



DATASHEET

4D SYSTEMS

TURNING TECHNOLOGY INTO ART

DIABLO OGM

OEM Graphics Module

Document Date: 23rd July 2013
Document Revision: 1.0

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	8
4.4. Alternate Pin Funtions - Overview.....	10
4.5. SPI.....	11
4.6. I ² C	11
4.7. Pulse Out	11
4.8. PWM Out.....	12
4.9. Pin Counter	12
4.10. Quadrature In.....	12
4.11. Analog Inputs	13
5. PmmC/Firmware Programming	14
6. Module Features	14
6.1. DIABLO16 Processor.....	14
6.2. Audio	14
6.3. SD/SDHC Memory Cards	15
6.4. FAT16	15
6.5. Upgrading from PICASO-OGM	15
7. Display Information	16
7.1. Display Precautions	16
7.2. Compatible Displays.....	16
7.3. Custom Design solutions.....	17
8. Hardware Tools	17
8.1. 4D Programming Cable/Adaptor.....	17
8.2. DIABLO16 OGM Base Board.....	18
9. 4DGL - Software Language	18
10. 4D Systems - Workshop 4 IDE	19
10.1. Workshop 4 – Designer Environment	19
10.2. Workshop 4 – ViSi Environment.....	19
10.3. Workshop 4 – ViSi Genie Environment	20
10.4. Workshop 4 – Serial Environment.....	Error! Bookmark not defined.

11. Notes	21
12. Scribble Box.....	21
12.1. Mechanical Details	22
13. Recommended PCB Footprint.....	23
14. Schematic Diagram	24
15. Example External Components	25
16. Specifications and Ratings	26
17. Legal Notice.....	27
18. Contact Information.....	27

PRELIMINARY

1. Description

The DIABLO16 OGM (OEM Graphics Module) is a compact and low profile custom SMT mounted PCB module, designed specifically for the integration into OEM products, with minimal space requirements.

The OGM Module breaks out all of the General Purpose I/O (GPIO) that the DIABLO16 Processor provides, along with providing a microSD Card connector for the storage of images/videos/files used by the processor, and a 40 way FPC connector to connect to existing 4D displays.

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

The DIABLO16 OGM Module is the perfect solution for integrating the DIABLO16 Processor into new designs where space and cost is an issue, and provides all the resources the DIABLO16 Processor has available.

The DIABLO16 OGM Module is pin compatible in most ways with the less powerful PICASO OGM Module, allowing simple transfer/upgrade of existing designs. Please refer to the Upgrade Section (Section 6.5) of this document for further information, and read about any caveats that may exist if upgrading from a PICASO OGM.

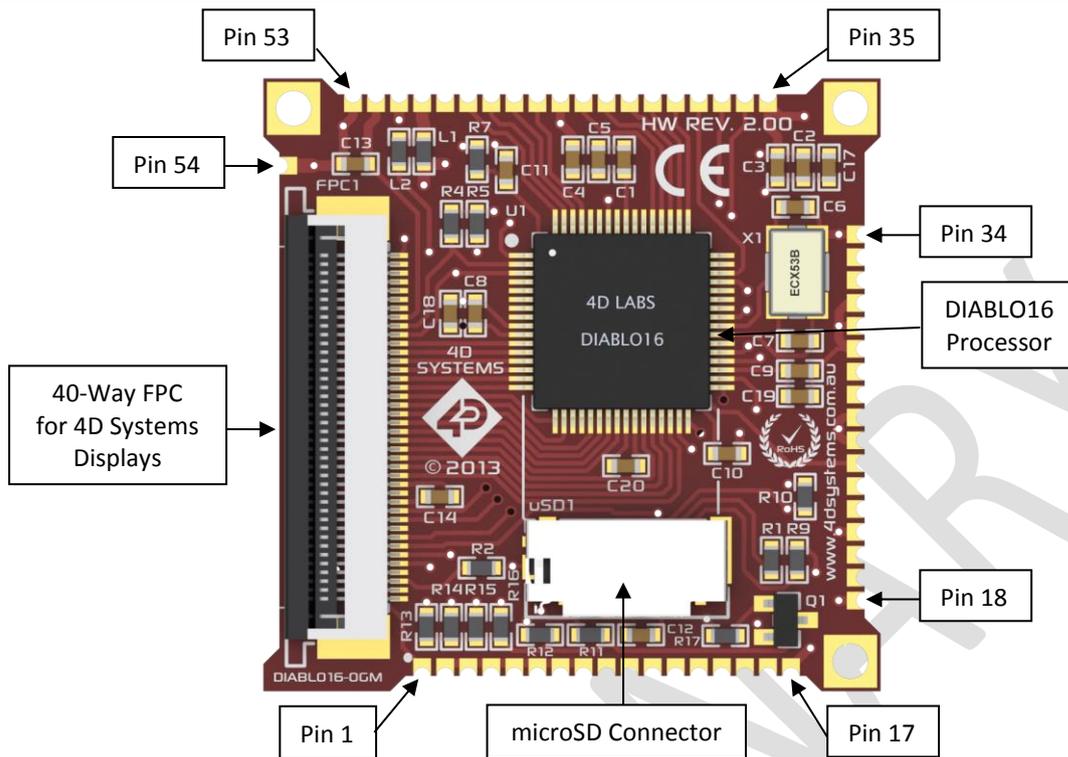
Anything that has been designed in the past to run on a PICASO or DIABLO16 Processor can theoretically run on this DIABLO16 OGM Module. Please ensure you contact the 4D Systems' support team if unsure when designing with this DIABLO16 OGM Module.

Please note, DIABLO16 OGM Modules are designed for volume customers with volume orders only. Please contact the 4D Systems Sales Department for volume pricing.

