



TechNote: MuraTool

Mura: The Japanese word for blemish has been widely adopted by the display industry to describe almost all irregular luminosity variation defects in liquid crystal displays. Mura defects are caused by process flaws usually related to cell assembly, which affect the transmission of light through the display. The cyclical nature, randomness, and often, low contrast of mura makes accurate detection and classification extremely difficult for LCD manufacturers.



Figure 1: High contrast "fringe ring" mura on a microdisplay

The Need to Standardize: Lacking any more definition than that above, a huge amount of variation exists in how LCD manufacturers classify and determine what is a fatal mura. Lack of a standard classification method has hampered industry growth as LCD manufacturers and integrators chronically disagree on how to determine if a display meets acceptance criteria. Based on extensive applications knowledge from developing mura detection systems since 1991, Photon Dynamics (PDI) has developed a 15-phase, 23-class scheme of classifying all types of mura. This methodology has been adopted by the Video Electronics Standards Association (VESA) Flat Panel Display Measurements Standard (FPDM) and will be published in Version 2 in the spring of 2000. This new standard is expected to help bring easy classification of mura to the FPD industry and increase procurement efficiency for panel integrators.

The Standard: The mura standard consists of fifteen rules (an algorithm) which categorize any blemish defects found in a Device Under Test (DUT) image into one of the 23 classes described in the table below.

Phase	Class	Class Description	Defect Examples
1	1	Column Line	Signal Line
2	2	Row Line	Gate Line
3	3	Random Thin Line Pattern	Multiple Irregular Dark Streaks
4	4-1	White Interior Spot	Bright Pixel, Bright Cluster
4	4-2	White Corner Bloom	Bright Corner
4	4-3	White Border Bloom	Bright Panel Edge
5	5-1	Black Interior Spot	Dark Pixel, Dark Cluster
5	5-2	Black Corner Bloom	Dark Corner
5	5-3	Black Border Bloom	Dark Panel Edge
6	6	Horizontal Line	Thin Rubbing Line
7	7	Vertical Line	Thin Rubbing Line
8	8	Positive Slope Diagonal Line	Thin Rubbing Line
9	9	Negative Slope Diagonal Line	Thin Rubbing Line
10	10-1	Bright Region	Elliptical Region, Wide Rubbing Line,
10	10-2	Bright Region Collection	Bright Ring, Bright Streak
11	11-1	Dark Region	Elliptical Region, Wide Rubbing Line, Dark Streak
11	11-2	Dark Region Collection	Newton Ring, Vertical Periodic Lines, Dark Streak
12	12	Wide Horizontal Line	Panel Driver Block, Shot
13	13	Wide Vertical Line	Panel Driver Block, Shot
14	14-1	Bright Region Non-Uniformity	Brightness Non-uniformity
14	14-2	Bright Border Non-Uniformity	Fill Port
15	15-1	Dark Region Non-Uniformity	Darkness Non-uniformity
15	15-2	Dark Border Non-Uniformity	Fill Port

Table 1: Fifteen phases and twenty-three classes of the mura standard algorithm

TechNote: MuraTool

Procedure: A DUT image is captured via a Light Measuring Device (LMD) –usually a CCD camera. This image is input into the algorithm and is processed following the sequence shown in Figure 2. The Initialization phase generates a background image. The Segmentation component sequentially examines the DUT image for defects in a 15-phase process moving from high contrast to low contrast defects. Potential defects that exceed parameters for luminosity, size and shape are passed to the Classification segment. In the Classification component, if the contrast of the display image data with respect to the background image is above a user-set contrast threshold, the potential defect is classified as a valid defect. Independent segmentation and classification permits acceptance of brightness anomalies that are present in the image data, but which are not considered defects. Background generation and the Segmentation component image processing steps are not specified in detail by the VESA standard. These steps can be independently developed, implemented manually using MuraTool, or can be fully automated.

