

Name of document Display module communication protocol –public version		Document no 0-103	Page 1 (18)
Product/Activity Display module		Valid from Apr 12, '02	Replacing 0-101
Operation	Any belonging manuals for modules -	Written by AM, BQ	Approved by QA routines -

LC-Tec Display Module Communication Protocol

In order to guarantee an error free communication link between the host and the display a communication protocol with a common packet structure is used. The protocol will also allow for a multiple master/slave network.

Master packet format

	Start byte	Address Hi byte	Address Lo byte	Packet id #	Command	Data field size hi byte	Data field size lo byte	Data	Crc
Byte #	1	2	3	4	5	6	7	8-x	x+1

Start byte	Fixed 0x55
Address hi byte	System address 0x00..0xFF
Address lo byte	Slave address 0x00..0xFF
Packet id #	Packet id number
Command	Transfer command (see table below)
Data field size	The number of bytes in the data field 0-1024
Data	Application layer data. 0-1024 bytes
Crc	Packet checksum see algorithm below

Slave response packet format

The slave (sign) responds to all correctly addressed messages with either a positive (ACK) or negative (NACK) response.

Positive response packet format (ACK)

The slave responds by sending an ACK packet directly after a valid packet is received. There are some ACK responses that include data in the data field.

	Start byte	Address hi byte	Address lo byte	Packet id #	Command	Data field size hi	Data field size lo	Data	Crc
Byte #	1	2	3	4	5	6	7	8-x	x+1
Value	0x55				0x06				

Start byte	Fixed 0x55 hex
Address hi byte	System address 0x00..0xFF
Address lo byte	Slave address 0x00..0xFF
Packet id #	Id number of the packet for which the ACK is issued
Command	Fixed 0x06 hex
Data field size	The number of bytes in the data field 0-1024
Data	Usually 0x0000 but there are some ACK responses that return data.
Crc	Packet checksum see algorithm below

Document no	Page
0-103	2 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Negative response packet format (NACK)

The slave responds by sending a NACK packet if the crc-sum is wrong or an invalid command or argument is received.

	Start byte	Address hi byte	Address lo byte	Packet id #	Command	Data field size hi	Data field size lo	Data	Crc
Byte #	1	2	3		4	5	6		
Value	0x55				0x15				

Start byte	Fixed 0x55 hex
Address hi byte	System address 0x00..0xFF
Address lo byte	Slave address 0x00..0xFF
Packet id #	Id number of the packet for which the NACK is issued
Command	Fixed 0x15 hex
Data field size	Usually 0x0000 (crc error).
Data	NACK error code if present. Error codes see table below
Crc	Packet checksum see algorithm below

If the master has not received either a positive (ACK) or negative (NACK) response 500 ms after transmitting a packet the packet should be considered lost and be resent.

After 8 retries the transmission should be cancelled.

NACK return codes

1	Invalid command
2	Invalid argument(s)
3	Low voltage input
4	Low temperature
5	Module is busy

Document no	Page
0-103	3 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Crc Algorithm

The packet checksum is calculated by the sum of the crc8 of each byte in the packet. See code below.

```
unsigned char crc8(unsigned char x, unsigned char r)
{
    unsigned char i,g;
    g = 0x9B;

    for (i=0;i<8;i++)
    {
        if (r & 0x80)
        {
            r<<=1;
            r ^=g;
            if(x &0x80) r^= 1;
        }
        else
        {
            r<<=1;
            if(x &0x80) r^= 1;
        }
        x<<=1;
    }
    return r;
}

void main()
{
    unsigned char csum;
    unsigned int i;
    int packet_length=9; // Example packet length
    unsigned char buffer[1024];
    csum=0;
    for (i=0;i<packet_length; i++)
    {
        csum = crc8(buffer[i],csum);
    }
}
```

Name of document Display module communication protocol –public version		Document no 0-103	Page 4 (18)
Product/Activity Display module		Valid from Apr 12, '02	Replacing 0-101
Operation	Any belonging manuals for modules -	Written by AM, BQ	Approved by QA routines -

Command summary

All command hex codes are reserved for future needs.

