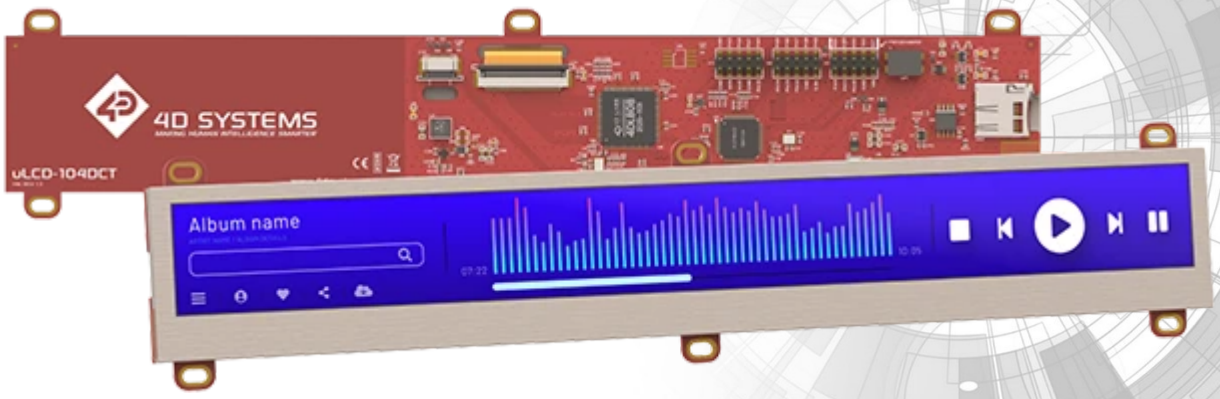
uLCD-104D Series



uLCD-104D (Non-Touch)

uLCD-104DCT (Capacitive Touch)

Datasheet

Revision 1.2

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1. Description

This 10.4" DIABLO-16 Integrated Display Module is part of the microLCD range of modules Designed and Manufactured by 4D Systems.

The 10.4" model is highly unique in its formfactor and was designed specifically to cater for the demand of physically large displays, for ease of integration and use, and with careful consideration for space requirements and functionality.

This specific module features a 10.4" colour TFT IPS LCD display with optional Capacitive Touch. It is powered by the feature-rich 4D Systems DIABLO-16 Graphics Processor, which offers an array of functionality and options for any Designer / Integrator / User.

The DIABLO-16 processor features include 16 customisable GPIO, capable of PWM, Serial, I2C, SPI, Pulse Out, Quadrature Input, and Analog Input.

The 10.4" DIABLO-16 Integrated Display Module features a TFT LCD Display, is capable of Touch Detection, microSD memory Storage and/or Flash memory Storage, GPIO and Communications, along with multiple millisecond resolution timers, and Audio Generation.

This 10.4" module is 100% compatible with the Workshop4 IDE and its 4 different development environments, providing the User with a wealth of options for programming and controlling their system.

This module features 3x 10-pin male headers, designed for easy connections to standard 2.54mm pitch female plugs or jumpers, for easy and simple connection to an application or mother board, or for connecting to accessory boards for a range of functionality advancements.

The uLCD-104DCT integrates PCB mounting ears designed for M3 machine screws, each of which has a slot for positioning, and is designed for mounting directly into a display housing or product.

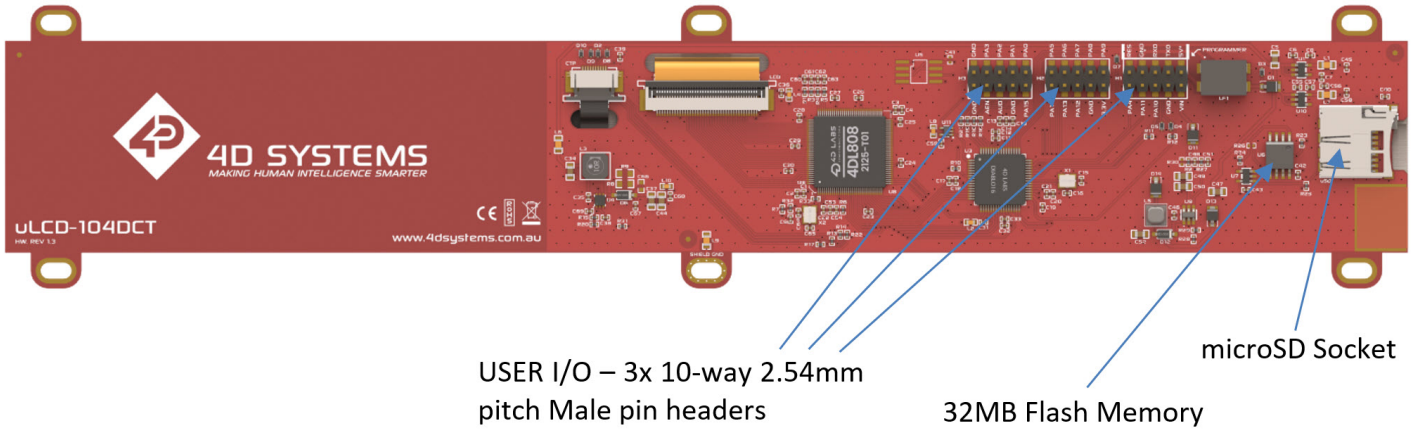
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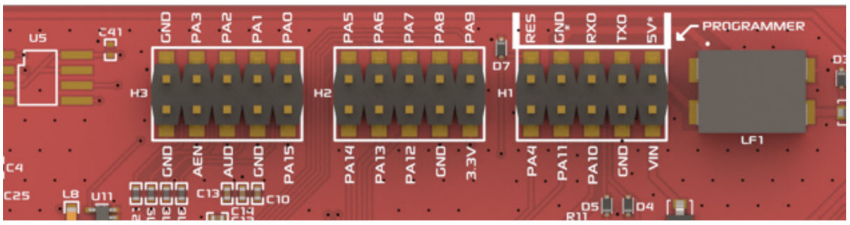
2. Features

- Powerful 10.4" Intelligent LCD-TFT display module powered by DIABLO16.
- 1024 x 100 Resolution, RGB 65K true to life colours, TFT Screen with optional Capacitive Touch.
- 6 banks of 32750 bytes of Flash memory for User Application Code and Data.
- 32Kb of SRAM purely for the User.
- 15 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).
- 3x 10-pin headers, for all signals, power, communications, GPIO and programming.
- On-board push-push type micro-SD memory card connector for multimedia storage and data logging purposes.
- On-board 32MB Flash Memory, for use instead of the microSD card (cannot be used at the same time)
- Optional On-board secondary 32MB Flash memory, which can be used in conjunction with the microSD card storage, or the Flash memory storage – Custom order request, please contact 4D Sales.
- DOS compatible file access (FAT16 format) as well as low level access to card memory.
- Dedicated PWM Audio pin driven by WAV files from micro-SD card, and for sound generation, for an external amplifier.
- Display full colour images, animations, icons and video clips.
- Supports all available Windows fonts.
- 4.0V to 5.5V range operation (single supply).
- 6x metal mounting tabs with 3mm slots for mechanical mounting using M3 machine screws or similar.
- RoHS, REACH compliant.
- CE and UKCA Compliant.

