

PE-HMI1 v2.0

User's Manual: Hardware

RENESAS SYNERGY™ S7G2

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This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.*
- Increase the separation between the equipment and receiver.*
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- Consult the dealer or an experienced radio/TV technician for help.*

The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by Purple Communications, Inc, may void the user's authority to operate the equipment.

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This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:

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2. This device must accept any interference received, including interference that may cause undesired operation of the device.

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1. Cet appareil ne doit pas provoquer d'interférences
2. Cet appareil doit accepter toute interférence reçue, y compris les interférences pouvant provoquer un fonctionnement indésirable de l'appareil.

Precautions

This Renesas PE-HMI1 is only intended for use in a laboratory environment under ambient temperature and humidity conditions. A safe separation distance should be used between this and sensitive equipment. Its use outside the laboratory, classroom, study area or similar such area invalidates conformity with the protection requirements of the Electromagnetic Compatibility Directive and could lead to prosecution.

The product generates, uses, and can radiate radio frequency energy and may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment causes harmful interference to radio or television reception, which can be determined by turning the equipment off or on, you are encouraged to try to correct the interference by one or more of the following measures;

- Ensure attached cables do not lie across the equipment
- Reorient the receiving antenna
- Increase the distance between the equipment and the receiver
- Connect the equipment into an outlet on a circuit different from that which the receiver is connected
- Power down the equipment when not in use
- Consult the dealer or an experienced radio/TV technician for help NOTE: It is recommended that wherever possible shielded interface cables are used.

The product is potentially susceptible to certain EMC phenomena. To mitigate against them it is recommended that the following measures be undertaken;

- The user is advised that mobile phones should not be used within 10m of the product when in use.
- The user is advised to take ESD precautions when handling the equipment.

The Renesas PE-HMI1 does not represent an ideal reference design for an end product and does not fulfill the regulatory standards for an end product.

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1. Preface

1.1 Cautions

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Designer's Notebook

The PE-HMI1 was jointly designed by the Renesas IoT Solutions Team and Serious Integrated, Inc.: <http://www.seriousintegrated.com/> Notes formatted in this style are from the *Design Team* and may be helpful in the analysis of the design and the design of your own hardware. These are our notes only, and the recommendations and comments therein are subject to the Disclaimer and Precautions notes at the beginning of this document.

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1.4 Website

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1.5 Glossary

| | | | |
|-----|--------------------------|-----|-------------------------|
| CPU | Central Processing Unit | HMI | Human Machine Interface |
| GUI | Graphical User Interface | USB | Universal Serial Bus |

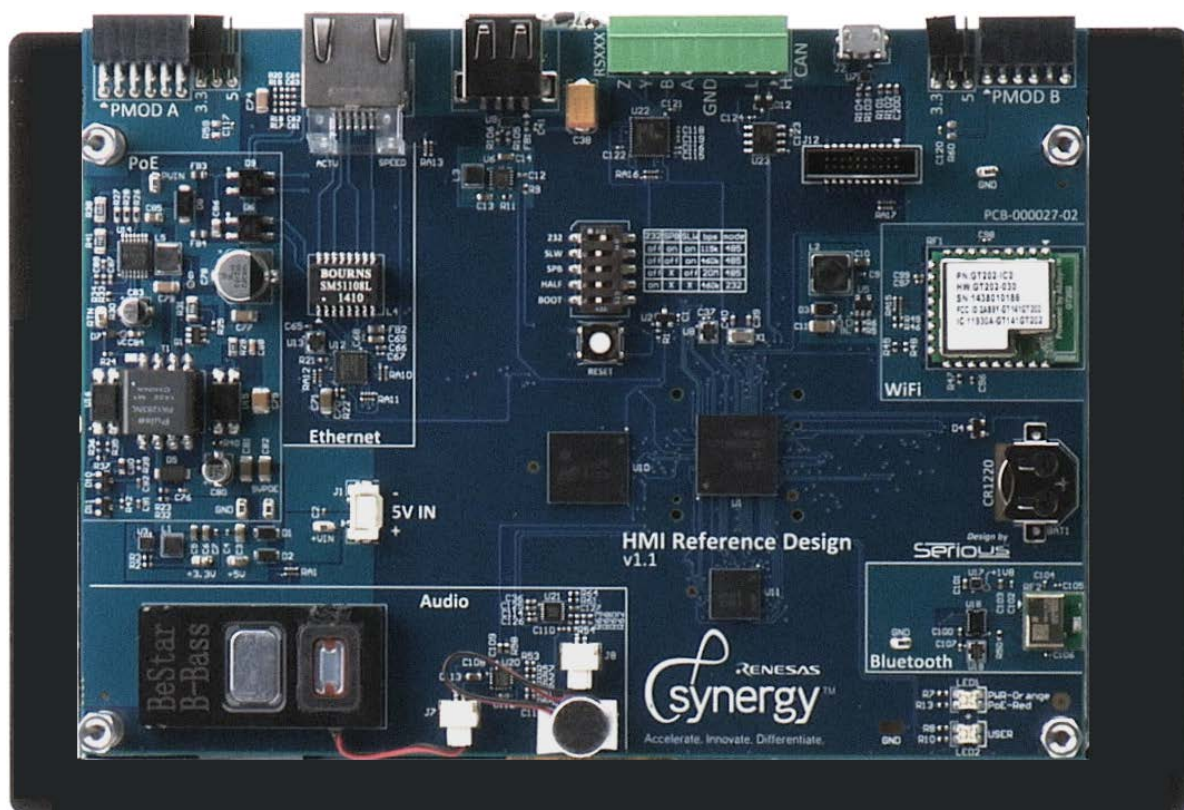
2. Introduction and Purpose

The Renesas Synergy PE-HMI1 S7G2 WVGA HMI Product Example is a flexible and full-featured Human Machine Interface plus communications platform based on the Synergy S7G2 Microcontroller. While production worthy, the PE-HMI1 is primarily intended for software and hardware developers to experiment and evaluate the extensive I/O features of the S7G2 on the PE-HMI1 prior to development of their own customized hardware.

The PE-HMI1 contains several communications ports, including 10/100 Ethernet with Power over Ethernet support, CAN, RS232/RS485, USB Host, and USB Device. In a slight deviation from a pure product example, the board includes two popular Pmod™ connectors for external prototyping modules from Digilent (<http://www.digilentinc.com/>) and other vendors, making it attractive for software and systems developers to add unique functionality such as sensors and custom networking for prototyping purposes.

For more information on the Synergy PE-HMI1, visit www.renesassynergy.com

2.1 Hardware



The PE-HMI1 has two main elements:

- A full featured S7G2 MCU-based processing and I/O board
- A 800x480 Multi-Viewing Angle (MVA) LCD with 24-bit RGB color interface and capacitive touch sensing

These elements come pre-assembled in the PE-HMI1 kit in an acrylic enclosure along with various cables, power supplies, and accessories.

The MCU/memory subsystem of the PE-HMI1 includes:

- Synergy S7G2 MCU with
 - 240MHz ARM Cortex™-M4 core with 640 kB on-chip RAM, 4MB on-chip FLASH
 - On chip graphics controller, including JPEG decoder and video frame capture engine unit
- 32 MB 120MHz SDRAM
- 2GB eMMC intelligent NAND flash “drive on a chip”
- 32.768kHz RTC crystal and 24MHz MCU clock

The PE-HMI1 has a rich power subsystem supporting the needs of the MCU and I/O, including:

- Power input 802.3af-compliant Power over Ethernet or 5V using 2.1-mm barrel connector
- High efficiency 5V to 3.3V system power DC-DC converter
- Current managed USB Host 5V power supply
- High efficiency constant-current LCD backlight boost power supply

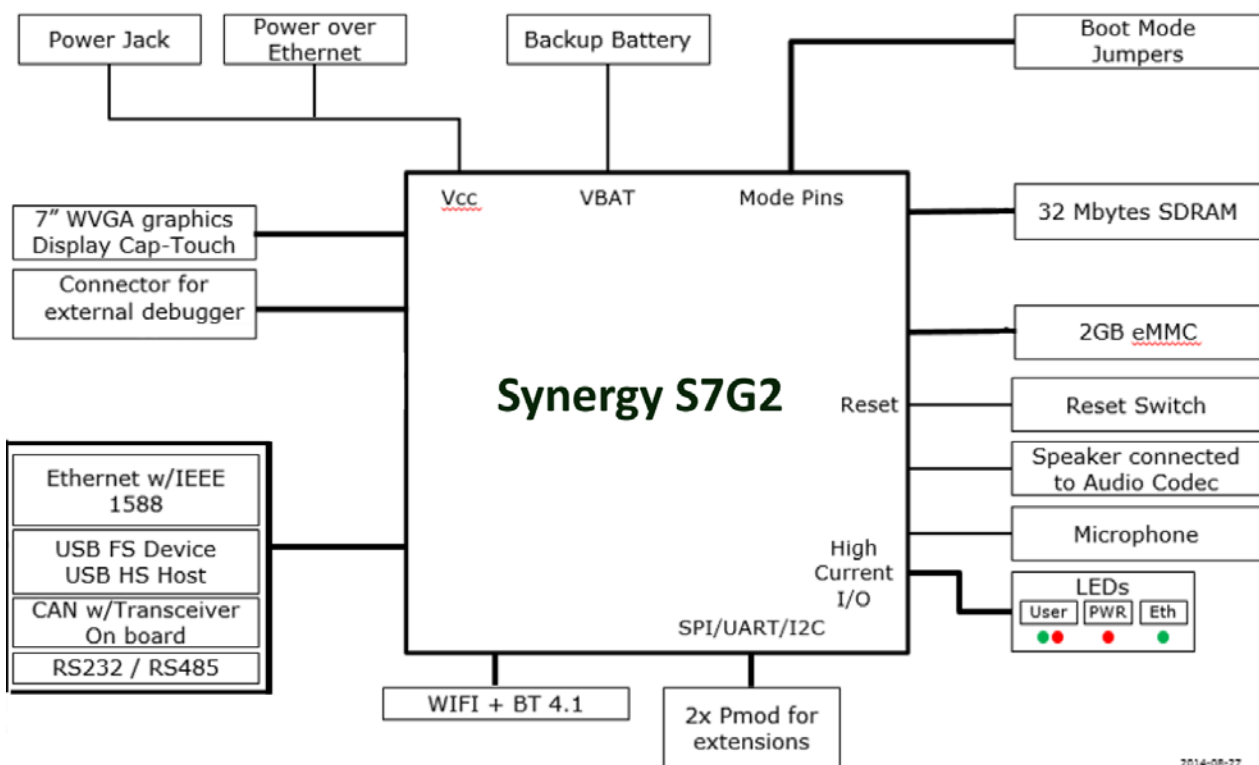
The I/O features of the PE-HMI1 are typical of many feature-leading HMI-equipped embedded systems, including:

- CAN plus RS232/RS485 port on an industrial-style 3.5-mm screw terminal plug connector
- 10/100 Ethernet Port on standard RJ45 CAT5/6 jack with dual indicator LEDs
- Mono audio with 1W speaker and microphone
- Full Speed USB 2.0 Device port (Micro-B)
- High Speed USB 2.0 Host port (Type-A) with available current-managed 5V@500mA power
- Coin-cell battery-backed real time clock and calendar
- Qualcomm/Atheros [QCA4002 WiFi](#)
- Bluetooth dual mode (Classic & BLE)
- Ambient light sensor, reset button, power indicator LED

Venturing outside the realm of a true product example, the PE-HMI1 also includes two Digilent Pmod ports, one 2x6-pin version with Type 2A (expanded SPI) and Type 4A (expanded UART) support and the other with the more limited 1x6 UART capabilities. This enables software and systems developers to add functionality to the PE-HMI1 specific to their own application in advance of developing their own custom hardware.

2.2 Hardware Block Diagrams






The PE-HMI1 has the following basic hardware block diagram:



2.3 Software and Software Development Tools: The Synergy Platform

The Renesas Synergy Platform is a new, easy-to-use, qualified platform designed to accelerate time to market, reduce total cost of ownership and remove many of the obstacles engineers face as they develop embedded products. With this new platform, product development can start at the API level, providing more time to design innovative and

differentiated features for IoT devices. The Renesas Synergy Platform integrates qualified software with a new family of MCUs and an ecosystem of tools and support options into one scalable and secure platform:

| Software | Microcontrollers | Tools & Kits | Solutions | Gallery |
|---|--|--|---|---|
| <ul style="list-style-type: none"> Qualified Synergy Software Package (SSP) for guaranteed operation Complete package fully integrated and maintained Applications can be written at the package API level  | <ul style="list-style-type: none"> Wide MCU spectrum based on 32bit cores Completely scalable and pin compatible On-chip Flash memory up to 4 MB Security & encryption acceleration Ultra low power  | <ul style="list-style-type: none"> Integrated Solution Development Environment (ISDE) with context-aware documentation Starter Kits (SK) and Development Kits (DK) for immediate access to entire software package  | <ul style="list-style-type: none"> Product Example (PE) kits: Complete design journeys representative of end-product designs Application Example (AE) kits: Technology building-block examples to build upon  | <ul style="list-style-type: none"> Web access to Synergy specific software, tools, licensing plus 3rd party software & services Future growth to complete secure cloud access infrastructure for end-products to use  |

See the Synergy website for more information: <http://www.renesassynergy.com>.

2.4 Usage Models

The PE-HMI1 is designed as an initial hardware product example platform as well as software development platform for OEM applications not only requiring sophisticated LCD-based GUI Human Machine Interface (HMI) capabilities but also extensive communications. The platform has some direct machine-control GPIO available through the Pmod ports, although the platform will often be used in conjunction with an OEM's intelligent I/O and power subsystem, possibly communicating with that subsystem over RS232, RS485, or UART/SPI.

For more extensive GPIO connectivity, more flexible port assignments and experimentation with MCU features, the complete Synergy S7G2 Development Kit DK-S7G2 is recommended.

3. Getting Started

The PE-HMI1 assembly comes pre-assembled, and requires no initial assembly to operate out of the box.

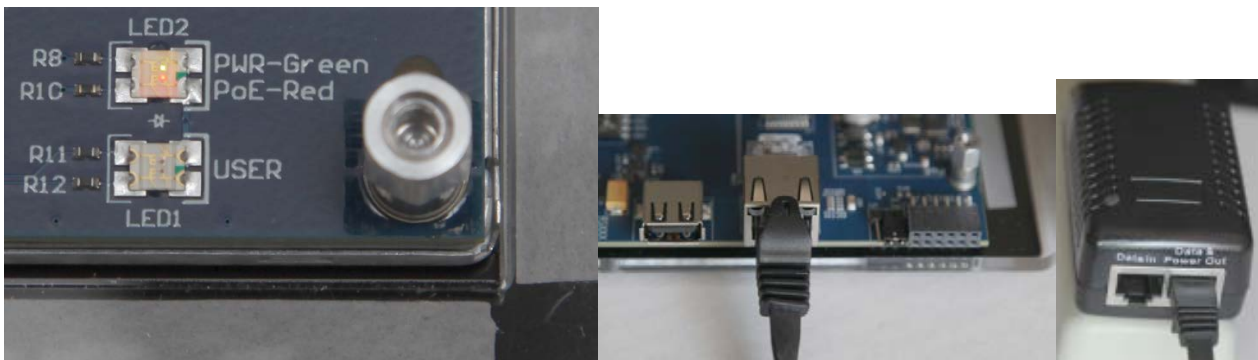


Some elements, such as the LCD to the top bezel, are bonded with high performance adhesive: do not attempt to detach the LCD or disassemble any element not fastened by screws.

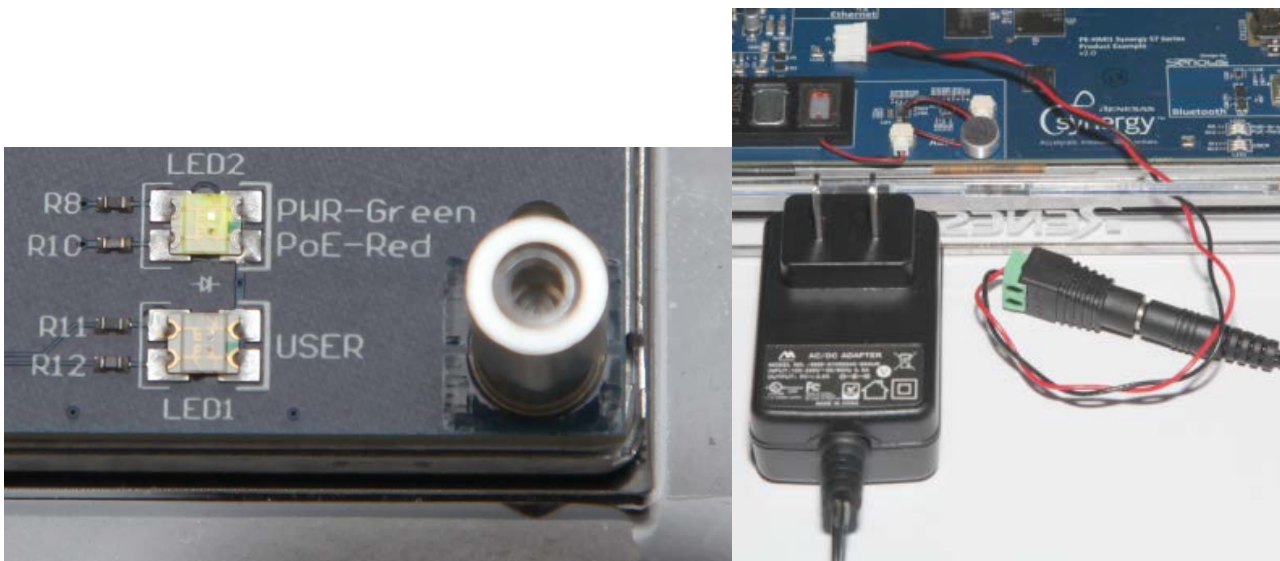
3.1 Powering the PE-HMI1

The PE-HMI1 can be powered via two different methods: the 5V direct input power connector and the 802.3af-compliant Power-over-Ethernet capability.

Connect the supplied UL/CSA/CE/PSE-certified 802.3af PoE power injector to the PE-HMI1 with the supplied Ethernet cable and power the injector from any standard 110/220-V wall socket. When the PoE power is present and active, LED1 will be RED.



Alternatively, use the small barrel jack adapter cable and your own 2.1-mm positive-center 5-V barrel jack power supply to power the PE-HMI1 directly. When the 5-V direct power input is present and active, the LED1 power indicator will be GREEN.



There is no overvoltage protection on the 5-V direct power input: applying more than 5.5-V (for example, incorrectly using a 12V adapter) or using a reverse-polarity barrel plug will permanently damage the unit.

