1. ABSOLUTE MAXIMUM RATINGS

T_A=25 °C, 50 % R.H., unless noted.

	Parameters/Conditions	Min.	Max.	Units
1.1	AC Applied Voltage 1 minute		9	V_{p-p}
1.2	DC Applied Voltage		50	mV

2. ENVIRONMENTAL REQUIREMENTS

	Parameters/Conditions	Min.	Max.	Units
2.1	Non-operating Temperature and Humidity Contrast Ratio>=2.0 and appearance per section 6 after testing			
2.1.1	T_A= -40 (+2,-0) to 80 (+0,-2) °C	1000		h
2.1.2	T_A= 40 (+0,-2) °C, 95 (+0,-5) % R.H.	1000		h
2.1.3	Humidity Cycle, see Figure 2.1	240		h
2.1.4	Altitude, 40,000 feet (5.54 inches Hg), see Note 2.3.1	4		h
2.2	Operating Temperature and Humidity Contrast Ratio >=2.0 and appearance per section 6 after testing			
2.2.1	T_A=-20 (+2,-0) to 55 (+0,-2) °C	1000		h
2.2.2	T_A=40 (+0,-2) °C, 95 (+0,-5) % R.H.	1000		h
2.2.3	Altitude, 15,000 feet (16.88 inches Hg), see Note 2.3.1	0.5		h

2.3 Notes

2.3.1 Altitude Test Procedure

2.3.1.1 Place the LCD in a fixture that energizes the digits per spec in suitable test chamber and measure performance parameters per section 1 through 5 of this document at ambient conditions.

2.3.1.2 Reduce the internal chamber pressure to the appropriate pressure. After 30 minutes at least one significant measurement shall be made at maximum input or output. This test can be extended up to between 24 to 48 hours in order to test all parameters (Due to difficulties encountered in attempting to operate front panel controls in an altitude chamber, it is recommended that the equipment be set up prior to de-energizing so that it is only necessary to turn the equipment on externally to make at least one significant measurement at the maximum rated input or output).

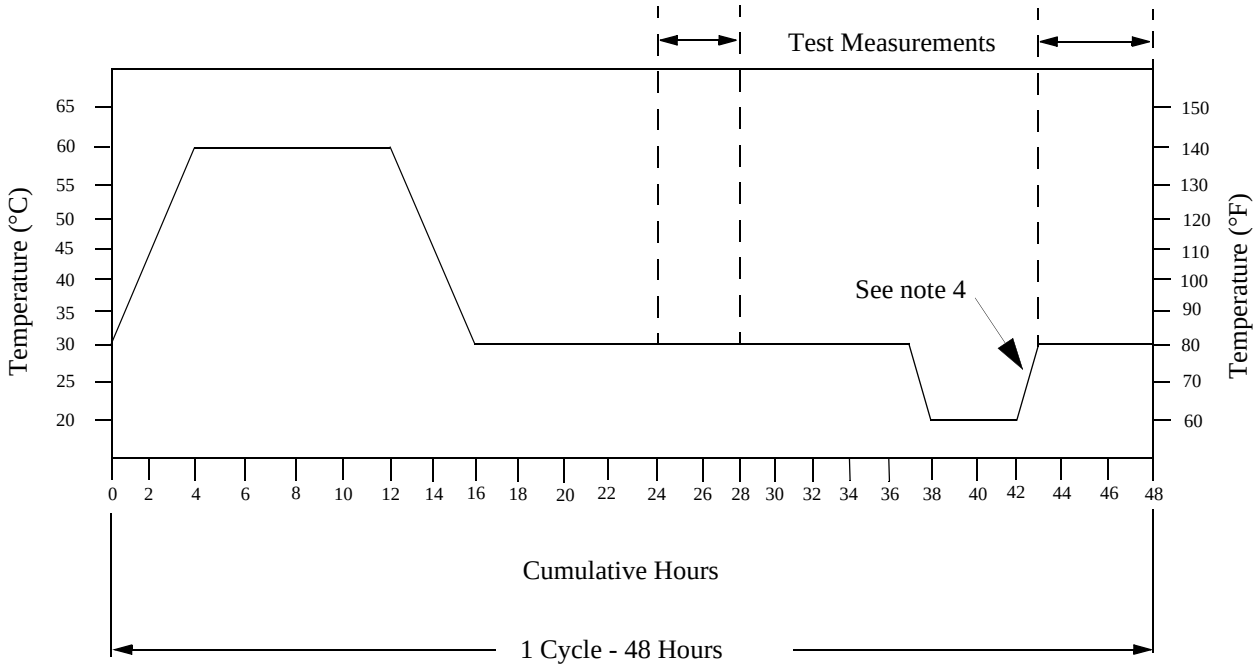
2.3.1.3 Return the internal chamber pressure to local ambient and measure performance parameters per sections 1 through 5 of this document.

2.3.2 Contrast Ratio Definition and Test Conditions

2.3.2.1 Definition: (Output of photo detector with no voltage applied)/(Output of photo detector at V_{op}=3.1 V, f=64 Hz)

2.3.2.2 Test Conditions: Photo detector angle<15° (θ_1) from the normal line of the cell. Halogen Lamp angle<45° (θ_2) from the normal line of the cell.

