

# Hybrid PLC and Sub-GHz Communication Evaluation Kit: Y-G-HYBRID-PLC-RF

## User's Manual

### Target Devices

Power Line Modem LSI R9A06G037

Sub-GHz Wireless Modem LSI RAA604S00

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# General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

## 1. Precaution against Electrostatic Discharge (ESD)

A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

## 2. Processing at power-on

The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

## 3. Input of signal during power-off state

Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

## 4. Handling of unused pins

Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

## 5. Clock signals

After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

## 6. Voltage application waveform at input pin

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between  $V_{IL}$  (Max.) and  $V_{IH}$  (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between  $V_{IL}$  (Max.) and  $V_{IH}$  (Min.).

## 7. Prohibition of access to reserved addresses

Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

## 8. Differences between products

Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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## Precautions

The Y-G-HYBRID-PLC-RF Communication Board 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 any 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. 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 10 m of the product when in use.
- The user is advised to take ESD precautions when handling the equipment.

The Evaluation Kit does not represent an ideal reference design for an end product and does not fulfil the regulatory standards for an end product.

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## Hybrid PLC and Sub-GHz Communication Evaluation Kit

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**Glossary**

AC	Alternating Current
ACK	Acknowledge
BoM	Bill of Materials
bps	Bits Per Second
CMOS	Complementary Metal-Oxide Semiconductor
CRC	Cyclic Redundancy Check
CSMA-CA	Carrier Sense Multiple Access – Collision Avoidance
DC	Direct Current
DCDC	Direct Current - Direct Current
DIP	Dual In-Line Package
DSP	Digital Signal Processor
FEC	Forward Error Correction
FEM	Front End Module
FSK	Frequency Shift Keying
GFSK	Gaussian Frequency Shift Keying
GHz	Giga Hertz
GPIO	General Purpose Input Output
HMI	Human machine Interface
HVQFN	Thermal Enhanced Very Thin Quad Flatpack; No Leads
I/O	Input/Output
I <sup>2</sup> C (or IIC)	Inter-Integrated Circuit
IC	Integrated Circuit
IDE	Integrated Development Environment
kB	Kilo Byte
kbps	Kilo Bits Per Second
kHz	Kilo Hertz
LDO	Low Dropout
LED	Light Emitting Diode
LFQFP	Low Profile Quad Flat Package
LSI	Large-Scale Integration
MAC	Multiply Accumulate
MB	Mega Byte
MCU	Micro Controller Unit
MHz	Mega Hertz
MISO	Master In Slave Out
mm	Millimetres
MOSI	Master Out Slave In
N/A	Not Applicable
NC	Not Connected
PD	Phase Detection
PLC	Power Line Carrier
PMOD™	Peripheral Module
QFN	Quad Flat Package (No Lead)
RAM	Random Access Memory
RF	Radio Frequency
RXD	Receive Data
SCI	Serial Communications Interface
SCL	Serial Clock Line
SDA	Serial Data Line
SMA	Sub Miniature Version A
SMD	Surface Mount Device

SPI	Serial Peripheral Interface
Tamb	Ambient Temperature
TXD	Transmit Data
UART	Universal Asynchronous Receiver-Transmitter
USB	Universal Serial Bus
V	Voltage

Table 1. List of Abbreviations and Acronyms

## 1. Safety Notice

### 1.1 Intended Use

The Renesas Y-G-HYBRID-PLC-RF communication kit is intended for **ELECTRICAL LABORATORY USE ONLY**.

The demonstration system should be operated within a temperature and humidity-controlled environment only. It should only be operated by suitably trained persons.

### 1.2 Recommended Operating Conditions

Operating temperature:  $T_{amb} = 0^{\circ}\text{C}$  to  $40^{\circ}\text{C}$

Relative humidity:  $0^{\circ}\text{C}$  to  $40^{\circ}\text{C}$ , 0-80% relative humidity, non-condensing

Altitude: Operating, up to 2000m

Pollution degree: PD2

Power source: The Y-G-HYBRID-PLC-RF communication kit comes provided with a power supply. It is not recommended to use any other power supply, using any other may affect the safety of the equipment, please contact your supplier of the Y-G-HYBRID-PLC-RF communication kit if in doubt. The power supply details are:

- Ideal Power: 15DYS818-150120W-K
- 15V, 1.2A, 18W, International Plug In Power Supply (Level VI), 2.1mm Plug.
- Input voltage: range from 110Vac to 230Vac (full range), 47/63Hz frequency range
- Input current (RMS) is 0.4A at 110Vac and 0.2A at 230Vac
- 15VDC output voltage,  $\pm 5\%$  voltage regulation at constant voltage mode
- 1.2A output current, barrel plug centre positive 2.1mm x 5.5mm output connector
- 18W maximum output power, size of 77mm x 47.5mm x 35mm

AC cable: The Y-G-HYBRID-PLC-RF communication kit comes provided with a 2 Pin Euro Plug to Figure 8 (C7) Power Cable with the following ratings:

- Mains Plug, Euro to IEC 60320 C7
- Current Rating: 2.5A
- Insulation rating: Voltage rating = 300/500V, Temperature =  $90^{\circ}\text{C}$  or greater

Y-G-HYBRID-PLC-RF communication kit, Power Line Communication Line Coupler:

- Input voltage: 110Vac to 230Vac, 50/60Hz.
- Input current: 2A Max.
- Operating temperature:  $T_{amb} = 0^{\circ}\text{C}$  to  $40^{\circ}\text{C}$
- Relative humidity:  $0^{\circ}\text{C}$  to  $40^{\circ}\text{C}$ , 0-80% relative humidity, non-condensing

### 1.3 Equipment Installation

The Y-G-HYBRID-PLC-RF communication kit is intended for short-term **EVALUATION AND DEVELOPMENT USE ONLY**.

The demonstration system is not intended for use within a permanently connected environment.

### 1.4 Service

**NO USER SERVICEABLE PARTS ARE INCLUDED WITHIN THE EQUIPMENT.**

If the demonstration systems protective enclosure becomes damaged in any way that can expose the high voltage terminals within, or signs of overheating of any component are observed, immediately disconnect the equipment, and take the unit out of service.

In the event of a malfunction or unexpected operation, the demonstration system must be returned to Renesas for service and repair. Please return faulty equipment to:

*Renesas Electronics Europe GmbH, Arcadiastrasse 10, 40472 Dusseldorf, Germany*

For technical support please contact your local sales representative. See [www.renesas.com](http://www.renesas.com) for details.

## 1.5 Symbols Used



**Warning – Dangerous high voltages are present within the Y-G-HYBRID-PLC-RF communication kit, Power Line Communication Line Coupler.**

## 1.6 Protection of the Sub-GHz RF Analog Front End.

The Y-G-HYBRID-PLC-RF solution kit contains an FEM module on the AFE of the Sub-GHz RF. Directly connecting two Y-G-HYBRID-PLC-RF communication boards with an un-attenuated SMA cable will cause permanent damage to the boards. For this, connect the boards using an SMA connector with 50dB attenuation between. Alternatively, a wireless configuration may be used.

## 1.7 Assumptions and Advisory Notes

- It is assumed that the user has a basic understanding of microcontrollers and embedded systems **hardware**.
- It is recommended that the user refers to the quick start guides to get acquainted with the board.
  - r12qs0057eg0100\_y-g-hybrid-plc-rf\_qsg\_plc: Y-G-HYBRID-PLC-RF quick start guide **PLC part**.
  - r12qs0058eg0100\_y-g-hybrid-plc-rf\_qsg\_rf: Y-G-HYBRID-PLC-RF quick start guide **RF part**.
- Integrated Development Environment (IDE) such as e<sup>2</sup> studio are required to develop embedded applications on Y-G-HYBRID-PLC-RF board.
- Instructions to download and install software, import example projects, build them and program the Y-G-HYBRID-PLC-RF Communication board are not part of this user manual.

## 2. Hybrid PLC and Sub-GHz Communication Evaluation Kit Overview

The Y-G-HYBRID-PLC-RF communication system has been built around the proven hardware for PLC, Cool Phoenix 3 - R9A06G037, and the proven hardware for Sub-GHz RF for IEEE802.15.4 SUN FSK / WiSUN, the RAA604S00 devices. This kit supports CENELEC-A, FCC and ARIB frequency bands for PLC communication and the 863/915 MHz bands for RF communication.

This document is a guide to explain the configurations and setup for the Y-G-HYBRID-PLC-RF communication kit.

The board orderable part name is "Y-G-HYBRID-PLC-RF".

Please read the safety notice before operating this kit.

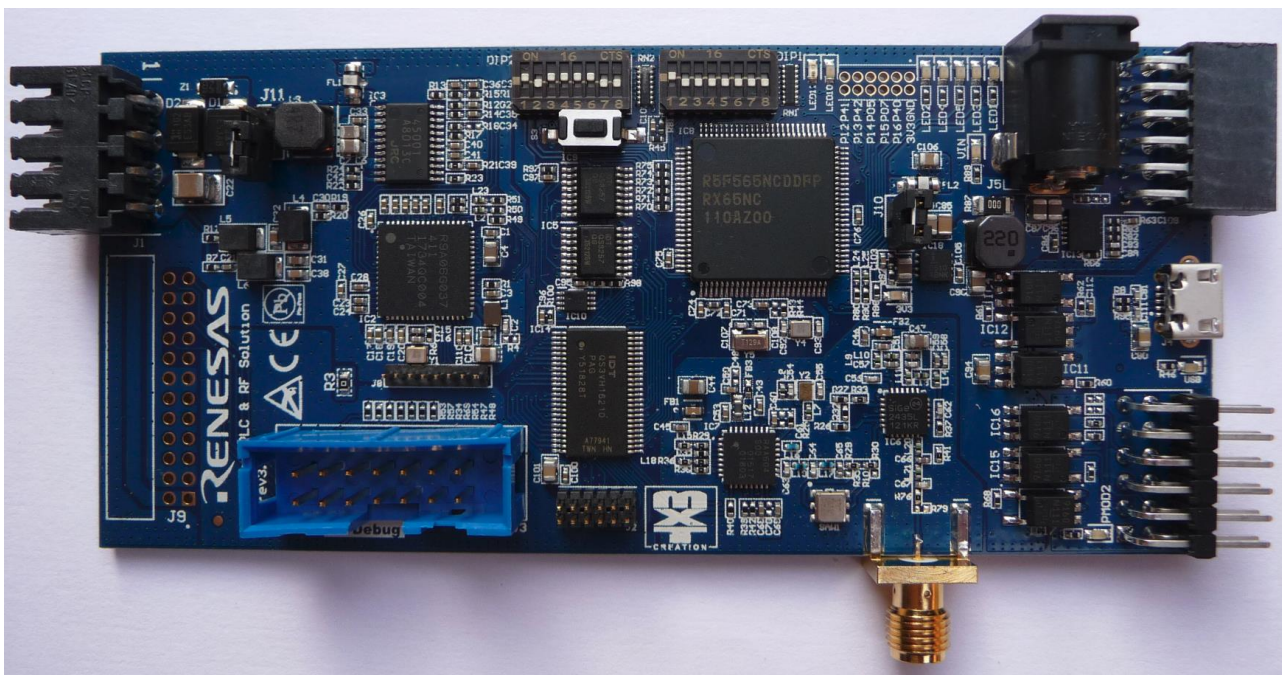


Figure 1. Y-G-HYBRID-PLC-RF Communication Board Top Side

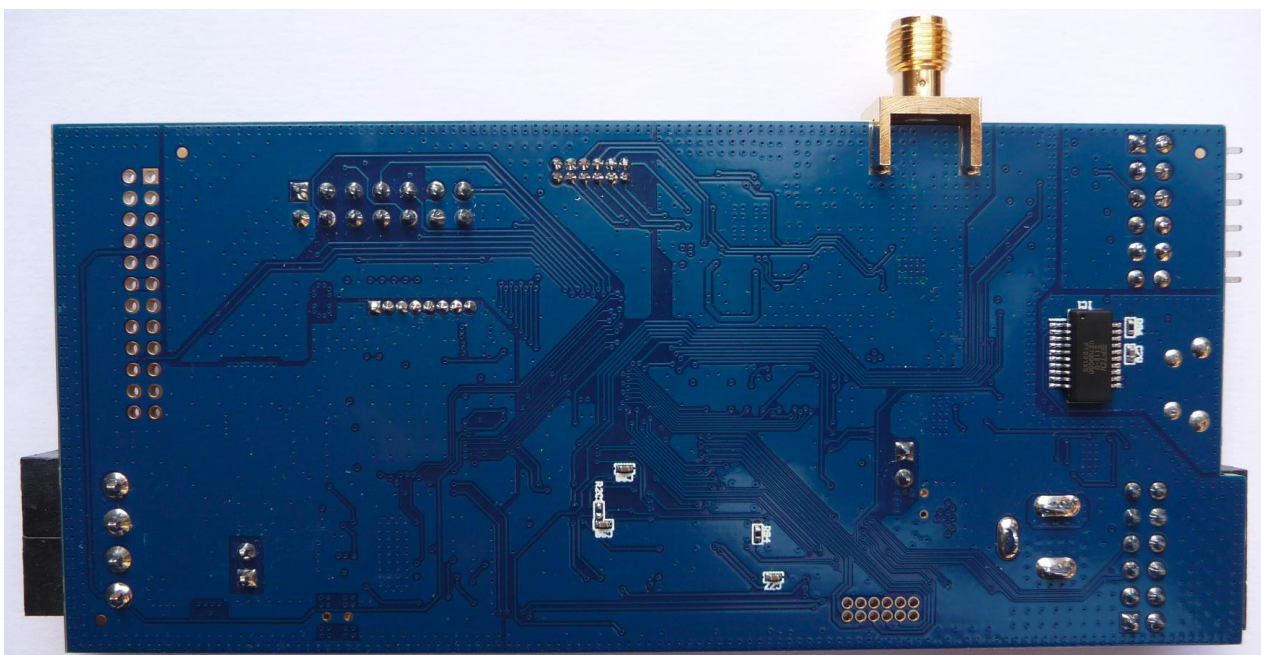


Figure 2. Y-G-HYBRID-PLC-RF Communication Board Bottom Side



The key features of the Y-G-HYBRID-PLC-RF communication system are categorized in four groups (consistent with the architecture of the board) as follows:

