readout comparison guide

INTRODUCTION

In this guide we have attempted an objective comparison of some of the many in-line readout devices currently available. We feel that this kind of comparison is necessary, and that it will serve as the basis for more knowledgeable readout selection. In addition to the comparison of actual published data which is presented in the chart on pages 6 & 7, you will find a discussion of the various parameters on which any objective comparison of readout devices must be made.

Since there are more than 125 manufacturers currently offering readout devices, we have limited our comparison chart to include 22 representative devices from various manufacturers. Those readouts selected present a true cross sampling of available readout types. In that we are using manufacturers' published data, we have identified each readout type by company name. However, all other specific reference to company or brand names has been eliminated and throughout the balance of the guide generic terms are used for identification purposes. In selecting specific readout devices for inclusion in our comparison chart, we have covered each of the major types: cold cathode glow discharge, electroluminescent, projected image (incandescent), electro-mechanical (incandescent), edgelighted (incandescent) and sphericular optic (incandescent).

In the comparison chart, each of the selected devices is compared in 14 different categories. The categories discussed are: character height, packaging economy, readability (maximum viewing distance, brightness, stroke width, viewing angle), weight, associated drive circuitry, input code, power, speed, presentation, life and reliability, and cost. When reading these discussions, it should be remembered that a comparison arbitrarily limited to any single attribute may not give a true picture of the relative merit of the readouts. In general, the designer with a specific requirement will seek to choose a readout which, together with related circuitry and hardware, adequately fulfills his requirements at the minimum overall cost.

READABILITY

Character height, stroke thickness, display brightness, ambient light, viewing angle and viewing distance all affect the readability of a display. Maximum viewing distance and the included angle are the parameters dictated by the application. Brightness is also an important consideration if the display is to be viewed in high or low ambient light. Stroke thickness should have a definite relation to character height in order to produce a legible character at an acceptable viewing distance and angle.

Maximum viewing distance is the most important readability parameter as far as application is concerned. It is defined as the maximum distance at which observers are able to correctly read a given readout 90% of the time. It can be seen from Figure 1 that for character heights up to approximately 3 inches, all readouts exhibit a linear increase to a maximum viewing distance. This clearly indicates that character height more

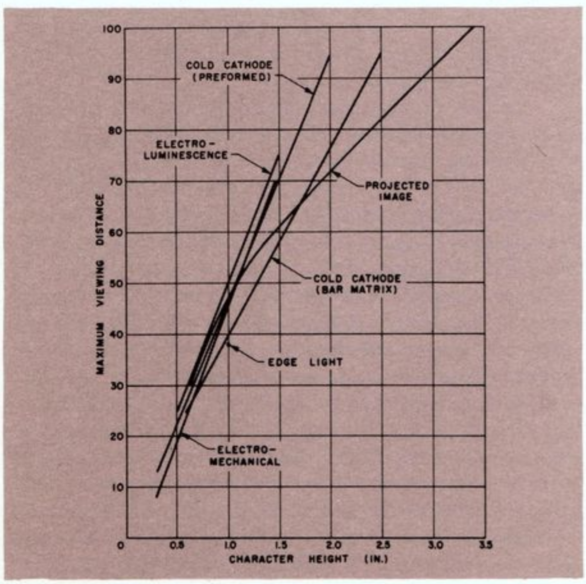

Fig. 1—Maximum viewing distance vs. character height

than anything else determines the maximum viewing distance (in normal ambient light). Brightness has little or no effect in normal ambient light; cold cathode (200 ft. lamberts), electro-mechanical (30 ft. lamberts), projected image (50 ft. lamberts), all have approximately equal viewing distance limits. Further, it should be noted that displays with stacked or in-plane characters can be equally well read, and that these design configurations have little or no effect on viewing distance.

Brightness of the display becomes important if the display is to be viewed in high ambient light. In general, readouts, such as the electro-mechanical types which depend on reflected light for viewing, profit in readability under conditions of high ambient light; however, a point is reached where too much ambient lighting causes almost total reflection and, therefore, impairs readability. Light emitting devices such as the cold cathode, electroluminescent, and the incandescent types start washing out as ambient light increases. A readout with high brightness, however, can be read in high ambient light easier than one with low brightness. Figure 2 shows that the cold cathode type is more than twice as bright as any other type, thus yielding the best results in high ambient light.

