



APPLICATION NOTE

Matrix 300™

Guide to Lighting System Selection for DPM Applications

Reference Software Versions:

6.61 and later

History

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1 LIGHTING SYSTEMS FOR DPM

1.1 OVERVIEW

The Matrix 300™ **Wide** angle integrated illuminators are an optimum solution for all applications where codes are printed on paper and for most applications where direct part marking is obtained by ink jet or laser etching technology on flat non-reflective surfaces, without any evident machining flaws made by machine tools (i.e. cutters or lathes).



**Matrix 300 41x-xxx
Red Wide**



**Matrix 300 45x-xxx
White Wide**

When codes are marked on very reflective surfaces however, the above illuminators can be used only if the reader's pitch or skew angle required to avoid direct reflection doesn't compromise code reading due to perspective distortion of which the code images are inevitably affected.

In other cases, where the above mentioned illuminators do not permit code image acquisition of sufficient quality for decoding, it is necessary to select a different lighting system. There are currently two Bright Field and Dark Field integrated illuminators which have been specifically designed by Datalogic for Direct Part Marking (DPM) code reading applications.



**Matrix 300 47x-xxx
LT-DPM**



**Matrix 300 48x-xxx
MLT-DPM**

Accessory external lighting systems are also available and can be used for DPM applications.



LT-510 Mini-Dome Lighting System



LT-511 Dome Lighting System

The following paragraph gives a guideline to help select the most suitable Lighting System for a specific application.

1.2 LIGHTING SYSTEM SELECTION CRITERIA

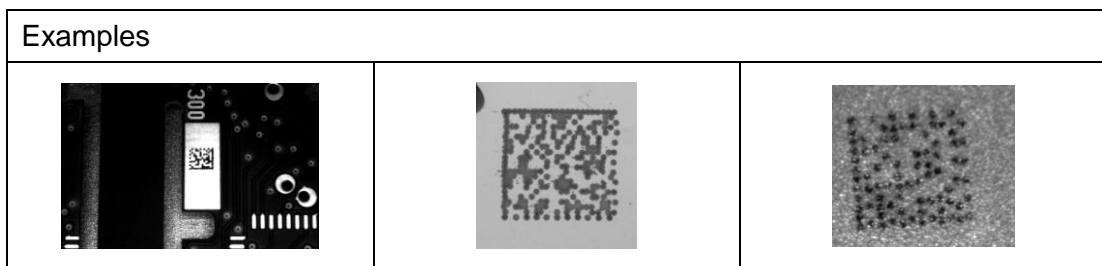
The principle factors that determine selection of the most suitable Lighting System for a code reading application are:

1. Code Printing or Marking Technique:

- Printing on paper or labels



- Direct Marking with Ink Jet process



- Direct Marking with Laser Etching process

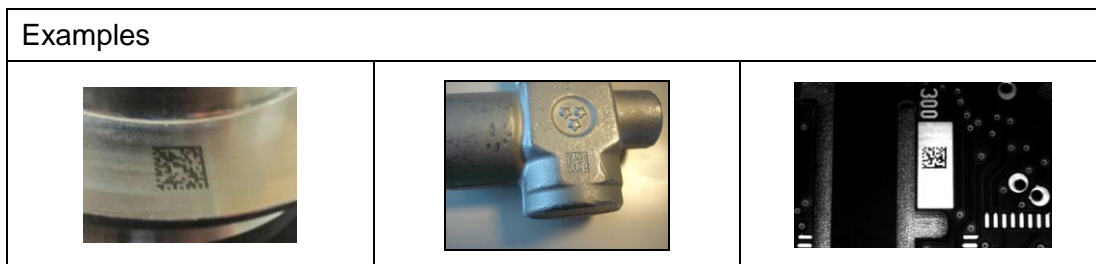


- Direct Marking with Dot Peening process



2. Shape of the code marking surface:

- Flat surface

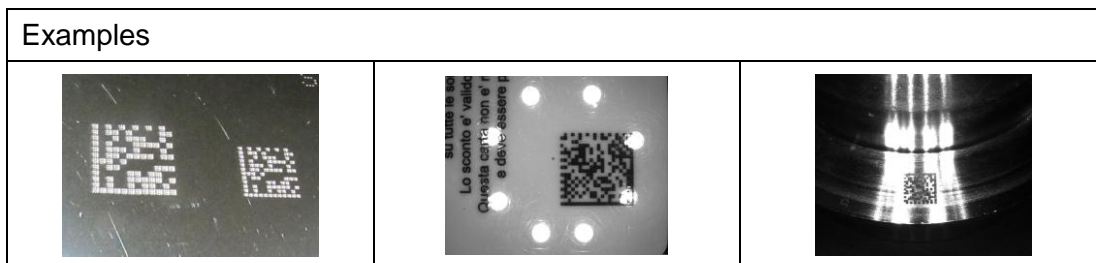


- Curved surface



3. Reflectivity of the code marking surface:

- Highly reflective surface



- Opaque surface

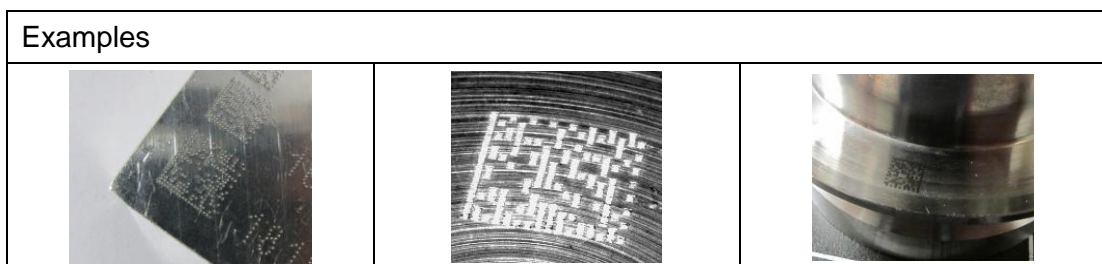


4. Texture of the code marking surface:

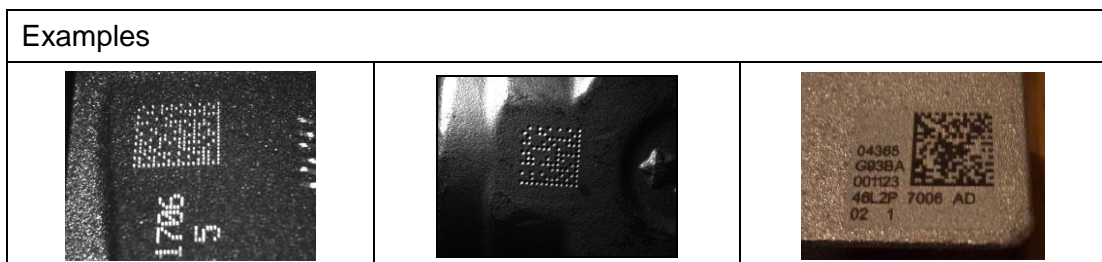
- Smooth surface without any defects (such as scratches or streaks)



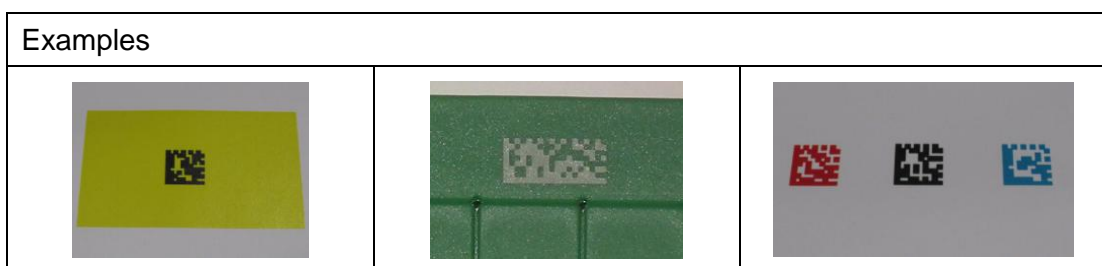
- Surface with machining flaws produced by machining tools



- Rough surface typical of die-cast parts



















































5. Colored codes and/or background:



Typically, in DPM applications, the above mentioned factors are present in different combinations creating a vast number of cases. However, it is possible to subdivide the most common applications into macro-cases having characteristics that determine the choice of the most suitable lighting system to resolve the relative application, guaranteeing the best compromise between performance and cost.

In the following table these macro-cases are listed, and for each of them, the most suitable Matrix 300™ lighting systems used to resolve the application.

Application Characteristics	Red Wide	White Wide	LT-DPM	MLT-DPM Central	MLT-DPM Peripheral	LT-51x
Printed codes on opaque paper or labels having a flat surface						
Laser Etching or Ink Jet code marking on an opaque, flat surface having no evident machining flaws						
Code marking on an opaque, rough surface						
Code marking on a flat surface with evident machining flaws produced by machining tools						
Laser Etching or Dot Peening code marking on a flat, highly reflective surface						
Code marking on a curved surface						
Red-printed code on white background						
Mixed color codes/background						

Legend:



Suggested Lighting System



Compatible Lighting System



Lighting System Not Recommended



NOTE: For correct use of the **MLT-DPM Peripheral** and **LT-51x** illuminators, verify that the application working distance is within the lighting systems working distance. See the following table.