#### **MCU: Host MCU**

- R5F5651EDDFP#30 MCU (referred to as RX651 MCU)
- RX651 microcontrollers with, large-capacity RAM, and enhanced security, connectivity, and human machine interface (HMI) capabilities.
- 120 MHz, RXv2 core
- 2048 MB Code Flash, 640 KB Data Flash, 32 KB E2 Data Flash (Largest memory for evaluation purpose only)
- 100-pin, LFQFP package

<https://www.renesas.com/RX651>

#### **Power Line Modem LSI R9A06G037, Cool Phoenix 3**

- R9A06G037: High Performance Narrow Band Power Line Communication Modem IC
- High performance DSP:
  - Handles PLC PHY layer and other real time operations
  - 276MHz maximum clock frequency
  - 128KB of instruction RAM and 128KB of data RAM
  - Dedicated instructions for Viterbi, Reed Solomon and others
- MCU(ARM® Cortex™-M3)
  - Handles PLC MAC layer and upper layer operation
  - 138 MHz maximum clock frequency
  - 512KB of RAM
  - AES128 encryption and decryption hardware engine
  - CRC hardware engine
- 64-pin, QFN package

<https://www.renesas.com/R9A06G037>

#### **Sub-GHz Wireless Modem LSI RAA604S00**

- RAA604S00 is an RF transceiver with low power consumption
- Transceiver
  - RF frequency range: 863 to 928 MHz
  - Modulation method: 2FSK/GFSK, 4FSK/GFSK
  - Data rate:
    - 2FSK/GFSK; 10 k to 300 kbps
    - 4FSK/GFSK; 200 k/400 kbps
  - Forward Error Correction (FEC) function
- MAC
- 32-bit timer function
- Transmission RAM/Receiving RAM: both 256 bytes
- 16-bit/32-bit auto CRC function
- Address filter & auto ACK reply function
- Antenna diversity function
- Auto CSMA-CA function
- 32-pin, HVQFN package

[Sub-GHz Wireless Communication Solutions | Renesas](#)

**System Control and Ecosystem Access**

- One 15 V input source
  - External power supply (using barrel connector, J5)
- E20 / E2 / E2 Lite Emulator programmer/debugger connector (J3)
- User LEDs and buttons
  - Five User LEDs (green)
  - Two Power LED (green) indicating availability of regulated power (15V and 3V3)
  - Two Power LED (green) indicating availability of USB power or PMOD2 power
  - Two R9A06G037 LED for transmission/reception indication.
  - One Reset button
- Two popular ecosystem expansions
  - Two Digilent Pmod™ (SPI, I2C, UART) connectors
- USB connection
- RF SMA connection
- PLC Interface connection.

### 3. Y-G-HYBRID-PLC-RF Solution Kit Contents

The following is a list of items which are included in the Y-G-HYBRID-PLC-RF Communication kit:

- Y-G-HYBRID-PLC-RF communication board as shown in Figure 3. Y-G-HYBRID-PLC-RF Communication Board
- USB micro-B Cable
- 15V, 1.2A, 18W, International Plug-In Power Supply. Similar to:
- [15V DC 1.20A \(18W\) IEC/UL/EN 62368-1 | EXTERNAL POWER SUPPLY \(PSU\) | Interchangeable | Ideal Power Ltd](#)
- RF Antenna 868-928 MHz SMA Male, Similar to:
- [W1063M PulseLarsen Antennas](#)
- Y-G-HYBRID-PLC-RF Line Coupler Box.
- Y-G-HYBRID-PLC-RF board to Y-G-HYBRID-PLC-RF Line Coupler Box connector cable
- 2 Pin Euro Plug to Figure 8 (C7) Power Cable Euro to IEC 60320 C7
- China RoHS document

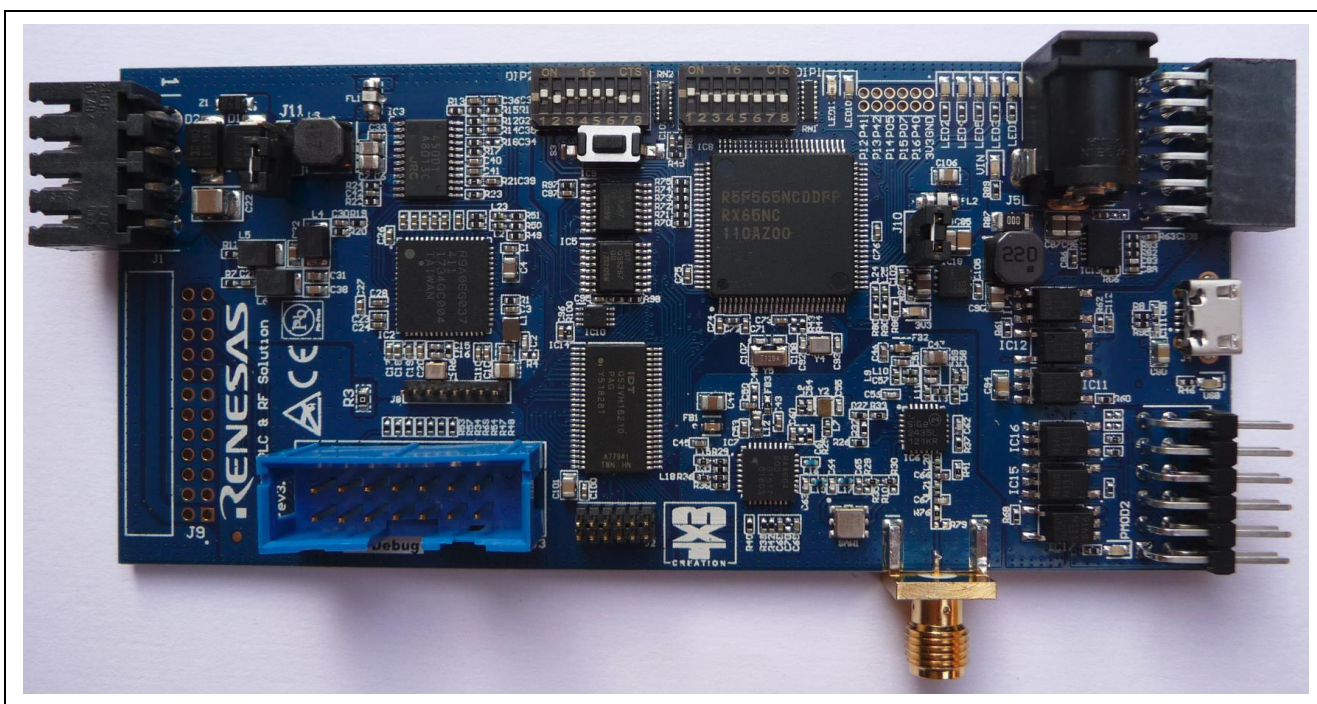


Figure 3. Y-G-HYBRID-PLC-RF Communication Board



Figure 4. Y-G-HYBRID-PLC-RF Line Coupler Box



The following is a list of items which are not included in the Y-G-HYBRID-PLC-RF kit:

- RF SMA Type Connector Cable
- E2, E2 Lite or E20 Emulator.
  - <https://www.renesas.com/us/en/design-support/development-tools#dev-tools-list>

If these are required, please order these separately.

#### 4. Y-G-HYBRID-PLC-RF Ordering Information

- The Y-G-HYBRID-PLC-RF solution kit orderable part number: Y-G-HYBRID-PLC-RF
- The Y-G-HYBRID-PLC-RF solution kit comes as two parts:
  - Y-G-HYBRID-PLC-RF Communications Board
    - board dimensions: 60 mm (width) x 120 mm (length) x 14 mm (thickness).
  - Y-G-HYBRID-PLC-RF Line Coupler Box.
    - box dimensions: 68 mm (width) x 123 mm (length) x 37 mm (depth).

### 5. Y-G-HYBRID-PLC-RF Kit Hardware Architecture

#### 5.1 Block Diagram

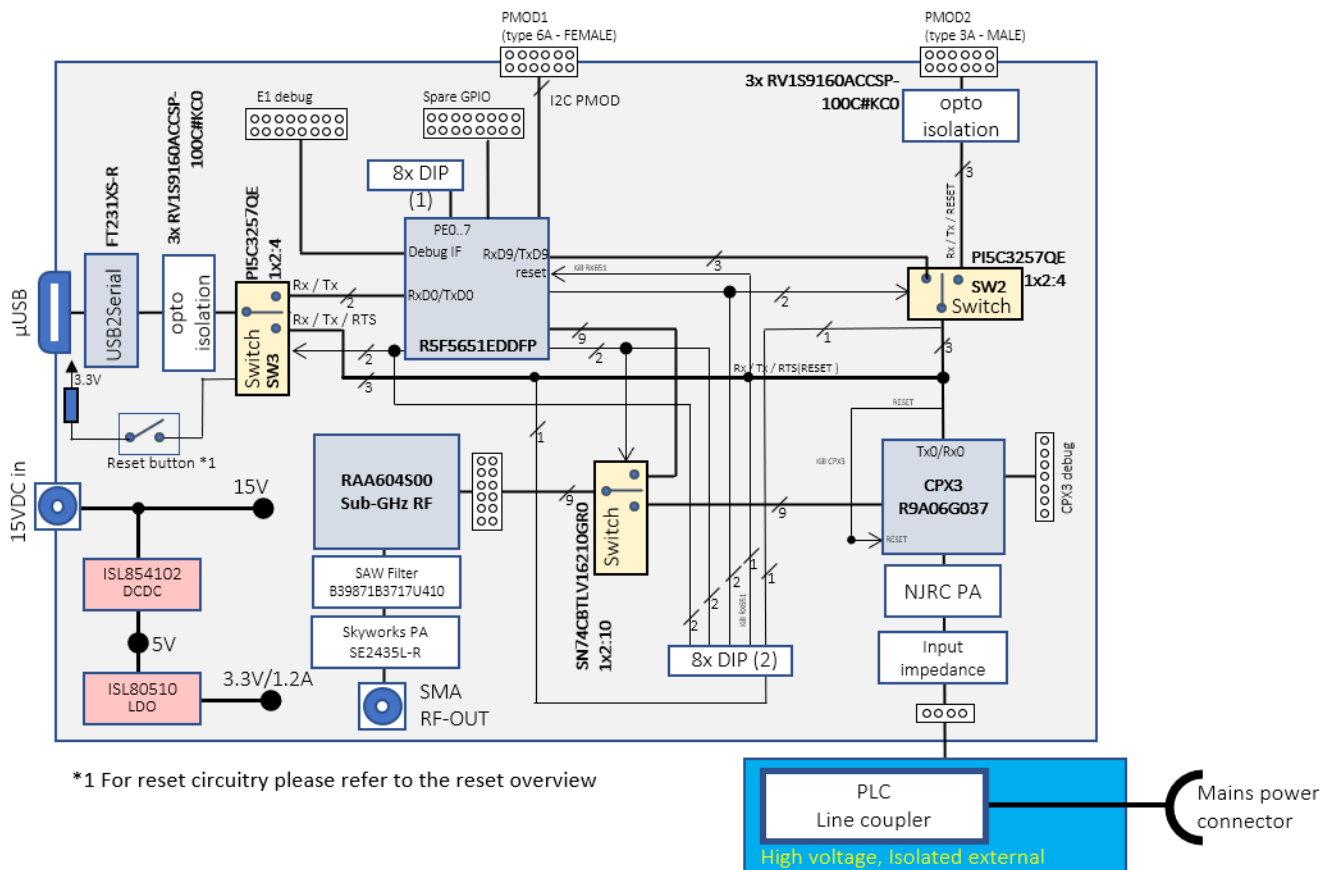


Figure 5. Y-G-HYBRID-PLC-RF Communication Board Block Diagram

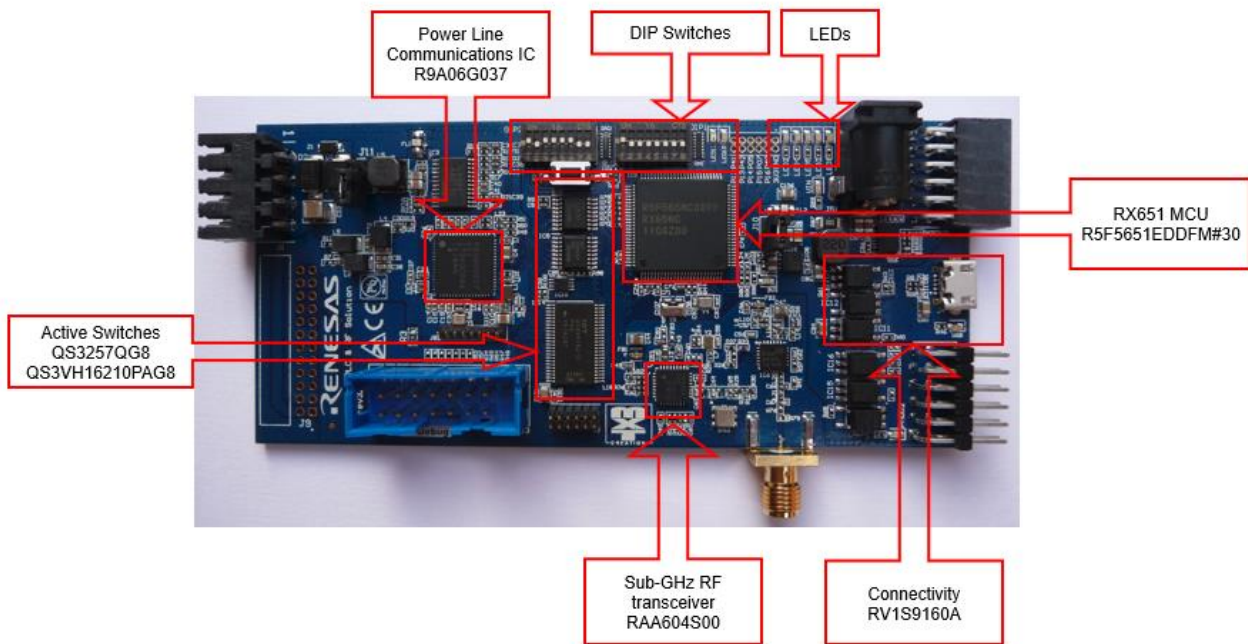


Figure 6. Y-G-HYBRID-PLC-RF Board Architecture

## 5.2 MCU

The MCU used on the board is the Renesas RX651 (orderable part name: R5F5651EDDFM#30), a 32-bit microcontroller with RXv2 Core, large-capacity RAM, and enhanced security, connectivity and HMI capabilities. For more information, please refer to:

<https://www.renesas.com/RX651>

## 5.3 Power Line Communication

The Renesas power line communications IC (orderable part name: R9A06G037) is a high-performance narrow band power line communication modem IC.

