# Surfscan® 4500
# Surface Contamination Analyzer

# Service Manual

Tencor

Increasing Personal Productivity Through Training

Text Only: # S302082-27 Rev. A

FOR CLEAN-ROOM USE ONLY

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**This manual is :**
**P/ N XXXXXX-XX**

## Servicing Safety

The Surfscan has two systems that the service technician must be aware of:

1. Helium-Neon Laser

2. High-Voltage Power Supply for the Photomultiplier Tube

The illustration on the next page shows the positions.of the caution labels placed on various parts of the instrument. This product complies with the Class II requirements of the US Bureau of Radiological Health and comforms to the Class I requirements of ANSI Standard Z 136.1 for the safe use of lasers. A report of compliance to these requirements has been submitted to the Center for Devices and Radiological Health (CDRH) by Tencor Instruments.

### Laser

The helium-neon laser is rated for 2 milliwatts with an effective operating power of 0.2 milliwatts. A safety interlock is provided on the laser scan circuit which automatically turns off the laser if the scanning mirror fails to operate and/or if the scan unit cover is removed. **Do not** defeat the function of this safety feature, except where explicitly stated in this Service Manual.

Use of controls or adjustments, or performance of procedures other than those specified herein may result in hazardous light exposure. Laser caution labels are placed on various parts of the instrument for Warning purposes.

### High Voltage

This system contains components requiring high voltage, between 500 and 2500 VDC, and has safety interlocks to prevent operation of the high-voltage power supplys if the Scan Unit cover is removed. Do not defeat these interlocks or attemt to modify them in any way, unless explicitly stated in the Service Manual. The Scan Unit cover should be removed only by a qualified service technician.

## Operating Safety

This system contains a helium-neon laser rated for 2 milliwatts with a maximum operating power of 10 milliwatts. A safety interlock is provided on the laser scan circuit that will automatically turn off the laser if the scanning mirror fails to operate. Do not defeat the function of this safety feature.

| | |
|---|---|
| **Caution:** | **Use of controls or adjustments, or performance of procedures other than those specified herein may result in hazardous light exposure. Caution labels located on both sides of the scan unit cover are reminders of laser hazards. See label reproductions below.** |

| | |
|---|---|
| **Caution** | **Laser radiation when open and interlock defeated. DO NOT STARE INTO BEAM OR VIEW DIRECTLY WITH OPTICAL INSTRUMENTS.** |

| | |
|---|---|
| **Caution** | **Laser radiation when open. DO NOT STARE INTO BEAM OR VIEW DIRECTLY WITH OPTICAL INSTRUMENTS.** |

Pursuant to the Regulations for the Administration and Enforcement of the Radiation Control for Health and Safety Act of 1968 (pertinent to laser products), a document describing this product has been filed with the Consumer Industrial Products Branch (HFZ-312) of the Division of Radiological Products of the National Center for Devices and Rdiological Health (CDRH). This product conforms to the requirements for a Class I Laser product.

## High Voltage

This system contains components requiring high voltage (between 500 and 2500 VDC).

## Company History

Tencor Instruments was founded in December 1976 to develop innovative test and measurement instruments for the semiconductor industry which would be highly precise and reliable, cost effective and easy-to-use. Five months later, the company introduced its first product the Alpha-Step® surface profiler. Designed to help semiconductor manufacturers precisely measure thin-film thickness, it received immediate market acceptance. Within 18 months the Alpha-Step had captured a dominate share of the market for surface profilers -- a leadership position Tencor profilers hold to this day.

In the years since, Tencor Instruments has developed and brought to market a number of precision instruments, many of which have introduced unique technologies. The number of patents the company has received testifies to its continued innovation in the area of product development and enhancement. The company's products continue to be used primarily for process monitoring and other areas of the seimconductor industry. However, in recent years some products have found applications in other industries where precision metrology is required.

Tencor Instruments has grown from a handful of employees to more than 350 today, with 1990 sales exceeding $50 million dollars. Corporate headquarters, including operations, research and development, marketing, and manufacturing facilities are located in Mountain View, California. Sales and service offices are located worldwide.

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# 1 INTRODUCTION

## 1.1 PURPOSE OF MANUAL

This Service Manual has been written to help you repair problems with the instrument and is intended for use by an electronics technician who has previously attended a Basic Maintenance Training Class taught by Tencor Instruments. The technician should be experienced in integrated circuits (analog and digital) and printed circuit board troubleshooting.

Before beginning the actual repair of an instrument, we recommend that you first discuss the symptoms with a Field Engineer or Technical Support Engineer at Tencor Instruments. To aid in minimizing downtime, it is important that the instrument problem first be analyzed and identified as one of the categories below:

- Problems you can fix (included in this Service Manual).
- Problems requiring service by a Field Service Engineer.

Some procedures can be rather lengthy and complex. For example, the precise optical alignments are not done easily without experience, and if performed improperly may cause the instrument to malfunction. Certain procedures are omitted because they require greater skills or tools than most customer service departments can supply. If in doubt, defer the repair to someone with more electronics experience or call the Tencor Instruments Service Department at **1-800-722-6775** for assistance.

## 1.2 HOW TO USE THIS MANUAL

To assist you in locating information, tables, procedures, and specific topics, this manual uses chapter headings, major and minor topic headings within a chapter, bullets, and step-by-step listings.

Each of these headings or listings are itemized in the index, in the back of the manual, for quick and fast reference to a particular topic. Most major topics are located in the Table of Contents as well.

This manual makes use of liberal examples, drawings, and partial schematic drawings to clarify and speed procedures. This manual also makes use of some *very important* typesetting techniques to establish a hierarchy within this manual and to call attention to important lists, cautions and notes, etc. Listed below and on the next page are a few samples of the techniques use for this purpose.

| Warning: | **These are set in a box, use heavy bold type, in a typeface different from the normal text. Warning means that PERSONAL INJURY could occur if proper caution is not exercised.** |
|---|---|

| Caution: | **These are set in a box, use heavy bold type, in a typeface different from the normal text. Caution means that equipment could be damaged or severely mis-calibrated or mis-aligned.** |
|---|---|

Type size is indicative of the **CHAPTER** whereas UPPER case and smaller type size are indicative of the **SUBSECTION** of the chapter. The smaller the type size the deeper you are within a chapter or subsection. See Fig. 1-1.

| | |
|---|---|
| **XX. CHAPTER NAME** | **"DIAGNOSTICS"** |
| **XX.X MAJOR NAME** | **"Trolley Diagnostics"** |
| **XX.X.X MINOR NAME** | **"Trolley Diagnostic Setup"** |

**Fig. 1-1 Manual Hierarchy**

Other important techniques are listed in Table 1-1.

| **Technique** | Meaning |
|---|---|
| *ITALIC NAMES IN SMALL CAPS* | These are SIGNALS within the SFS 4500 |
| Italics in *normal* text | These are important items, *name*, topics, etc within the body text. |

**Table 1-1 Key Typesetting Techniques**

# 1.3 INSTRUMENT DESCRIPTION

## 1.3.1 GENERAL DESCRIPTION

This instrument handles wafers robotically to swiftly measure the size, number, and location of particles in the size range from submicron to 255 square microns. Two configurations of the instrument are available : one Sender and one Receiver, called Two-Indexer; or one Sender and two Receivers, called Three-Indexer. Each Indexer holds a wafer cassette to send or receive wafers; the Transporter system carries each wafers into the Scan Unit for measurement.

**Features**

The Surfscan* 4500 has the following features:

- Submicron Particle Sensitivity - system specification, measured with latex spheres on a bare silicon substrate, is 0.3 $\mu$m diameter with 95% detection probability.
- Non-Contaminating Wafer Transport - robotic Handler with Vacuum Puck eliminates belt handling. The Vacuum Puck is made of a material which is easy to clean.
- High Efficiency Light Collection Optics - maximizes scattered light collection while minimizing collection of background stray light.
- Real-Time Data Collection and Display - high speed digital signal processing (16 MHz) produces Particle Maps, Histograms, and Haze Maps with X-Y particle addressing in real time.
- Menu - Driven Operating System - data, help, and set-up screens for ease of operation.
- Automatic Calibration - closed-loop feedback system continuously monitors and maintains system calibration 400 times per second.

*U.S Patent No. 4,378,159

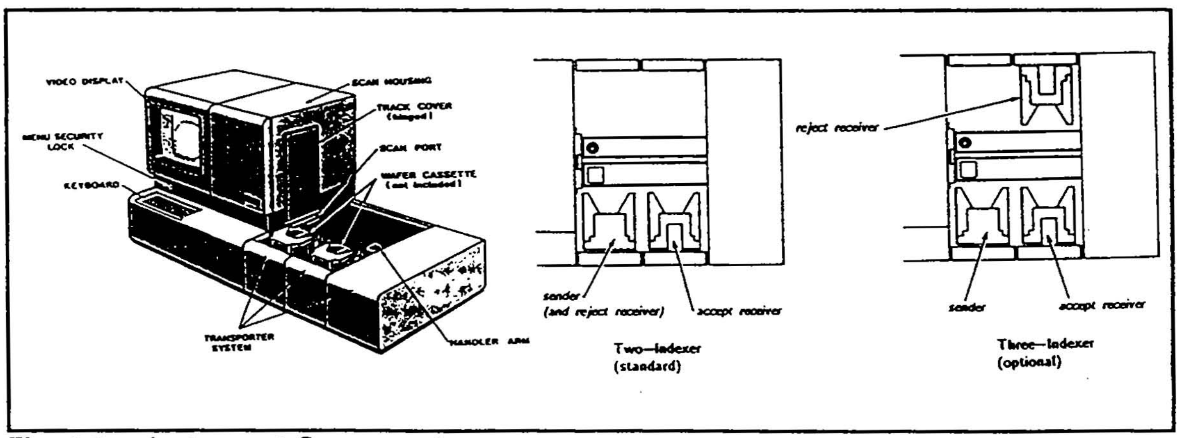



Fig. 1-2 Instrument Components

## 1.3.2 PERFORMANCE SPECIFICATIONS

### MEASURABLE MATERIALS AND RANGES

**Substrate Size**
Diameter of 2", 3", 100 mm (4"), 125 mm (5"), and 150 mm (6"). Two sets of locater blocks are available: PA-72 for 2" and 3", 100 mm, and 125 mm, cassettes; PA-182 for 100 mm, 125 mm, and 150 mm cassettes. (Only one set can be installed at a time. Only one set is provided with the instrument at time-of-purchase.)

**Substrate Thickness**
SEMI standard wafer thickness from 0.3 - 0.75mm. (The scanning beam focuses on this plane above the Vacuum Puck; substrates not on this plane will be measured incorrectly.)

**Material Type**
In most sensitive range, any opaque, polished surface that scatters less than 0.25% of incident light averaged over the substrate. In least sensitive range, less than 5%.

**Particle Sensitivity**
With 90% detection probability, 0.22 $\mu$ diameter latex spheres on bare silicon substrate.

**Haze Sensitivity**
.4 PPM

**Defect-Size Range**
Spacing of 50 $\mu$ between defects.

Programmable between 0.006 $\mu$m and 1024 $\mu$m in seven ranges. Each range can be resolved by 256 graduations.

**Count Accuracy**
± 1%, as measured on VLSI Standards wafer.

**Repeatability**
Defect counts repeatable to 1% at one standard deviation. (Mean count of 500 particles, 1$\mu$ diameter latex spheres.)

**Contamination**
No more than two particles with scattering cross-section greater than 0.5 $\mu m^2$ per 50 passes (with 97% confidence).

## MEASUREMENT SPEED AND THROUGHPUT

**Scanning Beam**
Cycle of 400 laser scans per second.

**Substrate Speed**
During scanning, forward motion at rate of 10 mm/second.

**Throughput**
For 100 mm wafer fetch-measure-unload cycle, 36 seconds.

## OPERATING MODES

**Automatic**
Cassette-to-cassette handling and sorting of 3", 100 mm (4"), 125 mm (5"), and 150 mm (6") wafers.

**Manual**
Cassette-to-cassette handling for same substrates as Automatic Mode, but scan of each wafer must be commanded by operator.

**One-Wafer**
Within specified substrate thickness, handling of any substrate shape up to a maximum of 150 mm across the longest span.

## INSTRUMENTATION FEATURES

**Light Source**
Helium-neon ; 2mW; wavelength($\lambda$) = 6328 Å.

**Automatic Calibration**
An internal sensor is monitored to allow compensation for effects of photomultiplier drift, laser aging, and other long-term circuit drifts.

**Automatic Zeroing**
An internal sensor is monitored checked after each laser scan to ensure measurements independent of ambient light level.

**Overload Protection**
The photomultiplier is automatically disabled whenever the scattered or ambient light level exceeds the detector limits, preventing overload damage and invalid readings.

**Pulse Position Correlator**
Enables defect counting classification to determine defect count to high precision.

## DATA OUTPUTS

**Monitor**
High resolution color monitor. Summary Data (text), Defect Map (yellow), Histogram (orange), and Haze Map (blue). While in Menu mode, screen shows parameters and values. While in Help mode, Help Screens display information for operation and application assistance (a summarized user's manual stored in the Instrument's memory).

**Port**
Serial RS-232C data output port. When keyboard [PRINT] key is pressed, data are transmitted through this port to the external printer (or other device configured to receive serial data).

**External Printer**
Standard printer is a 20-column alphanumeric printer for text data (no graphics). Optional Converter/Buffer interfaces Serial Port to a parallel-input graphics printer, such as Epson FX-80 + ™ or parallel printer port may be used to interface to a parallel printer such as Epson FX-80 + ™.

### 1.3.3 OPERATING SPECIFICATIONS

These specifications should be reviewed to plan for any necessary modifications to the intended installation site.

**Electrical Power**

The Instrument has an assembly called the Power Drawer which transforms and regulates the utility power. Besides supplying the electronics, it also provides an outlet for use by the Monitor. This "courtesy" outlet is intended for the **Monitor only**.

The 20-column Printer has a power cord that does not connect to the rest of the system; this component must be connected to its own utility outlet.

There are four parts of the installation site's utility power to be considered: 1) voltage supply from outlet, 2) power demand, 3) location of outlets, and 4) quality of power.

**Voltage**

The Instrument operates at the voltage selected by the AC Voltage Selector. To switch voltages, refer to the procedure in Section 10.8 - Changing Instrument Voltage Selector.

100 VAC 10%, 50 OR 60 Hz.

117 VAC 10%, 60 Hz.

220 VAC 10%, 50 Hz.

240 VAC 10%, 50 Hz.

The Printer operates at the voltage selected by the Printer Voltage Selector. Each setting allows a voltage range to allow the Printer to use the same utility power source as the Instrument. To switch voltages, refer to the procedure in User's Manual or Section 10.9 - Changing Printer Voltage Selector.

115 VAC 10%, 50 or 60 Hz. (For 100 VAC to 117 VAC.)

230 VAC 10%, 50 or 60 Hz. (For 220 VAC to 240 VAC.)

With a multimeter or probe, check the voltage of the utility power outlets intended for the Instrument. Be sure that the voltage matches the type of line cord plug and the value shown on the AC Voltage Selector of the Instrument's Power Drawer.

> **WARNING: The utility power outlet must be properly grounded to prevent possible electric shock from the metal chassis of the instrument. Check the ground connection BEFORE plugging the line cord into the outlet.**

### Power Demand

Instrument: Single-phase only; 350 VA.

Printer: Single-phase only; 28 VA.

### Outlets

For an Instrument with the standard 20-column Printer, two outlets must be located near the installation site: one for Instrument power and another for Printer power. For an Instrument with the optional Converter/Buffer, three outlets are needed: one for Instrument power, one for the Converter/Buffer external power supply, and another for the 80-column printer. An additional convenience outlet for other devices may be useful.

As shown in Fig. 1-3, there are two types of plugs for the Instrument Power Cord and Printer Power Cord: one type for 100 or 117 VAC, and another type for 220 or 240 VAC. When the Instrument is unpacked, check that it has the correct power cord for the site (contact Tencor Instruments if the other cord is needed).

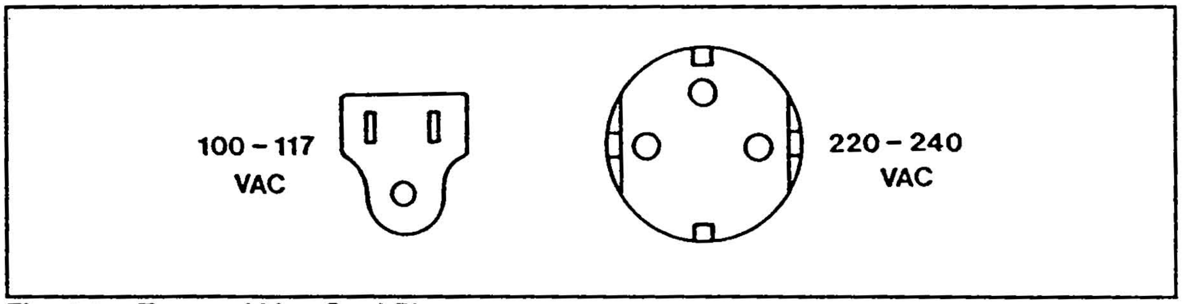



Fig. 1-3 Types of Line Cord Plugs

### Power Quality

If the utility power source has radio-frequency interference from other equipment on the same line, an isolation transformer may provide some radio-frequency filtering in addition to the filtering done by the Power Drawer. Treat the Instrument's power with as much care as a computer deserves; the internal computer and other sophisticated electronics require computer-grade power, free from spikes, dips, and surges. The AC Voltages Selector (on the left side panel ) must match the available utility power. Check this during installation and before operation.

## FUSES

**Instrument**
For 100 VAC or 117 VAC, (2) 5 Ampere slow-blow.

For 220 VAC or 240 VAC, (2) 2 Ampere slow-blow.

These fuses are time-lag, low-breaking capacity. Replacements equivalent to Schurter 034.3124 (5 A) (Tencor P/N 063932) or 034.3120 (2 A) (Tencor P/N 142956) can be ordered from Tencor Instruments.

**Monitor**
For 117 VAC only: (1) 2 Ampere 117 VAC slow-blow.

**Printer**
For 115 VAC (110-117): (1) 1/4 Ampere 125 VAC slow-blow.

For 230 VAC (220-240): (1) 1/8 Ampere 250 VAC slow-blow.

**Temperature**
The normal operating temperature range is 18 to 22 degrees C (64 to 72 degrees F).

**Air Quality**
The Instrument should be operated in an environment of Class 100 or cleaner.

**Room Lighting**
Since the Instrument detects small quantities of light inside its detection system, lighting outside the Scan Housing should be subdued. The Auto-Zero feature of the detection system compensates for normal amounts of overhead illumination, but excessive amounts light may affect the measurement. The tinted-plexiglass track cover helps block stray light.

Under no circumstances should direct light enter the Scan Port. This raises the dark noise level of the photomultiplier tube reducing the sensitivity temporarily. Under some conditions, the PMT can be permanently damaged by intense direct light. (Normal room lighting will not change the dark noise level or damage the PMT.)

**Vacuum**

The Instrument requires a vacuum supply to operate the Vacuum Puck (part of the Transporter System). The vacuum supplied to the Puck holds the substrate in place during fetching, scanning, and unloading. The quality of the vacuum is important - it must be clean with no backstreaming to Vacuum Puck.

It is also very important that the vacuum supply to the instrument **does not have** any tees for other instruments, vacuum wands or accessories.

**Gauge Reading - Port Closed**

The minimum vacuum supplied to the Instrument must be equivalent to 22 inches Hg (gauge reading). Vacuum can range from 22 to 29 inches Hg Fig. 1-4 while the Instrument vacuum port (on the Puck) is **closed** .

**Interference Level**

The Instrument should **not be** operated near heavy emitters of radio-frequency interference (RFI) or in strong electrical or magnetic fields.

**Vibration Limit**

The Instrument should not be operated near sources of vibration, such as fans, motors, or in **excessive flow** of cleanroom laminar flow. Equipment should not be placed on top of the Transporter or other parts of the Instrument or vibration may be transferred to measurement optics.

**Weight**

TOTAL (after installation): 94 kilograms (206 pounds). The cleanroom bench must be able to support the Instrument without sagging. The cleanroom bench much also be long enough to allow all six support feet, on the bottom of the instrument, to rest on the bench. **Do not** position the instrument so that any of the feet are unsupported by the table. This action may cause permanent damage to the instrument or seriously misalign the transporter assembly and chassis. Except for the pedestal feet, no other part of the chassis should be touching the cleanroom bench.

Instrument: 84 kg (184 lb.).

Monitor: 10 kg (22 lb.).

Printer: 1.59 kg (3.5 lb.).

Shipping Weight: 219 kg (482 lb.).

DIMENSIONS

**Instrument**

127 cm (50") wide x 61 cm (24") deep x 64 cm (25") high.

**Printer**

18.8 cm (7.38") wide x 15.5 cm (6.12") deep x 7.8 cm (3.08") high.

**Shipping Carton**

156 cm (61.5") wide x 84 cm (33") deep x 107 cm (42") high.

**PLAN VIEW**

Fig. 1-5 shows a plan view of the Instrument installation site. The bench must be a hard surface (may be a "laminar" type bench) so the Scan Unit and Control Unit's mounting pads hold them with sufficient room for airflow underneath. Allow approximately one foot of free space on the left side for access to the power switch and fuseholders. Allow between 8 to 10 inches of free space behind the Instrument to permit the HEPA Filter Purging Vent to be opened and closed.

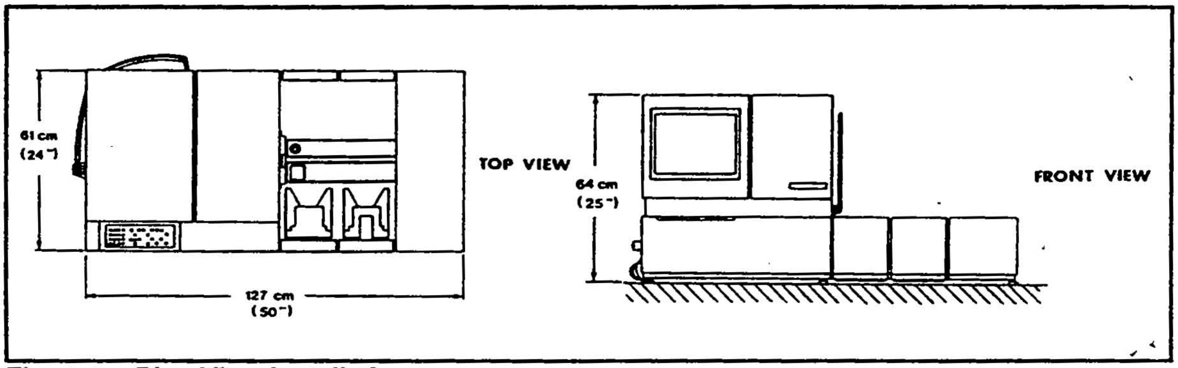



**Fig. 1-4 Plan View Installation**

### 1.3.4 PRODUCT EVOLUTION

| TYPE | WAFER SIZE | SENSITIVITY | PERFORMANCE ENHANCMENTS |
|---|---|---|---|
| SF 100 | 3"-5" wafers | $1\mu m^2$ - 255 $\mu m^2$ | PMT Direct in Split Hemisphere Belt Handling Transport |
| SF 160 | 3"-6" wafers | $.3\mu m^2$ - 25.5 $\mu m^2$ | Ellipitical Mirror & Integrating Sphere |
| SF 164 | 3"-6" wafers | $.1\mu m^2$ - $25.5\mu m^2$ | Ellipitical Mirror & Fiber Optics |
| SF 200 | 3"-5" wafers | $1\mu m^2$ - 255 $\mu m^2$ | PMT Direct in Split Hemisphere No Handler |
| SF 260 | 3"-6" wafers | $.3\mu m^2$ - 25.5 $\mu m^2$ | Ellipitical Mirror & Integrating Sphere |
| SF 300 | 4"-6" Photomask | $1\mu m^2$ - 255 $\mu m^2$ | PMT Direct in Split Hemisphere |
| SF 364 | 4"-7" Photomask | $.1\mu m^2$ - $25.5\mu m^2$ | Ellipitical Mirror & Fiber Optics |
| SF 3000 | 2"-6" wafers | $.01\mu m^2$ - 255 $\mu m^2$ | Integrating Hemisphere, Ellipitical Mirror & Pixel Counting, Robotic Transport |
| SF 4000 | 2"-6" wafers | $.01\mu m^2$ - 255 $\mu m^2$ | Integrating Hemisphere, Ellipitical Mirror & PPC, Robotic Transport TrendTrak |
| SF 4500 | 2"-6" wafers | $.006\mu m^2$ - 1024 $\mu m^2$ | Ellipitical Mirror & Fiber Optics Bundle, Robotic Transport, SECS II Communication |
| SF 5000 | 4"-8" wafers | $.006\mu m^2$ - 1024 $\mu m^2$ | Ellipitical Mirror & Fiber Optics Bundle Robotic Transport SECS II Communication |
| SF 5500 | 4"-8" wafers | $.003\mu m^2$ - 1024 $\mu m^2$ | Improved Optic Plate, "A-frame" Design, Stronger Laser Robotic Transport SECS II Communication |

**Table 1-2 Product Evolutiomn**

## 1.4 INDUSTRIES

Surfscan™ instruments are used in three major areas of semiconductor manufacturing. These areas are: wafer processing, semiconductor processing, and monitoring manufacturing of equipment used in the first two processes mentioned above.

All of these industries use Surfscan instruments to measure cleanliness or contamination levels during a particular process of manufacturing.

Wafer manufacturers use Surfscan instruments primarily as an outgoing contamination inspection instrument.

Semiconductor manufacturers use Surfscan instruments for incoming and outgoing inspection, for cleaning process monitoring, and for equipment contamination to processing monitoring.

Equipment manufacturers use Surfscan instruments to monitor cleanliness of equipment manufactured for wafer processing and semiconductor manufacturing.

# 2 GENERAL THEORY of OPERATION

## 2.1 THEORY

This section covers general light-scattering theory and describes the measurement mechanism used in the Instrument. A brief overview of the data-processing electronics and mechanical transporter is included.

### 2.1.1 DEVELOPMENT OF WAFER INSPECTION SYSTEMS

With increasing integration density, the need for clean, particle-free wafer stock becomes ever more important. Wafer inspection systems that measure the size and number of particles on wafers must use non-contact methods to prevent additional contamination. Since particles are a surface phenomenon, they affect the way light is reflected or scattered. A common example of this can be demonstrated by dust on the hood of a polished automobile. If viewed from the proper angle, the dust can be easily seen. Wafer inspection systems use controlled light to detect particles.

**Types of Systems**

Based on the type of light used for detection, there are two basic types of wafer inspection systems: (1) high-intensity collimated light, or (2) laser light.

**Collimated Light Systems**

High intensity collimated light systems, the earliest type, use bright light from a slide projector or similar sources to illuminate the surface of a silicon wafer. Positioning the light beam so it reflects off the wafer, the inspector examines the surface while avoiding the high-intensity specular reflection. (The word "specular" comes from the Latin speculum, meaning "mirror.") This is dark field inspection, where particles appear as bright specks or spots on the dark background.

**Laser Light Systems**

Most laser light systems work on the same dark field inspection principle: shine a concentrated beam at the wafer surface and measure the amount of light scattered by particles.

**Dark-Field Inspection**

The Instrument uses the same principle for detection as dark-field microscopy. A simplified view of a dark-field inspection system (Fig. 2-1) has two basic components: a light source and a detector. The light is focused onto the surface of the substrate. The specular beam reflects at the same angle as the incident beam. If, however, there is a particle on the substrate, a small portion of this incident light scatters. The scattered light can be measured by placing a detector at an appropriate location.

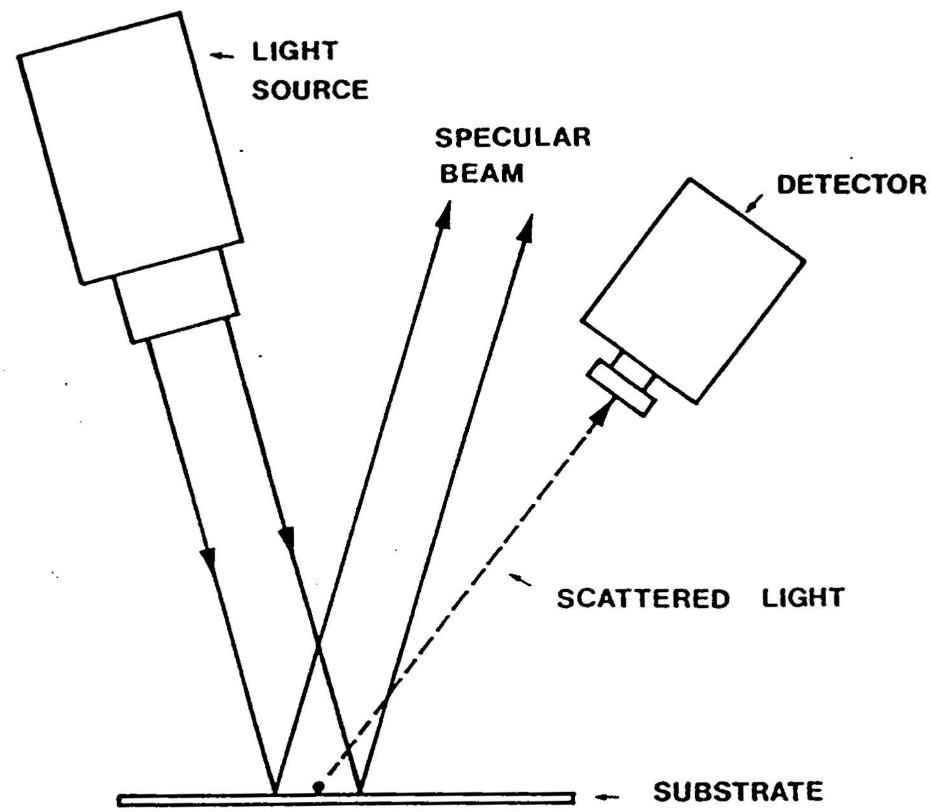



Fig. 2-1 Dark-Field Inspection

**Problems With Early Detection Systems**

Using early collimated-light systems, an inspector simply looked at the surface and counted or estimated the number and size of particles. This was later replaced in some systems by an instant-film camera loaded with sensitive (ASA 3000) film. A time exposure allowed smaller particles to be counted from the picture of the surface.

Later systems replaced the inspector with electronic measurements devices, such as a Vidicon tube and image-analysis circuitry, reducing human error and improving resolution.

However, there were some inherent problems with these systems. Since the detector spanned only a small fraction of the solid angle in which light is diffused, light scattered at most angles did not enter the detector. With only a small portion of the scattered light detected, incorrect sizing could occur.

Other technologies to collect light scattered over wide angles were therefore developed to alleviate this problem. This Instrument uses state-of-the-art technology to extend automated particle detection to submicron levels. However, before describing the Instrument's detection system, this service manual covers some background theory of light-scattering physics in "Scattering Theory."

## 2.1.2 SCATTERING THEORY

**Types of Light Scatter**

Particles scatter light either isotropically or preferentially. Isotropic scattering means that the scattering takes place at many angles and is relatively uniform when viewed from different angles. Preferential scattering means that the light is scattered in only a few selected directions with bright components. To scatter preferentially, the particle must be at least one wavelength long in one or more dimensions. For this discussion, the wavelength, $\lambda = 0.6328\,\mu m$, is that of the scanning laser used in the Instrument detection system. The optimum detection system must cope with both types of scatter in order to handle all types of wafer particles.

Since isotropic scattering is done over many angles, the collection efficiency depends on the shape and collecting properties of the measurement system. A high collection efficiency provides more accurate sizing since more of the total scattered light is collected. The collection angle is therefore made as large as possible to gather as much light as possible.

A large collection angle is also necessary to handle particles scattering preferentially, but for a different reason. For these types of particles, the system must detect light scattered in many different directions so that bright components are not missed. Fig. 2-2 shows a light source causing plane waves of light to shine down on a surface containing particles.

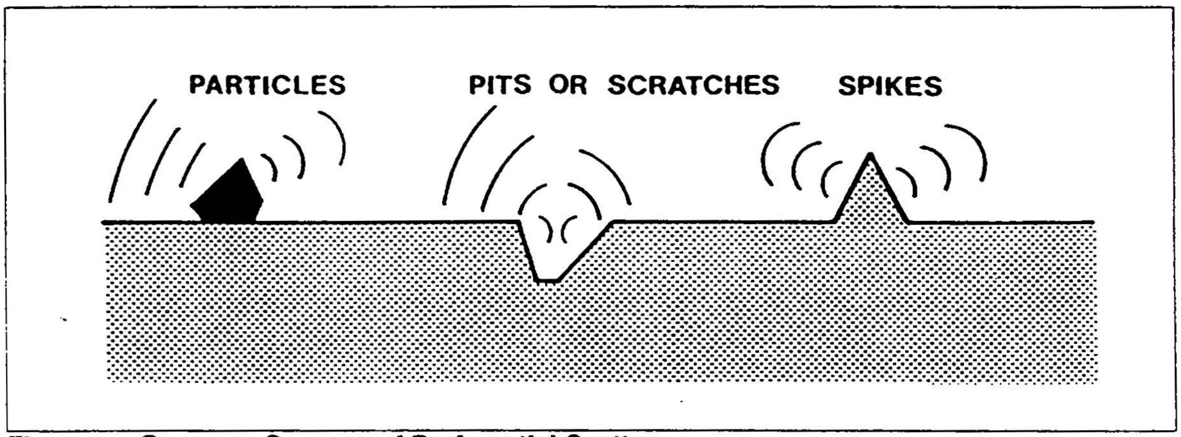



Fig. 2-2 **Common Sources of Preferential Scatter**

If the detector is placed at only one point, the particle can be missed entirely or incorrectly sized. Correct size measurement can only be done if all the scattered light is collected and measured since the amount of scattered light is related to the particle size. A large collection efficiency is therefore a key element, not only for sensitivity, but also for correct sizing.

For example, if a small-collector system has its detector placed at a certain position and the particle is an epi spike (Fig. 2-3), the particle may be only partially seen. With the light impinging from above, the shape of the epi spike causes the scatter of two relatively large components of light. If the collection angle is narrow (such as with a camera lens for a Vidicon tube) only part of the total scatter will be measured since the other components will be missed by the detector. However, this Instrument's collection system covers the top surface of the wafer and both components are gathered.

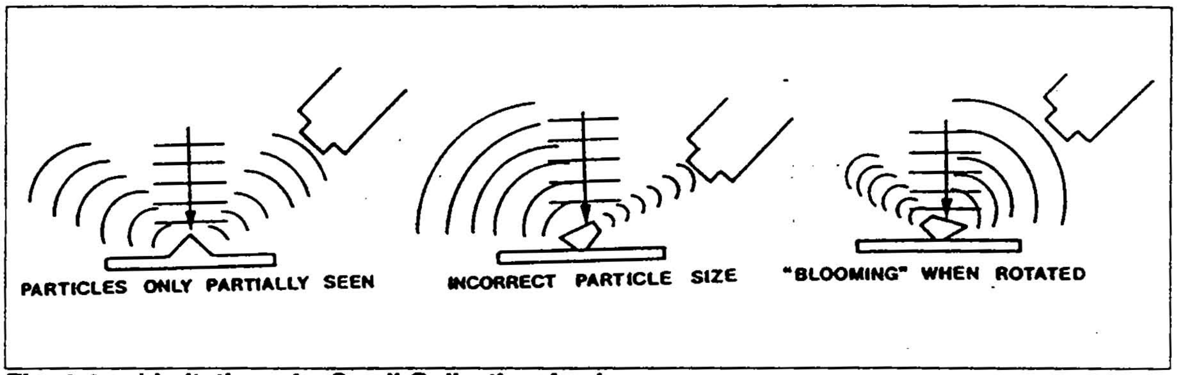



**Fig. 2-3 Limitation of a Small Collection Angle**

Another problem with the small-collector system arises when an irregularly shaped particle is struck by the scanning light. For this case, the detector measures a small component and the larger component is lost in the other direction. If the wafer is then rotated, the large component is measured instead. This leads to incorrect sizing of the particle, with magnitude depending on wafer orientation. Again, with this Instrument's collection system, nearly all scattered components are collected for measurement.

### Defect Classification

From the standpoint of light scattering, surface irregularities can be divided into three categories based on size (Fig. 2-3) compared to the light's wavelength ($\lambda$).

### Small Particles

Isolated particles smaller or comparable in size to k can, to some degree, scatter preferentially. Isotropic scattering can also take place, where uniform scatter is distributed over many angles. This category includes cleanroom dust and ultrafine silicon dust.

### Large Particles

Other particles that in at least one direction are large relative to $\lambda$ tend to scatter preferentially. These include scratches, particles, handling marks, skin flakes, process-related contamination, and other particles.

### Correlated Irregularities

Some irregularities have heights small relative to $\lambda$, but many have spatial dimensions much larger. Called haze, these irregularities may be aggregates of particles covering the surface, chemical residues (including organic films), or a small-scale roughness due to deposition processes or surface textures. In general, haze scatters isotropically. A large collection efficiency is important to accurately measure haze.

### The Mie Theory of Scattering

The physics involved with light scattering from dielectric spheres was explored by Gustav Mie in 1908. He derived a series of equations to describe the light scattering from a dielectric sphere suspended in free space and illuminated by an incident plane electromagnetic wave. By expressing the plane wave in spherical harmonics, he found a correct analytical solution which came to be known as the Mie theory of scattering.

Computers were later used to solve series summations for Mie-theory calculations using specific optical characteristics of polystyrene latex spheres. Since latex spheres, traceable to National Bureau of Standards, can be used to calibrate equipment measuring light-scattering, the background of Mie's theory and interpretation for latex spheres will help describe what the Instrument measures.

**Free-Space Model**

Light incident from the plane wave strikes the sphere and scatters light through a combination of processes: reflection, refraction, and diffraction. Fig. 2-5 illustrates a case for the given wavelength $\lambda$ and diameter D of a polystyrene latex sphere. A relatively large component ($I_f$) is scattered in the forward direction. There is also a smaller back-scattered component ($I_b$). The ratio of $I_f / I_b$ is a function of $\lambda / D$ where D is the diameter of the sphere.

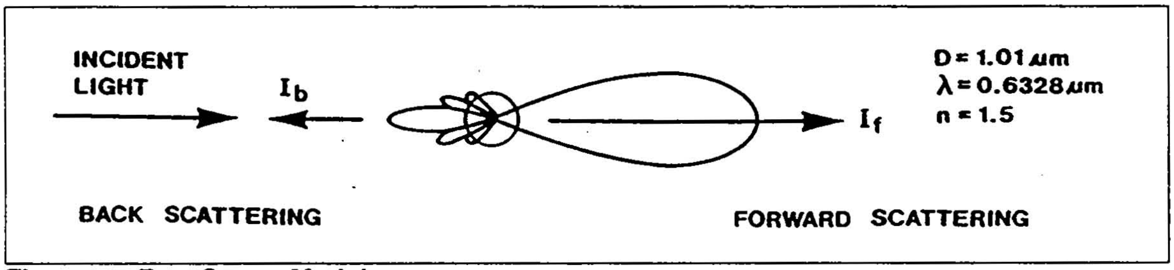



Fig. 2-4 Free Space Model

**Model Including Substrate Effects**

For the Instrument's application, the particle is resting on a surface. The surface is typically a silicon wafer, bare, coated, or metalized. Therefore, Mie's free-space model must be modified to include the effects caused by the surface.

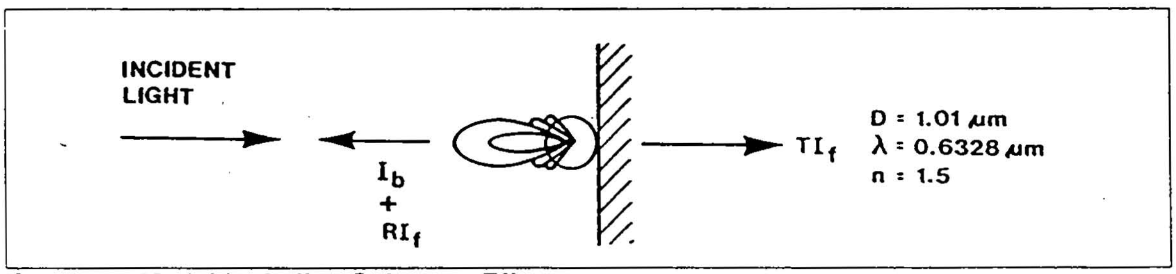



Fig. 2-5 Model Including Substrate Effects

This model, shown in Fig. 2-6, is for a particle resting on a substrate. No correct analytical solutions exist for this model to include the effects of the substrate. The forward-scattered light components are now reflected by the substrate, a fraction of $I_f$ depending on its reflectivity R which is always less than or equal to 1. Furthermore, induced image charges in the substrate alter the radiation pattern. The dielectric properties of the substrate determine the strength of the image charges. Since various substrates have different values of R and different dielectric properties, approximate solutions for a specific substrate may be obtained only through numerical methods.

**The Concept of Scattering Cross-Section**

The Instrument measures the amount of light scattered from a particle as a fraction of the incident beam's intensity. The amount of light scattered from a given particle depends on its shape and on characteristics of the substrate. From the amount of scattered light, an approximate diameter may be inferred, provided that the dielectric constant of the scatterer and the substrate's reflectivity are known.

For example, particles on a silicon wafer coated with a quarter-wavelength of silicon oxide will appear to scatter less than those on bare silicon. A quarter-wavelength film is antireflective since scatter in the forward direction, $I_f$ in Fig. 2-6, passes into the silicon oxide and is absorbed rather than reflected.

Due to the effects of the substrate on scattering, the abcissa of the Instrument's Data Display Histogram expresses not particle size, but scattering cross-section ($d_{sc}$). This is the quantity measured directly; particle sizes can only be estimated once the compositions of the particle and the substrate are known.

**Definitions of Scattering and Geometric Cross-Section**

The amount of light removed from a collimated beam by a particle is defined as the scattering cross-section. Consider a collimated light beam of 1 $cm^2$ cross-section illuminating a particle with uniform intensity. The scattering cross-section is then defined as the ratio of the total light removed from the beam to the light incident on one $cm^2$. Hence

$$d_{sc} = S/I \ (cm^2)$$

where S is the scattered light, I is the incident intensity, and $d_{sc}$ is the scattering cross-section expressed in square centimeters or square microns if the incident light beam is expressed as 1 $\mu m^2$. The units for this Instrument are related in terms of 1 $\mu m^2$ since the particles detected are within the submicron range. Note that S includes all the light removed from the beam through absorption, reflection, refraction, and diffraction. The processes of scattering by a free-space particle are illustrated in Fig. 2-7.

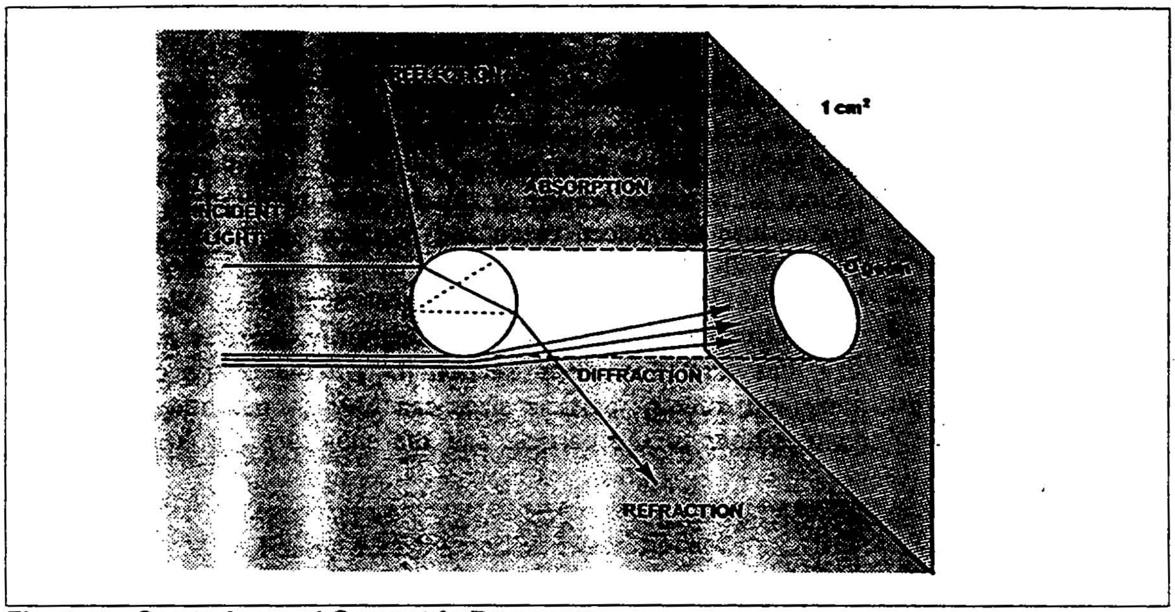



Fig. 2-6 **Scattering and Geometric Processes**

The part of the light intercepted by the scattering cross-section is removed from the collimated beam (Fig. 2-8). A particle with a scattering cross-section of 1 $\mu m^2$ removes one part in $10^8$ from the light incident on 1 $cm^2$ (since 1 $\mu m = 10^{-4}$ cm).

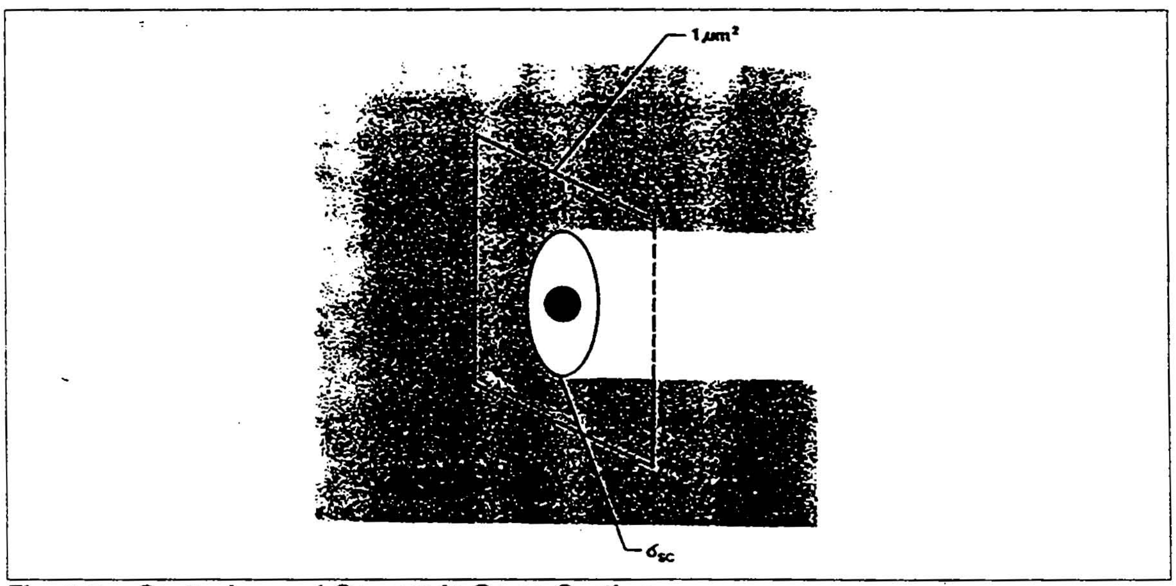



Fig. 2-7 **Scattering and Geometric Cross Section**

The scattering cross-section is not equal to the geometric cross-section of the particle, since it depends upon the optical properties of the particle and the substrate. For a sphere of diameter D, the geometric cross-section ($d_{geom}$) equals $PD^2/_4$.

### Scattering From Large Particles

For particles large compared to $\lambda$, the scattering cross-section approaches twice the geometric cross-section. This seems to contradict physical intuition, but light scattered at any angle is considered removed from the collimated beam. Common sense suggests that the shadow is the light energy intercepted by the geometric cross-section. A second factor is the diffraction of the light filling the "hole" left by the intercepted light. From Babinet's Principle, this is equal to the amount of light intercepted by the geometric cross-section. Since it is no longer collimated, the diffracted light is considered removed from the beam. Hence the total scattering cross-section is twice the geometric cross-section. Normal perception of objects does not take the diffraction into account; only when working at small distances where a shadow is no longer clearly perceived is this second factor noticed. However, this microscopic scale is the mode in which particulates are observed.

### Scattering From Small Particles

For particles with dimensions comparable to $\lambda$, several resonances take place and the scattering cross-section does not vary monotonically with the diameter of the particle. Fig. 2-9 illustrates this phenomenon for a latex sphere in free space.

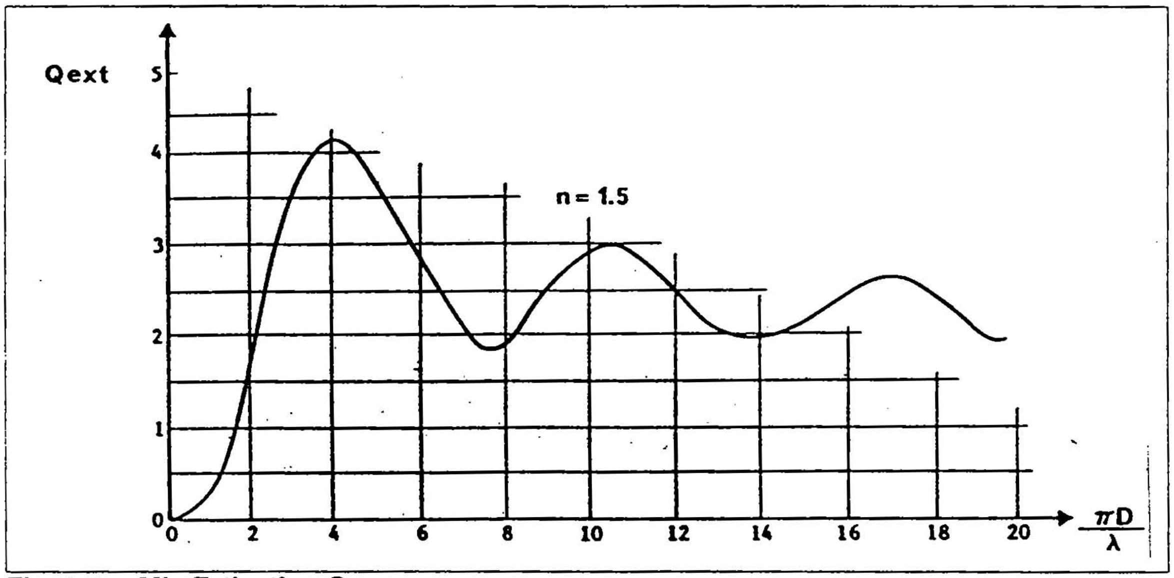



Fig. 2-8 Mie Extinction Curve

Plotted on the ordinate is the quantity:

$Q_{ext} = d_{sc}/d_{geom}$

A term commonly used in scattering theory, $Q_{ext}$, is the ratio of the scattering cross-section (dsc) to the geometric cross-section ($d_{geom}$). The abcissa plots the quantity PD/λ, where D is the particle diameter. For the peak where PD/λ = 4.2, $Q_{ext}$ = 4, indicating that $d_{sc}$ is four times as great as $d_{geom}$. For PD/λ = 4.2 and λ = 0.6328 μm, the corresponding diameter is 0.84 μm.

The scattering cross-section of a latex sphere in free space, based on Mie theory, is illustrated in Fig. 2-9 as a function of the particle diameter. This is basically the same plot as in Fig. 2-8 except that the ordinate is now the scattering cross-section:

$$d_{sc} = Q_{ext}(d_{geom})$$

or, since $d_{geom}$ is the geometric area perpendicular to the collimated beam:

$$d_{sc} = Q_{ext}(Pr^2)$$

$$d_{sc} = Q_{ext}(PD^2/4)$$

This equation has been reduced to the second form to retain D as a common unit. The lower end of the abcissa (0.2 μm) represents the Rayleigh regime, where the scattering efficiency varies as the fourth power, and the scattering cross-section as the sixth power of the diameter D. This explains the difficulty in measuring small particles: a 0.1 μm diameter sphere scatters only 1/64 as much light as a 0.2 μm diameter sphere.

For spheres approximately 1.2 μm in a diameter, a measurement of the scattering cross-section does not allow an unambiguous determination of the diameter. However, for random-shape rather than spherical particles, in general one tends to obtain unambiguous results.

The curves in Fig. 2-9 and Fig. 2-10 are theoretical curves. In practice, the particles of interest are not floating in free space but are resting on a wafer. In addition, the Instrument captures only a fraction of the incident light since the real collection efficiency is not ideal.

The Instrument is therefore calibrated by experimentally measuring the amount of light scattered by 0.364 μm & 1.091 μm diameter latex spheres sitting on a bare silicon wafer as compared to the amount of scatter from a totally diffusing surface. This ratio shows that the scattering cross-section for a 0.364 μm latex sphere is 0.220 $\mu m^2$ and for a 1 μm latex sphere is 0.92 $\mu m^2$. This procedure is done at the factory to calibrate the horizontal axis of the Instrument's Data Display Histogram.

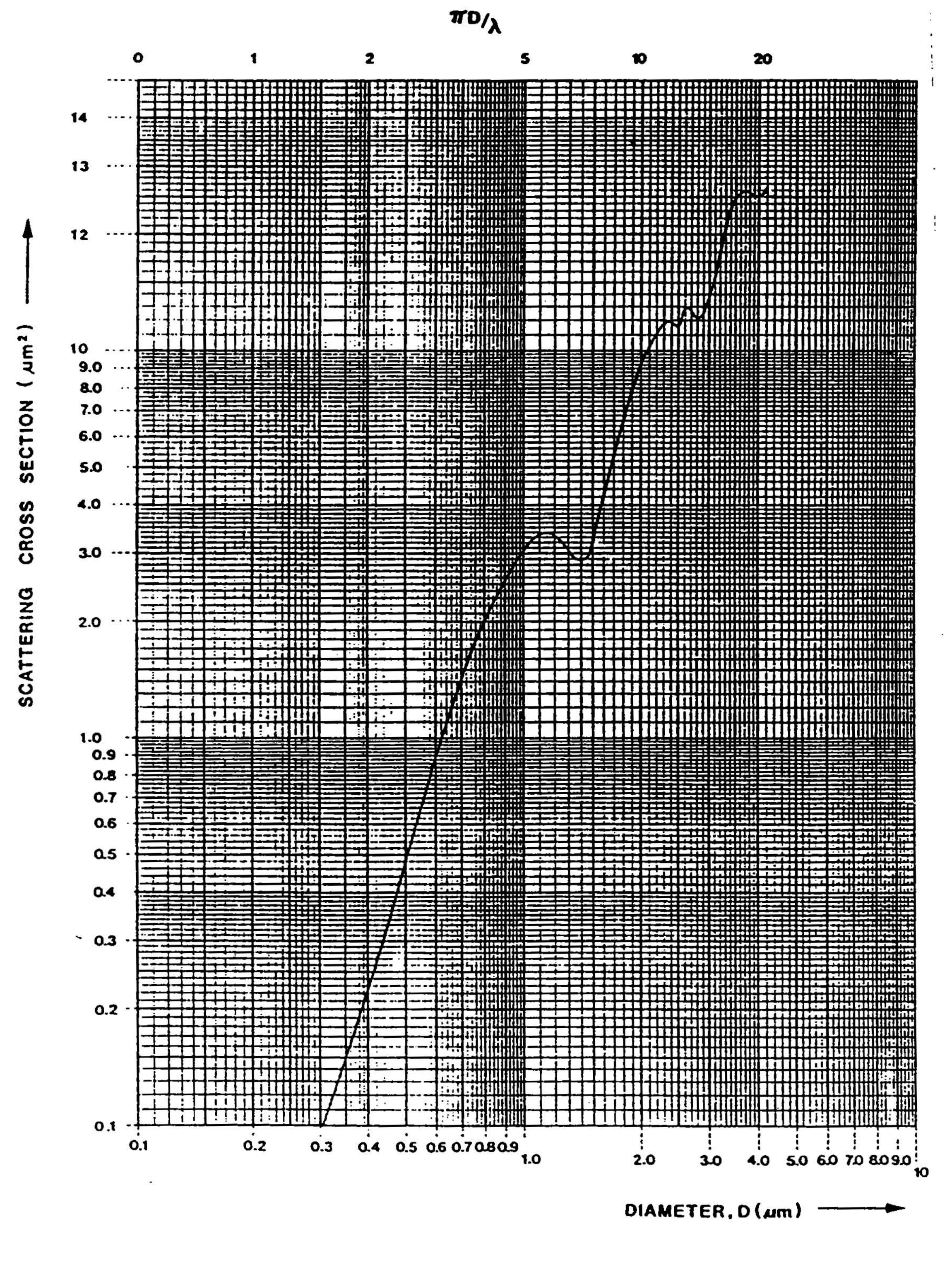



Fig. 2-9 Scattering From Latex Spheres in Free Space

### The Concept of Haze

Haze is generally, although not always, related to the surface roughness of the wafer. Haze is expressed in parts per million (ppm), which refers to the fraction of the incident light captured by the collector. Haze is related to the quantity called total integrated scatter (TIS), which in turn is related to the RMS surface roughness (d) by the equation

$$dR/R_0 \text{ Å} = (4Pd/\lambda)^2 \text{ for } d < \lambda$$

where dR is the haze expressed in decimal form (from ppm) and $R_0$ is the surface reflectivity in decimal form (from %). Approximations of the surface roughness can therefore be made. For example, for silicon with R = 33% ($R_0$ = .33) and a ppm haze measurement of 1000 ppm (dR = 0.001) then d = 27 to 28 Å. This is much smaller than the 6328 Å $\lambda$, so the equation is valid.

Light scattering is a very powerful technique for detecting contamination difficult to detect by any other method. For example, the Instrument readily recognizes a transparent deposit a few hundred Angstroms thick and a few microns in diameter as haze or a particle. Due to the low contrast of these deposits, they may be extremely difficult to find by either optical or electron microscopes.

### Summary of Scattering Theory

Scatter from particles resting on a surface is affected by many factors besides particle size. The dielectric properties and refractive index of the particle change the amount of light scattered by it. The substrate's dielectric properties and reflectivity also change the amount of light scattered and reflected. The Instrument therefore measures the amount of scattered light and further interpretation of particle size must be done after taking the other factors into account.

This describes the physical measurement needed to determine the relative size of particles on a surface. There are three Instrument systems that make rapid wafer inspection possible: detection (including scanning, collection, and measurement systems) signal processing, and substrate handling. The rest of this section discusses these Instrument systems.

**Further Reading**

The following reference list is supplied for those interested in reading more about light scattering. for specific information about Instrument applications, refer to the Application Notebook-contact Tencor Instruments Sales for availability of this guide.

