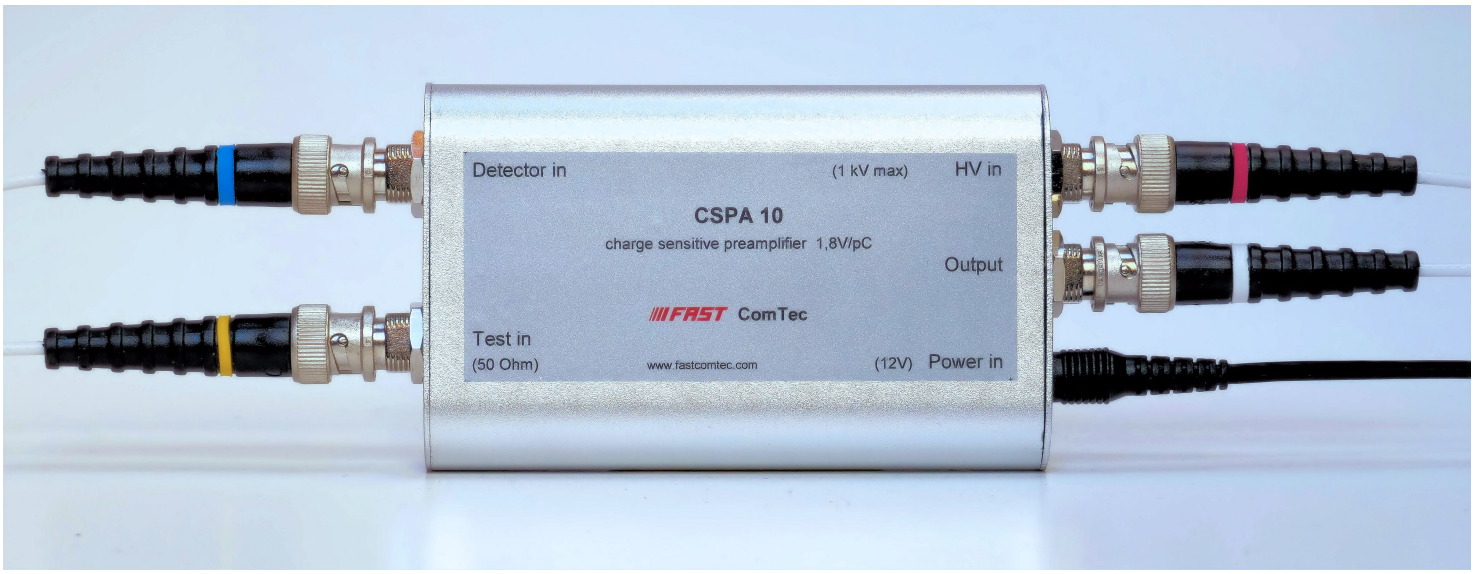
CSPA1X charge sensitive preamplifier



Description

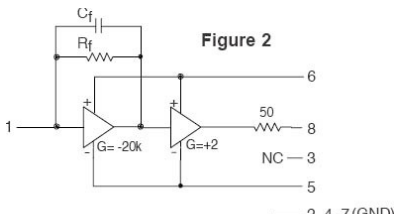
FAST ComTec's CSPA10...13 is a single channel charge sensitive preamplifier module intended for use with various types of radiation detectors including semiconductor detectors (e.g. CdTe and CZT), p-i-n photodiodes, avalanche photodiodes (APDs), and various gas-based detectors.
The CSPA10 is one of a 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.
The CSPA1X is a successor model of CSP1X, with easier classic power supply. Other improvements include integrated protection circuits and better variability.

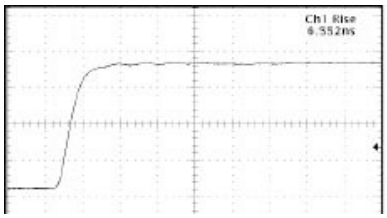
Equivalent circuit diagram

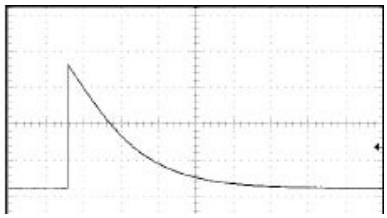
Figure 2 shows a simplified equivalent circuit diagram of the CSPA10, which is a two stage amplifier. The first stage is high gain, and the second stage is low gain with an emphasis on supplying sufficient output current to drive a terminated coaxial cable. R_f (100 MΩ) and C_f (1.4 pF) are the feedback 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 (CSPA11),
R_f =680 kΩ and C_f =75 pF, t_{decay}= 50µs (CSPA12),
R_f =68 kΩ and C_f =750 pF, t_{decay}= 50µs (CSPA13).

