DATASHEET

4D SYSTEMS

TURNING TECHNOLOGY INTO ART

0.96” *microO*LED GOLDELOX Display

µOLED-96-G2

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

Overview

The **µOLED-96-G2** is a compact and cost effective Intelligent Display Module using the latest state of the art Passive Matrix OLED (PMOLED) technology with an embedded **GOLDELOX** graphics processor that delivers 'stand-alone' functionality to any project.

The module is an elegant combination of a 0.96" PMOLED Passive Matrix Screen, along with a modest but comprehensive collection of I/O Features. These include a micro-SD card connector, two general purpose input/output pins (GPIO's) with Dallas 1-Wire Support, Analog Input and sound generation capability, along with serial communications.

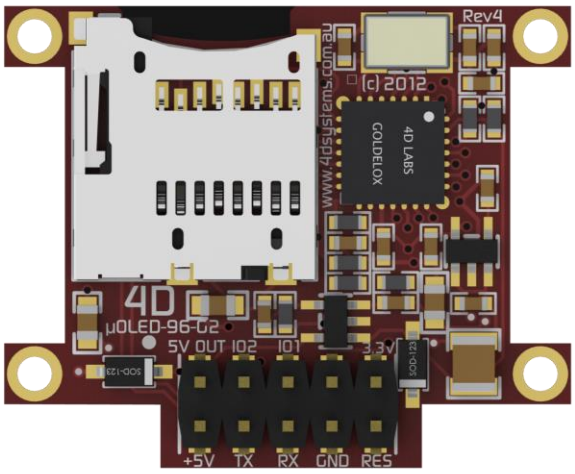
Embedded at the heart of the design is the **GOLDELOX** processor, which is driven by a highly optimised virtual core engine called **EVE** (Extensible Virtual Engine).

This display module serves as a perfect solution to be deployed at the forefront of any product design requiring brilliance of colour, animation or images, or in any application requiring a small display where there may be space constraints. This **GOLDELOX** driven Intelligent Display Module is a perfect example of where art meets technology.

The **µOLED-96-G2** has a **0.96''** PMOLED Display at the forefront of the design that showcases the power and capabilities of the GOLDELOX processor. Combining a resolution of **96x64** pixels with **65K** True to Life colours, this display module is perfect for animations, slideshows and other multimedia presentations.

Basic audio generation is possible on the module through the use of RTTTL sounds and beeps. These can be executed easily with a simple command, and are non-blocking which enables user code to be executed while audio is playing.

The **micro-SD** card slot on the module provides the user with expandable memory space suitable for multimedia file retrieval, including images, animations and movie clips, as well as data logging applications.



This microOLED module can be programmed in its native 4DGL language (similar to C), using the Workshop 4 IDE Software tool suite. It can also be configured very easily as a serial slave device, for use with your favourite host controller. Freedom is at your fingertips with the intelligent **µOLED-96-G2** display module.

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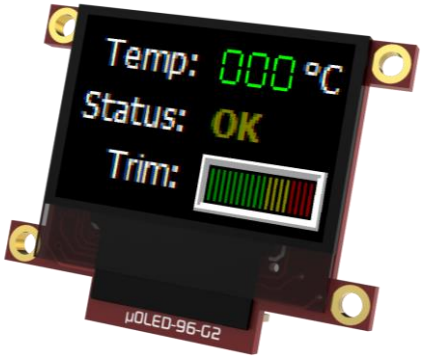
1. Description

The µOLED-96-G2 is an impressive OLED display module in the 4D Systems microOLED graphics display range. Featuring a 0.96” 96x64 resolution display, it is the ideal size for attractive embedded display applications.

Driving the module and its peripherals is the GOLDELOX processor, a very capable chip which provides impressive graphics power, programmed with 4D Systems Workshop IDE Software. 4D Systems Workshop enables graphic solutions to be constructed rapidly and with ease due to its design being solely for 4D’s graphics controllers.

The µOLED-96-G2 has a modest but comprehensive range of features suited for an application requiring a bright eye catching display, an analog input, Dallas 1-wire sensor capability, audio generation, or simply digital I/O. This is truly an impressive little module.

