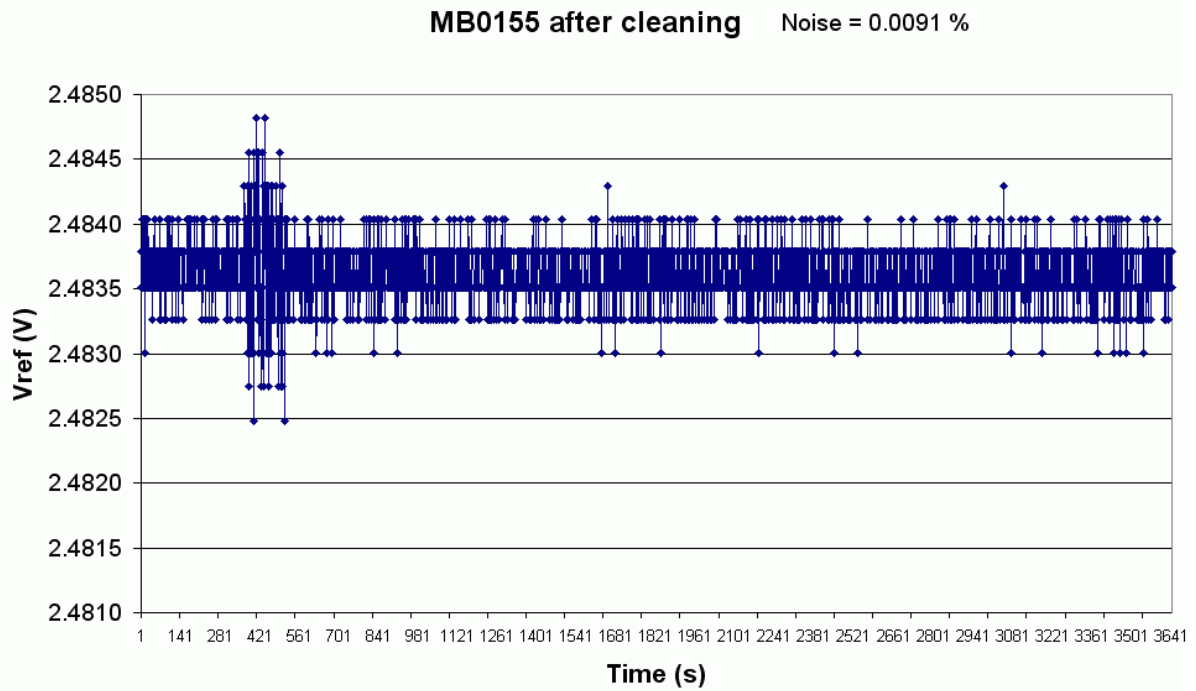


Figure 11 MB0155 showing a RMS noise level of 0.0091 % of mean value

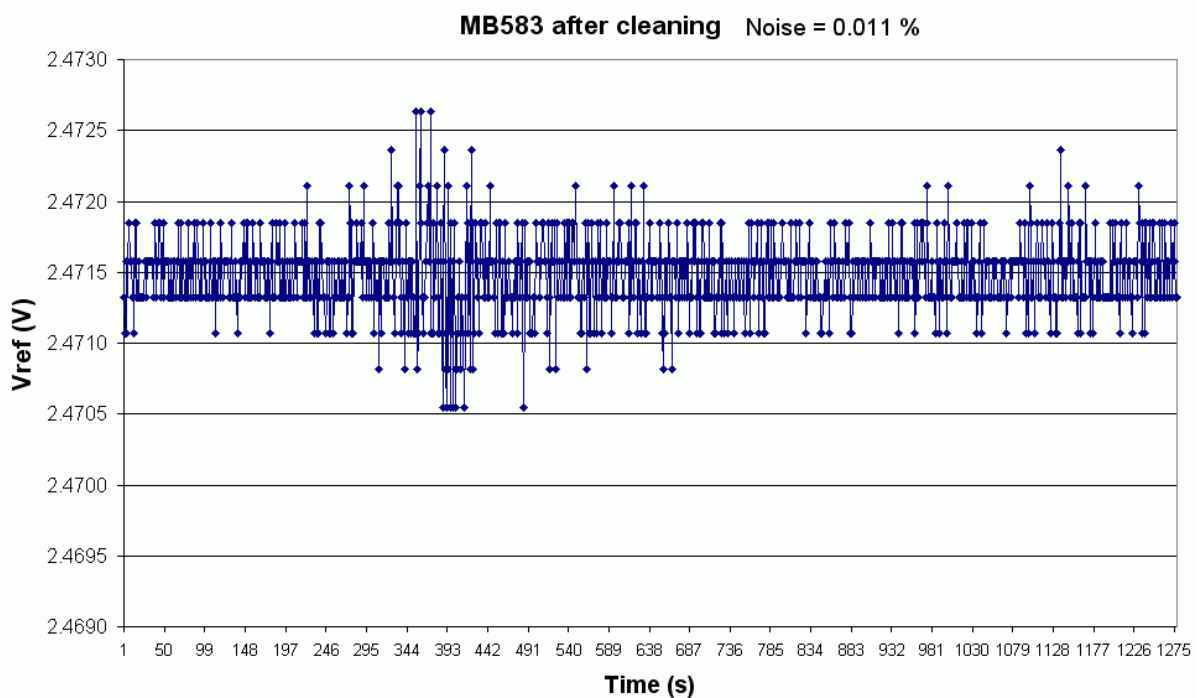


Figure 12 MB0583 showing a RMS noise level of 0.011 % of mean value

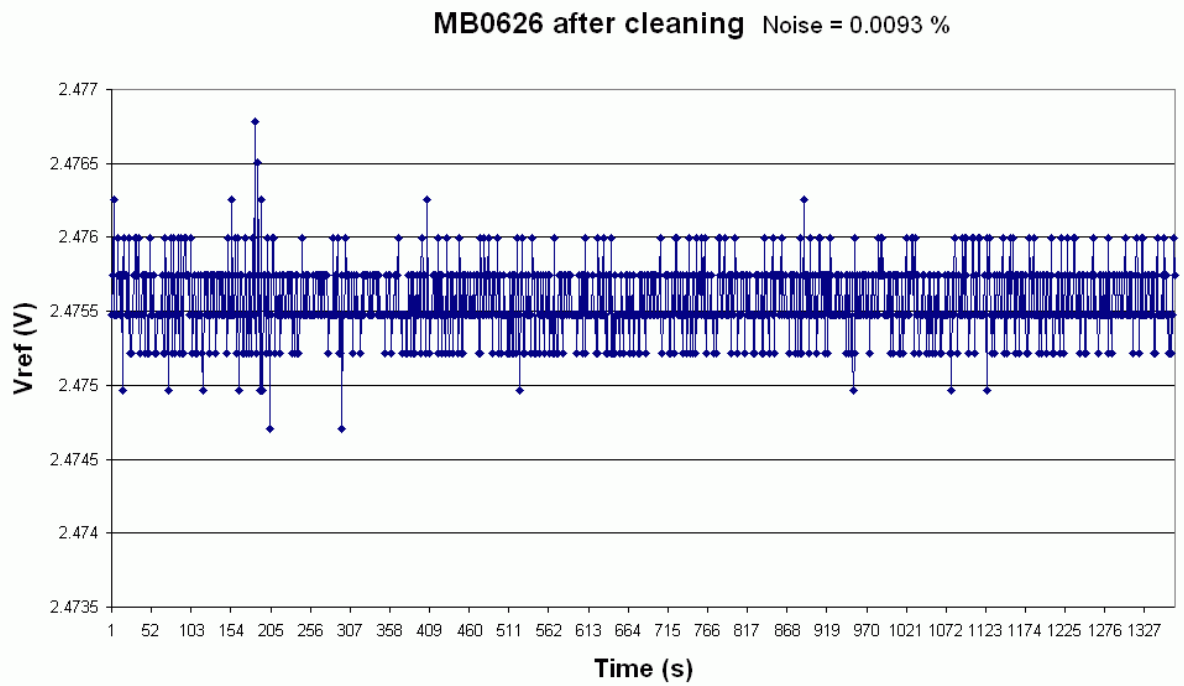


Figure 13 MB0626 showing a RMS noise level of 0.0093% of mean value

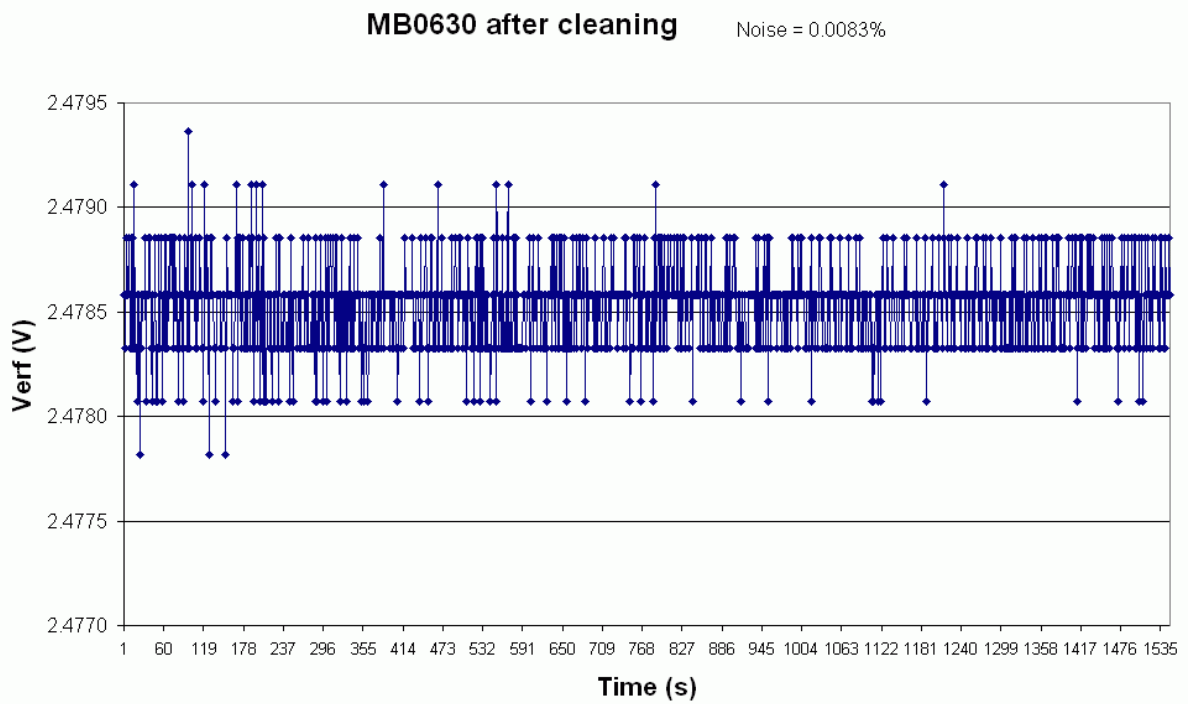


