

High-Speed Receivers

Models 1580-A, 1544-A, 1580-B, 1544-B,
1484-A-50, and 1474-A

High-Speed Detectors

Models 1414, 1014, 1444, and 1024



Warranty

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Operation

Introduction

High-speed and ultrahigh-speed measurements of optical waveforms are easy with the Newport, formerly New Focus, photoreceiver/photodetector modules. These modules convert optical signals to electrical signals and can be used to provide every high-speed/high-frequency instrument in your lab an optical input. The small size of the modules allows you to connect them directly to your test instrument, amplifier if needed, or another high-speed component. This eliminates the need to follow the photoreceiver with coaxial cables, which can distort time-domain waveforms and attenuate CW microwave signals. The optical signal is delivered to the photodiode in the module through a single-mode or multimode optical fiber.

Photoreceivers (Amplified Photodiodes)

For the photoreceiver models, the photodiode is followed by a low-noise, linear, high-bandwidth amplifier. This combines gain and low noise to reduce the input-referred noise floor of your system and maintains linearity at high output levels, providing a high dynamic range. The high output level also facilitates operation with logic circuits. The high-speed amplifier, which follows the photodiode, produces a clean impulse response with minimal ringing. This is ideal for digital communication measurements. Most receivers have a negative conversion gain due to the inverting amplifier used – if you are using an oscilloscope and would like to see a positive output, an inverting function can be used.

DC-coupled

For DC-coupled receivers, the DC coupling is achieved by summing the signal's DC component with the high-speed

AC component at the output of an AC-coupled high-speed transimpedance amplifier. The gain of the DC path is set equal to that of the AC path and temperature compensated so that extinction ratios may be accurately measured.

Photodetectors (Unamplified Photodiodes)

Frequency Domain Optimized

Applications that rely on transmitting signals at RF and microwave frequencies benefit from detectors with flat frequency responses and improved response at higher frequencies. These applications include linear fiber-optic transmission to and from remote antennas for communication satellites, wireless cellular networks, and cable television. Since the time-domain response is not critical in these applications, the impulse response can have ringing. In particular, Models 1414 and 1014 detectors are frequency domain optimized to provide especially flat frequency responses over wide bandwidths.

Time Domain Optimized

If you need accurate reproduction of your signal in the time domain, choose Model 1444 or 1024 time-domain-optimized detectors. These models provide clean, fast impulse responses with minimal ringing, and are ideal for pulse measurements with digital high-speed oscilloscopes. Moreover, they can be used in digital communications applications, where spurious ringing can degrade eye diagrams and the bit-error-rate (BER) measurement of your system. And, because these detectors are internally terminated at 50 Ω , you won't have to worry about any reflections between the detector and filter for standardized BER testing with SDH and SONET filters.

Internal 9-V Battery

Models 1414, 1014, 1444, and 1024 combine an internal 9-V battery with the bias circuitry which make these self-contained, eliminating the need for an external power supply and reducing the possibility of photodiode damage due to overvoltage.

Mechanical/Optical Description

A gold-plated microwave housing inside the module contains the high-frequency circuitry. This housing is bolted to a printed-circuit board which regulates the bias for the high frequency components and amplifies the DC photocurrent for the monitor port. The optical signal is brought from the front-panel connector to the microwave housing using the appropriate fiber. In models with single-mode fiber input, the optical signal is delivered to the PIN photodiode through a 9- μm core optical fiber. For multimode input the signal is delivered through a 50- μm (or 62.5- μm) core graded-index multimode fiber. For 12 GHz models and faster, an internal lens focuses the light onto the small high-speed PIN photodiode. In modules with a battery, the fiber is protected by a sheet metal flange to prevent damage while replacing the battery.

Newport offers several photodetectors and photoreceivers, allowing you to match the wavelength, bandwidth, and fiber type of your application.

