ACS

Color 320 x 240 LCD

Display Terminal

User's Manual

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ACS
Ackerman Computer Sciences

On The Cutting Edge of Technological Evolution

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Overview

The **ACS Color 320 x 240 LCD Display Terminal** is designed to provide a cost effective RS-232/RS-485/USB/Ethernet operator interface or stand-alone controller. A high contrast Color 320 x 240 pixel LED backlight TFT LCD provides viewing in direct light, and well as indoors. It is equipped with a resistive touchscreen. It has a 12:00 to 6:00pm viewing angle, which means that it can be viewed from straight on to about 80 degrees downward.

Features

- FLASH based design for easy in-field software updates
- Color TFT LCD display with touchscreen, LED backlight and noon to 6:00PM viewing angle
- Single Power Supply
- Emulation of earlier ACS-128x64 and ACS-320x240 monochrome displays
- Fully scriptable using powerful ACS Basic
- RS-232 Serial Port for communication.
- USB port for connection to PC as a Flash Drive or Serial device.
- Ethernet connection with programmable configuration and multiple protocol support: DHCP client, FTP server, VNC server, HTTP, TCP/IP Raw, NTP client, SMTP client (via Basic) and Art-Net™.
- Optional Power Over Ethernet operation.
- On board 250mW audio amplifier for sounds and tone generator
- On board diagnostic LED
- Support for either a front or rear loadable micro SD memory card
- User configurable non-volatile settings for:
    - Operating mode
    - Baud rate
    - Display communications address for multi-drop operation
    - Backlight timeout seconds
    - Optional display logo on power-up
    - Optional display settings on power-up
    - Optional pop-up touchscreen QWERTY / NUMERIC keypad
    - Protocol selection:
        - SOH / ETX commands for full graphics
        - ANSI subset for scrolling character data
        - Full scripting using ACS Basic
    - MAC and IP address
    - other
- Small form-factor, mounts in standard dual-gang electrical switchbox with optional mounting plate and overlay
- Low power
    - 25mA Typical with LED Backlight Off
    - 75mA Typical with LED Backlight On

Manual Conventions

In this manual the following assumptions, abbreviations and conventions are used:

ASCII – Is the abbreviation for the American Standard Code for Information Interchange. As ASCII code is the agreed upon 7-bit numerical representation of a character. (***see ASCII Table appendix***)

BASIC – Is the abbreviation for Beginners All purpose Symbolic Instruction Code – a family of general purpose, high-level programming languages.

ASCII Hex – The use of one or more ASCII characters to represent one or more hexadecimal digits to encode a decimal value:

ASCII Character(s)	Represents Decimal Value
'0'	0
'1'	1
'2'	2
'3'	3
'4'	4
'5'	5
'6'	6
'7'	7
'8'	8
'9'	9
'A'	10
'B'	11
'C'	12
'D'	13
'E'	14
'F'	15
'10'	16
…	…
'28'	40
…	…
'7F'	127
'80'	128
…	…
'FF'	255
…	…
'0EF'	239
…	…
'13F'	319

DTE – Data Terminal Equipment – an end piece of equipment that converts signals to and from user information.

DCE – Data Communications Equipment – a piece of equipment that sits between the data terminal equipment (DTE) and a transmission circuit

EIA – Electronic Industries Association – a standards and trade organization composed as an alliance of trade associations for electronic manufacturers in the United States. They developed standards to ensure that equipment of different manufacturers was compatible and interchangeable.

USB – Is the abbreviation for Universal Serial Bus.

UCS – Is the abbreviation for Universal Character Set. A standard set of characters upon which many character encodings are based.

UTF-8 – Is the abbreviation for UCS Transformation Format – 8-bit. This is a variable width encoding that provides support for extended characters beyond 7-bit ASCII yet is backward-compatible. (***See the Displayed Characters, Extended Characters appendix***)

<SOH> – Is the printed representation of a single ASCII Start of Heading character; CTRL-A, 01 decimal, 01 hex. This character delineates the start of a command or response in SOH/ETX the protocol modes.

<ETX> – Is the printed representation of a single ASCII End of Text character; CTRL-C, 03 decimal, 03 hex. This character delineates the end of a command or response in SOH/ETX the protocol modes.

<CR> – Is the printed representation of a single ASCII Carriage Return character, CTRL-M, 13 decimal, 0D hex.

<LF> – Is the printed representation of a single ASCII Line Feed character, CTRL-J, 10 decimal, 0A hex.

<GS> – Is the printed representation of a single ASCII Group Separator character, CTRL-], 29 decimal, 1D hex.

<RS> – Is the printed representation of a single ASCII Record Separator character, CTRL-^, 30 decimal, 1E hex.

<US> – Is the printed representation of a single ASCII Unit Separator character, CTRL-_, 31 decimal, 1F hex.

SOH/ETX Protocol – The use of a command/response protocol where the messages are bracketed by the non-printing, non-displaying SOH and ETX characters and the bracketed message contents are expressed by a sequence of one or more printable, displayable characters.

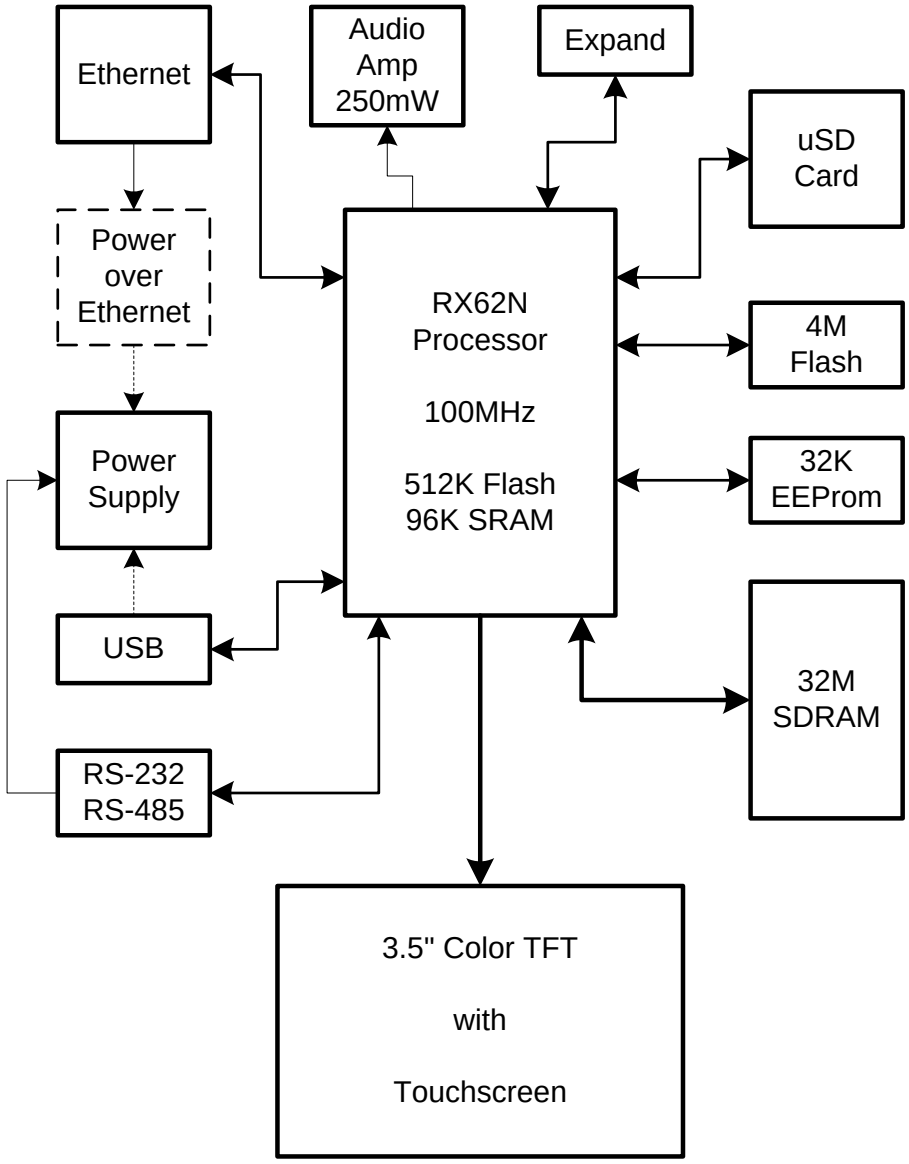
BPP – Is the abbreviation for Bits Per Pixel. This value controls the number of possible color combinations with larger values providing more accurate color at the expense of requiring larger amounts of memory.

RGB565 – Is the printed representation of a 16-bit color comprised of 5 bits of Red, 6 bits of Green and 5 bits of Blue shown as a four digit hexadecimal number:

15 MSB	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0 LSB
Red					Green						Blue				

Block Diagram

The ACS Color LCD 320x240 consists of the following elements:



Connections

There are three communication connections: EIA Serial, USB and Ethernet.

The **SERIAL** connection may be either full duplex RS-232 configurable as DCE or DTE with hardware flow control, or half duplex RS-485. The display may be optionally powered using two pins on the DB-9 serial connector.

The **USB** connection may be configured to emulate a flash drive or virtual serial port. The display may be optionally powered from the USB port.

The **ETHERNET** connection provides a 10Base-T/100Base-T with auto negotiation and auto MDI/MDI-X detection and correction. The display may be optionally powered using IEEE802.3af Power Over Ethernet.

Supplying Power

The display requires a source of power to operate. There are three ways to power the display:

1. Using a couple of pins on the SERIAL connector to connect an external power supply.
2. Using a USB connection to supply power.
3. Using the optional Power Over Ethernet (POE) module and an external Ethernet power injection module.

WARNING: Do not install the USB_POWER jumper if powering the display through the SERIAL connector or external Ethernet power injection module. High voltage will be injected back through your USB cable to the host computer.

Let's look at each of these options in more detail.

Via SERIAL Connector with ACS Power Injector

This consists of a back-to-back pair of DB-9 serial connectors with a wall transformer. The Color LCD can be powered through two pins on its SERIAL connector. This injector supplies that power while allowing the other serial connector pins to pass through to your application cabling and hardware.

ACS LCD Power Injector

Via USB DEVICE Connector with USB Cable

This consists of a USB A to Micro B cable that connects the Color LCD's DEVICE connector to your PC. The USB_POWER jumper by the USB DEVICE connector must be installed.

WARNING: Do not install the USB_POWER jumper if powering the display through the SERIAL connector or external Ethernet power injection module. High voltage will be injected back through your USB cable to the host computer.

USB A to Micro B Cable

Via ETHERNET Connector with Power Over Ethernet

This requires the optional POE module be installed on the Color LCD and an IEEE802.3af Ethernet power injector cabled to the ETHERNET jack on the display.

PWR128RA 19W Power Over Ethernet Injector

The connection supports Power Over Ethernet (POE) if the optional POE module is installed on the controller and can be used to power the display with remote power injection. The POE support is IEEE802.af compliant and provides a Class 0 signature. Both DC power on Spares (mode B) and DC power on Data (mode A) operation is supported:

ETHERNET Pin #	POE DC Power on Spares		POE DC on Data	
	MDI Signal	MDIX Signal	MDI Signal	MDIX Signal
1	TX+	RX+	TX+ PSE+	RX+ PSE+
2	TX-	RX-	TX- PSE+	RX- PSE+
3	RX+	TX+	RX+ PSE-	TX+ PSE-
4	PSE+	PSE+		
5	PSE+	PSE+		
6	RX-	TX-	RX- PSE-	TX- PSE-
7	PSE-	PSE-		
8	PSE-	PSE-		

SERIAL Connector

The display can function as either a RS-232 DTE (Data Terminal Equipment) or RS-232 DCE (Data Communications Equipment) device. There is a jumper block site on the controller labeled JB1 that can be used to reverse the pins of the signals pairs TxD, RxD and RTS, CTS on the SERIAL connector to accomplish this change.

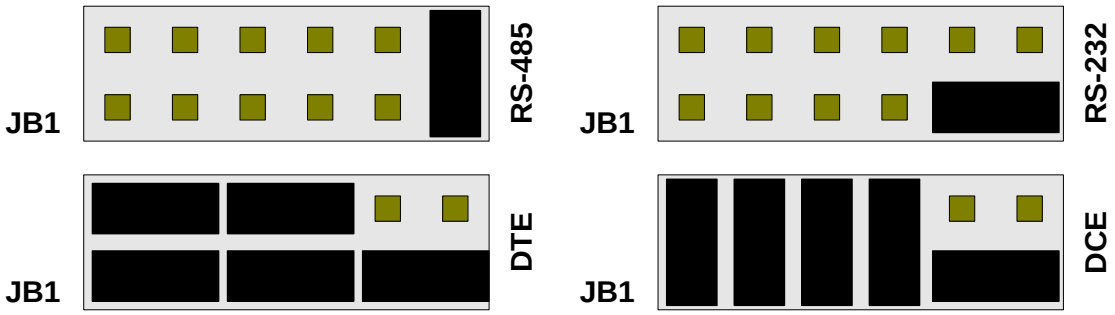
DB-9P Signals

Connection to the SERIAL connector requires a female DB-9S mating connector. The following signals appear on the male SERIAL DB-9P connector:

SERIAL DB-9P Connector

PIN	DCE Signal	JB1 as DCE Direction		DTE Signal	JB1 as DTE Direction
1	RS-485 B-	I/O		RS-485 B-	I/O
2	RS-232 TxD	OUT		RS-232 RxD	IN
3	RS-232 RxD	IN		RS-232 TxD	OUT
4					
5	GND	PWR		GND	PWR
6	RS-485 A+	I/O		RS-485 A+	I/O
7	RS-232 CTS	IN		RS-232 RTS	OUT
8	RS-232 RTS	OUT		RS-232 CTS	IN
9	+12-15VDC	PWR		+12-15VDC	PWR

JB1 Configuration Jumpers



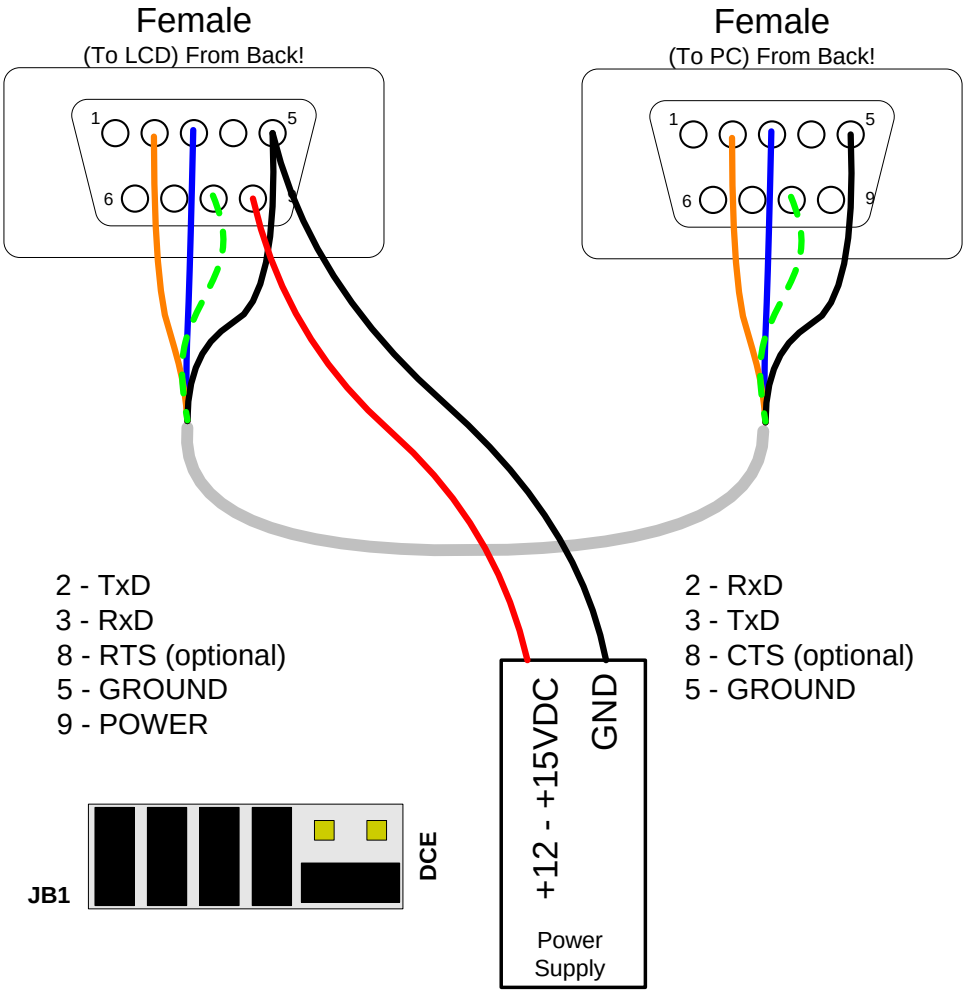
RS-232 Connection to PC

The PC is configured as a DTE device. A one-to-one, female DB-9S to DB-9S cable can be used to connect the PC communication port to the Color LCD SERIAL connector when the Color LCD is configured as DCE. Only four wired connections are required.

The RTS connection is for optional flow control of the transmit data to the display to prevent over-flowing the display input buffer at higher baud rates. It requires disabling the RS-485 enable in the display configuration and implementation of flow control on the host device supplying the data to the display.

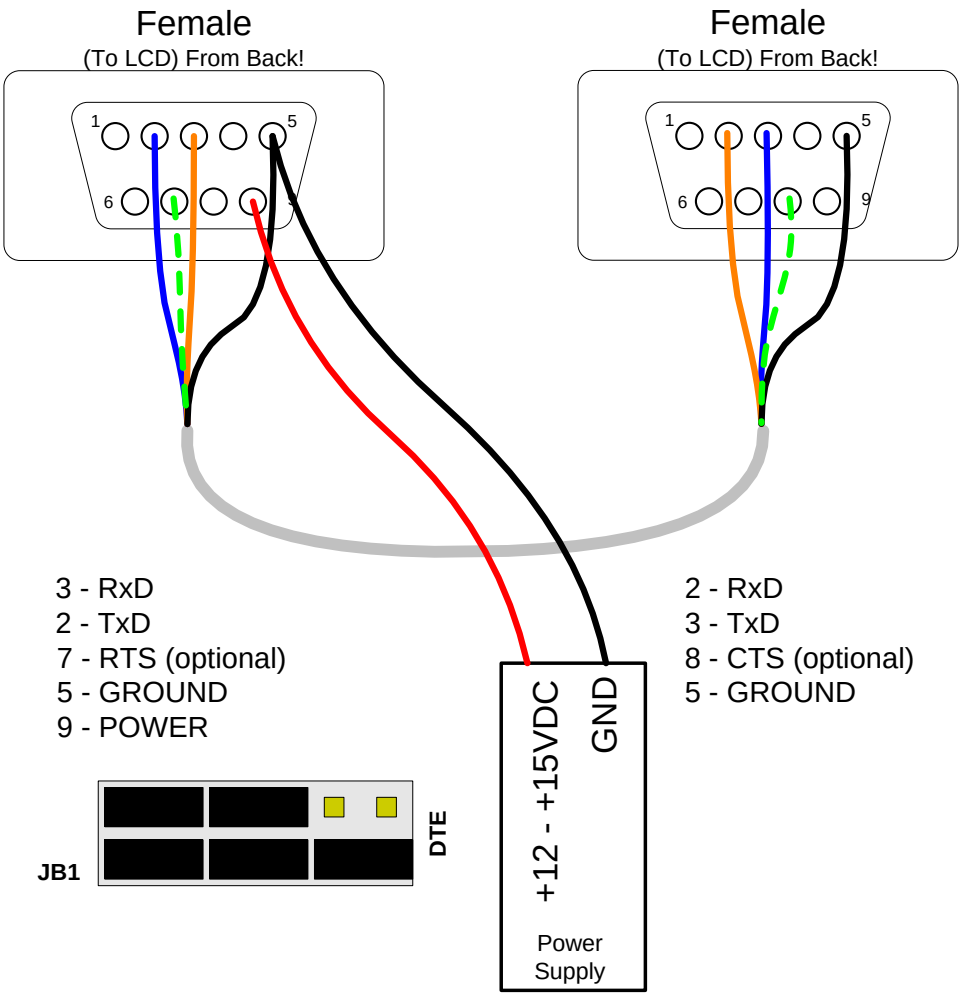
RS-232 LCD (JB1 jumpered as DCE) to PC (DTE)

The Color LCD can be connected with a one-to-one cable between the display and host PC when JB1 is configured for DCE:



RS-232 LCD (JB1 jumpered as DTE) to PC (DTE)

The Color LCD can be connected with a null modem cable (or one-to-one cable with null modem adaptor) between the display and host PC when JB1 is configured for DTE:



RS-485 Connection

The LCD display can be used with RS-485 serial connections. The RS-485 Enable configuration item must be turned on to control when the driver is enabled on the bus:

SERIAL Pin #	Power Supply	LCD SIGNAL
6		A+
1		B-
5	GND	GND
9	+12 → +15VDC	+12 → +15VDC

NOTE: Be sure to connect both the Ground of the PC or Host computer and the Ground of your +12 → +15VDC Power supply together!

The RS-485 A+ and B- signals are terminated with a 100 ohm resistor between them. In addition, there is a 10K pull-up resistor on the A+ signal to +3.3v and a 10K pull-down resistor on the B- signal to Ground, to put the received data line in an idle state when there is no connection.

USB Connector

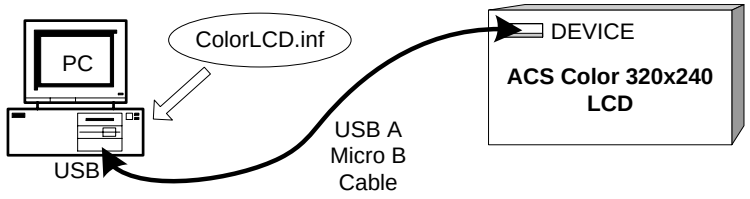
The ColorLCD can be connected as a USB peripheral device. A standard micro USB B receptacle connector is provided and it can be connected to a PC using a standard USB-A to micro USB B cable. The ColorLCD can be configured to function as either a USB flash drive or USB serial device. When configured as a flash drive (the default) the ColorLCD SD card appears as a USB drive on the host PC and supports file transfers. When configured as a serial device the ColorLCD sends and receives serial data as if connected to the RS-232 port.

DEVICE Pin #	Signal Name	Description
1	VBUS	USB Power +4.5v
2	D-	Data -
3	D+	Data +
4	ID	Identification (nc)
5	GND	Ground

A ColorLCD.inf file is available that identifies the Color LCD as a virtual serial port device that implements the Communications Device Class. (A Linux USB CDC configuration file is also available)

WARNING: Do not install the USB_POWER jumper if powering the display through the SERIAL connector or external Ethernet power injection module. High voltage will be injected back through your USB cable to the host computer.

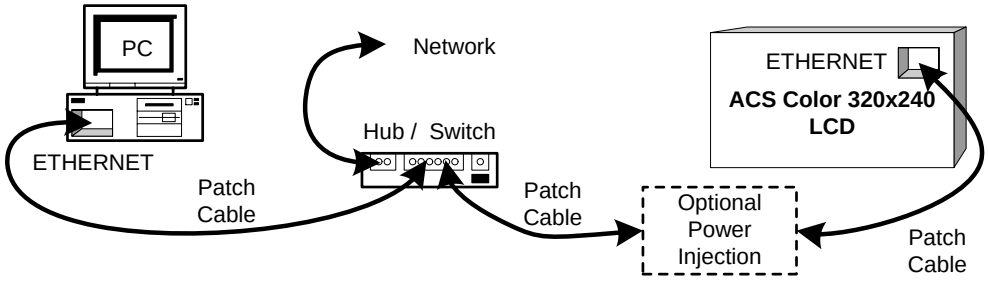
Connect the **USB A to Micro B cable** to the Color LCD **DEVICE** connector. Connect the other end of the cable into a USB port on your PC.



Windows will indicate that it has found new hardware and will eventually prompt for the location of a driver for the Color LCD. Browse to the location of the ColorLCD.inf file that you have downloaded and select it. Windows should now finish installing the new hardware and it should be ready to use. The COM port identifier that Windows will assign to the Color LCD will depend upon what other communications devices are present in the system and can be determined using the Device Manager.

Ethernet Connector

The LCD display can be connected as an Ethernet device. A standard RJ-45 connector is provided and it can be connected to a network with a standard Ethernet cable – either straight or crossover, detection and correction is automatic via HP Auto MDI/MDI-X configuration. The network speed can be either 10 or 100 mbps with auto link negotiation. A link activity indicator is provided on the ETHERNET jack.



The LCD display supports a configurable MAC address and configurable static IP address and IP mask. Communication is performed using TCP/IP Raw Sockets with a configurable port address.

How the Communication Works

The RS-232 SERIAL connection is essentially always connected – even if no physical connection is present.

The USB connection is 'connected' when the cable is plugged into a host PC where the driver has been installed and the display is configured for USB Mode: SERIAL.

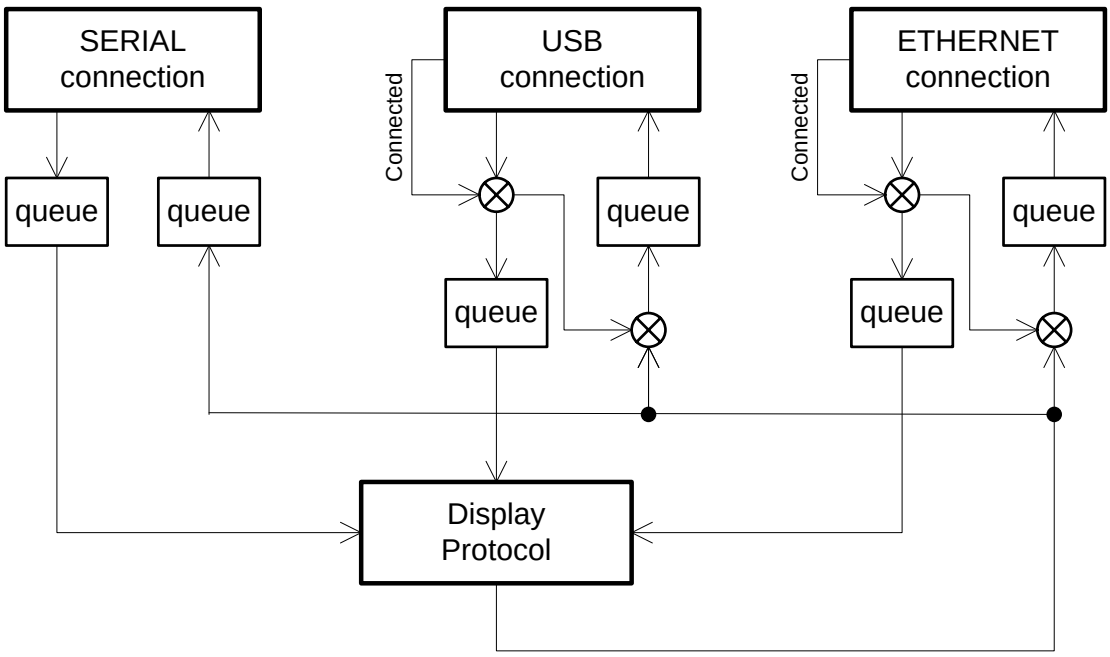
The ETHERNET connection is 'connected' when the display has been connected to the network and a TCP/IP raw sockets link has been established.

Incoming data from each of the three sources are combined asynchronously in parallel into the display protocol that is running.

Any output that the display protocol generates is copied to all three outputs synchronously. If a connected output queue fills up, the other outputs are delayed until the full queue has space available - so the slowest connected output limits the output data rate to all of the outputs.

Note that some USB hosts will stop responding to the USB connection if it is connected and there is no application running to receive the incoming data – stopping the output data to all of the outputs.

Here's a diagram:



Speaker Connector

The following signals appear on the two pin KK-100 SPKR connector:

PIN	SIGNAL
1	Speaker +
2	Speaker -

Mating Connector: KK-100 0.1" 2 position

microSD Card Connector

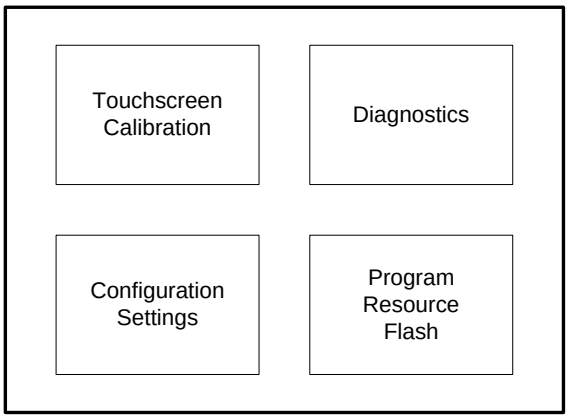
There are two slots for use of a microSD memory card – one along the upper left-hand edge of the display, and the other on the display controller board. These two slots are parallel – there can only be a single microSD card installed in either slot at the same time. All card accesses are performed in SPI mode using the following signals:

uSD Pin #	Signal Name	Description
1	DAT2 / NC	No connection
2	CD / DAT3 / CS-	Chip Select (active low)
3	CMD / DI	Data Input
4	VDD	Power (+3.3v)
5	CLK	Clock
6	VSS	Ground
7	DAT0 / DO	Data Output
8	DAT1 / RSV	No connection

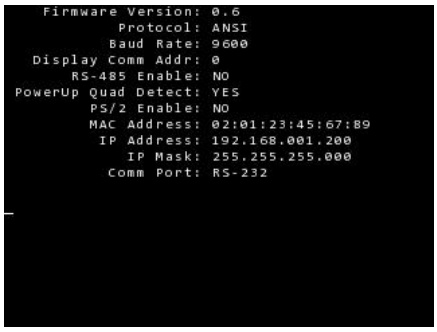
MicroSD cards of Standard Capacity (SDSC or SD, 1MB to 4GB) and High Capacity (SDHC, 2GB to 32GB) are supported.

