Print Engine Calibration Workbook

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1 Calibration Process Overview

The XLI ImageChip™

The XLI ImageChip operates on the page image data that would normally be passed from the print controller to the print engine. The ImageChip provides direct control over the width of each pulse that is produced by the laser to write each black pixel on the page. The LUT (Look Up Table) in the XLI ImageChip is used to vary the size of the black pulse within a pixel. The ability to vary the size and position of the pulse within each pixel allows both edge and image enhancement, as well as printing at a 2X resolution on the engine. There are two LUTs in the ImageChip; in the 1-bit modes, only one is used to store calibration data; in the 8-bit modes, both are used, each on alternative lines to break up the inherent vertical line screen that would result from this processing. By alternating LUTs, the ImageChip produces a dot screen, and the size and shape of the dot can be controlled for maximum print quality. In the Edge Enhancement and 1200 DPI modes, the edges of the characters are affected, while in the Grayscale mode, the overall grayscale response (i.e. linearity) is compensated.

In any given pixel *space* or *time slot*, the width of the black pulse controls how large a spot is written by the laser, and subsequently how large a spot of toner (pixel) is deposited. The ImageChip is capable of outputting sub-nanosecond pulse widths. However, the laser driver has a minimum response time, so there will be a threshold below which the output pulses will have no effect, and will not write a dot. This means that there are a group of values from zero to, say 20, out of the 0-255 input range, that produce a 0 output. Conversely, the laser has a finite size dot, and will therefore, at some input value other than full scale (255) write a full black pixel. This again groups a number of values, this time at the high end, say from 230-255, which produce solid black areas on paper. To add to this situation, each operating mode of the ImageChip, different line screens, engine, and toner cartridge variations will affect the output. Lastly, the print engine itself has its own response curve, or linearity. The calibration process attempts to compensate for as many of these sets of variables as possible, to maximize print quality. This means that each possible mode and operating condition must be calibrated, and individual Look Up Tables for each must be generated. Multiple tables can be created for each operating mode to accommodate toner saver or other variations within any given operating mode.

To illustrate the point above, if we look at a grayscale step wedge printed with no calibration such as the one shown in figure 1-1, we see that the last few steps are solid black, with virtually no differentiation between them. Similarly, at the white end of the step wedge, there is a "threshold" after which pixels are appearing on the paper. Finally, the relative weight of the gray value from one gray step to the next may or may not be linear. This is what the calibration process attempts to correct.

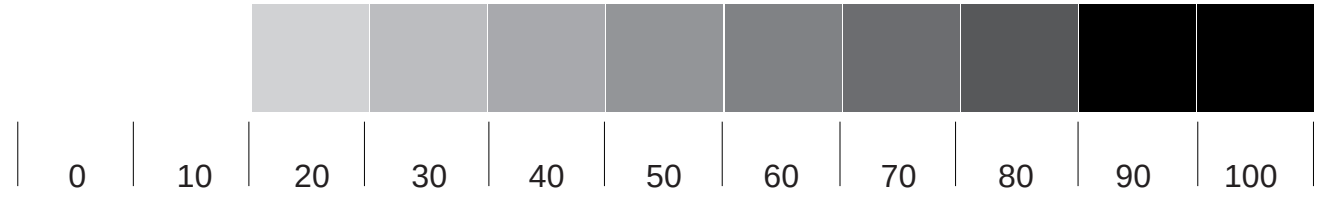


Figure 1-1. Uncalibrated Step Wedge

2 Supplied Software and Recommended Equipment

7-10x Loupe

A loupe with magnifying power of 7-10x is required to visually inspect various sections of reference and test printouts during the procedures. Magnifications higher than 10x are not necessary and provide no useful information.

Densitometer

A good quality reflective densitometer, capable of percentage readings is required. Suitable equipment is available from companies such as Macbeth, X-Rite and others.

XLI Cubic Spline Interpolation Algorithm Source Code

The XLI Cubic Spline Interpolation Algorithm Source Code is provided for integration with the remainder of the print controller software. This allows a minimum of control points to be stored in PROM, yet allows the full 256 values to be generated *on the fly* for each operating mode LUT required.

XLI Curve Editing Program

The XLI Curve Editing Program, running under Windows 95® or greater, allows direct graphical editing of the overall response curve. Based on the shape of the curve and the control points entered along the curve, the program will generate the 256 LUT values using the XLI CSI algorithm, and store the result in the appropriate section of an XLI .INI file, which the printer driver accesses when test target files are printed during the calibration procedures. The program will also overwrite the values corresponding to override values for BLACK, WHITE and the MIDPOINT, after the CSI algorithm is run.

XLI Test Target Files

The following image files are provided to aid in both pre-calibration and calibration procedures:

- ✓ STEPWEDGE.TIF .. 11 step grayscale wedge
- ✓ GRAY512.TIF ..... 512 step grayscale
- ✓ GRAY256.TIF ..... 256 step grayscale
- ✓ 30-60GRAD.TIF ..... 30 to 60% gradient
- ✓ GHOSTTEST.TIF .... Ghost Test
- ✓ 1200X1.TIF ..... 1200dpi x1-bit mode test
- ✓ 200X1.TIF* ..... 200dpi x1-bit mode test*
- ✓ XLI600.TIF ..... XLI 600dpi test target
- ✓ XLI300.TIF ..... XLI 300dpi test target

* The 200 dpi x 1-bit modes do not require calibration. The 200X1.TIF file is included to test the 200dpi, 1-bit enhancement functionality.

3 Pre-Calibration/Baseline Procedures

The precalibration procedures provide the starting point for evaluating what the printer engine alone is capable of, its typical performance and variations, and its anomalies. This starting point is the basis for determining when you're getting the best possible output from the engine/XLI ImageChip combination, and what are reasonable performance expectations for the combination.

To perform this precalibration, you will need multiple print engines and multiple toner cartridges. Humidity and temperature will also affect print quality; while it isn't practical to go *on the road*, these factors must be considered as well.

The following are the sequence of steps recommended by XLI to obtain the data necessary to determine the baseline performance of the print engine, without processing by the ImageChip.

With ImageChip mode 01 selected (600 dpi, 1-bit, no enhancement), for each toner cartridge and print engine combination, and using the unity curve, print the following files. Make a notation on eachprintout of the print engine and toner cartridge, serial numbers, and paper type for future reference.

1. Print the file *GRAY512.TIF* and inspect the printout for horizontal and vertical banding associated with the print engine itself. Refer to figure 3-1.
2. Print the file *30-60GRAD.TIF* at a minimum of 106 line screen. This will print a horizontal gradient, varying from 30% to 60% gray across the full image area of a letter-size sheet. Inspect the printout for anomalies such as horizontal or vertical lines, which are associated with the print engine itself – gear mesh problems, defects in the drum, etc. Refer to figure 3-2.

