User's Manual

Application Example for Cloud Connectivity (AE-CLOUD1)

User's Manual

Renesas Synergy™ Platform

Synergy Tools & Kits

Kits: Connectivity

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• 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 10 m of the product when in use.

• The user is advised to take ESD precautions when handling the equipment.

The Renesas Synergy™ Kit does not represent an ideal reference design for an end product and does not fulfill the regulatory standards for an end product.

1. Overview

The AE-CLOUD1 is a Synergy MCU Application Example Kit intended for fast prototyping of embedded systems specifically targeting Internet of Things. The kit includes all components required for development and debugging of applications that can collect information from a variety of sensors and communicate it securely to the Cloud.

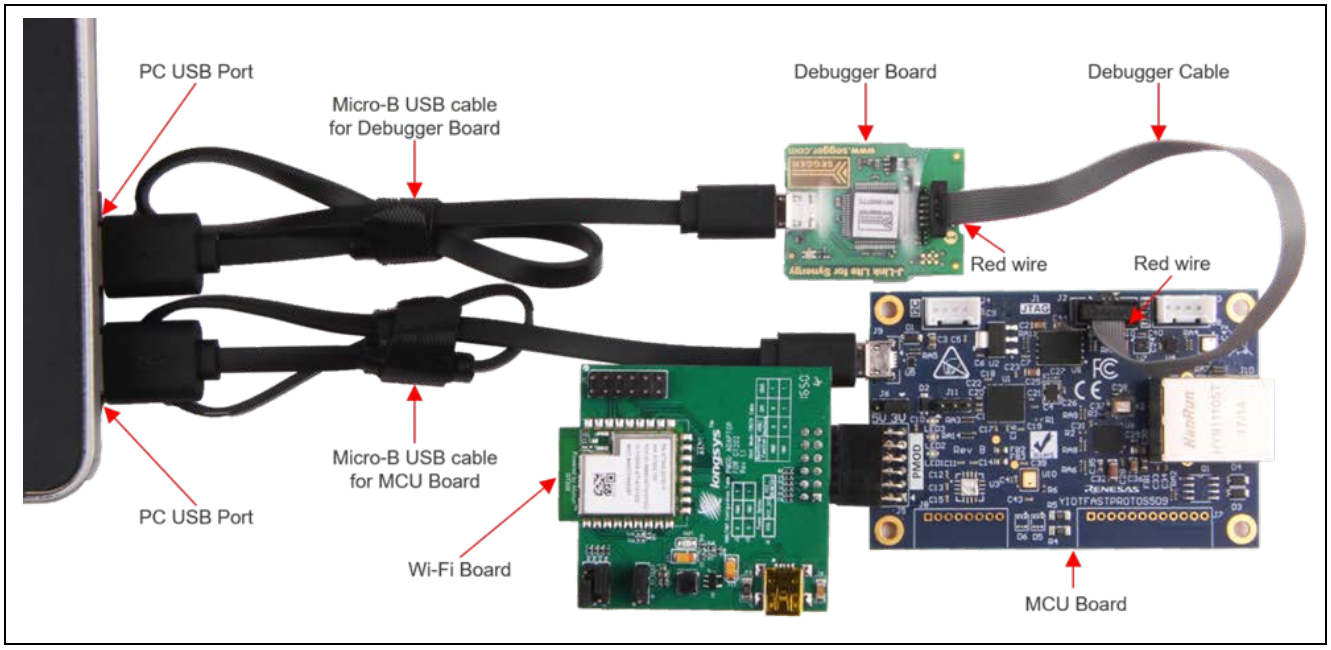


Figure 1 Application Example Kit

The kit includes a Wi-Fi board based on the GT202 module that uses a Qualcomm® QCA4002 system on a chip. The board supports 802.11 b/g/n communication standards.

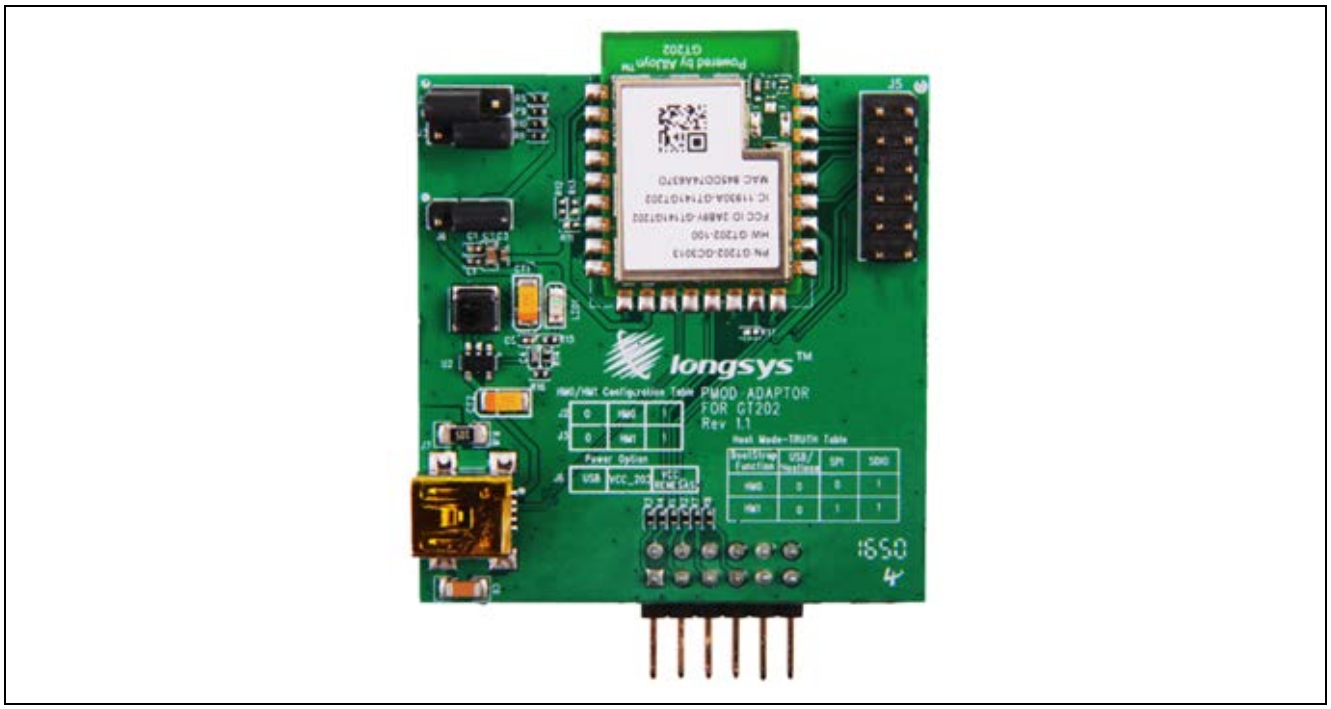


Figure 2 Wi-Fi Board Based on the GT202 Module

The debugging of the firmware application is possible through the included debugging probe. It is supported by SEGGER J-Link® software. The drivers are integrated with the Integrated Synergy Development Environment.

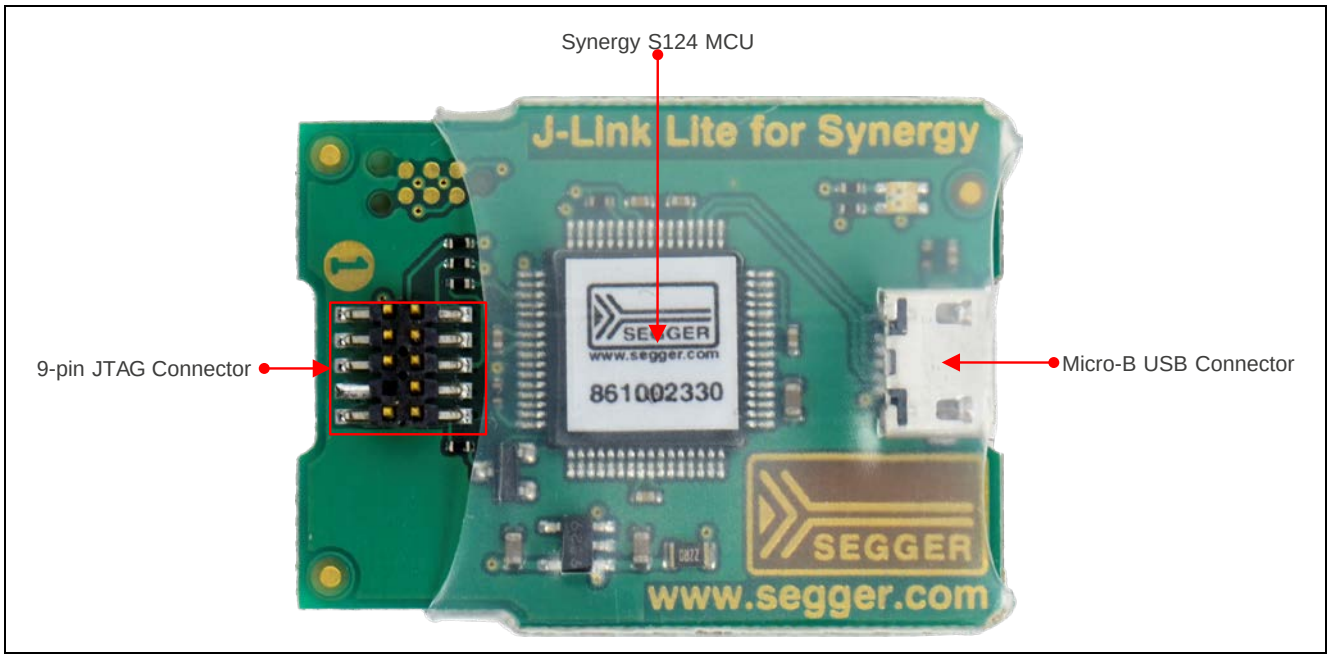


Figure 3 SEGGER J-Link Debug Probe

At the heart of the kit is the board based on the S5D9 Synergy MCU. The picture below shows the main board components, the interface connectors, and their purpose.

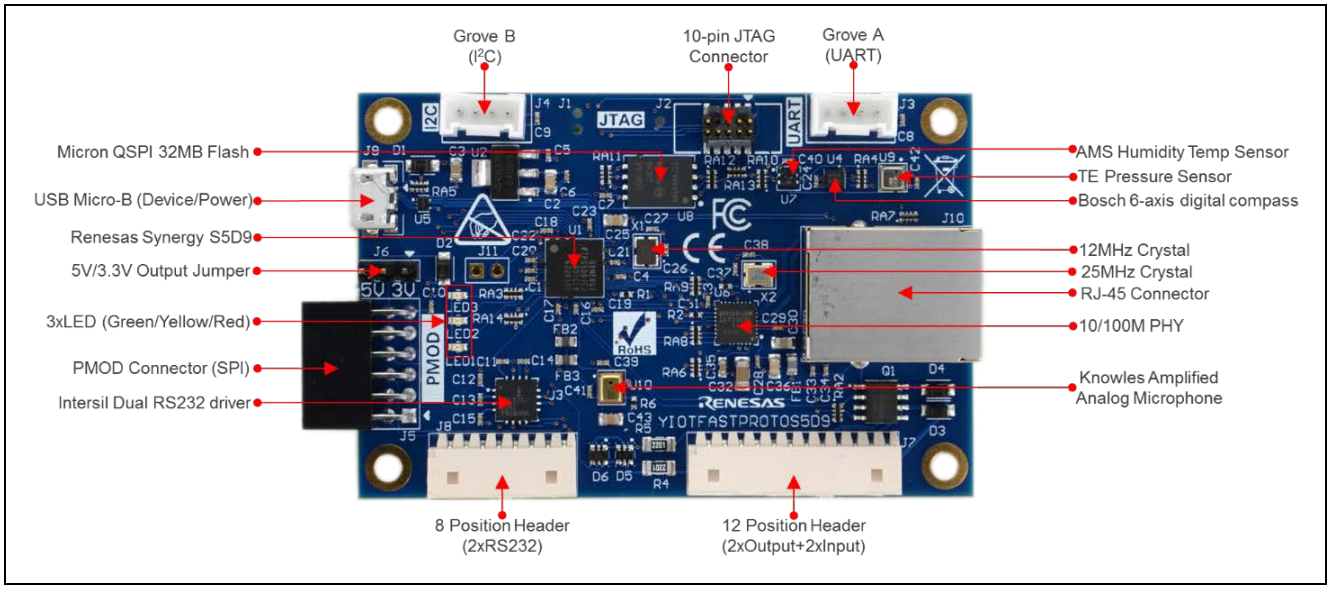


Figure 4 S5D9 Synergy MCU Board Components

1.1 Board Features

- Synergy S5D9 Arm® Cortex®-M4F Core
  - Arm® v7E-M architecture
  - Maximum operating frequency: 120 MHz
  - Secure Crypto Engine
  - Memory Protection Unit
  - Floating Point Unit
  - JTAG debugging interface
- Memory
  - 640 KB RAM
  - 2 MB Code Flash
  - 64 KB Data Flash
  - 32 MB External QSPI Flash
- Connectivity
  - Wired Ethernet (RJ45) 10/100 Mbps
  - USB 2.0 Full Speed
  - UART (through the Seeed Grove connector)
  - I^2C (through the Seeed Grove connector)
  - SPI (through the Digilent PMOD connector)
  - RS232 (dual channel, optional, Intersil ISL3232E)
- Sensors
  - Accelerometer (Bosch BMC150)
  - Environmental (AMS ENS210)
  - Pressure (TE Connectivity MS563702)
  - Acoustic (Knowles MEMS microphone SPU0414HR5H)
- General Purpose I/O Ports
  - Parallel I/O (optional, Diodes Inc. ZXMS6004)
  - User defined LEDs
  - The MCU pins brought to the PMOD and Seeed connectors can be multiplexed as communication or GPIO ports.
- Operating Voltage
  - 5V

