APPLICATION		REVISIONS			
NEXT ASSY	FINAL ASSY	LTR	DESCRIPTION	DATE	APPROVED
		-	PRODUCTION RELEASE/E.O. 16624	1-8-85	[illegible]
		A	E.O. 18372	8-5-85	[illegible]
		B	E.O. 18695	9-19-85	[illegible]
		C	REVISED & REDRAWN/E.O. 25631	8-14-90	[illegible]
		D	E.O. 26882	7/15/91	[illegible]
		E	E.O. 28079	9-30-95	[illegible]

VACUUM FLUORESCENT DISPLAY
1 X 20 CHARACTER
S03601-16-020

REV	E	C	E	E	E	E	E	E	C	D	D	E	D	C	E	E
SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

SHEET	17	18	19	20	21	22	23	24	25	26	27	28	29	30

REVISION STATUS

PROJ. NO. 246	CONTRACT	IEE INDUSTRIAL ELECTRONIC ENGINEERS, INC. VAN NUYS, CALIFORNIA
	DRAWN V. Richards 1/5/85	VACUUM FLUORESCENT DISPLAY 1 X 20 CHARACTER
	CHECK	
	APPROVED	SIZE A / CODE IDENT NO. 05464 / S03601-16-020
	APPROVED [illegible] 1-2-85	SCALE / SHEET 1 OF 16

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PARAGRAPH NUMBER & TITLE

1.0 GENERAL DESCRIPTION

1.1 Introduction

This specification describes the interface requirements and features of a 1 line Vacuum Fluorescent Display, 20 characters wide. The characters are formed using a 5x7 dot matrix.

1.2 Application

This unit may be used as a console display which provides alphanumeric information that is easily readable in high ambient light. It is ideal for point-of-sale terminals, office computers, and a wide range of business and industrial equipment.

1.3 Special Features

ECMA-7 character alternates
Character 7F HEX (rubout) - all dots on
Jumper-selectable RS-232C
Hardware reset
Metal enclosure
15mm characters

1.4 Description

This Vacuum Fluorescent Display is a self-contained multiplexed unit which provides a simple interface to a microprocessor system.

Satisfactory unidirectional operation may be achieved with only seven bits, while full bidirectional capability requires eight. In either mode, timing is not critical for data communication except that which is shown in Section 5.5. Data is entered either serially (1200 Baud) or in parallel at rates determined by execution times.

This unit consists of a vacuum fluorescent display tube and a minimal amount of electronic hardware. Primary complexity is contained within the microprocessor software, which controls all display functions.

A single +5VDC power supply (approximately 900mA typical) is required for operation. Total power is thus about 4.5 watts.

