



Final Test Results of Anode Front-End Electronics

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Outline

- ❑ **AD16 Board Test Steps**
 - **Step 1: Selection Procedure for CMP16 Chips**
 - **Step 2: Functionality Test for AD16 Boards**
 - **Step 3: Burn-in Procedure for AD16 Boards**
 - **Step 4: Final Test and Certification of AD16 Boards**
 - **10AD16A Test Stand Stability Monitoring**

- ❑ **Test Result Summary of AD16 Boards**
- ❑ **DEL16 Delay Chip Certification**
- ❑ **DEL16 Chip Temperature Measurements**
- ❑ **Conclusions**



Step 1: Selection Procedure for CMP16 Chips

Goal

- Acceptance for installation on the AD16 boards

Acceptance criteria

- Current consumption ($100 \text{ mA} \pm 10\%$)
- Functionality of all channels
- The critical dynamic parameters are within the allowed range

Measurements

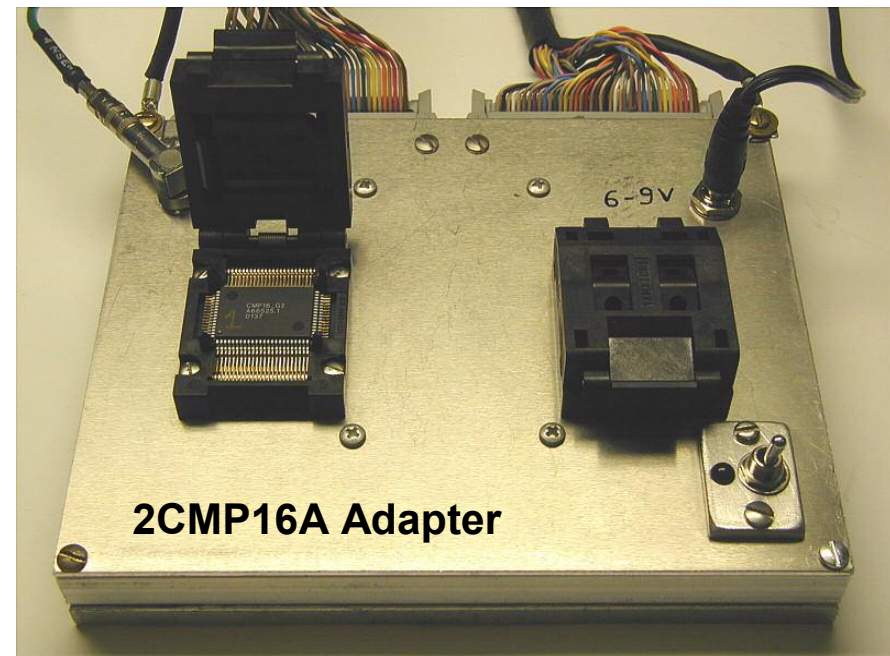
- Threshold measurement
- Time measurement

Yield

- Total tested chips **25,000**
- Good chips **~ 90 %**

Dominant failures

- Dead channel
- Significant threshold deviation
- Significant time deviation
- Large current consumption





Step 2: Functionality Test for AD16 Boards

Performed by AD16 manufacturer after board assembly.

Manufacturer: ACC Electronix Inc., <http://www.accelectronix.com>

Goals

- Check the board functionality
- Assure the quality of the board assembly

Test

- Threshold measurement only

Results

- All boards passed
- Good assembly quality





Step 3: Burn-in Procedure for AD16 Boards

Goals

- Detect hidden defects
- Increase the board reliability

Conditions

- Temperature 90°C
- Duration 72 hours
- Powered and pulsed

- **Total tested** 12,200 boards
- **Found not operational** ~ 30 boards
(all failures were due to bad solder joints,
with no chip failures)

The burn-in time is ~ 1% of the equivalent AD16 board reliability test duration.

The estimation of the AFEB reliability was made earlier by burning in 100 boards in an oven for 4000 hours at a temperature of 110°C (equivalent to about 7 years of real operation at 30°C).

