http://www.cubesatkit.com/

CubeSat Kit™
GPSRM 1 GPS Receiver Module
Hardware Revision: C

GPS Receiver for Space Use

Applications
- CubeSat nanosatellite GPS

Features
- For use with 104-pin CubeSat Kit™ Bus
- Compatible with entire NovAtel® OEM615 dual-frequency GNSS receiver family; L1/L2/L2C GPS and L1/L2 GLONASS signal tracking available
- Compatible with a wide range of active GPS antennas
- Utilizes vibration-resistant OEM615V version with COCOM limits unblocked
- With dedicated nanopower supervisor MCU for:
  - GPS power control
  - GPS power monitor
  - GPS reset and external events
  - GPS isolation from CSK bus signals
  - I2C interface / "back door"
  - Additional user-defined functionality
  - CLK Out clock w/divider
- OEM615 receiver communication ports:
  - TXD1/RXD1 ↔ CSK Bus
  - TXD2/RXD2 ↔ supervisor MCU
  - USB ↔ host via micro-AB connector
- OEM615 receiver outputs:
  - 50Ω PPS signal (x2)
  - Variable frequency signal (VARF)
  - Position Valid (PV) indicator
- Enhanced EMC / EMI design yields improved SNR over unshielded receiver
- Integrated heatsink / EM shield is tied to thermal conductive pads for use with CSK thermal standoffs in all four corners (top and bottom)
- Flexible interface to CSK –RESET signal
- Auto-selected power sources:
  - +5V & +3.3V from CSK Bus
  - +5V from USB
- Independent latchup (device overcurrent) protection on critical subsystems

ORDERING INFORMATION

Pumpkin P/N 710-00908

Option Code	GPS band(s) & CubeSat Kit Bus Connector[1]
/00 (standard)	L1 GPS & non-stackthrough
/10	L1 GPS & stackthrough

Contact factory for availability of optional configurations.
Option code /00 shown.

CAUTION

Electrostatic Sensitive Devices

Handle with Care

- PC/104-size footprint
- Stackable 104-pin CubeSat Kit Bus connectors includes processor's complete I/O space, user-assignable signals and more
- Wiring-free module interconnect scheme
- 6-layer gold-plated blue-soldermask PCB with triple ground planes for enhanced signal integrity
- Supervisor MCU programmed with Pumpkin's space-proven Salvo™ RTOS for easy user customization

[1] Stackthrough connectors are used in CubeSat Kit configurations where the MB is not in Slot 0.

CHANGELOG

Rev.	Date	Author	Comments
A	20131218	AEK	Initial release of hardware Rev C.
B	20140120	AEK	Updated to include oscilloscope captures of **VARF** and **CLK Out** signals. Included Assembly Revisions table, along with jumper settings. Added COM1 Output screen capture.
C	20140210	AEK	Updated to state compatibility with all members of the OEM615/OEM615V family, including dual-frequency GPS and GLONASS satellite signal tracking.
D	20140721	AEK	Added pin descriptions for J1 (in-circuit debugging connector), J2 (USB Debug Adapter connector), and H3 (expansion module connector). Added more codes for configurations. Clarified what is meant by “jumper.”

OPERATIONAL DESCRIPTION

The GPSRM 1 GPS receiver adds GPS functionality to the CubeSat Kit™ (CSK) by integrating a NovAtel® OEM615-series receiver onto a CSK-compatible module. A supervisor MCU controls power and interface to the CSK bus. The interface to the supervisor MCU is via I2C.

The GPSRM 1 is designed to mount directly above the combination of a CSK Motherboard (MB) + Pluggable Processor Module (PPM), at the standard inter-module distance of 0.600" (15.24mm), using a GPS antenna cable terminated in a right-angle MCX plug. This arrangement provides the necessary clearance for the GPS antenna cable's connector.

In its default configuration, the GPSRM 1 utilizes the NovAtel® OEM615V-G1S-B0G-TT0-H[2] GPS L1 receiver module with a 20Hz update rate and a vibration-resistant TCXO. As fitted on the GPSRM 1, these GPS receiver modules have had their COCOM limits removed / unblocked.

For an additional cost, customers can request any model from the OEM615 family for use on the GPSRM 1. This includes versions with L1/L2/L2C GPS and/or L1/L2 GLONASS signal tracking. Please contact the factory for more details.

Power to the GPS receiver is under the control of the PIC24E-series supervisor MCU and can switched on or off via I2C commands. Power is automatically selected from available power: either (external) USB or the CubeSat Kit bus.

The OEM615 receiver's **–RESET**, **EVENT1** and **EVENT2** inputs are under the control of the supervisor MCU.[3]

The first serial port of the OEM615 module is normally used to communicate with the rest of the CubeSat via one of the three CubeSat Kit bus signal pairs **IO.4** & **IO.5**, **IO.16** & **IO.17** or **IO.32** & **IO.33**. This serial port can be isolated from the CubeSat Kit bus via I2C commands. The second serial port of the OEM615 module is connected to the supervisor MCU and can be used to transfer data and commands between the OEM615 module and the supervisor MCU. The third serial port of the OEM615 module – implemented as USB – is connected directly to a micro-AB USB connector. This USB connection can also power the OEM615 module.

A Position Valid (PV) LED indicator from the OEM615 receiver is provided, as well as a status LED from the supervisor MCU.

The 50Ω **TIMEMARK** (**PPS**) signal from the OEM615 receiver is available in one of two user-selectable forms: on an MCX jack for use with discrete RF cabling, and on the CubeSat Kit bus **PPS** signal.

The **VARF** (variable frequency) signal from the OEM615 receiver is present on an MMCX jack for use with discrete RF cabling, and also (optionally) on **IO.31** of the CubeSat Kit bus.

An additional TX/RX debug port to the supervisor MCU is provided, to aid in supervisor MCU firmware development & debugging. Additionally, a 20-pin connector is provided as a means of connecting expansion boards (where possible) under the control of the supervisor MCU. Lastly, an MMCX connector is provided for measuring the supervisor MCU's unbuffered internal clock frequency.

Particular attention has been paid to the shielding and heatsinking of the OEM615 receiver. An integrated EMC / EMI shield and heatsink covers the entire OEM615 receiver and is electrically and thermally tied to all four corner standoff locations. Special attention in the PCB design has been paid to avoid any isolated dielectric regions resulting from unconnected swatches of copper.