When both the PoE power and the 5-V direct power input are present, the PoE supply will automatically shut down and the 5-V power supply will be used. There might be a very short time when LED1 shows both RED and GREEN (i.e. ORANGE) during the transitional period as both supplies are applied or one is removed.

3.2 Connecting the Programmer/Debugger

The kit comes with the “lite” edition of the powerful and full-featured Segger J-Link series of JTAG debugger/programmers. For faster and more powerful debugging, explore the [Segger J-Link product line](#) as well as the [IAR I-jet product line](#).

To connect the included Segger J-Link Lite ARM debugger, with the power removed from the PE-HMI1 carefully plug in the polarized end of the 20 pin fine-pitch ribbon cable header into the corresponding socket on the PE-HMI1. Pin 7 is removed on the header and blocked on the IDC cable header to ensure correct orientation. The other end of the cable plugs into the Segger J-Link Lite unit. Then connect the USB Mini B cable to the J-Link Lite ARM and your PC. The PC powers the debugger but cannot power the PE-HMI1. Installing the Synergy tools also installs the corresponding driver for the debugger, so there is no need to independently download and install the tools from the Segger website. In fact, the Synergy ISDE ensures (even in the presence of other drivers on your PC) that its own internal version of the Segger drivers are used to ensure compatibility and reliable debugging.



4. Specifications

4.1 DC Characteristics

The DC characteristics of the I/O elements of the platform are governed by the underlying AC timing characteristics of the individual components. Consult the [bill of materials](#) and component data sheets for more information.

| Specification | Minimum | Maximum | Unit |
|-----------------------------|---------|---------|------|
| PoE Voltage | 44 | 57 | VDC |
| Power | | 12.75 | W |
| 5-V Direct Input Voltage | 4.0 | 5.5 | VDC |
| Power | | 10 | W |

4.2 Environmental Characteristics

The PE-HMI1, while designed with production-worthy methods and components, is not designed as a production unit to be used direction in OEM equipment. Contact Renesas for a list of hardware design partners who can develop and deliver production-ready platforms based on the ingredients used in the PE-HMI1 kit.

The environmental characteristics are separated into two components: the PCB with circuitry and the Liquid Crystal Display with Touch Panel; the PCB will continue to operate in its full operational range even if the LCD is outside its operational range.

| Specification | Permissible | | | |
|---------------------------|-------------|---------|------------------------|------|
| | Minimum | Typical | Maximum | Unit |
| Storage Temperature | -30 | 25 | 80 | C |
| Humidity (Non-condensing) | | | 90% < 50C 60% > 50C | RH |
| PCB Operating Temperature | -40 | 25 | 80 | C |
| LCD Operating Temperature | -20 | 25 | 70 | C |

4.3 Physical Characteristics

The outer dimensions of the PE-HMI1, with enclosure, are approximately 254 x 343 x 57 mm. Weight of the unit is approximately 907 grams.

5. Power

The PE-HMI1 has 2 power input options:

- 802.3af-compliant 13W maximum Power over Ethernet to 5-V supply
- 5-V direct power input

The 5-V direct power input overrides any PoE supply present, turning off the PoE power supply. When either power input is present, 5-V is supplied to the on-board power subsystems:

- 3.3V buck switcher for the PE-HMI1 MCU and most I/O
- LCD Backlight boost constant-current supply
- USB Host current-managed 5-V-output supply

In addition to these main power options and subsystems, the Real Time Clock Calendar (RTCC) internal to the Synergy S7G2 MCU has a battery backup power input.

A detailed discussion of each input and subsystem follows.

5.1 Direct 5-V Input

5 V may be directly applied to the circuit through J1 [Molex 503471-0200](#). The mating header for this connector is the [503473](#) housing with [503485](#) crimp pins. By virtue of the extensive use of switching power supplies on the design, this voltage can be anywhere from 4.5 to 5.5 V. Note if PMODs are used at 5 V there may be a narrower range required for this voltage based on the voltage tolerance of the specific PMODs.



There is no overvoltage/polarity protection on the 5-V direct power input: applying more than 5.5 V (for example, incorrectly using a 12V adapter) or reversing polarity will permanently damage the unit.

Designer's Notebook

We saw this connector gaining traction in the burgeoning LED lighting industry and we were attracted to its low cost, good power handling (2A per pin), wide temperature range (-40 to +85C), strong locking features, and good distribution availability. The hand assembly crimp tool was also reasonably priced

Most development kits include some sort of input voltage production, such as a bridge rectifier and a voltage clamp, just in case the intrepid software developer or marketing person plugs the wrong adapter into the board; as a Product Example this extra circuitry is not included as most production designs would be targeted at a well-controlled power environment not subject to this issue and those circuits, to be effective, add significant cost. The sister design to the PE-HMI1 for the Synergy S7G2 MCU, the Synergy S7G2 Development Kit, does include such circuitry.

5.2 Power over Ethernet Input

The PE-HMI1 includes an 802.3af-compliant Power over Ethernet input power supply. Included in the PE-HMI1 kit is an inexpensive PoE power injector to demonstrate this usage. You can plug a standard non-PoE Ethernet network connection into the power injector, and the output of the injector will include the network signals plus up to 13W of power for the PE-HMI1. If your environment has PoE VoIP phones, you can use one of these lines to power the PE-HMI1 instead of using the injector.





Take care with selecting and using so-called PoE power injectors; many are not 802.3af compliant and are cheaper devices used to power surveillance cameras etc. Use of a non-802.3af compliant source may damage the PE-HMI1.

The circuit, managed by a TPS23753A, is a fully 1500V isolated design compliant with the [IEEE 803.3af specification](#) for Class 0 (12.95W) devices. The circuit is capable of generating as much as 10W of output power at 5 V. When a PoE-capable device is connected to a PoE-capable source, a negotiation process is performed in the hardware to select the power level required by the device (and supported by the source). If this negotiation process fails, including the absence of a PoE capable supply, the PoE power supply does not turn on.



The PoE circuit is designed to, but not tested or certified for, 1500V isolation. Take care in probing this circuit with the (up to) 57V present. Consider using a fully certified module-level product in your design.

Aside from the negotiation and isolation aspects, the heart of the PoE design is a buck switcher converting the 44 to 57VDC on the PoE line to 5-VDC required by the PE-HMI1. The PoE switcher is turned off when the [direct 5-V input supply](#) is provided. This is similar in behavior to a VoIP phone where the supply of the wall adapter power overrides the PoE input.

The detailed operation of this circuit is beyond the scope of this TRM; consult page 7 of the schematics for the full details of the design and the [TPS23753A documentation](#) as well as the various TPS23753A Evaluation Modules.

Designer's Notebook

We wanted to explore the usage model, for example, of a conference room scheduling device on the wall where 110/220VAC was expensive to pull and awkward to mount. In an office building a new AC circuit install can cost well over \$1000! And then you have an ugly wall blob and barrel jack to your device. With the proliferation of PoE powered VoIP desk phones, PoE switches reducing per-port costs down below \$50, as well as Ethernet line a fraction of the installation cost compared to AC power, the PoE circuit was a great addition to the product example.

We originally researched off-the-shelf PoE modules that were fully isolated, certified and cost effective. There are many such modules from Asian suppliers, but domestic sources were difficult to find and those that existed were very expensive. A carefully sourced supply chain from Asia may be your best avenue if you want a certified implementation.

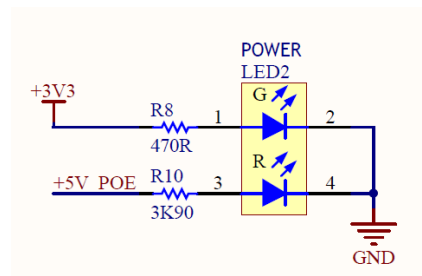
We found this to be a very challenging circuit! It took 4 revisions to get the layout and individual component selections correct, including the opto-isolator required for the enable in order to shut the supply down in the presence of the direct 5-V input. BOM selection was equally challenging to match the flyback transformer to the on-board magnetics for the signaling lines. The TPS23753A design guidelines and evaluation kits were useful but used BOM components we felt were either too expensive or inadequately specified. We purposely increased the voltage capabilities of several capacitors and components to 100V as we discovered, in various discussions with FAEs and in research, PoE can sometimes glitch up to 80V and exceed the often-specified 63V limit on capacitors. We chose to use the highest reliability electrolytic capacitors without going to extremes and cost-prohibitive parts, however it is possible with careful design and validation and in consultation with the manufacturer some or all of the non-input electrolytics could be replaced by ceramics.

5.3 Power LED

LED2 on the PE-HMI1 indicates the currently used source of power on the system. LED2 has two LEDs in one package (red, green) so three colors can be visible: red, green, and orange (when both are lit).

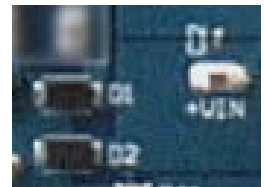
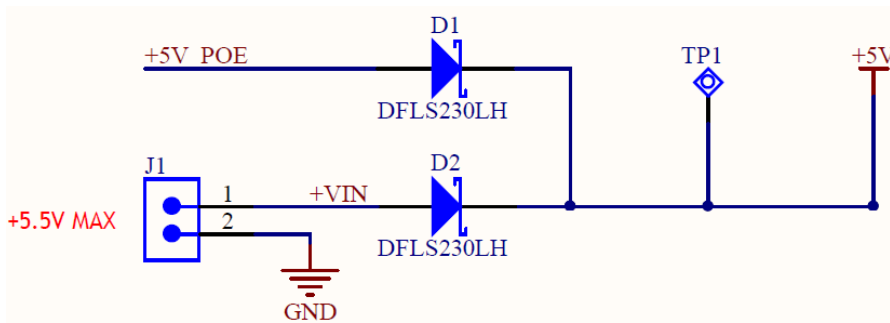
When the green portion of LED2 is lit, the system is currently under power.
When the red portion of LED2 is lit, the PoE supply is currently active.

Therefore LED2 orange indicates PoE power is being used, and LED2 green indicates 5-V Direct Input power is active.



5.4 +5-V Main Voltage Rail

Low-drop [Schottky diodes](#) merge the two power inputs (direct 5-V input and PoE 5 V) such that whichever is available and higher is delivered downstream as the power rail +5V to various switching power supplies for MCU/logic/memory, LCD backlight boost and USB Host power.



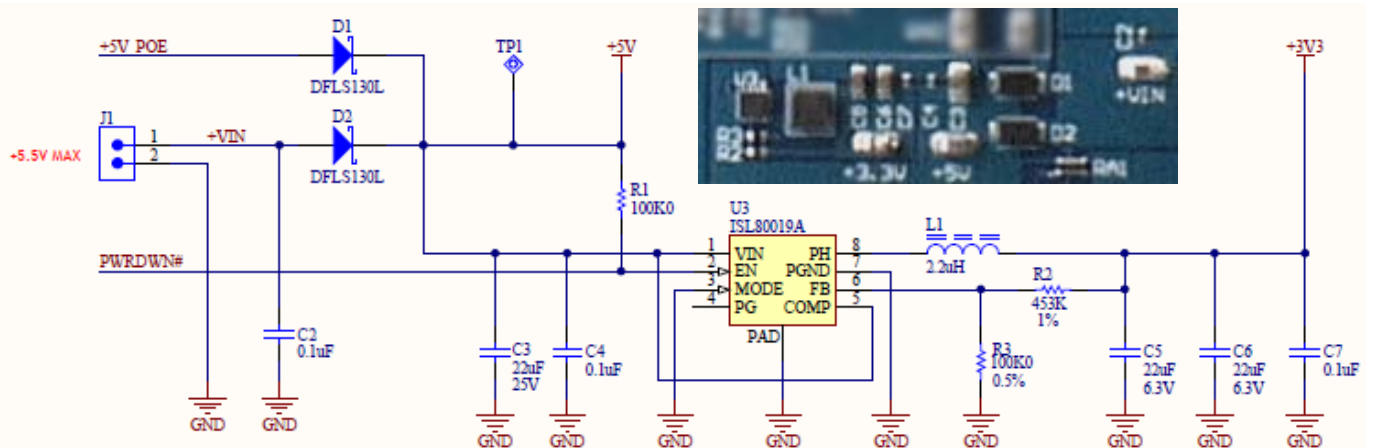
Designer's Notebook

This circuit ensures that power from one input does not flow backwards into the other power input's circuitry which, if connected but off, would often damage that power supply. In the transitional period where potentially both circuits are on, it ensures only the higher of the two is delivered downstream and prevents the two supplies from clashing.

The [DFLS230LH](#) diode is popular for this application as it has a very low forward voltage and with a 30V V_{br} it can also be used in the LCD backlight circuit. You can cost optimize this with a cheaper one at the expense of some heat dissipated in the diode due to extra losses – there is a lot of margin between the 5-V input and the required V_{min} for the regulator. Obviously, if your design eliminates one of the two power input circuits, you do not need these diodes to steer/select the input source. We initially calculated 1A capacity on these diodes based on 1.5A output of the switcher at 90% efficiency: $1.5\text{ A}/0.90 \times 3.3\text{ V}/5.5\text{ V} = 1\text{ A}$, however the LCD backlight, audio, and USB host supplies are parallel to the 3.3V switcher, so the total for the whole board is nearer to 2A. See the [power budget](#) discussion below.

5.5 3.3-V Main Power Subsystem

Almost all the circuits on the board require 3.3 volts, including MCU, memory, and logic. The dual low-drop 1A merge the two power inputs (direct 5-V input and PoE 5 V) such that whichever is available and higher is delivered to the [ISL80019A buck switcher](#). This switcher, using a tiny inductor, creates 3.3V at up to 1.5A for the PE-HMI1. The PWRDWN# signal is marked here explicitly, but is not used elsewhere on this platform: the 100-k Ω R1 ensures the supply is always enabled.



Designer's Notebook

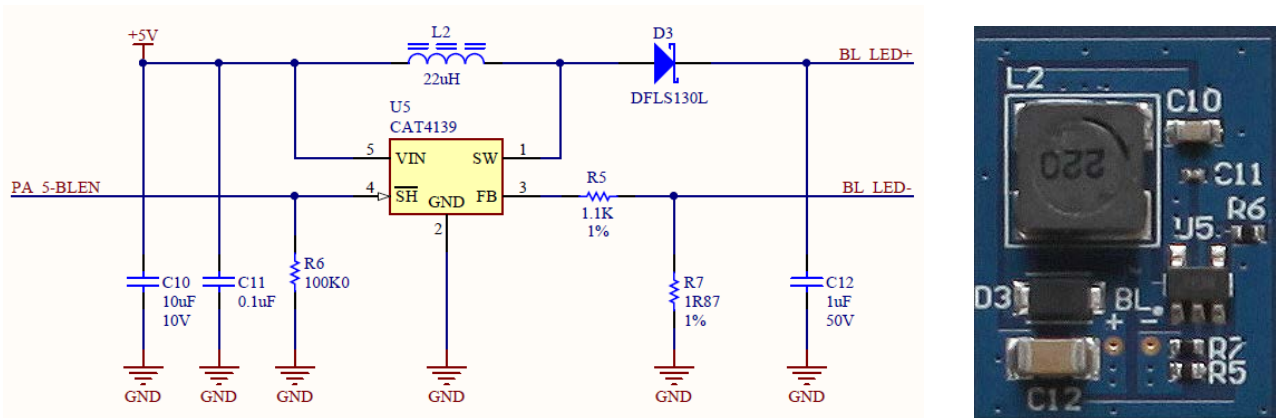
The two precision feedback resistors at R2/R3 set the output voltage to 3.3V, as at the time of the design there was no fixed-output version of this switcher. While there are many such switchers from many vendors (and we looked at many!) we use this one for its package (2 mm x 2 mm DFN!), excellent efficiency (up to 95%), and very competitive pricing. At typical-worst-case 90% efficiency and VIN (5.5 V), the power lost in the switcher is approximately $(5.5-3.3) = 2.2 \text{ V} \times 1.5 \text{ A} \times 10\% = 0.33 \text{ W}$. $71\text{C}/\text{W T}_{\text{ja}} = 23$ degrees rise, a very acceptable temperature.

The 22μF output capacitors are small 0603 ceramic caps, saving significant space and improving long term reliability over electrolytic options. Pay special notice to the 6.3V rating on the output caps: when using ceramics as buck switcher outputs you want to provide ample voltage headroom to avoid DC bias issues which can reduce the effective capacitance significantly. Most buck switcher data sheets talk about this phenomenon extensively. The switching inductor, a [Bourns SRN3015-2R2M](#), is a great compromise between small size (2 mm square), efficiency (72mΩ DCR), and price. It is also fully shielded, a consideration for a 2MHz high frequency switcher design to manage EMI emissions. If your board has more space or is less cost restrictive, you may look at a physically bigger inductor or higher technology inductor to reduce DCR, further improve efficiency, and thereby reduce unwanted heat dissipation due to switcher losses.

5.6 LCD Backlight Power Subsystem

The LCD on the PE-HMI1 is backlit by an array of LEDs. This array requires a constant current supply of 160 mA at approximately 9.6VDC, or approximately 1.5W. The ability to pulse width modulate (PWM) this supply is important to enable well-controlled backlight dimming, and the ability to turn off the backlight is important for power management. Factoring in the boost conversion efficiency approximately 1.75W of power from the input +5-V supply. Unlike other power systems where typical is normally much less than maximum, this is a typical number as the LEDs are actually run at this power.

The +5V main power signal feeds a constant current boost controller delivering this 160mA to the LCD backlight.



A PWM-capable MCU port bit is connected to this controller's **SH#** (shutdown) pin:

| MCU | | | Schematic Net Name | Operation |
|------|------------------|-------|--------------------|---|
| Port | Mode | PSEL | | |
| PA05 | GTIO0C11A_B: I/O | 00011 | PA_5-BLEN | LCD Backlight Enable (active high, weakly off @ RESET#) |

Designer's Notebook

The [CAT4139](#) is a very efficient constant current backlight boost supply. The two precision feedback resistors at **R5/R7** set the output current, in this case to 160mA. We used the [22µH Bourns SRR5028-220Y](#) to balance physical size, cost, and efficiency in a shielded package; you can improve efficiency with a lower DCR than the 120mΩ of this specific part at the expense of a larger package and/or higher cost. We measure typical efficiencies of this circuit of approximately 88%, so the 5-V input power required for this circuit is about $1.5W/0.88 = 1.70W$ out of the total 5W power budget.