Startup

When power is applied or the ACS Color LCD 320x240 Display is reset, the controller initializes the display, turns on the backlight, then initializes the non-volatile memory, keypad, serial communications and touch screen. Next, if the touch screen reports that it has a continuous touch, the coordinate of the touch location is used to force the display into one of four startup modes depending upon which quadrant is being touched:

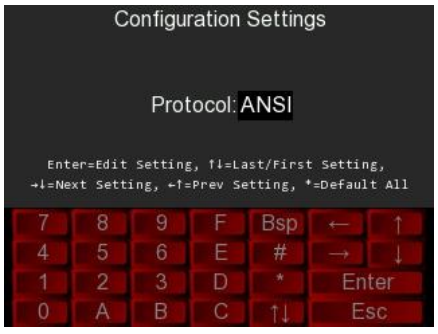


If there is no touch held in any quadrant, the display finishes powering up:



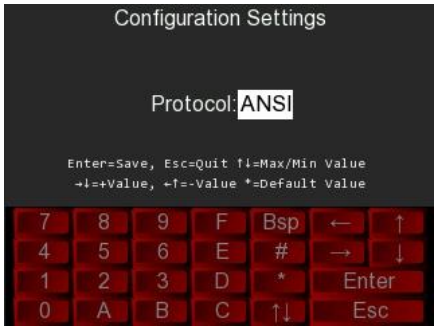
Configuration Settings Mode

In Configuration Settings mode, the touch keypad is used to adjust or default User Configuration settings. In this mode, the touch keypad is displayed, and the ↑ and ↓ keys are used to scroll between configuration items, one at a time. Let's try it. Press and release the down arrow once. The screen shows the Protocol: setting.

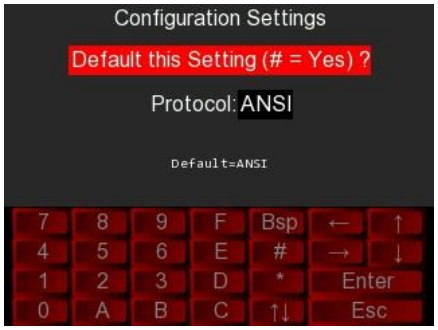


Notice that the fine print legend under the setting and above the keypad indicates that the ← and → keys can also be used to scroll between settings. Try scrolling between the various settings and notice how the settings wrap around after the End Of Config: 0 setting is reached.

The legend indicates that you can Edit a setting by pressing the Enter key. Try it – scroll to the Protocol: setting and press the Enter key. The setting highlights to show that it is being edited and the legend changes:

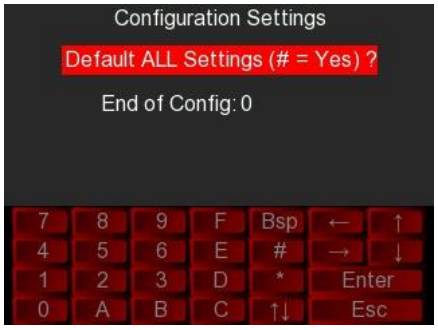


Try changing the setting using the arrow keys. Note that the display supports five different Protocols and that the setting value doesn't wrap around. You can Save the setting at any time by pressing the Enter key again. You can also default the individual setting when editing it by pressing the * key. The Default this Setting question appears:



Some settings allow numeric entry of a new value via the number keys.

The legend also indicates that we can default all of the settings – probably a good idea so we start with a clean slate. Press and release the * key. The Default ALL Settings question appears:



If you press any key other than the # key, the question is answered NO and all the settings will not be defaulted.

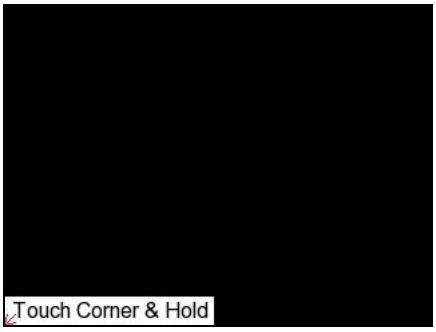
Press and release the # key to answer yes. The settings are defaulted and the settings screen reverts to the first setting.

Touch Screen Calibration Mode

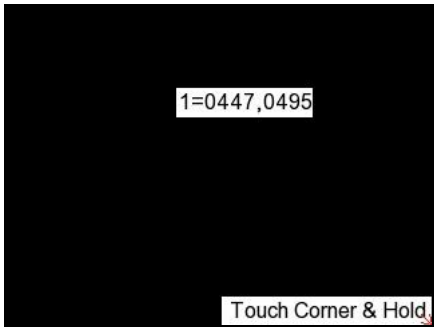
When the screen is held touched in this quadrant during power-up, the LCD enters the Touch Screen calibration process.

Incorrect entry of the touch screen coordinates during calibration can result in the inability of the touch screen to function properly and require that the touch screen calibration be defaulted and re-attempted. The protective plastic covering should be removed before attempting calibration.

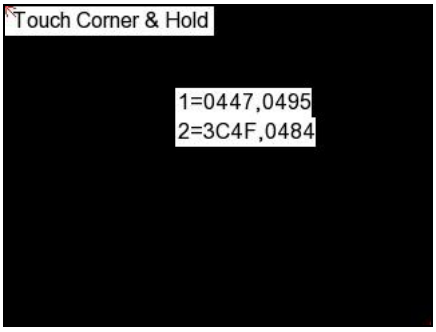
Calibration is a six step process. A soft pointed stylus should be used to touch each point in sequence for improved accuracy. As each point is touched, the display computes and displays the alignment coefficients. After the last point is touched, the display shows a Save button and allows testing the alignment by showing touches on the screen. When the Save button is pressed the coefficients are saved to non-volatile memory. Further touch screen activity is then compensated by the saved coefficients so that touch screen coordinates align with display pixel locations.



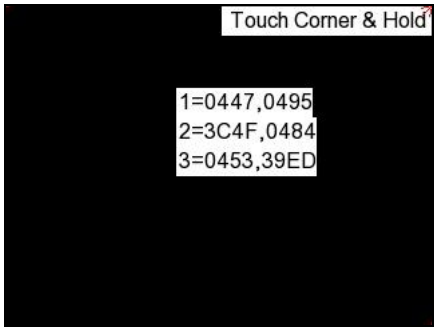
1 - First Corner



2 - Second Corner

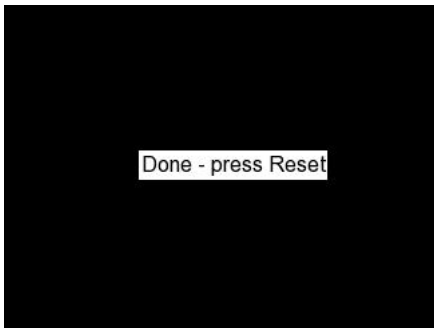


3 - Third Corner



4 - Fourth Corner

5 - Test and Save if OK

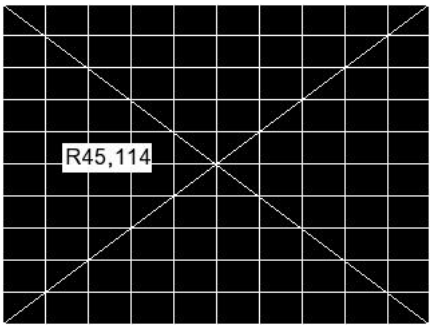


6 - Calibration done

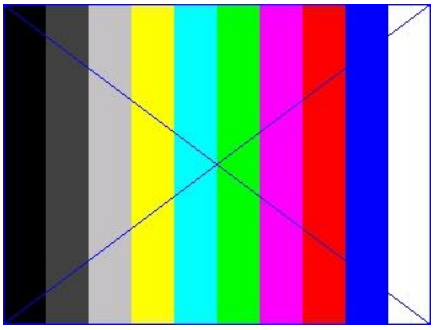
Diagnostics Mode

When the screen is held touched in this quadrant during power-up, the LCD enters the Diagnostics Mode.

In Diagnostics Mode, the display alternates between drawing a grid and color bars, toggles the backlight on and off, produces an intermittent tone and shows the status of any touch screen touch interaction:



Grid with Touch Coordinates


Color Bars

Program Resource Flash

When the screen is held touched in this quadrant during power-up, the LCD enters the Program Resource Flash Mode.

The Color LCD uses a serial flash memory to optionally hold fonts and other graphics that it can display. In order to program the contents of this flash an external programming utility is used in conjunction with the display operating in this mode.

1. Start the SPIBOOT programming utility.
2. Select the hex file containing the resources to be programmed.
3. Click the SPIBOOT Program button to start the resource programming.

User Configuration

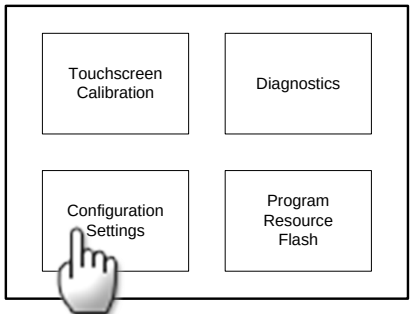
Entering User Configuration

User configuration can be entered in two ways:

1. Pressing on the Lower Left touch screen quadrant during power-up or Reset.
2. Shorting EXP connector pin 7 to EXP pin 8 during power-up or Reset.

To enter the User configuration screen using the quadrant method:

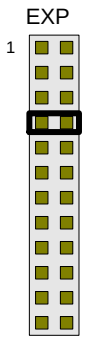
1. Press and hold the lower-left quadrant of the screen:



2. Press and release the RESET button or power cycle the display
3. Release the lower-left quadrant of the screen.

To enter the User configuration screen using the second jumper method:

1. Remove power, or hold the RESET button
2. On the EXP connector connect pin 7 to pin 8 using a jumper shunt:



3. Power up the display, or release the RESET button if power was not removed.
4. The display should initialize and default the Non Volatile Memory (configuration settings). The Configuration Settings screen should appear.
5. Remove the EXP connector pin 7 to pin 8 jumper from step 2.

Follow the on screen soft menus to edit, select, and edit the configuration values as required.

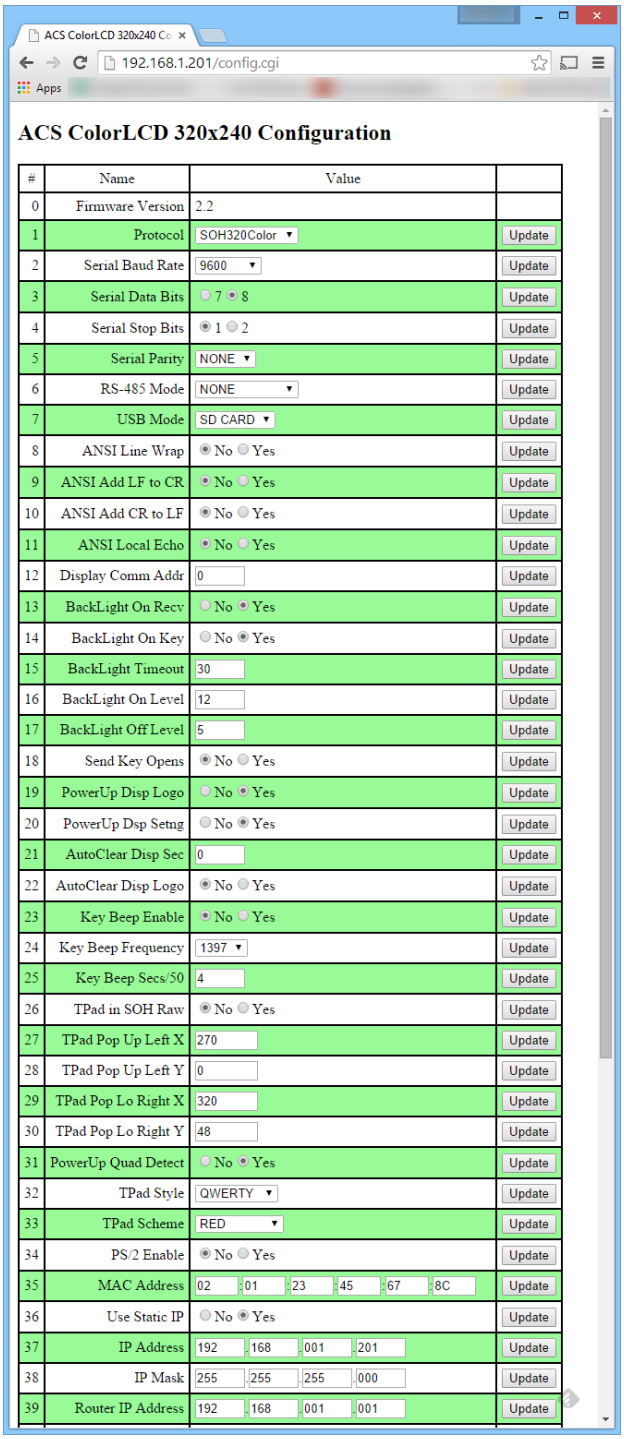
NOTE: Some configuration setting changes will not take effect until the display is Reset.

Configuration Settings

#	Setting	Description
00	Firmware Version	= version # of firmware
01	Protocol	0 = ANSI (default), 1 = SOH128Mono, 2 = SOH320Mono, 3 = SOH320Color, 4 = ACS Basic
02	Serial Baud Rate	1200, 2400, 4800, 9600 (default), 19200, 38400, 57600
03	Serial Data Bits	7, 8 (default)
04	Serial Stop Bits	1 (default), 2
05	Serial Parity	NONE (default), EVEN, ODD
06	RS485 Mode	None (default), Primary, Secondary
07	USB Mode	SD Card (default), Serial port
08	ANSI Line Wrap	0 = no wrap (default), 1 = ANSI lines exceeding screen width wrap to next line
09	ANSI Add LF to CR	0 = CR (default), 1 = incoming CR replaced by CR/LF pair
10	ANSI Add CR to LF	0 = LF (default), 1 = incoming LF replaced by CR/LF pair
11	ANSI Local Echo	0 = no echo (default), 1 = echo
12	Display Comm Addr	0 = no address (default), xx = display's address for SOH/ETX protocol
13	Backlight on Recv	0 = disabled, 1 = backlight on for time when characters received
14	Backlight on Key	0 = disabled, 1 = backlight on for time when switch pressed
15	Backlight Timeout	= number of seconds backlight stays lit (default = 30)
16	Backlight On Level	0 = off, 12 = default, 15 = full brightness
17	Backlight Off Level	0 = off, 5 = default, 15 = full brightness
18	Send Key Opens	0 = no (default), 1 = yes
19	Power Up Disp Logo	0 = no logo upon reset, 1 = display graphic page 0 (logo) upon reset (default)
20	Power Up Disp Setng	0 = no settings shown upon reset, 1 = display settings screen upon reset (default)
21	Auto Clear Disp Sec	= number of seconds before display clears (default = 0, off)
22	Auto Clear DispLogo	= number of seconds before logo clears (default = 0, off)
23	Key Beep Enable	0 = disabled (default), 1 = enabled
24	Key Beep Frequency	262Hz, 440Hz, 880Hz, 1397Hz (default), 1760Hz, 2093Hz, 3520Hz
25	Key Beep Secs/50	= duration of key beep in fiftieths of a second (default = 12)
26	TPad in SOH Raw	= Touch Keypad characters sent outside of SOH/ETX protocol
27	TPad Show Up Left-X	= Touch Keypad Show upper left X coordinate (0 – 319) (default=270)
28	TPad Show Up Left-Y	= Touch Keypad Show upper left Y coordinate (0 – 239) (default=0)
29	TPad Show Lo Right-X	= Touch Keypad Show upper left x coordinate (0 – 319) (default=319)
30	TPad Show Lo Right-Y	= Touch Keypad Show upper left x coordinate (0 – 239) (default=48)
31	Power Up Quad Detect	= 0 no touchscreen quadrant detect upon reset, 1 = detect touchscreen quadrant held upon reset (default)
32	TPad Style	= NONE, QWERTY, NUMERIC, QWERTY TOP, NUMERIC TOP
33	TPad Scheme	= RED, GREEN, BLUE, GRAY 25%, GRAY 50%
34	PS/2 Enable	0 = disabled (default), 1 = enabled (requires external adaptor on EXP)
35	MAC Address	= 02:01:23:45:67:89 (default)
36	Use Static IP	= 0-DHCP client, 1-static IP (default)
37	IP Address	= 192.168.1.200 (default)
38	IP Mask	= 255.255.255.0 (default)
39	Router IP Address	= 192.168.1.1 (default)
40	FTP Server Port	= 21 (default)
41	VNC Server Port	= 5900 (default)
42	HTTP Server Port	= 80 (default)
43	TCP/IP Raw Port	= 23 (default)
44	NTP Server	= 192.168.1.1 (default)
45	NTP Client Port	= 123 (default)
46	Local Time Zone	= -5 hours from UTC (default)
47	Daylight Savings	0 = no (default) adds one hour to received NTP time
48	Serial Number	00000000 (default)
49	Volume	Last volume setting (not currently implemented)
50	Art-Net IP Port	6454
51	Art-Net Net	0 (default) – 127
52	Art-Net Sub-Net	0 (default) – 15
53	Art-Net Universe	0 (default) – 15
54	Art-Net Target IP	255.255.255.255 (default)
55	End of Config	= end of configuration items placeholder
56	NV Status Byte	= NV status byte (default = 227)

Note that if you disable the Power Up Quad Detect you will have to use a hardware jumper to force the display into the Configuration Settings screen on power-up.

The built-in HTTP configuration server is accessed using a web browser to access the ColorLCD's URL: http://192.168.1.200/config.cgi. The following built-in configuration page is displayed:



Touch Screen

The ACS LCD320x240 display is equipped with a four wire resistive touch screen. Touch event coordinates may be reported to the host computer. An optional pop-up touch keypad may be displayed to allow interactive data entry. The calibration data to align the touch screen coordinates with the display is stored in non-volatile memory on the display.

Touch Keypad

A touch keypad is also available. The touch pad overlays graphics or text underneath. There are five available styles: QWERTY, QWERTY TOP, NUMERIC, NUMERIC TOP and CONFIGURATION.

The touch pad appears on the display when a calibrated touch screen is tapped within a designated pop-up box. The location and size of this pop-up box is configurable and defaults to a small box at the lower right of the screen. It may be disabled by configuring the designated pop-up box coordinates to all zeroes or by selecting a **`TPad Style`** of NONE. The touch pad can also be controlled by receipt of serial commands in SOH/ETX protocol mode.

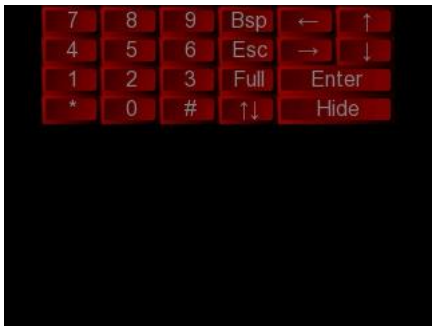
Here are the layouts of the various touch pads. Notice that with this configured TPad Scheme (RED) the keys highlight when pressed:

QWERTY un-shifted

QWERTY shifted

QWERTY top, un-shifted

NUMERIC



NUMERIC top

CONFIGURATION

When the display is operating in SOH/ETX protocol mode, the keys that are touched are sent as Keypad Closed ('K') response messages. ***See the Keypad Closed Response in the SOH/ETX Modes section for details.***

When the display is operating in ANSI mode, the keys are sent via the serial connection as ASCII characters.

When the display is operating in ACS Basic mode, the keys are presented to the Basic interpreter as if they were received from a serial connection.

Note that the small key size on the QWERTY keypads may require the use of a stylus for accurate entry.

Serial Flow Control

CFSound firmware provides optional support for flow control of transmit data to the player to prevent overflowing the input buffer at higher baud rates.

The CFSound will assert its RTS signal on power-up and whenever there is room in its input buffer.

The CFSound will de-assert its RTS signal whenever the input buffer is at 90% of its 1024 byte capacity or higher.

It will re-assert its RTS signal whenever the input buffer is below 80% capacity.

The host device that the CFSound is connected to should monitor the RTS signal, typically by connecting it to the host's CTS input, and only send transmit data to the player when the signal is asserted.

Without flow control it is possible to overrun the CFSound input buffer at baud rates above 9600 baud. Symptoms of input buffer overflow include missing or incorrectly displayed data or commands.

RS-485 Driver Enable

CFSound firmware provides configurable support for enabling the RS-485 transceiver to operate in a half-duplex mode. This allows multiple devices to exist on a multi-drop bus with devices receiving from the bus when they are not transmitting.

The player will enable its transceiver driver whenever it needs to transmit data, then it will disable the driver after the data is fully transmitted.

Enabling this option in the configuration menu overrides the Serial Flow Control via RTS above as it uses the RTS signal to control the RS-485 driver enable.

Display Operating Modes

The display supports five different operating modes selectable by the Protocol configuration item:

Protocol	Description
ANSI Mode	ANSI terminal emulation with UTF-8 support
SOH128Mono Mode	ACS LCD 128x64 emulation
SOH320Mono Mode	ACS LCD 320x240 emulation
SOH320Color Mode	ACS Color LCD 320x240
ACS Basic Mode	ACS Basic programmable

These different operating modes are further defined in the following sections.

ANSI Mode

The ANSI subset protocol allows the display to be used as a limited ANSI terminal with scrolling. The display consists of 20 lines of 45 characters shown using a fixed pitch 6 x 10 pixel font that is drawn in a 7 x 12 pixel matrix. The display supports the concept of a 'cursor', which is displayed as a blinking underline, and represents the insertion point on the display where the next printable character that is received will be placed.

The following ANSI characters and commands are supported:

Displayed Characters

The ANSI mode supports UTF-8 character coding. Receipt of byte values of printable US ASCII characters (32 decimal / 20 hex through 126 decimal / 7E hex) displays those characters. Extended characters may be displayed using a multi-byte UTF-8 sequence. ***(See the Displayed Characters appendix for details)***

Receipt of these printable characters cause the display to show the character on the screen at the current cursor location, and then move the cursor right to the next position. Escape character sequences may be used to pre-position the cursor, clear one or more lines and/or set the coloring for subsequently displayed text.

There is a User Configuration setting that will automatically wrap the cursor to the beginning of the next line, if required, scrolling up if the cursor was on the last line.

BELL

Value (ASCII 7 decimal / 07 hex) Receipt of this character causes the display to produce a 1KHz tone for 0.2 seconds.

Backspace (BS)

Value (ASCII 8 decimal / 08 hex) Receipt of this character causes the display to move the cursor one position to the left.

Horizontal Tab (HT)

Value (ASCII 9 decimal / 09 hex) Receipt of this character causes the display to move the cursor right to the next tab stop. Moving past the rightmost tab stop causes the cursor to move to the beginning of the following line with display scrolling up if the cursor was on the last line. There are 9 tab stops per line at positions 4, 8, 12, 16, 20, 24, 28, 32 and 36.

Line Feed (LF)

Value (ASCII 10 decimal / 0A hex) Receipt of this character causes the display to move the cursor down to the next line in the same column. The display will scroll up if the cursor was on the last line. Lines scrolled off the top of the screen are discarded. There is a User Configuration setting that will automatically add receipt of a Carriage Return (CR) character after a line feed if required.

Vertical Tab (VT)

Value (ASCII 11 decimal / 0B hex) Receipt of this character causes the display to move the cursor down to the next line in the same column. The display will scroll up if the cursor was on the last line.

Form Feed (FF)

Value (ASCII 12 decimal / 0C hex) Receipt of this character causes the display to move the cursor down to the next line in the same column. The display will scroll up if the cursor was on the last line.

Carriage Return (CR)

Value (ASCII 13 decimal / 0D hex) Receipt of this character causes the display to move the cursor left to the first column on the current line. There is a User Configuration setting that will automatically add receipt of a Line Feed (LF) character after a carriage return if required.

Cancel (CAN)

Value (ASCII 24 decimal / 18 hex) Receipt of this character causes the display to abort any escape sequence that may be in process. No other action is taken.

Escape (ESC)

Value (ASCII 33 decimal / 1B hex) Receipt of this character causes the display to attempt to decode one or more of the following characters as a control or escape sequence that will affect the display.

Reset Display (ESC c)

Values (ASCII 33, 99 decimal / 1B, 63 hex) Receipt of this character sequence causes the display to clear, and the cursor position to move to the upper left corner.

Cursor Down (ESC D)

Values (ASCII 33, 68 decimal / 1B, 44 hex) Receipt of this character sequence causes the display to move the cursor down to the next line in the same column. The cursor will not move and the display will not scroll up if the cursor was on the last line.

Cursor Down to column 1 (ESC E)

Values (ASCII 33, 69 decimal / 1B, 45 hex) Receipt of this character sequence causes the display to move the cursor down to the next line and the first column. The cursor will not move and the display will not scroll up if the cursor was on the last line.

Cursor Up (ESC M)

Values (ASCII 33, 77 decimal / 1B, 4D hex) Receipt of this character sequence causes the display to move the cursor up to the previous line in the same column. The cursor will not move if the cursor was on the first line.

ANSI Escape Sequences (ESC [ )

Values (ASCII 33, 91 decimal / 1B, 5B hex) Receipt of this character sequence causes the display to attempt to decode one or more of the following characters as an ANSI control sequence. These sequences can have 1 or 2 parameters that are expressed as decimal numbers separated by a semicolon. These are represented by the ***italic*** letters in the sequence description.

Cursor Up *n* lines (ESC [*n* A)

Values (ASCII 33, 91, 48-57, 65 decimal / 1B, 5B, 30-39, 41 hex) Receipt of this character sequence causes the display to move the cursor up '*n*' (default n=1) lines in the same column. The cursor will not move up past the first line in the display.

Cursor Up *n* lines to column 1 (ESC [*n* F)

Values (ASCII 33, 91, 48-57, 70 decimal / 1B, 5B, 30-39, 46 hex) Receipt of this character sequence causes the display to move the cursor up '*n*' (default n=1) lines and to the first column. The cursor will not move up past the first line in the display.

Cursor Down *n* lines (ESC [*n* B)

Values (ASCII 33, 91, 48-57, 66 decimal / 1B, 5B, 30-39, 42 hex) Receipt of this character sequence causes the display to move the cursor down '*n*' (default n=1) lines in the same column. The cursor will not move past the bottom line in the display and the display will not scroll up.

Cursor Down *n* lines to column 1 (ESC [*n* E)

Values (ASCII 33, 91, 48-57, 69 decimal / 1B, 5B, 30-39, 45 hex) Receipt of this character sequence causes the display to move the cursor down '*n*' (default n=1) lines and to the first column. The cursor will not move past the bottom line in the display and the display will not scroll up.

Cursor Right *n* characters (ESC [*n* C)

Values (ASCII 33, 91, 48-57, 67 decimal / 1B, 5B, 30-39, 43 hex) Receipt of this character sequence causes the display to move the cursor right '*n*' (default n=1) characters on the same line. The cursor will not move past the end of the current line.

Cursor Left n characters (ESC [*n* D)

Values (ASCII 33, 91, 48-57, 68 decimal / 1B, 5B, 30-39, 44 hex) Receipt of this character sequence causes the display to move the cursor left '*n*' (default n=1) characters on the same line. The cursor will not move past the beginning of the current line.

Move cursor to *n* (ESC [*n* G)

Values (ASCII 33, 91, 48-57, 71 decimal / 1B, 5B, 30-39, 47 hex) Receipt of this character sequence causes the display to move the cursor to column '*n*' (default n=1) on the current line. The cursor will not move past the beginning or end of the current line.

Move cursor to *r, c* (ESC [*r* ; *c* H)

Values (ASCII 33, 91, [[48-57], 59, [48-57]], 72 decimal / 1B, 5B, [[30-39], 3B, [30-39]], 48 hex) Receipt of this character sequence causes the display to move the cursor to row '*r*', column '*c*'. The value for '*r*' ranges from 1 – 20 ((default r=1), the value for '*c*' ranges from 1 – 44 (default c=1).

Erase all or part of display (ESC [*n* J)

Values (ASCII 33, 91, 48-50, 74 decimal / 1B, 5B, 30-32, 4A hex) Receipt of this character sequence causes part or all of the display to clear. If '*n*' = 0 (default), the display is cleared from the cursor position to

the end. If '*n*' = 1, the display is cleared from the beginning to the cursor position. If '*n*' = 2 the entire display is cleared, and the cursor is moved to the upper left (0, 0).

Erase all or part of line (ESC [*n* K)

Values (ASCII 33, 91, 48-50, 75 decimal / 1B, 5B, 30-32, 4B hex) Receipt of this character sequence causes part or all of the line that the cursor is on to clear. If '*n*' = 0 (default), the line is cleared from the cursor position to the end of the line. If '*n*' = 1, the line is cleared from the beginning to the cursor position. If '*n*' = 2 the entire line is cleared. The position of the cursor is not affected by this command.

Save cursor position (ESC [s)

Values (ASCII 33, 91, 114 decimal / 1B, 5B, 73 hex) Receipt of this character sequence causes the display to save the current cursor position.

Restore cursor position (ESC [u)

Values (ASCII 33, 91, 116 decimal / 1B, 5B, 75 hex) Receipt of this character sequence causes the display to restore the previously saved cursor position.

