



4D SYSTEMS

TURNING TECHNOLOGY INTO ART

gen4 Internet of Displays Series

gen4-IoD-24T, 28T, 32T

gen4-IoD-24T Resistive touch

gen4-IoD-28T Resistive touch

gen4-IoD-32T Resistive touch

DATASHEET

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1. Description

The gen4-IoD (Internet of Displays) series of is part of the latest gen4 Range of modules Designed and Manufactured by 4D Systems.

The gen4 series was designed specifically for ease of integration and use, with careful consideration for space requirements and functionality.

This specific gen4 module features a 2.4", 2.8" or a 3.2" colour TFT LCD display, with Resistive Touch. It is powered by the WiFi enabled ESP8266, which offers an array of functionality and options for any Designer / Integrator / User.

The gen4-IoD range can be easily programmed using 4D Systems Workshop4 or the Arduino IDE installed with the ESP8266 core.

The feature rich 4D Systems GFX4d library enables speedy development of applications by providing extensive primitive graphics functions, enhanced graphics via Workshop4, SD card and touch routines, integrated into a single library.

The on-board SD card socket enables the use of FAT16 or FAT32 formatted cards for extensive storage capabilities.

The gen4-IoD series of Integrated Display Modules features a 10 pin ZIF socket, designed for a 10 pin FFC cable, for easy and simple connection to an application or mother board, or for connecting to accessory boards for a range of functionality advancements.

The gen4 series of modules has been designed to minimise the impact of display related circuitry, and provide a platform suitable for integration into a product. Application boards can sit flush on the back of the gen4 if required, as the display related electronics sit inside the plastic mounting base, leaving the application board surface clear for User circuitry.

More information on the Espressif ESP8266 SoC can be found on the Espressif website <http://espressif.com>, and from the ESP8266EX SoC datasheet itself: http://www.espressif.com/sites/default/files/documentation/0a-esp8266ex_datasheet_en.pdf

