

**BC-NV100**

**Nanovolt Amplifier**

**User's Guide**

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which retains all rights to its contents.**

**Warning: This amplifier is not to be used with human subjects.** The BC-NV100 is not to be used in any system for use with human subjects and the manufacturer will not be responsible for the results of such misapplication of this device.

**Burns Consulting**

3059 Santa Rosa Ave.

Altadena, CA 91001

Tel 818/398-6356

Fax 818/398-7607

email: [mjburns@ix.netcom.com](mailto:mjburns@ix.netcom.com)

<http://ourworld.compuserve.com/homepages/mjburns>

## Congratulations!

You have just purchased a precision preamplifier capable of amplifying nanovolt ( $10^{-9}$ ) and microvolt signals ( $10^{-6}$ ). This affordable instrument will allow you to observe small signals from low source impedance sensors and signal generators simply and cleanly.<sup>1</sup>

### I. Setting Up the Nanovolt Amplifier

The first step in operating your nanovolt amplifier is to be sure you have all of the necessary equipment. Figure I.1 shows the components that are provided with BC-NV100. They are as follows:

- the electronic amplifier box,
- the power cable,
- User's Guide,

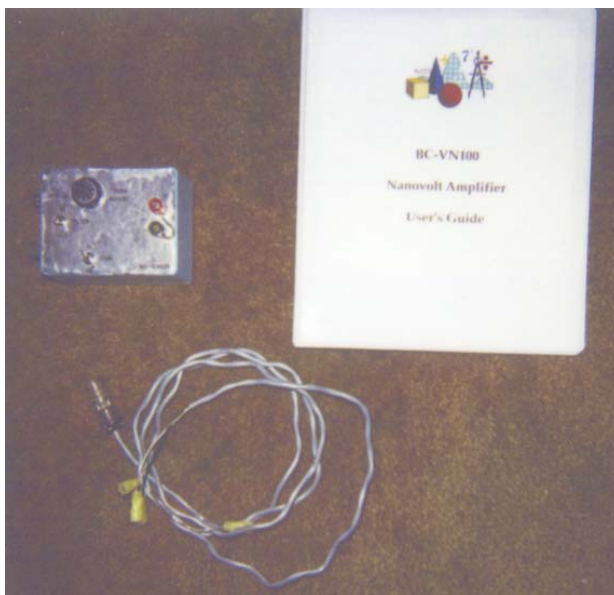


Figure I.1 – Amplifier box, power cable and User's Guide supplied as the BC-NV100 system.

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<sup>1</sup> The BC-NV100 will function with any size source resistance, however the noise performance will degrade with increasing source resistance. For source resistances above  $400\Omega$ , other amplifier designs will offer lower noise performance than the BC-NV100. For low-noise amplifiers for signal sources or sensors with source impedances greater than  $400\Omega$ , contact Burns Consulting.

Apart from the items included in the BC-NV100 package, there are several items that the user must supply in order to operate the system:

- An output device – either a strip chart recorder or a computer with analog-to-digital recording capability. There are advantages to having both on hand, if possible.
- Hand-held digital voltmeter.
- BNC coaxial cables for connecting the electronics box to the output device. These are standard items for any laboratory using electronic instruments.
- Two 12 volt batteries. These may be lantern batteries, car batteries or lead-acid gel-packs such as the type that dataloggers use. The amplifier should have its own pair of 12 volt batteries without any other equipment drawing power from them for best results.

## II. Assembling the BC-NV100 Nanovolt Amplifier System

In this section, we explain how to assemble the various parts of BC-NV100 nanovolt amplifier system. The set-up instructions refer to the various controls and connectors on the BC-NV100 electronics box with the numbers shown in Figures II.1 and II.2 below:

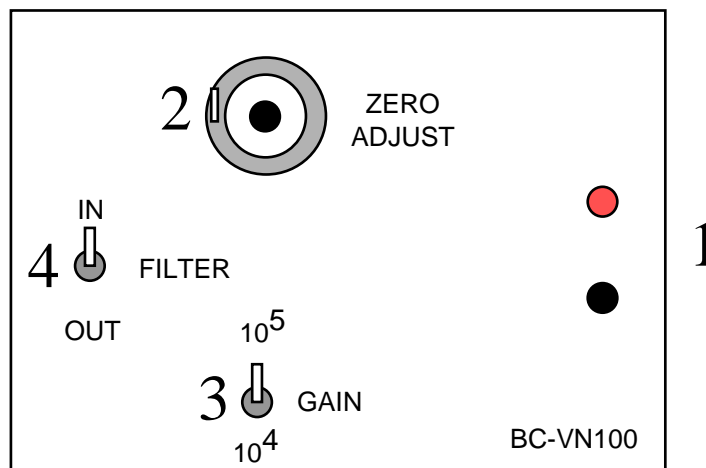


Figure II.1 -- Front panel of the amplifier.

