



APPLICATION NOTE

Matrix 210™ and Matrix 410™

Guide to Lighting System Selection for DPM Applications

Reference Software Versions:

6.35

6.50 and later

History

Issue	Date	Paragraph	Change
Rev. 0	August 8th 2012		First Release
Rev. 1	January 22nd 2013		Corrected typing errors and cropped images

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1 LIGHTING SYSTEMS FOR DPM

1.1 OVERVIEW

The Matrix 210™ integrated illuminator and the Matrix 410™ internal ring illuminators (8 or 15 LEDs) 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).

When codes are marked on very reflective surfaces, 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 for the Matrix reader among those specifically designed by Datalogic for Direct Part Marking (DPM) code reading applications.



LT-005 Blue 8x4 LED chain for DPM
(only for Matrix 410™)



LT-700 Linear Array Lighting System



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

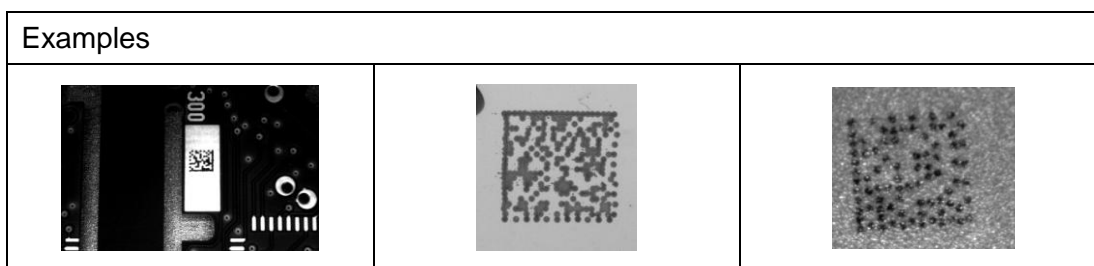
The principle factors that determine selection of the most suitable Lighting System for a code reading application are:

1. Code Printing or Marking Technique:

- Printing on paper or labels



- Direct Marking with Ink Jet process



- Direct Marking with Laser Etching process

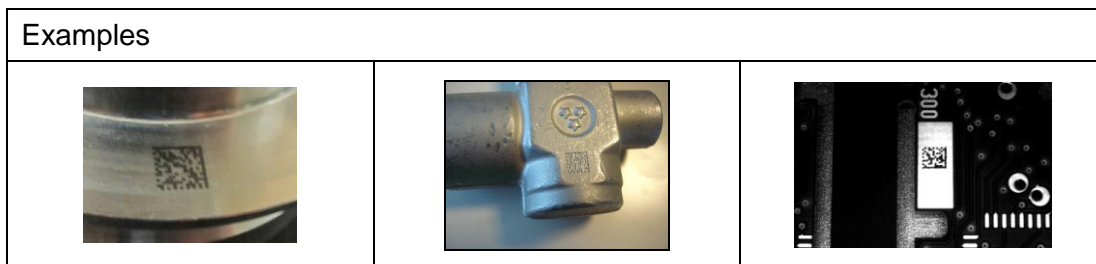


- Direct Marking with Dot Peening process



2. Shape of the code marking surface:

- Flat surface

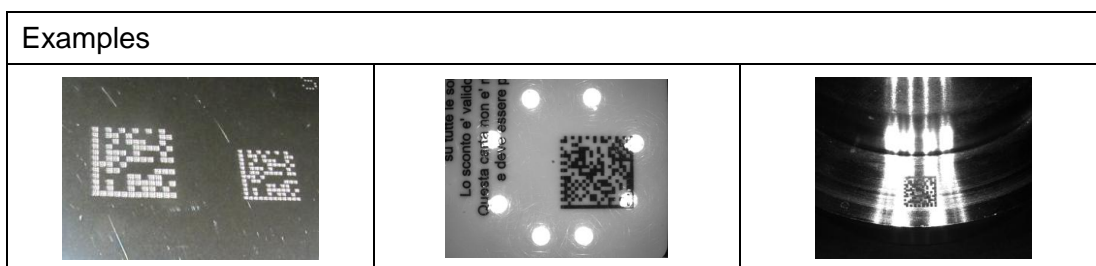


- Curved surface



3. Reflectivity of the code marking surface:

- Highly reflective surface



- Opaque surface

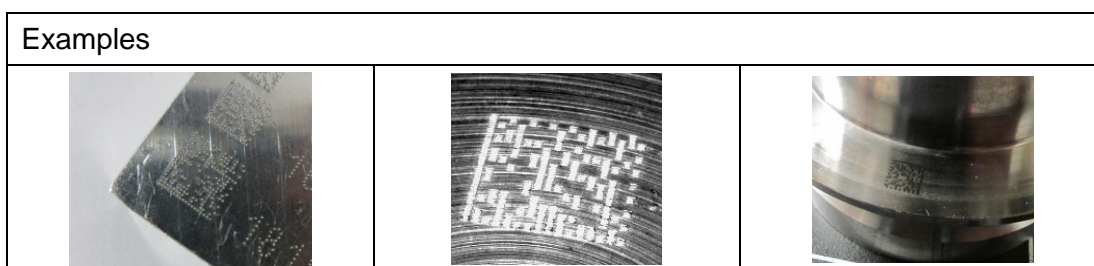


4. Texture of the code marking surface:

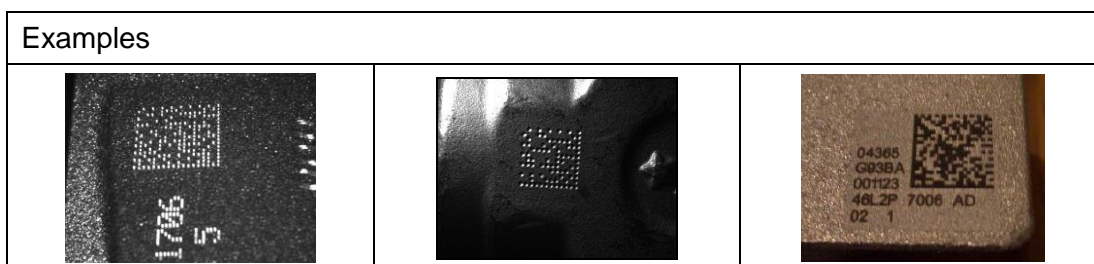
- Smooth surface without any defects (such as scratches or streaks)



- Surface with machining flaws produced by machining tools



























- Rough surface typical of die-cast parts



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 reader lighting systems to resolve the application are indicated.

Application Characteristics	Standard Internal Illuminator	LT-005	LT-700	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				

Legend:



Suggested Lighting System



Compatible Lighting System



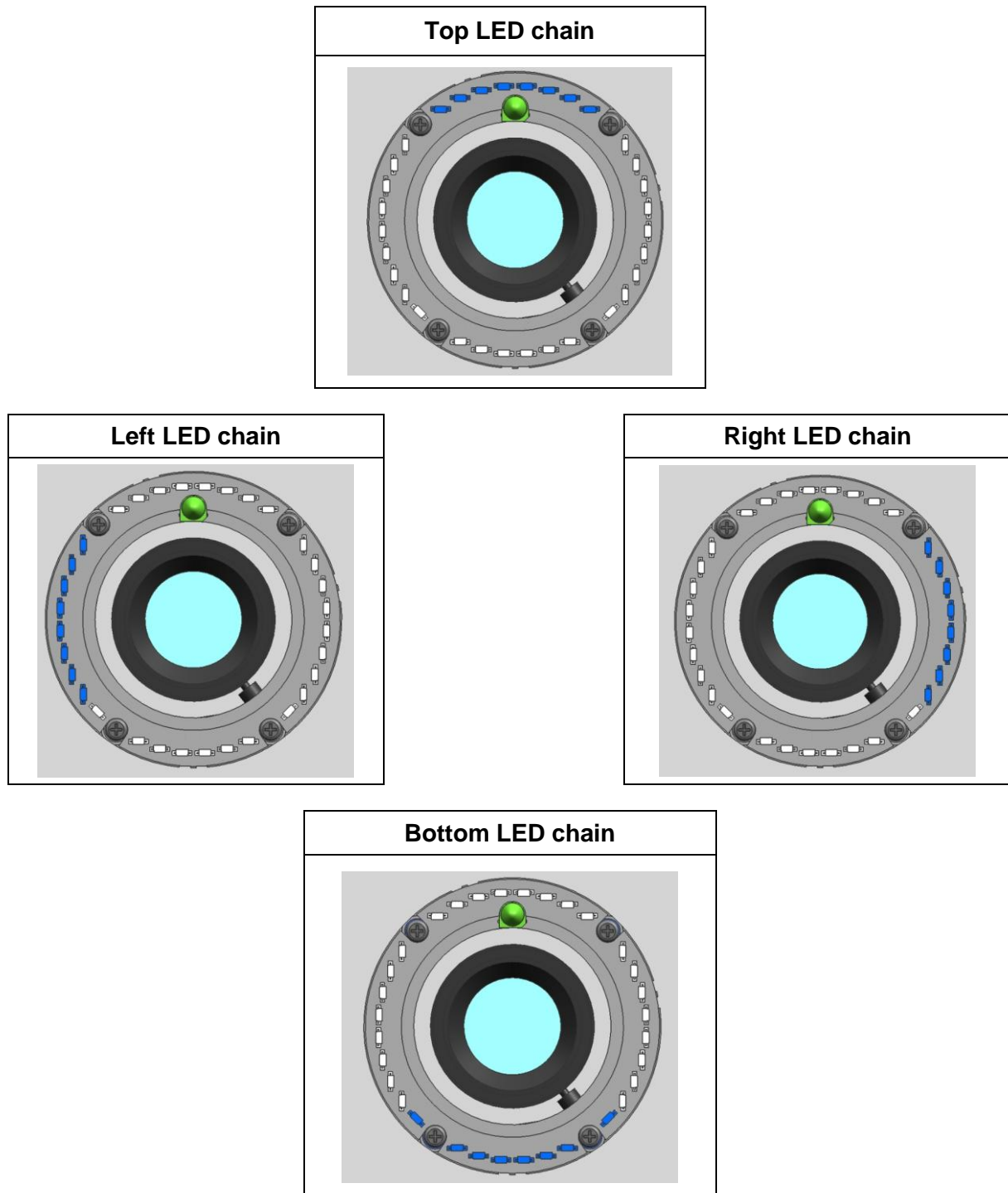
Lighting System Not Recommended

2 LT-005 ILLUMINATOR

The LT-005 is made up of 32 *side-emitting blue LEDs* divided into four chains of 8 LEDs each. The application software allows controlling each chain separately; therefore all of the possible ON/OFF combinations of the four LED groups are possible.

Using VisiSet™ it is possible to set several different Image Acquisition Settings for the LT-005, and consequently use multiple LT-005 lighting conditions within the same reading phase.

Front Views



The LT-005 has significantly less lighting power than the other Matrix 410™ internal illuminators and is advised for applications having a reading distance between 50 and 100 mm.

In addition, it is suggested to use LT-005 only with the following combination of lenses:

- **9 mm**
- **12.5 mm**
- **16 mm**

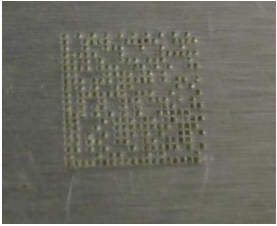
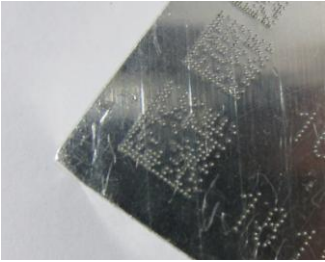

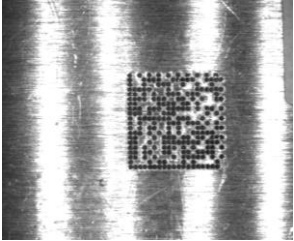
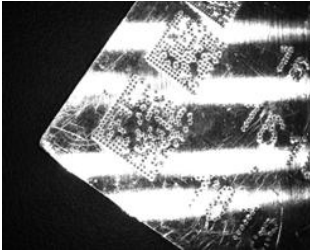

