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Xizhi Dist., New Taipei City 22101, Taiwan
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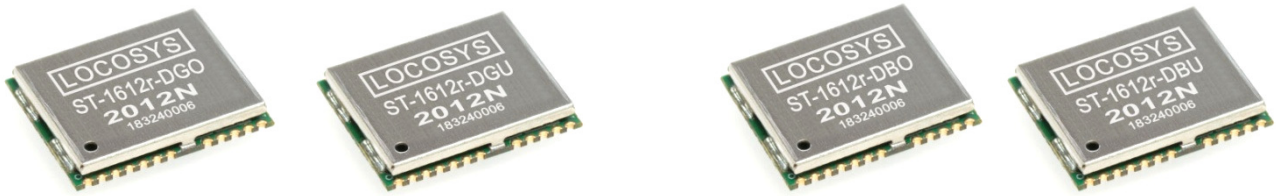
Product name	Description	Version
ST-1612r-DGx	Multi-constellation GNSS UDR/ADR module (GPS, GLONASS, GALILEO, QZSS)	0.4
ST-1612r-DBx	Multi-constellation GNSS UDR/ADR module (GPS, BEIDOU, GALILEO, QZSS)	



1 Introduction

LOCOSYS ST-1612r-DGx/ST-1612r-DBx dead reckoning (DR) modules are the perfect solution for automotive application. They not only support GPS, GLONASS, BEIDOU, GALILEO and QZSS, but also have inertial sensors (3-axis accelerometers and 3-axis gyros) to provide dead reckoning. They will detect if there is an odometer connection or vehicle speed input, and then automatically operate in ADR or UDR mode. Both raw data of the inertial sensors and vehicle's altitude including pitch, roll and heading angles are outputted for the driver behavior analysis. For example, the internet connected vehicles can automatically send emergency calls (i.e. E-Call) for help based on the vehicle's altitude. No requirement of installation orientation and automatic calibration function make them easy to use. With these features, ST-1612r-DGx/ST-1612r-DBx can reduce position errors in multipath environment and continue to work where GNSS signals are poor or not available, such as tunnels and indoor parking lots, as well as deliver seamless car navigation.

2 Features

- AEC-Q100 qualified GNSS chip
- Support GPS, GLONASS, BEIDOU, GALILEO and QZSS
- Capable of SBAS (WAAS, EGNOS, MSAS)
- Fast TTFF at low signal level
- Built-in MEMS sensor (3-axis gyroscope and 3-axis accelerometer)
- Support MEMS raw data output (up to 100Hz)
- No requirement for installation orientation
- Auto detect and operate in ADR or UDR mode
- Support odometer (wheel-tick pulse) and forward/reverse signal input
- Support vehicle speed input from UART port

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- Support vehicle speed input from CAN Bus (ISO 15765-4)
- Support AGPS autonomous solution
- LOCOSYS IATF 16949 quality control
- Small form factor 16 x 12.2 x 2.3 mm
- SMD type, RoHS compliant

3 Application

- Automotive Navigation.
- Marine Navigation.
- M2M.
- Track patrol and examine car.

