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PENN Fast Amp for CMS Detector at CERN

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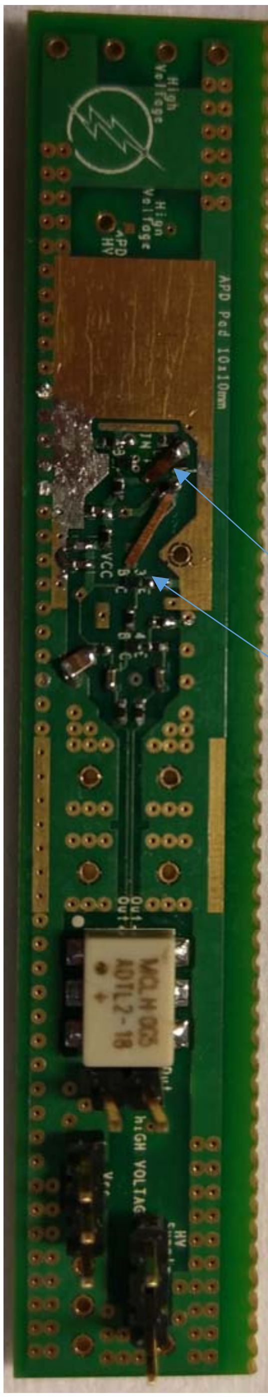
BFR2

Top view of the board:



Notes

- The long strip of copper is connecting a 200 ohm resistor to the base of the third transistor. This was done to reduce stray capacitance at the collector of the second transistor by placing the 200 ohm closer to the second transistor instead.

- The short copper strip is connecting two 1pF capacitors (2pF) from the base of the second transistor to the collector of the first transistor (input transistor).

