

uLCD-70D Series



uLCD-70D (Non-touch)
uLCD-70DT (Resistive touch)

Datasheet

Revision 1.11

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1. Description

The uLCD-70D range of display modules is brilliant 7.0" Intelligent Display Modules powered by the 4D Systems' Diablo16 Graphics Processor.

The uLCD-70D range is designed for applications demanding a large intelligent display module.

Driving the display and peripherals is the Diablo16 processor, a very capable and powerful chip that enables stand-alone functionality, programmed using the 4D Systems Workshop 4 IDE Software. The Workshop4 IDE enables graphic solutions to be constructed rapidly and with ease due to its design being solely for 4D graphics processors.

The Diablo16 Processor offers considerable FLASH and RAM upgrades over the PICASO processor, and also provides mappable functions such as I2C, SPI, Serial, PWM, Pulse Out, and Quadrature Input, to various GPIO, and also provide up to 4 Analog Input channels.

The display module has an array of features including PWM for Sound, Touch Detection, micro-SD memory storage, general-purpose I/O including Analog Inputs, multiple TTL Serial, I2C and SPI channels and multiple millisecond resolution timers, amongst many more features.

Anything that has been designed in the past to run on a PICASO Processor can theoretically run on this Diablo16 Module with minor changes. Please ensure you contact the 4D Systems' support team if unsure if upgrading from a PICASO product and wanting to design with or change over to this uLCD-70D Module.

The uLCD-70D range includes 3 models, the uLCD-70D (Non-Touch), uLCD-70DT (Resistive Touch) and uLCD-70DCT (Capacitive Touch).

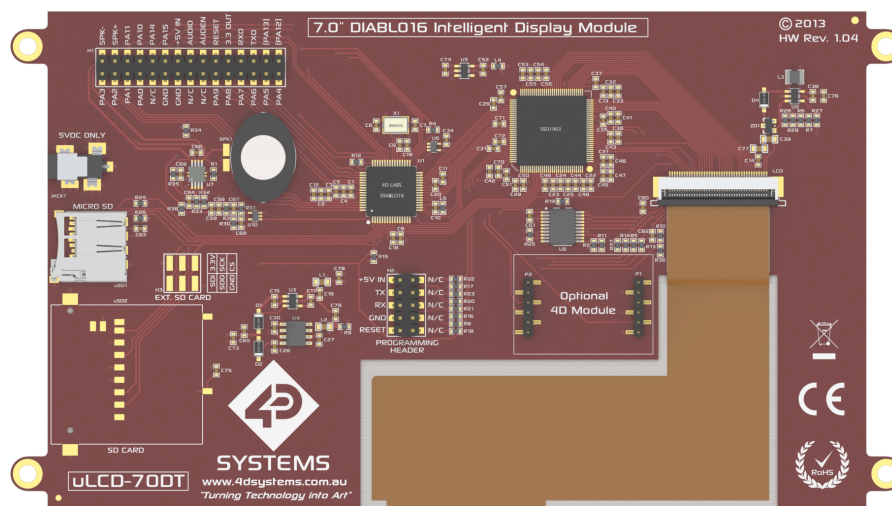
Note

DC JACK (JACK1) on Hardware Rev 1.05 has been found to have an issue and is therefore not populated. Powering is via USB or 5V pin on headers. This is rectified on HW Rev 1.06 and above.

2. Features

- Powerful 7.0" Intelligent LCD-TFT display module powered by Diablo16.
- 800 x 480 Resolution, RGB 65K true to life TFT Screen. Available in Non-Touch, Resistive Touch, and Capacitive Touch models.
- Easy 5-pin interface to any TTL Serial Host: VCC, TX, RX, GND, RESET
- 6 banks of 32750 bytes of Flash memory for User Application Code and Data
- 32Kb of SRAM purely for the User.
- 16 General Purpose I/O pins for user interfacing, which include 4 configurable Analog Inputs.
- The GPIO is variously configurable for alternative functions such as:
 - 3x I²C channels available
 - 1x SPI dedicated for SD Card and 3x configurable SPI channels available
 - 1x dedicated and 3x configurable TTL Serial comm ports available
 - Up to 6 GPIO can be used as Pin Counters
 - Up to 6 GPIO for PWM (simple and Servo)
 - Up to 10 GPIO for Pulse Output
 - Up to 14, GPIO can be configured for Quadrature Encoder Inputs (2 channels)
- On-board micro-SD memory card connector for multimedia storage and data logging purposes.
- Full-sided SD memory card connector is available for volume purchases.
- DOS-compatible file access (FAT16 format) as well as low-level access to card
- A dedicated raw PWM Audio pin driven by WAV files from a micro-SD card.
- On-board audio amplifier with a tiny 8Ω speaker for sound generation and WAV file playback.
- Display full colour images, animations, icons and video clips on chosen 4D Systems display.
- Supports all available Windows fonts.
- 4.0V to 5.5V range operation (single supply).
- Module dimensions: 179.9 x 100 x 15.5mm (including tabs)
- Weighing ~ 215g.
- Display Viewing Area: 154.1 x 85.9mm
- 4x mounting tabs with 3.5mm holes for mechanical mounting.
- RoHS and CE Compliant.

3. Pin Configuration and Summary



Note

Full Sized SD socket and EXT. SD Card Header (H3) are NOT populated, Populated on special orders only. JACK1 (5V DC JACK) NOT populated until HW Rev. 1.06. Optional 4D Module socket removed in HW Rev 2.0+, to be replaced by a new bus system in HW Rev 2.2

H2 Pinout (Programming Header) – REV 2.1 (see note)

Pin	Symbol	I/O	Description
1, 2	+5V IN	P	Main Voltage Supply +ve input pin. Reverse polarity protected. The range is 4.0V to 5.5V, nominal 5.0V. 500mA minimum required.
3, 4	TX	O	Asynchronous Serial Transmit pin, TTL level. Connect this pin to the Receive (Rx) signal of other serial devices. Used in conjunction with the RX pin for programming this micro LCD. 5.0V Tolerant Pin. Connected to TX0 via Resistor.
5, 6	RX	I	Asynchronous Serial Receive pin, TTL level. Connect this pin to the Transmit (Tx) signal of other serial devices. Used in conjunction with the TX pin for programming this micro LCD. 5.0V Tolerant Pin. Connected to RX0 via Resistor.
7, 8	GND	P	Supply Ground
9, 10	RESET	I	Master Reset signal. Internally pulled up to 3.3V via a 10K resistor. An active Low pulse greater than 2 micro-seconds will reset the module. If the module needs to be reset externally, only use open collector-type circuits. This pin is not driven low by any internal conditions. The host should control this pin via one of its port pins using an open collector/drain arrangement.

Note


- **I** = Input, **O** = Output, **P** = Power
- The Programming Header pinout has changed in REV 2.0+ hardware. Both sides of the Programming header now feature the same signals. Previously only the left side featured the programming signals, and the right side was all No Connect (N/C) - as depicted in the [image above](#).

H1 Pinout			
Pin	Symbol	I/O	Description
1	PA3	I/O	General Purpose I/O pin with Analog Capability. This pin is 3.3V tolerant when used as a Digital, with a range of 0-3.3V when used as an Analog Input
2	SPK-	O	Speaker Output -ve if a different speaker is used externally. Disconnected on board speaker if utilised.
3	PA2	I/O	General Purpose I/O pin with Analog Capability. This pin is 3.3V tolerant when used as a Digital, with a range of 0-3.3V when used as an Analog Input
4	SPK+	O	Speaker Output +ve if a different speaker is used externally. Disconnected on board speaker if utilised.
5	PA1	I/O	General Purpose I/O pin with Analog Capability. This pin is 3.3V tolerant when used as a Digital, with a range of 0-3.3V when used as an Analog Input
6	PA11	O	General Purpose I/O. This pin is 5.0V tolerant.
7	PA0	I/O	General Purpose I/O pin with Analog Capability. This pin is 3.3V tolerant when used as a Digital, with a range of 0-3.3V when used as an Analog Input
8	PA10	I/O	General Purpose I/O. This pin is 5.0V tolerant.
9	N/C	-	No Connect – Leave this pin unconnected
10	PA14	I/O	General Purpose I/O. This pin is 3.3V tolerant only. Special I2C Capability.
11	GND	P	Supply Ground
12	PA15	I/O	General Purpose I/O. This pin is 3.3V tolerant only. Special I2C Capability.
13	GND	P	Supply Ground
14	+5V IN	P	Main Voltage Supply +ve input pin. Reverse polarity protected. The range is 4.0V to 5.5V, nominal 5.0V. 500mA minimum Required.
15	N/C	-	No Connect – Leave this pin unconnected
16	AUDIO	I/O	Audio Output or Input direct to Amplifier, TTL Line level
17	N/C	-	No Connect – Leave this pin unconnected
18	AUDENB	O	External Amplifier enable pin, to control an external amplifier from the module
19	PA9	I/O	General Purpose I/O. This pin is 5.0V tolerant.
20	RESET	I	Master Reset, Active Low (GND), See H2 Pin 9 Description
21	PA8	I/O	General Purpose I/O. This pin is 5.0V tolerant.
22	3.3V_OUT	O	3.3V Output, limited to approximately 20mA, for external use.
23	PA7	I/O	General Purpose I/O. This pin is 5.0V tolerant.
24	RX0	I	Asynchronous serial port 0 receive pin. COM0. 3.3V Level – 5V tolerant.