Query (ESC [6 n)

Values (ASCII 33, 91, 54, 110 decimal / 1B, 5B, 36, 6E hex) Receipt of this character sequence causes the display to report the current cursor position as <ESC> [row ; column R. The 'n' character is actually part of the command and is not replaced by a number. The value for row is 1 – 20, the value for column is 1 – 44.

Select Graphic Rendition (ESC [*n [;k]* m)

Values (ASCII 33, 91, xx, xx decimal / 1B, 5B, xx, xx hex) Receipt of these character sequences cause the display to use different coloring for subsequently displayed characters. (default n=0)

Code	Effect
0	Reset / Normal
30	Text Color Black
31	Text Color Red
32	Text Color Green
33	Text Color Yellow
34	Text Color Blue
35	Text Color Magenta
36	Text Color Cyan
37	Text Color White
40	Background Color Black
41	Background Color Red
42	Background Color Green
43	Background Color Yellow
44	Background Color Blue
45	Background Color Magenta
46	Background Color Cyan
47	Background Color White

SOH/ETX Modes

The SOH/ETX protocols allow full control of the display features and functionality, but require that the host computer properly format sequences of commands using the protocol to control the display, and interpret a formatted response to receive status and data from the display.

The SOH/ETX protocol starts each command or response with a single ASCII Start of Header control character = 01_{16} or CTRL-A, represented herein as **<SOH>** and ends each command with a single ASCII End of Text control character = 03_{16} or CTRL-C, represented herein as **<ETX>**.

Command or Response data arguments are sent as ASCII Hex strings one to four characters in length or as printable ASCII characters. Multiple fields may be delineated by embedded ASCII separator control characters depending upon the actual display mode.

The SOH128Mono and SOH320Mono Modes are emulated to provide an upgrade path from earlier displays. To perform 'Printing' in these modes requires specific embedded font resources (.efnt) to be available either in the on-board serial EEProm or via a Resources.bin file on the microSD card. ***See the SOH320Color, Resources section for more information.***

In the SOH/ETX command / response descriptions that follow there are spaces shown between the different parts of each command.

THE EMBEDDED SPACES IN THE FOLLOWING DESCRIPTIONS ARE FOR CLARITY ONLY, ARE NOT PART OF THE TRANSMITTED / RECEIVED COMMANDS AND SHOULD NOT BE INCLUDED !

Display Addressing

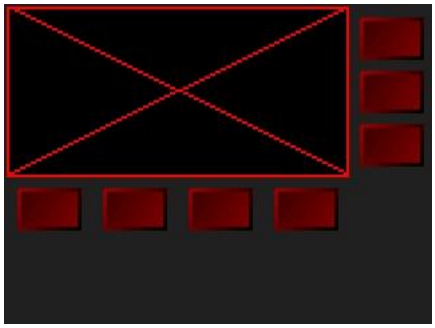
If you set the User Configuration Setting 'Display Comm Addr' item to a value greater than zero, you must take the following into consideration when using the SOH/ETX protocol:

Commands sent to the display must have a two-digit ASCII hex address sent between the leading **<SOH>**, and the following command letter. If the display's address does not match the address in the command, it will ignore the command. If a command is sent with an address of zero, it is considered a broadcast message, and all displays with an address set will display the command. This allows multiple displays to be updated via a single RS-232 interface.

Keystroke responses received from displays with their address greater than zero, will have the displays address in two digit ASCII hex between the <SOH> and the "K" or "k". Note that the return RS-232 RxD signals from multiple displays would have to be wire 'OR'ed using circuitry such as diodes that are external to the display. (***See the Multiple Display Wiring appendix*****)**

SOH128Mono Mode

This display operating mode emulates most of the functions of the ACS-LCD-128x64 monochrome display. The pixels are drawn doubled in size and there is no support for the hardware keypad overlay – it is emulated on-screen:

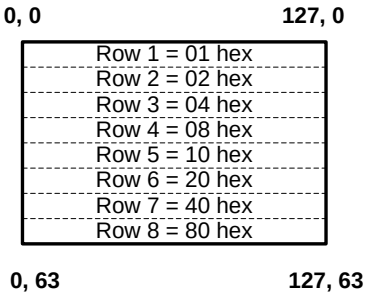


The color scheme is controlled by the TPad Scheme configuration item.

The fonts required for emulating the print commands in this mode must be available as loaded resources via the serial EEProm or microSD - Resources.bin file. If one or more are not available a default font is substituted that will not match the requested font size or spacing. These fonts provide simulation of the older display's fonts and will not match them exactly:

Font #	Style	Resource Name
0	Small 5x7 proportional	AcsSoh128Small.efnt
1	Medium 9x15 proportional	AcsSoh128Medium.efnt
2	Micro 4x5 proportional	AcsSoh128Micro
3	Giant 30x55 proportional	AcsSoh128Giant.efnt
4	Small 5x7 fixed	AcsSoh128Fixed.efnt
5	Large 18x30 proportional	AcsSoh128Large.efnt

The X and Y coordinates for drawing start at **0, 0** at the upper left corner of the display:

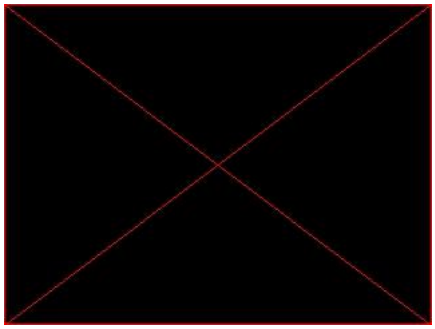


Drawing is clipped at the coordinate boundaries of the display.

Please refer to the separate document *"ACS-LCD-128x64 User's Manual"* for the serial protocol and commands.

SOH320Mono Mode

This display operating mode emulates most of the functions of the ACS-LCD-320x240 monochrome display. There is no support for a hardware keypad or input polling:

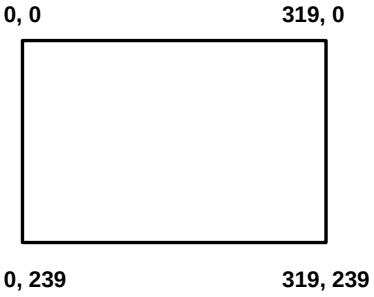


The color scheme is controlled by the TPad Scheme configuration item.

The fonts required for emulating the print commands in this mode must be available as loaded resources via the serial EEProm or microSD - Resources.bin file. If one or more are not available a default font is substituted that will not match the requested font size or spacing. These fonts provide simulation of the older display's fonts and will not match them exactly:

Font #	Style	Resource Name
0	Small 5x7 proportional	AcsSoh320Small.efnt
1	Medium 9x15 proportional	AcsSoh320Medium.efnt
2	Micro 4x5 proportional	AcsSoh320Micro
3	Giant 30x55 proportional	AcsSoh320Giant.efnt
4	Small 5x7 fixed	AcsSoh320Fixed.efnt
5	Large 18x30 proportional	AcsSoh320Large.efnt

The X and Y coordinates for drawing start at **0, 0** at the upper left corner of the display:



Drawing is clipped at the coordinate boundaries of the display.

Please refer to the separate document *"ACS-LCD-320x240 User's Manual"* for serial protocol and commands.

SOH320Color Mode

This display operating mode provides an extended command set for operation of the display features. Commands are provided for drawing graphics, displaying bitmaps with transparency, printing UTF-8 text with user-supplied fonts and receiving touchscreen interaction. There is also a higher level screen and object model available to simplify user interaction with buttons and sliders and facilitate multiple screen navigation.

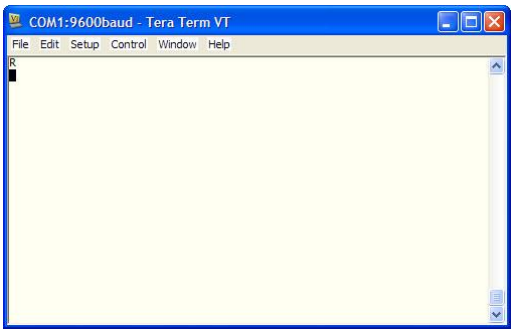
NOTE that embedded spaces are used in the following command/response descriptions for clarity/readability and they are NOT PART OF THE COMMANDS.

Quick Start

With the display powered, configured for SOH320Color Mode and connected to your PC use Hyperterminal, TeraTerm or another terminal emulator program to exercise the display.

When you power-up or reset the display in this mode there is a resource loading status screen shown. This screen clears and the following screen should be momentarily displayed:

This screen should also clear and leave the display blank. At this time you should see the letter R displayed in your terminal emulator program:



The R is the display's Reset status message. It is actually bracketed with **<SOH>** and **<ETX>** characters, but the terminal emulator doesn't show the non-printing characters without enabling a debug mode. The display is now ready to accept commands.

Drawing Graphics

Let's draw a white diagonal line across the display. Looking ahead to the Draw commands we find the following command template for drawing a line:

Draw Line

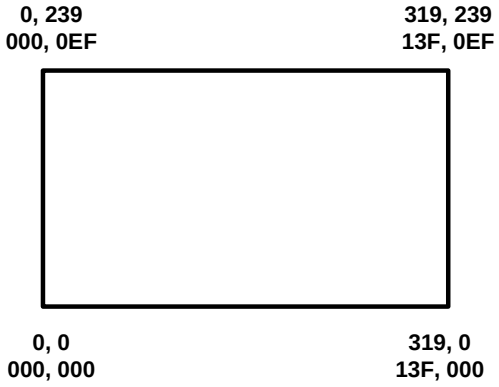
Draws a single color line on the current draw surface between the two coordinates:

<SOH> dl XXX YYY xxx yyy CCCC <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dl	Draw Line	Command/modifier
XXX	Line Starting X Coordinate	3-digit ASCII Hex 000-13F
YYY	Line Starting Y Coordinate	3-digit ASCII Hex 000-0EF
xxx	Line Ending X Coordinate	3-digit ASCII Hex 000-13F
yyy	Line Ending Y Coordinate	3-digit ASCII Hex 000-0EF
CCCC	Line Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

At the beginning of the Drawing section the screen coordinates are defined - the X and Y coordinates for drawing start at **0, 0** at the lower left corner of the display and range to 319, 239 at the upper right corner. The hex values of each corner coordinate are shown below each pair:



In the Manual Conventions at the beginning of this manual, the **<SOH>** and **<ETX>** were defined to be printed representations of single ASCII control characters:

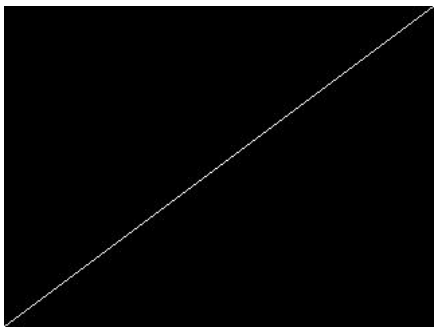
<SOH> Is the printed representation of a single ASCII Start of Heading character; CTRL-A, 01 decimal, 01 hex. This character delineates the start of a command or response in SOH/ETX the protocol modes. This character may be sent from your terminal emulator by holding down the Ctrl key and pressing the A key.

<ETX> Is the printed representation of a single ASCII End of Text character; CTRL-C, 03 decimal, 03 hex. This character delineates the end of a command or response in SOH/ETX the protocol modes. This character may be sent from your terminal emulator by holding down the Ctrl key and pressing the C key.

We should be able to draw this diagonal line by sending the following characters to the display by typing them into your connected terminal emulator (***without the spaces***):

Ctrl-A dl 000 000 13F 0EF FFFF Ctrl-C

The display screen should now look like:



If your display doesn't look like this try typing the command again making sure that you typed all of the letters correctly and that there aren't any spaces.

Now draw a red circle. Looking ahead in the manual to the Draw Circle command we find the following command template:

Draw Circle

Draws a single color circle on the current draw surface with a radius at the center coordinates:

<SOH> dc XXX YYY RRR CCCC <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dc	Draw Circle	Command/modifier
XXX	Circle Center X Coordinate	3-digit ASCII Hex 000-13F
YYY	Circle Center Y Coordinate	3-digit ASCII Hex 000-0EF
RRR	Circle Radius	3-digit ASCII Hex 000-13F
CCCC	Circle Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

To draw this in the center of the screen, the Center X Coordinate should be 320 / 2 = 160 = 0A0 in hex. The Center Y Coordinate should be 240 / 2 = 120 = 078 in hex. Try using a radius of 48 = 030 in hex.

The last command parameter is the color. In the Manual Conventions at the beginning of this manual, there is a definition for RGB565:

RGB565
Is the printed representation of a 16-bit color comprised of 5 bits of Red, 6 bits of Green and 5 bits of Blue:

15 MSB	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0 LSB
Red					Green						Blue				

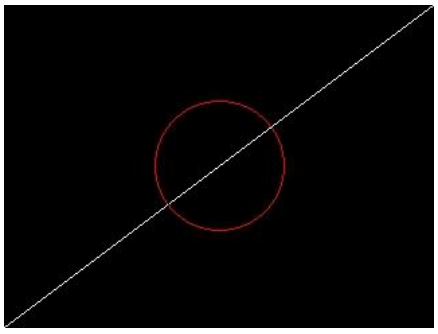
To draw a bright red circle, the leftmost five red bits would all be ones, and the rest would be zero. Translating these RGB565 bit fields to 4-bit hexadecimal fields:

	15 MSB	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0 LSB
	Red					Green						Blue				
Binary	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Hex	**F**				**8**				**0**			**0**				

So a bright red ASCII HEX RGB565 color would be F800 in hex. We should be able to draw this circle by sending the following characters to the display by typing them into your connected terminal emulator (***without the spaces***):

Ctrl-A dc 0A0 078 030 F800 Ctrl-C

The display screen should now look like:



Try some of the other Draw commands using different colors to see how they work.

Drawing Text

Let's add some text. Looking ahead at the Drawing commands we find the following template for drawing text:

Draw Text

Draws a UTF-8 text string on the current draw surface using the specified font at the coordinates:

<SOH> dt FF XXX YYY textString <ETX>

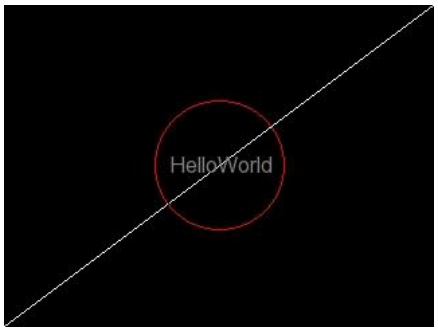
Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dt	Draw Text	Command/modifier
FF	Font Number	2-digit ASCII Hex 00-1F
XXX	Text X Coordinate	3-digit ASCII Hex 000-13F
YYY	Text Y Coordinate	3-digit ASCII Hex 000-0EF
textString	Text to be drawn	8-bit UTF-8 text string
<ETX>	End of Text	Ctrl-C (Hex 03)

So let's print HelloWorld in the center of the screen. We will use font number 00 which defaults to a built-in font that the display uses for diagnostics. Type the following command (***without the spaces***):

Ctrl-A dt 00 0A0 078 HelloWorld Ctrl-C

The display screen should now look like:



The actual font color will depend upon the configured TPad Scheme – when the display resets the fonts are initialized from the configured, built-in scheme.

On your terminal emulator you should see a response from the **dt** command:

dts004F0016

Looking ahead to the Draw Text section of the manual, we can see that this is a response from the draw text command:

This command returns a response containing the width and height of the drawn text string to facilitate chaining /aligning subsequent text:

<SOH> dts WWWW HHHH <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dts	Draw Text Size	Response/modifier/parameter

Field	Field Name	Notes
WWWW	Drawn Text Width	4-digit ASCII Hex 0000-013F
HHHH	Drawn Text Height	4-digit ASCII Hex 0000-00EF
<ETX>	End of Text	Ctrl-C (Hex 03)

This text is being drawn with Font #00. Fonts are a 'resource' used by other commands and objects and are controlled by entries in two tables.

The first requirement for font usage is an embedded font file that is loaded into the Resource table. There are two or more embedded fonts built-in to the display, and more can be loaded from the on-board serial flash or micro SD card memory.

The second requirement for font usage is an entry in the Font table that links the name of the embedded font resource with other font attributes such as color, transparency, spacing and alignment.

You can query the display for Font #00's attributes, and then issue other commands to change them. Looking ahead in this manual to the Query commands you can see that there are commands to Query Fonts and Resources. The command template for a font query command is:

Query Font Item

The Query Font Item command returns a response showing the requested font item's current value:

<SOH> qti NN <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qti	Query Font Item	Command/modifier/parameter
NN	Font Number	2-digit ASCII Hex 00-FF
<ETX>	End of Text	Ctrl-C (Hex 03)

To see the attributes for Font #00 type the following Query Font Item command (***without the spaces***):

Ctrl-A qti 00 Ctrl-C

On the terminal emulator you should see the response from the **qti** command:

```
qt00AcsDefaultFont.efnt001600008410001110
qt00
```

Again, there are the bracketing **<SOH>** and **<ETX>** characters, and, in addition the individual fields of the response are delineated by embedded **<US>** characters with the record ending with a **<RS>** character. The end of the response is indicated by the trailing **qt00** followed by the **<GS>** character. The terminal emulator typically doesn't show these non-printing control characters – some programs can.

Looking at these fields we can determine the following information about Font #00:

Field	Field Name	Value
<SOH>	Start of Header	Ctrl-A (Hex 01)
qt	Query Font	Response/modifier
00	Font Number	Font #00
AcsDefaultFont.efnt	Font File Resource Name	Name of loaded .EFNT resource
0016	Font Height	0016 = 22 pixels high
0000	Font Background Color	0000 = Black
8410	Font Foreground Color	8410 = Grey
0	Font Spacing-X	0 = fixed width of the font
0	Font Spacing-Y	0 = fixed width of the font
1	Font Horizontal Alignment	1 = Center Justify

Field	Field Name	Value
1	Font Vertical Alignment	1 = Center Justify
1	Background Transparency	1 = Transparent
0	Foreground Transparency	0 = Solid
<ETX>	End of Text	Ctrl-C (Hex 03)

Change font number 00 to be white foreground letters on a red background. To do this you have to change the Font Background Color, the Font Foreground Color and the Background Transparency. Looking ahead in this manual to the Font commands you can see that there are commands to set the Font Colors and Font Attributes.

The command template for the command to set the Font Colors is:

Font Colors

Sets the background and foreground colors used to draw this font table entry:

<SOH> fc FF BRGB FRGB <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
fc	Font Color	Command/modifier
FF	Font Table entry number	2-digit ASCII Hex 00-1F
BRGB	Font Background Color	4-digit ASCII Hex RGB565
FRGB	Font Foreground Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

To set the background color to red and the foreground color to white type the following command (***without the spaces***):

Ctrl-A fc 00 F800 FFFF Ctrl-C

The command template for the command to set the Font Attributes is:

Font Attributes

Sets the background and foreground colors used to draw this font table entry:

<SOH> fa FF X Y H V B F <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
fa	Font Attribute	Command/modifier
FF	Font Table entry number	2-digit ASCII Hex 00-1F
X	Font Spacing-X	1-digit ASCII Hex: 0 = fixed width of the font 1→E = pixels between characters F = bounding box character width
Y	Font Spacing-Y	1-digit ASCII Hex: 0 = fixed width of the font 1→E = pixels between characters F = bounding box character width
H	Font Horizontal Alignment	1-digit ASCII Hex: 0 = Left Justify 1 = Center Justify 2 = Right Justify
V	Font Vertical Alignment	1-digit ASCII Hex: 0 = Top Justify

Field	Field Name	Notes
		1 = Center Justify 2 = Bottom Justify
B	Background Transparency	1-digit ASCII Hex: 0 = Solid 1 = Transparent
F	Foreground Transparency	1-digit ASCII Hex: 0 = Solid 1 = Transparent
<ETX>	End of Text	Ctrl-C (Hex 03)

To set the background transparency to solid (and keep the other font attributes the same type the following command (without the spaces):

Ctrl-A fa 00 0 0 1 1 0 0 Ctrl-C

You can verify that the colors and attributes have been set by using the Query Font Item command again:

Ctrl-A qti 00 Ctrl-C

Now the response should be:

qti00qt00AcsDefaultFont.efnt0016F800FFFF001100
qt00

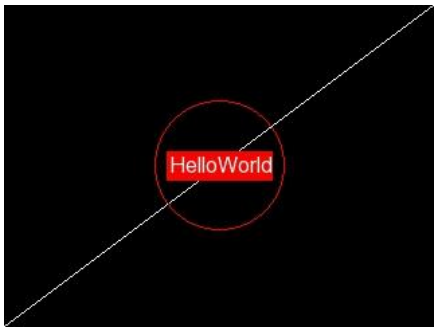
Looking at these fields we can verify that we changed Font #00:

Field	Field Name	Value
<SOH>	Start of Header	Ctrl-A (Hex 01)
qt	Query Font	Response/modifier
00	Font Number	Font #00
AcsDefaultFont.efnt	Font File Resource Name	Name of loaded .EFNT resource
0016	Font Height	0016 = 22 pixels high
F800	Font Background Color	F800 = Red
FFFF	Font Foreground Color	FFFF = White
0	Font Spacing-X	0 = fixed width of the font
0	Font Spacing-Y	0 = fixed width of the font
1	Font Horizontal Alignment	1 = Center Justify
1	Font Vertical Alignment	1 = Center Justify
0	Background Transparency	0 = Solid
0	Foreground Transparency	0 = Solid
<ETX>	End of Text	Ctrl-C (Hex 03)

Issue the same Draw Text command by typing the following command (***without the spaces***):

Ctrl-A dt 00 0A0 078 HelloWorld Ctrl-C

The display screen should now look like:



Try changing the other Font Attributes to see the results.

Clearing the Display

So, how do we clear the display? Again looking ahead to the Draw commands we don't see a Clear sub-command, but there is a Fill. The display is cleared by filling the screen with the desired color. Here's the command description:

Draw Fill Flat

Fills an area of the current draw surface defined by a lower-left coordinate, width and height with a constant color:

<SOH> dff XXX YYY WWW HHH CCCC <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dff	Draw Fill Flat	Command/modifier/parameter
XXX	Lower-left Fill X Coordinate	3-digit ASCII Hex 000-13F
YYY	Lower-left Fill Y Coordinate	3-digit ASCII Hex 000-0EF
WWW	Fill Width	3-digit ASCII Hex 000-140
HHH	Fill Height	3-digit ASCII Hex 000-0F0
CCCC	Fill Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

To clear the screen to black, issue a Draw Fill Flat command that covers the entire screen with the color black (0000):

Ctrl-A dff 000 000 140 0F0 0000 Ctrl-C

The screen should now be blank (black).

Command Structure

Commands to the display are bracketed by <SOH> and <ETX>. The requested command is designated by a single lower-case ASCII character. The command *may be modified* by an additional character specifying a sub-command, and some commands *may also have one or more parameters*:

<SOH> c [m [p … p]] <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
c	Command designator	Single lower-case ASCII letter
m	Command Modifier	Single lower-case ASCII letter (optional)
p … p	Command Parameter(s)	One or more letters or ASCII Hex fields (optional)
<ETX>	End of Text	Ctrl-C (Hex 03)

Command Responses

In this mode, commands return a response indicating success or failure. If a command would return information, the return of that information is considered a success – otherwise a short Failure response is returned. If a command is not expected to return any information, a small response is returned indicating the success or failure of the command:

Success response if no results:

<SOH> <ACK> <ETX>

Failure response:

<SOH> <NAK> XX <ETX>

Where **XX** is the error code:

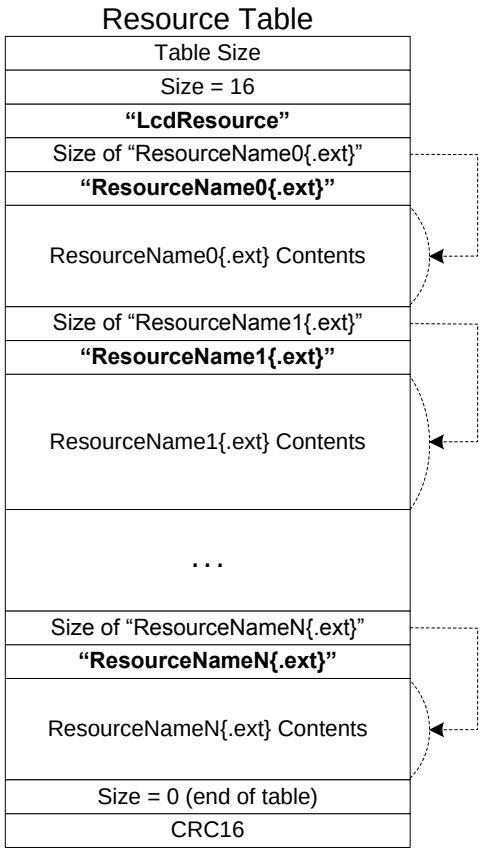
Code	Label	Notes
02	Unknown Command	Not a known command character
03	Invalid Command Length	Length of command incorrect
04	Unknown Command Modifier	Not a known command modifier for this command
05	Unknown Command Parameter	Not a known command parameter for this command
06	Invalid Command Value	One or more command fields unable to be parsed
07	Command Value Out of Range	A command parameter value is out of range
08	Resource Not Found	Requested resource is not found in the table
09	Invalid File Format	JSON file can't be loaded
0A	File System OK	
0B	File System Not Ready	Can't read microSD card
0C	No File	Can't find file on microSD card
0D	No Path	Can't find path on microSD card
0E	Invalid File Name	File name or path not correct
0F	Invalid Drive	n/u
10	Denied	Can't create directory entry – disk full or file read only.
11	Exist	File or directory already exists
12	Read/Write Error	Error while reading or writing the microSD card
13	Write Protected	n/u
14	Not Enabled	n/u
15	No Filesystem	No FAT16 or FAT32 valid partition found
16	Invalid Object	File System object invalid
18	End of File	File read fell short – end of file before end of read
19	Disk Full	File write fell short – disk may be full

Resources

The ACS Color LCD 320x240 uses 'resources' to provide fonts, bitmaps and sounds in this mode. These resources are loaded into a 'table' in RAM where they can be rapidly accessed by the different commands that require them.

This resource table can be loaded from the on-board Serial Flash or from the micro SD card upon reset, or dynamically from the micro SD card during operation. The table is searched from the beginning when resources are accessed, with newly added resources located at the front of the table.

Each entry in the table consists of the size of the resource, its name– including any extension, and then the resource contents. The entire Resource Table is protected by a cyclic redundancy check value of its contents. Dynamically added resources are added to the front of the Resource Table:



Resource Commands

All resource commands start with the lower-case letter 'r' followed by a command modifier character specifying the command. The remainder of the command consists of zero or more data arguments expressed as ASCII printable characters:

<SOH> r … <ETX>

Resource Load All From Flash

Initializes then loads the Resource Table from the on-board serial EEProm. The serial EEProm must have previously been loaded with a binary image of a valid table of resources.

<SOH> r l <ETX>

Resource Save All To Flash

Writes the current Resource Table image to the on-board serial EEProm.

<SOH> r s <ETX>

Resource Load All From File

Initializes then loads the Resource Table from a binary file image located on the microSD card.

<SOH> r < fileName <ETX>

Resource Save All To File

Saves the current Resource Table to a binary file image located on the microSD card.

<SOH> r > fileName <ETX>

Resource Add From File

Loads the resource at the beginning of the Resource Table from a file image located on the microSD card. The subsequent resource name is the filename.

<SOH> r + fileName <ETX>

Resource Remove

Removes the named resource from the Resource Table.

