2200SLE single grain laser scanner Revision 0.0 4/4/2003
Command Structure

This document specifies the commands and coomunications protocols for the 2200SLE single grain laser scanner. It is based on the original firmware specification, and as development continued, some of the commands became redundant, or were not implemented initially. As a more comprehensive user manual gets written, this document will get cleaned up.

Commands are sent to the device using the following format:

```
]nnx n0 n-1<CRLF>
```

']' - Left Bracket is the identification of a command input string.

nn - Is the Command to perform. There must be one or two characters in the command field. There may be a space before it.
E.G. To send a command to turn on echo.
]90<CR>
To send a command to initialize the system.
]0<CR>

x,y...z - The values input. They can be any of the following.
- Values are separated by any character other then a Minus, Plus, Digit ('-','+', '0-9'). A <space> is the usual delimiter.

Data Formats:
Integer (16 bit signed/unsigned)
Float
At present, only signed integers are used.

<CRLF> - This indicates the end of the command string. The termination of the command string can be any combination of these control characters, or even lacking one of the control characters. But, there must be atleast one of these control characters present to terminate the command.

EG:

```
]90<CR>               - This would set the echo on, if off (default = OFF).
]0<CR>                - This would call the function Initialize()
]2 -2000 1000  - This would call command 2 and pass parameter 1 as
                 -2000 and parameter 2 as 1000.
```

Error Codes:

0	OK
-1	Bad Command Number
-2	Bad Parameter
-3	Too Few Parameters
-4	No Disk Detected
-5	Could not acquire index
-6	Communications Timeout
-7	Actuator #n Timeout
-8	Command Buffer Overrun (too many characters)
-9	Bad Command String identifier
-10	Other error
-20	Starting too far from the edge of the disk (LineScanReport)
-21	Starting too close to the edge of the disk (LineScanReport)
-22	A raw Threshold not found
-23	The filtered threshold not found
-24	No Reflectivity Found
-25	Edge Not Found
-52	External laser Control Timeout.

The following is a list of input commands:
Command - Function

---

00 - Initialize()
DESCRIPTION: Acquire disk orientation.

REPORTS:
Theta, xdac_center, ydac_center, xScale, yScale
REPORT FORMAT- SERIAL COMM &f f f f f<LFCR>

INPUT: None
LIMITS: None

01 - GetStatus() NOTE: NOT IMPLEMENTED
DESCRIPTION:
INPUT:
LIMITS:

02 - MoveXYCenter(x, y)
DESCRIPTION: Move to xy position relative to disk center (i.e. untransformed coordinates, orientation hole is up)
INPUT: Parameter 1: x Value
Parameter 2: y Value
OUTPUT: &x1,y1 x2,y2\n\r

x1,y1 Micron Units (float)
x2,y2 DAC Units (Integer), as transformed
LIMITS:

03 - MoveXYAbs(int x, int y)
DESCRIPTION: Moves the laser to the x,y position
INPUT: x: -2048 to 2048
y: -2048 to 2048
LIMITS: as above

04 - Shutter() NOTE: NOT IMPLEMENTED as shutter not required for this version of instrument
DESCRIPTION: Open Shutter
INPUT: 0 = Close Shutter
1 = Open Shutter

05 - MoveToPosition(pos)
DESCRIPTION: This command will move to the 'pos' hole number.
INPUT: Hole number 0 - 99 (depends on the holes per row)

LIMITS: None.

06 - LaserPower(power, task)
DESCRIPTION: Controls laser intensity and mode of operation
INPUT: Power = 0 Set Laser power off
Power > 1 - 4095 Set Laser power
Power = < 0 Set Laser power with external intensity control signal

task = 0 Use internal intensity control
task = 1 Wait for External Enable Control PD3 to go low,
Turns off when PD3 goes high.

NOTE: During external events, there is a 100 second timeout in the event an external event does not occur.

