Charge Sensitive Preamplifier CSA77
for Operation at Liquid Nitrogen Temperature

Description:

The preamplifier CSA77 is a very low noise, medium bandwidth charge sensitive amplifier in surface mount technology, intended for use with liquid nitrogen cooled (temperature 77 K) Ge-Li-detectors. It is composed of two parts: a preamplifier and a main amplifier.
The preamplifier can be directly immersed in the liquid nitrogen and is able to drive a 50 Ω cable of several meters in length. Thus coupling of the CSA to the detector is possible with minimal additional capacitance and minimal threat to pick up external noise.
The two parts are connected via two coaxial cables, one for the supply voltage and one for the signal. A test input is also provided.

Preamplifier:

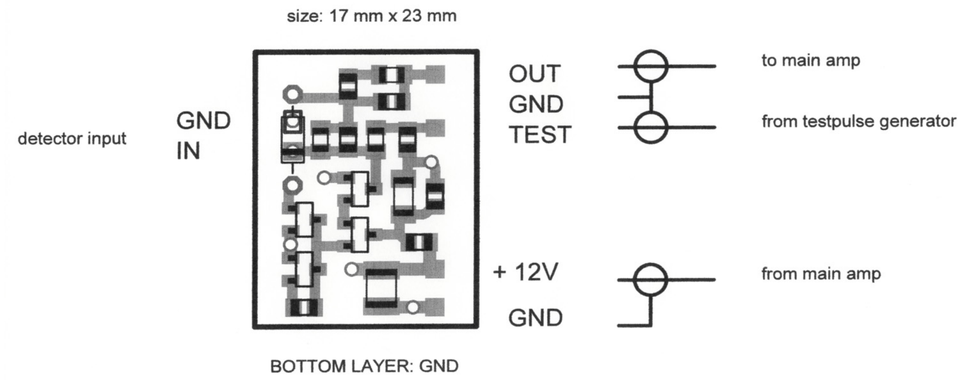

Fig. 1: Preamplifier layout and connections

Technical Data (typical @ 25 °C):

Supply voltage:	+ 12 V ± 0,5 V
Supply current:	10 mA (no signal, no load)
Feedback capacitor:	5.0 pF ± 0.5 pF
Feedback resistor:	220 MΩ
Decay Time Constant:	1.1 ms ± 10%
Output resistance:	50 Ω
Output offset voltage:	-300 mV (-1 V to 0 V)
Input referred noise voltage density:	0.8 nV / √ Hz
Input capacitance:	15 pF
Test input:	50 Ω, 1.3 pF ± 0.3 pF

Data at 77 K are quite similar but not precisely predictable. Conversion gain may change by up to ± 10 %, noise decreases, and bandwidth is changed very little.

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Main Amplifier:

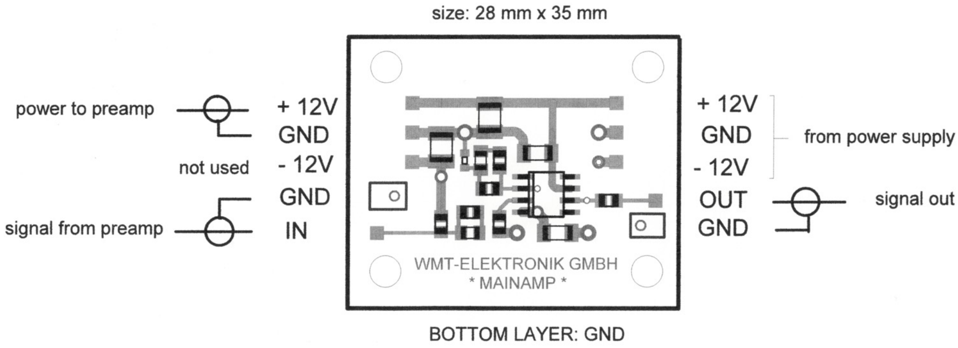

Fig. 2: Main amplifier layout and connections

Overall Technical Data (preamp plus mainamp, typical @ 25 °C):

Supply voltage:	± 12 V ± 0,5 V)[1]
Supply current:	+ 17 mA, - 12 mA (no signal, no load)
Output Impedance:	50 Ω)[2]
Conversion Gain:	210 mV / MeV [Ge] ± 10 % into hi-Z)[3])[4]
Max. Output Signal:	40 MeV [Ge])[3]
Decay Time Constant:	1.1 ms
Coupling Time Constant:	50 ms)[4])[5]
Bandwidth (- 3 dB):	} depending on detector capacitance, see fig. 3
Rise time:	} depending on detector capacitance, see fig. 3
Overshoot:	} depending on detector capacitance, see fig. 3
Noise:	see fig. 4

Notes:

1. The negative supply voltage can be lowered down to -5 V to save power, if the application does not require the negative swing. One resistor has to be chosen according to the negative supply voltage.
2. The CSA77 is capable of driving 50 Ω, unnecessary in most cases, conversion gain is halved.
3. Conversion gain and max. output may be taylored within certain limits to the customer´s needs. Consult factory for details.
4. For short cable lengths between preamp and mainamp, i. e. cable delay < (0.3 x risetime), the main amplifier´s input resistance can be 1 kΩ, because reflections occur during pulse rise. For longer cables the input resistance must be 50 Ω (or 75 Ω) for matched cable termination. In this case the conversion gain is halved and the negative voltage swing is reduced due to limeted negative-going driving capabilities of the preamplifier.
5. The preamplifier is capacitively coupled to the main amplifier. This coupling time constant is present in addition to the preamplifiers decay time constant and must be taken into account in high counting-rate applications. For applications with matched cables (see note 4) the coupling time constant is 5 ms for 50 Ω cables and 7.5 ms for 75 Ω cables.

