

1.0 GENERAL DESCRIPTION

This series of graphical 140 x 32 dot matrix Vacuum Fluorescent Display (VFD) modules are capable of displaying both graphics and text. The modules contain the VFD driver circuitry, microcontroller with built-in font tables, DC-DC converter, and serial and/or parallel interfaces.

1.1 INTERFACE OPTIONS

NAGP1250AB/BB-0: parallel and/or RS-232 level asynchronous serial communication

NAGP1250AB/BB-2: parallel and/or synchronous or asynchronous CMOS level serial communication

NAGP1250AB/BB-3: synchronous or asynchronous CMOS level serial communication

1.2 FEATURES

- 5VDC operation
- -40°C to +85°C operation
- 1000 cd/m² luminance and wide viewing angles
- Display both graphics and text simultaneously
- Fixed and proportional fonts for smoother character spacing
- 14 international font sets
- 8 levels of luminance control from 12.5% to 100%
- Screen saver modes to reduce power consumption and to reduce image burn-in
- 4 User Windows in addition to the Base Window for quicker image updates
- Variable speed scrolling
- Choice of serial and/or parallel interfaces (input buffer shared when using 2 interfaces at once)

1.2.1 NEW FEATURES ADDED

- Increased size of Extended Memory from 116 to 140 columns allowing page swapping
- Increased number of user defined characters from 16 to 224 allowing an entire font table to be defined
- Increased user defined characters size from 5x7 to 5x8 allowing descenders (g, j, p, q, y)
- Added 3X and 4X vertical font magnification allowing up to 4X x 4X characters
- Added a 255 byte input buffer for increased communication speeds

2.0 APPLICABLE DOCUMENTS

- Futaba Vacuum Fluorescent Display Specification GP1250AI
- Futaba America Engineering Standard FAES 801, Printed Circuit Board Markings

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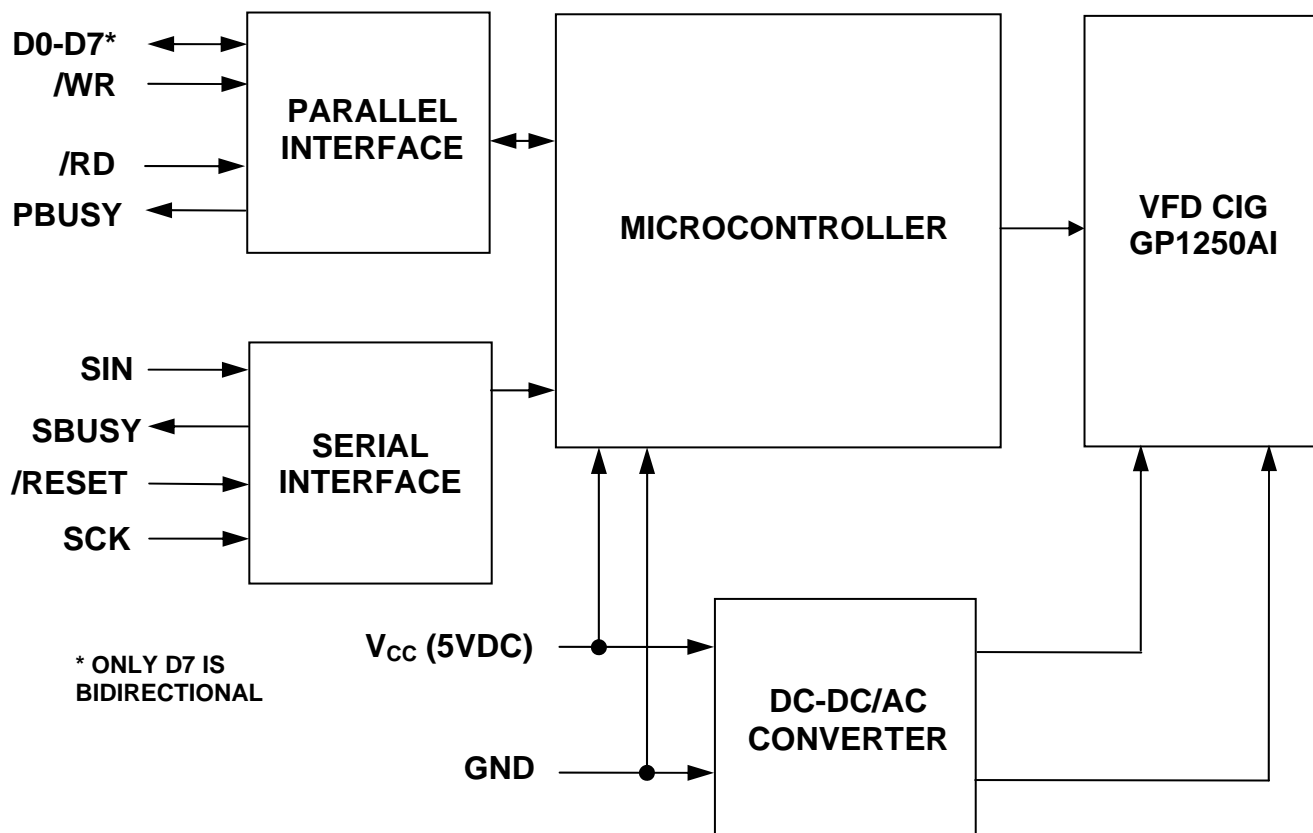
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3.0 GENERAL SPECIFICATIONS

Item	Value	Unit
Number of dots	140 columns x 32 rows	-
Dot height	0.57	mm
Dot width	0.4	mm
Dot pitch vertical	0.67	mm
Dot pitch horizontal	0.5	mm
Pattern width	69.9	mm
Pattern height	21.34	mm
Peak wavelength of illumination	x = 0.24, y = 0.41 (green)	-
Luminance	500 (min.) – 1000 (typ.)	Cd/m ²

4.0 SYSTEM BLOCK DIAGRAM



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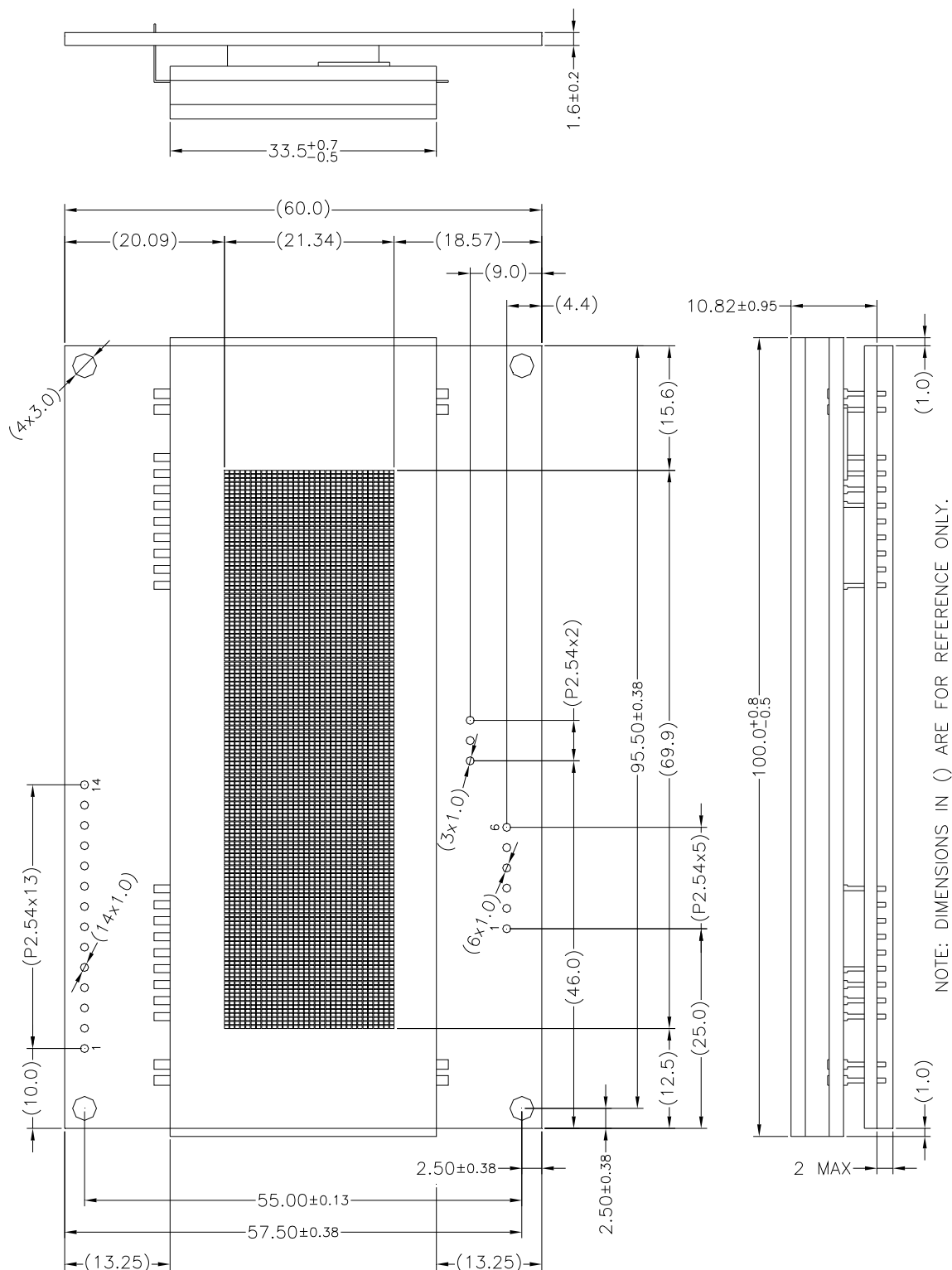
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5.0 NAGP1250AB-X MECHANICAL DRAWING