200 boards tested simultaneously





Step 4: Final Test and Certification of AD16 Boards

Goals

- **Functionality checking after burn in test.**
- **Measurement and certification of the critical board parameters.**

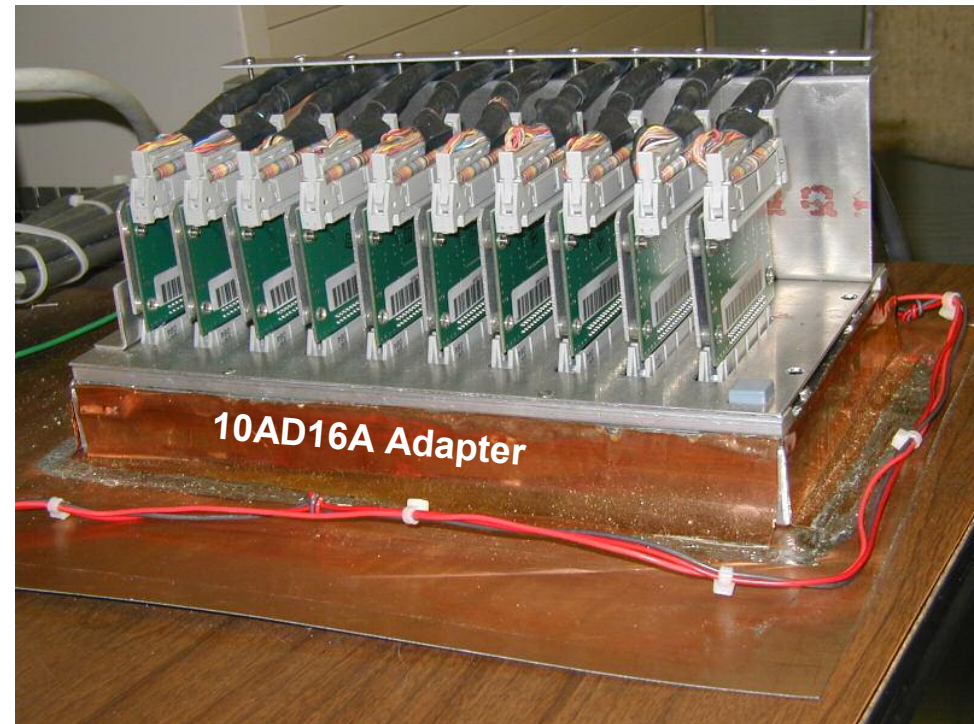
The parameter calculations and selection of the good boards are made off-line.

Measured Parameters

- **Threshold, noise, gain and threshold offset**
- **Internal test capacitance**
- **Resolution, propagation and slewing time**

Yield

- **Total tested boards** **12,200**
- **Good boards** **~ 90 %**
- **Final yield (after repair)** **> 95 %**





