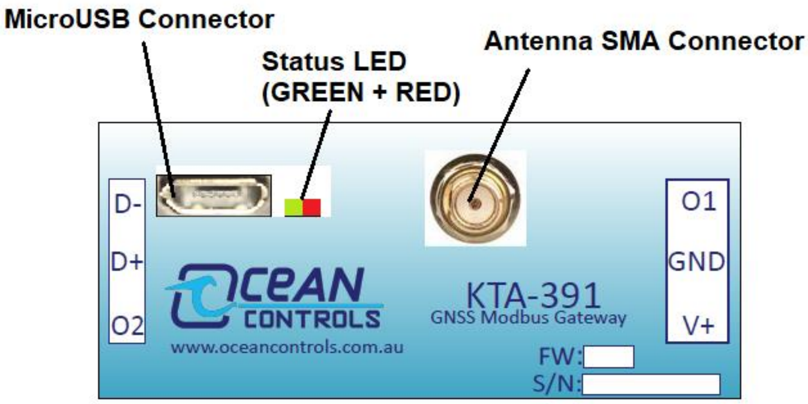
- UTC time accurate up to 30ns
- Latitude and Longitude accurate to 2.5m
- Altitude, speed, and direction of travel
- Modbus RTU slave on RS-485 and USB
- Access GNSS Receiver via USB
- Open collector outputs to indicate position fix and to synchronise external clock
- Status LED to indicate position fix details
- DIN rail mountable enclosure
- Active GNSS antenna included with 3m length cable
- Dimensions: 85H X 81D X 25W mm

The KTA-391 provides a Modbus interface for the high performance U-blox NEO-M8Q GNSS receiver. Acting as a Modbus RTU slave, any Modbus Master (PC, PLC, SCADA system, etc) can poll the unit over RS-485 and retrieve extremely accurate time, position, and velocity data. It can also be used as a Serial Gateway for the GNSS receiver.

Connections:



Name	Description
V+	5 to 36 V DC power, 0.4W
GND	Ground
D+	RS-485 Data+
D-	RS-485 Data+
O2	Open Collector 1. Active when there a position lock
O1	Open Collector 2. Pulses once a second. See appendix 1.
SMA connector	GNSS Active Antenna connector
Micro USB Connector	Fixed Modbus Comms or GNSS Antenna Serial Passthrough
Status LED (Green)	- Rapid Flashing (0.5s period) = no position lock - Slow Flashing (2.5s period) = Satellite found, no reliable position lock - Solid on = accurate position lock
Status LED (RED)	Indicates Modbus Communication on RS-485 line

Holding Registers:

Register Number	Register Name	Description	Units/Notes
40001	GNSS Quality Status	0: Position fix unavailable 1: Valid position fix, SPS mode 2: Valid position fix, differential GNSS mode 4: Fixed Real Time Kinematic 5: Float Real Time Kinematic 6: Estimated (dead reckoning) Mode	
40002	Satellites in Use	The number of simultaneous satellite connections currently being used by the receiver	
40003	Navigation Mode	1: No position fix 2: 2D mode (only horizontal coordinates) 3: 3D mode (horizontal coordinates + altitude)	
40004	Year	Current year; UTC	
40005	Month	Current month of the year; UTC	
40006	Day	Current day of the month; UTC	
40007	Hour	Current hour of the day; UTC	
40008	Minute	Current minute of the hour; UTC	
40009	Second	Current second of the minute; UTC	
40010	Decimal Second	Current thousandth fraction of the second; UTC.	
40011	Latitude Degrees	Degrees of Latitude	x 1
40012	Latitude Degrees Decimals	Degrees Decimals of Latitude (Format 1 – see below)	x 0.0001 (Four decimal places of accuracy)
40013	Latitude Minutes	Minutes of Latitude (Format 2 – see below)	x 1
40014	Latitude Seconds	Seconds of Latitude (Format 2 – see below)	x 0.001 (Three decimal places of accuracy)
40015	Latitude Thousandth Minutes	Ten thousandths of a minute of latitude (Format 3 – see below)	x 0.0001 (Four decimal places of accuracy)
40016	Latitude N/S	Latitude hemisphere indicator 1: Northern hemisphere 0: Southern hemisphere	
40017	Longitude Degrees	Degrees of Longitude	x 1
40018	Longitude Degrees Decimals	Degrees Decimals of Longitude (Format 1 – see below)	x 0.0001
40019	Longitude Minutes	Minutes of Longitude (Format 2 – see below)	x 1
40020	Longitude Seconds	Seconds of Longitude (Format 2 – see below)	x 0.001 (Three decimal places of accuracy)
40021	Longitude Thousandth Minutes	Ten thousandths of a minute of Longitude (Format 3 – see below)	x 0.0001 (Four decimal places of accuracy)
40022	Longitude E/W	Longitude hemisphere indicator 1: Eastern hemisphere 0: Western hemisphere	
40023	Altitude (Above Sea Level)	Altitude above sea level in tenths of metres (145 = 14.5 m ASL)	x 0.1 (One decimal places of accuracy)
40024	Altitude unit	0: meters (default – raw value) 1: feet (Onboard calculated)	