1.3 LIGHTING SYSTEM WORKING DISTANCES

Matrix 300 Model	Lighting System	Working Distance
Matrix 300 41x-xxx	Red Wide	20 to 550 mm
Matrix 300 45x-xxx	White Wide	20 to 550 mm
Matrix 300 47x-xxx	LT-DPM both chains	20 to 250 mm
Matrix 300 48x-xxx	MLT-DPM Central Chains	20 to 250 mm
Matrix 300 48x-xxx	MLT-DPM Peripheral Chains	20 to 50 mm
Any model	LT-51x	12.7 to 50 mm

2 INTERNAL ILLUMINATORS

2.1 WIDE ANGLE ILLUMINATORS



8 LED Red or White Wide Angle Illuminator

The two *Wide Angle* illuminators are made up of 8 LEDs which are all controlled simultaneously by the software application.

These are Bright Field general purpose illuminators used in the operating distance range from 20 to 550 mm.

The **RED Wide** illuminator is an optimum solution for applications where codes are printed on paper and where Direct Part Marking (DPM) is obtained by ink jet or laser etching technology on flat non-reflective surfaces, without any evident machining flaws made by machine tools (i.e. cutters or lathes). The reader's pitch or skew angle helps to avoid direct reflection when codes are marked on very reflective surfaces.

The **WHITE Wide** illuminator is suitable for applications with colored codes and/or colored backgrounds (e.g. red code on white background) or with mixed color codes (e.g. blue/red ink on white background).

2.2 LT-DPM ILLUMINATOR

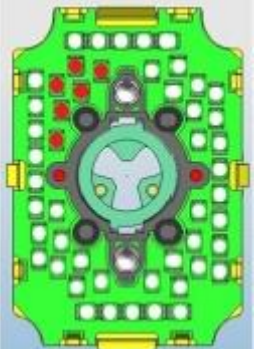
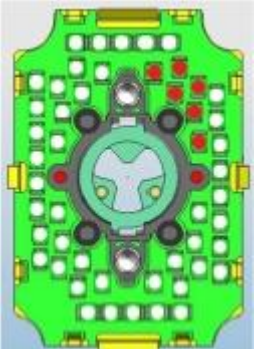
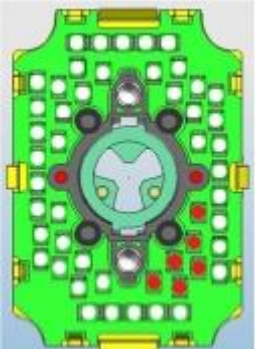
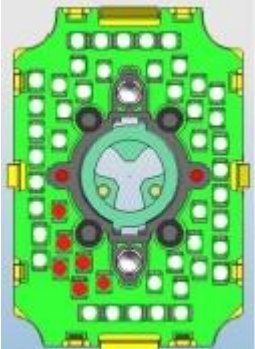
In many DPM applications the *Wide Angle* Illuminator models do not provide sufficient code image quality for decoding. Therefore **LT-DPM** and **MLT-DPM** illuminators were developed in order to solve such applications with smarter and more flexible solutions.

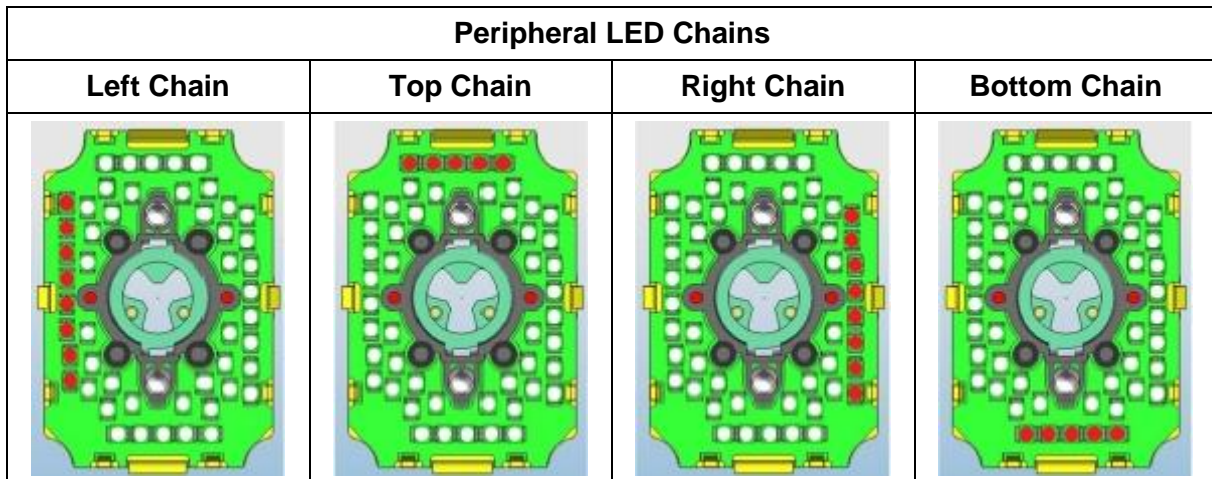


26/24 LED LT-DPM Illuminator

The **LT-DPM** illuminator is made up of 50 LEDs divided into two groups of four chains each which are independently controlled by the software application. Four chains make up the internal group called *Central LED Chain*. The other four chains make up the external group called *Peripheral LED Chain*.

