EIKONAL Optics

TIA-F-01

Large area, fast amplified Si photodiode

FEATURES

- Large area Si PIN photodiode
- Compact package (1-inch diameter lens tube) for convenient integration
- Fast response (61 ns rise time)
- High gain (0.2 V/μW @ 850nm)
- High speed line driver for large amplitude output into 50 Ω
- Dynamic range from pW to μW
- Johnson-noise limited from 250 Hz to 100 kHz.

APPLICATIONS

- Sensitive synchronous detection
- Fast time domain monitoring
- Characterization of diffuse radiation

DESCRIPTION

Amplified, large-area (7 mm^2) Si photodiode, with fast response and Johnson-noise limited performance. A low-noise JFET isolates the photodiode capacitance from a fast (140 MHz) op amp allowing speed typically only found in detectors with an order of magnitude smaller sensor size. A high slew-rate (1.3 V/ns) line driver delivers up to 9 V_{pp} into a 50 Ω load. The photodiode is packaged in a 2" long lens tube standard with 1.035"-40 threads for convenient integration (Figure 1). The photodiode head includes an ultra low noise linear voltage regulator and can be powered directly from a ±12V lab bench supply via a 3-pin M8 connector.

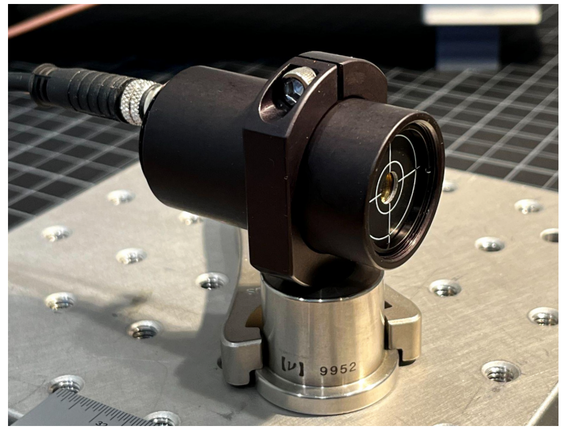

Figure 1. Detector mounted on a breadboard. (1" slip ring and post not included.)

SPECIFICATIONS

Wavelength	400-1100 nm
Sensitive area	2.65 mm x 2.65 mm
Quantum efficiency	0.9 @ 850 nm
Responsivity	0.62 A/W @ 850 nm
Gain	330 kV/A into 50 Ω
Bandwidth (3dB)	3.8 Hz - 1.6 MHz
Rise time	61 ns
Noise (0.3-100 kHz)	77 nV $Hz^{-1/2}$
NEP @ 850 nm	380 fW $Hz^{-1/2}$
Maximum output	9 V_{pp} into 50 Ω
Power supply	±12 V @ 250 mA
Power connector	3-pin M8
Signal connector	SMA
Lens tube	1.035"-40 x 2"
Operating Temp	5-30 °C

OPERATION

The sensor head comprises a Si PIN photodiode, a JFET input stage, a transimpedance amplifier, and an output stage capable of driving a 50 Ω load. The photodiode is reverse biased so incident light is converted to a photocurrent.

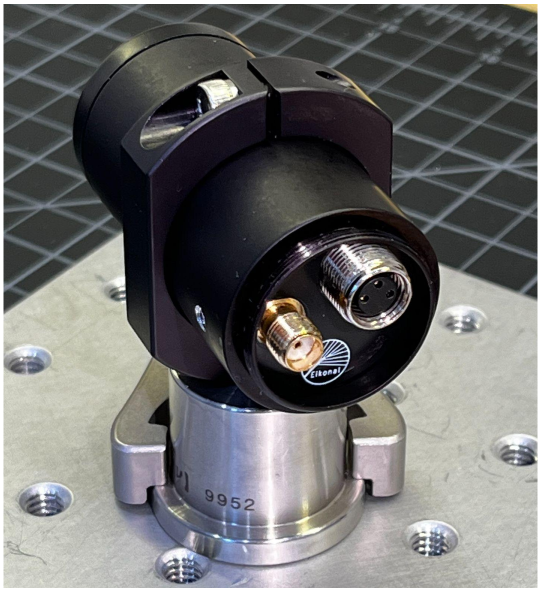

Figure 2. Detector back panel showing M8 power connector and SMA output. (Included power cable not shown.)