2. What's in the Box

The AE-CLOUD1 Kit includes the following components:

- S5D9 Synergy MCU board
- Wi-Fi board
- Debugging probe with 10-wire ribbon cable
- Two USB cables
- *AE-CLOUD1 Quick Start Guide*

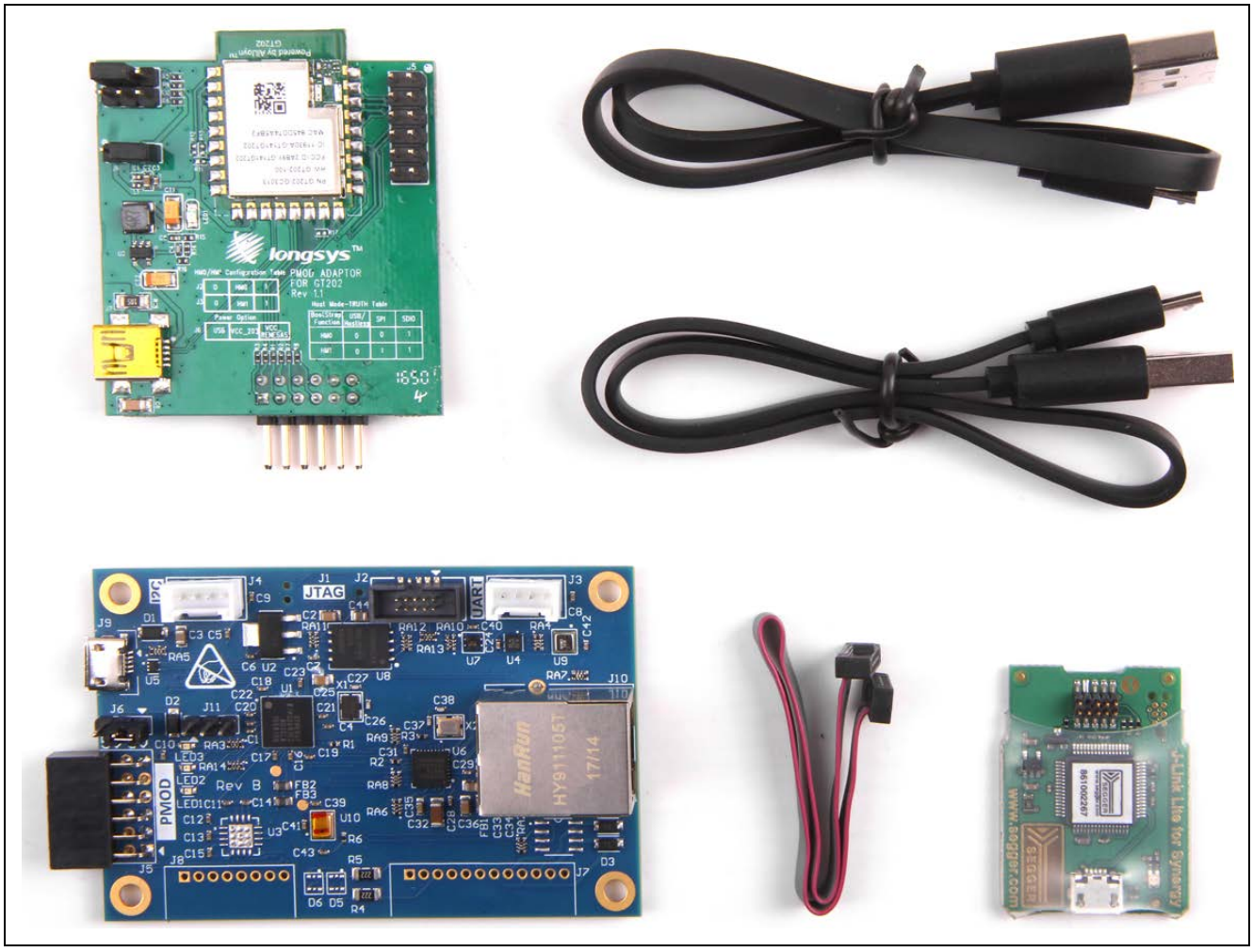


Figure 5 AE-CLOUD1 Synergy MCU Kit Box Content

3. Getting Started

Before you start working with your development board, you must obtain the latest version of the Synergy Software Package (SSP) as well as the development tools needed to work with it.

If you are new to the Renesas Synergy Platform development, download the *AE-CLOUD1 Quick Start Guide* from the Synergy Enterprise Cloud Toolbox Demo Dashboard. This guide will provide detailed instructions on how to register an account on the Renesas Synergy Solutions Gallery to obtain a developer's license, and how to download and install all software & tools that are required. Once you have completed these steps, return to this section for more in-depth information on how to work with your S5D9 Synergy MCU board.

3.1 Jumpers and DIP Switch Settings

The jumper J6 defines the voltage provided by the PMOD connector J5. The default setting is connecting pins 1 and 2 corresponding to 3.3 V.

Table 1 J6 Function

J6 Pins Bridged	Selected Voltage
1 - 2	3.3V (default)
2 - 3	5V

The jumper J11 defines the MCU mode during startup. If pins 1 and 2 are connected then the MCU enters the factory bootloader upon reset.

Table 2 J11 Function

J11 Pins Bridged	Function
1 - 2	Factory bootloader
2 - 3	User defined

3.2 Connecting the Wi-Fi Board

The Wi-Fi Module must be connected to the MCU board as shown in the following figure.

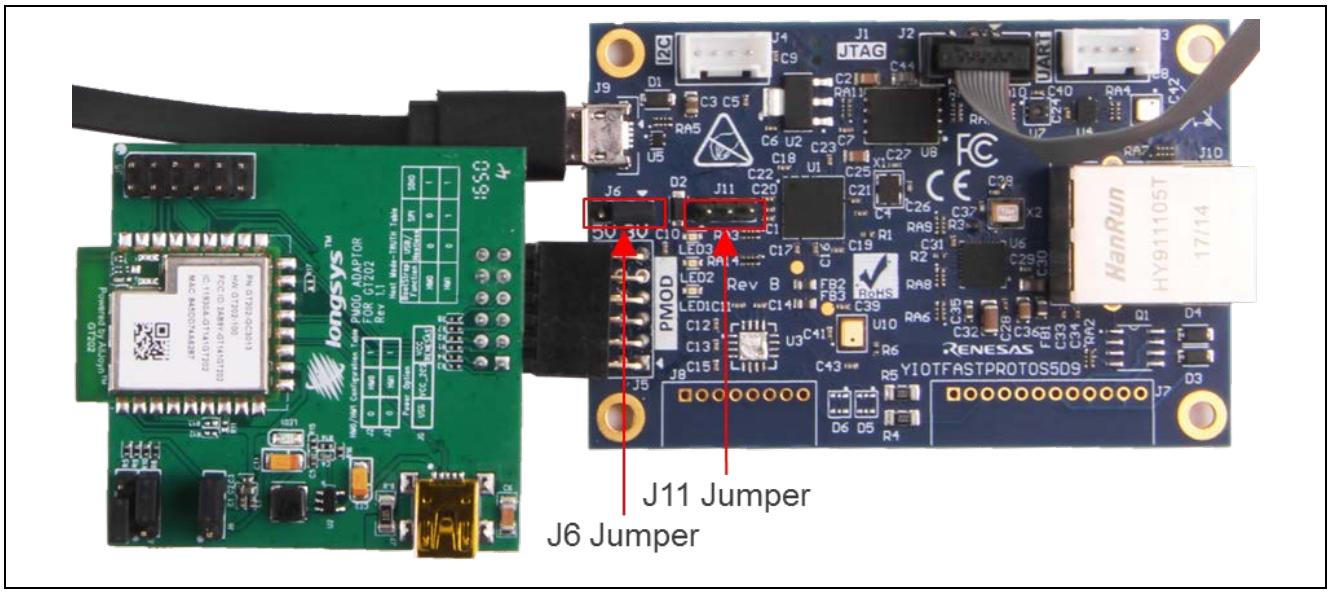


Figure 6 Connecting the Wi-Fi Board

The jumper at J6 header should be bridge pins 1 and 2 to enable 3.3 V power to the PMOD connector.

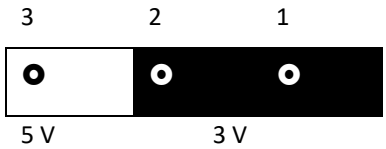


Figure 7 Configuring PMOD Voltage by Jumper J6

4. Wi-Fi Board

The Wi-Fi board is based on the GT202 module. It incorporates the Qualcomm® Atheros QCA4002 device. The QCA4002 is a system on a chip (SoC), implementing the 802.11 b/g/n communication standards. It is optimized for low-power embedded applications with single-stream capability for both transmit and receive streams. The SoC has an integrated network processor with a large set of TCP/IP with IPv4/IPv6-based services. They can be accessed via high-speed SPI interface that is accessible on 12-pin PMOD header.

Table 3 Wi-Fi Board Specifications

Parameter	Value
Size	Area: 24 x 18 x 2.5 mm Height: 3.6 mm
Operating voltage	3.3 V ± 10%
Operating humidity	20-70%
Operating temperature range	10°C ~ +65°C
RF connector	U.FL of Hirose
Host interface	UART, SPI

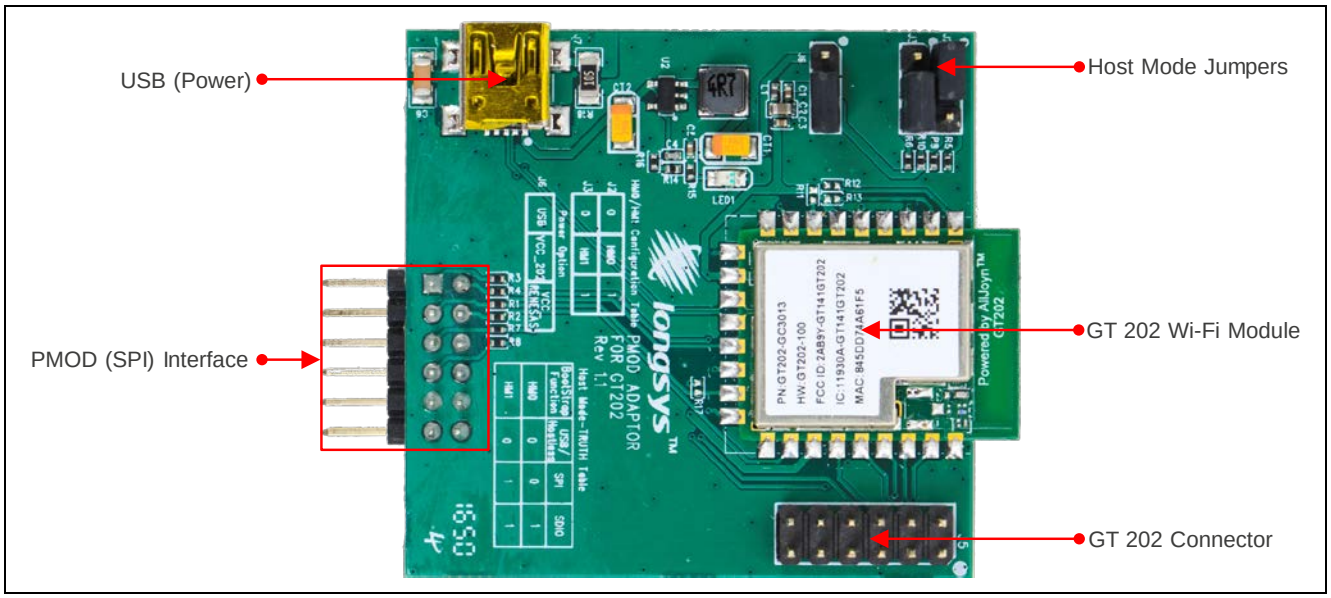


Figure 8 Main Wi-Fi Board Components

4.1 Wi-Fi Board Block Diagram

The following block diagram shows the Wi-Fi board. Its main component is the GT202 module that incorporates the QCA4002 SoC. The power options include USB and PMOD header. The 5 V USB power is regulated to 3.3 V with a step-down converter to 3.3 V. A dedicated jumper is used to select the desired power source.

