

Display Board Thin Protocol 97000119 - DBTP

This document is the specification for Display Board Thin Protocol (DBTP).

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Protocol overview

Display Board Thin Protocol is a very simple protocol intended for small bit mapped signs. Additionally this protocol can be compatible with Light (and other) sensing devices (modules, peripherals).

The design philosophy intended to minimize network traffic and processing overhead and resources.

DBTP is a master slave protocol. And supports up to 126 slave devices.

This specification addresses from the perspective of the slave device. Additional and application specific operation is to be defined in the target devices (application) firmware specification.

This protocol is for full duplex operation on multi-drop RS-422 networks.

Data format is 8-bit, no parity, one stop-bit.

Baud rate is determined by the application and is not specified by this specification.

This protocol is generally a command response protocol, however not all commands will issue a response. Also this protocol supports broadcast messages for various (not all) commands. Broadcast is not supported on data messages.

This protocol is a 'lightly' delimited packetized protocol with only a Start of Packet and implied end of packet. The Start of Packet flag is the highest bit of the Start of Packet Descriptors and will identify as such. So, any received byte with B7 set indicates a start of packet and will effect control of serial receive and command response state machines. This results in a word (character) size of 7-bits.

Message types

- Data used to write binary image data
- Operation command Used to control Display board function(s).

Packet format: data packet

Start of packet address descriptor		data byte	Data n
STP	address		As required
B 7	B 6:0	0xXX	

Data packets consist of a start of packet descriptor comprising of start of packet bit, bit-7 set, Ored with a non-zero device address. Following are 1 or more bytes of data.

A data response packet has the same construction.

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Packet format: command packet

Start of command packet	address	Command code	Command data (optional)	Command data N (optional)
0x80	aa	0x00 – 0x7F	0x00 – 0x7F	0x00 – 0x7F

Command packets consist of a start of command packet character, 0x80, followed by a 7-bit address character identifying a particular device. For broadcast messages, an address of zero is used. Address 0x7F is reserved. This results in 126 unique addresses. Next is the command code, followed by zero or more data characters.

Packet format: command response packet

Start of command response				
B 7	B 6:0	Command code	Data byte	Data N
STP	address			
1	aa	0xXX	0xXX	0xXX

Command response packets are issued by a responding device and have a similar format to a data response packet. The start of packet descriptor consists of a start of packet flag set, bit-7, ORed with a 7-bit (non-zero) address field. The address field is the address of the responding device. Following this is the command code, which is the same as the command that invoked the response. Following is one or more bytes of data.

Timeout periods

- Inter-character timeout: None
- Inter-packet timeout: 1000mS

Command response cycles

The Start of Packet bit in the start of packet descriptor or identifier triggers command response cycles. The command and responses are initiated with this element.

A command is sent, received, and processed. The slave device wishes to return a response. But the response is triggered at the reception of the successive (next) start of packet. When using the “80 00 00” it does not specifically need to be addressed for the previous module, you can use a “00” for the address. This can be used at the end of a data transmission so that the last device on the bus will respond accordingly.

This requires full duplex operation.

Data address

A data packet (message) is sent to an addressed unit. This cannot be a broadcast message. The receiving unit receives the Start of Data Packet Descriptor. Next data is received, until a Start of Packet descriptor is detected again. This can be any number of characters. As the characters are received, they are written into display memory over writing the individual rows (datam).

Since this data is addressed to a specific unit, it will issue its' response packet when reception ceases and at the next start of packet reception.

See Data packet section for command and response packet construction details.

Data broadcast

This protocol doesn't support this function.

Command Address with response

This is a command sent to a specific unit. This command requires a response back, and as such is a query.

The respondent unit receives this command, identifies that it is specific to itself, performs the associated action, formulates a response packet and waits until a start of packet is received. At this point the response is sent.

Beware, there is an exception possible here, where the successive Start of packet is not received in a specified timeout period. This timeout period is the inter-packet timeout.

Command Addressed w/o response

This is a command issued to a specific unit, and the command does not expect a response.

Command broadcast

This is a command issued to a broadcast address. This refers to each unit on the receive bus. No responses are returned.

Data Packet

Data packets, or data messages are used to move data into the display boards display data memory. The driver board provides a checksum to validate that the data sent to the driver board was received properly. See below for further information.

