Description

The CR-200 is a single channel shaping amplifier, intended to be used to read out the signals from charge sensitive preamplifiers. Gaussian shaping amplifiers (also known as pulse amplifiers, linear amplifiers, or spectroscopy amplifiers) accept a step-like input pulse and produce an output pulse shaped like a Gaussian function. The purposes of this are to filter much of the noise from the signal of interest and to pro-vide a quickly restored baseline to allow for higher counting rates. The CR-200 is available in 7 different shaping times: 100 ns, 250 ns, 500 ns, 1 µs, 2 µs, 4 µs, and 8 µs. Each has a fixed gain of 10. If additional gain is desired, it is recommen-ded that this be done with the application of an additional amplifier between the preamplifier and the CR-200 shaping amplifier. Cremat offers an evaluation board (CR-160) which includes a multi-stage variable-gain amplifier, as well as all necessary connectors. More information on the CR-160 eva-luation board can be found at http://www.fastcomtec.com
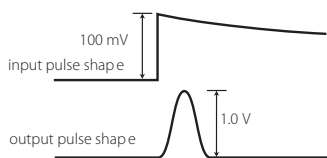

Figure 1. Comparison of sample input and output pulse shapes

Definition of „Shaping Time"

The shaping time is defined as the time-equivalent of the „standard deviation" of the Gaussian output pulse. A simpler measurement to make in the laboratory is the full width of the pulse at half of it's maximum value (FWHM). This value is greater than the shaping time by a factor of 2.4. For example, a Gaussian shaping amplifier with a shaping time of 1.0 µs would have a FWHM of 2.4 µs.

Equivalent circuit diagram

Figure 2 shows an equivalent circuit. Pin numbers corres-ponding with the CR-200 shaping amplifier are shown. Input components Cin and Rin form a differentiating circuit. The following circuitry consists of two Sallen and Key filters, pro-viding 4 poles of integration and signal gain. The numerous integration stages produce an output pulse that approxima-tes a Gaussian function.
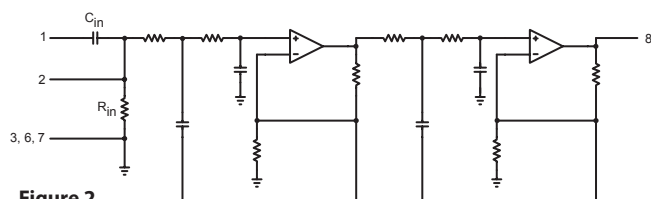

Figure 2.

Pole/Zero Correction

The long decay time of the input pulse creates a small overshoot in the shape of the ≠output pulse unless a pole/zero correction is utilized. This can be done by connecting a resistor (RP/Z) between pin 1 (input) and pin 2 (P/Z). This resistor is in parallel with the input capacitor (internal to the CR-200 circuit) and creates a 'zero' in the amplifier's transfer function which cancels the 'pole' created by the charge sen-sitive preamplifier's feedback resistor. To achieve proper pole/zero cancellation, RP/Z should be selected to be equal to Rf*Cf/Cin where Rf and Cf are the feedback resistor and feed-back capacitor of the charge sensitive preamplifier and Cin is the value of the input capacitor in the CR-200. The value of Cin for the CR-200 circuit can be found in the provided table. Keep in mind that adding RP/Z will likely affect the DC offset of the shaping amplifier output. This is because RP/Z directly couples the DC offset from the charge sensitive preamplifier output into the shaping amplifier input. Some fraction of this DC offset is amplified along with the pulse. It is recom-mended that instrumentation which includes the CR-200 include a DC offset adjustment to be used to correct for this. An example of this can be found in the design of the CR-160 evaluation board found here: http://www.cremat.com/CR-160schematic.pdf . You may wish to realize RP/Z as a potenti-ometer so to adjust the value precisely. The effect of RP/Z on the pulse shape can be seen in the pulse waveforms shown in Figure 3.
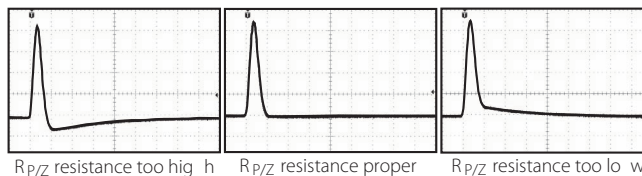

R $_{P/Z}$ resistance too high   R $_{P/Z}$ resistance proper   R $_{P/Z}$ resistance too low

Figure 3.

