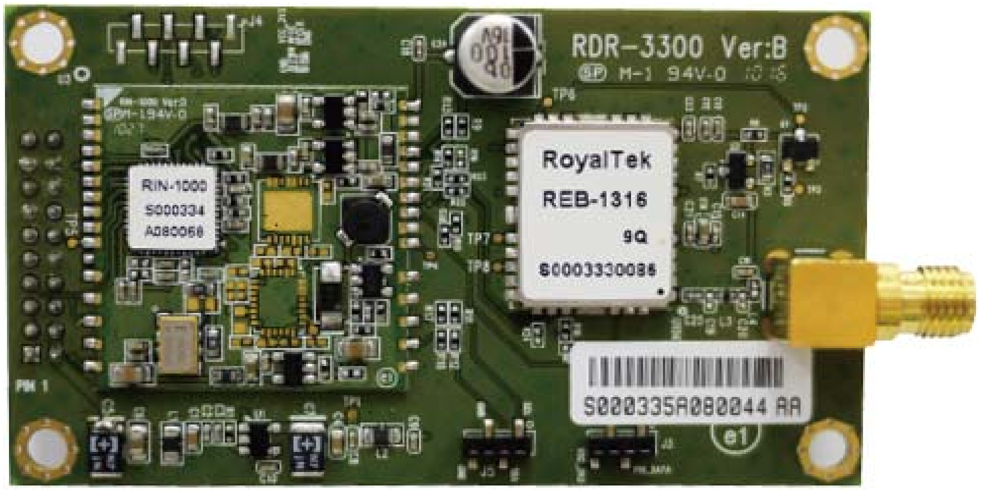
# RDR-3300




Abstract

This document describes the feature and specifications of the RDR-3100/3200/3300 low power DR Module. It guides through a design in and provides information to get maximum GPS performance.

## TABLE OF CONTENTS

## Revision History

| Version | Date | Description | Editor |
|---|---|---|---|
| 1.0 | 2010/08/31 | New Draft Version | Royaltek |
| 1.1 | 2011/1/19 | | |
| 1.2 | 2011/4/12 | Add RIN-1000 ODR Board spec and interface document | Royaltek |
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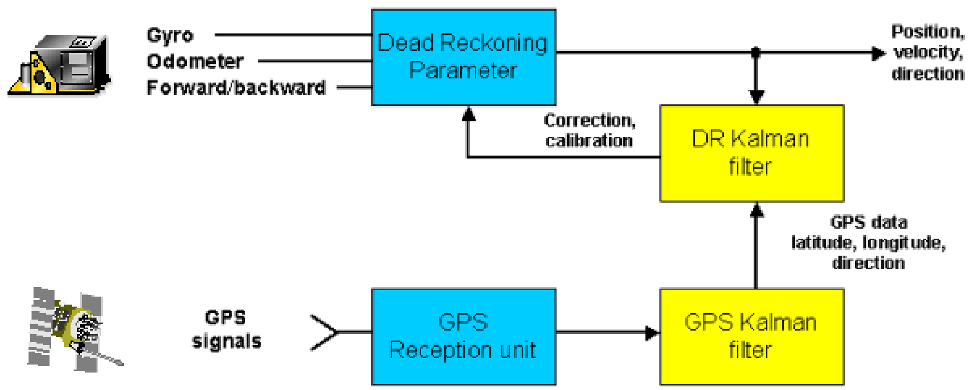
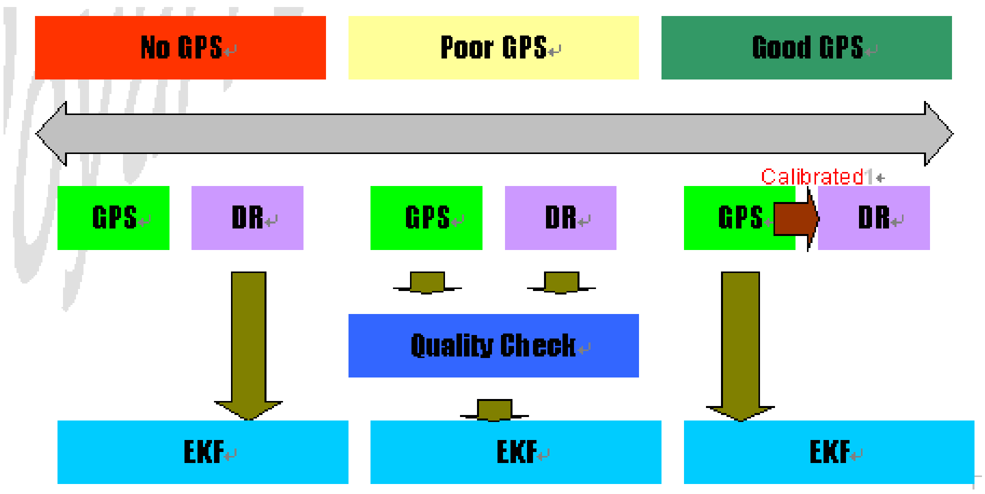
# 1 Introduction

Dead Reckoning (DR) is feature to make GPS more accurate and reliable in urban canyon environment and during GPS outage. It uses additional sensors to measure speed, heading and direction, include forward and backward. It is consist of a GPS receiver, a turn rate sensor (gyro MEMS) and speed indicator (Odometer/Backward or 3D accelerometer sensor). By combining the information of all sensors a position can be determined even if GPS positioning is degraded or impossible due to restricted sky view. This means that a DR enabled receiver continues to report position when GPS signals are blocked, such as in tunnels or in heavy urban canyon environments.

## Dead Reckoning Functional Block Diagram




## GPS/INS Switch Logic



# 2 Hardware Design Specification

This document describes the recommended schematic and layout design of gyro and odometer circuit, and is designed to operate with RDR-3300 algorithm correctly. This document also describes the application of DR protocol and illustrates how to optimize the performance of DR using known digital map information.

## 2.1 Product Feature

- 20 parallel channels
- Screw holes type
- Newest generation of RoyalTek® GPS module integrated Dead Reckoning technology
- Keep on producing an accurate position after loosing contact to the GPS satellites.
- Enhanced algorithm for navigation stability and minimizes the effects of GPS outages, and provide improved position accuracy in urban environments.
- Excellent sensitive for urban canyon and foliage environments

## 2.2 Product Specification

### 2.2.1 RDR-3300

| | |
|---|---|
| GPS Chipset | - SiRF Star III GPS chipset |
| Frequency | - L1 1,575.42 MHz |
| Channel | - 20 channels |
| C/A Code | - 1,023 MHz |
| chipset Fix time<br>(Open sky) | - Reacquisition: less than 0.1s<br>- Hot start: 1 sec<br>- Warm start: 35 sec<br>- Cold start: 35 sec |
| Accuracy | - Position: within 10m for 90%<br>- Velocity: 0.1m/s |

| | |
|---|---|
| Interface Protocol | - NMEA 0183 |
| DGPS | - Default is Disable |
| WAAS | - Default WAAS is Disable |
| Altitude | - 18,000 meter maximum |
| Velocity | - 514 meter/second maximum |
| **Antenna** | |
| Active Antenna RF Connector | - SMA R/A PCB JACK (J1)<br>- Option for MCX Jack |
| External Antenna input Voltage | - Recommend using +3.3V@15mA |
| **Power** | |
| Voltage Type | - DC +5V ± 5% |
| System current | Avg 60mA@ +5V (without GPS antenna ) |
| Antenna Detect function | GPIO; Follow customer GPS antenna detector protocol<br>Port 2 baud Rate: 38400bps<br>0: with external antenna<br>1: without external antenna |
| **HW Connector** | |
| Connector | 20 Pin Header，2.0 mm pitch (J2) Male seat |
| **Physical and Environment** | |
| Dimension | 71±0.3mm(L) x 40.8±0.3mm(W) x 18.3mm±0.3mm (H)<br>Screw Hole type |
| Weight | - ≦19.6(g) |
| Temperature | - Operating: -40 ~ 85℃<br>- Storage: -40 ~ 85℃ |

| **Interface** |
|---|
| Hardware UART: baud rate 38400. Connect with GPS Module |
| Software UART: baud rate 38400. Connect with CAN BUS |
| Odometer : Connect with Car’s odometer line |
| Reverse : Connect with Car’s reverse line |
| TimeMark : 1pps source. Connect with GPS Module. |
| GyroOUT : Connect with Gyro Chipset. |