This is a Bright Field illuminator used in the operating distance range from 20 to 250 mm.

Central LED Chains			
Left Top Chain	Right Top Chain	Right Bottom Chain	Left Bottom Chain
			

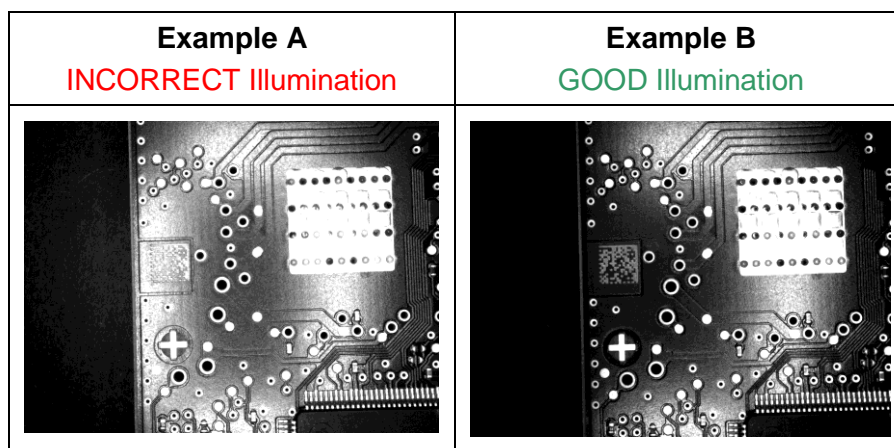


Via software each single chain can be turned on, however it is **NOT** possible to simultaneously turn on chains belonging to the separate LED Chain groups Peripheral and Central. Even with this restriction, thirty different combinations of ON/OFF lighting configurations can be obtained.

By enabling Multi Acquisition Settings, each having a different ON/OFF LED combination, it is possible to acquire different consecutive images, changing the activation of the eight LED chains. This feature is particularly effective for reading codes printed/marked on reflective surfaces, by sequentially turning OFF the single LED chains.

In the example below, a Data Matrix code which has been etched onto a PCB (reflective surface) must be read.

With all four LED chains enabled (Example A), the code is not readable due to the LED reflections on the code surface. By setting a different Acquisition Setting in which the Right Chain is turned off (removed from the parameter combination – Example B), the code is illuminated by the other LED chains without the reflections on the code surface.



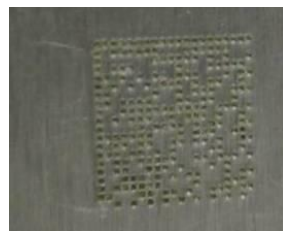
Furthermore, the use of **LT-DPM** is really effective in direct part mark applications (DPM), where linear machining flaws are present on the part surfaces. In fact, in these cases, an image of the code can be obtained having a very light background. In addition, the high number of LEDs and the diffuser increase background uniformity because the dark bands that are generated by the spacing between adjacent LEDs are minimized.

Take into consideration that when using **LT-DPM** to illuminate surfaces where linear machining flaws are present, the well-lighted area depends on the direction of the machining flaws with respect to the illuminator's LED chains, but independent of the reading distance.

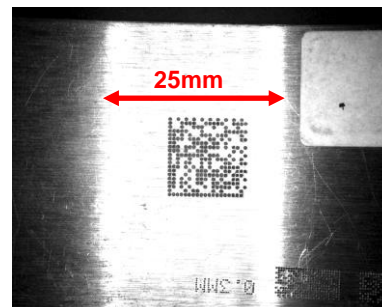
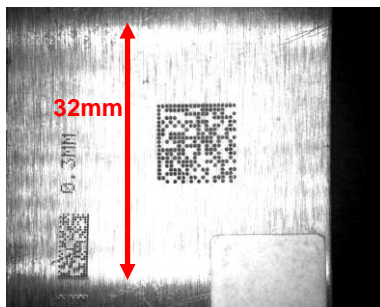
Clearly this characteristic fixes the upper limit of the code dimensions compatible with the use of the **LT-DPM**. In reality, it is an actual limit of the usable part of the field of view. Therefore this limit must be taken into consideration during the feasibility analysis of the solution, including the eventual positioning variation of the codes with respect to the center of the reader's field of view.

The arrangement of the LED chains allows obtaining a well-lighted area even when the direction of the machining flaws is changed.