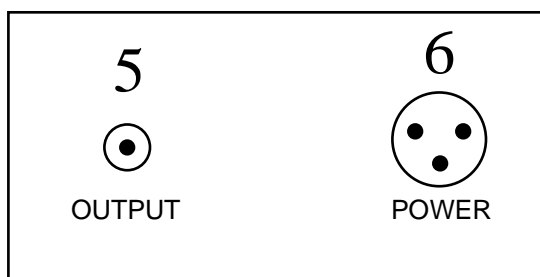


Figure II.2 -- Left side panel of the amplifier.

**Before you start**, please touch a grounded object such as a faucet in order to discharge any static electricity you may have built up on your person. This is especially important when the humidity is low as in the winter in areas that see snow or severe cold.

### STEP 1: Battery check

The first step is to check the batteries by checking them with the hand-held digital voltmeter. They should be nominally 12 volts and more importantly,

they should read within 10 millivolts of each other. To maximize the lifetime of the batteries, make sure the power connector is disconnected any time that the BC-NV100 is not in use.

### STEP 2: Power Cable Battery Connection

Make sure the power is *not* plugged into the power cable receptacle (6). Attach the spade ends of the power cable to the two 12 volt batteries as illustrated in Figure II.3 below. The black wire is connected to -12 volts, the white wire to +12 volts, and the two-connector silver uninsulated wire is connected as the power ground tying the + terminal on one battery to the - terminal on the other.

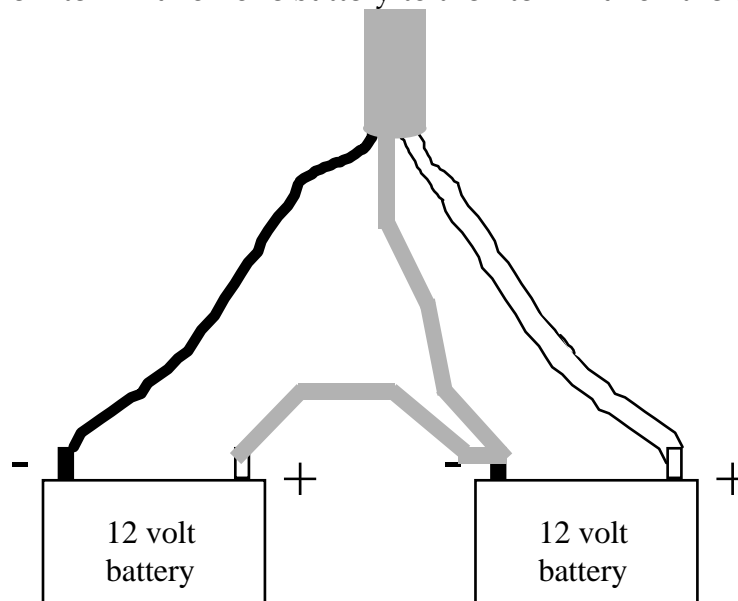


Figure II.3 -- Power cable connections.

### STEP 3: Input Connection

Connect the thermocouple under test to the input terminals (1) of the BC-NV100. You may use the screw terminals or you may solder banana jacks to your wires. The inputs of the BC-NV100 are true differential inputs, so do not ground either lead. The BC-NV100 is not to be used in any system for use with human subjects and the manufacturer will not be responsible for the results of such misapplication of this device.

#### STEP 4: Output Connection

Connect your recording device to the output BNC (5) using a coaxial cable. The shield of the coaxial cable may be grounded on the recording device.

#### STEP 5: Thermal Isolation

***Important!!!*** Thermal emf's are usually in the range of 10's of  $\mu\text{V}/^\circ\text{C}$ . This means that you need to have the BC-NV100 (or any other nanovolt amplifier) as thermally stable as possible. For best results the amplifier should be placed out of the way for drafts and away from windows or direct sunlight. For best results, place the BC-NV100 in a cooler and lay cloth over the input terminals (1).

