Receiver Shaper Setup for GPC01

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Goals

- Convert the board from CLAS preamp input requirements (which were the basis of the original design) to GAS-1 / GPC-01 input requirements.
- Set input impedance to 100 Ω (new cable) instead of 131 Ω (conventional twist-n-flat)..
- Set full scale input range so that preamp nonlinearity turns on somewhere at the 60-80% full scale range. In other words, we want to set the gain a bit lower than it probably will be set with the ADC125 boards. Setting it too high now may improve SNR for some detector tests but will preclude effective studies of the actual linear operating range with detector pulses and quantitative studies of the desired gain for ADC125 and/or GAS-2. Fortunately, the GAS-1 noise is quite low and this goal doesn't compromise much.
- Have a pulse shape similar to GPC-01 + cable + ADC125. In an attempt to minimize the component changes, "similar" is interpreted to mean "within 10 – 15 % or so" as regards peaking time or percentage tail remaining after 3 – 4 peaking times.
- Overall peaking time something like 24 ns.
- Incorporate proper frequency equalization for the 18 m cable.
- Assume the GAS-1 / GPC-01 detector tail cancellation is perfect (which is pretty near true). In other words, the frequency equalization circuit on the receiver/shaper board, previously used to cancel detector tail with the CLAS preamp, is now used exclusively for cable frequency equalization. In practice, this means the component values are picked for a flat step response from the combination 18 m cable (with source termination) + receiver/shaper board.
- For boards which might be used for crosstalk measurements, terminate all lines including the 8 unused ones. This is probably of little or no practical effect, so it need not be done for boards which are just used for detector tests.

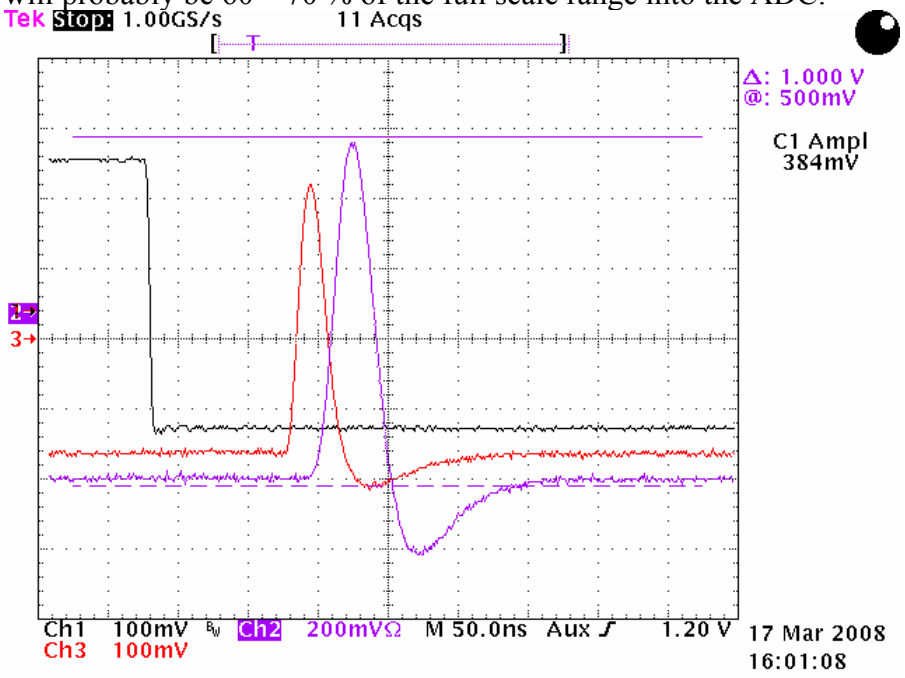
Assumptions

- The Struck ADC is set up for a 1.0 V full scale range. Whether that is -1.0 to 0.0 V, or -0.5 to 0.5 V, or whatever, is irrelevant – both the receiver/shaper and the Struck ADC have nice offset controls to play with.
- The preamp card has termination resistors (59.0 Ω) installed. This of course cuts the voltage swing on the cable by about a factor of 2.
- The goals above apply to the "anode" version of the receiver/shaper board. The "cathode" version is identical except it has 5× higher gain. The same changes (detailed below) should be applied to the "cathode" boards, but for those of course the full scale range at the ADC will be rather less than the GAS-1 can deliver.
- I don't care about polarity. You shouldn't either. Flip the bits in software if required.

