Color, contrast and content that survive the sun

A working manual for anyone designing messages for an outdoor LED sign, or selling one to a retailer, a fuel operator or a sign company. It covers what to put on the face, how big, in which colors, and how bright at each hour.

PIXEL PITCH
6.35 mm · 7.62 mm · 9.52 mm

APPLICATION
Retail · Roadside · Fuel & Convenience

COMPANY
Shenzhen Only Optoelectronic · since 2006

10,000
cd/m² · U-PRO-S peak at 100% drive

12,700
cd/m² · reflected off a 0.40 face at noon

1.8:1
contrast left on that same face

OL-CDG-2026-02 · REVISION 2 · NOVEMBER 2026 · WALLY XIANG, SALES DIRECTOR

READ TIME 22 MINUTES · 4 PHOTOGRAPHS · 1 CHART · 3 TABLES · 1 WORKED EXAMPLE

Two luminance values decide whether a message survives noon: the light the panel emits, and the light the face reflects back at the driver. A 10,000 cd/m² panel and a washed-out sign can be the same object. **Brightness is what the panel produces. Contrast is what the driver receives.** This manual works through the second number in units, in palettes, in type size, and in the dimming curve that runs the sign from sunrise to midnight.

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01

The problem at noon

A sign company installs a message center in May. In June the customer drives past it at lunch and calls back: the letters look grey. Nobody touched a setting between the shop test and the roadside. The panel is running at full power.

What changed is the light in front of the face. Think of two numbers competing. The LEDs add light where the content is bright. The face adds reflected light everywhere, including where the content is black. At noon the second number gets large and the ratio between them collapses.

12,700 cd/m² Reflected luminance off a 0.40-reflectance surface under 100,000 lx of noon sun. L = E · ρ / π	**10,000 cd/m²** U-PRO-S peak luminance at 100% drive. The nit is the same unit, written differently
1.8 : 1 Effective contrast of a 100:1 face once that reflected veil sits on it. Worked through below	**5 s** Read time left to a driver at 45 mph (66 ft/s) inside a 350 ft legibility window



Fig. 1 Fire station message center at midday. Black ground, one yellow line at full weight, one white line under it. Nothing on this face depends on a subtle color difference.

So the useful question is not how bright the panel is. It is how much separation survives after reflected light lands on every pixel. Content that starts with maximum contrast keeps the most separation. Content that starts pale has nowhere left to fall.

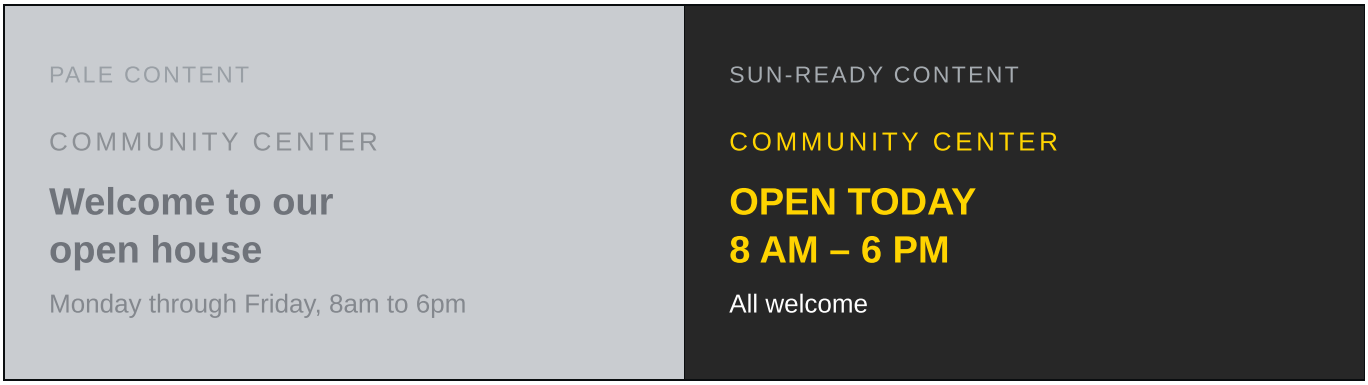
THE ARITHMETIC

$$C = (L_{max} + L_r) / (L_{min} + L_r)$$

PANEL AT FULL DRIVE	REFLECTED VEIL AT NOON
L_{max} 10,000 · L_{min} 100 cd/m²	**L_r 12,700 cd/m²**
CONTRAST, NO SUN	CONTRAST, NOON SUN
(10,000 + 0) / (100 + 0) = 100 : 1	**(10,000 + 12,700) / (100 + 12,700) = 1.77 : 1**

L_{min} is taken at 1% of peak, the black level a dark mask over a black LED package returns in the field. Reflection is Lambertian at 0.40 reflectance, the value for weathered white concrete. Substituting another surface changes L_r and the second ratio; it does not change the first.