07 - FilterWheel() NOTE: NOT IMPLEMENTED
DESCRIPTION:
INPUT:

```
08 - Dither()          NOTE: NOT IMPLEMENTED
     DESCRIPTION:      Enable dithering of beam position with parameters.
     INPUT:            Diameter =     Size of the sample hole
                                      > 0 run function.
                                      == 0 Turn Off
                       Grid           =       In microns
                       Mode           =  0 = raster
                                      1 = circle
                       Dwell          =       Number of millisecs at one point.



09 - DumpGlobalParameters()  NOT IMPLEMENTED—SEE COMMAND 29
     DESCRIPTION:      This function will dump System Globals in either
                       a labeled format or unlabeled format.
     INPUT:            0       -       Unlabeled format.
                       1       -       Labeled format.

                       Unlabeled format:
                              &n n n n n n n n n n ....

                       Labeled example:
                              Laser Power = 100        Disk Diameter = 9700    ....


10 - SelectLaser()     NOTE: NOT IMPLEMENTED for future version of instrument
     DESCRIPTION       Selects the laser type
     INPUT:            0 = Green, 1 = IR


20 - LineScanReport()
     DESCRIPTION:
     INPUT:    int xyStart           0 - 4096
               int iQuad             1, 2, 3, 4
               int iNPoints    0 - MAX_LINE_SCAN_POINTS (300)
               int iVerbose    0 = VERBOSE_OFF
                               1 = VERBOSE_SERIAL_ON (SERIAL COMM)
       `                       2 = VERBOSE_TTY_ON (stdio terminal,debug only)


               BOOL bEdge      0 = RISING_EDGE
                               1 = FALLING_EDGE

21 - ArcScanReport()    NOTE: NOT IMPLEMENTED
     DESCRIPTION:      Finds edges of either 1 or 3 hole and reports the x1,y1 and x2,y2, theta1,
                       and theta2
     INPUT:            1 = Quadrant 1 Orientation Hole, 3 = Quadrant 3 Orientation Hole.
     LIMITS:           None.

22 - FindCenter()
     DESCRIPTION:      Finds the disk Center
                                      Might have to call ]40 to initialize.
     INPUT:                  None
     LIMITS:

23 - FindHoleCenter()
     DESCRIPTION: Finds the hole center.
     INPUT:
     LIMITS:
     RETURN:   - error code
               - writes to comm the center points.


26 - SetFindOnlyLaserPower( int iPower )
     DESCRIPTION: Sets the power for the linescan function.
               Sets variable GiSetFindOnlyLaserPower
               Default: 200
     INPUT:    0 - 4096
     LIMITS:
```

```
28 - HoleLineScanReport()     /////////////// NOT IMPLEMENTED FUNCTION OBSOLETED
     DESCRIPTION:             Finds the for quadrant edges.
     INPUT:    int xStart     0 - 4096 x Center point
               int yStart     0 - 4096 y Center point
               int iQuad      1, 2, 3, 4
               int iVerbose   0 = VERBOSE_OFF
                              1 = VERBOSE_SERIAL_ON (SERIAL COMM)
                              2 = VERBOSE_TTY_ON (stdio terminal, debug only)
```

```
29 - DumpVariables()
       DESCRIPTION:   Dumps global variables in either raw format or formatted.
       INPUT:         0 - Dump variables unformated
                      1 - Dump variables formatted

       Unformatted:   & GiPhotoGain GiLaserPower ... CRLF
       Formatted  :   GiPhotoGain = xxxxxx GiLaserPower = .....

       Format: (order)                     Data Type
       ------------------------------------------
       GiPhotoGain                         integer
       GiLaserPower                        integer
       GiLaserState                        integer
       GfXScaleFactor                      float
       GfYScaleFactor                      float
       GiHolePerRow                        integer
       GiDiskDiameter                      integer
       GiSampleGrid                        integer
       GiHoleDistance                      integer
       GiHoleSize                          integer
       GiNHoles                            integer
       GiXYStart                           integer
       GiMaxAngle                          integer
       GfThreshold                         float
       GiSetFindOnlyLaserPower             integer
       GiPointsPastThreshold               integer
       GiLaserExtTimerEvent                integer
       GbUseExtDAC                         integer
       GfDelta                             float
       GfBeta                              float
```

```
////////////////////////////////////////////////////////
////////////////////////////////////////////////////////