Adley, J. M., and E. F. Gorey. 1970. "The Measurement of Specular Particles on Semiconductor Surface." J. Electrochem. Soc. 117 (July; no.7):971-75.

Bennett, H. E. and J. O. Porteus. 1961. J. Opt. Soc. Am. 51:123.

Bohren, C. F., and D. R. Huffman. 1983. Absorption and Scattering of Light by Small Particles. New York: John Wiley and Sons.

Van de Hulst, H. C. 1981. Light Scattering by Small Particles. New York: Dover Publications.

## 2.1.3 SCANNING SYSTEM

**Scattering Geometry**

Fig. 2-11 shows how a wafer is scanned by a light beam in this Instrument. The incoming laser beam is focused to a small spot at the wafer surface, and any surface particles within the spot scatter light. The specular beam is allowed to pass out of the detector but all other scattered light is collected and then measured with a photomultiplier tube.

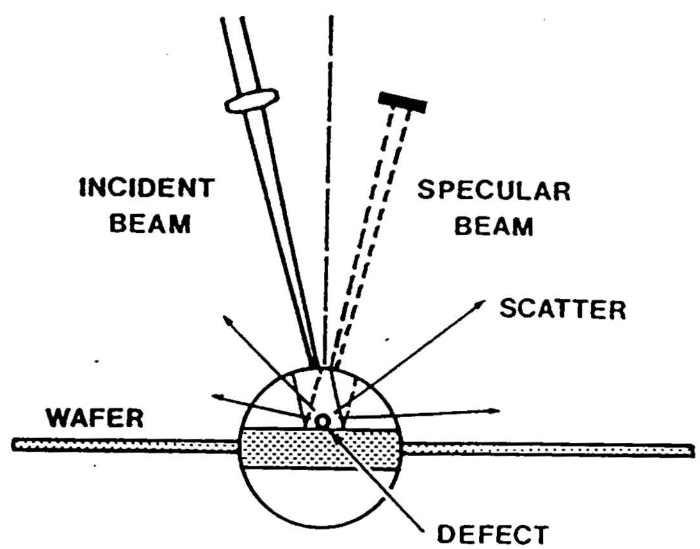



Fig. 2-10 Scan Method

Optical and mechanical systems direct a focused laser beam onto each point of a wafer. The amount of scattered light is measured electronically and stored in memory with position coordinates to permit plotting on the Data Display's Particle Map.

**Beam Generation and Spot Focusing**

The optical system, shown in Fig. 2-12, generates the tightly focused laser beam which scans the substrate. Light from a linearly-polarized laser passes through a double right-angle prism which folds the light path and converts the beam to circularly-polarized light. By using circular polarization, scattering effects dependent on polarization are eliminated. The light then enters lens L1, focusing the light to a spot somewhat smaller than the pinhole in the spatial filter placed at the focal point of L1. The spatial filter removes stray laser light which would otherwise degrade the quality of the final focused spot. The light leaving the spatial filter is turned 90 degrees by the terret mirror M and then enters lens L2. The scanning mirror oscillates, sweeping the beam which is focused by lens L2 at the substrate plane.

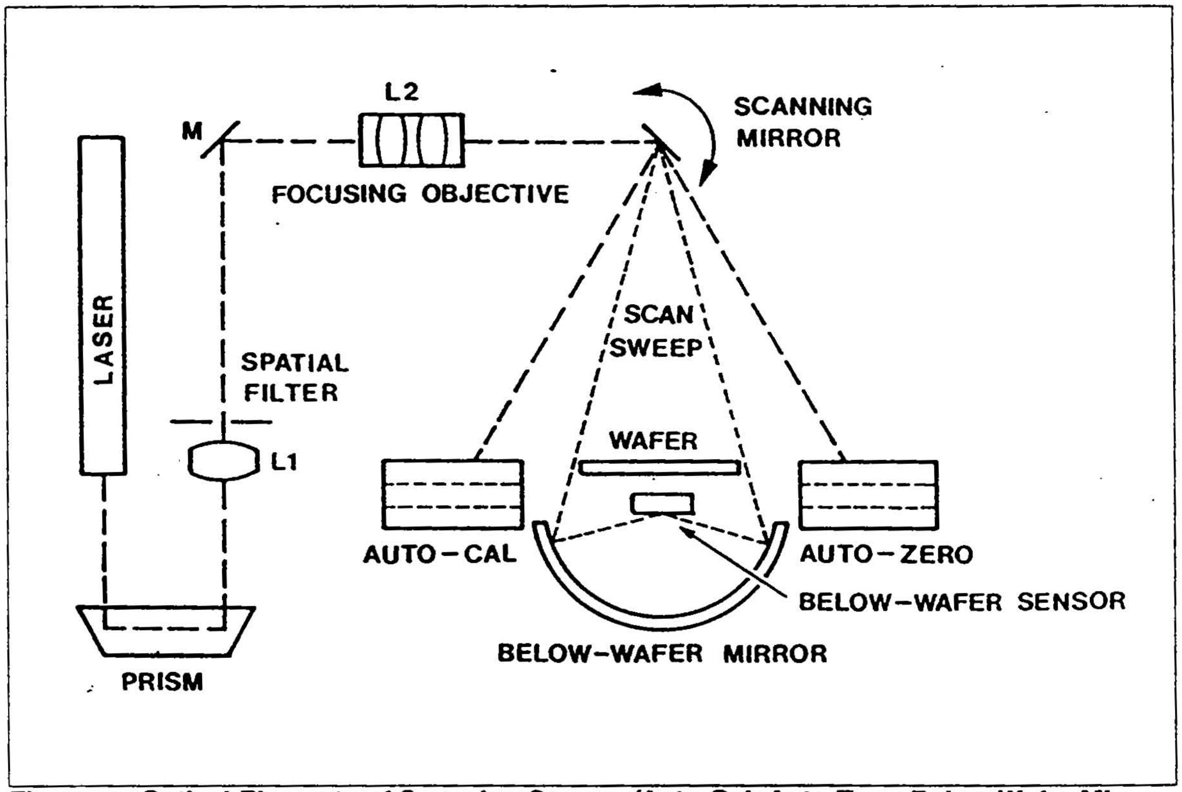



Fig. 2-11 Optical Elements of Scanning System (Auto-Cal, Auto-Zero, Below-Wafer Mirror, and Below-Wafer Sensor are part of Measurement System)

**Scanning Path**

While the focused beam sweeps the wafer, the Transporter slowly steps the wafer perpendicular to the scan line so the focused light spot sweeps the entire wafer surface. The end result is a spot 50 $\mu$m in diameter following scan lines 25 $\mu$m apart.

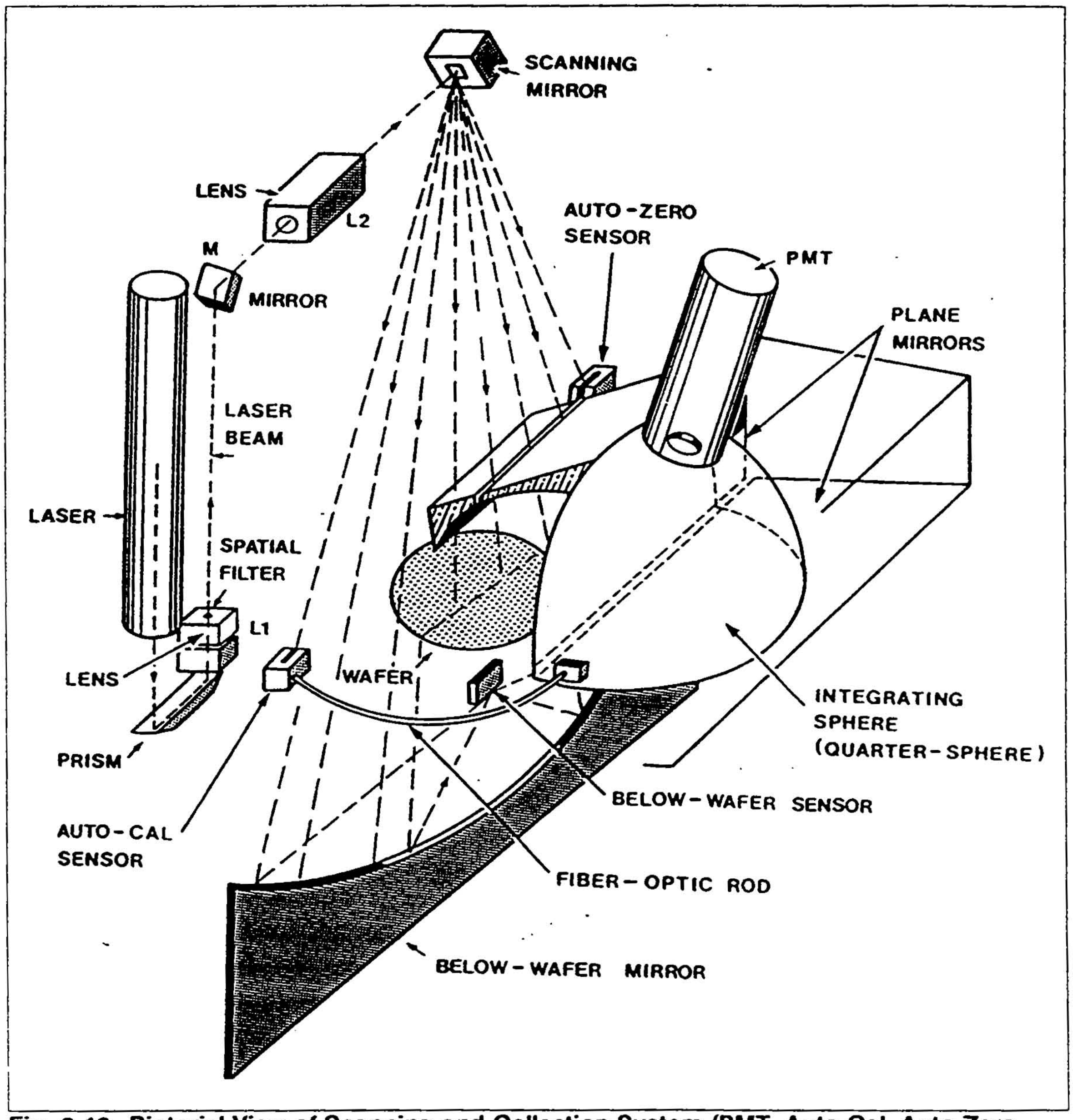



Fig. 2-12 Pictorial View of Scanning and Collection System (PMT, Auto-Cal, Auto-Zero, Below-Wafer Mirror, and Below-Wafer Sensor are part of Measurement System)

The scanning plane of the incoming beam is offset slightly from vertical so that the specularly-reflected (retro-beam) beam can be absorbed by a blue beam-catcher rather than striking the beam-forming optics.

The beam sweeps from the Auto-Zero sensor, across the wafer, to the Auto-Cal sensor. During the retrace time the wafer advances 25 microns, insuring that every point on the wafer surface is repeatedly addressed by the light spot and no particles are overlooked. The combination of scanning-mirror oscillation and wafer travel creates and X-Y laser beam raster scan. The signal produced by the collection and measurement systems during this raster scan is handled by the signal processing electronics like slow-scan video or facsimile data, converting the analog measurement of the scattered light into digital from.

**Focusing and Scan Line Requirements**

The scanning optics produces a beam with tightly controlled focus over the entire area of the wafer to insure that the beam intensity is the same for all particles. If the intensity were not the same, particles of equal size in different locations could scatter different amounts of light and therefore would be sized incorrectly. For the same reason, the overlaps of the scans are tightly bunched (Fig. 2-14) so that a particle is relatively unaffected by the beam intensity across the spot diameter.

In Fig. 2-14, spot A has center a. Corresponding spots B and C have centers b and c. The scatter from each spot is measured and digitized. Due to the digital conversion rate and the speed of the scan, there is a distance of 21 $\mu$m/ conversion. Since the conversions provide discrete sampling points, the scan line can be represented as a succession of spots. This means that the greatest distance between the centers of data points is the length of line ac. The intensity diagram shows how a particle P midway between a and c would be illuminated. The overlap of the scans prevents this worst-case position from receiving less than 89% of maximum beam intensity. Particles, on the average, are exposed to an intensity about 96% of maximum, such as a particle midway between a and b.

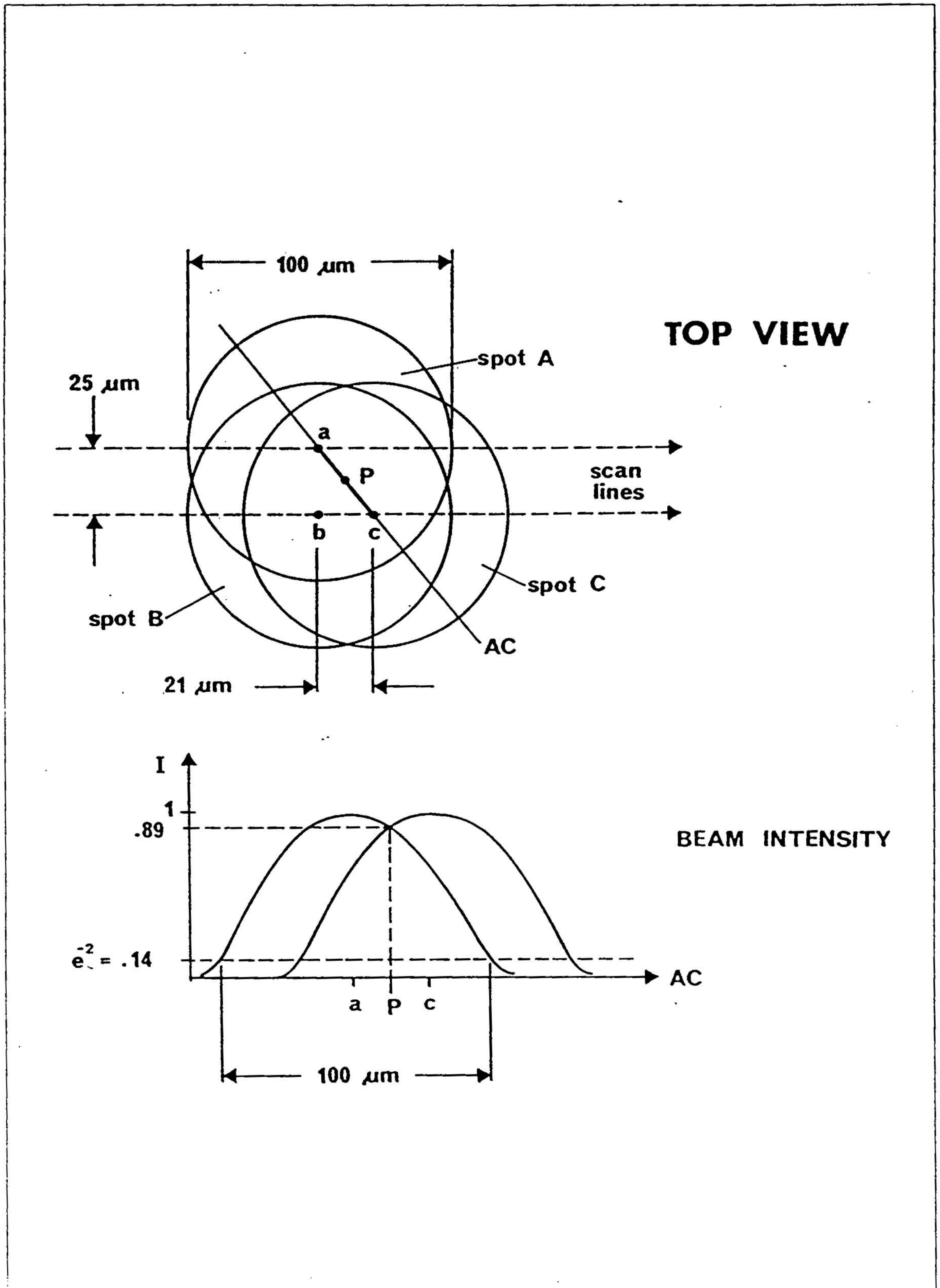



Fig. 2-13 Scan Overlap and Beam Intensity

### 2.1.4 COLLECTION SYSTEM

The scanning optics provides the light signal for the collection system to gather and present to the measurement system. The major components of the collection system are an elliptical mirror and an integrating sphere.

**Elliptical Mirror**

The elliptical mirror collects the scattered light. To understand how this mirror works, an earlier system (Fig. 2-15) can be examined to see how the elliptical mirror improves response. This earlier system had an integrating quarter-sphere consisting of a inner white-painted surface and two plane mirrors spaced a small distance above the surface of the silicon wafer. An elliptical mirror brings the beam through a slot between the two plane mirrors and, with the wafer motion from the handling system, produces the raster scan of the focused spot.

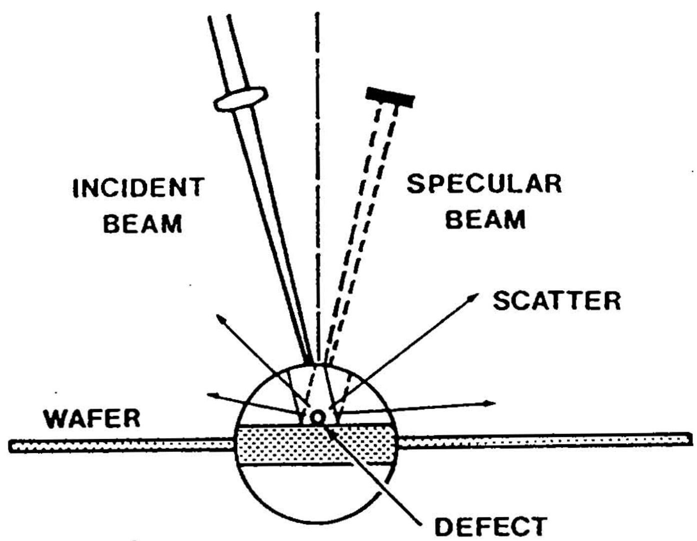



Fig. 2-14 Earlier Integrating Sphere Collection System

A certain amount of stray light or background light around the beam reaches the wafer due to the imperfect optical system. This off-axis light is then reflected or scattered, entering the integrating sphere where it raises the noise level.

This stray or background light level can be considered optical noise, it raises the system's overall signal-to-noise ratio. An apparent solution was to increase the amount of signal. However, raising the beam power to increase the signal also increased the power of the stray light. Therefore, the true solution was to decrease the background noise of the system since there were limitations to the improvements that could be made to the scanning optics to reduce unwanted light.

The elliptical mirror collector used in the present Instrument, Fig. 2-16, significantly reduces the effects from off-axis light. The optical system still has imperfections producing stray light. However, due to the optical properties of the elliptical mirror, any light scattered by particles in the first focal point $F_1$ will always be focused at the second focal point $F_2$.

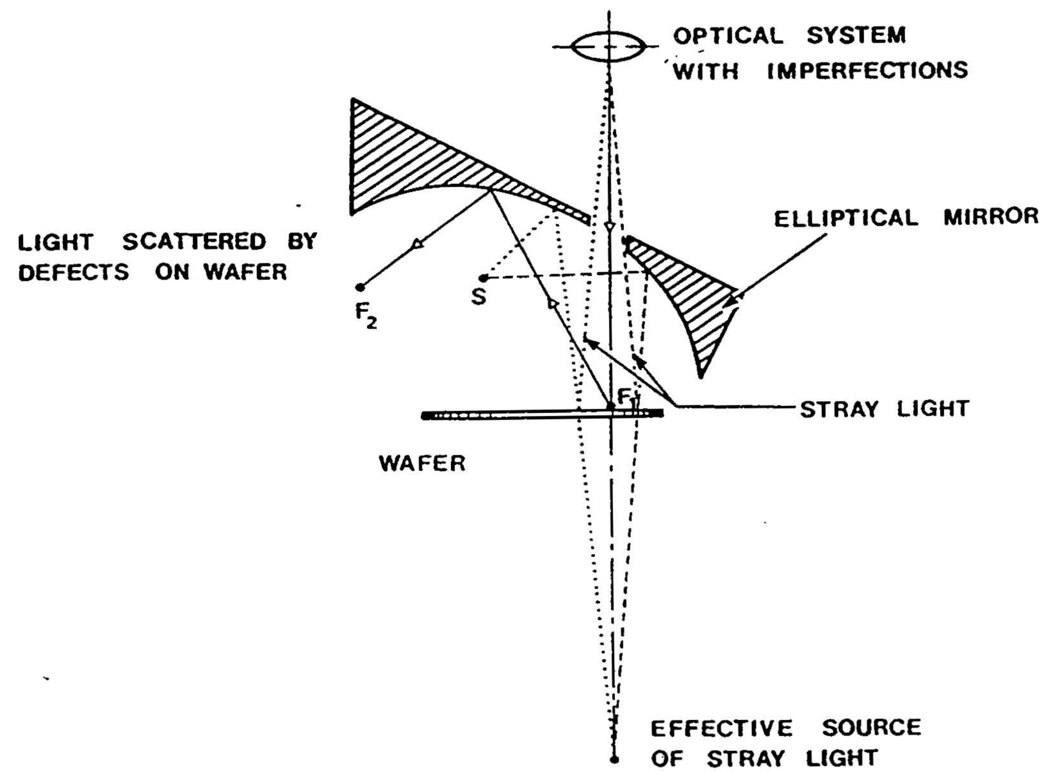



Fig. 2-15 Elliptical Mirror Collection System

Conversely, any light which does not emanate from $F_1$ will be focused at other points. The stray light that comes in with the laser beam is off-axis; therefore it strikes the wafer outside of $F_1$ and reflects at a certain angle up into the elliptical mirror. Due to the geometrical optics of this elliptical mirror, the stray light is focused by the mirror at point S (or other points) and does not enter the integrating sphere.

The large collection efficiency of the elliptical mirror is due to the effective solid angle above the wafer, approximately P out of a possible 2P. This large collection angle of the elliptical mirror avoids problems associated with a small collection angle.

The elliptical mirror has allowed the aperture of the integrating sphere to be placed at point $F_2$, effectively eliminating the beam's stray light by allowing only the particle's scattered light to be measured. Using the elliptical mirror gives the Instrument about an order of magnitude increase in the signal-to-noise ratio without any changes in the incident laser light. Additional refinements in the scanning optics have also been done to improve beam quality. These include improved focus lenses, higher quality & lower oscillating frequency scanning mirrors, and higher quality turning mirror.

**Integrating Sphere**

The elliptical mirror collects light scattered by particles on the wafer surface and rejects stray light. The integrating sphere (Fig. 2-17) averages the light entering from the second focal line of the elliptical mirror collector. The directional-averaging properties of the sphere ensure that the scattered-light signal will be essentially independent of scattering angle as well as position of the particle on the wafer surface. This improves response when presented with particles which scatter light preferentially (e.g. scratches, irregular particles, fibers, etc.). The light scattered by particles ultimately reaches the photomultiplier tube (PMT) after multiple reflections from the integrating sphere's plane mirrors and white inner surface.

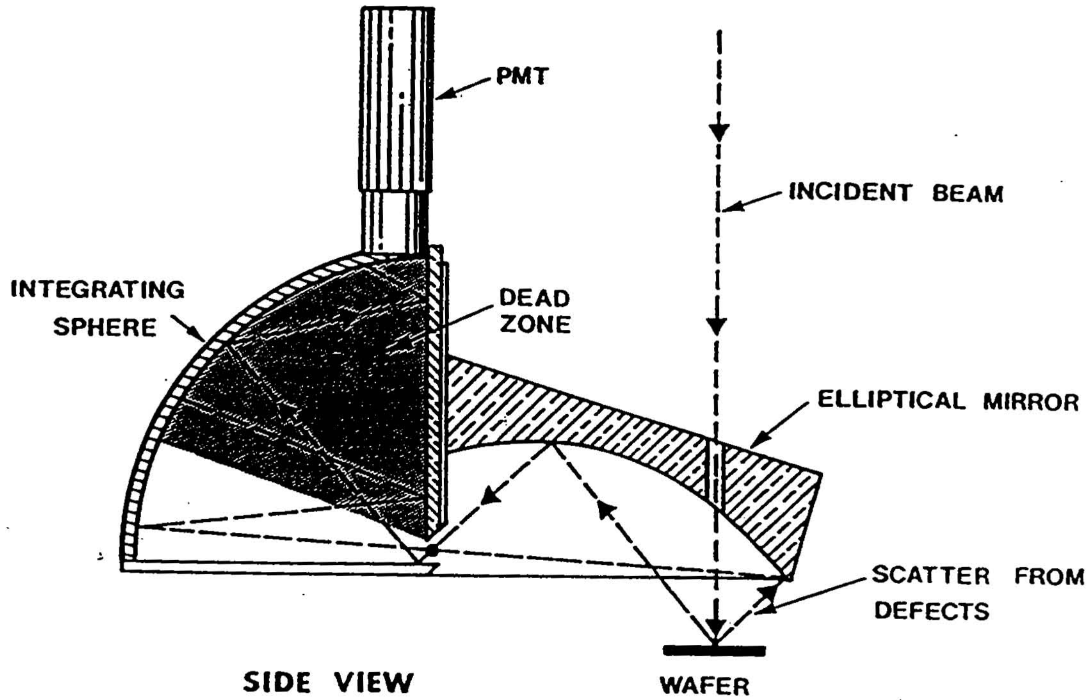



**Fig. 2-16 Elliptical Mirror and Integrating Sphere**

Besides increasing the signal-to-noise ratio, the elliptical mirror creates a dead zone, prohibiting the PMT from ever seeing direct light from the particle. This helps whenever a particle scatters light preferentially toward the entrance of the PMT. In the earlier system, the particle was measured to be larger than actual size because there was no integration of this preferential component. With a dead zone, the response is uniform no matter which direction the light is scattered.

**Fiber Optics Bundle**

The final improvement (Fig. 2-18) to the collection system was to replace the integrating sphere with a high efficency fiber optics bundle and add a set of mirrors to the ends of the elliptical mirror.

The addition of the fiber optics bundle eliminated (or nearly so) the multiple reflections from integrating spheres. The addition of a mirror at each end of the elliptical mirror gave the elliptical mirror an effectively infinite collection view capable of collecting all reflections from particles.

Collectively, these improvements greatly enhanced the signal-to-noise ratio of the instrument allowing accurate measurement of submicron particles.

### 2.1.5 MEASUREMENT SYSTEM

There are three parts of the measurement system: the detector, Auto-Cal, and Auto-Zero. The detector, a photomultiplier tube (PMT), provides an electrical signal proportional to the light focused onto it from the fiber optics bundle. The Auto-Cal and Auto-Zero circuits enhance the performance of the measurement system by providing continuous calibration.

**Photomultiplier Tube**

The photomultiplier tube is used as the scattered-light detector. No other light detector rivals it in terms of the sensitivity, bandwidth and sensitive area. Signal rise times for PMT's can be a few nanoseconds. Under the right conditions, single photons can be detected. The PMT has a large sensitive area of several hundred square millimeters. All of these features make the PMT a high performance detector.

**Auto-Cal Circuit**

The PMT's high performance can be unstable unless proper attention is given to circuit design and PMT control. The Instrument's Auto-Cal circuit functions as a PMT gain controller and stabilizer.

To maintain long-term precision, the measurement system compensates for changes in the laser beam's intensity. The beam may change due to the aging of the laser, which, like an incandescent light bulb, gradually loses intensity over its operating lifetime. Gradual, long-term contamination of the optical system will also cause a decrease in the beam intensity. There may also be slight changes in the laser output due to slight changes in its power supply.

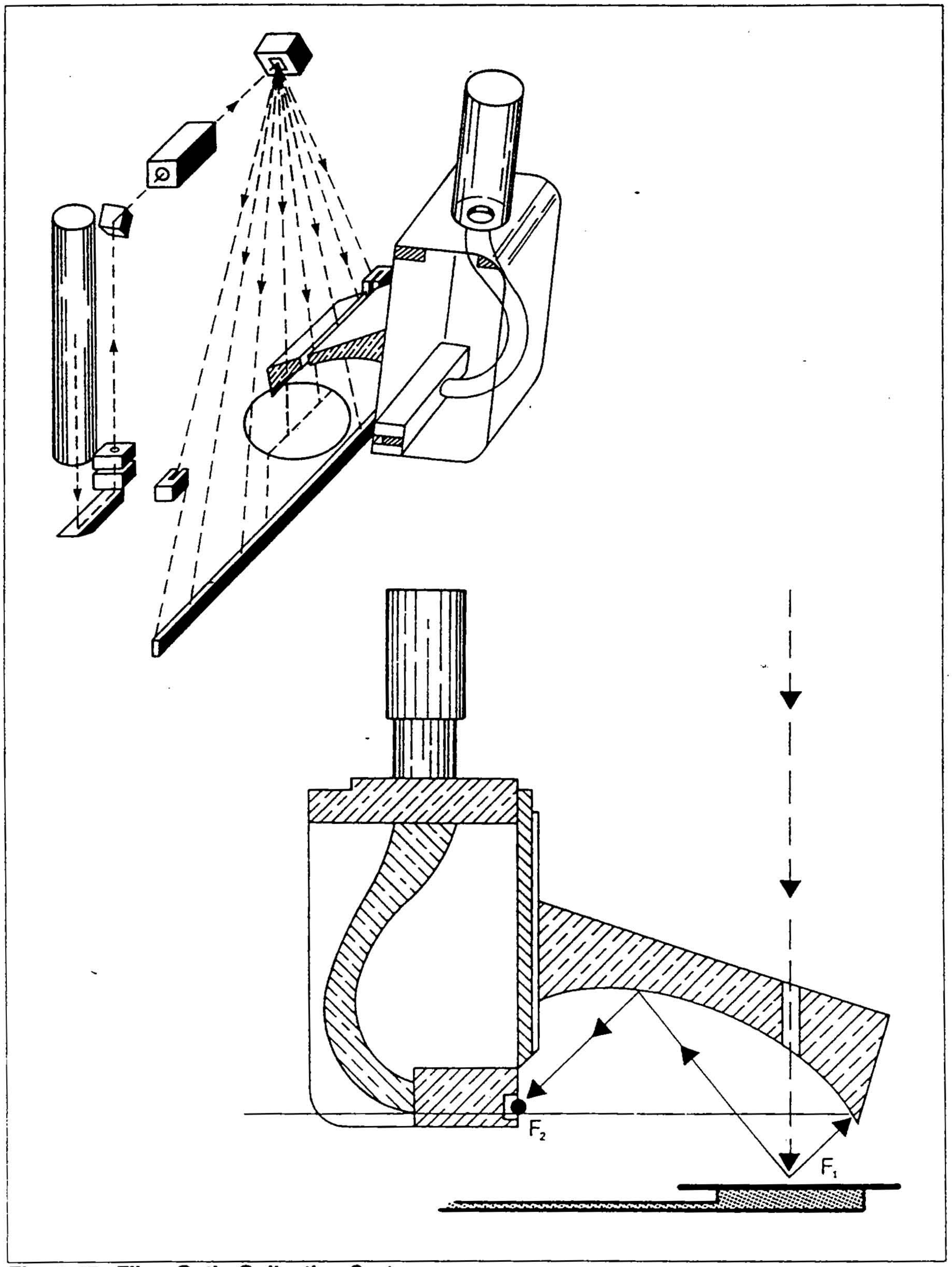



Fig. 2-17 Fiber Optic Collection System

Compensation for PMT aging and power supply changes are also provided. Photomultipliers require high voltages (500-1500 V) and the gain is dependent on this voltage. For example, a 1% change in operating voltage can produce a 6 to 10% gain change. The PMT gain is kept constant by operating it from a tightly regulated, stable power supply. This is not completely satisfactory, however, because of two other PMT phenomena: hysteresis and aging.

Under constant PMT voltage conditions, hysteresis is a gain change that occurs when sudden changes in light input cause internal electric field shifts due to electron bombardment of the tube walls and insulators. Aging is the gradual loss of sensitivity caused by bombardment of the photocathode and secondary electrodes by ions generated from minute traces of residual gas in the tube. Even with a tightly regulated power supply, hysteresis and aging affect the PMT, reducing short-term and long-term precision.

The PMT is stabilized by measuring the gain and compensating for any changes. A feedback circuit continuously measures the PMT gain and removes the hysteresis and aging effects by using the operating voltage as a gain-controlling input in the feedback loop.

The scanning beam enters sensors after sweeping across the wafer. When the laser beam enters the Auto-Cal sensor a small portion is captured and conducted through a fiber optic tube into the fiber optics bundle and, subsequently, the PMT. A precise amount of the incoming laser beam is therefore sampled at a rate of 400 times per second. During the Auto-Cal time interval, electrically defined as while the beam is inside the Auto-Cal sensor, the PMT measures the light conducted by the optical fiber. This voltage offsets (adjusts) the PMT gain.

Because the Instrument sensitivity to particles is also proportional to the PMT sensitivity, holding the PMT signal constant during Auto-Cal automatically guarantees constant Instrument sensitivity. The PMT control card compares the auto-zeroed PMT signal during Auto-Cal with a fixed reference and adjusts the PMT voltage to keep this signal equal to the reference level. The PMT high voltage is held constant during active scans between Auto-Cal and Auto-Zero intervals, but can adapt to changing tube parameters that take place over time intervals greater than 2.5 milliseconds (the time between Auto-Cal intervals at 400 scans per second). This is fast enough to remove the effects of PMT aging and greatly attenuates hysteresis effects.

When new, the PMT operates at a voltage and gain somewhat lower than the "typical" value. This provides a gain reserve that allows the PMT control circuit to increase the high-voltage, compensating for PMT or laser aging while remaining within safe operating boundaries. Protection features shut down the PMT high voltage if excess light reaches the tube, if it is damaged, or if it runs out of its gain reserve due to aging.

**Auto-Zero Circuit**

Due to amplifier offsets, drift, and small amounts of stray and ambient light entering the detector, the signal voltage presented to the particle and haze A/D converters would not be zero even if there were zero light scatter from the wafer. The Auto-Zero circuit removes this offset (error) signal.

The Auto-Zero sensor compensates for any light entering through the scan port from outside the scan housing. This ambient level entering the fiber optics bundle changes when room lighting varies, or other error signals are produced. The Auto-zero circuit has a reference also.

During the Auto-Zero period, the beam enters an Auto-Zero (AZ) detector which generates a logic signal. When the laser beam is on the Auto-Zero sensor, the only light present in the fiber optics bundle is the ambient light. The only signals presented to the electronics are error signals. That ambient light and these error signals are referenced as the zero point. During the Auto-Zero period, the PMT preamp signal is forced to zero at the two A/D converter inputs to correct for relatively rapid drifts or changes in ambient light levels and drifts ro changes in electronic circuits.

**PMT Signal Output**

There are two types of light scatter that the system measures: relatively high-level rapid pulses of light produced by discrete particles, appearing in the PMT output as a pulse, and low-level background scatter due to the nature of the surface of the wafer, appearing in the PMT output as a slowly varying DC component called haze.

A typical PMT output signal is shown in Fig. 2-18. The Instrument uses three levels for measurement: (1) the Auto-Zero level discussed above, (2) the DC level from the haze of the substrate, and (3) an adjustable threshold level for measuring particles.

Different ranges of operation can be represented on this figure by expanding or shrinking the vertical scale. The range of data collection can be changed by the variable PMT gain circuit, or the threshold can be moved up or down. The threshold is measured from the baseline of the Auto-Zero level. Increasing the particle-size range of operation reduces both the DC level and the pulse amplitude. The threshold can be set to prevent wafer granularity from overloading the peak detector circuit.

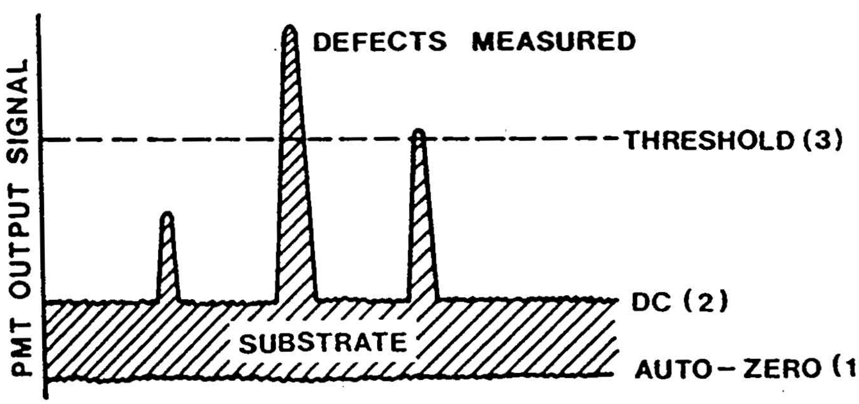



Fig. 2-18 PMT Signal

The variable PMT gain permits visibility on some films which, because of high background light scattering, would not otherwise be possible. By reducing the operating bias of the PMT, the variable PMT gain feature allows continued operation in a high-scatter environment. The reduced bias also protects the PMT from damage.

For low-scatter wafers, you can operate the Instrument at maximum PMT gain by setting the MAX SIZE parameter to its lowest value, 0.256 $\mu m^2$. At this 100% gain level, particles of 0.364 $\mu m$ or smaller size and haze levels of 255 ppm or less can be handled.

However, some wafers, such as polysilicon or metalized, have higher levels of scatter. Some metalized wafers can scatter enough light to trigger the PMT protection circuit. High-gain operation is suspended for these high-scatter surfaces. In these cases, the Instrument sensitivity must be deliberately lowered. This proportionately reduces the scattered-light signals from particles and haze, bringing them back into the linear measurement range of the Instrument. The computer automatically rescales the apparent size of the particles for an accurate Histogram.

### 2.1.6 SIGNAL PROCESSING SYSTEM

After the scattered light has been collected by the elliptical mirror, transfered by the fiber optics bundle, and converted to an electrical signal by the photomultiplier tube, the Signal Processing System can extract the useful information.

**Block Diagram Circuit Theory -Fig. 2-19**

The PMT current signal, containing the particle and haze information, is converted to a voltage by the PMT preamplifier. The Analog Board uses a video amplifier and high-pass filter, for particle data, and an op-amp and low-pass filter, for haze data, to condition the PMT signal before it is presented to the Analog-to-Digital converters. The processing of the particle digital data output from the Analog PCB by the Preprocessor Board extracts the peak value of each pulse along the scan line. The FIFO (First In, First Out) buffer, on the Preprocessor, stores the preprocessed data until it can be sent to the pulse position correlator, PPC, for final processing. The processing of the haze digital data output from the Analog PCB by the Slave CPU Board is called Haze data.

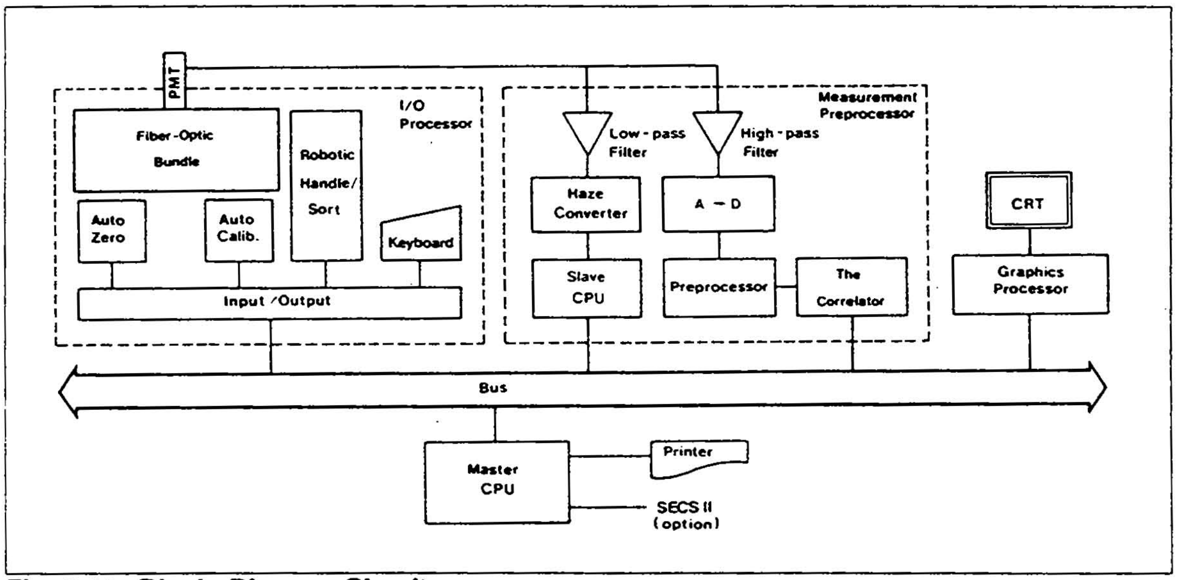



Fig. 2-19 Block Diagram Circuit

**Analog-to-Digital Conversion**

The Y-axis scan (the beam travel) occurs 400 times per second. An 8-bit flash analog-to-digital converter is used to change the PMT analog signal to digital form. This converter samples at 16 MHz, providing a conversion of the PMT signal every 62.5 nanoseconds. This translates into a distance along the wafer of 21 $\mu$m/ conversion as the scan beam travels.

The X-axis translation results from the movement of the wafer by the robotic handler arm of the transporter. This moves the wafer at a rate of 1 cm/ sec, which converts to 25 $\mu$m between successive scan lines.

The information from the Y-axis scan and the X axis location is then correlated in real time to allow the results to be plotted on the monitor.

**Preprocessing Digital Data**

The laser beam has a radius of 50 $\mu$m. Since the scan lines are 25 $\mu$m apart, overlapping occurs. Referencing Fig. 2-20, imagine that there is a typical particle, such as the particle shown, located on the wafer where scan line 7 occurs. A scan across scan line 4 causes no PMT pulse because the distance from the bright center of the scan line to the point where the intensity is negligible is 50 $\mu$m. From scan line 4, a distance of 50 $\mu$m is on scan line 6. Since the edge of the beam is not crossing over the particle, the z-axis, representing the PMT output amplitude, has no height for scan line 4.

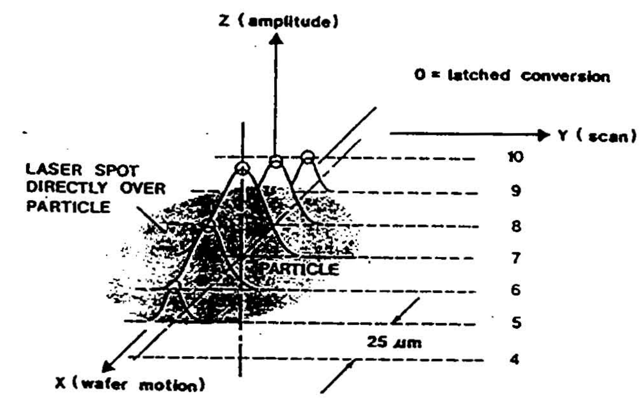



Fig. 2-20 Pulse Generation

After the wafer advances 25 $\mu$m, the beam follows along scan line 5. The lowest-intensity portion of the beam now reaches the particle and is scattered. The PMT thus generates a small output pulse along scan line 5 when the beam passes over the particle.

Since the A/D is converting at a high rate, this pulse is actually converted a number of times as the pulse amplitude increases, reaches a peak, and then decreases. If the conversion is greater than the THRESHOLD parameter value, the Preprocessor latches onto the maximum amplitude for the pulse.

The Preprocessor also classifies Area as larger than 250$\mu$m or exceeding 12 counts or scan lines. This data is later accounted for by the Summary Data value AREA $mm^2$, the total active wafer area covered by Area, measured in square millimeters. Single counts exceeding threshold are accumulated as Particles Total.

If the data is classified as a PARTICLE, the Preprocessor sends the peak magnitude and corresponding y-address to the FIFO buffer. If the data is classified as an AREA, the data is sent to memory separate from the particle data.

Continuing on scan line 6, 7, 8 and 9 for Fig. 2-21, the beam generates more pulses and the latched value of each pulse peak is sent to the FIFO. This process continues for the entire wafer: the Preprocessor finds the magnitude and y-address of each pulse peak and transfers the data to the FIFO buffer.

**Defect Counting Classification**

Data from the FIFO is passed to the Pulse Position Correlator (PPC). The PPC identifies the magnitude and location of each recognized particle.

This data is stored in system memory so the master CPU can categorize the particles into bins and generate the final results. Depending on the Data Display parameter values for particle from and particles to, all particles may or may not be shown in the results. If the range defined by the parameter values include these particle sizes, then they are counted in the Summary Data. The Area Zoom permits examination of a wafer area to determine the amplitude of a particle and it's coordinates relative to the wafer map display.

**Sensitivity**

Sensitivity refers to the smallest pulse height that the Instrument can reliably detect. Particle sensitivity is stated as 0.2$\mu$m diameter latex spheres. Haze sensitivity is stated as .4ppm.

**Resolution**

The Instrument has two types of resolution: spatial resolution and amplitude resolution.

**Spatial Resolution**

Spatial resolution is the minimum distance between particles that can be resolved. That is, how close two particles can be and still be recognized as separate particles. This distance depends on the average intensity of the 50$\mu$m diameter laser beam. Two particles within the laser spot at the same time will scatter light and generate only one PMT pulse. To provide two pulses, two particles must not be within the width of the laser spot at the same time. The spatial resolution is therefore 50$\mu$m minimum.

**Amplitude Resolution**

Amplitude resolution refers to the measurable difference between amplitudes corresponding to two pulses and depends on the range of operation. Since there are 256 divisions of the pulse (because of the 8-bit A/ D), each range can be divided into 256 parts.

In the most sensitive range, corresponding to 0.256 $\mu m^2$ full- scale, the resolution from one pulse to the next can be as fine as 0.001 $\mu m^2$. This is also the minimum bin width for this range that can be shown on the Data Display Histogram.

**Haze Processing**

In addition to transient signals produced when the laser beam scans discrete particles, the wafer may reflect an overall generalized background scatter, or haze. Background scatter is caused by the diffuse scattering of incident light resulting from a non-perfect mirror surface.

For many surfaces, this background scatter is significantly lower than the scatter caused by a particle, so the particles stand out and are easily counted. However, some surfaces have rough or granular surfaces which scatter a great deal of light. Compensating by reducing the PMT gain eliminates the PMT overload and allows the particles to be counted.

The components of the PMT's signal corresponding to surface haziness normally change slowly over the entire measured surface, appearing as a continuous, slowly-varying voltage component at the Preamplifier output. This signal is processed by a low-pass filter, input to a medium speed A/D converter on the Analog Board, and the resulting haze data sent to the central processor through an interface board.

After the scan, the haze data can be extracted to calculate average haze or display a map or haze between chosen limits. Average haze (in ppm) is a number representing the haze averaged over the entire measurement area of the wafer.

**Edge Exclusion**

The zone near the edge of the wafer scatters a good deal of light because the edge of a wafer is generally rounded and not planar like the bulk of the wafer surface. A large specular light signal is directed into the collector when the scanning beam crosses the edges. This can add to the particle count, causing a reject even though the center area is acceptably clean. This edge exclusion zone is be excluded from measurements. Approximately ring-shaped (Fig. 2-23), this edge exclusion zone applies both to discrete particle and haze data storage and display, defining an active wafer area within the exclusion boundaries.

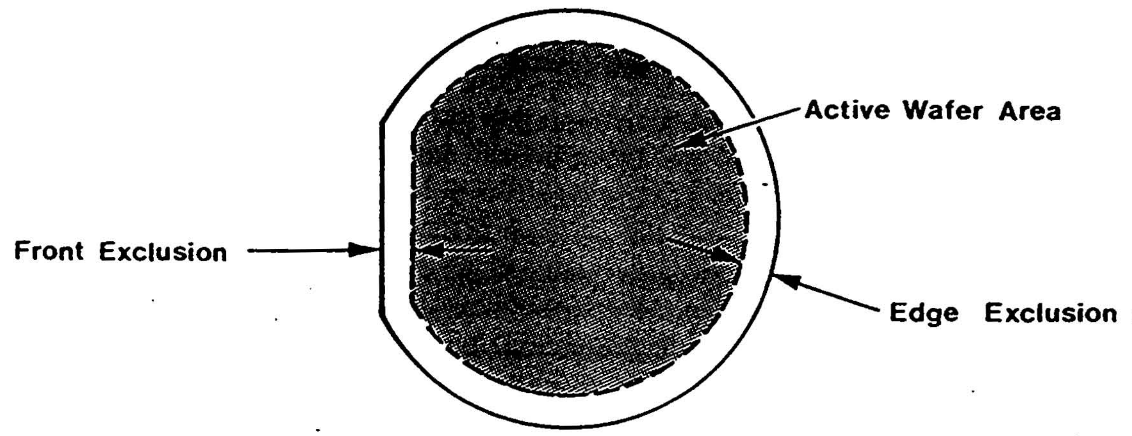



Fig. 2-21 Edge Exclusion

A reference for the edge of the wafer is needed to signal the start of the measurement. This is done by placing a narrow concave mirror beneath the wafer's traveling plane so that when the laser beam is off the surface of the wafer, it reflects into a below-wafer sensor.

This sensor, a small photodiode array, generates the edge exclusion signal on a scan-by-scan basis using current information about the wafer edge location along the scan line and a mathematical model of the wafer shape.

**Substrate Handling System**

The Transporter moves each wafer through the path of the scanning beam for measurement. The Transporter may also sort the scanned wafers into the appropriate Receive Indexer, if the Instrument has sorting capabilities and these are programmed.

A typical measurement cycle starts when the Vacuum Puck grasps a wafer by the back side. Holding it steady with vacuum, the Vacuum Puck removes the wafer from the Sender cassette, rotates 90 degree and moves into the Scan Housing through the Scan Port. The Transporter moves the wafer under the beam. After the wafer has been completely scanned, the Transporter reverses direction and places the wafer in the correct cassette, depending on whether Sorting Parameters have been selected or not.

Further information on programming the Instrument for scanning, sorting, and a tutorial on these topics can be found in Section 3.

# 3 TUTORIAL AND APPLICATIONS

## 3.1 TUTORIAL

If this is the first time you have used this Instrument, read this section to learn the basic operating instructions. By following this hands-on training, you will be guided through the most common procedures.

### 3.1.1 OBJECTIVES

By reading and following the steps in this Tutorial, you will find out how to scan a single wafer. You will be led through all the steps to demonstrate the major operating controls and features of the Instrument. After learning how to scan one wafer, you will be ready to apply the Instrument for real measurements used during maintenance and calibration. This Tutorial will show you how to:

- Power up the Instrument
- Change parameters
- Identify the major components
- Load and initialize a wafer cassette
- Scan a wafer in Manual Mode
- Interpret the Data Display
- Print a hardcopy of results
- Use the Histogram Cursors

This example uses a 125 mm (5") wafer in a wafer cassette. The scan results are then printed for a permanent record. If you use a different diameter wafer, the procedure for changing parameters will help you adjust this procedure for your wafer diameter.

There are four basic operating states: idle, fetch, scan, and unload. Idle means the instrument is waiting for an instruction. Fetch is the phase when the puck picks up a wafer. The scan phase is the period while the wafer is taken inside the instrument, scanned by the laser, and returned outside. Unload is the phase when the puck puts the scanned wafer back into the wafer cassette.

### 3.1.2 POWERING UP

If the instrument is not already powered up, follow this procedure:

1. Check that the AC Voltage Selector value, in the small window on the power receptacle fuse cover, is the same as the voltage supplied by the power outlet.

   DO NOT POWER UP IF INCORRECT VALUE-see "Section 8 Installation" for procedure to change AC Voltage Selector.

2. If the standard 20-column or 80-column printer is connected turn the printer on. If a printer is not available you will not be able to print when this tutorial instructs you to do so.

3. Turn the instrument power switch (on the left side of the instrument) to "1" for ON. The LED on the keyboard should turn ON.

| | |
|---|---|
| **Note:** | **For the most precise measurements, allow the instrument to warm up for at least thirty minutes before scanning. You can continue immediately with the next page, however, since these are only sample measurements.** |

**The following text uses [KEYNAME] to indicate keys on the instrument keyboard, ie; [MENU] indicates the menu key.**

4. Check that the keyboard is active by pressing the button below and to the left of the label MENU. This blank key is the [MENU] key. The one marked NXT is the [NXT] key.

   If the Monitor changes from blank or the Data Display to display the Menu, the keyboard is active.

   If pressing [MENU] did not change anything, the keyboard is temporarily locked out. Turn the Menu Security Lock, above the Keyboard, to the other position. Now the keyboard should be active. Press the [MENU] key again.

5. Now the monitor should display four Quadrants, labeled Data Collection, Data Display, System Configuration, and Sort Parameters. One of the quadrant titles is highlighted (displayed as black lettering on a white background). Press [NXT] to move the highlighting to each quadrant in turn. The [NXT] key selects the specific quadrant for changing parameters. Do not change any parameters yet.

6. Turn the Menu off by pressing [MENU]. The Data Display appears when the Menu is turned off.

7. If the Instrument lacks a HEPA Filter, check that the Purging Vent is closed, or else stray light may affect sensitivity. If the Instrument has a HEPA Filter, check that the Purging Vent is open and press **[HEPA]** to turn the fan ON. The bottom line of the Data Display, called the Status Line, will indicate HEPA while the fan is ON.

### 3.1.3 CHANGING PARAMETERS

The menu provides choices for operating the instrument. Parameters can be changed via the keyboard to allow detailed analysis of collected data. In this part of the tutorial, you'll be shown how to check parameters values and change them.

The menu can be turned on and off at any time by pressing **[MENU]**.

The instrument "falls asleep" after three or four minutes when it is idle, clearing the video monitor to extend its operating life. To "wake up" the instrument, press **[MENU]**.

1. If the Menu is not displayed, press **[MENU]**.
2. Press **[NXT]** until the Data Collection quadrant title is highlighted.
3. Check the values of the parameters with those shown in Table 3-1.

```
                              MENU # 01

DATA COLLECTION                         DATA DISPLAY

EXCLUSION       EDGE:  5 mm             DISPLAY MODE               : COMPOS
                FRONT: 5 mm             DEFECTS [µm²] FROM:   12.00
SUBSTRATE SIZE         : 125 mm                        TO:  256.00
MAX DEFECT SIZE  [µm²] : 256.00         HISTOGRAM      TYPE:    PPC
DEFECT THRESHOLD [µm²] :  12.00                         BIN:   4.00
DATA CORRELATION       : SINGLE         HAZE   [ppm]   FROM:   1200
MAX.HAZE 25600ppm  DYN.RANGE 95%                        TO:  25600

SYSTEM CONFIGUR.                        SORT PARAMETERS

PRINTER  OUTPUT : SUMARY                UPPER LIMITS FOR ACCEPTANCE
         TYPE   : 80 COL   < >
AUTO PRINT      :    OFF                POINT  DEFECTS          :
TRANSFER MODE   : SINGLE                       DEF/cm²          :
CASSETTE TILT   :     ON                AREA DEFECTS            :
SUBSTRATE       :  WAFER                HAZE   AVG.TOTAL [ppm]  :
STATUS DISPLAY  :    OFF                       AREA             :
```

**Table 3-1 Tutorial Parameter Values**

To change a value, press the buttons marked with the "up" and "down" arrows, noted as [↑] and [↓], to move the cursor up and down the quadrant's parameters. The way the value can be changed depends on whether or not the symbols < > are next the be highlighted parameter.

If the < >symbols are not present, use the numeric keys to type values and press [ENT] to enter the change.

If the <> symbols are present, use the [←] or [→] keys to change the listed parameter values. As you press the ←→ keys, the instrument will list values for you to choose. You do not need to press [ENT] to enter these values. They are stored as you move to the next parameter choice or as you switch to the data display screen.

Other keys besides [ENT] will enter numbers for a direct entry parameters are: [↑], [↓], [NXT], [PLT], or [START]. DO NOT press [START] yet, since all the steps have not been done to prepare for the test scan.

4. Check the PRINTER TYPE parameter. Select 20 COL if the standard 20-column Printer is being used. Select 80 COL if the 80-column printer is being used.

5. Check the SUBSTRATE DIA parameter. If you are not going to use a 125 mm (5") wafer for the test scan, change this parameter value to match your wafer.

6. Press [MENU] to store the changes in menu memory and display the data display screen. When [MENU] is pressed after changes are made, the entire menu is stored in non-volatile memory (saved even when power is off). [START] works to store the changes too, but do not press it yet.

**Identifying Transporter Components**

In order to complete the rest of the necessary parameters in the menu, you must now identify the transporter components available for use.

The components of the instrument's Transporter are shown in Fig. 3-1. This transporter system, located on the right side of the instrument, is comprised of the handler and the indexers. The puck, attached to the handler arm shown in Fig. 3-1, carries the individual wafers from the sender cassette into the scan unit for measurement. Each indexer moves its wafer cassette up or down so the puck can unload the wafer depending on the sorting parameters.

Two configurations of the instrument are available:

Two-Indexer (with one Sender and one Receiver) or

Three-Indexer (with one Sender and Two Receivers).

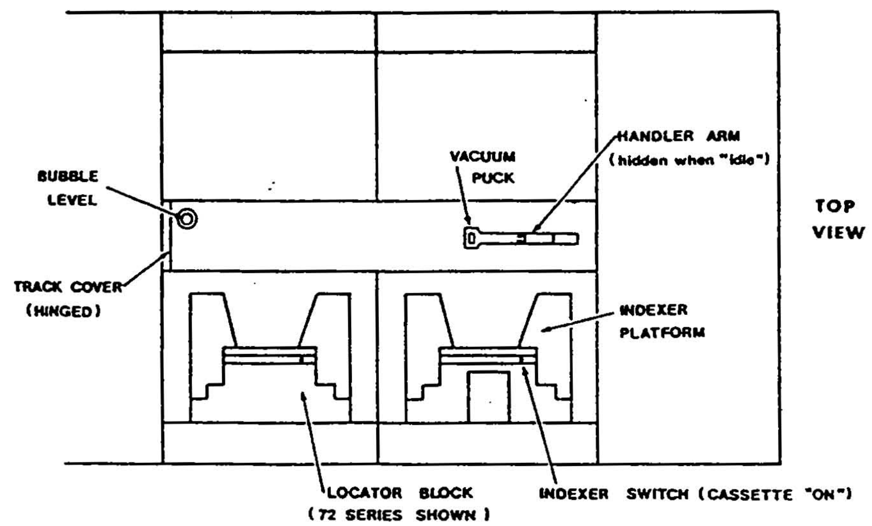



**Fig. 3-1 Transporter System**

The send indexer is used to hold the wafer cassette filled with wafers to be scanned. This indexer is the front one next to the scan housing. The cassette depresses the indexer switch, allowing the instrument to verify that a cassette is loaded before trying to fetch or unload a wafer. Be sure that the cassette depresses this switch. The receive indexer holds an empty cassette into which the sorted wafers are placed.

During this tutorial only one cassette will be used to keep programming and discussion to a minimum. Review Table 3-1, on the previous page, and finish programming your menu to match this menu. Note that the System Configuration menu's Transfer Mode is selected as Single. Single mode selects the send indexer as both send and receive.