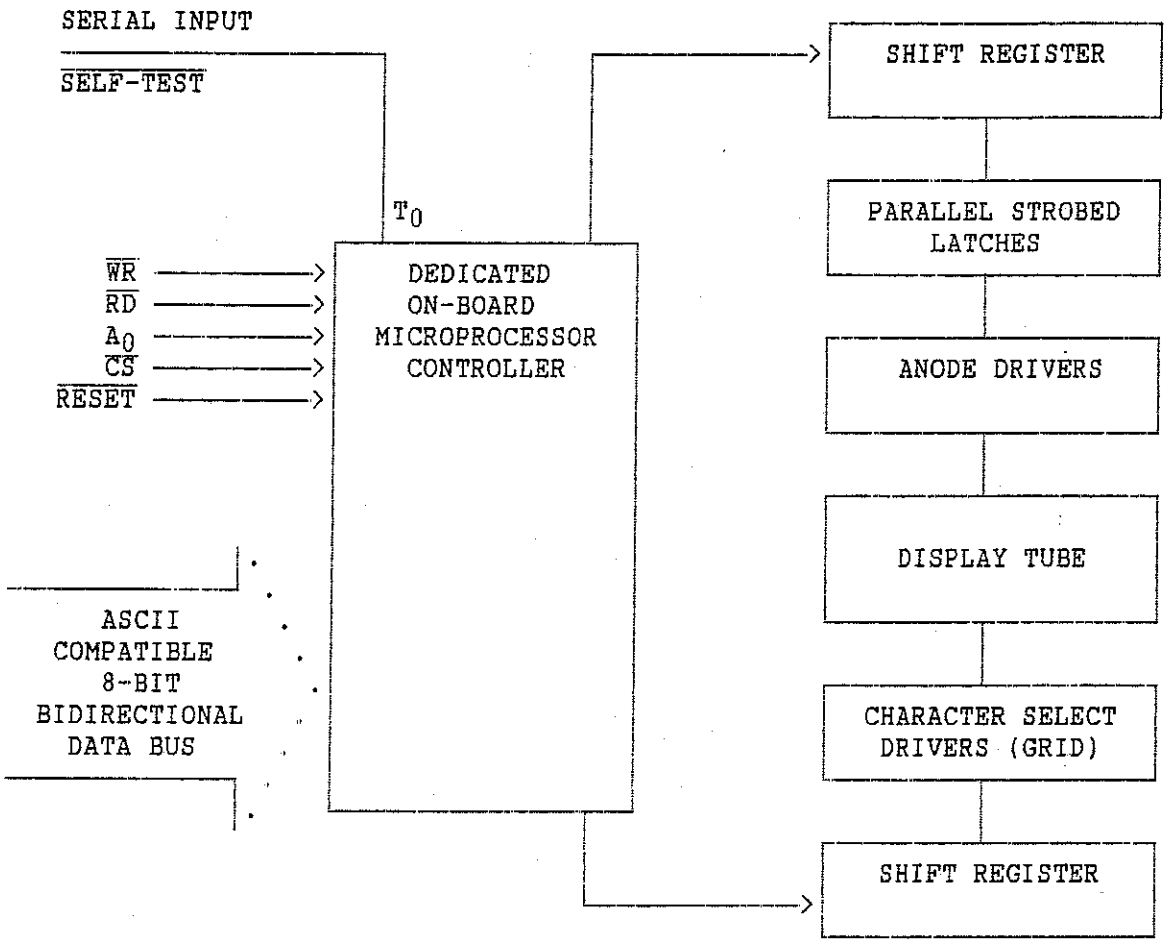
All display characters and standard control codes are in 7-bit ASCII. All inputs are TTL compatible. No unusual coding or critical timing is required to interface with and operate this display.

A wide spectrum of color filters is available to fit all applications. The characters are bright, but soft, providing comfortable short or long-term viewing.

An ASCII-coded English font employs a standard 96 character set.

Figure 3 depicts the standard ASCII character set as displayed by the 03601-16-020 module.

2.0 BLOCK DIAGRAM



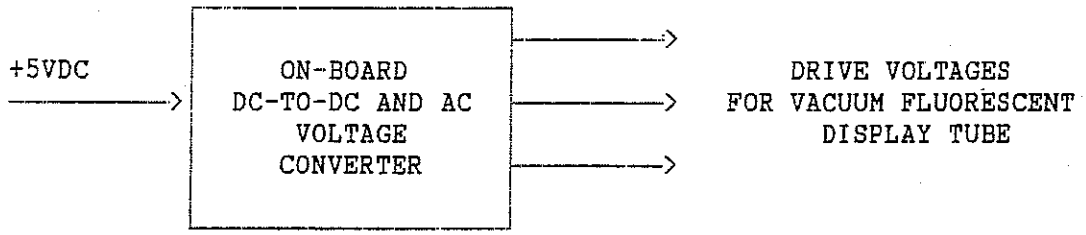


FIGURE 1

3.0 THEORY OF OPERATION (Dot Matrix Displays)

The vacuum fluorescent display array consists of three basic electrodes which are enclosed in an evacuated glass chamber. The first electrode is the filament, which spans the entire length of the display, and is made from a small diameter oxide coated tungsten wire. This element is common to all characters and supplies the electron emission needed for operation. Individual grid electrodes are provided, one for each character, to control current passing to the anodes. Each grid is a fine mesh metal screen which provides digit-select electrical control with no visual interference. When the grid is positive with respect to the filament, electrons are allowed to pass on to the third electrode, the anode dots, causing the fluorescent phosphor coating on each positively charged dot to glow. Selectively energizing these fluorescent dots causes the desired character to be displayed.