- Amplifier input impedance is controlled through Vcc. Supply voltage must be 3.9V for an added 22pF capacitance. See discussion below.

Connections

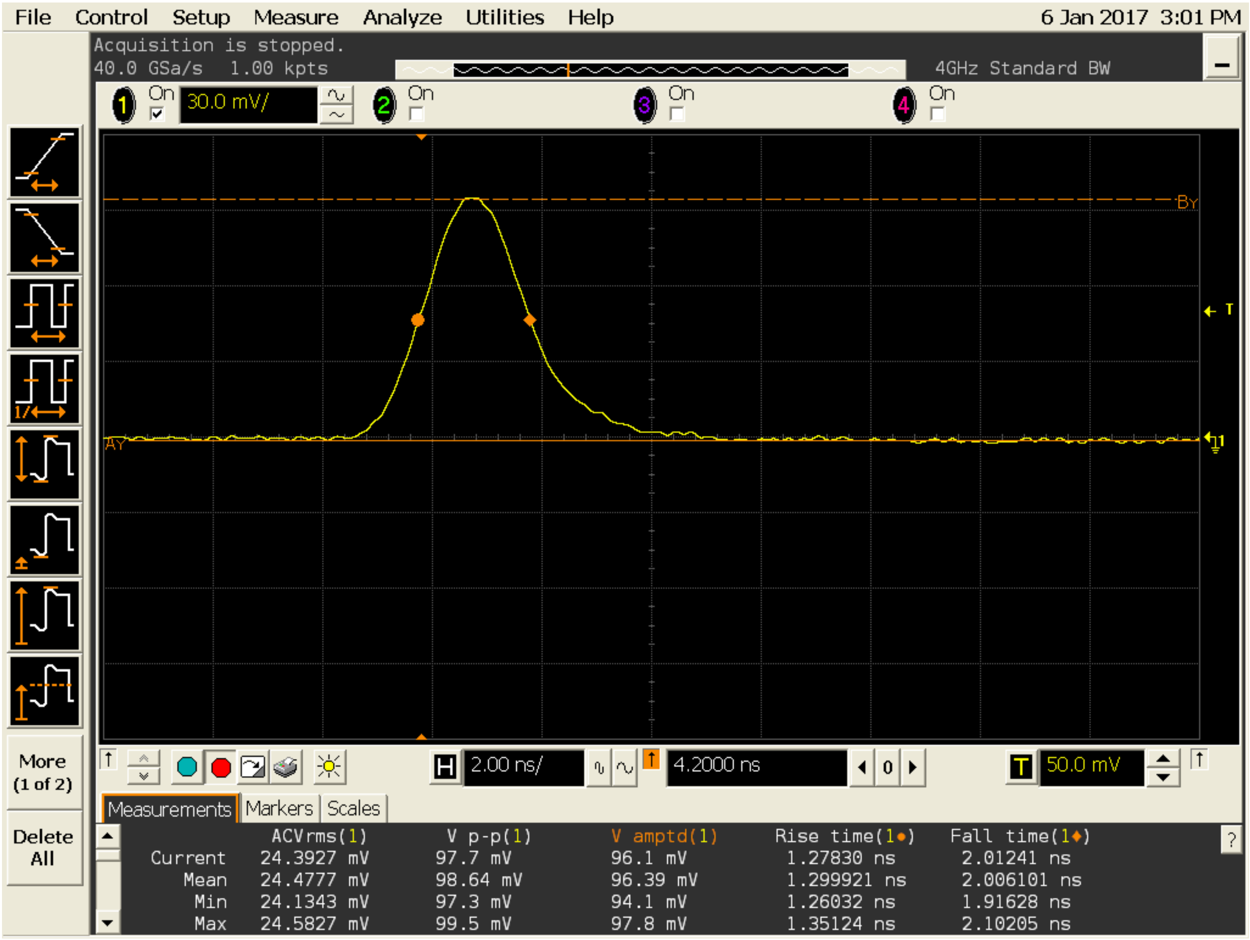
The output of the board is a two pin connector where the bottom pin is ground and the top pin is the signal out. The board's power is delivered by a three pin connector where the middle pin is Vcc and the adjacent pins are ground. For the detector's power, there is a two pin connector the width of a three pin where the leftmost pin (see image below) sets the high voltage for the detector at the other end of the board. The rightmost pin connects to the high voltage return, and is separated from the board's ground reference by a 10k ohm series resistor.