Command	Code (hex)	Valid from version
Download image	0x01	3.14
<i>Download partial image</i>	<i>0x02</i>	
Erase image memory	0x03	3.14
<i>Write ASCII string</i>	<i>0x04</i>	
Acknowledge	0x06	3.14
No acknowledge	0x15	3.14
Display image	0x20	3.14
Clear display black	0x21	3.14
Clear display green/yellow	0x22	3.14
Image cycle mode	0x23	3.14
Clear pressure marks	0x24	3.14
Display image without ACK	0x2F	3.14
Image cycle delay	0x30	3.14
Set image cycle sequence	0x31	3.14
Image display mode	0x32	3.14
Image invert mode	0x33	3.14
<i>Wipe effect mode</i>	<i>0x34</i>	
Set row update time	0x35	3.14
<i>Quick partial update mode</i>	<i>0x36</i>	
Set button	0x37	3.14

enable		
Set refresh mode	0x38	3.14
Set sleep mode	0x40	3.14
Set inactive to sleep time	0x41	3.14
Query image storage	0x50	3.14
Query image parameters	0x51	3.14
Query display parameters	0x52	3.14
Query last image	0x53	3.14
Query image status bits	0x54	3.14
Query checksum	0x55	3.14
Query temperature	0x56	3.14
Reserved	0xA0	
Reserved	0xA1	
Reserved	0xA2	
Reserved	0xA3	
Reserved	0xA4	
Set User Data	0xDA	3.17
Query User Data	0xDB	3.17
Set baudrate	0xFA	3.14
Version #	0xFB	3.14
Address request	0xFC	3.14
Set address	0xFD	3.14
Confirm set address	0xFE	3.14
Reset	0xFF	3.14

Name of document Display module communication protocol –public version		Document no 0-103	Page 5 (18)
Product/Activity Display module		Valid from Apr 12, '02	Replacing 0-101
Operation	Any belonging manuals for modules -	Written by AM, BQ	Approved by QA routines -

Image Memory Commands

Download image

The bitmap is transferred to the display using multiple packets.

The bitmap should be divided into pages of 256 bytes.

The page number field in the data field should be consecutively numbered starting with 0.

The page count field contains the total number of data pages in the transfer 0-234

The length of the data field should always be 259 bytes except for the last page.

Command 0x01

Data field content

	Image #	Page #	Page count	Bitmap data
Byte #	1	2	3	4-259

Image # The Image memory location in the display 1-8

Page # The current bitmap page number 0-234

Page count The total number of bitmap pages in the transfer 0-235

Bitmap data Uncompressed monochrome bitmap data 1-256 bytes

Partial image download

Future command. Not implemented yet

Erase image memory

Command 0x03

Data field content

	Image #
Byte #	1

Image # The image memory location to be erased (1-8).

Write ASCII string

Future command. Not implemented yet.

Document no	Page
0-103	6 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Display Commands

Display image

Command 0x20

Data field content

	Image #
Byte #	1

Image # The image memory location to be displayed (1-8).

Display image without ACK

Command 0x2F

Data field content

	Image #
Byte #	1

Image # The image memory location to be displayed (1-8).

Clear display (black, blue)

Clears the current image on the display by turning it black/blue. Does not erase the memory.

Command 0x21

Data field content

No arguments

Clear display (green/yellow, white)

Clears the current image on the display by turning it green/yellow/white. Does not erase the memory.

Command 0x22

Data field content

No arguments

Document no	Page
0-103	7 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Set image cycle mode

The image cycle mode will display all the images stored in memory in consecutive order. The delay between image updates is set using the image cycle delay commands below.

Command 0x23

Data field content

	Mode #
Byte #	1

Mode #

- 0-Stop image cycle
- 1-Start normal image cycle sequence
- 2-Start preprogrammed image cycle sequence
- 3-Set module as Master in normal cycle sequence
- 4-Set module as Slave in cycle mode
- 5-Set module as Master in preprogrammed cycle sequence

Clear pressure marks

This command reduces any pressure mark that may have emerged on the display. This command can take from 2-10 minutes depending on temperature.

Command 0x24

Data field content

No arguments

Set default image cycle delay

Sets the delay between all image updates when using the normal image cycle mode.

Command 0x30

Data field content

	Delay
Byte #	1

Delay Delay in steps of 1 s. 1-255 second delay

Document no	Page
0-103	8 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Set image cycle sequence

Sets the sequence and update delays for images when using the image cycle mode. The sequence can consist of up to 10 images and display times.