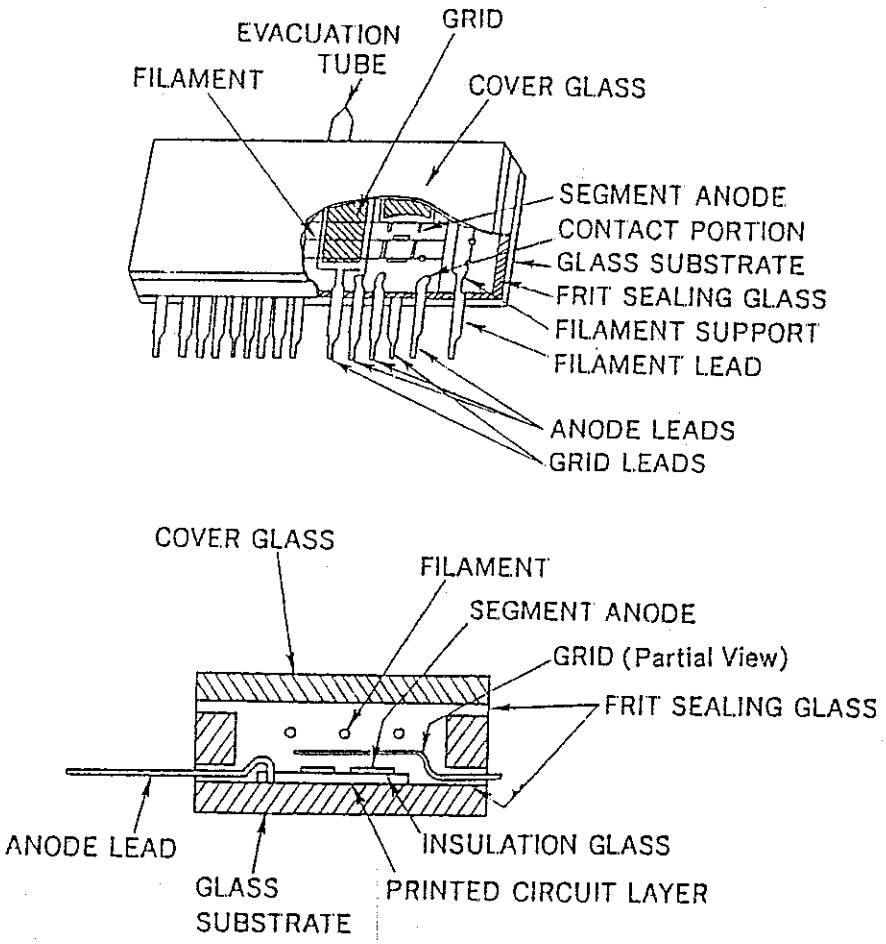


FIGURE 2

4.0 OPERATION

4.1 Loading ASCII Character Data

All printing characters are located in standard ASCII code locations from 20 (HEX) to 7F (HEX), and can be written with $CS=A_0=0$ by pulsing WR low. Control character assignments are as follows.

4.2 Control Codes

NOTE: CARE SHOULD BE TAKEN NOT TO SEND UNDEFINED CONTROL OR COMMAND CODES TO THE FLIP DISPLAY MODULE AS THIS MAY CAUSE A SOFTWARE MALFUNCTION OF THE MODULE.

4.2.1 Instructions For $A_0=0$ (Pulse $\overline{WR}$ Low, $\overline{CS}=0$, Input Buffer Empty)

DATA (HEX)	DESCRIPTION	FUNCTION AVAILABLE IN SERIAL MODE
08	BACK SPACE CURSOR LOCATION ONE POSITION	YES
09	ADVANCE CURSOR LOCATION ONE POSITION	YES
0A	LINE FEED (clears one-line displays; cursor position is the left-most grid)	YES
0D	CARRIAGE RETURN (returns cursor to left-most character position of the same line; does not clear display)	YES
<11>	+ NORMAL DATA ENTRY WITH AUTOMATIC CARRIAGE RETURN	YES
<12>	OVERWRITE OF RIGHT-MOST CHARACTER/AUTOMATIC CARRIAGE RETURN OFF	YES
<13>	HORIZONTAL SCROLL MODE (from right to left after line has been filled)	YES
[1C]	+ SELECT ENGLISH CHARACTER SET (U.S. ASCII-7)	YES
[1D]	SELECT GENERAL EUROPEAN CHARACTER SET (ECMA-7)	YES
[1E]	SELECT SCANDINAVIAN CHARACTER SET (ECMA-7)	YES
[1F]	SELECT GERMAN CHARACTER SET (ECMA-7)	YES
20-7F	CHARACTER SET (see CHARACTER CHART)	YES