### 2.2.2 RIN-1000 (Gyro)

| General usage and system specification | |
|---|---|
| MCU specification | - ATXMEGA32A4-MH |
| Gyro Chipset | - Epson XV8000CB |
| Environment | - Car electronic device |
| Temperature | - Operating : -40 ~ 85℃<br>- Storage : -40 ~ 85℃ |
| Operation | - Odometer & Reverse Line |
| Size | - Dimension: 25.4 x 25.4 x2.7 ±0.3mm |
| Voltage Type | - DC +5V ± 5% |
| Gyro Chipset | - Epson XV8000CB |
| Power Consumption | - Avg. 30mA @ 5V |
| RoHS | - Supported |
| Module SMD TYPE | - Screw Hole |
| Antenna Detect function | 0: with external antenna<br>1: without external antenna |
| **Gyro specification** | |
| Gyro Chipset | - Epson XV-8000CB |
| Operation voltage Range | - +5 ±0.25 V |
| Temperature Range | - -40 ~ 85℃ |
| Zero point voltage | - +2.5±0.4V |
| Sensitivity | - 25mV/(°/S) |
| Frequency response(7Hz) | - ＞–4dB |
| Output voltage range | - 0.7~Vdd-0.7 |
| Output noise | - ＜5mVpp |

| Interface |
|---|
| Hardware UART: baud rate 38400. Connect with GPS Module |
| Software UART : baud rate 38400. Connect with CAN BUS |
| Odometer : Connect with Car's odometer line |
| Reverse : Connect with Car's reverse line |
| TimeMark : 1pps source. Connect with GPS Module. |
| GyroOUT : Connect with Gyro Chipset. |

## 2.3 Schematic Design (RDR-3300 & RIN-1000)

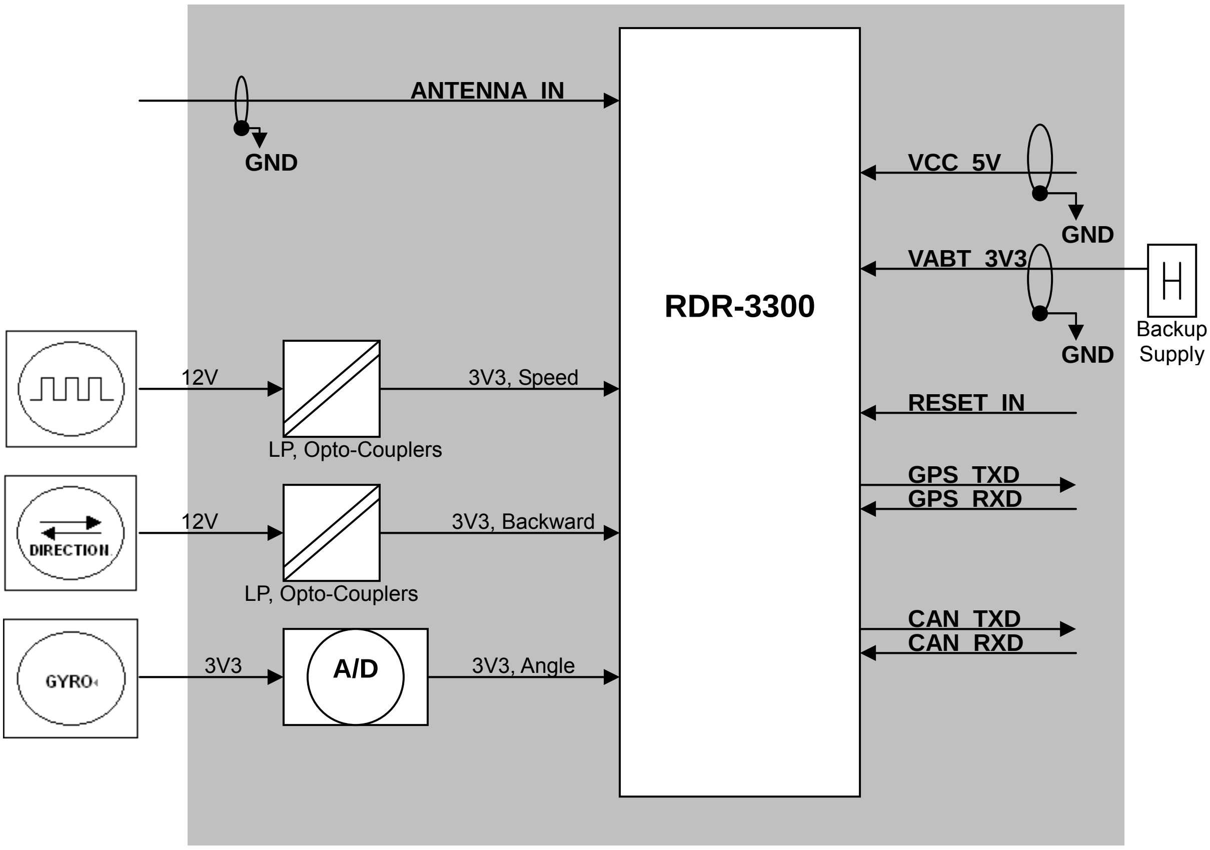



**Figure 1: Block Diagram of RDR-3300 Design**

### 2.3.1 Direction Indicator

The direction indicator is used to predict vehicle's heading info and this signal is optional but strongly recommended for good performance. You need to check the voltage levels and the quality of the vehicle signals

### 2.3.2 Odometer Pulse Detector

DR receiver is captured this signal to calculate the delta distance per second. It can be designed odometer pulses, speed ticks, wheel pulse or ticks. When this signal is connected and converter voltage levels from 12V to 3.3V by opto-couplers, you must to check the voltage levels and quality of vehicle signals. Otherwise, the opto-couplers or other approved EMI protection and filtering is strongly recommended. The reference design of odometer/direction circuit is shown as figure 2.