LeCroy Pulser Tests

The charge input into the board is calculated to be 120fC, and has a 1ns rising edge with a 1ns falling edge. The signal coming from the pulser goes through a 0.1uF capacitor and then a 1k ohm resistor before going into the input node. The input charge from the pulser was measured by integrating the voltage at the end of the pulser cable on the scope and dividing by the 1000 ohm resistance that was not part of the scope readout. The output voltage is in good agreement with SPICE simulations of the circuit.

The first two images below show the voltage response of the amplifier with NO added capacitance for the 120fC input signal. The amplifier output was measured with a 50 ohm load into a 4GHz scope (on loan from Princeton).

Sample 1: No Detector Capacitance



- V_{cc}: 3.8V
- $V_{amplitude}$: 96.1mV
- $T_{leading\ edge}$: 1.28ns

Increasing Vcc above 3.8V didn't change the behavior of the output signal.

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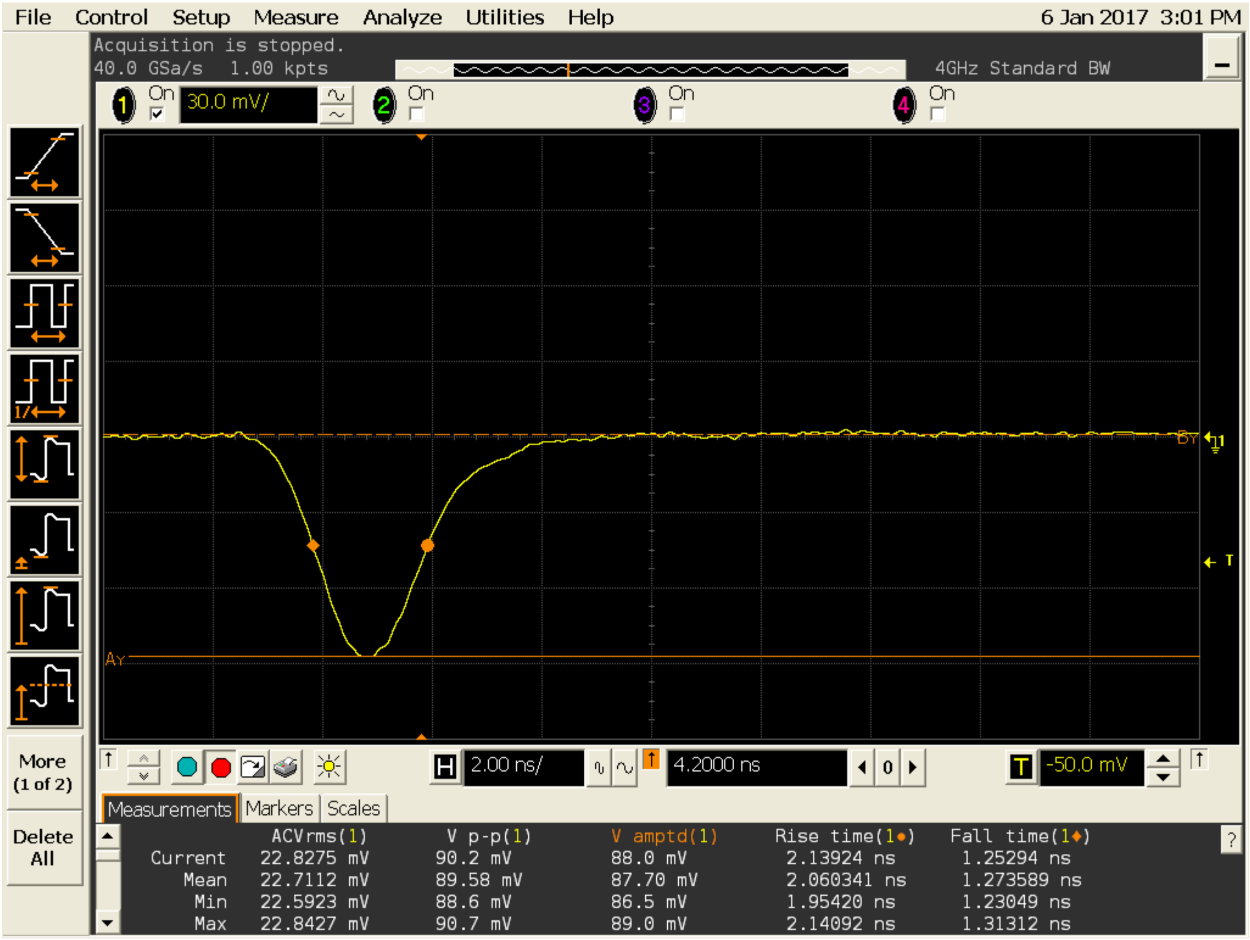
Sample 2: No Detector Capacitance



- V_{cc}: 3.8V
- $V_{amplitude}$: 88.0mV
- $T_{leading\ edge}$: 1.25ns

Increasing Vcc above 3.8V didn't change the behavior of the output signal.