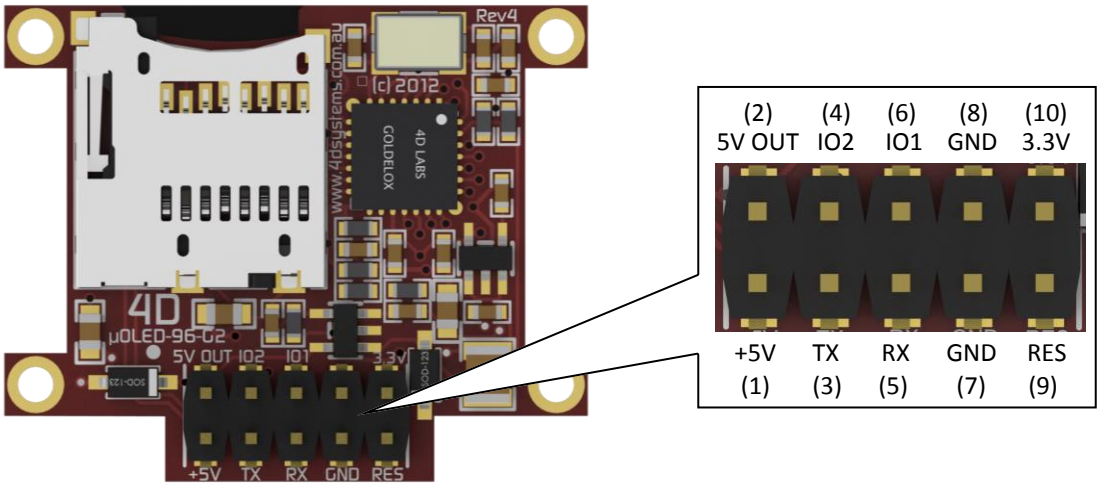


2. Features

- Low-cost 0.96" OLED display graphics user interface solution.
- 96 x 64 resolution, RGB 65K true to life colours, PMOLED Screen.
- No back lighting with near 180° viewing angle.
- Easy 10 pin interface to any host device: 3.3Vout, IO2, GND, IO1, RESET, GND, RX, TX, +5V, 5V OUT
- Powered by the 4D-Labs GOLDELOX processor (also available as separate OEM IC)
- 10KB of flash memory for user code storage and 510 bytes of RAM for user variables (255 x 16bit vars).
- Asynchronous hardware serial UART port with auto-baud, TTL interface, with 300 to 600K baud.
- 2 x General Purpose I/O pins.
  IO1 supports:
  - Digital I/O
  - A/D Converter with 8/10 bit resolution
  - Complex sound generation
  - Dedicated RTTTL tune engine
  - Multi-Switch Joystick, Buttons
  - Dallas 1-Wire

  IO2 supports:
  - Digital I/O
  - Complex sound generation
  - Dedicated RTTTL tune engine
  - Dallas 1-Wire
- On-board micro-SD memory card adaptor for multimedia storage and data logging purposes. HC memory card support is also available for cards larger than 4GB.
- Built in extensive 4DGL graphics and system library functions.
- Display full colour images, animations, icons and video clips (no audio support for video).
- Supports all available Windows fonts and characters (imported as external fonts).
- 4.0V to 5.5V range operation (single supply), nominal 5.0V.
- Module dimensions: 32.7 x 26.7 x 13.2mm (including mounting tabs), 4x 2mm holes.
- Weight ~ 5.5g.
- Display Viewing Area: 20.1 x 13.4mm
- RoHS Compliant.

3. Pin Configuration and Summary



Interface/Programming Header			
Pin	**Symbol**	**I/O**	**Description**
1	+5V	P	Main Voltage Supply +ve input pin. Reverse polarity protected. Range is 4.0V to 5.5V, nominal 5.0V.
2	5V OUT	P	5V OUT provides approximately 4.7 V through a protection diode.
3	TX	O	Asynchronous Serial Transmit pin. Output data is at TTL voltage levels. Connect this pin to external device Serial Receive (Rx) signal. This pin is tolerant up to 5.0V levels.
4	IO2	I/O	General purpose IO2 pin. See section 2.2 for more detail.
5	RX	I	Asynchronous Serial Receive pin. Connect this pin to external device Serial Transmit (Tx) signal. This pin is tolerant up to 5.0V levels.
6	IO1	I/O	General purpose IO1 pin. See section 2.2 for more detail.
7	GND	P	Supply Ground.
8	GND	P	Supply Ground.
9	RESET	I	Master Reset signal. Internally pulled up to 3.3V via a 4.7K resistor. An active Low pulse greater than 2.0µs 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	3.3V	P	Regulated 3.3 Volts output, maximum available current 50mA to power external circuitry.

