



PDA-750

Photodiode Amplifier

Operating Instructions

Terahertz Technologies Inc.
169 Clear Road Oriskany NY 13424
TEL: (315) 736-3642 FAX: (315) 736-4078
www.terahertztechnologies.com

Copyright 2003-2008

Table of Contents

<u>Topic</u>	<u>Page</u>
GENERAL INFORMATION	
Introduction.....	1
Unpacking and Inspection.....	1
Power Requirements.....	2
Specifications.....	2
OPERATING INSTRUCTIONS	
Operation.....	3
Display and Controls.....	4
Operation (continued).....	5
Operating Considerations.....	6
Rs-232 Operation	7
WARRANTY INFORMATION	
Repair Information.....	8
Limited Warranty.....	8

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 Optical TRAP Detectors such as the TRAP-7-SI-C manufactured by Gentec-EO USA Inc., 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.

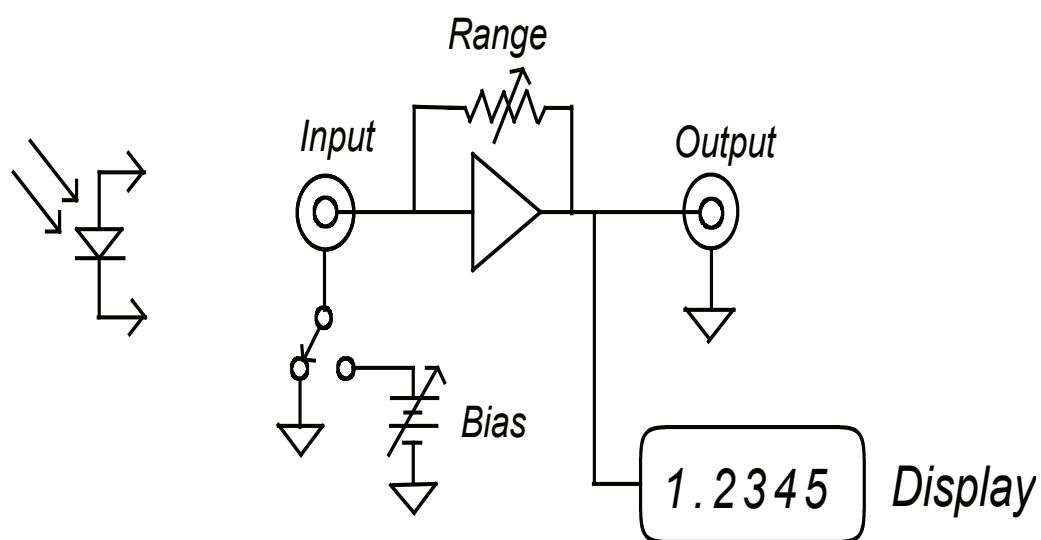
The batteries supplied will provide thousands of hours of operation. Failure to hold a charge for any significant amount of time is evidence of the need to replace the cells. The batteries may be accessed by removing the two screws holding the back bezel in place. Slide off the top aluminum cover. Observe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