Figure 2.1 - Humidity Cycle



Notes:

1. Tolerance during temperature change shall not be greater than 3 °C (5.4 °F).
2. Relative humidity shall be maintained at 94 ±4 % at all times, except that during the descending temperature period, the relative humidity may be permitted to drop as low as 85 %.
3. Rate of temperature change between 30 and 60 °C (86 and 140 °F) shall be not less than 8 °C (14.4 °F) per hour.
4. The temperature increase in this portion of the curve shall be not less than 10 °C (18 °F).
5. Test measurements shall be taken only at the period specified.

Ref: MIL-STD-810C, Method 507.1

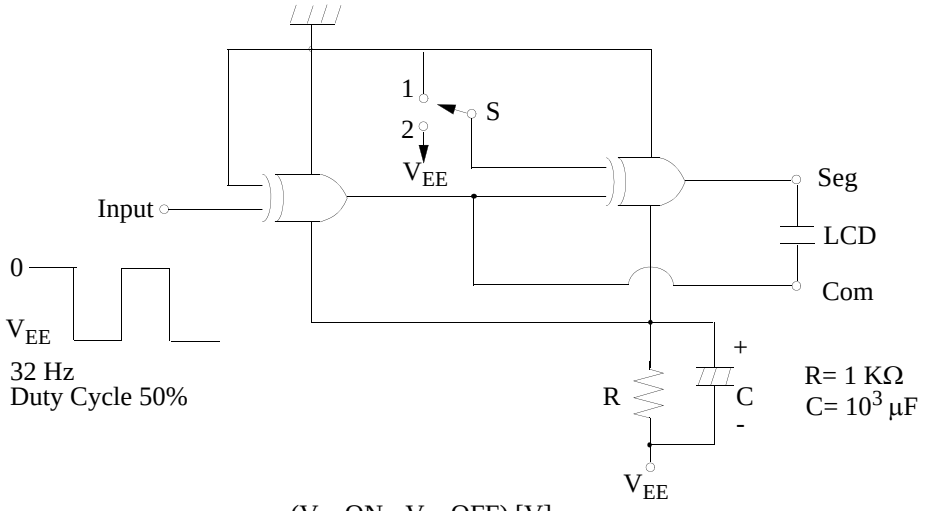
3. ELECTRICAL/OPTICAL REQUIREMENTS

V_{op}=3.0 V, f=64 Hz, T_A=25 °C, 50 % R.H., unless noted.

	Parameters/Conditions	Min.	Typ.	Max.	Units
3.1	V_{op}, Operating Voltage		3.0		V
3.2	Temperature Coefficient of V_{op} T_A = 0 to 40 °C		6.0		mV/°C
3.3	f_F, Frame Frequency $f_F=1/t_F$		64		Hz
3.4	Current Consumption All Segments ON, See Figure 3.1			10	µA
3.5	Lifetime Current Consumption All Segments ON, t_{op}=50,000 hours, See Figure 3.1			20	µA

	Parameters/Conditions	**Min.**	**Typ.**	**Max.**	**Units**
3.6	Contrast Ratio See Note 2.3.2	3			
3.7	Viewing Angle				
3.7.1	θ_1, Contrast Ratio≥2, See Figure 3.2	45			°
3.7.2	θ_2, Contrast Ratio≥1.5, See Figure 3.2	5			°
3.7.3	ϕ_1, Contrast Ratio≥2, See Figure 3.2	40			°
3.7.4	ϕ_2, Contrast Ratio≥2, See Figure 3.2	40			°
3.8	Response Time				
3.8.1	T_r, See Figure 3.3 and Note 2.3.2.2			200	ms
3.8.2	T_d, See Figure 3.3 and Note 2.3.2.2			150	ms
3.9	V_{sat1} and V_{th2}	See Figure 3.4			

Figure 3.1 - Current Consumption Test Procedure, All Segments ON



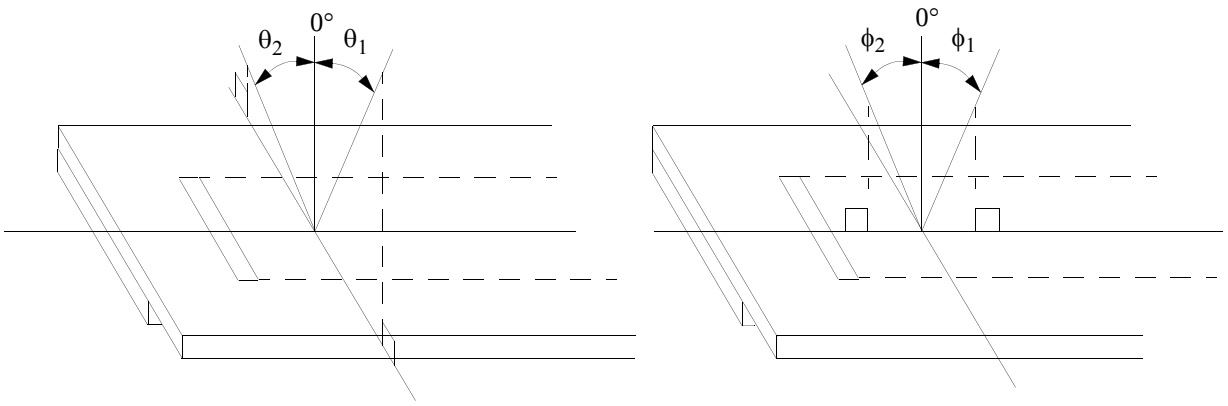
$$\frac{(V_{EE}ON - V_{EE}OFF)\ [V]}{10^3\ [\Omega]}$$

Current consumption is defined as follows:
VEE=-3.1 V when using the above detecting circuit.

$$\text{Current consumption } I[\mu A] = 10^6 \times \frac{(V_{EE}ON - V_{EE}OFF)\ [V]}{10^3\ \Omega}$$

V_{EE}ON is the voltage developed across the 1 kΩ resistor when the switch S is set to 1;
V_{EE}OFF is the voltage developed across the 1 kΩ resistor when S is set to 2.