Broadcast: not supported

Data packet message			
Start of Packet descriptor		Data	Data N
B 7	B 6:0		
STP	address		
1	aa	0x00-0x7F	0x00-0x7F

Data packet response		
Start of Packet descriptor		checksum
B 7	B 6:0	
STP	address	
1	aa	0x00-0x7F

A checksum is derived from the complete display memory. Adding up all the contents in modulus-128 creates them. This means that each character is added up and bit-7 is masked off.

Remember that this protocol cannot support byte size characters due to the use of bit-7 as the Start of Packet flag.

After the Checksum is computed, the display status flags are checked. If any are non-zero, then the low order seven bits of the checksum are complemented. This gives the master the indication that the data was received correctly, but there is a failure on the display board. If the Pixel Fault Flag is set in the Display Status byte, it will be from the previous data displayed, not from the data just delivered. Refer to Command 0x10 for byte structure for number of bytes required to light a Driver Board.

example	
Row 1	0x67
Row 2	0x43
Row 3	0x2A
Row 4	0x32
Row 5	0x18
Row 6	0x7C
Row 7	0x23
Row 8	0x56
Row 9	0x70
result	0x83
And w/ 0x7F	0x03

These ITS display board modules are equipped with failure detection circuitry. Anytime a display pattern is displayed, the circuitry determines if the actual pixels are in the correct state (ON or OFF). If an error is detected, a status flag is set. Reference command x16 for Stuck on and Stuck Off pixel failures. Also, some modules do stuck on and stuck off, but some modules only do stuck off pixel failure detection. Contact manufacturer for which modules perform these functions.

Operation commands

Operation commands control the function and operation of the display board.

Operation commands table

Ver	Command code (hex)	Command Type	Command name	Notes
1.0	0x00	Standard	No op	Can be used to initiate a response cycle
	0x01		Read Firmware ID	Identify device and protocol and firmware
	0x02 – 0x0F		reserved	
1.0	0x10	Display board commands	Read display config	Identify display matrix
	0x11		Update display	aka latch data
	0x12		Blank display	Disp off, bin image stays
	0x13		Clear	Clear display memory
	0x14		Set dimming level	
	0x15		Get dimming level	
	0x16		Read display status flags	
0x17 – 0x1F	Reserved			
1.0 only	0x20		Read binary image	Command Obsolete – Replaced by Command 0x22-0x26
1.0 only	0x24		Read pixel string image	Command Obsolete – Replaced by Command 0x22-0x26
2.0	0x24		Read pixel error status	New command for version 2.0. Used to identify pixel faults on a display board Command Obsolete – Replaced by Command 0x22-0x26
2.0	0x22		Pixel Test /Return Pixel Error	New command for Version 4.0
4.0	0x23		Return Pixel Feedback LED String 1	New command for Version 4.0
4.0	0x24		Return Pixel Feedback LED String 2	New command for Version 4.0
4.0	0x25	Return Pixel Feedback LED String 3	New command for Version 4.0	
4.0	0x26	Return Pixel Feedback LED String 4	New command for Version 4.0	
2.0/ 4.0	0x27-0x2F		reserved	
	0x30 – 0x3F		Reserved	
	0x40-0x5F		Reserved for other devices	
2.0	0x60	Light sensor	Read light levels	
	0x61 – 0x6F		reserved	
2.0	0x70	Temp sensor	Read temp	Returns temperature in _C [∞]
	0x71 – 0x7F		reserved	

Command fault tolerance handling

- Broadcast address used on a command that does not support broad cast
Result: command is ignored.
- Inter-character timeout
None, fully static
- Inter-packet timeout
This deals with the time from receiving and complying with a command until the next Start of Packet (STP) is received.
After inter-packet timeout period the response will not be sent
- Unknown command
Ignored

Command 0x00 no-op

Use this command to initiate a response cycle, if there are no other commands to be issued. This will supply a start of packet, initiating the response from the device. Additionally, this will reset the command response state machine on the device.

No-op command		
Start of command	address	Command code
0x80	aa	0x00

Response: none

Broadcast: yes

Command 0x01 Firmware ID

This command instructs the display board to return it's firmware, protocol version, device type and manufacturer identification.