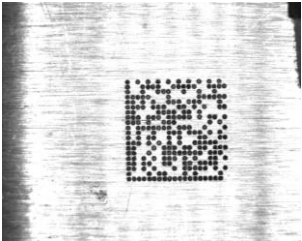
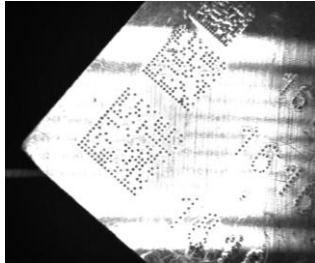
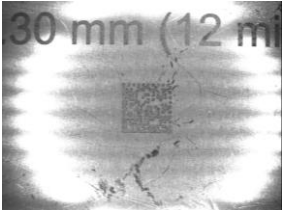
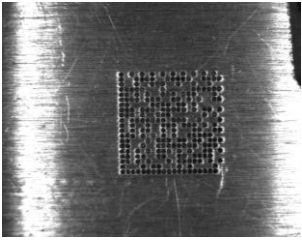
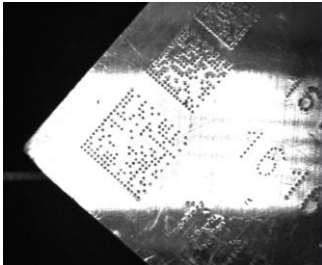
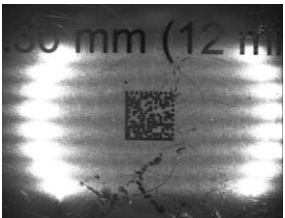

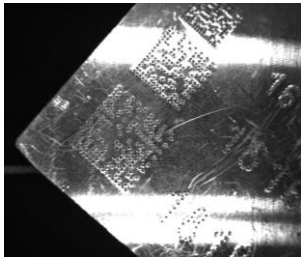

These lenses can also be focused at distances between 50 and 85 mm, measured from the Matrix 410™ reading window. It should however be taken into account that in this focusing distance range there can be a small loss of image quality at the edges of the field of view.

The use of LT-005 is particularly efficient in direct part mark applications (DPM), where linear machining flaws are present on the part surfaces. In fact, in these cases, by illuminating the surface of the part perpendicularly to the machining direction, an image of the code is obtained having a very light background. In addition, the high number of LEDs increases background uniformity because the dark bands that are generated by the spacing between adjacent LEDs are minimized.

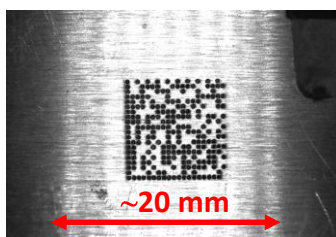
To better understand the advantages of using the LT-005 in DPM applications where linear machining flaws are present on the part surfaces, see the first two examples in the table below (A and B). In both examples, Data Matrix codes are imprinted using *dot peening* onto metal surfaces having evident machining flaws previously produced by machine tools.

Example C, instead, shows the benefits obtained with LT-005 on 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.

The benefits obtained using LT-005 with respect to LT-002 on example C are analogous to those of examples A and B.

	Example A <i>Horizontal Machining Flaws</i>	Example B <i>Vertical Machining Flaws</i>	Example C <i>Anisotropic Reflectance</i>
Color photo of code			
Matrix 410™ acquired image using LT-002 (8 LEDs)			
Matrix 410™ acquired image using LT-005: Top, Bottom, Left, Right (all 32 LEDs on)			
Matrix 410™ acquired image using LT-005: Left, Right (16 LEDs on)			
Matrix 410™ acquired image using LT-005: Top, Bottom (16 LEDs on)			

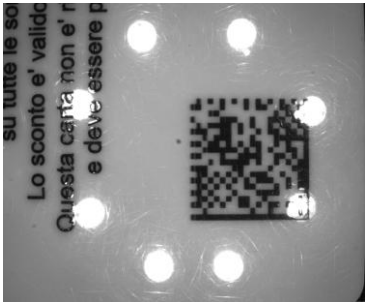
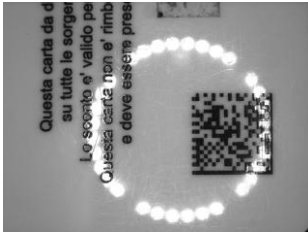
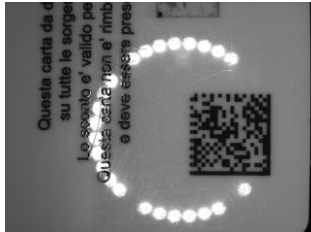
Take into consideration that when using LT-005 to illuminate surfaces where linear machining flaws are present, the well lighted area in the parallel direction to the machining flaws has a width of about 20 mm, independent of the reading distance. See the figure below.