I = Input, O = Output, P = Power

4. Hardware Interface - Pins

The µOLED-96-G2 provides both a hardware and software interface. This section describes in detail the hardware interface pins of the device.

4.1. Serial Ports - COM0 UART

The µOLED-96-G2 has a dedicated hardware UART that can communicate with external serial devices.

The primary features are:
• Full-Duplex 8 bit data transmission and reception through the TX and RX pins.
• Data format: 8 bits, No Parity, 1 Stop bit.
• Auto Baud feature.
• Baud rates from 300 baud up to 600K baud.

The Serial port is also the primary interface for downloading compiled 4DGL application code as well as future PmmC/Firmware updates for the on-board GOLDELOX processor. Refer to **Section 5. PmmC/Firmware Programming** for more details.

TX pin 3 (Serial Transmit):
Asynchronous Serial port Transmit pin, TX. The serial output data is at TTL voltage levels. Connect this pin to external serial device Rx signal.

RX pin 5 (Serial Receive):
Asynchronous Serial port Receive pin, RX. Connect this pin to external serial device Transmit Tx signal.

4.2. General Purpose I/O

There are 2 GPIO pins available, **IO1** and **IO2**. Each GPIO has a multitude of high level functions associated with it and these can be selected within 4DGL user application code.

Refer to the separate document titled ***"GOLDELOX-4DGL-Internal-Functions.pdf"*** for a complete set of built in 4DGL library functions.

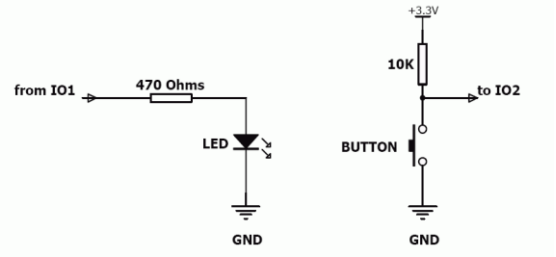
IO1 pin 6 (General Purpose IO1):
General purpose IO1 pin. The following table lists the available GPIO functions and features.

IO2 pin 4 (General Purpose IO2):
General purpose IO2 pin. The following table lists the available GPIO functions and features.

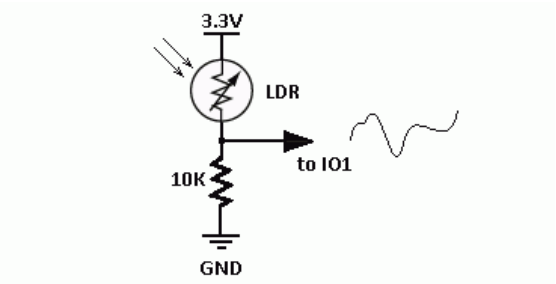
Note: GPIO pins are 5.0V tolerant.

GPIO Functions and Features		
Function	**IO1**	**IO2**
Digital Input	√	√
Digital Output	√	√
A/D Converter 8/10 bits	√	--
Joystick – 5 position multi-switch	√	--
Dallas 1-Wire support	√	√
Sound Generation, RTTTL Tunes	√	√

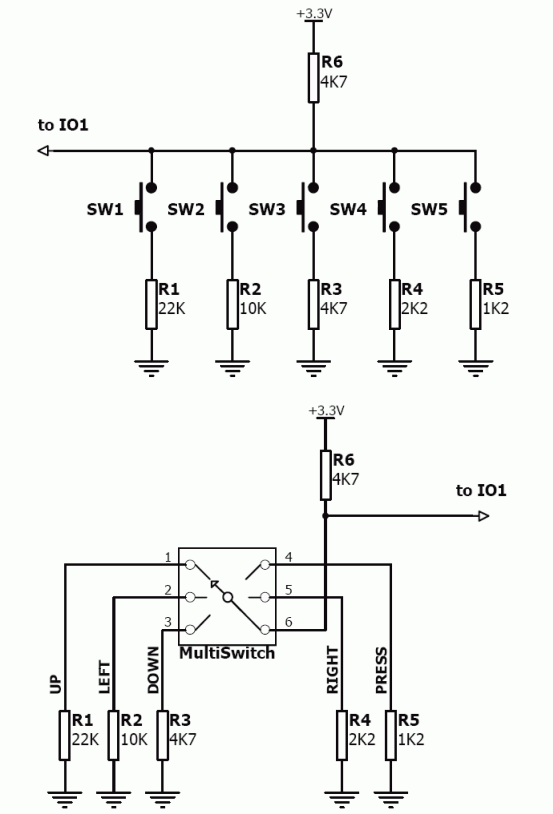
Input/Output:
Both IO1 and IO2 pins can be programmed to be Inputs or Outputs. Diagram below shows a LED connected to IO1 (programmed as an output) and a button connected to IO2 (programmed as an input).



