DATASHEET

4D SYSTEMS

TURNING TECHNOLOGY INTO ART

4.3” DIABLO16 Intelligent Display Module

uLCD-43D/DT/DCT

D – Display Only Version
DT – Resistive Touch Version
DCT – Capacitive Touch Version

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Please refer to the 4D Systems website for the latest Revision of this document

Contents

1. Description 4

2. Features 4

3. Pin Configuration and Summary 5

4. Hardware Interface - Pins 7

4.1. Serial Ports – TTL Level Serial 7

4.2. General Purpose I/O 8

4.3. System Pins 9

4.4. Alternate Pin Funtions - Overview 9

4.5. SPI 10

4.6. I2C 11

4.7. Pulse Out 11

4.8. PWM Out 11

4.9. Pin Counter 12

4.10. Quadrature In 12

4.11. Analog Inputs 12

5. PmmC/Firmware Programming 13

6. Module Features 14

6.1. Display – 4.3” TFT Touch Screen 14

6.2. DIABLO16 Processor 14

6.3. Audio 14

6.4. SD/SDHC Memory Cards 14

6.5. FAT16 15

7. Display Precautions 15

8. Hardware Tools 15

8.1. 4D Programming Cable/Adaptor 15

9. 4DGL - Software Language 16

10. 4D Systems - Workshop 4 IDE 16

10.1. Workshop 4 – Designer Environment 17

10.2. Workshop 4 – ViSi Environment 17

10.3. Workshop 4 – ViSi Genie Environment 17

10.4. Workshop 4 – Serial Environment 18

11. Starter Kit 18

12. Notes 19

13. Scribble Box 19

14. Mechanical Details 20

15. Schematic Diagram – HW REV 2.0 21

16. Comparison between uLCD-43P and uLCD-43D based display modules 22

16.1. Comparison Table 22

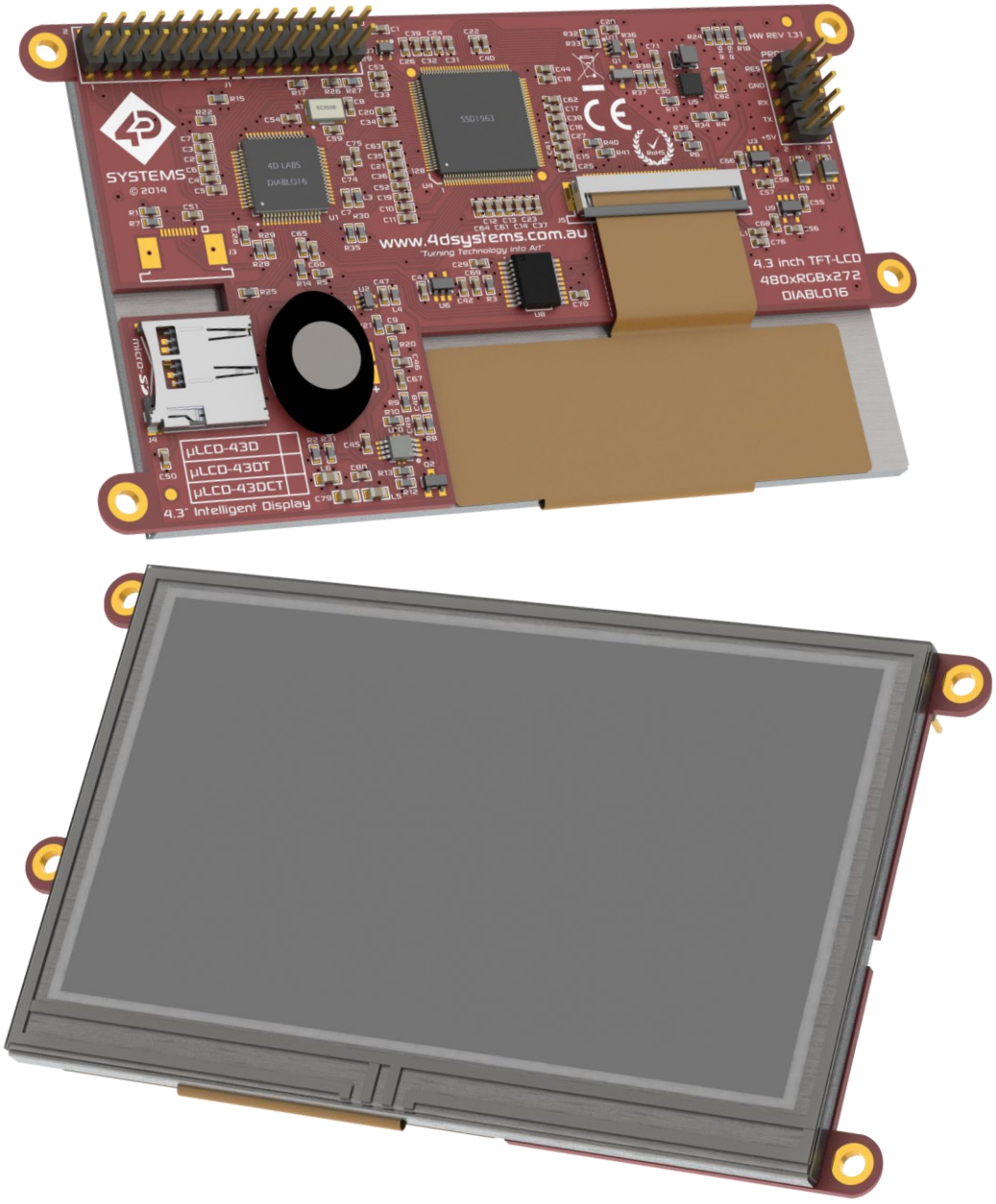
16.2. Differences in the GPIO – For upgrading from uLCD-43P to uLCD-43D 22