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3. Hardware Overview





USER I/O – LEFT 10 Way Header (H3)

Pin	Symbol	I/O	Description
1	PA0	I/O/A	General Purpose I/O pin with Analog Capability. This pin has a range of 0-3.3V when used as an Analog Input, and is 3.3V tolerant only. If Optional 32MB Flash is loaded, then this pin is not available for usage and will be disconnected from this header at the factory.
2	PA15	I/O	General Purpose Input/Output, 3.3V Tolerant only. Special I2C Pin (used in conjunction with PA14).
3	PA1	I/O/A	General Purpose I/O pin with Analog Capability. This pin has a range of 0-3.3V when used as an Analog Input, and is 3.3V tolerant only. If Optional 32MB Flash is loaded, then this pin is not available for usage and will be disconnected from this header at the factory.
4	GND	P	Supply Ground
5	PA2	I/O/A	General Purpose I/O pin with Analog Capability. This pin has a range of 0-3.3V when used as an Analog Input, and is 3.3V tolerant only. Also used for Bus Write. If Optional 32MB Flash is loaded, then this pin is not available for usage and will be disconnected from this header at the factory.
6	AUO	O	Audio Output, Buffered PWM, to feed into external amplifier.
7	PA3	I/O/A	General Purpose I/O pin with Analog Capability. This pin has a range of 0-3.3V when used as an Analog Input, and is 3.3V tolerant only. Also used for Bus Read. If Optional 32MB Flash is loaded, then this pin is not available for usage and will be disconnected from this header at the factory.
8	AEN	O	Audio Amplifier Enable, to enable/disable external amplifier.
10	GND	P	Supply Ground
9	GND	P	Supply Ground

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USER I/O – CENTRE 10 Way Header (H2)

Pin	Symbol	I/O	Description
1	PA9	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
2	3.3V	P	3.3V Output – Approximately 100mA available for usage by User – shared with system. Drawing too much current from this pin could cause system instability.
3	PA8	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
4	GND	P	Supply Ground
5	PA7	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
6	PA12	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
7	PA6	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
8	PA13	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
9	PA5	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
10	PA14	I/O	General Purpose Input/Output, 3.3V Tolerant only. Special I2C Pin (Used in conjunction with PA15).

USER I/O – RIGHT 10 Way Header (H1)

Pin	Symbol	I/O	Description
1	5V*	P	Main Voltage Supply +ve input pin. Range is 4.0V to 5.5V DC, nominal 5.0V. The " *indicates this pin goes through a common-mode choke, to help reduce emissions and feedback when the module is powered from this pin, paired with the GND pin also marked with a "*.
2	VIN	P	Main Voltage Supply +ve input pin. Range is 7.0V to 30V DC, nominal 12-24V.
3	TX0	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.
4	GND	P	Supply Ground
5	RX0	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.
6	PA10	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
7	GND*	P	Supply Ground. The " *indicates this pin goes through a common-mode choke, to help reduce emissions and feedback when the module is powered from this pin, paired with the 5V pin also marked with a "*.
8	PA11	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant
9	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.
10	PA4	I/O	General Purpose Input/Output, 3.3V Level - 5V Tolerant

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Note

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

1. The H1 header is used for Programming of the module, with the 5 programming pins indicated on the PCB with a PROGRAMMER marker, for ease of use. These pins can also be used for communicating to a Host etc once programming has concluded.
2. The centre bottom mounting tab of the module is connected via an inductive bead to GND, providing a 'Shield' ground, suitable for connecting to a metal enclosure. This may aid efforts for EMI/EMF shielding for compliance applications. This mounting tab is showing in the mechanical drawing also.

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4. Hardware Interface - Pins

This section describes in detail the hardware interface pins of the device.

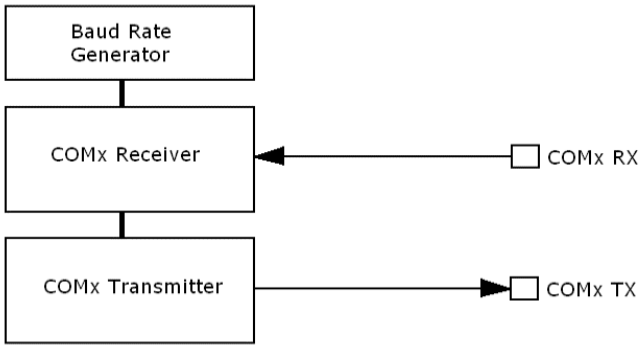
4.1. Serial Ports - TTL Level

The DIABLO16 Processor has three hardware asynchronous serial portsn (COM1 - COM3) that can be configured on a variety of 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.

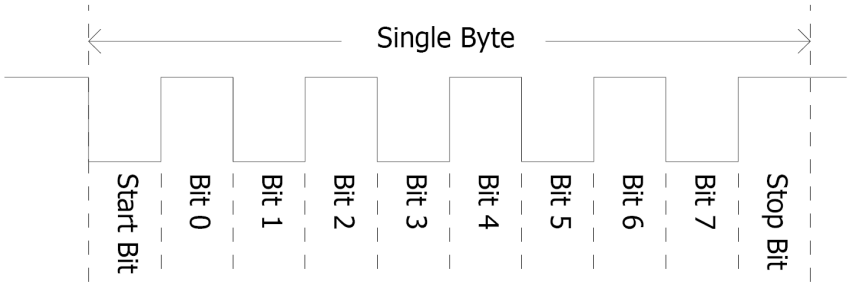
TX/RX0 is referred to as COM0 and is the only one used for programming the DIABLO16 itself.

The primary features are:

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



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



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COM0 is also the primary interface for User program downloads and configuration PmmC/Driver 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.

TX0 pin (Serial Transmit COM0):

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

RX0 pin (Serial Receive COM0):

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

TX1 pin (Serial Transmit COM1):

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

RX1 pin (Serial Receive COM1):

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

TX2 pin (Serial Transmit COM2):

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

RX2 pin (Serial Receive COM2):

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

TX3 pin (Serial Transmit COM3):

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

RX3 pin (Serial Receive COM3):

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

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DIABLO16 Serial TTL Comm Port Configuration Options

	TX1	RX1	TX2	RX2	TX3	RX3
PA0		Yes		Yes		Yes
PA1	Yes	Yes	Yes	Yes	Yes	Yes
PA2		Yes		Yes		Yes
PA3	Yes	Yes	Yes	Yes	Yes	Yes
PA4	Yes	Yes	Yes	Yes	Yes	Yes
PA5	Yes	Yes	Yes	Yes	Yes	Yes
PA6	Yes	Yes	Yes	Yes	Yes	Yes
PA7	Yes	Yes	Yes	Yes	Yes	Yes
PA8	Yes	Yes	Yes	Yes	Yes	Yes
PA9	Yes	Yes	Yes	Yes	Yes	Yes
PA10		Yes		Yes		Yes
PA11		Yes		Yes		Yes
PA12	Yes	Yes	Yes	Yes	Yes	Yes
PA13	Yes	Yes	Yes	Yes	Yes	Yes
PA14						
PA15						

As per the table, not all GPIO can be configured to be every serial port, or RX/TX.

Note

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

Please refer to the DIABLO-16 Internal Functions Manual datasheet for information on how to set the DIABLO16 pin mappings.