A related module – GPSRM 2 – provides similar features and performance in a form factor designed expressly for Pumpkin's MISC 3 bus.

[2] Throughout this datasheet, the NovAtel GPS receiver will be referred to as the "OEM615."

[3] The OEM615 receiver's **CAN2TX** and **CAN2RX** signals are left unconnected.

ABSOLUTE MAXIMUM RATINGS

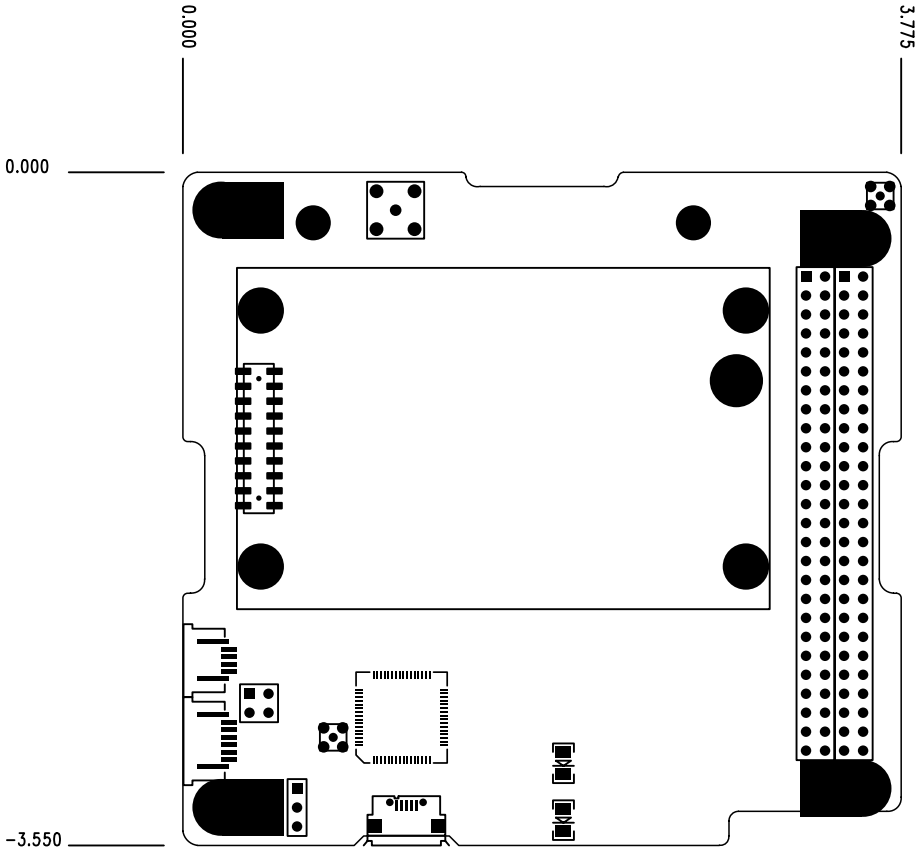
Parameter	Symbol	Value	Units
Operating temperature	T_A	-40 to +85	ºC
Voltage on **+5V_USB** bus		-0.3 to +6	V
Voltage on **+5V_SYS** bus			
Voltage on **VCC_SYS** bus			
Voltage on local **VCC_MCU** bus		-0.3 to +5.5	V

PHYSICAL CHARACTERISTICS

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
Mass [4]	With aluminum heatsink / EM shield			106		g
Height of components above PCB	With mating cable to MCX PPS jack				11	mm
Height of components below PCB	Without GPS antenna cable connected				2.75	mm
	With GPS antenna cable connected via RA MCX plug				5.5	
PCB width	Corner hole pattern matches PC/104			96		mm
PCB length				90		mm
PCB thickness				1.6		mm
CubeSat Kit Bus Connector terminal pitch	Horizontal or vertical distance to nearest terminal			2.54		mm

[4] With OEM615V-G1S-B0G-TT0-H and with heatsink / EM shield fitted. Dual-band OEM615V versions may be slightly heavier.

SIMPLIFIED MECHANICAL LAYOUT [5]



[5] Dimensions in inches.

ELECTRICAL CHARACTERISTICS

(T = 25ºC, +5V bus = +5V unless otherwise noted)

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
Operating power consumption	Supervisor MCU & GPS active, no antenna connected	$P_{OP\_SUP\_GPS\_LNA}$		1.3		W
	Supervisor MCU active, GPS unpowered	P_{OP_SUP}		25		mW
Operating current [6]	Supervisor MCU & GPS active, with active antenna connected	$I_{OP\_SUP\_GPS\_LNA}$		300		mA
	Supervisor MCU & GPS active, no antenna connected	$I_{OP\_SUP\_GPS}$		260		mA
	Supervisor MCU active, GPS unpowered	I_{OP_SUP}		4.5		mA
	Supervisor MCU asleep, GPS unpowered	I_{SLEEP}		1.5		mA
Supervisor MCU internal clock frequency	Base frequency, can be multiplied by onboard PLL	f_{CLK_MCU}		7.3728		MHz
USB bus current [7]	Powered over USB	I_{USB_MAX}			500	mA
Overcurrent trip point for OEM615	For +3.3V, set by R19 & R20	$I_{TRIP\_3V3\_GPS}$		TBD		mA
	For +5V, set by R15 & R16	$I_{TRIP\_+5V\_GPS}$		TBD		mA
Data rate through any on-board isolator (U4 & U5)			50			MHz

OEM615 GPS RECEIVER ELECTRICAL CHARACTERISTICS

Parameter	Conditions / Notes	Min	Typ	Max	Units
PPS Output at J7	Impedance		50		Ω
	Rise & fall times		6		ns
	Negative pulse width		1.000		ms
	Amplitude (3V3_GPS = +3.3V, unterminated)		3.24		V
	Amplitude (3V3_GPS = +3.3V, terminated with 50Ω)		2.40		
Effect on GPS SNR of GPSRM 1's EM shield	Observed SNR improvement of multiple, individual GPS satellites with GPSRM 1 EM shield present and absent, using NovAtel® receiver software.		5		dB

[6] Terrestrial GPS receiver tracking a minimum of 5 satellites when active antenna with LNA is connected.

