MOTOROLA

Position and Navigation Systems Business

VP ONCORE
Engineering Notes

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Motorola. Inc.
Position and Navigation Systems Business Rev 1.0 8/21/96

1. Product Specifications

VP ONCORE GPS Receiver Technical Characteristics

Receiver Architecture	• 6 (or 8) channel • L1 – 1575.42 MHz • C/A code (1.023 MHz chip rate) • Code plus carrier tracking (carrier aided tracking)
Tracking Capability	• 6 (or 8) simultaneous satellite vehicles
Dynamics	• Velocity: 1000 knots (515 m/s) >1000 knots at altitudes < 60,000 ft • Acceleration: 4g • Jerk: 5 m/s^3 • Vibration: 7.7G per MIL-STD 810E
Acquisition Time (Time to First Fix (TTFF)	• 20 sec. typical TTFF (with current almanac, position, time, and ephemeris) • 45 sec. typical TTFF (with current almanac, position, and time) • 2.5 sec. typical reacquire
Positioning Accuracy	• Less than 25 meters, SEP (without SA) • Less than 100 meters, SEP (with SA) • DGPS accuracy: 1-5 meters typical
Timing Accuracy (1 Pulse Per Second, 1PPS)	• 130 ns observed (1σ) with SA on • In Position-Hold mode, <50 ns observed (1σ) with SA on
Antenna	• Active micro-strip patch antenna module • Powered by receiver module (25 mA @ 5V) • Passive antenna configuration (see optional features)
Datums	• 49 std datums, 2 user defined, default WGS-84
Output Messages	• Latitude, longitude, height, velocity, heading, time, satellite tracking status (Motorola Binary protocol) • NMEA-0183 v2.00 (selected formats) available • Software selectable output rate (continuous or poll) • Broad list of command/control messages • TTL interface
Power Requirements	• 5 +/- 0.25 Vdc; 50 mV p-p ripple max
"Keep Alive" BATT Power	• External 2.5 V to 5.25 V; 15 μA typ, 60 μA max • 3V onboard battery; 15 μA typ., 60 μA max.
Power Consumption	• 1.1 W @ 5 Vdc
Dimensions	• Receiver: 2.00 x 3.25 x 0.64 in. (51 x 83 x 16 mm) • Active antenna: 4.01d x 0.89 in. high (102 x 22.6 mm)
Weight	• Receiver: 1.8 oz (51 g) • Active antenna module: 4.8 oz (136 g)
Connectors	• Data/Power: 10 pin (2x5) unshrouded header on 0,1" centers • RF: Right Angle OSX (subminiature snap-on)
Antenna to Receiver Interconnection	• Single coaxial cable (6 dB max loss at L1; 1574.42 MHz)
Operating Temperature	• Receiver module -30°C to + 85°C
Humidity	• 95% non-condensing, +30°C to + 60°C
Altitude	• 60,000 ft (18 km) • > 60,000 ft (18 km) for velocities < 1000 knots
Optional Features	• 1PPS Timing Output • Raw measurement data • Onboard rechargeable lithium battery • Onboard LNA option for use with passive antenna
DGPS	• Differential GPS – standard software feature • RTCM-104 format (remote input) • Motorola Custom Format

2. Operating Voltage and Current Ranges

5 Vdc PWR (Main power)

- Voltage
  4.75 Vdc to 5.25 Vdc
- Power
  1.1 W @ 5 Vdc over temperature range
- Current
  with Active Antenna (no LNA option onboard)
  230 mA typical @ 5 V at 25°C
  275 mA max @ 5.25 V over temperature range
  with Passive Antenna (LNA option onboard)
  215 mA typical @ 5 V at 25°C
  250 mA max @ 5.25 V over temperature range

BATTERY

External Applied Back-up Power

- Voltage
  2.5 V to 5.25 V
- Current
  15 μA typical; 60 μA max over temperature range

OR

Lithium Battery Option

- Voltage: 3V
- Current
  Typical 5 μA @ 25°C
  10 μA max @ 25°C
  60 μA max @ 60°C
- Battery life
  25 mAh life between charges
  at 10 uA load a fully charged battery will last 3 months without recharging.
  Full component life: 5+ years
  - Recharge
    Automatically recharged by 5V main power
    Recommended first time charge: 24 hours

Lithium Battery Option Users

CAUTION

Production Units

No electrical connection exists between the Lithium battery and the external applied back-up power. This opening was designed intentionally and it is recommended that this pin be left open and unused.