**Scanning Test Wafer**

You need a wafer cassette with at least one 5" wafer. There are two types of wafer cassettes that can be loaded on the indexer platform: Series PA-72 or PA-182. These need different Locater Blocks as shown in Fig. 3-2. Use the wafer cassette to match the type of Locater Blocks installed.

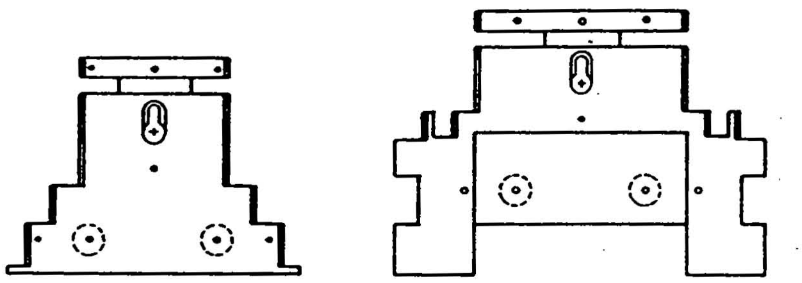



Fig. 3-2 Types of Locator Blocks

To run this test scan:

- load the wafer cassette
- initialize the wafer cassette
- start the scan

**Load Wafer Cassette**

Place the wafer cassette on the tilted sender indexer; platform as shown in Fig. 3-3. The wafer cassette must be held securely in place by the locater block.

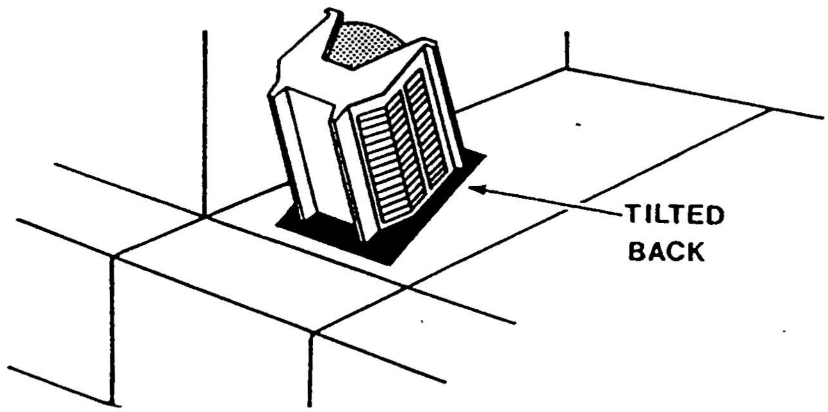



Fig. 3-3 Loading Wafer Cassette

**Initialize Wafer Cassette**

The sender indexer allows the puck to fetch a wafer from any slot of the loaded wafer cassette. The scanning sequence of the wafers in a cassette may be normal or random. For this test scan, you will initialize the wafer cassette so the wafers are scanned in normal sequence starting with the top slot, usually 25, and working down to the bottom, slot 1.

**Press [CASS] to initialize the cassette.**

Press [CASS]. The indexer initializes the loaded wafer cassette by lowering it and optically detecting which slots are occupied by wafers. This inventory is displayed in the Cassette Map Fig. 3-4 with twenty-five boxes stacked vertically. Full slots are revealed by the slot number inside the box. If there is no number, there is no wafer in that slot.

You must press [CASS] to display the cassette map. If you had not pressed cassette and simply pressed [START], the indexer would have move the cassette to the first slot containing a wafer. Scanning would have begun from this wafer. However, you should press cassette and initialize for this test scan.

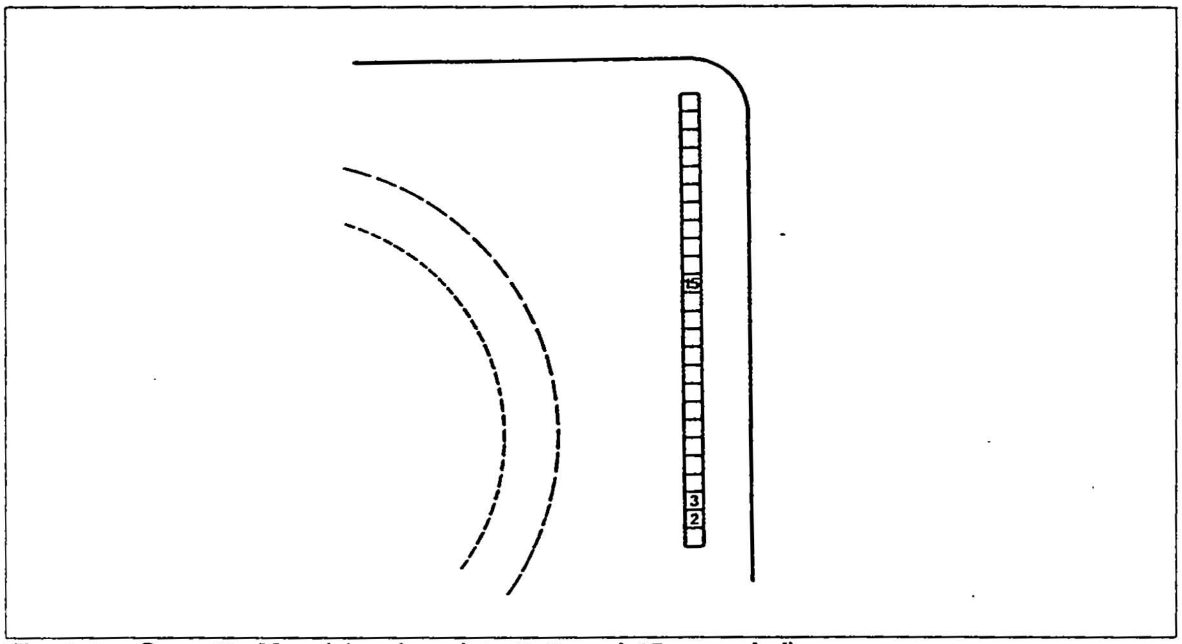



**Fig. 3-4 Cassette Map (showing slots 2, 3, and 15 occupied)**

**Initiate Scan**

Press [START]. The indexer will bring the cassette up to the first slot cantaining a wafer. If the cassette is full then this would by slot 25. For the example shown in Fig 3-4 this would be slot 15.

The puck moves from its home position and slides underneath the top-most wafer. The indexer then lowers slightly to set the wafer on the puck. Using vacuum to grasp the wafer, the puck removes it. This is the fetch phase. With SINGLE as the selected transfer mode the wafer will be unloaded in the same slot as it came from, so the indexer remains stationary.

Do not remove the wafer cassette from the indexer platform while the wafer is on the puck. Always wait until the puck has unloaded and returned to the home position before removing the wafer cassette.

After fetching the wafer, the puck carries it inside the scan housing for measurement. The collected data appears on the monitor as the scan progresses. When the scan is done, the puck carriers the wafer back to the cassette and then returns to the home position.

The unload phase now takes place and the puck puts the wafer back into the wafer cassette. (If you want to take the wafer cassette off, you can do that now.)

The test scan is done. Now you can interpret the results displayed on the monitor.

### 3.1.4 INTERPRETING PLOTTED RESULTS

A plot of the wafer appeared on the monitor during the scanning phase. This data display can be examined in more detail by adding or deleting the particle map, histogram, or haze map. These three types of displays are selected by pressing the **yellow**, **orange**, or **blue** key corresponding to the color of the overlay displayed on the screen. Toggle an overlay ON by pressing its color-coded key; toggle it OFF by pressing the same key again. Any or all these overlays can be displayed together on the data display or the menu.

**Defect Map**

Toggled with [YELLOW], the particle map (Fig. 3-5) shows the outline of the wafer around a blank ring. Data is not collected in this blank edge exclusion; zone. The remaining area is called the active wafer area. The position of particles in the size range between the PARTICLES FROM and PARTICLES TO parameter values are displayed in the active wafer area as yellow display pixels.

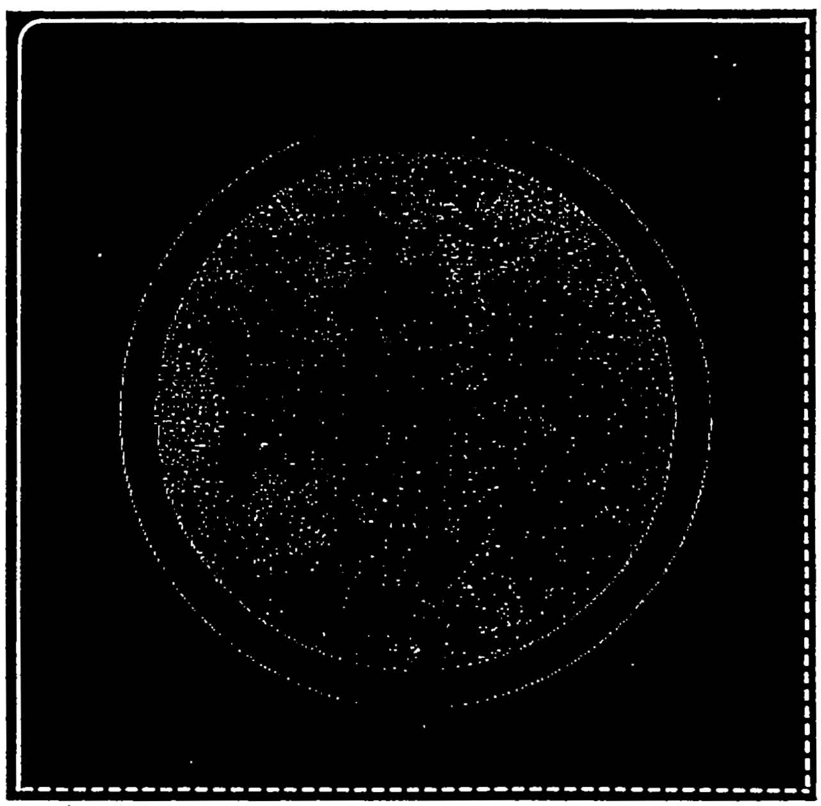


Fig. 3-5 Particle Map

**Histogram**

The orange histogram (Fig. 3-6) presents a vertical-bar distribution curve of the number of particles in discrete size histogram bins. Particle size along the horizontal axis is broken into bins for the range from data display parameters PARTICLES FROM and PARTICLES TO. Defining a small range of particles, the bin width is also one of the data display parameters. The number of particles in each bin is plotted vertically. The horizontal range is set by the values of the data display parameters; the Instrument automatically scales the vertical range for the most useful histogram. This overlay is toggled with **[ORANGE]**.

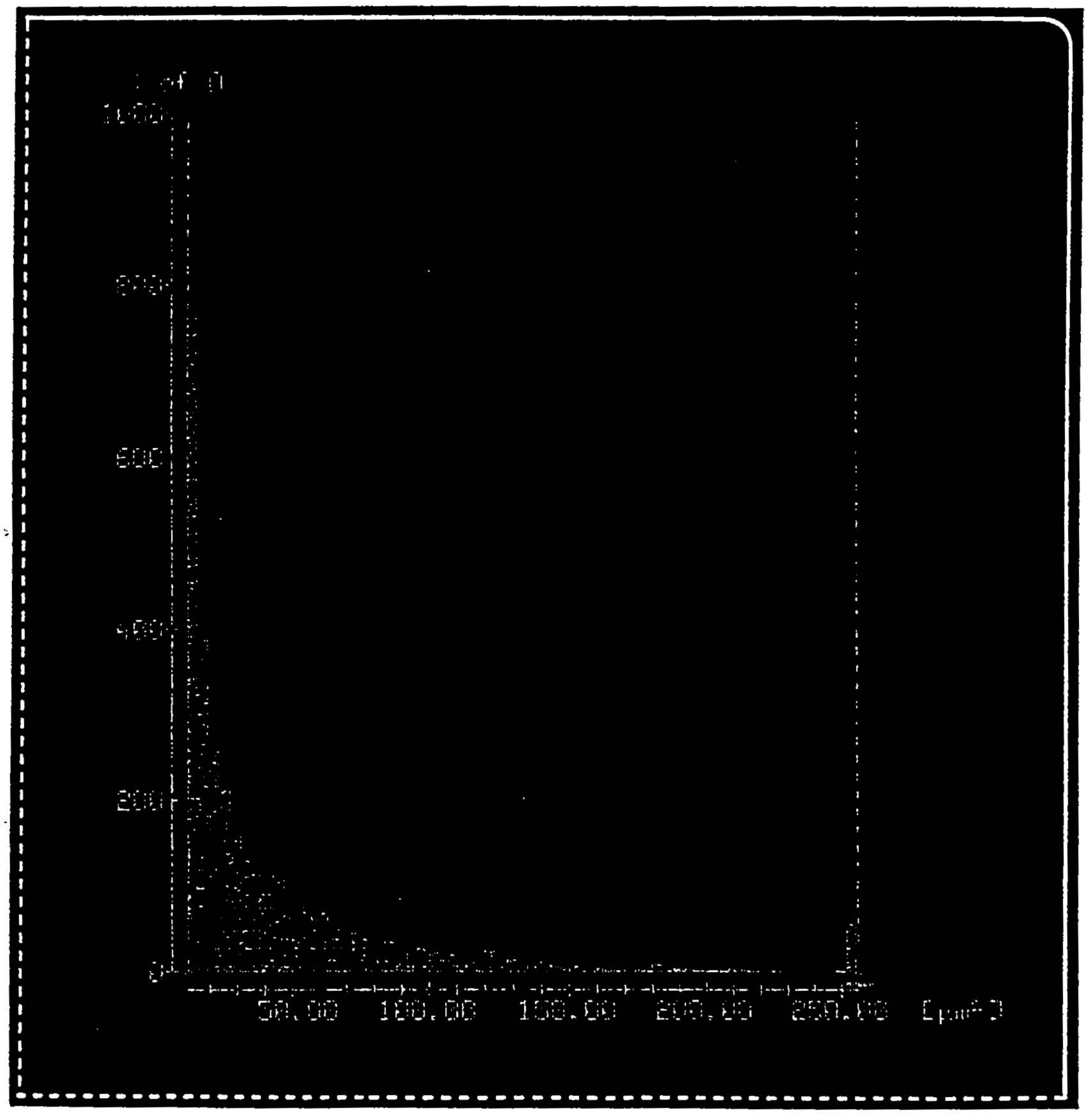



**Fig. 3-6 Histogram**

## Haze Map

The haze map (Fig. 3-7) displays the haze within the active wafer area. Areas with haze levels within the range set by the HAZE FROM and HAZE TO parameter values are displayed in blue. Haze is useful for judging the wafer's overall surface roughness. This overlay is toggled with **[BLUE]**.

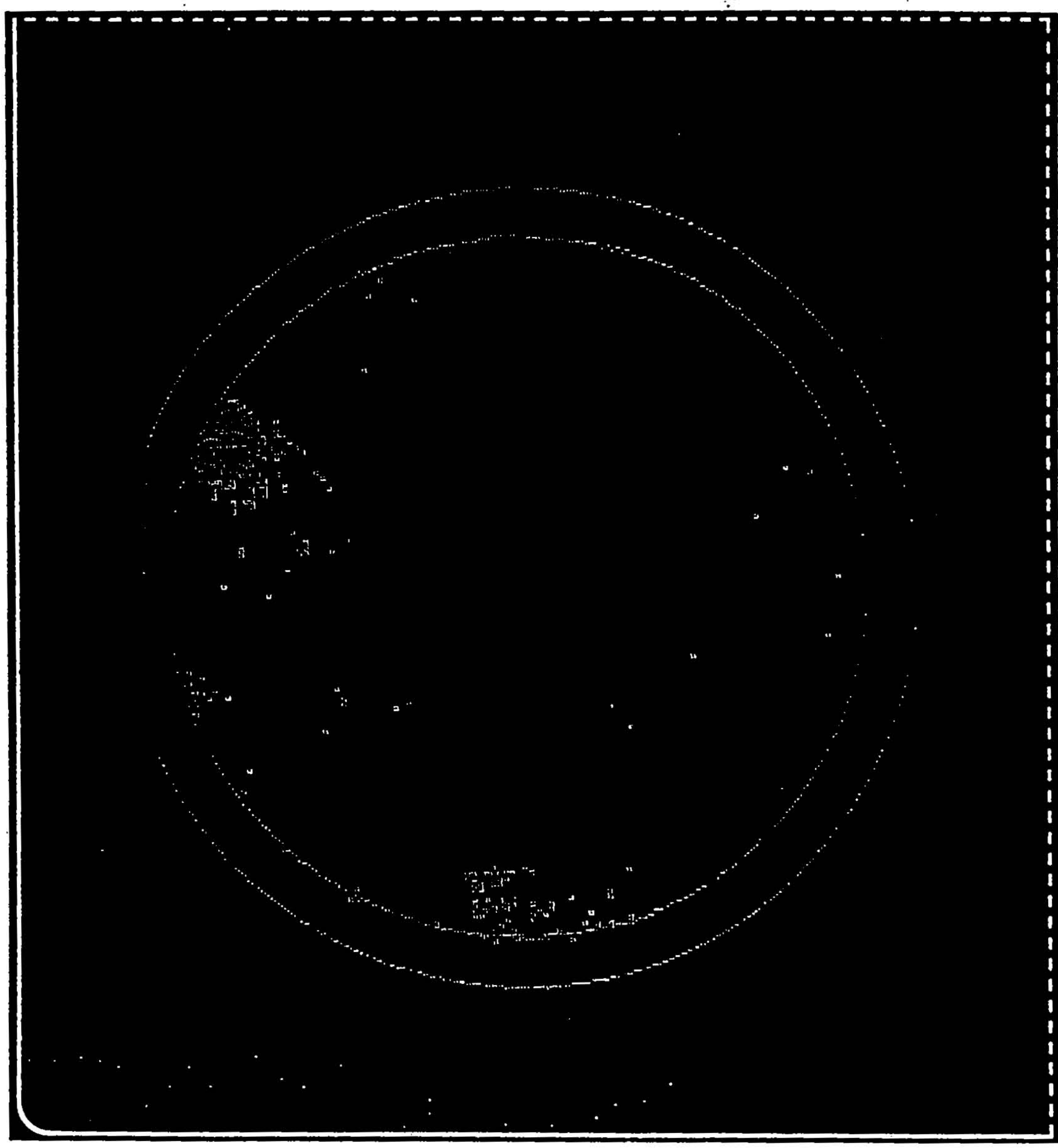


Fig. 3-7 Haze Map

**Interpreting Summary Data**

The area along the left side of the data display is called the summary data. The summary data is always displayed by the data display even if all the color overlays are toggled off.

**Point Defect**

This is the measured number of particles within the range set by the data display parameters PARTICLES FROM and PARTICLES TO.

**Summary Histogram**

This table has two columns, one for "range" and another for "number". The range is similar to the individual bins of the histogram overlay but groups many bins together. Next to each range is the number of particles within that group of bins. This data is taken from the region between histogram cursors on the orange histogram (more about histogram cursors in "analyzing scan").

**Mean and Standard Deviation**

The mean value is the mean size of the particles shown by the summary histogram. Standard deviation describes the distribution around the mean.

**Haze Average Total**

This indicates the total integrated scatter.

**Parameter Values**

Near the bottom of the summary data, values for the data collection and data display parameters are shown. These indicate the conditions for the collection and display of the summary data.

### 3.1.5 PRINTING

In this part of this tutorial, you'll be shown how to print out the test scan results.

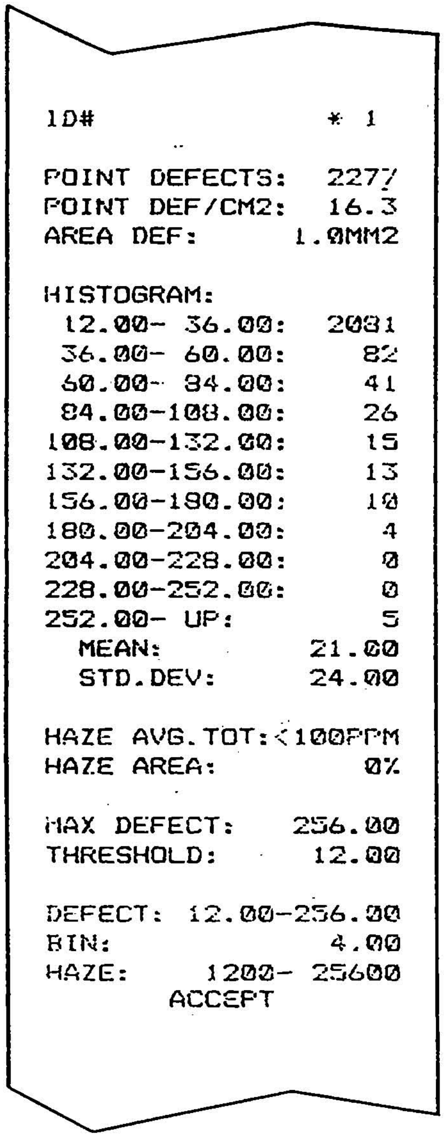
1. If a 20-column printer is used, check that its serial signal cable is connected. Check that its power cord is also connected. If an 80-column printer is used, check that its parallel signal cable is connected and the printer are powered up.
2. Display the menu and check these parameters:

   PRINTER OUTPUT: SUMARY

   PRINTER TYPE: set to match printer
3. Return to the data display.
4. Press [**PRINT**]. (The white key.)

The printer should now be printing the summary data. The standard 20-column printer can print only this summary data or the short summary. With an 80-column printer any available printout can be selected by changing the printer parameters.

A sample printout is shown in Fig. 3-8. The numbers on your printout will be different than the ones shown here. Save your printout to compare with another one you will make later in this tutorial.



```
ID#                    * 1

POINT DEFECTS:      2277
POINT DEF/CM2:      16.3
AREA DEF:         1.0MM2

HISTOGRAM:
 12.00- 36.00:      2081
 36.00- 60.00:        82
 60.00- 84.00:        41
 84.00-108.00:        26
108.00-132.00:        15
132.00-156.00:        13
156.00-180.00:        10
180.00-204.00:         4
204.00-228.00:         0
228.00-252.00:         0
252.00- UP:            5
   MEAN:           21.00
   STD.DEV:        24.00

HAZE AVG.TOT:<100PPM
HAZE AREA:            0%

MAX DEFECT:       256.00
THRESHOLD:         12.00

DEFECT: 12.00-256.00
BIN:                4.00
HAZE:       1200- 25600
           ACCEPT
```

**Fig. 3-8 Sample Printout of Summary Data**

## Analyzing Scan

The easiest way to analyze the scan is with the histogram cursors. These can be used only while the histogram is on the data display.

Another way to analyze the scan is by changing parameter values. There are two ways to analyze the wafer by changing parameters: (1) change the data display parameters and; (2) change the data collection parameters and rescan.

Using the histogram cursors or changing the data display parameters does not require rescanning since these techniques only change the set of displayed data. However, if the data collection parameters are changed, the wafer must be rescanned to collect the newly defined range of data.

**Use Histogram Cursors**

The histogram cursors are the two white vertical bars on the orange histogram. These histogram cursors can be moved to analyze the histogram and particle map. The summary data's summary histogram uses the region between the histogram cursors for its data set; therefore, when the histogram cursors are moved, the summary histogram is automatically updated. Additionally, the particle map, hHistogram, and the remainder of the summary data can be replotted to display only the data included between the histogram cursors.

1. While the data display is on the monitor, the movable histogram cursor is shown by a small marker attached to the bottom of the dashed white vertical bar. Press **[SEL]** to switch to the other one whenever you want to move it. For now, select the right-hand one.
2. Press [←] or [→] to move the selected histogram cursor back and forth over the histogram. Leave it about a third of the way from the right-hand edge of the histogram. Notice that the summary histogram has changed.
3. Select the left-hand histogram cursor and move it toward the right histogram cursor. Move it until it "hits" the other one. Now they both move together as if the left-hand one is pushing the right-hand one. The minimum spacing between these histogram cursors is equal to the current bin width. Notice that the summary histogram now shows the numerical contents of the single bin.
4. Move the histogram cursors so they are about ten bins apart.
5. Replot the histogram by pressing **[PLT]**. The new histogram is a "magnified" display of the previous one.
6. Display the particle map - it now displays the particles for the range defined by the replotted histogram. You can rapidly isolate the positions of particles in one or more bins by this technique.
7. To return the histogram cursors and the data display to the original setting, press **[ABT]**. (The histogram must be displayed for **[ABT]** to erase replotting.

### 3.1.6 TUTORIAL SUMMARY

**What You Learned**

By now, you have worked through all the objectives listed on the first page of the Tutorial:

- Powering up: toggle one switch and plug in Printer.
- Changing parameters: move the cursor to the parameter of the Menu and enter a new value. Scan, rescan, or replot.
- Identifying components: the major parts used are the Keyboard and the Indexer; Platform(s). The Handler robotics manipulate the wafers.
- Loading and initializing: load the wafer cassette on the Indexer platform and press **[CASS]**.
- Scanning in Manual Mode: press **[START]**.
- Interpreting the Data Display: look at the Particle Map, the Histogram, the Haze Map, and the Summary Data.
- Printing: press **[PRINT]**.
- Using Histogram Cursors: press keys **[SEL]**, [←] or [→], and **[PLT]**.

These are the basic techniques of operating the Instrument. Other functions can be done by changing parameter values in the four Menu Quadrants and using other keys on the keyboard.

# 4 SYSTEM OVERVIEW AND DESCRIPTION

## 4.1 FUNCTIONAL BLOCK DIAGRAM AND DESCRIPTION

The functional block diagram shown below in Fig. 4-1 is a basic block diagram of the Surfscan 4500 instrument. It illustrates the basic connectivity of the instrument and the individual PCBs necessary to operate a Surfscan.

The following chapters of this section provide the details of each PCB necessary for maintenacne and repair of the instrument.

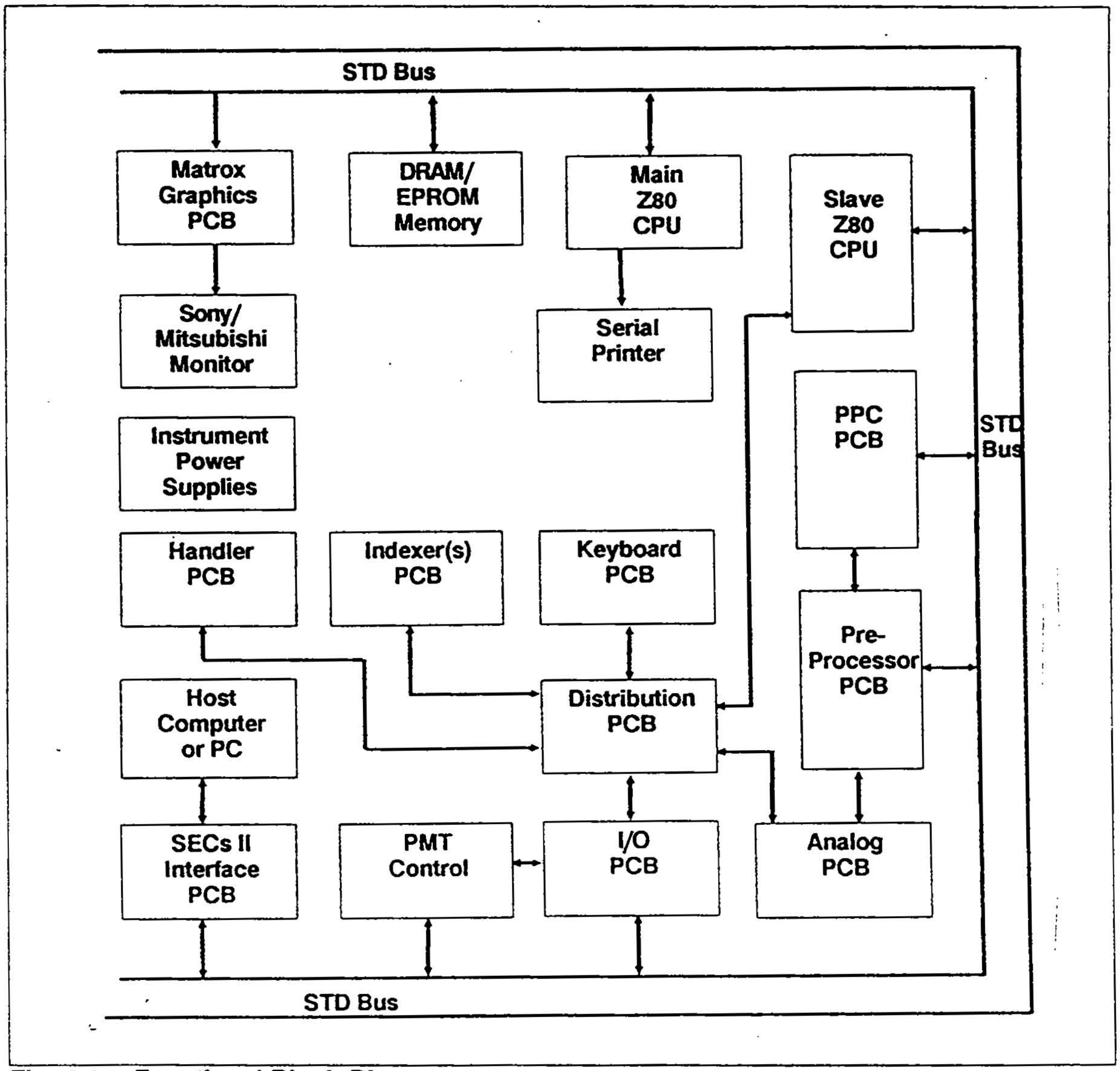



Fig. 4-1 Functional Block Diagram

## 4.2 I/O PROCESSOR

**General Information**

The I/OProcessor section is formed by three system components utilizing the I/O PCB as the information center for collecting, processing, and disperment of information. The three system components making up the I/O Processor are:

1. The Keyboard PCB.
2. The I/O PCB.
3. The Wafer Handling System.

The Keyboard PCB initiates an instruction sequence through its depress keys. The I/O PCB reads the Keyboard instruction and routes the instruction through the standard (STD) bus for data processing. Instructions are forwarded from the system operating software to the I/O PCB. The I/O PCB routes the instructions to the Wafer Handling System for execution.

The Wafer Handling System executes instructions from the I/ O PCB. It has a self monitoring functional status for real time progress information.

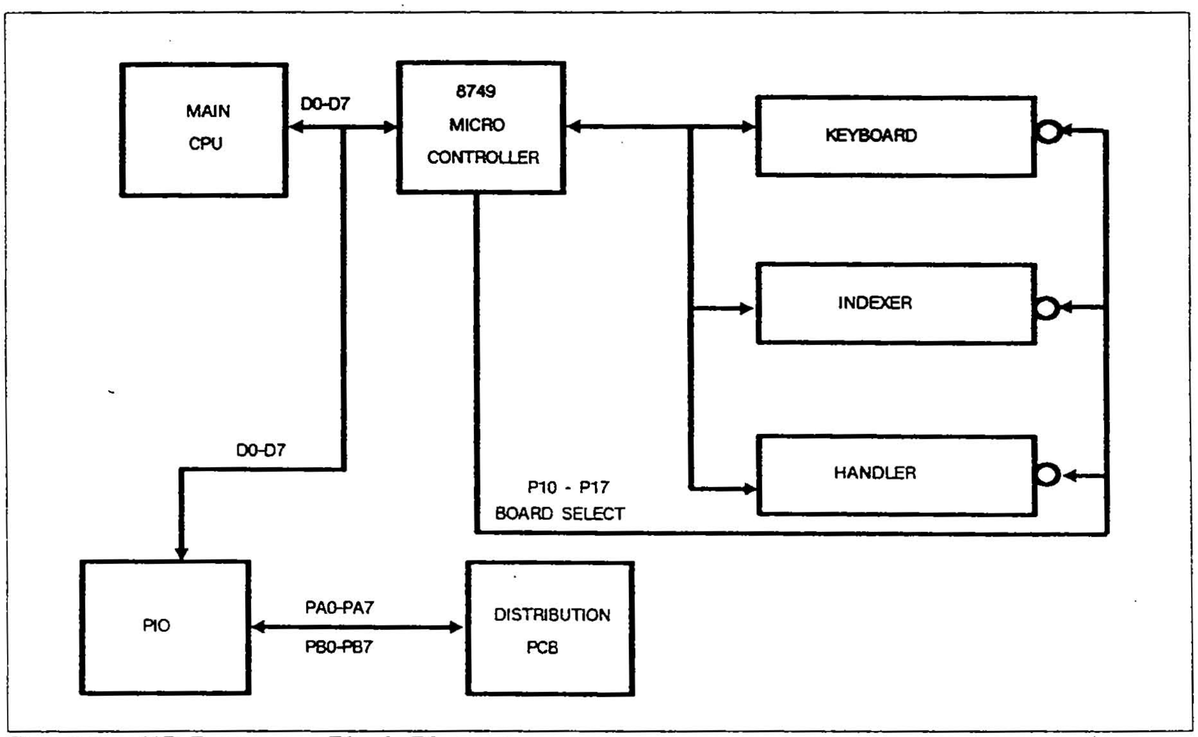



Fig. 4-2 I/O Processor Block Diagram

### 4.2.1 I/O PCB

**General**
The I/O PCB interfaces the I/O Processor and the Measurement Processor subsystems.

**I/O PCB Functional Description**
The I/O PCB uses an Intel 8749 Microcontroller for data management and instructions processing. The Microcontroller is used to interface the Main CPU to the Keyboard, the Indexers, and theHandler. The PIO, programmable I/O, is used for data collection. Its major responsibility is to monitor the system status from the Distribution PCB.

Both the 8749 Microcontroller and the PIO have 8-bit data lines, D0-D7, for bi-directional communication with the main CPU. Both ICs also have dual 8-bit programmable ports for subsystem communication.

The programmable ports for both the 8749 Microcontroller and the PIO are individually programmed to receive or send data.

**System Communication**
Communications between the Main CPU PCB, the Z80 Microprocessor, and I/O PCB is routed through the STD bus. Data lines D0- D7 provide integral communication between the 8749 Microcontroller, U1, the PIO, U2, of the I/O PCB, and the Main CPU PCB.

Communications between the PIO, U2, and the Z80 microprocessor is handled by enabling the *INTRQ** and *IORQ** address lines.

Communications between the 8749 Microcontroller, U1, and the Z80 microprocessor is actived by enabling the chip select line to the data latches, U12 and U13. U13 is designated as the input data latch to the 8749 Micro-Controller. U12 is designated as the output data latch.

Communications between the Keyboard, the Indexers, and the Handler PCBs to the I/ O PCB is bussed through the bi-directional data latch, U14. Input data, from the 8749 Microcontroller to the Keyboard, the Indexers, and the Handler PCB is controlled by the control lines going to the output buffer, U15. The control lines, at U15, *IOA0,* IOA1, and *IOA2* are used to enable the input data latch to the three PCBs.

The data accessing lines *IORD**, *IOWR**, *SOBF**, and *SIBF** identifies where the data is drawn from.

The control line *PINT** is used by the individual Micro- Controllers, the Keyboard, the Indexers, the Handler, and the I/ O PCBs, to signal each other that it has data for it to read.

**System Status Transfer/The PIO**

The PIO provides the status report communication between the Distribition PCB and the Main CPU. Status report information from the Distribution PCB are bussed to the programmed lines PA0- PA7 of the PIO.

The Key switch is monitored on line PB1. The *Hepa Filter On* signal is driven from line PB2.

**Counter/Timer Chips**

The Counter/Timer Chips provides four independent, programmable channels for either software or hardware controlled counting and timing function. Presently, they are not used.

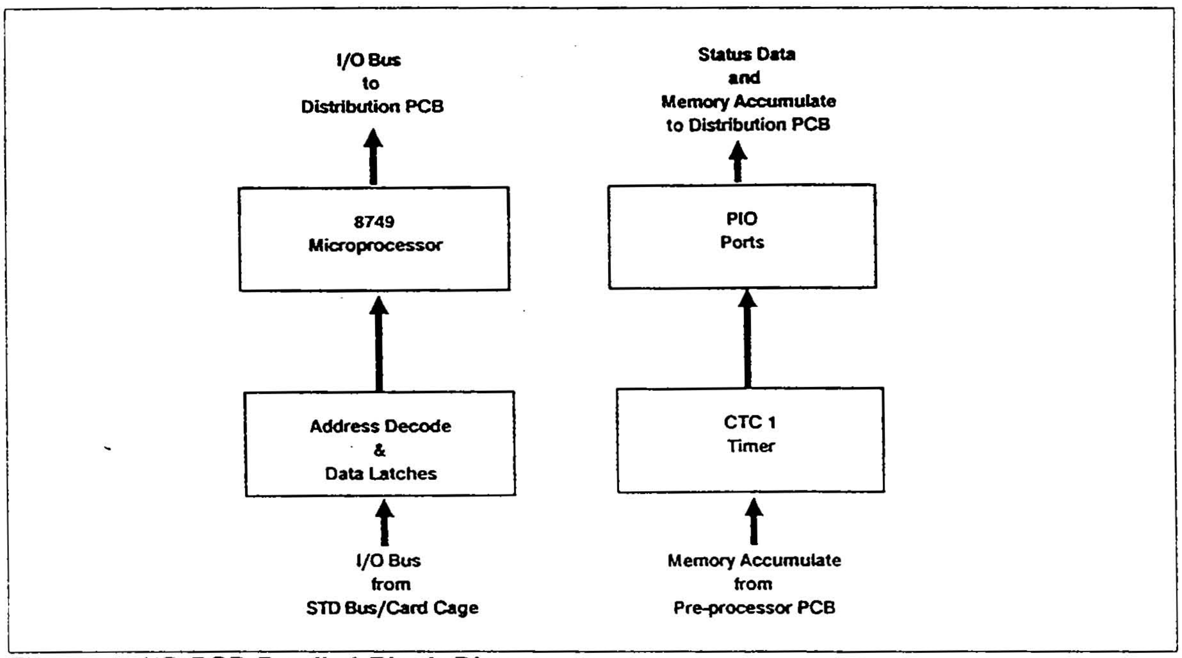



Fig. 4-3 I/O PCB Detailed Block Diagram

### 4.2.2 KEYBOARD PCB

**General**

The Keyboard is the user interface for sending various commands to the Surfscan. Upon depressing an individual key on the specially designed keypad, an instruction is transferred from the keyboard to the I/O PCB for execution.

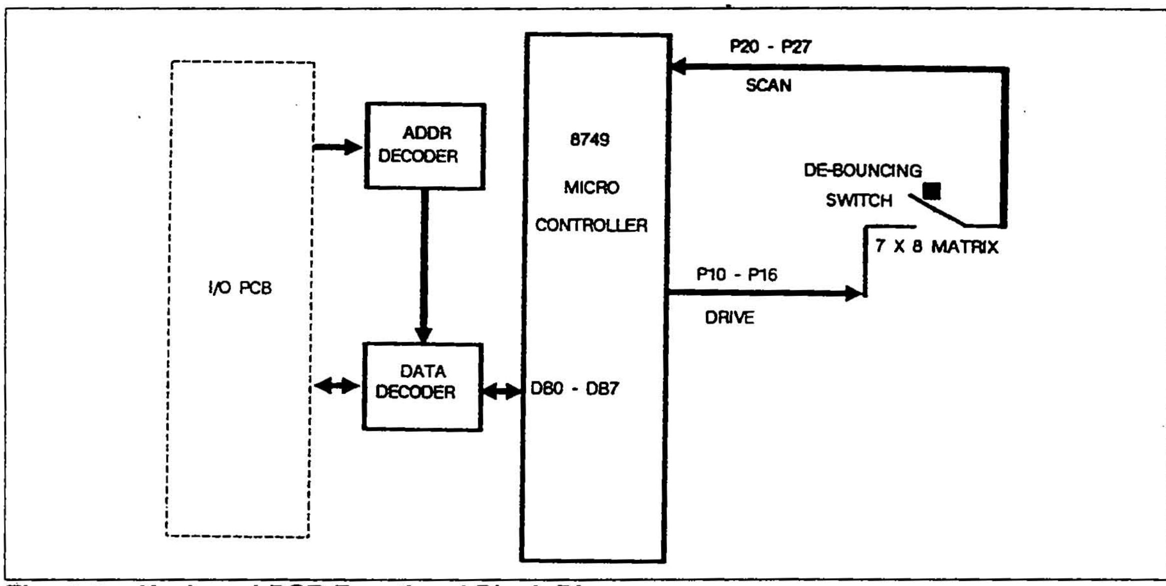



Fig. 4-4 Keyboard PCB Functional Block Diagram

**Keyboard PCB Functional Block Description**

The Keyboard PCB uses an 8749 Micro-Controller, U1, to identify the depressed key and relay the corresponding instructions to the I/ O PCB. U3 and U4 provide bi-directional buffering of the Micro-Controller data lines DB0 through DB7. All communications from the Keyboard to the I/ O PCB take place on the I/ O Data Bus. Refer to Fig. 4-3.

**Key Press Detection**

The Intel 8749 Micro-controller provides for key-press detection and instruction distribution. The two 8-bit programmable ports are used to create a seven-by-eight matrix array to identify a depressed key.

Keyboard de-bouncing switches are interfaced to the Micro-Controller matrix array. Each row and column is represented by a separate port line to the 8749 Micro-Controller, U1. The programmable port lines P10-P16 are designated as drivers. The programmable port lines P20-P27 are designated as scanners. The 8749 Micro-Controller identifies the depressed key by driving each row of switches while scanning each column for a short condition.

**Control Data Lines**

The control line *PINT** is the processor interrupt line to the I/O PCB. When this line is low, the I/O PCB knows the Keyboard has key-press data for the I/O PCB to read.

The control lines *IORD**, *IOWR**, *IOA0*, *IOA1*, and *IOA2* are used to enable the data latch for input/output data transfer.

The control lines *SIBF** and *SOBF** identifies whether the data to the I/O PCB Micro-Controller is an input or an output.

Table 4-1 identifies each individual control line and their definition.

| CONTROL LINE | CONTROL NAME | DEFINITION |
|---|---|---|
| PINT* | Processor Interrupt | Causes a Micro-Controller interrupt mode for I/O instructions or data. |
| IORD* | I/O Read | I/O read strobe of Keyboard. |
| IOWR* | I/O Write | I/O write strobe to Keyboard. |
| IOA0-A2 | I/O Address Lines | System I/O Address Lines used for selectiong various I/O peripherals. The Keyboard has address 0. |
| SIBF* | Input Buffer Full | Indicates the Input buffer has Signal Data during an I/O write. |
| SOBF* | Output Buffer Full | Indicates the Output buffer has Signal Data during an I/O read. |

**Table 4-1 Data Line Chart**

### 4.2.3 PMT CONTROL PCB

**General**

The PMT Control PCB is used to convert three operator programmed parameters for measuring the wafer quality area outline, and for adjusting the sensitivity of the light collection optics, the Photomultiplier Tube (PMT). The three programmable parameters are:

1. The Edge Exclusion
2. The Front Exclusion
3. The Max Defect Size

It also contains the circuitry to check and compensate calibration drifts due to aging components within the optics electronics.

The three functions provided by the PMT Control PCB are listed in Table 4-2.

| | |
|---|---|
| 1. | Generate Measure Gate and Width Threshold Signal |
| 2. | Allow general calibration adjustment to calibration standard parameters |
| 3. | Check and compensate for calibration drift |

Table 4-2 PMT Control PCB Functions

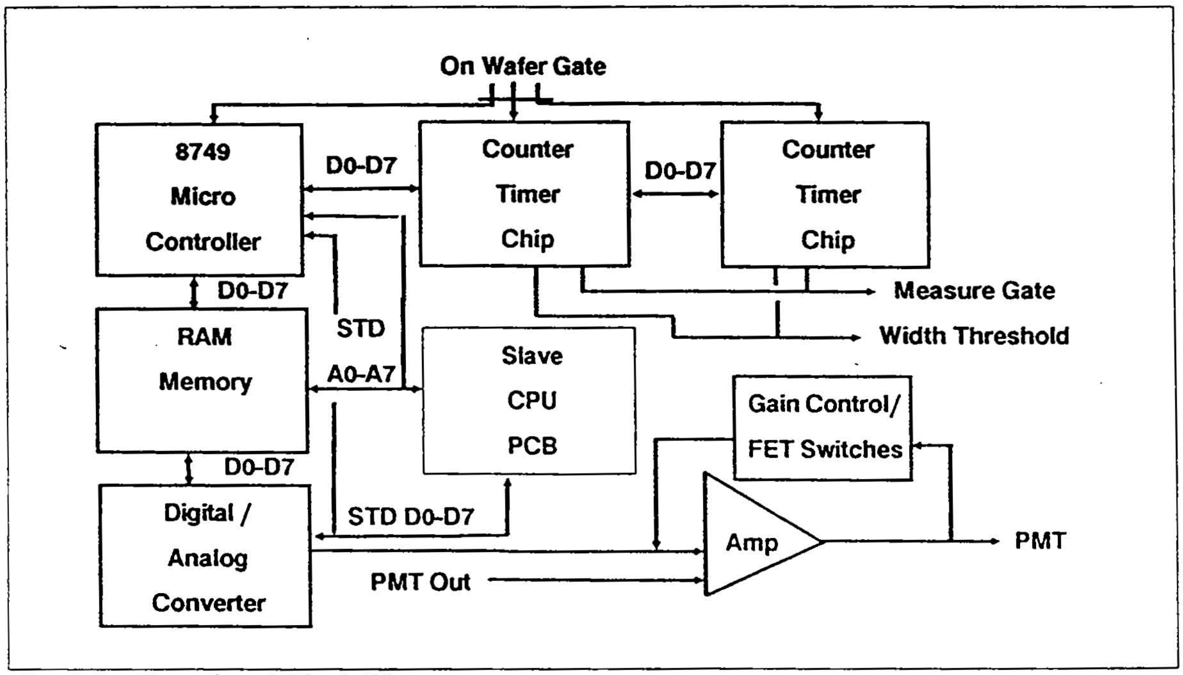



Fig. 4-5 Functional Block Diagram

### PMT Control PCB Functional Description

The PMT Control PCB uses a RAM IC, U11, for external interface with the Slave CPU PCB. The RAM IC is activated by the I/ O PCB. The RAM memory IC contain a data table to calculate the Measure Gate and Width Threshold Signals. The two 8253A Counter Timer Chips (CTC), U13 and U14, generates both the Measure Gate and Width Threshold signals from the data table within the RAM IC.

The 8749 Micro-Controller, U12, translates the data instructions from the Slave CPU PCB for processing. The data instructions, located in RAM memory, consist of the length of the Edge Exclusion, and the sensitivity range of the PMT. The digital signal, containing the sensitivity range of the PMT, is channelled to a D/A Converter, U27 and U7, to set an appropriate drive voltage to the PMT.

### 8749 Micro-Controller

The 8749 Micro-Controller, U12, is used for communication interface with the Slave CPU PCB. The 8749 Micro-Controller has an 8 bit input data line, DB0-DB7, for bi-directional communication interface. It has two 8 bit programmable input/ output ports, P10-P27, for instruction distribution and system response.

Communication interface between the Micro-Controller and the Slave CPU PCB is channelled through the RAM memory, U11. The RAM memory is activated by the I/ O PCB through the RAM Select* line. Contain within the RAM memory is the PMT gain data, and a data table relating the Measure Gate signal length to the On Wafer Gate Signal.

### 8253 Counter/Timer Chip

The 8253 Counter/ Timer Chip (CTC) generates two important timing signals. The two timing signals generated are used to define the wafer edge exclusion. The wafer edge exclusion is used to outline the quality area of the wafer for defect measurement. The two timing signal generated by the two Counter/Timer Chips, U13 and U14, are the Measure Gate and Width Threshold signals.

The active time duration of the Measure Gate signal is determined by the data table located in RAM memory in reference to the length of the On Wafer Gate signal. The data table located in RAM memory is generated by the Slave CPU PCB.

The Width Threshold signal is the measured difference time period between the Measure Gate signal and the On Wafer Gate signal. The Width Threshold signal defines the wafer edge exclusion.

**D/A Converter**

The D/A Converter, U7, is used to change the operator programmed Max Defect Size setting from a digital signal to an analog signal. The analog signal is used to step the DC/DC converter, at the power supply drawer, to increase or decrease the sensitivity to the PMT. The stepping function is controlled through the switches at U16, U19, and U21. These switches controls the feedback gain of the PMT.

The Max Defect Size information from the Slave CPU PCB is routed through the STD bus to the input of the data latch, U6, of the PMT Control PCB. This Max Defect Size information is then clocked by a 4-line-to-10-line decoder, U27, to the D/A converter, U7, for signal conversion.

**PMT Gain & Auto Calibration for Calibration Drift**

The use of Fine Calibration and Auto Calibration for Calibration Drift instills confidence and accuracy in measurement of the surfscan. Calibration drift is continously compensated and corrected by comparing the PMT Preamp Out signal to the D/A PMT Gain signal.

The Preamp Out signal is offset to zero during Auto-Zero at U18. Both the Preamp Out, minus the Auto-Zero offset, and the PMT Gain signal is amplified and summed with a DC offset at U21-pin 2. These combined signals are routed to an Integrator, U22, during the Auto-Cal pulse to compensated for sensitivity drifts that may have occurred. The output of the Integrator is inversely proportional to the summed signal voltage at U21-pin 2.

Fine PMT Gain adjustment for calibration is accomplished through the trimpot R28.

**PMT Shutdown**

To prevent possible damage to the PMT, a failsafe monitoring system has been incorporated in the design of the surfscan to increase its longevity. There are 3 possible events that can cause the PMT to shut down.

1. PMT Out signal exceeding 1 volt DC; monitored at U25-pin 4

   Cause: Excessive light scatter

2. PMT drive signal exceeding 12 volts DC; monitored by the distribution PCB at U18-pin 6

   Cause: DC/ DC power supply to the PMT is at its maximum setting before damage incures

3. The magnetic interlock switch at the scan hood is open. This prevents the PMT from being damage from excessive light when the scan hood is removed.

### 4.2.4 DISTRIBUTION PCB

**General**

The Distribution PCB is a Tencor designed PCB integrated with many different functions. Its integration of the drive and controls for the various active devices make this PCB an excellent starting point for system checkout, status monitoring and troubleshooting.

The Distribution PCB interacts with the major active devices responsible for producing the raw scan signals from a substrate. Because of the Distribution PCB's interaction with these active devices, and the PCB's easy access to circuits, the PCB is covered in great detail.

The four active devices in the Scan Unit are as follows:

1. The He-Ne Laser
2. The Oscillating Scan Mirror
3. The Photomultiplier (PMT)
4. The Key Sensors Auto-Zero, Auto-Cal, Below Wafer

In its interaction with the active devices, The Distribution PCB has seven major functions shown in Figure 4-5.

1. Provide regulated DC power to other sub-systems
2. Provide Scan Mirror Drive and Control
3. Laser Check and Enable
4. Generate System Timing
5. System Status Indicators
6. Photomultiplier Tube (PMT) monitoring and power
7. System Bussing

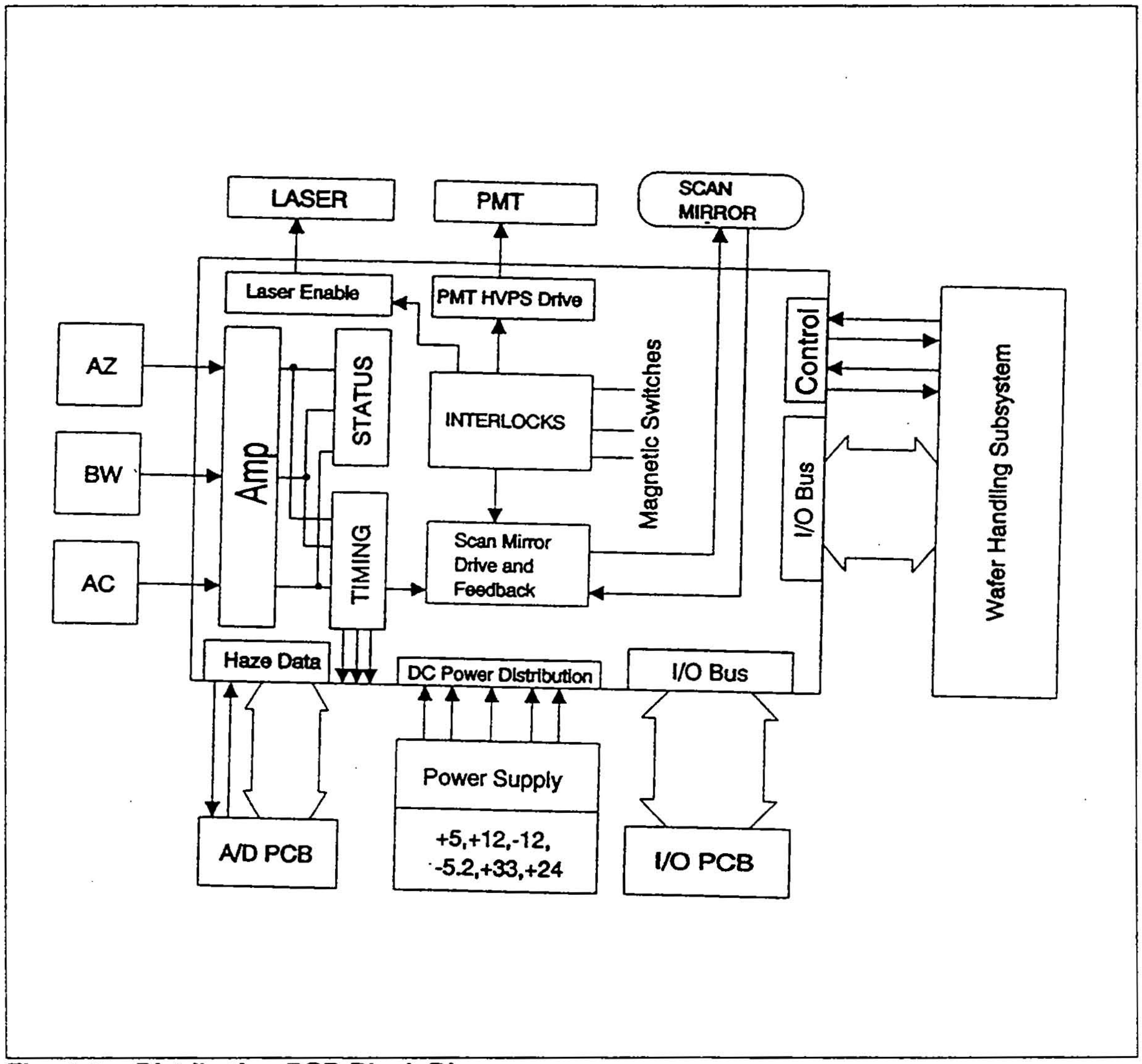



**Fig. 4-6 Distribution PCB Block Diagram**

## DC Power

The DC power provided is regulated and filtered to contain less than 100 millivolts of AC ripple.

DC power is drawn from the Power Supply Drawer and is routed to the Distribution PCB through the "J" connector cables J10, J11, J13, J31, J32, and J33. For convenience, voltage test pins are located on the bottom left hand corner of the Distribution PCB for easy access in measuring voltages.

Each "J" connector supplies specific voltage(s), reference J Connector Power, Table 4-3.

| CONNECTOR | POWER |
|---|---|
| J10 | + 5 volts DC |
| J11 | DC ground |
| J13 | + 12 volts DC |
| J31 | Analog ground |
| J32 | + 12, - 12, and - 5.2 volts DC |
| J33 | + 33, + 24, and + 12 volts DC |

**Table 4-3 J Connector Power**

## Scan Mirror Drive and Control

### General Description

The Scan Mirror is used to provide a vertical raster scan over the substrate. After each scan, the substrate is stepped forward until the entire substrate is completely scanned.

There are three objectives which the Drive and Control Circuits must maintain, Under-scan, Over-scan, and Scan Anplitude/Frequency Stability.

Under-scan indicates the Scan Amplitude is not great enough to reach the System Timing Sensors. Over-scan, which is the opposite condition, indicates the Scan Length is too great surpassing the System Timing Sensors. Over-scan can be a very dangerous condition in that the mirror may become highly unstable and cause damage through excessive vibration. The third objective is Scan Mirror/ Frequency Stability. Scan Stability is important in maintaining stable timing functions.

### Start Up (Positive Feedback)

Initial drive voltage to the Scan Mirror is supplied when the Scan Mirror Sense coils pick up the Scan Mirror's naturally occuring vibrations. The vibrations are converted into a sinusoidal signal, inverted and premplified by U17-Pin 1, the Loop Gain Amp. The signal is re-inverted and re-amplified and is fed back to itself at the Drive Coils, J15-Pin`1. Once Self-Start occurs, The Scan Amplitude Drivers, U19-Pin 10 & 12 provide the Amplitude swing to reach the sensors. The voltages are summed with the Feedback Sine-Wave produced by Q1. D5 and D6 switch the positive and negative halves of the Sine-Wave to the Positive and Negative DC Offset created by the Scan Amp Drivers, U19.

R52, the Loop Gain Potentiometer, sets the gain factor for U17 and subsequently, the strength and ability of the Scan Mirror to Self- Start.

The Feedback from the Sense Coils and the Drive Signals must be in phase to ensure that the Scan Mirror is driven continuously.

Continuous drive to the Scan Mirror is maintained in this manner, using positive feedback drive. The settings for the Loop Gain Pot, R25, in conjunction with the Scan Amplitude Pot, R52, determine whether the Scan Mirror will self-start and whether the scan amplitude will reach both sensors, Auto-Zero and Auto-Cal.

Scan Mirror Stabilization (Negative Feedback)

**The Scan Stabilization Circuitry provides control over two items:**

1. On Start-Up, the initial swing of the Scan Mirror must be monitored and then dampened to prevent damage to the Scan Mirror.

2. Once the Scan Mirror is oscillating, the Scan Stabilizer must regulate the Scan Amplitude/Frequency.

   Scan Stabilization is achieved with U17-Pin 7, an inverting integrating amplifier.

**Start-Up Control**

Upon Power Up, the initial drive to the Scan Mirror is operating in Open-Loop mode, without negative feedback. Negative Feedback, which provides a Closed-Loop System, is used to control and regulate the Scan Amplitude. However, Negative Feedback to the Scan Mirror Drive will not be present until the laser scan reaches the Auto-Cal Sensor.

The Scan Mirror will Over-scan the sensors momentarily, producing two pulses. The first pulse indicates the initial period of the laser beam on the AC sensor. The second pulse is produced as the laser beam over-scans, comes off of the AC sensor, and then back-scans over the AC sensor again, as the laser beam returns towards the Auto-Zero sensor.

The Pulse Width Monitor, U7, a re-triggerable One-Shot, checks for the Double Pulsing condition.