17. Specifications and Ratings 23

18. Hardware Revision History 24

19. Legal Notice 25

20. Contact Information 25



1. Description

The uLCD-43D/DT/DCT is an upgrade to the favourite uLCD-43P/PT/PCT range of 4.3" Intelligent Display Modules, now powered by the 4D Systems' DIABLO16 Graphics Processor.

The uLCD-43D/DT/DCT intelligent display modules are designed for applications demanding a good sized intelligent display module, and where performance is important, along with a good amount of Flash and RAM.

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 or uLCD-43P/PT/PCT intelligent display 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-43D/DT/DCT Module.

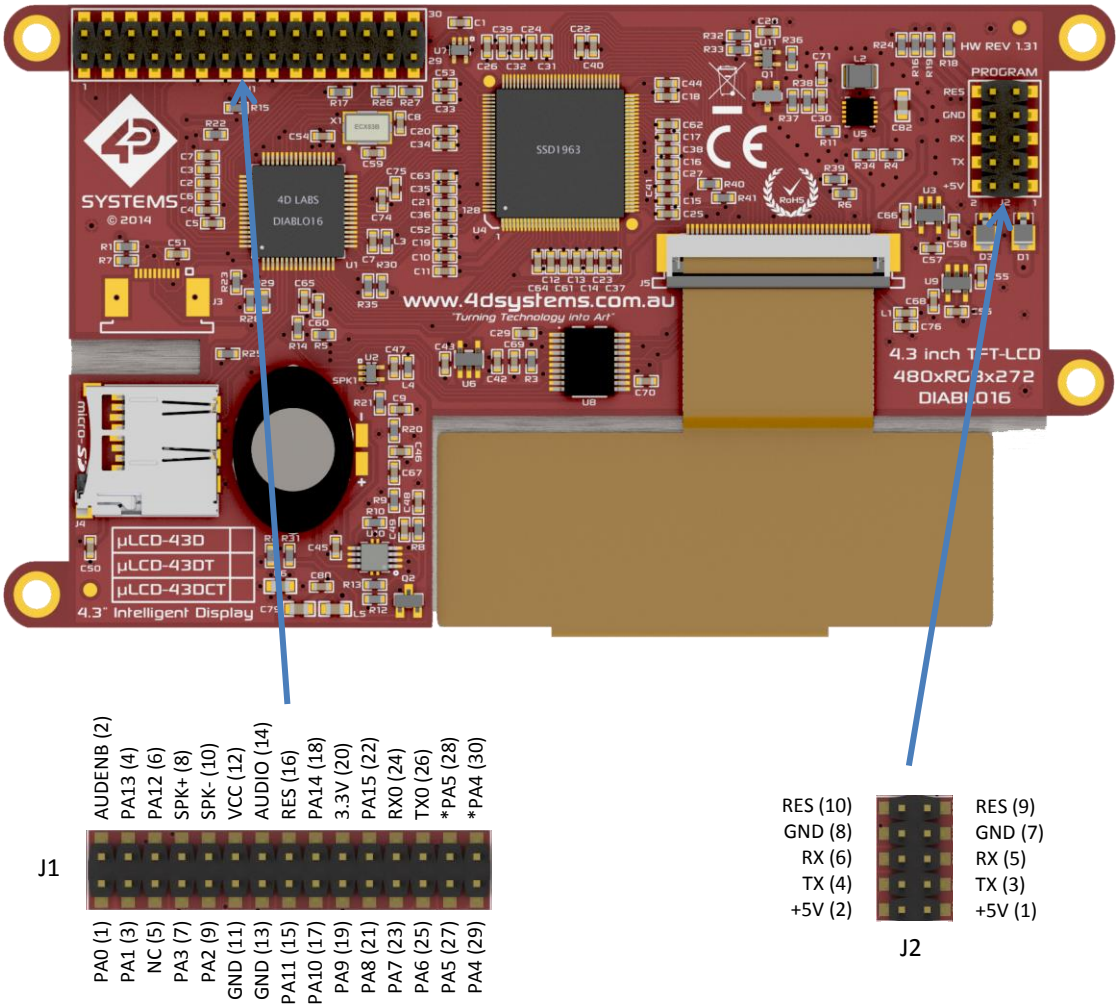
A table in included in this datasheet to outline the main differences between the uLCD-43P versions and the uLCD-43D version.

