RDR-3100
User Manual

Version 1.5

2008/04/29

Prepared by
RoyalTek Company LTD.

4F, No. 188, Wen Hwa 2nd Rd.,
Kuei-Shan, Tao-Yuan 333, Taiwan
TEL: 886-3-3960001
FAX: 886-3-3960065

Content

1. Introduction

RoyalTek RDR-3100 is the newest generation of RoyalTek GPS module integrated Dead Reckoning technology. The RDR-3100 includes dead reckoning sensors to track your vehicle's course when your GPS signal is blocked for example in urban areas or tunnels. If you lose GPS coverage in areas with tall buildings or tunnels, the RDR-3100 keeps on navigating.

This document describes the recommended schematic and layout design of gyro and odometer circuit, and is designed to operate with RDR-3100 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. 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 sensitivity for urban canyon and foliage environments.

- 2.1 Product Applications

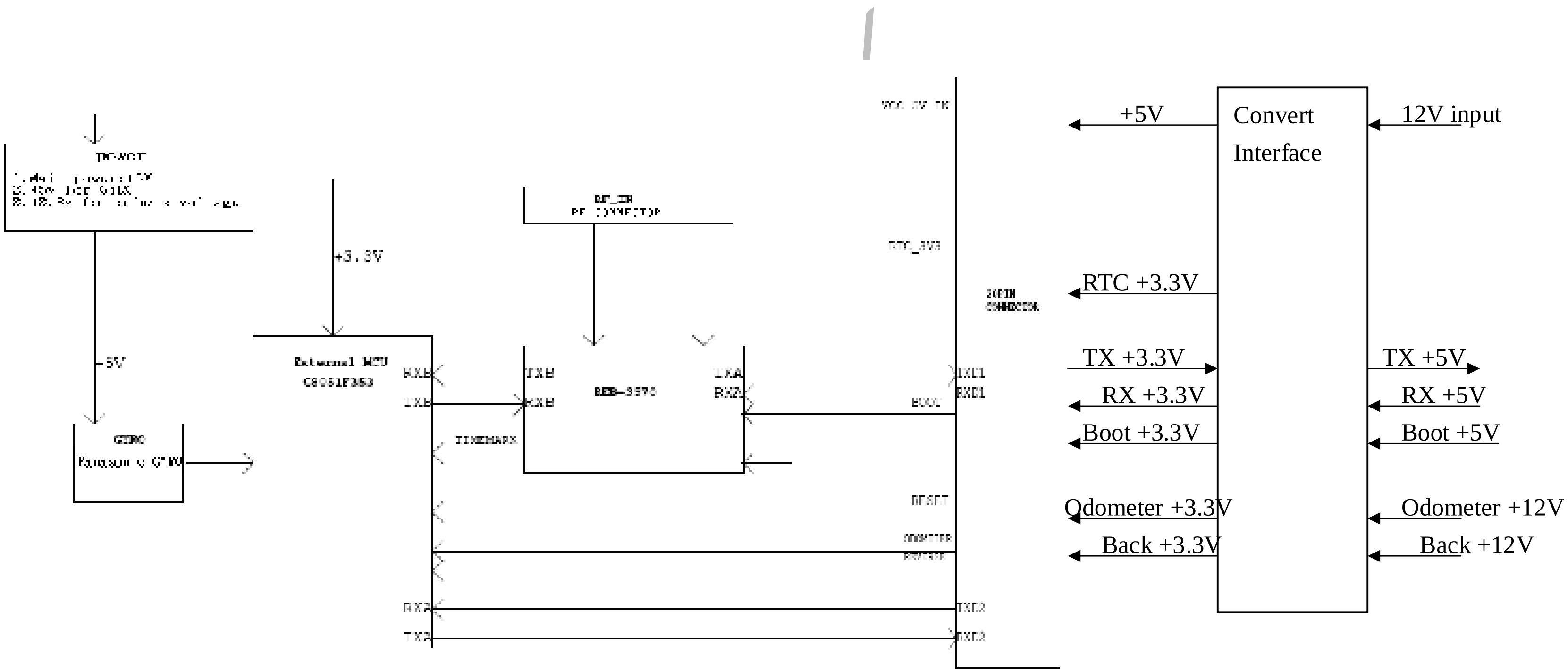
- Automotive navigation

3. Specification

GPS Module	- REB-3570 /LP
GPS Chipset	- Star III GPS Gsc3f/LP chipset
Frequency	- L1 1,575.42 MHz
Channel	- 20 channels
C/A Code	- 1,023 MHz
chipset Fix time (Open sky)	- Reacquisition: less than 0.1s - Hot start: 1 sec - Warm start: 35 sec - Cold start: 35 sec
Accuracy	- Position: within 10m for 90% - Velocity: 0.1m/s
Interface Protocol	- NMEA 0183 ver 3.0, GGA, GSA, GSV (5), RMC - SiRF Protocol + DR protocol + Map Matching Protocol - 4800 bps, 8 data bits, no parity, 1 stop bits
DGPS	- Default is Disable