Two panels, same hardware



The right panel keeps two things the left one loses: a ground dark enough to stay dark, and a line short enough to read before the light changes.

In short. At noon a 100:1 panel delivers about 1.8:1 to the driver. Half of that number is decided by the content, before the panel is specified.

02 Six rules that survive direct sun

These are the rules our sign company customers come back to, in the order they matter.

1

Start with a dark ground

Black or near-black leaves the LEDs as the only light source on the sign. Reflected sun lifts the floor, but it lifts a floor that started low. A ground above roughly 18% reflectance stops acting as a ground and starts acting as a second light source, and the letters then have to out-shout the whole face of the sign.

2

Use saturated color, not pastel

Pastel is white mixed into a hue at the source, and reflected sunlight adds the same white on top of it, so the field converges on the background instead of separating from it. Yellow, white, red and bright green hold, because each sits near full drive and none of them needs white to be a color.

3

Fat strokes, simple letterforms

Stroke width carries reading distance. A light weight or a thin serif asks the eye to resolve detail that reflected light is already erasing. Sans serif in bold or heavy weights is the default; condensed faces are avoided because they push strokes together. Cap height of at least 1 in per 10 ft of viewing distance, and stem width no thinner than one eighth of cap height, are the working numbers behind the examples in this manual.

4

Four to seven words per screen

The driver gets a few seconds, and part of that is spent turning their head. Break the message down: price, product, time, one call to action. If the copy needs a comma and a second comma, it belongs on a website or on the LED billboard, not on an EMC.

5

Hold each frame long enough to read

Fast transitions feel impressive in the shop and unusable on a sunny road. Three to five seconds per frame for a passing driver, and eight seconds before the sequence repeats, so a driver entering the legibility window sees the whole message once. A static frame beats an animated one that flashes. Sub-second cuts, scrolling text and storm effects read as noise at speed.

6

Photographs with real shadows

A photo works on a daytime sign only when it carries its own contrast, with a luminance ratio of at least 6:1 between its lightest and darkest area. A bright sky and a dark subject hold. A flat, evenly lit frame with a white sky turns into grey mush, and white type sitting on it turns into a grey smudge. When a photo is unavoidable, place the words on a solid band below 5% reflectance.

Rule six is the one designers argue about. It is also the one that produces the most support calls, because a photo that looks right on a laptop has no way to predict what a 100,000-lux face will do to its midtones.

03

Blue and grey, two different failures

Both are common in content built on a monitor, and both fail outdoors for reasons that have nothing to do with taste.

Blue is a luminance problem first. At 460 nm the photopic luminous efficiency V(λ) is 0.06, against 1.00 at 555 nm, so a blue field at the same drive current returns roughly one sixteenth of the perceived light a green field does, and it reaches its drive ceiling sooner. Blue also sits close to the blue cast of open sky, which is where the viewer is already looking, and reflected sunlight lifts it into the same family as the background. The field turns cyan-grey and the message stops separating.

Mid grey is the opposite case. It has no hue to separate anything with, so it relies on lightness alone, and reflected light lifts it toward the same lightness as white type. Showing grey on an LED face also means running red, green and blue together at partial output, which spends brightness to produce a colour the panel holds badly at low levels. Banding appears where the driver cannot resolve the low grey steps, colour shift follows any gamma error, and mura (the panel-industry term for luminance non-uniformity) becomes visible across the face before it would on a black ground.

Near-black navy is a different decision from mid-blue and it holds up. The rule is not about hue names, it is about how much light the ground emits.

