

## Balanced Photoreceivers

*Models 1607-AC & 1617-AC*



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*These photoreceivers are sensitive to electrostatic discharges and could be permanently damaged if subjected even to small discharges. Ground yourself adequately prior to handling these detectors or making connections. A ground strap provides the most effective grounding and minimizes the likelihood of electrostatic damage*

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## **Warranty**

Newport Corporation 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. Information in this document is subject to change without notice.

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# Contents

<b>Introduction</b>	<b>5</b>
Overview .....	5
Quick Start .....	5
General Principles .....	7
<b>Operation</b>	<b>11</b>
Connecting the Power Supply .....	11
Mounting the Photoreceiver .....	12
Connecting the Optical Inputs .....	12
Connecting the Electrical Output .....	13
Testing the Photoreceiver .....	14
<b>Customer Service</b>	<b>15</b>
Technical Support .....	15
Service .....	15
<b>Specifications</b>	<b>16</b>

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# Introduction

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## Overview

The Newport Model 16X7-AC balanced photoreceiver consists of two matched photodiodes and an RF amplifier that generates an output voltage proportional to  $I_1 - I_2$ , the difference between the photocurrents in the two photodiodes.

The Quick Start and General Principles sections below give an overview of setting up the photoreceiver and understanding its principles and design. The chapters that follow give detailed operating instructions and specifications.

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## Quick Start

The following parts are supplied with the Model 16X7-AC balanced photoreceiver:

- Model 0923 Pico (m8) double-ended, male power cable
- Model 0924 Pico (m8) male to banana plug power cable
- Model 0927 SMB-to-BNC cable

The steps on the following pages describe the basics of setting up and using the photoreceiver. The Operation chapter contains more detailed information.

1. Use one of the supplied power cables to connect the photoreceiver to a  $\pm 15$ -volt power source that can supply 200 mA. (Page 11.)

For the Newport Model 0901 power supply, use the 0923 power cable. For other power supplies, use the 0924 banana plug power cable.

*When using the 0924 cable, take care to hook up the banana plugs as follows to avoid damaging the photoreceiver: Red = +15 V, Black = -15 V, Green = Ground.*



2. Mount the photoreceiver to your optical table. A pair of 8-32 and a pair of M4-threaded holes are located on the bottom of the unit. (Page 12.)
3. Connect the optical source to one or both optical inputs. (Page 12.)

For the free space model, take care not to overfill the photodiode. The 1607-AC has a 0.4-mm diameter photodiode; the 1617-AC has a 0.1-mm diameter photodiode.

*To prevent saturation of the RF amplifier, keep the input power below the saturation power shown on page 16.*



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*The optical power must remain below the absolute maximum power listed in the specifications on page 16. Exceeding the maximum power can damage the photodiode and the amplifier.*

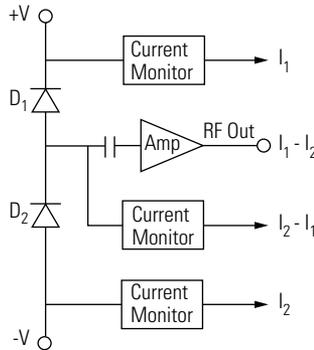
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4. Use the low-frequency  $I_1$  and  $I_2$  outputs to check and adjust the optical inputs so that the output powers are in the desired 0–10 V range. (Page 13.)  
You can use the  $I_2 - I_1$  output to fine tune the optical power balance between the two diodes.
5. Finally, connect the **RF Out** SMA connector to the desired load or instrument via a 50- $\Omega$  coaxial cable. (Page 13.)

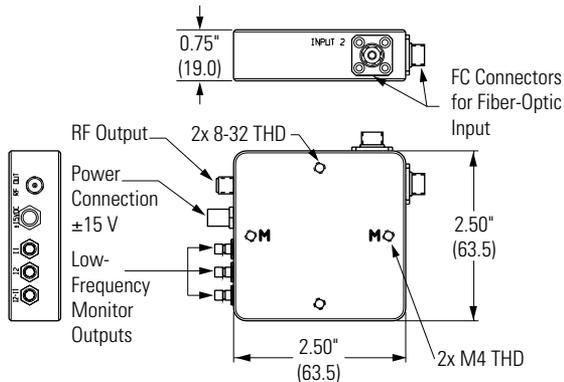
# General Principles

The Newport Model 16X7-AC balanced photoreceiver consists of two matched photodiodes and an RF amplifier that generates an output voltage proportional to  $I_1 - I_2$ , the difference between the photo-currents in the two photodiodes. A functional block diagram of the balanced photoreceiver is shown in Figure 1, and a mechanical drawing is given in Figure 2.