Typical values intended only for design guidance: (with main amplifier input resistance = 1 kΩ)

Risetime and Bandwidth:

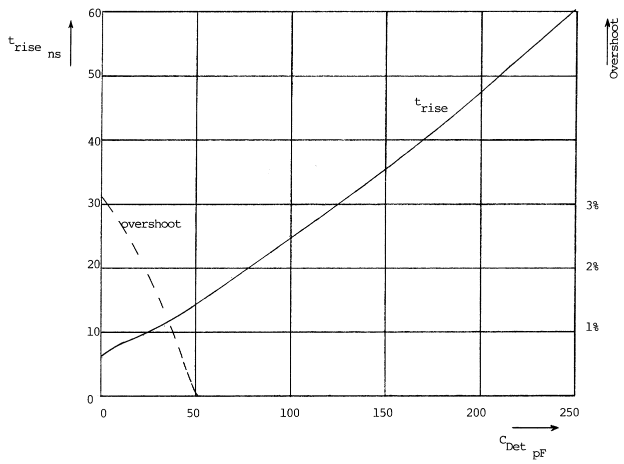

Fig.3: Risetime and overshoot vs. detector capacitance

Parameters for design guidance:

$f_{-3dB} \approx 0.35 / t_{rise}$

Noise Gain $\approx [\ 4 + C_{Det}\,/pF\ ]$

Bandwidth ≈ 350 MHz / Noise Gain

Noise:

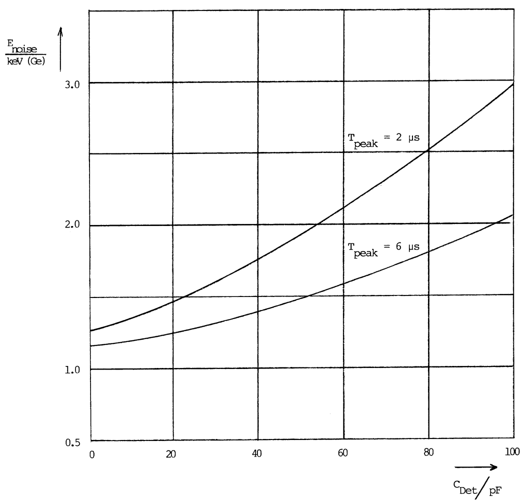

Fig.4: Noise vs. detector capacitance

Noise data in fig.4 are measured with 6^{th} order filter (1 diff, 5 int) with peaking time 2 µs and 6 µs.

For Gaussian shape pulse forming filters with peaking time 1 µs $\leq t_{peak} \leq$ 6 µs output noise can be estimated as:

$$E_{noise,\,FWHM} \approx \sqrt{1.3 + (\,0.7 + C_{Det} / 30\text{ pF}\,)^2 / (t_{peak} /\mu s)}\quad \text{keV [Ge]}$$

No leakage current is taken into account in this approximation as applicable for 77 K .

Option FD:

Option FD is available for applications, where space near the detector or threat of nuclear radiation of materials near the detector are of particular concern.

For these applications the input FET and the feedback components can be separated by up to 50 cm. Connection to the preamplifier is via a coaxial cable and a single wire:

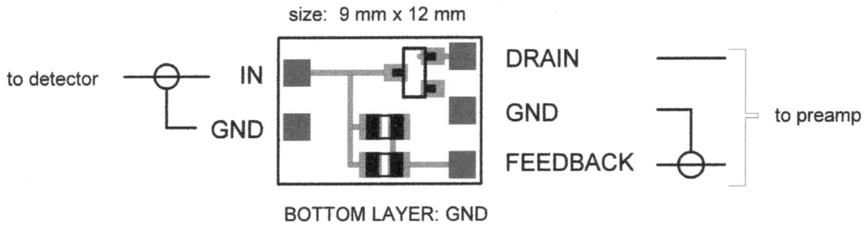

Fig.5: Separated input FET and feedback elements

A test input is not provided for option FD.
The board in fig. 5 is for direct coupling to the detector. If capacitive coupling is to be used, a slightly larger board with input capacitor is provided, size 14 mm x 12 mm.

The additional phase shift due to the cable delay within the feedback loop reduces the phase margin of the preamplifier, entailing ringing and overshoot of the step response and even possible instability of the preamplifier, if the detector capacitance is small (= low noise gain).
As a countermeasure the bandwidth has to be reduced by means of compensation. The degree of compensation and bandwidth reduction depends on the specific requirements of the application: detector capacitance, allowable overshoot, required bandwidth.

Example:
With detector capacitance 30 pF and the input FET set 30 cm apart, 17.5 ns risetime (= 20 MHz bandwidth) with < 2 % overshoot can be achieved.
Consult factory for your specific application.