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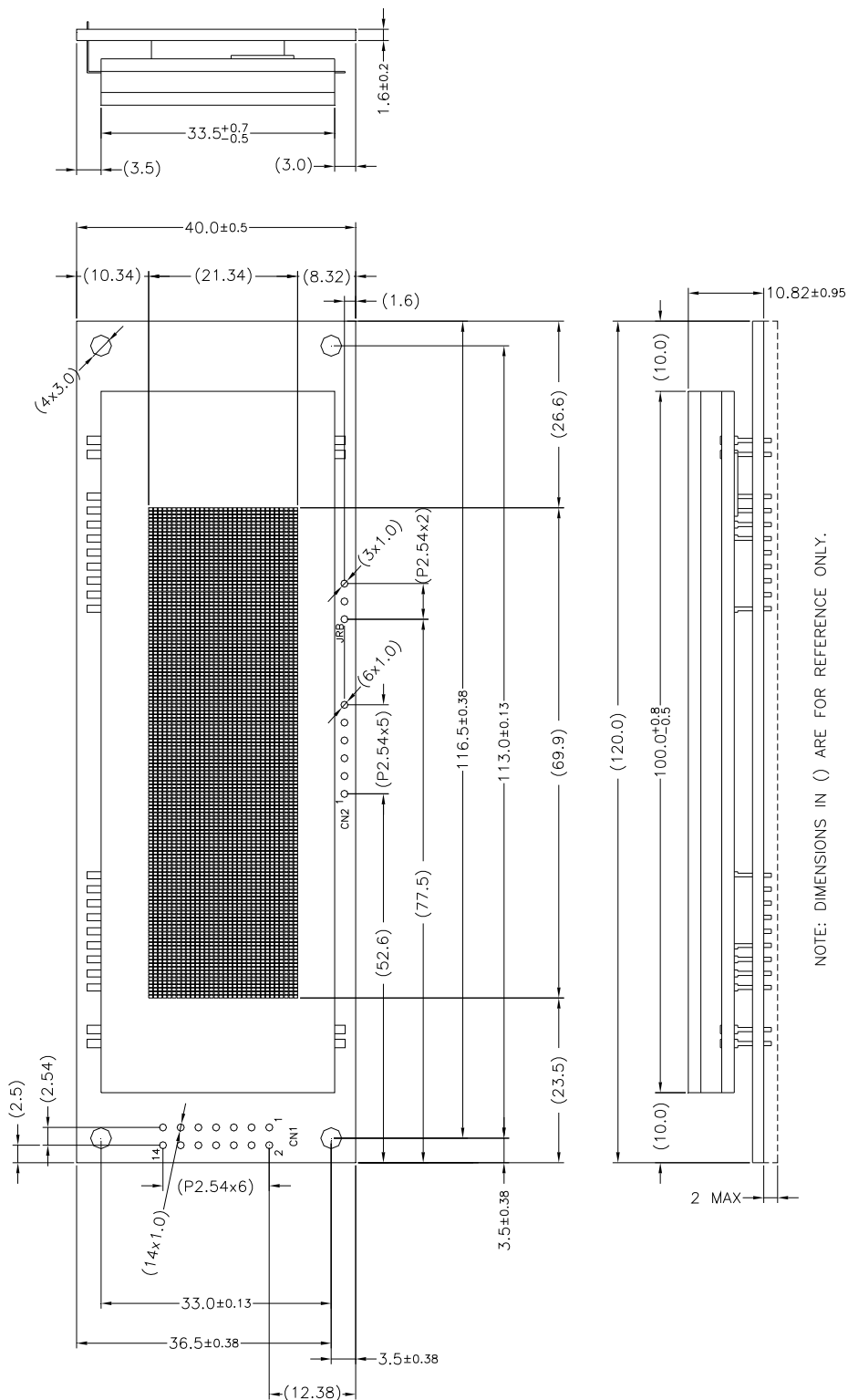
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5.1 NAGP1250BB-X MECHANICAL DRAWING



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6.0 SPECIFICATIONS

6.1 ENVIRONMENTAL SPECIFICATIONS

Item	Symbol	Min.	Max.	Unit	Comment
Operating temperature	Topr	-40	+85	°C	
Storage temperature	Tstg	-40	+85	°C	
Operating humidity	Hopr	—	85	%RH	without condensation
Storage humidity	Hstg	—	90	%RH	without condensation
Vibration (non-operating)	—	—	4	G	total amplitude: 1.5mm freq: 10 ~ 55 Hz sine wave sweep time: 1 min / cycle duration: 2 hrs / axis (X, Y, Z)
Shock (non-operating)	—	—	40	G	duration: 11ms waveform: half sine wave 3 times / axis (X, Y, Z, -X, -Y, -Z)

6.2 MISCELLANEOUS SPECIFICATIONS

6.2.1 MTBF SPECIFICATIONS

Design target of greater than 425,000 hours.

6.2.2 ROHS COMPLIANCE SPECIFICATIONS

RoHS 6 of 6 compliant.

6.3 ABSOLUTE MAXIMUM ELECTRICAL SPECIFICATIONS

Item	Symbol	Min.	Max.	Unit
Supply voltage	V _{CC}	-0.3	6.0	V
Input signal voltage D0-D7, /WR, /RD, /RESET, SIN _{-2,3} , SCK _{-2,3}	V _{IS}	-0.3	V _{CC} +0.03	V
Input signal voltage SIN ₋₀	V _{IS}	-20	+20	V

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6.4 NORMAL ELECTRICAL SPECIFICATIONS

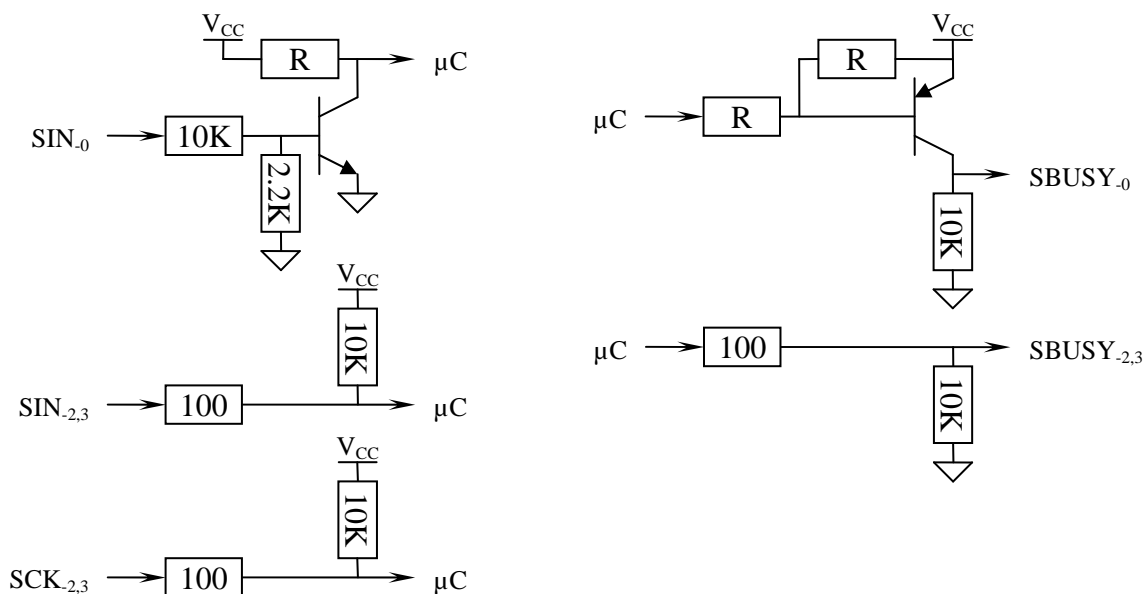
$V_{CC} = 5.0V$, -40 to $+85^{\circ}C$

Item	Symbol	Min.	Typ.	Max.	Unit
Supply voltage	V_{CC}	4.75	5.0	5.25	V
Supply current (all dots on)	I_{CC}	–	400	520	mA
Supply current (all dots off)	I_{CC}	–	330	430	mA
Supply current (screen saver – power supply off)	I_{CC}	–	35	45	mA
High level input signal voltage: D0-D7, /WR, /RD, /RESET, SIN _{2,3} ,	V_{IH}	$0.7 * V_{CC}$	–	V_{CC}	V
Low level input signal voltage: D0-D7, /WR, /RD, /RESET, SIN _{2,3}	V_{IL}	0.0	–	$0.3 * V_{CC}$	V
High level input signal voltage: SCK _{2,3}		$0.8 * V_{CC}$	–	V_{CC}	V
Low level input signal voltage: SCK _{2,3}		0.0	–	$0.2 * V_{CC}$	V
High level input signal voltage: SIN ₀	V_{IH}	3.0	–	15.0	V
Low level input signal voltage: SIN ₀	V_{IL}	-15.0	–	0.5	V
High level output signal voltage: PBUSY		$V_{CC} - 0.1$	–	–	
Low level output signal voltage: PBUSY		–	–	0.1	
High level output signal voltage: SBUSY _{2,3} (Note 2)	V_{OH}	4.0	–	5.0	V
Low level output signal voltage: SBUSY _{2,3} (Note 2)	V_{OL}	0.0	–	0.6	V

Notes:

1) A 50uS surge current of up to 10X I_{CC} can occur at power-up on V_{CC} . However, the exact peak amplitude and duration of surge current is dependent on the characteristics of the host power supply.

2) $R_{LOAD} = 3K\Omega$ to GND



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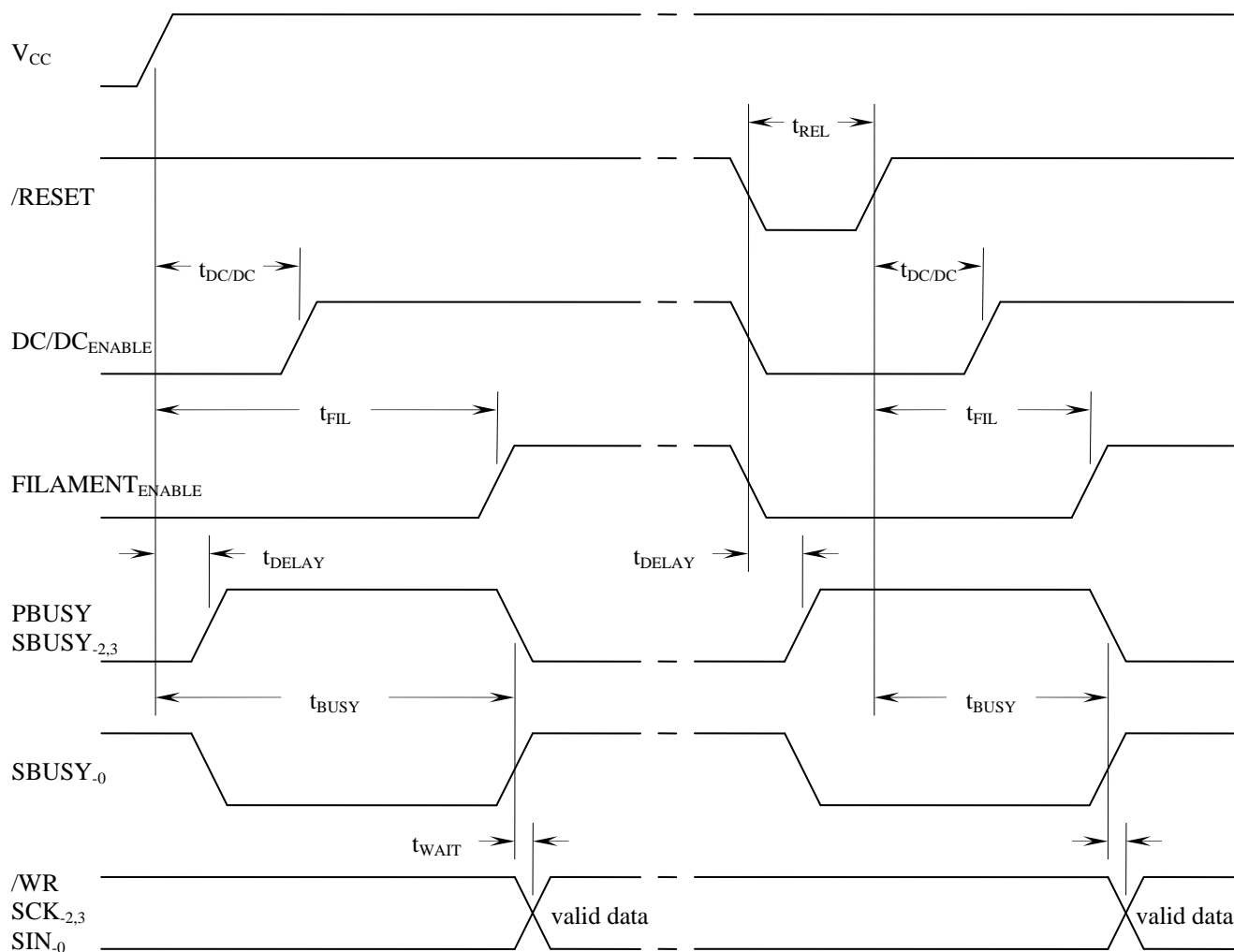
6.5 RESET TIMING SPECIFICATIONS

The module is reset automatically at power-up or by an external /RESET pulse. The module initializes to the same conditions as after the Initialize Display command, plus the input buffer is cleared.

