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4D SYSTEMS
TURNING TECHNOLOGY INTO ART

uLCD-70D
uLCD-70DT

7.0" DIABLO16 Intelligent Display Module

Document Date: 6th October 2015
Document Revision: 1.5

DATASHEET

Contents

uLCD-70DT Display Module

1. Description

The uLCD-70D range of display modules are 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, and is the largest size available from 4D Systems.

Driving the display and peripherals is the DIABLO16 processor, a very capable and powerful chip which enables stand-alone functionality, programmed using the 4D Systems Workshop 4 IDE Software. The Workshop IDE enables graphic solutions to be constructed rapidly and with ease due to its design being solely for 4D's 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 memory.
- Dedicated raw PWM Audio pin driven by WAV files from 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 ~215 g.
- 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
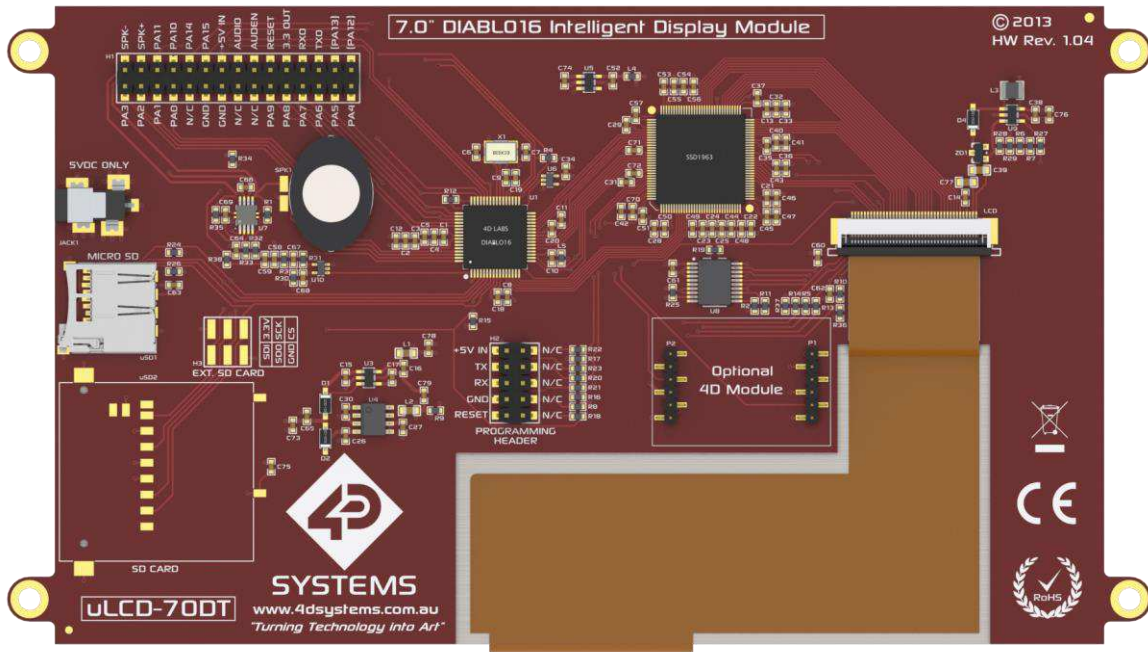
NOTE: Full Sized SD socket and EXT. SD Card Header (H3) are NOT populated,
Populated on special orders only. JACK1 (5V DC JACK) NOT populated until HW Rev. 1.06
Optional 4D Module socket removed in HW Rev 2.0+, to be replaced by a new bus system in HW Rev 2.2

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. 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 microLCD. 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 microLCD. 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.

I = Input, O = Output, P = Power

NOTE: 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.

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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. 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.
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 Section 4.2
29	PA4	I/O	General Purpose I/O. This pin is 5.0V tolerant.
30	PA12	I/O	(RESERVED FOR RESISTIVE TOUCH) – See Section 4.2

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 utilising 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 Serial

The DIABLO16 Processor has three hardware asynchronous serial ports (COM1 – COM3) that can be configured on a variety of the processors 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 or 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.
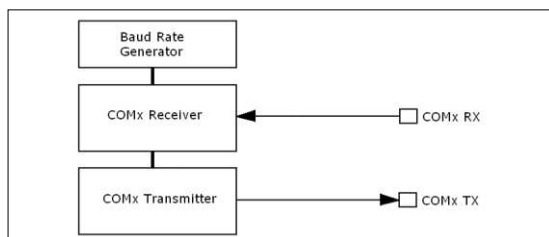
A single byte serial transmission consists of the start bit, 8-bits of data followed by the stop bit. The start bit is always 0, while a stop bit is always 1. The LSB (Least Significant Bit, Bit 0) is sent out first following the start bit. Figure below shows a single byte transmission timing diagram.
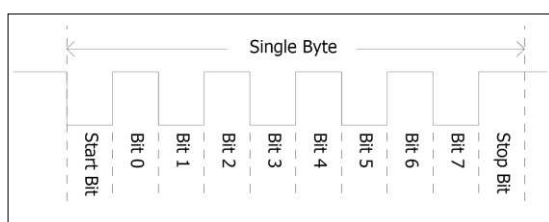
COM0 is also the primary interface for 4DGL user program downloads and chip configuration PmmC programming. Once the compiled 4DGL application program (EVE byte-code) is downloaded and the user code starts executing, the serial port is then available to the user application. Refer to Section 5 for more details on PmmC/Firmware programming.

