DE Series: 2000, 3000 Digital Electronics

User Manual

COMPONENTS PRODUCTS GROUP
GMAX™ SYSTEMS
MULTI-AXIS BEAM HANDLING
39 Manning Road
Billerica, Massachusetts 01821

GSI PN 12P-DE
Rev. E

Warranty Information

The Customer shall examine each shipment within 10 days of receipt and inform of any shortage or damage within that period. If no discrepancies are reported, GSIL shall assume the shipment was delivered complete and defect free. *GSIL* warrantees products against defects up to 1 year from manufacture date, barring unauthorized modifications or misuse. Repaired product is warranted 90 days after the repair is made, or one year after manufacture date - whichever is longer.

Contact Customer Service to obtain a Return Materials Authorization number *before returning any product for repair*.

All orders are subject to the GSIL Terms and Conditions and Limited Warranty. Visit www.gsilumonics.com/opticalscanning/ for the latest version of these documents and other useful information.

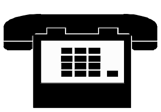
IMPORTANT: Line Scan Engines are normally tuned, serialized and warranted as a matched set for optimized performance. Mismatched components negatively affect performance and void the warranty. A matched set typically consists of galvanometer motor, mirror load, electronic driver board and interface cable.

Customer Support

GSI Lumonics has support services to address your questions or concerns with either the product or manual you are using. Before calling for assistance, be sure to refer to any appropriate sections in the manual that may answer your questions. Call GSI Lumonics' Customer Service Department Monday through Friday between

8 A.M. and 5 P.M. local time (GMT –05:00 Eastern Time (US & Canada)).

The customer service personnel will be able to give you direct assistance and answers to your questions.



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********** USER NOTE **********

PLEASE OBSERVE THAT, FOLLOWING THIS INTRODUCTORY NOTE, RELEASE NOTE SUPPLEMENTS HAVE BEEN ADDED TO THIS MANUAL TO ACCOMMODATE THE LATEST VERSION OF THE DE SOFTWARE.

YOU SHOULD REFER TO THESE INSERTS WHEN WORKING WITH THE NEWER SOFTWARE. THE NOTES ARE AS FOLLOWS:

1. BEHAVIORAL DIFFERENCES IN NEWER VERSION

2. TC COMMAND WITH CRC ALGORITHM DEVELOPMENT

3. DE SOFTWARE ENHANCEMENTS FOR SPOT WELDING

*********** RELEASE NOTES ***********

6 - 10 - 91

DE3000/DE2000 Version 5.11

General Scanning, Inc.
500 Arsenal Street
Watertown, MA 02172
(617) 924-1010

The current version DE code is now at level 5.11. Among its new features are faster step periods, point and shoot vector commands, and a block communications error checking scheme. For complete details on how to use these features, refer to the DE Manual.

This release note will describe how the new software differs from the older versions. There are two main behavioral differences in version 5.11:

1. **The RS232 Hardware handshaking works correctly.**

   The RS232 signal CTS (Clear To Send) will now be asserted when the DE can accept data. The prior release (3.01) would never assert this signal. Note, however, that there is a 4 character FIFO (First In First Out buffer) present in the DE. Therefore, if you attempt to send data or commands during vector execution, the FIFO will fill before the CTS line is de-asserted. No data will be lost, but the serial output routine from the controlling computer may hang until vector execution is complete and the FIFO read.

2. **Inter-vector processing delays have been shortened.**

   The Inter-vector processing delay is the time the DE requires to set up output of the next vector in a consecutive stream of vectors. In version 3.01 this time was approximately 250 μS. Version 5.11 has reduced this number to approximately 150 μS. In most cases, this will improve vector performance, except in systems that rely on the inter-vector delay for at least partial scanner settling.

   If the DE is operating in the Non-Continuous (default) vector mode (NC), the Inter-vector time difference (100 μS) can simply be added to the value used for Scanner Delay (SD) (see pp. 49-51 of DE Manual). No further changes are necessary.

   If the DE is operating in the Continuous Vector mode (CV) (see p. 55 of DE Manual), several system parameters are involved. When operating in CV mode, the DE's Scanner Delay (SD) times are disabled, and the resulting inter-vector time is a direct result of which version of the DE code the system is running on (v.3.01/250 μS or v.5.11/150 μS). This time difference can aggravate corner rounding and scanner ringing effects if the drawing velocity is high. Since CV mode is primarily intended for sequences of short drawing vectors where the main concern is to keep the beam moving, this reduction in inter-vector processing time should be an advantage. If you still have problems, consult factory.

************* RELEASE NOTES *************
5 - 7 - 91

APPLICABLE TO VERSIONS 5.01 AND UP

DE3000 SUPPLEMENT FOR THE 'TC' COMMAND

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COMMAND: TOGGLE CRC CHARACTER, **TC**

This command has two (2) forms:

TC1 = Enables CRC Checking

TCO = Disables CRC Checking and returns the accumulated character's CRC.

When a **TC1** command is received, the CRC accumulation register is cleared, and the CRC accumulation function is enabled. ALL characters sent following the 'TC' <CR> will be totalized in the CRC accumulation register.

When a **TCO** command is issued, the CRC accumulation register will be returned in the form of the following character string:

<CR><LF>'XXXX'<CR><LF>

The value 'XXXX' will be a four-digit hexidecimal CRC-16 Forward sum of the characters received. This value will include the 'TCO'<CR> in the total CRC. Additionally, the CRC function will be turned off.

NOTE: **FOR A 'C' SOURCE CODE EXAMPLE OF THE ALGORITHM USED, SEE EXAMPLE 1 ON NEXT PAGE.**

If the TCO command is repeated, the value returned will be the contents of the CRC accumulation register.

NOTE: **IF YOU USE GENERAL SCANNING'S 'QD.EXE' PROGRAM WITH THE TC COMMAND, MAKE SURE THAT IT IS VERSION 2.0 OR LATER.**

EXAMPLE 1

. . . . CRC ALGORITHM DEVELOPMENT . . . .

This program is an example implementation of the CRC algorithm used in the DE v5.11 software. Input is taken through stdin (Console) and add to the CRC. The four digit hex result is sent to the console.

Usage:

crc2 < filename.bpc

NOTE: **THE FILE 'FILENAME.BPC' SHOULD HAVE AS THE LAST LINE:**

TCO<CR>

THIS IS NECESSARY TO MAKE THE CALCULATED CRC THE SAME AS THAT RETURNED BY THE DE V5.11 SOFTWARE.

. . . . SAMPLE PROGRAM . . . .

```
#include        <stdio.h>

void    main()
{
        unsigned        k, l;
        unsigned        crc_reg, mask;

        puts("\n* CRC Calculator V1.01 *");
        puts(  "  (c) General Scanning");
        puts(  "       7 May 1991\n");

        mask = 0x01;
        crc_reg = 0x0000;                    /* Clear CRC register */

        while ( (int) (k = getchar()) != EOF)
        {
                {
                        if (k == 0x0a)  /* Convert LF to CR */
                        {               /*  --DOS Issue-- */
                                k = 0x0d;
                        }

                        crc_reg = crc_reg ^ (k & 0xff);
                        for (l = 0; l < 8; l++)
                        {
                                if (mask & crc_reg)
                                {
                                        crc_reg >>= 1;
                                        crc_reg ^= 0xa001;
                                }
                                else
                                {
                                        crc_reg >>= 1;
                                }
                        }
                }
        }
        printf("\n Totalized CRC: %4X\n", crc_reg);
}
```

. . . . END OF PROGRAM . . . .

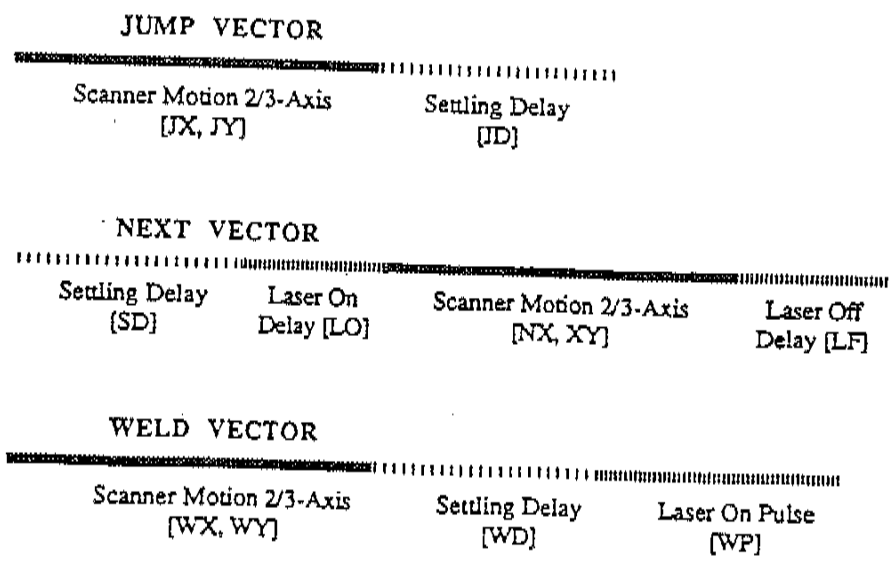
DE Software Enhancements for Spot Welding

General Parameters Supported:

Laser Enable Pulse Duration:	2µS - 65.536 msec
Vector List Length:	32,767 (unchanged from std. DE2000/DE3000)
Laser Burn List Length:	16,383
Shortest Step Period:	3-Axis - 206µS (formerly 270µS) 2-Axis - 162µS (formerly 205µS)

General Description:

To meet the need for stable, accurate positioning of the laser beam when welding, changes to the DE's operation were required. Most clearly, the laser must be activated *after* vectoring to a new location, rather than while doing so. Also, the duration of the laser pulse should be variable. The desired welding sequence of move, settle and burn is more akin to the Jump vector sequence of move and settle than it is to the Next vector sequence of settle, laser on timing, move and laser off timing. This can be seen by comparing the vector drawings.



Schematic Representation of DE Vector Types

To provide the most adaptable product, five new vector commands specifically for a point & shoot style of scanning have been designed. These Weld commands are analogous to the existing Jump and Next vector commands and produce intuitive results, if the standard DE operation is already understood. Additional changes to the existing DE command structure were unnecessary and all existing software should execute transparently on the new version.

In order to provide a flexible method of programming the laser pulse durations, a new data structure (a list of weld pulse lengths) was added to the revised code. It was assumed that although different locations (welds) would most likely require different amounts of energy (i.e. laser on time) to weld correctly, there would be instances when more than one endpoint in succession would use the same time interval. Thus, by re-using the weld pulse duration value unless given a new one, the total list length would be shorter (a requirement due to memory availability within the DE), possibly make programming the DE easier, and definitely make downloading the DE faster, since successive duplicate weld durations need not be sent.

For example, if the user wished to make five (5) spot welds comprising the following pattern:

Location (x,y)	Laser Pulse Duration
67, 1700	120 µS
3877, 4386	120 µS
3877, 51000	3400 µS
65500, 51000	1200 µS
1200, 35767	1200 µS

The command sequence transmitted to the DE would be:

Command	Parameter
WP	120
WX	67
WY	1700
WX	3877
WY	4386
WP	3400
WX	3877
WY	51000
WP	1200
WX	65500
WY	51000
WX	1200
WY	35767
[EX, EC, or RX]	

- The first WP command overrides the default value (500 µS) and sets the laser pulse duration at 120 microseconds (µS). The next two command pairs store points to which the galvanometers will execute a jump-like vector, settle and then enable the laser for the previously stored value, 120 µS.

- The second WP command replaces the previous duration with 3400 µS. This value is used for only one vector, after the scanners slew to (3877, 51000).

- Third WP command replaces the previous duration with 1200 µS and is used for the remaining two weld vectors, positions (65500, 51000) and (1200, 32767). As stated above, the maximum number of WP commands that can be transmitted is 16,383. However, as this example illustrates, there are no other restrictions on the way WP commands can be sequenced or interleaved between position commands.

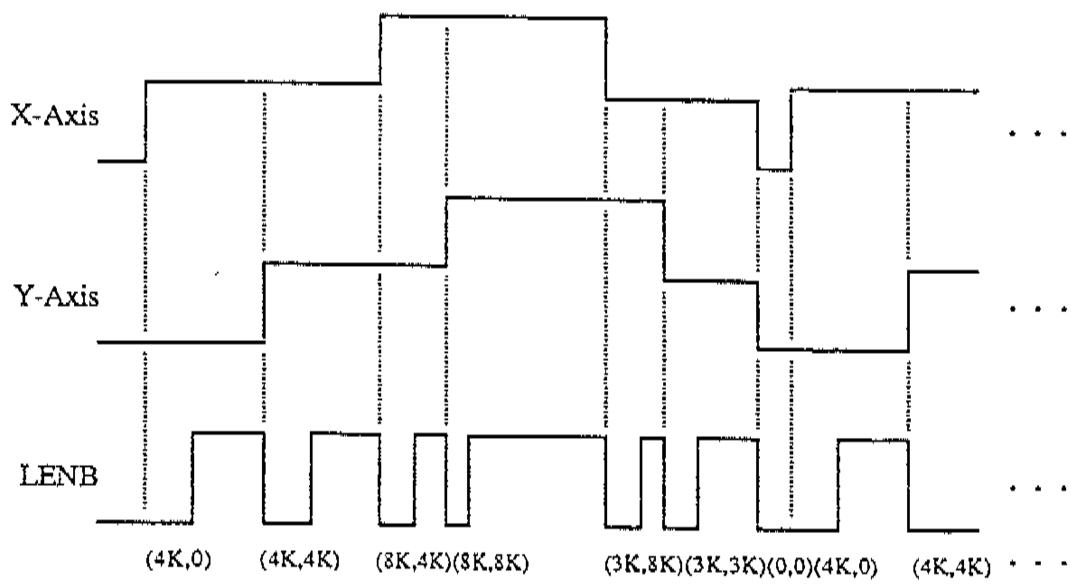
To further illustrate how the laser timing works, the following sample pattern will activate the laser for a variety of intervals, while stepping (one large step---no intermediate points) in X and Y separately. The sample moves in one axis at a time for clarity, not because two axis motion is not supported. The associated drawing reproduces the waveforms that can be seen by looking at the DAC outputs of the X and Y servo amplifiers and the Laser Enable signal (LENB).

The pattern is setup by the step and delay parameter commands (WS, JS, WD, JD) and the initial jump (JX, JY, EC). The pattern will execute continuously because the RX (Repeatedly Execute) command is given at the end of the vector list. The DE will ignore any I/O commands except for the RESET switch on the CPU's front panel.

Command	Parameter
WS	10000
JS	10000
WD	2
JD	2
JX	0
JY	0
EC	—
WP	10000
WX	4000
WY	0
WX	4000
WY	4000
WP	500

(cont.)

Command	Parameter
WX	8000
WY	4000
WP	2000
WX	8000
WY	8000
WP	300
WX	3000
WY	8000
WP	600
WX	3000
WY	3000
RX	—



Scanner Step & Laser Enable Sequence

New DE Commands:

Weld Commands — WX, WY

Format: WX <ARG> [CR] Argument Range: 0 - 65535
WY <ARG> [CR] Argument Range: 0 - 65535

WX, WY commands create the endpoint of a non-drawn vector, at whose completion the scanners are allowed to settle. Then, the laser is enabled for a pre-programmable interval.

Weld Size (Increment) — WS

Format: WS <ARG> [CR] Argument Range: 1 - 32767 LSBs

Default: 512 LSBs

The distance (voltage) between increments on the vector ramp is programmed with the Weld Size (WS) command for weld vectors. New WS commands only affect vector pairs sent to the DE after the WS change. (See also DE Manual, section 2.2.2.1)

Weld Delay — WD

Format: WD <ARG> [CR] Argument Range: 2 - 65534 μS

Default: 3000 μS

WD sets the time that the DE waits after completing a weld vector movement The delay allows the scanners to fully settle before enabling the laser. To ensure that the laser energy is applied to only the desired location, the scanners must be allowed to completely stabilize, first. The amount of delay required is a function of the scanning velocity (set by WS & SP), the average size (length) of the vectors, the XY scan head and servo tuning.

Weld Pulse (Duration) **WP**

Format: WP <ARG> [CR] Argument Range: 20 - 65534 µS

Default: 500 µS

The Weld Pulse (WP) command sets the duration of the laser enable pulse. To ensure accurate and high-quality spot welding, the amount of energy directed at each spot should be well-controlled and precisely aimed. The laser enable pulse length is programmable and is generated after the scanners are settled. The user may precede every WX,WY vector pair with a WP command, up to the maximum of 16,000. If no new command is sent, the previous WP value is reused.

Contents

Contents (cont.)

Contents (cont.)

CHAPTER 1: Digital Electronics Hardware

1.1.0 General Information

1.1.1 LIMITED WARRANTY

General Scanning, Inc. (GSI) warrants this product to be free from defects in materials and workmanship for 12 months from the date of shipment. GSI will, at its option, repair or replace the product if it is defective within the warranty period and returned, freight pre-paid, to a service center designated by GSI.

General Scanning requests that customers obtain a Return Authorization Number prior to returning units, and that they carefully pack units in their original packing or equivalent.

Under warranty, GSI in not obligated to repair damage to any units resulting from the following conditions (customers are responsible for defining which conditions are applicable to their product):

a) Personnel other than GSI representatives attempting to repair or service the product;

b) Improper use of the equipment;

c) Connecting the product to incompatible equipment;

d) Personnel other than GSI representatives modifying the product;

e) Scratches and chips on any optical surface after three weeks from the date of receipt;

f) Damage to any optical surface from improper handling or cleaning procedures. This applies specifically to those items subjected to excess laser radiation, contaminated environments, extreme temperature or abrasive cleaning.

Customers assume all responsibility for maintaining a laser-safe working environment. OEM customers must assume all responsibility for CDRH certification.

There is no implied warranty of fitness for a particular purpose, and GSI is not responsible for consequential damages. Individual components manufactured by GSI or others may be covered by their own warranties. Refer to the appropriate manuals for this information.

Printed in U.S.A.

1.1.2 Introduction

General Scanning's Digital Electronics Scanner Control (DE Series) is a multi-axis galvanometer controller that supports the generation of vectors in an X-Y or X-Y-Z scanning system. The DE2000 Series interfaces with a PC computer to control two-axis X-Y scan heads. The DE3000 Series controls a three-axis scanning system that includes the generation of X,Y and Z coordinates. The Z coordinate provides focus correction.