**Figure 1:**  
Functional block diagram of the Model 16X7-AC



**Figure 2:**  
Mechanical drawing of the balanced photoreceiver (fiber-coupled version)



Transmission lines connect the photodiode to the amplifier and the amplifier to the output. The transmission lines help to preserve speed and reduce parasitic inductance and capacitance that can cause ringing. DC power is delivered to the balanced photoreceiver through a microconnector on the side

of the unit, and the entire package is shielded to eliminate noise pickup.

## Low-frequency Monitor Outputs

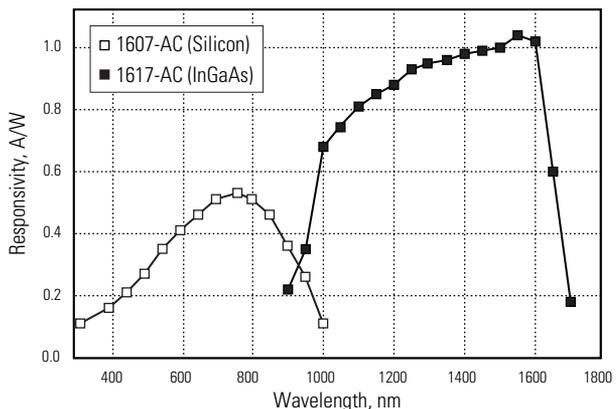
In addition to the RF output, the balanced photo-receiver has three low-frequency monitor outputs,  $I_1$ ,  $I_2$  and  $I_2 - I_1$ . These monitor outputs can be used to help align light onto the photodiodes and to perform low-frequency diagnostics. The monitor outputs have SMB connectors, and an SMB-to-BNC cable is provided with the photoreceiver.

All three monitor outputs have a transimpedance gain of 10 V/mA. The bandwidth of the  $I_2 - I_1$  output is DC to 15 kHz, and the bandwidth of the  $I_1$  and  $I_2$  outputs is DC to 100 kHz.

## Responsivity and Input Power

The Model 1607-AC uses a matched pair of silicon photodiodes, and the Model 1617-AC uses a matched pair of InGaAs photodiodes. Figure 3 shows the typical responsivity of the photodiodes.

**Figure 3:**  
Typical  
responsivities  
of the Silicon  
and InGaAs PIN  
photodiodes in  
the 1607-AC  
and 1617-AC



The amplifier has a maximum input current of 2 mA; to avoid damage to the amplifier, never exceed this input current. The Model 1607-AC has a peak responsivity of 0.5 A/W, which means that 2 mA of photo-

current corresponds to a maximum input optical power of 4 mW. The Model 1617-AC has a 1.0-A/W peak responsivity, and so the maximum input optical power is 2 mW. At wavelengths away from the peak responsivity the maximum input optical power scales inversely with the responsivity.

## Gain, Bandwidth and Noise

The RF amplifier is a low-noise device with 50- $\Omega$  input and output impedances. The RF amplifier's trans-impedance gain is 700 V/A, and the amplifier is AC-coupled with a 40-kHz low-frequency roll-off.

The RF output stage can drive up to +12 dBm into a 50- $\Omega$  load. To avoid saturating the RF amplifier, keep the input optical power below about 2 mW for the 1607-AC and below 1 mW for the 1617-AC.

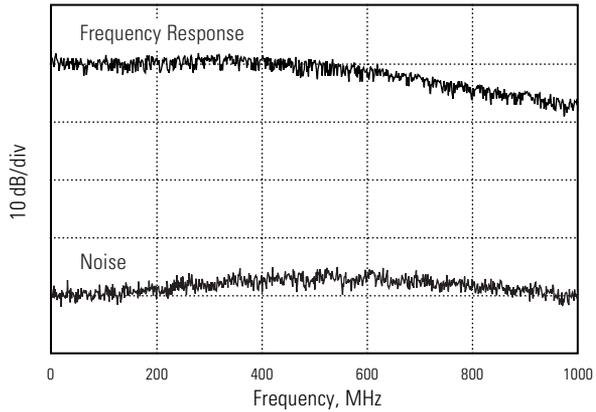
The RF bandwidth is 650 MHz for the Model 1607-AC and 800 MHz for the Model 1617-AC. Figures 4 and 5 show typical frequency responses for the two photoreceivers. From the bandwidths, we estimate rise times of 0.8 ns for the 1607-AC and 0.6 ns for the 1617-AC.

Figures 4 and 5 also show the typical noise spectrum. Since the RF amplifier is the dominant source of noise, the noise spectrum is the same for both the 1607-AC and 1617-AC. The noise is frequency dependent and has a minimum input noise current in the 40-kHz to 100-MHz range of about 20 pA/ $\sqrt{\text{Hz}}$ . This corresponds to a minimum noise-equivalent power (NEP) of 40 pW/ $\sqrt{\text{Hz}}$  for the 1607-AC and 20 pW/ $\sqrt{\text{Hz}}$  for the 1617-AC.