              START of Parameter set functions
////////////////////////////////////////////////////////
////////////////////////////////////////////////////////
40 - FactorySetup()
       DESCRIPTION:   Initialize all data to factory setup Data values.
       INPUT:  none
       LIMIT:
       IMPORTANT NOTE: this is done automatically whenever the backup battery power has been
disconnected (i.e., new battery or new microprocessor sub-board).  In this circumstance you must do
the calibration command ‘]62’ to set the x and y scale corrections before proceeding to do
measurements.

41 - SetGfDelta()
       DESCRIPTION:   Filter Delta
       INPUT:  Type int
       LIMIT:
42 - SetGfBeta()
       DESCRIPTION:   Filter Beta
       INPUT:  Type int
       LIMIT:
43 - SetGiPhotoGain()
       DESCRIPTION:   Current Photo Gain
       INPUT:  Type int
       LIMIT: 0-3  default 0 is highest gain
44 - SetGiSampleGrid()
       DESCRIPTION: Sample grid
       INPUT:  Type int
       LIMIT:  default 600 Microns
45 - SetGiHoleDistance()
       DESCRIPTION:   Distance between holes
       INPUT:  int
       LIMIT:  default 8000 microns
46 - SetGiHoleSize()
       DESCRIPTION:   Sets Hole size
       INPUT:                 int
       LIMIT:                 default = 400 microns
47 - SetGiNHoles()
       DESCRIPTION:   Sets sample array default holes row.
       INPUT:                 int
       LIMIT:                 default = 10 (10 x 10 = 100 holes)
48 - SetGiDiskDiameter()
       DESCRIPTION:   Sets disk diameter
       INPUT:                 int
       LIMIT:                 default = 9700 microns
49 - SetGbUseExtDAC()
       DESCRIPTION:   Set the external DAC Use
       INPUT:                 int
       LIMIT:                 Default = Internal
50 - SetGbUseExtEnable()
       DESCRIPTION:   Set the external enable
       INPUT:                 int
       LIMIT:                 default = Disabled
51 - SetGiThreshold()
       DESCRIPTION:   Set Threshold
       INPUT:                 int 0 - 5000 millivolts
       LIMIT:                 default = 1500
52 - SetGiPointsPastThreshold()
       DESCRIPTION:   Set the pre/post Points for peak detection threshold
       INPUT:                 int
       LIMIT:                 default = PRE_POST_SAMPLES
                              NOTE: It is not recommended to set this
                              parameter. Mainly used for development.
53 - SetGiXYStart()
       DESCRIPTION:   Set the x, y start for linescanning ONLY
       INPUT:                 int
       LIMIT:                 0 - 2047
```

```
54 - SetGiCenters( Type, value x, value y )
       DESCRIPTION:   Sets the x, y centers for either the holes or disk Centers.
       INPUT:                Type = 0 - Reset Both x, y to zero
                             Type = 1 - Set Disk Edge Center
                             Type = 2 - Set Hole Center
                             Value range: -2048 to 2048
55 - SetGiNPoints( int iValue )
       DESCRIPTION:   Sets the max points to scan in linescan routines
       INPUT:                0 to MAX_LINE_SCAN_POINTS - 1
56 - SetGiMaxAngle( int iValue )
       DESCRIPTION:   Sets the max angle either side of hole for linescanreport routines
       INPUT:                0 to 360 ( DEFAULT: 15 )
57 - SetGiLaserExtTimerEvent( int iValue )
       DESCRIPTION:   Sets the Time out for external laser control
       INPUT:                0 to 3600 (1 hour) ( DEFAULT: 100 seconds )
////////////////////////////////////////////////////////
////////////////////////////////////////////////////////
              END Parameter set functions
////////////////////////////////////////////////////////
////////////////////////////////////////////////////////
```

```
////////////////////////////////////////////////////////
////////////////////////////////////////////////////////
              START OF SET UP COMMANDS
////////////////////////////////////////////////////////
////////////////////////////////////////////////////////
60 - DrawPattern()
       DESCRIPTION:   This function command will display either a circle or a box on the disk.
       INPUT:         xStart - starting x OFFSET (make 0 to center)
                      yStart - starting y OFFSET
                      iRadius - this is the circle radius or the length of
                                the box sides.
                      iType   -    0 = BOX, 1 = Circle

61 - DumpReflectivity()
       DESCRIPTION:   This function will just dump a A/D value on STDIO and comm port
                                          Used for debugging only!
       INPUT:                NONE.
62 - CalScales()