PDA-750 Photodiode Amplifier Specifications	
Full Scale Ranges	± 20 nA to ± 20 mA in decade steps, 1 pA maximum resolution
Resolution	1 pA maximum resolution
Maximum Input Current Without Damage	± 25 mA
Measurement Uncertainty	± 0.05 % of Reading ± 2 Least Significant Digits
A/W Setting	0.100 to 1.000 A/W in increments of .005 A/W
Input Impedance (DC to 2 KHz)	Zero Ohms Virtual Ground, Single Ended
Input Capacitance	25 pF
Output Impedance	100 Ohms
Bias Voltage	Selectable from - 14 V to + 14 V in 6.5 mv increments
Analog Output Port	± 2 V corresponds to ± 20 000 counts of range in use
Noise and Drift	$< \pm 1$ pA/5 seconds on most sensitive range
Background Cancellation	± 100 % of the range in use
Analog Output Port Frequency Response	DC to 2 KHz, most sensitive range, DC to 40 KHz, least sensitive range
Rs-232 Interface	9600 Baud, N-8-1, 3 wire, Bi-directional, Cable Provided
Display	4 1/2 Digit LCD, 0.4 " high
Power Requirements	Rechargeable Ni-mH batteries provide approximately 10 hours of use
External Power Supply/Charger	85 - 250 VAC, 50-60 Hz, < 9 VA
Mains Adaptors	Adaptors provided for US, Continental Europe, Great Britain and Australia
Operating Temperature Range	0 - 40 C
Dimensions	5.5" W x 2.5" H x 8.5" L (140 x 63 x 215 mm)
Weight	2 Lbs., 0.9 kg (excluding external power supply)
Interconnecting cable supplied	Rs-232, 14 feet max length
CE Certification	Yes
Accessories Provided	Rs-232 cable, Power Supply/Charger, Operating Manual
Standard Warranty	Two years, Components and Workmanship, 30 Day Satisfaction Guarantee
Application Software Provided	Downloadable from TTI website, www.terahertztechnologies.com

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

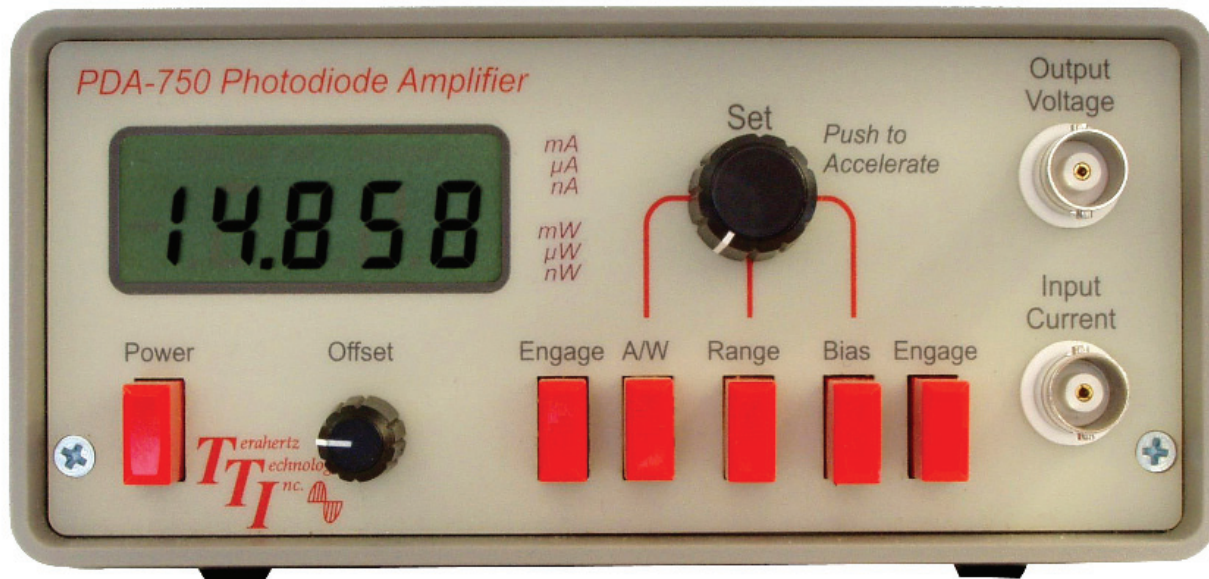


Current input to the unit generates a voltage across the range feedback resistor. This voltage is then measured and displayed in units of amperes. A variable bias voltage may be introduced in series with the detector in use. The output presented is calibrated such that 2.0000V represents the full scale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

This unit is non-inverting, that is that a positive going input current results in a positive going output voltage.