Analogue to Digital Converter:
The IO1 pin can be programmed as an A/D input. Option is available to select 8 bit or 10 bit resolution. Diagram below is a circuit of a Light Dependant Resistor (LDR) connected to IO1 to measure and record changes in ambient light.



Joystick - Multi Switch:
Multiple buttons or a multi-switch Joystick can be connected to the IO1 pin on the µOLED-96-G2 module. Up to five buttons or a 5 position multi-switch joystick connects to a junction of a resistor ladder network that forms a voltage divider. The A/D converter of the IO1 pin internally reads the analogue value and decodes it accordingly. This feature is supported by dedicated 4DGL library functions. The following diagrams indicate how to connect up to five individual buttons or a multi switch joystick to the IO1 pin.



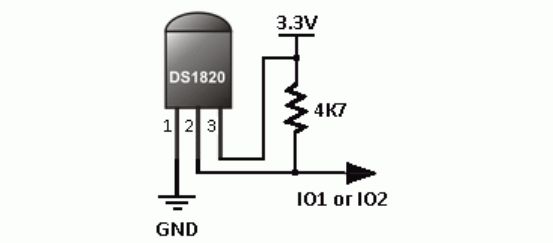
Unused buttons do not need resistors to be connected to the circuit. Table below lists the buttons and corresponding resistor values.

Number of Buttons	Button Number	Resistor Value
1	SW1	22K
2	SW2	10K
3	SW3	4.7K
4	SW4	2.2K
5	SW5	1.2K

Dallas 1-Wire:

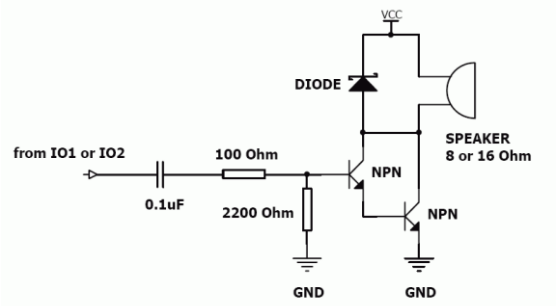
The Dallas 1-Wire protocol is a form of serial communications designed to operate over a single data line plus ground reference. Multiple 1 Wire devices can be attached to the same shared data line to network many devices. One wire device support is available on both the IO1 and the IO2 pins on the µOLED-96-G2 module.

The following diagram depicts a typical 1-Wire temperature sensor interface.



Sound Output:

The µOLED-96-G2 module is capable of generating complex sounds and RTTTL tunes from its IO1 and IO2 pins. A simple speaker circuit as shown below can be utilised.



4.3. System Pins

+5V (Module Voltage Input)
Pin 1:

Module supply voltage input pin. This pin must be connected to a regulated supply voltage in the range of 4.0 Volts to 5.5 Volts DC. Nominal operating voltage is 5.0 Volts.

5V Out (~4.7V)
Pin 2:

External circuitry that requires approximately 5V supply can be powered up via this pin. Maximum available current is 50mA.

GND (Module Ground)
Pins 7, 8:

Device ground pins. These pins must be connected to ground.

RESET (Module Master Reset)
Pin 9:

Module Master Reset pin. An active low pulse of greater than 2 micro-seconds will reset the module. Internally pulled up to 3.3V via a 4.7K resistor. Only use open collector type circuits to reset the device if an external reset is required.

3.3Vout (3.3V Regulated Output)
Pin 10:

External circuitry that requires a regulated 3.3V supply can be powered up via this pin. Maximum available current is 50mA.

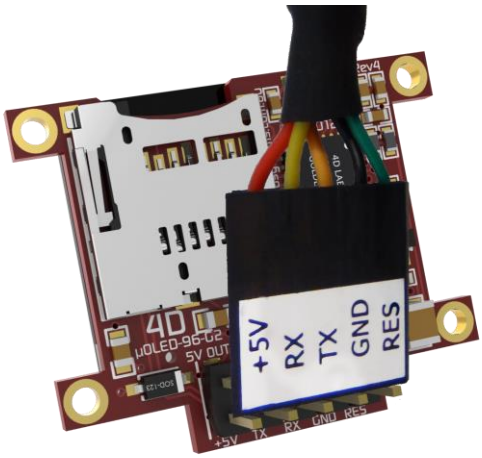
5. PmmC/Firmware Programming

The GOLDELOX processor on the µOLED-96-G2 module can be re-programmed with the latest PmmC configuration for updates and future proofing. The chip-level configuration is available as a PmmC (Personality-module-micro-Code) file and the programming must be performed over the serial interface. The chip-resident internal 4DGL functions are part of the GOLDELOX PmmC configuration file so please check regularly for the latest updates and enhancements.

