APPLICATION		REVISIONS			
NEXT ASSY	FINAL ASSY	LTR	DESCRIPTION	DATE	APPROVED
		-	PRODUCTION RELEASE/E.O. 32901	7-21-97	D. Goodale
		A	E.O. 33241	10-14-97	B. Lo
		B	E.O. 33304	11-4-97	D. Goodale
		C	E.O. 37192	8-13-02	B. Lo
		D	E.O.		

LIQUID CRYSTAL DISPLAY
SPECIAL THAI CHARACTERS
MODEL LB324-04XI
MODEL LB324-14XI

REV	D	B	D	B	B	D	D	D	D	D	D	D	D	D	D	D	D	D						
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	
CHECK	D. Summers	8-18-97

LIQUID CRYSTAL DISPLAY
SPECIAL

APPROVED
D. Goodale 7-21-97

APPROVED

SIZE	CODE IDENT NO.	
A	**05464**	SLB324-X4XI

SCALE | SHEET 1 OF 18

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1.0 GENERAL DESCRIPTION

1.1 Introduction

This specification describes the interface requirements and features of a 2 line Liquid Crystal Display (LCD) , 15 characters wide. The characters are formed using a 8x18 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

Thai character set
Power and data on same connector
12-29 Volt Operation
Low cost
Shielded I/O Connector standard
Wide operating temperatures (-20 to +70°)
EIA-232C data interface
EIA-422A data interface
Software self test
Minimum depth
4 canned messages, 500 bytes each

1.4 Description

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

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

EIA-232C = Model LB324-04XI
EIA-422A = Model LB324-14XI

This unit consists of a liquid crystal display cell 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.

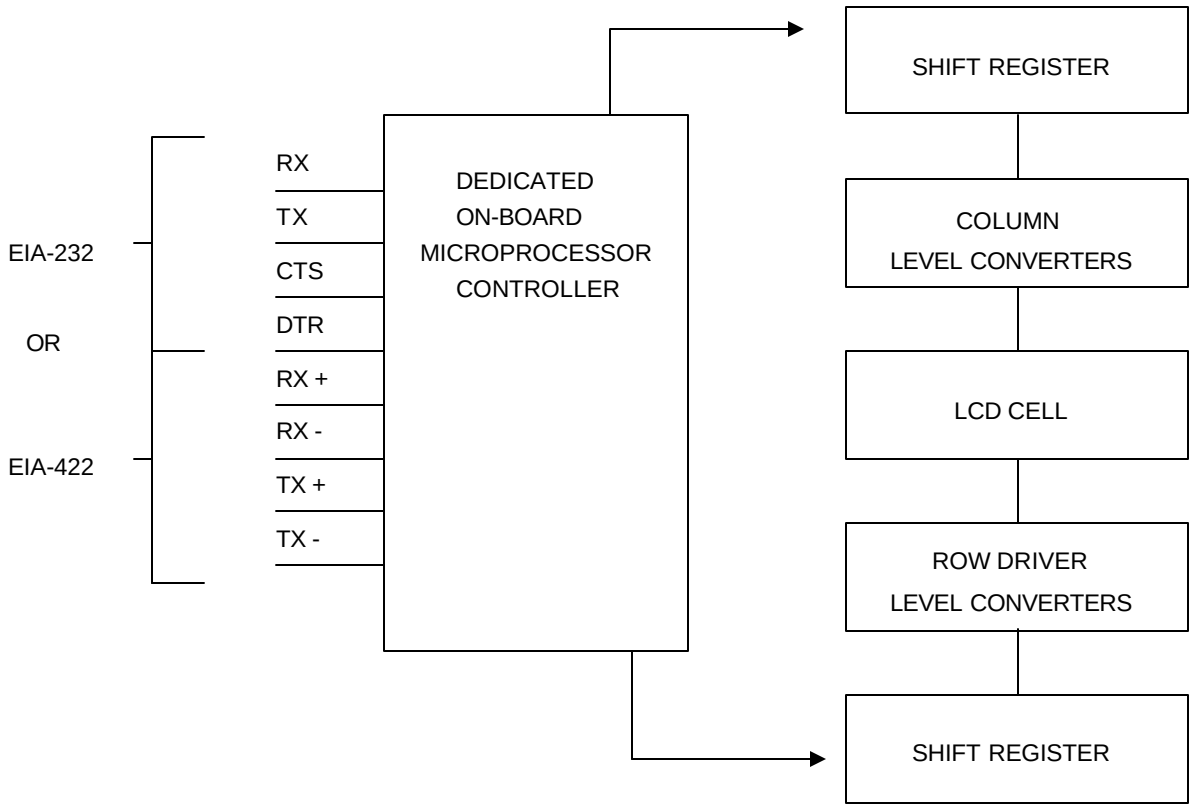
A single 12-29 volt power supply is required for operation. At +12VDC, total power is approximately .72 watts and current is about 60mA.