       DESCRIPTION:   This function will acquire the 4 quadrants for a given
                      disk. It will scan the disk in the x and y axes after finding the disk center
                      on the diagonal, then display the result through the communication port.

                      IMPORTANT NOTE:This function is for setting up disk parameters and the disk
                      MUST BE well centered in order to work.  Because the scans are along the x
                      and y axes, they hit the corners of the heating plate.  Therefore a thin
                      black tape must be put on the heating plate to cover it completely.

       INPUT:         None.

63 - FindRawDiskCenter()
       DESCRIPTION:   This function will find the Raw disk center. It is used to
                      reduce the size of the data buffer and be more precise
                      in finding the disk.
       INPUT:         NONE.

64 - TestHoleCenters()
       DESCRIPTION:   (A SPECIAL 5x5 Test disk, 400 micron through hole diameter, on 1200 micron
                      centers)
                      NOTE: THESE HOLES ARE THROUGH HOLES. There must be black tape on the heating
                      plate to avoid reflections in the hole.  Be sure the disk is right side up.
                      There is a chamfer on the bottom edge,  and there are mill tool marks on the
                      top surface, whereas the bottom surface is turned.
                      NOTE: The test disk must be clean.  Any debris in the holes will affect
                      performance.
                      All 25 holes plus the orientation holes are tested.

       INPUT:         NONE.
       OUTPUT:        Position Number (hole number)
                      Each Hole center - X,Y Center in DAC coordinates when moved.
                      Actual Hole Center by actually finding the center based on the move.
                      At the end, the difference between measured and computed hole centers is
                      output. The last two holes done are the two orientation holes.

65 - SetProgrammersVerbose()
       DESCRIPTION:   Sets a verbose mode for programming ONLY.
                      WARNING: USING THIS FUNCTION MAY HAVE ADVERSE EFFECTS ON SYSTEM PERFORMANCE
       INPUT:         1 = Turn it on, 0 = off (default - off) GbVerbose.
       OUTPUT:        NONE.

68 - DoTest68()
                      Programmer only information and testing
```

```
69 - DoTest()
       DESCRIPTION:   This function will run a routine called DoTest() and will only run code that
                      a programmer or someone wants to activate from a terminal. DoTest() is
                      located in the TESTTOOLS.LIB.
                      DO NOT ACTIVATE OR CALL THIS FUNCTION UNLESS YOU HAVE VIEWED THE CODE AND ARE
                      SURE OF THE RESULTS.

       INPUT:         NONE

//////////////////////////////////////////////////////////
//////////////////////////////////////////////////////////
              END TEST FUNCTIONS
//////////////////////////////////////////////////////////
//////////////////////////////////////////////////////////




90 - Echo Serial port C control
     DESCRIPTION:
          This command will toggle echo on or off with each sequential call.
          Used mainly for manual entering command.
     INPUT: None
     LIMITS:
     DEFAULT CONDITION: OFF

91 - Set System Clock                NOT IMPLEMENTED FULLY

       (NOTE: Year does not display properly)
     DESCRIPTION: This command will set the system clock. This command
                  is in the 24 hour format.
     !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
     ! NOTE: VERY IMPORTANT. THE TIME AND DATE SET WILL NOT TAKE EFFECT!
     !       UNTIL THE PROGRAM IS RESTARTED.                           !
     !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
     INPUT:
               Format: ]91HH:MN:SS MM/DD/YRCR
               HH = 00 - 23
               MN = 00 - 59
               SS = 00 - 59
               MM = 00 - 12
               DD = 00 - 31
               YR = 00 - 99 If the year is between 49 - 79 the year is
                            1949 to 1979.
                            If the year is between 0 - 48 the year is
                            2000 - 2048.
                            If the year is between 80 - 99 the year is
                            1980 - 1999.

               NOTES: There must be a space between the time and date.

     DEFAULT CONDITION: What ever the system first turns on with.
     LIMITS: See INPUT:


92 - Get Product ID
DESCRIPTION:
       This command will return a product ID.
INPUT: None
LIMITS: None
DEFAULT CONDITION: None
```