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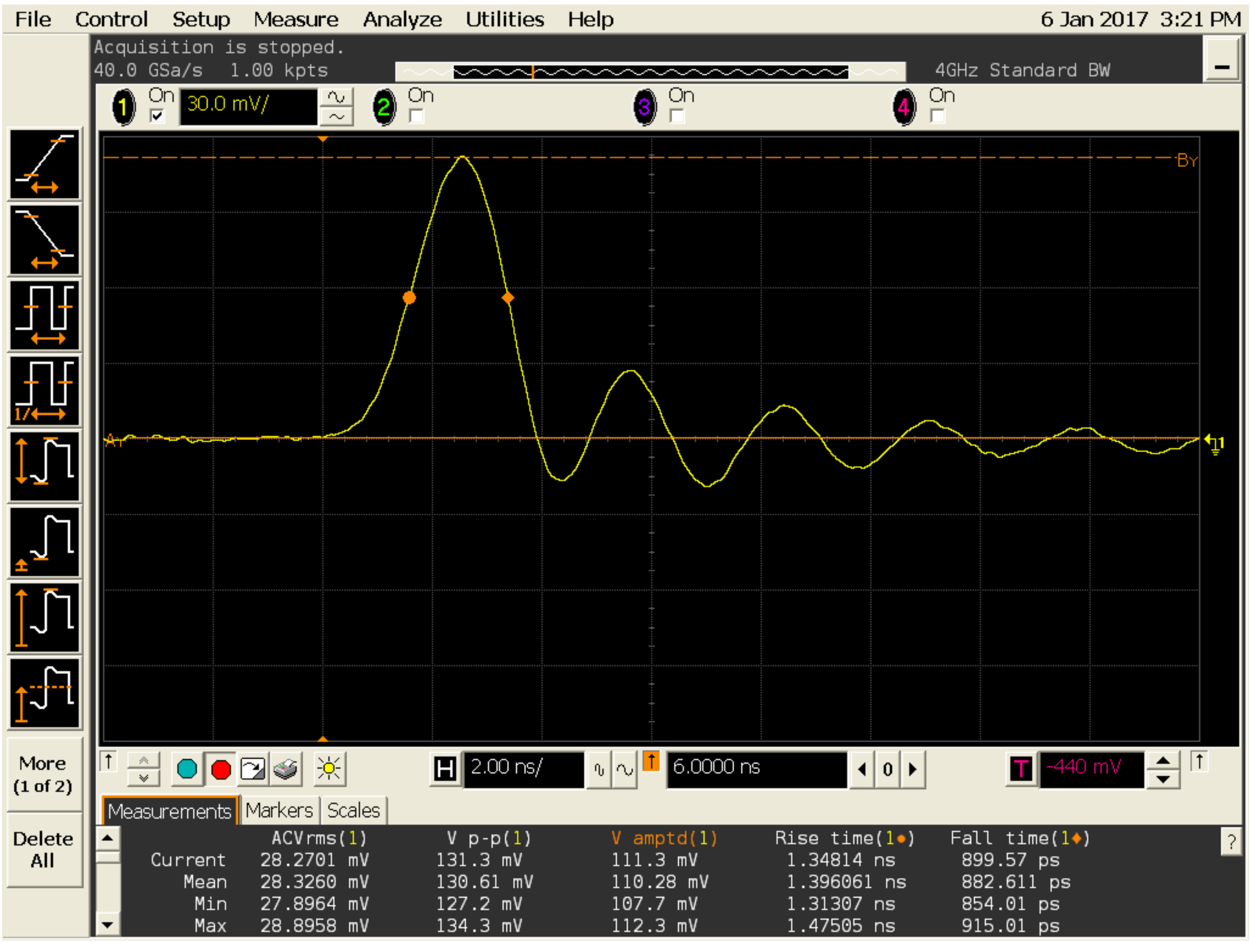
- The following measurements were taken with the same setup but with a 22pF capacitor added at the amplifier input to mimic the maximum estimated screen capacitance from an 8X8mm APD.