In low ambient light, the display brightness is also important. Electro-mechanical types which depend

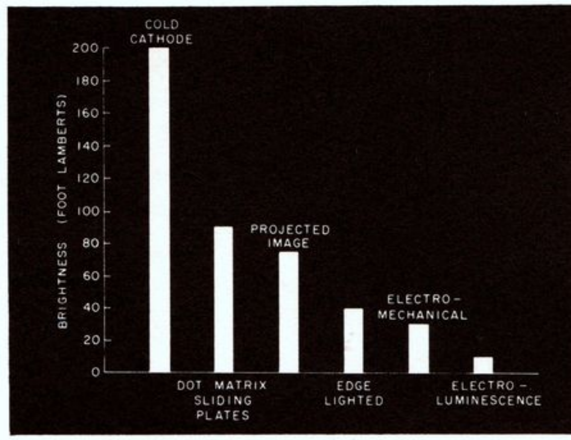

Fig. 2 — Display brightness comparison

on external lighting become difficult to see. Cold cathode types, however, retain about the same viewing distance as in normal lighting (see Figure 1). Other light emitting devices also retain approximately the same viewing distance.

Some readouts which use bulbs or electroluminescent lighting fade with use. However, the glow discharge type device does not. It retains the same brightness throughout its life. In the case of various readouts which utilize incandescent bulbs, more brightness can be obtained by increasing lamp voltage, but this has the adverse effect of shortening the life of the device.

Stroke thickness should have a proper relation to the character height. A good ratio of stroke to height is .06 to 0.1 (depending on character height). Too much variation from this value can seriously affect readability. If the stroke is too wide, the characters will tend to block up and become one mass. If it is too thin, the characters will tend to break as viewing distance increases and give confusing results. Both of these conditions adversely affect maximum viewing distance and angle.

Viewing angle is approximately the same for all readouts with the exception of electromechanical and edgelighted types. In general, two factors contribute to limit the viewing angle of these types of displays. First, intensity and contrast diminish as viewing angle increases and second, at large viewing angles, ambient light reflections increase to the point where the readout is actually obscured. According to the manufacturers' data these factors are not so evident in projection type displays where the light emitted from the surface is not limited to a narrow angle, and a claim of a viewing angle of 160° is made.

Viewing angle for cold cathode displays is determined by a completely different set of factors. Since many of these displays involve stacked numerals, the maximum viewing angle is determined by the requirement that characters near the bottom of the stack be visible over the next tube in the display. Test data indicate that a viewing angle of 135° may be anticipated. For a single tube display, a viewing angle of 160°, or greater, is achieved. For in-plane cold cathode displays, the only factor limiting viewing angle is ambient light reflections off the surface of the tube and a viewing angle of 160°, or greater, may be achieved under all mounting conditions.

PACKAGING ECONOMY

Today's trend towards more functional and economical packaging should be considered in readout design evaluation. Character height should be compared to the over-all dimensions of the device. A ratio which will relate the character height to its dimensions should be established.

A usable formula for determining this ratio is: Divide the product of the over-all dimensions by the character height.

H – HEIGHT
D – DEPTH
W – WIDTH
CH. HT. – CHARACTER HEIGHT

$$\text{FIGURE OF MERIT} = \frac{H \times W \times D}{\text{CH. HT.}}$$

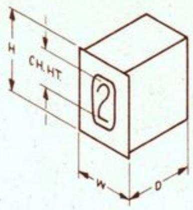

Fig. 3—Comparison of display dimensions to character height

When considering the readout to be selected, one should be guided by its end use. Is the center-to-center spacing disproportionately wide compared to character height? Will complex or large associated circuitry adversely affect your over-all design? With answers to questions such as these, you can make a valid comparison of readouts. (In summation, the volume-to-height ratio; i.e., width to height, and width to depth, is the true measure of relative size. That ratio should be as low as possible for optimum packaging.) Cold-cathode glow discharge and electroluminescent display devices offer the greatest advantages in this area. See Figure 4 for plots of volume versus character height.