Test Result Summary for AD16 Boards

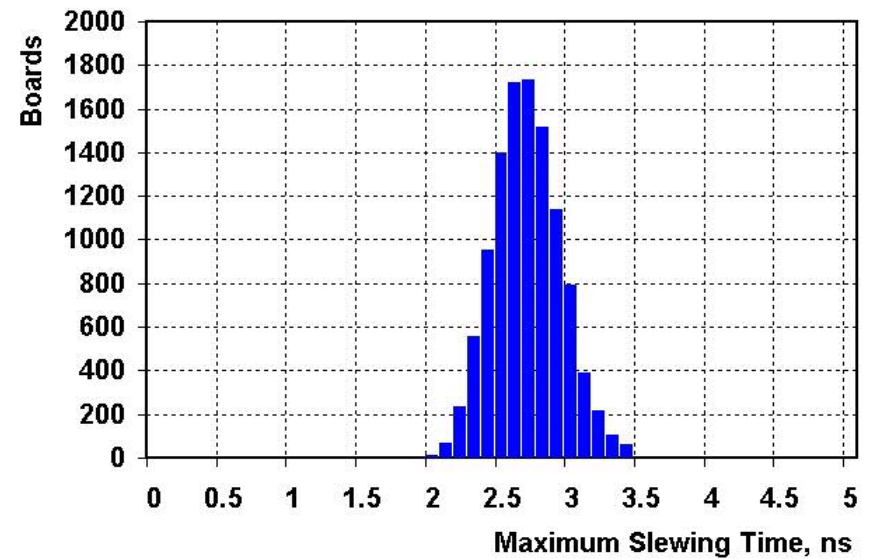
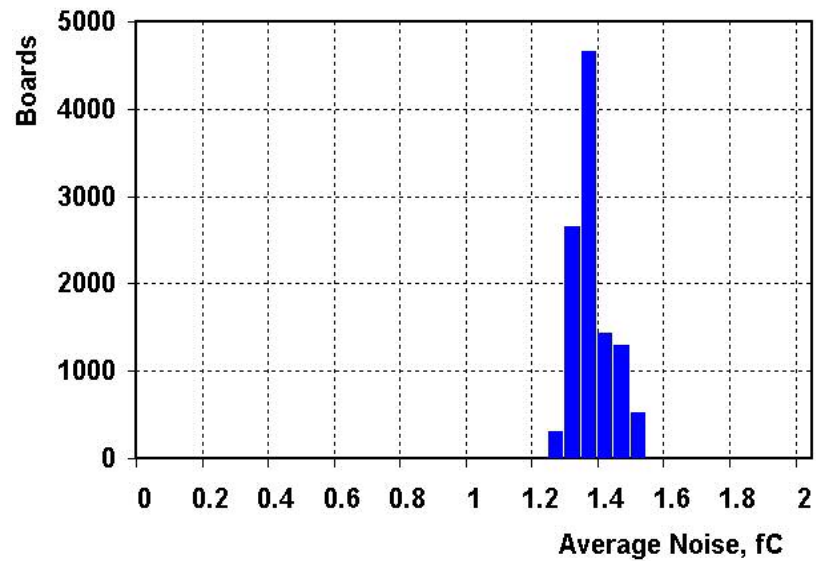
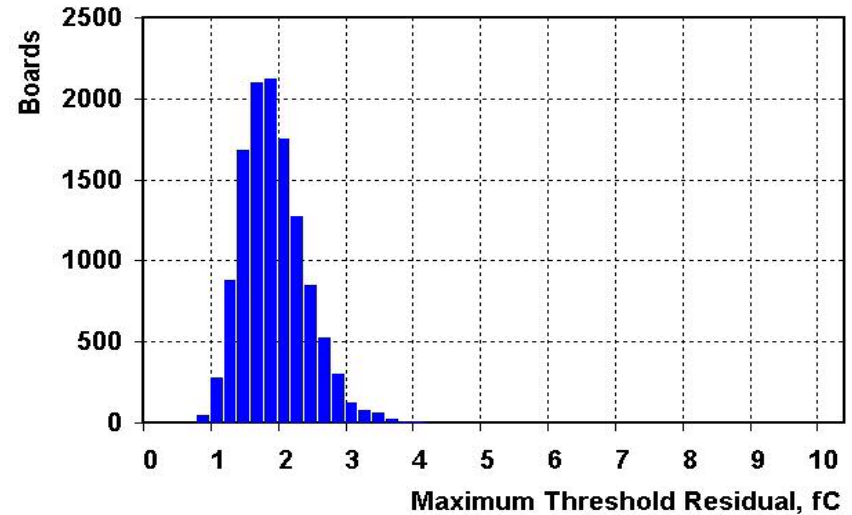
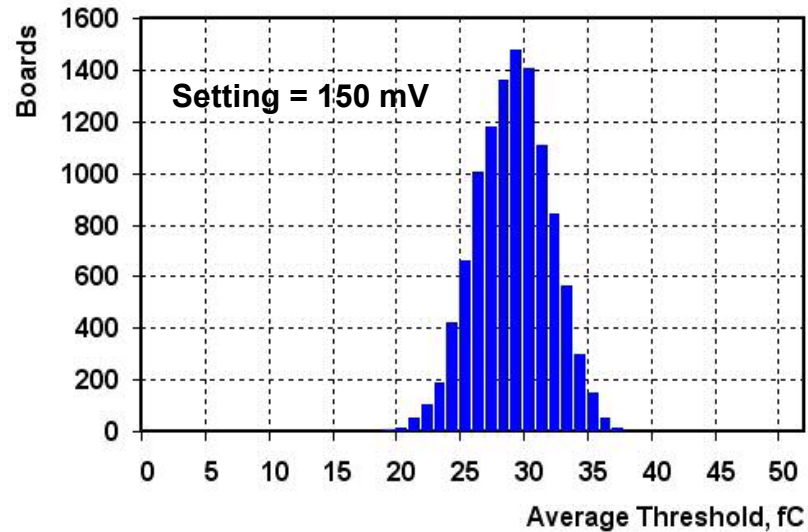
Board certified parameters.