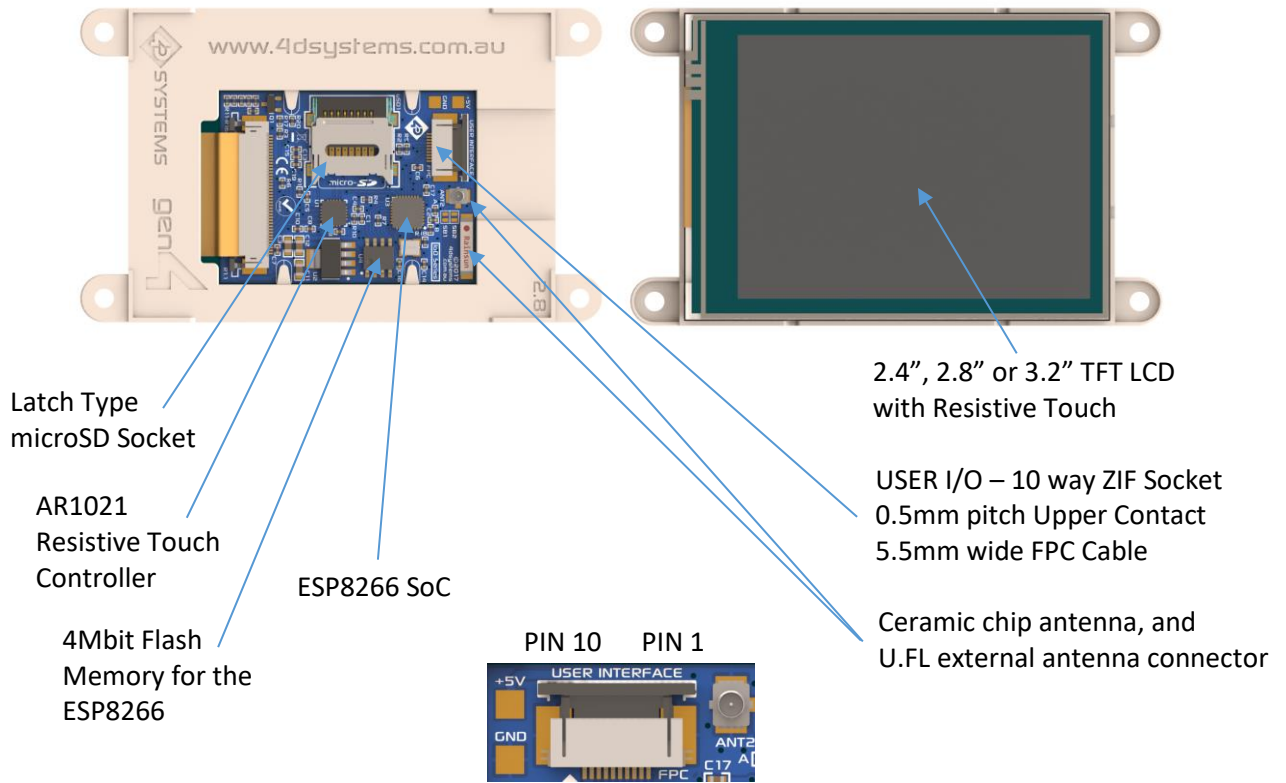
2. Features

- Powerful Intelligent LCD-TFT display module powered by the Espressif ESP8266 SoC.
- 320 x 240 Resolution, RGB 65K true to life colours, TFT Screen with integrated 4-wire Resistive Touch Panel.
- Built in WiFi suitable for 'Internet of things' applications.
- 802.11 b/g/n/e/i support
- Integrated TCP/IP protocol stack
- WiFi 2.4 GHz, supporting WPA/WPA2 and WEP/TKIP/AES, along with STA/AP/STA+AP/P2P operation modes
- 4Mbit (512kb) of Flash memory for User Application Code and Data.
- 128Kb of SRAM of which 80kb is available for the User.
- 10pin FPC connection, for all signals, power, communications and programming.
- On-board latch type microSD memory card connector for multimedia storage and data logging purposes.
- DOS compatible file access (FAT16 or FAT32 format).
- Display full colour images, animations, and icons.
- 4.0V to 5.5V range operation (single supply). A 1Amp+ supply is highly recommended for stability.
- Module dimensions:
(2.4") 78.4 x 44.8 x 7.2mm.
(2.8") 87.3 x 52.1 x 7.3mm.
(3.2") 95.7 x 57.1 x 7.5mm.
- Weighing: ~26 g (2.4"), ~36 g (2.8"), ~44 g (3.2"),
- 4x mounting tabs with 3.2mm holes for mechanical mounting using M3 screws.
- RoHS, REACH and CE compliant.

NOTE: Arduino is a trademark of Arduino Team, and all references to the word "Arduino" or use of its logo/marks are strictly in reference to the Arduino product, and how this product is compatible with the aspect of the product but is not associated with the Arduino Team in anyway.

ESP8266 / ESP8266EX are products made by Espressif. 4D Systems is not associated with Espressif in anyway, other than utilising their product inside of ours.

3. Hardware Overview



USER I/O – 10 Way FPC			
Pin	Symbol	I/O	Description
1	GND	P	Supply Ground.
2	GND	P	Supply Ground.
3	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.
4	GPIO0	I/O	I/O pin. This pin is used for backlight control and flash programming
5	RX	I	Asynchronous Serial Receive pin, TTL level. Connect this pin to the Transmit (Tx) signal of other serial devices. Used in conjunction with the TX pin for programming this microLCD. This pin is tolerant up to 3.3V levels.
6	TX	O	Asynchronous Serial Transmit pin, TTL level. Connect this pin to the Receive (Rx) signal of other serial devices. Used in conjunction with the RX pin for programming this microLCD. This pin outputs 3.3V levels.
7	GND	P	Supply Ground.
8	GPIO16	I/O	I/O pin. Can be used as digital input or output. Can also be used for PWM and 1-wire device interfacing. This pin is available to the user. This pin is tolerant up to 3.3v levels.
9	5V IN	P	Main Voltage Supply +ve input pin. Range is 4.0V to 5.5V, nominal 5.0V.
10	5V IN	P	Main Voltage Supply +ve input pin. Range is 4.0V to 5.5V, nominal 5.0V.

I = Input, O = Output, P = Power

4. Hardware Interface - Pins

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

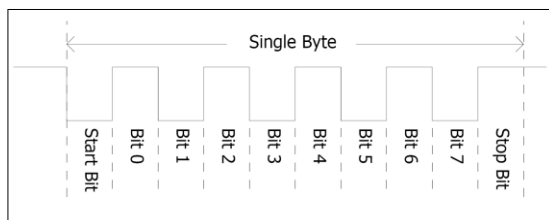
4.1. Serial Port – TTL Level Serial

The ESP8266 Processor has a hardware asynchronous serial ports that can be accessed via the 10 way FPC or via the gen4-IoD-programmer. The serial port can be used to communicate with external serial devices.

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 921600 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.



The serial port is also the primary interface for User program downloads, and configuration via the IDE.

4.2. 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. Nominal operating voltage is 5.0 Volts. Note backlight brightness will be dimmer for voltages under 5.0V.

GND (Module Ground)

Device ground pins. Both pins should be connected to ground.

RESET (Module Master Reset)

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.

GPIO0 (Backlight/Flash)

This pin is dedicated to both backlight control and the Flashing of the IoD program memory via the programming software. This pin must be left floating at power-up to enable the ESP8266 to boot correctly. If GPIO0 is set to be an input in User code once the ESP8266 has booted, then this pin could be controlled externally to adjust backlight brightness using PWM or simple on/off control. Else, the backlight can be controlled from the ESP8266 itself, with appropriate User code.

GPIO16 (User GPIO)

Input/Output available to the user. This pin can be used as a digital input or digital output to connect to sensors, relays etc. This pin can also be used for '1-wire' protocol devices and as a PWM output.