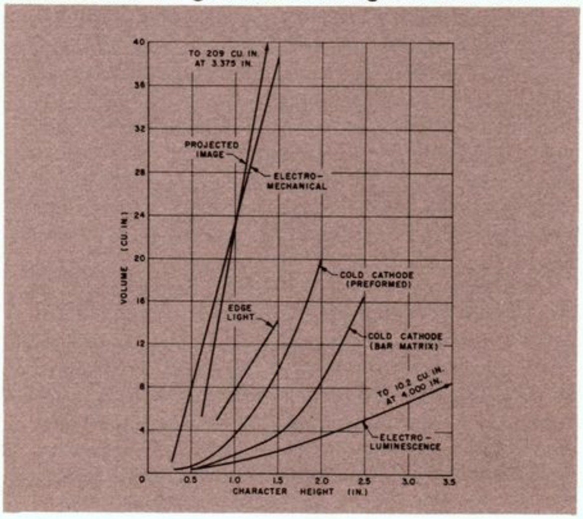

Fig. 4 — Display volume vs. character height

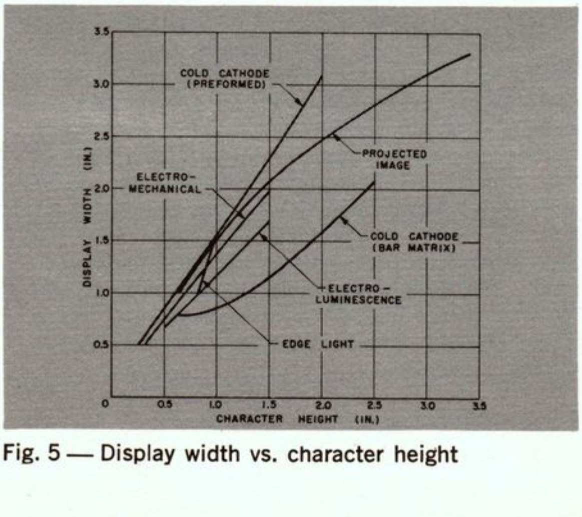

Fig. 5 — Display width vs. character height

Of course, character height is also related to the display width. The smaller this width, the shorter a multi-display assembly will be. Figure 5 shows that for a given character height cold-cathode gas discharge displays have the smallest display width.

WEIGHT

When comparing readouts, it is important to include the weight of associated circuitry and driver modules as well as the readout weight itself, in order to achieve a true weight evaluation. A simple comparison of device weights alone may be misleading. A true measure of a readout's weight is its weight to character height ratio $\left(\frac{Wt}{Ch\,Ht}\right)$. Good packaging economy is synonymous with a low ratio. From the chart on pages 6 and 7, it can be seen that the cold cathode type has a much lower ratio than any other.

ASSOCIATED DRIVER CIRCUITRY

To properly evaluate a readout, one must also consider associated driver circuits, their cost, availability, and reliability.

One of the most frequent comparisons is between the cost of the driver for incandescent displays and the glow discharge type displays. The general belief is that very low cost driver transistors are available for the incandescent lamp displays, but not for the glow discharge types. In the last few years high voltage, silicon NPN transistors specified for operation with glow discharge devices, have become available at competitive prices. It has been recognized that the full voltage across the glow discharge type indicator need not be switched in order to turn the character on and off. Instead, a voltage roughly ⅓ of the total (about 60V) is sufficient. A number of manufacturers[1] have published engineering notes detailing the factors which must be considered when specifying transistors for use as glow discharge readout drivers. When the amount of current required to drive incandescent lamps is taken into consideration, it is found that there is little or no difference in cost of driver transistors between these two approaches.

Several readout manufacturers offer driver modules, memory circuits and decoding modules. When equipment is being designed for systems applications or for applications not involving large production quantities, designers should evaluate the possibilities of using driver modules made available by the indicator manufacturers. Most of these modules involve a significant amount of engineering design and tooling costs which are being amortized over a relatively large number of driver modules. Even though the designer may be able to purchase the necessary components at a fraction of the cost of the modules, his own costs for drafting, production schedules, engineering evaluation and similar overheads should be allocated to the cost of the "in house" design and compared to the cost of purchased driver modules.