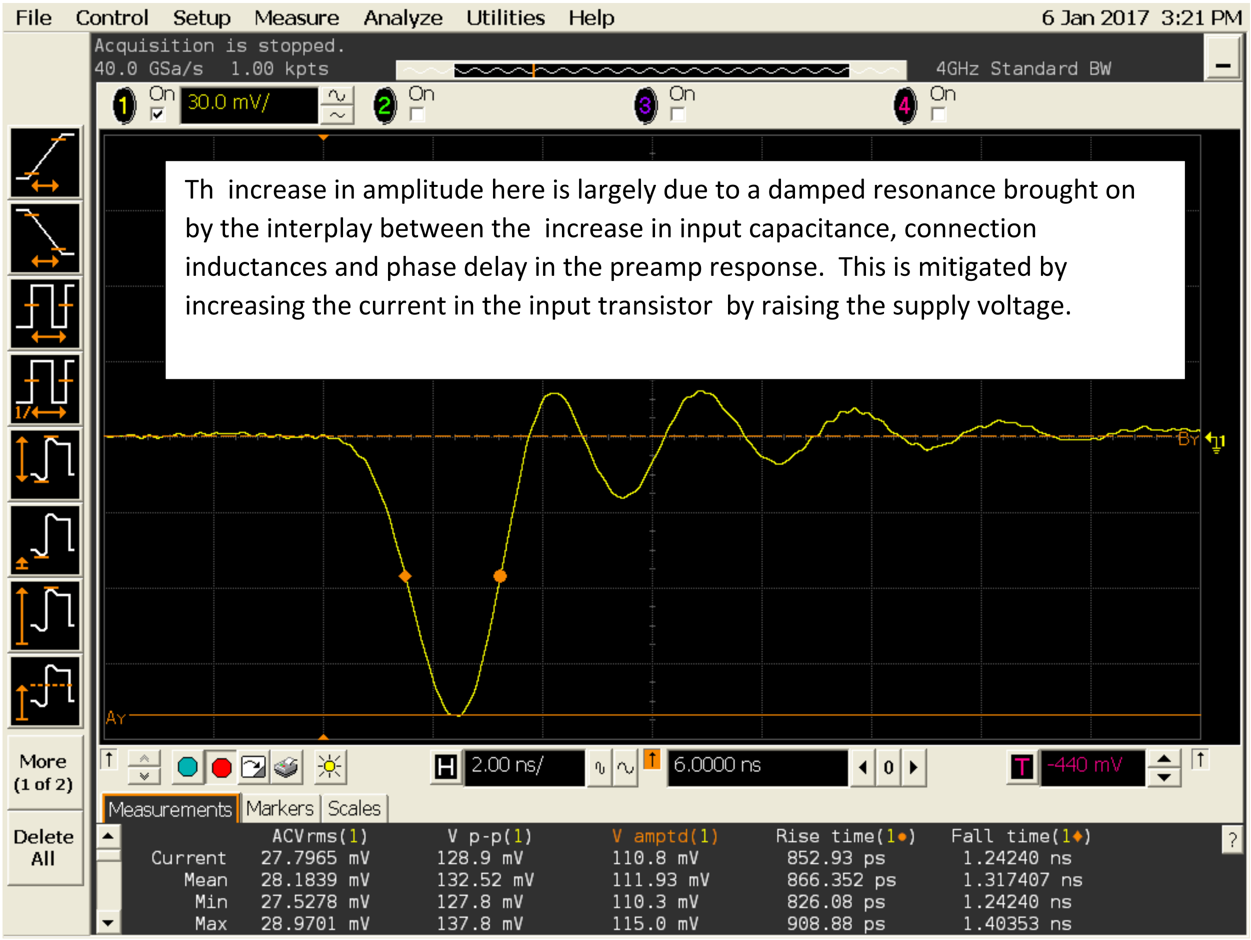
Sample 3: 22pF Detector Capacitance



- V_{cc}: 3.9V
- $V_{amplitude}$: 111mV
- $T_{leading\ edge}$: 1.35ns

The circuit oscillates with a supply voltage lower than 3.9V. LTspice shows that the current through the collector of the input transistor should be 11.6mA.

