Radiation Testing of
TMP36 Temperature Sensors in a Proton Beam

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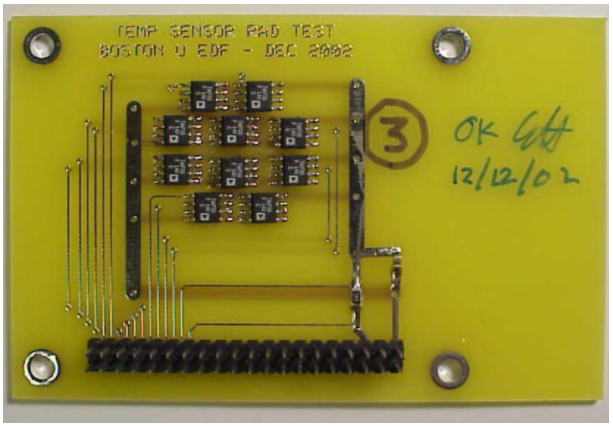
PRELIMINARY

Test Setup

A test board (see photo) was designed which supports (10) TMP36 devices in SO-8 packages. A 5m ribbon cable connected this board to a 32-channel, 12-bit ADC, which digitized the 10 TMP36 outputs, along with the 3.3V power supply voltage.



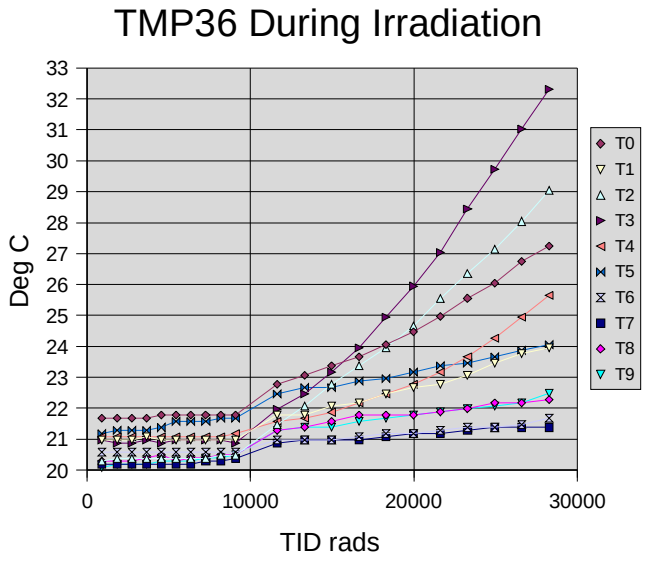
Irradiation Procedure

The test board was placed in a 157.6 MeV proton beam at the Northeast Proton Therapy Center (at Mass General Hospital in Boston). The beam size was about 2.5 cm which was large enough to provide uniform irradiation of all devices to within about 10%. The radiation was delivered in 15 "runs". The first 5 runs delivered 10krad each over a period of about 1 minute per run. The ADC values were recorded every 5 seconds. The remaining dose was delivered in 10 additional runs of 25krad each. The total elapsed time was about 30 minutes (including down time between runs).

After the test data was recored for about 5 minutes, then the irradiated board was disconnected. The board was then stored at room temperature for 6 weeks.

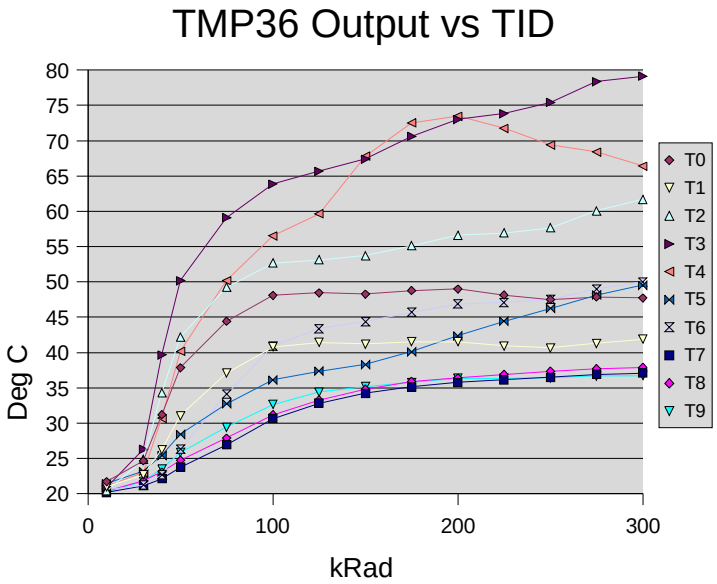
Test Results

During irradiation, all 10 device outputs were recorded at 5 second intervals, with data up to 30 kRad shown in Plot 1 below. Unfortunately, the ambient temperature in the radiation area was not independently monitored, but before the test it was 20.8 C and after the test it was 21.4 deg C (average reading of 10 non-irradiated sensors). Plot 2 shows the data averaged by run up to the full dose of 300 kRad.

