



*Electronic Instrumentation for Nuclear,
Astroparticle Physics and Industrial Electronics.*

Charge sensitive preamplifier

Model DCB200.

Operation Manual

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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.

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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 DCB200 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.

DCB200 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 V_{out} , and a decay time constant τ_f , given respectively by

$$V_{out} = Q_d / C_f \quad \text{where} \quad \begin{array}{l} Q_d \text{ is the charge released by the detector,} \\ C_f \text{ is the feedback capacitor (0.1 to 30 pF),} \\ R_f \text{ is the feedback resistor.} \end{array}$$

R_f 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

$$Q_d = (E * e) / \epsilon;$$

where E is the energy in eV of the incident radiation, e is the charge of an electron (1.6×10^{-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

$$V_o = (E * e) / C_f * \epsilon;$$

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 DCB200 is shown. The module has HV bias SHV connector (if up to 250VDC - DSUB connector), Input Multi pin connector (defined by customer), Output DSUB connector and Test LEMO connector. Input power (DSUB9 connector) through captive power cable from NAICAM spectrometric Amplifier, Model DCB100 portable power supply or other linear power supply¹.

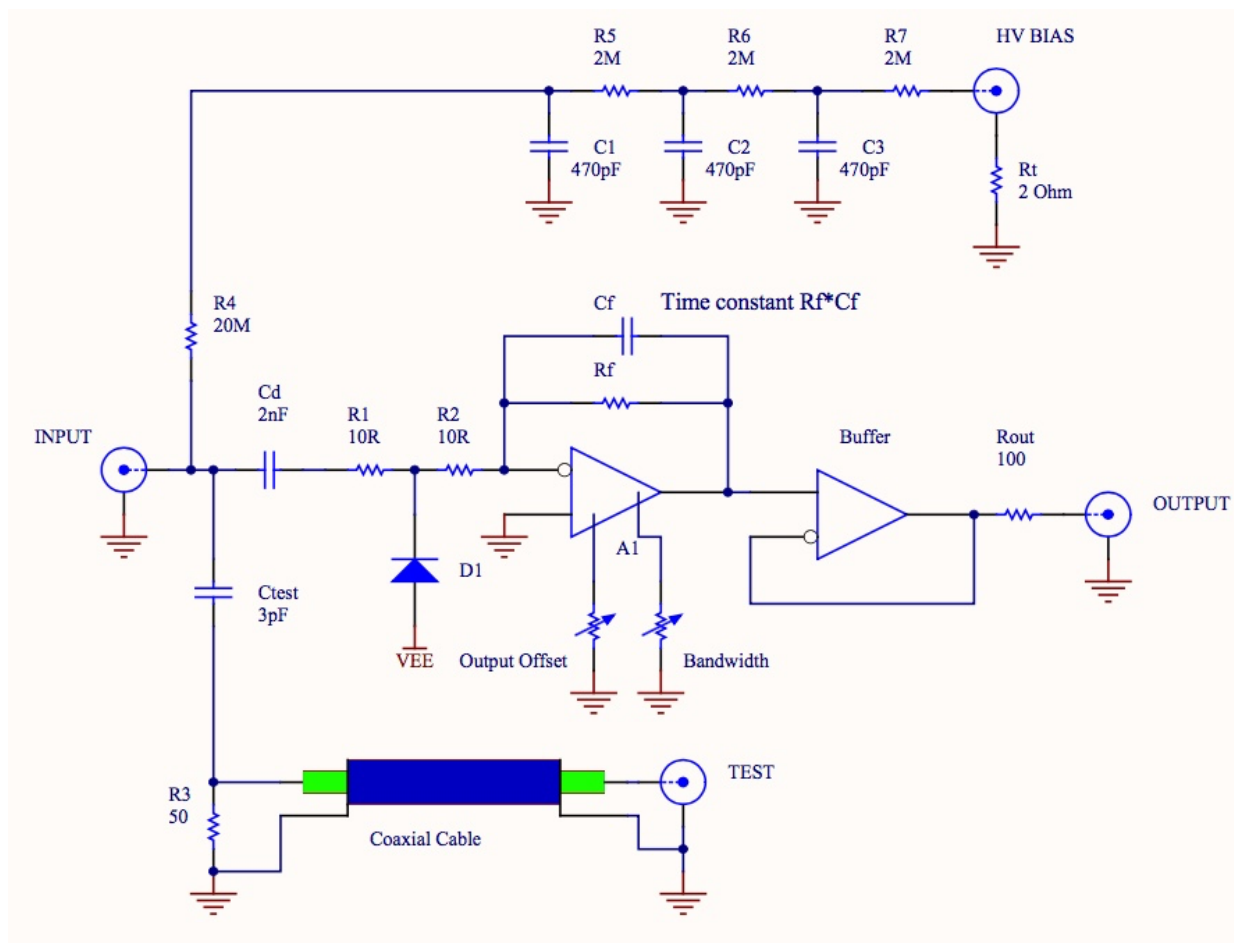


Figure 1. Simplified schematic of the model DCB200.

Test Pulse.

To calibrate the preamplifier the equivalent charge must be injected through test LEMO 00 connector. The amplitude of the pulse V_{test} determine the injected charge by formula

¹ don't use pulse generator with switching power supply.

$$Q_t = V_{test} * 3 \text{ pF.}$$

Spectrometric chain with DCB200 preamplifiers.

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

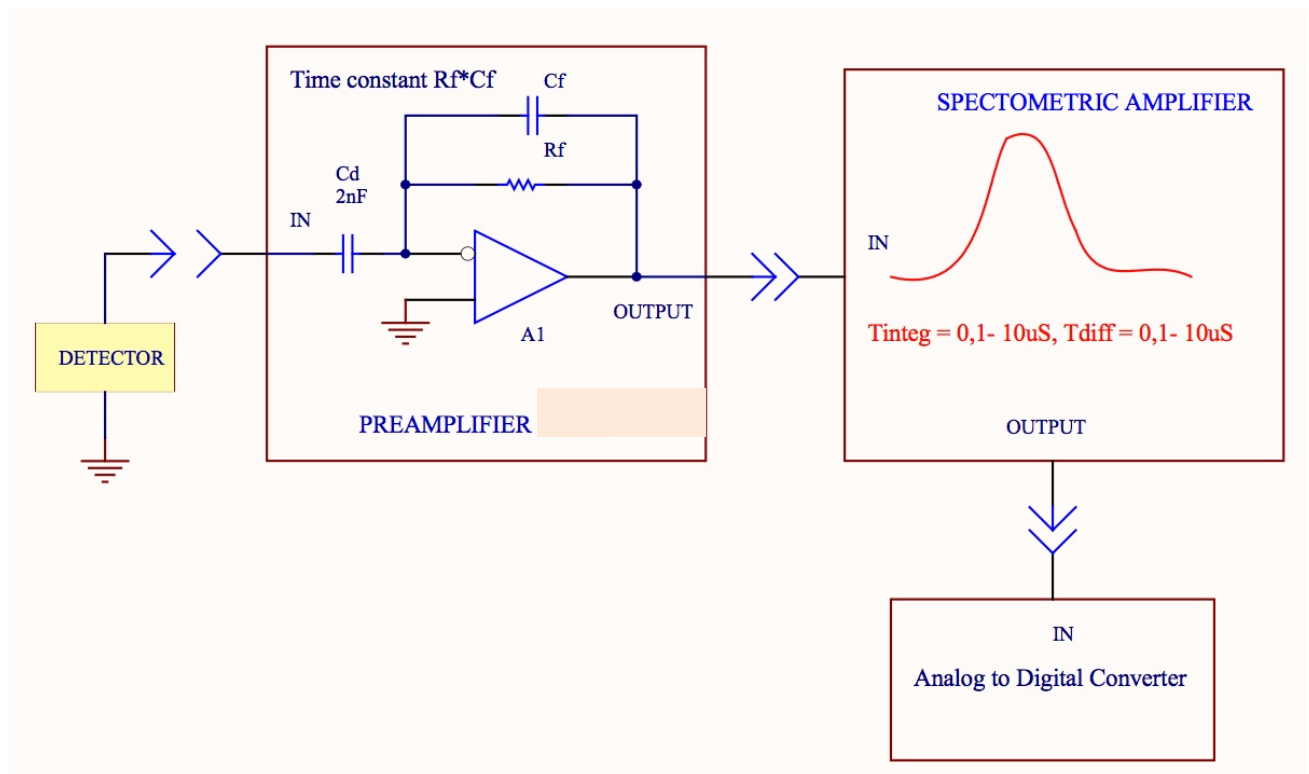


Figure 2. Typical set up with the module DCB200.

spectrometric amplifier.

