Mark III Interferometer With a 4-inch Mainframe Operation Manual OMP-0087F

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CONTENTS

CONTENTS

CONTENTS

CHAPTER 10 – MAINTENANCE AND WARRANTY

1 Introduction

Function of Each Component in the System

List of Optional Units That Can Be Added to the System

Summary of the Contents of Each Chapter in This Manual

Explanation of Warning, Caution, and Note Usage

The Mark III System

This interferometer and data analysis system enables you to measure and evaluate wavefront and surface figure information for a wide range of interferometric test configurations. Depending upon the accessories used with the Mark III system, you can measure surface flatness, plano transmitted wavefront, parallelism, concave and convex surface figure, lens system performance, surface figure of conic sections, mild aspheres, and more.

The Mark III system includes a Mark III Mainframe with Phase Measuring Receptacle (PMR-1), Processor Module (PM-2), Control Terminal (CT-2), and Video Monitor (VM-2). The system is shown in Figure 1-1. The function of each component is described as follows.

The Mark III Mainframe*

This unit is a Fizeau type interferometer, which means that the wavefront reflected from the transmission element and the wavefront from the item being measured recombine to form an interference pattern with nominally cosine squared (cos2) fringes. This pattern provides a great deal of information about the surface or wavefront quality of the item being tested

How does this happen? - Interferometers operate using the phenomenon of optical interference, which is based on the wave properties of light. An interferometer must use a coherent, monochromatic light source. In the Mark III, this source is provided by the Helium-Neon (HeNe) laser.

A transmission element attached to the Accessory Receptacle on the mainframe divides the laser light into two identical wavefronts. These wavefronts travel different paths, and recombine when they return to the mainframe. One is the reference wavefront produced by the transmission element, and the other is the wavefront reflected from the item under test. When recombined, the wavefronts produce an interference pattern.

Fringe Measurement (ZAPP Mode) - The simplified description above explains the fringe acquisition process in any Fizeau interferometer. Data acquired in this way is analyzed by the Mark III system using the Processor Module and ZAPP Processing routine. The interference pattern is seen by the mainframe's camera as a series of light and dark values. These values correspond to certain output voltages that get transferred to the Processor Module. In the module, these voltages are digitized, permitting the processor to evaluate the data. The processor calculates the deviation of the optical path differences (OPDs) between the two wavefronts from the positions of the data points in the fringe centers.

From this measurement process, the range of deviations from a flat surface that can typically be measured are 1λ - $\lambda/20$. Data acquisition is fast, and data analysis can be done on real-time patterns or hard copy patterns (if the optional Interferogram Reader is installed). The fringe measurement mode lends itself to large aperture test parts, and no modulation is required.

Figure 1-1 System Components

There are limitations to this method though. Geometric distortion from the camera reduces accuracy. The number of data points the processor uses for evaluation is limited, and this factor is important because higher data density is critical to higher accuracy evaluations.

Phase Measurement - The Phase Measuring Receptacle (PMR) on the Mark III mainframe enhances the entire measurement process. It piezoelectrically translates the transmission element over a distance of ½ wavelength, causing the interference pattern to modulate. While the modulation is occurring, the diode array camera inside the mainframe samples the varying light intensity falling on each diode a total of four times.

The light level detected by each diode in the array is converted to an electrical signal and transferred to the processor via the interface cable. The signals are transformed in the processor to digital data which is used to calculate the deviations, or optical path differences between the two wavefronts.

Using this method of measurement, the range of deviations from a flat surface that can typically be measured is 5λ - $\lambda/50$. The system is relatively insensitive to geometric distortion to the first order, and accuracy is increased because of the large number of uniformly sampled data points.

With the Mark III system, you have the option of processing in either the ZAPP or Phase mode. In many cases the method used will be determined by your application. See the "Specifications" chapter of this manual for more detailed accuracy, data acquisition, and processing parameters for both fringe and phase measurement.

The Processor Module

This module contains all of the electronic hardware and software needed to perform the system tasks, including: executing system diagnostics at system power up or reset, processing phase measurement data, automatic fringe center acquisition, manual fringe center acquisition, least-squares analysis calculation, fiducial digitization, 3-D plot generation, user prompting, generation of error codes, and interfacing with an auxiliary computer.

The Control Terminal

The Control Terminal contains the controls (pushbuttons and switches) you need to interact with the Mark III system in order to activate and control the various processing functions. This unit is divided into three sections. The controls in each section are designed for a specific set of functions. The controls and functions are described in detail in *Chapter 4*.

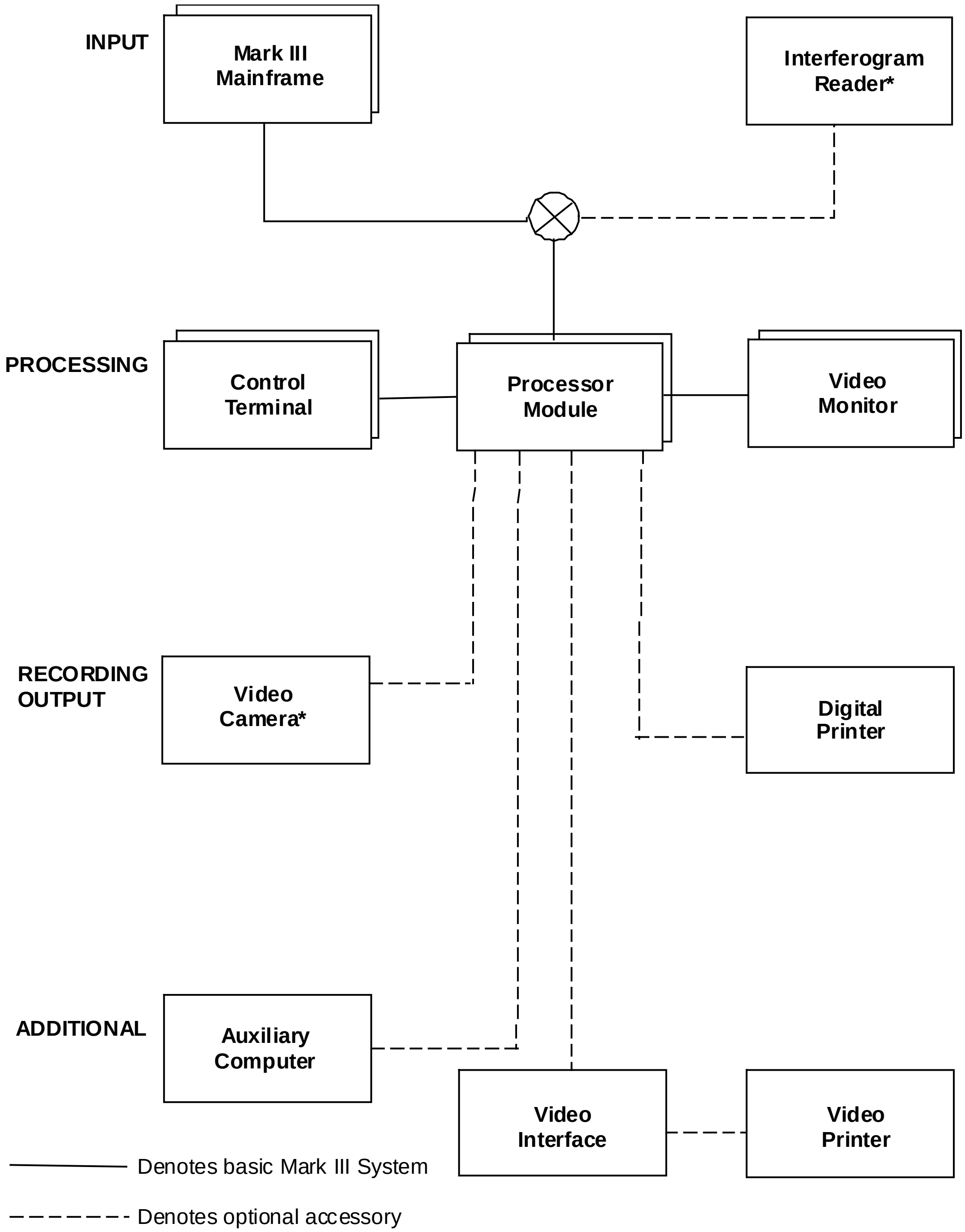
The Video Monitor

The monitor displays the interference patterns, the four prompting pages (where you identify the values the system uses to make calculations), and the evaluation data from the processor.

The monitor is mounted on a gimbal bracket, which may be placed on a tabletop, or on a riser bracket. The riser bracket enables you to position the monitor above the Mark III Mainframe.

Optional Components

Each of the following components can be added to the basic Mark III system. See the System Diagram in Figure 1-2.



*** You may purchase a desktop console incorporating both the Interferogram Reader and Video Camera to the basic Mark III System to form the expanded system configuration.**

Figure 1-2 Mark III Interferometer System Diagram

Video Camera

This camera records all information displayed on the monitor. It contains an integral monitor, a video-synchronized shutter, low distortion imaging optics, and a Polaroid, or 35 mm camera back.

For additional information on the camera, refer to the ZYGO brochure, SB-0006.

Video Printer and Interface

This printer enables you to obtain hard copies of video images (interferograms and text) displayed on the monitor. It connects to the Processor Module through the interface.

Interferogram Reader

The reader looks at hard-copy interferograms and sends information about them to the ZAPP II Processor. The reader can view interferograms ranging in size from 35-mm to 4x5 inches. It contains an integral CCTV camera, low distortion zoom imaging optics, and an internal light source. A continuous zoom feature provides magnification up to 6X of small patterns.

Digital Printer

The printer provides you with a hard copy of the digital information displayed on the monitor. The input is transmitted through a standard RS-232C interface.

Auxiliary Computer

The Mark III system provides digital output to an auxiliary computer through a standard RS-232C port, or an optional IEEE-488 port.

The ZAPP or Phase data transmitted over the RS-232C port, or the Phase data (100 x 100 array) transmitted over the IEEE-488 port, is compatible with the Zygo Interferometer Software package. This package can be run on the Hewlett-Packard 9816, 9836, 310 or 320 computer systems. The software program provides Zernike polynomial coefficients, point spread function, modulation transfer function and several other data analysis routines.

How This Manual Is Organized

Each chapter of this manual covers a particular subject. Each topic that applies to the subject appears in boldface type. Procedural steps are identified with a numeral. If further divisions occur within a procedural step, they are identified with a lowercase letter.

Chapter 2:	Lists specifications for the Mark III System components and optional units.
Chapter 3:	Contains important laser radiation information.
Chapter 4:	Includes a description of the controls for the Mark III Mainframe, Control Terminal, Processor Module, and Video Monitor.
Chapter 5:	Covers unpacking and setup of the equipment, including transmission element installation and test setup procedures.
Chapter 6:	Describes how to interact with the Phase Processing software.
Chapter 7:	Describes how to interact with the ZAPP Processing software.
Chapter 8:	Provides important data transfer information for both the RS-232C and IEEE-488 ports.
Chapter 9:	Includes an explanation of error codes and troubleshooting information for the Mark III Mainframe, Processor Module, and Video Monitor.
Chapter 10:	Covers maintenance and warranty information.
Appendix A:	Contains handling tips for optical components and a list of suppliers for optical cleaning materials.
Appendix B:	Includes a Glossary of Terms, Quick Reference Guide, and Interferogram Scale Factor chart, and a Decimal to Fraction Fringe Conversion Chart. An index follows the material in this appendix. Several notes pages are included in the back of the manual also.

About the Use of Warnings, Cautions and Notes in this Manual

As you read this manual, you will notice that certain information is presented as a WARNING, CAUTION, or Note. These headings are used to call your attention to information of a special nature.

WARNINGS point out the precise use of materials, processes, methods, procedures, or limits to avoid injury to you or others.

CAUTIONS point out methods and procedures you must follow to avoid damage to the equipment.

Notes provide additional, helpful information that makes the job easier.

2

Specifications

Fringe Measurement (ZAPP Mode)

Accuracy:

Plano Testing	
with Error Subtraction	$\lambda/40$
without Error Subtraction	$\lambda/20$
Spherical Testing	
with Error Subtraction	$\lambda/40$
without Error Subtraction	$\lambda/10$
Precision* (Repeatability):	$\lambda/80$ Peak-to-Valley

*Note: Accuracy and precision assume an Interferogram Scale Factor of 1 fringe = $\lambda/2$, where wavelength is equal to 632.8 nm.

The accuracy and repeatability of the ZAPP mode of operation is based on the ability of the system to digitize a pattern of 25 equally spaced lines superimposed in the measurement aperture. As the horizontal resolution is 1 part in 1000, there are 1000 clock counts across the full measurement aperture. This means that in the measurement situation above, there are 40 clock counts between each fringe center.

Because the hardware and software can determine the location of a fringe center to ±1 clock count, this means that the maximum uncertainty for the location of the fringe center is $1/40^{th}$ of the spacing between fringes, or $1/40^{th}$ of a fringe. As most measurements are made in a double pass configuration, the repeatability of the system is $\lambda/80$.

Resolution:

Vertical	
(Automatic)	32 equally spaced scan lines
(Manual)	32 equally spaced scan lines
(Fiducial)	1 part in 256
Horizontal	
(Automatic)	1 part in 1000
(Manual)	1 part in 1000
(Fiducial)	1 part in 1000

Geometrical Distortion:

with Error Subtraction	Less than or equal to 0.25 percent
without Error Subtraction	Less than or equal to 0.5 percent
Number of Fringes:	Less than or equal to 25
Number of Data Points:	1,024 maximum
Data Acquisition Time:	1/60 second or 1/12 second*
Fringe Spacing:	Greater than or equal to 25 resolution units

Fringe Geometry:

Automatic	Slope less than or equal to 45° from vertical fringe width variation less than or equal to 3:1 No closed fringes
Manual	No closed fringes

*Acquisition time is 1/12 second only when the BROAD/NORMAL/NARROW control switch is in the BROAD position.

Fringe Types:	Either two beam $\cos^2$ or multiple beam high finesse, Fizeau fringes Real-time interference patterns
Least Squares Computation Time:	0.25 second to 5 seconds depending upon the number of fringe centers acquired

Phase Measurement

Accuracy:

Plano Testing	
with Error Subtraction	$\lambda/50$
without Error Subtraction	$\lambda/20$
Spherical Testing	
with Error Subtraction	$\lambda/50$
without Error Subtraction	$\lambda/10$

Precision (Repeatability):	Less than or equal to $\lambda/100$, p-v Less than or equal to $\lambda/350$, rms
Resolution:	$\lambda/720$
Spatial Resolution:	100 x 100 diodes
Fringe Types:	Cos^2 fringes
Fringe Geometry:	Null fringe fields, straight fringes in any orientation, closed fringe patterns, or fringe patterns with multiple zero orders.
Maximum Number of Fringes:	Approximately 7-8 fringes (above this number, accuracy decreases).
Maximum Fringe Density:	0.5 fringes/diode spacing
Number of Data Points:	10,000 maximum
Data Acquisition Time:	12 msec to 195 msec depending upon the scan rate set by the system

Note: Accuracy and precision assume an Interferogram Scale Factor of 1 Fringe = $\lambda/2$, where wavelength is equal to 632.8 nm.

Mark III Mainframe

Aperture:	4-inch diameter with continuous zoom to 2/3-inch diameter, i.e., 6X zoom range. (33mm and 6-inch aperture converters are available from Zygo.)
System Quality:	λ/20 (632.8 nm) for plano testing λ/10 for spherical testing λ/4 for cylindrical testing
Light Source:	632.8 nm HeNe laser with circularly polarized output beam.
Alignment:	Quick Fringe Acquisition System
Viewing:	Low distortion, 9-inch Video Monitor (VM-2)
Recording:	Simultaneous fringe observation and recording using an optional Model VC-2A Video Camera or a Model VP-1 Video Printer with VS-1 Interface (not included).
Sample Dimension:	Unrestricted
Video Connectors:	BNC Type
Electrical Signal Inputs:	X and Y clock from the Processor Module (PM-2) to the Diode Array Camera High voltage (up to 600 VAC) from Processor Module to Phase Measuring Receptacle (PMR-1)
Electrical Signal Outputs:	
Fringe Measurements	CCTV camera, video, horizontal, and vertical sync
Phase Measurements	Diode array camera, video and end-of-frame sync. Diode array camera test outputs including video test, line sync, and end-of-frame sync.
Video Output:	525 lines/60 Hz, 2:1 Interlace, RS170 standard, or 625 lines 50 Hz, 2:1 Interlace, CC1R standard
Electrical Power Requirements:	115 ± 10%, 60 Hz, or 100 ± 10%, 50 Hz*, or 230 ± 10%, 50 Hz* 50 watts, single phase without monitor 75 watts, single phase with monitor

* When wired for this input voltage and frequency, there is a duplex outlet on the Mark III which provides 115 ± 10%, 50 Hz for the Video Monitor and/or the Video Camera or Video Printer.

Video Monitor (Model # VM-2)

Size:	9-inch diagonal
Connectors:	BNC type
Sync:	Internal or external, switch selectable
Electrical Power Requirements:	115 ± 10%, 60 Hz or 115 ± 10%, 50 Hz*, or 35 watts, single phase

* When wired for this input voltage and frequency, the Video Monitor plugs into one of the outlets on the Mark III Mainframe, which provides 115 ± 10 VAC, 50 Hz.

Processor Module (Model #PM-2)

RS-232C Printer Interface:	Alphanumeric characters in ASCII code 1200 baud rate 7 data bits 1 stop bit no parity
RS-232C Computer or Disk Unit Interface:	Alphanumeric characters in ASCII code 9600 baud rate (4800 baud rate for disk unit) 7 data bits 1 stop bit no parity
Connectors:	BNC Type
Electrical Signal Inputs:	
Fringe Measurements	Video, horizontal, and vertical sync. These signals are provided by a CCTV camera. The video input is terminated at 75 ohms.
Phase Measurements	Video and en-of-frame sync from the Diode Array Camera.

Electrical Signal Outputs:	
Fringe Measurements	Video and composite sync
Phase Measurements	High voltage to Phase Measuring Receptacle (up to 600 VAC)
Electrical Power Requirements:	115 ± 10%, 60 Hz or 100 ± 10%, 50 Hz or 230 ± 10%, 50 Hz or 150 watts

Optional Digital Printer (Model #DP-1A)

Print Performance:	80 characters per second 8-inch (204 mm) maximum print width 80 character columns
Characters:	9 x 7 dot matrix
Character Spacing:	10 characters per inch for 80 character columns
Data Input:	Serial Interface (RS-232C)

Dimensions and Weights

Mark III Mainframe (L x W x H):	31-1/2 x 21 x 8 inches (800 x 533 x 203) 80 lbs. (36 kgs.)
Video Monitor (L x W x H):	12-1/4 x 9 x 9-1/2 inches (310 x 228 x240 mm) 14 lbs. (6.3 kgs.)
Processor Module (L x W x H):	24 x 17 x 8-1/2 inches (610 x 432 x 216 mm) 45 lbs. (20.3 kgs.)

Control Terminal(L x W x H):	8 x 14 x 4 inches (203 x 356 x 102 mm) 3 lbs. (1.4 kgs.)
Digital Printer (L x W x H):	13-3/8 x 9-3/8 x 4 inches 340 x 240 x 102 mm) 14 lbs. (6.3 kgs.)

Power Distribution

WARNING! Ensure that all power is off when connecting cables. The equipment is intended to be electrically grounded. It is equipped with a grounding plug to fit a grounding-type outlet. Ensure that the components are properly grounded through the outlet.

3

Laser Radiation Safety Information

Laser Safety Notes, Including ANSI Classification

NCDRH Regulations Statement

Laser Beam Output Data

Federal Regulations Usage Statement

Illustrations Showing Labels and Their Locations

Laser Safety

The Mark III laser emits visible red light only. No harmful or invisible radiation is emitted.

The radiant output power of the internal laser and of the instrument is low. The radiation emitted cannot burn or drill holes, even if a lens is used to focus the light.

However, the laser light emitted by the Mark III should be treated with caution and common sense. It will not hurt your skin, but to protect your eyes, don't look directly into the laser beam or stare at its bright reflections.

The American National Standard for the Safe Use of Lasers (ANSI Z136.1--1980) classifies this laser product as Low Power - Class II (per Table A1), and provides reasonable and adequate guides for its safe use. The user and personnel responsible for the safe use of the Mark III in the user's organization should consult this ANSI standard. It is available from:

American National Standards Institute
1430 Broadway
New York, NY   10018

NCDRH Regulations

Effective August 2, 1976, the National Center for Devices and Radiological Health (NCDRH) of the Food and Drug Administration has established regulations for laser products manufactured after August 1, 1976

Output Beam Data

Emission Duration:	more than 0.25 second
Radiant Power:	less than one milliwat (1/1000 watt)
Wavelength:	632.8 nanometers only

Additional Information

Emission Indicator

This green light is located on the front panel of the mainframe directly above the ON/OFF switch (Figure 3-1). When lit during operation, it indicates that Class II radiation is being emitted.

Beam Attenuator

This is an aluminum knob located on the front panel of the mainframe. It is marked BEAM ATTEN., and is a mechancial beam shutoff (Figure 3-1). Pull the knob OUT to shut off the laser beam. Push the knob IN to turn on the laser beam.

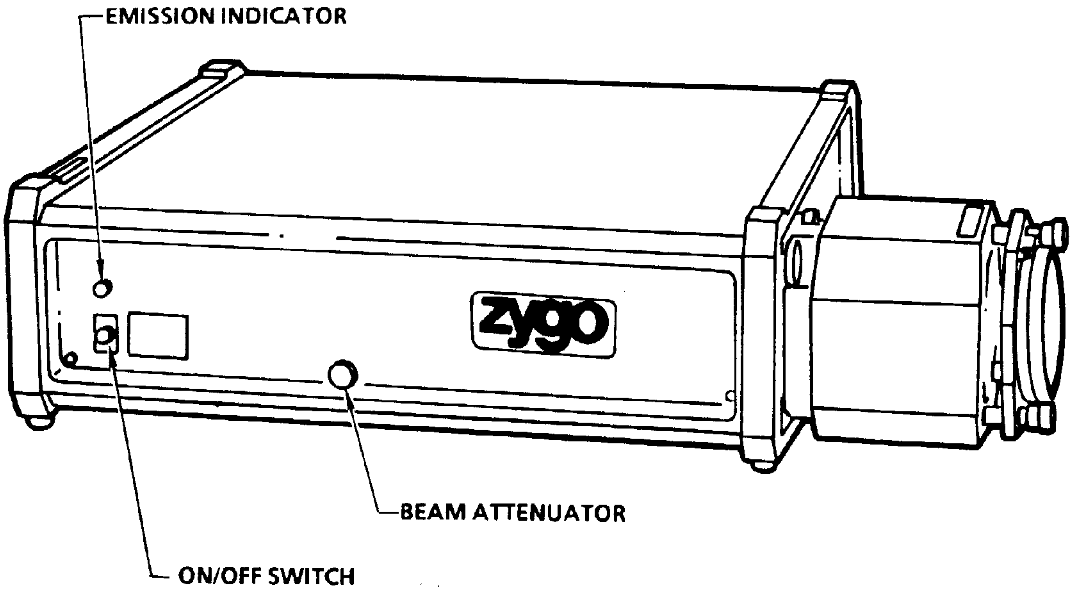


Figure 3-1 Mark III Mainframe

Replacement of Laser Heads and/or Laser Power Supplies

Use only ZYGO supplied laser heads and/or power supplies labeled for use in the Mark III. Install the replacement part following the specified procedure in the Mark III Service Manual, SP-0053. Follow the installation procedure exactly to ensure conformity to Federal Radiation Standards.