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, 4, and 5 depict the character sets used in this module.

2.0 BLOCK DIAGRAM



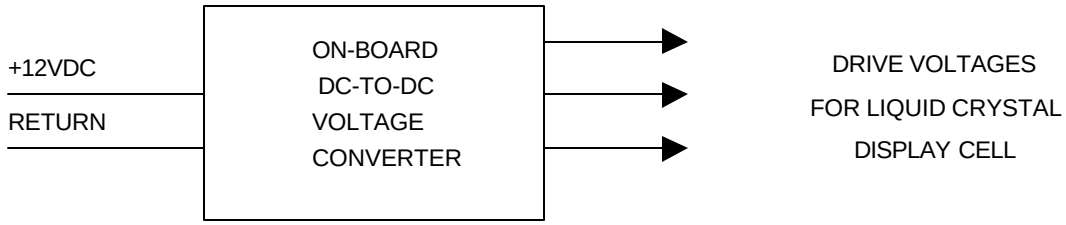


FIGURE 1

Industrial Electronic Engineers, Inc.	SIZE **A**	CODE IDENT NO. **05464**	**SLB324-X4XI**
Van Nuys, California	SCALE N/A	REV **D**	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 four lines of characters. A matrix addressing technique provides individual control of the electric field applied to each dot used to create the character. A standard character is generated within a 8 x 18 dot matrix. A unselected dot passes the light which reflects back appearing as a yellow-green background. Selected dots block the light to create the lines of 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.

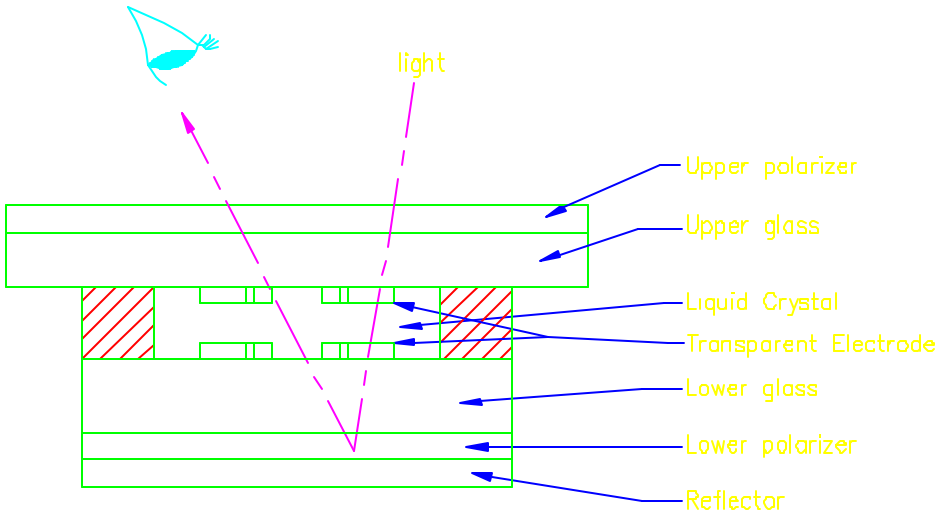


FIGURE 2

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 1E (HEX))

02 DISPLAY SOFTWARE CHECKSUM AND SOFTWARE NUMBER

03 READ CURSOR LOCATION VALUE (DISPLAY RESPONDS WITH 1 BYTE)

FOR 8 x 18 DOT CHARACTERS	FOR 5 x 8 DOT CHARACTERS
01-0F (HEX) FOR LINE 1	01-14 (HEX) FOR LINE 1
21-2F (HEX) FOR LINE 2	21-34 (HEX) FOR LINE 2
	41-54 (HEX) FOR LINE 3
	61-74 (HEX) FOR LINE 4

