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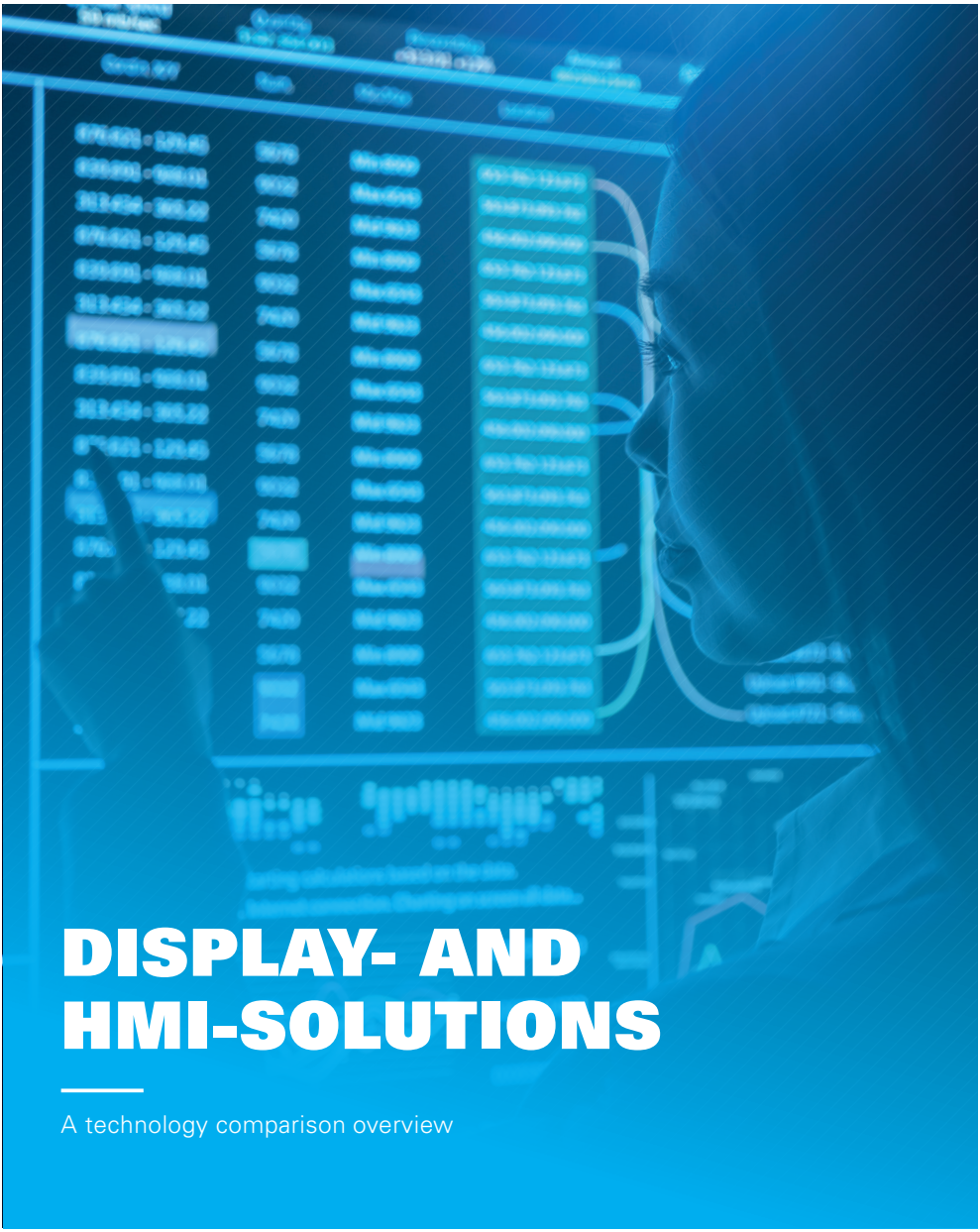