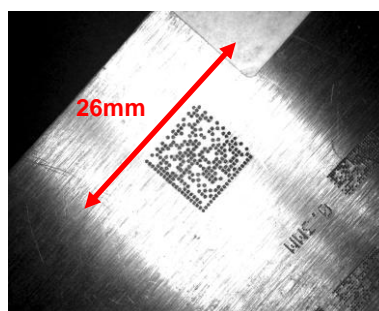
Refer to the following images for the dimension of lighted area illuminated by the different LED chains.



Color Photo of Code



LT-DPM Peripheral LED Chains



LT-DPM Central LED Chains

2.3 MLT-DPM ILLUMINATOR

This is both a Bright Field and a Dark Field illuminator.



39/24 LED MLT-DPM Illuminator

The **MLT-DPM** illuminator is made up of 63 LEDs divided into two groups of four chains each which are independently controlled by the software application.

Four chains of six LEDs each make up the internal group called *Central LED Chain* and correspond to Bright Field illumination. The operating distance range is typically from 20 to 250 mm.

The use of the **MLT-DPM** *Central LED Chains* is particularly effective in direct part mark applications (DPM), where linear machining flaws are present on the part surfaces. In fact, in these cases, an image of the code can be obtained having a very light background.

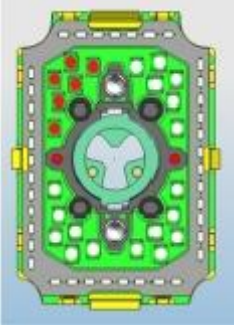
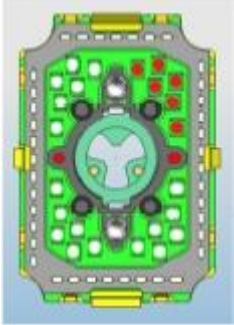
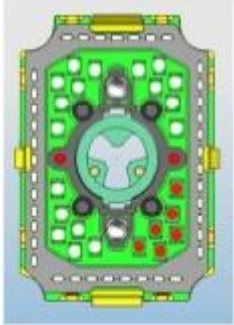
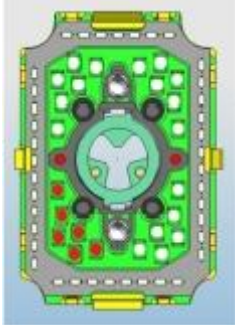
The other four chains make up the external group called *Peripheral LED Chain* and correspond to Dark Field illumination. Dark Field illumination is guaranteed by the 39 side-emitting blue LEDs divided as follows: a TOP chain of 7 LEDs, a BOTTOM chain of 8 LEDs and two chains (LEFT and RIGHT) of 12 LED each.

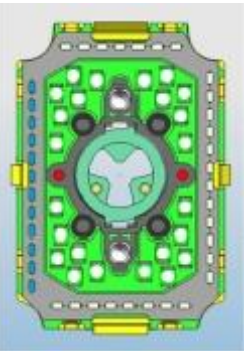
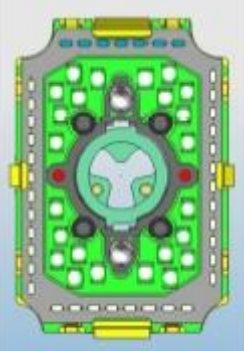
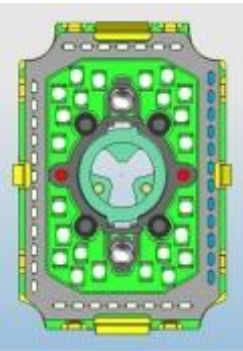
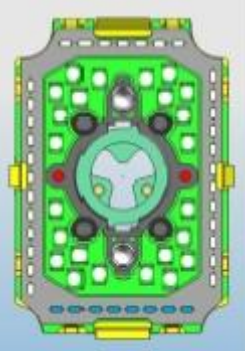
The *Peripheral LED Chains* can be the correct solution for DPM applications with highly reflective surfaces. In these applications, by using a traditional bright field illuminator, the code can result unreadable because in the acquired image some parts of the code are made invisible due to grey-level saturation generated by direct reflection of the illuminator LEDs.

To obtain optimum Dark Field illumination, it is necessary to work at close range, typically in the range from 20 to 50 mm.

An orange filter is applied to the cover in front of the *Central LED Chains* in order to avoid harmful blue light reflections off the Central LED component packages.

The *Peripheral LED Chains* can also be used as a Bright Field illuminator in the range from 50 to 100 mm. These chains are similar to the **LT-DPM Peripheral LED Chains** but differ by the light intensity (lower in the **MLT-DPM**) and wavelength emitted by the LEDs.

