CR-111 charge sensitive preamplifier: application guide

Rev. 1 (Mar. 2006)

General Description

Cremat's CR-111 is a single channel charge sensitive preamplifier intended for use with various types of radiation detectors including semiconductor detectors (e.g. CdTe and CZT), p-i-n photodiodes, avalanche photodiodes (APDs), and various gas-based detectors. The CR-111 is small (less than one square inch in area), allowing for compact multichannel detection systems to be created using a modular design.

Other preamplifier choices

The CR-111 is similar in many respects to the model CR-110 charge sensitive preamplifier. The CR-111, however, has lower gain by a factor of 10 due to differences in the feedback components used internally in these circuits. This results in the CR-111 having faster pulse rise times than the CR-110. The pulse decay time of the CR-111 is the same as that of the CR-110, however the CR-111 is capable of higher counting rates due to its lower valued feedback resistor. The use of this lower valued feedback resistor, however, also results in somewhat higher noise in the CR-111.

Cremat model CR-112 is available for photomultiplier tube (PMT) applications and for other applications (e.g. using microchannel plates) where there are large signals.

Detector coupling

The CR-111 can be used either in a *direct coupled* (DC) mode, or an *AC coupled* mode. If the detector current exceeds ± 100 nA, it is recommended that an AC coupled mode be used to prevent the resulting DC offset of the preamplifier output from saturating (Detector current produces an offset in the preamplifier output voltage at a rate of 20 mV per nA). For further discussion of this topic and a schematic diagram of an AC-coupled detection circuit utiltizing the CR-111, see the specification sheet for the CR-150-AC evaluation board at http://www.cremat.com/CR-150-AC.pdf .

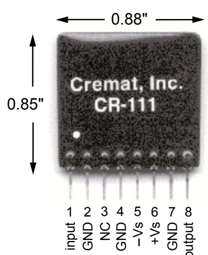


Figure 1.

Package Specifications

The CR-111 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.

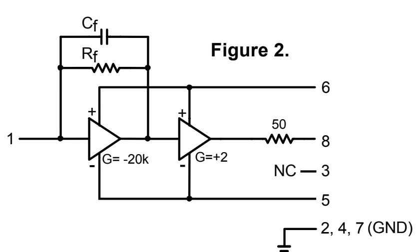


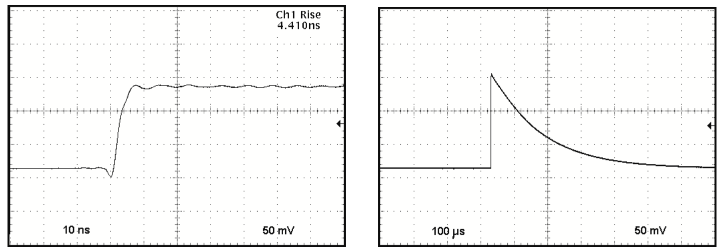
Figure 2.

Equivalent circuit diagram

The figure above shows a simplified equivalent circuit diagram of the CR-111, which is a two stage amplifier. The first stage is high gain, and the second stage is low gain with an emphasis on supplying sufficient output current to drive a terminated coaxial cable.. Pin numbers corresponding with the CR-111 preamplifier are shown. R_f (10 MΩ) and C_f (15 pF) are the feedback resistor and capacitor respectively.

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. The detected charge (time integral of the input current) from each detection event will ideally take the form of a step function. Due to limitations in either the detector or the preamplifier, however, the measured output waveform will occur during a certain non-zero risetime. Output waveforms from the CR-111 are shown below. 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 150 µs.



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Specifications

Assume temp =20 °C, V_S = ±6.1V, unloaded output

	CR-111	units
Preamplification channels	1	
Equivalent noise charge (ENC)*		
ENC RMS	630	electrons
	0.1	femtoCoul.
Equivalent noise in silicon	6	keV (FWHM)
ENC slope	3.7	elect. RMS /pF
Gain	0.15	volts /pC
Rise time **	3	ns
Decay time constant	150	µs
Unsaturated output swing	-3 to +3	volts
Maximum charge detectable per event	1.3×10^8	electrons
	21	pC
Power supply voltage (V_s)		
maximum	V_s = ±13	volts
minimum	V_s = ±6	volts
Power supply current (pos)	7.5	mA
(neg)	3.5	mA
Power dissipation	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 =0.11 C_d + 3 ns, where t_r is the pulse rise time in ns, and C_d is the added capacitance (e.g. detector capacitance) in pF.

*** For other supply voltages within the range ±6 to ±13V, P (mW) = 29 V_S -107

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