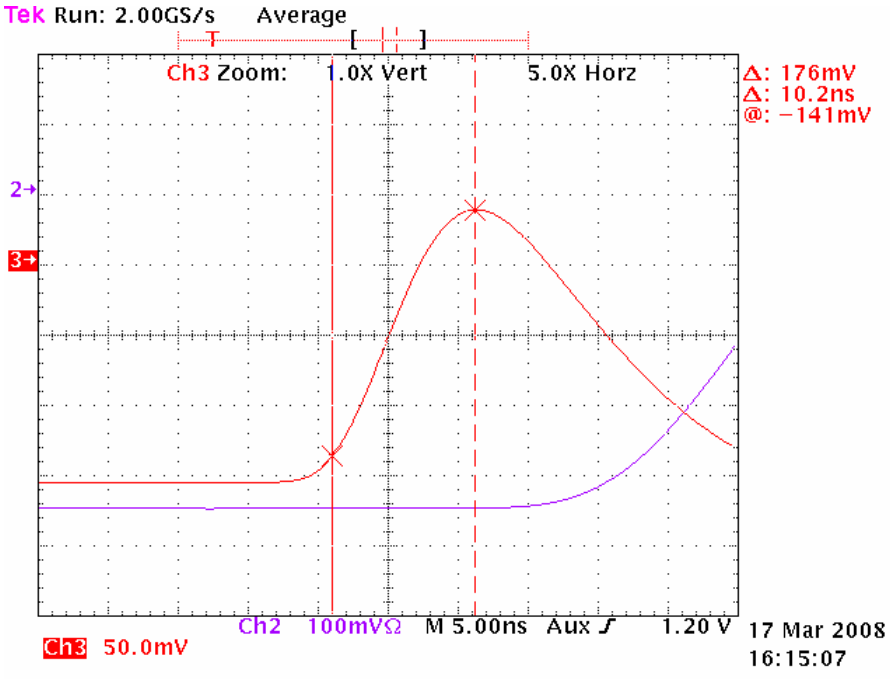
- If you do care about polarity, and it is not what you want, feel free to swap each of the differential pairs on one of the cable connectors.

Performance/Tests

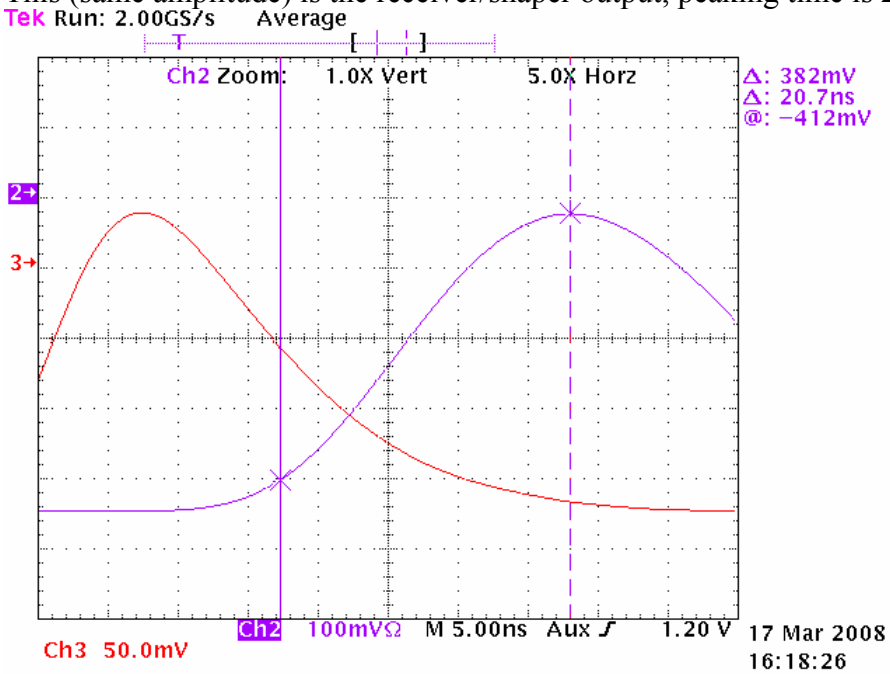
Response of the GPC-01 (ch3, red) and the receiver/shaper output (ch2, purple) to a 768 fC instantaneous charge input (ch1, blk, into 2.0±0.1 pF capacitor). This is a nearly full scale (1.0 V) output to the ADC, and is about double the good linear range (300 fC) of the GAS-1 for instantaneous charge input. For detector pulses the good linear range will probably be 60 – 70 % of the full scale range into the ADC.