TX0 pin (Serial Transmit COM0):
Dedicated Asynchronous Serial port COM0 transmit pin, TX0. Connect this pin to 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 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 external serial device receive (Rx) signal. This pin is 5.0V tolerant. This can be configured to 1 of the GPIO pins, see table below.

RX1 pin (Serial Receive COM1):
Asynchronous Serial port COM1 receive pin, RX1. Connect this pin to external serial device transmit (Tx) signal. This pin is 5.0V tolerant. This can be configured to 1 of the GPIO pins, see table below.

TX2 pin (Serial Transmit COM2):
Asynchronous Serial port COM2 transmit pin, TX2. Connect this pin to external serial device receive (Rx) signal. This pin is 5.0V tolerant. This can be configured to 1 of the GPIO pins, see table below.

RX2 pin (Serial Receive COM2):
Asynchronous Serial port COM2 receive pin, RX2. Connect this pin to external serial device transmit (Tx) signal. This pin is 5.0V tolerant. This can be configured to 1 of the GPIO pins, see table below.

TX3 pin (Serial Transmit COM3):
Asynchronous Serial port COM3 transmit pin, TX3. Connect this pin to external serial device receive (Rx) signal. This pin is 5.0V tolerant. This can be configured to 1 of the GPIO pins, see table below.

RX3 pin (Serial Receive COM3):
Asynchronous Serial port COM3 receive pin, RX3. Connect this pin to external serial device transmit (Tx) signal. This pin is 5.0V tolerant. This can be configured to 1 of the GPIO pins, see table below.

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DIABLO16 Serial TTL Comm Port Configuration Options						
	TX1	RX1	TX2	RX2	TX3	RX3
PA0		✓		✓		✓
PA1	✓	✓	✓	✓	✓	✓
PA2		✓		✓		✓
PA3	✓	✓	✓	✓	✓	✓
PA4	✓	✓	✓	✓	✓	✓
PA5	✓	✓	✓	✓	✓	✓
PA6	✓	✓	✓	✓	✓	✓
PA7	✓	✓	✓	✓	✓	✓
PA8	✓	✓	✓	✓	✓	✓
PA9	✓	✓	✓	✓	✓	✓
PA10		✓		✓		✓
PA11		✓		✓		✓
PA12	✓	✓	✓	✓	✓	✓
PA13	✓	✓	✓	✓	✓	✓
PA14						
PA15						

Please refer to the '*DIABLO16-4DGL-Internal-Functions.pdf*' document 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 of individual bit operations along with serving collectively for byte wise operations using the BUS functions

DIABLO16 Alternate Pin Configurations General Purpose I/O					
	Digital Input	Digital Output	Bus Read	Bus Write	Analog Read
PA0	✓	✓	✓	✓	✓
PA1	✓	✓	✓	✓	✓
PA2	✓	✓	✓	✓	✓
PA3	✓	✓	✓	✓	✓
PA4	✓	✓	✓	✓	
PA5	✓	✓	✓	✓	
PA6	✓	✓	✓	✓	
PA7	✓	✓	✓	✓	
PA8	✓	✓	✓	✓	
PA9	✓	✓	✓	✓	
PA10	✓	✓	✓	✓	
PA11	✓	✓	✓	✓	

PA12	✓	✓	✓	✓	
PA13	✓	✓	✓	✓	
PA14	✓	✓	✓		
PA15	✓	✓	✓		

Please refer to the separate document titled '*DIABLO16-4DGL-Internal-Functions.pdf*' for more information.

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 Chapter 17, 'Specifications and Ratings'.
When set as Analog Inputs, the pins have a 0 to 3.3V range, and have 12 bit resolution.
For more information, see Section 4.11 'Analog Inputs'.

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 Section 14, 'Specifications and Ratings'.

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 Section 14, 'Specifications and Ratings'.

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. 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 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 2μs 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 enable or disable and 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 into the on-board amplifier, but also with the filtered PWM output from the DIABLO16 Processor. This pin can be used to input a signal into the on-board amplifier to play audio from an external device using the on-board 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 Funtions - 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, I^{2}C, 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 alternative functions.