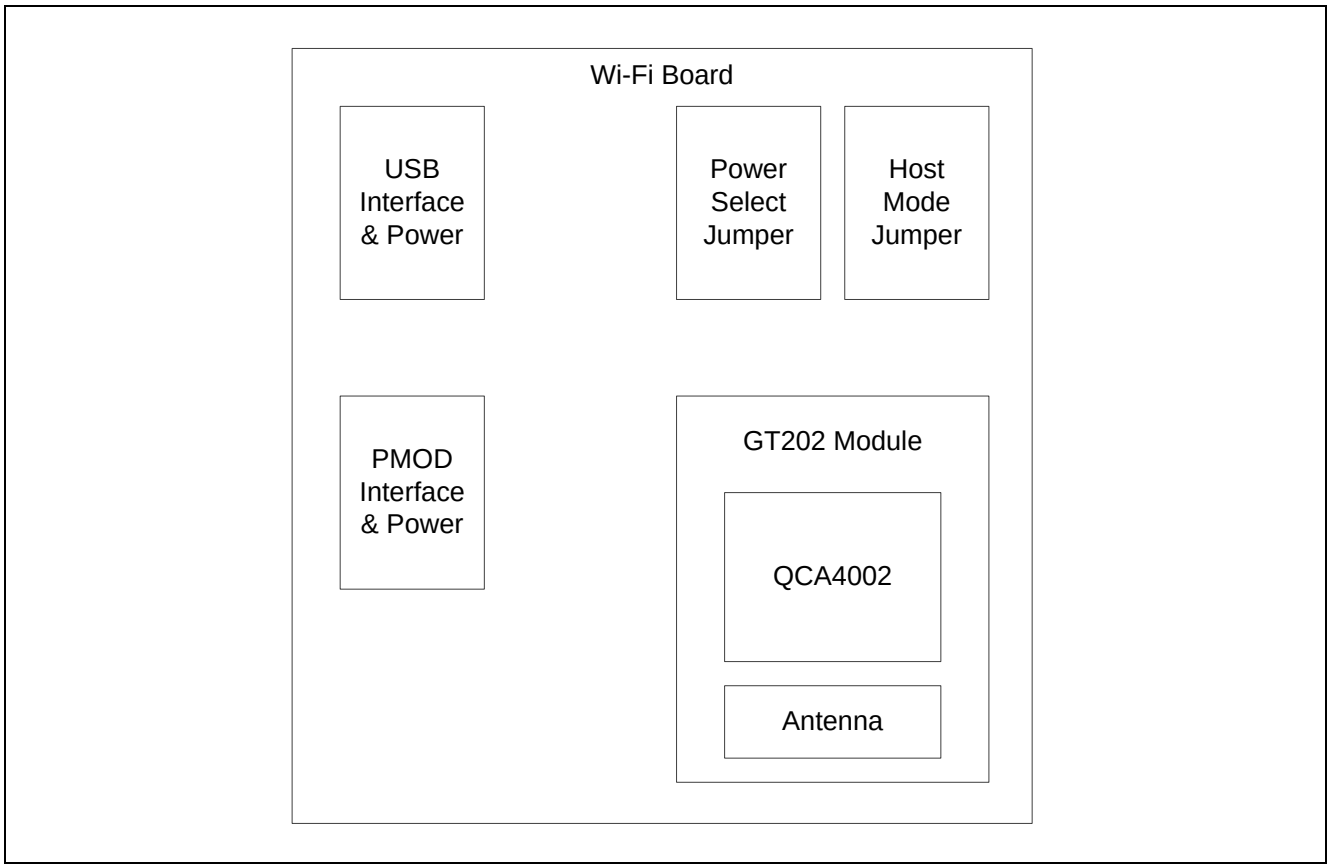


Figure 9 Wi-Fi Board Block Diagram

The GT202 Wi-Fi module integrates the QCA4002 SoC on a carrier board that brings out three different Host connectivity options:

- SPI Interface through the PMOD connector is used for interfacing with the AE-CLOUD1 Synergy MCU board and power supply source. This interface provides fast communication speed and access to the full networking functionality.
- SDIO/UART Interface is used for rapid prototyping and low communication speeds (not utilized by the AE-CLOUD1 Synergy MCU Kit).
- USB Interface/Host-less is used for fast prototyping, diagnostic and alternative power supply (not utilized by the AE-CLOUD1 Synergy MCU Kit).

The Wi-Fi board includes jumpers that configure the desired host connectivity option. The jumper settings that control these options are described in the following table.

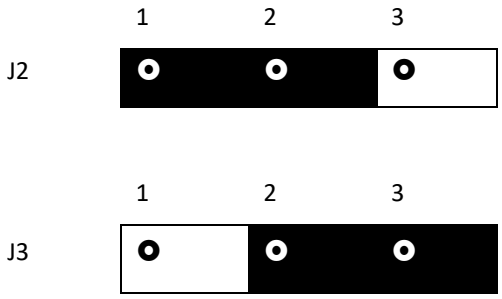
Jumper J2 Bridge Pins	Jumper J3 Bridge Pins	Communication Interface
1 - 2	1 - 2	USB
1 - 2	2 - 3	SPI (Default)
2 - 3	2 - 3	SDIO/UART

The power selection jumper setting is described in the following table.

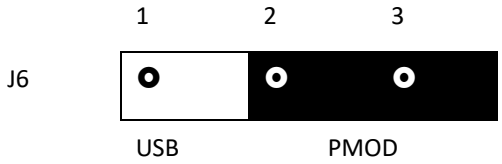
Jumper J6 Bridge Pins	Power Source
1 - 2	USB
2 - 3	PMOD (Default)

The following settings are required for the operation of the AE-CLOUD1 Synergy MCU Kit.

Host mode jumpers (J2 and J3) to select SPI communication interface.



Power selection jumper (J6) to select PMOD.



Wi-Fi board PMOD connector pinout is described in the following table. Since the PMOD specification allows for configurable voltage, make sure the host is configured to deliver 3.3 V.

Table 4 PMOD Pin Map

Pin	Function	Pin	Function
1	CS	7	Interrupt (Out)
2	MOSI	8	Power Down (In)
3	MISO	9	N.C.
4	CLK	10	N.C.
5	GND	11	GND
6	3.3V	12	3.3V

4.2 Wi-Fi Board Schematic

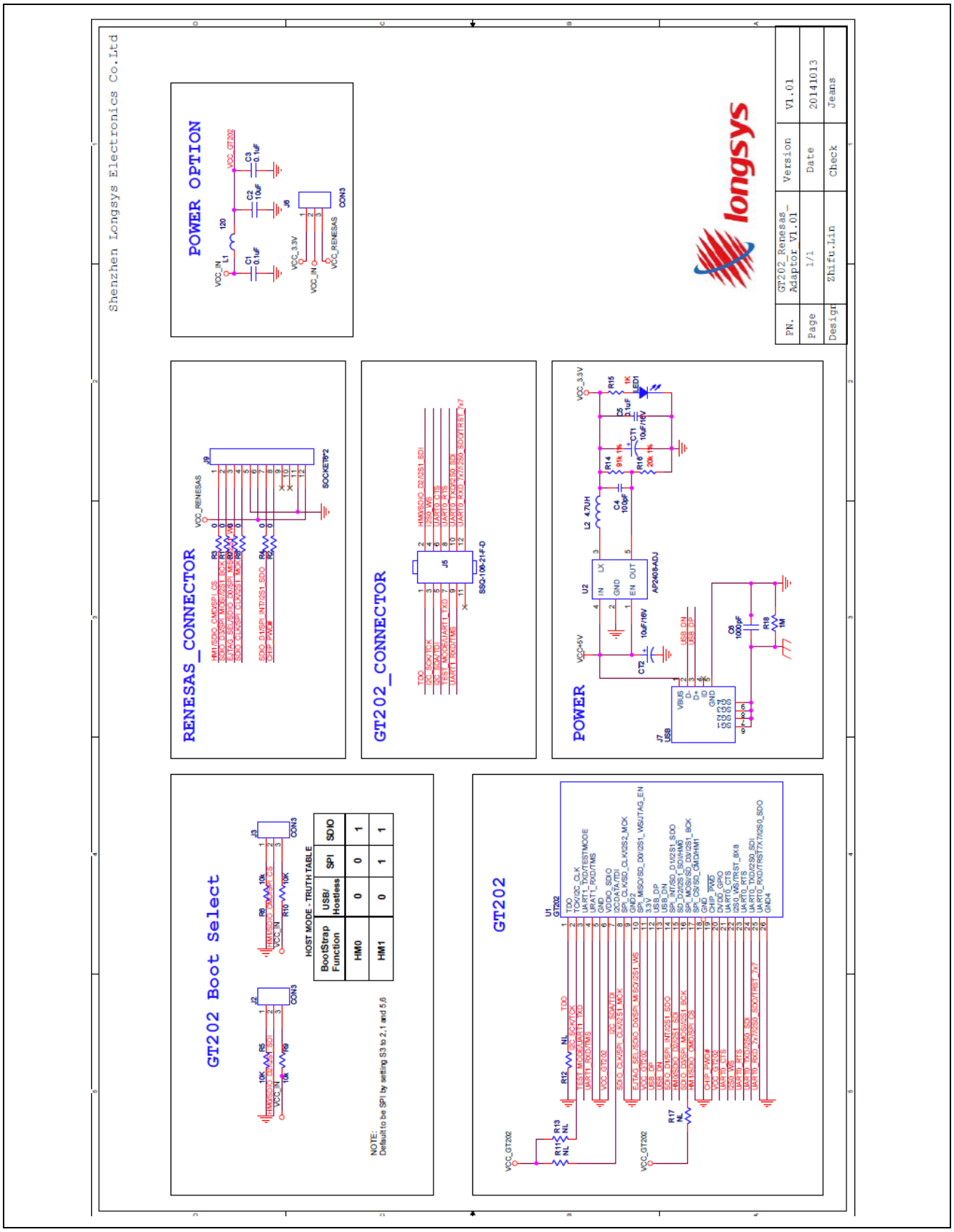


Figure 1 Wi-Fi Board Schematic

5. S5D9 Synergy MCU Board

5.1 System Block Diagram

The following figure shows the AE-CLOUD1 Synergy MCU system block diagram. It includes the possible interfaces and their connections to external components.