Text from scanner for initialize command ‘]0’

```
_____Find Disk_____
FRDC(); Quadrant 1 Found edge[ 1140, 1140]
FRDC(); Quadrant 2 Found edge[ 1112,-1112]
FRDC(); Quadrant 3 Found edge[-1120,-1120]
FRDC(); Quadrant 4 Found edge[-1140, 1140]
FRDC(); Disk Center =    -4,   24
FRDC(); Quad 1-3 Diameter in microns =  9588
FRDC(); Radius(GiXYStart) =  1276

Filtered Reflectivity Range(iThreshold+-(2*GiQ)) = 0.335445  3.694335
FindEdge() Quad 1  X = 1128.632690   Y = 1156.632440

Filtered Reflectivity Range(iThreshold+-(2*GiQ)) = 0.137662  3.711014
FindEdge() Quad 2  X = 1124.458370   Y = -1104.458610

Filtered Reflectivity Range(iThreshold+-(2*GiQ)) = 0.554445  3.740235
FindEdge() Quad 3  X = -1133.375610   Y = -1105.375850

Filtered Reflectivity Range(iThreshold+-(2*GiQ)) = 0.328176  3.708055
FindEdge() Quad 4  X = -1132.839960   Y = 1152.839960
ComputeCenter() X = -2.562316   Y = 25.818966

Scale Factor x = 0.329447    y = 0.329447

Falling edge[106] x,y = 1065,799   Theta = 36.537815              //scanned from 0 degrees. Not

Rising edge[196] x,y = 984,897   Theta = 42.088787               //the same as the angle for
                                                                 //transform sent below
Rough Centers  x = 1024.000000    y = 848.000000

Falling edge[109] x,y = -1068,-751   Theta = 216.722854          //for other hole
Rising edge[197] x,y = -988,-846   Theta = 222.150466
Rough Centers  x = -1028.000000    y = -798.000000
Better Centers 1: x = 1016.999870    y = 840.999870
Better Centers 2: x = -1032.999750    y = -802.999870
FindHoleEdge(1) x = 1064, y = 888
FindHoleEdge(1) Reflectivity Range = 0.180599  3.730614
FindHoleEdge(2) x = 1062, y = 796
FindHoleEdge(2) Reflectivity Range = 0.237604  3.781114
FindHoleEdge(3) x = 970, y = 794
FindHoleEdge(3) Reflectivity Range = 0.153398  3.742874
FindHoleEdge(4) x = 970, y = 888
FindHoleEdge(4) Reflectivity Range = 0.165893  3.736320
Hole 1 Center  x = 1017.000120    y = 842.000120

FindHoleEdge(1) x = -987, y = -757
FindHoleEdge(1) Reflectivity Range = 0.322731  3.761338
FindHoleEdge(2) x = -989, y = -847
FindHoleEdge(2) Reflectivity Range = 0.386334  3.706079
FindHoleEdge(3) x = -1079, y = -849
FindHoleEdge(3) Reflectivity Range = 0.207306  3.752266
FindHoleEdge(4) x = -1077, y = -759
FindHoleEdge(4) Reflectivity Range = 0.149781  3.775494
Hole 2 Center  x = -1032.000240    y = -803.000120

Angle degrees = 50.606472                                        //rotation angle of orientation
X Scale Factor    = 0.332231                                     //holes from 90 degrees
Y Scale Factor    = 0.324791
Disk Center X     = -7.500061
Disk Center Y     = 19.499998
&50.606472 0.332231 0.324791 -7.500061 19.499998                 //host computer readable

!0                                                               //completion code
                                                                 //elapsed time 12 seconds
```