Baseline Restoration (BLR)

The CR-200 does not contain active baseline restoration circuitry. For this reason there will be a negative 'baseline shift' (change in the output DC offset) at high counting rates. In order to determine whether this will be a problem for your application, use the equation (valid for small baseline shifts):

$$S/H = R * \tau * 2.5 \times 10^{-6}$$

where S is the negative baseline shift, H is the pulse height, R is the count rate (counts/sec), and τ is the shaping time of the shaping amplifier (in µs). For example, using a 1 µs shaping amplifier we would predict a 0.025 (2.5%) shift in the baseline at a count rate of 10,000 counts per second. To address this potential problem, Cremat offers the CR-210 baseline restorer. More information on this circuit can be found at the fastcomtec.com website.

Package Specifications

The CR-200 circuit is contacted via an 8-pin SIP connection (0.100" spacing). Pin 1 is marked with a white dot for identification.
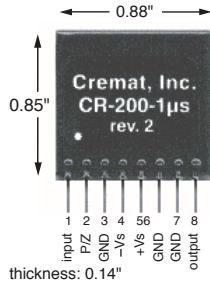
Figure 4

0.88"
0.85"
Cremat, Inc.
CR-200-1µs
rev. 2

1 2 3 4 56 7 8
input P/Z GND –Vs +Vs GND GND output

thickness: 0.14"

Typical Application

Figure 6 shows the CR-200 in a typical application, coupled to a detector via a CR-110 charge sensitive preamplifier. Depending on the requirements of your application, an AC-coupled amplifier may be added between the preamplifier and shaping amplifier to further increase the signal size.
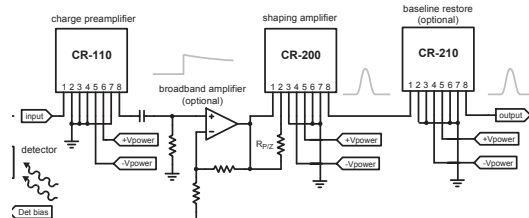
Figure 5

Choosing the Optimal Shaping Time for your Application

There are a number of considerations in the choice of the optimal shaping time for your application. Consider:

1. The shaping time must be long enough to collect the charge from the detector. This may be a limiting factor in slow detectors such as gas-based drift chambers or when collecting the light from slow-decay scintillators.

2. The shaping time must be short enough to achieve the high counting rates you require. Assuming randomly spaced pulses, long-shaped pulses have a higher probability of 'piling up' than short pulses. Note that 'pile-up' will only be a problem at very high count rates; 'Baseline shift' will start to be a problem at somewhat lower count rates. See the previous section regarding 'Baseline Restoration'.

3. Choose a shaping time that filters as much of the electronic noise as possible. Electronic noise at the preamplifier output is created by a number of different aspects of the detection system. Many of these 'noise components' have different power spectra, allowing us to use the filtering capability of the shaping amplifier to choose a shaping time that minimizes the noise for the particular detection system under design. Keep in mind it may be difficult to precisely predict the shaping time at which the noise will be minimum. The surest method may be to determine this noise minimum experimentally by measuring the noise using a variety of shaping times.

### Example: Shaping Amplifier used in Nuclear Pulse Detection

Shown below are two oscilloscope traces: the input (blue) and output (yellow) of a Gaussian shaping amplifier (1µs shaping time) reading pulses from a charge sensitive preamplifier in the presence of noise. Not only does the shaping amplifier amplify the pulses, but the fall time is quickened, greatly reducing the problem of pulses 'piling up' on the tails of preceding pulses. Also, the filtering effects of the shaping amplifier significantly filters the noise. This allows for pulses to be clearly detected that would be otherwise buried within the noise.