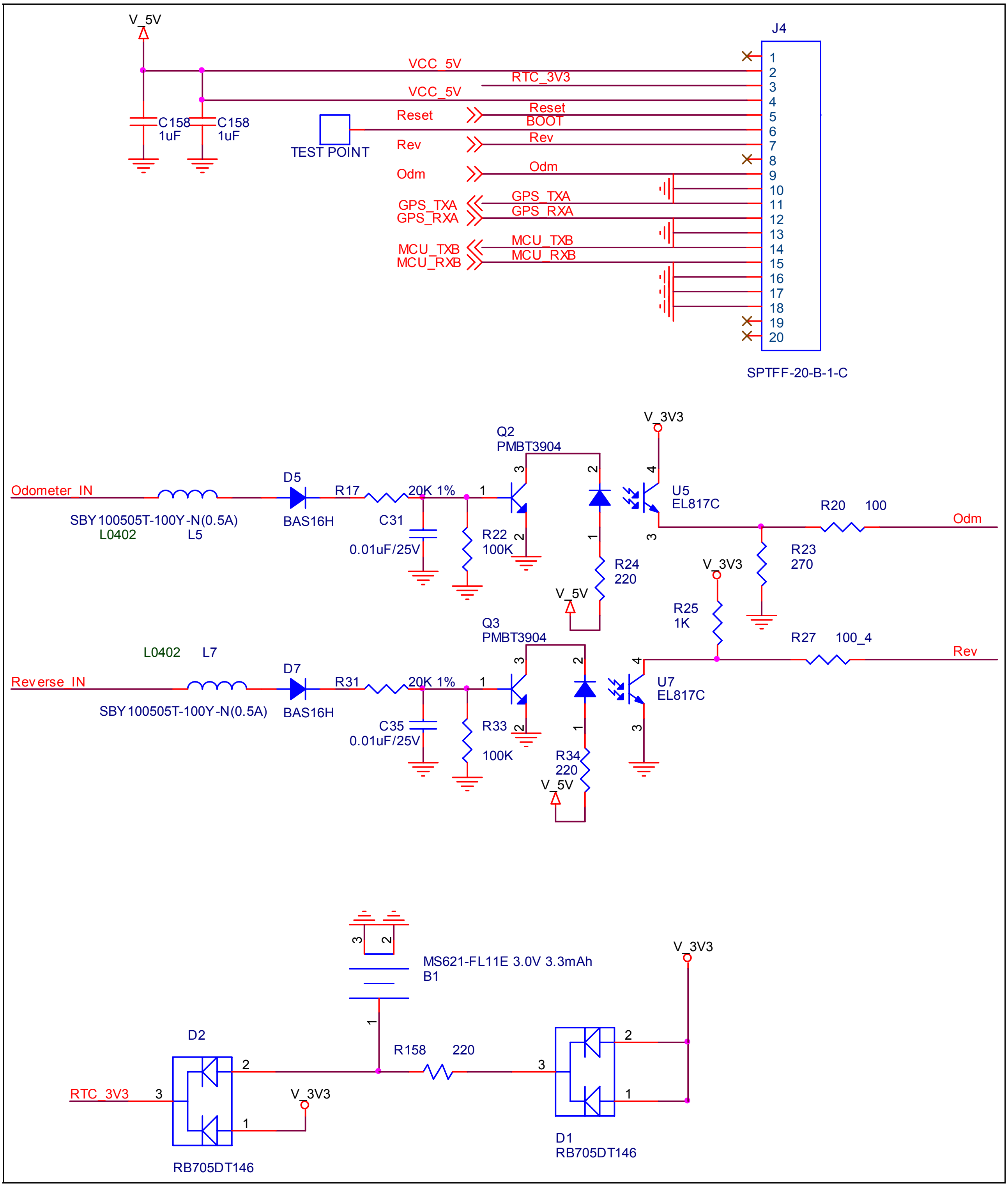



**Figure 2: Odometer/Backward Circuit Reference Design**

### 2.3.3 Angle Turn Rate Sensor

The RDR-3300 module is provided EPSON® XV-8000CB Gyro MEMS to retrieve DR system delta angle info by 12-bits A/D capture. The z-axis sensor only supports the tilt angle drift base on cradle up to +/- 10° (figure 2). Otherwise, the turn rate sensor z-axis is located at top of cradle planet is shown as figure 3.

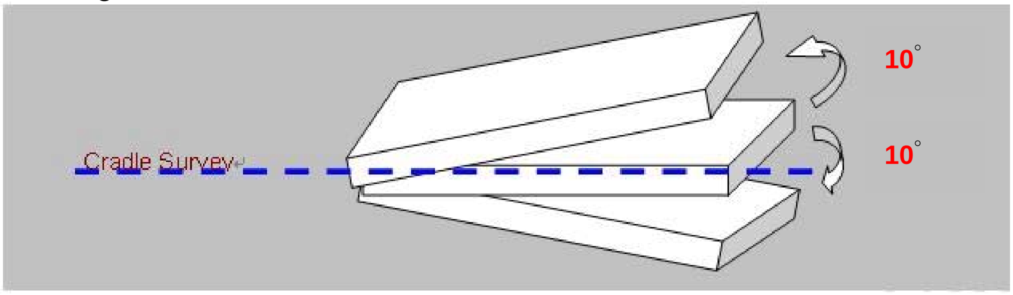



**Figure 3: Tilt Angle Tolerance of RDR-3300 Design**

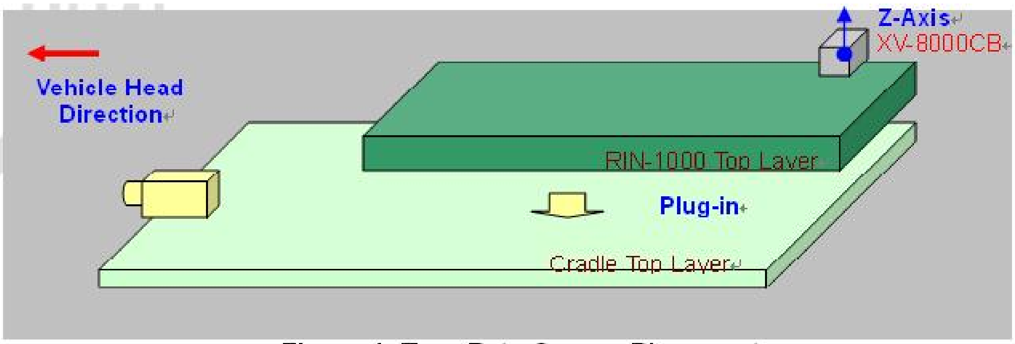
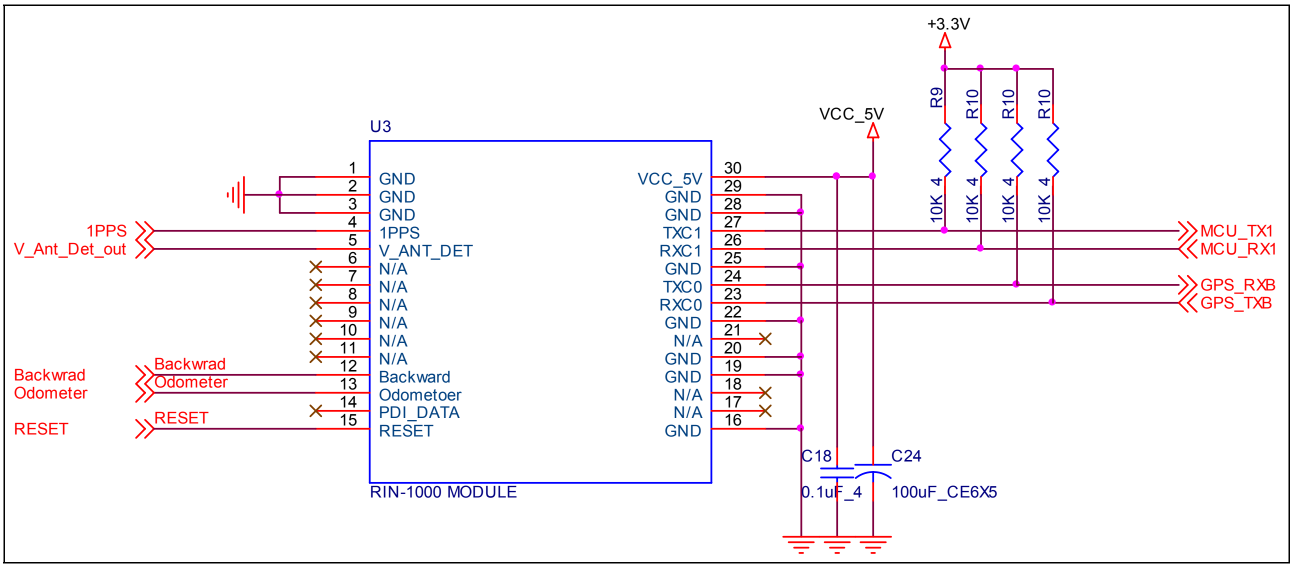



**Figure 4: Turn Rate Sensor Placement**

### 2.3.4 Suggest circuit for RIN-1000 Module




***GND***

GND provides the ground.

***1PPS***

This pin provides one pulse-per-second input from the board.

***V_Ant detector***

The Antenna detecting pin.

"Low": Have antenna function

"High": Without antenna function

***Backward***

This pin provides for connecting to backward signal.

***Odometer***

This pin provides for connecting to odometer

***PDI_DATA***

Program and Debug Interference data pin. It doesn't connect anything.

***RESET***

MCU system reset pin.

***RXC***

This is the main receiver channel and is used to receive software commands to the board for serial port C0

***TXC***

This is the main transmitting channel for serial port C0 and measurement data

***RXC1***

This is the main receiver channel and is used to receive software commands to the board for serial port C1

***TXC1***

This is the main transmitting channel for serial port C1 and measurement data

***VCC_5V (+5V DC power Input)***

This is the DC power supply input pin for MCU system. It provides voltage to module. This is pin should be adding a bypassing capacitor (100uF). It can reduce noise and increase the stability.

## 2.4 Pin Table List (RDR-3300 & RIN-1000)

### 2.4.1 RDR-3300

**[20 Pin Header, 2.0 mm pitch]**

| Pin NO | Signal Name | I/O | Description | Characteristics |
|---|---|---|---|---|
| 1 | N.C | | None connector | |
| 2 | GPS 5V | I | +5V DC Power Input | DC +5V ± 5%. |
| 3 | VBAT_3V3 | I | User Supply DC +2.6 ~ +3.6V | DC +2.6 ~ +3.6V.<br>Current ≤ 10uA w/o battery |
| 4 | GPS 5V | I | +5V DC Power Input | |
| 5 | Reset | I | Reset (Active low) | $V_{IH} > 2.3V$ $V_{IL} < 0.8V$ |
| 6 | Boot | I | Boot mode | $3.15 \ge V_{IH} \ge 1.995V$ $-0.3V \le V_{IL} \le 0.855V$ |
| 7 | Back (Reverse) | I | Forward or Back | Forward (Hi level :>2V)<br>Backward (Lo level: <0.8V) |
| 8 | N.C | | None connector | |
| 9 | Odometer | I | Odometer | Input frequency<4k HZ<br>Vih > 2V Vil<0.8V |
| 10 | GND | G | Ground | Reference Ground |
| 11 | TXD1 | O | NMEA (transmit) Car PC (UAR1)<br>4800bps, 8 data bits, no parity, 1 stop bit | $2.85V \ge V_{OH} \ge 2.375V$ $V_{OL} \le 0.715V$ |
| 12 | RXD1 | I | NMEA (Receive) Car PC (UAR1) | $3.15V \ge V_{IH} \ge 1.995V$ $-0.3V \le V_{IL} \le 0.855V$ |
| 13 | GND | G | Ground | Reference Ground |
| 14 | TXD2 | O | Can bus data (transmit) Car PC (UAR2) | Vih > VDD-0.1V Vil<0.6V<br>VDD:3.3V for MCU |
| 15 | RXD2 | I | Can bus data (Receive) Car PC (UAR2) | Vih > 2V Vil<0.8V |
| 16 | GND | G | Ground | Reference Ground |
| 17 | GND | G | Ground | |
| 18 | GND | G | Ground | Reference Ground |
| 19 | N.C | | NC | |
| 20 | N.C | | NC | |

***GPS_5V***

This is the DC power supply input pin for system. .

