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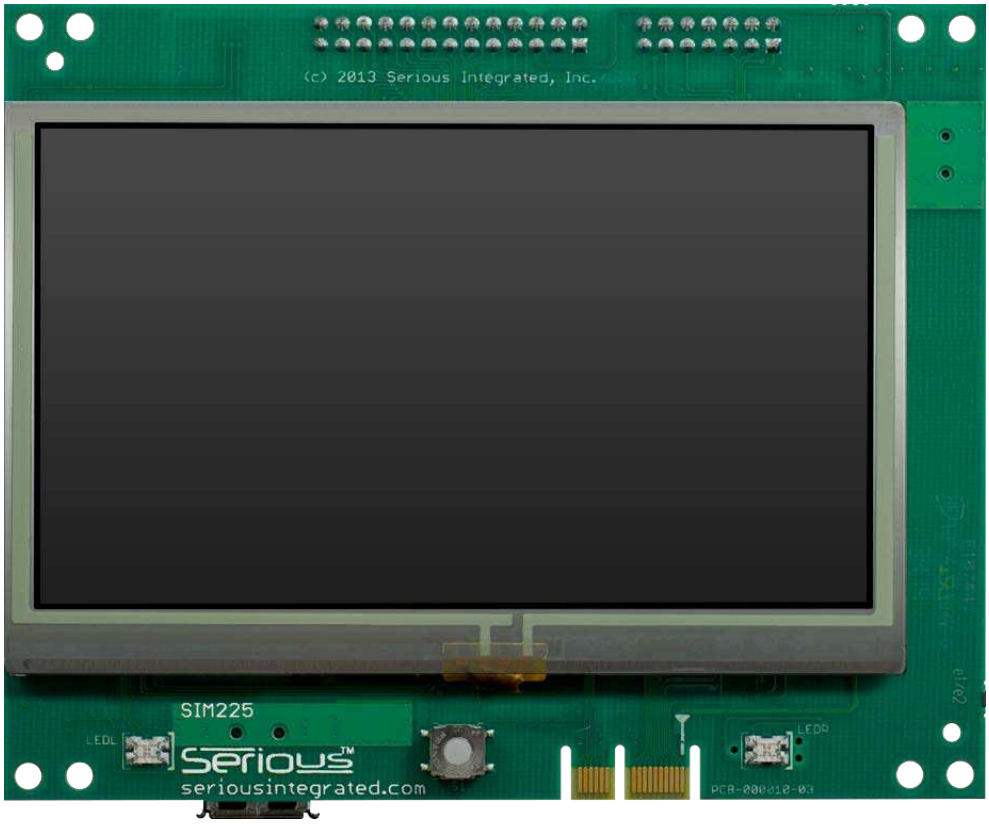
SIM225

Technical Reference Manual



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TRADEMARKS AND COPYRIGHTS

CONTENTS

DOCUMENT INFORMATION AND APPLICABLE PRODUCTS

CHANGE HISTORY AND APPLICABLE PRODUCTS

The following table summarizes major changes to this document and the applicable versions of the product corresponding to this document:

Doc Vers	Date	For HW Variants/Versions	Major Changes
A0	13 Dec 12	A00 v1.0	• Initial prerelease version
A1	08 Jan 13	A00 v1.0	• First public release
A2	29 Jun 13	A00 thru A04 v1.0	• Fixed mechanical drawing; LCD was incorrectly 0.012” right • Updated info for production A01..A04
A3	05 Aug 13	All	• Clarified boot modes and DIP switch with new picture • Added updated variant feature table

DOCUMENT CONVENTIONS

This symbol indicates an advanced tip for hardware or software designers to extract interesting or unique value from the Serious Integrated Module.

WARNING: You can damage your board, damage attached systems, overheat or cause things to catch fire if you do not heed these warnings.

Notes with this symbol are related to license and associated legal issues you need to understand to use this software. We’re big believers in honoring license agreements, so please help the industry by respecting intellectual property ownership.

Some hardware features may be preconfigured or permanently reserved for use by the SHIPEngine software (the GUI management engine component of the Serious Human Interface™ Platform). Notes with this symbol indicate where the module comes pre-configured or uses these resources.

INTRODUCTION

The SIM225 family of Serious Integrated Modules is a series of complete intelligent 4.30” WQVGA graphic front panels, some with touch capability.

These cost-effective modules are designed for use by Original Equipment Manufacturers (OEMs), custom design shops, and hobbyists to add sophisticated and user-friendly graphical user interfaces to their products.

HARDWARE

SIM225 family features include:

- 4.3” WQVGA 480×272 color TFT display
  - Various touch panel options
- 100MHz 32-bit Renesas RX631/RX63N MCU
  - 128KB RAM, 512KB-2MB FLASH, Direct Drive
  - Integrated Temp Sensor & RTCC
- On Module Memory
  - 8-16MB SDRAM
  - 8-16MB serial FLASH + 2Kbit EEPROM
- Extensive I/O
  - 24-Pin FFC Expansion Connector (GPIO, +5V, RESET#, UART; RMII on 63N-based units)
  - Serious 7-pin system-to-system Power and Communications Connector
  - 26-Pin Baseboard Connector (GPIO, +5V, RESET#, 2xUART, I2C, SPI, audio, CAN and more)
  - 14-Pin JTAG Connector
  - USB Mini-B Device Connector
  - USB A Host Connector
  - Tag-Connect Programming Port
- -20 to 70°C extended operating temperature

Within the SIM225 are numerous family members, or “variants”. Each variant has a slightly different set of features and price points for an OEM to select the appropriate feature/cost point for their specific application.

Consult the latest SIM225 Product Brief for a listing of current variants and options. As of the time of this document's publish date, the variants/options are:

SIM225-	A00	A01	A02	A03	A04
MCU RX Family	63N	63N	63N	631	631
MCU FLASH (KB)	2048	768	768	512	512
MCU RAM (KB)	128	128	128	128	128
SDRAM/Serial FLASH (MB)	16/16	16/16	16/16	8/8	8/8
LCD Touch	R4	R4		R4	
LCD Brightness (NITs)	300	300	330	300	330
7 Pin Power/UART Connectors	✓	✓	✓	✓	✓
PCB Edge Program/Test	✓	✓	✓	✓	✓
USB2.0 FS device circuitry	✓	✓	✓	✓	✓
USB2.0 FS device mini-B	✓	✓	✓		
USB2.0 FS 150mA host	✓	✓	✓		
Speaker/Amplifier	✓				
Piezo Sounder		✓	✓		
LiPo Battery Support	✓				
Battery Backed Clock	✓	✓	✓		
PCB Temp Sensor	✓	✓	✓		
26 Pin 0.1" I/O Expansion Header	✓	✓	✓		
24-Pin FFC (GPIO, +5V, UART)	✓	✓	✓		
RMII on 24-Pin FFC	✓	✓	✓		
Front LEDs & User Button	✓	✓	✓		

SOFTWARE

The SIM225 is supported by a growing collection of Renesas, open source, as well as *Serious* proprietary software, allowing designers to gain confidence that their essential software can not only get it done, but perform to the needed end result. Available at mySerious.com for download, SIM225 programmers can obtain an out-of-the-box experience with a pre-ported version of the Renesas GAPI library on Micrium uCOS-III, Segger embOS and FreeRTOS operating systems. The SIM225 includes full single-unit production licenses of the Micrium and Segger kernels for use with each module.