4.3. SPI - (Used internally)

There is 1 hardware SPI channel (HWSPI) which is dedicated to drive the screen, SD card and Resistive Touch. The SPI channel can communicate at speeds up to 80Mhz. The SPI channel is Master only, and cannot be configured to be slave at this time, nor is it available for the User externally.

Note: The SPI channel (HWSPI) is dedicated to memory card, screen and touch controller. The HWSPI channel cannot be reconfigured for alternate uses.

5. ESP8266 SoC

The module is designed around the ESP8266 SoC from Espressif.

The ESP8266 is a 32bit RISC Microcontroller with built in WiFi controller, and GPIO capability, however most GPIO are utilised for on board features, such as the TFT LCD, Touch Controller and microSD card.

The TFT-LCD display interfaces to the ESP8266 using SPI, along with the microSD card and touch controller. This enables high speed transfers for these peripherals, providing fast graphics, fast SD card access and responsive touch control.

Powerful graphics, text, image, animation, internet access and countless more features are available to the user via the 4D Systems GFX4d library and 4D Systems Workshop 4 IDE. Alternatively, the Arduino IDE can be used, and the User is able to write drivers/software for the module as they require.

6. SD/SDHC Memory Cards

The gen4-IoD module supports microSD memory cards via the on-board latch type micro-SD connector.

The memory card is used for all multimedia file retrieval such as images, animations and data files.



The memory card can also be used as general purpose storage for data logging applications.

Support is available for off-the-shelf high capacity HC memory cards (4GB and above). Memory cards up to 32GB is size can be used, as FAT16 or FAT32, however it must be noted that only a portion of this can be utilised by the FAT16 file system.

7. FFC Cable

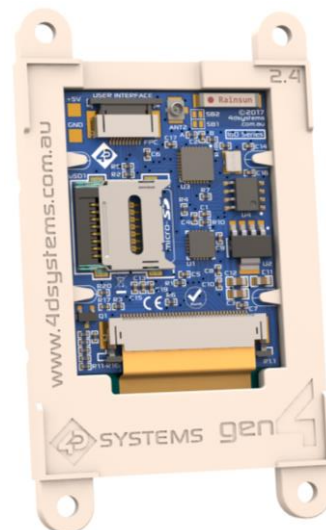
The Standard FFC cable supplied has the following specifications:

- 10 Pin Flexible Flat Cable, 150mm Long, 0.5mm (0.02") pitch
- Cable Type: AWM 20624 80C 60V VW-1
- Heat Resistance 80 Degrees Celsius
- Connections on the opposite side at each end (Type B)

8. Application PCB Support

The gen4-IoD Display Module Series is designed to accommodate a range of applications, and therefore is suited for those wanting to make a customised module, without the need for piggy-back or daughter boards mounted on headers.

On the back of the gen4 module, the display related circuitry will be found, which is recessed into the plastic. The level of the plastic on the back of the gen4 module is higher than the tallest component on the display circuit PCB, meaning an Application PCB can be mounted on the back of the gen4, without affecting the display related circuitry. An application board can be made to fit inside the corner notches of the gen4 plastics.



Pictured: gen4-IoD-24T

The 10 way FFC flex cable can come out of the gen4 display module and into the application board, either by coming up through a slot in the Users application board, or by travelling along the channel in the gen4 plastic's and emerging at the edge of the display module then curving around into the Users application board.

The microSD socket is a latch type, so it is accessible from the top, rather than a push/push or push/pull style which is accessible from the side. A slot can be routed in the Users application board so this is accessible, if required.

If an external antenna is being used, the antenna can also run down the plastic channel next to the 10 way FFC cable, not affecting the Users Application Board, if fitted.

9. Display/Module Precautions

- Avoid having to display the same image/object on the screen for lengthy periods of time. 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, damage will certainly occur. 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 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 where possible.
- Display modules have a finite life, which is typically dictated by the display itself, more specifically the backlight. The backlight contains LED's, which fade over time. In the Specifications section is a figure for the typical life of the display, and the criteria are listed.
- Resistive Touch model features a touch sensitive film over the display which is sensitive to pressure. Take note when mounting the display module in an enclosure that pressure is not applied to the surface of the display by the enclosure, or false touches will occur, or the touch will simply not function at all.

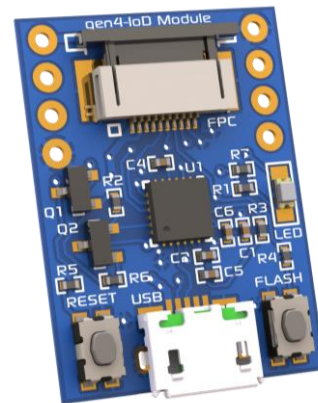
10. Hardware Tools

The following hardware tools are required for full control of the gen4 IoD Display Modules.

10.1. gen4-IoD programmer

The 4D Systems gen4-IoD-Programmer is an essential hardware tool to program, customise and test the gen4-IoD Display Module.

