DISPLAY LC
The LCD Leader

Whitepaper

Display guide

The six most important display features in a nutshell

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Introduction

Anyone who is working with displays will soon come across a specification (also called „data sheet“ - or simply „spec“).

This whitepaper contains all important information required for the operation of a display. Moreover it describes the most important features and limit values a display typically has. This includes, among other things, the lifetime, contrast and brightness. Only those who can correctly understand and interpret a specification, will be able to operate a display successfully in the long term. In this whitepaper, we therefore take a closer look at the six most important features.

After reading this whitepaper, you‘re going to

- Interpet limit values correctly
- Dissolve misunderstandings
- Understand connections between certain features
- Drive displays correctly

About the author

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- More than 20 years experience as FAE and quality manager

The six most important features in a nutshell

01

The lifetime

And its depency on the temperature range.

02

The contrast

A great difference.

03

The brightness

The visible range of electromagnetic radiation.

04

The chromaticity

The color perceived by the human eye.

05

The response time

From one state to the other.

06

The electric power

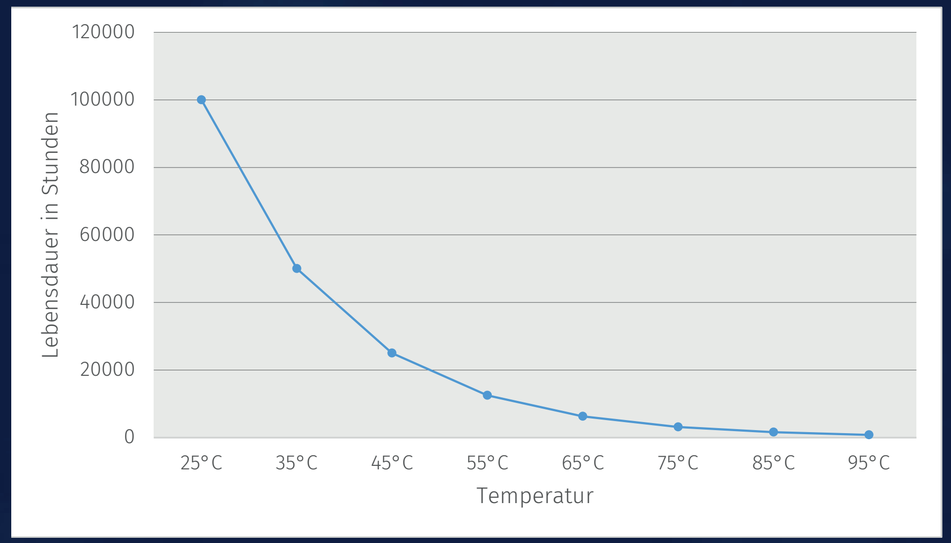
The product of electrical voltage and current.

01: The lifetime of a display

The component of a display with the shortest lifetime (in hours) determines the achievable lifetime of the complete display. When reaching its lifetime, either the brightness or the contrast show 50% of the originally specified value. Beyond this point, the display can continue to operate nonetheless.

Important: The lifetime depends on ambient conditions.
The data in the specification usually refers to ambient conditions of 25°C and 60% relative humidity (RH).

As a **rule of thumb** for deviating temperatures, the Arrhenius-law can be applied: For every +10°C, the lifetime will be halved.



Graphical representation of the Arrhenius law
(Source: own illustration)

„A display is not defective once it has reached its lifetime. It can continue to operate at 50% of its specified brightness or contrast value without any problems.“

The dependence of the lifetime on the temperature

In order to understand the lifetime of a display in its entirety, it is worthwhile to take a closer look at the specified temperature ranges. These can be found in the specification under „absolute maximum ratings“.

To what extent does the temperature influence the lifetime?

Temperatures outside the specified maximum values can have a significant negative impact on the lifetime. Display specifications usually refer to 2 maximum values: the storage temperature and the operating temperature.

Storage and operating temperature in a nutshell

«storage temperature»: -20° to +70°C
The display should not be stored below -20°C **and** not above than +70°C.

The storage temperature

Defines the range between a minimum and maximum temperature (in °C) in which a display can be stored or exposed in a non-operated state at temperature X for a certain time.

