APPLICATION		REVISIONS			
NEXT ASSY	FINAL ASSY	LTR	DESCRIPTION	DATE	APPROVED
		-	PRODUCTION RELEASE/E.O. 32986	7-1-97	D. Goodale
		A	E.O. 33084	9-19-97	D. Goodale
		B	E.O. 35402	6-29-00	D. Goodale

LIQUID CRYSTAL DISPLAY
4 X 20 CHARACTER
5x8 DOT MATRIX
WITH FIBER OPTIC BACKLIGHT
MODEL SLB325-X4X0

REV	B	-	-	-	-	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-	A			
SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

REVISION STATUS

PROJ. NO. 368	**CONTRACT**		**INDUSTRIAL ELECTRONIC ENGINEERS, INC.** **VAN NUYS, CALIFORNIA**
	DRAWN	R. January	6/24/97
	CHECK		
	APPROVED D. Goodale 7-1-97		
	APPROVED		

LIQUID CRYSTAL DISPLAY
4 X 20 CHARACTER
WITH FIBER OPTIC BACKLIGHT (11-29V)

SIZE	CODE IDENT NO.	
A	**05464**	SLB325-X4X0

SCALE N/A SHEET 1 OF 21

NOTICE IS HEREBY GIVEN THAT THIS DRAWING IS PART OF A PROPRIETARY ITEM OWNED BY INDUSTRIAL ELECTRONIC ENGINEERS, INC. AND SHALL NOT BE REPRODUCED, OR COPIED OR USED AS THE BASIS FOR MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION OF I.E.E. INC.

TABLE OF CONTENTS

PARAGRAPH NUMBER & TITLE

1.0 GENERAL DESCRIPTION

- 1.1 Introduction
- 1.2 Application
- 1.3 Special Features
- 1.4 Description

2.0 BLOCK DIAGRAM

3.0 THEORY OF OPERATION

4.0 OPERATION

- 4.1 Loading ASCII Character Data
- 4.2 Control Codes
- 4.3 Character Chart
- 4.4 User Defined Characters
- 4.5 Dedicated Hardware Lines
- 4.6 Serial Data and Self-test
- 4.7 Connector Pin Assignments

5.0 ELECTRICAL CHARACTERISTICS

- 5.1 Power ON / OFF Sequence
- 5.2 Interface Signals
- 5.3 Absolute Maximum Ratings
- 5.4 Normal Operating Ratings

6.0 OPTICAL CHARACTERISTICS

7.0 ENVIRONMENTAL CHARACTERISTICS

8.0 FIBER OPTIC BACKLIGHT

9.0 ACCESSORIES

10.0 OUTLINE DRAWING

1.0 GENERAL DESCRIPTION

1.1 Introduction

This specification describes the interface requirements and features of a 4 line supertwist Liquid Crystal Display (LCD) with 20 characters per line and a fiber optic (FO) backlight. The characters are formed using a 5x8 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 or with the backlight, in low light conditions. It is ideal for point-of-sale terminals, office computers, and a wide range of business and industrial equipment.

1.3 Special Features

Minimum depth
Power and data on same connector
11-29 VDC operation
Low cost
Shielded I/O and Connector
Wide operating temperatures (-20 to +70°)

8 User defined characters
ASCII + 6 additional character sets
EIA-232C or EIA-422A data interface
Software selectable blink
Software self test

1.4 Description

This LCD module is a self-contained multiplexed display which provides a simple serial interface to a microprocessor system.

The display is available with one I/O connector and a choice of EIA-232C or EIA-422A interfacing.

The SBE liquid crystal cell used in this display has a golden-green background with dark blue-black characters.

This unit consists of a liquid crystal display tube and a minimal amount of electronic hardware. All display characters and control codes can be accessed in a 8-bit format. Primary complexity is contained within the microprocessor software, which controls all display functions. Temperature compensation circuitry is provided to insure that viewing characteristics are optimized for all temperatures.

A fiber optic backlight illuminated by two ultra-bright yellow LEDs is mounted behind the LCD to allow for low light level operation. Note that the display background remains golden-green. Backlight power is controlled by two software control codes

A single 5VDC ± 5% power supply is required for operation. At 12.0VDC, total power is approximately .70 watts and current is about 58mA without the backlight, and 100mA with the backlight ON.

Data is entered serially at 9600 Baud at rates determined by execution times.

The large characters are easily readable, even in direct sunlight and provide comfortable short or long-term viewing.

Figures 3 through 10 depict character sets used in this module.