2. Features

- Powerful 4.3" Intelligent LCD-TFT display module powered by DIABLO16.
- 480 x 272 Resolution, RGB 65K true to life colours, TFT Screen with integrated 4-wire Resistive Touch Panel.
- 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 I^2C 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: 119.5 x 67.0 x 15.2mm (including tabs) – See drawing, Weighing ~80 g.
- Display Viewing Area: 95.04 x 53.85mm
- 4x mounting tabs with 3.0mm holes for mechanical mounting.
- RoHS and CE Compliant.

3. Pin Configuration and Summary



J2 Pinout (Programming Header)			
Pin	**Symbol**	**I/O**	**Description**
1, 2	+5V	P	Main Voltage Supply +ve input pin. Reverse polarity protected. Range is 4.5V to 5.5V, nominal 5.0V.
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. This pin is tolerant up to 5.0V levels.
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. This pin is tolerant up to 5.0V levels.
7, 8	GND	P	Supply Ground
9, 10	RES	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.

Continued overleaf...

I = Input, O = Output, P = Power

J1 Pinout (I/O Expansion Header)			
Pin	**Symbol**	**I/O**	**Description**
1	PA0	I/O/A	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	AUDENB	O	Audio Amplifier Enable, to enable external amplifier
3	PA1	I/O/A	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	PA13	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant. Used for I2C for Resistive and Capacitive Touch on the uLCD-43DT and uLCD-43DCT models. Please refer to Section 4.2 under heading PA12-PA13 for more information.
5	NC	-	Not connected
6	PA12	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant. Used for I2C for Resistive and Capacitive Touch on the uLCD-43DT and uLCD-43DCT models. Please refer to Section 4.2 under heading PA12-PA13 for more information.
7	PA3	I/O/A	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, also used for Bus Read
8	SPK+	O	Speaker Output + Can connect to external speaker (disconnect on-board)
9	PA2	I/O/A	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, also used for Bus Write
10	SPK-	O	Speaker Output – Can connect to external speaker (disconnect on-board)
11	GND	P	Supply Ground
12	+5V	P	Supply Input +ve, 4.0V to 5.5V, 5.0V Nominal
13	GND	P	Supply Ground
14	AUDIO_OUT	O	Audio Output, to feed into external amplifier
15	PA11	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
16	RES	I	Master Reset, Active Low (GND) (Refer J2 Pinout)
17	PA10	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
18	PA14	I/O	General Purpose Input/Output, 3.3V Level – only 3.3V Tolerant
19	PA9	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
20	3.3V	I	Regulated 3.3 Volts output, maximum available current 250mA (HW REV 2.0, previously 150mA) to power external circuitry.
21	PA8	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
22	PA15	I/O	General Purpose Input/Output, 3.3V Level – only 3.3V Tolerant
23	PA7	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
24	RX0	I	Asynchronous serial port 0 receive pin. COM0 (same as the RX pin on the J2 Programming Header). 3.3V Level - 5V Tolerant
25	PA6	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
26	TX0	O	Asynchronous serial port 0 transmit pin. COM0 (same as the TX pin on the J2 Programming Header). 3.3V Level Output.
27	PA5	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
28	-	-	Connected to PA5, to allow this pin to be used as Serial TX1 like uLCD-43P
29	PA4	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
30	-	-	Connected to PA4, to allow this pin to be used as Serial RX1 like uLCD-43P