Clearly this characteristic fixes the upper limit of the code dimensions compatible with the use of the LT-005. 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 using LT-005, including the eventual positioning variation of the codes with respect to the center of the reader's field of view.

LT-005 can also be the correct solution for DPM applications with highly reflective surfaces. In these applications, the code can result unreadable because in the acquired image some parts of the code are rendered invisible due to grey-level saturation generated by direct reflection of the illuminator LEDs.

In the example in the following table, while using LT-002 inevitably presents white spots on the code corresponding to reflection of the 8 LEDs; with LT-005 it is possible to acquire different consecutive images, changing the activation of the four LED chains so that regardless of the code position within the field of view, at least one image will be obtained that does not have part of the code effected by direct LED reflection.

Matrix 410™ acquired image using LT-002	Matrix 410™ acquired images using LT-005	
 <p>NOT readable</p>	Top, Bottom, Left, Right (all 32 LEDs on)	Top, Bottom, Right (Left LED chain off)
	 <p>NOT readable</p>	 <p>Readable</p>

3 LT-700 ILLUMINATOR

The LT-700 is made up of 38 red LEDs having an emission angle of 60° and are arranged in three interlaced rows in order to produce a very uniform illumination.

The 38 LEDs cover a rectangular surface of 50 x 13 mm; the field of illumination at a distance of 75 mm is about equal to 80 x 70 mm. Further technical features are listed in the following table:

Supply Voltage	10 to 30 Vdc
Power Consumption	0.25 to 1.0 A; 3 W max.
Optimal Working Distance	application dependent
Effective Working Range	application dependent
Illumination Area:	
@ 50 mm (2 in)	70 × 55 mm (2.75 × 2.16 in)
@ 75 mm (3 in)	80 × 70 mm (3.15 × 2.75 in)
@ 100 mm (4 in)	90 × 85 mm (3.54 × 3.35 in)
Wavelength	630 nm
Typical Irradiance	180 W/m ² @ 75 mm (with Exposure Time ≤ 500 μs)
Operating Temperature	0 to 50 °C (32 to 122 °F)
Storage Temperature	-20 to 70 °C (-4 to 158 °F)
Max Humidity	90% non-condensing
Vibration Resistance EN 60068-2-6	1.5 mm @ 5 to 9 Hz; 0.5 g @ 9 to 150 Hz 2 hours on each axis
Shock Resistance EN 60068-2-27	15g; 11 ms; 3 shocks on each axis
Protection Class EN 60529	IP65
Dimensions (L x H x W) (without bracket)	68 x 33 x 28 mm (2.7 x 1.3 x 1.1 in)
Weight (without bracket)	113 g. (4 oz.)

LT-700 is a high lighting power illuminator and is designed to be used in pulse mode with pulse durations not longer than 500 μs and time between consecutive pulses not less than 6 ms.

The following table shows the wiring diagram used to connect LT-700 so that it will be driven by one of the two Matrix reader digital outputs; configurable through VisiSet™.

Wire Color	CBX/Matrix Signal	Meaning
Red	Vdc	10 to 30 Vdc
Black	GND	Ground
White	Earth	Shield/Earth Ground
Green	O1- or O2-	Control Signal -
Yellow	O1+ or O2+	Control Signal +

3.1 SOFTWARE PARAMETER CONFIGURATION

In the VisiSet™ Parameter Setup window make the following settings.

In the **Digital I/O** folder:

- for the desired output set **Line Function** to *External Lighting System*

In the **Calibration** folder:

- if **Output x External Lighting Mode** is set to *Trggered*
LT-700 is normally off and produces a light pulse corresponding to the exposure time of the Matrix sensor.
- if **Output x External Lighting Mode** is set to *Always On*
LT-700 enters protection mode. The LEDs are driven with high frequency pulses but at low average current levels, (Pulse Width = 10 μ s, Pulse Frequency = 2 KHz). Although the illuminator seems to be always on, in reality the LEDs are driven with asynchronous current pulses with respect to the exposure time of the Matrix sensor.