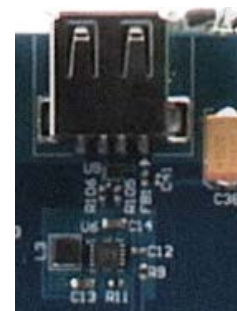
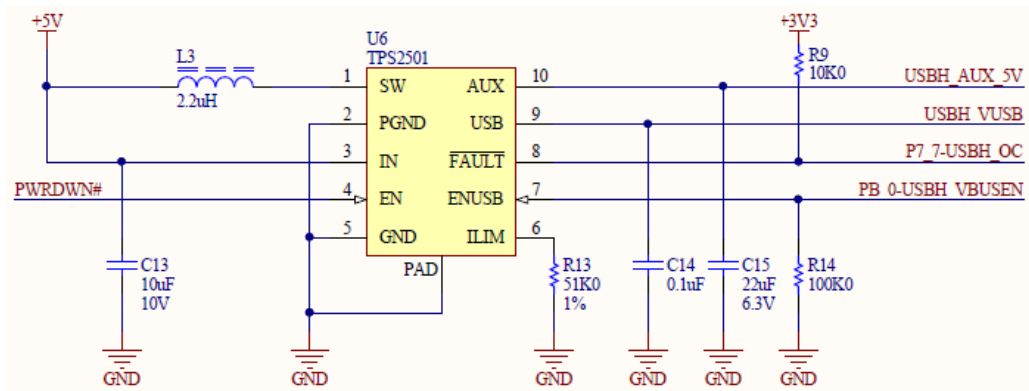
R6 ensures that on **RESET#** and until the MCU explicitly turns it on, the supply is powered off to minimize startup power requirements. Software can choose to “soft on” the power by carefully increasing the PWM percentage over a (for example) 1 second period.

The LCD display used in the PE-HMI1 has very high performance and efficiency LEDs for a 7” display: most displays of this size require 2W or even 3W of power for the backlight at this brightness so pay special attention to the backlight power needs of your chosen display.

Note that in the even the LCD display is disconnected (for example, during initial board testing prior to LCD attach) the CAT4139 clips the open-loop voltage to 28V. This is why the diode in the circuit is rated at 30V V_{br} and the output 1µF capacitor is rated above 30V, even though the typical LCD backlight voltage is 9.6V for this display.

5.7 USB Host Power Subsystem

While the USB Host Type-A connector could have been driven directly from **+5V** (or at least via a high-side FET power switch for enable control), the design incorporates a current limited design to ensure that an inappropriate high-load device does not crash the board or overstress the main power system.



R13 sets the current limit: in this design 51.0kΩ indicates a limit of ~500mA. At currents above this limit, the voltage on the output to the connector drops precipitously to limit the current to this maximum. The **FAULT#** open drain output from the chip indicates when the chip is in current-limiting mode and can be used by software to detect this fault condition.

The chip has two enables (**EN**, **ENUSB**) that enable the buck/boost supply to operate and enable the USB output respectively. As mentioned above, the **PWRDWN#** signal is inactive and unused on this design, so the chip is always enabled when the board has power; the buck/boost supply takes minimal power when the USB output is off. The USB output voltage is enabled by the active-high **PB_0- USBH_VBUSEN** signal with a weak **R14** pull-down to ensure on initial power-up the USB host circuit is off and does not cause a power-up stress on the system. The alternate backup 5.1V from **AUX** is not used on this design.

| MCU | | | Schematic Net Name | Operation |
|------|---------------|-------|--------------------|--|
| Port | Mode | PSEL | | |
| P707 | USBHS_OVRCURA | 10100 | P7_7- USBH_OC | USB Host Over Current fault (active low) |
| PB00 | USBHS_VBUSEN | 10100 | PB_0- USBH_VBUSEN | USB Host Power Enable (active high, reset condition low) |
| - | - | | PWRDWN# | Not connected on this design (weakly pulled inactive) |
| - | - | | USBH_AUX_5V | Aux 5.1V output unused on this design |
| - | - | | USBH_VUSB | Power managed 5-V output to USB A host connector |

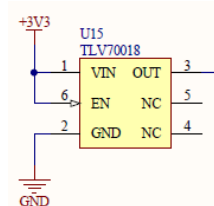
Designer's Notebook

The TPS2501 may be a bit overkill for this circuit, but is used in many of our other designs as it is a buck/boost switcher as well as a current manager, so on many of our boards the input power can dip as low as 3.6V and the USB Host can still be powered at the correct 5-V output. It is also a little difficult to find current-limiting USB power switches that work in the sub-1A space (most are designed for USB chargers and designed for 1A+).

The current limit description in the TPS2501 data sheet is quite tricky to follow – there are several modes the chip can use. In this case, the current limit set by the 51.0kΩ resistor limits the USB Host Type-A connector to supply a maximum of ~500mA. Therefore the typical maximum power from the +5-V main rail for the USB Host Power is 2.5W (assuming a 5-V input requiring little buck/boost conversion).

5.8 Bluetooth Module Power

The on-board Bluetooth module is a 1.8V device. Since the power on this circuit is minimal, a simple and inexpensive LDO accomplishes the task, in conjunction with level translators to bridge the 1.8V I/O domain of the module with the 3.3V MCU domain. Note this LDO is powered by the +3V3 rail to minimize power dissipation in the LDO (vs. using the 5-V rail).



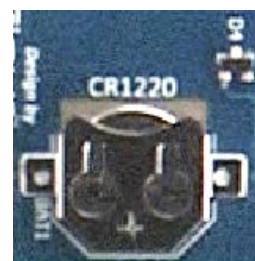
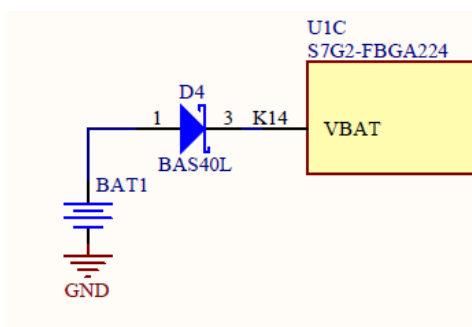
Designer's Notebook

There are many Bluetooth modules we could have chose – see the Bluetooth section of this manual for more information. In this case, the strengths of the selected module outweighed the cost and complexity of adding a separate 1.8V power domain. If your design does not need the capabilities of this module, and can (for example) do a simple BLE module or even no Bluetooth at all, this whole power domain can be eliminated.

5.9 Real Time Clock (RTC) Battery Backup Power

The Renesas S7G2 MCU has a built-in Realtime Clock (RTC) with calendar function. In order to maintain time and date integrity when the system power is removed, the S7G2 has the ability to auto-manage the power switchover to a battery backup system.

The PE-HMI1 includes a CR1220 battery Lithium coin cell for this purpose, connected through a diode to prevent reverse current flow into the cell.



When replacing the battery, ensure correct orientation: the flat side (+) should be up and away from the PCB surface, and the rounded side (-) should be contacting the PCB surface.

5.10 Power Budgets

The following table summarizes the power budgets associated with each subsystem, including the typical efficiency losses through each corresponding power conversion subsystem:

| Subsystem | Power Requirements (W) | | Power Supply | Typical Efficiency | 5-V Input Power (W) | |
|--------------|------------------------|-------|-----------------------|--------------------|---------------------|-------|
| | Typ | Max | | | Typ | Max |
| USB Host | 0.500 | 2.500 | TPS2501 | 100% | 0.500 | 2.500 |
| LCD BL | 1.530 | 1.530 | CAT4139 | 88% | 1.750 | 1.750 |
| LCD Logic | 0.280 | 0.396 | ISL80019A | 92% | 0.304 | 0.430 |
| Audio | TBD | TBD | - | 100% | TBD | TBD |
| MCU & Memory | TBD | TBD | ISL80019A | 92% | TBD | TBD |
| Ethernet | TBD | TBD | ISL80019A | 92% | TBD | TBD |
| CAN | TBD | TBD | ISL80019A | 92% | TBD | TBD |
| RS232/485 | TBD | TBD | ISL80019A | 92% | TBD | TBD |
| WiFi | TBD | TBD | ISL80019A | 92% | TBD | TBD |
| Bluetooth | TBD | TBD | TLV70018 ISL80019A | *92% | TBD | TBD |

Take care to ensure the total power used, including any Pmods, is under the maximum 10W capability of the power subsystem.

6. Graphics Capacitive Touch LCD

One of the most important features of the PE-HMI1 is the high resolution LCD graphic color display with the following characteristics:

- 800x480 pixel resolution
- Multi-viewing angle (MVA) technology for excellent visibility at nearly any viewing angle in portrait or landscape mode
- Integrated capacitive touch controller with I2C interface
- Full 24-bit color RGB interface

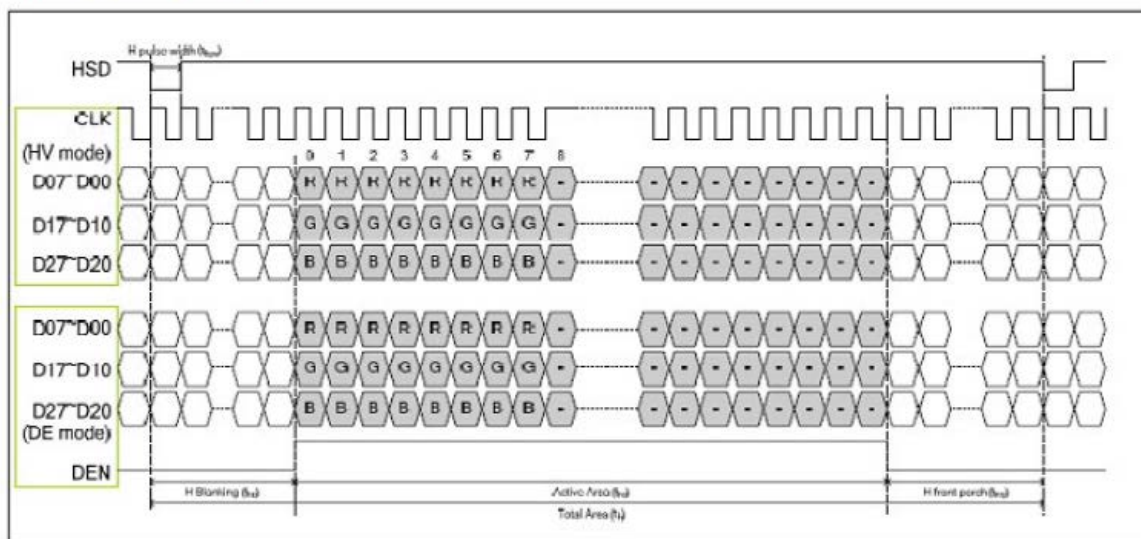
6.1 LCD Interface

Typical of displays with resolution at and below 800x480 (WVGA), the PE-HMI1 LCD uses a parallel RGB (red green blue) interface rather than a higher performance but more expensive LVDS interconnect. While most commercial displays and systems use 16-bit color (RGB565), this color range is inadequate for modern user interfaces that make heavy use of color gradients. The superior color capability of full 24-bit color (RGB888) enables smooth shading on gradients as compared to the “jagged” color stepping common on gradients in a 16-bit color environment.

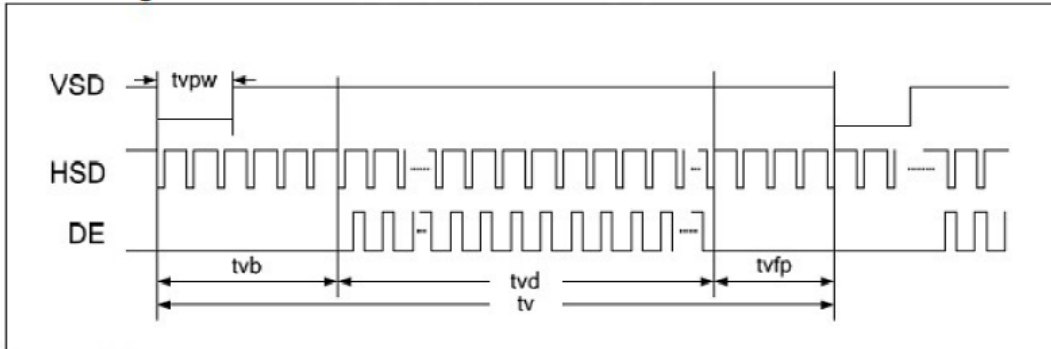
However, the LCD and the S7G2 MCU graphics controller can both be operated in 16-bit or 24-bit color mode as enabled in software. For graphics speed and memory efficiency, a dual 16-bit frame buffer only requires 1,536,000 bytes of RAM, whereas a dual 32-bit frame buffer (you must use 32-bit words in order to support 24-bit color) requires double that at 3,072,000 bytes.

The LCD has the following timing requirements:

Horizontal timing



Vertical timing



Horizontal timing

| Parameter | Symbol | Spec. | | | Unit |
|--------------------------|--------|-------|------|------|------|
| | | Min. | typ. | Max. | |
| Horizontal Display Area | thd | 800 | | | DCLK |
| DCLK frequency | fclk | - | 30 | 50 | MHz |
| One Horizontal Line | th | 862 | 1056 | 1200 | DCLK |
| HS pulse width | thpw | 1 | - | 40 | DCLK |
| HS Back Porch (Blanking) | thb | 46 | | | DCLK |
| HS Front Porch | thfp | 16 | 210 | 354 | DCLK |
| DE mode Blanking | th-thd | 85 | 256 | 400 | DCLK |

Vertical timing

| Parameter | Symbol | Spec. | | | Unit |
|--------------------------|--------|-------|------|------|----------------|
| | | Min. | typ. | Max. | |
| Vertical Display Area | tvd | 480 | | | T _H |
| VS period time | tv | 513 | 525 | 650 | T _H |
| VS pulse width | tvpw | 3 | - | 20 | T _H |
| VS Back Porch (Blanking) | tvb | 23 | | | T _H |
| VS Front Porch | tvfp | 7 | 22 | 147 | T _H |
| DE mode Blanking | tv-tvd | 30 | 45 | 170 | T _H |

RGB data is connected to the MCU as follows:

| MCU | | | Schematic Net Name | Operation |
|------|--------------|-------|--------------------|--------------|
| Port | Mode | PSEL | | |
| P513 | LCD_DATA16_B | TBD | P5_13-LCD_D16 | LCD R0 (LSB) |
| P805 | LCD_DATA17_B | 11001 | P8_5-LCD_D17 | LCD R1 |
| PA11 | LCD_DATA18_B | 11001 | PA_11-LCD_D18 | LCD R2 |
| P914 | LCD_DATA19_B | 11001 | P9_14-LCD_D19 | LCD R3 |
| P915 | LCD_DATA20_B | 11001 | P9_15-LCD_D20 | LCD R4 |
| P909 | LCD_DATA21_B | 11001 | P9_9-LCD_D21 | LCD R5 |
| P910 | LCD_DATA22_B | 11001 | P9_10-LCD_D22 | LCD R5 |
| P902 | LCD_DATA23_B | 11001 | P9_2-LCD_D23 | LCD R6 (MSB) |
| PA09 | LCD_DATA8_B | 11001 | PA_9-LCD_D8 | LCD G0 (LSB) |
| PA08 | LCD_DATA9_B | 11001 | PA_8-LCD_D9 | LCD G1 |
| P615 | LCD_DATA10_B | 11001 | P6_15-LCD_D10 | LCD G2 |
| P905 | LCD_DATA11_B | 11001 | P9_5-LCD_D11 | LCD G3 |
| P906 | LCD_DATA12_B | 11001 | P9_6-LCD_D12 | LCD G4 |
| P907 | LCD_DATA13_B | 11001 | P9_7-LCD_D13 | LCD G5 |
| P908 | LCD_DATA14_B | 11001 | P9_8-LCD_D14 | LCD G6 |
| P901 | LCD_DATA15_B | 11001 | P9_1-LCD_D15 | LCD G7 (MSB) |
| P804 | LCD_DATA0_B | 11001 | P8_4-LCD_D0 | LCD B0 (LSB) |
| P803 | LCD_DATA1_B | 11001 | P8_3-LCD_D1 | LCD B1 |
| P802 | LCD_DATA2_B | 11001 | P8_2-LCD_D2 | LCD B2 |
| P606 | LCD_DATA3_B | 11001 | P6_6-LCD_D3 | LCD B3 |
| P607 | LCD_DATA4_B | 11001 | P6_7-LCD_D4 | LCD B4 |
| PA00 | LCD_DATA5_B | 11001 | PA_0-LCD_D5 | LCD B5 |
| PA01 | LCD_DATA6_B | 11001 | PA_1-LCD_D6 | LCD B6 |
| PA10 | LCD_DATA7_B | 11001 | PA_10-LCD_D7 | LCD B7 (MSB) |

The LCD control and backlight signals are wired as follows to the MCU:

| MCU | | | Schematic | Operation |
|------|-------------|-------|-----------------|---|
| Port | Mode | PSEL | Net Name | |
| P900 | LCD_CLK_B | 11001 | P9_0-LCD_CLK | LCD Pixel dot clock |
| P313 | LCD_TCON2_B | 11001 | P3_13-LCD_DE | LCD Data Enable (active high) |
| P315 | LCD_TCON0_B | 11001 | P3_15-LCD_HSYNC | LCD Horizontal Sync |
| P314 | LCD_TCON1_B | 11001 | P3_14-LCD_VSYNC | LCD Vertical Sync |
| PA03 | GPIO | - | PA_3-LCD_ON | LCD Logic Enable (active high, weakly inactive on RESET#) |
| - | - | - | BL_LED- | LCD Backlight LED String Cathode |
| - | - | - | BL_LED+ | LCD Backlight LED String Anode |

6.2 Capacitive Touch Controller

The LCD on the PE-HMI1 includes a capacitive touch sensor system and built-in [FocalTech Systems](#) FT5302 controller in a 20 transmit by 12 receive-line sensor configuration. The controller has the following features:

- 400-kHz I2C interface with activity interrupt out
- 5 finger simultaneous multi-touch detection
- Palm detection for lock function, and
- <100 idle-to-active touch response time

The FT5302 controller operates on the MCU's I2C bus as follows:

| Address | | | I2C Bus | Max kHz | Location | Device |
|---------|------|-------|---------|---------|----------|-----------------------------------|
| 7-bit | Read | Write | | | | |
| 0x38 | 0xF1 | 0xF0 | 1 | 400 | LCD | FocalTech FT5302 Touch Controller |

The [I2C Device Summary](#) lists all the I2C devices on the PE-HMI1.