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

PDA-750 Front Panel Controls



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

Operating continued

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 microprocessor will automatically shut the unit 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.
11. 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 μ V. The input offset current will then be: 100 μ V/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:

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

Where k is Boltzmann's Constant, T is the temperature of the feedback resistor in degrees Kelvin, R_f 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, $en(\omega)$ 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.

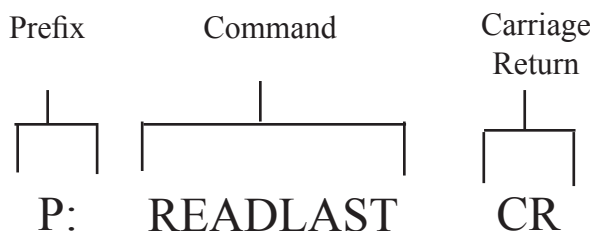
As the values of input voltage noise, feedback resistance, and bias current are fixed, the main variables under control of the user are the input capacitance, and shunt resistance of the source. The lowest noise levels and DC errors will be provided by detectors with low capacitance and high shunt resistance.

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:



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:TURN A/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”.

Note: The PDA-750 is configured to automatically transmit readings following each measurement without the need for a command. This occurs at a rate of approximately six readings per second. To turn off streaming, send an XOFF character. To resume streaming, send an XON control character.

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 and factory repair services are available. Call (315) 736-3642 for information. For IN-WARRANTY REPAIRS, call us to obtain a Returned Material Authorization number, (RMA Number). 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.

LIMITED WARRANTY

TERAHERTZ TECHNOLOGIES INC. (TTI) WARRANTS THAT TO THE FIRST PURCHASER, FOR A PERIOD OF TWO YEARS FROM THE DATE OF RECEIPT, THAT THIS PRODUCT (THE PRODUCT) WILL BE FREE FROM DEFECTS IN MATERIALS AND MANUFACTURING. THE FOREGOING WARRANTY IS THE ONLY WARRANTY, EXPRESS OR IMPLIED, GIVEN BY TTI, I.E., THERE IS NO WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE. TTI HEREBY DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY OTHER THAN THE WARRANTY IN THE FIRST SENTENCE TO THE FULLEST EXTENT PERMITTED BY LAW. THE SOLE AND EXCLUSIVE REMEDY UNDER THIS WARRANTY IS REPAIR OR REPLACEMENT AT TTI'S OPTION OF ANY PRODUCT THAT PROVES TO BE DEFECTIVE IN MATERIALS OR MANUFACTURING WITHIN TWO YEARS OF RECEIPT OF THE PRODUCT. NOTE: THIS WARRANTY DOES NOT APPLY TO ANY PRODUCT WHICH HAS BEEN SUBJECT TO MISHANDLING, MISUSE, OR SERVICE BY UNAUTHORIZED PERSONNEL OR TO ANY PRODUCT WHICH HAS BEEN DAMAGED, MODIFIED, ALTERED OR TAMPERED WITH. TO THE FULLEST EXTENT OF THE LAW, TTI DISCLAIMS ALL LIABILITY FOR ANY OTHER DIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES ALLEGED TO BE CAUSED BY A DEFECTIVE PRODUCT, I.E., TTI WILL NOT BE RESPONSIBLE FOR ANY PERSONAL INJURY, PROPERTY DAMAGE OTHER THAN THE COST OF REPLACING THE PRODUCT OR ANY OTHER MONETARY DAMAGE SUCH AS LOST WAGES OR PROFITS CAUSED BY ANY USE, ATTEMPTED USE OR INABILITY TO USE THE PRODUCT. NOTE: BY USING THE PRODUCT, YOU AGREE THAT REPAIR OR REPLACEMENT AT TTI'S OPTION WILL FULLY SATISFY TTI'S WARRANTY OBLIGATION TO YOU, WHETHER IN CONTRACT, TORT, NEGLIGENCE, STRICT LIABILITY OR OTHER APPLICABLE LAW.