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4.2. General Purpose I/O

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

DIABLO16 Alternate Pin Configurations GPIO

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

Please refer to the DIABLO-16 Internal Functions Manual datasheet for information on how to set the DIABLO16 pin mappings.

PA0-PA3:

General purpose I/O pins, or can serve as Analog Input pins. Each pin can be individually set for INPUT or OUTPUT or ANALOG. Power-Up Reset default is all INPUTS. Digital GPIO can source/sink 10mA. For more information, the Specifications section. These pins have a **0** to **3.3V** range and have a 12-bit resolution.

For more information, refer to the Analog Inputs Section.

PA4-PA11:

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

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PA12-PA13:

PA12 and PA13 are reserved and are used exclusively for the resistive touch controller, or the capacitive touch controller (DT/DCT models). These pins should not be connected else Touch performance may be degraded. There are 4.7K pullup resistors on each of this GPIO. Avoid these pins in normal situations. However, using these pins on non-touch (D model) is OK, or in situations where touch is not required. 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. Under special situations, these pins can be used for a high-speed I2C interface. Please refer to the table under the Alternate Pin Function Overview section and the information under the I2C section.

Note

Digital GPIO pins are 5.0V tolerant, except PA14-PA15, which are 3.3V tolerant only. PA0-PA3 are 3.3V tolerant only. All pins output at 3.3V levels.

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4.3. System Pins

+5V IN (Module Voltage Input):

Module supply voltage input pins. Both of these pins should be connected to a stable supply voltage in the range of 4.0 Volts to 5.5 Volts DC. The nominal operating voltage is 5.0 Volts. Note backlight brightness will be lower for voltages under 5.0V.

VIN (Module High Voltage Input):

Module high supply voltage input pin. This pin can be supplied between 7.0VDC and 30VDC, and these must not be exceeded. Typical voltages are between 12V and 24VDC. Note if long cables are used, the minimum 7V needs to be presented at the module, so voltage drops need to be considered. If this pin is not used, a 5VDC source can be applied to 5V_IN instead.

GND (Module Ground):

Device ground pins. These are the reference of the module for power and GPIO.

RESET (Module Master Reset):

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.

AEN (Audio Enable Output):

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

AUO (PWM Audio Output):

Output specifically for Audio. This pin is a PWM output from the DIABLO16 Processor. This pin is a 3.3V level PWM output to drive an external amplifier with DIABLO16 generated Audio, via an external filtering circuit to turn digital PWM into Analog. Note that AEN must be enabled in DIABLO16 for any input signal to be heard.

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4.4. Alternate Pin Function Overview

Most of the GPIO pins have an alternate function other than being for General Purpose I/O.

GPIO pins can be configured to be SPI, I²C, Serial or a range of other functions.

Note

Not all pins can be configured to be any of the alternate pin functions. Please refer to the tables.

Refer to the tables below that illustrate the GPIO pins you can associate with alternative functions.

DIABLO16 Alternate Pin Configurations I/O Support Functions

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

Note

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

The table above illustrates the GPIO pins you can use for the 4 different I/O Support Functions.

Please refer to the DIABLO-16 Internal Functions Manual datasheet for more information on how to set the alternate pin configurations.

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

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

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

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DIABLO16 Alternate Pin Configurations SPI Communications

	SPI1 SDO	SPI1 SDI	SPI1 SCK	SPI2 SDO	SPI2 SDI	SPI2 SCK	SPI3 SDO	SPI3 SDI	SPI3 SCK
PA0		Yes			Yes			Yes	
PA1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PA2		Yes			Yes			Yes	
PA3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PA4	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA5	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA6	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA7	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA8	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA9	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA10		Yes			Yes			Yes	
PA11		Yes			Yes			Yes	
PA12	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA13	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
PA14									
PA15									

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

DIABLO16 Alternate Pin Configurations I2C Communication

	I²C1 SDA	I²C1 SCL	I²C2 SDA	I²C2 SCL	I²C3 SDA	I²C3 SCL
PA0	Yes	Yes	Yes	Yes	Yes	Yes
PA1	Yes	Yes	Yes	Yes	Yes	Yes
PA2	Yes	Yes	Yes	Yes	Yes	Yes
PA3	Yes	Yes	Yes	Yes	Yes	Yes
PA4	Yes	Yes	Yes	Yes	Yes	Yes
PA5	Yes	Yes	Yes	Yes	Yes	Yes
PA6	Yes	Yes	Yes	Yes	Yes	Yes
PA7	Yes	Yes	Yes	Yes	Yes	Yes
PA8	Yes	Yes	Yes	Yes	Yes	Yes
PA9	Yes	Yes	Yes	Yes	Yes	Yes
PA10	Yes	Yes	Yes	Yes	Yes	Yes
PA11	Yes	Yes	Yes	Yes	Yes	Yes
PA12	Yes	Yes	Yes	Yes	Yes	Yes
PA13	Yes	Yes	Yes	Yes	Yes	Yes
PA14		SPECIAL		SPECIAL		SPECIAL
PA15	SPECIAL		SPECIAL		SPECIAL	

Note

SPECIAL - please see I2C section.

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4.5. SPI

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

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

Please refer to the table for details on which GPIO can be configured for SPI.

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

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

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

where:

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

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

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

Please refer to the DIABLO-16 Internal Functions Manual datasheet for more information on how to use the SPI functions, along with the DIABLO16-Processor datasheet.

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4.6. I2C

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

Please refer to the table for details on which GPIO can be configured for I²C.

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

- **I2Cx_Open(Speed, SCLpin, SDApin);**

where:

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

'Speed' is the desired I2C Bus speed, and

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

Note

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

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

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

Please refer to the DIABLO-16 Internal Functions Manual datasheet for more information on how to use the I²C functions, along with the DIABLO16-Processor datasheet.

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4.7. Pulse Out

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

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

Please refer to the table for details on which GPIO can be configured to Pulse Out.

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

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

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

where:

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

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

Please refer to the DIABLO-16 Internal Functions Manual datasheet for more information on how to use the Pulse Out functions, along with the DIABLO16-Processor datasheet.

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4.8. PWM Out

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

Please refer to the table for details on which GPIO can be configured to PWM.

Servo Mode allows a millisecond input value with 0.01ms resolution, which runs at a frequency of approximately 50Hz or 50pps (20ms). The position of the servo is determined by the width of the pulse. Generally, 1.5ms is 90 degrees, 1ms is 0 degrees and 2ms is 180 degrees. Servos however vary, and the DIABLO16 PWM control can be adjusted to suit most applications.

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

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

- **PWM_Init(pin, mode, value);**

where:

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

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

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

Please refer to the DIABLO-16 Internal Functions Manual datasheet for more information on how to use the PWM functions, along with the DIABLO16-Processor datasheet.

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4.9. Pin Counter

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

The counters can be read and written at any time.

Please refer to the table for details on which GPIO can be configured to Pin Counter.

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 DIABLO-16 Internal Functions Manual datasheet for more information on how to use the Pin Counter functions, along with the DIABLO16-Processor datasheet.

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4.10. Quadrature In

There are two Quadrature Input channels available on the DIABLO16 processor, which requires 2 GPIO pins each.

Please refer to the table for details on which GPIO can be configured for Quadrature Input.