The controller is connected as follows:

| MCU | | | Schematic Net Name | Operation |
|------|----------|-------|---------------------------|---|
| Port | Mode | PSEL | | |
| PA02 | GPIO | - | PA_2- TOUCH_RST# | Touch Controller Reset (active low) |
| P205 | SCL1_A | 00111 | P2_5/SCL1 | Touch Controller I2C Bus Clock |
| P206 | SDA1_A | 00111 | P2_6/SDA1 | Touch Controller I2C Bus Data |
| P008 | IRQ12-DS | ISEL | PO_8/IRQ12-DS- TOUCH_IRQ# | Touch Controller Activity Interrupt (open drain active low) |

The signal **PA_2- TOUCH_RST#** signal is asserted on/after **RESET#** via a weak pull-down and the **PA02** GPIO must be configured and deasserted in software in order to release the touch controller from its reset condition.

Similar to nearly all touch controllers, the FocalTech FT5302 instruction set and data sheet are available only under non-disclosure agreement from [FocalTech Systems](#).

7. MCU Subsystem (MCU, Memory, Clocking, Reset)

The heart of the PE-HMI1 design is the MCU subsystem, comprised of:

- Synergy S7G2 240-MHz Cortex-M4 MCU by Renesas
- 32-MByte 100-MHz SDRAM
- 2-GByte embedded MultiMedia Card (e•MMC)
- 32.768-kHz RTCC crystal and 24-MHz MCU clock
- System reset

7.1 Synergy S7G2 MCU by Renesas

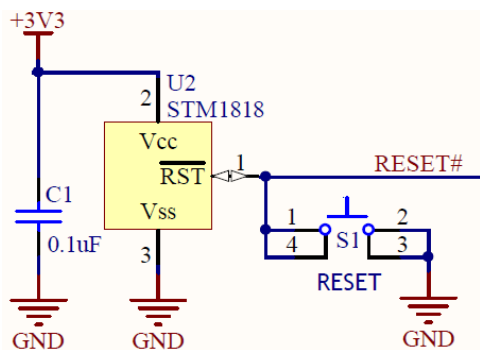
The Synergy MCU family has several members; the PE-HMI1 uses the S7G2 MCU with the following key features:

- 240-MHz ARM Cortex™-M4 processor with FPU
- 120-MHz 4MB program FLASH
- 640-kB on-chip SRAM
- 64-kB data flash (100,000 E/W cycles)
- LCD Controller with 800x600x24-bit capability and BitBLT/JPEG acceleration
- 120MHz x16 SDRAM controller
- 224 pin 13x13 mm 0.8 mm pitch BGA

The MCU is fully described in the Synergy S7G2 Group User’s Manual: Hardware; see [Additional Information](#) for links to obtaining Synergy and other design documentation.

7.2 System Reset

The PE-HMI1 includes a small system reset chip, designed to not only reset the MCU but all on-board peripherals. On power-up, the system reset is asserted low for approximately 100-250mS and then is released to rise high with a simple pull-up resistor. Pushbutton S1 on the baseboard is connected directly to this **RESET#** signal – the reset chip automatically senses the pushbutton and, when pressed (**RESET#** grounded) debounces the switch and initiates a reset cycle as if power were being applied for the first time.



The **RESET#** signal is connected to the MCU as follows:

| MCU | | | Schematic | Operation |
|-------------|-------------|------|---------------|---|
| Port | Mode | PSEL | Net Name | |
| RES# | RES# | | RESET# | System Reset (open drain, active low, weakly pulled high) |

7.3 MCU Boot Mode

The S7G2 MCU boot mode is selectable by the levels present on the **MD** pin on the MCU when **RES#** is de-asserted. The PE-HMI1 DIP Switch (S3 position 6) which controls the MD pin and MCU boot mode:

| MD | S3.6 Position | Description |
|----|---------------|---------------------------|
| 0 | On | Boot into USB boot loader |
| 1 | Off | Boot from MCU FLASH |

Normally, the PE-HMI1 should be operated with S3.6 in the “off” position to boot normally from the MCU’s FLASH. The operation of the built-in USB boot loader is beyond the scope of this document; see [Additional Information](#).

7.4 SDRAM

The Synergy S7G2 MCU has a full on-chip SDRAM controller capable of operating external x16 SDRAM at up to 120MHz.

The PE-HMI1 RZ Module has this SDRAM connection (address, data, control) isolated on the module connected to one Micron 32-MByte SDRAM device capable of operation to 100 MHz.

The SDRAM address/data bus is connected to the MCU as follows:

| MCU | | | Schematic Net Name | Operation |
|------|------|-------|--------------------|---------------|
| Port | Mode | PSEL | | |
| P310 | A15 | 01011 | P3_10/A15 | MCU A15 |
| P309 | A14 | 01011 | P3_9/A14 | MCU A14 |
| P308 | A13 | 01011 | P3_8/A13 | MCU A13 |
| P307 | A12 | 11011 | P3_7/A12 | MCU A12 |
| P306 | A11 | 11011 | P3_6/A11 | MCU A11 |
| P305 | A10 | 11011 | P3_5/A10 | MCU A10 |
| P304 | A9 | 11011 | P3_4/A9 | MCU A9 |
| P303 | A8 | 11011 | P3_3/A8 | MCU A8 |
| P302 | A7 | 11011 | P3_2/A7 | MCU A7 |
| P301 | A6 | 11011 | P3_1/A6 | MCU A6 |
| P111 | A5 | 01011 | P1_11/A5 | MCU A5 |
| P112 | A4 | 01011 | P1_12/A4 | MCU A4 |
| P113 | A3 | 01011 | P1_13/A3 | MCU A3 |
| P114 | A2 | 01011 | P1_14/A2 | MCU A2 |
| P115 | A1 | 01011 | P1_15/A1 | MCU A1 |
| P801 | DQ15 | 01011 | P8_1/DQ15 | MCU D15 (msb) |
| P800 | DQ14 | 01011 | P8_0/DQ14 | MCU D14 |
| P603 | DQ13 | 01011 | P6_3/DQ13 | MCU D13 |
| P604 | DQ12 | 01011 | P6_4/DQ12 | MCU D12 |
| P605 | DQ11 | 01011 | P6_5/DQ11 | MCU D11 |
| P614 | DQ10 | 01011 | P6_14/DQ10 | MCU D10 |
| P613 | DQ9 | 01011 | P6_13/DQ9 | MCU D9 |
| P612 | DQ8 | 01011 | P6_12/DQ8 | MCU D8 |
| P107 | DQ7 | 11011 | P1_7/DQ7 | MCU D7 |
| P106 | DQ6 | 11011 | P1_6/DQ6 | MCU D6 |
| P105 | DQ5 | 11011 | P1_5/DQ5 | MCU D5 |
| P104 | DQ4 | 11011 | P1_4/DQ4 | MCU D4 |
| P103 | DQ3 | 11011 | P1_3/DQ3 | MCU D3 |
| P102 | DQ2 | 11011 | P1_2/DQ2 | MCU D2 |
| P101 | DQ1 | 11011 | P1_1/DQ1 | MCU D1 |
| P100 | DQ0 | 11011 | P1_0/DQ0 | MCU D0 (lsb) |

The SDRAM control bus is connected to the MCU as follows:

| MCU | | | Schematic Net Name | Operation |
|------|-------|-------|--------------------|--|
| Port | Mode | PSEL | | |
| P611 | SDCS | 01011 | P6_11/SDCS# | SDRAM Chip Select (active low) |
| P311 | RAS | 11011 | P3_11/RAS# | SDRAM Row Address Strobe (active low) |
| P312 | CAS | 11011 | P3_12/CAS# | SDRAM Column Address Strobe (active low) |
| P610 | WE | TBD | P6_10/WE# | SDRAM write enable (active low) |
| P608 | DQMI | TBD | P6_8/DQMI | SDRAM I/O data mask enable for D15 to D8 |
| P601 | DQMD | TBD | P6_1/DQMD | SDRAM I/O data mask enable for D7 to D0 |
| P609 | CKE | TBD | P6_9/CKE | SDRAM Clock Enable |
| P602 | SDCLK | 11011 | P6_2/SDCLK | SDRAM Clock |

Designer's Notebook

This was a much-debated tradeoff in the whole team. On one hand, we really wanted to use the high speed SDRAM to enable the 120MHz operation. The Synergy DK-S7G2 Development Kit design did exactly that to demonstrate the maximum performance of the solution. On the other hand, as a product example, we wanted to demonstrate products we have strong confidence will have long term availability based Micron's. Micron's "PLP" list indicates which of their products are targeted for long-term availability, and the 120MHz-capable parts in full -40 to +85C and BGA package were not on that list. In addition, going with a slower part would enable far more sourcing solutions since the faster parts would drop in as alternates. We chose to make the decision we'd make for high-volume products: to favor long term supply stability over that extra 20% of performance on the external memory. Your company's relationship with memory suppliers such as Micron, ISSI, Samsung and others may uncover a different result, or your design lifetime may not be as long as the typical industrial HMI target of 15 years, and you may be able to design your own device taking advantage of the full 120MHz capability of the S7G2 memory controller.

Note at the slightly slower speed and the tight layout, it was unnecessary to use series "dampening" resistors in our design, but a higher speed design or using the larger TSSOP packages (i.e. longer and less balanced traces) may require an increased focus on managing signal integrity. Our experience with the higher speed SDRAM chips is they have very strong output drivers to achieve these speeds, and these output drivers can easily cause ground-bounce/over/undershoot issues and even latch-up conditions on connected chips if not properly designed and the PCB layout is inadequate.

7.5 Embedded MultiMediaCard (e•MMC)

The PE-HMI1 includes a large on-board FLASH storage device, the 2 Gigabyte Micron embedded MultiMediaCard, ("e•MMC").

The e•MMC device conforms to the [JEDEC MMC Specification](#) (v4.41 or later), and provides large and reliable storage for files and objects, as well as have two linear and reliable areas for direct booting. FLASH-less MCUs, such as the Renesas RZ A1/H MCU can boot directly from an e•MMC 's boot area with an on-MCU boot loader that copies the FLASH boot code to RAM and executes it. The Synergy S7G2 MCU has on chip FLASH which supports the boot operation, and the PE-HMI1 e•MMC device cannot be booted from, but rather is a cost effective storage mechanism for large user interfaces, fonts, images, web pages, machine logging data, and more.

The e•MMC can only communicate with a CPU via a dedicate interface similar to the one used to drive SD Cards. In fact, an e•MMC device is nearly identical to an SD Card, just in chip vs. plug-in card packaging. The on-chip controller in the e•MMC takes care of all wear levelling, bad block management, and more, greatly simplifying software interactions as compared to a raw NAND flash.

The eMMC is connected to the S7G2 MCU on channel 1 of the SDIO/MMC controller as follows:

| MCU | | | Schematic Net Name | Operation |
|----------|-------------|-----------|--------------------|--|
| Port | Mode | PSEL | | |
| P50 6 | SD1CD | 1010 1 | P5_6/SD1CD | eMMC Card Detect input |
| P50 7 | SD1WP | 1010 1 | P5_7/SD1WP | eMMC Write Protection input |
| P90 3 | GPIO | - | P9_3-MMC_RST# | eMMC reset GPIO (active low) |
| P50 1 | MMC_CM D | 1010 1 | P5_1-MMC_CMD | eMMC command output, response input signal |
| P50 0 | MMC_CL K | 1010 1 | P5_0-MMC_CLK | eMMC Clock (MCU→MMC) |
| P50 2 | MMC_D0 | 1010 1 | P5_2-MMC_D0 | eMMC D0 (lsb) |
| P50 3 | MMC_D1 | 1010 1 | P5_3-MMC_D1 | eMMC D1 |
| P50 4 | MMC_D2 | 1010 1 | P5_4-MMC_D2 | eMMC D2 |
| P50 5 | MMC_D3 | 1010 1 | P5_5-MMC_D3 | eMMC D3 (msb) |

The **P9_3-MMC_RST#** signal holds the eMMC in reset when asserted, and is weakly asserted by a pull-down on/after **RESET#** until MCU software configures the GPIO and actively de-asserts the signal.

Designer's Notebook

The choice of the eMMC was also hotly debated. We had two basic options: a large Quad SPI NOR serial flash, such as the Micron N25Q series, or the eMMC. It really could have gone either way, but in the end we chose the eMMC. Both eMMC and serial FLASH are supported on our design for the full-featured Synergy DK-S7G2 Development Kit and only the serial FLASH on the SK-S7G2 Starter Kit design.

Serial FLASH is supported on the S7G2 in full QSPI mode, with a maximum clock of 60 MHz, enabling high speed transfers at a very cost effective price in a small package with modest (0.8 mm) ball pitch or even DFN/SOP-style packaging for small densities (<16 megabytes). The Micron N25Q series in a single BGA can be as large as 128 *Megabytes!* On the other hand, the 0.7 *second* typical erase times of the large NOR serial flashes adds extra complexity to the software designer, forcing background erases, erase-suspend challenges (if the FLASH device needs to be accessed during a background erase), as well as (typically) integrating these sophisticated features into the file system stack.

Some systems use a fully linear GUI-asset format: images, fonts, etc., are all put in a fully linear manner in bulk storage for rapid access without file system overhead. The S7G2 MCU supports direct-addressing mode to serial FLASH, so the external assets would appear to software as if they were completely memory mapped – no SPI-port reads and writes would be required.

However, often modern high-performance HMI designs need to support very sophisticated customer GUIs with replaceable assets and many different user experience elements. A real file system, such as a FAT32 file system, is an absolute must in these designs for simple and reliable management of GUI ingredients. We also have sophisticated IoT connectivity and built-in upgradability, so it is common for customers to log data and do frequent updates to the

device, prompting long term concerns of wear leveling, background erase/writes while the GUI is operational, etc. While these file systems are often implemented on top of serial FLASH in smaller smaller-screen designs, with the PE-HMI1 we favor eMMC strongly for several reasons:

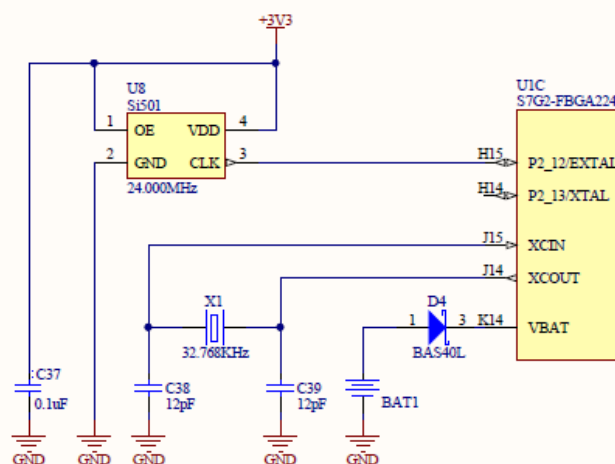
- Built-in background erase and wear levelling
- Scalable to 8 Gigabytes
- More cost effective at 2 Gigabytes than serial FLASH devices at 128Mbytes
- High performance
- Standardized in the industry by JEDEC with long life supply alternatives

Because the PE-HMI1 was so full featured, we were slightly pin constrained so there was no way to use a full 8-bit eMMC interface and had to compromise to a 4-bit interface. Even with this constraint, we felt the strengths of the eMMC-based system solution outweighed the serial QSPI solution.

If your GUI is fairly straightforward, you have limited GUI assets/data, update your GUI/data infrequently, and have a packaging/compiling mechanism for managing and updating these linearly packed assets, the serial FLASH is probably the best choice for your design. You can experiment with this using the DK-S7G2 Development Kit which includes a 4.3" WQVGA resistive touch LCD.

7.6 MCU Clock Sources

On the PE-HMI1 there are two local clocks used by the MCU. A simple 32.768 kHz tuning fork crystal is attached to the MCU to drive the on-chip Real Time Clock (RTC) with calendar function. An on-board lithium coin-cell battery provides backup capability for the RTC. The MCU, with a single 24MHz clock, can internally generate all the frequencies necessary for the LCD controller, core, and peripherals including USB.



Designer's Notebook

Until very recently, the MEMs oscillator business was vibrant and these devices were more configurable than their crystal counterparts and often far more competitively priced especially in smaller packages. In addition, stability and other operational parameters were becoming equivalent to better quality crystals. This is why we originally chose to use the Si501 in this circuit. However, with the recent (and untimely) exit of SiLabs from the MEMs business and the increasing uncertainty in the MEMs oscillator supply chain, future revisions of the PE-HMI1 will replace the Si501 with a traditional (albeit more expensive) 24MHz crystal +

8. Communications

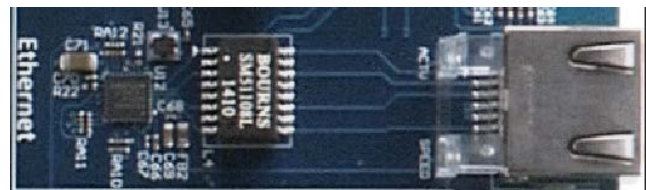
The PE-HMI1 includes extensive on-board communications peripherals, including:

- 10/100 Ethernet
- Bluetooth dual mode Classic and BLE
- WiFi
- CAN plus RS232/485, including differential and single ended, full and half duplex support
- High Speed USB 2.0 Host and Device ports
- 6-pin Digilent PMOD* port with Type 1 (GPIO), 2 (SPI), and 4 (UART) support
- 12-pin Digilent PMOD* port with Type 1 (GPIO), 2A (expanded SPI), and 4A (expanded UART) support

8.1 10/100 Ethernet

The S7G2 has an on-chip 10/100 Ethernet MAC with RMI interface. The PE-HMI1 brings these signals to a Micrel KSZ8091RNB RMI PHY through a magnetics-down design to a standard RJ45 10/100 CAT5 jack.

The RMI interface is connected to the SGS7 MCU as follows:



| MCU | | | Schematic Net Name | Operation |
|------|--------------|-------|-----------------------|---------------------------------|
| Port | Mode | PSEL | | |
| P706 | GPIO | - | P7_6-ETH_RESET# | Holds PHY in reset (active low) |
| P002 | IRQ8-DS | ISEL | P0_2/IRQ8-DS-ETH_IRQ# | PHY Interrupt (active low) |
| P404 | ET1_MDI0 | 10111 | P4_4/ET1_MDI0 | Management data I/O |
| P403 | ET1_MDC | 10111 | P4_3/ET1_MDC | Management data clock |
| P705 | RMI11_CRS_DV | 10111 | P7_5/RMI11_CRS_DV | Carrier detection |
| P704 | RMI11_RX_ER | 10111 | P7_4/RMI11_RX_ER | Receive error |
| P702 | RMI11_RXD0 | 10111 | P7_2/RMI11_RXD0 | Receive data 0 (LSB) |
| P703 | RMI11_RXD1 | 10111 | P7_3/RMI11_RXD1 | Receive data 1 |
| P701 | REF50CK1 | 10111 | P7_1/REF50CK1 | Transmit clock |
| P405 | RMI11_TXD_EN | 10111 | P4_5/RMI11_TXD_EN | Transmit enable |
| P700 | RMI11_TXD0 | 10111 | P7_0/RMI11_TXD0 | Transmit data 0 (LSB) |
| P406 | RMI11_TXD1 | 10111 | P4_6/RMI11_TXD1 | Transmit data 1 |

The **P7_6-ETH_RESET#** signal holds the Ethernet PHY in reset when asserted, and is weakly asserted by a pull-down on/after **RESET#** until MCU software configures the GPIO and actively de-asserts the signal.