Pin	Symbol	I/O	Description
25	PA6	I/O	General Purpose I/O. This pin is 5.0V tolerant.
26	TX0	O	Asynchronous serial port 0 transmit pin. COM0. 3.3V Level Output.
27	PA5	I/O	General Purpose I/O. This pin is 5.0V tolerant.
28	PA13	I/O	(RESERVED FOR RESISTIVE TOUCH) – See the General Purpose I/O section
29	PA4	I/O	General Purpose I/O. This pin is 5.0V tolerant.
30	PA12	I/O	(RESERVED FOR RESISTIVE TOUCH) – See General Purpose I/O section

 **Note**

I = Input, **O** = Output, **P** = Power

 **H3 Pinout (EXT. SD Header) – NOT POPULATED NORMALLY**

Pin	Symbol	I/O	Description
1	SD_SDI	I	SD Card SDI Signal for SD Card Only (shared with uSD/SD Sockets)
2	3.3V	P	3.3V Supply for SD Card Only
3	SD_SDO	O	SD Card SDO Signal for SD Card Only (shared with uSD/SD Sockets)
4	SD_SCK	O	SD Card SCK Signal for SD Card Only (shared with uSD/SD Sockets)
5	GND	P	Supply Ground
6	SD_CS	O	SD Card Chip Select Signal for SD Card Only (shared with uSD/SD Sockets)

 **Note**

Caution must be used if using this header, only 1 SD card can be installed at any given time

4. Hardware Interface - Pins

The uLCD-70D range of modules provides both a hardware and software interface. This section describes in detail the hardware interface pins of the device.

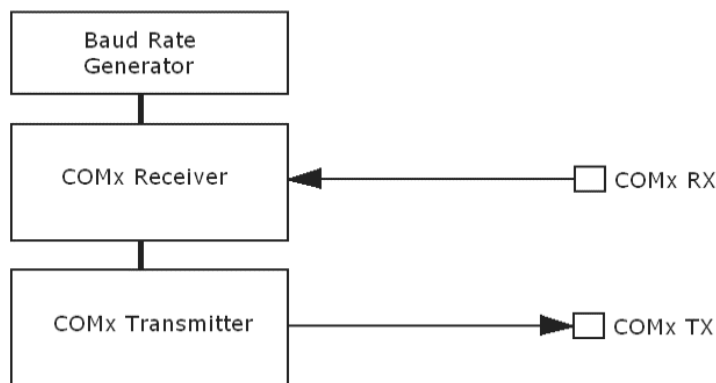
4.1. Serial Ports - TTL Level

The Diablo16 Processor has three hardware asynchronous serial ports (COM1 - COM3) that can be configured on a variety of processor GPIO pins. TX/RX0 (COM0) is dedicated and its pins are fixed. All of the Diablo16's serial ports can be used to communicate with external serial devices.

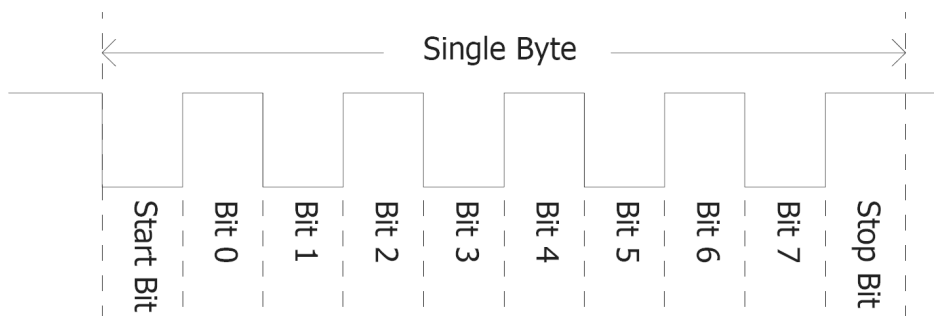
TX/RX0 are referred to as COM0 and is the only one used for programming the Diablo16 itself.

The primary features are:

- Full-Duplex 8-bit data transmission and reception.
- Data format: 8 bits, No Parity, 1 Stop bit.
- Independent Baud rates from 300 baud up to 600K baud.
- Single byte transmits and receives a fully buffered service. The buffered service feature runs in the background capturing and buffering serial data without the user application having to constantly poll any of the serial ports. This frees up the application to service other tasks.



A single-byte serial transmission consists of the start bit, 8 bits of data followed by the stop bit. The start bit is always 0, while a stop bit is always 1. The LSB (Least Significant Bit, Bit 0) is sent out first following the start bit. The figure below shows a single-byte transmission timing diagram.



COM0 is also the primary interface for 4DGL user program downloads and chip configuration PmmC programming. Once the compiled 4DGL application program (EVE byte-code) is downloaded and the user code starts executing, the serial port is then available to the user application. Refer to the [PmmC/Firmware programming](#) section for more details.

TX0 pin (Serial Transmit COM0):

Dedicated Asynchronous Serial port COM0 transmit pin, TX0. Connect this pin to the external serial device receive (Rx) signal. This pin is 5.0V tolerant.

RX0 pin (Serial Receive COM0):

Dedicated Asynchronous Serial port COM0 receive pin, RX0. Connect this pin to an external serial device transmit (Tx) signal. This pin is 5.0V tolerant.

TX1 pin (Serial Transmit COM1):

Asynchronous Serial port COM1 transmit pin, TX1. Connect this pin to the external serial device receive (Rx) signal. This can be configured to one of the GPIO pins, see the [table](#) below.

RX1 pin (Serial Receive COM1):

Asynchronous Serial port COM1 receive pin, RX1. Connect this pin to an external serial device transmit (Tx) signal. This can be configured to one of the GPIO pins, see the [table](#) below.

TX2 pin (Serial Transmit COM2):

Asynchronous Serial port COM2 transmit pin, TX2. Connect this pin to the external serial device receive (Rx) signal. This can be configured to one of the GPIO pins, see the [table](#) below.

RX2 pin (Serial Receive COM2):

Asynchronous Serial port COM2 receive pin, RX2. Connect this pin to an external serial device transmit (Tx) signal. This can be configured to one of the GPIO pins, see the [table](#) below.

TX3 pin (Serial Transmit COM3):

Asynchronous Serial port COM3 transmit pin, TX3. Connect this pin to the external serial device receive (Rx) signal. This can be configured to one of the GPIO pins, see the [table](#) below.

RX3 pin (Serial Receive COM3):

Asynchronous Serial port COM3 receive pin, RX3. Connect this pin to an external serial device transmit (Tx) signal. This can be configured to one of the GPIO pins, see the [table](#) below.

Diablo16 Serial TTL Comm Port Configuration Options						
	TX1	RX1	TX2	RX2	TX3	RX3
PA0		Yes		Yes		Yes
PA1	Yes	Yes	Yes	Yes	Yes	Yes
PA2		Yes		Yes		Yes
PA3	Yes	Yes	Yes	Yes	Yes	Yes
PA4	Yes	Yes	Yes	Yes	Yes	Yes
PA5	Yes	Yes	Yes	Yes	Yes	Yes
PA6	Yes	Yes	Yes	Yes	Yes	Yes
PA7	Yes	Yes	Yes	Yes	Yes	Yes
PA8	Yes	Yes	Yes	Yes	Yes	Yes
PA9	Yes	Yes	Yes	Yes	Yes	Yes
PA10		Yes		Yes		Yes
PA11		Yes		Yes		Yes
PA12	Yes	Yes	Yes	Yes	Yes	Yes
PA13	Yes	Yes	Yes	Yes	Yes	Yes
PA14						
PA15						

Note

Pins **PA4-PA13** are 5.0V tolerant, while pins **PA0-PA3, PA14, PA15** are 3.3V tolerant only. All pins output at 3.3V levels.

Please refer to the [Diablo16 Internal Functions Manual](#) for information on how to set the Diablo16 pin mappings.

4.2. General Purpose I/O

There are 16 general purpose Input/Output (GPIO) pins available to the user. These provide flexibility for individual bit operations along with serving collectively for byte-wise operations using the BUS functions.

Diablo16 Alternate Pin Configurations GPIO					
	Digital Input	Digital Output	Bus Read	Bus Write	Analog Read
PA0	Yes	Yes	Yes	Yes	Yes
PA1	Yes	Yes	Yes	Yes	Yes
PA2	Yes	Yes	Yes	Yes	Yes
PA3	Yes	Yes	Yes	Yes	Yes
PA4	Yes	Yes	Yes	Yes	
PA5	Yes	Yes	Yes	Yes	
PA6	Yes	Yes	Yes	Yes	
PA7	Yes	Yes	Yes	Yes	
PA8	Yes	Yes	Yes	Yes	
PA9	Yes	Yes	Yes	Yes	
PA10	Yes	Yes	Yes	Yes	
PA11	Yes	Yes	Yes	Yes	
PA12	Yes	Yes	Yes	Yes	
PA13	Yes	Yes	Yes	Yes	
PA14	Yes	Yes	Yes		
PA15	Yes	Yes	Yes		

Please refer to the [Diablo16 Internal Functions Manual](#) for information on how to set the Diablo16 pin mappings.

PA0-PA3:

General purpose I/O pins, or can serve as Analog Input pins. Each pin can be individually set for INPUT or OUTPUT or ANALOG. Power-Up Reset default is all INPUTS. When set as Digital Inputs, the pins are 3.3V tolerant. Digital GPIO can source/sink 10mA. For more information see the [Specifications] section.

When set as Analog Inputs, the pins have a 0 to 3.3V range and have 12 bit resolution. For more information, see the [Analog Inputs] section.

PA4-PA11:

General purpose I/O pins. Each pin can be individually set for INPUT or OUTPUT. Power-Up Reset default is all INPUTS. When set as Digital Inputs, the pins are 5V tolerant. Digital GPIO can source/sink 10mA. For more information see the [Specifications] section.

PA12-PA13:

PA12 and PA13 are reserved and are used exclusively for the resistive touch controller, or the capacitive touch controller. These pins are NOT to be connected on the uLCD-70DT and uLCD-70DCT models else Touch may not perform correctly. These feature 4.7K pull-up resistors on PA12 and PA13. These are present on the Headers for special cases only where Touch is not installed. Do not attempt to use these pins in normal situations. Using these pins on the uLCD-70D (non-touch) is however OK, or in situations where touch is not used. These pins are 5V Tolerant.

PA14-PA15:

General purpose I/O pins. Each pin can be individually set for INPUT or OUTPUT. Power-Up Reset default is all INPUTS. When set as Digital Inputs, the pins are 3.3V tolerant. Digital GPIO can source/sink 10mA. For more information see the [Specifications] section.

4.3. System Pins

+5V IN (Module Voltage Input): H1 Pin 14, H2 Pin 1, 5V Barrel Jack centre

Module supply voltage input pins. At least one of these pins must be connected to a stable supply voltage in the range of 4.0 Volts to 5.5 Volts DC. The nominal operating voltage is 5.0 Volts. Note backlight brightness will be lower for voltages under 5.0V. 500mA of current is the minimum recommended for module stability. It is highly recommended to use a 1A supply for the best stability and results.