2.0 BLOCK DIAGRAM

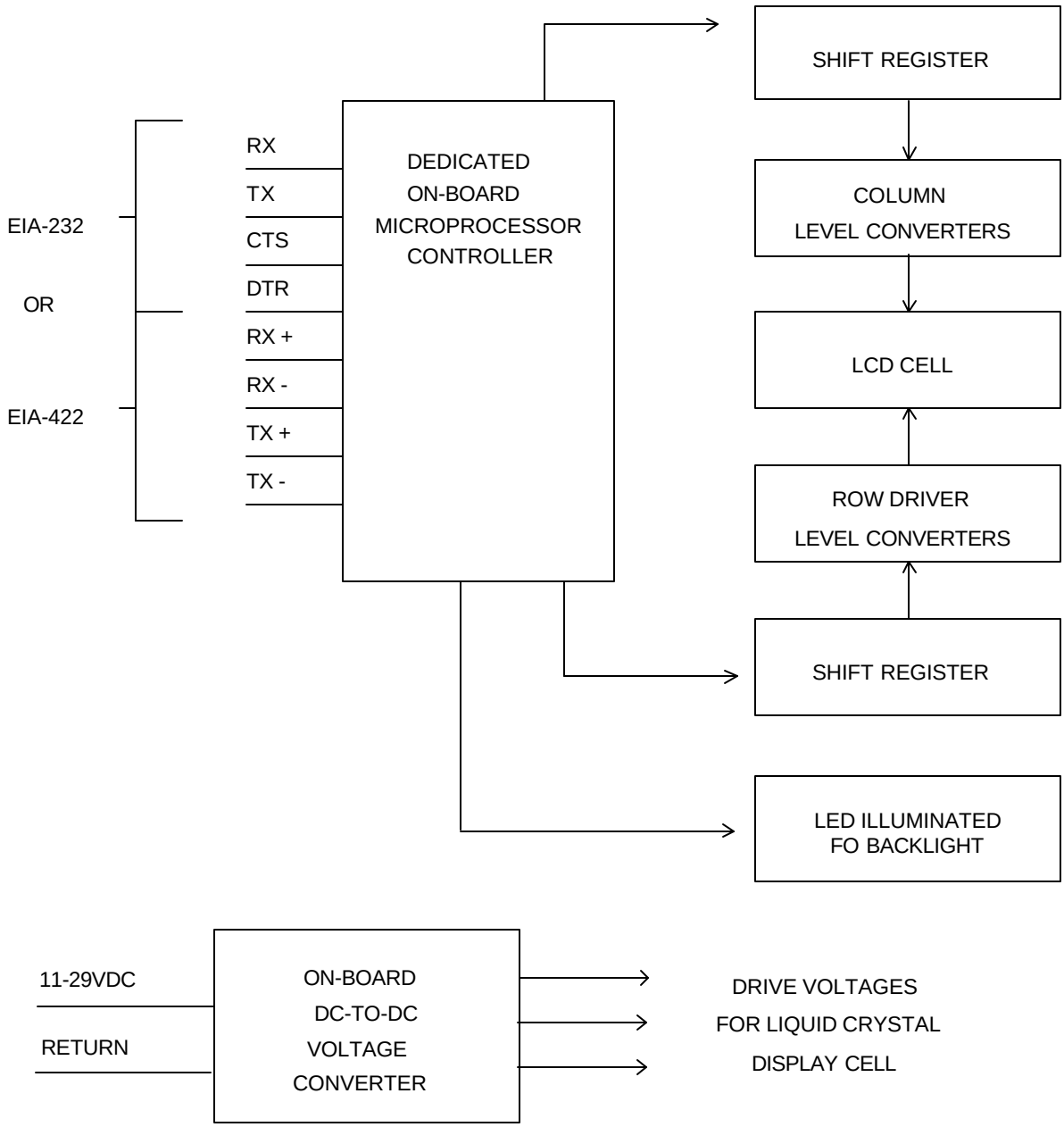


FIGURE 1

Industrial Electronic Engineers, Inc.	SIZE **A**	CODE IDENT NO. **05464**	**SLB325-X4X0**
Van Nuys, California	SCALE N/A	REV **B**	SHEET 4

3.0 THEORY OF OPERATION

Liquid Crystal Displays utilize ambient light falling on the display to reflect the image to the observer. The LCD cell is constructed by sandwiching a liquid crystal mixture between two glass plates that are coated with a polarizer, and lined with transparent electrodes. A selectively applied electric field aligns the nematic molecules (crystals) so that they either transmit or block the polarized light from being reflected back out of the cell to the viewer.

This display consists of two display areas, each comprising a matrix of 18 x 120 dots, to display two lines of characters. A matrix addressing technique provides individual control of the electric field applied to each dot used to create the character. The reflected light appears as a yellow-green background, and the light is blocked to create the dark blue characters. The 18 high dot columns allow for creation of special characters and fonts. Liquid crystal displays have several advantages over other display technologies. LCDs operate from low voltage and power, are viewable in direct sunlight, have long life, and are more economical to manufacture.

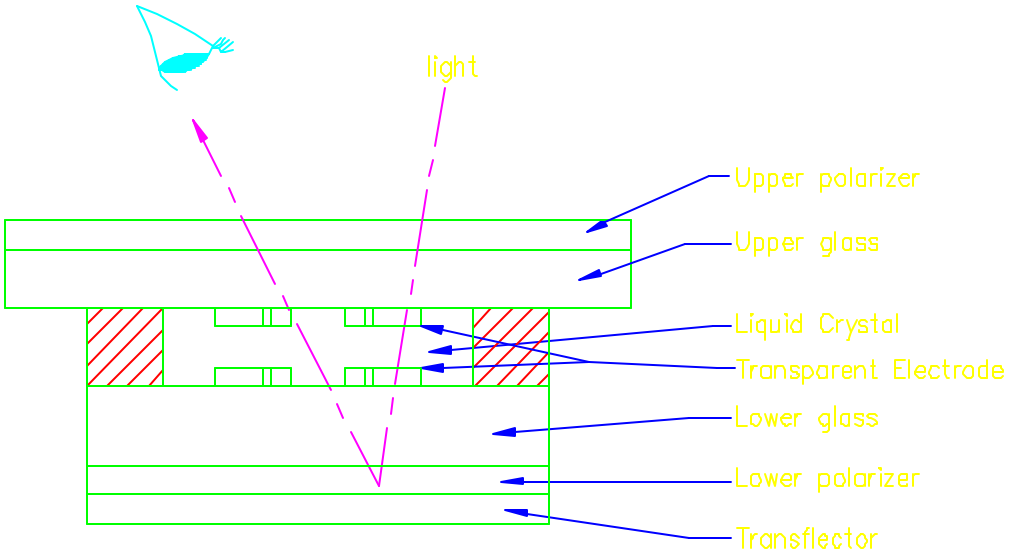


FIGURE 2

4.0 OPERATION

4.1 Loading ASCII Character Data

All printing characters are located in standard ASCII code locations from 20 (HEX) to FF (HEX). 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 DISPLAY MODULE AS THIS MAY CAUSE A SOFTWARE MALFUNCTION OF THE MODULE.