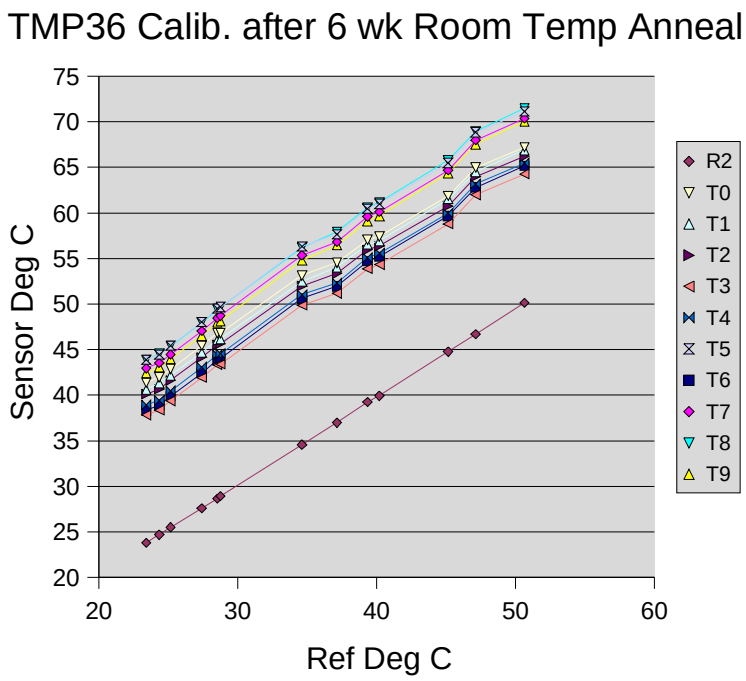


Plot 1. TMP36 Outputs During Proton Beam Irradiation

The 8 curves (T0...T9) represent the 10 sensors. The gap in the values around 10krad represents the transition between the first and second cyclotron runs.

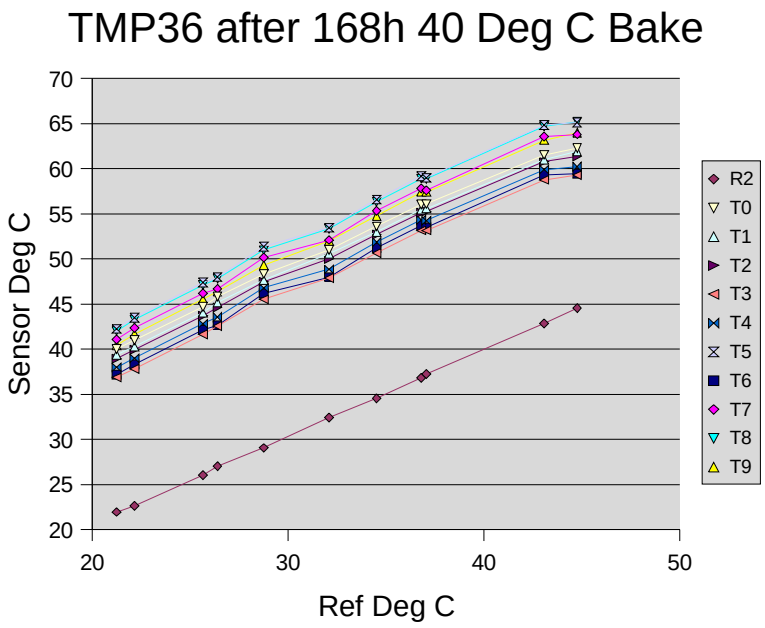


Plot 2. TMP36 Outputs During Irradiation (averaged by run)

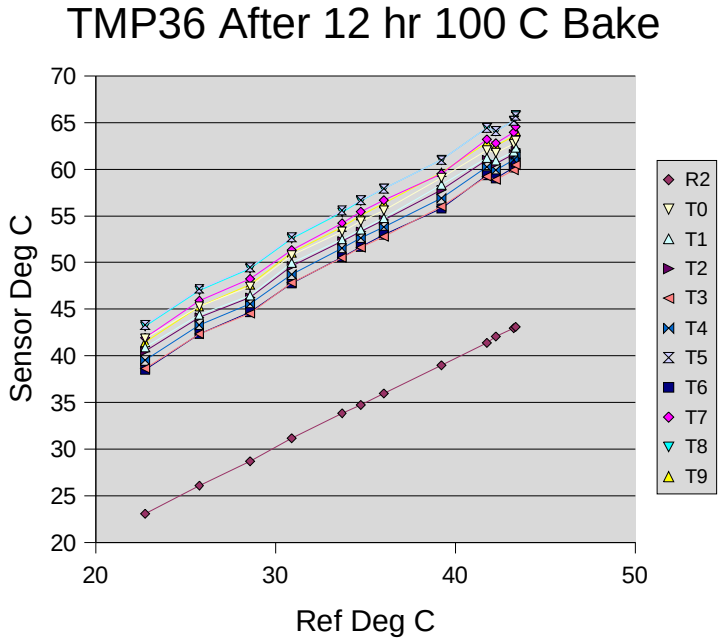


Plot 3. Calibration After Room Temperature Annealing for 6 Weeks.

After irradiation, the boards were stored at room temperature for 6 weeks. They were then calibrated in a temperature-controlled box. The results are shown in Plot 2 below. The absolute calibration of the irradiated sensors is drastically shifted, but the relative calibration is still fairly good. Plot 3 and 4 show the calibration after 168 hour 40 deg. C annealing and 12 hour 100 deg. C annealing, respectively. Essentially no recovery is observed.



Plot 4. Calibration After 168 Hour Annealing at 40 Deg C.



Plot 5. Calibration after 12 Hour 100 Deg. C Annealing

Conclusions

The TMP36 temperature sensor appears to lose absolute calibration after about 10krad equivalent dose in a 167MeV proton beam. Immediately after delivery of a 300 kRad

dose, the readings from the 10 test devices were widely scattered from 35 to 80 degrees C. After room-temperature annealing, the readings are much more tightly clustered with a total spread of about 5 degrees C. Subsequent high-temperature annealing had no significant affect.