<https://www.renesas.com/R9A06G037>

## 5.4 Sub-GHz RF Communication

The Renesas Sub-GHz RF transceiver device (orderable part name: RAA604S00) is an RF transceiver with low power consumption dedicated for IEEE802.15.4 SUN FSK / WiSUN data transmission.

[Sub-GHz Wireless Communication Solutions | Renesas](https://www.renesas.com/raa604s00)

## 5.5 Connectivity

External control of the boards is achieved via an isolated USB-to-serial interface connecting to a standard GUI, obtained with an FTDI device. This part allows full control of a UART port from the USB input.

The galvanic isolation between the board and a controlling MS Windows™ PC is achieved with two high speed (15Mbps) optocouplers (orderable part name: RV1S9160A).

[www.renesas.com/RV1S9160A](https://www.renesas.com/rv1s9160a)

## 5.6 Active Switches

The different modes of operation of the board, as well as the physical data connections between the active devices are obtained using active switches. The board contains 2 variants of the switches: the simple serial connections are guided via quad high-speed CMOS switch 2:1 (orderable Part name: QS3257QG8).

<https://www.renesas.com/QS3257QG8>

The wide bus to the Sub-GHz wireless modem LSI RAA604S00 is controlled via a high-speed CMOS 2:1 x 10 switch (orderable part name: QS3VH16210PAG8)

<https://www.renesas.com/QS3VH16210PAG8>

## 5.7 Power Supply

The board is designed to work from an external 15V power supply. This voltage is issued to the PLC power amplifier.

From this voltage, an intermediate voltage [5V] is generated with a DCDC device (orderable part name: ISL854102)

<https://www.renesas.com/ISL854102>

From this intermediate 5V the board level device voltage of 3.3V is generated with an LDO (ordering part name: ISL80510), this to have as little as possible ripple on the 3.3V power rail which is used by the PLC and RF devices.

<https://www.renesas.com/ISL80510>

## 5.8 DIP Switches

The board modes of operation are controlled by a DIP switch bank (8 switches) connected to the RX651 GPIO pins. The DIP settings can be used by the device object code in the RX651 for deciding the operation mode.

A 2<sup>nd</sup> DIP switch bank of 8 switches is connected to the different active switches. This allows a manual setting of the operation mode and overrides the activation of the data switches by the RX651 MCU.

Additionally, the board holds a reset button, allowing to reset the active elements of the board (RX651, Cool Phoenix 3)

## 5.9 Indicator LEDs

The board contains a set of Indicator LEDs connected to GPIO pins of the RX651 MCU as well as to GPIO pins from the Cool Phoenix, this shows the status of the different devices running their respective object codes.

Next to the indicator LED controlled by the active devices, the board has also indicator LED for each of the different power supply inputs:

- 15V main power supply
- 3.3V board level supply
- External USB power input (needed for the galvanic isolation)
- External PMOD input (needed for the galvanic isolation)

Below is a table showing the LED indications and the corresponding connections. Note the functionality of the LEDs is dependent on the application being used and the meaning/status of the LED can change from application to application.

LED	Connection
1	RX651 Port 1.5
2	RX651 Port A.5
3	RX651 Port 2.5
4	RX651 Port 4.3
5	RX651 Port 2.4

6	USB_VBUS USB Power Status
7	3V3 Power Status
8	15V Power Status
9	PMOD2_VDD USB Power Status
10	CPX3 GPIO10 Rx LED
11	CPX3 GPIO11 Tx LED

Table 2: LED Connections

## 6. Board Overview

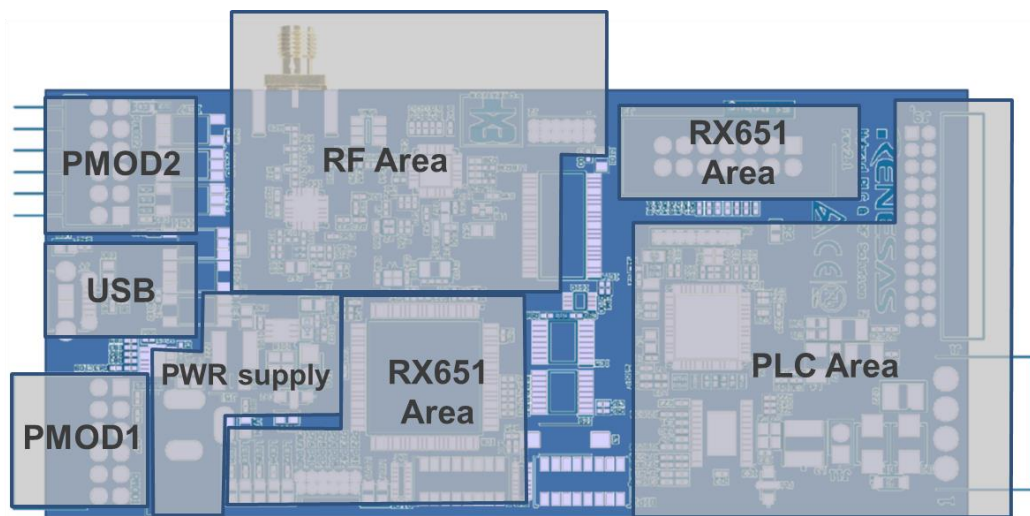


Figure 7. Y-G-HYBRID-PLC-RF Board Main Board Areas

### 6.1 Board connections

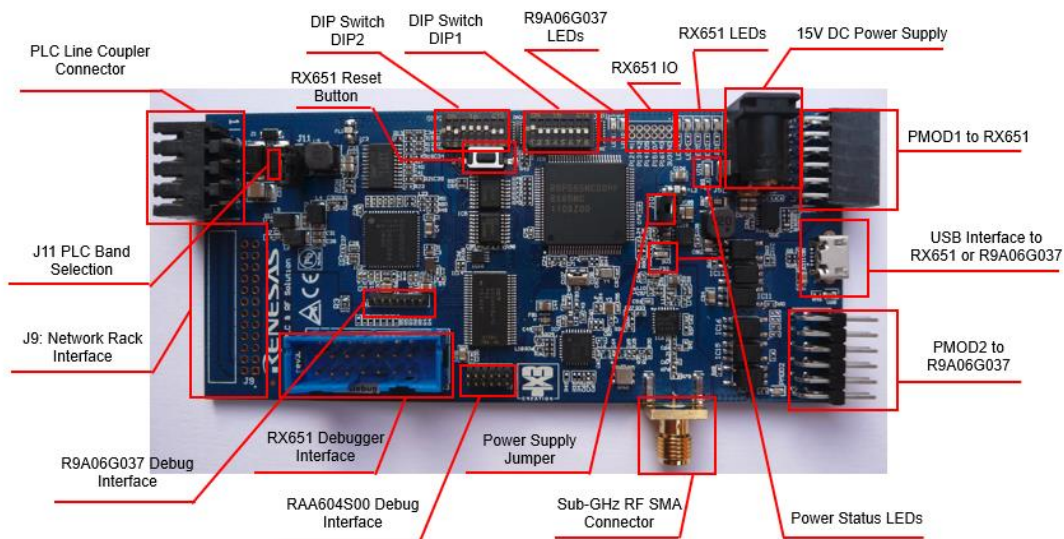


Figure 8. Y-G-HYBRID-PLC-RF Board Overview

## 6.2 J1 PLC Line Coupler Connector

The line coupler connector provides a galvanic isolated connection to the mains power line for sending/receiving the PLC signals. Additionally, zero-crossing feedback is issued to the Y-G-HYBRID-PLC-RF board. This connector is expected to be connected to the Power Line Communication Line Coupler using the cable supplied.

Pin	function
1	Zero crossing
2	3.3V
3	GND
4	PLC signal

**Table 3: J1 Line Coupler**

## 6.3 J2 Sub-GHz Wireless Modem LSI RAA604S00 External Data Connector

This 1.27 mm pin pitch connection allows an external MCU to connect to the Sub-GHz wireless modem LSI RAA604S00 device thus taking control of the RF communication.

Pin	function	Pin	function
1	NC	2	+3.3V
3	GND	4	RF_RESET
5	RF_DON	6	RF_INTOUT
7	RF_Standby	8	RF_SCLK
9	RF_SEL	10	RF_TX
11	RF_CS	12	RF_RX

**Table 4: Sub-GHz Wireless Modem LSI RAA604S00 External Connection**

## 6.4 J3 E20/E2/E2 Lite Emulator Connector

Connector J3 allows connection to an E20/E2/E2 Lite emulator, using a full size 14 pin 2.54 mm pin pitch connector.

Pin	function	Pin	function
1	RX_TCK	2	GND
3	RX_TRST	4	RX_EMLE
5	RX_TDO	6	NC
7	RX_MD	8	RX_VDD
9	RX_TMS	10	RX_UB
11	RX_TDI	12	GND
13	RX_RST	14	GND

**Table 5: J3 E20/E2/E2 Lite Emulator Connector**

## 6.5 J4 USB Connector

The board USB connector allows a PC connection via USB to Serial FTDI on the board. The FTDI device has an automatic serial baud rate switch and does not need any reprogramming. The FTDI device driver is usually part of the drivers that come as standard with Windows 10 and later. It can also be installed from:

<http://www.ftdichip.com/Drivers/VCP.htm>

## 6.6 J5 Power Supply Barrel Connector (15V / 2A)

The board is powered from an external 15V DC power supply, connecting via a 3.5mm barrel connector.

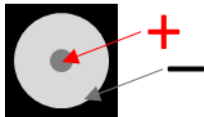


Figure 9. J5 Power Supply Barrel Connector

## 6.7 J6 RX651 Auxiliary Connector

The spare pins from the RX651 are made available on this connector

Pin	function	Pin	function
1	GND	2	+3.3V
3	P40	4	P16
5	P07	6	P15
7	P05	8	P14
9	P42	10	P13
11	P41	12	P12

Table 6: J6 RX651 Auxiliary Connector

## 6.8 J8 Cool Phoenix 3 Debugging Interface

This connector allows external debugging of the Cool Phoenix 3 device

Pin	function
1	+3.3V
2	CPX_TCK
3	GND
4	CPX_TMS
5	CPX_TDO
6	CPX_TDI
7	CPX_TRST
8	CPX_TICE

Table 7: J8 Cool Phoenix 3 Debugging Interface

## 6.9 J9 Network Rack Connector

The board can be used as part of a large network when plugging into a network rack (an internal PLC evaluation system). Using this interface, it is possible to control the programming of the RX651 device, control the power supply 15/12V and 3.3V supplies and couple the PLC signal. This connector allows wired connection of external data to the board, as well as send/receive signals to the PLC interface. Details of this pinout are below, make sure that J10 is NOT set when using this connection if external power is supplied via this connector. Ensure no other power supply is connected.



Pin	function	Pin	function
1	CAR_TX_AMP	2	CAR_TX_AMP
3	GND	4	GND
5	CAR_12V	6	CAR_12V
7	CAR_ZC	8	NC
9	NC	10	NC
11	CAR_3.3V	12	CAR_3.3V
13	GND	14	GND
15	NC	16	NC
17	NC	18	CAR_RST
19	CAR_TDI	20	CAR_TDO
21	GND	22	GND
23	CAR_UB	24	CAR_MD

**Table 8: J9 Network Rack Connector**

### 6.10 J10 Jumper Setting for External 3.3V

It is possible (not recommended) to supply the Y-G-HYBRID-PLC-RF communication system with an external 3.3V power source. In normal operation J10 should be shorted, in the case of using an external supply ensure these are not connected.

Pin	function
1	PSU 3.3V
2	Board 3.3V

**Table 9: Jumper J10**

### 6.11 J11 Jumper Setting for PLC Frequency Bands, CENELEC/FCC/ARIB

The Y-G-HYBRID-PLC-RF communication system allows for optimising the power line analog front end. For low impedance loads in the CENELEC-A band, the PLC transmission output power can be increased by inserting an L3 inductor in series with the transmission output. For low impedance loads in the CENELEC-A band, ensure that J11 is disconnected. For all other configurations, FCC / ARIB / Global, L3 should be bypassed otherwise the transmission output will be decreased. The output power of CENELEC-A band increases by approximately 2-3dB when using this inductor when the load impedance is low.

When choosing CENELEC frequency bands for the PLC communication, jumper J11 must be not connected. When choosing FCC/ARIB frequency bands for the PLC communication, jumper J11 must be set, which bypasses the inductor.

### 6.12 PMOD1 RX651 connection

Via PMOD1, the RX651 can connect to external modules using a full type 6A female connector, connected as expanded I<sup>2</sup>C.

Pin	function	Pin	function
1	INT	7	GPIO0 ()
2	NC	8	GPIO1 ()

<b>3</b>	SCL (P12)	<b>9</b>	GPIO2 ()
<b>4</b>	SDA (P13)	<b>10</b>	GPIO3()
<b>5</b>	GND	<b>11</b>	GND
<b>6</b>	Periph VCC	<b>12</b>	Periph VCC

Table 10: PMOD1 RX651 Connection – TYPE 6A

### 6.13 PMOD2 Cool Phoenix 3 connection

The PMOD2 allows an external MCU board using a full type 3A male connector. The serial communication signals are galvanically isolated from the rest of the board, therefore Peripheral Vcc must be providing power (maximum 5V). Note that only TX/RX and RESET are connected on the Y-G-HYBRID-PLC-RF communication system.

Pin	function	Pin	function
<b>1</b>	NC	<b>7</b>	NC
<b>2</b>	TXD	<b>8</b>	RESET
<b>3</b>	RXD	<b>9</b>	NC
<b>4</b>	NC	<b>10</b>	NC
<b>5</b>	Periph GND	<b>11</b>	Periph GND
<b>6</b>	Periph Vcc	<b>12</b>	Periph Vcc

Table 11: PMOD2 Cool Phoenix 3 Connection – TYPE 3A

### 6.14 SMA

The RF output to an antenna is done via an SMA connector on the side of the board.