DIABLO16 Alternate Pin Configurations I/O Support Functions			
	Pulse Out	**PWM Out**	**Pin Counter**	**Quadrature In**

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

The previous table illustrates which of the GPIO can be used for the four different I/O Support Functions.

> **Note:** Once a pin is allocated to an alternate function, another pin cannot also be allocated to the same alternate function.

Please refer to the separate document titled '*DIABLO16-4DGL-Internal-Functions.pdf*' 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

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communication based functions, and I/O support based functions.

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

Note: Quadrature In requires 2 Pins

The following table illustrates which of the GPIO can be used 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		✓			✓			✓	
PA1	✓	✓	✓	✓	✓	✓	✓	✓	✓
PA2		✓			✓			✓	
PA3	✓	✓	✓	✓	✓	✓	✓	✓	✓
PA4	✓	✓	✓	✓	✓	✓	✓	✓	✓
PA5	✓	✓	✓	✓	✓	✓	✓	✓	✓
PA6	✓	✓	✓	✓	✓	✓	✓	✓	✓
PA7	✓	✓	✓	✓	✓	✓	✓	✓	✓
PA8	✓	✓	✓	✓	✓	✓	✓	✓	✓
PA9	✓	✓	✓	✓	✓	✓	✓	✓	✓
PA10		✓			✓			✓	
PA11		✓			✓			✓	
PA12	✓	✓	✓	✓	✓	✓	✓	✓	✓
PA13	✓	✓	✓	✓	✓	✓	✓	✓	✓
PA14									
PA15									

The following table illustrates which of the GPIO can be used for the three different I^2C channels available.

DIABLO16 Alternate Pin Configurations I^2C Communications						
	I^2C1 SDA	I^2C1 SCL	I^2C2 SDA	I^2C2 SCL	I^2C3 SDA	I^2C3 SCL
PA0	✓	✓	✓	✓	✓	✓
PA1	✓	✓	✓	✓	✓	✓
PA2	✓	✓	✓	✓	✓	✓
PA3	✓	✓	✓	✓	✓	✓
PA4	✓	✓	✓	✓	✓	✓
PA5	✓	✓	✓	✓	✓	✓
PA6	✓	✓	✓	✓	✓	✓
PA7	✓	✓	✓	✓	✓	✓
PA8	✓	✓	✓	✓	✓	✓
PA9	✓	✓	✓	✓	✓	✓
PA10	✓	✓	✓	✓	✓	✓
PA11	✓	✓	✓	✓	✓	✓
PA12	✓	✓	✓	✓	✓	✓
PA13	✓	✓	✓	✓	✓	✓
PA14		SPECIAL		SPECIAL		SPECIAL
PA15	SPECIAL		SPECIAL		SPECIAL	

SPECIAL – please see Section 4.6

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 on the previous page for details on which GPIO can be configured for SPI.

Note: The additional SPI channel (SPI0) is dedicated to 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 is the 4DGL application.

Please refer to the separate document titled '*DIABLO16-4DGL-Internal-Functions.pdf*' for more information on how to use the SPI functions, along with the separate document titled '*DIABLO16-Processor-Datasheet-REVx.x.pdf*'.

4.6. I2C

There are 3 user configurable I^2C channels available for mapping to GPIO, for use by the user for the target application. All 3 I^2C channels are Master only, and cannot be configured to be slaves at this time.

Please refer to the table on the previous page for details on which GPIO can be configured for I^2C.

To map an I^2C 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 use of these pins has a few limitations.
> a) There is no slew rate control at I2C_MED
> b) I2C_FAST is not truly 1MHz.
> If either of these restrictions need 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 separate document titled '*DIABLO16-4DGL-Internal-Functions.pdf*' for more information on how to use the I^2C functions, along with the separate document titled '*DIABLO16-Processor-Datasheet-REVx.x.pdf*'.

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 is 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 on the previous page for details on which GPIO can be configured to this.

> **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 separate document titled '*DIABLO16-4DGL-Internal-Functions.pdf*' for more information on how to use the Pulse Out functions, along with the separate document titled '*DIABLO16-Processor-Datasheet-REVx.x.pdf*'.

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 on the previous page for details on which GPIO can be configured for 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 being 0 degrees and 2ms being 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 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 which defined the PWM pulse itself.

Please refer to the separate document titled '*DIABLO16-4DGL-Internal-Functions.pdf*' for more information on how to use the PWM functions, along with the separate document titled '*DIABLO16-Processor-Datasheet-REVx.x.pdf*'.

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 in section 4.4 'Alternate Pin Functions – Overview' for details on which GPIO can be configured for this.