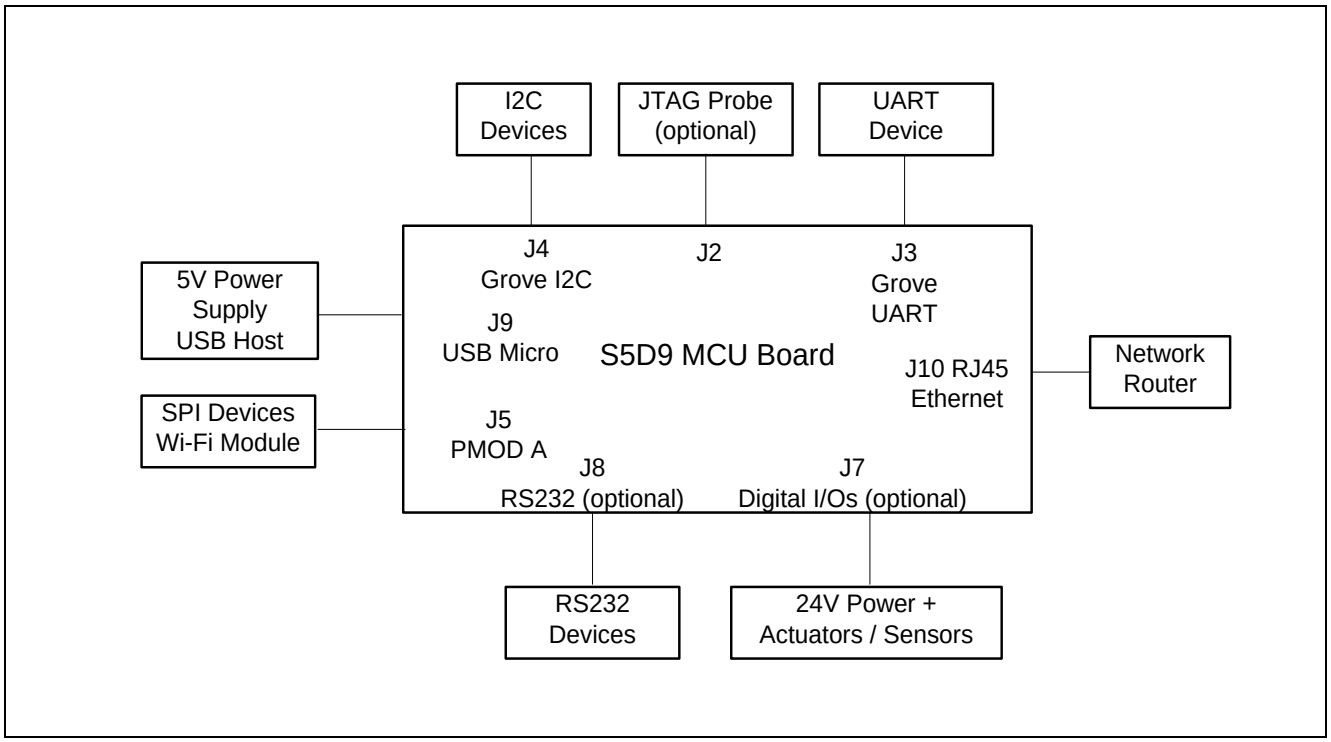


Figure 10 System Block Diagram

The following figure shows the S5D9 Synergy MCU board block diagram. It includes the main components and their functions.

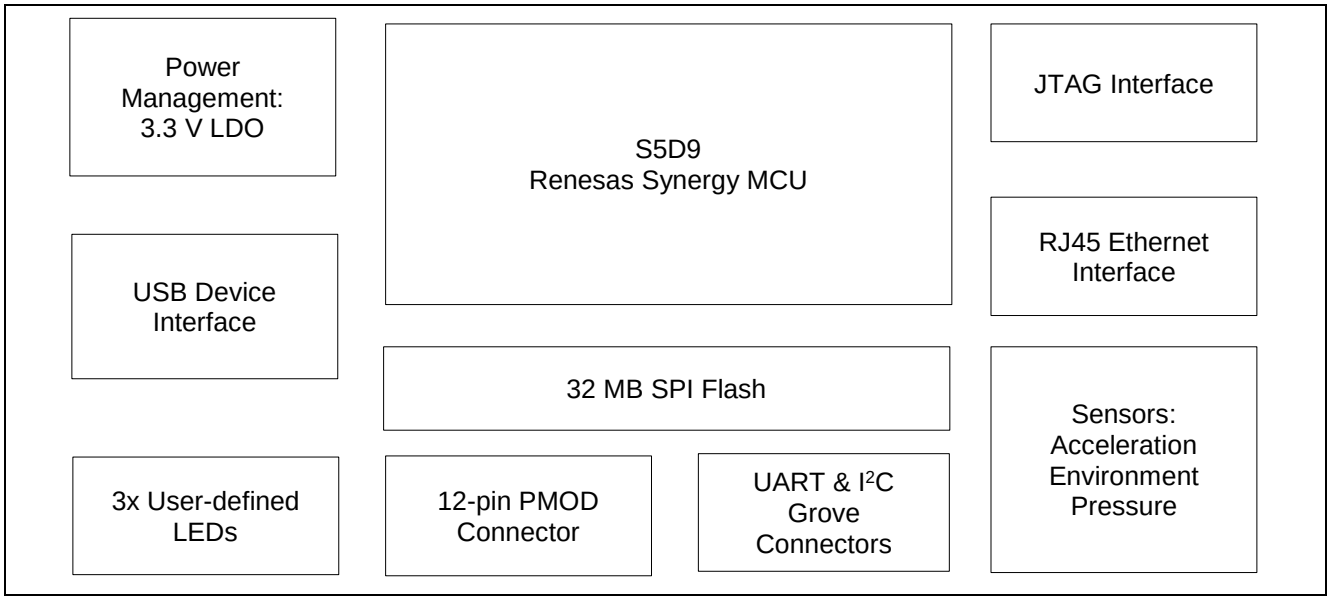


Figure 11 S5D9 Synergy MCU Board Block Diagram

The S5D9 Synergy MCU board includes the following main components:

- The S5D9 Synergy MCU board
- A power management based on 3.3 V LDO voltage regulator required for the operation of the microcontroller.
- Quad SPI Flash – the MCU flash memory is expanded with an external 32 MB memory device connected over a high-speed QSPI interface. The external flash can be used for storage of graphics and other digital assets, or for execution of code in place (XIP).
- User-defined LEDs – the user-defined LEDs are useful in indicating the current state of the firmware. The 3 LEDs have different colors for easy identification.
- USB device interface – the S5D9 Synergy MCU includes one USB interface operating in Full Speed. The USB device connector is used to power the board.
- PMOD interface header – the board includes one 12-pin PMOD header that can be configured by jumper to provide either 3.3 V or 5 V on its power pins. The header enables interfacing with other devices over SPI or UART.
- Grove Connectors – the Grove Connectors are compatible with the Seeed Studio's line of peripheral modules that include a very large selection of sensors and actuators. One of the Grove connectors can be configured to communicate over UART and the other is dedicated for I^2C interface.
- JTAG interface that is available on a 10-pin connector, J20 compatible with SEGGER debugging probe.
- The board includes many sensors described in detail in section 5.3.

5.2 Power Requirements

The AE-CLOUD1 Synergy MCU is designed to be powered by the USB interface. The optional digital I/O interface requires external power supply.

The S5D9 Synergy MCU board can supply power to the devices connected to it. The PMOD interface has configurable (by J6) power supply 3.3 V or 5 V. The power provided through the Grove Connectors is 3.3 V only.

The power supply requirements and current consumption specifications are listed in the following table.

Table 5 Electrical Specifications

Parameter	Value	
	Minimum	Maximum
Required Logic Power Voltage	3.7 V	5.5 V
Current Consumption		300 mA
Digital Outputs Drive Capability		1 A
Digital Inputs Voltage	5 V	24 V
Operating Temperature	0 °C	+75 °C
PMOD Connector Power Voltage	3.3 V	5 V
Grove Connectors Power Voltage	3.3 V	

5.2.1 Power Supply Options

The power supply source is the J9 - USB Micro-B connector providing 5 V and up to 500 mA of power.

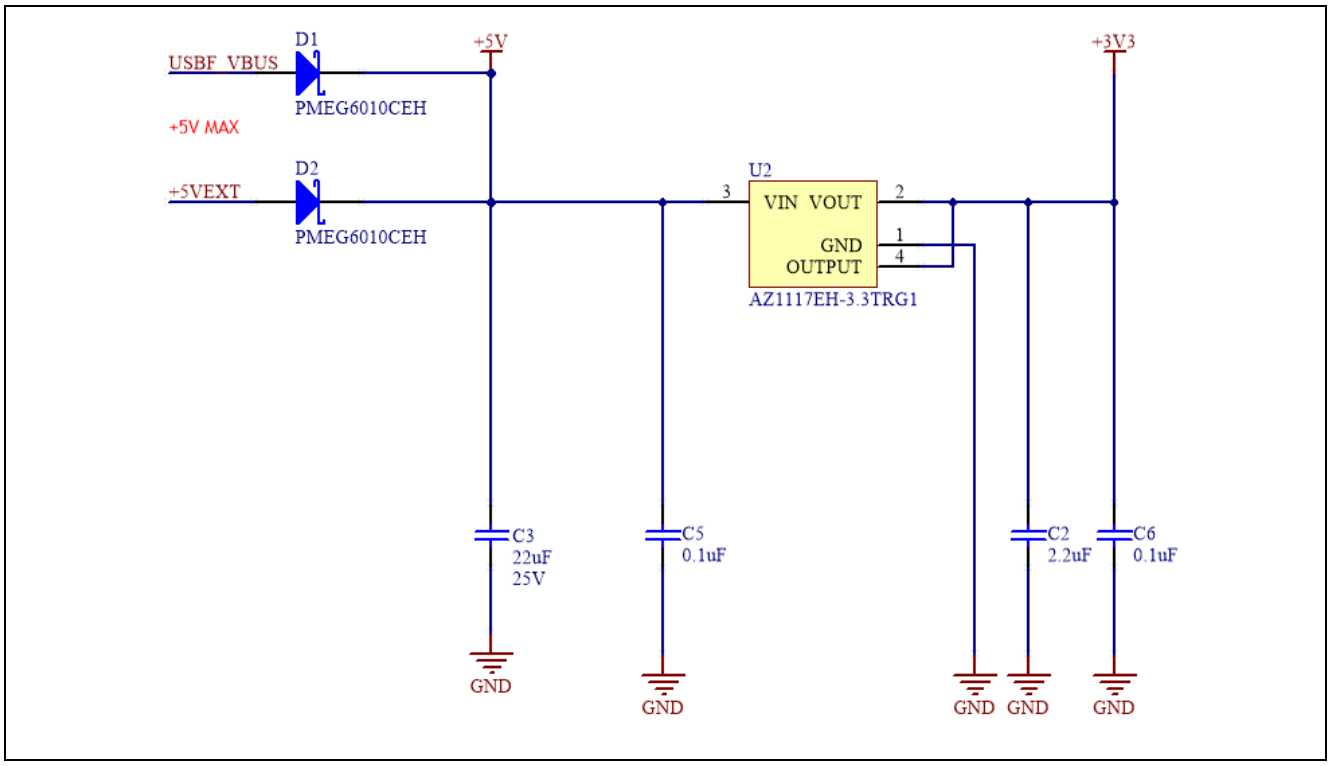


Figure 12 Power Supply Management

There are Schottky diodes provided in series with the power source. This protects them from overload in case both are connected and one has higher voltage than the other.

Alternatively, the 5 V power could be provided through the J7 connector, pins 1 (VCC) and 2 (GND) or through the J8 connector, pins 1 (VCC) and 2 (GND). The following figure shows two power supply alternatives.

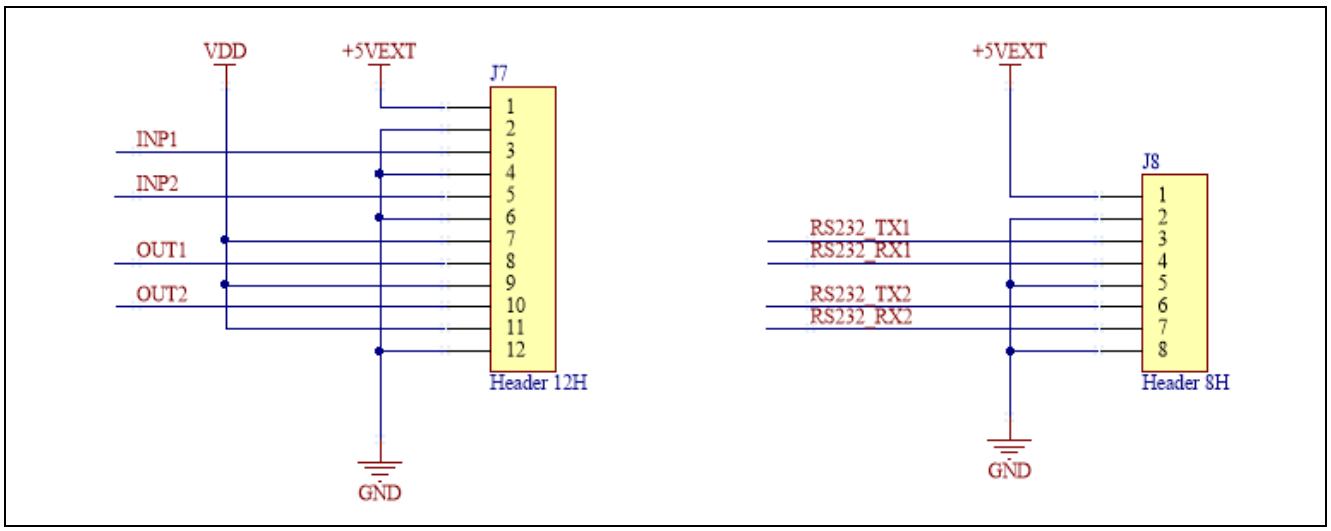


Figure 13 Auxiliary Power Supply

5.2.2 Power-up Behavior

Upon power up, the MCU is idle until its RESET pin registers transition to logic 1. The MCU hardware samples the logic level of the MD pin. The level determines if the MCU will enter **Factory Boot Mode**. In this mode, the MCU executes an internal firmware code that initializes the USB interface and prepares the device to communicate with utilities that can update the content of its memory.