4.2.1 Instruction

DATA (HEX)	DESCRIPTION
01	READING THE CHARACTER CAPACITY OF THE DISPLAY (DISPLAY RESPONDS SENDING 50 (HEX))
02	DISPLAY SOFTWARE CHECKSUM AND SOFTWARE NUMBER
03	READ CURSOR LOCATION VALUE (DISPLAY RESPONDS WITH 1 BYTE)

FOR 5X8 DOT CHARACTERS	FOR 10X14 DOT CHARACTERS
01-14 (HEX) FOR LINE 1	01-0A (HEX) FOR LINE 1
21-34 (HEX) FOR LINE 2	21-2A (HEX) FOR LINE 2
41-54 (HEX) FOR LINE 3	
61-74 (HEX) FOR LINE 4	

04	READ DATA AT PRESENT CURSOR LOCATION	
05	05-C-L-D	GRAPH MODE: DISPLAY 8 PIXEL DATA D ON LINE L COLUMN C C = 01-0F (HEX) (15 columns, each 8 pixels wide = 120 pixels) L = 01-24 (HEX) (36 pixel lines) D = 8 PIXEL DATA example: 05-01-01-A3: turn on 1st, 3rd, 7th and 8th pixel from upper left corner
06	BEGIN BLINK FIELD AT CURRENT CURSOR LOCATION	
07	END BLINK FIELD AT CURRENT CURSOR LOCATION	
08	BACKSPACE CURSOR LOCATION ONE POSITION (cursor stays when at HOME location)	
09	ADVANCE CURSOR LOCATION ONE POSITION (cursor wraps around after bottom right character location)	
0A	LINE FEED (vertical scroll from bottom line; cursor position does not change)	
0C	CLEAR THE DISPLAY (cursor stays)	
0D	CARRIAGE RETURN (returns cursor to left-most character position of the same line; does not clear display)	

4.2.1 Instruction (Cont'd)

DATA (HEX)		DESCRIPTION
0E		MAKE CURSOR INDICATOR INVISIBLE (the cursor location counter continues to function but there is no visible indicator of next character location)
0F	+	MAKE CURSOR INDICATOR VISIBLE, FLASHING BLOCK.
<10>		BOTTOM LINE DATA ENTRY WITH AUTOMATIC CARRIAGE RETURN & LINE FEED (puts cursor a left side bottom row and data enters beginning at the left-most character position of the bottom row, vertical scroll from bottom line after line has been filled)
<11>	+	NORMAL DATA ENTRY WITH AUTOMATIC CARRIAGE RETURN AND LINE FEED (data enters beginning at the home position, vertical scroll from bottom line after line has been filled)
<12>		OVERWRITE OF RIGHT-MOST CHARACTER ON THE PRESENT LINE/AUTOMATIC CARRIAGE RETURN OFF
<13>		HORIZONTAL SCROLL MODE (from right to left on bottom line only, after line has been filled)
14		RESET (go to system default settings and clear all DOWN LOAD CHARACTERS)
15	+	DISPLAY CLEAR (puts cursor at left side bottom row in Mode 10 HEX, & home in Modes 11 HEX, 12 HEX, 13 HEX and 1A HEX)
16	+	CURSOR HOME (returns cursor to upper left-most position)
17		BACKLIGHT ON
18	+	BACKLIGHT OFF (Blinks ON momentarily during power-up)
19		SET BIT 7 HIGH FOR NEXT BYTE ONLY: 19-00 TO 19-7F: Same as ASCII 80-FF
<1A>		WRAP AROUND DATA ENTRY: (After bottom right character enters, cursor moves to home position)
1B		1B-05-49 — IEE SPECIFIC RESPONSE CODE (Sent without regard for flow control) D,2,IEE,35964,-03 (CR) (18 BYTES)
		1B-26-01-M-N — DEFINE DOWN LOAD CHARACTERS (5x8 DOT CHARACTER ONLY) M=BYTE LOCATION TO BEGIN DOWNLOAD (20 to FF) N=NUMBER OF CHARACTERS TO BE DOWNLOADED EACH CHARACTER PATTERN IS 5 BYTES (See 4.4)
		1B-3F-N — DELETE DOWNLOAD CHARACTER LOCATION N (N=20-FF)
		1B-40 — TERMINATE SELF TEST (all configurations go to default setting and clear all DOWN LOAD CHARACTERS)

4.2.1 Instruction (Cont'd)

DATA (HEX)		DESCRIPTION
	1B-74-N	SELECT CHARACTER SET + N=01, ASCII AND GENERAL EUROPEAN (fig. 3 & 4) N=03, ASCII AND CYRILLIC (fig. 5) N=02, ASCII AND KATAKANA (fig. 6) N=04, ASCII AND HEBREW (fig. 7) N=05, ASCII AND GREEK (fig. 8) N=06, ASCII AND POLISH (fig. 9) N=07, BOLD FONT (fig. 10)
1D-05		EPSON SPECIFIC RESPONSE CODE DISPLAY RESPONDS SENDING 05 TO HOST.
1F	1F-24-C-L	MOVE CURSOR TO COLUMN C LINE L FOR 5X8 DOT CHARACTERS: C=01-14 (HEX) L=01-04 (HEX) FOR 10X14 DOT CHARACTERS: C=01-0A (HEX) L=01-02 (HEX)
	1F-40	EXECUTE SELF TEST (Use 1B-40 to terminate self test)
	1F-45-T	SET ALL DISPLAY BLINK FIELDS AT INTERVAL T T x 50 msec, 50% DUTY CYCLE T_{max} = 3F (HEX)
20 to 7F		MAIN CHARACTER SET
80 to F7		ALTERNATE CHARACTER SET

+ Display automatically defaults to these conditions after power-up or reset.

< > These instructions are mutually exclusive

4.3 Character Chart (5x8 Dot Matrix)

The LB325-X4X0 module offers seven independently-selectable Character sets. Six consist of the ASCII set shown below in Fig 3 occupying hex 20 through hex 7F, plus either General European (fig 4), Cyrillic (fig 5), Katakana (fig 6), Hebrew (fig 7), Greek (fig 8), or Polish (fig 9). These “special” portions of the character field occupy all or portions of hex 80 through hex F4 as shown. The seventh set consists of Bold characters (fig 10) occupying hex 20 through hex 5F.