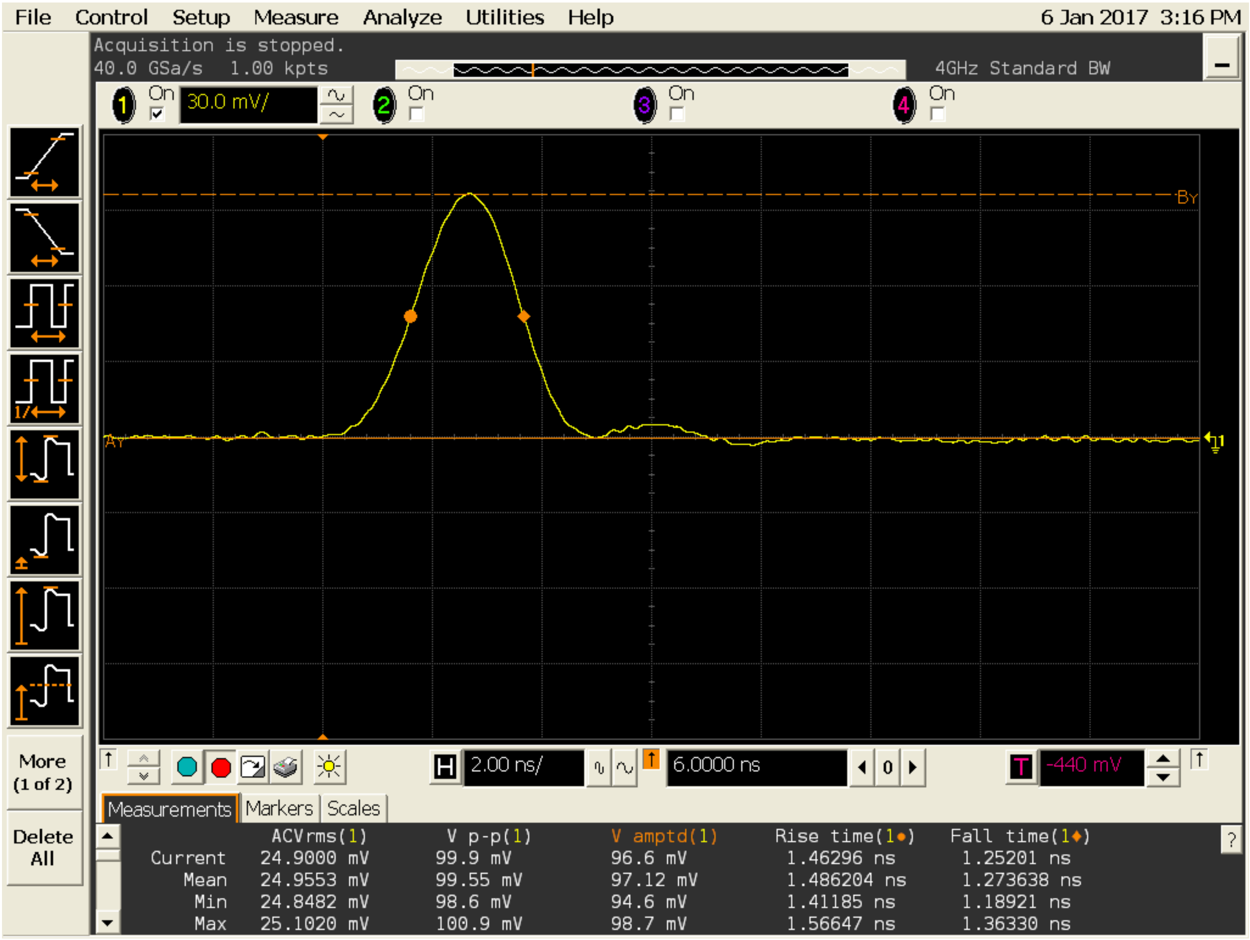
Sample 4: 22pF Detector Capacitance



- V_{cc}: 3.9V
- $V_{amplitude}$: 111mV
- $T_{leading\ edge}$: 1.24ns

Under 3.9V there are oscillations. LTspice shows that the current through the collector of the input transistor should be 11.6mA.