Use of Controls Statement

Federal Regulations require that the following statement be included in this manual.

> **WARNING: Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.**

Labels and Locations

The various labels used on the Mark III Mainframe and their locations are shown in Figures 3-2 through 3-4.

Summary

The laser radiation emitted from the Mark III Mainframe will not damage eyes or skin provided you follow the usage guidelines established in this chapter.

ANSI provides additional information about the class of laser used in the Mark III. You can obtain this information by writing to ANSI at the address listed in this chapter.

Labels on the Mark III clearly identify apertures from which laser radiation is emitted.

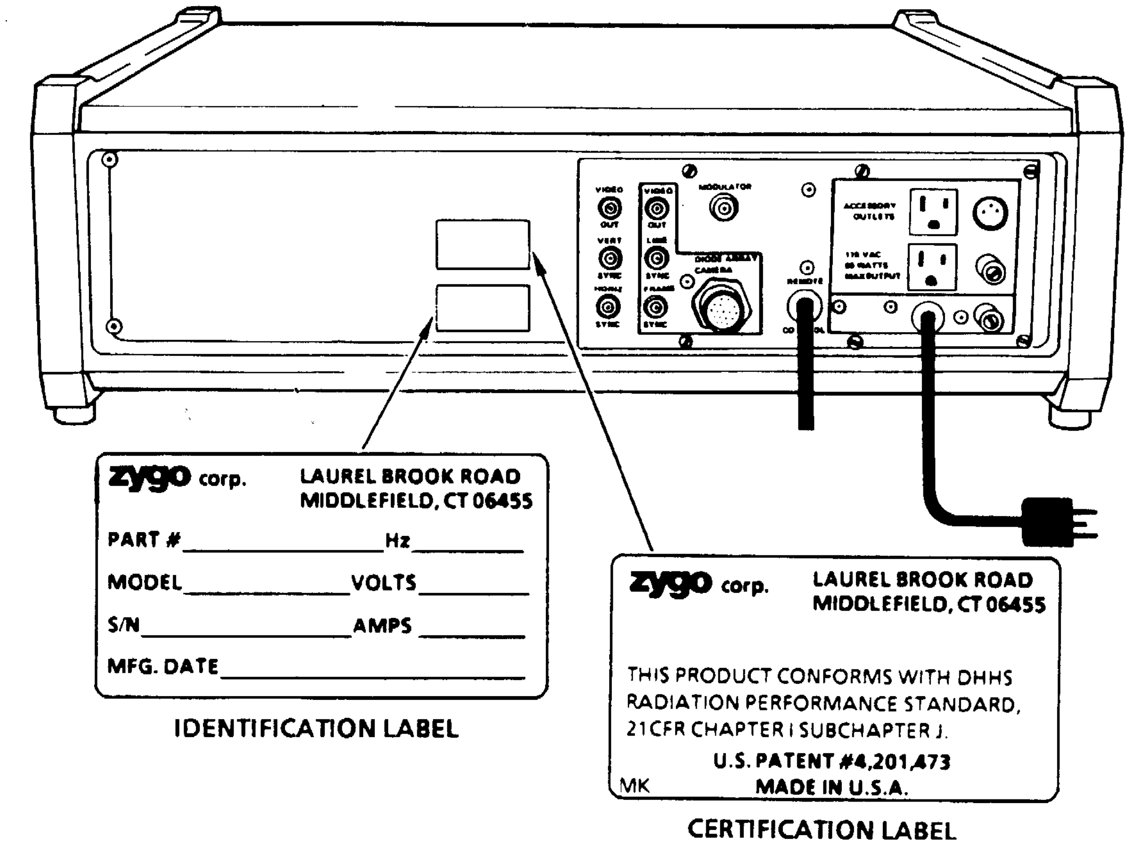


Figure 3-2 Mainframe Back View

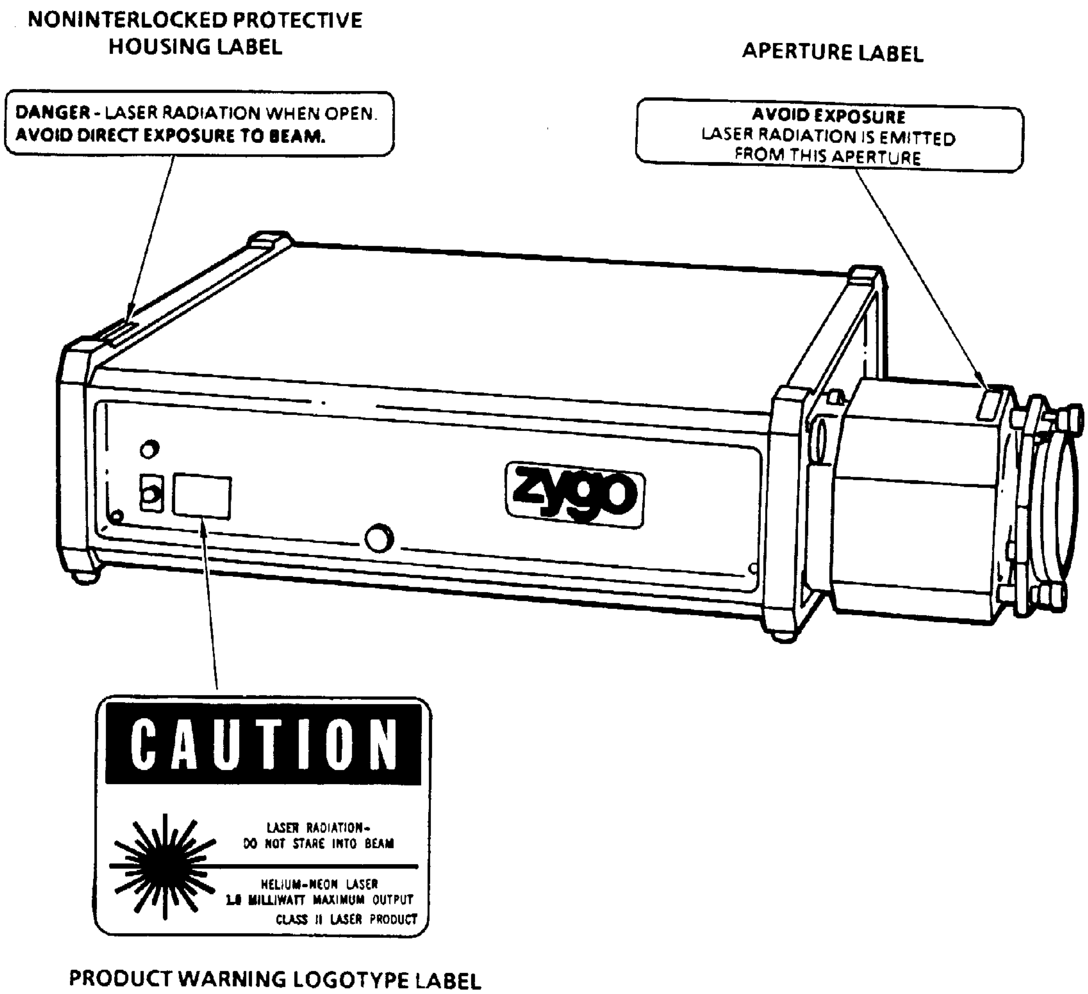


Figure 3-3 Mainframe Front View

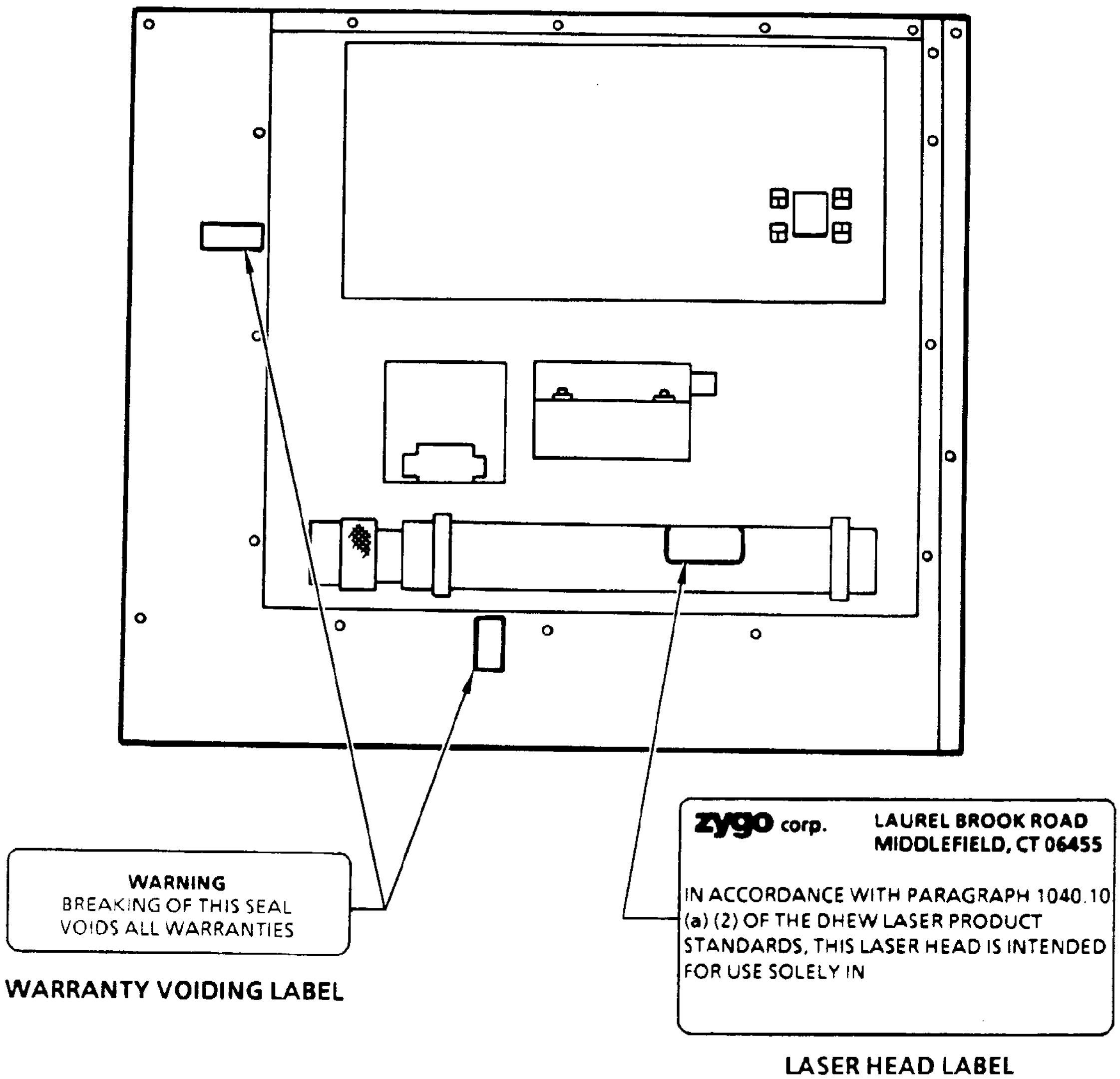


Figure 3-4 Mark III Mainframe with Top Cover Removed

4 Equipment Controls

Function of the Mark III Mainframe Controls

Function of the Processor Module Controls

Function of the Video Monitor Controls

Before You Begin

Operating the Mark III system is easy once you are familiar with the function of the controls on the system components. Most of the controls described in this chapter are for the Control Terminal, which is used for both phase and ZAPP processing. Take a few minutes now to read through this chapter; look at the illustrations showing the location of the controls, and locate the controls on the equipment.

You'll find a quick reference guide for the Control Terminal controls in Appendix B of this manual. It can be removed from the manual and placed near the equipment.

Mark III Mainframe Controls (Figure 4-1)

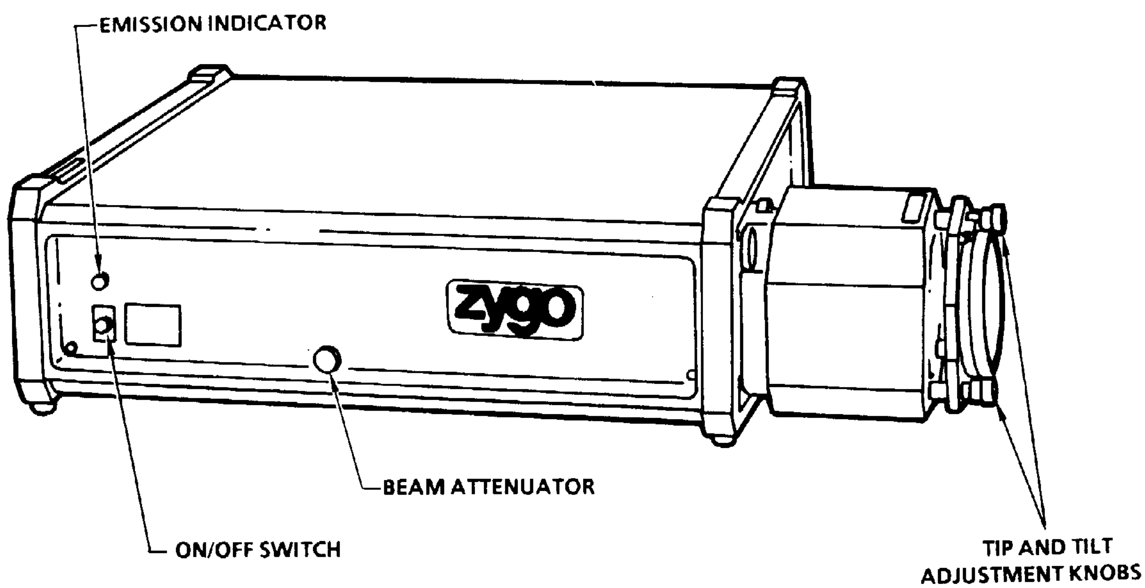


Figure 4-1 Mainframe Controls

ON/OFF Switch

This switch is located on the front panel of the mainframe. It turns the unit on and off.

BEAM ATTEN. Knob

The BEAM ATTEN. knob pulls out to block laser emission. This knob is also on the front panel of the mainframe.

Emission Indicator

When lit, this green light on the front of the mainframe indicates that Class II radiation is being emitted.

Tilt Adjustment Knobs (2)

These knobs are located on the mainframe, or on a separate accessory receptacle. They adjust the tilt of the element in the receptacle so that you can align the element perpendicular to the output beam.

The following controls described below are located on the Remote Operator Control Box attached to the mainframe. See Figure 4-2.

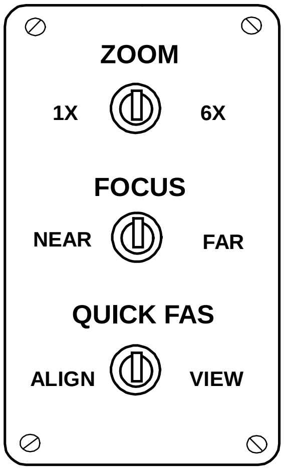


Figure 4-2 Remote Operator Control Box

Alignment and Focus Controls

ZOOM Switch- This switch controls diameter (plano testing), or f/number (spherical testing) in a magnification range from 1X to 6X.

FOCUS Switch- This switch enables you to focus the aperture of the test item. Use it only when the test item is at or near 6X magnification. The *Setup* chapter of this manual includes additional information on this switch.

QUICK FAS (Fringe Acquisition) Switch- Use this switch in the alignment process (displays the crosshairs and alignment spot on the monitor), and to display the interference pattern on the monitor. You must hold the switch in place for approximately two seconds to complete the mode change.

Processor Module Controls

ON/OFF Switch

This switch is located on the left-hand side of the unit. When you flip it on, the system begins running a diagnostics program automatically. This program checks the control terminal switches, performs a checksum operation on the system software, and tests all volatile memory. If when the diagnostics program is finished, you see one or more error codes on the monitor screen, see the *Troubleshooting* chapter of this manual to determine the fault indicated, and the suggested solution. Not all error codes indicate hardware failure, and in many cases you can continue processing by pressing the NEXT PAGE/RESTORE pushbutton. However, if an error code is displayed repeatedly, contact the ZYGO Service Department.

The keys described in the next section of this chapter are located on the Control Terminal. See Figure 4-3.

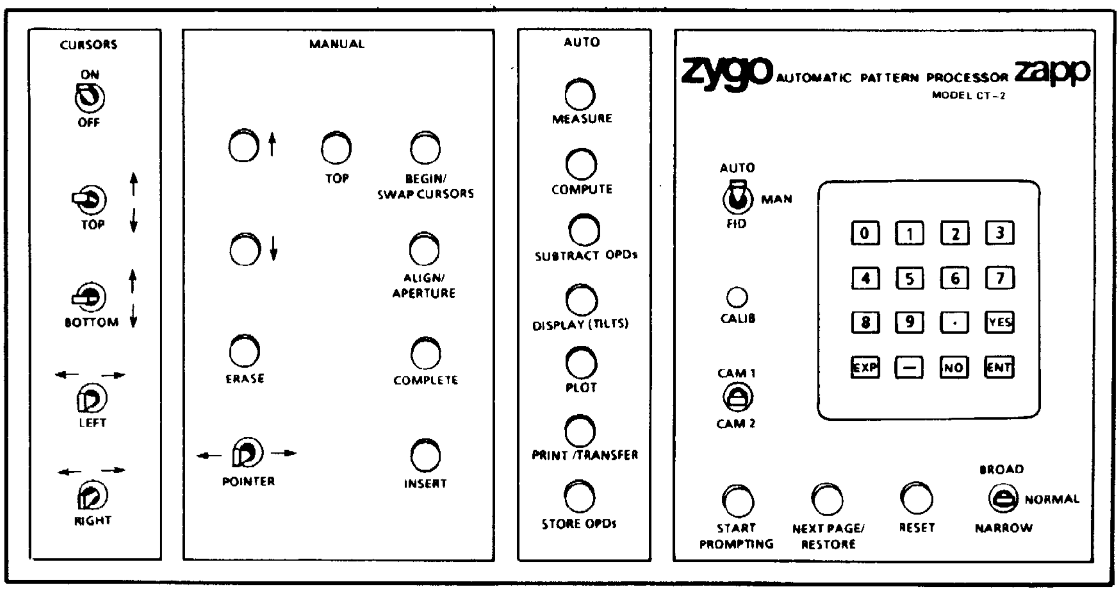


Figure 4-3 ZAPII Control Terminal

The keypad (Figure 4-4) has 10 numeral keys, a dash key, decimal point key, and four command code keys. Use them to enter new default data on the prompting pages. The command code keys function as follows:

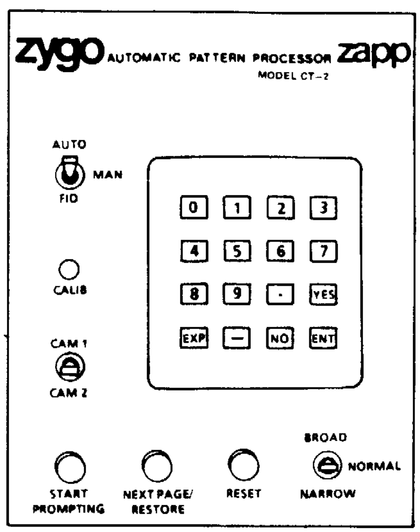


Figure 4-4 Keypad Controls

Keypad Controls

YES- Accepts prompting page defaults.

NO- Indicates that the default is not accepted.

ENT- Moves the pointer DOWN one line at a time.

EXP- Moves the pointer UP one line at a time, and erases numerical data in the middle of an entry.

START PROMPTING- Displays the mode selection page on the monitor.

NEXT PAGE/RESTORE - Displays the next prompting page. Also, it redisplays the previously acquired fringe centers, exits from error codes, and in the ZAPP mode, steps through the displayed output information on the screen.

RESET - Discontinues all processing and automatically begins the diagnostics routine. When you press RESET, all previously entered default, calibration, and stored OPD data is erased.

BROAD/NORMAL/NARROW Switch- Use this switch to adjust for broad, normal, or narrow fringes.

AUTO/MAN/FID Switch- Acquires and edits fringe centers in the ZAPP mode.

CAM 1/CAM 2 Switch- This switch enables video input to be received. The CAM 2 position receives input from the mainframe CCTV camera. The CAM 1 position receives input from the optional interferogram reader, or an additional Mark III Mainframe.

CALIB Indicator Light- Lights up when the geometric distortion (ZAPP mode) has been computed using calibration grids and is to be subtracted from subsequent measurements as requested in the defaults. (The CALIB Indicator is not used in the Phase mode and should be disregarded when making Phase Measurements.)

The next set of switches described is located in the CURSORS portion of the Control Terminal. See Figure 4-5.

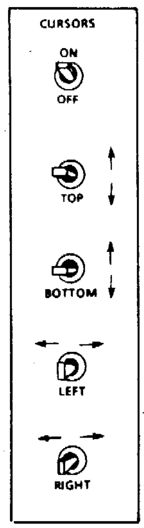


Figure 4-5 Cursor Controls

Cursor Controls

ON/OFF- This switch turns the cursors on and off. When the switch is in the ON position, four white cursor lines are displayed on the monitor. When this switch is in the OFF position, the cursors do not appear on the monitor.

TOP- This button provides manual control of the upper horizontal cursor line.

BOTTOM- This button provides manual control of the lower horizontal cursor line.

LEFT - Provides manual control of the left-most vertical cursor line.

RIGHT - Provides manual control of the right-most vertical cursor line.

The next set of controls described are located on the Control Terminal beneath the word MANUAL. (See Figure 4-6). Use these controls only when processing in the ZAPP mode. Exceptions are noted.

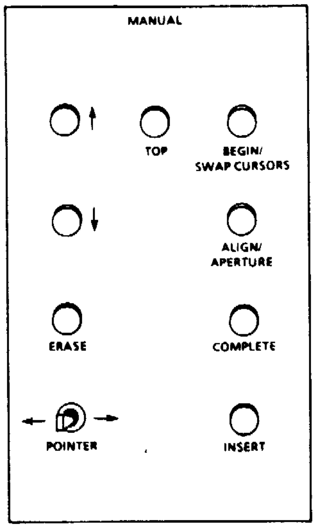


Figure 4-6 Manual Controls

Manual Controls

BEGIN/SWAP CURSORS- (ZAPP Mode) If the AUTO/MAN/FID switch is in the AUTO position, you can insert data or erase data. With the AUTO/MAN/FID switch in the MAN mode, you can erase all fringe centers from memory.

BEGIN/SWAP CURSORS- (Phase Mode) Switches back and forth between two separate sets of cursors.

UP ARROW- Moves the pointer on the monitor up by 8 TV scan lines.

Note: In Mark III systems with 50 Hz, the pointer moves up by 10 TV scan lines.