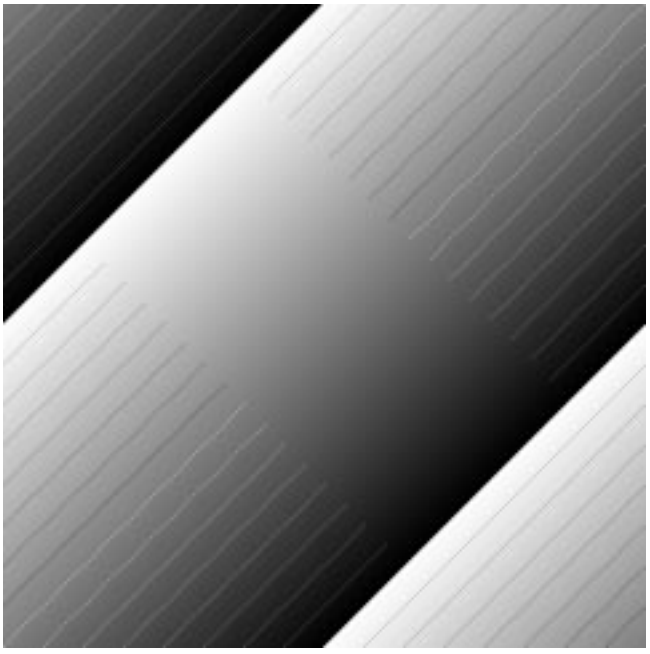


Figure 3-1. *GRAY512.TIF* Test Print File

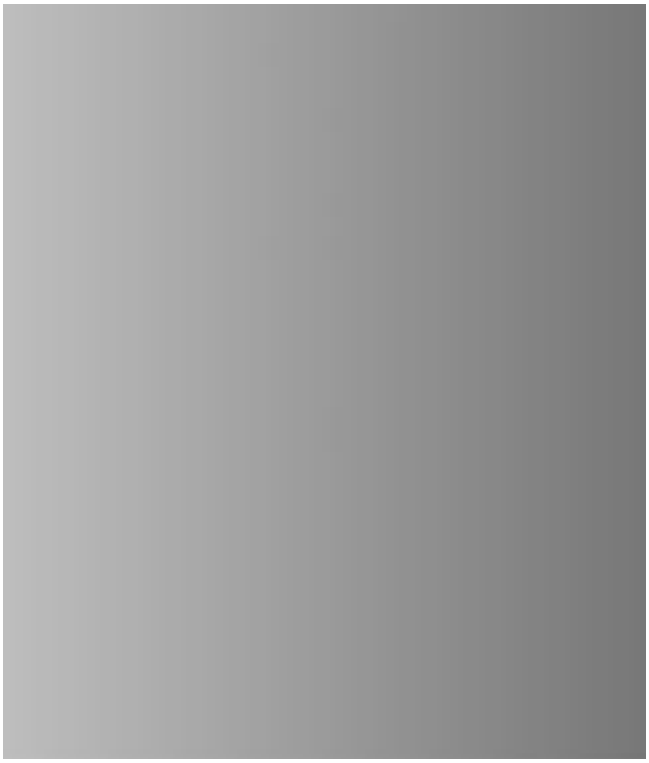


Figure 3-2. *30-60GRAD.TIF* Test Print File

3. Print the file *GHOSTTEST.TIF* and inspect the printout for ghosts of either the black or white squares anywhere else on the page. Refer to figure 3-3.

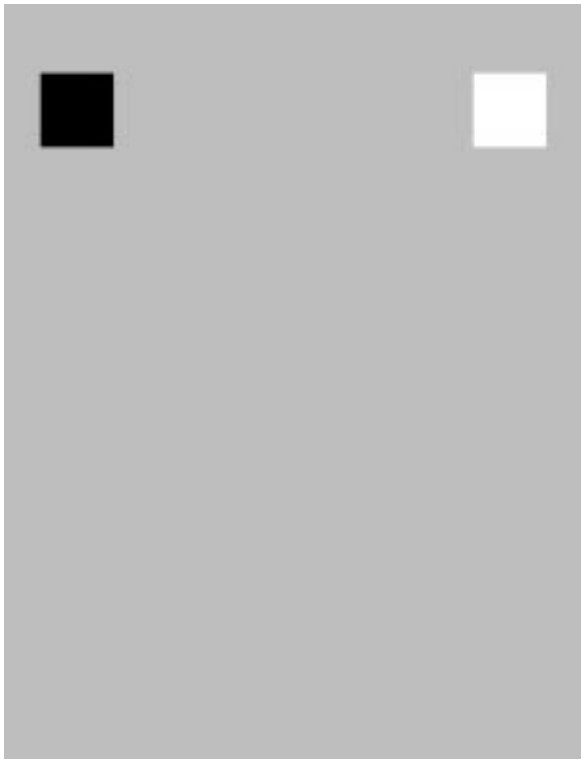


Figure 3-3. *GHOSTTEST.TIF* Test Print File

Print Engine/Toner Cartridge Data Collection

With an understanding of the anomalies of each print engine/toner cartridge combination on controlled test images, the collection of the actual data for those combinations can be done.

If the print engine you are calibrating has an ENGINE DENSITY control or its equivalent, this can be used to compensate for large variations in toner cartridge density characteristics that may not be handled adequately with just LUT changes. As a starting point, XLI recommends the ENGINE DENSITY control be set toward the light end, midway between its minimum and midpoint setting.

Determine the BLACK point:

1. Run the Curve Editing Program for the (default) Unity Table.

   To edit the LUT:

   a. Run the XLI Curve Edit Program.

   b. Select the FILE ==> OPEN menu.

   c. From the pop-up menu, select the \Windows\XLIPRINT.INI file. Click OK.

   d. At the *Enter Table* prompt, enter the number of the mode, from 00 to 12. In this case, enter mode 01 (600 dpi, 1-bit, no enhancement). The entry should read "lut01". Click OK.

   Note: The first time the curve is displayed prior to any modifications, the curve defaults to a unity curve.

   e. When the curve is displayed, enable the BLACK Override, and enter a value for the BLACK point somewhat above the midpoint.

   The curve should look similar to figure 3-4. In the example, a value of 150 was chosen.

   f. Select the FILE ==> SAVE menu to have the software calculate the LUT values and store them in the .INI file.

   g. Exit the Curve Edit Program.

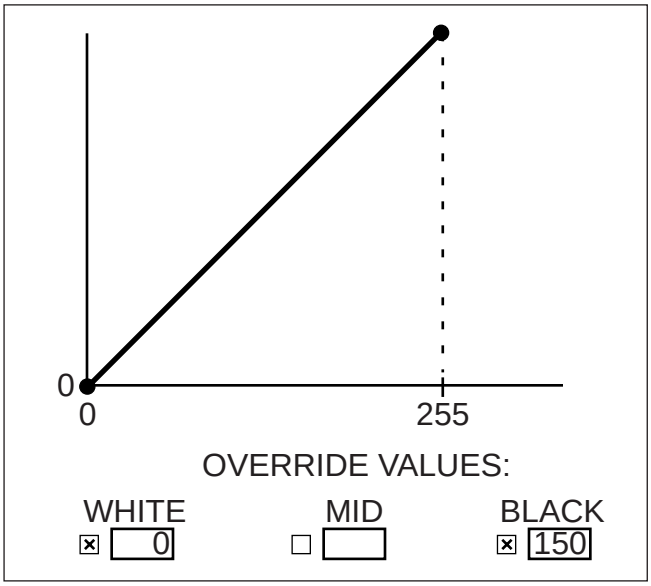
2. Print the file *XLI600.TIF (600dpi test target)*. The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:
   600 dpi
   1-Bit
   No Enhancement

3. Measure the horizontal step portion as shown in figure 3-5, and record the densitometer reading as a percentage. This should be in the range of 30%-70%. As an example, we will assume the reading is 70% Record the value in Table 3-1.

4. Repeat steps 1 through 5, changing the BLACK value until the densitometer reading is as close to 50% as possible.

7. Repeat the entire procedure above for each combination of print engine/toner cartridge. Record your densitometer readings and black values. Blank masters for the worksheet tables depicted throughout this workbook are provided in the back of this book.

Once you have a BLACK value for each print en-



Default for White override is 0 and Enabled.

Figure 3-4. Setting the Black Point

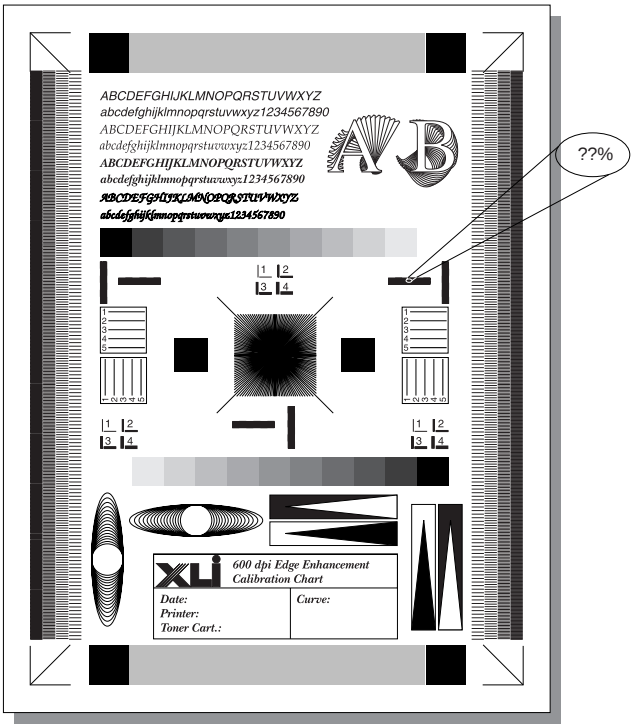


Figure 3-5. Black Point Measurement

Table 3-1. Determine the BLACK Point

Disable all operating modes on the XLI ImageChip

Step	LUT BLACK Value	Densitometer Reading	Condition/Note
Step 3	BLACK = _____	% reading = _____	First pass measurement
Step 5	BLACK = _____	% reading = _____	1st adjustment
Step 5	BLACK = _____	% reading = _____	2nd adjustment
Step 5	BLACK = _____	% reading = _____	3rd adjustment
Step 5	BLACK = _____	% reading = _____	4th adjustment
Step 5	BLACK = _____	% reading = _____	5th adjustment
Step 5	BLACK = _____	% reading = _____	6th adjustment
Step 5	BLACK = _____	% reading = _____	7th adjustment
Step 5	BLACK = _____	% reading = _____	8th adjustment

Printer_____ Toner Cartridge_____

Ambient Temperature_____ Relative Humidity_____

Table 3-1. Black Point Worksheet

gine/toner cartridge combination that produces a horizontal step reading of 50%, use Table 3-3 to assist in calculating the standard deviation of these values to determine the value for the BLACK point that will provide a solid black output for all print engine/toner cartridge combinations. **This value is then used as the BLACK point in all normal operating mode LUTs.** The value may or may not have to be modified for economy modes or other considerations.