***GND***

GND provides the reference ground.

***BOOT***

Set this pin to high for programming flash.

***RXD1***

This is the main receiver channel and is used to receive software commands to the board from SIRFdemo software or from user written software.

***RXD2***

This is the auxiliary receiving channel communicated with car pc with can bus

***TXD1***

This is the main transmitting channel and is used to output navigation and measurement data to SiRFdemo or user written software.

***TXD2***

This is the auxiliary transmitting channel communicated with car pc with can bus

***ODOMETER***

This pin provides for connecting to odometer.

***RTC (Backup voltage)***

This is the battery backup input that powers the SRAM and RTC when main power is removed. Typical current draw is 10uA.

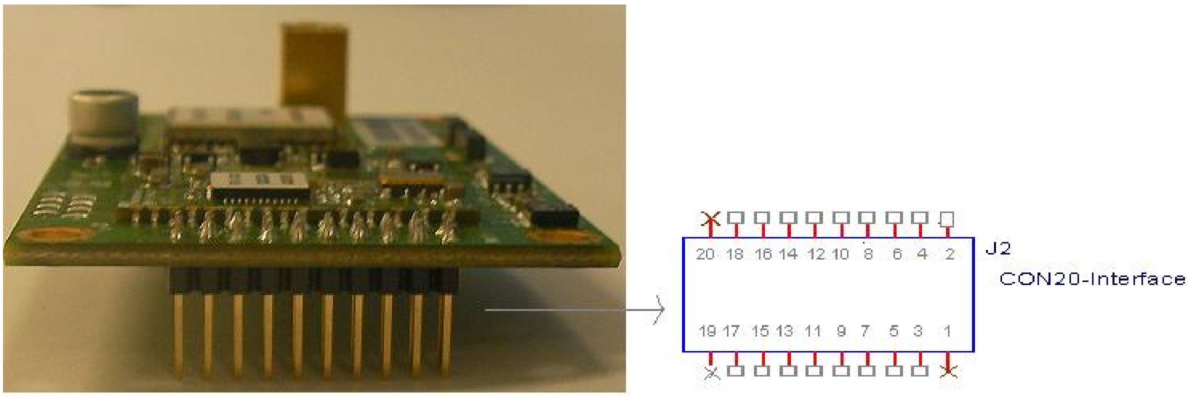
The supply voltage should be between 2.5V and 3.6V.

***BACK (Reverse)***

This pin provides for connecting to backward signal.

***Reset***

This pin provides an active-low reset input to the board. It causes the board to reset and start searching for satellites. If not utilized, it may be left open.




***RF connector type: SMA R/A PCB JACK (J1)**

***RF_IN***

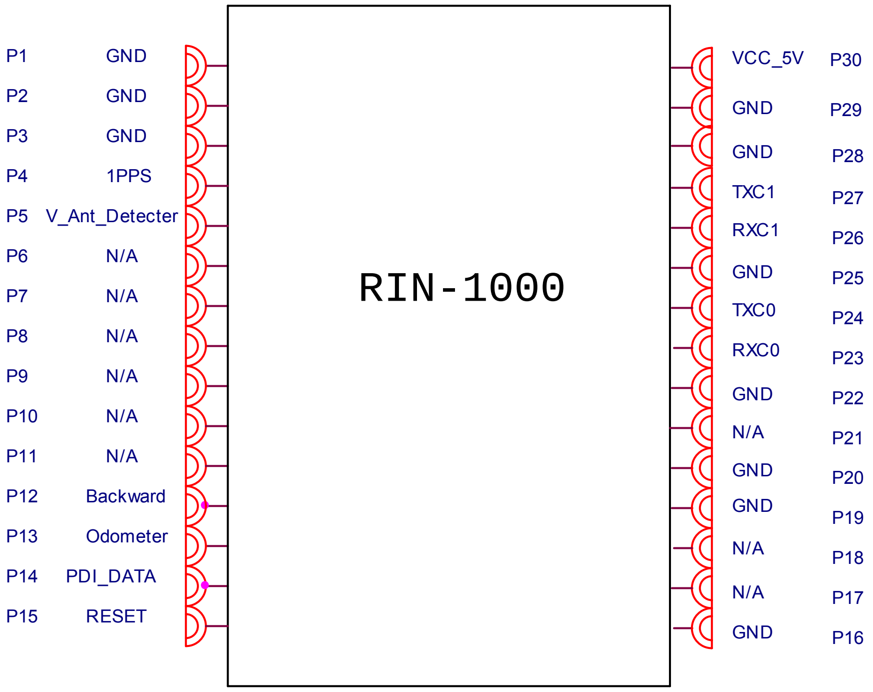
This pin receives GPS analog signal. The line on the PCB between the antenna (or antenna connector) has to be a controlled impedance line (Microstrip at 50Ω). This pin can

provide maximum power 30mA@3.3V for active antenna.

***J3, J4, J5 connector**

These connectors do not use.

## 2.4.2 RIN-1000




Top view

| Pin # | Signal Name | I/O | Description | Characteristics |
|---|---|---|---|---|
| 1 | GND | G | Ground | Reference Ground |
| 2 | GND | G | Ground | Reference Ground |
| 3 | GND | G | Ground | Reference Ground |
| 4 | 1PPS | I | One pulse per second | $3.8V \geq V_{IH} \geq 2.3V$ $0V \leq V_{IL} \leq 0.99V$ |
| 5 | V_Ant_Detector | I | Antenna Detector | $3.8V \geq V_{IH} \geq 2.3V$ $0V \leq V_{IL} \leq 0.99V$ |
| 6 | N/A | ~ | N/A | None connector |
| 7 | N/A | ~ | N/A | None connector |
| 8 | N/A | ~ | N/A | None connector |
| 9 | N/A | ~ | N/A | None connector |
| 10 | N/A | ~ | N/A | None connector |
| 11 | N/A | ~ | N/A | None connector |
| 12 | Backward | I | Backward of car device | $3.8V \geq V_{IH} \geq 2.3V$ $0V \leq V_{IL} \leq 0.99V$<br>*Forward (Hi level :>2.3V)*<br>*Backward (Lo level: <0.99V)* |
| 13 | Odometer | I | Measure the speed of car | $3.8V \geq V_{IH} \geq 2.3V$ $0V \leq V_{IL} \leq 0.99V$<br>**Input frequency<4k HZ** |
| 14 | PDI_DATA | I/O | Debug port | $3.8V \geq V_{IH} \geq 2.3V$ $0V \leq V_{IL} \leq 0.99V$<br>$V_{OH} \geq 2.6V$ $V_{OL} \leq 0.4$ |
| 15 | RESET | I | Reset | $V_{IH} > 1.48V$ $V_{IL} < 1.3V$ |
| 16 | GND | G | Ground | Reference Ground |
| 17 | N/A | ~ | N/A | None connector |
| 18 | N/A | ~ | N/A | None connector |
| 19 | GND | G | Ground | Reference Ground |
| 20 | GND | G | Ground | Reference Ground |
| 21 | N/A | ~ | N/A | None connector |
| 22 | GND | G | Ground | Reference Ground |
| 23 | RXC | I | Receive<br>Serial port C0 | $3.8V \geq V_{IH} \geq 2.3V$ $0V \leq V_{IL} \leq 0.99V$ |
| 24 | TXC | O | Transmit<br>Serial port C0 | $V_{OH} \geq 2.6V$ $V_{OL} \leq 0.4$ |
| 25 | GND | G | Ground | Reference Ground |
| 26 | RXC1 | I | Receive<br>Serial port C1 | $3.8V \geq V_{IH} \geq 2.3V$ $0V \leq V_{IL} \leq 0.99V$ |

| | | | | |
|---|---|---|---|---|
| 27 | TXC1 | O | Transmit<br>Serial port C1 | $V_{OH} \geq 2.6V$ $V_{OL} \leq 0.4$ |
| 28 | GND | G | Ground | Reference Ground |
| 29 | GND | G | Ground | Reference Ground |
| 30 | VCC | I | DC Supply Voltage<br>input | DC +5V±5% |

***GND***

GND provides the ground.