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. In the module DCB200 can be mounted from 4 up to 16 channels. For 4 channels version can be used SHV/BNC input connectors. For 8-16 channels input connector is multi pins connector. The preamplifier can be used with output differential driver or without output driver. In last case, the driver amplifier is low noise high output current OP amplifier.

The gain of preamplifier can be changed by two jumpers. One of them on the preamplifier and second one on the output driver. Total factor can be from 2 up to 10. This parameters usually defined by customer. Default version - factor 2 on the preamplifier and factor 2 on the output driver.

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 noise versus external capacitance for a typical preamplifier. It is desirable to keep the external capacitance at a minimum to obtain the best timing resolution, as well as the

best energy resolution.

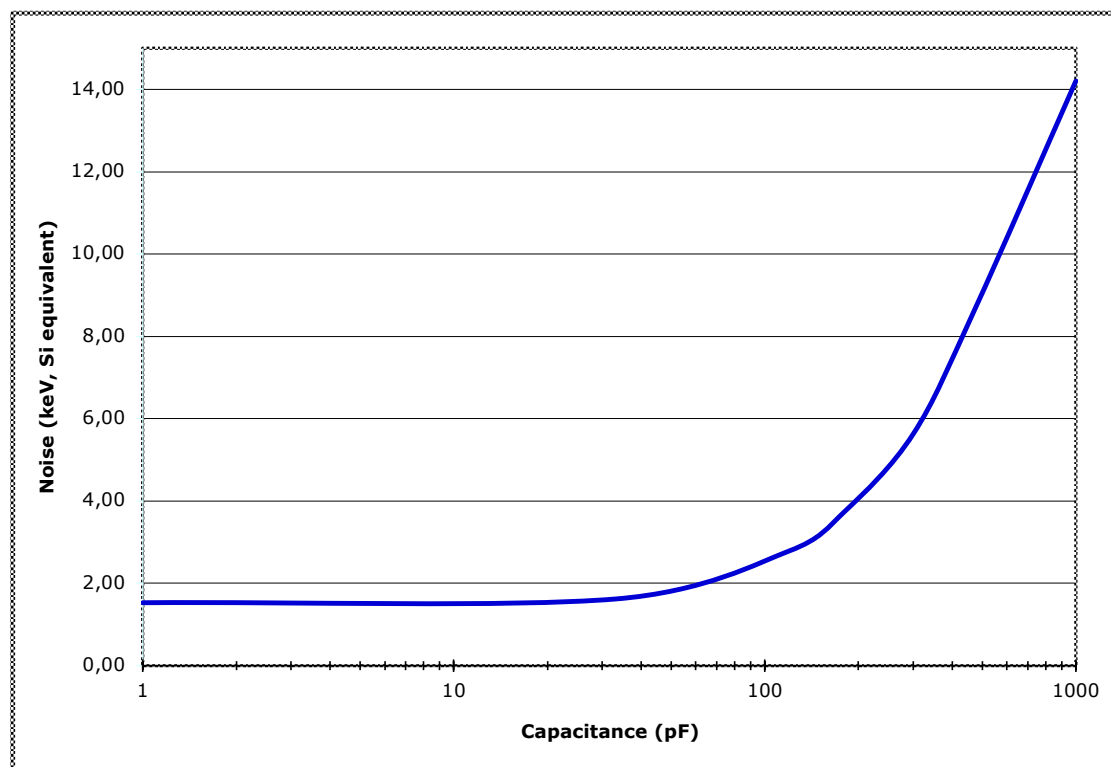


Fig.3. Typical noise as function of input capacitance measured with spectrometric amplifier (2 us Integration and 2 us Differential constants).

