QLG2-SE GPS/GNSS Receiver

This manual is for the QLG2-SE GPS/GNSS Receiver module

Contents

1. Introduction

The QLG2-SE GNSS (Global Navigation Satellite System) receiver module is an upgrade over the former QLG1 with higher performance and highly flexible features:

QLG2-SE is a reduced functionality version of the QLG2. Compared to QLG2, it lacks the USB to Serial converter interface and the capability to use an optional LCD module.

- Multi GNSS satellite constellation receiver supports GPS (US), Galileo (Europe), GLONASS (Russia) and Beidou (Chinese) - (default GPS + Beidou) - giving a faster more accurate position fix – Module is E108-GN01 (GK9501 GNSS chip set)
- Supplied with included magnetic-mount active antenna, approx 2m coax and SMA connectors
- Supply voltage range 3.3 to 6V.
- Board 80 x 37mm (Same as, and compatible with, Ultimate3S, VFO and Clock kits).
- Onboard LEDs for status indication: Red (Power), Yellow (Serial data) and Green (PPS).
- 2.8 to 5V logic level conversion to provide 5V serial data for full compatibility with all QRP Labs kits.
- Supports 2.8/3.3V logic OR 5V logic (jumper wire selected)
- SMD assembly already undertaken by factory facility - only SMA connector to solder.
- Space provided for optional ultra-capacitor for faster hot-start

All QLG2-SE GPS modules are comprehensively tested before shipment including:

- Active antenna with 2m coax and SMA connector functions correctly
- Satellite reception and Time To First Fix is under 1 minute
- Serial data and 1pps outputs are correctly present

PLEASE READ THE BASIC ASSEMBLY AND USE INSTRUCTIONS IN THIS MANUAL VERY CAREFULLY BEFORE APPLYING POWER TO THE BOARD!

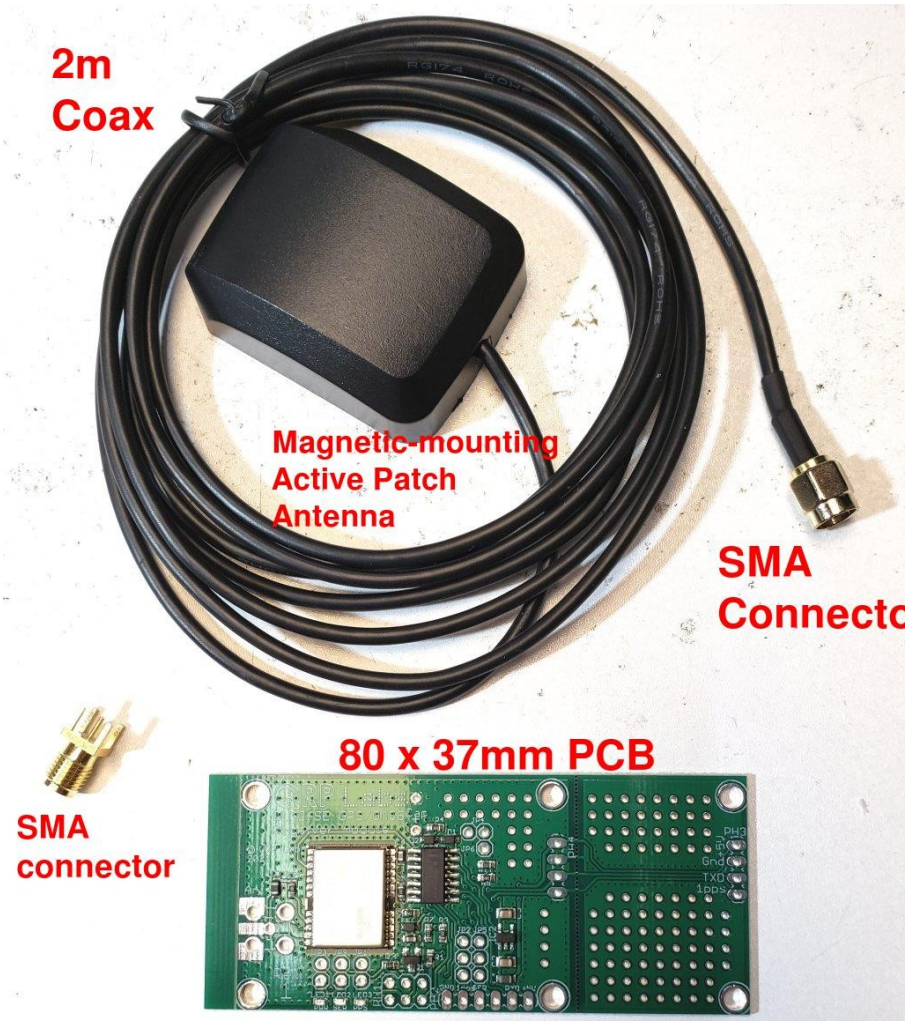
2. Getting to know your QLG2-SE

There are only THREE parts in the QLG2-SE kit:

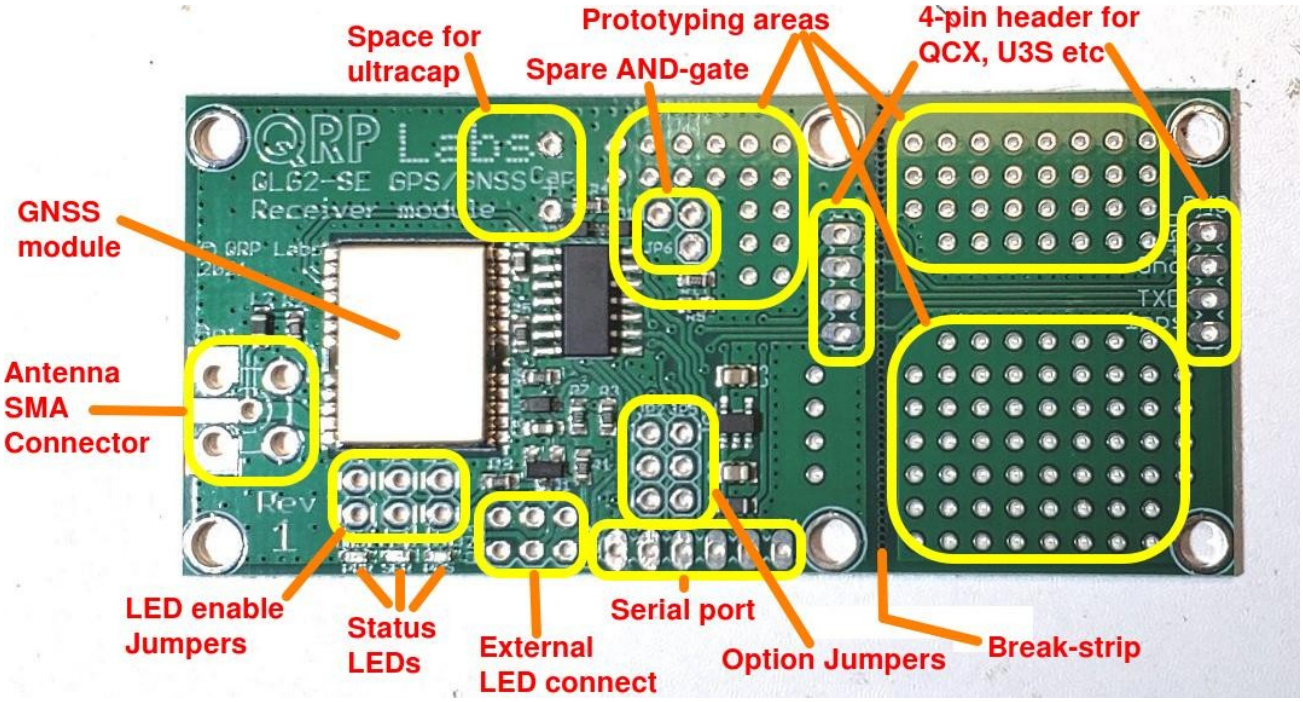
1. 80 x 37mm PCB with assembled SMD
2. Active antenna including 2m coaxial cable and SMA connector
3. SMA connector for installation on the PCB

The parts list of the PCB is provided later in this manual in the circuit description section.

Kit contents:



Know your QLG2:



With reference to the above photograph, looking anti-clockwise from left:

- GNSS Module: The E108-GN01 GNSS receiver module, multi-satellite system capable (GPS and Beidou enabled by default).
- Antenna SMA Connector (supplier): Can be board edge-mounted or at 90-degrees standing up on the board (**DO refer to important assembly instructions later**).
- LED enable jumpers: these are wired by default, and connect the signals to the onboard LEDs. If you wanted to use external LEDs for example in a front panel, you would cut the tiny traces under these jumpers (see later section).
- Status LEDs:
  - Power (RED): always lit
  - Serial Data (Yellow): flashes once per second in time with the serial data burst
  - 1 PPS (Blinding Green): flashes once per second when a 3D satellite lock is acquired
- External LED connect: Three LEDs may be connected here using wires if you prefer external LEDs to the onboard SMD LEDs.
- 6-pin interface: this provides six pads:
  - GND
  - GNSS 1pps
  - GNSS serial data
  - No connection
  - RxD serial data
  - +5V power supply input
- Option Jumpers: configure how the serial port pads are connected, allowing either 2.8/3.3V logic or 5V logic levels
- Break-strip: this line of drilled holes allows you to easily snap off the right-hand part of the board, if you would like a smaller board (53 x 37mm)
- 4-pin interface: pads for QCX, U3S etc: the standard QRP Labs 4-pin connector: +5V, Gnd, Serial Data (TxD) and 1PPS. There are two 4-pin connectors, they are wired in parallel, so that you can use either one depending on whether or not you break apart the PCB (see above).
- Prototyping areas – the unused space on the PCB is populated by a 0.1-inch pitch matrix of tinned through-holes where you can add your own components if you need to.
- Spare AND-gate: one of the four AND gates in the 74AC08 is not used, you can use it as a buffer if you need to.
- Space for Ultracap: 5mm-spaced pads suitable for installation of an Ultracap for ephemeris backup purposes; this provides faster hot-start.