### 6.15 DIP switch 1

The DIP1 switches allow to set the RX651 into certain functioning modes. Below table only shows the connected pins to the switch – the functionality is to be taken from the software user's manual.

switch	RX651 port
<b>0</b>	PE0
<b>1</b>	PE1
<b>2</b>	PE2
<b>3</b>	PE3
<b>4</b>	PE4
<b>5</b>	PE5
<b>6</b>	PE6
<b>7</b>	PE7

Table 12: DIP Switch 1

### 6.16 DIP switch 2

The DIP2 switches allow to set the Active Switches in such a way to control the mode of operation of the Y-G-HYBRID-PLC-RF communication system. Note that they are also connected to the RX651 GPIO ports, to allow full control from the microcontroller. The user can either use the RX651 object code to control the



mode or set the switch accordingly, below details the switch settings. Section 7: Operation Modes describes the settings for each operation mode.

DIP2 switch	RX651 port	Controls active switch	
0	PD0	SW 1	Control of LSI RAA604S00 data input: ON: RAA604S00 SPI and R9A06G037 connected OFF: RAA604S00 SPI and R9A06G037 disconnected
1	PD1	SW 1	Control of LSI RAA604S00 data input: ON: RAA604S00 SPI and RX651 connected OFF: RAA604S00 SPI and RX651 disconnected
2	PD2	SW 2	Control of Cool Phoenix 3 Data input ON: Switch 2 enabled OFF: Switch 2 disabled
3	PD3	SW 2	Control of Cool Phoenix 3 Data input ON: R9A06G037 UART connected to RX651 OFF: R9A06G037 UART connected to PMOD2.
4	PD4	SW 3	Control of USB interface connection ON: Switch 3 enabled OFF: Switch 3 disabled
5	PD5	SW 3	Control of USB interface connection ON: USB connected to RX651 OFF: USB connected to R9A06G037 UART
6			ON: Hold RX651 RESET in reset state. OFF: Normal operation of RX651
7			ON: Controls USB RTS line connection DIP2 PD5: ON: USB RTS connected to RX651 (Mount R201) DIP2 PD5: OFF: USB RTS connected to R9A06G037 (See Figure 10. Reset Circuitry) OFF: Disconnects USB RTS line connection.

**Table 13: DIP Switch 2**

Control for the Active Switch 1 decides the data input to the RF device (Sub-GHz wireless modem LSI RAA604S00), control can be done by either the RX651 or the CPX3

	DIP2-0 ON (0)	DIP2-0 OFF (1)
DIP2-1 ON (0)	Do not set.	RX651
DIP2-1 OFF (1)	CPX3	External from J2

**Table 14: Switch 1 Control**

Control for the Active Switch 2 decides the data input to the PLC device (Cool Phoenix 3, R9A06G037)

	<b>DIP2-2 ON (0)</b>	<b>DIP2-2 OFF (1)</b>
<b>DIP2-3 ON (0)</b>	From RX651	USB to CPX3 [Decision by SW 3]
<b>DIP2-3 OFF (1)</b>	From PMOD2	Not applicable

Table 15: Switch 2 Control

Control for the Active Switch 3 decides the target for the board data input via USB

	<b>DIP2-4 ON (0)</b>	<b>DIP2-4 OFF (1)</b>
<b>DIP2-5 ON (0)</b>	USB to RX651	USB not connected
<b>DIP2-5 OFF (1)</b>	USB to CPX3	USB not connected

Table 16: Switch 3 Control

### 6.17 Reset Circuitry

The Y-G-HYBRID-PLC-RF communication system contains a single reset button, S3. This button can be used to reset either the RX651 device or the power line modem LSI R9A06G037 depending on the active switch settings described in Section 6 Board Overview.

If DIP2:4 is “On” then switch 3 becomes active, the control of the reset is then dependant on DIP2:5:

- ON: Reset button connected to RX651.
- OFF: Reset button connected to R9A06G037.

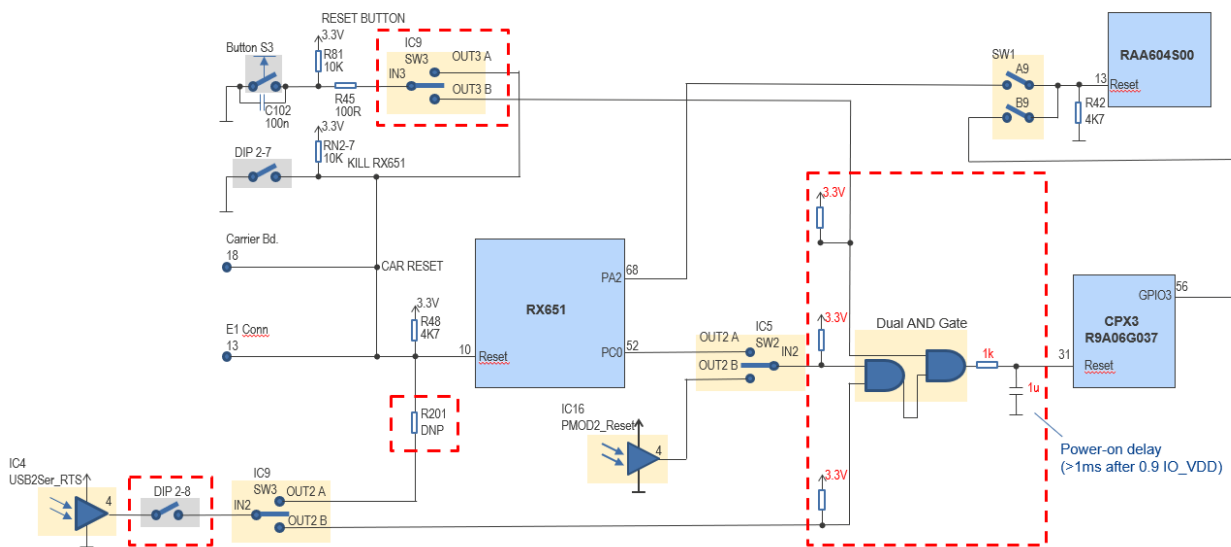


Figure 10. Reset Circuitry

### 6.18 Power Line Communication Receive Filter

The Y-G-HYBRID-PLC-RF communication system contains a bandpass filter on the PLC receiving path. The RX-BPF is used to suppress a noise of out of the signal frequency band, suppressing the noise which is outside of the frequency band used for transmission increases the PLC performance of the system. The filter chosen on the board is for “Global” use (35-500kHz). The schematic indicates the required components for each frequency band, CENELEC-A (35-95kHz), FCC/ARIB (150-500kHz) and Global (35-500kHz). Please contact your Renesas representative when considering the RX-BPF constants for frequency bands other than CENELEC-A and FCC/ARIB.)

Figure 12. Frequency characteristics example of RX-BPF shows frequency characteristics example of RX-BPF. Since the magnitude of noise outside the frequency band differs depending on the installed environment, decide after considering noise outside the frequency band when deleting C3/L3 to reduce component costs

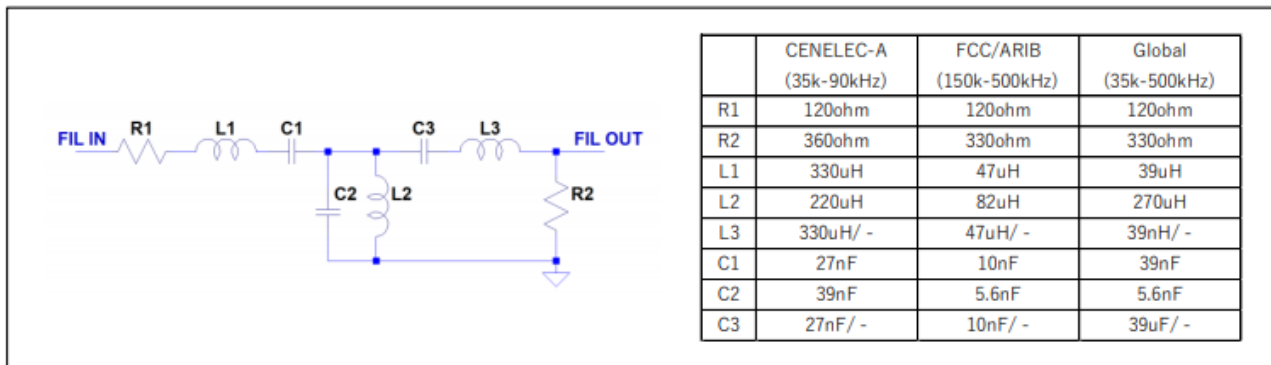


Figure 11. Configuration of the RX-BPF and circuit constants

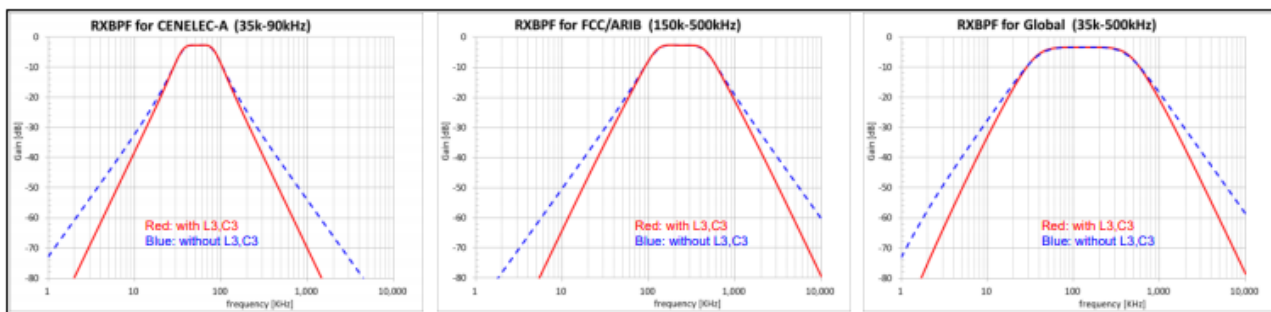


Figure 12. Frequency characteristics example of RX-BPF

## 7. Operation Modes

The board allows several configurations. All combinations can be controlled by the RX651, alternatively, the DIP2 settings can override the RX651 settings. The active digital high-speed CMOS switches (2:1) can be used to switch the paths of the following parts:

- USB connection, USB interface can be connected to either the RX651 or the power line modem LSI R9A06G037.
- PMOD2 connection, the PMOD2 interface can be connected to either the RX651 or the power line modem LSI R9A06G037.
- The sub-GHz wireless modem LSI RAA604S00 connection, the sub-GHz wireless modem LSI RAA604S00 can be connected to either the RX651 or the power line modem LSI R9A06G037.

### 7.1 Factory Default Setting

The board is shipped with the DIP switches set as 'USB to RX651 Host Control (PLC Only)' mode, with the RX651 connected to a PC Windows™ GUI. The RX651 contains the firmware for the power line modem LSI R9A06G037 running a PLC SimpleMAC program and sub-GHz RF evaluation via Renesas RF Test Studio. (Please refer to the Y-G-HYBRID-PLC-RF quick start guides for information on the operation). This allows the user to quickly evaluate the Y-G-HYBRID-PLC-RF powerline and sub-GHz RF communication evaluation board using the G3 PLC PHY or SUN FSK RF PHY Layer evaluation software.

### 7.2 USB to RX651 Host Control (PLC Only)

This configuration is used when there is a sample application running on the RX651 and the user either wants to develop on the RX651 or use the functionality of the RX651 to control the power line modem LSI - R9A06G037. This is shown in Figure 13. USB to RX651 Host Control Connection (PLC Only). In this mode

the USB connection is connected to the RX651 and a UART interface is used to connect the RX651 and power line modem LSI - R9A06G037, in this configuration the Sub-GHz wireless modem LSI RAA604S00 is not used.

This configuration is required for:

- G3-PLC Sample Applications.
- G3-PLC SimpleMAC.
- Wireshark Application.
- PRIME 1.4 Sample Applications.
- Meters and More Sample Application.
- G3-PLC Network Communicator and PRIME Base Node.

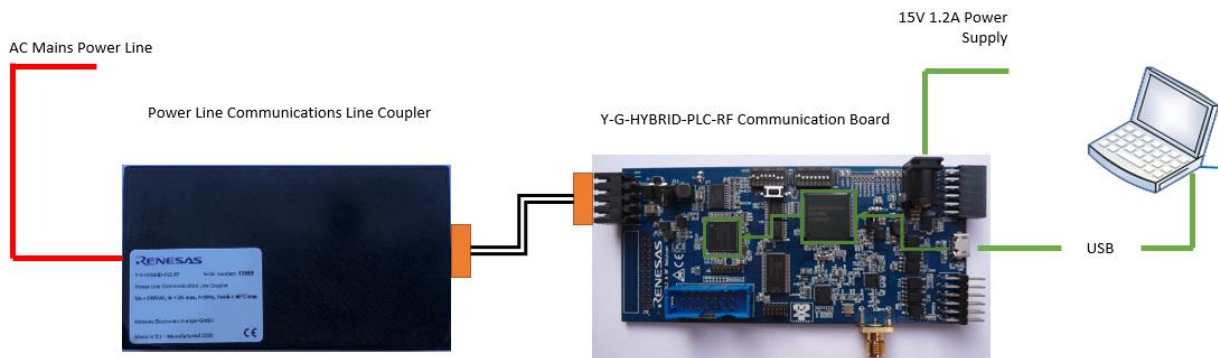


Figure 13. USB to RX651 Host Control Connection (PLC Only)

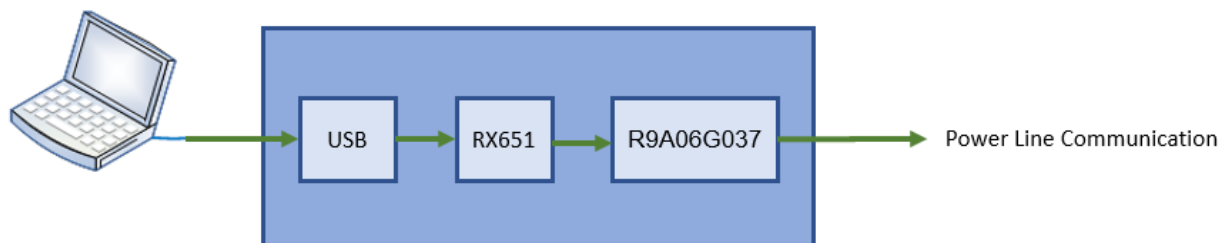


Figure 14: USB to RX651 Host Control Connection (PLC Only) Block Diagram.

The following table shows the DIP2 switch settings for this mode.