Item	Symbol	Min.	Typ.	Max.	Unit
Delay from power-up or reset to DC/DC on	$t_{DC/DC}$	-	25	-	ms
Delay from power-up or reset to filament on	t_{FIL}	-	25	-	ms
Delay from power-up or reset to busy	t_{DELAY}	-	-	2	μs
/RESET low time	t_{REL}	2.5	-	-	μs
Busy time during initialization	t_{BUSY}	-	-	50	ms
Wait time before command byte	t_{WAIT}	0	-	s	ms

Notes:

- 1) All timing is specified using 20% and 80% of V_{CC} as the reference points.



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6.6 SERIAL INTERFACE SPECIFICATIONS

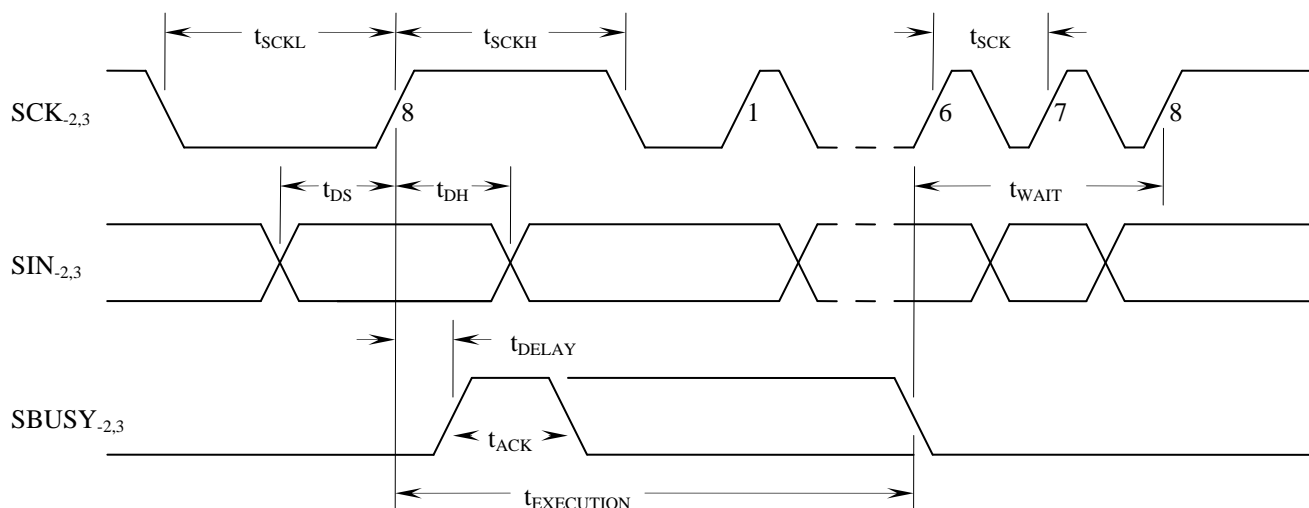
Three serial interface options are available in the NAGP1250xx-x module series; CMOS level synchronous, CMOS level asynchronous and RS-232 level asynchronous. The options and baud rates are selected by module part number and jumper settings.

A 255 byte input buffer allows data to be sent to the module without monitoring the SBUSY output. However, the buffer may overflow if too many commands with long execution times are sent without waiting for them to execute. The SBUSY outputs an ACK pulse after each byte is received and remains active if the buffer is almost full indicating a busy condition. SBUSY remains active when the buffer can hold 16 or less additional bytes, this allows a host's 16 byte transmit buffer to be flushed without overflowing the input buffer.

Item	Symbol	Min.	Typ.	Max.	Unit
SCK frequency	$1 / t_{SCK}$	-	-	2.45	MHz
SCK low time	t_{SCKL}	163	-	-	ns
SCK high time	t_{SCKH}	163	-	-	ns
SIN setup time	t_{DS}	50	-	-	ns
SIN hold time	t_{DH}	50	-	-	ns
Delay time before SBUSY ACK pulse (Note 2)	t_{DELAY}	-	-	60	μ s
SBUSY ACK pulse width	t_{ACK}	2.5	4.0	10.5	μ s
Command execution time	$t_{EXEC.}$	See Command and Characters Section			
Wait time before next command byte (Note 2)	t_{WAIT}	0		-	s

Notes:

- 1) All timing is specified using 20% and 80% of V_{CC} as the reference points.
- 2) Up to 20Khz data rate can be achieved by monitoring SBUSY in synchronous mode, data rate is limited by the baud rate in asynchronous mode.



CMOS level synchronous serial interface NAGP1250xx-2 and NAGP1250xx-3 (J2 shorted)

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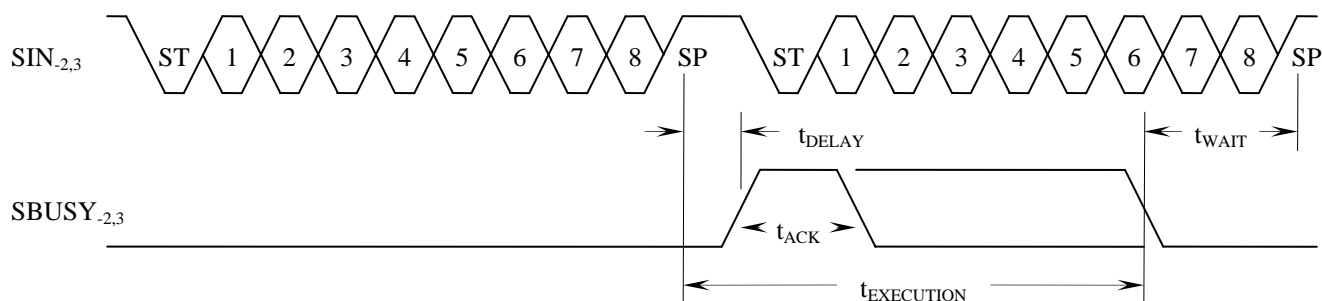
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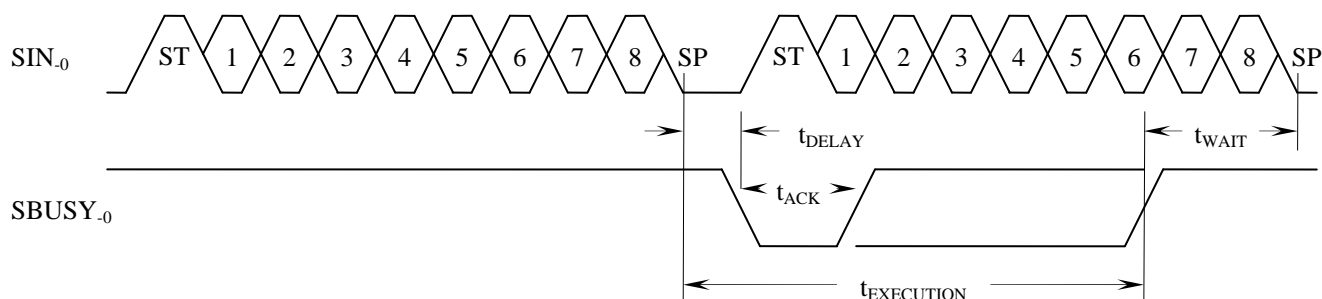
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CMOS level asynchronous serial interface NAGP1250xx-2 and NAGP1250xx-3 (J2 open)



RS-232 level asynchronous serial interface NAGP1250xx-0 (J2 open)

Asynchronous Parameter	Value
Baud rate	9600, 19200, 38400, 115200
Parity	no parity
Format	start (1 bit) + data (8 bits) + stop (1 bit)
Handshake	SBUSY

6.7 PARALLEL INTERFACE SPECIFICATIONS

The parallel interface option is available on NAGP1250xx-0 and NAGP1250xx-2 modules. The parallel interface consists of an 8-bit data bus and /WR and /RD control inputs. Only bit D7 is bi-directional and is used to monitor the PBUSY output. PBUSY can also be read directly from a separate pin when jumper JB is shorted.

A 255 byte input buffer allows data to be sent to the module without monitoring the PBUSY output. However, the buffer may overflow if too many commands with long execution times are sent without waiting for them to execute. The PBUSY output goes high when data is latched in hardware by the rising edge of /WR, and goes low when data is read from the latch by the module software unless the buffer is almost full. PBUSY remains active when the buffer can only hold 16 or less additional bytes, indicating a busy condition, this allows a host's 16 byte transmit buffer to be flushed without overflowing the input buffer.

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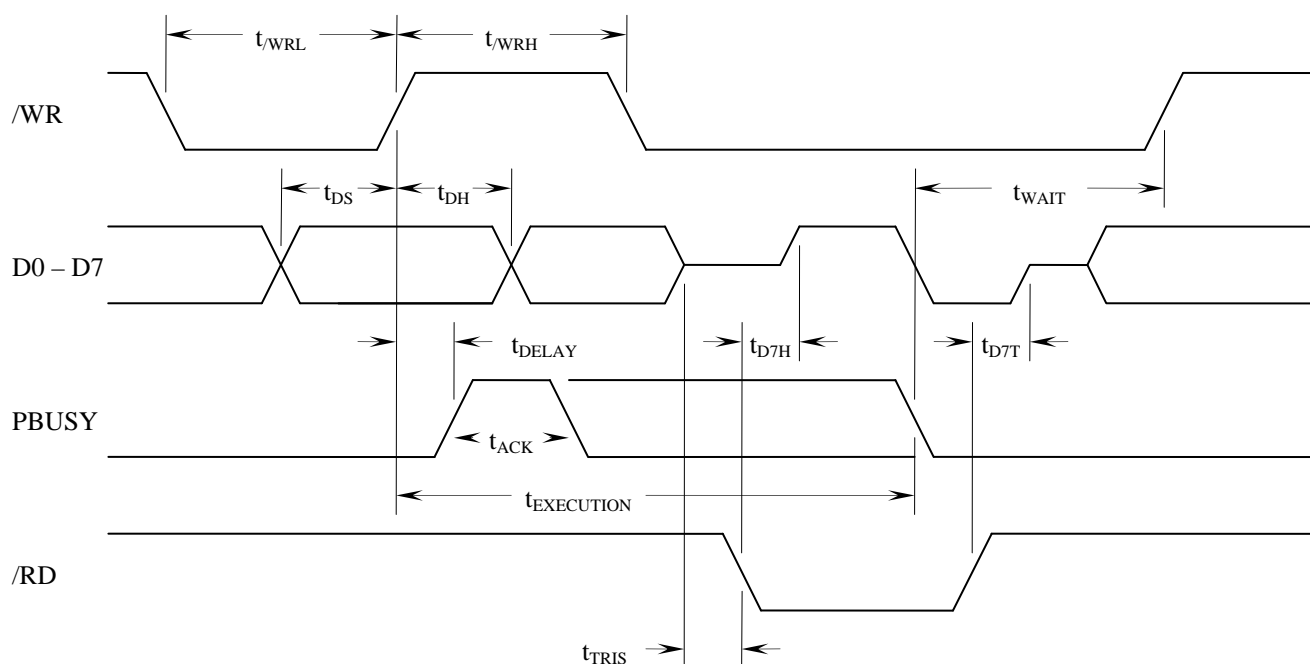
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Item	Symbol	Min.	Max.	Unit
/WR low time	t_{WRL}	5	-	ns
/WR high time	t_{WRH}	5	-	ns
Data setup time	t_{DS}	3	-	ns
Data hold time	t_{DH}	2	-	ns
Delay time before PBUSY high (Note 2)	t_{DELAY}	-	15	ns
D7 tri-state setup time	t_{TRIS}	0		s
Delay time after /RD low to PBUSY on D7	t_{D7H}		5.8	ns
Delay time after /RD high to D7 an input	t_{D7T}		5.0	ns
ACK pulse width	t_{ACK}	2.5	60	μ s
Command execution time	$t_{EXEC..}$	See Command and Characters Section		
Wait time before next command byte (Note 2)	t_{WAIT}	0	-	s

Notes:

- 1) All timing is specified using 20% and 80% of V_{CC} as the reference points.
- 2) Up to 20Khz data rate can be achieved by monitoring SBUSY in synchronous mode, data rate is limited by the baud rate in asynchronous mode.