This is (for a smaller amplitude) the GAS-1 / GPC-01 output, peaking time measured from 10% to 100% is 10.2 ns. This is measured at receiver/shaper input terminals, i.e., the pulse shape here is a combination of the preamp and cable frequency responses.

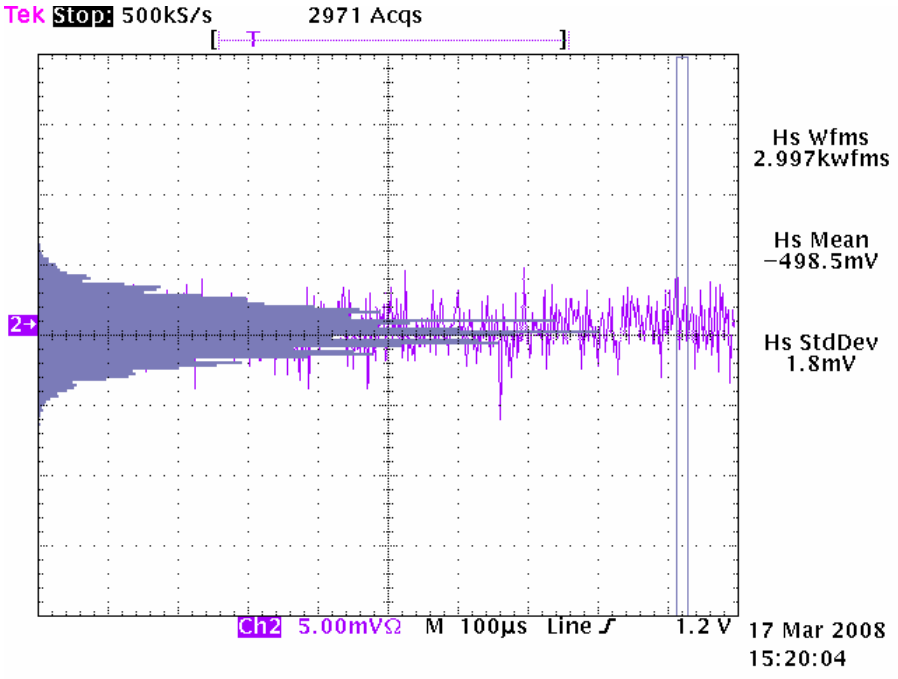


This (same amplitude) is the receiver/shaper output, peaking time is 20.7 ns.