DIP2 Switch	Setting
1	OFF
2	ON
3	ON
4	ON
5	ON
6	ON
7	OFF
8	OFF

Table 17: DIP2 Switch Control for USB to RX651 Host Control Connection (PLC Only)

### 7.3 USB to RX651 Host Control (RF Only)

This configuration is used when there is a sample application running on the RX651 and the user either wants to develop on the RX651 or use the functionality of the RX651 to control the sub-GHz wireless modem LSI RAA604S00. This is shown in Figure 15. USB to RX651 Host Control Connection (RF Only). In this mode the USB connection is connected to the RX651 and an SPI interface is used to connect the RX651 and sub-GHz wireless modem LSI RAA604S00. In this configuration the power line modem LSI R9A06G037.

This configuration is required for:

- WiSUN FAN Development Environment.
- WiSUN FAN Demonstrator.
- WiSUN FAN Wireshark.

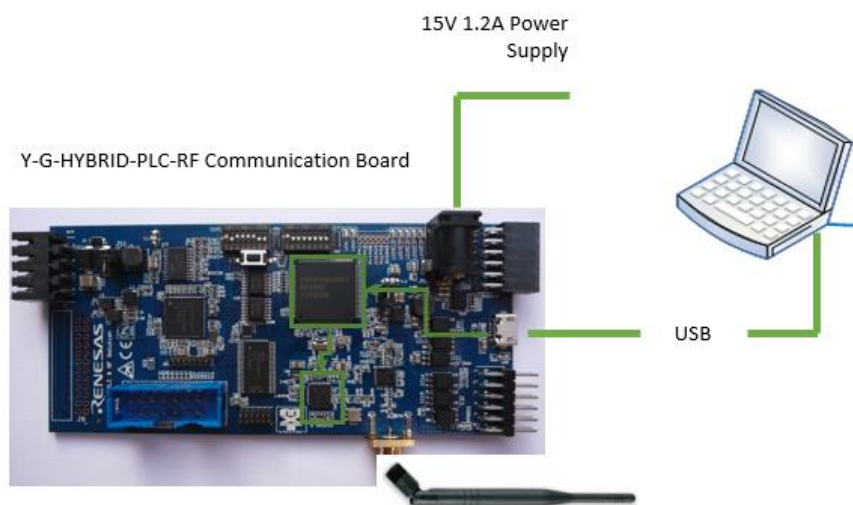


Figure 15. USB to RX651 Host Control Connection (RF Only)

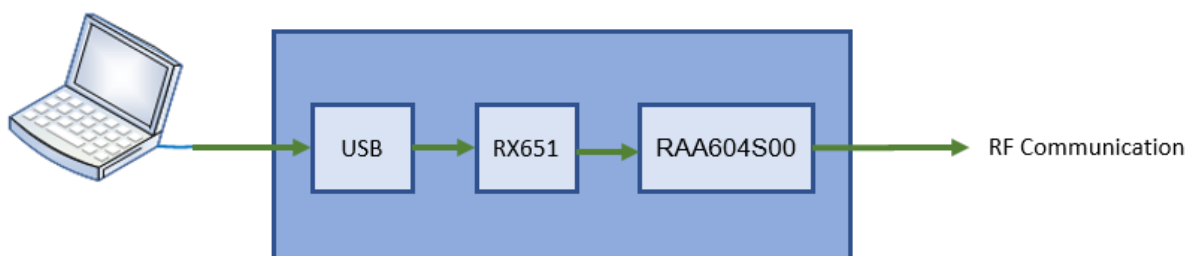


Figure 16: USB to RX651 Host Control Connection (RF Only) Block Diagram.

The following table shows the DIP2 switch settings for this mode.

DIP2 Switch	Setting
1	OFF
2	ON
3	OFF
4	ON

5	ON
6	ON
7	OFF
8	OFF

Table 18: DIP2 Switch Control for USB to RX651 Host Control Connection (RF Only)

### 7.4 USB to RX651 Host Control (Hybrid)

This configuration is used when there is a sample application running on the RX651 and the user either wants to develop on the RX651 or use the functionality of the RX651 to control the power line modem LSI - R9A06G037, which in turn also controls the sub-GHz wireless modem LSI RAA604S00. This is shown in Figure 17. USB to RX651 Host Control Connection (Hybrid). In this mode the USB connection is connected to the RX651 and a UART interface is used to connect the RX651 and power line modem LSI - R9A06G037. The power line modem LSI - R9A06G037 is then connected via SPI to the sub-GHz wireless modem LSI RAA604S00.

This configuration is required for:

- G3-PLC Hybrid Sample Applications.
- G3-PLC SimpleMAC.
- G3-PLC Hybrid Wireshark Application.
- PRIME 1.4+MultiPHY Sample Applications.
- G3-PLC Hybrid Network Communicator and PRIME Base Node for Hybrid.
- Renesas RF Test Studio.

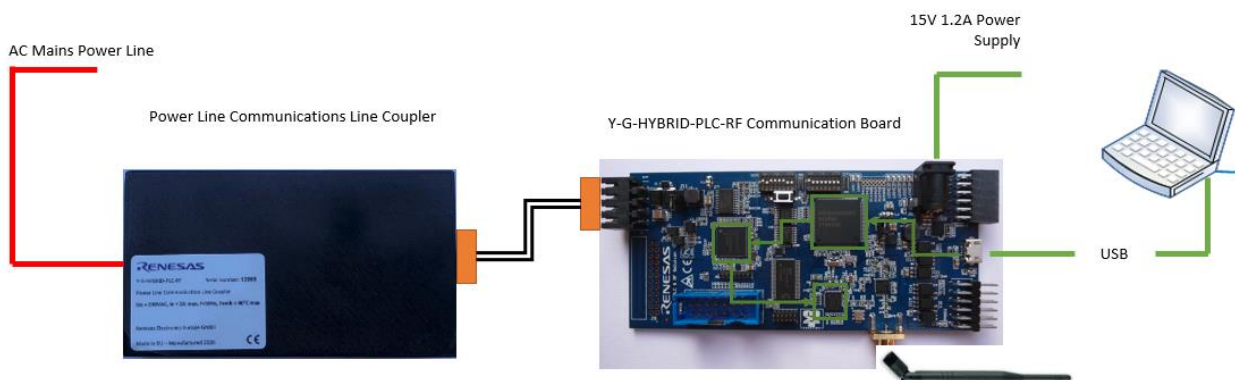


Figure 17. USB to RX651 Host Control Connection (Hybrid)

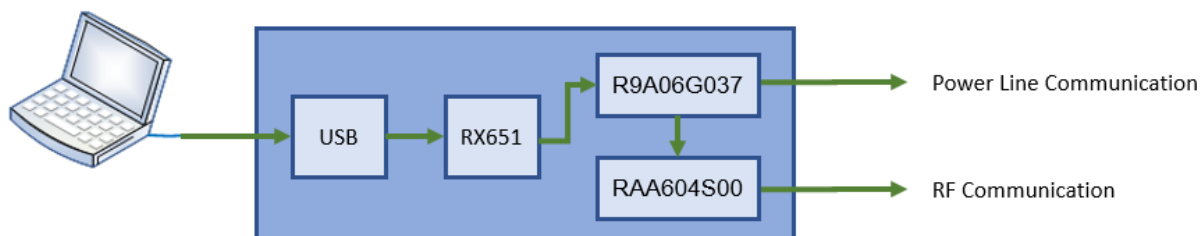


Figure 18: USB to RX651 Host Control Connection (Hybrid) Block Diagram.

The following table shows the DIP2 switch settings for this mode.

DIP2 Switch	Setting
1	ON
2	OFF
3	ON
4	ON
5	ON
6	ON
7	OFF
8	OFF

Table 19: DIP2 Switch Control for USB to RX651 Host Control (Hybrid)

### 7.5 USB to R9A06G037 (PLC Only)

This configuration is used when there is no requirement for a sample application running on the RX651 and the user wants to bypass the RX651 and connect directly to the power line modem LSI - R9A06G037. This is shown in Figure 19. USB to R9A06G037 Connection (PLC Only). In this mode the USB connection is connected directly to the Power line modem LSI - R9A06G037. In this configuration the sub-GHz wireless modem LSI RAA604S00 is not used. This mode can be used for users wishing to develop applications directly on the PC or to interface directly the R9A06G037 via the appropriate Serial Command Specifications.

Note in this mode the user can select whether the RTS line for the USB interface is connected to the R9A06G037 device or not. DIP2:8 controls this function, DIP2:8 'ON' connects the RTS line, DIP2:8 'OFF' disconnects the RTS line.

This configuration is required for:

- CPX Downloader.
- Continuous Wave Test Application.

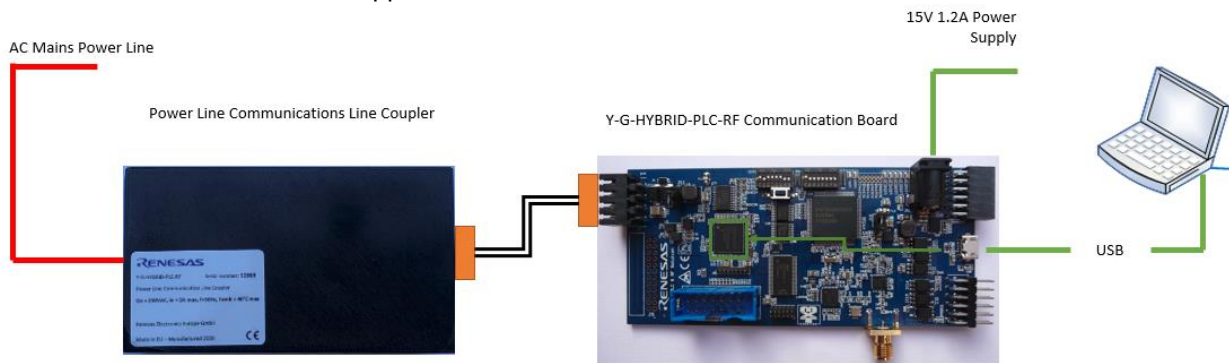
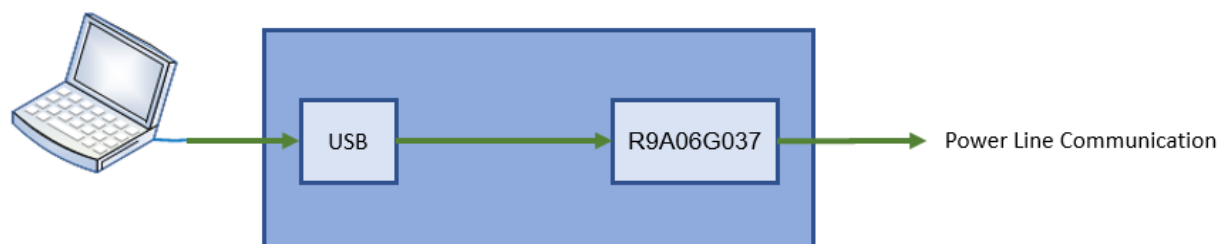


Figure 19. USB to R9A06G037 Connection (PLC Only)





**Figure 20: USB to R9A06G037 Connection (PLC Only) Block Diagram.**

The following table shows the DIP2 switch settings for this mode.

DIP2 Switch	Setting
1	OFF
2	ON
3	OFF
4	ON
5	ON
6	OFF
7	ON
8	ON/OFF

**Table 20: DIP2 Switch Control for USB to R9A06G037 Connection (PLC Only)**

## 7.6 USB to R9A06G037 (Hybrid)

This configuration is used when there is no requirement for a sample application running on the RX651 and the user wants to bypass the RX651 and connect directly to the power line modem LSI - R9A06G037. This is shown in Figure 21. USB to R9A06G037 Connection (Hybrid). In this mode the USB connection is connected directly to the power line modem LSI - R9A06G037. In this configuration the sub-GHz wireless modem LSI RAA604S00 is connected and controlled via SPI to the R9A06G037. This mode can be used for users wishing to develop applications directly on the PC or to interface directly the R9A06G037 via the appropriate Serial Command Specifications.

Note in this mode the user can select whether the RTS line for the USB interface is connected to the R9A06G037 device or not. DIP2:8 controls this function, DIP2:8 'ON' connects the RTS line, DIP2:8 'OFF' disconnects the RTS line.

This configuration is required for:

- CPX Downloader.
- Continuous Wave Test Application.



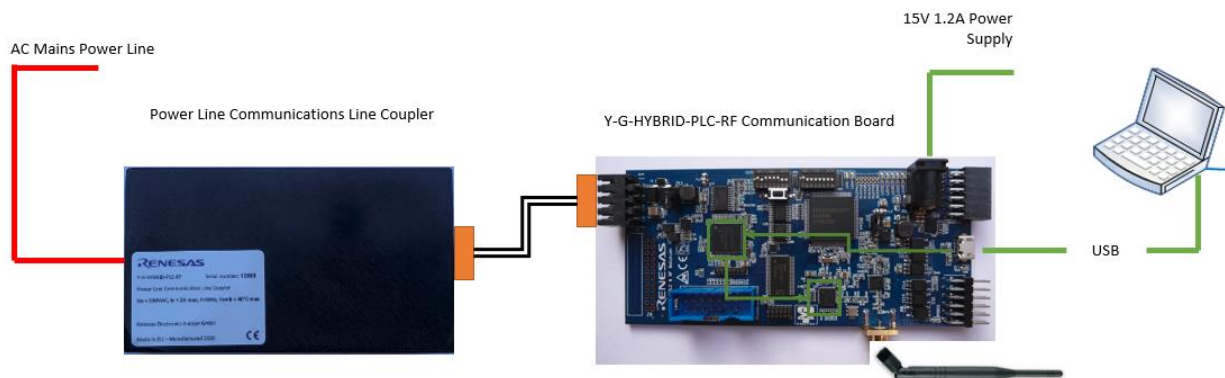


Figure 21. USB to R9A06G037 Connection (Hybrid)

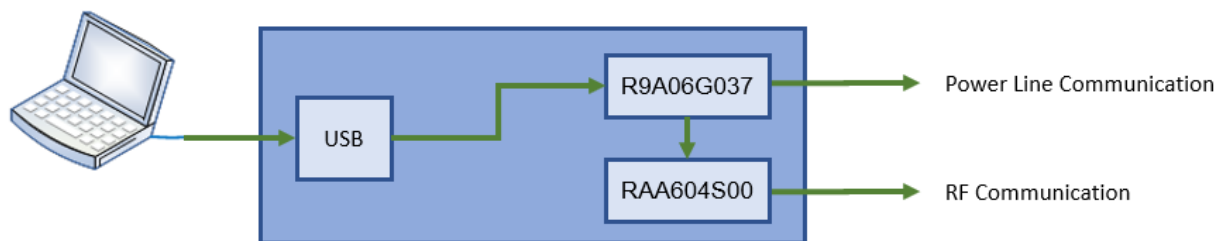


Figure 22: USB to R9A06G037 Connection (Hybrid) Block Diagram.