When making readout comparisons, the adaptability and versatility of the various driver circuits should be stressed. Obviously, selection of versatile readouts and associated circuitry will make it easier for you to meet future requirements.

POWER

With such a wide assortment of readouts available, an equally wide range of power supply requirements exists. Some systems require AC, others low

[1] *Texas Instruments, Fairchild, Pacific Semiconductor, Sylvania, etc.*

voltage DC, and still others, high voltage DC. Ordinarily, in electro-mechanical systems AC sources are available and present no special problems for some types of electro-mechanical, electroluminescent, or sphericular optic devices. The relatively high voltage, high frequency AC required to obtain acceptable brightness from electroluminescent displays can cause circuit problems, since high voltage AC circuitry is not compatible with transistor logic.

The DC voltage required by incandescent lamps is usually available in transistorized systems. This is often thought to be a good reason for using the incandescent lamp displays; however, in many types of equipment sufficient current for the lamps cannot be provided without adding buffer circuits between the readouts and the logic or counter circuitry. This, of course, increases the over-all equipment costs, sometimes significantly.

The glow discharge type readout requires relatively high voltage DC which is often not available in transistorized equipment; however, the amount of power consumed is small and voltage regulation requirements are not stringent; therefore, these special voltages do not add appreciably to the cost of the equipment.

SPEED

The speed of a readout can be defined both as the inherent rate at which the data can be changed and as the rate at which the readout will accept new information. Except for electro-mechanical type readouts, the potential speed of the readout is greater than the rate at which observers can follow changes. Therefore, speed becomes important only when it tends to limit the performance of the equipment. For example, readouts associated with counters or computers should accept information at a fast rate so that a disproportionate amount of time will not be required to supply information to the readouts. For this reason, electro-mechanical readouts are not often considered suitable for computer readout purposes.

PRESENTATION

Presentation may be defined as the way information is presented in the readout device; i.e., numbers, alphabet characters, words, complete messages or symbols. Although the great majority of today's applications utilize simple numeric readouts, more sophisticated readouts of messages or symbols are being incorporated into systems. Both incandescent and sphericular optic readouts are capable of projecting whole words or phrases into a single viewing area which can be highlighted with various colors to indicate mode, polarity, or alarms. These types are particularly useful where only a limited number of predetermined messages will be used.

In the more general displays, which must be capable of presenting information in the form of continually varying messages and words; e.g., military tactical or strategic displays, command and control systems, or air flight control information, alpha-numeric indicators have been introduced by several manufacturers. Usually consisting of a dot matrix or bar matrix in which each dot or bar can be individually turned on or off, these indicators offer a very broad choice of numbers, characters and special symbols. Because circuitry capable of selecting the proper combination of bars or dots for each character must be provided, the over-all cost of this display type will generally be found to be greater than the cost for simple numeric readouts.

LIFE

In our Comparison Chart the life tabulated is that quoted in the manufacturer's current data sheets.

The life of electro-mechanical readouts is generally quoted as the rated number of operations. This rating must be converted to life time by estimating the number of operations per year in the application. The life may decrease, however, if the speed of operation is excessive for the given electro-mechanical readout.

Incandescent lamp life is ordinarily stated as an average figure, meaning that 50% of the lamps will fail prior to the time that the average life figure is reached. Furthermore, end of life for incandescent lamps is usually taken to be the time at which the filaments short or burn out. During the life of the lamp, material is continually sublimed from the filament as the lamp operates. Eventually this sublimation causes the filament to break, but it should also be noted that the sublimed material accumulates on the inner surface of the lamp bulb, gradually making it opaque and reducing the brightness of the display. The gradual dimming of the display can be sufficient to require bulb replacement prior to the time failure occurs.

With currently available electroluminescent displays, relatively high frequencies and voltages must be used to obtain acceptable brightness, but increased brightness is achieved only with a proportionate decrease of life. The electroluminescent device will dim more quickly as drive voltage and frequency are increased.

The brightness of electroluminescent displays gradually diminishes as the indicator is operated under given operating conditions, so that end of life is reached (assuming no prior catastrophic failure) at the time that brightness becomes insufficient for use.