Central LED Chains			
Left Top Chain	Right Top Chain	Right Bottom Chain	Left Bottom Chain
			




Peripheral LED Chains			
Left Chain	Top Chain	Right Chain	Bottom Chain
			

Like the **LT-DPM**, in software each single chain can be turned on, however it is **NOT** possible to simultaneously turn on chains belonging to the separate LED Chain groups Peripheral and Central. Even with this restriction, thirty different combinations of ON/OFF lighting configurations can be obtained.

By enabling Multi Acquisition Settings, each having a different ON/OFF LED combination, it is possible to acquire different consecutive images, changing the activation of the eight LED chains. This feature is particularly effective for reading codes printed/marked on reflective surfaces, by sequentially turning OFF the single LED chains.

In the example below, two Data Matrix codes which have been etched onto a plastic reflective surface must be read.

With all four LED chains enabled (Example A), the code is not readable due to the LED reflections on the code surface. By setting different Acquisition Settings in which the Right Bottom Chain is turned off (removed from the parameter combination – Example B) and Left Top Chain is turned off (removed from the parameter combination – Example C), the code is illuminated by the other LED chains without the reflections on the code surface.

Example A INCORRECT Illumination	Example B GOOD Illumination on Left code	Example C GOOD Illumination on Right code
		

Take into consideration that, like **LT-DPM**, when using **MLT-DPM Central LED Chains** to illuminate surfaces where linear machining flaws are present, the well-lighted area depends on the direction of the machining flaws with respect to the illuminator's LED chains, but independent of the reading distance.

Clearly this characteristic fixes the upper limit of the code dimensions compatible with the use of the **MLT-DPM**. In reality, it is an actual limit of the usable part of the field of view. Therefore this limit must be taken into consideration during the feasibility analysis of the solution, including the eventual positioning variation of the codes with respect to the center of the reader's field of view.

The arrangement of the LED chains allows obtaining a well-lighted area even when the direction of the machining flaws is changed.

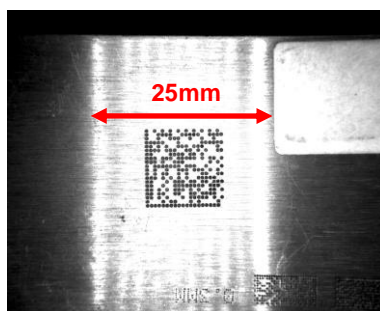
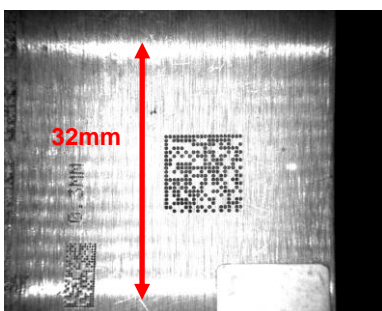
Refer to the following images for the dimension of lighted area illuminated by the different LED chains.



Color Photo of Code



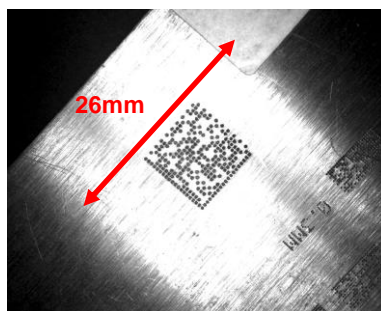
NOTE: When using the **MLT-DPM Peripheral LED Chain (Dark Field)**, the photometric parameters (*Exposure Time* and *Gain*) are set to higher values in order to obtain results similar to the **LT-DPM Peripheral LED Chain (Bright Field)**.



MLT-DPM Peripheral LED Chains



NOTE: When using the **MLT-DPM Central LED Chain (Bright Field)**, the photometric parameters (*Exposure Time* and *Gain*) are set to lower values in order to obtain results similar to the **LT-DPM Central LED Chain (Bright Field)**.