Command 0x31

Data field content

	First image #	Wipe& display mode	Display time	Second image #	Wipe& display mode	Display time	Image #n	Wipe& display mode	Display time
Byte #	1	2	3	4	5	6	7	n*3-1		n*3

First Image #

The image number of the first image in the sequence

Wipe& display mode

Select wipe effect and normal/inverted display mode.

Invert mode high nibble 0-Normal, 1-inverted

Wipe effect low nibble 0-2 *Not supported!*

Display time s

Delay in seconds. 0-255 seconds

Second image #

The next image in the sequence

-"-

Document no	Page
0-103	9 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Display Mode Settings

Set image display mode

Sets the display mode.

Mirror and rotate image.

All image display updates following this command will use the selected mode.

Command 0x32

Data field content

	Display mode
Byte #	1

Display mode	0	Normal mode
	1	Vertical image flip
	2	Horizontal image flip
	3	Rotate 180°

Set image invert mode

Sets the display mode to normal or inverted.

All image display updates following this command will be displayed using the new mode.

Command 0x33

Data field content

	Display mode
Byte #	1

Display mode	0	Normal mode
	1	Inverted mode

Wipe effect mode

Future command. Not implemented yet.

Document no	Page
0-103	10 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Set row update time

Sets the row update time for the display. Normal value is 100. By increasing this value the row time will be longer. If decreasing the value the row time will be shorter. Normally the user should not need to change this value.

Command 0x35

Data field content

	Time
Byte #	1

Time 1-255 Row update time

Set quick partial update mode

Future command. Not implemented yet.

Set button enable

Enables handling of input signal INT1.

An active signal on this input will display the next image in memory.

Command 0x37

Data field content

	Display mode
Byte #	1

Display mode	0	Button disabled
	1	Button enabled (default)

Document no	Page
0-103	11 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Set refresh mode

Sets the image update refresh mode to one of 3 modes. Using mode 1 or 2 will allow for faster image update times by setting the row update time to a lower value. Mode 2 is used as default.

Command 0x38

Data field content

	Display mode
Byte #	1

Display mode	0	No refresh before image update
	1	Green/Yellow refresh before image update
	2	Black clear refresh before image update

Set sleep mode

Sets the sleep mode to activated or inactivated. When sleep is enabled the module enters a power saving sleep mode. The time from inactivity to sleep is determined by the value of sleep_time. When cycle mode is enabled sleep mode is disabled. When cycle mode is disabled the module will enter sleep mode if sleep is enabled.

Command 0x40

Data field content

	Sleep mode
Byte #	1

Sleep mode	0	Sleep disabled
	1	Sleep enable

Set inactive to sleep time

Sets the time from inactivity to sleep.

Command 0x41

Data field content

	Sleep-time (s)
Byte #	1

Document no	Page
0-103	12 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Sleep time 1-255 s

Query commands

Query image storage

This command returns the number of images that can be stored in the module.

Command 0x50

Returned data field content

	Number of images
Byte #	1

Query image and module parameters

This command returns the current settings of the image and module parameters.

Command 0x51

Returned data field content

	Image cycle mode	Image cycle delay	Image display mode	Image invert mode	Wipe effect mode
Byte #	1	2	3	4	5

	Quick partial update mode	Row update time	Sleep mode	Sleep time	Image cycle sequence
Byte #	6	7	8	9	10...39

Query display parameters

This command returns the current settings of the display parameters.
The transfer data block size is 256 bytes today, but in the future it might increase.

Command 0x52

Returned data field content

	Display width in pixels		Display height in pixels		Transfer Data block size	
Byte #	1	2	3	4	5	6

Document no	Page
0-103	13 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Query last image number

This command returns the number of the last displayed image. This value is cleared to 0 when power is turned off.

Command 0x53

Returned data field content

	Image number
Byte #	1

Query image status bits

This command returns a bitmapped byte array showing the status of the image memory location. 1 indicates image loaded. 0 indicates no image loaded. LSB of byte 1 is image memory 1.

Command 0x54

Returned data field content

	Image status byte
Byte #	1

Query image checksum

This command returns the checksum of an image. Every image has a 16-bit checksum that makes it possible to identify an image. The checksum is a 16-bit number calculated by adding all the bytes in the image.