#### STEP 6: Gain Setting

Set the gain switch (3) to the gain setting you will be using. If you are not sure, it is best to use the 104 setting. The  $10^5$  setting provides a gain of  $\times 102,051$  and the  $10^4$  setting provides a gain of  $\times 10028$ .

#### STEP 7: Filter Setting

Set the filter switch (4) to the setting you will be using. If you are not sure, it is best to have the filter "on".

#### STEP 8: Warm-up

Attach the power cable to the receptacle (6). ***Please allow at least 15 minutes after applying power to the amplifier, or switching the filter on, before proceeding so that the amplifier's internal components can reach their steady state operating temperatures.***

#### STEP 9: Zero Adjustment

If necessary, adjust the zero adjustment setting (2) to bring the signal level to where you want it. To set this only once at the beginning of a series of measurements.

At this point, your BC-NV100 is ready to run. Happy data collection!

### III. Troubleshooting and Getting Help

The BC-NV100 has been designed to be trouble-free, easy to operate system for the amplification of low level signals from low source resistance sensors such as thermocouples. It is, however, a complex instrument incorporating ultra-low noise operational amplifier chips. The amplifier has been designed with two goals in mind: durability and precision. These goals are not necessarily complementary. It is possible that the operational amplifier chips, especially the ones at the front of the amplifier, may fail as they see the brunt of the influences from the outside world such as static discharges. In this case, Burns consulting will repair or replace, at our discretion, a defective BC-NV100 for a period of 1 year from the purchase of the BC-NV100.

It is possible that the troubles you are encountering are of a less catastrophic nature and can be remedied by corrective actions outlined in this section. In the following table, we outline some common difficulties along with recommendations. The suggested actions are listed in order of most common occurrence.

Symptom:	Action:
Amplifier output is zero all of the time.	<ol style="list-style-type: none"> <li>1. Check connections of cables to the amplifier input.</li> <li>2. Check connections of cables to the output device. (chart recorder, datalogger, etc.)</li> <li>3. Check connections of cables to the batteries.</li> <li>4. Check settings on the output device. (chart recorder, datalogger, etc.)</li> <li>5. Check the batteries. Both batteries should read approximately 12 volts.</li> </ol>

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Symptom:	Action:
Amplifier output is $\pm 12$ volts all of the time on the $10^5$ gain setting, near zero on the $10^4$ gain setting. Seems to be ignoring input signals.	<ol style="list-style-type: none"> <li>1. Adjust the "Zero Adjust" knob to bring the signal back within range.</li> <li>2. The input protection diodes are latched from improperly powering up unit by hooking up batteries one-at-a-time with power cable connected. Momentarily ground the input to the battery ground.</li> <li>3. The input protection diodes are latched from a static discharge. Momentarily ground the input to the battery ground.</li> </ol>
Zero adjust knob has no effect on the output. Amplifier output is $\pm 12$ volts all of the time on the $10^5$ gain setting, near zero on the $10^4$ gain setting. Seems to be ignoring input signals.	<ol style="list-style-type: none"> <li>1. Check that thermocouple is not grounded, especially to amplifier's power ground.</li> <li>2. The input protection diodes are latched from improperly powering up unit by hooking up batteries one-at-a-time with power cable connected. Momentarily ground the input to the battery ground.</li> <li>3. The input protection diodes are latched from a static discharge. Momentarily ground the input to the battery ground.</li> </ol>
Amplifier output shows excessive noise.	<ol style="list-style-type: none"> <li>1. Check that thermocouple is not grounded, especially to amplifier's power ground.</li> </ol>
Amplifier output drifts over the course of the day.	<ol style="list-style-type: none"> <li>1. Amplifier is on a place warmed by sun. Thermally isolate amplifier.</li> <li>2. Amplifier is being hit with draft from ventilation system. Thermally isolate amplifier.</li> </ol>

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Symptom:	Action:
Chart recorder "buzzes". Excessive 60 or 120 Hz pickup.	<ol style="list-style-type: none"> <li>1. Wall voltage cords too close to unit. Reroute power cords away from amplifier.</li> <li>2. Grounding system is feeding 60Hz into amplifier-recorder cable. Place low-pass filter inline between amplifier and chart recorder.</li> </ol>

**Important!!!** Thermal emf's are usually in the range of 10's of  $\mu\text{V}/^\circ\text{C}$ . This means that you need to have the BC-NV100 (or any other nanovolt amplifier) as thermally stable as possible. For best results the amplifier should be placed out of the way for drafts and away from windows or direct sunlight.