Figure 3.2 - Viewing Angle Definition and Test Procedure



The viewing angle is defined as shown, where θ and ϕ are angles between the viewer's line of sight and a line perpendicular to the surface plane of the LCD. Standard notations are such that θ is measured from the perpendicular towards the "6 o'clock" position (θ_1) and towards the "12 o'clock position (θ_2), while ϕ is measured from the perpendicular towards the "3 o'clock" position (ϕ_1) and towards the "9 o'clock" position (ϕ_2).

The standard requirement is that the display must have a contrast ratio of Contrast Ratio≥2.0 when ϕ and θ are within the specified ranges.

Figure 3.3 - Response Time Wave Form

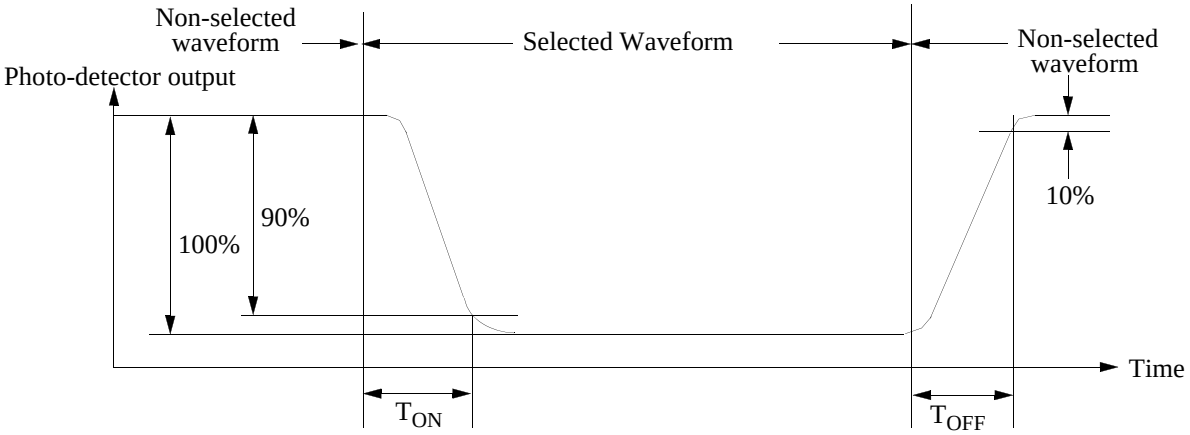
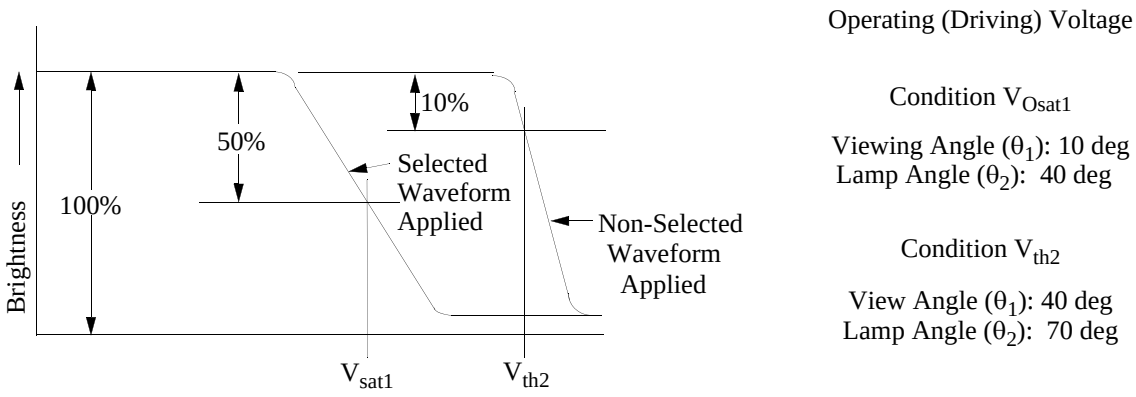


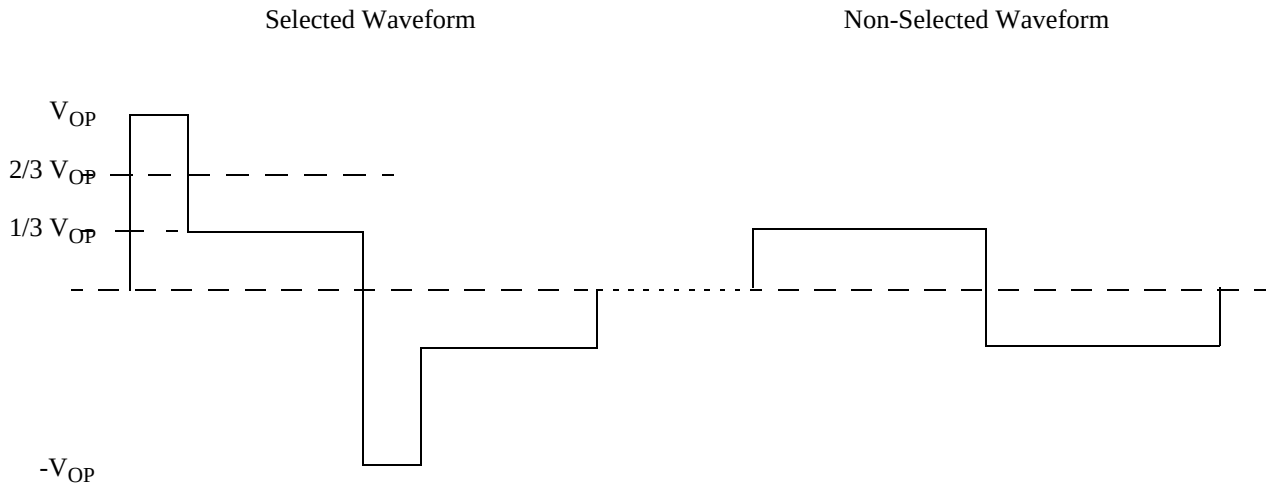
Figure 3.4 - Measuring Condition of Voltage V_{ON} and V_{OFF}



