Charge sensitive preamplifier

Series **CB300.**

Operation Manual.

WARRANTY

NAICAM S.R.L. warrants this product to be free from defects in material and workmanship for a period of 1 year from date of shipment from headquarter in Italy.

NAICAM SRL warrants the following items for one year from the date of shipment: probes, cables, and documentation of specified equipment.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local NAICAM SRL representative, or contact NAICAM SRL headquarters in Italy. You will be given prompt assistance and return instructions. Send the product, transportation prepaid, to the indicated service facility. Repairs will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from product modification without NAICAM SRL express written consent, or misuse of any product or part.

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OUTPUT
BIAS
TEST


INPUT

1. GENERAL DESCRIPTION.

1.1. DESCRIPTION.

The function of a preamplifier is to extract the signal from the detector without significantly degrading and receive maximum the signal to noise ratio. Usually the preamplifier is located as close as possible to the detector, and the input circuits are designed to match the characteristics of the detector.

Different types of detectors produce moderately large signals at their outputs, and this relaxes the restrictions on the noise contribution from the preamplifier. Detectors that typically include in this category are: photodiodes, photomultiplier tubes (PMT), scintillation detectors (different scintillator mounted on a PMT), micro channel plate PMTs, micro channel plates and Si multipliers. For such detectors, a wideband amplifier with a low input impedance can be used directly at the detector output to generate short, fast rising pulses for timing or counting purposes.

Some detectors produce very small output signals, it is essential that the input stage of the preamplifier contribute little noise. The requirement for low noise and stable sensitivity with these detectors is met by using a charge sensitive preamplifier with an FET (Field-Effect Transistor) input stage. For silicon particle detectors and proportional counters the entire preamplifier usually is operated at room temperature. However, the excellent resolution of the cooled germanium and Si(Li).

NAICAM manufactures a preamplifier to fit your detector, your application, and your budget. The applications information and selection guides will help you to choose the optimum preamplifier for your task. The CB300 series **preamplifier** is a low noise charge sensitive preamplifier with fixed gain values. The preamplifier is optimized for high input capacitance (up to 1000pF). The module has bias input up to +/-3 kV and protection circuit to avoid breakdown of the input of the preamplifier circuit.

1.2. CHARGE-SENSITIVE PREAMPLIFIER.

CB300 series preamplifiers are preferred for most energy spectroscopy applications. The signal from a semiconductor detector or ion chamber is a current pulse and the waveform of signal is depending on the type of detector and its size. For most applications the parameters of interest are the quantity of charge and the time of occurrence of an event.

The current pulse integrates the charge on the feedback capacitor, its gain is not sensitive to a change in detector capacitance and the rise time of the output pulse is equal to the detector current pulse width.

The output voltage from the preamplifier has an amplitude Vout, and a decay time constant τf, given respectively by

Vout = Qd/Cf where Qd is the charge released by the detector,

Cf is the feedback capacitor (0.1 to 30 pF),
Rf is the feedback resistor.

Rf is a noise source and in direct-coupled system, is made as large as possible consistent with the signal energy-rate product and the detector leakage current. The preamplifier package is kept small to permit mounting it as close as practical to the detector, thus reducing input capacitance caused by cabling and decreasing microphonic noise, ground loops, and radio frequency pickup, all of which are sources of noise for the charge-sensitive preamplifier.

The gain of preamplifier can be expressed in mV/fC, but usually a sensitivity is generally expressed in mV per MeV of energy deposited in a given detector material. The charge released by the detector is a function of the photon or particle energy and the detector material, and is given by

$$Qd = (E * e)/ \varepsilon;$$

where E is the energy in eV of the incident radiation, e is the charge of an electron (1.6 X 10–19 coulomb), and ε is the amount of energy required to produce an electron-hole pair in the detector. Approximate values for ε for various detectors are given in Table 1. The output voltage produced by a charge-sensitive preamplifier is

$$Vo = (E*e)/Cf* \varepsilon;$$

Table 1.

Detector	ε (eV)
Silicon	3.62 (300° K)* to 3.71 (77° K)
Germanium	2.96 (77° K)
Proportional Counters	
Argon	26.4
Methane	29.2

1.3. FUNCTIONAL BLOCK DIAGRAM.

On the figure 1 the simplified circuit of the CB300 is shown. The module has HV bias SHV connector, Input SHV connector, Output BNC connector and Test BNC connector. Input power through captive power cable from NAICAM spectrometric Amplifier, Model DCB100 portable power supply or other linear power supply.