Figure 1:
Models 1580-B,
1544-B, and
1544-B-50

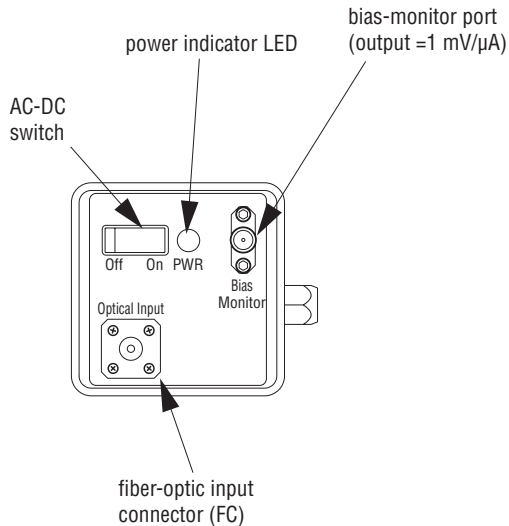


Figure 2:
Models 1580-A,
1544-A,
1544-A-50

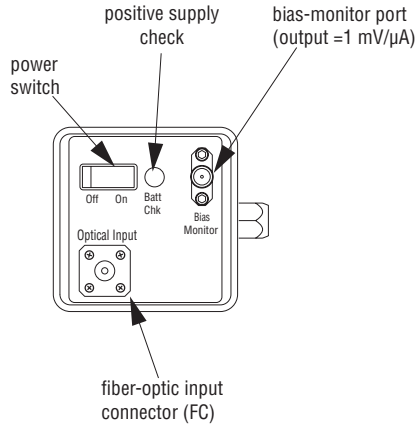


Figure 3:
Models 1414,
1414-50, 1014,
1024, 1444, and
1444-50

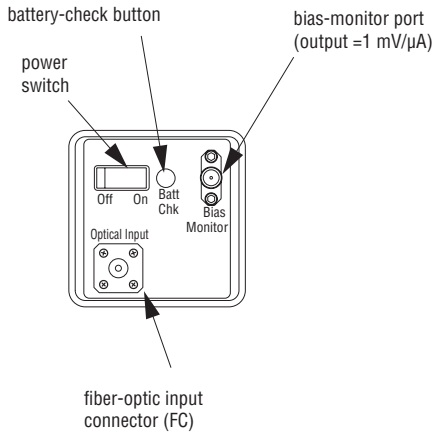


Figure 4:
Models 1484-A-
50, and 1474-A

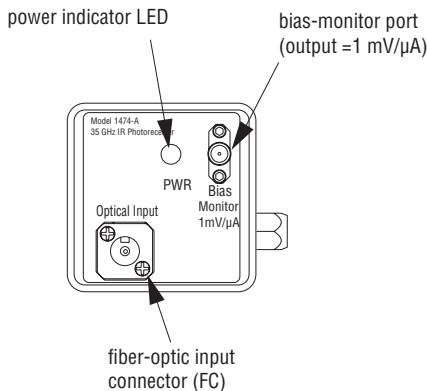
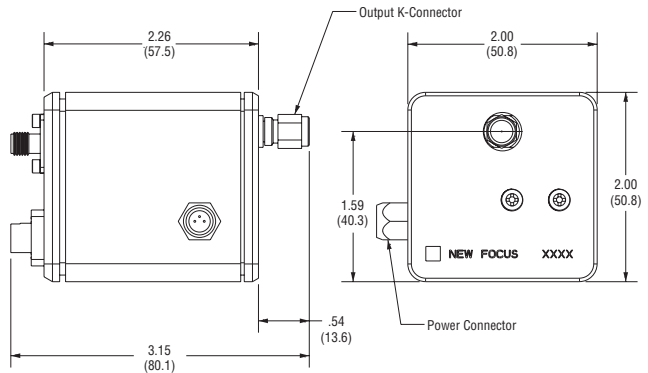


Figure 5:
Side and back
view. (Note that
the battery
operated
modules will
not have the
power connector
on the side.)



