

**Model 3211 User's Manual**

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**High-Voltage Amplifier**

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## Introduction

The New Focus Model 3211 High-voltage Amplifier can be used as a versatile gain block in applications involving high-speed and high-voltage signals. The amplifier is extremely linear and can be used to drive capacitive loads up to 100 nF with peak voltages up to  $\pm 200$  V. These features make the device useful for driving electro-optic modulators and piezo-electric transducers. For instance, with the Model 400X Electro-optic Phase Modulators, the Model 3211 can be used to provide a linear phase modulation of greater than  $\pi$  for frequencies up to 1 MHz. The amplifier can also provide output current up to 120 mA.

## Safety

The Model 3211 is a high-voltage amplifier capable of putting out 200 V at 120 mA. Because of the high-voltage capabilities of the amplifier, proper precautions should be taken to avoid electrical shock. The unit is equipped with a High Voltage On/Off switch which acts independently of the AC power switch. The three high-voltage outputs (High-voltage Output, -200 V and +200 V) will not operate unless the front-panel rocker Power switch is on and the green LED light is indicated on the High Voltage On/Off switch.

In the typical application, the user may not want to use the  $\pm 200$  V outputs. Since these outputs are turned on when the High-voltage Output is enabled, New Focus recommends putting dust covers over these  $\pm 200$  V outputs (which are DC current limited to 2 mA) when they are not being used to avoid electrical shock.

**NOTE:** Your safe and effective use of this product is of utmost importance to New Focus. Please read through the entire manual before attempting to operate the amplifier.

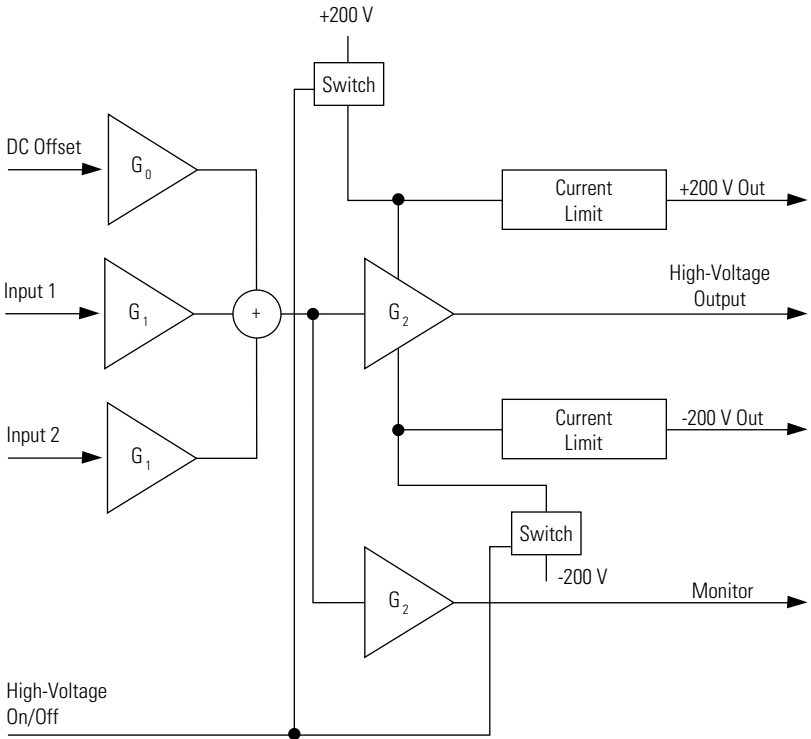
## Operation

The Model 3211 consists of a current-limited, high-voltage operational amplifier used in a summing-amplifier configuration. As shown in Fig.1, three signals are summed together at the input and amplified: DC offset, Input 1, and Input 2. The DC offset is adjustable from the front-panel potentiometer, and Input 1 and Input 2 come from the front-panel BNC jacks. The outputs consist of a high-voltage output, a monitor output (which is high-voltage output/30, or 1.5 times the sum of the inputs), a +200 V DC current-limited output and a -200 V DC current-limited output.

**NOTE:** Before connecting the AC power cable, verify the the line voltage setting in the amplifier agrees with the local voltage. (See Appendix 2: Operating Voltages & Fuses.)

**Fig. 1**

***Block diagram of the Model 3211  
High-voltage Amplifier.***



The  $\pm 200$  V outputs (nominally  $\pm 212$  V) are designed to be used as bias voltages for electro-optic modulators or piezo-electric transducers. They are current limited at DC (with 2-mA maximum DC out), but at higher frequencies act as an AC return.