Broadcast: illegal

Command: Read Firmware ID		
Start of command	address	Command code
0x80	aa	0x01

Response: 0x01 returning firmware ID data							
Start command response packet		Command Code	Firmware ID code	Firmware Revision	Protocol version	Device code	Manuf'r code
B7	B 6:0						
STP	Address						
1	Aa	0x01	0xXX	0xXX	0xXX	0xXX	0xXX

Where

- Firmware ID code: 0x00-0x7F: Firmware ID code. Defined in the firmware specification. Zero if not implemented.
- Firmware revision: 0x00-0x7F: convert to decimal, divide by ten; quotient is version, remainder is revision. Zero if not implemented.
- Protocol version: 0x00-0x7F: Convert to decimal, divide by ten, quotient is version, remainder is revision. (Zero if not implemented)
- Device code: 0x – 0x7F: Identifies device type. (zero if not implemented) See Device type chart
- Manufacturer code; 0x01 Adaptive Micro Systems. See manufacturer types

Response: Yes

Broadcast supported: No

Command 0x10 Read display Matrix config

This command instructs the display board to return its display matrix information, the number of rows (X), the number of columns (Y) and number of 'strings' per pixel (Z).

Broadcast: Illegal

Command: Read Display Matrix		
Start command packet	address	Command code
0x80	aa	0x10

Response: Return display Matrix data					
Start command response packet		Command code	Columns	Rows	Strings per pix
B 7	B 6:0				
STP	Address				
1	Aa	0x10	0xXX	0xXX	0x0X

If the number of columns for a display is greater than 7 then display is divided amongst two bytes of data. Pixels are divided evenly across the two bytes, if this is not possible, the least significant byte has the greater amount. Example: 6 row x 9 column display. The data format is as shown below to turn all pixels on for each row for this display configuration.

" 0x80 + Address" 0F 1F 0F 1F 0F 1F 0F 1F 0F 1F 80 00 11

Response: Yes

Broadcast supported: No

Command 0x11 Update display

Use this command to instruct the display board to update the display. This is the transfer of the displays binary image, to the actual display.

Update display		
Start command packet	address	Command code
0x80	aa	0x11

Response: none

Broadcast supported: yes

Command 0x12 Blank display

This command instructs the display board to blank its display. The display image in the display boards memory remains unaltered. If the brightness command(0x14) is sent to the device, the current image in the buffer will be redisplayed. Pixel Test(Command 0x22) cannot be run after sending this command to test for stuck on. The reason this cannot be done is due to the fact that the Thin Protocol requires checking for stuck on and stuck off pixels. The Status Flags are not updated after issuing this command.

If Command 0x22 is issued after receiving the 0x12 command the display will return its last known bad pixel table.

Blank Command		
Start command packet	address	Command code
0x80	aa	0x12

Response: none

Broadcast supported: Yes

Command 0x13 Clear display

This command instructs the display board to clear its display memory. Its display is not updated. The Status Flags are not be updated by issuing this command.

Clear Command		
Start command packet	address	Command code
0x80	aa	0x13

Response: none

Broadcast supported: Yes

Command 0x14 Set Dimming level

This command instructs the display to set its dimming level. Its internal dimming register is updated, and the display's brightness is adjusted to the specified dimming level.

Dimming level is big Endian

Note: dimming level is the converse of brightness.

Set dimming level				
Start command packet	Address	Command Code	Dimming level (0x0000 – 0x00FF)	
0x80	Aa	0x14	0x0X	0xXX

Response: none

Broadcast supported: Yes

Command 0x15 Get Dimming level

This command instructs the display board to return the display boards dimming level setting (in memory).

Command get dimming level		
Start command packet	address	Command code
0x80	aa	0x15

Return dimming level				
Start command response packet		Command Code	Dimming level (0x00 – 0xFF)	
B 7	B 6:0			
STP	Address			
0x80	Aa	0x15	0x0X	0xXX

Response: Yes

Broadcast supported: No

Command 0x16 Read display status flags

This command instructs the board to return its display status flags. These status flags indicate the operating status of the display. ~~Status flag states are live, they reflect the current fault state, and they are not latched.~~ If the Pixel Fault Flag is set in the Display Status byte, it will represent a failure from the previous displayed image.

Exception: Inter-packet timeout; Does not effect flags. Refer to firmware specification for specific slave operational details.

