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DISPLAY SELECTION CONSIDERATIONS

MORE THAN A PRETTY FACE – DISPLAY SELECTION CONSIDERATIONS

In today's world of vehicle controls for on/off highway markets, a display plays an important role in providing critical information that the operator requires to safely operate the vehicle. Good looks in the form of a bright, colorful LCD and pleasing mechanical design may turn heads up front, but that display needs to last the lifetime of the vehicle and withstand the rigors of the harsh environment that the vehicle will operate in.

10.1" Display with full color graphics and video

In selecting a display for your vehicle, there are a number of factors to consider during the control system design process. These factors include where your display is installed on the vehicle, how much information you are presenting to the operator, and what the operating environment is.

DISPLAY SIZE

Most displays used in the on/off highway market today range in size from 3" to 12". The right size tends to require a balancing act between available space for mounting the display and space needed on the display to show the necessary gages, dials, data, and video that is required for the operator to safely and efficiently operate the vehicle. There are a number of factors to consider:

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Limited Dash Space – then you likely will be pushed to a 3-7" display to squeeze into a smaller space.
High Information Content – then you likely will need a 7"-12" display in order to accommodate the space needed to fit in all of the data that needs to be exhibited to the user at any one time. **Require Simultaneous Video and Graphics** – a 7"-12" display is the right fit to allow enough space for video (backup camera or maps for example) and an area for displaying other graphical information at the same time.
User Location – in some cases the user is not sitting or standing in close proximity to the display. In applications where the user may need to walk around the vehicle and view the display from a distance, a 7"-12" display is the right choice.

Finding a supplier with a family of displays is advantageous. This allows you to maintain a common look as you cycle across the various vehicles in your family of products.

Display family to cover all applications - 4.3"...7"...10.1"

BUTTON DESIGN

Many displays are offered with buttons around the perimeter of the display. In some cases one of the buttons will be a navigation key to allow navigation through areas of the screen menu or through a series of screens. In other cases, a touch screen interface may be preferred over fixed buttons. It's important to investigate:

Durability – most displays will be subjected to sunlight, and many use cases require a user with gloves or use in a dirty environment. Fixed buttons need to have a UV-resistant and abrasion resistant coating to assure that they don't fade in extended sunlight exposure and stand up to abrasion from gloves or dirt without allowing icons to be abraded over time in use to the point where the operator can no longer identify what the icon is.

Tactile Feedback – in a fixed button design, it's important that the user have physical feedback when they press the button so it is obvious that they have pressed the key. In most designs a metal dome or mechanical tac button would be used to provide a snap or click when the button is pressed. Today's metal domes should provide >1

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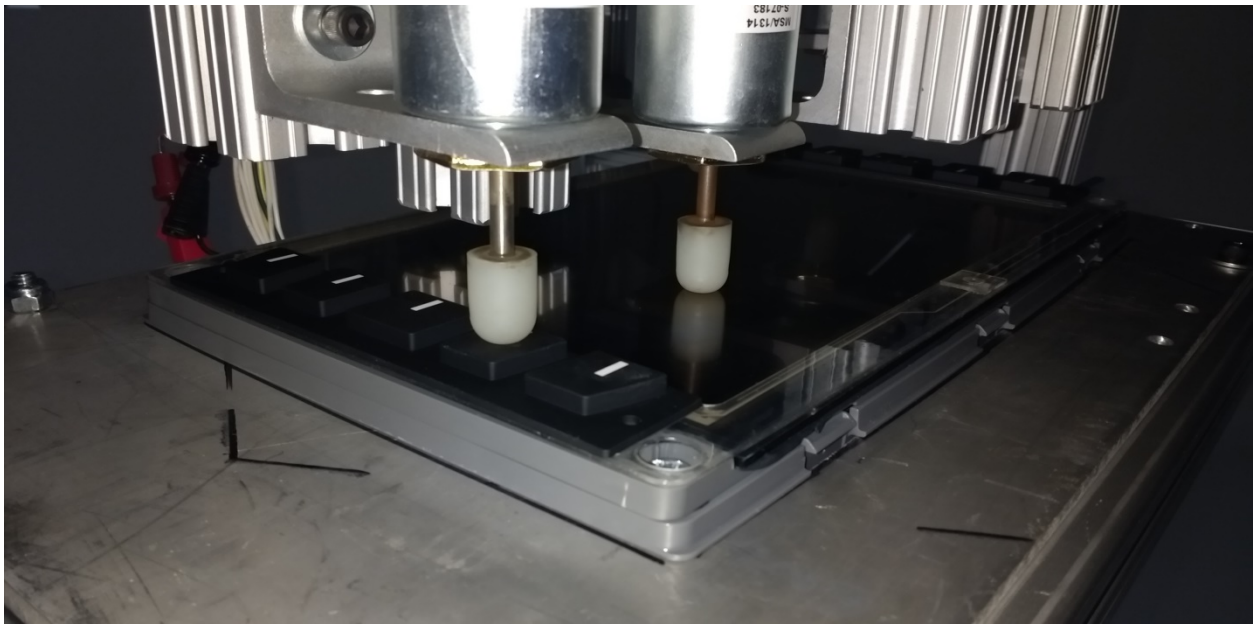
million cycles. The feel of the button day one and through the life of the vehicle is important for a positive user experience. A firm feel day one can't turn to a mushy feel a year into the life of the vehicle.