***1PPS***

This pin provides one pulse-per-second input from the board.

***V_Ant detector***

The Antenna detecting pin.

"Low": Have antenna function

"High": Without antenna function

***Backward***

The backward connect to car.

***Odometer***

This pin provides for connecting to odometer

***PDI_DATA***

Program and Debug Interference data pin. It doesn't connect anything.

***RESET***

MCU system reset pin.

***RXC***

This is the main receiver channel and is used to receive software commands to the board for serial port C0

***TXC***

This is the main transmitting channel for serial port C0 and measurement data

***RXC1***

This is the main receiver channel and is used to receive software commands to the board for serial port C1

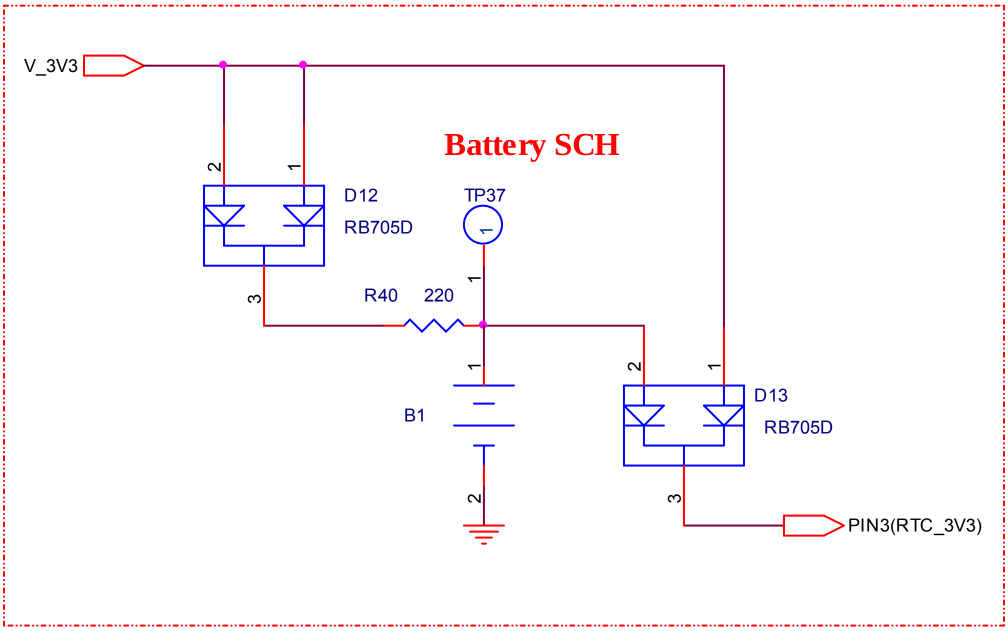
***TXC1***

This is the main transmitting channel for serial port C1 and measurement data

***VCC_5V (+5V DC power Input)***

This is the DC power supply input pin for MCU system. It provides voltage to module. This is pin should be adding a bypassing capacitor (100uF). It can reduce noise and increase the stability.