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

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

- **Qencoderx(PHApin, PHBpin, mode);**

where:

'Qencoderx' is substituted for 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 DIABLO-16 Internal Functions Manual datasheet for more information on how to use the Quadrature Input functions, along with the DIABLO16-Processor datasheet.

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4.11. Analog Inputs

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

The analog inputs on the DIABLO16 have a range of 0V to 3.3V, each with a max resolution of 12 bits. You can read the analog inputs using either the standard mode, averaged mode or high-speed mode.

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

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

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

where:

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

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

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

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

where:

'rate' is the number of samples per second,

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

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

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

Please refer to the DIABLO-16 Internal Functions Manual for more information on how to use the Analog Input functions, along with the DIABLO16-Processor datasheet.

> **Note**
>
> Analog Inputs are 0V-3.3V tolerant only. Do not apply voltages outside of this range as you will damage DIABLO-16.

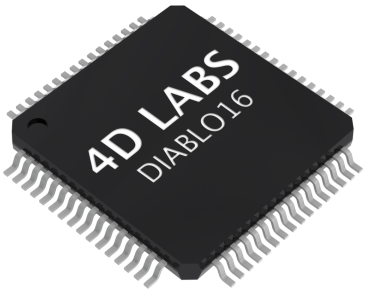
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5. Module Features

The uLCD-104DT/CT displays are designed to accommodate most applications where a large physical size display module is required. Some of the main features of the module are listed below.

5.1. 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-LCDs is almost plug-n-play.

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

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

You can refer to the DIABLO16 graphics processor datasheet for more information.

5.2. Audio

Audio playback support in the DIABLO16 Processor enables this module to play audio WAV files stored in the micro-SD memory card. Filtered PWM audio is generated and made available on the AUDIO pin of the 30-way ZIF connector, ready to interface with an audio amplifier on your application board.

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

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5.3. SD/SDHC Memory Cards

The module supports micro-SD memory cards via the onboard latch-type 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).



Memory cards up to 32GB in size can be used, however, it must be noted that only a portion of this can be used by the FAT16 file system. See the FAT16 section below for more details.

Note

A microSD card capable of SPI is a requirement for all 4D Systems' display modules powered by GOLDELOX, PICASO or DIABLO-16 Processors. If a non-SPI compatible card is used, it will simply fail to mount, or may cause intermittent issues resulting in lockups and crashing of the application. Please refer to the 4D Systems website for microSD cards offered by 4D Systems.

5.4. FAT16

All 4D Systems display modules featuring 4D Labs processors use 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 correctly. Built into Workshop4 is a tool created by 4D, called RMPET (please refer to the Tools menu, in any Environment, inside the Workshop4 IDE). RMPET allows the User to easily partition and format microSD cards, to make their file system ready to be used with 4D Systems modules. The formatting of the card can be done on any PC system with a card reader.

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.

A Max of 4GB can be used by the FAT16 file system. The FAT partition is always first (if it exists). Any space larger than 4GB will be RAW, and can still be used by your 4D Systems module, using different functions. Please refer to the Application Notes.

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5.5. SPI Flash Memory

On the uLCD-104D/DCT displays, there is 32MB of SPI Flash memory mounted on the board, which can be used instead of the micro-SD card if desired.

The SPI Serial Flash Memory and the micro-SD card are mutually exclusive, meaning only one or the other can be used. Both cannot operate together, so a choice is needed at the time of development.

The automatic hardware selection of the memory device being used is dictated by the presence of a microSD card inserted into the display module.

When using the uSD card as the memory device, simply insert the uSD card into the socket.

When using the Flash Memory as the memory device, simple eject the uSD card or yet do not insert anything in the socket.

The presence of the uSD card triggers a card detect switch inside the uSD socket, which enables or disables the Flash Memory. Only one can be enabled at once due to sharing the same bus, so your project needs to be designed with either uSD or Flash in mind.

Inside the Workshop4 IDE, the software selection for Flash or FAT (micro-SD) can be made.

SPI Flash Memory can be used in applications where a micro-SD card is either not permitted, or not desirable. The memory capacity is considerably smaller than micro-SD, so there is also a limitation on what can be stored. Smart project planning of widget types is required. It may be desirable to use a majority of Internal or Inherent widgets when using SPI Flash Memory and leave the SPI Flash Memory itself for GCI widgets / Images etc which cannot be stored any other way. Please refer to our Workshop4 User Manual for more information on the available widget types.

In addition to this primary SPI Flash memory, the uLCD-104D/DCT module can be ordered with a second SPI Flash memory loaded on the PCB. This is handled differently to the primary SPI Flash memory, and is connected to the DIABLO-16 processor via the PA0-PA3 GPIO, thus making those GPIO no longer available to the user on the H3 header. This flash memory is connected to a different SPI Bus to the primary SPI Flash memory but can be utilised in similar ways, and still loaded with File Transfer if desired. If this flash memory is desired for your application, please contact the 4D Systems Sales team, as this module would be custom ordered.

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6. Display/Module Precautions

- Avoid having to display the same image/object on the screen for lengthy periods. This can 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 should not cause any problems, however, if water is to enter the display either from the front or from the rear, or come in contact with the PCB, it will damage. Wipe off any moisture gently or let the display dry before usage. If using this display module in an environment where it can get wet, ensure an appropriate enclosure is used.
- Dirt from fingerprint oil and fat can easily stain the surface of the display. Gently wipe off any stains with a soft lint-free cloth.
- The performance of the display will degrade under high temperatures and humidity. Avoid such conditions when storing.
- Do not tamper with the display flex cable that is connected to the control board. This may affect the connection between the display and the driving circuitry and cause failure.
- Displays are susceptible to mechanical shock and any force exerted on the module may result in deformed zebra stripes, a cracked display cell and a broken backlight.
- Always use the mounting holes on the module's corner plates to mount the display where possible.
- Display modules have a finite life, which is typically dictated by the display itself, more specifically the backlight. The backlight contains LEDs, which fade over time. In the Specifications section is a figure for the typical life of the display, and the criteria are listed. The resistive Touch model features a touch-sensitive film over the display which is sensitive to pressure. When mounting the display module in an enclosure, you should not apply pressure to the surface of the display by the enclosure. It could result in false touches or the touch will simply not function at all.

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7. Hardware Tools

The following hardware tool is required for full control of the uLCD-104DT/DCT display module.

7.1. Programming Cable/Adaptor

The 4D Programming Cable and uUSB-PA5/uUSB-PA5-II Programming Adaptors are essential hardware tools to program, customise and test the DIABLO16 Processor.

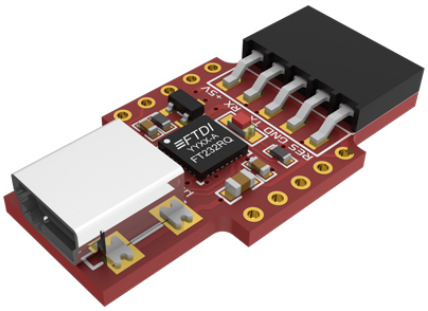
Either the 4D Programming Cable or the uUSB-PA5 Programming Adaptor can be used.

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 website.