The state of the MD pin at startup is defined by J11. If there is a jumper installed between pins 1 and 2 of J11 then the factory bootloader will execute on startup.

5.3 Major Components

On-Board Sensors

- **Accelerometer and Magnetometer**: Bosch Sensortec - BMC150 (U4)
  - BMC150 is an extremely small low power and low noise 6-axis digital compass. It measures the earth's geomagnetic field as well as dynamic and static acceleration in all three dimensions and outputs tilt-compensated heading or orientation information.
  - The integrated accelerometer provides all functionalities of Bosch Sensortec's leading-edge 12-bit digital accelerometer, including a 32 frame FIFO buffer storing acceleration data.
  - The interface to the MCU is based on the I^2C protocol. The sensor has hard coded individual addresses:
    - Accelerometer = 0x11
    - Magnetometer = 0x13
  - Connected to MCU I^2C Channel 2 with pins configured to use Port 5 bits 11 and 12:
    - Data (SDA) = P5_11
    - Clock (SCL) = P5_12
- **Humidity and Temperature Sensor:** AMS Inc. - ENS210 (U7)
  - ENS210 integrates one relative humidity sensor and one high-accuracy temperature sensor.
  - The sensor provides ultra-accurate readings with precision of 0.2° C temperature and 3.5% Relative Humidity. It is pre-calibrated and outputs data directly in Kelvin and %RH units.
  - The interface to the MCU is based on the I^2C protocol. The sensor has hard coded address on the I^2C Bus: 0x43
  - Connected to MCU I^2C Channel 2 with pins configured to use Port 5 bits 11 and 12:
    - Data (SDA) = P5_11
    - Clock (SCL) = P5_12
- **Altimeter (Pressure) and Temperature Sensor**: TE Connectivity - MS563702BA03-50 (U9)
  - The MS5637 is an ultra-compact micro altimeter and precision thermometer. The sensor module includes a high-linearity pressure sensor and an ultra-low power 24-bit ΔΣ ADC with internal factory-calibrated coefficients. It provides a precise digital 24-bit pressure and temperature value and different operation modes that allow you to optimize for conversion speed and current consumption.
  - The interface to the MCU is based on the I^2C protocol. The sensor has a hard-coded address on the I^2C Bus: 0x76
  - Connected to MCU I^2C Channel 2 with pins configured to use Port 5 bits 11 and 12:
    - Data (SDA) = P5_11
    - Clock (SCL) = P5_12
- **MEMS Microphone**: Knowles SPU0414HR5H-SB-7 (U10)
  - The SPU0414HR5H-SB is a miniature, high-performance, low power, top port silicon microphone. It consists of an acoustic sensor, a low noise input buffer, and an output amplifier.
    - The device has the following main features:
    - 20 dB of Gain
    - Low current consumption
    - MaxRF protection
    - Ultra-stable performance
    - Omnidirectional
  - The microphone output is wired to MCU ADC Channel 1 (P0_1)

Table 6 Summary of the Sensors and their MCU Interface

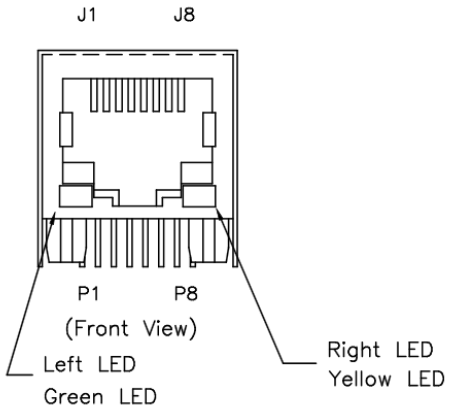
Sensor	I^2C MCU Ch#2 Bus Address	ADC Channel #	Manufacturer
BMC150 Accelerometer	0x11	N/A	Bosch
BMC150 Magnetometer	0x13		
ENS210 Humidity and Temperature	0x43		AMS
MS563702	0x76		TE Connectivity
SPU0414 Microphone	N/A	1 (P0_1)	Knowles

5.4 Connectivity and Settings

RJ45 Ethernet Connector

The S5D9 Synergy MCU features standard Ethernet connector RJ45 with built-in magnetics. It is connected to Micrel PHY interface P/N: KSZ8081RNB. The PHY is connected to the MCU via RMII interface.

The RJ45 connector is Hanrun Electronics Ltd. P/N: HY911105. Its front view is shown on the following figure.



The pin mapping of the connector matches the standard for Ethernet ports.

Table 7 Ethernet RJ45 Pin Map

Pin	RJ45 Ethernet Port
1	TX+
2	TX-
3	RX+
4	Neutral
5	Neutral
6	RX-
7	Neutral
8	Neutral

PMOD Connector

The S5D9 Synergy MCU board includes one PMOD connector. It can interface with modules that require UART, I^2C, or SPI interface. The function of the PMOD is dependent on the MCU pin functions initialization. The PMOD connector pin map is shown in the following table.

Table 8 PMOD Pin Functions

Pin	**PMOD D**
1	SSLB0/CTS9 – P2_5
2	MOSI/TXD9 – P2_3
3	MISO/RXD9 – P2_2
4	RSPCK/SCK9 – P2_4
5	GND
6	J6 defined 3.3/5V
7	GPIO – P7_8/IRQ11
8	GPIO – P2_6/SSLB1_A
9	GPIO – P2_7/SSLB2_A
10	GPIO – P8_1
11	GND
12	VCC (3.3V or 5V)

The PMOD connector has a selectable power voltage provided by the J6 header. The jumper position for each voltage option is described in the following table:

Table 9 PMOD Voltage Selection

Pins	Selected Voltage
1 - 2	3.3V
2 - 3	5V

The following figure shows the wiring of the PMOD interface schematic.

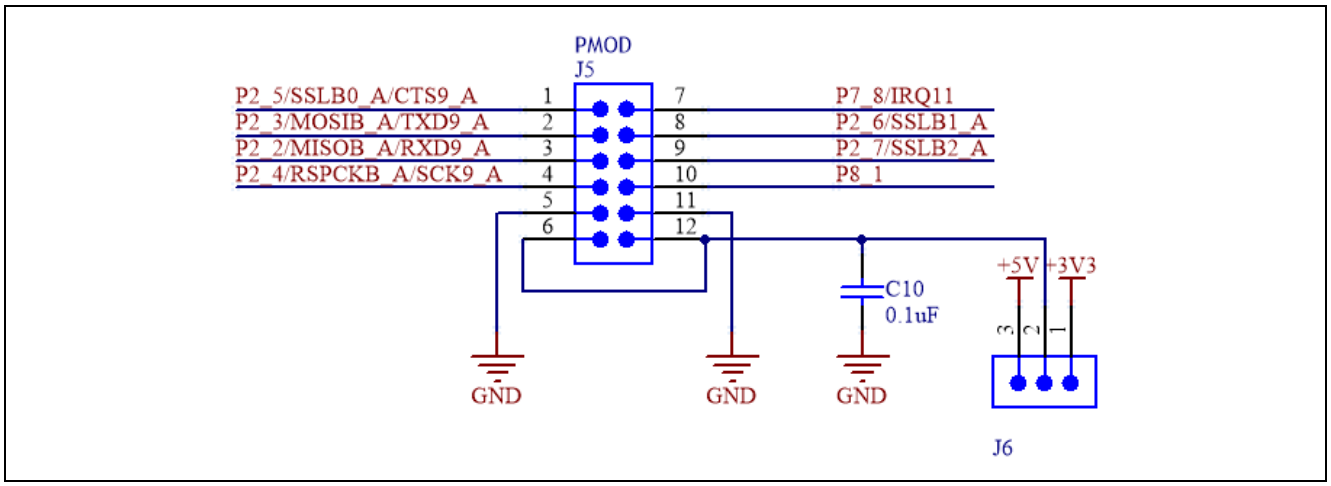


Figure 14 PMOD Interface Schematic

Grove A and B Connectors

The Grove Connectors offer the following interfaces:

- UART interface (Grove A)
- I^2C interface (Grove B)

The pin-mapping of the connectors is described in the following table:

Table 10 Grove Connectors

Pins	Grove A (UART)	Grove B (I^2C)
1	P4_10/RXD0	P1_0/SCL1
2	P4_11/TXD0	P1_1/SDA1
3	3.3 V	3.3 V
4	GND	GND

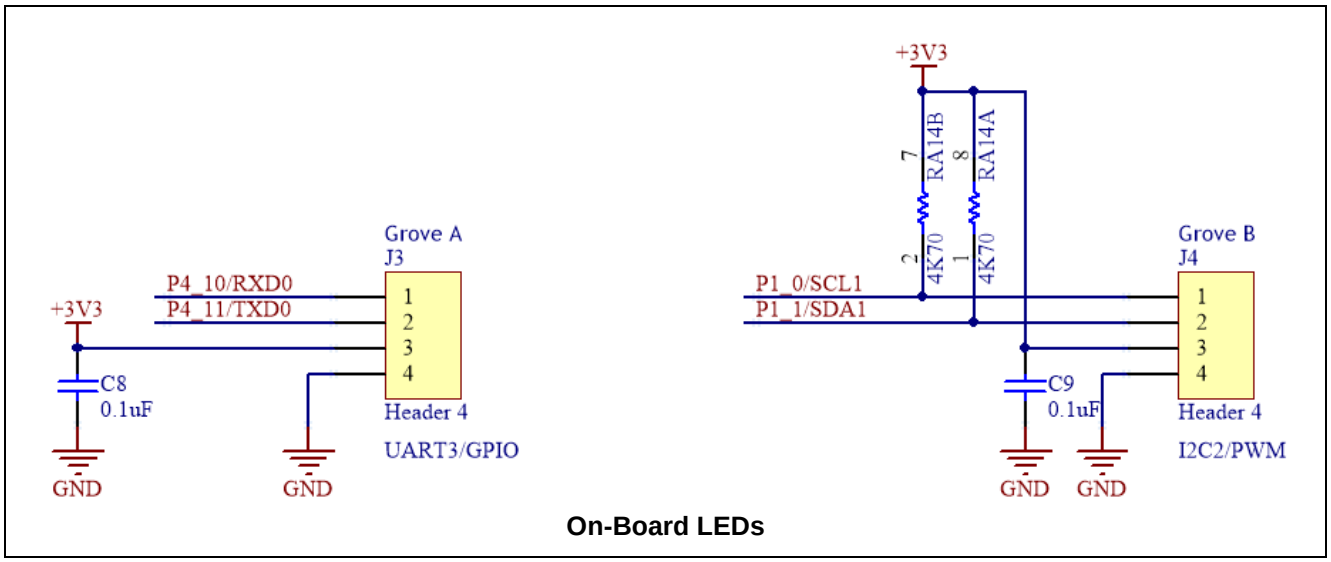


Figure 15 Grove Connectors Schematic

The S5D9 Synergy MCU board provides three on-board LEDs for user-defined functions. They are connected to general purpose output pins through a single resistor. The output active state is one. When set, it turns the LED on. The following table describes the mapping between the LEDs and the ports that drive them.