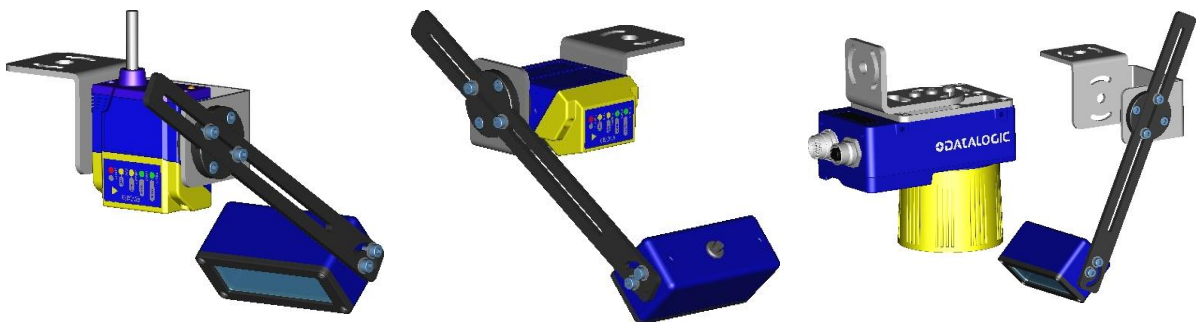
Also if **Output x External Lighting Mode** is set to *Trggered* and **Exposure Time** > 500 μ s or Frame Rate > 166 fps

LT-700 enters protection mode and doesn't guarantee the correct illumination pulses with respect to the exposure time of the Matrix sensor.

3.2 MOUNTING

The LT-700 body is very compact and has 6 holes for mounting to allow it to be installed in different positions (distances and inclination angles) with respect to the reader.

An accessory mounting bracket kit (BK-21-000) has been designed to facilitate using LT-700 in applications with Matrix 210™. The brackets are used to mount both the Matrix 210™ and the LT-700 assembly together.



LT-700 can also be used as an external illuminator for Matrix 410™. In this case there are no dedicated mounting brackets for the reader+illuminator assembly; however kit BK-21-000 can be used to mount the illuminator separately from the reader.

3.3 APPLICATIONS


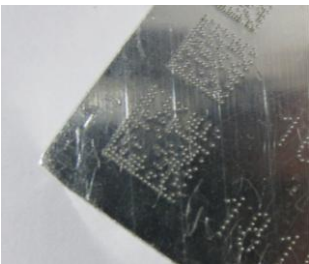

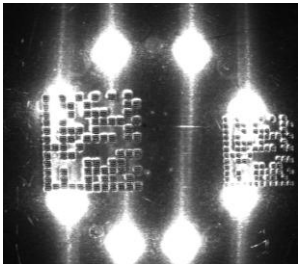
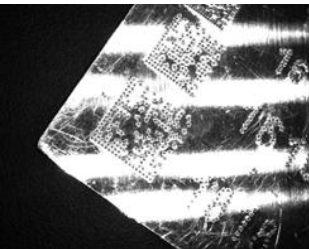
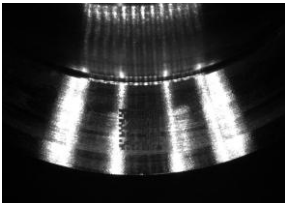
Regarding applications, LT-700 results to be an optimum solution both as a bright-field high lighting power illuminator, for example where the Matrix 210™ integrated illuminator doesn't provide sufficient lighting, as well as an adjustable angle illuminator in DPM applications for both Matrix 210™ and Matrix 410™.