4D Programming Cable



uUSB-PA5/uUSB-PA5-II Programming Adaptor

> **Note**
>
> In addition to these modules, the gen4-PA and uUSB-PA5/uUSB PA5-II can also be used.

Using a non-4D programming interface could damage your processor, and **void your Warranty**. These programming interfaces are available from the 4D Systems website.

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8. Programming Language

The DIABLO16 processor belongs to a family of processors powered by a highly optimised softcore virtual engine called EVE (Extensible Virtual Engine). EVE was designed and created by 4D Systems in the early 2000s, and should not be confused with FTDI's solution of EVE, which was developed a decent decade or so later.

EVE is a proprietary, high-performance virtual machine with an extensive byte-code instruction set optimised to execute compiled 4DGL programs.

4DGL (4D Graphics Language) was specifically developed from the ground up for the EVE engine core. It is a high-level language that is easy to learn and simple to understand yet powerful enough to tackle many embedded graphics applications.

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

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

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

- 4DGL Programmers Reference Manual
- DIABLO-16 Internal Functions Manual

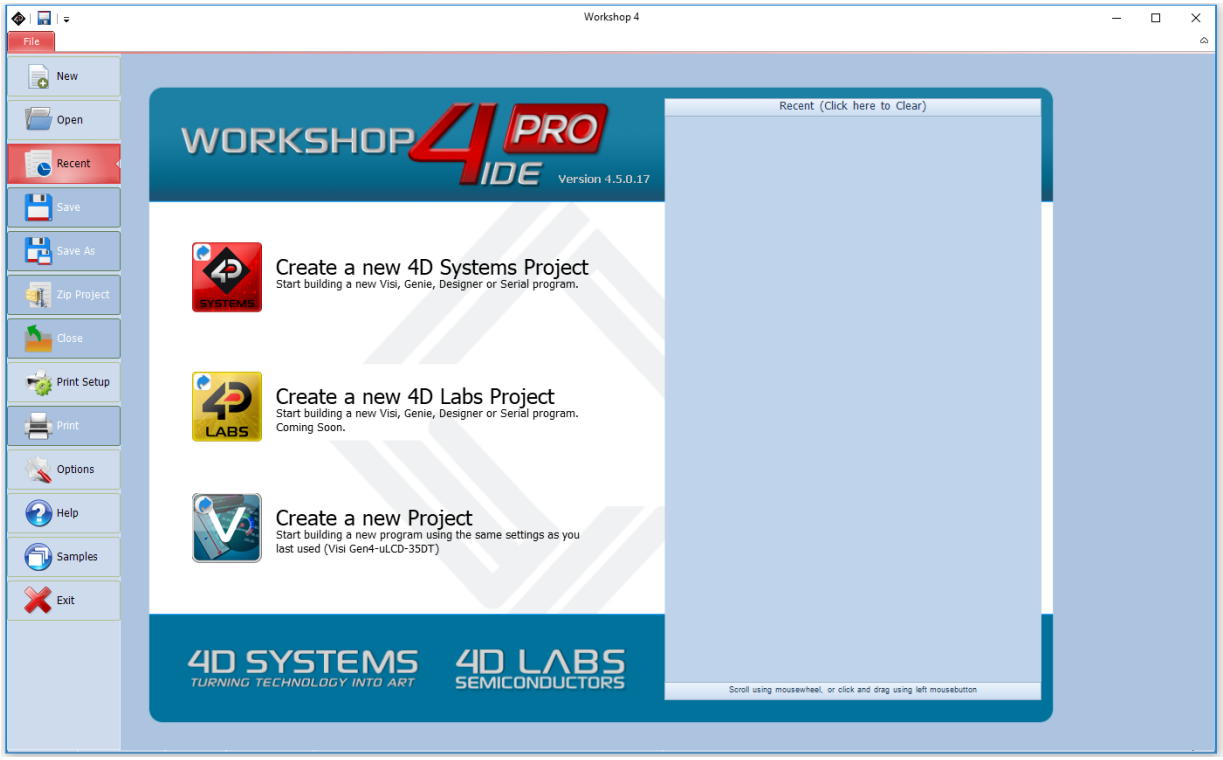
To assist with the development of 4DGL applications, the Workshop4 IDE combines a full-featured editor, a compiler, a linker and a downloader into a single PC-based application. It's all you need to code, test and run your applications.

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

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9. Workshop4 IDE

Workshop4 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 Workshop4 IDE.



The Workshop4 IDE supports multiple development environments for the user, to cater to different user requirements and skill levels.

- The **Designer** environment enables the user to write 4DGL code in its natural form to program the range of 4D System's intelligent displays.
- 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. This can be extended with additional features when a Workshop4 PRO license is purchased from the 4D Systems website. Extended Advanced features for Visi-Genie are available in the PRO version of WS4. Further details are explained in the Visi Genie section of the Workshop4 documentation.
- 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.

For more information regarding these environments, refer to the Workshop4 manuals.

The Workshop 4 IDE is available from the 4D Systems website.

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9.1. PmmC/Firmware Programming

The DIABLO16 processor is a custom graphics processor. All functionality including the high-level commands is built into the chip. This chip-level configuration is available as a PmmC (Personality-module-micro-Code) file, which can be likened to traditional Firmware. There is also a Display Driver file, which separates specific display settings from the PmmC, unlike on the PICASO processor where everything is combined.

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

The Display Driver contains the initialisation and parameters associated with the particular display that is to be connected to the DIABLO16 processor, along with product-specific settings and parameters which are required over and above what is found in the PmmC.

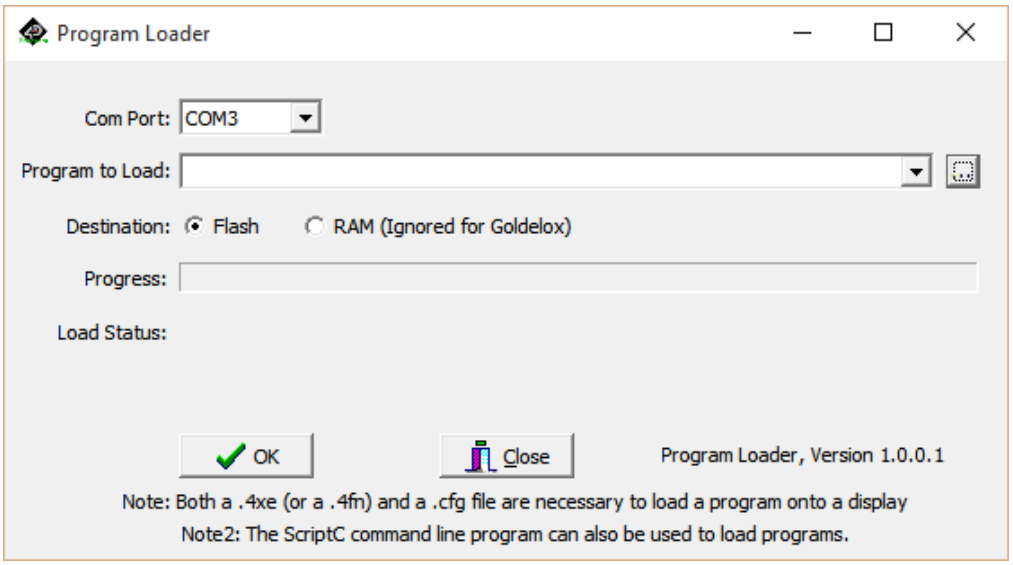
The PmmC file and Display Driver file can only be programmed into the device via the COM0 serial port with the aid of Workshop 4, the 4D Systems IDE software.