The gen4-IoD-Programmer is used to program the IoD via Workshop 4 and the Arduino IDE. It even serves as an interface for communicating serial data to the PC.



The 4D gen4-IoD-Programmer is available from 4D Systems website, www.4dsystems.com.au

Please note, the gen4-IoD-Programmer can be used as a simple interface to power the IoD or to connect to other serial devices.

The IoD programmer features an Auto-Reset circuit (*credit – NodeMCU*), but also features Reset and Flash buttons, for flexibility.

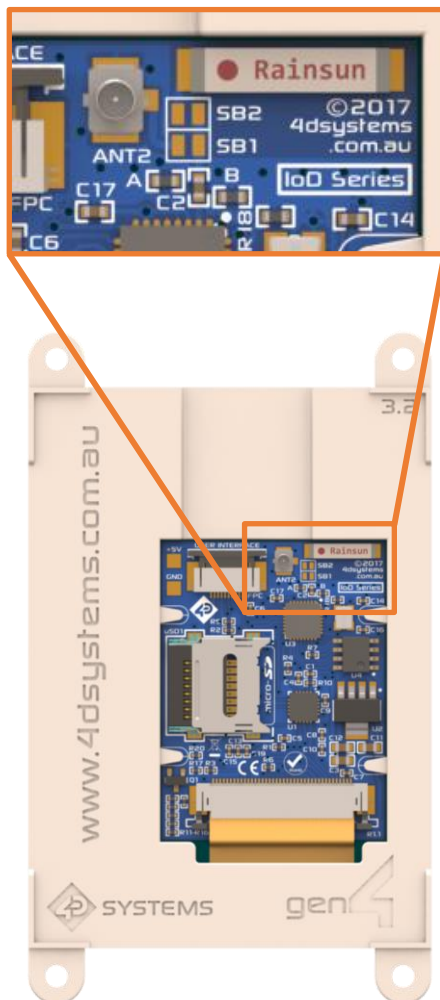
Alternatively, other programming devices could be used, including programming from a host controller. Please refer to the ESP8266 datasheet for more options on programming this SoC.

11. Internal / External Antenna

The gen4-IoD is capable of using either the on-board ceramic chip antenna, or using an external antenna connecting using the U.FL connector on the PCB.

By default, the on-board ceramic chip antenna is used, and SB2 (Solder Bridge 2) is shorted, enabling contact of the LBA pin to the ceramic chip antenna.

If the external antenna is desired instead, SB1 (Solder Bridge 1) needs to be shorted, using a small blob of solder via a soldering iron, and SB2 needs to be de-soldered. SB2 'can' be left connected if required, however WiFi performance may be impeded to some degree, due to two antennas being connected at the same time, however it should still work in most situations.



12. Programming the IoD

There are two IDE's available to program the IoD. Using the Arduino IDE, or using the 4D Systems Workshop4 IDE.

Using the Workshop4 IDE provides additional graphical benefits over using the Arduino IDE, however the Workshop4 IDE is only Windows based (unless via a Virtual Machine).

If using the Workshop4 IDE, Workshop4 installation will call the Arduino IDE in the background for programming the board (handled automatically and invisibly). Some minor setup is required to install the board into the Arduino IDE, using the Board Manager and installing the JSON file. See the following section.

If the Workshop4 IDE is not going to be used at all, then the IoD board needs to be added into the Arduino IDE in the same way, using the Arduino Board Manager. More details below.

12.1. Arduino IDE

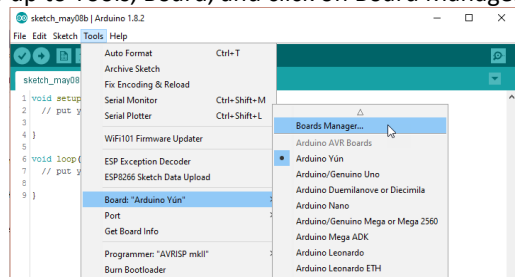
The gen4-IoD is Arduino IDE compatible. The IoD can be directly programmed via Arduino IDE like any other ESP8266/Arduino module.

The gen4-IoD must be added to the Arduino IDE. This is typically done using the Boards Manager, however the 'STABLE' ESP8266 core is not regularly updated by the ESP8266 community, so the gen4-IoD board is not yet available via the JSON file method.

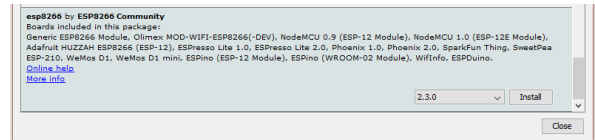
The easiest way to install the gen4-IoD into the Arduino IDE, is by installing the Stable release JSON file. This is done by starting up the Arduino IDE, going File, Preferences, and entering the following line into the 'Additional Boards Manager URLs' field. If you already have a listing in there, simply add a comma after the last one, and paste this new URL in at the end:

http://arduino.esp8266.com/stable/package_esp8266com_index.json

Click OK on the preferences window to close it. Go up to Tools, Board, and click on Board Manager.