Under normal conditions its output at Pin 5 will produce a clock pulse determined by C26 and R64. The Clock Pulse is 800 $\mu$s long and is triggered by the AC pulse which occurs at a 400 Hz rate. The Clock pulse is used by U11 the D Flip-Flop to maintain a SET condition (Q Output = 1).

However, as the laser beam over-scans the AC sensor, the second pulse causes a RESET (Q Output = 0) to U11. The RESET condition closes the FET Analog Switch, U5, until the next AC pulse of the next cycle occurs. The switching of +5V to the input of the inverting integrating amplifier, U17-Pin 6, causes a sharp increase in negative voltage. This sharp increase serves to "dampen" the Scan Amplitude by reducing the offset voltages produced by R52 at U19. U11 will stay in the RESET condition until the Scan Amplitude shrinks where Over-Scanning is no longer occurring. See Fig. 4-6.

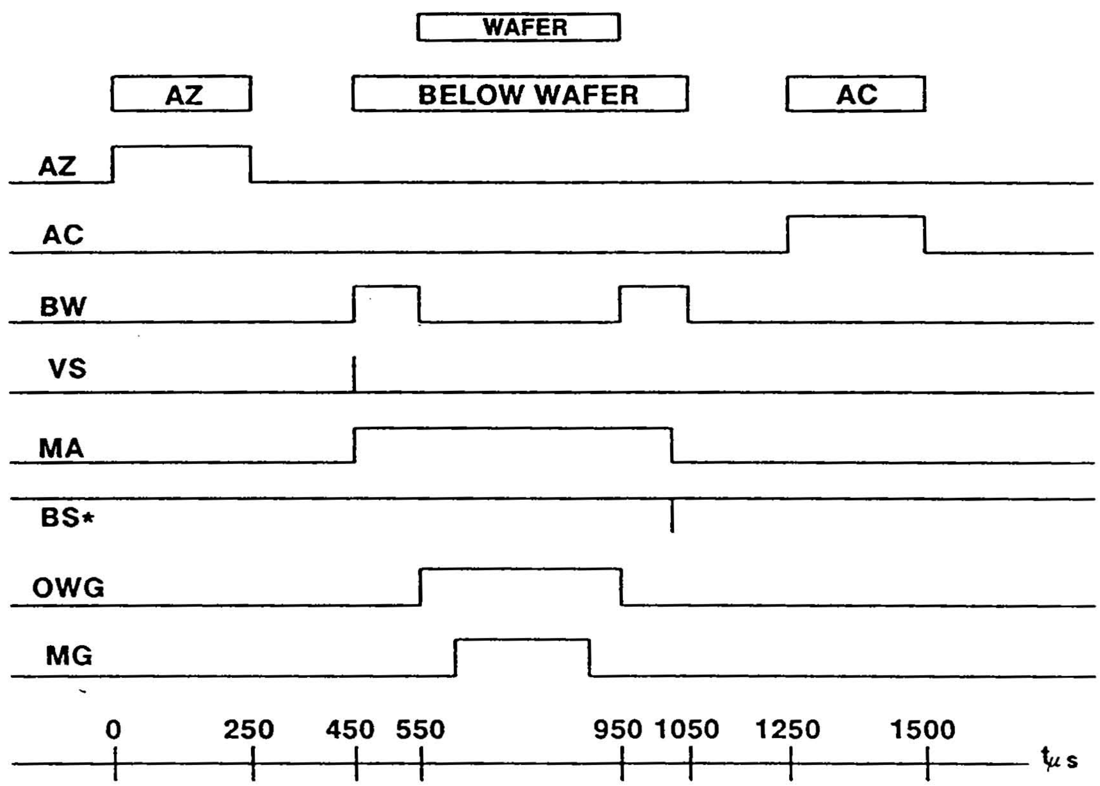



Fig. 4-7 System Timing with Wafer

**Scan Amplitude/Frequency Stabilization**

Another important function of the Scan Mirror Amplitude Regulator, U17-Pin 7, is to maintain the Scan Amplitude/ Frequency once Start-Up is achieved. Without a stable Scan Amplitude/ Frequency, System Timing at 400 Hz will fluctuate. A jagged wafer outline display is a typical symptom of this problem.

Once the laser beam reaches the AC sensor, the AC pulse enables the Negative Feedback Circuitry to regulate the scan amplitude.

The amount of Negative Feedback is determined by the time period of the laser beam upon the Auto-Cal Sensor. Typically, the singular AC pulse should last approximately 250 $\mu$s. Regulation and maintaining the Scan Amplitude is achieved by injecting the Digital Auto-Cal pulse into the Scan Amplitude Regulator. Regulation of the Scan Amplitude is inversely proportional to the width of the AC pulse. If the Scan Amplitude begins to expand, the AC pulse will expand proportionately to make the output of U17 more negative; immediately reducing the Scan Amplitude to its quiescent state.

The Closed-Loop system settles after a few iterations producing a very stable regulating DC voltage at the output of U17-Pin 7. Minor variations in Scan Frequency are compensated rapidly with this setup.

A window comparator circuit, U14, determines whether there is a proper amount of negative feedback applied to the Scan Amplitude for stabilization. U14, has a window set up by the Voltage Dividers, R72, R75, and R71. U14-Pin 7 is set at +10.5V and U14-Pin 8 is set at +1.5V. With the input voltage divider set by R101 and R100, limits are set on the output of U17-Pin 7 whereby the Scan Amplitude is considered stable. The limits dictate the acceptable output of U17, the Scan Amplitude Regulator, as measured at TP7, must rest between 9 V. If the output of U17 falls outside of this window, the *STABILIZER HAPPY STATUS* at U10-Pin 6, switches to a fail state and causes an interrupt to the Z80 processor.

Typically, the voltage at TP7 (U17-Pin7) is set around -2V. This is achieved by the settings of R25 (Loop Gain Pot) and R52 (Scan Amplitude Pot). The two settings affect each other directly. (For instructions on setting these electronic alignments see SECTION 7.1.2).

## Key Sensor/Photocell Processing

### Key Sensors/Photocell

The Key Sensors in the Scan Unit are made up of Silicon Photocells. The Auto-Zero and Auto-Cal sensors are positioned at both ends of the Scan Length, and are side-mounted within their light integrating drums. The Below Wafer Sensor is mounted on an adjustable bracket underneath the wafer scan plane. All the sensors are biased with -5.2 volts at the cathode for improved sensor response.

### Scan System Timing

Timing for the Main Scan System is determined by the three key sensors AZ, AC and BW. System timing is determined by the scan rate which is 400 Hz.

The three signals, *AZ*, *BW*, and *AC* are source signals used to enable Automatic Zeroing and Automatic Calibration of Measurement Circuits, as well as provide synchronization for scan data collection.

### A/D Interfacing

The main purpose of the A/D Interface is to convert the analog sensor signals to Digital signals. As Digital signals, they are then used to generate System Timing Signals and Status Indicators.

The A/ D Interfacing Circuits are somewhat identical for all three sensors. For convenience, we will only cover the Auto-Zero section.

The AZ A/D Interface is made up of the following circuits:

| | |
|---|---|
| U22 | A HF Filtered inverting amplifier |
| D1 & C7 | A Peak Detecting Circuit |
| U16 | An Inverting Variable Level Comparator |

Assuming the laser intensity is adequate and the scan amplitude stable, the analog output of U22 consists of a + 10 to + 12 volt 250 $\mu$s pulse. The analog pulse is applied to C7 through D1. C7, a .1uF cap, charges to V-Peak minus the D1 diode drop. C7 maintains this charge since D1 opens as soon as the analog pulse drops to 0.

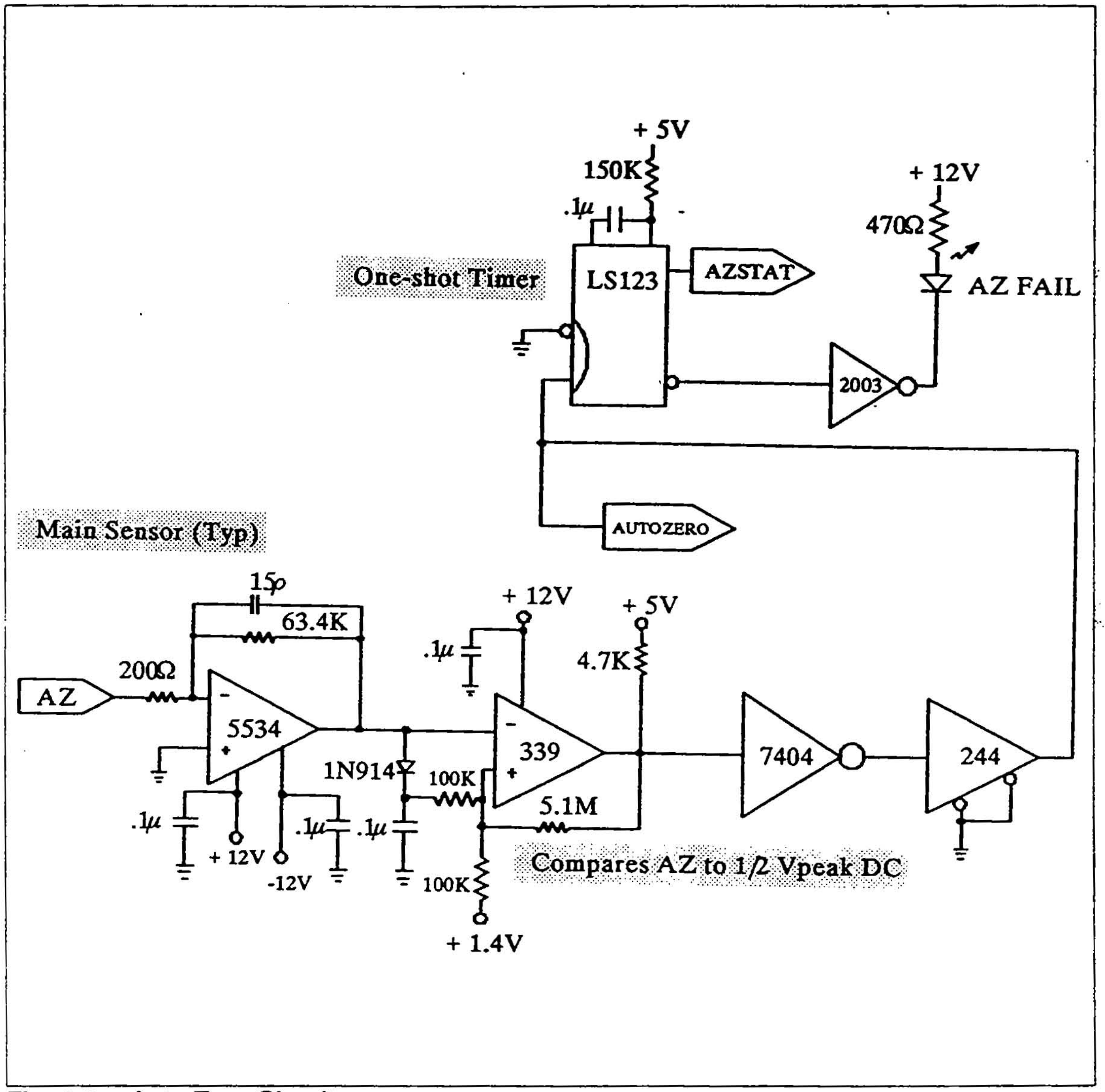



**Fig. 4-8 Auto-Zero Circuit**

V-Peak, of the Analog Pulse at U22-Pin 6, is primarily dependent upon the intensity of the laser; the greater the intensity, the greater the amplitude of the Analog pulse. U16, the Inverting Variable Level Comparator, compares the input analog pulse, at U16-Pin 4, with a variable DC level determined by V-Peak of the Analog Pulse. The variable DC level is divided in half by R5 and R6. D4, a 1N914 Diode, ensures the non-inverting input of each comparator is at +.7 volts. The diode prevents false Digital Signals from occuring, when the Analog Pulse produces ringing as it drops to 0 volts. By using a variable voltage level for comparison, a digital AZ pulse can be created without being dependent on the laser intensity. Reference the Typical Vpeak Detector, Fig. 4-7.

**Auto-Zeroing & Auto-Calibration (Negative Feedback)**
During AZ time, the Surfscan undergoes a Zeroing process whereby the ambient noise level signals are measured and removed for the next subsequent scan. This is accomplished by measuring the PMT output while the laser beam is within the AZ sensor. At this time, a dark level noise signal is produced by the PMT along with its associated circuits, such as the PMT Pre-Amp and PMT Drive. It is this dark level noise which must be subtracted previous to the next scan to assure measurement consistency and precision.

The Surfscan re-calibrates the PMT Drive during AC time, also to ensure consistency and precision. As the laser beam intensity decreases or measurement circuits become unstable with age, Auto-Calibration compensates for these minor drifts in measurement sensitivity. This occurs after the beam has performed Auto-Zeroing and scans the wafer. Upon reaching the AC sensor, the beam produces an integrated amount of light within the AC sensor. The integrated light scatter is monitored by the PMT via a Fiber-Optic line. The analog AC PMT Pulse is used as a reference to make fine adjustments to the PMT Drive. As the amplitude of the AC PMT Pulse increases or decreases, with circuit instabilities and laser aging, the PMT Drive is inversely compensated to decrease or increase respectively to maintain a constant level of sensitivity.

### Key Timing Signals

From the three key sensors various timing and synchronization signals are generated. Listed in Table 4-4 are the Key Timing Signals with a short summary of their major function.

| ABBREV. | SIGNAL NAME | SIGNAL FUNCTION |
|---|---|---|
| AZ | Auto-Zero | Re-Zeroes Measurement Circuits |
| BW | Below Wafer | Determines Outline of Substrate |
| AC | Auto-Cal | Re-Calibrates the PMT Drive/Sensitivity |
| VS | Vertical Sync | Generated by AZ & BW. Generates MA in the Pre-Processor PCB. |
| MA | Memory Accumulate | Generated by VS. Data is taken and recorded during MA. |
| BS | Beam Sync | Generated the falling edge f MA. BS is used to step the trolley motor after each scan. |
| OWG | On Wafer Gate | Generated by BW and MA. OWG indicates when the laser is on the wafer. |

**Table 4-4 Key Timing Signals**

Vertical Sync (*VS*) is generated using *AZ* and *BW* to drive an RS Flip Flop, U15. The *VS* signal is routed to the Preprocessor PCB where Memory Accumulate (*MA*) is generated. *MA* defines the beginning of the data collection period. The Beam Sync (*BS*) pulse is created with the falling edge of *MA* at the one-shot Timer, U9. It is used by the Handler to step the trolley motor immediately after each scan pass.

Utilizing both *MA* and *BW*, at the inputs of the NAND Gates U15 pin 10 and pin 9 respectively, On Wafer Gate (*OWG*) signal is generated. This signal indicates the period when the laser beam is on a wafer. This signal defines the period of time to synchronize actual data collecting with the scan itself.

The *OWG* signal generates both Measure Gate (*MG*) and Width Threshold (*WT*) signals. Measure Gate signal along with Width Threshold signals indicate and define the Edge Exclusion area where data collecting is not to take place.

System Timing created by Auto-zero, Below Wafer, and Auto-Cal are shown on Fig. 4-6.

### Status Monitors and Indicators

Status Indicators LEDs are located on the top left hand corner of the Distribution PCB. Green LEDs indicate the status condition is good and are normally on. Red LEDs indicate missing system timing signals or instability and are normally off. All status data is transmitted to the I/ O PCB. If a failure occurs, it generates an interrupt to the Z80 CPU and halts the system until the failure is corrected.

There are twelve status indicator LEDs. Eight of the status indicators are driven by re-triggerable one shot multi-vibrators used as time-out timers. Without the presence of the status signal, the one-shots go into a RESET condition. See Table 4-5.

| SIGNAL | FAIL CODE | COLOR | NORMAL STATUS | LOCATION | LED |
|---|---|---|---|---|---|
| Auto-Zero | AZF | Red | Off | U4-Pin 13 | L3 |
| Auto-Cal | ACF | Red | Off | U4-Pin 5 | L4 |
| Below Wafer | BWF | Red | Off | U8-Pin 13 | L5 |
| Vertical Sync | VSF | Red | Off | U8-Pin 5 | L8 |
| Memory Acc. | MAF | Red | Off | U2-Pin 4 | L6 |
| On Wafer Gate | OWG | Grn | On | U3-Pin 2 | L9 |
| Measure Gate | MGF | Grn | On | U2-Pin 10 | L1 |
| Beam Sync | BSF | Red | Off | U3-Pin 10 | L10 |
| Width Threshold | WTH | Grn | Off/On | U13-Pin 3 | L2 |
| Stabilizer Happy | STAB | Red | Off | U6-Pin 1 | L12 |
| PMT1 On | PMT1 | Grn | Off/On | N/A | L14 |
| PMT2 On | PMT2 | Grn | Off/On | Not Used | L13 |

Table 4-5 Status Monitors and Indicators

The status indicator, Width Threshold Fail (*WTF*), is generated by an 8748 Micro-Controller at the PMT Control PCB.

Stabilizer Happy Indicator (*STAB*) monitors the level of negative feedback applied to the Scan Amplitude Drivers, U19.

The status indicators for the *PMT1 ON* (PMT1), *PMT2 ON* (PMT2) signal provide a visual representation of the collection level strength of the PMT; the brighter the illumination, the stronger the voltage drive to the PMT, the greater its sensitivity.

PMT2 status indicator is not used as only one PMT is presently used.

**Laser Check and Enable**

The laser check and enable circuit is used to identify the presence and strength of the laser beam. The status of the laser is also monitored by the I/O PCB.

**Laser Enable/Disable**

In order to meet Laser Safety requirements electrical interlocks were added to disable the Laser whenever the hood is removed, turning the beam off. In order for the Laser to turn on, two interlock conditions must be met. The Laser Magnetic Interlock Switch must be enabled and the Scan Mirror must be oscillating. These signals can be found at the Interlock Switch itself and U6-Pin 12 for the signal, *LASER ENABLED.*

The Laser Magnetic Interlock Switch is enabled whenever the Scan Unit Hood is in place. The enabling magnet attached to the hood disables the Laser when the hood is removed.

The second part of the Laser Safety design utilizes a comparator, U18 with a reference voltage of 1.67 volts, which compares the Scan Mirror Drive signal at TP-8 before enabling the laser. If the Scan Mirror Amplitude is less than +1.67V, the Laser will not be enabled to turn on. U18 checks only the positive half cycle due to D7 and D8.

The Laser Intensity Monitor, U16, determines if the intensity, as monitored by the amplitude of the BW analog pulse, is greater than a required minimum level. At the junction of U16-Pin 9, R16 and R18, a signal marked *X* is fed into the input of U16-Pin 10. If the signal "X" falls below 2VDC, 0the Laser is considered weak and must be replaced. Otherwise, if *X* is greater than +2VDC, the laser is "O.K.". The *LASER OK** status can be found at U16-Pin 13.

**Photomultiplier Drive and Protection/Disable**

The Photomultiplier Tube is a vacuum tube device which converts light energy into electrical signals. The electrical signal output is in the form of Current which is proportional to the PMT's Drive Voltage and the amount of light the PMT is collecting. The PMT is inherently a High Gain device which makes it somewhat unstable if not properly driven and controlled.

The PMT Sensitivity and/or Gain is determined by the PMT Drive Voltage. Indirectly, it is a User Selectable parameter through the MAX SIZE selections; the higher the value selected, the lower the Gain and PMT Drive will be.

After a selection of MAX SIZE is made, the PMT Control PCB provides an inversely proportional DC voltage, *PMT1 DRIVE* to the input of Q3 on the Distribution PCB, a unity gain buffer amplifier. Q3's output is then fed to a high input impedance emitter follower Q5. Q5's output, HVD1, is then routed to the HVPS (High Voltage Power Supply) PCB and switched to the PMT DC-DC HVPS.

**PMT Protection/Disable**

The PMT can be easily damaged through excessive light collection. Three protection circuits are implemented to minimize the probability of damage through excessive light exposure.

1. A PMT Magnetic Interlock Switch, placed within the back of the Scan Unit next to the Laser Interlock Switch, is disabled whenever the Scan Unit Hood is removed, exposing the PMT to ambient room light. When the interlock switch is disabled, power to the PMT HVPS is immediately shut off.

2. When excessive light scatter occurs during a wafer scan, a circuit on the PMT Control PCB senses this condition and shuts off its PMT1 Drive.

3. Over driving the PMT can also cause damage to the PMT. The Over-Drive Protection/Disable Circuitry is made up of U18-Pin 1. U18 is a comparator circuit which can issue a PMT1 *SHUTDOWN** command via the I/O PCB and to the PMT CONTROL PCB which "KILLS" (a signal command on the PMT Control PCB) the PMT1 DRIVE. U18-Pin 7 is tied to +12V limiting the HVD1 DRIVE. *HVD1 DRIVE* is voltage divided by R91 and R89 at U18-Pin 6. This sets an effective limit of *HVD1 DRIVE*, at Q5, to a maximum of + 13 volts.

**Other Functions**

**System Busing**
The Distribution PCB also provides inter-connection between the Keyboard, the Indexers, the Handler, and I/O PCB. It also provides inter-connection between the Analog PCB and the Slave CPU PCB.

**Miscellaneous Functions**
The HEPA switch from the Keyboard is buffered at the Distribution PCB through HEPA ON at U1-Pin 10 before being sent to the I/O PCB.

The MENU KEYLOCK SWITCH is tied to +5 volts with R32. *KEY/SW1* low indicates the Menus are locked.

### 4.2.5 WAFER HANDLER

**General Outline**
The following chapters, graphs, and diagrams provides an indepth study and understanding of the wafer handling system and its supporting subsystems. The outline covers an exploded view of each individual subsystem, defining, in detail, its functional purpose and how it interact to provide a working wafer handling system. The topic covers:

1. The Trolley

   The Puck Arm
   The Puck
   The Puck Arm Guide
   Vacuum
   Drive Motor
   Vacuum PCB

2. The Guide Rail

   The Lead Screw

3. The Associated Sensors

   The Home Sensor
   The Trolley Motor Encoder Sensor
   The Vacuum Control Sensor

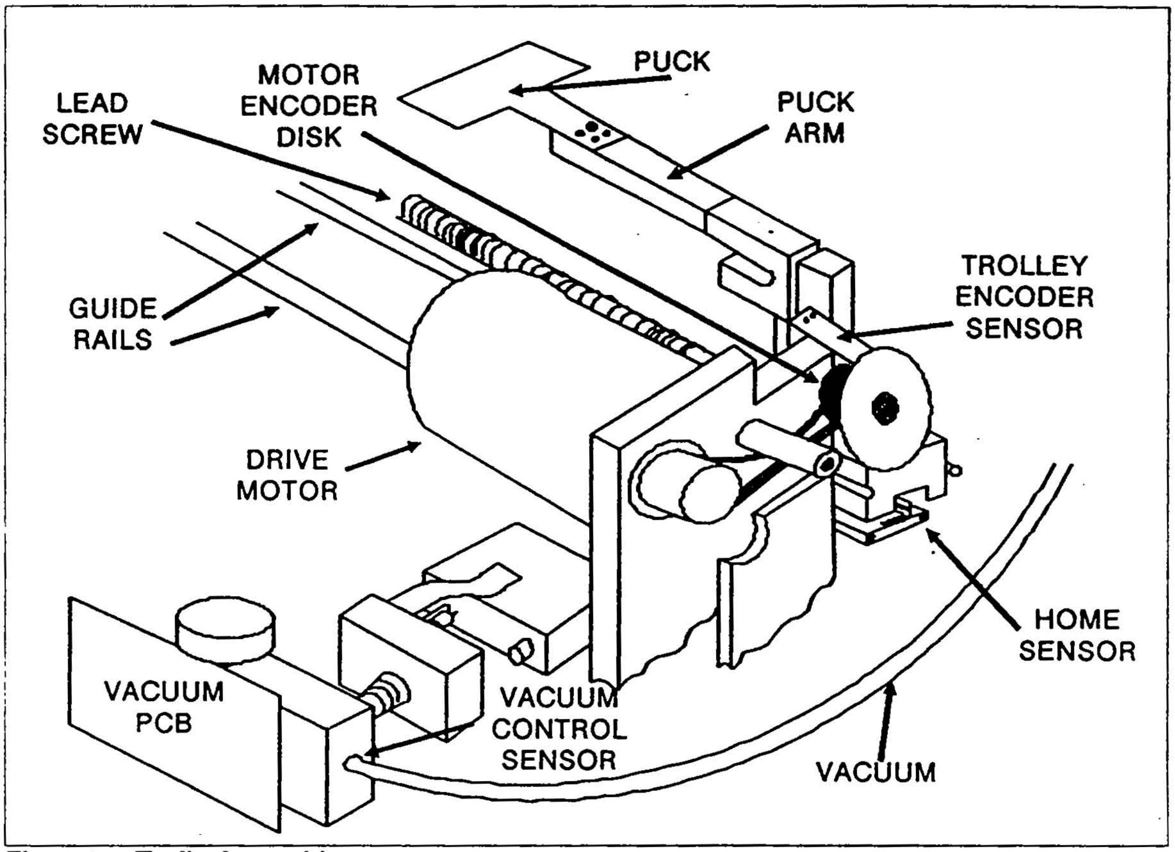



**Fig. 4-9 Trolly Assembly**

### 4.2.6 INDEXER SUBASSEMBLY GENERAL DESCRIPTION

The Indexer is a modularized subassembly which allows for the cassette handling of wafers. It gives the instrument the capability to load and unload wafers serialy, top to bottom, or randomly, in which the operator can select any wafer from the cassette.

Commands and Status are sent and received from and to the I/ O Controller via the I/ O Bus.

The subassembly is made up of the following items:

1. Indexer PCB
2. Elevator Motor/Assembly
3. Coullise Motor /Assembly
4. Cassette, Wafer, and Home Sensors

## INDEXER PCB

### General

The Indexer PCB drives and controls the various peripheral components for Cassette Handling, Wafer Sensing/Indexing as well as Trolley Guide during Load and Unload conditions.

### DC Power

Input power is supplied by the Main Power Supply Drawer. Using only +24 volt line, it is routed to the the Indexer PCBs and dropped by VR1, a 7812 Voltage Regulator for +18 volts and VR2, a 7805 Voltage Regulator, for +5M volts. +24 Volts is used to power the Elevator Motor, + 18 Volts is used to power the Kulisa Motor, and +5M Volts is for the logic circuitry.

### Indexer Logic Circuitry

Upon Power-Up only, the Z80 CPU, via the I/O PCB, determines which Indexers are present.

Communications to the Indexer PCB is provided through the I/O Bus. Depending on the position and function of the Indexer Module, the Indexer PCB is assigned a specific address with SW2. The address, determined by I/ OA0 to I/ OA2 of the I/ O Address Bus, is decoded with U1, an 8 to 1 Decoder.

SW2 can have the following configurations stated in Fig. 4-9.

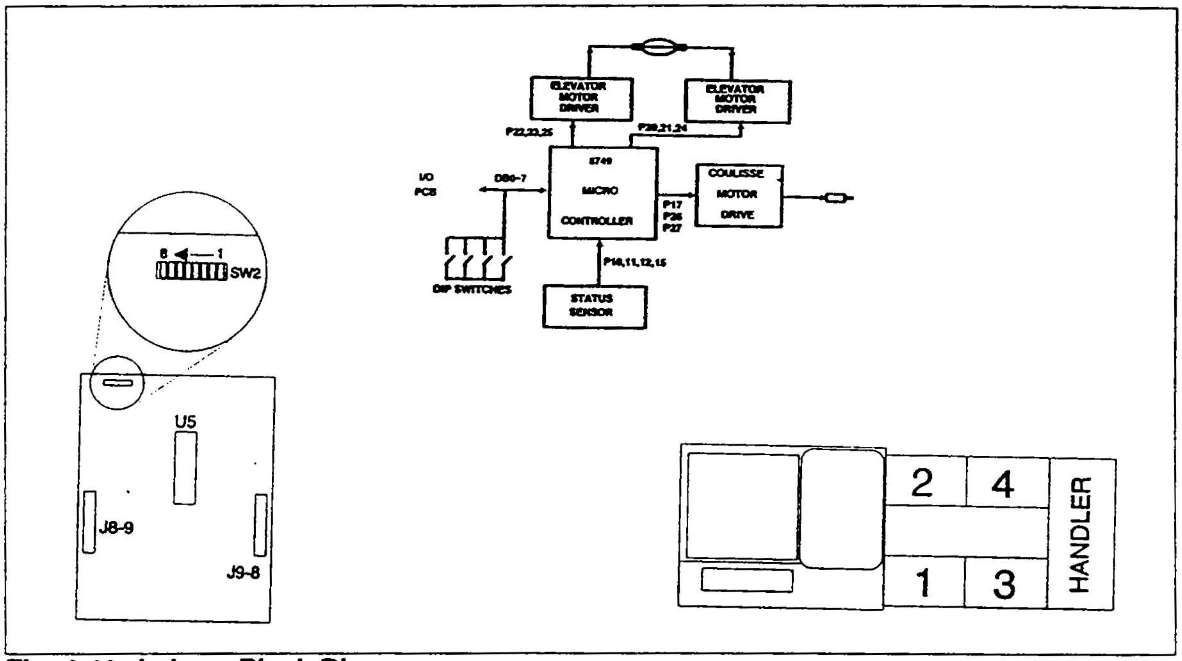



**Fig. 4-10 Indexer Block Diagram**

The I/O Data Bus, BUS0 to BUS7, is bi-directionally bufferred with U2, the 8-Bit Input Buffer, and U3, the 8-Bit Output Buffer. Data Read and Write to an Intel 8749 Micro-Controller is accomplished with an *IORD** and *IOWR* request from the I/O PCB. Data Read and Write Acknowledgements are accomplished through *SIBF** and *SOBF** from U8.

Peripheral Interrupt (*PINT**) and Beam Sync (*BSYNC**) are signals which can cause an interrupt to the Micro-Controller.

*RESET**, at the I/O BUS, causes a non-maskable reset to the Micro- Controller. *RESET** causes the Indexer to re-initialize and sends the Indexer Platform to home position.

**8749 Microcontroller**

At the heart of the Indexer PCB is an Intel 8749 Micro-Controller used for communication interfacing, instruction encoding and decoding, as well as peripheral status monitoring. Data processing and instruction execution are performed by the Microcontroller.

The fully programmable Microcontroller consists of a bi-directional 8-bit data line, for communications with the I/ O PCB. It also has two 8-bit input/ output programmable ports for motor controls, and status monitoring.

**Stepper Motor Drive and Control**

**Coulisse Motor**

The Coulisse Motor switches and guides the Trolley Puck Arm into the Load/ Unload Position at the Indexer Module. The four coil two-phase Coulisse Stepper Motor receives drive and directional control signals from a Stepper Motor Driver IC, U11. The SAA1027 stepper motor IC has one Rotation control line Pin 3, one Trigger line Pin 15, and four current drive lines, Pins 6, 8, 9, & 11. The Rotation control line selects the direction of the motor. It operates as a pulse input 4 Step sequence square wave output device.

The Coulisse Motor position is not monitored by the Micro-Controller.

However, on Power-Up only, the Indexer initializes the Kulisa position by driving the Coulisse to its Home position.

**The Elevator Motor**

The Elevator Motor is also a four coil two-phase stepper motor. However, it is driven by two PBL3717 Rifa Motor Control Drivers, U9 and U10. The PBL3717 Rifa Motor Control Driver has a single phase control line, and two current control lines. The phase line provides directional control of the elevator motor. The two current lines provide variable speed control of the elevator motor. Together, U9 and U10 provide the proper phase control and drive to the Elevator Stepper Motor.

The 8749 Micro-Controller programmable ports designated to drive the two Rifa motor control ICs are P20, P21, P24, P22, P23, and P25.

The three motor driver ICs, U9, U10, and U11, have a separate ground, designated as Chassis Ground. The separate grounding system reduces transient feedback noise spikes, created by the motor driver ICs.

**Status LEDs**

The Status LEDs, located at the top right corner of the Indexer PCB, indicate the various indexer peripheral status. There are four peripherals monitored by the Micro-Controller and indicated active by with an ON State.

1. Coulisse Motor (KUL), Red LED, indicates Coulisse is engaged
2. Wafer On (WFR), Yellow LED, Indicates a wafer has been detected
3. Carriage (CAR), Red LED, Indicates the presence of a cassette
4. Park (PRK), Green LED, Indicates the Elevator Platform is Home

## Assembly Descriptions

### Elevator Motor/Assembly

This assembly is primarily made up of a lead screw driven elevator drive assembly with a platform for cassette placement. Its major functions is to step the elevator, up and down, for the loading and unloading of wafers.

### Coullise Motor/Assembly

The Coullise Assembly switches and guides the trolley assembly into the corresponding Indexer during load and unload cycles. It is moved by a bi-directional linear stepping motor. The motor is enabled by the 8749 microprocessor and driven by an SAA1027 Stepper Motor IC.

### Cassette, Wafer, and Home Sensors

The various sensors interface to the 8749 Micro-processor through logic circuitry. The cassette sensor, placed within the elevator platform, is a normally open SPDT switch. The Home sensor, an optical switch, sets the Home position of the elevator. From this position, the cassette slot positions are determined. The height of the sensor should be set accordingly so that wafers are loaded and unloaded from the center of the slots. This greatly reduces wafer contamination. Wafer sensing is achieved through the use of Through-Beam sensors. An emitter and collector is positioned on opposite ends of the indexex, front to back. Each wafer is sensed as the wafer breaks the tightly controlled beam path.

## 4.2.7 Matrox Graphics PCB

**Functional Description**

The STD-800 is a high resolution color graphics controller contained on a single STD card. The STD-800 contains four major subsections (Fig. 4-10): the Graphics Display Controller, the Display Refresh Memory, the color Lookup Table, and the STD Interface.

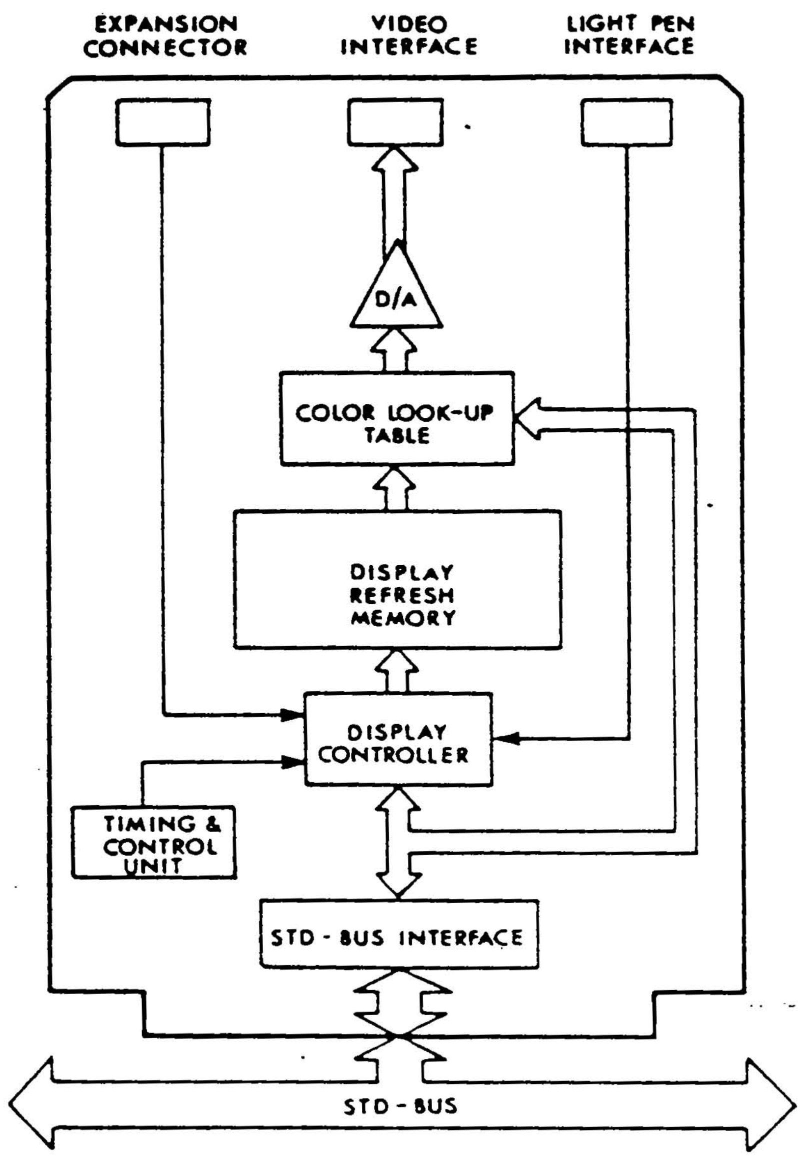



Fig. 4-11 Matrox Graphics PCB Block Diagram

**Display Memory**
The STD-800/64 contains sixteen 64K bit RAM chips, on-board, for a total display read/write memory of 1,042,176 bits (128K bytes). This memory area is divided into four bit planes (allowing up to 16 simultaneously displayable colors or grey levels) and is configured into a three dimensional array of 512 horizontal by 512 vertical pixels by 4 bits per pixel. Each bit plane provides one address line to the color memory. The resolution capabilities of the STD-800 can be increased by sacrificing bit planes. This feature enables the user to configure the on-board read/write memory for 1024 x 512 x 2 bits/pixel.

**Display Controller**
An on-board VLSI display controller chip (NEC 7220 GCD) is the heart of the STD-800. All of the display maintenance requirements (horizontal/vertical sync and blanking) and the display memory refresh functions are provided by the Display Controller and are completely transparent to the user. The responsibility for display memory maintenance is thus removed from the host processor, reducing software overhead and increasing system throughput.

**Color Lookup Table**
The STD-800 contains an on-board color lookup table which looks, to the user, like a 16 x 12 bit RAM. Through this lookup table, displays with up to 16 colors can be accommodated, with the displayed colors being user selected from a palette of 4096 colors. The color lookup table can be rewritten at any time.

The color lookup table allows the user to create a wide variety of video effects. Manipulation of the color lookup table allows the generation of such high performance effects as animation.

**Timing and Control Unit**
The STD-800 contains an on-board 20 MHz clock which is the heart of the module's Timing and Control Unit. The Timing and Control Unit,, using the 20MHz crystal together with a pair of PALs, supplies all of the individual functional blocks of the STD-800 with their required timing inputs and synchronizes their operation for maximum throughput. This circuit also enables the STD-800 to generate displays of up to 800 x 655 x 4 bits per pixel using an average drawing speed of 1.6 micro-seconds/pixel.

### Video Interface

The video output signals are supplied, via a 12-pin header on the module, as analog RGB signals (Fig. 4-11). Sync and blanking signals are provided both combined withe the Green video output and as a separate composite signal. A composite grey scale video output signal is derived from the green output by programming the lookup table appropriately.

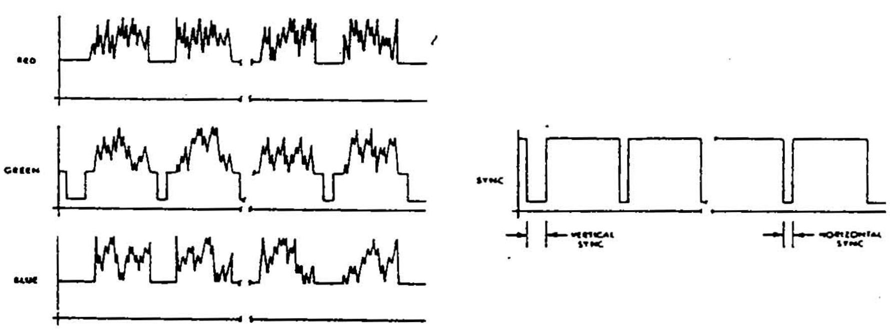


**Fig. 4-12 RGB Video Interface Signals**

### STD Interface

The STD-800 interfaces directly to the STD bus and meets all STD bus specifications as laid out in the Mostek Specification No. MK79646. To the system CPU, the STD-800 looks like a group of eight 8-bit registers which are in the bus I/O address space. Reading locations 0 and 1 will read the Display Controller's status and FIFO read buffer respectively. Writing to these locations will transfer either a command byte (Location 1) ore a parameter byte (Location 0) to the STD-800 FIFO. Writing to I/O port 2 (Command Register) sets various control parameters for the board. Reading this port allows the user to monitor the status of the Light Pen Enable signal and the Horizontal Blank. The following two registers are used to read/ write the color lookup table. The Board Enable Register allows strapping of up to three STD-800 boards within the same address space. By enabling or disabling access to the board, each board can be accessed individually or all three can be written at the same time.

## 4.3 MEASUREMENT PROCESSOR

### General Information

The Measurement Processor block is a computer subsystemthat gathers, deciphers, and sorts input data from the scan unit. The measurement processor block consist of:

1. The Distribution PCB
2. The Analog PCB.
3. The Pre-Processor PCB
4. The PPC PCB.
5. The Slave CPU PCB.
6. The Z80 Environment.
7. The Peripheral Interface.

The Analog PCB gathers and digitized the analog data signalfrom the Photomultiplier Tube.

The Pre-Processor PCB sorts, categorizes, and provides a means to draw and correctly position the particle data from the Analog PCB.

The PPC PCB correlates the information derived from the Pre- Processor PCB.

The Slave CPU processes the haze data from the Analog PCB. It also functions as a co-processor to the Main CPU to provide a faster data processing process.

The Z-80 environment processes data from the PPC PCB. It integrates the individual components of the Surfscan through the standard (STD) bus.

The Peripheral Interface allows outside communication with the Surfscan.

### 4.3.1 ANALOG PCB

**General**

The Analog PCB has two major functions. The first major function of the PCB is to separate the Photomultiplier signal into its two components for data processing. Secondly, after separation is completed, Haze and Particle Analog data are converted into their respective Digital values.

The signal collected by the PMT is separated into two separate components distinguished by the frequency of the laser light scatter. These two components are defined as Haze and Particle data. The Haze signal is made up of the low frequency component of a wafer scan; whereas the Particle signal is made up of high frequency components.

Once the two components are separated, both the Haze and Particle signals are routed to separate analog to digital converters on two separate channels. See Fig. 4-12.

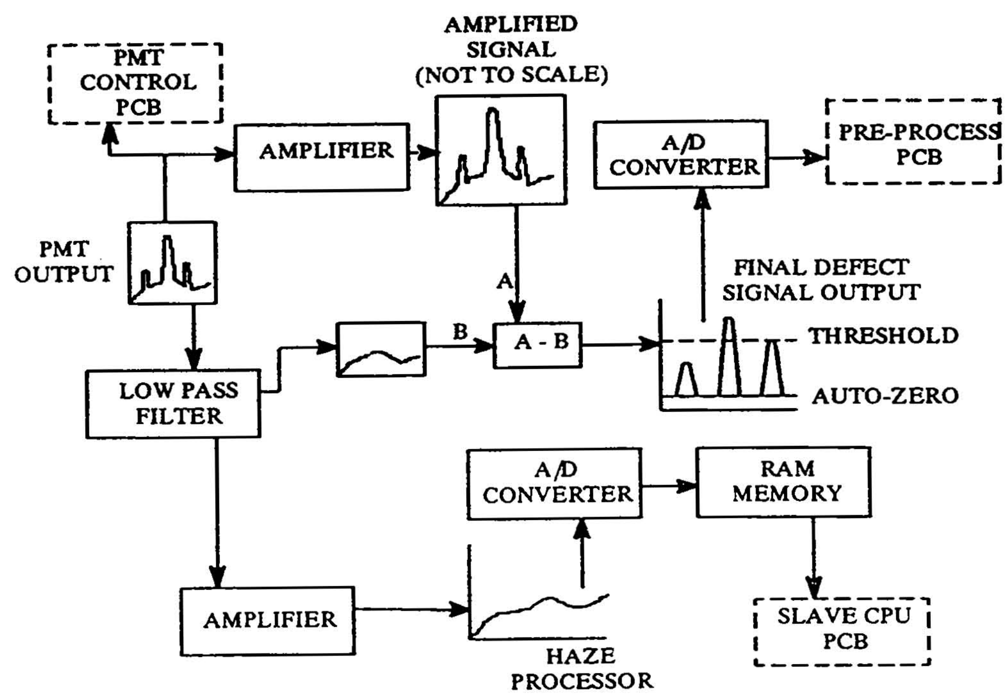



Fig. 4-13 Analog PCB Functional Block Diagram

**Analog PCB Functional Block Description**

After the PMT signal is amplified and filtered through the first low pass buffer amplifier of the Analog PCB, the Haze and Particle data are separated by filtering a specific frequency of the PMT signal. When signal separation is completed through the filter network, both the Haze data and the Particle date are amplified and digitized, using an A/ D Converter, for further signal processing. The Haze data is latched into RAM memory and bussed to the Slave CPU PCB for data processing. The Particle data is transferred to the Pre-Processor PCB for data processing.

**Haze Data Circuitry**

On the Surfscan, Haze is defined as the ratio of the tôtal collected scattered light intensity to the incident intensity.

The Haze data circuitry measures the low frequency background scatter noise created by the overall surface characteristics of the wafer surface. The signal is measured in reference to the Auto-zero signal.

**Haze Signal Separation/Conversion**

The Haze Signal Separation circuitry, U31, is used to remove the particle data and the Auto-zero signal from the input PMT signal.

From the output of the first buffer amplifier, U26-Pin 11, the PMT signal is routed into a low pass filter differential amplifier, U31-Pin 2. The Auto-zero reference signal is routed through an integrator, U30, to provide an equal but inverted Auto-zero reference signal level. This inverse Auto-zero reference signal is then channelled to the positive input of U31-Pin 3. The low pass filter differential amplifier, U30, filters out the high frequency signal and removes the Auto-zero reference signal at its input, leaving only the Haze data at the amplifier's output. The Haze data is strobed at 16 MHz into a buffer amplifier, U25-Pin 3, for proper signal amplification for the A/D Converter. After signal amplification, the analog Haze data is fed to an A/ D Converter to be converted into 8-bit words for digital data processing.

The analog Haze data signal at the output of U31-Pin 6 is also routed to an integrator circuit, U34-Pin 3. This inverted Haze data signal is used for subtraction from the input PMT signal, at the input of the Particle data separation circuitry, U28.

**Haze Data Processing**

The Haze data is transferred from the A/D Converter to memory data registers, U16 and U5, to be loaded onto RAM memory for processing by the Slave CPU PCB. Data transfer to RAM memory is only active when the *WREN* (Write Enable) line is active. The *WREN* line is triggered by the Vertical Sync signal. Data transfer, from the RAM memory to the Slave CPU PCB, is enabled if the *WREN* line is active and the *Haze Start* signal from the Pre-Processor PCB is low.

**Particle Data Circuitry**

The Particle Data circuitry measures the high frequency component of each wafer scan. The signal is measured in reference to the auto-zero reference signal.

**Particle Data Separation/Conversion And Processing**

The Particle Data Separation circuitry, U28, filters out the low frequency signal, and subtracts the Auto-zero reference signal from the PMT input signal. The PMT input signal containing the Particle and Haze data, and the Auto-zero reference signal is routed to the inverting input of the high pass filter differential amplifier, U28-Pin 5. At the junction of U28-Pin 5, the Haze data is subtracted from the input PMT signal. The Haze data is derived from the Haze separation circuitry, U31. An inverted Auto-zero reference voltage is input to U28-Pin 6, from the integrator circuit U29. By filtering and differentiating the two input signals, the Particle data is isolated through the high pass filter of the difference amplifier, U28-Pin 11.

After signal separation, the Particle data is transferred to an A/D Converter, a Flash 8-bit Converter. The 8-bit word, from the A/ D converter, is latched onto the Data Latches, U18 and U1. The 8-bit word is bussed to the Pre-Processor PCB at 16 MHz for data processing.

**PMT Signal Distribution**

The PMT Signal is also used as a feedback response to monitor the system calibration. The input PMT signal, also named as the Pre-Amp Out signal, is routed to the PMT Control PCB through the output coax cable of the Analog PCB for Auto-Zeroing and Auto-Calibration.

### 4.3.2 PRE-PROCESSOR PCB

**General**

The Pre-Processor PCB provides the surfscan a process to draw an image of the wafer scanned, defined as wafer mapping. It also provides a method to identify location and compute defect size of the particle within the scanned wafer. Utilizing key signals to identify the outline of the scanned wafer, the mapping process is stored in address registers generated within the Pre-Processor PCB.

The four major functions of the Pre-Processor PCB are:

1. Edge definition and edge exclusion
2. Wafer mapping
3. Memory Accumulate signal generation
4. Particle magnitude comparing

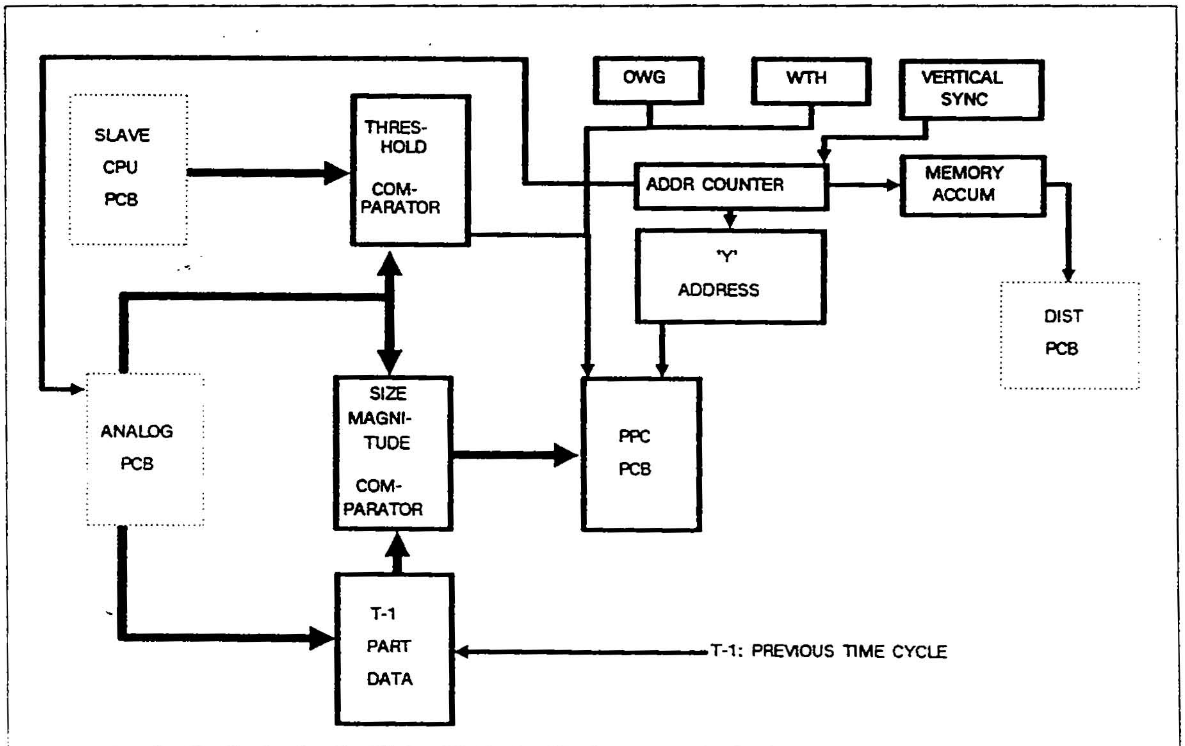



Fig. 4-14 Pre-Processor Block Diagram

**Pre-Processor PCB Functional Block Description**

The Pre-Processor PCB uses two 8-bit magnitude comparators, U9 and U14, for programmed threshold comparison and particle sizing. The two 8-bit magnitude comparators are supported by data latches, U5, U10, and U15, to hold and store particle data for comparison.

Triggered by the *VERTICLE SYNC* signal, four address counters, U19, U24, U34, and U29, tied in series, provides an address counter for the 'Y' address map of the wafer being scanned. The 'Y' address registers for each completed cycle of the address counter are stored at the address latches, U25, U35, U30, and U20.

Both the *ON WAFER GATE* and *WIDTH THRESHOLD* signals are used to provide a data clock to the PPC PCB for particle data processing.

**Edge Definition And Edge Exclusion**

The edge logic circuitry, U17, U6, U22, U32, U28, U27, and U20, determine the wafer edge and the edge exclusion from the *ON WAFER GATE* (OWG) and *MEASURE GATE* (MG) signal. Upon sensing the wafer edge,the *ONWAFER GATE* signal is generated by the Distribution PCB. *MEASURE GATE* signal is calculated on the PMT Control PCB to determine the size of the wafer edge exclusion. The *WIDTH* THRESHOLD signal, defining the wafer edge exculusion, is calculated by subtracting the *MEASURE GATE SIGNAL* from the *ON WAFER* GATE signal. The *ON WAFER GATE* and *WIDTH THRESHOLD* signals are bussed through the STD bus to the Pre-Processer PCB to define the start and end of the data extrapolation process.

The three signals, *ON WAFER GATE*, *WIDTH THRESHOLD*, and the output decision of the Threshold Comparator at U9, generate the data clock signal at U8-pin 3 to the PPC PCB. The data clock provides the PPC PCB the means to process data.

**Wafer Mapping**

Since the 'X' location is predetermined by the incremented steps of 25um per each laser pass over the wafer, only the 'Y' scanned locations of the wafer are needed to be calculated. The Address Counters, U19, U24, U34, and U29, provide the 'Y' address location corresponding to the 'Y' position of the wafer being scanned. The address counters are triggered by the *VERTICLE SYNC* pulse. A ripple effect within the the four D-flop address counters, clocked at 16 MHz, is directed into four D-flop latches, U25, U35, U30, and U20, to provide each sector of the laser scan with an appropriate address location. Each 'Y' address location is linked together with its corresponding defect computation at the PPC PCB.

These same address counters and address latches are also used to provide a map for the Haze data.

**Memory Accumulate Signal**

MEMORY ACCUMULATE SIGNAL (MA) is used to define the beginning of the 'Y' address counter for wafer mapping. Initiated by the *VERTICLE* SYNC signal, the four address counters, U19, U24, U34, and U29, triggers the D-flop clock, U7, generating the beginning of the MA signal. The time duration of the MA signal is determined by one complete cycle of the four address counters.

Only fourteenD-flops of the four address counters are used. They are clock at 16 MHz. One complete cycle takes 544 $\mu$sec.

**Magnitude Comparator ICs**

The Magnitude Comparator ICs compare the particle data size, from the Analog PCB, to a set threshold value for particle comparison. The magnitude comparators consist of dual input 8 bit data lines for data comparison, and 3 output decision lines. The three possible output decision are:

1. The set threshold value is greater than the particle data compared.
2. The set threshold value is equal to the particle data compared.
3. The set threshold value is less than the particle data compared.

**Particle Threshold Comparison**

The Particle Threshold Comparison circuitry compares the operator's programmed threshold value to the particle data collected from the Analog PCB. The dual input 8 bit threshold comparator, U9, receives the programmed threshold values from the Slave CPU PCB. An 8-Bit word containing the programmed threshold value is latched at data lines P0-P7 on U9. The particle data from the Analog PCB is routed to the data latch of U5 at the rate of 16 MHz. This latched particle data is compared to the set threshold value at U9 through the input lines Q0-Q7. If the particle data is greater than the set threshold value, the dual 8 Bit Threshold Comparator, U9, turns on the *WRTE* CLK line. The *WRTE CLK* line provides the PPC PCB its data clock to record particle data that are greater than the threshold value.

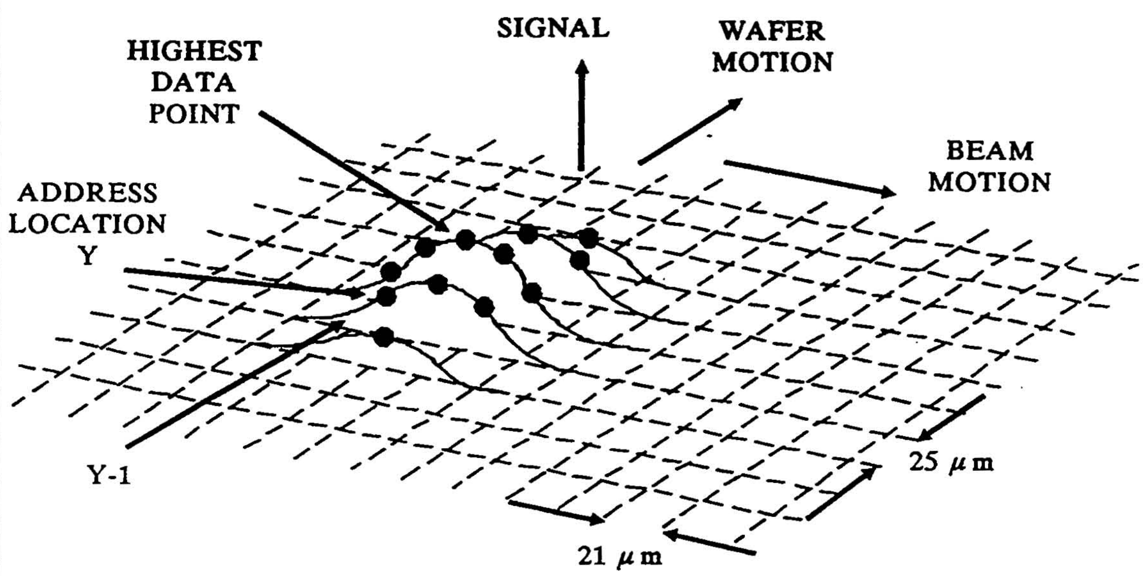



**Fig. 4-15 Particle Magnitude Sizing**

**Particle Magnitude Sizing**

The Particle Magnitude Sizing circuitry determines the peak size of a particle by comparing two sequential bytes of digital data. The twosequential bytes of digital data fromtheAnalog PCB could be a combination of background scatter noise and true particle data. The particle magnitude sizing circuitry will not differentiate between the two types of digital siganls. The particle magnitude sizing circuitry will only transfer output data when present digital data, at 'Y' address register, is greater than the previous digital data, at 'Y-1' address register. The present particle data, from the Analog PCB, are latched to data lines Q0-Q7 at the magnitude comparator, U14. The Data Latch, U10, containing the previous particle data is input to the data lines P0-P7 of U9. The result from the magnitude comparison is clocked by the *WRTE CLK* line to the PPC PCB. Refer to Fig. 4-14.

The time duration of the *WRTE CLK* staying high is determined by the Long Pulse counter, U18.

## 4.3.3 PPC (PULSE POSITION CORRELATOR) PCB

**Pixel Counting Classification**

This section describes the Instrument for applications when it has been changed to pixel counting classification. The interpretation of data is slightly different and some features are not possible, compared to particle counting classification.

**Description**

This Instrument normally operates in particle counting classification by using a Pulse Position Correlator. Although particle counting classification has many advantages for correlating data, there may be applications for pixel counting to allow use of an existing pixel-oriented database. Refer to "Signal Processing System" in Section 4 for a description of these two classifications. The circuit boards that provides these classifications can be switched to provide the desired correlation - contact Tencor Instruments for details.