WAAS	- Default WAAS is Disable
Dynamics	
Altitude	- 18,000 meter maximum
Velocity	- 514 meter/second maximum
MCU	- Silicon Lab C8051F353
Antenna	
Active Antenna RF Connector	- MCX (Male Head), 180 degree 8mm (standard) - Option for any kind of RF Connector
External Antenna input Voltage	- Recommend using 2.7V~3.3V
Power	
Voltage Type	- DC +5V ± 1%
Screw Hole type	
Antenna Detect function	
	GPIO; Follow customer GPS antenna detector protocol Port 2 baud Rate: 38400bps 1: YES / 0:NO
Interface	
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 18.6mm±0.3mm (H)
Weight	- ≦17(g)
Temperature	- Operating : -40 ~ 85℃ - Storage : -40 ~ 85℃

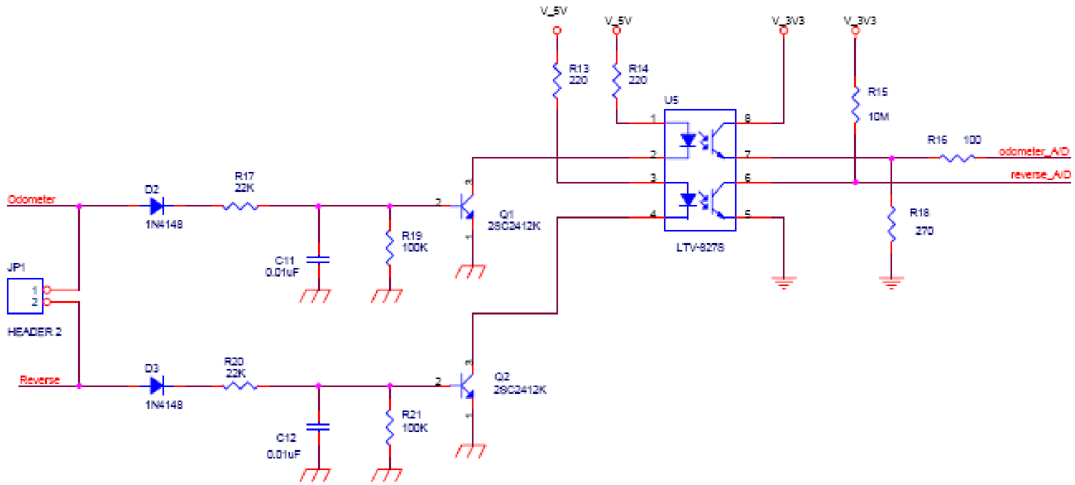
4. Reference design of Gyro and Odometer circuit design

4.1 System Block Diagram



4.2 Application Circuit

Figure 1 illustrates the proposed schematic diagram of Gyro, odometer and RDR-3100. RDR-3100 supports the Gyro, Panasonic EWT S84/86. Please care about the ground partition design among Gyro circuit, RDR-3100 and odometer input. It would be better to use 2 kinds of ground. The input of odometer is around 12V typically. It transfers the voltage level to accommodate the I/O voltage level of RDR-3100. The photo coupling transistors also isolate the noise of car from the RDR-3100 system.
The power of the gyro is 5Vwhich is different from the power of RDR-3100. Please use a separate analog ground for gyro. And please keep high speed signal away from the signal path of gyro and power when doing layout.