4. FUNCTIONAL REQUIREMENTS

4.1 Drive Waveforms See Figure 4.1

Figure 4.1 - Drive Waveforms, Examples



5. MECHANICAL REQUIREMENTS

5.1	Dimensions	See Figure 5.1, and Reference CAD graphics file provided by Fluke.
5.2	Display Pattern	Reference CAD graphics file provided by Fluke.
5.3	Marking	Displays shall be marked with Fluke P/N and date code on upper left side of contact ledge.
5.4	Packaging	Styrofoam trays - trays shall be 1 row in width; displays shall not have protective film over front or back of display.
5.5	Packaging Drop Test	No glass chips shall be found after subjecting the packing container to 10 drops (each corner, 3 edges and 6 sides) onto a steel plate from a height of 24 inches (60 cm).
5.6	Polarizer Hue	Neutral gray
5.7	Character	
5.7.1	Electrical Connections	Reference CAD graphics file provided by Fluke.
5.7.2	Configuration	Reference CAD graphics file provided by Fluke.

Figure 5.1 - LCD, Display Dimensions, mm

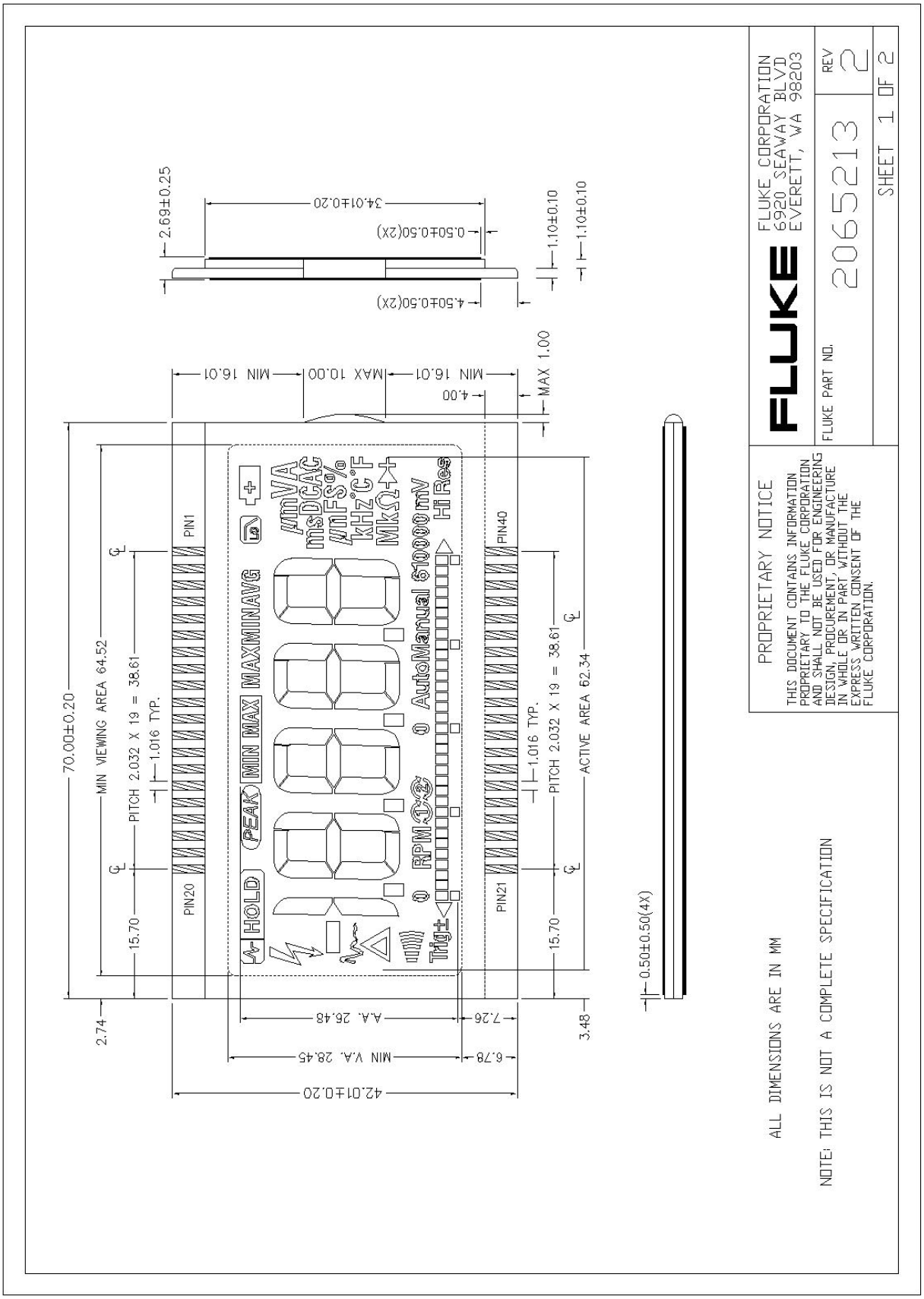
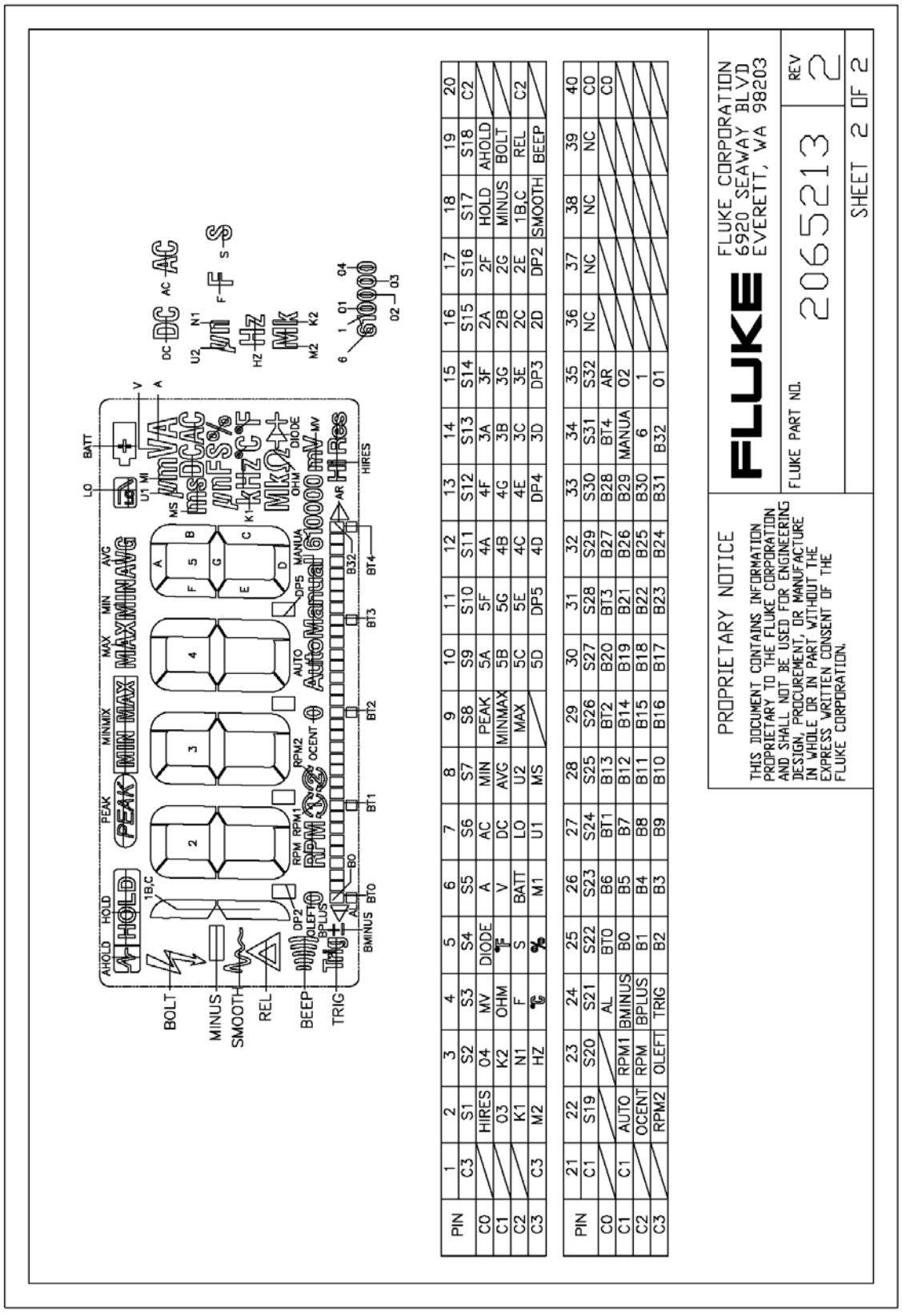


Figure 5.2 - Pattern Connections & Pinout



PIN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C0	C3	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	C2
C1		HIRES	04	MV	DIODE	A	AC	MIN	PEAK	5A	5F	4A	4F	3A	3F	2A	2F	HOLD	AHOLD	
C2		03	K2	OHM		V	DC	AVG	MINMAX	5B	5G	4B	4G	3B	3G	2B	2G	MINUS	BOLT	
C3		K1	N1	F	S	BATT	LO	U2	MAX	5C	5E	4C	4E	3C	3E	2C	2E	1B,C	REL	C2
		M2	HZ		%	M1	U1	MS		5D	DP5	4D	DP4	3D	DP3	2D	DP2	SMOOTH	BEEP	

PIN	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
C0	C1	S19	S20	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32	NC	NC	NC	NC	C0
C1				AL	BT0	B6	B5	B7	B12	B14	B15	B18	B22	B25	B30	6				
C2	C1	AUTO	RPM1	BMINUS	B0	B5	B4	B8	B11	B15	B18	B22	B25	B30	6	1				C0
C3		OCENT	RPM	BPLUS	B1	B4	B3	B9	B10	B16	B17	B23	B24	B31	B32	01				
		RPM2	OLEFT	TRIG	B2	B3	B3	B9	B10	B16	B17	B23	B24	B31	B32					