The board size is 80 x 37mm, and the holes in the four corners are at exactly the same positions as on the Ultimate3S, Clock and VFO kits; therefore the board can be stack-mounted behind these kits on suitable spacers (12 or 25mm).

These features will be described in more detail in subsequent sections.

Compatibility

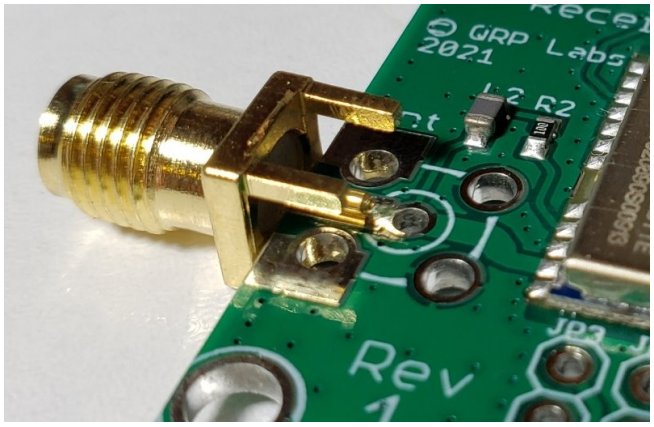
Straight out of the box, if you simply install the coaxial connector and plug in the antenna, the QLG2-SE is backwardly compatible by default with the former QLG1 kit. It is therefore directly compatible with all other QRP Labs kits:

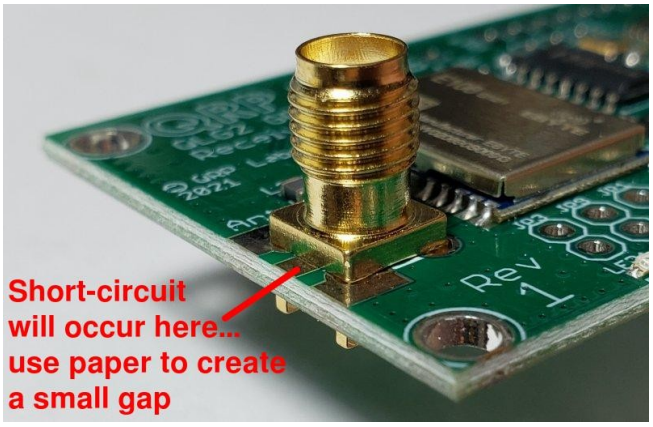
- QCX-series CW transceivers (QCX, QCX+ and QCX-mini)
- Ultimate3S (and preceding kits in the Ultimate- series)
- Clock kit
- VFO/Signal generator kit
- ProgRock kit

3. Assembly

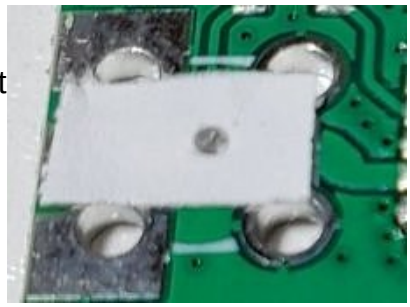
3.1 Assembly for basic operation

Assembly of this kit is EXTREMELY straightforward; you need only solder in the SMA connector. This can be installed horizontally or vertically (below left and right, respectively), to suit your particular application.

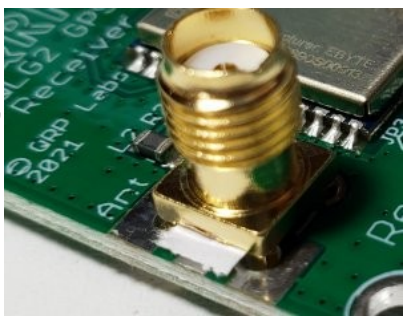




Vertical installation: **IMPORTANT! The body of the SMA connector WILL DEFINITELY short to the center pad of the component footprint on the board.** This will not only short out the antenna, rendering it completely ineffective, it will also draw high current from the GNSS module through the 10-ohm resistor R2. You will soon note the temperature rise of the GNSS module as well as the 3.3V voltage regulator chip (you don't need to ask me how I know...).



Therefore it is essential to create a little gap between the body of the SMA connector and the board.



The best way to do this is via small piece of paper. It's a simple, cheap and effective solution.