V_5V
V_5V
V_3V3
V_3V3
R13
220
R14
220
U5
R15
10M
R16
100
odometer_A/D
reverse_A/D
LTV-8278
R18
270
Odometer
D2
1N4148
R17
22K
C11
0.01uF
R19
100K
Q1
2SC2412K
JP1
HEADER 2
Reverse
D3
1N4148
R20
22K
C12
0.01uF
R21
100K
Q2
2SC2412K

5. HW Interface

5.1 Connector Type：20 Pin Header，2.0 mm pitch (J2)

Pin NO	Signal Name	I/O	Description	Characteristics
1	N.C		None connector	
2	GPS 5V	I	+5V DC Power Input	DC +5V ± 1%.
3	RTC (Backup voltage)	I	User Supply DC +2.6 ~ +3.6V	DC +2.6 ~ +3.6V. 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	$3.15 \geq V_{IH} \geq 1.995V$ $-0.3V \leq V_{IL} \leq 0.855V$
7	Back (Reverse line)	I	Forward or Back	Forward (Hi level :>2V) Backward (Lo level: <0.8V)
8	N.C		None connector	
9	Odometer	I	Odometer	Input frequency<4k HZ Vih > 2V Vil<0.8V
10	GND	G	Ground	Reference Ground
11	TXD1 (SiRF 3 TXD1)	O	NMEA (transmit) Car PC (UAR1) 4800bps, 8 data bits, no parity, 1 stop bit	$2.85V \geq V_{OH} \geq 2.375V$ $V_{OL} \leq 0.715V$
12	RXD1 (SiRF 3 RXD1)	I	NMEA (Receive) Car PC (UAR1)	$3.15V \geq V_{IH} \geq 1.995V$ $-0.3V \leq V_{IL} \leq 0.855V$
13	GND	G	Ground	Reference Ground
14	TXD2 (SiRF 3 TXD2)	O	Can bus data (transmit) Car PC (UAR2)	Vih > VDD-0.1V Vil<0.6V VDD:3.3V for MCU
15	RXD2 (SiRF 3 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 (Backward)**
  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.

5.2 RF connector type: MCX STRAIGHT PCB JACK (J1)

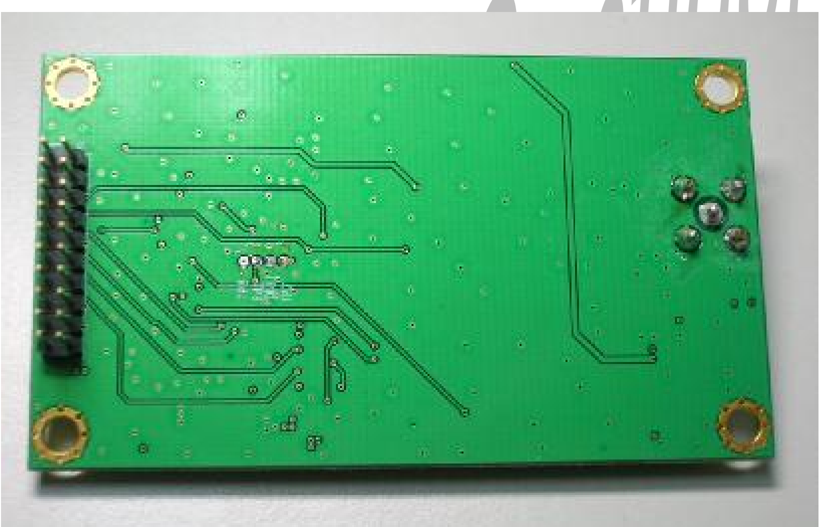
RF IN:

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 @ 2.85V for active antenna.