40025	Velocity	Velocity over ground in tenths of knots (152 = 0.152 knots)	x 0.001 (Three decimal places of accuracy)
40026	Velocity unit	0: knots (Raw value) 1: kilometres per hour (Onboard calculated) 2: miles per hour (Onboard calculated)	
40027	Course	Direction of travel in tenths of degrees from North (2409 = 24.09°)	x 0.01 (Two decimal places of accuracy)
40028	Precision PDOP	Positional Dilution of Precision. Gives a measure of the accuracy/confidence of the GPS lock	x 0.01 (Two decimal places of accuracy)
40029	Precision HDOP	Horizontal Dilution of Precision	x 0.01 (Two decimal places of accuracy)
40030	Precision VDOP	Vertical Dilution of Precision	x 0.01 (Two decimal places of accuracy)
40031	USB Mode	0: GPS Passthrough Mode 1: Modbus Mode (default and constant mode)	
40032	GNSS Receiver Mode	8: Reset and runs on default GPS settings 9: Do not reset and runs on modified configurations – Require battery backup	8 or 9
40033	Modbus Address	Modbus RTU slave address. 1 to 247 (default 1)	
40034	Modbus Baud	Modbus RTU baud rate 1: 2400 baud 2: 4800 baud 3: 9600 baud (default) 4: 19200 baud 5: 38400 baud 6: 57600 baud 7: 115200 baud	
40035	Modbus Parity	1: None (default) 2: Even 3: Odd	
40036	Modbus Stop bits	1: 1 Stop bit 2: 2 Stop bits	
40037	Modbus Set Parameters	Write to 1 to commit Modbus comms settings to the slave. Upon successful write, register will return to 2.	
40038	Reserved		

Interpreting Latitude and Longitude Readings:

The KTA-391 presents GNSS position readings in 3 different formats simultaneously:

1. Format 1: Decimal Degrees (DD) – Onboard calculated

Decimal Degrees Format uses Registers 11, 12, 16 (for Latitude) and Registers 17, 18, 22 (for Longitude). For example, if the registers have these readings:

Register	Value	Register Name
11	38	Lat Degrees
12	1030	Lat Degrees Decimals
16	0	Lat Hemisphere
17	145	Long Degrees
18	1607	Long Degrees Decimals
22	1	Long Hemisphere
Current Position in Degrees Decimals Format	Latitude: -38.1030° or 38.1030° S Longitude: +145.1607° or 145.1607° E	

2. Format 2: Degrees, Minutes, Seconds (DMS) – Onboard calculated

DMS Format uses registers 11, 13, 14, 16 (for Latitude) and 17, 19, 20, 22 (for Longitude) to express data in Degrees – Minutes – Seconds – Hemisphere. For example, if the registers have these readings:

Register	Value	Register Name
11	38	Lat Degrees
13	6	Lat Minutes
14	10545	Lat Seconds
16	0	Lat Hemisphere
17	145	Long Degrees
19	9	Long Minutes
20	38621	Long Seconds
22	1	Long Hemisphere
Current Position in Degrees, Minutes, Seconds Format	Latitude: 38° 6’ 10.545’’ S Longitude: 145° 9’ 38.621’’ E	

3. Format 3: Degrees, Minutes and Ten thousandths of a minute – Raw reading

This is the raw data from the GNSS receiver. This format uses registers 11, 13, 15, 16 (for Latitude) and registers 17, 19, 21, 22 (for Longitude) to express data in Degrees – Minutes – Ten thousandths of a minute. For example, if the registers have these readings:

Register	Value	Register Name
11	38	Lat Degrees
13	6	Lat Minutes
15	1814	Lat Thousandth Minutes
16	0	Lat Hemisphere
17	145	Long Degrees
19	9	Long Minutes
21	6414	Long Thousandth Minutes
22	1	Long Hemisphere
Current Position in Degrees, Minutes, Thousandth Minutes Format	Latitude: 38° 6.1814’ S Longitude: 145° 9.6414’ E	