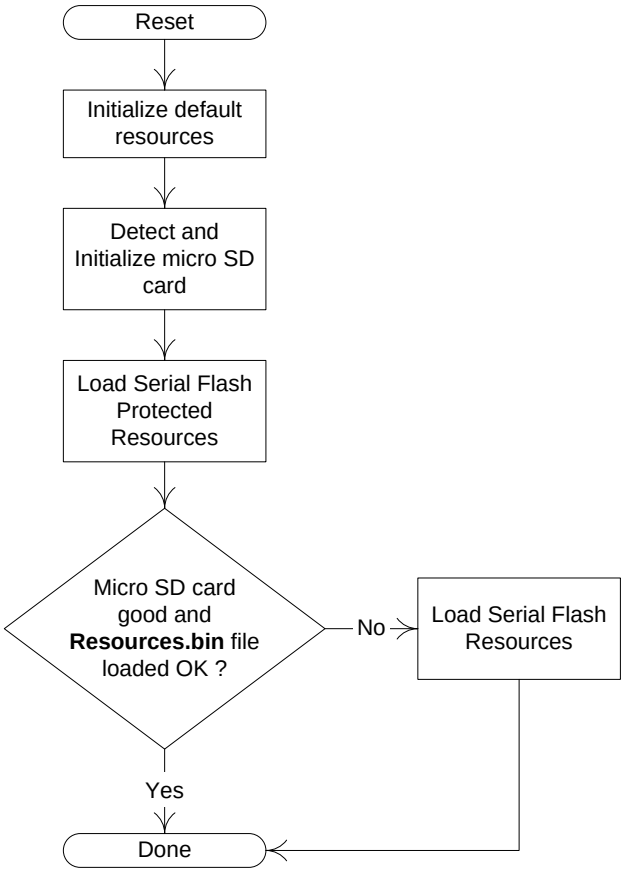
<SOH> r – resourceName <ETX>

Resource File Generation

The binary resource file image can be generated by an ACS Windows utility that supports the concept of resource generation projects (.rsrcgen XML project files). (***See the appendix Resource File Generation)***

Initial Resource Table Load

When the ACS Color LCD 320x240 is powered-up or reset, it attempts to locate and load the resource table from several sources. This process is outlined in the following flowchart:

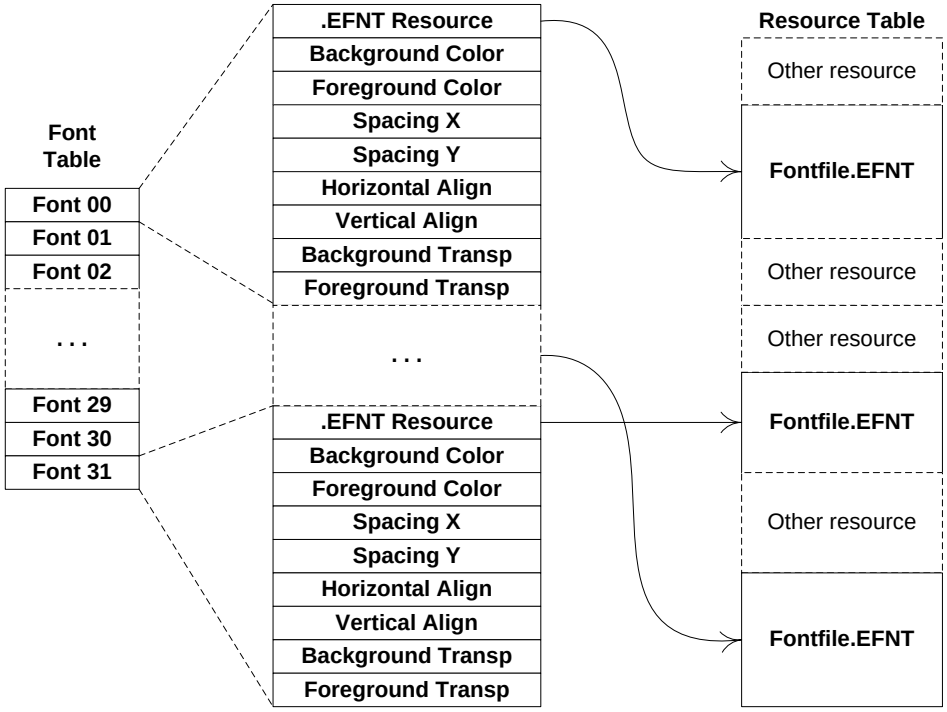


1. The AcsDefaultFont.efnt (used for the diagnostics and keypad keys) and the AcsAnsiFont.efnt resources are loaded from internal flash memory.
2. The micro SD card is detected and, if present, the file system is initialized.
3. A check is made for protected resources located at the top of the external Serial Flash memory and they are loaded if found.
4. If the micro SD card was detected and initialized in step 2 attempt to load the binary resources file named: Resources.bin. If it loads and verifies then initial resource table loading is complete.
5. If step 4 fails, attempt to load and verify the resources located at the bottom of the external Serial Flash memory.

Fonts

The appearance of all text that is drawn on the display is controlled by fonts selected from a font table. The character images are extracted from previously constructed and loaded .EFNT resources. Each table entry holds the Font Name (.EFNT resource name), several attributes for horizontal and vertical alignment and spacing and background/foreground colors and transparency.

The table holds 32 entries. The table entry number is used as the selector of the font for drawing and display access.



Font Commands

All Font commands start with the letter 'f' followed by a command modifier character specifying the command. The remainder of the command consists of one or more data arguments expressed as ASCII Hex strings or ASCII printable characters:

<SOH> f … <ETX>

There are commands to specify the font resource name, attributes and colors for each table entry, and load or save the font table from/to a file on the microSD card.

Font Name

Sets the name of the character image resource (.EFNT) used to draw this font table entry:

<SOH> fn FF resourceName <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
fn	Font Name	Command/modifier/parameter
FF	Font Table entry number	2-digit ASCII Hex 00-1F
resourceName	Font File Resource Name	Name of loaded .EFNT resource
<ETX>	End of Text	Ctrl-C (Hex 03)

Font Colors

Sets the background and foreground colors used to draw this font table entry:

<SOH> fc FF BRGB FRGB <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
fc	Font Color	Command/modifier/parameter
FF	Font Table entry number	2-digit ASCII Hex 00-1F
BRGB	Font Background Color	4-digit ASCII Hex RGB565
FRGB	Font Foreground Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

Font Attributes

Sets the background and foreground colors used to draw this font table entry:

<SOH> fa FF X Y H V B F <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
fa	Font Attributes	Command/modifier
FF	Font Table entry number	2-digit ASCII Hex 00-1F
X	Font Spacing-X	1-digit ASCII Hex: 0 = fixed width of the font 1→E = pixels between characters F = bounding box character width
Y	Font Spacing-Y	1-digit ASCII Hex: 0 = fixed width of the font 1→E = pixels between characters F = bounding box character width
H	Font Horizontal Alignment	1-digit ASCII Hex: 0 = Left Justify 1 = Center Justify 2 = Right Justify
V	Font Vertical Alignment	1-digit ASCII Hex: 0 = Top Justify 1 = Center Justify 2 = Bottom Justify
B	Background Transparency	1-digit ASCII Hex: 0 = Solid 1 = Transparent
F	Foreground Transparency	1-digit ASCII Hex: For 1bpp fonts: 0 = Solid 1 = Transparent For 4 & 8bpp fonts: 0 = Solid TBD
<ETX>	End of Text	Ctrl-C (Hex 03)

Font Table Load from File

Loads the Font Table from a .JSON file located on the microSD card. (***See the appendix JSON File Formats)***:

<SOH> f < fileName <ETX>

Font Table Save to File

Saves the Font Table to a .JSON file located on the microSD card. (***See the appendix JSON File Formats)***:

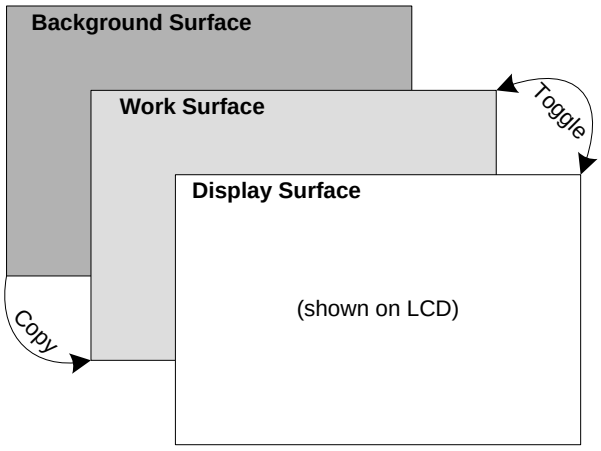
<SOH> f > fileName <ETX>

Font File Generation

The embedded font files (.EFNT) are generated using a DOS font generation utility: gapi_font_gen.exe which is based upon FreeType 2. ACS has provided a GUI front-end for this utility that supports the concept of font conversion projects (.fontgen XML project files). (***See the appendix Embedded Font Generation)***

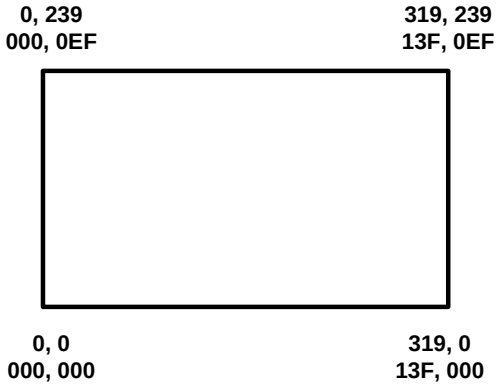
Drawing

There are three drawing surfaces: Display, Work and Background. The Display surface is the one that is currently being shown on the LCD. The Work surface is where most drawing is done before being swapped with the Display surface. The Background surface provides a content area that can be seldom drawn, and copied to the Work surface before additional drawing is done on top.



All drawing takes place on the currently selected draw surface. Commands are provided to render pixels, lines, fills, boxes, circles, ellipses, text and images.

The X and Y coordinate for drawing start at **0, 0** at the lower left corner of the display:



Drawing is clipped at the coordinate boundaries of the display.

In order to avoid flickering as the display is updated the following sequence should be utilized:

1. Switch to the Background draw surface.
2. Draw any required static background content.
3. Switch to the Work surface.
4. Copy in the content from the Background surface to the Work surface and draw any dynamic content on top of it.
5. Toggle the Work and Display surfaces.
6. Repeat from step 4.

Draw Commands

All Draw Commands start with the command letter 'd' followed by a command modifier character specifying the command. Some commands also require a following command parameter character to select different command features. The remainder of the command consists of zero or more data arguments expressed as ASCII Hex strings or printable ASCII characters.

<SOH> d … <ETX>

There are commands to set the surface to draw on, copy between drawing surfaces and toggle the displayed and work drawing pages.

Draw Surface

There are three drawing surfaces; Display, Work and Background. The Display drawing surface is always being shown on the LCD. The Work and Background surfaces may be drawn on without affecting what is being shown on the LCD.

The Draw Surface commands follow the Draw command letter 'd' with the command modifier character 's' and a command parameter character to specify the surface operation:

<SOH> ds … <ETX>

Draw Surface Set

Sets the current draw surface for all subsequent drawing commands:

<SOH> dss N <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dss	Draw Surface Set	Command/modifier/parameter
N	Drawing Surface number	2-digit ASCII Hex: 0 = display surface 1 = work surface 2 = background surface
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Surface Copy

Copies a region from the specified source drawing surface to the current draw surface:

<SOH> dsc N XXX YYY xxx yyy WWW HHH <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dsc	Draw Surface Copy	Command/modifier/parameter
N	Source Drawing Surface	2-digit ASCII Hex 0 = display surface 1 = work surface 2 = background surface
XXX	Lower-left Copy Source X Coordinate	3-digit ASCII Hex 000-13F
YYY	Lower-left Copy Source Y Coordinate	3-digit ASCII Hex 000-0EF
xxx	Lower-left Copy Destination X Coordinate	3-digit ASCII Hex 000-13F
yyy	Lower-left Copy Destination Y Coordinate	3-digit ASCII Hex 000-0EF
WWW	Copy Width	3-digit ASCII Hex 000-140
HHH	Copy Height	3-digit ASCII Hex 000-0F0

Field	Field Name	Notes
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Surface Translate

Copies a region from the specified source drawing surface to the current draw surface:

<SOH> dsx N XXX YYY xxx yyy WWW HHH MM <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dsc	Draw Surface Copy	Command/modifier/parameter
N	Source Drawing Surface	2-digit ASCII Hex 0 = display surface 1 = work surface 2 = background surface
XXX	Lower-left Copy Source X Coordinate	3-digit ASCII Hex 000-13F
YYY	Lower-left Copy Source Y Coordinate	3-digit ASCII Hex 000-0EF
xxx	Lower-left Copy Destination X Coordinate	3-digit ASCII Hex 000-13F
yyy	Lower-left Copy Destination Y Coordinate	3-digit ASCII Hex 000-0EF
WWW	Copy Width	3-digit ASCII Hex 000-140
HHH	Copy Height	3-digit ASCII Hex 000-0F0
MM	Translation Mode	2-digit ASCII Hex 00-FF • 0 = no rotation • 1 = rotate 90 CCW • 2 = rotate 180 CCW • 3 = rotate 270 CCW • + 4 = flip horizontally • + 8 = flip vertically
<ETX>	End of Text	Ctrl-C (Hex 03)

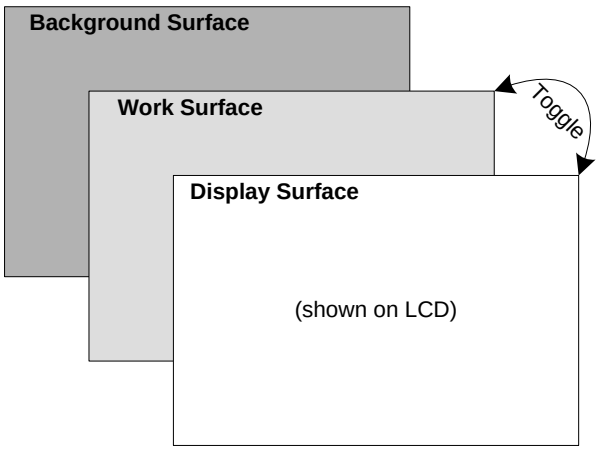
Draw Surface Toggle

Toggles the Work and Display surfaces – work becomes display and display becomes work:

<SOH> dst <ETX>

Where:

Field	Field Name	Notes
dst	Draw Surface Toggle	Command/modifier/parameter



Draw Fill

The Draw Fill commands follow the Draw command letter 'd' with the command modifier character 'f' and a command parameter character to indicate the type of fill:

<SOH> df … <ETX>

Draw Fill Flat

Fills an area of the current draw surface defined by a lower-left coordinate, width and height with a constant color:

<SOH> dff XXX YYY WWW HHH CCCC <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dff	Draw Fill Flat	Command/modifier/parameter
XXX	Lower-left Fill X Coordinate	3-digit ASCII Hex 000-13F
YYY	Lower-left Fill Y Coordinate	3-digit ASCII Hex 000-0EF
WWW	Fill Width	3-digit ASCII Hex 000-140
HHH	Fill Height	3-digit ASCII Hex 000-0F0
CCCC	Fill Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Fill Gradient

Fills an area of the current draw surface defined by a lower-left coordinate, width and height with a linear gradient of color computed between the start and final colors in the angle direction (only 0, 90, 180 & 270 degrees):

<SOH> dfg XXX YYY WWW HHH CCCC FFFF AAA <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dfg	Draw Fill Gradient	Command/modifier/parameter
XXX	Lower-left Fill X Coordinate	3-digit ASCII Hex 000-13F
YYY	Lower-left Fill Y Coordinate	3-digit ASCII Hex 000-0EF
WWW	Fill Width	3-digit ASCII Hex 000-140
HHH	Fill Height	3-digit ASCII Hex 000-0F0
CCCC	Gradient Start Color	4-digit ASCII Hex RGB565
FFFF	Gradient Final Color	4-digit ASCII Hex RGB565
AAA	Gradient Fill Angle	3-digit ASCII Hex 000, 05A, 0B4, 10E
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Fill Darkened

Darkens an area of the current draw surface defined by a lower-left coordinate, width and height with a constant color:

<SOH> dfm XXX YYY WWW HHH CCCC <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dfm	Draw Fill MulK	Command/modifier/parameter
XXX	Lower-left Fill X Coordinate	3-digit ASCII Hex 000-13F
YYY	Lower-left Fill Y Coordinate	3-digit ASCII Hex 000-0EF
WWW	Fill Width	3-digit ASCII Hex 000-140
HHH	Fill Height	3-digit ASCII Hex 000-0F0
CCCC	Fill MulK Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Pixel

Draws a single color pixel on the current draw surface at the coordinate:

<SOH> dx XXX YYY CCCC <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dx	Draw Pixel	Command/modifier
XXX	Pixel X Coordinate	3-digit ASCII Hex 000-13F
YYY	Pixel Y Coordinate	3-digit ASCII Hex 000-0EF
CCCC	Pixel Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Line

Draws a single color line on the current draw surface between the two coordinates:

<SOH> dl XXX YYY xxx yyy CCCC<ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dl	Draw Line	Command/modifier
XXX	Line Starting X Coordinate	3-digit ASCII Hex 000-13F
YYY	Line Starting Y Coordinate	3-digit ASCII Hex 000-0EF
xxx	Line Ending X Coordinate	3-digit ASCII Hex 000-13F
yyy	Line Ending Y Coordinate	3-digit ASCII Hex 000-0EF
CCCC	Line Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Dashed Line

Draws a single color dashed line on the current draw surface between the two coordinates:

<SOH> dd XXX YYY xxx yyy CCCC PPPP SS <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dd	Draw Dashed Line	Command/modifier
XXX	Line Starting X Coordinate	3-digit ASCII Hex 000-13F
YYY	Line Starting Y Coordinate	3-digit ASCII Hex 000-0EF
xxx	Line Ending X Coordinate	3-digit ASCII Hex 000-13F
yyy	Line Ending Y Coordinate	3-digit ASCII Hex 000-0EF
CCCC	Line Color	4-digit ASCII Hex RGB565
PPPP	Line Pattern	4-digit ASCII Hex 0000-FFFF
SS	Pattern Scale	2-digit ASCII Hex 00-FF
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Arc

The Draw Arc commands follow the Draw command letter 'd' with the command modifier character 'a' and a command parameter character to indicate the type of arc:

<SOH> da … <ETX>

Draw Arc Empty

Draws an empty arc on the current draw surface using single color lines on the display of width and height with center at x and y with starting angle s through ending angle e:

<SOH> dae XXX YYY www hhh sss eee CCCC <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dae	Draw Arc Empty	Command/modifier/parameter
XXX	Arc X Coordinate	3-digit ASCII Hex 000-13F
YYY	Arc Y Coordinate	3-digit ASCII Hex 000-0EF
www	Arc Width	3-digit ASCII Hex 000-13F
hhh	Arc Height	3-digit ASCII Hex 000-0EF
sss	Arc Start Angle	3-digit ASCII Hex 000-167
eee	Arc End Angle	3-digit ASCII Hex 000-167
CCCC	Box Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Arc Styled

Draws an arc on the current draw surface using single color lines on the display of width and height with center at x and y with starting angle s through ending angle e styled by S:

<SOH> dae XXX YYY www hhh sss eee CCCC S<ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dae	Draw Arc Empty	Command/modifier/parameter
XXX	Arc X Coordinate	3-digit ASCII Hex 000-13F
YYY	Arc Y Coordinate	3-digit ASCII Hex 000-0EF
www	Arc Width	3-digit ASCII Hex 000-13F
hhh	Arc Height	3-digit ASCII Hex 000-0EF
sss	Arc Start Angle	3-digit ASCII Hex 000-167
eee	Arc End Angle	3-digit ASCII Hex 000-167
CCCC	Box Color	4-digit ASCII Hex RGB565
S	Arc Style	1-digit ASCII Hex 0-7 Where (bits may be combined): 1 = Chord 2 = No Fill 4 = Edged
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Box

The Draw Box commands follow the Draw command letter 'd' with the command modifier character 'b' and a command parameter character to indicate the type of box:

<SOH> db … <ETX>

Draw Box Empty

Draws an empty box on the current draw surface using single color lines on the display between the two corner coordinates:

<SOH> dbe XXX YYY xxx yyy CCCC <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dbe	Draw Box Empty	Command/modifier/parameter
XXX	Box 1st Corner X Coordinate	3-digit ASCII Hex 000-13F
YYY	Box 1st Corner Y Coordinate	3-digit ASCII Hex 000-0EF
xxx	Box 2nd Corner X Coordinate	3-digit ASCII Hex 000-13F
yyy	Box 2nd Corner Y Coordinate	3-digit ASCII Hex 000-0EF
CCCC	Box Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Box Filled

Draws a filled box on the current draw surface using single color lines on the display between the two corner coordinates:

<SOH> dbf XXX YYY xxx yyy CCCC <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dbf	Draw Box Filled	Command/modifier/parameter
XXX	Box 1st Corner X Coordinate	3-digit ASCII Hex 000-13F
YYY	Box 1st Corner Y Coordinate	3-digit ASCII Hex 000-0EF
xxx	Box 2nd Corner X Coordinate	3-digit ASCII Hex 000-13F
yyy	Box 2nd Corner Y Coordinate	3-digit ASCII Hex 000-0EF
CCCC	Box Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Box Dashed

Draws a box on the current draw surface using single color dashed lines on the display between the two corner coordinates:

<SOH> dbd XXX YYY xxx yyy CCCC PPPP SS<ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dbd	Draw Box Dashed	Command/modifier/parameter
XXX	Box 1st Corner X Coordinate	3-digit ASCII Hex 000-13F
YYY	Box 1st Corner Y Coordinate	3-digit ASCII Hex 000-0EF
xxx	Box 2nd Corner X Coordinate	3-digit ASCII Hex 000-13F
yyy	Box 2nd Corner Y Coordinate	3-digit ASCII Hex 000-0EF
CCCC	Box Color	4-digit ASCII Hex RGB565
PPPP	Line Pattern	4-digit ASCII Hex 0000-FFFF
SS	Pattern Scale	2-digit ASCII Hex 00-FF
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Circle

Draws a single color circle on the current draw surface with a radius at the center coordinates:

<SOH> dc XXX YYY RRR CCCC <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dc	Draw Circle	Command/modifier
XXX	Circle Center X Coordinate	3-digit ASCII Hex 000-13F
YYY	Circle Center Y Coordinate	3-digit ASCII Hex 000-0EF
RRR	Circle Radius	3-digit ASCII Hex 000-13F
CCCC	Circle Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Ellipse

The Draw Ellipse commands follow the Draw command letter 'd' with the command modifier character 'e' and a command parameter character to indicate the type of ellipse:

<SOH> de … <ETX>

Draw Ellipse Empty

Draws an empty ellipse on the current draw surface with a width and height at the center coordinates:

<SOH> dee XXX YYY WWW HHH CCCC <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dee	Draw Ellipse Empty	Command/modifier/parameter
XXX	Ellipse Center X Coordinate	3-digit ASCII Hex 000-13F
YYY	Ellipse Center Y Coordinate	3-digit ASCII Hex 000-0EF
WWW	Ellipse Width	3-digit ASCII Hex 000-140
HHH	Ellipse Height	3-digit ASCII Hex 000-0F0
CCCC	Ellipse Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Ellipse Filled

Draws a filled ellipse on the current draw surface with a width and height at the center coordinates:

<SOH> def XXX YYY WWW HHH CCCC <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
def	Draw Ellipse Filled	Command/modifier/parameter
XXX	Ellipse Center X Coordinate	3-digit ASCII Hex 000-13F
YYY	Ellipse Center Y Coordinate	3-digit ASCII Hex 000-0EF
WWW	Ellipse Width	3-digit ASCII Hex 000-140
HHH	Ellipse Height	3-digit ASCII Hex 000-0F0
CCCC	Ellipse Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Text

Draws a UTF-8 text string on the current draw surface using the specified font at the coordinates:

<SOH> dt FF XXX YYY textString <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dt	Draw Text	Command/modifier
FF	Font Number	2-digit ASCII Hex 00-1F
XXX	Text X Coordinate	3-digit ASCII Hex 000-13F
YYY	Text Y Coordinate	3-digit ASCII Hex 000-0EF
textString	Text to be drawn	8-bit UTF-8 text string
<ETX>	End of Text	Ctrl-C (Hex 03)

The specified Font number controls the text spacing, the text justification relative to the coordinates, the text color and background/foreground transparency by selecting an entry from the fonts table.

This command returns a response containing the width and height of the drawn text string to facilitate chaining /aligning subsequent text:

<SOH> dts WWWW HHHH <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dts	Draw Text Size	Response/modifier/parameter
WWWW	Drawn Text Width	4-digit ASCII Hex 0000-013F
HHHH	Drawn Text Height	4-digit ASCII Hex 0000-00EF
<ETX>	End of Text	Ctrl-C (Hex 03)

Draw Image

The Draw Image commands follow the Draw command letter 'd' with the command modifier character 'i' and a command parameter character to specify the image drawing mode:

<SOH> di … <ETX>

Supported Image Formats

The image to be drawn must reside in-memory as a resource. All images are encoded in the Windows .BMP binary format which consists of a descriptive header describing the width, height and color format of the image and a raster containing the actual image.

The .BMP format allows tradeoffs to be made in raster size versus color depth. The raster can be stored in the file formatted as 1, 2, 4, 8, 16, 24 or 32 bits per image pixel. Different .BMP formats can be generated using various graphic tools with the generated color-depth usually specified when 'saving' the image.

There is an image size 'cost' associated with the different .BMP formats:

BPP	Number of Colors	Pixel Format R:G:B	Size of 320x240 Image
1-bpp	2 (indexed)	8:8:8	9.6 Kbytes
4-bpp	16 (indexed)	8:8:8	38.4 Kbytes
4-bpp RLE	16 (indexed)	8:8:8	varies
8-bpp	256 (indexed)	8:8:8	76.8 Kbytes
8-bpp RLE	256 (indexed)	8:8:8	varies
16-bpp	64K	5:6:5	153.6 Kbytes
24-bpp	24M	8:8:8	230.4 Kbytes
32-bpp	24M with transparency	8:8:8 + 8 alpha	307.2 Kbytes

The indexed formats locate the color data in a lookup table in the file header instead of within the raster. Each of the colors in the lookup table are 24-bpp so while there are a smaller number of total colors, they each can be any color.

Drawn images are converted to the 16-bpp RGB565 format for display. The use of 24-bpp and 32-bpp color formats require extra overhead in their conversion to 16-bpp with the extra information being discarded (unless the transparency information is being used).

Most images should probably be generated using the indexed or 16-bpp formats to save resource space and maximize drawing speed. The freeware graphics utility GIMP is very capable of working with these formats.

Draw Image Normal

Draws a named image from the resource table on the current draw surface with no transparency:

<SOH> din XXX YYY imageName <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
din	Draw Image Normal	Command/modifier/parameter
XXX	Lower-left Image X Coordinate	3-digit ASCII Hex 000-13F
YYY	Lower-left Image Y Coordinate	3-digit ASCII Hex 000-0EF
imageName	Name of Image Resource	Name of loaded.BMP resource
<ETX>	End of Text	Ctrl-C (Hex 03)

Indexed Images

For simple animated image generation a command is provided that will draw a selected portion of a horizontally stacked image. The stacked images must be square (based upon the image height). The number of instances or portions contained in the image equals the image width divided by the image height.

Draw Image Indexed

Draws a named instance of an indexed image from the resource table on the current draw surface with no transparency:

<SOH> dii NN XXX YYY imageName <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dii	Draw Image Indexed	Command/modifier/parameter
NN	Image Instance Index	2-digit ASCII Hex 00-FF
XXX	Lower-left Image X Coordinate	3-digit ASCII Hex 000-13F
YYY	Lower-left Image Y Coordinate	3-digit ASCII Hex 000-0EF
imageName	Name of Image Resource	Name of loaded.BMP resource
<ETX>	End of Text	Ctrl-C (Hex 03)

BMP Transparency

Images that require transparent areas can be generated in a few ways. When drawing 16-bpp images a 'magic-color' can be specified that will not be drawn onto the draw surface as the image is rendered. On the source BMP file this 'magic color' is used to draw/fill the desired transparent areas.

With indexed images some graphics tools allow specification of a 'magic color' index. This is typically the last used index in the lookup table – it would be index number 255 on an 8-bpp indexed image. This index value can then be used as the 'magic color' for transparency.

Both of these techniques may produce jagged edges since each pixel is either copied or not. An alternative is to use 32-bpp images with the transparency encoded as an alpha channel for seamless blending into the overlaid drawing surface.

Greyscale images can also be used as an 'alpha-mask' to be transparently rendered onto the drawing surface.

Draw Image Transparent

Draws a named image from the resource table on the current draw surface with no transparency:

<SOH> dit M CCCC XXX YYY imageName <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
dit	Draw Image Transparent	Command/modifier/parameter
M	Image Transparency Mode (see following table)	1-digit ASCII Hex 0-7
CCCC	Transparency Color Value	4-digit ASCII Hex RGB565
XXX	Lower-left Image X Coordinate	3-digit ASCII Hex 000-13F
YYY	Lower-left Image Y Coordinate	3-digit ASCII Hex 000-0EF
imageName	Name of Image Resource	Name of loaded .BMP resource
<ETX>	End of Text	Ctrl-C (Hex 03)

Where:

M	Operation	Transparency Color Value	Description
0	Magic Value	Magic index or magic color	For indexed .BMP images the index value corresponding to the magic color For 16bpp .BMP images the RGB565 magic color.
1	None	Not used	Surface pixel = image pixel
2	Darken	RGB565 color to be used as a multiplier	Surface pixel = surface pixel * RGB565 color (can darken image)
3	Source Color Filter	Not used	Surface pixel = surface pixel * image pixel (5:6:5 channel by channel multiply) (color filter from image)
4	Source Alpha Mask	RGB565 color to be used as a 'white' replacement	Surface pixel = (surface pixel * RGB565 color) + (1 – image pixel) * surface pixel (treats image as an alpha mask, white solid, black transparent, intermediate blended)
5	Fill	RGB565 fill color	Surface pixel = RGB565 color
6	Transparency Blend	RGB565 color to use as an Alpha multiplier	Surface pixel = (RGB565 color * image pixel) + (1 – RGB565 color) * surface pixel (blends image into surface by ratio determined by RGB565 color)
7	Shadow	RGB565 color to use as an Alpha multiplier	Surface pixel = (RGB565 color * image pixel * surface pixel) + (1 – image pixel) * surface pixel (image is mask to apply multiplication of RGB565 color)

Queries

The display provides commands to interrogate (query) the various resources.

Query Commands

All Query Commands start with the command letter 'q' followed by a command modifier character indicating the command. Some commands also require a following command parameter character to select different command features. The remainder of the command consists of zero or more data arguments expressed as ASCII Hex strings or printable ASCII characters.