I = Input, O = Output, P = Power, A = Analog Input

4. Hardware Interface - Pins

The uLCD-43D/DT/DCT Module provides both a hardware and software interface. This section describes in detail the hardware interface pins of the device.

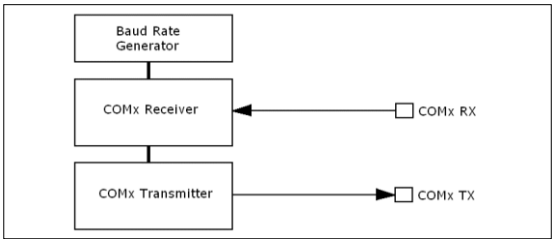
4.1. Serial Ports – TTL Level Serial

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.

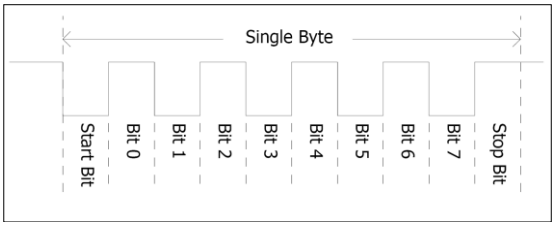
TX/RX0 are referred to as COM0, and is the only one used for programming the DIABLO16 itself.

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 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.

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 used for the resistive touch controller or capacitive touch controller, on the uLCD-43DT or uLCD-43DCT models. These pins should ideally not to be used for other I2C devices on these models, else it may impact Touch performance. These signals feature 4.7K pull up resistors on PA12 and PA13. These signals are present on the J1 Header and are not used for touch on the uLCD-43D so are available as GPIO on this model. 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. These pins can be used for high speed I2C, please refer to Section 4.6 for more information.

4.3. System Pins

+5V IN (Module Voltage Input)
J1 Pin 12, J2 Pin 1
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.

3.3V_OUT (3.3V Output)
J1 Pin 20:
3.3V Output for the user, 250mA (HW REV 2.0, previously 150mA). Used for powering small external devices or components.

GND (Module Ground)
J1 Pin 11/13, J2 Pin 7/8
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)
J1 Pin 16, J2 Pin 9/10:
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)
J1 Pin 2:
Output dedicated to enable or disable and external amplifier, where required. Active Low.

AUDIO (PWM Audio Input/Output)
J1 Pin 14:
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 (low) 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^2C, 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
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 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 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);

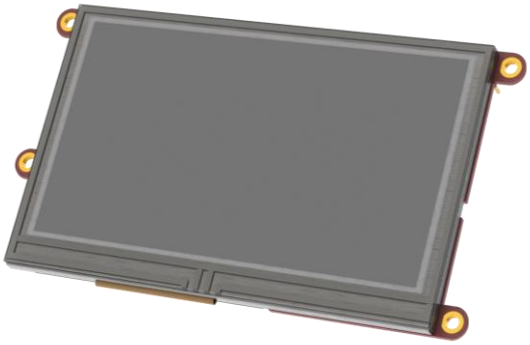
Where 'mode' is the desired mode defined above, either Standard or Averaged, and 'pin' is the GPIO compatible with this function which is to become an Analog Input.

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-43D/DT/DCT module is designed to accommodate most applications. Some of the main features of the module are listed below.