Life testing station to simulate human finger activation of buttons and touch screen

Touch Screen Options – traditionally, 4 and 5 wire resistive touch screens are utilized in displays designed for the off highway market due to their ability to operate in wet environments and respond to a gloved press. However with the expansion of the smart phone market, end users are becoming accustomed to the multi touch and movement motions available with a capacitive touchscreen (swipe, zoom in). Projected capacitive touch technology has improved in recent years, but it is still susceptible to ghost touches due to moisture. The expected location and utilization of the display will determine if a touchscreen is advantageous and which style of touchscreen to use. Displays external to the cab will perform best using traditional buttons or a resistive touchscreen.

When choosing a supplier it is important to ask for test data that shows extended UV exposure and button life cycle testing.

ENVIRONMENT

Most off highway vehicle applications operate in a rugged environment. Applications mounted outside the cab will certainly be exposed to rain, snow, and washdowns, and in cab applications can often be exposed to moisture as well. In each of these cases the display is going to be exposed to sunlight as well and the operator needs to be able to view the display on a sunny day. Surviving the effects of Mother Nature requires some important design considerations:

Sunlight Readability – operating in sunlight requires a display that has the right backlight to overcome the effects of the sun. The brightness of a display is measured in nits and typically a 500 nit or greater brightness is required

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for a display to be visible in sunlight. It's important to note that the backlight generates a lot of heat and a good design regulates the level of the backlight to avoid overheating the inside of the display and taxing the components. The backlight should scale down as the temperature inside the housing increases. The use of an IPS (in-plane switching) LCD will provide for ultra-wide viewing angles as compared to a TN (twisted nematic) LCD, as well as improved color reproduction quality.

Enclosure – the display itself and buttons are packaged in a plastic enclosure. If an inferior resin system is chosen, the plastic enclosure can embrittle and become susceptible to cracking and yellowing/chalking. Excessive exposure to ultraviolet light can cause damage to plastic resulting in loss of mechanical properties and a change in color. Since the LCD itself is the core of a display assembly, it's important to understand the specs on the LCD and the method that it is bonded into the final assembly.

Sealed Construction – the best designs use an optically bonded LCD without an air gap. In this design an optically clear adhesive is used to bond the LCD to the outer lens. If there is an airgap between the display and the outer user surface then there is the potential for condensation to develop in that interface – optical bonding eliminates that gap. The interface to the buttons and the entire mechanical design play a role as well. An IP67 and IP69K rating assures that the display is dust proof as well as able to survive immersion and pressure washes.

Washdown testing to confirm IP69K rating for ingress protection

Mounting Location - When selecting a display, the location it will be mounted and what environment it will be exposed to is also important to consider. If they display will be exposed to sever rain & moisture, and possibly even short durations of submersion, than an IP67 rated display is important. If the display will be exposed to high pressure wash downs by the user, then an IP69K rated display is critical. An IP67 rated display has been tested for 1m submersion under water for 30 minutes. An IP69K rated display has been tested against high-pressure jet

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cleaning (volume: 14-16 liters per minute; pressure: 8,000-10,000 kPa; distance: 0.1-0.15cm; water temperature: 80°C; spray angle: 0°, 30°, 60°, 90°). A display would need to be rated for both IP67 and IP69K to cover both conditions. If the display will be post or RAM mounted (vs panel mounted), it is important for the back of the display to also be capable of surviving the environment.