Recharge

Recharging of the Lithium Battery is accomplished automatically while the receiver is powered on. A one time, overnight recharge is recommended prior to usage to ensure the battery is charged and ready.

3. Active versus Passive Antenna Information

- Active Antenna
  24 dB amplification
  25 mA @ 5 Volts (max. 50 mA)

Please see attached "Active Antenna RF Interface Specifications v1.5"

- Passive Antenna
  Onboard LNA = 23 dB

Assuming 0 dBic gain levels from the antenna, the acquisition and tracking thresholds for various cable lengths of RG-58 cable (ie. 1 dB loss per meter) are as follows:

Cable Length	Acquisition Threshold	Tracking Threshold
0m	-137 dBm	-143 dBm
1m	-136 dBm	-142 dBm
5m	-132 dBm	-138 dBm

The Acquisition threshold is the minimum signal level of a GPS satellite signal received at the antenna in order for the receiver to acquire and lock onto that signal.

The Tracking threshold in the minimum signal level of a GPS satellite signal received at the antenna in order for the receiver to maintain lock (ie. tracking) once acquisition is achieved.

GPS satellites by design are guaranteed to provide at least -130 dBm level signals on the earth's surface at the end of satellite life. This assumes direct line of sight to the satellite with no interference. In order to allow for a certain margin of attenuation of the signal caused by overhead foliage, etc. a 7 dB margin beyond the -130 dBm was designed into the receiver for acquisition and 13 dB for tracking. As the table above indicates, increasing the cable length narrows these margins due to signal loss along the cable. As the cable length increases, so does the total signal loss along the cable and consequently the tracking thresholds are not as low.

Please see attached "Passive Antenna RF Interface specifications v1.5".

MOTOROLA ONCORE
GPS RECEIVER/ACTIVE ANTENNA RF INTERFACE SPECIFICATIONS
V1.5

Input Impedance	50 Ω
VSWR	2:1 maximum @ 1575.42 MHz (+/- 1 MHz)
Connector type	OSX Jack, Straight
Preamplifier power	+5V, 25 mA available at connector

Recommended Antenna Design Guidelines

Operating frequency	1575.42 MHz
Bandwidth	30 MHz typical
Polarization	Right hand circular
Pattern	Essentially hemispherical
Gain Characteristics	• +3 dBic minimum at 90° above the horizon (zenith) • 0 dBic minimum at 30° above the horizon • -6 dBic minimum at 0° (horizon)
VSWR	2:1 maximum at 1575.42 MHz, +/- 1 MHz into a 50 Ω system
Preamplifier Gain	18 dB minimum (including 6 dB cable loss)
Noise Figure	2.5 dB maximum

MOTOROLA GPS VP ONCORE
PASSIVE ANTENNA RF INTERFACE SPECIFICATIONS
V1.5

Input Impedance	50 Ω
VSWR	2:1 maximum @ 1575.42 MHz (+/- 1 MHz)
Connector type	OSX Jack, Straight

Recommended Antenna Design Guidelines

Operating frequency	1575.42 MHz
Bandwidth	30 MHz typical
Polarization	Right hand circular
Pattern	Essentially hemispherical
Gain Characteristics	• +3 dBic minimum at 90° above the horizon (zenith) • 0 dBic minimum at 30° above the horizon • -6 dBic minimum at 0° (horizon)
VSWR	2:1 maximum at 1575.42 MHz, +/- 1 MHz into a 50 Ω system

4. EMC (Electro-Magnetic Compatibility) Considerations

- *RF Interference:* The RF circuitry sections on the VP Oncore GPS receiver board are protected with a tin plate shield to guard against potential interference from external sources. When designing the VP Oncore near and around RF sources such as radios, it is recommended that the VP Oncore be tested and tried in the target environment to identify potential interference issues prior to final design.