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

pin_Counter(pin, mode, OVFfunction);

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

Please refer to the separate document titled '*DIABLO16-4DGL-Internal-Functions.pdf*' for more information on how to use the Pin Counter functions, along with the separate document titled '*DIABLO16-Processor-Datasheet-REVx.x.pdf*'.

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 on the previous page 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 Quencoder1 or Quencoder2 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 separate document titled '*DIABLO16-4DGL-Internal-Functions.pdf*' for more information on how to use the Quadrature Input functions, along with the separate document titled '*DIABLO16-Processor-Datasheet-REVx.x.pdf*'.

4.11. Analog Inputs

Please refer to the table in section 4.2 for details on which GPIO can be configured to be analog inputs.

The analog inputs on the DIABLO16 have a range of 0 to 3.3V, each with a max resolution of 12-bits.

The analog inputs can be read using three modes, standard mode, averaged mode or high speed mode.

Standard Mode results in a sample being immediately read. Standard Mode can read over 40000 values per second. Operates at 12-bit.

Averaged Mode results in a 16 sample being immediately read and their average returned. Averaged Mode can read approximately 20000 values per second. Operates at 12-bit.

Highspeed Mode collects a user specified number of samples at a user specified rate/frequency and

uLCD-70DT Display Module

can execute a user function when complete. The updated value updates approximately 250000 times across 1-4 channels. Operates at 10-bit.

To enable a GPIO to be used as an Analog Input for Standard or Averaged modes, the following 4DGL function is used 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, the following 4DGL function is used 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' → '4buf' are the buffer addresses for the 4 channels, and 'func' is the user function to call when the number of samples specified have been collected.

Please refer to the separate document titled '*DIABLO16-4DGL-Internal-Functions.pdf*' for more information on the Analog Input functions, along with the separate document titled '*DIABLO16-Processor-Datasheet-REVx.x.pdf*'.

5. PmmC/Firmware Programming

The DIABLO16 processor is a custom graphics processor. All functionality including the high level commands are 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 define the characteristics and functionality of the device. The ability of programming 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 are 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 to the display.

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

The data sheet for the processor is available from the http://www.4dsystems.com.au website: *"DIABLO16-Processor-Datasheet-REVx.pdf"*

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 on-board 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: *"DIABLO16-4DGL-Internal-Functions.pdf"*

Note: The on-board 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 'Hardware Interface Pins' – 'System Pins' section for more information.

6.4. SD/SDHC Memory Cards

The module supports micro-SD memory cards via the on-board 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 lock ups 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 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 of time. 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 temperature 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 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 4D Systems, www.4dsystems.com.au

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

4D Programming Cable

uUSB-PA5 Programming Adaptor

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9. 4DGL - Software Language

The uLCD-70 modules utilise the DIABLO16 processor, which belongs to a family of processors powered by a highly optimised soft core 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 ground up for the EVE engine core. It is a high level language which 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.
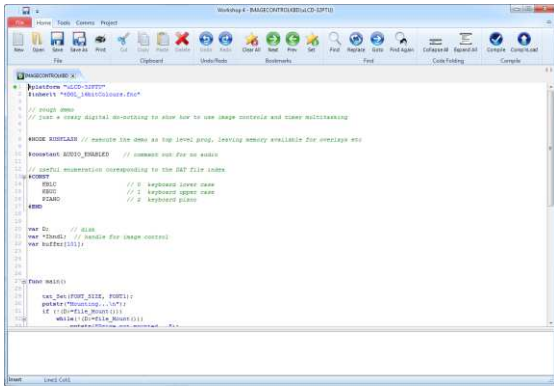
For detailed information pertaining to the 4DGL language, please refer to the following documents:
"4DGL-Programmers-Reference-Manual.pdf"
"DIABLO16-4DGL-Internal-Functions.pdf"

To assist with the development of 4DGL applications, the Workshop 4 IDE combines a full-featured editor, a compiler, a linker and a down-loader 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 Workshop 4 IDE, Designer and ViSi.

10. 4D Systems - Workshop 4 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 for different user requirements and skill level.

- 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. www.4dsystems.com.au

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.

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10.1. Workshop 4 – Designer Environment

Choose the Designer environment to write 4DGL code in its raw form.

The Designer environment provides the user with a simple yet effective programming environment where pure 4DGL code can be written, compiled and downloaded to the uLCD-70 module.

10.2. Workshop 4 – ViSi Environment

ViSi was designed to make the creation of graphical displays a more visual experience.

