CSP10 charge sensitive preamplifier

Description

FAST ComTec's CSP10 is a single channel charge sensitive preamplifier module 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 CSP10 is one of a series of four charge sensitive preamplifiers offered by FAST ComTec, 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://www.fastcomtec.com. As with all FAST ComTec's preamplifier modules, the CSP10 is small shielded metal case with a D-sub 9 connector for power supply .

Equivalent circuit diagram

Figure 2 shows a simplified equivalent circuit diagram of the CSP10, 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. R_f (100 MΩ) and C_f (1.4 pF) are the feedback resistor and capacitor respectively (t_{decay}= 140µs).
The feedback values for the other models are:
R_f =10 MΩ and C_f =15 pF, t_{decay}= 150µs (CSP11),
R_f =680 kΩ and C_f =75 pF, t_{decay}= 50µs (CSP12),
R_f =68 kΩ and C_f =750 pF, t_{decay}= 50µs (CSP13).

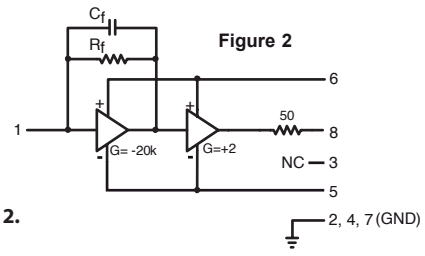
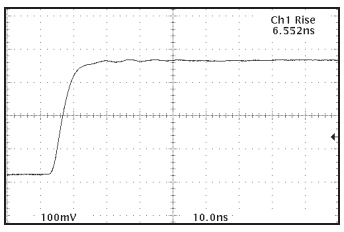
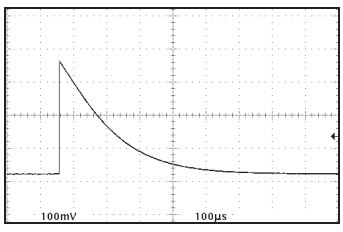


Figure 2.

Theory of operation

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 CSP10 this figure is approximately 7 ns. Furthermore, capacitance at the preamplifier input (i.e. detector capacitance) will further slow the rise time at a rate of 0.4 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)/photodiode 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 CSP10 using a capacitively-coupled fast square wave pulser at the input 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 140 µs. This decay of the output waveform is also shown below, to the right.





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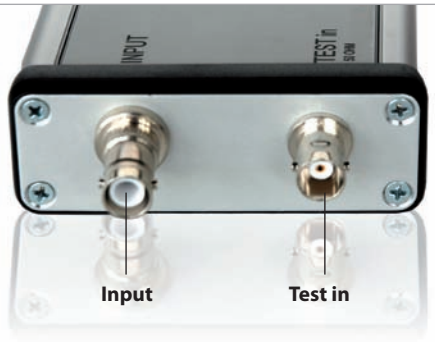
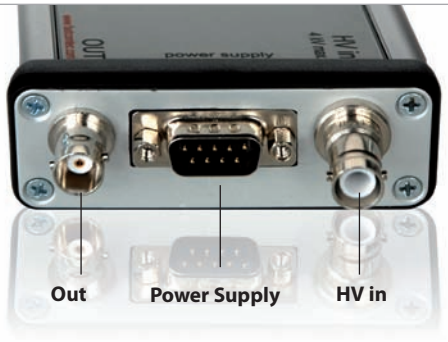
Front view:



Back view:



Specification

(@ 20°C, ±12V, unloaded output)

Preamplification channels: 1

Equivalent noise charge (ENC)*:

ENC RMS: 200 electrons, 0.03 femtoCoul.

Equivalent noise in silicon: 1.7 keV (FWHM)

Equivalent noise in CdZnTe: 2.4 keV (FWHM)

ENC slope: 4 electrons RMS /pF

Gain: see table 1

Rise time:** 7 ns (see table 1)

Decay time constant: 140 µs (150 µs, 50 µs, 50 µs resp.)