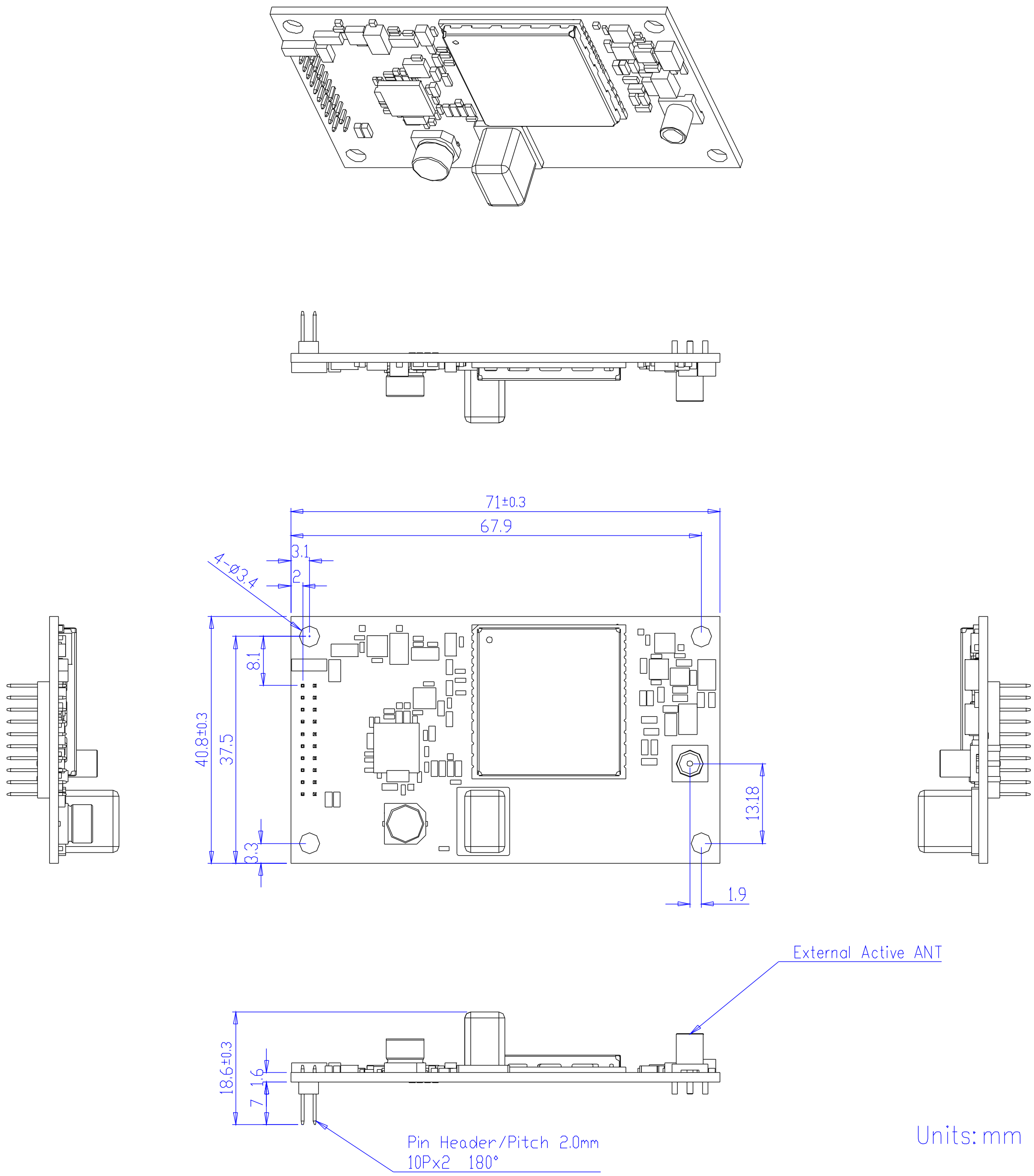
6. Product Picture

TOP:

Bottom:



7. Mechanical Layout



8. SW Protocol

8.1 GPS output Protocol

The communication settings:

Baud rate: 38400, n, 8, 1

The UARTA will output GPS NMEA 0183 V3.0 protocol and RoyalTek DR protocol. There are 4 type sentence will output as the follow table:

Table 1-1 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

The RoyalTek DR protocols are NMEA like protocol to show the DR navigation and calibration information.