For even faster development, the Serious Human Interface™ Platform offers PC-based GUI design tools and rapid GUI prototyping, development, and deployment. With minimal coding, you can create attractive and functional GUIs in a fraction of the time of traditional C-based development. See www.seriousintegrated.com/SHIP for details.

It is very difficult to know, as a designer selecting the hardware for a graphic/touch interface, if the result after many months of software and graphic design will have acceptable performance. Will the system be responsive? Will it be visually attractive? Will the look-and-feel be consistent with the company's brand image? *Serious* addresses these OEM designer challenges by delivering video best-of-class GUI examples, fostering community demos and solutions, and providing software, tools, and consulting services.

USAGE MODELS

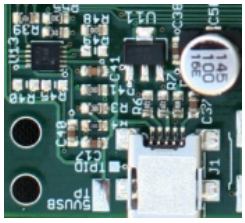
The SIM225 can be used as a stand-alone controller for a whole system – where all the intelligence and control is in the SIM225 with few external components – or can act just as a front-panel touch/graphic human interface, a sort of "super-interface", to an attached intelligent system. In reality, there are many usage models in between these extremes.

There is often additional software and hardware functionality in the user's system beyond the SIM225; for example, a machine control system. The SIM225 is equipped with several connectors allowing simple communications to an external hardware system.

Often a designer has an existing product with a traditional button-and-segment-LCD user interface and is seeking to give the product an "extreme makeover" with a new front graphic/touch panel. The existing design may already be an intelligent system, such as a pool control system including motor controllers, valve relays, sensors, and power supply circuits as well as its own microcontroller on a "baseboard" PCB. In some designs, this baseboard has a wire harness to a simple front panel interface. In others, the baseboard is combined with front panel buttons and indicators. All user configuration and operation is managed by the existing baseboard and its software. Rather than completely redesigning the hardware and software of the existing OEM system, the old front panel can be replaced by a simple UART+Power connection to one of the SIM225's connectors. The designer can then architect inter-board messages such as "pump is on" which could be sent over the UART causing visual indicators to appear or change on the display. A GUI on the SIM225 could change user preferences, for instance, sending back messages such as "pump on days: MWF" which the baseboard may store in its configuration EEPROM.

The possibilities are endless: the SIM225 module contains not only a powerful MCU but also a suite of hardware features that are commonly needed in many designs. A high-end thermostat or alarm panel, for example, could be as simple as a SIM225 connected to another PCB with a few relays and a battery.

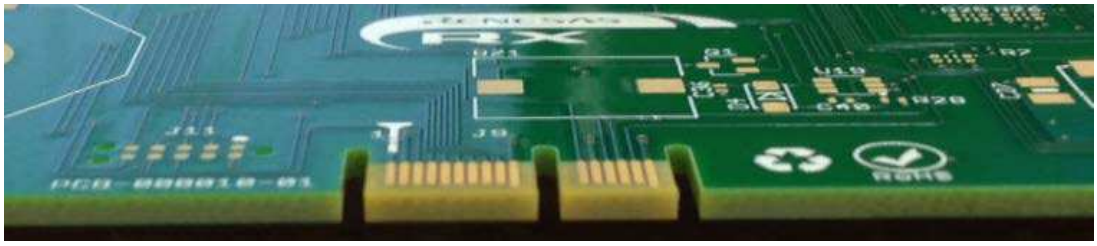
GETTING STARTED



The SIM225 comes pre-configured with a demo program loaded in the system FLASH. To startup the system, plug a USB cable from your PC or USB supply into the USB device Mini-B connector. The system will use a maximum of 500mA of current from the USB connection when in operation.

The demo will start running and displaying info on the LCD screen. For more getting started information and out-of-the-box tips, see www.seriousintegrated.com/oob.

Some SIM225 variants, for example the SIM225-A03 and SIM225-A04, do not have the USB device connector populated. However, all SIM225's have the USB device circuit available via the PCB Edge Connector.



An inexpensive Serious Programming Adapter 100 (SPA100) can connect to this edge connector and expose the USB device port to a physical USB Mini-B connector.

Several connectors may be used to power the SIM225. See Power Supplies.

SPECIFICATIONS

DC MAXIMUM RATINGS

The following are absolute maximum limits for the specified variants:

Specification	Variant	DC Limits			
		Min	Typ	Max	Units
Input Supply Voltage +5V_USBF	All	4.75	5.00	5.25	V
Input Supply Voltage +5V_EXT/+VEXT	A00	4.35	5.00	5.25	V
	A01	4.50[1]	5.00	5.25	V
	A02	4.50[1]	5.00	5.25	V
	A01	3.60[2]	5.00	5.25	V
	A02	3.60[2]	5.00	5.25	V
	A03	3.60	5.00	5.50	V
	A04	3.60	5.00	5.50	V
LiPo Battery Rated Voltage	A00	-	3.70	4.30	V

Notes: [1]USB Host circuit enabled
[2] USB Host circuit never enabled

DC OPERATING CHARACTERISTICS

VARIANT A00

The following DC characteristics apply ***only*** to variants with LiPo capabilities, including the SIM225-A00.

Specification	LCD Backlight State	USB Host State	LiPo State[4]	Audio Amp State	Range			
					Min	Typ	Max	Units
Input Supply Current +5V_USBF	off	off	N	off		25[1,3]	tbd[1,2]	mA
	100%	off	N	off		141[1,3]	tbd[1,2]	mA
	100%	on	N	on		141[1,3]	tbd[1,2]	mA
	any	any	C	any			500	mA
Input Supply Current +5V_EXT	off	off	N	off		25[1,3]	tbd[1,2]	mA
	100%	off	N	off		141[1,3]	tbd[1,2]	mA
	100%	on	N	on		tbd[1,3]	tbd[1,2]	mA
	any	any	C	any			tbd[1,2]	mA
Charging Current to LiPo Battery	any	any	C	any			480	mA

Notes: [1]Any additional external current draw from the module is in addition to this value
[2]At minimum voltage on supply
[3]At typical input supply voltage
[4] LiPo Status: N = not draining nor charging, or not present, C = Charging, D = Draining

VARIANTS A01, A02, A03, A04

The following DC characteristics apply ***only*** to all variants without LiPo capabilities, including the SIM225-A01, A02, A03, and A04.