Designer's Notebook

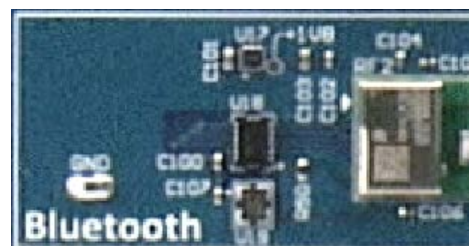
We debated using a simple magnetics-included jack, but opted to figure out a 100% SMD design. Finding a true SMD PoE-capable jack with LEDs was surprisingly problematic! Eventually we found this one from Amphenol that uses LEDs on the board and a light pipe. Unfortunately, the Bourns magnetics are about 1 mm too tall to rotate it 90° and nestle it up inside the “uprights” of the light pipes – we needed to leave room to insert the light pipes post-reflow which is why there is a PCB gap between the two elements.

8.2 Bluetooth Classic + BLE

Bluetooth connectivity is rapidly being adopted in a variety of HMI-related applications, whether for simple Beacon support or for more sophisticated usage models including field device updates.

The [Panasonic ENW-89823A3KF](#) fully-certified module includes the popular CC2560B controller, and supports both high data rate Classic as well as BLE operating modes.

The module is connected (through the level translation) to the MCU as follows:



| MCU | | | Schematic Net Name | Operation |
|------|-------|-------|--------------------|---------------------------------|
| Port | Mode | PSEL | | |
| PB01 | GPI0 | - | PB_1-BT_SHUDN# | Bluetooth Shutdown (active low) |
| P708 | RXD1 | 00101 | P7_8/RXD1 | Bluetooth UART RxD |
| P709 | TXD1 | 00101 | P7_9/TXD1 | Bluetooth UART TxD |
| P711 | CTS1# | 00101 | P7_11/CTS1 | Bluetooth UART CTS# |
| P712 | GPI0 | - | P7_12-RTS1 | Bluetooth UART RTS# |

Designer's Notebook

In another nod to the verging-on-dev-kit nature of the Product Example, we wanted to include both Bluetooth operating modes so that, depending on your specific application, you could experiment with the mode you needed. If you need Bluetooth you'll probably optimize this implementation down to the specific single-mode radio you actually need for your product.

8.3 WiFi 802.11 b/g/n

The PE-HMI1 includes a Longsys GT202 WiFi module, based on a [Qualcomm/Atheros QCA4002](#) device and has the following features:

- 802.11 b/g/n 2.4GHz support with integrated power amplifier
- Low power modes and fast wake-up times
- Integrated AllJoyn® software to ensure seamless connectivity and services
- Integrated IPv4/IPv6 networking and WPS, WPA, WPA2, WEP security with SSL Client with AES encryption
- Fully FCC and CE certified



The WiFi module is connected to the MCU as follows:

| MCU | | | Schematic Net Name | Operation |
|------|----------|-------|------------------------|---|
| Port | Mode | PSEL | | |
| P904 | GPI0 | - | P9_4-WIFI_PWD# | WiFi Shutdown (active low) |
| P001 | IRQ7-DS | ISEL | P0_1/IRQ7-DS-WIFI_IRQ# | WiFi Interrupt |
| P410 | MISOA_B | 00110 | P4_10/MISOA | WiFi RSPIA MISO |
| P411 | MOSIA_B | 00110 | P4_11/MOSIA | WiFi RSPIA MOSI |
| P412 | RSPCKA_B | 00110 | P4_12/RSPCKA | WiFi RSPIA Clock |
| P413 | GPI0 | - | P4_13/SSLA0 | WiFi RSPIA Slave Select (active low GPIO) |

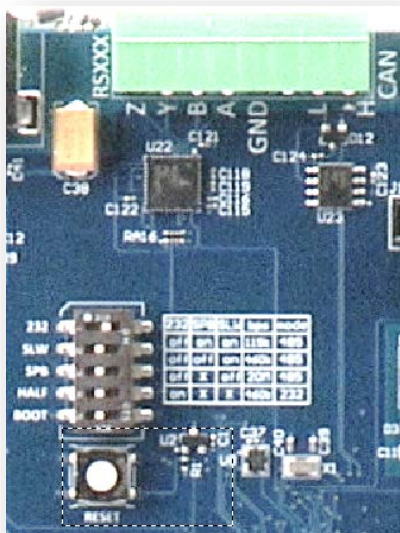
Designer's Notebook

The QCA4002 has some of the most available drivers in the ecosystem. In addition to the internal stacks, which can speed and minimize software development, the module also permits bypassing all the upper stack layers and doing these software tasks on the SGS7. In this model, you can have more complete control of connectivity to the network, including seamless roaming between wireless and WiFi.

If you have a different WiFi module you'd like to try with the PE-HMI1, you can use one of the [Pmod™ ports](#) to connect your module of choice.

For simplicity of certification and distribution as an example, we used the version of the module with integrated antenna. In reality, most designs will want to use a module with an external patch/whip antenna connected via micro-coax to an U.FL connector on the module in order to get the WiFi signal out of the OEM's product chassis.

8.4 Industrial Networking CAN & RS232/485



The large green 3.5-mm connector J10 delivers RS232, RS422, or RS485 as well as high performance CAN to external industrial networks. A screw terminal plug is supplied, enabling easy wiring of termination or daisy chained cabling. The connector's signals are clearly marked on the PCB as follows:

| Pin | Name | Description |
|-----|---------|-------------------------------|
| 1 | CANH | CAN Transmit/Receive H |
| 2 | CANL | CAN Transmit/Receive L |
| 3 | | Unconnected |
| 4 | GND | Ground |
| 6 | RSXXX_A | Receive inverting input |
| 7 | RSXXX_B | Receive non-inverting input |
| 8 | RSXXX_Y | Transmit inverting output |
| 9 | RSXXX_Z | Transmit non-inverting output |

There is no termination facility on the PE-HMI1; if cable termination is required insert a 75 ohm resistor across the appropriate signals at the screw-in connector.

Note that two additional UARTs and an additional CAN port are available on the [Pmod™ Port](#); only one of those UARTs is in a standard Digilent PMOD configuration however it is possible to create custom non-standard PMODs for that port and access these extra serial interfaces.

Designer's Notebook

Many industrial communication modules use this configuration and we wanted to support a wide variety of target industrial networking and in-chassis communications connectivity. Using this on the PE-HMI1 is definitely stretching the "Product Example" concept into more dev kit territory – your design will likely optimize this down to the specific connectivity you need and correspondingly reduce the BOM cost and footprint as well as reducing the need for the DIP switch configurability.

8.4.1 RS232, RS422, and RS485

The PE-HMI1 employs an [Intersil ISL41387IRZ-T](#) multi-protocol transceiver has the following key features:

- Selectable RS232 or RS485/RS422
- $\pm 15\text{kV}$ (HBM) ESD protected
- Single ended or differential
- Half or full duplex
- Large (2.7V) differential V_{OUT} for improved noise immunity in RS485/RS422 networks
- Full failsafe (open/short) RX in RS485/RS422 mode
- RS232 transmit rates up to 650kbps, receive rates to 2mbps
- RS485/RS422 data rates up to 20Mbps
- RS485/RS422 slew rate limit options for 460kbps and 115kbps

It is an excellent choice for many RS485 point-to-point and multi-drop networks and works particularly well in many industrial PLC configurations. The dual mode support enables, via the S4 DIP switch, RS232 instead of RS485 levels. Only one mode (RS232 or RS422/485) can be supported at any given time, and the mode is not software selectable – it is assumed that the installation process and environment determines which transmission standard is being connected.

The transceiver is connected to the MCU's UART as follows:

| MCU | | | Schematic Net Name | Operation |
|------|------|-------|--------------------|---|
| Port | Mode | PSEL | | |
| PB06 | GPI0 | - | PB_6-RS_DEN | RSxxx Transmit Drive Enable (active high) |
| P508 | GPI0 | - | P5_8-RS_ON | RSxxx Transceiver Enable (active high) |
| P509 | TXD5 | 00101 | P5_9/TXD5 | RSxxx Transmit Data |
| P510 | RXD5 | 00101 | P5_10/RXD5 | RSxxx Receive Data |

The DIP Switch S3 enables a variety of features on this port. The legend on the Baseboard PCB can help with these settings:



8.4.1.1 RS232 or RS422/RS485 Mode

DIP switch **S3. 1** controls which standard the transceiver conforms to; setting this switch ON puts the transceiver in RS232 level mode; the switch OFF puts the transceiver in RS422/RS485 mode.

8.4.1.2 Slew Rate and Speed Limiting (RS422/RS485 only)

In RS422/485 mode, DIP switch **S3. 2** and **S3. 3** control the slew rate and speed limits respectively. Set these switches as slow as possible but adequate for the target network rate according to the table.

8.4.1.3 RSXXX Half/Full Duplex Selection

The RSXXX port can operate in full duplex mode where data can be independently and simultaneously flowing *in* the receive and *out* the transmit pins. It can also be configured to operate in half duplex mode where input/output data is often carried on the same wire(s) and the directionality takes turns.

The main difference between the modes lies in how the transmit and receive enable of the transceiver are configured and used. In full duplex mode, the transceiver receive data is always enabled and being processed by the MCU. In half duplex mode, the receive data is only valid when not transmitting – this avoids receive MCU algorithms from “seeing” the same data that they send if the network shares the same wires for transmit and receive. Full duplex mode always implies separate network wires for transmit and receive. Even then, you may not want to always have your transmitter enabled – there are many custom networks where the “master” in a network owns one network wire (or pair in differential mode)

and can broadcast at any time to the “slaves” whereas the slaves must share the return line according to some convention to avoid collisions.

Given the many possible combinations on custom networks, there are two key elements that need to be addressed:

1. Is the receiver always on, delivering data to the MCU’s UART all the time, or is the network wiring half duplex and the receiver disabled during transmission to avoid “seeing your own packets”?
2. Is the transmitter always on, or must it be only turned on when the UART transmits on the network?

8.4.1.4 Receive Enable: Full and Half Duplex Selection

DIP switch **S3. 4** controls how the RSXXX transceiver’s *receiver* is enabled. When **S4. 4** is **OFF** (full duplex mode), a weak pull-up on the RSXXX transceiver’s **RXEN** pin ensures that by default the RSXXX transceiver’s receiver is always enabled and delivering data to the MCU.

When **S3. 4** is **ON** (half duplex mode), the RSXXX transceiver’s **RXEN** pin is connected to GND. In this mode, the RSXXX transceiver’s receive enable is controlled by its **RXEN#** which is connected to the opposite polarity **DEN** (drive enable) pin. In this configuration, whenever the transmitter is enabled, the receiver is disabled and the receive data “marks idle” with a weak pull-up.

8.4.1.5 Transmit Enable

The transceiver’s transmit drive enable (**DEN**) pin (when asserted/high) turns on the output drivers on the transceiver and presents UART transmit data onto the network. To avoid any network glitches on power-up, this is always held low (inactive) until the MCU explicitly asserts this signal active/high.

8.4.1.6 Mode & Speeds Summary Table

The following table summarizes the state of the transceiver as configured by the DIP switch and the RXEN/DEN GPIO signals from the MCU:

| DIP Switches | | | | MCU Control | | TX/RX Status | | | Max Speed (Mbps) | Mode | | |
|--------------|-----|--------|------|----------------|---------------|-------------------|--------|------------------|------------------|---------|------------------|------|
| 232 | SLW | SPD | HALF | PB_6 RS_DEN | P5_8 RS_ON | P5_1 0 RXD5 | Y | Z | | | | |
| OFF | OFF | OFF | OFF | 0 | X | B-A | - | - | 20 | 422/485 | | |
| | | | | 1 | | | TXD5 # | TXD5 | | | | |
| | | | ON | 0 | X | B-A | - | - | | | | |
| | | | | 1 | | H* | TXD5 # | TXD5 | | | | |
| | ON | OFF/ON | OFF | 0 | X | B-A | - | - | 0.460/0.115 | | | |
| | | | | 1 | | | TXD5 # | TXD5 | | | | |
| | | | ON | 0 | X | B-A | - | - | | | | |
| | | | | 1 | | H ¹ | TXD5 # | TXD5 | | | | |
| ON | X | X | OFF | 0 | 1 | A# | - | - | 0.460 | 232 | | |
| | | | | 1 | | | TXD5 # | TXD5 | | | | |
| | | | | ON | | | 0 | A# | | | - | - |
| | | | | | | | 1 | H* | | | TXD5 # | TXD5 |
| | | | OFF | 0 | 0 | A# | - | - | | | | |
| | | | | 1 | | | TXD5 # | DNU ² | | | | |
| | | | | ON | | | 0 | A# | - | | - | |
| | | | | | | | 1 | H* | TXD5 # | | DNU ² | |

¹P5_10- RXD5 has a weak pull-up, ensuring that when the receiver is disabled the receive data will mark high.

²Do not use

8.4.2 CAN

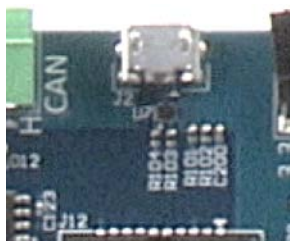
The CAN transceiver on the PE-HMI1 Baseboard is implemented with an Infineon [IFX1050GVIO](#) or similar device with the following specifications:

- CAN data transmission rate up to 1 Mbaud
- Suitable for 12V and 24V network applications
- Excellent EMC performance (very high immunity and very low emission)
- ISO/DIS 11898 compatible

The transceiver is connected to the MCU's CAN1 port as follows:

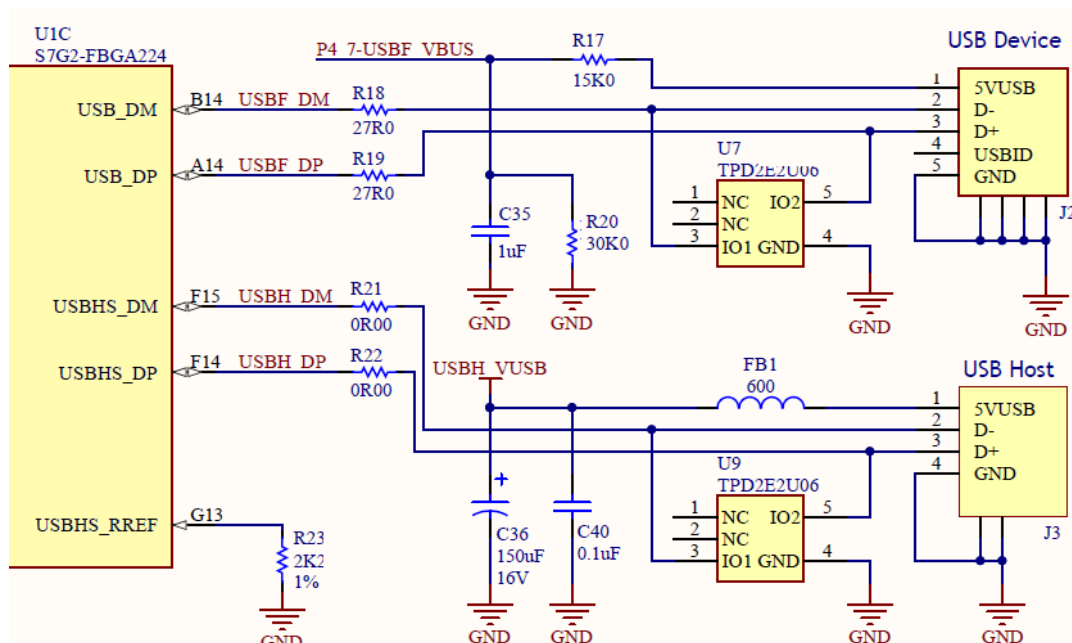
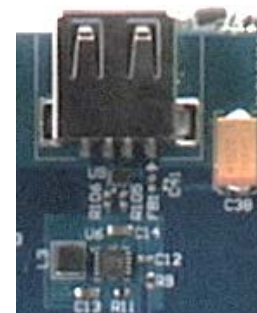
| MCU | | | Schematic | Operation |
|------|--------|-------|------------|--------------------|
| Port | Mode | PSEL | Net Name | |
| P512 | CTX1_B | 10000 | P5_12/CTX1 | CAN1 Transmit Data |
| P511 | CRX1_B | 10000 | P5_11/CRX1 | CAN1 Receive Data |

8.5 USB Host and Device



The Synergy S7G2 MCU features independent USB 2.0 Host and USB 2.0 Device (or “function”) ports; the Host port capable of High Speed 480mbps data rates, the Device port limited to Full Speed 12mbps.

The USB Device port is exposed via a standard USB Micro-B connector on the PE-HMI1 and is connected to the Full Speed port of the MCU; the USB Host port is exposed via standard USB TypeA connector and is connected to the High Speed port of the MCU.



The ports are connected to the MCU as follows:

| MCU | | | Schematic Net Name | Operation |
|----------|---------------|-------|--------------------|--|
| Port | Mode | PSEL | | |
| P407 | USBO_VBUS | 10011 | P4_7- USBF_VBUS | USB Device (“Function”) VBUS Detect |
| USB_DP | USB_DP | - | USBF_DP | USB Device (“Function”) D+ |
| USB_DM | USB_DM | - | USBF_DM | USB Device (“Function”) D- |
| PB00 | USBHS_VBUSEN | 10100 | PB_0- USBH_VBUSEN | USB Host Power Enable (active high) |
| P707 | USBHS_OVRCURA | 10100 | P7_7- USBH_OC | USB Host Over Current fault (active low) |
| USBHS_DP | USBHS_DP | - | USBH_DP | USB Host D+ |
| USBHS_DM | USBHS_DM | - | USBH_DM | USB Host D- |

The USB host port is current limited to 500mA to prevent inappropriately large current devices from affecting the operation of the PE-HMI1 system. See [USB Host Power Subsystem](#) for more information.

Designer’s Notebook

Another debate ensued... which port to put the HS and which one the FS? In the end, we opted to optimize the speed of attached devices to the Host port, including thumb drives and potentially fast wireless devices, etc.

