Edmund Optics SN 57-601
Photodiode Amplifier
Operating Instructions

Terahertz Technologies Inc.

Edmund Optics America

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Introduction

The PDA-750 is a low noise, high gain transimpedance amplifier that is designed to provide a direct digital readout of the current generated from a photodiode, photomultiplier, or other similar current source. With full scale input ranges of 20 nA to 20 mA and a noise level of less than 1 pA, the PDA-750 offers superb dynamic range.

Digital selection of a calibration factor in terms of Amps/Watt via the front panel controls permits the unit to display the measurement directly in terms of Watts. The A/W setting may range from 1.000 to 0.100 in .005 steps. Subsequent current readings are divided by this cal factor when the Amps / Watt control is engaged.

A variable bias voltage ranging from +14 V to -14 V may be digitally selected from the front panel and applied in series with the photodiode under test. The background cancellation feature allows offsets of from +100 % to -100 % of the selected full scale range to be added or subtracted from the input signal.

Rechargeable batteries isolate the unit from the mains and eliminate the effects of ground loops and/or power line noise. They will provide power to the unit for a minimum of 10 hours of operation between charges. The unit may be operated normally while the batteries are charging.

The large 4 1/2 digit Liquid Crystal Display provides a maximum resolution of 1 part in 20 000 thus permitting the detection of very small changes in the variable that is to be measured.

An analog output is provided with a 2 volt full-scale signal that is proportional to the maximum display reading of 20 000 counts. Applications for this unit include; serving as a readout for Unity Quantum Efficient Detectors such as those manufactured by UDT Instruments, characterization of detector dark current, spectral calibration of detectors, and use as a sensitive, low cost optical power meter.

The instrument may be controlled and interrogated by means of its built-in bi-directional Rs-232 serial port.

All settings are retained in non-volatile memory so that the user need not reset all values when the unit is turned back on.

Unpacking and Inspection

Prior to shipment this instrument was inspected and found to be free of mechanical and electrical defects. Upon acceptance by the carrier he assumes responsibility for its safe arrival. After unpacking, examine the unit for any evidence of shipping damage. Should you receive this instrument in a damaged condition, apparent or concealed, it must be noted on the freight bill or express receipt and signed by the carrier's agent. Failure to do so could result in the carrier refusing to honor the claim. Upon filing a claim TTI should be notified.

Power Requirements

The PDA-750 is powered by a set of four AA size Nickel-Metal-Hydride rechargeable cells. It may also be operated by its wall mount charging supply when access to line power exists. The unit may also be powered from alkaline AA cells in cases where the batteries have run down and no line power is available.

☞ *DO NOT attempt to use the charger with batteries other than Nickel-Metal-Hydride cells as severe damage may be caused to the unit.*

The batteries supplied will provide thousands of hours of operation. Failure to hold a charge for any significant amount of time is evidence of the need to replace the cells. The batteries may be accessed by removing the two screws holding the back bezel in place. Slide off the top aluminum cover. Observe and note the battery polarity markings whenever cells are being replaced. Replace cover and bezels when the operation is completed.

PDA-750 Specifications

Full Scale Ranges	+/- 20 nA to 20 mA in Decade Steps
Max Input Without Damage	+/- 25 mA
Accuracy	+/- 0.1 % Rdg. +/- 2 L.S.D.
Amps / Watt Setting	0.100 to 1.000 in steps of .005
Input Impedance	0 Ohms, Single Ended
Input Capacitance	25 pF
Output Impedance	100 Ohms
Bias Voltage	-14 V to +14 V
Drift	< 5 pA/hr. after 10 minute warm up
Voltage Noise	< 1.8 μV P-P, 0.1 to 10 Hz
Noise	< 1 pA p-p, DC-1 KHz with < 10 pF Det.
Background Cancellation	+/- 100 % of range in use
Temperature Coefficient	< 1 pA / C
Frequency Response (-3 dB)	20 nA - DC to 2.0 kHz, 100 nA - DC to 5.25 kHz, 2μA - DC to 22 kHz, 20 μA, 200 μA, 2 mA, 20 mA- DC to 40 kHz
Display	4 1/2 Digit, 0.4" High LCD, 6 rdgs / second
Maximum Resolution	1 part in +/- 20 000
Power Requirements	Rechargeable NMH Batteries provide approximately 10 hours of use.
External Supply	85 to 260 VAC, 47-60 Hz, 15W max.
Dimensions	5.75" W, 9" L, 2.5" H 14.5 cm, 23 cm, 6.5 cm
Weight	2.5 Lbs., 1.13 kg Excluding Ext. Supply
Operating Temperature	0 - 40 C
Limited Warranty	2 Years from date of receipt