\+ Display automatically defaults to these conditions after power-up and reset.
< > These instructions are mutually exclusive.
[ ] Character set control affects ASCII characters 5B, 5C, 5D, & 23

4.2.2 Cursor Positioning Instruction (Pulse $\overline{WR}$ Low $\overline{CS}$=0, Input Buffer Empty)

DATA (b_7-b_0)	DESCRIPTION	A_0	FUNCTION AVAILABLE IN SERIAL MODE
00XX XXXX	MOVE CURSOR TO LOCATION XX XXXX (Location in binary - "0000 0000" moves cursor to left-most position)	1	NO

4.2.3 Instruction for A_0=1 (Pulse $\overline{WR}$ Low, $\overline{CS}$=0, Input Buffer Empty)

DATA (HEX)	DESCRIPTION	FUNCTION AVAILABLE IN SERIAL MODE
40	RESET	NO
41	* PREPARE TO READ CURSOR LOCATION VALUE	NO
42	* PREPARE TO READ DATA AT PRESENT CURSOR LOCATION	NO
43	* PREPARE TO READ DATA AT PRESENT CURSOR LOCATION AND INCREMENT CURSOR	NO

DATA (b_7-b_0)	DESCRIPTION	FUNCTION AVAILABLE IN SERIAL MODE
10XX XXXX	* PREPARE TO READ DATA AT POSITION XX XXXX (Location in binary - "1000 0000" reads data at left-most position)	NO

* "PREPARE TO READ..." commands should be followed with a "READ DATA FROM DISPLAY MODULE " operation, which is accomplished by pulsing RD low when A_0=0 and CS=0. See Section 4.3.

4.3 Reading Data and Status Information ($\overline{CS}$=0 and A_0=1)

Status may be read from the display by pulsing $\overline{RD}$ low. Instructions are as follows:

DATA (b_7-b_0)	DESCRIPTION	FUNCTION AVAILABLE IN SERIAL MODE
	READ OUTPUT BUFFER STATUS (Data may be read from the display module when the output buffer is full)	NO
XXXX XXX1	DATA BIT 0 = 1: OUTPUT BUFFER FULL	
OR		
XXXX XXX0	DATA BIT 0 = 0: OUTPUT BUFFER EMPTY	
	READ INPUT BUFFER STATUS (Data may be written to the display module when the input buffer is empty)	NO
XXXX XX1X	DATA BIT 1 = 1: INPUT BUFFER FULL	
OR		
XXXX XX0X	DATA BIT 1 = 0: INPUT BUFFER EMPTY	
Bits 2-7	Not defined.	

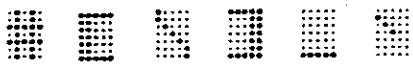
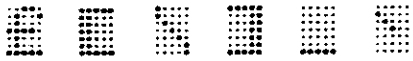
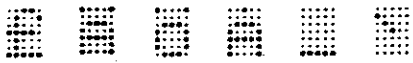
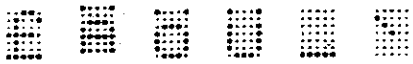
4.4 Character Chart (5x7 Dot Matrix)

DATA BITS				b7 b6 b5 b4	0 0 0 0	0 0 0 1	0 0 1 0	0 0 1 1	0 1 0 0	0 1 0 1	0 1 1 0	0 1 1 1
b3	b2	b1	b0	HEX	0	1	2	3	4	5	6	7
0	0	0	0	0			SP					
0	0	0	1	1								
0	0	1	0	2								
0	0	1	1	3								
0	1	0	0	4								
0	1	0	1	5								
0	1	1	0	6								
0	1	1	1	7								
1	0	0	0	8								
1	0	0	1	9								
1	0	1	0	A								
1	0	1	1	B								
1	1	0	0	C								
1	1	0	1	D								
1	1	1	0	E								
1	1	1	1	F								

FIGURE 3

4.5 Alternate Character Codes

1C-1F are mutually exclusive latched functions. The following characters appear as a function of the last control code (1C-1F) and their ASCII location.

CONTROL CODES	CHARACTER SET	ASCII LOCATION (HEX) CHARACTERS 23	5B	5C	5D	5F	60
1C	English						
1D	General European						
1E	Scandinavian						
1F	German						

Default at power-up is 1C (English).