Driving blue harder is not the fix

The obvious answer is more current, and it does not work. Blue dies at the shortest wavelength in the set, so the package already runs close to its rated drive to reach a usable white point. Push past it and two things move: the dominant wavelength shifts toward shorter blue as current density climbs, so the blue drifts purple. Junction temperature rises with the extra current, so lumen maintenance falls faster than the curve in the datasheet. On a sign built to run sixteen hours a day, that is a two-year answer to a ten-year problem.

White is a mixture, not a source

A white pixel on an RGB sign is three channels running together at a ratio the controller holds. That ratio is the white point, and it is a calibration result, not a property of the LEDs. Set it to 6,500 K and white reads neutral next to daylight; set it to 9,000 K and the same file reads cool blue on a sunny face, because the sign is now being judged against a brighter, warmer surround. This is why a white headline can look clean on the bench and wrong on the wall, and why the white point belongs in the commissioning record rather than in a personal preference.

Grey is the driver's hardest test

A grey field asks the driver IC to hold a level it cannot easily resolve. An eight-bit channel has 256 steps; below about 5% of peak only a dozen of them are left, and they are the ones that decide whether a dark panel looks black or looks blotchy. Ten-bit processing gives four times the resolution in that range, which is the difference between a clean fade and visible banding at dusk.

Practical check: convert the artwork to grayscale and set it beside an 18% neutral grey card. If the ground reads lighter than the card, direct sun washes the field out and no brightness setting recovers the separation.

04 Six palettes to standardize on

Each set holds one ground below 15% reflectance, one saturated accent at or near full drive, and white for detail. No set uses more than two hues, and none of them depends on hue alone to separate. They drop straight into a template library.

50% OFF ENDS SUNDAY	GRAND OPENING NOW OPEN	FRESH FOOD OPEN DAILY
Black + yellow + white Promotions, clearance, price-led retail. Yellow carries at full weight, white carries the offer detail.	**Navy + white + cyan** Corporate retail, electronics, banks, clinics. A saturated navy ground reads as a brand color rather than a black field.	**Dark red + white + yellow** Restaurants, supermarkets. Deep red reads as appetite without dropping the lightness of the type.
DRIVE SMART NEW TECHNOLOGY	SAVE MORE EVERY DAY	OPEN 24 HRS FUEL + COFFEE
White + black + green AVOID AT NOON Grocery and produce. Good in morning and evening light; at midday the white ground becomes a glare panel.	**Black + cyan + white** Automotive, technology, modern retail. Cyan separates from a black ground better than mid-blue does.	**Dark green + yellow + white** Convenience stores, gas stations, supermarkets. Green separates from road and foliage; yellow keeps the price line readable.



Fig. 2 The same system in the field: a deep green ground, white for the message, yellow for the number the driver is meant to catch. Three colours, no competing fourth hue, and the price stays the brightest element on the face.

05

Pairs that fail

All six look distinguishable on a monitor. On a sunny face they collapse, usually for a measurable reason.

Yellow on white	Both read above 90 on the L* axis, a split of under 8 points. Nothing that small survives a 12,700 cd/m² veil.
Dark blue on black	Blue returns about 6% of the perceived luminance of green at the same drive. A two-pixel stroke at 460 nm goes first, and a bold one follows.
Red on green	Both values are dark and both sit low on V(λ). At 300 ft the hue cue is gone and the pair collapses into one dark mass; to a deuteranope it never separated at any distance.
Light grey on white	About 16 L* points apart. Readable at arm’s length on a monitor, gone past 350 ft in sun.
Thin red type on a dark face	Red carries roughly 0.12 relative luminance against 0.05 for the deep green, and both are low. A thin stroke loses its edge to the ground before a bold one does.
Several bright colors, equal lightness	Equal lightness leaves the eye no ranking. Every element competes, so none of them reads as primary.

Do not assume a pair will read because it looks different on screen. Reflected light adds the same value to both sides of the ratio, so a pair that started 16 L* points apart can finish under 6.

06

Type size follows pitch, not taste

Pixel pitch does not change contrast, but it sets how much information the screen can carry. In a one-foot-high band of a U-PRO-S module, the vertical resolution works out roughly like this.

Table 1 Recommended starting points for primary text. Practical guidance, not a mandatory standard.