1.1.3 Specifications

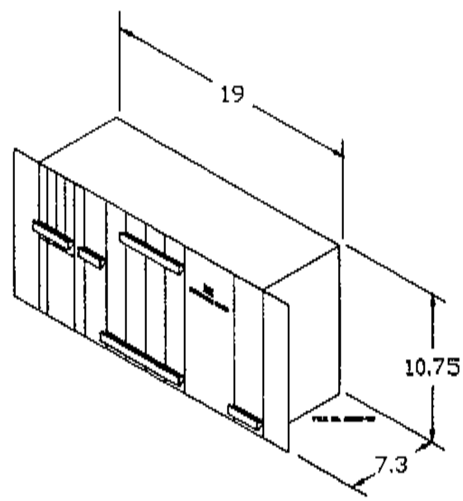


Diagram 1. Dimensions of the DE

Card Frame:	10.75"H x 19" W X 7.3" D
Double Euro Card:	233.4 mm x 160 mm
Single Euro Card:	133 mm x 160 mm
Weight:	19 lbs
Fan Tray:	4 lbs
Storage Temperature:	-20° to +80°C
Operating Temperature:	15°C to 32°C
Power Requirement:	115/220 VAC, 50/60 Hz, 4 A Max.

Connectors: All Eurocard backplane connectors meet DIN 41612 standards. The EDG (VME compatible) connectors are Type C 96 pins. The EDD connectors are Type 64 pins (Rows A and C only). Power supply connectors are type H 11 lugs. Non-Din connectors include D-sub, D (Centronics), and ribbon headers.

Single high cards contain one DIN plug P1 which mates to the VME backplane J1. Double high cards contain two DIN plugs P1 and P2 which mate with backplane connector J1 and J2. J1 is located below J2 in the rack. Pin 1 is at the top of the connectors. For more detailed connector information consult the appropriate text and appendix.

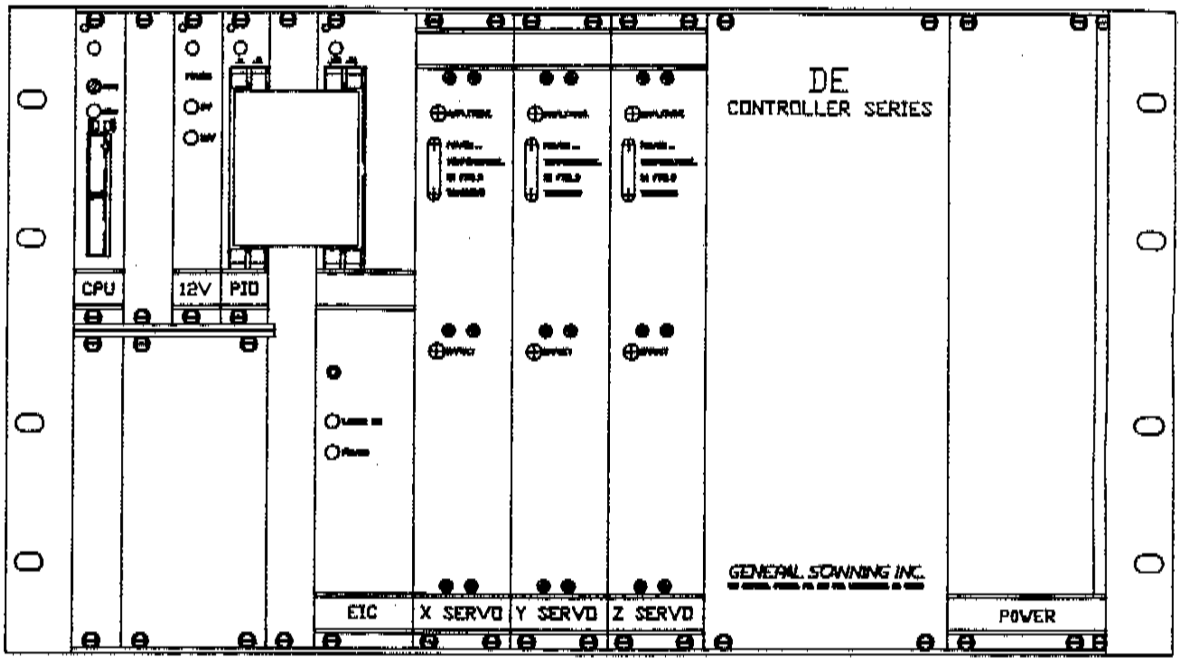


Diagram 2. Front View of the DE

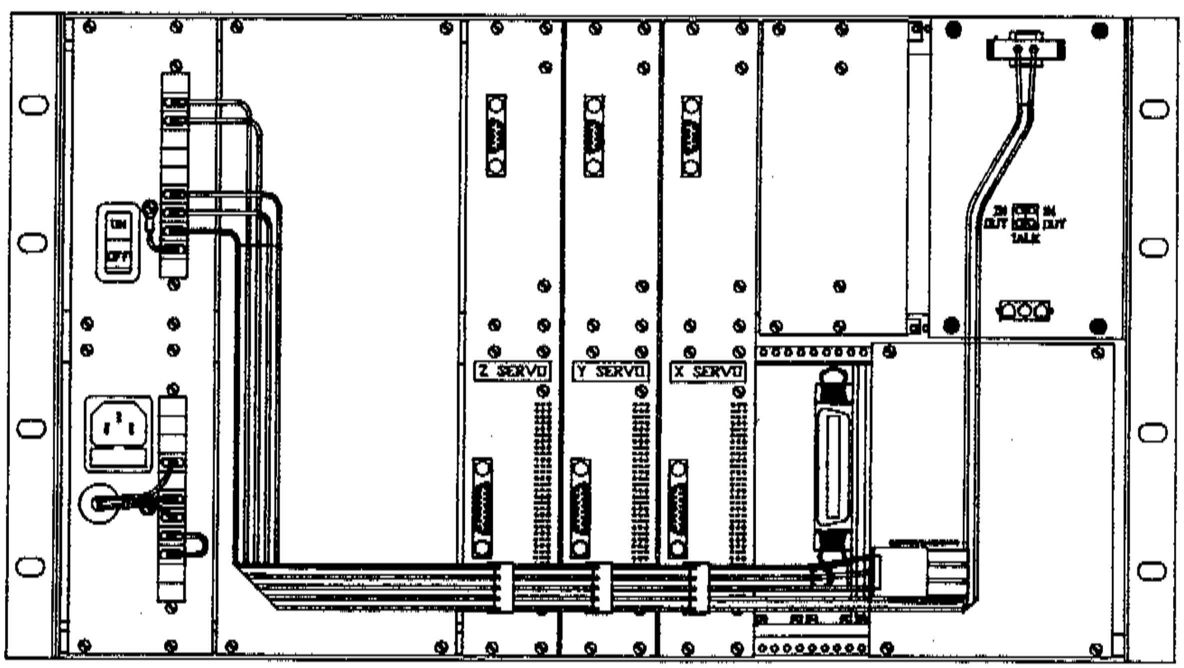


Diagram 3. Rear View of the DE

1.1.4 Circuit Card Overview

The DE consists of 5 major components: The **Euro Digital Generator** (**EDG**) generates the digitally-corrected X,Y, and Z digital coordinates. The **Euro Digital Drivers** (**EDD**) cards drive the galvanometer. The **Euro Interface Card** (**EIC**) assists in the process of internal and external communications. The **Euro Power Supply** (**EPS**) generates the DE's required voltages from the available AC source. The **Euro Card Frame** (**ECF**) houses the eurocard card and essential backplane wiring.

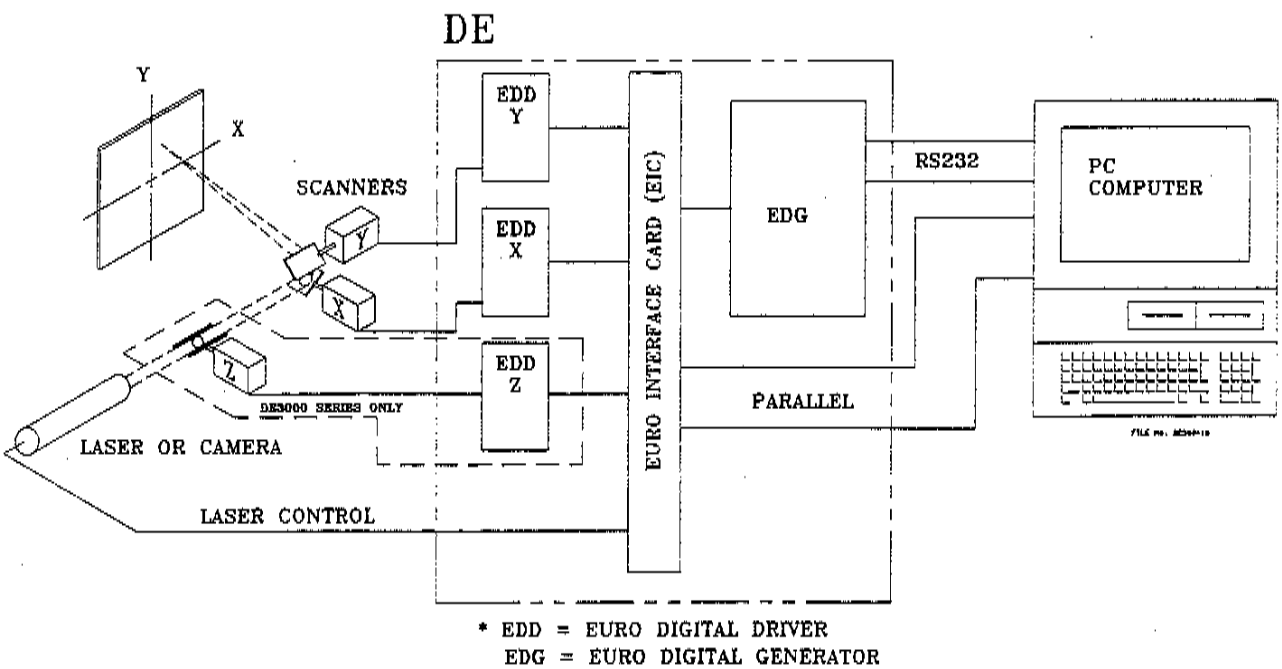


Diagram 4. Scan System with the Digital Electronics Controller

The EDG houses the DE's **Central Processor Unit (EDG CPU)** The EDG also contains a 12V power supply card (EDG 12V) and a parallel input/output conversion card (EDG PIO). The primary responsibility of the EDG is to generate X, Y, and Z coordinates and maintain system timing clocks for laser synchronization.

The **Euro Digital Driver Cards (EDD)** use the digitally-generated coordinates to produce analog drive signals for the galvanometer. The EDD cards house a 16-bit D/A and a closed loop servo amp that controls the galvanometer scanheads.

The **Euro Interface Card (EIC)** serves as a communications bridge between the EDG unit and the EDD circuit cards. The Euro Interface Card accepts the laser control signals that are generated by the CPU and generates modulation signals for laser control. The EIC also accepts the parallel input from the host computer.

The **Euro Power Supply (EPS)** supplies the required voltages for the circuit boards. The EPS supplies +5 VDC and ±18 VDC.

In open rack configurations, a **Euro Fan Tray (EFT)** forces air up through the electronics for cooling. Closed rack applications may also need a system for cooling.

1.1.5 General Optical Configurations

Using a laser beam and galvanometer scanners with mirrors in an orthogonal configuration is a simple way to scan an X-Y flat field in a vector mode. Its major drawback has been geometric distortions inherent in two-axis, flat field scanning - primarily pincushion, tangent, and focus errors of the imaged beam on the target field. The DE, using lookup tables stored in memory, electronically corrects for pincushion and tangent distortion

Focus may be either post-objective or pre-objective. The position of the scanning elements defines the type of scanning system. Thus, in a **post-objective** system the scanning elements act upon the beam **after** the imaging optics. In a **pre-objective** system the scanning mirrors act upon the laser **before** the beam is focused.

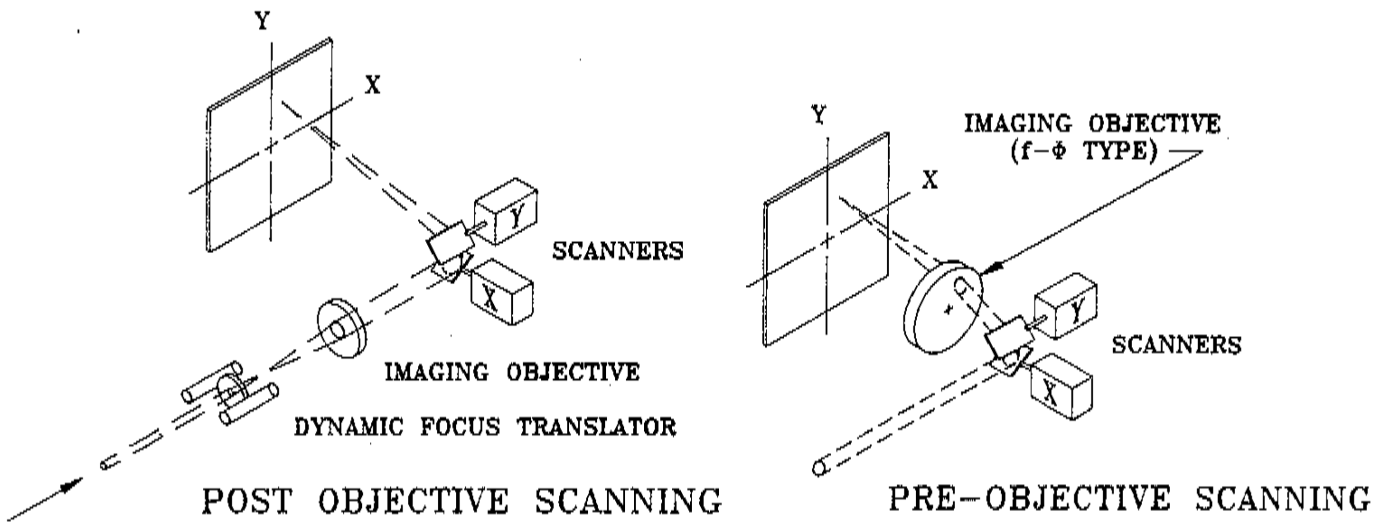


Diagram 5: Pre- and Post-Objective Scanning

1.1.5.1 Post-Objective Scanning

General Scanning's system compensates for flat field scanning errors using post-objective scanning. The DE digitally corrects the coordinates to compensate for pin-cushion and tangent distortion. The Linear Translator, a specialized galvanometer that moves a lens, provides focus correction. The lens moves in a linear, bi-directional motion before the objective lens. The

DE controls its position. Its driver card is labeled the Z-axis. The motion of the lens is a form of optical leveraging that changes the focus distance of the imaged beam. The focus correction, in real time, maintains a focused spot in all areas of the field. Focus correction is not required by all scanning systems (For a more detailed account of post-objective scanning, contact General Scanning, Optical Products Marketing Services)

1.1.5.2 Pre-Objective Scanning

Pre-objective scan systems use a flat field lens after the scanning equipment to compensate for flat field errors. The collimated laser beam passes through the lens at different points. The lens focuses the beam on the target maintaining a uniform spot size in all points in the field. Among the factors in determining which lens to use are the size and distance of the target. If the size of or the distance to the target changes, a new flat field lens may be required.

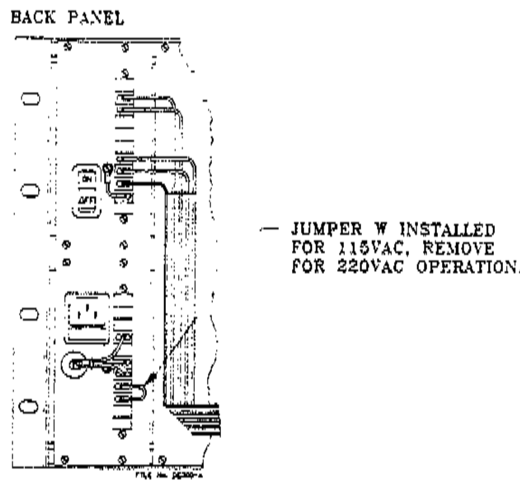
Using software to control the coordinate correction, the DE can correct a pre-objective scanning system. If the flat field lens has been characterized, the user can digitally correct coordinates to compensate for the effects of the flat field lens. This is a complicated approach and is not recommended for novices.

1.1.6 Getting Started

Note: Please read the rest of the manual before powering up the system.

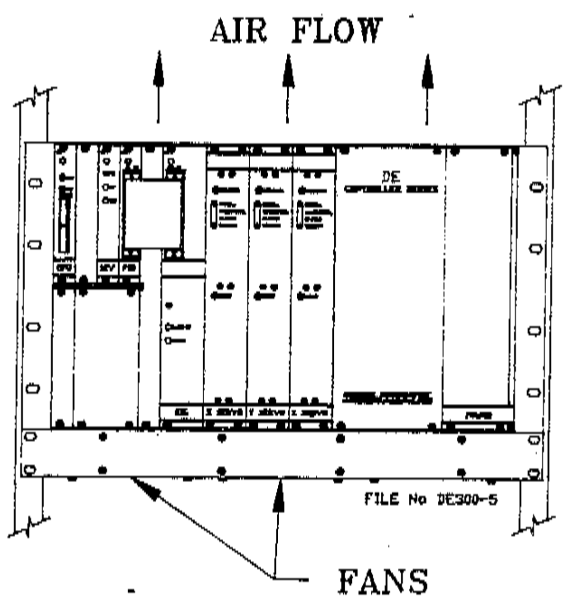
1. Unpack. Save the box for reshipping.

2. Voltage selection.



3. Set-up Euro Interface Card for your laser system (Refer to Section 2.3.1).

4. Mount the DE and Fan Cage in a rack. Connect the fan power supply cable (See Diagram 6).



5. Connect the parallel cable from the host computer to the back of the Euro Interface Card (EIC).

   Note: Attach the RS232 Line to port Ja (located on the front of the EDG CPU card) if you intend to use serial diagnostics (Refer to Section 2.1.1).