### What if it never looks right?

Your BC-NV100 has been tested before shipping and demonstrated acceptable characteristics within the designed specifications. It is possible that something may have gone wrong with the unit subsequent to its departure for our test bench. If all else fails, fax or email us and describe your problem.

#### Email:

We are anxious to help you make the most out of your BC-NV100 Nanovolt Amplifier. You can best talk to us by email. You can send questions regarding your BC-NV100 Nanovolt Amplifier to us at:

mjburns@ix.netcom.com.

When you do contact us, please send a description of the problem and what steps you have already taken to try to rectify the problem. Please allow at least 24 hours for a reply to your question.

#### Fax:

You can also reach us by fax at (818) 398-7607. When you do contact us, please send a description of the problem and what steps you have already taken to try to rectify the problem. Please allow at least 24 hours for a reply to your question.

## IV. Technical Specifications and Schematics

### Electronics:

Box: Cast aluminum construction. 11.7 cm x 9.0 cm x 5.7 cm.

Power Supply:  $\pm 12$  volts @ 10 milliamperes supplied by two external (user supplied) batteries.

#### Input:

Type:	True differential.
Differential input impedance:	250k $\Omega$
Impedance to ground:	11k $\Omega$

#### Outputs:

10 <sup>4</sup> gain setting:	1 volt/100 $\mu$ volts
10 <sup>5</sup> gain setting:	1 volt/10 $\mu$ volts

#### Amplifier (for zero source resistance)<sup>2</sup>:

Voltage Gain (selectable):	$\times 10028$ (10 <sup>4</sup> ) and $\times 102051$ (10 <sup>5</sup> )
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#### Frequency Response:

dc to 0.13Hz	(Filter In)
dc to 1kHz	(Filter Out)

Zero Adjust Span (referred to input):  $\pm 500\mu$ V

Common Mode Rejection Ratio:	> 120dB
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#### Noise Specifications (Battery Operation Only):

1/f Corner Frequency:	$\sim 3$ Hz
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#### Total Input Noise Voltage (at input jack):

57 nV rms	(Filter Out, Gain Ind.)
3 nV rms	(Filter In, Gain Ind.)

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<sup>2</sup> The BC-VN100 will function best with source resistances less than 400 $\Omega$ . The BC-VN100 will function with any source resistance, however the noise performance will degrade with increasing source resistance. For source resistances above 400 $\Omega$ , other amplifier designs will offer lower noise performance than the BC-NV100. For low-noise amplifiers for signal sources or sensors with source impedances greater than 400 $\Omega$ , contact Burns Consulting.

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Total Output Noise Voltage (at output jack):

0.57 mV rms	( $10^4$ gain, Filter Out)
30 $\mu$ V rms	( $10^4$ gain, Filter In)
5.7 mV rms	( $10^5$ gain, Filter Out)
300 $\mu$ V rms	( $10^5$ gain, Filter In)

Voltage Noise (referred to input):