Once it loads, scroll down to the bottom, and you should see a listing for esp8266. Click on it, and then on install, and install the latest version.



Once this has been completed, click Close, and then shut down the Arduino IDE.

Modifications of one of the files which came with this set of esp8266 boards is required, since the stable build does not include changes since mid 2016 (at the time of writing this document). So the manual addition of some lines into the boards.txt file is required, to enable the gen4-IoD board to work.

For Windows, navigate to:

"C:\Users\USER\AppData\Local\Arduino15\packages\esp8266\hardware\esp8266\2.3.0"

Replace **USER** with the username relevant for your computer.

In there you should find the boards.txt file. This is the file you need to edit. Use something like Notepad++ or Wordpad, which displays the spacing of the boards.txt file correctly. Normal windows Notepad is not recommended.

Add the following at the end of the file, starting on a new line. Copy and paste this text:

```
#####
##

gen4iod.name=4D Systems gen4 IoD Range

gen4iod.upload.tool=esptool
gen4iod.upload.speed=921600
gen4iod.upload.resetmethod=nodemcu
gen4iod.upload.maximum_size=434160
gen4iod.upload.maximum_data_size=81920
gen4iod.upload.wait_for_upload_port=true
gen4iod.serial.disabledDTR=true
gen4iod.serial.disabledRTS=true

gen4iod.build.mcu=esp8266
gen4iod.build.f_cpu=16000000L
gen4iod.build.board=GEN4_IOD
gen4iod.build.core=esp8266
gen4iod.build.variant=generic
gen4iod.build.flash_mode=qio
# flash chip: AT25SF041 (512 kbyte, 4Mbit)
gen4iod.build.flash_size=512K
gen4iod.build.flash_ld=eagle.flash.512k0.ld
gen4iod.build.flash_freq=80
gen4iod.build.debug_port=
gen4iod.build.debug_level=

gen4iod.menu.CpuFrequency.160=160 MHz
gen4iod.menu.CpuFrequency.160.build.f_cpu=16000000L
gen4iod.menu.CpuFrequency.80=80 MHz
gen4iod.menu.CpuFrequency.80.build.f_cpu=80000000L

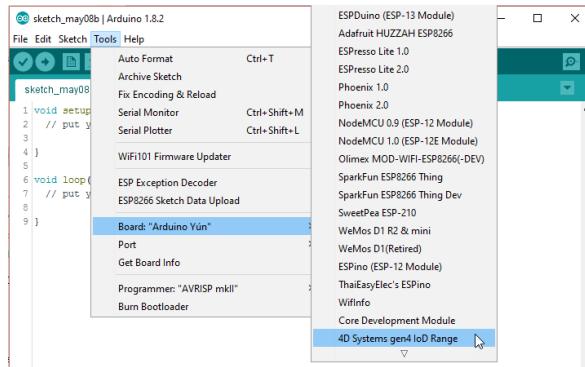
gen4iod.menu.UploadSpeed.115200=115200
gen4iod.menu.UploadSpeed.115200.upload.speed=115200
gen4iod.menu.UploadSpeed.9600=9600
gen4iod.menu.UploadSpeed.9600.upload.speed=9600
gen4iod.menu.UploadSpeed.57600=57600
gen4iod.menu.UploadSpeed.57600.upload.speed=57600
gen4iod.menu.UploadSpeed.256000.windows=256000
gen4iod.menu.UploadSpeed.256000.upload.speed=256000
gen4iod.menu.UploadSpeed.230400.linux=230400
gen4iod.menu.UploadSpeed.230400.macosx=230400
gen4iod.menu.UploadSpeed.230400.upload.speed=230400
gen4iod.menu.UploadSpeed.460800.linux=460800
gen4iod.menu.UploadSpeed.460800.macosx=460800
```

```
gen4iod.menu.UploadSpeed.460800.upload.speed=460800
gen4iod.menu.UploadSpeed.512000.windows=512000
gen4iod.menu.UploadSpeed.512000.upload.speed=512000
gen4iod.menu.UploadSpeed.921600=921600
gen4iod.menu.UploadSpeed.921600.upload.speed=921600
```

Save the file, and open the Arduino IDE.

You should then see at the end of the ESP8266 boards listing, a new entry for '4D Systems gen4-IoD Range'.

Select the board.



The Arduino IDE should then be set up to start using the gen4-IoD.

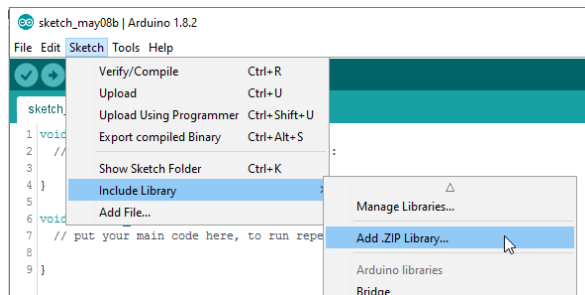
NOTE: The ESP8266 Core is not maintained or created by 4D Systems. It belongs to esp8266.com

Check out the GFX4d library from the 4D Systems github page: <https://github.com/4dsystems> Which contains the library specifically for the gen4-IoD and some demo applications.