Specification	LCD Backlight State	USB Host Boost	Range				
			Typ[1,2,5]	Typ[1,3,5]	Max[1,2]	Max[1,3]	Units
Input Supply Current +5V_USBF/+VEXT	RESET		58	45			mW
	off	off	284	294	tbd	tbd	mW
	100%	off	1374	1225	tbd	tbd	mW
	100%	on[4]	tbd	Tbd	tbd	tbd	mW

Notes: [1]Any additional external current draw from the module is in addition to this value
[2]At minimum voltage on supply
[3]At typical input supply voltage
[4]No device inserted; device power is in addition to this number plus typical conversion loss of 10%.
[5]Measured

SUBSYSTEM-BY-SUBSYSTEM DC OPERATING CHARACTERISTICS

The amount of power necessary for SIM225 to function is highly dependent on how you use the various features of the SIM225, especially the major power consumers. If your application does not enable these features, the typical and maximum power numbers can be appropriately subtracted from the maximums for the SIM respectively. Assuming typical switching conversion efficiency, the power breakdown of the elements is as follows.

VARIANT A00

The following DC characteristics apply ***only*** to variants with LiPo capabilities, including the SIM225-A00.

+5V_MAIN Powered Subsystem	Local Power Required (mW)[1]			+5V_MAIN to Local Conversion Efficiency (typ)	+5V_MAIN Power Required (mW)[1]		
	Min	Typ	Max		Min	Typ	Max
Battery Charging (+5V_USBF)			2500	100%			2500
Battery Charging (+5V_EXT)			4750	100%			4750
LCD Backlight		800	850	86%		931	1000
USB Host		375	750	90%		417	833
Audio Amplifier/Speaker		700	1000	100%		700	1000
DRAM 8MB or 16MB		200	594	92%		217	645
SFLASH 8MB or 16MB		33	83	92%		36	90
Resistive Touch		33	56	92%		36	61
USB Host		tbd[2]	tbd[2]	90%		tbd[2]	tbd[2]
Other logic and miscellaneous							

Notes: [1]At typical input supply voltage
[2]No device inserted; device power is in addition to this number plus typical conversion loss of 10%.

VARIANTS A01, A02, A03, A04

The following DC characteristics apply ***only*** to all variants without LiPo capabilities, including the SIM225-A01, A02, A03, and A04.

+VIN_MAIN Powered Subsystem	Circuit-Local Power Required (mW)[1]			+VEXT to Local Conversion Efficiency (typ)	+VEXT Power Required (mW)[1]		
	Min	Typ	Max		Min	Typ	Max
LCD (backlight)		800	850	86%		931	1000
LCD (logic)		tbd	tbd	92%		tbd	tbd
Piezo w/Boost Enabled		3	12	80%		4	15
MCU		178	370	92%		194	402
DRAM 8MB or 16MB		200	594	92%		217	645
SFLASH 8MB or 16MB		33	83	92%		36	90
Resistive Touch		33	56	92%		36	61
USB Host		tbd[2]	tbd[2]	90%		tbd[2]	tbd[2]
Other logic and miscellaneous							

Notes: [1]At typical input supply voltage
[2]No device inserted; device power is in addition to this number plus typical conversion loss of 10%.

MCU I/O

Many I/O signals on the SIM225 are directly and exclusively connected to RX MCU pins. Consult the RX63N/RX631 data sheet for complete specifications of each pin.

There are specific power limitations on the RX MCU pins. Consult the RX63N/RX631 data sheet for more information. **Exceeding these limits may damage your board, damage attached systems, overheat or cause things to catch fire.**

AC TIMING CHARACTERISTICS

The AC timing characteristics at the module level are governed by the underlying AC timing characteristics of the individual components. Consult the component data sheets for more information.

The no-cost SHIPWare source code as well as the full-featured Serious Human Interface™ Platform software initializes the MCU and other SIM components for correct operation.

ENVIRONMENTAL CHARACTERISTICS

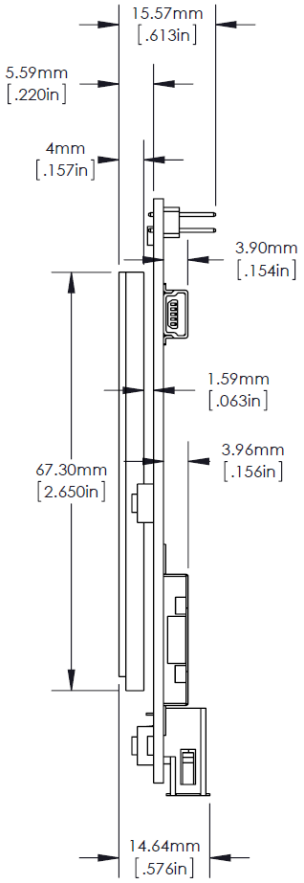
Specification	Permissible Range			
	Min	Typ	Max	Units
Operating Temperature	-20		+70	C
Storage Temperature	-30		+80	C
Humidity			90% (@60C)	RH

PHYSICAL CHARACTERISTICS

The outer dimensions of the SIM225 are approximately 116 x 94 x 15.57 mm. Thickness of the module is 1.15mm less for variants without touch capabilities.