4.6 External Font Loading (5 X 7 Dot Matrix)

Not available at this time.

4.7 Execution Times (Maximum)

Character rate:	150µS
Line feed:	710µS
Horizontal scroll:	590µS
Control codes:	120µS
Reset (Software):	660µS
Reset (Hardware):	500mS

4.8 Dedicated Hardware Lines

4.8.1 $\overline{\text{RESET}}$

Hardware reset is available on J1 (power), pin 6. Holding $\overline{\text{RESET}}$ low for at least 50µS, and then returning it to high, will clear the display and set the cursor to the home position (power-up condition); this sequence requires approximately 500mS to complete. Sinking current must be able to discharge a 1µf capacitor connected internally.

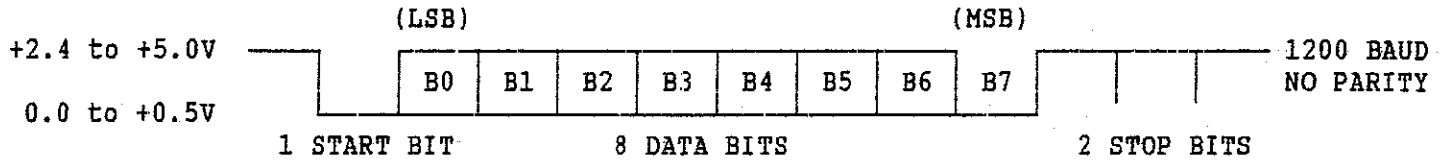
4.8.2. $\overline{\text{INTERRUPT}}$ ($\overline{\text{INT}}$)

Not available at this time.

4.9 Serial Data and Self-test

Included as a standard feature is a serial asynchronous receiver with a jumper-selectable input (T_0) which allows for either TTL or RS-232C input levels. This input is unidirectional. The display is shipped from the factory with E2 jumpered to E3 for TTL level operation. For RS-232C level input, remove the jumper from E3 and jumper E1 to E2.

A logic high represents a "mark" and a logic low represents a "space" with data formatted as an 11-bit word of one start bit, eight data bits and two stop bits. The data is input at a fixed rate of 1200 baud. NOTE: The eighth bit (MSB) must always be low, not parity, in order for data to be received properly. (For RS-232C input, a marking level is a negative voltage; but data is formatted identically with respect to data start and stop bits, MSB, LSB, etc.) In the serial mode, device select ($\overline{CS}$) has no effect.



STANDARD TTL SERIAL INPUT

Self-test is a very useful feature and can be activated by maintaining a logic low (or high, if strapped for RS-232C on the serial input (T_0) for a period longer than 4 seconds. ASCII characters from 20 (HEX) to 7F (HEX) will be displayed advancing through the character field at approximately a 3-character per second rate. This self-test capability can be used to speed up both in-field fault isolation, and incoming receiving inspection.

4.10 Connector Pin Assignments

J1 (POWER)

PIN NO.	FUNCTION
J1-1	+5VDC @ 900mA (typ)
J1-2	NO CONNECTION
J1-3	NO CONNECTION
J1-4	COMMON
J1-5	NO CONNECTION
J1-6	$\overline{\text{RESET}}$

J2 (DATA)

PIN NO.	FUNCTION
J2-1	SERIAL IN/$\overline{\text{SELF-TEST}}$ (T_0)
J2-2	COMMON
J2-3	$\overline{\text{DEVICE SELECT}}$ ($\overline{CS}$)
J2-4	INTERNAL CONNECTION
J2-5	$\overline{\text{READ}}$ ($\overline{RD}$)
J2-6	COMMON
J2-7	ADDRESS ZERO BIT (A_0)
J2-8	COMMON
J2-9	$\overline{\text{WRITE}}$ ($\overline{WR}$)
J2-10	COMMON
J2-11	DATA B0 (LSB)
J2-12	COMMON
J2-13	DATA B1
J2-14	COMMON
J2-15	DATA B2
J2-16	COMMON
J2-17	DATA B3
J2-18	COMMON
J2-19	DATA B4
J2-20	COMMON
J2-21	DATA B5
J2-22	COMMON
J2-23	DATA B6
J2-24	COMMON
J2-25	DATA B7 (MSB)
J2-26	COMMON

4.10 Connector Pin Assignments (Continued)

CMOS Note: Care must be taken to insure that input signals do not exceed the supply voltage or ground levels. Data cables must be as short as possible to reduce signal overshoots.