2. Features

- OEM DIABLO16 Module designed for integrators designing with 4D Systems DIABLO16 processors/modules
- Offers 40 way FPC connection to existing 4D Systems display solutions, 2.4", 2.8", 3.2" and 3.2" Wide
- 4 wire Resistive Touch support is built in
- 6 banks of 32750 bytes of Flash memory for User Application Code and Data
- 32Kb of SRAM purely for the User.
- 16 General Purpose I/O pins for user interfacing, which include 4 configurable Analog Inputs.
- The GPIO is variously configurable for alternative functions such as:
 - 3x I²C channels available
 - 1x 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. HC memory card support is also available for cards larger than 4GB.
- Micro-SD signals available externally if an external micro-SD card connector is preferred
- 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.
- Display full colour images, animations, icons and video clips on chosen 4D Systems display.
- Supports all available Windows fonts.
- 3.3V DC Input for the processor
- 5.0V DC input for the display backlight
- Module dimensions: 34.8 x 34.8 x 4.3mm, weighing ~ 5 grams.
- 3x alignment holes for module positioning, with 1.3mm pitch SMT pads for soldering of OGM module to host PCB or Baseboard.
- RoHS and CE Compliant.

3. Pin Configuration and Summary



OGM Pin Outs			
Pin	Symbol	I/O	Description
1	FMARK	O	Frame Marker signal from LCD (Not connected to DIABLO16, direct from Display)
2	GND	P	Supply Ground
3	GND	P	Supply Ground
4	GND	P	Supply Ground
5	GND	P	Supply Ground
6	GND	P	Supply Ground
7	GND	P	Supply Ground
8	GND	P	Supply Ground
9	CD_POL	-	Card Detect signal direct from on-board microSD Card, not connected to DIABLO16. Simple switch side 1, can be connected as required.
10	CD_DET	-	Card Detect signal direct from on-board microSD Card, not connected to DIABLO16. Simple switch side 2, can be connected as required.
11	SD_CS	O	microSD Chip Select. SD memory card use only. Connect this pin to the Chip Enable (CS) signal of an external SD card connector if not using the on board. Using both on-board and external SD is not advised.
12	SD_SDO	O	microSD Serial Data Output. SD memory card use only. Connect this pin to the SPI Serial Data Out (SDO) signal of an external SD card connector if not using the on board. Using both on-board and external SD is not advised.
13	SD_SCK	O	microSD Serial Clock output. SD memory card use only. Connect this pin to the SPI Serial Clock (SCK) signal of an external SD card connector if not using the on board. Using both on-board and external SD is not advised.
14	SD_SDI	I	microSD Serial Data Input. SD memory card use only. Connect this pin to the SPI Serial Data In (SDI) signal of an external SD card connector if not using the on board. Using both on-board and external SD is not advised.

Continued overleaf...

I = Input, O = Output, P = Power

OGM Pin Outs (Continued)			
Pin	Symbol	I/O	Description
15	BACKLITE	I	Backlight control for external PWM or Digital Control. Please refer to Section 4.3 for information on how this can be controlled externally
16	DISPON	O	Backlight control from the DIABLO16, must be connected externally to the BACKLITE pin (Pin 15) in order for the DIABLO16 to control the backlight.
17	GND	P	Supply Ground
18	GND	P	Supply Ground
19	PA12	I	General Purpose I/O. This pin is 5.0V tolerant.
20	PA13	O	General Purpose I/O. This pin is 5.0V tolerant.
21	GND	P	Supply Ground
22	RESET	I	Master Reset, Active Low (GND)
23	TX0	O	Asynchronous serial port 0 transmit pin. COM0
24	RX0	I	Asynchronous serial port 0 receive pin. COM0
25	GND	P	Supply Ground
26	GND	P	Supply Ground
27	PA11	I/O	General Purpose I/O. This pin is 5.0V tolerant.
28	PA10	O	General Purpose I/O. This pin is 5.0V tolerant.
29	GND	P	Supply Ground
30	GND	P	Supply Ground
31	GND	P	Supply Ground
32	AUDENB	O	Audio Amplified Enable, Active High (5V)
33	AUDIO	O	Raw PWM Audio Output (requires external components)
34	GND	P	Supply Ground
35	GND	P	Supply Ground
36	PA15	I/O	General Purpose I/O. This pin is 5.0V tolerant.
37	PA14	I/O	General Purpose I/O. This pin is 5.0V tolerant.
38	PA4	I/O	General Purpose I/O. This pin is 5.0V tolerant.
39	PA5	I/O	General Purpose I/O. This pin is 5.0V tolerant.
40	PA6	I/O	General Purpose I/O. This pin is 5.0V tolerant.
41	PA7	I/O	General Purpose I/O. This pin is 5.0V tolerant.
42	PA8	I/O	General Purpose I/O. This pin is 5.0V tolerant.
43	PA9	I/O	General Purpose I/O. This pin is 5.0V tolerant.
44	GND	P	Supply Ground
45	PA0	I/O	General Purpose I/O pin with Analog Capability. This pin is 5.0V tolerant when used as a Digital, with a range of 0-3.3V when used as an Analog Input
46	PA1	I/O	General Purpose I/O pin with Analog Capability. This pin is 5.0V tolerant when used as a Digital, with a range of 0-3.3V when used as an Analog Input
47	PA2	I/O	General Purpose I/O pin with Analog Capability. This pin is 5.0V tolerant when used as a Digital, with a range of 0-3.3V when used as an Analog Input
48	PA3	I/O	General Purpose I/O pin with Analog Capability. This pin is 5.0V tolerant when used as a Digital, with a range of 0-3.3V when used as an Analog Input
49	N/C	-	Not Connected
50	RAW+3.3V	P	Supply Input +3.3VDC to +3.6VDC, +3.3VDC Nominal
51	GND	P	Supply Ground
52	RAW+VCC	P	Backlight Supply Input +3.3VDC to +5.5VDC, +5VDC Nominal
53	GND	P	Supply Ground
54	GND	P	Supply Ground

I = Input, O = Output, P = Power

4. Hardware Interface - Pins

The DIABLO16 OGM Module provides both a hardware and software interface. This section describes in detail the hardware interface pins of the device.

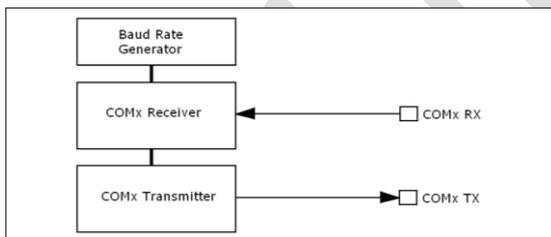
4.1. Serial Ports – TTL Level Serial

The DIABLO16 Processor has three hardware asynchronous serial ports that can be configured on a variety of the processors GPIO pins. TX/RX0 is dedicated and is fixed on to pins 23 (TX0) and 24 (RX0). All of the DIABLO16's serial ports can be used to communicate with external serial devices.