Altitude (above sea level) and Velocity units

By default, the unit for Altitude is in meters and velocity is in knots. These are all raw values from the GNSS receiver. The KTA-391 also supports changing these values into different units:

- Altitude: feet
- Velocity: kilometres per hour (km/h) and miles per hour (mph)

To change the units, simply change the values in registers 24 and 26. Please note the operational limit of the GNSS receiver:

Altitude Operational Limit	50,000	m
	164,041	feet
Velocity Operational Limit	500	m/s
	971.9	knots
	1800	Km/h
	1118.47	mph

Setting RS-485 Modbus Communications Parameters:

By default, the KTA-391 communicates with these settings:

Modbus Default Parameter	Modbus Default Parameter Value	Register	Register Default Value	Register Range Limit
Address	1	**33**	1	1 – 247
Baud Rate	9600	**34**	3	1 – 7
Parity	None	**35**	1	1 – 3
Stop bit	1	**36**	1	1 – 2
		37	2	

These settings can be altered by writing your preferred address, baud rate, parity and stop bit to Modbus holding registers 33, 34, 35, and 36. Writing register 37 to a one (1) will commit the values to the slave.

The values in 33, 34, 35 and 36 will revert to current COM values if register 37 is not set to 1 after approximately 20 seconds from the first parameter change. The values in 33, 34, 35 and 36 must also not exceed their range limit or they will automatically revert to current COM values immediately.

USB Modbus Mode (Default, Mode 1)

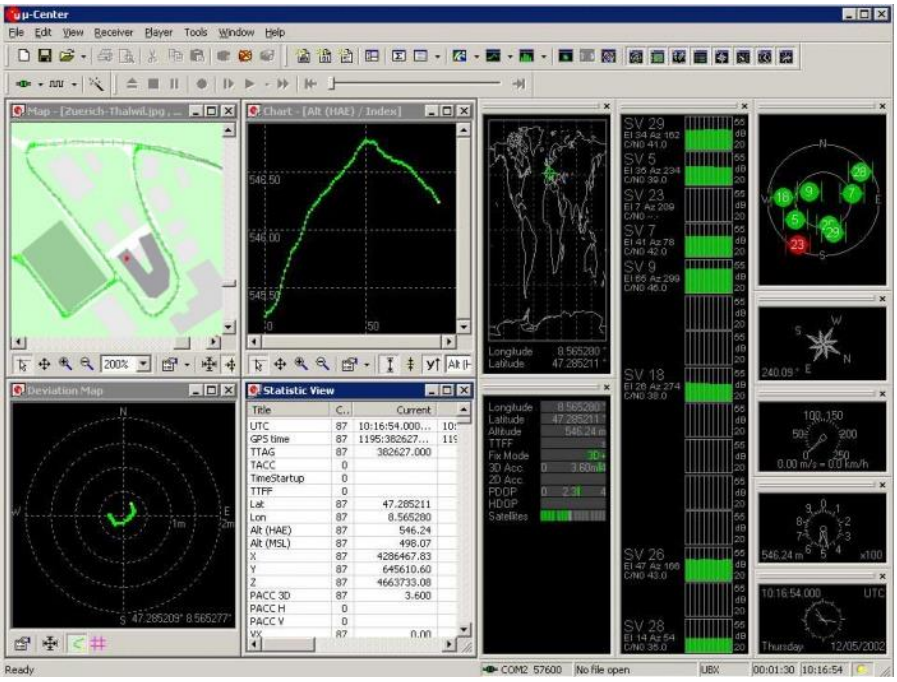
The micro USB connection on the KTA-391 can be used for communicating, troubleshooting and resetting COM settings on the RS-485. It will always run in Modbus RTU (Value in Register 31 is 1) mode at start up with these unchangeable settings:

USB Modbus COM Parameter	USB Modbus COM Value	Note
Address	1	These parameters are not changeable
Baud Rate	115200	
Parity	None	
Stop bit	1	

USB GNSS Receiver Mode (Mode 0)

It is possible to communicate directly to the Ublox' NEO-M8Q GNSS receiver via the micro USB connection. In order to put the USB in this mode, register 31's value needs to be changed to 0. The KTA-391 can then talk to Ublox' U-center software or a third-party Serial program with the above COM settings.

Please note that U-center might force a reset on the KTA-391 when disconnecting, thus reverting register 31 back to 1 (Modbus mode) – its default value.



