In2visible Displays - An evolution of the automotive cockpit

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ABSTRACT
The In2visible Display is the new automotive interior smart home living-style oriented design direction made by Continental. It is a consistent alternative “shy technology” approach to giant display consoles. Key intention is to reduce a potential information overload by providing content only when and where necessary (on-demand principle). This paper introduces design opportunities, use cases, challenges and technical solutions for premium image quality, natural-looking and genuine-feeling surface textures, daylight readability and postcard effect avoidance. It introduces a range of innovative products which Continental offers to car makers that provide unique and beneficial solutions for drivers and passengers in vehicles.

1. Displays dominate the automotive cockpit
Over many years, displays in the car cockpits have grown in number and surface area. This continuous trend is heralding what is justly referred to as the age of the display in the car. FIG. 1 provides a timeline starting in the early days of the automotive display until the year 2021 and beyond. The evolution is impressive: Starting from tiny and few, we are now using pillar-to-pillar solutions which dominate the whole cockpit with up to 50” display size. Displays are giving the vehicle interior an immersive quality [2].

There are many well-known influencing factors behind this development. Clearly, displays offer a matchless solution to present the constantly growing scope of information and functions. This in turn is driven by global mega trends such as digitalization, in-car domain networking, electrification and automated driving – all of which bring a wealth of information and new (control) options.

The potential flipside of this coin is the strong influence the attractive visual depiction of information can have on the driver. Large displays are showing lots of content that can distract the driver from his/her main task. The balance between keeping the driver in the loop through a measured amount of workload and the right choice of information versus an information overload is becoming a fine line. What is more important: The driver’s needs change, depending on the time of day, familiarity with the road, the individual car, the personal mood and condition etc. There is no “one-size-fits-all”. A fully awake driver who sets out on a business trip in the morning may have totally different information requirements than a tired person driving home through the night.

Presenting information and the right control options only when they are needed (and in the area where they are required) is the logical conclusion. However, just switching a display off is not a satisfying answer from a design point of view: In the off-state, a display loses its visual appeal almost completely. From being a brightly colored eyecatcher, it suddenly turns into a bland, black glass surface.

In2visible Displays from Continental provide a new “shy technology” solution to reconcile changing ergonomic needs and the look-and-feel issue of standard displays in the off-state. The new technology makes it possible to access information and control functions on demand by activating hidden displays in simple ways. FIG. 2 provides an example of an In2Visible Display fully activated. FIG. 3 shows the same cockpit fully deactivated.

Figure 1. Displays in the car – number and diagonal screen measurement go up.
The idea behind the In2visible Display is to make complex technology and user guidance invisible when not needed, enabling interaction only on user demand. Instead of presenting ‘empty’ black display surfaces or numerous physical buttons, an In2visible Display solution blends well into a purist approach to cockpit design that creates a calm atmosphere by presenting a decorative surface.

In principle, In2visible Displays can be a pillar-to-pillar solution, utilizing the full width of the dashboard. However, they can also be introduced to create completely new interactive areas for drivers and passengers where displays traditionally were not in use before. The information scope and the full range of control options – through touch and other interaction – is always there but the relevant content becomes visible on demand only.

The appearance of wood, as shown in Figure 2 and Figure 3 as an exemplary curved display surface has several benefits. For once, precious timber has a very noble look. Also, this premium surface is free of any ‘white shirt’ effect. At the same time, recreating a credible wood pattern is a technical challenge. This can also be achieved with artificially produced decorative surfaces, e.g. in imitating wood or leather or even technical designs like brushed aluminum or a carbon look, which gives a visually and haptically realistic surface impression while conserving natural resources, Figure 4. User acceptance of artificial surfaces representing, e.g., wood, leather, brushed aluminum, or carbon has been elaborated in [3].

The surface prevents distracting reflections, such as those caused by sunlight. Metal effects such as decorative strips or trims can also be included in the display surface, but they will show the same level of reflection as the real thing.

2. **Look and feel**

In2visible Displays fully combine, for instance, three displays in a single pillar-to-pillar cockpit panel. The individual display areas as shown in Figure 5 are covered by a foil with optimal light transmittance properties. The foil surface has a graphic and tactile layer with a fine 3D structure reproducing the look and feel of a natural material.

Underneath the foil surface are three state of the art 12.3” LTPS LCDs with 1920 x 720 pixels resolution and local dimming matrix backlights. Local dimming processing with a high dynamic range and a luminance of more than 800cd/m² is available across the whole display area. The center and passenger areas offer touch control using InCell touch technology. Contents is depicted in full color with true color representation and minimal color shift. There is no visible
postcard effect, i.e., no visible display dimension zone around the backlit active display area and the foil front. All graphic contents are sharply contoured, FIG. 6.

**Figure 6.** Curved Ultrawide Display, In2visible control panel prototype with natural-looking wooden appearance and examples of active display contents.

The matrix backlight and the local dimming algorithms reduce power consumption depending on the shown content.