## 2.5 Backup Supply Reference Circuit

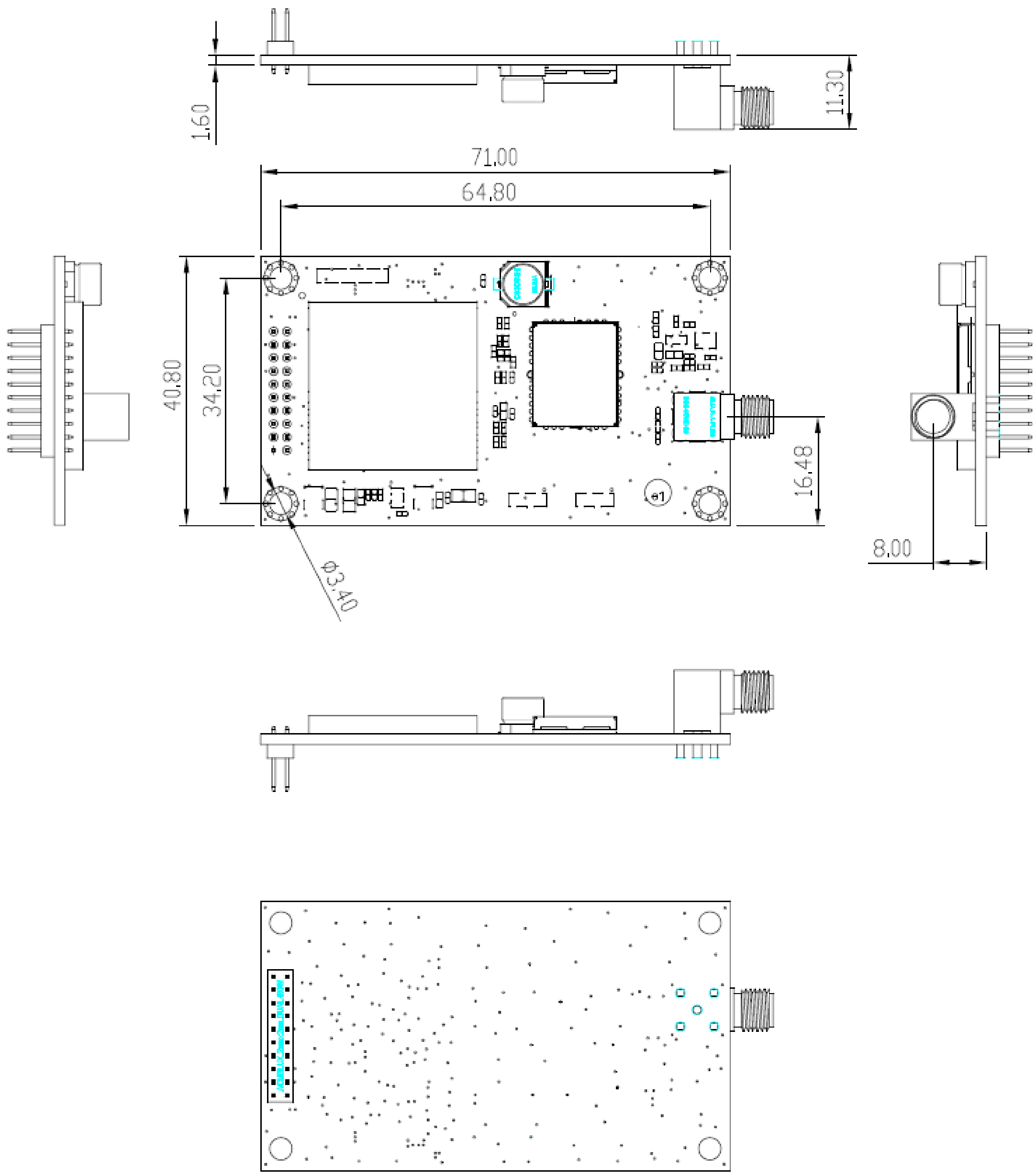



## 2.6 RF Antenna Connector

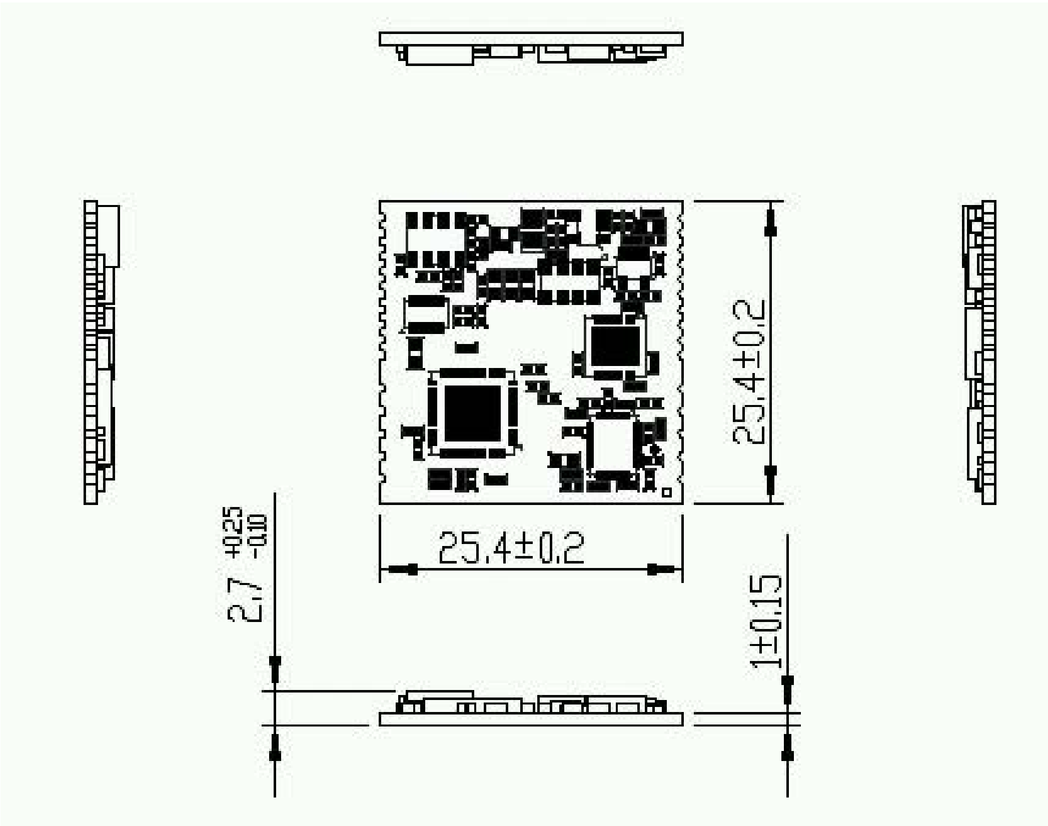
This pin receives GPS analog signal. The line on the PCB between the antenna (or antenna connector) has to be a controlled impedance line (Microstrip at 50Ω). This pin can provide maximum power 30mA @ 2.85V for active antenna.

## 2.7 Mechanical Layout

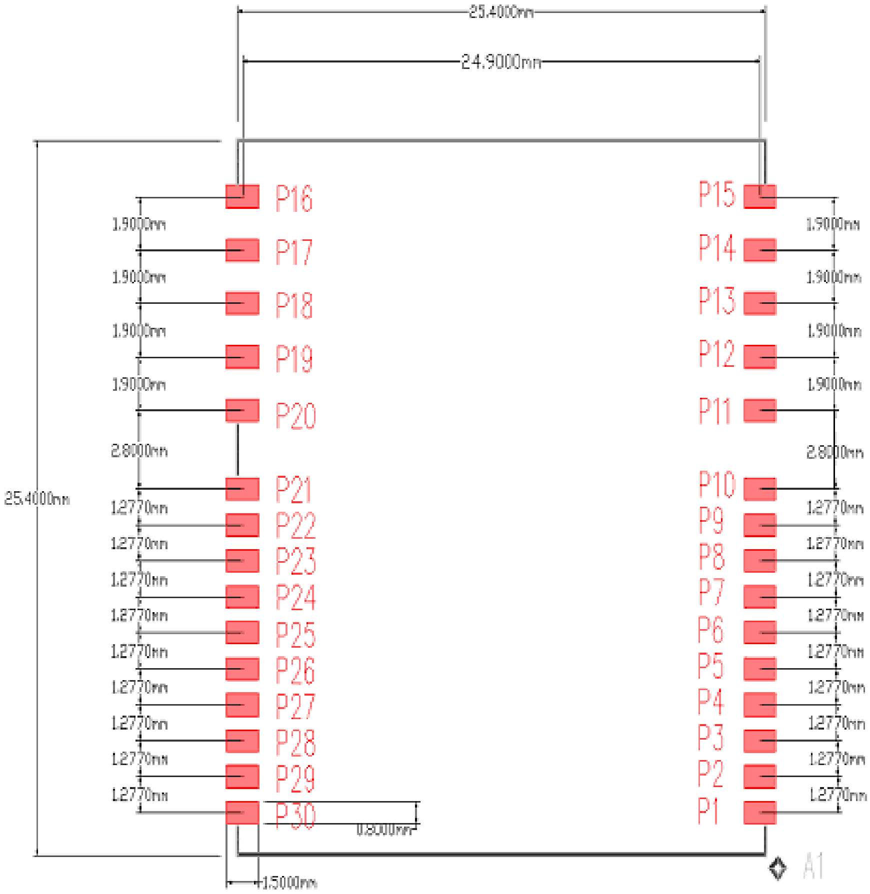
### 2.7.1 RDR-3300



### 2.7.2 RIN-1000



## 2.8 Recommend layout pad for RIN-1000 Module



# 3 Module Specification Description

This chapter is described the how to connect to RDR-3300 DR and calibration it. Otherwise, RDR-3300 is used the Enhanced Kalman Filter(EKF) to combine all the sensor signal(gyro, odometer, direction indicator), which is sampled with 40 Hz and match with GPS. This algorithm offers the best position solution from GPS and INS base system. It is also controlled by GPS quality and variances for all DR related parameters.

## 3.1 Turn Rate Angle Sensor – Gyro Scope/MEMS

This gyro sensor is captured via A/D interface by RDR-3300 MCU and sampled at 40 Hz. The integration of gyro signal over one measurement period is equal to relative turn if device during this period. Otherwise, there are two major parameters of angle sensor in EKF, includes bias and scale.

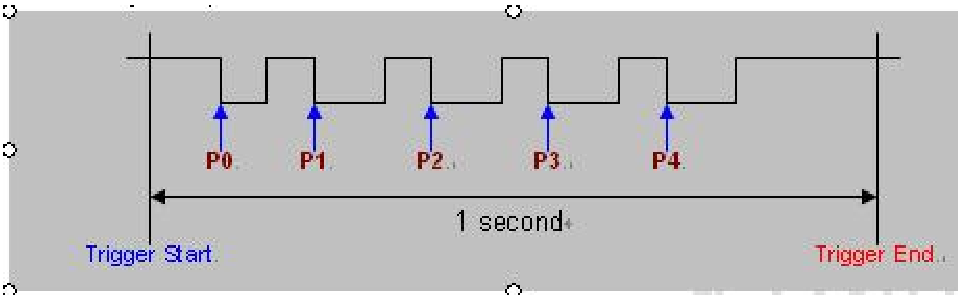
For the gyro bias parameter, it describes the offset of gyro signal at turn rate of 0 [deg/s] to +/- 60.0 [deg/s] is maximum allowed gyro bias offset. After power on reset, DR algorithm is check if DR EKF parameter is reload (no any parameters are reloaded after factory reset). If yet, gyro static calibration process is running now.

The second is gyro scale factor, it describes the relation of typical gyro sensitivity [V/(deg/s)] of real measured output voltage [V] to the actual turn rate [degree/sec]. It is varied by input gyro voltage and GPS position info.

Otherwise, the mounting angle that is located at RDR-3300 influences its performance significantly. The angle of incline should not exceed the maximal value referring to turn axis of vehicle. Consult the datasheet (refer to 2.3.3 Angle Turn Rate Sensor) of gyro carefully to choose the appropriate mounting technique as well the right parameter setting.

### 3.2 Speed & Direction Indicator from Odometer/Backward

RDR-3300 required speed pulse detector from odometer input source. It is trigged by EIC mode and integrates it into EKF input speed pulse count parameter by low pass filter.




When direction indicator signal is connected to vehicle, it can be check if vehicle is moving forward or backward. When input signal is driven to low, vehicle is moving backward. On the other hand, vehicle is moving forward.

In addition to the EKF speed parameter, there is an odometer scale factor to use the ratio between the frequency of speed pulse signal and GPS speed by input falling edge EIC trigger. After power on reset, DR algorithm is check if DR EKF parameter is reload (no any parameters are reloaded after factory reset). If yet, odometer scale factor is set to default 0.38.

### 3.3 Speed & Direction Indicator from CAN Bus

In expect to the speed pulse detector from odometer, RDR-3300 also provides the second interface to retrieve speed and direction info from CAN bus via RXD1 TTL UART port. The CAN bus controller delivery the speed and direction info message to module per second by $PSRF command.