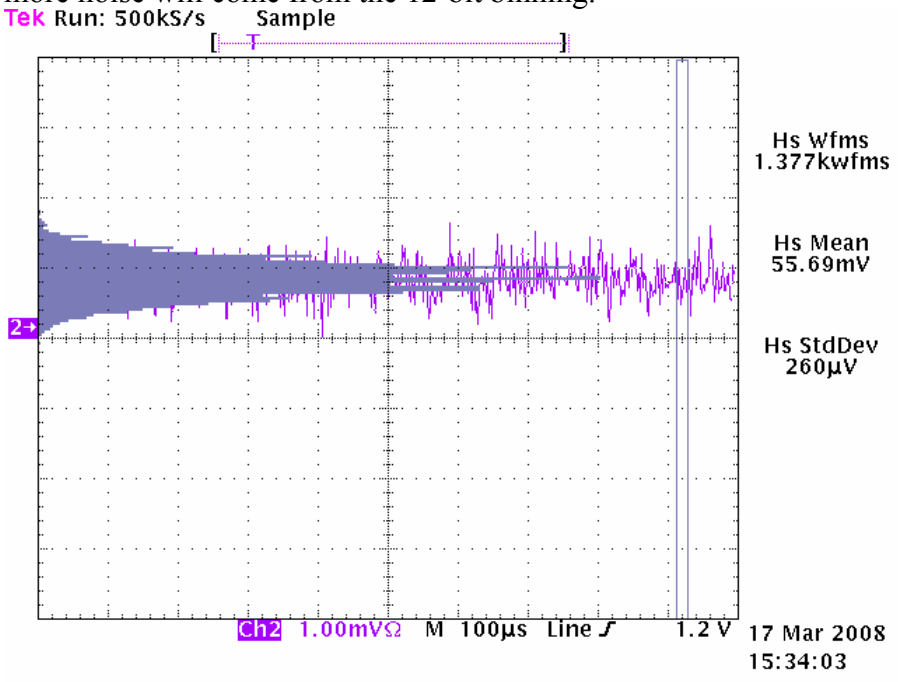


Here's the noise level, 1.8 mV rms, with 2 pF capacitance at the GPC-01 input. Referring* to input charge (instantaneous) this is 1.1 fC, i.e., 6800 electrons. Tbis value would be slightly different in reference to a detector pulse shape.

* The small-signal gain from GPC-01 input to receiver/shaper output is measured to be 1/(609 fF), i.e., 1.64 mV/fC. This is of course influenced by the additional shaping.



Here is the noise when the preamp power is switched off. It is basically the same as removing the preamp card and terminating the lines with 100 Ω resistors. But that is less convenient. Noise is about 14 % of the full noise, i.e., if the receiver/shaper and cable contributed no noise, the overall noise level would be reduced by 1.05 %. That is good enough. The performance of ADC125 analog front end is expected to be similar. Slightly more noise will come from the 12-bit binning.



The component changes

1. Second leg of input attenuator, replace the resistors, this lowers the gain and fixes the input impedance. New value is 61.9 Ω.
    a. Part number: Vishay/Dale CRCW060361R9FKEA
    b. Refdes: R239, R241, R243, R245, R247, R249, R251, R253, R255, R257, R259, R261, R263, R265, R267, R269, R271, R273, R275, R277, R279, R281, R283, R285, R287, R289, R291, R293, R295, R297, R299, R301
2. Longer time constant equalization resistor, replace, new value is 68.1 Ω.
    a. Part number: Vishay/Dale CRCW060368R1FKEA
    b. Refdes: R6, R14, R20, R28, R36, R45, R51, R59, R185, R193, R199, R207, R213, R223, R230, R238
3. Longer time constant equalization capacitor, replace, new value is 2.2 nF, must be an NP0/C0G type.
    a. Part number: KOA NPO0805HTTE222J – note this is an 0805 part, the footprint is for 0603, but it fits ok with a little extra care in soldering – sorry!
    b. Refdes: C7, C16, C23, C32, C40, C50, C57, C67, C83, C93, C100, C109, C116, C127, C134, C143
4. Shorter time constant equalization resistor, replace, new value is 232 Ω.
    a. Part number: Vishay/Dale CRCW0603232RFKEA
    b. Refdes: R5, R13, R19, R27, R35, R44, R50, R58, R184, R192, R198, R206, R212, R222, R229, R237
5. (Optional) add termination at input connector on the 8 unused pairs. This requires an 0201 resistor, 100 Ω. Rather difficult to handle these, I wouldn't recommend doing this part except if really necessary for some tests.
    a. Part number: CRCW02011100RFNED
    b. Refdes: N/A