6. Attach the scanner control cables to the scanner ports located on the back of the EDD cards.

7. Attach the laser On/Off BNC cable from the back of the EIC card and connect to the laser modulation input.

8. Read the rest of the manual.

DE3000 REAR VIEW

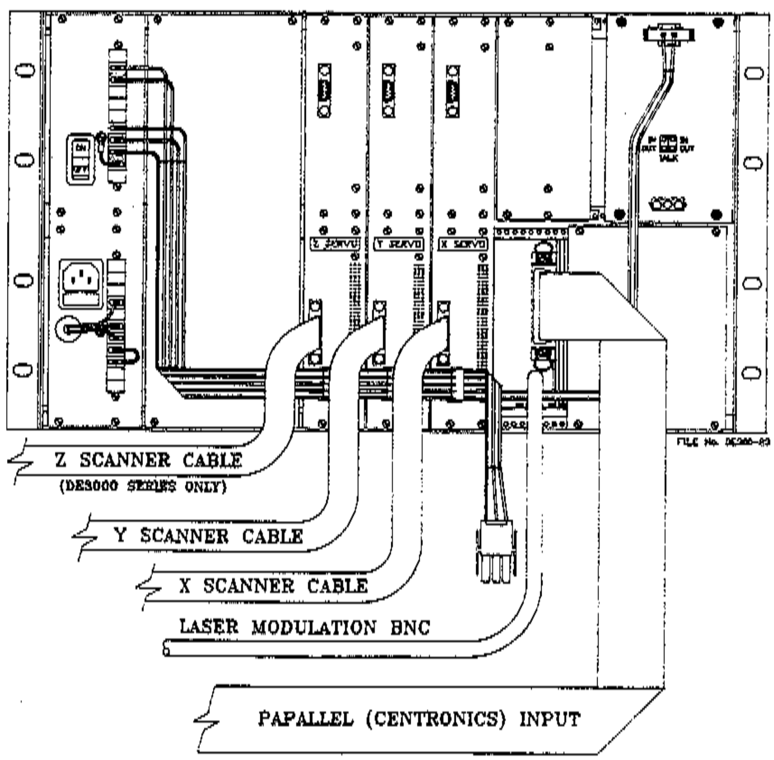


Diagram 6. Backplane Connectors

9. Power up DE. The ON/OFF switch is located on the back panel.

10. Run Gridgen for your field. This creates your correction table.

11. Load your correction table with QD (see "How to Use the Geometric Correction Software", section 2.3.2, p. 66).

12. Create vector list.

13. Load vector list with QD and run.

1.2.0 Digital Electronics Circuit Cards

1.2.1 Euro Digital Generator (EDG)

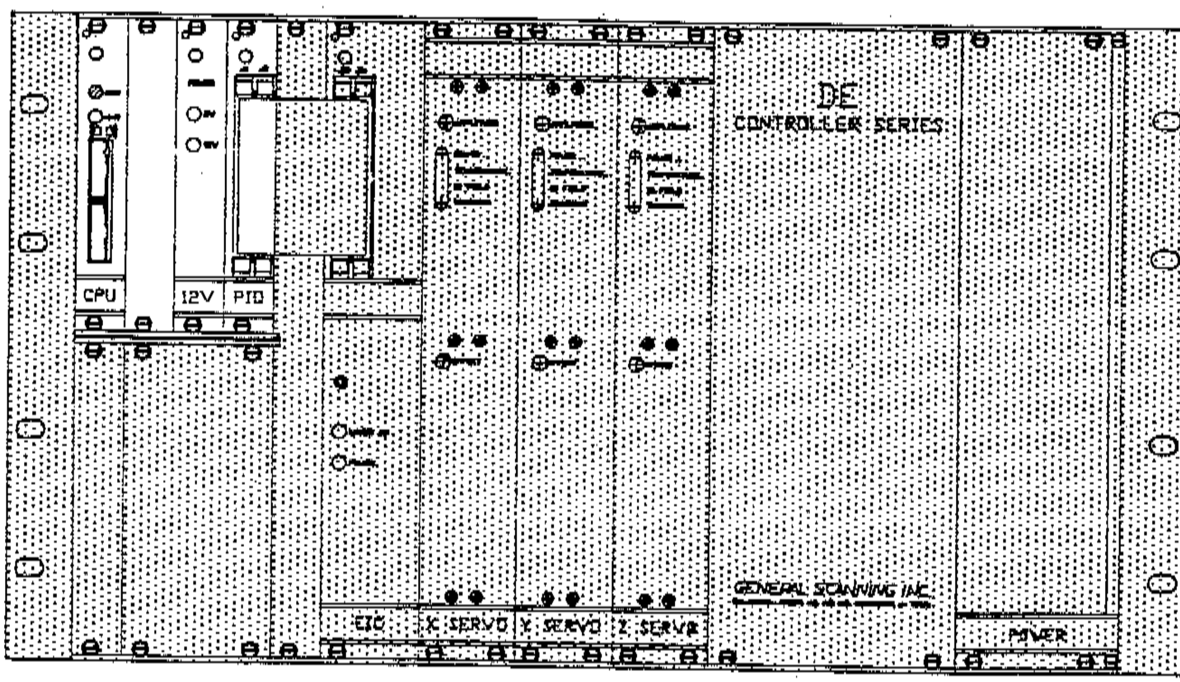


Diagram 7. Euro Digital Generator

The EDG provides the digital coordinate generation as well as system timing and control. The EDG contains three circuit cards: the EDG Central Processing Unit circuit card (EDG CPU), the EDG 12V circuit card (EDG

12V), and the EDG Parallel Input/Output circuit card (EDG PIO). The EDG cards communicate to each other via a standard VME Bus Backplane.

1.2.1.1. EDG Central Processing Unit (EDG CPU)

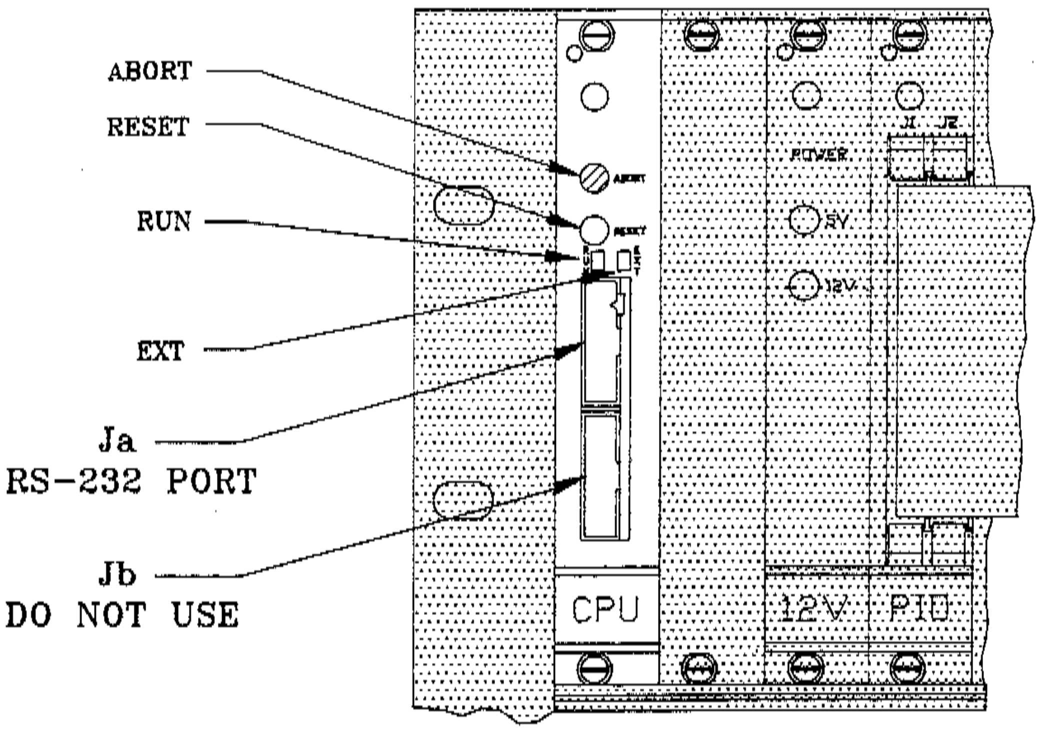


Diagram 8. EDG Central Processing Unit

The EDG CPU card is a single board computer based on the Motorola 68000 microprocessor complete with programmed ROMs, 512K of RAM and a serial I/O port. The CPU receives data from the host computer and generates field corrected vector endpoints. In a Z-axis system it calculates the position of the Z coordinate based upon software generated lookup tables. The CPU also reads scanner status information generated by the Euro Digital Driver cards.

The EDG CPU has a **Reset** button that interrupts a repeated execution of a file (See Chapter 2, Section 2.2.4 RX command for more information). The **Run** light indicates that the CPU is active. The **EXT** light indicates that the EDG CPU is transferring data (In active modes. a light blinks). The **Abort** should not be used (It halts the CPU. A Reset is required after an abort).

The EDG CPU communicates with the host computer via the serial port. The CPU has an RS232 port located on the front of the EDG CPU card at the point labeled Ja. The RS232 port is configured for the following:

Table 1: RS232 Data Input Configuration

-	9600 baud rate
-	8 data bits
-	2 stop bits
-	No Parity
-	XON/XOFF Handshaking IS Active

WARNING: If the operator is using the serial port to transmit data, connect only the RS232 cable. If the host serial port is not properly configured and active, the DE will not operate. We recommend that you use serial communications software to communicate with the DE.

Table 2. RS232 Pin Out Configuration

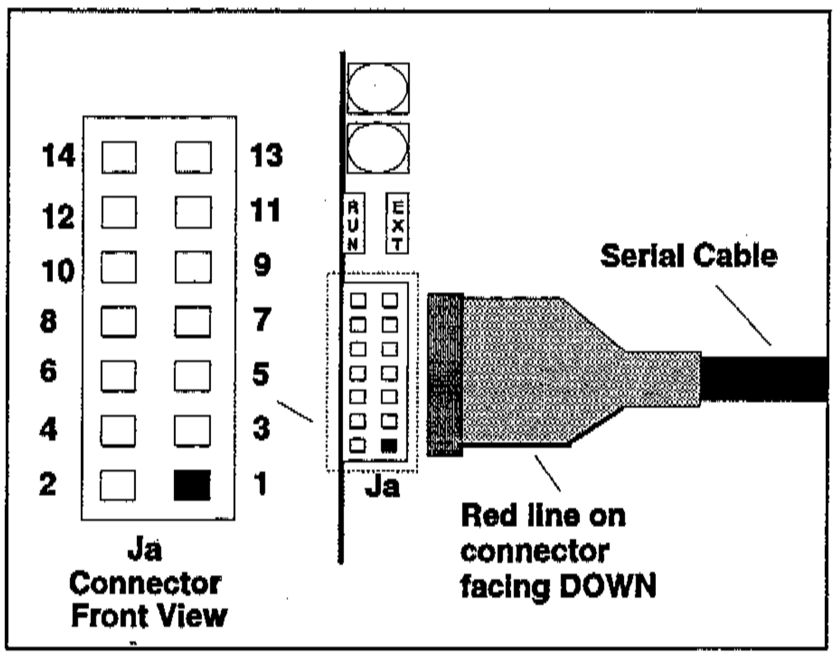
Ja Pin (14 Pin)	DE Function Signal/Description	Host Computer D-sub 25 Pin#	Typical Connector AT 9 Pin#
3	RXD Receive Data	3	2
5	TXD Transmit Data	2	3
7	CTS Clear to Send	5	8
9	RTS Request to Send	4	7
13	GND Signal Ground	7	5

NOTE: A 25 pin to 14 pin converter cable will be required by most computers. Jb is not used!

CAUTION:
Please carefully check the pin-out configuration of the host computer to insure pin-out compatibility.

Make sure you plug in the serial cable per the diagram on the right. The cable must be plugged in so that the red line side of the connector is facing **DOWN.**

If the red line is facing up, you have plugged the cable in upside-down. Connector Ja is shown as front view with pin 1 shaded.



1.2.1.2 EDG 12V

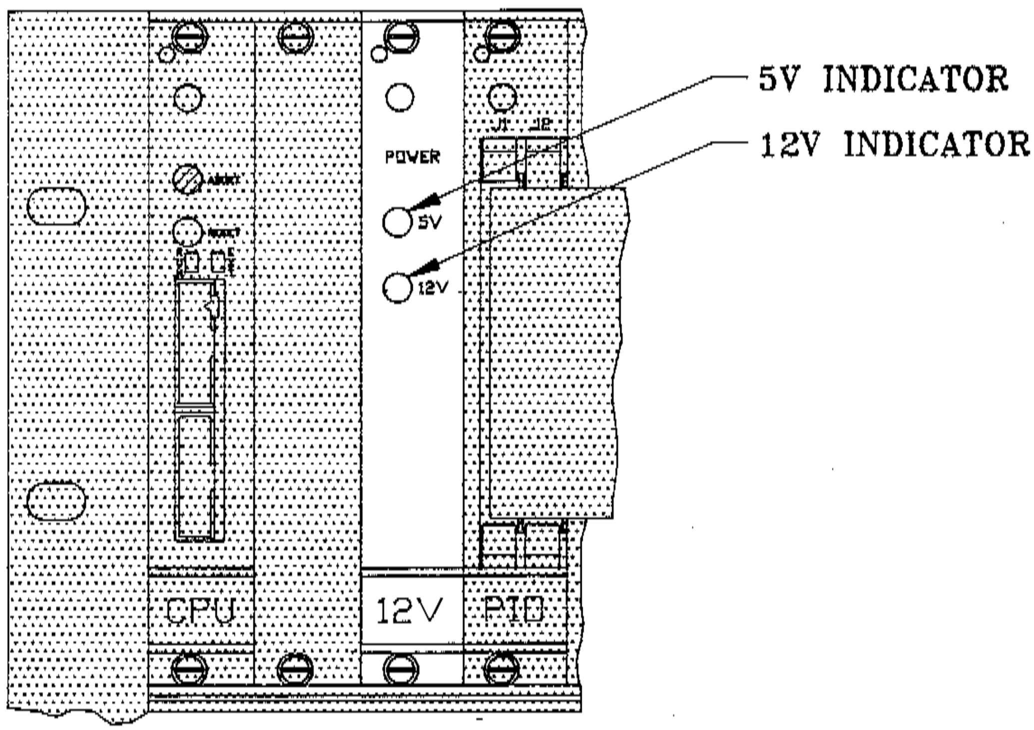


Diagram 9. EDG 12V

The EDG has its own 12V power source. The +5V is input to the card and converted to a ±12V output rated at 40 mA. The VME bus carries the ±12V supply voltage back to the EDG CPU. This ±12V is needed to drive the RS232 communications port.

Note: The 5V light is on whenever the 12V cord is getting 5V input. The 12V light is on when the board is producing ±12V output.

1.2.1.3 EDG Parallel Input/Output (EDG PIO)

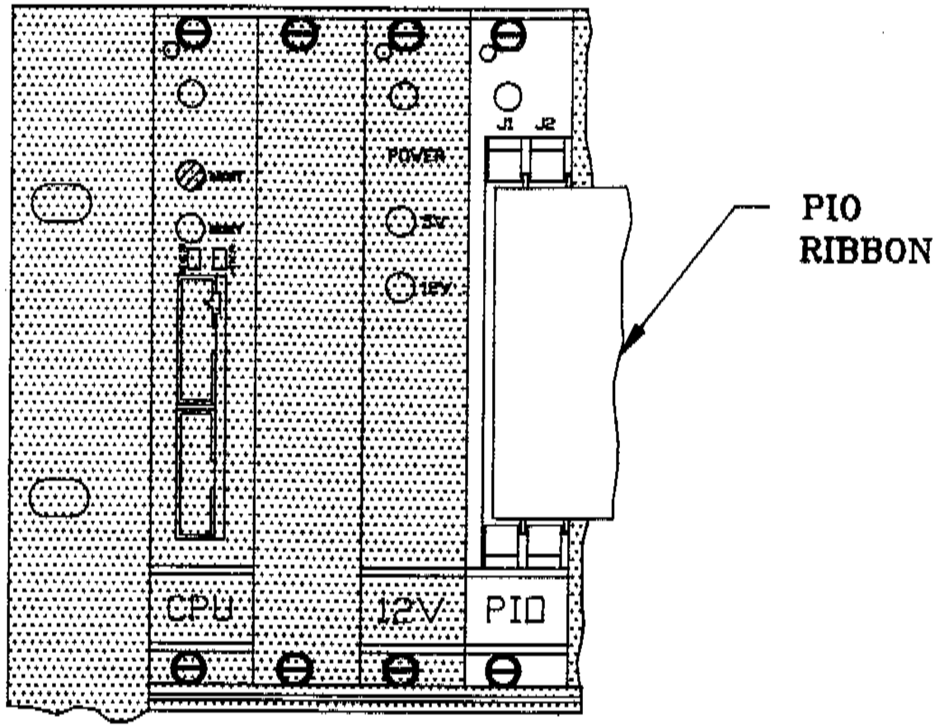


Diagram 10. EDG Parallel Input/Output

The EDG PIO circuit card provides for the exchange of data between the EDG circuits and the Euro Interface Card (EIC). The EDG PIO circuit card transfers the signals received from the CPU via the VME bus and transfers signals from the EIC card onto the VME bus (VME bus pin-out, Refer to Appendix 2). The circuit also provides additional timing and I/O circuitry to support the exchange of information and laser synchronization (A more detailed DE Block Diagram is in Appendix 5).

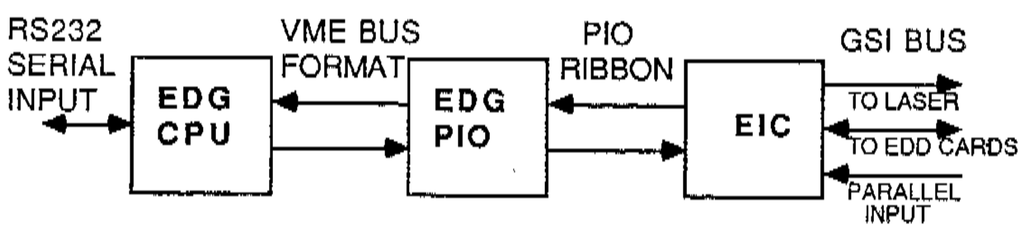


Diagram 11. DE Simplified Block Diagram

1.2.2 Euro Digital Driver (EDD)

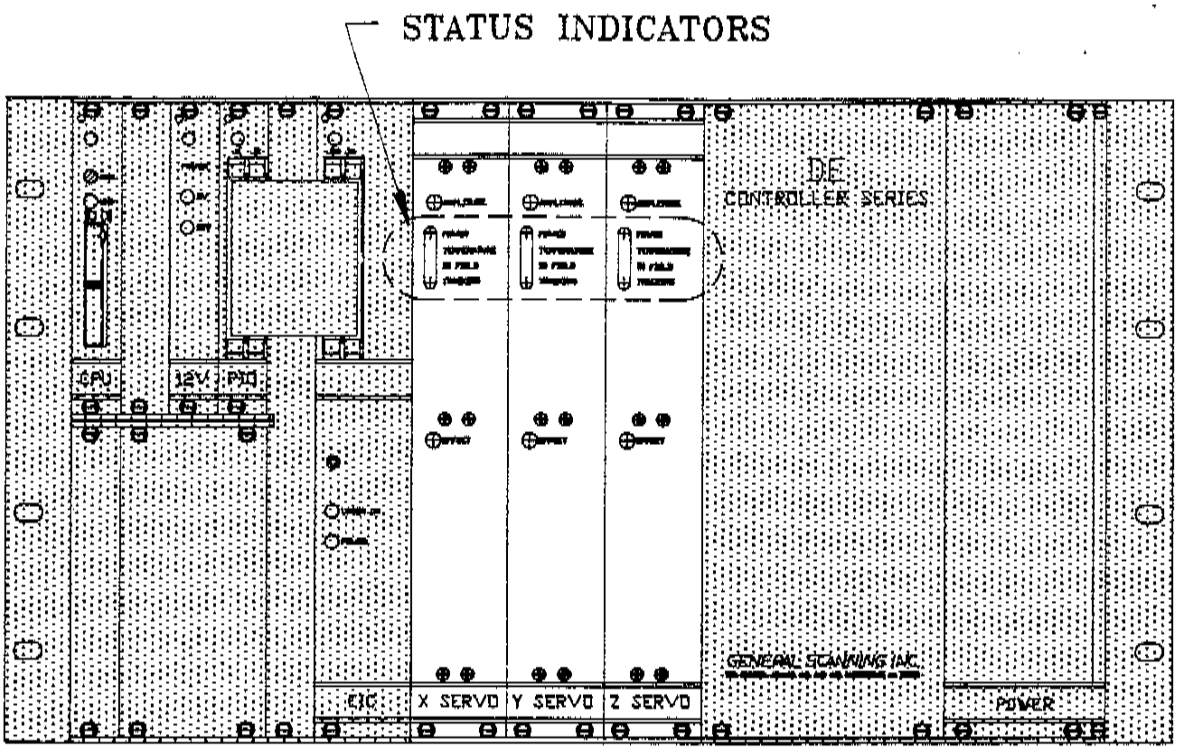


Diagram 12. Euro Digital Drivers

The EDD circuit cards control the X, Y, and Z (optional) scanners. Each axis requires an EDD circuit card to control the appropriate galvanometer. When dynamic focus correction is required, there are three EDD cards to drive the X,Y, and Z galvanometers. For systems that do not require focus correction there are two EDD cards. EDD circuit cards convert the digital information generated by the EDG to analog drive signals. The analog signals are amplified in a closed loop servo and used to drive the scanners. The EDD closed loop servo amp uses position information from the galvanometer to compensate for feedback into the drive circuitry (See Block Diagram 13).