ViSi is a great software tool that allows the user to see the instant results of their desired graphical layout. Additionally, there is a selection of inbuilt dials, gauges and meters that can simply be placed onto the simulated module display. From here each object can have its properties edited, and at the click of a button all relevant 4DGL code associated with that object is produced in the user program. The user can then write 4DGL code around these objects to utilise them in the way they choose.
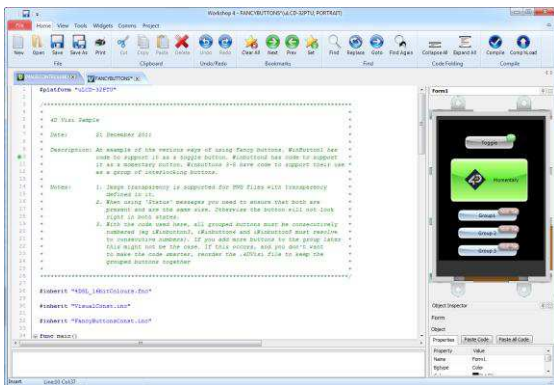
10.3. Workshop 4 – ViSi Genie Environment

ViSi Genie is a breakthrough in the way 4D Systems' graphic display modules are programmed. It is an environment like no other, a code-less programming environment that provides the user with a rapid visual experience, enabling a simple GUI application to be 'written' from scratch in literally seconds.

ViSi Genie does all the background coding, no 4DGL to learn, it does it all for you.

Pick and choose the relevant objects to place on the display, much like the ViSi Environment yet without having to write a single line of code. Each object has parameters which can be set, and configurable events to animate and drive other objects or communicate with external devices.

Simply place an object on the screen, position and size it to suit, set the parameters such as colour, range, text, and finally select the event you wish the object to be associated with, it is that simple.

In seconds you can transform a blank display into a fully animated GUI with moving sliders, animated press and release buttons, and much more. All without writing a single line of code!

ViSi Genie provides the user with a feature rich rapid development environment, second to none.

10.4. Workshop 4 – Serial Environment

The Serial environment in the Workshop 4 IDE provides the user the ability to transform the uLCD-70 into a slave serial graphics controller.

This enables the user to use their favourite microcontroller or serial device as the Host, without having to learn 4DGL or program in a separate IDE. Once the uLCD-70 is configured and downloaded to from the Serial Environment,

simple graphic commands can be sent from the users host microcontroller to display primitives, images, sound or even video.
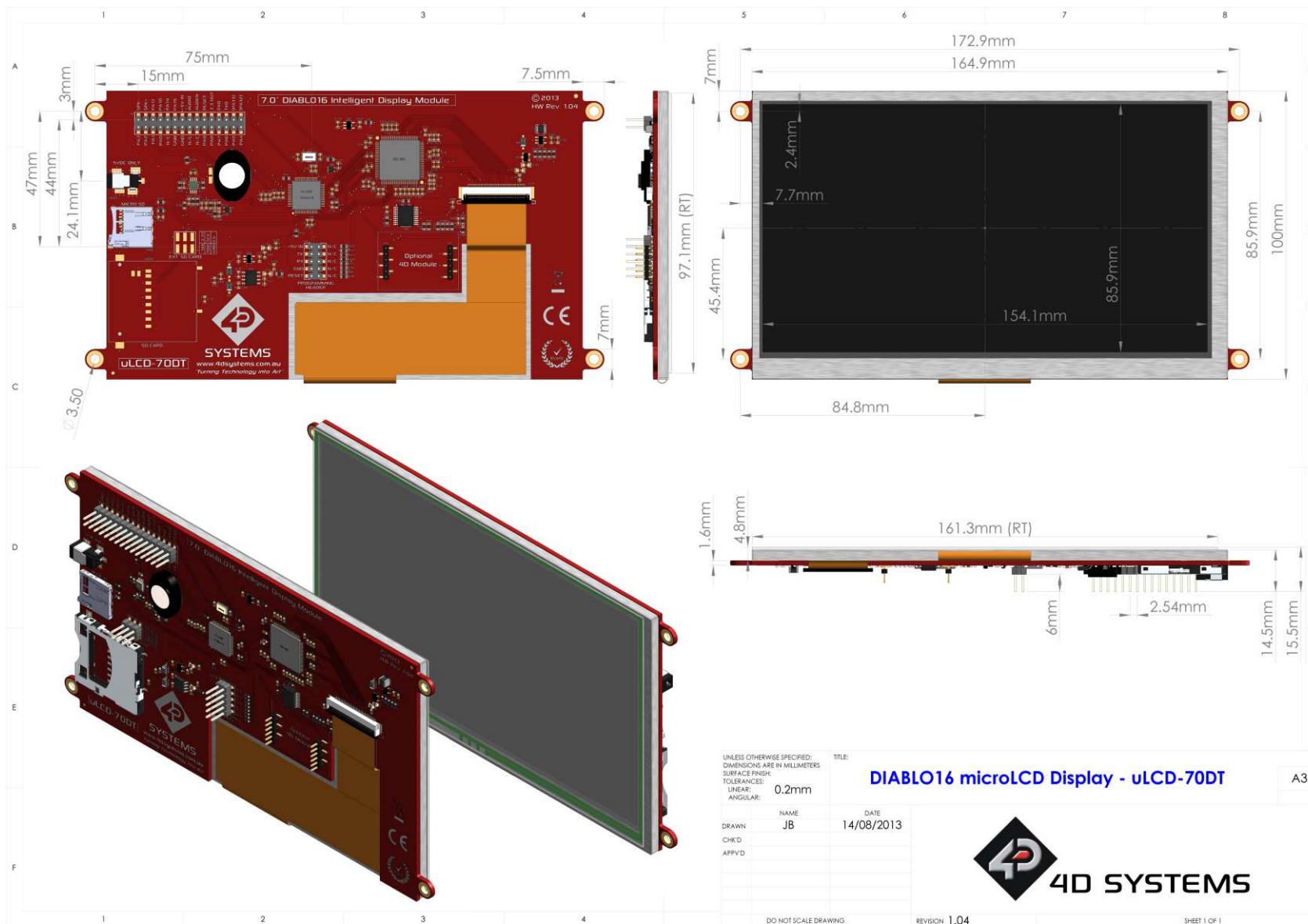
Refer to the "**Serial Command Set Reference Manual**" from the Workshop 4 product page on the 4D Systems website for a complete listing of all the supported serial commands