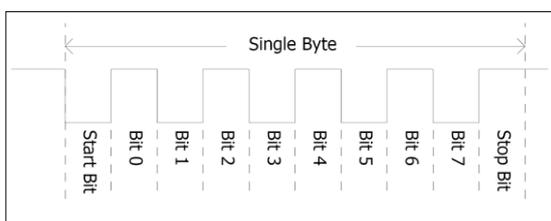
TX/RX0 are referred to as COM0, and is the only one used for programming the DIABLO16 itself.

The primary features are:

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



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



COM0 is also the primary interface for 4DGL user program downloads and chip configuration PmmC programming. Once the compiled 4DGL application program (EVE byte-code) is downloaded and the user code starts executing, the serial port is then available to the user application. Refer to Section 5 for more details on PmmC/Firmware programming.

TX0 pin (Serial Transmit COM0):

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

RX0 pin (Serial Receive COM0):

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

TX1 pin (Serial Transmit COM1):

Asynchronous Serial port COM1 transmit pin, TX1. Connect this pin to external serial device receive (Rx) signal. This pin is 5.0V tolerant. This can be configured to 1 of the GPIO pins, see table below.

RX1 pin (Serial Receive COM1):

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

TX2 pin (Serial Transmit COM2):

Asynchronous Serial port COM1 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 COM1 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 COM1 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 COM1 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.

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 5V 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-PA13:

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 Chapter 17, 'Specifications and Ratings'.

PA14-PA15:

Input only pins. These pins can only be Digital Inputs.

Note: All GPIO pins are 5.0V tolerant.

4.3. System Pins

RAW+3.3V (Module Voltage Input)

Pin 50:

Module supply voltage input pin. This pin must be connected to a stable and regulated supply voltage in the range of 3.3 Volts to 3.6 Volts DC. Nominal operating voltage is 3.3 Volts. Anything less than 3.3V could result in SD card corruption/errors (brand/model dependant).

RAW+VCC (Backlight Voltage Input)

Pin 52:

Backlight supply voltage input pin. This pin must be connected to a stable and regulated supply voltage in the range of 3.3 Volts to 5.5 Volts DC. Nominal operating voltage is 5.0 Volts. This will ensure optimal backlight brightness.

GND (Module Ground)

Pins 2-8, 16-18, 21, 25-26, 29-31, 34-35, 44, 51, 53-54:

Device ground pins which are all joined on the OGM Module. These pins must be connected to ground.

Note: Not ALL are required to be connected, however where possible, connect as many as possible to GND.

RESET (Module Master Reset)

Pin 22:

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

AUDENB (Audio Enable Output)

Pin 32:

Output dedicated to enable or disable and external amplifier, where required. Active High.

AUDIO (Raw PWM Audio Output)

Pin 33:

This pin outputs a raw PWM from the DIABLO16 Processor, designed to be connected to external components for filtering and amplification (where

required). When used in conjunction with AUDENB this pin can be used to feed PWM signals to a filtering and amplifier, and the AUDENB can enable or disable the amplifier as required.

FMARK (Frame Mark Output)

Pin 1:

This pin is not connected to the DIABLO16 Processor, it comes directly from the LCD and can be used if required, and is used to detect the start of a Frame. If this is required, simply connect it externally to one of the GPIO pins, and use as required.

CD POL (SD Card Detect POL)

Pin 9:

This pin is side 1 of a simple switch located on the on-board microSD card connector. It is not connected to the DIABLO16 Processor, and may be connected to external components or back onto one of the OGM GPIO pins as required. Used in conjunction with CD DET, if one is pulled up to 3.3V, and the other to a GPIO pin configured as an Input, then when a card is inserted the 3.3V will be detected on the GPIO Input, and an action can be undertaken, as required.

CD DET (SD Card Detect DET)

Pin 10:

This pin is side 2 of a simple switch located on the on-board microSD card connector. It is not connected to the DIABLO16 Processor, and may be connected to external components or back onto one of the OGM GPIO pins as required. Used in conjunction with CD POL, if one is pulled up to 3.3V, and the other to a GPIO pin configured as an Input, then when a card is inserted the 3.3V will be detected on the GPIO Input, and an action can be undertaken, as required.

SD_CS (SD Card Chip Select)

Pin 11:

This is for SD memory card use only. Connect this pin to the Chip Enable (CS) signal of an external SD card connector if not using the on-board connector, providing flexibility for the end product. Using both on-board and external SD is not advised. Leave Open if external SD is N/A.

SD_SDO (SD Serial Data Output)

Pin 12:

This is for SD memory card use only. Connect this pin to the Serial Data Out (SDO) signal an external SD card connector if not using the on-board connector, providing flexibility for the end product. Using both on-board and external SD is not advised. Leave Open if external SD is N/A.

SD_SCK (SD Serial Clock Output)

Pin 13:

This is for SD memory card use only. Connect this pin to the Serial Data Clock (SCK) signal an external SD card connector if not using the on-board connector, providing flexibility for the end product. Using both on-board and external SD is not advised. Leave Open if external SD is N/A.

SD_SDI (SD Serial Data Input)

Pin 14:

This is for SD memory card use only. Connect this pin to the Serial Data Input (SDI) signal of an external SD card connector if not using the on-board connector, providing flexibility for the end product. Using both on-board and external SD is not advised. Leave Open if external SD is N/A.

BACKLITE (External Display Backlight Control)

Pin 15:

This pin allows external control of the backlight, to enable/disable/dim the backlight on the display. If an external PWM signal is connected to this pin, it can be used to drive the backlight and dim as required, or more simply a digital on/off signal to enable/disable as required.

DISPON (PICASO Display Backlight Control)

Pin 16:

This is directly connected to the DIABLO16 Processor and allows the DIABLO16 to enable or disable the backlight on the display. The DIABLO16 Processor is however unable to change the level of brightness on the display as it does not offer PWM functionality on this pin. In order to gain dimming control, the BACKLITE pin should be used with an external PWM signal. If DIABLO16 backlight control is required, simply join BACKLITE (Pin 15) with DISPON (Pin 16) externally, allowing the DIABLO16 to then control the backlight directly.