6.1. Display – 4.3" TFT Touch Screen

The uLCD-43D/DT/DCT module is equipped with a 4.3" TFT display. Details of the display are listed below:

- Screen Size: 4.3" diagonal, 480x272 resolution, 65K colours
- Integrated 4-Wire Resistive Touch Screen (DT)
- Integrated Capacitive Touch Screen (DCT)
- Screen Dimensions: 105.5 x 67.2 x 4.2mm
- Viewing Area: 95.04 x 53.85mm
- Pixel Pitch: 0.066(H) x 0.198(V)mm
- Brightness: 480cd/m2
- Contrast Ratio: 350:1
- Viewing Angle Above Centre: 35 degrees
- Viewing Angle Below Centre: 15 degrees
- Viewing Angle Left of Centre: 45 degrees
- Viewing Angle Right of Centre: 45 degrees
- Viewing Direction: 12 O'clock
- 5x2 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-43D/DT/DCT module 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 (< 4GB) 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-43D/DT/DCT Module uses off the shelf standard SDHC/SD/micro-SD memory cards (SPI Compatible Only) with up to 4GB 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. Refer to the 4D Systems RMPET tool in the Workshop4 IDE.

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-43D/DT/DCT module.

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

9. 4DGL - Software Language

The uLCD-43D/DT/DCT Module utilises 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 Downloader 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-43D/DT/DCT Module.
- 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.

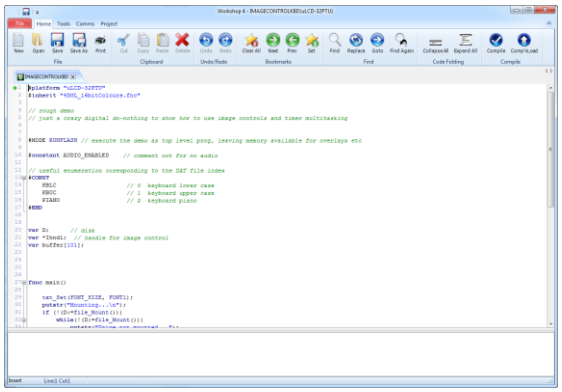
The Workshop 4 IDE is available from the 4D Systems website. www.4dsystems.com.au

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.

10.1. Workshop 4 – Designer Environment

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

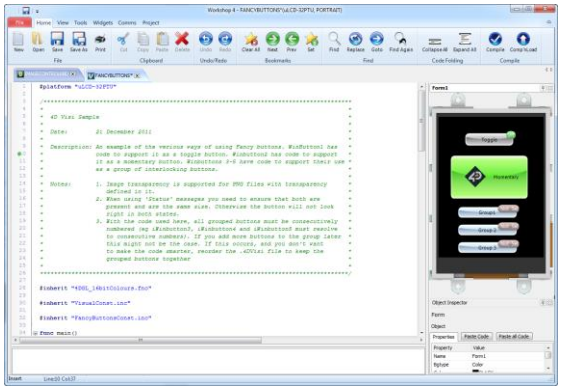
The Designer environment provides the user with a simple yet effective programming environment where pure 4DGL code can be written, compiled and downloaded to the uLCD-43D/DT/DCT Module.



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-43D/DT/DCT 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-43D/DT/DCT 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, unless purchased as a Starter Kit (SK).

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 by purchasing the display solution in a Starter Kit, it 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 utilise 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 datalogging to uSD, and a programming cable is definitely 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 utilise both depending on the user requirements. The uSD card can be used for such things as storage of multimedia files and datalogging, and the Programming cable for PmmC/Firmware updates, or changing to one of the other three programming environments.

