Sunlight Readability Contrast Measurements for the ISD2351 and ISD2353 Serial Input Small Alphanumeric Display Appnote 47

by Bob Krause

Introduction

Light emitting diode alphanumeric displays have had a long and successful relationship with military and avionic equipment. Applications with very high light ambients now are possible because of advances in the efficiency of LEDs. Polarized filters enhance the readability of LEDs by eliminating much of the ambient reflection from the LED die and the surrounding package.

Readability Criteria

An observer's ability to perceive the information from an alphanumeric display depends on two factors. These include font and size of the message in relationship to the viewing position and the optical contrast of the message to the surrounding environment.

Optical contrast is the comparison of the brightness or sterance (L) of the On/Off/LED to the brightness of the surrounding environment. High readability results by optimizing the following contrast ratios. The first ratio, C_1, involves the OnLED stearance, L_{LEDon}, and the background steerance, L_B, is optimized when the OnLED is brighter than the surrounding area. Thus C_1 will be much greater than unity (1).

The next ratio, C_2, involves the sterance ratio of the On, L_{LEDon}, and Off, L_{LEDoff}, LED. C_2 is optimized when the L_{LEDon} is much greater than the L_{LEDoff}, resulting in being much greater than unity (1).

The optimal ratio of C3, involving OffLED to the background, is achieved when the ratio is near zero. The OffLED should have minimal contrast with the background.

Ratio Equations

1) C_1—OnLED to Background

$$C_1 = \frac{L_{LEDon} - L_B}{L_B}$$

2) C_2—OnLED to OffLED

$$C_2 = \frac{L_{LEDon} - L_{LEDoff}}{L_{LEDoff}}$$

3) C_3—OffLED to Background

$$C_3 = \frac{|L_{LEDoff} - L_B|}{L_B}$$

The equations for these three ratios are given b

The U.S. military has established contrast ratios sunlight readability criteria. These criteria are pu "*Night Vision Goggle Lighting Specification.*" Th are shown below:

C1—OnLED to Background	≥ 2.0:1 Minim
C2—OnLED to OffLED	≥ 2.0:1 Minim
C3—OffLED to Background	≤ 0.25:1 Maxi

Optical Filtering

An LED, regardless of its brightness, has a diffic peting with the sterance of the sun. An LED dis ity can be greatly improved by using contrast en filters. The filter of choice is one that eliminates ence of the sun with the background of the disp of filter vendors offer anti-reflection coated, circ (AR/CP), optically tinted bandpass and neutral d which have proven very helpful in satisfying the ability contrast requirements.

The display front surface and the areas surround have specular reflector characteristics. This refle allows optimum contrast when used with a circu ter with anti-reflective coating. See Table 1 for F Guide.

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Table 1. Contrast enhancement filter selection guide

Display P/N or Condition	Display Color	Transmission	Filter Color	Filter Model I Filter Manufa
ISD2010 ISD2012 ISD2352* ISD2310 ISD2312	Red/ Hi Eff. Red	25% at 635 nm	Red	MPC 20-15C Marks
ISD2011 ISD2351* ISD2311	Yellow	25% at 585 nm	Amber	MPC 30-25C Marks
ISD2013 ISD2353* ISD2313	Hi Eff. Green	22% at 565 nm	Yellow/Green	MPC 50-22C Marks
High Ambient Light	All Colors	10% Neutral	Neutral Gray	MPC 80-10C Marks
High Ambient Light	All Colors	37% Neutral	Neutral Gray	MPC 80-37C Marks
ISD2010 ISD2012 ISD2352* ISD2310 ISD2312	Red/ Hi Eff. Red	14%	Reddish Orange	HLF-608-5R Hoya
ISD2011 ISD2351* ISD2311	Yellow	14%	Yellowish Orange	HLF-608-3Y Hoya
ISD2013 ISD2353* ISD2313	Hi Eff. Green	14%	Yellow/Green	HLF-608-1G Hoya
High Ambient Light	All Colors	10% Neutral	Neutral Gray	HNCP10 Polaroid

* Sunlight viewable displays. All other part numbers represent all the standard Military Small Alphanumeric Displays.

Manufacturers

Marks Polarized Corporation
25B Jefryn Blvd. West
Deer Park, NY 1179-5715
(516) 242-1300

HOYA Optics, Inc.
3400 Edison Way
Fremont, CA 94538-6138
(415) 490-1880

Polaroid Corp.
Polarizer Division
1Upland Road
Norwood, MA 02062
(617) 577-2000

Contrast Measurements

The ability to read a display in direct sunlight used to be determined by using a series of standard observers and irradiating the display with one sun. Recent technical studies have established contrast criteria permitting laboratory measurements that verify sunlight readability.