4.4. Alternate Pin Functions - Overview

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

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

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

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

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 I²C channels available.

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

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 in 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 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 on the previous page 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.

Please refer to the separate document titled '[DIABLO16-4DGL-Internal-Functions.pdf](#)' for more information on how to use the I²C 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 70Hz.

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 5.8 '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, OVfunction);
```

Where 'pin' is the GPIO pin compatible with this particular function, 'mode' is the type of trigger used to count on such as Rising/Falling/Edge, and 'OVfunction' is the user function to call when the counter overflows, if desired.

Please refer to the 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.

Note: The various analog modes can interfere with the operation of the touch screen if their functions are called too frequently. It is recommended to limit the calls of the analog functions to a maximum of once every millisecond. Please refer to the Internal Functions documentation for further information on this topic.

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.**

NOTE: The typical interface to a 4D Programming cable or adaptor is a vertical or horizontal 5-way 2.54mm pitch male pin header. The 4D Programming cables and adaptors provide a 5V supply which can be used to power up 4D products. The DIABLO16 OGM Module however has no on board regulation of its own, so cannot be directly connected to a 4D Programming cable or adaptor without an off board regulator to provide a stable regulated 3.3V supply for the OGM Module. Once a suitable 3.3V supply is provided to the OGM Module, then the TX0, RX0 and RESET lines can be utilized to program the on board PICASO Processor as usual.

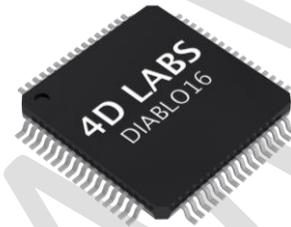
4D Systems has a BaseBoard to provide as an example of how the DIABLO16 OGM Module can be connected to a host PCB, and how it can be powered and programmed using a 4D Programming Cable or Adaptor. Please contact 4D Systems Sales for more information. More information about this can be found in Section 7.3

6. Module Features

The DIABLO16 OGM module is designed to accommodate most OEM applications. Some of the main features of the module are listed below.

6.1. 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- 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"***

6.2. Audio