MLT-DPM Central LED Chains

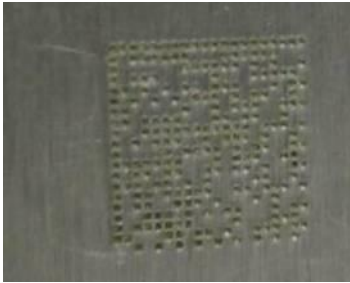
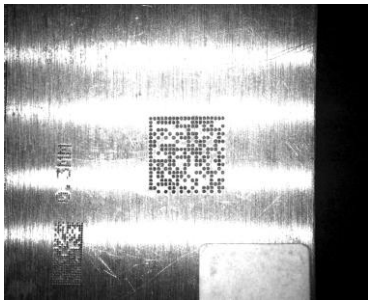
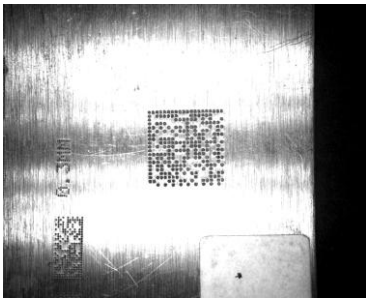
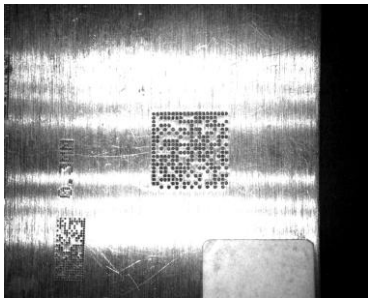
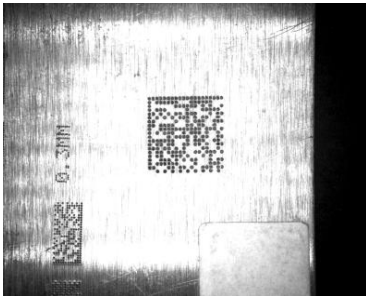
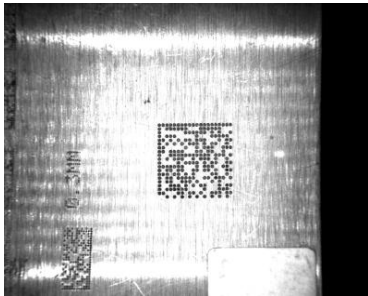
3 APPLICATIONS

Several examples are given in this chapter regarding the four illuminator models previously described.

3.1 EXAMPLE A


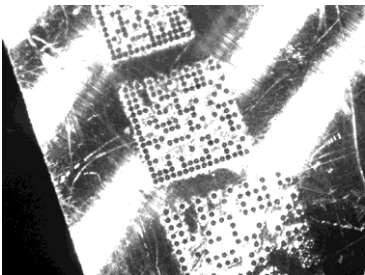
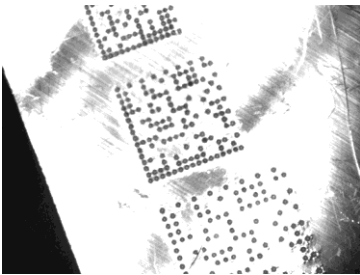
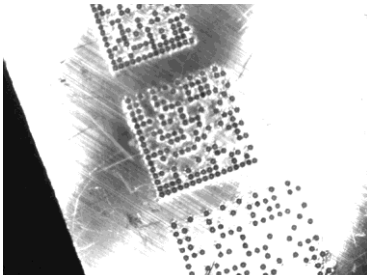
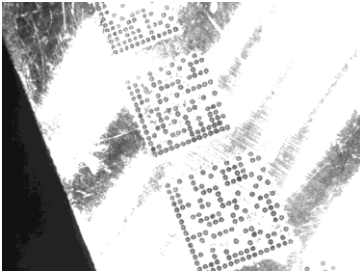
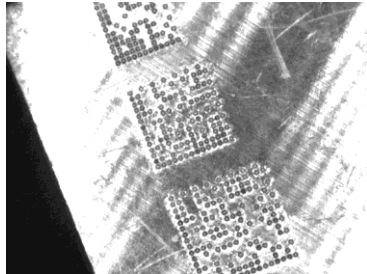
To better understand the advantages of using the **LT-DPM** e **MLT-DPM** in DPM applications where linear machining flaws are present on the part surfaces, see the first two examples (A and B). In both examples, Data Matrix codes are marked using *dot peening* onto metal surfaces having evident machining flaws previously produced by machine tools.

Example of Dot Peening on a flat surface with vertical streak-like processing flaws produced by machining tools.

	Color photo of code	
		
Red Wide	LT-DPM - Central	MLT-DPM - Central
		
INCORRECT Illumination	INCORRECT Illumination	INCORRECT Illumination
	LT-DPM - Peripheral	MLT-DPM - Peripheral
		
	GOOD illumination	GOOD illumination

3.2 EXAMPLE B


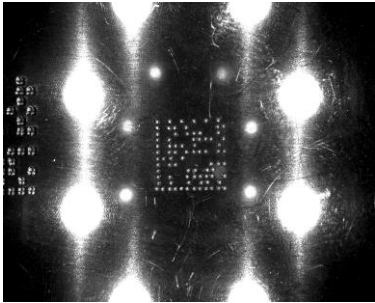
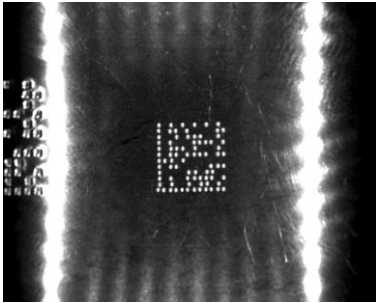

Example of Dot Peening on a flat surface with diagonal processing flaws produced by machining tools.