5.0 ELECTRICAL CHARACTERISTICS

5.1 Power ON / OFF Sequence

There are no deleterious effects associated with power ON and OFF of this display; however, rapid ON/OFF sequencing is not recommended. Neither data nor power connectors should be connected/disconnected while power is applied.

CAUTION: Do not apply data or strobe signals unless logic power is also applied; otherwise, the input circuits may be damaged.

Because of the power-up cycle within the microprocessor, rise time of the power supply should be less than 100mS. The display module is not ready to accept data for 500mS.

5.2 Interface Signals

All logic signals abide by the following convention: logic "1" is a high, logic "0" is a low.

Input Levels:

Logic 1 > 2.4VDC @ 1uA.
Logic 0 < 0.5VDC @ 0.5mA.

Output Levels:

Logic 1 > 3.5VDC @ 150uA.
Logic 0 < 0.5VDC @ 0.5mA.

All parallel interface lines are internally pulled up using 10K resistors connected to the +5V supply.

5.3 Absolute Maximum Ratings

Primary voltage:	+5.5VDC
Logic range:	-0.5VDC thru +5.5VDC
RS-232C:	+15.0VDC to +3.0VDC/-1.0VDC to -15.0VDC

5.4 Normal Operating Ratings

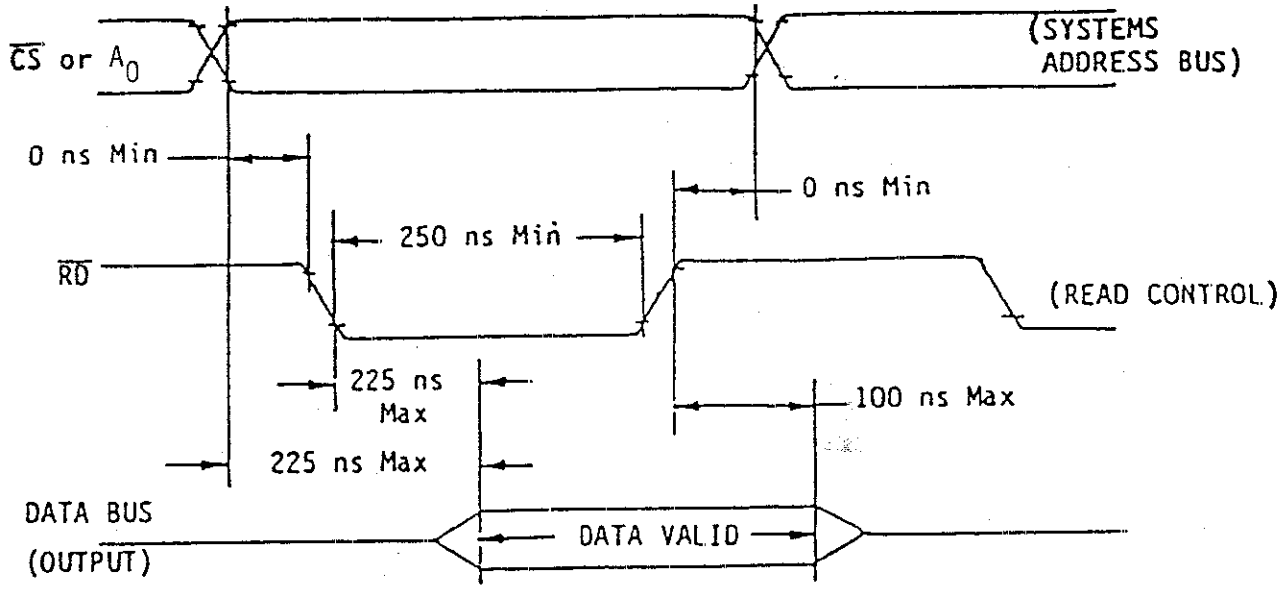
Primary Voltage: +5.0 +/- 0.25VDC

Production
Brightest

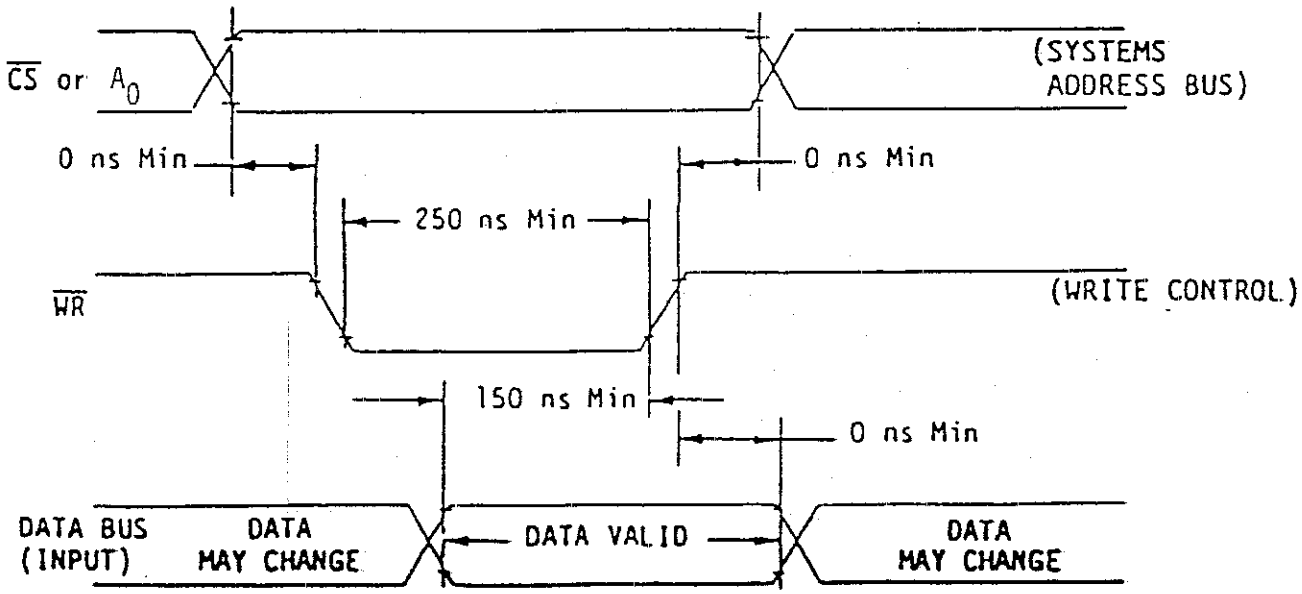
700mA Min.	(Screen clear at 5.0V)
900mA Typ.	(Screen filled with "A" character at 5.0V)
1.08A Max.	(Screen filled with "A" character at 5.25V)

5.5 Timing Characteristics And Timing Diagrams