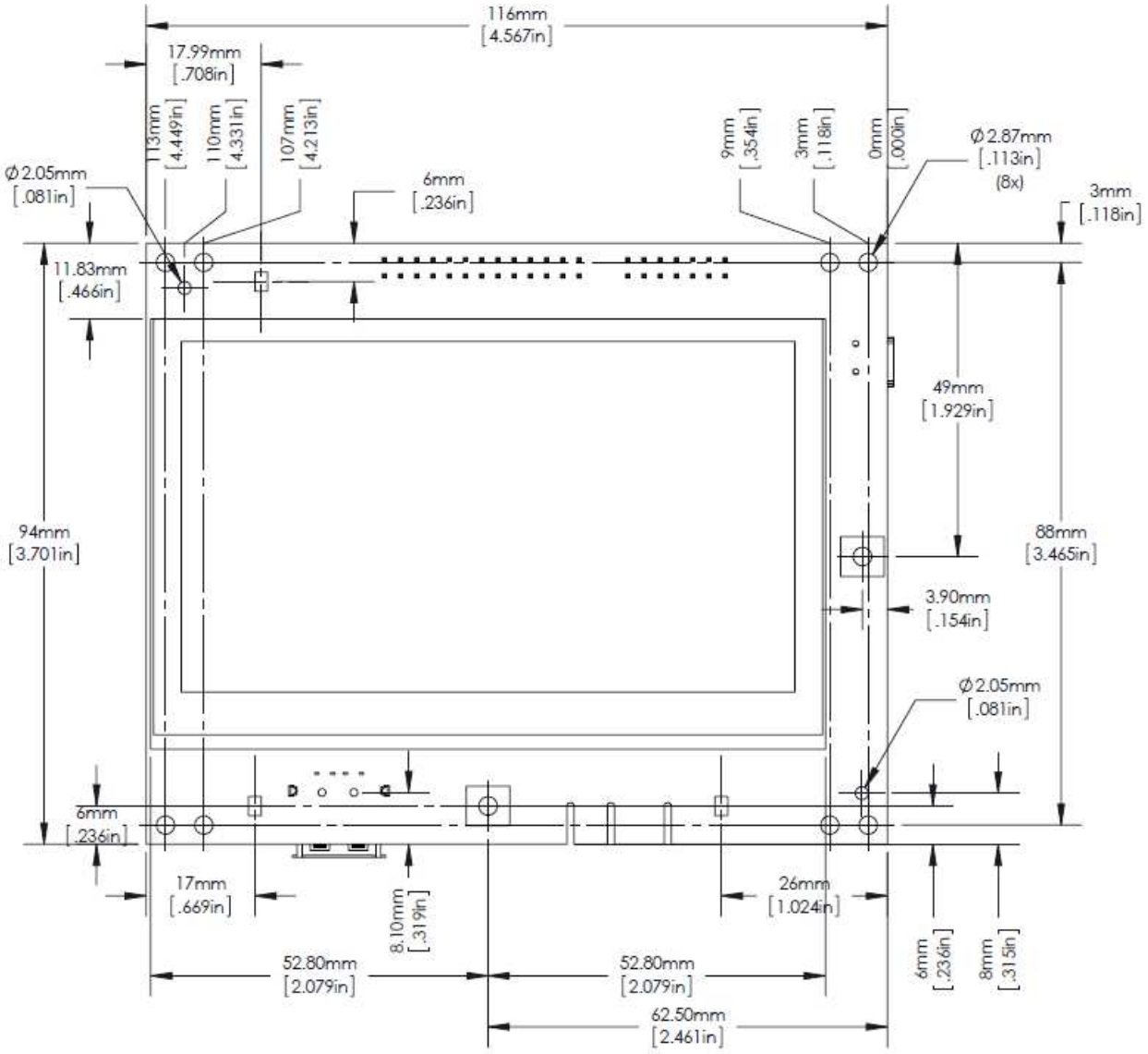
Mechanical drawings, SolidWorks, and STEP models are available for most SIMs.
Visit www.seriousintegrated.com/docs for more information.

The cross-sectional dimensions of SIM225 variants with touch panel support (e.g. SIM225-A00, A01, and A03) are as follows:



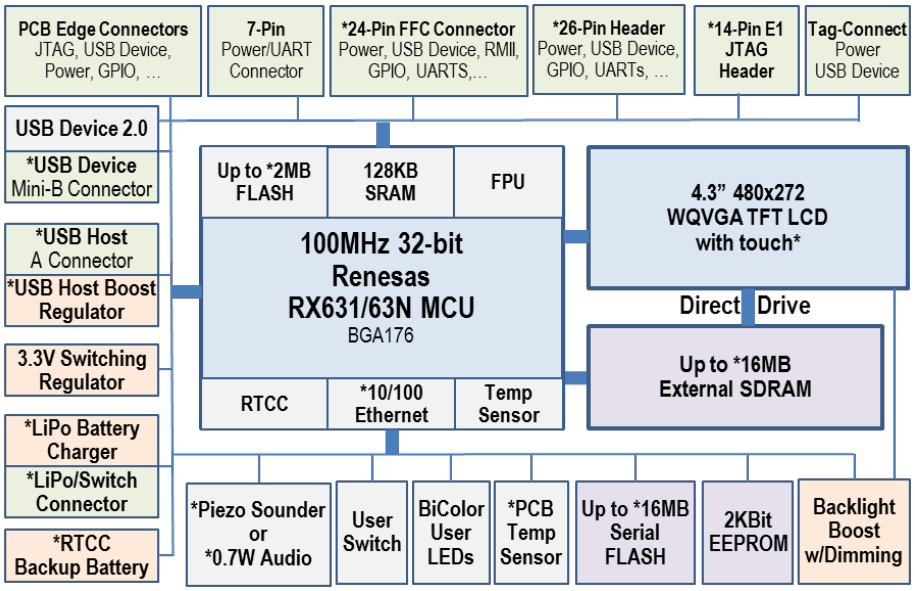
For units without touch support, the surface glass and plastic touch layers on the LCD are not present, reducing the height of the surface of the LCD by 1.15mm.

The positioning of the LCD glass and various connectors is well defined in the SolidWorks/STEP files, and are shown here for reference:



Early versions of the mechanical specification had the LCD screen incorrectly shifted right by 0.012". Current mechanical drawings, SolidWorks, and STEP models at www.seriousintegrated.com/docs have corrected this issue.

HARDWARE OVERVIEW



SIM225 Hardware Block Diagram *options depend on family member

Not all features are available on all SIM225 family members.

HIGH PERFORMANCE RENESAS RX MCU

The heart of the SIM225 is the 32-bit Renesas RX63N/RX631 microcontroller (MCU) with up to 2MB of zero wait state FLASH, 128KB RAM, and FPU. This powerful MCU is equipped with extensive analog and digital peripherals and, with software, can deliver an excellent user interface experience. On the SIM225, the MCU should be operated at 96MHz to ensure usable timing sources for peripherals such as USB.

GRAPHIC COLOR LCD DISPLAY WITH DIRECT DRIVE AND TOUCH OPTION

The SIM225's Liquid Crystal Display ("LCD" or "glass") has an on-glass row-column driver chip for illuminating pixels but has no on-glass frame buffer or memory. The pixel data must be delivered at approximately 60Hz per complete frame by the MCU, and stored and managed in the SDRAM attached to the MCU. The RX631/63N MCU family has no hardware graphics engine, but rather implements a "Direct Drive" architecture whereby the MCU's DMA, timers, and other peripherals are used to deliver pixel data directly from SDRAM to the LCD at the specific timing required by the LCD. The performance of the RX MCU can enable surprising GUI performance and the Direct Drive architecture on the RX requires few external components. This combination can yield a modern-looking GUI, including alpha blending effects, with low system cost.