DISPLAY- AND HMI-SOLUTIONS

A technology comparison overview

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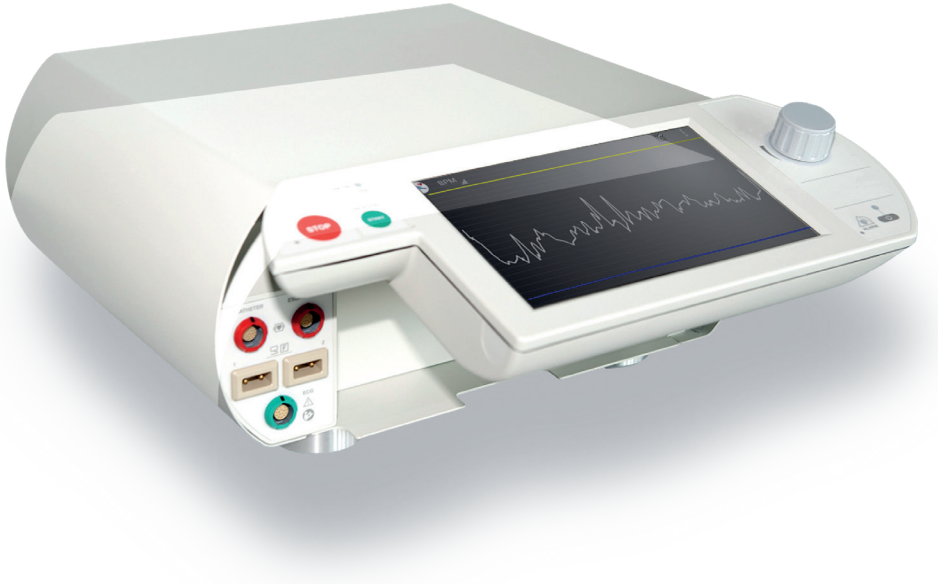
INTRODUCTION

Human Machine Interfaces, or HMI for short, are playing a more and more important role in today's world. The operator comfort of our everyday electronic devices is becoming a key factor. Whether it's a cell phone, coffee machine or e-book reader - how you can interact with a device often makes a much bigger difference to its market success than the technical potential of the product itself. Displays, especially those with a touch function, take up a decisive part.

There are numerous factors to consider in terms of functionality, user experience and design, when selecting the right display solution for a specific product. There are many different technology options and therefore countless possible combinations, all of which have their place in the market: There is no such thing as the perfect display solution. It always depends on the specific project and its individual requirements.

On the following pages, we provide an overview of the various technologies, presenting the benefits and drawbacks, as well as highlighting areas of application in the field.



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THE DISPLAY

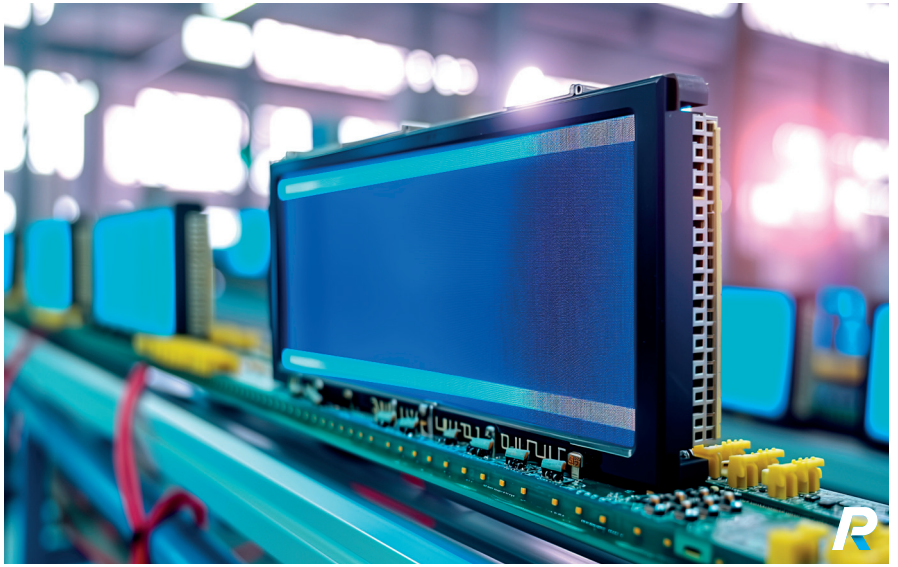
There are three main display technologies on the market: LCD, LED and e-paper technology. The differences relate to image generation.

LCD (LIQUID CRYSTAL DISPLAY)

LCD technology is the oldest existing display technology. It was developed in the early 1970s. Liquid crystals produce images by changing their orientation when an electrical voltage is applied. This change influences how much light can pass through the crystals. This basic principle of the display has not changed to this day. The driving circuits at that time, so called passive matrix' were quite slow. They were used to build simple displays eg. for household devices or watches. Video viewing was and is not possible on these simple displays. Only the introduction of the active matrix driving circuit and the TFTs (Thin Film Transistors) made it possible to fastly switch and control each individual pixel. This paved the way for applications such as monitors, TV devices, cell phones, etc. LCDs always require a light source in order to visualize something. The light is provided by the display itself (background lighting or backlight) or from the environment (sunlight) or both. Therefore, LCDs can be divided into transmissive, reflective or transfection types.

+ Low price

- Only simple visualizations possible



LED (LIGHT EMITTING DIODE)

LED technology options are by far the most expensive technology of the three mentioned. Each pixel essentially consists of a three-color LED (red, green and blue). The main benefit of this technology is that no external light is needed to show an image, as each pixel is already a light source in itself. This allows very thin displays to be produced, as the backlight required for LCDs can be removed. The best-known application of this technology is probably video walls, which are used for advertising purposes or at sports events, for example. Video walls often have individual, frameless elements that can be put together to form a complete picture. In addition to static image content (advertising), videos can also be shown on video walls (e.g., drive-in cinema).