Parallel interface NAGP1250xx-0 and NAGP1250xx-2

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6.8 DISPLAY MEMORY

The Display Memory consists of 280x4 vertical bytes (280x32 bits) with each byte addressed by an X and Y pointer. The Display Memory is divided into 2 areas, the Standard Memory area (0,0 to 139,3) and the Extended Memory area (140,0 to 279,3).

		X											
		0	1	---	---	138	139	140	141	---	---	278	279
Y	0	Standard Memory 140x4 bytes (140x32 bits)						Extended Memory 140x4 bytes (140x32 bits)					
	1												
	2												
	3												

Display Memory is 280x4 bytes (280x32 bits)

Pixel data stored in the Standard Memory area is displayed on the VFD. Pixel data stored in the Extended Memory area can be displayed by scrolling it into Standard Memory area using the Display Memory Scroll command. For example, scrolling Display Memory data by 140 columns (560 bytes) would instantly change the displayed image to the pixel data that was in the Extended Memory area, i.e. “page swap”. When scrolling pixel data from the Extended Memory area into the Standard Memory area, Standard Memory area data is scrolled back into the other end of the Extended Memory area (no data is lost).

6.9 WINDOWS

In addition to the Base Window, four User Windows can be defined anywhere in the Display Memory area (this includes the Extended Memory) and can overlap one another. Each window supports independent control and can be selected anytime.

6.9.1 BASE WINDOW

The Base Window (Window 0) is located either in the entire Standard Memory area between X,Y location 0,0 (upper left corner) and 139,3 (lower right corner), in the entire Extended Memory area between 140,0 and 279,3, or in the entire Display Memory area between 0,0 and 279,3.

6.9.2 USER WINDOWS

Each User Window (Window 1 to 4) is defined separately with an upper left corner and size anywhere within the Display Memory. User Windows can be re-defined anytime without affecting data stored in the Display Memory.

6.10 COMMANDS AND CHARACTERS

Commands are sent to the module in single-byte or multi-byte command packets and characters are sent to the module as single-byte packets. Command codes range from 00h to 1Fh and character codes from 20h to FFh.

Command Packet Byte 1								Command Packet Byte 2								---								Command Packet Byte N							
8-bit Command								8-bit Command Data								8-bit Command Data								8-bit Command Data							
C7	C6	C5	C4	C3	C2	C1	C0	D7	D6	D5	D4	D3	D2	D1	D0	D7	D6	D5	D4	D3	D2	D1	D0	D7	D6	D5	D4	D3	D2	D1	D0

8-bit Command:

CMD Code	Description	Execution Time
08h	Backspace	n/a (execution time is less than 50us)
09h	Horizontal Tab	n/a to 6.2ms depending on size, mode, and cursor position
0Ah	Line Feed	n/a (MD1 and MD3), n/a to 5.9ms (MD2)
0Bh	Home Position	n/a
0Ch	Clear Window	2.6ms (base), 96us to 4.4ms (user), 1.75ms (all memory)
0Dh	Carriage Return	n/a
10h	Select Window 0	n/a
11h	Select Window 1	n/a
12h	Select Window 2	n/a
13h	Select Window 3	n/a
14h	Select Window 4	n/a
1Bh + 25h	Select UDF Character Set	n/a
1Bh + 26h	Define UDF Character Set Characters	135us (End Character Code Byte), all others n/a
1Bh + 3Fh	Delete UDF Character Set Character	128us (single UDF character), 356us (all UDF characters)
1Bh + 40h	Initialize Display	2.11ms (when power supply is on), 256ms (when PS is off)
1Bh + 52h	Select Font Set (20h through 7Fh)	n/a
1Bh + 74h	Select Font Set (80h through FFh)	n/a
1Fh + 01h	Select Overwrite Mode (MD1)	n/a
1Fh + 02h	Select Vertical Scroll Mode (MD2)	n/a
1Fh + 03h	Select Horizontal Scroll Mode (MD3)	n/a
1Fh + 24h	Set Cursor Position	n/a
1Fh + 28h + 61h + 01h	Wait	0 to 127.5 seconds
1Fh + 28h + 61h + 10h	Display Memory Scroll	0 to 65 hours
1Fh + 28h + 61h + 11h	Display Blink	28ms to 30 minutes
1Fh + 28h + 61h + 40h	Screen Saver	n/a
1Fh + 28h + 66h + 11h	Graphic Image	n/a
1Fh + 28h + 67h + 03h	Select Character Width / Character Spacing	n/a
1Fh + 28h + 67h + 40h	Font Magnification	n/a
1Fh + 28h + 77h + 01h	Select Window	n/a
1Fh + 28h + 77h + 02h	Define User Window (Windows 1 to 4)	n/a
1Fh + 28h + 77h + 10h	Define Base Window (Window 0)	n/a
1Fh + 43h	Cursor On / Off	n/a
1Fh + 58h	Select Luminance Level	n/a
1Fh + 72h	Reverse Video Write Mode Enable / Disable	n/a
1Fh + 73h	Set Horizontal Scroll Speed	n/a
1Fh + 77h	Select Write Logic Mode	n/a
20h to FFh	Write Character	170us to 6.2ms depending on size, mode, and cursor position

Note: The module's 255 byte input buffer coupled with the maximum byte input rate of 20KHz (50us) in parallel and synchronous serial modes or 115,200 baud (87us) in asynchronous serial mode allow most commands to be sent without monitoring the Busy output. The Busy output may need to be monitored depending on how many commands with long execution times are sent at once to avoid overflowing the input buffer. The Busy output toggles when room for 16 bytes remains in the input buffer allowing a host's 16 byte transmission buffer to be flushed after a Busy is detected.

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6.10.1 BACKSPACE

This single-byte command packet backspaces the cursor one character position within the current window based on the current Cursor Mode (MD1, MD2, or MD3), the current Character Spacing and the current Font Magnification. This command only moves the cursor it does not erase any data.

Command Packet Byte 1							
8-bit Command 08h							
0	0	0	0	0	1	0	0

Width of the Backspace:

Character Spacing	Font Magnification X	Width of the Backspace (columns)
0 (space after each character)	1	6
	2	12
	3	18
	4	24
1 (space before and after each character)	1	7
	2	14
	3	21
	4	28

Backspace operation when Cursor Mode = Overwrite (MD1) or Vertical Scroll (MD2):

Font Magnification Y	X Direction	Y Direction	Backspace Operation
1, 2, 3 or 4 rows	Space is available on the current row for the Backspace.	---	1) The cursor moves to the left the Width of the Backspace.
	Space is not available on the current row for the Backspace.	Space is available for 1, 2, 3 or 4 rows above the current row. + Current window is wide enough for the Backspace.	1) The cursor moves to the column, the Width of the Backspace from the right end of the row 1, 2, 3 or 4 rows above the current row.
		Space is available for 1, 2, 3 or 4 rows above the current row. + Current window is not wide enough for the Backspace.	1) The cursor moves to the left end of the row 1, 2, 3 or 4 rows above the current row.
		Space is not available for 1, 2, 3 or 4 rows above the current row.	1) The cursor does not move.

Backspace operation when Cursor Mode = Horizontal Scroll (MD3):

Font Magnification Y	X Direction	Y Direction	Backspace Operation
1, 2, 3 or 4 rows	Space is available on the current row for the Backspace.	---	1) The cursor moves to the left the Width of the Backspace.
	Space is not available on the current row for the Backspace.	---	1) The cursor does not move.

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6.10.2 HORIZONTAL TAB

This single-byte command packet tabs the cursor one character position within the current window based on the current Cursor Mode (MD1, MD2, or MD3), the current Character Spacing and the current Font Magnification.

Command Packet Byte 1							
8-bit Command 09h							
0	0	0	0	1	0	0	1

Width of the Horizontal Tab:

Character Spacing	Font Magnification X	Width of the Tab (columns)
0 (space after each character)	1	6
	2	12
	3	18
	4	24
1 (space before and after each character)	1	7
	2	14
	3	21
	4	28

Horizontal Tab operation when Cursor Mode = Overwrite (MD1):

Font Magnification Y	X Direction	Y Direction	Horizontal Tab Operation
1, 2, 3 or 4 rows	Space is available on the current row for the Horizontal Tab.	---	1) The cursor moves to the right the Width of the Horizontal Tab.
	Space is not available on the current row for the Horizontal Tab.	Space is available for 1, 2, 3 or 4 rows below the current row.	1) The cursor moves to the left end of the row 1, 2, 3 or 4 rows below the current row.
		Space is not available for 1, 2, 3 or 4 rows below the current row.	1) The cursor moves to the left end of the top row.

Horizontal Tab operation when Cursor Mode = Vertical Scroll (MD2):

Font Magnification Y	X Direction	Y Direction	Horizontal Tab Operation
1, 2, 3 or 4 rows	Space is available on the current row for the Horizontal Tab.	---	1) The cursor moves to the right the Width of the Horizontal Tab.
	Space is not available on the current row for the Horizontal Tab.	Space is available for 1, 2, 3 or 4 rows below the current row.	1) The cursor moves to the left end of the row 1, 2, 3 or 4 rows below the current row.
		Space is not available for 1, 2, 3 or 4 rows below the current row.	1) The displayed pattern is scrolled up 1, 2, 3 or 4 rows while clearing the bottom 1, 2, 3 or 4 rows. 2) The cursor moves to the left end of the current row.

Horizontal Tab operation when Cursor Mode = Horizontal Scroll (MD3):

Font Magnification Y	X Direction	Y Direction	Horizontal Tab Operation
1, 2, 3 or 4 rows	Space is available on the current row for the Horizontal Tab.	---	1) The cursor moves to the right the Width of the Horizontal Tab.
	Space is not available on the current row for the Horizontal Tab.	---	1) The displayed pattern on the cursor row and the 1, 2 or 3 rows below are scrolled left, clearing the rightmost columns, to make room for the Horizontal Tab. 2) The cursor moves to the right end of the current row.

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6.10.3 LINE FEED

This single-byte command packet performs a Line Feed. The cursor moves to a new row within the current window based on the current Cursor Mode (MD1, MD2, or MD3) and the current Font Magnification.

Command Packet Byte 1							
8-bit Command 0Ah							
0	0	0	0	1	0	1	0

Line Feed operation when Cursor Mode = Overwrite (MD1):

Font Magnification Y	X Direction	Y Direction	Line Feed Operation
1, 2, 3 or 4 rows	---	Space is available for 1, 2, 3 or 4 rows below the current row.	1) The cursor moves down 1, 2, 3 or 4 rows and remains in the same column.
	---	Space is not available for 1, 2, 3 or 4 rows below the current row.	1) The cursor moves to the top row and remains in the same column.

