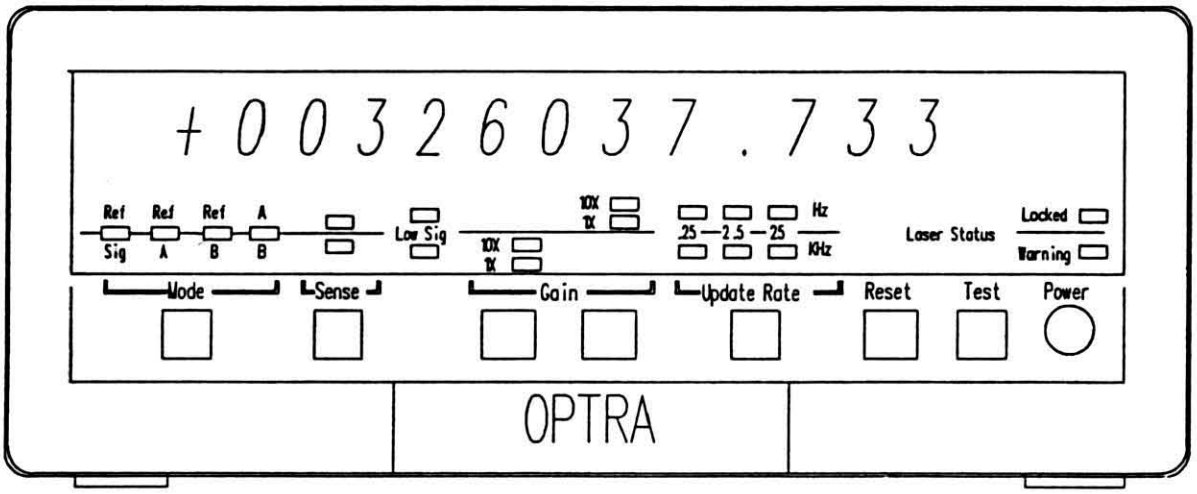
OPTRAMETER Measurement Module



Operator's Manual

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OPTRA

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1.0 INTRODUCTION

The OPTRAMETER Measurement Module is a high performance cumulative phase measuring component for critical measurement applications. When coupled with a 2-frequency laser[1] (for example the OPTRALITE Laser) and the appropriate optical transducer, this instrument will enable the user to make quantitative interferometric measurements. The OPTRAMETER is used primarily for precision metrology in which an optical path difference is measured by monitoring the phase of a corresponding electrical signal.

The function of the OPTRAMETER is to provide an accurate and convenient means for keeping track of the relative phase difference between two input signals. Unlike conventional electronic phasemeters, the OPTRAMETER will measure up to 100,000,000 cycles of cumulative phase difference as well as provide a resolution of 0.001 cycle. The OPTRAMETER incorporates many useful features -- such as input signal and reference selection, selectable update rates (averaging times), gain control, analog output, serial output, and a parallel interface.

We encourage you to read this manual to better understand the capabilities provided by this instrument. For further details, please contact OPTRA, Inc., 66 Cherry Hill Drive, Beverly, MA 01915, (508) 921-2100.

[1] The 2-Frequency laser must have a beat frequency of 250.000 _+ 0.015 kHz.

2.0 INSTALLATION INFORMATION

2.1 Equipment

The OPTRAMETER Measurement Module has been shipped in a protective package to prevent damage. We recommend that you save this package in the event that the unit needs to be serviced or repaired at OPTRA's facility.

In addition to the measurement unit, the following items have been enclosed in the package:

1. Operator's Manual.
2. Power Cord.
3. Spare fuse.

2.2 Power Requirements

The OPTRAMETER Module operates on 105 to 125 VAC (50 - 60Hz). The normal power dissipation is 25 Watts. OPTRA can provide the option for operating the unit at 230 VAC (50-60 Hz).

2.3 Line Fuse

This instrument will use a commonly available 2 AMP 3 AG Type fuse which is located on the rear panel of the instrument. ***CAUTION: The unit must be unplugged when changing fuses.***

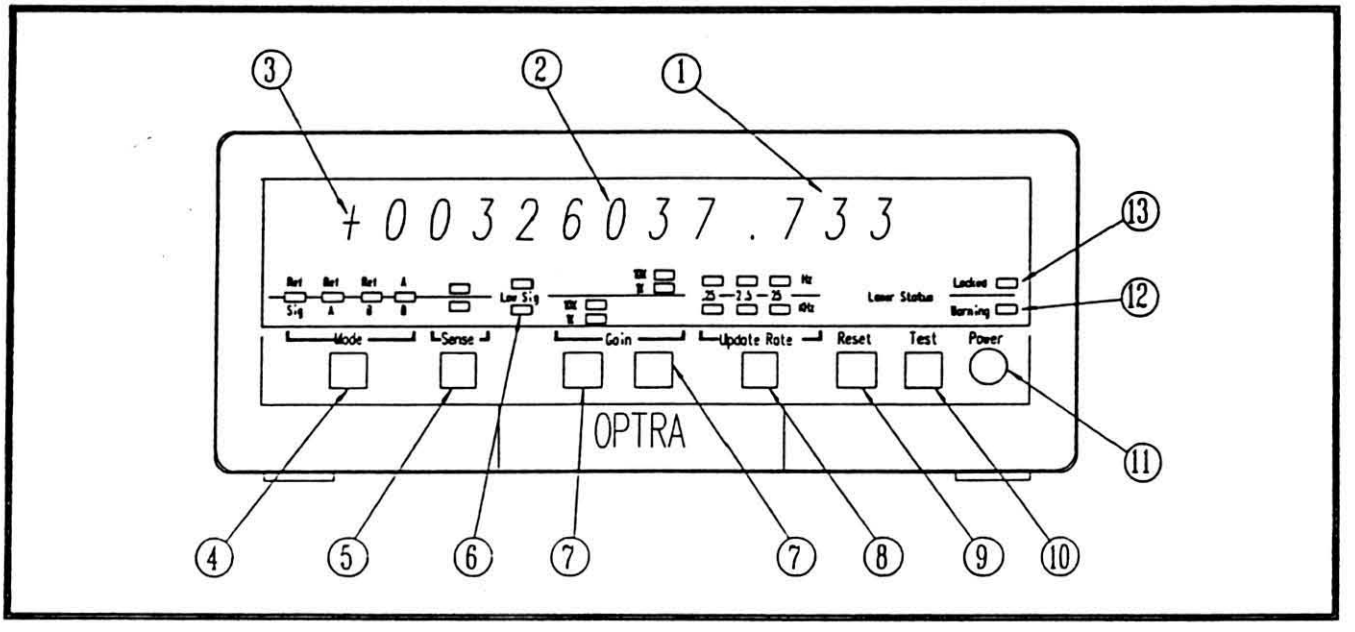
3.0 CONTROLS, CONNECTIONS, AND DISPLAY

3.1 Front Panel

The design of the OPTRAMETER unit allows the user to manipulate all of the functions from the front panel. A description of these controls and displays follows:

Illustration #1:

OPTRAMETER FRONT PANEL



1. **PHASE DISPLAY:** The OPTRAMETER will resolve 0.001 of a cycle of phase and displays this information to the right of the decimal point. The instrument always monitors the fractional phase between two signals, therefore, the phase display will be continuously updated. The range of this display is from .000 to .999.

2. **FRINGE DISPLAY:** Provides an 8 digit cumulative display of the whole fringes which are generated with each cycle of phase. The range of this display is from -99999999. to +99999999.

3. **SIGN INDICATOR:** This portion of the display will indicate either + or - for the numerical region where the count is being accumulated.

4. **MODE:** Selects the pair of the input signals to be measured. The indicator light will move sequentially as the function changes. Further details on this feature may be found in section 4.3, Operation.

5. **SENSE:** Indicates the direction in which the accumulated phase data changes with respect to the input signals. The yellow LED indicates which signal input is the reference for the phase measurement.

6. **LOW SIGNAL:** A red LED associated with each input channel will indicate when the signal input amplitude is below the minimum required level for proper operation.

7. **GAIN:** This function allows the operator to select 1X or 10X signal gain in each input channel. The indicators will display the status of the gain.

8. **UPDATE RATE:** This control permits the user to manually select an update rate consistent with the type of measurement being made. The selected update rate from 0.25 Hz to 25.0 kHz is displayed on the front panel. The UPDATE feature is described in the section 4.3, Operation.

9. **RESET:** Clears the fringe counter by setting the eight integer significant digits on the display to zero. The display will still read the current phase difference between the two input signals.

10. **SELF-TEST:** This control clears the fringe counters and injects test signals into the phase measuring circuits. At the conclusion of the test, the display should read - 00000000.508 $\pm$ .005. **Note this function clears the display so the test function should be used only when displayed data is not useful.**

11. **POWER:** Turns the OPTRAMETER On and Off.