Table 11 LED Port Map

LED	Color	Designator	Device Port/Pin
0	Green	LED1	P1_2
1	Yellow	LED2	P1_3
2	Red	LED3	P1_13

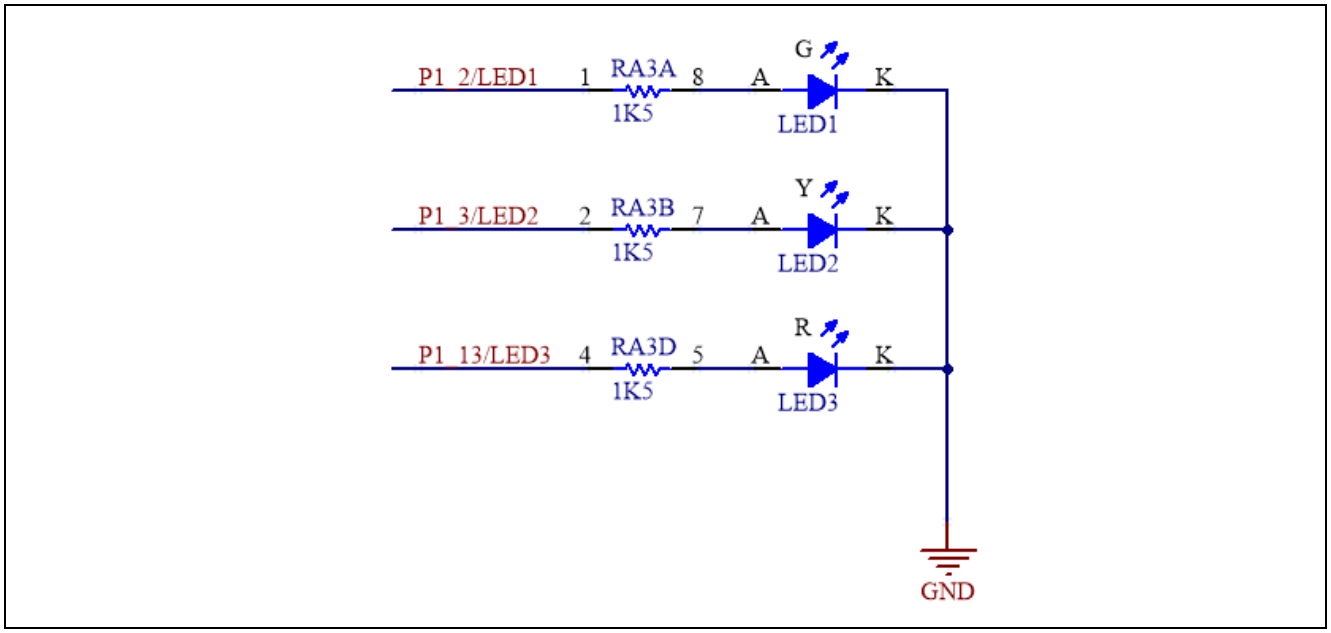


Figure 16 LED Schematic

USB Device

This USB Micro-B connection jack connects the S5D9 MCU to an external USB 2.0 Host, Full Speed capable.

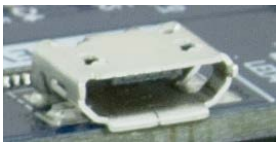


Table 12 USB Device Connector (J14)

USB Device Connector		S5D9 Microcontroller	
Pin	**Description**	**Pin**	**Function**
1	VBUS, +5VDC	P4_7/USB_VBUS	USB voltage detection
2	Data-	USB_DM	Negative data line
3	Data+	USB_DP	Positive data line
4	USB ID, jack internal switch, cable inserted	-	(Not connected)
5	Ground	VSS	Circuit Ground

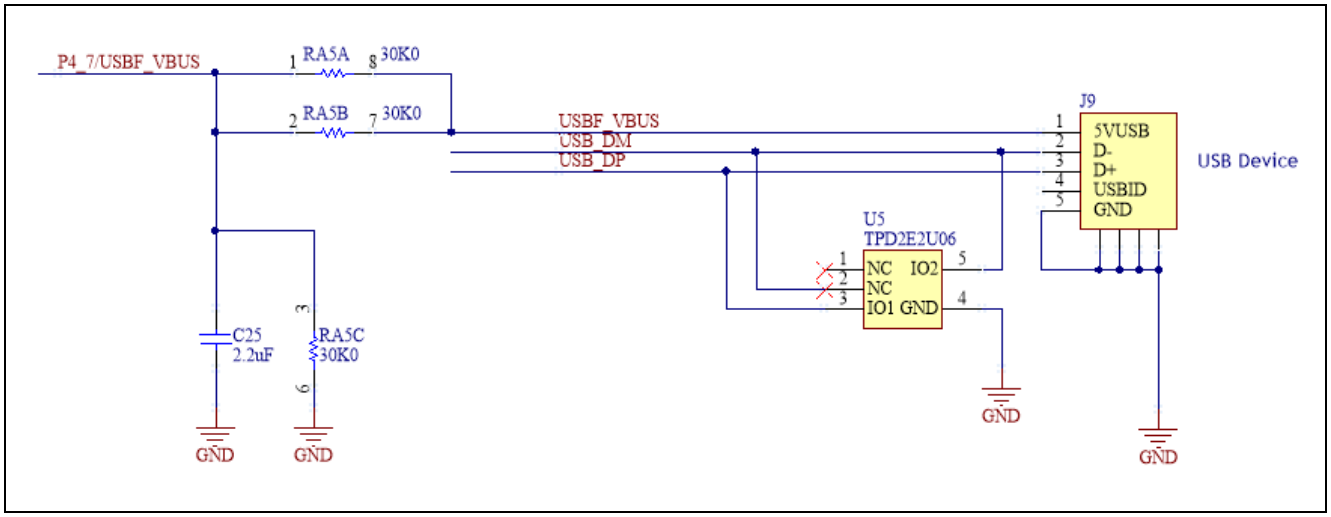
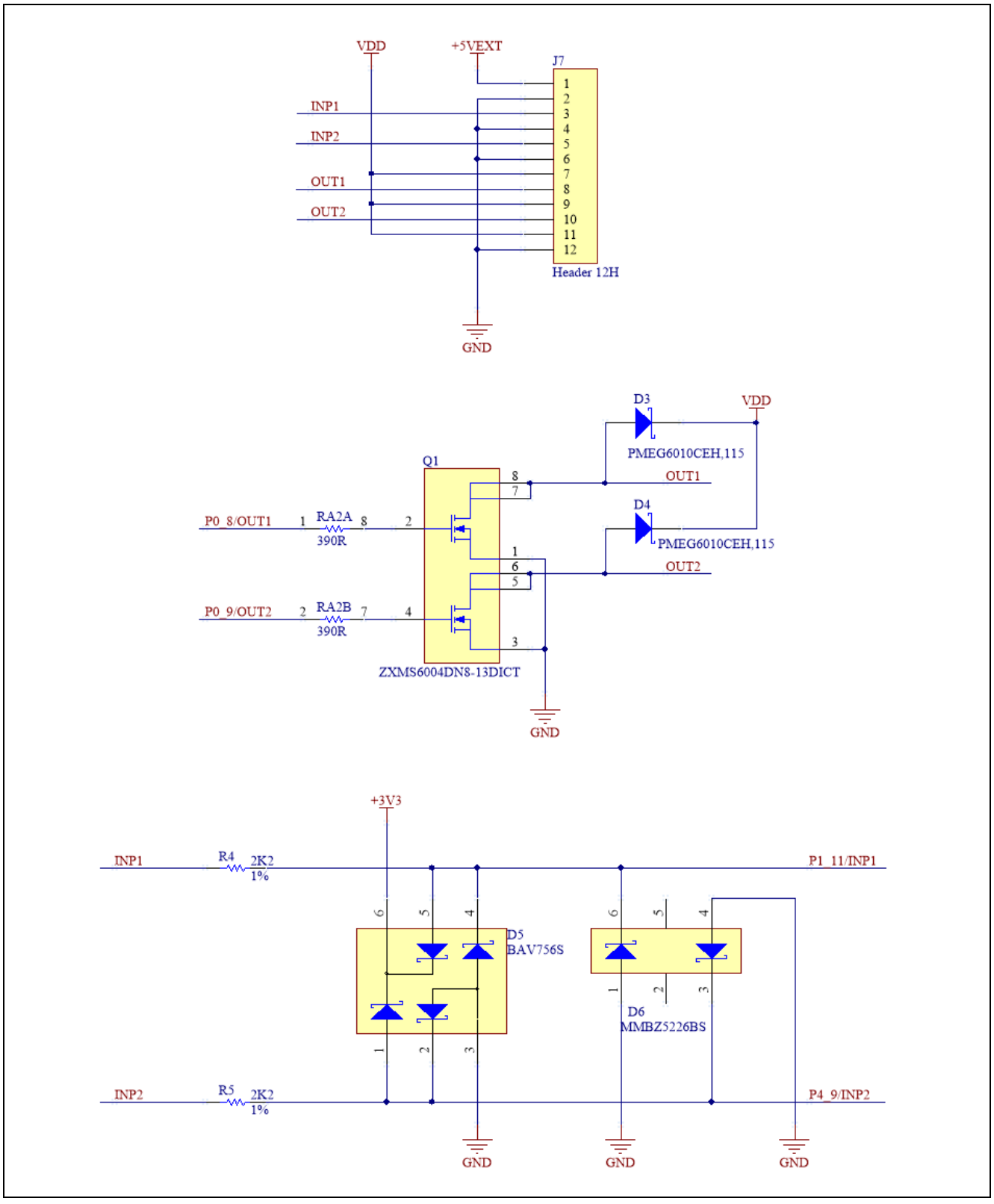


Figure 17 USB Interface

Expansion Connectors

The S5D9 Synergy MCU board includes 24 V tolerant interface to digital inputs as well as dual MOSFETs suitable to drive inductive loads such as solenoids with up to 1A rated current. The schematic below shows the circuits related to these interfaces.



The following table shows the mapping between the digital inputs, outputs and the matching MCU pins used for interfacing to them.

Table 13 24 V-Tolerant Digital Input and Output Map

Molex MicroBlade Connector J7	Pin Type	MCU Pins
0	Power +5V	
1	Ground	
2	Red	
3	Input – INP1	P1_11
4	Ground	
5	Input – INP2	P4_9
6	Ground	
7	Power +24V	
8	Output – OUT1	P0_8
9	Power +24V	
10	Output – OUT2	P0_9
11	Power +24V	
12	Ground	

Another expansion connector provides access to dual RS232 interface transceiver. The two serial interface channels are available on connector J8.

Table 14 Dual RS232 Pin Map

Molex MicroBlade Connector J8	Pin Type	MCU Pins	MCU UART Port
1	Power +5V		
2	Ground		
3	TX1	P3_2/TXD2	SCI Ch.2
4	RX1	P3_1/RXD2	
5	Ground		
6	TX2	P6_13/TXD7	SCI Ch.7
7	RX2	P6_14/RXD7	
8	Ground		