It is recommended that the µOLED-96-G2 display module be socketed on the application board so that it can be easily removed for PmmC programming.

The PmmC file is programmed into the device with the aid of Workshop 4, the 4D Systems IDE software (See Section 10). To provide a link between the PC and the ICSP interface, a specific 4D Programming Cable is required and is available from 4D Systems.

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



6. Module Features

The µOLED-96-G2 module is designed to accommodate most applications. Some of the main features of the module are listed below.

6.1. Display – 0.96" PMOLED

The µOLED-96-G2 is equipped with a full colour PMOLED screen. Some of the features of the screen are:

- Screen Size: 0.96" diagonal
- 96 x 64 Resolution PMOLED display
- Screen Dimensions: 25.7 x 22.2mm.
- Active Area: 20.1 x 13.4mm
- 65K true to life colours
- Brightness: 100 cd/m2
- Contrast Ratio: 5000:1
- Viewing Angle: > 160 degrees
- No Back lighting

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

6.2. GOLDELOX Processor

The module is designed around the GOLDELOX Graphics Processor from 4D-Labs.

The GOLDELOX is a custom embedded graphics processor designed to interface with many popular OLED and LCD display panels. Powerful graphics, text, image, animation and countless more features are built right inside the chip. It offers a simple plug-n-play interface to many 8bit 80-Series colour LCD and OLED displays.

The chip is designed to work with minimal design effort and all of the data and control signals are provided by the chip to interface directly to the display. Simply choose your display and interface it

to the GOLDELOX on your application board. This offers enormous advantage to the designer in development time and cost saving and takes away all of the burden of low level design.

The data sheet for the chip is available from the http://www.4dsystems.com.au website:
"GOLDELOX-DS-revx.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).

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

7. OLED Screen Precautions

• Avoid having a White Background. The more pixels that are lit up, the more the display module will consume current. A full white screen will have the highest power consumption.

• Avoid displaying objects or text on White Backgrounds. This will cause a smearing effect which is inherent to all PMOLED displays. Instead try a shaded mixed colour as the background or better still a black background. Ideally have mixed coloured objects/text/icons on a black background.

• 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.

• The display can be easily scratched. The soft polarisation film on the glass surface may be damaged if rubbed by hard objects. Handle with care to avoid scratching the display.

• 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.

• Displays are susceptible to mechanical shock and any force exerted on the module may result in deformed zebra strips and cracks.

• Always use the mounting holes on the module's printed circuit board to mount the display.

8. Hardware Tools

The following hardware tools are required for full control of the µOLED-96-G2 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 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

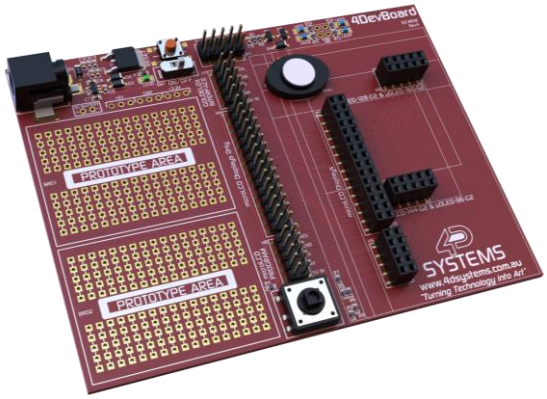
Using a non-4D programming interface could damage your processor, and **void your Warranty.**

4D Programming Cable

uUSB-PA5 Programming Adaptor

8.2. Development Hardware

4D Systems has designed a development board compatible with the µOLED-96-G2, enabling easy prototyping to take place and to experiment with the µOLED-96-G2 display module.



This development board is called the 4DevBoard, and is available from the 4D Systems website store, or from 4D Systems distributors.