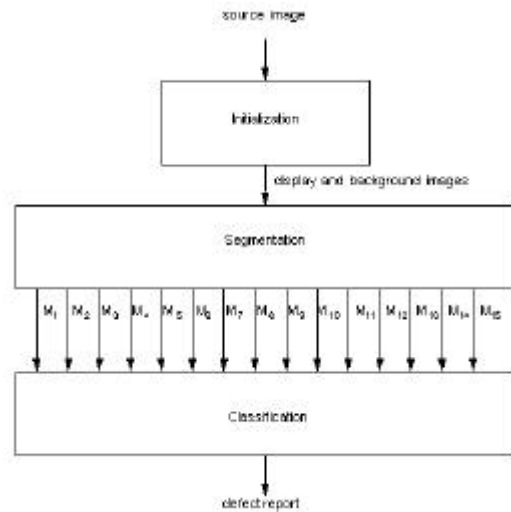


Figure 2: Mura standard algorithm flow chart

Reporting: The algorithm produces a defects report file. In this file, each potential defect is indexed in the order that it is detected; the centroid x,y coordinates, width, height, area, and contrast of the potential defect are reported. The file also indicates the phase in which the potential defect was detected and the class it was assigned to. Finally, the report identifies if the blob was classified as a valid defect or not.

* A more detailed description of the standard can be found the document titled "303-x Mura Defects" available from Photon Dynamics.

MuraTool: In order to help FPDM users better understand the new standard Photon Dynamics created MuraTool. MuraTool is freeware that runs on the Windows NT operating system. After the operator manually determines the type of blemishes that exist in a DUT image and manually selects a background reference point, MuraTool will automatically classify those defects according to the rules of the VESA standard.

TechNote: MuraTool

MuraTool Operating Instructions:

- 1. Starting:** Evoke MuraTool by double clicking on the MuraTool icon. The MuraTool Main Window will be displayed.
- 2. Opening Test Files:** Pull down the File Menu and click on Open. Double click on the desired “*.tst” file in the test folder. MuraTool will not execute until a test file is opened.

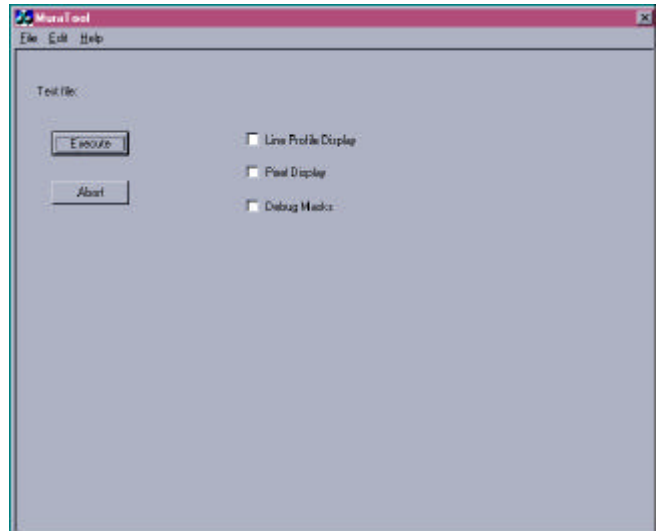


Figure 3: MuraTool Main Window

- 3. Editing Test Files:** A test file contains a set of panel parameters and test parameters. Test files can be viewed or edited by pulling down the Edit Menu. Panel Parameters define the size and resolution of the DUT. The Basic Parameter Window contains key contrast settings for the main defect groups. The Advanced Parameter Menu includes a specific parameter setup window for each phase of the algorithm. Set parameters to desired values. After editing parameters click OK and Save (under current file name) or Save As (as a new test file) under the File Menu.

* More information about parameters and how they affect segmentation and classification can be found in the MuraLook Theory of Operation, available from Photon Dynamics