1.2.2.1 EDD Circuit Card Description

The closed loop servo amplifier in the EDD circuitry produces the current required to drive the scanners. The precision of the galvanometer is maintained by comparing the output voltage of the DAC to the actual position signal being returned from the galvanometer. The difference between the ideal position and the real position is corrected in the closed loop servo. The following simplified circuit diagram and description is for those users who want more insight into how the EDD card operates.

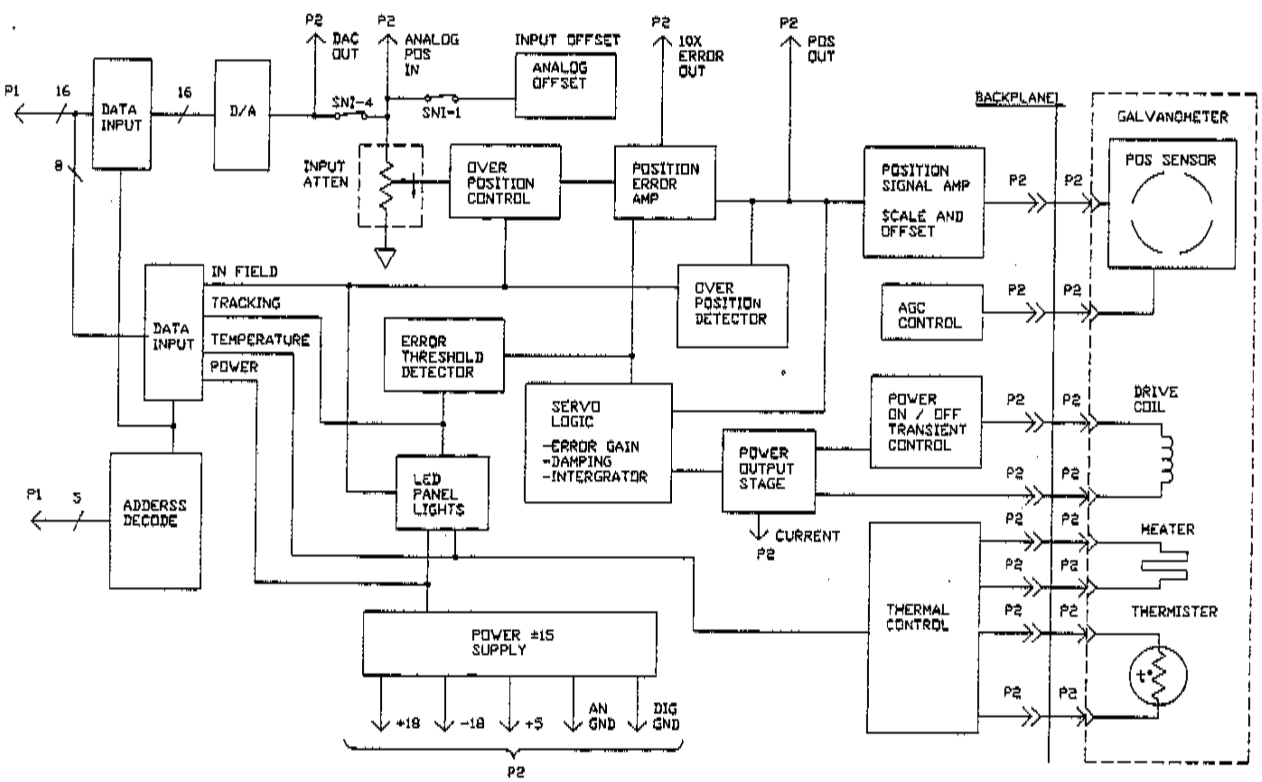


Diagram 13. Simplified EDD Circuit Diagram

The scanner position signal is derived from position sensors that surround the rotor of the galvanometer. The position sensors generate a differential output current proportional to the rotor's angular position. A current-to-voltage converter transforms the current to a raw position signal, and the EDD circuit card then calibrates it for offset and gain differences.

The position sensors are capacitive devices that are charged by an oscillating voltage. If the oscillating voltage changes, the accuracy of the position detection diminishes. The Automatic Gain Correction (AGC) line regulates the position sensor's supply voltage to maintain the integrity of the position signal.

The closed loop servo amplifier compensates for positional errors by increasing or decreasing the level of drive signal to the galvanometer. The calibrated position signal is fed to the position error amplifier, where it is subtracted from the DAC output to generate the position error signal. The position error voltage is applied to the input stage of the drive signal amplifier, which either increases or decreases the drive signal. The position error signal is also sent to an integrator. The integrator removes the static position error.

A damping signal is the third input to the drive signal amplifier stage. The position signal is differentiated to create a velocity signal. This velocity signal provides damping feedback to the galvanometers.

The EDD card also provides circuits for protection, status, and reduction of thermal drift. The EDD circuit detects when the scanners position signal is greater than the rated maximum of ±5V or exceeds the current maximum of 1A. This protects the scanners from damage caused by over-angle position transients or damaged circuitry. When this condition exists the over-position circuitry drastically reduces the drive signal.

To maintain a stable operating temperature the EDD cards regulate the temperature of the scanners. The galvanometers have a thermistor inside its housing and a heater blanket outside. The thermistor forms one leg of the bridge circuit whose output connects to a high gain amplifier. The amplifier drives the scanner's heater blanket. The temperature controlled scanners are elevated to the nominal temperature of 40°C ±4 . This temperature, which is maintained to better than ±0.5°C, reduces temperature-created positional drifts.

1.2.2.2 EDD Status Indicators

The status indicators, located on the front of each EDD card, ensure a visual confirmation that the scanners are operating properly.

POWER STATUS when lit, indicates that the EDD board is receiving ±18V and +5V. The power light must be on for the EDD card to function.

TEMPERATURE monitors the scanner temperature. When the light is ON, the scanner temperature has stabilized. The TEMPERATURE light is OFF, while the scanner is warming up or if the scanner is overheating. It is recommended that the user waits for temperature regulation before scanning.

The over-position circuitry controls the **ON FIELD** light. When the scanners are driven below their maximum rated excursion, the ON FIELD light is ON. When the scanners are being driven beyond their maximum rated excursion, the over position circuitry turns the ON FIELD light OFF.

The status indicator for **TRACKING** derives from a position error signal. If the error signal is within a preset limit, the TRACKING light is ON. If the error signal is greater than the preset limit, the TRACKING light is OFF. The tracking status light may blink for many applications. The size of the error signal is proportional to the speed of the galvanometer; the faster the slew of the mirrors, the larger the error signal. When the scanner is stationary, the tracking light should be ON. If not, there is a problem (See Trouble Shooting, Chapter 3, Section 3.3.0).

Note: All of these signals are available to the host computer via the RS-232 interface with the status command (see Chapter 2, Section 2.2.5).

Table 3: Status Light Indicators

Status Light	Condition	Description
Power	Light On	EDD card is receiving power
	Light Off	EDD is not receiving power
Temperature	Light On	Scanner Temperature is stabilized
	Light Off	Scanner Temperature is not stabilized
In Field	Light On	Scanner Excursion is within proper limits.
	Light Off	Scanner Excursion is out of range.
Tracking	Light On	Scanner is following the DAC output within set error threshold
	Light Off	Position error is greater then set error threshold.

Note: When the scanners are at rest and warmed up, all indicators should be on. The G100 Series scanners take approximately five minutes to warm up. The G300 Series scanners take approximately 30 minutes to warm up. Ambient temperature influences the warm up time.

1.2.2.2 EDD Backplane

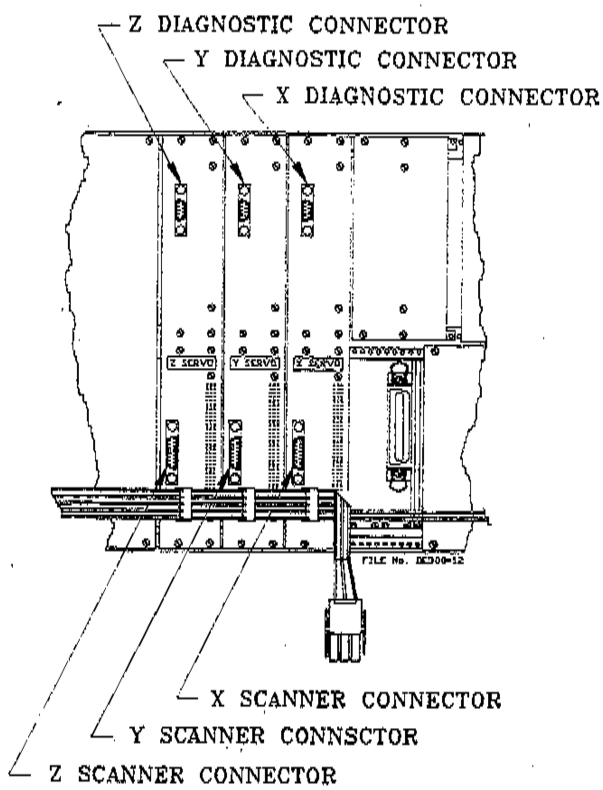


Diagram 14. EDD Backplane

The 15 pin D connector that connects the EDD cards to the appropriate scanner is located on the EDD backplane. This scanner connector carries:

1. High and low drive signals to the scanners,

2. Thermal control signals required by the heater blanket and a thermistor circuit to regulate the scanner temperature.

3. Control signals for the position detection circuit and Automatic Gain Correction (AGC) circuit

Note: Details of the pin out configuration of the connectors are found in Appendix 3.

The diagnostic connector, which is on the EDD backplane, may help in troubleshooting and servo tuning. A summary of the information located on the diagnostic ports follows (Diagnostic connector is a 9 pin D-sub socket female AMLAN CDF9P; Mate 3M 3730-1000).

Pin 1: **10 Times the Position Error.** The voltage is equal to 10x the position error. This signal is used to tune the scanners.
Note: This zero error signal is usually several millivolts off 0 due to op amp offset voltages.

Pin 6: **Velocity Signal.** This signal is proportional to the slew rate of the mirrors.

Pin 2: **Position Signal:** This signal is proportional to the scanner's position.

Pin 7: **External Input.** This pin is used to supply the galvanometer with an analog input. To use the analog input, the DAC must be off.

Pin 3: **D/A Out.** The DAC signal may be used to check the output of the waveforms generated by the computer program.

Pin 5: **Scanner Current.** This line monitors the drive current to the galvanometers (Frequency roll opp with 3K resistor and 0.01 μ cap).

Pin 8: **AGC Voltage.** This line monitors the voltage to the position sensors.

Pin 4, Pin 9: **Diagnostic Ground.**

Warning: These signals are intended for diagnostics by qualified technicians. Tampering with factory tuned circuits is strongly discouraged and voids the warranty.

1.2.3 Euro Interface Card (EIC)

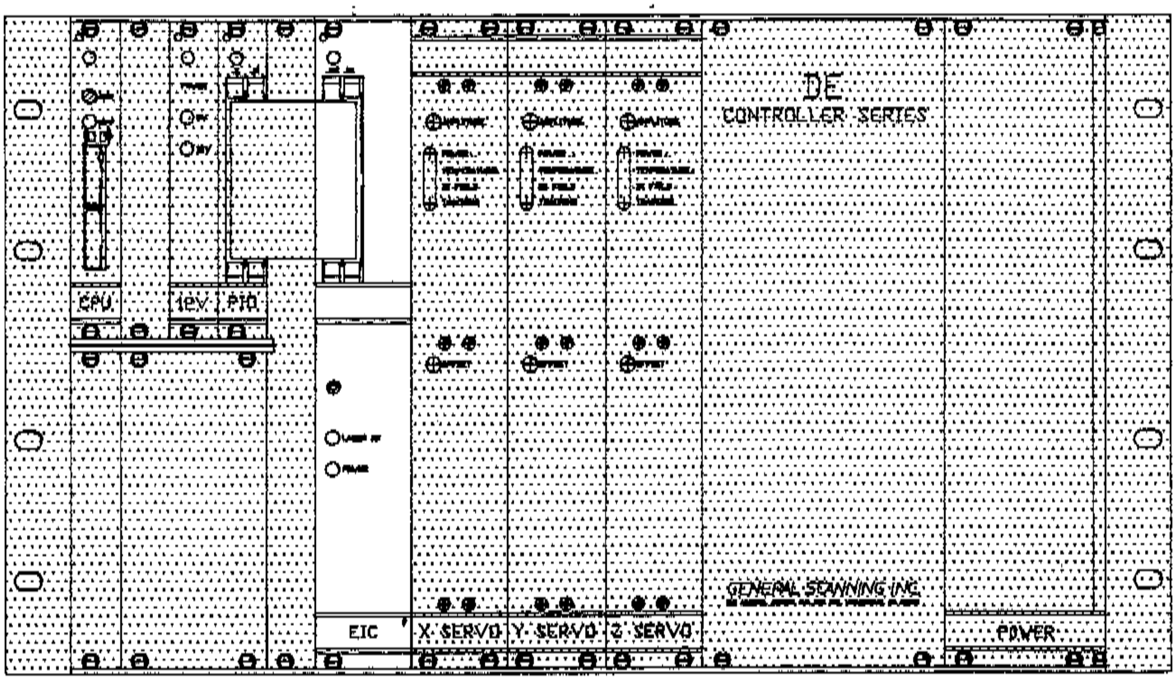


Diagram 15. Euro Interface Card

The EIC is the bridge between the EDG PIO and the EDD cards (Refer to Diagram 11). The EIC circuit buffers and outputs laser control signals received from the EDG PIO. The EIC outputs the Laser ON/OFF command signals in various modes. The EIC also receives the parallel input from the host computer (See Appendix 4 for parallel input pin-out configuration).

The EIC circuit card takes laser control signals from the EDG PIO card and converts them to laser ON/OFF signals. The type of signal the EIC provides depends on the laser modulation type. Signals that can be provided are: Active High TTL, Active Low TTL, or 50 ohm drive signals. This is the only circuit card that users must configure.

The EIC card has two status indicators. When the power light is on, the EIC and is receiving +5V. **LASER ON** indicates when the laser is being signaled to turn on.

The EIC is configured in the factory for Active High signal generation. If your laser needs a different ON/OFF signal, use the circuit block diagram and the circuit card layout below. The procedures configuring laser ON/OFF modulation follow.

W104

LM / LM

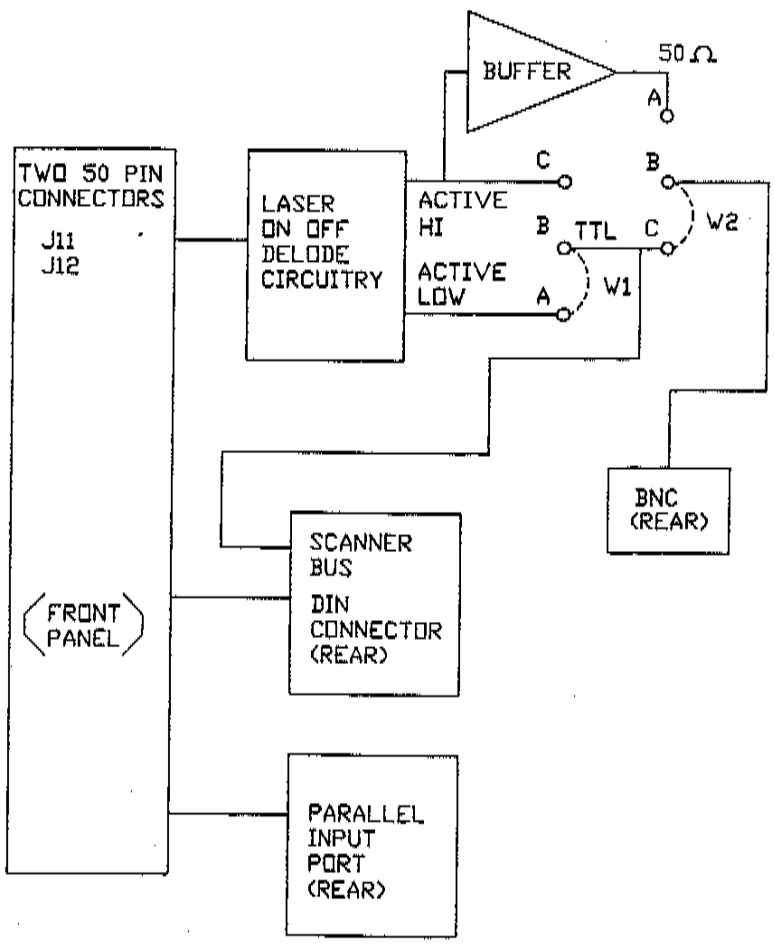


Diagram 16. Laser ON/OFF Circuitry Block Diagram

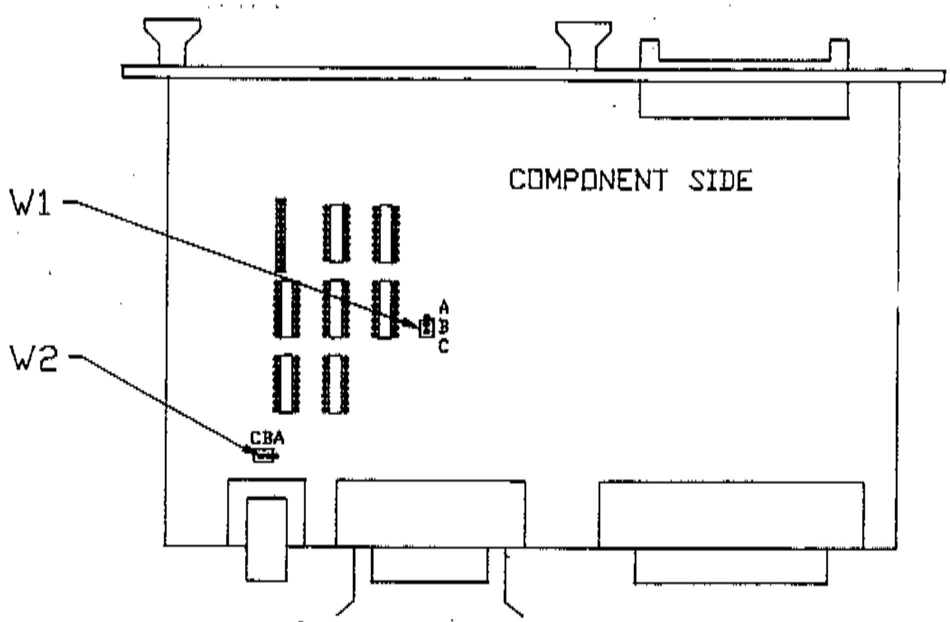


Diagram 18. EIC Circuit Card Layout

How to Configure Laser On/Off Modulation

1a.	If the DE is **not** set-up, disconnect the two 50 pin ribbons on the front of the EIC card.
1b.	If the DE is set-up, disconnect parallel, BNC, and the two 50 pin ribbons on the front of the EIC card.
2.	Loosen screws on the front of the EIC card.
3.	Slide EIC out the front.
4.	Determine the required laser modulation.
5.	Find the required jumper connections in Table 4.
6.	Find the W1 and W2 required jumper locations on the EIC card using Diagram 18.
7.	Establish the correct jumper configuration.
8.	Double check jumpers.
9.	Replace the EIC card and tighten screws.
10.	Return to Step 5 in the Set-Up instructions.