Solutions, that remove the need to use Workshop4 to program the display modules, are available for commercial customers requiring batch programming or production line programming. These solutions are practical for production staff and minimize the chance of unwanted or unauthorised modifications on the production line.

Three solutions come with the Workshop4 IDE, which can be separated for production line computers if required, **ScriptC**, **PmmC Loader** and **Program Loader**.

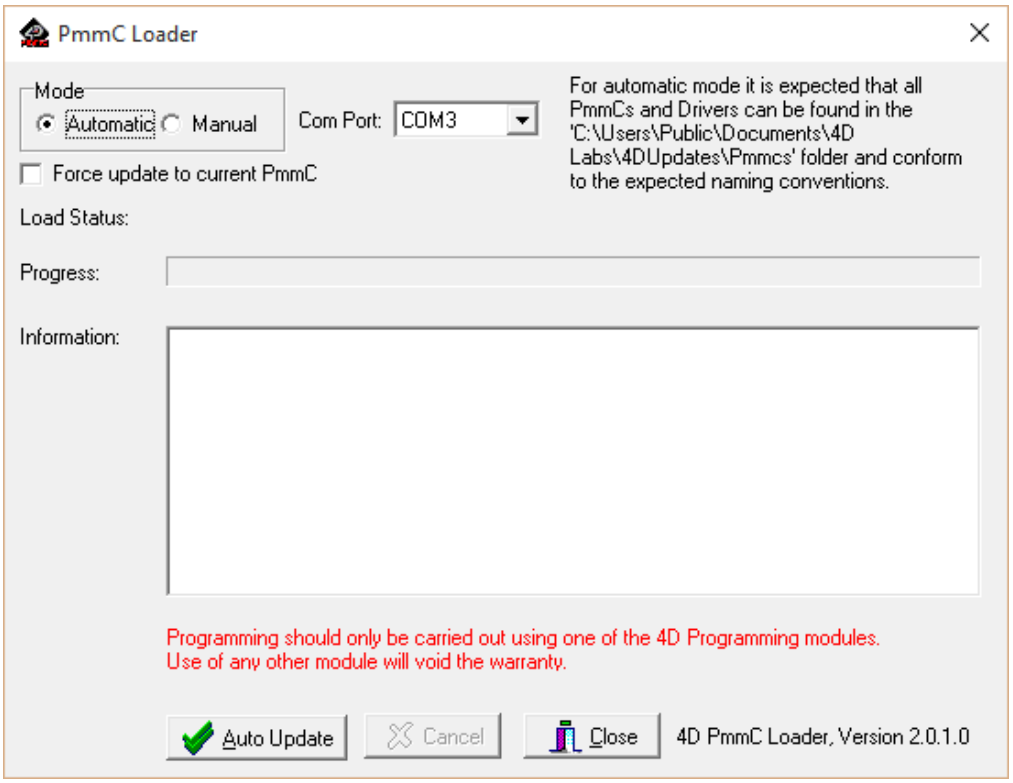
ScriptC is a command line interface that can be controlled from a Batch Script or similar, useful for repetitive loading or when controlled from an external application. Example scripts are provided, showing how to load PmmC, Display Drivers and Applications using a batch script.

PmmC Loader is a GUI interface designed to download PmmC's and Drivers to 4D Systems Processors. It can automatically update existing PmmC's and Drivers present on a module, or manually change or force download to a blank processor or module, overwriting anything written in previously.



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Program Loader is a GUI interface designed to download Applications to either Flash or RAM, useful for testing or production loading, without the need for Workshop4 itself.



Please contact our Support Team for more information on what we can provide. Some solutions also exist for external processor-based loading, if there is a requirement for that. This solution is available under NDA. Using a non-4D programming interface could damage your module, and **void your warranty**.

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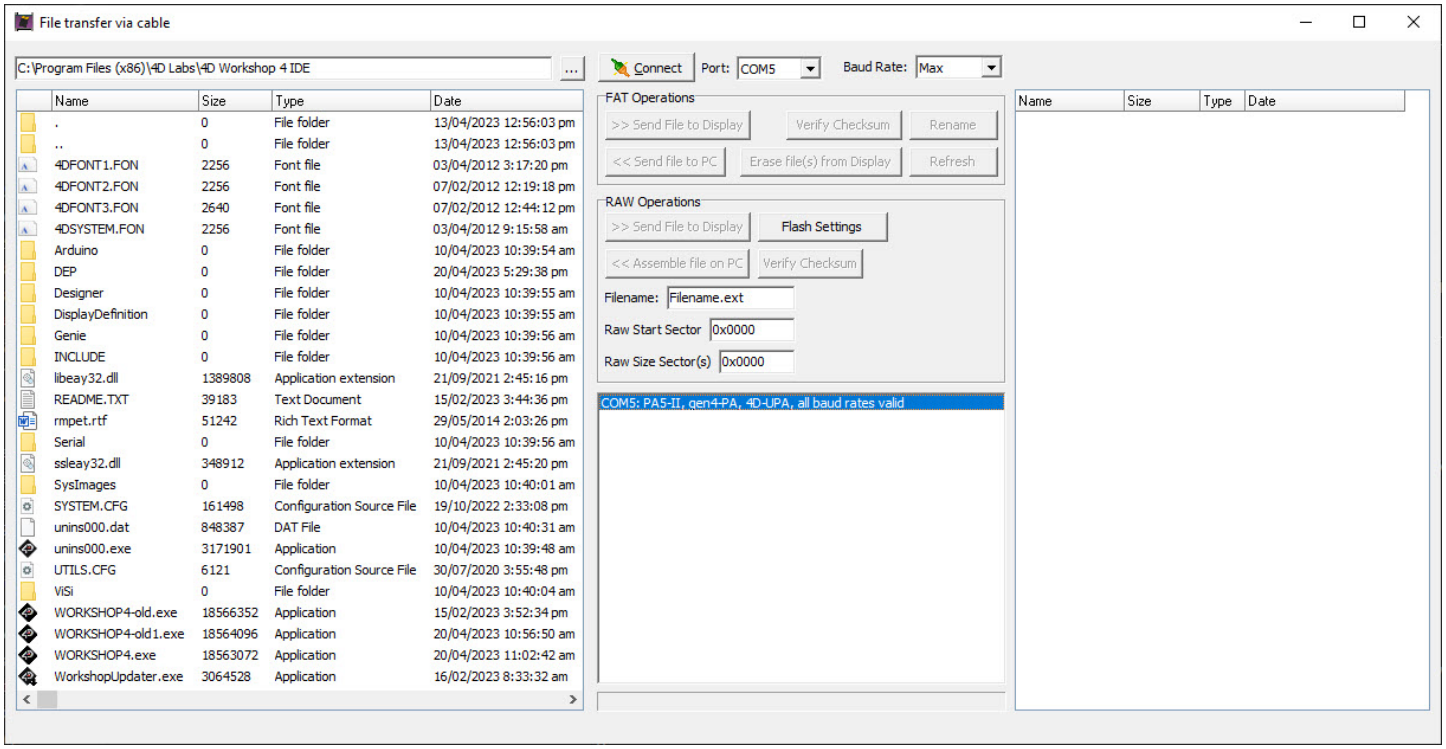
9.2. File Transfer

The DIABLO-16 processor is capable of transferring files over the serial UART from the PC. This is used when the SPI Serial Flash Memory is loaded by Workshop4, but it can also be used to load the micro-SD card if desired.

