CR-113 charge sensitive preamplifier: application guide

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General Description

Cremat's CR-113 is a single channel charge sensitive preamplifier module intended for use with various types of radiation detectors. The CR-113 is one of a series of four charge sensitive preamplifiers offered by Cremat, which differ from each other most notably by their gain. A guide to selecting the best charge sensitive preamplifier for your application can be found at our web site: http://cremat.com. As with all Cremat's preamplifier modules, the CR-113 is small (less than one square inch in area), allowing for compact multichannel detection systems to be constructed using a modular design.

Detector coupling

The CR-113 can be used either in a direct coupled (DC) mode, or an AC coupled mode. If the average detector current exceeds 10 µA, it is recommended that an AC coupled mode be used to prevent the resulting DC offset of the preamplifier output from saturating. Low frequency detector current (e.g. 'dark' current, or leakage current) produces an offset in the preamplifier output voltage at a rate of 70 mV per µA. The use of AC coupling also is useful in improving the counting rate capability of the preamplifier. A schematic diagram of an AC-coupled charge sensitive preamplifier detection circuit can be found at **http://cremat.com/CSP_app_notes.htm**

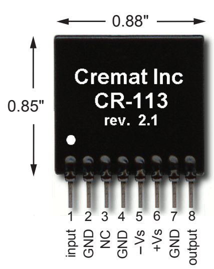


Figure 1

Package Specifications

The CR-113 circuit is contacted via an 8-pin SIP connection (0.100" spacing). Leads are 0.020 inches wide. Pin 1 is marked with a white dot for identification.

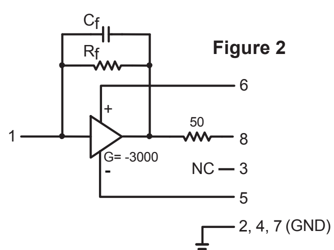


Figure 2

Equivalent circuit diagram

Figure 2 above shows a simplified equivalent circuit diagram of the CR-113, which is a single stage amplifier. Pin numbers corresponding with the CR-113 preamplifier are shown. R_f (68 kΩ) and C_f (750 pF) are the feedback resistor and capacitor respectively. This RC produces the 50 µs decay time evident in each pulse.

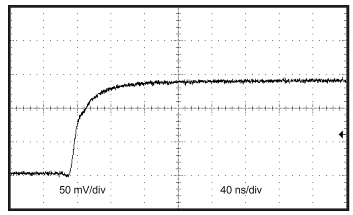
Output waveform

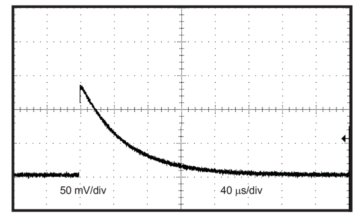
Charge sensitive preamplifiers are used when radiation is detected as a series of pulses, resulting in brief bursts of current flowing into or out of the preamplifier input. Depending on the type of detector, this burst of current may be very brief (<1 ns) or as long as a few µs. For an idealized detection current pulse taking the form of a delta function, the detected charge (time integral of the input current) will ideally take the form of a step function.

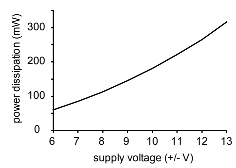
The output waveform of an actual charge sensitive preamplifier will of course have a non-zero rise time: for the CR-113 this figure is approximately 1 ns. Furthermore, capacitance at the preamplifier input (i.e. detector capacitance) will further slow the rise time at a rate of 0.09 ns/pF.

Keep in mind the output rise time will also be limited by the speed of the detector. For example, the detection current pulse from a CsI(Tl)/PMT scintillation detector has a duration of approximately a couple µs, so the expected rise time of the charge sensitive preamplifier output will be at least that long.

The output waveform of the CR-113 using a plastic scintillator/PMT detector is shown below to the left. At long time domains, the output decays due to the discharge of the feedback capacitor through the feedback resistor, with an RC time constant of 50 µs. This decay of the output waveform is also shown below, to the right.







The power dissipation of the CR-113 is shown to the left as a function of supply voltage. The minimum supply voltage for good operation is +/- 6V. Any supply voltage applied in excess of this figure does not change or improve CR-113 performance, but instead results in unnecessary power dissipation.

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Specifications

Assume temp =20 °C, V_s = ±6V, unloaded output

	CR-113	units
Preamplification channels	1	
Equivalent noise charge (ENC)*		
ENC RMS	18,000	electrons
	3	femtoCoul.
ENC slope	30	elect. RMS /pF
Gain	1.3	mV / picoCoul.
Rise time **	1	ns
Decay time constant	50	µs
Unsaturated output swing	-3 to +3	volts
Maximum charge detectable per event	1.3×10^{10}	electrons
	2.1	nanoCoul.
Power supply voltage (V_s)		
maximum	V_s = ±13	volts
minimum	V_s = ±6	volts
Power supply current (pos)	5	mA
(neg)	5	mA
Power dissipation with no load	70	mW
Operating temperature	-40 to +85	°C
Output offset	+0.2 to -0.2	volts
Output impedance	50	ohms

* Measured with input unconnected, using Gaussian shaping amplifier with time constant =1 µs. With a detector attached to the input, noise from the detector capacitance, leakage current, and dielectric losses will add to this figure.

** Pulse rise time (defined as the time to attain 90% of maximum value) has a linear relationship with input capacitance. Value cited in the table assumes zero added input capacitance. To calculate pulse rise time for practical situations, use the equation: $t_r = 0.09\ C_d + 1$ ns, where t_r is the pulse rise time in ns, and C_d is the added capacitance (e.g. detector capacitance) in pF. Keep in mind that others factors within the detection system may further limit this value.