This photocurrent is converted to a voltage by a transimpedance amplifier with a large feedback resistor (330 kΩ). A JFET follower drives the anode of the photodiode. This reduces the effective input capacitance at the op amp summing junction and boosts the detection bandwidth. The transimpedance amplifier is AC coupled to a low-noise, high-voltage, current-feedback amplifier configured as a non-inverting 3 dB gain stage capable of driving 9 V_{pp} into 50 Ω. When driving a high impedance load the sensor gain is 660 kV/A and 330 kV/A when used with a 50 Ω terminator.

The signal output is via a SMA RF coax connector (Figure 2). To guarantee a good connection make sure the plug is torqued correctly (0.3-0.6 Nm).

Power & Grounding

The sensor head requires a bipolar ±12 V power supply capable of delivering 250 mA via the 3-pin M8 power connector on the rear of the unit (Figure 3). Filtering and regulation is implemented on board. A linear supply with no more than 10 mV_{pp} ripple is recommended for best noise performance (e.g., GlobTek GS-1121). Although the unit will operate at voltages below ±12 V the noise performance and stability will be degraded due to reduced regulation. **Do not exceed ±13 V**. Switching power supplies are not recommended due to unpredictable levels of switching noise.

Grounding the sensor chassis improves immunity from radio frequency interference, typically accomplished via the shielded conductor of the SMA connector. To avoid ground loops pin 4 of the power connector (0 V) should be left floating.

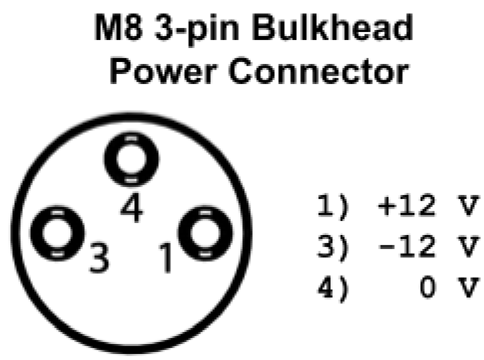

Figure 3. The power connector on the rear of the sensor head. Pin 4 should be left floating if the SMA shielded conductor is grounded.

Saturation

The sensor can saturate in bright indoor lighting. Because it is AC-coupled, saturation may not be immediately evident. If no signal appears at the output, cover the entrance aperture and look for a transient increase in the output voltage.

Mechanical Interface

Mounting of the sensor head is achieved by inserting the tube in a 1-inch optical slip ring (e.g., Newport LT10-PR) or via the 1.035"-40 threads at either end of the unit.

Performance

Figure 4 shows the sensor response to a 6 μW, 650 nm illumination with square wave modulation. The signal is detected with an amplitude of 1 V_{pp}.

The square wave modulation is recorded with high fidelity without signal overshoot or drooping. The lowest frequency trace (500 Hz) is recorded with the scope DC coupled, since the frequency response of the detector extends significantly below that of the scope's AC cutoff (10 Hz). Although the bandwidth of the sensor extends to 1.6 MHz, representation of a square wave above 500 kHz begins to degrade because the amplitude and phase of higher harmonics are not faithfully represented.

The impulse response of the detector is shown in Figure 5. The measured rise time is 61 ns. The fall time is 210 ns, consistent with the 1.6 MHz amplifier bandwidth.

The measured noise power spectral density is shown in Figure 6. At frequencies suitable for synchronous detection (< 100 kHz), the spectrum is flat and limited by the Johnson noise of the 330 kΩ feedback resistor. To accommodate fast square wave modulation and to capture time domain phenomena on timescales of hundreds of nanoseconds the maximum achievable bandwidth (1.6 MHz) is unfiltered. As a consequence, the input voltage noise of the op amp couples via the input capacitance of the photodiode to current noise in the feedback resistor.