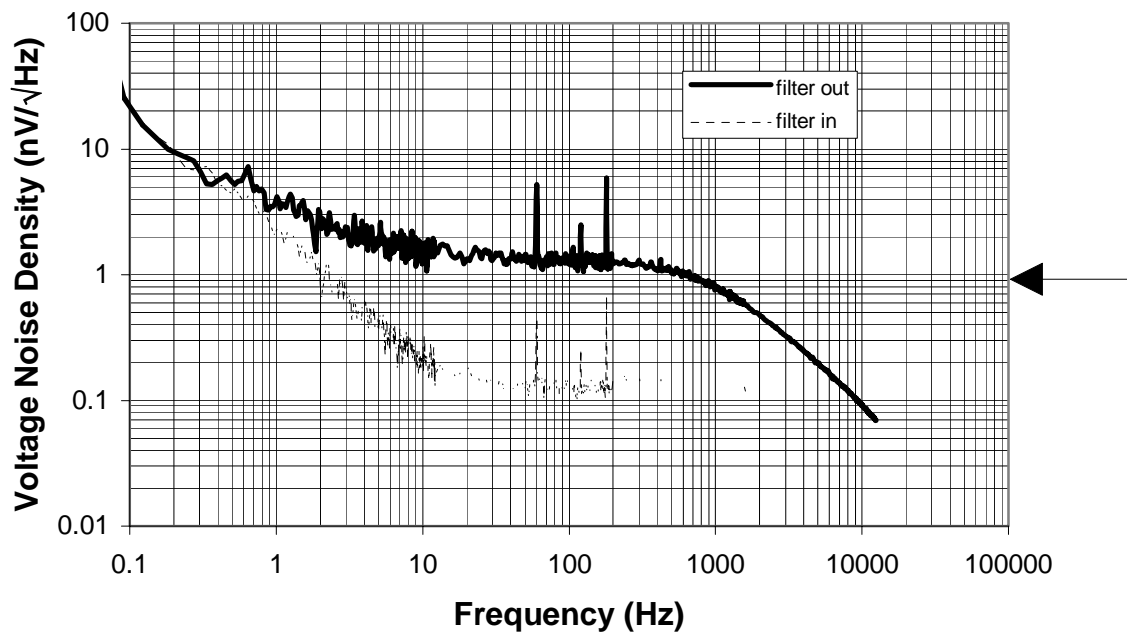


Figure IV.1 -- Input voltage noise density of the BC-NV100 under battery operation, zero source resistance, and gain setting of  $10^4$ . The arrow on the right indicates the level of thermal white noise that a  $50\Omega$  resistor creates at room temperature.  $1\text{nV} = 10^{-9}$  volts.

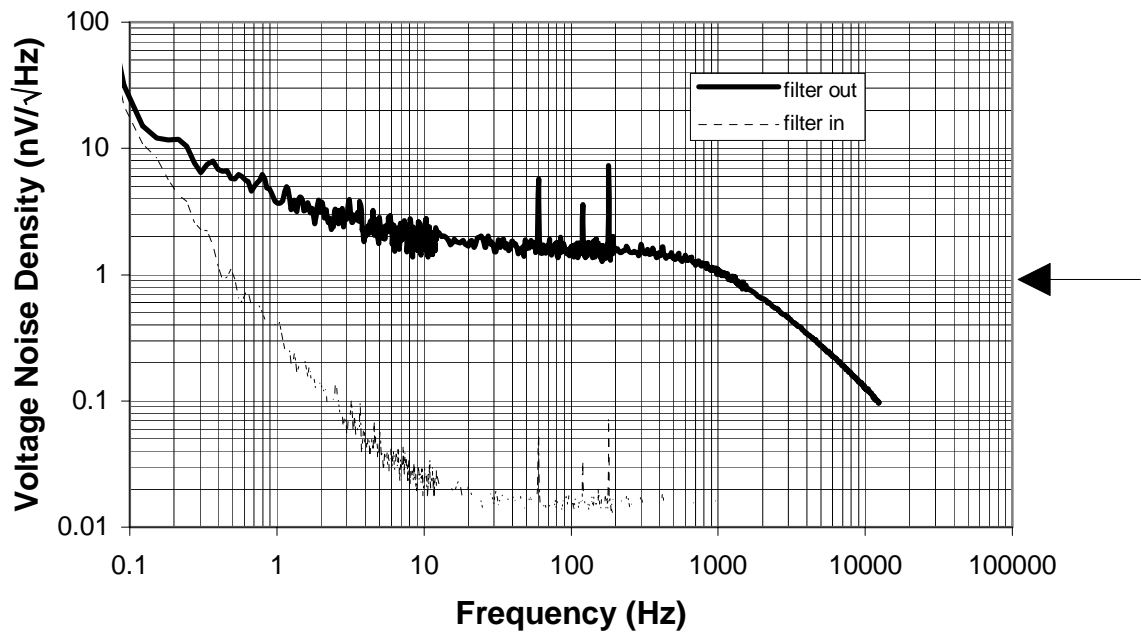


Figure IV.2 -- Input voltage noise density of the BC-NV100 under battery operation, zero source resistance and gain setting of  $10^5$ . The arrow on the right indicates the level of thermal white noise that a  $50\Omega$  resistor creates at room temperature.  $1\text{nV} = 10^{-9}$  volts.