Determine the WHITE point

8. Edit the LUT so the BLACK value is at some arbitrarily low value. As an example, use 50.

   To edit the LUT:

   a. Run the XLI Curve Edit Program.

   b. Select the FILE ==> OPEN menu.

   c. From the pop-up menu, select the \Windows\XLIPRINT.INI file. Click OK.

   d. At the "Enter Table" prompt, enter the number of the mode, from 00 to 12. In this case, enter mode 01 (600 dpi, 1-bit, no enhancement). The entry should read "lut01". Click OK.

   e. When the curve is displayed, enable the BLACK Override, and enter a value for the BLACK point of 50.

The curve should look similar to figure 3-7.

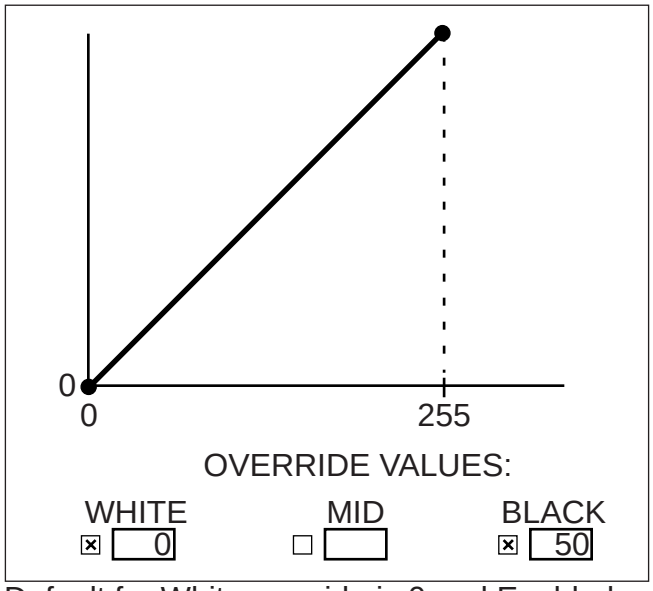


Figure 3-6. Setting the White Point

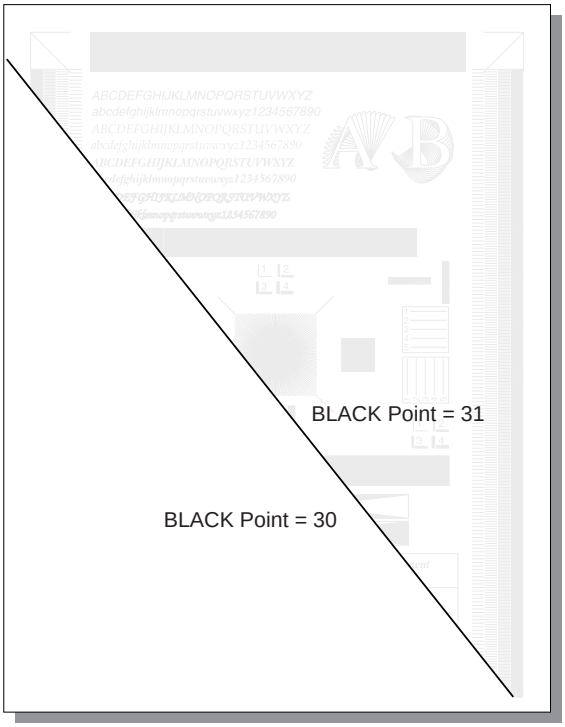


Figure 3-7. White Point

   f. Select the FILE ==> SAVE menu to have the software calculate the LUT values and store them in the .INI file.

   g. Exit the Curve Edit Program

9. Print the file *XLI600.TIF (600 dpi test target)* again. The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:
   600 dpi
   1-Bit
   No Enhancement

10. Record the value for the WHITE point in Table 3-2.

11. Repeat steps 8 through 10, reducing the BLACK value until there is no image on the page. The BLACK value at which the image just disappears is the **WHITE point value**. In the example in figure 3-7, the final value at which the image disappears is 30.

12. Repeat the entire procedure above for each combination of print engine/toner cartridge. Record your white point value for each combination. Blank masters for the worksheets depicted throughout this workbook are provided in the back of this book.

Once you have a WHITE point value for each print engine/toner cartridge combination that causes the image to just disappear on the page, use Table 3-3 to assist in calculating the standard deviation of these values to determine the value for the WHITE point for all print engine/toner cartridge combinations. **This value is then used as the WHITE point for the curve in all normal operating mode LUTs. The override value should always be enabled and set to 0.**

Proceed to Section 4 - Calibration Procedure.

Table 3-2. Determine the WHITE Point

Disable all operating modes on the XLI ImageChip

Step	LUT WHITE Value	Condition/Note
Step 8	WHITE = ___50	First pass measurement
Step 10	WHITE = _____	1st adjustment
Step 10	WHITE = _____	2nd adjustment
Step 10	WHITE = _____	3rd adjustment
Step 10	WHITE = _____	4th adjustment
Step 10	WHITE = _____	5th adjustment
Step 10	WHITE = _____	6th adjustment
Step 10	WHITE = _____	7th adjustment
Step 10	WHITE = _____	8th adjustment

Printer_____ Toner Cartridge_____

Ambient Temperature_____ Relative Humidity_____

Table 3-2. White Point Worksheet

Table 3-3. Determine Standard Deviation			
Serial Numbers		WHITE Value	BLACK Value
Printer	Toner Cartridge		
Standard Deviation:			
Ambient Temperature_____ Relative Humidity_____			

Table 3-3. Standard Deviation Worksheet

Table 3-4. Modes	
Mode	Function
00	600x600x1 Enhanced Text Only
01	600x600x1 Test (EEU Bypassed)
02	600x600x1 Enh. Text & 1-Bit Gray
03	600x600x1 Enh. 1-Bit Grayscale Only
04	300x300x1 Enhanced Text Only
05	300x300x1 Test (EEU Bypassed)
06	200x200x1 Enhanced Text Only
07	200x200x1 Test (EEU Bypassed)
08	200x100x1 Enhanced Text Only
09	200x100x1 Test (EEU Bypassed)
10	1200x1200x1 Enhanced Text Only
11	600x600x8
12	300x300x8

Table 3-4. ImageChip™ Operating Modes

4 Calibration Procedure

With both BLACK and WHITE points chosen that should accommodate all variations in printer engine/toner cartridge combinations, the calibration tables can be created.

From the precalibration printouts, select the three toner cartridges which represent the mid-range and light and dark end extremes. For all calibration procedures, use the mid-range toner cartridge. Once the LUTs are set up, check them against the light and dark cartridges to verify print quality is within acceptable limits. If necessary, adjust the LUTs to compensate for these extremes.

Reference Printouts

Prior to performing the actual calibration, it is helpful to have reference printouts that depict the areas affected by each area of the calibration curve. Print these by performing the following procedures.

Note: It is very helpful to note the mode, curve values and overide settings on each printout to reduce confusion and to facilitate tracking adjustments.

Full Reference Printout

1. Starting with the UNITY table, edit the LUT so the BLACK and WHITE values are set to those values determined in the precalibration section.

   To edit the LUT:

   a. Run the XLI Curve Edit Program.

   b. Select the FILE ==> OPEN menu.

   c. From the pop-up menu, select the \Windows\XLIPRINT.INI file. Click OK.

   d. At the *Enter Table* prompt, enter the number of the mode, from 00 to 12. In this case, enter mode 00 (600 dpi, 1-bit, edge enhancement). The entry should read "lut00". Click OK.

   Note: The first time the curve is displayed prior to any modifications, the curve defaults to a unity curve.

   e. When the curve is displayed, verify that the the WHITE Override is enabled. Move the WHITE and BLACK points **on the curve** to the points (values) determined in the precalibration section.

      The curve should look similar to figure 4-1. (In this example, the values used are WHITE=80 and BLACK=235.)