[7] The OEM615's USB interface is configured at the factory as a bus- or self-powered device and reports a maximum current of 100mA to the attached USB host.

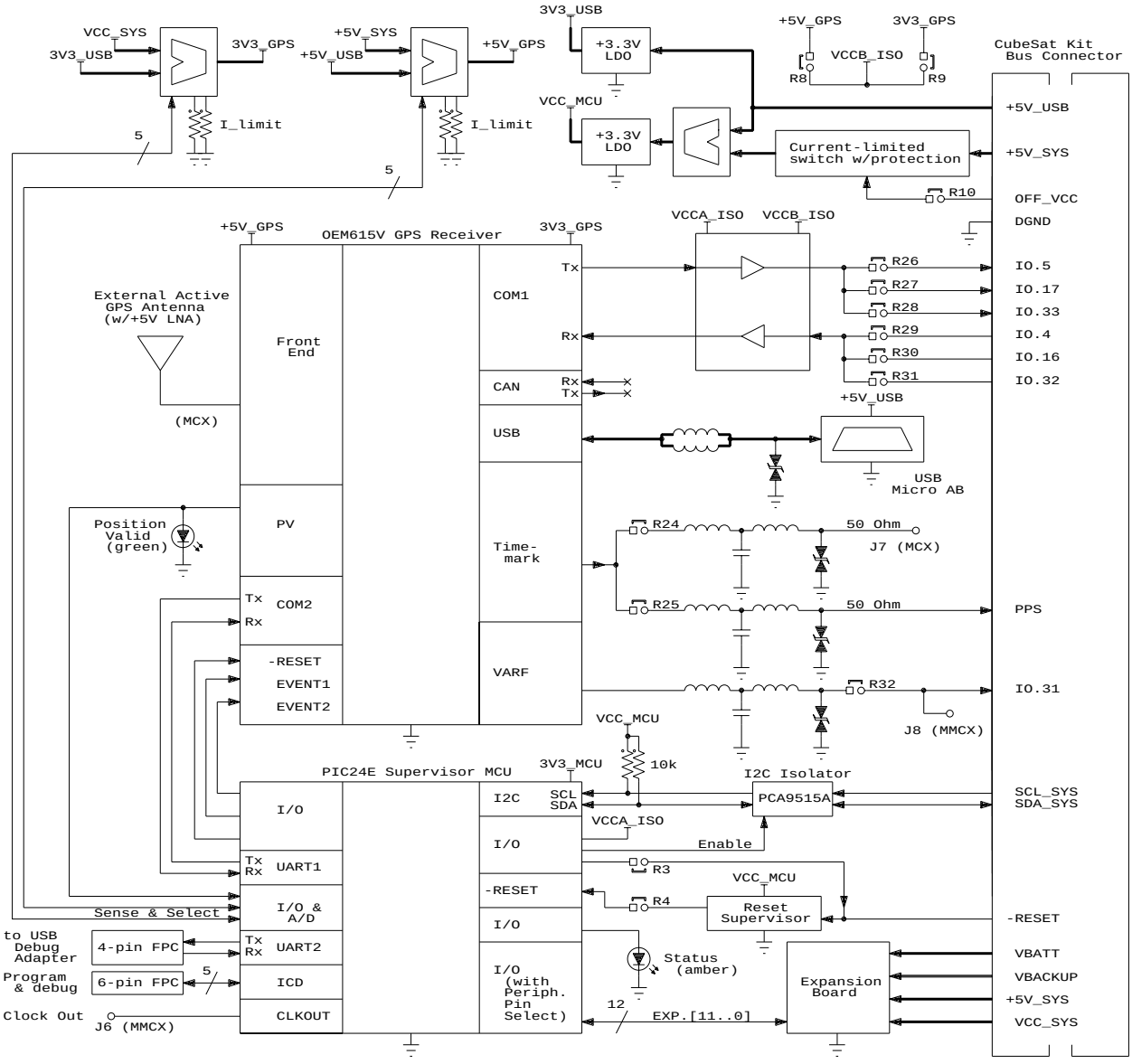
I2C CHARACTERISTICS

Parameter	Conditions / Notes	Min	Typ	Max	Units
I2C address	7-bit I2C address		0x51		
I2C clock speed				400	kHz
I2C pull-up resistors	No pull-up resistors are fitted to **SCL_SYS** or **SDA_SYS**		∞		Ω

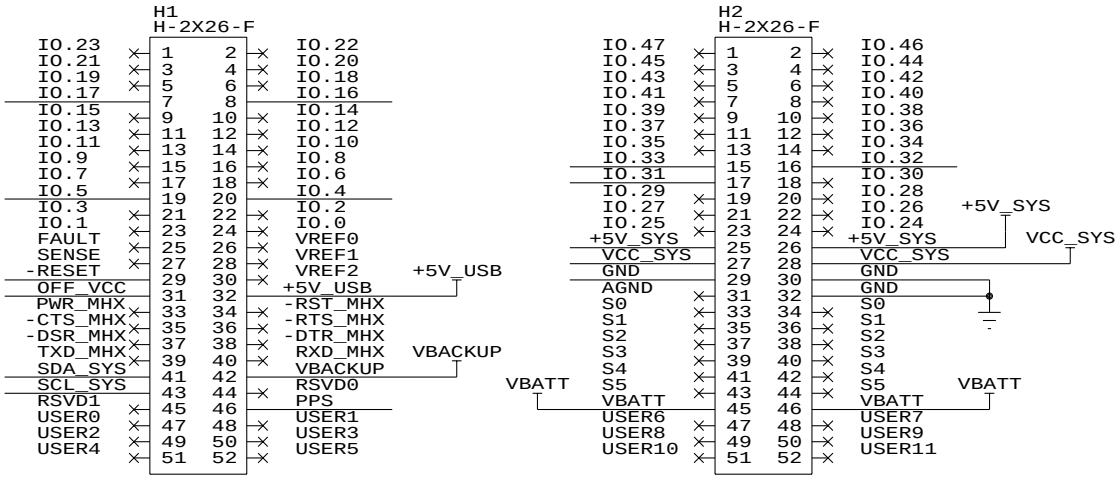
USB DEVICE CHARACTERISTICS

Parameter	Conditions / Notes	Value
Speed	USB 2.0 compatible	Full Speed (12Mbps)
Vendor ID (VID)		0x09D7
Product ID (PID)		0x0100
Required driver	Supplied by NovAtel	