Handling Precautions



The detector is sensitive to electrostatic discharges and could be permanently damaged if subjected to even to small discharges. Whenever handling, make sure to follow these precautions:

- *Follow standard electrostatic-discharge precautions, including grounding yourself prior to handling the detector or making connections—even small electrostatic discharges could permanently damage the detector. A ground strap provides the most effective grounding and minimizes the likelihood of electrostatic damage.*
- *Do not over-torque the microwave K-connector. Excessive torque can damage connectors.*
- *Make sure the optical connector is clean and undamaged before connecting it to the detector module.*

Powering and Connecting the Photoreceiver / Photodetector

Connecting the Power Supply and Bias Monitor

1. Prior to handling the detector, ground yourself with a grounding strap to prevent electrostatic damage to the module.
2. Connect the power cable to your disabled power supply. Two power cables were included with the receiver; use the appropriate cable for your power supply.

Connecting to a New Focus 0901 power supply:

Using the appropriate cable, connect one end of the cable to one of the power supply's 300-mA outputs, and the other end to the module. If the 300-mA outputs are in use, the 300-mA banana-plug output can also be used with the appropriate cable. On older 0901's, the 100-mA banana-plug output can provide enough current for certain models. Check the current rating for your specific model in the Power Requirements section of the specifications table.

Connecting to another power supply:

Use the cable with the three-pin power connector on one end and three banana plugs on the other end. Be careful to connect the banana plugs to the power supply as follows; connect the red plug to a +15-V source; connect the black plug to a -15-V source; connect the green plug to the common or ground of the two sources. The +/- 15-V sources must be able to provide at least the required current for your specific model. Connect the three-pin power connector to the module.

3. **Microwave Connection and Set-up**

A. Connect the photoreceiver module's K-connector to a test instrument or component that has a 50-Ohm input impedance. If necessary, use a high-frequency cable (best performance is achieved without a cable).

B. To avoid connector damage and signal distortion, be sure that the cable and the instrument you intend to

connect to the module have compatible connectors. See “Appendix: Microwave Connectors”.

4. After connecting to the supply, enable or turn on the supply. While the module can handle any power-on sequence, it is recommended that both positive and negative be turned on together.
5. If desired, connect the Bias Monitor port to a voltmeter and observe the voltage level with no optical input. This dark voltage should be < 10 mV. Changes from the dark level will be proportional to photocurrent and will provide a low-frequency indication of signal strength.

Note:

If you are coupling light into a fiber, use the voltmeter to monitor the photocurrent to help optimize the coupling.

Battery Check For Units with Internal Batteries

1. Turn on power using the Off/On switch.
2. Connect a voltmeter to the Bias Monitor SMA connector.
3. Press the Batt Chk button. Per the table below, replace the battery if the voltage falls below the replacement threshold.

Model	Replacement Threshold
1014	3.8V
1024	7.0V
1414(-50)	6.7V
1444(-50)	4.3V

4. When finished using the module, turn off power to preserve battery life.

DC-coupled Modules

The 1580-B, 1544-B, and the 1544-B-50 have a front panel switch to select either the DC- or AC-coupled electrical output. The DC-coupled mode is indicated by a

red light while the AC-coupled mode is indicated by a green light.

Connecting the Optical Input to the Receiver

Be aware that if your fiber is multimode at the operation wavelength then excessive fiber length can lead to signal distortion. If you have the multimode “-50” model, use 50/125- μm graded index fiber. If you have model 1580-A, or 1580-B use 62.5/125- μm graded index fiber.

1. Before connecting to the photoreceiver, verify the power in the fiber is within the safe operating range.
2. Make sure the fiber is clean and undamaged, then connect the fiber-optic cable to the module's input.

Troubleshooting

Possible Problems and Solutions

1. **Low Gain:**

Verify that the power supply has sufficient voltage and current capability.