### 3.4 Antenna Detector Function

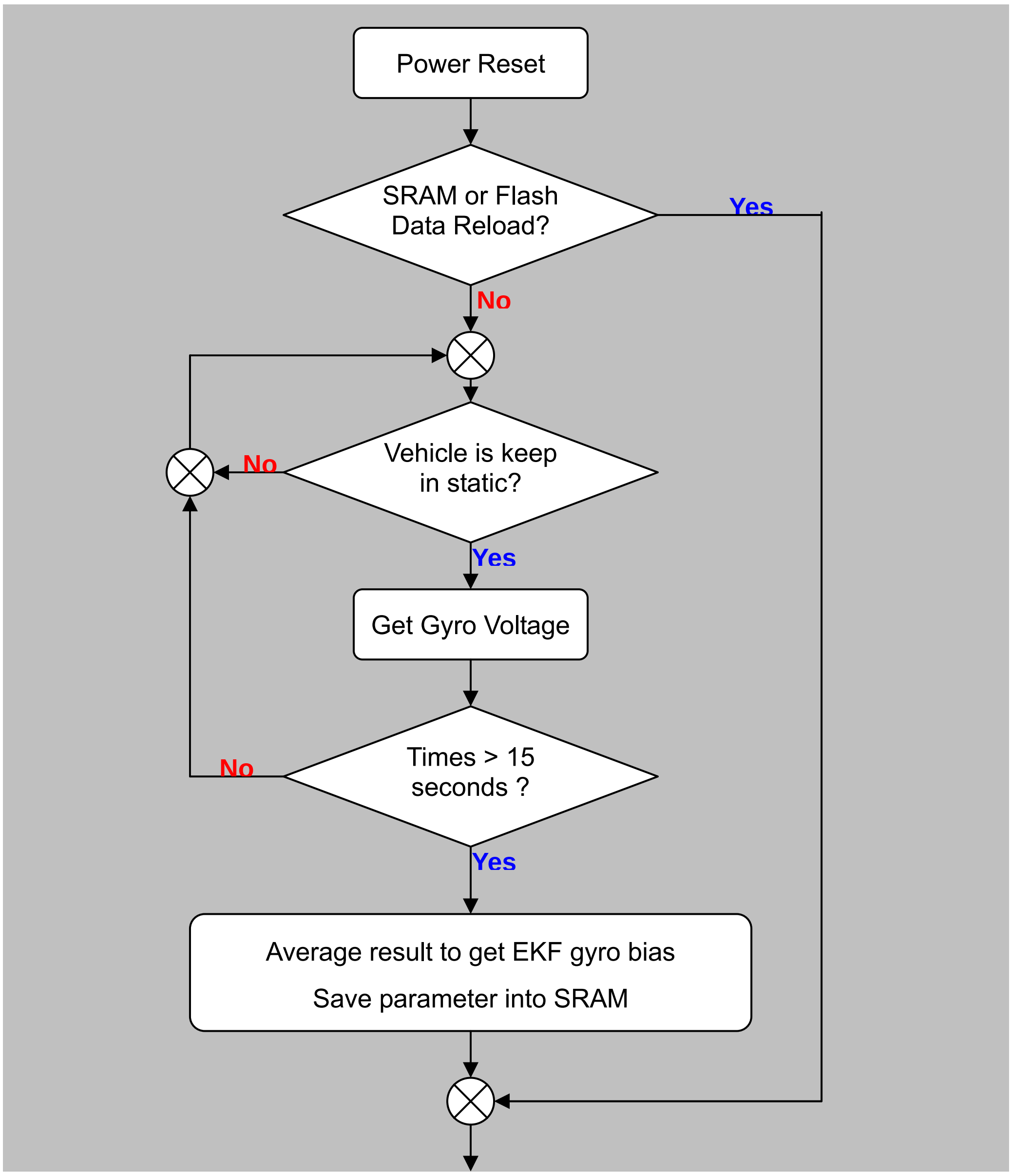
For information about antenna, RDR-3300 offers the specific function to delivery its insert/abort message over TXD0 and TXD1 (for CAN bus only)

### 3.5 DR Calibration

When a new module is installed into vehicle, the accuracy is only moderately good until sufficient calibration process is running and valid EKF parameter is collected. Base on EKF algorithm, continuous calibration results in continuous improvement of DR accuracy.

On the other hand, DR EKF is must to re-calibration when vehicle is transfer to different or factory reset is received.

All the DR calibration process is divided into phase I-static & phase II-dynamic calibration action. The phase I static calibration is only used to retrieve gyro bias and is shown as below.



After static calibration process is completed, DR is working and set odometer initial scale into default value (0.38).

In the phase II, for optimum navigation performance the system needs some learning time and distance for calibrating the various sensors inputs. The following driving directions are recommended to achieve and efficient calibration so DR yields high accuracy after the shortest possible period of time.

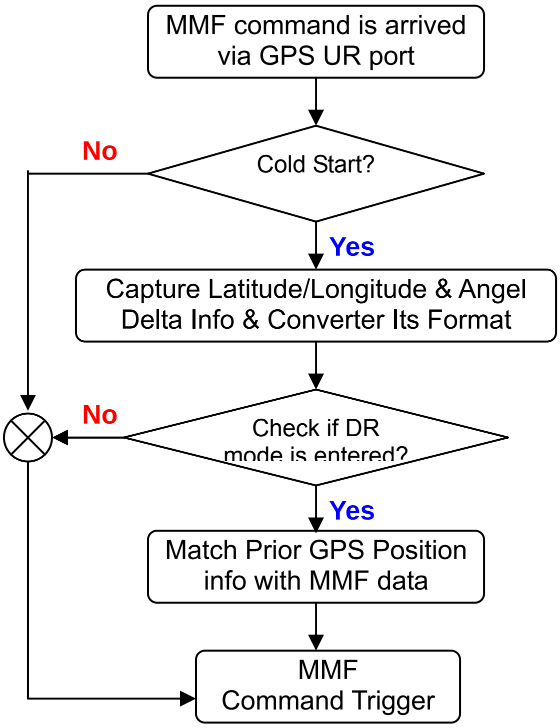
### 3.6 EKF Parameter Saving

For EKF parameter saving, all data is dynamic updated and option to store into flash every 5 seconds and BBRAM per second, allowing continued DR when vehicle has been parked and shut down at an obstructed site. At startup, the previously stored position/heading will retrieved in order to continue accurate DR navigation in the right direction until sufficient number of satellite is visible again to calculate an absolute position fix. The stored parameter is shown as below,

- Latitude/Longitude/Heading
- Gyro Bias & Scale
- Odometer Scale

### 3.7 Map Match (MMF) Command Handle Flow Chart

MMF command is offered the second source to calibrate DR position by MAP and it is trigged per second. It is only valid when DR mode is activated. Because DR position is changed immediately after command delivery so that navigator needs to keep the time synchronizes between device and command generator.



### 3.8 Map Match (MMF) Command Format

This MMF command is used to let the navigation program send the map matching information to the DR module to update the current position and azimuth angle of device using known information..

$MMF, Delta_Latitude,A,Delta_Longitude,A,Delta_ Cog,A*ck<CR><LF>

| Item | Field | Length | Description |
|---|---|---|---|
| 1 | $ | 1 | Beginning of sentence |
| 2 | MMF | 5 | Message Header |
| 3 | Delta Latitude (ddddddd) | 7 | The correction of latitude value to calibrate DR position that generated by map. Value the unit is 1.0e-6 degree |
| 4 | A | 1 | A: use above value to calibrate the DR Latitude<br>V: Do not use. |
| 5 | Delta Longitude (dddddddd) | 8 | The correction of longitude value to calibrate DR position that generated by map. Value the unit is 1.0e-6 degree |
| 6 | A | 1 | A: use above value to calibrate the DR Longitude<br>V: Do not use. |
| 7 | Del_Cog | 4 | The correction angle (COG) of current movement to calibrate DR Heading that generated by map. Value the unit is 0.1 degree. |
| 8 | A | 1 | A: use above value to calibrate the DR Longitude<br>V: Do not use. |
| 9 | *CC<CR><LF> | 5 | Check Sum and sentence termination delimiter. The algorithm of checksum calculation is same with the one to calculate NMEA checksum. |

Example:

=> Current DR position is (24.106928 N, 120.299588 E) with COG=213.19 degree

=> $MMF,156,A,288,A,10,A*2D

(Latitude Offset = 156 * 1.0e-6, unit = degree)

(Longitude Offset = 288 * 1.0e-6, unit = degree)

(Angle Offset = 10 * 0.1, unit = degree)

(A: Valid, V: Invalid)

=> MMF DR position to (24.117084 N, 120.299876 E) with COG = 214.19 degree.

# 4 GPS Output DR Protocol

This chapter is provided detail description about user RTOEM protocol. This user define sentence offers DR system operation info, like EKF calibration flag, odometer count/scale and delta angle info.