Command 0x55

Data field content

	Image #
Byte #	1

Image # The image memory location whose checksum is to be calculated (1-8).

Returned data field content

	16 bit checksum for image #
--	-----------------------------

Document no	Page
0-103	14 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Byte #	1	2
--------	---	---

Query temperature

This command returns a value that can be used to determine the module temperature. This value is used by the module to adjust the row time in order to obtain a good image over the entire temperature range.

Below is a table showing temperature units and the approx. temperature.

° C	0	2	4	6	8	10	12	14	16	18	20	22	25	30	35	40	50	60
Units	123	113	100	92	82	76	68	61	56	49	45	39	33	27	24	19	13	9

Command 0x56

Returned data field content

	Temp unit
Byte #	1

Document no	Page
0-103	15 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Miscellaneous Commands

Set User Data

This command sends 1-32 bytes of data to the module. The data is intended to be used for user configuration.

Command 0xDA

Returned data field content

	User Data
Byte #	1-32

Query User Data

This command returns the User Data that have been saved in the module.

Command 0xDB

Returned data field content

	User data bytes
Byte #	0-32

Set baud rate

Sets the baud rate.

Command 0xFA

Data field content

	Baud-rate
Byte #	1

Baud rate	For baud rate	send
	2400	0x01
	4800	0x02
	9600	0x04
	14400	0x08
	19200	0x10
	28800	0x20

Name of document Display module communication protocol –public version		Document no 0-103	Page 16 (18)
Product/Activity Display module		Valid from Apr 12, '02	Replacing 0-101
Operation	Any belonging manuals for modules -	Written by AM, BQ	Approved by QA routines -

57600 0x40
115200 0x80

The ack is sent with the old baud rate. The baud rate is updated after the ack has been sent.

Version

Returns the model, version and serial number of the display as an ASCII text string.

The text string is returned in the data field of the ACK response.

The string is as follows: "MMMM HH.HH RR.RR SSSSSSSS<Text with legal information>".

MMMM is the model.

HH.HH is hardware version and revision.

RR.RR is software version and revision.

SSSSSSSS is the serial number.

<Text with legal information> Text string with legal information concerning the module.

Command 0xFB

Returned data field content

ASCII text string with 25 characters + (0–103) characters with legal information

Document no	Page
0-103	17 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Address request

In this command the broadcast address 0xFF, 0xFF is used. The address can therefore not be used for regular use. When using this command change the hi and lo address bytes to 0xFF.

Returns the address of the connected display.

Only one display should be connected and powered on when this command is issued. The address is returned in the data field of the ACK response.

Command 0xFC

Returned data field content

	Address Hi byte	Address Lo byte
Byte #	1	2

Address hi byte System address 0x00..0xFF

Address lo byte Slave address 0x00..0xFF

Set address pending

Sets the system and slave address of the display.

The address will be changed when the confirm set address command is issued. See below.

Command 0xFD

Data field content

	Address Hi byte	Address Lo byte
Byte #	1	2

Address hi byte System address 0x00..0xFF

Address lo byte Slave address 0x00..0xFF

Document no	Page
0-103	18 (18)
Valid from	Replacing
Apr 12, '02	0-101
Written by	Approved by QA routines
AM, BQ	-

Name of document	
Display module communication protocol –public version	
Product/Activity	
Display module	
Operation	Any belonging manuals for modules
	-

Confirm set address

Sets the system and slave address of the display.

This command must be given directly after a set address pending command.

The address will be changed immediately after this command is issued.

Command 0xFE

Data field content

	Address Hi byte	Address Lo byte
Byte #	1	2

Address hi byte System address 0x00..0xFF

Address lo byte Slave address 0x00..0xFF

The ack is sent with the old address. The address is updated after the ack has been sent.

Reset display

Resets the display to the factory settings.

Command 0xFF

Data field content

No argument

The factory settings are

Baud rate code	0x04	(9600)
Baud rate	0x2F	(9600)
Button enable	1	(enable)
Refresh mode	2	(black)
Cycle mode	0	(disable)
Cycle delay	10	
Display mode	0	(normal)
Invert mode	0	(normal)
Sleep mode	0	(disable)
Sleep time	40	
Status bits	0	(no images)
User defined cycle mode	0	(no cycle sequence)