If your output signal is lower than expected, a dirty input fiber may be causing the problem. See “Basic Optical Test” below and verify that the input fiber is clean.

The photodiode can be damaged by electrostatic discharge or excessive optical power, which leads to an increased dark voltage. A damaged photodiode can result in excess leakage current, lower responsivity, or a slower frequency/impulse response. See “Checking the Dark Voltage,” below. A damaged photodiode must be replaced by Newport.

Severe mechanical shock may misalign the optics and lower the responsivity. See “Basic Optical Test” below. If dirty fiber tips have been ruled out, then the module must be repaired by Newport.

2. **Slow Response:**

Verify that the power supply has sufficient voltage and current capability.

If the frequency or time domain response is slower than expected, then most likely the photodiode or amplifier is damaged. See “Checking the Dark Voltage,” below. A damaged photodiode must be replaced by Newport. If the dark voltage is okay, then the problem is most likely a damaged amplifier and the module must be repaired by Newport.

Severe mechanical shock may misalign the optics. If the frequency response drops excessively from a low frequency up to several gigahertz (or if the time response has a slow component) then misalignment is a possibility and the module must be repaired by Newport.

3. **Little or No Response:**

Verify that the power supply has sufficient voltage and current capability.

After ruling out a dirty or defective fiber and making sure there is no loss due mismatch of input fiber core diameter, a damaged component is the most likely cause. The module must be repaired by Newport.

For assistance in troubleshooting or arranging for a repair, please see the “Customer Service” section of this manual.

Checking the Dark Voltage

1. With no light entering the module, turn on power to the detector.
2. Use a voltmeter to measure the Bias Monitor output voltage. This voltage is the dark voltage.
3. If the dark voltage is >10 mV, then the photodiode may be damaged and may need to be repaired by Newport. It is possible the module will still operate well with a voltage only somewhat higher than 10 mV. The user may wish to continue using the module and monitor this voltage to see if it degrades.

Basic Optical Test

To quickly test your receiver, run this simple optical test.

1. Turn the receiver on.
2. Using a voltmeter or oscilloscope, measure the output voltage from the Bias Monitor on the front panel of the module. With no light input, the Bias Monitor voltage should be <10 mV.
3. Illuminate the photodetector.
4. With the voltmeter or oscilloscope, you should observe a DC output voltage. If you know the optical power and wavelength, you can calculate the expected output voltage (V_{out}) using the expression:

$$V_{out} = P_{in} \cdot R \cdot G,$$

where P_{in} is the input optical power (Watts), R is the photodiode's responsivity (A/W) found on the datasheet shipped with the unit and G is the Bias Monitor's transimpedance gain, 1 V/mA. If the measured voltage is substantially less than expected, the module may need to be returned to Newport for repair.

Specifications

12-GHz Optical Photoreceivers.....	1580-A, 1544-A.....	Table 1
12-GHz DC-coupled Photoreceivers.....	1580-B, 1544-B.....	Table 2
22-GHz Photoreceivers	1484-A-50	Table 3
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25-GHz Photodetectors	1414.....	Table 4
45-GHz Photodetectors	1014.....	Table 5
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12-ps Photodetector.....	1024.....	Table 6
Characteristics (typical, except as noted)		