BLOCK DIAGRAM



CubeSat Kit Bus PIN DESCRIPTIONS



CubeSat Kit Bus PIN DESCRIPTIONS – I/O

Name	Pin	I/O	Description
IO.0	H1.24		Not connected.
IO.1	H1.23		Not connected.
IO.2	H1.22		Not connected.
IO.3	H1.21		Not connected.
IO.4	H1.20	I	Serial input to the OEM615 receiver's **RX1D** pin. This input receives data from **IO.4** if/when jumper[8] **R29** is fitted. Typically serial data **UTX0** from the PPM processor.
IO.5	H1.19	O	Serial output from the OEM615 receiver's **TX1D** pin. This output sends data to **IO.5** if/when jumper **R26** is fitted. Typically serial data **URX0** to the PPM processor.
IO.6	H1.18		Not connected.
IO.7	H1.17		Not connected.
IO.8	H1.16		Not connected.
IO.9	H1.15		Not connected.
IO.10	H1.14		Not connected.
IO.11	H1.13		Not connected.
IO.12	H1.12		Not connected.
IO.13	H1.11		Not connected.
IO.14	H1.10		Not connected.
IO.15	H1.9		Not connected.
IO.16	H1.8	I	Serial input to the OEM615 receiver's **RX1D** pin. This input receives data from **IO.16** if/when jumper **R30** is fitted. Typically serial output from a module to the OEM615.
IO.17	H1.7	O	Serial output from the OEM615 receiver's **TX1D** pin. This output sends data to **IO.17** if/when jumper **R27** is fitted. Typically serial input to a module from the OEM615.
IO.18	H1.6		Not connected.
IO.19	H1.5		Not connected.
IO.20	H1.4		Not connected.
IO.21	H1.3		Not connected.
IO.22	H1.2		Not connected.
IO.23	H1.1		Not connected.

[8] On the GPSRM 1, all jumpers are implemented as zero-Ohm resistors soldered in place at time of assembly at the factory.

IO.24	H2.24		Not connected.
IO.25	H2.23		Not connected.
IO.26	H2.22		Not connected.
IO.27	H2.21		Not connected.
IO.28	H2.20		Not connected.
IO.29	H2.19		Not connected.
IO.30	H2.18		Not connected.
IO.31	H2.17	O	Variable-frequency output from the OEM615 receiver's **VARF** pin. This output places the **VARF** square wave on **IO.31** if/when jumper **R32** is fitted. Typically used by modules desiring a high-accuracy clock signal.
IO.32	H2.16	I	Serial input to the OEM615 receiver's **RX1D** pin. This input receives data from **IO.32** if/when jumper **R31** is fitted. Typically serial output from a module to the OEM615.
IO.33	H2.15	O	Serial output from the OEM615 receiver's **TX1D** pin. This output sends data to **IO.33** if/when jumper **R28** is fitted. Typically serial input to a module from the OEM615.
IO.34	H2.14		Not connected.
IO.35	H2.13		Not connected.
IO.36	H2.12		Not connected.
IO.37	H2.11		Not connected.
IO.38	H2.10		Not connected.
IO.39	H2.9		Not connected.
IO.40	H2.8		Not connected.
IO.41	H2.7		Not connected.
IO.42	H2.6		Not connected.
IO.43	H2.5		Not connected.
IO.44	H2.4		Not connected.
IO.45	H2.3		Not connected.
IO.46	H2.2		Not connected.
IO.47	H2.1		Not connected.

CubeSat Kit Bus PIN DESCRIPTIONS – Analog References

Name	Pin	I/O	Description
VREF0	H1.26		Not connected.
VREF1	H1.28		Not connected.
VREF2	H1.30		Not connected.

CubeSat Kit Bus PIN DESCRIPTIONS – Reserved

Name	Pin	I/O	Description
RSVD0	H1.44	–	Not connected.
RSVD1	H1.45	–	Not connected.

CubeSat Kit Bus PIN DESCRIPTIONS – I2C Bus

Name	Pin	I/O	Description
SDA_SYS	H1.41	I/O	I2C data. To/from supervisor MCU (an I2C slave device) via a PCA9515A I2C isolator. Typically from the PPM processor.
SCL_SYS	H1.43	I	I2C clock. To supervisor MCU (an I2C slave device) via a PCA9515A I2C isolator. Typically from the PPM processor.

CubeSat Kit Bus PIN DESCRIPTIONS – Control & Status

Name	Pin	I/O	Description
-FAULT	H1.25		Not connected.
SENSE	H1.27		Not connected.
-RESET	H1.29	I/O	Input to and/or output from reset supervisor controlling supervisor MCU. Functionality depends on resistors **R3** & **R4**.
OFF_VCC	H1.31	I	When resistor **R10** is fitted and no USB power is present, an active signal on this pin will disable **VCC_MCU** power to the supervisor MCU.
PPS[9]	H1.46	O	**PPS**. From the OEM615 receiver's **TIMEMARK** (PPS) output. This output is present whenever the OEM615 is powered and operating. 50Ω impedance.

CubeSat Kit Bus PIN DESCRIPTIONS – RBF and Separation Switches

Name	Pin	I/O	Description
S0	H2.33 H2.34		Not connected.
S1	H2.35 H2.36		Not connected.
S2	H2.37 H2.38		Not connected.
S3	H2.39 H2.40		Not connected.
S4	H2.41 H2.42		Not connected.
S5	H2.43 H2.44		Not connected.

CubeSat Kit Bus PIN DESCRIPTIONS – Power

Name	Pin	I/O	Description
VBATT	H2.45 H2.46	I	Battery voltage. EPS-dependent. Typically +7V to +10V. To expansion connector **H3.5** & **H3.6** only.
+5V_USB	H1.32	I/O	+5V USB power. From USB host.
+5V_SYS	H2.25 H2.26	I	+5V system power.
PWR_MHX	H1.33		Not connected.
VBACKUP	H1.42	I	Battery backup voltage. To expansion connector **H3.8** only.
VCC_SYS	H2.27 H2.28	I	VCC System power. Assumed to be +3.3V.
AGND	H2.31		Not connected.
DGND	H2.29 H2.30 H2.32	–	Digital ground.