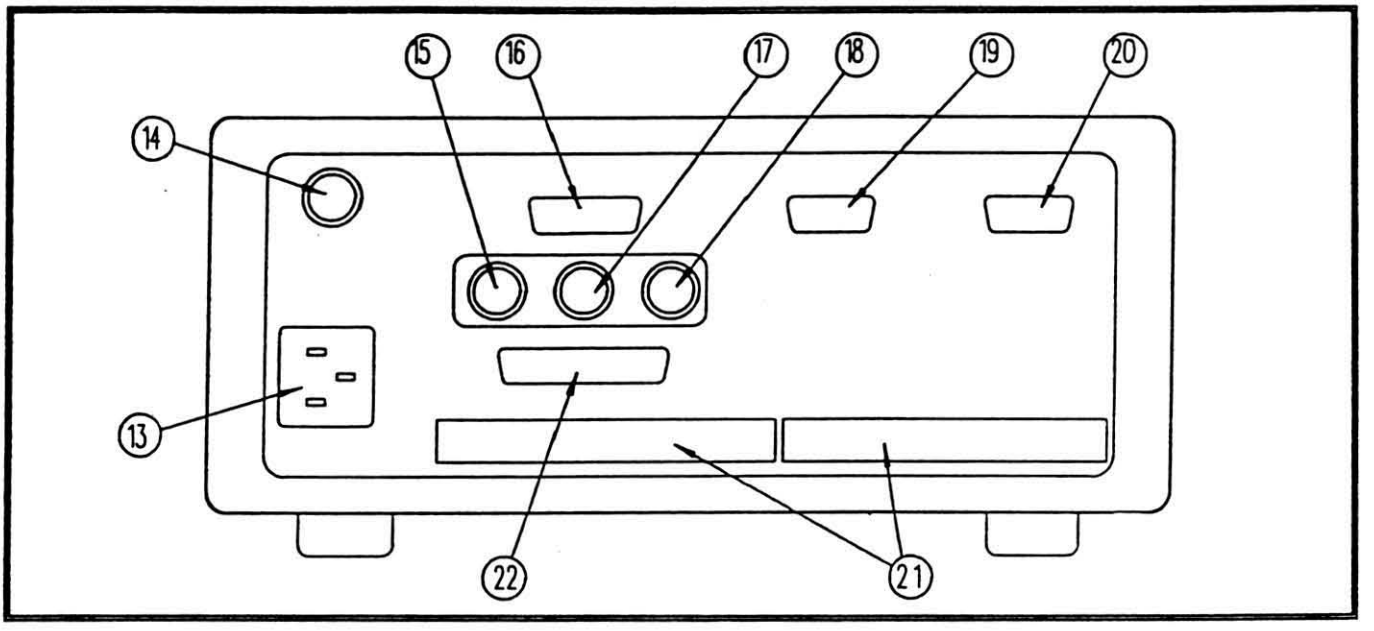
12. **LASER STATUS:** When connected to an OPTRALITE Laser, these two indicators provide the user with a visual indication of the laser status. Refer to your OPTRALITE Laser Owner's Manual for a description of the status signals. If an OPTRALITE Laser is not connected to the OPTRAMETER the WARNING indicator will remain illuminated. Note: it is not necessary that the OPTRALITE Laser be connected.

3.2 Rear Panel

The connecting ports for the OPTRAMETER are located on the rear panel of the instrument. A description of each connection and its function has been included below:

Illustration #2

OPTRAMETER REAR PANEL



13. **POWER INPUT:** The power cord shipped will your unit attaches at this port. For further information about power requirements consult section 2.2, Power Requirements.

14. **FUSE:** The OPTRAMETER uses a fuse to prevent damage to the instrument. The fuse is accessed by unscrewing the fuse cap on the rear panel. ***CAUTION: The unit must be unplugged when changing fuses.***

15. **ANALOG OUTPUT:** is accessed through this BNC connector. The range of this output is ±10 VDC, and corresponds to a selected range of 4 digits on the front display. The default mode outputs +10 VDC to -10 VDC corresponding to a phase difference of +9.999 to -9.999 respectively. For further information about the Analog Output, consult section 4.4.2, Analog Output.

16. **LASER INPUT:** provides a connection for the OPTRALITE 2-Frequency Laser. Information about laser status, reference signals, and detected signals are provided to the OPTRAMETER at this port. Additional information about these connections may be found in section 4.2.1,

Laser Input.

17. **A INPUT SIGNAL MONITOR:** This BNC connection is a monitoring port, for the INPUT A connector. The connection may be used in conjunction with an oscilloscope to view the conditioned inputs to the OPTRAMETER squaring circuitry. The load impedance for these outputs should be at least 10K Ohms.

18. **B INPUT SIGNAL MONITOR:** Same as #17 for the INPUT B channel.

19. **SIGNAL INPUT A:** is a connection port for an incoming signal that is to be processed by the OPTRAMETER. A discussion of these ports and their relevant parameters may be found in section 4.2.2, Signal Inputs.

20. **SIGNAL INPUT B:** This input port functions in the same as #19 INPUT A. See section 4.2.2, Signal Inputs.

21. **PARALLEL INTERFACE:** The OPTRAMETER is equipped with two, fifty pin connectors for a parallel interface and remote processing. These two connectors provide parallel TTL outputs of all 11 digits of displayed fringe and phase information, including sign, (45 lines). The output is updated at a rate determined by the UPDATE RATE function located on the front panel. Also included are selected status signals and control lines. Refer to section 4.4.3, Parallel Interface.

22. **SERIAL INTERFACE (RS232c):** The OPTRAMETER is equipped with a Serial RS232c output to interface with a host computer or other related equipment. The connections are for a RS232c serial interface. Please refer to section 4.4.4, Serial Interface for further information about this output.

4.0 OPERATION

4.1 Functional Description

OPTRAMETER is an integrating phasemeter which measures, stores, and displays the cumulative phase difference between two input signals. The display has three digits for fractional phase with a resolution of .001 cycle and eight digits for accumulating whole cycles of phase. These two values are often referred to as phase (fraction of a cycle) and fringe (whole cycles), respectively. One fringe represents a one cycle (2π radians or 360^{o}) phase shift between the two input signals.

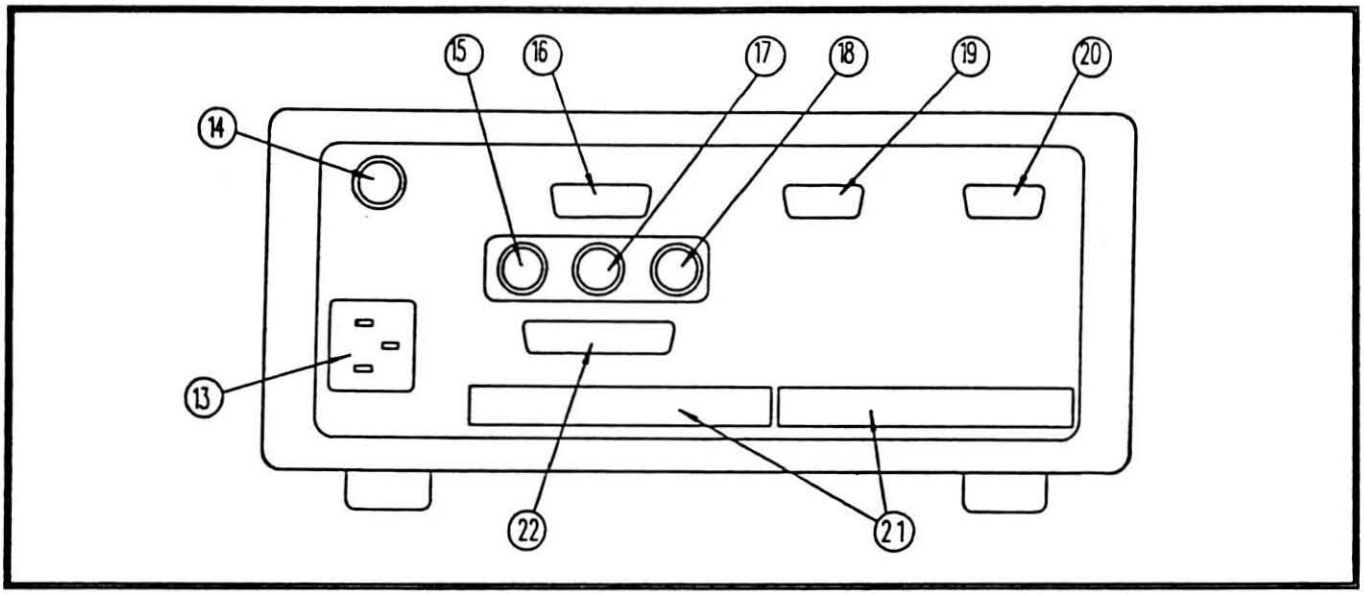
The OPTRAMETER will accept input signals which are interfaced at the three ports; INPUT A, INPUT B, and the OPTRALITE Laser Interface:

OPTRALITE Input:	Provides an interface for the Laser Reference Signal and the front end detector SIGNAL. Laser Status information is also brought to the OPTRAMETER at this point.
INPUT - A:	This Input will accept a signal from a remote Detector/Preamplifier, inputs from the OPTRALITE REF and SIGNAL ports (BNC type), or other unspecified inputs. These ports also provide $\pm$ 15 VDC for powering external preamplifiers (see section 4.2.2, SIGNAL INPUT).
INPUT - B:	This INPUT performs a similar function as INPUT A.

4.2 Inputs

Illustration #3

OPTRAMETER REAR PANEL



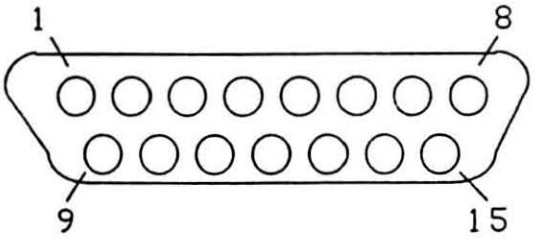
The design and function of the OPTRAMETER require that two signals always be present in order for the instrument to operate correctly. The product has been designed to accommodate a number incoming signal inputs, and allows the user to select any pair of channels for the measurement.

4.2.1 Laser Input

The input sources must be connected to the OPTRAMETER. If the OPTRALITE Laser is used in the measurement system, an interface cable may be connected between the laser and the port labeled "OPTRALITE" on the rear panel. This interface brings the laser reference information and the front end signal detector information to the OPTRAMETER. These two signal inputs will be compared when the MODE selection function is positioned at the REF/SIG position.

Illustration #4

LASER INPUT LEGEND



1	Reference	6	Unused	11	Unused
2	Reference Return	7	Signal Return	12	Unused
3	Lock Indicator	8	Signal	13	Unused
4	Warning Indicator	9	Ground	14	Remote On/Off
5	Remote Reset	10	Unused	15	Remote Return

For further information about the OPTRALITE™ 2-Frequency Laser, please consult your Owner's Manual or contact OPTRA.

Several signal input options are possible with the OPTRAMETER. The phase between the OPTRALITE Laser reference (REF) and the laser's front end detector (SIGNAL) can be measured by selecting the REF/SIG mode on the front panel and using the laser interface cable. A change in phase between the laser reference (REF) and either INPUT A or INPUT B can be measured by selecting either REF/A or REF/B while using the laser interface cable and ports INPUT A or INPUT B. The OPTRAMETER will measure the phase between signals on ports INPUT A and INPUT B by selecting mode A/B.