By default, each module shipped from the 4D Systems factory will come pre-programmed ready for use in the Serial mode.

uLCD-70DT Display Module

uLCD-70DT Display Module

11. Notes

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12. Scribble Box

uLCD-70DT Display Module

13. Mechanical Details – HW REV 1.05/1.06
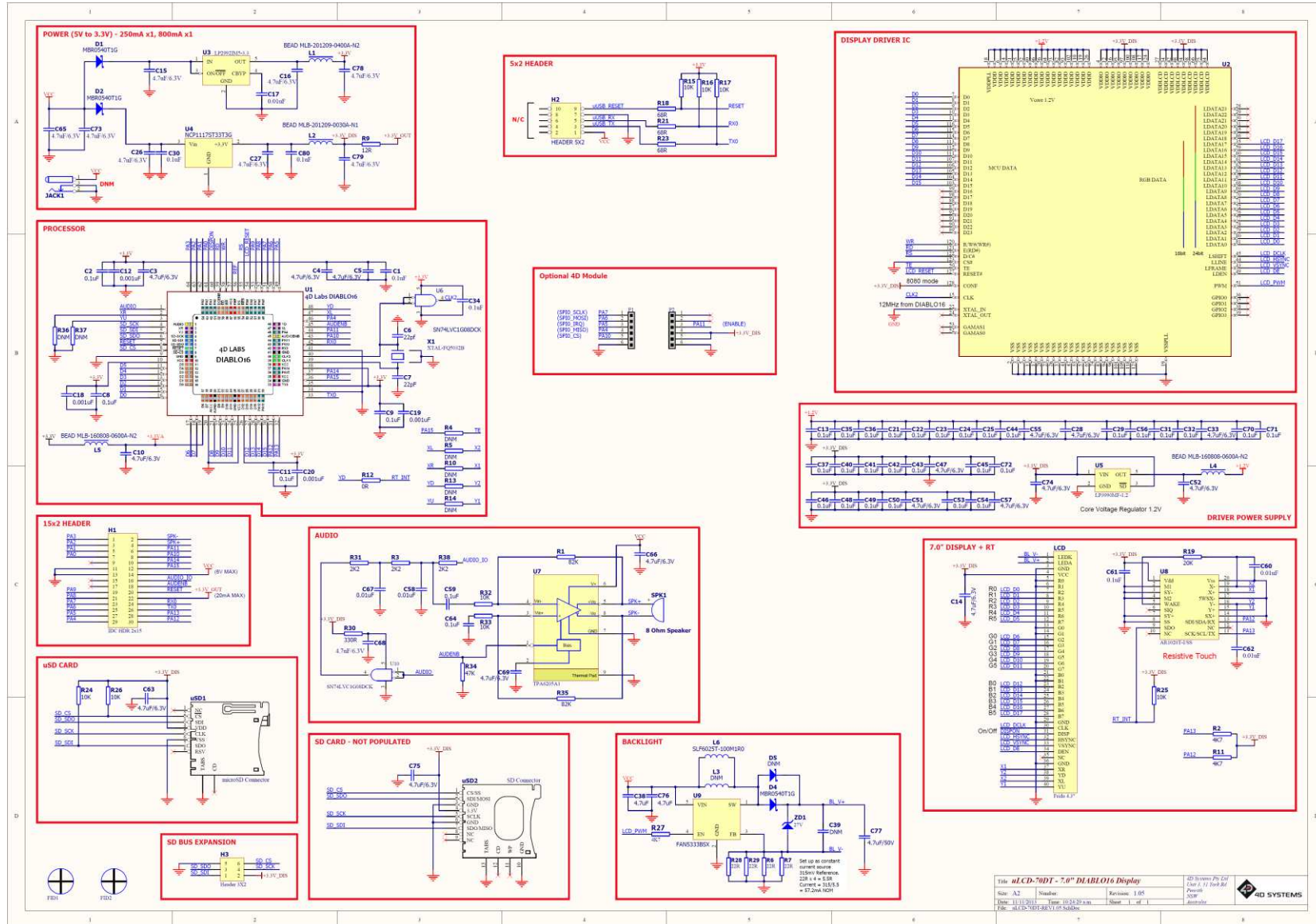
uLCD-70DT Display Module

14. Mechanical Details – HW REV 2.1

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 Tocuh model.

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: 0.2mm ANGULAR:	TITLE: DIABLO16 microLCD Display - uLCD-70D/DT	A3