3.3V_OUT (3.3V Output): H1 Pin 22

3.3V Output for the user limited to approximately 20mA. Used for powering small external devices or components.

GND (Module Ground): H1 Pin 11/13, H2 Pin 7, Barrel Jack sheath

Device ground pins. Any of these pins can be used to GND the module, at least one must be connected to ground.

RESET (Module Master Reset): H1 Pin 20, H2 Pin 9

Module Master Reset pin. An active low pulse of greater than 2 μ s will reset the module. Internally pulled up to 3.3V via a 10K resistor. Only use open collector-type circuits to reset the device if an external reset is required.

AUDENB (Audio Enable Output): H1 Pin 18

Output dedicated to enabling or disabling an external amplifier, where required. Active High.

AUDIO (PWM Audio Input/Output): H1 Pin 16

Universal Input or Output specifically for Audio. This pin connects directly to the onboard amplifier, but also with the filtered PWM output from the Diablo16 Processor. This pin can be used to input a signal into the onboard amplifier to play audio from an external device using the onboard amplifier, or as a line-level output to drive an external amplifier with Diablo16-generated Audio. Note that AUDENB must be enabled (high) in Diablo16 for any input signal to be heard.

4.4. Alternate Pin Function Overview

Most of the GPIO pins have an alternate function other than being for General Purpose I/O. GPIO pins can be configured to be SPI, I2C, Serial or a range of other functions.

Note

Not all pins however can be configured to be any of the alternate pin functions.

Please refer to the following tables which illustrate which pins can be associated with alternative functions.

Diablo16 Alternate Pin Configurations I/O Support Functions

	Pulse Out	PWM Out	Pin Counter	Quadrature In
PA0	Yes			Yes
PA1	Yes			Yes
PA2	Yes			Yes
PA3	Yes			Yes
PA4	Yes	Yes	Yes	Yes
PA5	Yes	Yes	Yes	Yes
PA6	Yes	Yes	Yes	Yes
PA7	Yes	Yes	Yes	Yes
PA8	Yes	Yes	Yes	Yes
PA9	Yes	Yes	Yes	Yes
PA10				Yes
PA11				Yes
PA12				Yes
PA13				Yes
PA14				
PA15				

Note

- Once you allocate a pin to an alternate function, you can't allocate another pin to the same alternate function.
- Quadrature In requires 2 Pins

The [table](#) above illustrates the GPIO pins you can use for the 4 different I/O Support Functions.

Please refer to the [Diablo16 Internal Functions Manual](#) for more information on how to set the alternate pin configurations.

The Alternate pin functions have been broken up into a few tables for simplification. There are communication-based functions and I/O support-based functions.


Further information is available in the next sections for each of the alternative pin functions.

The table below illustrates the GPIO pins you can use for the three different SPI channels available.

Diablo16 Alternate Pin Configurations SPI Communications									
	SPI1 SDO	SPI1 SDI	SPI1 SCK	SPI2 SDO	SPI2 SDI	SPI2 SCK	SPI3 SDO	SPI3 SDI	SPI3 SCK
PA0		Yes			Yes			Yes	
PA1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PA2		Yes			Yes			Yes	
PA3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PA4	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA5	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA6	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA7	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA8	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA9	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA10		Yes			Yes			Yes	
PA11		Yes			Yes			Yes	
PA12	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA13	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA14									
PA15									

The table below illustrates the GPIO pins you can use for the three different I²C channels available.

Diablo16 Alternate Pin Configurations I ² C Communication						
	I ² C1 SDA	I ² C1 SCL	I ² C2 SDA	I ² C2 SCL	I ² C3 SDA	I ² C3 SCL
PA0	Yes	Yes	Yes	Yes	Yes	Yes
PA1	Yes	Yes	Yes	Yes	Yes	Yes
PA2	Yes	Yes	Yes	Yes	Yes	Yes
PA3	Yes	Yes	Yes	Yes	Yes	Yes
PA4	Yes	Yes	Yes	Yes	Yes	Yes
PA5	Yes	Yes	Yes	Yes	Yes	Yes
PA6	Yes	Yes	Yes	Yes	Yes	Yes
PA7	Yes	Yes	Yes	Yes	Yes	Yes
PA8	Yes	Yes	Yes	Yes	Yes	Yes
PA9	Yes	Yes	Yes	Yes	Yes	Yes
PA10	Yes	Yes	Yes	Yes	Yes	Yes
PA11	Yes	Yes	Yes	Yes	Yes	Yes
PA12	Yes	Yes	Yes	Yes	Yes	Yes
PA13	Yes	Yes	Yes	Yes	Yes	Yes
PA14		SPECIAL		SPECIAL		SPECIAL
PA15	SPECIAL		SPECIAL		SPECIAL	

 **Note**

SPECIAL - please see I²C section.

4.5. SPI

There are 3 user-configurable SPI channels available for mapping to GPIO, for use by the user for the target application. All 3 SPI channels are Master only, and cannot be configured to be slaves at this time.

The SPI Bus speed is configurable using the **SPIx_Init()** Function in 4DGL and allows various speeds from 78.125Khz to 17.5Mhz.

Please refer to the [table](#) for details on which GPIO can be configured for SPI.

Note

The additional SPI channel (SPI0) is dedicated to the memory cards and cannot be reconfigured for alternate uses.

To map an SPI channel to a set of GPIO pins, the following 4DGL functions are used:

- **SPIx_SCK_pin(pin);** // Map the SCK pin
- **SPIx_SDI_pin(pin);** // Map the SDI pin
- **SPIx_SDO_pin(pin);** // Map the SDO pin

where:

'SPIx' is substituted with SPI1, SPI2 or SPI3 accordingly, and

'pin' is the target GPIO pin compatible with that particular pin function.

Chip Select for use with SPI can be any other unused GPIO pin, configured as a Digital Output. The lowering and raising of the selected CS (GPIO) pin is done manually by the user in the 4DGL application.

Please refer to the [Diablo16 Internal Functions Manual](#) for more information on how to use the SPI functions, along with the [Diablo16-Processor](#) datasheet.

4.6. I2C

There are 3 user-configurable I2C channels available for mapping to GPIO, for use by the user for the target application. All 3 I²C channels are Master only, and cannot be configured to be slaves at this time.

Please refer to the [table](#) for details on which GPIO can be configured for I²C.

To map an I²C Channel to a set of GPIO pins, the following 4DGL function is used:

· I2Cx_Open(Speed, SCLpin, SDAPin);

where:

'I2Cx' is substituted with I2C1, I2C2 or I2C3 accordingly,

'Speed' is the desired I2C Bus speed, and

'SCLpin' and 'SDAPin' are the target GPIO pins compatible with that particular pin function.

Note

The normal I²C pins are PA0 to PA13, however, the use of these pins has a few limitations.

1. There is no slew rate control at I2C_MED.
2. I2C_FAST is not truly 1MHz.

If either of these restrictions needs to be addressed, a special case of SCLpin = PA14 and SDAPin = PA15 exists ONLY for speeds I2C_MED (which uses slew rate control) and I2C_FAST (which is truly 1MHz)

Please refer to the [Diablo16 Internal Functions Manual](#) for more information on how to use the I²C functions, along with the [Diablo16-Processor](#) datasheet.

4.7. Pulse Out

Pulse Out is used to create a single pulse of set duration on the selected pin of choice, which is inverted in polarity to the current state of the pin.

This '*inversion of polarity*' means if a Pin is currently held HI, and Pulse Out is executed on that Pin, the pin will pulse LO and then return to HI. Same with vice versa, if currently LO and Pulse Out are executed on that Pin, it will pulse HI and then return to LO.

This is available in both blocking and non-blocking versions.

Please refer to the [table](#) for details on which GPIO can be configured to Pulse Out.

Note

Each Pulse Out request needs at least a 1ms lead time due to the scheduling of the event with the internal 1ms timer.

To enable the Pulse Out function on a GPIO pin, the following 4DGL functions are used:

- **pin_Pulseout(pin, value);** //Non-Blocking
- **pin_PulseoutB(pin, value);** //Blocking

where:

'pin' is the target GPIO pin compatible with that particular pin function, and

'value' is the length of the pulse in milliseconds.

Please refer to the [Diablo16 Internal Functions Manual](#) for more information on how to use the Pulse Out functions, along with the [Diablo16-Processor](#) datasheet.

4.8. PWM Out

There are 6 PWM channels available to be configured by the user, with 4-time bases available for selection. The PWM can be configured to be used in Servo Mode, or Simple Mode.

Please refer to the [table](#) for details on which GPIO can be configured to PWM.

Servo Mode allows a millisecond input value with 0.01ms resolution, which runs at a frequency of approximately 50Hz or 50pps (20ms). The position of the servo is determined by the width of the pulse. Generally, 1.5ms is 90 degrees, 1ms is 0 degrees and 2ms is 180 degrees. Servos however vary, and the Diablo16 PWM control can be adjusted to suit most applications.

Simple Mode allows a percentage input value with a resolution of 0.1%, which runs at a frequency of approximately 70KHz.

To enable the PWM output on a GPIO pin, the following 4DGL function is used:

· **PWM_Init(pin, mode, value);**

where:

'pin' is the GPIO compatible with the particular pin function,

'mode' is the type of PWM to generate, and

'value' is the parameter that defined the PWM pulse itself.

Please refer to the [Diablo16 Internal Functions Manual](#) for more information on how to use the PWM functions, along with the [Diablo16-Processor](#) datasheet.

4.9. Pin Counter

There are 6 Pin Counter channels available to be configured by the user, used to count incoming pulses with the ability to call a user function on overflow. The Pin Counter function is available for use in a variety of modes.

The counters can be read and written at any time.

Please refer to the [table](#) for details on which GPIO can be configured to the Pin Counter.

To enable the Pin Counter function on a GPIO pin, the following 4DGL function is used:

· **pin_Counter(pin, mode, OVFunction);**

where:

'pin' is the GPIO pin compatible with this particular function,

'mode' is the type of trigger used to count on such as Rising/Falling/Edge, and

'OVFunction' is the user function to call when the counter overflows if desired.