A yellow ISD2351 and a high efficiency green ISD2353 Small Alphanumeric Display were evaluated for sunlight readability under a simulated sun with an incident of 4200 fc. These two displays were tested with both pass-band and neutral density AR/CP filters. The measurement technique and results follow.

Contrast Measurement Setup

Contrast measurements require the use of a sp
which measures the luminance of the surface w
spot size. A Photo Research Spectra Pritchard sp
Model 1980B with a Macro Spectar MS-80 Lens
and set to read out in foot Lamberts, fL. The dis
were mounted on a micro adjustable X/Y/Z stag
the spot photometer, and a 500 W Unimat LX80
were mounted on a optical bench. The light sou
ented 30° from the normal of the display. See F

Figure 1. Sunlight readability contrast measurement setup

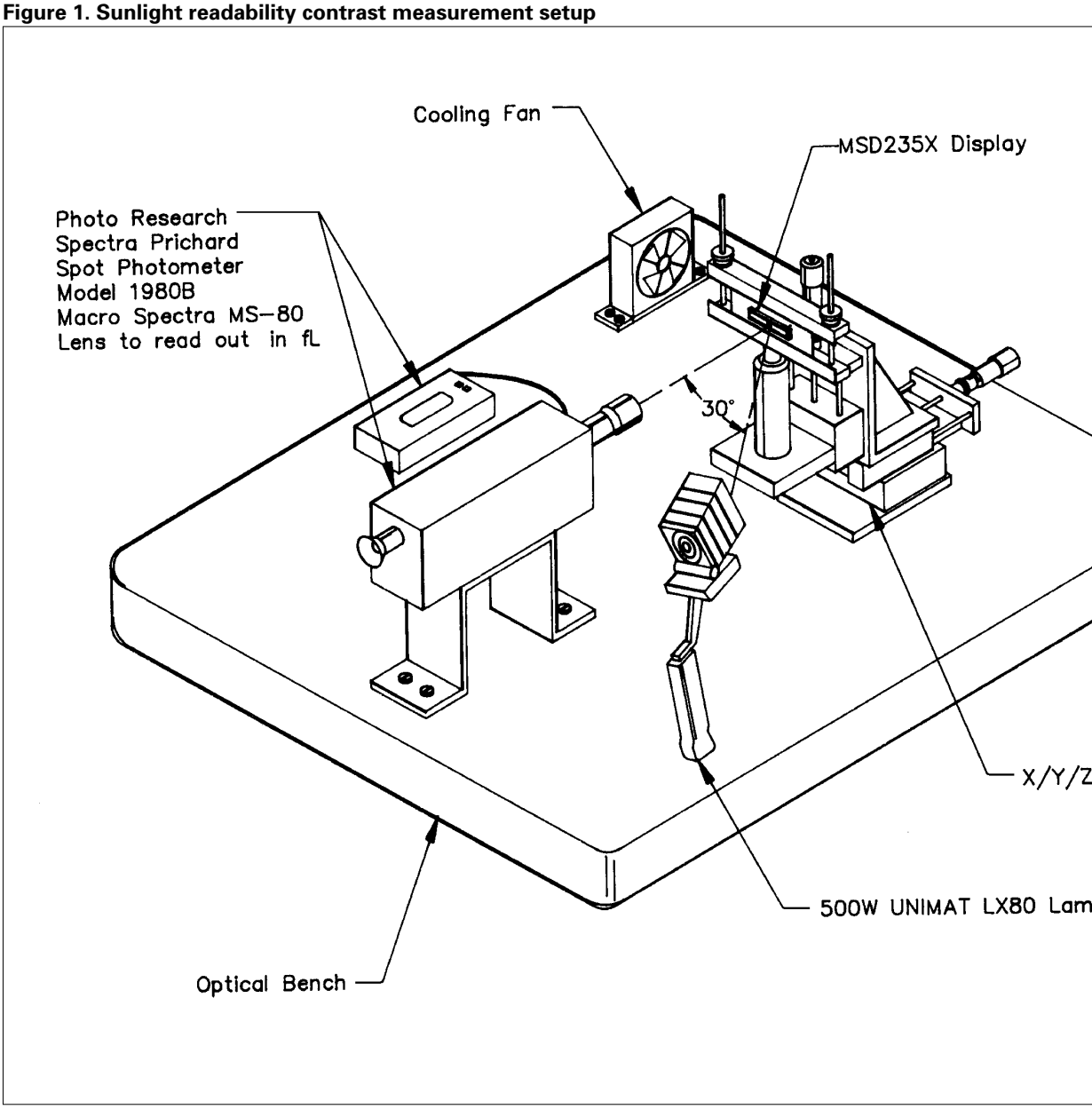
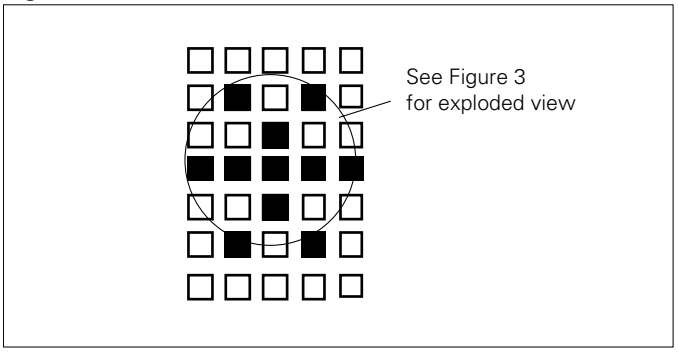