Operation

The PDA-750 is equipped with an electrically isolated BNC input connector. Current injected into the center contact (with respect to the outer contact) provides a positive indication on the display. The equivalent electrical circuit of the unit as is illustrated below.

Equivalent Circuit
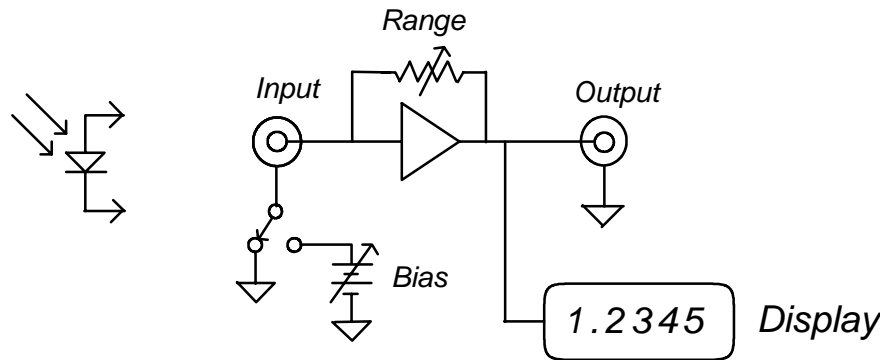
Current input to the unit generates a voltage across the range feedback resistor. This voltage is then measured and displayed in units of amperes. A variable bias voltage may be introduced in series with the detector in use. The output presented is calibrated such that 2.0000V represents the full scale range in use, e.g. 2.0000 V corresponds to 20.000 nA and so on.

For the remainder of this discussion refer to the front panel display and controls drawing that appears on the following page.

Control	Function
Power	*Alternately applies and removes power to the unit.*
Offset	*Offsets the display by up to +/- 20 000 counts.*
Range Set	*Selects one of seven ranges in conjunction with rotary Set control. Units LEDs and decimal points indicate the range that is currently in use.*
Amps/Watt Set	*Momentary push button used in conjunction with rotary Set control. Inputs an A/W cal factor that is displayed when button is pushed.*
Bias Set	*Momentary push button used in conjunction with rotary Set control. Selects a level of bias voltage that is displayed when the button is pushed. Pushing rotary control in accelerates the setting.*
Amps/Watt Engage	*Alternately enables and disables the A/W setting. When engaged, all subsequent current readings are divided by the A/W cal factor. LED's will then indicate units of Watts*
Bias Engage	*Alternately adds or deletes the selected bias voltage in series with the input.*
Set	*Changes of the value of the variable designated by the Set button in use.*