Some SIM225 family members ("variants") include an integrated 4-wire resistive touch feature: a resistive film over the LCD returns an analog voltage in two dimensions which can be read by the MCU's 12-bit analog-to-digital converter channels and translated with a simple algorithm into a pixel hit position.

ON-MODULE PERIPHERALS

The SIM225 contains numerous on-module peripherals – many common to a vast and diverse set of OEM applications, including a Real Time Clock/Calendar (RTCC) (battery-backed on some modules), temperature sensor, USB device, USB host, serial FLASH, a high speed UART, EEPROM, bi-color indicator LEDs, a user "select" switch, and more.

ON-MODULE MEMORY

The SIM225 module has a variety of memory for storage of program, data, images, parameters, etc.:

FLASH Memory:

- Up to 2 MB zero wait state FLASH program memory within the RX63N/RX631
- Up to 16Mbytes (128 Mbits) serial FLASH memory attached via dedicated SPI

EEPROM

- 2Kbits EEPROM

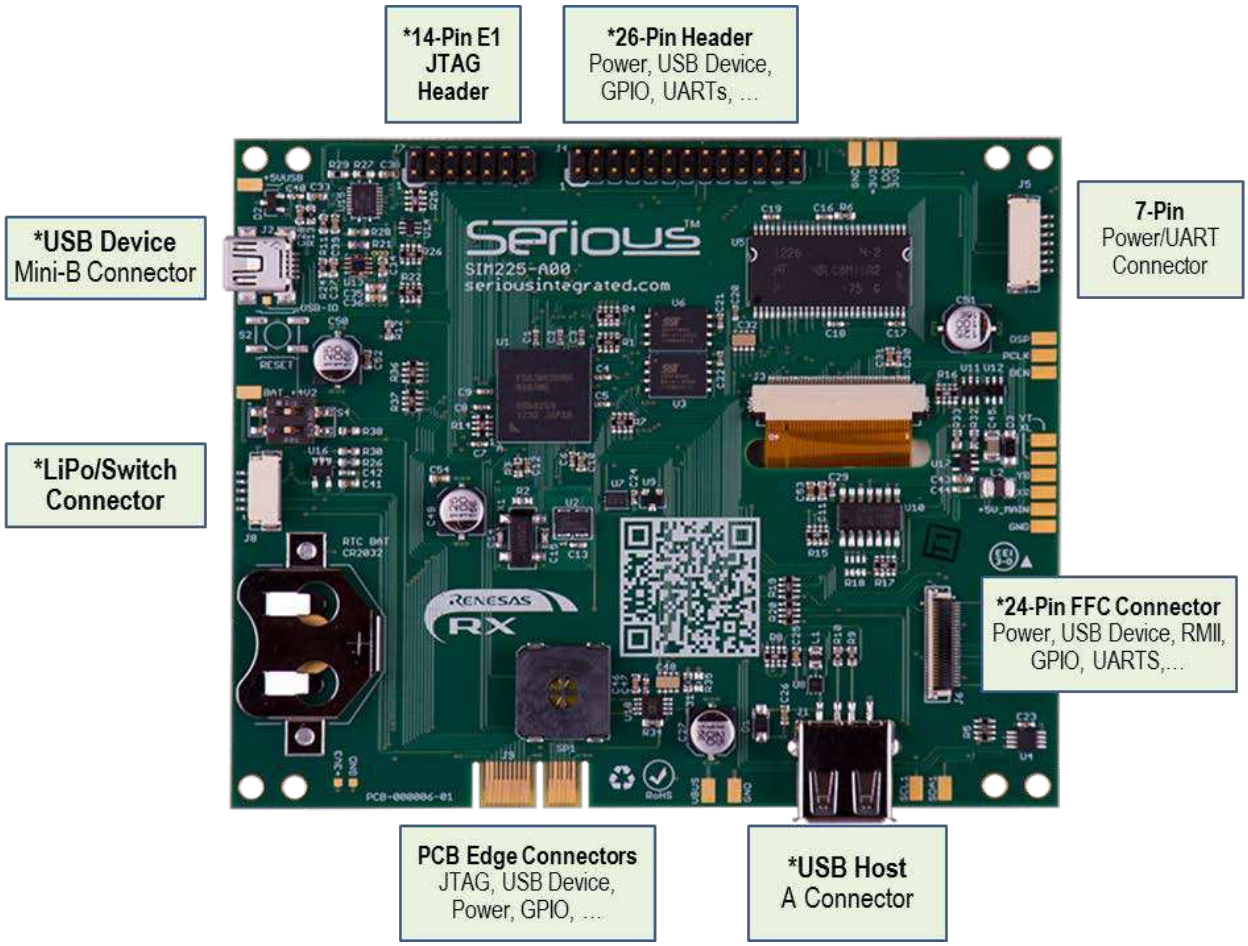
RAM

- 128KBytes RAM within the RX63N/RX631
- Up to 2MBytes of external SDRAM

COMMUNICATIONS AND CONNECTORS

The SIM225 has numerous off-module communication ports and connectors. Some may or may not be available on specific SIM225 family members.

- 26-Pin Baseboard Connector with extensive I/O including:
  - SPI, I2C, CAN, and high-speed UART ports
  - USB device connections
  - Power input/output
  - GPIO
  - DA0/DA1 mono/stereo audio and/or general purpose DAC outputs
- PCB Edge Connector for high speed programming and MCU-level debugging, including:
  - SPI and high-speed UART ports
  - JTAG for connection (with adapter) to 14-pin Renesas E1, Segger J-Link and equivalent devices
  - USB 2.0 device port (shared with USB mini-B connector if present)
- USB Mini-B Device Port
  - USB 2.0 full speed device port
- USB Host Port
  - USB 2.0 full speed embedded host port capable of supplying up to 150mA
- 24-Pin Flex Cable Connector with extensive I/O including:
  - Reduced MII (RMII) Ethernet connection (if the SIM225 is equipped with an RX63N MCU)
  - SPI, I2C, CAN, and high-speed UART ports
- 7-Pin Wire-to-Board Power and Communications Connector
  - Suitable for an inexpensive wire harness with latching plug connection
  - UART, +5V in, +3V3 out, and RESET#
- 5-Pin Wire-to-Board LiPo Battery/Switch Connector
  - Suitable for an inexpensive wire harness with latching plug connection
  - Connects to optional LiPo battery and low current power switch
- 14-Pin JTAG Connector
  - For connection to standard Renesas E1/E10 and Segger J-Link programmer/debuggers
- Tag-Connect port for a convenient in-service programming capability