	Color photo of code	
		
Red Wide	LT-DPM - Central	LT-DPM - Peripheral
		
INCORRECT Illumination	GOOD Illumination	INCORRECT Illumination
	MLT-DPM - Central	MLT-DPM - Peripheral
		
	INCORRECT illumination	INCORRECT Illumination

3.3 EXAMPLE C

Example C shows the benefits obtained with **MLT-DPM** on codes produced using *dot peening* on metal surfaces with high reflectance.

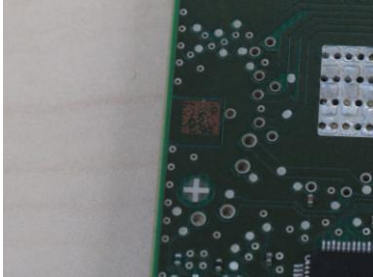
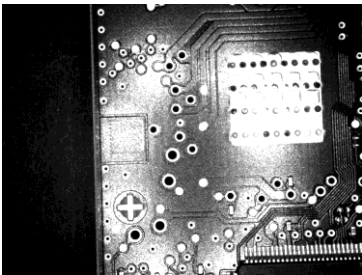
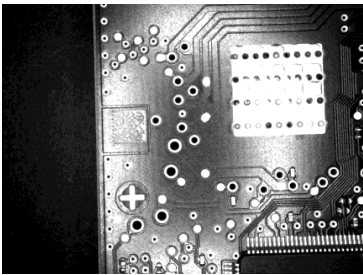
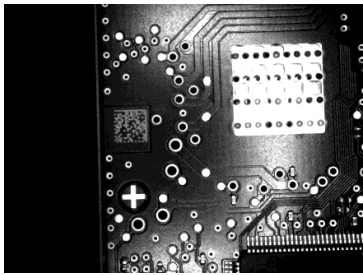
Example of Dot Peening on a flat highly reflective surface.

	Color photo of code	
		
Red Wide	MLT-DPM - Peripheral	MLT-DPM - Central
		
INCORRECT Illumination	GOOD Illumination	INCORRECT Illumination

3.4 EXAMPLE D

The following examples, D and E, show the advantages obtained with **LT-DPM** and **MLT-DPM** and the **Multi Acquisition Setting Mode**.






Example of laser etching on PCB: LT-DPM with Multi Acquisition Settings.

	Color photo of code	
		
Red Wide	LT-DPM – Peripheral All Chains ON	LT-DPM – Peripheral Right Chain OFF
		
INCORRECT Illumination	INCORRECT Illumination	GOOD Illumination

3.5 EXAMPLE E

Example E refers to codes produced using the laser etching process on metal surfaces that do not have evident machining flaws, but are however characterized by reflectance dependent on the direction of illumination.

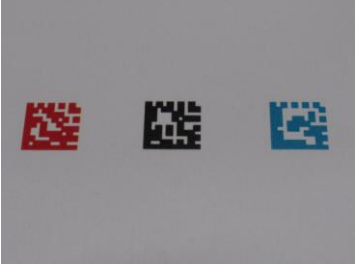
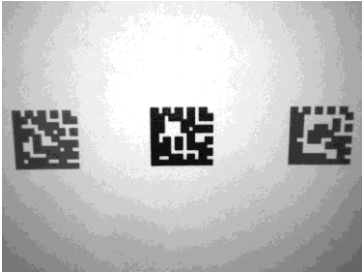
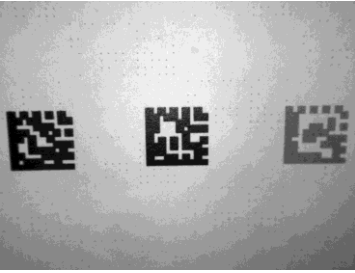
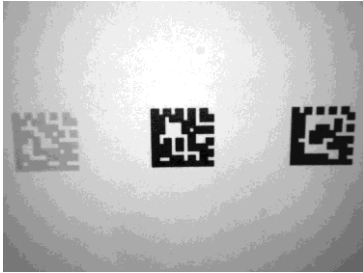
Background with anisotropic reflectance.

	Color photo of code	
		
Red Wide	MLT-DPM – Peripheral All Chains ON	
		
INCORRECT Illumination	SUBOPTIMAL Illumination	
	MLT-DPM – Peripheral Top, Bottom Chains ON	MLT-DPM – Peripheral Left, Right Chains ON
		
	INCORRECT Illumination	GOOD Illumination

3.6 EXAMPLE F

Finally, the last example shows the performance of **WHITE Wide** for applications with mixed-color codes on a white background.

Example of multi coloured codes on white paper.

	Color photo of code	
		
White Wide	MLT-DPM – Peripheral	MLT-DPM – Central
		
GOOD contrast on all codes	Red left code has GOOD contrast Blue right code has LOW contrast	Red left code has VERY LOW contrast Blue right code has GOOD contrast