The following table shows the DIP2 switch settings for this mode.

DIP2 Switch	Setting
1	ON
2	OFF
3	OFF
4	ON
5	ON
6	OFF
7	ON
8	ON/OFF

Table 21: DIP2 Switch Control for USB to R9A06G037 Connection (Hybrid)

### 7.7 PMOD2 to R9A06G037 (PLC Only)

This configuration is used when there is no requirement for a sample application running on the RX651 and the user wants to bypass the RX651 and connect directly to the power line modem LSI - R9A06G037. This is shown in Figure 23. PMOD2 to R9A06G037 Connection (PLC Only). In this mode the PMOD2 UART interface connection is connected directly to the power line modem LSI - R9A06G037. In this configuration the sub-GHz wireless modem LSI RAA604S00 is not used. This mode can be used for users wishing to develop applications on an external HOST MCU such as the RA6M4 and connect a host processor easily to the R9A06G037 using the PMOD standard interface. The PMOD standard interface is available on most of the Renesas starter kits allowing users to develop on a wide range of application processors using standard starter kits. The interface to the R9A06G037 is then via the appropriate Serial Command Specifications.

This configuration is required for:

- G3-PLC Sample Applications (For RA6M4 – EK-RA6M4)
- G3-PLC, PRIME and Meters and More Sample Applications for porting to a different Host MCU.

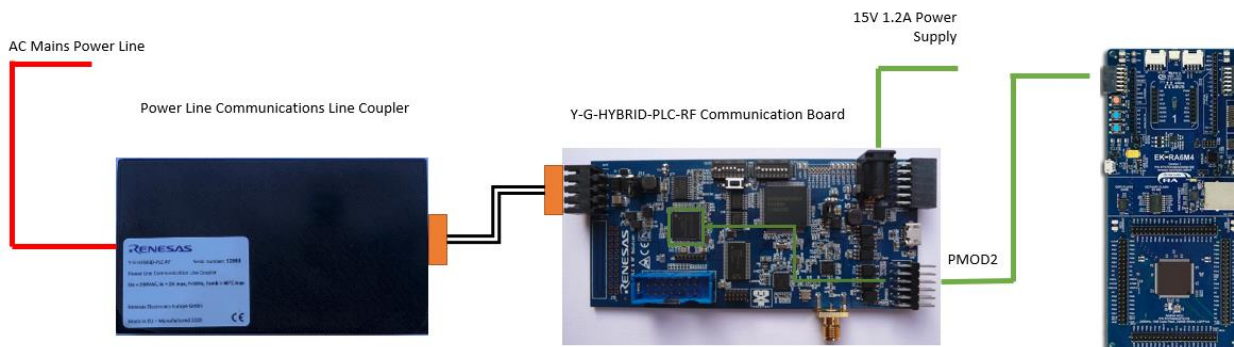


Figure 23. PMOD2 to R9A06G037 Connection (PLC Only)

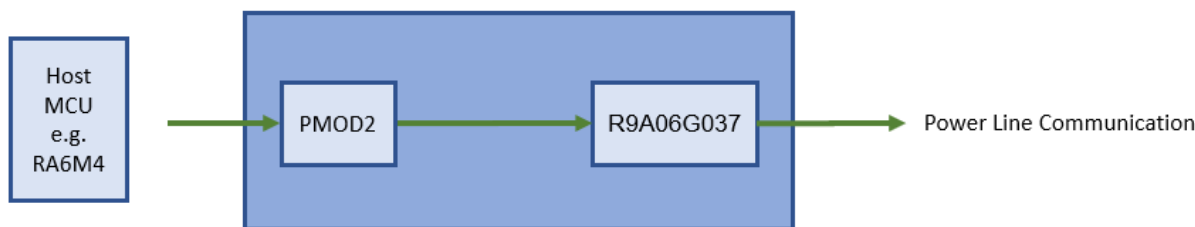


Figure 24: PMOD2 to R9A06G037 Connection (PLC Only) Block Diagram.

The following table shows the DIP2 switch settings for this mode.

DIP2 Switch	Setting
1	OFF
2	ON
3	ON
4	OFF
5	OFF
6	ON
7	ON
8	OFF

Table 22: DIP2 Switch Control for PMOD2 to R9A06G037 Connection (PLC Only)

### 7.8 PMOD2 to R9A06G037 (Hybrid)

This configuration is used when there is no requirement for a sample application running on the RX651 and the user wants to bypass the RX651 and connect directly to the power line modem LSI - R9A06G037. This is shown in Figure 25. PMOD2 to R9A06G037 Connection (Hybrid Only). In this mode the PMOD2 UART interface connection is connected directly to the power line modem LSI - R9A06G037. In this configuration the sub-GHz wireless modem LSI RAA604S00 is connected and controlled via SPI to the R9A06G037. This mode can be used for users wishing to develop applications on an external HOST MCU such as the RA6M4 and connect a host processor easily to the R9A06G037 using the PMOD standard interface. The PMOD standard interface is available on most of the Renesas starter kits allowing users to develop on a wide range

of application processors using standard starter kits. The interface to the R9A06G037 is then via the appropriate Serial Command Specifications.

This configuration is required for:

- G3-PLC Hybrid Sample Applications (For RA6M4 – EK-RA6M4)
- G3-PLC and PRIME Hybrid Sample Applications for porting to a different Host MCU.

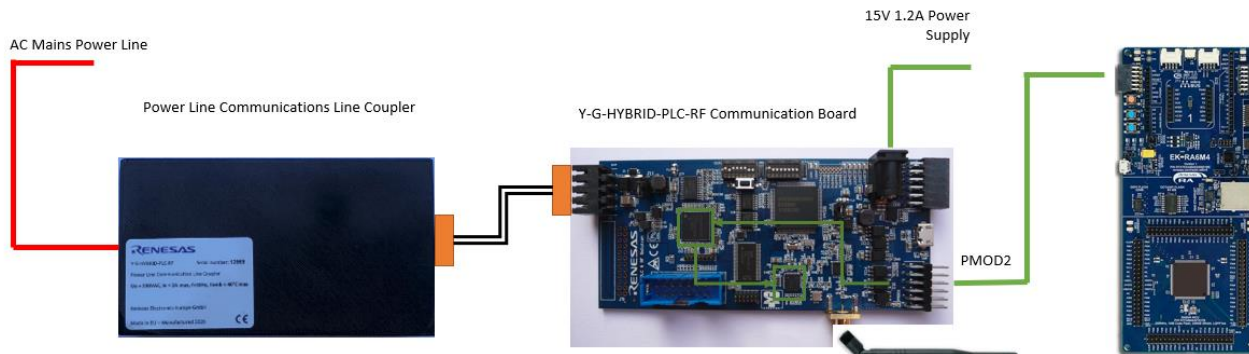


Figure 25. PMOD2 to R9A06G037 Connection (Hybrid Only)

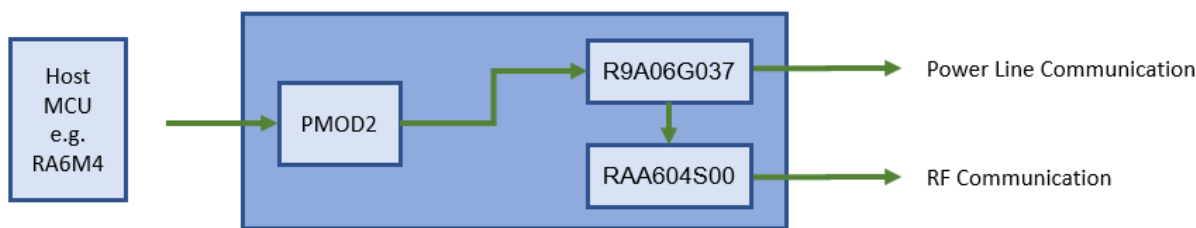


Figure 26: PMOD2 to R9A06G037 Connection (Hybrid) Block Diagram.

The following table shows the DIP2 switch settings for this mode.

DIP2 Switch	Setting
1	ON
2	OFF
3	ON
4	OFF
5	OFF
6	ON
7	ON
8	OFF

Table 23: DIP2 Switch Control for PMOD2 to R9A06G037 Connection (Hybrid)

### 7.9 USB to RX651 Host Control (RF) and PMOD2 to R9A06G037 (PLC Only)

This configuration is used when there is a sample application running on the RX651 (such as the WiSUN FAN stack) and the user also wishes to connect to and control the power line modem LSI - R9A06G037 in parallel. The user can then develop on the RX651 or use the functionality of the RX651 to control the sub-GHz wireless modem LSI - RAA604S00 and use an external host MCU or other application to connect via PMOD2 using the UART interface to the R9A06G037. This is shown in Figure 27: USB to RX651 Host

Control (RF) and PMOD2 to R9A06G037 Connection (PLC Only). In this mode the USB connection is connected to the RX651 which has an SPI interface connection to control the sub-GHz wireless modem LSI - RAA604S00 and the PMOD2 has a UART interface to connect and control the power line modem LSI - R9A06G037 via the appropriate Serial Command Specifications. This mode can be used for users wishing to develop applications on a HOST MCU such as the RA6M4 and connect a host processor easily to the R9A06G037 using the PMOD standard interface

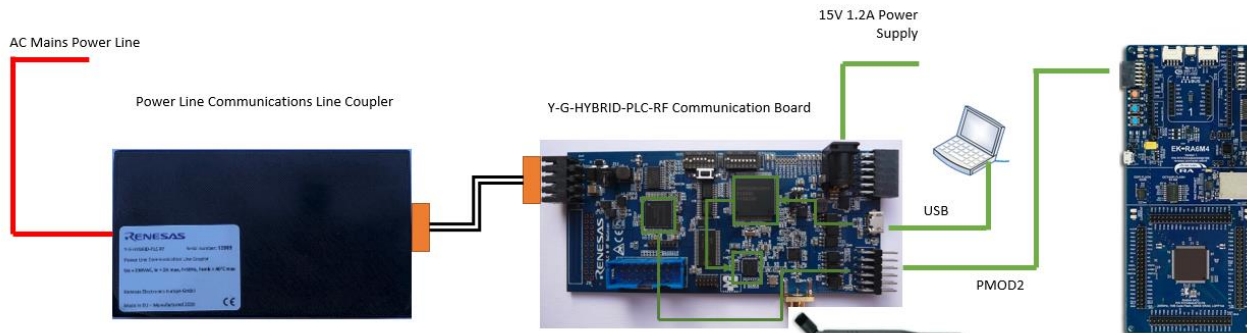


Figure 27: USB to RX651 Host Control (RF) and PMOD2 to R9A06G037 Connection (PLC Only)

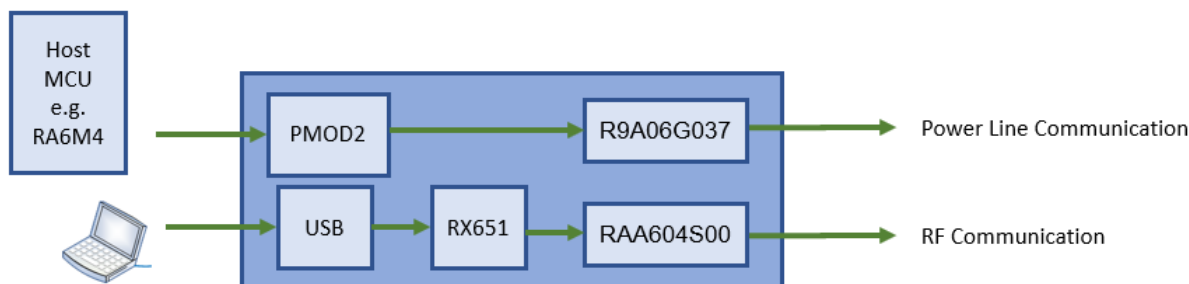


Figure 28: USB to RX651 Host Control (RF) and PMOD2 to R9A06G037 Connection (PLC Only) Block Diagram.

The following table shows the DIP2 switch settings for this mode.

DIP2 Switch	Setting
1	OFF
2	ON
3	ON
4	OFF
5	ON
6	ON
7	OFF
8	OFF

Table 24: DIP2 Switch Control for USB to RX651 Host Control (RF) and PMOD2 to R9A06G037 Connection (PLC Only)

## 8. MyRenesas Software Registration

Software packages are available for this communication platform. The protocol stacks from Renesas are available via “MyRenesas”, please register and sign up to receive protocol updates from Renesas. To make these packages available Renesas will need to complete an ICP and export control check. Registration can be done following this link:

<https://www.renesas.com/us/en/gur/ssRegisterUser.do>

Once registered inform your Renesas representative indicating the email address used for registration, providing the following information (required for ICP and Export checks)

- Customer Legal Name: (including GmbH, SA, AE, Inc., or any other)
- Company Web Link
- Email domain: (e.g. @xxxxx.com)
- Country
- ZIP Code/Postal Code
- City
- Full address
- Phone number of contact person