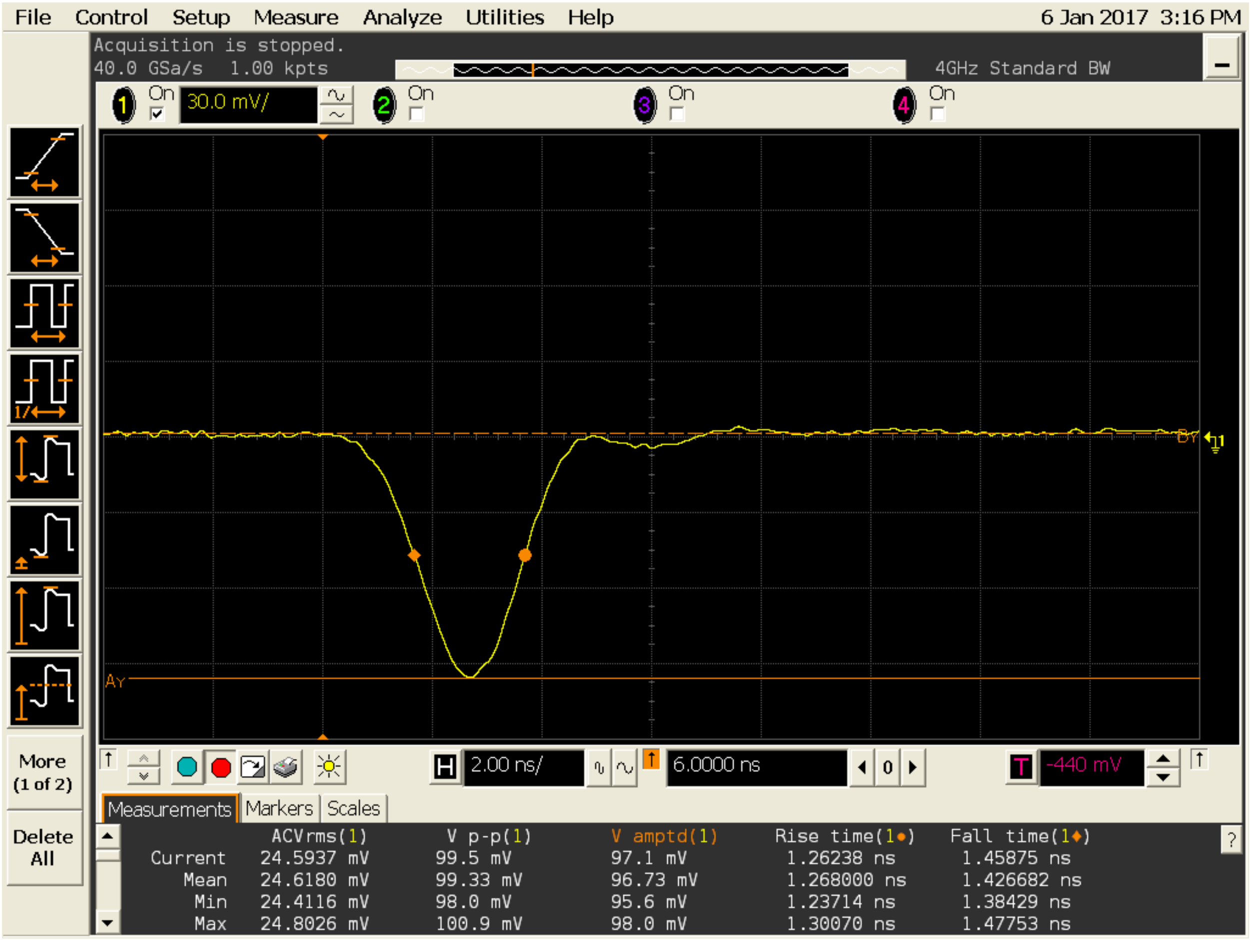
Sample 5: 22pF Detector Capacitance



- V_{cc}: 4.2V
- $V_{amplitude}$: 96.6mV
- $T_{leading\ edge}$: .1.46ns

Going over 4.2V doesn't make much difference. LTspice shows that the current through the collector of the input transistor is 13.8mA.

Sample 6: 22pF Detector Capacitance



- V_{cc}: 4.2V
- $V_{amplitude}$: 97.1mV
- $T_{leading\ edge}$: 1.42ns

Going over 4.2V doesn't make much difference. LTspice shows that the current through the collector of the input transistor is 13.8mA.

Conclusions from Amplifier Bench Tests without an APD

- The Discrete AMP has been shown to be stable (with input Voltage adjustment) for a detector capacitance of 0 and 22pF covering the range of expected values from a screened RMD 8X8mm APD.
- The change in the leading edge time observed is 210pS between 0 and 22pF of added input capacitance suggesting a very low input impedance of 10 ohms or less consistent with the intended circuit design. The fact that the measured output amplitude with 22pF of input capacitance is nearly the same as with 0pF input capacitance suggests that

the same amount of signal charge is being integrated by the amplifier and thus there is a very low loss of signal for the larger input capacitance.