04 READ DATA AT PRESENT CURSOR LOCATION

05-H1-H2-3A-MI-M2-CR: Enable the display of the internal clock and the changing of the internal clock contents.
"H1-H2-3A-M1-M2" is an optional parameter that to replace the original internal clock data.
H1=30 hex to 32 hex (HOUR)
H2=30 hex to 39 hex (HOUR)
3A=":"
M1=30 hex to 35 hex (MINUTE)
M2=30 hex to 39 hex (MINUTE)
CR=0D hex

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)

4.2.1 Instruction (Cont'd)

DATA (HEX)		DESCRIPTION
0D		CARRIAGE RETURN (returns cursor to left-most character position of the same line; does not clear display)
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 (goes to system default settings and clears 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-NN		DISPLAY AND EXECUTE MESSAGE NN=01 TO 04 MESSAGE NUMBER
<1A>		WRAP AROUND DATA ENTRY: (After bottom right character enters, cursor moves to home position)

0B-NN-XX-XX- . . . . XX-CR		STORE MESSAGES COMAND. NN=01 TO 04 MESSAGE NUMBER XX . . . . XX = MESSAGE. (MAX. = 500 BYTES) CR = CARRIAGE RETURN = 0D HEX
1B	1B-05-49	IEE SPECIFIC RESPONSE CODE (Sent without regard for flow control) D,2,IEE,36368,-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 (01 to 08) EACH CHARACTER PATTERN IS 5 BYTES (See 4.5)

4.2.1 Instruction (Cont'd)

DATA (HEX)		DESCRIPTION
	1B-3D-N	N=01 The display is not selected. All the data from the host is not processed in the display. +N=02 The display is selected. All the data from the host is processed in the display.
	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)
	1B-52-N	SELECT OVERLAY CHARACTER SET COUNTRY +N=00H USA N=01H FRANCE N=02H GERMANY N=03H GREAT BRITAIN N=04H DENMARK 1 N=05H SWEDEN N=06H ITALY N=07H SPAIN N=08H JAPAN N=09H NORWAY N=0AH DENMARK 2
	1B-74-N	SELECT CHARACTER SET (change character set will set cursor home) N=01 ASCII AND GENERAL EUROPEAN (5x8 DOT) +N=02 THAI (8x18 DOT)
	1B-74-N	SELECT CHARACTER SET (change character set will set cursor home) N=01 ASCII AND GENERAL EUROPEAN (5x8 DOT) +N=02 THAI (8x18 DOT)
<1C>-XX-XX-. . . . XX-0D		DISPLAY TOP ROW MESSAGE CONTINUOUSLY SCROLLING LEFT UP TO 80 ASCII CODES (Any further input data will stop the scrolling and clear the row)
1D-TT		DELAY SECONDS TT=01-0A DELAY 1 TO 10 SECONDS
<1E>-XX-XX-. . . . XX-0D		DISPLAY BOTTOM ROW MESSAGE CONTINUOUSLY SCROLLING LEFT UP TO 80 ASCII CODES (Any further input data will stop the scrolling and clear the row)
1F	1F-24-C-L	MOVE CURSOR TO COLUMN C LINE L FOR 8x18 THAI CHARACTERS: C=01-0F (HEX) L=01-02 (HEX) FOR 5x8 CHARACTERS: C=01-14 (HEX) L=01-04 (HEX)

4.2.1 Instruction (Cont'd)

DATA (HEX)	DESCRIPTION
1F-40	EXECUTE SELF TEST (Use 1B-40 to terminate self test)
1F-45-T	SET ALL DISPLAY BLINK FIELDS AT INTERVAL T Tx50msec, 50% DUTY CYCLE Tmax = 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 Set Charts

4.3.1 8 x 18 Dot Matrix Characters

The LB324-X41I offer's a Thai character set in a 8x18 dot matrix font (it displays 2 rows of 15 characters), and a 5x8 ASCII character set in 4 rows of 20 characters.

FIGURE 3 - 8 x 18 THAI CHARACTER SET

4.3.1 8 x 18 Dot Matrix Characters (Cont'd)

Thai vowel (80-98, D1, D4-D9, E7) and tone (E8-EC) should follow Thai consonant (A1-CF).