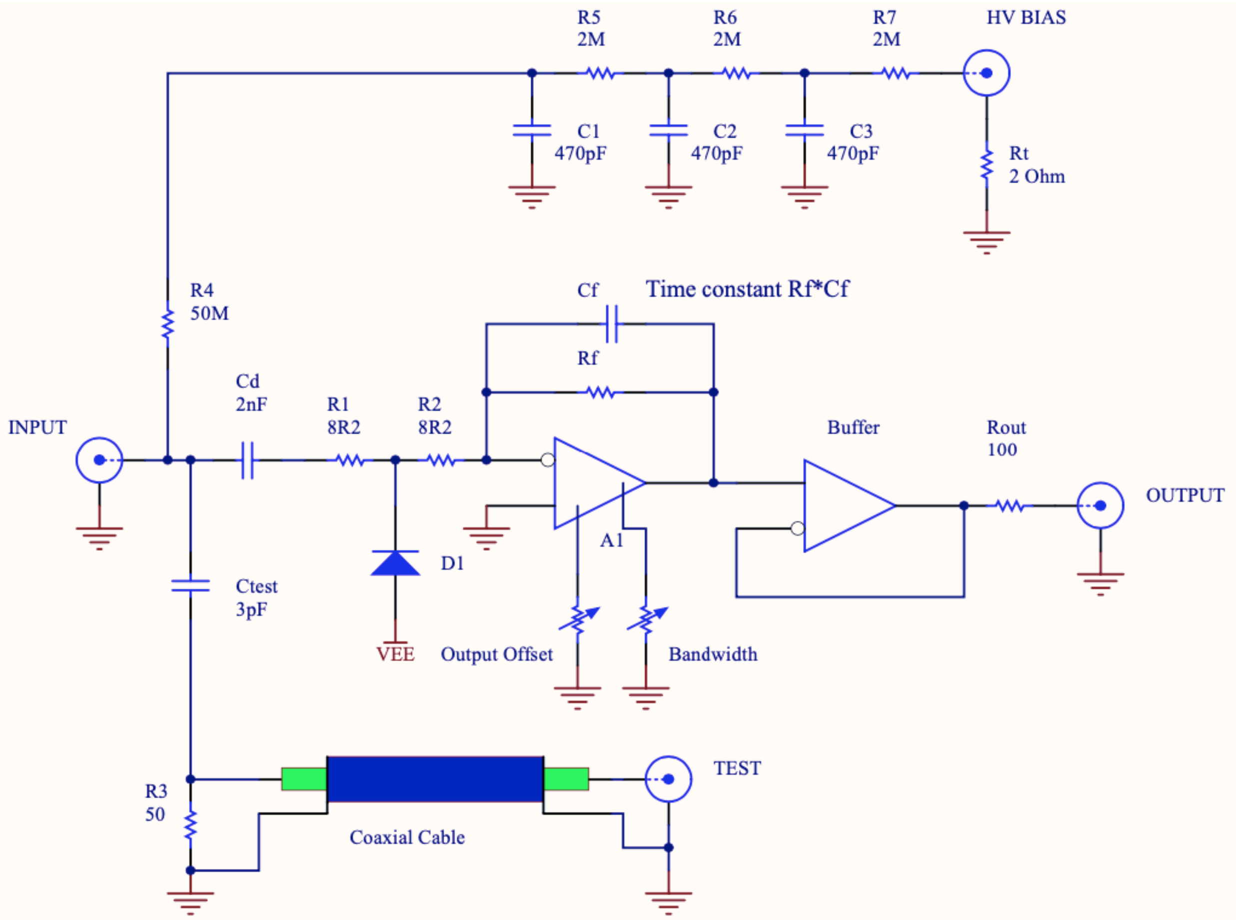

Figure 1. Simplified schematic of the model CB300.

The values of capacitance C1, C2, C3 usually 470 nFx3kV, but can be changed to 2200 pFx3kV.

Test Pulse.

To calibrate the preamplifier the equivalent charge must be injected through test BNC connector. The amplitude of the pulse Vtest determine the injected charge by formula

Qt = Vtest*3 pF.

Note: don’t use pulse generator with switching power supply.

Spectrometric chain with CB300 preamplifiers.

The model CB300 should be used with a shaping amplifiers, such as NAICAM NCB215, NCB226 and DCB215. Figure 2 shows typical amplifier usage preamplifier and spectrometric amplifier.