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**Figure 4:**  
1607-AC typical  
frequency  
response and  
noise spectrum

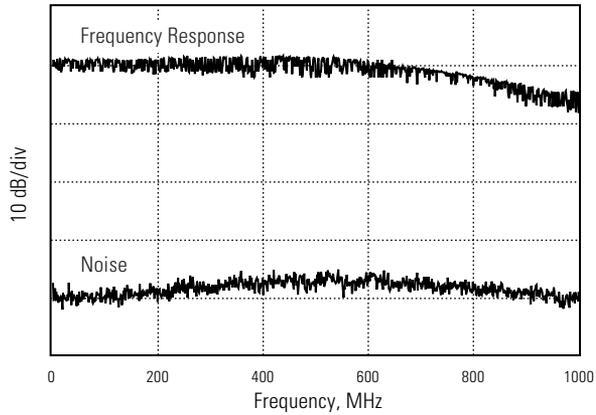
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**Figure 5:**  
1617-AC typical  
frequency  
response and  
noise spectrum

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From 40 kHz to 800 MHz the integrated input noise current is approximately  $1.5 \mu\text{A}_{\text{rms}}$ . Multiplying this by the 700-V/A transimpedance gain gives an output voltage noise of  $1.1 \text{ mV}_{\text{rms}}$ .

The  $1.5\text{-}\mu\text{A}_{\text{rms}}$  integrated input noise current corresponds to an equivalent input optical noise of  $3 \mu\text{W}$  for the Model 1607-AC and  $1.5 \mu\text{W}$  for the Model 1617-AC. This input optical noise level is the approximate minimum optical signal that can be detected with these photoreceivers. To detect a weaker signal, you can reduce the noise by adding an electronic bandpass filter at the output of the photoreceiver.

# Operation

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## Connecting the Power Supply

The balanced photoreceiver's power supply connector is a 3-pin shielded microconnector. This should be connected to a  $\pm 15$ -V power supply capable of providing a current of 200 mA. (We recommend the Newport Model 0901 power supply.)

Two different power cables are shipped with the photoreceiver: Model 0923 Pico (m8) double-ended, male power cable for use with the Newport power supply, and a Model 0924 Pico (m8) male to banana plug power cable for use with other power supplies.

### Using a Newport Power Supply

If you have a Newport Model 0901 power supply, use the Model 0923 Pico (m8) double-ended, male power cable to connect the photoreceiver to one of the power supply's 0.3-A microconnector outputs.

Be careful to align the notches on the connectors when attaching the cable. If the connectors are not mated correctly or the pins are bent, the photoreceiver may be damaged.

### Using Another Power Supply

Use the Model 0924 Pico (m8) male to banana plug power cable when working with a power supply other than the Newport Model 0901. Be sure to hook up the banana plugs correctly, or the photoreceiver can be damaged. The convention for the three banana plugs

is as follows:

Red = +15 V, Green = Ground, Black = -15 V.

Be careful to align the notches on the connectors when attaching the microconnector end of the cable to the photoreceiver. If the connector is not mated correctly or the pins are bent, the photoreceiver may be damaged.

## Checking the Power Connection

With no light on the photodiodes, the photoreceiver draws approximately 90 mA on the +15-V line and 10–15 mA on the -15-V line.

If the current draw is 0 mA, the power supply cable may have a bad connection. If the current draw is greater than 150 mA, then the cable could be shorted or there may be an internal problem with the photoreceiver. Contact Newport for support and, if necessary, instructions on returning the unit.

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## Mounting the Photoreceiver

The bottom of the photoreceiver has two pairs of holes for mounting it to a post or pedestal. The pair labeled “M” is for mounting with M4-threaded screws. The other pair is threaded for 8-32-threaded screws.

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## Connecting the Optical Inputs

When connecting the optical inputs, keep the power below the saturation power listed on page 16. This will keep the RF amplifier operating in the linear region.



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*The optical power must remain below the absolute maximum power listed in the specifications on page 16. Exceeding the maximum power can damage the photodiode and the amplifier.*

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The balanced photoreceiver is available with two types of optical input. The -FS option is for free-space optical coupling, and the -FC option has FC fiber connectors.

### **Using the Free Space (FS) Model**

Direct an optical beam onto one or both of the photodiodes.

Overfilling the photodiode can cause a decrease in the photoreceiver's frequency bandwidth. To avoid this, you may need to focus the beam onto the photodiode. The 1607-AC has a 0.4-mm diameter photodiode, and the 1617-AC has a 0.1-mm diameter photodiode.