Line Feed operation when Cursor Mode = Vertical Scroll (MD2):

Font Magnification Y	X Direction	Y Direction	Line Feed Operation
1, 2, 3 or 4 rows	---	Space is available for 1, 2, 3 or 4 rows below the current row.	1) The cursor moves down 1, 2, 3 or 4 rows and remains in the same column.
	---	Space is not available for 1, 2, 3 or 4 rows below the current row.	1) The displayed pattern is scrolled up 1, 2, 3 or 4 rows while clearing the bottom 1, 2, 3 or 4 rows. 2) The cursor does not move.

Line Feed operation when Cursor Mode = Horizontal Scroll (MD3):

Font Magnification Y	X Direction	Y Direction	Line Feed Operation
1, 2, 3 or 4 rows	---	---	1) The cursor does not move.

6.10.4 HOME POSITION

This single-byte command packet sets the Cursor Position to the upper left hand corner of the currently selected Window.

Command Packet Byte 1							
8-bit Command 0Bh							
0	0	0	0	1	0	1	1

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6.10.5 CLEAR WINDOW

This single-byte command packet clears the Display Memory of the currently selected Window and sets the Cursor Position to the upper left hand corner.

Command Packet Byte 1							
8-bit Command 0Ch							
0	0	0	0	1	1	0	0

6.10.6 CARRIAGE RETURN

This single-byte command packet sets the Cursor Position to the leftmost column of the current row of the currently selected Window.

Command Packet Byte 1							
8-bit Command 0Dh							
0	0	0	0	1	1	0	1

6.10.7 SELECT WINDOW 0

This single-byte command packet selects Window 0 as the current Window.

Command Packet Byte 1							
8-bit Command 10h							
0	0	0	1	0	0	0	0

6.10.8 SELECT WINDOW 1

This single-byte command packet selects Window 1, if defined, as the current Window.

Command Packet Byte 1							
8-bit Command 11h							
0	0	0	1	0	0	0	1

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6.10.9 SELECT WINDOW 2

This single-byte command packet selects Window 2, if defined, as the current Window.

Command Packet Byte 1							
8-bit Command 12h							
0	0	0	1	0	0	1	0

6.10.10 SELECT WINDOW 3

This single-byte command packet selects Window 3, if defined, as the current Window.

Command Packet Byte 1							
8-bit Command 13h							
0	0	0	1	0	0	1	1

6.10.11 SELECT WINDOW 4

This single-byte command packet selects Window 4, if defined, as the current Window.

Command Packet Byte 1							
8-bit Command 14h							
0	0	0	1	0	1	0	0

6.10.12 SELECT UDF CHARACTER SET

This three-byte command packet selects the UDF Character Set to be used when writing a character to Display Memory. An entire font table, 20h through FFh, can be defined by using all 16 UDF characters of all 14 UDF Character Sets. To disable writing UDF characters, select UDF Character Set 0.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3
8-bit Command 1Bh	8-bit Command 25h	8-bit UDF Character Set
0 0 0 1 1 0 1 1	0 0 1 0 0 1 0 1	CS7 CS6 CS5 CS4 CS3 CS2 CS1 CS0

8-bit UDF Character Set (CS7:CS0):

0 UDF characters are disabled

1 to 14 UDF characters, if defined, are written to the display from this UDF Character Set

224 All UDF characters, defined or not, are combined into a single font table, 20h through FFh

0 <= CS value <= 14 or CS value = 224

Note: Invalid values are ignored.

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6.10.13 DEFINE UDF CHARACTER SET CHARACTERS

This multi-byte command packet defines up to 16 UDF characters in a UDF Character Set. The UDF characters are stored in volatile RAM and are undefined at power-up. The command terminates after all bytes are received or an error is detected.

Up to 16 UDF characters can be defined at once if the Character Codes for the UDF characters are numerically continuous. If not continuous, then a separate command needs to be used for each individual Character Code and/or group of Character Codes. Each of the UDF characters can be defined in either the 5x8 (which allows characters with descenders) or the 7x8 format.

After 16 UDF characters are defined in a UDF Character Set, any additional UDF characters must replace those already defined or some existing UDF characters must be deleted first.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3	Command Packet Byte 4
8-bit Command 1Bh	8-bit Command 26h	8-bit UDF Character Set	8-bit Start Character Code
0 0 0 1 1 0 1 1	0 0 1 0 0 1 1 0	CS7 CS6 CS5 CS4 CS3 CS2 CS1 CS0	S7 S6 S5 S4 S3 S2 S1 S0

Command Packet Byte 5	Command Packet Byte 6	Command Packet Byte 7	---
8-bit End Character Code	8-bit 1 ST UDF Character Size	8-bit 1 ST UDF Character Pixel Data	8-bit 1 ST UDF Character Pixel Data
E7 E6 E5 E4 E3 E2 E1 E0	Z7 Z6 Z5 Z4 Z3 Z2 Z1 Z0	D7 D6 D5 D4 D3 D2 D1 D0	D7 D6 D5 D4 D3 D2 D1 D0

Command Packet Byte 11 or 13	Command Packet Byte 12 or 14	Command Packet Byte 13 or 15	---
8-bit 1 ST UDF Character Pixel Data	8-bit 2 ND UDF Character Size	8-bit 2 ND UDF Character Pixel Data	8-bit UDF Character Pixel Data
D7 D6 D5 D4 D3 D2 D1 D0	Z7 Z6 Z5 Z4 Z3 Z2 Z1 Z0	D7 D6 D5 D4 D3 D2 D1 D0	D7 D6 D5 D4 D3 D2 D1 D0

Command Packet Byte N (up to 133)
8-bit Last UDF Character Pixel Data
D7 D6 D5 D4 D3 D2 D1 D0

8-bit UDF Character Set (CS7:CS0):

1 <= CS value <= 14

8-bit Start Character Code (S7:S0):

20h <= S value <= FFh

8-bit End Character Code (E7:E0):

S value <= E value <= FFh

8-bit UDF Character Size (Z7:Z0):

5 = Z value Selects 5x8 format

7 = Z value Selects 7x8 format

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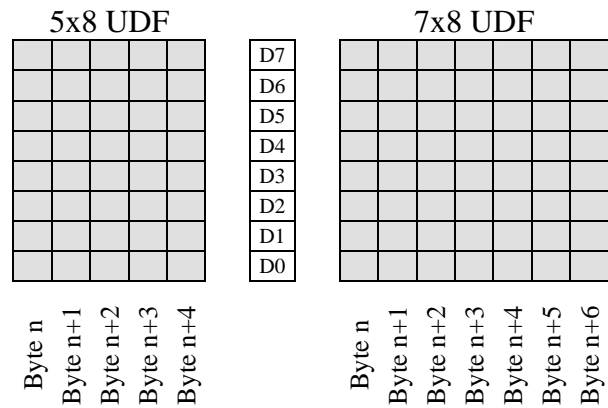
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8-bit UDF Character Pixel Data:



Note: An invalid value terminates the command packet at that byte. Subsequent bytes are considered part of the next command packet.

6.10.14 DELETE UDF CHARACTER SET CHARACTER

This four-byte command packet deletes a UDF character from a UDF Character Set.

Command Packet Byte 1								Command Packet Byte 2								Command Packet Byte 3								Command Packet Byte 4							
8-bit Command 1Bh								8-bit Command 3Fh								8-bit UDF Character Set								8-bit Character Code							
0	0	0	1	1	0	1	1	0	0	1	1	1	1	1	1	CS7	CS6	CS5	CS4	CS3	CS2	CS1	CS0	C7	C6	C5	C4	C3	C2	C1	C0

- 8-bit UDF Character Set (CS7:CS0):**
- 0 Deletes all UDF Character Set characters (This also terminates the command)
 - 1 to 14 Selects UDF Character Set to delete Character Code from
 - 0 <= CS value <= 14

- 8-bit Character Code (C7:C0):**
- 20h <= C value <= FFh

Note: An invalid value terminates the command packet at that byte. Subsequent bytes are considered part of the next command packet.

6.10.15 INITIALIZE DISPLAY

This two-byte command packet resets the module to the conditions listed below which are the same as at power-up. This command does not clear the 255 byte input buffer.

Command Packet Byte 1								Command Packet Byte 2							
8-bit Command 1Bh								8-bit Command 40h							
0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1

Reset Conditions:

- Entire Display Memory cleared (Standard and Extended)
- Base Window selected and defined from 0,0 to 139,3 with cursor at position 0,0
- All User Windows deleted
- Overwrite Mode (MD1) selected for all Windows
- Write Logic Mode set to normal
- Reverse Video Write Mode disabled
- Font Magnification set to 1x1
- Character Width / Spacing set to fixed width with left and right spaces
- Font Set 0 selected for both 20h through 7Fh and 80h through FFh characters
- All UDF characters deleted and UDF Character Set 0 selected (UDF's disabled)
- Luminance set to 100%
- Cursor off
- Horizontal Scroll Speed set to 0
- Display Blink canceled
- Switching power supply turned on

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6.10.16 SELECT FONT SET (20H THROUGH 7FH)

This three-byte command packet selects the International Font Set characters that replace a few of the Common Font Set characters between 20h and 7Fh.

Command Packet Byte 1									Command Packet Byte 2									Command Packet Byte 3							
8-bit Command 1Bh									8-bit Command 52h									8-bit Font Set							
0	0	0	1	1	0	1	1		0	1	0	1	0	0	1	1		n7	n6	n5	n4	n3	n2	n1	n0

8-bit Font Set (n7:n0):

n value	Font Set
00h	America
01h	France
02h	Germany
03h	England
04h	Denmark 1
05h	Sweden
06h	Italy

n value	Font Set
07h	Spain 1
08h	Japan
09h	Norway
0Ah	Denmark 2
0Bh	Spain 2
0Ch	Latin America
0Dh	Korea

Note: Invalid values are ignored.

6.10.16.1 INTERNATIONAL FONT SET

International Font Set (23H, 24H, 40H, 5BH - 5EH, 60H, 7BH - 7EH)														
	n=00H	n=01H	n=02H	n=03H	n=04H	n=05H	n=06H	n=07H	n=08H	n=09H	n=0AH	n=0BH	n=0CH	n=0DH
23H	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘
24H	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘
40H	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘
5BH	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘
5CH	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘
5DH	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘
5EH	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘
60H	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘
7BH	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘
7CH	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘
7DH	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘
7EH	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘	⌘

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6.10.16.2 COMMON FONT SET

Common Font Set (20H - 7FH)						
	2xH	3xH	4xH	5xH	6xH	7xH
x0H		0	a	P	^	P
x1H	!	1	B	Q	a	a
x2H	"	2	B	R	b	r
x3H	#	3	C	S	c	s
x4H	\$	4	D	T	d	t
x5H	%	5	E	U	e	u
x6H	&	6	F	V	f	v
x7H	*	7	G	W	g	w
x8H	(8	H	X	h	x
x9H)	9	I	Y	i	y
xAH	+	:	J	Z	z	z
xBH	+	:	K	C	k	c
xCH	.	<	L	\	l	l
xDH	-	=	M	I	m	i
xEH	.	>	N	^	n	n
xFH	/	?	O	_	o	o

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6.10.17 SELECT FONT SET (80H THROUGH FFH)

This three-byte command packet selects the Font Set for characters between 80h and FFh.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3
8-bit Command 1Bh	8-bit Command 74h	8-bit Font Set
00011011	01110100	n7n6n5n4n3n2n1n0

8-bit Font Set (n7:n0):

n value	Font Set
00h	PC437 (US – European)
01h	Katakana – Japanese
02h	PC850 (Multilingual)
03h	PC860 (Portuguese)
04h	PC863 (Canadian – French)
05h	PC865 Nordic
10h	WPC1252
11h	PC866 (Cyrillic #2)
12h	PC852 (Latin #2)
13h	PC858

Note: Invalid values are ignored.