Parameter	Average \pm RMS	Uniformity *
Threshold (fC)	29.2 \pm 2.9	0.9
Noise (fC) at Cdet = 180 pF	1.4 \pm 0.06	0.05
Transfer function (gain, mV/fC)	6.9 \pm 0.3	0.07
Discriminator offset (mV)	50 \pm 19	6
CMP16 chip internal Capacitance (pF)	0.24 \pm 0.02	0.01
Propagation time (ns)	66.5 \pm 1.5	0.3
Slewing time (ns) at Qin = 50 – 550 fC	2.4 \pm 0.2	0.2

*) Uniformity - the standard deviation (RMS) of the channel residual within each board.



Test Result Summary for AD16 Boards



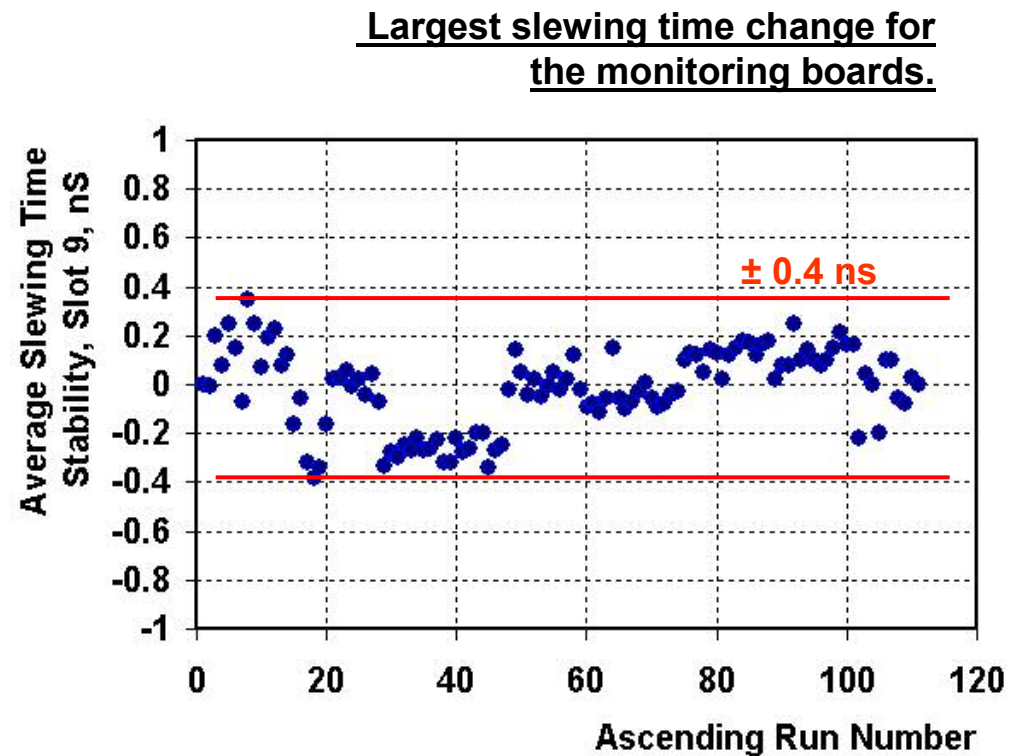


Test Result Summary for AD16 Boards

10AD16A Test Stand Stability Monitoring

The stability of the AFEB test stand is monitored through data taken each day using the same set of ten boards assigned to each of the 10 slots of the 10AD16A adapter.