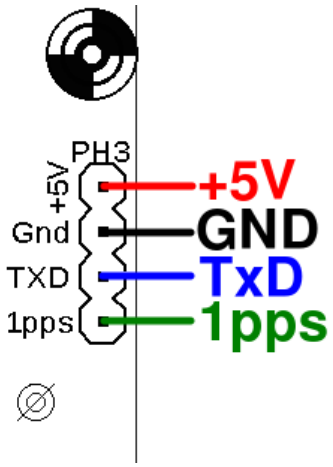
Cut a small piece of paper as shown (above right), place it on the board and push the center pin of the SMA connector through the paper.

Solder the SMA connector in place as usual. Don't overdo the heat and burn the paper.

Horizontal installation: The SMA connector happens to fit the board nicely too in the horizontal, edge-mounted position. Place it with the center pin on the top side of the board, and two of the corner pins on the bottom side, and solder in place. The other two ground pins can be ignored. This works very well.

3.2 Use with QCX, U3S, Clock, VFO, ProgRock etc. kits

In this application, you need only plug in the antenna coax SMA connector and the QLG2-SE is ready to use. It is entirely compatible with the former QLG1 kit and the 4-way pin header pads at the right side of the board can be used in the same way as a QLG1 kit.

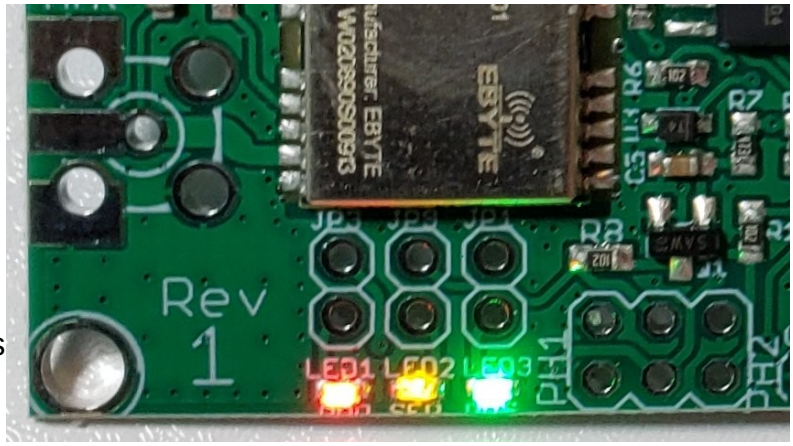


+5V power can be supplied to the module via the +5V connection if desired.

These signals are also available on the 6-way pin header pads at the bottom of the board edge.

3.3 Status LEDs

Just like it's predecessor the QLG1, the QLG2-SE module has the same three LED status LEDs.



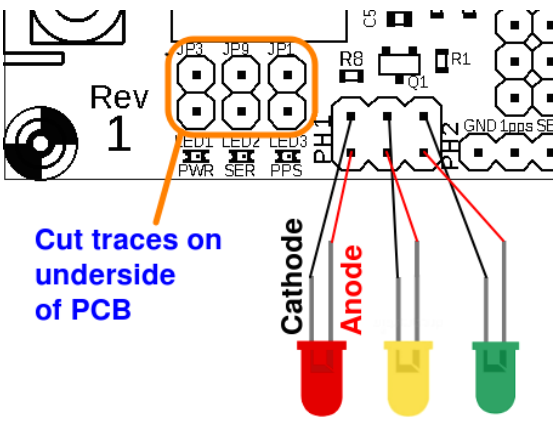
In the case of QLG2-SE, these are 0603-size SMD LEDs installed on the PCB near the GNSS receiver module.

LED 1 (red) is the Power LED and is always lit when QLG2-SE is powered.

LED 2 (yellow) is the Serial data LED and pulses in time with the serial data. Note that in a departure from the QLG1, this LED is actually OFF during the data burst (whereas on QLG1 it is ON during the data burst). The reasons for this are explained later, in the circuit explanation section.

LED 3 (blinding green) is the 1pps indicator and flashes once per second, for 0.1 seconds, coincident with the 1pps pulse whose leading edge indicates the exact UT second. This LED only starts blinking once a satellite lock (3D fix computation) has been achieved.

Together, these three LEDs provide an accurate diagnosis of correct operation of the QLG2-SE.

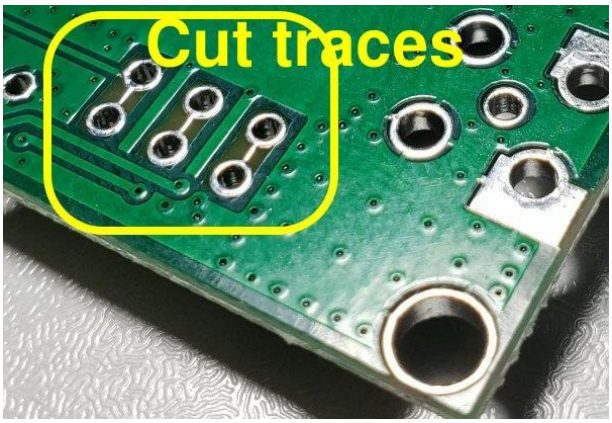


Connecting external LEDs

You may wish to use external LEDs instead of the onboard ones. For example, you may wish to make

the LEDs visible on the front panel of your equipment. After all, which of us does not like blinking lights on his equipment, and generally the more the merrier.