DOWN ARROW- Moves the POINTER on the monitor down by 8 TV scan lines.

Note: In Mark III systems with 50 Hz, the pointer moves down by 10 TV scan lines.

ERASE Pushbutton - With the AUTO/MAN/FID switch in the AUTO position, this button erases the data point closest to the POINTER. (You must press BEGIN/SWAP first.) With the AUTO/MAN/FID switch in the MAN position, this button erases an entire line of data. (In the Phase mode, this button removes all computer-generated information displayed on the System Monitor.)

POINTER Switch - The POINTER appears as an asterisk (*) on the monitor. A single contact of this switch moves the POINTER horizontally. A quick, double contact of this switch moves the POINTER horizontally, but faster. The movement is in increments of one resolution element.

COMPLETE Pushbutton - If the AUTO/MAN/FID switch is in the MAN mode, this button ends editing after each row.

If the AUTO/MAN/FID switch is in the AUTO position, this button ends editing when single point editing is completed.

INSERT Pushbutton - Enters data points into memory.

TOP Pushbutton - When the AUTO/MAN/FID switch is in the MAN position, this button returns the pointer to the top of the monitor, increments the fringe order number, and prepares to acquire the next fringe.

ALIGN/APERTURE Pushbutton - In the ZAPP mode, this button enters the data points when the fringes have been misordered due to artifacts, the close proximity of fringe spacing, or slopes in excess of 45 degrees from the vertical.

In the PHASE mode, this button changes the shape of the test aperture from rectangular to elliptical or vice versa.

The controls described in the following section are on the Control Terminal in the section beneath the word AUTO. See Figure 4-7. To use these controls the AUTO/ MAN/FID switch must be in the AUTO position.

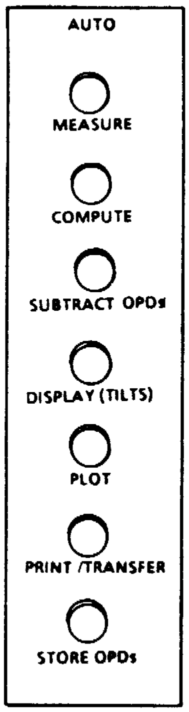


Figure 4-7 Auto Controls

Auto Controls

MEASURE- In the ZAPP mode, this button automatically acquires and displays the coordinates of an array of points falling on the fringe centers. The data appears on the monitor as a series of x's and +'s.

In the Phase mode, this button acquires data from the mainframe and automatically computes and displays the number of data points, root-mean-square, and peak-to-valley values.

COMPUTE- In the ZAPP mode, this button activates the requested processing mode: peak-to-valley, root-mean-square, and accept/reject. The results are displayed on the monitor.

It also performs computations on previously acquired data. In the Phase mode, this button recomputes the root-mean-square and peak-to-valley values automatically. It can also be used to recompute data if a change was made on a prompting page.

PLOT- This button displays the 3-D plot of OPDs in the uniform grid on the monitor.

PRINT/TRANSFER- This button prints out and/or transfers format and output data to a printer or computer. See the “Data Transfer” chapter of this manual for specific information on data transfer through the RS-232C or IEEE-488 port.

SUBTRACT OPDs - Transfers OPDs to a uniform grid and subtracts stored OPDs from the interference pattern OPDs.

DISPLAY (TILTS) - In the ZAPP mode, this button displays the output data on the monitor.

In the PHASE mode, this buttton calculates the X, Y tilt values for a test part with respect to the transmission flat mounted on the PMR. Both values are calculated in waves/diode.

PLOT - This button displays the 3-D plot of OPDs in the uniform grid on the monitor.

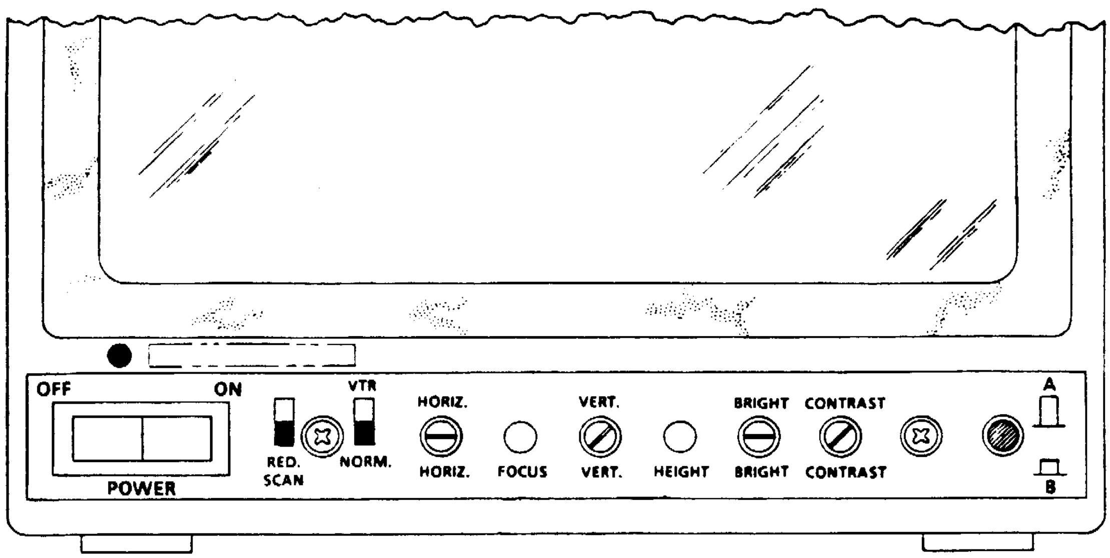
PRINT/TRANSFER - This button prints out and/or transfers format and output data to a printer or computer. See the *Data Transfer* chapter of this manual for specific information on data transfer through the RS-232C or IEEE-488 port.

STORE OPDs - In the ZAPP Processing mode, this button transfers and stores OPDs to a uniform grid in Random Access Memory (RAM).

In the PHASE mode, this button transfers and stores OPDs in two, separate grids in RAM.

Video Monitor Controls

Figure 4-8 shows the monitor controls. They function as follows:



ON/OFF Switch- This switch turns the unit on and off. Press this switch to the right to turn on the monitor, and to the left to turn off the monitor.

RED SCAN Switch- This switch changes the size of the image on the monitor. Slide it to the Red position for a reduction in image size. With the switch in the Red position, you're able to view edges of the image that you may not be able to see with the switch in the Scan position.

VTR/NORM Switch- This switch allows the monitor to be used with video recorder equipment. (You can leave this switch in either position when using the monitor with the Mark III system.)

HORIZ Knob-This knob adjusts and locks the image on the screen in place horizontally. Turn it to the left and/or right until the image is adjusted as desired.

VERT Knob-

This knob adjusts and locks the picture in place vertically. Turn the knob to the right and/or left until the image is adjusted as desired.

BRIGHT and CONTRAST Knobs- These knobs adjust the image to the desired contrast level. To properly adjust the image contrast and brightness on the monitor, turn both the brightness and contrast controls fully counterclockwise. Adjust the brightness control until the TV raster scan is just visible on the monitor screen. Adjust the contrast control until you have the desired image.

A and B PUSHBUTTONS- The function of this button is to switch between channels A and B. While the monitor is connected to the Mark III system, the button must be in the A position.

Summary

This chapter describes the function of the controls that you use to operate the MarkÊIII system, and illustrates control locations.

Most of the controls described in this chapter are on the Processor Module Control Terminal. They are a combination of switches and pushbuttons that you use to activate Phase or ZAPP processing.

A Quick Reference Guide covering the function of each control on the Processor Module Control Terminal is provided in the back of this manual also. It can be removed and placed near the equipment.

5 System Setup

Before You Begin

If you have not read the *Equipment Controls* chapter, take a few minutes to do so now. You need to know where the equipment controls are in order to perform the installation and alignment procedures covered in this chapter.

Unpacking and Handling

Before you begin to unpack the system, be sure that you are unpacking in an area that is clean and dry. When you move the system from one location to another, use foam rubber or another shock absorbing material.

The shipping boxes should contain the following:

- Mark III Mainframe
- Processor Module
- Control Terminal
- Video Monitor with gimbral bracket
- Riser bracket and hardware; flat, black Control Terminal cable; gray, Video Monitor power cord; round, black Diode Array cable, and 6 coaxial cables.

Removing Equipment from the Boxes

Follow these general guidelines as you remove the system components from the shipping boxes.

1. When removing the Mark III Mainframe, two persons (one at each end) should grasp the underside of the unit and LIFT it out of the box. Remove the Processor Module in the same way. DO NOT PULL ON THE COVERS of either unit when removing them from the shipping boxes.
2. Check each shipping box to be sure you've removed all items.
3. Save the shipping boxes in case you must return any equipment to Zygo Corp.
4. You can now set up the system. Keep in mind that the Mark III Mainframe should be placed on a vibration isolation or optical testing table.

Connecting the Cables

Figures 5-1 and 5-2 show the connector panels of the Mark III Mainframe, Processor Module, and Video Monitor. Connect the cables for these units following the Cable Connection Chart (Figure 5-3). Each cable is labeled, except for the flat Control Terminal connector and the large, round Diode Array Camera cable.

Note: The Mark III Interferometer and Processor Module for each system are matched to each other. They cannot be interchanged with the same components from another Mark III Interferometer system. Before you connect the interferometer to the processor, check to be sure that the same serial number is listed on the Product Identification Label, which is located on the connector panel of each component.

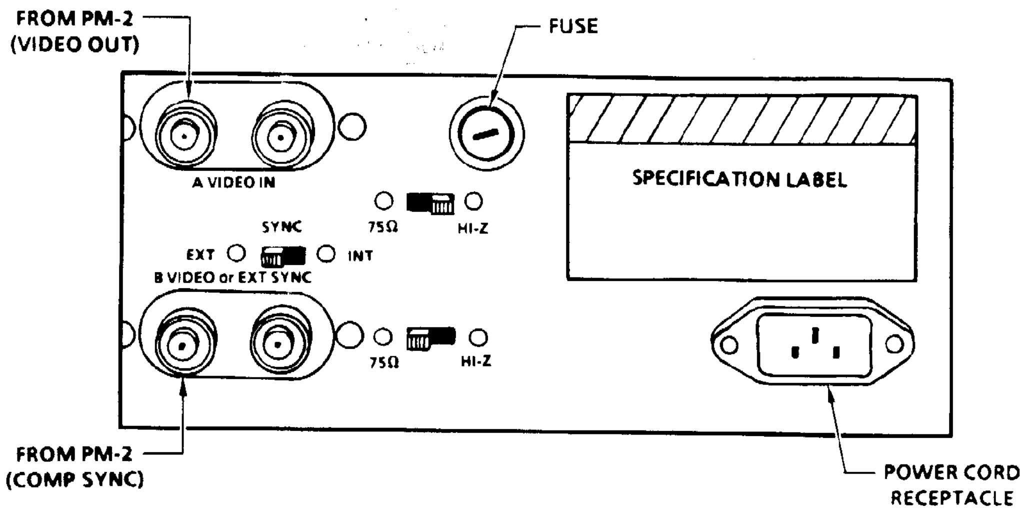


Figure 5-1a Video Monitor Connector Panel

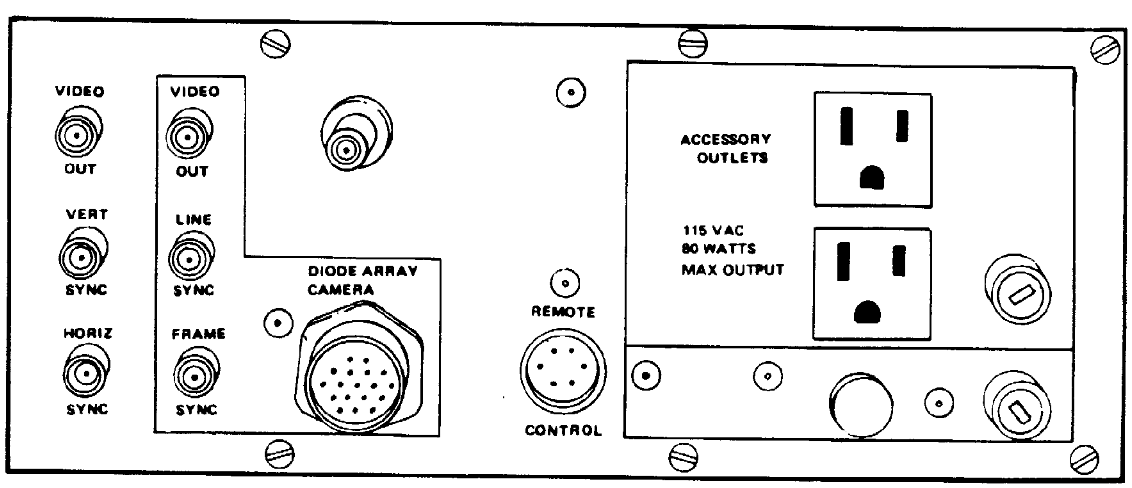


Figure 5-1b Mark III Mainframe Connector Panel

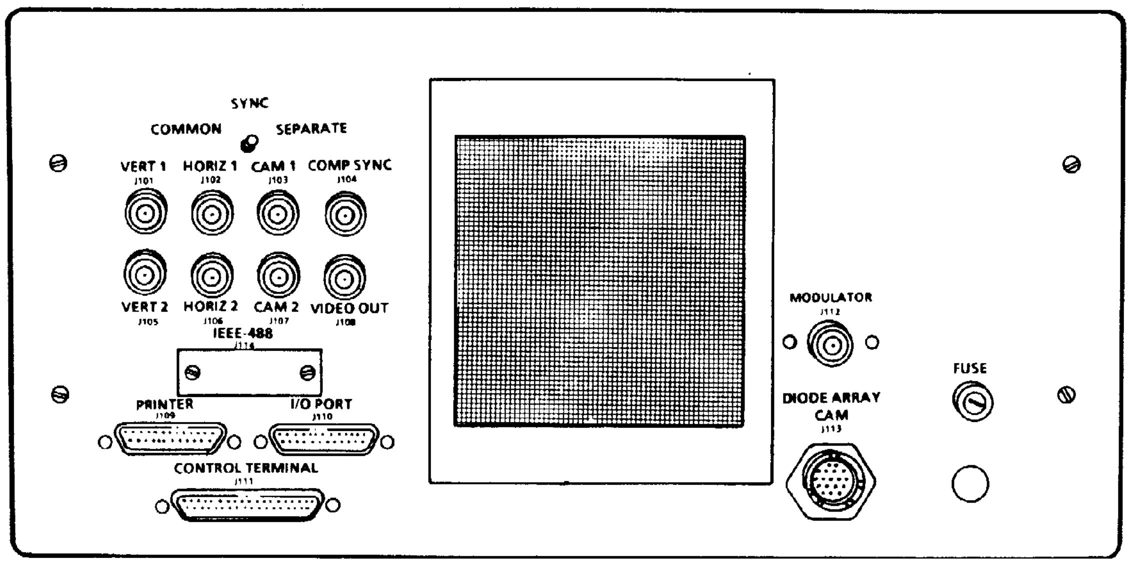


Figure 5-2 Processor Module Connector Panel

After you have completed connecting the cables, continue with the following procedure. Refer to Figure 5-3.

1. Set the switches on the Video Monitor to the following settings. (See Figure 5-1 for the location of the switches.)

Switch	**Setting**
EXT/INT SYNC	EXT
TOP 75/HI-Z	75*
BOTTOM 75/HI-Z	75

* If an optional Video Camera (VD-2A) is connected, set the TOP switch to HI-Z.

2. Plug the female end of the gray Video Monitor power cord into the outlet at the bottom right of the monitor connector panel
3. Plug the male end of the gray Video Monitor power cord into either one of the accessory outlets on the right side of the Mark III Mainframe connector panel.
4. Plug the Processor Module and Mark III Mainframe power cords into the power source specified in the Specifications chapter of this manual.

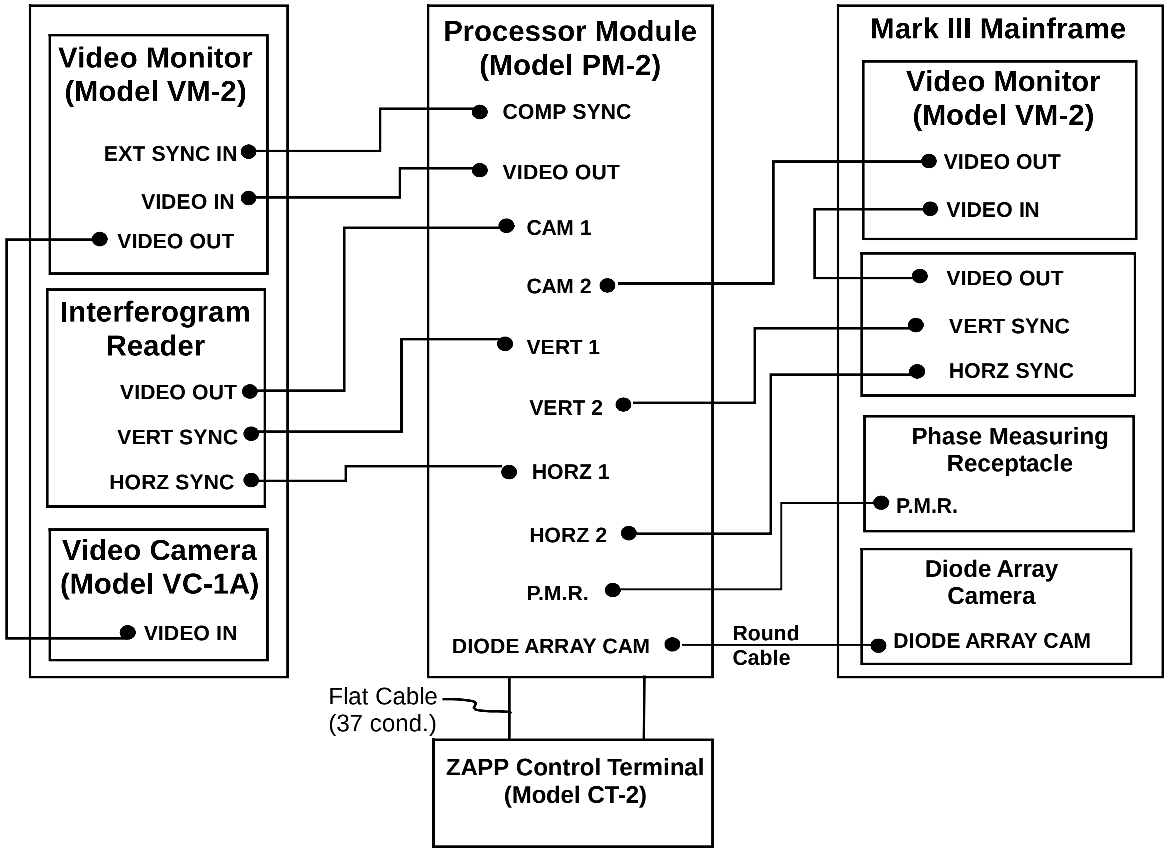


Figure 5-3 Cable Connections

Turn on the System Components

1. Make sure the knob labeled BEAM ATTEN. on the front of the Mark III Mainframe is pushed in.
2. Push the red power switch on the Processor Module in. Be sure to read the following Note.
3. Flip the Mark III Mainframe ON/OFF switch to on. (This switch also turns on the Video Monitor.)
4. Allow the entire system to warm up for 30 minutes.
5. You are now ready to install the transmission element using the following procedure.

Note: After you turn on the Processor Module, a system diagnostics program begins automatically. You'll notice that a software revision level message appears on the screen (e.g. Rev K). This is normal. Other messages may also begin to appear on the monitor. They indicate certain system conditions. These messages are explained in the *Troubleshooting* chapter of this manual. When a message is displayed, press the NEXT PAGE/RESTORE button on the Control Terminal. However, if you get a particular message repeatedly, contact the Zygo Corp. Service Department.

Installing the Transmission Element

The term transmission element (used throughout this procedure) refers to a transmission flat, sphere or cylinder. Your choice of a particular element depends upon the application, but the installation instructions apply to all three element types. If you use a transmission cylinder, the 4-6 inch Aperture Converter must be installed first. This procedure appears later in this chapter.

Handling the Element

Do so very carefully, holding it by the metal rim. Do not put your fingers on the glass. Always return the element to its container when not in use.

Installing the Element on the Accessory Receptacle

Refer to Figure 5-4 for the location of the Mark III Mainframe Accessory Receptacle.

1. Engage the two short, metal pins of the element in the slots on the Accessory Receptacle.
2. Push the element straight in, and turn it clockwise until you hear it click in to place.
3. You're ready to align the element.

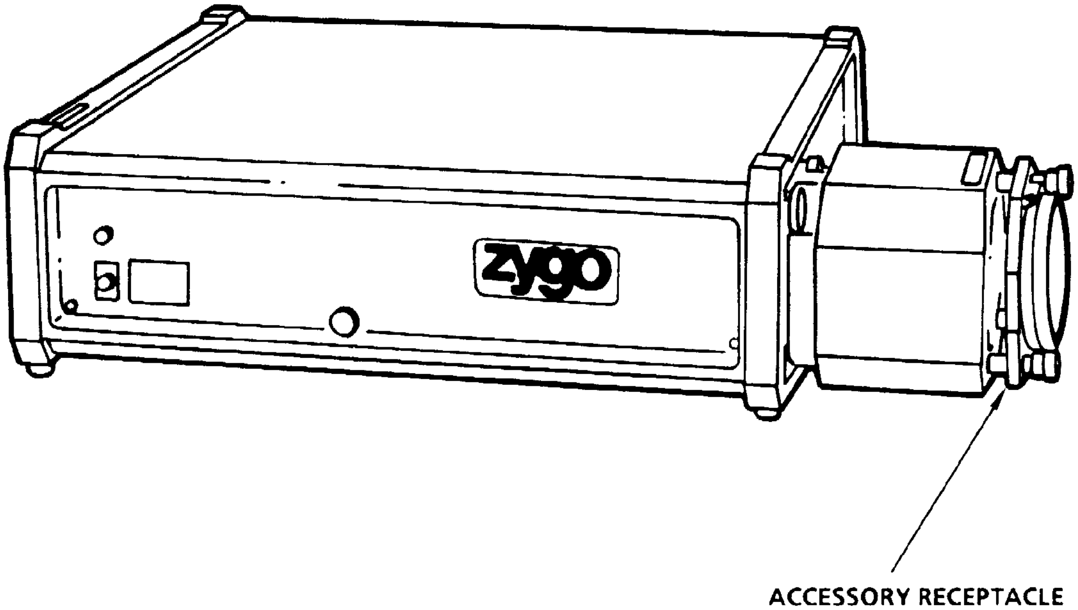


Figure 5-4 Mainframe Accessory Receptacle

Aligning the Transmission Flat

1. Move the Quick FAS switch on the Remote Operator Control Box to the Align position, and hold it there for approximately two seconds.
2. The alignment target (crosshairs) will appear on the monitor. In addition to the crosshairs, there will be two bright spots displayed. The brighter of the spots represents the reflection off the outermost surface of the transmission element. Turn the two tip and tilt knobs on the Accessory Receptacle (Figure 5-4) until the brighter spot is superimposed on the crosshairs center. Refer to Figure 5-5.
3. When the brighter spot is superimposed, you've completed the alignment. You can now perform the Test Setup procedure.