Monitored Parameter	Maximum Deviation
Threshold (fC)	± 1.3
Noise (fC) at Cdet = 180 pF	± 0.1
Transfer function (gain, mV/fC)	± 0.3
Discriminator offset (mV)	± 5.0
CMP16 chip internal capacitance (pF)	± 0.01
Propagation time (ns)	± 1.2
Slewing time (ns) at Qin = 50 – 550 fC	± 0.4





DEL16 Delay Chip Certification

Goal

- Acceptance for installation on the ALCT boards

Acceptance criteria

- Functionality of all channels
- Delay uniformity at each delay code
- Linearity of the delay time versus delay code

The selection of the good delay chips is made on-line using the test stand.

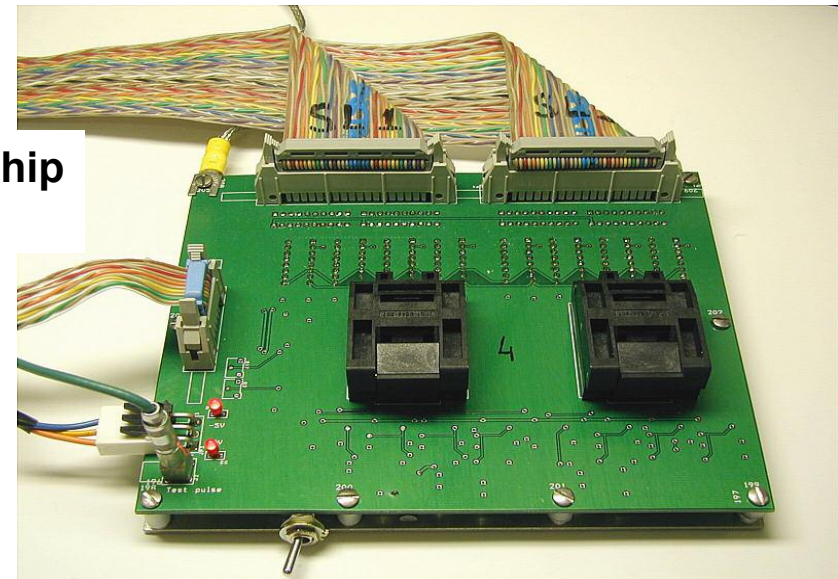
Measurements

- Checking of the test level feature of the chip
- Propagation time versus delay code

Main Problem

- Contact degradation of the commercial clamshell (~ 3000 connections)

2DEL16A adapter





DEL16 Delay Chip Certification

Certified parameters

Parameter	Average Value	Typical Deviation	Maximum Deviation
Propagation time, code = 0, ns	19.5 – 24.0	± 0.28	± 1.0
Propagation time, code = 15, ns	42.0 – 60.0	± 0.94	± 1.5
Slope, ns/LSB	1.0 – 3.0	± 0.06	± 0.15
Maximum nonlinearity, ns	-----	± 0.72	± 2.0

Yield

- **Total tested delay chips** **24,000**
- **Yield of accepted chips** **88 %**
- **For ALCT board production** **78 %**
 (of the accepted chips)