READ OPERATION



WRITE OPERATION



6.0 OPTICAL CHARACTERISTICS

Format:	1 line of 20 characters
Character height:	0.60 in. (15.1mm)
Character width:	0.32 in. (8.2mm)
Character spacing:	0.50 in. (12.7mm) center-to-center
Character design:	5 x 7 dot matrix
Type of cursor indicator:	Invisible
Character set:	96-character U.S. ASCII-7 General European ECMA-7 Scandinavian ECMA-7 German ECMA-7
Color:	Blue-green, peak at 5000 Angstroms
Viewing angle:	150 degrees
Brightness:	100 fL (min), 175 fL (typ)
Projected life at rated operating conditions:	40,000 to 100,000 hours*

*Note: End of useful life is defined as the point when the display tube light output has decreased to half its initial minimum rated brightness. This life rating is based on use with random text messages. To obtain maximum life, users are encouraged to avoid fixed messages and to blank or clear the display when it is not in use.

7.0 ENVIRONMENTAL CHARACTERISTICS

Operating temperature:	0 to +55 (^{O}C) +32 to +131 (^{O}F)
Storage temperature:	-50 to +85 (^{O}C) -58 to +185 (^{O}F)
Relative humidity:	0 to 95% (non-condensing)
Vibration:	10 to 50 Hz 2mm peak-to-peak (3 axis)
Shock:	20 G (3 axis)
Weight:	20 ounces (567 grams)

8.0 ACCESSORIES

Cables	Part Number	Qty Required
Power	25387-XX*	1
Data	26160-XX*	1

* XX=Length in inches: - 99 omits cables

Filters	P/N 26781-XX
Gray	-01
Blue	-02
Aqua	-04
Neon Yellow-Orange	-05
Green	-07
Neutral Gray CP	-09
Yellow CP	-10