The life of the glow discharge readouts is a function of the rate at which the cathode material sublimates during operation. In currently available neon numeric indicators, this sublimation is suppressed by use of a special combination of gases so that individual cathodes can be used continuously for periods exceeding 40,000 hours. If all cathodes in the tube are used equally, over-all life of the indicator exceeds five times the life of the individual cathode or 200,000 hours. Material sublimated from the cathodes would coat the bulb, just as filament material does in an incandescent lamp, but this is prevented by a sublimation screen mounted in the indicator between the numbers and the viewing area of the bulb. No appreciable reduction in brightness is apparent throughout the life of the indicator.

COST

Costs on the accompanying Comparison Chart are presented in both 1 and 1000 quantities on standard units. This gives the reader an indication of both the prototype and production cost. In any cost comparison, one should determine the "true" or "whole" cost which includes cost of associated circuitry, cost per hour of life, cost of replacement, repair labor cost, and money lost during equipment "down time." It is only in view of all these considerations that one can come up with true cost figures comparable among readout types. With very few exceptions, the glow discharge readouts are the least expensive when all factors are taken into consideration.

READOUT COMPARISON CHART

	READABILITY				PACKAGING					
Type	Character Height (Inches)	Maximum Viewing Distance (Feet)	Included Viewing Angle (Degrees)	Brightness (Ft. Lamberts)	Height (Inches)	Width (Inches)	Depth (Inches)	Volume Ratio (Vol. / Ch. Ht.)	Weight (Ounces)	W[illegible] Height (Ratio)
ELECTRO-MECHANICAL										
Belt	0.281	8	90	30	1.73	0.609	10.78	40.6	16.0	57.0
Revolving Wheel	0.375	8	90	30	1.64	0.59	5.125	13.2	7.0	18.7
Union Switch and Signal										
ELECTRO-MECHANICAL Revolving Drum	0.3125	12	120	—	2.25	0.520	1.50	5.6	1.25	4.0
Patwin Electronics										
ELECTRO-MECHANICAL Split-flap, book page	1.5	70	145	—	2.75	2.0	7.0	25.7	24.0	16.0
CBS Labs										
PROJECTED IMAGE										
Small	0.625	30	160	50	1.31	1.0	4.0	8.4	4.0	6.4
Medium	1.0	50	160	75	2.625	1.56	5.75	23.6	12.0	12.0
Large	3.375	100	160	45	5.30	3.29	12.00	62.2	60.0	17.8
Industrial Electronic Engineering										
DOT MATRIX Sliding Plates	1.375	60	160	60-120	3.34	1.84	6.84	30.6	29.0	21.1
Industrial Electronic Engineering										
EDGE LIGHTED	0.8	—	60°Vert. 120°Horiz.	6.28 Lumens	2.0	1.0	2.5	6.25	4.5	5.6
General Radio										
EDGE LIGHTED	1.0	40	45	—	3.188	1.6	1.5	7.65	4.0	[illegible]
Non-Linear Systems Inc.										
ELECTROLUMINESCENT Bar Matrix										
Small	0.5	25	170	10	1.28	0.685	0.5	0.875	—	—
Large	1.5	75	170	10	2.28	1.72	0.5	1.3	—	—
Sylvania										
SPHERICULAR OPTIC	0.725	26-28	120	.43 Candle Power	1.50	1.00	3.11	6.43	3.0	4.14
Burroughs Corporation										
COLD-CATHODE GLOW DISCHARGE Preformed Characters										
Miniature Rectangular	0.31	11-14	160	200	0.625	0.470	1.010	0.96	0.2	0.65
Standard Rectangular	0.6	27-30	160	200	1.02	0.790	1.120	1.51	0.4	0.67
Super	0.8	37-38	160	200	1.35 dia.	1.35 dia.	1.512	2.71	0.8	1.0
Large	1.375	60-65	160	200	2.06 dia.	2.06 dia.	2.28	5.5	2.3	1.68
Jumbo	2.0	90-100	160	200	3.10 dia.	3.10 dia.	2.65	10.0	4.0	2.0
Burroughs Corporation										
COLD-CATHODE GLOW DISCHARGE Bar Matrix										
Standard	0.625	25-27	160	200	1.020	0.790	0.958	1.23	0.5	0.80
Medium	1.440	50-55	160	200	3.365	1.15 dia.	1.15 dia.	2.42	1.3	0.87
Large	2.50	90-100	160	200	4.85	2.065 dia.	2.065 dia.	6.6	3.4	1.36
Burroughs Corporation										
COLD-CATHODE GLOW DISCHARGE Pixie Preformed Numbers	0.125	6-8	110	200	1.080 dia.	1.080 dia.	1.040	7.61	1.0	[illegible]
Burroughs Corporation										