9. 4DGL - Software Language

The heart of the µOLED-96-G2 module is the GOLDELOX graphics processor from 4D Labs. The GOLDELOX 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"
"GOLDELOX-4DGL-Internal-Functions.pdf"

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

4DGL is available to be written in two of the three environments offered by the Workshop 4 IDE, Designer and ViSi.

10. 4D Systems - Workshop 4 IDE

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

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

- The **Designer** environment enables the user to write 4DGL code in its natural form to program the µOLED-96-G2.
- 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.
- A **Serial** environment is also provided to transform the µOLED-96-G2 into a slave serial module, allowing the user to control the display from any host microcontroller or device with a serial port.

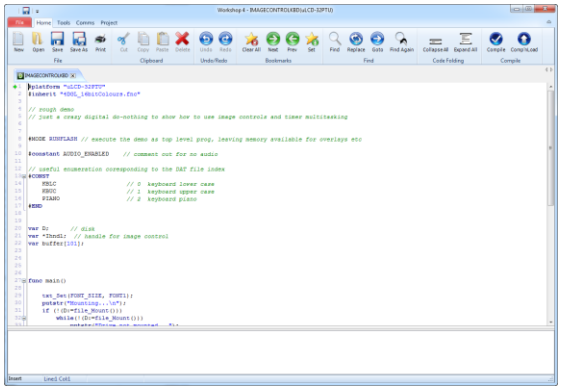
The Workshop 4 IDE is available from the 4D Systems website. www.4dsystems.com.au

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

10.1. Workshop 4 – Designer Environment

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

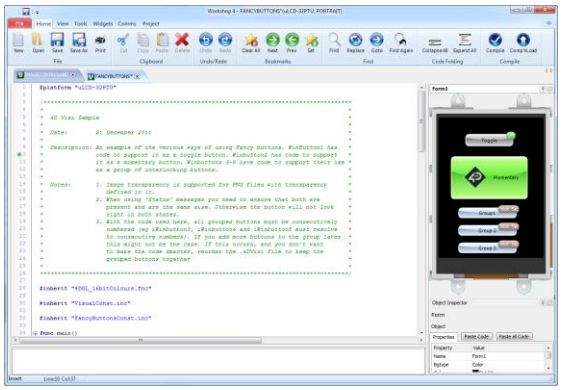
The Designer environment provides the user with a simple yet effective programming environment where pure 4DGL code can be written, compiled and downloaded to the Module.



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 – Serial Environment

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

This enables the user to use their favourite microcontroller or serial device as the Host, without having to learn 4DGL or program in a separate IDE. Once the Module is configured and downloaded to from the Serial Environment, simple graphic commands can be sent from the users host microcontroller to display primitives, images, sound or even video.

Refer to the **"Serial Command Set Reference Manual"** from the Workshop 4 product page on the 4D Systems website for a complete listing of all the supported serial commands