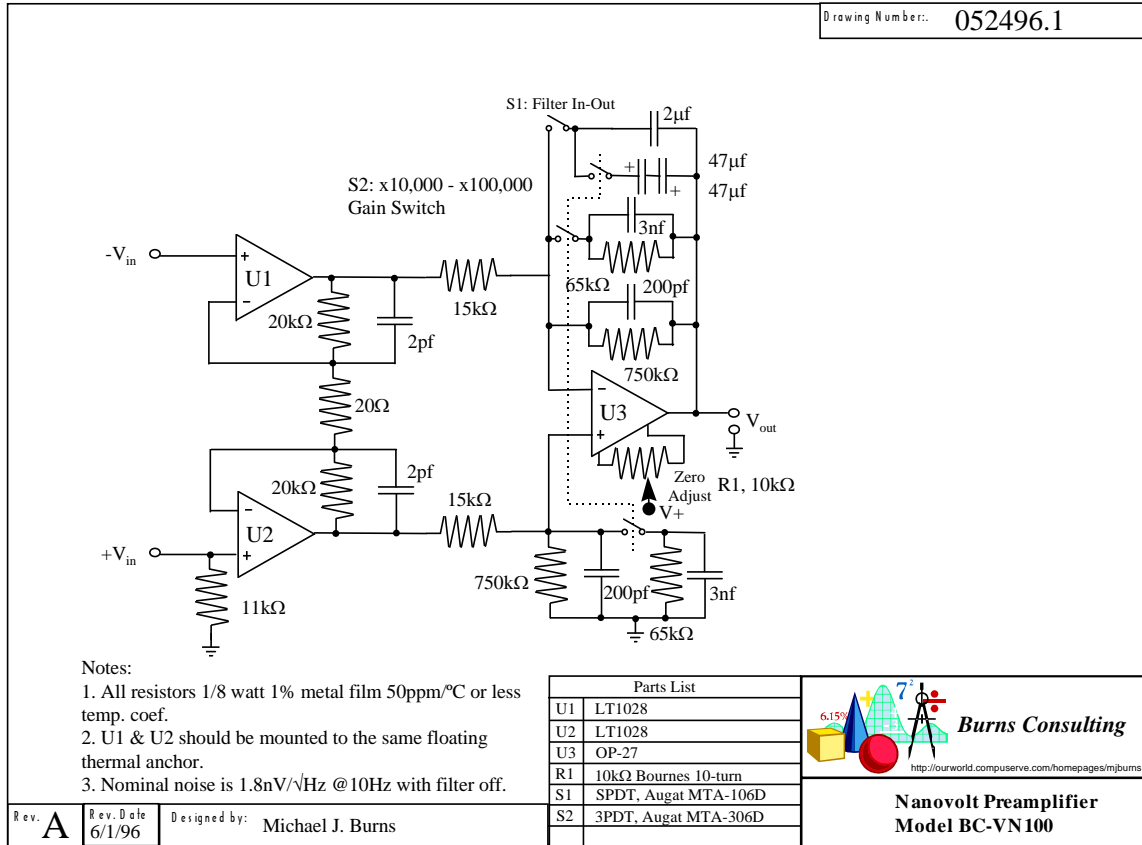


Figure IV.3 -- Schematic diagram of the core amplifier circuit of the BC-NV100.

## **V. Customer Service and Guarantee Information**

### **Customer Service**

#### **Email:**

We are anxious to help you make the most out of your BC-NV100 Nanovolt Amplifier. You can best talk to us by email. You can send questions regarding your BC-NV100 Nanovolt Amplifier to us at:

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You can also reach us by fax at (818) 398-7607. When you do contact us, please send a description of the problem and what steps you have already taken to try to rectify the problem. Please allow at least 24 hours for a reply to your question.

### **Guarantee**

Your BC-NV100 is warranted free from defects for a period of one year from the date of purchase. Burns Consulting will repair or replace at its option any piece of defective equipment returned during this period. This service does not apply to apparatus subjected to excessive physical abuse or products that have been modified in any way. This amplifier is not to be used in any system for use with human subjects and the manufacturer will not be responsible for the results of such misuse. To return equipment for repair or replacement, email us at [mjburns@ix.netcom.com](mailto:mjburns@ix.netcom.com) or fax us at (818) 398-7607 to receive a return authorization number.

### **Prices**

Prices are effective January 1, 1996 and supersede any previously published prices. Prices do not include any federal, state or local taxes and are subject to change without notice.

### **Shipping**

Goods are shipped F.O.B. Altadena, California. Shipping charges are prepaid and billed with the goods. If special shipping instructions are required by the purchaser, they must be specified in writing on the customer's purchase order or letterhead.

**Minimum Order**

A minimum order of \$50.00 is required. Orders less than \$50.00 are subject to a \$10.00 service charge.

**Specifications**

Specifications on all products are subject to change without notice. Burns Consulting reserves the right to make improvements to the products without incurring any obligation to incorporate these changes in products previously sold.

**Return of Materials**

To return equipment for repair or replacement, email us at [mjburns@ix.netcom.com](mailto:mjburns@ix.netcom.com) or fax us at (818) 398-7607 to receive a return authorization number.