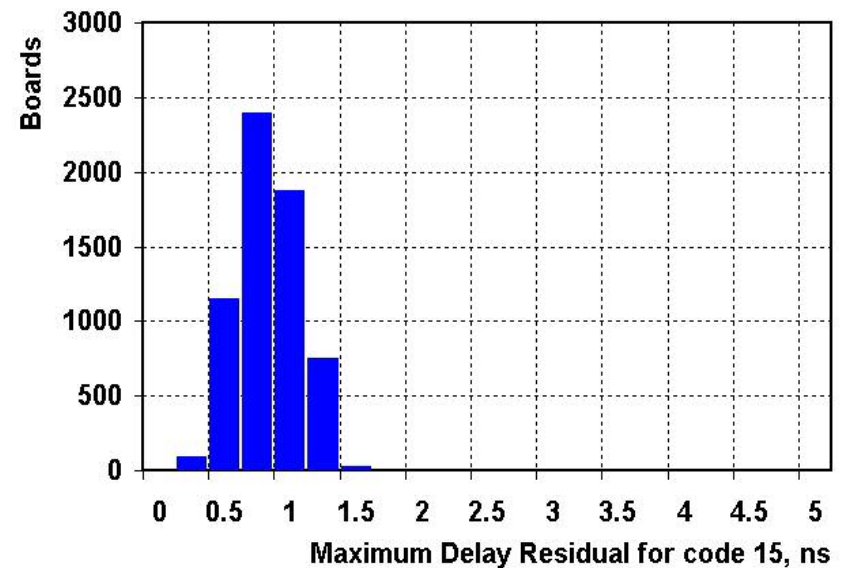
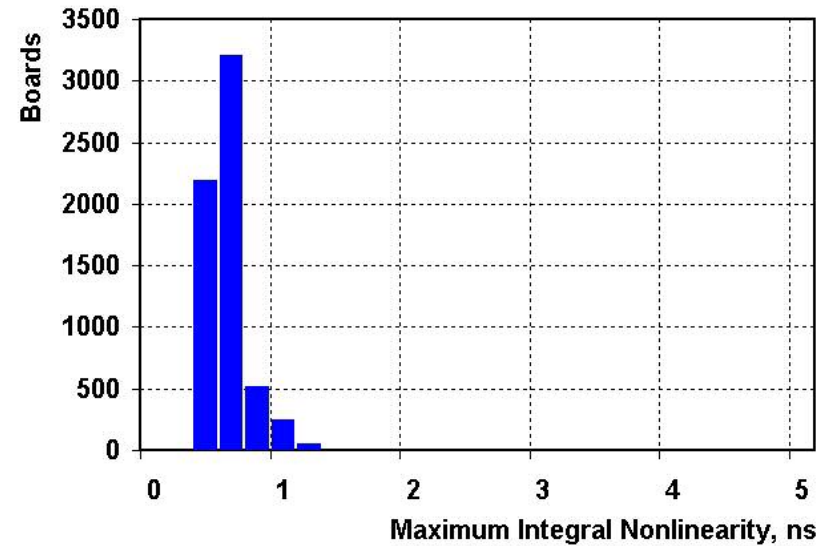
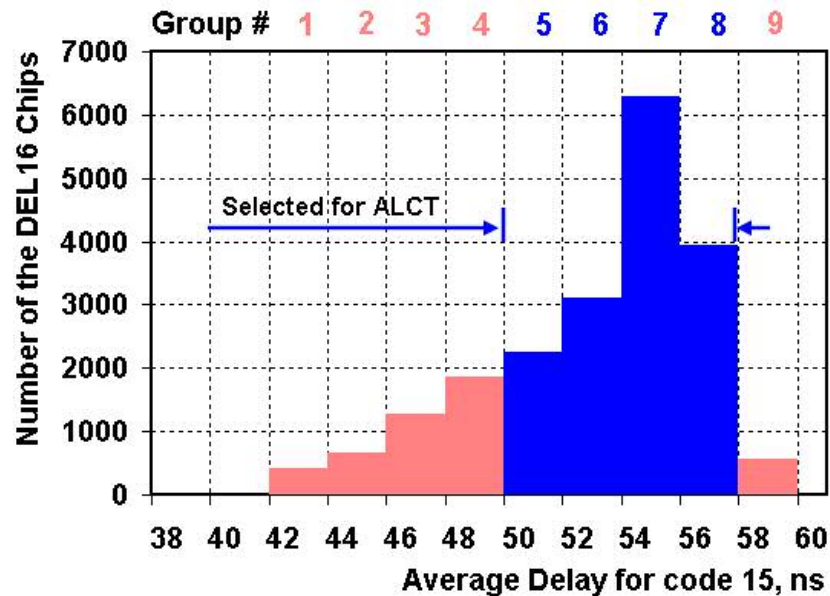
DEL16 Delay Chip Certification

Delay chip grouping

- Groups 9
- Group bin width 2 ns

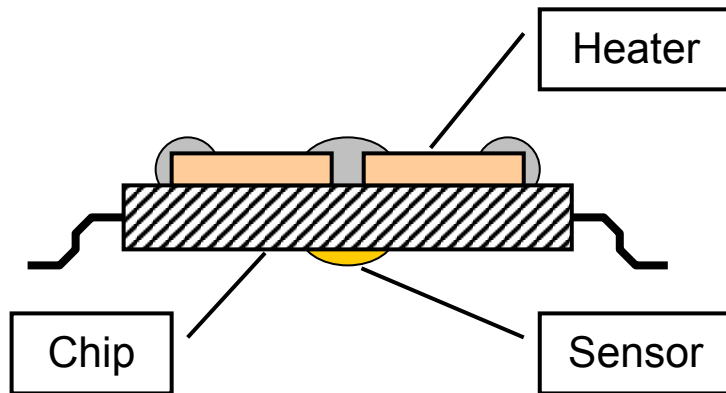
Group from 5 to 8 used for ALCT board production.