POWER

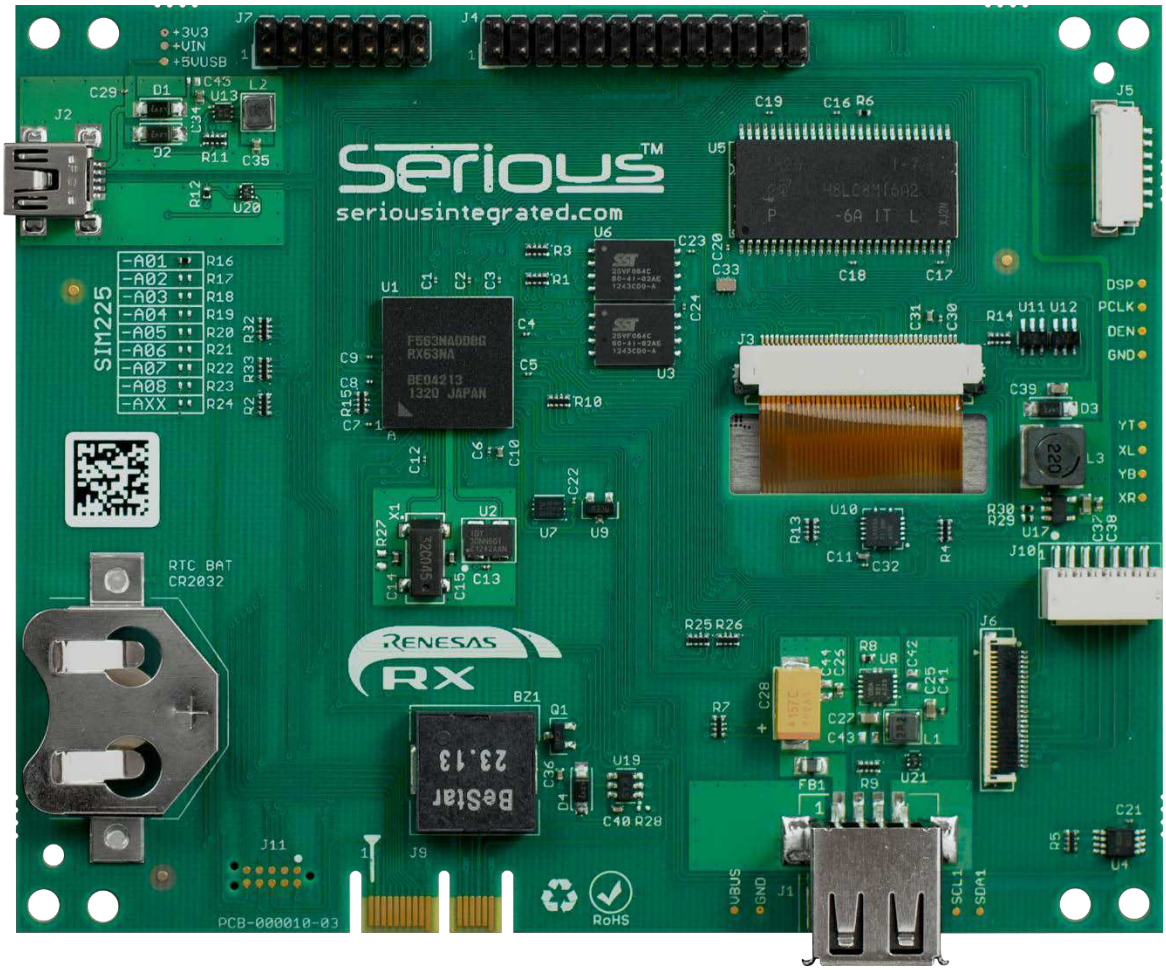
The SIM225 module can be powered in several ways:

- USB Device Power (+5 V_USBF) available on numerous different connectors (if present):
  - USB Mini-B connector,
  - PCB Edge Connector
  - Tag-Connect
  - Baseboard Connector
- External 5VDC (+5 V_EXT/ +VEXT) available on several connectors (if present):
  - Power and Communications Connector
  - FFC Expansion Connector
  - Baseboard Connector
- External LiPo battery input (BAT_+4 V2) available on several connectors (if present):
  - Baseboard Connector
  - LiPo Battery/Switch Connector

For development, it is common to power the module from the device USB connector by connecting the SIM to a PC or powered USB hub. The complete module may require as much as 500mA from the USB power supply, so ensure that the USB hub or USB power supply can deliver enough power.

The SIM225 can support concurrent connection from some of these supplies. See the Power Supplies for details.

MODULE FEATURE DETAIL



RENESAS RX63N/RX631 MCU

At the heart of the SIM225 is a 100MHz 32-bit Renesas RX63N/RX631 MCU equipped with extensive analog and digital peripherals. Features include:

MCU Core & Memory

- 100MHz 32-bit core
- Up to 2MBytes FLASH – zero wait state at up to 100MHz
- 128KBytes RAM – zero wait state at 100MHz
- Single cycle multiply and hardware divide unit
- Single precision hardware Floating Point Unit (FPU)
- 16 32-bit registers
- Fast context switching/interrupt response, including a dedicated “fast interrupt”

Peripherals include:

- Two USB 2.0 ports (one device, one host)
- SDRAM external bus controller
- Four-channel general hardware DMA controller plus Data Transfer Controll
- A/D Converters: 4 channels x 2 units 10-bit or 8 channels x 1 unit 12-bit
- Hardware real time clock calendar (RTCC) with battery backup capability
- D/A Converter: 10-bit x 2 channels
- Watchdog timer
- Numerous SPI, I2C, CAN, and high-speed-capable serial ports

Some SIM225 family members feature the RX63N MCU, which has the Ethernet peripheral, and others the RX631 MCU without Ethernet. Renesas provides extensive documentation of the RX63N/RX631 MCU family as well as example software: consult their website. In addition, many community resources are available for RX family developers, including the rxmcu and renesasrulz websites.

Note that on the SIM225, the MCU should normally be operated at 96MHz to ensure the clocking system can generate the appropriate clocks for SRAM, USB, and other peripherals.