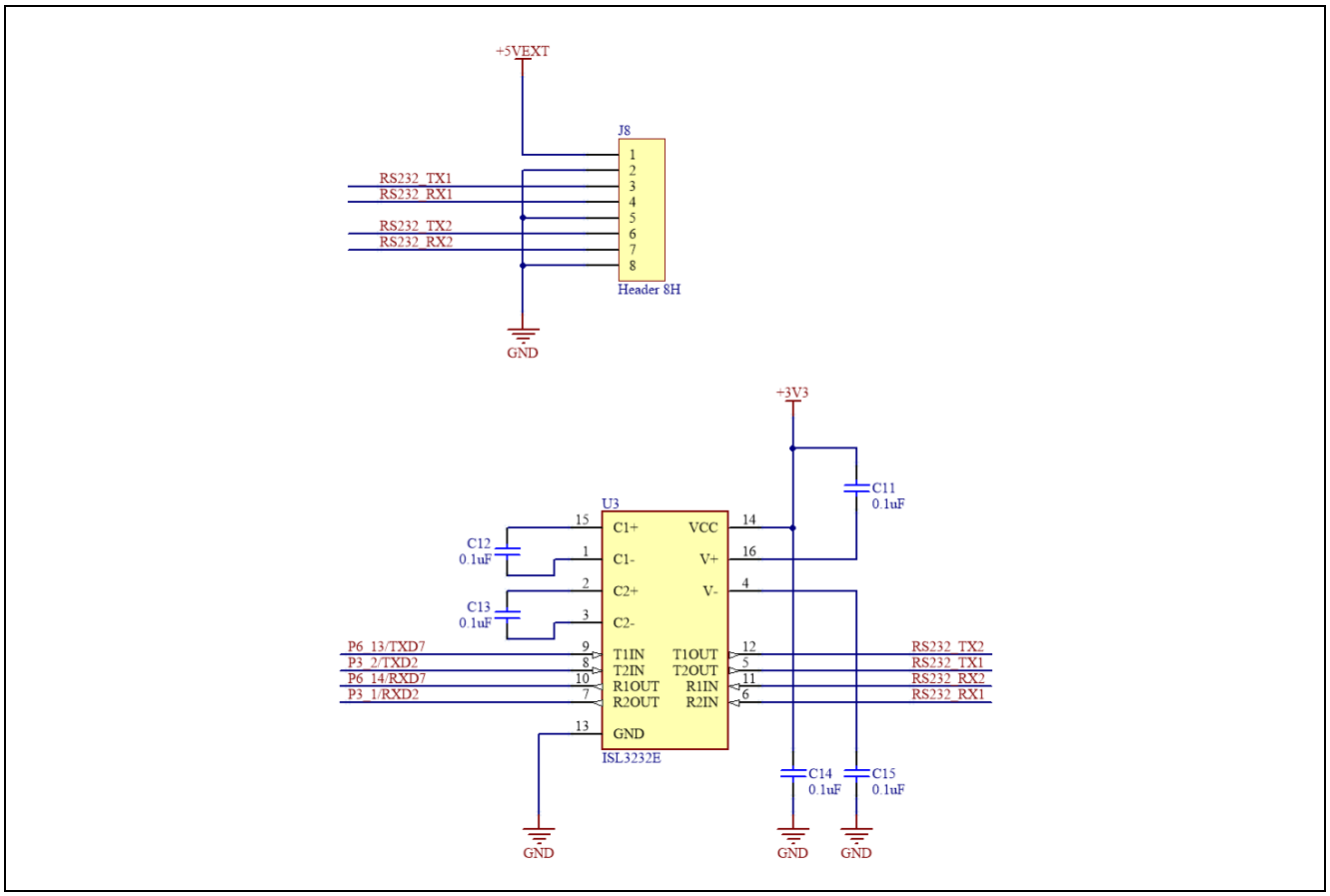
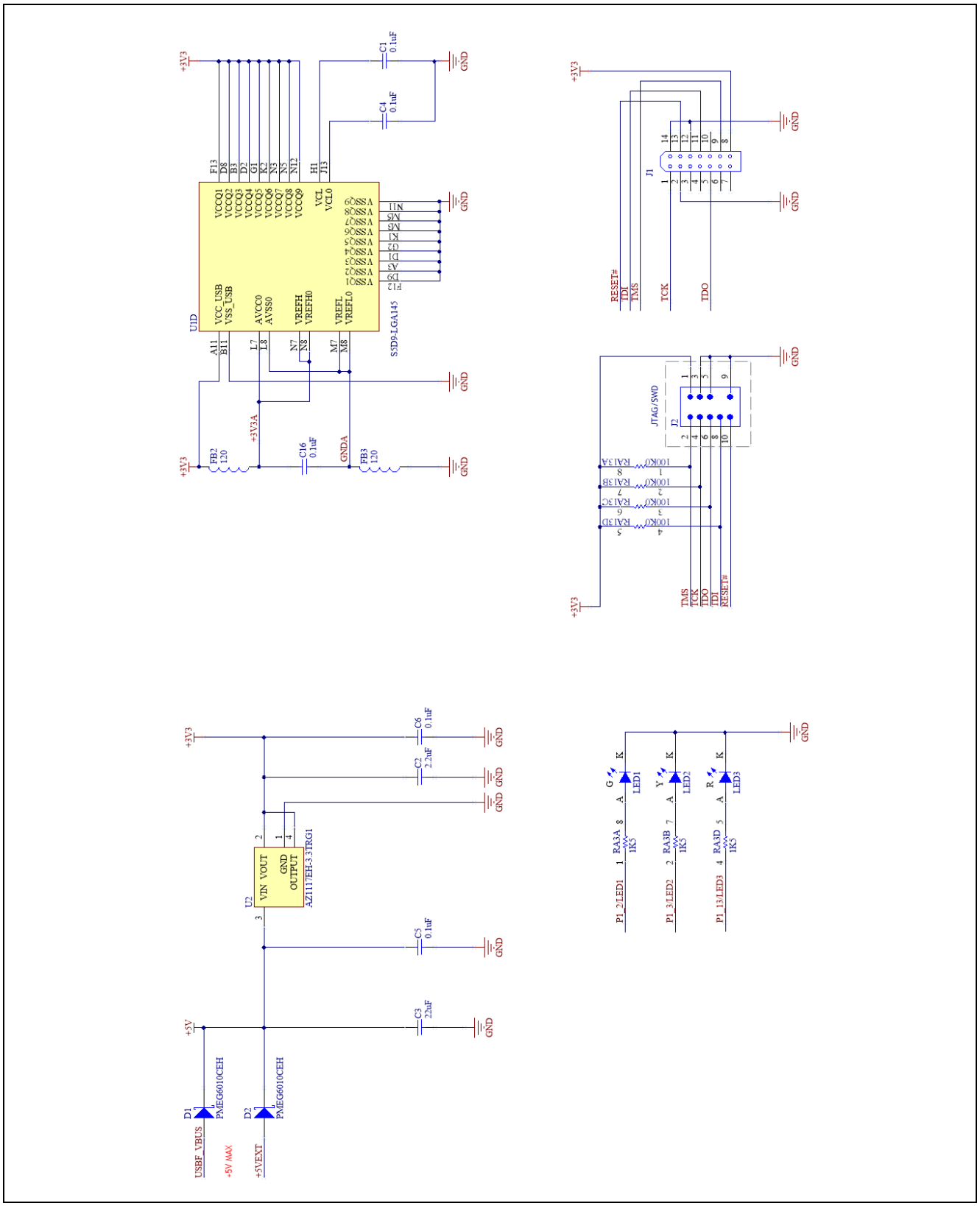


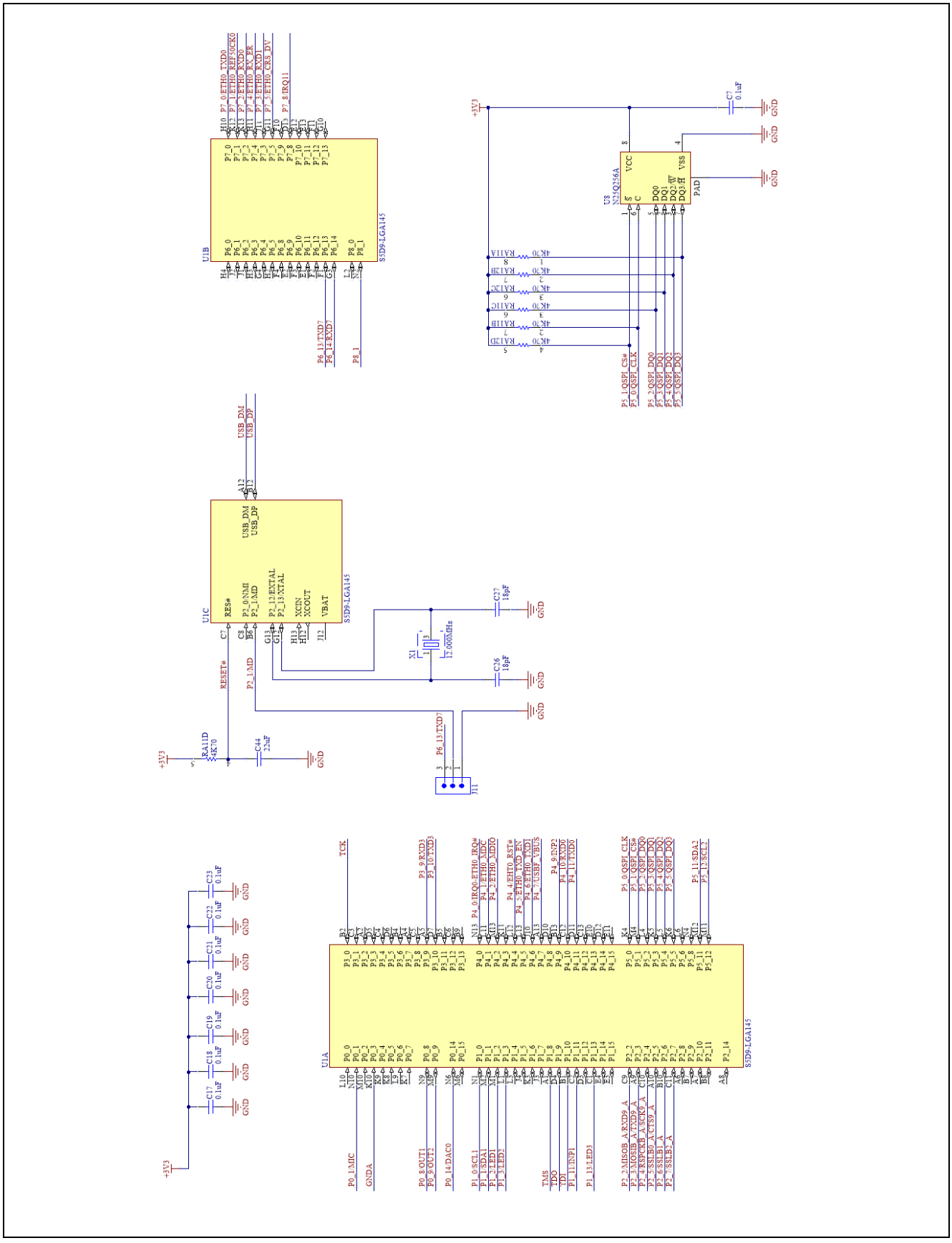
Figure 2 Dual RS232 Interface Schematic

6. Electrical Schematics

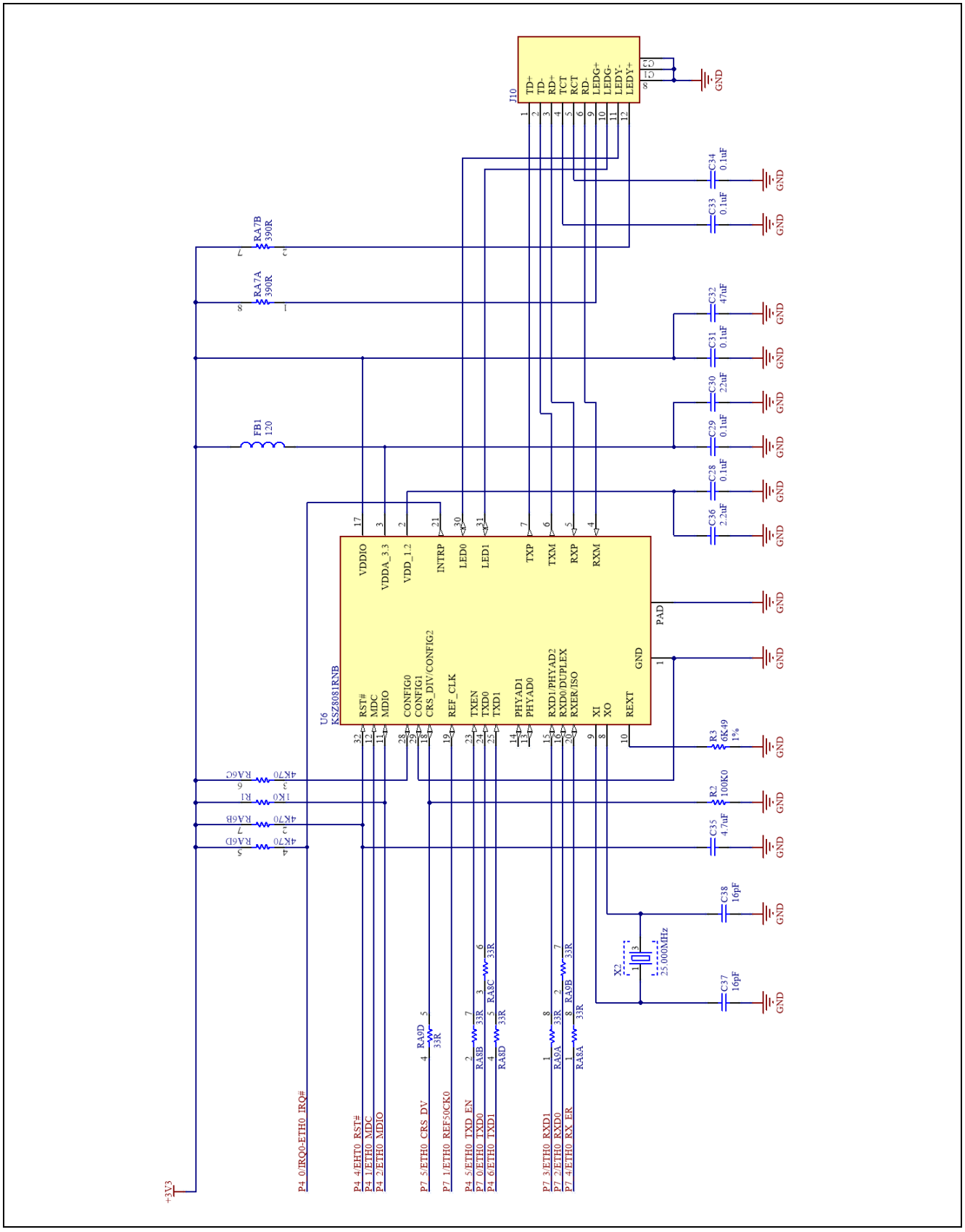
Power Supply, JTAG Interface, User LEDs.