CubeSat Kit Bus PIN DESCRIPTIONS – Transceiver Interface

Name	Pin	I/O	Description
-RST_MHX	H1.34		Not connected.
-CTS_MHX	H1.35		Not connected.
-RTS_MHX	H1.36		Not connected.
-DSR_MHX	H1.37		Not connected.
-DTR_MHX	H1.38		Not connected.
TXD_MHX	H1.39		Not connected.
RXD_MHX	H1.40		Not connected.

[9] This signal was formerly called **RSRVD2** and was reserved.

CubeSat Kit Bus PIN DESCRIPTIONS – User-defined

Name	Pin	I/O	Description
USER0	H1.47		Not connected.
USER1	H1.48		Not connected.
USER2	H1.49		Not connected.
USER3	H1.50		Not connected.
USER4	H1.51		Not connected.
USER5	H1.52		Not connected.
USER6	H2.47		Not connected.
USER7	H2.48		Not connected.
USER8	H2.49		Not connected.
USER9	H2.50		Not connected.
USER10	H2.51		Not connected.
USER11	H2.52		Not connected.

EXPANSION BOARD PIN DESCRIPTIONS

The expansion board connector H3 utilizes a 2mm-pitch, dual-row, 20-pin Samtec® CLT-110-02-G-D-BE-A socket (not fitted). The H3 connector provides power and ground – as well as twelve unused Supervisor MCU I/O pins – to a user-supplied expansion module. The mechanical footprint of the expansion module is similar to that of the OEM615 GPS receiver module, though its mating connector is in a different location. Reprogramming of the Supervisor MCU will be required to utilize the I/O pins.

N.B.: Any expansion board mounted to the bottom of the GPSRM 1 will exceed the standard component height for the underside of a CubeSat Kit-compatible module. Therefore additional accommodations must be made in terms of module stacking, so as to be able to accommodate an expansion module attached to the underside of the GPSRM 1.

Name	Pin	I/O	Description
+5V_SYS	H3.1 H3.2	–	+5V system power. From CSK bus connector.
VCC_SYS	H3.3 H3.4	–	VCC System power. Assumed to be +3.3V. From CSK bus connector.
VBATT	H3.5 H3.6	–	Battery voltage. EPS-dependent. Typically +7V to +10V. From CSK bus connector.
DGND	H3.7	–	Digital ground. From CSK bus connector.
VBACKUP	H3.8	–	Battery backup voltage. From CSK bus connector.
EXP.0	H3.9	I/O	Supervisor MCU's **RE15/AN15** pin.
EXP.1	H3.10	I/O	Supervisor MCU's **RC9/RP57** pin.
EXP.2	H3.11	I/O	Supervisor MCU's **RE14/AN14** pin.
EXP.3	H3.12	I/O	Supervisor MCU's **RD6** pin.
EXP.4	H3.13	I/O	Supervisor MCU's **RA4/RP20/SDO1** pin.
EXP.5	H3.14	I/O	Supervisor MCU's **RC8/RP56** pin.
EXP.6	H3.15	I/O	Supervisor MCU's **RA9/RPI25/SDI1** pin.
EXP.7	H3.16	I/O	Supervisor MCU's **RC7/RP55** pin.
EXP.8	H3.17	I/O	Supervisor MCU's **RC3/RPI51/SCK1** pin.
EXP.9	H3.18	I/O	Supervisor MCU's **RC6/RP54** pin.
EXP.10	H3.19	I/O	Supervisor MCU's **RG6/RP118** pin.
EXP.11	H3.20	I/O	Supervisor MCU's **RB9/RP41** pin.

IN-CIRCUIT DEBUGGING PIN DESCRIPTIONS

The Microchip® ICD®-compatible debugging/ programming connector J1 is implemented with a standard 6-pin Pumpkin PIC24 FPC connector. It is designed to mate to a Pumpkin JFPC-PIC24 debugging adapter via a 6-terminal flexible printed circuit (cable). This in turn can be connected to various Microchip in-circuit debuggers and programmers.

Name	Pin	I/O	Description
	J1.1	–	Unused.
PGEC	J1.2	I/O	**PGEC1** – clock signal for in-circuit debugging.
PGED	J1.3	I/O	**PGED1** – data signal for in-circuit debugging.
DGND	J1.4	–	Digital ground.
VCC	J1.5	–	Supervisor MCU power.
-MCLR	J1.6	I	Supervisor MCU's reset.

DEBUGGING ADAPTER PIN DESCRIPTIONS

The Pumpkin USB Debugging Adapter-compatible debugging connector J2 is implemented with a standard 4-pin Pumpkin USB Debug FPC connector. It is designed to mate to a Pumpkin USB Debugging Adapter via a 4-terminal flexible printed circuit (cable).

Name	Pin	I/O	Description
VCC	J2.1	–	Supervisor MCU power. When used with the GPSRM 1, users must ensure that this voltage from the Pumpkin USB Debug Adapter is set to 3.3V, or disconnected (preferred).
DGND	J2.2	–	Digital ground.
TXD	J2.3	O	Asynchronous serial data out of the Supervisor MCU.
RXD	J2.4	I	Asynchronous serial data into the Supervisor MCU.

PPS Output

The OEM615 GPS receiver has a 50Ω output driver for its **TIMEMARK** (PPS) signal. The default valid PPS signal is a low-going, 1.000ms pulse every second that is synchronized to GPS time when a valid position has been computed. Its behavior can be configured via commands to the OEM615.

The GPSRM 1 module provides two PPS outputs from the OEM615 receiver's **TIMEMARK** signal:

1. PPS is available at connector **J7** – an MCX jack – when jumper **R24** is fitted.
2. PPS is available on connector **H1.46** when jumper **R25** is fitted.[10]

By default, jumpers **R24** (for PPS to **J7**) and **R24** (for PPS to **H1.46**) are both fitted, thus making PPS available on both **J7** and **H1.46**. Customers can choose to remove one or the other based on their system-level design in an attempt to maximize the quality of the PPS signal at its endpoint(s).

For proper operation and accurate timing, the **TIMEMARK** (PPS) output requires a 50Ω termination. No termination is provided on the GPSRM 1 module. It is up to the end-user to provide the proper 50Ω termination if/when utilizing the GPSRM 1's PPS feature. Only one 50Ω termination should be applied to the PPS signal; either via **J6** or via **H1.46**.