6. LCD INSPECTION AND ACCEPTANCE STANDARDS

6.1	Inspection Conditions	
6.1.1	Temperature	20 to 25 °C
6.1.2	Humidity	30 to 70 % R.H.
6.1.3	Lighting	Two 20 W fluorescent lamps with a distance of 1 meter (39.57 inches) between the cell and the light source.
6.1.4	Distance, Cell to Naked Eye	30 cm (12 in.)
6.1.5	Viewing angle	45° maximum in the 3, 6, and 9 o'clock positions.
6.1.6	V_{op}	3.1 V
6.1.7	f_F	64 Hz
6.2	Inspection Zones	Zone "A" - Inside Viewing Area and Zone "B" - Outside Viewing Area, See Figure
6.3	Glass Surface/Edge Inspection Diagram	See Figure 6.2
6.4	Defect Classifications	Major and Minor, see Section 9 for definitions.
6.5	Limit Samples	Shall be provided by the manufacturer to facilitate external visual inspection and establish precise guidelines for accept-reject decisions between supplier and Fluke as noted in Inspection Section 7.

Figure 6.1 - Inspection Zones

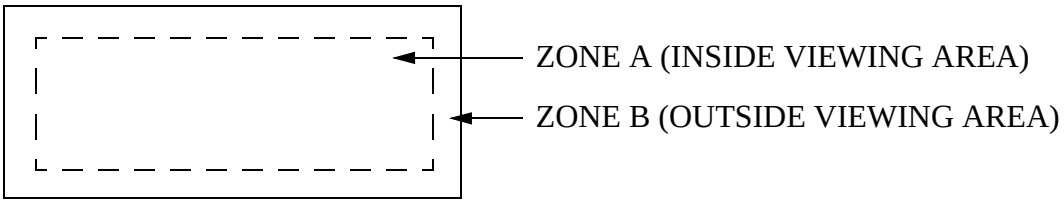
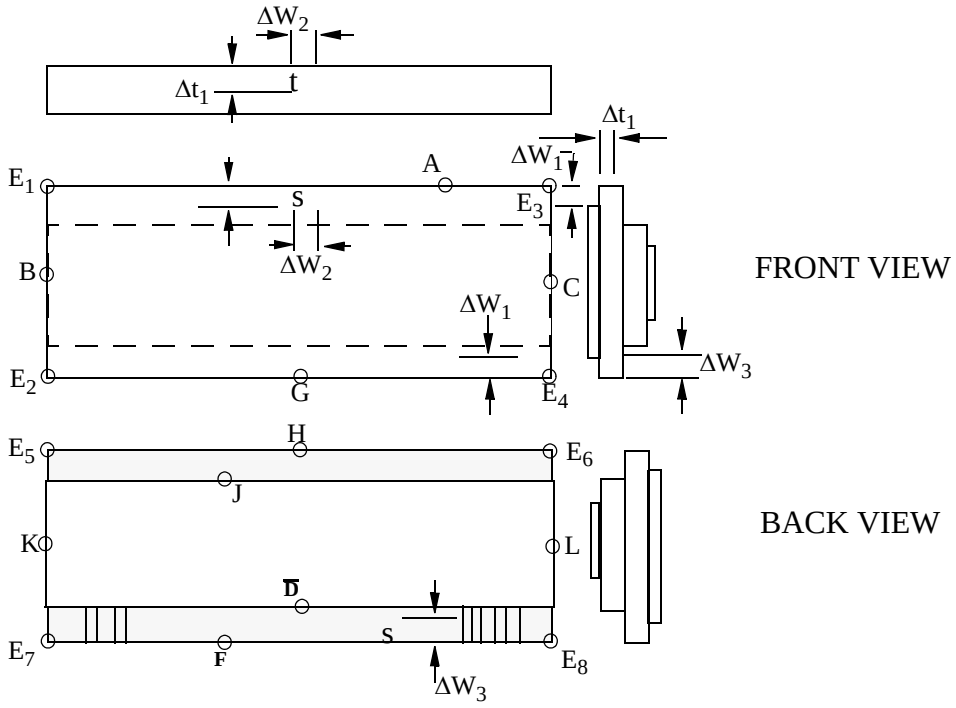


Figure 6.2 - Glass Surface/Edge Inspection Diagram.