Note: After the DE is set-up, you may connect the BNC output to an oscilloscope to insure the proper signal is being generated by the EIC card (Refer to Section 2.2.5 for test state laser commands).

1.2.5 Euro Fan Tray (EFT)

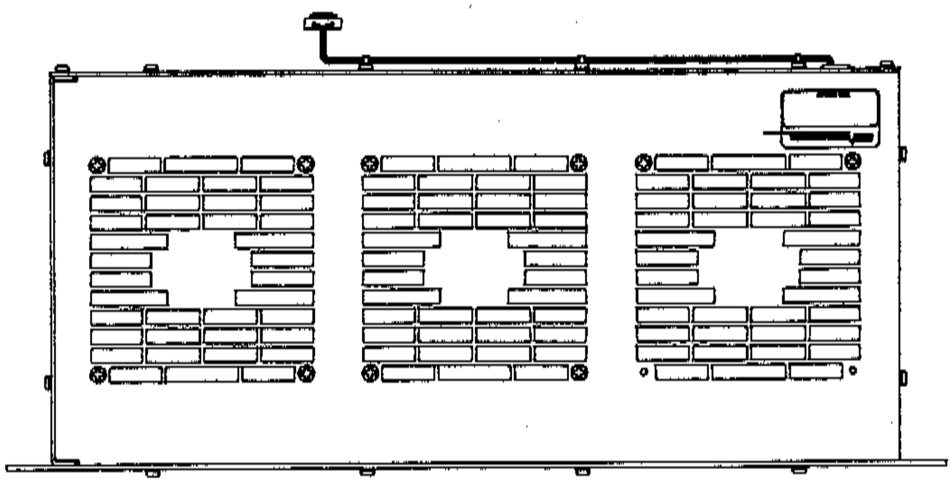


Diagram 20. Euro Fan Tray

The Euro Fan Tray (EFT) cools the DE electronics in open rack configurations. It consists of two DC fans and a mounting cage. It is recommended that some other type of cooling be used in a closed rack systems.

Chapter 2: Digital Electronics Software

2.1.0 Digital Electronics Software Overview

The EDG is a dedicated computer for generating vector output using a General Scanning, Inc. X,Y or X,Y,Z scan system. It contains a high speed 16-bit microprocessor and parallel and serial interfaces. The standard firmware computes and outputs X,Y, and Z coordinates on a programmed line. These high speed drive coordinates, when converted to analog, provide high quality drive signals for galvanometer optical scanners. In addition these signals may be digitally corrected to remove geometric scanning distortions and provide focus.

The EDG is controlled by a set of two letter commands followed by an argument and/or a terminator. The command language allows the user to completely control all aspects of vector generation.

2.1.1 Talking to the DE

The EDG receives commands from the HOST PC via an asynchronous serial (RS-232) interface or 8-bit parallel (Centronics) interface. The serial port provides bidirectional communications between host computer and EDG CPU. Although the parallel port is much faster, it may only be used to send information to the EDG CPU. Either port may be used alone for communicating with the EDG, but utilizing them both allows the user the speed of parallel communications along with the error and status feedback features of the bidirectional serial port.

Notes: Only connect the RS232 cable if it is being used. If it is connected to a host PC that is not actively using the serial port, the DE will not function.

Warning: Care must be taken never to send messages over both ports simultaneously. Messages sent simultaneously cause the DE to malfunction.

2.1.2 DE Commands

Commands are control statements sent to the EDG CPU via the serial or parallel ports. The command format consists of the two letter commands. Commands must be in upper case format, followed by an argument, if any. A carriage return is the terminator. A command summary is located in the Quick Look Up Command Charts in Chapter 3, Section 3.2.0.

Programmer's Note: All commands and messages shall be terminated by a carriage return [CR] (ASCII 0D Hex). All arguments (decimal numbers) are sent in ASCII format (0 = 30H,1 = 31H...), not binary. The EDG ignores line feeds (0AH).

There are two types of command modes; **TABLE** commands and **IMMEDIATE** commands. They differ in their effect on the execution of the vector table. The vector table is a list of vector endpoints that are sent from the host computer and are stored in the EDG CPU RAM for execution. IMMEDIATE commands immediately affect the output of **all** the vectors in the vector table. Immediate commands are equivalent to global operations in conventional programming. TABLE commands are localized commands, and as such they only affect how portions of the vector table are executed.

Regardless of when they are sent, IMMEDIATE commands change the handling of all the vectors that follow. For example, if the step period (Command: SP<ARG>) is changed and then the vector list is executed, the vectors are output at the new step period. The step period is a global command that immediately is changed in memory.

TABLE commands either load values in a table for later use or affect the vectors following the command. TABLE commands do not affect vectors that were stored in the vector list before the table command is transmitted to the EDG. TABLE commands only affect that portion of the vector list that comes after the table command transmission. For example, if after sending a partial list of vectors, the user changes the step size (Command: SS<ARG>), sends more vectors and then executes; only the second set of vectors will be executed at the new step size. In essence, the step size is stored in the table.

Note: Some serial communications have been known to cause DE malfunctions when using line feeds. If communication malfunction occurs, the user may be required to delete all line feeds from the program being sent.

2.2.0 Command Functional Groups

When the system starts up, the EDG enters the INPUT state, (The INPUT state is disabled during EXECUTION and re-enabled on completion.) The input state allows communication of commands from host to EDG. Listed below are five functional types of commands used by the EDG CPU for vector processing and system control. The following sections detail the commands of each functional group. (See Chapter 3 for a quick look-up guide of the DE commands)

Function Commands: **Description**

Vector Coordinate (Sec.2.2.1): These commands define vector endpoints. They include the **JX, JY, NX, NY, AB, DL** commands.

Scanner Control (Sec.2.2.2): These commands specify the speed of vector execution and delays for scanner control. They include the **SS, JS, SP, SD, JD** commands.

Laser Control (Sec.2.2.3): These commands specify the timing signals for laser control. (These indirectly change scan rate.). They include **LO, LF, CV, NV** commands.

Vector Table Execution (Sec. 2.2.4): These commands specify how vector coordinate tables are executed. They include the **CL, EC, EX, RX** commands.

Utility (Sec. 2.2.5): Utility commands are used for system status requests and test state commands for laser control in a test mode. They include the **ST**, **TS** commands.

Grid Correction (Sec. 2.3.1): Grid correction commands load and clear geometric correction tables. They include **CT**, **LT**, **QT** commands.

2.2.1 Vector Coordinate Commands

Vector coordinates define the input data the endpoints of vector lines to be drawn. **Jump** (JX,JY) commands specify the motion of the scanners with the **laser off**. **Next** (NX,NY) commands specify the motion of the scanners with the **laser on**. Vectors are drawn by using JUMP commands to position the scanners at the beginning of the vector while the laser is off, then using NEXT commands to draw a line to the vector endpoint with the laser on.

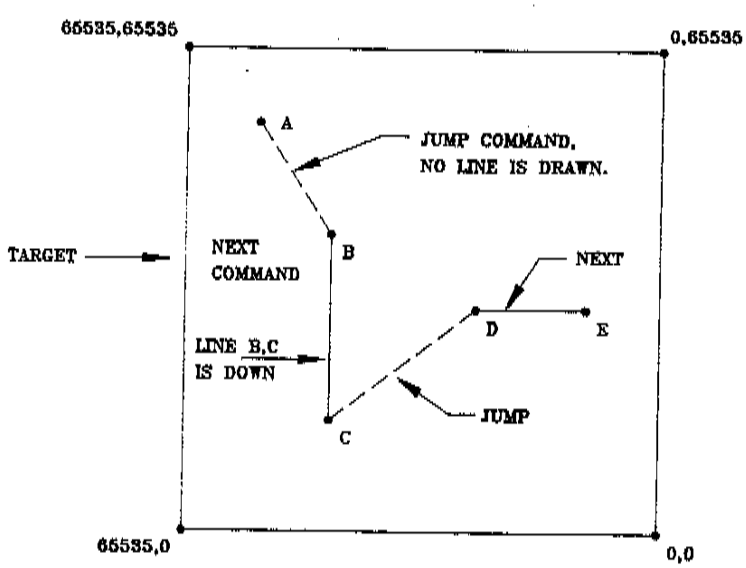


Diagram 21: Examples of Jump and Next Commands

An X,Y coordinate range of 0 to 65535 describes the 16-bit square field. The X, Y points 0,0 are in the lower right corner of the target field, and 65535, 65535 are in the upper left corner of the field. Vector arguments may be sent in Absolute endpoint location mode or relative motion from current location using Delta mode.

Both X and Y coordinates must be entered for each vector, even though one or the other does not change from its previous value. The X coordinate must be entered first, followed by the Y coordinate. Leaving out either X or Y in a vector causes misalignment of the X/Y tables and errors in vector calculation. It also corrupts the rest of the vector list. Clear and re-enter the table.

The vector table allows storage of up to 32000 X,Y vector pairs at one time. The 32000 X,Y pair limit is the sum of NEXT and JUMP commands. If the file to be executed contains more than 32000 vector pairs, it must be drawn with multiple Execute and Clear commands.

Programmer's Note: If the 32000 limit is exceeded, pertinent data may be wiped out, and a system RESET required. It is responsibility of the host computer to limit the download to 32000 vector pairs.

A vector list usually contains both NEXT and JUMP commands. The vector pair must always be either two NEXT or two JUMP commands. Mixed pairs yield undefined results.

Vector coordinate arguments (Jump or Next commands) may be interpreted by the EDG CPU in two ways. In **Absolute (AB)** mode, the vector endpoints are specified by explicit arguments. In **Delta (DL)** mode, the endpoints are specified by a relative move from the current coordinate (See Diagram 22 for examples).

In **Absolute (AB)** mode, each Next X, Next Y, Jump X, and Jump Y arguments specify an absolute vector endpoint position on the field. An absolute mode argument of 22 specifies the vector to end at coordinate 22. An absolute mode argument of 65000 specifies the vector to end at coordinate 65000. An absolute mode argument of 0 (zero) specifies the vector to end at coordinate 0 (zero).

If **Delta (DL)** mode is specified by sending a DL command, each Next X, Next Y, Jump X, and Jump Y commands specify an increment or decrement from the current X,Y position. The command argument specifies direction and magnitude in delta mode.

Vector lists may contain both DL and AB command pairs. The X and Y argument of each vector must be in the same mode, but the mode may switch between vector X,Y pairs anytime. After receiving a DL or AB interpretation mode change command, the EDG CPU interprets all following arguments in that mode. If the DL command is the most recently sent mode, it is not necessary to send a DL command prior to every vector. A short example illustrates the mixed use of AB and DL mode.

Program Section

```
AB
NX30000 {Point A}
NY30000
NX50000 {Point B}
NY50000
DL
NX10000 {Point C}
NY10000
NX35536 {Point D}
NY55536
        :
        :
```

Scanner Result

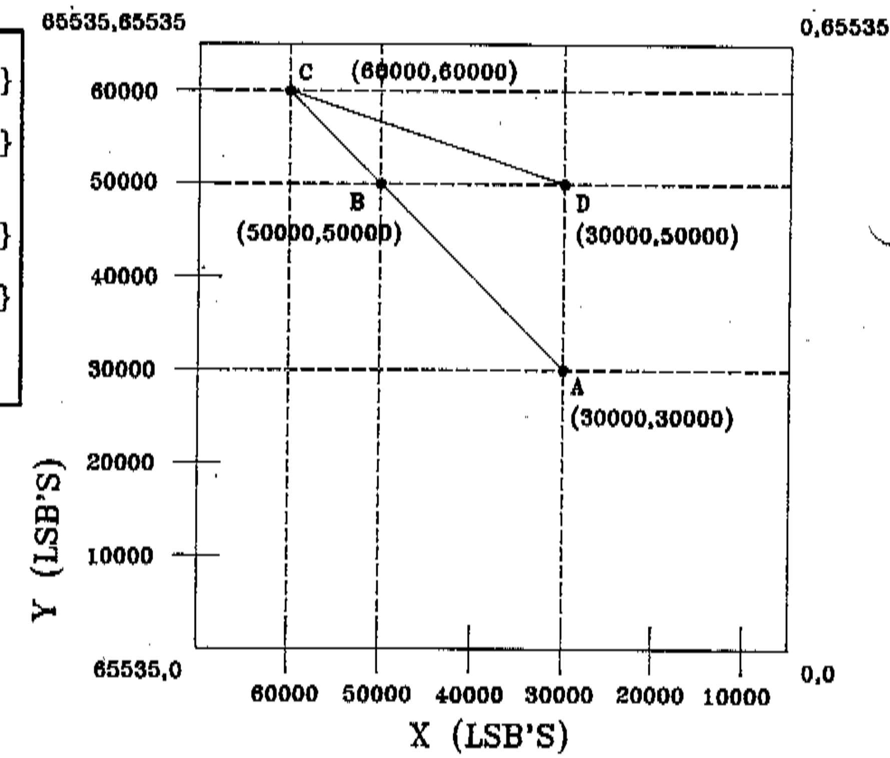


Diagram 22: Example of Absolute and Delta Commands

Command: COMMAND MODE, Absolute and Delta **(AB & DL)**

Symbol: Absolute Mode = AB
Delta Mode = DL

Command Type: Table

Syntax: AB[CR] No argument is allowed for AB and DL.
DL[CR]

Default: Absolute

Description: **Absolute** mode (**AB**) defines an explicit location in the target field. The XY coordinates in **AB** mode represent a fixed point on the target.

Delta mode (DL) coordinates define a relative position increment. The coordinates represent a specific distance from the present location. The Delta argument 1 through 32767 represents a positive move. A positive move increments the current position. A Delta mode argument 65535 through 32768 represents a negative motion or a decrement from the current coordinate. The maximum delta argument is limited to 32767 LSBs in a positive direction or 32768 LSBs in a negative direction (See Diagram 22 with respect to the placement of vectors BC and CD).

Conditions:

1. As a protection to scanners, the EDG CPU checks for delta values that send a scanner outside of the valid 0 through 65535 range. If the EDG CPU determines that a delta argument would send the scanner to less than 0 or more than 65535, the argument is considered invalid. The INVALID ARGUMENT message is sent to the serial port and the argument is ignored.

2. The AB and DL commands cannot separate an XY coordinate pair.

Example:	Command	Comments
	JX30000	(default mode was AB)
	JY12000	(jump to 30000,12000)
	DL	(switch to delta mode)
	NX58017	(represents change of -7519)
	NY847	(represents change of +847)
	NX203	(represents change of +203)
	NY0	(maintain current Y position)
	NX40000 (Invalid)	(represents a change of -25534)
	NY62700 (Invalid)	(represents a change of +62700)
	AB	(return to absolute mode)
	NX7000	(represents a change of 7000)
	NY55000	(represents a change of -535)

When executed, the above listing jumps to coordinate position **30000,12000,** draws a line to **22481** (30000 - 7519),**12847** (12000 + 847). A line is then drawn to **22684** (22481 + 203), **12847** (1287 + 0). The next XY increment is **Invalid.** The delta increments sends the scanners out of range. An error message of Invalid Argument is sent to the host computer and the command is ignored. The coordinate mode now changes to **Absolute.** The scanners then draw a line from **22684,12847,** to the coordinate position **7000,55000.**

Note: The AB and DL modes are both valid for either NC (Non-Continuous vector) or CV (Continuous Vector) modes.

Programming Tip: Delta mode programming is particularly useful for font generation, logos, or special graphics images that are repeated in many locations in the field. The image may be stored in delta values and plotted out at any field location by first jumping in Absolute mode (or Delta for step and repeats) to a beginning location then drawing the image using delta arguments.

Command: NEXT COMMANDS (NX and NY)

Symbols: Next X coordinate = NX
Next Y coordinate = NY

Command Type: Table Command

Syntax: NX<ARG>[CR] **Argument Range:** 0 - 65535
NY<ARG>[CR} **Argument Range:** 0 - 65535

Default Argument: 32,768

Description: The NX and NY commands create the end point coordinates of DRAWN vectors. As they are entered, the commands accumulate in a memory table in the EDG CPU RAM. Upon Execution, with the laser on, sets of vectors are drawn, one after another, in the order of their entry. If the vector pair are NEXTs, **the laser is turned on**, and the scanner slews according to the Next scanning control parameters.

Conditions:

1. <ARG> is a valid argument from 0 to 65535 and [CR] is a carriage return. The units are in terms of LSB's.