Figure 2. LEDs selected for measurement



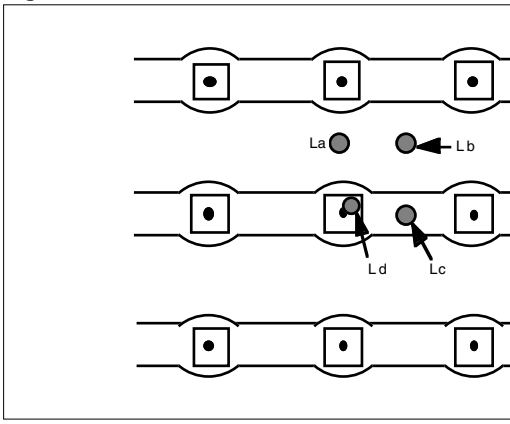
The sterance measurements were made using the photometer with an angle setting of 2 minutes resulting in a spot size of .004 in. The incidence flux was determined by using a Kodak 6080 standard lambertian reflector painted slide.

The X/Y/Z stage supported the display, the AR/CP filter, and the display drive electronics. Figure 3 shows the asterisk (*) programmed on the display. Each LED had a duty factor of ON 17.6%. The center of the asterisk was used as the measurement LED. The stage was used to position the display at the four contrast measurement points as shown in Figure 2.

Contrast Calculations

The data derived from the spot photometer was used to calculate the three contrast ratios, C_1, C_2, C_3. For best accuracy, L_B was the average of three spot locations. Figure 3 shows these as L_a, L_b, L_c. L_a is the substrate sterance between two LED die, L_b is the substrate sterance of the area between four LED die; and L_c is the sterance of a gold trace connecting the LEDs.

Figure 3. Points for luminous stearance meas



Measurements were made using a yellow ISD2 Marks MPC80-10C neutral density gray filter. Th typical intensity of 2450 µcd/LED with an averag of 585 nm.

Measurements were also made using a green I Marks MPC50-22C yellow/green bandpass filte MPC80-10C neutral density gray filter. This disp cal intensity of 3470 µcd/LED with an average 572 nm.

The data and results of the experiment are shov

Conclusion

From the data, the most readable combination i ISD2353 display and a green bandpass AR/CP filt the green display and the 10% transmissive neu gray AR/CP filter. In both cases these combinati the military limit by almost 2.5 times. The yellow optimum contrast with a neutral density AR/CP

Table 2. Luminous contrast at 4200 fc

Display Color Filter Model #	Status	Footlamberts						
		L_a	L_b	L_c	L_d	L_B	C_1	C_2
Green MPC50-22C	LED-On LED-Off	12.00 11.00	10.20 9.40	27.10 20.60	101.60 12.60	16.43 13.67	5.18	7.06
Green MPC80-10C	LED-On LED-Off	9.70 8.80	8.60 8.60	17.80 11.40	69.80 10.10	12.03 9.60	4.80	5.91
Green MPC50-22C	LED-On LED-Off	12.60 11.10	11.30 9.80	37.30 17.70	111.00 14.40	15.30 12.87	6.25	6.71
Yellow MPC80-10C	LED-On LED-Off	9.30 7.80	8.20 7.20	19.40 10.30	46.50 7.70	12.30 8.43	2.78	5.04
Yellow No Filter	LED-On LED-Off	208.00 198.00	198.00 171.00	650.00 853.00	480.00 171.00	352.00 407.33	0.36	1.81