OLED-based displays are a subcategory of the LED technology. OLEDs consist of organic (carbon-containing) materials that emit light when a voltage is applied. OLED displays also do not need an external light source. Their main benefit is the ability to show “true black” and the resulting high contrast. Similar to LCDs, a difference is made between actively and passively controlled OLEDs. While passive types are used for smartwatches or household devices, the active type is mainly used in cell phones and televisions.
MicroLED technology offers an insight into the future. The difference to OLEDs is the material choosen, which consists of non-organic indium gallium nitride. The main aim is to achieve an image with microscopically small light-emitting diodes (pixel size < 50 µm). Although the first televisions based on this technology are already available, they are still far too expensive for the mass market.

+ Fast switching time

+ Complex visualizations possible

+ Contrast ratio

+ Energy efficient

+ Available in very thin options

- Expensive

E-PAPER TECHNOLOGY

Anyone who owns an e-book reader will already be familiar with the benefits of this technology: it can be read even in bright sunlight, and the battery what feels to lost for weeks. This is because e-paper, like paper, reflects light. The pixels of the e-paper are made of tiny capsules filled with positively charged white and negatively charged black particles. These are integrated in a transparent, liquid polymer. If a voltage is now shortly applied, the particles turn around (e.g., from white to black), and the status of the individual capsules is maintained for weeks. E-paper displays only use power when the image changes; in a static state, they keep the image virtually power-free. The control can also be passive or active like LCDs.

Initially, there were only e-paper displays in grayscale, but today there are also multicolored e-paper solutions on the market. In addition to e-book readers, applications like this technology include supermarket price tags and electronic timetable displays.

+ Highly energy efficient

+Excellent readability in sunlight

+ Comparatively low priced

- Limited to mainly static displays

OVERVIEW OF DISPLAY TECHNOLOGIES

TECHNOLOGY	LCD Liquid Crystal Display	LED Light Emitting Diode	E-PAPER Electronic Paper
DRIVING CIRCUIT	**Active matrix LCD** (TFT) + High resolutions + Fast response time + Sizes up to >100 inch - No true black visualization - Lower contrast than OLED **Application:** Laptop, monitors, TV	**AMOLED** Active Matrix (TFT) OLED + Fast response time + Flat design + High contrast - Aging performance - Service life **Application:** Cell phone, TV	**Passive or active matrix E-paper** + Lowest power supply + Long-term use suitable + High contrast + Eye friendly - Long switching times - No colors, only black and white **Application:** E-book reader
	Passive matrix LCD (TN, STN, FSTN) + Inexpensive + Affordable customizing - Slow response time - Limited resolution - Low contrast **Application:** Watches, calculators, household devices	**PMOLED** Passive Matrix OLED + Inexpensive + Affordable customizing + Color display - Short service life - Sizes up to approx. 5 in **Application:** Fitness trackers, household devices, Mp3	
		LED Light Emitting Diode + Fast response time + Long-term use suitable + High contrast - Expensive **Application:** LED walls	
DRIVING CIRCUIT	**IPS-LCD** In-Plane-switching LCD	**Micro LED**	**Color e-paper**
ILLUMINATION	LCD displays always require a light source to display Transmissive (backlight) Reflective (ambient light) Transflective (backlight and ambient light)	LED displays do not need an external light source for display Self-illuminating	E-paper only needs a source of light at night (frontlight) Reflective (ambient light)

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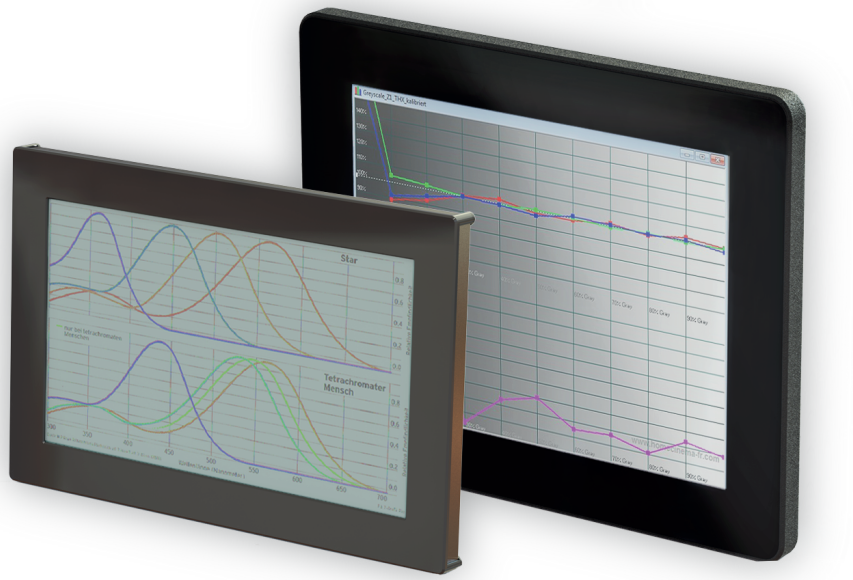
THE DISPLAY BRIGHTNESS IN BRIGHT SURROUNDINGS