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6.10.17.1 PC437 (US – EUROPEAN) AND KATAKANA – JAPANESE FONT SETS

PC437 (US - European) (80H - FFH)								
n=0	8xH	9xH	AxH	BxH	CxH	DxH	ExH	FxH
x0H								
x1H								
x2H								
x3H								
x4H								
x5H								
x6H								
x7H								
x8H								
x9H								
xAH								
xBH								
xCH								
xDH								
xEH								
xFH								

Katakana - Japanese (80H - FFH)								
n=1	8xH	9xH	AxH	BxH	CxH	DxH	ExH	FxH
x0H								
x1H								
x2H								
x3H								
x4H								
x5H								
x6H								
x7H								
x8H								
x9H								
xAH								
xBH								
xCH								
xDH								
xEH								
xFH								

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6.10.17.2 PC850 (MULTILINGUAL) AND PC860 (PORTUGUESE) FONT SETS

PC850 (Multilingual) (80H - FFH)								
n=2	8xH	9xH	AxH	BxH	CxH	DxH	ExH	FxH
x0H								
x1H								
x2H								
x3H								
x4H								
x5H								
x6H								
x7H								
x8H								
x9H								
xAH								
xBH								
xCH								
xDH								
xEH								
xFH								

PC860 (Portuguese) (80H - FFH)								
n=3	8xH	9xH	AxH	BxH	CxH	DxH	ExH	FxH
x0H								
x1H								
x2H								
x3H								
x4H								
x5H								
x6H								
x7H								
x8H								
x9H								
xAH								
xBH								
xCH								
xDH								
xEH								
xFH								

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6.10.17.3 PC863 (CANADIAN – FRENCH) AND PC865 (NORDIC) FONT SETS

PC863 (Canadian - French) (80H - FFH)								
n=4	8xH	9xH	AxH	BxH	CxH	DxH	ExH	FxH
x0H								
x1H								
x2H								
x3H								
x4H								
x5H								
x6H								
x7H								
x8H								
x9H								
xAH								
xBH								
xCH								
xDH								
xEH								
xFH								

PC865 (Nordic) (80H - FFH)								
n=5	8xH	9xH	AxH	BxH	CxH	DxH	ExH	FxH
x0H								
x1H								
x2H								
x3H								
x4H								
x5H								
x6H								
x7H								
x8H								
x9H								
xAH								
xBH								
xCH								
xDH								
xEH								
xFH								

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6.10.17.4 WP1252 AND PC866 (CYRILLIC #2) FONT SETS

WPC1252 (80H - FFH)								
n=16	8xH	9xH	AxH	BxH	CxH	DxH	ExH	FxH
x0H								
x1H								
x2H								
x3H								
x4H								
x5H								
x6H								
x7H								
x8H								
x9H								
xAH								
xBH								
xCH								
xDH								
xEH								
xFH								

PC866 (Cyrillic #2) (80H - FFH)								
n=17	8xH	9xH	AxH	BxH	CxH	DxH	ExH	FxH
x0H								
x1H								
x2H								
x3H								
x4H								
x5H								
x6H								
x7H								
x8H								
x9H								
xAH								
xBH								
xCH								
xDH								
xEH								
xFH								

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6.10.17.5 PC852 (LATIN #2) AND PC858 FONT SETS

PC852 (Latin #2) (80H - FFH)								
n=18	8xH	9xH	AxH	BxH	CxH	DxH	ExH	FxH
x0H								
x1H								
x2H								
x3H								
x4H								
x5H								
x6H								
x7H								
x8H								
x9H								
xAH								
xBH								
xCH								
xDH								
xEH								
xFH								

PC858 (80H - FFH)								
n=19	8xH	9xH	AxH	BxH	CxH	DxH	ExH	FxH
x0H								
x1H								
x2H								
x3H								
x4H								
x5H								
x6H								
x7H								
x8H								
x9H								
xAH								
xBH								
xCH								
xDH								
xEH								
xFH								

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6.10.18 SELECT OVERWRITE MODE (MD1)

This two-byte command packet selects the Overwrite Mode (MD1) for the currently selected Window.

Command Packet Byte 1								Command Packet Byte 2							
8-bit Command 1Fh								8-bit Command 01h							
0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	1

6.10.19 SELECT VERTICAL SCROLL MODE (MD2)

This two-byte command packet selects the Vertical Scroll Mode (MD2) for the currently selected Window.

Command Packet Byte 1								Command Packet Byte 2							
8-bit Command 1Fh								8-bit Command 02h							
0	0	0	1	1	1	1	1	0	0	0	0	0	0	1	0

6.10.20 SELECT HORIZONTAL SCROLL MODE (MD3)

This two-byte command packet selects the Horizontal Scroll Mode (MD3) for the currently selected Window.

Command Packet Byte 1								Command Packet Byte 2							
8-bit Command 1Fh								8-bit Command 03h							
0	0	0	1	1	1	1	1	0	0	0	0	0	0	1	1

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6.10.21 SET CURSOR POSITION

This six-byte command packet sets the Cursor Position within the currently selected Window. The address of a Window's upper left corner is 0,0 for Windows 1 through 4 and either 0,0 or 140,0 for Window 0 depending on how it is defined.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3	Command Packet Byte 4
8-bit Command 1Fh	8-bit Command 24h	8-bit X Cursor Position – Low Byte	8-bit X Cursor Position – High Byte
00011111	00100100	X7X6X5X4X3X2X1X0	X15X14X13X12X11X10X9X8

Command Packet Byte 5	Command Packet Byte 6
8-bit Y Cursor Position – Low Byte	8-bit Y Cursor Position – High Byte
Y7Y6Y5Y4Y3Y2Y1Y0	Y15Y14Y13Y12Y11Y10Y9Y8

16-bit X Cursor Position (X15:X0):

Valid X Cursor Positions are based on the size of the currently selected window.

16-bit Y Cursor Position (Y15:Y0):

Valid Y Cursor Positions are based on the size of the currently selected window.

Note: After all command packet bytes are received, invalid values cause entire command packet to be ignored.

6.10.22 WAIT

This five-byte command packet is a waste of time. Command execution halts until the Wait Time elapses.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3	Command Packet Byte 4
8-bit Command 1Fh	8-bit Command 28h	8-bit Command 61h	8-bit Command 01h
00011111	00101000	01100001	00000001

Command Packet Byte 5
8-bit Wait Time
W7W6W5W4W3W2W1W0

8-bit Wait Time (W7:W0):

Wait Time is approximately $0.5s * W$.

$0 \leq W \text{ value} \leq 255$

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6.10.23 DISPLAY MEMORY SCROLL

This nine-byte command packet sets the display scrolling parameters. The Display Memory will scroll, any number of columns, repeatedly, at the Scroll Speed. Command execution halts while scrolling.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3	Command Packet Byte 4
8-bit Command 1Fh	8-bit Command 28h	8-bit Command 61h	8-bit Command 10h
0001111	00101000	01100001	00010000

Command Packet Byte 5	Command Packet Byte 6	Command Packet Byte 7	Command Packet Byte 8
8-bit Number of Column Bytes to Scroll Low Byte	8-bit Number of Column Bytes to Scroll High Byte	8-bit Number of Repetitions Low Byte	8-bit Number of Repetitions High Byte
C7C6C5C4C3C2C1C0	C15C14C13C12C11C10C9C8	R7R6R5R4R3R2R1R0	R15R14R13R12R11R10R9R8

Command Packet Byte 9
5-bit Scroll Speed
S7S6S5S4S3S2S1S0

16-bit Number of Column Bytes to Scroll (C15:C0):

This number specifies how many Column Bytes to scroll Display Memory for each repetition. This number should be a multiple of 4 since there are 4 bytes of Display Memory per display column.

0 ≤ C value ≤ 1119

16-bit Number of Repetitions (R15:R0):

This number specifies how many times to repeat the scroll.

1 ≤ R value ≤ 65535

8-bit Scroll Speed (S7:S0):

Scroll Speed is approximately 14ms * S per repetition.

0 ≤ S value ≤ 255

Note: An invalid value terminates the command packet at that byte. Subsequent bytes are considered part of the next command packet.

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6.10.24 DISPLAY BLINK

This eight-byte command packet sets the display blinking parameters. The display will repeat the Normal / Blink Pattern cycle at the blink rate set by T_1 and T_2 indefinitely, or by the Number of Repetitions specified.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3	Command Packet Byte 4
8-bit Command 1Fh	8-bit Command 28h	8-bit Command 61h	8-bit Command 11h
0 0 0 1 1 1 1 1	0 0 1 0 1 0 0 0	0 1 1 0 0 0 0 1	0 0 0 1 0 0 0 1

Command Packet Byte 5	Command Packet Byte 6	Command Packet Byte 7	Command Packet Byte 8
8-bit Blink Pattern	8-bit T_1 = Time of Normal Pattern	8-bit T_2 = Time of Blink Pattern	8-bit Number of Repetitions
P7 P6 P5 P4 P3 P2 P1 P0	T ₁ 7 T ₁ 6 T ₁ 5 T ₁ 4 T ₁ 3 T ₁ 2 T ₁ 1 T ₁ 0	T ₂ 7 T ₂ 6 T ₂ 5 T ₂ 4 T ₂ 3 T ₂ 2 T ₂ 1 T ₂ 0	R7 R6 R5 R4 R3 R2 R1 R0

8-bit Blink Pattern (P7:P0):

- 0 Normal display pattern during period T_2
- 1 Blank display pattern during period T_2
- 2 Reverse Video display pattern during period T_2
- $0 \leq P \text{ value} \leq 2$

8-bit Time of Normal Pattern (T₁7:T₁0):

- Normal Pattern is displayed approximately $14\text{ms} * T_1$ per cycle.
- $1 \leq T_1 \text{ value} \leq 255$

8-bit Time of Blink Pattern (T₂7:T₂0):

- Blink Pattern is displayed approximately $14\text{ms} * T_2$ per cycle.
- $1 \leq T_2 \text{ value} \leq 255$

8-bit Number of Repetitions (R7:R0):

- This number specifies how many times to repeat the Normal / Blink Pattern cycle.
- 0 Command execution continues and the cycle repeats until the Number of Repetitions is changed by another Display Blink command or the Initialize command. Command execution is not interrupted.
- >0 Command execution halts until the Number of Repetitions is reached.
- $0 \leq R \text{ value} \leq 255$

Note: An invalid value terminates the command packet at that byte. Subsequent bytes are considered part of the next command packet.

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6.10.25 SCREEN SAVER

This five-byte command packet sets the Screen Saver parameters.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3	Command Packet Byte 4
8-bit Command 1Fh	8-bit Command 28h	8-bit Command 61h	8-bit Command 40h
00011111	00101000	01100001	01000000

Command Packet Byte 5
8-bit Screen Saver Mode
SS7SS6SS5SS4SS3SS2SS1SS0

8-bit Blink Pattern (SS7:SS0):

- 0 Turns off module's internal switching power supply.
 - 1 Turns on module's internal switching power supply.
 - 2 Turns all display dots off (Display Memory is not affected).
 - 3 Turns on all display dots (Display Memory is not affected).
 - 4 Alternates between all dots on and reverse video display patterns every 2 seconds.
- 0 <= SS value <= 4

Note: Invalid values are ignored.