	NAME	DATE
DRAWN	4D	15/07/2015
CHK'D		
APPV'D		

DO NOT SCALE DRAWING	REVISION 2.1	SHEET 1 OF 1

4D SYSTEMS

15. Schematic Diagram – HW REV 1.05

uLCD-70DT Display Module

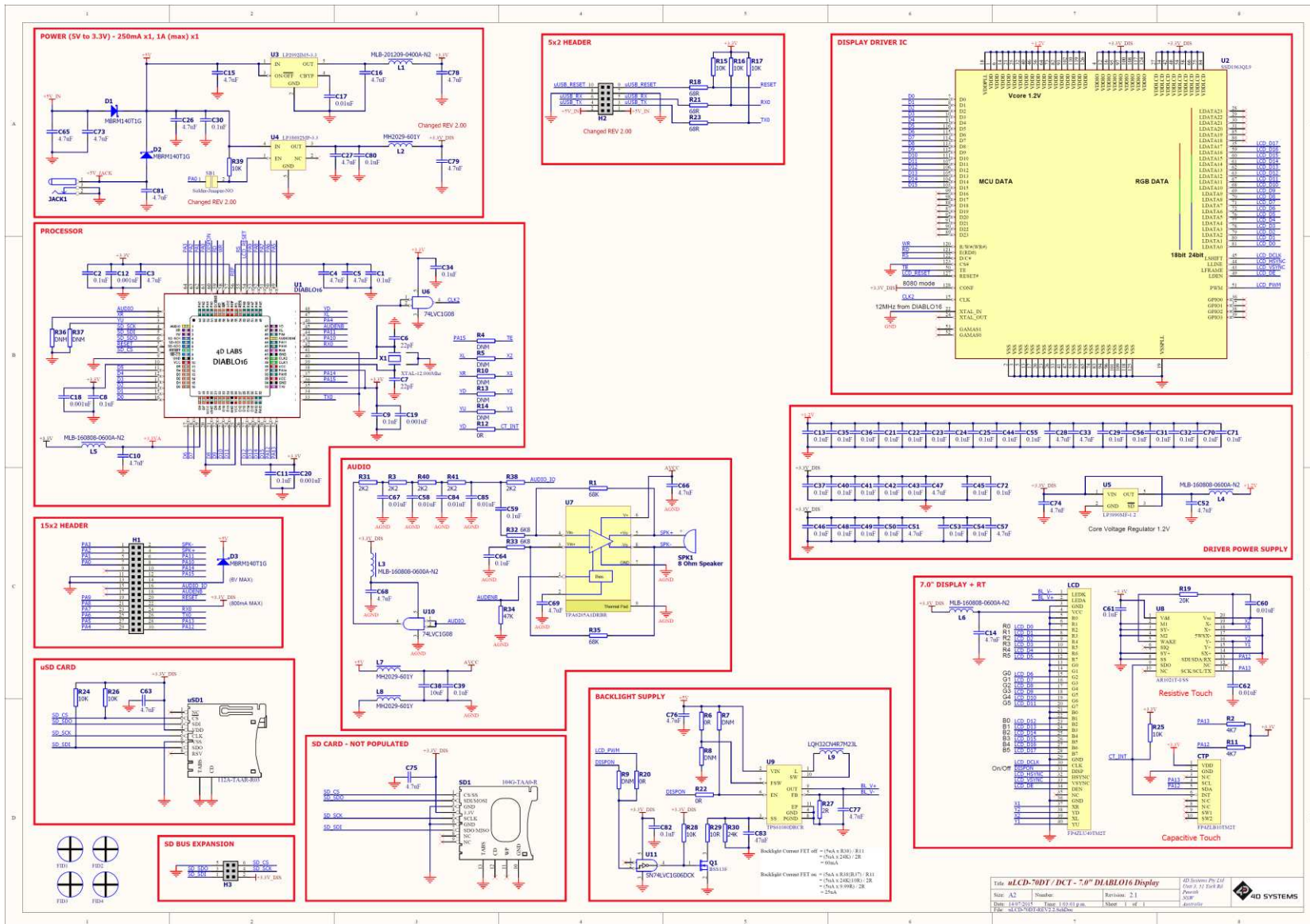**uLCD-70DT Display Module**