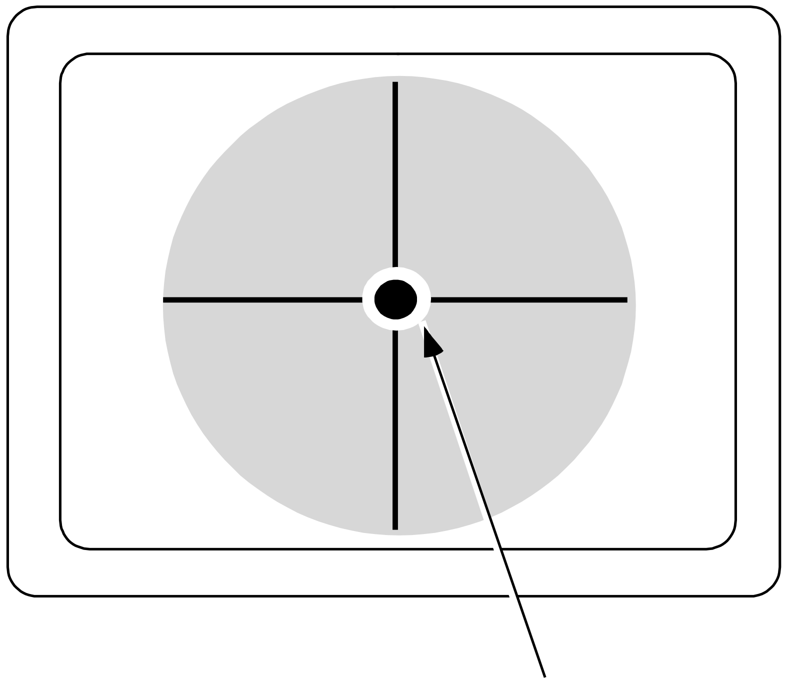


Figure 5-5 Alignment Dot

Preparing a Test Setup

This procedure involves setting up a cavity and aligning the test item. The term cavity means the area between the transmission element and the surface of the item to be measured.

Cavity Setup and Test Item Alignment

This procedure covers cavity setup for testing surface flatness. There are many possible cavity setups, depending upon the component you are testing. See the Zygo brochure, SB-0006 for illustrations and descriptions of other setups.

Have on hand the appropriate mount to hold your test item. It is a good idea to keep the cavity as short as possible. This minimizes wavefront distortions that are caused by fluctuations in the airpath.

1. Place the mount (with the test item installed) on the table, and in the center of the laser beam path.
2. Move the mount around until it is positioned such that a second spot appears on the monitor. This spot is the reflection from the test part.
3. Turn the two tip and tilt knobs (Figure 5-6) on the mount until the second spot is superimposed on the first bright spot. When the two spots are perfectly superimposed, they disappear from the monitor. This is normal.

4. Move the Quick FAS switch to the View position. If the element is installed properly, and both alignment procedures have been completed, the interferogram pattern will be displayed on the monitor. To adjust fringe spacing and orientation, use the tip and tilt knobs on the mount.
5. You can now evaluate the interferogram using the data analysis routine (ZAPP or Phase) best suited to your application. For operating information on ZAPP, see the *ZAPP Processing* chapter of this manual.

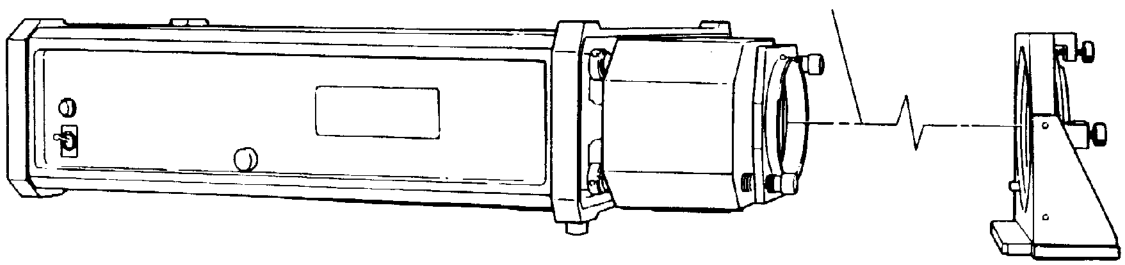


Figure 5-6 Positioning the Two-Axis Mount

Installing and Aligning an Aperture Converter

For applications that require the use of an aperture converter, use the following installation procedure.

1. Remove any transmission element installed in the Accessory Receptacle. Return it to its storage container.
2. Place a plano reflector (either a reference flat or transmission flat) mounted on a two-axis mount in the laser beam path. Position the mount approximately 18-inches from the mainframe. Refer to Figure 5-6.
3. Move the Quick FAS switch to the align position and hold it in place for approximately two seconds.
4. Align the plano reflector using the *Transmission Element Alignment* procedure (in this chapter). This alignment must be kept for the remainder of the procedure.
5. Engage the two short, metal pins on the converter in the slots on the Accessory Receptacle.
6. Push the converter straight in, and turn it clockwise until you hear it click in to place.
7. Tighten the small, locking screw on the converter. (Figure 5-7)
8. If there is a transmission element installed on the converter, remove it.
9. Align the converter using the two mainframe Accessory Receptacle tip and tilt knobs.
10. Once the converter is aligned, remove the plano reflector from the setup.
11. Insert the transmission element in the aperture converter.

12. Align the element using the two tip and tilt knobs on the aperture end of the converter. (Refer to Figure 5-7.) DO NOT adjust the tip and tilt knobs on the mainframe Accessory Receptacle. You will misalign the aperture converter.

> Note: If you are using transmission sphere or cylinder, perform the Sphere/Cylinder Alignment procedure. If you are using a transmission flat, follow the Aligning a Transmission Element procedure described previously in this chapter.

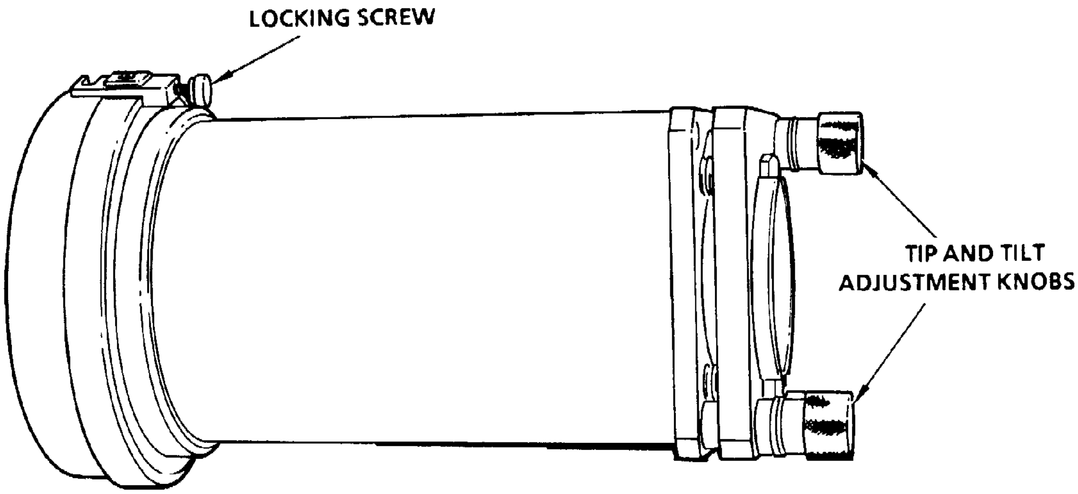


Figure 5-7 Aperture Converter

Sphere/Cylinder Transmission Element Alignment

Perform the following procedure if you are using a sphere or cylinder in the Aperture Converter. A small residual alignment error of approximately 15 seconds or arch exists because of the Quick FAS alignment system. Therefore, this procedure aligns the spherical or cylindrical reference wavefront to the optical axis of the interferometer.

1. After you have installed the transmission sphere or cylinder on the converter, place the test item (or any 4% reflectivity concave or convex surface) in the center of the laser beam path.
2. With the Quick FAS switch in the View position, there will be a bull’s eye pattern on the monitor. If the pattern is not in the center of the monitor screen, use the two tip and tilt knobs on the receptacle end of the converter to center it.

> Note: Do not touch the mainframe Accessory Receptacle tip and tilt knobs on the 3 or 5-axis mounts to adjust the pattern.

3. If the bull’s eye pattern does not fill the screen, use the X and Y axis adjustment knobs on the 3 or 5-axis mounts to adjust the pattern
4. Once you have centered the patter and it fills the screen, you can focus the test item. Lightly, push on the back of the mount and observe the direction in which the rings move.

5. If the rings move toward the bull's eye center, turn the Z Adjustment knob on the mount counterclockwise until the fringes are straight. If the rings move out (away from the bull's eye center), move the entire mount back from the transmission sphere until the fringes are straight.
6. To adjust the position and number of fringes, turn the tip and tilt knobs at the receptacle end of the converter. For optimum performance, the transmission sphere should be adjusted to have zero to seven fringes at best focus.
7. This procedure is completed. Once you have your interference pattern displayed, process with the appropriate analysis routine (ZAPP or Phase). Operation instructions for ZAPP appear in the *ZAPP Processing* chapter of this manual. Operation instructions for the Phase appear in the *Phase Processing* chapter of this manual.

Checking for Geometrical Distortion

As the equipment is warming up, you may notice a change in image roundness (as displayed on the monitor). This is normal and doesn't mean that there is geometrical distortion. Be sure to give the equipment the 30 minutes required warm up time.

Occasionally, you may see a change in image roundness when a connection is made from the Mark III Mainframe to additional accessories (such as the Video Camera). Usually, these changes are caused by a slight variation in aspect ratio which is the ratio of a frame width to frame height. In most cases, you can ignore changes in aspect ratio.

Periodically, check the system quality for geometric distortion following the procedure below.

1. Remove the transmission element from the mainframe Accessory Receptacle.
2. Place a reference flat (4 or 90%) which is installed in a two-axis mount in the center of the laser beam path, approximately 12-inches from the mainframe.
3. Align the flat using the *Aligning a Transmission Element* procedure (in this chapter).
4. Lean the Zygo Corp. supplied parallelogram against the reference flat. The wires of the parallelogram must be in a vertical position.
5. Use the Zoom switch to zoom up to 6X.
6. Adjust the focus using the Focus switch to get the most sharply defined lines.
7. Zoom back to 1X
8. Inspect the lines on the monitor for distortion.

Distortion can be caused by the monitor and/or video camera. For problems of this kind that can't be corrected through adjustment, contact the Zygo Corp. Service Department. Refer to the *Maintenance and Warranty* chapter of this manual for information on contacting Zygo.

Summary

Evaluating test items with a Mark III system can begin once the system has been set up. Setup includes connecting the appropriate cables, installing and aligning a transmission element, and establishing a cavity.

A variety of setups are possible, and they are described and illustrated in the Zygo brochure, number SB-0006.

Data analysis of interference patterns occurs when the ZAPP or Phase processing routines are activated.

6 Phase Measurement Processing

Before You Begin

Be sure you have a test setup prepared and have aligned the transmission element and the test item before beginning Phase processing. Chapter 5 of this manual covers setup procedures. If you are unsure about how any button or switch on the Control Terminal or other components work, see Chapter 4.

Processing in the Phase or ZAPP mode depends upon your application. Phase processing provides you with an error range of 5λ to λ/50 and a high level of accuracy which is unaffected by geometric distortion. This mode of processing can analyze complex interference patterns, but it is somewhat slower than fringe processing. The differences between phase and fringe processing are described in more detail in *Chapter 1*.

The terms default and prompting pages appear frequently throughout this chapter. A prompting page appears on the monitor screen and is a list of questions you must respond to in order for processing to occur. Usually there is more than one response the computer will accept. However, on each prompting page you will notice that certain information or answers have been supplied by the computer. These are called default values. You have the option to change or process with them depending upon your application.

Most of this chapter describes the procedure for filling in the prompting pages. The specific information required for each prompting page, as well as the format to enter it in, is described in a series of steps located opposite the sample prompting page. Think of these steps as a reference guide and use them as needed. The next 11 steps describe the basic Phase Measuring process.

To Begin Phase Processing

1. Press the START PROMPTING button on the Control Terminal. The following lines will appear on the monitor.

   ZYGO ZAPP II

   PHASE (Y/N)?

2. Press the YES button to begin the Phase processing routine. The next screen displayed is the first prompting page (Figure 6- 1).
3. Notice that a default value appears in each field on Prompting Page 1. To change a value(s), use the YES, NO, ENT, EXT, and numeral buttons (on the Control Terminal keypad). The ENT button moves the cursor DOWN a line. The EXT button moves the cursor UP a line. The following instructions tell you how to respond to each field on this page. Refer to these steps when you are not sure about the type of information, or format to use when entering new values. Otherwise, you can skip to Step 4.

* ID NUMBER	0000
TIME	00:02
DATE	00-00-00
UNITS	W
ISF	0.5 W/F
WAVELENGTH INT	0.633 UM
WAVELENGTH OUT	0.633 UM

Figure 6-1 Prompting Page 1

ID NUMBER - This field is provided so that you can enter up to a 6-digit number to identify a specific set of phase measurement data. After you enter an ID number (or if you want to leave this field blank), press ENT.

TIME - This field enables you to enter up to a 4-digit number to identify the time that the phase data was acquired by the Mark III. This entry can be in standard or military time format. Key a period between the hours and minutes. Example: 2.30 or 14.30. After you make an entry, or to skip to the next field, press ENT.

DATE - Key in a 6-digit number to identify the date on which the phase data was acquired. Enter the date in the format below, or leave this field blank. Press ENT when done. Example: December 1, 1985 = 12-01-85.

UNITS - Press the YES button to keep wavelength (W) as the unit of measurement. Press NO to change the measurement unit to fringes (F). Press ENT to move to the next field.

ISF - (Interferogram Scale Factor) The number in this field identifies the distance (in waves) between each fringe. This space corresponds to an OPD (optical path difference) which is an important value used in interferogram evaluation. Adjusting ISF enables you to compensate for different interferometer configurations and setups. (See *Appendix B* for a list of ISF common interferometric setups.) Key in up to a 3 digit number, or use the default value. Press ENT to move to the next field.

WAVELENGTH INT - (Wavelength Interferometer) This field identifies the wavelength of the laser light the interferometer is operating at in micrometers. Use the default value listed, or key in up to a 5-digit number (plus the decimal point). The maximum number the computer will accept is 655.35. Press ENT to move to the next field.

WAVELENGTH OUT - (Wavelength Output) Changing this value tells the computer to scale the results of the measurement. In other words, the computer will simulate the effect of testing an item at different wavelengths. Key in up to a 5-digit number (plus the decimal point). The maximum number the computer will accept is 655.35. Press ENT to move to the next field. The system calculates fringe and wave output differently. As a result, if the Wave Out value is changed in the Fringe mode, there will not be a difference in the pv and rms values. The wave value is calculated as follows: In Fringe mode, the system ignores the ISF, WVIN, and WVOUT parameter values and that is why the pv and rms values do not change. To use this parameter effectively, do the following: •Set the Units parameter to W for waves on Prompting Page 1. •Set the ISF parameter to 1.0 on Prompting Page 1. •Set the WVOUT parameter to the desired values and process. The resulting output will indicate waves as the unit of measurement, but the value actually represents fringes.

4. Press the NEXT PAGE/RESTORE button to display Prompting Page 2. This page is shown in Figure 6-2.

* TOL. LIMIT P-V	00.000 W
TOL. LIMIT RMS	00.000 W
TOL. LIMIT POWER	00.000 W
FIDUCIAL SPACING	00.000 CM
SUBTRACT POWER?	N
AVERAGING?	N
NUMBER OF AVERAGES	00

Figure 6-2 Prompting Page 2

5. To change a default value on this screen, use the keys listed in Step 3. The instructions on the opposite page tell you how to respond to each field on Prompting Page Refer to these steps when you are not sure about the type of information, or the format to use when entering new defaults. Otherwise, you can skip to Step 6

TOL. LIMIT P-V (Tolerance Limit Peak-to-Valley) - This field establishes the accept and reject limits for peak-to- valley distortion. (P-V is the most extreme point of distortion on the test item.) Key in up to 5 digits including the decimal point. Wavelength or fringes (W or F) depends upon the unit entered on Prompting Page 1. Press ENT to move to the next field.

TOL. LIMIT RMS (Tolerance Limit Root-Mean-Square) - This field sets the accept/reject limits for RMS distortion. (RMS tells you what the average distortion is on the entire test item.) Key in up to 5 digits including the decimal point. Wavelength or fringes (W or F) depends upon the unit entered on Prompting Page 1. Press ENT to move to the next field.

TOL. LIMIT POWER (Tolerance Limit Power) - This field sets the accept/reject limits for the degree of surface curvature. You press YES for SUBTRACT POWER, and key in up to 5 digits including the decimal point. W or F depends upon the unit entered on Prompting Page 1. Press ENT to move to the next field.

FIDUCIAL SPACING - Unavailable in Phase Processing. Press ENT to move to the next field.

SUBTRACT POWER? - Press YES to activate subtract power. The system calculates the deviation of the test part from an ideal, best-fitting, spherical surface. To move to the next field, press ENT. (If you respond NO to this prompt, the system automatically calculates the deviation of the test item from a best-fitting, plano surface.)

AVERAGING - This field enables you to activate the data acquisition and reduction averaging function. To move to the next field, press ENT.

NUMBER OF AVERAGES - If you respond YES to the above field, key in the number of data cycles you want. The data acquired during the specified number of cycles is then averaged. Key in a number from 1 to 1,000 and press ENT.

6. Press NEXT PAGE/RESTORE to display Prompting Page 3. This screen is shown in Figure 6-3. To change default data on this screen, use the keys listed in Step 3. The instructions on the opposite page tell you how to respond to each field on Prompting Page 3. Refer to these steps when you are not sure about the type of information, or the format to use when entering new default values. Otherwise, skip to Step 7.

```
* DENSITY

  CALIBRATE?

  AUTO AGC?

  SCAN RATE

  SLOPE?

  PRINT OPDS?

  TRANS TO AUX COMP?
```

Figure 6-3 Prompting Page 3

DENSITY - This option tells the computer how many data points to look at and analyze on the OPD grid. The 1 in this field means a 100 x 100 grid. Changing this default value also adjusts the resolution of the interferogram displayed on the monitor. Key in a 2 for a 50 x 50 OPD grid, a 3 for a 32 x 32 grid, or a 4 for a 25 x 25 grid. To move to the next field, press ENT.

CALIBRATE? - Activating this routine calibrates the motion of the piezoelectric crystals in the Mark III Phase Measuring Receptacle (PMR), to produce precisely ½ wavelength of modulation. It takes several seconds for the procedure to be completed, but you only need to do it 2 or 3 times a day. However, if the interferometer configuration, or the test setup changes, the calibration routine should be performed immediately to ensure maximum accuracy. To move to the next field, press ENT.

AUTO AGC? (Automatic Gain Control) - Activate this mode by pressing the YES button. AUTO AGC changes the scan rate of the Diode Array Camera to compensate for varying light conditions. This enables the system to accurately measure test surfaces with a wide range of reflectivities at different zoom magnifications. To move to the next field, press ENT.

SCAN RATE - Key in a number from 1 to 16, or use the default value. This processing mode sets the scan rate if NO is entered for AUTO AGC. If YES is entered, the system initially tries to operate the Diode Array Camera at the requested rate. The AGC feature will change the scan rate to compensate for varying light conditions. To move to the next field, press ENT.

SLOPE? - Currently unavailable in Phase Processing. Press ENT to move to the next field.

PRINT OPDS? (Print Optical Path Differences) - This option activates the printing process for the data displayed on the monitor. Press ENT to move to the next field.

TRANS TO AUX COMP? (Transfer to Auxiliary Computer) - Press the YES button to transfer data displayed on the screen to an auxiliary computer via the IEEE-488 port. To move to the next field, press ENT.

7. Press the NEXT PAGE/RESTORE button to display Prompting Page 4 (Figure 6-4). To change default data on this screen, use the keys listed in Step 3. The instructions on the opposite page tell you how to respond to each field on Prompting Page 4. Refer to these steps when you are not sure about the type of information, or the format to use when entering new values. Otherwise, skip to Step 8.

DENSITY - This option tells the computer how many data points to look at and analyze on the OPD grid. The 1 in the field means a 100 x 100 grid. Changing the default value also adjusts the resolution of the interferogram displayed on the monitor. Key in a 2 for a 50 x 50 OPD grid, a 3 for a 32 x 32 grid, or a 4 for a 25 x25 grid. To move to the next field, press ENT.

CONTOUR STEP SIZE - Currently unavailable in Phase Processing. Press ENT to move to the next field.

TRANS UNIFORM GRID? (Transfer Uniform Grid) - Press YES to transfer the grid to the auxiliary computer via the IEEE-488 interface. Press ENT to move to the next field.

TRANS PHASE ARRAY? (Transfer Phase Array) - Press the YES button to transfer the phase array data to the auxiliary computer. This function transfers raw data (wedge and offset not removed). Press ENT to move to the next field.

* CONTOUR STEP SIZE	0.100 W
TRANS UNIFORM GRID?	N
TRANS PHASE ARRAY?	N
AUTO PLOT?	N
DELETE OBS EDGES?	N
SPHERICAL TESTING?	N

Figure 6-4 Prompting Page 4

AUTO PLOT? (Automatic Plot) - This option automatically displays an isometeric plot when the processor has completed the COMPUTE function. To activate AUTO PLOT, press YES and then ENT.

DELETE OBS. EDGES? (Delete Obscuration Edges) - Press the YES button to smooth edge diffraction effects adjacent to obscurations. The data points along the edge of the test surface are also deleted. Press ENT to move to next field. (An obscuration can be a hole or any ground or edge section on a test item.)

SPHERICAL TESTING? - Press the YES button to initiate the software routine that evaluates data from fast sphere measurements. The spherical testing software corrects measurement errors that are significant with an f/number < 4.0. Press ENT to move to next field.

8. You've completed the prompting pages. This question will now be displayed on the monitor:

   STANDARD DEFAULTS?

a. Press the YES button if you are finished changing or reviewing the defaults.

b. Press the NO button if you want to go back and look at a specific prompting page. After you press NO, Prompting Page 1 will be redisplayed.

9. You are just about ready to acquire and analyze data. Before doing so, take a few minutes to familiarize yourself with the cursor positioning procedure below.

Cursor Positioning Procedure - Cursors are the 4 white lines that surround the entire interferogram or just a portion of it. When you position the cursors, you tell the computer to analyze that portion of the interferogram within the cursor lines.

a. Flip the CAM 1/CAM 2 switch to the CAM 2 position.

b. Flip the AUTO/MAN/FID swich to the AUTO position.

c. Flip the CURSORS ON/OFF switch to the ON position.

d. Use the TOP, BOTTOM, LEFT, and RIGHT switches to move the vertical and horizontal cursor lines to the desired position. See Figure 6-5 for a representative sample of possible cursor positions.