4.2.2 Signal Inputs (A & B)

Remote detectors are frequently used in a variety of measurement applications which require compact, portable, detection capability. In addition to remote detectors, signals generated from other sources can also be utilized by the OPTRAMETER for measurement. The required input parameters will be discussed in this section.

Signal inputs are sine waves generated by the following sources:

1. Remote Detectors: These detectors are available on a specialty basis from OPTRA. To connect a remote detector, simply turn off the OPTRAMETER power, and plug in the connection to either INPUT A or INPUT B. For further information about the interface for a remote detector, see section 4.0 of this manual or contact OPTRA.

2. OPTRALITE Laser: If your application utilizes the detector located at the front of the OPTRALITE Laser, the signal will be delivered to the OPTRAMETER at the OPTRALITE port on the back panel.

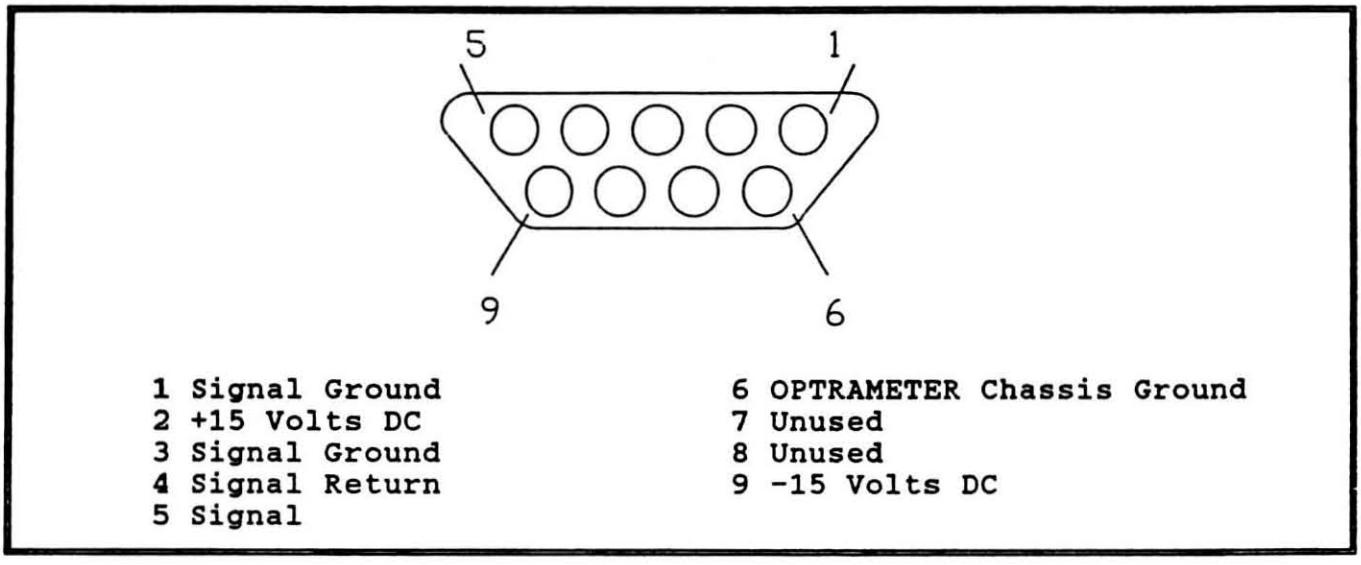
3. Customer Designed Inputs: For a detector/preamplifier of your own

design, the connection can be made at either INPUT A or INPUT B. If desired, the ±15 VDC, provided at this input can be used to power the detector/preamplifier, however, care must be taken not to short circuit these pins. The maximum current available from the ±15 VDC is ±100 mADC.

A description of the input connector is included below:

Illustration #5

SIGNAL INPUT CONNECTION LEGEND

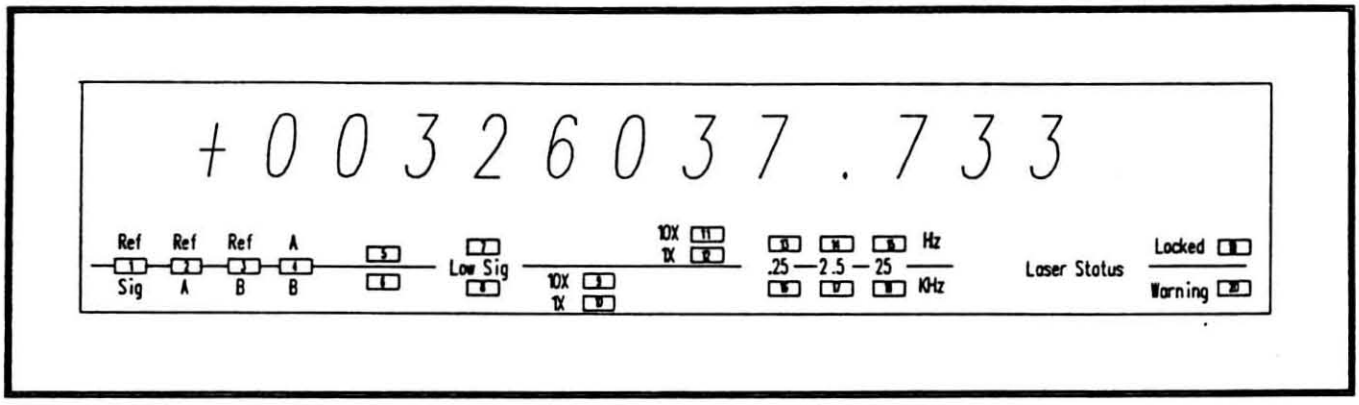


CAUTION: *When using a detector/preamplifier which is not an OPTRA product, care must be taken to not create ground loops that may interfere with OPTRAMETER. The unit contains a single point connection between power supply ground and earth ground. The remote preamplifier should be grounded only through the OPTRAMETER.*

4.3 Operation

Illustration #6

OPTRAMETER FRONT PANEL DISPLAY



With the signal inputs connected and the power on, the OPTRAMETER is ready for use. If further information is needed consult section 4.2, INPUTS. Five basic steps are used to prepare the OPTRAMETER for a measurement, once the INPUTS have been connected. These basic steps are listed in order:

1. MODE — The mode selects the pair of Inputs to be measured.

2. SENSE — The sense must be selected to identify which of the two incoming signals will be used as the reference.

3. GAIN — The gain setting is then adjusted if necessary to enhance weak signals as indicated by the low signal indicators (#5 or #6).

4. UPDATE RATE — Update is adjusted to provide averaged data at a desired rate.

5. RESET — The fringe display should be reset to zero to begin counting. Note that the phase display (3 fractional digits) will display the phase difference and does not reset to zero.

First, the mode must be selected. The indicators (1-4) will display which input channels are being compared at any given time. The OPTRAMETER has four mode settings which are summarized below:

REF/SIG — This setting compares the Laser Reference signal to the signal generated by the detector located at the front end of the OPTRALITE Laser. The OPTRALITE Interface cable or equivalent is needed for using this mode)

REF/A — In this Mode setting, the Laser Reference is compared with a signal that is present on INPUT A. INPUT A may be a signal from a remote Detector/Preamplifier, an OPTRALITE Laser input (REF or SIGNAL), or some other source.

REF/B — At this Mode setting, the Laser Reference is compared with the signal that is present on INPUT B. INPUT B may be a signal from a remote Detector/Preamplifier, an OPTRALITE Laser input (REF or SIGNAL), or some other source.

A/B — The A/B mode enables the OPTRAMETER to compare the signal on INPUT A with a signal on INPUT B.

Secondly, the SENSE position must be chosen to indicate the order in which the signal channels are compared. When the top indicator (#5) is lit, the display will increase in value as the phase of the input shown on the base line {Sig,A,B,B,} increases relative to the phase of the input on the top line {Ref,Ref,Ref,A}. Conversely, the displayed value will increase as the phase of the top line inputs {Ref,Ref,Ref,A} are increased relative to the phase of the bottom line Inputs {Sig,A,B,B} while the lower sense indicator (#6) is lit. This feature is useful for controlling the direction of the displayed count for a given phase relationship between two signals.

Adequate signal levels must be maintained in order to make accurate measurements. When low signals are present, as indicated by the Low Signal indicators (#7 and #8) the GAIN function will permit 10X signal amplification. If the input signal levels are adequate on the 1X GAIN setting then the 10X setting should be avoided in order to prevent the amplifiers from becoming saturated. Note: that if a signal input falls below the minimum level the Low Sig indicator will come on and the display is blanked, except for the ± sign. The display will remain blanked until the Reset button is pushed. For more information on low signal strength and alignment, see section 4.6 Signals & Detector Alignment.

Next, the UPDATE RATE must be adjusted for the specific application. The selection is made by repeatedly pressing the momentary switch until the indicator (13-18) designates the desired rate. This function will control the UPDATE RATE of the parallel output as well. The OPTRAMETER module compares the relative phase of the two input channels every four microseconds, and the UPDATE RATE determines how many phase measurements are averaged internally to provide the output. At the 25 kHz setting, 10 sample measurements are averaged for the display however, at the 0.25 Hz setting 1

million readings are averaged and the display is updated every 4 seconds.

The RESET feature may be used to clear the fringe display to 0. Remember that the phase information displayed to the right of the decimal will remain unchanged. The RESET capability is frequently used before a test or measurement to "zero" the fringe registers.

These five functions MODE, SENSE, GAIN, UPDATE and RESET permit the user to utilize the OPTRAMETER for a variety of diverse measurement applications. The other features on the front panel are useful for controlling the output or statusing the equipment.

SELF TEST verifies that the OPTRAMETER is working correctly. For further information on this function, consult section 3.1, Front Panel.

The LASER STATUS indicators provide information about the OPTRALITE ϑ-Frequency laser, when the laser interface cable is in use. The LOCKED (#19) indicator will be lit if the interface is used and the laser is stabilized. The WARNING light (#20) will come on before the laser unlocks. During the OPTRALITE warm up sequence, (see OPTRALITE owner's manual) or while the laser is restabilizing its' output, the WARNING light (#20) will blink to indicate that the system needs more time before the measurement can be made. If the laser interface cable is not used, then this WARNING light will remain lit. For further details on the operation of the OPTRALITE Laser, please consult your Owner's manual.