8.6 PMODs

The PE-HMI1 has two Digilent Pmod™ compatible ports: PMOD A is a full 2x6 port and PMOD B is a more limited 1x6. These ports can be used to expand the PE-HMI1 for your own exploration and pre-design software development, as many Pmod™-compatible plug-in modules are available on the market including serial I/O, various WiFi and Bluetooth units, and a vast array of intelligent sensors.

For information on the Pmod™ convention, see the [Digilent](#) website, or [read the Pmod™ standard](#).

While most PMODs require 3 V to operate, some require 5 V. Each port can supply either 3.3 V or 5 V to the attached Pmod™ depending on the position of the co-located jumper shut beside each Pmod™ connector. In the picture to the right, the jumper is shown in the 3.3V position.



Always check the jumper position prior to inserting a Pmod™. Applying 5 V to a 3.3 V PMOD will damage the PMOD and potentially the PE-HMI1: the power to this port is not fused.



The MCU pins connected to the Pmod™ are not 5 V tolerant. Even though some Pmods require 5 V to be powered (using the 5 position of the jumper), **do not connect 5 V or higher signals** to the MCU-connected signals on this port directly. If, for example, a full-level RS232 port is desired use the [Digilent Pmod RS232X](#) which plugs into the connector and translates these voltages.

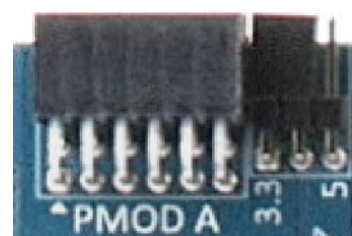
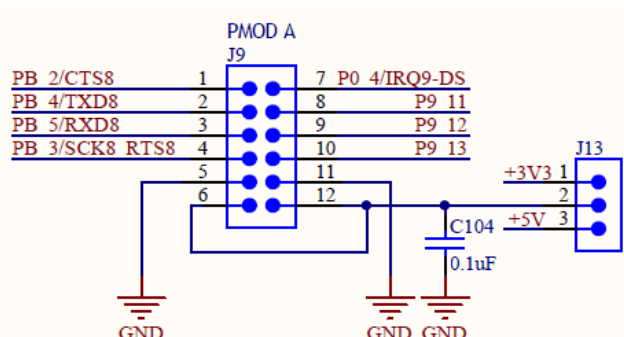
Designer's Notebook

Few real-world products would include a PMOD port – their main use is for dev kits and starter kits to allow expansion to off-the-shelf and custom modules as well as jury-rigged board-to-board/debug connections. Even so, we anticipated you might want to connect to a machine via UART/I2C/SPI or try out a different WiFi module, so this was the best compromise solution to allow some expandability and experimentation with the PE-HMI1 prior to your own hardware being available.

8.6.1 PMOD A: 2x6 Digilent Pmod™ Port

The PE-HMI1 has one Digilent Pmod™ compatible 2x6 host port. It supports, depending on MCU configuration and software, one of these standard Pmod™ configurations:

- Type 1 - GPIO
- Type 2 (SPI) and Type 2A (Expanded SPI with interrupt input)
- Type 4 (UART) and Type 4A (UART with CTS/RTS flow control)



Pay special attention to the pin order of dual row Pmod™ connectors: it is not the zigzag numbering convention normally used for headers. Incorrectly wiring to the Pmod™ connectors may damage your PE-HMI1 or even other connected equipment.

The port is wired to the MCU as follows:

| MCU | | | Schematic Net Name | Operation |
|------|---------|-------|--------------------|--|
| Port | Mode | PSEL | | |
| PB02 | CTS8# | 00100 | PB_2/CTS8 | PMOD A.1 UART CTS8 (or GPIO, or SPI SS8#) |
| PB04 | TXD8 | 00100 | PB_4/TXD8 | PMOD A.2 UART TxD8 (or GPIO, SCL8, or SPI MOSI8) |
| PB05 | RXD8 | 00100 | PB_5/RXD8 | PMOD A.3 UART RxD8 (or GPIO, SDA8, or SPI MISO8) |
| PB03 | GPI0 | - | PB_3/SCK8_RTS8 | PMOD A.4 UART RTS (or GPIO, SPI SCK8) |
| P004 | IRQ9-DS | ISEL | P0_4/IRQ9-DS | PMOD A.7 IRQ9 (or GPIO) |
| P911 | GPI0 | - | P9_11 | PMOD A.8 External Reset Out |
| P912 | GPI0 | - | P9_12 | PMOD A.9 GPIO |
| P913 | GPI0 | - | P9_13 | PMOD A.10 GPIO |

Note that the S7G2 MCU's multi-function serial peripheral SCI8 is dedicated to this port, and SCI8 can be configured in UART, SPI, or even I2C mode. This adds the possibility of additional non-standard/custom Pmods that can leverage the I2C connection on pins 2 and 3 by leaving the PSEL register at **00100b** but configuring the SCI8 to operate in I2C mode and adding external I2C bus pull-ups and devices.

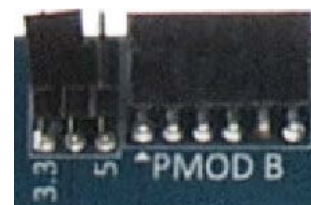
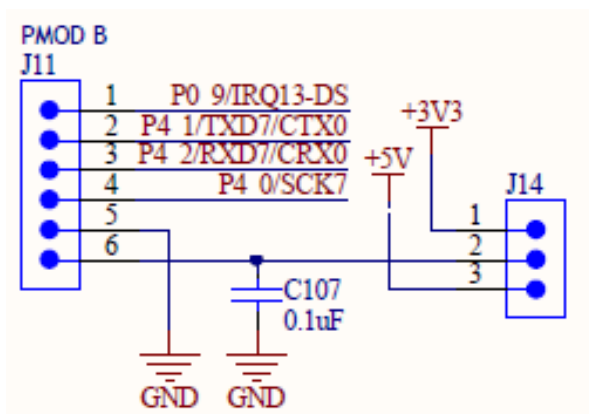
To operate the PMOD A port in SPI master/slave mode, program all four PSEL registers for the 4 SPI signals (SS#, MISO, MOSI, CLK) to **00100b** and set the SCI8 to SPI mode.

8.6.2 PMOD B: 1x6 Digilent PMOD Port

In addition to the full-featured PMOD A port, the PE-HMI1 has one more limited Digilent Pmod compatible 1x6 port. It supports, depending on MCU configuration and software, one of these standard Pmod configurations:

- Type 1 - GPIO
- Type 4 - UART without CTS/RTS flow control

Note that in addition to the Digilent-standard GPIO and UART modes, pin 2 and 3 also can be software-configured to be an additional CAN port or I2C port to a custom/non-standard PMOD or externally connected device.



The port is wired to the MCU as follows:

| MCU | | | Schematic Net Name | Operation |
|------|------|-------|-----------------------|--|
| Port | Mode | PSEL | | |
| P009 | GPI0 | - | PO_9/IRQ13_DS | PMOD B.1 GPIO (or interrupt 13 input) |
| P401 | TXD7 | 00101 | P4_1/TXD7/CTX0 | PMOD B.2 UART TxD7 (or GPIO, SCL7, or CAN0 TX) |
| P402 | RXD7 | 00101 | P4_2/RXD7/CRX0 | PMOD B.3 UART RxD7 (or GPIO, SDA7, or CAN0 RX) |
| P400 | GPI0 | - | P4_0/SCK7 | PMOD B.4 GPIO |

To use the CAN port, configure the PSEL bits for both pins to **10000b** and add an external transceiver to the port.

To use the I2C port, configure the PSEL bits for both pins to **00101b** and add external pull-ups and I2C devices to the port. This is the same PSEL configuration as the UART mode; the I2C and UART both are part of the SCI7 multi-function serial peripheral and depending on the configuration of the peripheral you get I2C or UART functionality on these pins.

9. Other I/O

Aside from the LCD with Touch Panel and communications subsystems, the PE-HMI1 includes many other user and IO and system support subsystems, including:

- Mono audio with 1W speaker output and microphone input
- Ambient light sensor
- General purpose pushbutton
- General purpose LED

9.1 Audio Output 1W Amplifier with Speaker

Because the PE-HMI1 is designed for HMI type applications requiring modest audio capabilities, usually prompt sounds and occasionally voice feedback, the PE-HMI1 uses a simple monophonic DAC-driven amplifier/speaker combination. Higher end audio applications where stereo sound and high fidelity are required could leverage the more sophisticated serial sound channels supported on the Synergy S7G2 family with an external codec and high performance amplifier subsystem.



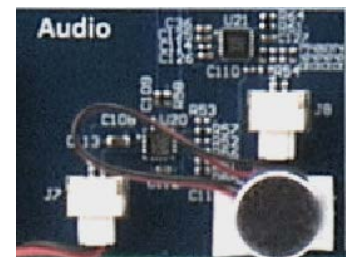
A BeStar B-Bass 1-W speaker is driven by a [WM9001 1W Dual-Mode Class AB/D Speaker Driver](#) operated in Class D mode. The input to the WM9001 is AC-coupled from the 12-bit DAC channel 0 of the Synergy S7G2 MCU. A GPIO is used to enable the amplifier, saving power if/when audio output is not required:

| MCU | | | Schematic Net Name | Operation |
|------|------|-------|-----------------------|--|
| Port | Mode | SEL | | |
| PA04 | GPO | - | PA_4-AUDI0_EN | Speaker audio amplifier enable (active high) |
| P014 | DAO | ASELO | PO_14/DAO | Speaker audio DAC output |

9.2 Microphone Input

For simple audio input, for example capturing user commands that could be sent to the cloud for speech-to-text interpretation, a microphone input is included on the PE-HMI1.

The inexpensive BeStar electret microphone requires special voltage biasing as well as a dynamic and automatic input gain control in order to effectively capture sounds. The [MAX9814 Microphone Amplifier with AGC and Low-Noise Microphone Bias](#) handles all these tasks inexpensively and delivers an analog voltage representation of the incoming sound waveform to an ADC input of the Synergy S7G2 MCU:

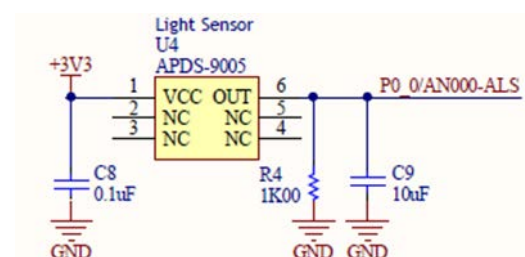


| MCU | | | Schematic Net Name | Operation |
|------|-------|------|-----------------------|----------------------------------|
| Port | Mode | SEL | | |
| P005 | AN101 | ASEL | PO_5/AN101 | Microphone analog waveform input |

9.3 Ambient Light Sensor

In low-light conditions, the LCD can be so bright it can visually “bloom” and difficult to read. As in mobile phones and tablets, the PE-HMI1 includes a forward-facing through-glass ambient light sensor, enabling software to monitor the ambient light conditions and dynamically adjust the LCD backlight intensity.

The Avago [APDS-9005-020](#) Ambient Light Sensor (ALS) is a simple device that outputs a current proportional to the ambient light conditions. Through a resistor, this appears as a voltage between 0 and

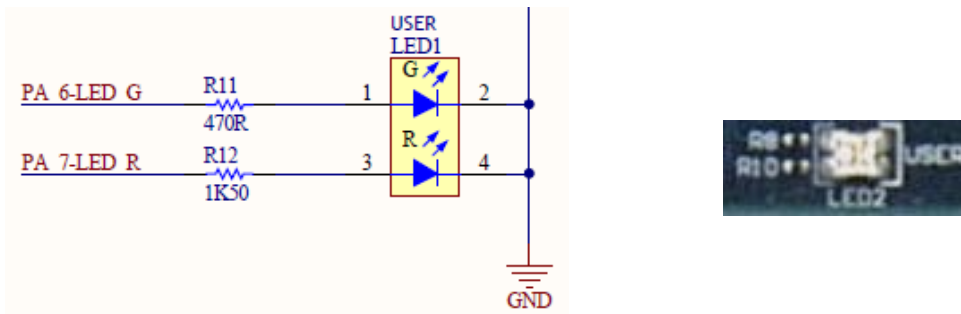


3.3 V on an Analog to Digital Converter (ADC) input on the MCU. Software can poll this ADC periodically. The ALS is connected as follows:

| MCU | | | Schematic Net Name | Operation |
|------|-------|------|-----------------------|-----------------------------------|
| Port | Mode | SEL | | |
| P000 | AN000 | ASEL | PO_0/AN000-ALS | Ambient Light Sensor Analog Input |

9.4 User LEDs

The PE-HMI1 has a two-in-one-package LED (red, green, orange=red+green) for any software-directed purpose:



User LED1 is connected as follows:

| MCU | | | Schematic Net Name | Operation |
|------|------|-----|-----------------------|------------------------------|
| Port | Mode | SEL | | |
| PA06 | GPO | - | PA_6-LED_G | User LED Green (active high) |
| PA07 | GPO | - | PA_7-LED_R | User LED Red (active high) |

10. JTAG/SWD Programming and Debug

The HMI1 Product Example, unlike a development or starter kit, has no SWD/JTAG debugger on board. Programming/Debugging is done similar to a real product, using the on-board 20-pin Cortex M debug connector J12 with an external Programmer/Debugger – see [Connecting a Programmer/Debugger](#). The connector exposes all the normal required MCU signals:



| MCU | | | Schematic | Operation |
|------|-----------|-----|------------------------|--------------------------------|
| Port | Mode | SEL | Net Name | |
| P108 | TMS/SWDIO | - | P1_8/TMS/SWDIO | JTAG test mode select |
| P300 | TCK/SWCLK | - | P3_0/TCK/SWCLK | JTAG test clock |
| P109 | TDO | - | P1_9/TDO/TXD9/TRACESWO | JTAG test data out |
| P110 | TDI | - | P1_10/TDI/RXD9 | JTAG test data In |
| RES# | RES# | - | RESET# | Reset (active low, open drain) |
| PA12 | TCLK | - | PA_12/TCLK | JTAG trace Clock |
| PA13 | TDATA0 | - | PA_13/TDATA0 | JTAG trace data 0 (lsb) |
| PA14 | TDATA1 | - | PA_14/TDATA1 | JTAG trace data 1 |
| PA15 | TDATA2 | - | PA_15/TDATA2 | JTAG trace data 2 |
| P813 | TDATA3 | - | P8_13/TDATA3 | JTAG trace data 3 (msb) |

11. External Interrupt Summary

| MCU | | | Schematic Net Name | Operation |
|------|----------|-------|------------------------------|---|
| Port | Mode | PSEL | | |
| P001 | IRQ7-DS | I SEL | PO_1/IRQ7-DS- WIFI_IRQ# | WiFi Interrupt |
| P002 | IRQ8-DS | I SEL | PO_2/IRQ8-DS- ETH_IRQ# | PHY Interrupt (active low) |
| P004 | IRQ9-DS | I SEL | PO_4/IRQ9-DS | PMOD A.7 IRQ9 (or GPIO) |
| P009 | GPIO | - | PO_9/IRQ13_DS | PMOD B.1 GPIO (or interrupt 13 input) |
| P008 | IRQ12-DS | I SEL | PO_8/IRQ12-DS- TOUCH_IRQ# | Touch Controller Activity Interrupt (open drain active low) |

12. I2C Device Summary

The three I2C interfaces available on the PE-HMI1 are as follows:

| MCU | | | Schematic Net Name | Operation |
|------|--------|-------|-----------------------|---|
| Port | Mode | PSEL | | |
| P205 | SCL1_A | 00111 | P2_5/SCL1 | Touch Controller I2C1 Bus Clock (dedicated) |
| P206 | SDA1_A | 00111 | P2_6/SDA1 | Touch Controller I2C1 Bus Data (dedicated) |
| PB04 | SCL8 | 00100 | PB_4/TXD8 | PMOD A.2 I2C8 Bus Clock (non-standard PMOD) |
| PB05 | SDA8 | 00100 | PB_5/RXD8 | PMOD A.3 I2C8 Bus Data (non-standard PMOD) |
| P401 | TXD7 | 00101 | P4_1/TXD7/CTXO | PMOD B.2 I2C8 Bus Clock (non-standard PMOD) |
| P402 | RXD7 | 00101 | P4_2/RXD7/CRXO | PMOD B.3 I2C8 Bus Data (non-standard PMOD) |

The devices on these channels are as follows:

| Address | | | I2C Bus | Max kHz | Location | Device |
|---------|------|-------|------------|------------|----------|-----------------------------------|
| 7-bit | Read | Write | | | | |
| 0x38 | 0xF1 | 0xF0 | 1 | 400 | LCD | FocalTech FT5302 Touch Controller |

13. SPI Device Summary

The SPI interfaces on the PE-HMI1 are as follows:

| MCU | | | Schematic Net Name | Operation |
|------|----------|-------|----------------------------|---|
| Port | Mode | PSEL | | |
| P410 | MISOA_B | 00110 | P4_10/MISOA | WiFi RSPIA MISO |
| P411 | MDSIA_B | 00110 | P4_11/MDSIA | WiFi RSPIA MOSI |
| P412 | RSPCKA_B | 00110 | P4_12/RSPCKA | WiFi RSPIA Clock |
| P413 | GPIO | - | P4_13/SSLA0 | WiFi RSPIA Slave Select (active low GPIO) |
| P001 | IRQ7-DS | ISEL | PO_1/IRQ7-DS- WIFI_IRQ# | WiFi Interrupt |
| PB02 | SS8# | 00100 | PB_2/CTS8 | PMOD A.1 SPI SS8# |
| PB04 | MDSI8 | 00100 | PB_4/TXD8 | PMOD A.2 SPI MOSI8 |
| PB05 | MISO8 | 00100 | PB_5/RXD8 | PMOD A.3 SPI MISO8 |
| PB03 | SCK8 | 00100 | PB_3/SCK8_RTS8 | PMOD A.4 SPI SCK8 |
| P004 | IRQ9-DS | ISEL | PO_4/IRQ9-DS | PMOD A.7 SPI IRQ9 |

The devices on these interfaces are:

| SPI Bus | Slave Select | Max MHz | Location | Device |
|---------|--------------|------------|----------|----------------|
| RSPI A | P4_12/RSPCKA | 48 | Module | WiFi Module |
| SCI8 | PB_2/CTS8 | | PMOD A | PMOD A Mode 4A |

