"Understanding the Technical Specifications of Outdoor Digital Displays for QSR"

Outdoor digital signage is becoming increasingly important in Quick Service Restaurant (QSR) operations. With 60-70% of QSR revenue typically coming from the drive-thru, having reliable and effective order confirmation, pre-sell, and digital menu-board displays are necessary to grow and maintain business. Evaluating outdoor digital displays and determining the best options for a QSR application, especially by a non-technical manager or owner, can be an overwhelming challenge.

When selecting the best outdoor digital display for QSR applications, there are four main factors that will shape the technical requirements: environment, sunlight readability, reliability and connectivity. Each of these factors has critical technical specifications that must be carefully reviewed and compared. Understanding what these criteria mean and how they will be applied in a business is crucial to choosing the best display for your business. This document outlines some of the most important technical criteria used evaluate outdoor digital displays, why it is important in application, and how they should be evaluated within outdoor digital signage to make the best selection for today and in the future.

Environmental Technical Specifications

The environment in which the display must function is perhaps the most important factor in the technology selection process. First, we need a basic knowledge of Liquid Crystal Display (LCD) technology. An LCD is made by sandwiching a layer of "liquid crystal" between two panes of glass that have transparent electrodes attached to them. A liquid crystal is a unique substance that is both a liquid and a solid at the same time. They can hold their shape like a solid, but can also flow and change their shape like a liquid. By applying a tiny electric charge between the electrodes surrounding the liquid crystal, the crystal pattern can be changed to let in more or less light. This creates the image on the display. Like all liquids, when they get too cold, they "freeze solid" and can no longer change their shape to display an image. On the other hand, if an LCD gets too hot it cannot hold its shape at all (called "isotropic"), which manifests itself as a black area on the screen.

When selecting an outdoor LCD system, it is important to make sure it will continue operating well beyond the range of "ambient" (outside) temperatures at the store location, keeping in mind that on a hot sunny day the enclosure surrounding the display (speaker post, canopy, menu-board, etc.) can behave just like an oven, cooking the display inside. This additional heat from the sun is called "solar loading" and can significantly increase the temperature of the display over the outside ambient temperature. For this reason, it is important to select a display with an operational temperature range greater than the ambient temperature where it is to be instlled.

<u>Operational Temperature Range:</u>

This is the range of ambient temperatures within which the display is rated to operate properly. A common specification for this range is -40°F to +122°F (-40C to +50C). The display should startup and function properly at the rated refresh rate throughout this

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temperature range. The operational temperature range is based on the standards originally set by Bell Laboratories (which since changed its name to “Telcordia”) for outdoor telephone electronic equipment. These standards are still used across many industries today.

Staying Warm When It Is Cold - Heater Equipped:
Outdoor displays are, by their very nature, can be exposed to very low temperatures. At cold temperatures, liquid crystal displays respond slower and will refresh their images very slowly. At temperatures close to freezing, the liquid crystal material will freeze, causing the display to stop functioning and may cause permanent damage. For these reasons, it is critical that outdoor displays be equipped with internal heating elements that will insure that the LCD stays within normal operating limits in low ambient temperatures.

Staying Cool When It Is Hot - Air Curtain:
In many parts of the world, outdoor displays can be subject to very high ambient temperatures. In order to prevent damage to the LCD, the heat must be removed from liquid crystal material. To accomplish this, one design approach utilizes a gap between the exterior glass and the surface of the LCD. Air is circulated across the front of the LCD, removing heat buildup in the LCD and preventing overheating. Also, with an air gap solution, if vandalized, the front cover glass can be easily replaced without having to replace the entire LCD assembly.

Bonded Glass (also known as No Air Gap):
Another design approach is to utilize bonded glass, where the front cover glass is bonded directly to the front surface of the LCD. The primary reasons for bonding are; 1) additional protection of the LCD (beyond the glass that comes with the LCD); 2) improvement in contrast and clarity due to the glass being close to the front of the LCD; and 3) reduction in reflections by matching the index of reflection between the glass and LCD via the bonding material. While this approach works well in outdoor displays that are not exposed to direct sun, it does little to remove heat from the LCD. As mentioned above, excess heat buildup can cause the LCD to go isotropic and may be permanently damaged when extremely high temperatures are encountered. Additionally, if the cover glass is damaged in a bonded display, the entire LCD assembly must be replaced. This makes repairing bonded glass units more expensive.