PDA-750 Front Panel Controls
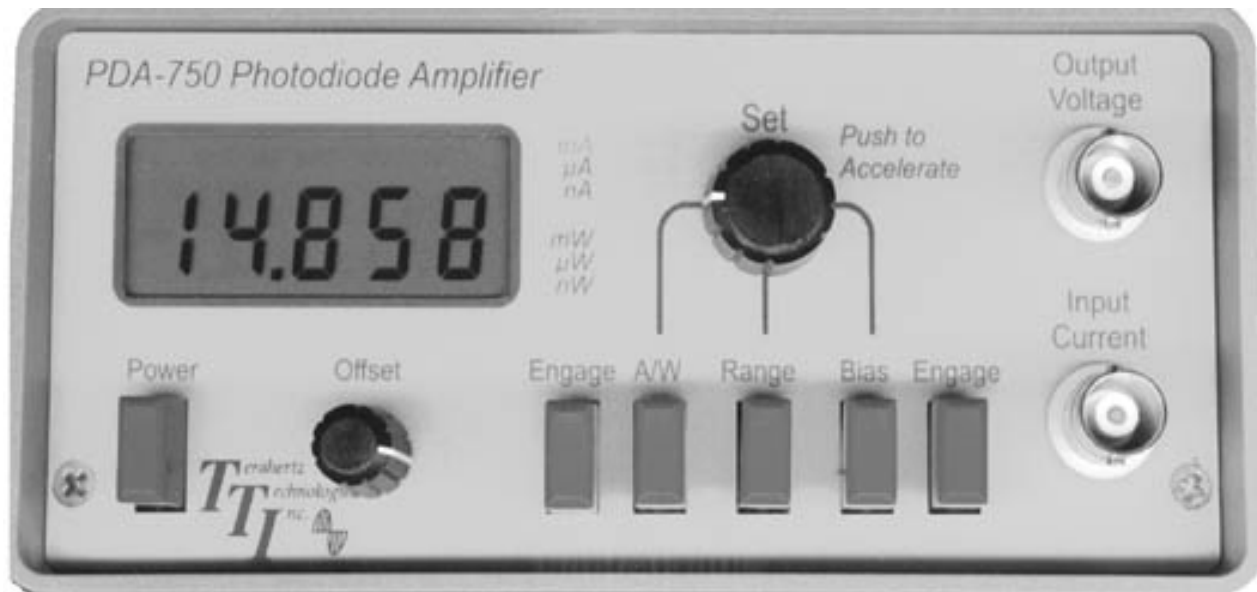
Operation

The operation for measuring photodiode current is as follows:

1. Disengage both the **Bias** and **Amps/Watt Engage** push buttons.

2. Select the range that includes the highest expected current to be measured. If this is unknown, select the least sensitive range.

3. Before connecting the photodiode, adjust the **Offset Control** for a zero reading on the display.

4. Connect the photodiode to the instrument by means of the Input BNC connector.

5. Illuminate the photodiode with the light to be measured. The display will then indicate the magnitude of the input current.

6. If a reading in units of Watts is desired, input the current responsivity of the detector by depressing the **A/W Set** push button and adjusting the SET control knob until the desired value is displayed. Depressing the **A/W Set** button will divide all subsequent readings by the responsivity value and the units LEDs will switch to the appropriate value of Watts.

7. If reverse bias is desired, depress the **Bias Set** button. The bias voltage will then be displayed. Adjust the **Rotary Set Control** for the desired magnitude and polarity. Depressing the **Bias Engage** button will then apply this voltage in series with the photodiode. **NOTE:** *it is not advisable to forward bias most photodiodes. Make sure that the bias is of the proper polarity such that the detector is reverse biased.*

8. If the display is blanked, the unit is indicating an over-range condition. Change the range to progressively less sensitive ranges until the display indicates an on-scale reading.

9. If the *BAT LO* annunciator is activated on the LCD display, the batteries require charging. This may be accomplished by plugging in the wall-mount power supply provided with the unit. The instrument may be operated while the batteries are charging. Recharging requires about 14 hours from a fully discharged condition. The microproccessor will automatically shuthe unit t down if the batteries are too low to be used.

10. If it is necessary to measure a small signal in the presence of ambient light, the **OFFSET Control** may be used to null the background light to zero with the signal of interest turned off. This subtracts the background illumination from the signal of interest. Note that detector noise will increase with a large background signal.

12. High detector capacitance and/or cable capacitance will add add to the noise level.

Operating Considerations

Input Offset Voltage Effects

The input offset voltage of the PDA-750 in conjunction with the shunt resistance of the photodiode in use will cause an offset current to be generated. For example, let us consider the case of a germanium photodiode that is intended to be used at zero bias voltage. Typical shunt resistances of small germanium detectors are in the range of 100 K. The maximum input offset voltage of the PDA-750 is 100 µV. The input offset current will then be: 100 µV/100 K = 1.0 nA. This current may be nulled out with the offset control. Note however that shunt resistance is reduced by approximately half with every 10 C increase in detector temperature. Dark current levels should be checked frequently when making very sensitive measurements.

InGaAs detectors provide higher shunt resistances than germanium and offer similar spectral sensitivity. Silicon detectors provide higher resistivity yet but their responsivity falls off rapidly for wavelengths longer than 1000 nm.