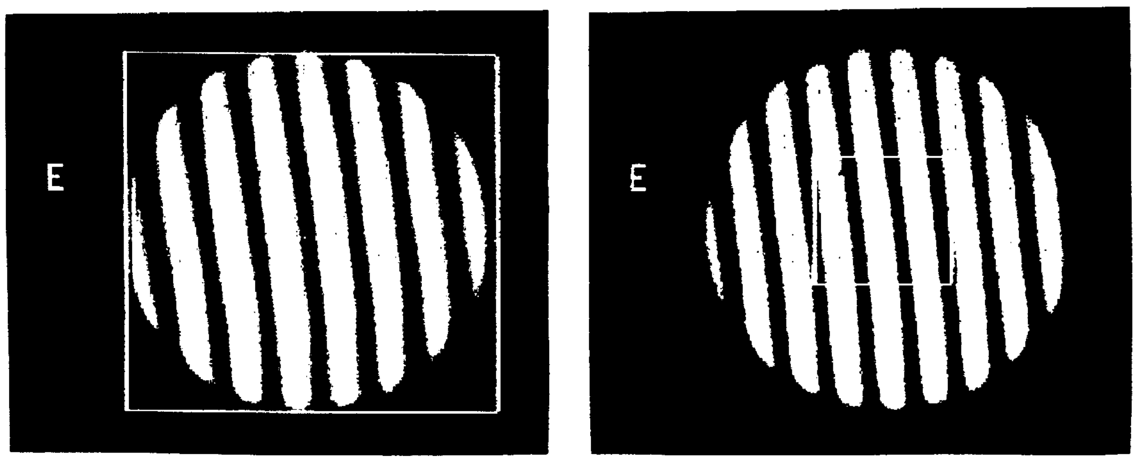


Figure 6-5 Cursor Positioning

Positioning a Second Set of Cursors - If your application requires establishing a second set of cursors, follow the procedure below.

a. After you perform the steps for positioning a cursor, press the BEGIN/ SWAP CURSORS button.

b. Repeat the Cursor Positioning Procedure to create the second set of cursors.

c. To switch back and forth between the two sets of cursors, press the BEGIN/ SWAP CURSORS button.

10. To acquire and analyze data, press the MEASURE button. Depending upon the defaults you entered on the prompting pages, one or more of the following messages appears on the monitor:

AGC

CALIBRATING

MEASURING (N)

COMPUTING (N)

N represents the measurement number. For single measurements, N will always be 1. If you are in the averaging mode, N will indicate the measurement/ computation cycle being performed in the measurement series.

These messages are normal and indicate where the computer is in the data analysis process.

After the COMPUTING N message is displayed, you will see information on the monitor showing the type of test aperture (elliptical or rectangular), the number of acquired data points, the peak to valley (P-V) and root-mean-square (RMS) values, and other data that corresponds to the defaults you entered previously on the prompting pages. See Figure 6-6.

The steps above cover the basic Phase measuring process. Read through the remaining portion of this chapter for additional information and hints on Phase processing.

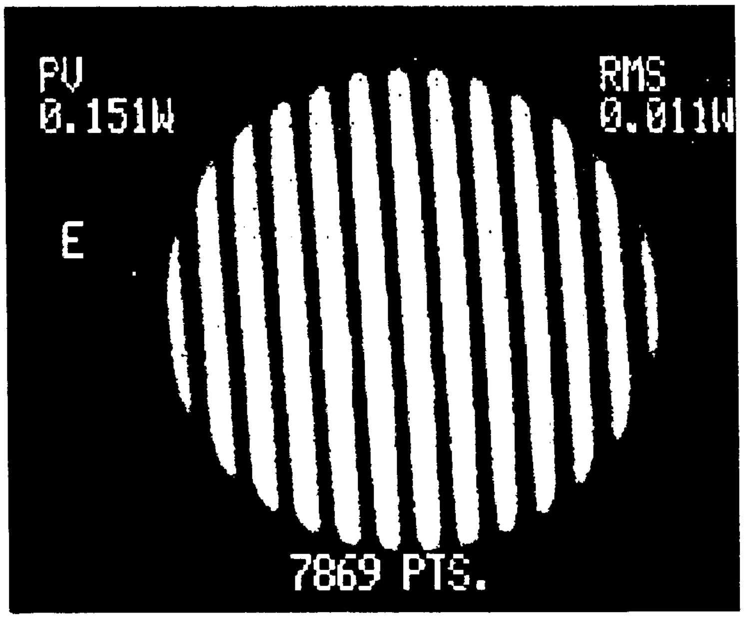


Figure 6-6 Data Display after Pressing MEASURE

Phase Processing Hints

Manual Calibration of the PMR

The automatic calibration routine (activated on Prompting Page 3) calibrates the motion of the piezoelectric crystals in the PMR. This routine ensures precise modulation of the interference pattern. Once this routine is done, the interference pattern should completely cover the clear aperture. An obscuration can prevent reliable calibration of the PMR. If this condition occurs, perform the following procedure to assure calibration when an obscuration is present.

1. Return to Prompting Page 3 and press YES for AUTO AGC?
2. Press the NO button for CALIBRATE? on Prompting Page 3.
3. Press the MEASURE button so that the system automatically sets the scan rate for the Diode Array Camera.

4. Return to Prompting Page 3 and press the NO button for AUTO AGC?, and the YES button for CALIBRATE.
5. Remove the test item from the mount and replace it with an item that has a similar surface, shape, and reflectivity but completely covers the clear aperture. DO NOT CHANGE THE ZOOM MAGNIFICATION.
6. Press the MEASURE button.
7. Return to Prompting Page 3 and press the NO button for CALIBRATE. (Make sure the default for AUTO AGC is still NO.)
8. Return the test item to the mount. DO NOT CHANGE THE ZOOM MAGNIFICATION.
9. You can now continue processing. If the zoom magnification or the reflectivity of the test part changes or the system produces a *Check AGC* message, repeat this procedure.

Obscuration Processing

For best results, focus the edges of the obscurations as sharply as possible. Use the mainframe Remote Control Box FOCUS switch for this. Also, you may have to perform the "Manual Calibration of the PMR" procedure before you start Obscuration Processing. The obscured regions do not affect the analysis of the interference pattern. They are marked with flat, horizontal lines in the isometric plots of OPD data.

When Obscuration Processing is used on input data, accuracy can be affected by diffraction which occurs at the edges of the obscurations. The DLTA warning may appear on the screen, or the isometric plots may show spikes or peaks adjacent to the obscured regions.

Averaging Measurement Data

This feature allows you to minimize the effects of random noise in the measurement. Such noise can be caused by vibration, air turbulence or the electronics. It is typically used when measuring high quality components.

After responding to the appropriate default and pressing MEASURE, the system will complete a first measurement cycle and display the data. Press the ENT button to complete the remaining number of averages requested. Separate RMS and peak- to-valley values are calculated for each measurement, and the final calculation is displayed on the monitor.

You may discontinue averaging at any time by pressing and holding down any button on the Control Terminal for several seconds, until the current measure/compute cycle is completed.

A peak-to-valley value > 3.5 waves cannot be averaged.

Isometric Plots

Pushing the PLOT button displays an isometric view of OPD data. All of the 3-D plots are scaled to a constant height equal to the maximum P-V for any data greater than 0.004 fringes.

Pressing PLOT the first time (after you've pressed MEASURE) diplays the isometric view of the OPD data. Press PLOT a second time, and the system displays the inverse of the OPD data. Press PLOT a third time, and the system exits from the Isometric Plots mode.

To view a 3-D plot with OPDs subtracted, press SUBTRACT and then PLOT, but do not press STORE. The reason for this is that after subtracting, the OPDs are already on the uniform grid and pressing STORE will give you incorrect information.

Subtracting OPDs

When you press this button, OPDs in an original interference pattern are subtracted from OPDs in a second pattern. After you've acquired the first pattern, press STORE OPDs. Acquire the second interference pattern and press SUBTRACT OPDs. The OPDS of the first pattern will be subtracted from the second pattern.

Subtract Power Mode

This processing mode allows you to subtract spherical power from the interference pattern. Usually, you'll use this mode for testing spherical surfaces. If you use it for other surfaces: plano, cylindrical, or aspheric, the analysis of the interference pattern will always subtract only a best-fitting sphere from the wavefront. This mode is enabled when you respond YES on the Prompting Page 2.

If you press PLOT while in the Subtract Mode, the isometric view of the OPDs with power removed is displayed. Press PLOT again and the inverse view will be displayed.

Accept/Reject Mode

When you enter data for TOL. LIMIT P-V, TOL. LIMIT RMS, and TOL. LIMIT POWER on Prompting Page 2, Accept/Reject mode is automatically activated. After you press MEASURE, the system lets you know if the limits entered are in tolerance by displaying ACC. If any of the limits are out of tolerance, the system displays REJ with an asterisk (*) beside the out-of- tolerance parameter.

Calculation of Tilt Values

The system computes X and Y tilt values in waves/diode for the test surface. For specific applications, the tilt values for two separate regions in a single test aperture may be computed, and the two sets of values subtracted from each other (e.g., to provide the relative tilt between the rails of a magnetic read/write head). If you want to determine how X and Y tilt values may be converted to height difference across a test part, consult the ZYGO Application Bulletin, AB-0031.

Transfer Operation

Once you've pressed the MEASURE button, the raw data points are automatically acquired and transferred to the computer before the COMPUTING step. A normal message that will be displayed on the screen during this process is *TRANSFER IN PROGRESS*. To discontinue this processing, press SKIP/RESTORE.

Specific information about transferring data appears in the Data Transfer chapter of this manual.

Summary

Phase Processing is automatic once you have changed the default values on the four prompting pages, or accepted the system supplied values.

Use the YES, NO, EXT, ENT, and numeral keys on the Control Terminal to change the defaults. The MEASURE button then begins the analysis process. Further processing is activated by pressing the appropriate buttons on the Control Terminal.

The analyzed data is displayed on the monitor screen and can be transferred to a printer and/or data storage unit via the RS- 232C interface, or to an auxiliary computer via the IEEE-488 interface.

7 ZAPP Processing

Before You Begin

Be sure you have a test setup prepared and have aligned the transmission element and the test item before beginning ZAPP processing. *Chapter 4* of this manual covers setup procedures. If you are unsure how any button or switch on the Control Terminal or other components work, see Chapter 4 of this manual.

Processing in the Phase or ZAPP mode depends upon your application. ZAPP processing provides you with an error range of 1λ to $\lambda/20$, and fast data analysis. It is easily adaptable to large aperture testing, and no modulation is required. However, accuracy is somewhat affected by geometric distortion, and complex interference patterns cannot be analyzed. For more information on the differences between Phase and ZAPP processing, see *Chapter 1*.

The terms default and prompting pages appear frequently throughout this chapter. A prompting page appears on the monitor screen and is a list of questions you must respond to in order for processing to occur. Usually there is more than one response the computer will accept. However, on each prompting page you will notice that certain information or answers have been supplied by the computer. These are called default values. You have the option to change or process with them depending upon your application.

The specific information required for each prompting page, as well as the format to enter it in, is provided in a series of steps located opposite the sample prompting page. Think of these steps as a reference guide and use them as needed.

To Begin ZAPP Processing

1. Press the START PROMPTING button on the Control Terminal. The following lines will appear on the monitor:

   ZYGO ZAPP II

   PHASE (Y/N)?

2. Press the NO button.
3. The next line displayed will be: ZAPP (Y/N)? Press YES or NEXT PAGE/ RESTORE to display the first, ZAPP prompting page (Figure 7-1).

ID NUMBER - This field is provided so that you can enter up to a 6-digit number to identify a specific set of ZAPP measurement data. After you enter an ID number (or if you want to leave this field blank), press ENT to move to the next field.

TIME - This field enables you to enter up to a 4-digit number to identify the time that the ZAPP data was acquired by the Mark III. This entry can be in standard or military time format. Key a period between the hours and minutes. Example: 4.30 or 16.30. To move to the next field, press ENT.

DATE - Key a 6-digit number to identify the date on which the ZAPP data was acquired. Enter the date in the format below, or leave this field blank. Press ENT to move to the next field. (Example: December 1, 1985 = 12-01-85)

* ID NUMBER	0000
TIME	00:02
DATE	00-00-00
UNITS	W
ISF	0.5 W/F
WAVELENGTH INT	0.633 UM
WAVELENGTH OUT	0.633 UM

Figure 7-1 Prompting Page 1

UNITS - Press the YES button to keep wavelength (W) as the unit of measurement. Press NO to change the measurement unit to fringes (F). Press ENT to move to the next field.

ISF - (Interferogram Scale Factor) The number in this field identifies the distance (in waves) between each fringe. This space corresponds to an OPD (optical path difference) which is an important value used in interferogram evaluation. Adjusting ISF enables you to compensate for different interferometer configurations and setups. (See *Appendix B* for a list of ISF common interferometric setups.) Key up to a 3-digit number, or use the default value. Press ENT to move to the next field.

WAVELENGTH INT - (Wavelength Interferometer) This field identifies the wavelength of the laser light the interferometer is operating at in micrometers. Use the default value listed, or key up to a 5-digit number (including the decimal point). The maximum number the computer will accept is 655.35. Press ENT to move to the next field.

WAVELENGTH OUT - (Wavelength Output) Changing this value tells the computer to scale the results of the measurement. In other words, the computer will simulate the effect of testing an item at different wavelengths. Key up to a 5-digit number (including the decimal point). The maximum number the computer will accept is 655.35. Press ENT to move to the next field.

4. Notice that a default value appears in each field on the above screen. To change a value, use the YES, NO, ENT, EXT, and numeral buttons (on the Control Terminal Keypad). The ENT button moves the cursor DOWN a line. The EXT button moves the cursor UP a line. The instructions on the previous page tell you how to respond to each field on Prompting Page 1. Refer to these steps when you are not sure about the type of information, or format to use when entering new values. Otherwise, skip to Step 5.
5. Press NEXT PAGE/RESTORE to display Prompting Page 2. See Figure 7-2.

* TOL. LIMIT P-V	00.000 W
TOL. LIMIT RMS	00.000 W
TOL. LIMIT POWER	00.000 W
FIDUCIAL SPACING	00.000 CM
SUBTRACT POWER?	N
AVERAGING?	N
NUMBER OF AVERAGES	00

Figure 7-2 Prompting Page 2

6. To change a value in any of the fields on Prompting Page 2, use the buttons described in Step 4. The instructions on the opposite page tell you how to respond to each field on Prompting Page 2. Refer to these steps when you are not sure about the type of information, or the format to use when entering new values. Otherwise, skip to Step 7

TOL. LIMIT P-V - (Tolerance Limit Peak-to-Valley) This field establishes the accept and reject limits for peak-to- valley distortion. (P-V is the most extreme point of distortion on the test item.) Key in up to 5 digits plus the decimal point. Wavelength or fringes depends upon your response to the UNIT prompt on Prompting Page 1. Press ENT to move to the next field.

TOL. LIMIT RMS - (Tolerance Limit Root-Mean-Square) This field sets the accept/reject limit for RMS distortion. (RMS tells you what the average distortion is on the entire test item.) Key in up to 5 digits including the decimal point. Wavelength or fringes (W or F) depends upon your response to the UNIT prompt on Prompting Page 1. Press ENT to move to the next field.

TOL. LIMIT POWER - (Tolerance Limit Power) This field sets the accept/ reject limit for the degree of surface curvature. You must respond YES to the SUBTRACT POWER prompt to activate this function. Key in up to 5 digits including the decimal point. Wavelength or fringes (W or F) depends upon your response to the UNIT prompt on Prompting Page 1. Press ENT to move to the next field.

FIDUCIAL SPACING - This number represents the diameter of the test area on the test item in centimeters. The system uses this value in slope calculations only. Key in up to 5 digits including the decimal point. The maximum number the computer will accept is 655.35. Press ENT to move to the next field.

SUBTRACT POWER? - Press YES to subtract power. The system calculates the deviation of the test item from an ideal, best- fitting, spherical surface. To move to the next field, press ENT. (If you respond NO to this prompt, the system automatically calculates the deviation of the test item from a best-fitting plano surface.)

AVERAGING - To activate the data acquisition and reduction averaging function, press YES. To move to the next field, press ENT.

NUMBER OF AVERAGES - If you respond YES to the above field, key in the number of data cycles you want averaged. The computer will accept a 1, 2, 4, 8, or 16.

7. Press NEXT PAGE/RESTORE to display Prompting Page 3. See Figure 7-3. To change values on this page, use the buttons described in Step 4. The instructions on the oppposite page tell you how to respond to each field on the page. Refer to these steps when you are not sure about the type of information, or the format to follow when entering new values. Otherwise, skip to Step 8.

* ZERO ORDER	LF
POSITIVE	Y
TRANS TO AUX COMP?	N
MEASURE G.D.?	N
NO. OF MEASUREMENTS	00
SUBTRACT G.D.?	N
APERTURE	E

Figure 7-3 Prompting Page 3

ZERO ORDER - Press YES to keep the displayed default value LF (left). Press NO to change the value to RT (right). Right or left is determined when you set up the measurement cavity. If you press lightly on the back of the mount, you will see the fringes move -- either left or right. Zero order is a reference point important for calculations concerning concave or convex surfaces.

POSITIVE- Press YES if you are evaluating a real time interference pattern or positive photographic print. If you are using the interferogram reader to analyze a photographic negative of an interference pattern, change this default to NO. The fringe center digitizing routine will look for areas of lowest density to determine fringe center coordinates when in this mode.

> Note: You can activate this prompt only if your system includes an Interferogram Reader.

TRANSFER TO AUX COMP? - Press YES to transfer OPD data to an auxiliary computer. Press NO if you are not transferring data.

> Note: Do not respond YES to this prompt if you are planning to print OPDS. (The printing prompt is on the next prompting page).

MEASURE G.D.? - Press YES to measure geometric distortion, or NO if you do not want to measure G.D. This function identifies the degree of geometric distortion from the CCTV. This distortion can affect data analysis.

NO OF MEASUREMENTS - Key in the number of geometric distortion measurements you want the system to make. The computer will accept a 1, 2, 4, 8, or 16. Press ENT to move to the next field.

SUBTRACT G.D.? - Press YES to have the system subtract geometric distortion from the analysis data. Press NO if you do not want G.D. subtracted.

APERTURE - Press YES to have an elliptical test aperture, or NO to have a rectangular aperture. Defining an elliptical or rectangular aperture depends upon the test item being evaluated

8. Press the NEXT PAGE/RESTORE button to display Prompting Page 4. See Figure 7-4. To change values on this page, use the keys described in Step 4. The instructions on the opposite page tell you how to respond to each field on Prompting Page 4. Refer to these steps when you are not sure about the type of information, or the format to use when entering new values. Otherwise, skip to Step 9.

* CONTOUR STEP SIZE	0.100 W
PRINT OPDS?	N
OBSCURATION?	N
SLOPE?	N
MANUAL AVERAGING?	N

Figure 7-4 Prompting Page 4

CONTOUR STEP SIZE - This function is currently inactive. Press ENT to move to the next field.

PRINT OPDS? - Press YES to print OPD data, or NO if you are not printing data.

Note: Do not respond YES to Print OPDS? if you said YES to the TRANSFER prompt on Prompting Page 3.

OBSCURATION? - Press YES if the interference pattern being evaluated has an obscuration that makes the fringes discontinuous. Obscuration mode is a special editing routine that allows you to manually connect discontinuous fringes and establish correct fringe ordering. Press NO if you do not need to activate this function. An obscuration can be a hole or any ground or polished section on a test item.

SLOPE? - Press YES to activate the slope calculation. The processor will calculate the maximum local change in OPD and display the value in waves per centimeter and identify the location with an asterisk (*). (If you respond YES, you must enter the diameter or clear aperture of the part in centimeters for fiducial spacing.)

MANUAL AVERAGING - Press YES if you want to perform manual averaging. You must also respond YES to the AVERAGING and NUMBER OF AVERAGES prompts on Prompting Page 3. Manual Averaging is described in more detail in the ZAPP Processing Hints section of this chapter.

9. When you have finished entering or accepting values on Prompting Page 4, this question is displayed on the monitor:
   STANDARD DEFAULTS?

   Press the YES button if you are ready to continue with processing, or press NO if you want to go back and look at a prompting page. After you press NO, Prompting Page 1 is redisplayed.

10. You are just about ready to acquire and analyze data. Before doing so, take a few minutes to familiarize yourself with the following cursor positioning procedure.

Cursor Positioning Procedure - Cursors are the 4 white lines displayed on the monitor that surround the entire interferogram, or just a portion of it. There are two horizontal and two vertical lines. When you position the cursors, you tell the computer to analyze the portion of the interferogram within the cursor lines.

a. Flip the CAM 1/CAM 2 switch to CAM 2.

b. Flip the AUTO/MAN/FID switch to AUTO.

c. Flip the CURSORS ON/OFF switch to ON.

d. Use the TOP, BOTTOM, LEFT, and RIGHT switches to adjust the cursor lines to the desired position.

Positioning a Second Set of Cursors - If your application requires a second set of cursors, see the following procedure.

a. After you position the first set of cursors, press the BEGIN/SWAP CURSORS button.

b. Establish the second set of cursors following the "Cursor Positioning Procedure".

c. To switch back and forth between the two sets of cursors, press the BEGIN/ SWAP CURSORS button.

11. To automatically acquire interference pattern data, place the AUTO/MAN/ FID switch in the AUTO position. Flip the CAM 1/CAM 2 switch to CAM 2, and flip the CURSORS ON/OFF switch to ON.

12. Press the MEASURE button. The processor acquires and automatically displays fringe center data. See Figure 7-5.

13. If necessary, the fringe centers can be edited as follows: 1) erasing and inserting a few fringe centers using single point erase mode; 2) editing an entire row; 3) digitizing the entire pattern manually if a few edit corrections are not possible. Editing is described later in this chapter.

14. If the fringe centers are satisfactory, press COMPUTE. The processor will perform a least squares analysis. Peak-to- valley, root-mean-square, and spherical power (if requested) are displayed on the monitor.

These steps cover the basic ZAPP measuring process. Read through the remaining sections of this chapter for additional information and hints on ZAPP processing.

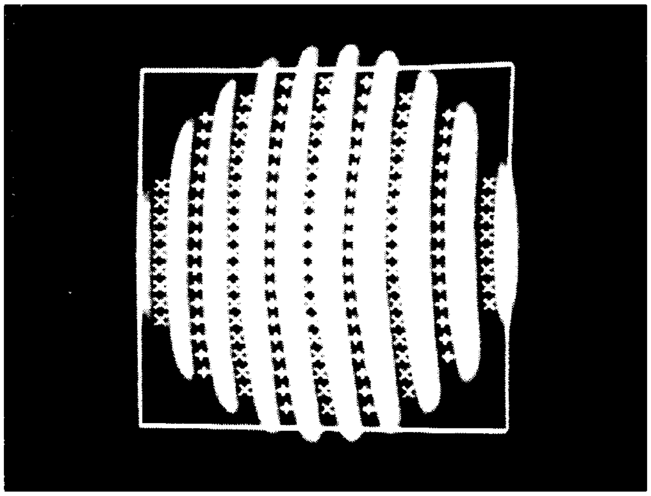


Figure 7-5 Fringe Centers

ZAPP Processing Hints

Editing

Editing includes a variety of methods you use to adjust and/or correct conditions that are displayed on the interferogram and can affect data analysis.