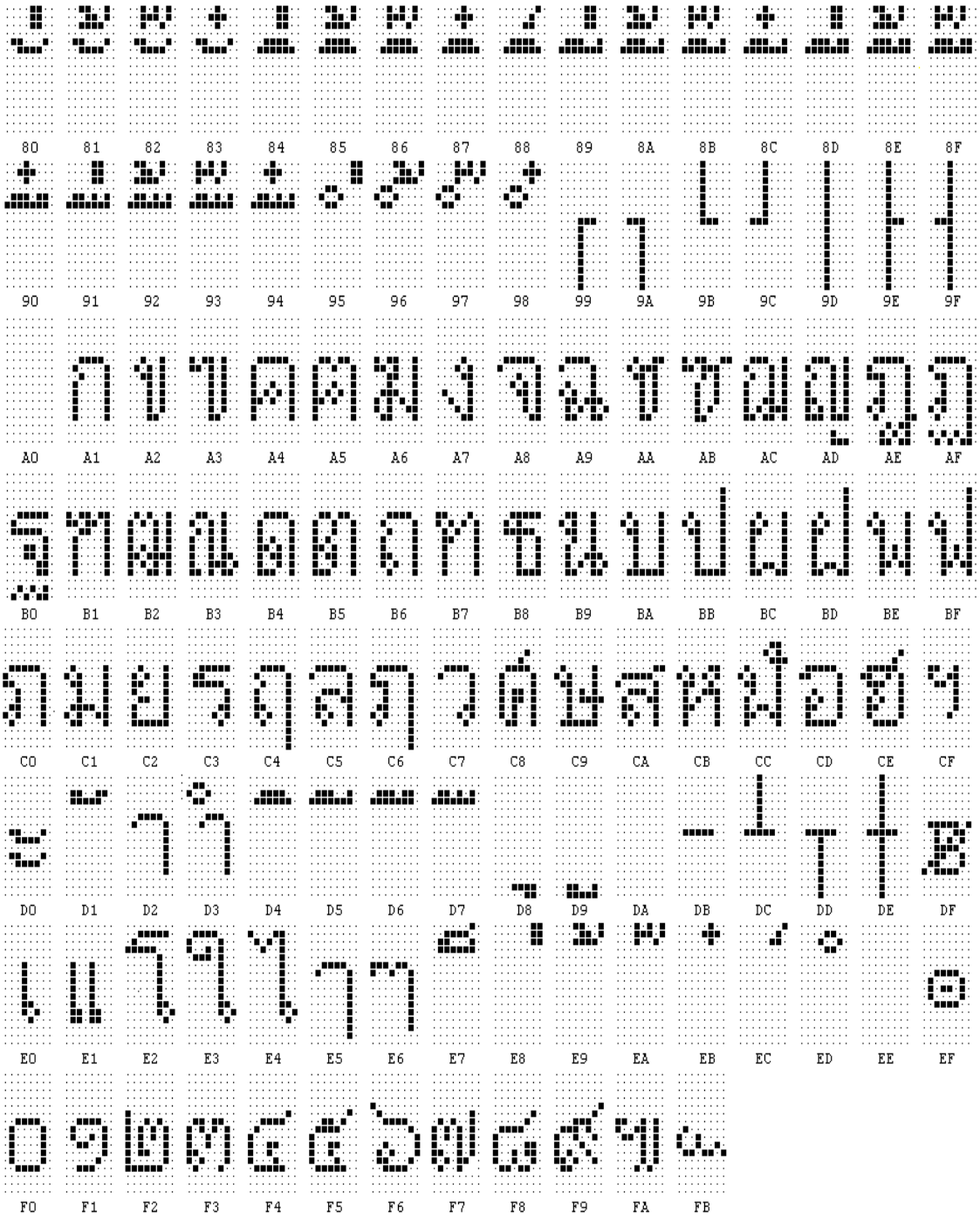


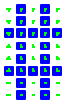
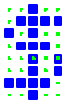
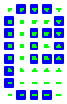
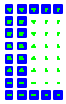
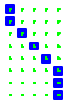
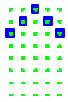
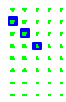
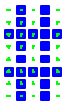
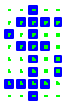
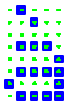
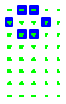
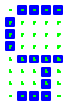
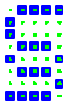
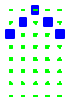
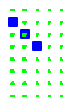
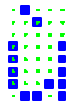
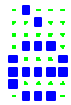
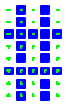
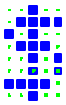
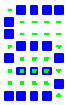
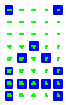
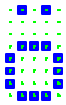
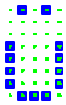
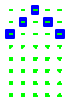
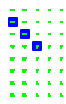
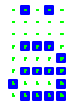
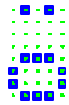
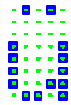
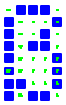
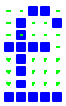
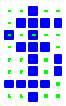
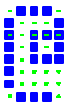
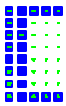
FIGURE 4 - 8 x 18 THAI CHARACTER SET

Industrial Electronic Engineers, Inc. Van Nuys, California	SIZE **A**	CODE IDENT NO. **05464**	**SLB324-X4XI**
	SCALE N/A	REV **D**	SHEET 11

4.3.2 5 x 8 Dot Matrix Characters

FIGURE 5 - 5 x 8 U.S. ASCII CHARACTER SET

4.4 Overlay Character Codes

SELECT CODES (HEX)	CHARACTER SET	23	24	40	5B	5C	5D	5E	60	7B	7C	7D	7E
0	*U.S A.												
1	FRANCE												
2	GERMANY												
3	U.K.												
4	DENMARK I												
5	SWEDEN												
6	ITALY												
7	SPAIN I												
8	JAPAN												
9	NORWAY												
A	DENMARK II												