7. INSPECTION - PHYSICAL CHARACTERISTICS

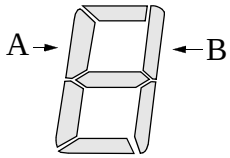
	Defect	**Classification**
7.1	Dark Lines and Scratches, Zone A	
7.1.1	1+ places >.004 in. (0.1mm) in width and >.118 in. (3mm) in length.	MINOR
7.1.2	1+ places .001 to .004 in. (0.03 to 0.1mm) in width and >.079 in. (2mm) in length	MINOR
7.1.3	3+ places .0004 to .001 in. (0.01 to 0.03mm) in width and <.079 in.(2mm) in length.	MINOR
7.2	Chips or Cracks on Glass	
7.2.1	A, B, C, D, G, J, K, and L; ΔW_1<.079 in. (2.00 mm), ΔW_2<.100 in. (2.54 mm), Δt_1>1/2 plate thickness.	MINOR
7.2.2	E_1-E_8; <.118 in. (3.00 mm) in width plus depth	MINOR
7.2.3	F and H; ΔW_3<.040 in. (1.02 mm), ΔW_2<.100 in. (2.54 mm)	MINOR
7.3	Defects in the Glass	
7.3.1	A, B, C, D, G, J, K, and L; ΔW_1<.079 in. (2.00 mm), ΔW_2<.100 in. (2.54 mm), Δt_1>1/2 plate thickness.	MINOR
7.3.2	F and H; ΔW_3<.040 in. (1.02 mm), ΔW_2<.100 in. (2.54 mm)	MINOR
7.4	Black Spot(s) on Surface Part	
7.4.1	1+ places; diameter>.040 in. (1.02 mm)	MAJOR
7.4.2	1+ places; .008 to .040 (0.20 to 1.02 mm) in diameter.	MINOR
7.4.3	5+ places; .004 to .008 (0.10 to 0.20 mm) in diameter	MINOR
7.4.4	2+ places; .004 to .008 (0.10 to 0.20 mm) in diameter, not separated by .197 in. (5mm or more)	MINOR
7.5	Width of Sealing	MINOR
	Sealing agent shall not spread over to Zone A from Zone B, Refer to the conforming limit sample.	

	Defect	**Classification**
7.6	Flow of Sealing Agent on End Sealing Part Shall not protrude (Zone B)	MINOR
7.7	Bubbles in Sealing Agent on Sealing Part Not to reduce the sealing width more than 20 % in Zone B	MINOR
7.8	Flow of Bonding Agent on Contacts Amount of flow, 0.032 in. (0.82mm) or less in Zone B	MINOR
7.9	Bonded Positioning of the Polarizer and Reflector Sheets. Sheet shall not protrude past the end of the glass. Edges shall not lie within Zone A	MINOR
7.10	Exfoliation of Polarizer There shall be no exfoliation in Zone A. There shall be no conspicuous exfoliation in Zone B	MINOR
7.11	Bubbles in Polarizer	
7.11.1	1+ places over .020 in. (0.51 mm) in average diameter.	MINOR
7.11.2	3+ places .012 in. to .020 in. (0.30 to 0.51 mm)	MINOR
7.11.3	5+ places .004 to .012 in. (0.10 to 0.30 mm) in average diameter.	MINOR
7.12	Swelling of Polarizer There shall be no conspicuous swelling in Zone A.	MINOR
7.13	Dirt	
7.13.1	Insulating type foreign matter on the electrical contacts	MINOR
7.13.2	Dirt on the surface of the glass which is not covered under 7.13.1	MINOR
7.14	Color Tone As judged against Conforming Limit samples provided by the manufacturer.	MINOR
7.15	Defect of Alignment in Surface Part Misalignment shall not be visible. Refer to Conforming Limit sample, Zone A.	MINOR
7.16	Rainbow (Color Irregularity) in Surface Part Zone A, Shall comply with an approved Conforming Limit sample.	MINOR
7.17	Reverse Tilt Declination and Reverse Twist Declination on Segment. Not allowed in Zone A.	MINOR
7.18	Electrical Contacts Shall be slanted left or right less than .020 in. (0.51 mm). Front and rear glass alignment shall be within .020 in. (0.51 mm).	MAJOR
7.19	Air Leakage No visible signs of air leaking into, or LC material leaking out of, the display. (All fill-holes visibly plugged with epoxy, etc.).	MAJOR

8. Inspection - Operating Characteristics

	Defect	Classification
8.1	Breakage of Segment Visual inspection shall indicate no breakage in segment(s).	MAJOR
8.2	Short Circuit Visual inspection shall indicate no short circuit.	MAJOR
8.3	Segment Inspection	
8.3.1	Does not light (segments of any or all digits)	MAJOR
8.3.2	Segments other than those selected light.	MAJOR
8.3.3	Blank spots, pinholes or lines as described below appear in segments that are lit.	MAJOR
8.3.4	1+ places that exceed .012 in. (0.30 mm) in diameter.	MINOR
8.3.5	2+ places that are .008 to .012 in. (0.20 to 0.30 mm) in diameter.	MINOR
8.3.6	3+ places that are .004 to .008 in. (0.10 to 0.20 mm) in diameter.	MINOR
8.3.7	1+ places .002 in. (0.05mm) or more in width and .120 in. (3.05 mm) or more in length.	MINOR
8.3.8	2+ places .004 in. (0.10 mm) in width and .020 to .039 in. (0.51 to 1.00 mm) in length.	MINOR
8.3.9	Three widths of segments that make up the letters or numbers in a given pattern when lit, vary by more than .006 in. (0.15 mm) when compared. See Figure	MINOR
8.4	Current Consumption - All Segments Lit	
8.4.1	The rated value as given in the specifications is exceeded by up to 150 % of the rated value.	MINOR
8.4.2	The rated value as given in the specifications is exceeded by more than 150% of the rated value.	MAJOR
8.5	Contrast Ratio Contrast ratio as measured in Section 3.6 of this specification.	MINOR
8.6	Response Time Response time as measured in Section 3.8 of this specification.	MINOR
8.7	Viewing Angle Viewing angle as measured in Section 3.7 of this specification.	MINOR
8.8	Ratings The ratings as given in the specifications are not met.	MINOR

Figure 8.1 - Segment Width Example



Example: In the diagram above, the width of segments on side A and B differ by .006 in. (0.16 mm) or more