4 System Block Diagram

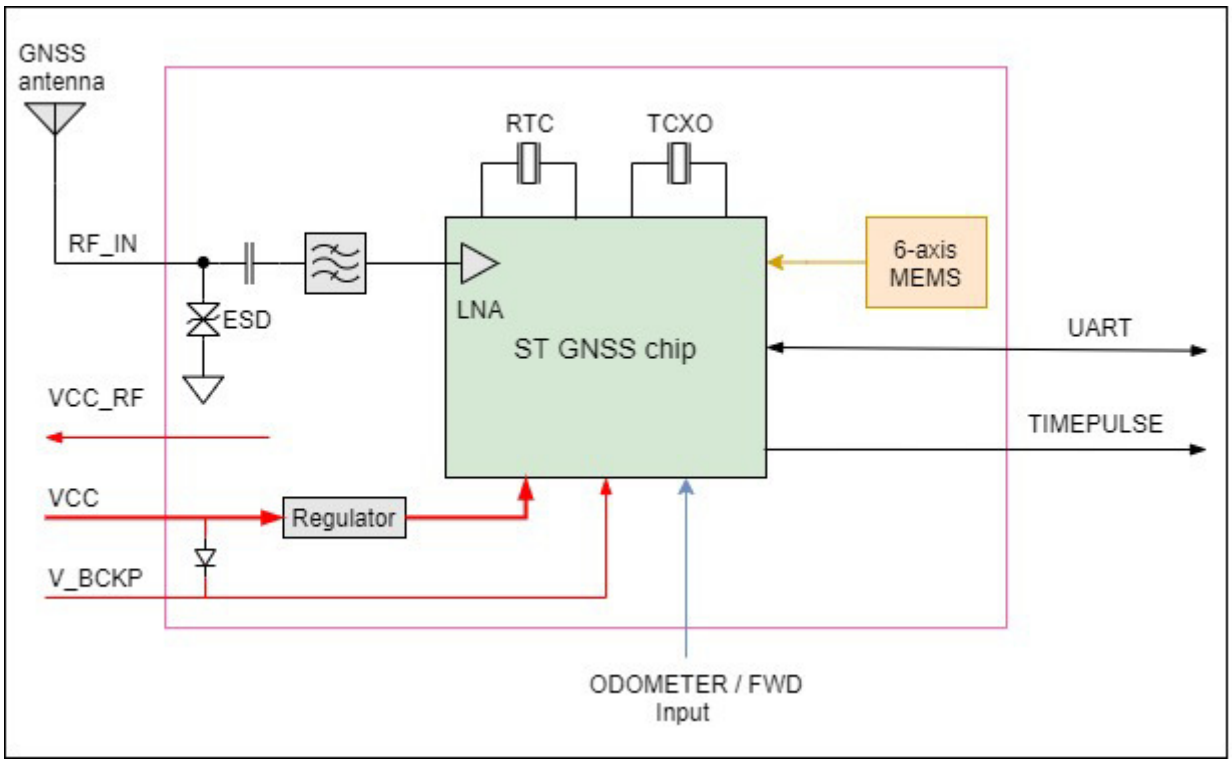

Fig 4-1 System block diagram.

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5 GNSS receiver

Chip	Teseo III Series	
Frequency	GPS: L1C/A (1575.42MHz) GLONASS L1OF (1598.0625MHz ~ 1605.375MHz) BEIDOU: B1 (1561.098MHz) GALILEO: E1B/C (1575.42MHz) QZSS: L1C/A (1575.42MHz)	
Channels	Support 48 channels	
Update rate	1Hz default	
Sensitivity	Tracking	Up to -163dBm (with external LNA)
	Cold start	Up to -147dBm (with external LNA)
Acquisition Time	Cold Start (Open Sky)	30s (typical)
	Hot Start (Open Sky)	1s (typical)
Position Accuracy	Autonomous	1.8m CEP
	SBAS	1.5m CEP (depends on accuracy of correction data)
	ADR Mode	0.5% of distance travelled without GNSS
	UDR Mode	CEP ≤ 10% of distance travelled without GNSS (1)
Max. Altitude	< 50,000 m	
Max. Velocity	< 515 m/s	
Protocol Support	NMEA 0183 ver. 3.01	115200 bps (2), 8 data bits, no parity, 1 stop bits (default) 1Hz: GGA, GLL, GSA, GSV, RMC, VTG, ZDA, $PSTMDR1, $PSTMDR2, $PSTMDRCAL, $PSTMDRGPS, $STMDRPVA, $PSTMDRPVASD, $PSTMDRSENMSG, $PSTMDRSINT

Note (1): Test condition: after calibration, drive at 30 m/s for 60 seconds without GNSS signals.

Note (2): Both baud rate and output message rate are configurable to be factory default.

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6 Pin assignment and descriptions

Table 6-1 Pin descriptions

Pin #	Name	Type	Description	Note
1	BOOTSEL		Boot mode selection. High: firmware update. Leave unconnected for normal operation.	
2	NC		Not connected	
3	TIMEPULSE	O	Time pulse output (1PPS, default 500ms pulse/sec). Do not input high-level voltage when the module powers on. For example, connecting a pull-up resistor will make the module fail to work.	
4	ODOMETER	I	Odometer wheel-tick pulse input. The pulse frequency must be less than 5000 Hz. The distance between 2 ticks must not exceed 0.4m. Leave unconnected if not used.	1
5	RSV		Reserved pin. Leave unconnected.	
6	RSV		Reserved pin. Leave unconnected.	
7	NC		Not connected	
8	NC		Not connected	
9	VCC_RF	O	Output voltage for active antenna	2
10	GND	P	Ground	
11	RF_IN	I	GNSS RF signal input	

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12	GND	P	Ground	
13	GND	P	Ground	
14	RESERV		Reserved pin. Leave unconnected.	
15	FWD	I	Forward/reverse signal input. Low: forward; High: reverse. Leave unconnected if not used.	1
16	NC		Not connected	
17	NC		Not connected	
18	CANTX	O	CAN bus transmit data output	
19	CANRX	I	CAN bus receive data input	
20	TXD	O	UART, asynchronous output (Default NMEA)	
21	RXD	I	UART, asynchronous input	
22	V_BCKP	I	Backup battery input. It is recommended to connect a backup supply voltage to V_BCKP in order to enable warm and hot start features. If no backup power is available, connect V_BCKP to the main power supply (VCC).	
23	VCC	I	DC supply input	
24	GND	P	Ground	

Note (1): The user has to add level-shift circuits and ESD protection for the application if needed.