4.4 Outputs

The OPTRAMETER provides four output modes which include:

1. The front panel display.
2. Analog output.
3. Serial RS232c Interface.
4. Parallel BCD Interface.

The display provides a visual output of the data and allows the user to quickly status the parameters set on the instrument. The analog output transmits fringe and phase information via a ±10 VDC output.

The OPTRAMETER provides a standard Serial Interface (RS232c) enabling the output to be sent to a host computer for processing. For further details in interfacing with the serial output consult section 4.4.4 Serial Interface. The parallel BCD output provides data at a faster rate than the other outputs and will allow the user to control the instrument functions (MODE, SENSE,...) from a remote location. This interface is covered in detail in section 4.4.3, Parallel Interface.

4.4.1 Display Output

The display is an 11 digit LED with sign that will be updated at a maximum rate of 5 Hz. The fractional portion of the display, corresponding to phase, will change at rate which is governed by the UPDATE RATE selected, providing this rate does not exceed the maximum 5 Hz. At the .25 Hz update setting, the phase display will be updated every four seconds, while at settings higher than 2.5 Hz the display will updated at 5 Hz. The fringe display will be updated every time a full cycle is measured.

When either of the input signals drops below the minimum required level of 1 Volt (peak to peak) at the monitor outputs, the display digits will blank and remain blanked until the OPTRAMETER is reset. The low signal indicators on the front panel will display the status of each signal. A momentary drop of the signal will cause the display to blank and the accumulated data will be lost.

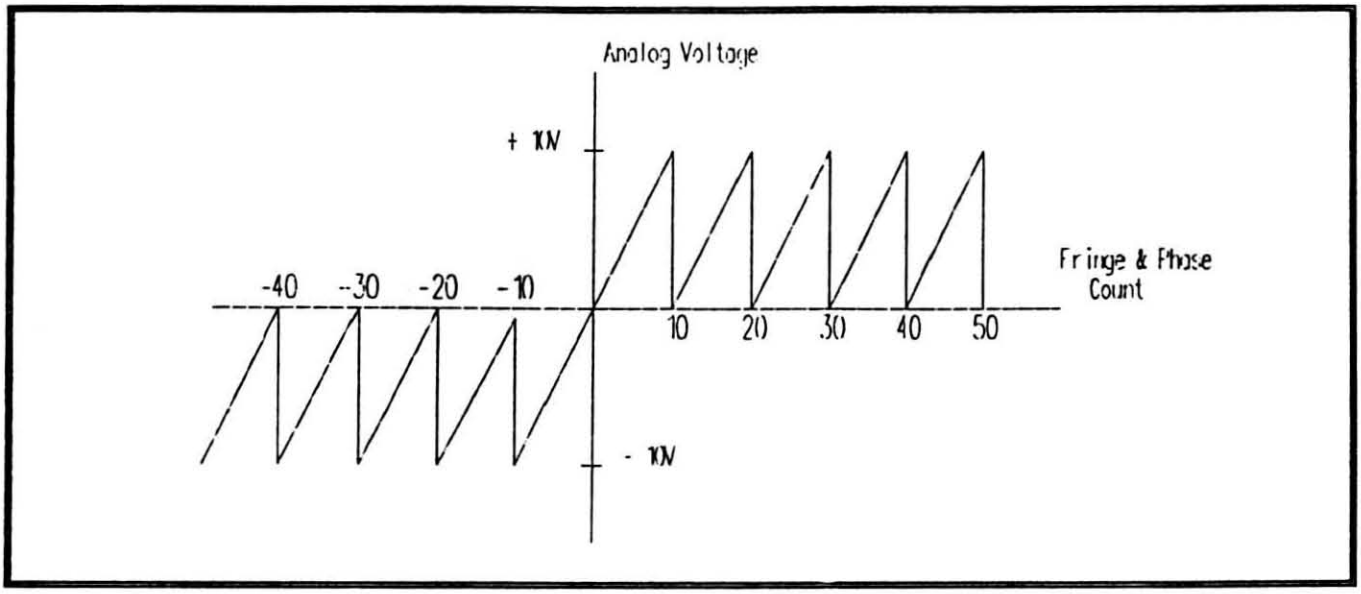
4.4.2 Analog Output

The OPTRAMETER is equipped with an analog output that provides a ± 10VDC range corresponding to selected set of four digits on the front display. In the default mode a change in the relative phase from 0 to +9.999 cycles will produce a corresponding analog voltage up to +9.999 Volts. A negative change in the relative phase from 0 to -9.999 cycles will result in a change in the analog voltage from 0 to -9.999 Volts.

The transfer function for the Analog output can be displayed as follows:

Illustration #7

ANALOG TRANSFER FUNCTION



The X axis corresponds to the measured cumulative phase difference while the Y axis is the specific analog voltage (ie; ± 10VDC). The magnitude of the transfer function output range is increased by orders of magnitude as the range is selected. For the example, the range of 10, 20, 30, 40. . . could be changed to 100, 200, 300, 400. . . or 1000, 2000, 3000, 4000... and so on. Information on selecting the range of the analog output can be found in section 4.5.3, Analog Range Selection.

The load impedance on the Analog output should be greater than 10K Ohms, and the output drive is ± 2mA maximum. The bandwidth of the Analog output corresponds to a typical rise and fall time of 500 microseconds.

4.4.3 Parallel Interface

The OPTRAMETER is equipped with two fifty pin connectors which provide a BCD interface for remote data gathering and control. These two connections provide parallel TTL outputs of all eleven digits of displayed fringe and phase information including sign. Status signals and control lines are also present on this interface.

Port A carries the digital output information. The display digits are designated as follows:

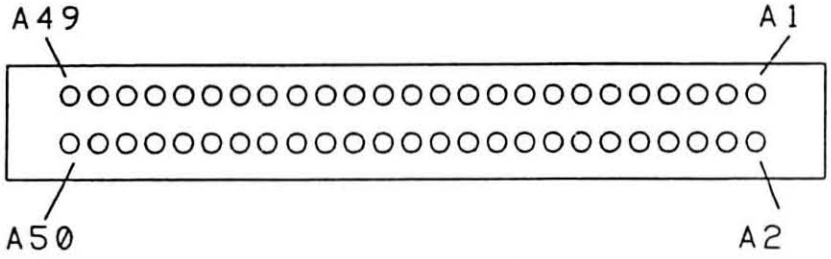
Table #1

	PARALLEL INTERFACE DIGIT ASSIGNMENT										
	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
+	8	8	8	8	8	8	8	8.	8	8	8

The connection pin assignments for the parallel interface are described in the following table;

Illustration #8

PARALLEL INTERFACE CONNECTION LEGEND A

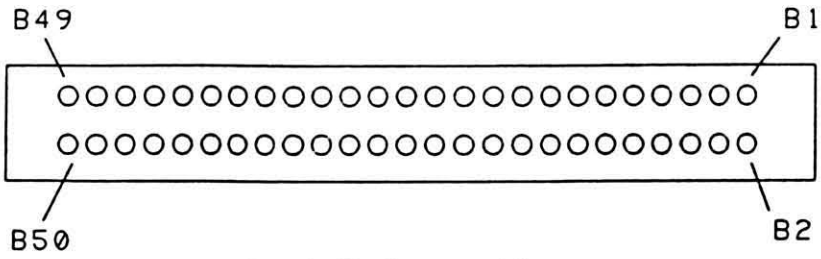


Port A Connections

1.	D0-0	18.	D4-1	35.	D8-2
2.	D0-1	19.	D4-2	36.	D8-3
3.	D0-2	20.	D4-3	37.	D9-0
4.	D0-3	21.	D5-1	38.	D9-1
5.	D1-0	22.	D5-2	39.	D9-2
6.	D1-1	23.	D5-3	40.	D9-3
7.	D1-2	24.	D6-0	41.	D10-0
8.	D1-3	25.	D6-1	42.	D10-1
9.	D2-0	27.	D6-2	43.	D10-2
10.	D2-1	28.	D6-3	44.	D11-3
11.	D2-2	29.	D7-0	45.	POS/NEG
12.	D2-3	30.	D7-1	46.	UPDATE PULSE
13.	D3-0	31.	D7-2	47.	ANALOG SLCT 0
14.	D3-1	32.	D7-3	48.	ANALOG SLCT 1
15.	D3-2	33.	D8-0	49.	GND
16.	D3-3	34.	D8-1	50.	GND
17.	D4-0				

Illustration #9

PARALLEL INTERFACE CONNECTION LEGEND



Port B Connections

1.	SENSE	18.	EXTSENSE	35.	
2.	UPDATE 0	19.	LASER RESET	36.	
3.	MODE 0	20.	EXTAX10	37.	
4.	UPDATE 1	21.	RESET RETURN	38.	
5.	MODE 1	22.	EXTBX10	39.	
6.	UPDATE 2	23.	EXTWRITE	40.	
7.	X10A	24.	EXTTEST	41.	
8.	EXTM1	25.	EXTREMOTE	42.	
9.	X10B	27.	BAUD SLCT 0	43.	
10.	EXTM0	28.	BAUD SLCT 1	44.	
11.	LOW A	29.		45.	
12.	EXTUPD3	30.		46.	
13.	LOW B	31.		47.	EXTRESET
14.	EXTUPD2	32.		48.	
15.	LASER LOCK	33.		49.	GND
16.	EXTUPD1	34.		50.	GND
17.	LASER WARNING				

Parallel Output Signal Definitions

Logic 1 on the parallel interface exists if 2.0 to 5.0 VDC is present on a pin relative to ground and logic 0 exists if there is less than 0.8 VDC on such a pin relative to ground. The maximum source or sink is 10 mA.

The MODE status of the OPTRAMETER is presented on pins B-3 and B-5. A summary of the logic follows;

Table #2

PARALLEL INTERFACE MODE STATUS

MODE	MODE 0 (Pin B-3)	MODE 1 (Pin B-5)
REF/SIG	0	0
REF/A	1	0
REF/B	0	1
A/B	1	1

The SIGN of the FRINGE COUNT is presented on pin A-45 relative to the ground pin (A-49). Logic 0 indicates a negative value while logic 1 corresponds to a positive fringe value.