Audio playback support in the DIABLO16 Processor enables the DIABLO16 OGM module to play audio WAV files stored in the micro-SD memory card. A raw PWM is output by the Processor (and OGM Module itself) which can then be filtered with a simple circuit, and amplified if required.

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"***

6.3. SD/SDHC Memory Cards

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

6.4. FAT16

The DIABLO16 OGM Module uses off the shelf standard SDHC/SD/micro-SD memory cards with up to 2GB capacity usable with FAT16 formatting. For any FAT file related operations, before the memory card can be used it must first be formatted with FAT16 option. The formatting of the card can be done on any PC system with a card reader. Select the appropriate drive and choose the FAT16 (or just FAT in some systems) option when formatting. The card is now ready to be used in the PICASO based application.



The DIABLO16 Processor also supports high capacity HC memory cards (4GB and above). The available capacity of SD-HC cards varies according to the way the card is partitioned and the commands used to access it.

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

6.5. Upgrading from PICASO-OGM

Upgrading from the PICASO-OGM to the DIABLO16-OGM is a simple process, however there are some caveats to the upgrade process which need to be noted.

There is 1 less GPIO available on the DIABLO16-OGM than on the PICASO OGM. IO1 on the PICASO OGM located on pin 49 is a N/C (Not Connected) pin on the DIABLO-16 OGM.

The DIABLO16 Processor is more advanced than the PICASO processor, so Serial/I2C/SPI channels

can be mapped to various GPIO, which wasn't previously possible on the PICASO. There are also a number of new features for the GPIO such as Analog Input, Quadrature Output, etc. These need to be taken into account if moving from PICASO to DIABLO as these new features may be desired and require a redesign of the host system.



DIABLO-16 OGM Module



PICASO OGM Module

7. Display Information

This section will outline some basic precautions when using 4D Systems' displays with the DIABLO16 OGM Module, along with a list of compatible 4D Systems' displays available.

7.1. Display Precautions

Below are some general guidelines and precautions when using a 4D Systems display. The DIABLO16 OGM Module itself does not include a display, however is compatible with 4D Systems 40 pin displays, 2.4", 2.8", 3.2" and 3.2" Wide.

- 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.

7.2. Compatible Displays

The DIABLO16 OGM Module is compatible with four displays currently offered by 4D Systems.

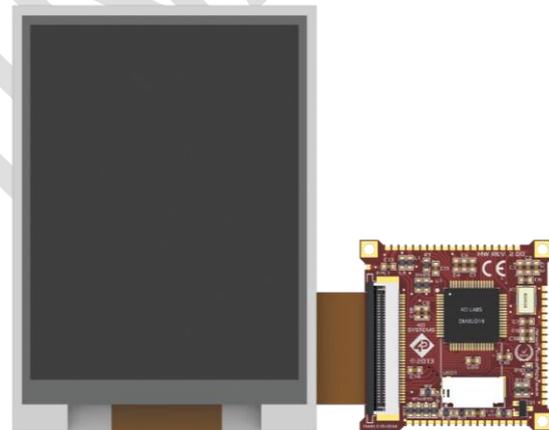
4DLCD-24QA – this is a 2.4" TFT LCD Display with a resolution of 240x320 and Resistive Touch. This is also available without Resistive Touch on special request.

4DLCD-28QA – this is a 2.8" TFT LCD Display with a resolution of 240x320 and Resistive Touch. This is also available without Resistive Touch on special request.