- Note the measured noise referred to the input is approximately 1/3 fC with 22pF input capacitance and not measureable with our equipment for the case with no added input capacitance.

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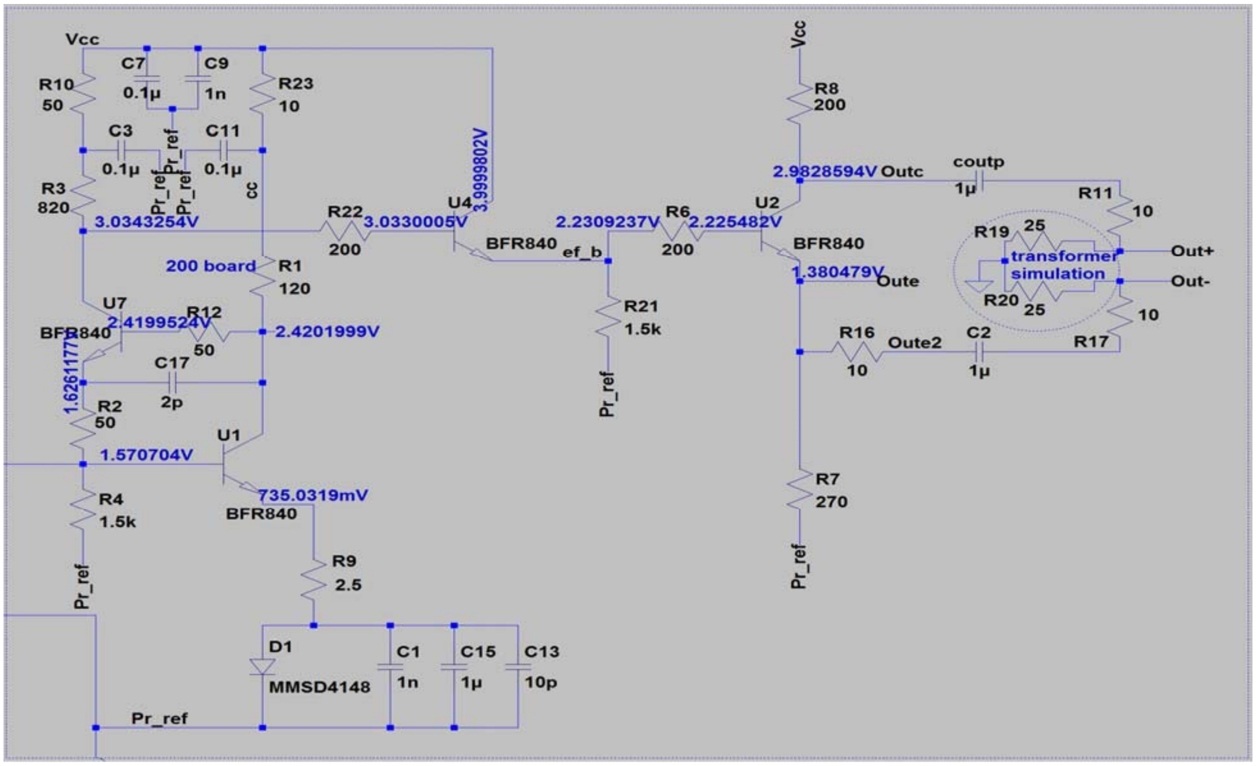
LT Spice Schematic

This design is optimized for discrete component transistors. It does not reflect the power or final configuration we would use in an ASIC preamp.



Varying the voltage from 3.5V to 4.5V on LTspice shows the following current draw at R1:

Vcc (V)	R1 current (mA)
3.5	8.7
3.6	9.49
3.7	10.2
3.8	10.9
3.9	11.6
4.0	12.3
4.1	13.0
4.2	13.8
4.3	14.5
4.4	15.2
4.5	15.9