Command: read status codes		
Start command packet	address	Command code
0x80	aa	0x16

Return status flags			
Start command response packet		Command Code	Status flags
b7	b6:0		
STP	Address		
0x80	Aa	0x16	0xXX

Status flags

- B6 Pixel fault flag-Stuck Off.
- B5 Pixel fault flag-Stuck On.
- B4 reserved
- B3 reserved
- B2 reserved
- B1 reserved
- B0 reserved

Response: Yes

Broadcast supported: No

Command 0x20 — Return display Input image

OBSOLETE-Not Supported

This command is used to return the stored display input image.

Broadcast: illegal

Command; Return display image		
Start of command packet	address	Command code
0x80	aa	0x20

Response, return display image data				
Start of command response		Command code	Data byte	Data n
STP	Address			
1	Aa	0x20	0xXX	0xXX

Where Data byte is the first ROW, and Data N is the last Row. The number of data bytes returned is the number of rows available on the display board. Refer to the command to read the display matrix config to determine the number of rows, and hence the number of bytes returned.

Command 0x21 — Return Pixel error state(s)

OBSOLETE-Not Supported

This command is used to read the error state form the display board.

Broadcast: illegal

Command; Return display error state		
Start of command packet	address	Command code
0x80	aa	0x21

Response, Display no error			
Start of command response		Command code	Error code
STP	Address		
1	Aa	0x21	0x00

If, when queried, there is no fault (or error) detected, the packet returned will contain and error code 0. There is no other data following.

Response, return error code					
Start of command response		Command code	Error code	Pixel	
b7	b6:0			×	Y
STP	Address	0x21	0xXX	0xXX	0xXX
1	Aa				

If there is one errant pixel, an error code will be returned and the pixel's XY coordinates are returned to identify the errant pixel. If only one errant pixel, the error codes next record flag will be clear indicating the last pixel error record.

If there are multiple errant pixels the error code next record flag will be set until the last record, indicated by the next record flag clear.

The error code field contains a bit used to indicate if there are more errors to follow within the packet. Since bit 7 can never be used, and now bit 6 is a flag, the remaining bits comprise a field with 32 possibilities.

Error code word format							
7	6	5	4	3	2	1	0
N/a	Next record flag	Error code field					

The error code field is used to identify a particular error status condition. A zero in this field always indicates no error (or status OK).

Error code	Meaning
0	OK, no faults detected
1	Pixel stuck ON
2	Pixel stuck OFF
3	General Electrical Failure

Command 0x22 with Broadcast Address- Pixel Test

This command is used to have the Display Board run a Pixel Test. This command must be broadcasted to the display boards to activate the test. Reference Command 0x22 Return Pixel Error(s) and Commands 0x23-0x26 Return Pixel Feedback LED String “1-4” for details on returning test results. Display image cannot be changed on Display Board before Pixel Test completes. Pixel Testing on the driver board cannot be accomplished in short time period. This will take a maximum of 2 seconds to be performed on a driver board. The controller must allow this time in order to receive an accurate display image back from the display board.

Command; Return display image		
Start of command packet	Address	Command code
0x80	00	0x22

Response: none

Broadcast supported: Yes-To perform Pixel Test

Command 0x22 with a Specific Address-Return Pixel Error(s)

This command is used to return pixel status when this command is not broadcasted to display boards. The return data indicates pixels not completely displaying the currently commanded information. If the pixel is to be on, and is not on, or is to be off and is stuck on, the return data is one. If the displayed result is as expected, the return data is zero. If multiple strings of LEDs comprise a pixel, a failure in any string will produce a bit in the failure information.

Response, Return Pixel Error Data				
Start of command response		Command code	Data byte	Data n
STP	Address			
1	Aa	0x22	0xXX	0xXX

Where Data byte is the first ROW, and Data N is the last byte for the last Row. The number of data bytes returned depends on the number of columns available on the display board. Refer to command 0x10 which reads the display matrix config and rules which apply when 7 columns is exceeded on Display Board.

0x80	aa	0x22		
Response				
Byte 1	Byte 2	Byte 3	Byte 4	Byte N+2
0x80+aa	0x22	0xxx	0xxx . . .	0xxx

Byte 3 corresponds to the top row of the display, byte N+2 is the last byte of the bottom (Nth) row of the display.