The front-panel BNC inputs can be used independently or together in a summing configuration. The input resistance is  $5.75\text{ k}\Omega$  and the output resistance is  $25\ \Omega$ . The total gain from input to output is  $+40$  and the maximum output voltage is 200 V. The maximum input voltage is therefore  $\pm 5$  V for linear operation. **The absolute maximum voltage at Input 1 and Input 2 without damage is  $\pm 10$  V peak.**

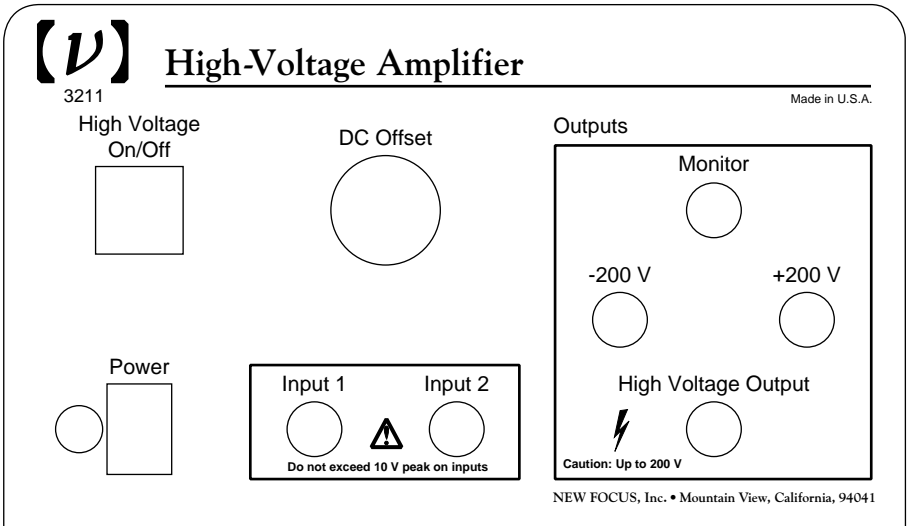
#### **NOTE: OPERATING PRECAUTIONS**

The high-voltage operational amplifier in the Model 3211 can be permanently damaged if thermally stressed. Thermal stress occurs only if the unit is operated well into its current-limited mode for at least 5–10 minutes; the unit is adequately protected for all other conditions. To avoid the possibility of overheating the amplifier and reducing its lifetime, you should ensure that it doesn't operate in the current-limited mode for more than a couple of minutes. The amplifier will operate in this mode under certain combinations of peak voltage, frequency, and load capacitance. Please refer to the Appendix 1: Bandwidth Limitations for a discussion on calculating the frequency at which current limiting occurs given the load capacitance and the signal's peak voltage.



Fig. 2

Front panel view of the Model 3211 Amplifier.

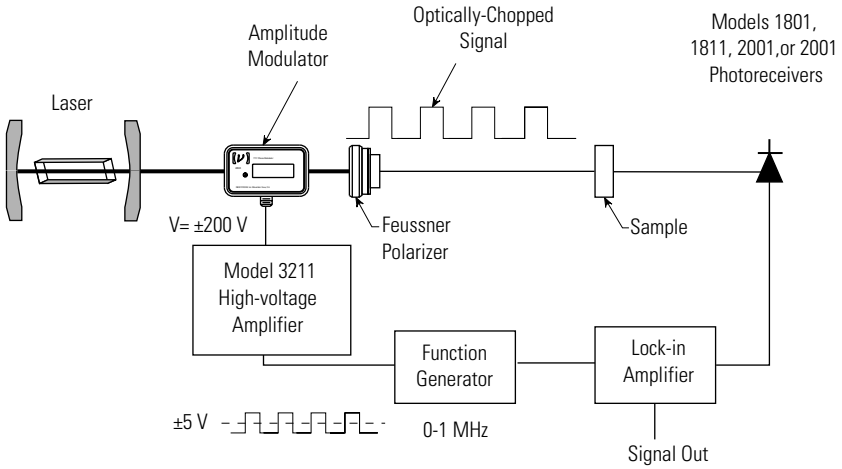


## Applications

The Model 3211 was designed primarily to drive electro-optic modulators and piezo-electric transducers. However, you can use it as a general-purpose amplifier to drive any capacitive load less than 100 nF. The amplifier can be used in conjunction with a low-voltage source to create a broad-bandwidth, low-voltage modulator driver. To prevent undesirable external signals from appearing on the High-voltage Output, the user should terminate any unused inputs.