PIXEL PITCH	PIXELS PER FT	CAP (MM)	CAP (IN)	DESIGN STYLE
6.35 mm	48	152 – 203	6.0 – 8.0	Detailed but simple layouts
7.62 mm	40	152 – 213	6.0 – 8.4	Bold and simple
9.52 mm	32	171 – 229	6.7 – 9.0	Large and minimal only

Cap height is the height of a capital letter, not the line box. On 6.35 mm there are 48 pixels in a foot of panel height, so a 24-pixel capital measures 152 mm. Retail main copy sits at 24 pixels or more whatever the pitch, because below that a bold sans loses its counters at distance. A finer pitch also packs more emitters into each square metre, so the same face luminance is reached with more, smaller LED packages and a higher current per unit area. Detail and power scale together; contrast does not.

A second rule of thumb runs alongside it: minimum viewing distance in feet is roughly ten times the pitch in millimetres, so 9.52 mm suits 95 ft and out. On 9.52 mm, skip secondary lines and fine graphics altogether: they consume the detail budget the headline needs.

A 9.52 mm panel is not a worse panel. It is a panel for twelve words at 300 feet, and it will beat a finer pitch on a highway where nobody has time to read a second line.

07 How much of the screen each element gets

A workable hierarchy for retail content. The main message takes the eye first, the supporting line confirms it, and the brand or call to action closes it. When all three compete at equal weight, the driver reads none of them.

PRIMARY MESSAGE	SUPPORTING LINE	LOGO / CTA
60 – 70% of visual attention	20 – 25%	10 – 15%

These are shares of visual attention, not fixed screen area. A small logo on a dark field can carry more weight than its pixel count suggests, and a large pale block can occupy a third of the face while reading as background.



Fig. 3 Two lines, three words, one idea. At highway distance the large format buys legibility, not more content.

08

Brightness by the hour

The same face sees low sun in the morning, hard overhead light at noon and nothing at all after dark. Brightness should follow that curve, and content should be built for the worst hour rather than the average one.

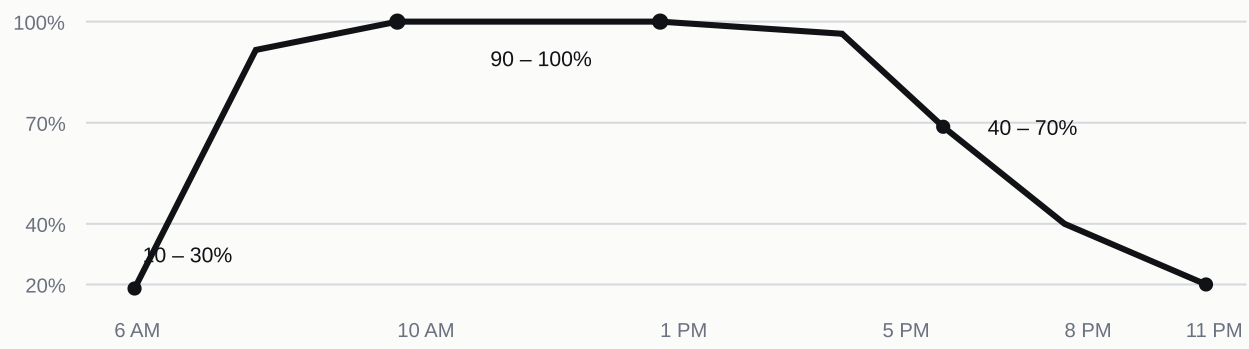


Fig. 4 Starting dimming curve for an electronic message center driven by an ambient light sensor and an astronomical time clock. Values are percentages of the panel peak, and they are tuned on site against the actual sun path.

Table 2 Daypart values for a panel with a 10,000 cd/m² peak.

DAYPART	BRIGHTNESS	CONTENT APPROACH
Dawn – 10 AM	90 – 100%	Low sun rakes across the face at a shallow angle. Highest-contrast frames only, no pale grounds, fewer messages in the rotation.
10 AM – 4 PM	100%	Two or three messages on a black ground, five words each. This is the window the sign is judged in.
4 PM – dusk	60 – 90%	West-facing faces take the worst of this. Reduce the rotation before reducing the brightness.
Dusk – 11 PM	30 – 50%	More detail and photography become readable. Brightness still has to fall, or the face glares into traffic.
11 PM – dawn	10 – 20%	Photography reads best here. Check the local sign ordinance for a night luminance cap before setting the floor.