The beam may be positioned by microns from center (orientation hole 1 up), or by sample hole number using the disk parameters entered. Parameters for 10 x 10 array on 600 micron centers is default.

```
]2 600 600                                          //movexycenter x, y in microns from center of
&273.058715,-7.424294  600,600                      //disk (orientation hole 1 up)
                                                    //'&' string is x,y DAC and x,y microns
!0                                                  //completion code
```

Position numbers run from 0 to 99 for 10 x 10 array. Position 0 is upper left corner, 9 is upper right, 99 is lower right corner

```
]5 12                                               //move to sample position 12
&215.402374,828.866210  -1500,2100                  //'&' string is x,y DAC and x,y microns


!0                                                  //completion code
```

Arm laser for external control. If the first parameter is negative, then the external analog laser intensity signal from the 2200 is used. If it is positive (1-4095) the internal DAC will be set and used. If it is zero, the laser will turn off if it was on. The second parameter is 1 for control by the 2200. The laser will go on when the OSL enable signal goes low, and then off when the signal returns high. When the second parameter is zero, the laser will turn on immediately. DO NOT WAIT FOR A COMPLETION CODE BEFORE SENDING THE OSL COMMAND TO THE 2200!! The completion code is sent only AFTER the laser on/off is completed (for the external OSL enable mode). In the external mode, there will be a '&ON' returned when the laser goes on, and '&OFF' when turned off.

```
]6 –1 1
Waiting for external control signal to go low       //now issue shinedown command to 2200
&ON                                                 //when it does
Waiting for external control signal to return high
&OFF                                                //when it does that, i.e. shinedown over

!0                                                  //successful completion code, -52 if timed out
```

Dump of variable parameters in host computer readable form

```
]29 0
&0 0 0 0.331813 0.324047 5 9700 1200 8000 400 25 1277 15 0 200 36 0.000003 0 4.3
03348 25.000000

!0                                                  //completion code
```

Dump of variable parameters in human-readable form. This one is for the test disk (5 x 5 array)

```
]29 1
GiPhotoGain    = 0
GiLaserPower   = 0
GiLaserState   = 0
GfXScaleFactor = 0.331813
GfYScaleFactor = 0.324047
GiHolePerRow   = 5
GiDiskDiameter = 9700
GiSampleGrid   = 1200
GiHoleDistance = 8000
GiHoleSize     = 400
GiNHoles       = 25
GiXYStart      = 1277
GiMaxAngle     = 15
GfThreshold    = 1.750000
GiSetFindOnlyLaserPower = 200
GiPointsPastThreshold   = 36
GiLaserExtTimerEvent    = 100
GbUseExtDAC   = 0
GfDelta       = 4.303348
GfBeta        = 25.000000

!0                                                  //completion code
```