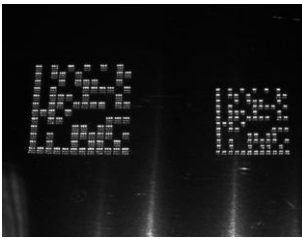
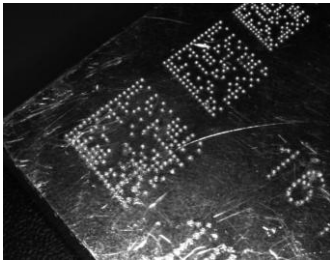
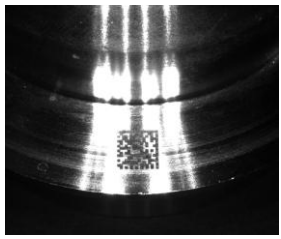


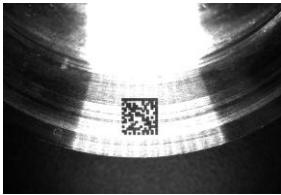
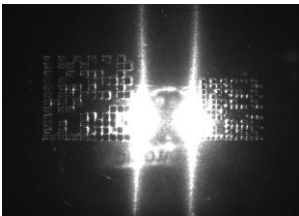
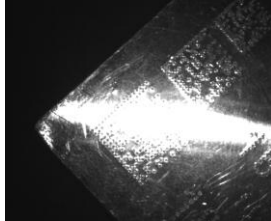
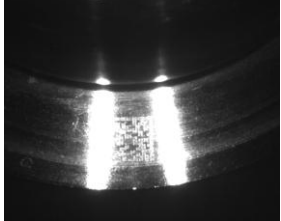

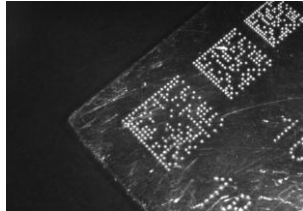
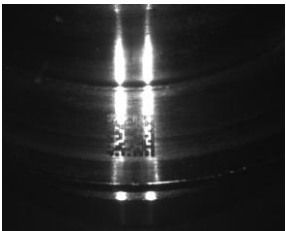
In DPM applications, LT-700 is particularly efficient when the code is produced by dot peening technology on reflective surfaces and/or with evident machining flaws. In these cases, to capture an image with good contrast, typically it is necessary to illuminate the code with a very low angle light with respect to the perpendicular axis of the marked surface.

When using the internal illuminator, if the pitch angle of the reader is significantly increased, the problem of glare due to the direct reflection of the LEDs can be avoided and images can be acquired with a fairly good contrast level. However, due to the elevated pitch angle, the image of the code is affected by angular distortion and decoding it can be very difficult.

By using the LT-700 external illuminator, instead, the illumination angle can be optimized while maintaining a reader pitch angle of near zero. Consequently, as shown in examples A and B in the table below, with LT-700 acquired images of codes can be obtained characterized by better contrast and without any distortion.

LT-700 can also be successfully used in applications where code marking is produced by the *laser etching* process on metal surfaces with evident machining flaws. Example C shows Data Matrix codes marked using the *laser etching* process on metal surfaces machined on a lathe. Only LT-700 illumination obtains a high contrast image on the entire code and not only in correspondence to the areas illuminated by the single LEDs in the Matrix internal illuminator. In these cases even if the reader's pitch angle is increased, the internal illuminator is not able to obtain a high contrast uniform code image. The worst case without LT-700 is with Matrix 210™ which has an internal illuminator with only two LEDs.

	Example A <i>Dot Peening on Reflective Surfaces</i>	Example B <i>Dot Peening on Surface with Vertical Machining Flaws</i>	Example C <i>Laser Etching on Surface with Circular Machining Flaws</i>
Color photo of code			
Matrix 410™ acquired image using LT-002 (8 LEDs) pitch angle = 0°			

	Example A <i>Dot Peening on Reflective Surfaces</i>	Example B <i>Dot Peening on Surface with Vertical Machining Flaws</i>	Example C <i>Laser Etching on Surface with Circular Machining Flaws</i>
Matrix 410™ acquired image using LT-002 (8 LEDs) pitch angle = 30°			
Matrix 410™ acquired image using LT-700 inclined 45° with respect to the Matrix optical axis			
Matrix 210™ acquired image using its internal illuminator pitch angle = 0°			
Matrix 210™ acquired image using its internal illuminator pitch angle = 30°			
Matrix 210™ acquired image using LT-700 inclined 45° with respect to the Matrix optical axis	