If the display is stored within the specified storage temperature, the display will function properly at the operating temperature and will meet all specified parameters.

The operating temperature

Defines the minimum and maximum range in °C at which a display can be operated at temperature X for a certain time when switched on.

Operated at the correct operating temperature, the the display fulfills all specified parameters. The specified parameters (such as the lifetime) are therefore directly temperature-dependent.

02: The contrast of a display

The contrast describes the difference between bright and dark pixels. The general principle is: the higher the contrast, the better the image.
The specified contrast value in specifications is thus given as the ratio of the brightness of the pixels in the on and off state (X:1).

The contrast is usually displayed as a function of the viewing angle using a false-color or ISO contrast diagram. This marks the places where the same contrast prevails (one color for each contrast value).

Good to know
The contrast varies greatly depending on the technology. A TFT display can have a contrast of 500:1, while an OLED can quickly reach a contrast of 10,000:1.

How is the contrast determined?

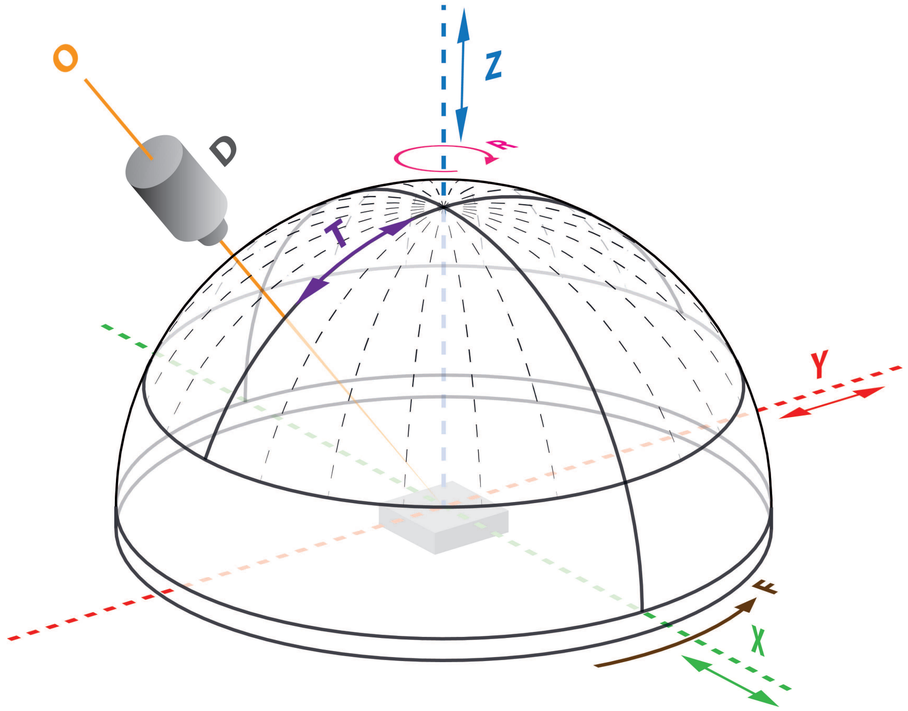
To determine the contrast, the following measurement is performed:

The display to be measured is located in the center of a hemisphere (see illustration on the right). The brightness value of the display is determined over the complete hemisphere above the display with a camera.

Two measurement runs are performed: One run each with all pixels in the on state and one run with all pixels in the off state. The ratio of the brightness values at a specific measuring point then results in the contrast value

GOOD TO KNOW

With an IPS TFT, the contrast is the same from all viewing directions (from left, right, up, down). But:
The contrast is always highest in the center of the display, from the top view.