Note (2): VCC_RF does not have short circuit protection.

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7 DC & Temperature characteristics

7.1 Absolute maximum ratings

Parameter	Symbol	Ratings	Units
Input Voltage	VCCabs.	3.6	V
Input Backup Battery Voltage	V_BCKPabs.	4.3	V
Operating Temperature Range	Topr_abs.	-40 ~ 85	℃
Storage Temperature Range	Tstg_abs.	-40 ~ 85	℃

7.2 DC Electrical characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Input Voltage	VCC		3.0	3.3	3.6	V
Input Backup Battery Voltage	V_BCKP		1.6		4.3	V
VCC_RF Output Voltage	VCC_RF			VCC		V
Supply Current	Iss	VCC = 3.3V, w/o active antenna, Peak Max Acquisition Tracking		 71 68(2)	284(1) 124 	 mA mA mA mA
Backup Battery Current	Ibat	VCC = 0V		37		uA
VCC_RF Output Current	I_{out}	VIN = 3.3V			25	mA
High Level Input Voltage	V_{IH}		2.0		3.6	V
Low Level Input Voltage	V_{IL}		-0.3		0.8	V
High Level Output Voltage	V_{OH}		2.6			V
Low Level Output Voltage	V_{OL}				0.4	V

Note (1): Measured with 2MHz sampling rate. The power consumption of the module focuses on the current consumption of long-term use i.e. the tracking current in the specification, and the transient current consumption, which is the minimum design requirement for power supply to the module. It can ensure that the VCC power supply is sufficient without causing abnormal operation of the module.

Note (2): Measured when position fix (1Hz) is available and input voltage is 3.3V with UART interface.

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7.3 Temperature characteristics

Parameter	Symbol	Min.	Typ.	Max.	Units
Operating Temperature	Topr	-40	-	85	℃
Storage Temperature	Tstg	-40	25	85	℃

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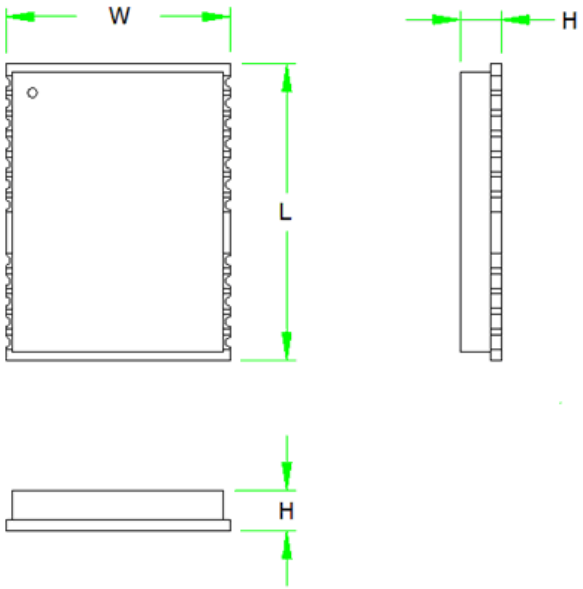
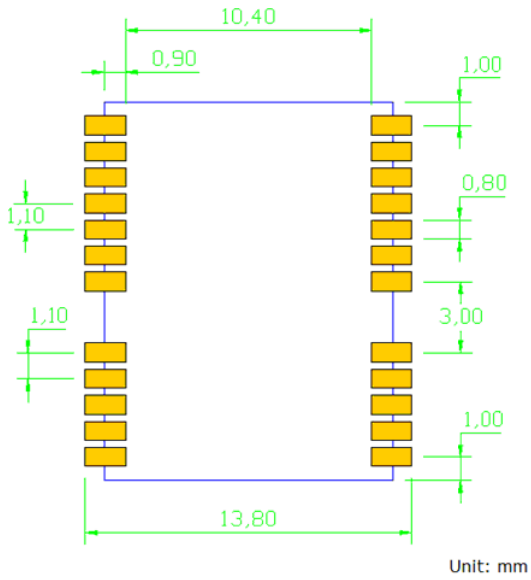
8 Mechanical specification

8.1 Outline dimensions



Symbol	Min. (mm)	Typ. (mm)	Max. (mm)
W	12.1	12.2	12.3
L	15.7	16.0	16.4
H	2.1	2.3	2.5

8.2 Recommended land pattern dimensions



Note: The recommended land pattern dimensions are shown for reference only, as actual layout may vary depending on application.