In this case, you can connect wires at pin header PH1, as follows in the diagram (right).



The cathodes (negative, indicated by black lines) of the LEDs are connected to the pads nearer the center of the board; the anodes (positive, indicated by red lines) are connected to the pads nearest the board edge. The sequence of the pads, is as three pairs from left to right, as Power (RED), Serial data (YELLOW) and 1pps (GREEN) – in other words, the same order as that of the SMD LEDs on the board.

You would also need to cut the thin exposed tinned copper traces on the underside of the PCB, in order to disconnect the onboard LEDs. This should be done with a sharp knife, carefully so as not to damage any other nearby traces.

3.4 Fitting an ultracap (a.k.a. supercap)

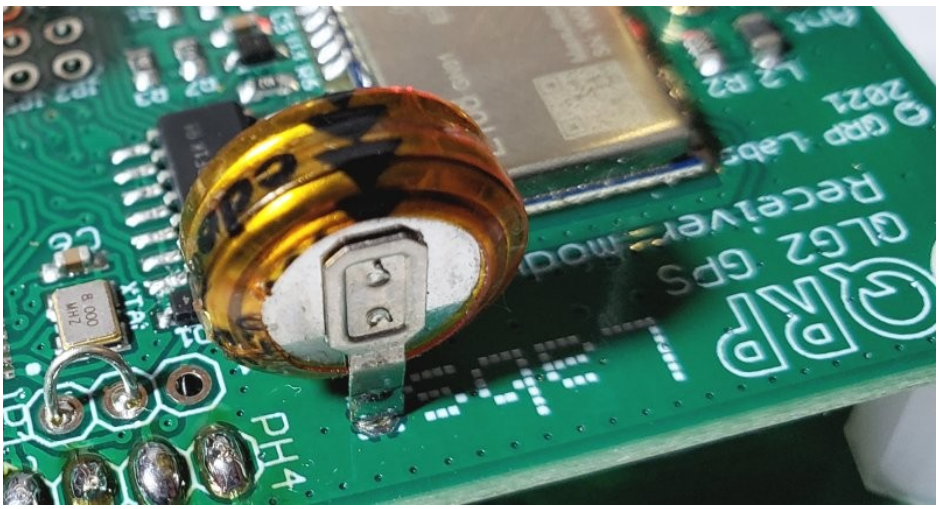
There is a place on the QLG2-SE board to fit an ultracap (a.k.a. supercap). This is a lot more reliable means of providing backup power, than the little rechargeable battery on the QLG1.

Backup power permits the operation of the internal Real Time Clock (RTC) in the GNSS module and also retains the downloaded satellite ephemeris data, which will enable a hot-start (satellite fix computation) within a second or two of power-up.

Most amateur radio applications will not need this, but the pads are made available on the board in case you do wish to use it.

Be careful to observe the correct polarity to avoid a possible bang and a nasty chemical mess (don't ask me how I know about this, either). **The black arrows on the capacitor body point to the negative pin.**

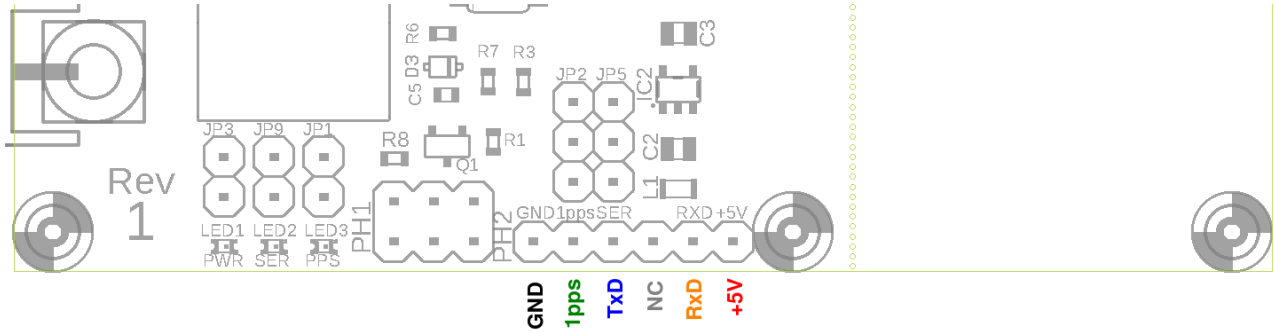
The photograph shows a 0.47 Farad, 5V capacitor installed on the QLG2 board. The position is the same on the QLG2-SE board.



The pads are separated by 0.2-inches (5.08mm) and the capacitor fits perfectly. **This capacitor appears sufficient to backup the QLG2 GPS for at least 12 hours.**

3.5 6-pin interface header

At the center of the QLG2-SE board's bottom edge, is a 6-pin header that provides access to the power supply rails, the GNSS outputs, and the Serial port of the USB to Serial converter.