This library can be downloaded and added to the Arduino IDE, like any normal library.

Navigate to <https://github.com/4dsystems/GFX4d> And download the repository, using the download/clone button. Save the zip file to your PC.

Open the Arduino IDE, and go to Sketch – Include Library – Add Zip Library



The library will then be installed, and will be available for you to use. There are example applications available in the examples folder.

12.2. 4D Systems - Workshop 4 IDE

Workshop 4 is a comprehensive software IDE that provides an integrated software development platform for all 4D Systems Intelligent Display Modules, including the IoD.

Workshop4 allows rapid development of applications, and on the gen4-IoD can take full advantage of the available extended graphics functions.

The Workshop IDE can create/edit Arduino code and verify/compile and then load the code into the IoD's ESP8266 processor, without having to use the Arduino IDE directly. It makes it possible to create both simple and complex graphical user interfaces.

When Workshop4 is started, it presents the User with a screen to start a new project, or to load a project. Upon selecting to start a new project, another screen is displayed, presenting the wide range of 4D Systems products available to be programmed or configured by the Workshop4 IDE, of which there is the gen4-IoD-24T, gen4-IoD-28T and gen4-IoD-32T.

The Workshop4 IDE can be used to program the gen4-IoD, just as the Arduino IDE does. This is possible due to the integration of the Arduino compiler via the Arduino IDE, which allows Arduino sketches to be written and compiled from within the Workshop4 IDE, which then provides WS4 the benefit of adding graphical widgets and features to the gen4-IoD, which would otherwise not be available when using the Arduino IDE.

If you use the Workshop4 IDE, you can program the gen4-IoD module and have the opportunity to create graphics which you can call using Arduino code via the GFX4d library. Many options are possible.



Note: Workshop requires the Arduino IDE to be installed as Workshop calls the Arduino IDE for compiling the Arduino sketches. The Arduino IDE

however is not required to be opened or modified to program the gen4-IoD, once it has been set up. Please follow the steps found in the previous section to install and add the gen4-IoD to the Arduino IDE, prior to installing the Workshop4 IDE.

13. Starter Kit

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

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

Not all development environments and features will be needed by every User. However, by purchasing the display solution in a Starter Kit allows you to take full advantage of all of the features of the 4D Systems Display Solution and try out each of the 4D Workshop4 Environments prior to settling with the preferred feature-set.

Starter Kits typically include:

- gen4 IoD Display Module
- gen4 IoD Programmer
- 150mm 10-way FFC cable for connecting gen4 display to gen4 IoD programmer
- 4GB micro-SD Card

Please refer to the 4D Systems website for current components included in the Starter Kit, if available. Simply select the Starter Kit option when purchasing the chosen display module on the 4D Systems shopping cart, or from your local distributor.

14. Display Module Part Numbers

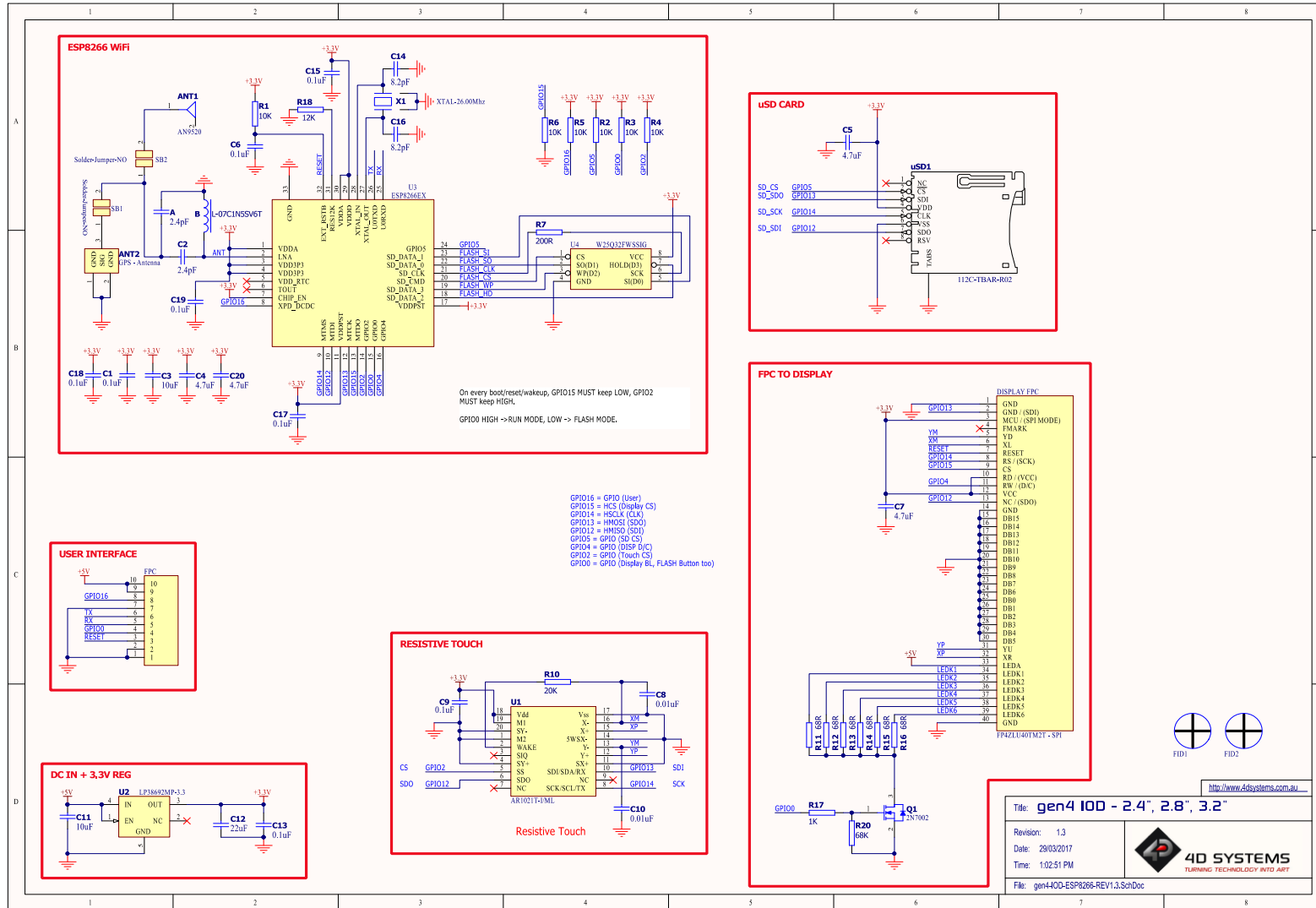
The following is a breakdown on the part numbers and what they mean.