12-GHz Fiber Optic Photoreceivers

Model		1580-A	1544-A	1544-A-50
Wavelength Range	nm	780-870	500-1630	780-1630 ¹
Bandwidth, 3-dB, typ / min	GHz	12 / 10.5	12 / 10.5	12 / 10.5
Low-Frequency Cutoff	kHz	10	10	10
Risetime, 10-90%	ps	32	32	32
Conversion Gain ² , typ / max	V/W	-550 / -450	-900 / -800	-800 / -700
NEP ²	pW/rt(Hz)	42	24	27
Output Noise	mVrms	2.9	2.8	2.8
Saturation Power ²	mW	1.5	0.7	0.7
Maximum Safe Input, ^{2,5}	mW	3	2	2
Output Impedance	Ohm	50	50	50
Bias-Monitor Gain	V/mA	1	1	1
Bias-Monitor Bandwidth	kHz	50	50	50
Bias-Monitor Output Impedance	Ohm	10k	10k	10k
Power Requirements ⁶		+/- 15 V, 200 mA	+/- 15 V, 200 mA	+/- 15 V, 200 mA
Detector Type		GaAs	InGaAs	InGaAs
Output Connector		Anritsu K	Anritsu K	Anritsu K
Input Connector		FC/PC	FC/PC	FC/PC
Input Fiber		62.5- μ m MM	SM	50- μ m MM
Operating Temperature, min/max	$^{\circ}$ C	10/35	10/35	10/35

Table 1

12-GHz DC-coupled Photoreceivers

Model		1580-B	1544-B	1544-B-50
Wavelength Range	nm	780-870	500-1630	780-1630 ¹
Bandwidth, 3-dB (DC coupled), typ / min	GHz	DC to 12 / 10.5	DC to 12 / 10.5	DC to 12 / 10.5
Low-Frequency Cutoff (AC coupled)	kHz	10	10	10
Risetime, 10-90%	ps	32	32	32
Conversion Gain ² , typ/max	V/W	-550 / -450	-900 / -800	-800 / -700
NEP ²	pW/rt(Hz)	42	24	27
Output Noise	mVrms	2.9	2.8	2.8
Saturation Power ²	mW	1.5	0.7	0.7
Maximum Safe Input ^{2,5}	mW	3	2	2
Output Impedance	Ohm	50	50	50
Bias-Monitor Gain	V/mA	1	1	1
Bias-Monitor Bandwidth	kHz	50	50	50
Bias-Monitor Output Impedance	Ohm	10k	10k	10k
Power Requirements ⁶		+/-15 V, 200 mA	+/-15 V, 200 mA	+/-15 V, 200 mA
Detector Type		GaAs	InGaAs	InGaAs
Output Connector		Anritsu K	Anritsu K	Anritsu K
Input Connector		FC/PC	FC/PC	FC/PC
Input Fiber		62.5- μ m MM	SM	50- μ m MM
Operating Temperature,min/max	$^{\circ}$ C	10 / 35	10 / 35	10 / 35

Table 2

22 and 38-GHz Photoreceivers

Model		1484-A-50	1474-A
Wavelength Range	nm	800-865 ¹	630-1620
Bandwidth, 3-dB, typ / min	GHz	22/20	38/35
Low-Frequency Cutoff	kHz	15	15
Risetime, 10-90%	ps	16.5	12.5
Conversion Gain ² , typ / max	V/W	-75 / -65	-75 / -65
NEP ²	pW/rt(Hz)	38	38
Output Noise ³	μVrms	590	590
Output Voltage ⁴	V	-0.6	-0.6
Maximum Safe Input ^{2,5}	mW	8	8
Output Impedance	Ohm	50	50
Bias-Monitor Gain	V/mA	1	1
Bias-Monitor Bandwidth	kHz	15	15
Bias-Monitor Output Impedance	Ohm	10k	10k
Power Requirements		+/-12 to +/-15V, 100 mA	+/-12 to +/-15V, 100 mA
Output Connector		Anritsu K	Anritsu K
Input Connector		FC/PC	FC/PC
Input Fiber		50-μm	SM
Operating Temperature, min/max	°C	10/35	10/35