A sign tuned for noon glares at night. A sign tuned for night disappears at noon. One curve serves both only when the photocell reads the light falling on the face, and the time clock stops the curve from jumping at sunrise or cloudbreak. Set the white point at the same visit: a panel calibrated to 6,500 K keeps white type white, while a 9,000 K setting reads blue-grey under a warm afternoon sun.

In short. Brightness is a schedule, not a number. The panel needs at least a four-decade range between its noon output and its night floor, and the content has to be built for the top of that range.

09

Ten minutes on site

Before you blame the panel, run this. It costs one visit and settles the argument with evidence rather than opinion.

1. **Stand where the driver actually looks**, not directly under the sign. Most complaints are filed from the wrong vantage point.
2. **Take a photo at noon with HDR off and spot metering.** Meter the white letters, not the sky. HDR rescales detail your viewer will never see and makes a failing sign look acceptable.
3. **Convert the photo to grayscale.** If the letters and the background sit at the same lightness, brightness cannot fix it.
4. **Read the message aloud at three seconds.** If you cannot finish it, the copy is too long for the speed limit on that road.
5. **Come back at dusk** and confirm the dimming curve. A panel that reads well at noon and glares at night is only half configured.



Fig. 5 A school message center at the same noon light. White primary line, yellow second line, two words above one. The face is black and stays black.

10

Before the sign ships

Eight checks, run on the real panel with the real content. Three need a meter, the rest need a phone and a tape measure.

Table 3 Pre-ship checks, with the measurement that settles each one.

CHECK	HOW	PASS LOOKS LIKE
Daylight	View from the driver’s seat in direct sun, never from the shade of the sign.	The main message reads in under three seconds.
Color	Compare RGB output with the artwork file, side by side, on the real face.	Saturated hues stay saturated and do not clip to white.
Contrast	White, yellow and cyan, each on a dark ground, viewed at the reading distance.	Edge bleed under one pixel; no halo around thin strokes.
Viewing distance	Walk to ten times the pitch in millimetres, converted to feet.	The primary line still resolves there, and not only at half that distance.
Viewing angle	45° left and right of centre, same distance.	Luminance drops, legibility does not; the primary line survives the falloff.
Luminance	Hand-held meter at the reading distance, white field, then a black field.	Peak within ±5% of the specified value; black field under 1% of peak.
White point	Photograph at 1/125 s, f/4, ISO 100 with a grey card beside the face.	Grey stays neutral; white type does not read blue under warm light.
Night	Drop to the night setting and photograph the face from the road.	No bloom, no glare, and the letters still separate from the ground.

RGB values are source colors, not guaranteed physical output. Actual appearance depends on LED wavelength, calibration, brightness, receiving-card processing and the environment in front of the face.

11

What the panel still has to do

Content sets the ceiling. The panel has to reach it. Four things matter on the hardware side, and three of them are part of the build on the U-PRO-S 1×2 ft panel we supply to sign companies.

Brightness headroom

10,000 nits peak, with an automatic dimming curve so the panel does not blind traffic at night. Headroom is what buys contrast back at noon.

A face that does not bounce light

A low-reflectance mask over dark LED packages keeps reflected sunlight from filling the gaps between pixels; a matte black mask returns under 2% specular reflection, a glossy one several times more. This is the difference between a deep black and a grey one at midday.

Refresh at 3,840 Hz or higher

1,920 Hz is enough for the eye alone. Cameras and dash cams are not: a rolling shutter at 1/125 s samples the panel scan by scan, and anything under about 3,000 Hz shows banding in the photo. 3,840 Hz keeps the face clean in a phone photo, which is how most customers judge it after installation.

Orientation decided at design time

A face pointed west takes low sun every afternoon and will always be the hardest panel on the site. Give that face the highest brightness configuration and the most conservative content. LED packages also fall to half their on-axis luminance around 60–70° off axis, so a face angled across an approach spends most of its light on the wrong side of the road.

The fourth item is not a purchase decision, it is a drawing decision, and it is the cheapest of the four to get right.

12

Terms used in this manual

Every figure in the previous chapters depends on one of these definitions. They are listed in the order they first appear.