Connectors	Mates With:
Power	Molex 09-50-3061
Data	3M3399-6026

9.0 OUTLINE AND INSTALLATION DRAWING

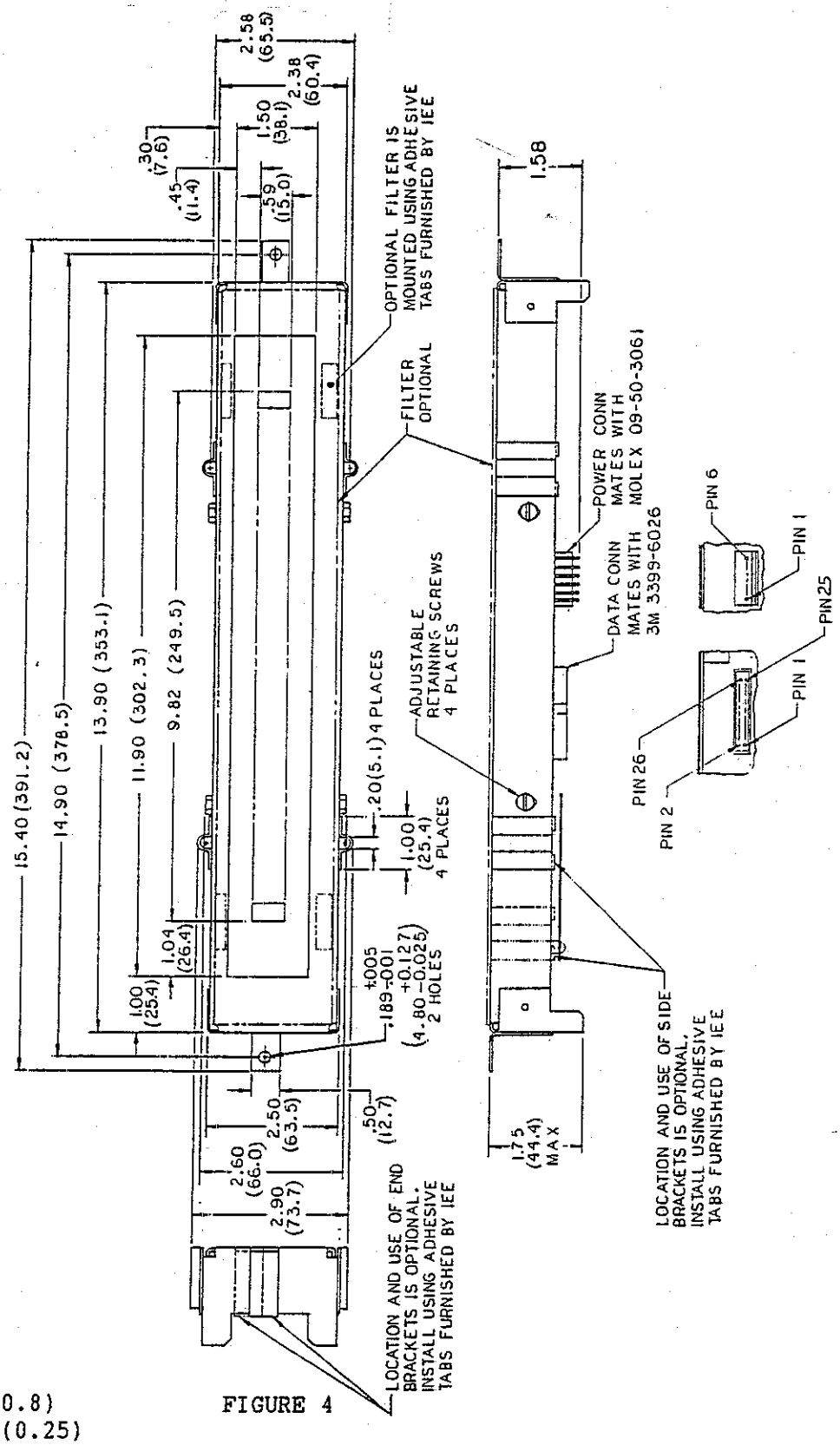


FIGURE 4

TOLERANCES:

.XX = ± .03 (0.8)
.XXX = ± .010 (0.25)
Dim. in inches (mm)