- *Note:* Because the VP Oncore receiver contains a very sensitive RF receiver you must observe certain precautions to prevent possible interference from the host system. Because the electromagnetic environment will vary for each OEM application, it is not possible to define exact guidelines to assure electromagnetic compatibility.

5. RTC (Real Time Clock)

The RTC is a feature of the VP Oncore. The user has three options regarding time initialization:

1) Set time manually in idle mode, OR,
2) Set time in fix mode **BEFORE** receiver acquires any satellites, OR,
3) Receiver will automatically set time in fix mode **AFTER** the receiver acquires satellites.

- *Note:* Time cannot be set in fix mode while the receiver is tracking satellites.

With the Real-time clock and no Lithium battery option, the receiver will start up but will have an incorrect time unless it was previously set and maintained by an external battery. To ensure a faster time to first fix, the time, date and GMT offset should be re-set if both the main power and battery backup power have been disconnected.

With the RTC and the Lithium battery option on-board, the receiver clock is set to UTC time prior to shipping and maintained by the on-board Lithium battery automatically.

6. 1 PPS Signal Definition

- 0 to 5V level pulse
- 1PPS time mark is synchronous with rising edge of pulse - rising from 0V to 5V. Rise Time is approx. 20 to 30 nanoseconds
- 5V pulse width is approx. 200 milliseconds (+/- 1 millisecond), i.e. the falling edge will occur approximately 200 milliseconds after.rising edge
- Accuracy: 130 nanoseconds observed (1σ) with SA on. In position hold mode, <50 nanoseconds observed with SA on.

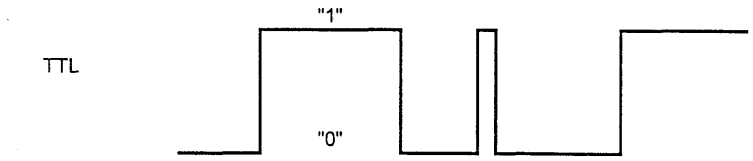
7. TTL Serial Interface

The serial interface signals, RXD and TXD, are available for user connection. A ground signal is also required to complete the serial interface. There is no additional protection and signal conditioning besides the internal protection of the micro. These signals are coming from the microprocessor directly. They are regular TTL signals with voltage ranges from 0 to 5V. For input signals, minimum input high voltage is 2.0V and the maximum input high voltage is 5V. Minimum input low voltage is 0V and the maximum input low voltage is 0.8V. For output signals, minimum output high voltage is 2.4V and the maximum output low voltage is 0.5V.

This interface is not a conventional RS232 interface that can connect to a PC (which is normally equipped with RS232 interface) directly. An RS232 driver/receiver is required to make this connection. The driver/receiver provides a voltage shifting from 0 to 5V to a positive and negative voltage (for example, +/-10V), and also has an inversion process in it. Some RS-232 driver/receiver IC's (Integrated Circuits) for example; Motorola's MC145407, will provide all these functions with only a +5V supply.

The microprocessor used in the VP ONCORE is the MC68331.

- DC characteristics:
  - Sink/drain current: 5.3 mA max
  - Source/drive: 0.8 mA
  - Impedance: High



TTL	0 V	to	0.8 V	=	Logic "0"
TTL	2.4 V	to	5.0 V	=	Logic "1"

Nominal Voltage Levels (ie. when transmit/receive lines are idle).