### **Using the FC Fiber-Coupled Model**

For fiber-optic input, connect the fiber-optic cable from your optical source to the FC connectors on the sides of the photoreceiver.

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## **Connecting the Electrical Output**

Three low-frequency DC-coupled monitor outputs ( $I_1$ ,  $I_2$ ,  $I_2 - I_1$ ) are provided for diagnostics and for use when first aligning an optical beam onto the photodiodes. These monitor outputs have 10 V/mA gain. All three outputs use SMB connectors, and an 0927 SMB-to-BNC cable is provided with the photoreceiver.

1. Using the 0927 SMB-to-BNC cable, connect the  $I_1$  output to a voltmeter or oscilloscope.
2. Adjust the input optical power to achieve the desired output voltage, somewhere in the 0–10-V range.
3. Connect the cable to the  $I_2$  output and adjust the input power to again achieve an output voltage in the 0–10-V range.
4. (Optional) You can use the  $I_2 - I_1$  low-frequency output to fine adjust the optical power balance between the two photodiodes.

5. Connect the high-frequency RF Out SMA connector to the desired load or instrument via a 50-W coaxial cable. This output has a 50-W impedance and is AC-coupled with a 40-kHz low-frequency roll-off.

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## Testing the Photoreceiver

To quickly test whether the photoreceiver is working, you can perform a simple DC optical test.

1. Apply power to the photoreceiver.
2. Using a voltmeter or oscilloscope, measure the output voltage from one of the low-frequency monitor outputs.

With no light on the photodiodes, the output voltage should be less than 10 mV. If the voltage is greater than 10 mV, there may be a problem with the power cable, or a photodiode or amplifier may be damaged.

3. Shine light onto one of the photodiodes (room light or a bright light source may be sufficient, or you can use a CW laser source). Do not exceed the saturation power shown on page 16.
4. Measure the voltage from the monitor output.

If you know the optical power and wavelength, you can calculate the approximate output voltage ( $V_{\text{out}}$ ) using the expression  $V_{\text{out}} = P_{\text{in}} \cdot R \cdot G$ , where  $P_{\text{in}}$  is the input optical power (watts),  $R$  is the photodetector's responsivity in units A/W (see Figure 3), and  $G$  is the amplifier's transimpedance gain (V/A). For the low-frequency monitor outputs, the gain is  $10^4$  V/A.

**Note:**

*If you are testing with the high-frequency output, the gain is 700 V/A.*

# Customer Service

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## Technical Support

Information and advice about the operation of any Newport product is available from our applications engineers. For quickest response, ask for “Technical Support” and know the model number and serial number for your product.

**Hours:** 8:00–5:00 PST, Monday through Friday (excluding holidays).

**Phone:** 1-877-835-9620

Support is also available by email and chat

**Chat:** Connect with us at [www.newport.com](http://www.newport.com)

**Email:** [tech@newport.com](mailto:tech@newport.com)

We typically respond to emails within one business day.

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## Service

In the event that your device malfunctions or becomes damaged, please contact Newport for a return merchant authorization (RMA) number and instructions on shipping the unit back for evaluation and repair.

# Specifications

	Model 1607-AC	Model 1617-AC
Wavelength Range	320–1000 nm	900–1700 nm
3-dB Bandwidth	40 kHz–650 MHz	40 kHz–800 MHz
Rise Time (estimated)	0.8 ns	0.6 ns
Typical Max. Responsivity	0.5 A/W	1.0 A/W
Transimpedance Gain	700 V/A	700 V/A
Max. Conversion Gain	350 V/W	700 V/W
Output Impedance	50 $\Omega$	50 $\Omega$
Minimum NEP	40 pW/ $\sqrt{\text{Hz}}$	20 pW/ $\sqrt{\text{Hz}}$
Saturation Power	2 mW	1 mW
Absolute Maximum Power	4 mW	2 mW
Common-Mode Rejection Ratio (typical)	25 dB	25 dB
Max. Output Power	+12 dBm (into 50 $\Omega$ )	+12 dBm (into 50 $\Omega$ )
Photodiode Material/Type	Silicon/PIN	InGaAs/PIN
Photodiode Diameter	0.4 mm	0.1 mm
Power requirements	$\pm 15$ V DC, $\leq 200$ mA	$\pm 15$ V DC, $\leq 200$ mA
Optical input	FC or Free Space (FS)	FC or Free Space (FS)
RF Output Connector	SMA	SMA
Monitor Output Connector	SMB	SMB
I <sub>1</sub> and I <sub>2</sub> Monitor Bandwidth	DC–100 kHz	DC–100 kHz
I <sub>2</sub> -I <sub>1</sub> Monitor Bandwidth	DC–15 kHz	DC–15 kHz