<SOH> q … <ETX>

Query Configuration

The Query Configuration commands follow the Query command letter 'q' with the command modifier character 'c' and a command parameter character to indicate the target configuration item:

<SOH> qc … <ETX>

Query Configuration All

The Query Configuration All command returns multiple responses in configuration item number order listing all of the current configuration settings:

<SOH> qc * <ETX>

Where the responses are formatted as:

<SOH> qc NN <US> TT <US> itemName <US> mmmm <US> MMMM <US> DDDD <US> VVVV <RS> <ETX>

And the last response is formatted as:

<SOH> qc NN <GS> <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qc	Query Configuration	Response/modifier
NN	Item Number	2-digit ASCII Hex 00-FF
TT	Item Type	2-digit ASCII Hex 00-FF
itemName	Item Name	Printable ASCII characters
mmmm	Item minimum value	4-digit ASCII Hex 0000-FFFF
MMMM	Item maximum value	4-digit ASCII Hex 0000-FFFF
VVVV	Item current numeric value	4-digit ASCII Hex 0000-FFFF
<ETX>	End of Text	Ctrl-C (Hex 03)

Query Configuration Item

The Query Configuration Item command returns a response showing the requested item's current value:

<SOH> qc i NN <ETX>

Where the response is formatted as:

<SOH> qci NN = VVVV <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qci	Query Configuration Item	Response/modifier/parameter
NN	Item Number	2-digit ASCII Hex 00-FF
=	Equals	ASCII 61 (3D hex)
VVVV	Item current value	4-digit ASCII Hex 0000-FFFF
<ETX>	End of Text	Ctrl-C (Hex 03)

Query Configuration All Formatted

The Query Configuration All Formatted command returns multiple responses in configuration item number order listing all of the current configuration settings in a human readable form:

<SOH> qc a <ETX>

Where the responses are formatted as:

<SOH> qcf stringName = stringValue <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qcf	Query Configuration Formatted item	Response/modifier/parameter
stringName	Item name	Printable ASCII characters
=	Equals	ASCII 61 (3D hex)
stringValue	Item current value formatted	Printable ASCII characters
<ETX>	End of Text	Ctrl-C (Hex 03)

Query Configuration Formatted item

The Query Configuration Formatted item command returns a response showing the requested item's current value formatted as shown on the display's configuration screen:

<SOH> qc f NN <ETX>

Where the responses are formatted as:

<SOH> qcf stringName = stringValue <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qcf	Query Configuration Formatted item	Response/modifier/parameter
stringName	Item name	Printable ASCII characters
=	Equals	ASCII 61 (3D hex)
stringValue	Item current value formatted	Printable ASCII characters
<ETX>	End of Text	Ctrl-C (Hex 03)

Query Draw Surface

The Query Draw Surface command returns the currently selected drawing surface:

<SOH> qd s <ETX>

Where the response is formatted as:

<SOH> qds N <RS> <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qds	Query Draw Surface	Response/modifier/parameter
N	Surface Number	1-digit ASCII Hex 0-3: 0 = Display surface 1 = Work surface 2 = Background surface
<ETX>	End of Text	Ctrl-C (Hex 03)

Query File

The Query File command returns the results of the path search on the optional microSD card file system:

<SOH> qf path <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qf	Query File	Response/modifier/parameter
path	Path and file pattern	Name pattern to match including optional '*' and '?' wildcards
<ETX>	End of Text	Ctrl-C (Hex 03)

And the response(s) are formatted as:

<SOH> qf fileName <US> attrib <US> size <RS> <ETX>

With the last response formatted as:

<SOH> qf <GS> <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qf	Query File	Response/modifier/parameter
filename	Name of the file matching the query path	
attrib	File attributes	2-digit ASCII Hex: 7 MSB | 6 | 5 | 4 | 3 | 2 | 1 | 0 LSB - | - | ARC | DIR | VOL | SYS | HID | RDO ARC Archive DIR Directory VOL Volume SYS System

Field	Field Name	Notes
		HID Hidden RDO Read Only
size	File size in bytes	8-digit ASCII Hex
<ETX>	End of Text	Ctrl-C (Hex 03)

Query Font

The Query Font commands follow the Query command letter 'q' with the command modifier character 't' and a command parameter character to indicate the target font item:

<SOH> qt … <ETX>

Query Font All

The Query Font All command returns multiple responses in font item number order listing all of the current font settings:

<SOH> qt * <ETX>

Where the responses are formatted as:

<SOH> qt NN <US> fontName <US> HHHH <US> BRGB <US> FRGB <US> X <US> Y <US> H <US> V <US> B <US> F <RS> <ETX>

And the last response is formatted as:

<SOH> qt NN <GS> <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qt	Query Font	Response/modifier
NN	Font Number	2-digit ASCII Hex 00-FF
fontName	Font File Resource Name	Name of loaded .EFNT resource
HHHH	Font Height	4-digit ASCII Hex 0000-FFFF
BRGB	Font Background Color	4-digit ASCII Hex RGB565
FRGB	Font Foreground Color	4-digit ASCII Hex RGB565
X	Font Spacing-X	1-digit ASCII Hex: 0 = fixed width of the font 1→E = pixels between characters F = bounding box character width
Y	Font Spacing-Y	1-digit ASCII Hex: 0 = fixed width of the font 1→E = pixels between characters F = bounding box character width
H	Font Horizontal Alignment	1-digit ASCII Hex: 0 = Left Justify 1 = Center Justify 2 = Right Justify
V	Font Vertical Alignment	1-digit ASCII Hex: 0 = Top Justify 1 = Center Justify 2 = Bottom Justify
B	Background Transparency	1-digit ASCII Hex: 0 = Solid 1 = Transparent
F	Foreground Transparency	1-digit ASCII Hex: For 1bpp fonts: 0 = Solid 1 = Transparent For 4 & 8bpp fonts: 0 = Solid TBD
<ETX>	End of Text	Ctrl-C (Hex 03)

Query Font Item

The Query Font Item command returns a response showing the requested item's current value:

<SOH> qti NN <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qti	Query Font Item	Response/modifier/parameter
NN	Font Number	2-digit ASCII Hex 00-FF
<ETX>	End of Text	Ctrl-C (Hex 03)

Where the response is formatted as:

<SOH> qt NN <US> fontName <US> HHHH <US> BRGB <US> FRGB <US> X <US> Y <US> H <US> V <US> B <US> F <RS> <ETX>

Followed by:

<SOH> qt NN <GS> <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qt	Query Font	Response/modifier/parameter
NN	Font Number	2-digit ASCII Hex 00-FF
fontName	Font File Resource Name	Name of loaded .EFNT resource
HHHH	Font Height	4-digit ASCII Hex 0000-FFFF
BRGB	Font Background Color	4-digit ASCII Hex RGB565
FRGB	Font Foreground Color	4-digit ASCII Hex RGB565
X	Font Spacing-X	1-digit ASCII Hex: 0 = fixed width of the font 1→E = pixels between characters F = bounding box character width
Y	Font Spacing-Y	1-digit ASCII Hex: 0 = fixed width of the font 1→E = pixels between characters F = bounding box character width
H	Font Horizontal Alignment	1-digit ASCII Hex: 0 = Left Justify 1 = Center Justify 2 = Right Justify
V	Font Vertical Alignment	1-digit ASCII Hex: 0 = Top Justify 1 = Center Justify 2 = Bottom Justify
B	Background Transparency	1-digit ASCII Hex: 0 = Solid 1 = Transparent
F	Foreground Transparency	1-digit ASCII Hex: For 1bpp fonts: 0 = Solid 1 = Transparent For 4 & 8bpp fonts: 0 = Solid TBD

<ETX>	End of Text	Ctrl-C (Hex 03)

Query Font Width Text

The Query Font Width Text command returns a response showing the width of the supplied text when rendered in the specified font:

<SOH> qtw NN textString <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qtw	Query Font Text Width	Response/modifier/parameter
NN	Font Number	2-digit ASCII Hex 00-FF
textString	Text string to measure	Name of loaded .EFNT resource
<ETX>	End of Text	Ctrl-C (Hex 03)

Where the response is formatted as:

<SOH> qw NN <US> WWWW <RS> <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qw	Query Width Response	Response/modifier
NN	Font Number	2-digit ASCII Hex 00-FF
WWWW	Text Width	4-digit ASCII Hex 0000-FFFF
<ETX>	End of Text	Ctrl-C (Hex 03)

Query Font Height

The Query Font Height command returns a response showing the height of the specified font:

<SOH> qth NN <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qth	Query Font Height	Response/modifier/parameter
NN	Font Number	2-digit ASCII Hex 00-FF
<ETX>	End of Text	Ctrl-C (Hex 03)

Where the response is formatted as:

<SOH> qh NN <US> HHHH <RS> <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qw	Query Width Response	Response/modifier
NN	Font Number	2-digit ASCII Hex 00-FF
HHHH	Font Height	4-digit ASCII Hex 0000-FFFF
<ETX>	End of Text	Ctrl-C (Hex 03)

Query Resource

The Query Resource command returns one or more responses showing entries in the resource table that match the name pattern:

<SOH> qr pattern <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qr	Query Resource	Response/modifier
pattern	Resource name pattern	Name pattern to match including optional '*' and '?' wildcards
<ETX>	End of Text	Ctrl-C (Hex 03)

And the response(s) are formatted as:

<SOH> qr resourceName <US> size <US> RO <RS> <ETX>

With the last response formatted as:

<SOH> qr <GS> <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qr	Query Resource	Response/modifier
resourceName	Name of the resource matching the pattern	
size	File size in bytes	8-digit ASCII Hex
RO	Read Only	1-digit ASCII Hex: 0 = Read/Delete 1 = Read Only (internal)
<ETX>	End of Text	Ctrl-C (Hex 03)

Query Scheme

The Query Scheme commands follow the Query command letter 'q' with the command modifier character 'm' and a command parameter character to indicate the target font item:

<SOH> qm … <ETX>

Query Scheme All

The Query Scheme All command returns multiple responses in scheme item number order listing all of the current scheme settings:

<SOH> qm * <ETX>

Where the responses are formatted as:

<SOH> qm NN <US> BRGB <US> WRGB <US> FF <US> C <US> PPPP <US> M <ETX>

And the last response is formatted as:

<SOH> qm NN <GS> <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qm	Query Scheme	Response/modifier
NN	Scheme Number	2-digit ASCII Hex 00-FF
BRGB	Black Replace Color	4-digit ASCII Hex RGB565
WRGB	White Replace Color	4-digit ASCII Hex RGB565
FF	Font Number	2-digit ASCII Hex 00-FF
C	Colorization	1-digit ASCII Hex: 0 = no change 1 = grayscale 2 = shade
PPPP	Text Position	4-digit ASCII Hex: 0 = no text 1 = centered 2-1FF = X, Y position
M	Transparency Mode	(see below)
<ETX>	End of Text	Ctrl-C (Hex 03)

Where:

M	Operation	Transparency Color Value	Description
0	Magic Value	Magic index	For indexed .BMP images only, the last index value is the magic color.
1	None	Not used	Surface pixel = image pixel.
2	Darken	Scheme white replace color to be used as a multiplier	Surface pixel = surface pixel * RGB565 color.
3	Source Color Filter	Not used	Surface pixel = surface pixel * image pixel (5:6:5 channel by channel multiply).
4	Source Alpha Mask	Scheme white replace color to be used as a 'white' replacement	Surface pixel = (surface pixel * RGB565 color) + (1 – image pixel) * surface pixel (treats image as an alpha mask, white solid, black transparent, intermediate blended).
5	Fill	Scheme white replace fill color	Surface pixel = RGB565 color
6	Transparency Blend	Scheme white replace color to use as an Alpha multiplier	Surface pixel = (RGB565 color * image pixel) + (1 – RGB565 color) * surface pixel (blends image into surface by ratio determined by RGB565 color).
7	Shadow	Scheme white replace color to use as an Alpha multiplier	Surface pixel = (RGB565 color * image pixel * surface pixel) + (1 – image pixel) * surface pixel (image is mask to apply multiplication of RGB565 color).

Query Screen

The Query Screen commands follow the Query command letter 'q' with the command modifier character 's' and a command parameter character to indicate the target font item:

<SOH> qs … <ETX>

Query Screen Object

The Query Screen Object command returns a screen object response followed by multiple responses for all of the screen objects for that screen:

<SOH> qsi NN <ETX>

Where the responses are formatted as a screen object response:

<SOH> qs NN <US> backgroundImage <RS> <ETX>

Followed by all of the screen object responses for that screen in numerical order:

<SOH> qo NN <US> II <US> T <US> objectImage <US> objectOverlayImage <US> MM <US> label <US> XXX <US> YYY <RS> <ETX>

<SOH> qp NN <US> II <US> 0000 <US> 1111 <US> 2222 <US> 3333 <US> 4444 <US> 5555 <US> 6666 <US> 7777 <US> 8888 <US> 9999 <US> <ETX>

. . .

With the last screen object response formatted as:

<SOH> qi NN <US> II <GS> <ETX>

Then the last screen response is formatted as:

<SOH> qs NN <GS> <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
qo	Query Object	Response/modifier
NN	Screen Number	2-digit ASCII Hex 00-FF
II	Object Number	2-digit ASCII Hex 00-FF
T	Object Type	1-digit ASCII Hex 0-F: 0 = none 1 = Icon 2 = Button 3 = Toggle Button 4 = Back Button 5 = Slider 6 = Label 7 = Touchscreen 8 = Radial Gauge
objectImage	Object Image resource name	Name of loaded .BMP resource
objectOverlayImage	Object Overlay Image resource name	Name of loaded .BMP resource
MM	Scheme Number	2-digit ASCII Hex 00-FF
label	Object Label	Printable UTF-8 string
XXX	Object X Coordinate	3-digit ASCII Hex 000-1EF
YYY	Object Y Coordinate	3-digit ASCII Hex 000-0EF
<ETX>	End of Text	Ctrl-C (Hex 03)

And where:

Field	Field Name	Notes
qP	Query Option	Response/modifier
NN	Screen Number	2-digit ASCII Hex 00-FF
II	Object Number	2-digit ASCII Hex 00-FF
0000	Object Option 0 Value	4-digit ASCII Hex 0000-FFFF
1111	Object Option 1 Value	4-digit ASCII Hex 0000-FFFF
2222	Object Option 2 Value	4-digit ASCII Hex 0000-FFFF
3333	Object Option 3 Value	4-digit ASCII Hex 0000-FFFF
4444	Object Option 4 Value	4-digit ASCII Hex 0000-FFFF
5555	Object Option 5 Value	4-digit ASCII Hex 0000-FFFF
6666	Object Option 6 Value	4-digit ASCII Hex 0000-FFFF
7777	Object Option 7 Value	4-digit ASCII Hex 0000-FFFF
8888	Object Option 8 Value	4-digit ASCII Hex 0000-FFFF
9999	Object Option 9 Value	4-digit ASCII Hex 0000-FFFF
<ETX>	End of Text	Ctrl-C (Hex 03)

Query Screen All

The Query Screen All command returns multiple Query Screen Object responses, one set per screen, for all screens in numerical order:

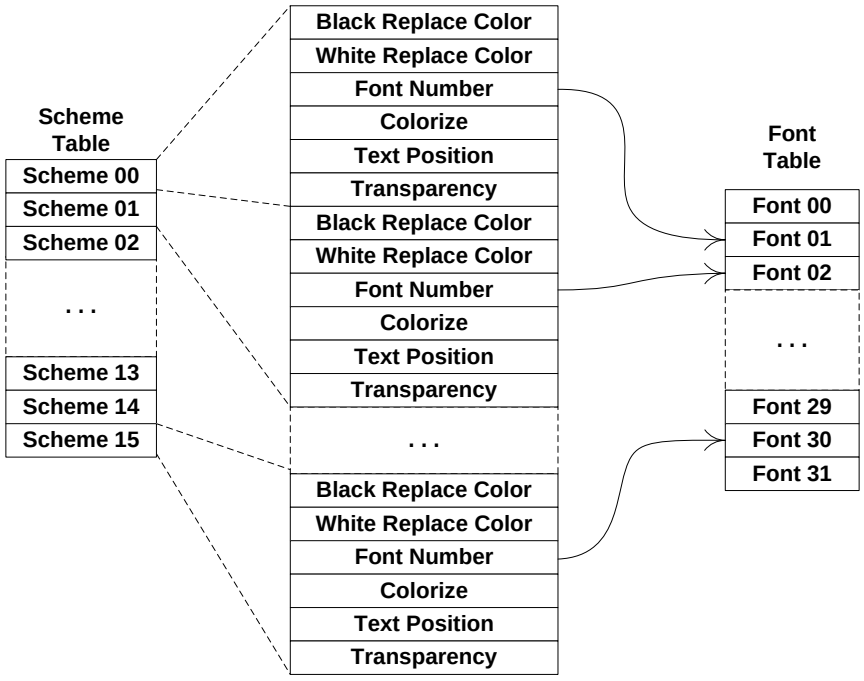
<SOH> qs * <ETX>

See the prior Query Screen Object response for response details.

Schemes

Schemes are implemented to provide a common way to label and colorize all higher level screen objects such as buttons, sliders and icons. Schemes are used in pairs with the first element of the pair used for rendering the screen object when it isn't touched, and the second used to render the object when it is touched. The two replacement colors can provide colorization of gray scale buttons that changes when the buttons are touched and released. The schemes are stored in a table and are referenced by the entry number.

There sixteen entries in the Schemes table yielding eight scheme pairs.



Scheme Commands

All Scheme commands start with the letter 'm' followed by a command modifier character specifying the command. The remainder of the command consists of one or more data arguments expressed as ASCII Hex strings or ASCII printable characters:

<SOH> m … <ETX>

There are commands to specify the scheme colors and attributes for each table entry, and load or save the scheme table from/to a file on the micro SD card.

Scheme Colors

Sets the scheme black replace and white replace colors used for colorization as defined by the attributes:

<SOH> mc NN BRGB WRGB <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
mc	Scheme Colors	Command/modifier
NN	Scheme Number	2-digit ASCII Hex 00-0F

BRGB	Black Replace Color	4-digit ASCII Hex RGB565
WRGB	White Replace Color	4-digit ASCII Hex RGB565
<ETX>	End of Text	Ctrl-C (Hex 03)

Scheme Attributes

Sets the scheme Font number, colorization, text position and transparency:

<SOH> ma NN FF C PPPP M <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
ma	Scheme Attributes	Command/modifier
NN	Scheme Number	2-digit ASCII Hex 00-0F
FF	Font Number	2-digit ASCII Hex 00-1F
C	Colorization	1-digit ASCII Hex: 0 = no change 1 = grayscale 2 = shade
PPPP	Text Position	4-digit ASCII Hex: 0 = no text 1 = centered 2-1FF = X, Y position
M	Transparency Mode	(see below)
<ETX>	End of Text	Ctrl-C (Hex 03)

Where:

M	Operation	Transparency Color Value	Description
0	Magic Value	Magic index	For indexed .BMP images only, the index value of the upper leftmost is the magic color index.
1	None	Not used	Surface pixel = image pixel.
2	Darken	Scheme white replace color to be used as a multiplier	Surface pixel = surface pixel * RGB565 color.
3	Source Color Filter	Not used	Surface pixel = surface pixel * image pixel (5:6:5 channel by channel multiply).
4	Source Alpha Mask	Scheme white replace color to be used as a 'white' replacement	Surface pixel = (surface pixel * RGB565 color) + (1 – image pixel) * surface pixel (treats image as an alpha mask, white solid, black transparent, intermediate blended).
5	Fill	Scheme white replace fill color	Surface pixel = RGB565 color
6	Transparency Blend	Scheme white replace color to use as an Alpha multiplier	Surface pixel = (RGB565 color * image pixel) + (1 – RGB565 color) * surface pixel (blends image into surface by ratio determined by RGB565 color).
7	Shadow	Scheme white replace color to use as an Alpha multiplier	Surface pixel = (RGB565 color * image pixel * surface pixel) + (1 – image pixel) * surface pixel (image is mask to apply multiplication of RGB565 color).

Scheme Load All from File

Loads the Scheme Table from a .JSON file located on the microSD card. (***See the appendix JSON File Formats***):

<SOH> m < fileName <ETX>

Scheme Save All to File

Saves the Scheme Table to a .JSON file located on the microSD card. (***See the appendix JSON File Formats)***:

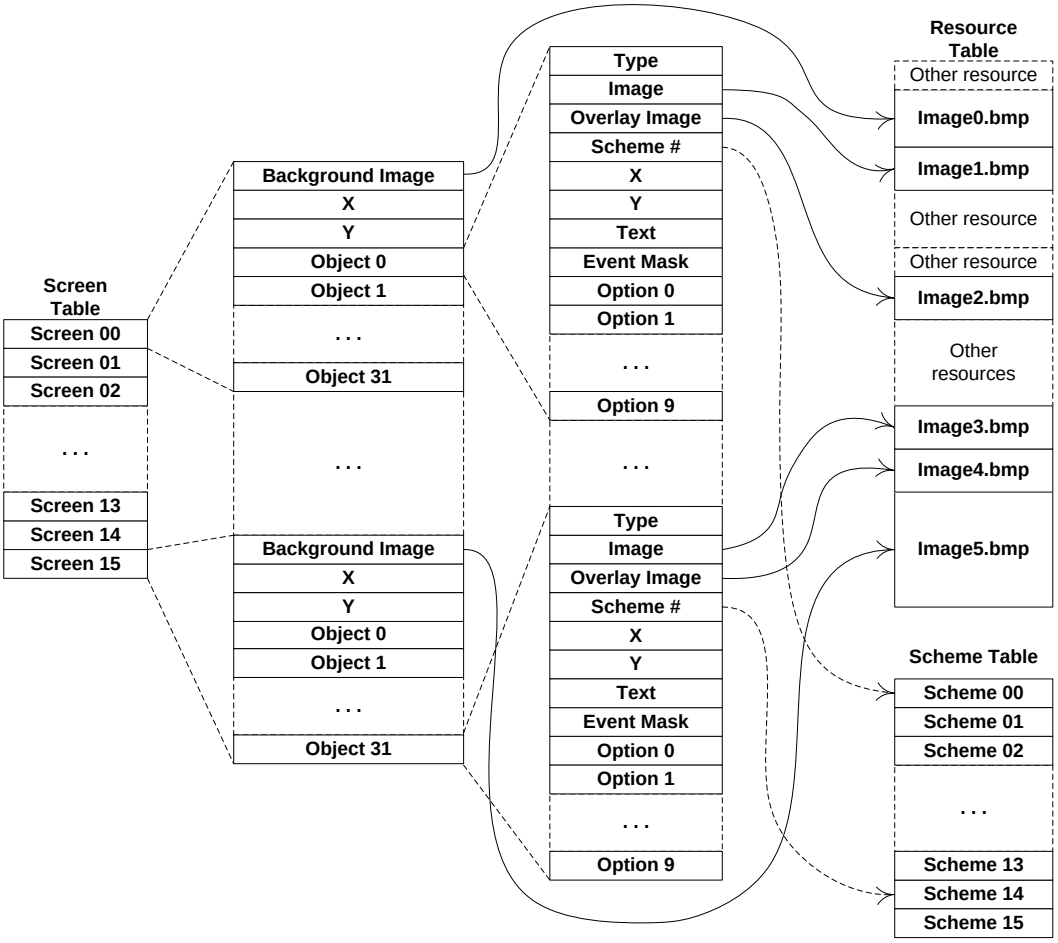
<SOH> m > fileName <ETX>

Screens

Screens are implemented to provide a grouped collection of placed screen objects such as buttons, sliders and icons overlaid on top of a background image. Screens are drawn entirely by the display including the automatic drawing and colorization of objects as they are manipulated with the interactions reported as messages.

The screens may be navigated to directly by their number or like a stack – last in, first out. Messages are sent when screens are navigated to or away from. The screens are stored in a table and are referred to by their entry number.

There are sixteen entries in the Screen table and each screen can contain up to thirty two screen objects. Object entries in the Screen table must be contiguous – screen objects will not be processed beyond the first zero entry.



Screen Commands

All Screen commands start with the letter 's' followed by a command modifier character specifying the command. The remainder of the command consists of one or more data arguments expressed as ASCII Hex strings or ASCII printable characters:

<SOH> s … <ETX>

There are commands to specify the screen background and object collection for each table entry, navigate between screen entries, and load or save the screen table from/to a file on the microSD card.

Screen Background Image

Sets the background image for a screen:

<SOH> sb NN backgroundImage <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
sb	Screen Background	Command/modifier
NN	Screen Number	2-digit ASCII Hex 00-0F
backgroundImage	Name of Background Image Resource	Name of loaded .BMP resource
<ETX>	End of Text	Ctrl-C (Hex 03)

Screen Attribute

Sets the attributes for a screen:

<SOH> sa NN xxx yyy <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
sa	Screen Attribute	Command/modifier
NN	Screen Number	2-digit ASCII Hex 00-0F
xxx	Screen lower left X coordinate	3-digit ASCII Hex 000 – 1EF
yyy	Screen lower left Y coordinate	3-digit ASCII Hex 000 – 0EF
<ETX>	End of Text	Ctrl-C (Hex 03)

Screen Object Commands

All Screen Object commands start with the two character command/modifier sequence 'so' specifying the command. The remainder of the command consists of one or more data arguments expressed as ASCII Hex strings or ASCII printable characters:

<SOH> s … <ETX>

There are commands to specify the type of screen object, associated bitmap images that the object requires, a scheme pair for rendering, its position relative to the containing screen, an event mask and text.

Screen Object Attributes

Sets the attributes used to render a screen object on the screen:

<SOH> so NN a II T MM XXX YYY mask text <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
so	Screen Object	Command/modifier
NN	Screen Number	2-digit ASCII Hex 00-0F
a	Object Attribute	Parameter
II	Object Number	2-digit ASCII Hex 00-0F
T	Object Type	1-digit ASCII Hex 0-F: 0 = none 1 = Icon 2 = Button 3 = Toggle Button 4 = Back Button 5 = Slider 6 = Label 7 = Touchkeypad 8 = Radial Gauge 9 = Linear Gauge 10 = Listbox 11 = Spinner Knob ***(see Screen Object Types below)***
MM	Object Scheme Pair(0)	2-digit ASCII Hex 00-FF: Number of scheme pair 0
XXX	Object X Coordinate	3-digit ASCII Hex 000-1EF
YYY	Object Y Coordinate	3-digit ASCII Hex 000-0EF
mask	Object Event Mask	4-digit ASCII Hex 0000-FFFF
text	Object Text	Printable UTF-8 string
<ETX>	End of Text	Ctrl-C (Hex 03)

Screen Object Image

Sets the image used to render a screen object on the screen:

<SOH> so NN n II objectImage <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
so	Screen Object	Command/modifier
NN	Screen Number	2-digit ASCII Hex 00-0F
n	Object Image Name	Parameter
II	Object Number	2-digit ASCII Hex 00-0F
objectImage	Name of Object Image Resource	Name of loaded .BMP resource
<ETX>	End of Text	Ctrl-C (Hex 03)

Screen Object Overlay Image

Sets the overlay image used to render a screen object on the screen:

<SOH> so NN o II objectOverlayImage <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
so	Screen Object	Command/modifier
NN	Screen Number	2-digit ASCII Hex 00-0F
o	Object Image Overlay	Parameter
II	Object Number	2-digit ASCII Hex 00-0F
objectOverlayImage	Name of Object Overlay Image Resource	Name of loaded .BMP resource
<ETX>	End of Text	Ctrl-C (Hex 03)

Screen Object Options

Sets the options used to render a screen object on the screen:

```
<SOH> so NN p II 0000 1111 2222 3333 4444 5555 6666 7777 8888 9999
                                                          <ETX>
```

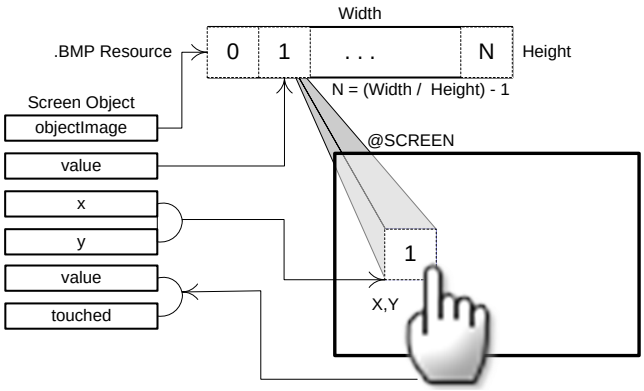
Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
so	Screen Object	Command/modifier
NN	Screen Number	2-digit ASCII Hex 00-0F
a	Object Attribute	Parameter
II	Object Number	2-digit ASCII Hex 00-0F
0000	Object Option 0 Value	4-digit ASCII Hex 0000-FFFF
1111	Object Option 1 Value	4-digit ASCII Hex 0000-FFFF
2222	Object Option 2 Value	4-digit ASCII Hex 0000-FFFF
3333	Object Option 3 Value	4-digit ASCII Hex 0000-FFFF
4444	Object Option 4 Value	4-digit ASCII Hex 0000-FFFF
5555	Object Option 5 Value	4-digit ASCII Hex 0000-FFFF
6666	Object Option 6 Value	4-digit ASCII Hex 0000-FFFF
7777	Object Option 7 Value	4-digit ASCII Hex 0000-FFFF
8888	Object Option 8 Value	4-digit ASCII Hex 0000-FFFF
9999	Object Option 9 Value	4-digit ASCII Hex 0000-FFFF
<ETX>	End of Text	Ctrl-C (Hex 03)

Screen Object Types

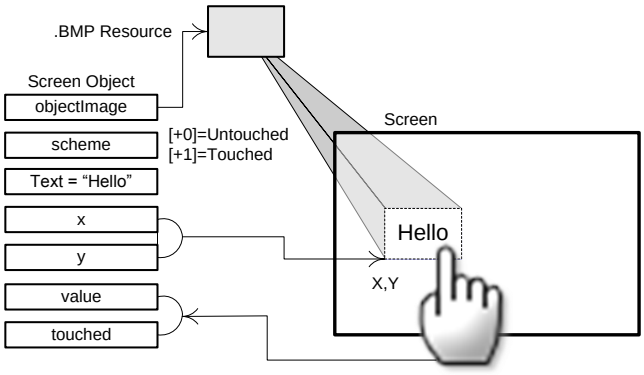
Icon Screen Object

The Icon screen object provides the ability to display a portion of a bitmap resource where the displayed portion of the bitmap is controlled by the screen object's Value. The displayed portion of the bitmap may be a square based upon the image width divided by the image height or a portion selected from the bitmap width divided by a screen object Option value.