To verify which type of classification is installed, check the Menu parameter HISTOGRAM TYPE:

PIXEL = pixel counting classification

PPC = particle counting classification

Although listed as a parameter, HISTOGRAM TYPE is not selectable from the Menu. It only indicates which type of classification is installed. The other parameter affected is DATA CORRELATION: with pixel counting, this is fixed at SINGLE.

**Software Features**

Pixel counting does not allow the Area Zoom software feature to work. Otherwise, all other ways of operating the Instrument are the same.

**Data Interpretation**

Since the particles are recognized as pixels in pixel counting classification, the Summary Data represents the particle display pixels assigned to the Particle Map; particle counting classification has the total number of measured particles listed in the Summary Data even though all of them may not be displayed on the Particle Map.

**Specifications**

Some performance specifications (listed in Section 1) are different with pixel counting classification.

**Repeatability**

Particle counts repeatable to 3% or less, independent of wafer orientation. (Mean count of 500 particles, 1 $\mu$ diameter latex spheres.)

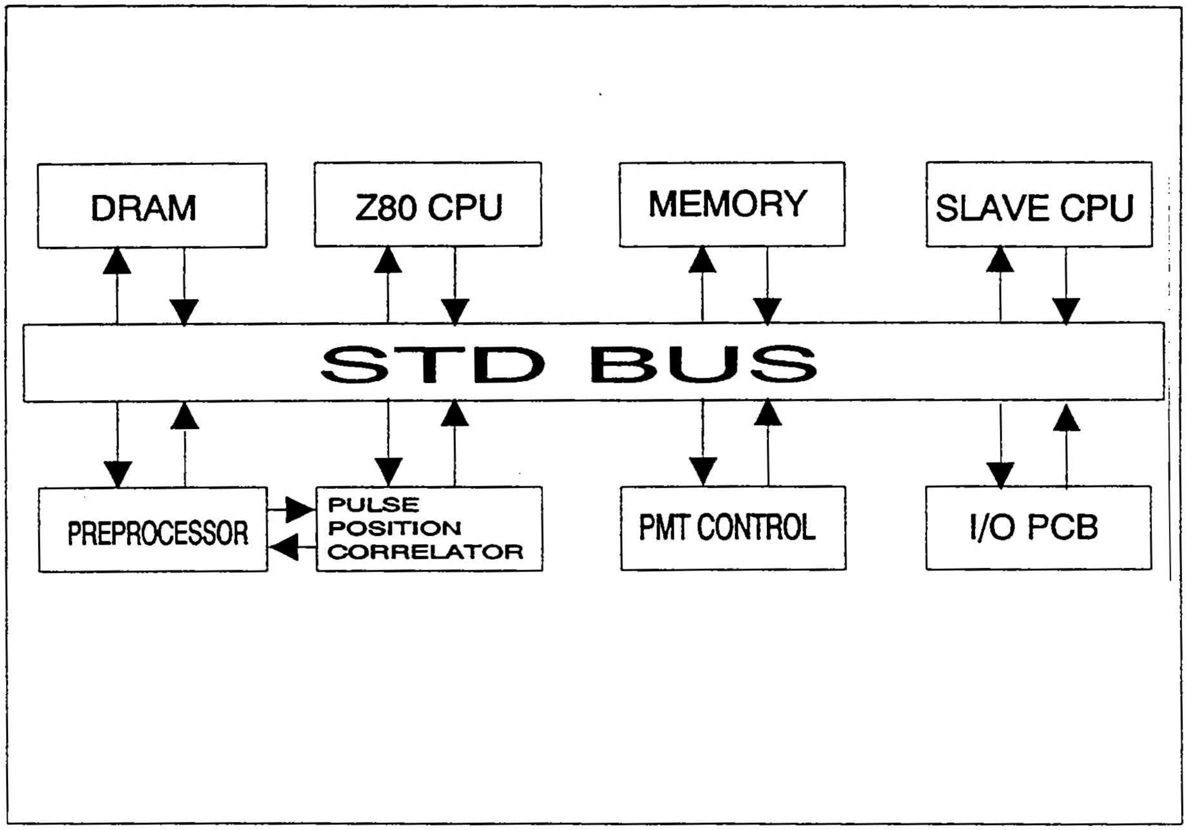
**Throughput**

For a 100 mm (4") wafer, approximately 35 seconds, measured for the period that the wafer is carried by the Vacuum Puck (fetching, scanning, and unloading). Wafer throughput may be slower, depending on the total number of particles on the substrate and the value set for MAX SIZE and THRESHOLD. If there are a high number of measured particles, it takes longer for the pixel correlator to process all the data in the FIFO buffer.

## 4.4 Z80 ENVIRONMENT

**General Description**

The following block diagram shows the general STD bus of the Surfscan 4500. The Surfscan 4500 is controlled by the Z80 CPU shown below in the figure below. The sections following this section give details on all of the PCBs on the STD bus within the Z80 environment.



## 4.4.1 STS BUS DESCRIPTION

**STD Bus Specifications**

The STD BUS defines an 8-bit microcomputer bus standard where the small card size in conjunction with LSI semiconductor technology creates a modular-by-function approach to control-oriented system design. The standard card size, connector and pinout lend itself to a bused motherboard that *permits any card to work in any slot.*

The bus interface connector as shown in Fig. 4-15 is dedicated to microprocessor control of card functions. Peripheral and device connections are made at the edge of the card defined as the user interface. This concept gives an orderly signal flow across the card from the bus interface to the user interface. Peripheral and I/O devices can be connected to the system using their own unique connector and cabling requirements and complete functions can be modularly added to the system.

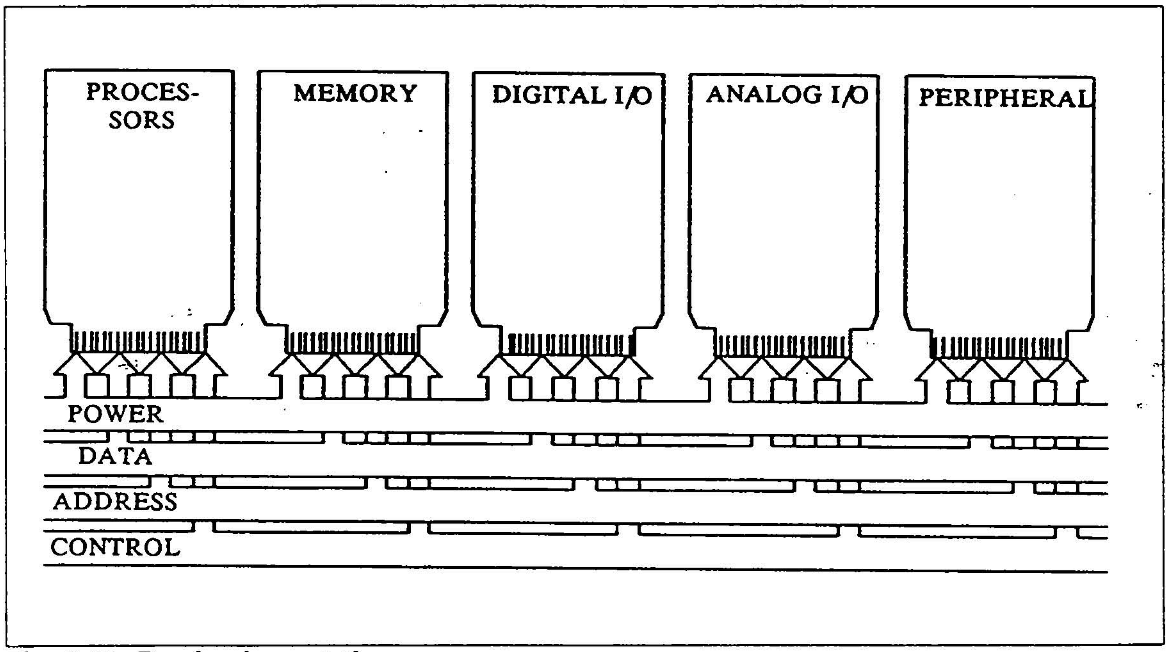



Fig. 4-16 Bus Implementation

**Logical Specifications**

Bus Pin Assignments. The BUS pinout is organized into five functional groups:

- Logic Power Bus:Pins 1-6
- Data Bus:Pins 7-14
- Address Bus:Pins 15-30
- Control Bus:Pins 31-52
- Auxiliary Power Bus:Pins 53-56

The organization and pinouts are shown in Table 4-6. Signal flow is referenced to the current master.

| | COMPONENT SIDE | | | | CIRCUIT SIDE | | | |
|---|---|---|---|---|---|---|---|---|
| | PIN | SIGNAL NAME | SIGNAL FLOW | DESCRIPTION | PIN | SIGNAL NAME | SIGNAL FLOW | DESCRIPTION |
| LOGIC POWER BUS | 1 | Vcc | In | Logic Power | 2 | Vcc | In | Logic Power |
| | 3 | GND | – | Logic Ground | 4 | GND | – | Logic Ground |
| | 5 | Vbb #1 | In | Logic Bias #1 | 6 | Vbb #1 | In | Logic Bias #1 |
| DATA BUS | 7 | D3/A19 | In/Out | Data Bus/ Address Ext | 8 | D7/A23 | In/Out | Data Bus/ Address Ext |
| | 9 | D2/A18 | In/Out | | 10 | D6/A22 | In/Out | |
| | 11 | D1/A17 | I | | 12 | D5/A21 | In/Out | |
| | 13 | D0/A16 | In/Out | | 14 | D4/A20 | In/Out | |
| ADDR BUS | 15 | A7 | Out | Address Bus | 16 | A15 | Out | Address Bus |
| | 17 | A6 | Out | | 18 | A14 | Out | |
| | 19 | A5 | Out | | 20 | A13 | Out | |
| | 21 | A4 | Out | | 22 | A12 | Out | |
| | 23 | A3 | Out | | 24 | A11 | Out | |
| | 25 | A2 | Out | | 26 | A10 | Out | |
| | 27 | A1 | Out | | 28 | A9 | Out | |
| | 29 | A0 | Out | | 30 | A8 | Out | |
| CONT'L BUS | 31 | WR* | Out | Write Mem or I/O | 32 | RD* | Out | Rd Mem or I/O |
| | 33 | IORQ* | Out | I/O Addr Set | 34 | MEMRQ* | Out | Mem Addr Sel |
| | 35 | IOEXP | In/Out | I/O Expan | 36 | MEMEX | In/Out | Mem Expan |
| | 37 | REFRESH* | Out | Refresh Timing | 38 | MCSYNC* | Out | Mach Cyc Sync |
| | 39 | STATUS 1* | Out | CPU Status | 40 | STATUS 0* | Out | CPU Status |
| | 41 | BUSAK* | Out | BUS Acknow | 42 | BUSRQ* | In | BUS Request |
| | 43 | INTAK* | Out | Interrupt Ack | 44 | INTRQ* | In | Interrupt Req |
| | 45 | WAITRQ* | In | Wait Request | 46 | NMIRQ* | In | Nonmask Int |
| | 47 | SYSRESET* | Out | System Reset | 48 | PBRESET* | In | Pushbut Reset |
| | 49 | CLOCK* | Out | Clock fm Proc | 50 | CNTRL* | In | Aux Timing |
| | 51 | PCO | Out | Prior Chain Out | 52 | PCI | In | Prior Chain In |
| AUX POWER | 53 | AUX GND | – | AUX Ground | 54 | AUX GND | – | AUX Ground |
| | 55 | AUX + V | In | + 12VDC | 56 | AUX -V | In | -12 VDC |

Table 4-6 Bus Connector Pin Assignment

**Signal Descriptions**

**Power Busses (pins 1-6 and 53-56).** The dual power busses accommodate logic and analog power distribution. As many as five separate power supplies can be used with two separate ground returns as shown in Table 4-7. Pins 5 and 6 provide for alternate use. If used for their alternate purpose these pins shall provide for disconnect capability on the card for conflict resolutions.

| PIN | DESCRIPTION | COMMENT |
|---|---|---|
| 1 & 2 | Logic Power | Logic Power Source (+5 VDC) |
| 3 & 4 | Digital Ground | Logic Power Return Bus |
| 5 | Logic Bias Voltage | Low-current Logic Supply #1 (-5 VDC) |
| *5 | Battery Backup Voltage | Alternate use as Battery Backup Voltage |
| 6 | Logic Bias Voltage | Low-current Logic Supply #2 |
| *6 | DC Power Down | Alternate use as DC Power Down Signal |
| 53 & 54 | Auxiliary Ground | Auxiliary Power Return Bus |
| 55 | Auxiliary Positive | Positive DC Supply (+12 VDC) |
| 56 | Auxiliary Negative | Negative DC Supply (-12 VDC) |

**Table 4-7 Power Bus Pin Assignments**

Data Bus (Pins 7-14). (8-bit, Bidirectional, Tri-state, Active-High). Data bus direction is controlled but the current master and is affected by such signals as read (*RD**), write (*WR**), and interrupt acknowledge (*INTAK**).

All cards should release the data bus to a high-impedance state when not in use. The permanent master shall release the data bus in response to bus request (*BUSRQ**) input from a temporary master, as in DMA transfers.

The Data Bus lines may be multiplexed for address space expansion. The pin assignment for address expansion shall be as shown in Table 4-6.

**Address Bus (Pins 15-30).** (16-bit, Tri-state, Active-High). The address originates at the current master. The permanent master shall release the address bus in response to a *BUSRQ** input from a temporary master.

The address bus provides 16 address lines for decoding by either memory or I/O. Memory request (*MEMRQ**) and I/O request (*IORQ**) control lines distinguish between the two operations. The particular microprocessor that is used determines the number of address lines and how they are supplied.

**Control Bus (Pins 31-52).** The control bus signal lines are grouped into five areas: memory and I/O control, peripheral timing, clock and reset, interrupt and bus control, and priority chain.

**Memory and I/O Control lines** provide the signals for fundamental memory and I/O operations. Simple applications may only require the following six control signals. All STD BUS cards shall support the memory and I/O control lines.

**PIN 31 WR* - Write to memory or output (Tri-state, active-low).** *WR** originates from the current master and indicates that the BUS holds valid data to be written to the addressed memory or output device. *WR** is the signal which writes data to memory or output ports.

**PIN 32 RD* - Read from memory or input (Tri-state, active-low).** *RD** originates from the current master and indicates that it needs to read data from memory or from an input port. The selected input device or memory shall use this signal to gate onto the BUS.

**PIN 33 IORQ* - I/O request (Tri-state, active-low).** *IORQ** originates from the current master and indicates an I/O read or write or a special operation. It is used on the I/O cards and is gated with either *RD** or *WR** to designate I/O operations. For some processors, *IORQ** is gated with other processor signals to indicate a special operation, *IORQ** with *STATUS 1** (*M1**) indicates interrupt acknowledge for the Z80.

**PIN 34 MEMRQ* - Memory request (Tri-state, active-low).** *MEMRQ** originates from the current master and indicates memory read or memory write operations or a special operation. It is used on memory cards and is gated with either *RD** or *WR** to designate memory operations. For some processors, *MEMRQ** is gated with other processor signals to indicate a special operation, *MEMRQ** with *STATUS 1** (*DT/R**) and *STATUS 0** (*SS0**) indicates Passive for the 8088.

**PIN 35 IOEXP - I/O expansion (high expand, low enable).** *IOEXP* may originate from any source and should be used to expand or enable I/O port addressing. An active-low shall enable primary I/O operations. I/O slaves shall decode *IOEXP*.

**PIN 36 MEMEX - Memory expansion (high expand, low enable).** *MEMEX* may originate from any source and should be used to expand or enable memory addressing. An active-low shall enable the primary system memory. *MEMEX* may be used to allow memory overlay such as in bootstrap operations. A control card may switch out the primary memory to make use of an alternate memory. Memory slaves shall decode *MEMEX*.

**Peripheral Timing Control Lines** provide control signals that enable the use of the STD BUS with microprocessors that service their own peripheral devices. In this way, the bus is not limited to only one processor.

**PIN 37 REFRESH* - (tri-state, active-low).** *REFRESH** may originate from the current master or from a separate control card and should be used to refresh dynamic memory. The nature and timing of the signal may be a function of the memory device or of the processor. In systems without refresh, this signal can be any specialized memory control signal. Systems with static memory may disregard *REFRESH**.

**PIN 38 MCSYNC* - Machine cycle sync (Tri-state, active-low).** *MCSYNC** shall originate from the current master. This signal should occur once during each machine cycle of the processor. *MCSYNC** defines the beginning of the machine cycle. The exact nature and timing of this signal are processor-dependent. *MCSYNC** keeps specialized peripheral devices synchronized with the processor's operation. It can also be used for controlling a bus analyzer, which can analyze bus operations cycle-by-cycle.

*MCSYNC** should be used to de-multiplex extended addressing on the data bus.

**PIN 39 STATUS 1* - Status control line 1 (Tri-state, active-low).** *STATUS* 1* shall originate from the current master to provide secondary timing for peripheral devices. When available, *STATUS 1** should be used as a signal for identifying instruction fetch.

**PIN 40 STATUS 0* - Status control line 0 (Tri-state, active-low).**

*STATUS 0** shall originate from the current master to provide additional timing for peripheral devices.

**Interrupt and bus control lines** allow the implementation of such bus control schemes as direct memory access, multiprocessing, single-stepping, slow memory, power-fail-restart, and a variety of interrupt methods. Priority for multiple interrupts or bus requests can be either serial or parallel priority schemes.

**PIN 41 BUSAK* - Bus acknowledge (active-low).** *BUSAK** originates from the permanent master and is used to indicate that the bus is available for use by a temporary master. The permanent master shall respond to a *BUSAK** by releasing the bus and driving an acknowledge signal on the *BUSAK** line. *BUSAK** should occur at the completion of the current machine cycle. The signal should be combined with a priority signal if multiple controllers need bus access.

**PIN 42 BUSRQ* - Bus request (active-low, open collector/drain).** *BUSRQ** originates from a temporary master and causes the permanent m,aster to suspend operations on the bus by releasing all Tri-state bus lines. The bus should be released when the current machine cycle has been completed. *BUSRQ** shall be used in applications requiring direct memory access (DMA). This signal can be an input, or an output, or it can be bidirectional, depending on the supporting hardware.

**PIN 43 INTAK* - Interrupt acknowledge (active-low).** *INTAK** originates from the permanent master to indicate to the interrupting device that it is ready to respond to the interrupt. For vectored interrupts, the interrupting device shall place the vector address on the data bus during *INTAK**. This signal can be combined with a priority signal, if multiple controllers need access to the permanent master. *INTAK** is used in vectored interrupt schemes.

**PIN 44 INTRQ* - Interrupt request (active-low, open-collector/drain).** INTRQ* originates from any slave function to interrupt the processor on the permanent master. It should be masked and ignored by the processor, unless deliberately enabled by a program instruction. If the processor accepts the interrupt, it should acknowledge by asserting *INTAK** (pin 43). Other actions depend on the specific type of processor, the interrupt-related program instructions, and the hardware support of the interrupt mechanism.

**PIN 45 WAITRQ* - Wait request (active-low, open-collector/drain).** *WAITRQ** may originate from any master or slave and shall cause the current master to suspend operations as long as it remains low. The current master should hold in a state that maintains a valid address on the address bus. *WAITRQ** can be used to insert wait states in the processor cycle. Examples of its use include slow-memory operations and single stepping.

**PIN 46 NMIRQ* - Nonmaskable interrupt (active-low, open-collector/ drain).** *NMIRQ** may originate from any master or slave and shall be used as an interrupt input of the highest priority to the permanent master. It should be used for critical processor signaling, e.g., power-fail indications.

**Clock and reset** lines provide the bus with basic clock timing and reset capability.

**PIN 47 SYSRESET* - System reset (active-low, open-collector/drain).** *SYSRESET** originates from any system reset circuit, which may be triggered by power-on detection, or by the pushbutton reset. All cards with circuits requiring initialization should decode *SYSRESET**.

**PIN 48 PBRESET* - Pushbutton reset (active-low, open-collector/drain).** *PBRESET** may originate from any card as an input to the system reset circuit.

**PIN 49 CLOCK* - Clock from processor.** *CLOCK** originates from the permanent master and is a buffered, processor clock signal, for use in system synchronization or as a general clock source.

**PIN 50 CNTRL* - Control.** *CNTRL** may originate from any card as an auxiliary circuit for special clock timing. It may be a multiple of the processor clock signal, a real-time clock signal, or an external input to the processor.

**Priority chain lines** are provided for serial interrupt or bus control. Two bus pins are allocated to the chain, which requires logic on the card to implement the serial priority function. Cards not needing the chain shall jumper *PCI* to *PCO* on the card.

**PIN 51 - Priority chain out (active-high).** *PCO* originates from every card as a signal sent to the *PCI* input of the next lower card in priority. A card that needs priority shall hold *PCO* low.

**PIN 52 PCI - Priority chain in (active-high).** *PCI* originates directly from the *PCO* of the next higher card in priority. A high level on *PCI* gives priority to the card sensing the *PCI* input.

## 4.4.2 MASTER CPU PCB

**Introduction**
The Z80 CPU PCB was designed to provide a cost effective solution for the problem of microprocessor systems integration.

**Features**

- Mostek STD-Z80 compatible
- UART with RS-232C interface
- Software controlled baud rate
- 4 MHz Z80 CPU
- JEDEC compatible byte-wide memory sockets
- User selectable communications interface (DTE/DCE)
- Complete interrupt control structure
- 9511/9512 Math coprocessor

**Functional Description**
The Z80 CPU PCB has the following major functional blocks:

- Clock Source
- Bus Interface
- Z80 Processor
- 9511/9512 Math Coprocessor
- Counter/Timer Circuit
- Serial I/O (UART)

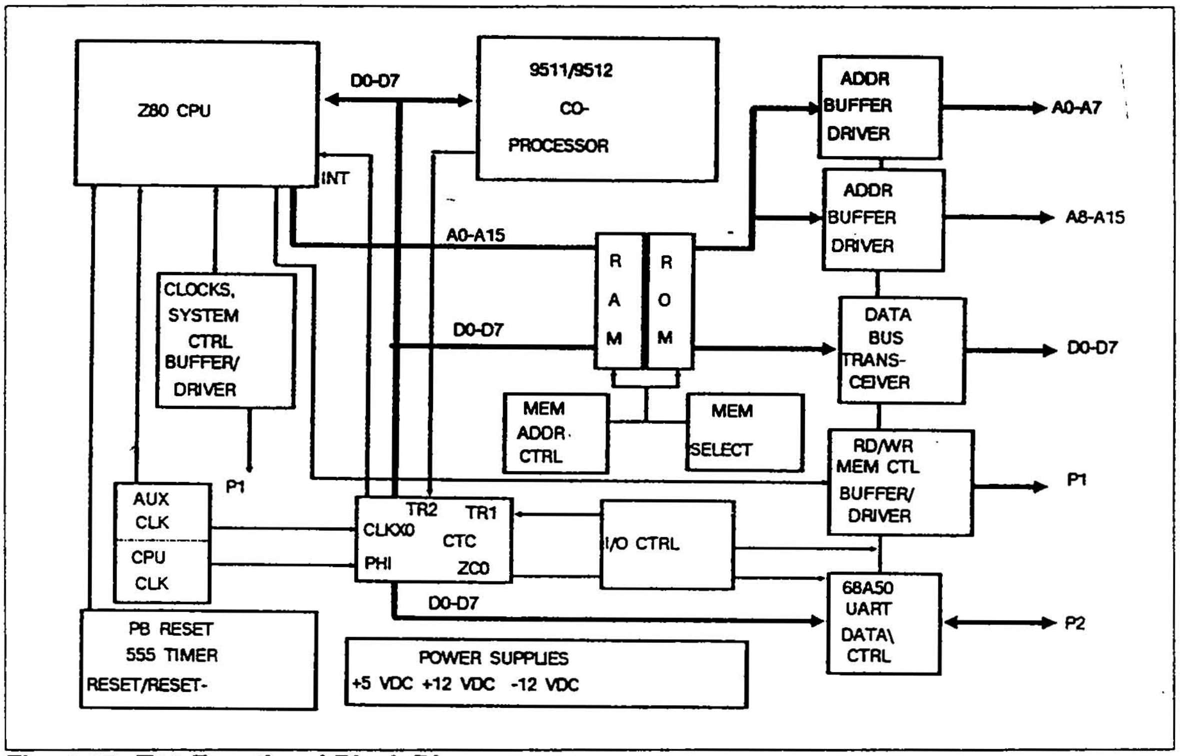



**Fig. 4-17 Z80 Functional Block Diagram**

The following sections describe each of the functional blocks of the Z80 PCB and reference the Z80 Functional Block Diagram shown above and the SFS 4500 Schematic Pre-release SPC STD Z80 CPU.

**Clock Source**

The CPU clock module, *AUX CLK* and *CPU CLK*, provides clock signals to both the Z80 CPU, U12, and the counter timer chip(CTC), U16. The 4.0 MHz clock signal to the Z80 requires an active driver circuit, Q1, R6, R7, R8 and C5, to provide sufficient current to the processor. This clock signal is called *CLOCK* on bus line 49 and Φ on the input pin 6 of the Z80 CPU. The 2.45 MHz clock signal to the CTC is called *CLX0.*

**Baud Rate and Clock Generation (4.0 MHz operation)**

4.0 MHz CPU operation requires the 8 MHz crystal installed in the *CPU CLK* position, and the 4.9152 MHz crystal installed in the *AUX CLK* position. Baud rate, for the 68A50 UART, U21, is generated by the CTC, U16, *ZC0* output. This output drives a J-K Flip-flop, U24, which divides the clock by 2. This signal is used by the UART *RXC* and *TXC* clock lines as a master clock.

**Bus Interface**

The bus interface section provides buffering of address lines A0-A15, and data lines D0-D7, buffered by ICs U1-3 respectively. ICs U4 and U5 buffer the following interface signals shown in Table 4-8.

| INTERFACE SIGNAL | DEFINITION |
|---|---|
| IORQ* | I/O Request |
| BUSQ* | Bus Request |
| WR* | Write |
| NMI* | Non-maskable Interrupt |
| RD* | Read |
| INTAK* | Interrupt Acknowledge |
| BUSAK* | Bus Acknowledge |
| RFSH* | Refresh |
| MEMRQ* | Memory Request |
| SYRESET* | System Reset |
| PCO | |
| WAIT* | Wait Command |
| CLOCK* | 4.0 MHz Master Clock |
| INT* | Interrupt |
| DEBUG* | Debug Mode |
| PCI | |
| MI* | |
| PB RESET* | Push-button Master Reset |

**Table 4-8 Z80 Key Signals**

**Z80 Processor**

The Z80 PCB utilizes the popular Z80 microprocessor, U12, and supports CP/M 2.2. The processor signals provided at the bus are defined by the Mostek STD-Z80 definition. Therefore, all STD-Z80 boards are compatible.

The Z80 processes instructions from the operating system (OS) ROM. These instructions primarily deal with system administration functions of the SFS 4500. The Z80 and the BOOT ROM controls system reset and system boot functions.

**9511/9512 Math Coprocessor**

The math coprocessor, U15, is provided to allow the Z80 to function at greater processing speeds and capacity. This chip performs math calculations by providing a memory-like interface to enter numbers or receive results. The math coprocessor allows both integer and floating point operations. A full set of transcendental functions are provided along with number format conversions. This device greatly enhances the SFS4500.

The coprocessor communicates with the Z80 on data lines D0-D7. The CTC signals the Z80 with *SVRQ*, *ERR* and *END* control signals via the CTC interrupt control routines and the CTC *TR2* trigger input.

**Counter Timer Circuit**

The counter timer circuit (CTC), U16, is used to provide a programmable baud rate generator and an interrupt controller. The hardware is configured so the external interrupts are brought to the CTC's trigger inputs, TR1, TR2. Upon an active transition of the trigger inputs the CTC uses mode 2 interrupts to vector to the service routine. Using the CTC to control interrupts allows the Z80 to use its powerful interrupt mode on non-Z80 peripheral devices.

The CTC provides the *ZC0* clock to the UART. This clock is then processed by the UART to produce the programmed baud rates. The CTC develops the UART clock *ZC0*, and trigger input timing from the externally provided clocks *CLX0* and Φ produced by the clock source.

UART

The universal asynchronous receiver/transmitter(UART), U21, is used for communication with the various printer configurations. The UART receives a master clock, *ZC0*, from the CTC. The UART then generates the programmed baud rates for the transmitted data sent on the TX DATA line, P1-3.

## Jumper Options

The following table list the jumper options for the Z80 CPU PCB to properly operate in the SFS 4500.

| JUMPER | ACTION |
|---|---|
| J3 E1-2 | IN |
| J3 D1-2 | OUT |
| J3 C1-2 | OUT |
| J3 B1-2 | OUT |
| J3 A1-2 | OUT |
| J4 | OUT |
| J5 B-C | IN |
| J6 A1-2 | IN |
| J6 G1-2 | IN |
| J6 I1-2 | IN |
| J7 | OUT |
| J9 A-B | IN |
| J10 | OUT |
| HEADER 20 - J6 to D2 | N |

**Table 4-9 Z80 Jumper Configuration**

## Reset Timing and Control

The NE555 timer, U8, provides the *RESET* and *RESET* *signals to the Z80 CPU and all other PCBs in the SFS 4500. The 555 is triggered by the *PB RESET** signal on P1-48. The *PB RESET* signal is developed on the PPC PCB from a push-button switch closure.

### I/O Control

Input/ Output control for the Z80 CPU is decoded by U20. This device decodes *CTC*, *ACIA*, *MATH* and *BIO* signals from LSB address bits A1-A7. *CTC* is the chip select (CS) signal for the counter timer chip. *ACIA* is *CS* signal for the UART. *MATH* is the *CS* signal for the coprocessor. *BIO* and other internal control signals develope the direction *DIR* control signal for the bi-directional data buffer for the data lines D0-D7.

### 4.4.3 SLAVE CPU PCB

**General**

Three major functions provided by the Slave CPU PCB are:

1. Haze data processing
2. Maintenance of one-half of the operator programmed menus
3. Assist the Main Z80 CPU in data management

The Slave CPU PCB is a Z80 based microcomputer board. It is designed to be a slave processor on the Z80 STD bus.

The Slave CPU PCB provides the Surfscan with a more efficient, faster method of data processing.

Features

- The Z80 microprocessor
- STD Z80 bus
- Two 8-bit parallel I/O ports
- 2K RAM memory
- 8K ROM memory
- 2K Non-Volatile RAM memory
- Software controled baud rate

**Slave CPU PCB Functional Block Description**

The Slave CPU PCB processes Haze data, maintains part of the operator programmed menus, and assist the Main CPU PCB to integrate the individual PCBs of the Surfscan. Haze data and its control lines are bussed through the two 8-bit parallel I/ O ports. The Haze data is latched onto RAM memory, awaiting processing by the Z80 CPU. The Z80 CPU inputs operating instructions and programmed parameters from the ROM and the Dallas non-volatile RAM memory for processing Haze data. The Counter/ Timer Circuit controls the baud rate of data processing. Output instructions from the Z80 CPU are routed through the STD bus. Refer to Fig. 4-17.

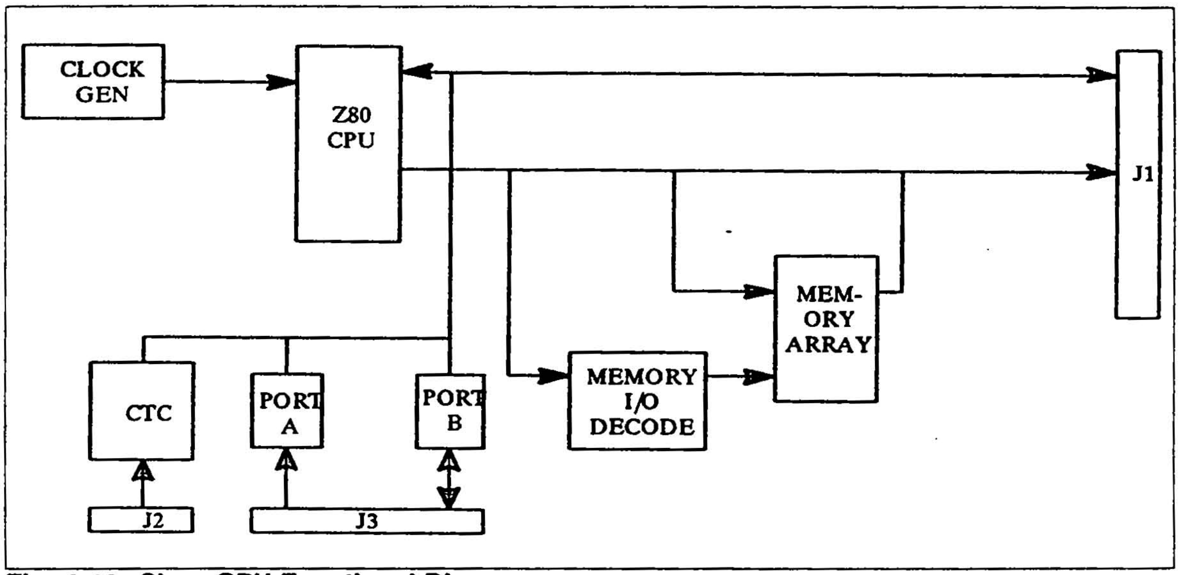


**Fig. 4-18 Slave CPU Functional Diagram**

## Z80 Microprocessor

The Z80 CPU, U10, is the board controller. It fetches, decodes and executes instructions from memory and generates the necessary address and control signal to co-ordinate data flow between the CPU and memory, or between the CPU and system I/O.

## Counter/Timer Circuit

The Counter/Timer Circuit (CTC), U4, provides four independent, programmable channels for either software or hardware controlled counting and timing functions. The CTC enables the Z80 CPU to read from memory by controlling the speed of delivery during read cycle time. The CTC is enabled by the *MEMORY ACCUMULATE*, (MA), signal from the Pre-Processor PCB.

## 2K RAM Memory

The 2K RAM Memory, U6, stores input data awaiting processing during the next time cycle. The input data could be instructions from the system I/ O from the STD bus, or Haze data from the parallel I/O port.

## 8K ROM Memory

The 8K ROM Memory, U5, contains the operating instructions of the Slave CPU PC. The information, contained within the ROM memory, is instructions to process Haze data and I/O system management.

## 2K Non-Volatile RAM Memory

The 2K Non-Volatile RAM Memory, U7, the Dallas DS1220Y IC, stores part of the operator programmed menus. Contained within the 24 DIP IC has a Lithium battery to maintain its memory upon system power down.

## Two 8-Bit Parallel I/O Ports

The two 8-bit parallel I/ O ports, J28, interfaces the Analog PC and Slave CPU PCB. The Analog PCB routes the Haze data through the two 8-bit parallel ports for processing at the Slave CPU. Haze data are routed through J28-pin 1 through pin 8.

The control lines *HAZE STB, WREN,* and *WIDTH THRESHOLD* identifies when data are to be process. These control lines are routed through J28-pin 10, 11, and 12 respectively.

**System Interface**

The Slave CPU PCB interfaces to the system I/O through the STD bus. It has bus arbitration logic which uses *BUSRQ* (Bus Request) and *BUSAK* (Bus Acknowledge) control lines to access and share the STD bus with the Main CPU PCB.

**System Configuration**

Certain Jumper Straps are tied together to identify the capabilities of the Slave CPU PCB. These jumpers inform the Z80 CPU how much memory is available and what I/O port lines are input and output. Fig. 4-19 labels the proper jumper configuration for the Surfscan Slave CPU, **NOTE: JB 10, 11, 14, and 15 have no jumpers.**

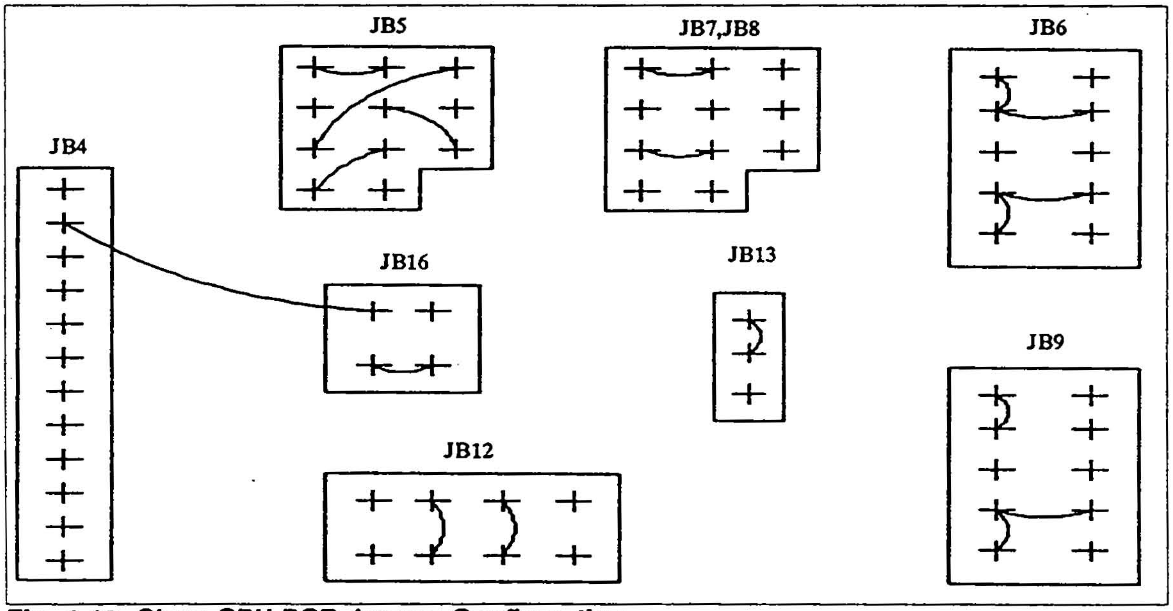



**Fig. 4-19 Slave CPU PCB Jumper Configuration**

## 4.4.4 Memory PCB

Introduction

The DY-4 Systems Inc. DSTD-503 board is a general purpose 4-bytewide memory module. It has twelve 28 pin sockets which can individually be configured for any of the popular bytewide memory devices. The DSTD-503 supports PROM, EPROM, RAM and EEPROM devices.

The software programmable memory mapping facility allows the sockets to be individually positioned anywhere in the Z80 processors address space on any 64K byte boundary.

**Features**

- Compatible with STD Z80 bus

- Twelve 28-pin memory sockets
- Each socket individually configurable
- Each socket allows individual address positioning on 4K/8K/16K address boundaries
- More than one DSTD-503 can be used in a system
- The mapping RAM is accessed as an I/O port

**Functional Description**

The DSTD-503 consists basically of STD bus interface logic, memory mapping logic and twelve sockets each with its own configuration jumper block. Logic is included to allow the DSTD-503 to be configured for the Z80 bus.

Fig. 4-20 below illustrates the flow of address, data and control signals on the DSTD-503. The following sections describe the function of each of the major blocks.

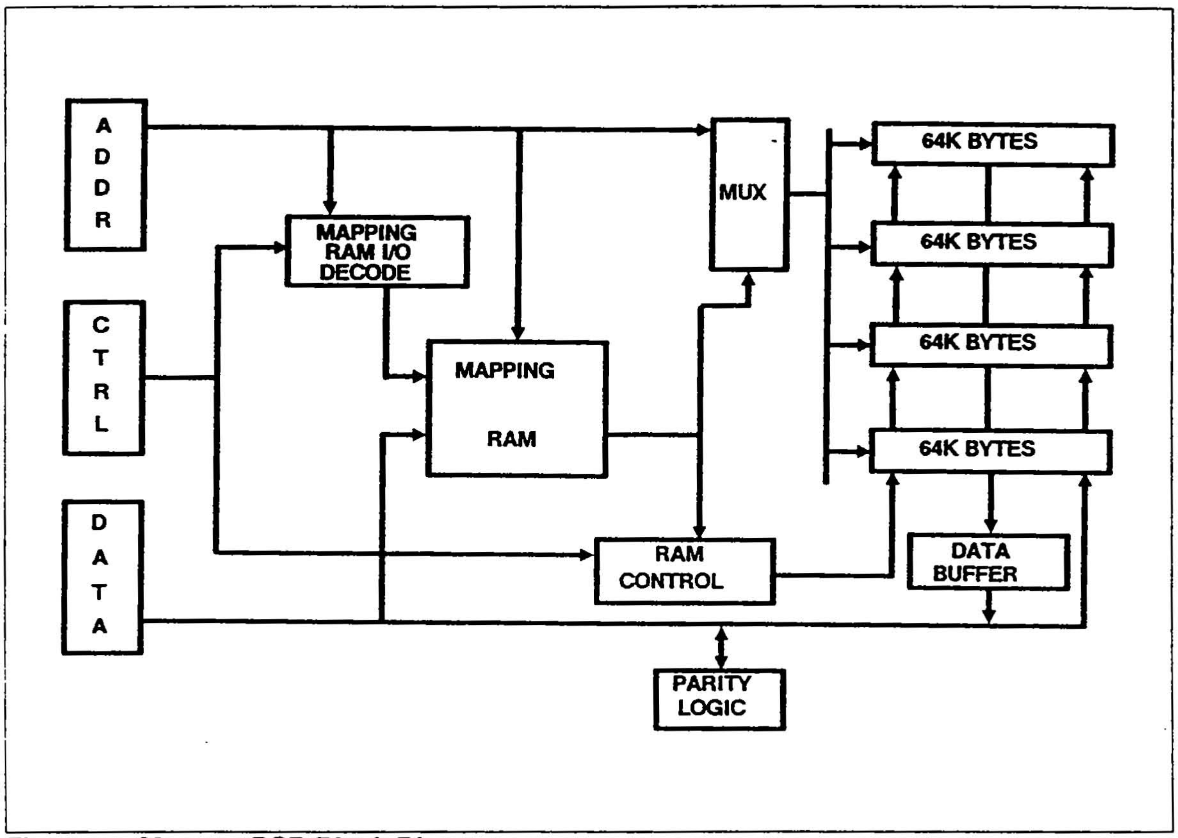



Fig. 4-20 Memory PCB Block Diagram

### Memory Mapping Logic

The main element of the memory mapping logic is a very high speed 16 X 6 bit memory array. The array may be read from, or written to via a single I/ O port. A latch is also provided to enable or disable the module.

### Memory Sockets

Each of the memory sockets can be individually configured for any of the supported bytewide memory devices.

EPROM memory selection by the Z80 CPU PCB is performed by device U19 pin 12. The *ROM** signal enables the EPROM memory PCB.

The following Table 4-10 shows the jumpers for the EPROM memory PCB.

| JUMPER | CONNECTION |
|---|---|
| JB1-8 | 1A-3C |
| JB1-8 | 1B-2C |
| JB1-8 | 1C-4B |
| JB1-8 | 2A-4B |
| JB1-8 | 3A-3B |
| JB9-12 | 1A-3C |
| JB9-12 | 1B-2B |
| JB9-12 | 1C-3B |
| JB13 | NONE |
| JB14 | 1-2 |
| JB15 | 1-2 |
| JB16 | NONE |
| JB17 | B8 A-B |
| JB17 | B7 A-B |
| JB17 | B6 A-B |
| JB17 | B5 A-B |
| JB17 | B4 A-B |
| JB17 | B3 A-B |
| JB17 | B2 NONE |
| JB17 | B1 NONE |
| JB18 | NONE |

**Table 4-10 EPROM Memory Jumpers**

### 4.4.5 DRAM PCB

**Introduction**

The dy-4 Systems DSTD-325 is a very dense dynamic memory module designed for use with the dy-4 Systems STD-Z80 bus products.

**Features**

- Configured With and Without Parity Checking
- 256K-bytes for 4.0 MHz Operation
- Unique Paging System

Since only 64K-bytes of memory can be accessed by the microprocessor, the DSTD-325 provides the additional memory decoding. This is accomplished using a high speed memory mapping RAM which is programmed using I/O port instructions.

The following Table 4-11 lists the jumper settings for the DRAM Memory PCB.

| JUMPER | CONNECTION |
|---|---|
| JB1 | 1A-1B |
| JB1 | 2A-2B |
| JB1 | 3A-3B |
| JB1 | 4A-4B |
| JB1 | 5A-7B NONE |
| JB1 | 8A-8B |
| JB2 | NONE |
| JB3 | NONE |

Table 4-11DRAM PCB Jumpers

### 4.4.6 CPU-9 PCB

The CPU-9 PCB is a single board computer which brings multi-user, multi-processing, and networking to the STD BUS. The CPU-9 provides a Z80 central processing unit, two fully programmable serial RS-232/422 (optional RS-485) ports and two 16-bit timers. The board has a memory management system that allows up to 64k bytes of on-board static memory (which may be battery backed0, up to 32k bytes of on-board EPROM, and up to 128k bytes of off-board memory by using MEMemory EXpand (MEMEX). The maps, in 4k segments, may fill up to three memory mapped banks. Multiple CPU-9 boards may be connected in parallel through the RS-422 serial port. This networking system uses tristate balanced drivers and receivers providing a high-speed long distance synchronous interconnect for distributed process control applications.

Standard Features

- Z80 STD Bus compatible
- Up to to 8 MHz operation
- 64k bytes of on-board static RAM w/opt battery backup
- From 4k to 32k (27256) bytes EPROM
- Three software selectable memory maps in 4k segments
- MEMEX and IOEXP are supported
- Ghostable EPROM
- Two serial communication ports with handshaking
  - Baud rates individually software selectable
  - Each port maybe interrupt driven or polled
  - Each port configurable as RS-232 or RS-422
  - RS-422 includes tristate drivers and receivers (opt RS-485)
- Centronics printer interface
- Two 16-bit timer channels w/ interrupts
- SBX interface connector allows daughter-board expansion
- Real-time clock with battery backup
- Full DMA supported

The CPU-9 PCB's major function is to interface with the instrument's master CPU and provide serial output for SECS II communication at J1, and parallel output for downloading to a printer at J2.

| RS-422 | RS-232 | SIGNAL NAME | DIR | DB25 | CPU-9 J1 | | DB25 | DIR | SIGNAL NAME | RS-232 | RS-422 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| X | X | GND | – | 1 | 1 | 2 | 14 | < | TXA | – | X |
| X | X | TXA* | > | 2 | 3 | 4 | 15 | > | RXA | – | X |
| – | X | RXA* | < | 3 | 5 | 6 | 16 | > | RXA* | – | X |
| – | – | N/C | – | 4 | 7 | 8 | 17 | > | CTSA* | – | X |
| – | X | CSTA | – | 5 | 9 | 10 | 18 | > | CSTA | – | X |
| – | – | N/C | – | 6 | 11 | 12 | 19 | < | DTRA* | – | X |
| X | X | GND | – | 7 | 13 | 14 | 20 | < | DTRA | X | X |
| X | X | GND | – | 1 | 15 | 16 | 14 | < | TXB | – | X |
| X | X | TXB* | > | 2 | 17 | 18 | 15 | > | RXB | – | X |
| – | X | RXB* | < | 3 | 19 | 20 | 16 | > | RXB* | – | X |
| – | – | N/C | – | 4 | 21 | 22 | 17 | > | CSTB* | – | X |
| – | X | CSTB | – | 5 | 23 | 24 | 18 | < | CSTB | – | X |
| – | – | N/C | | 6 | 25 | 26 | 19 | < | DTRB* | – | X |
| X | X | GND | | 7 | 27 | 28 | 20 | < | DTRB | X | X |
| | | unused | | | 29 | 30 | | | unused | | |
| | | unused | | | 31 | 32 | | | unused | | |
| | | unused | | | 33 | 34 | | | unused | | |

**Table 4-12Serial Port Wiring**

**Serial Communications**

All serial communications are handled by the Z8530 serial communications controller chip. It is a dual channel, multi-protocol data communications peripheral. The SCC functions as a serial-to-parallel, parallel-to-serial converter/ controller. The SCC can be software configured to satisfy a wide variety of serial communications applications. The device contains sophisticated internal functions including dual on-chip baud rate generators, digital phase-locked loops, and a crystal oscillator.

**Output Connections**

Outputs are available for RS-232 (+/- 12V), RS-422 (0 to 5V differential) and optionally RS-485 (RS-422 w/ improved drive) on connector J1. The following considerations were used to determine the pinout of J1: STD BUS PCB size specifications must be met; RS-232 was considered to be the most often used standard; mass termination was desirable; and signals for the other standards must be available to the user.

Connection requires a cable with a 34-pin mass termination header connector plugged into P1. Conductors 1 through 14 are mass terminated into a female DB-25 connector, matching cable conductor 1 to DB-25 pin 1. Conductors 15 through 28 are mass terminated into a second female DB-25 connector, matching cable conductor 15 to DB-25 pin 1. Conductors 28 through 34 are unused and trimmed at P1.

The interface cable to the user's RS-232 terminal or printer may use a maximum of four conductors and a grounded shield. The CPU-9 is wired as DCE with the following connections on the DB-25 connectors:

| DB-25 CONNECTIONS |
|---|
| 1 - GND |
| 2 - /TX (CPU-9 input) |
| 3 - /RX (CPU-9 output) |
| 5 - CTS (CPU-9 output) |
| 7 - GND |
| 20 - DTR (CPU-9 input) |

Table 4-13 CPU-9 DCE wiring

SF1 allows the user to terminate the other side of the differential receivers when a single ended connection (RS-232) is used. If channel A is single ended, strap SFS1 pins 3-4-5. If channel B is single ended, strap SF1 pins 1-2-3. Strap all the pins together if both channels are single ended. Remove the straps from the applicable channel if differential receivers (RS-422) are desired. The pignut of SF1 is as shown in .Table 4-14

| SF1 | FUNCTION | |
|---|---|---|
| 1 | /DTRB | CHANNEL B |
| 2 | TXDB | CHANNEL B |
| 3 | GROUND | |
| 4 | TXDA | CHANNEL A |
| 5 | /DTRA | CHANNEL A |

Table 4-14SF1 Wiring

Table 4-12 explains the connections to J1, the two DB-25 connectors, the name and direction of the signals with respect to the CPU-9, and which standards apply.
* indicates a signal which is low ( or negative) true.

**Parallel Printer Port**

The "Centronics Standard" for parallel printers is non-standard. That is, there is no set protocol for handshaking, number of bits used, strobe, or logic polarity. The parallel printer port on the CPU-9 can support approximately 90% of the parallel printers sold today. the CPU-9 transmits eight data bits with a software programmable length low true strobe pulse. Two printer status bits may be read through general purpose inputs on the Serial Communications Controller (SCC).

### Connections

A mass terminated cable may be manufactured to connect directly between J2 and the printer. Handshaking should meet the requirements of most printer. The following table illustrates J2 pignut.

| PRINTER PIN | SIGNAL NAME | SIGNAL DIR | CPU-9 J2 | SIGNAL DIR | SIGNAL NAME | PRINTER PIN |
|---|---|---|---|---|---|---|
| 1 | STROBE* | < | 1-2 | – | GND | 19 |
| 2 | DATA 0 | < | 3-4 | – | GND | 20 |
| 3 | DATA 1 | < | 5-6 | – | GND | 21 |
| 4 | DATA 2 | < | 7-8 | – | GND | 22 |
| 5 | DATA 3 | < | 9-10 | – | GND | 23 |
| 6 | DATA 4 | < | 11-12 | – | GND | 24 |
| 7 | DATA 5 | < | 13-14 | – | GND | 25 |
| 8 | DATA 6 | N/C | 15-16 | – | GND | 26 |
| 9 | DATA 7 | >DCDA | 17-18 | – | N/C | 27 |
| 10 | SSLCT | N/C++ | 19-20 | – | GND | 28 |
| 11 | BUSY | >DCDB | 21-22 | – | GND | 29 |
| 12 | PE | | 23-24 | – | GND | 30 |
| 13 | ACK* | | 25-26 | – | N/C | 31 |
| 14 | unused | | | | FAULT | 32 |
| 15 | unused | | | | unused | 33 |
| 16 | unused | | | | unused | 34 |

**Table 4-15 Parallel Printer Port Wiring**

NOTE: Some printers use undefined pins for other functions. The ribbon cable must have at least 21 conductors for all printers tested, however, additional conductors from beyond #22 may be removed if the printer does not operate.

++ This pin may be used to generate an interrupt to the CPU-9.

# 4.5 POWER SUPPLIES

**General**

The Surfscan 4500 power supplies are contained in the Power Drawer located on the left end and to the rear of the main chassis.

The power drawer contains the following supplies and provides the following power to the SFS 4500:

- ±5 VDC
- ±12 VDC
- +24 VDC
- +33 VDC
- Laser Power Supply
- Laser High Voltage PCB

The power drawer also contains the following:

- Video Monitor 115 VAC Power Connector
- Video Monitor Fuse, F3 (2A FST)
- Main Power ON/OFF Switch, S1
- Main Power Fuses, F1 and F2 (5A FST)
- Main Power Transformer, T1
- Input Power Line Filter
- Voltage Select Module, Selections of 100, 120, 220, or 240 VAC

For the following discussions on power supplies, calibration, and routing reference Tencor schematic #060518-02 "Power Supply Drawer", assembly print # 106828 "Power Drawer Assembly", assembly print # 106771 "Harness Assembly - Power Drawer", and schematic/assembly print # 061050-02 "PCB Schematic, High Voltage".

**Electrical Requirements**

| | |
|---|---|
| **Note1:** | **Permit a three minute warm-up before proceeding.** |

| | |
|---|---|
| **Note2:** | **The following voltage verification/ calibration measurements require** *different ground lead locations.* |

**Warning:** **NEVER attempt to verify the high-voltage power supply secondary voltage or associated voltages on the high-voltage PCB. Personal injury and/or equipment damage can occur.**

**Stepl:**

Connect the ground lead of a digital voltmeter to **TB2 - Pin 1** or **TB2 - Pin 2** on PS1 in the power drawer. Verify and adjust, if necessary, the following voltages:

System +5 VDC +4.90 VDC measured at the card cage

+5.10 VDC at the distribution PCB.

The idea is to balance these two measurement points around 5 VDC, e.g., 4.95 VDC and 5.05 VDC.

System +12 VDC 12.0 VDC ±1.0V

System -12 VDC 12.0 VDC ±1.0V

System +36 VDC 31.0 VDC ±1.0v at the handler PCB

**Step 2:**

The remaining voltages can only be verified. If the voltage is found to be out of tolerance either the regulator on the respective PCB must be replaced or troubleshooting should be performed to locate the voltage drop between the power drawer and the PCB.

Distribution +5 VDC5.0V ±0.1V

Indexer +5 VDC5.0V ±0.25V

Handler +5 VDC5.0V ±0.25V

Distribution +12 VDC12V ±1.0V

Distribution -12 VDC12.0V ±1.0V

Distribution +24 VDC21.0V ±1.0V

Handler +33 VDC31.0V +1.0V/-0V

Distribution -5.2 VDC5.2V ±0.25V

**Note 3:** **Voltages ±5, ±12, +24 are supplied from PS1 in the power supply drawer. If any of these voltages are found to be out of specification, non-adjustable, or faulty, PS 1 must be replaced.**

**Note 4:** **The high-voltage supply input voltage of 117 VAC is the only voltage that can be verified. If the supply is suspect, a replacement supply must be obtained from Tencor.**

| | |
|---|---|
| **Warning:** | **NEVER attempt to verify the high-voltage power supply secondary voltage or associated voltages on the high-voltage PCB. Personal injury and/or equipment damage can occur.** |

# 5 ELECTRONIC ALIGNMENTS

## 5.1 INTRODUCTION

The following sections of this manual contain the electronic alignment procedures for the surfscan alignment.

Each section deals with a unique sub-section of the instrument and is a stand-alone procedure independent of other procedures. Please note, however, that the above statement is not meant to suggest that the alignment of one section does not influence another section. Quite the opposite, as many sub-systems adjustments do effect other sections of the instrument, thus the overall alignment.

| | |
|---|---|
| Note: | **It is important to note that the following electronic alignments depend on mechanical alignment. It is important that the mechanical be performed before the electronic alignments. Mechanical alignment begins with Section 7.2.** |

### 5.1.1 ADJUSTING THE PMT DRIVE

**Objective**

The PMT Control PCB Calibration Procedure sets the basic calibration of the Surfscan 4500. This procedure assumes that other subsystems are properly aligned.

Basic calibration requires fine adjustments made during the final calibration of the Surfscan using two VLSI Standards, which are traceable to the National Bureau of Standards (NBS).

The ACS1423 Standard contains 1.091 $\mu$m diameter Latex Spheres and is used for setting the Secondary Calibration Point. The ACS1425 Standard contains 0.364 $\mu$m diameter Latex Spheres and is used for a Primary Calibration Point and verifying submicron sensitivity. These standards have unique and specific MEAN SCATTERING CROSS-SECTION values stated in units of square-microns ($\mu m^2$).

The Calibration Objective is to achieve the specified MEAN SCATTERING CROSS-SECTION values for each Standard by setting PMT1 DRIVE with R28.

The adjustment only allows for an approximate maximum of a ±6% change from the current setting with R28 set at absolute midpoint.

| | |
|---|---|
| NOTE: | **With a very small dynamic range of adjustment (±6%), this procedure assumes that the AUTO-CAL, (AC), reference PMT Analog Pulse set by the AC fiber-optic tube is at a correct level. With the level set correctly, very small adjustments can be made with R28, to achieve calibration and still maintain an acceptable range of adjustment for future calibrations.** |

**Items/Tools Required**

- Small Pot Tweaker
- Digital Volt Meter (DVM)
- VLSI Standard Model ACS1423; Tencor #081957
- (Sphere Size = 1.091 $\mu$m)
- VLSI Standard Model ACS1425; Tencor #081973
  (Sphere Size = 0.364 $\mu$m)
- PMT Control PCB Assy Drawing; Tencor #128066
- Distribution PCB Assy Drawing; Tencor #055972

**Setup**
Locate the following items:

1. On the Distribution PCB Assy, locate transistor Q5-Pin 3.3.
2. Using a DVM, monitor the PMT drive signal, HVD1, at Q5 pin 3 on the Distribution PCB.4.
3. Using Table 5-1, set the MENU parameters to the appropriate values based upon the Standard selected for scan.