The following table summarizes the size, speed, and configuration of each family member:

SIM225 Variant	Renesas RX63x Family Member			
	Part Number	FLASH	RAM	Peripherals
-A00	R5F**63NEDDBG**	2MB	128KB	Ethernet, CAN
-A01	R5F**63NADDBG**	768KB	128KB	Ethernet, CAN
-A02	R5F**63NADDBG**	768KB	128KB	Ethernet, CAN
-A03	R5F**6318DDBG**	512KB	128KB	CAN
-A04	R5F**6318DDBG**	512KB	128KB	CAN

MCU BOOT MODES, SWITCH S4, AND THE USB BOOT FLASH

Three separate FLASH memory areas are available inside the RX MCU: Program FLASH, Data FLASH, and USB Boot Mode FLASH as well as one Boot Mode ROM. Three "boot modes" are available on the RX631/RX63N MCU family based on the state of the MD and PC7 pins when the RESET# signal is released. Depending on which of the three boot modes is determined at reset, the MCU jumps to a corresponding start address for code execution.

MD	PC7	Boot Mode	Execution start after RESET#
High	X	Normal Program Boot Mode	Program FLASH reset vector
Low	Low	ROM Boot Mode	Start of Boot Mode ROM
Low	High	USB Boot Mode	Start of USB Boot Mode FLASH

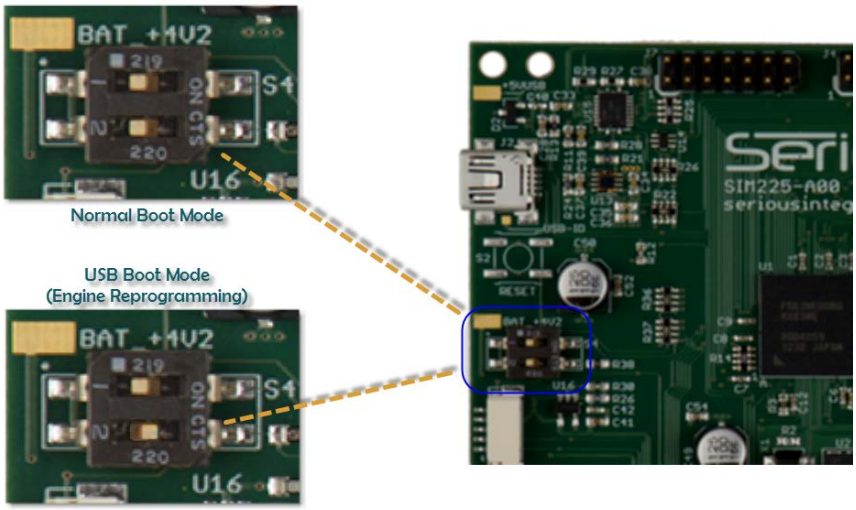
In normal Program boot mode, the PC7 signal is completely available for program and system use. However, in the two special boot modes, PC7 must remain fixed throughout the operation of the mode until the subsequent RESET# and is not available for general program and system use during these special modes.

The MD1 and PC7 signals are weakly pulled high on the SIM225, ensuring that for normal operation the MCU will boot in Normal Program Boot Mode, starting execution at the main RX MCU Program FLASH reset vector. The Program FLASH can be (re)programmed in a variety of ways, including the JTAG port exposed on the PCB Edge Connector as well as under user program control.

Because the PC7 and MD1 signals are available on the PCB Edge Connector, they can be pulled low externally to the SIM forcing the SIM to go into one of the two special boot modes. Consult the Renesas RX63N/RX631 MCU Hardware Manual for additional boot mode details.

Some SIM225 variants have a DIP switch S4 populated on the PCB. PC7 and MD1 are connected to switch positions 1 and 2 respectively. For normal execution, ensure both are in the OFF position. When MD1/S4.2 is ON (and because PC7 is weakly pulled high on the SIM225) the MCU will enter USB Boot Mode on release of RESET#.

For those variants without S4 populated, the SPA100 adapter also has this same switch.



S4.1 and S4.2, when "ON", are connected directly to GND.
Do not externally drive these signals high while the corresponding switches are ON or you may damage the SIM and/or attached equipment.

In USB Boot Mode, the processor begins execution in the 16KB USB Boot FLASH rather than the normal Program FLASH. ***Serious*** programs the USB boot area with special firmware designed to function with the Serious Human Interface™ Platform tools, enabling reprogramming of the SHIPEngine and Serial FLASH with new GUI cargo files. The algorithm in this firmware is proprietary, and when the SIM225 boots in USB Boot mode the USB port will identify itself as requiring up to 500mA of bus power and having USB Vendor ID $0x25D8$ (registered exclusively to *Serious*) and USB Product ID in the $0x0001$ to $0x0099$ range depending on the version of the protocol contained in the area.

Renesas supplies a standard load for this FLASH area. With the standard Renesas load installed and USB Boot Mode selected, the Renesas firmware reads $P35$ (NMI #) and finds it pulled high, causing the USB device port to tell a connected USB host (such as a PC) that the SIM225 is bus powered and requires up to 500mA of power from the USB port. The USB VID will be $0x045B$ (registered exclusively to Renesas) and USB PID of $0x0025$.

To use the full features of the Serious Human Interface™ Platform, you need to preserve the ***Serious*** firmware in this area. Overwriting and/or re-installing this firmware can only be accomplished with Renesas tools and a JTAG debugger.

GRAPHIC LCD DISPLAY

The LCD display (or "glass") on the SIM225 is a 4.3" diagonal active area 480x272 TFT with optional 4-wire resistive touch layer. Features include:

Parameter	Typical Value
Type	TFT TRANSMISSIVE
Active Area	95.04×53.86 mm
Pixel Dimensions/Depth	480 x 272
Pixel Color Depth	24-bit connected as 16-bit RBG565
Pixel Pitch	Approx. 128 DPI
On Board Frame Buffer	none
Driver IC	HX8257 or equiv.
Backlight Type	LED
Backlight Luminance (with touch)	300cd/m^2
Backlight Luminance (without touch)	350cd/m^2

The LCD display has no on-glass frame buffer or memory. The MCU is responsible for delivering pixel data at a specific frequency to the LCD display as well as various clock signals otherwise the display will not function correctly and will not display a stable image. No valid image is possible unless the MCU is operating and, under software control, the MCU is delivering pixel and timing data to the LCD display continuously. The LCD display, in absence of a valid signal from the MCU, may automatically enter self-test mode and display various cycling test patterns.

The LCD backlight is enabled when RX P11/ BLEN is driven high, which turns on the backlight power boost circuit driving approximately 16.5V to flow to the backlight LEDs on the LCD. This enable signal has a weak pull-down, so the backlight is off until the MCU pin is initialized, including during and directly after system RESET#. Software algorithms can PWM this pin to enable backlight dimming. A PWM driven by a typical 1 KHz clock with 16 PWM steps for a PWM net frequency of 64 Hz is generally sufficient and flicker free with duty cycles from 0 to 100%. In no circumstances should the PWM clock exceed 16 KHz.