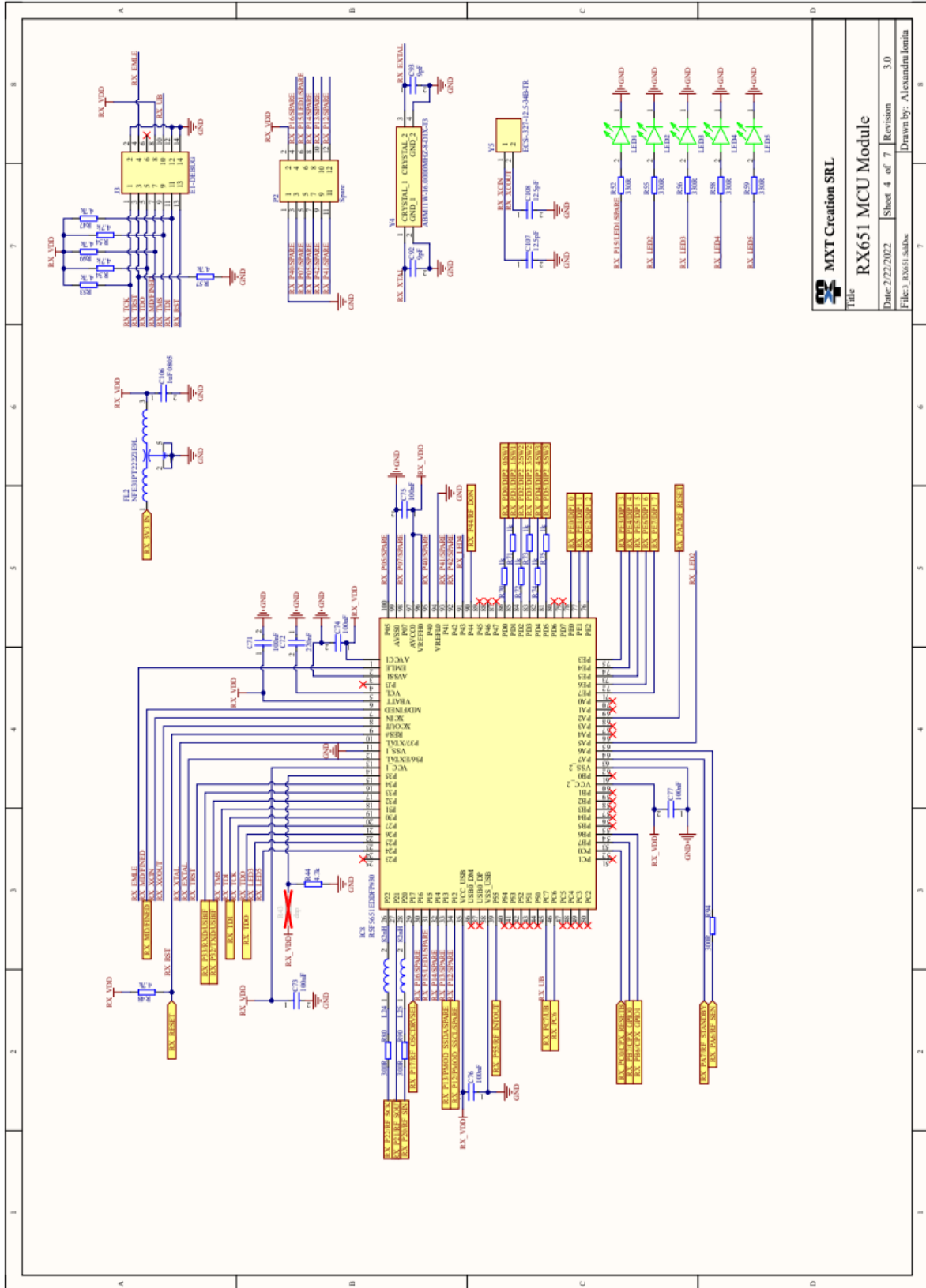




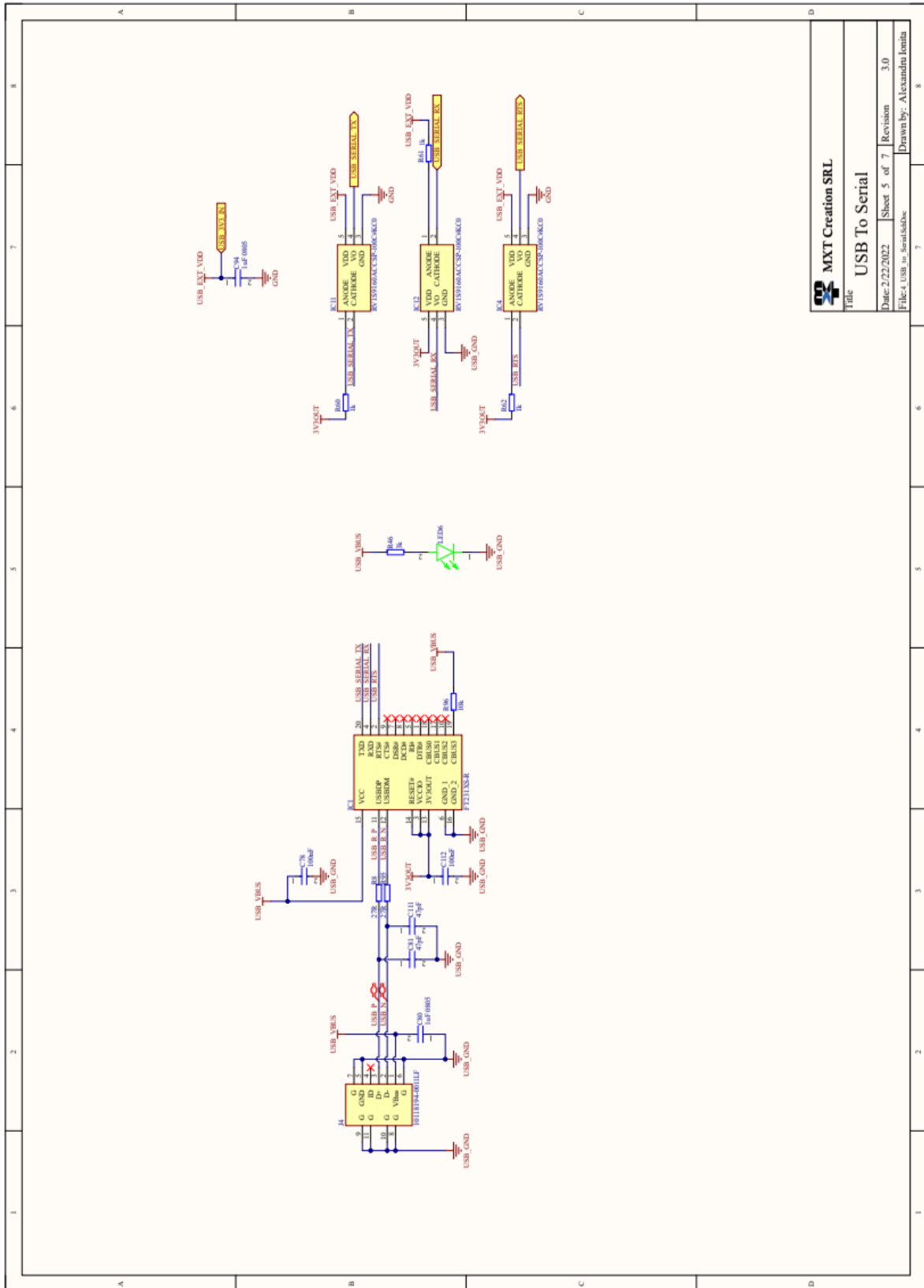




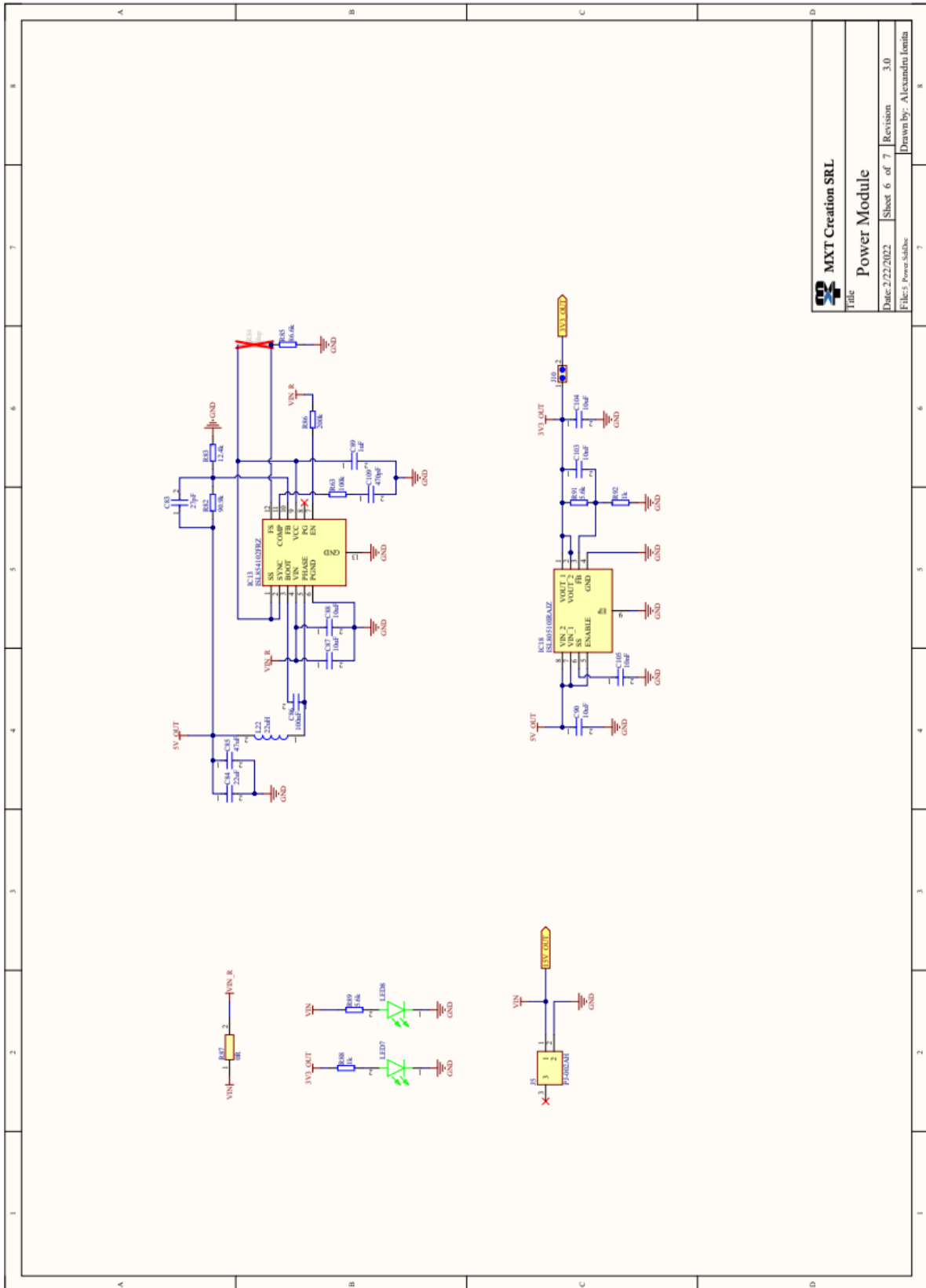


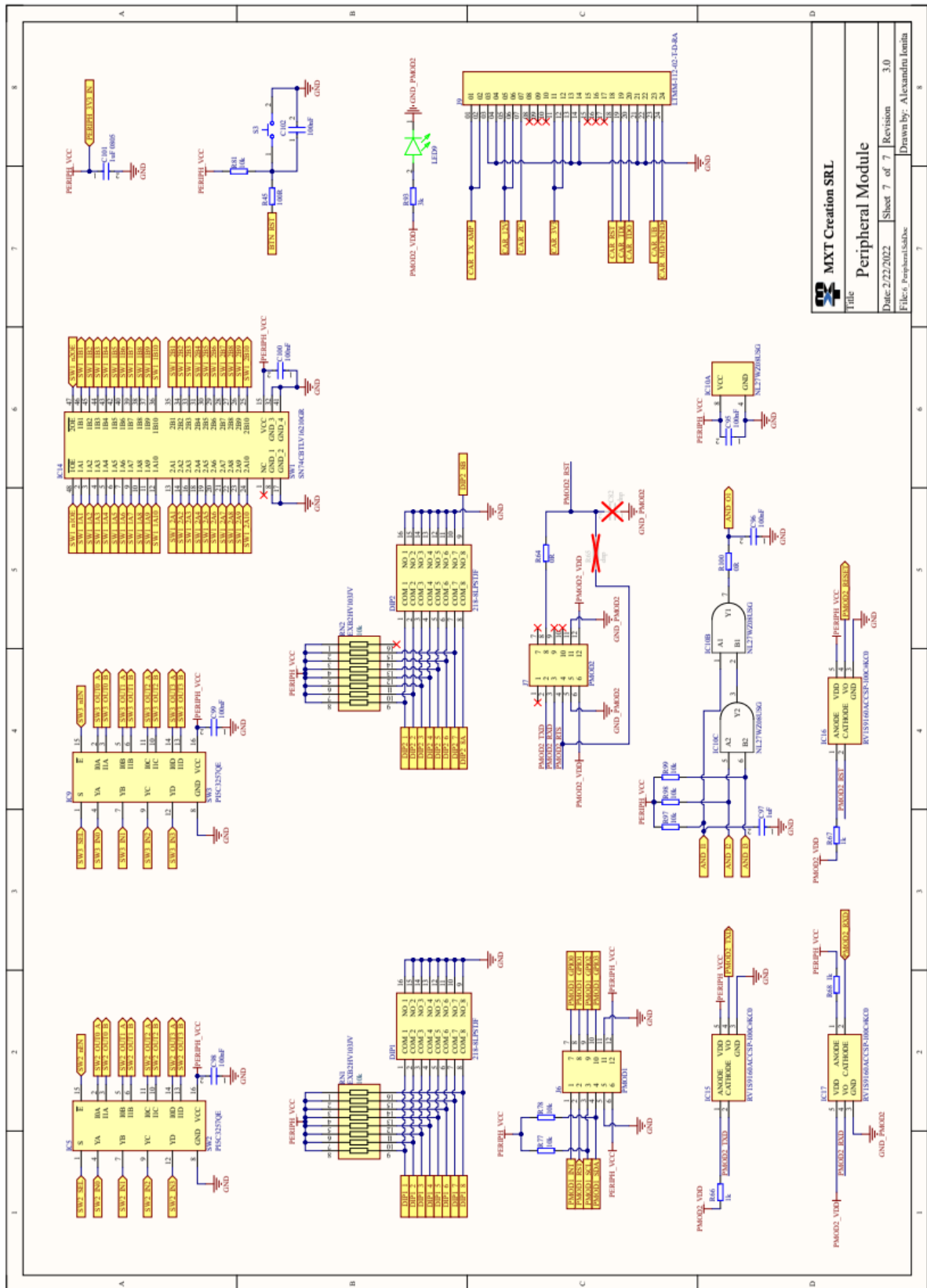


**MXT Creation SRL**  
Title: **RX651 MCU Module**  
Date: 2/22/2022 | Sheet 4 of 7 | Revision 3.0  
File: rx651\_sabw | Drawn by: Alexandru Ionita