8.1.1 RoyalTek DR protocol – RTOEM,3

This sentence contains the navigation and calibration information of DR.
The protocol is illustrated as follows:

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 /0: Gyro not calibrated
6	Odometer Calibrate Status	1: Odometer already calibrated /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 0: Odometer Input not available
9	MCU Read Count	The count of data read count from MCU
10	Odometer Input Source	1: CAN BUS / 0: Vehicle’s Odometer PWM
11	DR position status	4: Initial Status /3: GPS Fix /2:DR Mode
12	Backward Status	1: Activated / 0: Normal
13	Antenna Detecting	1: Available / 0: Abort

14	Gyro Offset	The voltage of Gyro input. The unit is 0.002v
15	Odometer scale factor	The scale factor of odometer pulse. The scale is cm/pulse
16	Delta angle	Vehicle's Cog per second (unit = degree)
17	Pulse count	The pulse count of last second of odometer sensor. The unit is pulse / second.
18	Delta distance	The delta distance of last second. (Unit = m / s)
19	Map Matching Status	1: Received and executed a map matching sentence; 0: Not receive any map matching sentence.
20	*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, 1, 1, 1, 1, 10301, 831.95, 29.78, 27.45, 77, 22.93, 0 *50

GPS is validated.

Gyro calibrate / Odometer calibrate / Gyro input is available /Odometer input is available

MCU Count = 1 / ODO-PWM input /GPS fix /No backward/Antenna is available

Gyro bias is 831.95 * 0.002 = 1.6639 V

Odometer scale = 29.78 pulse/second

Heading Rate = 27.45 degree

Pulse count of odometer = 77 pulses.

Delta distance = 22.93 m/s.

Received no any map matching command

Check sum = 0x 50.

8.1.2 GGA-Global Positioning System Fixed Data

Table 1-3 contains the values of the following example:

$GPGGA,161229.487,3723.2475,N,12158.3416,W,1,07,1.0,9.0,M, , , ,0000*18

Table 1-1 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 1-4
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 1-2 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

8.1.3 GSA-GNSS DOP and Active Satellites

Table 1-5 contains the values of the following example:

$GPGSA,A,3,07,02,26,27,09,04,15, , , , , ,1.8,1.0,1.5*33

Table 1-1 GSA Data Format

Name	Example	Units	Description
Message ID	$GPGSA		GSA protocol header
Mode 1	A		See Table 1-6
Mode 2	3		See Table 1-7
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 1-2 Mode 1

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

Table 1-3 Mode 2

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

8.1.4 GSV-GNSS Satellites in View

Table 1-8 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
$GPGSV,2,2,07,09,23,313,42,04,19,159,41,15,12,041,42*41

Table 1-8 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.

8.1.5 RMC-Recommended Minimum Specific GNSS Data

Table 1-9 contains the values of the following example:
$GPRMC,161229.487,A,3723.2475, N,12158.3416,W,0.13,309.62,120598,,,A*10

Table 1-1 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		

GPS DR (UART A) Input command

The input command is used to let the navigation program send command to DR.