FEATURES and CAPABILITIES

Video – with today's larger display sizes, there is enough screen space to have a video as well as the traditional display data. Consideration must be given to the camera interface – traditionally off highway systems utilized one of the analog standards, NTSC or PAL. As the technology has improved, cameras are switching to a digital signal, often transmitted over Ethernet. As with communication interfaces, displays should be designed to be versatile and accept multiple camera formats.

Communication – the current communication hardware for off highway vehicles is CAN (Controller Area Network) with the common protocols being J1939, ISO bus, and CANopen. This is a mature, robust communication system, but as the upcoming J1939 transition to 500 KBPS shows, today's systems are starting to run out of bandwidth. Modern displays needs to be designed to interface to existing systems (CAN) while providing options for faster communication methods, such as Ethernet. Long utilized in industrial automation, Ethernet will also provide a faster medium to deliver software updates to the display.

Software Development Environment – equally important to the mechanical and electrical portions of display design, the software development environment allows the OEM to adapt the display to their custom application. Customers expect compelling graphics that present mission critical data in a logical real-time format. On one end of the spectrum are displays that are preprogrammed and only offer the ability to configure – add or subtract a few predefined items form a screen, change colors, etc. At the other end are displays that are fully programmable, be it with a programming language such as C or a fully graphical what-you-see-is-what-you-get (WYSIWYG) tool. The need for OEMs to differentiate their vehicles is driving the need for fully programmable displays. The development environment needs to be robust and powerful, but also easy to use. One solution to these needs is a hybrid system that combines the power of C for logic development while having a graphical WYSIWYG for laying out the screen.

Display I/O - I/O (inputs and outputs) available on a display can also help increase available space and reduce system cost. If there are I/O needs in close proximity to the display, I/O on the display can be used instead of locating a separate I/O module at that location. When space in a cab is limited, eliminating a module can free up space allowing for easier manufacturability and serviceability. The cost of the I/O in a display comes at a lower cost than a separate module, and many times even lower cost than running wires to a module located elsewhere.

Processor Speed - Processor speed should also be considered to ensure the display is capable of accommodating the application it will be used in. If the display will have complex or high speed graphics, or need to update many data items on a screen simultaneously, the display will need to have a fast processor capable of updating the LCD graphics without the user seeing a lag in the data or screen refresh rate. If the display will also need to display video and graphics at same time, processor speed is even more important. Also, the higher the resolution of LCD, the more pixels the processor will need to be capable of drawing at an appropriate speed. The best way to ensure

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the display is capable of handling your application is to see a demonstration of the display handling a similar application, or even better, a more complex application.

Single vs Dual Processor - If display has I/O that will be utilized to read in inputs and control outputs, ensure that the display processor architecture is capable of meeting your control needs. A Linux operating system is not ideal for real-time control of I/O. For example, if your application requires the display to control a PWM signal to a hydraulic valve, you need to ensure the output will be appropriately responsive. A dual processor architecture accommodates such a requirement by having the ARM processor handle the LCD display, but a separate microcontroller handling the real-time I/O control and CAN interface responsibilities. Another benefit to a dual processor architecture is that the I/O and CAN will be available immediately upon power-up without the need to wait for the Linux operating system to load on the ARM processor. When display I/O is being utilized, this can be critical for the application control.

Memory Storage - It is critical to confirm there is enough available memory storage for the graphics desired for your application. If your display will have many screens available, the required Flash memory needed to store all of the screens can add up quickly, especially for higher resolution displays. In addition, if you will want the display to make available user manuals, vehicle wire diagrams and similar information to service personnel, the memory needed will be even higher. Many applications will be able to fill up gigabytes of memory faster than you might expect with the cool graphics capabilities available. To ensure you will not exceed your memory requirements, it is best to have a display that has 2GB or possibly even a larger size if you think you might want to take full advantage of the display's capabilities.

Selecting and implementing the optimal display and graphics can offer a performance and safety advantage to the vehicle operator. The display is the core of the Human-Machine Interface, so it needs to offer a good looking, easy to understand experience that will last the lifetime of the vehicle.

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