Noise Considerations

Noise in a transimpedance amplifier is governed by three primary effects. The first is Thermal or Johnson Noise. The output voltage noise generated is given by:

$$V_{nj} = [\ 4k\ T\ R_f\ BW]^{1/2}$$

Where k is Boltzmann's Constant, T is the temperature of the feedback resistor in degrees Kelvin, Rf is the value of the feedback resistor in Ohms, and BW is the bandwidth of interest.

The second noise source is shot noise. This is due to the quantum nature of electrons. It is given by:

$$V_{ns} = R_f\ [\ 2e\ I\ BW]^{1/2}$$

Where: e represents the charge of the electron in Coulombs and I is the input current.

The voltage noise of the amplifier provides the third important source of noise. The noise current is represented by the voltage noise divided by the impedance represented by the source impedance in parallel with the feedback impedance.

$$V_{nv}\ (\omega) = R_f\ en(\omega) / [R_f\ /\ j\omega C_{in} R_f + 1]$$

Where ω represents the angular frequency of interest, en(ω) represents the voltage noise of the amplifier, and C_{in} represents the capacitance of the source. The input resistance is assumed to be high compared with the feedback resistance. Integrating this expression over the bandwidth of interest provides the noise contribution.

As the values of input voltage noise, feedback resistance, and bias current are fixed, the main variables under control of the user are the input capacitance, and shunt resistance of the source. The lowest noise levels and DC errors will be provided by detectors with low capacitance and high shunt resistance.

Large detector capacitance will cause gain peaking and thus ringing of the output waveform following step functions of the input. The junction capacitance of a semiconductor detector may be reduced by reverse biasing of the detector in order to increase the depth of its depletion region. This will however, increase the DC errors observed since the bias voltage generates an error current (known as detector dark current) when impressed across the detector shunt resistance.

Rs-232 Operation

The PDA-750 is equipped with a bi-directional "three-wire" Rs-232c interface. It permits the unit to be remotely controlled via an external computer and will report readings and the unit's status on request.

An interface cable is supplied with each unit. Plug the RJ-14 (telephone style) connector into the port on the unit's rear panel. Plug the 9 pin D connector into the computer serial port. Using a communications program (such as WINDOWS Hyperterminal) set the appropriate communications parameters. The protocol is 9600 N 8 1, i.e. Baud Rate of 9600 Baud, no parity bit, 8 data bits, and one stop bit. The command structure is as follows:

Prefix	Command	Carriage Return
P:	READLAST	CR

Command List   Function
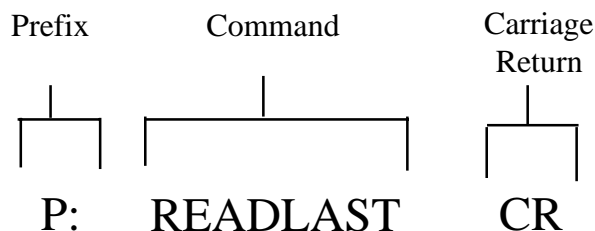
Command List	Function
P:READLAST	INVOKES THE SENDING OF THE CURRENT READING
P:STATUSRQ	INVOKES THE SENDING OF THE UNIT'S STATUS
P:USERNG0X	SETS RANGE (X = 0-6) (0 is the most sensitive range)
P:BS-14.00	SETS BIAS FROM -14.00 V TO +14.00 V
P:A/W1.000	SETS A/W VALUE TO 0.100 TO 1.000
P:SETBIASX	TURNS BIAS ON (X = 1) OR OFF (X = 0)
P:TURNA/WX	TURNS A/W ON (X = 1) OR OFF (X = 0)

CR is Carriage Return, hex 0D, or Enter on a PC keyboard. The significance of the characters is as shown above. A correct command will be met with the response: "OK".
An incorrect command will be met with the response: "Invalid Command".

Warranty And Repair Information

REPAIR INFORMATION

Products manufactured by Terahertz Technologies Inc. are designed and fabricated to provide reliable performance. However, in the event that service is required, both telephone technical assistance / factory repair services are available. Call Edmund Optics at (800) 363-1992 for information.

All products are to be returned to TTI with freight charges pre-paid. Those products sent under warranty will be returned to our customers pre-paid. We cannot be responsible for returned products that do not reference the TTI RMA number. For OUT-OF-WARRANTY repairs, services are billable for both time and materials.

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