The SENSE setting is indicated on pin B-1 relative to ground pin (B-49). When {REF,REF,REF,A} is selected logic 1 is present.

LOW SIGNAL indication for the {REF,REF,REF,A} group and the {SIG,A,B,B} group are statused on pins B-11 and B-13 respectively (relative to ground B-49). In both cases, logic 1 indicates that a low signal is present.

The status of the GAIN is available on pins B-7 and B-9 relative to the ground pin B-49. Logic 1 on pin B-7 means that the 10X GAIN feature is being used for the {REF,REF,REF,A} group, while logic 0 means that 1X GAIN is in use. The {SIG,A,B,B} group is statused in the same way on pin B-9.

The UPDATE RATE setting is available on the parallel output and is found on pins B-2, B-4, and B-6 relative to ground (B-49).

Table #3

PARALLEL INTERFACE UPDATE STATUS

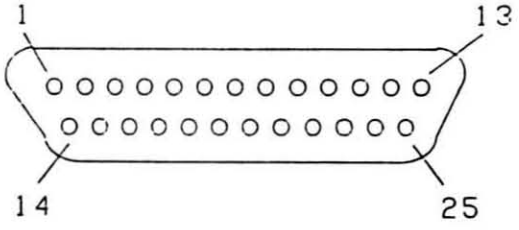
Update Rate	Update 0 (B-2)	Update 1 (B-4)	Update 2 (B-6)
0.25 Hz	0	0	0
2.5 Hz	1	0	0
25.0 Hz	0	1	0
0.25 kHz	1	1	0
2.50 kHz	0	0	1
25.0 kHz	1	0	1

For further information on the use of the parallel interface for receiving data or controlling the OPTRAMETER, please see section 4.5 Remote Control or contact OPTRA directly.

4.4.4 Serial Interface

Illustration #10

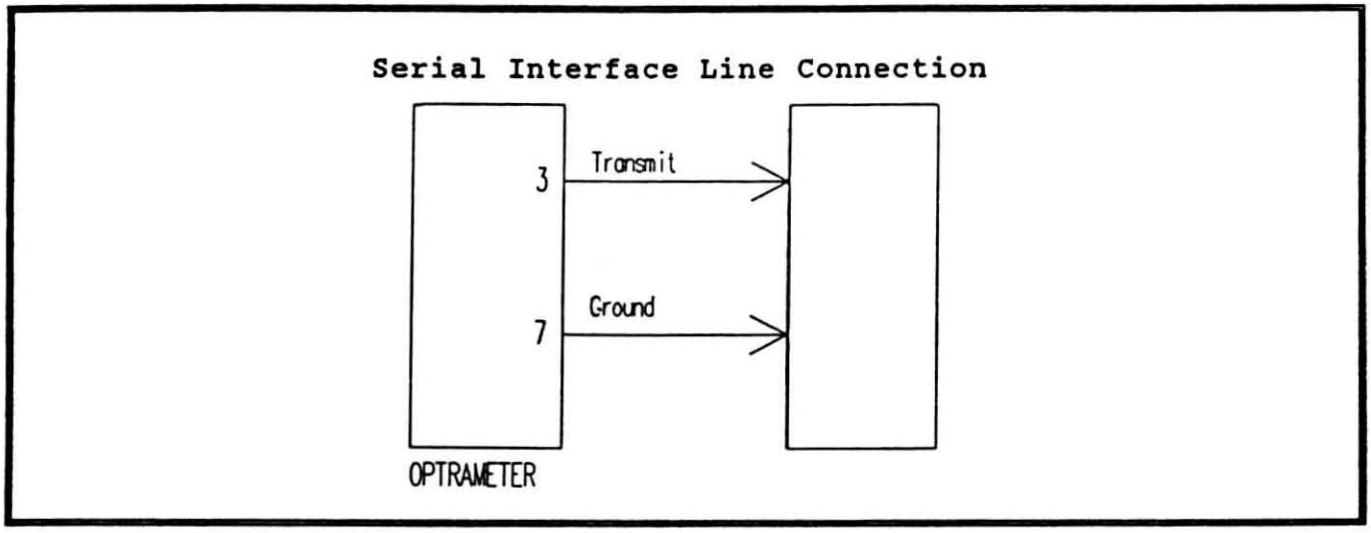
SERIAL INTERFACE CONNECTION LEGEND



The interface connection is a 25 pin D connector (male). Pin 3 is for transmitting data and pin 7 is the ground.

The OPTRAMETER is equipped with a RS232c Serial Interface for use with a host computer or other related equipment. The connections on the serial output correspond to the standard RS232c protocols.

Illustration #11



The OPTRAMETER uses Pin #3 for transmitting data and Pin #7 for the signal ground. The data rates are limited by either the UPDATE RATE selected or the baud rate. For further information on the UPDATE RATE and its function, see section 4.3, Operation.

The Serial Output data string consists of 15 ASCII characters. The format of each Byte is illustrated below.

Table #4

SERIAL INTERFACE BYTE FORMAT

Start Bit	0 LSB	1	2	3	4	5	6	7 MSB	Stop

The contents of the 15 Bytes are as follows:

Table #5

SERIAL INTERFACE BYTE DEFINITION

Byte	Character	Byte	Character
1	.001 cycle	9	10,000
2	.01 cycle	10	100,000
3	.1 cycle	11	1,000,000
4	Decimal point	12	10,000,000
5	1	13	Status Byte[3]
6	10	14	Polarity (+/-)
7	100	15	Carriage Return
8	1,000		

[3] The status byte contains 4 bits of data.

SERIAL STATUS BYTE DEFINITION

Bit	Data
B_0 (LSB)	SENSE[4]
B_1	UPDATE 2
B_2	UPDATE 1
B_3	UPDATE 0

[4] When the sense bit is logic 1 and the output is increasing, the frequency into "A" Signal Input is greater than that in "B" signal input.

SERIAL INTERFACE UPDATE DEFINITION

UPDATE RATE	Bit B1	Bit B2	Bit B3
0.25 Hz	0	0	0
2.50 Hz	0	0	1
25.0 Hz	0	1	0
0.25 kHz	0	1	1
2.50 kHz	1	0	0
25.0 kHz	1	0	1

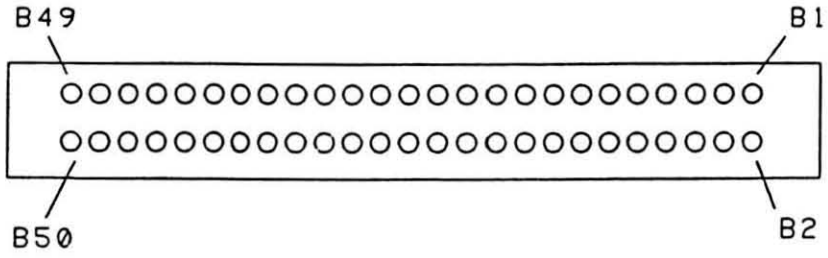
The serial output is capable of driving up to 25 feet (7 meters) of RS232c cable.

4.5 Remote Control

The OPTRAMETER Module can be controlled remotely through specific connections on the parallel interface. These connections control the functions on the front panel of the unit, the BAUD rate for the serial interface, and the range of the analog output (connections on Port A). An illustration of this connection follows;

Illustration #12

PARALLEL INTERFACE CONNECTION LEGEND



Port B Connections

1.	SENSE	18.	EXTSENSE	35.	
2.	UPDATE 0	19.	LASER RESET	36.	
3.	MODE 0	20.	EXTA10X	37.	
4.	UPDATE 1	21.	RESET RETURN	38.	
5.	MODE 1	22.	EXTB10X	39.	
6.	UPDATE 2	23.	EXTWRITE	40.	
7.	X10A	24.	EXTTEST	41.	
8.	EXTM1	25.	EXTREMOTE	42.	
9.	X10B	27.	BAUD SLCT 0	43.	
10.	EXTM0	28.	BAUD SLCT 1	44.	
11.	LOW A	29.		45.	
12.	EXTUPD3	30.		46.	
13.	LOW B	31.		47.	EXTRESET
14.	EXTUPD2	32.		48.	
15.	LASER LOCK	33.		49.	GND
16.	EXTUPD1	34.		50.	GND
17.	LASER WARNING				

Control of the unit through the interface is achieved by connecting specific pins to a ground pin (Pin B-49 or B-50). The logic levels are TTL compatible where logic 1 = open circuit and logic 0 = a short or connection.

4.5.1 Remote Function Control

The remote control capability is initiated by connecting the EXTREMOTE (Pin B-25) to ground, setting logic levels of the external control signals to the desired level, and strobing the EXTWRITE line (Pin B-23) with a negative pulse of >1 microsecond duration. When the remote interface is in use, the

display and indicators on the front panel will respond to changes in the instrument however the front panel switches will be disabled.

A. MODE The input mode is selected by pins B-8 and B-10. The logic levels and mode choices are summarized in the following chart.

Table #6

REMOTE MODE SETTING

MODE	EXTM1 (B-8)	EXTM0 (B-10)
REF/SIG	0	0
REF/A	0	1
REF/B	1	0
A/B	1	1

B. SENSE The sense selection is changed through pin B-18 EXTSENSE. Logic 1 selects the {REF,REF,REF,A} setting and logic 0 is for {SIG, A,B,B}.

C. GAIN The 10X gain mode for {REF,REF,REF,A} is activated by bringing EXTA10X (Pin B-20) to logic 1. Logic 0 is for the 1X setting. The 10X gain for {SIG,A,B,B} is controlled in the same way through EXTB10X (Pin B-22).

D. UPDATE The update selection has six settings that are controlled by EXTUPD3 (Pin B-12), EXTUPD2 (Pin B-14), AND EXTUPD1 (Pin B-16). The selection options and corresponding logic levels are summarized in the following chart.