**Fig. 3**

***Driving an electro-optic amplitude modulator with the Model 3211 Amplifier.***



## Appendix 1:

### *Bandwidth Limitations*

When driving capacitive loads with a high-voltage amplifier, such as the Model 3211, there are several factors which determine the bandwidth of the system.

#### **Closed-Loop Bandwidth**

The closed-loop bandwidth of the high-voltage operational amplifier in the Model 3211 determines the maximum bandwidth attained by the Model 3211; this bandwidth is at least 1 MHz. Other factors, such as slew rate, current limiting and RC filtering can limit the bandwidth even further, as described below.

#### **Slew Rate**

The slew rate of the Model 3211 is at least 700 V/ $\mu$ s. Thus, the maximum frequency of operation is dependent on the peak voltage. With a peak voltage of 200 V, the maximum frequency, and therefore the largest signal bandwidth, is given by:

$$V_{\text{out}} = V_p \sin(2\pi ft)$$

$$dV_{\text{out}}/dt = 2\pi f V_p \cos(2\pi ft) < 700 \text{ V}/\mu\text{s}$$

$$f_{\text{max}} (\text{large signal}) = 111 \times 10^6 / V_p,$$

where  $V_p$  is the peak voltage,  $f$  is the frequency in Hz,  $t$  is time, and  $V_{\text{out}}$  is the output voltage.

Therefore, when the peak voltage is 200 V and the amplifier is not current limited as described in the section below, the maximum frequency on the high-voltage output is 555 kHz.

## Current Limit

The maximum current that can be provided by the amplifier Model 3211 is 120 mA. For this reason, when driving capacitive loads, the maximum frequency is capacitance dependent. The displacement current drawn by a capacitor is given by:

$$I = C dV/dt < 0.12 \text{ A}$$

$$dV/dt_{\max} = 2\pi f V_p.$$

Therefore,

$$f_{\max} \text{ (current limit)} \sim 0.0191/CV_p.$$

If the peak voltage into the capacitor is 200 V, then the maximum frequency (in Hz) is given by:

$$f_{\max} \text{ (current limit/large signal)} \sim 9.55 \times 10^{-5}/C.$$

Therefore, if the capacitive load is 100 nF (0.1 μF), the maximum frequency before current limiting begins to distort a 200-V waveform is 955 Hz.

## RC Filter

The Model 3211 has an output resistance of approximately 25 Ω. This resistance, along with the capacitive load, forms a low-pass, RC filter with the 3-dB point at a frequency of  $1/(2\pi RC)$ . This RC filter can limit the bandwidth performance of the Model 3211 for large capacitive loads and very small peak voltages.

## Summary

When determining the maximum bandwidth of the Model 3211 for a known capacitive load and a desired peak voltage, the user must calculate the bandwidth determined by the slew rate (dominates

for small—on the order of 100 pF or less—capacitive loads and large voltages), the current limit (dominates for large—on the order of tens of nanofarads—capacitive loads) and the RC filter (dominates for large capacitive loads and very small peak voltages). The smallest of the 1-MHz closed loop bandwidth, the calculated slew-rate limited bandwidth, the calculated current-limited bandwidth, and the calculated RC bandwidth determines the maximum bandwidth of the Model 3211. Four examples illustrating how to determine the maximum bandwidth follow.

### **Example 1 (slew-rate-limited case)**

Peak voltage=200 V

Load capacitance=10 pF

1. Slew-rate-limited bandwidth:

$$111 \text{ MHz}/200=555 \text{ kHz}$$

2. Current-limited bandwidth:

$$0.0191/(10 \times 10^{-12} \times 200)=9.55 \text{ MHz}$$

3. Closed-loop bandwidth: 1 MHz

4. RC bandwidth:  $1/(2\pi \times 25 \times 10 \times 10^{-12})=637 \text{ MHz}$

Therefore, the maximum bandwidth is the smallest of the four, or 555 kHz.

### **Example 2 (current-limited case)**

Peak voltage=200 V

Load capacitance=100 nF

1. Slew-rate-limited bandwidth:

$$111 \text{ MHz}/200=555 \text{ kHz}$$

2. Current-limited bandwidth:

$$0.0191/(100 \times 10^{-9} \times 200)=955 \text{ Hz}$$

3. Closed-loop bandwidth: 1 MHz

4. RC bandwidth:  $1/(2\pi \times 25 \times 100 \times 10^{-9}) = 63.7 \text{ kHz}$

Therefore, the maximum bandwidth is the smallest of the four, or 955 Hz.