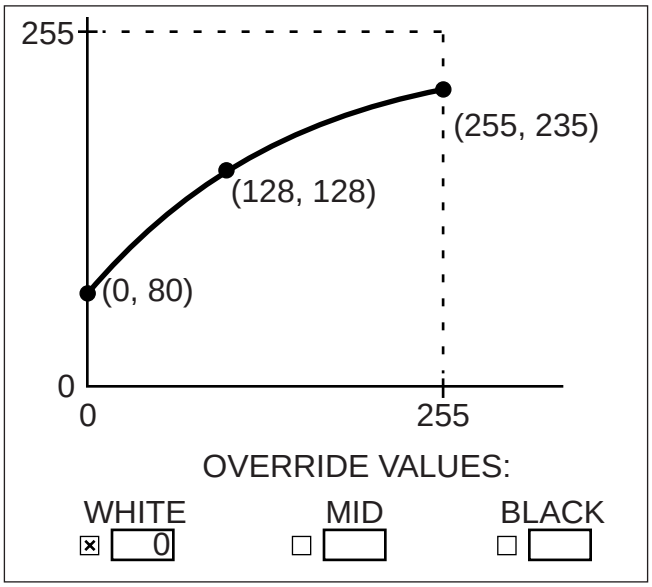


Figure 4-1. Unity Curve With Black and White Overrides and White Point Set.

   f. Select the FILE ==> SAVE menu to have the software calculate the LUT values and store them in the .INI file.

   g. Exit the Curve Edit Program.

4. Print the file *XLI600.TIF (600 dpi test target)*. The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:

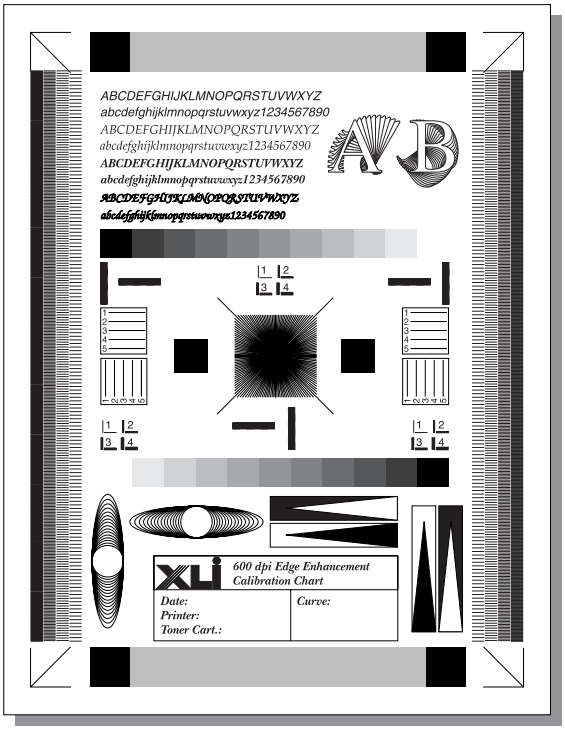
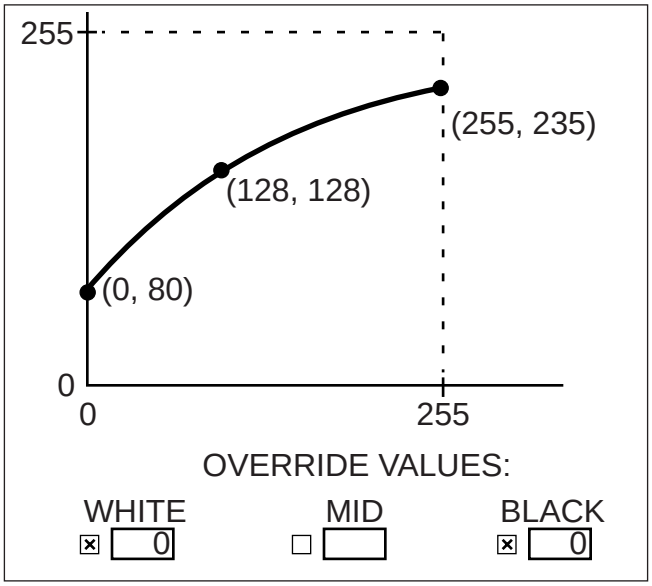


Figure 4-2. Full Reference Printout



Default for White override is 0 and Enabled.

Figure 4-3. Black Point Set to 0

600 dpi
1-Bit
Edge Enhancement Enabled

What will be printed is a reference page with horizontal, vertical and 45° lines intact, with edge enhancement operating. It should look similar to figure 4-2.

Edge Enhancement Only Printout

3. Reopen the curve and set the BLACK Override to 0. Leave all other values unchanged.

   To edit the LUT:

   a. Run the XLI Curve Edit Program.

   b. Select the FILE ==> OPEN menu.

   c. From the pop-up menu, select the \Windows\XLIPRINT.INI file. Click OK.

   d. At the "Enter Table" prompt, enter the number of the mode, from 00 to 12. In this case, enter mode 00 (600 dpi, 1-bit, edge enhancement). The entry should read "lut00". Click OK.

   e. When the curve is displayed, enable the BLACK Override, and enter a value for the BLACK point of 0. Leave the WHITE Override value unchanged.

   The curve should look similar to figure 4-3.

   f. Select the FILE ==> SAVE menu to have the software calculate the LUT values and store them in the .INI file

   g. Exit the Curve Edit Program

4. Print the file *XLI600.TIF (600 dpi test target)* again. The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:

   600 dpi
   1-Bit
   Edge Enhancement Enabled

   What will be printed are only those areas of the test image where edge enhancement is performed. This page indicates the areas that are affected by the overall shape of the curve and the number of control points along the curve. The printout should look similar to figure 4-4.

Edge Enhancement Without Vertical and 45° Lines Printout

5. Reopen the curve and leave the WHITE and BLACK values unchanged. Set the MIDPOINT Override to 0.

   To edit the LUT:

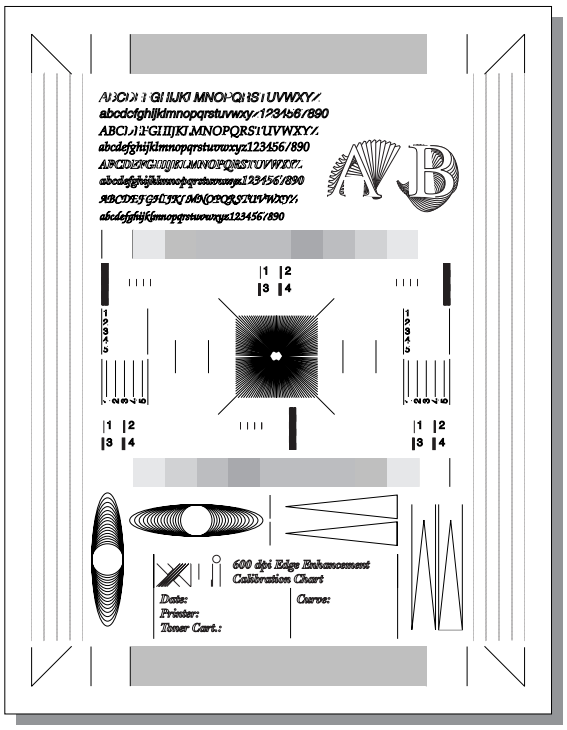


Figure 4-4. Edge Enhancement Only Printout

a. Run the XLI Curve Edit Program.

b. Select the FILE ==> OPEN menu.

c. From the pop-up menu, select the \Windows\XLIPRINT.INI file. Click OK.

d. At the *Enter Table* prompt, enter the number of the mode, from 00 to 12. In this case, enter mode 00 (600 dpi, 1-bit, edge enhancement). The entry should read "lut00". Click OK.

e. When the curve is displayed, enter a value for the MIDPOINT of 0. Leave the WHITE and BLACK values unchanged.

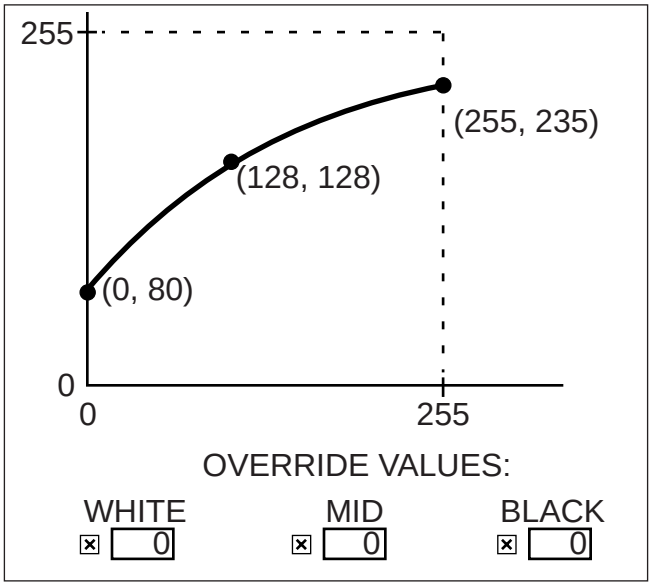
The curve should look similar to figure 4-5.

f. Select the FILE ==> SAVE menu to have the software calculate the LUT values and store them in the .INI file

g. Exit the Curve Edit Program

6. Print the file *XLI600.TIF (600 dpi test target)* again. The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:

600 dpi
1-Bit
Edge Enhancement Enabled



Default for White override is 0 and Enabled.