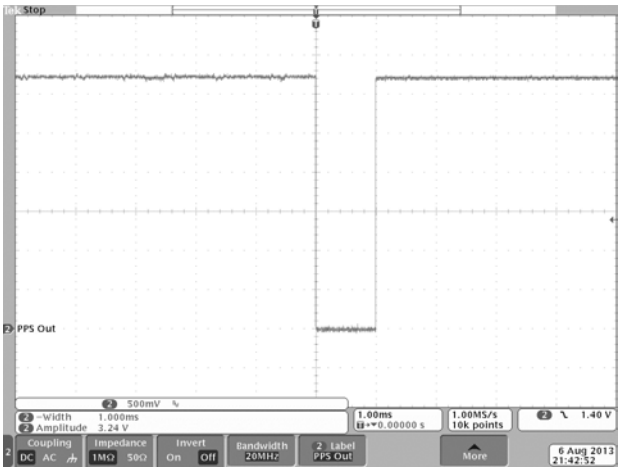


Figure 1: PPS on **J7**, unterminated. **R24** & **R25** fitted.

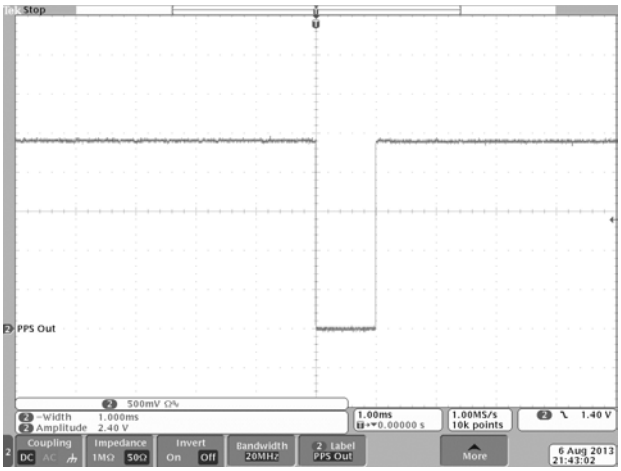


Figure 2: PPS on **J7**, terminated (50Ω) at oscilloscope. **R24** & **R25** fitted.

VARF Output

The OEM615 GPS receiver has a programmable variable-frequency output (**VARF**), that is coherent with its PPS output. Its enabled / disabled status, period and duty cycle can all be configured via commands to the OEM615. **VARF**'s period and duty cycle can be set with 10ns resolution.

VARF can replace a user's TCXO on another module, as long as the need for a stable and accurate frequency reference is compatible with the power requirements of the OEM615 receiver.

The GPSRM 1 provides the OEM615 receiver's **VARF** in two forms to the user:

1. On MMCX connector **J8**.
2. On the CubeSat Kit Bus Connector **IO.31**, if zero-Ohm jumper **R32** is fitted.

For example, the OEM615's **frequencyout enable 40 80** command results in a 1.25MHz output pulse train via **VARF**, as shown below.

[10] The signals on the CubeSat Kit Bus Connector are not controlled-impedance signals. Therefore the customer will have to experiment with the ideal termination (e.g., on another module in the module stack) in their particular application in order to achieve the best possible waveform from the PPS signal.

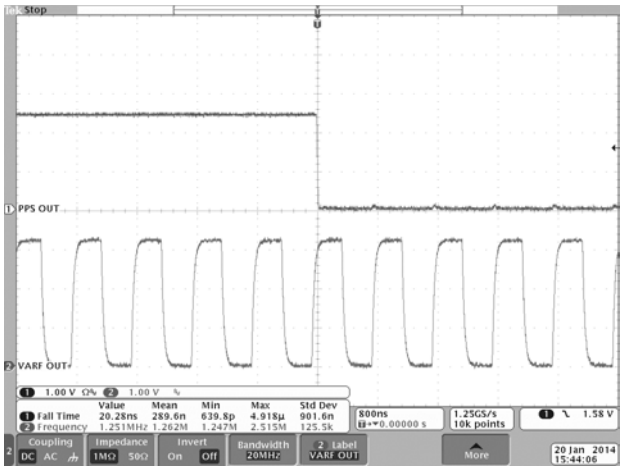


Figure 3: Resulting **VARF** output (below) on **J8** for OEM615 **frequencyout enable 40 80** command. Shown with **TIMEMARK** output (above) on **J7** with OEM615 locked to GPS. **R32** not fitted.

CLK Out Output

The GPSRM 1 provides an additional clock output – **CLK Out** – albeit with much less accuracy than the GPS-locked OEM615's **TIMEMARK** and **VARF**. **CLK Out** is the CPU clock of the GPSRM 1's Supervisor MCU, with a selectable postscaling divider of 1 to 2^15 in sixteen steps. This clock is generated on the Supervisor MCU via an internal high-accuracy RC oscillator and is presented on one of the Supervisor MCU's output pins. The nominal value of this oscillator is 7.3728MHz at room temperature.

The GPSRM 1 provides the Supervisor MCU's **CLK Out** in just one form to the user:

1. On MMCX connector **J6**.

CLK Out is controlled via commands to the GPSRM 1's Supervisor MCU, and is off by default. Apart from some additional power consumption and possible noise associated with driving the **CLK Out** output pin, there is no discernable effect on the Supervisor MCU when **CLK Out** is active.

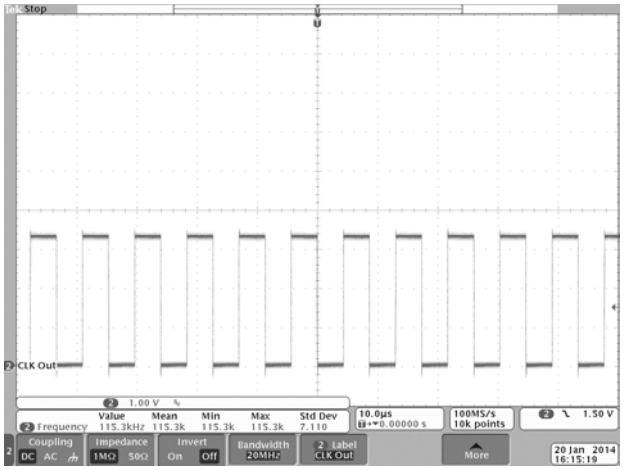


Figure 4: **CLK Out** output on **J6** when Supervisor MCU is commanded to output MCU clock with the divider set to 64.