### **Example 3 (closed-loop-bandwidth-limited case)**

Peak voltage = 100 V

Load capacitance = 100 pF

1. Slew-rate-limited bandwidth:

$$111 \text{ MHz}/100 = 1.11 \text{ MHz}$$

2. Current-limited bandwidth:

$$0.0191/(100 \times 10^{-12} \times 100) = 1.91 \text{ MHz}$$

3. Closed-loop bandwidth: 1 MHz

4. RC bandwidth:

$$1/(2\pi \times 25 \times 100 \times 10^{-12}) = 63.7 \text{ MHz}$$

Therefore, the maximum bandwidth is the smallest of the four, or 1 MHz.

### **Example 4 (RC-bandwidth-limited case)**

Peak voltage = 1 V

Load capacitance = 100 nF

1. Slew-rate-limited bandwidth:

$$111 \text{ MHz}/1 = 111 \text{ MHz}$$

2. Current-limited bandwidth:

$$0.0191/(100 \times 10^{-9} \times 1) = 191 \text{ kHz}$$

3. Closed-loop bandwidth: 1 MHz

4. RC bandwidth:  $1/(2\pi \times 25 \times 100 \times 10^{-9}) = 63.7 \text{ kHz}$

Therefore, the maximum bandwidth is the smallest of the four, or 63.7 kHz.

## Appendix 2:

### *Operating Voltages and Fuses*

The Model 3211 can operate from 100, 120, 220, or 240 V AC with AC frequencies of 47–63 Hz. The unit is configured at the factory for the standard AC voltage in the user's country. To select a different operating voltage, please refer to Fig. 4 and follow the directions below:

1. Disconnect the power cord.
2. Open the cover of the power entry module on the rear panel with a small blade screwdriver or similar tool.
3. Insert the tool into the voltage selection slot and remove the wheel from the unit.
4. Turn the wheel and re-insert into the module so the desired voltage is shown.

**NOTE:** Do not attempt to rotate the wheel while it is still in the power entry module; the wheel must be removed, turned, and then re-inserted.

5. Close the cover.
6. Verify that the proper voltage is showing through the module's window.

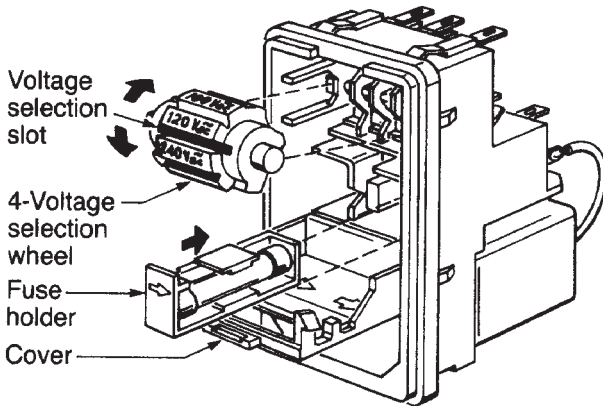
The power entry module requires two 5x20-mm, slow-blow fuses, such as Littlefuse's® Slo-Blo® 239 Series: one for the hot line and the other for the neutral line. Replacement fuses should be as follows:

<u>AC Voltage</u>	<u>Fuse Rating</u>	<u>Little Fuse</u>
100 V AC	1.6 A	239 01.6
120 V AC	1.6 A	239 01.6
220 V AC	0.8 A	239.800
240 V AC	0.8 A	239.800



**Fig. 4**

*Model 3211 Amplifier voltage selection.*



## Specifications

### Performance

Bandwidth, 3 dB(C<100 pF)	1 MHz
Slew Rate	700 V/μs
Output Voltage	±200 V
Voltage Gain	40
Input Impedance	5.75 kΩ
Output Impedance	25 Ω
Max. Load Capacitance	0.1 μF
Max. Output Current	120 mA
Max. Input without Damage	±10 V peak
Operating AC Voltage	100, 120, 220, or 240 V AC

## **Warranty, Service, & Support**

### **Warranty**

New Focus guarantees its products to be free of defects for one year from the date of shipment. This is in lieu of all other guarantees, expressed or implied, and does not cover incidental or consequential loss.

### **Technical Support**

Information and advice about the operation of your New Focus products are available from our technical support engineers.

Engineers are on duty from 8:00–5:00 PST, Monday through Friday (excluding holidays). For quickest response, ask for "Technical Support" and know the model number for your product.

Phone: (408) 980-8088

Fax: (408) 980-8883

Support is also available by email.

Email: [techsupport@newfocus.com](mailto:techsupport@newfocus.com)

We typically respond to email within one business day.

### **Service**

In the event that your amplifier malfunctions or becomes damaged, please contact New Focus for a return authorization number and instructions on shipping the unit back for evaluation and repair.