Please refer to the [Diablo16 Internal Functions Manual](#) for more information on how to use the Pin Counter functions, along with the [Diablo16-Processor](#) datasheet.

4.10. Quadrature In

There are two Quadrature Input channels available on the Diablo16 processor, which requires 2 GPIO pins each.

Please refer to the [table](#) for details on which GPIO can be configured for Quadrature Input.

Quadrature Input allows a quadrature encoder to be connected, and the position counter and delta counter can be read at any time.

To enable the Quadrature Input function on a set of GPIO pins (2 pins required), the following 4DGL function is used:

```
· Qencoderx(PHApin, PHBpin, mode);
```

where:

'Qencoderx' is substituted for Qencoder1 or Qencoder2 accordingly,

'PHApin' is the pin connected to the A Phase of the Encoder,

'PHBpin' is the pin connected to the B Phase of the Encoder, and

'mode' is not currently used so is to be set to zero (0).

Please refer to the [Diablo16 Internal Functions Manual](#) for more information on how to use the Quadrature Input functions, along with the [Diablo16-Processor](#) datasheet.

4.11. Analog Inputs

Please refer to the [table](#) under the [General Purpose I/O](#) section for details about pins you can configure to analog inputs.

The analog inputs on the Diablo16 have a range of 0V to 3.3V, each with a max resolution of 12 bits. You can read the analog inputs using either the standard mode, averaged mode or high-speed mode.

- **Standard Mode** results are immediately read in a sample. Standard Mode can read over 40000 values per second. Operates at 12-bit.
- **Averaged Mode** results are immediately read in 16 samples and their average is returned. Averaged Mode can read ~20000 values per second. Operates at 12-bit.
- **Highspeed Mode** collects a user-specified number of samples at a user-specified rate/frequency and can execute a user function when complete. The updated value updates ~250000 times across 1-4 channels. Operates at 10-bit.

To enable a GPIO as an Analog Input for Standard or Averaged modes, you must use the following 4DGL function to set the pin:

- **pin_Set(mode, pin);**

where:

'mode' is the desired mode defined above, either Standard or Averaged, and

'pin' is the GPIO compatible with this function which is to become an Analog Input.

For highspeed mode, you must use the following 4DGL function to set the pin and define the parameters:

- **ana_HS(rate, samples, 1buf, 2buf, 3buf, 4buf, func);**

where:

'rate' is the number of samples per second,

'samples' is the number of samples to collect per channel,

'1buf' to '4buf' are the buffer addresses for the 4 channels, and

'func' is the user function to call when the number of samples specified has been collected.

Please refer to the [Diablo16 Internal Functions Manual](#) for more information on how to use the Analog Input functions, along with the [Diablo16-Processor](#) datasheet.

5. PmmC/Firmware Programming

The Diablo16 processor is a custom graphics processor. All functionality including the high-level commands is built into the chip. This chip-level configuration is available as a PmmC (Personality-module-micro-Code) file, which can be likened to traditional Firmware. There is also a Display Driver file, which separates specific display settings from the PmmC, unlike on the PICASO processor where everything is combined.

A PmmC file contains all of the low-level micro-code information (analogy of that of a soft silicon) which defines the characteristics and functionality of the device. The ability to program the device with a PmmC file provides an extremely flexible method of customising as well as upgrading it with future enhancements.

The Display Driver contains the initialisation and parameters associated with the particular display that is to be connected to the Diablo16 processor.

The PmmC file and Display Driver file can only be programmed into the device via the COM0 serial port with the aid of Workshop 4, the 4D Systems IDE software.

Using a non-4D programming interface could damage your module, and **void your Warranty**.

6. Module Features

The uLCD-70D range of modules is designed to accommodate most applications. Some of the main features of the module are listed below.

6.1. Display - 7.0" TFT Screen

The uLCD-70D range of modules is equipped with a 7.0" TFT display. Details of the display are listed below:

- Screen Size: 7.0" diagonal, 800x480 resolution, 65K colours
- Screen Dimensions: 164.9 x 100.0 x 4.7mm
- Viewing Area: 154 x 85.92mm
- Pixel Pitch: 0.0632(H) x 0.179(V)mm
- Brightness: 300cd/m²
- Contrast Ratio: 500:1
- Viewing Angle Above Centre: 75 degrees
- Viewing Angle Below Centre: 70 degrees
- Viewing Angle Left of Centre: 75 degrees
- Viewing Angle Right of Centre: 75 degrees
- Viewing Direction: 6 O'clock
- 7x2 Parallel LEDs for Backlighting

Note

The Displays used are the highest-rated 'Grade A' Displays, which allow for 0-4 defective pixels. A defective pixel could be solid Black (Dead), White, Red, Green or Blue.

6.2. Diablo16 Processor

The module is designed around the Diablo16 Graphics Controller from 4D-Labs.

The Diablo16 is a smart Controller and the interface to the TFT-LCD displays is almost plug-n-play.

All of the data and control signals are provided by the chip to interface directly with the display.

Powerful graphics, text, images, animation and countless more features are built right inside the chip.

You can refer to the [Diablo16 graphics processor datasheet](#) for more information.



6.3. Audio

Audio playback support in the Diablo16 Processor enables the uLCD-70D range of modules to play audio WAV files stored in the micro-SD memory card. PWM and an onboard audio amplifier with 8Ω speaker ensure ample audio output capability. A simple instruction enables the user to play/pause/stop audio files while continuing the execution of the user application code, such as display updates, touch recognition, communications, etc. The audio system also allows real-time pitch change of audio samples.

For a complete list of audio commands please refer to the separate document titled:

- [Diablo16 Internal Functions Manual](#)

Note

The onboard speaker is a small device designed to project into an audio cavity. It is not very loud by itself. To enable louder audio, it is recommended to use a larger external 8Ω speaker. See the [Systems Pins](#) section for more information.

6.4. SD/SDHC Memory Cards

The module supports micro-SD memory cards via the onboard micro-SD connector. The memory card is used for all multimedia file retrieval such as images, animations and movie clips. The memory card can also be used as general-purpose storage for data logging applications. Support is available for off-the-shelf micro-SD and high-capacity HC memory cards (4GB and above).



Note

A microSD card capable of SPI is a requirement for all 4D Systems' display modules powered by Goldelox, Picaso or Diablo16 Processors. If a non-SPI compatible card is used, it will simply fail to mount, or may cause intermittent issues resulting in lockups and crashing of the application. Please refer to the 4D Systems website for microSD cards offered by 4D Systems.

6.5. FAT16

The uLCD-70D range of display modules uses off-the-shelf standard SDHC/SD/micro-SD memory cards (SPI Compatible Only) with up to 2GB capacity usable with FAT16 formatting. For any FAT file-related operations, before the memory card can be used it must first be formatted with the FAT16 option. The formatting of the card can be done on any PC system with a card reader. Select the appropriate drive and choose the FAT16 (or just FAT in some systems) option when formatting. The card is now ready to be used in the Diablo16-based application.

The Diablo16 Processor also supports high-capacity HC memory cards (4GB and above). The available capacity of SD-HC cards varies according to the way the card is partitioned and the commands used to access it.

The FAT partition is always first (if it exists) and can be up to the maximum size permitted by FAT16. Windows 7 will format FAT16 up to 4GB. Windows XP will format FAT16 up to 2GB and the Windows XP command prompt will format FAT16 up to 4GB.

7. Display Precautions

- Avoid having to display the same image/object on the screen for lengthy periods. This will cause a burn-in which is a common problem with all types of display technologies. Blank the screen after a while or dim it very low by adjusting the contrast. Better still; implement a screen saver feature.
- Moisture and water can damage the display. Moisture on the surface of a powered display will cause the electrodes to corrode. Wipe off any moisture gently or let the display dry before usage.
- Dirt from fingerprint oil and fat can easily stain the surface of the display. Gently wipe off any stains with a soft lint-free cloth.
- The performance of the display will degrade under high temperatures and humidity. Avoid such conditions when storing.
- Do not tamper with the display flex cable that is connected to the control board. This may affect the connection between the display and the driving circuitry and cause failure.
- Displays are susceptible to mechanical shock and any force exerted on the module may result in deformed zebra stripes, a cracked display cell and a broken backlight.
- Always use the mounting holes on the module's corner plates to mount the display.

8. Hardware Tools

The following hardware tools are required for full control of the uLCD-70D range of modules.

8.1. 4D Programming Cable/Adaptor

The 4D Programming Cable and uUSB-PA5 Programming Adaptor are essential hardware tools to program, customise and test the Diablo16 Processor.

Either the 4D Programming Cable or the uUSB-PA5 Programming Adaptor can be used.

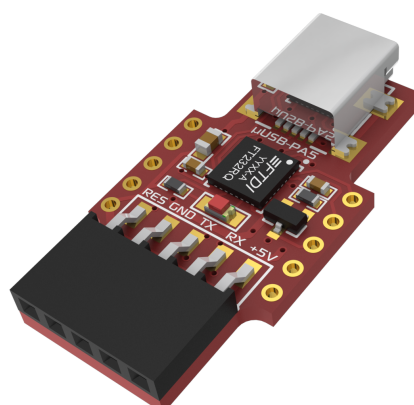
The 4D programming interfaces are used to program a new Firmware/PmmC, Display Driver and for downloading compiled 4DGL code into the processor. They even serve as an interface for communicating serial data to the PC.

The 4D Programming Cable and uUSB-PA5 Programming Adaptor are available from the [4D Systems website](#).

Using a non-4D programming interface could damage your processor, and **void your Warranty**.



4D Programming Cable



uUSB-PA5 Programming Adaptor

9. Programming Language

The uLCD-70 modules use the Diablo16 processor, which belongs to a family of processors powered by a highly optimised softcore virtual engine, EVE (Extensible Virtual Engine).

EVE is a proprietary, high-performance virtual machine with an extensive byte-code instruction set optimised to execute compiled 4DGL programs. 4DGL (4D Graphics Language) was specifically developed from the ground up for the EVE engine core. It is a high-level language that is easy to learn and simple to understand yet powerful enough to tackle many embedded graphics applications.