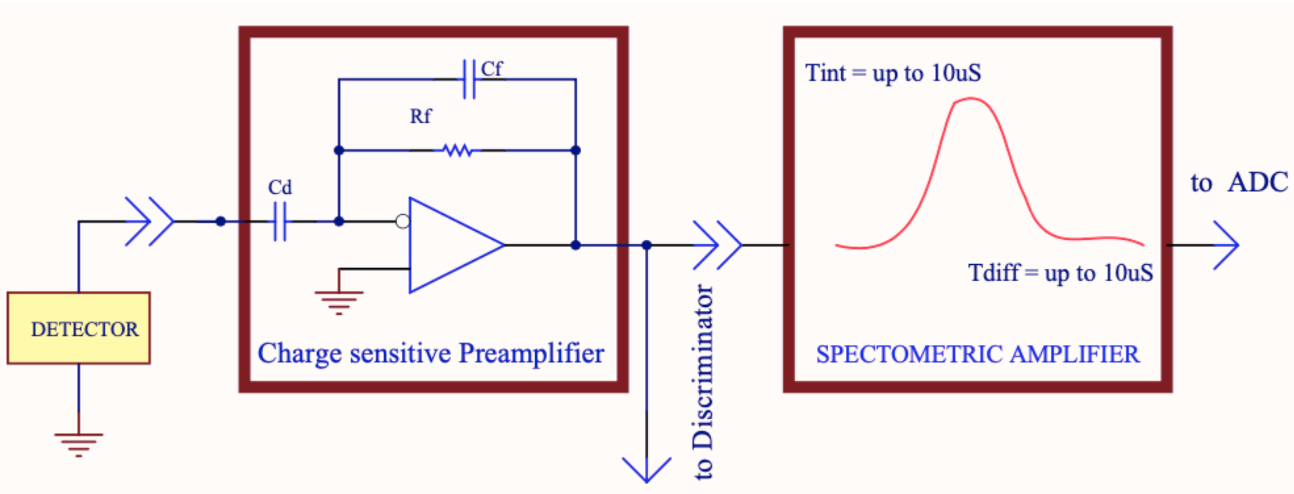

Figure 2. Typical set up with the module CB300.

The preamplifier noise has determined signal to noise resolution. Using the spectrometric amplifier the lows value of this parameters can be richen. The shaping time of amplifier determines the time resolution of the timing system and common gain of spectrometric channel. The amplifier is important components in a pulse processing system for applications in counting, timing, or pulse amplitude (energy) spectroscopy. Normally, it is the amplifier that provides the pulse-shaping controls needed to optimize the performance of the analog electronics.

Noise of preamplifier.

Noise in charge-sensitive preamplifiers is generally controlled by four components: the input field effect transistor (FET), the total capacitance at the input (Cf, the detector capacitance, etc.), the resistance connected to the input, and input leakage currents from the detector and FET. Figure 3 is a graph showing the output noise of preamplifier versus input capacitance. It is desirable to keep the input capacitance at a minimum to obtain the best timing resolution, as well as the best energy resolution.

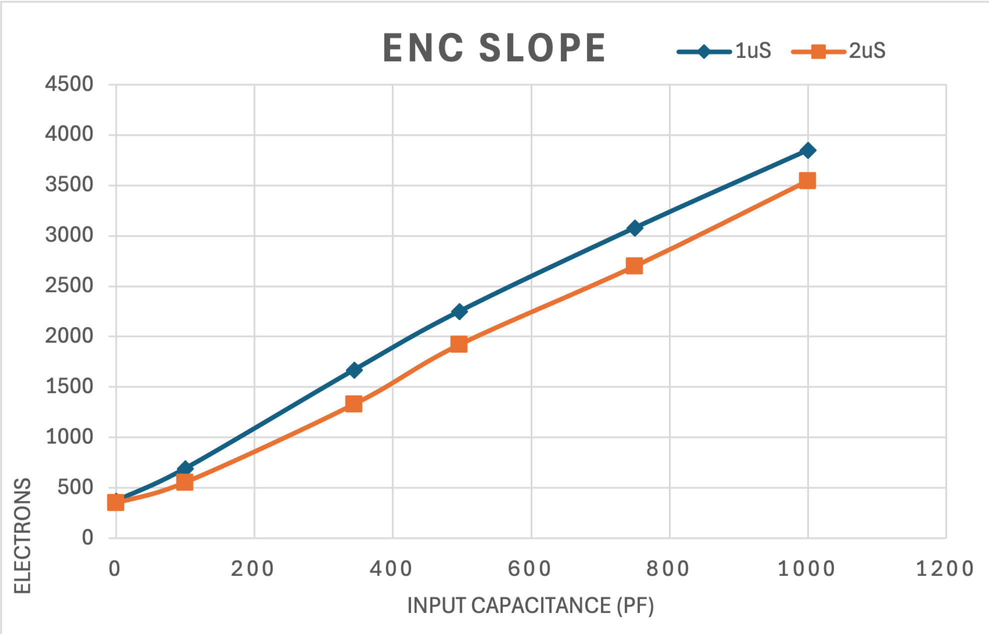

Fig.3. Typical noise as function of input capacitance measured with spectrometric amplifier (1us and 2 us Integration&Differential constants).

2. TECHNICAL SPECIFICATIONS.

2.1 PERFORMANCE.

The series CB300 has four models (table 2,3). All modules have fixed gain, energy range and can be used in different applications.