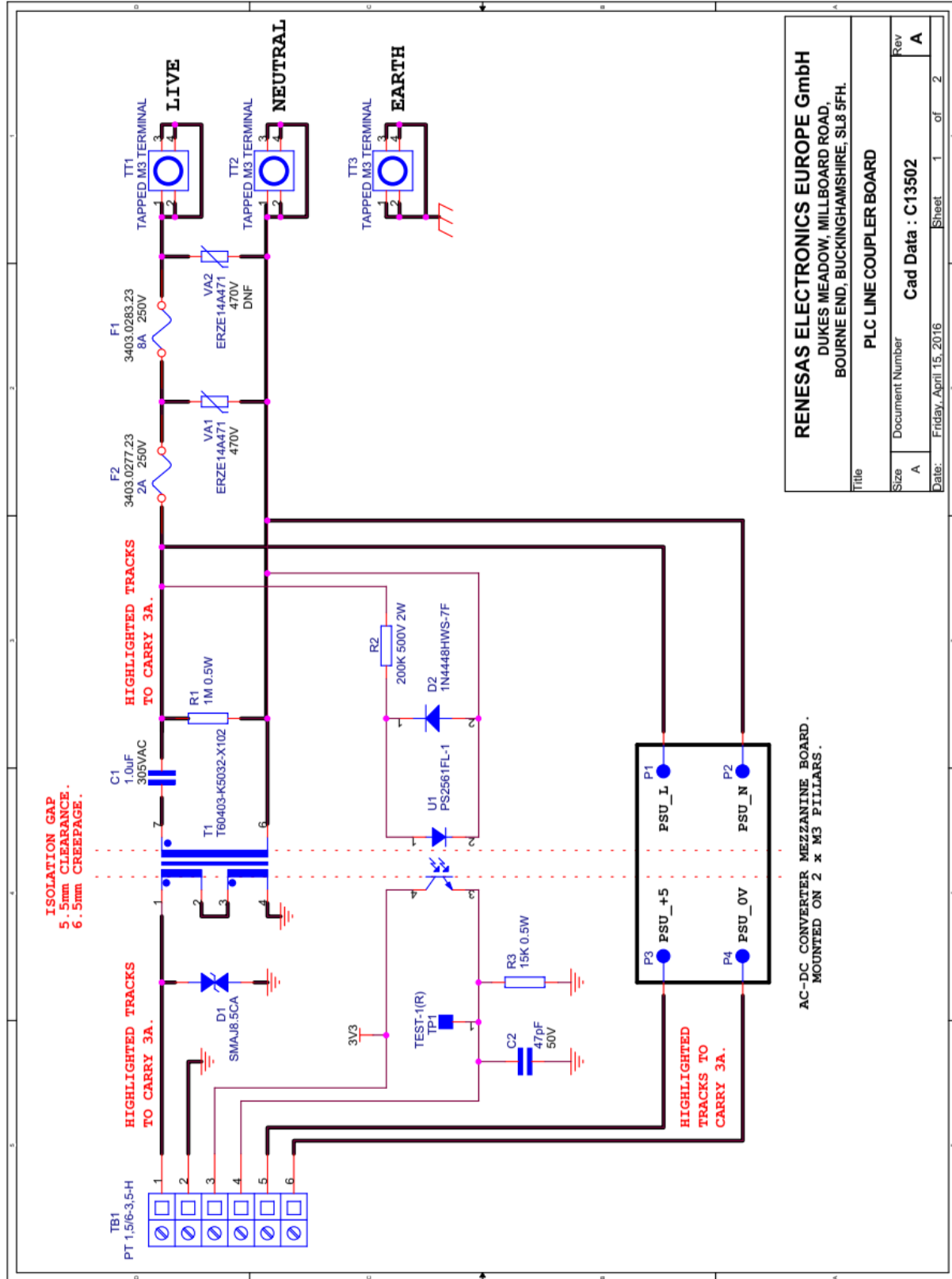
**MXT Creation SRL**  
**USB To Serial**  
 Title  
 Date: 2/22/2022 | Sheet 5 of 7 | Revision 3.0  
 File: 4\_USB to Serial.sch  
 Drawn by: Alexandru Ionita





**MXT Creation SRL**  
**Peripheral Module**  
 Date: 2/22/2022 | Sheet 7 of 7 | Revision 3.0  
 File: PeriphModule.docx | Drawn by: Alexandru Ionita

## 9.2 Y-G-HYBRID-PLC-RF Communication Line Coupler



## 10. System BOM list

### 10.1 Y-G-HYBRID-PLC-RF Communication Board

Designator	Comment	Quantity 1 pcs
3V3, LED1, LED2, LED3, LED4, LED5, LED9, LED10, USB, VIN	APT1608SGC	10
C1, C3, C9, C10, C11, C12, C17, C20, C26, C28, C30, C71, C73, C74, C75, C76, C77, C78, C86, C95, C96, C98, C99, C100, C102, C110, C112	100nF	27
C2	10pF	1
C4, C6, C7, C84	22uF	4
C5, C44, C87, C88, C90, C104	10uF	6
C8, C18	4.7uF	2
C13, C19, C21, C33, C36, C37, C40, C41, C42, C43, C45, C46, C50, C53, C60, C68, C69, C89, C97	1uF	19
C14, C25	47nF	2
C15, C16	12pF	2
C22	10uF	1
C23, C24	4.7nF	2
C27, C39	22nF	2
C29, C35	33nF	2
C31, C32	39nF	2
C38	5.6nF	1
C47	4.7uF	1
C49	1nF	1
C51, C103, C105	10nF	3
C52	33pF	1
C54, C55, C92, C93	9pF	4
C56	100pF	1
C57	22pF	1
C58	8.2pF	1
C59	1.8pF	1
C62	2.4pF	1
C63	4.7pF	1
C64	5.6pF	1
C65, C66	3.3pF	2
C67	0.5pF	1

C72	220nF	1
C80, C94, C101, C106	1uF 0805	4
C81, C111	47pF	2
C83	27pF	1
C85	47uF	1
C91	10uF	1
C107, C108	12.5pF	2
C109	470pF	1
D1, D2	ES3AB-13-F	2
DIP1, DIP2	218-8LPSTJF	2
FB1, FB2	NFM18CC222R1C3D	2
FB3	OR	1
FL1, FL2	NFE31PT222Z1E9L	2
IC1	FT231XS-R	1
IC2	R9A06G037	1
IC3	NJM45001	1
IC4, IC11, IC12, IC15, IC16, IC17	RV1S9160ACCSP-100C#KCO	6
IC6	SE2435L-R	1
IC7	RAA604S00	1
IC8	R5F5651EDDFP#30	1
IC5, IC9	SW2, SW3	2
IC10	NL27WZ08USG	1
IC13	ISL854102FRZ	1
IC14	SW1	1
IC18	ISL80510IRAJZ	1
J1	SL_3.50/04/90G	1
J2	FTSH-106-01-F-D	1
J3	E1-DEBUG	1
J4	10118194-0011LF	1
J5	PJ-002AH	1
J6	PMOD1	1
J7	PMOD2	1
J8	M50-3530842	1
J9	LTMM-112-02-T-D-RA	1
J10, J11	10129378-902001BLF	2
L1	4.7uH	1
L2, L23	100nH	2
L24, L25	82nH	2
L3	4.7uH	1
L4, L5	39uH	2
L6	270uH	1
L7, L8	22nH	2
L9	3.3nH	1
L10	4.7nH	1



L11, L20, L21	6.8nH	3
L12	10uH	1
L13	1.3nH	1
L14	5.6nH	1
L15, L18	0R	2
L16	2.2nH	1
L17, L19	5.6nH	2
L22	22uH	1
LED11	APT1608SRCPRV	1
R1	5.1k	1
R3	0R	1
R5, R9, R60, R61, R62, R66, R67, R68, R70, R71, R72, R73, R74, R75, R88, R92	1k	16
R6	560R	1
R7, R11, R26, R27	120R	4
R8, R95	27R	2
R10, R21, R23, R28, R33, R35, R36, R38, R41, R64, R76, R100	0R	12
R12, R14	681R	2
R13, R18	6.81k	2
R15, R16, R19	390R	3
R17, R77, R78, R81, R96, R97, R98, R99	10k	8
R20, R52, R55, R56, R58, R59	330R	6
R22	33R	1
R24, R46, R93	3k	3
R25	56k	1
R31, R40, R49, R50, R80, R90, R94	300R	7
R32, R37	51R	2
R34, R42, R44, R47, R48, R53, R54, R57, R69	4.7k	9
R39, R63	100k	2
R45, R51	100R	2
R82	90.9k	1
R83	12.4k	1
R85	86.6k	1
R86	200k	1
R87	0R	1
R89, R91	5.6k	2
RN1, RN2	EXB2HV103JV	2

S3	PTS636_SP43_SMTR_LFS	1
SAW1	B39871B3717U410	1
SMA1	60312202114514	1
Y1	ABM11W-16.0000MHZ-8-B1U-T3	1
Y2	XRCMD48M000FXQ60R0	1
Y4	ABM11W-16.0000MHZ-8-D1X-T3	1
Y5	ECS-.327-12.5-34B-TR	1
Z1	KDZTR18B	1

Table 25: Y-G-HYBRID-PLC-RF Communication Board BoM list

## 10.2 Y-G-HYBRID-PLC-RF Communication Board

Designator	Comment	Quantity 1 pcs
C1	0.47uF	1
C2	47pF	1
D1	SMAJ8.5CA	1
D2	1N4448HWS-7F	1
F1	8A	1
F2	2A	1
R1	1M 0.5W	1
R2	200K 500V 2W	1
R3	15K 0.5W	1
TT1,TT2,TT3	TAPPED M3 TERMINAL	3
T1	T60403-K5032-X102	1
U1	PS2561L-1	1
VA1	ERZE14A471	1

Table 26: Y-G-HYBRID-PLC-RF Communication Line Coupler BoM list

## 11. Certifications and Regulatory Compliance.

The Y-G-HYBRID-PLC-RF board meets the following certifications/standards. See page 7 of this user's manual for the disclaimer and precautions.

### 11.1 EMC/EMI Standards



FCC: This is an evaluation kit as defined in the Code of Federal Regulations: Title 47: Section 2.1. The Y-G-HYBRID-PLC-RF kit is for evaluation only; not FCC approved for resale.

FCC Notice: This kit is designed to allow:

- (1) Product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and
- (2) Software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of the Code of Federal Regulations: Title 47, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5.

CE Class A (EMC)



This product is herewith confirmed to comply with the requirements set out in the Council Directives on the Approximation of the laws of the Member States relating to Electromagnetic Compatibility Directive 2014/30/EU.

**Warning** – This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures to correct this interference.

ETSI:

The Y-G-HYBRID-PLC-RF evaluation kit has been externally tested and complies to the following European standards:

Radio Equipment Directive 2014/53/EU                      Harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC

ETSI EN 301 489-1 V2.2.3:                      Electromagnetic Compatibility (EMC) standard for radio equipment and services;  
Part 1: Common technical requirements; Harmonised Standard for Electromagnetic Compatibility

ETSI EN 301 489-3 V2.1.1:                      Electromagnetic Compatibility (EMC) standard for radio equipment and services;  
Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9 kHz and 246 GHz;  
Harmonised Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU

ETSI EN 300 220-1 V3.1.1:                      Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz;

Part 1: Technical characteristics and methods of measurement

ETSI EN 300 220-2 V3.2.1: Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz;

Part 2: Harmonised Standard for access to radio spectrum for non specific radio equipment

The Y-G-HYBRID-PLC-RF evaluation kit supports the frequencies as defined by ETSI EN 303 204 V2.1.2 and ETSI EN 303 204 V3.1.1 standard but has not been tested according to these specifications.

UKCA Class A (EMC)



This product is in conformity with the following relevant UK Statutory Instrument(s) (and its amendments): 2016 No. 1091 Electromagnetic Compatibility Regulations 2016.

**Warning** – This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures to correct this interference.

The Y-G-HYBRID-PLC-RF evaluation kit has been externally tested and complies the Radio Equipment Regulations 2017 No. 1206.

## 11.2 Material Selection, Waste, Recycling and Disposal

2011/65/EU Restriction of Hazardous Substances (RoHS Directive) + amendment (EU) 2015/863 (RoHS3)

2012/19/EU Waste Electrical and Electronic Equipment (WEEE Directive)

2012 No. 3032 The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations

2013 No. 3113 Waste Electrical and Electronic Equipment Regulations

## 12. Website and Support

Visit the following URLs to learn about the kit and the RA family of microcontrollers, download tools and documentation, and get support.

RX651 Host MCU	<a href="https://www.renesas.com/RX651">https://www.renesas.com/RX651</a>
Power Line Modem LSI R9A06G037, Cool Phoenix 3	<a href="https://www.renesas.com/R9A06G037">https://www.renesas.com/R9A06G037</a>
Sub-GHz Wireless Modem LSI RAA604S00	<a href="#">Sub-GHz Wireless Communication Solutions   Renesas</a>
E2, E2 Lite or E20 Emulator.	<a href="https://www.renesas.com/us/en/design-support/development-tools#dev-tools-list">https://www.renesas.com/us/en/design-support/development-tools#dev-tools-list</a>
Optocouplers	<a href="http://www.renesas.com/RV1S9160A">www.renesas.com/RV1S9160A</a>
Active switches	<a href="https://www.renesas.com/QS3257QG8">https://www.renesas.com/QS3257QG8</a>
	<a href="https://www.renesas.com/QS3VH16210PAG8">https://www.renesas.com/QS3VH16210PAG8</a>
Regulator DCDC	<a href="https://www.renesas.com/ISL854102">https://www.renesas.com/ISL854102</a>
LDO	<a href="https://www.renesas.com/ISL80510">https://www.renesas.com/ISL80510</a>
FTDI Driver	<a href="http://www.ftdichip.com/Drivers/VCP.htm">http://www.ftdichip.com/Drivers/VCP.htm</a>
MyRenesas Registration	<a href="https://www.renesas.com/us/en/gur/ssoRegisterUser.do">https://www.renesas.com/us/en/gur/ssoRegisterUser.do</a>
Renesas Support	<a href="https://www.renesas.com/support">renesas.com/support</a>

**Revision History**

Rev.	Date	Description	
		Page	Summary
1.00	July.14.22	—	Initial release
1.01	Feb. 03.23	27	Corrected Table 19: DIP2 Switch Control for USB to RX651 Host Control
1.02	April. 04.24	48	Updated MyPages registration to MyRenesas
		33	Updated MyPages registration to MyRenesas
		46, 47	Added section on certifications and regulatory compliance

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