U-center is Ublox' GNSS evaluation software for automotive, mobile terminal and infrastructure applications which provides a power tool for evaluation, performance analysis and configuration of U-blox GNSS receivers. The NEO-M8Q can be configured using the U-center including GPS System settings, update rate, messages, etc. For hardware version 1.0, when register 32 has value 8, the KTA-391 will use these settings:

Receiver Parameter Name	Parameter Default Value
GNSS	GPS + GLONASS + QZSS + SBAS
Update Rate	10Hz
NMEA Messages	GGA, GSA, RMC (the KTA-391 only decodes these messages)

All configuration settings can be changed and save to Battery Backup RAM (BBR). This requires battery backup as shown in the next section. To achieve this, register 32 needs to be changed to 9 so that the KTA-391 does not use its default settings.

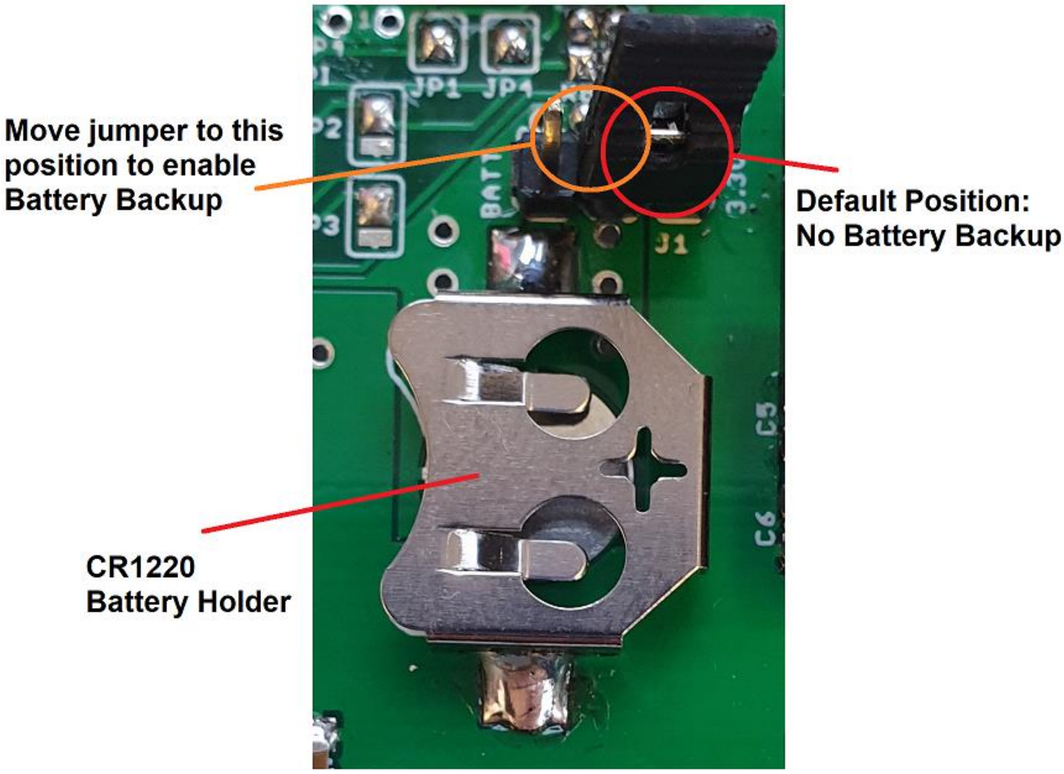
When Register 32's value changes to 8, the KTA-391 will immediately reset and runs on its default GPS receiver settings.

Any value other than 8 or 9 written to Register 32 will be discarded.

Battery Backup Supply – Hardware Backup Mode

The KTA-391 provides the option to have a battery backup supply for the GNSS receiver. If the module has a power failure, the battery will supply the RTC and battery backed RAM (BBR) of the receiver. In this mode, the RTC will keep providing timing reference for the receiver and all relevant data is saved in the backup RAM including modified configuration (already saved in BBR) and tracking details which allow a hot or warm start later.

To enable this function, a CR1220 battery needs to be put inside the internal battery holder socket. Then the position of the jumper needs to be switched:



Open Collector Outputs:

The two open collector outputs are capable of sinking up to 200mA at up to 50V. Open Collector 2 is active when the GPS has a position lock. Open Collector 1 gives a pulse output once a second as a means to accurate the received time (see appendix 1).