The average delay steps can be tuned.

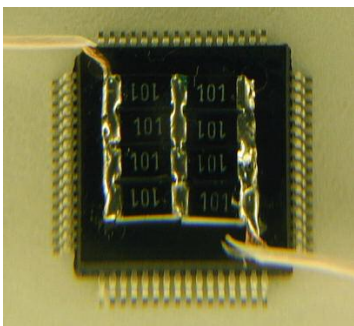




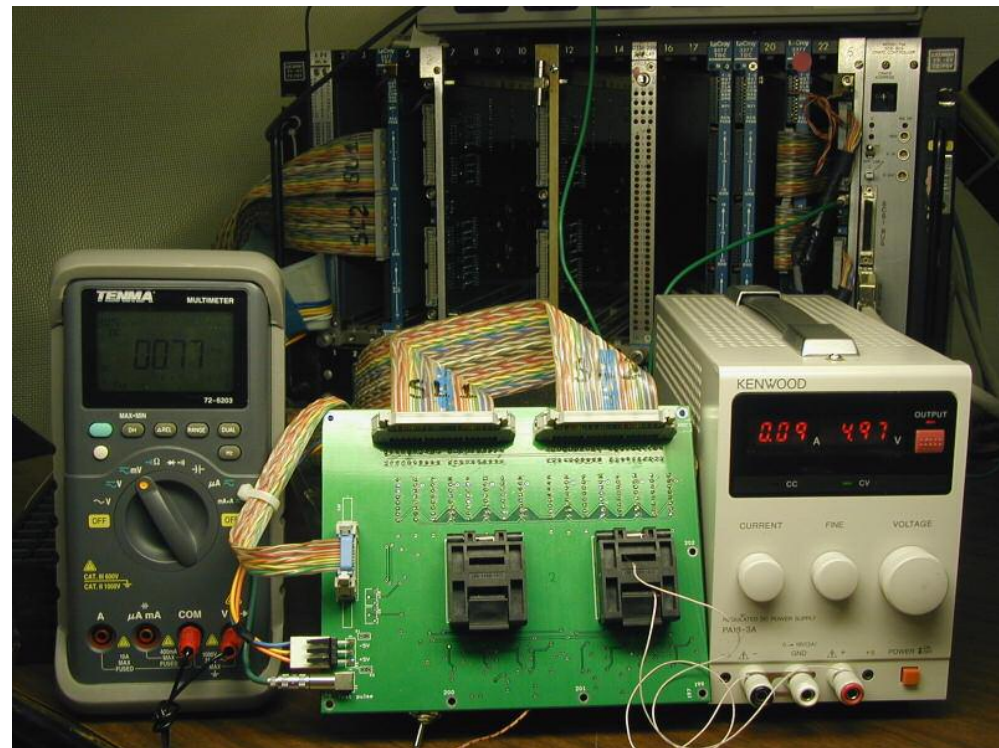
DEL16 Chip Temperature Measurements



Heater: resistor, 50 Ohm, 1 W



Measurement Setup

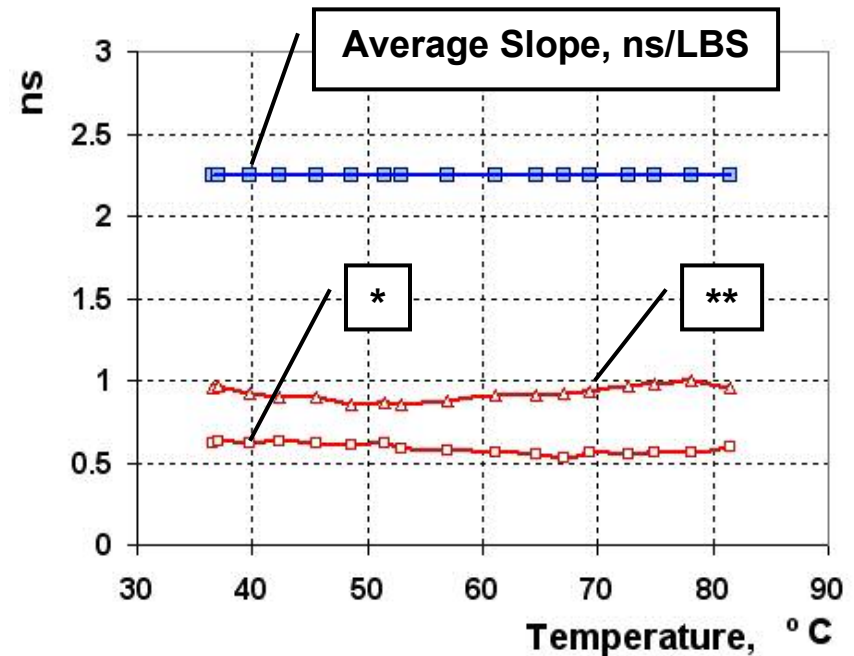
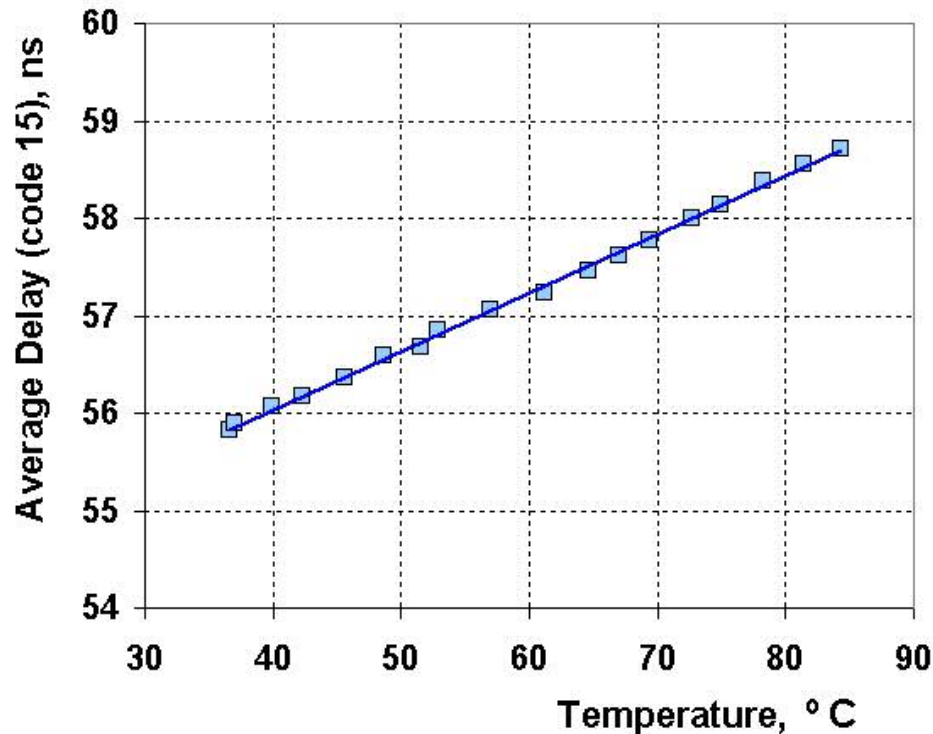




DEL16 Chip Temperature Measurements

Results

- Temperature from 36 ° C to 85 ° C
- Delay for code 15 - 0.6 ns / 10 ° C
- Slope - constant



- *) Maximum delay residual for code 0
**) Maximum delay residual for code 15



Conclusions

- ➔ **We developed and successfully used a specialized set of test equipment, technique and corresponding software.**
- ➔ **The quantity of certified electronics are enough to equip all the chambers of the CMS Muon Endcap System.**
- ➔ **The mass production test of AD16 boards almost finished.**
- ➔ **We tested all DEL16 delay chips.**