8.2.1 $MMF

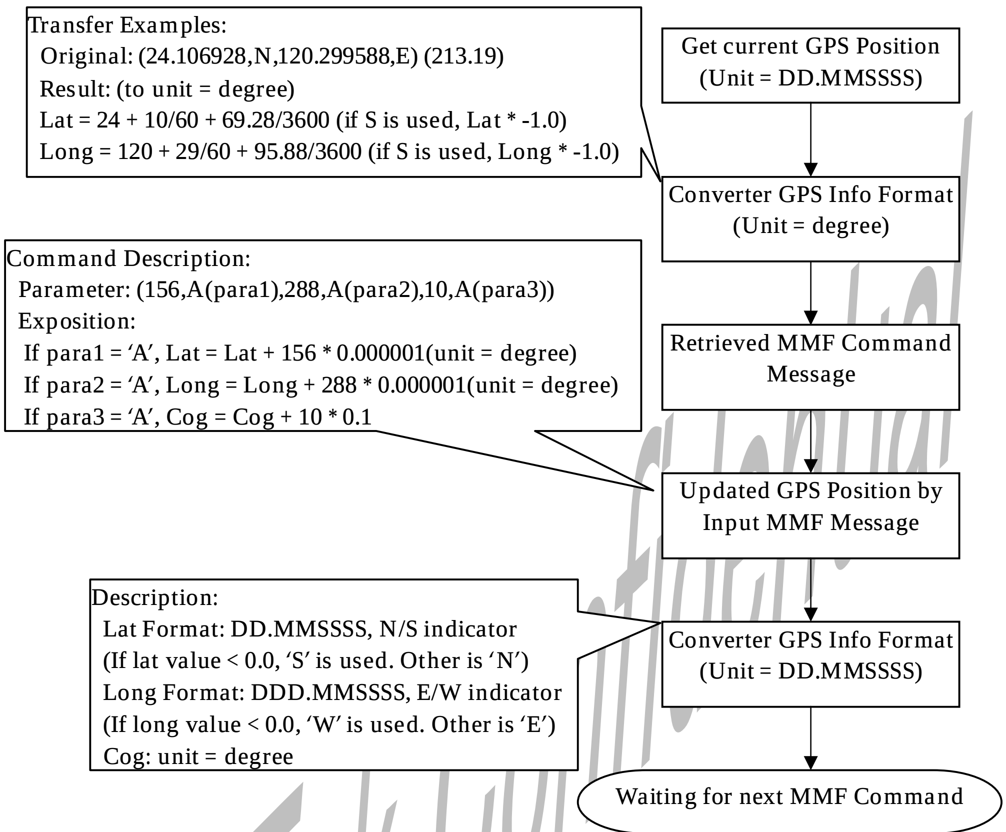
This MMF command is used to let the navigation program send the map matching information to the DR module to update the current position and azimuth angle of device using known information. Please refer to section 2.2 Calibration of DR using digital map information for further information.

$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 (dmmmmmm)	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 V: Do not use.
5	Delta Longitude (dmmmmmm)	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 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 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:

Example:
=> If current DR position is (24.106928 N, 120.299588 E) with COG=213.19 degree
=> $MMF,156,A,288,A,10,A*2D
=> It will set the DR position to (24.178370 N, 120.499603 E) with COG = 214.19 degree.


Transfer Examples:
Original: (24.106928,N,120.299588,E) (213.19)
Result: (to unit = degree)
Lat = 24 + 10/60 + 69.28/3600 (if S is used, Lat * -1.0)
Long = 120 + 29/60 + 95.88/3600 (if S is used, Long * -1.0)
Get current GPS Position (Unit = DD.MMSSSS)
Converter GPS Info Format (Unit = degree)
Command Description:
Parameter: (156,A(para1),288,A(para2),10,A(para3))
Exposition:
If para1 = ‘A’, Lat = Lat + 156 * 0.000001(unit = degree)
If para2 = ‘A’, Long = Long + 288 * 0.000001(unit = degree)
If para3 = ‘A’, Cog = Cog + 10 * 0.1
Retrieved MMF Command Message
Updated GPS Position by Input MMF Message
Description:
Lat Format: DD.MMSSSS, N/S indicator
(If lat value < 0.0, ‘S’ is used. Other is ‘N’)
Long Format: DDD.MMSSSS, E/W indicator
(If long value < 0.0, ‘W’ is used. Other is ‘E’)
Cog: unit = degree
Converter GPS Info Format (Unit = DD.MMSSSS)
Waiting for next MMF Command

8.3 CAN bus (UART B) protocol

The RDR-3100 provides a second port to receive the speed and reverse message from the input source. If the module receives the following input message then the DR module will stop reading the speed and reverse message from MCU.
The communication settings:

Baud rate: 38400, n, 8, 1
Update rate: 1 Hz

8.3.1 Speed, Reverse status input Message

This sentence contains the speed and reverse information that read from CAN bus. The protocol is illustrated as the following:

Item	Field	Description
1	$	Beginning of the sentence
2	PSRF121	Message Header
3	Speed	
4	Reverse	High-normal / Low - activated
5	*CC<CR><LF>	

Example:

Example:
$PSRF121, 100, 1*25
Speed = 100 * scaled meter/second
Reverse isn't activated
Checksum = 25

8.3.2 GPS antenna detection output Message

This sentence contains the GPS antenna detector information which read from GPS module and send to the CAN bus.