Output Characteristics

The CR-200 shaping amplifiers have low output impedance (<5Ω) and can source/sink 10 mA of output current. This may not be sufficient to drive a terminated cable in your application, depending on the size of the signal. For this reason it is best to use a cable driver circuit at the CR-200 output to make maximum use of the CR-200 output voltage swing capability. The unloaded output voltage swing comes to within 0.5 volt of the power supply rails.
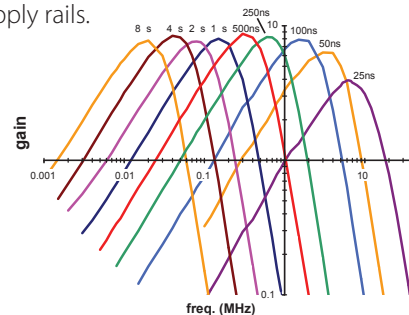
CR-200 Bandpass filtering properties
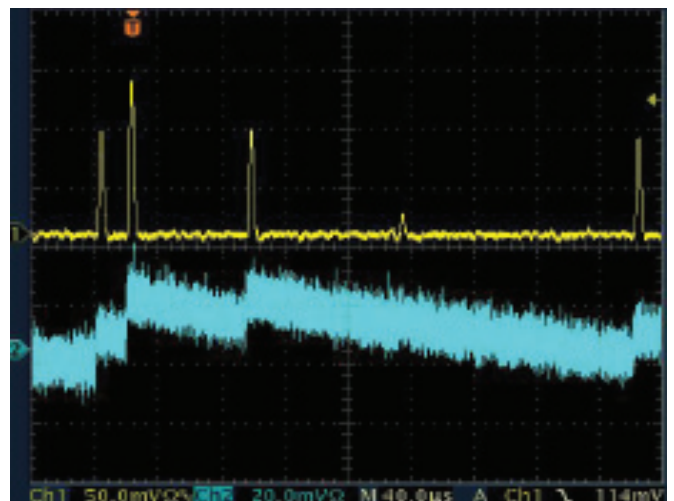
For optional bipolar shaping (see section on „Baseline Restoration" and Figure 4)

part #	shaping time	output pulse width (FWHM)	R_{in}	C_{in}	R_{out}	C_{out}	gain
CR-200-25ns	25 ns	59 ns	82 Ω	220 pF	50 Ω	x pF	4
CR-200-50 ns	50ns	120 ns	220 Ω	220 pF	50 Ω	x pF	8
CR-200-100ns	100 ns	240 ns	220 Ω	470 pF	50 Ω	2200 pF	10
CR-200-250 ns	250ns	590 ns	240 Ω	1000 pF	50 Ω	4700 pF	10
CR-200-500ns	500 ns	1.2 μs	510 Ω	1000 pF	50 Ω	0.01 μF	10
CR-200-1μs	1 μs	2.4 μs	1.0 kΩ	1000 pF	50 Ω	0.022 μF	10
CR-200-2μs	2 μs	4.7 μs	2.0 kΩ	1000 pF	50 Ω	0.039 μF	10
CR-200-4μs	4 μs	9.4 μs	1.2 kΩ	3300 pF	50 Ω	0.082 μF	10
CR-200-8μs	8 μs	19 μs	2.4 kΩ	3300 pF	50 Ω	0.15 μF	10

see ‚equivalent circuit diagram' on previous page.

Specifications Assume temp =20°C, Vs = 9V, unloaded output		
-	CR-200	units
amplification channels	1	-
gain	10	-
polarity	non-inverting	-
operating temperature range	-40 C to 85 C	-

input noise voltage		
CR-200-25ns	160	μV RMS
CR-200-50ns	115	μV RMS
CR-200-100ns	90	μV RMS
CR-200-250ns	60	μV RMS
CR-200-500ns	47	μV RMS
CR-200-1μs	36	μV RMS
CR-200-2μs	30	μV RMS
CR-200-4μs	24	μV RMS
CR-200-8μs	22	μV RMS

output impedance	<5	Ω
output offset	-40 to +40	mV
output temperature coefficient	-60 to +60	μV / C

power supply voltage (Vs)		
maximum	$V_S = +$ - 12	volts
minimum	$V_S = +$ - 6	volts

quiescent power supply current	7	mA
maximum output current	10	mA
maximum output swing	+ - 8.5	volts
operating temperature range	- 40 C to 85 C	-