Button Screen Object

The Button screen object provides the ability to display a bitmap with a Text label that acts like an on-screen button. The button can auto-colorize for press/release feedback using the object's Scheme pair and provide Event notifications.



Toggle Button Screen Object

The Toggle Button screen object provides the ability to display a bitmap with a Text label that acts like an on-screen latching button – each press/release toggles the button state. The button can auto-colorize for press/release feedback using the object's Scheme pair and provide Event notifications.

Back Button Screen Object

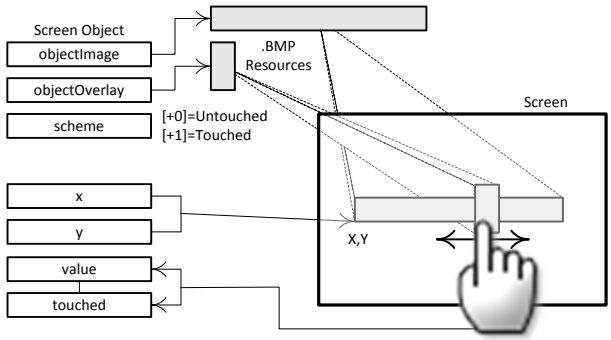
The Back Button screen object provides the ability to display a bitmap with a Text label that will pop the screen stack when pressed. The button can auto-colorize for press/release feedback using the object's Scheme pair and provide Event notifications.

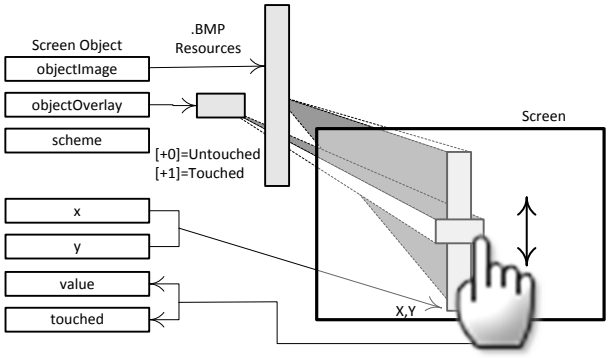
Slider Screen Object

The Slider screen object provides the ability to display a horizontal or vertical slider. The slider uses two bitmap resources configured with the object Image and overlay Image. The Image bitmap resource supplies the slider base and the Overlay bitmap resource supplies the slider button.

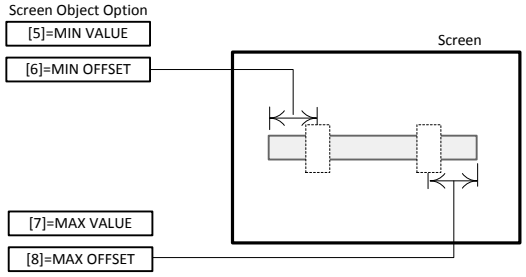
The slider orientation is controlled by the aspect ratio of the object Image resource – bitmaps that are wider than they are tall operate horizontally and bitmaps that are taller than they are wide operate vertically.

The slider screen object can be configured for min/max values and button to base bitmap offsets via the Option properties.





The slider screen object can be configured for min/max values and corresponding button center to base bitmap pixel offsets via the Option properties.

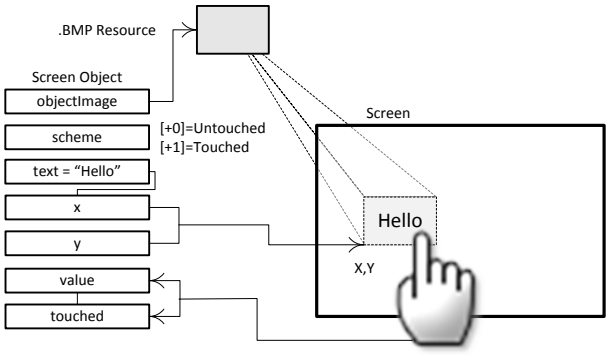


If an Option offset property is zero the corresponding offset is equal to the width (height) of the button bitmap.

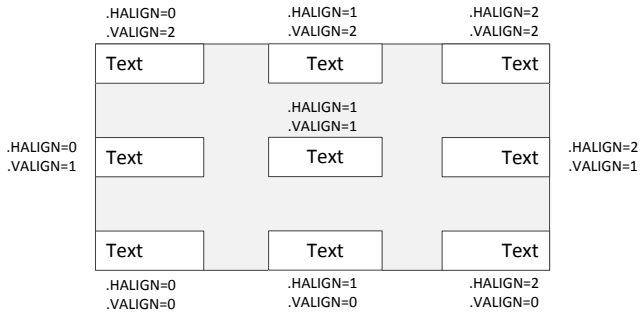
If both of the Option min and max value properties are zero the slider object's Value ranges from 0 ↔ 32767.

Label Screen Object

The Label screen object provides the ability to display Text justified within the control's bitmap resource. The width and height of the displayed text area is controlled by the text's width and height as rendered by the Scheme pair fonts or can be overridden via Option values.



The position of the Text within the label boundary is controlled by the Scheme font justification – the object's scheme Font HALIGN and Font VALIGN properties:

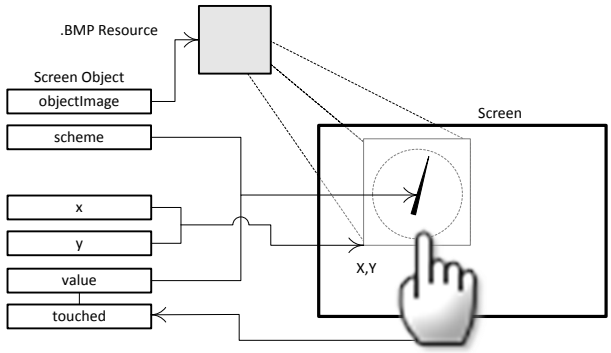


Touchscreen Screen Object

The Touchscreen object provides the ability for the screen to pop-up and display several different on-screen keypads, receive the pressed characters as input and also provide non-keypad touchscreen events.

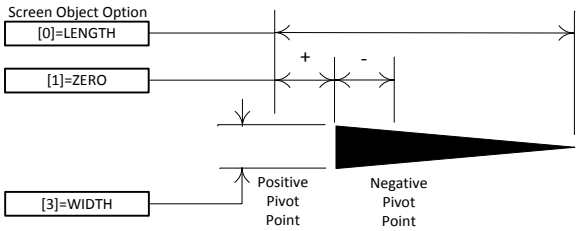
Radial Gauge Screen Object

The Radial Gauge screen object displays the .IMAGE$ bitmap resource with an overlaid graphical needle that can be justified to the bitmap and configured for angle and value range using .OPTION properties. The object's .VALUE then sets the needle angle.

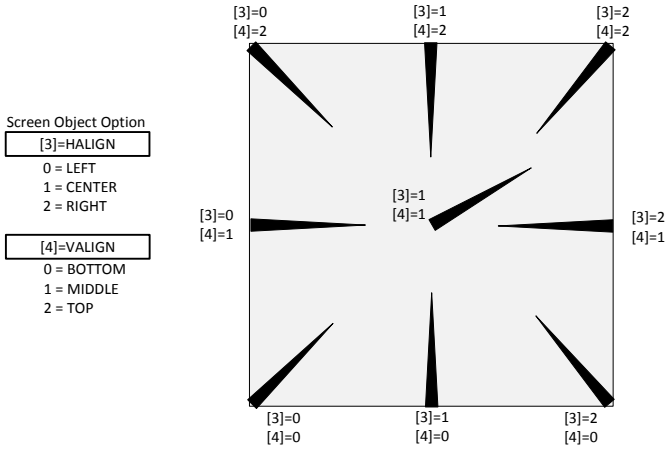


The first three Option properties set the gauge needle length, pivot point offset and width in pixels. A positive pivot point offset allows the needle to rotate about a point before its base. A negative pivot point offset allows the needle to rotate about a point along its length.

Shorter, skinnier needles draw faster.



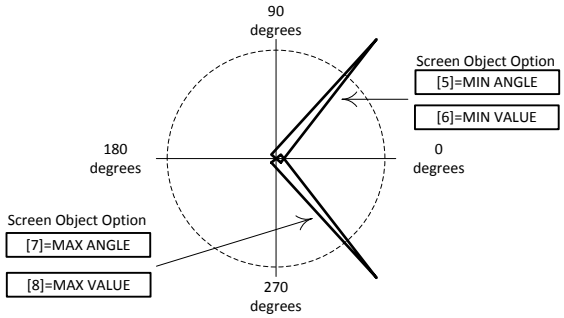
The next two Option properties align the needle's pivot point to the objectImage bitmap resource.



The last four Option properties configure the needle's minimum and maximum angles and the corresponding minimum and maximum values. Both the angles and values can be negative. Angles advance in value counter-clockwise rotation with zero to the right as shown in the following diagram.

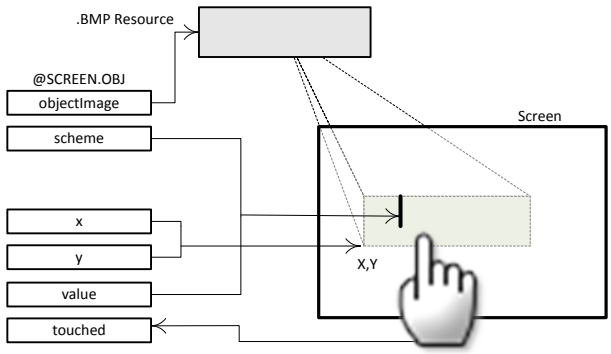
The minimum angle is the angle the needle will be drawn at when the object's Value is at the specified minimum value.

The maximum angle is the angle the needle will be drawn at when the object's Value is at the specified maximum value.



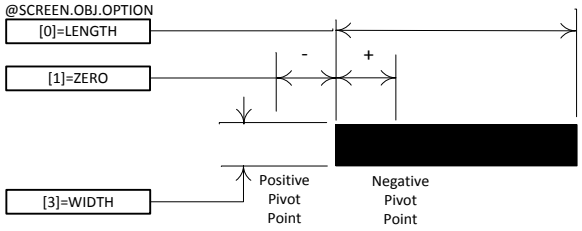
Linear Gauge Object

The Linear Gauge screen object display the .IMAGE$ bitmap resource with overlaid graphical needle that can be justified to the bitmap and configured for offset and value range using the .OPTION properties. The object's .VALUE then sets the needle position.

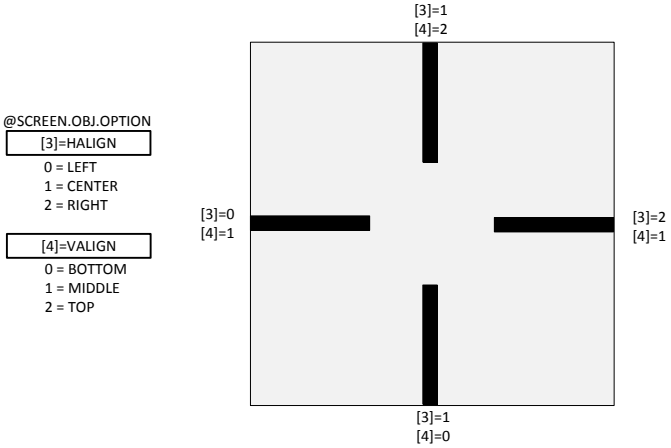


The first three .OPTION properties set the gauge needle length, zero offset and width in pixels. A positive zero offset allows the needle to move along a line parallel to and inside its base. A negative offset allows the needle to move along a line parallel to and outside of its base.

Shorter, skinnier needles draw faster.



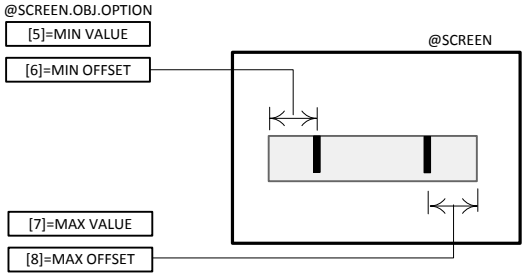
The next two .OPTION properties align the needle to the .IMAGE$ bitmap resource.



The last four .OPTION properties configure the needle's minimum and maximum offsets and the corresponding minimum and maximum values. Both the offsets and values can be negative.

The minimum offset is the offset from the .IMAGE$ edge the needle will be drawn at when the object's .VALUE is at the specified minimum value.

The maximum offset is the offset from the .IMAGE$ edge the needle will be drawn at when the object's .VALUE is at the specified maximum value.



Listbox Screen Object

The Listbox screen object displays the .IMAGE$ bitmap resource with overlaid up/down buttons on the right hand side and the object's DATA displayed as text strings using the object's .SCHEME font. The number of displayed items and the topmost item in the list may be controlled by .OPTION properties.

An item may be selected or deselected by touching. The object's .VALUE reflects the selected item number with minus one (-1) indicating no item is selected.

Spinner Knob Object

Screen Navigation Commands

Screen Change To

Changes to the screen and displays it.

<SOH> s= NN <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
S=	Screen Change To	Command/modifier
NN	Screen Number	2-digit ASCII Hex 00-0F
<ETX>	End of Text	Ctrl-C (Hex 03)

Screen Push To

Pushes to the screen and displays it, stacking the screen number that was being displayed. The screen stack can hold up to seven screens pushed to:

<SOH> s+ NN <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
S+	Screen Push To	Command/modifier
NN	Screen Number	2-digit ASCII Hex 00-0F
<ETX>	End of Text	Ctrl-C (Hex 03)

Screen Pop

Pops from the current screen to the previously pushed screen and displays it, un-stacking the screen number that was previously displayed:

<SOH> s- <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
S-	Screen Pop To	Command/modifier
<ETX>	End of Text	Ctrl-C (Hex 03)

Screen Load All from File

Loads the Screen Table from a .JSON file located on the microSD card. (***See the appendix JSON File Formats)***:

<SOH> s < fileName <ETX>

Screen Save All to File

Saves the Screen Table to a .JSON file located on the microSD card. (***See the appendix JSON File Formats)***:

<SOH> s > fileName <ETX>

Screen Responses

The screen system produces several autonomous response messages as screens are changed and screen objects are interacted with.

Screen Changed Event Response

The Screen Change Event response messages are sent whenever the number of the active screen changes:

<SOH> sc NN <US> S <RS> <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
sc	Screen Changed	Command/modifier
NN	Screen Number	2-digit ASCII Hex 00-0F
S	Screen State	1-digit ASCII Hex 1 – 2 1 = Screen Constructed 2 = Screen Destructed
<ETX>	End of Text	Ctrl-C (Hex 03)

Screen Object Event Response

The Screen Change Event response messages are sent whenever the number of the active screen changes:

<SOH> so NN <US> OO <US> T <US> vvvv <US> tttt <RS> <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
sc	Screen Changed	Command/modifier
NN	Screen Number	2-digit ASCII Hex 00-0F
OO	Screen Object Number	2-digit ASCII Hex 00-1F
T	Object Type	1-digit ASCII Hex 0-F: 0 = none 1 = Icon 2 = Button 3 = Toggle Button 4 = Back Button 5 = Slider 6 = Label 7 = Touchscreen 8 = Radial Gauge
vvvv	Object value	4-digit ASCII Hex 0000-FFFF
tttt	Object touched	4-digit ASCII Hex 0000-0001
<ETX>	End of Text	Ctrl-C (Hex 03)

Touch Screen

Touchscreen Commands

All Touchscreen commands start with the letter 't' followed by a command modifier character specifying the command. The remainder of the command consists of a data argument expressed as ASCII Hex:

<SOH> t … <ETX>

There are commands to show and hide several touch keypads in top and bottom locations. There are response messages to detail keypad and touchscreen interaction.

Touch Keypad

The Touch Keypad command controls the presence and appearance of a on-screen keypad:

<SOH> tk N <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
tk	Touch Keypad	Command/modifier
N	Keypad Number	1-digit ASCII Hex 0-F: 0 = No keypad (hide) 1 = QWERTY keypad 2 = Numeric keypad 3 = QWERTY keypad top 4 = Numeric keypad top 5 = Configuration keypad
<ETX>	End of Text	Ctrl-C (Hex 03)

Touchscreen Responses

All Touchscreen responses start with the letter 't' followed by a response modifier character specifying the response. The remainder of the response consists of a data argument expressed as ASCII Hex:

<SOH> t … <ETX>

Touch Keypad Status

The Touch Keypad Status response indicates the presence and appearance of the current on-screen keypad and is sent whenever they change either by received command or user interaction:

<SOH> tks N <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
tks	Touch Keypad Status	Response/modifier/parameter
N	Keypad Number	1-digit ASCII Hex 0-F: 0 = No keypad (hide) 1 = QWERTY keypad 2 = Numeric keypad 3 = QWERTY keypad top 4 = Numeric keypad top 5 = Configuration keypad
<ETX>	End of Text	Ctrl-C (Hex 03)

Touch Keypad Key

The Touch Keypad Key response indicates user interaction pressing a keypad key:

<SOH> tkk NN <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
tkk	Touch Keypad Key	Response/modifier/parameter
NN	Key Code	2-digit ASCII Hex 00-FF value of the pressed key
<ETX>	End of Text	Ctrl-C (Hex 03)

Touch Screen Status

The Touch Screen Status response indicates user interaction with the touchscreen when not interacting with a keypad:

<SOH> ts A XXX YYY <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
ts	Touch Screen	Response/modifier/parameter
A	Action	ASCII character: P = Touchscreen Pressed M = Touchscreen Moved R = Touchscreen Released
XXX	X Coordinate	3-digit ASCII Hex 000-01EF
YYY	Y Coordinate	3-digit ASCII Hex 000-00EF
<ETX>	End of Text	Ctrl-C (Hex 03)

Backlight

Backlight Commands

All Backlight commands start with the letter 'b' followed by a command modifier character specifying the command. The remainder of the command consists of a data argument expressed as ASCII Hex:

<SOH> b … <ETX>

There are commands to turn the backlight on or off or on for the configured time value.

Backlight

The Backlight command controls the state of the LCD display backlight:

<SOH> b N <ETX>

Where:

Field	Field Name	Notes
<SOH>	Start of Header	Ctrl-A (Hex 01)
b	Backlight	Command
N	State	1-digit ASCII Hex 0-F: 0 = off 1 = on 2 = on timed
<ETX>	End of Text	Ctrl-C (Hex 03)

Power Up / Reset Response

The Power Up / Reset Response message is sent whenever the display is reset:

<SOH> R <ETX>

AcsBasic Mode

The AcsBasic mode provides full access to all of the display's features using a superset of the Beginners All-purpose Symbolic Instruction Code – BASIC. The superset provides additional commands and enhancements for manipulating the display.

See the separate documents "Color 320x240 LCD Basic Programming User's Manual" and "ACS Basic Graphics Programming Manual" for information on operating the display in this mode.

Network Support

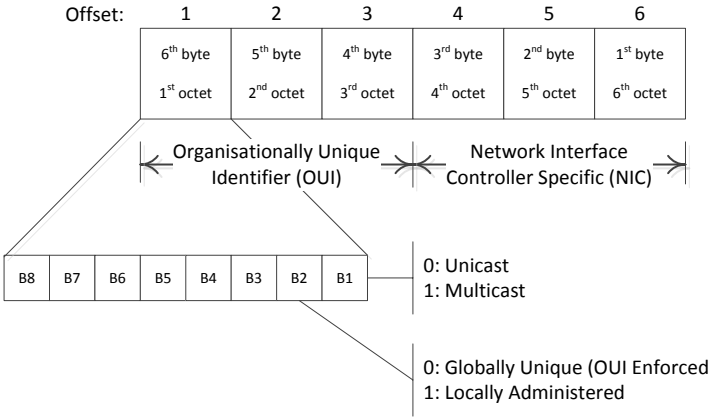
The ACS Color 320x240 LCD Display Terminal supports multiple modes of access via the Ethernet connection. The networking support is controlled by several configuration parameters accessible through the Configuration Settings screen. Here are the relevant settings shown with their default values:

#	Setting	Description
34	MAC Address	= 02:01:23:45:67:89 (default)
35	IP Address	= 192.168.1.200 (default)
36	IP Mask	= 255.255.255.0 (default)
37	Router IP Address	= 192.168.1.1 (default)
38	FTP Server Port	= 21 (default)
39	VNC Server Port	= 5900 (default)
40	HTTP Server Port	= 80 (default)
41	TCP/IP Raw Port	= 23 (default)
42	NTP Server	= 192.168.1.1 (default)
43	NTP Client Port	= 123 (default)
44	Local Time Zone	= -5 hours from UTC (default)
45	Daylight Savings	0 = no (default) adds one hour to received NTP time

MAC Address

The Media Access Control address (MAC Address) is a unique identifier assigned to network interfaces for communications on the physical network segment. Each device on a physical network segment must be unique amongst all devices on the network segment to allow network traffic to be routed to and from the correct hardware device. MAC addresses may be assigned universally across all manufactured devices or locally by the device users. The ACS Color LCD supports locally administered MAC addresses – the address is assigned to the display by the user or network administrator, replacing the configured default address.

The MAC address is 48 bits long and is typically expressed as six groups of hexadecimal digits separated by colons in transmission order.



Universal and locally administrated MAC addresses are distinguished by setting the second-least significant bit of the most significant byte of the address – known as the U/L bit. If the U/L bit is zero the address is universally administered, if it is one the address is locally administrated.

If the least significant bit of the most significant octet is zero the network frame is meant to reach only one receiving network device (NIC). This type of transmission is called Unicast addressing – the frame is transmitted to all nodes within the collision domain, which usually ends at the nearest network switch or router. Only the network device with the matching MAC address will accept the frame.

If the least significant bit of the most significant octet is one each network device will choose to accept the frame based upon a different criteria other than a matching MAC address; maybe a configurable list of accepted MAC addresses. This type of transmission is called Multicast addressing.

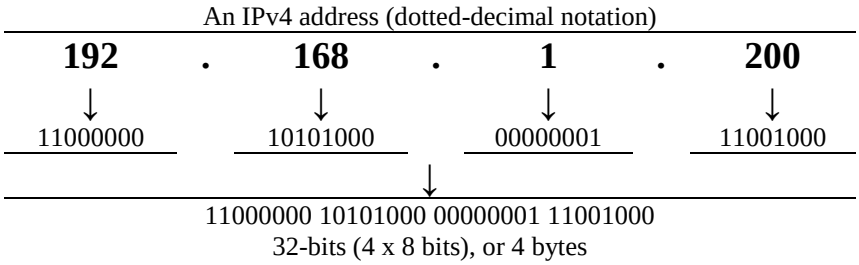
The ACS Color LCD currently only supports Unicast addressing. The default MAC address is 02:01:23:45:67:89 – which designates a Unicast, Locally Administrated MAC address.

The MAC address must be configured to be unique amongst all devices on the network segment that the display is attached to.

IP Address

An Internet Protocol address (IP Address) is a numerical label assigned to each device participating in the network that uses Internet Protocol for communication. The IP Address serves two functions; host or network identification and location addressing. The Color LCD currently supports IPv4 protocol which requires a 32-bit IP Address number.

The IP Address is a 32-bit binary number, but it is usually expressed as 4 decimal numbers, each ranging from 0 to 255, separated by dots. Each decimal number represents a group of 8 bits (octet) of the address:



Devices that are not directly connected to the Internet but only use the network to communicate do not need globally unique IP Addresses. The Internet Assigned Numbers Authority (IANA) has defined three ranges of reserved, private IP Addresses for these devices:

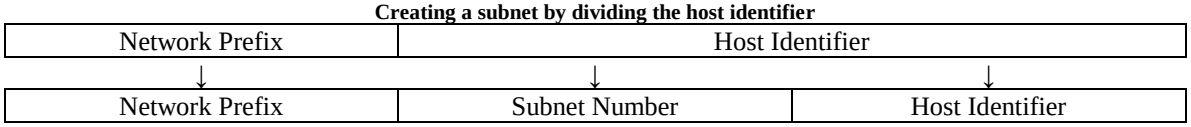
IANA-reserved private IPv4 network ranges			
	Start	**End**	**# of addresses**
8-bit prefix 24-bit block	10.0.0.0	10.255.255.255	16,777,216
12-bit prefix 20-bit block	172.16.0.0	172.31.255.255	1,048,576
16-bit prefix 16-bit block	192.168.0.0	192.168.255.255	65,536

Private networks typically connect to the Internet through a Network Address Translation (NAT) device such as a router. The NAT hides a large number of IP Addresses in the private network by mapping TCP and UDP port numbers on the public network to individual addresses on the private network; the port numbers are site specific extensions to an IP Address. This allows a large number of devices on the private network to appear to have a single IP Address on the public Internet.

IP Mask

A sub-network or subnet is a logically visible subdivision of an IP network. All computers that belong to the subnet are addressed with a common, identical, most-significant bit-group in their IP Address. This results in the logical division of an IP Address into two fields; a network or routing prefix and the host identifier:

Creating a subnet by dividing the host identifier



The process of sub-netting involves the separation of network prefix and subnet number portion of the IP Address from the host identifier. This is performed by a bitwise AND operation between the IP Address and the IP Mask. The result yields the network address or prefix and the remainder is the host identifier. Here is an example showing the separation of the network prefix and the host identifier from an IP Address (192.168.1.200) and IP Mask (255.255.255.0):

	Binary form	Dotted-decimal notation
IP Address	11000000.10101000.00000001.11001000	192.168.1.200
IP Mask	11111111.11111111.11111111.00000000	255.255.255.0
Network prefix	11000000.10101000.00000001.00000000	192.168.1.0
Host identifier	00000000.00000000.00000000.11001000	0.0.0.200

The purpose of sub-netting is to divide a network into smaller subnets. This is achieved by designating some high-order bits from the host part and grouping them with the network mask to form the IP Mask. Here the previous example is modified by moving two bits from the host part to the IP mask to form four smaller subnets one quarter the previous size:

	Binary form	Dotted-decimal notation
IP Address	11000000.10101000.00000001.11001000	192.168.1.200
IP Mask	11111111.11111111.11111111.11000000	255.255.255.192
Network prefix	11000000.10101000.00000001.11000000	192.168.1.192
Host identifier	00000000.00000000.00000000.00001000	0.0.0.8

The host identifier of all zeroes is reserved for the network ID, and the host identifier of all ones is reserved for the broadcast address, so in general the number of hosts on a subnet is 2^N-2 where N is the number of bits reserved for the host portion of the address. For a 24-bit prefixed network:

Network prefix size	IP Mask	Available subnets	Usable Hosts per subnet	Total usable Hosts
24-bits	255.255.255.0	1	254	254
25-bits	255.255.255.128	2	126	252
26-bits	255.255.255.192	4	62	248
27-bits	255.255.255.224	8	30	240
28-bits	255.255.255.240	16	14	224
29-bits	255.255.255.248	32	6	192
30-bits	255.255.255.252	64	2	128
31-bits	255.255.255.254	128	2 (point-to-point)	256

Router IP Address

In computer networking a router is a node that connects two networks – such as a private network and the public Internet. The host devices on the private network send IP packets addressed to IP Addresses on the private network by resolving the destination MAC address into a destination IP Address through an Address Resolution Protocol (ARP) sequence if the MAC address is not already in the host's cache. The IP packet is then encapsulated into a physical MAC frame addressed to the destination host.

IP packets addressed outside of the private network range cannot travel directly to the destination. Instead they must be sent to the router as a gateway to the other network. In order to resolve the MAC address of the outside device the router's MAC address is used as the go-between – the outgoing packet is physically addressed to the router, and the router performs the outside network ARP to handle the physical message routing.

By definition any packet who's IP Address network prefix doesn't match the subnet network prefix of the private network needs to resolve to the MAC address of the router in order to be directed to the public network. This configuration item allows that to happen.

FTP Server Port

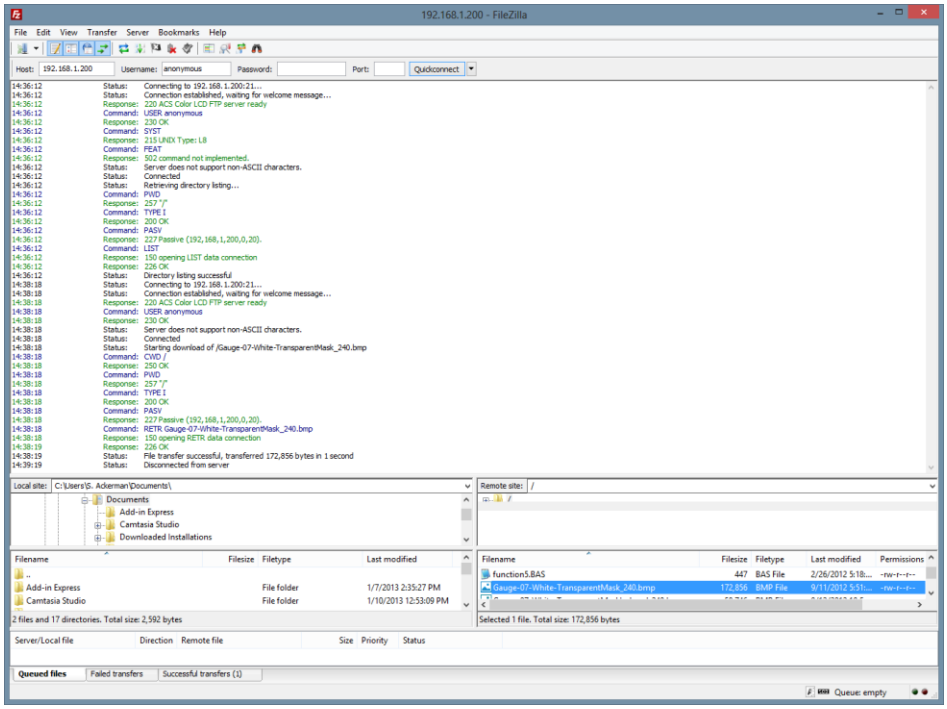
The ACS Color LCD provides a limited File Transfer Protocol (FTP) server capability. FTP is a standard internet protocol used to transfer files between network hosts. It is built on a client/server architecture and uses separate control and data connections between the client and server.

