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White Paper

Dithering explained

Typically, High Brightness / Low Power-consuming LCD displays, such as ThinX Displays, are built with highly transparent TN (Twisted Neumatic) LCD panels to achieve the overall display light output. This TN LCD technology is limited to 6 bits per color, while other LCD technologies usually have 8 bits per color. This means there is a technology trade-off between color depth and efficiency, brightness, and power consumption.

While 6-bit color depth often meets the threshold requirement for a Rugged Army Display, Esterline fully understands the 8-bit objective performance. Unfortunately, there are currently no true COTS 8-bit TN panels on the market. Therefore, to emulate 8-bit performance on a 6-bit panel, Esterline provides a zero-artifact **patented dithering algorithm**.

There are many variants of spatial and/or temporal dithering algorithms on the market that work with small groups (e.g. 4) of pixels and/or frames, respectively. The Esterline algorithm works over 64 pixels and 64 frames, yielding a display image that has no perceptible dithering artifacts.

What is dithering

Whenever an image color depth needs to be reduced in a digital system, a technique called ‘dithering’ can be used to represent the original high-color depth image by fewer bits. The idea behind this is that, by introducing small modulations in the video data stream with reduced color depth, a correct average can be obtained in an area as small as possible and/or a period as small as possible. Offset pattern dithering is a commonly used technique, because its circuitry is simple to implement and its results are predictable and reliable. This technique deliberately adds noise to the video to avoid artifacts and thus obtain a visually better result.

Suppose video data are rendered at 8-bit (per pixel per color) and are to be displayed on a 6-bit LCD display. Imagine a dark sky before sunrise undergoing a subtle and continuous change in luminosity. In this case, the rendered steps are a quarter of the steps tat can be displayed by the LCD. For example, imagine an area in which one color (e.g. blue) fades from 7 to 8. The following values are rendered by the video generator: 7.00, 7.25, 7.50, 7.75 and 8.00.

When these values are truncated without dithering (i.e. when the last 2 bits are ignored), the result becomes 7, 7, 7, 7 and 8 – and the gradual color changes are lost:

Input data		Output data
7.00	➔	7
7.25	➔	7
7.50	➔	7
7.75	➔	7
8.00	➔	8

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8-bit grayscale to 6-bit without dithering

We get a different result by adding a 2x2 noise pattern to the video before truncation. The output varies spatially and, for every 2x2 input pixels, the average output is the same as the input:

Input data			2x2 pattern			Added together			Output data	
7.00	7.00	+	0.00	0.75	=	7.00	7.75	→	7	7
7.00	7.00		0.50	0.25		7.50	7.25		7	7
7.25	7.25	+	0.00	0.75	=	7.25	8.00	→	7	8
7.25	7.25		0.50	0.25		7.75	7.50		7	7
7.50	7.50	+	0.00	0.75	=	7.50	8.25	→	7	8
7.50	7.50		0.50	0.25		8.00	7.75		8	7
7.75	7.75	+	0.00	0.75	=	7.75	8.50	→	7	8
7.75	7.75		0.50	0.25		8.25	8.00		8	8
8.00	8.00	+	0.00	0.75	=	8.00	8.75	→	8	8
8.00	8.00		0.50	0.25		8.50	8.25		8	8

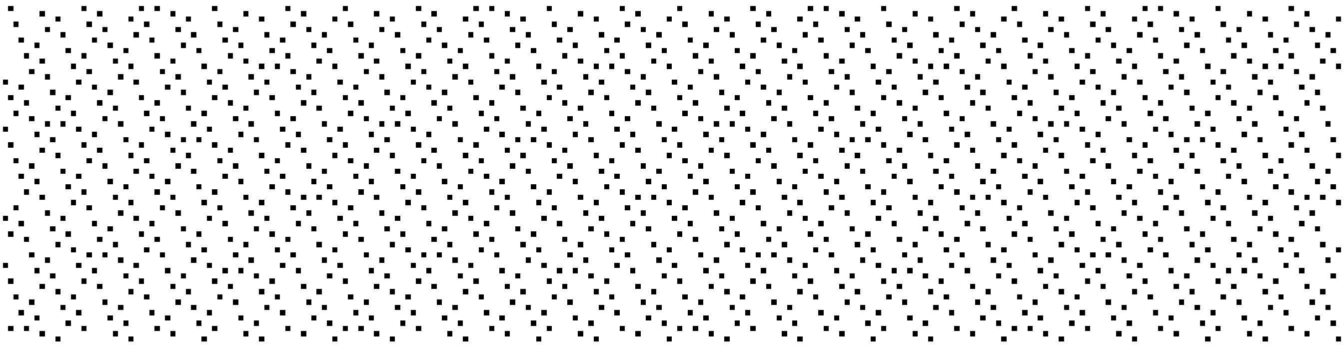
8-bit grayscale to 6-bit with dithering

A small 2x2 pattern like the one described above is very repetitive (the pattern repeats itself every 2 pixels) and it has only 4 unique values. So, for example, this means that we cannot use the 2x2 patterns to represent an input of 7.10 at the output. By using larger patterns with carefully chosen dithering values, more input values can be represented and repetition can be reduced.