Luminance · cd/m²

Light leaving a surface per unit area in a given direction. The nit is the same unit, and datasheets use both, so this manual does too.

Illuminance · lx

Light arriving on a surface, per square metre. A different quantity from luminance, and the reason 100,000 lx and 10,000 cd/m² cannot be placed side by side without a reflectance.

Reflectance · ρ

Share of arriving light a surface sends back. Weathered white concrete sits near 0.40, black sign mask near 0.02.

Contrast ratio

L_{max} over L_{min} on the panel. Once a reflected veil L_r is added to both terms, the ratio is the one the driver actually receives.

Pixel pitch

Centre-to-centre distance between pixels of the same colour, in millimetres. It sets pixels per foot and therefore the detail budget, not the contrast.

Cap height

Height of a capital letter, measured without ascenders or descenders. All type sizes in chapter 06 are cap heights.

V(λ)

The CIE 1924 photopic luminous efficiency function, normalised to 1.00 at 555 nm. It is what makes 460 nm

Dimming curve

The mapping from ambient light to panel output, run from a photocell with an astronomical clock as a floor and a

blue cost more drive current for less perceived light.

Mura

Luminance non-uniformity across a panel. Low grey levels expose it first, which is why mid grey is a poor ground outdoors.

Gamma

The exponent relating grey value to emitted light. A gamma error shows up as banding in gradients before it shows up as a colour shift.

ceiling.

Dwell time

How long one frame stays on the face. Three to five seconds for a passing driver; eight before the sequence repeats.

White point

The colour temperature the panel is calibrated to. 6,500 K reads as daylight; 9,000 K reads blue against a warm afternoon sun.

Where a term has a trade meaning and a plain meaning, the trade meaning is used throughout. “Brightness” appears only where the sentence refers to what an operator sets, not to a measured value.

13

Units, standards and scope

The working references behind the numbers above, and the limits of what this document claims.

How the two headline numbers were produced

Noon sun in June at 40° latitude delivers roughly 100,000 lx to a face oriented toward it. That figure is illuminance. A surface with 0.40 reflectance returns $L = E \cdot \rho / \pi = 100{,}000 \times 0.40 / 3.14 \approx 12{,}700$ cd/m². That figure is luminance, and it is the one that competes with the panel. Every ratio in this manual follows from that conversion, so the comparison holds whatever panel is specified.

Standards the numbers lean on

- **ANSI/UL 48** — the safety standard for electric signs in the US and Canada, and the frame every EMC installation sits inside.
- **FCC Part 15, Subpart B** — unintentional radiator limits that a sign controller and driver set has to meet before it is installed on a US site.
- **CIE 1924** — the photopic luminous efficiency function V(λ) used for every wavelength argument in chapter 03.
- **USSC and Sign Research Foundation legibility studies** — the source of the 1 in of cap height per 10 ft of viewing distance rule of thumb used in chapter 02.

These are the references the guidance is built on. They are not certification claims: listing, labelling and site approval are separate processes carried out by the authority having jurisdiction, and product certification is documented on the product datasheet and the contract, not in a design guide.

Scope and limits

This manual covers content and configuration decisions for outdoor electronic message centers in the US and Canadian markets. It does not specify a product, promise a measured performance figure on any particular site, or replace a site survey. Peak luminance, black level, reflectance, viewing distance and sun path all

move with the installation, and the numbers here are the starting points this company works from rather than guaranteed outcomes.

Colour values quoted as RGB are source values. What reaches the eye depends on LED binning, calibration, brightness setting, receiving-card processing, mask reflectance and the light in front of the face. Two panels built to the same drawing can differ by a visible step if one is calibrated and the other is not.

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PRODUCTS COVERED **U-PRO-S · 6.35 / 7.62 / 9.52 mm**	MARKET **United States · Canada**	ISSUED BY **Shenzhen Only Optoelectronic Co., Ltd.**

Send us the sign at noon

A photo taken at midday, the viewing distance, and the message that is failing. We will come back with content changes and the panel configuration that fits the site. Sign companies and distributors can also ask for the template files behind the six palettes in this manual.

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Color, Contrast & Content Design Guide · 6.35 / 7.62 / 9.52 mm · revision 2 · 2026