Table 3

25-GHz Photodetectors

Model		1414	1414-50
Wavelength Range	nm	500-1630	850-1630 ¹
Bandwidth, 3-dB, typ/min	GHz	25	25
Risetime, 10-90%	ps	14	14
Conversion Gain ² typ/min	V/W	17/15	14/12
Responsivity ²	A/W	0.7	0.6
Saturation Power ²	mW	2	2
Maximum Safe Input ^{2,5}	mW	10	10
Output Impedance	Ohm	50	50
Bias-Monitor Gain	V/mA	1	1
Bias-Monitor Bandwidth	kHz	50	50
Bias-Monitor Output Impedance	Ohm	1k	1k
Power Requirements ⁶		Internal 9-V Battery	Internal 9-V Battery
Detector Type		InGaAs	InGaAs
Output Connector		Anritsu K	Anritsu K
Input Connector		FC/PC	FC/PC
Input Fiber		SM	50- μ m MM
Operating Temperature, min/max	$^{\circ}$ C	10 / 35	10 / 35

Table 4

45-GHz Photodetectors

Model		1014
Wavelength Range	nm	500-1630
Bandwidth, 3-dB, typ/min	GHz	45 / 40
Risetime, 10-90%	ps	9
Conversion Gain typ/min ²	V/W	11/9
Peak Responsivity	A/W	0.45
Saturation Power	mW	2
Maximum Safe Input ⁵	mW	5
Output Impedance	Ohm	50
Bias-Monitor Gain	V/mA	1
Bias-Monitor Bandwidth	kHz	50
Bias-Monitor Output Impedance	Ohm	1k
Power Requirements		Internal 9-V Battery
Detector Type		InGaAs
Output Connector		Anritsu K
Input Connector		FC/PC
Input Fiber		SM
Operating Temperature, min/max	°C	10/35

Table 5

12- and 18.5-ps Photodetectors

Model		1444	1444-50	1024
Wavelength Range	nm	500-1630	850-1630 ¹	500-1630
FWHM, Impulse Response typ/max	ps	16.5/18.5	16.5/18.5	11/12
Bandwidth, 3-dB,	GHz	20	20	26
Conversion Gain ² typ/min	V/W	17/15	14/12	11/9
Responsivity ²	A/W	0.7	0.6	0.45
Saturation Power ²	mW	2	2	2
Maximum Safe Input, ^{2,5}	mW	10	10	5
Output Impedance	Ohm	50	50	50
Bias-Monitor Gain	V/ mA	1	1	1
Bias-Monitor Bandwidth	kHz	50	50	50
Bias-Monitor Output Impedance	Ohm	1k	1k	1k
Power Requirements		Internal 9-V Battery	Internal 9-V Battery	Internal 9-V Battery
Detector Type		InGaAs	InGaAs	InGaAs
Output Connector		Anritsu K	Anritsu K	Anritsu K
Input Connector		FC/PC	FC/PC	FC/PC
Input Fiber		SM	50- μ m MM	SM
Operating Temperature, min/max	$^{\circ}$ C	10 / 35	10 / 35	10 / 35

Table 6

¹ Lens dispersion limits wavelength range.

² At 1550 nm for InGaAs Models and 775nm for GaAs models. For GaAs models, response at 850nm will be similar.

³ DC - 50 GHz; noise bandwidth is ~42 GHz for each model.

⁴ 5% compression of impulse response.

⁵ CW, or average power with high-speed modulation.

⁶ Model 0901 recommended.

Customer Service

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

Email: tech@newport.com

We typically respond to emails within one business day.

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.

Appendices

Appendix 1: Microwave Connectors

The performance you obtain when making high-speed measurements depends in part on the instruments you use and how connections are made to the instruments. Connect the male connector of the photoreceiver directly to the female connector of the instrument. If you need to use an adapter, make sure it is designed for your frequency range of interest. The following table lists common connectors, their upper frequency limit, and mating compatibility. If you use an intervening coaxial cable, select a shorter cable to minimize loss and verify that its bandwidth rating is sufficient. For more information please see the Optical Measurement section in the Application Notes selection guide on the Newport webpage. In particular, Application Note 1: Insights into High-Speed Detectors and High Frequency Techniques.