Example:

gen4-IoD-24T

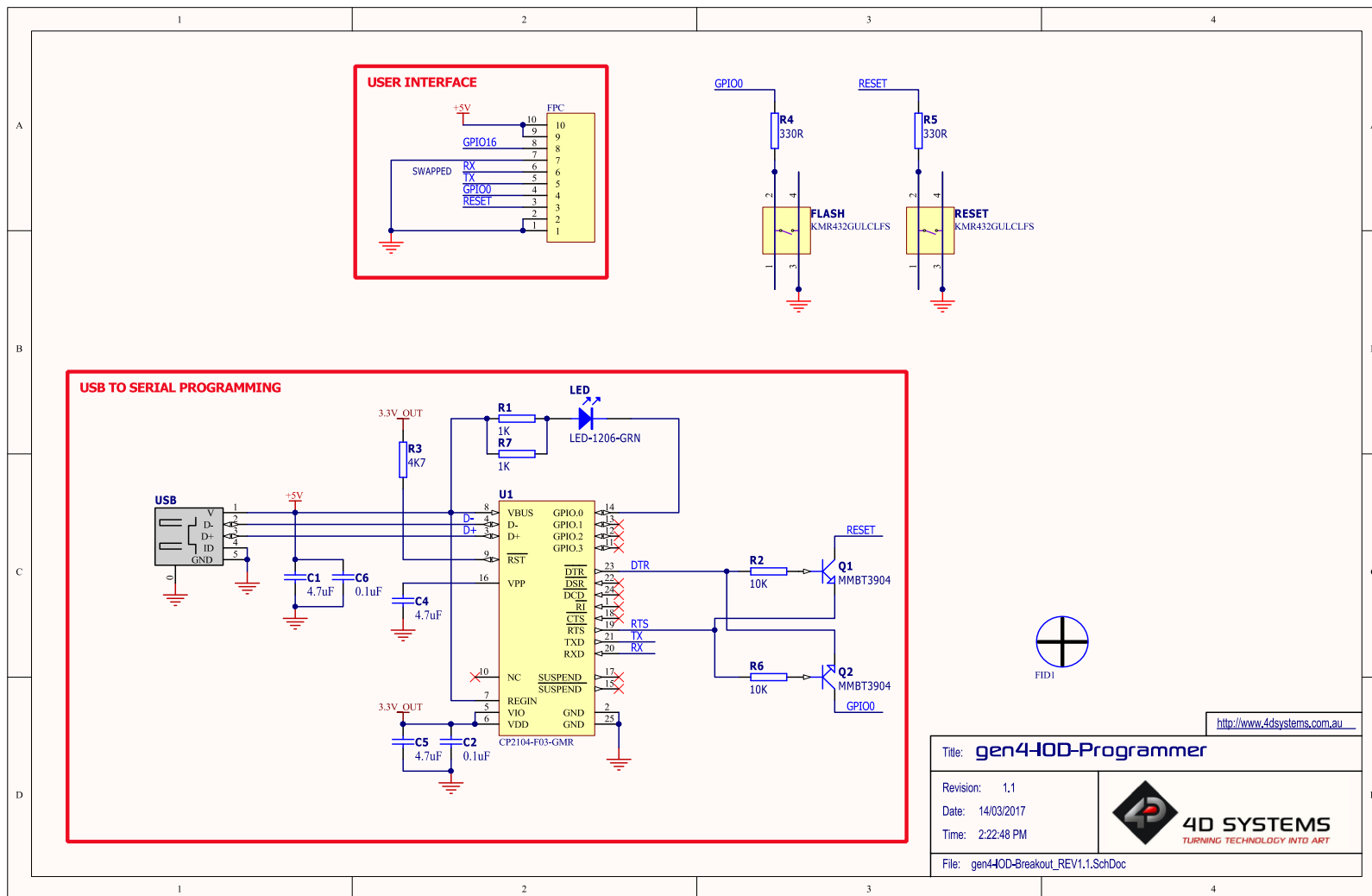
gen4	- gen4 Display Family
IoD	- IoD (Internet of Displays) Range
24	- Display size (2.4")
T	- Resistive Touch