Figure 4-5. Midpoint Set to 0

This page indicates that the one (1) pixel vertical and 45° lines are affected by the midpoint values. The printout should look similar to figure 4-6.

With the reference printouts available and suitably identified, we can now calibrate the engine.

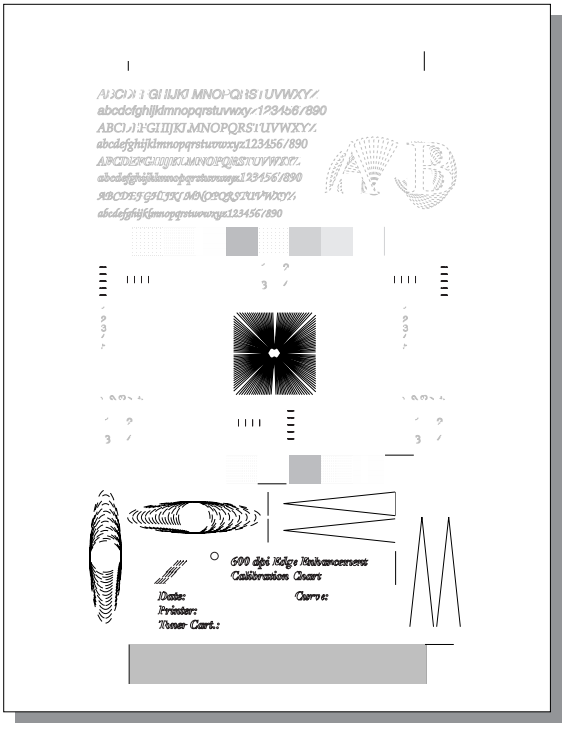


Figure 4-6. Enhancement Areas without 1-Pixel Vertical or 45° Lines Printout

The three primary steps to engine calibration are:

1. Set the BLACK point on the curve, which affects how horizontal lines will print. This is accomplished directly when the BLACK point is set to that value determined from the precalibration procedures.
2. Set the midpoint (50% pulse width) value on the curve; this affects how vertical lines will print, and therefore the relative balance between the overall gray values of horizontal and vertical lines. The midpoint value is adjusted to achieve an overall balance between the horizontal and vertical lines.
3. Adjust the shape of the overall curve to affect the edge enhancement transitions, and balance them against the horizontal and vertical line segments.

In general terms, keep these guidelines in mind when performing the calibration.

1. If the horizontal lines are darker than the vertical lines, compensate by either:
   - moving the BLACK point on the curve toward WHITE, or
   - moving the midpoint on the curve toward BLACK.
2. If the vertical lines are darker than the horizontal lines, compensate by either:
   - moving the BLACK point on the curve toward BLACK, or
   - moving the midpoint on the curve toward WHITE.
3. Ideally, both the vertical and horizontal lines would be 25% in density, since these lines are one (1) pixel ON and three (3) pixels OFF in the *XLI600.TIF* file. However, due to the dot gain of the laser, they will typically read about 60%. The BLACK point should not be adjusted away from the value determined in the precalibration section more than what results in a 50-55% gray reading.
4. When adjusting the midpoint to make the vertical lines darker, watch that the two (2) pixel line pairs don't fill in, indicating the adjustment has gone too far.
5. The midpoint value shouldn't be moved too far so that the 45° single pixel line disappears.
6. Leading and trailing edges of a line are controlled by the midpoint value.
7. One pixel vertical lines are easier to maintain than true 45° lines due to the cumulative nature of the laser dots on a vertical line.

600x600x1-Bit, Edge Enhancement Mode (00) Calibration (Nomal)

Make sure the toner cartridge used is the mid-range unit selected from the precalibration section.

Step 1 - Set the Black Point

1. Starting with the UNITY table, edit the LUT so the BLACK and WHITE values on the curve are set to those values determined in the precalibration section.

   To edit the LUT:

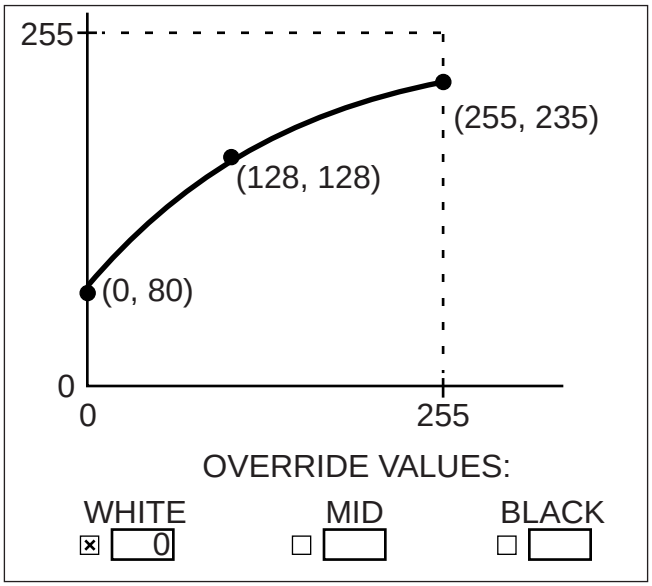
   a. Run the XLI Curve Edit Program.

   b. Select the FILE ==> OPEN menu.

   c. From the pop-up menu, select the \Windows\XLIPRINT.INI file. Click OK.

   d. At the *Enter Table* prompt, enter the number of the mode, from 00 to 12. In this case, enter mode 00 (600 dpi, 1-bit, edge enhancement). The entry should read "lut00". Click OK.

   e. When the curve is displayed, verify that



Default for White override is 0 and Enabled.

Figure 4-7. Set the Black and White Points

the the WHITE Override is enabled. Move the WHITE and BLACK points **on the curve** to the points (values) determined in the precalibration section.

NEED DATA

The curve should look similar to figure 4-7. (In this example, the values used are WHITE=80 and BLACK=235.) Make sure the curve between the BLACK and WHITE points is a straight line.

f. Select the FILE ==> SAVE menu to have the software calculate the LUT values and store them in the .INI file.

g. Exit the Curve Edit Program.

2. Print the file *XLI600.TIF (the 600 dpi test target)*. The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:

   600 dpi
   1-Bit
   Edge Enhancement Enabled

Evaluate the overall gray balance between the horizontal and vertical lines. Refer to the general guidelines for suggestions on balancing the relative weight of the vertical and horizontal lines as necessary.

Step 2 - Set the Midpoint Values

Adjust the midpoint values to achieve an overall balance between the horizontal and vertical lines. Remember that:

1. If the horizontal lines are darker than the vertical lines, compensate by either:
   - moving the BLACK point on the curve toward WHITE, or
   - moving the midpoint on the curve toward BLACK.
2. If the vertical lines are darker than the horizontal lines, compensate by either:
   - moving the BLACK point on the curve toward BLACK, or
   - moving the midpoint on the curve toward WHITE.

Since the BLACK point is where we want it to be, based on the precalibration procedures, initially, only the two midpoints should be adjusted in this step.

To adjust the midpoint value

1. Reopen the Edge Enhancement table saved in step 1.

   To edit the LUT:

   a. Run the XLI Curve Edit Program.

   b. Select the FILE ==> OPEN menu.

   c. From the pop-up menu, select the \Windows\XLIPRINT.INI file. Click OK.