2. TECHNICAL SPECIFICATIONS.

2.1 PERFORMANCE.

The series DCB200 has four models (table 2). All modules have fixed gain, energy range and can be used in different applications.

Table 2.

Model	Charge sensitivity	Max. Noise	Energy range
	(Si Equivalent 3,62)	(keV/(Si) (Cin=0 pF)	
DCB200	80-90 mV/MeV	<1.5 keV	0-100 MeV
DCB200A	40-45 mV/MeV	<1.5 keV	0-200 MeV
DCB200A2	20-25 mV/MeV	<1.5 keV	0-400 MeV
DCB200A3	12-15mV/MeV	<1,9 keV	0-600 MeV
DCB200A7	5,5 mV/MeV	<1,9 keV	0-1200 MeV

Decay time	DCB200A	100 us/50us/30us
	DCB200A2	100 us/50us/30us
	DCB200A3	90 us/40us/20us
	DCB200A7	70 us/35us
Dynamic input capacitance:	up to 1000 pF	
Noise/Input capacitance ratio:	DCB200A	9 e-/pF
	DCB200A2	10 e-/pF
	DCB200A3	12 e-/pF
	DCB200A7	14 e-/pF
Integral nonlinearity:	0,03 % (without termination)	
Dynamic output range:	+/- 6 V (without termination).	
	+/-3 V (with 100 Ohms termination).	
Temperature stability:	+/- 100 ppm/C.	
Rise time	Less than 12 ns	
Open loop gain:	30,000	
HV Bias resistor	50 MOhm ²	
Output resistors:	100 Ohm	
Test Capacitance:	3 pF (+/-5%).	

² Low pass filter could be integrated in module.

2.2 INPUT/OUTPUT CONNECTIONS AND SIGNAL CHARACTERISTIC

INPUT	Accepts positive or negative charge signal. SHV or Multi pin connector defined by customer.
BIAS	High voltage can be applied through SHV input connector (up to 3 kV). DSUB9 connector for bias under 250VDC.
TEST	Pulse input connector is LEMO type connector. Test capacitance is 3 pF.
POWER	DSUB9 connector.
OUTPUT	Output negative or positive linear pulse. Output signal can be single ended or differential (defined customer). The module can use LEMO type connectors, DSUB25, 34 header or other multi pin connector. One output 34 pin Header connector is standard (optional version one connector, pin out defined by customer).
CASE GROUND	Two M4 Screws.

2.3 POWER REQUIREMENTS

The best solution is alimentation from a NIM standard power supply or special low noise linear power supplies.

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

P. Voltage (V)	Current. (mA)
+12 Preamplifier	25,0 x (Number of channels)
-12 Preamplifier	15,0 x (Number of channels)
+12/+6 Driver	15,0 x (Number of channels)
-12/-6 Driver	15,0 x (Number of channels)

Power supply DSUB 9 pin out:

Pin number	
3	+6 Volt
5	-6 Volt
4	+12 Volt
9	-12 Volt
1	Ground
2	Ground

Cable length 3 m (different length should be specified in order).

2.4. BIAS Connector.

Table 2. Bias Voltage Connector

Connector type D9 (9 pin)

<i>case</i>	<i>EARTH</i>
<i>2</i>	<i>BIAS 1</i>
<i>3</i>	<i>BIAS 2</i>
<i>4</i>	<i>BIAS 3</i>
<i>5</i>	<i>BIAS 4</i>
<i>6</i>	<i>GND 1</i>
<i>7</i>	<i>GND 2</i>
<i>8</i>	<i>GND 3</i>
<i>9</i>	<i>GND 4</i>

Bias 1 is connected to 13,14,15,16 channels

Bias 2 is connected to 12,11,10,9 channels

Bias 3 is connected to 8,7,6,5 channels

Bias 4 is connected to 4,3,2,1 channels

SHV version.

All channels connected in parallel to Bias connector though low frequency pass filter.

Cable length should be defined in order.

2.4. DIMENSION AND WEIGHT

Single channel version:

Box dimensions: 111x80x40 mm.

Weight: 480 gr. (box with cable)

8/16 channels version :

Box dimensions :160x165x52 mm.

Weight: 1000 gr. (box without cables)

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

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