16. Schematic Diagram – HW REV 1.06
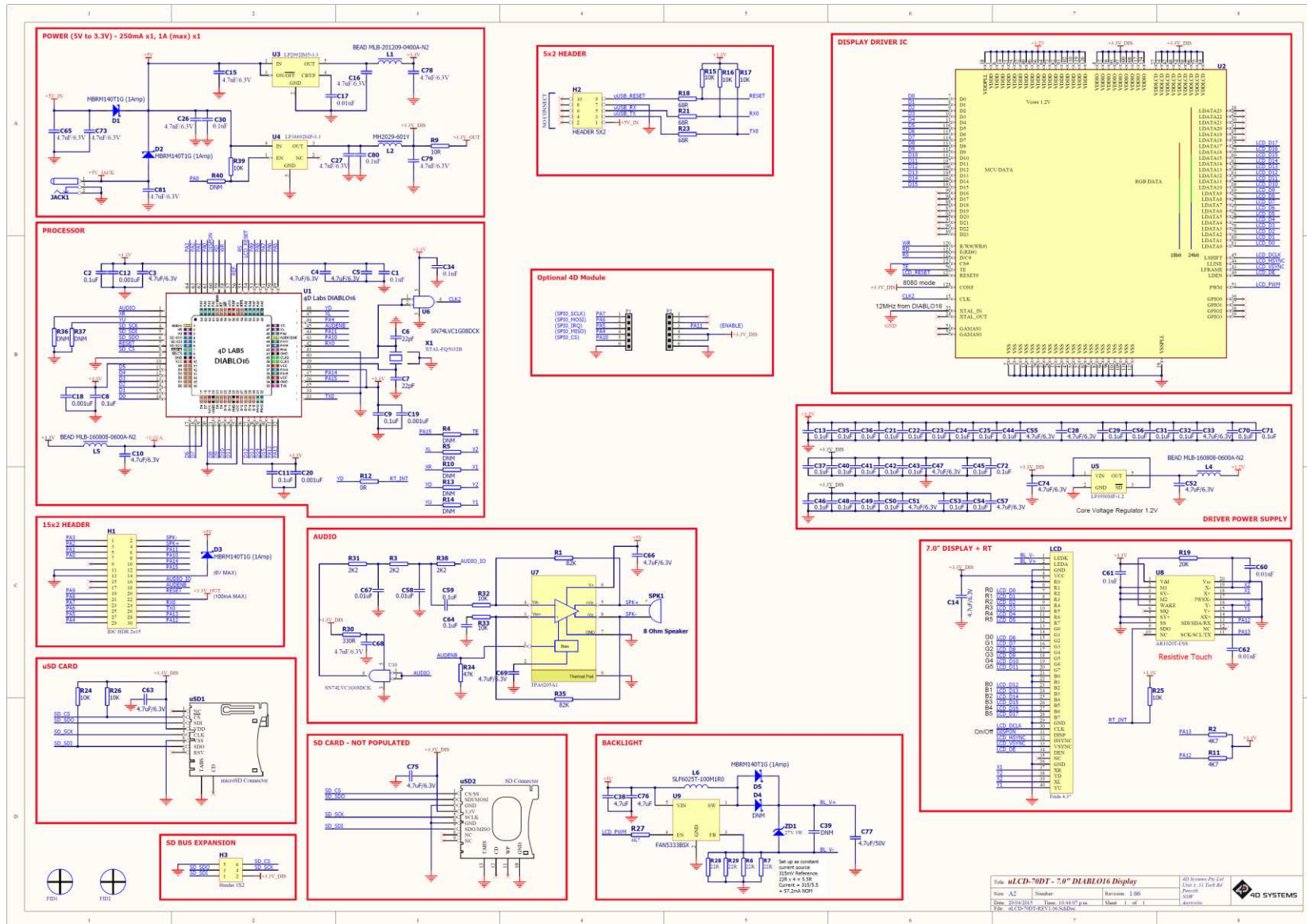
17. Schematic Diagram – HW REV 2.1

uLCD-70DT Display Module

18. Schematic Diagram – HW REV 2.2

uLCD-70DT Display Module