Table #7

REMOTE UPDATE RATE SETTING

UPDATE RATE	EXTUPD3	EXTUPD2	EXTUPD1
0.25 Hz.	0	0	0
2.5 Hz.	0	0	1
25.0 Hz.	0	1	0
0.25 kHz.	0	1	1
2.5 kHz.	1	0	0
25 kHz.	1	0	1

E. RESET The fringe count can be reset to zero by bringing EXTRESET (Pin B-47) to logic 0.

F. TEST The self-test feature is activated by bringing EXTTEST (Pin B-24) to logic 0.

For further information on the use of the front panel controls, please refer to section 3.1, Front Panel Controls.

4.5.2 Serial Interface Baud Selection

The Baud rate for the serial RS232c interface may be changed from the default setting of 9600 to 300, 1200, or 2400 through BAUDSLCT0 (Pin B-27) and BAUDSLCT1 (Pin B-28). The settings and associated logic are summarized in the following chart.

Table #8

SERIAL INTERFACE BAUD SELECTION

BAUD RATE	BAUDSLCT0 (B-27)	BAUDSLCT1 (B-28)
300	0	1
1200	0	0
2400	1	0
9600[5]	1	1

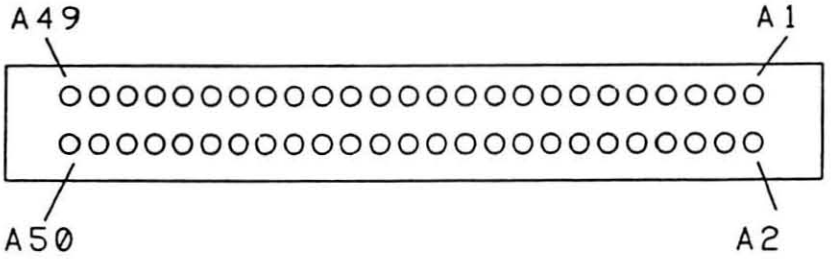
[5] Default Setting

4.5.3 Analog Range Selection

The range of the analog output can be selected with the ANALOGSLCT0 (Pin A-47) and ANALOGSLCT1 (Pin A-48) on Port A.

Illustration #13

PARALLEL INTERFACE CONNECTION LEGEND A



Port A Connections

1.	D0-0	18.	D4-1	35.	D8-2
2.	D0-1	19.	D4-2	36.	D8-3
3.	D0-2	20.	D4-3	37.	D9-0
4.	D0-3	21.	D5-1	38.	D9-1
5.	D1-0	22.	D5-2	39.	D9-2
6.	D1-1	23.	D5-3	40.	D9-3
7.	D1-2	24.	D6-0	41.	D10-0
8.	D1-3	25.	D6-1	42.	D10-1
9.	D2-0	27.	D6-2	43.	D10-2
10.	D2-1	28.	D6-3	44.	D11-3
11.	D2-2	29.	D7-0	45.	POS/NEG
12.	D2-3	30.	D7-1	46.	UPDATE PULSE
13.	D3-0	31.	D7-2	47.	ANALOG SLCT 0
14.	D3-1	32.	D7-3	48.	ANALOG SLCT 1
15.	D3-2	33.	D8-0	49.	GND
16.	D3-3	34.	D8-1	50.	GND
17.	D4-0				

The Analog output has a range of $\pm$ 10 VDC which corresponds to a selected range of four digits on the front display. The range of the analog output can be selected with Pins A-47, A-48 and A-49 on the parallel port. The logic levels are TTL compatible where Logic 1 = Open circuit and Logic 0 = a short (or connection) to Pin A-49.

The following chart summarizes the pin settings for selecting the Analog output range. The output is comprised of fringe and phase information (i.e. Fringe. Phase).

Table #9

ANALOG OUTPUT RANGE SELECTION

Format	Output Range	Logic Level A-48 Pin	Logic Level A-47 Pin
#1	+9.999 to -9.999 [6]	1	1
#2	+99.99 to -99.99	1	0
#3	+999.9 to -999.9	0	1
#4	+9999 to -9999	0	0

[6] Default setting.

4.6 Signals and Detector Alignment

The accuracy of the OPTRAMETER depends upon adequately strong signal inputs which have minimal distortion. The fringe display maintains a cumulative count of each whole cycle of phase and therefore depends upon the long term consistency of the signals. This becomes particularly important in applications where lasers and detector configurations may result in weak or distorted signals.

In order to maximize the reliability of the measurement, an oscilloscope (attached to the "A" monitor and/or the "B" monitor connections) should be used to view the INPUT SIGNAL levels. The optimum signal is a sine wave, without distortion which is 10 volts peak to peak with a signal to noise ratio of > 10:1. Should this signal level fall to 1 volt peak to peak, the 10x GAIN may be used to enhance the signal.

The detectors can be adjusted to maximize the Input signal. However, care should be taken to avoid surface reflections that reenter the laser cavity and cause feedback. For further information, please consult your OPTRALITE™ Laser Owner's Manual.

5.0 THEORY OF OPERATION

5.1 Input Circuits

The input circuits consist of 2 differential analog multiplexers which select the source of the signals whose phase is to be compared, Port A, B, or OPTRALITE Laser.

These signals are buffered by differential amplifiers and further amplified by amplifiers whose gain is nominally 1 or 10, selectable by front panel controls. A and B monitors allow the user to ensure these signals are adequate for proper operation.

These signals are then squared by high speed comparators and routed to the phase measuring circuits through a multiplexer which implements the test functions by allowing a two phase signal to be applied to the phase measuring circuits. The SENSE function is also implemented by reversing the inputs to the phase measuring circuits.

5.1.1 Input Signal Requirements

OPTRAMETER requires input signals of sufficient amplitude and signal to noise ratio in order to provide reliable operation of the squaring circuits. The frequency of the inputs must be 250.000 kHz $\pm$ 015 kHz at rest. The minimum amplitude signal <u>at the input</u> is 100 millivolts peak to peak, with 10 X gain, this provides a 1 volt peak to peak signal to the squaring circuits. The signal to noise ratio must exceed 10:1 to prevent spurious zero crossing detection which will result in erroneous fringe counting. The maximum signal <u>at the monitors</u> must be less than 15 Volts peak to peak, to prevent clipping and distortion induced phase measurement errors. The frequency range of the input signals is 25 kHz to 2 MHz.

5.2 Phase and Fringe Measuring Circuits

The phase measuring circuit determines phase by measuring the time between positive going zero crossings of the 2 squared inputs, and accumulating these measurements in a BCD counter, controlled by the phase averaging logic circuits. The number of measurements accumulated depends on the UPDATE RATE selected. For an UPDATE RATE of 25 kHz, 10 measurements are accumulated. The accuracy of the basic measurement is determined by the ratio of a master clock and the input signal frequency. The master clock in OPTRAMETER is 24.975 MHz. Inputs to the phase measuring circuit are zero crossing pulses synchronized to the master clock.

The zero crossing pulses are also used to detect fringe crossing (phase exceeds 2π rad). When a fringe crossing is detected, the fringe counter is either incremented or decremented, the phase counters are cleared or preset, and the output latches are updated. **NOTE that the output latches are updated at a rate determined by the UPDATE RATE selected, except when a fringe crossing is detected, which results in an immediate update.** When

the fringe counter is incremented, the phase reading is .000, when decremented the reading is .999.

5.3 Display/Output Circuits

The display and output circuits provide user access to the measurements and include the display and parallel, serial, and analog interfaces.

5.3.1 Display

The display is an 11 digit plus sign, 7 segment LED display controlled by 2 display driver ICS. The display is updated at a maximum rate of 5Hz.

5.3.2 Serial Output

The serial output is an RS232c compatible output, transmit only, with a selectable BAUD RATE. Normal BAUD RATE is 9600. The circuits consist of a 48/4 multiplexer controlled by a 6402 UART IC. The clock input is generated by a crystal controlled oscillator and divider circuits which have 4 frequencies selectable by the BAUD SELECT controls on the parallel connector B.