19.Schematic Details – gen4-IoD Display



gen4 Display - gen4-IoD-24T, 28T, 32T

20. Schematic Details – gen4-IoD Programming Module



Title: gen4-IoD-Programmer	
Revision: 1,1	 4D SYSTEMS <small>TURNING TECHNOLOGY INTO ART</small>
Date: 14/03/2017	
Time: 2:22:48 PM	
File: gen4-IoD-Breakout_REV1.1.SchDoc	

21. Specifications

ABSOLUTE MAXIMUM RATINGS	
Operating ambient temperature	-20°C to +70°C
Storage temperature	-30°C +80°C
Voltage on any digital input pin with respect to GND	-0.3V to 6.0V
Voltage on VCC with respect to GND	-0.3V to 6.0V
Maximum current sunk/sourced by any pin	12.0mA
<p>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.</p>	

RECOMMENDED OPERATING CONDITIONS					
Parameter	Conditions	Min	Typ	Max	Units
Supply Voltage (VCC)	Stable external supply required	4.0	5.0	5.5	V
Operating Temperature		-10	--	+60	°C
Input Low Voltage	3.3V, all pins	-0.3	--	0.25VCC	V
Input High Voltage	GPIO0, GPIO16, and RX Pins	0.7VCC	--	3.3	V
Output Low Voltage		--	--	0.1VCC	V
Output High Voltage		0.8VCC	--	--	V

GLOBAL CHARACTERISTICS BASED ON OPERATING CONDITIONS					
Parameter	Conditions	Min	Typ	Max	Units
Supply Current (ICC)	gen4-IoD-24T – Average, not Peak	--	200	--	mA
	gen4-IoD-28T – Average, not Peak	--	200	--	mA
	gen4-IoD-32T – Average, not Peak	--	220	--	mA
Display Endurance	Hours of operation, measured to when display is 50% original brightness	30000	--	--	H
Touch Screen Endurance (Resistive Touch)	Number of touches/hits with a 12.5mm tip at a rate of 2x per second with 250gf force	--	1M	--	Touches
	Slide stylus on screen, 100gf force, 60mm/s speed with a 0.8mm polyacetal tip stylus pen	--	100K	--	Slides
Touch Screen Transparency	Resistive Touch	82	--	--	%
Touch Screen Operational Force (Resistive Touch)	Only use Finger or Stylus, do not use anything sharp or metal	20	--	100	Gf

LCD DISPLAY INFORMATION		
Parameter	Conditions	Specification
Display Type		TFT Transmissive LCD
Display Size	gen4-loD-24T	2.4" Diagonal
	gen4-loD-28T	2.8" Diagonal
	gen4-loD-32T	3.2" Diagonal
Display Resolution		240 x 320 (Portrait Viewing)
Display Brightness	gen4-loD-24T	182 cd/m2
	gen4-loD-28T	140 cd/m2
	gen4-loD-32T	160 cd/m2
Display Contrast Ratio	Typical (2.4", 2.8")	250:1
	Typical (3.2")	500:1
Display Viewing Angles	Above Centre	35 Degrees
	Below Centre	55 Degrees
	Left of Centre	55 Degrees
	Right of Centre	55 Degrees
Display Viewing Direction		6 o'clock Display (Optimal viewing is from below when in Portrait mode)
Display Backlighting	gen4-loD-24T	1x4 Parallel LED's
	gen4-loD-28T	1x4 Parallel LED's
	gen4-loD-32T	1x6 Parallel LED's
Pixel Pitch	gen4-loD-24T	0.153 x 0.153mm (Square pixels)
	gen4-loD-28T	0.18 x 0.18mm (Square pixels)
	gen4-loD-32T	0.2025 x 0.2025mm (Square pixels)
Pixel Density	Number of pixels in 1 row in 25.4mm	166 DPI/PPI
		141 DPI/PPI
		127 DPI/PPI

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