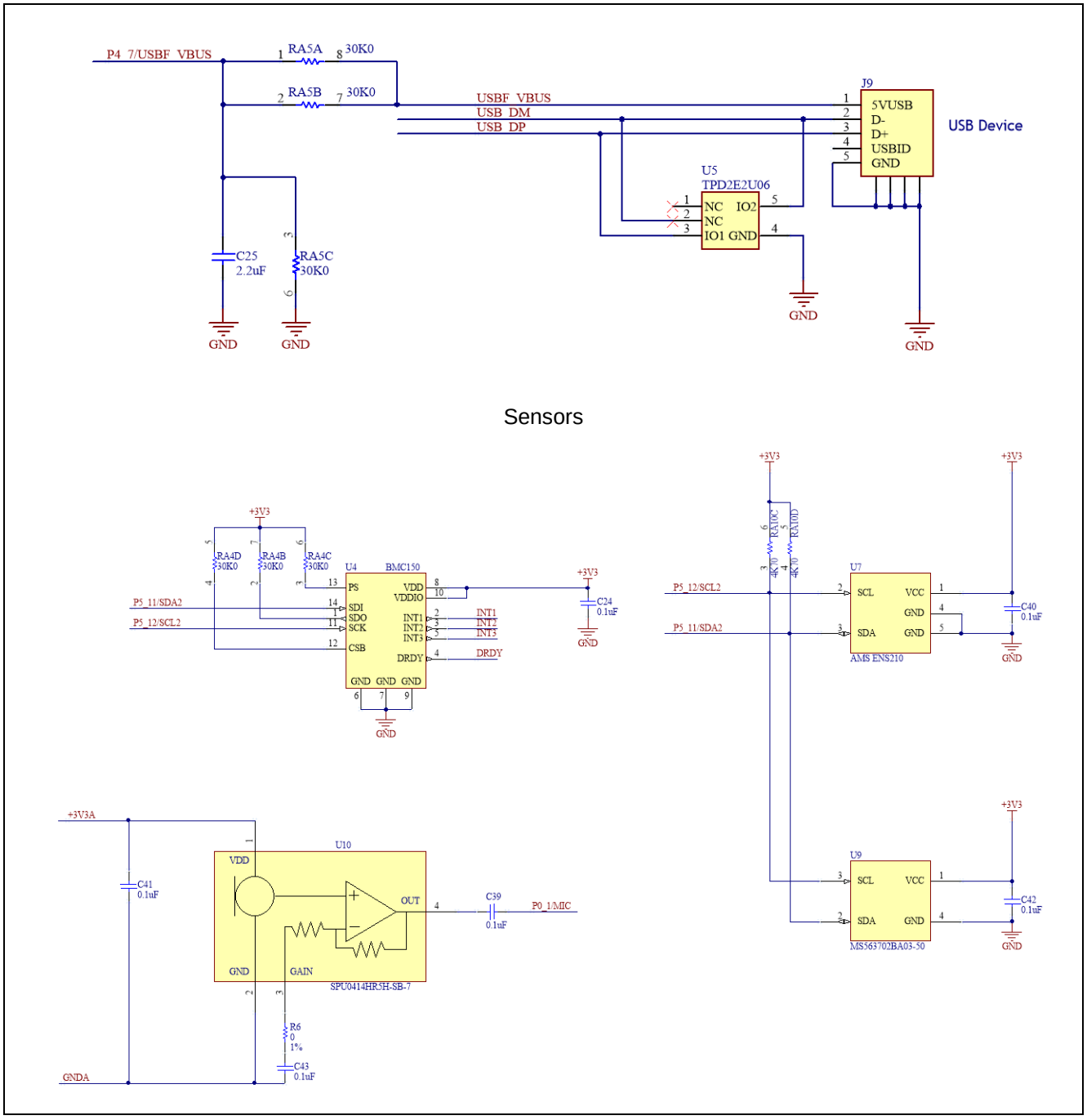
S5D9 Synergy MCU, Reset Circuit, QSPI Flash Memory



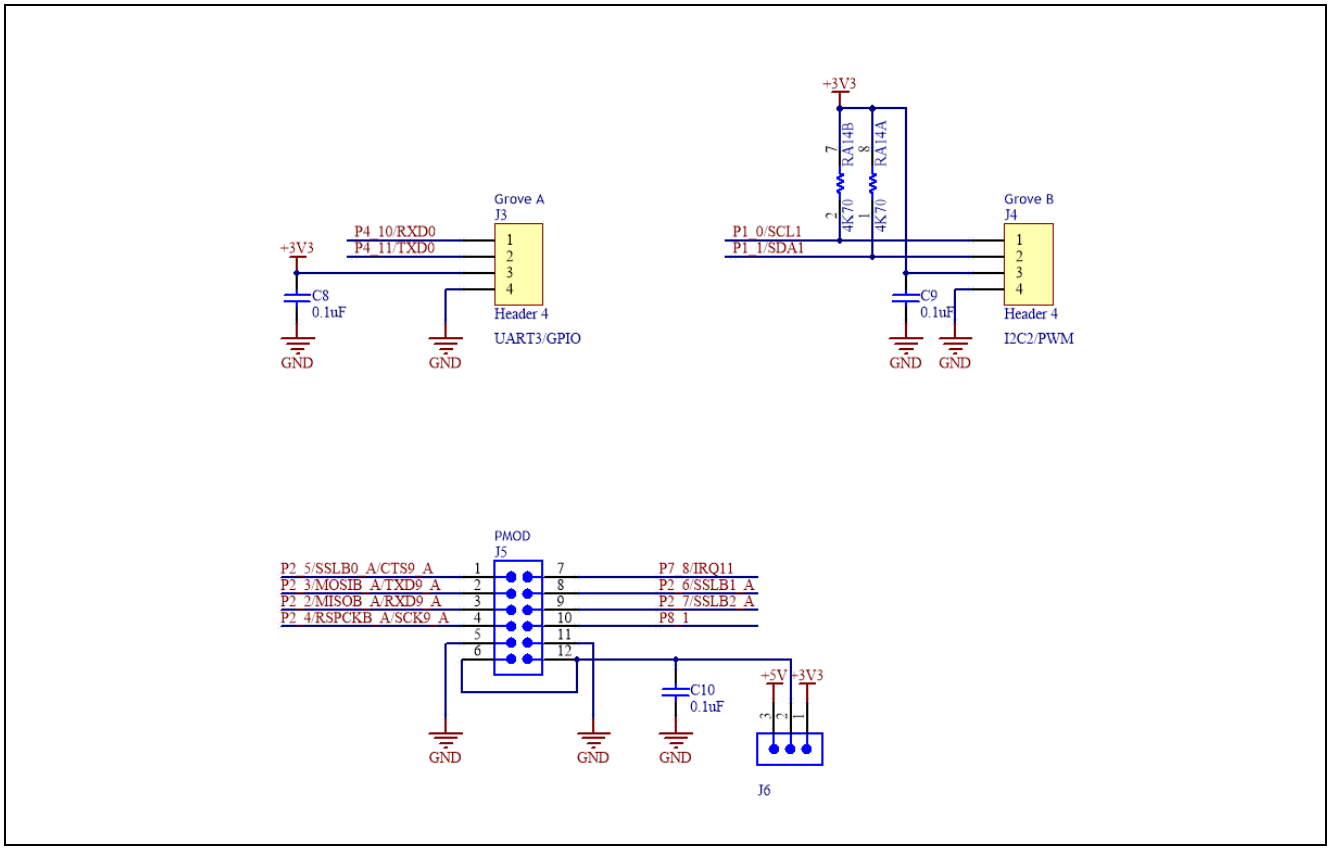
Ethernet Interface, PHY



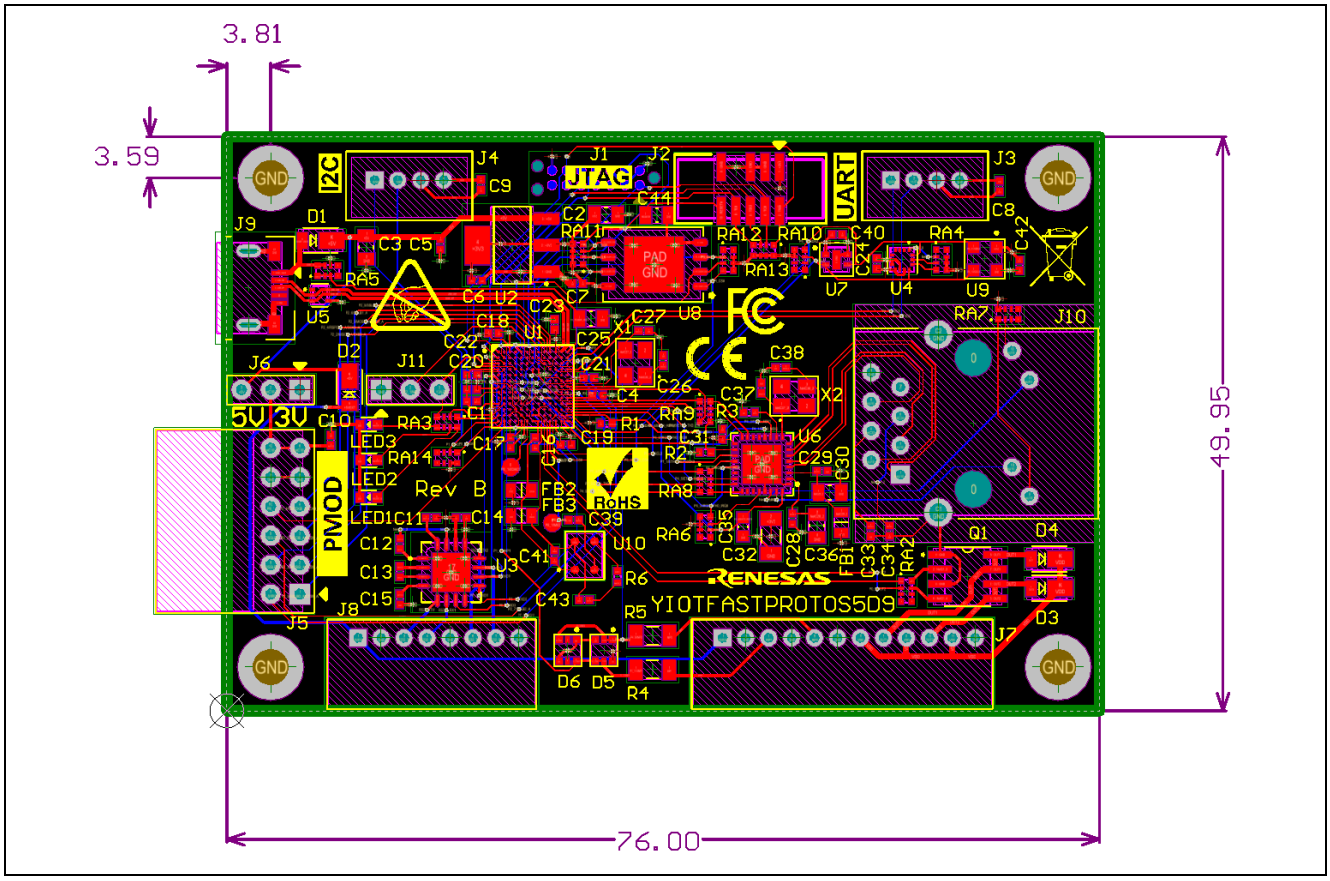
USB Interface



PMOD and Grove Connectors



7. Mechanical Drawing



All dimensions are in millimeters.

8. Additional Resources

For more information on how to order this kit from Renesas or from a local distributor, visit the kit page on our website. In addition to ordering information, you will also be able to download schematics, relevant application projects, technical updates and more: http://www.renesassynergy.com/kits

To learn more about Renesas Synergy development tools, MCUs and utilities, visit us on the web at: http://www.renesassynergy.com/

The Out of Box demo that came with this development board can be found on the web here: http://www.renesassynergy.com/kits

For technical support resources, including access to live chat with a Synergy Platform expert, visit: http://www.renesassynergy.com/support

The Renesas knowledgebase contains many useful articles for Synergy developers: www.renesassynergy.com/knowledgebase

Visit our Professor IoT blog for technical articles on the latest additions to the Synergy platform: https://www.renesasrulz.com/synergy/b/weblog

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Website and Support

Visit the following vanity URLs to learn about key elements of the Synergy Platform, download components and related documentation, and get support.

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Rev.	Date	Description	
		Page	Summary
1.00	Apr 4, 2018	-	Initial release
1.01	Nov 28, 2018	-	Updated link in section 3, Getting Started, template updates, and other minor edits.

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Application Example for Cloud Connectivity (AE-CLOUD1)
User's Manual

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Renesas Electronics Corporation
TOYOSU FORESIA, 3-2-24 Toyosu, Koto-ku, Tokyo 135-0061, Japan

Renesas Electronics America Inc.
1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.
Tel: +1-408-432-8888, Fax: +1-408-434-5351

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

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Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
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Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
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Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5338

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Colophon 5.2

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