**Procedure**

1. Setting the Primary Calibration Point (Sphere Size = .364 $\mu$m)
2. Set the appropriate MENU parameters for the ACS1425 Standard.
3. Note the voltage at Q5-Pin 3, Distribution PCB, **HVD1**.
4. Scan the .364 $\mu$m latex sphere standard.
5. Determine the MEAN SCATTERING CROSS-SECTION value.
6. The value should be 0.235 (±2%) $\mu m^2$. If the mean value of the particle data is not at the correct value, an adjustment of R28 is necessary.

| NOTE: | **An increase or decrease in HVD1 voltage as measured at Q5-Pin 3 of the Distribution PCB, corresponds with an increase or decrease in PMT sensitivity respectively.** |
|---|---|

**Verifying Higher Sensitivity (Sphere Size = 1.091 $\mu$m)**

1. Set the appropriate MENU parameters for the ACS1423 Standard.

2. Note the voltage at Q5-Pin 3, Distribution PCB, **HVD1**.
3. Scan the 1.091 $\mu$m diameter latex sphere standard.
4. Determine the MEAN SCATTERING CROSS-SECTION value.
5. The value should be .924 (±6%) $\mu m^2$. If the mean value of the particle data is not at the correct value, an adjustment of R28 is may be necessary to allow the Surfscan to measure and determine the specified MEAN SCATTERING CROSS-SECTIONS for the ACS1423 and ACS1425 standard.

| NOTE: | **If adjustments with R28 do not achieve the specified values for both standards, a problem may exist with the system, either optically or electrically. The instrument may need comprehensive calibration.** |
|---|---|

| | | | PARTICLE | | | SCATTERING CROSS-SECTION | | |
|---|---|---|---|---|---|---|---|---|
| SPHERE | MAX SZ | THRESHOLD | FROM | TO | BIN | MIN | MEAN | MAX |
| 0.212 | 0.256 | 0.002 | .003 | .030 | .001 | 0.013 | (0.014) | 0.015 |
| 0.238 | 0.256 | 0.004 | .012 | .040 | .001 | 0.022 | (0.024) | 0.026 |
| 0.364 | 0.512 | 0.008 | .160 | .280 | .002 | 0.216 | (0.220) | 0.224 |
| 0.500 | 2.56 | 0.02 | .380 | .820 | .01 | 0.562 | (0.585) | 0.608 |
| 1.091 | 2.56 | 0.02 | .58 | 1.32 | .01 | 0.87 | (0.924) | 0.98 |
| 2.02 | 5.12 | 0.04 | 1.32 | 3.12 | .02 | 1.97 | (2.14) | 2.31 |
| 4.00 | 10.24 | 0.08 | 2.64 | 6.32 | .04 | 3.80 | (4.32) | 4.84 |

**Table 5-1 Surfscan Calibration Table**

### 5.1.2 SETTING THE SCAN MIRROR GAIN & AMPLITUDE

**Objective**

The Distribution PCB drives and controls the Scan Mirror. Two potentiometers are provided for adjusting the drive and control. The adjustments to both potentiometers affect Start-Up, Scan Amplitude, and Scan Stabilization.

Improper settings of drive and control can cause a system interrupt and/ or scan inconsistencies.

**Items/Tools Required**

- Digital Volt Meter (DVM)
- Oscilloscope
- Small Pot Tweaker
- Distribution PCB Assy Drawing; Tencor # 055972

**Setup**
On the Distribution PCB, locate the following items:

1. R25, Scan Feedback Gain Pot, Next to U17
2. R52, Scan Amplitude Pot, Next to U19
3. C16, Next to R25
4. TP-7, Marked "AMPL" on the PCB, Next to R25
5. TP-8, Marked "SCON" on the PCB, Lower/Left Corner of PCB
6. TP-6, Marked "AGND" on the PCB, Lower/Left Corner of PCB

**Alignment Procedure**

1. Power OFF the Surfscan.

2. Set both R25 and R52 to the following:
R25: Using a DVM place the test leads across C16 of the Distribution PCB. Adjust R25 until the DVM reads approximately 12.5 kΩ.

R52: Place the test leads at R51-Top and **AGND**. Adjust R52 until the DVM reads approximately 833 Ω.

1. Switch DVM to voltage mode and place the DVM ( + ) lead at TP-7, **AMPL**, and (-) lead at TP-6, **AGND**. Using an oscilloscope, monitor the Scan Mirror Drive signal at TP-8, **SCON**.

2. Power ON the Surfscan. Note the sinuosity waveform and **AMPL** voltage reading displayed on the DVM. Reference Fig. 5-1 shown below.

3. Measure the period of one cycle of the waveform. If it is less than 2500 $\mu$S, increase the gain by adjusting R25 (CW) until one cycle-period measures 2500 $\mu$S, as shown below in Fig. 5-1.

4. Use the appropriate step, A or B, based on the **AMPL** voltage reading.
Greater than -2.5 Volts indicates lack of Scan Amplitude. Increase the Scan Amplitude by adjusting R52 (CCW) until the **AMPL** voltage reads -2.5 Volts ±0.5V.

Less than -2.5 Volts indicates an excess of Scan Amplitude. Decrease the Scan Amplitude by adjusting R52 (CW) until the **AMPL** voltage reads -2.5 Volts ±0.5V.

1. Verify the settings by powering **OFF**, then powering **ON** the instrument. The Scan Mirror should Self-Start and the **AMPL** voltage should settle at -2.5 Volts ±0.5V within 5 to 10 seconds.

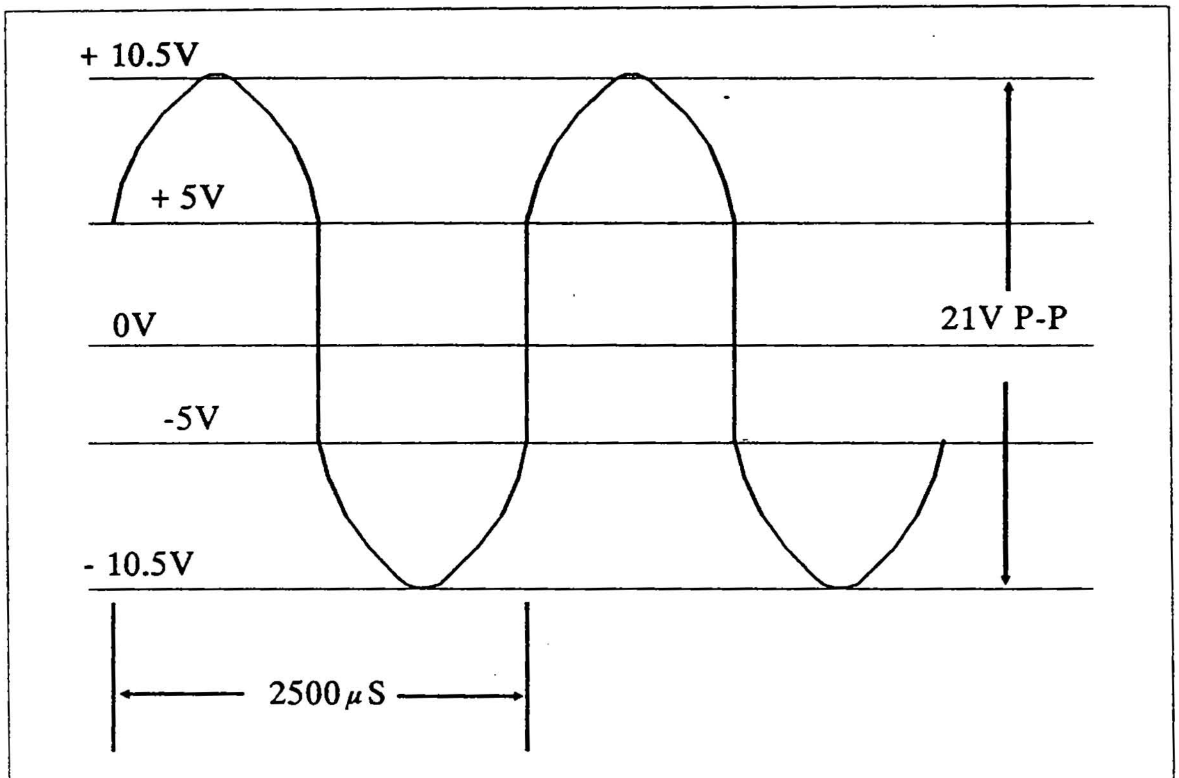



**Fig. 5-1 Scan Mirror Drive Signal**

### 5.1.3 ADJUSTING THE MONITOR DISPLAY

**Introduction**
The following procedures are used to adjust and align thje Mitsubishi Electric and Sony monitors used on the Surfscan instruments.

These procedures begin with the equipment needed and then proceed thru various alignment and calibration stages of monitor alignment.

| | |
|---|---|
| **DANGER:** | **It is recommended that the service technician remove ALL jewelry, watches, and rings, as well as any other metal jewelry. This is for your personal safety.**<br>**Exercise greqat caution when adjusting the high-voltage supplying the 2nd anode of the picture tube.** |

## 5.2 POWER SUPPLIES

**General**
The Surfscan 4500 power supplies are contained in the Power Drawer located on the left end and to the rear of the main chassis.

The power drawer contains the following power supplies for the SFS 4500:

- ±5 VDC
- ±12 VDC
- +24 VDC
- +33 VDC
- Laser Power Supply
- Laser High Voltage PCB

The power drawer also contains the following:

- Video Monitor 115 VAC Power Connector
- Video Monitor Fuse, F3 (2A FST)
- Main Power ON/OFF Switch, S1
- Main Power Fuses, F1 and F2 (5A FST)
- Main Power Transformer, T1
- Input Power Line Filter
- Voltage Select Module, Selections of 100, 120, 220, or 240 VAC

For the following discussions on power supplies, calibration, and routing reference Tencor schematic #060518-02 "Power Supply Drawer", assembly print # 106828 "Power Drawer Assembly", assembly print # 106771 "Harness Assembly - Power Drawer", and schematic/assembly print # 061050-02 "PCB Schematic, High Voltage".

## Electrical Requirements

| | |
|---|---|
| **NOTE1:** | **Permit a three minute warm-up before proceeding.** |

| | |
|---|---|
| **NOTE2:** | **The following voltage verification/ calibration measurements require *different ground lead locations*.** |

| | |
|---|---|
| **WARNING:** | **NEVER attempt to verify the high-voltage power supply secondary voltage or associated voltages on the high-voltage PCB. Personal injury and/or equipment damage can occur.** |

**Step 1:**

Connect the ground lead of a digital voltmeter to **TB2 - Pin 1** or **TB2 - Pin 2** on PS1 in the power drawer. Verify and adjust, if necessary, the following voltages:

System +5 VDC +4.90 VDC measured at the card cage

+5.10 VDC at the distribution PCB.

The idea is to balance these two measurement points around 5 VDC, e.g., 4.95 VDC and 5.05 VDC.

System +12 VDC12.0 VDC ±1.0V

System -12 VDC12.0 VDC ±1.0V

System +36 VDC31.0 VDC ±1.0v at the handler PCB

**Step 2:**

The remaining voltages can only be verified. If the voltage is found to be out of tolerance either the regulator on the respective PCB must be replaced or troubleshooting should be performed to locate the voltage drop between the power drawer and the PCB.

Distribution +5 VDC5.0V ±0.1V

Indexer +5 VDC5.0V ±0.25V

Handler +5 VDC5.0V ±0.25V

Distribution +12 VDC12V ±1.0V

Distribution -12 VDC12.0V ±1.0V

Distribution +24 VDC21.0V ±1.0V

Handler +33 VDC31.0V +1.0V/-0V

Distribution -5.2 VDC5.2V ±0.25V

**NOTE 3:** Voltages ±5, ±12, +24 are supplied from PS1 in the power supply drawer. If any of these voltages are found to be out of specification, non-adjustable, or faulty, PS 1 must be replaced.

**NOTE 4:** The high-voltage supply input voltage of 117 VAC is the only voltage that can be verified. If the supply is suspect, a replacement supply must be obtained from Tencor.

**WARNING:** NEVER attempt to verify the high-voltage power supply secondary voltage or associated voltages on the high-voltage PCB. Personal injury and/or equipment damage can occur.

## 5.2.1 LASER POWER SUPPLY TEST CABLE OPERATION & TEST PROCEDURE

**Overview**

This test cable enables maintenance personnel to safely measure laser plasma tube current on Helium Neon laser systems. The cable is inserted between the laser head and the laser power supply. A voltage is read across a series resistor in the cable assembly. This value is then converted to current by a conversion factor 1 volt = 1 milliamp.

**Objective**

The purpose of this test is to measure the laser tube current to ensure proper operating current. This parameter, when not correctly set, can drastically effect the laser performance and tube life.

| CAUTION: ELECTRICAL SHOCK HAZARD COULD OCCUR. |
|---|

**List of Equipment**

- Laser Test Cable; P/ N 167320-19
- Digital Volt Meter

**Setup and Procedure**

1. Unplug the AC power cable and turn off master power switch to ensure that AC power to the laser power supply is off.
2. Carefully unplug the laser head from the power supply by separating the male/ female molded plug pair. Be sure not to touch the male/ laser plug end until the residual charge on the laser has been discharged. This can be accomplished by shorting both male ends together against the optical plate or the chassis.
3. Plug in the double lead into the multimeter and measure the resistance. This should be 1KΩ ±1%. Be sure to reset the meter to voltage measurement before proceeding to the next step in the procedure.
4. For *SAFETY*, be sure not to touch the male laser plug end until the residual charge on the laser has been discharged. This can be accomplished by shorting both male ends together against the optical plate or the chassis.

| NOTE: | Be sure all connections between the laser cable, the laser power supply and the test cable are tight and secure. |
|---|---|

5. Connect the test harness in the following manner. Connect the test harness male molded plug into the power supply female plug. Connect the laser plug into the test harness female plug. Set the meter to at least 10 volts full scale.

| NOTE: | All plugs/sockets are labeled for proper connections. |
|---|---|

6. Turn on the system and record the voltage reading after a 90 second warm-up period. If the instrument has been powered down for an extended period of time (several days), allow the instrument to warm-up and stabilize for 30 minutes.

| NOTE: | 1.0 volt is equivalent to 1.0 mA of laser tube current. |
|---|---|

7. Turn off the main power switch and carefully disconnect the molded plugs. Be careful of shock hazard and short the leads from laser together.

**Results**

The following should be considered when evaluating and adjusting tube currents.

The tube current should fall with in the ranges.

| SYSTEM | LASER POWER/MODEL | CURRENT | RANGE |
|---|---|---|---|
| SFS100 | 2.0 mW | 5.0 mA | ±0.3 μA |
| SFS160 | " | " | " |
| SFS164 | " | " | " |
| SFS200 | " | " | " |
| SFS260 | " | " | " |
| SFS300 | " | " | " |
| SFS364 | " | " | " |
| SFS3000 | " | " | " |
| SFS4000 | " | " | " |
| SFS4500 | " | " | " |
| SFS5000 | " | " | " |
| SFS5500 | 5.0 mW | .5 mA | ± 0.3 μA |

**Table 5-2 Laser Power Supply Adjustment Table**

| | |
|---|---|
| **NOTE:** | **Not all units have current adjustments available on the power supply.** |

The laser power supply should be adjusted to the correct tube current if the value measured falls outside the specified range. This is accomplished by removing the tape covering the adjustment trim pot. Adjust the pot the specified value from Table 5-2. After adjustment is complete, replace the tape seal with a new seal.

This tape seal is used to indicate possible tampering and unauthorized adjustments. Be sure to replace (or put in place, if missing) this tape with a new seal, P/N 167606.

It should also be noted that beam intensity should be steady after any adjustments are made.

## 5.3 MECHANICAL ALIGNMENTS

**General Information**

By providing periodic mechanical checks and alignments on the Surfscan wafer handling system, downtime attributed from mechanical problems can be greatly reduce. The mechanical alignments involve the many settings needed by the Surfscan for its proper functional characteristics. These Surfscan functional characteristics are:

1. Smooth wafer transport system
2. Smooth wafer indexing system
3. Correct wafer positioning for scanning

To achieved the 3 functional characteristics of the Surfscan wafer handling system, checks and alignments must be made on the various components. The Surfscan wafer handling system consists of:

1. The trolley
2. Vacuum valve and vacuum
3. Various optical sensors and test flags
4. Puck and puck arm
5. Stepper motor and clutch system
6. Indexer platform
7. Lead screw and guide rails
8. The Coulissa

## 5.3.1 SCANNING OPTICS

**Objective:**
This procedure is a two step process covering the installation of a Laser, and the Beam Scan alignment itself. The overall objective is to create a tightly focused, circularly polarized beam spot; then create a vertical raster scan properly aligned with the positions of the Auto- Zero and Auto-Cal sensors.

Proper installation of the Laser Assembly, and precise alignment of the Laser Beam/ Scan is critical to the instrument's measurement performance. It ensures proper beam positioning and polarization. This procedure entails mechanical alignments made only at the Optics Plate.

| | |
|---|---|
| **NOTE:** | **Adjustments made on the Scanning Optics Assembly assume that the AC and AZ sensors are located in their factory set position. With this assumption, the sensors are used as a reference in positioning the beam scan. See Section XXX for AC and AZ sensor alignment.** |

**Items/Tools Required**

- 1 InterLock Magnet
- Polarizer
- Beam Targets

| | |
|---|---|
| **NOTE:** | **Upon determining the Laser Assy requires replacement, DO NOT REMOVE THE BAD LASER ASSY, until its vertical position within its Mounting Brackets have been determined.** |

**PROCEDURE**

**Setup**

1. With the instrument power off and the Scan Unit Hood removed, place the Interlock Magnet on the Laser Interlock Switch.
2. Remove the front cover of the instrument. Also, remove the black cover plate directly, behind the Distribution PCB.
3. Disconnect the Laser from the High Voltage connector.

**Laser Removal and Installation**

1. Install the Polarizer, flush, under the bad Laser and securely tighten the Polarizer set screws. This sets the vertical laser position.

2. Loosen the Laser Mounting screws and count the number of CCW turns on each screw to within a 1/4 turn. Loosen only to allow easy removal of the Laser.

| | | |
|---|---|---|
| Top Bracket: | Left ________ | Right ________ |
| Bot Bracket: | Left ________ | Right ________ |

**Table 5-3 Turns: Laser Mounting Set Screws**

3. Remove the bad laser and insert the new laser from the top mounting bracket. If necessary, depress the spring loaded pins while inserting the new laser. Insert the new laser flush with the Polarizer.
4. Reconnect the Laser with the HV cable and Power On instrument.
5. The Laser should come on; if not, reposition the Interlock Magnet.

**Polarization**

1. Slowly rotate the laser until the Laser beam disappears from the surface of the Double Right Angle Prism.
2. Using Table 5-3, secure the Laser by turning the mounting set screws CW, the number of turns noted.
3. Remove the Polarizer and insert the Turret Mirror Beam Target. Using a small white piece of paper (approx. 2" x 2"), clean room type, check the shape and intensity of the Beam Spot.

> NOTE: **It should be circular and somewhat uniform in intensity from center to edge. It should also be free of defects at its perimeter. If not, proceed to the Advanced Optical Alignment section.**

### Advanced Optical Alignment

> **NOTE:** **These next sections deal with Advanced Optical Alignments and extreme caution should be used. These alignments should be performed by a qualified Tencor Instrument Representative only. Misalignment may cause invalid readings and degrade the performance of the instrument.**

1. Remove the Spatial Filter and Spring by removing the top plate and then the Spatial Filter Block.

   **DO NOT LOOSEN OR REMOVE THE SPATIAL FILTER MOUNTING ASSY.**

2. Adjust the Laser Mounting Set Screws to position the Beam at the Turret Mirror Target or center of Turret Mirror. Since laser replacement is all that is involved the adjustments to the Laser position are all that is required.

   **DO NOT ADJUST THE DOUBLE RIGHT ANGLE PRISM.**

3. Replace the Spatial Filter, Spring and cover. Lightly secure the cover to allow for X-Y positioning.

4. Position the Spatial Filter, using the X-Y Adjustment Screws, for a circular beam spot with uniform intensity and free of defects.

5. Once beam positioning is accomplished with the Beam Target, check the beam path beginning at the Turret Mirror. Using the white piece of paper, ensure that the beam is approximately centered on each optical element stated below in the following order:

   - Turret Mirror (Target) Checks Laser and Prism X-Y Positions relative to Turret Mirror Target.
   - Main Focus Lens
   - Scan Mirror (Target) Checks Turret Mirror X-Y Position relative to Scan Mirror Target.

6. Adjust the Turret Mirror to center the beam on the Scan Mirror if necessary. Upon correcting the Beam Path, verify the Beam Scan is positioned properly on both the Auto-Zero (AZ) and Auto-Cal sensors.

   - Centering
   - Stand-off
   - Twist

If the Beam Scan is not properly positioned on both sensors, perform Scan Mirror Alignment.

### Scan Mirror Alignment

The Scan Mirror mount has three adjustment degrees of freedom; Centering, Stand-off, and Twist. See Fig. 5-2.

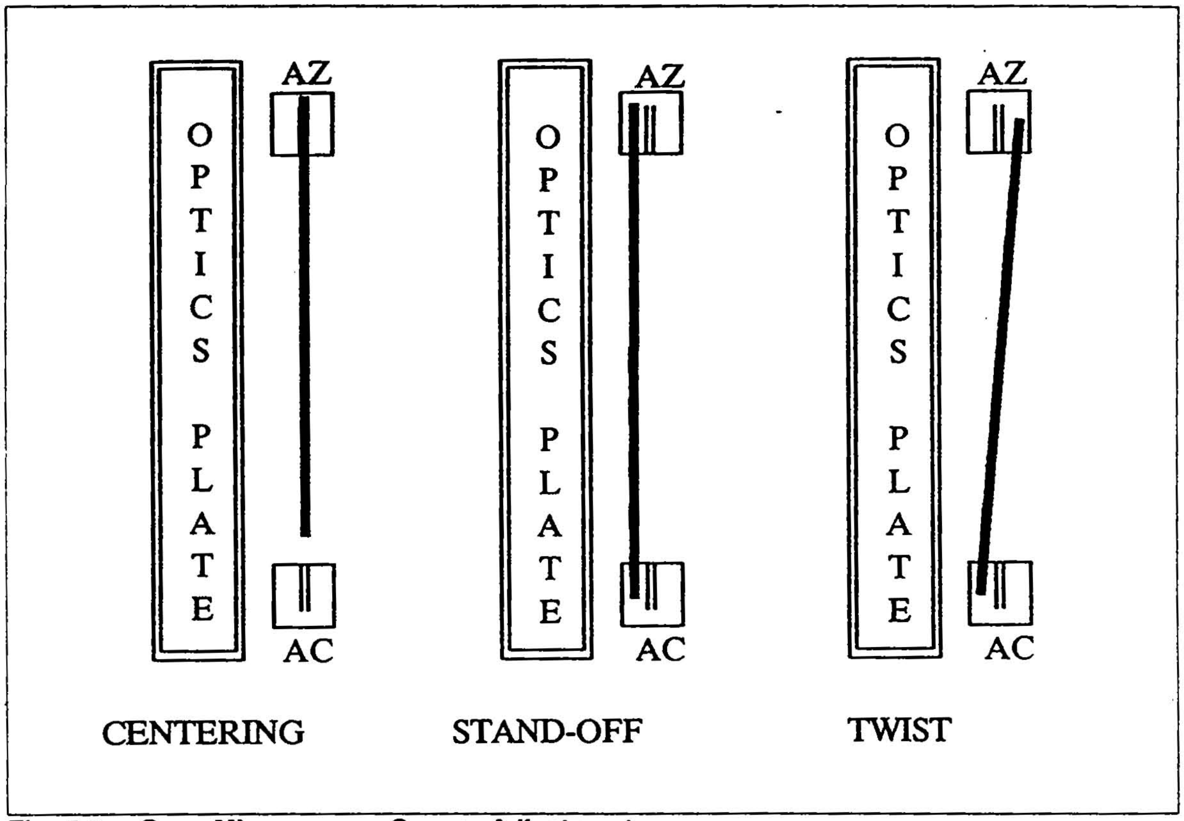



Fig. 5-2 Scan Mirror versus Sensor Adjustment

The adjustments are made with the screws described in Fig. 5-3.

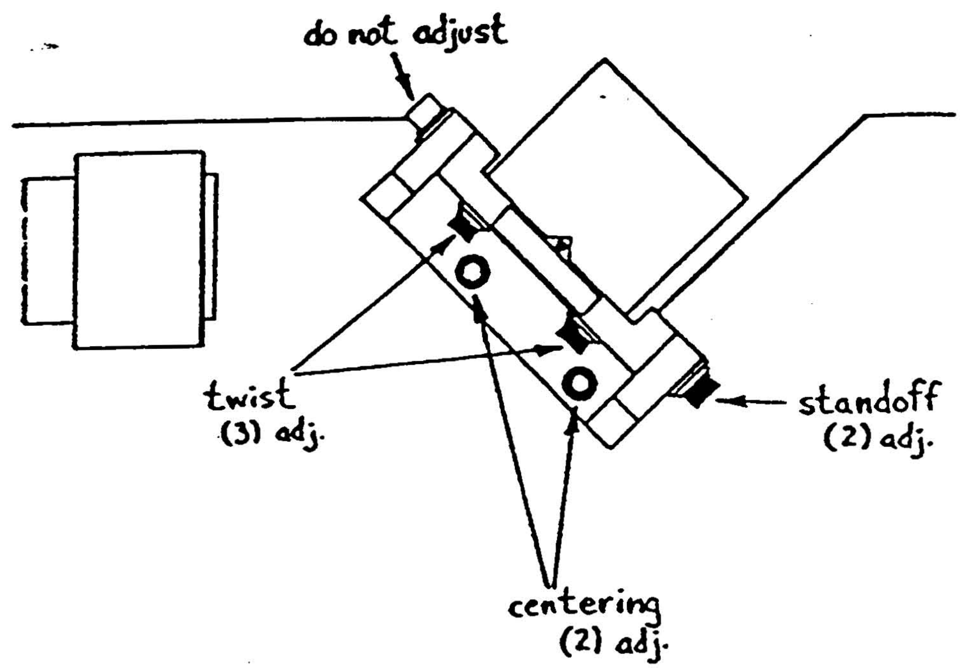



Fig. 5-3 Scan Mirror Adjustment Screws

| | |
|---|---|
| NOTE: | **Adjustments made on the Scanning Optics Assembly assume that the AC and AZ sensors are located in their factory set position. With this assumption, the sensors are used as a reference in positioning the beam scan. See Section XXX for AC and AZ sensor alignment.** |

**Centering**

Disconnect the AC sensor to allow the Beam Scan to remain fixed. The scan amplitude will be longer than normal. Centering should be done with the scanned laser beam hitting the tops of the Auto-Cal (AC) and Auto-Zero detectors but not entering the slots. Place the ruler or scale under the beam scan, on top of the sensors. This allows the limits of the beam scan to be easily seen referenced to the scale.

1. With the Centering adjustment screws slightly loosened, adjust the scanning mirror mount so that the overscan length portions are equal on the AZ and AC sensors.

2. Support the Scan Mirror assembly while slowly tightening the Centering adjustment screws. Alternate the tightening of the screws to avoid shifting the assembly.

**Stand-off and Twist**

1. Move the Scan Mirror in the directions that affect the beam Stand-Off. Twist the Scan Mirror assembly so that the beam scans close to the sensor slots, on the same side of the slots of the two sensor assemblies, but still does not enter the slots.

2. Look at the surface of the Scan Mirror with somewhat subdued ambient light and check to see that the beam spot is centered on the Scan Mirror. If it is not, the beam spot will have to be recentered on the Scan Mirror. Repositioning of the beam with the Turret Mirror may be necessary.

3. Re-check the Centering of the beam scan on the sensors and readjust if necessary.

4. Now adjust the Stand-off and twist to place the beam scan directly into the centers of the slots of both detectors.

5. Support the Scan Mirror assembly while slowly tightening the adjustment screws. Alternate the tightening of the screws to avoid shifting the assembly.

### 5.3.2 COLLECTION OPTICS ALIGNMENT

**Objective**

This procedure deals with the alignment of the Collection Optics. The Collection Optics is made up of the following items:

- Elliptical Mirror
- Light Baffle
- Beam Catcher

The main objective of the procedure is to optimize the collection of scattered light occurring during a wafer scan.

This procedure assumes both the Scanning Optics and Puck Arm related alignments are accurate and complete.

**Item/Tools Required**

- White Striped Wafer
- 2" x 2" Post Its (Clean Room Type)
- Standard Allen Wrench Set (Inch)
- Interlock Magnet

**Setup**

1. Disable the PMT by setting the MAX SIZE parameter to 0.

2. Set the Wafer Transfer Mode to 1-Wafer Mode.

3. Remove the Beam Catcher and Light Baffle.

4. Remove the Scan Hood and enable the laser by placing the magnet over the Laser interlock switch.

**Procedure**
Elliptical Mirror Alignment (Setting F2)

1. Reset the SFS4500 to ensure the system is properly initialized.

2. Press **[START]** and place the White Striped wafer on the puck with the strip perpendicular to the puck (See Fig. 5-4).

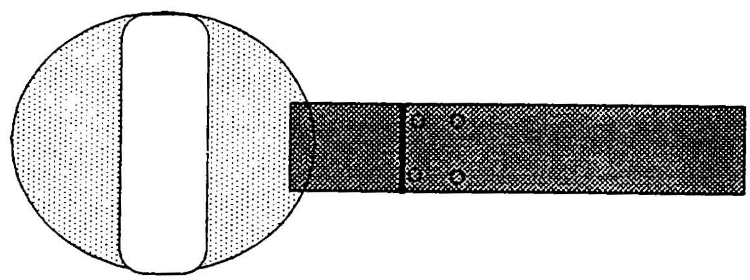


**Fig. 5-4 White Striped Wafer Placement**

3. Press **[START]** again to scan the wafer. **[STOP]** when the scan reaches the middle of the wafer where the stripe is located.

4. A bright sharply focused line should be present at the center of the fiber-optics bundle. This point is known as F2, focal point 2. See Fig. 5-5.

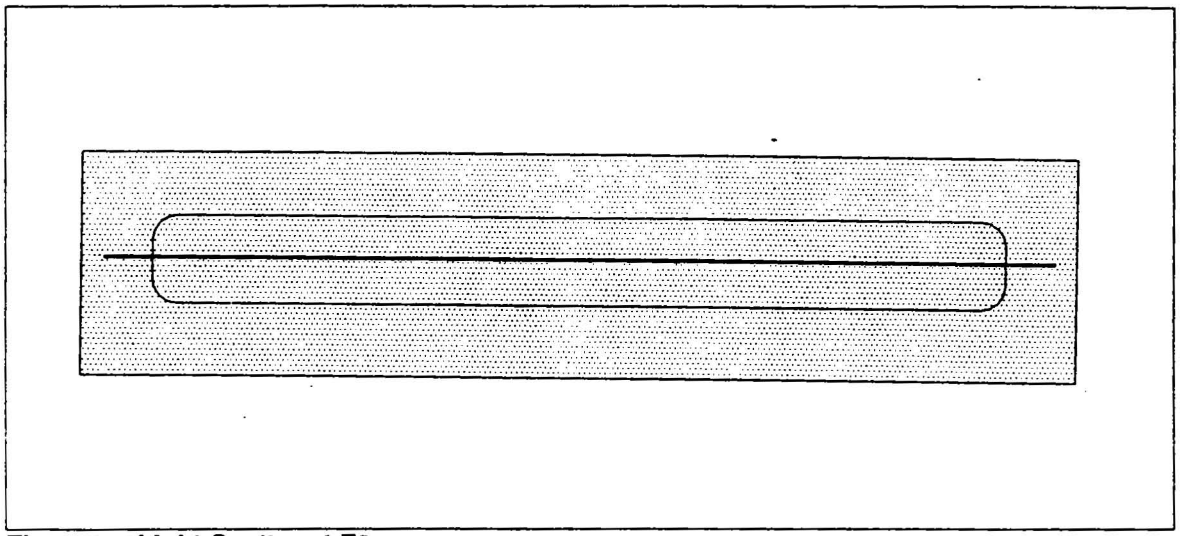


Fig. 5-5 Light Scatter at F2

5. Loosen the Elliptical Mirror screws, and adjust the mirror with a twisting and lifting action for a sharp line across the center of the bundle.

6. Secure the mounting set screws of the Elliptical Mirror and press [HOME] to remove the wafer.

**Light Baffle Installation**

1. Once F2 has been set with the Elliptical Mirror, the light baffle can be installed.

2. Scan a bare silicon wafer and [STOP] at mid-scan to achieve a reflected beam.

3. The light baffle should be placed so that the sides of the baffle opening do not interfere with either the primary or reflected beam. Using the Post Its, place one across the baffle opening at both ends of the scan so that both the primary and reflected beams can be observed. See Fig. 5-6.

4. The primary and reflected beams should be placed symmetrically at the thirds points of the baffle opening. Secure the mounting set screws and carefully verify the beams aren't touching the sides of the baffle opening.

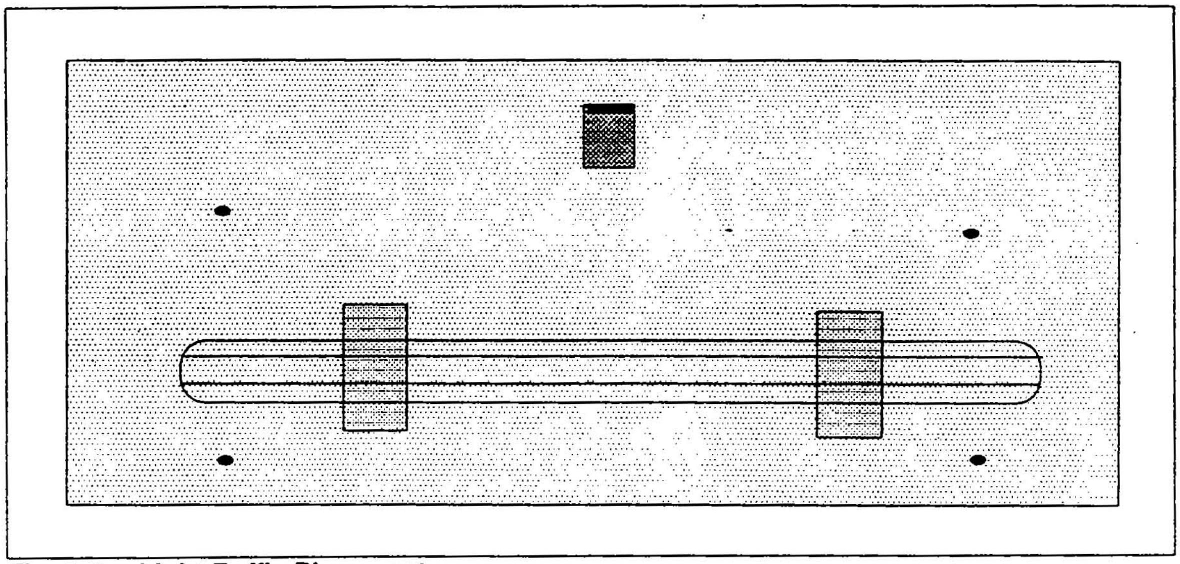


Fig. 5-6 Light Baffle Placement

**Beam Catcher Installation**

1. Install the beam catcher and keep the mounting set screws loose for adjustments.
2. It should be installed so that it "catches" the reflected beam and not interfere with the primary beam.
3. Post Its can be placed onto the beam catcher for easier verification of the beam on the assembly (Fig. 5-7).

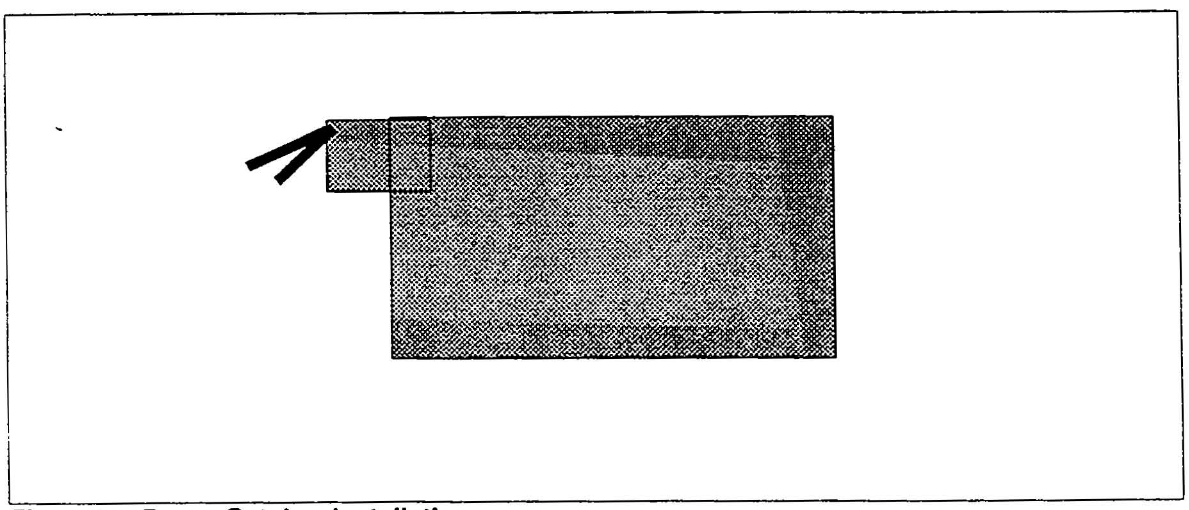


Fig. 5-7 Beam Catcher Installation

4. Secure the mounting screws and verify the reflected beam is parallel with the edge of the beam catcher. Also, verify the tops of the Beam Catcher mounting blocks are parallel with the top of the collection optics housing (See Fig. 5-8).

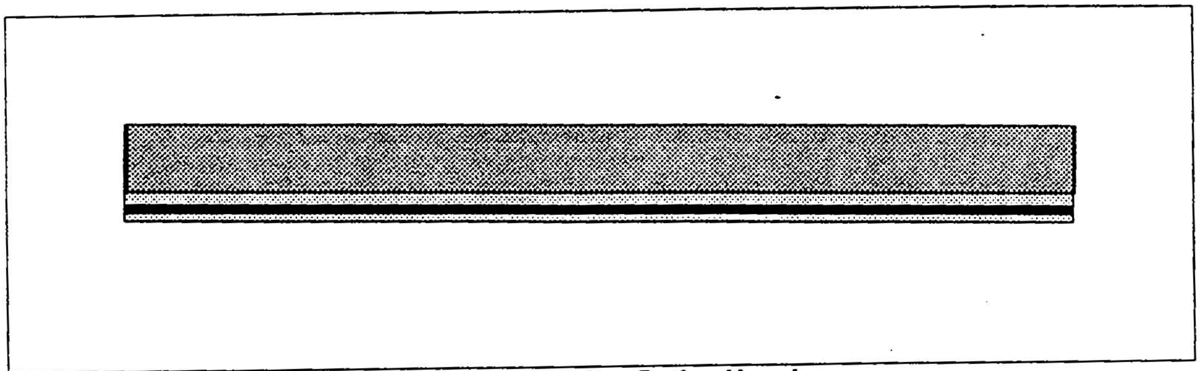


**Fig. 5-8 Beam Catcher Aligned with Collection Optics Housing**

## 5.4 TROLLEY ALIGNMENT

**General Information**

Proper robotic alignment insures proper functional characteristics of the Surfscan wafer handling system and the scan unit optical collection system. The trolley, elevators and the vacuum valve control assembly are the major components that will be adjusted in this section.

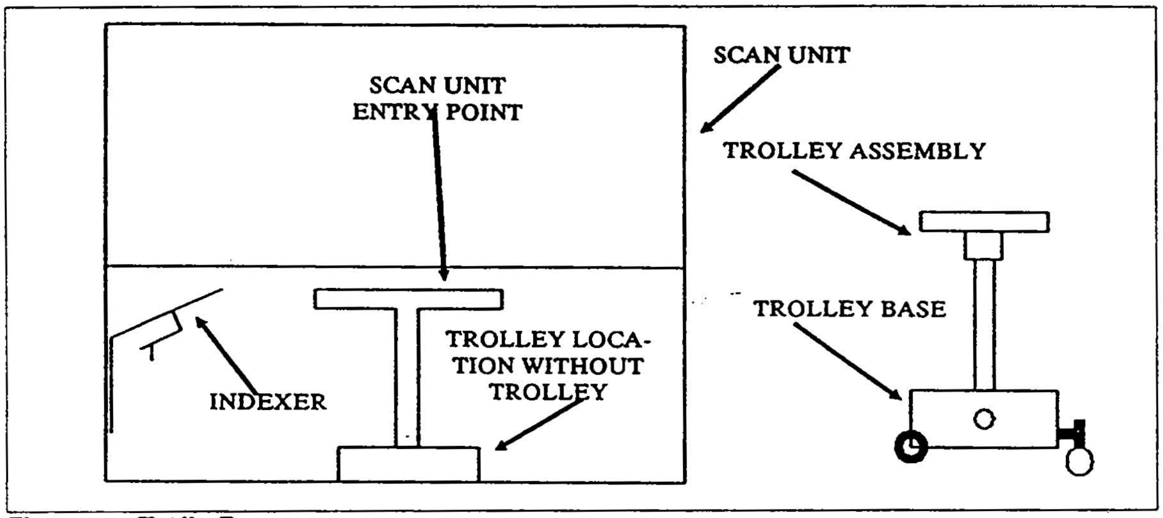



Fig. 5-9 Trolly Base

The Trolly Home Sensor Alignment provides proper trolly positioning to load and unload a wafer from an indexer. Improper alignment can cause wafer crash due to the puck reaching into the wafer cassette at an incorrect angle of approach. Refer to Fig. 5-10

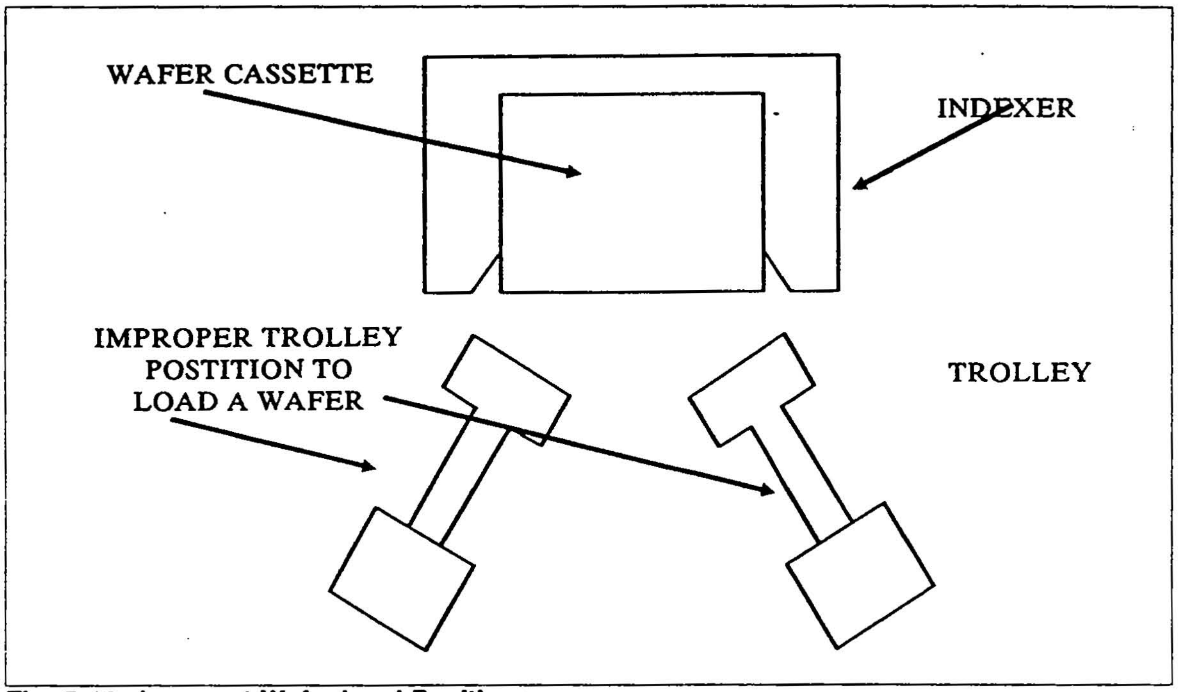



Fig. 5-10 Incorrect Wafer Load Positions

### 5.4.1 TROLLEY BASE ALIGNMENT

The Trolley Base alignment objective is to align the trolley base holding the puck arm parallel to the guide rails on which it rides.

**Items/Tools Required**

- Bubble level
- A standard Allen wrench set.

**Alignment Procedure**

1. Power off the Surfscan.
2. Place a bubble level on top of the trolley base (Fig. 5-11).

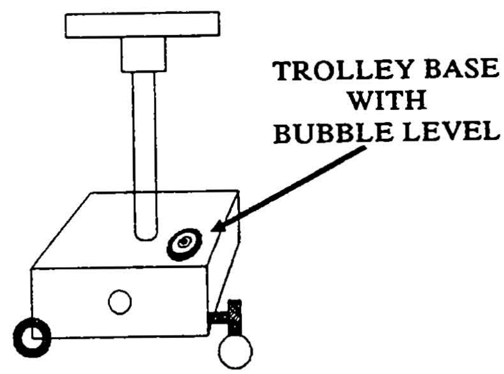



**Fig. 5-11 Trolly base with bubble level**

3. Move the trolley base as close to the scan unit entry point as is possible and still be able to observe the bubble level on the base. Compare the bubble level on the base of the trolley to the system bubble level located on the handler frame near the trolley home position.
4. If the two bubble level positions match, no adjustment is needed. If they do not, loosen the eccentric bearing locking screw.
5. Reposition the eccentric bearing adjust screw until the two bubble levels match each other.
6. Tighten the eccentric bearing locking screw.

## Puck Arm Alignment

### Objective

The Puck Arm and Puck alignment objective is to provide a correct angle of wafer tilt for proper laser beam reflection.

| NOTE: | The Puck Arm and Puck alignment is performed within the scan unit with the collection optics removed for accurate wafer tilt positioning. It is possible to perform this alignment at the scan unit entry port, but at a cost of reduce wafer tilt accuracy. |
|---|---|

### Items/Tools Required

- Puck alignment tool, T bar
- A standard set of Allen wrenches

### Alignment Procedure

1. Place the specially designed puck alignment tool fixture between the Puck and the two guide bars (See Fig. 5-12).

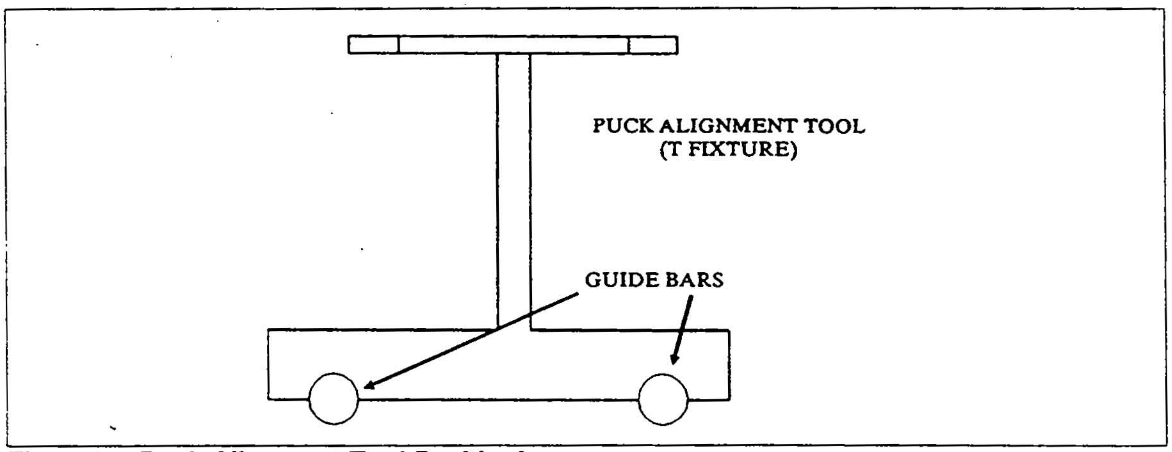



**Fig. 5-12 Puck Alignment Tool Positioning**

2. If the front face of the puck is fitted smoothly flush with the top of the puck alignment tool, no adjustment is needed (See Fig. 5-13).

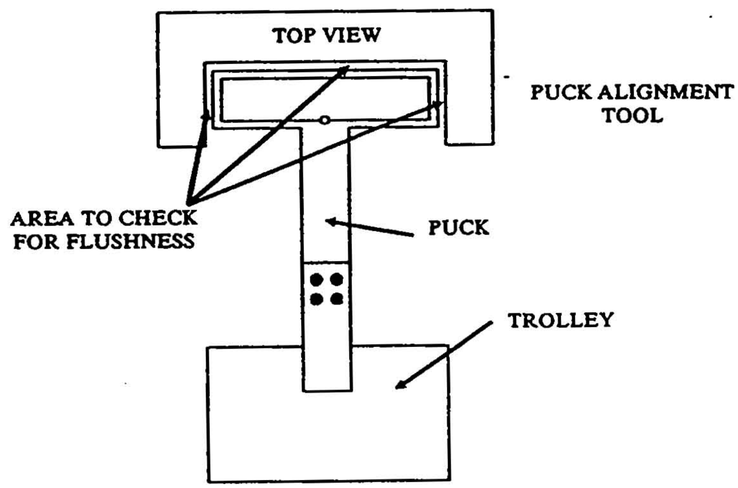



**Fig. 5-13 Proper Puck Arm And Puck Alignment**

3. If the puck is situated below or above, and/or tilted from the puck alignment tool, loosen and adjust Height adjust screw and/ or the Arm Roll adjust screw. Adjust the height and roll of the puck arm to have the puck front face fit flush with the puck alignment tool.

4. Adjust the Pitch Adjust and Pitch Clamping screws to align the puck front and side faces flush within the enclosed puck alignment tool.

**Setting the Home Position**

**Objective**

The Trolley Home Sensor alignment provides proper trolley positioning to load and unload a wafer from an indexer.

**Items/Tools**

- A standard set of Allen wrenches

**Alignment Procedure**

1. Set menu parameter to 1 wafer mode.
2. Press [START] and watch the trolley move and position itself in front of the sender indexer.
3. If the puck is not perpendicular to the indexer to load a wafer, reposition the trolley home sensor.
4. To reposition the trolley home sensor, loosen its two position screws. Move the home sensor forward toward the trolley home flag if the trolley travels short of the perpendicular position relative to the indexer. Move the home sensor away from the trolley home flag if the trolley travels beyond the perpendicular position relative to the indexer (See Fig. 5-14)

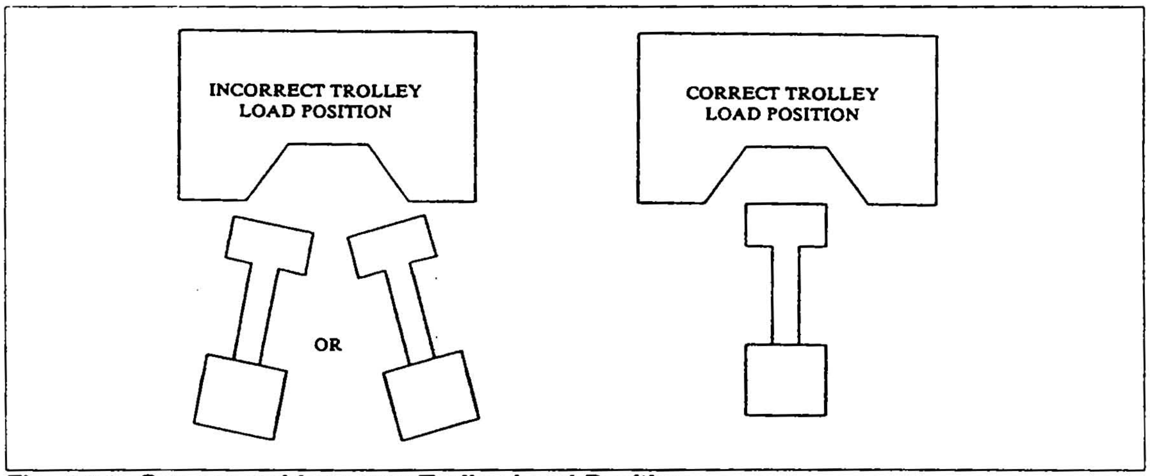



**Fig. 5-14 Correct and Incorrect Trolley Load Position**

5. Repeat step 2, 3, and 4 until correct trolley home sensor position is achieved.

## 5.5 INDEXER ALIGNMENT

**General**
Alignment to the Indexer Assembly needs to be accomplished for proper wafer location identification and handling from the puck.

### 5.5.1 ELEVATOR PLATFORM ALIGNMENT

The platform holding the wafer cassette must be adjusted parallel to the puck. To identify if the platform is in need of adjustments, implement the following instructions.

1. Set menu parameter to 1 wafer mode.
2. Press [START] to move the Trolley so that the puck is in front of the platform waiting to load a wafer.
3. Place a bubble level on the end of the puck and identify the position of the bubble.
4. Place the same bubble level upon the center of the platform and verify the bubble's location matches that of the puck. If the two bubble locations does not match, adjust the platform's pitch or roll (Fig. 5-11) to match the bubble level position of the puck.

### 5.5.2 PARK FLAG ALIGNMENT

The park flag alignment is made to provide proper wafer removal and insert by the puck onto the wafer cassette on the indexer. To align the park flag, implement the following steps.

1. Place a wafer at the bottom slot of the wafer cassette carrier. Place the cassette on the indexer and press [START].
2. Press [STOP] just as the puck starts to its turn into the indexer.
3. Use the manual buttons located on the Handler PCB to bring the puck slowly toward the indexer. Check to make sure the puck does not run into the wafer.
4. Press [START], when you achieved vacuum and the indexer lowers the cassette's wafer onto the puck. Press [STOP] as the wafer is about to be drawn out of the cassette.
5. Run the wafer out with manual controls, checking to make sure the wafer is in the middle of the cassette slot (Front to back and on both sides).
6. Disconnect the EMOT connector, J19, on the bottom left hand corner of the indexer PCB. Turn the elevator lead screw to center the wafer in its slot.
7. Turn the Flag Position Screw just until the Park LED of the indexer PCB comes on.
8. Re-install the EMOT connector, J19.

9. Press [HOME], and recheck the Park Position, making sure the wafers at the bottom and top of the wafer cassette are pulled out of the center of the cassette slots.

### 5.5.3 THROUGH-BEAM SENSOR

The Through-beam sensor is adjusted to identify wafer location within its carrier cassette. To identify if the through-beam sensor is at its optimal position, place a wafer at every other slot in the wafer carrying cassette. Load that cassette onto the indexer. Press [CASS] on the keypad. Located on the right side of the monitor is a drawing of twenty-five vertical contiguous boxes corresponding to the twenty-five slots on the wafer carrying cassette. If the marked boxes identifying the presence of a wafer at a specific slot does not match that within the cassette, the through-beam sensor needs to be adjusted. To adjust the through-beam sensor, implement the following steps.

1. Place the test leads of a digital volt meter (DVM) at test point 8 of the Indexer PCB and the Analog Gnd of the Distribution PCB. Set the DVM to read in milli-volts DC.

2. Place an Allen wrench on top and while depressing the carriage switch, press [CASS] on the keypad and watch the indexer platform go to the bottom position.

3. Adjust the through-beam sensor post (the receiver) and its infra-red light source to face each other to achieve maximum sensitivity registered in milli-volts on the DVM.

4. Tighten both the through-beam sensor post and its light source into position.

5. Remove the Allen wrench from the carriage switch and watch the platform find home position.

6. Place a half filled wafer cassette, one wafer in every other slot, onto the Indexer and press [CASS] on the keypad.

7. Adjust the through-beam sensor light source so that the wafers in the cassette match that printed on the monitor. Use the voltage reading on the DVM as a guide for adjusting the through-beam sensor light source. The voltage reading at test point 8 will vary corresponding to the through-beam sensor sensitivity.

8. Repeat step 6 until the wafers in the cassette matches that shown on the monitor. Tighten down the through-beam sensor light source.

## 5.5.4 THROUGH-BEAM WAFER SENSOR

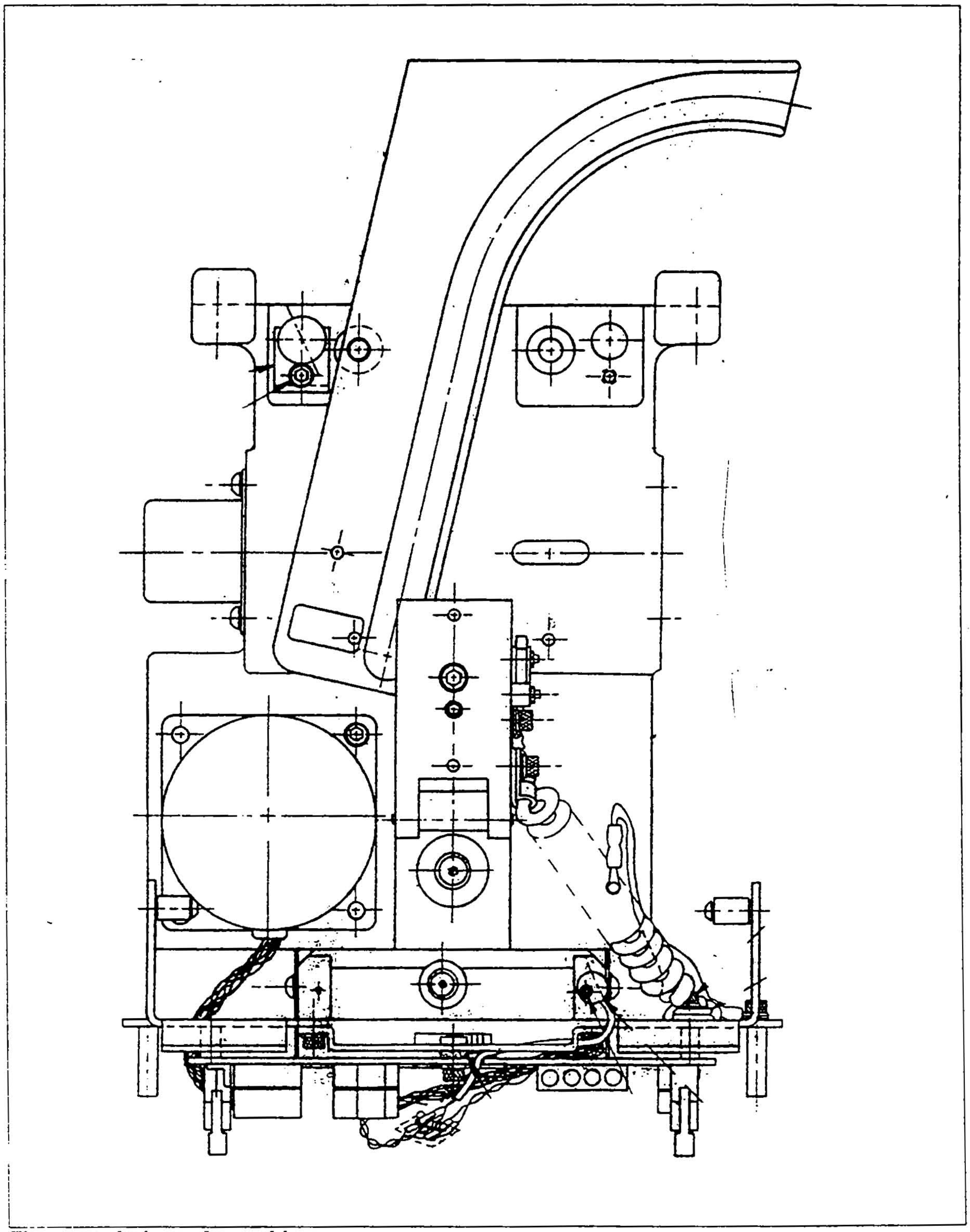


Fig. 5-15 Indexer Assembly

## 5.6 CALIBRATION

Calibration Verification

Section Contents

- VLSI Standards Brochure
- VLSI Standards Scattering Table
- Adjusting PMT Drive
- Setting Haze Calibration
- Comprehensive Calibration
- Verifying F1 and F2
- Basic Calibration

### 5.6.1 VLSI STANDARDS BROCHURE

**Reference -- "Increase Your Instrument Accuracy" VLSI Standards Spring/Summer Catalog in the front pocket of this manual.**

## 5.6.2 VLSI STANDARDS SCATTERING TABLE

**Objective**

Table 5-4VLSI Standards Scattering Table lists the mean scattering cross-sectional minimum, mean and maximum values for the VLSI Latex Sphere Reference Wafers listed in the previous section and used to calibrate the instrument in the following sections.

| | | | PARTICLE | | | SCATTERING CROSS-SECTION | | |
|---|---|---|---|---|---|---|---|---|
| SPHERE | MAX SZ | THRESHOLD | FROM | TO | BIN | MIN | MEAN | MAX |
| 0.212 | 0.256 | 0.002 | .003 | .030 | .001 | 0.013 | (0.014) | 0.015 |
| 0.238 | 0.256 | 0.004 | .012 | .040 | .001 | 0.022 | (0.024) | 0.026 |
| 0.364 | 0.512 | 0.008 | .160 | .280 | .002 | 0.216 | (0.220) | 0.224 |
| 0.500 | 2.56 | 0.02 | .380 | .820 | .01 | 0.562 | (0.585) | 0.608 |
| 1.091 | 2.56 | 0.02 | .58 | 1.32 | .01 | 0.87 | (0.924) | 0.98 |
| 2.02 | 5.12 | 0.04 | 1.32 | 3.12 | .02 | 1.97 | (2.14) | 2.31 |
| 4.00 | 10.24 | 0.08 | 2.64 | 6.32 | .04 | 3.80 | (4.32) | 4.84 |

**Table 5-4 VLSI Standards Scattering Table**

### 5.6.3 BASIC CALIBRATION

Basic calibration involves adjustment of the Surfscan hardware listed below:

- Adjusting the PMT Control PCB.
- Setting the PMT Drive with the Auto-Cal Fiberoptic line.
- Setting the Haze Calibration.