4DLCD-32QA – this is a 3.2" TFT LCD Display with a resolution of 240x320 and Resistive Touch. This is also available without Resistive Touch on special request.

4DLCD-32WA – this is a 3.2" Wide TFT LCD with a resolution of 240x400 and Resistive Touch. This is also available without Resistive Touch on special request.

More information on these 4D Systems' displays can be found on the 4D Systems website, and their associated product pages.

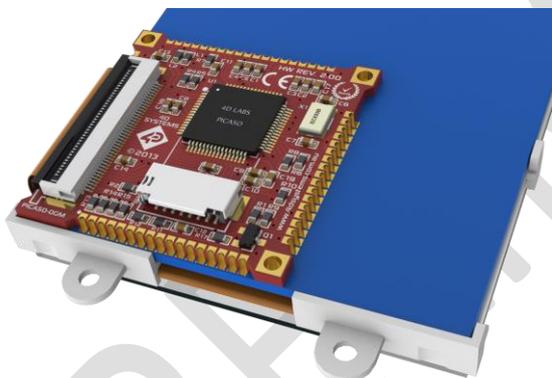


The DIABLO16 OGM Module connected to a 4DLCD-32QA Display.

7.3. Custom Design solutions

The DIABLO16 OGM Module is designed to be small and integrate easily into new product designs, to offer the full features of the DIABLO16 Processor to the end product, while taking up a minimal amount of real estate on the host system.

An example of the PICASO OGM Module is illustrated below (exactly same concept for this DIABLO16 OGM), showing its connection to a host PCB (shown in Blue), and the connection to a 4DLCD-32QA Display, and mounted on the plastic corner plates, which are also used in the microLCD Range of display modules, such as the uLCD-32PTU.



This is further illustrated using the 4D Systems BaseBoard, which can be seen in Section 8.2

8. Hardware Tools

The following hardware tools are required for full control of the DIABLO16 OGM 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 PICASO 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

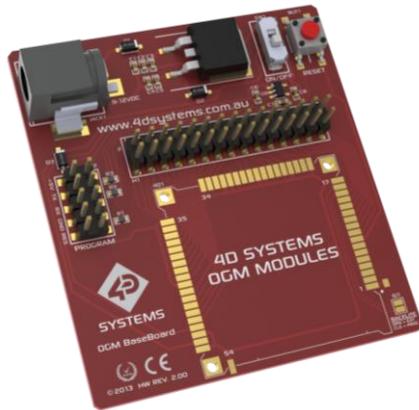


uUSB-PA5 Programming Adaptor

NOTE: The 4D Programming cables and adaptors provide a 5V supply which can be used to power up 4D products. The PICASO OGM Module however has no on board regulation of its own, so cannot be directly connected to a 4D Programming cable or adaptor without an off board regulator to provide a stable regulated 3.3V supply for the OGM Module. Once a suitable 3.3V supply is provided to the OGM Module, then the TX0, RX0 and RESET lines can be utilized to program the on board PICASO Processor as usual.

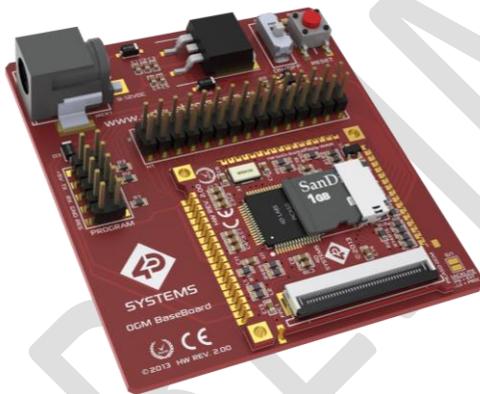
8.2. DIABLO16 OGM Base Board

4D Systems has designed a BaseBoard for the OGM Module, which provides an evaluation type interface for the OGM Modules, to enable it to be easily powered up, programmed and tested.

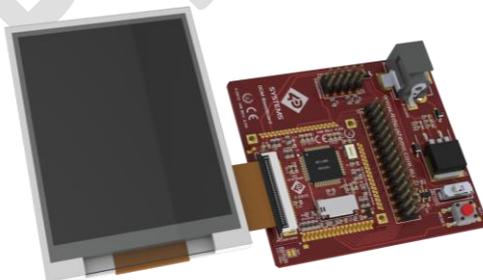


This evaluation board is called the OGM BaseBoard, and is available from the 4D Systems. Please discuss with the 4D Systems Sales team if a BaseBoard would assist with your development.

The OGM Module is required to be soldered into place on the OGM BaseBoard.



BaseBoard with PICASO OGM and 4DLCD-32QA
(Same concept with DIABLO OGM Module)



Please refer to the datasheet for the BaseBoard, available from the DIABLO16 OGM Product Page.

9. 4DGL - Software Language

The DIABLO16 OGM 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 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 Workshop 4 IDE, Designer and ViSi.

10. 4D Systems - Workshop 4 IDE

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