Test suite command]64 for use with 25 hole array test disk to show quality of fit

```
==== Scanning Test Disk ====                                  // for command ‘]64’== test disk
_____Find Disk_______
FRDC(); Quadrant 1 Found edge[ 1140, 1140]                    //acquire disk center
FRDC(); Quadrant 2 Found edge[ 1112,-1112]
FRDC(); Quadrant 3 Found edge[-1120,-1120]
FRDC(); Quadrant 4 Found edge[-1140, 1140]
FRDC(); Disk Center =    -4,   24
FRDC(); Quad 1-3 Diameter in microns =  9588
FRDC(); Radius(GiXYStart) =  1276

Filtered Reflectivity Range(iThreshold+-(2*GiQ)) = 0.396036  3.773663
FindEdge() Quad 1  X = 1128.611930   Y = 1156.611930

Filtered Reflectivity Range(iThreshold+-(2*GiQ)) = 0.128226  3.721061
FindEdge() Quad 2  X = 1124.463740   Y = -1104.463500

Filtered Reflectivity Range(iThreshold+-(2*GiQ)) = 0.433061  3.757850
FindEdge() Quad 3  X = -1133.782830   Y = -1105.782590

Filtered Reflectivity Range(iThreshold+-(2*GiQ)) = 0.297456  3.727515
FindEdge() Quad 4  X = -1133.153190   Y = 1153.153190
ComputeCenter() X = -2.930236   Y = 25.759518

Scale Factor x = 0.329498    y = 0.329498

Falling edge[106] x,y = 1065,799   Theta = 36.537815        //acquire orientation holes
Rising edge[196] x,y = 983,897   Theta = 42.088787          //angle from 0 degrees

Rough Centers  x = 1024.000000    y = 848.000000

Falling edge[109] x,y = -1068,-751   Theta = 216.722854
Rising edge[197] x,y = -988,-846   Theta = 222.150466
Rough Centers  x = -1028.000000    y = -798.000000
Better Centers 1: x = 1016.999870    y = 840.999870
Better Centers 2: x = -1032.499750    y = -802.499870
FindHoleEdge(1) x = 1064, y = 888
FindHoleEdge(1) Reflectivity Range = 0.147070  3.722120
FindHoleEdge(2) x = 1062, y = 796
FindHoleEdge(2) Reflectivity Range = 0.151683  3.732028
FindHoleEdge(3) x = 970, y = 794
FindHoleEdge(3) Reflectivity Range = 0.163189  3.740614
FindHoleEdge(4) x = 970, y = 888
FindHoleEdge(4) Reflectivity Range = 0.183977  3.777306
Hole 1 Center  x = 1017.000120    y = 842.000120

FindHoleEdge(1) x = -987, y = -757
FindHoleEdge(1) Reflectivity Range = 0.303673  3.751762
FindHoleEdge(2) x = -988, y = -846
FindHoleEdge(2) Reflectivity Range = 0.378605  3.725783
FindHoleEdge(3) x = -1079, y = -849
FindHoleEdge(3) Reflectivity Range = 0.175924  3.768988
FindHoleEdge(4) x = -1077, y = -757
FindHoleEdge(4) Reflectivity Range = 0.134140  3.773641
Hole 2 Center  x = -1032.500240    y = -802.500120

Angle degrees = 50.621852                                     //the results for the transform
X Scale Factor    = 0.332283                                  //angle for xform is from 90 degrees
Y Scale Factor    = 0.324842
Disk Center X     = -7.750061
Disk Center Y     = 19.749998
&50.621852 0.332283 0.324842 -7.750061 19.749998              //the string for the host computer
                                                              //now find the test hole centers

&102.732543,1116.996580  -2400,2400                           //hole 0 DAC coordinates and in microns
Seeking Center for Hole 0
FindHoleEdge(1) x = 152, y = 1169
FindHoleEdge(1) Reflectivity Range = 0.179513  3.738889
FindHoleEdge(2) x = 152, y = 1069
```

```
FindHoleEdge(2) Reflectivity Range = 0.144601  3.803016
FindHoleEdge(3) x = 52, y = 1069
FindHoleEdge(3) Reflectivity Range = 0.134718  3.719607
FindHoleEdge(4) x = 53, y = 1168
FindHoleEdge(4) Reflectivity Range = 0.172687  3.750426
&355.707092,815.682860  -1200,2400                                   //now for hole 1
Seeking Center for Hole 1
FindHoleEdge(1) x = 407, y = 868
FindHoleEdge(1) Reflectivity Range = 0.223082  3.713130
FindHoleEdge(2) x = 404, y = 769
FindHoleEdge(2) Reflectivity Range = 0.253270  3.762985
FindHoleEdge(3) x = 305, y = 766
FindHoleEdge(3) Reflectivity Range = 0.134864  3.719440
FindHoleEdge(4) x = 307, y = 866
FindHoleEdge(4) Reflectivity Range = 0.149169  3.749979
&608.681640,514.369010  0,2400                                       //hole 2, etc.
Seeking Center for Hole 2
FindHoleEdge(1) x = 660, y = 567
FindHoleEdge(1) Reflectivity Range = 0.145673  3.765408
FindHoleEdge(2) x = 658, y = 469
FindHoleEdge(2) Reflectivity Range = 0.285795  3.766602
FindHoleEdge(3) x = 560, y = 467
FindHoleEdge(3) Reflectivity Range = 0.323574  3.734731
FindHoleEdge(4) x = 560, y = 567
FindHoleEdge(4) Reflectivity Range = 0.129094  3.764742
&861.656120,213.055267  1200,2400
Seeking Center for Hole 3
FindHoleEdge(1) x = 913, y = 266
FindHoleEdge(1) Reflectivity Range = 0.139617  3.715572
FindHoleEdge(2) x = 913, y = 166
FindHoleEdge(2) Reflectivity Range = 0.131911  3.665139
FindHoleEdge(3) x = 812, y = 165
FindHoleEdge(3) Reflectivity Range = 0.139239  3.790087
FindHoleEdge(4) x = 813, y = 266
FindHoleEdge(4) Reflectivity Range = 0.169695  3.695444
&1114.630610,-88.258514  2400,2400
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Seeking Center for Hole 22
FindHoleEdge(1) x = -576, y = -430
FindHoleEdge(1) Reflectivity Range = 0.573967  3.731522
FindHoleEdge(2) x = -578, y = -520
FindHoleEdge(2) Reflectivity Range = 0.605543  3.762281
FindHoleEdge(3) x = -669, y = -523
FindHoleEdge(3) Reflectivity Range = 0.412411  3.737923
FindHoleEdge(4) x = -668, y = -430
FindHoleEdge(4) Reflectivity Range = 0.689937  3.806604
&-371.207153,-776.182980  1200,-2400
Seeking Center for Hole 23
FindHoleEdge(1) x = -327, y = -732
FindHoleEdge(1) Reflectivity Range = 0.677318  3.753589
FindHoleEdge(2) x = -329, y = -820
FindHoleEdge(2) Reflectivity Range = 0.638365  3.792415
FindHoleEdge(3) x = -416, y = -821
FindHoleEdge(3) Reflectivity Range = 0.542381  3.725438
FindHoleEdge(4) x = -415, y = -734
FindHoleEdge(4) Reflectivity Range = 0.680001  3.679258
&-118.232650,-1077.496820  2400,-2400
Seeking Center for Hole 24                                          //last hole in the array of 25
FindHoleEdge(1) x = -70, y = -1029
FindHoleEdge(1) Reflectivity Range = 0.160198  3.741159
FindHoleEdge(2) x = -70, y = -1127
FindHoleEdge(2) Reflectivity Range = 0.151201  2.878206
FindHoleEdge(3) x = -168, y = -1127
FindHoleEdge(3) Reflectivity Range = 0.127448  3.728675
FindHoleEdge(4) x = -168, y = -1029
FindHoleEdge(4) Reflectivity Range = 0.316619  3.713634
```