The 1pps, Serial data, TXD and RXD signals can be configured to be either 2.8V/3.3V logic level, or 5V logic level. The configuration is done using jumper wires that will be described in the next section. Note that 2.8V logic will be compatible with 3.3V systems, without issue.

From left to right:

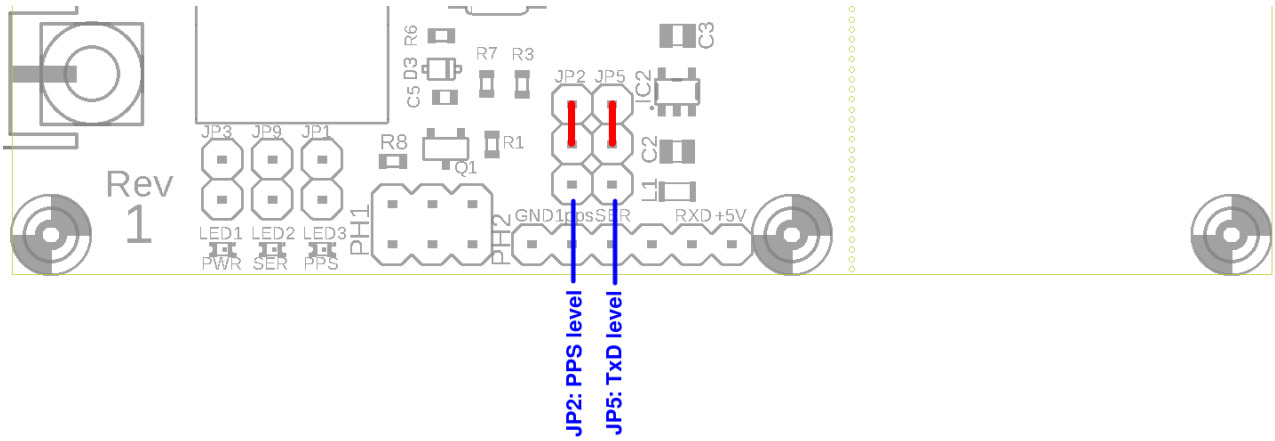
- Power supply ground.
- 1pps: 1 Pulse Per Second output from the GNSS module; by default this pulse is 0.1 seconds wide and it is sent once per second. By default, the voltage level is 5V which is suitable for use with QRP Labs products such as QCX, Ultimate3S, VFO, ProgRock and Clock kits.
- TxD: The NMEA serial data output from the GNSS module. By default this is at 9600 baud and is 5V logic level, which is suitable for use with QRP Labs products such as QCX, Ultimate3S, VFO and Clock kits. Note that this signal is connected to the "TxD" signal of the 4-pin header on the right side of the board.
- NC: This pin is not connected on QLG2-SE
- RxD: Serial data input to the GNSS module. This RxD (receive) pin is tolerant of 2.8, 3.3 or 5V logic levels and QLG2-SE automatically converts this to 3.3V for the GNSS module.
- +5V: Power supply positive. It is nominally 5V, but in fact you could power the QLG2-SE module from any positive supply voltage in the range 3.3V to 6.0V, and the onboard voltage regulator will provide 3.3V to the GNSS module which is its correct supply voltage.

NOTE that the 5V logic levels referenced above, assume a 5V supply voltage to the QLG2-SE; if you use a different supply voltage in the range 3.3V to 6.0V then the "high" logic level will be at that different supply voltage, not 5.0V.

3.6 Interface configuration

The configuration of the 6-pin interface (and indeed, the 4-pin interface on the right edge of the board) is controlled by the jumper wire area above the 6-pin interface pin header pads.

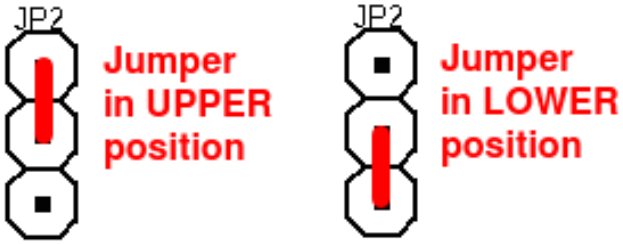
In the default configuration (specified by the tinned copper traces jumper wires), all outputs are 5V logic level



In the following description, the nomenclature adopted is – as illustrated in the diagram (right):

UPPER: means the jumper wire is connected from the center of the group of three pads, to the top pad.

LOWER: means the jumper wire is connected from the center of the group of three pads, to the lower pad.