If the configured FTP Server Port is non-zero, FTP protocol control request packets will be accepted and processed. The Color LCD FTP Server responds to these requests over the control port with three-digit status codes and text in ASCII. The Color LCD FTP Server only supports Passive mode and the data port that is used is always one less than the control port. The server only supports anonymous logins with no password support.

The following FTP Commands are supported:

Command	Description	Response	Data
USER	Authentication username	230 OK	
SYST	Return system type	215 Unix Type: L8	
PWD	Print working directory	257 working directory	
TYPE	Sets the transfer mode Ascii/Binary	200 OK	
QUIT	Disconnect	221 OK	
PASV	Enter passive mode	227 Passive (IP.IP.IP.IP.port).	
SIZE	Return size of a file	502 command not implemented	
LIST NLST	Return list of files in current directory	150 opening LIST data connection 550 colorLCD file system error	*
RETR	Retrieve a copy of a file	150 opening RETR data connection 550 colorLCD file system error	*
STOR	Store a copy of a file	150 opening STOR data connection 550 colorLCD file system error	*
CWD	Change working directory	250 OK 550 colorLCD file system error	
DELE	Delete file	250 OK 550 colorLCD file system error	
MKD	Make directory	257 newDirectoryName 550 colorLCD file system error	
RMD	Remove directory	250 OK 550 colorLCD file system error	
NOOP	No operation	250 OK	
	Any other command not listed here	502 command not implemented	

Here's a sample session using the freeware FTP client FileZilla:



VNC Server Port

The ACS Color LCD provides limited Virtual Network Computing (VNC) server capability. VNC is a graphical desktop sharing system that uses the Remote Frame Buffer (RFB) protocol to remotely control another computer. It transmits the keyboard and mouse events from the client to the server, relaying the graphical screen updates from the server back to the client over a network connection.

If the configured VNC Server Port is non-zero, RFB protocol messages will be exchanged over that port to establish and update a VNC session between VNC client software on a PC and the Color LCD acting as a VNC server.

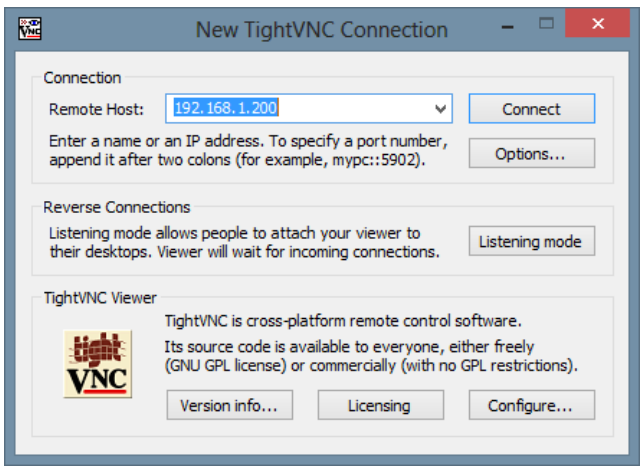
No passwords or authentication are supported. The server reported protocol is RFB 003.003.

Supported graphical update formats are 16-bit R5G6B5 or 32-bit R8G8B8A8. This is negotiated during the connection phase.

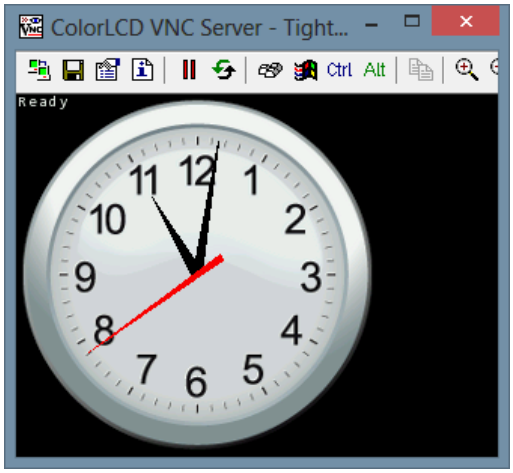
Received mouse events are translated are translated to touchscreen events; Press, Move, Release.

Received keyboard events for keys that have an ASCII code equivalent including Backspace, Tab, Escape and Enter are processed upon key down only – key up and all other keys are ignored.

Here's an example using Tight VNC to connect to the Color LCD:



Setup connection



Connected

HTTP Server Port

The ACS Color LCD has the ability to serve HTML pages from the micro SD card. If the configured HTTP Server Port is non-zero then HTTP GET requests for SD card resident files will retrieve the file contents.

The server only responds to HTTP GET requests. The file path should immediately follow the IP Address:

GET /pathToFile

If the GET is followed by a slash/space "/ " with no filename, an attempt is made to return the file "index.html" off of the card.

If the requested file is found and opens OK on the micro SD card a 200 response is returned:

HTTP/1.0 200 OK
Server: uIP/1.0 http://www.sics.se/~adam/uip/
Connection: close

This is immediately followed by a content type header determined by the requested file's extension:

File extension	Returned Header
no extension	Content-type: application/octet-stream
.html	Content-type: text/html
.css	Content-type: text/css
.png	Content-type: image/png
.gif	Content-type: image/gif
.jpg	Content-type: image/jpeg
.bmp	Content-type: image/x-ms-bmp
any other extension	Content-type: text/plain

The content type header is followed by an empty line, then the requested file's contents.

If the requested file doesn't exist or can't be opened on the micro SD card a 404 response is returned:

HTTP/1.0 404 Not found
Server: uIP/1.0 http://www.sics.se/~adam/uip/
Connection: close

This is immediately followed by the contents of file 404.html if it exists on the card.

TCP/IP Raw Port

The ACS Color LCD has the ability to send and receive its serial data stream using TCP/IP raw sockets. Normally network traffic between two ports is encapsulated using an agreed upon protocol which may include message headers and other information required by the application. With raw sockets the data is sent / received un-encapsulated with no accompanying headers or other information.

If the configured TCP/IP Raw Port is non-zero a remote connection to that port allows the remote end to send data and received data to and from the Color LCD as if over the conventional serial port.

NTP Server

The ACS Color LCD has the ability to synchronize its Real Time Clock (RTC) from a remote time server using the Network Time Protocol (NTP). NTP is a networking protocol for clock synchronization between computer systems over packet-switched, variable latency data networks.

There are published lists of NTP time servers, and the selected server should be geographically close. If at all possible the use of a local NTP server on the private network is strongly recommended to avoid overloading the public time servers. Windows XP for example can be configured to act as a NTP server.

The use of a remote time server external to the private network requires a correctly configured Router IP Address in order to perform the ARP for the requisite outgoing UDP packets.

NTP Client Port

If the configured NTP Client Port is non-zero and the NTP Server address is correctly addressing an IP Address hosting a NTP Server the Color LCD will attempt to sync its Real Time Clock to the time server after reset or power-up. No direct indication of successful synchronization is provided, however the RTC defaults to Tuesday, January 1, 2013, 12:00AM after reset or power-up.

Local Timezone

By definition, NTP servers provide Coordinated Universal Time (UTC). In order to compute the correct time the local time zone (offset hours from UTC) must be configured. For example; Eastern Standard Time is -5 hours from UTC.

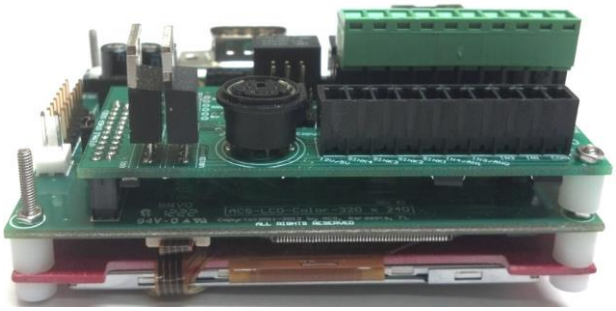
Daylight Savings

In addition to the time zone offset from UTC correct local time requires knowledge of whether the location of the Color LCD is currently experiencing Daylight Savings time. Setting this configuration item to Yes adds one hour to the computed local time.

IO Expansion

The ACS Color 320x240 LCD Display Terminal has an expansion connector that supports an optional I/O expansion module – the ACS-COLOR-LCD-PS2-IO. This module provides 4 relay outputs, 4 optoisolated contact inputs and a PS/2 keyboard connector.

The expansion module installs on the back of the display, plugging onto the EXP connector and secured with a corner mounting fastener and spacer. Circuitry on the module requires the display to be powered from a 12-15VDC source supplied via the SERIAL connector or by the optional Power Over Ethernet – USB powered operation is not possible.



There are three user connectors on the expansion module; PS2, IO and RLYS.

The PS2 connector is a 6-pin DIN connector that allows a standard IBM PC/AT keyboard to be connected to the display. Characters typed on the attached keyboard are entered as if they arrived over the serial port or via the on-screen pop-up keypad. The PS2 connector pin out:

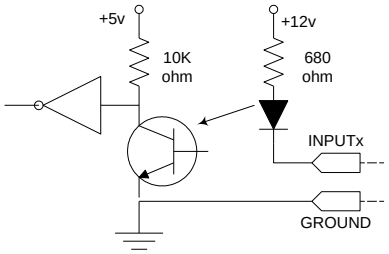
PS2 Pin #	Signal
1	Data
2	n/c
3	Ground
4	+5VDC
5	Clock
6	n/c

The IO connector is a 10-pin two piece terminal block style connector that allows access to the optoisolated input contact inputs and to the current sink relay drivers. These contact inputs may be polled by ACS Basic commands. The IO connector pin out:

IO Pin #	Signal
1	Ground
2	IN1
3	IN2
4	IN3
5	IN4
6	OUT1 sink output
7	OUT2 sink output
8	OUT3 sink output
9	OUT4 sink output
10	+5VDC / +12VDC fused

Switch contacts are wired between the Input pin number and a ground located on pin 1 of the connector. The inputs are optically isolated using optocouplers. The cathodes of the LEDs in the optocouplers are connected to the INx connector port pins. The Anodes of the LEDs in the optocouplers are connected to an

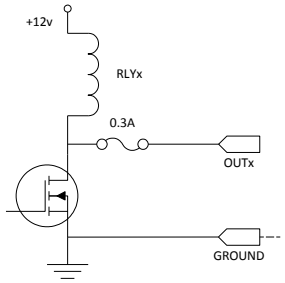
internal 12VDC power supply, with a 680 ohm current limiting resistor in series. The output transistor of each optocoupler has a 10K pullup resistor on its collector, with the emitter connected to ground and is buffered by an inverting gate. The following diagram is representative of one input:



An input is activated by sinking current from the corresponding input pin to ground. A Ground connection is supplied on pins 1 and 10 of each Input connector for this purpose. The input current sink requirement is approximately 15 mA.

Switches may be one of two forms: Normally Open (N.O.) or Normally Closed (N.C.). Switches that are Normally Open have no electrical connection between the switch terminals unless the switch is activated closed. Switches that are Normally Closed have an electrical connection between the switch terminals unless the switch is activated open.

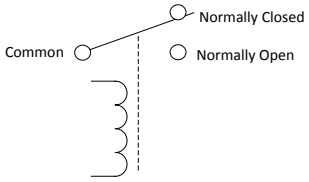
The OUTx current sink relay drivers are the MOSFET transistors used to activate the relay coils. Each output is fused at 300mA. The following diagram is representative of one current sink output:



The RLYS connector is a 10-pin two piece terminal block style connector that allows access to the contacts of the four output contact relays on the expansion module. These contact outputs may be controlled by ACS Basic commands. The RLYS connector pin out:

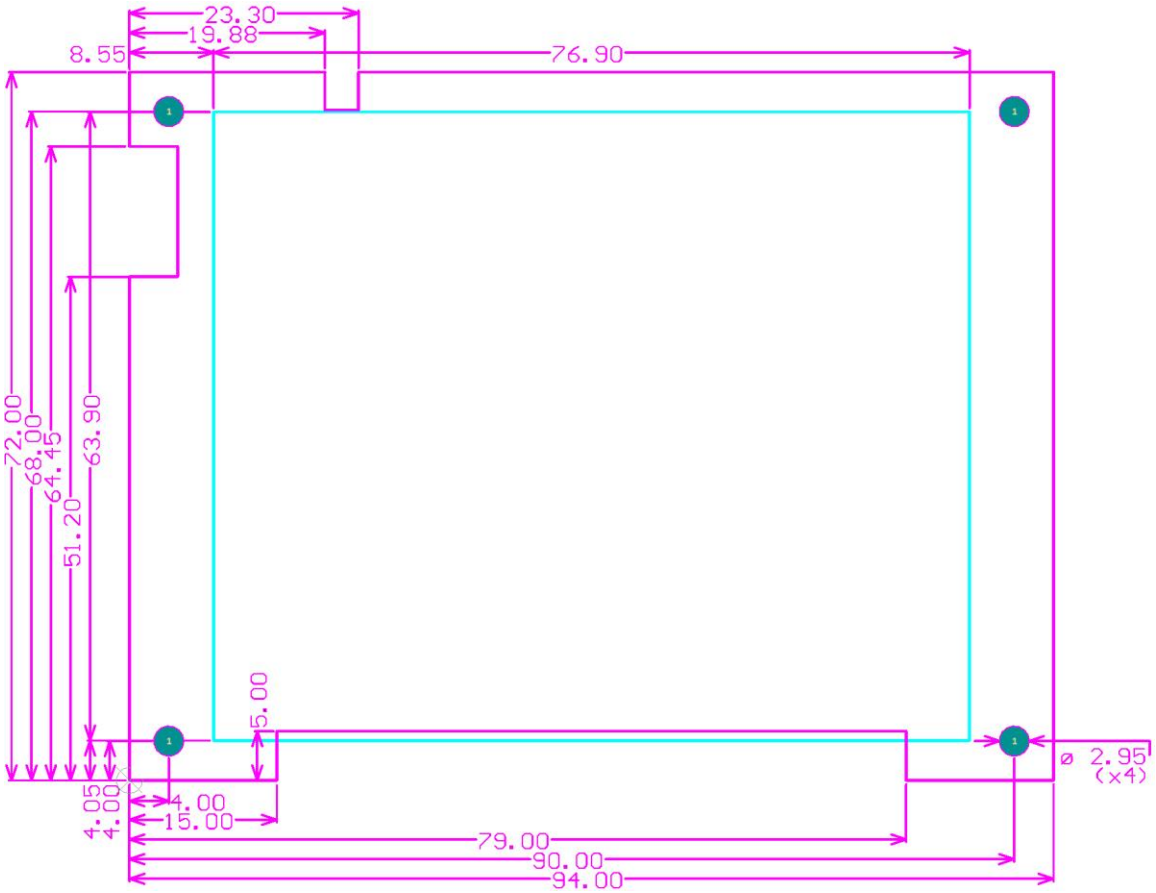
RLYS Pin #	Signal
1	OUT1 Normally Open
2	OUT1 Common
3	OUT2 Normally Open
4	OUT2 Common
5	OUT3 Normally Open
6	OUT3 Common
7	OUT3 Normally Closed
8	OUT4 Normally Open
9	OUT4 Common
10	OUT4 Normally Closed

The relay contacts are shown schematically as:



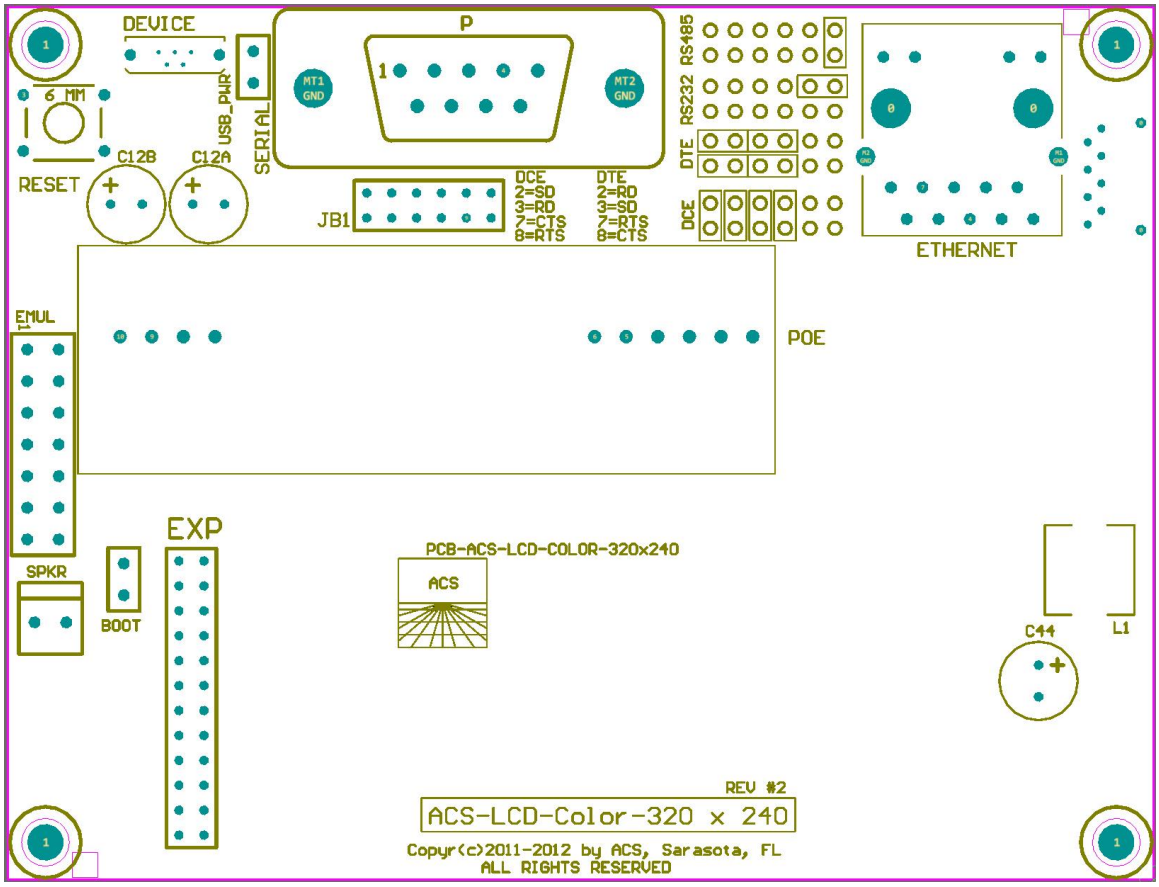
Appendices

Mechanical Mounting Diagram



Dimensions in millimeters

Board Legend



Wiring Harness Diagram

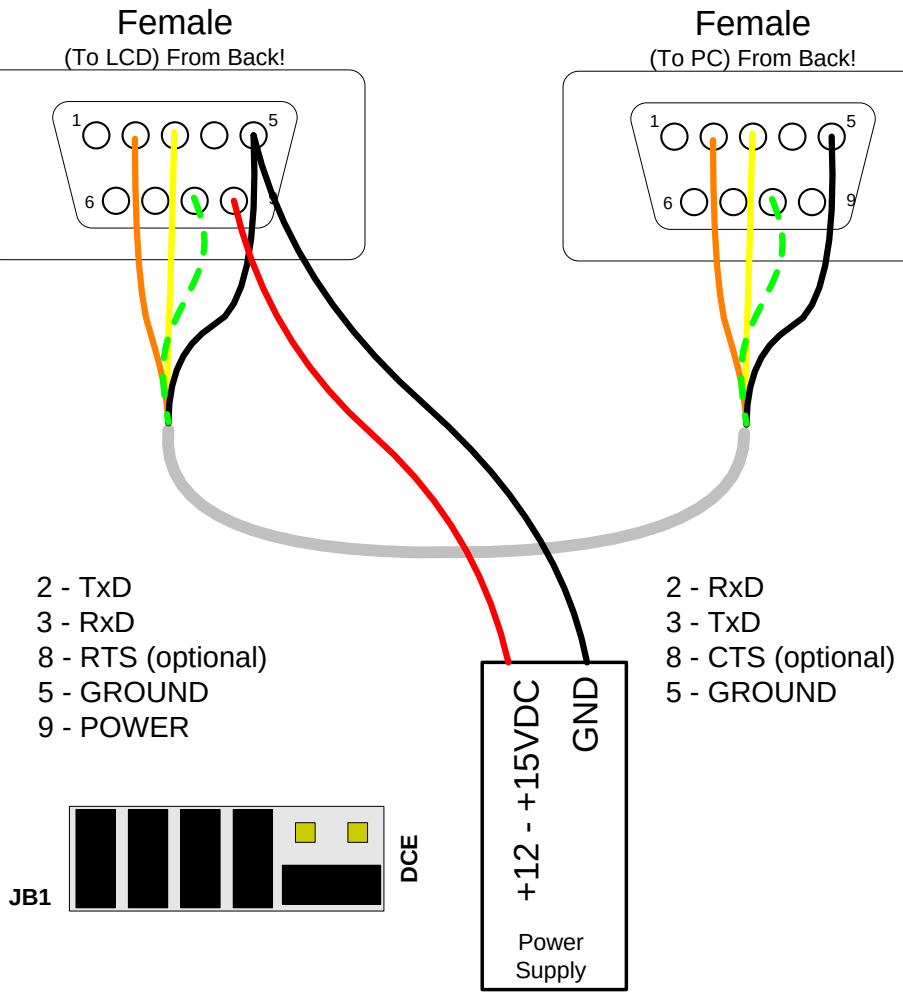
RS-232 Connection to PC

The PC is configured as a DTE device. A one-to-one, female DB-9S to DB-9S cable can be used to connect the PC communication port to the Color LCD SERIAL connector when the Color LCD is configured as DCE. Only four wired connections are required.

The RTS connection is for optional flow control of the transmit data to the display to prevent over-flowing the display input buffer at higher baud rates. It requires disabling the RS-485 enable in the display configuration and implementation of flow control on the host device supplying the data to the display.

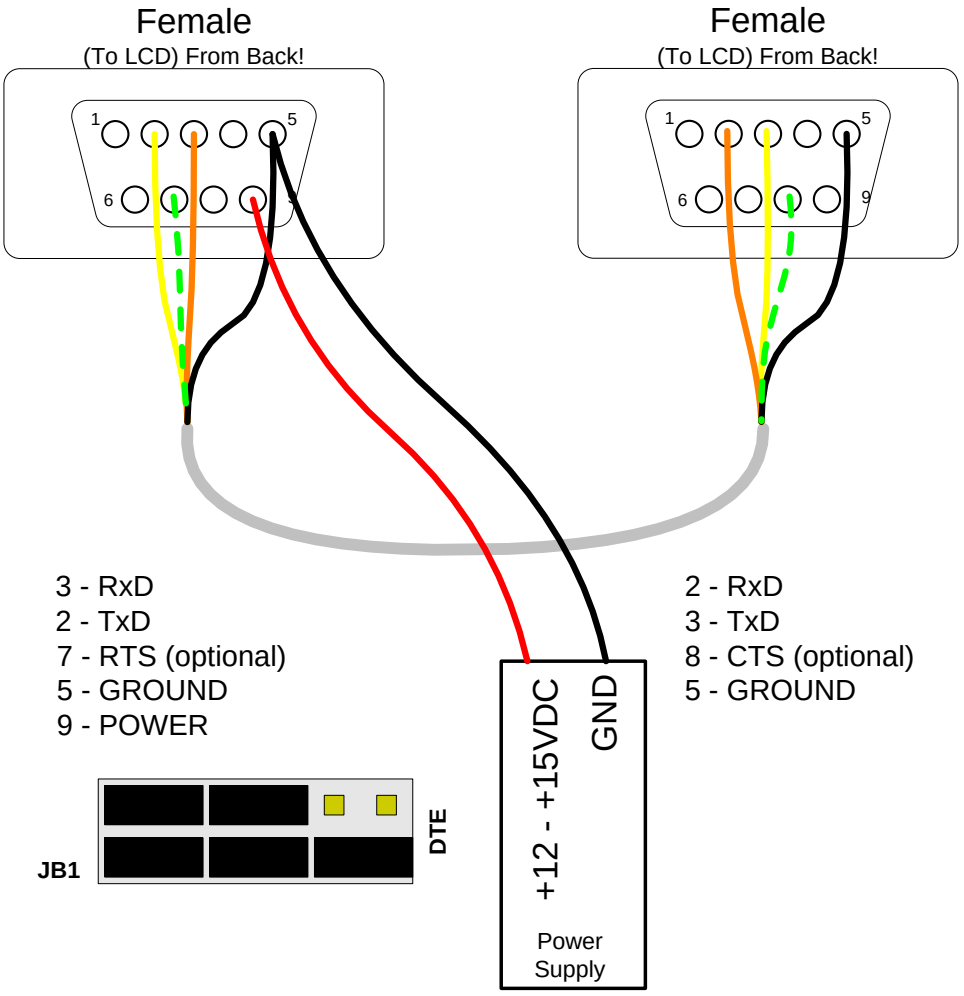
RS-232 LCD (JB1 jumpered as DCE) to PC (DTE)

The Color LCD can be connected with a one-to-one cable between the display and host PC when JB1 is configured for DCE:



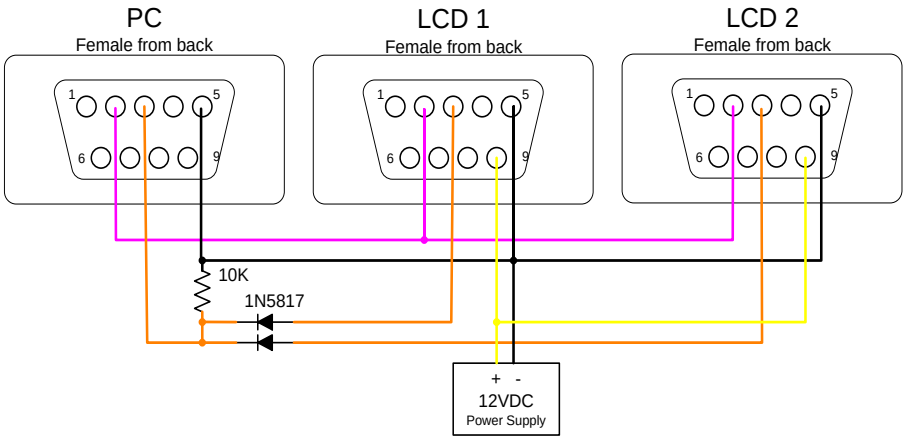
RS-232 LCD (JB1 jumpered as DTE) to PC (DTE)

The Color LCD can be connected with a null modem cable (or one-to-one cable with null modem adaptor) between the display and host PC when JB1 is configured for DCE:



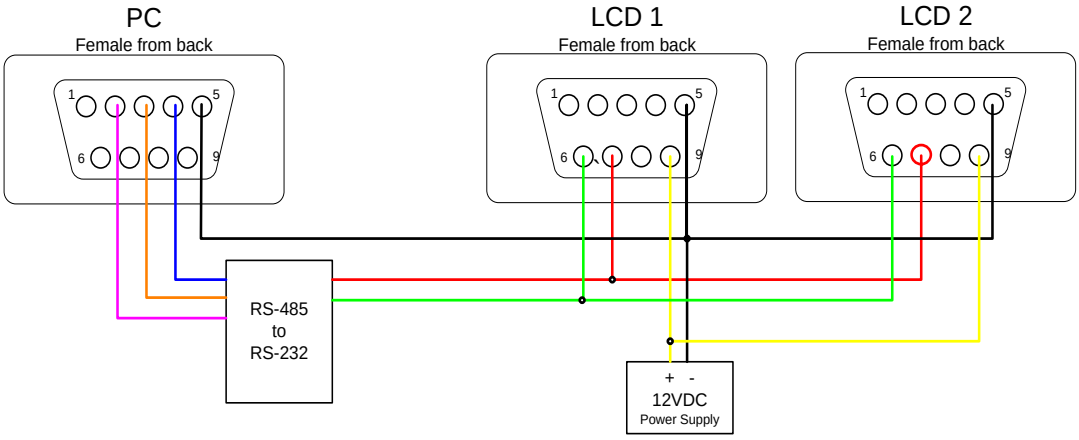
Multiple Display Wiring (RS-232)

Multiple displays can be connected via RS-232 by wiring the transmit data lines to the LCDs together, and 'OR'ing the receive data lines from the LCDs using low voltage drop Schottky diodes and a resistor to ground. Data to be displayed may be directed to the required display by configuring the display's **`Display Comm Addr`** and using the addressed communications outlined in the **Display Addressing** section above.



Multiple Display Wiring (RS-485)

Multiple displays can be connected via RS-485 by wiring the A+ and B- data lines to the LCDs together. RS-485 operation is enabled by configuring the RS-485 Enable in the settings. Received data may be polled by configuring the **`Switches Polled`** in the settings. Data to be displayed may be directed to the required display by configuring the display's **`Display Comm Addr`** and using the addressed communications outlined in the **Display Addressing** section above.