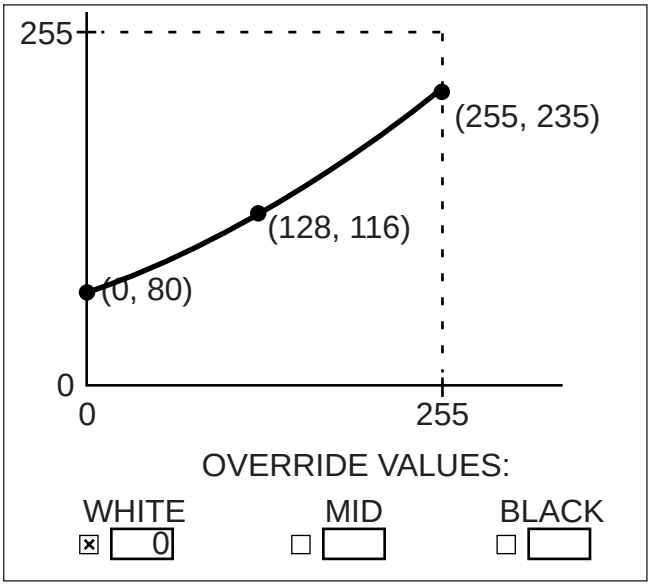
   d. At the *Enter Table* prompt, enter the number of the mode, from 00 to 12. In this case, enter mode 00 (600 dpi, 1-bit, edge enhancement). The entry should read "lut00". Click OK.

   e. When the curve is displayed, verify that the the WHITE Override is enabled. Move the MIDPOINT **on the curve** to a higher value to lighten the horizontal lines, and to a lower value to darken the horizontal lines.

NEED DATA

The curve should look similar to figure 4-8. (In this example, the values used are WHITE=80, BLACK=235, and MIDPOINT=116.) Make sure the curve between the BLACK and WHITE points is a straight line.

   f. Select the FILE ==> SAVE menu to have the software calculate the LUT values and store them in the .INI file.



Default for White override is 0 and Enabled.

Figure 4-8. Set the Midpoint

g. Exit the Curve Edit Program.

2. Print the file *XL600.TIF (600 dpi test target)*. The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:
   600 dpi
   1-Bit
   Edge Enhancement Enabled

3. Evaluate the overall gray balance between the horizontal and vertical lines. If necessary, repeat steps 1 and 2 until an overall gray balance is achieved.

Step 3 - Edge Enhancement Transition Balance

With the horizontal and vertical lines balanced, the third step is to balance those image areas where edge enhancement processing is done. Refer to the Edge Enhancement Only reference printout.

The shape of the overall curve affects the edge enhancement areas. To make editing the curve easier, and to provide more control over only that segment of the curve where the adjustment is to be made, add control points in pairs, symmetrically about the midpoint value. Although not strictly necessary, this will help constrain the adjustment closer to the point where the adjustment is being made. Refer to figure 4-9. For the majority of cases, five (5) points will be sufficient to adequately adjust the shape of the curve.

1. Reopen the Edge Enhancement table saved in step 2.

   To edit the LUT:

   a. Run the XLI Curve Edit Program.

   b. Select the FILE ==> OPEN menu.

   c. From the pop-up menu, select the \Windows\XLIPRINT.INI file. Click OK.

   d. At the *Enter Table* prompt, enter the number of the mode, from 00 to 12. In this case, enter mode 00 (600 dpi, 1-bit, edge enhancement). The entry should read "lut00". Click OK.

   e. When the curve is displayed, choose EDIT ==> ADD POINT from the menu

   f. Immediately click on the curve where you want the point to be added. If the point is in the wrong place, move it by dragging with the mouse. Repeat for a second point. Points can also be removed by choosing EDIT ==> DELETE POINT from the menu, and immediately clicking on the point to be removed. A minimum of three points is required to define the curve.

The curve should look similar to figure 4-9. (In this example, the values used are WHITE=80, BLACK=235, and MIDPOINT=116.)

   f. Select the FILE ==> SAVE menu to have the software calculate the LUT values and store them in the .INI file.

   g. Exit the Curve Edit Program.

2. Print the file *XLI600.TIF (600 dpi test target)*. The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:

   600 dpi
   1-Bit
   Edge Enhancement Enabled

3. Evaluate the printout. If necessary, repeat steps 1 and 2.

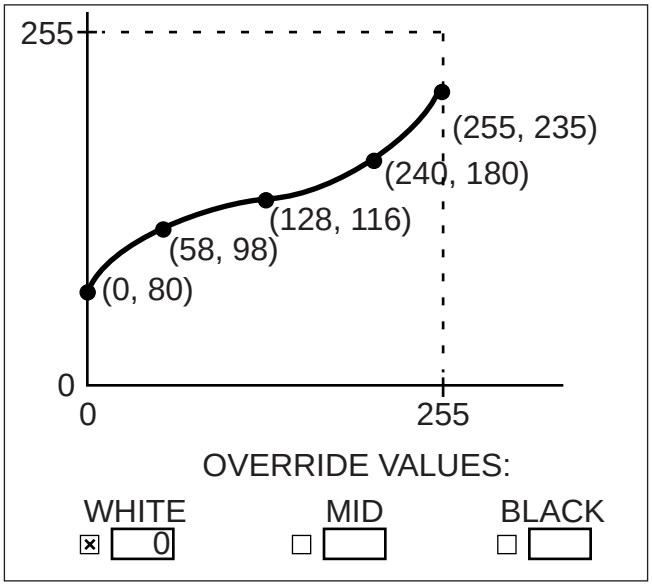


Figure 4-9. Adjust the Curve Shape

300x300x1-Bit, Edge Enhancement Mode (04) Calibration (Nomal)

Make sure the toner cartridge used is the mid-range unit selected from the precalibration section.

Step 1 - Set the Black Point

1. Starting with the UNITY table, edit the LUT so the BLACK and WHITE values on the curve are set to those values determined in the precalibration section.

   To edit the LUT:

   a. Run the XLI Curve Edit Program.

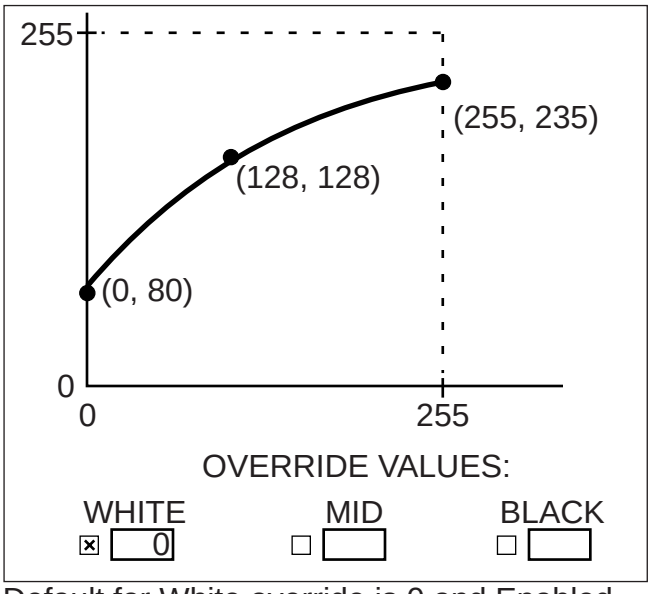
   b. Select the FILE ==> OPEN menu.

   c. From the pop-up menu, select the \Windows\XLIPRINT.INI file. Click OK.

   d. At the *Enter Table* prompt, enter the number of the mode, from 00 to 12. In this case, enter mode 04 (300 dpi, 1-bit, edge enhancement). The entry should read "lut04". Click OK.

   e. When the curve is displayed, verify that the the WHITE Override is enabled. Move the WHITE and BLACK points **on the curve** to the points (values) determined in the precalibration section.

The curve should look similar to figure 4-10. (In this example, the values used are WHITE=80 and BLACK=235.) Make sure the curve between the BLACK and WHITE points is a straight line.



Default for White override is 0 and Enabled.

Figure 4-10. Set the Black and White Points

   f. Select the FILE ==> SAVE menu to have the software calculate the LUT values and store them in the .INI file.

   g. Exit the Curve Edit Program.

2. Print the file *XLI300.TIF (the 300 dpi test target)*. The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:

   300 dpi
   1-Bit
   Edge Enhancement Enabled

Evaluate the overall gray balance between the horizontal and vertical lines. Refer to the general guidelines for suggestions on balancing the relative weight of the vertical and horizontal lines as necessary.

Step 2 - Set the Midpoint Values

Adjust the midpoint values to achieve an overall balance between the horizontal and vertical lines. Remember that:

1. If the horizontal lines are darker than the vertical lines, compensate by either:
   - moving the BLACK point on the curve toward WHITE, or
   - moving the midpoint on the curve toward BLACK.
2. If the vertical lines are darker than the horizontal lines, compensate by either:
   - moving the BLACK point on the curve toward BLACK, or
   - moving the midpoint on the curve toward WHITE.

Since the BLACK point is where we want it to be, based on the precalibration procedures, initially, only the two midpoints should be adjusted in this step.