Caution: When requesting responses from Driver Board the control module only needs to send three bytes of data for the request. However, the display will send significantly more bytes on the return path and data collisions will occur if the requests are not properly formatted. IE: Two 8 column by 14 row drivers(Address 1 and 2) are on a bus and they have all

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of their pixels lit and are sent the test command(0x80 0x00 0x22). Then a response is required from the display, the control module must send the following commands with proper timing to ensure data collisions do not occur.

Sent to Display Boards:

81 0F 80
01 00

Response from Display Board(Address 1-If display board has no errors):

81 24

Sent to Display Boards:

82 0F 80
01 00

Response from Display Board(Address 2-If display board has no errors):

82 24

Sent to Display Boards(Pixel Test Command Broadcast):

80 00 22 {Display Image cannot be updated and control module must allow the display to finish processing Pixel Test before issuing another Pixel Test. There must be a delay of at least 2 seconds before changing the display image and requesting the data from commands 0x22 – 0x26.}

Sent to Display Boards (Address 1-Request Pixel Error(s) Status) :

80 01 22 80 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0000 00 00 00 00 00
00 00 00 00 00

Note: Pad the command sent to the display with nulls to allow the display board to respond on the receive path and not have data collisions with other devices.

Response from Display Board(Address 1- If display board has no errors)

81 22 00

Sent to Display Boards(Address 2-Request Pixel Error(s) Status) :

80 02 22 80 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0000 00 00 00 00 00
00 00 00 00 00

Response from Display Board(Address 2):

82 22 00

Response: Yes

Broadcast supported: No-Individual Addresses sent to device to return pixel error(s) status information

Command 0x23 Return Pixel Feedback LED String 1

This command is used to return current LED string 1 status. The return data indicates the current feedback data from pixel string 1. If the pixel appears to be on, the return data is one. If the pixel appears to be off, the return data is zero. Data is returned row by row exactly as described for Return Pixel Error(s) (Command 0x22).

0x80 aa 0x23

Response

Byte 1	Byte 2	Byte 3	Byte 4	Byte N+2
0x80+aa	0x23	0xxx	0xxx . . .	0xxx

Response: Yes

Broadcast supported: No

Command 0x24 Return Pixel Feedback LED String 2

If supported by the driver board, this command is used. Reference Commandx10 to determine number of strings are supported by the driver board. This command is used to return current LED string 2 status. The return data indicates the current feedback data from pixel string 2. If the pixel appears to be on, the return data is one. If the pixel appears to be off, the return data is zero. Data is returned row by row exactly as described for Return Pixel Error(s) (Command 0x22).

0x80 aa 0x24

Response

Byte 1	Byte 2	Byte 3	Byte 4	Byte N+2
0x80+aa	0x24	0xxx	0xxx . . .	0xxx

Response: Yes

Broadcast supported: No

Command 0x25 Return Pixel Feedback LED String 3

If supported by the driver board, this command is used. Reference Commandx10 to determine number of strings are supported by the driver board. This command is used to return current LED string 3 status. The return data indicates the current feedback data from pixel string 3. If the pixel appears to be on, the return data is one. If the pixel appears to be off, the return data is zero. Data is returned row by row exactly as described for Return Pixel Error(s) (Command 0x22).

0x80 aa 0x25

Response

Byte 1	Byte 2	Byte 3	Byte 4	Byte N+2
0x80+aa	0x25	0xxx	0xxx . . .	0xxx

Response: Yes

Broadcast supported: No

Command 0x26 Return Pixel Feedback LED String 4

If supported by the driver board, this command is used. This command is used to return current LED string 4 status. The return data indicates the current feedback data from pixel string 4. If the pixel appears to be on, the return data is one. If the pixel appears to be off, the return data is zero. Data is returned row by row exactly as described for Return Pixel Error(s) (Command 0x22).

	0x80	aa	0x26
Response	Byte 1	Byte 2	Byte 3 Byte 4 Byte N+2
	0x80+aa	0x26	0xxx 0xxx . . . 0xxx

Response: Yes

Broadcast supported: No

Command 0x60 Read light level

This command is used to return the light level sensor reading.

Note, this command only works with light sensors. This is not a display board command.