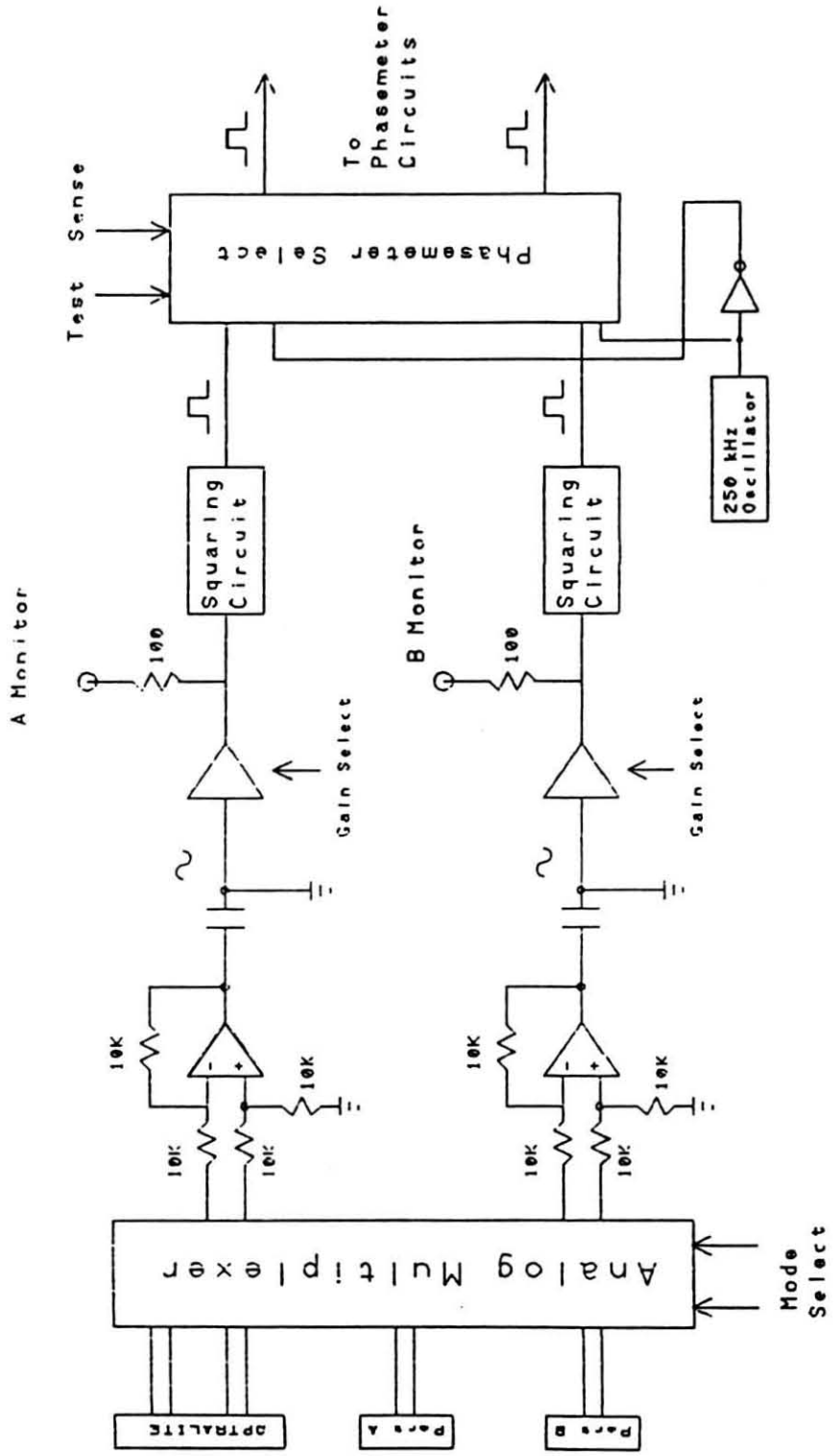
5.3.3 Parallel Outputs

The parallel outputs are 74LS241 buffers capable of sourcing or sinking 10 mA. An UPDATE PULSE 40 nanoseconds wide, positive going, indicates the output latches have been updated. The output data are valid 100 nanoseconds after the negative going pulse edge. Status bits for MODE, UPDATE RATE, SENSE, and polarity (positive or negative sign) are also provided.

5.3.4 Analog Output

The analog output is generated by a 16 bit BCD encoded D/A, a programmable amplifier, and a multiplexer which selects the parallel data inputs to the D/A. The programmable amplifier has gains of +1 or -1, controlled by the POS/NEG signal. This results in an analog output voltage with a polarity the same as the front panel display. The voltage is buffered by a unity gain amplifier capable of driving a 2K Ohm load.

Illustration #14

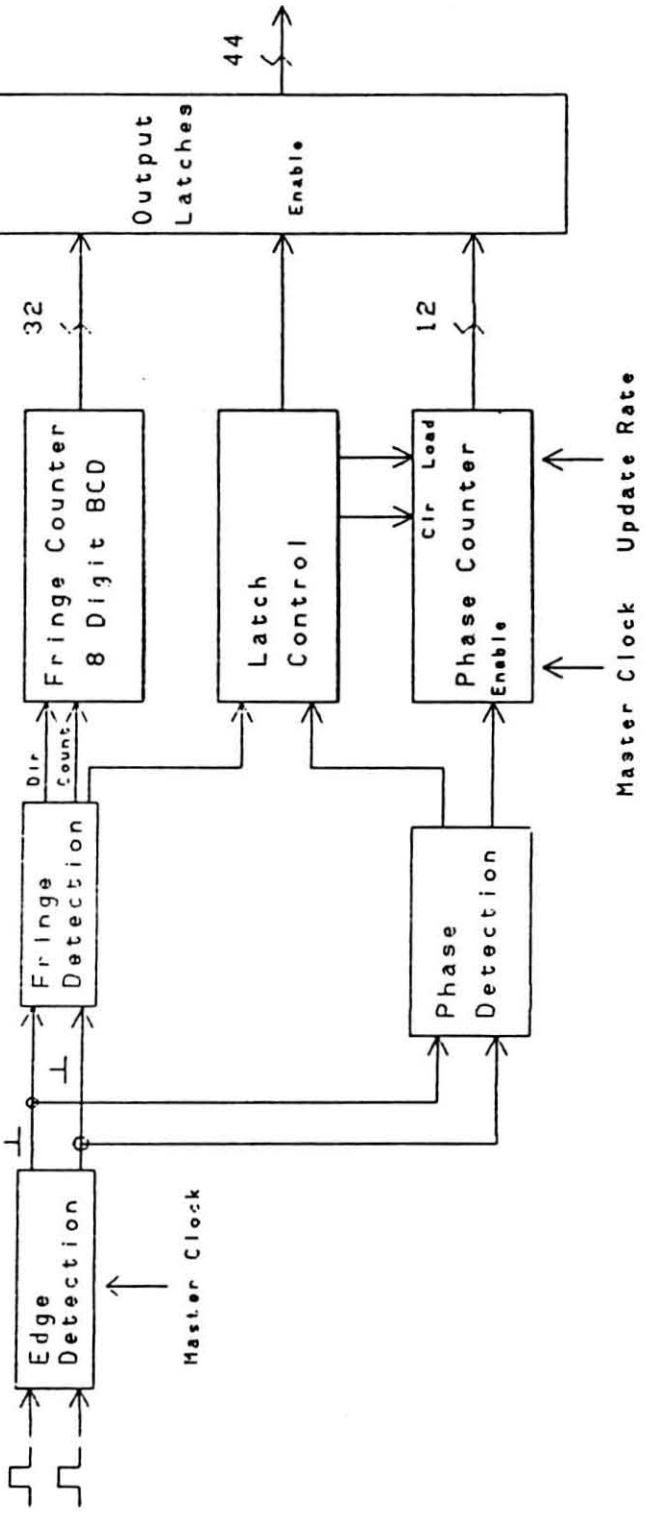


OPTRAMETER™

Input Circuitry

OPTRA

Illustration #15

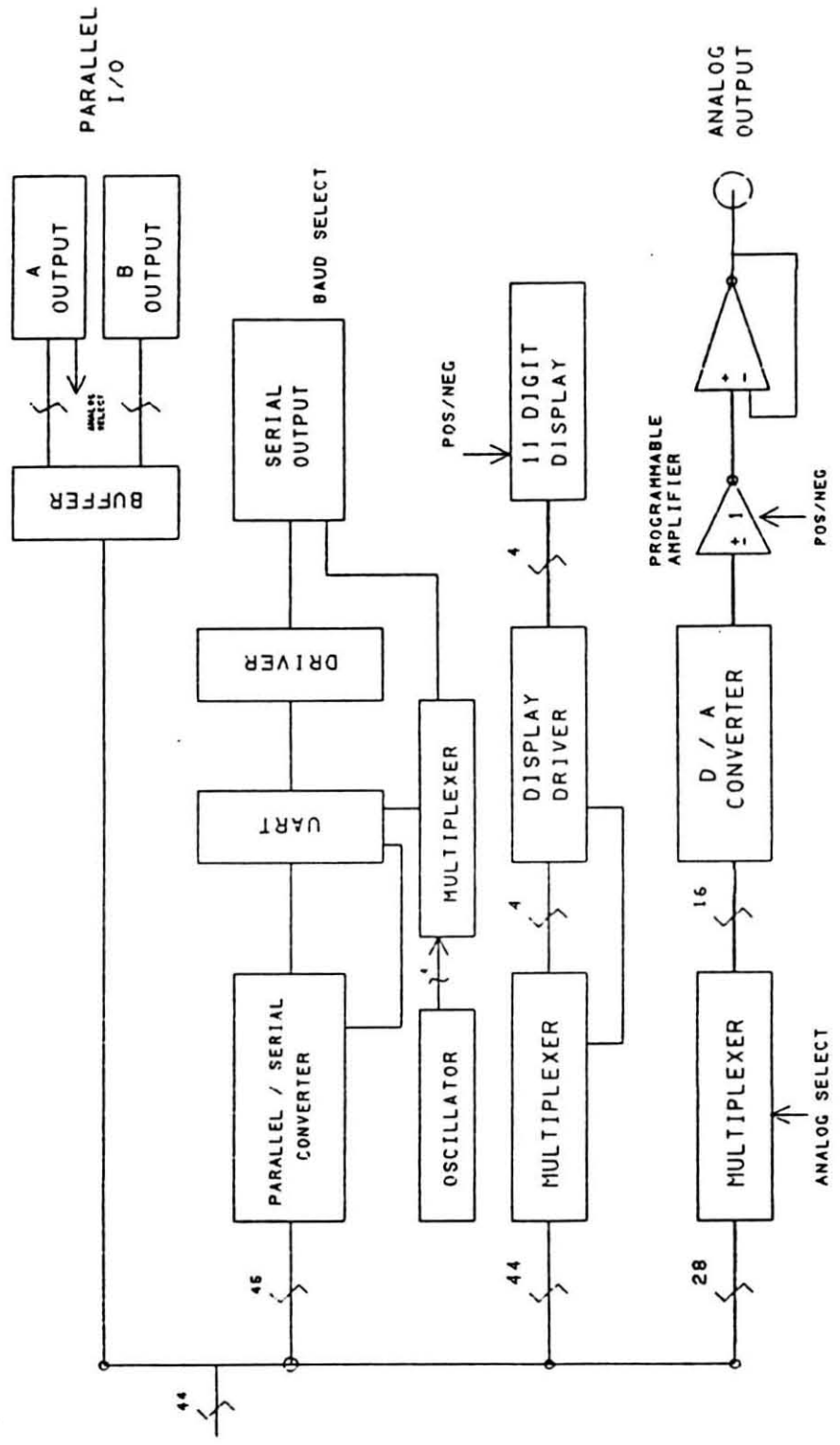


Fringe and Phase Measurement Circuits

OPTRAMETER™

OPTRA

Illustration #16



OPTRAMETER™
OUTPUT / DISPLAY CIRCUITS

OPTRA

6.0 SPECIFICATIONS

Measurement Accuracy	$<1x10^{-3}$ Cycle @ 100 Hz. $<1x10^{-2}$ Cycle @ 1000 Hz.
Measurement Range	10^{8} Cycles
Measurement Resolution	0.001 Cycles
Input Signal Range	100mV to 10V (peak to peak at 250kHz.)
Input Frequency Range	25 kHz to 2 MHz.
Phase Noise	$<3x10^{-3}$ cycles @ 25 kHz. (peak to peak)
Phase Drift	Short Term: $<2x10^{-3}$ cycles (1 min.) Long Term: $<5x10^{-3}$ cycles (8 hrs.)
Selectable Update	0.25, 2.5, 25 Hz. 0.25, 2.5, 25 kHz.
Gain Control	1x or 10x Manual Selection
Parallel Output	44 Bit, BCD Format plus Sign, TTL Compatible.
Serial Output	RS232c, ASCII Format, Selectable BAUD rate.
Analog Output	$\pm$ 10 VDC Range: $\pm$ 9.999 cycles to $\pm$9999
Display	11 Digit, LED with status indicators
Instrument Range	-99999999.999 to +99999999.999
Power Requirements	115 VAC @ 60 Hz. 25 VA avg. 240 VAC @ 50 Hz. (factory option)
Environment	Temp; +10°C to +40°C Humidity; 10% to 95% non-condensing
	Specifications for 250 kHz inputs.