4DGL is a graphics-oriented language allowing rapid application development, and the syntax structure was designed using elements of popular languages such as C, Basic, Pascal and others.

Programmers familiar with these languages will feel right at home with 4DGL. It includes many familiar instructions such as `IF..ELSE..ENDIF`, `WHILE..WEND`, `REPEAT..UNTIL`, `GOSUB..ENDSUB`, `GOTO`, `PRINT` as well as some specialised instructions `SERIN`, `SEROUT`, `GFX_LINE`, `GFX_CIRCLE` and many more.

For detailed information about the 4DGL language, please refer to the following documents:

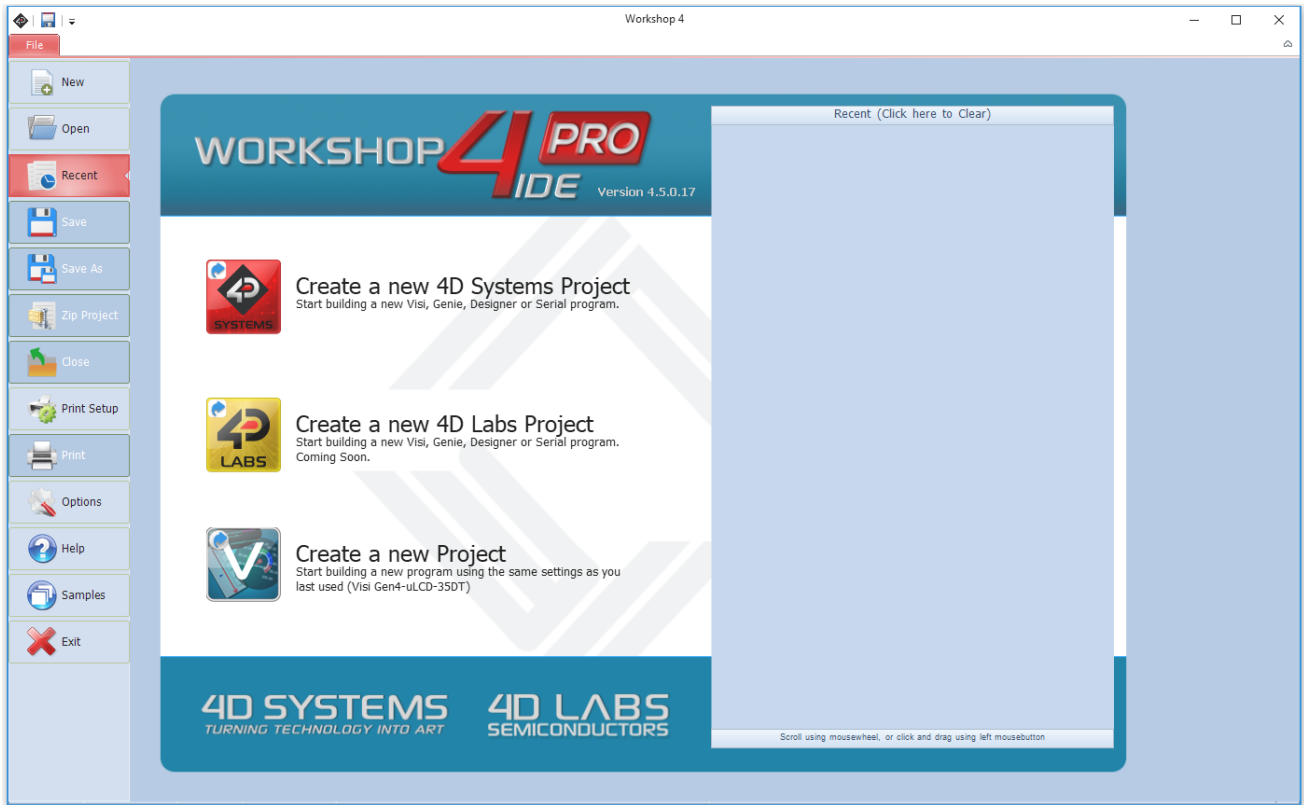
- [4DGL Programmers Reference Manual](#)
- [Diablo16 Internal Functions Manual](#)

To assist with the development of 4DGL applications, the Workshop4 IDE combines a full-featured editor, a compiler, a linker and a downloader into a single PC-based application. It's all you need to code, test and run your applications.

4DGL is available to be written in two of the four environments offered by the Workshop4 IDE, Designer and ViSi. The other two environments, Serial and ViSi-Genie do not directly use 4DGL by the User (Except in Workshop4 Pro, for ViSi-Genie), however, it is present in the background. Serial is an application that runs, and that is written in 4DGL. ViSi-Genie automatically generates 4DGL itself based on what is configured in the GUI. More information about each follows.

10. Workshop4 IDE

Workshop 4 is a comprehensive software IDE that provides an integrated software development platform for all of the 4D family of processors and modules. The IDE combines the Editor, Compiler, Linker and Down-Loader to develop complete 4DGL application code. All user application code is developed within the Workshop 4 IDE.



The Workshop 4 IDE supports multiple development environments for the user, to cater to different user requirements and skill levels.

- The **Designer** environment enables the user to write 4DGL code in its natural form to program the uLCD-70 modules.
- A visual programming experience, suitably called **ViSi**, enables drag-and-drop type placement of objects to assist with 4DGL code generation and allows the user to visualise how the display will look while being developed.
- An advanced environment called **ViSi-Genie** doesn't require any 4DGL coding at all, it is all done automatically for you. Simply lay the display out with the objects you want, set the events to drive them and the code is written for you automatically. ViSi-Genie provides the latest rapid development experience from 4D Systems.
- A **Serial** environment is also provided to transform the display module into a slave serial module, allowing the user to control the display from any host microcontroller or device with a serial port.

The Workshop 4 IDE is available from the [4D Systems website](#).

For a comprehensive manual on the Workshop 4 IDE Software along with other documents, refer to the documentation from the 4D Systems website, on the Workshop 4 product page.

11. Starter Kit

4D Systems highly recommends all first-time buyers of 4D Systems' displays, to purchase the Starter Kit when purchasing their first 4D Systems display solution.

The Starter Kit provides all the hardware that is required to get the user up and running.

Not all development environments and features will be needed by every user, however, purchasing the display solution in a Starter Kit, ensures that if you want to take full advantage of the 4D Systems display solution and try out each of the 4D Workshop4 Environments, upgrade PmmC/firmware, you can.

The **Designer** environment can use every feature of the display, however, depending on the user requirements, a micro-SD (uSD) card may not be required. The uSD card is used when displaying images/video/sound, along with data logging to uSD, and a programming cable is required for downloading compiled code and PmmC/Firmware updates.

The **Visi** environment is the same as Designer in terms of feature utilisation, but is image based so requires a uSD card, along with a programming cable.

The **Visi-Genie** environment is also image-based, and therefore requires a uSD card and programming cable also.

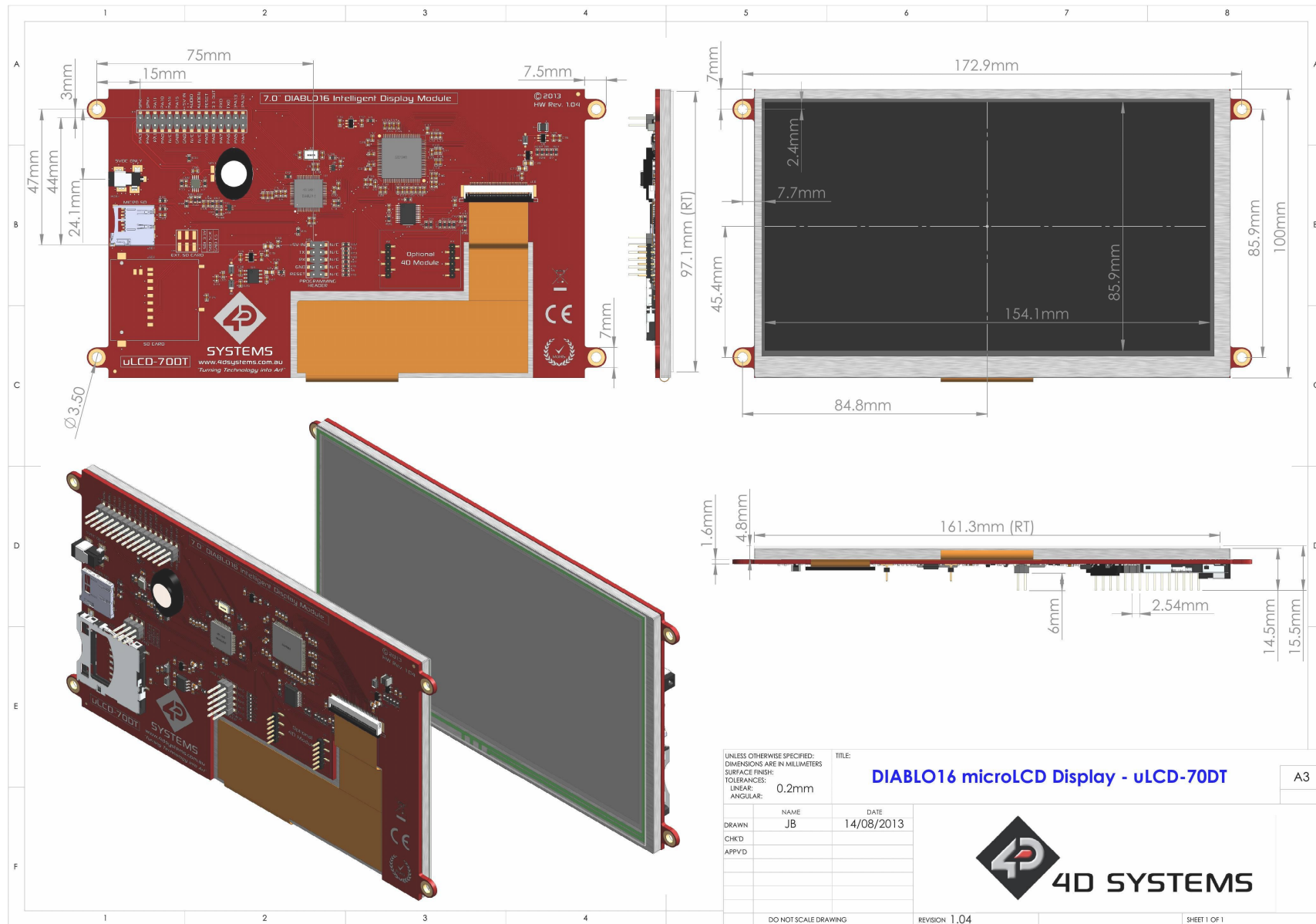
The **Serial** environment does not require either a uSD or Programming cable to be used, however, can use both depending on the user's requirements. The uSD card can be used for such things as storage of multimedia files and data logging, and the Programming cable for PmmC/Firmware updates, or changing to one of the other three programming environments.