6.10.26 GRAPHIC IMAGE

This multi-byte command packet writes a Graphic Image to Display Memory within the currently selected Window starting from the current cursor location. Only the portion of the Graphic Image that fits within the currently selected Window is written to Display Memory.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3	Command Packet Byte 4
8-bit Command 1Fh	8-bit Command 28h	8-bit Command 66h	8-bit Command 11h
00011111	00101000	01100110	00010001

Command Packet Byte 5	Command Packet Byte 6	Command Packet Byte 7	Command Packet Byte 8
8-bit Image Size X Low Byte	8-bit Image Size X High Byte	8-bit Image Size Y Low Byte	8-bit Image Size Y High Byte
X7X6X7X6X7X6X7X6	X15X14X13X12X11X10X9X8	Y7Y6Y5Y4Y3Y2Y1Y0	Y15Y14Y13Y12Y11Y10Y9Y8

Command Packet Byte 9	Command Packet Byte 10	---	Command Packet Byte N
8-bit Image Mode	8-bit Image Data	8-bit Image Data	8-bit Image Data
IM7IM6IM5IM4IM3IM2IM1IM0	D7D6D5D4D3D2D1D0	D7D6D5D4D3D2D1D0	D7D6D5D4D3D2D1D0

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16-bit Image Size X (X15:X0):

This is the number of columns in the Graphic Image.

1 <= X value <= 280

16-bit Image Size Y (Y15:Y0):

This is the number of rows in the Graphic Image.

1 <= Y value <= 4

8-bit Image Mode (IM7:IM0):

1 Fixed Mode

1 <= IM value <= 1

8-bit Image Data (D7:D0):

The Graphic Image is written to Display Memory as the Image Data bytes are received starting from the current cursor location filling each row of a column of the Graphic Image from top to bottom, from the left to the right column. The MSB of Image data represents the upper pixel of each byte in a column.

0 <= D value <= 255

Note: An invalid value terminates the command packet at that byte. Subsequent bytes are considered part of the next command packet.

6.10.27 SELECT CHARACTER WIDTH / CHARACTER SPACING

This five-byte command packet selects the Character Width and Charter Spacing to be used when writing characters to Display Memory.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3	Command Packet Byte 4
8-bit Command 1Fh	8-bit Command 28h	8-bit Command 67h	8-bit Command 03h
0 0 0 1 1 1 1 1	0 0 1 0 1 0 0 0	0 1 1 0 0 1 1 1	0 0 0 0 0 0 1 1

Command Packet Byte 5
8-bit Width / Spacing
D7 D6 D5 D4 D3 D2 D1 D0

8-bit Width / Spacing (D7:D0):

0 Fixed Character Width and a space on the right side of each character.

1 Fixed Character Width and a space on the left and right sides of each character.

2 Proportional Character Width and a space on the right side of each character.

3 Proportional Character Width and a space on the left and right sides of each character.

0 <= D value <= 3

Note: Invalid values are ignored.

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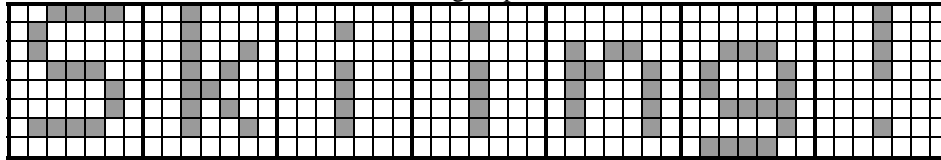
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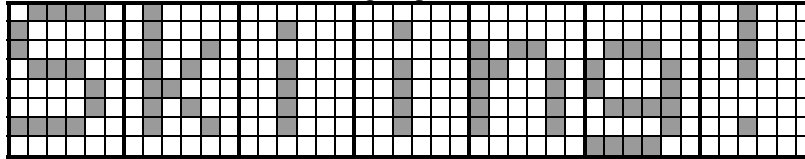
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6.10.27.1 CHARACTER WIDTH / CHARACTER SPACING EXAMPLES

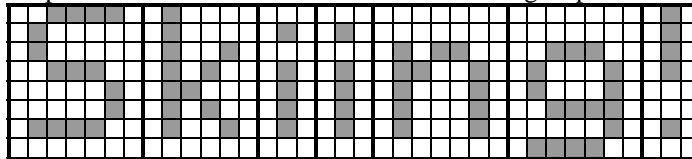
Fixed 5x7 character width with left and right spaces



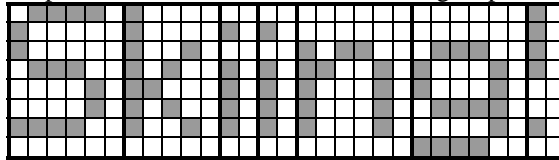
Fixed 5x7 character width with right space



Proportional 5x7 character width with left and right spaces



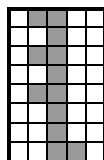
Proportional 5x7 character width with right space



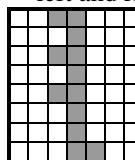
Note:

- 1) The descender of the lower case "g" requires a 5x8 UDF charcter.

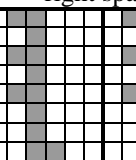
5x8
UDF



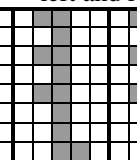
Fixed Width
with
left and right spaces



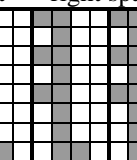
Fixed Width
with
right space



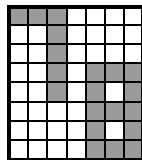
Proportional
with
left and right



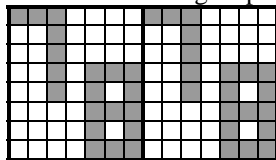
Proportional
with
right space



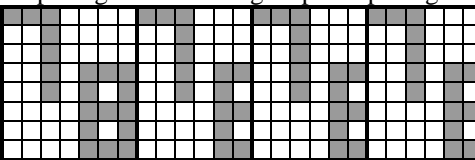
7x8 UDF



with left and right space spacing



with right space spacing



Notes:

- 1) Only the left most 6 columns of a 7x8 UDF are displayed with right space spacing.
- 2) Fixed / Proportional Width setting is ignored by 7x8 UDF characters.

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6.10.28 FONT MAGNIFICATION

This six-byte command packet selects the Font Magnification X and Y values to be used when writing characters to Display Memory.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3	Command Packet Byte 4
8-bit Command 1Fh	8-bit Command 28h	8-bit Command 67h	8-bit Command 40h
0001111	00101000	01100111	01000000

Command Packet Byte 5	Command Packet Byte 6
8-bit Font Magnification X	8-bit Font Magnification Y
X7X6X5X4X3X2X1X0	Y7Y6Y5Y4Y3Y2Y1Y0

8-bit Font Magnification X (X7:X0):

1 <= X value <= 4

8-bit Font Magnification Y (Y7:Y0):

1 <= Y value <= 4

Note: After all command packet bytes are received, invalid values are ignored.

6.10.29 SELECT WINDOW

This five-byte command packet selects a Window, if defined, as the current Window. Window 0 is always defined.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3	Command Packet Byte 4
8-bit Command 1Fh	8-bit Command 28h	8-bit Command 77h	8-bit Command 01h
0001111	00101000	01101111	00000001

Command Packet Byte 5
8-bit Window Number
W7W6W5W4W3W2W1W0

8-bit Window Number (W7:W0):

0 <= W value <= 4

Note: Invalid values are ignored.

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6.10.30 DEFINE USER WINDOW (WINDOWS 1 TO 4)

This fourteen-byte command packet defines a User Window. The Cursor Position of the new Window is automatically set to 0,0. The Cursor Control Mode, MD1, MD2, MD3 of the Window is not affected.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3	Command Packet Byte 4
8-bit Command 1Fh	8-bit Command 28h	8-bit Command 77h	8-bit Command 02h
0 0 0 1 1 1 1 1	0 0 1 0 1 0 0 0	0 1 1 1 0 1 1 1	0 0 0 0 0 0 1 0

Command Packet Byte 5	Command Packet Byte 6	Command Packet Byte 7	Command Packet Byte 8
8-bit Window Number	8-bit Define / Delete	8-bit Upper Left Corner X Position Low Byte	8-bit Upper Left Corner X Position High Byte
W7 W6 W5 W4 W3 W2 W1 W0	D7 D6 D5 D4 D3 D2 D1 D0	X7 X6 X5 X4 X3 X2 X1 X0	X15 X14 X13 X12 X11 X10 X9 X8

Command Packet Byte 9	Command Packet Byte 10	Command Packet Byte 11	Command Packet Byte 12
8-bit Upper Left Corner Y Position Low Byte	8-bit Upper Left Corner Y Position High Byte	8-bit Window Size X Low Byte	8-bit Window Size X High Byte
Y7 Y6 Y5 Y4 Y3 Y2 Y1 Y0	Y15 Y14 Y13 Y12 Y11 Y10 Y9 Y8	X7 X6 X5 X4 X3 X2 X1 X0	X15 X14 X13 X12 X11 X10 X9 X8

Command Packet Byte 13	Command Packet Byte 14
8-bit Window Size Y Low Byte	8-bit Window Size Y High Byte
Y7 Y6 Y5 Y4 Y3 Y2 Y1 Y0	Y15 Y14 Y13 Y12 Y11 Y10 Y9 Y8

8-bit Window Number (W7:W0):

1 <= W value <= 4 (Invalid values terminate the command.)

8-bit Define / Delete (D7:D0):

0 Delete Window (If current Window is deleted, Window 0 becomes the current Window. This also terminates the command. Invalid values terminate the command.)

1 Define Window

0 <= D value <= 1

16-bit Upper Left Corner X Position (X15:X0):

0 <= X value <= 279

16-bit Upper Left Corner Y Position (Y15:Y0):

0 <= Y value <= 3

16-bit Window Size X (X15:X0):

1 <= X value <= 280

16-bit Window Size Y (Y15:Y0):

1 <= Y value <= 4

Note: After all command packet bytes are received, invalid values or if the Window does not fit in Display Memory cause entire command packet to be ignored.

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6.10.31 DEFINE BASE WINDOW (WINDOW 0)

This five-byte command packet defines Window 0's size, either 140x32 or 280x32.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3	Command Packet Byte 4
8-bit Command 1Fh	8-bit Command 28h	8-bit Command 77h	8-bit Command 10h
0001111	00101000	01110111	00010000

Command Packet Byte 13
8-bit Window 0 Size
Z7Z6Z5Z4Z3Z2Z1Z0

8-bit Window 0 Size (Z7:Z0):

- 0 Use either the Standard Memory area or the Extended Memory area for Window 0. Whichever area Window 0's cursor is in becomes the defined area for Window 0, even when using the Set Cursor Position command to move the cursor to the opposite area.
 - 1 Use both the Standard Memory and Extended Memory areas for Window 0.
- 0 <= Z value <= 1

Note: Invalid values are ignored.

6.10.32 CURSOR ON / OFF

This three-byte command packet turns the cursor on or off. When the cursor is on, it blinks at about 1Hz.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3
8-bit Command 1Fh	8-bit Command 43h	8-bit Cursor On / Off
0001111	01000011	C7C6C5C4C3C2C1C0

8-bit UDF Cursor On / Off (C7:C0):

- 0 Cursor off.
 - 1 Cursor on.
- 0 <= C value <= 1

Note: Invalid values are ignored.