Specifications

General Specifications	Min	Typical	Max	Unit
Voltage	6	--	36	V
Power		0.4		W
Operating Temperature	-20	25	80	C

RS-485 Transceiver	Min	Typical	Max	Unit
Driver Current			28	mA
Symbol Rate	2400	9600	115200	Baud
Data Bits		8		
Parity		None	Odd, Even	
Stop Bit		1	2	

Open Collector Outputs	Parameter	Unit
Max Current Sink	220	mA
Max Voltage	50	V

GNSS Receiver NEO-M8Q	Nominal	Unit
Receiver	72-channel u-blox M8 engine GPS L1C/A, SBAS L1C/A, QZSS L1C/A, QZSS L1 SAIF, GLONASS L1OF, BeiDou B1I, Galileo E1B/C	
Horizontal Position Accuracy (GNSS)	2.5	m CEP
Max Navigation Update rate	GNSS: 10 Single System: 18	Hz
Velocity Accuracy	0.05	m/s
Heading Accuracy	3	Degrees
Timing Accuracy	RMS: 30 99%: 60	ns
Start-up Time to Fix	Cold start: 26 Hot start: 1	s
Sensitivity (GNSS)	Tracking and Navigation: -167 Reacquisition: -160 Cold start: -148 Hot start: -157	dBm
Altitude Operational Limit	50,000	m
Velocity Operational Limit	500	m/s

Appendix 1

Improving Timing Accuracy

The GNSS receiver has a nominal timing accuracy of 60 nanoseconds, however much larger timing errors will be introduced by the delays associated with communications. The GNSS receiver by default updates the Modbus holding registers 10 times a second. Therefore, the data in the registers can be as much as 100ms old. If the KTA-391 is then polled at a slow baud rate, the delay in the slave receiving the request, and then sending a response, could be approaching half a second (a typical timeout period for a Modbus Master is 400ms).

The KTA-391 specifies a timing accuracy better than 2 seconds. This is a conservative figure that considers the worst case from each of the timing interfaces. However, timing accuracy can be dramatically improved by using the PPS output from open collector 2.

The PPS output is derived directly from the GNSS module, and provides a pulse once a second, on the second (100ms duration).

If better timing accuracy is required, this output can be used to match up the Modbus received data with a known time stamp from the open collector. Ideally, this allows all communications delays to be cancelled out downstream (in the controller).

Example using a PLC:

1. The PLC polls the KTA-391. At some later period, the Modbus command is received.
2. The PPS output from the open collector is sensed on a digital input of the PLC. This pulse gives the exact time that the previous second expires, and the next second begins.
3. The time stamp received over Modbus is incremented to the next whole second. At that instant, the time is accurate to 60 nanoseconds.

Appendix 2

Description of GPS fix data

0: Position fix unavailable
Not enough satellites can be found; no position fix.

1: Valid position fix, SPS mode
A valid position fix is provided using the Standard Positioning Service (SPS). SPS could be described as the “regular” GNSS service using satellites and is what the KTA-391 will typically use most of the time.

2: Valid position fix, differential GNSS mode
A valid position fix is provided using Differential GNSS. This system improves upon the nominal accuracy of SPS using land-based reference stations to broadcast the difference between the SPS data and the known fixed positions of the ground stations.

4: Real Time Kinematic
Valid position fix with enhanced accuracy by using Real Time Kinematic techniques. RTK uses the phase of the carrier signal - received from the satellites - to find a position lock; ignoring the actual information contained within.

5: Float Real Time Kinematic
Same as above except uses floating point integers as opposed to fixed integers. Fixed integers generally give a more accurate position lock but require more satellites and a longer processing time.

6: Estimated (dead reckoning) Mode
Uses knowledge of a previous position fix, and known or estimated speeds, to estimate the current position.

Appendix 3

Horizontal Dilution of Precision

The Horizontal Dilution of Precision values gives an indication of the strength or quality of the GPS fix. The KTA-391 has a nominal accuracy of 2.5m CEP (Circular Error Probable), meaning that 50% of the time, the location fix will fall within a 2.5m radius circle of the actual absolute position.

The Horizontal Dilution of Precision values gives a factor representing the current accuracy of the location fix. This factor is **roughly** in relation to this absolute accuracy.

Example:
Horizontal Dilution of Precision is currently 3.4. The current location data can be roughly trusted as:

$$CurrentAccuracy \approx HorisontalDilutionofPrecision \times AbsoluteAccuracy$$
$$CurrentAccuracy = 3.4 \times 2.5 = 8.5\mathrm{m}CEP$$

This table can be used as a general guideline for measurement confidence:

HDOP	Rating	Description
<1	Ideal	Best possible accuracy
1-2	Excellent	Good enough accuracy for almost all applications
2-5	Good	The minimum required accuracy for most sensitive applications
5-10	Moderate	Positional data is degraded and may not be accurate enough to make decisions
10-20	Fair	Low accuracy. Measurements should be discarded unless a very rough estimate of positional data is required
>20	Poor	Measurements should be discarded