4.5 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.

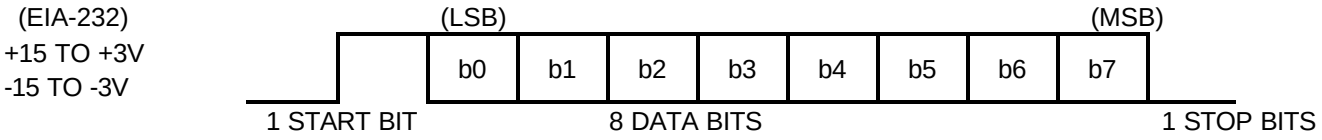
1Bh	BYTE 1, start load
26h	BYTE 2, start load
01h	BYTE 3, start load
F8h	BYTE 4, location to begin download
01h	BYTE 5, download 1 character
0Ch	BYTE 6, Dots 16, 11 ON
91h	BYTE 7, Dots 37, 22, 2 ON
FFh	BYTE 8, Dots 38, 33, 28, 23, 18, 13, 8, 3 ON
91h	BYTE 9, Dots 39, 24, 4 ON
0Ch	BYTE 10, Dots 20, 15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

4.6 Dedicated Hardware Lines

Not available.

4.7 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 FB (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.

4.8 Connector Pin Assignment

EIA-232C

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

* Shielded connector is standard.

EIA-422A

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

* Shielded connector is 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: 12-29 VOLTS DC

Power dissipation: 0.72 WATTS at 12.0 VDC

6.0 OPTICAL CHARACTERISTICS

Format:	2 lines of 15 characters
Character height:	.91 in. (23mm)
Character width:	.35 in. (9mm)
Character spacing:	.41 in. (10.4mm) center-to-center
Character design:	8 x 18 dot matrix and 5 x 8 dot matrix
Type of cursor indicator:	FLASHING BLOCK
Character set:	ASCII, Thai
Color:	Dark blue characters on yellow-green background
Viewing angle:	100 degrees vertically, 90 degrees horizontally

6.1 Display Viewing/Contrast

This display has built-in temperature compensation circuitry and therefore should not require readjustment of the contrast once it is set at the factory. Potentiometer R4 (when used) is adjusted to obtain 10.70 VDC at 22°C when measured from +5V to TP1.

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:	10G, 10-400Hz (3 axis)
Shock:	10G, 18ms

8.0 ACCESSORIES

IEE has a large selection of cable lengths and connector combinations available. The display enclosure is available in several standard colors with multiple mounting methods and pole lengths. Contact IEE for specifics.