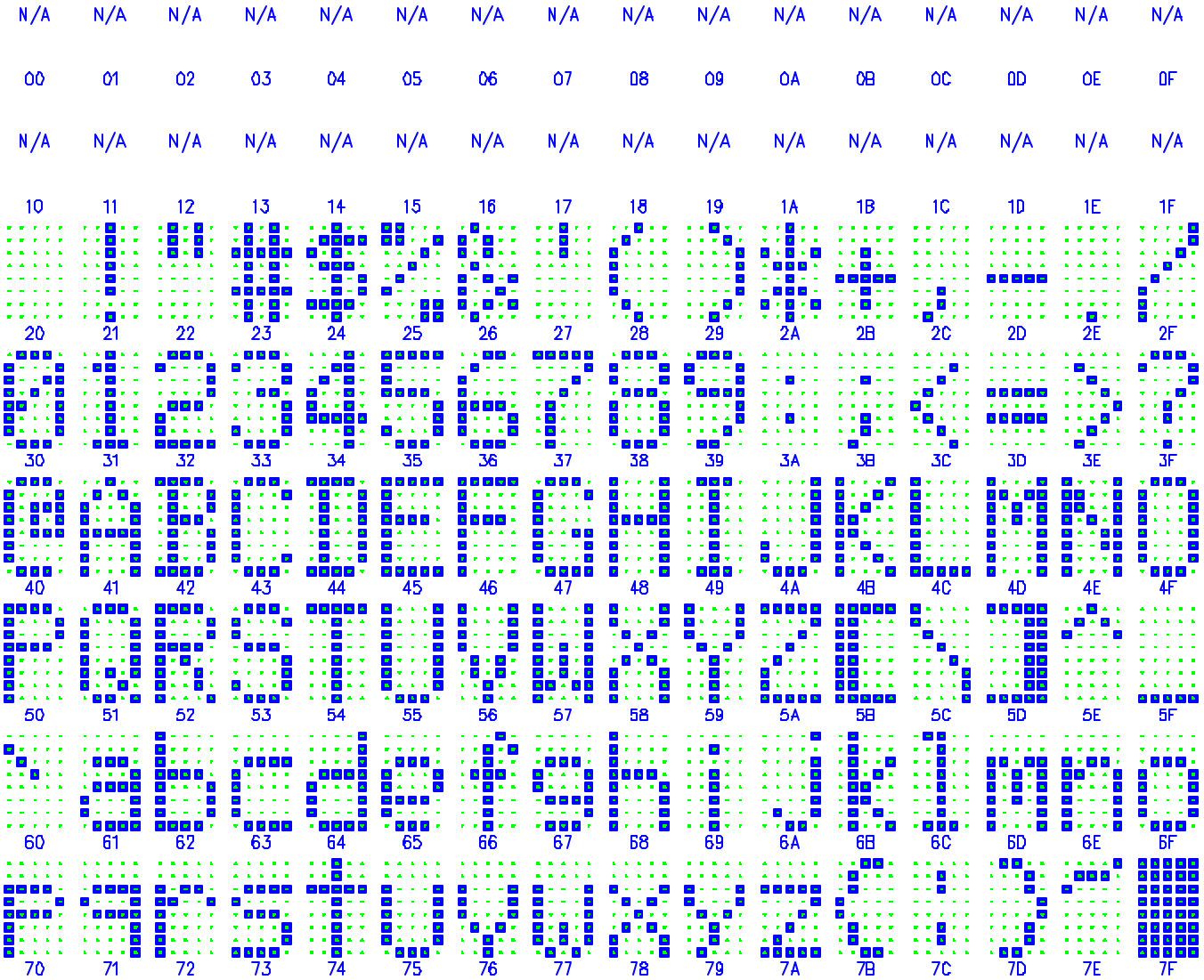


FIGURE 3 - ASCII CHARACTER SET

Note: N/A = Non-Applicable

FIGURE 4 - GENERAL EUROPEAN CHARACTER SET
(Default Setting)