### 5.6.4 ADJUSTING THE PMT CONTROL PCB

**Objective**

The PMT Control PCB Calibration Procedure sets the basic calibration of the Surfscan 4500. This procedure assumes that other subsystems are properly aligned.

Basic calibration requires fine adjustments made during the final calibration of the Surfscan using two VLSI Standards, which are traceable to the National Bureau of Standards (NBS).

The ACS1423 Standard contains 1.091 $\mu$m diameter Latex Spheres and is used for setting the Secondary Calibration Point. The ACS1425 Standard contains 0.364 $\mu$m diameter Latex Spheres and is used for a Primary Calibration Point and verifying submicron sensitivity. These standards have unique and specific MEAN SCATTERING CROSS-SECTION values stated in units of square-microns ($\mu m^2$).

The Calibration Objective is to achieve the specified MEAN SCATTERING CROSS-SECTION values for each Standard by setting PMT1 DRIVE with R28.

The adjustment only allows for an approximate maximum of a ±6% change from the current setting with R28 set at absolute midpoint.

| | |
|---|---|
| Note: | **With a very small dynamic range of adjustment (±6%), this procedure assumes that the AUTO-CAL, (AC), reference PMT Analog Pulse set by the AC fiber-optic tube is at a correct level. With the level set correctly, very small adjustments can be made with R28, to achieve calibration and still maintain an acceptable range of adjustment for future calibrations.** |

**Items/Tools Required**

- Small Pot Tweaker
- Digital Volt Meter (DVM)
- VLSI Standard Model ACS1423; Tencor #081957
- (Sphere Size = 1.091 $\mu$m)
- VLSI Standard Model ACS1425; Tencor #081973 (Sphere Size = 0.364 $\mu$m)
- PMT Control PCB Assy Drawing; Tencor #128066
- Distribution PCB Assy Drawing; Tencor #055972

**Setup**

Locate the following items:

1. On the Distribution PCB Assy, locate transistor Q5-Pin 3.3.
2. Using a DVM, monitor the PMT drive signal, HVD1, at Q5 pin 3 on the Distribution PCB.4.
3. Using Table 7-1, set the MENU parameters to the appropriate values based upon the Standard selected for scan.

**Procedure**

1. Setting the Primary Calibration Point (Sphere Size = .364 $\mu$m)
2. Set the appropriate MENU parameters for the ACS1425 Standard.
3. Note the voltage at Q5-Pin 3, Distribution PCB, **HVD1**.
4. Scan the .364 $\mu$m latex sphere standard.
5. Determine the MEAN SCATTERING CROSS-SECTION value.
6. The value should be 0.235 ($\pm$2%) $\mu m^2$. If the mean value of the particle data is not at the correct value, an adjustment of R28 is necessary.

| NOTE: | An increase or decrease in HVD1 voltage as measured at Q5-Pin 3 of the Distribution PCB, corresponds with an increase or decrease in PMT sensitivity respectively. |
|---|---|

**Verifying Higher Sensitivity (Sphere Size = 1.091 $\mu$m)**

1. Set the appropriate MENU parameters for the ACS1423 Standard.

2. Note the voltage at Q5-Pin 3, Distribution PCB, **HVD1.**
3. Scan the 1.091 $\mu$m diameter latex sphere standard.
4. Determine the MEAN SCATTERING CROSS-SECTION value.
5. The value should be .924 ($\pm$6%) $\mu m^2$. If the mean value of the particle data is not at the correct value, an adjustment of R28 is may be necessary to allow the Surfscan to measure and determine the specified MEAN SCATTERING CROSS-SECTIONS for the ACS1423 and ACS1425 standard.

> **NOTE:** **If adjustments with R28 do not achieve the specified values for both standards, a problem may exist with the system, either optically or electrically. The instrument may need comprehensive calibration.**

| | | | PARTICLE | | | SCATTERING CROSS-SECTION | | |
|---|---|---|---|---|---|---|---|---|
| SPHERE | MAX SZ | THRESHOLD | FROM | TO | BIN | MIN | MEAN | MAX |
| 0.212 | 0.256 | 0.002 | .003 | .030 | .001 | 0.013 | (0.014) | 0.015 |
| 0.238 | 0.256 | 0.004 | .012 | .040 | .001 | 0.022 | (0.024) | 0.026 |
| 0.364 | 0.512 | 0.008 | .160 | .280 | .002 | 0.216 | (0.220) | 0.224 |
| 0.500 | 2.56 | 0.02 | .380 | .820 | .01 | 0.562 | (0.585) | 0.608 |
| 1.091 | 2.56 | 0.02 | .58 | 1.32 | .01 | 0.87 | (0.924) | 0.98 |
| 2.02 | 5.12 | 0.04 | 1.32 | 3.12 | .02 | 1.97 | (2.14) | 2.31 |
| 4.00 | 10.24 | 0.08 | 2.64 | 6.32 | .04 | 3.80 | (4.32) | 4.84 |

**Table 5-5 Surfscan Calibration Table**

### 5.6.5 PMT DRIVE & FIBER OPTIC LINE

**General**

The purpose of this section is to provide a guide for alignment of the fibre optics line. This line is the course adjustment of the PMT drive feedback adjustment during PMT calibration. This is adjustment is made when instrument calibration can not be achieved with R28 on the PMT Control PCB.

**Procedure**

You are now ready to verify calibration against a standard. Depending on the age of your instrument, you may either calibrate using a 1.091m sphere standard or a .364$\mu$

sphere standard. IF YOU ARE NOT SURE CALL TENCOR PRODUCT SERVICES with your serial number and they will verify against your instrument file.

Reference section 7.1.1 - Adjusting PMT Drive. Set a menu to the parameters shown on page 7-5 of this procedure for either the 1.091 or .364uspheres depending on which you use. For this discussion we used the .364$\mu$ spheres. Follow the steps on page 7-5. If the mean, as displayed by the histogram and summary data is only slightly off, adjust R28 to obtain the desired mean. If the mean is off quite a lot, it will not be possible to adjust using R28. Do the following:

1. Power-down the instrument.
2. Using an ohmmeter, center R28.
3. Remove the scan chamber top hat cover
4. Loosen the plastic screw on the auto-cal sensor holding the fiber optic tube used for PMT feedback.
5. Move the tube slightly in one direction and tighten screw. TAKE CARE not to crush fiber optic tube.
6. Replace top hat and power-up
7. Scan cal wafer. Is the mean close to the desired valve? Repeat steps a-g until the mean is close to the desired values. Then fine tune with R28 as outlined in the previous section.
8. Once this step is complete, the instrument optical calibration is complete and may be used for wafer inspection.

# 6 TROUBLESHOOTING

## 6.1 RECOMMENDED TOOLS AND FIXTURES LISTING

### 6.1.1 SERVICE FIXTURES

- Level, Bubble, aligns platform and puckSVC-064920
- Tri-flo LubricantSVC 069213
- Tool, Puck Alignment; sets Puck height, roll, pitchSVC-132063-19
- Fixture Assy, Laser Polarizer; Laser PolarizationSVC-132446-19
- Fixture Assy, Leveling; used for leveling IndexerSVC-134350-19
- Fixture Assy, Trolley Alignment; Leveling TrolleySVC-134368-19
- Beam Target; for beam path alignment verificationSVC-143596-19
- Complete Set of Above FixturesSVC-165077

### 6.1.2 ELECTRONIC EQUIPMENT

- 50 MHz or better, Dual Trace Oscilloscope
- 4 1/2 Digit DVM, such as a Fluke 8062A

### 6.1.3 HANDTOOLS

- Bondhus BLX 12 Ball Allen-wrench set, or similar
- Standard Handtool Set

### 6.1.4 RECOMMENDED VLSI STANDARDS

- ACS4-0.364 Absolute Contamination Standard *
- ACS4-1.091 Absolute Contamination Standard*
- ACS4-0.269 Absolute Contamination Standard**
- ACS4-0.305 Absolute Contamination Standard**
- ACS4-0.5 Absolute Contamination Standard**
- ACS4-2.02 Absolute Contamination Standard**
- ACS4-4.0 Absolute Contamination Standard **

*Required for calibration
**Recommended for Linearity Verification

## 6.2 BLOCK DIAGRAMS

# 6.3 SIGNAL TABLES

## Objective

This section covers helpful troubleshooting tips and signal tables to be used for reference. Refer to the Surfscan 4500 Assembly schematics (-02) and layouts when checking signals during troubleshooting.

The tables in this section show various key signals as measured on a unit. These can be used as typical values while troubleshooting. Each signal notes the measuring point, name, value or waveform, and helpful notes. Some tables show signals for the various logic levels under pertinent conditions.

By using the schematics and these signal tables, most problems can be isolated to a specific board and/or component where the signal is faulty or distorted.

## Items/Tools Required

The most useful pieces of test equipment are as follows:

Oscilloscope (dual-trace)

Digital Voltmeter (DVM)

Various hand-tools such as screwdrivers and Hex Allen wrenches for adjustments and removal of parts.

### 6.3.1. Signal Tables

6.3.1.1. Distribution PCB

One of the most convenient places to chek various key signals is located on the TJA test points of the PCB. The signals are all digital and are represented in Table 6-1. The signals shown are all drawn with the rising edge of Auto-Zero as synchronization reference. In other words the signals are drawn relative to Auto-Zero.

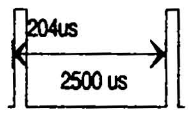
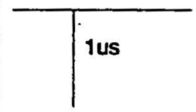
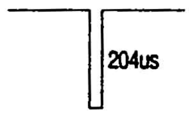
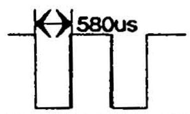
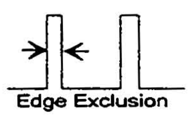
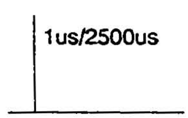
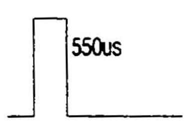
| Pin | Mnemonic | Name | Signal | Pin | Mnemonic | Name | Signal |
|---|---|---|---|---|---|---|---|
| 1 | AZ | Auto-Zero |  | 9 | BS | Beam Sync |  |
| 2 | AC* | Auto-Cal* |  | 10 | WTH | Width Threshold | Standby= High<br>Scan = Low |
| 3 | BW* | Below Wafer |  | 11 | | BLANK | |
| 4 | OWG | On Wafer Gate | <br>Wafer outline during scan. | 12 | | +12VDC | |
| 5 | MG | Measure Gate | <br>Wafer Edge Exclusion from PMT Control PCB during scan. | 13 | | LASER ENABLED | High as long as the Magnetic Interlocks are enabled and the Scan Mirror is oscillating. |
| 6 | VS | Vertical Sync |  | 14 | | BLANK | |
| 7 | MA | Memory Accumulate |  | 15 | | HV PMT ENABLE* | Low as long as the Magnetic Interlocks are enabled |
| 8 | | PMT GATE | | 16 | GND | Ground | |

Table 6-1 TJA Test Points

The next table shows the various drive and feedback signals from the various sensors, Scan Mirror, PMT Drive, and Laser Enable. They are mostly analog and are included because much can be derived from the shape and condition of these signals. It can provide helpful clues when troubleshooting, such as optical misalignment or electronic degradation.

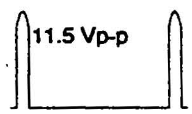
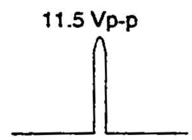
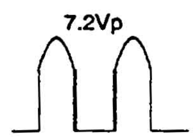
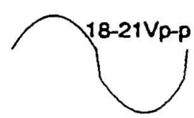
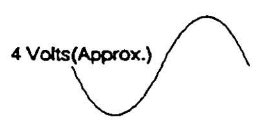
| Name | Location | Signal | Notes |
|---|---|---|---|
| AZ(analog) | U22/6 |  | Typical peak voltages. |
| AC(analog) | U21/6 |  | Typical peak voltages. |
| BW(analog) | U20/6 |  | The spike at the end of the BW signal is normal. |
| Scan Mirror Drive | TP-8 |  | Typical peak voltages. |
| Scan Gain Output | U17/1 |  | This voltage sets the amount of Scan Mirror feedback Gain |
| Scan Mirror Feedback | TP-7 | Approx. -1Vdc | Typically the Scan Mirror is stable at this voltage. |
| Scan Drive/Laser Enable Comparator | D7/Cathode | Approx. +6Vdc | Monitor this voltage for Laser Intensity. |

Table 6-2 Distribution PCB, Analog Signals

**Status Indicator LEDs**

The status indicator LEDs are very useful for a quick diagnosis of the instrument, should the instrument not initialize properly. It is also useful for quickly determining the status of the PMT drive. The LEDs are simple pass/fail indicators of various key signals. As a rule, no red LED should be stay on upon power up. Green LEDs indicate the presence of the signal.

| LED/Instrument Mode | Controlling Source | Where Used/ Destination | Standby | Scan |
|---|---|---|---|---|
| MGF<br>Measure Gate Fail | PMT Control PCB | A/D Analog PCB; Pre-Processor PCB | On | Off |
| WTH<br>Width Threshold | PMT Control PCB | A/D Analog PCB; Pre-Processor PCB | Off | On |
| AZF<br>Auto-Zero Fail | Auto-Zero Sensor | A/D Analog PCB; PMT Control PCB | Off | Off |
| ACF<br>Auto-Cal Fail | Auto-Cal Sensor | PMT Control PCB | Off | Off |
| BWF<br>Below Wafer Fail | Below Wafer Sensor | Used to Generate OWG on Distribution PCB | Off | Off |
| MAF<br>Memory Accum. Fail | Pre-Processor PCB | Slave CPU; I/O PCB; | Off | Off |
| VSF<br>Vertical Sync Fail | R-S Flip Flop of AZ and BW @ Distribution PCB | Pre-Processor PCB; A/D PCB | Off | Off |
| OWGF<br>On Wafer Gate Fail | Product of BW and MA @ Distribution PCB | PMT Control PCB; A/D PCB; Pre-Processor PCB | On | Off |
| BSF<br>Beam Sync Fail | Distribution PCB, Trailing Edge of MA | Indexer PCBs; Handler PCB | Off | Off |
| PMT1<br>PMT Drive | PMT Control PCB / PMT Drive | HVD1 to PMT HVPS | On (Intensity varies with Max Size selected) | On |
| STAB<br>Scan Mirror Stability | AC Pulse Width. | I/O PCB | Off | Off |

Table 6-3 Status Indicator LEDs

## 6.3.1.2. Indexer PCB

**Test Points Tables**

| Test Point | Name | Signal | Notes |
|---|---|---|---|
| 1 | +5V L | | |
| 2 | +24 V | | |
| 3 | 24 V Return | | |
| 4 | +5 V Return | | |
| 5 | +18 V | | |
| 6 | +5V M | | |
| 7 | WFRON | | |
| 8 | WFRON Detect | | |

Table 6-4 Indexer PCB Test Points

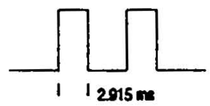
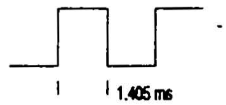
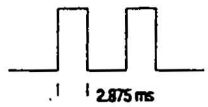
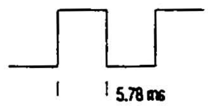
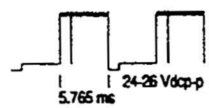
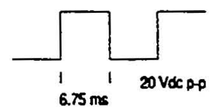
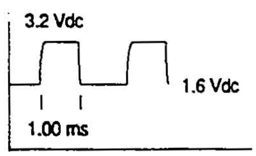
| Point | Name | Signal | Notes |
|---|---|---|---|
| U10 pin 8 | Rifa ø Clk input |  | Wafer 1 thru 25 |
| | |  | Wafer 1 thru home/tilt |
| | Rifa $I_{\emptyset}$ input |  | Wafer 1 thru 25 |
| | |  | Wafer 1 thru home/tilt |
| | Rifa $M_B$ output |  | Wafer 1 thru 25 |
| | |  | Wafer 1 thru home/tilt |
| U 11 pin 9 | |  | Coulisse Driver |
| TP-8 | |  | Through Beam Sensor Pulses |

Table 6-5 Indexer PCB Signals

6.3.1.3. Handler PCB

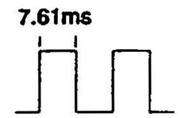
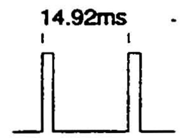
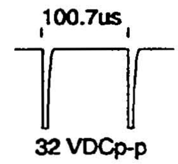
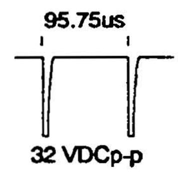
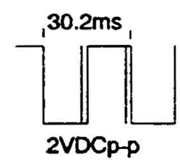
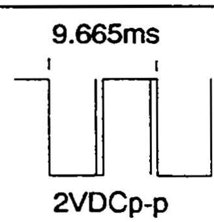
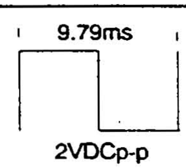
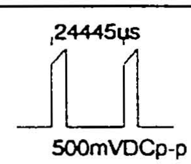
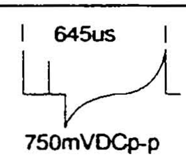
| Point | Name | Signal | Notes |
|---|---|---|---|
| U16 or U17 pin 9 | $I_0$ |   | Only during scan |
| U16 or U17 pin 7 | $I_1$ |   | Only during scan |
| U16 or U17 pin 1 | $M_B$ |   | Scan Moving |
| U16 or U17 pin 15 | $M_A$ |   | Scan Moving |
| U16 or U17 pin 8 | Phase |   | Scan |
| U16 or U17 pin 8 | Phase |   | Manual FWD |
| U16 or U17 pin 8 | Phase |   | Manual REV |
| U16 or U17 pin 10 | C |   | Jitter approx 2445 us - Scan |
| U16 or U17 pin 10 | C |   | Auto Test Mode |

Table 6-6 Handler PCB Signals

### 6.3.2. Common Problems

This section discusses some of the more commonly occurring problems in the SFS4500 and it also provides helpful troubleshooting references to quickly solve these problems. It makes use of a table listing the problem/symptoms, possible causes, and any pertinent notes. The problems are divided into two major sections of the instrument; those problems occurring in the Scan Unit and others occurring in the Wafer Handling System.

6.3.2.1.Scan Unit

The problems occurring in the Scan Unit have been broken down into two sections. One section deals mainly with the processor section in which the instrument is not initializing properly. The second section deals mainly with Measurement and Calibration related problems. These two categories of problems make up the majority of the most commonly occurring failures in the Scan Unit.

It is noteworthy to say, however, that the most common problems that occur in the Scan Unit can be quickly diagnosed on the Distribution PCB. The problems usually relate to the Scan Mirror, PMT, and AZ, AC, BW sensors. These three items make up the "heart" of the sytem's major functions. If it isn't the actual hardware itself, the drive and control circuits are usually the next suspect.

The following troubleshooting tables are a guide to diagnosing and repairing commonly occuring problems with the SFS4500 instrument.

**Instrument Not Initializing**

The following table lists some the more common initialization problems.

| Problem/Symptoms | Cause/Solutions | Notes |
|---|---|---|
| Processor PCB Not Initializing, No Display | Usually caused by one of the major processor PCB's such as the Main CPU, Memory PCB, Graphics PCB, etc... | Any of the PCB's in the Card Cage can cause a failure of this type. Swapping of PCB's will usually isolate the problem. |
| Multiple Failure Messages displayed on the monitor; can't initiate a scan. | Laser Out or Severe Misalignment of the Beam. | With the laser out, all the sensors will indicate a failure. The Distribution PCB Shows all Failure LED(s) On. Check the LASER ENABLE signal is true. If it is true, chances are either the Laser or HVPS is dead. |
| Can't initiate a scan. | One of the Status LEDs are indicating a failure. | Check the LED's on the Distribution PCB. No Red LED should be on.<br><br>Also, ensure that there is sufficient Vacuum, which would otherwise cause a TE trolley error. This can be monitored at the Handler Vacuum PCB assembly. |

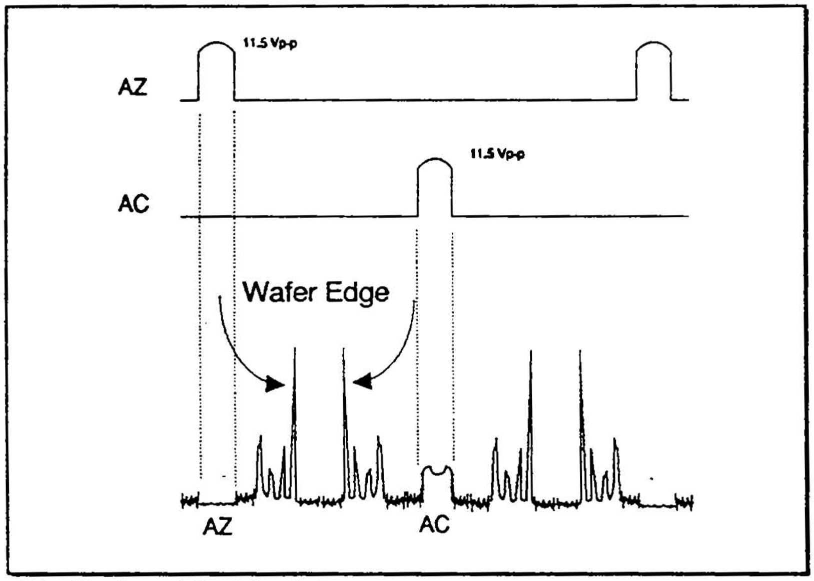
Table 6-7 Initialization Problems

**Measurement/Calibration Problems**

Sensitivity Problems

Most of the problems that are related to measurement sensitivity and calibration can be diagnosed properly by directly analyzing the PMT signal. There are certain characteristics to look for when looking at a PMT signal. See Table 6-8.

Low DC offset, maintained and set by Auto-Zero
Sufficient Auto-Cal Feedback pulse
No Artifact producing signals in the "Below Wafer" portion of the signal




PMT Signal Table 6-8

PMT Drive

Measurement problems can be traced also to the PMT Drive voltages themselves. By measuring the PMT drive voltages, it may lead you to closely examine the condition of the Auto-Calibration closed loop circuitry and/or the PMT Drive ciruits themselves. It may also help confirm the electrical degradation of some of the hardware components such as the PMT itself or the laser.

The voltages listed in the following table are typical voltages for the PMT High Voltage Power Supply drive as measured with the instrument fully calibrated with a 0.364 um Latex Sphere VLSI Standard as a primary calibration point, and a 1.091 um Latex Sphere VLSI Standard as secondary calibration point. This table is very useful in determining whether the PMT Drive is less than or greater than typical voltages.

| Max Size | PMT1 Drive (R87-Bottom) | HVD1 (Q5/3) |
|---|---|---|
| 0.256 | 4.70 | 5.54 |
| 0.512 | 4.40 | 5.16 |
| 1.024 | 4.15 | 4.82 |
| 2.560 | 3.83 | 4.38 |
| 5.120 | 3.63 | 4.10 |
| 10.24 | 3.44 | 3.84 |
| 25.60 | 3.21 | 3.52 |
| 51.20 | 3.06 | 3.31 |
| 102.4 | 2.93 | 3.12 |
| 256.0 | 2.77 | 2.89 |
| 512.0 | 2.65 | 2.73 |
| 1024 | 2.54 | 2.57 |

Table 6-9 PMT Drive Voltages

The following table lists some of the more common problems relating to calibration and measurement of wafers.

| Problem/Symptoms | Cause/Solutions | Notes |
|---|---|---|
| Jagged Wafer Outline | Scan Mirror Not Oscillating Properly | Usually resulting from a Scan Mirror degradation. Or, the closed loop circuit utilizing Auto-Cal is failing to control the Scan Mirror drive. |
| PMT Drive is Unstable or Fluctuates | Scan Mirror Not Oscillating Properly; The AC Feedback to the PMT or Distribution PCB may be failing. | If the AC and AZ Digital pulse is good, then there may be a problem with the PMT Signal Feedback from either AZ or AC (may be too little). Check the PMT Signal to ensure the baseline during AZ is approximately 0 volts. Check the AC feedback signal amplitude is sufficient. |
| PMT Drive is Too High | Laser Beam has degraded to a low level. | Check the AC and AZ Analog Signals. Should have a peak voltage greater than 10 Vdc. |
| | AC PMT Feedback is insufficient. | Ensure that the PMT Adjust Pot is set to midpoint. Move the AC FiberOptic line inwards either at the PMT itself or AC Sensor so that the PMT drive is typical. If these adjustments do not work, then the FiberOptic line may be damaged. Also, there may be the possibility that the PMT Drive Circuits on the Distribution or PMT Control PCB may be failing |
| PMT Drive is Too Low | Too much AC PMT Feedback. Faulty Drive Circuits | Ensure that the PMT Adjust Pot is set to midpoint. Move the AC FiberOptic line outwards either at the PMT itself or AC Sensor so that the PMT drive is typical. If these adjustments do not work, the PMT Drive Circuits at the Distribution or PMT Control PCB may be failing. |

Figure 6-10 Common Measurement/Calbration Problems

6.3.4.2. Wafer Handling System

| Problem/Symptoms | Cause/Solutions | Notes |
|---|---|---|
| Aborts Fetch | | |
| Wafer Sensing Problems | | |
| Trolley Error | | |
| Grinding Noises During Trolley Movements | | |

Table 6-11 Common Wafer Handling Problems

## 6.4 TECH TIPS

The following sections contain technical information that will aid the service technician or engineer in troubleshooting the Surfscan 4500 instrument. The following sections contain information on:

1. Status Messages
2. Surfscan Firmware Evolution
3. Signal Tables for:
4. Distribution PCB
    - Indexer PCB
    - Handler PCB
5. Common Problems vs. Common Solutions Table

### 6.4.1 SURFSCAN STATUS MESSAGES

**Line 1:**

**AZ** AutoZero signal is missing or shorter than 50 us

**AC** Auto Cal signal is missing or shorter than 50 us

**BW** Below Wafer Detector signal is missing

**VS** Vertical Sync signal is missing

**MS** Mirror not Stable; scanning mirror servo out of range

**LO** Laser Off

**PD** PMT Disabled

**SE** Slave Error; slave processor malfunctioning

**IS** Indexer Send

**IA** Indexer Accept

**Line 2 & 3:**

**DA** Direct Access indexer present

**RG** Ready to Give; wafer can be fetched from this indexer

**RT** Ready to Take; wafer can be unloaded to this indexer

**CR** Carrier; cassette is placed on indexer's platform

**KU** Coulissa; track switch selected for this indexer

**IE** Indexer Error; indexer malfunctioning

**Line 4:**

FT Fetching in progress

SC Scanning in progress

UL Unloading in progress

AB Abort; used in association with the three preceding messages

MN Menu key has been pressed when menu access is not allowed

ST Stop key has been pressed

AU Instrument in Auto mode

TE Trolley Error; trolley malfunctioning

TW Trolley Wafer; wafer sucked down

TV Trolley Vacuum; vacuum valve open

MV Indexer Platform Movement

**Data Errors:**

BC Bad Counter; sweep counter is bigger than 255

BP Bad Pairing; beginning or ending address for run length data is missing

BL Bad range

| | |
|---|---|
| NOTE: | **Displayed in 2.0 or older versions of software only** |

## 6.5 SURFSCAN FIRMWARE EVOLUTION

| PCB ASSEMBLY | LOC. | REVISION 2.4 | REVISION 2.5 | REVISION 2.6 |
|---|---|---|---|---|
| Keyboard | U1 | 118605 KBD2.4 | Same | Same |
| CPU | U13 | 094218 SBOT2.3 | 127167 SBOT2.5 | Same |
| SLAVE | U5 | 094226 SLV2.3 | Same | Same |
| MEM | U1 | 118508 SFS2.4A | 127051 SFS2.5A | 143057 SFS2.6A |
| MEM | U2 | 118516 SFS2.4B | 127060 SFS2.5B | 143065 SFS2.6B |
| MEM | U3 | 118524 SFS2.4C | 127078 SFS2.5C | 143073 SFS2.6C |
| MEM | U4 | 118532 SFS2.4D | 127086 SFS2.5D | 143081 SFS2.6D |
| MEM | U5 | 118541 SFS2.4E | 127094 SFS2.5E | 143090 SFS2.6E |
| MEM | U6 | 118559 SFS2.4F | 127108 SFS2.5F | 143103 SFS2.6F |
| MEM | U7 | NONE | NONE | NONE |
| MEM | U8 | NONE | NONE | NONE |
| PMT CONT. | U1 | 095427 EXC2.3 | Same | Same |
| I/O | U1 | 118567 MCP2.4 | Same | 144037 MCP2.5 |
| RA INDEX | U5 | 118575 DAI2.4 | Same | 136310 DAI2.5* |
| SEQ INDEX | U5 | 118583 IND2.4 | Same | Same |
| HANDLER | U5 | 118591 TRL2.4 | Same | Same |
| CPU-9 | U13 | 118664 SECS2.4 | 127116 SECS2.5 | 143120 SECS2.6 |
| CPU-9 | U13 | 095435 PR2.3 | Same | Same |
| Manuals | | SECSII Manual (P/N 129127) | | SECS Manual REV C (P/N 129135) |
| Misc. | | | | DALLAS CHIP (P/N 071960) |

Table 6-1 Surfscan Firmware Evolution

*Part of an earlier ECO. Necessary for 2.6 update. (2) per kit.

# 7 PREVENTIVE MAINTENANCE

## 7.1 CLEANING AND LUBRICATION

**General Information**
By providing periodic cleaning and lubrication maintenance on the Surfscan, it will remove outside particles from contaminating the wafer, and increase the life duration of the many moving parts. Periodic cleaning involves wiping the Surfscan with the proper solvent. The areas that need periodic cleaning are:

1. The Surfscan skin covers
2. The Wafer Handling System
3. The Optics System

Lubrication is applied only to the leadscrews for smooth trolley motion and smooth indexer motion. Lubricant should always be applied sparingly, a little lubricant goes a long way!

### 7.1.1 REPLACING THE HEPA FILTER

**OVERVIEW**

**Vertical Laminar Flow Stations**
The work horse of the clean work station approach is the vertical laminar flow station. These units, known as V.L.F. hoods are a miniature version of a clean room.

Room air is pulled into the hood top through a prefilter by a blower unit. The air passes through a special filter and on down to the work surface. The arrows in fig. 7.4 indicate the laminar nature of the air flow. A V.L.F. hood is effective for two reasons. Wafers in the hood are exposed only to clean air. And any contamination from the room or personnel is prevented from entering the hood by the slight positive pressure of the air flow. The final filter used in V.L.F. hoods is called a high efficiency particulate air (hepa) filter. Constructed of fragile fibers, the filter has an accordion-folded design, allowing a large filtering area at an air velocity low enough for operator comfort.

The unique design of the hepa filter permits a filtering efficiency of 99.99%.

A problem arises in maintaining wafer cleanliness during the many chemical or "wet" operations. The fumes from the various chemicals have to be exhausted from the room for safety reasons. The classic fume exhaust hood used in chemical labs solves the safety problem, but the dirtier room air is drawn across the wafers in the process.

This problem is solved by setting a V.L.F. unit on top of a fume hood. With this addition, both safety and cleanliness can be achieved. The hoods have to be designed so that the acid fumes are exhausted out the back with clean laminar flow air covering the front portion of the work surfaces.

**HEPA Replacement Procedure**
The HEPA filter assembly is illustrated on the next page in Figure 7.1 HEPA Filter Assembly.

This assembly is mounted on the back panel of the Scan chamber. To replace the HEPA filter reference Figure 7.1 and the procedure steps below:

1. Power-down the instrument.
2. Remove the two cap screws at the seam-line at on the Scan Chamber Hood.
3. Remove the Scan Chamber Hood by lifting the front of the hood just enough to remove it from the main chassis wall. Then slide the hood forward about 1 inch. Tilt the hood up at the back and slide it off of the chamber. The ESD / RFI grounding (if installed) should be long enough for the hood to be laid across the indexer / trolley assembly. If the service person is more comfortable with the hood elsewhere, remove the grounding strap. **NOTE:** if the grounding strap is removed, it **MUST** be replaced for proper instrument operation. **TIGHTEN** the nut **VERY TIGHT** when reinstalling to insure proper grounding.
4. Remove the Bungee retainer cords. Remove the HEPA filter, noting the air flow direction arrow. Insert the new HEPA filter and reinstall the Bungee cords.
5. Reverse steps 1 through 3 to complete the replacement procedure.

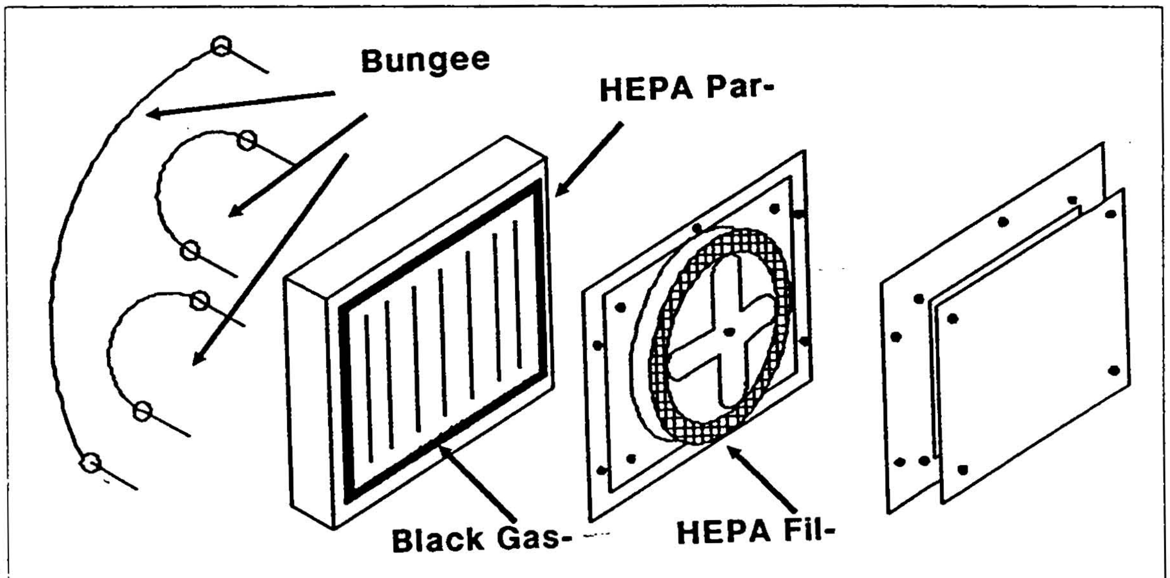



**Fig. 7-1 HEPA Filter Subassembly**

### 7.1.2 Cleaning the Optics System

| | |
|---|---|
| **NOTE:** | **Do not use any cleaning agent on ANY PART of the optics except DI water. All other cleaning agents, such as; IPA or Methanol can very seriously damage the mirror and lense surfaces of the instrument.**<br><br>**The elliptical mirror and the below wafer mirror surfaces are acetate film and adhere to the mirror frames with an adhesive. IPA and other cleaning agents soak underneath the acetate and eventually loosen the adhesive. If this happens the entire mirror assembly must be replaced. This is costly, time consuming and will require complete optical alignment.**<br><br>**If you are not sure whether the optical system is clean or needs cleaning, contact Tencor Technical Support for assistance.** |

Cleaning the optics requires care and careful placement of the cleaning agent and lense tissue or cleanroom towel. Care must be taken when cleaning mirrors that the location (angle or placement) is not disturbed.

This particularly true with the turret mirror (M) at the top left corner of the optics plate. Reference Fig. 7-2 below for location details.

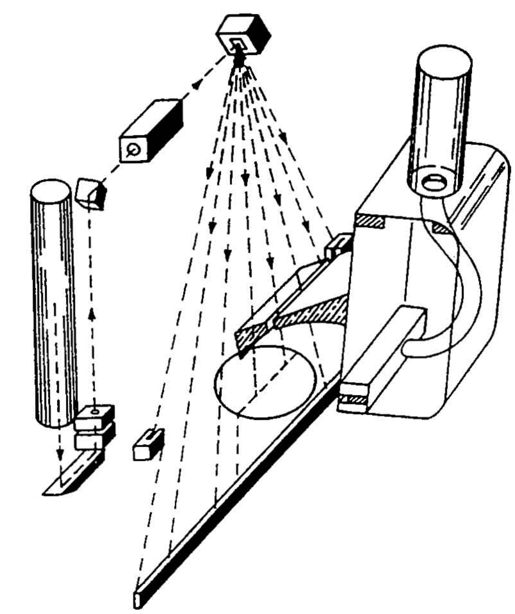


**Fig. 7-2 Pictorial View of Scanning & Collection System**

The prism, turret mirror (M), lense L1 and the scanning mirror are easily cleaned using the following procedure:

1. Power-down the instrument.
2. Remove the scan chamber hood by removing the cap screws from the right side of the hood. Lift the front just enough to move the hood out of the chamber well. Then tilting the hood up at the back, slide the hood forward and out of the way. If the instrument has ESD / RFI grounding, the ground cable will have to be removed.
3. Dampen a piece of lense tissue or a small area of the cleanroom towel. Using a "drop and drag" method clean the prism, turret mirror, lense L1 and scanning mirror.

| Note: | **The "drop and drag" method is simply placing the towel or tissue on the surface and wiping with one continuous, smooth motion. Always keep the towel or tissue damp as this causes the particles to adhere to the towel rather than be moved around. REMEMBER that if you can see residue so can the laser beam. This will produce distortion in the beam thus mis-measurements or impossible calibration due to low-end optical noise.** |
|---|---|

4. The below wafer mirror is accessed by removing the three screws in the distribution PCB mount and tilting the pcb and mount forward. Remove the two screws in the top of the cover plate directly behind the distribution PCB and remove the plate. The below wafer mirror is located at the bottom of the scan chamber. Using a flashlight and the "drop and drag" method, clean the below wafer mirror. Replace the cover plate insuring that the cables running under it are not stressed and that the plate fits into the recess area provided. This plate should be flush with the chassis frame when it is in the proper place. Replace the distribution PCB taking care that NONE of the cables attached to it are pinched underneath the mounting bracket.
5. Contact Tencor Technical Support for assistance and evaluation before attempting to clean the elliptical mirror.
6. Replace the scan chamber cover and perform the instrument calibration verification steps listed in the calibration section of this manual.

### 7.1.3 Cleaning And Lubrication: Wafer Handling System

**Objective**

The main objective in providing cleaning and lubrication to the wafer handling system is to induce a smooth trolley motion, and remove any dried, old lubricant which will cause erratic trolley action.

**Items / Tools Required**

- Clean room cloth
- IPA (Alcohol)
- Triflo lubricant

| | |
|---|---|
| NOTE: | **Tencor uses another special lubricant on their equipment. This lubricant, Brayco 1624, MUST NOT be used instead of Triflo. These two lubricants are NOT compatable. Deep cleaning, ie; a vapor degreasing process, is required to remove all traces of the old lubricant.** |

- A standard Allen wrench set

**Procedure**

1. Dampen a clean room cloth with IPA and do general wiping of the Surfscan outer skin covers.

2. Check the lead screw for excess lubrication build up. If the Lead Screw Wiper, if installed (older instruments may not have a wiper), has absorbed to its maximum coverage, leaving a thick film of lubrication on the lead screw, a replacement is needed.

3. Remove the screws securing the outer cover covering the Handler PCB, and the Trolley assembly. Remove the outer cover housing the Handler PCB, and the Trolley aassembly. Using the manual override buttons located at the top left corner of the Handler PCB, drive the Trolley assembly toward the scan chamber and back to its home position as you clean the lead screw with a clean room cloth soaked (not dripping) with IPA. This process of trolley back and forth and a clean room cloth soaked with IPA will have to be repeated several times in sever cases. As the leadscrew becomes clean it will appear bright and shinny.

   In sever cases (long times between cleanings) a clean room cloth may have to be folded and placed under the orange leadscrew nut as the nut is soaked with IPA and the trolley is moved back and forth.

4. After the leadscrew and nut have been allowed to dry of excessive IPA and has been wiped several times with a dry cloth, apply a light coat of Triflo lubricant along the lead screw.

5. Again, using the manual override buttons on the Handler PCB, drive the Trolley assembly toward the scan chamber and back to its home position until the lubricant is evenly distributed.

6. Reinstall and secure the outer cover on the Handler PCB, and the Trolley assembly.

### 7.1.4 Mechanical

Tencor recommends that preventative maintenance be performed on the instrument at least every 90-days. The following sections provides lists and tips for performing preventative maintenance on the:

- Trolley
- Vacuum System
- Indexers

### 7.1.5 Trolley

The following items should be checked, verified or performed at least every 90 days:

- Trolley Leadscrew & Nuts; Cleaning & Lubrication
- Trolley Vacuum Line Inspected
  - For Tight Fit at Fittings / Coulpings
  - For Cracks, Breaks or Leaks
- Trolley Puck
  - Proper Height
  - Proper Tilt
  - Proper Roll
- Trolley Puck Inspection
  - Puck Vacuum Groove & Hole for Cleanliness
  - Puck Underside; Inspect Acetate Tape Seal
  - Puck Underside; Inspect Vacuum Channel with Bright Light
  - Free of Foreign Particles, ie; Broken Wafer Chips
- Trolley Linear Bearings
  - Smooth Action, Not Rough, Binding
  - No Side-to-Side Play
  - No Up-to-Down Play
- Trolley Home Flag
  - Not Bent or Cracked
  - Runs Evenly Between Sensor Posts

### 7.1.6 Vacuum

The following items should be checked, verified or performed at least every 90 days:

- Vacuum Coupling at Rear of Instrument
  - For Tight Fit at Fittings / Coulpings
  - For Cracks, Breaks or Leaks
- Vacuum Line from Coupling to Vacuum Switch / Handler Assy Inspected
  - For Tight Fit at Fittings / Coulpings
  - For Cracks, Breaks or Leaks
- Vacuum Trip Points
  - Proper High Trip Point -- 19" Hg
  - Proper Low Trip Point -- 16.5" Hg
- Inspect All Fittings and Couplings
  - At Gauge
  - Feed Line to Trolley

### 7.1.7 Indexer

The following items should be checked, verified or performed at least every 90 days:

- Indexer Leadscrew & Nuts; Cleaning & Lubrication
- Indexer Elevator Platform
  - Proper Height
  - Proper Tilt
  - Proper Roll
- Indexer Microswitch Inspection
  - Not Binding

Cable Wires Not Frayed or Broken

- Indexer Elevator Bearings
  - Smooth Action, Not Rough, Binding
  - No Side-to-Side Play
- Indexer Elevator Pillow Block
  - Pivot Pin Not Bent or Worn
- Indexer Park Flag
  - Runs Evenly Between Sensor Posts
  - Not Bent or Cracked

## 7.2 Electrical

Tencor recommends that preventative maintenance be performed on the instrument at least every 90-days. The following sections provides lists and tips for performing preventative maintenance on the:

- Power Supplies
- Scan Drive & Feedback
- Laser Intensity
- PMT Drive & Calibration

### 7.2.1 Power Supplies

The following items should be checked, verified or performed at least every 90 days:

- Master Power Supplies
  - Verify All Master Power Supplies at Distribution PCB
  - Verify +5 VDC at the Card Cage
  - Verify Current Drawn by Laser / Laser Power Supply
- Verify Indexer +24 VDC Power at Indexer PCB(s)
- Verify Handler +33 VDC Power Handler PCB

### 7.2.2 Scan Drive & Feedback

The following items should be checked, verified or performed at least every 90 days:

- Verify Proper Operation of Scan Mirror & Drive
  - Perform or Check Alignment Using Procedure 5.1.2

### 7.2.3 Laser Intensity

### 7.2.4 PMT Drive & Calibration

The following items should be checked, verified or performed at least every 90 days:

- Verify Proper Operation of PMT Drive & Calibration
  - Perform or Check Alignment Using Procedure 5.1.1

# 8 INSTALLATION AND SHIPPING

## 8.1 INSTALLATION

This section provides installation instructions for proper handling and operation of the Instrument. Unpacking, moving, installing, and testing are fully covered.

### 8.1.1 PLANNING THE INSTALLATION

Do not unpack the Instrument until the installation site has been prepared. Inside the shipping crate, the Instrument is wrapped in plastic to prevent contamination from dust. When the facilities have been checked to meet the Instrument's operating specifications, unpacking can begin.

The carrier (transportation company) is responsible for any shipping damage incurred during shipping - contact them immediately if is found.

Before unpacking the Instrument, read "Operating Specifications" in Section 1.

### 8.1.2 UNPACKING

The carrier (transportation company) is responsible for any damage incurred during shipping - contact them immediately if damage is found during unpacking.

If the Instrument must be moved with lifting equipment (from one floor to another or from a receiving dock), check the load limits to be sure the total shipping weight can be handled safely. Treat the Instrument with care.

| | |
|---|---|
| **CAUTION** | **Follow these instructions carefully. If not handled properly, the Transporter System can be damaged.** |

After the shipping crate is opened, the Instrument can be lifted onto a cart to move it near the cleanroom.

**Opening Shipping Crate**

The shipping crate has two parts: a bottom pallet and a box cover for the top. To open the crate, remove the bolts along the bottom edge of the shipping crate and lift the box cover straight up. Do not, at this time, remove the plastic sheeting around the Instrument or other components, or dust may contaminate the system.

**Lifting**

Two or three strong people are recommended for lifting the Instrument onto a cart since it is heavy and the effort should be distributed evenly.

| | |
|---|---|
| CAUTION | **Do not lift at all by the Transporter end! Internal supports may be shipping damaged by lifting from this end of the Instrument. The junction between the Transporter chassis and the main chassis provides strength in case the Transporter end droops slightly. However, if the Transporter end is used to lift the main chassis, the junction will be damaged, preventing proper caution handling of the wafers.** |

The lifting positions (Fig. 8-1) are:

1. (optional) at the Power Drawer end
2. at the center, one in front and the other in back

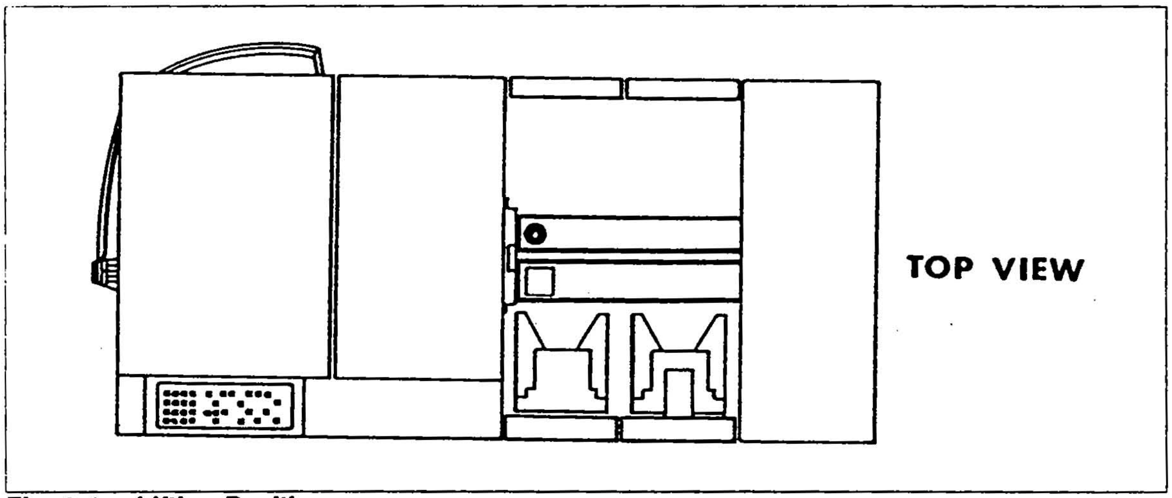



**Fig. 8-1 Lifting Position**

Lifting together, gently place the Instrument on the cart. Roll the cart to the entrance of the cleanroom, being careful not to bump into obstructions or jar the Instrument.

Unpacking Other Components

Check the crate for parts packed separately. Inspect all parts for any visible shipping damage and move them near the entrance of the cleanroom.

- Monitor
- 20-column Printer
- Monitor signal cable assembly (marked "RGB")
- Printer serial signal cable (marked "RS232 ONLY")
- Instrument power cord
- Monitor power cord
- Two rolls of cleanroom printer paper
- Accessories ordered with the Instrument

Save the shipping crate and shipping materials in case the Instrument must be moved to another facility or shipped to Tencor Instruments. The Instrument must be shipped in the same crate for proper protection of the Instrument's mechanical components.

**Moving Into Cleanroom**

Wipe the shipping plastic sheeting clean with alcohol and cleanwipes. Remove the plastic and move the cart into cleanroom. Using a coordinated effort (as with lifting onto the cart), move the Instrument onto the cleanroom bench.

The surface of the cleanroom bench should be a hard surface that does not flex under the Instrument's weight. All pedestal feet should be able to support the Instrument (leveling is described later). Although a cart may seem to be a sensible place to leave the Instrument, the Instrument is not meant to be portable.

The other components should also be wiped clean before moving them into the cleanroom.

### 8.1.3 SETTING UP

**Leveling**

The Instrument must be leveled before operation. The six pedestal feet (fig. 2.3a) are used to raise or lower the Instrument until the bubble level (mounted on the Instrument) shows that it is level.

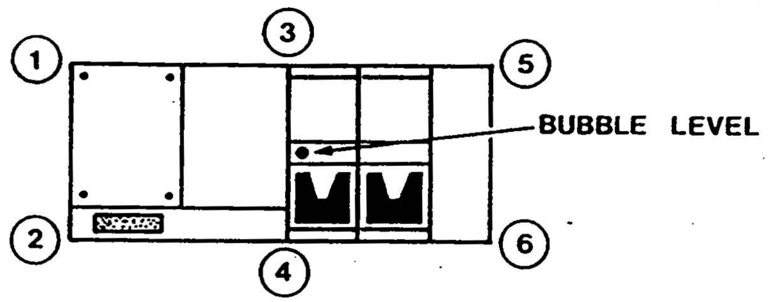



**Fig. 8-2 Leveling Feet**

1. Turn feet #5 and #6 in so they are not supporting any weight on the Transporter end. Keep turning until the feet are about 1/ 2" off the cleanroom bench.
2. Turn feet # 1 and #2 until the bottom of the Instrument is between 3/4" and 1" above the cleanroom bench (this allows for free flow of cooling air into the Power Drawer).
3. Check that #5 and #6 are not touching the bench. (If they are, turn them in more.)
4. Check the bubble level located on the metal rib of the Transporter (fig. 2.3b). Level the Instrument as much as possible by turning feet #3 and #4 while watching the bubble level. (Keep at least 3/ 4" but not more than 1" of free space under the Power Drawer.)

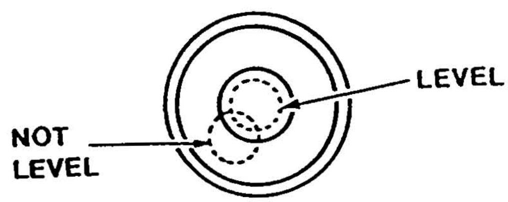



**Fig. 8-3 Bubble Level**

5. Raise or lower feet #1, #2, #3, and #4 until the Instrument is level. Level until the bubble is entirely within the black circle on the bubble glass. Check that the Instrument does not "wobble" diagonally-related feet (the #1/#4 pair or the #2/#3 pair).

6. Turn feet #5 and #6 down until they support only the weight of the Transporter end of the Instrument. Do not turn too far or the level will be changed. Check the level again.

7. Unwrap the and place it next to the Scan Housing above the Keyboard. The feet should set into the small indents on the Instrument cover.

8. Check the level again. Check that the button of the Instrument is no lower than 3/4" and no higher than 1" from the cleanroom bench.

**Connecting System Reset Button**

The System Reset Button, if not already installed, mounts on the 25-pin connector above the Printer connector. This connects to the Instrument's computer bus to allow the system to be reset. The System Reset Button is a small connector with a momentary pushbutton.

| | |
|---|---|
| **CAUTION** | **Power must be OFF when installing or removing Button.** |

To install, connect the Button to the top connector on the Instrument's left side panel. Tighten the jackscrews to prevent it from being removed accidentally while power is on.

**Connecting Cables**

After placing the Instrument in the specified operating environment, connect the cables shown in Figure 2.3c according to the following steps. Watch for the correct polarity of cables.

1. Raise the rear access cover of the monitor.

2. Connect the three coaxial cables of the Monitor signal cable assembly to the Monitor BNC plugs marked R, G, B.

3. Run the free end of this cable assembly underneath the Instrument and toward the I/ O Panel (on the left side). Connect each coaxial cable to their respective plug on the I/O Panel (input/output; on the left side of the Instrument).

4. Connect the Monitor power plug to the Monitor power outlet located on the Power Drawer (the panel with the ON/ OFF switch). Set the Monitor power switch to ON and then close the rear access cover.

5. Unwrap the Printer and set it nearby (preferably below the cleanroom bench) within reach of the 10-foot long Printer signal cable.

6. The Printer serial signal cable connects the serial output port of the Instrument to the external 20-column Printer. Connect the serial signal cable to the connector marked "OUT 1 PRINT" on the I/ O Panel. Connect the other end to the Printer. DO NOT plug in the Printer power cord yet.

If you have the optional Converter/Buffer, connect the serial signal cable to the serial output port and the Converter/ Buffer input. Connect the output of the Converter/Buffer to an 80-column printer (such as the Epson FX-80+™). Connect the Converter/Buffer external power supply to a suitable power outlet, and connect the power supply's output to the power jack of the .

7. Check the voltage shown by the AC Voltage Selector (on the left side of the Instrument). Below the power switch is the power receptacle, which holds the two main power fuses, the AC Voltage Selector, and the receptacle for the power cord. The VAC value shown in the small "window" on the fuse cover must match the utility power.

The AC Voltage Selector is not a thumbwheel switch. It is a cam which must be removed, rotated (to select the desired AC voltage), and reinserted. Refer to the procedure in "Section 7 Service" to change the selected value if it does not match the voltage delivered by the outlet.

8. Check that the Instrument's ON/ OFF switch is towards "0" (for OFF).

| | |
|---|---|
| **CAUTION** | **THE UTILITY POWER OUTLET MUST BE PROPERLY GROUNDED TO PREVENT POSSIBLE ELECTRIC SHOCK FROM THE METAL CHASSIS OF THE INSTRUMENT. CHECK THE CONNECTION <u>BEFORE</u> PLUGGING THE LINE CORD INTO THE OUTLET.** |

9. Plug the Instrument power cord into the Power Drawer's power receptacle. Connect the other end into an outlet rated for the power demand of the Instrument.