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

11. Notes

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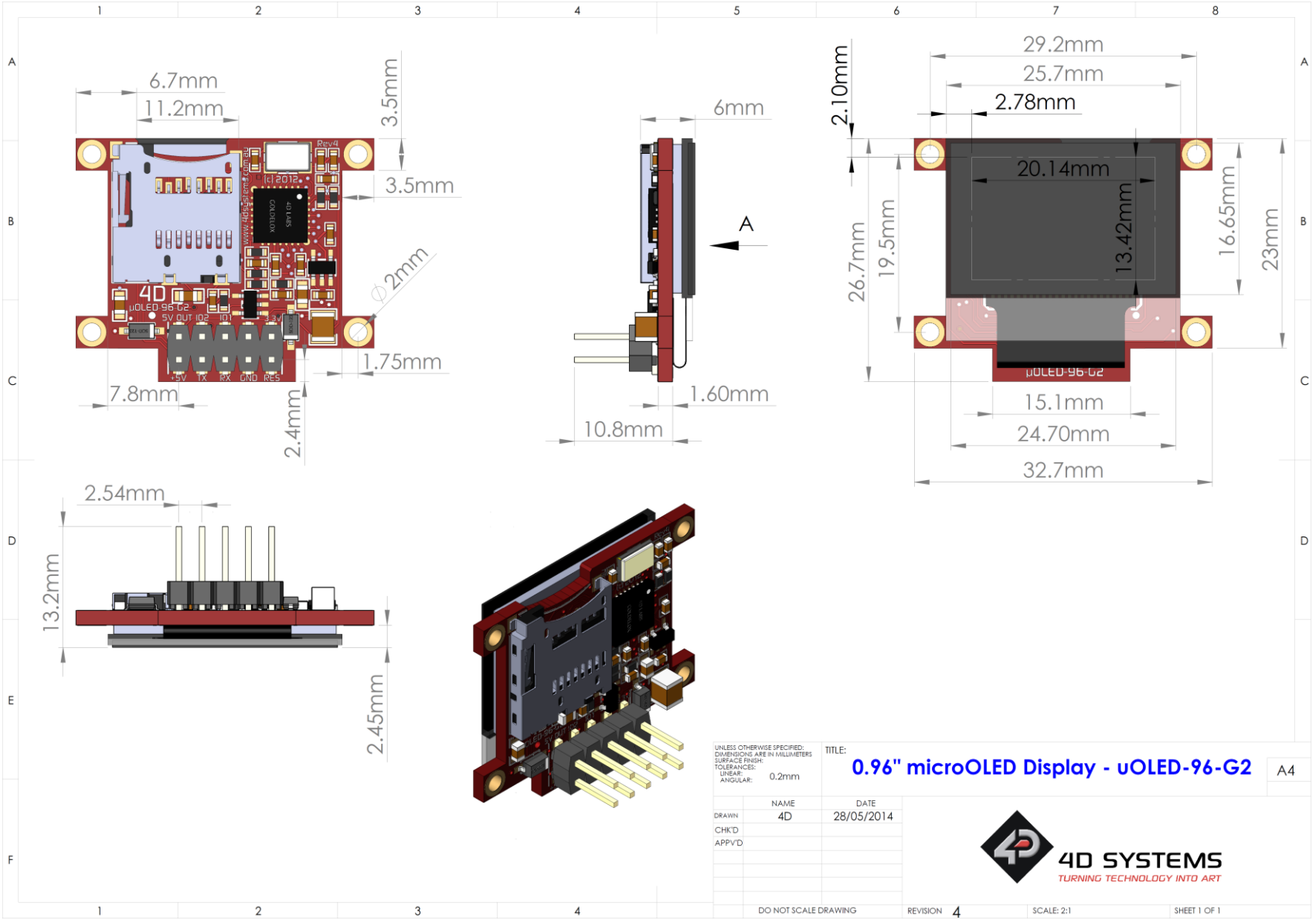
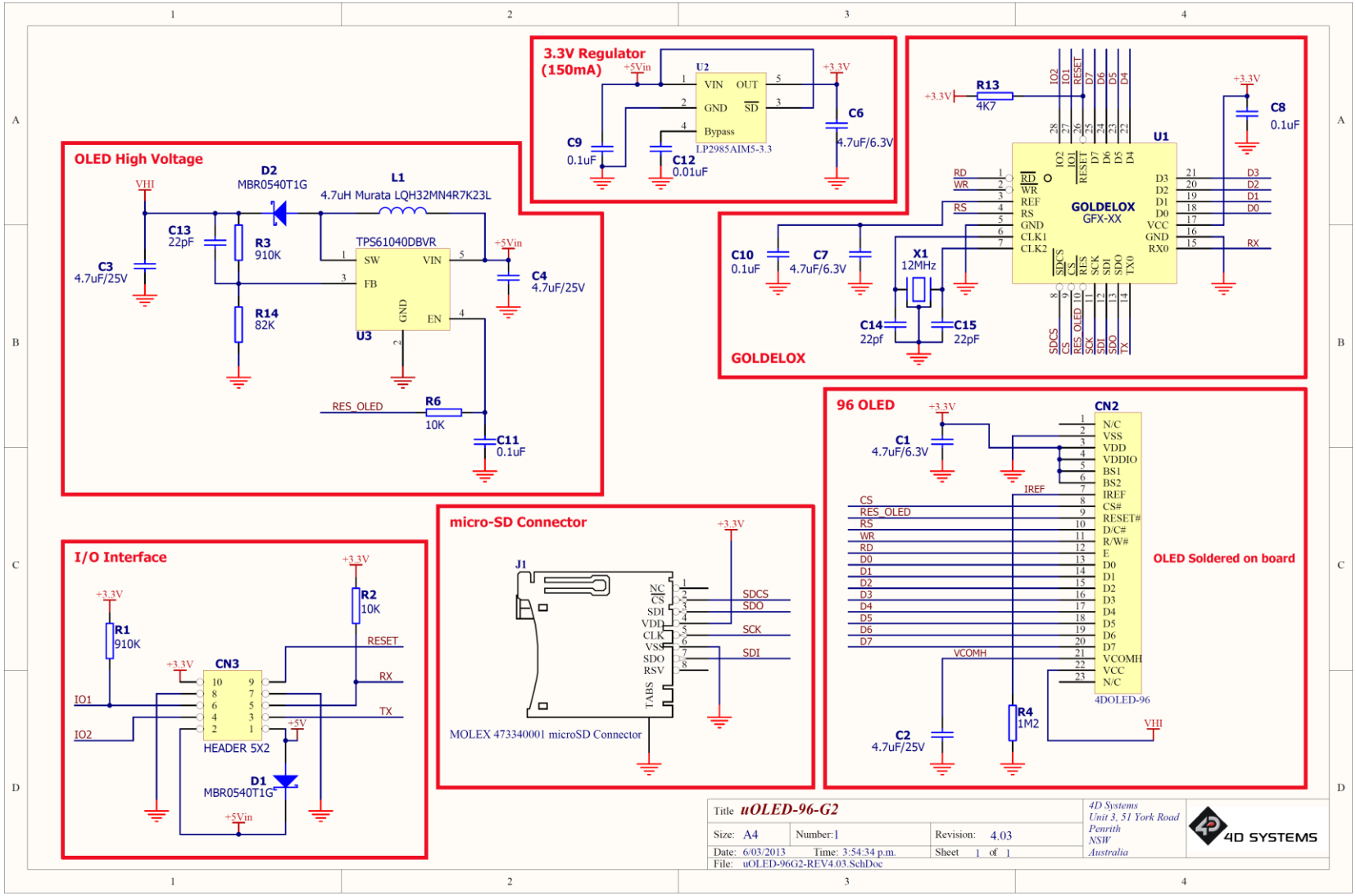
12. Mechanical Details