These conditions are produced by the system, and include artifacts (random spots), gaps in fringes, and large variations in fringe widths, to name a few.

What you see on the monitor that reflects these system conditions are data points that do not correspond to an actual condition on the test item (spurious data points), missed data points, and improperly ordered data.

The following editing tips will help you adjust and eliminate these conditions. When you are done editing in any of the modes described, see the "Exiting from Editing Mode" instructions (in this chapter).

Single Point Erasure

Use this mode to erase or insert a few isolated data points. If you are not sure about the function of any button or switch mentioned in the following procedures, see the *Equipment Controls* chapter of this manual.

1. Place the AUTO/MAN/FID switch in the AUTO position.
2. Press the BEGIN/SWAP CURSORS button to display the POINTER on the screen. (The POINTER appears as an asterisk (*).
3. Use the POINTER switch to move the pointer left or right. Use the UP and DOWN arrow buttons to move the POINTER up and down.
4. Press the ERASE button to remove the data point closest to the pointer.

Single Point Insertion

1. Follow the first three steps in the *Single Point Erasure* process.
2. Press the INSERT button to insert a data point into memory.

   Note: You cannot enter new data points on an empty line. You must do this with the "Editing a Line of Data Points" procedure.

Editing a Line of Data Points

Use this mode to edit an entire line of problem data points and/or insert data points on a blank line. If you are inserting an entire line of data points, and the first point is not located on the center of fringe number one, see the "Correcting Fringe Order Number" procedure. Correct fringe order number is important for accurate data analysis.

Insert Data Points

1. Place the AUTO/MAN/FID switch in the MAN position.
2. Use the POINTER switch to move the POINTER horizontally from left to right.
3. When the POINTER rests on a fringe center, press INSERT. The fringe order number is increased by one each time you press INSERT.

Correcting Fringe Order Number

For example purposes in this procedure, the first data point is described as being located on fringe number three. This does not mean that the only time you must correct fringe order number is when the first data point is on fringe number three. The purpose of this procedure is to make adjustments to the data points so that the first data point is on fringe number one.

1. Enter a data point to the left of the fringe pattern (outside of the fringes).
2. Press INSERT twice. A 2 will appear on the monitor. It stands for fringe number two.
3. Move the POINTER (*) to the location of the first data point on fringe number three.
4. Press INSERT. A 3 will appear on the monitor.
5. Continue to insert data points from left to right until the entire line is entered.
6. Move the POINTER to the data point outside of the fringe pattern.
7. Place the AUTO/MAN/FID switch in the AUTO position.
8. Press ERASE to remove the extra data point.
9. Fringe order number is now corrected, and you can continue processing.

Editing a Complete Pattern

Usually, you'll use this mode for hard-copy interferograms. Editing a complete pattern enables you to adjust a bad pattern (e.g. poor photo quality, no contrast, artifacts, etc.), and supply the system with enough good data points to evaluate.

1. Position the AUTO/MAN/FID switch in the MAN mode.

2. Press BEGIN/SWAP CURSORS. The POINTER (*) will move to the upper left-hand corner of the monitor.
3. Move the POINTER to the top part of the left-most fringe. Center the POINTER in the fringe.
4. Press INSERT. The data point is entered into memory, and the POINTER moves down by 8 tv lines (10 lines if your system is 50 Hz).
5. Repeat this process until data points for the entire fringe are entered in memory.
6. Press TOP to return the POINTER to the top of the monitor.
7. You can insert data points for the remaining fringes following these steps. When you're done, place the AUTO/MAN/FID switch in the AUTO position.
9. Press COMPUTE and the system performs data analysis.

Correcting Misordered Data Points

Misordered data points are those points that appear outside of the fringe center. You only need to edit the misordered points, not the entire fringe. Use one or more of the editing procedures described to correct this condition. When you are done editing misordered points, perform the following procedure.

1. Place the AUTO/MAN/FID switch in the AUTO position.
2. Press the ALIGN/APERTURE button to reorder the data points.
3. Press COMPLETE.
4. Press ALIGN.

Exiting From the Edit Mode

When you are done editing in any of the previously described editing modes, complete the process with the following procedure.

1. Press the COMPLETE pushbutton.
2. Return the AUTO/MAN/FID switch to the AUTO position.
3. Press COMPUTE.

System Geometric Distortion

The following two part procedure describes how to evaluate and subtract system geometric distortion (e.g. from the CCTV camera) from interference pattern data. In addition to the following procedure, you must have the adjustable parallelogram (provided with the system) on hand.

Whenever test parts with errors greater than $\lambda/10$ are measured, the amount of system distortion is relatively small compared to the error in the part.

Measure the Parallelogram

1. Change the UNITS default value on Prompting Page 1 from W to F.
2. Change the MEASURE G.D. default value on Prompting Page 3 to YES.

3. Enter the number of measurements in the NO. OF MEASUREMENTS field on Prompting Page 3. (For maximum accuracy, make 16 measurements.)
4. Change the Subtract G.D.? default value on Prompting Page 3 to YES.
5. Place a two-axis adjustable mount (with a 4 or 90 percent reference flat installed) approximately 12 inches from the Mark III Mainframe. The grid lines on the parallelogram should be perpendicular to the mainframe and vertical.
6. Position the adjustable parallelogram as close to the reference flat as possible. Adjust the focus control on the mainframe Remote Control Box to minimize diffraction effects around the grid lines displayed on the video monitor.
7. Adjust the grid spacing so that the maximum number of lines for a given zoom position covers the aperture. (Use the adjustment knobs on the mount to adjust grid spacing.)
8. Press MEASURE.
9. Once the fringes are displayed on the monitor, remove the parallelogram from the setup.
10. Place the test item on a mount between the reference flat and the mainframe.
11. Adjust the ZOOM control on the mainframe Remote Control Box until the outer edge of the part falls completely within the area defined by the displayed fringe center coordinates.
12. This portion of the procedure is completed. You're ready to perform the "Distortion Measurement" procedure.

Perform the Distortion Measurement

1. Remove the test item and mount, and place the parallelogram in front of the reference flat. Make sure the parallelogram is centered within the cursors established in the *Parallelogram Measurement* procedure.
2. Press MEASURE and then COMPUTE.
3. Check the peak-to-valley reading on the monitor. The P-V value should be less than or equal to one percent of the number of grid lines displayed. Example: If 10 grid lines are visible, then the approximate P-V value should be 1 percent of 10, or .100 fringes.

   If 15 grid lines are displayed, the approximate P-V value should be 1% of 15, or .150 fringes.

   If the P-V value is much greater than the one percent mentioned, look for misordered data points. Correct these data points using the single point editing mode, or press MEASURE then COMPUTE.

   > Note: You will find it very helpful during the measurement process to press STORE OPDS and then PLOT after each MEASURE and COMPUTE cycle. Single error points will show prominently in the isometric plot enabling you to edit easily. Each line in the plot corresponds to a data line from the bottom up.

4. When you've obtained a valid measurement, press ENT. The measurement number will be displayed on the monitor.
5. Continue with subsequent measurements following this procedure. Shift the parallelogram slightly for each measurement to obtain better smoothing of the average distortion. The average distortion correction of each measurement is stored in the processor's memory

> Note: You will have to evaluate geometric distortion in the system if one or more of the following conditions occur: 1) the processor is turned off, or RESET is pressed; 2) the interferometer zoom position is changed; 3) the cursors are moved from the position they were in when geometric distortion data was acquired.

Measurement with Distortion Automatically Subtracted

Perform this procedure if you want to determine and subtract residual system error which remains after the subtract geometric distortion process is completed.

1. After the system makes the final measurement, press COMPUTE. The system will subtract the average correction from the last measurement.

Once the geometric distortion procedure is complete, the "MEASURE G.D?" default will return to NO. As long as the red calibration light is on, the system distortion will automatically be subtracted from subsequent interference data.

Measurement without Distortion Subtracted

You do not have to subtract distortion to acquire interference data during the subtract geometric distortion process. To acquire the data:

1. Respond NO to the SUBTRACT G.D.? prompt on Prompting Page 3.
2. Press COMPUTE.

Averaging Data Mode

Before activating the averaging mode, perform several MEASURE and COMPUTE cycles and record the P-V values. This procedure enables you to see the range (or spread) of P-V values from one measurement to the next, and prevents invalid values from being used when the system computes averaging data.

Figure 7-6 shows averaging mode error limits. This information indicates what the reasonable spread in P-V values can be when performing repetitive, singular measurements.

> Note: Do not use the averaging function when the fringes are being subjected to excess vibration or temperature changes. In addition, you cannot use averaging if the peak-to-valley value is less than or equal to 3.5 waves.

Automatic Averaging

Automatic Averaging functions as follows to obtain the average P- V and RMS values: 1) the fringe center data points are acquired and a least squares computation is performed for each measurement; 2) the OPDs for each measurement are added to the uniform grid; 3) after all the measurements are made, the OPDs on the grid are divided by the number of averages, and the P-V and RMS values are recalculated for the averaged OPDs on the uniform grid.

Once you activate Automatic Averaging (respond to the appropriate prompts on Prompting Pages 3 and 4), measure an interference pattern in the AUTO mode following the steps below.

1. Press MEASURE.
2. Press COMPUTE.
3. If the data is satisfactory (i.e., within the range established above), press ENT. The system will make the remaining number of specified measurements. While the system is averaging, RMS and P-V values are calculated for each measurement and displayed on the monitor.

If one of the measurements calculated during Automatic Averaging does not meet the error limit requirements, Warning K is displayed on the screen. If three consecutive measurements are unacceptable, Automatic Average is discontinued. To correct this, establish a more accurate mean P-V value before starting the averaging process again.

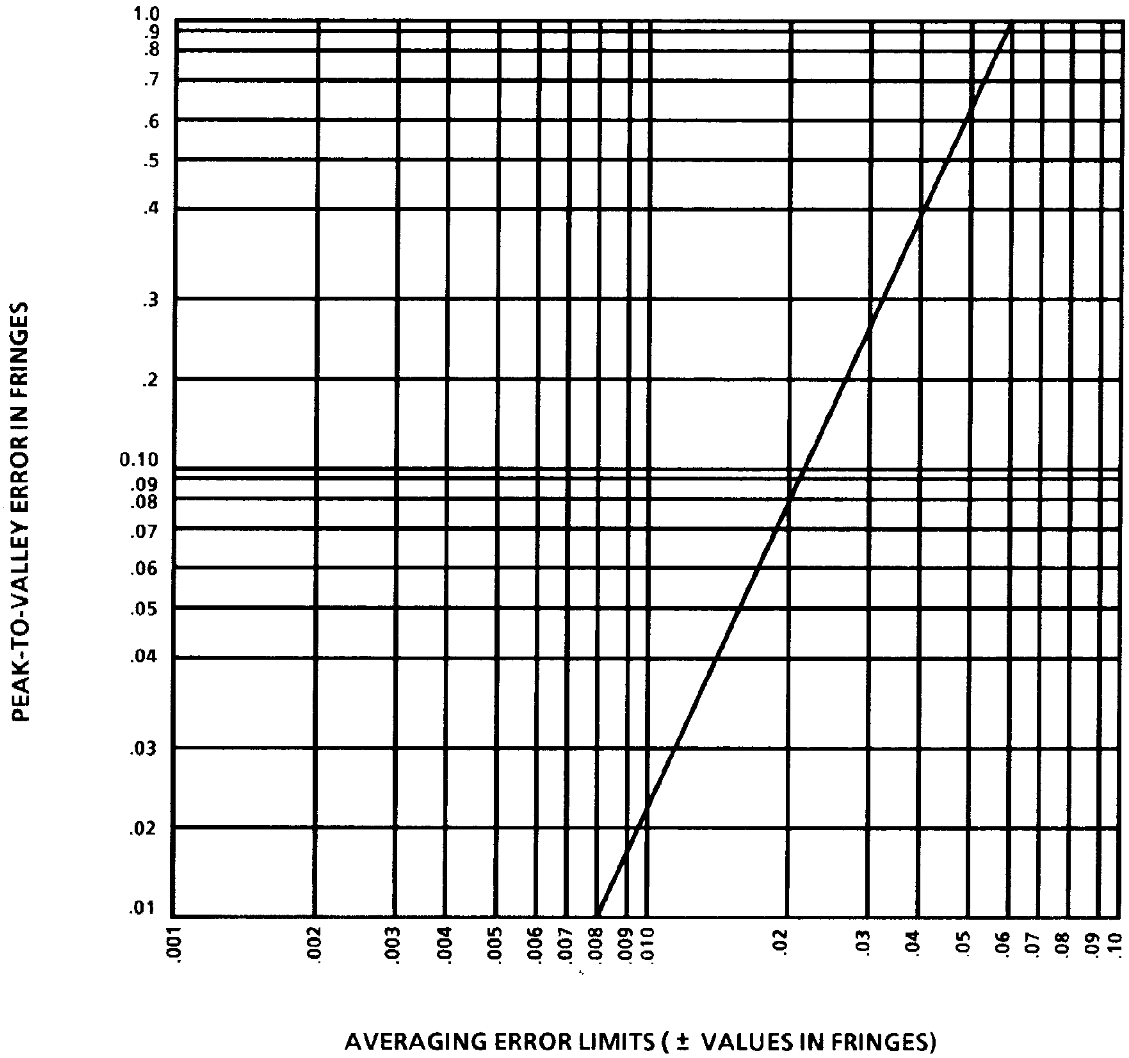


Figure 7-6 PV and Averaging Errors (in Fringes)

Manual Averaging

This mode functions as follows: 1) the OPDs common to all the measurements are added to a uniform grid; 2) the OPDs on the uniform grid are divided by the number of measurements; 3) the P- V and RMS values are recalculated for the averaged OPDs on the uniform grid.

Manual Averaging is activated by responding to the appropriate prompts on Prompting Pages 2 and 3. Once you have done this and pressed MEASURE and COMPUTE, the first measurement of the interference pattern is displayed on the monitor. To continue with the processing, perform the following steps.

1. If the measurement data is satisfactory, press ENT. This automatically enters the measurement for averaging, and redisplays the fringe centers to start a new manual cycle. At this point, you can reposition the cursors and/or manually edit the fringe centers.

2. Press MEASURE and COMPUTE to perform the next measurement. The calculated values are displayed, and the number you see on the monitor represents the current measurement cycle.
3. To accept the calculated values, press ENT. If the calculated values are unsatisfactory, you can either edit and recompute, or press the MEASURE button to acquire a new data set.
4. Repeat steps 2 and 3 until all of the measurement cycles are completed.
5. When the Manual Averaging process is completed, and you've pressed YES for the final time, the system calculates the average of the measurements. If you want to discontinue Manual Averaging at any time prior to completion of the last cycle, press START PROMPTING.

Isometric Plots

Pressing PLOT provides you with an isometric view of the OPD data (Figure 7-7). All of the 3-D plots are scaled to a constant height equal to the maximum P-V for any data greater than 0.004 fringes.

The first time that you press PLOT, the isometric view is displayed. Press PLOT a second time, and the system displays the inverse of the OPD data. Press PLOT a third time and the system exits the 3-D plot mode. You can also exit this mode by pressing NEXT PAGE/RESTORE.

To view an isometric plot with OPDs subtracted, press PLOT after SUBTRACT. You do not need to press STORE because the OPDs are already on the uniform grid. If you press STORE, you will lose the data resulting from the subtract operation.

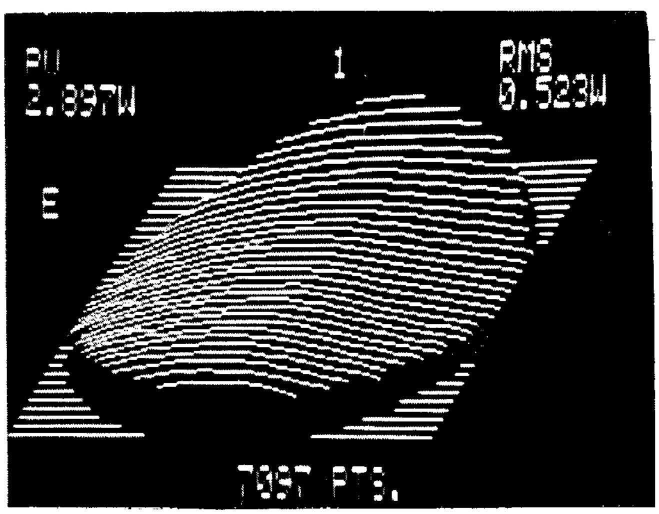


Figure 7-7 Isometric Plot

Subtract OPDs

This mode allows you to subtract OPDs in an original interference pattern from OPDs in a second pattern. Perform the following steps.

1. Store the measurement data from the first interference pattern by pressing STORE OPDS.
2. If Automatic Averaging is activated, press ENT.
3. Measure the second pattern by pressing MEASURE and then COMPUTE.
4. If the pattern is satisfactory, press SUBTRACT OPDS. You can now plot the pattern, or transfer the data to a printer.

Note: The first pattern measured is retained in OPD memory until you press STORE OPD again, the RESET button, or turn the system off. This means that a single reference measurement can be retained for subtraction over one or several measurements.

Subtract Power Mode

This mode should be used primarily for testing spherical surfaces. If you use it on plano, cylindrical, or aspheric surfaces, the system will subtract only a best-fitting sphere from the wavefront.

The power value is identified as either CC (concave) or CX (convex) depending upon the zero order value you entered on Prompting Page 3.

Accept/Reject Mode

The symbols ACC (accept) or REJ (reject) are displayed on the monitor when you set limits for Peak-to-Valley, Root-Mean- Square, and/or Power. When the results of the data reduction are within the limits you established, an ACC is displayed on the monitor.

If a limit is out of tolerance, REJ is displayed, and the out- of-tolerance parameter is indicated by an asterisk (*) beside the displayed value.

Slope Mode

This mode is activated when you respond to the FIDUCIAL SPACING and SLOPE prompts. The fiducial spacing value is determined in centimeters. The slope deviation is calculated in waves or fringes per centimeter. The POINTER (*) flashes several times and then remains on to identify the area of the maximum slope on the test item.

Transfer Operation

If you respond yes to the TRANS TO AUX COMP prompt on Prompting Page 4, the raw data points will be transferred each time you press PRINT/TRANSFER. You can find additional information on data transfer in the "Data Transfer" chapter of this manual.

To transfer the data array to the auxiliary computer, use the following procedure.

Make sure you perform the geometric distortion procedure before you transfer data to the auxiliary computer.

1. Respond YES to the SUBTRACT G.D.? prompt.
2. Press COMPUTE.

3. The system will stop in the middle of the computing routine and wait for you to press PRINT/TRANSFER.
4. The Compute routine will be completed after the transfer is done. If you need to get out of the waiting state, press START PROMPTING, and the system returns to Prompting Page 1.

Summary

ZAPP Processing is automatic once you have responded to the prompts on the four prompting pages and pressed MEASURE and COMPUTE.

When necessary though, you can manually edit a fringe pattern to remove bad data points that would affect data analysis. A geometric distortion routine enables you to subtract geometric distortion for the interference data.

The output from the data analysis is displayed on the monitor screen and can be transferred to a printer or computer via the RS-232C interface port.

8 Data Transfer

Information for Data Transfer to a Printer, Auxiliary Computer or Disk Storage Unit via RS-232C

Pin Assignment Descriptions & Illustrations

Jumper Change Procedure

Information for Data Transfer to an Auxiliary Computer via IEEE-488

Before You Begin

Any printer or auxiliary computer you use for ZAPP data transfer must have an RS-232C port. The computer must also be able to accept the ZAPP output format which is described later in this chapter.

Data Transfer to an Auxiliary Computer via RS-232C

Type of Data Transferred

The data that is transferred through the RS-232C port to the computer includes: 1) the coordinate of each acquired data point along with a real number representing the exact location of the point in fringes; 2) the coordinates of the clear aperture cursors represented by eight fiducial readings; 3) pertinent input prompting information.

The data transferred through the RS-232C port is compatible with the ZYGO Fringe program. The auxiliary computer will enable you to obtain Zernike polynomial coefficients, point spread function, and a variety of other optical computations.

Data transferred through the IEEE-488 port to the computer is compatible with the Phase Array program. For more information, see the IEEE-488 section of this chapter.

Electrical Specifications

A standard RS-232C connector is used to connect the Mark III system to an auxiliary computer. The port on the processor unit connector panel is labeled I/O PORT J110. The pin assignments are shown in Figure 8-1 and described in Table 8-1.

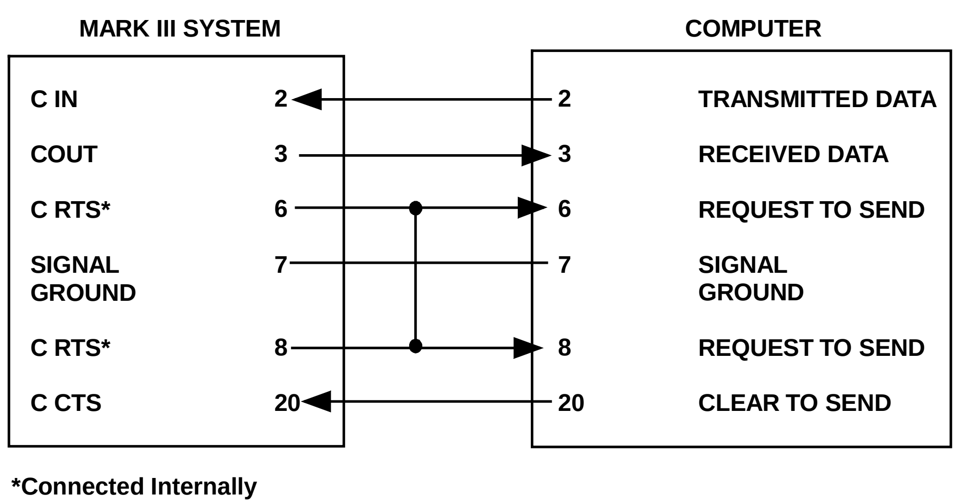


Figure 8-1 Pin Assignments for Mark III System to Auxiliary Computer

PIN	CIRCUIT	AUXILIARY COMPUTER	MARK III SYSTEM
2		Transmitted Data	C IN (Line of received data)
3	BB	Received Data	C OUT (System output. Line of transmitted data.) -V = 1 = Mark, +1 = 0 = Space (+V = voltage> +3 volts) (-V = voltage < -3 volts)
6*			
8*	CF	Carrier	C RTS (Request computer to send) Whenever the Mark III System transmits a character, this goes to +V.
7	AA	Signal Ground	
20	CD	Data Terminal Ready	C CTS (Computer Clear to Send) Can be jumpered to +5VDC for Fringe I/O compatability. +V in this line enables Mark III system to transmit a character.

*Pins 6 and 8 are jumpered internally.