Note: N/A = Non-Applicable

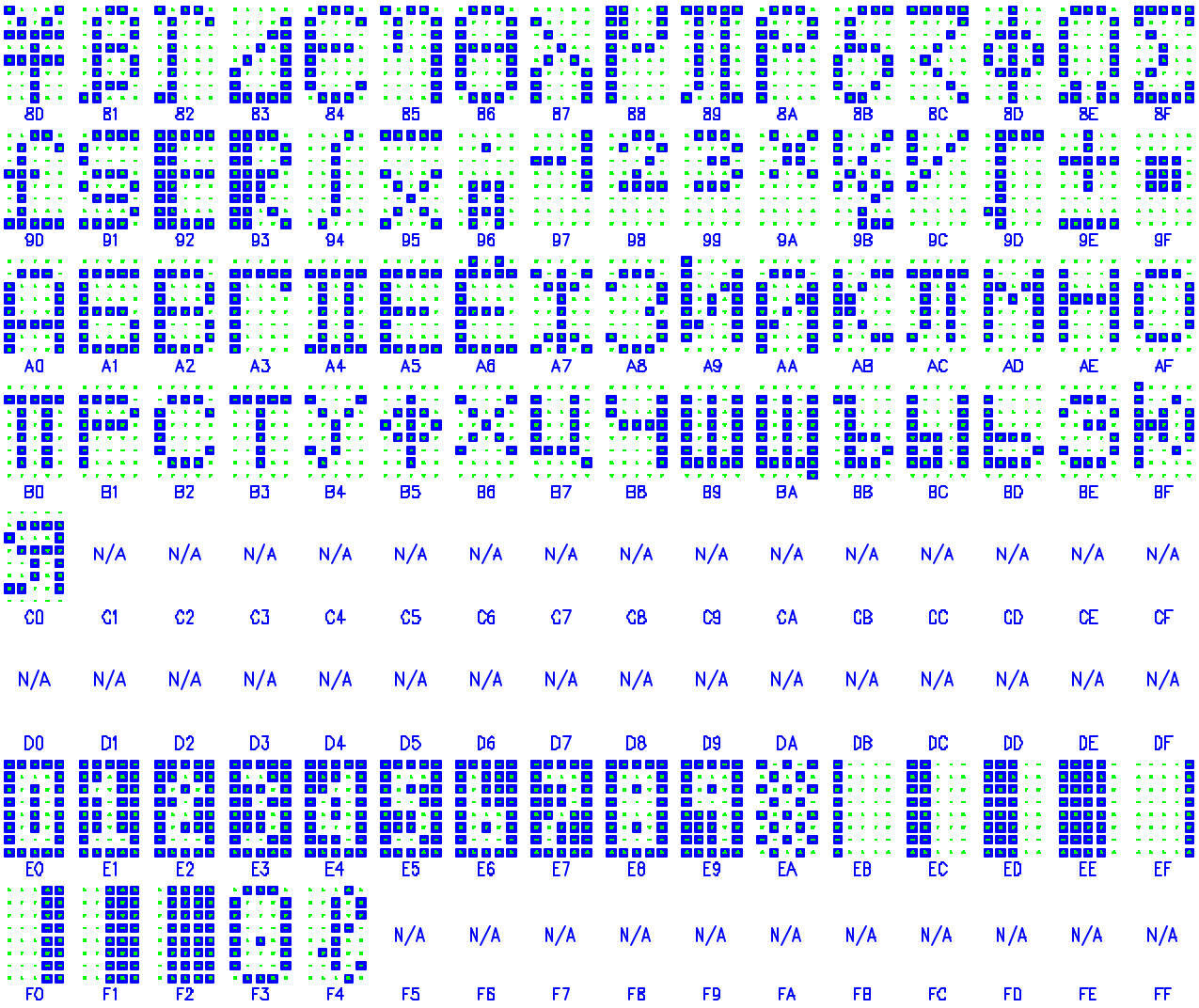


FIGURE 5 - CYRILLIC CHARACTER SET

Note: N/A = Non-Applicable

FIGURE 6 - KATAKANA CHARACTER SET

Note: N/A = Non-Applicable

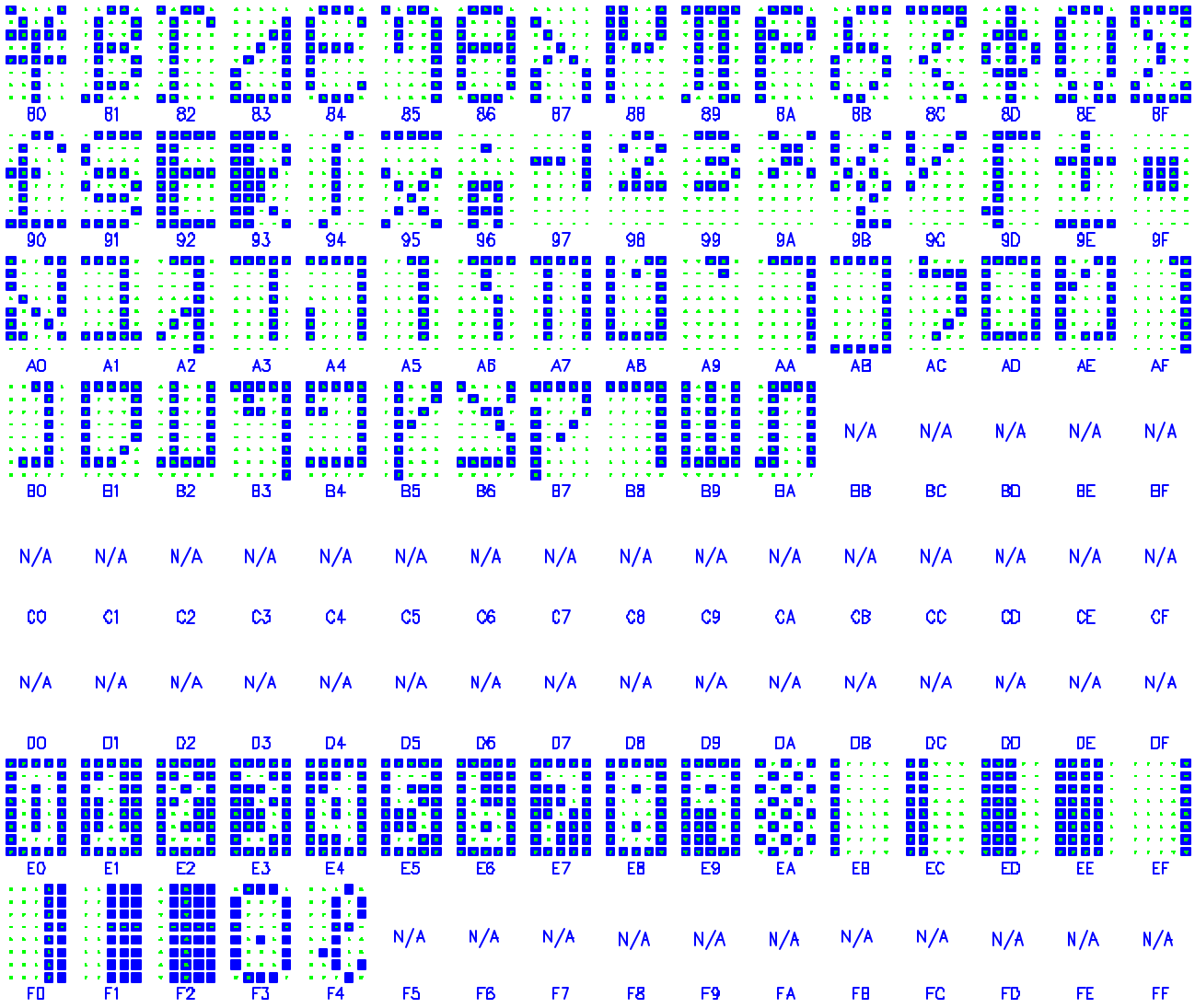


FIGURE 7 - HEBREW CHARACTER SET

Note: N/A = Non-Applicable

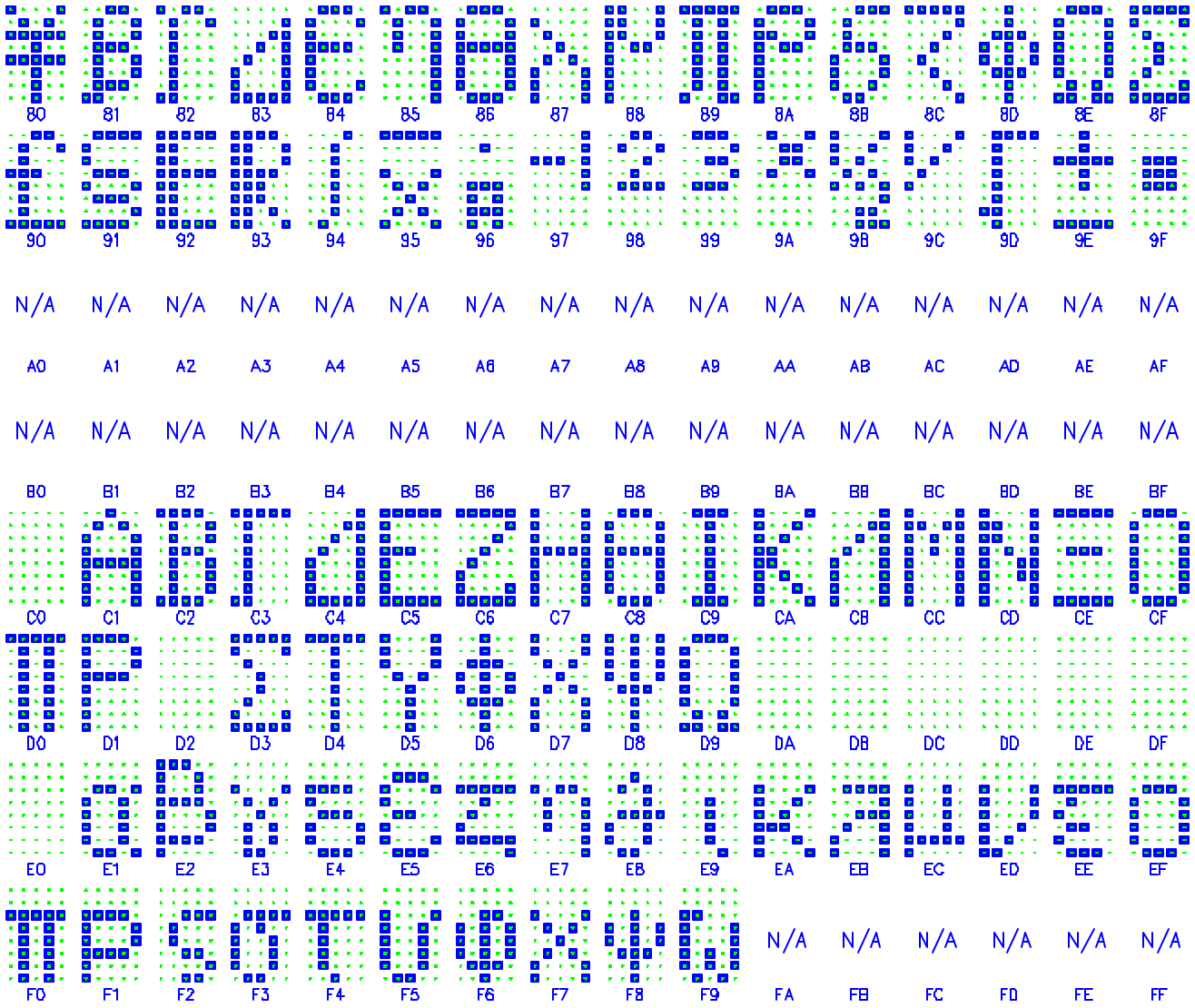


FIGURE 8 - GREEK CHARACTER SET

Note: N/A = Non-Applicable

FIGURE 9 - POLISH CHARACTER SET

Note: N/A = Non-Applicable

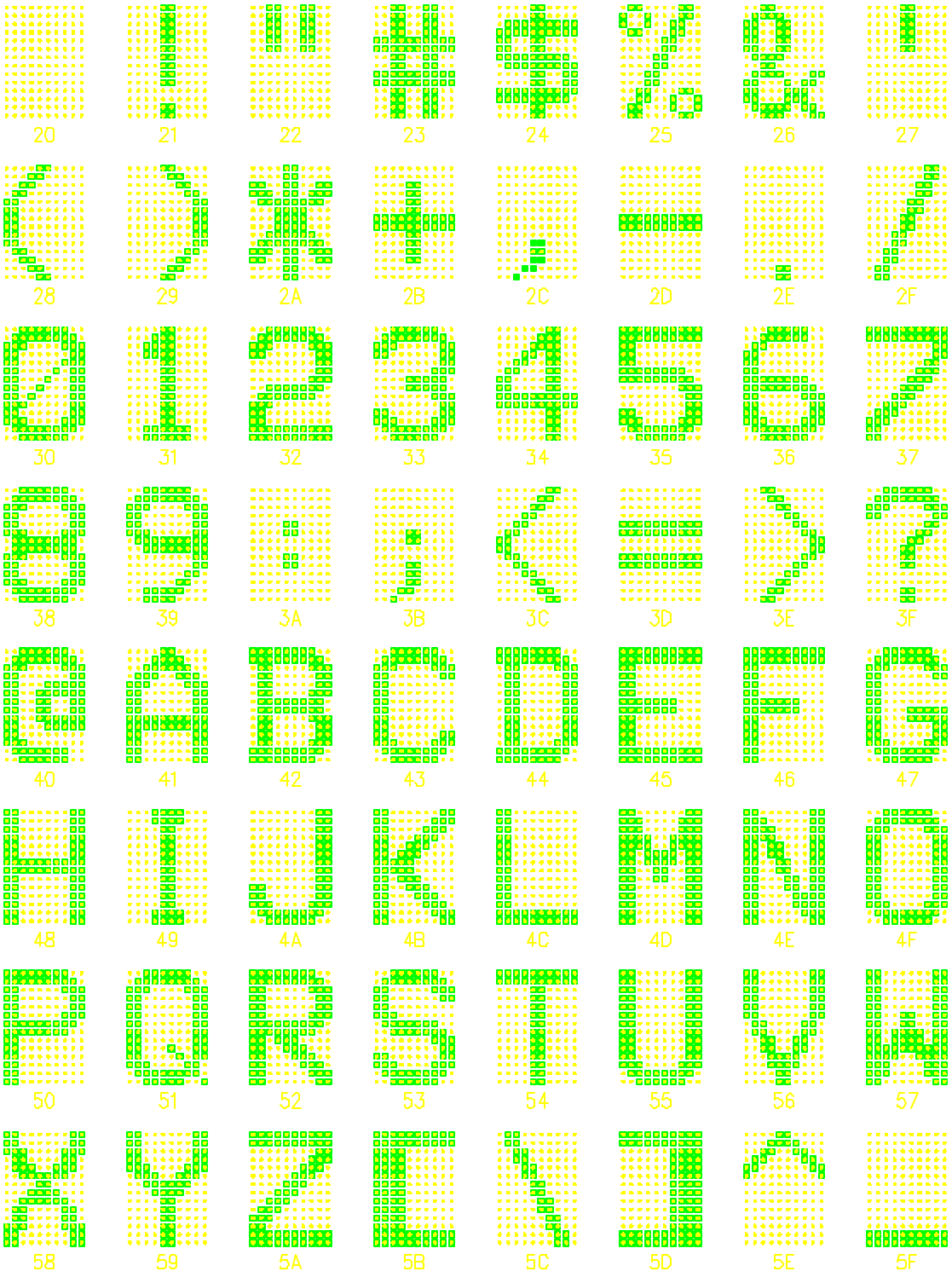


FIGURE 10 - 10 x 14 BOLD CHARACTER SET

4.4 User Defined Character Loading (5 x 8 Dot Matrix)

A maximum of eight characters may be created temporarily (until power-off or reset) by a user-defined down-loaded character pattern. To do so, enter the following sequence of commands and data:

BYTE	DESCRIPTION
1-3	Start load 1B-26-01 (HEX)
4	Location to begin download (20-FF hex)
5	Number of characters to download (01-08)
6-10	*Character dot data