### RTOEM3 Sentence Format

| Item | Field | Description |
|---|---|---|
| 1 | $ | Beginning of sentence |
| 2 | RTOEM | Message Header |
| 3 | 3 | Message ID |
| 4 | GPS validated | Number of SV in use > 3 = 1, other is 0 |
| 5 | Gyro Calibrate Status | 1.Gyro already calibrated<br>0: Gyro not calibrated |
| 6 | Odometer Calibrate Status | 1: Odometer already calibrated<br>0: Odometer not calibrated |
| 7 | Gyro Input Status | 1: Gyro Input available / 0: Gyro Input not available |
| 8 | Odometer Input Status | 1: Odometer Input available<br>0: Odometer Input not available |
| 9-1 | MCU Read Count | The count of data read count from MCU |
| 9-2 | Odometer Input Source | 1: CAN BUS<br>0: Vehicle's Odometer Source Input |
| 9-3 | DR position status | 4: Initial Status<br>3: GPS Fix<br>2: DR Mode |
| 9-4 | Direction | 1: Backward<br>0: Forward |
| 9-5 | Antenna Status | 1: Available<br>0: Abort |
| 10 | Gyro Voltage | Current Gyro Input Voltage. The unit scale = 0.002 |
| 11 | Odometer scale factor | The scale factor of odometer pulse. The scale is cm/pulse |
| 12 | Delta angle | Vehicle's Cog per second (unit = degree) |
| 13 | Pulse count | The pulse count of last second of odometer sensor. |

| | | |
|---|---|---|
| | | The unit is pulse / second. |
| 14 | Delta distance | The delta distance of last second. (Unit = m / s) |
| 15 | Map Matching Status | 1: Received and executed a map matching sentence;<br>0: Not receive any map matching sentence. |
| 16 | *CC<CR><LF> | Check Sum and sentence termination delimiter. The algorithm of checksum calculation is same with the one to calculate NMEA checksum. |

**Example:**

$RTOEM,3,1(X1),1(X2),1(X3),1(X4),1(X5),1(X6)0(X7)3(X8)0(X9)1(X10),831.95(X11),29.78(X12),27.45(X13),77(X14),22.93(X15),0(X16) *50

X1: GPS is validated.

X2: Gyro bias is initialized

X3: Odometer scale is initialized

X4: Gyro input source is available

X5: Odometer input source is available

X6: 1 time for capture sensor per

X7: Odometer source is used

X8: GPS mode is used

X9: No backward is captured

X10: Antenna is available

X11: Gyro voltage is 831.95 / 500 = 1.6639 (V)

X12: EKF odometer scale parameter is 29.78 (cm/pulse)

X13: Delta angel for Device is turn right 27.45 (degree)

X14: Odometer capture pulse count is 77

X15: Delta Distance for Device is 22.93 (meter)

X16: No MMF command is accepted

# 5 NMEA Output Message Format

The DSC Logger GPS receiver will output the standard NMEA V3.0 protocol GPS message The output protocol settings are: Baud rate 38400,n,8,1. There are 4 type sentence will output as the follow table:

Table 6-1 NMEA-0183 Output Messages

| NMEA Record | Description |
|---|---|
| GGA | Global positioning system fixed data |
| GSA | GNSS DOP and active satellites |
| GSV | GNSS satellites in view |
| RMC | Recommended minimum specific GNSS data |

## GGA-Global Positioning System Fixed Data

Table 6-2 contains the values of the following example:
$GPGGA,161229.487,3723.2475,N,12158.3416,W,1,07,1.0,9.0,M, , , ,000 0*18<CR><LF>

Table 6-2 GGA Data Format

| Name | Example | Units | Description |
|---|---|---|---|
| Message ID | $GPGGA | | GGA protocol header |
| UTC Position | 161229.487 | | hhmmss.sss |
| Latitude | 3723.2475 | | ddmm.mmmm |
| N/S Indicator | N | | N=north or S=south |
| Longitude | 12158.3416 | | Dddmm.mmmm |
| E/W Indicator | W | | E=east or W=west |
| Position Fix Indicator | 1 | | See Table 5-3 |
| Satellites Used | 07 | | Range 0 to 12 |
| HDOP | 1.0 | | Horizontal Dilution of Precision |
| MSL Altitude | 9.0 | meters | |
| Units | M | meters | |
| Geoid Separation | | meters | |
| Units | M | meters | |
| Age of Diff. Corr. | | second | Null fields when DGPS is not used |
| Diff. Ref. Station ID | 0000 | | |
| Checksum | *18 | | |
| ＜CR＞＜LF＞ | | | End of message termination |

Table 6-3 Position Fix Indicators

| Value | Description |
|---|---|
| 0 | Fix not available or invalid |
| 1 | GPS SPS Mode, fix valid |
| 2 | Differential GPS, SPS Mode, fix valid |
| 3-5 | Not Supported GPS PPS Mode, fix valid |

| | |
|---|---|
| 6 | Dead Reckoning Mode, fix valid |

## GSA-GNSS DOP and Active Satellites

Table 6-4 contains the values of the following example:
$GPGSA,A,3,07,02,26,27,09,04,15, , , , , ,1.8,1.0,1.5*33<CR><LF>

Table 6-4 GSA Data Format

| Name | Example | Units | Description |
|---|---|---|---|
| Message ID | $GPGSA | | GSA protocol header |
| Mode 1 | A | | See Table 5-5 |
| Mode 2 | 3 | | See Table 5-6 |
| Satellite Used | 07 | | Sv on Channel 1 |
| Satellite Used | 02 | | Sv on Channel 2 |
| …. | | | …. |
| Satellite Used | | | Sv on Channel 12 |
| PDOP | 1.8 | | Position Dilution of Precision |
| HDOP | 1.0 | | Horizontal Dilution of Precision |
| VDOP | 1.5 | | Vertical Dilution of Precision |
| Checksum | *33 | | |
| ＜CR＞＜LF＞ | | | End of message termination |

Table 6-5 Mode 1

| Value | Description |
|---|---|
| 1 | Fix not available |
| 2 | 2D |
| 3 | 3D |

Table 6-6 Mode 2

| Value | Description |
|---|---|
| M | Manual-forced to operate in 2D or 3D mode |
| A | Automatic-allowed to automatically switch 2D/3D |

### GSV-GNSS Satellites in View

Table 6-7 contains the values of the following example:
$GPGSV,2,1,07,07,79,048,42,02,51,062,43,26,36,256,42,27,27,138,42*71<CR><LF>
$GPGSV,2,2,07,09,23,313,42,04,19,159,41,15,12,041,42*41<CR><LF>

Table 6-7 GSV Data Format

| Name | Example | Units | Description |
|---|---|---|---|
| Message ID | $GPGSV | | GSV protocol header |
| Number of Messages[1] | 2 | | Range 1 to 3 |
| Messages Number[1] | 1 | | Range 1 to 3 |
| Satellites in View | 07 | | |
| Satellite ID | 07 | | Channel 1(Range 1 to 32) |
| Elevation | 79 | degrees | Channel 1(Maximum 90) |
| Azimuth | 048 | degrees | Channel 1(True, Range 0 to 359) |
| SNR (C/No) | 42 | dBHz | Range 0 to 99, null when not tracking |
| …. | | | …. |
| Satellite ID | 27 | | Channel 4(Range 1 to 32) |
| Elevation | 27 | degrees | Channel 4(Maximum 90) |
| Azimuth | 138 | degrees | Channel 4(True, Range 0 to 359) |
| SNR (C/No) | 42 | dBHz | Range 0 to 99, null when not tracking |
| Checksum | *71 | | |
| ＜CR＞＜LF＞ | | | End of message termination |

[1]Depending on the number of satellites tracked multiple messages of GSV data may be required.

## RMC-Recommended Minimum Specific GNSS Data

**Table 6-8 contains the values of the following example:**

$GPRMC,161229.487,A,3723.2475,
N,12158.3416,W,0.13,309.62,120598,,,A*10<CR><LF>

Table 6-8 RMC Data Format

| **Name** | **Example** | **Units** | **Description** |
|---|---|---|---|
| Message ID | $GPRMC | | RMC protocol header |
| UTC Position | 161229.487 | | hhmmss.sss |
| Status | A | | A=data valid or V=data not valid |
| Latitude | 3723.2475 | | ddmm.mmmm |
| N/S Indicator | N | | N=north or S=south |
| Longitude | 12158.3416 | | dddmm.mmmm |
| E/W Indicator | W | | E=east or W=west |
| Speed Over Ground | 0.13 | knots | |
| Course Over Ground | 309.62 | degrees | True |
| Date | 120598 | | Ddmmyy |
| Magnetic Variation | | degrees | |
| Variation sense | | | E=east or W=west(Not Shown) |
| Mode | A | | A=Autonomous, D=DGPS, E=DR |
| Checksum | *10 | | |