The Serious Human Interface™ Platform has the backlight driver included; setting the platform glass backlight value to 0 to 100% automatically modulates the dimming circuit.

LCD DIRECT DRIVE

Since the LCD display has no on-glass frame buffer, pixel data must be held in memory and streamed continuously to the display hardware. This memory must also be MCU accessible in order for software to "draw" into the frame buffers and transfer images and drawings to the screen.

On the SIM225, the external SDRAM can accommodate one or more full-frame buffers for pixel data and, under software control, algorithms can "draw" into these frame buffers. Delivering the pixel data from bulk frame memory to the LCD normally requires an LCD controller, either as an external hardware circuit or built into the MCU. The RX MCU, without a dedicated LCD controller and with little external circuitry, can deliver pixel data directly from external RAM to the LCD display. This technology is called "Direct Drive" and can deliver excellent user interface experiences at low hardware cost.

For a detailed explanation of Direct Drive operation, consult the Renesas RX600 Series Direct Drive LCD Demonstration Application Note. The concept is straightforward: the RX MCU instructs the SDRAM to deliver the pixel data to the LCD panel at exactly the right frequency (the "dot clock") so that each line of the screen is "painted" in the correct sequence and at the right time. Typically this painting of the frame is done every 60Hz (16ms) and the paint time is only about

8ms for the frame. Therefore there is a "blank" time that represents about 30-50% of the total 16ms frame time. During the painting time, the MCU software *must not access the SDRAM,* as the MCU access can disrupt the timing of the data delivery to the LCD from the SDRAM and cause visible flickering and shearing on the LCD screen. However, the MCU is free to manipulate and access the SDRAM during the blanking time. Both Renesas and *Serious* software include special "monitor" tasks to lock/unlock tasks needing access to the external RAM without disrupting the LCD operation. Software that uses the external SDRAM needs to be written with the understanding that it is subject to frequent ~8ms delays while the frame is being painted.

The overall advantage of a Direct Drive system is lower cost and circuit complexity. With almost no external components, no graphics controller, no dedicated frame buffers, no dual ported RAM or arbiters, one can create a complete graphic LCD output very inexpensively with excellent visual results.

The LCD panel has two timing modes: VSYNC/HSYNC mode and DEN mode. The SIM225 uses DEN mode which provides better Direct Drive performance and uses less pins and software overhead than VSYNC/HSYNC mode. In DEN mode, the LCD's VSYNC# and HSYNC# pins are both always pulled inactive, and the DEN signal (when active) indicates when data is being clocked into the LCD panel. DEN is inactive a minimum of 45 clocks between lines, allowing the 480 pixel line previously clocked into the chip to be driven to the screen. DEN is inactive a minimum of 13 lines to signal that the next line is the beginning of a new 272 line frame.

The no-cost SHIPWare software at mySerious.com includes all initialization code, drivers, and utilities to enable Direct Drive operation, including portrait and landscape modes and adjustable frame rates. This software is available after account sign-up and registration of your SIM225 serial number.

The Serious Human Interface™ Platform software system has fully-integrated and optimized Direct Drive drivers and frame buffer management, making the Direct Drive system transparent to the GUI designer.

TOUCH

Some SIM225 family members include a resistive touch layer bonded to the LCD display. The layer can return an analog voltage in two dimensions to be read by the MCU's analog-to-digital converters and translated with a software algorithm into a pixel hit position. These four input signals are as follows:

Signal	Description	MCU Port
TOUCH_YB	Y-/YB/YDown	AN000/ P40/ IRQ8-DS
TOUCH_XR	X+/XR/XRight	AN001/ P41/ IRQ9-DS
TOUCH_XL	X-/XL/XLeft	AN002/ P42
TOUCH_YT	Y+/YU/YTop	AN003/ P43

Resistive touch layers are made from a highly resilient Polyethylene Terephthalate (PET) film, and have the advantage of being robust and usable with a stylus, finger, or any blunt object. Unlike typical capacitive touch screens, resistive touch screens do not require the bare finger and can be used with gloves on – important for certain medical, industrial, and automotive applications. They also work well in wet conditions, although appropriate caution must be taken to ensure liquids do not flow onto the SIM225 or other circuitry. ***Serious*** application note AN0201: Resistive Touch Bezel Guidelines is a good resource for understanding how to mount a touch screen behind a bezel.

Some chemicals (especially but not limited to Ketone-based products), harsh cleansers, and abrasive cleaning products can discolor and/or damage the PET film. To ensure long usable lifetime, make sure end users are well-informed on how to clean and maintain the touch screen.

One challenge with resistive touch layers is power: applying power through the resistive layer is normally required to sense the change in resistance created when touched. There are two very different modes where power is applied to the panel: (1) basic "is the panel touched?" and (2) actual sensing of the touched position.

BASIC TOUCH TESTING AND WAKE-UP

There are two common places where a simple detection of panel hit is required:

- during CPU sleep modes where a panel touch needs to wake up the CPU and the system, and,
- as a quick test to see if more detailed coordinate reading is needed.

Basic touch testing requires only the ADC pins. The ADC pins, connected through current-limiting resistors to the touch panel, can be configured dynamically by software to be low current outputs or ADC inputs. To do a basic "are we touched?" test on the SIM225, the pins can be configured as follows:

Signal	Mode	State
TOUCH_XL	Output	Drive low via P42
TOUCH_YB	ADC Input	Weakly pulled high

When not touched, the YB analog input will read at-or-near the maximum ADC value. The ADC on the RX631/RX63N has 12-bit resolution, so the reading will be at-or-near 0x0FFF. When the panel is touched, the two layers connect, and the weak pull-up on YB is overwhelmed by the strong low on XL, causing the ADC value to drop significantly.

In sleep modes, setting an interrupt on IRQ8-DS can wake the system when the panel is touched. In this mode the standby power is extremely low – the resistance across the panel planes when not touched is typically 10MΩ.

This simple test can be used in a timer-driven software event to determine if/when a more precise and rigorous full reading of the XY location of the touch screen is required.

TOUCH PANEL COORDINATE READING

Because of current limitations on the MCU pins, 1KΩ resistors are placed in series with the four ADC pins such that when they are used as outputs the current is limited to approximately 1mA. As well, the ADC reading is then limited to the center of the range – the two 1KΩ resistors with the ~500Ω touch plane in between form a voltage divider.