The Starter Kit includes:

- uLCD-70DT Display Module
- 4GB MicroSD Card
- uUSB-PA5-II Programming Adaptor
- 150mm 5-way Female-Female jumper cable, for quick connection to another device or breadboard
- 5-way Male-Male adaptor (for converting the Female-Female cable to be Male-Female)

Simply select the Starter Kit option when purchasing the chosen display module on the 4D Systems shopping cart, or from your local distributor.

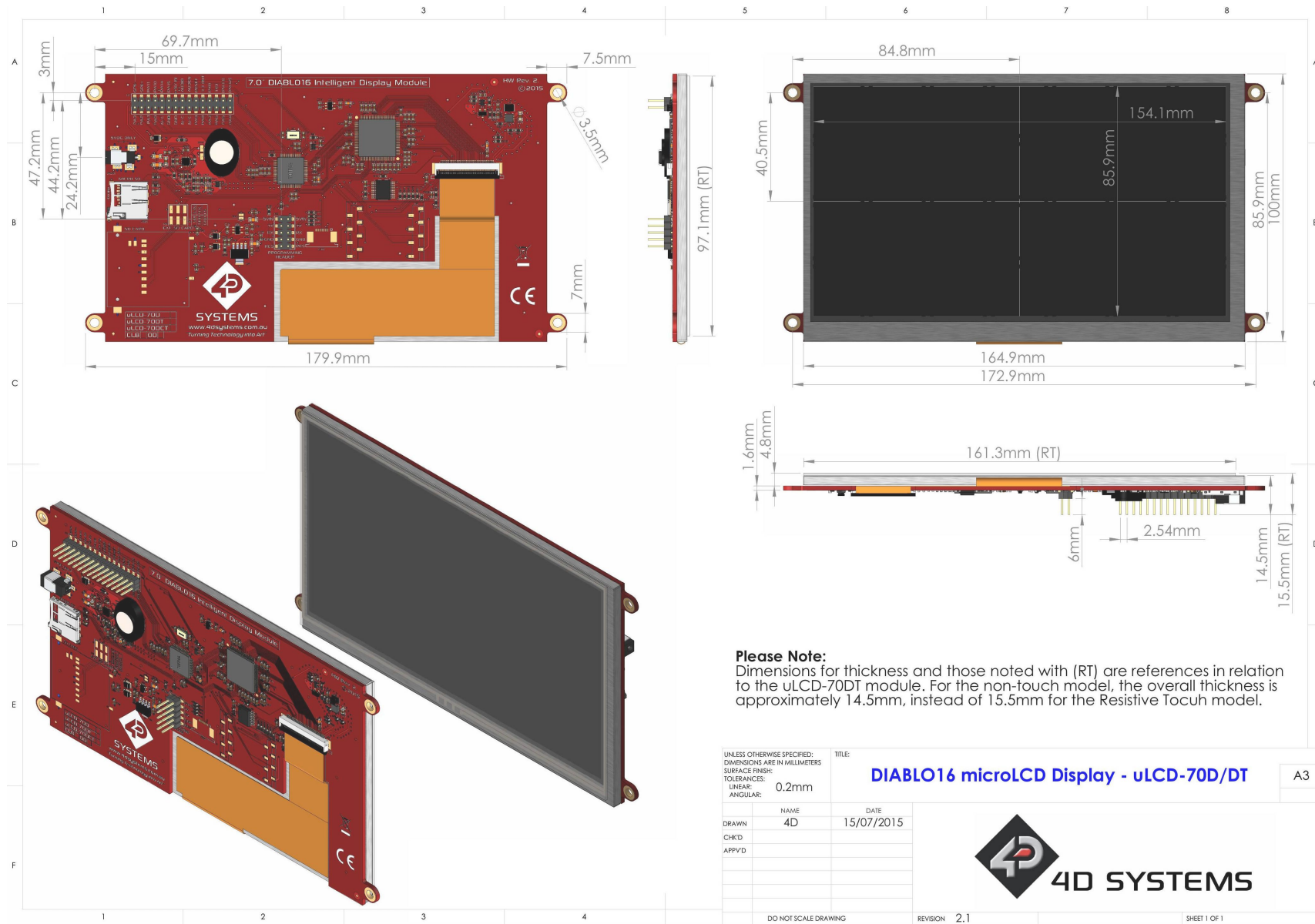
12. Mechanical Details - HW REV 1.05/1.06



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: 0.2mm ANGULAR:		TITLE: DIABLO16 microLCD Display - uLCD-70DT	A3
DRAWN: CHKD: APPVD:	NAME: JB	DATE: 14/08/2013	
DO NOT SCALE DRAWING		REVISION: 1.04	SHEET 1 OF 1



13. Mechanical Details - HW REV 2.1/2.2/2.3

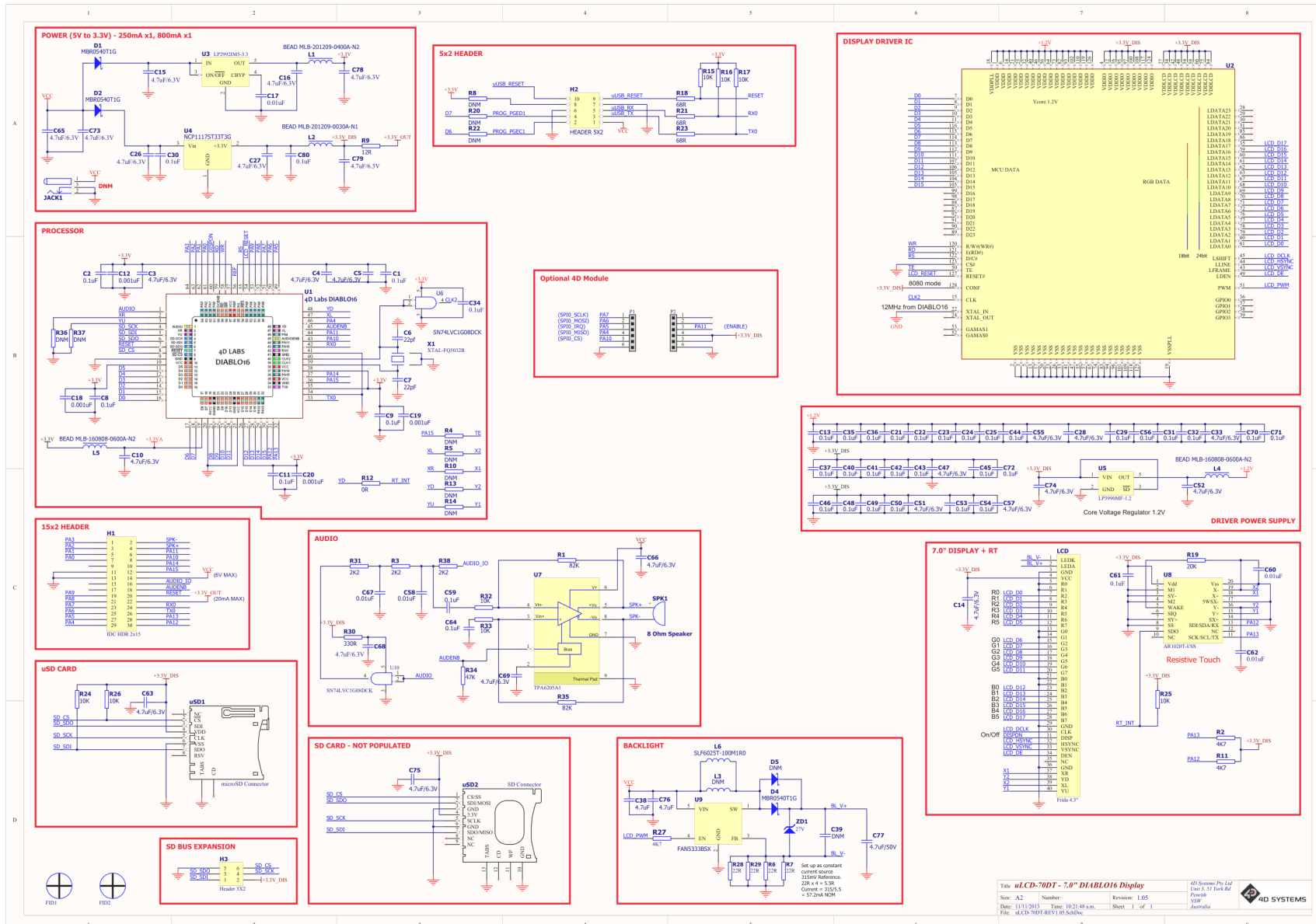


Please Note:
 Dimensions for thickness and those noted with (RT) are references in relation to the uLCD-70DT module. For the non-touch model, the overall thickness is approximately 14.5mm, instead of 15.5mm for the Resistive Touch model.