NOTES: 1. A dash indicates information not available
2. A blank indicates product not available
3. An X indicates product available from readout manufacturer
4. A double N indicates that a converter is not necessary as input is binary

ASSOCIATED CIRCUITRY			INPUTS			DISPLAY CAPABILITIES				COST		RELIABILITY
Memory	Driver	BCD to Decimal Con-verter	Input Code	Input Power	Display Speed (Milli-Sec.)	Nu-meric	Com-plete Alpha Numeric	Sym-bols	Color	1	1000	Life (Hours)
X	X	NN	BCD	24-28 V DC, 150 MA	1700	X	X	X	White	155.00	—	10^6 indications
X	X	NN	BCD	24-28 V DC, 125 MA	800	X		X	White	65.00	—	10^6 indications
X	X	X	Decimal	6, 12, 24, 28 or 36 V DC 1.3-1.7 W	500 (180°) 250 (each)	X		X	Any	50.00	32.50	28 x 10^6, 180° rotations @ 2/sec.
X	X	X	Decimal	115 V 60 cps & 24 V DC 2.7 W	3,000 per cycle 250 (each)	X		X	Any	55.00	39.00	—
			Decimal	6.3 V DC 200 MA	1.0	X		X	Any	35.00	27.00	500/bulb
			Decimal	6.3 V DC 250 MA	1.0	X		X	Any	18.00	12.50	3,000/bulb
			Decimal	6.3 V DC 900 MA	1.0	X		X	Any	33.00	25.00	3,000/bulb
X	X	NN	BCD	Signal 100 MW, 6-24 V DC + pulse, 4 — 12 W, 6-48 V DC + lamp 5-8.4 W, 6.3-28 V DC/AC	50	X	X	X	Any	39.25	31.45	20 x10^6)perations, lamp 500-3000 hrs.
	X	—	Decimal	14 V DC 80 MA	—	X		X	Several	32.00	22.00	6,000/bulb 10% duty cycle
	X	—	Decimal	6, 14 or 28 V DC	1.0	X		X	White	25.00	15.00	5,000/bulb
X	X	X	Decimal	250 V 400 CPS 50 MW	.002	X	X	X	Green	30.33	9.33	4600
X	X	X	Decimal	250 V 400 CPS 25 MW	.002	X	X	X	Green	18.46	5.68	4600
			Decimal	6 V, 200 MA 14 V, 80 MA 24 V, 50 MA 28 V, 40 MA	1.0	X		X	Any	18.00	13.90	750 to 8750 depending on bulb
X	X	X	Decimal	170 V DC, 2 MA	0.1	X		X	Red Glow	36.30	22.00	200,000
X	X	X	Decimal	170 V DC, 3.5 MA	0.1	X		X	Red Glow	15.75	8.75	200,000
X	X	X	Decimal	170 V DC, 4.0 MA	0.1	X		X	Red Glow	19.00	12.50	200,000
X	X	X	Decimal	170 V DC, 6.5 MA	0.1	X		X	Red Glow	30.00	19.00	200,000
X	X	X	Decimal	300 V DC, 7.5 MA	0.1	X		X	Red Glow	45.00	30.00	200,000
X	X	X	Decimal	170 V DC, 7 MA	0.1	X	X	X	Red Glow	16.75	12.50	50,000
X	X	X	Decimal	170 V DC, 14 MA	0.1	X	X	X	Red Glow	20.00	14.00	50,000
X	X	X	Decimal	170 V DC, 19 MA	0.1	X	X	X	Red Glow	18.00	12.00	50,000
	X		Decimal	150 V DC, 400 μA	0.1	X			Red Glow	5.00	4.75	200,000

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