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&1019.635980,844.115110  0,4000                                  //check orientation hole 1
Seeking Center for Hole 25
FindHoleEdge(1) x = 1064, y = 888
FindHoleEdge(1) Reflectivity Range = 0.166477  3.696387
FindHoleEdge(2) x = 1063, y = 795
FindHoleEdge(2) Reflectivity Range = 0.183785  3.734213
FindHoleEdge(3) x = 970, y = 794
FindHoleEdge(3) Reflectivity Range = 0.185279  3.715261
FindHoleEdge(4) x = 970, y = 888
FindHoleEdge(4) Reflectivity Range = 0.201647  3.754690
&-1035.136230,-804.615230  0,-4000
Seeking Center for Hole 26                                       //check orientation hole 2
FindHoleEdge(1) x = -987, y = -758
FindHoleEdge(1) Reflectivity Range = 0.298513  3.752803
FindHoleEdge(2) x = -989, y = -846
FindHoleEdge(2) Reflectivity Range = 0.378063  3.751219
FindHoleEdge(3) x = -1078, y = -849
FindHoleEdge(3) Reflectivity Range = 0.189031  3.772947
FindHoleEdge(4) x = -1077, y = -758
FindHoleEdge(4) Reflectivity Range = 0.189731  3.745820

                                                                 //the resulting differences
0 Delta x = 3.044739    y = -6.089478  Microns                   //between actual and computed
1 Delta x = 3.044739    y = -3.044739  Microns                   //positions
2 Delta x = -3.044739    y = -9.134217  Microns
3 Delta x = -4.567109    y = -7.611847  Microns
4 Delta x = 6.089478    y = -15.223695  Microns
5 Delta x = -4.567109    y = 7.611847  Microns
5 Delta x = -4.567109    y = 7.611847  Microns
7 Delta x = -1.522370    y = -4.567109  Microns
8 Delta x = -4.567109    y = -13.701325  Microns
9 Delta x = -1.522370    y = -13.701325  Microns
10 Delta x = -13.701325    y = 4.567109  Microns
11 Delta x = -10.656680    y = 4.567109  Microns
12 Delta x = -3.044740    y = 0.000006  Microns
13 Delta x = -9.134217    y = 9.134217  Microns
14 Delta x = 4.567109    y = 7.611847  Microns
15 Delta x = -7.611847    y = 10.656587  Microns
16 Delta x = 3.044739    y = 3.044716  Microns
17 Delta x = 4.567109    y = -1.522370  Microns
18 Delta x = 9.134194    y = -9.134217  Microns
19 Delta x = 1.522370    y = -7.611847  Microns
20 Delta x = -15.223695    y = 3.044739  Microns
21 Delta x = -10.656587    y = 7.611847  Microns
22 Delta x = -4.567109    y = 1.522370  Microns
23 Delta x = 3.044739    y = 3.044739  Microns
24 Delta x = 3.044739    y = 3.044739  Microns
25 Delta x = 9.134217    y = 6.089478  Microns                   //the orientation holes
26 Delta x = -9.134217    y = -6.089478  Microns                 //not too shabby!!

!0                                                               //completion code
```