Solar Protection for Displays:
People reach for their sunglasses whenever they walk outside on a bright sunny day. Displays are no different. In bright sunlight it is important to protect the display with specially treated glass, similar to the treatments used in sunglass lenses. There are two common types of treatments. The first is for Ultra Violet (UV) light protection. Over time, UV light can fade the color cells in the display diminishing its vibrancy. The second is for blocking Infrared (IR) radiation. IR radiation makes us feel warmth on our skin when exposed to sunlight. In the same way, IR blocking helps to reduce heat up on the LCD.

Environmental Protection for Displays:

Outdoor displays can be subject to many harsh environmental conditions such as wind, rain, snow, dust and chemicals. The sensitive electronics in displays must be protected from these elements to prevent damage from corrosion causes by exposure foreign substances like water, dust, dirt, salt and other chemicals.

- **Water**: Water is a conductor of electricity, so when electronic circuits get wet, the water can create new pathways for the electric current to follow ("short circuit"), which often permanently destroy circuits by bridging power and signal pathways.
- **Dust** and Dirt: Dust can act as a heat insulator. Think of it as putting a blanket on the electronic circuit. Under this blanket of dust, the electronic components cannot dissipate their heat properly, which can often raise the temperature of the component by as much as 30°F. This buildup of heat can literally burn out the circuits inside the display.
- **Salt**: Salt goes great on food, but can accelerate corrosion on electronic circuits. Salt combines with water in the air (humidity) to speed the corrosion of the metal that makes up the circuits on an electronics board. The result is circuits that no longer connect, which will cause the unit to fail to operate.
- **Chemicals**: Other chemicals such as cleaning solvents, detergents and degreasers can quickly corrode internal electronic circuits, leading to permanent damage and costly repairs.

To ensure the outdoor display continues functioning properly, it should be environmentally sealed to protect from these and other contaminates.

Enclosure Requirements:

The National Electrical Manufacturer's Association (NEMA) has developed a series of standards that define requirements for various types of enclosures. When complied with, these standards are designed to prevent physical contact between personnel and the electrical components inside the equipment. The standards also specify various levels of intrusion prevention from environmental hazards such as water, rain, snow, sleet, dirt, dust and ice. The NEMA-4**X** rating requires that the enclosure is able to resist corrosion as well.

NEMA is an organization that sets standards for conformance, but does not actually perform the tests necessary to confirm the product conforms to the standards.
Some companies do their own "testing" to see if their units perform in accordance with these standards. It is one thing to claim that an outdoor display meets these standards, but it is quite another to have an independent third party certify this is the case. Accordingly, all outdoor displays deployed in QSR drive-thru applications should be certified by the Underwriters Laboratory (or similar recognized equipment safety certification organization). Another common rating standard for enclosures is the Ingress Protection (IP) Code system as defined by the IEC. This coding system utilizes two digits to define protection from solids (dust) and liquids (water). A common enclosure rating is IP65, which is defined as: "Totally protected from dust" (6) and "Protected against low pressure jets of water from all directions" (5).

UL Approval:
Underwriters Laboratories (UL) is one of the oldest independent product performance and safety certifying organizations in the world. UL testing laboratories provide certification on the safety of products as well as their environmental claims. Because UL is fully independent, compared to manufacturer self-testing, it is considered the "gold standard" for product quality and safety in the United States. Products that have received UL 50 approval have been certified for safety when subjected to rain, sleet, snow, wind-blown dust, dirt, hose-directed water, external ice formation and corrosive elements. Purchasing outdoor digital displays that are UL approved provides another level of safety and reliability and is often required. Two common certification standards for outdoor displays are shown in the table below.

Hazards	**UL**	**NEMA**	**IP**
• Rain • Low pressure water jet spray • Ice • Windblown dust	UL 50 / 508 Type 4	NEMA Type 4	IP64/IP65
• Rain • High pressure water jet spray • Ice • Windblown dust • Corrosion	UL 50 / 508 Type 4x	NEMA Type 4x	IP65/IP66

Table: Standards Number Cross-Reference

Sunlight Readability Technical Specifications
Perhaps the biggest environmental factor for outdoor displays is bright sunlight. Bright sunlight makes reading a printed sign easy, but it has the opposite effect on a video display. The "rod" cells in the human eye allow people to see shapes by sensing the difference between light shapes and dark shapes. Physical objects like tables and chairs are "visible" because they reflect light back to the human eye. "Lighter" (example white) objects reflect more light, "darker" (example black) objects reflect less. The overall level of light is called brightness. The difference in brightness between the whitest white and the blackest black is called contrast.