The protocol is illustrated as follows:

Item	Field	Description
1	$	Beginning of sentence
2	PSRF122	Message Header
3	GPS antenna status	1: antenna connected 0: antenna not connected
4	*CC<CR><LF>	Check Sum and sentence termination delimiter. The algorithm of checksum calculation is same With the one to calculate NMEA checksum.

Example:

$PSRF 122,1*3B<CR><LF>

GPS antenna connected

Check sum= 0x3B.

8.4 NMEA Output Message

9 Calibration of DR

9.1 Self calibration of DR

RDR-3100 calibrates the Gyro bias and odometer scale using the information of GPS satellites automatically. It also updates the position and azimuth using GPS navigation information automatically. Customer is not required to calibrate the Gyro bias and odometer scale factor. In respect to the position and azimuth angle, RDR-3100 DR provides a protocol, which is used to calibrate the position and azimuth angle using digital map.

9.2 Calibration Criterion

•Keep vehicle in static with 15 seconds at least after power on to retrieve gyro initial bias
•During normal operation, the calibration of gyro and odometer scale take place automatically during periods of good GPS reception.

9.3 Calibration of DR using digital map information

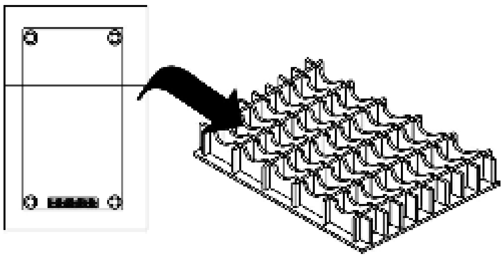
The DR is used to output the navigation data when GPS signal is absent or poor. The longer time of losing GPS signal, the Gyro precision and odometer would become worse. The best way to have better DR performance is to use the digital map information. Once the map matching completed, it could provide useful information for DR algorithm to continuously output the accurate navigation information as possible. The PROYRESET is designed for this purpose. Navigation application can reset the DR position and COG especially when no or poor GPS signal occurs. Because digital map provides very accurate and stable positioning information, to get longer and more accurate DR output, please use PROYRESET to achieve it.

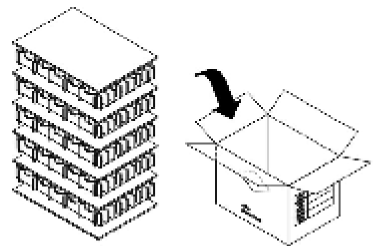
9.4 Gyro Electric Characteristics

Gyro Chipset	- Panasonic EWTS86
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	- 0.3~4.7V
Output noise	- ＜10mVpp

10. Package Specification and Order Information





11. Contact Royaltek

Contact: sales@royaltek.com

Headquarter:

4F, No. 188, Wen Hwa 2nd Rd., Kuei Shan, Tao Yuan 333, Taiwan
TEL: 886-3-3960001
FAX: 886-3-3960065

Web Site: http://www.royaltek.com

Web Site Customer Service: http://www.royaltek.com/contact

12. Revision History

Revision Number	Date	Author	Change notice
0.1	2007/03/16	May Chen	Initial Release
1.0	2007/03/21	May Chen	V1.0 Release
1.1	2007/11/22	May Chen	V1.1 Release (running change sirf LP chipset)
1.2	2008/02/01	May Chen	V1.2 Release (company address, Active antenna spec)
1.3	2008/02/15	May Chen	Change RTOEM3 Parameter, Map Match Command Format. CAN bus protocol, GPS DR Input command Voltage Type
1.4	2008/02/29	May Chen	Add flow chart for 8.2.1
1.5	2008/04/29	May Chen	Change Company address and add calibration criterion