Measurement setup for contrast determination

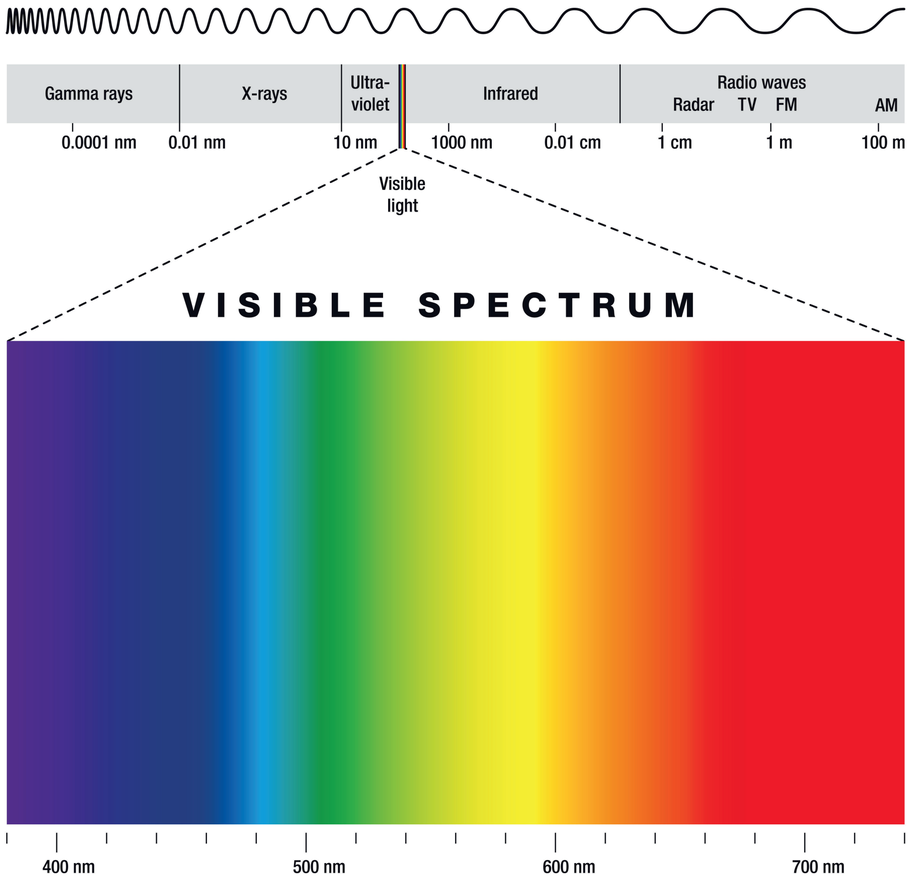
(Source: Own illustration)

03: The brightness of a display

Light is the visible range of electromagnetic radiation from about 380 to 780 nanometers (nm) wavelength.

Luminance L [cd/m2] is the photometric measure of brightness. A light source appears brighter, the smaller its area is in comparison to the luminous intensity [cd]. Luminance is what people perceive as brightness.

1 candela [cd] corresponds to the luminance of a candle..



The visible spectrum

(Source: Adobe Stock)

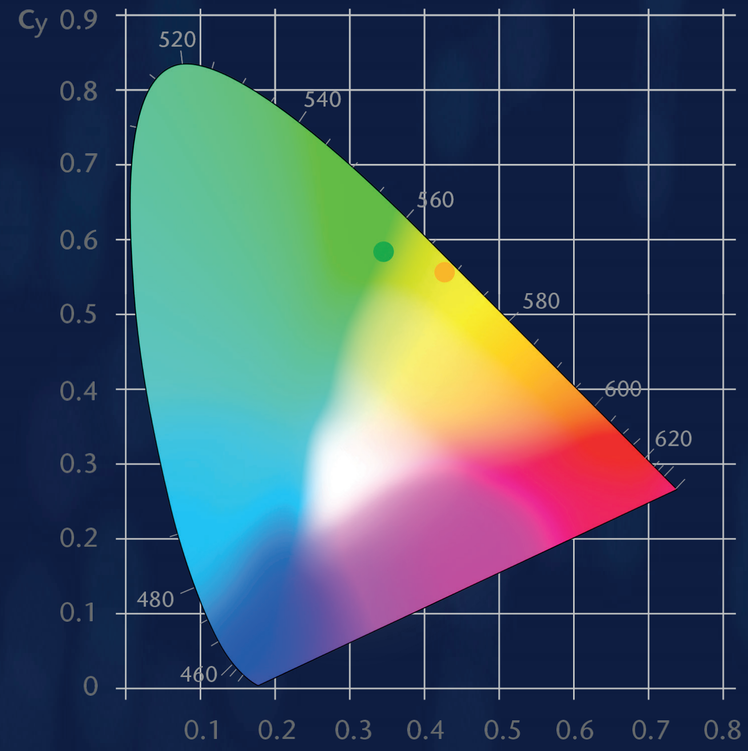
Good to know

Applications exposed to direct sunlight should have at least 800 cd/m2 (example: e-bike display).