The Starter Kit includes:

- 4D Programming Adaptor or Cable
- 4GB micro-SD Card
- 5 way cable for easy connection to a breadboard or host
- Display Module
- Quick Start Guide

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

12. Notes

13. Scribble Box

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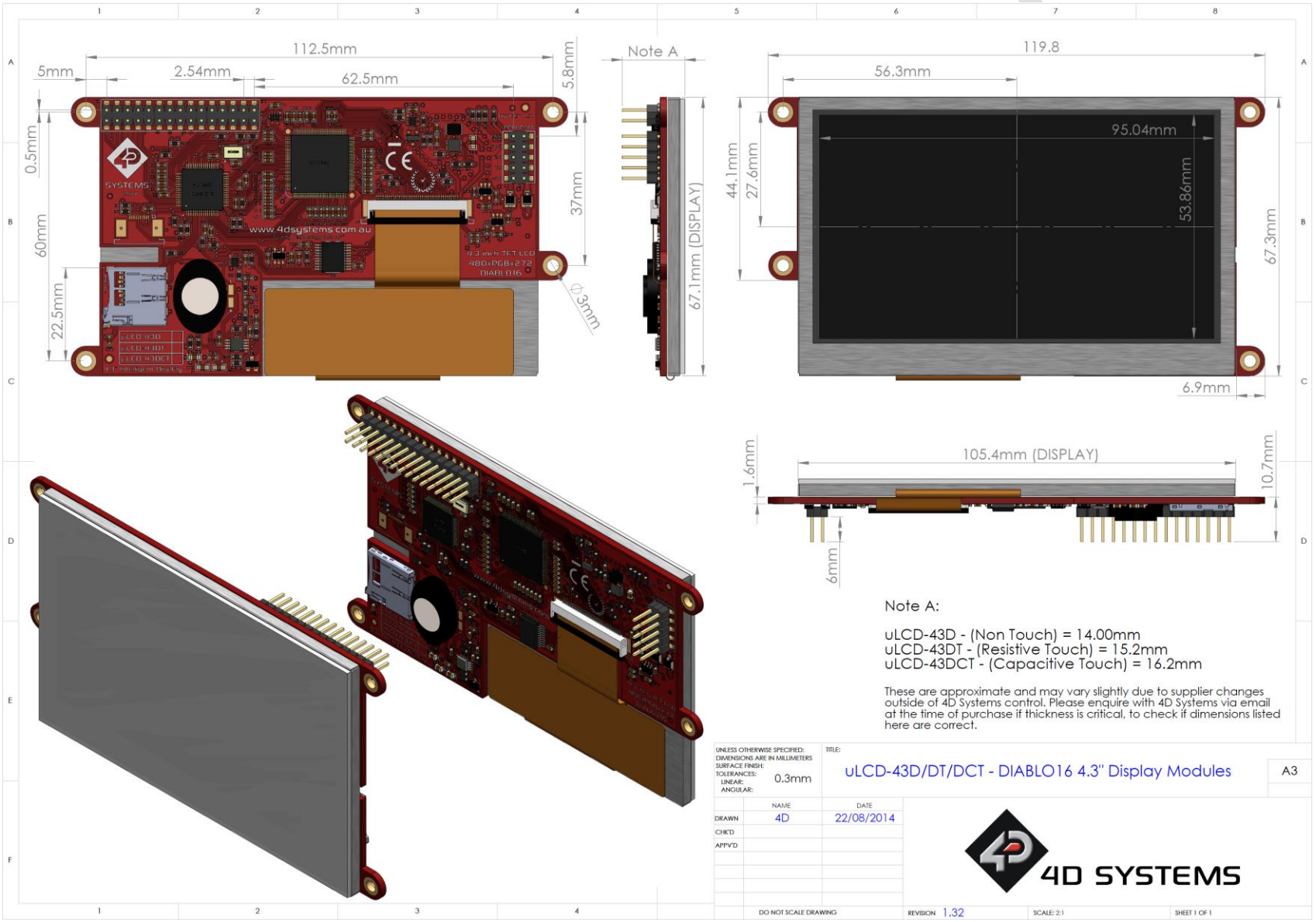
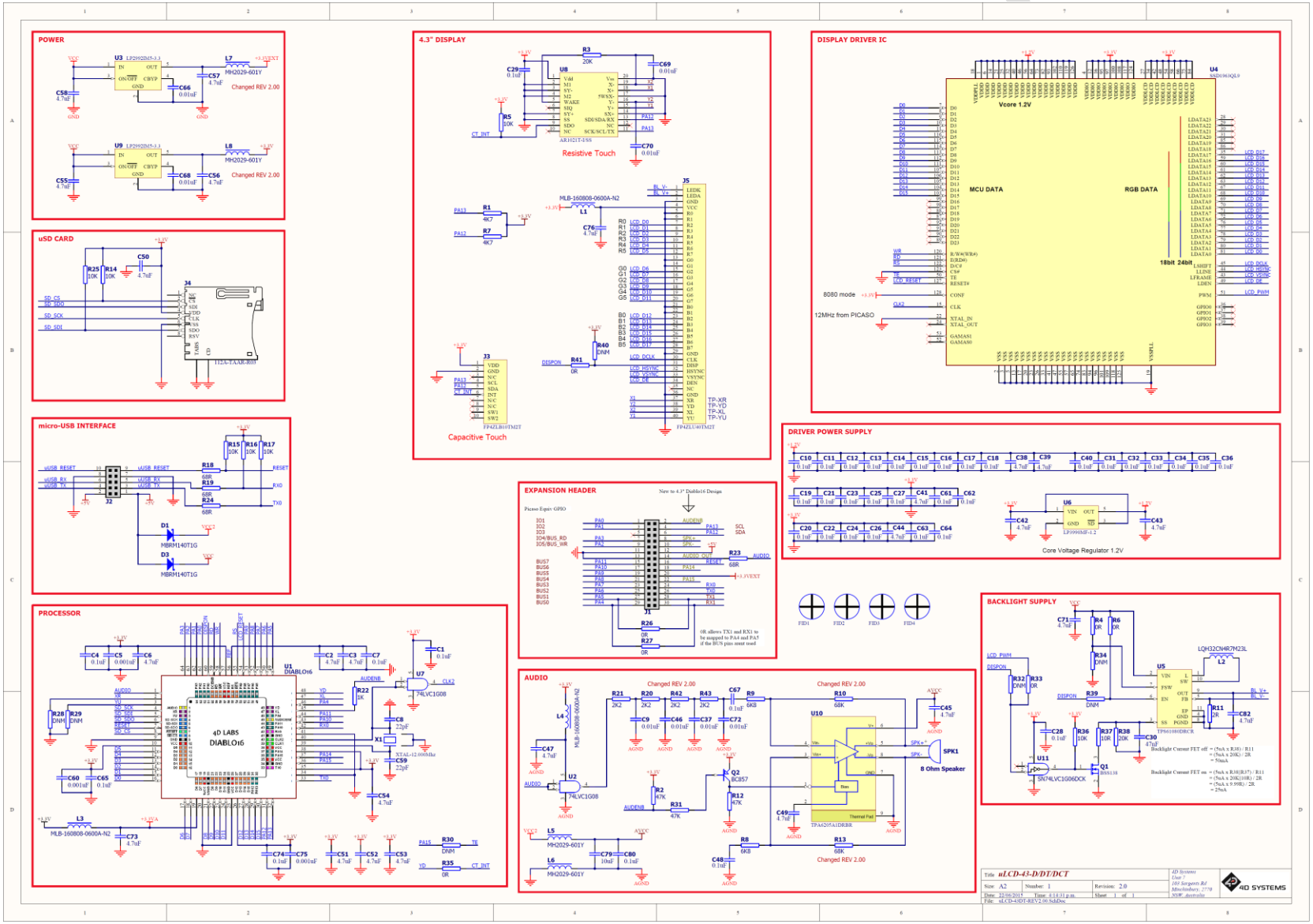
14. Mechanical Details