Command; Read Light level		
Start of command packet	address	Command code
0x80	aa	0x60

Return light level								
Start command response packet		Command Code	light level					
b7	b6:0		instantaneous		Short term average		Long Term average	
STP	Address							
0x80	aa	0x60	0xXX	0xXX	0xXX	0xXX	0xXX	0xXX

This command reads the light level and converts it to an unsigned 14-bit integer to be returned.

The light probe provides averaging capabilities; instantaneous, short-term and long-term averaged results are returned.

The results returned are big endian.

Response: Yes

Broadcast supported: No

Command 0x70 Read temperature centigrade

This command is used to return the current temperature.

Note, this command works on temperature sensor devices. This is not a display board function.

Command; Read temperature		
Start of command packet	address	Command code
0x80	aa	0x70

Return temp centigrade				
Start command response packet		Command Code	Temperature, signed twos comp _ C ∞	
b7	b6:0			
STP	Address			
0x80	Aa	0x70	0xXX	0xXX

Temperature is returned in _ degrees centigrade. These units are used to provide sufficient resolution for the host to perform a Fahrenheit conversion with sufficient resolution to obtain 1-degree resolution for its result.

This value returned is a signed 14-bit integer using twos complement format for negative values.

The returned result is big endian.

Response: Yes

Broadcast supported: No

Appendices

Appendix A: Device type codes

0x00	Not Implemented/Unknown
0x01	Display Board
0x40	Light Sensor
0x50	Temperature sensor

Appendix B: Manufacturer codes

0x00	Not Implemented/ Unknown
0x01	Adaptive Micro Systems
0x02-0x7F	Not supported by Adaptive Micro Systems.

Note to developer

This protocol is a bare minimum protocol. It is designed to move a large amount of data without requiring a high powered processor to both handle communications and run the display. The protocol relies on the high order bit being set on the first byte in a "packet" and a deterministic response timing. **The response to all of the commands (except 0x22-26) is a packet of a specific size.** Since all modules respond on the same wires, the display will need to respond to commands (and data packets) in time so that one module will not "step on" another module. In order to make this scheme work, the module must respond very quickly after the command arrives at the board. On a data packet, the two byte response packet should be initiated within one byte time of the arrival of the 0x80+ byte of the next packet.

A small/slow/less capable processor must process packets "on the fly", so that in most cases the response is immediately available when the packet is closed. [The pixel feed back response may require slightly more time, but it should be both short and repeatable]. The processor might choose to ignore the next packet if required to perform the request of this packet. The priority should be, first respond to the packet, second to execute the command (or data), and then third respond to the next packet.

Likewise, the controller will need to provide for sufficient time for a module to respond, by padding the communication stream if necessary, so that one module will not "step on" the response of the previous module.

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Revision history

version	Release date	Notes
4.0	Review of Document and addition of clarity to the listed items in notes	<ul style="list-style-type: none">• Commandx16 had Stuck On and Stuck Off status reversed swapped B6 and B5 to correct issue.• Fixed example for commandx10 for bit breakout
4.0	8-13-04-Preliminary Review	<ul style="list-style-type: none">• Moved Commands 0x22 – 0x26 from Appendix C contents to organize document further.• Moved Additional Data Packet Information from Appendix C contents Information to Data Packet• Moved information for Status Flags from Appendix C to Command 0x16. Striked out the original statement stating static flags are live.• Clarified to Command 0x16 for Pixel Status- Currently B6 is Pixel fault flag-Stuck On and B5 is Pixel fault flag-Stuck Off.• Added Data Packet for byte structure for display for rows and columns to reference Command 0x10 for further information• Added to Command 0x10 the byte structure to light Driver Board• Changed on Command 0x10 for Columns and Rows for 0x0X to 0xXX because we support more columns and rows that 0x0X.• All changes listed above are for Protocol Version 4.0 and correcting document for clarity
4.0	6-26-03	Added appendix C, which includes the additional pixel test commands – 0x22 to 0x26. The document was updated February 15, 2004. These commands were available back in June 03.
2.0	11-22-2002	<ul style="list-style-type: none">• Eliminate commands 21 – 2F from version 1.0• New command 0x21 is for read display pixel fault data• New command 0x60 is for reading of a light sensor• New command 0x70 is for reading of a temperature sensor
1.0	07-16-2002	Initial Release of Thin Protocol