OEM615 COM1 Output

When the GPSRM 1's passthrough feature is enabled, the OEM615's COM1 port is mapped to two pins on the CubeSat Kit Bus. A typical usage for the COM1 port is for the CubeSat Kit's PPM to command the OEM615 (e.g., to start logging), and for the OEM615 to respond with logs in human-readable form that will be received and parsed by the PPM. With passthrough enabled, the CubeSat Kit's PPM has the entire command set of the OEM615 available to configure, command and receive telemetry from the OEM615.

An example of the serial output stream of the OEM615's COM1 port is shown below:

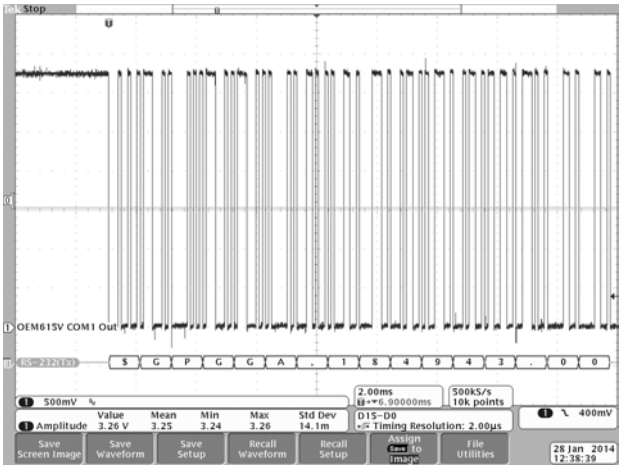


Figure 5: OEM615 COM1 output on CubeSat Kit Bus after OEM615 receives **`LOG COM1 GPGGA ONTIME 1`** command.[11]

Power Sources

The GPSRM 1 module uses controllable ideal diodes with programmable current limits to route +5V and +3.3V power to the OEM615 receiver's **`LNA_PWR`** and **`3V3`** power pins, respectively.

The supervisor MCU can be commanded to select **`+5V_SYS`** and **`VCC_SYS`** as the sources for the OEM615 receiver's **`+5V`** and **`+3.3V`** power, respectively. Therefore, whenever **`+5V_SYS`** is present on the CubeSat Kit bus connector, even if **`+5V_USB`** is present in these conditions, the GPSRM 1 module will not draw appreciable power from it.

If/when **`+5V_SYS`** is not present, then the GPSRM 1 may draw its power from +5V via USB, either from a directly connected USB host (via connector **`J3`**) or via the CubeSat Kit bus signal **`+5V_USB`**. The operation of the OEM615 in this configuration depends on the MAXPOWER attribute of the OEM615, which by default is 100mA, but may be configurable to something greater (e.g. 500mA) via firmware updates to the OEM615.

Use with USB

When powered via the CubeSat Kit bus, the GPSRM 1 module provides a means of communicating with the OEM615 receiver via its USB COM port (**`J3`**). A USB cable with a Micro-B connector is required. This feature is provided so that the module can be easily reconfigured by and used with e.g. NovAtel's software.

I2C Interface

The GPSRM 1 functions as an I2C Slave device.

The GPSRM 1's I2C interface is compatible with 100kHz and 400kHz I2C clock speeds.

When being written to or being read from by an I2C Master device, the GPSRM 1 (as a clock-stretching I2C Slave device) may stretch the I2C clock (**`SCL_SYS`**) as a means of avoiding overruns. This is part of the I2C protocol.

No pull-up resistors are present on the GPSRM 1. Pull-up resistors must be implemented elsewhere in the system; typically, they are on or close to the system's I2C Master device.

[11] Note that this OEM615 logging command can also be received via the OEM615's USB and other COM ports.

Signal Grounds

In an effort to minimize conducted and radiated emissions, all of the grounds of the GPSRM 1 are tied together into a single net: **DGND**. Those nodes tied to **DGND** include:

1. The grounds for the OEM615 GPS receiver (i.e., pins 10, 13, 16 & 18 of Its 20-pin connector P1101).
2. The grounds for the PIC24E Supervisor MCU (both analog and digital).
3. The ground of the USB micro AB connector.
4. **DGND** from the CubeSat Kit Bus Connector **H2**.
5. The (RF) ground of the OEM615 receiver's MCX GPS antenna connector.
6. The grounds of connectors **J6**, **J7 and J8**.
7. The heatsink cover / EM shield.
8. The four corner mounting holes of the module, along with their thermal pads.

I/O Level Mapping: OEM615 Receiver's COM1 I/O level

The OEM615's COM1 port is mapped to the CubeSat Kit bus through low-power level-shifting transceivers. The voltage level on the bus side (**VCCB_ISO**) can be selected via the selective jumpers implemented as zero-Ohm resistors **R8** and **R9**:

I/O level Configuration	Description	Example Host	Jumpers	
			Fitted	Omitted
A	COM1 I/O is at 5V logic levels.	PPMs that operate with 5V I/O.	**R8**	**R9**
B	COM1 I/O is at 3.3V logic levels.	PPMs that operate with 3.3V I/O (i.e., the majority).	**R9**	**R8**

CSK Bus Mapping: OEM615 Receiver's COM1

For applications that wish to talk serially to the OEM615 receiver via its COM1 port, four different configurations are supported via the selective jumpers implemented as zero-Ohm resistors **R26**-**R30**:

COM1 Configuration	Description	Example Host	Jumpers	
			Fitted	Omitted
A	Maps OEM615 receiver's **TXD1** to **IO.5** (**URX0**) and **RXD1** to **IO.4** (**UTX0**).	All PPMs that map **UTX0** to **IO.4** and **URX0** to **IO.5**.	**R26**, **R29**	**R27**, **R28**, **R30**, **R31**
B	Maps OEM615 receiver's **TXD1** to **IO.17** and **RXD1** to **IO.16**.	PPM D1 (PIC24FJ256GA110), configured via PPS to map UART3 to **IO.16** (data out) & **IO.17** (data in).	**R27**, **R30**	**R26**, **R28**, **R29**, **R31**
C	Maps OEM615 receiver's **TXD1** to **IO.33** and **RXD1** to **IO.32**.	With PPM B1 (which has no connections to **IO.[33.31]**), a user module with e.g. expansion I2C-to-UARTs can connect to **IO.32** & **IO.33**.	**R28**, **R31**	**R26**, **R27**, **R29**, **R30**
D	OEM615 receiver's COM1 is isolated from CubeSat Kit Bus Connector – interface only through GPSRM 1 Supervisor MCU via I2C.	Any PPM that needs to interface to the GPSRM 1 solely via I2C on **SCL_SYS** and **SDA_SYS**.		**R26**, **R27**, **R28**, **R29**, **R30**, **R31**

N.B. For proper operation, a maximum of one pair of jumpers (**R26** & **R29**, **R27** & **R39**, or **R28** & **R31**) should be fitted at any time. Fitting more than one pair of jumpers may damage the GPSRM 1. Jumpers are to be soldered in place by a qualified technician.