The process of loading a micro-SD card can take some time, depending on the size of the files needing to be transferred, and it is often faster to remove the micro-SD card from the display module, place it into your PC using a Media/Card reader, and copying the files directly. However in cases where this is not possible, transferring over the serial UART is available.

Additional to Workshop4 natively using File Transfer during its programming phase, File Transfer can also be run manually by opening the File Transfer application from the Windows Start Menu, or from the /DEP folder inside the Workshop4 installation folder.

When loading content on to the SPI Serial Flash Memory manually, you must erase the memory before writing new files.



File Transfer can be used for loading SPI Serial Flash Memory or the micro-SD card. When actioning the programming process from Workshop4, the appropriate one will be loaded based on your hardware and software settings.

If using the 4D Programming Cable, some software modifications to the USB chip inside the cable are required in order to transfer at full speed. Please refer to THIS POST on the 4D Systems Forum, for details on the change.

When using the 4D-UPA, uUSB-PA5-II or gen4-PA, this is not required, it only relates to the 4D Programming Cable.

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10. Starter Kit

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

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

Not all development environments and features will be needed by every User. However, purchasing the display solution in a Starter Kit allows you to take full advantage of all of the features of the 4D Systems Display Solution and try out each of the 4D Woskshop4 Environments before settling with the preferred feature set.

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

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

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

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

Starter Kits typically include:

- uLCD-104DT/DCT Integrated Display Module
- Interface Module (gen4-IB)
- 4D Universal Programming Adaptor (4D-UPA)
- 4GB micro-SD Card
- 5-way cable for easy connection to a breadboard or host via the gen4-IB
- 150mm 30-way FFC cable for connecting the display to gen4-IB or 4D-UPA
- Quick Start Guide

Please refer to the 4D Systems website for the current components included in the Starter Kit.

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

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11. Display Module Part Numbers

The following is a breakdown of the part numbers and what they mean.

Example:

- uLCD-104D
- uLCD-104DCT

Example Starter Kits:

- SK-uLCD-104D
- SK-uLCD-104DCT

SK - Starter Kit (kitting of multiple parts)

uLCD - microLCD Display Family

104 - Display size (10.4")

D - "DIABLO-16" Processor

T - Resistive Touch

CT - Capacitive Touch

Note

- The SK at the start denotes it's a Starter Kit, and the rest of the part number describes the display module in the Starter Kit.
- For the part number which does not include CT, this is a non-touch variant.

12. Module Weights

Weighs in grams, of each of the different variations of the uLCD range covered in this document.

uLCD-104D – 175g grams

uLCD-104DCT – 185g grams

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13. Backlight Brightness Levels

All uLCD-104D/DCT modules ship with the backlight set at 12 (out of 15) by default.

This is to lower the current draw as some computers USB ports are limited to around 500mA, and these models draw more than this (Please see Specifications section). Lowering the brightness down to 12 by default, enables code development of the module to occur with less hassle of the module not being supplied enough current.

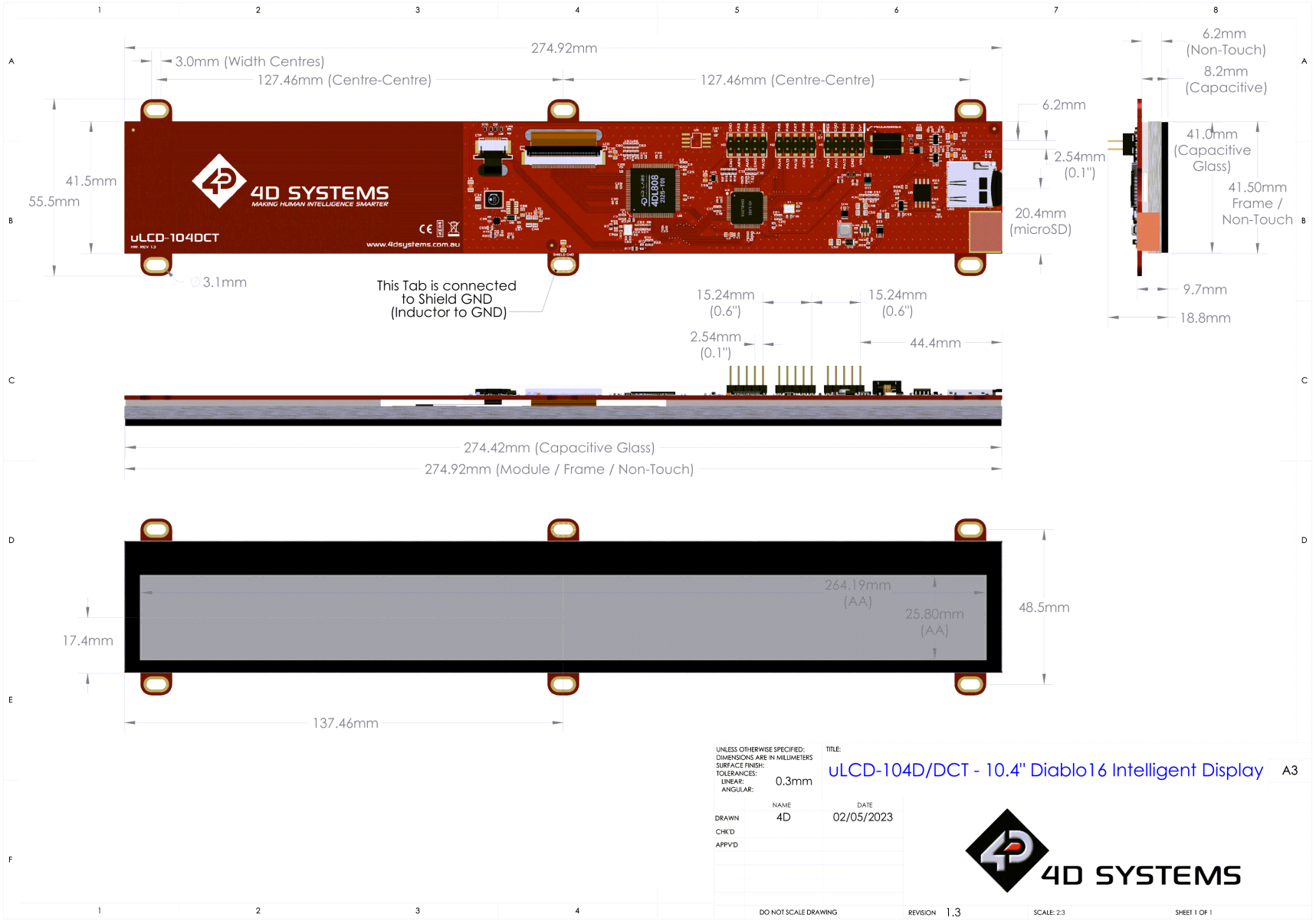
Insufficient Current can be seen with a flashing backlight and constant resetting/looping. For best results, use a Powered USB Hub, which can supply 1A or more current to each USB Port.