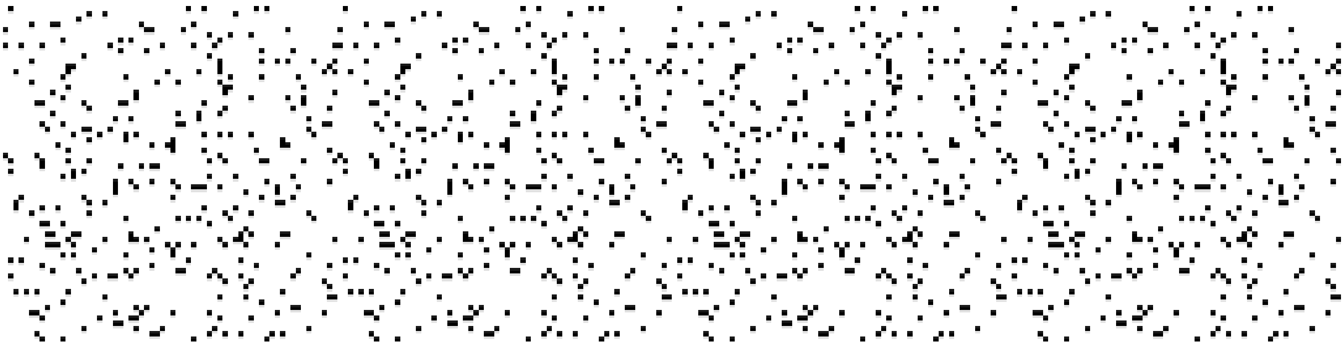
Esterline's dithering solution

To visualize the difference between the various dithering techniques, consider a situation in which we have only 2 colors – black and white – and we want to show a gray color that is 92% white. After applying dithering, for every 100 pixels, an average of 92 pixels should be white and 8 pixels should be black.

This first image shows the result of a 64x64 pattern – a repetitive pattern is clearly visible, which can lead to visual artifacts that interfere with image processing:



This second image is created using a 64x64 white noise pattern. The randomness of the white noise removes the repetitiveness and thus avoids interference with other image processing, but the output is grainy. In some areas, the black pixels are clustered together; in other areas, there are very few black pixels – which creates dark and light areas:



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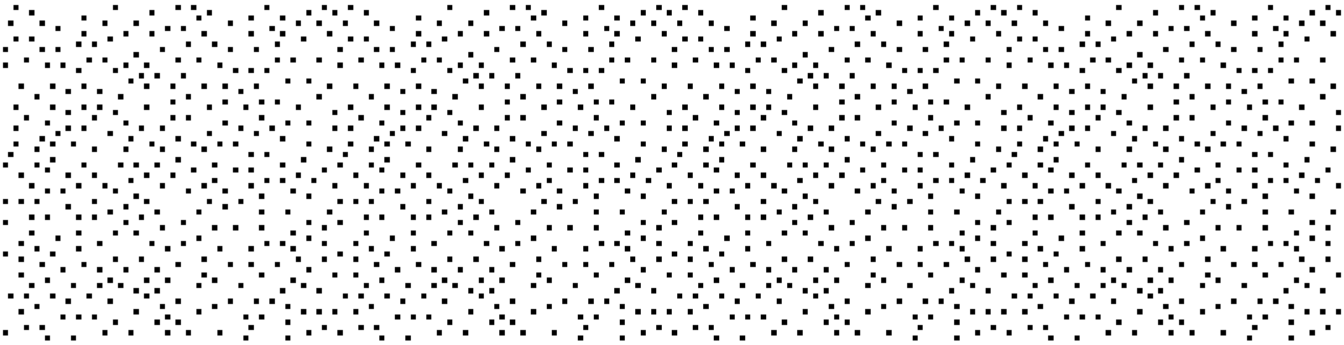
This third example shows the result of dithering using a 64x64 pattern with a so-called Poisson-Disc distribution. This produces a pattern that has randomness similar to the second image, but it has no clusters of black pixels:



In a digital system, the first two patterns are easy to implement, but they can generate visual artifacts.

The third pattern gives the best results (no artifacts), but it requires a lot more computational power. Esterline uses a patented implementation of this pattern, which runs real-time on all ThinX displays.

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