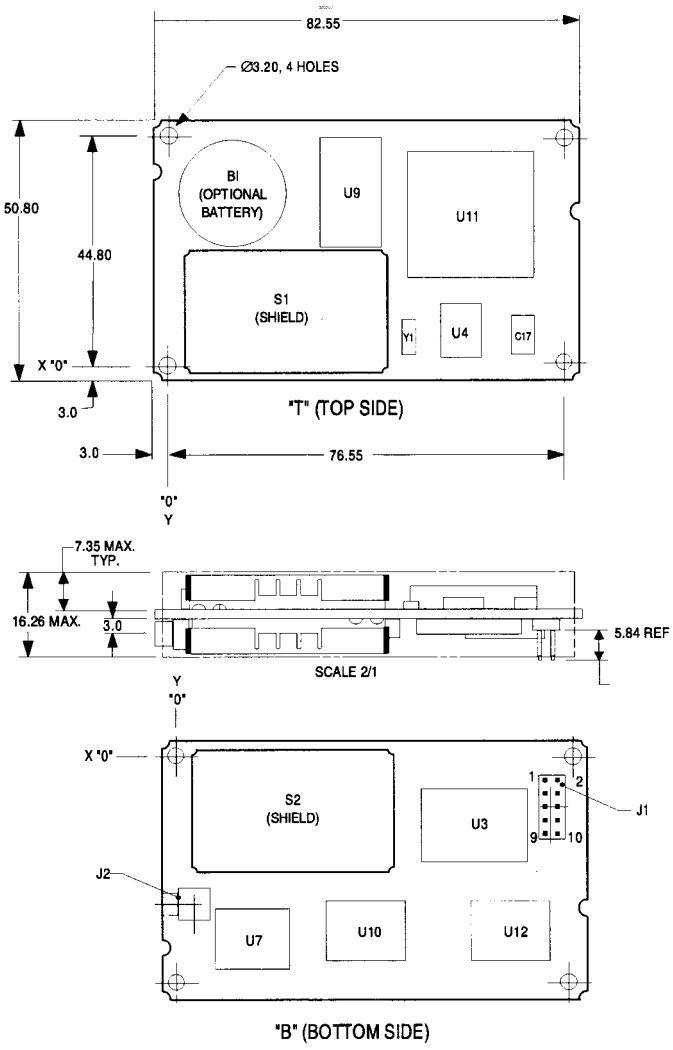
TTL_TXD	(PIN #8)	Logic "1"
TTL_RXD	(PIN #9)	Logic "0"

Note: for conversion reference

RS	-232 -5 V	to	-15 V	=	Logic "1"
	5 V	to	15 V	=	Logic "0"

Note: 50 pf maximum capacitance on TTL level output.

APPENDIX A. Mechanical Dimensions



(J1) POWER/DATA LEGEND		
PIN#	SIGNAL NAME	DESCRIPTION
1	BATTERY	EXTERNAL APPLIED BACK-UP
2	5V PWR	+5Vdc REGULATED
3	GROUND	GROUND (RECEIVER)
4	VPP	FLASH EPROM PROGRAMMING
5	(NOT USED)	
6	ONEPPS	1 PULSE PER SECOND OUTPUT
7	ONEPPS-RTN	1 PULSE PER SECOND RETURN
8	TTL-TXD	TRANSMIT 5V LOGIC
9	TTL-RXD	RECEIVE 5V LOGIC
10	TTL-RTN	TRANSMIT/RECEIVE RETURN