The liquid crystal material in an LCD allows some light to pass through it. The source of this light is called the "back light" because the light is behind the LCD screen. This light can be generated by any number of sources from fluorescent tubes to more energy-efficient LEDs. The back light has to be bright enough so that the display can be read in direct sunlight. The LCD also needs to have enough contrast to distinguish between black and white shapes in direct sunlight.

Display Brightness:
The brightness or luminance of an LCD is measured in candela per square meter (cd/m^2), which is also commonly referred to as a “nit.” When reading an LCD outdoors in direct sunlight, more nits are better. For the best results in direct sunlight, the outdoor display should be able to continually operate at a minimum of 1,500 nits in bright sunlight. Anything less than 1,500 nits of brightness may not be sufficient for good visibility in direct sunlight and make the display difficult to read. As a side note, when it is night or dark outside, the display should automatically scale back to a lower brightness level so conserve energy while maintaining optimal viewability. Many local ordinances also limit the brightness of digital displays at night.

Display Contrast:
To perceive shapes, the human eye has to detect the difference between black and white. For example on a typical indoor TV display, white might have a brightness of 200 nits, whereas black would have a brightness of only 0.5 nits. The “contrast ratio” compares the difference between white and black brightness. In this example, the contrast ratio would be a striking 200/0.5 = 400. Now take this same display outside into the sunlight and watch what happens. Brightness is additive, which means that the more candles you light, the brighter the room gets. The same is true with displays. In the sunlight, glare on the LCD screen will add brightness. Say for example that this display is exposed to sun glare on the screen that reflects back 100 nits of extra brightness. Now the brightest white would be 200 + 100 = 300 nits, and the darkest black would be 0.5 + 100 = 100.5 nits but, look what happens to the contrast ratio. What was once 400 is now much lower 300/100.5 = only 3! The result to the eye is the text or image on the display looks like muddy gray instead of sharp black and white. For a display to be readable in outdoor direct sunlight, it should have a contrast ratio as high as possible – typically a minimum of 100.

Reliability Technical Specifications
Of course having an outdoor display that will operate at -40°F is of little value if the display only runs for a month. In a QSR drive-thru application, the LCD should work reliably for many years to get the required capital equipment return on investment. There are several technical specifications that uniquely measure the reliability and lifespan of an outdoor display.

Failure Rate:
Failure rate can be a misleading statistic if stated without any context. For example, A simple stated percentage failure rate such as, “a failure rate of only 5%” without knowing the number of units, when they were deployed and over what time period, a “failure rate” is relatively useless in indicating future performance. For example if 100 units are deployed on Tuesday and one fails on Wednesday, the failure rate would be only 1%, but the mean time between failures would be a very poor 23 hours!

<u>MTTH (Mean Time To Half-brightness, also known as MTHB):</u>
This is a time measurement of the longevity of the display. For an LCD to be seen, it has to be lit from behind. The most energy efficient method of providing this back lighting is to use LEDs, which slowly lose their brightness over time. The human eye can readily notice that a screen is dim once it reaches 50% of its original brightness. As a result, the industry standard measurement for useful LED / LCD life is the hours it takes for a display to reach half brightness. This is known as the Mean Time to Half Brightness, and uses the acronyms MTTH and MTHB interchangeably. The longer the MTTH, the longer the display will be visibly readable to the customer.

<u>MTBF (Mean Time Between Failure):</u>
Mean Time Between Failures is another measure of the expected lifespan for the display. Unlike MTTH (see above), this is a measurement of when the display can be expected to fail (i.e. one or more internal components fail rendering the display partialy or completely non-functional). MTBF is typically longer than MTTH, in other words it is more common for a display to dim before it fails completely. When comparing competing displays, the useful life of each display is the lesser of the MTTH and MTBF hours. For example (see chart below), if display A has a MTBF of 80,000 hours and a MTTH of 70,000 hours, while display B has a MTBF of 100,000 hours and a MTTH of 50,000 hours; display A would be the best choice because it would have the longest <u>useful</u> life at 70,000 hours MTTH. Even though display B would keep "running," its picture would be barely readable, rendering it virtually useless as an outdoor display.