*Repeat bytes 6-10 for the number of characters to be downloaded.

CHARACTER DOT DATA

BYTE #	7	6	5	4	3	2	1	0
6	36	31	26	21	16	11	6	1
7	37	32	27	22	17	12	7	2
8	38	33	28	23	18	13	8	3
9	39	34	29	24	19	14	9	4
10	40	35	30	25	20	15	10	5

CHARACTER MATRIX

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35
36	37	38	39	40

Example: To download 1 Greek letter Psi for character F8.

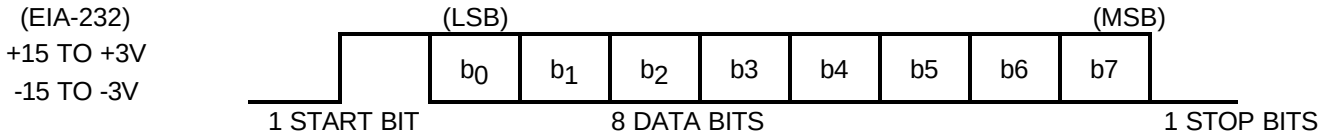
1Bh	BYTE 1, start load
26h	BYTE 2, start load
01h	BYTE 3, start load
F8h	BYTE 4, location to begin download
01h	BYTE 5, download 1 character
0Ch	BYTE 6, Dots 16, 11 ON
91h	BYTE 7, Dots 37, 22, 2 ON
FFh	BYTE 8, Dots 38, 33, 28, 23, 18, 13, 8, 3 ON
91h	BYTE 9, Dots 39, 24, 4 ON
0Ch	BYTE 10, Dots 20, 15 ON

4.5 Dedicated Hardware Lines

Not available.

4.6 Serial Data and Self-test

Serial characters are received with data formatted as a 10-bit word. The command set is structured to allow transmission of 8 data bits. The data rate is fixed at 9600 baud. The level is EIA-232C.



Self-test is a very useful feature and can be activated by sending 1F-40 (HEX). The test may be terminated by sending 1B-40 (HEX). Characters from 20 (HEX) to F4 (HEX) will be displayed advancing through the characters at approximately 2.0 characters per second. This self-test capability can be used to speed up both in-field fault isolation and incoming receiving inspection.

4.7 Connector Pin Assignment

EIA-232C

J1 (RJ-45) PIN NO.	FUNCTION
*1	SIGNAL GROUND
2,7	11-29 VDC
3	TRANSMIT DATA (OUTPUT)
4	DATA SET READY (INPUT)
5	DATA TERMINAL READY (OUTPUT)
6	RECEIVE DATA (INPUT)
*8	POWER RETURN

* Shielded cable and connector are standard.

EIA-422A

J1 (RJ-45) PIN NO.	FUNCTION
*1	SIGNAL GROUND
2,7	11-29 VDC
3	TRANSMIT DATA (A+)
4	TRANSMIT DATA (A-)
5	RECEIVE DATA (A-)
6	RECEIVE DATA (A+)
8	POWER RETURN

* Shielded cable and connector are standard.

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.

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 850mS (typ) - 1.2 sec (max).