Unsaturated output swing: -3 to +3 volts

Maximum charge detectable per event: (see table 1)

Power supply voltage (Vs): ± 12 volts nominal (± 2 volts)

Power supply current: < 10 mA

Power dissipation: < 240 mW

Operating temperature: -40 to +85°C

Output offset: +0.2 to -0.2 volts

Output impedance: 50 ohms

Physical: Net weight: 250 gr.

Size without connectors: 126 mm x 80 mm x 30 mm

Size with connectors: 165 mm x 80 mm x 30 mm

* 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. Tocalculate pulse rise time for practical situations, use the equation: tr =0.4 Cd + 7 ns, where tr isthe pulse rise time in ns, and Cd 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.

* @1µs shaping time, input unconnected

Table 1: Sensitivity Versions

preamp model	gain (mV / pico-Coulomb)	max. detect. pulse (e^-)	Equiv. noise in silicon keV (FWHM)
CSP10	1400	10^7	1.7 keV
CSP11	150	10^8	6.0 keV
CSP12	15	10^9	65 keV
CSP13	1.5	10^{10}	230 keV

Table 2: Model specifications (noise, risetime)

preamp model	noise (ENC) in e^- RMS*	noise (ENC) slope e^-/pF	rise time (C_d=0pF)	rise time slope
CSP10	200 e^-	4 e^-/pF	7ns	0.4ns/pF
CSP11	630 e^-	3.7 e^-/pF	3ns	0.25ns/pF
CSP12	6,800 e^-	28 e^-/pF	6ns	0.25ns/pF
CSP13	24,000 e^-	27 e^-/pF	20ns	0.25ns/pF

Table 3: Input / High-Voltage-Connectors

model	Input	HV-Connectors (Input/HV)
CSP1X-2S	2kV/10n	SHV/SHV
CSP1X-4S	4kV/4.7nF	SHV/SHV
CSP1X-1B	1kV/10nF	BNC/BNC
CSP1X-1BS	1kV/10nF	BNC/SHV

Table 4: Ordering Information

Model No.	Description	Order No.
CSP10-2S	Charge sensitive preamp, SHV, 2kV/10nF, 1.4V/pC	CSP102S
CSP11-2S	Charge sensitive preamp, SHV, 2kV/10nF, 150mV/pC	CSP112S
CSP12-2S	Charge sensitive preamp, SHV, 2kV/10nF, 15mV/pC	CSP122S
CSP13-2S	Charge sensitive preamp, SHV, 2kV/10nF, 1.5mV/pC	CSP132S
CSP10-4S	Charge sensitive preamp, SHV, 4kV/4.7nF, 1.4V/pC	CSP104S
CSP11-4S	Charge sensitive preamp, SHV, 4kV/4.7nF, 150mV/pC	CSP114S
CSP12-4S	Charge sensitive preamp, SHV, 4kV/4.7nF, 15mV/pC	CSP124S
CSP13-4S	Charge sensitive preamp, SHV, 4kV/4.7nF, 1.5mV/pC	CSP134S
CSP10-1B	Charge sensitive preamp, BNC, 1kV/10nF, 1.4V/pC	CSP101B
CSP11-1B	Charge sensitive preamp, BNC, 1kV/10nF, 150mV/pC	CSP111B
CSP12-1B	Charge sensitive preamp, BNC, 1kV/10nF, 15mV/pC	CSP121B
CSP13-1B	Charge sensitive preamp, BNC, 1kV/10nF, 1.5mV/pC	CSP131B
CSP10-1BS	Charge sensitive preamp, BNC/SHV, 1kV/10nF, 1.4V/pC	CSP101BS
CSP11-1BS	Charge sensitive preamp, BNC/SHV, 1kV/10nF, 150mV/pC	CSP111BS
CSP12-1BS	Charge sensitive preamp, BNC/SHV, 1kV/10nF, 15mV/pC	CSP121BS
CSP13-1BS	Charge sensitive preamp, BNC/SHV, 1kV/10nF, 1.5mV/pC	CSP131BS

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