Dimensions

Length of Unit -- 13"
Height of Unit -- 3.80"
with feet (for table mount) -- 4.20"
Width of Unit -- 9.50"
Weight of Unit -- 10 lbs

APPENDIX A

WARRANTY STATEMENT

OPTRA, Inc., warrants the OPTRAMETER against defects in workmanship or materials for a period of one year from the date of shipment. This warranty covers the repair or replacement of the product provided that the unit has not been electrically or physically abused, including internal tampering (opening the enclosure) as determined by OPTRA. The manufacturer in no way guarantees the suitability of this product to the customer's final application. OPTRA is in no way liable for damages that occur to property, equipment, and/or personnel as a result of the use or misuse of this product.

(PRODUCT RETURN POLICY)

Upon approval by OPTRA, the unit may be shipped (prepaid) back to the factory, with a statement of the problem, for evaluation and repair. If the unit is still under warranty, as is determined by OPTRA the unit will be repaired or replaced, free of charge, and returned (prepaid) to the customer. If the unit is determined to be out of warranty, OPTRA will immediately notify the customer of the cost to repair the unit. Should the customer choose not to have the product repaired, the unit will be promptly shipped back (prepaid) to the customer.

(NON-WARRANTY REPAIR)

The OPTRAMETER Measurement Module which is not under warranty may be returned (prepaid) to the factory for evaluation at a preset cost. The unit will be tested and the customer notified of the repair cost and return date. Should the customer decide not to have the unit repaired it will be promptly returned to the customer. Should the customer require another unit during the repair period, OPTRA will provide a replacement unit for a daily charge.

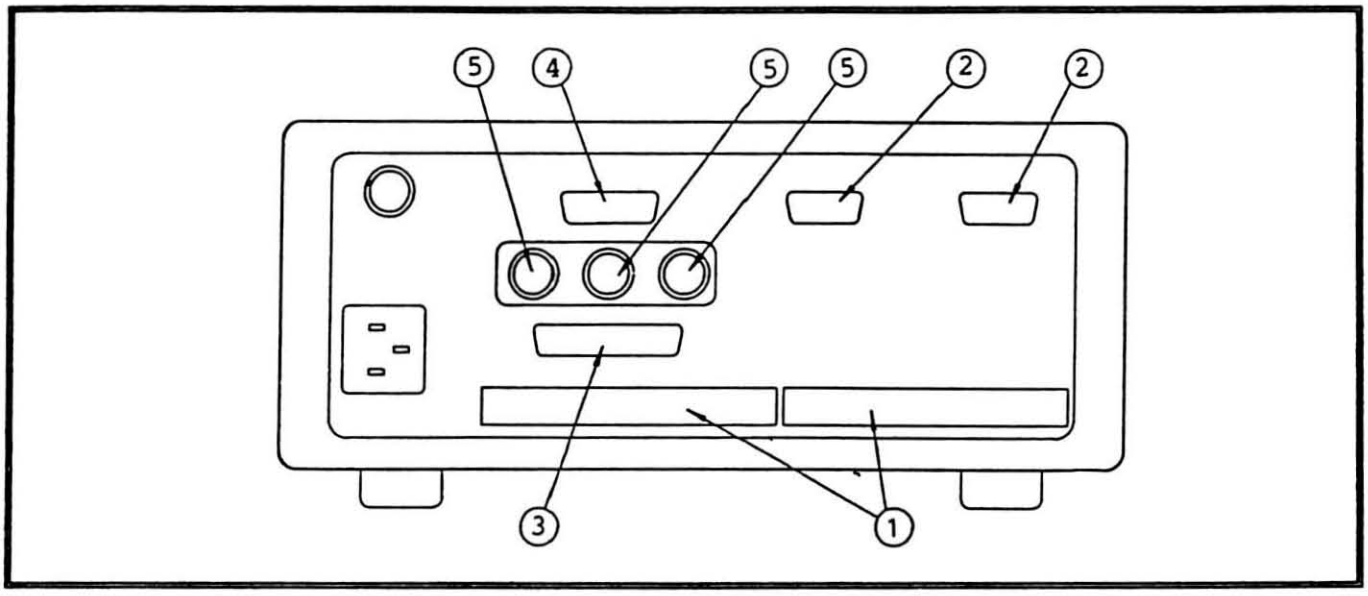
Warranty subject to change without notice.

APPENDIX B

MATING CONNECTORS

Illustration #17

OPTRAMETER REAR PANEL MATING CONNECTOR



1. PARALLEL INTERFACE CONNECTORS: (A & B)

   3M Part #3425-7650 Socket Connector (IDC) or equivalent

2. CHANNEL A & B INPUTS

   Amphenol 117D E 9P Sub-miniature "D" connector or equivalent

3. SERIAL PORT

   Amphenol 117 D B 25S Sub-miniature "D" connector or equivalent

4. LASER PORT

   Amphenol 117 D A 15S Sub-miniature "D" connector or equivalent

5. A MONITOR, B MONITOR, ANALOG OUTPUT

   Standard BNC plug connector

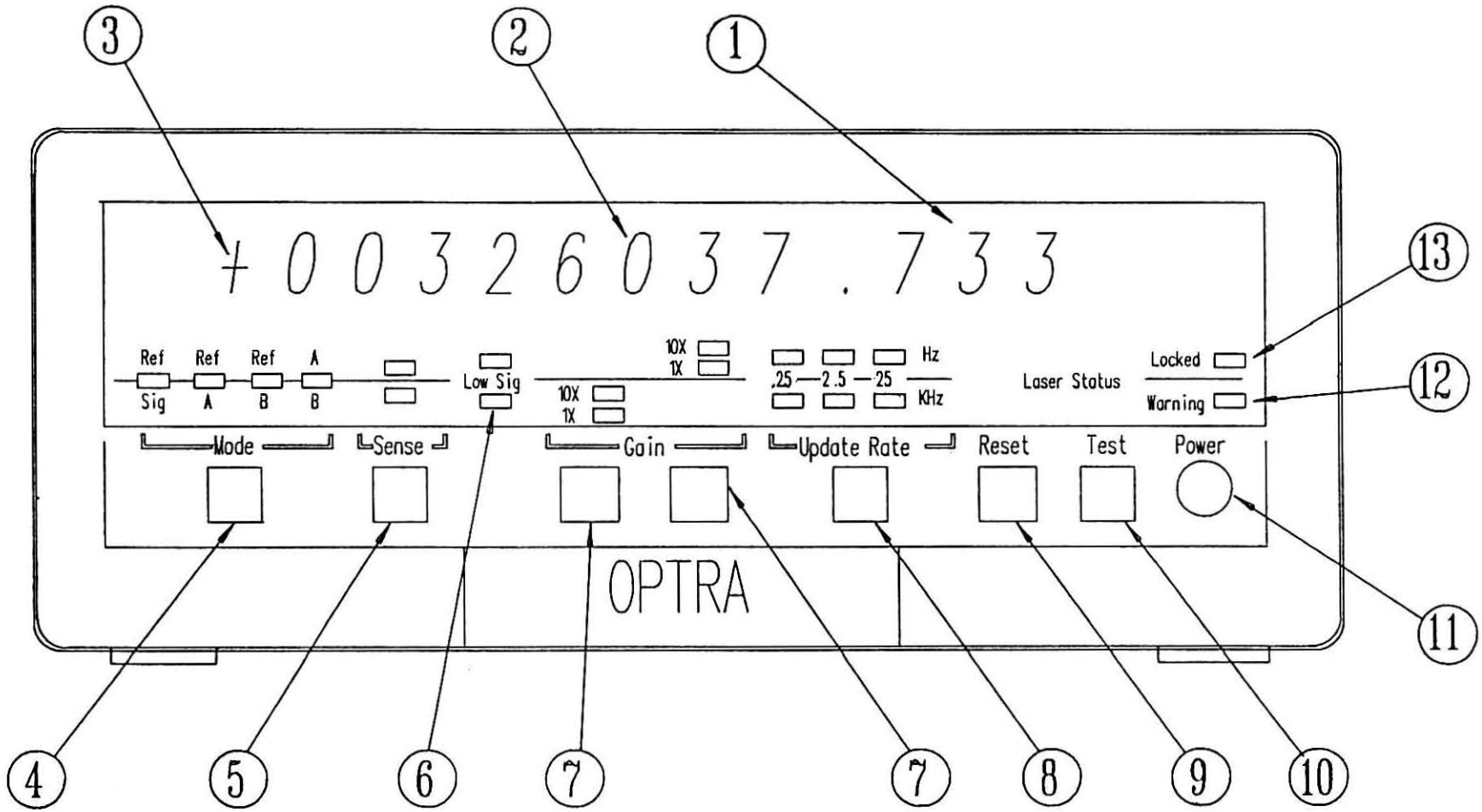
APPENDIX C

UNIT INFORMATION

Model: OPTRAMETER

Serial Number: 1034

Date of Manufacture: DEC. 1991


+00326037.733
Ref Sig
Ref A
Ref B
A B
Low Sig
10X
1X
10X
1X
Hz
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2.5
25
KHz
Laser Status
Locked
Warning
Mode
Sense
Gain
Update Rate
Reset
Test
Power
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