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS		TITLE: DIABLO16 microLCD Display - uLCD-70D/DT		A3
SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:		0.2mm		
DRAWN	NAME 4D	DATE 15/07/2015		
CHKD				
APPVD				
DO NOT SCALE DRAWING		REVISION 2.1	SHEET 1 OF 1	

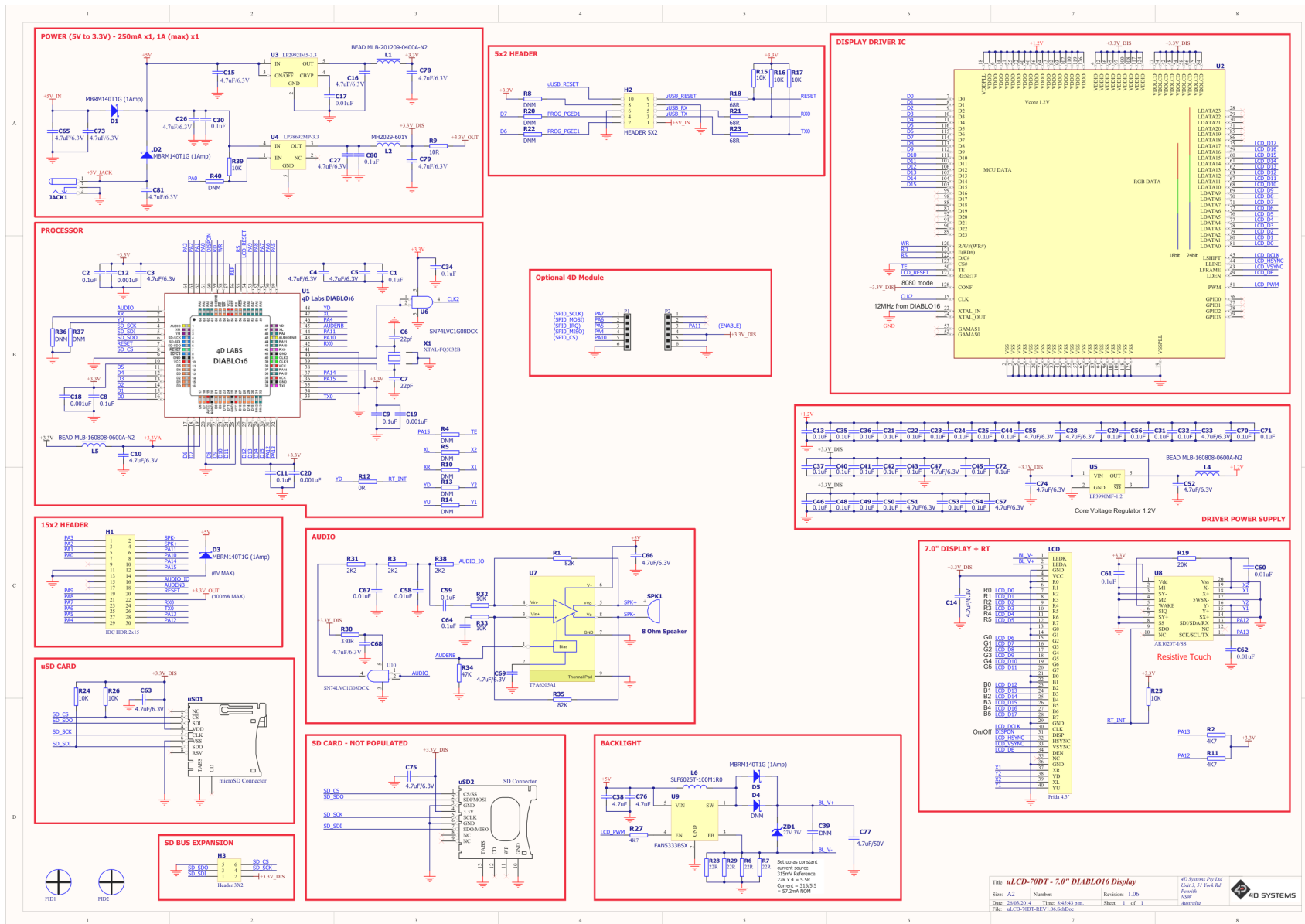


14. Schematic Diagram - HW REV 1.05

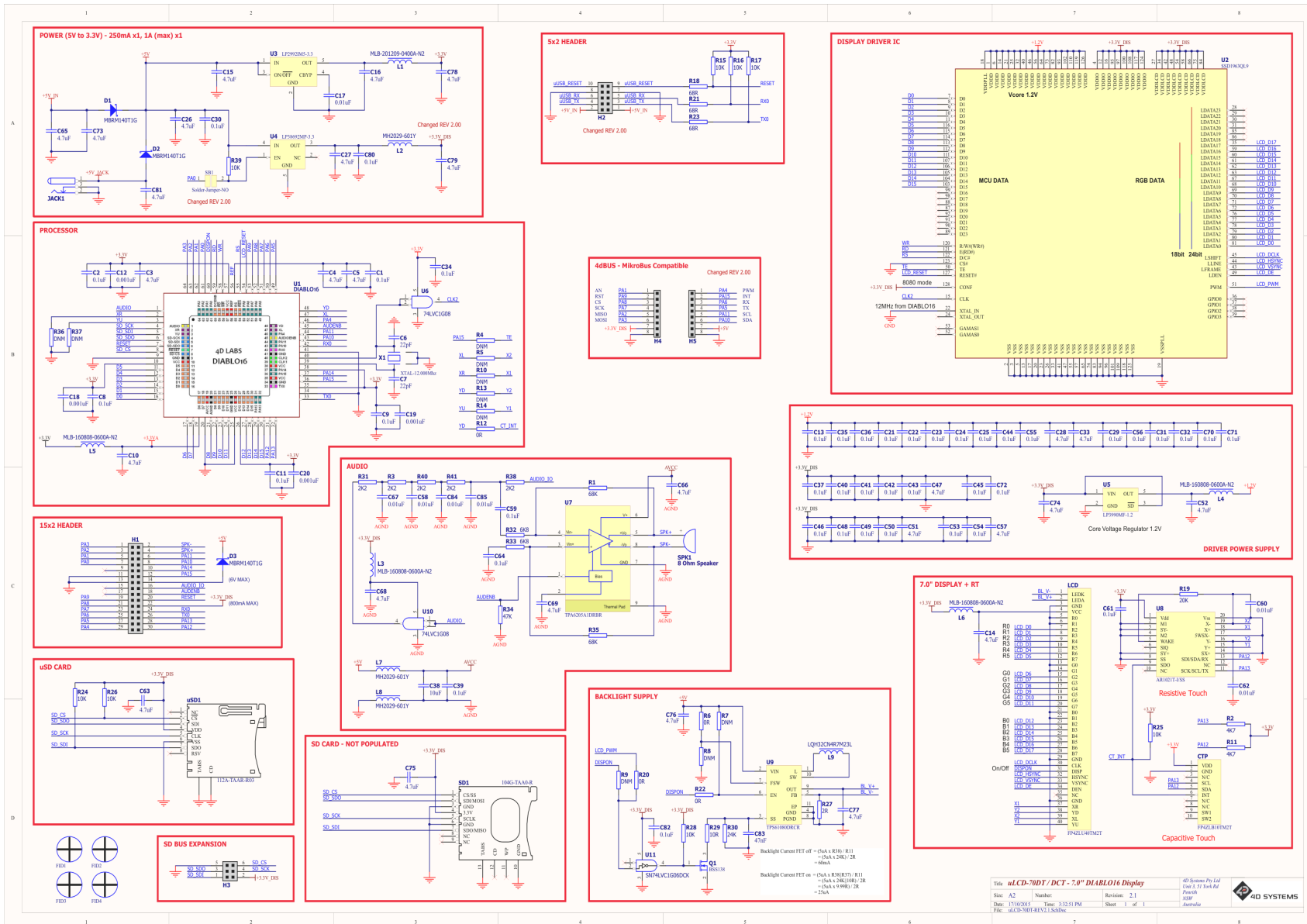


Title	uLCD-70D-7.0" DIABLO16 Display	4D Systems Pty Ltd
Size	A2	Revision
Date	11/11/2017	Author
File	uLCD-70D-REV1.05 SchDoc	Sheet