2. Always enter NX before NY. They must be entered as a pair even if one stays the same as previous point.

3. In Absolute mode, the argument is interpreted as an endpoint. In Delta mode the argument is treated as a relative move.

Examples: ABsolute Mode:
NX3875[CR]
NY358[CR]

Upon execution the mirrors slew with **laser on** to the point 3875,358 LSB's in the target plane.

DeLta Mode
NX3875[CR]
NY358[CR]

Upon execution the mirrors slew with **laser on** to a point located 3875 LSB's in the X direction and 358 LSB's in the Y direction from the current location in the target plane.

Command: JUMP COMMANDS **(JX and JY)**

Symbols: Jump to X coordinate = JX
Jump to Y coordinate = JY

Command Type: Table Command

Syntax: JX<ARG>[CR] **Argument Range:** 0 - 65535 LSB's
JY<ARG>[CR] **Argument Range:** 0 - 65535 LSB's

Default Argument: 32,768

Description: The JX and JY commands create the end point coordinates of Non-Drawn vectors. As they are entered the commands accumulate in the same memory table as Next commands in the EDG CPU RAM. Upon Execution, sets of vectors are drawn, one after another, in the order of their entry. If the vector pair are Jumps, **the laser remains off**, and the scanner slews according to the Jump scanning control parameters.

Conditions:

1. <ARG> is a valid argument from 0 to 65535 and [CR] is a carriage return.

2. Always enter JX before JY. They must be entered as a pair even if one stays the same as previous point.

3. In ABsolute mode, the argument is interpreted as an endpoint. In DeLta mode the argument is treated as a relative move.

Programming Tip: Jumps are usually set to slew faster than Nexts. Since the laser is off during Jump execution, tracking performance is not critical. The Jump, however, must settle before the next drawn vector begins.

Examples: ABsolute Mode

JX2000[CR]
JY65000[CR]

Upon execution the mirrors slew with **laser off** to point 2000,65000 LSB's in the target plane..

DeLta Mode
JX2000[CR]
JY65000[CR]

Upon execution the mirrors slew with the **laser off** to a point 2000 LSB's in the X direction and -536 LSB's in the Y direction from the current location in the target plane.

2.2.2 Scanner Control Commands

Vectors are output as digital ramps. The size of the incremental step and the time between step outputs controls the velocity of the ramps. The scanner control commands adjust the speed at which the Next and Jump vectors are executed. Scanner settling delays are provided to optimize performance.

2.2.2.1 Vector Speed Control Commands

To control scanner speed, each vector must be divided into a number of incremental points, each point lying along the line of the vector, and all points equidistant. These points are output from the EDG to the DACs and appear to the scanners as analog voltage ramps that direct the scanner positions in the field.

The time period between DAC voltage level changes is called the **Step Period (SP)**. The Step Period changes the slew rate at which the Jump and Next vector pairs are executed. The distance (voltage) between increments on the vector ramp is programmed with the **Step Size (SS)** , command for Next commands and the **Jump Size (JS)** for Jump commands. Therefore, the speed at which the vector pairs are executed is a function of the step size and step period. The step period determines the rate of each increment and the step size determines the spacing of each increment.

Step Size and Jump Size do not have to be sent together or in a particular order. Either may be changed independently at any point in the vector list except between the X and Y coordinate of a vector pair. The SS and JS are Table commands. The new SS and JS commands only affect vector pairs sent down after the change.

Both the SS and JS commands may be nested in a vector list to change the scanning speed from one vector to the next. As the EDG receives X,Y coordinates, it computes the slope of the vector and then adjusts the X and Y steps. Each vector's X,Y steps are stored in a table. This reduces the number of computations required during the execute routine.

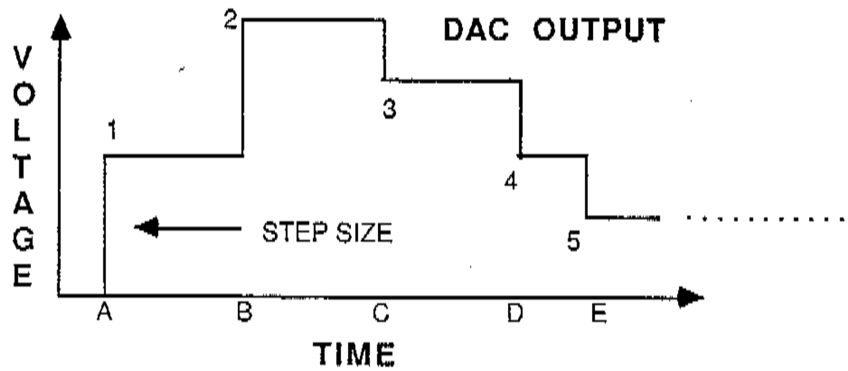


Diagram 23: Step Size and Step Period Example

Mirror Result: Diagram 23 represents the movement of one mirror while holding the other mirror fixed.

AB: The mirror moves to Position 1 and remains at the position for time X. It then moves the same increment to Position 2 and remains at that position for time X

BC: The mirror moves to Position 3; however it is a smaller increment than moves 1 and 2. The dwell time is still time X.

CE: The mirror moves to Position 4 with the same increment as the last movement; however the scanner stays at the position for X/2. Then the mirror increments to Position 5 with the same increment and dwells for time X/2 again.

Programmer's Note: The SS or JS value refers to the Vector step size. The vector scan rate is kept constant to maintain uniform exposure. The X and Y velocity is dependent on vector direction. For a Jump, where X does not change, Y increments at the JS value. If both X and Y change, the vector increments at the JS value. However, X andY increment proportionally to the slope of the vector. This is all calculated by the EDG BPC. The user must only specify the vector increment size.

Command: STEP PERIOD (SP)

Symbol: Step Period = SP

Syntax: SP<ARG>[CR] Range: 270 - 65534 μs

Command Type: Immediate

Default Argument: 270 μs (DE3000)
210 μs (DE2000)

Description: The step period determines the rate at which all DACs increment. The longer the step period, the slower the EDD cards output the steps that compose Next and Jump commands.

Conditions:

1. <ARG> is a valid argument from 270 to 65534 microseconds.

2. The SP command can not separate an X and Y coordinate pair.

Programming Tip: For smooth vector output, the Step period should be as short as possible. In general, use the Step Size or Jump Size command to change speeds. The default value of Step Period is recommended for all but very slow scan systems.

Example: SP1000[CR]

The increment rate is 1000 μS (1 ms) per step. Due to SP being an immediate command it affects the vector list previously stored.

Note 1: DE2000: Two-axis Control
The DE2000 version of the DE Series has two-axis (X and Y) control only. There is no Z-focus control in this unit. These electronics were designed for applications that use pre-objective scanning or post-objective systems - those that do not require dynamic focus.

Faster Step Speed: The ROMs in the DE2000, which are from different those in the DE3000, permit Step Periods as fast as 162 µs. Removing the Z-axis interpolations and overhead in the DE3000 made this faster step period possible.

Benefits of New ROMs: General Scanning developed the new ROMs primarily for the XY2100 Scan Head. At high speeds, however, these ROMs may also benefit those X-Y Scan Heads using G100 Series galvanometers or those Scan Heads with G300 Series galvanometers using small apertures. The faster data output rate of 4.98 KHz - as compared to the 3.7 KHz of the DE3000 - allows smaller step sizes and reduces line ending problems for the same vector velocity. The ROMs also allow for a data output rate above the bandwidth of the scanner, a desireable feature.

Note 2: CPU Assembly, Version -4
The CPU assembly, Version -4, uses the new ROMs. Note that the ROMs in the DE2000 change the Power Up default and the Version message.

Specifications	DE3000	DE2000
Step Period, min.	206 µs	162 µs
Step Period, default	270 µs	210 µs
Version	DE3000 V3.01	DE2000 V1.01

Command: INCREMENT SIZE Step Size and Jump Size **(SS and JS)**

Symbol: Jump Size (JS)
Step Size (SS)

Syntax: SS<ARG>[CR] Range: 1 - 32767 LSB's
JS<ARG>[CR] Range: 1 - 32767 LSB's

Command Type: Table

Default Argument: SS - 32 LSB's
JS - 512 LSB's

Description: The size of the increments that compose the execution of a Next or Jump command is determined by the size of the voltage increment from the DAC. **Step Size** (SS) is the size of the voltage change for **Next** commands. **Jump Size** (JS) is the size of the DAC increment for the **Jump** command.

Conditions:

1. <ARG> is 1 to 32767 and [CR] is a carriage return. Units are in Least Significant Bits of the DAC. 1 LSB = 1/65536 of scan field.

2. Neither the SS or JS commands can separate an X and Y coordinate pair

3. SS and JS do not have to be change together. They may be changed independently anywhere in the vector list.

Example: SS100[CR]
JS300[CR]

The Next commands increment 100 LSB's per step. The Jump commands increment 300 LSBs per step.

Programming Tips: The vector period is the time the scanner takes to draw a vector. The vector period is dependent on vector length and may be calculated as follows:

1) Determine vector length in LSB's:
$Lv = ((NX\text{-}BX)^2 + (NY\text{-}BY)^2)^{1/2}$

Note: BX and BY represent the current location.

2) Compute the number of steps:
$Ns = Lv/SS$ (step size in LSB's)

3) Multiply by the step period, (μs):
$Ns \times SP$ = Vector Period

4) Add laser off delay and scanner delay

2.2.2.2 Settling Commands

The **Scanner Delay (SD)** and **Jump Delay (JD)** commands control the time the scanner waits before it proceeds with the next vector. The delays allow the scanner to fully settle in order to begin the next drawn vector in the proper place. The amount of delay required is a function of the scanning velocity, average size of the vectors, the X-Y head, and servo tuning.

When the scanner searches a location, the overshoot occurs after the laser is off so the line ends properly. Additional time, however, is required to allow the scanner to settle before starting to draw the next vector. The SD command provides an **adjustable delay before** each drawn vector. For some systems this value is set to the minimum value of 2 μs.

Since the laser is off, the Jump speed is often set high. This moves the scanner quicker, but may require additional settling time. JD provides a **settling period at the end** of each Jump so the scanner may settle before drawing.

Command: DELAY COMMANDS **(SD and JD)**
Scanner Delay and Jump Delay

Symbols: Scanner Delay = SD
Jump Delay = JD

Syntax: SD<ARG>[CR] Range: 2 - 65534 µs
JD<ARG>[CR] Range: 2 - 65534 µs

Command Type: Immediate Commands

Default Argument: SD = 2 µs
JD = 3000 µs

Description: **Scanner Delay (SD)** sets the time before the EDG begins to execute a Next vector pair. Scanner Delay applies only to Next vectors and occurs **before** a Next execution. The SD command allows the scanner to settle before the drawing a vector.

The **Jump Delay** sets the time that the scanners delay after a Jump execution. Jump Delay applies only to Jump vectors and occurs **after** a Jump. The JD command settles the scanners after a Jump move has been executed.

Conditions:

1. <ARG> is a valid argument between 2 and 65534. Units of delay are in microseconds. Only even numbers of microseconds are implemented in the EDG BPC.

2.. These commands cannot separate an X and Y coordinate pair.

3. SD and JD do not have to be sent together or in a particular order. Either may be changed independently at any point in the vector list.

Example: SD2[CR]
JD3000[CR]

These commands set the Scanner Delay to 2 µs and the Jump Delay to 3000 µs (3 ms). SD and JD are Immediate commands. All vectors in the table when executed slew at the most recent SD and JD.

Programming Tips: With large vector moves, delays are often greater than a millisecond. On large vector files these delays may significantly prolong the total drawing time. Depending on the average length of the vectors, reducing vector lengths to smaller increments may shorten the settling delays. And reduce the total drawing time. This is particularly true of files with many small vectors such as CAD-generated drawings with many alphanumerics.

2.2.3 Laser Control Commands

Laser control commands set the ON / OFF synchronization of the scan system laser to the phase delay of the scanners for precise line endings. The DE also has a Continuous Vector generation capability. This prevents the laser from turning off and stops the scanners from delaying when the user is drawing small connected vectors.

2.2.3.1 Laser On/Off Signals

The scanners begin to move after an initial delay caused by the inertia of the mirror and rotor. This occurs after the DAC vector ramp has begun. To avoid the beginning of lines blooming from over exposure due to this delayed movement, a **Laser On (LO)** delay is required. The Laser On command turns the laser on after the scanner has begun accelerating.

At the end of the vector ramp, the scanner still lags the ramp signal by some amount and requires time to reach the actual endpoint of the drawn vector. The **Laser off (LF)** delay allows the scanner to reach the end of the drawn vector before the laser is turned off (For a graphic representation see below).

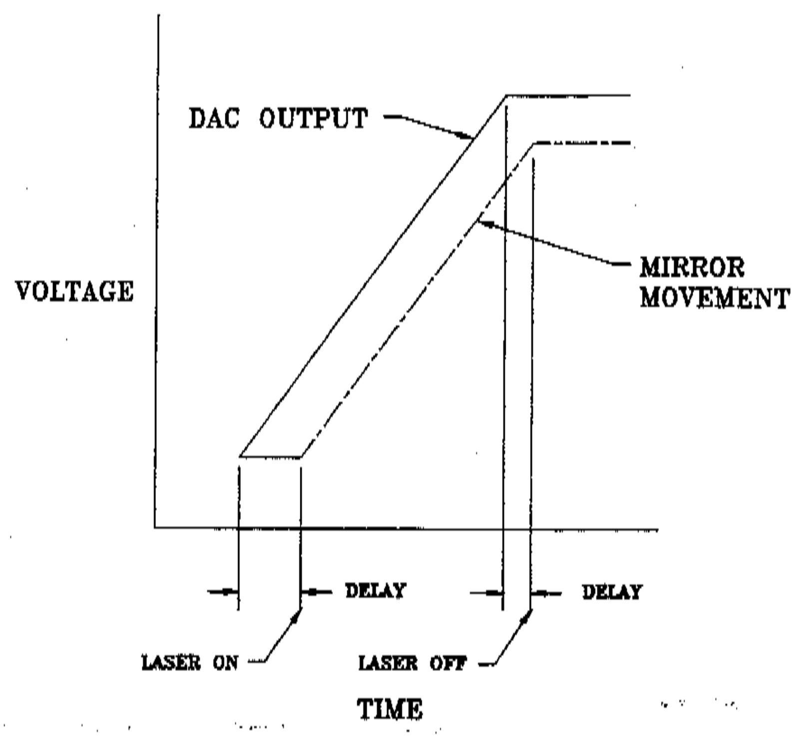


Diagram 24: Scanner Lag

Commands: LASER ON/OFF TIMING **(LO and LF)**

Symbols: Laser On = LO
Laser Off = LF

Syntax: LO<ARG>[CR] **Range:** LO = 20 - 65534 μs
LF<ARG>[CR] **Range:** LF = 2 - 65534 μs

Command Type: Immediate

Default Argument: LO = 290 μs
LF = 274 μs

Description: The **Laser On (LO)** command allows the user to turn on the laser after the scanner has begun moving. The scanner can not achieve its velocity instantly, it ramps to the scan rate with a small delay.

The **Laser Off (LF)** command allows the user to turn the laser off after the scanner has completed its motion. The scanner lags the final endpoint signal due to the delay caused by the initial ramping process.

Conditions:

1. Where <ARG> is a valid argument between 20 and 65534 for LO, and 2 thru 65534 for LF. Units of delay are in microseconds. Only even numbers of microseconds are implemented in the EDG.

2. These commands can not separate an X and Y coordinate pair.

3. LO and LF may be set independently.

Programming Tips: When LO is too long, the vector appears to start in the wrong place. When LO is too short, there is a bloom at the beginning of the line. If LF is too short the line does not reach the endpoint. If LF is too long, the end of the line blooms.

Example: LO200 [CR]
LF300[CR]

The laser turns on 200 μs after the DAC begins the vector ramp. The laser turns off 300 μs after the EDG has output the endpoint of the vector.

2.2.3.2 Continuous Vector Control

If the user is drawing an arc with a series of short vectors, the **Continuous Vector** mode (CV) command may be used to smooth the endings of the vectors. This makes the vectors appear to be a continuous line. This also may provide more uniform exposure of characters with many vectors. With very small vectors, the scanners do not reach full velocity, so the character tends to be overexposed.

The CV command causes the vectors following it, with the exception of the first and last vectors, to be executed without turning the laser off or pausing for the scanner delay between vectors.

Note: CV is only useful for Next (drawn) vectors. The first vector after the CV command starts with the normal scanner delay and laser on delay, but the laser does not turn off at the end of the vector. All the following vectors execute without the SD, LO, and LF delays until the NC (Not Continuous vector mode) command is sent. When the NC command is sent at the end of an arc, it causes the last vector sent before it to end with the laser turning off after the normal laser off delay. All the vectors following the NC command are executed in the normal fashion.

Command: CONTINUOUS VECTORS **(CV and NC)**

Symbol: Continuous Vectors = CV
Non-Continuous Vectors = NC

CV (CR) There is no argument for CV or NC
NC[CR]

Command Type: Table Command

Default Setting: Non-Continuous (NC)

Description: Continuous Vector (CV) generation means that the laser does not shut off between Next vector pairs. It is used when drawing arcs. The CV command smooths the appearance of the arc and speeds up the execution of the many small vector pairs that compose an arc. The execution speed increases because the laser does not shut off between vectors. The scanners do not delay before each vector pair.

Non-Continuous (NC) vector is the normal mode of operation. The scanners delay a set time between vector pairs. In the non-continuous mode the laser is modulated on/off .

Condition: The command cannot separate a vector coordinate pair.

Example: See programming example (Sec.2.4.0) for sample usage.

2.2.4 Vector Table Execution Control

The following commands execute the vector list in different ways. The four execution commands are **Clear Vector List (CL), Execute and Clear Vector List (EC), Execute and Maintain Vector List (EX),** and **Repeat Execution of the Vector List (RX).**

Command: CLEAR VECTOR LIST

Symbol: CL **Syntax:** CL[CR] No argument is allowed

Description: The **Clear List** (CL) vector table command clears the vector list, thus enabling a new list of vector coordinates to be entered without execution.

Command: EXECUTE and CLEAR VECTOR LIST

Symbol: EC **Syntax:** EC[CR] No argument is allowed.

Description: The vector list may be executed with three different commands. The EC (Execute and Clear table) command is used most often. This executes the list of vectors, remains at the last point of the list, clears the list, and returns to the input mode for the next set of vectors to be downloaded.

Command: EXECUTE and MAINTAIN VECTOR LISTS

Symbol: EX **Syntax:** EX[CR] No argument is allowed.

Description: The **Execute** (EX) command executes the vector list without clearing the current vector coordinates. If the user Executes again, the same line(s) are drawn. If additional coordinates are sent, the new coordinates are added to the current list.