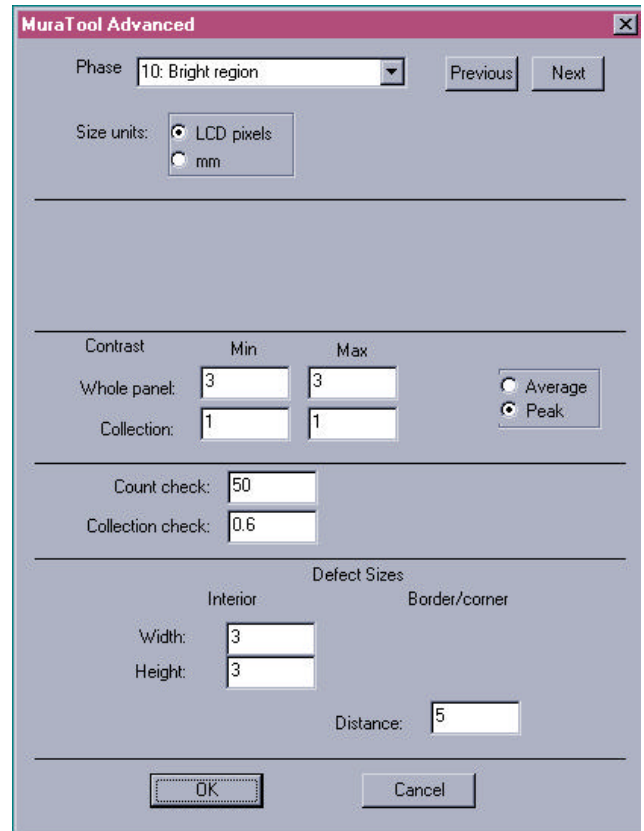


Figure 4: MuraTool Parameter Setup Window Example

TechNote: MuraTool

4. **Executing MuraTool:** Left click the Execute Button. Open any of the desired image files. Several seconds will pass before the following 4 windows are displayed.