10.0 OUTLINE AND INSTALLATION DRAWING

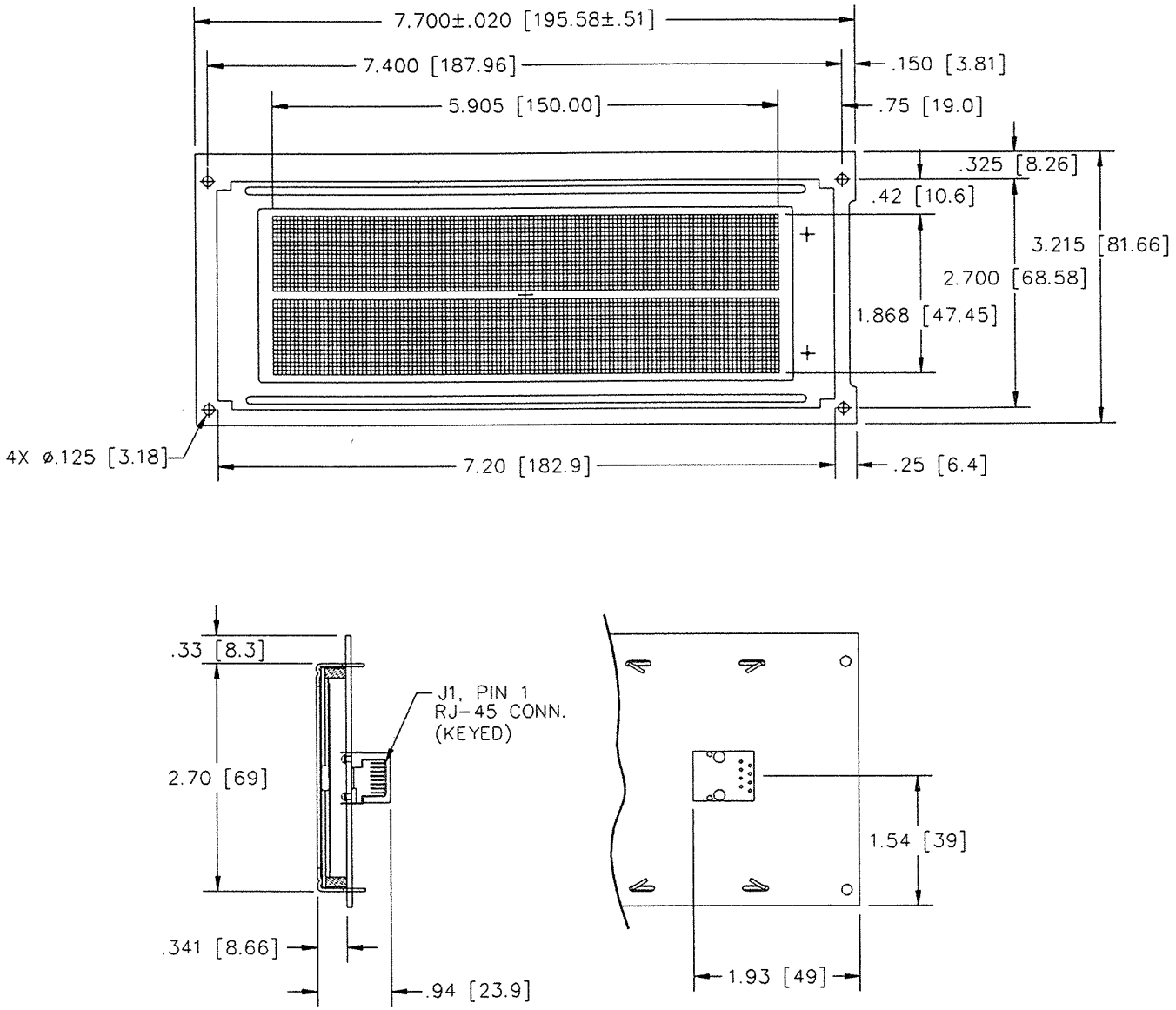


FIGURE 6

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

Industrial Electronic Engineers, Inc.	SIZE **A**	CODE IDENT NO. **05464**	**SLB324-X4XI**
Van Nuys, California	SCALE N/A	REV **D**	SHEET 18