The EDG automatically jumps back to the beginning X,Y coordinates and enters the Input state once execution is completed. The EX command is useful for making many copies of the same vector file. For each copy send down EX, not the entire list.

Note: JX0, JY0, EX sequence jump to coordinate 0,0 and then return to the starting coordinate. Use JX0, JY0, EC to jump and stay at point (0,0).

Command: REPEATEDLY EXECUTE VECTOR LIST

Symbol: RX **Syntax:** RX[CR] No argument is required

Description: The **Repeat Execute (RX)** command continuously executes the vector list until interrupted by a hardware RESET. Use it for scanner tuning and other diagnostics when a continuously repeated pattern is needed. It is particularly useful when using an oscilloscope to measure scanner performance for speed, delay or laser control parameter selection. Hit RESET on the front panel to halt execution. The vector list, scanning, and laser control settings are cleared after a RESET.

Note: This mode is not normally used for laser scanning. It is primarily a diagnostic mode.

2.2.5 Utility Commands

There are two utility commands. The **Status (ST)** command monitors scanner status information via the host computer. The **Laser Test (TS0,TS1)** are intended for testing the system after the initial system set-up is completed.

The laser test commands are helpful when the scanning system is first configured as it helps to focus the spot on the target. It may also be used for laser power measurements and alignment procedures.

Command: TEST STATE LASER CONTROL **(TS1, TS0)**

Symbol: Turn Laser On in test state = TS1
Turn Laser Off at a static location = TS0

Syntax: TS1[CR] **Argument Range:** No argument is required.
TS0[CR]

Description: This command turns the laser on in the field. It is used primarily for laser power measurements, alignment, or focus procedures. Use TS1 to turn the laser on at the current X,Y position. TS0 returns the laser control back to its normal state.

Condition:

1. The laser is off while the TS1 command executes a vector command. After sending a vector command, the TS1 command must be reentered to turn on the laser.

2. TS1 may be sent anytime the scanners are stationary.

3. TS0 returns the DE to the drawing state (Exit Test mode).

Command: HARDWARE STATUS INQUIRY **(ST)**

Symbol: Status Command = ST

Syntax: ST[CR] There is no argument for ST.

Description: Sending the Status (ST) command to the EDG tests the status lines of the EDD boards and transmit the results over the serial port. The status lines reports on power, temperature regulation, over position, and error threshold status for each scanner. If all the Status lines read correctly, the EDG responds with a "No Errors" message for each channel. If there are errors, the EDG responds with the appropriate error message. For example, in response to an ST command the EDG might transmit the message:

NO X OR Y ERRORS
Z TEMPERATURE ERROR

This indicates that while the X and Y channels are ready, the Z scanner has not had time to reach the operating temperature.

Conditions: The RS232 port must be connected to obtain status information through the host.

Note: On systems without dynamic focus, reported Z errors can be ignored. Status Indicators are located on the front of the EDD boards .

2.3.0 Geometric Correction

The EDG CPU applies real time correction to every point of a vector. This geometric correction can compensate for flat field scanning errors for post or pre-objective scan systems. The correction grid is calculated based on optical and geometric considerations. The grid correction is computed in the EDG CPU by four point linear interpolation (Technique for X,Y, and Z coordinate calculations is described in Appendix 6).

The EDG CPU is capable of X,Y geometric correction and output of Z values through grid interpolation. The grid tables are stored in EDG RAM. The table contains 12,675 values (4225 each for X,Y,Z). Grid correction interpolates on a 65 by 65 point correction table. X and Y table data is Delta from input while Z is Absolute based on that X,Y location. In systems without Z, the table only contains the 8450 values required for X and Y.

2.3.1 Grid Correction Commands

Each time the DE is turned on, the grid table must be downloaded to the EDG. The program named **GRIDGEN.EXE** calculates grid tables for flat fields and creates a file. The user supplies the system variables (Detailed later in this manual). Users may develop their own grid tables (See Appendix 6).

Note: When power is first applied to the EDG, the grid table is all zeroes. A grid table must be downloaded to the EDG for Z systems or systems that require coordinate correction.

The user specifies grid correction variables based on the optics path. These variables enable the EDG's CPU to correctly interpolate from the grid table based on the specified system parameters (Technique for X,Y and Z coordinate calculations is described in Appendix 6).

If either the Z coordinates or X/Y correction is required, a correction table must be sent to the EDG. If the system does not require Z coordinates or geometric correction for X and Y coordinates, no grid correction table must be sent.

Programmer's Note: If no Z table data is sent, the Z scanner always resides at DAC zero.

The Grid Correction software has several commands associated with its operation. The **Load Table (LT)** command must be sent. It prepares the EDG for receiving and storing a correction table. The **Quit Load Table (QT)** command is used at the end of the grid table download. It returns the EDG to the normal input mode. The **Clear Table** (CT) resets the table. It may be used each time a new table is loaded. This insures that previously loaded information is cleared.

Once the **Load Table** (LT) command has been sent, the table is downloaded to the EDG. When transmission of the correction values has been completed, the **Quit Table** (QT) command must be sent to return the EDG to normal input mode. The table remains in RAM until either the power is turned off or a **Clear Table (CT)** command is sent.

Note: The correction table is **not** cleared by **RESET**. This allows use of the RX command without having to send the correction table down each time RESET is hit to exit RX. The table is cleared by power down.

Commands:	GRID CORRECTION COMMANDS **(LT, QT, CT)** Load Table, Quit Table, Clear Table	
Symbols:	Clear Table = CT Load Table = LT Quit Table = QT	
Syntax:	LT[CR] CT[CR] QT[CR]	There are no arguments used by these commands.

Description: The **Load Table (LT)** command is required to run the DE. This command loads the programmed grid table into the RAM of the EDG CPU.

The **Quit Table (QT)** command returns the EDG to normal input mode after the grid table has been downloaded.

The **Clear Table (CT)** erases the Grid Table.

Programmer's Tip: The LT and QT commands may be sent through either the serial or parallel port regardless through which port the table is sent . It is recommended that the LT and QT commands is placed in the correction table, saving the chore of manually sending LT and QT.

The General Scanning **GRIDGEN.EXE** program for flat field geometric correction and focus generation **automatically** inserts the **LT** at the beginning and a **QT** at the end of the generated correction table file.

2.3.2 How to Use the Geometric Correction Software

On power up and after RESET, the EDG transmits over the serial port a message that varies with different configurations and revisions. A sample message is:

GENERAL SCANNING INC.
DE3000 Version 3.01
the grid correction table is cleared

The EDG then waits in the input mode for commands from the host. On power up the grid correction table is cleared to zeros and the message "Grid Table Cleared" is sent through the serial port. The grid table is not cleared on RESET. At the prompt the correction variables may be downloaded to the EDG CPU via the serial or parallel interface. The parallel interface is recommended because of its speed in downloading.

Programmer's Note: A CT may be sent to clear an existing table. However, it is not necessary to clear a table prior to sending a new one if both files are the same length.

2.3.2.1 The Digital Electronics Disk

The disk included contains three MS DOS compatible files. The **GRIDGEN.EXE** generates the geometric correction grid and focus correction for flat field scanning systems. The corrections are based on the user's input of scanning system data. GRIDGEN.EXE calculates values and creates a file that may later be downloaded to the EDG. The GRIDGEN.EXE automatically inserts required commands LT at the start and QT at the end of the file for EDG download.

TEST.ASC was generated using GRIDGEN.EXE and the following input data (XY3037 Scan Head). This program may be used as a sample grid table program. **QD.EXE** is a fast parallel download program to send the grid correction table to the EDG BPC. Enter correction table name at the prompt. The parallel port connected to the EDG CPU should be LPT1.

Programmer's Note: Data files for scanning created by GSI Plotter software may be also downloaded quickly using QD.

2.3.2.2 How to Change Field Sizes:

The Grid Table needs the user to specify four variables. To set these variables run GRIDGEN.EXE:

1. Enter name of new table file

2. Set values for d,e,f

3. And type 1 (Yes) for reverse Z.

4. Name new grid table file

Variable Defined:

d: is the distance from center of Y mirror to target.
e: is the X to Y mirror separation.
f: is the field size.
Laser kits require reverse Z values.

Help Notes:

1. New table names are typically named *.ASC since they are ASCII data files. Be sure there is at least 90K free on disk. GRIDGEN runs faster if file *.ASC is sent to a hard disk.

2. The variable e is fixed at 3.7 cm for the XY3037 Scan Head. The last two numbers of the scan head model number represent the distance in millimeters between the center of the X mirror and the center of the Y mirror.

3. Since scanner angle is fixed at ± 20 degrees optical, f and d are related by: **f** = (.72794)**d** or **d** = (1.3737)**f**. Choose either f or d and calculate the other.

4. All kits with a Z-axis must reply 1 (Yes) to reverse Z value setting.

The test file named **TEST.ASC** on the disk uses the following settings:

d = 22.86 cm (9")
e = 3.7 cm
f = 16.641 cm (6.55")
Z translator is **reversed.**

2.3.3 Error Messages

Invalid commands or arguments sent to the EDG are ignored and a message is sent to the serial port. The EDG returns to input mode and waits for the next command. Lower case letters are **not** valid. They are ignored by the EDG CPU. Be sure to always use **UPPER CASE LETTERS** for commands (Lower case commands cause an error message and the EDG does not function properly).

If a character message is sent that is not a legal command, the command is ignored and the message is sent to the host via the serial port.

INVALID COMMAND: When arguments exceed the valid command argument range, the command is ignored and the message is sent to the host via the serial port.

INVALID ARGUMENT: Invalid argument is also used in Delta mode. It indicates that a relative move command would send the scanner out of valid argument range.

System Status error messages are covered in Utility Commands, Section 2.2.5

2.3.4 Hardware Reset

A RESET button is located on the front panel of the EDG CPU. Pressing this button stops execution and resets the microprocessor. The vector table is cleared, and scanning and laser control parameters are returned to their default arguments. The geometric correction table remains valid after a RESET. The General Scanning message is sent to the serial port.

RESET **ends** Repeat Execute mode. If using RX for scanner tuning, send scanning and laser control parameters again after each RESET .

The **ABORT** button on the front of the EDG halts the CPU execution but does not reset it. Always use the RESET button. If you press the ABORT button by accident, simply hit RESET to restart. Your vector list and scan parameters will be cleared.

2.4.0 Sample Program and Explanation

The following vector command list demonstrates the previously discussed commands. A detailed explanation follows the listing.

Note: [CR] stands for Carriage Return. Line numbers are for explanation reference only and cannot be included in actual vector command lists.

<u>Sample Program</u>

1. LT[CR] (send grid correction table after LT)
2. QT[CR]
3. ST[CR] (1 - 3 not required if GRIDGEN is used.)

4. CL[CR]
5. SS42[CR]
6. JS210[CR]
7. SD666[CR]
8. JD4700[CR]
9. LO200[CR]
10. LF290[CR]

11. JX32768[CR]

12. JY0[CR]
13. EC[CR]

14. JX10000[CR]
15. JY40000[CR]
16. NX20000[CR]
17. NY40000[CR]
18. NX20000[CR]
19. NY50000[CR]
20. NX10000[CR]
21. NY50000[CR]
22. NX10000[CR]
23. NY40000[CR]

24. JX51000[CR]
25. JY20000[CR]

26. CV[CR]

27. SS21[CR]

28. NX50994[CR]
29. NY20104[CR]
30. NX50978[CR]
31. NY20207[CR]
32. NX50951[CR]
33. NY20309[CR]
34. NX50913[CR]
35. NY20406[CR]
36. NX50866[CR]
37. NY20500[CR]
38. NX50809[CR]
39. NY20587[CR]
40. NX50743[CR]
41. NY20669[CR]

42. NC[CR]

43. JX5000
44. JY12000[CR]
45. DL[CR]
46. NX1000[CR]
47. NY63536[CR]
48. NX0[CR]
49. NY2000[CR]
50. NX64536[CR]
51. NY0[CR]

52. AB[CR]

53. JX32768[CR]
54. JY0[CR]

55. EX[CR]

Explanation of Command Listing

Line 1: Readies the EDG for receiving the Geometric Correction Table. When the table is generated by the "GRIDGEN" program, the LT and QT commands are automatically inserted. When using GRIDGEN, Lines 1 and 2 are not needed. They are used only for custom field correction programs if LT and QT are not included in the table.

Line 2: After the table has been transmitted the EDG returns to normal input mode. If X,Y correction and Z coordinates are not required, lines 1 and 2 are replaced by the CT command to clear the an existing correction table.

Line 3: Causes the EDG to report on the status of the hardware if a terminal is connected to the serial port (Optional command).

Line 4: Clears any coordinates that remains in the vector table.

Line 5: Sets the Step Size to 42 LSBs. A vector across the full field (0,0 to 65535,0) takes (65535 / 42) * 270 µs or about 421 ms to draw.

Line 6: Sets the Jump Size to 210 LSBs. A jump across the full field (0,0 to 65535,0) takes about 84 ms.

Line 7: Sets the Scanner Delay to 666 µs. The scanners settle for 666 µs before starting each non-continuous drawn vector.

Line 8: Sets the Jump Delay to 4700 µs. The scanners settle for 4.7 ms after executing a Jump.

Line 9: Sets the Laser On delay to 200 µs. The EDG sends the Laser On trigger pulse 200 µs after the coordinates for the first step of a non-continuous drawn vector have been output to the EDD boards.

Line 10: Sets the Laser Off delay to 290 µs. The laser remains on for 290 µs after the endpoints of non-continuous drawn vector have been output to the EDD boards.

Lines 11 - 13: Jump the scanners to an "off-field" position and park them so that any laser light leaking from the user's modulator does not expose the target area during large vector table download. The user's imaging target area has to be smaller than the digital full field for this purpose. These coordinates are the starting point for the next vector list.

Lines 14 - 23: Jump the scanners to the upper-right quadrant of the field with the laser turned off, then draw a square with the laser turned on.

Lines 24 and 25: Jump the scanners to the lower-left quadrant of the field with the laser off.

Line 26: Puts the EDG in Continuous Vector mode for the vectors that follow.

Line 27: Changes the Step Size to 21 LSBs. The vectors that follow are drawn half as fast as the previous vectors.

Lines 28 - 41: Draw a small arc in a clockwise direction. Because the EDG is now in Continuous Vector mode, the laser remains on. There is no Scanner Delay between vectors.

Line 42: Ends Continuous Vector mode. The laser turns off after the last vector before this command. All timing delays are reinstated.

Lines 43-51: Demonstrate using DeLta mode to draw a triangle. First the scanners are jumped in ABsolute mode to 5000,12000. Line 45 causes the EDG to interpret the following vector arguments as relative moves by entering DeLta mode. The next 6 lines are relative Nexts that draw three sides of a triangle. The three vectors create lines with endpoints at absolute coordinates 6000,10000; 6000,12000; 5000,12000.

Line 52: Returns the EDG to ABsolute mode.

Lines 53 and 54: Return the scanners to their beginning off field position with the laser off.

Line 55: Executes the vector list and leaves it in memory to be executed the next time an EX command is sent. The RX command causes this list to be executed repeatedly until the EDG is reset. The EC command executes the list once and then clears the list.

Notes:

1. When using the EX or RX commands to execute a vector list, the scanners slew to their beginning coordinates immediately after completing the list.

2. None of the motions from coordinates in line 14 through 54 occur until the execute statement is sent.

2.5.0 Optimizing Vector Output

Different scan heads require different scanner speed and settling time parameters. Consult General Scanning's *X-Y Scan Head* manual and BE PREPARED TO EXPERIMENT to determine the most effective values for your particular system. Suggested beginning parameter values for various scan heads are listed in the Appendix 7.

Faster scan rates may decrease scanning repeatability. Slower scan rates may be required if laser power is limited. Jump and Step delays and rates are application dependent for optimized performance. Typical Next and Jump Vector length, performance criteria, and material characteristics must be considered to select optimum performance.

The user may also want to experiment with different speeds for different length vectors and the Continuous Vector mode command for optimum performance from high resolution fonts.

The most effective Laser On/Off timing for your system depends on a number of other factors, including the type of laser being used and the system controlling its output. Some experimentation by the user is required to determine the best LO and LF values.

Large Vector files and geometric correction files should be sent through the parallel port to decrease download time. A high speed machine language printer output routine should be written for the host PC to send large files. The DOS print or BASIC print commands slows vector throughput significantly.

Correction for skew, squareness, gain, offset, or flat field lenses may be done by the EDG by modifying the geometric correction table prior to download.

Delta mode programming increases host computer vector computation efficiency. This is particularly useful for font generation, logos, or special graphics images that are repeated in many locations in the field.

The image may be stored in delta values and plotted out at any location by first jumping in Absolute mode to a beginning location and then drawing the character using deltas. This is accomplished without the host doing the additional math of adding offset to all the vectors that are required by absolute mode. This additional math slows the host down during vector generation. Step and repeat patterns are easily accomplished if the pattern is in Delta mode and Delta Jumps are used between images.

Chapter 3: Quick Reference Guide

3.1.0 Glossary

AGC: Automatic Gain Control regulates the supply voltage used by the galvanometers' position sensors. This helps maintain position repeatability.

Baud Rate: The rate at which data is sent over the RS-232 line in bits/second. The DE requires the baud rate set for 9600.

Centronics: It is a brand name of the printer company that established a PC industry standard parallel port for printers to communicate with hosts byte by byte.

Closed Loop Servo Amp: Refers to the portion of the EDD cards that controls the drive current to the galvanometers. It is based on position feedback from the scanners.

DAC: Digital to Analog Converter.

Data bits: It is the number of data bits in a serial ASCII transmission, usually either 7 or 8. The DE's serial port (RS-232) is set to 8.

DE: Digital Electronics unit which controls General Scanning's galvanometer scanners in an X,Y or X,Y,Z system.

ECF: The Euro Card Frame houses the DE's circuit cards, backplane, power supply.

EDD: The Euro Digital Driver controls the galvanometers with digital input data.

EDG: The Euro Digital Generator section of the DE controls vector generation and maintains system timing.

EDG CPU: EDG Central Processing Unit computes and corrects digital X,Y and Z coordinates. The EDG CPU serves as the brain for the DE.

EDG PIO: EDG Parallel Input/Output provides parallel data input and output as well as timing for the CPU.

EDG 12V: EDG 12V supplies the voltage required by the RS-232 circuitry.

EFT: Euro Fan Tray cools the DE electronics in open rack configurations.

EIC: Euro Interface Card provides the modulation signals to the laser, accepts the parallel input, and functions as a bridge between the EDG and EDD cards.

EPS: Euro Power Supply supplies the DC power required to operate the DE circuit cards from an AC line.

Galvanometer: A electro-magnetic drive motor that uses current to produce a magnetic flux that deflects a rotor. The galvanometer may be used to move a mirror mounted on the rotor.