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

- The **Designer** environment enables the user to write 4DGL code in its natural form to program the OGM 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.

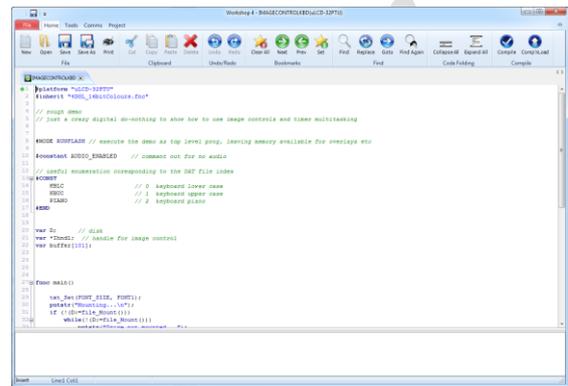
The Workshop 4 IDE is available from the 4D Systems website. www.4dsystems.com.au

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.

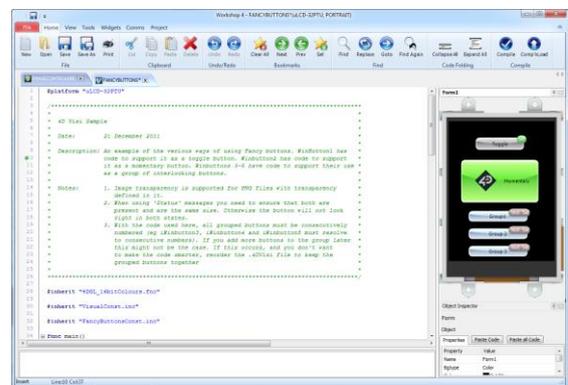
The Designer environment provides the user with a simple yet effective programming environment where pure 4DGL code can be written, compiled and downloaded to the OGM Module.



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.

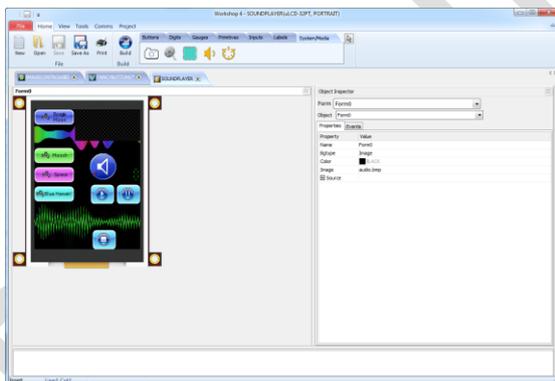
ViSi Genie does all the background coding, no 4DGL to learn, it does it all for you.

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.

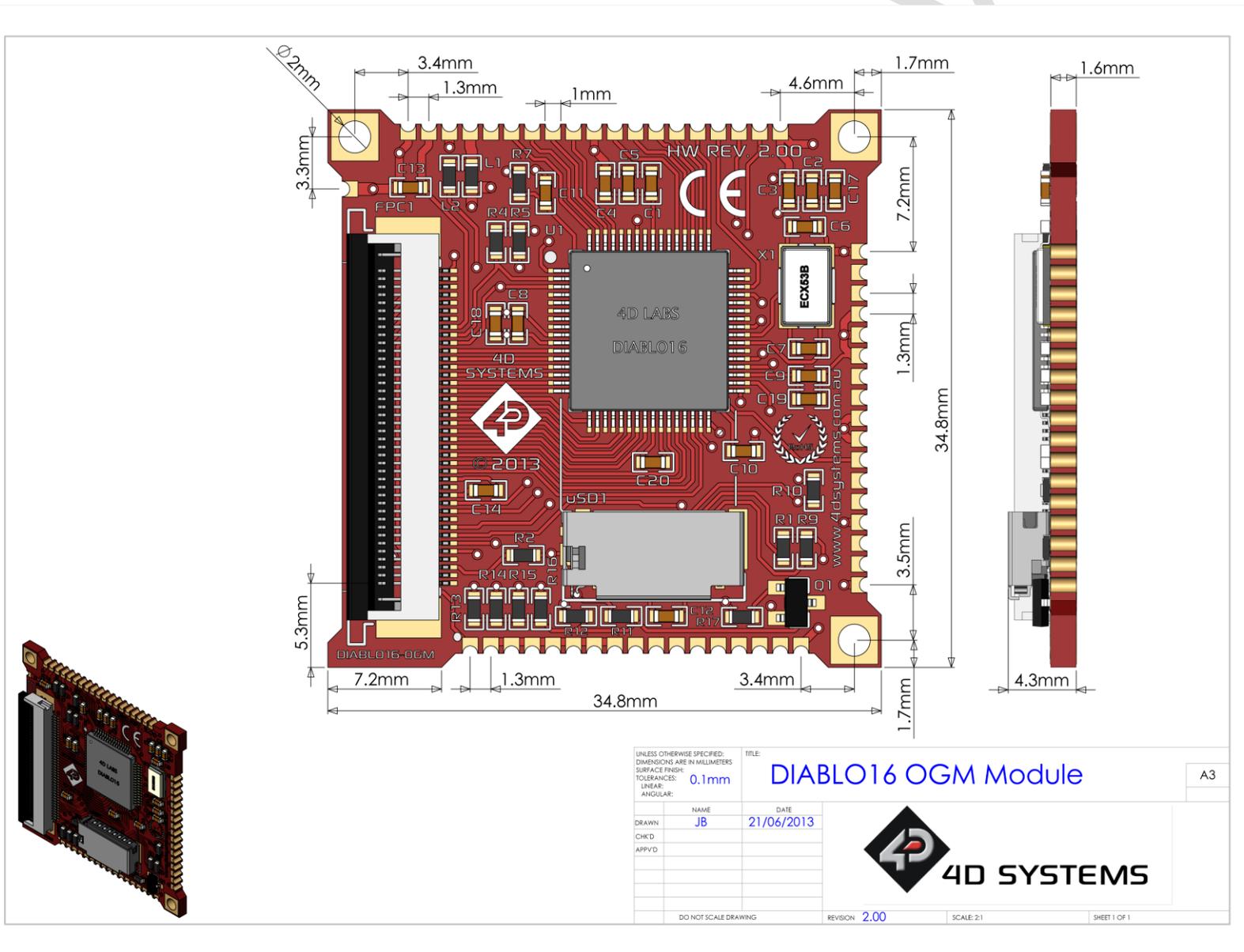
Simply place an object on the screen, position and size it to suit, set the parameters such as colour, range, text, and finally select the event you wish the object to be associated with, it is that simple.

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.

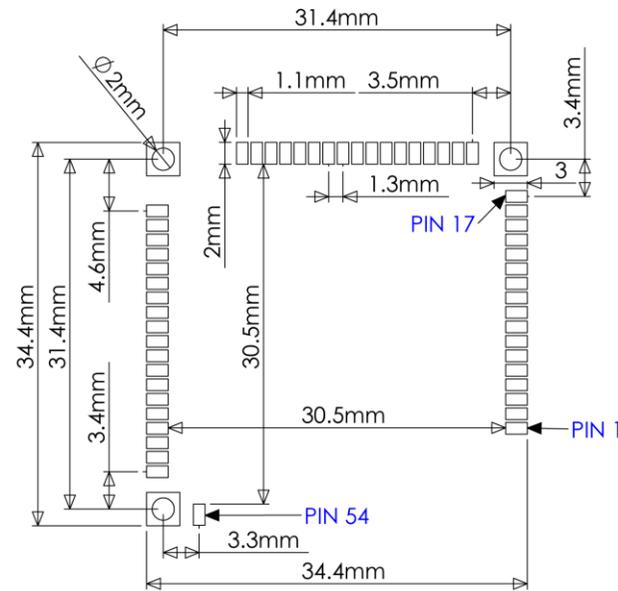
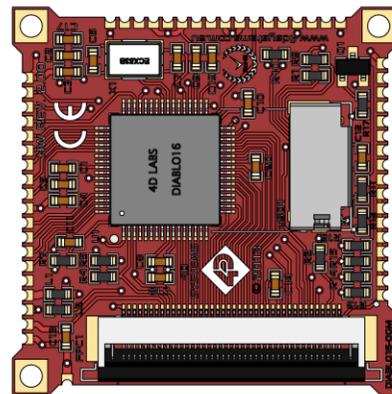


12.1. Mechanical Details



13. Recommended PCB Footprint

DIABLO16 OGM Module



UNLESS OTHERWISE SPECIFIED:
 DIMENSIONS ARE IN MILLIMETERS
 SURFACE FINISH:
 TOLERANCES: 0.1mm
 LINEAR:
 ANGULAR:

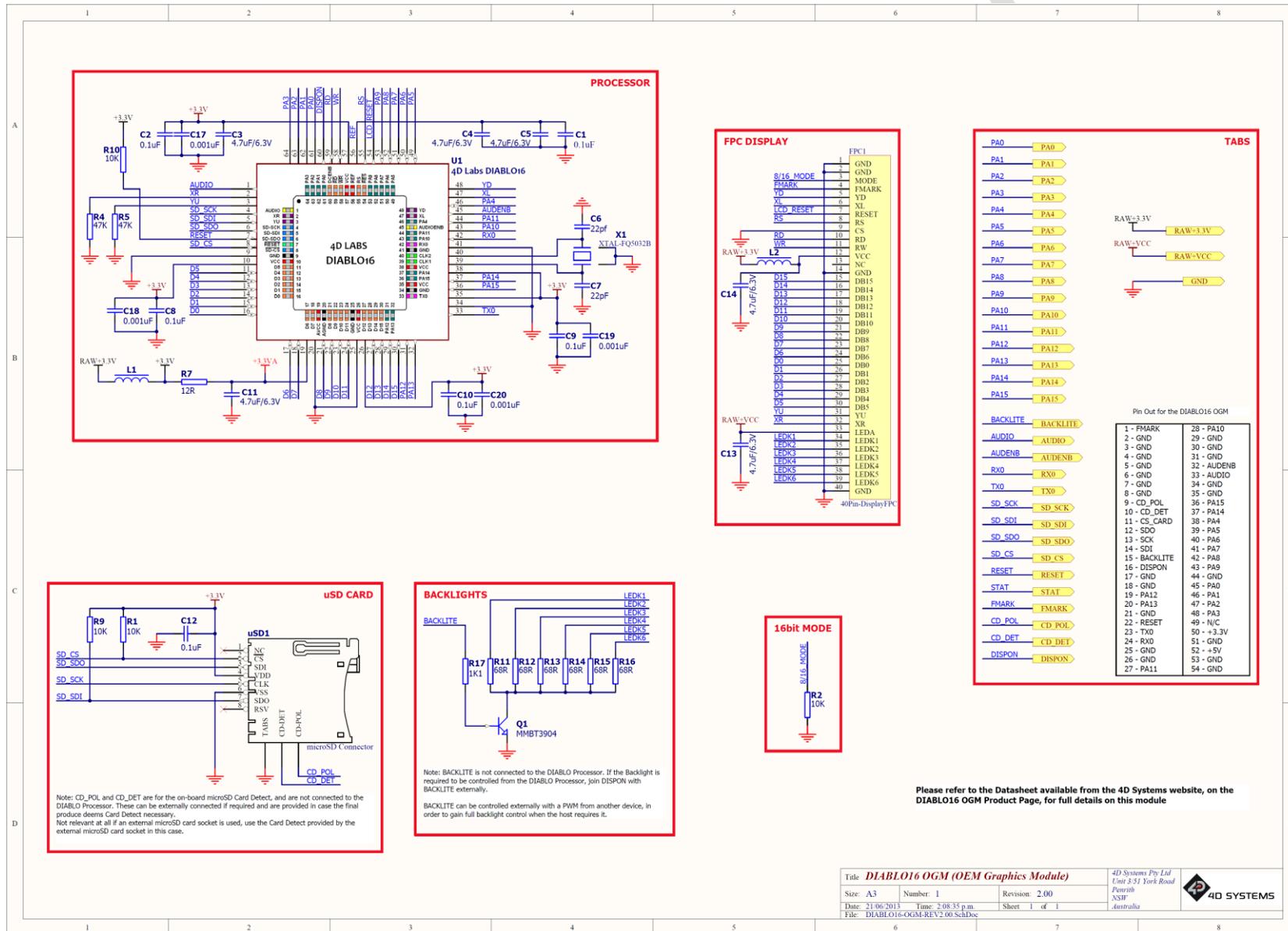
TITLE: **DIABLO16 OGM - PCB Footprint** A3

	NAME	DATE
DRAWN	JB	21/06/2013
CHK'D		
APP'VD		



DO NOT SCALE DRAWING REVISION 2.00 SCALE: 2:1 SHEET 1 OF 1

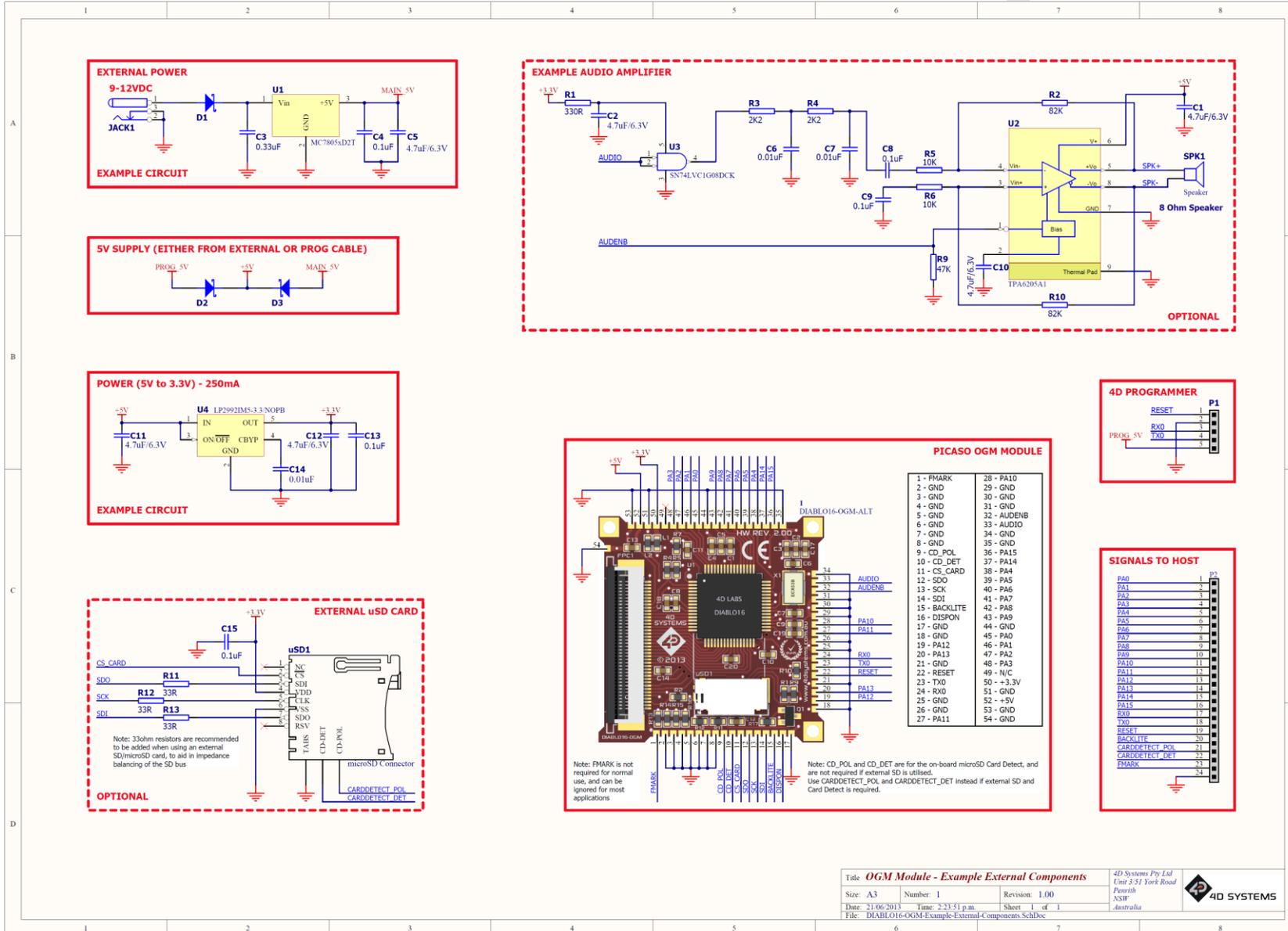
14. Schematic Diagram



DIABLO16 OGM Module

15. Example External Components

DIABLO16 OGM Module



16. Specifications and Ratings

ABSOLUTE MAXIMUM RATINGS

Operating ambient temperature	-15°C to +65°C
Storage temperature	-30°C to +70°C
Voltage on any digital input pin with respect to GND	-0.3V to 6.0V
Voltage on RAW+3.3V with respect to GND	-0.3V to 3.6V
Voltage on RAW+VCC with respect to GND	-0.3V to 5.5V

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 (RAW+3.3V)	Stable Regulated external supply required	3.3	3.3	3.6	V
Backlight Supply (RAW+VCC)	Stable Regulated external supply required (3.3V results in dim backlight)	3.3	5.0	5.5	V
Operating Temperature		-10	--	+60	°C
Input Low Voltage (VIL)	3.3V, all pins	0	--	0.2	V
Input High Voltage (VIH)	3.3V, non 5V tolerant pins	0.8	--	3.3	V
Input High Voltage (VIH)	All GPIO pins, RX0 and TX0 pins	0.8	--	5.5	V
Reset Pulse	External Open Collector	2.0	--	--	µs
Operational Delay	Power-Up or External Reset	500	--	3000	ms

GLOBAL CHARACTERISTICS BASED ON OPERATING CONDITIONS

Parameter	Conditions	Min	Typ	Max	Units
Supply Current (ICC)	3.3V, heavily depends on screen usage conditions, sleep mode	--	TBD	--	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	PICASO PmmC Programming	--	10000	--	E/W

ORDERING INFORMATION