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 CSPA10 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.







CSPA1X charge sensitive preamplifier

Front view:

Input Test in

Back view:

Power Supply Output HV input

Specification

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
Power supply current: < 30 mA
Power dissipation: < 400 mW
Operating temperature: -40 to +85°C
Output offset: +0.2 to -0.2 volts
Output impedance: 1 or 50 ohms, set by jumper
Physical: Net weight: 195 g (320 g including power supply)
Size without connectors: 113 mm x 70 mm x 24 mm
Size with connectors: 153 mm x 70 mm x 24 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. To calculate pulse rise time for practical situations, use the equation: $t_r = 0.4\ Cd + 7$ 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.

Table 1: Sensitivity Versions

Preamp model	Gain (mV /picoCoulomb)	Max. detect. Pulse (e^-)	equiv. noise in silicon keV (FWHM)
CSPA10	1400	10^7	1.7 keV
CSPA11	150	10^8	6.0 keV
CSPA12	15	10^9	65 keV
CSPA13	1.5	10^{10}	230 keV

Table 2: model specifications (noise, risetime)

Preamp model	noise (ENC) e^- (RMS)*	noise (ENC) slope e^- /pF	rise time (C_d=0pF)	rise time slope
CSPA10	200 e^-	4 e^- /pF	7 ns	0.4 ns/pF
CSPA11	630 e^-	3.7 e^- /pF	3 ns	0.25 ns/pF
CSPA12	6,800 e^-	28 e^- /pF	6 ns	0.25 ns/pF
CSPA13	24,000 e^-	27 e^- /pF	20 ns	0.25 ns/pF

Table 3: input / High voltage connectors

model	Input	Connectors input / HV
CSPA1X-2S	2 kV / 4.7 nF	SHV / SHV
CSPA1X-4S	4 kV / 3.3 nF	SHV / SHV
CSPA1X-1B	1 kV / 4.7 nF	BNC / BNC
CSPA1X-1BS	1 kV / 4.7 nF	BNC / SHV

Table 4: ordering information

Model No.	Description	Order No.
CSPA10-2S	Charge-sensitive preamp, SHV, 2kV/ 4.7nF, 1.4 V/pC	CPA02S
CSPA11-2S	Charge-sensitive preamp, SHV, 2kV/ 4.7 nF, 150 mV/pC	CPA12S
CSPA12-2S	Charge-sensitive preamp, SHV, 2kV/ 4.7 nF, 15 mV/pC	CPA22S
CSPA13-2S	Charge-sensitive preamp, SHV, 2kV/ 4.7 nF, 1.5 mV/pC	CPA32S
CSPA10-4S	Charge-sensitive preamp, SHV, 4kV/ 3.3 nF, 1.4 V/pC	CPA04S
CSPA11-4S	Charge-sensitive preamp, SHV, 4kV/ 3.3 nF, 150 mV/pC	CPA14S
CSPA12-4S	Charge-sensitive preamp, SHV, 4kV/ 3.3 nF, 15 mV/pC	CPA24S
CSPA13-4S	Charge-sensitive preamp, SHV, 4kV/ 3.3 nF, 1.5 mV/pC	CPA34S
CSPA10-1B	Charge-sensitive preamp, BNC, 1kV/ 4.7 nF, 1.4 V/pC	CPA01B
CSPA11-1B	Charge-sensitive preamp, BNC, 1kV/ 4.7 nF, 150 mV/pC	CPA11B
CSPA12-1B	Charge-sensitive preamp, BNC, 1kV/ 4.7 nF, 15 mV/pC	CPA21B
CSPA13-1B	Charge-sensitive preamp, BNC, 1kV/ 4.7 nF, 1.5 mV/pC	CPA31B
CSPA10-1BS	Charge-sensitive preamp, BNC/SHV,1kV/4.7nF,1.4 V/pC	CPA01C
CSPA11-1BS	Charge-sensitive preamp, BNC/SHV,1kV/4.7nF,150mV/pC	CPA11C
CSPA12-1BS	Charge-sensitive preamp, BNC/SHV,1kV/4.7nF,15mV/pC	CPA21C
CSPA13-1BS	Charge-sensitive preamp, BNC/SHV,1kV/4.7nF,1.5mV/pC	CPA31C