The mechanical stack which is implemented for the demo version is a straightforward design specifically adapted for this prototype concept sample build. The In2visible Display cover lens is a multilayer optical stack which includes semitransparent printing layers, optical adhesives and also transparent mechanical parts. The lens is laminated with OCA to the display panel and the surrounding aluminum frame area. **FIG. 7.**

**Figure 7.** Prototype mechanical stack

A certain total lens thickness between the In2visible foil surface and the display is required to support mechanical stiffness and manufacturing requirements. As a trade-off, a thicker lens stack will have a direct negative impact on the optical performance like image clarity. For mass production of such optical stacks, an advanced plastic-based or glass-based process technology containing an IML (In Mold Labeling) or an IMD (In Mold Decoration) surface is required.

3. **Optical quality measurement and results**

The exemplary foil texture design is based on Continental specification and print data. The decisive factor was to achieve a meaningful balance between the surface’s color saturation for a natural incident light appearance, the highest possible transmittance, but also the best possible shielding against visibility of the underlying mechanical structure. A high transmittance of about 30%, a low reflectance of less than 10% with realistic matt appearance of natural textures and a minimized color shift to cover the full color spectrum provided by the display was achieved.

In2visible Display technology offers potential benefits to limiting the power consumption of large displays. With growing display sizes in the vehicle cockpit, display power consumption is gaining importance. This is a bonus point of the on-demand principle. **FIG. 8** shows a comparison between a state-of-the-art series-production LTPS LCD with edge backlight and the In2visible Display prototype with matrix local dimming backlight solution.

<table>
<thead>
<tr>
<th>Display panel</th>
<th>Luminance</th>
<th>Backlight concept</th>
<th>Power consumption (LED + Driver)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTPS LCD</td>
<td>12.3” / 1920x1200 / 170 PPI / LTPS InCell Touch</td>
<td>Edge Backlight</td>
<td>12 W (for any content)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Matrix Local/Dimming Backlight</td>
<td>0 W - 12 W</td>
</tr>
<tr>
<td></td>
<td>240 LEDs</td>
<td></td>
<td>8 W - 12 W</td>
</tr>
<tr>
<td></td>
<td>12 W</td>
<td></td>
<td>16 W - 18 W</td>
</tr>
</tbody>
</table>

**Figure 8.** Power consumption of a standard LTPS display and the In2visible Displays demonstrator.

The total power consumption of the prototype depends on the contents shown on the In2visible Display when activated. This is reflected in the power consumption ranging between 8 and 12 W. It should be noted that the In2visible Display prototype demonstrator uses not finally optimized materials. Further development in combination with an intelligent human machine interface design in a serial product will result in a reasonable power consumption and thermal load. In addition, the next generation of matrix local dimming backlight with a higher resolution of LED matrix will offer an even better power saving rate because the increased number of LEDs will better match the image and illuminate fewer surrounding pixels. Consequently, high resolution BLU would positively influence both, the contrast and the power saving rate.

4. **Continental UX**

Currently, customers demand for the cockpit styling has many varieties as shown FIG. 9.

**Figure 9.** Shape variety of cockpit styling

Continental is capable to integrate the necessary solutions inhouse such as the input devices, haptic feedback, assembling technology like an optical bonding and so on with optimized design and provide such as an interactive interface for the cockpit. **FIG.10.**
Furthermore, Continental is creating the unique, innovative and beneficial solution as shown in FIG.11. These products will provide an interactive control panel solution for the cockpit using the In2visible technology in combination with a regular pillar-to-pillar display.

![Figure 10. In2visible technology with haptic feedback](image1)

![Figure 11. Curved Ultrawide Display with In2visible display control panel](image2)

Product overview of the Curved Ultrawide Display:

**User Experience Highlights**
- World’s first curved pillar-to-pillar display with In2visible control surface
- 129 cm display area providing infinite space for a uniform user experience
- Innovative interaction concept with dynamic In2visible control surface
- Premium design creating a “living room on wheels”

**Technology Highlights**
- 47.5’ single panel TFT display (1 seamless display instead of 3)
- Local dimming for highest image quality and energetic efficiency

5. Conclusion and outlook

Although current and future cockpits are digital, immersive and provide an increasingly exciting user experience (UX), they can benefit from being ‘shy’ at certain times: Hiding control surfaces made of buttons, lights and switches behind device fronts is an ongoing trend in many areas and has already been applied to some extend in the automotive industry. Continental’s In2visible Display technology contributes to design, functionality and safety. The driver can keep an eye on what is relevant – without distraction by a visual overload. If, however, the full display surface is needed, it is at the driver’s and passenger’s fingertips. Giving displays this on-demand quality without impacting the overall cockpit design during the display off-state contributes to the UX.

In2visible Display cover foils can be used to create a purist and inspirational dashboard design with a classy look and feel when a display is deactivated. Thus, the changing need for information and control in the vehicle cockpit can be reconciled against the plain look of standard displays showing no contents. In addition, In2visible Displays enable a holistic, positive user experience with a classy design, which reduce potential sources of distraction in the vehicle.

**References**