1. PPS voltage level:

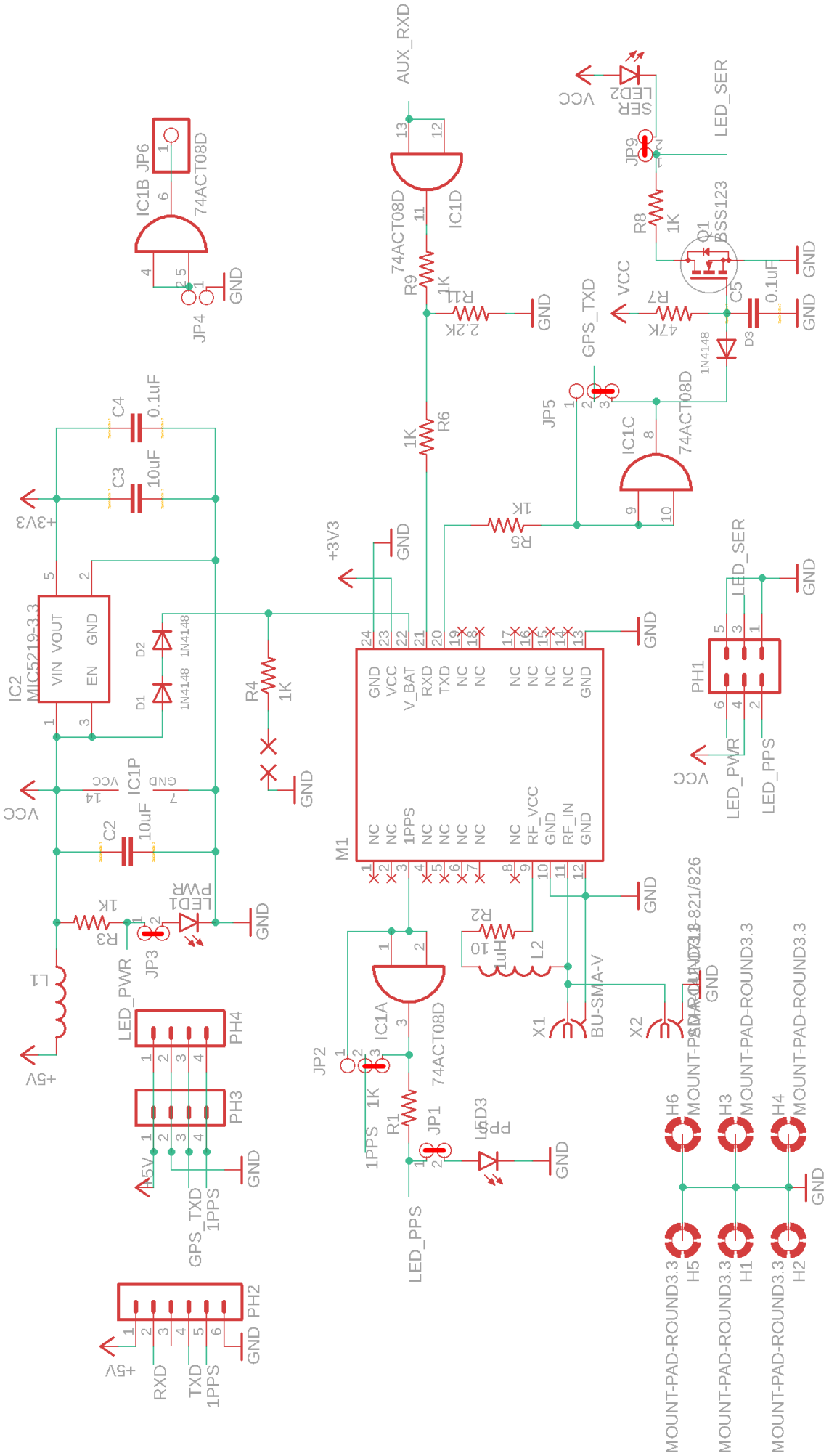
UPPER: 5V logic level (DEFAULT)
LOWER: 2.8V logic level

2. TxD voltage level (GNSS module serial data output, which is the TxD pin on the 4-pin header at the right of the board):

UPPER: 5V logic level (DEFAULT)
LOWER: 2.8V logic level

4. Circuit diagram (schematic) and description

In the above circuit below, the position of the default jumper wires, which are implemented by tinned copper traces on the PCB underside, are indicated with a thick red line.