The visibility of the content on displays is especially important outdoors and in sunlight. Mobile devices in particular, which need to be slim but lightweight and do not require an external power supply, are often reluctant to use bulky and power-intensive backlights. An alternative to emissive backlight technology with an active light source is offered by reflective solutions that use the incoming sunlight to brighten the display. This is a special solution for outdoor use that combines good visibility of the display with high energy efficiency.

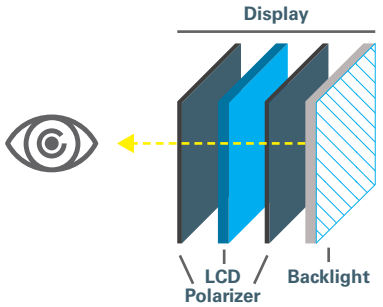


THE OVERVIEW OF THE VARIOUS DISPLAY ILLUMINATION TECHNOLOGIES

TRANSMISSIVE

- Can be used for indoor and outdoor
- Always requires a backlight
- Comparatively highest contrast ratio
- High power demand
  → Short battery life for portable devices

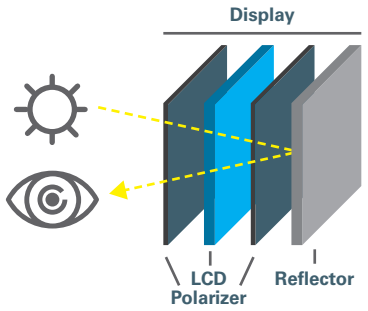
Example
Notebook, office monitor



REFLECTIVE

- Requires an external light source (e.g. sunlight or artificial light)
- Excellent for outdoor
- Low power requirement
- Very low height

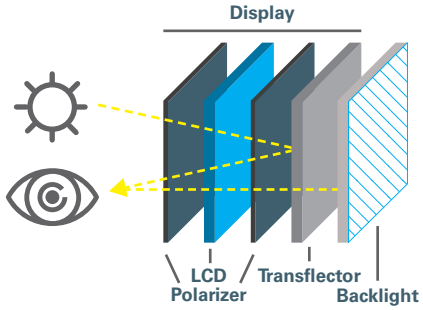
Example
Electronic price tags in the supermarket



TRANSFLECTIVE

- Mix of transmissive and reflective
- Requires backlight to be read in fading ambient light

Example
Smartwatch, e-book reader



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WHICH DISPLAY TECHNOLOGY IS TO CHOOSE?

In order to answer this question properly, the overall project must be analyzed. It must be defined what is essential and how the requirements are specified. This includes questions such as:

- **Is the power supply internal or external?**

  An OLED solution offers benefits when powered by a rechargeable battery, as no backlight is required.

- **Is energy consumption essential for sustainability reasons?**

  OLED technology is the most energy efficient.

- **Is the available space critical for the application?**

  OLED displays allow for very thin designs.

- **Will the device be used outdoors or indoors?**

  A reflective solution offers a number of advantages in outdoor areas.

- **Which content should be displayed?**

  LCD solutions can be considered for simple content, LED or OLED for more complex content.

- **What are the budget expectations?**

  LCD solutions are the most cost-effective.

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CONCLUSION

The display is only part of an entire package
In order to exploit the full potential of a good HMI solution, it must be well integrated into the overall product. Know-how and an understanding of trends are just as important as experience. It's not just about the combination of display and backlight technologies, but also the right combination of hardware and software, as well as tthe outher protective nd functional shell. Thus, requirements for protection against impact, weight, design, etc. can be optimized and fulfilled in a targeted manner with an integrated project approach.
The POLYRACK TECH-GROUP supports projects from planning to market launch and beyond with its decades of experience in various industries. Your reliable partner from idea to realization.

POLYRACK is neither a display manufacturer nor a distributor. Customer advisory consultation is therefore not based on a named product range, but exclusively on the individual parameters of a project in order to offer the best solution for every task.

YOUR CONTACT

VEROTEC LIMITED

Phone +44 2380 246900
info@verotec.co.uk
www.verotec.co.uk

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VEROTEC
Electronic Enclosures
A MEMBER OF POLYRACK

VEROTEC Ltd.
Unit 4, Bottings Industrial Estate
Curdridge, Southampton SO30 2DY
United Kingdom
www.verotec.co.uk

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