To adjust the midpoint value

1. Reopen the Edge Enhancement table saved in step 1.

   To edit the LUT:

   a. Run the XLI Curve Edit Program.

   b. Select the FILE ==> OPEN menu.

c. From the pop-up menu, select the \Windows\XLIPRINT.INI file. Click OK.

d. At the *Enter Table* prompt, enter the number of the mode, from 00 to 12. In this case, enter mode 04 (300 dpi, 1-bit, edge enhancement). The entry should read "lut04". Click OK.

e. When the curve is displayed, verify that the the WHITE Override is enabled. Move the MIDPOINT **on the curve** to a higher value to lighten the horizontal lines, and to a lower value to darken the horizontal lines.

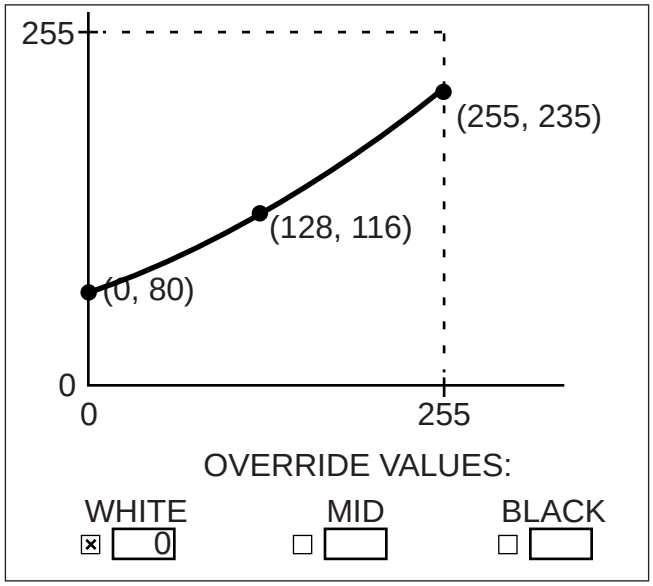
The curve should look similar to figure 4-11. (In this example, the values used are WHITE=80, BLACK=235, and MIDPOINT=116.) Make sure the curve between the BLACK and WHITE points is a straight line.

f. Select the FILE ==> SAVE menu to have the software calculate the LUT values and store them in the .INI file.

g. Exit the Curve Edit Program.

2. Print the file *XL300.TIF (300 dpi test target)*. The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:

300 dpi
1-Bit
Edge Enhancement Enabled



Default for White override is 0 and Enabled.

Figure 4-11. Set the Midpoint

3. Evaluate the overall gray balance between the horizontal and vertical lines. If necessary, repeat steps 1 and 2 until an overall gray balance is achieved.

Step 3 - Edge Enhancement Transition Balance

With the horizontal and vertical lines balanced, the third step is to balance those image areas where edge enhancement processing is done. Refer to the Edge Enhancement Only reference printout.

The shape of the overall curve affects the edge enhancement areas. To make editing the curve easier, and to provide more control over only that segment of the curve where the adjustment is to be made, add control points in pairs, symmetrically about the midpoint value. Although not strictly necessary, this will help constrain the adjustment closer to the point where the adjustment is being made. Refer to figure 4-9. For the majority of cases, five (5) points will be sufficient to adequately adjust the shape of the curve.

1. Reopen the Edge Enhancement table saved in step 2.

To edit the LUT:

a. Run the XLI Curve Edit Program.

b. Select the FILE ==> OPEN menu.

c. From the pop-up menu, select the \Windows\XLIPRINT.INI file. Click OK.

d. At the *Enter Table* prompt, enter the number of the mode, from 00 to 12. In this case, enter mode 04 (300 dpi, 1-bit, edge enhancement). The entry should read "lut04". Click OK.

e. When the curve is displayed, choose EDIT ==> ADD POINT from the menu

f. Immediately click on the curve where you want the point to be added. If the point is in the wrong place, move it by dragging with the mouse. Repeat for a second point. Points can also be removed by choosing EDIT ==> DELETE POINT from the menu, and immediately clicking on the point to be removed. A minimum of three points is required to define the curve.

The curve should look similar to figure 4-12. (In

this example, the values used are WHITE=80, BLACK=235, and MIDPOINT=116.)

f. Select the FILE ==> SAVE menu to have the software calculate the LUT values and store them in the .INI file.

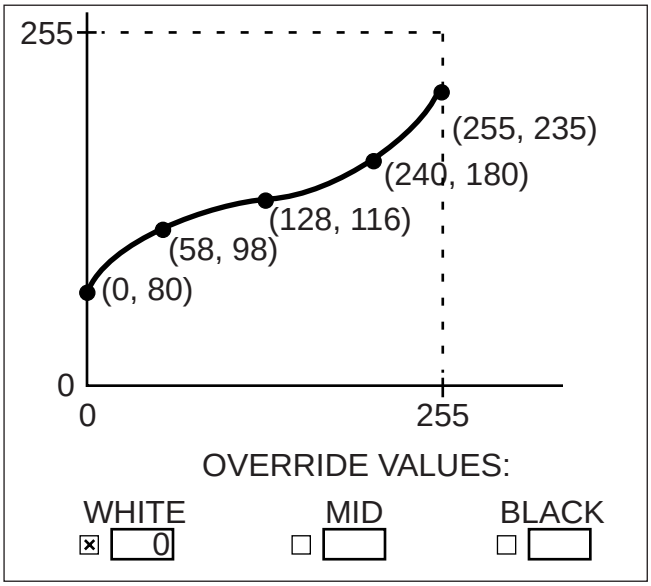
g. Exit the Curve Edit Program.

2. Print the file *XLI300.TIF (300 dpi test target)*. The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:
   300 dpi
   1-Bit
   Edge Enhancement Enabled

3. Evaluate the printout. If necessary, repeat steps 1 and 2.

1200x1200x1-Bit, Edge Enhancement Mode (10) Calibration (Normal)

For most print engines, the unity table is sufficient for use in the 1200x1200x1-bit mode (10). If minor adjustments from this table are required, use the preceding 600dpi or 300dpi procedure to fine-tune the table for the 1200x1-bit mode.



Default for White override is 0 and Enabled.

Figure 4-9/12. Adjust the Curve Shape

600x600x1-Bit, Edge Enhancement & 1-Bit Grayscale Mode (02) Calibration (Normal)

To follow.

600x600x1-Bit, Enhanced 1-Bit Grayscale Mode (03) Calibration (Normal)

To follow.

600x600x8-Bit Mode (11) Calibration (Normal)

To follow.

300x300x8-Bit Mode (12) Calibration (Normal)

To follow.

5 Worksheet Masters

The following pages contain blank tables. The pages are perforated to easily remove and duplicate as needed.

Table 3-1. Determine the BLACK Point

Disable all operating modes on the XLI ImageChip

Step	LUT BLACK Value	Densitometer Reading	Condition/Note
Step 3	BLACK = _____	% reading = _____	First pass measurement
Step 5	BLACK = _____	% reading = _____	1st adjustment
Step 5	BLACK = _____	% reading = _____	2nd adjustment
Step 5	BLACK = _____	% reading = _____	3rd adjustment
Step 5	BLACK = _____	% reading = _____	4th adjustment
Step 5	BLACK = _____	% reading = _____	5th adjustment
Step 5	BLACK = _____	% reading = _____	6th adjustment
Step 5	BLACK = _____	% reading = _____	7th adjustment
Step 5	BLACK = _____	% reading = _____	8th adjustment

Printer_____ Toner Cartridge_____

Ambient Temperature_____ Relative Humidity_____

Table 3-2. Determine the WHITE Point		
Disable all operating modes on the XLI ImageChip		
Step	**LUT WHITE Value**	**Condition/Note**
Step 8	WHITE = ___50	First pass measurement
Step 10	WHITE = _____	1st adjustment
Step 10	WHITE = _____	2nd adjustment
Step 10	WHITE = _____	3rd adjustment
Step 10	WHITE = _____	4th adjustment
Step 10	WHITE = _____	5th adjustment
Step 10	WHITE = _____	6th adjustment
Step 10	WHITE = _____	7th adjustment
Step 10	WHITE = _____	8th adjustment
Printer_____ Toner Cartridge_____		
Ambient Temperature_____ Relative Humidity_____		

Table 3-3. Determine Standard Deviation

Serial Numbers		WHITE Value	BLACK Value
Printer	Toner Cartridge		
	Standard Deviation:		

Ambient Temperature_______ Relative Humidity________

NOTES

Specifications subject to change without notice.

