PXIE 50 Ohm Fast Kicker: Measurement and Power Test Results of First Half Prototype

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50 Ohm fast kicker prototype (first half)

Feature:
50 Ohm: use available commercial amplifier
Shielded delay lines: reduce coupling/dispersion/rise time.

First half was assembled and power tested (2014, 2015)
Second half has been soldered, measured rf property is identical to the first half
Specification

Specification:

Voltage: 250 V (flat top: 10%)
Power: 625 W
Rise time: < 1ns
Signal travelling time along beam direction should match beam traveling time:
998.65 ps +/- 10 ps (per kicking unit)
Vacuum: 2E-7torr
RF measurement

Network analyzer measurement (22 units):
return loss/insertion loss/phase/dispersion etc.
Delay Time Measurement (Network Analyzer)

Delay time of each unit was controlled to 998.65ps +/- ~ 2 ps (Spec. : +/- 10 ps)

Delay time of 22 units should be (ideally) 21.970 ns
Delay time of 22 units measured with NWA: 21.952 ns
Delay Time Measurement (Oscilloscope/Arbitrary Waveform Generator)

Delay time of 22 units (ideally) 21.970 ns
Delay time measured with scope 21.983 ns
Rise time and delay time (oscilloscope)

Rise time (average):
Input: ~616-695 ps
Output: ~768-842 ps
Kicker: ~459-475 ps
Rise time and delay time (oscilloscope)
Pulse shape (kicker)

Yellow trace: input signal
Cyan trace: output signal

Shows minimum distortion

Asked AWG (arbitrary waveform generator) to generate pulse:
1 ns rise time, 4 ns flat top...

The AWG is really “arbitrary” now...
Pulse shape distortion caused by accessories (all coax line components)
Power test setup (August, 2014)

Directional coupler, load and cables were retested after the kicker test.
Power test setup (May, 2015)

Comark amplifier (3kW 162.5MHz)

15 kW load (water cooled)
Directional couplers, adapters, load and cables were tested at 840 W for 8 hours before kicker test. Return loss/insertion loss at the end of test were the same as at beginning.
Power test results

August, 2014 (250 MHz, CW)
Final 4 hours at:
Forward Power ~593 W, Transmitted Power ~524 W, Reflected Power 9 W (caused by accessories --- confirmed by a separate test without kicker)

May, 2015 (162.5 MHz, CW)
7 days, most time at:
Forward Power ~730-760 W, Transmitted Power 673-698 W, Reflected Power ~ <1 W
Final 8 hours at:
Forward Power ~800 W, Transmitted Power ~739 W, Reflected Power ~ 1.2 W

Vacuum and temperature were monitored. Final vacuum: ~7-8E-8 torr at ~ 800 W

RF property measured before and after power test --- no change.
Power test (August, 2014)
Vacuum during power test (August, 2014)

Fast time plot (180 second)

Ion pump was turned on
Temperature during power test (August, 2014)

At max. power level and power loss ~ 60 W (250MHz) for 4 hours, max. temperature increase of cable was ~ 6.5 F

Cooling water temperature:
In (93.5 – 93.8F) Out (93.3 – 93.6)
Flow rate 1 GPM

Ion pump was turned on
Power test (May, 2015)
Vacuum during power test (May, 2015)

This spike is due to RGA measurement.

Ion pump was turned on.
RGA measurement (May, 2015)

0 power

~ 765 W into the kicker
Temperature during power test (May, 2015)

At ~800W, power loss (~60W), the max. temperature of the cable was 89F.
Calibration - IR measurement before power test

Leftover of shredded fiber of woven insulation material of thermocouple after stripping

Cu electrode
**Electrode temperature during power test (IR measurement) (2014)**

At max. power level and power loss ~ 60 W (250 MHz) for 4 hours (cable high temp. spot was ~ 98F).
Viewport: ~8.75” away from electrode.
High temp. spot (screw head, not slot edge):
~111F(ε=0.55) ~146F(ε=0.25) -> “weighted average” ~135F (~57C)
Low temp. spot (electrode):
~107F(ε=0.55) ~136 F(ε=0.25) -> “weighted average”~120F (~49C)
Not accurate at all --- but may be used as a temp. range estimate
RF measurement before and after power test (May, 2015)

S21 (phase, delay time)
Data: after power test
Memory: before power test
They are identical -> the structure did not change
RF measurement before and after power test (May, 2015)

S21 (magnitude)
Data: after power test
Memory: before power test
They are identical -> the structure did not change
RF measurement before power test (July, 2014)

Insertion loss of full half structure before power test, July 2014
Summary

The first half of the kicker prototype has met and exceeded all specifications.

The rf property of second half has been measured and is identical to the first half…
Thanks

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