5.2 Interface Signals

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

5.3 Absolute Maximum Ratings

EIA-232C:	+15VDC to -15VDC
EIA-422A:	+15VDC to -10VDC

5.4 Normal Operating Ratings

Primary voltage: 11-29 VOLTS DC

Power dissipation:	1.7 W max. without backlight at 29 VDC
	3.0 W max with backlight at 29 VDC

6.0 OPTICAL CHARACTERISTICS

Format:	4 lines of 20 characters
Character height:	.39 in. (10mm)
Character width:	.24 in. (6.2mm)
Character spacing:	.30 in. (7.5mm) center-to-center
Character design:	5 x 8 dot matrix
Type of cursor indicator:	FLASHING BLOCK
Character set:	ASCII, European, Cyrillic, Katakana, Hebrew, Greek, Polish, Bold
Color:	Dark blue characters on yellow-green background
Viewing angle:	100 degrees vertically, 90 degrees horizontally

7.0 ENVIRONMENTAL CHARACTERISTICS

Operating temperature:	-20 to +70 (°C) -4 to 158 (°F)
Storage temperature:	-40 to +70 (°C) -40 to +158 (°F)
Relative humidity: (40°C)	0 to 95% (non-condensing)
(40°C)	Absolute humidity must be lower than the humidity of 95% RH at 40°C
Vibration:	10 to 50 Hz 2mm peak-to-peak (3 axis)
Shock:	10 G, 18msec (3 axis)

8.0 FIBER OPTIC BACKLIGHT

8.1 F.O. Backlight Description

The module contains a light emitting flat panel constructed of two woven layers of plastic optical fibers which convey the light from two separately located LED light sources. The panel is heat free, has indefinitely long life and has good brightness uniformity. The optical fibers are gathered into a bundle at the end of the flat panel and are routed to the light sources where it splits into two bundles, one layer to each LED.

The LEDs are affixed to a circuit board (PWB) that mounts behind this display module using two of the module mounting holes (see the outline drawing, section 10.0). The PWB contains the wiring for the two LEDs, their current limiting and power control circuitry, and a connector that plugs onto the display module where the LED power is obtained from the input connector.

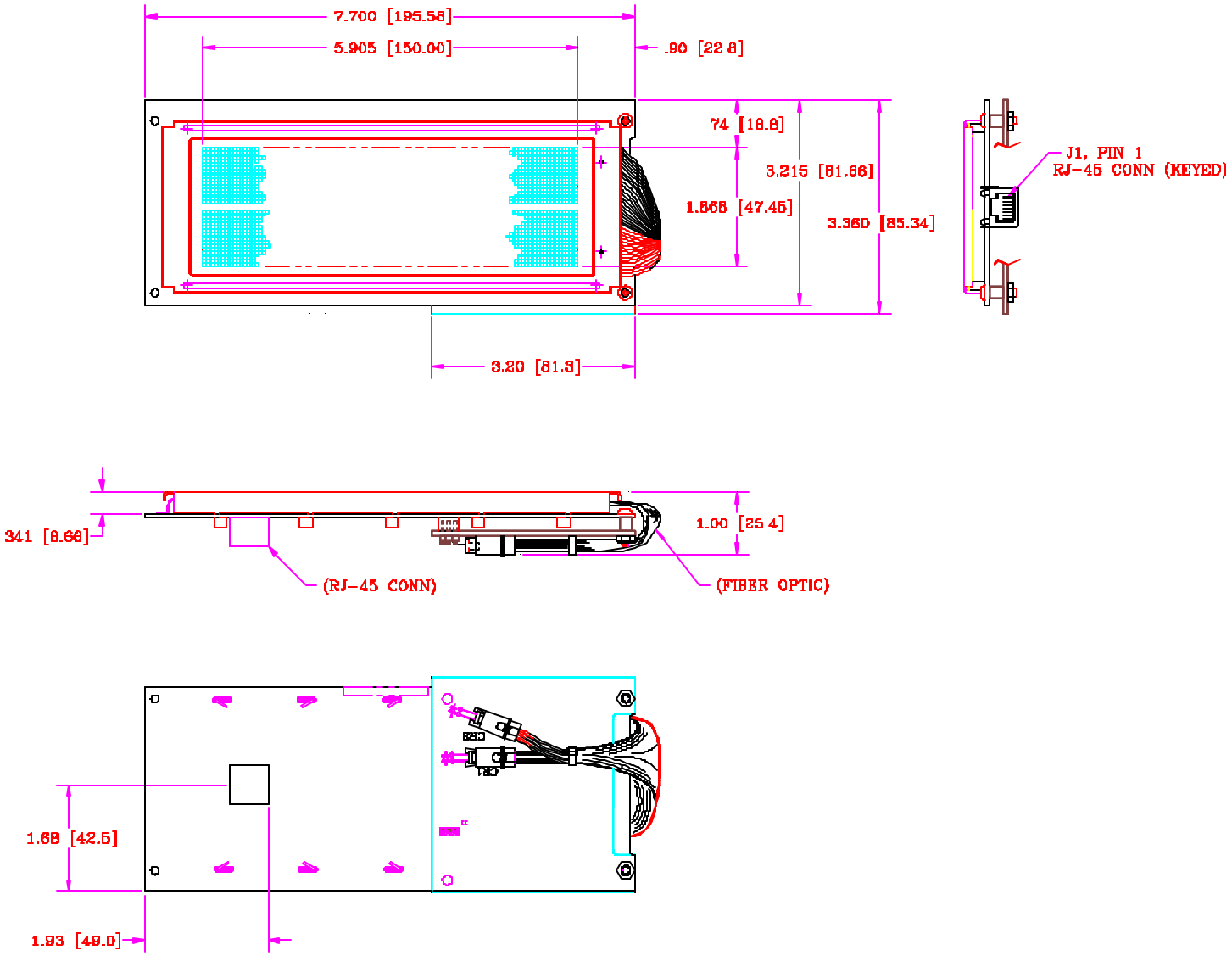
Because of the attenuation of the LCD cell, only approximately 15% of the backlight luminance is emitted from the display. Thus, to provide a brightly lit display, the original light source must be over six times brighter.

9.0 ACCESSORIES

Cables	**Part Number**
RJ-45 to DIN-8 male & DIN-8 female to DB-9 female (UNSHIELDED)	35754-XX & 35802-XX
RJ-45 to DIN-8 male & DIN-8 female to DB-9 female (SHIELDED)	35753-XX & 35801-XX

XX=length in inches

9.0 OUTLINE DRAWING



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

FIGURE 11

Industrial Electronic Engineers, Inc. Van Nuys, California	SIZE A	CODE IDENT NO. 05464	SLB325-X4X0
	SCALE N/A	REV B	SHEET 21