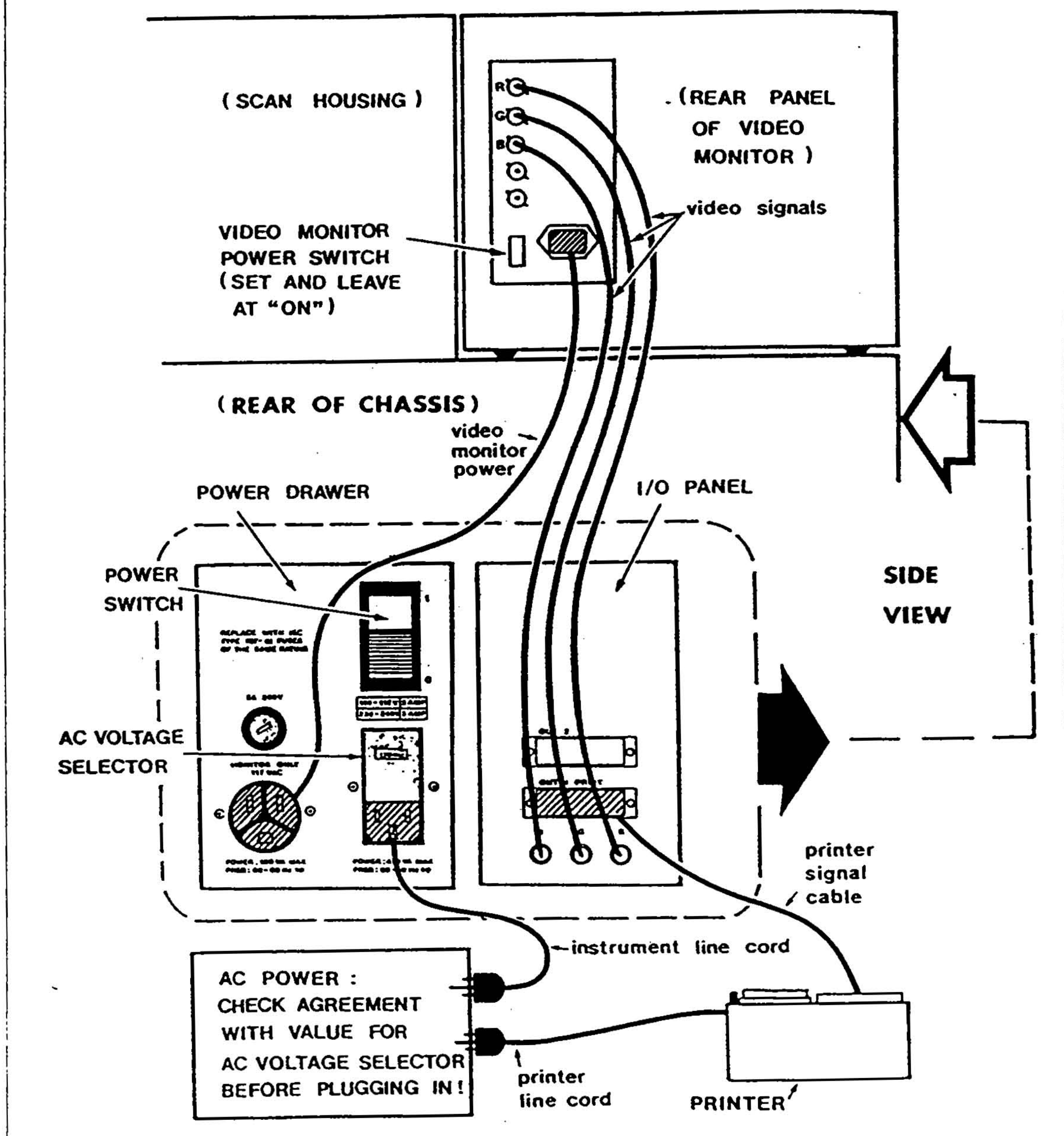



Fig. 8-4 Cable Connection Schematic

### Connecting Vacuum

Connect a vacuum line to the connector on the right rear side of the Transporter chassis (Fig. 8-5). The facilities vacuum supplied to the Instrument must be between 20 to 29 inches Hg (gauge reading, where 29 is perfect vacuum and 0 is normal atmospheric pressure).

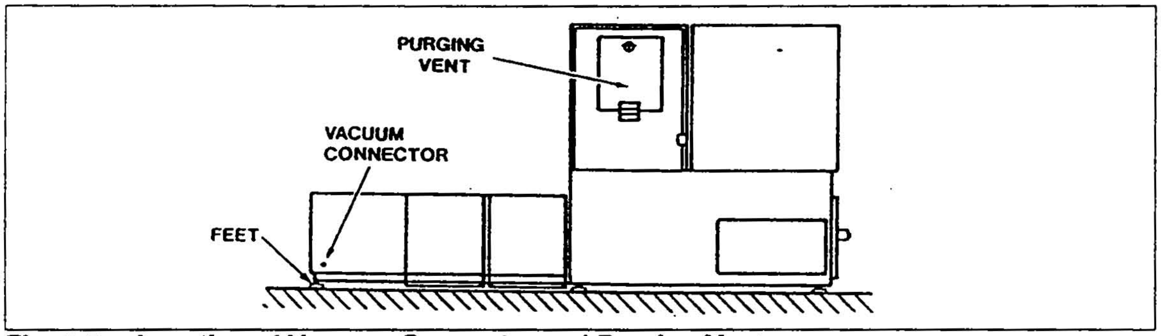



**Fig. 8-5 Location of Vacuum Connector and Purging Vent (viewed from behind the Instrument)**

### Purging

Open the Purging Vent (fig 2.3d) to allow the cleanroom airflow to "sweep" any particles out of the system. (If the Instrument has the optional HEPA Filter, follow the instructions given later after powering up. Leave the Purging Vent open while the is running.)

If the Instrument lacks a HEPA Filter, be sure the Purging Vent is closed before taking measurements, or stray light may reduce the sensitivity. (Instruments with a HEPA Filter can be operated with the Purging Vent open.)

**Checking the Installation**

To double-check all parts of the installation before powering up, complete the following checklist:

- ☐ Instrument leveled.
- ☐ Signal cable assembly connected.
- ☐ Monitor power cord connected to power Drawer.
- ☐ Serial signal cable connected.
- ☐ Utility power outlet voltage checked.
- ☐ AC checked to match outlet voltage.
- ☐ Instrument power cord connected to outlet.
- ☐ Printer power cord not connected to outlet.
- ☐ Vacuum line connected.
- ☐ Purging Vent opened. (If without HEPA Filter, close before taking measurements.)

## 9.1 POST REPAIR CHECKLIST

**Objectives:**

1. Standardize installations and servicing of Surfscans.
2. Establish an accepted minimum set of performance criteria.

**Notes/Instructions:**

1. For the most part, the form is somewhat self-explanatory except for the Optical Noise Check.
2. Optical Noise Check (Based on QA Procedures) :

To check for Optical noise, scan a very clean wafer with the following settings:

Currently QA specifies the 6" wafer to produce less than 2000 total particles at the 6mm edge exclusion and without 'smiley faces' at the larger edge exclusions selected.

| WAFER | EDGE EX-CLUSION | THRESHOLD | MODE | DISPLAY FROM | DISPLAY FROM |
|---|---|---|---|---|---|
| 4" | 2mm | .006 | Single | .006 | .050 |
| 4" | 4mm | .006 | Single | .006 | .050 |
| 4" | 2mm | .004 | Double | .006 | .050 |
| 4" | 4mm | .004 | Double | .006 | .050 |
| 5" | 2mm | .006 | Single | .006 | .050 |
| 5" | 5mm | .006 | Single | .006 | .050 |
| 5" | 2mm | .004 | Double | .006 | .050 |
| 5" | 5mm | .004 | Double | .006 | .050 |
| 6" | 2mm | .006 | Single | .006 | .050 |
| 6" | 6mm | .006 | Single | .006 | .050 |
| 6" | 2mm | .004 | Double | .006 | .050 |

The form asks that you specify which settings were selected for the optical noise check.

1. If a printer is available, attach the printout where specified.
2. Attach the Checklist along with printouts to the appropriate work order.

## SURFSCAN 4000-5500 POST-SERVICE CHECKLIST

Date:__________/________Engr: ____________________

**Model:** __________ **S/N** __________ **S/W Rev:** __________

SYSTEM CALIBRATION AND PERFORMANCE

1. Check the Calibration and Sensitivity of the Instrument using a VLSI 1.091μ PSL Wafer (Primary Calibration Pt) and VLSI 0.364μ PSL Wafer (Secondary Calibration Pt). Record the following Data using Multiple Scan mode:

| | SCAN# | COUNT 1.091μ | MEAN SIZE 1.091μ | COUNT 0364μ | MEAN SIZE .364μ |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| MEAN: | | | | | |
| SDEV: | | | | | |
| CV%: | | | | | |

SPEC: ( CV% = SDEV/ MEAN X 100 ) 3%

2. Print out the following:Histogram: 1.0μ _____Wafer Map: 1.0μ _______

   For both Standards. Histogram: 0.364μ _____ Wafer Map: 0.364μ _____

3. Using a VLSI Relative Standard (1400 or 1402), verify all four peaks are distinct and free of non-uniformities. TYPE.

4. Verify counting accuracy, check for Double-hits.

5. Print out the following: Histogram: REL _____ Wafer Map: REL_______.

6. Optical Noise Check:

Wafer Size: ________ Edge Exclusion: ______ Threshold:__________

Edge Exclusion: _____ Display From: ________ To:________________

Mode: ____________ Particle Count: _______ Wafer Map Printout:___

7. Measure and Record the following bus voltages:

Distribution, +5V__________ Distribution, +12V____________

Distribution, +24V_________ Distribution,-12V_____________

Distribution,-5.2V __________ Dist/Handler, +33V___________

8. Measure and Record the PMT Drive Voltages at the Distribution PCB

R87 Bottom for the following MAX SIZE settings:

| MAX SIZE | Measured | MAX SIZE | Measured |
|---|---|---|---|
| 0.000 | ______________volts | 2.56 | ______________volts |
| 0.256 | ______________volts | 5.12 | ______________volts |
| 0.512 | ______________volts | 10.24 | ______________volts |
| 1.024 | ______________volts | 25.6 | ______________volts |

9. Measure and record the "LASER OK" DC Voltage at the Distribution PCB,

U16 Pin 10. LASER OK Voltage: ______________ volts

10. Measure and record the scanner amplitude voltage at the test point marked "AMP" on the Distribution PCB (Nominal = -2.0V)

SCANNER AMP Voltage: ______________volts

## VIDEO MONITOR CHECKS

11. Check the range of brightness. The background raster-scan should be slightly visible with full CW rotation of the brightness control.

12. Select the MENU. Check Vertical Linearity of Characters.

13. Verify centering of display. All characters should be visible and a minimum of 1/4" from CRT edges.

14. Monitor 100mm, 125mm, 150mm wafer scans. Verify that the horizontal and vertical linearity adjustments produce a circular wafer pattern.

## KEYBOARD/OPERATIONS CHECKLIST

15. Verify the operation of the Power On LED.

16. Verify the operation of Help Screens.

17. Verify Menu #1 Quadrants through all parameters and options.

    DATA COLLECTION _____ DATA DISPLAY ______

    SORT PARAMETERS_____ SYS CONFIG ________

18. Initiate a wafer scanning operation; press STOP and then HOME. Verify correct operation.

19. Verify EXTERNAL RESET functions.

## SORTING/HANDLING CHECKLIST

20. Verify smooth operation of the Indexer's Stepping Motors for the platforms, and the coulisses.

21. Verify the smooth up and down operation of the cassette and indexer platforms.

22. Verify that each wafer is centered in the cassette slot as it is loaded and unloaded.

23. Verify that wafers in slots 1, 12, and 25 are taken out of the center of cassette slots and placed into the center of cassette slots.

24. Verify smooth wafer delivery between cassettes and scan unit without excessive noise or vibration.

## 9.2 COMMONLY USED PARTS

### 9.2.1 NUMERICAL SORT

| Part Number | Description |
|---|---|
| 054135-02 | PCB SCHEMATIC,I/O,SFS4 |
| 054135-24 | PCB ASSY,I/O |
| 054291-02 | PCB SCHEMATIC,KEYBOARD, |
| 054291-24 | PCB ASSY,KEYBOARD |
| 054364-02 | PCB SCHEMATIC,INDEXER |
| 054364-24 | PCB ASSY,INDEXER |
| 054453-02 | PCB SCHEMATIC,HANDLER,VACUUM |
| 054453-24 | PCB ASSY,HANDLER |
| 054526-24 | MIRROR,END,FRONT,SFS4 |
| 055069-24 | PL,ADJ,ELLIPTICAL MIRROR,SFS4 |
| 055972-02 | PCB SCHEMATIC,DISTRIBUTION,SFS4 |
| 055972-24 | PCB ASSY,DISTRIBUTION |
| 059366-24 | TROLLEY ASSY,HANDLER |
| 059390-24 | COULISSE ASSY,FRONT,INDEXER |
| 060518-02 | SCHEMATIC,PWR DRAWER,SFS4 |
| 060534-24 | PCB ASSY,DRAM |
| 060895-24 | ENCODER,DISK,LEAD SCR,HDLR |
| 060925-24 | MOTOR ASSY,COULISSE,INDEXER |
| 061050-02 | PCB SCHEMATIC,HIGH VOLT,SFS4 |
| 061050-24 | PCB ASSY,HIGH VOLTAGE |
| 061115-24 | SENSOR ASSY,OPTICAL |
| 062880-24 | MOTOR ASSY,TRACK,MOTOR |
| 062960-24 | MONITOR ASSY |
| 063827-24 | MOTOR SUBASSY,TRACK,HDLR |
| 063967-24 | PCB ASSY,SLAVE CPU |
| 063975-24 | PCB ASSY,MEMORY |
| 063983-24 | PCB,CPU 4MHZ |
| 063991-24 | PCB ASSY,VIDEO MATROX |
| 066192-24 | SCAN MIRROR,GS,SFS4 |
| 070602-24 | PCB ASSY,HANDLER&VACUUM CNTRL |
| 070734-24 | RESTRICTOR,FLOW,HDLR |
| 071480-24 | INDEXER ASSY,FRONT,RA |
| 072141-24 | ARM ASSY,RA,HDLR |
| 074349-02 | PCB SCHEMATIC,PMT PREAMP,S364 |
| 074349-24 | PCB ASSY,PRE-AMP PMT |
| 077054-24 | PCB ASSY,PPC,S4000 |
| 077860-02 | PCB SCHEMATIC,PREPROCESSOR,S4000 |
| 077860-24 | PCB ASSY,PRE-PROCESSOR |
| 079014-24 | PL,FRONT,MIRROR ASSY,S364 |
| 079294-02 | PCB SCHEMATIC,PHOTOMLT STR DV |
| 079294-24 | PCB ASSY,PMT STRING DIVIDER |
| 079316-24 | FIBER OPTICS ASSY,SFS |
| 079553-02 | PCB SCHEMATIC,PMT LID,S364 |
| 079553-24 | PCB ASSY,PMT LID |
| 080730-24 | PCB ASSY,PMT STRING DIVIDER |
| 080810-02 | PCB SCHEMATIC,A-D,S5000 |
| 080810-24 | PCB ASSY,A-D |
| 082260-24 | PCB ASSY,PMT,STR DIVIDER,S4000 |
| 083950-24 | PCB ASSY,PMT & SOCKET |
| 086045-24 | PCB,CPU-9 |
| 086630-24 | BLOCK DIAG,PROD STRCTR,S4500 |
| 086657-24 | PL ASSY,OPTICS |
| 086665-24 | FILTER & FIRST LENS ASSY,S5000 |
| 086681-24 | OPTICS&SUPPORT ASSY |
| 087696-24 | OPTICS ASSY,MIRROR/FIBER |
| 088021-24 | FOCUS LENS ASSY,S5000 |
| 088269-24 | POWER DRAWER ASSY |
| 088820-24 | LASER ASSY,S5000 |
| 090891-24 | CATCHER,BEAM,UPR |
| 090913-24 | MT,BEAM CATCHER |

| Part Number | Description |
|---|---|
| 090930-24 | BAR,RETROBEAM CATCHER |
| 092754-24 | WAND,VACUUM,SHORT,2IN WFR |
| 092819-02 | PCB SCHEMATIC,VAC CNTRL,MOD,S5 |
| 092819-24 | PCB ASSY,VACUUM CNTRL |
| 093866-24 | WAND ASSY,STD,OPTION |
| 093874-24 | WAND ASSY,2&3IN,OPTION |
| 106771-24 | HARNESS ASSY,PWR DRWR,S5000 |
| 106828-24 | PWR DRWR ASSY,S5500 |
| 117714-24 | MONITOR ASSY,S4500 |
| 128066-02 | PCB SCHEMATIC,PMT CNTRL,S5000 |
| 128066-24 | PCB ASSY,PMT |
| 142719-24 | MOTOR ASSY,HDLR |
| 143146-24 | PROGRAM SET,SFS |

### 9.2.2 Sorted By Description

| Part Number | Description |
|---|---|
| 072141-24 | ARM ASSY,RA,HDLR |
| 090930-24 | BAR,RETROBEAM CATCHER |
| 086630-24 | BLOCK DIAG,PROD STRCTR,S4500 |
| 090891-24 | CATCHER,BEAM,UPR |
| 059390-24 | COULISSE ASSY,FRONT,INDEXER |
| 060895-24 | ENCODER,DISK,LEAD SCR,HDLR |
| 079316-24 | FIBER OPTICS ASSY,SFS |
| 086665-24 | FILTER & FIRST LENS ASSY,S5000 |
| 088021-24 | FOCUS LENS ASSY,S5000 |
| 106771-24 | HARNESS ASSY,PWR DRWR,S5000 |
| 071480-24 | INDEXER ASSY,FRONT,RA |
| 088820-24 | LASER ASSY,S5000 |
| 054526-24 | MIRROR,END,FRONT,SFS4 |
| 062960-24 | MONITOR ASSY |
| 117714-24 | MONITOR ASSY,S4500 |
| 060925-24 | MOTOR ASSY,COULISSE,INDEXER |
| 062880-24 | MOTOR ASSY,TRACK,MOTOR |
| 142719-24 | MOTOR ASSY,HDLR |
| 063827-24 | MOTOR SUBASSY,TRACK,HDLR |
| 090913-24 | MT,BEAM CATCHER |
| 087696-24 | OPTICS ASSY,MIRROR/FIBER |
| 086681-24 | OPTICS&SUPPORT ASSY |
| 063983-24 | PCB,CPU 4MHZ |
| 086045-24 | PCB,CPU-9 |
| 054135-24 | PCB ASSY,I/O |
| 054291-24 | PCB ASSY,KEYBOARD |
| 054364-24 | PCB ASSY,INDEXER |
| 054453-24 | PCB ASSY,HANDLER |
| 055972-24 | PCB ASSY,DISTRIBUTION |

## 9.3 REVISED/ EXPANDED DRAWING SET

| Part Number | Drawing |
|---|---|
| 060534-24 | PCB ASSY,DRAM |
| 061050-24 | PCB ASSY,HIGH VOLTAGE |
| 063967-24 | PCB ASSY,SLAVE CPU |
| 063975-24 | PCB ASSY,MEMORY |
| 063991-24 | PCB ASSY,VIDEO MATROX |
| 070602-24 | PCB ASSY,HANDLER&VACUUM CNTRL |
| 074349-24 | PCB ASSY,PRE-AMP PMT |
| 077054-24 | PCB ASSY,PPC,S4000 |
| 077860-24 | PCB ASSY,PRE-PROCESSOR |
| 079294-24 | PCB ASSY,PMT STRING DIVIDER |
| 079553-24 | PCB ASSY,PMT LID |
| 080730-24 | PCB ASSY,PMT STRING DIVIDER |
| 080810-24 | PCB ASSY,A-D |
| 082260-24 | PCB ASSY,PMT,STR DIVIDER,S4000 |
| 083950-24 | PCB ASSY,PMT & SOCKET |
| 092819-24 | PCB ASSY,VACUUM CNTRL |
| 128066-24 | PCB ASSY,PMT |
| 054135-02 | PCB SCHEMATIC,I/O,SFS4 |
| 054291-02 | PCB SCHEMATIC,KEYBOARD, |
| 054364-02 | PCB SCHEMATIC,INDEXER |
| 054453-02 | PCB SCHEMATIC,HANDLER,VACUUM |
| 055972-02 | PCB SCHEMATIC,DISTRIBUTION,SFS4 |
| 061050-02 | PCB SCHEMATIC,HIGH VOLT,SFS4 |
| 074349-02 | PCB SCHEMATIC,PMT PREAMP,S364 |
| 077860-02 | PCB SCHEMATIC,PREPROCESSOR,S4000 |
| 079294-02 | PCB SCHEMATIC,PHOTOMLT STR DV |
| 079553-02 | PCB SCHEMATIC,PMT LID,S364 |
| 080810-02 | PCB SCHEMATIC,A-D,S5000 |
| 092819-02 | PCB SCHEMATIC,VAC CNTRL,MOD,S5 |
| 128066-02 | PCB SCHEMATIC,PMT CNTRL,S5000 |
| 055069-24 | PL,ADJ,ELLIPTICAL MIRROR,SFS4 |
| 079014-24 | PL,FRONT,MIRROR ASSY,S364 |
| 086657-24 | PL ASSY,OPTICS |
| 088269-24 | POWER DRAWER ASSY |
| 143146-24 | PROGRAM SET,SFS |
| 106828-24 | PWR DRWR ASSY,S5500 |
| 070734-24 | RESTRICTOR,FLOW,HDLR |
| 066192-24 | SCAN MIRROR,GS,SFS4 |
| 060518-02 | SCHEMATIC,PWR DRAWER,SFS4 |
| 061115-24 | SENSOR ASSY,OPTICAL |
| 059366-24 | TROLLEY ASSY,HANDLER |
| 092754-24 | WAND,VACUUM,SHORT,2IN WFR |
| 093866-24 | WAND ASSY,STD,OPTION |
| 093874-24 | WAND ASSY,2&3IN,OPTION |

## 9.4 Glossary

This appendix defines technical terms and names of Instrument components. For help with instructions, refer to the "Table of Contents" or the "Index."

**Active Wafer Area**
Area within the boundaries of the edge exclusion and the front exclusion.

**Area Zoom**
Feature that allows an area of Particle Map to be enlarged for detailed analysis of particle positions. (For particle counting classification only.)

**Automatic Mode**
Sequential scanning of all wafers carried in a wafer cassette.

**Bubble Level**
Shows the level of the Transporter System.

**Cassette**
(see "Wafer Cassette.")

**Cassette Map**
After wafer cassette initialized, shows which slots have wafers.

**Composite Display Mode**
Provides Particle Map, Histogram, and Haze Map for Data Display. (DISPLAY MODE = COMPOS.)

**Converter/Buffer**
Optional; interfaces the serial port to parallel 80-column printer.

**Cross-Sectional Light-Scattering Area**
Area of a particle measured in terms of the apparent size due to light scattering; refer to "Section 4 Theory" for more information.

**Data Display**
Screen on Monitor displaying results of scan.

**Particle**
Particle, pit, scratch, or any surface characteristic that scatters light as a pulse.

**Particle Display Mode**
Shows positions of particles in three size ranges. Yellow is smallest size, orange is medium, and blue is largest. Also called Three-Color Particle Map. (Display Mode = Particle)

**Particle Map**
Shows position of particles on the active wafer area.

**Direct Entry**
Parameter with value entry from numerical keypad.

**Edge Exclusion**
Parameter; a border within the edge of the wafer. Data is not collected outside the border.

**Fetch**
The operation of grasping and removing a wafer from a Sender wafer cassette.

**Handler**
The sub-system that handles the wafers while they are out of a wafer cassette; the part that moves back and forth between the wafer cassettes and the Scan Unit.

**Handler Arm**
The "arm" that holds the Puck.

**Haze**
Generalized scatter (not pulses) from surface roughness or other features smaller than the wavelength of scanning laser beam.

**Haze Map**
Shows position of haze on the active wafer area.

**Help Screen**
Screens with basic operating instructions and applications.

**HEPA Filter**
Optional; filters the air inside the Scan Housing of the Instrument.

**Histogram**
Depicts the number of particle display pixels versus the size in light-scattering cross-sectional area.

**Histogram Cursors**
Vertical bars on orange Histogram that can be moved to define range for analysis or replotting.

**Indexer**
The system that raises and lowers the wafer cassette so wafers can be fetched or unloaded by the Puck.

**Indexer Platform**
The platform that holds the wafer cassette.

**Initialization**
Pressing [CARR] after cassette is loaded, causing wafer inventory and display of Cassette Map. Random-Access function (Normal Sequential Scanning, programmed Sequential Scanning, and Random-Access Scanning) requires initialization; Sequential-Access function (Reverse Sequential Scanning) does not.

**I/O Panel**
Left side panel (when facing Monitor) with signal connections for Printer, Monitor, and external System Reset Button.

**Keyboard**
Contains keys for programming menus and commanding operation sequences.

**Levelers**
Feet on bottom for leveling Instrument.

**Listed Entry**
Parameter entry by cycling through list with cursor keys.

**Locator Block**
A plate attached to the Indexer Platform. The Locator positions the type of wafer cassette chosen (either type PA-72 or PA-182 series Fluoroware™).

**Manual Mode**
Scanning of single wafer carried in wafer cassette each time [START] is pressed.

**Menu**
Screen on Monitor displaying operating parameters.

**Message Window**
Area of Data Display showing messages to operator.

**Monitor**
(also called "Video Monitor"): CRT display; shows Menu or Data Display.

**Normal Sequential Scanning**
Manual Mode or Automatic Mode scanning of wafers starting with top wafer and ending with bottom one. Requires initialization.

**One-Wafer Mode**
Scanning of a single wafer not carried in a wafer cassette.

**Parameter**
Specifies variables for operating conditions.

**Plotting Area**
Part of Data that shows the colored overlays (Particle Map, Histogram, and Haze Map in Composite Display Mode; Three-Color Particle Map in Particle Display Mode).

**PMT Gain**
Percentage gain of photomultiplier tubes; sets maximum particle size measurable by Instrument.

**Power Drawer**
Conditions power for Instrument and Monitor. Holds power receptacle, AC Voltage Selector, and fuses.

**Power Receptacle**
Connector for line cord from utility outlet to Instrument.

**Printer**
Generates paper record of scan results.

**Programmed Sequential Scanning**
Similar to Normal Sequential Scanning except that selected group of wafers are scanned. Requires initialization and programming from Cassette Map. Can be used in Manual Mode or Automatic Mode.

**Puck (also called "Vacuum Puck")**
Grasps the wafer for handling; coated with Teflon™ to prevent wafer contamination.

**Purging**
Filtering or removing particles from inside the Scan Housing, either by cleanroom airflow (standard) or by HEPA Filter (optional).

**Purging Vent**
Small door on rear of Scan Housing for purging airflow.

**Receiver**
Indexer that accepts unloaded wafers (with the Two-Indexer Configuration, the Sender is also a Receiver for rejected wafers).

**Random-Access Scanning**
Selection of individual wafers to be scanned in Manual Mode. Requires initialization cassette and selection from Cassette Map.

**Reverse Sequential Scanning**
Manual Mode or Automatic Mode scanning of wafers starting with bottom wafer and ending with top one. Done without initialization.

**Scan Housing**
Contains the detection system and analog electronics.

**Scan Port**
Small slot in the Scan Housing to allow wafers to be transported into the detection system.

**Sender**
Indexer that wafers are fetched from. For Two-Indexer Configuration, also receives wafers sorted as rejects. Sender only for Three-Indexer Configuration.

**Status Line**
Row at bottom of Data Display that shows operating status of Instrument.

**Summary Data**
Part of the Data Display; displays numerical results of scan.

**Three-Color Particle Map**
(see "Particle Display Mode.")

**Track Cover**
Blocks stray light from entering the Scan Port.

**Transporter System**
Robotics which handle all physical transfers of wafers.

**Unload**
The operation of depositing a wafer in a wafer cassette.

**Vacuum Connector**
The connection on the rear of the Transporter System for facilities vacuum.

**Vacuum Puck**
(see "Puck")

**Wafer Cassette (also called "Cassette" or "Carrier")**
The tray that holds a group of wafers for handling; raised or lowered by the Indexer to allow the Puck to access to each wafer. (Locator Blocks standardized for Fluoroware™ series PA-72 or PA-182.)

**Wafer Comparison Display**
Screen on Monitor displaying results of two sets of scans made in Manual Mode or Automatic Mode. Use to compare wafers in the same cassette before and after a process.

## 10.1 Service

**Symptom**
Procedure (follow first to last)

**Menu not displayed when [MENU] pressed**
Check that Menu Security Lock is not locked.

**Keyboard not working**
1) If scanning or other operation being done, wait for a few moments. Try again.

2) Press System Reset Button (on left side panel).

**No power**
Check fuses - two for Instrument, one for Monitor, and one for Printer.

**20-column Printer not printing**
1) Check that parameter PRINTER TYPE = 20 COL. Try printing again.

2) Reset by unplugging Printer power cord and reconnecting. Try printing again.

**80-column Printer not printing**
1) Check that parameter PRINTER TYPE = 80 COL. Try printing again.

2) Reset Converter/ Buffer. Try printing again.

**Wafers rubbing or binding in cassette**
1) Check that cassette correctly loaded on Indexer Platform.

2) Check and adjust Indexer pitch and home using procedures in "Switching Locator Blocks."

**Wafer dropped into Transporter**
1) If wafer is unbroken, grasp with vacuum wand to retrieve.

2) If wafer is broken, vacuum chips out (call Tencor Instruments Service for assistance).

**Wafer dropped inside Scan Unit**
Call Tencor Instrument Service.

## 10.2 Using Status Display Codes

A parameter in the System Configuration Quadrant of the Menu can be set to display status messages on the Monitor. The status codes are useful during in-depth troubleshooting. Normally, the STATUS DISPLAY parameter is OFF, but it can be set to ON or TEST.

**Status Display Off**
The normal value for this parameter, OFF leaves the area for status codes blank. Unless an instrument error is suspected, leave the Status Display off.

**Status Display On**
If the parameter STATUS DISPLAY is set to ON, the Data Display includes codes that describe the internal machine operations. These codes appear in the bottom left corner of the Data Display, below the Message Window. The codes are arranged in lines, with each line pertaining to a type of operation. This feature is not intended for your use; Tencor Instruments Service Engineers will refer to it when needed.

**Status Display Test**
Compared to STATUS DISPLAY = ON, this uses more of the Data Display to provide test messages. While the value TEST is selected, the Histogram Cursors are not displayed sine the white "plane" of the Monitor is reserved in the plot area for the test messages.

The test messages are intended primarily to show how the program is running, revealing the contents of various registers and stacks. These do not indicate hardware states or problems.

Be sure to leave STATUS DISPLAY at OFF or ON or else the Histogram Cursors cannot be used.

## 10.3 Purging System

Purging removes airborne particles from inside the Scan Unit. There are two ways to purge: without a HEPA Filter or with one. Check the sales order to find out if the Instrument is equipped with this Filter feature. The system should be purged first when it is installed or whenever unfiltered air has reached the Instrument, such as when moving to another location.

**Purging Without HEPA Filter**

If the Instrument does not have a HEPA Filter, cleanroom airflow sweeps particles out. Air already filtered by the cleanroom system enters the Scan Housing, gradually displacing the contaminated air.

Open the Purging Vent located on the rear panel of the Scan Housing and allow several hours for the system to be purged. Close the Purging Vent before using the Instrument.

If without a HEPA Filter, the Instrument should not be used for measurement while the Purging Vent is open. Ambient light may affect the measurements.

**Purging With HEPA Filter**

If the Instrument has a HEPA Filter, an internal fan purges the Scan Housing by forcing in filtered air. Air containing particles is then pushed out of the Scan Housing since it is replaced with clean air (positive displacement).

Open the Purging Vent and turn on the HEPA Filter circulating fan by pressing **[HEPA]** (on the Keyboard). Check that the Status Line of the Data Display says "HEPA." Allow the filter to run for approximately half an hour or more. The fan may be left on continuously (leave Purging Vent open) or else turned off after purging.

Note: With a HEPA Filter, the Instrument can be used for measurement while the Purging Vent is open. Measurements will not be affected by ambient light or the fan.

## 10.4 Cleaning Puck

Coated with a special contamination-resistant surface, the Puck can be cleaned using a cleanroom wipe and .i.methyl alcohol warning;. The surface has a Teflon™ coating; any safe solvents for this substance can be used for cleaning. The Puck should not require regular cleaning unless gross contaminants from the bottoms of wafers have been transferred to it during wafer handling.

METHYL ALCOHOL (METHANOL) IS HIGHLY FLAMMABLE AND POISONOUS. FUMES SHOULD BE REMOVED BY ADEQUATE VENTILATION WHILE USING.

Without a cassette on the Sender Indexer, press **[START]** to bring the Puck out to the One-Wafer Mode load/ unload position. Check that vacuum is not being drawn into the ports on the Puck - if it is making a hissing sound, wait until it stops.

Dampen the wipe with methyl alcohol (excess alcohol might drain into the vacuum control system if the wipe is dripping wet).

Rub the wipe over the top and edges of the Puck. Dry it with a fresh wipe and allow any remaining alcohol to evaporate for a minute or longer.

Press **[HOME]** to send the Puck Home.

## 10.5 Replacing Instrument Fuses

If the keyboard power LED and the Monitor turn off while the Instrument is being used, the problem may be a blown fuse in the power receptacle (fig 7.5a) on the left side panel. There are two fuses in this fuse block. One or both may need replacing if the Instrument is not working.

Turn the Instrument power switch OFF.

Disconnect the Instrument line cord from the power receptacle.

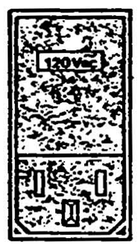



**Fig. 10-1 Power Receptacle**

Carefully pry open the fuse cover with a small screwdriver under the tab at the top.

Slide out both fuse holder inserts .

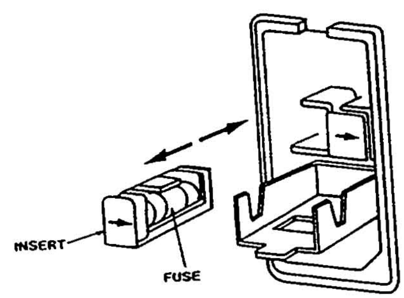



**Fig. 10-2 Fuse Holder Inserts**

Replace each blown fuse with a new one of the proper rating.

(2) 5 Ampere slow-blow, 220 VAC and 240 VAC

(2) 2 Ampere slow-blow, 100 VAC and 117 VAC

With the arrows pointing up, reinstall the fuse holder inserts.

Close the fuse cover and press until it snaps shut.

Connect the line cord to the power receptacle and turn the power switch ON. Resume scanning.

## 10.6 Replacing Monitor Fuse

The Instrument blanks out the Monitor after a few minutes of inactivity to preserve the CRT's life. It may be awakened by pressing any key, such as [HELP] or [MENU]. If the Instrument is working but the Monitor is blank, the problem may be a blown Monitor fuse.

Turn the Instrument power switch OFF.

Instrument power cord from the utility outlet.

The Monitor power fuseholder is mounted above the Monitor power outlet. Remove the fuse cover by turning counterclockwise. Remove and replace fuse with:

(1) 2 Ampere slow-blow, 117 VAC

Replace the fuse cover, plug in the Instrument power cord, and power up.

If this does not fix the problem, start at Step 1 again and check the fuseholder on the rear chassis of the Monitor (open the Monitor's rear cover). This 3 ampere fuse should not blow before the Monitor outlet power fuse does.

## 10.7 Replacing Printer Fuse

If the 20-column Printer's power LED is OFF even though it is plugged in, its internal fuse may need replacing. Follow the procedure "Changing Printer Voltage Selector.i.Voltage Selector;" for access to this fuse.

## 10.8 Changing Instrument Voltage Selector

If the Instrument is moved to a site having a different rating of AC power, its Voltage Selector must be switched. If the power change is from 100 VAC or 117 VAC to 220 VAC or 240 VAC, then the Instrument power cord must be replaced too (contact Tencor Instrument Sales).

Since the Monitor draws power from the side panel's Monitor power outlet (conditioned by the Instrument), changing the Voltage Selector (and replacing the cord too for 100-117 to 220-240) is the only adjustment necessary for the Instrument. However, the Printer Voltage Selector may need changing if its power source has been changed also.

To change:then:

---

from 100 VAC to 117 VACRotate selector.

from 117 VAC to 100 VAC

---

from 220 VAC to 240 VACRotate selector.

from 240 VAC to 220 VAC

---

from 110/117 to 220/2401)Rotate selector.

from 220/240 to 110/1172)Replace Instrument line

cord.

3)Replace fuses.

---

The Voltage Selector is not a thumbwheel switch. It is a cam which must be removed, rotated to select the voltage, and reinserted.

Turn the Instrument power switch OFF.

Disconnect the Instrument power cord from the power receptacle.

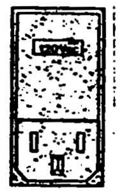


**Fig. 10-3 Power Receptacle**

Carefully pry open the fuse cover with a small screwdriver under the tab at the top.

Remove the Voltage Selector .

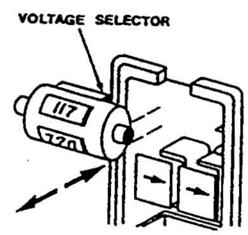



**Fig. 10-4 Removal of Voltage Selector**

Measure the utility outlet voltage with an AC voltmeter to verify the correct value for the Voltage Selector (refer to the operating specifications for voltage tolerances).

Rotate the Voltage Selector so the correct value will face outward when reinserted.

Slide the Voltage Selector back into the slot. If upside down, it will not fit. It must be inserted completely.

Check that the correct fuses for the line voltage are installed.

Close the fuse cover and press until it snaps shut.

THE LINE CORD MUST BE CONNECTED TO A GROUNDED OUTLET WHILE THE INSTRUMENT IS IN USE TO PREVENT POSSIBLE ELECTRIC SHOCK FROM THE METAL CHASSIS. CHECK THE GROUND CONNECTION BEFORE PLUGGING THE LINE CORD INTO AN OUTLET.

Connect the line cord (either the new one or the old one, depending on the outlet at the new location) to the power receptacle.

Turn the power switch ON. Resume scanning.

## 10.9 Changing Printer Voltage Selector

If the Instrument is moved to a site having a different rating of AC power, the 20-column Printer's internal Voltage Selector may need to be switched. If the power change is from 100 VAC to 117 VAC (or vice-versa), the selector does not need to be changed. A change from 220 VAC to 240 VAC (or vice-versa) also does not require a change of the Printer Voltage Selector. However, changing from 100 or 117 to 220 or 240 (or vice-versa) will require switching the Printer Voltage Selector.

If the Instrument needed a new line cord to match the new site, the Printer will probably need a new line cord.

For more detailed help in troubleshooting or repair of the Printer, refer to the Digitec User's Manual. Copies can be obtained from DIGITEC, 918 Woodley Road, P.O Box 458, Dayton, Ohio 45401.

This procedure can also be followed to gain access to the Printer fuse. Follow the steps below to replace a blown fuse or change the Voltage Selector.

Turn the Instrument power off and unplug the Printer power cable and serial signal cable.

Remove the four screws that hold the bottom cover to the Printer case. Lift the Printer case at the back to separate the two parts.

Switch the Voltage Selector (located near the transformer) to the position shown below:

positionVAC operation

115110 or 117

230220 or 240

Install a fuse of the correct rating.

VAC operationfuse

110 or 1171/4 A, 125 VAC slow-blow

220 or 2401/8 A, 250 VAC slow-blow

Replace the Printer case. Add the four screws to attach the bottom cover.

Reconnect the serial signal cable. Power up the Instrument.

THE LINE CORD MUST BE CONNECTED TO A GROUNDED OUTLET WHILE THE INSTRUMENT IS IN USE TO PREVENT POSSIBLE ELECTRIC SHOCK FROM THE METAL CHASSIS. CHECK THE GROUND CONNECTION BEFORE PLUGGING THE LINE CORD INTO AN OUTLET.

Connect the Printer power cord;.

## 10.10 Packing for Shipping or Moving

If the Instrument must be moved or shipped, review the instructions in "Section 2 Installation" before continuing here.

If the original crate has been lost or damaged, contact Tencor Instruments Sales for a replacement. A Tencor Instruments crate must be used for correct support during transportation or the Instrument may be _damaged during shipping.

Turn power off and disconnect all cables.

Disconnect the vacuum line. Plug the line from the facility to prevent draining the vacuum supply. Plug the vacuum line connector on the Instrument to prevent contamination.

Remove the Monitor from the top of the Scan Unit.

Close the Purging Vent.

To protect the optics from contamination, cut a piece of manila paper (or plastic) to 2-1/2" x 9" and tape it over the Scan Port (You may wish to clean the paper by spraying it with compressed nitrogen before attaching it.)

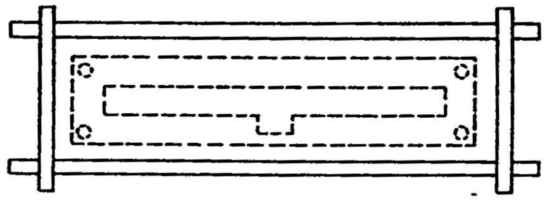


**Fig. 10-5 Covering the Scan Port**

Seal the entire Instrument (without Monitor) with plastic sheeting, taping all seams to prevent dust from leaking in.

Seal the Monitor with plastic sheeting.

Gently lift the Instrument into the shipping crate, being careful not to lift from the Transporter end.

Pack the rest of the system in the shipping crate.

## 10.11 Switching Locator Blocks

Locator Blocks hold the cassettes in place on the Indexer Platform, The Locator Blocks must be switched when changing cassette series between PA-72 and PA-182 or vice-versa. There are two types of Indexers that may be installed in the Instrument's Transporter, Random Access or Sequential Access. Each type requires a different mechanical assembly for the Locator Block - follow the appropriate procedure(s) below.

**Random-Access Blocks**

The Sender Indexer is always Random Access. The Receiver(s) may be either Random or Sequential. Random-Access Locator Blocks can be easily switched without any adjustments, in most cases - call Tenor Instruments Service if switching Blocks causes fetching or unloading problems.

Remove cassette and allow Indexer Platform to rise and tilt back.

With hex-key wrench, loosen the bolt in the middle of the Block (fig 7.11a) until it can be lifted up to clear the dowel pins. Slide the assembly toward the center of the Transporter and lift clear.

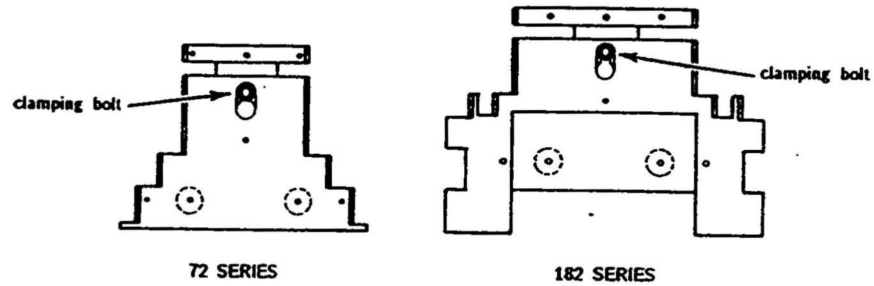



**Fig. 10-6 Clamping Bolt for Random-Access Locator Block**

Disconnect the coiled cord connecting the Indexer Platform to the Indexer chassis. Connect the replacement.

Set the replacement Locator Block in place and tighten the clamping bolt.

Repeat for any remaining Random-Access Indexers.

**Sequential-Access Blocks**

Receiver(s) may be either Random-Access or Sequential-Access. Compare the Locator Block with Figure 7.11a and Figure 7.11b to determine which it is. Switching Sequential-Access Blocks may require some adjustments of the Indexer Platform pitch and final home position. Follow the procedure given here - call Tencor Instruments Service if switching Blocks causes fetching or unloading problems that cannot be corrected with these steps.

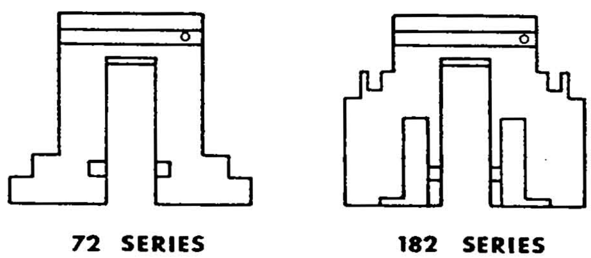



Fig. 10-7 Sequential-Access Locator Blocks

### Switching Indexer Platforms

Put an empty cassette on the Indexer Platform and press [CASS] to initialize. (It should level and lower.) Let it lower about one inch and then press [STOP].

Remove the cassette. Holding the "wings" of the Indexer Platform, tilt it up slightly and then push it toward the center of the Transporter (fig 7.11c) to gently pop it off the pivots.

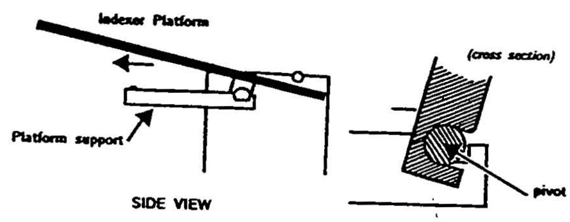



**Fig. 10-8 Removal of Sequential-Access Indexer Platform**

Disconnect the coiled cord connecting the Indexer Platform to the Indexer chassis. Connect the replacement.

Install the replacement by pushing it back onto the pivots.

Check that the Indexer Platform tilts up and down freely (if it does not, check to see if it is completely on the pivots).

Put a wafer in a cassette in the second or third slot from the bottom. Put the cassette on the Receiver Indexer Platform. Put a cassette with wafers on the Sender and press [CASS].

Scan a wafer in manual Mode and watch as it is unloaded into the Receiver cassette. It should not bind or rub in the cassette slots. If it does, adjust the pitch and home using the following procedures.

### Adjusting Pitch of Sequential-Access Indexer Platform

The Indexer Platform has a final rest point where it is tilted back waiting for a cassette to be loaded. When scanning starts, it levels and lowers. The pitch adjustment needs to be done when the wafer binds the cassette because the cassette slots are not parallel with the Puck's travel as it unloads a wafer.

Load a cassette with wafers on the Sender. Put a wafer in the second slot (from the bottom) in a second cassette and load it on the Receiver being adjusted. Press [START] to fetch a wafer, and when it is clear of the Sender, press

[HOME]. When the Puck stops at Home, press [START] to send the wafer to the Receiver. As it enters the slot, press [STOP] to halt.

Look at the cassette from the side to compare to gaps between the top and bottom of the wafer with respect to the cassette slot (fig 7.11d). Start and stop the Puck travel to compare the gaps along the whole slot as the wafer is unloaded. If the gaps are constant (i.e. the wafer plane is parallel with the slot's plane) go on to "Adjusting Indexer Platform Home." If the gaps are not constant, the pitch must be adjusted - continue.

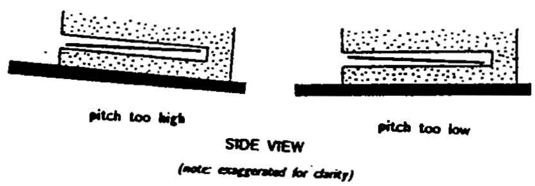



**Fig. 10-9 Checking Indexer Platform Pitch**

Press [START] to let the Puck unload the wafer and go Home. Remove the cassette (the Platform should rise to the top and tilt).

The pitch adjustment is done with a hex-key wrench by reaching underneath the platform support (fig 7.11e). This adjustment screw should be turned only 1/8 to 1/6 of a turn and then Step 1 and 2 repeated to recheck the pitch. If the Platform pitch is too high, turn the adjusting screw clockwise (as viewed from the top). If the Platform pitch is too low, turn the adjusting screw counterclockwise.

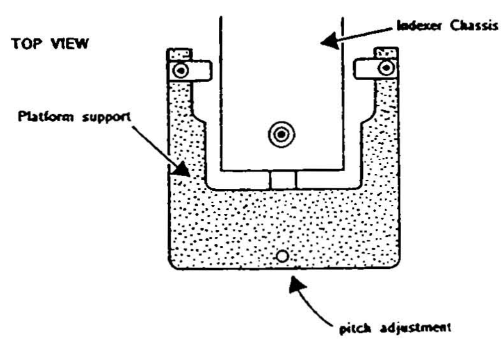



**Fig. 10-10 Sequential-Access Pitch Adjustment Screw**

**Adjusting Home of Sequential-Access Indexer Platform**

This procedure should be done only after the pitch has been checked. When the pitch is correct, the wafer's plane may still be too high or too low in the slot. In this case, the home position must be adjusted to ensure that the wafer will not rub during unloading.? Load a cassette with wafers on the Sender. Put a wafer in the second slot (from the bottom) in a second cassette and load it on the Receiver being adjusted. Press [START] to fetch a wafer, and when it is clear of the Sender, press [HOME]. When the Puck stops at Home, press [START] to send the wafer to the Receiver. Just before the wafer is fully unloaded, press [STOP] to halt.

sette from the side to compare the gaps between the top and bottom of the wafer with respect to the cassette slot (fig 7.11f). Compare the upper gap with the lower one. If they are the same (within visual comparison), no home adjustment is needed.

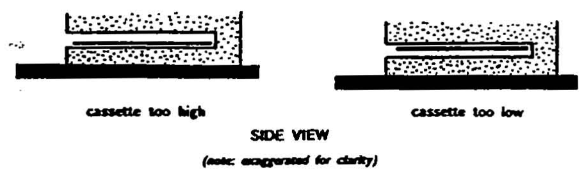



Fig. 10-11 Checking Indexer Platform Home (note: exaggerated for clarity)

Press [START] to let the Puck unload the wafer and go Home. Remove the cassette (the Platform should rise to the top and tilt).

The home adjustment is done with a hex-key wrench through an access hole in the top of the Indexer Chassis assembly (fig 7.11g). This adjustment screw should be turned only 1/8 of a turn and then Step 1 and 2 repeated twice, rechecking the home position on the second time. (Internal logic must be reset by Platform rising and tilting in order to recognize new adjustment.) If cassette is too high, turn adjusting screw counterclockwise (as viewed from the top) 1/8 turn. If cassette is too low, turn clockwise 1/8 turn.

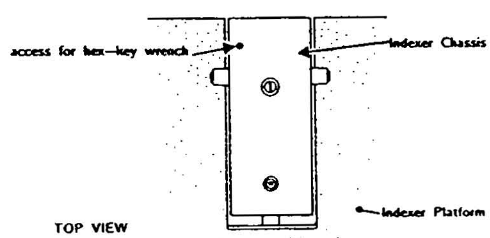



Fig. 10-12 Sequential-Access Home Adjustment Screw

## 11.1 Serial Output

A useful resources for special applications, this appendix describes the technical details of the serial output. For instructions on printing, refer to "Section 5 Operation."

The serial output is done by the CPU board via a UART (Universal Asynchronous Receiver/Transmitter) chip with a standard line driver converting logic levels to the RS-232C.i.RS-232C; definition for volts. The RS-232C serial data can be accessed from the 25-pin (DB-25) connector labeled "OUT 1 PRINT" (on the I/O Panel on the Instrument's left side). Wired as a DCE (Data Communication Equipment), this port can drive a signal up to the distance specified by the RS-232C standard.

This serial port is normally used to connect the standard 20-column alphanumeric Printer (fig A.1). Available from Tencor Instruments, an optional Converter/ Buffer.i.Converter/Buffer; can be interfaced to convert the serial data to parallel for other applications. With an 80-column graphics printer interfaced, the Instrument can transmit the Defect Map, Histogram, and/ or Haze Map for printing. The recommended printer is a parallel-input Epson FX-80 + interfaced to the Instrument serial port via the optional Converter/ Buffer. (This buffer could also be used to interface other devices requiring parallel input, such as a datalogger.)

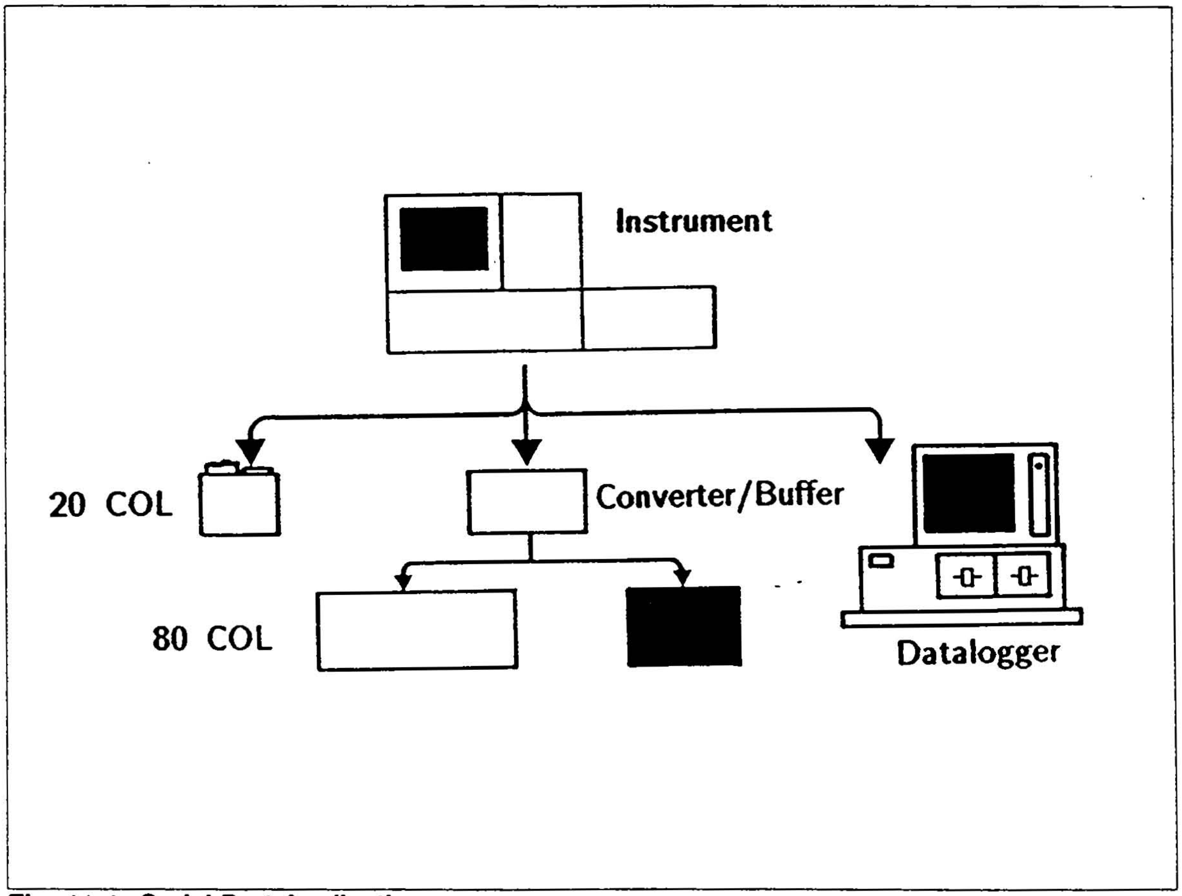



Fig. 11-1 Serial Port Applications

## 11.2 Serial Port Details

The baud rate and format is specified by the value selected for the PRINTER TYPE parameter. (Baud means "bits/ second.") The serial data is transmitted as 8 data bits with no stop bit or parity bit.

## 11.3 Handshaking

Handshaking is done via the DTR signal line (pin 20; active-low) monitored by the Instrument. While this pin is held high by the peripheral, no data is sent. As soon as the peripheral brings this pin low, the Instrument transmits data

## 11.4 Connector Pinout

The serial output connector on the I/ O Panel is a 25-pin (DB-25) female connector. The pin functions, shown in Figure A.2, set up the serial port as a DCE. Only three pins are used: 3, 7, and 20.

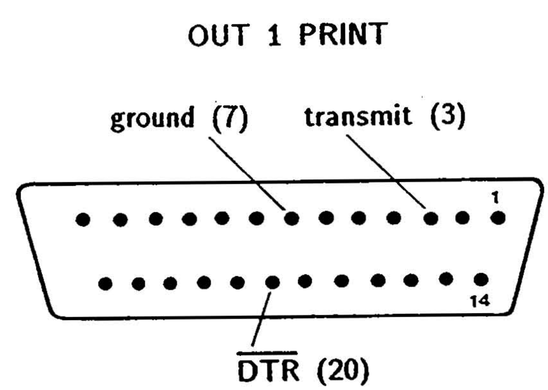



Fig. 11-2 Serial Pinout

## 11.5 Using Converter/ Buffer

The optional RS-232C Serial-to-Parallel Converter/Buffer (Converter/Buffer) can be used to interface the Instrument's serial output to an 80-column printer such as the parallel-input Epson FX-80+ TM. The Converter/ Buffer converts the serial output to parallel for driving this printer. (The standard 20-column Printer shipped with the Instrument is serially driven, so it does not require a Converter/ Buffer.) The Converter/Buffer from Tencor Instruments arrives configured for the Instrument's serial output. (The details are included here for special applications. Normal operation does not require any reconfiguration.) Refer to the Microfazer Operation Manual for additional guidance.

## 11.6 Memory

The Converter/Buffer has 64K of memory, allowing the complete transfer of data so the Instrument can fetch and scan another wafer without waiting for the printer to catch up.

## 11.7 Interface Cable

The serial signal cable normally used for the 20-column Printer can be used instead to connect the Converter/ Buffer to the Instrument Serial Port. A Centronics parallel signal cable is permanently attached to the Converter/Buffer.

## 11.8 Jumper Connections

Several jumpers inside the Converter/Buffer (fig A.3) configure it for the Instrument's data transmission format. (These jumpers have already been set by Tencor Instruments to match the Instrument's output.)

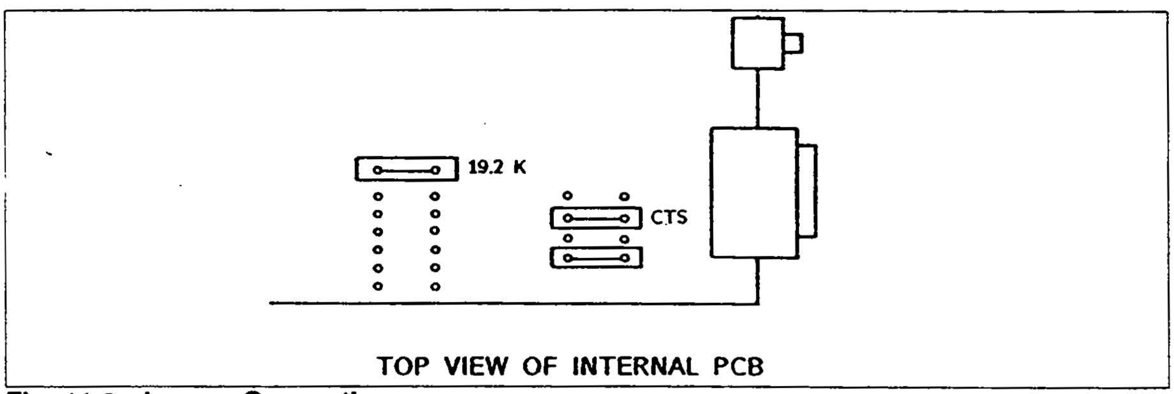



Fig. 11-3 Jumper Connections

## 11.9 Operation

Before connecting or disconnecting the serial signal cable, turn Instrument power off. Otherwise, the serial output circuit may be damaged by transient voltages.

Following the instructions in the Microfazer Operation Manual, connect the Converter/ Buffer, its external power supply, and the 80-column printer.

TYPE parameter to 80 COL. Select the PRINTER OUTPUT desired.
Power up the printer and Converter/Buffer and press the Converter/Buffer RESET button.

Now the printout chosen by the PRINTER OUTPUT parameter can be printed by pressing the Instrument **[PRINT]**. While the Instrument is transmitting data to the Converter/ Buffer, the Status Line says "PRINTING" and the keyboard is inactive. Operation can resume when this message goes away. Since the Converter/ Buffer has a large memory buffer, it will keep sending parallel data to the 80-column printer after the Status Line message goes away.

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