Table 8-1

Transmitted Data Specifications

Transmitted data includes alphanumeric characters in ASCII code; seven data bits; one stop bit (no parity), and serial transmission at 9600 baud.

A sample of data format is shown in Figures 8-2 and 8-3, and described below.

```
START OF TEXT      ID NUMBER      3 * TIME  9:26 * DATE 2-9-81
                   ZAPP
                   TILT
                   WVLI   0.633
                   WVL   0.633
                   WEDGE +0.5
                   ELLIPSE
                   SUBGD
                   FIDS  656 945 656 158 208 551 1104 551 END
DATA ARRAY         201 1 511 2 653 3 781 E
                   239 1 513 2 655 3 781 4 900 E
                   278 0 364 1 514 2 658 3 782 4 902 E
                   316 0 361 1 517 2 663 3 786 4 904 E
                   355 0 360 1 520 2 660 3 786 4 909 5 1023 E
                   393 0 364 1 521 2 660 3 788 4 910 5 1024 E
                   431 0 364 1 522 2 657 3 791 4 913 5 1026 E
                   470 0 366 1 522 2 655 3 788 4 916 5 1026 E
                   623 0 360 1 515 2 648 3 788 4 915 5 1031 E
                   622 0 358 1 515 2 651 3 790 4 914 5 1030 E
                   700 0 353 1 513 2 655 3 789 4 914 5 1027 E
                   739 0 347 1 508 2 652 3 785 4 908 5 1026 E
                   777 0 343 1 503 2 649 3 783 4 906 E
                   815 0 342 1 497 2 644 3 777 4 905 E
                   854 1 495 2 642 3 777 4 904 E
                   892 1 491 2 640 3 775 E
                   931 2 640 3 776 E
                   END
                   201 1 8180 2 10463 3 12511 E
CALIBRATION ARRAY  239 1 8219 2 10504 3 12514 4 14409 E
                   278 0 5814 1 8225 2 10540 3 12527 4 14428 E
                   316 0 5748 1 8256 2 10606 3 12570 4 14441 E
                   355 0 5746 1 8324 2 10579 3 12594 4 14535 5 16323 E
                   393 0 5809 1 8338 2 10578 3 12620 4 14546 5 16332 E
                   431 0 5805 1 8355 2 10523 3 12663 4 14594 5 16361 E
                   470 0 5848 1 8366 2 10505 3 12629 4 14660 5 16381 E
                   623 0 5743 1 8620 2 10396 3 12632 4 14639 5 16643 E
                   662 0 5703 1 8258 2 10439 3 12662 4 14617 5 16431 E
                   700 0 5623 1 8220 2 10504 3 12643 3 14617 5 16383 E
                   739 0 5519 1 8130 2 10450 3 12570 4 14509 5 16348 E
                   777 0 5454 1 8045 2 10399 3 12531 4 14484 E
                   815 0 5448 1 7940 2 10314 3 12434 4 14521 E
                   854 1 7915 2 10286 3 12441 E
END OF TEXT        892 1 7853 2 10252 3 12406 E
                   931 2 10239 3 12406 E
                   END
```

Figure 8-2 Sample Transmitted ZAPP Data Format

```
ID NUMBER     0000    *    TIME   13:10      * Date 03-24-86
ZAPP
TILT
WVLI       0.633
WVL       0.633
WEDGE    +0.5
RECT
FIDS  52 24 52 72 28 48 76 48 END
24 -0.588 48 -0.824 52 E
28 -0.216 40 -0.436 44 -0.658 48 -0.886 52 -1.122 56 -1.341 60
   -1.563 64 E
32 -0.108 36 -0.316 40 -0.508 44 -0.733 48 -0.966 52 -1.191 56
   -1.424 60 -1.638 64 -1.872 68 E
36 0.050 32 -0.169 36 -0.391 40 -0.597 44 -0.822 48 -1.058 52
   -1.255 56 -1.497 60 -1.727 64 -1.961 68 -2.180 72 E
40 -0.074 32 -.0255 36 -0.483 40 -0.683 44 -0.908 48 -1.136 52
   -1.358 56 -1.572 60 -1.791 64 -2.038 68 -2.261 72 E
44 0.091 28 -0.130 32 -0.344 36 -0.549 40 -0.749 44 -0.999 48
   -1.216 52 -1.452 E
```

Figure 8-3 Sample Transmitted Phase Data Format

Data Format Description

I.D. NO., DATE, TIME - All on one line so that the ZYGO Fringe program recognizes it as a title.

ZAPP - Identifies data as being transmitted in the ZAPP format.

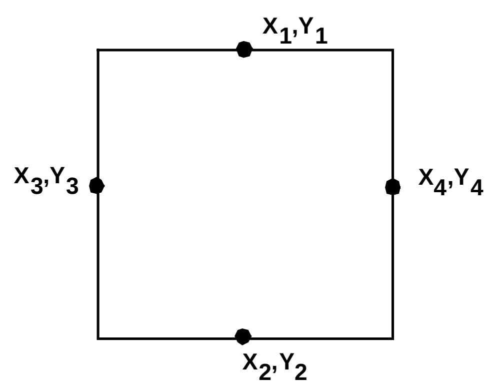
TILT - Indicates best fit plane to the data.

WVLI, WVL - These numbers identify wavelength in and wavelength out values entered during the prompting mode.

WEDGE - Contains ISF and zero order data as specified in the prompting mode. A negative value is identified with a minus character (-).

ELLIPSE (or RECT) - Identifies the shape of the test aperture (elliptical or rectangular) as specified during prompting.

FIDS (Fiducials) - These numbers are presented in X, Y pairs and identify the boundaries in which the data exists. Cursor definition sets up the boundaries. The first X, Y pair corresponds to the top row of data, the second pair to the bottom row, the third pair to the left column, and the fourth pair to the right column.



E - Signifies the end of each data line.

END - Signifies the end of data transmission. (ASCII code 16; DLE, Data Link Escape)

DATA ARRAY - This information identifies data point locations in each scanned row. When data is transmitted in the ZAPP mode (see Figure 8-2), these numbers are presented in a Y m X format. Y equals the Y coordinate, X the X coordinate, and m is a real number indicating the fringe order. When data is transmitted in the Phase mode (see Figure 8-3), the numbers are presented in a X, Y, m format. X equals the diode row number, Y the diode column number and m is a real number identifying the phase value.

ESC - (ASCII code 27) Assigns the end of data.

Data Transfer to a Printer Via RS-232C

Electrical Specifications

A standard RS-232C connector is used to connect the Mark III system to a printer. The port on the processor unit connector panel is labeled **Printer J109**. The pin assignments are shown in Figure 8-4 and described in in Table 8-2.

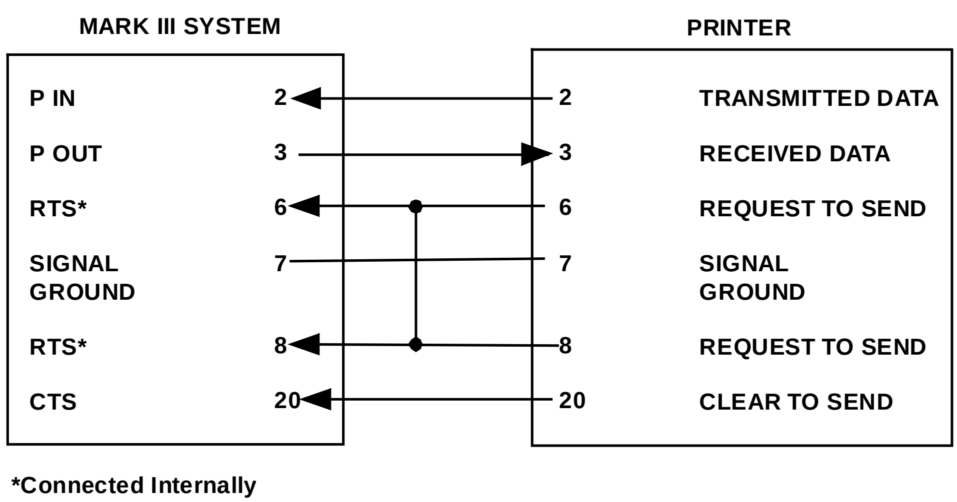


Figure 8-4 Pin Assignments Mark III System toPrinter

PIN	MARK III SYSTEM	PRINTER
2	Transmitted Data	P IN (Line of received data)
3	Received Data	P OUT (System output. Line of transmitted data.)
6		
8	Request to Send	RTS (Request printer to send) Whenever the Mark III system transmits a character, this goes to +V.
7	Signal Ground	
20	Clear to Send	CTS (MK III clear to send). -V = 1 = Mark, + V =0 = Space (+V = voltage> +3 volts) (-V = voltage< -3 volts)

Table 8-2

Transmitted Data Specifications

Transmitted data includes seven data bits, one stop bit (no parity), and serial transmission at 1200 baud.

Data Transfer to an Auxiliary Computer Via IEEE-488

Your Mark III System must have the IEEE-488 option installed before you can transfer data. This means that the Interface board must be in place in the ZYGO Processor Module. If your system was ordered with the option, the board is factory installed. If not, you'll have to order the option and install the Interface board following the procedure in manual OMP-0176.

Type of Data Transferred

Information sent to the computer via the IEEE-488 port includes:

- Header Data (ID Number; Time; Date; Wavelength IN; Wavelength OUT; ISF, and Focus, plus prompting information
- 100 x 100 Array (phase angles before tilt, offset and spherical power are removed)
- 32 x 32 Uniform Grid (tilt and offset subtracted. Spherical power is subtracted if the appropriate value is entered during prompting.)

The above data is compatible with the Phase Array Analysis and Interferogram Software packages, which run on the auxiliary computer. It calculates power, focus, astigmatism, and angle of astigmatism values. The Phase Array Analysis program also provides separate software routines to fit phase array data points to a plano, spherical, or cylindrical surface. The Interferogram Software package performs zernike, MTF, PSF computations, and addition and subtraction of wavefronts.

The data transferred to the auxiliary computer via the RS-232C port is different. See the *Data Transfer to an Auxiliary Computer via RS-232C* section of this chapter for details.

Electrical Specifications

Interconnections to the computer are through a standard IEEE-488 connector, labeled **IEEE-488 J114** on the processor module connector panel.

Transmitted Data Specifications

Header and prompting data are transferred as a string of ASCII characters with eight data bits in each character. A line feed is transmitted at the end of each line.

Phase array and uniform grid data are transmitted in binary format as two byte integers with eight data bits in each byte. The most significant byte (MSB) in each integer is sent first. All data bits for each byte and each ASCII character in the header data are transmitted in parallel, at a speed of up to 20,000 bytes per second (this depends upon the communications capabilities of the computer). The IEEE-488 address for the MarkIII is 17.

The data format is described in detail in Table 8-3.

Transmitted Data	Explanation
SRQ	Service request transmitted as decimal value 65, 66, or 68.
Header	Includes the following: ID Number is an 8 digit number that identifies the phase measurement data. Time identifies the time the data was acquired in the phase mode. Date represents the date on which data was acquired. Wavelength In identifies the operating wavelength of the laser. Wavelength Out identifies the wavelength used to process the data. Note: All Header data reflects values entered during prompting. ISF represents interferogram scale factor. Focus indicates that spherical power was subtracted from phase data. No focus indicates that power was not subtracted. (Spherical power is only subtracted from data in the 32 x 32 uniform grid.)
EOI	(End or Identify) Transmitted to the computer before the final line feed ending the header block of data (described above).
PHASE DATA	20,483 bytes are transmitted in this block of data. The data is positioned in a 100 x 100 matrix consisting of 10,000 16 bit words. The matrix is transmitted row by row; the first 100 words read into the computer's buffer represent Row #1 of the 100 x 100 phase array. At the end of each row, the number –30584 appears twice as a delimiter (sets off or identifies separate data items). For each row of data, 102 words or 204 bytes are transmitted. The last byte transmitted for each row of data is preceded by the EOI signal (described below). The first 20,401 bytes in the data block represent the 100 x 100 phase array. The last 82 bytes (or 41 words) sent are meaningless and may be discarded.
EOI	Transmitted by the auxiliary command register of the computer before the final byte in the phase array data block.

Uniform Grid	2,049 bytes are sent in this block of data. The first 64 bytes (consisting of 32, 16 bit words) represent the first row of data in the 32 x 32 OPD grid. The data is transmitted in the order of the most significant byte followed by the least significant byte until all of the data, representing the entire 32 x 32 grid is received in the computer. The last data byte sent in the data block is preceded by the EOI signal (see below).
EOI	Sent to the auxiliary command register of the computer before the final byte in the uniform grid data block. Note: All Header data reflects values entered during prompting.

Summary

Transferring ZAPP data requires an RS-232C port on the printer, auxiliary computer, or disk storage unit you are using. The auxiliary computer uses "I/O PORT J110" on the ZAPP Processor Module connector panel. Transferring Phase data requires an IEEE-488 port on the auxiliary computer.

9 Troubleshooting

Error Code List and Explanation

Problem Detection for the Mark III System

Possible Causes and Correction Procedures

Before You Begin

The Error Code section of this chapter contains a list and explanation of error codes and warnings that may be displayed on the monitor while you are operating the Mark III System. They are an indication that there is some type of problem with the system. The difference between an error code and a warning is in the condition that prompted the display of either one.

An error code identifies a condition that will not allow you to continue processing successfully. A warning tells you that the problem needs attention, but it does not necessarily mean the analysis of the interference pattern will cease altogether.

However, continued processing (without correcting the problem that caused the warning) may result in incorrect information.

The *Troubleshooting* section of this chapter provides you with an overview of common system problems and their solutions. The *Mark III Service Manual* (SP-0053) includes more detail, and also contains service procedures for certain problems listed here.

For any problem that you cannot solve easily with the information in this chapter or the Service Manual, contact ZYGO. See *Chapter 10* of this manual for more information on how to contact ZYGO and the procedure for returning equipment.

Error Codes (ZAPP Mode)

The following error codes advise you of system conditions that prevent successful data acquisition and/or evaluation.

Code # 2 - No data points were read. This is caused by 1) no fringes in the field; 2) the fringes are too thin or too light; 3) a hardware failure.

For a no fringe condition, check to see if the BEAM ATTEN. knob on the mainframe is pulled out, or check the ALIGN/VIEW button on the Remote Operator Control Box to see if it is in the ALIGN position. A no fringe condition can also be caused by improper alignment of the test item. Fringes that are too light or too thin can also be caused by poor alignment of the test item, or the contrast knobs on the Video Monitor may need adjustment. A hardware failure could be the Fringe Center Board. For this problem, contact the ZYGO Service Department.

Code # 4 - Too many fringes. This condition may result from 1) an excess number of fringes (30 or more); 2) residual values in random access memory (RAM).

The system cannot analyze more than 30 fringes; therefore, use the adjustments on the mount holding the test item to reduce the number of fringes. To clear residual values of RAM, press NEXT PAGE/RESTORE.

Code # 7 - Fringes too close. This is the most commonly displayed code, resulting from fringes being too close together for data analysis (approximately 1/50 width of the monitor).

To correct this condition, adjust the controls on the mount holding the test item, or adjust the ZOOM control on the Remote Operator Control Box.

Code # 8 - No data transfer (to computer or printer). This condition occurs when the computer or printer is off-line.

Code # 9 - Too Few Points. This code appears when 1) there are less than three data points in compute; 2) the points are not being transferred from the displayed matrix to a working matrix.

Three is the smallest number of data points the processor can analyze. Adjust this by using the manual edit mode. The second cause of Code #9 means that the matrix you see displayed is not the matrix that the processor is trying to analyze with. This is a hardware problem, and you should contact the ZYGO Service Department.

Warnings

The following WARNINGS may appear on the monitor during processing to advise you of operational conditions. Although these conditions do not necessarily stop the evaluation of an interference pattern, they may give you incorrect information.

Warning B - The change in the optical path differences is too sudden on the uniform grid (the error is too large). This is an uncommon warning and indicates a hardware problem, usually with the DMA, MPU, or Auxiliary Memory Board. Contact the ZYGO Service Department.

Warning C - The optical path difference location in the 32 x 32 array is out of range. Try moving both of the side (vertical) cursors in. If this doesn't help, check the alignment of the transmission element and the test item.

Warning D - Press COMPUTE before entering calibration data.

Warning F - The error is too large to calibrate.

Warning G - Do not respond YES to the SUBTRACT POWER prompt when calibrating.

Warning H - Overflow in adding OPDs in calibrate. This warning means that the memory space in the processor cannot accomodate the number entered for calibration. Make sure you are using the ZYGO supplied calibration grid because using any other grid will more than likely cause this problem.

Warning I - A coordinate on the uniform grid does not have a corresponding error correction. The coordinate is identified with an asterisk (*). This means that a region is being measured which was not calibrated. You can correct this condition by calibrating over the entire field.

Warning J - This warning identifies an illegal fringe entry, which is caused by a point that was entered to the left of an existing point (in the same row) during the manual or data editing mode. Remove the point and continue processing.

Warning K - Averaging readings are not within acceptable limits.

Warning L - A fringe center was entered or erased on an empty row during single point editing. Remove the point and continue processing.

Warning N - An error was made when defining an aperture obscuration. This warning means that the beginning of an obscuration cannot be placed at the beginning of a row (i.e. the left-hand side). Adjust the cursor positions and continue processing.

Warning S - Broad fringes cannot be acquired in the negative mode. To correct this, respond NO to the POSITIVE prompt.

The following warnings also identify operational conditions, but you will notice that they occur after the MEASURE button is pressed.

Error Codes (Phase Mode)

AGC - An improper entry was made in the AUTO AGC? field during prompting. Try raising the number by 1 in the SCAN RATE field, or enter YES for the AUTO AGC prompt.

APRT - The cursors are not positioned in the clear aperture region. Reposition them.

CAMP - The end-of-frame signal from the Diode Array Camera is not reaching the Processor Module. See *Chapter 3* of the *Service Manual* (SP-0053).

DLTA - Data analysis could not continue due to one of these reasons: 1) the fringes are too close together at some point on the interference pattern, or the system is not calibrated; 2) dirt on the optics is being read as a fringe; 3) diffraction is occurring along the edges of an obscuration.

To correct number 1, reduce the amount of fringes in the test aperture, or respond YES to the AUTO AGC and CALIBRATE prompts.

To correct number 2, clean the optics and retry. To correct number 3, enter YES for the DELETE OBS. EDGES? prompt and use the mainframe APERTURE FOCUS switch to focus the edges of the obscuration as sharply as possible.

MEMC - Data analysis cannot be continued for one of these reasons: 1) there is an improper entry for the SCAN RATE prompt; 2) the motion of the piezoelectric crystals in the Phase Measuring Receptacle is not calibrated; 3) an obscuration is too complex for processing.

To correct number 1, enter YES for the AUTO AGC? prompt. To correct number 2, respond YES to the CALIBRATE prompt. To correct number 3, change the position of the clear aperture cursors.

NMOD - No modulation is taking place. See Chapter 3 of the Service Manual (SP-0053).

NODA - There is no data or too little data for analysis. Check the QUICK FAS switch to see if it is in the VIEW position.

PATH - Data analysis could not be continued because of: 1) bad edge data; 2) dirt on the optics was read as a fringe.

To correct number 1, use the cursor controls to reduce the size of the test aperture. To correct number 2, clean the optics.

READ - Incorrect input information has been entered during prompting. Check all entries made on the four prompting pages. If this message occurs repeatedly, contact the ZYGO Service Department.

Some WARNINGS apply to the system diagnostic tests. If a particular test fails, one of the following warnings will be displayed on the monitor. After a warning is displayed, press NEXT PAGE/RESTORE to restart the input promping format. When a warning from the following list is displayed repeatedly, contact the ZYGO Service Department.

CTRL - A Control Terminal pushbutton and/or switch has shorted.

AROM/XXXX - There is a Read Only Memory (ROM) checksum error on the Auxiliary Memory Board.

MROM/XXXX - There is ROM checksum error on the MPU Board.

AUX - There is a Random Access Memory (RAM) read/write error on the Auxiliary Memory Board.

NVR - There is a Non-Volatile, Random Access Memory, read/write error on the Auxiliary Memory Board.

BMAP - There is a RAM read/write error on the Bit Map Board.

DMA - There is a RAM read/write error on the Direct Memory Access Board.

PMC - There is a read/write error on the Phase Measurement Control Board.

FCB - There is a RAM read/write error on the Fringe Center Board.

MPU - There is a RAM read/write error on the MPU Board.

> Note: The BMAP and DMA warnings may be listed twice, indicating that both pages of memory have failed.

Troubleshooting

Problem	Possible Cause and Correction
Image Out-of-Roundness (on monitor)	Check the system components to determine which one is responsible for the distortion. See the *Service Manual* (SP-0053) for this procedure.
Loss of Laser Light	Beam Atten. knob on the Mark III is pulled out. Push the knob in to restore the laser light. Laser head is not emitting a beam. See the *Service Manual* (OMP-0053) for the procedure to check this condition.
Loss of Power	Loose connections on a component connector panel. Check the wiring connection diagram (Figure 5-3).
No Cursors on Monitor(but interferogram and data are displayed)	Cursors On/Off switch is in the off position. Move to the on position. Contact Zygo. The processor's cursor board may be defective.
No Data on Monitor(but interferogram is displayed)	Contact Zygo. The analog or display board may be defective.
No Fringe Pattern Modulation	See the *Service Manual*, (SP-0053) for the procedure to determine the source of this problem.
No Interferogram on Monitor	Contrast and Brightness controls need adjustment. Adjust accordingly. Control terminal CAM 1/CAM2 switch is in the wrong position. Move to the CAM2 position. Check to see if the On/Off switch (on the monitor) is in the On position. Check to see if the monitor power cord is plugged in.
No Prompting Information on Monitor	Ribbon cable loose or disconnected. Check the flat ribbon cable between the Processor Module and Control Terminal. Make sure both ends of the cable are firmly seated and secured with the screw attachments.
Non-Uniform Image Field (on monitor)	The test part is not aligned in the Accessory Receptacle on the mainframe. Check and correct if necessary.
Pointer does not move to Next Prompting Page	Press Reset on the Control Terminal. If this does not correct the problem, contact Zygo as it may be the cursor board.
Random Pattern on Monitor	See "No Prompting Information on Monitor." Fuse(s) blown. Unplug the Mark III and the Processor Module and check the fuses. Replace if necessary.

Problem	Possible Cause and Correction
Vignetting (monitor image has no distinct border with gradual shading at edges)	The test part is not centered in the mainframe output beam. Check and realign if necessary. The Quick FAS switch is not fully advanced to View position. Check and correct if necessary. CCTV may need alignment. See the Service Manual for the procedure. The Spatial Filter Beam Diverger needs adjustment. See the Service Manual for the procedure.
Walk-Off Condition	When using a 90% transmission flat to produce high finesse fringes, lesser secondary fringes may appear successively farther from the main fringes. See the Service Manual for the procedure to correct this problem.

Summary

Occasionally, you may encounter a problem while operating the Mark III system. In most cases, you'll be able to solve the problem yourself.

Use the Error Code section of this chapter to determine what a code or warning displayed on the monitor means. These codes and warnings identify software, and hardware related conditions that may or may not need immediate attention.