The backlight can be set to any level from 0 (off) to 15 (max) using Workshop4 and the relevant 4DGL code or Host commands, however by default the above is what the levels are set to.

Please refer to the various documentation for the Workshop4 environment you are using, for more information.

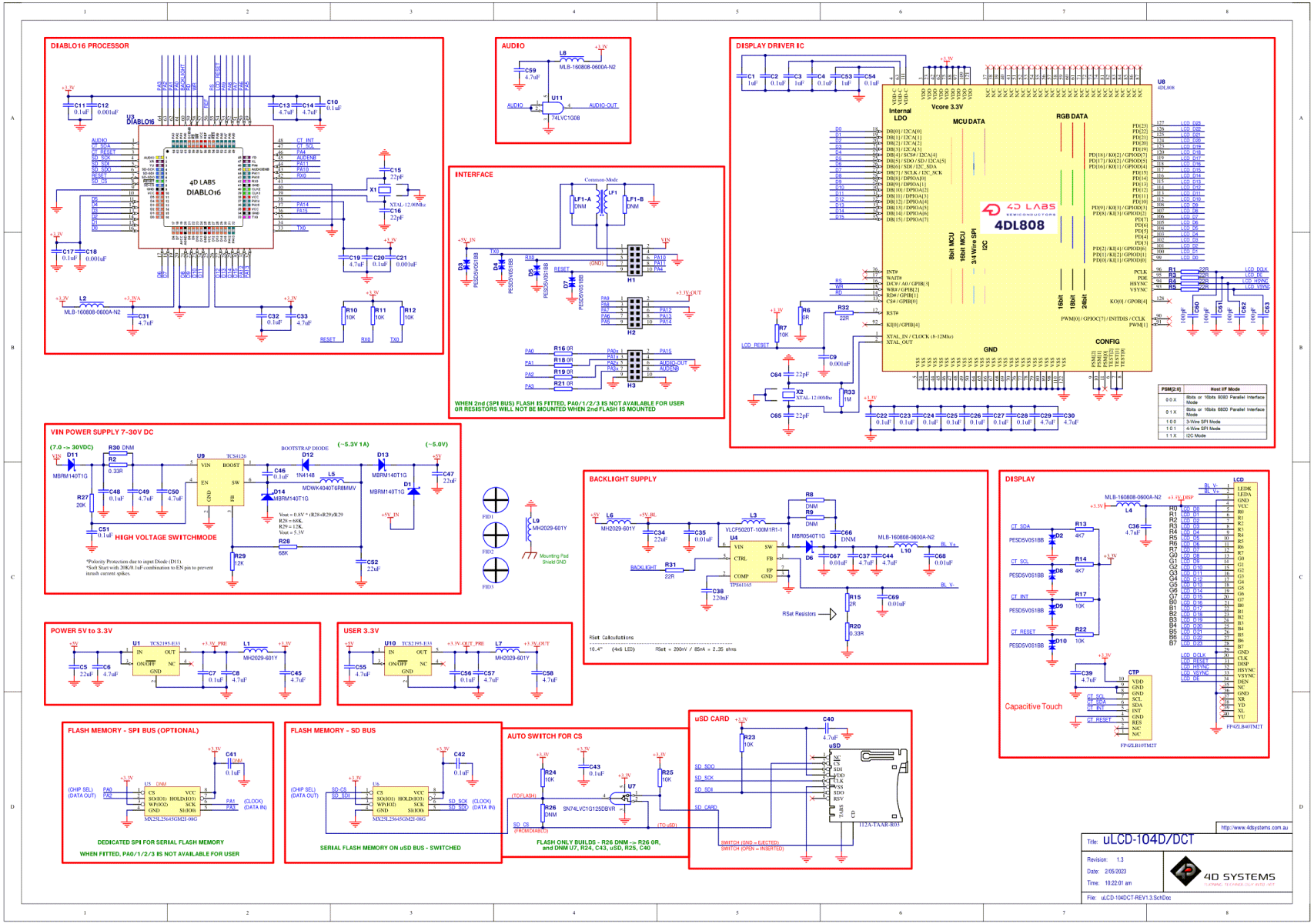
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14. Mechanical Details



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15. Schematic Details (HW REV 1.3)



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16. Specifications

Absolute Maximum Ratings	
Operating ambient temperature	-10°C to +60°C
Storage temperature	-20°C to +70°C
Voltage on any digital input pin with respect to GND	-0.3V to 6.0V
Voltage on 5V Pin with respect to GND	4.0V to 6.0V
Voltage on VIN with respect to GND	7.0V to 30V
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 (5V)	Stable external supply required	4.0	5.0	5.5	V
Supply Voltage (VIN)	Stable external supply required	7.0	12.0	30.0	V
Processor voltage (VP)		–	3.3	–	V
Input Low Voltage (VIL)	all pins	0	–	0.2VP	V
Input High Voltage (VIH)	non 5V tolerant pins	0.8VP	–	3.3	V
Input High Voltage (VIH)	PA4-PA13, RX0 and TX0 pins	0.8VP	–	5.5	V
Reset Pulse	External Open Collector	2.0	–	–	µs
Operational Delay	Power-Up or External Reset	500	–	3000	ms

Global Characteristics Based on Operating Conditions

Parameter	Conditions	Min	Typ	Max	Units
Supply Current(ICC)(5V Supply used to 5V pin)	uLCD-104D (Contrast = 15)	–	680	–	mA
	uLCD-104DCT (Contrast = 15)	–	680	–	mA
Supply Current(ICC)(12V Supply used to VIN)	uLCD-104D (Contrast = 15)	–	320	–	mA
	uLCD-104DCT (Contrast = 15)	–	320	–	mA
Display Endurance	Hours of operation, measured to when the display is 50% original brightness	50000	–	–	H
Touch Screen Transparency	Capacitive Touch	90	–	–	%
CTP Hardness	Glass Hardness	–	6	–	H

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LCD Display Information

Parameter	Conditions	Specification
Display Type		TFT IPS Transmissive LCD
Display Size		10.4" Diagonal
Display Resolution		1024 x 100 (Landscape/Wide Viewing)
Display Brightness	uLCD-104D (Contrast = 15) - Typical	950 cd/m2
	uLCD-104DCT (Contrast = 15) - Typical	855 cd/m2
Display Contrast Ratio	Typical	300:1
Display Viewing Angles	Above Centre	80 Degrees
	Below Centre	80 Degrees
	Left of Centre	80 Degrees
	Right of Centre	80 Degrees
Display Viewing Direction		ALL – IPS Display
Display Backlighting	White LED's	6x4 Parallel LED's (24 LED's)
Pixel Pitch	Width x Height – Landscape mode	0.258 x 0.258mm (Square pixels)
Pixel Density	Number of pixels in 1 row in 25.4mm	98.45 DPI/PPI

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17. Revision History

Hardware Revision

Revision Number	Date	Description
1.3	11/04/2023	Initial Public Release version

Datasheet Revision

Revision Number	Date	Description
1.0	13/07/2023	Initial Public Release Version.
1.1	02/08/2023	Updated compliances/certifications
1.2	20/03/2024	Updated formatting for resource centre redesign

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