15. Schematic Diagram - HW REV 1.06

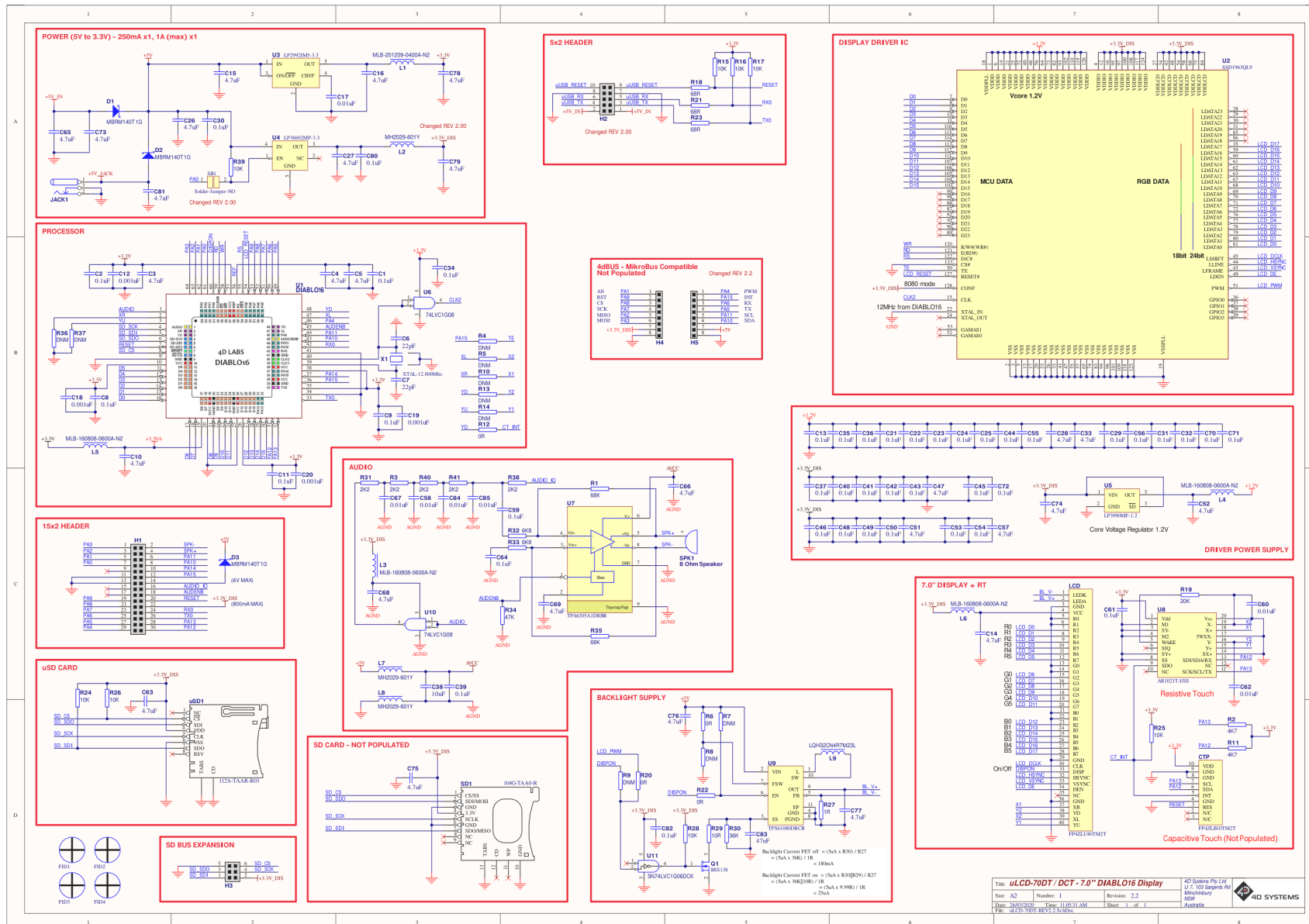


16. Schematic Diagram - HW REV 2.1

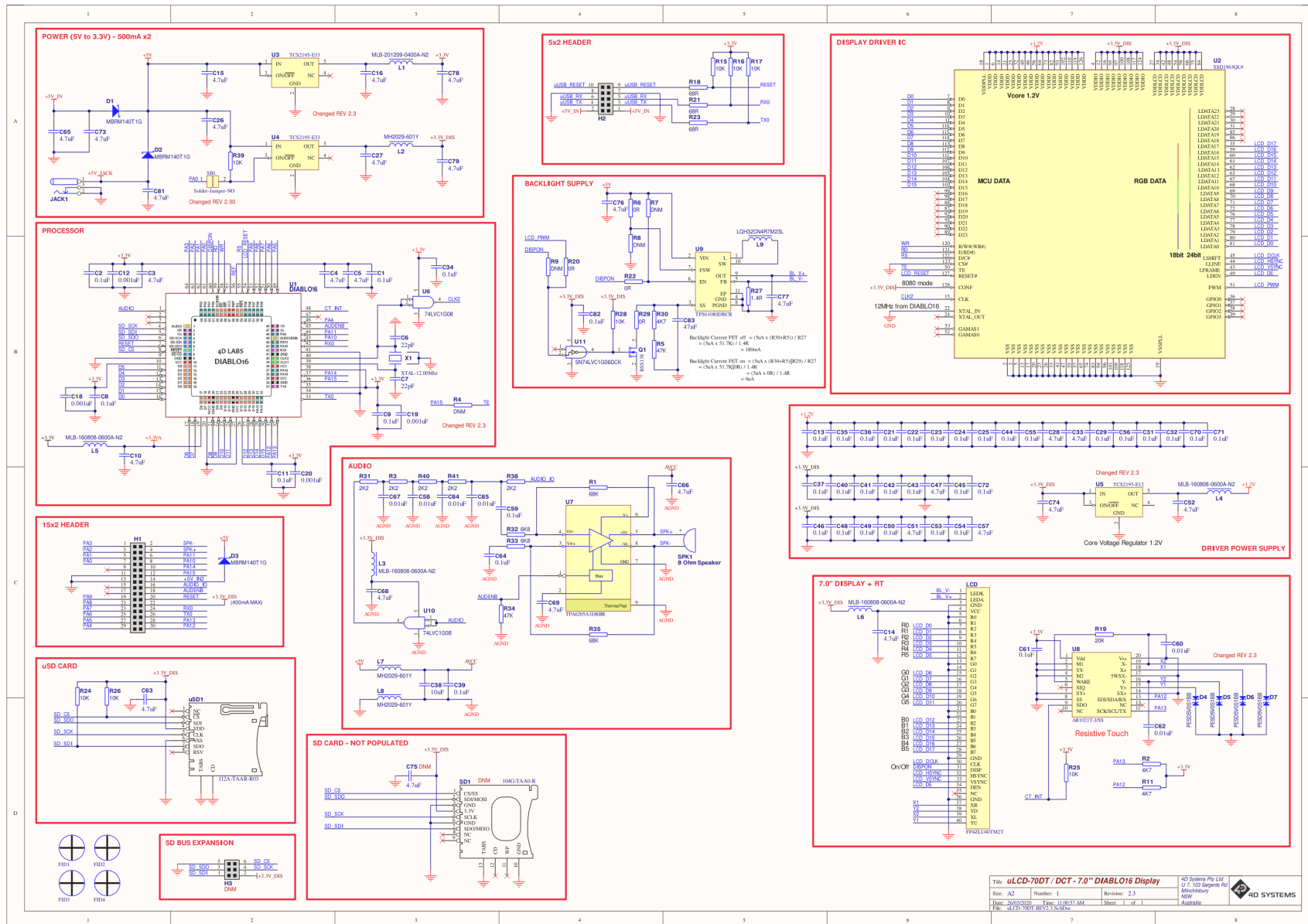


Title: uLCD-70D/DCT-7.0" DIABLO16 Display
 Rev: A2 / Number: 4D Systems Part List
 Date: 17/10/2015 / Time: 15:57 PM / Rev: 2.1 / (Rev. 2.1) Part List
 Pkg: uLCD-70D-REV1.1.SchDoc / Sheet: 1 of 1 / Author: ANP

17. Schematic Diagram - HW REV 2.2



18. Schematic Diagram - HW REV 2.3



19. Specifications

Absolute Maximum Ratings

Operating ambient temperature	-20°C to +70°C
Storage temperature	-30°C to +80°C
Voltage on any digital input pin with respect to GND	-0.3V to 6.0V
Voltage on VCC with respect to GND	-0.3V to 6.0V
Maximum current sunk/sourced by any pin	10.0mA
Maximum current sunk/sourced by all ports	200.0mA

Note

Stresses above those listed here may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the recommended operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Recommended Operating Conditions

Parameter	Conditions	Min	Typ	Max	Units
Supply Voltage (VCC)	Stable external supply required	4.0	5.0	5.5	V
Processor voltage (VP)		--	3.3	--	V
Operating Temperature		-10	--	+60	°C
Input Low Voltage (VIL)	all pins	0	--	0.2VP	V
Input High Voltage (VIH)	non 5V tolerant pins	0.8VP	--	3.3	V
Input High Voltage (VIH)	PA4-PA13, RX0 and TX0 pins	0.8VP	--	5.5	V
Reset Pulse	External Open Collector	2.0	--	--	µs
Operational Delay	Power-Up or External Reset	500	--	3000	ms

Global Characteristics Based on Operating Conditions

Parameter	Conditions	Min	Typ	Max	Units
Supply Current (ICC)	3.3V, heavily depends on screen usage conditions, sleep mode	--	500	--	mA
Output Low Voltage (VOL)	3.3V, IOL = 3.4mA	--	--	0.4	V
Output High Voltage (VOH)	3.3V, IOL = -2.0mA	2.4	--	--	V
Capacitive Loading	All pins	--	--	50	pF
Flash Memory Endurance	Diablo16 PmmC Programming	--	10000	--	E/W
LCD Backlight Operating Hours Endurance	Measured until the display is 50% original brightness, 25 degrees C.	--	30000	--	Hours

Ordering Information


Order Code:

uLCD-70D (Non-Touch)

uLCD-70DT (Resistive Touch)

Packaging: Module sealed in an antistatic foam padded 4D Systems box

20. Revision History

 Hardware Revision		
Revision Number	Date	Description
1.05	28/08/2013	Initial Public Release
1.06	26/03/2014	<ul style="list-style-type: none"> - Hardware fix for the DC Jack - this is now populated on this module - Change in 3.3V_DIS supply regulator. - Addition of additional protection diode on 5V pin on 30-way header, to prevent fighting with 5V supplies from 10 way and DC Jack. - Changed protection diodes to 1A, from 500mA rated versions. - Change in backlight driver components to manage display disconnection when powered, and heat, better.
2.0	07/05/2015	<ul style="list-style-type: none"> - Audio Amplifier circuitry has been improved to remove background noise. - Removal of R9 to allow more current on the 3.3V pin on the 30-way header, for the User. Can now deliver MAX 1A depending on the supply used. - The programming header has programming signals on both sides of the header now, rather than only one side is usable. - R40 resistor pads have been changed to be a solder bridge, to enable PA0 to enable/disable the secondary power supply, more easily. - Display backlight driver has been changed to one which is more efficient and effective, with less noise and heat. - Removal of 'Optional 4D Bus' headers. This will be replaced with a new bus system in REV 2.2 - A higher brightness 7" display is now used starting at this hardware revision. 470cd/m2 instead of 300cd/m2
2.1	22/06/2015	The 10-way programming header has moved in location. Please refer to the Mechanical Drawing . It has moved to the Left by 5.2mm and down by 0.2mm.
2.2	17/08/2015	Addition of 4D Bus expansion headers
2.3	26/03/2020	<ul style="list-style-type: none"> - Passive value changes and most passives changed to 0402 size due to manufacturing standard changes - Supplier of Regulators changed - functionality however is the same - Backlight Driver current values changed for better performance to match current displays - ESD Diodes added to RTP lines for better noise immunity - 4D Bus removed - Redundant CTP pads removed.

**Datasheet Revision**

Revision Number	Date	Description
1.2	08/09/2014	Initial Public Release Version
1.3	15/07/2015	Addition of HW Rev 2.1
1.4	19/08/2015	Addition of HW Rev 2.2
1.5	06/10/2015	Corrections on some technical Specifications
1.6	03/05/2017	Formatting and Date code changes
1.7	18/10/2017	Updated Recommended Operating Conditions table
1.8	04/03/2019	Cosmetic changes to uLCD-70D Series Datasheet
1.9	11/11/2019	Updated details regarding Serial Port voltage tolerance
1.10	26/03/2020	Updated HW Rev 2.2 and addition of HW Rev 2.3
1.11	06/01/2023	Modified datasheet for web-based documentation.