Geometric Correction: Refers to correcting coordinates in order to reduce scanning errors.

GRIDGEN.EXE: GRIDGEN is a software program that generates the information the EDG requires to correct the coordinates for a particular scanning system. The GRIDGEN program provides correction for flat field scanning.

Grid Table: GRIDGEN, as well as other software programs, creates a grid table. This table is a matrix of points. The EDG uses the grid to generate the correction required for each coordinate.

GSI Scanner Bus: This is the cable that connects the EDD cards to the EIC. It contains a digital signal for the scanner coordinates and status.

Heater Blanket: The insulator that wraps around the galvanometer to stabilize its temperature. It reduces errors from thermal drift.

HPGL: Hewlett Packard Graphics Language, a standard pen plotter language.

Jump: A command that refers to a vector being executed with the laser off.

Linear Translator: A specially designed galvanometer-driven device that translates angular motion into linear motion. The linear translator moves a lens back and forth to insure that the light spot stays in focus across the entire scanning field.

Mirror Separation: The distance between the center of the Y mirror and the center of the X mirror (in cm).

Next: A command that refers to a vector being executed with the laser on. Next is the equivalent of pen down in HPGL.

Parallel: The transfer of data multiple of bits at a time. The DE uses a Centronics 8-bit parallel bus standard that transfers a byte (an ASCII character) at a time.

Parity: An error checking scheme that may be set to Odd, Even, or None. The DE serial port (RS-232), is set to none, which indicates that parity checking is not used.

Scan Angle: The maximum angular deflection in either axis.

Scan Radius: The distance from the center of the Y mirror to the center of the target (in cm).

Serial Input: The transfer of data where the data is transmitted one bit at a time. The DE uses an RS-232 as its serial port standard.

Settling Time: The time required for a scanner to come to rest at a new position.

Slew Rate: Refers to the rate that the voltage level is changed. The faster the slew rate, the faster the galvanometers deflect the mirror.

Stop Bit: The number of separations in a serial transmission between ASCII bytes. It can be set to either 1 or 2. The DE serial port (RS-232) is set to 2.

Vector: A motion with magnitude and direction specified by current location and sending locations.

Vector Pair: A set of X and Y coordinates that define the endpoint of a vector.

VME BUS: A standardized bus format that uses 96 pins. The EDG boards are VME compatible.

XON/XOFF: Refers to characters sent between the host and DE for software handshaking over the RS-232 line. The DE supports the software handshaking. It should be active for the host to function properly.

3.2.0 Quick Look-up Command Charts

Command	Valid Range	Units	Power Up Default	Function
NX	0-65535	LSB's	32768	X endpoint of drawn vector.
NY	0-65535	LSB's	32768	Y endpoint of drawn vector.
JX	0-65535	LSB's	32768	X endpoint of non-drawn Jump.
JY	0-65535	LSB's	32768	Y endpoint of non-drawn Jump.
SP	270-65534	µs	270	Time between vector steps.
SS	1-32767	LSB's	32	Incremental Next Step Size.
JS	1-32767	LSB's	512	Incremental Jump step Size.
SD	2-65534	µs	4	Delay prior to NEXT vectors.
JD	2-65534	µs	1000	Delay after JUMP vectors.
LO	20-65534	µs	290	Laser On delay.
LF	2-65534	µs	274	Laser Off delay.

Mode, Utility, and Execution Commands

Command	Function
CV	Enter Continuous Vector mode.
NC	Non Continuous vector mode. (Default normal operation)
AB	ABsolute vector entry mode. (Default mode)
DL	DeLta vector entry mode.
ST	Request for system STatus.
CL	CLear vector list.
EC	Execute and then Clear vector list.
EX	EXecute stored vector list.
RX	Continuously Repeated eXecutes. RESET to stop.
LT	Enter Load geometric correction Table mode.
QT	Quit (exit) load correction Table mode.
CT	Clear correction Table. Fills grid with zeros.

3.3.0 Trouble shooting Guide

Problem	Probable Cause	Possible Solution
	Hardware Problems	
NO POWER TO THE DE	1. Loose plug connection. 2. Wrong power jumper connection. 3. Blown fuse in power supply.	1. Reinsert cord. 2. Refer to Section 1.1.6 for power jumper set up. 3. Replace fuse.
NO POWER TO ANY DE CIRCUIT	1. Loose circuit card. 2. Blown fuse in the power supply. 3. Hardware or software error.	1. Reinsert affected card. 2. Replace fuse to the power supply. See Section 1.2.4. 3. Check total system.
SCANNERS DO NOT MOVE	1. Loose scanner cable connection. 2. No power to EDD Card	1. Reconnect scanner cable to EDD card. 2. Check fuse in power supply.
RS232 WILL NOT WORK	1. Plugged into Jb port. 2. No power to EDD card.	1. Reconnect into Ja port and reset. 2. See Appendix 2 for pin out and port information.
LASER WILL NOT MODULATE	1. Incorrect EIC jumper connections 2. BNC is not signaling properly.	1. Rework EIC jumper set up. 2. Check the BNC signal output with an oscilliscope.
DE IS HUNG UP	1. Information sent over parallel and serial at the same time.	1. Press reset button on EDG CPU. 2. Disconnect serial cable and press reset.

Problem	Probable Cause	Possible Solution
	Hardware Problems	
IMAGE IS SIDEWAYS AND DISTORTED	1. Scanner cables are not connected to the proper port.	1. Check scanner connection and change scanner cables accordingly.
EDD TEMPERATURE LIGHT IS OFF	1. Scanners are not warmed up. 2. Ambient temperature too high or too low. 3. Scanners are overheated.	1. Wait for warming. 2. Control environment. 3. Check current signal using the diagnostic port.

Appendix 2 **VME Bus Pin-Out**

VME BUS Pin-Out
(Reference only)

Pin	Row A	Row B	Row C
1	D00	/BBSY	D08
2	D01	/BCLR	D09
3	D02	/ACFAIL	D10
4	D03	/BG0IN	D11
5	D04	/BG0OUT	D12
6	D05	/BG1IN	D13
7	D06	/BG1OUT	D14
8	D07	/BG2IN	D15
9	GND	/BG2OUT	GND
10	SYSCLK	/BG3IN	/SYSFAIL
11	GND	/BG3OUT	/BERR
12	/DS1	/BR0	/SYSRESET
13	/DS0	/BR1	/LWORD
14	/WRITE	/BR2	AM5
15	GND	/BR3	A23
16	/DTACK	AM0	A22
17	GND	AM1	A21
18	/AS	AM2	A20
19	GND	AM3	A19
20	/IACK	GND	A18
21	/IACKIN	SERCLK	A17
22	/IACKOUT	/SERDAT	A16
23	AM4	GND	A15
24	A07	/IRQ7	A14
25	A06	/IRQ6	A13
26	A05	/IRQ5	A12
27	A04	/URQ4	A11
28	A03	/IRQ3	A10
29	A02	/IRQ2	A09
30	A01	/IRQ1	A08
31	-12V	+5 STDBY	+12V
32	+5V	+V	+V

Note: / indicates active low signal

Appendix 3 **Scanner Connector Pin-Out**

Scanner Connections

Description	Pin
DRIVE HIGH	1,9
DRIVE LOW	2,10
POSITION (+)	3*
SIGNAL GND	4
HEATER LOW	5
(RESERVED)	6
HEATER HIGH	7
AGC OUT	8
POSITION (-)	11*
AGC SENSE	12*
AGC GND	13
(RESERVED)	14
THERMISTOR	15

Notes: The scanner connector is a 15 Pin D-sub Socket (female) Amlan CDF15P or equivalent.

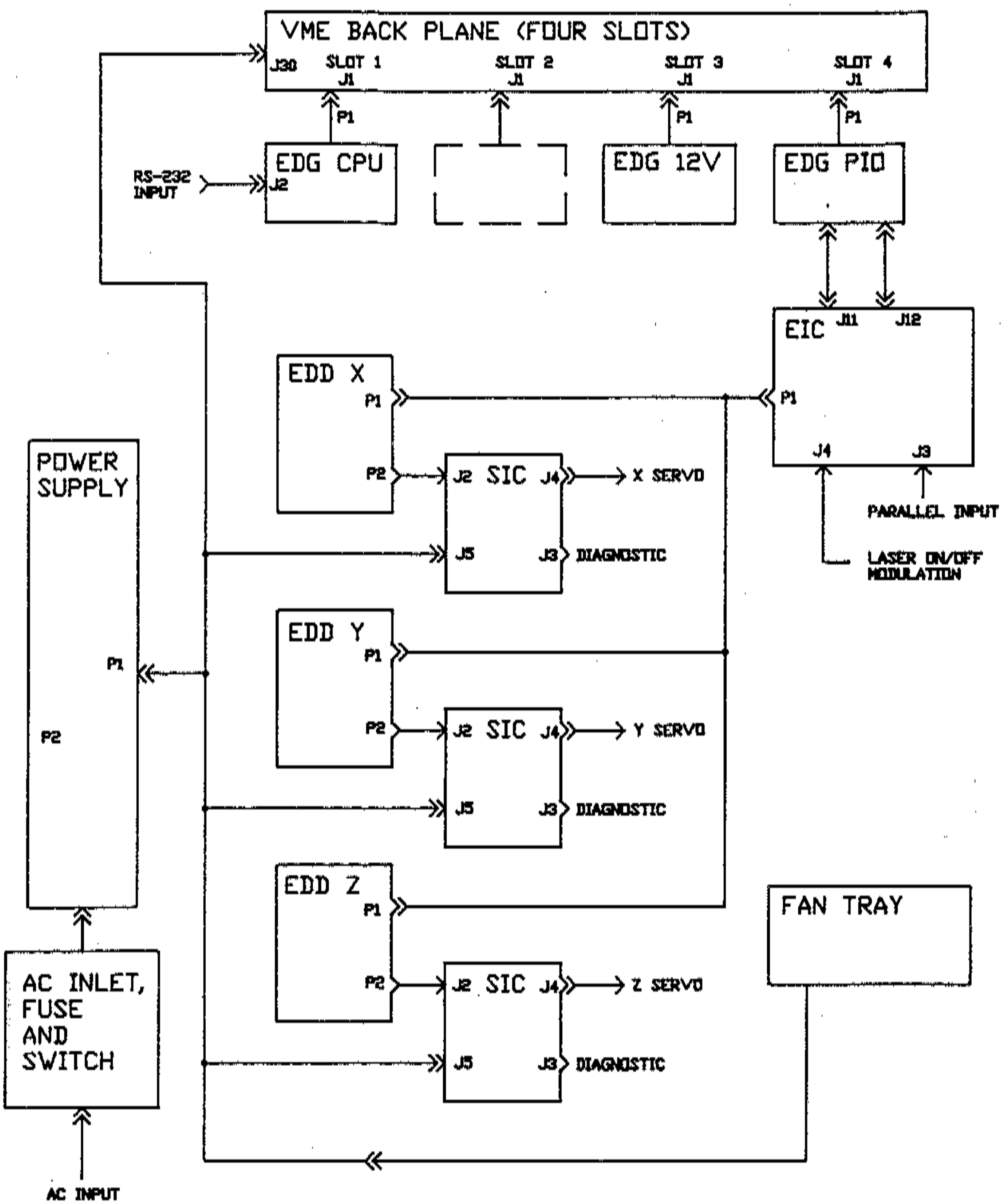
*If making a cable these lines need to be shielded using the signal ground.

Appendix 4 **Parallel (Centronics) Interface Pin-Out**

Pin #	Signal	Comment
1	/ Strobe	Input to DE
2	Data 0	LSB
3	Data 1	
4	Data 2	
5	Data 3	
6	Data 4	
7	Data 5	
8	Data 6	
9	Data 7	MSB
10	/ACK*	Non Connection
11	Busy	Output
12	Paper	Tied Low
13	Select	Tied High
14-18	AF, SG, FG, +5	No Connection
19-30	GND	GROUNDS
31	/Int	No Connection
32	/Fault	Tied High

* The DE supports only Busy handshaking and does not send /ACK.

Appendix 5 **DE Block Diagram**



DE 3000 BLOCK DIAGRAM

point to exceed 65535. Negative deltas must never cause a point to be less than 0. They cause wrap around transients that may damage scanners.

Any correction grid coordinate at X or Y equal to 0, X or Y delta corrections, therefore, must be positive or zero. At a grid coordinate X or Y equal to 65535 (64K), X or Y delta corrections must be negative or zero. Similarly at all other grid points, the value of the correction in the direction of the edge must not exceed the distance to the edge.

All grid correction schemes, therefore, must be based on reducing the 0 to 65535 range to achieve desired angles. The maximum scanner angle required is set to 0 and 65535 (Typical maximum angle is 20 degrees optical. Consult General Scanning's *X-Y Scan Head* manual for your particular model).

It is advised that new grid correction schemes be tested using the DAC signals on the EDD diagnostic connector with the scanners disconnected. Run various scans and watch for discontinuities that indicate under or overflow wrap arounds. Particular attention should be paid to boundary coordinates. The newly generated grid correction table might also be tested using a computer algorithm that checks each grid point.

Correction Grid Order of Data

The data is stored in the table in three blocks of 4225. First sent is 4225 delta Y corrections, next the 4225 delta X corrections, and finally the 4225 Z coordinates. Systems without Z need only to send the 8450 values required for X and Y.

The data for each block is sent for X,Y (0,0) first. Then increments in X by 1024 until reaching (65535,0). The next row starts with (0,1024) through (65535,1024). The last grid coordinate in each section is (65535,65535). The list below illustrates the order of data entry. The dY or dX stands for Y or X delta correction data at a X,Y grid point. Z represents the Z coordinate data at the X,Y grid point.

The LT (Load Table) command must be sent in order to prepare the EDG for receiving and storing a correction table. The QT (Quit load Table mode) command is used at the end to return to normal input mode. It is recommended that the LT and QT commands be included in the correction table to save the user the task of manually sending them. Refer to Section 5 for table command information.

Point #	Data (X,Y Grid Point)
	LT
1	dY(0,0)
2	dY(1024,0)
3	dY(2048,0)
	.
	.
65	dY(65535,0)
66	dY(0,1024)
	.
	.
4225	dY(65535,65535)
4226	dX(0,0)
4227	dX(1024,0)
	.
	.
4290	dX(65535,0)
4291	dX(0,1024)
	.
	.
8450	dX(65535,65535)
8451	Z(0,0)
8452	Z(1024,0)
	.
	.
12675	Z(65535,65535)
	QT

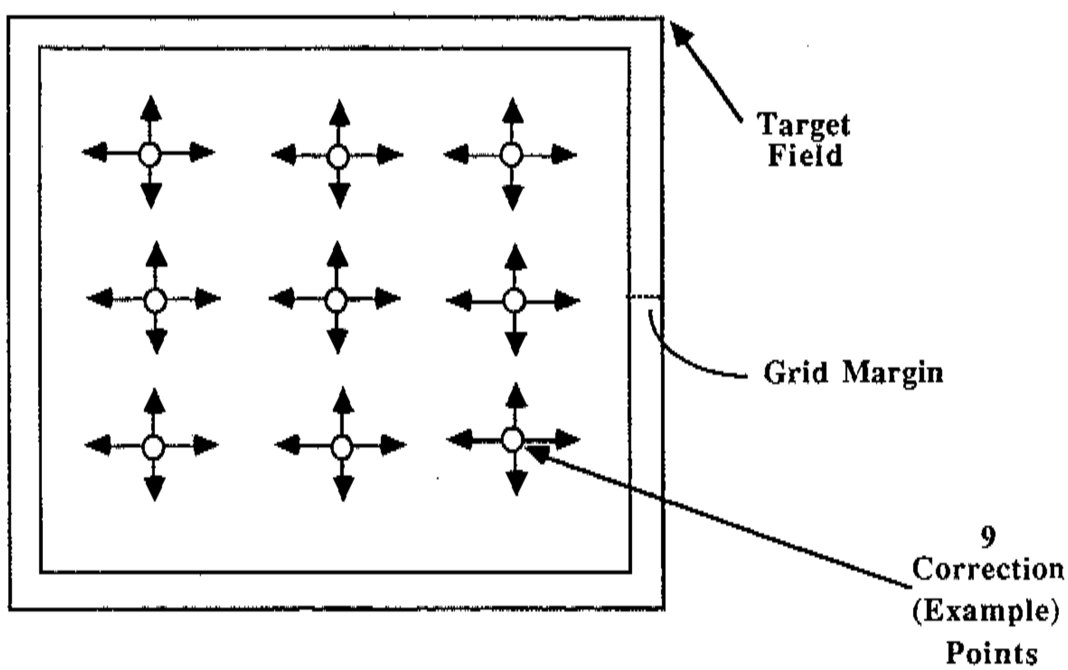
Appendix 7 **Field Measurement Multiple Point Grid Correction**

For DE Series users who require greater scanning performance, General Scanning has developed a software module to improve positional accuracy two times or more.

Field grid correction software allows the users of grid generation (DE theoretical table generator) to input the measured field values of coordinate placement versus the theoretical position on the target plane.

9-Point Correction

The 9-point correction option allows the user to measure and input delta values for correction that differ from the X,Y locations on a calibrated test target (See below).



This scaling program gives the user the capability of calibrating initial offset/gain errors in the scan system. Scanner positional accuracy may be calibrated to equal scanner repeatability. This procedure is typical in initial system set-up where accuracy requirements are demanding.

2-Point Correction

The 2-point correction option allows the user to check the system quickly when necessary. Measurements on the X axis, the Y axis, or both axes can be taken to check both gain or offset changes in the scanning system. This may improve axial linearity between the X and Y axes.

You may want to incorporate this procedure into your preventive maintenance schedule.

Appendix 8 Typical Scanning Parameters for General Scanning Scan Heads

A list of software parameters are listed below for the EDG CPU. Commands must be sent after power up or RESET. Default parameters reside in EDG CPU ROM and are used on power up. The X,Y and Z galvanometers were tuned with typical values. They are a good starting place.

Faster scan rates may decrease scanning accuracy. Slower scan rates may be required if laser power is limited. Jump and Step delays and rates are application dependent for optimized performance. Typical Next and Jump vector length, performance criteria, and material characteristics must be considered to select optimum performance.

XY3037 Scan Head

Command	Default	Typical	Units	Comments
SS	32	122	LSB	Next vector Step Size
JS	512	260	LSB	Jump vector Step Size
SD	4	5700	µs	Scanner Delay
JD	1000	10700	µs	Jump Delay
LO	290	900	µs	Laser On Delay
LF	274	1500	µs	Laser Off Delay

Note: On power up, in addition to scanning defaults, a Correction Table may be sent prior to scanning. There is no focus as well as geometric distortion unless a correction grid is sent. The table remains valid after RESET. To change the table either send a new one or a CT to clear it to zeroes.