9. GLOSSARY OF TERMS

9.1	Birefringence	A characteristic of crystals and liquid crystals. A beam of white light entering the material is divided into two beams which, refracted at different angles, are emitted parallel to each other.
9.2	Chip	A semi-circular/shell shaped pits which occur on the surface and edges of the glass.
9.3	Contrast	Is the ratio of the difference between the symbol (Bs) and the background (Bo) luminances to the luminance of the symbol or background [$C=(B_o-B_s)/B_o$; where $B_o>B_s$ for dark symbols on a light background]. Contrast is related to Contrast Ratio by the following equation: $C=1-(1/CR)$.
9.4	Contrast Ratio	Is the ratio of the off-voltage to on-voltage image brightness. For reflective displays under diffuse lighting, the contrast ratio seldom exceeds ten for a non-emissive device. When the display is reflective (black symbols on white background), which is usually the case for watch and instrument displays, it is described as follows: $CR=B_o/B_s$; where B_o and B_s are defined under Contrast, Item 9.3. Contrast Ratio is related to Contrast by the following equation: $CR=1/(1-C)$.
9.5	Defect in Glass	An imperfection in the glass which does not meet the definition of a chip, Item 9.2
9.6	Density Ratio	A value indicating the contrast ratio expressed by the following equation: $D.R.= \log(T_p\text{off})/\log(T_p\text{on})$. "$T_p$off" and "$T_p$on" are the transmitted percentage when the drive voltage is OFF and ON (respectively)
9.7	Exfoliation	To cast or come off in flakes, scales or layers.
9.8	F.E.M.	Field Effect Mode or twisted nematic type of LCD.
9.9	f_o	Operating frequency, typically 25 to 200 Hz
9.10	Homeotropic	A condition of a liquid crystal phase whereby the optical axis of the molecule is parallel to the light source, thereby giving optical extinction under crossed polarizers; this could cause confusion with an isotropic liquid phase but may be easily ascertained by a slight adjustment of the cover glass allowing light scattering to occur momentarily before relaxation to extinction.
9.11	I_{LCD}	Current consumption of LCD as determined by the equation: I_{ON}-I_{OFF}.

9.12	I_{ON}	Current consumption of LCD and drive circuitry.
9.13	I_{OFF}	Current consumption of drive circuitry with LCD off.
9.14	Isotropic	The phase into which a nematic liquid crystal passes when all ordering disappears. Most liquids exist in this phase. The nematic to isotropic phase transition can be conveniently determined by observing the temperature at which light scattering ceases under crossed polarizers.
9.15	Isotropic Temperature	That temperature above which the liquid crystal loses its crystalline properties and the molecules assume a random orientation. Effectively this defines the upper temperature limit at which the LCD can be operated. Excursions of a few degrees above the isotropic temperature will not damage the display.
9.16	LCD	Liquid Crystal Display
9.17	Liquid Crystals (LC)	A fluid that consists of organic compounds with optical properties of solids and the fluidity of liquids. It is a intermediate state between a crystalline solid and an isotropic liquid. This family of complex organic compounds consists of long, cigar shaped molecules that are blended to exhibit the desired optical properties over the temperature range of interest.
9.18	Major Defect	A defect other than critical, that is likely to result in failure, or to reduce materially the usability of the unit of product for its intended purpose.
9.19	Minor Defect	A defect that is not likely to reduce materially the usability of the unit of product for its intended purpose, or is a departure from established standards having little bearing on the effective use or operation of the unit.
9.20	Monotropic	An unstable nematic liquid crystal phase observed when a material is cooled below its normal melting point.
9.21	Nematic	The least ordered liquid crystal state. It may be easily recognized by its appearance under a polarizing microscope. Under crossed polarizers, the birefringent characteristic of the nematic state causes light scattering, yielding a spectrum of colors. The texture observed may be threadlike, stratified, and/or exhibit optical extinction in the form of a “maltese cross”.
9.22	Operating Lifetime	Time to failure when the recommended operating voltage is applied continuously.

9.23	Polarizer	A plastic film which has special characteristics in light filtering. It separates the natural light wave into passing light (p-axis, called the passing axis) and absorbed light (perpendicular to p-axis, absorbing axis).
9.24	Shelf Life	Storage time without deterioration in parametric performance beyond specified limits.
9.25	t_d(off)	Turn-Off Delay Time. The time it takes the contrast to decrease from maximum to 90% after removal of the excitation voltage.
9.26	TN	Twisted nematic.
9.27	t_{OFF}	Turn OFF Time. The time interval between the instant the drive voltage switches to zero (during transition from selected to non-selected waveforms) and the instant the display reaches 10% of its maximum response. See Figure 3.3
9.28	t_{ON}	Turn ON Time. The time interval between the instant the rated drive voltage is applied to the display and the instant the display reaches 90% of its maximum response. See Figure 3.3
9.29	T_{op}	Operating temperature.
9.30	t_r	Rise Time, the time interval between the instant the display reaches 10% of its maximum response and the instant it reaches 90% of its maximum response.
9.31	Transmissivity	The ratio of the intensity of light passing through a medium compared to the intensity falling on that medium.
9.32	User Lifetime	Time to failure under “normal” operating conditions (e.g. recommended operating voltage applied during 30% of the time).
9.33	V_{OFF}	OFF State Voltage, See Item 3.9 and Figure 3.4
9.34	V_{ON}	ON State Voltage, See Item 3.9 and Figure 3.4
9.35	V_{op}	Operating voltage, See Item 3.1 and Figure 4.1