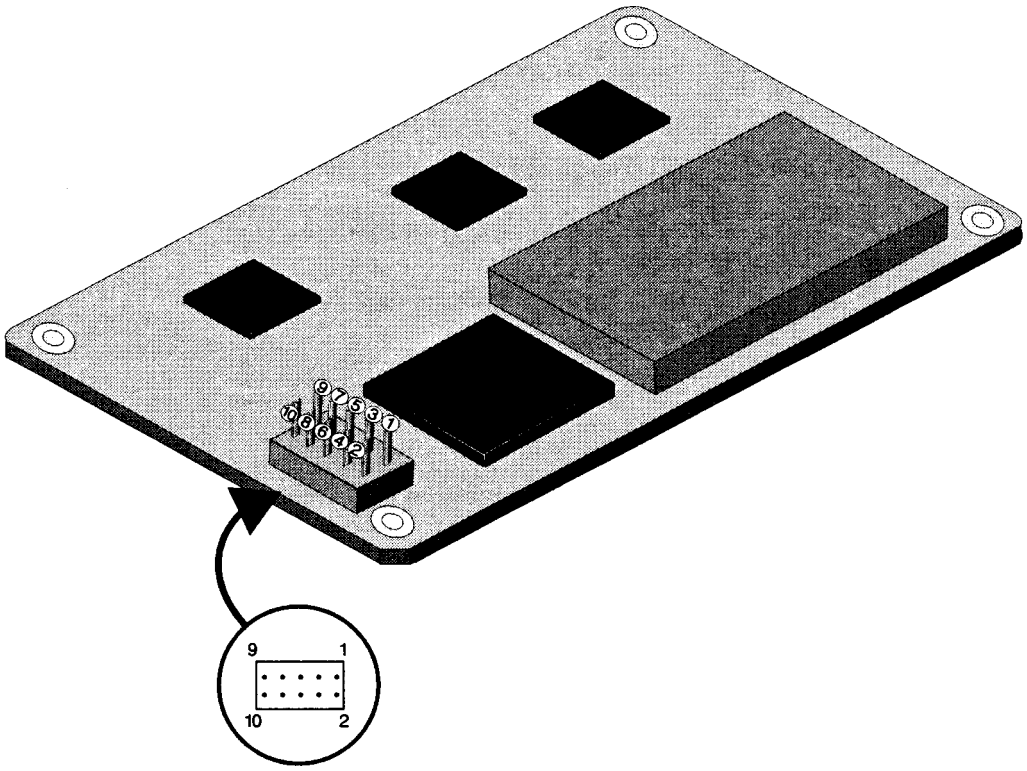
NOTE:

(J1) POWER/DATA CONNECTOR:
MFR: AMP #104326-06
HEADER, 10-PIN W/2.54 CENTERS

(J2) RF CONNECTOR:
MFR: MACOM #5864-5002-10
(OSX) SUB-MINIATURE SNAP-ON

COMPONENT LEGEND						
REF DESIG	PCB SIDE	LOCATION (NOMINAL TO CENTER)		SIZE (NOMINAL)		
		"X"	"Y"	WIDTH "X"	LENGTH "Y"	HEIGHT
B1	T	12.4	33.6	20.5	—	4.0
C17	T	67.1	6.4	4.3	7.3	2.8
J1	B	72.44	9.45	4.9	12.3	8.2
J2	B	3.35	28.75	6.0	6.0	6.0
S1	T	22.6	10.6	39.3	23.8	6.9
S2	B	22.6	10.6	39.3	23.8	6.9
U3	B	55.5	13.1	20.0	14.0	3.0
U4	T	56.8	7.2	7.5	10.3	2.5
U7	B	16.0	35.5	14.0	11.5	3.6
U9	T	34.1	35.5	11.7	21.0	3.2
U10	B	35.5	35.1	15.0	11.5	3.6
U11	T	60.0	33.7	24.2	24.2	4.6
U12	B	61.3	29.8	15.0	11.5	3.6
Y1	T	45.0	5.9	2.5	6.7	1.5

APPENDIX B. Pin Out Designations



APPENDIX C. RF Application Note

Active Antenna System

Both the gain and the noise of the overall system affect the performance of the A/D convertor in a GPS receiver. The illustration below illustrates typical values for the Oncore family of GPS receivers when used with the Motorola antenna and standard RG-58 cable. The thresholds and ranges listed should be considered with a tolerance of 2 to 3 dB.

System constraints:

1. The gain in decibels is cumulative through all stages (i.e. G = G1+ G2 + G3...). The optimal gain of the antenna, cabling and any in-line amplifiers and splitters is 18 dB +/- 8 dB. The Oncore receiver may operate outside of the optimal gain range but performance will degrade. Therefore, Motorola does not recommend operating outside of the optimal gain range as indicated above. For the system below, the gain is 18 dB in front of the receiver.

2) System noise (F) is not to exceed 4 dB. The cascaded system noise figure

   is F = F1 + (F2-1/G1) + (F3-1/(G1*G2)) + …., (= 2.7 dB for the system below)

   where F1 is the noise figure for stage one and G1 is the gain for stage one. Note that all of these values are absolute. Recall the formula for converting absolute values to decibels:

   F(dB) = 10 * log(F)