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OEMM/980216r0/

Grayscale Calibration — 600x600x8-Bit Mode (11) and 300x300x8-Bit Mode (12)

The grayscale calibration procedures makes use of both of the ImageChip LUTs in order to provide a dot pattern free of the vertical line screen that would result from using a single LUT with the image processing functions of the ImageChip. Each LUT has a corresponding curve displayed in the XLI Curve Edit program; the two individual curves, one for each LUT, are summed to produce the master response curve as described in the following procedure. The procedure is essentially identical for both grayscale modes; the curves, however, will not, and each mode must therefore be calibrated separately.

600x600x8-Bit Mode (11) Calibration (Normal)

To start the grayscale calibration procedure:

1. Run the Curve Editing Program for the (default) Unity Table.

   To edit the LUT:

   a. Run the XLI Curve Edit Program.

   b. Select the FILE ==> OPEN menu.

   c. From the pop-up menu, select the \Windows\XLIPRINT.INI file. Click OK.

   d. At the *Enter Table* prompt, enter the number of the mode, from 00 to 12. In this case, enter mode 11 (600 dpi, 8-bit, no enhancement). The entry should read "lut11". Click OK.

   Note: The first time the curve is displayed prior to any modifications, the curve defaults to a unity curve. Do not make any changes to the curve.

   e. Select the FILE ==> SAVE menu to have the software calculate the LUT values and store them in the .INI file.

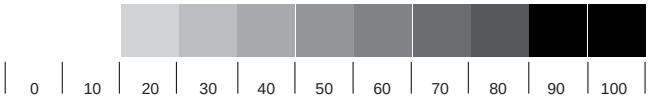


Figure 4-G1. 11-Step Wedge.

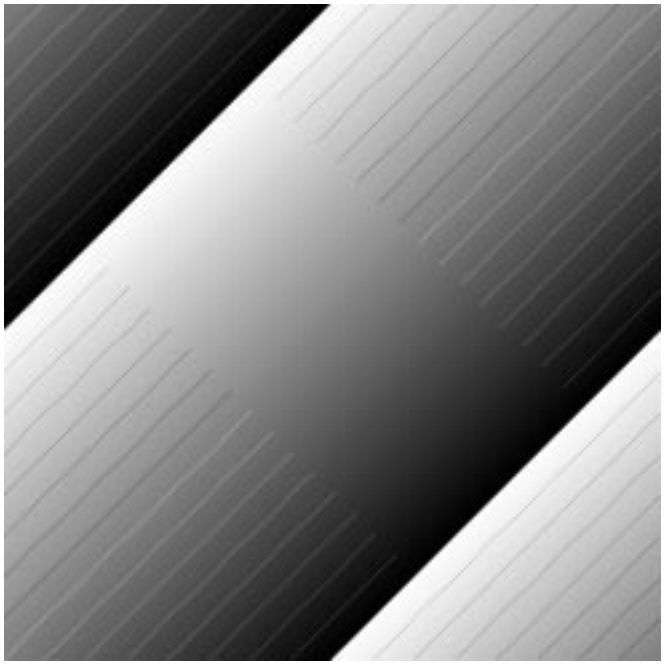


Figure 4-G2. GRAY512.TIF test file.

   f. Exit the Curve Edit Program.

2. Print the 11-step grayscale wedge file, *STEPWEDGE.TIF*. The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:

   600 dpi
   8-Bit
   No Enhancement

3. Print the 512-step grayscale file, *GRAY512.TIF.* The Test Program uses the calculated LUT values saved in the .INI file when printing. In the print dialog box, select:

   600 dpi
   8-Bit
   No Enhancement

4. Using both printouts, measure the response curve with a densitometer, and plot the resulting data on a graph. The result should look something like figure 4-G3.

The inverse of the response curve just plotted is the master curve that is needed in order to print in this mode. Since two LUTs are used in this mode, two curves will be needed to create the halftone dot structure. It is the two curves when summed together that yield the master curve. The WHITE and

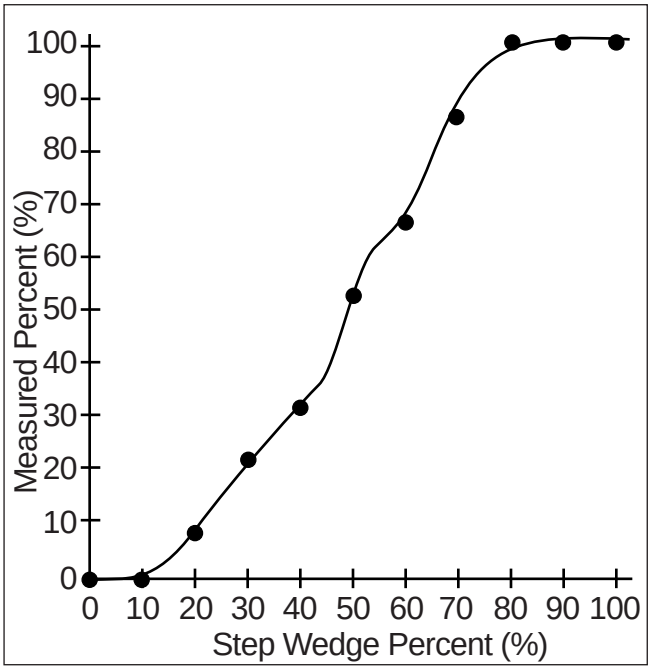


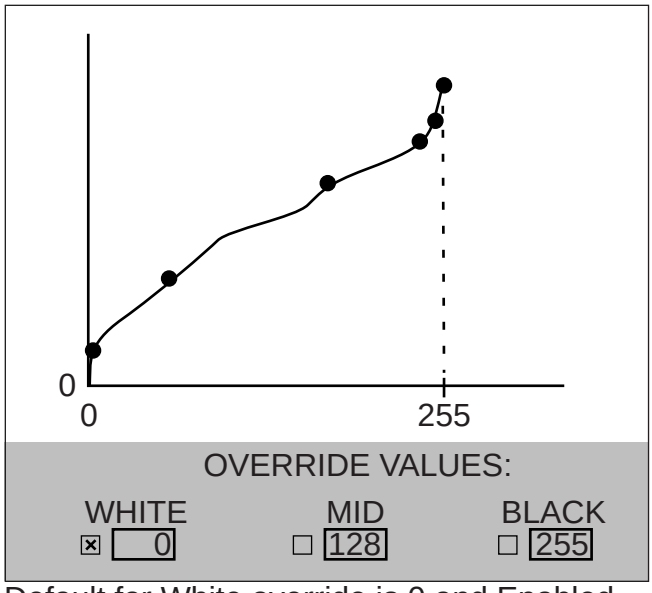
Figure 4-G3. Measured Data Points.

BLACK points that were obtained in the pre-calibration procedures can be used as starting points for the two ends of the curves.

A representative set of curves is shown in figure 4-G5.

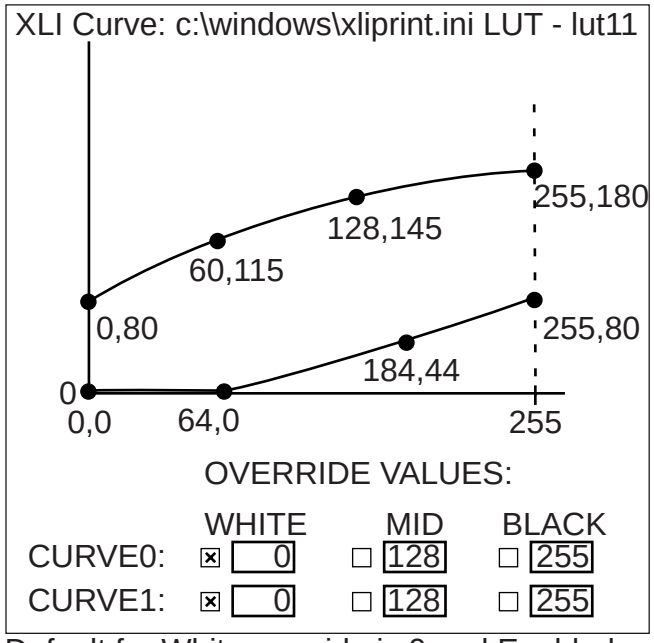
To continue the calibration procedure:

5. Observe the printout of the *GRAY512.TIF* test file. It should have a smooth, even gradation. If necessary, adjust the two curves to achieve this smooth gradation, while maintaining the proper densities as measured on the 11-step grayscale wedge.



Default for White override is 0 and Enabled.

Figure 4-G4. Master Curve



Default for White override is 0 and Enabled.

Figure 4-G5. Dual Curves for LUT11.

300x300x8-Bit Mode (12) Calibration (Normal)

To follow; dupe and edit as needed for GRAY256.TIF test file.