Connector Type	Frequency Limit, GHz	Compatibility
BNC	4	-
SMA	18 or 26.5	3.5 mm, K
3.5 mm	34	SMA, K
K (2.92 mm)	40	SMA, 3.5
2.4 mm	50	V
V (1.85 mm)	65	2.4 mm

Appendix 2: Replacing the Battery

1. Turn off the module and remove the two screws on the back panel with a Phillips screwdriver.
2. Remove the back panel and replace the battery.
3. Replace the back panel.
4. Check the battery level as described above in the “Battery Check” section.

Appendix 3: Difference between a time-domain-optimized detector and a frequency-domain-optimized detector

Circuitry in frequency-domain-optimized detectors is designed to produce a flat frequency response, where the responsivity varies only slightly across the operating bandwidth. Time-domain-optimized detectors, in contrast, produce clean, ring-free pulses. By using Fourier-transform methods, you can show that clean ring-free pulses result in a characteristic roll-off in the frequency domain. On the other hand, a flat frequency response results in some controlled ringing in the impulse response.

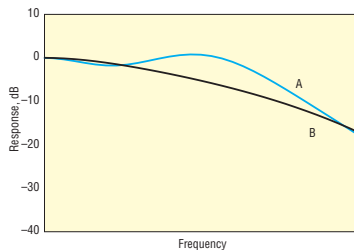


Figure 7. Frequency-Domain vs. Time-Domain: (A) Detectors designed for flat frequency response have enhanced responsivities at high frequencies. (B) Detectors that are optimized for clean, ring-free pulses show a characteristic drop off in 3-dB frequency response.

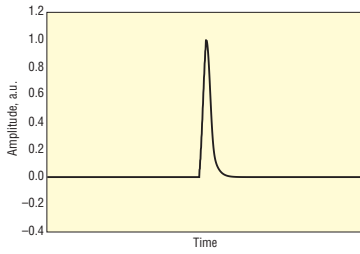


Figure 8. Time-Domain Optimized: This is the impulse response of a detector that is optimized for the time domain. You can see the characteristic frequency response in the figure above.

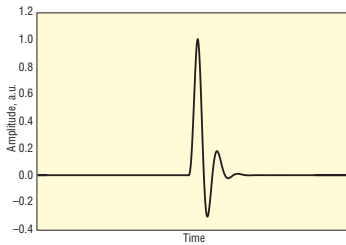


Figure 9. Frequency-Domain Optimized: This is the impulse response of a detector that is optimized for a flat frequency response. You can see the corresponding frequency response in figure above.

Appendix 4: DC-coupled Photoreceivers Crossover Region

In looking at the frequency response of the DC-coupled receivers, a “crossover” region exists where the DC response rolls off and the AC response rises. In this region, near 25kHz, the response is not flat. Signals with significant energy in this region will be somewhat distorted. A time-domain example is seen in Figure 10 which shows the response for a long-duration step input. For most applications, such as measurement of extinction ratios on gigabit-per-second waveforms, the crossover will be insignificant.

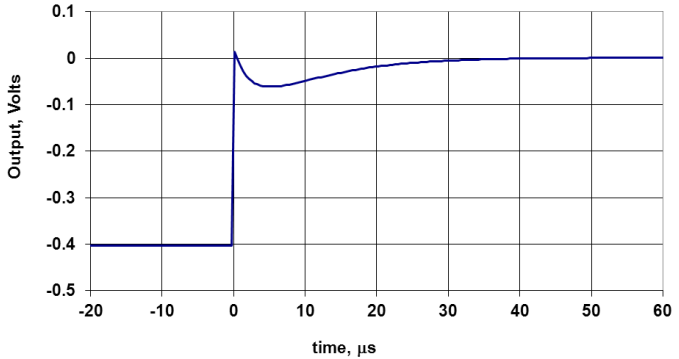


Figure 10. Example crossover behavior for DC-coupled receivers.