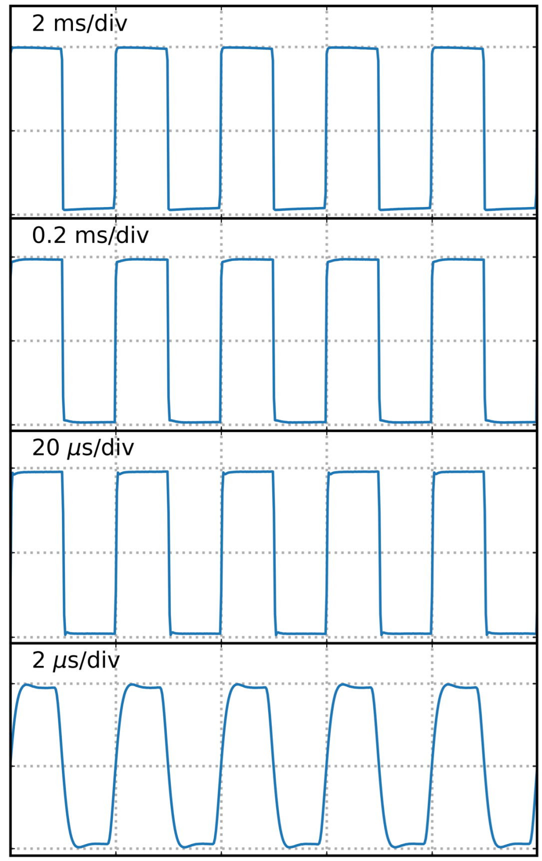

Figure 4. Representative waveforms for a 6 μW, 650 nm LED square-wave modulated at 0.5, 5, 50, and 500 kHz. Detected signals are 1V_{pp} into 50 Ω. The sensor is AC coupled (lower 3 dB point at 3.8 Hz) so that the signal shows no significant droop at 500 Hz and has sufficient bandwidth (upper 3 dB point at 1.6 MHz) to faithfully represent square waves of several hundred kHz. The light source is driven with an Agilent 33120a signal generator and measured using a Tektronix TDS 380 scope.

This noise increases linearly with frequency up to 280 nV $Hz^{-1/2}$ at 1.6 MHz. Because of this high frequency noise, consider using a low pass filter when examining low frequency signals (<100 kHz) directly on an oscilloscope.

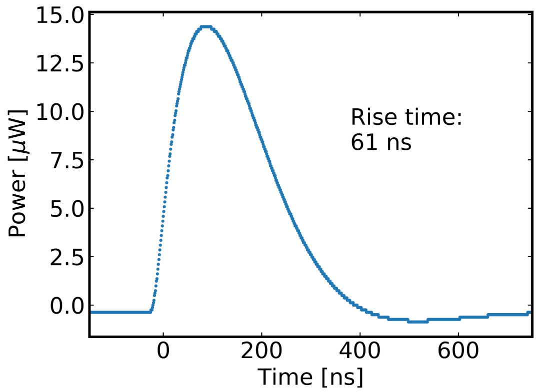

Figure 5. A record of a single nano-second duration laser pulse (650 nm). The rise time is 61 ns. The fall time is 210 ns. The light source is an Eikonal NLD-01. The signal is digitized at 2 GS/s using a Tektronix TDS 380, which has an intrinsic rise time of 0.87 ns.

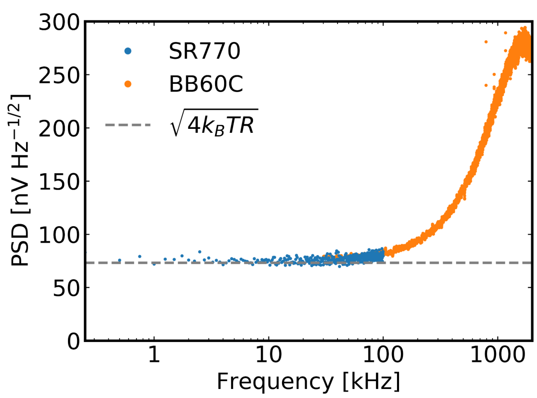

Figure 6. Power spectral density measured with Stanford Research 770 (0.25–100 kHz) and Signal Hound BB60C (30 kHz–2 MHz) spectrum analyzers. Below 100 kHz, noise (77 nV Hz$^{-1/2}$) is flat and dominated by the Johnson noise of the 330 kΩ feedback resistor. At higher frequencies, the noise increases linearly up to the rolloff frequency of the amplifier.

REQUIRED ACCESSORIES

- Bipolar linear power supply capable of supplying ±12 V at 250 mA
- 3-pin M8 cable, e.g., Lumberg Automation RSMV 3-06/2 M (included).
- SMA 50 Ω coaxial cable

WARNINGS

Our instruments are sensitive opto-electronic devices designed for professional use in a laboratory setting. As such you must strictly observe standard procedures for avoiding contamination of optical surfaces and establishing safe electronic operation, including observing input voltage limits and polarities and control of electrostatic discharge.

You must read and understand this document before operating.

- Observe precautions for handling electrostatic sensitive devices.
- Supply voltage should not exceed ±13 V. Carefully observe polarity labeled with included power cable.

QUALITY ASSURANCE

All units are tested and qualified by our technicians and test results are included with shipping to guarantee your device is working as described in this document.