Table 2. CB300 series sensitivity.

Model	Charge sensitivity	Max. Noise RMS	Energy range
	(Si Equivalent 3,62)	(keV)(Cin=0 pF)	
CB300A	40-45 mV/MeV	<1.3 keV	0-200 MeV
CB300A2	20-25 mV/MeV	<1.4 keV	0-400 MeV
CB300A3	12-15mV/MeV	<1.7 keV	0-600 MeV
CB300A7	5,5 mV/MeV	<1.8 keV	0-1200 MeV
CB300PC	160 mV/MeV	<0.7 keV[1]	0-50 MeV

Protection jumper.

The module has removeable jumper on the board of protection circuit. The position of this jumper is shown below.

[1] This parameter measured without protection circuit, 0,9 keV with protection circuit.

Protection Jumper position on the CB200 board.

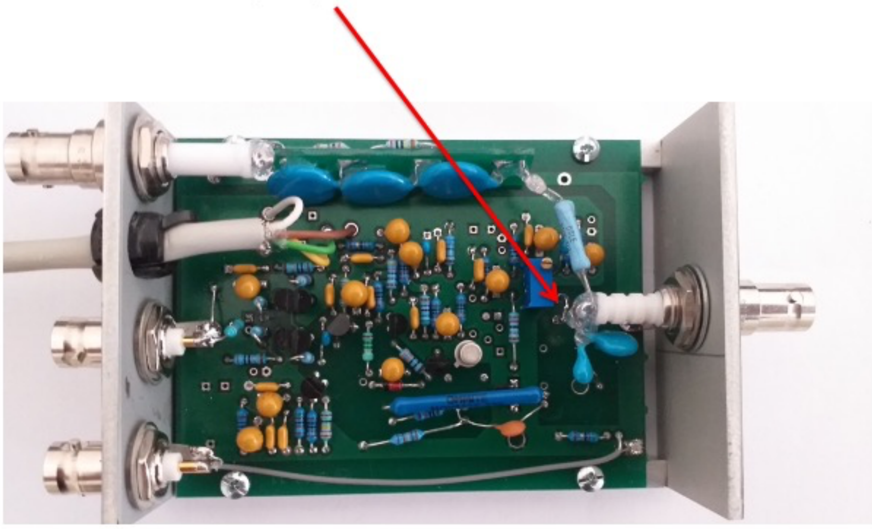

Table 3. CB300 series parameters.

Decay time	**CB300A**	100 us
	CB300A2	200 us
	CB300A3	165 us
	CB300A7	350 us
	CB300PC	120 us
Dynamic input capacitance:	up to 1000 pF	
Noise/Input capacitance ratio:	**CB300A**	4 e-/pF
	CB300A2	5 e-/pF
	CB300A3	7 e-/pF
	CB300A7	9 e-/pF
	CB300PC	3 e-/pF
Integral nonlinearity:	0,005 % (without termination)	
Dynamic output range:	+/- 10 V (without termination). +/- 5 V (with 100 Ohms termination). +/- 3,5 V (with 50 Ohms termination).	
Temperature stability:	+/- 50 ppm/C.	
Rise time	Less than 12 ns.	
Open loop gain:	70,000.	
HV Bias resistor	56 MΩ.	
Output resistors:	100 Ohm.	
Test Capacitance:	3 pF (+/-3%).	
Operating High Voltage:	+/-3 kV. Can be changed up to 5kV.	

2.2 INPUT/OUTPUT CONNECTIONS AND SIGNAL CHARACTERISTIC

INPUT	Accepts positive or negative charge signal. SHV connector standard, Optional solution is BNC connector without bias connection.
BIAS	High voltage can be applied through SHV input connector. The serial resistance between input and bias connectors is 56 MΩ..
TEST	Pulse input connector is BNC type connector. Test capacitance is 3 pF.
POWER	Input power through 3 meter screened cable from spectrometric amplifier or portable power supply.
ENERGY	Output negative or positive linear pulse. BNC connector.

2.3 POWER REQUIREMENTS

The best solution is alimentation from a NIM standard power supply[2] or special low noise linear power supplies (tables 4,5). Cable length 3 m.

Table 4. Power requirements.

P. Voltage (V)	Current. (mA)
+12	40,0
-12	30,0

Table 5. Power supply DSUB 9 pinout:

Pin number	
4	+12 Volt
9	-12 Volt
1	Ground
2	Ground

2.4 DIMENSION AND WEIGHT

The preamplifier screened by aluminum box. Box dimensions: 111x80x40 mm.
Optional version of preamplifier is special **brass nickel-plated box**.
This option should be specified in order.

Weight: 480 gr. (aluminum box with cable).

[2] Note: don't use switching power supply to avoid correlation noise components.

For More information on NAICAM products and applications contact your local NAICAM representative:

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