You'll find additional help for other types of problems in the Troubleshooting section of this chapter. The Troubleshooting chart is arranged alphabetically by problem and includes information on how to correct each condition.

10 Maintenance & Warranty

Maintenance and Cleaning Information for the Mark III Mainframe, Processor Module, and Video Monitor

Optical Cleaning Procedure

Fuse Schedule and User Replaceable Parts List

Equipment Return Procedure

Zygo Warranty

Before You Begin

The Mark III Mainframe, Processor Module, and Video Monitor are virtually maintenance-free. However, some of the best maintenance you can perform is to treat the system with care, handle and operate it as described in this manual, and keep it in a clean, dry environment.

The major optical components in the Mark III Mainframe are enclosed, and are therefore protected from dust and other contaminants. Breaking the seal on the L-shaped optical compartment inside the Mark III will void the warranty. If you believe the optics in this compartment need cleaning, contact the ZYGO Service Department.

The optical cleaning procedure in this chapter is intended for optics used on the Mark III and in conjunction with it (e.g. transmission and reference flats and spheres). Be sure you read the entire procedure before you begin to clean any optical component.

General Cleaning

The Processor Module

There is a filter behind the metal screen on the back of the processor (Figure 10-1) that collects dust. Once a month, check the filter to see if it is partially or completely clogged. In either case, remove the screen and the filter pad and clean them both. To remove the screen:

1. Insert a small, flat blade screwdriver behind the screen and carefully pry it off.
2. Brush or blow the dust off both parts and replace them. (There is a metal snap attachment at each corner of the screen.)
3. The procedure is complete.

If the external surfaces of the processor (top and sides) get dirty, clean them with a mild, commercially available furniture polish. You can also use a dampened cloth and mild soap detergent. However, make sure the cloth is not dripping because excess water could leak into the housing of the processor and cause damage.

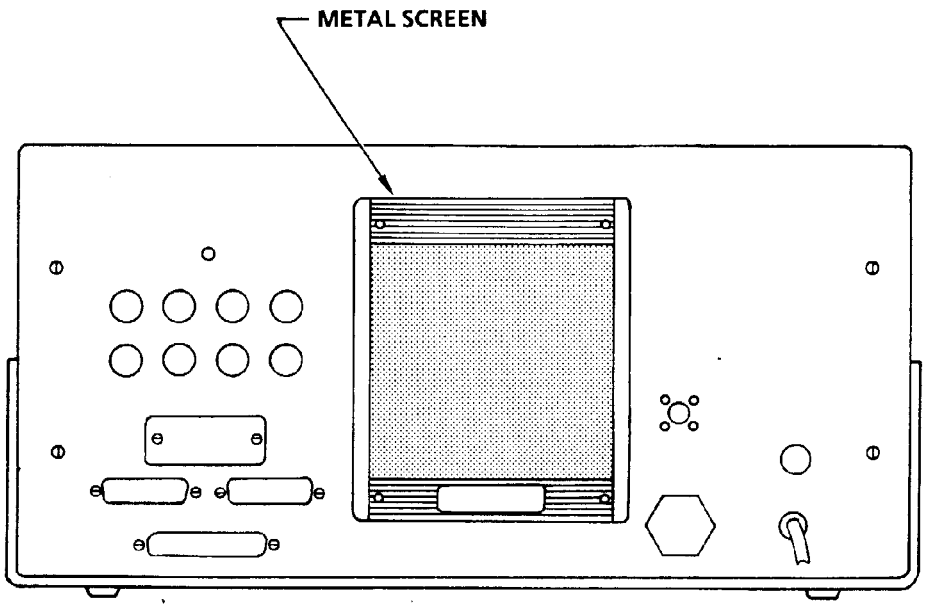


Figure 10-1 Processor Module Connector Panel

The Mark III Mainframe

The same guidelines for cleaning the exterior surfaces of the processor apply to the mainframe. However, take extra care when cleaning in the accessory receptacle area (at the front end of the unit on the Phase Measuring Receptacle). The collimator (behind the receptacle) is a coated optical component and can be damaged by spray cleaners. If you must clean the collimator, use the Optical Cleaning Procedure provided in this chapter.

The Video Monitor

This unit is maintenance-free with the exception of routine cleaning of the case and screen. Clean the sides and top of the unit with a clean, damp cloth, or commercially available, mild, spray cleaner.

Clean the screen with a commercially available glass cleaner, or one of the many products on the market for cleaning computer terminal screens.

There are no user serviceable parts in the monitor. If the monitor needs service, you will have to return it to the ZYGO Service Department. See the *Equipment Return Procedure* section of this chapter.

Optical Cleaning Procedure

Optics which are coated (4 percent reflectivity), or covered with either an antireflective or thin-film coating, are easily damaged by improper or unnecessary cleaning. Clean your ZYGO optics only when they are noticeably dirty. It is better to clean a localized area rather than the entire surface. Before you attempt to clean any optical components, read the entire procedure.

CAUTION: ZYGO recommends that you do not clean the high reflectivity coatings on transmission or reference elements. These are soft coatings and can be easily damaged. However, if it becomes absolutely necessary to clean one of these surfaces, you can do so with the following procedure. ZYGO will not be responsible for any damage that occurs to an optical component as the result of cleaning.

Recommended Cleaning Materials

You'll need to obtain the following materials and fluids to clean both coated and uncoated optical surfaces. You may use the products suggested below, or their equivalents. The addresses for the manufacturers of the listed products appear in Appendix B.

- Orvus WA Paste, manufactured by KWW Warehouse Chemicals.
- Distilled Water. (Use the best quality available.)
- Spectra-analyzed Methanol, A-408, Class 1B Certified, A.C.S., manufactured by Fisher Scientific.
- Spectra-analyzed Acetone, A-19, Certified, A.C.S., manufactured by Fisher Scientific.
- Multilith Pads, #200-847, manufactured by Multigraphics.
- Lens tissue, 8 x 9-inch, manufactured by Aldine Papers.
- Vinyl gloves, #607, manufactured by Laminare.

Preparing to Clean Coated and Uncoated Optics

1. Before cleaning any specialized, optical coatings, check the precautionary information supplied with the coatings.
2. Remove all rings and jewelry from your hands and wrists.
3. Wash your hands thoroughly to remove excess skin oils.
4. Put on vinyl gloves.
5. Use a clean, filtered, air supply to blow loose particles from the optical surface without touching the surface itself.
6. Examine the surface for any remaining loose particles and/or semi-solid contaminants. A cleaning procedure for each of the following conditions is described in this chapter: cleaning loose particles from an uncoated surface; cleaning loose particles from a coated surface, and cleaning semi-solid contaminants from a coated or uncoated surface.

Cleaning Loose Particles From an Uncoated Surface

1. Fold two sheets of lens tissue to form a pad approximately two inches square.
2. Read the Warning below before proceeding with this step. Dampen the pad with Methanol. The Methanol should not be dripping from the pad.

WARNING: Be careful when using Methanol or Acetone; both are TOXIC and FLAMMABLE.

3. For ROUND surfaces, start at the center and use a light, circular, motion. Wipe gently toward the outer edge using a new pad for each wiping motion.
4. For SQUARE or RECTANGULAR surfaces, start at one end and wipe gently toward the opposite end, using a new pad for each motion.
5. Continue with the above steps until the surface is completely free of loose particles.

CAUTION: Do not try to wash off any optical surface with running fluids. If the element is mounted or cemented, this may damage seals or destroy cement bonds. Do not reuse any tissue or pads.

Cleaning Loose Particles from a Coated Surface

1. Fold a Multilith pad in fours. Be sure you read the Warning below before performing the next procedure.

WARNING: Be careful when using Methanol or Acetone; both are TOXIC and FLAMMABLE.

2. Dampen the pad with Acetone. The Acetone should not be dripping from the pad.
3. Follow the instructions for wiping ROUND surfaces as listed in the procedure "Cleaning Loose Particles from an Uncoated Surface."
4. Follow the instructions for wiping SQUARE or RECTANGULAR surfaces as listed in the procedure "Cleaning Loose Particles from an Uncoated Surface."
5. Continue with the above steps until the surface is completely clean. DO NOT WASH OFF ANY OPTICAL SURFACE WITH RUNNING FLUIDS. (See the previous Caution.)

Cleaning Semi-Solid Contaminants from Coated and Uncoated Surfaces

1. Fold a Multilith pad in fours.
2. Dampen the pad with the Orvus solution. The pad should not be dripping.
3. See the Caution below before performing this step. Very gently apply the Orvus to the soiled area, observing the circular and square or rectangular wiping strokes described in the "Cleaning Loose Particles from an Uncoated Surface" procedure. Remember to throw away the used pad. Do not reuse any pad.

CAUTION: Do not scrub the surface. You could cause damage to it.

4. Remove the Orvus from the surface by moistening another Multilith pad with distilled water. Use the established procedure for ROUND or SQUARE and RECTANGULAR surfaces. Throw away the used pads.

5. Remove residual water by moistening a pad with Methanol and applying it to the surface following the established wiping procedure. The anhydrous property of the methanol should draw the water into the pad. Throw away the used pads.
6. Remove the residual Methanol by moistening a pad with Acetone, and wipe with a single, slow moving, light stroke, ending with a "pick-up" motion. (Don't drag the pad to the edge.) Too fast a stroke will leave a gritty trail of Acetone on the surface. Too slow a pick-up motion will leave liquid on the surface. Repeat this step, using a new pad each time, until all traces of Acetone are removed. If light stains are still visible, there is probably some Orvus left on the surface; you will have to repeat Steps 3, 4, and 5 above.
7. If you see remaining contamination after cleaning, repeat the entire procedure listed above.
8. This procedure is completed.

Fuse Schedule

All fuses are 3AG SLO-BLO, 250V type.

Component	U.S.	Europe	Japan
Mark III Mainframe	1-1/2 amp	3/4 amp	1-1/2 amp
Processor Module	2-1/2 amp	3/4 amp	1-1/2 amp
PMR	1 amp	1 amp	1 amp
Mark III Laser Power Supply	1/4 amp	1/4 amp	1/4 amp

Mark III User Replaceable Parts List

Replacement instructions for the first four items listed below are in the Mark III Service Manual, SP-0053.

Part Name	Zygo Part Number
Laser Head	6174-0101-01
Laser Power Supply	6176-0112-01
CCTV	6174-0126-01 (60 Hz) 6174-0126-02 (50 Hz)
Spatial Filter Beam Diverger	6174-0107-01
Video Monitor (without Riser Bracket)	6174-0206-01 (60 Hz) 6174-0206-02 (50 Hz)

Equipment Return Procedure

If it becomes necessary to return a Mark III System component for service or other reasons, follow the procedure below.

1. Have the serial number of your unit on hand. (See *Chapter 3* for the location of this label.)
2. Contact the ZYGO Service Department, Laurel Brook Road, P.O. Box 448, Middlefield, CT 06455-0448; or call (203) 347-8506, for a RETURN AUTHORIZATION (RA) number and the appropriate paperwork.
3. Pack the equipment securely (in its original container when possible) to prevent any damage in shipping. Be sure to mark the container with your RA number, and include it on any correspondence.

Zygo Statement of Warranty and Product Support

Zygo Corporation provides this warranty to protect its customers from defects in product workmanship or product materials. This warranty covers all products manufactured by Zygo Corporation.

Zygo warrants that the equipment purchased will be free from any defects in material and/or workmanship under normal operating conditions for a period of one year from the date of shipment.

In addition, being committed to providing our customers with superior service, Zygo will support all standard products for a period of seven years after the sale of the last newly-manufactured unit. Beyond this seven-year period, we will continue to support these products on a "best-effort" basis.

Warranty Service

Zygo's responsibility under this warranty shall be limited to the repair or replacement (at Zygo's option) of defective equipment at no cost to the buyer, except for transportation, cleaning, and recalibration charges.

Zygo will perform warranty service by: (1) sending replacement parts with appropriate installation instructions to the buyer, the buyer returning his defective part to Zygo or; (2) repairing the product at a Zygo repair facility after it has been returned freight prepaid, or; (3) at the buyer's request, dispatching a service representative to the buyer's facility. The buyer shall pay Zygo's travel and living expenses as well as travel time.

Defective products or parts will be repaired or replaced with new or like-new parts. These replacement parts will be warranted for a period of 90 days after they are shipped, or for the remainder of the original warranty period, whichever is longer.

Warranty service will be performed only if the buyer notifies Zygo within 14 days of discovering any defects. Equipment or parts that are to be returned to Zygo must be issued a Return Authorization number. This number can be obtained by contacting the Zygo Service Department. Should Zygo's subsequent inspection reveal that the parts were not defective, all expenses incurred by Zygo shall be charged back to the buyer. Defective equipment that is replaced shall become the property of Zygo.

Warranty period begins when the product is shipped from Zygo. In the case of new systems, the warranty period is 12 months.

Replacement parts, service workmanship, used equipment, and refurbished equipment are warranted for a period of 90Êdays.

Exclusions

The above warranty and product support statement applies only to equipment that is an integral part of a Zygo manufactured product. It does not apply to peripheral equipment manufactured by others, such as: computers, printers, vibration isolation tables, et cetera. In such cases, the warranty and the support that the original manufacturer supplies will apply.

In addition, warranty service does not include or apply to any product or part which, in Zygo's judgment:

a. Has been repaired by others, improperly installed, altered, modified, or damaged in any way.

b. Malfunctions because the customer has failed to perform maintenance, calibration checks or good operating procedures.

c. Is expendable or consumable (such as panel lights, fuses, batteries, windows, and filters) if such items were operable at the time of initial use.

d. Requires replacement because of decomposition due to chemical action.

e. Fails because of poor facility, operating conditions, or utilities.

Other than expressly decribed above, Zygo makes no express or implied warranties, including any regarding merchantability or fitness for a particular purpose relating to the use or performance of the equipment. Zygo will not be liable for personal injury or property damage (unless caused solely by its own negligence), loss or profit or other incidental or consequential damages arising out of the use or inability to use the equipment. Nor does this warranty apply to any equipment which has been subject to misuse, neglect or accident; or repaired or altered by other than service representatives qualified by Zygo.

Summary

The Mark III System is a low maintenance system. Operating it as specified is one of the best ways to keep it running smoothly.

If it becomes necessary to clean the optics you use with the Mark III, be sure to follow the Optics Cleaning Procedure in this chapter exactly.

Appendix A

Optical Components Handling Tips
Optical Cleaning Materials Suppliers

Hints for Handling Optical Components

The Zygo optical components you use with your Mark III System will provide you with many years of quality service provided you follow established guidelines for using and handling them. Some general reminders appear below.

- Don't touch the surfaces of optical accessories. Fingerprints are one of the worst contaminants. There are acids and salts in skin oils that can cause corrosion of both coated and uncoated optical surfaces. Other contaminants that are particularly destructive include smoke, airborne lint, dust, and moisture.
- Don't attempt to clean the surface of any Zygo optical component unless you have had previous experience in optical cleaning techniques. A detailed optical cleaning procedure is provided in *Chapter 8* of this manual.
- When you are done using an optical component, promptly return it to its protective box with the front surface down.
- Don't overtighten screws that hold an optical accessory in place. This can distort the accurate reference surface.
- When you work with mounted optical components, keep in mind that sudden moves or slips when applying force can result in a broken component.

The following list contains the names, addresses, and telephone numbers of the manufacturers of optical cleaning chemicals mentioned in *Chapter 8*.

Aldine Paper Company
315 Park Avenue South
NY, NY 10010 Telephone: (212)505-1000

Fisher Scientific
52 Faclem Road
Springfield, NJ 07081 Telephone: (201)379-1400

KWW Warehouse Chemicals
Main and Maple Street
Warehouse Point, CT 06088 Telephone: (203)623-4449

Laminare Corporation
960 East Hazelwood Avenue
Rahway, NJ 07065-0106 Telephone: (201)381-8200

Multigraphics
379 University Avenue
Westboro, MA 02090

Appendix B

Glossary of Terms

Interferogram Scale Factor

Decimal to Fraction Fringe Conversion

Glossary

ASCII	American Standard Code for Information Interchange. This code is understood by many different devices (computers, printers, plotters, etc.), making data transfer between devices possible. The code is made up of 256 characters that represent letters and numbers in 8-bit bytes.
ANALOG	A device or system that uses the characteristics of an electrical signal, or the position of a mechanical indicator, to represent information or physical properties. For example, the mercury in a thermometer that shows temperature, or the electrical signals that are used to create a television picture.
BAUD	A unit of measurement for the speed of data transmission over a communications line.
BIT	Abbreviation for binary digit. It is the smallest unit of information stored in computer memory.
BUFFER	A temporary storage area in memory. The buffer is like a rest stop for incoming information that can't be processed immediately. As soon as the processor is ready for more information, the buffer sends the stored information on its way.
BYTE	The amount of space it takes to store one letter, symbol, or character. Eight bits equal one byte.
CPU	Abbreviation for central processing unit. This portion of the computer contains circuitry which controls main memory, instruction processing, timing signals, and arithmetic functions.
CLEAR APERTURE	The square area of light comprising the total test area displayed on the video monitor.
COLLIMATOR	An optical device that converts converging or diverging light rays into parallel rays.
COMMAND	An instruction the user enters that tells the program to perform a certain function. The command is entered via the keyboard by either typing a message, or pressing a specific key.
DEBUG	A process in which a problem or mistake within a program is corrected.

DEFAULT	This word can identify both a function and a value. For example: if you are asked to make an entry in the date field, the instructions may say enter a six digit number with dashes in between the month and day numbers. If you do not make an entry, the system will default to a previously established program value, such as 00-00-00. This number is then known as the default value.
DIGITAL	A device or system that uses numbers to represent information or physical properties. It may be something simple like the numbers that represent the amount of gasoline pumped, or more complex like a photograph that is stored as a large group of numbers. In computers and related equipment, the numbers are usually stored and manipulated in the binary form (1's and 0's).
DISK	A device on which to store data. It is circular, has a magnetic surface, and functions in much the same way as a cassette tape does.
FILE	A collection of related data that is treated as a unit and is stored on a disk.
FORMAT	The pattern or method of organizing data on a disk.
HARD COPY	A paper copy of a data file or an image on the screen. Usually produced by a printer.
IEEE-488	See Interface.
INPUT	Any information entered into the computer through the keyboard, or read from a disk.
INTERFACE	Hardware device (modem, cables, etc.) or a software (program) that connects two components that otherwise could not be connected. An interface makes data transfer from a computer to a printer, storage unit, or another computer possible. This usually increases the processing capabilities.
INTERFEROMETER	An optical device used to measure many optical qualities, including surface flatness, radius of curvature, convex surface figure, etc.
LASER	Acronym for Light Amplification by Stimulated Emission of Radiation. A device that produces a coherent, monochromatic light source. This type of light is critical for applications that require precise measurement and alignment.

LED	Stands for light emitting diode. LEDs are used to numeric and alpha-numeric indicators (e.g. time and temperature displays on buildings).
MENU	This is a list of options displayed on the screen. The user chooses from this list to control a variety of program functions
MODEM	Stands for modulator-demodulator. It is a device that both encodes and converts information so that it can be transmitted from one device to another over communication lines.
OPTICAL PATH DIFFERENCE	The measurable difference (or distortion) in the path traveled by recombined wavefronts.
OUTPUT	Information (data) the computer produces. Output is sent to a monitor, printer, disk, or communications port.
PARAMETER	A value that the user supplies which will affect a particular processing function in a program. Sometimes the parameter for a given field will be as simple as a yes or no. In other instances there may be a range which is acceptable.
PARITY BIT	An internal self-check method to determine incorrect transmission of data. Parity bit is also called a check bit and is used to determine if the number of logic one bits in a pattern is odd or even.
PORT	An “entrance-way” for data to enter or leave a computer. The port provides a physical connection point for the data exchange process.
PROMPT	A request for information (from the computer) that you must respond to in order to have processing continue. For example, you must respond yes or no to the Mark III prompt: STANDARD DEFAULTS? (Y/N). the program will not continue until you answer the question.
RAM	Stands for random access memory. This is the read-write portion of memory in the computer. Think of it as blank pages that can be filled with instructions and data. These pages can be reviewed at any time, and changed.
ROM	Stands for read-only-memory. This portion of memory cannot be changed. In essence, the pages are already filled with instructions, data, and addresses, which can only be read.

REFLECTANCE	Identifies the amount of light that is reflected away from the surface of an object. Mirrors provide high reflectance, while a black sheet of paper would provide minimum reflectance.
REFRACTION	The change in direction of a light wave when it passes from one medium to another (e.g. from air to glass).
RS-232C INTERFACE	A special cable and connector that enables auxiliary computer equipment to be interconnected (e.g. terminal to modem) so that data transfer can occur. It got its name from : Recommended Standard number 232, revision C (from the Electronic Industry Association).
TRANSMITTANCE	The amount of light that is transmitted (or passes through) a substance. The amount of transmittance becomes important in certain applications, such as fiber optic devices and complex lens systems.
VIGNETTING	The image on the monitor has no distinct border and shows gradual shading at the edges.

Interferogram Scale Factor

(For some common interferometric setups and for a variety of measured parameters.)

Measured Parameter	Interferometric Setup	Interferogram Scale Factor
Reflective Surface	Normal Incidence, single pass	1 fringe spacing =$\lambda/2$
Reflective Surface	Angle of Incidence = θ , single pass	1 fringe spacing =$\lambda/2$, $(2\cos\theta)$
Reflective Surface	Normal Incidence, double pass	1 fringe spacing = $\lambda/4$
Reflective Surface	Angle of Incidence = θ, double pass	1 fringe spacing = $\lambda/4(4\cos\theta)$
Single-pass transmitted wavefront distortion	Single pass	1 fringe spacing = 1λ
Single-pass transmitted wavefront distortion	Double pass	1 fringe spacing = $\lambda/2$
Double-pass transmitted wavefront distortion	Single pass	1 fringe spacing = 2λ
Double-pass transmitted wavefront distortion	Double pass	1 fringe spacing = 1λ

Decimal to Fraction Fringe Conversion for Mark III/ZAPP

Decimal Value PV or RMS		Fractional Fringe 1/N	Decimal Value PV or RMS		Fractional Fringe 1/N
1.000	N =	1	0.045	N=	1/22
0.500		1/2	0.043		1/23
0.333		1/3	0.043		1/24
0.250		1/4	0.040		1/25
0.200		1/5	0.038		1/26
0.167		1/6	0.037		1/27
0.143		1/7	0.036		1/28
0.125		1/8	0.034		1/29
0.111		1/9	0.033		1/30
0.100		1/10	0.032		1/31
0.091		1/11	0.031		1/32
0.083		1/12	0.030		1/33
0.077		1/13	0.029		1/34
0.071		1/14	0.029		1/35
0.067		1/15	0.028		1/36
0.063		1/16	0.027		1/37
0.059		1/17	0.026		1/38
0.056		1/18	0.026		1/39
0.053		1/19	0.025		1/40
0.050		1/20	0.024		1/41
0.048		1/21			

INDEX

C – continued

D

E

E – continued,

F

G

H

I

K

L

L - continued

M

N

O

P

T

U

V

W

X

Y

Z