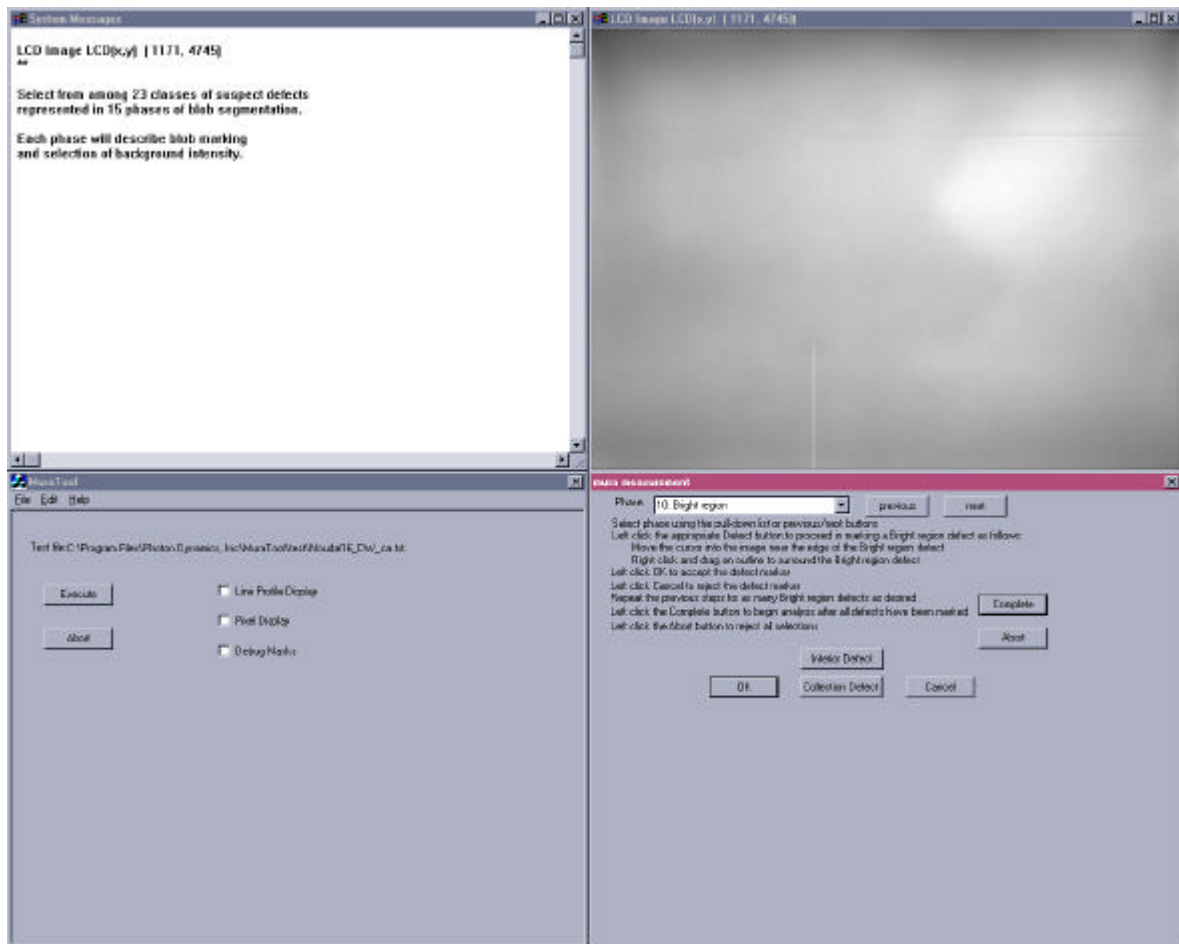


Figure 5: System Messages, DUT Image, Main, and Mura Measurement Windows of MuraTool

TechNote: MuraTool

5. **Evaluating the DUT Image:** Visually identify all blemish defects in the DUT Image Window (upper right hand corner).
6. **Segmenting & Classifying Defects:** Manually segment each identified blemish. Phase specific segmentation instructions are listed in the Mura Measurement Window (lower right). Left click the Complete Button in the Mura Measurement Window when all defects have been segmented. The Segmentation Window will replace the Mura Measurement Window. Segmented defects that meet the parameter criteria will be displayed in pseudo colors. Right click and the Classification Window will appear. Any segmented blemishes that exceed the contrast threshold will be classified as valid defects and will be displayed in pseudo colors. Click again and the Wide Line Defects Window will appear, displaying any phase 12 or 13 defects in pseudo colors. Click again the Region Defects Window will appear, displaying any phase 14 or 15 defects in pseudo colors.
7. **Reporting Classification Results:** Click on the Region Defects Window and the Defects Report Window will appear.
8. **Finishing Test:** Close the Defects Report Window, the Diagnostics Window will appear. Close this window. Run another test or exit MuraTool.
9. **Other Functions:**
 - a. **Line Profile Display:** This tool graphs luminosity vs. distance, which is very helpful for setting contrast parameters. Click the Line Profile Display Toggle in the MuraTool Main Window. Execute the program. In the DUT Image Window, hold down the right mouse button, move cursor along desired line and release button when ready. The graph in Figure 6 will be displayed. Close the Line Profile Window and repeat as many times are desired. Hit the space bar and MuraTool will move to the Segmentation stage.

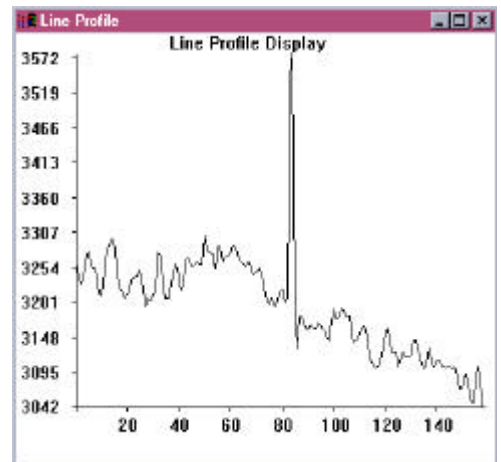


Figure 6: Line Profile Display

b. Pixel Display: A tool that displays the amplitude of all pixels in a 20X20 square window, which is useful for setting contrast parameters. Click the Pixel Display Toggle in the MuraTool Main Window. Execute the program. In the DUT Image Window, hold down the right mouse button, move cursor to the desired location and release button. The pixel amplitudes will be displayed in the System Messages Window. Repeat the process as many times as desired. Hit the space bar to move on to the Segmentation portion of the algorithm.