15. Schematic Diagram – HW REV 2.0



16. Comparison between uLCD-43P and uLCD-43D based display modules

The following table illustrates the main differences between the PICASO and DIABLO16 versions of the uLCD-43 intelligent display. These display modules are mechanically interchangeable, and electrically similar, however there are some differences which need to be noted.

16.1. Comparison Table

	uLCD-43P/PT/PCT PICASO Intelligent Display Modules	uLCD-43D/DT/DCT DIABLO16 Intelligent Display Modules
Processor	PICASO	DIABLO16
Number of GPIO	13	16*
Number of GPIO can be Analog	0	4
Number of Serial UARTs	2 dedicated	1 dedicated, 3 configurable
Number of SPI Channels	1 (dedicated to micro-SD)	1 dedicated to micro-SD, 3 configurable
Number of I2C Channels	1 (also used by touch controller)	3 (1 used for touch controller)
Dimensions (non-touch)	119.8 x 67.3 x 14 mm	119.8 x 67.3 x 14 mm
Dimensions (Resistive touch)	119.8 x 67.3 x 15.2 mm	119.8 x 67.3 x 15.2 mm
Dimensions (Capacitive touch)	119.8 x 67.3 x 16.2 mm	119.8 x 67.3 x 16.2 mm
Pixels per second capability	~650,000 pixels/second	~1,220,000 pixels/second
Max FPS on 4.3” 480x272	~5 FPS	~9.3 FPS

Note *: Diablo16 has 16 GPIO compared to PICASO’s 13, however PICASO has 2 fixed Serial Ports, and a fixed I2C port, whereas DIABLO16’s Serial ports and I2C ports are configurable and can be moved to alternative GPIO. What this means is, if DIABLO16 was to be configured in the same manner as PICASO, in terms of matching GPIO and communication channels, DIABLO16 would have 1 less GPIO due to 2 of the 16 having to be configured for the 2nd serial port, and another 2 having to be configured as the I2C, giving 12 GPIO spare for the User.

16.2. Differences in the GPIO – For upgrading from uLCD-43P to uLCD-43D

Based on the information in 16.1, it can be seen there are some differences between PICASO and DIABLO16 which affect the complete compatibility of the uLCD-43P based modules, and the uLCD-43D based modules.
If the uLCD-43P was used simply for a single Serial UART and no GPIO, then the uLCD-43D is 100% compatible.

In order to make the uLCD-43D as compatible as possible to the uLCD-43P, the TX1/RX1 UART had to be fixed to predefined GPIO, however due to the GPIO configuration, they had to be shared.

Due to PICASO uLCD-43P having 2 fixed Serial UART’s, the position on the 30 way header was predefined. Since DIABLO16 uLCD-43D is capable of having 3 of its Serial UART’s configured to be on a range of GPIO, selected GPIO were earmarked for the 2nd Serial UART, so it was the same as the PICASO version. This however means compromises had to be made to the GPIO BUS.
Where the PICASO uLCD-43P module had TX1 and RX1 on the 30 way header, the DIABLO16 uLCD-43D has 0R resistors to tie BUS0 and BUS1 (PA4 and PA5) to the old TX1 and RX1 positions, to retain compatibility. This means BUS0 and BUS1 cannot be used if TX1 and RX1 are used. If TX1 and RX1 are not required, the BUS can be used as per normal.

IO3 of the PICASO uLCD-43P is no longer available, due to the difference in GPIO between the PICASO and DIABLO16. This is now a N/C (Not connected) pin unfortunately.

Additional signals have been placed on the 30 way header, such as the addition of 2 GPIO’s (PA14 and PA15) – which can be used as a high speed I2C channel, the addition of the speaker outputs SPK+ and SPK- for attaching an external speaker, and the addition of the AUDIO and AUDENB signals to enable the use of an external amplifier.

17. Specifications and Ratings

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
Operating Temperature		-10	--	+60	°C
Input Low Voltage (VIL)	3.3V, all pins	0	--	0.2VCC	V
Input High Voltage (VIH)	3.3V, non 5V tolerant pins	0.8VCC	--	3.3	V
Input High Voltage (VIH)	PA4-PA13, RX0 and TX0 pins	0.8VCC	--	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)	5.0V, heavily depends on screen usage conditions, sleep mode	--	350	--	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 display is 50% original brightness, 25 degrees C.	--	20000	--	Hours

18. Hardware Revision History

Revision Number	Date	Description
1.32	17/10/2014	• Initial Public Release
2.0	22/06/2015	• Audio Amplifier circuitry has been improved to remove background noise. • Additional filtering added on 3.3V supply. • Power circuit has been changed: U3 & U9 are different components now and L7 and L8 have been added. • 30Pin Header 3.3V output can deliver 250mA instead of 150mA.

ORDERING INFORMATION

Order Code:

uLCD-43D – Non Touch 4.3” Model

uLCD-43DT – Resistive Touch 4.3” Model

uLCD-43DCT – Capacitive Touch 4.3” Model

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

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LifeElectronics
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