Displayed Characters

US ASCII

Values (ASCII 32 decimal / 20 hex through ASCII 127 decimal / 7F hex). The following characters are displayed:

	Upper Bits					
Lower Bits	**0010**	**0011**	**0100**	**0101**	**0110**	**0111**
0000	space	0	@	P	`	p
0001	!	1	A	Q	a	q
0010	"	2	B	R	b	r
0011	#	3	C	S	c	s
0100	$	4	D	T	d	t
0101	%	5	E	U	e	u
0110	&	6	F	V	f	v
0111	'	7	G	W	g	w
1000	(	8	H	X	h	x
1001	)	9	I	Y	i	y
1010	*	:	J	Z	j	z
1011	+	;	K	[	k	{
1100	,	<	L	\	l	|
1101	-	=	M	]	m	}
1110	.	>	N	^	n	~
1111	/	?	O	_	o	

UTF-8 Extended Characters

In addition to the US ASCII characters, the UTF-8 DOS Extended Character Set is supported. To display these extended characters a multi-byte encoding sequence is required:

# of Bits	Last Code	Byte 1	Byte 2	Byte 3	Byte 4
7	U+7F	0xxxxxxx			
11	U+7FF	110xxxxx	10xxxxxx		
16	U+FFFF	1110xxxx	10xxxxxx	10xxxxxx	
21	U+1FFFF	11110xxx	10xxxxxx	10xxxxxx	10xxxxxx

1. One byte codes are used only for the ASCII values 0 through 127. The UTF-8 code has the same value as the ASCII code.

2. Codes larger than 127 are displayed by multi-byte sequences, composed of a leading byte and one or more continuation bytes. The leading byte has two or more high-order '1's while the continuation bytes all have '10' in the high order position.

3. The number of '1's in the high-order position of the leading byte indicates the number of bytes in the sequence so the length of the sequence can be determined without examining the continuation bytes.

4. Single bytes, leading bytes and continuation bytes do not share any common values. This makes the sequence self-synchronizing, allowing the start of a character to be found by backing up at the most three bytes.

The first 128 characters (US-ASCII) need only one byte. The next 1,920 characters need two bytes to encode and the next 2,048 need three bytes.

The following extended characters are encoded in the default fonts. The displayed character is shown at the top, followed by the UTF-8 hexadecimal code, followed by the two or three hexadecimal byte sequence required to display that character:

Ç U+00C7 C3 87	ü U+00FC C3 BC	é U+00E9 C3 A9	â U+00E2 C3 A2	ä U+00E4 C3 A4	à U+00E0 C3 A0	å U+00E5 C3 A5	ç U+00E7 C3 A7
ê U+00EA C3 AA	ë U+00EB C3 AB	è U+00E8 C3 A8	ï U+00EF C3 AF	î U+00EE C3 AE	ì U+00EC C3 AC	Ä U+00C4 C3 84	Å U+00C5 C3 85
É U+00C9 C3 89	æ U+00E6 C3 A6	Æ U+00C6 C3 86	ô U+00F4 C3 B4	ö U+00F6 C3 B6	ò U+00F2 C3 B2	û U+00FB C3 BB	ù U+00F9 C3 B9
ÿ U+00FF C3 BF	Ö U+00D6 C3 96	Ü U+00DC C3 9C	¢ U+00A2 C2 A2	£ U+00A3 C2 A3	¥ U+00A5 C2 A5	₧ U+20A7 E2 82 A7	ƒ U+0192 C6 92
á U+00E1 C3 A1	í U+00ED C3 AD	ó U+00F3 C3 B3	ú U+00FA C3 BA	ñ U+00F1 C3 B1	Ñ U+00D1 C3 91	ª U+00AA C2 AA	º U+00BA C2 BA
¿ U+00BF C2 BF	⌐ U+2310 E2 8C 90	¬ U+00AC C2 AC	½ U+00BD C2 BD	¼ U+00BC C2 BC	¡ U+00A1 C2 A1	« U+00AB C2 AB	» U+00BB C2 BB
⣿ U+2591 E2 96 91	▒ U+2592 E2 96 92	▓ U+2593 E2 96 93	│ U+2502 E2 94 82	┤ U+2524 E2 94 A4	╡ U+2561 E2 95 A1	╢ U+2562 E2 95 A2	╖ U+2556 E2 95 96
╕ U+2555 E2 95 95	╣ U+2563 E2 95 A3	║ U+2551 E2 95 91	╗ U+2557 E2 95 97	╝ U+255D E2 95 9D	╜ U+255C E2 95 9C	╛ U+255B E2 95 9B	┐ U+2510 E2 94 90
└ U+2514 E2 94 94	┴ U+2534 E2 94 B4	┬ U+252C E2 94 AC	├ U+251C E2 94 9C	─ U+2500 E2 94 80	┼ U+253C E2 94 BC	╞ U+255E E2 95 9E	╟ U+255F E2 95 9F
╚ U+255A E2 95 9A	╔ U+2554 E2 95 94	╩ U+2569 E2 95 A9	╦ U+2566 E2 95 A6	╠ U+2560 E2 95 A0	═ U+2550 E2 95 90	╬ U+256C E2 95 AC	╧ U+2567 E2 95 A7
╨ U+2564 E2 95 A4	╤ U+2565 E2 95 A5	╙ U+2559 E2 95 99	╘ U+2558 E2 95 98	╒ U+2552 E2 95 92	╓ U+2553 E2 95 93	╫ U+256B E2 95 AB	╪ U+256A E2 95 AA
┘ U+2518 E2 94 98	┌ U+250C E2 94 8C	▉ U+2588 E2 96 88	▄ U+2584 E2 96 84	▌ U+258C E2 96 8C	▐ U+2590 E2 96 90	▀ U+2580 E2 96 80	α U+03B1 C3 B1
ß U+00DF C3 9F	Γ U+0393 CE 93	π U+03C0 CF 80	Σ U+03A3 CE A3	σ U+03C3 CF 83	µ U+00B5 C2 B5	τ U+03C4 CF 84	Φ U+03A6 CE A6
Θ U+0398	Ω U+03A9	δ U+03B4	∞ U+221E	φ U+03C6	ϵ U+03B5	∩ U+2229	≡ U+2261

CE 98	CE A9	CE B4	E2 88 9E	CF 86	CE B5	E2 88 A9	E2 89 A1
±	≥	≤	⌠	⌡	÷	≈	°
U+00B1	U+2265	U+2264	U+2320	U+2321	U+00F7	U+2248	U+00B0
C2 B1	E2 89 A5	E2 89 A4	E2 8C A0	E2 8C A1	C3 B7	E2 89 88	C2 B0
·	√	ⁿ	²	■	←	↑	→
U+00B7	U+221A	U+207F	U+00B2	U+25A0	U+2190	U+2191	U+2192
C2 B7	E2 88 9A	E2 81 BF	C2 B2	E2 96 A0	E2 86 90	E2 86 91	E2 86 92
↓							
U+2193							
E2 86 93							

ASCII Table

Dec	Hex	Octal	Character
Non-displaying control characters			
0	00	000	NUL (null)
1	01	001	SOH (start of heading)
2	02	002	STX (start of text)
3	03	003	ETX (end of text)
4	04	004	EOT (end of transmission)
5	05	005	ENQ (enquiry)
6	06	006	ACK (acknowledge)
7	07	007	BEL (bell)
8	08	010	BS (backspace)
9	09	011	TAB (horizontal tab)
10	0A	012	LF (line feed, new line)
11	0B	013	VT (vertical tab)
12	0C	014	FF (form feed, new page)
13	0D	015	CR (carriage return)
14	0E	016	SO (shift out)
15	0F	017	SI (shift in)
16	10	020	DLE (data link escape)
17	11	021	DC1 (device control 1)
18	12	022	DC2 (device control 2)
19	13	023	DC3 (device control 3)
20	14	024	DC4 (device control 4)
21	15	025	NAK (negative acknowledge)
22	16	026	SYN (synchronous idle)
23	17	027	ETB (end trans. block)
24	18	030	CAN (cancel)
25	19	031	EM (end of medium)
26	1A	032	SUB (substitute)
27	1B	033	ESC (escape)
28	1C	034	FS (file separator)
29	1D	035	GS (group separator)
30	1E	036	RS (record separator)
31	1F	037	US (unit separator)
Displaying characters			
32	20	040	Space
33	21	041	!
34	22	042	"
35	23	043	#
36	24	044	$
37	25	045	%
38	26	046	&
39	27	047	'
40	28	050	(
41	29	051	)
42	2A	052	*
43	2B	053	+
44	2C	054	,
45	2D	055	-
46	2E	056	.
47	2F	057	/
48	30	060	0
49	31	061	1
50	32	062	2
51	33	063	3
52	34	064	4
53	35	065	5
54	36	066	6

55	37	067	7
56	38	070	8
57	39	071	9
58	3A	072	:
59	3B	073	;
60	3C	074	<
61	3D	075	=
62	3E	076	>
63	3F	077	?
64	40	100	@
65	41	101	A
66	42	102	B
67	43	103	C
68	44	104	D
69	45	105	E
70	46	106	F
71	47	107	G
72	48	110	H
73	49	111	I
74	4A	112	J
75	4B	113	K
76	4C	114	L
77	4D	115	M
78	4E	116	N
79	4F	117	O
80	50	120	P
81	51	121	Q
82	52	122	R
83	53	123	S
84	54	124	T
85	55	125	U
86	56	126	V
87	57	127	W
88	58	130	X
89	59	131	Y
90	5A	132	Z
91	5B	133	[
92	5C	134	\
93	5D	135	]
94	5E	136	^
95	5F	137	_
96	60	140	`
97	61	141	a
98	62	142	b
99	63	143	c
100	64	144	d
101	65	145	e
102	66	146	f
103	67	147	g
104	68	150	h
105	69	151	i
106	6A	152	j
107	6B	153	k
108	6C	154	l
109	6D	155	m
110	6E	156	n
111	6F	157	o
112	70	160	p
113	71	161	q
114	72	162	r

115	73	163	s
116	74	164	t
117	75	165	u
118	76	166	v
119	77	167	w
120	78	170	x
121	79	171	y
122	7A	172	z
123	7B	173	{
124	7C	174	|
125	7D	175	}
126	7E	176	~
127	7F	177	

JSON File Formats

The information in the Fonts, Schemes and Screens tables can be loaded or saved, from or to text files in JSON format.

JSON is the abbreviation for JavaScript Object Notation. It is a text-based, open standard for human-readable data interchange. More information about JSON is available at: http://www.json.org/ .

The basic JSON data types are:

Data Type	Description
Number	32-bit Integer
String	Double-quoted UTF-8 characters with backslash escaping
Boolean	true or false
Array	An ordered sequence of values, comma-separated and enclosed in square brackets
Object	An unordered collection of "Key" : Value pairs, comma-separated and enclosed in curly braces; with the ':' character separating the key and the value. The Keys must be strings and should be distinct within the Object.
Null	Empty

Non-significant white space may be added freely around the "structural characters" consisting of square brackets, curly braces, colons and commas.

Fonts JSON Format

The Fonts JSON format consists of an Array [ ] containing 32 Font Objects { }. Each Font Object contains the information about a single font table entry as a collection of "Key" : Value pairs:

```
[
    {
        "FontNumber":  0,
        "Name": "AcsDefaultFont.efnt",
        "BgndColor":   0,
        "FgndColor":   8421504,
        "SpacingX":0,
        "SpacingY":0,
        "HAlign":  1,
        "VAlign":  1,
        "BgndTransp":  1,
        "FgndTransp":  0
    }, {
        "FontNumber":  1,
        "Name": "AcsDefaultFont.efnt",
        "BgndColor":   0,
        "FgndColor":   16777215,
        "SpacingX":0,
        "SpacingY":0,
        "HAlign":  1,
        "VAlign":  1,
        "BgndTransp":  1,
        "FgndTransp":  0
    }, {
        "FontNumber":  2,
        "Name": "AcsDefaultFont.efnt",
        "BgndColor":   0,
        "FgndColor":   8421504,
        "SpacingX":0,
        "SpacingY":0,
        "HAlign":  1,
        "VAlign":  1,
        "BgndTransp":  1,
        "FgndTransp":  0
    },
    ...

    {
        "FontNumber":  30,
        "Name": "AcsDefaultFont.efnt",
        "BgndColor":   0,
        "FgndColor":   16777215,
        "SpacingX":0,
        "SpacingY":0,
        "HAlign":  1,
        "VAlign":  1,
        "BgndTransp":  1,
        "FgndTransp":  0
    }, {
        "FontNumber":  31,
        "Name": "AcsDefaultFont.efnt",
        "BgndColor":   0,
        "FgndColor":   0,
        "SpacingX":0,
        "SpacingY":0,
        "HAlign":  1,
        "VAlign":  1,
        "BgndTransp":  1,
        "FgndTransp":  0
    }
]
```


Schemes JSON Format

The Schemes JSON format consists of an Array [ ] containing 16 Scheme Objects { }. Each Scheme Object contains the information about a single scheme table entry as a collection of "Key" : Value pairs:

```
[
    {
        "SchemeNumber":    0,
        "BlkReplColor":    0,
        "WhtReplColor":    10485760,
        "FontNumber":  0,
        "Colorize":1,
        "TextPos": 1,
        "IconTransp":  0
    }, {
        "SchemeNumber":    1,
        "BlkReplColor":    0,
        "WhtReplColor":    16711680,
        "FontNumber":  1,
        "Colorize":1,
        "TextPos": 1,
        "IconTransp":  0
    }, {
        "SchemeNumber":    2,
        "BlkReplColor":    0,
        "WhtReplColor":    40960,
        "FontNumber":  2,
        "Colorize":1,
        "TextPos": 1,
        "IconTransp":  0
    },
    ...
        {
            "SchemeNumber":    14,
            "BlkReplColor":    8421504,
            "WhtReplColor":    0,
            "FontNumber":  14,
            "Colorize":2,
            "TextPos": 1,
            "IconTransp":  1
        }, {
            "SchemeNumber":    15,
            "BlkReplColor":    0,
            "WhtReplColor":    0,
            "FontNumber":  15,
            "Colorize":0,
            "TextPos": 1,
            "IconTransp":  1
        }
]
```


Screens JSON Format

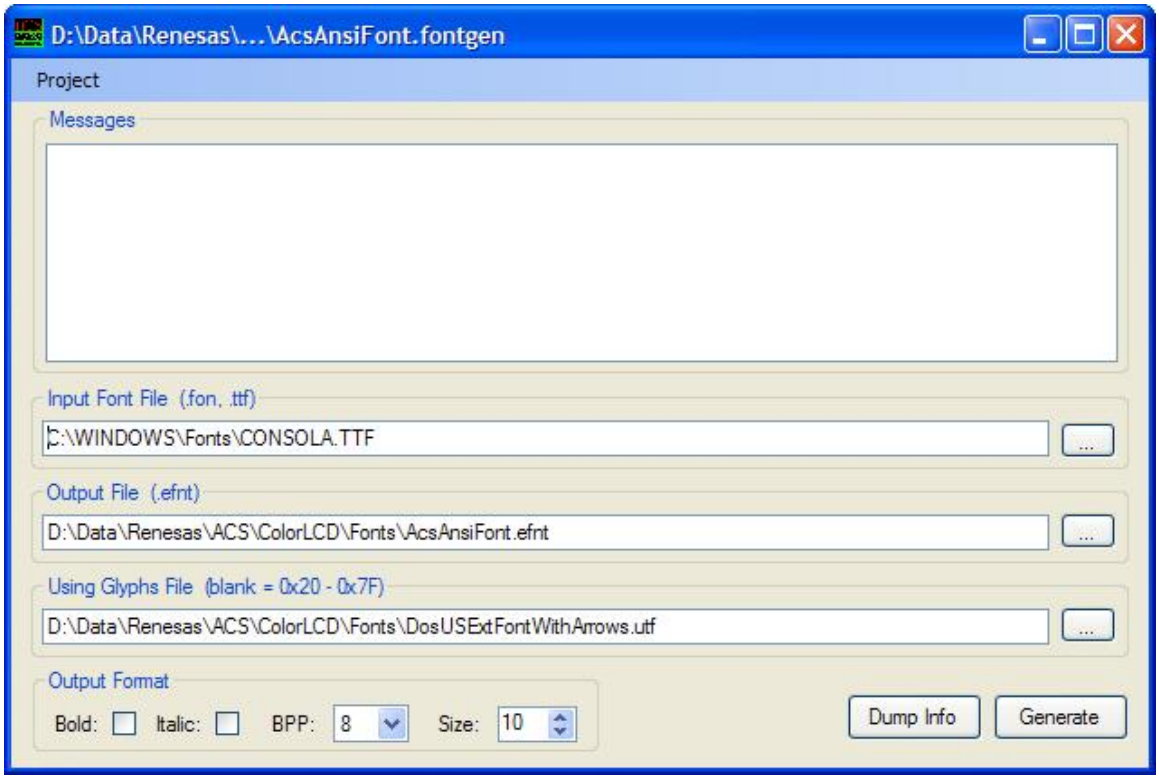
The Screens JSON format consists of an Array [ ] containing 16 Screen Objects { }. Each Screen Object contains the information about a single screen table entry as a collection of "Key" : value pairs.

One of "Key" : value pairs is also an Array [ ] of ScreenObject Objects { }. Each ScreenObject Object contains the information about a single screen table screen object entry as a collection of "Key" : Value pairs:

```
[
    {
        "ScreenNumber":    0,
        "Image":    "Background_HomeScreenWithACSLogo.bmp",
        "PosX": 0,
        "PosY": 0,
        "ScreenObjects":
        [
            {
                "ObjectNumber":    0,
                "Type": 2,
                "Image":    "ButtonK4.bmp",
                "OverlayImage":    "ButtonK4.bmp",
                "SchemeNumber":    4,
                "Text": "Pop Up",
                "PosX": 116,
                "PosY": 70,
                "EventMask":   4,
                "Options": [25, 0, 0, 0, 0, 0, 0, 0, 0, 0]
            }, {
                "ObjectNumber":    1,
                "Type": 0,
                "Image":    "",
                "OverlayImage":    "",
                "SchemeNumber":    0,
                "Text": "",
                "PosX": 0,
                "PosY": 0,
                "EventMask":   0,
                "Options": [0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
            },

    …
            {
                "ObjectNumber":    31,
                "Type": 0,
                "Image":    "",
                "OverlayImage":    "",
                "SchemeNumber":    0,
                "Text": "",
                "PosX": 0,
                "PosY": 0,
                "EventMask":   0,
                "Options": [0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
            }
        ]
    },

    …
    {
        "ScreenNumber":    15,
        "Image":    "PopUp_160x120.bmp",
        "PosX": 80,
        "PosY": 60,
        "ScreenObjects":
        [

            …
        ]
    }
]
```


Embedded Font Generation

The font resources used to display text on the display are generated from True-Type fonts using two DOS utilities based upon Free Type 2. The ACS ColorLcdFontGenerator.exe utility provides a .NET project-based front end for these two utilities to generate the .EFNT embedded font resource files used by the ACS Color LCD 320x240 display.



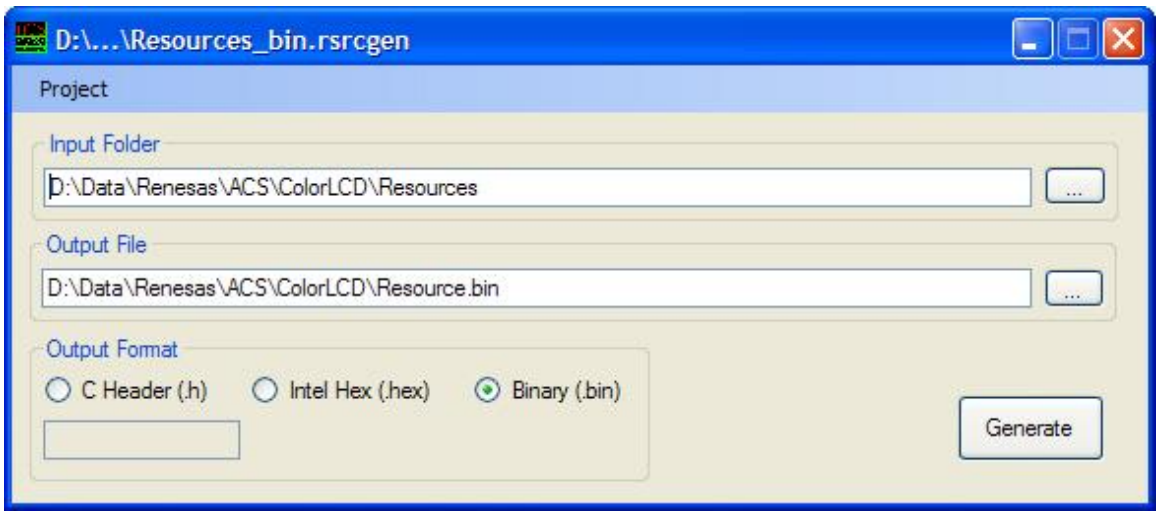
1. The input True Type Font file (.TTF) is selected using the browse (…) button.
2. Next the Output Embedded Font file (.EFNT) is selected using its browse (…) button.
3. The optional Using Glyphs file (.UTF) is selected using its browse (…) button. Leaving this textbox blank will result in only the glyphs for characters 0x20 (space) through 0x7F (del) being converted to the output file.
4. Next the output format style, resolution and height are selected.
5. Pressing the Generate button actually produces the .EFNT output file with the parameters that you have entered. The progress is displayed in the Messages area.

A Project menu provides commands to Load and Save font generator project files (.FONTGEN) for future reference and re-use.

The Dump Info button shows information about the embedded font file including the font family and what glyphs are present.

Resource File Generation

The embedded fonts, bitmaps and other files used to operate the ACS Color LCD 320x240 are loaded into a table in the display's memory for operation. The contents of this resource table are generated using a .NET project-based utility.



1. The input folder containing all of the resources targeted for the table is selected using the browse (…) button.
2. Next the output file is selected using its browse (…) button.
3. The output file format is selected.
4. Pressing the Generate button produces the output file containing all of the files in the input folder structured into the resource table format in the selected output file format. A message box is displayed when this is completed.

A Project menu provides commands to Load and Save resource generator project files (.RSRCGEN) for future reference and re-use.

Updating the Color LCD 320x240 firmware

Updating the Color LCD display firmware requires installation of a programming utility on a host PC that has a USB connection. The display is connected to and powered by the PC via a USB A to Micro B cable. The programming utility detects the presence of the Color LCD and sends commands to erase and reprogram its flash memory with the new firmware.

1) Obtain the Renesas Flash Development Toolkit (FDT) and install it on the host PC that you will be using to update the firmware. A version of this tool is available in the Software section of the ACS Color LCD website.

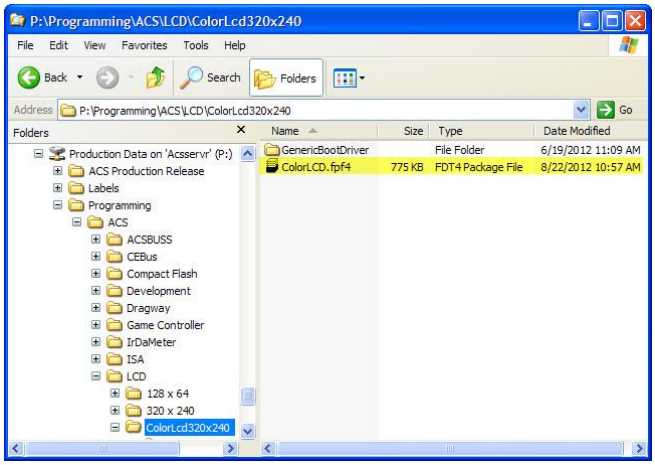
2) Download and save the desired firmware version from the ACS website into a folder on your PC.

3) Disconnect the Color LCD from any Serial, USB or Ethernet connections.

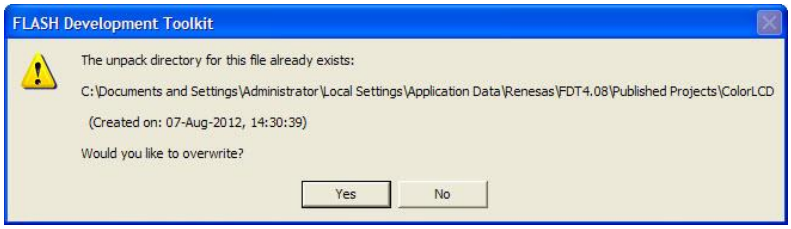
4) Install the USB_PWR and BOOT jumpers on the Color LCD:

WARNING: Do not install the USB_POWER jumper if powering the display through the SERIAL connector or external Ethernet power injection module. High voltage will be injected back through your USB cable to the host computer.

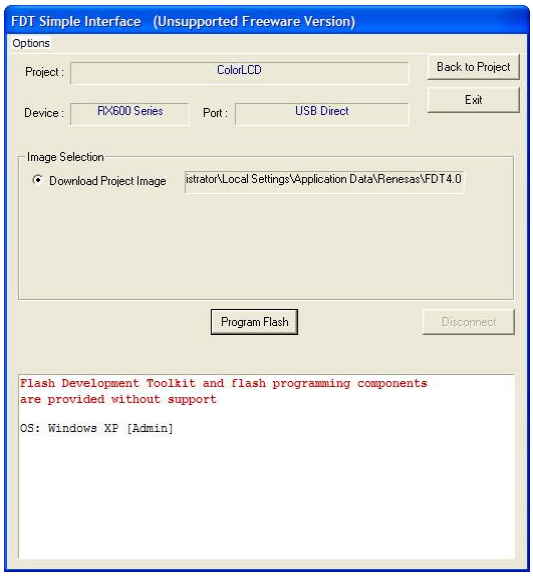
5) Double-click on the downloaded firmware ColorLCD.fpf4 file to open it in the FDT utility:



6) If you have already updated once on this machine you will get a message box asking for permission to overwrite – click Yes:



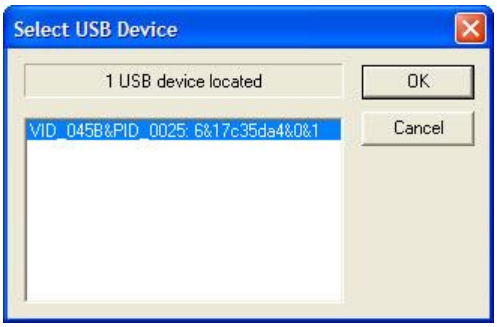
7) The main FDT program dialog should appear showing the project as ColorLCD:



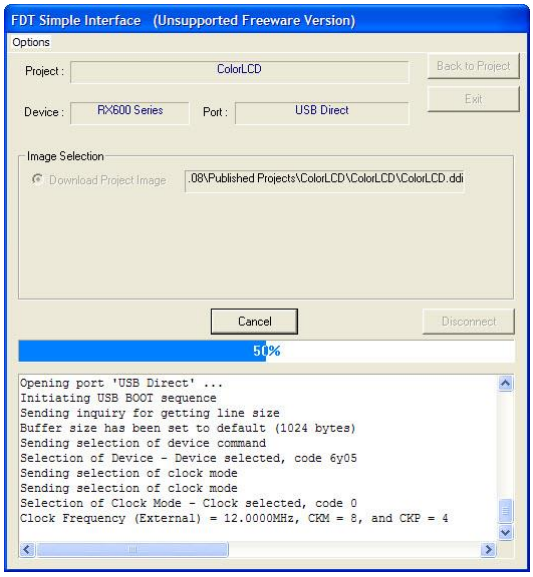
8) Use a USB A to Micro B cable to connect the Color LCD to the host PC:

9) Start the programming by pushing the FDT **Program Flash** button.

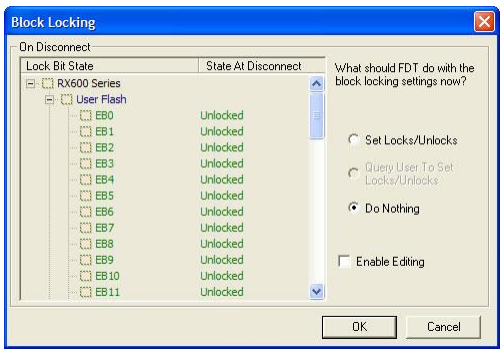
10) Select the USB device to be programmed – the VID should be 045B and the PID 0025:



11) Programming should begin:



12) When programming is complete a block locking dialog should appear. Select Do Nothing then click OK:



13) If there have been no errors, then programming is complete. Disconnect the Color LCD from the host PC

14) Remove the USB_PWR and BOOT jumpers.

WARNING: Do not install the USB_POWER jumper if powering the display through the SERIAL connector or external Ethernet power injection module. High voltage will be injected back through your USB cable to the host computer.

Firmware Revisions

Version	Date	Notes
1.0	Nov-15-2012	First release for new 320x240 display hardware.
1.1	Nov-27-2012	• Changes to trace path to correct detection of sfn/lfn combo, was failing on lfn(s) with only the last character different. • Upgrade ACS Basic to v2.1. • Added Label control width override options.
1.2	Dec-17-2012	• Fixed intermittent Raw received data. • Added control refresh to icon controls when .SCHEME property is set. • Fixed long standing lockup bug caused by audio and rtc handlers using interrupt priority higher than the RTOS and calling RTOS API. • Upgrade ACS Basic to v2.2.
1.3	Jan-3-2013	• Upgrade ACS Basic to v2.3.
1.4	Sept-25-2013	• Initial support for Listbox screen object type. • Initial support for Linear gauge screen object type. • Initial support for Spinner Knob screen object type. • Added Router IP Address configuration required for UDP ARP. • Initial support for NTP client; added configuration items for NTP Server, NTP Server port, Local Timezone and Daylight Savings. • Upgrade ACS Basic to v2.5. • Added SOH320COLOR mode protocol support for new DRAW commands.
2.0	May-9-2014	• Added USB SD Card / Serial option. • Added DHCP support. • Added Art-Net™ support. • Upgrade ACS Basic to v2.9.
2.1	August-9-2014	• Internal restructuring of program source files. • Added configuration settings access via browser. • Upgrade ACS Basic to v3.0.
2.2	September-4-2014	• Corrected handling of directory paths to support nested directories. • Upgrade ACS Basic to v3.1.

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