Figure 14 MB0630 showing a RMS noise level of 0.0083% of mean value

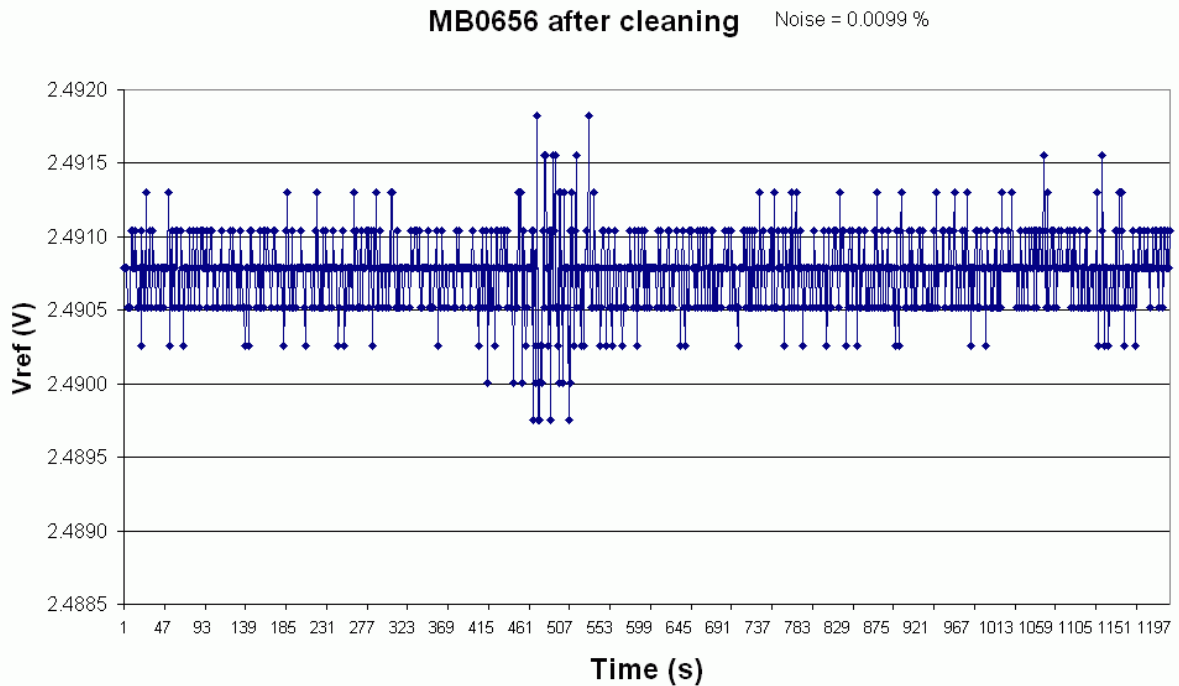


Figure 15 MB0656 showing a RMS noise level of 0.0099% of mean value

Conclusions

The noise problems observed were cured by cleaning the boards. The most likely cause is the solder flux on 4 of the 5 tested motherboards. The flux caused intermittent resistance changes which affected the high impedance attenuators used for the voltage measurement. In any case it is well-known that the flux may cause problems if left on the printed circuit board after the production. Therefore all boards which are fabricated with the help of TS-DEM group are cleaned in a well-established procedure consisting of several steps. However the ELMB motherboards were not fabricated in this manner.

References

- [1] <https://edms.cern.ch/document/348202/3>