14.MCU Port Summary

14.1 Port 0

| Port | MCU Mode | PSEL | Schematic Net Name | Operation |
|------|----------|---------|--------------------------|---|
| P000 | AN000 | A SEL I | P0_0/AN000-ALS | Ambient Light Sensor Analog Input |
| P001 | IRQ7-DS | I SEL | P0_1/IRQ7-DS-WIFI_IRQ# | WiFi Interrupt |
| P002 | IRQ8-DS | I SEL | P0_2/IRQ8-DS-ETH_IRQ# | PHY Interrupt (active low) |
| P003 | | | | unused |
| P004 | IRQ9-DS | I SEL | P0_4/IRQ9-DS | PMOD A.7 IRQ9 (or GPIO) |
| P005 | AN101 | A SEL I | P0_5/AN101 | Microphone analog waveform input |
| P006 | | | | unused |
| P007 | | | | unused |
| P008 | IRQ12-DS | I SEL | P0_8/IRQ12-DS-TOUCH_IRQ# | Touch Controller Activity Interrupt (open drain active low) |
| P009 | GPIO | | P0_9/IRQ13_DS | PMOD B.1 GPIO (or interrupt 13 input) |
| P010 | | | | unused |
| P011 | | | | unused |
| P014 | DA0 | A SEL O | P0_14/DA0 | Speaker audio DAC output |
| P015 | | | | unused |

14.2 Port 1

| Port | MCU Mode | PSEL | Schematic Net Name | Operation |
|------|-----------|-------|------------------------|-----------------------|
| P100 | DQ0 | 11011 | P1_0/DQ0 | MCU D0 (lsb) |
| P101 | DQ1 | 11011 | P1_1/DQ1 | MCU D1 |
| P102 | DQ2 | 11011 | P1_2/DQ2 | MCU D2 |
| P103 | DQ3 | 11011 | P1_3/DQ3 | MCU D3 |
| P104 | DQ4 | 11011 | P1_4/DQ4 | MCU D4 |
| P105 | DQ5 | 11011 | P1_5/DQ5 | MCU D5 |
| P106 | DQ6 | 11011 | P1_6/DQ6 | MCU D6 |
| P107 | DQ7 | 11011 | P1_7/DQ7 | MCU D7 |
| P108 | TMS/SWDIO | - | P1_8/TMS/SWDIO | JTAG test mode select |
| P109 | TDO | - | P1_9/TDO/TXD9/TRACESWO | JTAG test data out |
| P110 | TDI | - | P1_10/TDI/RXD9 | JTAG test data In |
| P111 | A5 | 01011 | P1_11/A5 | MCU A5 |
| P112 | A4 | 01011 | P1_12/A4 | MCU A4 |
| P113 | A3 | 01011 | P1_13/A3 | MCU A3 |
| P114 | A2 | 01011 | P1_14/A2 | MCU A2 |
| P115 | A1 | 01011 | P1_15/A1 | MCU A1 |

14.3 Port 2

| Port | MCU Mode | PSEL | Schematic Net Name | Operation |
|------|----------|-------|--------------------|--------------------------------|
| P202 | | | | unused |
| P203 | | | | unused |
| P204 | | | | unused |
| P205 | SCL1_A | 00111 | P2_5/SCL1 | Touch Controller I2C Bus Clock |
| P206 | SDA1_A | 00111 | P2_6/SDA1 | Touch Controller I2C Bus Data |
| P207 | | | | unused |

14.4 Port 3

| Port | MCU Mode | PSEL | Schematic Net Name | Operation |
|------|-------------|-------|--------------------|--|
| P300 | TCK/SWCLK | - | P3_0/TCK/SWCLK | JTAG test clock |
| P301 | A6 | 11011 | P3_1/A6 | MCU A6 |
| P302 | A7 | 11011 | P3_2/A7 | MCU A7 |
| P303 | A8 | 11011 | P3_3/A8 | MCU A8 |
| P304 | A9 | 11011 | P3_4/A9 | MCU A9 |
| P305 | A10 | 11011 | P3_5/A10 | MCU A10 |
| P306 | A11 | 11011 | P3_6/A11 | MCU A11 |
| P307 | A12 | 11011 | P3_7/A12 | MCU A12 |
| P308 | A13 | 01011 | P3_8/A13 | MCU A13 |
| P309 | A14 | 01011 | P3_9/A14 | MCU A14 |
| P310 | A15 | 01011 | P3_10/A15 | MCU A15 |
| P311 | RAS | 11011 | P3_11/RAS# | SDRAM Row Address Strobe (active low) |
| P312 | CAS | 11011 | P3_12/CAS# | SDRAM Column Address Strobe (active low) |
| P313 | LCD_TCON2_B | 11001 | P3_13-LCD_DE | LCD Data Enable (active high) |
| P314 | LCD_TCON1_B | 11001 | P3_14-LCD_VSYNC | LCD Vertical Sync |
| P315 | LCD_TCON0_B | 11001 | P3_15-LCD_HSYNC | LCD Horizontal Sync |

14.5 Port 4

| Port | MCU Mode | PSEL | Schematic Net Name | Operation |
|------|--------------|-------|--------------------|--|
| P400 | GPIO | - | P4_0/SCK7 | PMOD B.4 GPIO |
| P401 | TXD7 | 00101 | P4_1/TXD7/CTX0 | PMOD B.2 UART TxD7 (or GPIO, SCL7, or CAN0 TX) |
| P402 | RXD7 | 00101 | P4_2/RXD7/CRX0 | PMOD B.3 UART RxD7 (or GPIO, SDA7, or CAN0 RX) |
| P403 | ET1_MDC | 10111 | P4_3/ET1_MDC | Management data clock |
| P404 | ET1_MDIO | 10111 | P4_4/ET1_MDIO | Management data I/O |
| P405 | RMII1_TXD_EN | 10111 | P4_5/RMII1_TXD_EN | Transmit enable |
| P406 | RMII1_TXD1 | 10111 | P4_6/RMII1_TXD1 | Transmit data 1 |
| P407 | USB0_VBUS | 10011 | P4_7-USBF_VBUS | USB Device ("Function") VBUS Detect |
| P408 | | | | unused |
| P409 | | | | unused |
| P410 | MISOA_B | 00110 | P4_10/MISOA | WiFi RSPIA MISO |
| P411 | MOSIA_B | 00110 | P4_11/MOSIA | WiFi RSPIA MOSI |
| P412 | RSPCKA_B | 00110 | P4_12/RSPCKA | WiFi RSPIA Clock |
| P413 | GPIO | - | P4_13/SSLA0 | WiFi RSPIA Slave Select (active low GPIO) |
| P414 | | | | unused |
| P415 | | | | unused |

14.6 Port 5

| Port | MCU Mode | PSEL | Schematic Net Name | Operation |
|------|--------------|-------|--------------------|--|
| P500 | MMC_CLK | 10101 | P5_0-MMC_CLK | eMMC Clock (MCUàMMC) |
| P501 | MMC_CMD | 10101 | P5_1-MMC_CMD | eMMC command output, response input signal |
| P502 | MMC_D0 | 10101 | P5_2-MMC_D0 | eMMC D0 (lsb) |
| P503 | MMC_D1 | 10101 | P5_3-MMC_D1 | eMMC D1 |
| P504 | MMC_D2 | 10101 | P5_4-MMC_D2 | eMMC D2 |
| P505 | MMC_D3 | 10101 | P5_5-MMC_D3 | eMMC D3 (msb) |
| P506 | SD1CD | 10101 | P5_6/SD1CD | eMMC Card Detect input |
| P507 | SD1WP | 10101 | P5_7/SD1WP | eMMC Write Protection input |
| P508 | GPIO | - | P5_8-RS_ON | RSxxx Transceiver Enable (active high) |
| P509 | TXD5 | 00101 | P5_9/TXD5 | RSxxx Transmit Data |
| P510 | RXD5 | 00101 | P5_10/RXD5 | RSxxx Receive Data |
| P511 | CRX1_B | 10000 | P5_11/CRX1 | CAN1 Receive Data |
| P512 | CTX1_B | 10000 | P5_12/CTX1 | CAN1 Transmit Data |
| P513 | LCD_DATA16_B | TBD | P5_13-LCD_D16 | LCD R0 (LSB) |
| P514 | | | | unused |
| P515 | | | | unused |

14.7 Port 6

| Port | MCU Mode | PSEL | Schematic Net Name | Operation |
|------|--------------|-------|--------------------|--|
| P600 | | | | unused |
| P601 | DQM0 | TBD | P6_1/DQM0 | SDRAM I/O data mask enable for D7 to D0 |
| P602 | SDCLK | 11011 | P6_2/SDCLK | SDRAM Clock |
| P603 | DQ13 | 01011 | P6_3/DQ13 | MCU D13 |
| P604 | DQ12 | 01011 | P6_4/DQ12 | MCU D12 |
| P605 | DQ11 | 01011 | P6_5/DQ11 | MCU D11 |
| P606 | LCD_DATA3_B | 11001 | P6_6-LCD_D3 | LCD B3 |
| P607 | LCD_DATA4_B | 11001 | P6_7-LCD_D4 | LCD B4 |
| P608 | DQM1 | TBD | P6_8/DQM1 | SDRAM I/O data mask enable for D15 to D8 |
| P609 | CKE | TBD | P6_9/CKE | SDRAM Clock Enable |
| P610 | WE | TBD | P6_10/WE# | SDRAM write enable (active low) |
| P611 | SDCS | 01011 | P6_11/SDCS# | SDRAM Chip Select (active low) |
| P612 | DQ8 | 01011 | P6_12/DQ8 | MCU D8 |
| P613 | DQ9 | 01011 | P6_13/DQ9 | MCU D9 |
| P614 | DQ10 | 01011 | P6_14/DQ10 | MCU D10 |
| P615 | LCD_DATA10_B | 11001 | P6_15-LCD_D10 | LCD G2 |

14.8 Port 7

| Port | MCU Mode | PSEL | Schematic Net Name | Operation |
|------|---------------|-------|--------------------|--|
| P700 | RMII1_TXD0 | 10111 | P7_0/RMII1_TXD0 | Transmit data 0 (LSB) |
| P701 | REF50CK1 | 10111 | P7_1/REF50CK1 | Transmit clock |
| P702 | RMII1_RXD0 | 10111 | P7_2/RMII1_RXD0 | Receive data 0 (LSB) |
| P703 | RMII1_RXD1 | 10111 | P7_3/RMII1_RXD1 | Receive data 1 |
| P704 | RMII1_RX_ER | 10111 | P7_4/RMII1_RX_ER | Receive error |
| P705 | RMII1_CRS_DV | 10111 | P7_5/RMII1_CRS_DV | Carrier detection |
| P706 | GPO | - | P7_6-ETH_RESET# | Holds PHY in reset (active low) |
| P707 | USBHS_OVRCURA | 10100 | P7_7-USBH_OC | USB Host Over Current fault (active low) |
| P708 | RXD1 | 00101 | P7_8/RXD1 | Bluetooth UART RxD |
| P709 | TXD1 | 00101 | P7_9/TXD1 | Bluetooth UART TxD |
| P710 | | | | unused |
| P711 | CTS1# | 00101 | P7_11/CTS1 | Bluetooth UART CTS# |
| P712 | GPIO | - | P7_12-RTS1 | Bluetooth UART RTS# |
| P713 | | | | unused |

14.9 Port 8

| Port | MCU Mode | PSEL | Schematic Net Name | Operation |
|------|--------------|-------|--------------------|-------------------------|
| P800 | DQ14 | 01011 | P8_0/DQ14 | MCU D14 |
| P801 | DQ15 | 01011 | P8_1/DQ15 | MCU D15 (msb) |
| P802 | LCD_DATA2_B | 11001 | P8_2-LCD_D2 | LCD B2 |
| P803 | LCD_DATA1_B | 11001 | P8_3-LCD_D1 | LCD B1 |
| P804 | LCD_DATA0_B | 11001 | P8_4-LCD_D0 | LCD B0 (LSB) |
| P805 | LCD_DATA17_B | 11001 | P8_5-LCD_D17 | LCD R1 |
| P806 | | | | unused |
| P807 | | | | unused |
| P808 | | | | unused |
| P809 | | | | unused |
| P810 | | | | unused |
| P811 | | | | unused |
| P812 | | | | unused |
| P813 | TDATA3 | - | P8_13/TDATA3 | JTAG trace data 3 (msb) |

14.10 Port 9

| Port | MCU Mode | PSEL | Schematic Net Name | Operation |
|------|--------------|-------|--------------------|------------------------------|
| P900 | LCD_CLK_B | 11001 | P9_0-LCD_CLK | LCD Pixel dot clock |
| P901 | LCD_DATA15_B | 11001 | P9_1-LCD_D15 | LCD G7 (MSB) |
| P902 | LCD_DATA23_B | 11001 | P9_2-LCD_D23 | LCD R6 (MSB) |
| P903 | GPIO | - | P9_3-MMC_RST# | eMMC reset GPIO (active low) |
| P904 | GPIO | - | P9_4-WIFI_PWD# | WiFi Shutdown (active low) |
| P905 | LCD_DATA11_B | 11001 | P9_5-LCD_D11 | LCD G3 |
| P906 | LCD_DATA12_B | 11001 | P9_6-LCD_D12 | LCD G4 |
| P907 | LCD_DATA13_B | 11001 | P9_7-LCD_D13 | LCD G5 |
| P908 | LCD_DATA14_B | 11001 | P9_8-LCD_D14 | LCD G6 |
| P909 | LCD_DATA21_B | 11001 | P9_9-LCD_D21 | LCD R5 |
| P910 | LCD_DATA22_B | 11001 | P9_10-LCD_D22 | LCD R5 |
| P911 | GPIO | - | P9_11 | PMOD A.8 External Reset Out |
| P912 | GPIO | - | P9_12 | PMOD A.9 GPIO |
| P913 | GPIO | - | P9_13 | PMOD A.10 GPIO |
| P914 | LCD_DATA19_B | 11001 | P9_14-LCD_D19 | LCD R3 |
| P915 | LCD_DATA20_B | 11001 | P9_15-LCD_D20 | LCD R4 |

14.11 Port A

| Port | MCU Mode | PSEL | Schematic Net Name | Operation |
|------|----------------|-------|--------------------|---|
| PA00 | LCD_DATA5_B | 11001 | PA_0-LCD_D5 | LCD B5 |
| PA01 | LCD_DATA6_B | 11001 | PA_1-LCD_D6 | LCD B6 |
| PA02 | GPIO | - | PA_2-TOUCH_RST# | Touch Controller Reset (active low) |
| PA03 | GPIO | - | PA_3-LCD_ON | LCD Logic Enable (active high, weakly inactive on RESET#) |
| PA04 | GPO | - | PA_4-AUDIO_EN | Speaker audio amplifier enable (active high) |
| PA05 | GTIOC11A_B:I/O | 00011 | PA_5-BLEN | LCD Backlight Enable (active high, weakly off @RESET#) |
| PA06 | GPO | - | PA_6-LED_G | User LED Green (active high) |
| PA07 | GPO | - | PA_7-LED_R | User LED Red (active high) |
| PA08 | LCD_DATA9_B | 11001 | PA_8-LCD_D9 | LCD G1 |
| PA09 | LCD_DATA8_B | 11001 | PA_9-LCD_D8 | LCD G0 (LSB) |
| PA10 | LCD_DATA7_B | 11001 | PA_10-LCD_D7 | LCD B7 (MSB) |
| PA11 | LCD_DATA18_B | 11001 | PA_11-LCD_D18 | LCD R2 |
| PA12 | TCLK | - | PA_12/TCLK | JTAG trace Clock |
| PA13 | TDATA0 | - | PA_13/TDATA0 | JTAG trace data 0 (lsb) |
| PA14 | TDATA1 | - | PA_14/TDATA1 | JTAG trace data 1 |
| PA15 | TDATA2 | - | PA_15/TDATA2 | JTAG trace data 2 |

14.12 Port B

| Port | MCU Mode | PSEL | Schematic Net Name | Operation |
|------|--------------|-------|--------------------|--|
| PB00 | USBHS_VBUSEN | 10100 | PB_0-USBH_VBUSEN | USB Host Power Enable (active high, reset condition low) |
| PB00 | USBHS_VBUSEN | 10100 | PB_0-USBH_VBUSEN | USB Host Power Enable (active high) |
| PB01 | GPIO | - | PB_1-BT_SHUDN# | Bluetooth Shutdown (active low) |
| PB02 | CTS8# | 00100 | PB_2/CTS8 | PMOD A.1 UART CTS8 (or GPIO, or SPI SS8#) |
| PB03 | GPIO | - | PB_3/SCK8_RTS8 | PMOD A.4 UART RTS (or GPIO, SPI SCK8) |
| PB04 | TXD8 | 00100 | PB_4/TXD8 | PMOD A.2 UART TxD8 (or GPIO, SCL8, or SPI MOSI8) |
| PB05 | RXD8 | 00100 | PB_5/RXD8 | PMOD A.3 UART Rx8 (or GPIO, SDA8, or SPI MISO8) |
| PB06 | GPIO | - | PB_6-RS_DEN | RSxxx Transmit Drive Enable (active high) |
| PB07 | | | | unused |