IC1B JP6
74ACT08D
JP4
GND
AUX_RXD
IC1D
74ACT08D
R9
1K
R11
2.2K
GND
R6
1K
VCC
LED2
SER
JP9
LED_SER
R8
1K
Q1
BSS123
VCC
R7
47K
C5
0.1uF
GND
D3
1N4148
GPS_TXD
JP5
IC1C
74ACT08D
R5
1K
C4
0.1uF
C3
10uF
+3V3
IC2
MIC5219-3.3
VIN VOUT GND
EN
D2
D1
1N4148
1N4148
R4
1K
GND
+3V3
GND
M1
GND
VCC
V_BAT
RXD
TXD
NC
NC
NC
NC
NC
NC
NC
NC
GND
NC
NC
1PPS
NC
NC
NC
NC
NC
RF_VCC
GND
RF_IN
GND
PH1
LED_SER
GND
LED_PWR
LED_PPS
VCC
VCC
IC1P
GND
C2
10uF
LED1
PWR
R3
1K
JP3
LED_PWR
L1
+5V
PH4
PH3
+5V
GPS_TXD
1PPS
GND
PH2
+5V
RXD
TXD
1PPS
GND
JP2
IC1A
74ACT08D
1PPS
1K
R1
JP1
LED3
PPS
GND
LED_PPS
R2
10uH
L2
X1
BU-SMA-V
X2
GND
H6
MOUNT-PAD-ROUND3.3
H3
MOUNT-PAD-ROUND3.3
H4
MOUNT-PAD-ROUND3.3
GND
MOUNT-PAD-ROUND3.3
H5
MOUNT-PAD-ROUND3.3
H1
MOUNT-PAD-ROUND3.3
H2

SMD Components parts list:

Part	Value	Type	Package
C2, C3	10uF	Capacitor	0805
C4, C5	0.1uF	Capacitor	0603
D1, D2, D3	1N4148	Diode	SOD-323
IC1	74ACT08	IC	SOIC-14
IC2	MIC5219-3.3	IC	SOT23-5
L1, L2	1uH	Inductor	2012
LED1	Red	LED	0603
LED2	Yellow	LED	0603
LED3	Green	LED	0603
M1	E108-GN01	GNSS Module	16 x 12 mm
Q1	BSS123	Transistor	SOT23
R1, R3, R4, R5, R6, R8, R9	1K	Resistor	0603
R2	10-ohms	Resistor	0603
R7	47K	Resistor	0603
R11	2.2K	Resistor	0603

The QLG2-SE circuit is based around the E108-GN01 GNSS module. This module is capable of reception of multiple satellite systems, not just GPS. This aids faster satellite acquisition and higher sensitivity in difficult reception locations. The E108-GN01 module uses the GK9501 GNSS chipset. Links to the datasheets for both of these are on the QRP Labs QLG2-SE page http://qrp-labs.com/qlg2se

An active antenna module is used, having a magnetic mount, antenna patch and Low Noise Amplifier in a weather-resistant enclosure. It is supplied with 2m of coaxial cable and an SMA connector.

Compared to the QLG1 (former QRP Labs GPS module), which was already a highly sensitive receiver, the QLG2-SE is even more sensitive.

The E108-GN01 GNSS module and the microcontroller require a 3.3V power supply; this is provided from the host PC over USB, or from the host device (Ultimate3S, QCX-series transceiver etc) which provides a 5V supply. The chosen voltage regulator is MIC5219-3.3.

The backup ultracapacitor (if installed) is charged via two 1N4148 diodes and a 1K resistor (R4). When power to the board is removed, the ultracapacitor powers the E108-GN01's V_BAT pin, providing retention of the downloaded satellite ephemeris data and Real-Time Clock. A 0.47F 5V capacitor is suitable in this application (see section above).

Level conversion from the 2.8V output of the E108-GN01 module, to the 5V logic levels required by other QRP Labs kits, is done using a 74ACT08 quad AND-gate chip; it is not used as an AND gate (all gates have their two inputs tied together), it is simply used as a logic level converter. The T in the part number 74ACT08 indicates that the device has TTL voltage threshold compatibility, and this means a "1" (logic high) is 2.4V so it is ideally suited for accurately converting GNSS module 2.8V logic to 5V levels.

Q1 implements a simple timer which causes the yellow LED to be extinguished whenever a '0' appears on the serial signal. When the signal returns to '1', the capacitor C5 must charge up via R7, until the turn-on threshold voltage of the Q1 MOSFET is reached, at which point the yellow LED is switched on again. This simple circuit means that the data transmission does not directly modulate the yellow Serial data LED, the LED is only lit a small delay after the end of the data burst. This avoids generating any power line noise due to toggling the LED at 9600 baud rate, which could be radiated into sensitive radio receivers nearby.

5. Testing

All QLG2-SE modules are tested by QRP Labs before shipping.

The test includes:

- Test E108-GN01 module using the supplied active GNSS patch antenna
- Ensure time-to-first-fix (TTFF) is under 1 minute; on a sample of 20 units, the TTFF was found to range from 23 seconds to 52 seconds, with an average of 36 seconds.
- Check correct operation of Serial data and 1pps signals via status LEDs

These tests give a very high confidence that all QLG2-SE modules shipped by QRP Labs will be in proper working order.

6. Resources

For updates relating to this kit please visit the QRP Labs QLG2-SE kit page http://qrp-labs.com/qlg2se. This web page also contains links to the E108-GN01 datasheet and the GK9501 command reference

For any questions regarding the assembly and operation of this kit please join the QRP Labs group, see https://groups.io/g/qrplabs for details

7. Document Revision history

1.00	29-Jul-2020	First version for QLG2-SE