Order Code: DIABLO16-OGM

Packaging: Bulk Packaging

17. Legal Notice

Proprietary Information

The information contained in this document is the property of 4D Systems Pty. Ltd. and may be the subject of patents pending or granted, and must not be copied or disclosed without prior written permission.

4D Systems endeavours to ensure that the information in this document is correct and fairly stated but does not accept liability for any error or omission. The development of 4D Systems products and services is continuous and published information may not be up to date. It is important to check the current position with 4D Systems. 4D Systems reserves the right to modify, update or make changes to Specifications or written material without prior notice at any time.

All trademarks belong to their respective owners and are recognised and acknowledged.

Disclaimer of Warranties & Limitation of Liability

4D Systems makes no warranty, either expressed or implied with respect to any product, and specifically disclaims all other warranties, including, without limitation, warranties for merchantability, non-infringement and fitness for any particular purpose.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications.

Images and graphics used throughout this document are for illustrative purposes only. All images and graphics used are possible to be displayed on the 4D Systems range of products, however the quality may vary.

In no event shall 4D Systems be liable to the buyer or to any third party for any indirect, incidental, special, consequential, punitive or exemplary damages (including without limitation lost profits, lost savings, or loss of business opportunity) arising out of or relating to any product or service provided or to be provided by 4D Systems, or the use or inability to use the same, even if 4D Systems has been advised of the possibility of such damages.

4D Systems products are not fault tolerant nor designed, manufactured or intended for use or resale as on line control equipment in hazardous environments requiring fail – safe performance, such as in the operation of nuclear facilities, aircraft navigation or communication systems, air traffic control, direct life support machines or weapons systems in which the failure of the product could lead directly to death, personal injury or severe physical or environmental damage ('High Risk Activities'). 4D Systems and its suppliers specifically disclaim any expressed or implied warranty of fitness for High Risk Activities.

Use of 4D Systems' products and devices in 'High Risk Activities' and in any other application is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless 4D Systems from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any 4D Systems intellectual property rights.

18. Contact Information

For Technical Support: support@4dsystems.com.au

For Sales Support: sales@4dsystems.com.au

Website: www.4dsystems.com.au

Copyright 4D Systems Pty. Ltd. 2000-2013.