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6.10.33 SELECT LUMINANCE LEVEL

This three-byte command packet sets the display luminance to one of eight levels.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3
8-bit Command 1Fh	8-bit Command 58h	8-bit Luminance Level
00011111	01011000	L7L6L5L4L3L2L1L0

8-bit Luminance Level (L7:L0):

- 1 12.5%
- 2 25%
- 3 37.5%
- 4 50%
- 5 62.5%
- 6 75%
- 7 87.5%
- 8 100%
- 1 <= L value <= 8

Note: Invalid values are ignored.

6.10.34 REVERSE VIDEO WRITE MODE ENABLE / DISABLE

This three-byte command packet enables / disables the Reverse Video Write Mode. When enabled, all data written to Display Memory is logically inverted.

Command Packet Byte 1	Command Packet Byte 2	Command Packet Byte 3
8-bit Command 1Fh	8-bit Command 72h	8-bit Reverse Video Write Mode
00011111	01110010	R7R6R5R4R3R2R1R0

8-bit Reverse Video Write Mode (R7:R0):

- 0 Disabled
- 1 Enabled
- 0 <= R value <= 1

Note: Invalid values are ignored.

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6.10.35 SET HORIZONTAL SCROLL SPEED

This three-byte command packet sets the Horizontal Scroll Speed for the MD3 mode.

Command Packet Byte 1								Command Packet Byte 2								Command Packet Byte 3							
8-bit Command 1Fh								8-bit Command 73h								8-bit Horizontal Scroll Speed							
0	0	0	1	1	1	1	1	0	1	1	1	0	0	1	1	S7	S6	S5	S4	S3	S2	S1	S0

8-bit Horizontal Scroll Speed (S7:S0):

Horizontal Scroll Speed is approximately $S * 14\text{ms}$ per column.

$0 \leq S \text{ value} \leq 31$

Note: Invalid values are ignored.

6.10.36 SELECT WRITE LOGIC MODE

This three-byte command packet selects the Write Logic Mode. As character data or graphic data is written it is logically combined with the data already in the Display Memory.

Command Packet Byte 1								Command Packet Byte 2								Command Packet Byte 3							
8-bit Command 1Fh								8-bit Command 77h								8-bit Write Logic Mode							
0	0	0	1	1	1	1	1	0	1	1	1	0	1	1	1	L7	L6	L5	L4	L3	L2	L1	L0

8-bit Write Logic Mode (L7:L0):

0 Normal (overwrites existing data)

1 OR (combines new and existing data)

2 AND (masks existing data)

3 XOR (inverts existing data when new data is 0xFF)

$0 \leq L \text{ value} \leq 3$

Note: Invalid values are ignored.

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6.10.37 WRITE CHARACTER

This single-byte command packet writes the specified character to Display Memory at the Cursor Position in the currently selected Window based on the current Cursor Mode (MD1, MD2, or MD3), the current Character Width and Spacing and the current Font Magnification. The character is taken from selected Font Set unless it is redefined and enabled as a UDF.

Command Packet Byte 1							
8-bit Character Number 20h to FFh							
C7	C6	C5	C4	C3	C2	C1	C0

Write Character operation when Cursor Mode = Overwrite (MD1):

Font Magnification Y	X Direction	Y Direction	Write Character Operation
1, 2, 3 or 4 rows	Space is available on the current row for the character and the cursor.	---	1) The character is written at the current cursor position. 2) The cursor moves to the right of the new character.
	Space is available on the current row for the character but not the cursor.	Space is available for 1, 2, 3 or 4 rows below the current row.	1) The character is written at the current cursor position. 2) The cursor moves to the left end of the row 1, 2, 3 or 4 rows below the current row.
		Space is not available for 1, 2, 3 or 4 rows below the current row.	1) The character is written at the current cursor position. 2) The cursor moves to the left end of the top row.
	Space is available at the left end of a row for the character and the cursor.	Space is available for 1, 2, 3 or 4 rows below the current row.	1) The character is written at the left end of the row 1, 2, 3 or 4 rows below the current row. 2) The cursor moves to the right of the new character.
		Space is not available for 1, 2, 3 or 4 rows below the current row.	1) The character is written at the left end of the top row. 2) The cursor moves to the right of the new character.
	Space is available at the left end of a row for the character but not the cursor.	Space is available for 1, 2, 3 or 4 rows below the current row and space is available for 1, 2, 3 or 4 rows below that.	1) The character is written at the left end of the row 1, 2, 3 or 4 rows below the current row. 2) The cursor moves to the left end of the row 1, 2, 3 or 4 rows below the new character.
		Space is available for 1, 2, 3 or 4 rows below the current row but space is not available for 1, 2, 3 or 4 rows below that.	1) The character is written at the left end of the row 1, 2, 3 or 4 rows below the current row. 2) The cursor moves to the left end of the top row.
		Space is not available for 1, 2, 3 or 4 rows below the current row but space is available for 1, 2, 3 or 4 rows below the top 1, 2, 3 or 4 rows.	1) The character is written at the left end of the top row. 2) The cursor moves to the left end of the row 1, 2, 3 or 4 rows the new character.
		Space is not available for 1, 2, 3 or 4 rows below the current row and space is not available for 1, 2, 3 or 4 rows below the top 1, 2, 3 or 4 rows.	1) The character is written at the left end of the top row. 2) The cursor moves to the left end of the top row.
	Space is not available for the character.	Space is available for 1, 2, 3 or 4 rows below the current row.	1) The cursor moves to the left end of the row 1, 2, 3 or 4 rows below the current row.
		Space is not available for 1, 2, 3 or 4 rows below the current row.	1) The cursor moves to the right of the top row.

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Write Character operation when Cursor Mode = Vertical Scroll (MD2):

Font Magnification Y	X Direction	Y Direction	Write Character Operation
1, 2, 3 or 4 rows	Space is available on the current row for the character and the cursor.	---	1) The character is written at the current cursor position. 2) The cursor moves to the right of the new character.
	Space is available on the current row for the character but not the cursor.	Space is available for 1, 2, 3 or 4 rows below the current row.	1) The character is written at the current cursor position. 2) The cursor moves to the left end of the row 1, 2, 3 or 4 rows below the current row.
		Space is not available for 1, 2, 3 or 4 rows below the current row.	1) The character is written at the current cursor position. 2) The displayed pattern is scrolled up 1, 2, 3 or 4 rows while clearing the bottom 1, 2, 3 or 4 rows. 3) The cursor moves to the left end of the current row.
	Space is available at the left end of a row for the character and the cursor.	Space is available for 1, 2, 3 or 4 rows below the current row.	1) The character is written at the left end of the row 1, 2, 3 or 4 rows below the current row. 2) The cursor moves to the right of the new character.
		Space is not available for 1, 2, 3 or 4 rows below the current row.	1) The displayed pattern is scrolled up 1, 2, 3 or 4 rows while clearing the bottom 1, 2, 3 or 4 rows. 2) The character is written at the left end of the current row. 3) The cursor moves to the right of the new character.
	Space is available at the left end of a row for the character but not the cursor.	Space is available for 1, 2, 3 or 4 rows below the current row and space is available for 1, 2, 3 or 4 rows below that.	1) The character is written at the left end of the row 1, 2, 3 or 4 rows below the current row. 2) The cursor moves to the left end of the row 1, 2, 3 or 4 rows below the new character.
		Space is available for 1, 2, 3 or 4 rows below the current row but space is not available for 1, 2, 3 or 4 rows below that.	1) The character is written at the left end of the row 1, 2, 3 or 4 rows below the current row. 2) The displayed pattern is scrolled up 1, 2, 3 or 4 rows while clearing the bottom 1, 2, 3 or 4 rows. 3) The cursor moves to the left end of the row 1, 2, 3 or 4 rows below the new character.
		Space is not available for 1, 2, 3 or 4 rows below the current row.	1) The displayed pattern is scrolled up 1, 2, 3 or 4 rows while clearing the bottom 1, 2, 3 or 4 rows. 2) The character is written at the left end of the current row. 3) The displayed pattern is again scrolled up 1, 2, 3 or 4 rows while clearing the bottom 1, 2, 3 or 4 rows. 4) The cursor moves to the left end of the current row.
	Space is not available for the character.	Space is available for 1, 2, 3 or 4 rows below the current row.	1) The cursor moves to the left end of the row 1, 2, 3 or 4 rows below the current row.
		Space is not available for 1, 2, 3 or 4 rows below the current row.	1) The displayed pattern is scrolled up 1, 2, 3 or 4 rows while clearing the bottom 1, 2, 3 or 4 rows. 2) The cursor moves to the left end of the current row.

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Write Character operation when Cursor Mode = Horizontal Scroll (MD3):

Font Magnification Y	X Direction	Y Direction	Write Character Operation
1, 2, 3 or 4 rows	Space is available on the current row for the character and the cursor.	---	1) The character is written at the current cursor position. 2) The cursor moves to the right of the new character.
	Space is available on the current row for the character but not the cursor.	---	1) The character is written at the current cursor position. 2) The cursor moves to the right end of the current row.
	Space is available on current row for some of the character.	---	1) As much of the character that fits on the current row is written at the current cursor position. 2) The displayed pattern on the current row and the 1, 2 or 3 rows below are scrolled left, filling the rightmost column with the rest of the character data. 3) The cursor moves to the right end of the current row.
	The cursor is at the right end of the current row.	---	1) The displayed pattern on the current row and the 1, 2 or 3 rows below are scrolled left, filling the rightmost column with character data. 2) The cursor moves to the right end of the current row.

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7.0 CONNECTORS AND JUMPERS

Contact Futaba for customer specified connector and/or cable options and factory preconfigured jumper settings.

7.1 CN1 – PARALLEL INTERFACE

The parallel interface, CN1, consists of 14 plated through holes in the PCB, in a 1x14 or 2x7 array depending on the module version.

Pin	Signal	Pin	Signal
1	GND	8	D1
2	V _{CC}	9	D2
3	/RESET or PBUSY	10	D3
4	no internal connection	11	D4
5	/WR	12	D5
6	/RD	13	D6
7	D0	14	D7 and PBUSY

7.2 CN2 – SERIAL INTERFACE

The serial interface, CN2, consists of 6 plated through holes in the PCB, in a 1x6 array.

Pin	Signal
1	V _{CC}
2	SIN
3	GND
4	SBUSY
5	SCK
6	/RESET

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7.3 JRB – SIGNAL SELECT FOR CN1 PIN 3

The signal select, JRB, consists of 3 plated through holes in the PCB, in a 1x3 array. Connecting pin 1 to pin 2 routes the /RESET signal to CN1 pin 3, likewise connecting pin 3 to pin 2 routes the PBUSY signal to CN1 pin 3. Similarly, either jumper JR or JB can be placed to route a signal to CN1 pin 3.

Pin	Signal
1	/RESET
2	CN1 pin 3
3	PBUSY

Note: Do not route both signals to CN1 pin 3 at once or connect them together.

7.4 JUMPERS J0 THROUGH J3

These jumpers are used to select module options.

J0	J1	J2	J3	Function
open	open	open	x	Asynchronous serial at 38400 baud
shorted	open		x	Asynchronous serial at 19200 baud
open	shorted		x	Asynchronous serial at 9600 baud
shorted	shorted		x	Asynchronous serial at 115200 baud
x	x	shorted	x	Synchronous serial
x	x	x	shorted	Self-test image displayed at power-up and after a reset for about 4 seconds before the all dots on screen saver is displayed. (image includes software revision)

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