04: The chromaticity of a display

The chromaticity is defined as the color of a luminous object as perceived by the human eye. In the display industry, chromaticity is usually described with the CIE standard color chart (see graphic on the right). Pure colors (spectral colors) are surrounding the diagram, which are specified by means of a wavelength. The enclosing area contains all mixed colors that can be perceived by a human eye with average eyesight.

In display specifications, the coordinates of the three primary colors (red / green / blue) and the mixed color „white“ are indicated.



CIE standard color system
(Source: Schott AG / www.schott.com)

Good to know
The chromaticity coordinate for pure white is x,y = 0.33

05: The response time of a display

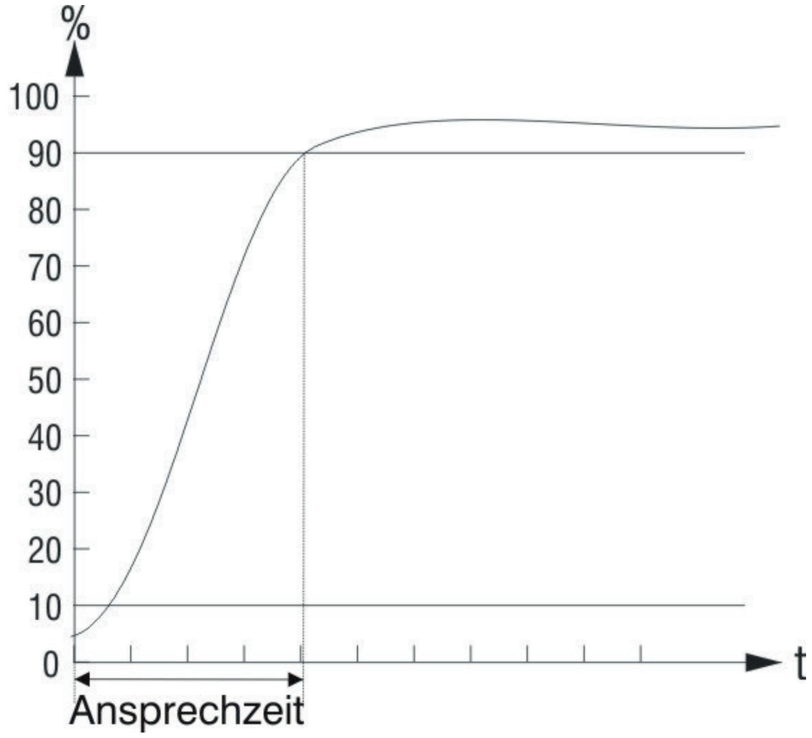
The response time is the time required by the signal output to increase the signal level from 10% to 90%. It is thus decisive for how many images can be displayed per second. In short: The response time tells you how long a pixel needs to change from one state to the other.

The response time when switching on (T rise) and when switching off (T fall) can vary. The technology also has a major influence on the response time.

Approximately 20 frames per second are necessary for humans to perceive a sequence of images as a moving sequence. Moving sequences are only perceived as smooth at a refresh rate of about 50 frames per second or more.

Good to know

A TFT has a typical response time of about 20-30 milliseconds.
A passive display is slower with 200-300 milliseconds.



The response time
(Source: own illustration)

06: The electrical power of a display

The electrical power converted in a component is, for direct current, the product of electrical voltage and current intensity:
P[W] = U[V] x I[A]

The power consumption P varies depending on the pattern to be displayed.

Most of the power consumption in an LCD-based display with backlight originates due to the backlight itself.

Good to know
Min. and max. regarding power consumption differ drastically depending on the pattern to be displayed for self-luminous displays (e.g. OLED), but not for displays with filter effect (e.g. LCD).

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because displays are our passion.

We are looking forward to hearing from you!

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