13. Schematic Diagram



14. Specifications and Ratings

ABSOLUTE MAXIMUM RATINGS	
Operating ambient temperature	-35°C to +75°C
Storage temperature	-40°C +80°C
Voltage on any digital input pin with respect to GND	-0.3V to 6.0V
Voltage on SWITCH pin with respect to GND	-0.3V to 6.0V
Voltage on VCC with respect to GND	-0.3V to 6.0V
Maximum current out of GND pin	300mA
Maximum current into VCC pin	250mA
Maximum output current sunk/sourced by any pin	4mA
Total power dissipation	1.0W

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

RECOMMENDED OPERATING CONDITIONS					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Supply Voltage (VCC)		4.0	5.0	5.5	V
Operating Temperature		-30	--	+70	°C
Input Low Voltage (VIL)	RX Pin	GND	--	0.8	V
Input High Voltage (VIH)	RX Pin	2.0	3.3	5.0	V
Reset Pulse	External Open Collector	2.0	--	--	µs
Operational Delay	Power-Up or External Reset	1000	--	--	ms

GLOBAL CHARACTERISTICS BASED ON OPERATING CONDITIONS					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Supply Current (ICC)	VCC = 5.0V, very dependent on operating conditions, uSD usage, screen display colour (ie White)	14	40	180	mA
Low Power Current (ICC)	VCC = 5.0V, Contrast = 0	300	500	--	µA
Output Low Voltage (VOL)	TX, IO1, IO2, IOL = 3.4mA	--	--	0.4	V
Output High Voltage (VOH)	TX, IO1, IO2, IOL = -2.0mA	2.4	--	3.3	V
A/D Converter Resolution	IO1 Pin	--	8	10	bits
Capacitive Loading	All pins	--	--	50	pF
Flash Memory Endurance	PmmC/4DGL Programming	--	1000	--	E/W

OPTICAL CHARACTERISTICS					
Parameter	**Condition**	**Min**	**Typ**	**Max**	**Units**
Luminance (L)	VCC = 5.0V	70	100	--	cd/m²
Viewing Angle (VA)	VCC = 5.0V	160	--	--	degree
Contrast Ratio (CR)	VCC = 5.0V	2000:1	5000:1	--	--
Operational Lifetime (LT)	50% checker board pattern. 90 cd/m². End of lifetime is 50% initial intensity.	10000	15000	--	hours
Storage Lifetime (ST)	Ta = 25°C, 50% RH	20000	--	--	hours

ORDERING INFORMATION

Order Code: µOLED-96-G2

Package: 65mm x 50mm x 30mm

Packaging: Module sealed in antistatic foam padded 4D Systems Box

microOLED GOLDELOX DISPLAY

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16. Contact Information

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FORSTAR®

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