CSK Bus Mapping: VARF

VARF can be mapped to **IO.31** of the CubeSat Kit Bus. Two different configurations are supported via the selective jumper implemented as zero-Ohm resistor **R32**:

VARF Configuration	Description	Example Host	Jumpers	
			Fitted	Omitted
A	**VARF** is not mapped to CSK Bus.	PPMs or other hosts that cannot effectively utilize VARF when mapped to **IO.31**.		**R32**
B	**VARF** is mapped to **IO.31**.	PPMs or other hosts that have facilities to utilize a programmable clock signal on **IO.31**.	**R32**	

CSK Bus Mapping: -RESET

The GPSRM 1 has its own independent reset supervisor (**U2**). The reset supervisor can be configured to interact with the CubeSat Kit Bus **–RESET** signal as an input to and/or an output. Four different configurations are supported via the selective jumpers implemented as zero-Ohm resistors **R3** and **R4**:

-RESET Configuration	Description	Resultant Behavior	Jumpers	
			Fitted	Omitted
A	Local reset supervisor **U2** is not used, GPSRM 1 is completely disconnected from **–RESET**.	Supervisor MCU utilizes only its own on-chip BOR/POR circuitry to enforce clean (re-)starts. *Not recommended.*		**R3**, **R4**
B	GPSRM 1's local reset supervisor **U2** resets Supervisor MCU and can be triggered via **–RESET**.	GPSRM 1 can be reset via local reset supervisor **U2** and external **–RESET** signal.	**R4**	**R3**
C	Local reset supervisor **U2** is not used, GPSRM 1 can drive **–RESET** signal.	Supervisor MCU utilizes only its own on-chip BOR/POR circuitry to enforce clean (re-)starts. GPSRM 1 can reset the CubeSat Kit Bus by forcing local signal **–FORCE_RESET** low. *Not recommended.*	**R3**	**R4**
D	GPSRM 1's local reset supervisor **U2** resets Supervisor MCU and can be triggered via **–RESET**. GPSRM 1 can drive **–RESET** signal.	GPSRM 1 can be reset via local reset supervisor **U2** and external **–RESET** signal. GPSRM 1 can also reset the CubeSat Kit Bus by forcing local signal **–FORCE_RESET** low – *this will in turn force a GPSRM 1 reset. Use with caution.*	**R3, R4**	

Assembly Revisions

As a consequence of the various jumper-driven configurations outlined above, end-users may specify an assembly revision when ordering their GPSRM 1. A binary code is utilized, as shown below, with the resulting assembly revision numbers shown in decimal format, with powers-of-2 weights from left to right:

ASSY REV	R9 or R8	R32	R3	R4	R28 &R31	R27 &R30	R26 &R29	Typical Application
8	R9	-	-	+	-	-	-	Sole interface to Supervisor MCU is via I2C.
9	R9	-	-	+	-	-	+	PPM Ax, OEM615 COM1 on **IO.5** & **IO.4**.
10	R9	-	-	+	-	+	-	PPM Dx, OEM615 COM1 on **IO.17** & **IO.16**.
41	R9	+	-	+	-	-	+	PPM Ax, OEM615 COM1 on **IO.5** & **IO.4**, additional module utilizes VARF on **IO.31**.
44	R9	+	-	+	+	-	-	PPM B1, OEM615 COM1 on **IO.33** & **IO.32**, additional module utilizes VARF on **IO.31**.
73	R8	-	-	+	-	-	+	Customer PPM with 5V I/O, OEM615 COM1 on **IO.5** & **IO.4**.

Use with alternate GPS Receivers

Bare COCOM-unblocked GPS receiver rated for space use can cost thousands of dollars. If/when an alternate GPS receiver has a compatible pinout and connectors, then it may be possible to use with the GPSRM 1 in place of the OEM615 receiver for ground-based development and test. The following caveats must be observed:

1. The integrated heatsink / RFI cover will likely not fit and should not be used.
2. All of the alternate GPS receiver module's I/O must match or be a subset of those of the OEM615 receiver series.
3. No part of the alternate GPS receiver may touch the GPSRM 1 PCB.
4. The protection circuits of the GPSRM 1 may not be compatible with those of the alternate GPS receiver.

For alternate GPS receivers that are powered exclusively via +3.3V on pins 3 and 4 of the 20-pin header **GPS1**,

1. Remove and do not plug in any USB cables to connector J3.
2. Fit two shorting jumpers on **J5**: 1-3 and 2-4.[12]
3. If necessary, prevent the existing +5V and +3.3V power on the header **GPS1** from reaching pins 1 and 2 of the alternate GPS receiver. This may require cutting the connector pins on the alternate GPS receiver.

This will feed the GPSRM 1's local +3.3V supply to pins 3 and 4 of the 20-pin header **GPS1** for use with a alternate, compatible GPS receiver (i.e., one other than the OEM615 receiver).

A sample, low-cost GPS receiver that can be used in this manner is the Royaltek REB-21R, in its 3.3V TTL & RS-232 output configuration.[13]

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[12] When installed, these jumpers are parallel to the H1 and H2 CubeSat Kit Bus connectors.

[13] The particular model tested (with a datecode of 2003, found at an electronics surplus store for under $10) had to have its right-angle MCX jack removed and replaced with a straight MCX plug on the opposite side of the PCB so as to be able to mate to the 20-pin connector on the GPSRM 1 PCB.