To display pixels, hold down right button, move cursor to desired location and release button when ready. Press any key or middle button in window to continue.

```

3268 3279 3287 3296 3300 3295 3324 3305 3262 3300 3293 3262 3299 3325 3328 3321 3306 3325 3326 3321
3259 3264 3283 3313 3323 3274 3333 3300 3254 3325 3283 3263 3304 3316 3319 3320 3318 3336 3339 3335
3252 3262 3282 3300 3316 3283 3342 3289 3252 3324 3281 3262 3315 3318 3209 3307 3311 3312 3321 3331
3271 3283 3289 3270 3274 3268 3332 3300 3269 3340 3301 3257 3301 3313 3200 3290 3295 3279 3285
3299 3300 3305 3264 3241 3228 3300 3279 3250 3333 3307 3263 3275 3307 3301 3303 3306 3299 3265 3247
3295 3284 3289 3263 3246 3235 3301 3256 3211 3280 3270 3267 3263 3296 3309 3304 3296 3309 3279 3254
3235 3243 3262 3266 3260 3254 3332 3272 3210 3284 3252 3266 3277 3277 3281 3269 3273 3262 3272 3258
3217 3226 3251 3266 3257 3238 3317 3275 3224 3295 3253 3273 3271 3254 3262 3273 3262 3270 3256
3210 3210 3231 3252 3247 3223 3309 3288 3219 3285 3262 3245 3246 3260 3254 3293 3310 3300 3284 3252
3228 3234 3242 3253 3240 3218 3290 3273 3215 3262 3246 3245 3243 3240 3251 3302 3323 3304 3282 3253
3234 3247 3256 3257 3242 3194 3263 3242 3296 3288 3254 3249 3243 3244 3265 3296 3299 3265 3265
3228 3225 3239 3245 3243 3291 3278 3266 3263 3272 3284 3250 3250 3261 3294 3293 3239 3236 3245
3226 3232 3229 3230 3230 3201 3293 3286 3227 3281 3250 3240 3230 3245 3245 3277 3267 3231 3219 3295
3209 3223 3234 3239 3235 3191 3266 3250 3249 3223 3241 3237 3226 3203 3234 3273 3265 3240 3243
3207 3220 3226 3227 3217 3184 3256 3229 3277 3254 3217 3215 3232 3212 3182 3193 3244 3254 3233 3238
3199 3206 3199 3187 3176 3150 3247 3233 3286 3241 3222 3233 3234 3222 3190 3187 3194 3201 3201 3195
3198 3187 3178 3150 3157 3140 3239 3235 3278 3238 3217 3263 3240 3221 3216 3185 3170 3170 3213 3213
3199 3199 3188 3170 3164 3142 3231 3233 3240 3208 3230 3265 3251 3221 3221 3202 3176 3170 3223 3209
3198 3174 3167 3163 3186 3167 3233 3236 3278 3235 3218 3296 3223 3142 3213 3210 3186 3173 3220 3263
3182 3199 3190 3166 3183 3144 3217 3299 3262 3281 3281 3222 3285 3194 3204 3289 3199 3193 3216 3262

```

Figure 7: Pixel Display tool as shown in System Messages Window

c. Debug Masks: Shows pseudo color maps for each segmented defect. Click the Debug Masks Toggle in the MuraTool Main Window. Execute the program. Segment desired defect. A pseudo color map showing the size and location of the segmentation mask will appear in the upper left hand corner. Continue segmenting defects, a debug mask will appear for every blemish segmented. Complete program. This tool is helpful in determining if the correct segmentation mask size was chosen by allowing the user to compare the DUT image to the segmented mask image.

Summary: Cyclical, random, low contrast blemish defects have hampered flat panel inspection and qualification since the birth of the industry. Version 2 of the VESA FPDM at long lasts addresses this issue by proposing a new mura measurement standard. This standard uses a set of 15 rules to classify all blemishes in to one of 23 classes of mura. This classification scheme will allow FPD integrators to write objective incoming inspection specifications and provide clear standards of quality that FPD manufacturers will be able to gauge their products against. Photon Dynamics developed MuraTool to help VESA members better understand this new standard and to allow basic, manual classification of blemishes in FPD images. For more information about MuraTool and how to get your free copy, please email charlesa@phodyn.com.