	Display A	**Display B**
MTBF	80,000	100,000
MTTH	70,000	50,000
Usability at: (hours)		
40,000	**Good Picture / Still Running**	**Good Picture / Still Running**
50,000	**Good Picture / Still Running**	**Good Picture / Still Running**
60,000	**Good Picture / Still Running**	Bad Picture / Still Running
70,000	**Good Picture / Still Running**	Bad Picture / Still Running
80,000	Bad Picture / Still Running	Bad Picture / Still Running
90,000	Stopped Running	Bad Picture / Still Running
100,000	Stopped Running	Bad Picture / Still Running
110,000	Stopped Running	Stopped Running

Connectivity Technical Specifications and Considerations
For a display to function it needs two important inputs, power and data. Data can be delivered to the display in several forms. It can be a video stream much like the signal sent to a television or monitor, or the data can be digital information such as what comes from a computer network. Likewise, power can be delivered in several forms, it can be 120 VAC like a standard wall plug, or it can be low (DC) voltage as might come from a car charger. Power is measured in Watts. The more watts, the more power is consumed by the device.

<u>120 VAC Power</u>

A standard 120 VAC 15 amp circuit can provide 1,800 watts of power for connected electric devices. A 20 amp circuit can provide up to 2,400 watts. A typical outdoor display for the drive-thru should require only a few hundred watts to power its LCD, back lights, control electronics, heaters and fans. Again, the heaters and fans are required to keep the display functioning in all kinds of weather. 120VAC power can be run over extremely long wires well over 1,000 feet. However, this type of power requires an electrician to properly install and must be physically separated from low voltage data cabling to avoid causing “noise” and interference.

<u>USB Power</u>

Universal Serial Bus (USB) connectivity provides a low voltage power source in addition to high speed serial data that can be transmitted using a USB cable. USB cables have a maximum usable length of approximately 16 feet, and can only deliver 2.5 watts of power, which is not enough to power the backlights and heaters required in sunlight readable outdoor displays.

<u>Power over Ethernet (PoE)</u>

Power can also be transmitted to a connected device over standard Cat 5 Ethernet cable. Power over Ethernet (PoE) is a specification that allows power to be transmitted on unused wires in standard CAT5 cabling over maximum distances of approximately 300 feet. PoE is a low power solution that can only carry up to 12.5 watts of power, which is again not enough to power a sunlight readable outdoor display. A new specification called PoE+ provides for double the power capacity and can carry up to 25 watts of power, which can be sufficient to run an LED backlight LCD, but not enough to power both a display and a heater. Because PoE uses standard Cat5 cable and is low voltage, an electrician is not required for cabling installation.

<u>Video over Cat5</u>

Video signals such as VGA are transmitted over standard VGA cabling. Unfortunately, a standard VGA-video cable typically can be no longer than approximately 12 feet or so without employing expensive shielding techniques. Triple shielded VGA cables can transmit video signals over 50 feet. Streaming video can be transmitted for much longer distances by using Video over Cat5 transmission technology. Using this technology, video can be transmitted over standard Cat5 cables for distances of up to 1,000 feet. There are similar technologies to transmit HDMI signals over long distances of Cat5 cable, however they may require two cables for accurate signal quality over long distances.

Display Architecture Considerations

Outdoor displays in the QSR come in basically two different architectures. One architecture has the video source (computer or media player) located within the store. The other has the video source integrated within the display enclosure. A drive-thru order confirmation display requires a computer to take data from the POS system and determine what to display on the screen (i.e. the order details and totals, as well as upsell messages, pictures and videos).

In-Store Computer Architecture
In-Store computers are typically located in the back office of the restaurant which provides a controlled indoor environment. In store computers have the advantage of a less hostile operating environment, but the disadvantage of having to find space in the restaurant for yet another piece of IT equipment. In addition, just because a computer is inside does not mean it is safe from harm. If the computer is not properly mounted, it can be exposed to mop water, dirt and other contaminants.

Embedded Computer Architecture
An embedded computer architecture is where the computer for the order confirmation or digital menu-board display is located within the display enclosure outside in the drive-thru. The main advantage in this architecture is that the display and the computer are one piece (like an iPad or smart phone), so that they can be serviced as a unit, and also do not take up any additional space in the store.

Summary
Outdoor Digital Displays have become an important tool to improve order accuracy and speed-of-service at drive-thru Quick Service Restaurants. The significance of their role coupled with exposure to extreme elements means selecting a reliable and durable display is critical for the success of QSRs. It is clear that when selecting an outdoor display, the QSR operator needs to pay close attention to the harshness of the environment (temperature, chemicals and weather), the amount of direct sunlight, useful reliability and what data connectivity best meets their needs. Armed with a solid understanding of how a display system works and the technical terms that describe its operation, choosing a reliable outdoor display can be a straight forward task.