15. Bills of Materials

| Schematic Designator | Mfg | Part Number | Description | QTY | Package |
|--|--------------|---------------------|--|-----|---------|
| BAT1 | Keystone | 3000TR | Keystone CR1220 Battery Coin Cell holder | 1 | |
| C1, C2, C4, C7, C8, C11, C17, C18, C20, C21, C25, C26, C27, C28, C29, C30, C31, C32, C33, C37, C40, C45, C48, C49, C51, C53, C54, C75, C76, C77, C78, C79, C81, C83, C85, C86, C87, C88, C90, C91, C98, C100, C101, C102, C103, C104, C105, C106, C107, C108, C109, C110, C112, C113, C114, C115, C116, C122, C123, C124, C125, C126 | Samsung | CL03A104KP3NNNC | Ceramic Chip Capacitor 0.1μF 10V | 62 | 0201 |
| C3 | Samsung | CL21A226MAQNNN | Ceramic Chip Capacitor 22μF 25V | 1 | 0805 |
| C5, C6, C15, C50 | Samsung | CL10A226MQ8NRNC | Ceramic Chip Capacitor 22μF 6.3V | 4 | 0603 |
| C9 | Samsung | CL10A106MQ8NNNC | Ceramic Chip Capacitor 10μF 6.3V | 1 | 0603 |
| C10, C13, C94 | Samsung | CL10A106KP8NNND | Ceramic Chip Capacitor 10μF 10V | 3 | 0603 |
| C12 | Samsung | CL31B105KBHNNNE | Ceramic Chip Capacitor 1μF 50V | 1 | 1206 |
| C14 | Samsung | CL05A104KO5NNNC | Ceramic Chip Capacitor 0.1μF 16V | 1 | 0402 |
| C16, C34 | Samsung | CL05A106MQ5NUNC | Ceramic Chip Capacitor 10μF 6.3V | 2 | 0402 |
| C19, C35, C73, C74, C80, C82, C84, C89, C97, C111 | Samsung | CL05A105KO5NNNC | Ceramic Chip Capacitor 1μF 16V | 10 | 0402 |
| C22, C23, C24, C68 | TDK | C1005X7R1H104K050BB | Ceramic Chip Capacitor 0.1μF 50V | 4 | 0402 |
| C36 | AVX | TPSD157M016R0150 | Tantalum Capacitor 7343-31 150μF 16V | 1 | D |
| C38, C39 | Samsung | CL05C120JB5NNNC | Ceramic Chip Capacitor 12pF 50V | 2 | 0402 |
| C41, C42, C43, C44 | TDK | C1005X7S2A103K050BB | Ceramic Chip Capacitor 0.01μF 100V | 4 | 0402 |
| C46, C92, C93 | Samsung | CL05A475MQ5NQNC | Ceramic Chip Capacitor 4.7μF 6.3V | 3 | 0402 |
| C47, C96, C127, C128 | Samsung | CL05A225MP5NNNC | Ceramic Chip Capacitor 2.2μF 10V | 4 | 0402 |
| C52 | Taiyo Uniden | LMK316BJ476ML-T | Ceramic Chip Capacitor 47μF 10V | 1 | 1206 |
| C55 | Johanson | 202R18W102KV4E | Ceramic Chip Capacitor 1000pF 2KV | 1 | 1206 |
| C56 | TDK | C3225X7S3D222K250AA | Ceramic Chip Capacitor 2200pF 2KV | 1 | 1210 |
| C57 | Samsung | CL05B681KB5NNNC | Ceramic Chip Capacitor 680pF 50V | 1 | 0402 |
| C58, C60 | Samsung | CL31B105KCHSNNNE | Ceramic Chip Capacitor 1μF 100V | 2 | 1206 |
| C59 | Panasonic | EEE-FK2A220P | Aluminum Capacitor 22μF 100V | 1 | 8x10.2 |
| C61 | Panasonic | EEE-FPJ470UAR | Aluminum Capacitor 47μF 6.3V | 1 | 4x5.8 |
| C62, C63 | Samsung | CL31A476MPHNNNE | Ceramic Chip Capacitor 47μF 10V | 2 | 1206 |
| C64 | Panasonic | EEE-FP1E100AR | Aluminum Capacitor 10μF 25V | 1 | 4x5.8 |

| Schematic Designator | Mfg | Part Number | Description | QTY | Package |
|------------------------------|--------------|------------------------|---|-----|-------------|
| C65 | TDK | C1608X7R1H224M080AB | Ceramic Chip Capacitor 220nF 50V | 1 | 0603 |
| C66 | Samsung | CL21B104KCFSFNE | Ceramic Chip Capacitor 0.1 μ F 100V | 1 | 0805 |
| C67 | Samsung | CL21C102JCFNNNE | Ceramic Chip Capacitor 1nF 100V | 1 | 0805 |
| C69 | AVX | 06032C331KAT2A | Ceramic Chip Capacitor 330pF 200V | 1 | 0603 |
| C70, C95 | TDK | C1005X7R1H223K050BB | Ceramic Chip Capacitor 22nF 50V | 2 | 0402 |
| C71 | Samsung | CL10C101JB8NNNC | Ceramic Chip Capacitor 100pF 50V | 1 | 0603 |
| C72 | Murata | GRM155R71H822KA88D | Ceramic Chip Capacitor 8.2nF 50V | 1 | 0402 |
| C99 | Samsung | CL05A474KP5NNNC | Ceramic Chip Capacitor 0.47 μ F 10V | 1 | 0402 |
| C117, C118, C119, C120, C121 | Samsung | CL03A103KP3NNNC | Ceramic Chip Capacitor 10nF 25V | 5 | 0201 |
| D1, D2, D3 | Diodes Zetex | DFLS130L-7 | Schottky Diode 30V 1A | 3 | PowerDI 123 |
| D4 | OnSemi | BAS40LT1G | OnSemi Schottky Power Rectifier 40V 120mA | 1 | |
| D5 | Micro Comm | SK54AFL-TP | Diodes Schottky 5A 40V | 1 | |
| D6, D9 | Diodes | HD01-T | Diodes Bridge Rectifier 100V 0.8A | 2 | MiniDIP |
| D7 | Micro Comm | BAS316-TP | Diodes Schottky Switching 500mA 100V | 1 | |
| D8 | Diodes | SMAJ58A-13-F | Diodes TVS 58V 1W | 1 | |
| D10 | OnSemi | MMBD7000LT1G | Dual switching diode 100V 200mA | 1 | |
| D11 | Diodes | TLV431AFTA | Low Voltage Adjustable Shunt Regulator | 1 | |
| D12 | OnSemi | NUP2105LT1G | Dual Line CAN Bus Protector 350W | 1 | |
| FB1 | Samsung | CIM05U601NC | Chip Ferrite Bead 600 300mA 25% | 1 | 0402 |
| FB2 | Murata | BLM21AG121SN1D | Chip Ferrite Bead 120 800mA 25% | 1 | 0805 |
| FB3, FB4 | TDK | MMZ2012R150A | Chip Ferrite Bead 15R0 1.5A | 2 | 0805 |
| J1 | Molex | 503471-0200 | Molex Flexi-Mate Receptacle 2pos | 1 | |
| J2 | FCI | 10118192-0001LF | USB Micro 2.0 Female 5 Pin Right Angle | 1 | |
| J3 | Samtec | USB-A-S-F-B-SM2-R-TR | USB Type A 2.0 Jack | 1 | |
| J4 | Amphenol | RJSSE-5381 | Amphenol RJ345 8pos w/light pipes | 1 | SMT |
| J5 | Omron | XF2W-4015-1A | Omron FPC/FFC Connector 40pos Pitch 0.5mm | 1 | |
| J6 | Omron | XF2W-0815-1A | Omron FPC/FFC Connector 8pos Pitch 0.5mm | 1 | |
| J7, J8 | JST | SM02B-GHS-TB | JST PH Connector 2 Position Right Angle 2mm Pitch | 2 | |
| J9 | Samtec | SSW-106-02-F-D-RA | Samtec Female Header 0.1" pitch PMOD 2x6 Right Angle | 1 | |
| J10 | FCI | 20020110-C081A01LF | FCI Terminal Block 3.5mm pitch 8pos Right Angle | 1 | |
| J11 | Samtec | SSW-106-02-FM-S-RA | Samtec Female Header 0.1" pitch 6pos 1x6 Right Angle | 1 | |
| J12 | Samtec | FTSH-110-01-L-DV-007-K | 20 Position Shrouded Header 1.27mm Pitch Pin #7 Removed | 1 | |
| J13, J14 | Harwin | M20-9960345 | Header 0.1" pitch 3pos 1x3 Right Angle | 2 | |

| Schematic Designator | Mfg | Part Number | Description | QTY | Package |
|--|-----------|------------------|---|-----|---------|
| L1, L3 | Bourns | SRN3015-2R2M | Bourns Semishielded Power Inductor 2.2uH 1.8A | 2 | |
| L2 | Bourns | SRR5028-220Y | Bourns Semishielded Power Inductor 22uH 2.2A | 1 | |
| L4 | Bourns | SM51108PEL | Bourns Ethernet Transformer PoE 10/100 | 1 | |
| L5 | Murata | LQH44PN4R7MP0L | Murata Semishielded Power Inductor 4.7uH 1.7A | 1 | |
| LED1, LED2 | Dialight | 598-8610-207F | Dialight Bicolor LED Red/Green | 2 | 1210 |
| LED3 | Avago | ASMT-RJ45-AQ502 | Avago LED Orange | 1 | 0603 |
| LED4 | Avago | ASMT-RF45-AN002 | Avago LED Green | 1 | 0603 |
| Q1 | Farichild | FDC2512 | N-FET 150V 1.4A | 1 | |
| R1, R3, R6, R14, R29, R50, R51, R54, R57, R65, R71 | Panasonic | ERA-2AED104X | Chip Resistor Thick Film 100K0 0.5% 1/16W | 11 | 0402 |
| R2 | Panasonic | ERJ-2RKF4533X | Chip Resistor Thick Film 453K 1% 1/10W | 1 | 0402 |
| R4, R42, R47 | Panasonic | ERA-2AED102X | Chip Resistor Thick Film 1K00 0.5% 1/16W | 3 | 0402 |
| R5 | NIC | NRC04F1101TRF | Chip Resistor Thick Film 1.1K 1% 1/16W | 1 | 0402 |
| R7 | Vishay | CRCW04021R87FKED | Chip Resistor Thick Film 1R87 1% 1/16W | 1 | 0402 |
| R8, R11 | Panasonic | ERA-2AED471X | Chip Resistor Thick Film 470R 0.5% 1/16W | 2 | 0402 |
| R9, R43, R52, R56 | Panasonic | ERA-2AED103X | Chip Resistor Thick Film 10K0 0.5% 1/16W | 4 | 0402 |
| R10 | Vishay | CRCW04023K90FKED | Chip Resistor Thick Film 3K90 1% 1/16W | 1 | 0402 |
| R12 | Panasonic | ERA-2AED152X | Chip Resistor Thick Film 1K50 0.5% 1/16W | 1 | 0402 |
| R13 | Panasonic | ERJ-2RKF1502X | Chip Resistor Thick Film 51K0 1% 1/10W | 1 | 0402 |
| R15 | Panasonic | ERA-2AED101X | Chip Resistor Thick Film 100R 0.5% 1/16W | 1 | 0402 |
| R16, R75 | Panasonic | ERA-2AED472X | Chip Resistor Thick Film 4K70 0.5% 1/16W | 2 | 0402 |
| R17 | Panasonic | ERJ-2RKF1502X | Chip Resistor Thick Film 15K0 1% 1/10W | 1 | 0402 |
| R18, R19 | Panasonic | ERJ-2RKF27R0X | Chip Resistor Thick Film 27R0 1% 1/10W | 2 | 0402 |
| R20 | Panasonic | ERJ-2RKF3002X | Chip Resistor Thick Film 30K0 1% 1/10W | 1 | 0402 |
| R21, R22, R37, R39, R60, R61, R68, R69, R70 | Vishay | CRCW04020000Z0ED | Chip Resistor Thick Film 0R00 1% 1/16W | 9 | 0402 |
| R23, R58 | Panasonic | ERA-2AED222X | Chip Resistor Thick Film 2K20 1% 1/10W | 2 | 0402 |
| R24, R25, R26, R27 | Panasonic | ERJ-2RKF75R0X | Chip Resistor Thick Film 75 1% 1/10W | 4 | 0402 |
| R28 | Panasonic | ERJ-2RKF6491X | Chip Resistor Thick Film 6K49 1% 1/10W | 1 | 0402 |

| Schematic Designator | Mfg | Part Number | Description | QTY | Package |
|---|-----------|------------------|---|-----|---------|
| R30 | Panasonic | ERJ-2RKF20R0X | Chip Resistor Thick Film 20R0 1% 1/10W | 1 | 0402 |
| R31, R32 | Panasonic | ERJ-2RKF49R9X | Chip Resistor Thick Film 49R9 1% 1/16W | 2 | 0402 |
| R33 | Panasonic | ERJ-3EKF1271V | Chip Resistor Thick Film 1K27 1% 1/10W | 1 | 0603 |
| R34 | Panasonic | ERJ-3EKF5902V | Chip Resistor Thick Film 59K0 1% 1/10W | 1 | 0603 |
| R35 | Panasonic | ERJ-3EKF8062V | Chip Resistor Thick Film 80K6 1% 1/10W | 1 | 0603 |
| R36 | Panasonic | ERJ-P06J820V | Chip Resistor Thick Film 82R0 5% 1/2W | 1 | 0805 |
| R38 | Panasonic | ERJ-8RQFR56V | Chip Resistor Thick Film 0R56 1% 1/4W | 1 | 1206 |
| R40 | Panasonic | ERJ-2RKF4990X | Chip Resistor Thick Film 499R 1% 1/10W | 1 | 0402 |
| R41 | Panasonic | ERA-2AED202X | Chip Resistor Thick Film 2K0 0.5% 1/16W | 1 | 0402 |
| R44 | Panasonic | ERJ-2RKF4122X | Chip Resistor Thick Film 41K2 1% 1/10W | 1 | 0402 |
| R45 | Panasonic | ERJ-8ENF1372V | Chip Resistor Thick Film 13K7 1% 1/4W | 1 | 1206 |
| R46 | Panasonic | ERJ-8ENF1132V | Chip Resistor Thick Film 11K3 1% 1/4W | 1 | 1206 |
| R48 | Panasonic | ERJ-2RKF1912X | Chip Resistor Thick Film 19K1 1% 1/10W | 1 | 0402 |
| R49 | Panasonic | ERJ-2RKF1332X | Chip Resistor Thick Film 13K3 1% 1/10W | 1 | 0402 |
| R53, R55, R62, R63, R64 | Panasonic | ERA-2AED103X | Chip Resistor Thick Film 10K0 0.5% 1/16W | 0 | 0402 |
| R59 | Vishay | CRCW0402143KFKED | Chip Resistor Thick Film 143K0 1% 1/16W | 1 | 0402 |
| R66, R67 | Vishay | CRCW04020000Z0ED | Chip Resistor Thick Film 0R00 1% 1/16W | 0 | 0402 |
| R72, R73 | TBD | TBD | Chip Resistor Thick Film 10K0 | 0 | 0805 |
| R74 | Panasonic | ERJ-2RKF22R0X | Chip Resistor Thick Film 22R0 1% 1/10W | 1 | 0402 |
| RA2, RA3, RA4, RA5, RA6, RA7, RA8, RA10, RA14 | Panasonic | EXB-28V472JX | Chip Resistor Array 4K70 5% 1/16W 4 x 0402 | 9 | 0804 |
| RA9, RA15 | Panasonic | EXB-28V473JX | Chip Resistor Array 47K0 5% 1/16W 4 x 0402 | 2 | 0804 |
| RA11, RA12 | Panasonic | EXB-28V330JX | Chip Resistor Array 33R 5% 1/16W 4 x 0402 | 2 | 0804 |
| RA13 | Panasonic | EXB-28V471JX | Chip Resistor Array 470R 5% 1/16W 4 x 0402 | 1 | 0804 |
| RA16, RA17 | Panasonic | EXB-28V104JX | Chip Resistor Array 100K0 5% 1/16W 4 x 0402 | 2 | 0804 |
| RF1 | Netcom | GT202-II | Netcom GT202 WiFi Module Ext Antenna | 1 | SMD |

| Schematic Designator | Mfg | Part Number | Description | QTY | Package |
|--|-------------------|----------------------------|---|-----|----------|
| RF2 | Panasonic | ENW-89823A3KF | Panasonic PAN1326 Bluetooth Module | 1 | SMD |
| S1 | C&K | KSC222J LFS | Sealed Push Button Switch 6.2x6.2x3.5mm | 1 | SMD J |
| S3 | CTS | 219-5LPST | SMD DIP Switch 5Position 2.54mm | 1 | SMD |
| SO1, SO2, SO3, SO4 | PEM | SMTSO-M3-6-ET | PEM SMT M3 6.0mm Standoff | 4 | SMD |
| SPK1 | BeStar | B-Bass | BeStar B-Bass Sounder | 1 | |
| T1 | Pulse | PA1283NLT | Pulse PoE Flyback Transformer 5V 7W | 1 | SMD |
| TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8 | Keystone | 5015 | Keystone SMT Test Point | 8 | SMD |
| U1 | Renesas | R7FS7G27H2A01CBD#WS2 | Renesas S7G2 240MHz 32-bit Cortex M4 MCU WS2 | 1 | FBGA-224 |
| U2 | ST | STM1818SWX7F | Low power reset circuit | 1 | |
| U3 | Intersil | ISL80019AIRZ-T | DC-DC Single Step Down 3.3V 1.5A | 1 | |
| U4 | Avago | APDS-9005-020 | Avago ADPS-9005 Ambient Light Sensor | 1 | |
| U5 | OnSemi | CAT4139TD-GT3 | 22V High Current Boost White LED Driver | 1 | |
| U6 | Texas Instruments | TPS2501DRCR | TI Integrated USB Power switch with boost converter | 1 | |
| U7, U9 | Texas Instruments | TPD2E2U06DRLR | Two channel 30kV ESD Dual Protection | 2 | |
| U8 | SiLabs | 501AAA-24M0000-DAGR | SiLabs MEMS Oscillator 24.000MHz | 1 | |
| U10 | Micrel | KSZ8091RNBIA | 10/100Base-TX Ethernet PHY EEE | 1 | |
| U11 | SiLabs | TBD | SiLabs MEMS Oscillator 50.000MHz | 1 | |
| U12 | Texas Instruments | TBD | TI PoE Interface & Converter Controller | 1 | |
| U13, U14 | Renesas | PS2501L-1-F3-A | Opto Coupler 80V 5KV DIP4 | 2 | |
| U15 | Texas Instruments | TLV70018DSET | LDO Regulator 1.8V 200mA | 1 | |
| U16 | NXP | NVT2006bq115#2ceM | Bidirectional Level Translator 6-bit | 1 | |
| U17 | SiLabs | TBD | SiLabs MEMS Oscillator 32.768KHz | 1 | |
| U18 | Maxim | MAX9814ETD+T | Maxim Microphone Preamp | 1 | |
| U19 | Wolfson | WM9001GEFL/R | Wolfson 1W Mono Speaker Driver | 1 | |
| U20 | Intersil | ISL41387IRZ-T | Intersil ISL41387 RS232/RS485 Transceiver | 1 | |
| U21 | Infineon | IFX1050GVIO | Infineon CAN Transceiver 1MBaud | 1 | |
| U22 | Micron | MTFC2GMVEA-0M WT | Micron 2GByte eMMC 3v3 | 1 | |
| U23 | Micron | MT48LC16M16A2B4-7E IT:G TR | Micron SDRAM 256M-Bit 16Mx16 3.3V | 1 | |
| X1 | Abracon | ABS07-32.768KHZ-T | Crystal 32.769KHz 12.5pF SMT | 1 | |

16. Post Production Modifications

None on v2.0 products.

17. Additional Information

Further information available for this product can be found on the Renesas Synergy website at:

<http://www.renesassynergy.com>

General information on Renesas Microcontrollers can be found on the global Renesas website:

<http://www.renesas.com/>

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PE-HMI1 v2.0 User's Manual: Hardware

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