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8.3 Installation and calibration

The module must be rigidly fixed on the vehicle before power-on. No requirement for installation orientation. Do not move the module after power-on. The module is only suitable for vehicle navigation with acceleration less than 4g.

In order to get the better fused navigation, the initialization and calibration steps are suggested in the following.

1. Power on the module and wait GNSS position fix in the open sky environment.
2. Stay still for about 1 minute or more.
3. Drive in the straight road at the speed above 30km/h for more than 5 minutes in the open sky environment.
4. Accelerate and decelerate linearly more than 5 times in the open sky environment.
5. Complete 2 or more 90-degree turns in the open sky environment.
6. The system ready flag in the message “$PSTMDR2” shows if the fused PVT is ready.

If the module is moved after rigidly fixing on the vehicle, it can automatically start initialization and calibration. If the user wants to force the module to do calibration again, please issue the software commands as below.

1. Send the command “$PSTMGPSSUSPEND<CR><LF>” to the module to suspend GNSS engine.
2. Wait for at least 50ms.
3. Send the command “$PSTMNVMITEMINV,80,1<CR><LF>” to the module.
4. Wait for at least 50ms.
5. Send the command “$PSTMNVMITEMINV,81,1<CR><LF>” to the module.
6. Wait for at least 50ms.
7. Send the command “$PSTMSRR<CR><LF>” to the module to reset GNSS system.
8. The module will restart the initialization and calibration.

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9 Software interface

9.1 NMEA output message

Table 9.1-1 NMEA output message

NMEA record	Description
GGA	Global positioning system fixed data
GLL	Geographic position - latitude/longitude
GSA	GNSS DOP and active satellites
GSV	GNSS satellites in view
RMC	Recommended minimum specific GNSS data
VTG	Course over ground and ground speed
ZDA	UTC, day, month and year.

- **GGA--- Global Positioning System Fixed Data**

Table 9.1-2 contains the values for the following example:

$GNGGA,013654.000,2503.71447,N,12138.74593,E,1,16,0.7,130.00,M,15.3,M,,*72

Table 9.1- 2 GGA Data Format

Name	Example	Units	Description
Message ID	$GNGGA		GGA protocol header
UTC Time	013654.000		hhmmss.sss
Latitude	2503.71447		ddmm.mmmmm
N/S indicator	N		Latitude Direction: North or South
Longitude	12138.74593		dddmm.mmmmm
E/W Indicator	E		Longitude Direction: East or West
Position Fix Indicator	1		See Table 8.1-3
Satellites Used	16		Satellites in use
HDOP	0.7		Horizontal Dilution of Precision,max:99.0
MSL Altitude	130.00	meters	Height above mean sea level
Units	M	meters	Reference Unit for Altitude (“M” = meters)
Geoidal Separation	15.3	meters	Geoidal Separation measure in “M” = meters
Units	M	meters	Reference Unit for Geoidal Separation (“M” = meters)
DGPS Age			Not supported
DGPS Reference			Not supported
Checksum	*72		
<CR> <LF>			End of message termination

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Table 9.1-3 Position Fix Indicators

Value	Description
0	Fix not available or invalid
1	GNSS fix valid
2	Differential GNSS fix valid
3-5	Not supported
6	Estimated (Dead Reckoning) Mode

• GLL--- Geographic Position – Latitude/Longitude

Table 9.1-4 contains the values for the following example:

$GNGLL,2503.71447,N,12138.74593,E,013654.000,A,A*42

Table 9.1-4 GLL Data Format

Name	Example	Units	Description
Message ID	$GNGLL		GLL protocol header
Latitude	2503.71447		ddmm.mmmmm
N/S indicator	N		Latitude Direction: North or South
Longitude	12138.74593		dddmm.mmmmm
E/W indicator	E		Longitude Direction: East or West
UTC Time	013654.000		hhmmss.sss
Status	A		Validity of Data; A=data valid or V=data invalid
Mode	A		A = Autonomous mode, D = Differential mode, E = Estimated (Dead Reckoning) Mode, N=Data invalid,
Checksum	*42		
<CR> <LF>			End of message termination

• GSA---GNSS DOP and Active Satellites

Table 9.1-5 contains the values for the following example:

$GNGSA,A,3,05,24,15,21,10,18,13,12,20,32,,,1.1,0.7,0.9*2C

$GNGSA,A,3,70,69,84,85,68,,,,,,,1.1,0.7,0.9*25

$GNGSA,A,3,193,,,,,,,,,,,1.1,0.7,0.9*19

$GNGSA,A,3,,,,,,,,,,,,,1.1,0.7,0.9*22

$GNGSA,A,3,,,,,,,,,,,,,1.1,0.7,0.9*22

Table 9.1-5 GSA Data Format

Name	Example	Units	Description
Message ID	$GNGSA		GSA protocol header
Mode 1	A		See Table 9.1-6

Mode 2	3		See Table 9.1-7
ID of satellite used	05		Sv on Channel 1
ID of satellite used	24		Sv on Channel 2
….			….
ID of satellite used			Sv on Channel 12
PDOP	1.1		Position Dilution of Precision,max:99.0
HDOP	0.7		Horizontal Dilution of Precision, max:99.0
VDOP	0.9		Vertical Dilution of Precision, max:99.0
Checksum	*2C		
<CR> <LF>			End of message termination

Table 9.1-6 Mode 1

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

Table 9.1-7 Mode 2

Value	Description
1	No Fix available
2	2D
3	3D

● GSV---GNSS Satellites in View

Table 9.1-8 contains the values for the following example:

$GNGSV,6,1,24,03,71,305,46,05,51,197,,11,08,327,45,15,18,289,*68

$GNGSV,6,2,24,16,35,215,45,18,68,103,,19,32,133,,25,23,012,*6B

$GNGSV,6,3,24,30,25,179,45,31,30,139,46,32,34,290,,74,17,006,44*68

$GNGSV,6,4,24,65,41,320,45,76,41,320,45,76,38,265,,75,45,311,*6A

$GNGSV,6,5,24,69,41,320,,70,24,142,,86,09,193,,80,41,320,*6F

$GNGSV,6,6,24,70,08,144,,85,11,142,44,71,56,108,44,72,47,004,43*6C

Table 9.1-8 GSV Data Format

Name	Example	Units	Description
Message ID	$GNGSV		GSV protocol header
Total number of messages[1]	6		Range 1 to 8
Message number[1]	1		Range 1 to 8
Satellites in view	24		Total Number of Satellites in view
Satellite ID	03		Channel 1 (Range 01 to 330)

Elevation	71	degrees	Channel 1 (Range 00 to 90)
Azimuth	305	degrees	Channel 1 (Range 000 to 359)
SNR (C/No)	46	dB-Hz	Channel 1 (Range 00 to 99, null when not tracking)
…..			…..
Satellite ID	15		Channel 4 (Range 01 to 330)
Elevation	18	degrees	Channel 4 (Range 00 to 90)
Azimuth	289	degrees	Channel 4 (Range 000 to 359)
SNR (C/No)		dB-Hz	Channel 4 (Range 00 to 99, null when not tracking)
Checksum	*68		
<CR> <LF>			End of message termination

Note (1): Depending on the number of satellites tracked multiple messages of GSV data may be required.

Note (2): GPS ID: 01~32, SBAS ID: 33~51, QZSS ID: 183~197, GLONASS ID: 65~92, GALILEO ID: 301~330

- **RMC---Recommended Minimum Specific GNSS Data**

Table 9.1-9 contains the values for the following example:

$GNRMC,015924.000,A,2503.71417,N,12138.74623,E,0.1,0.0,230217,,,D*77

Table 9.1-9 RMC Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GNRMC		RMC protocol header
UTC Time	015924.000		hhmmss.sss
Status	A		A=data valid or V=data invalid
Latitude	2503.71417		ddmm.mmmmm
N/S Indicator	N		Latitude Direction: North or South
Longitude	12138.74623		dddmm.mmmmm
E/W Indicator	E		Longitude Direction: East or West
Speed over ground	0.1	knots	Speed over ground in knots
Course over ground	0.0	degrees	Course made good,max
Date	230217		ddmmyy
Magnetic variation		degrees	
Variation sense			Magnetic Variation Direction: East or West
Mode	D		A = Autonomous mode, D = Differential mode, E = Estimated (Dead Reckoning) mode, N=Data invalid
Checksum	*77		
<CR> <LF>			End of message termination

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- **VTG---Course Over Ground and Ground Speed**

Table 9.1-10 contains the values for the following example:

$GNVTG,0.0,T,,M,0.1,N,0.1,K,D*16

Table 9.1-10 VTG Data Format

Name	Example	Units	Description
Message ID	$GNVTG		VTG protocol header
Course over ground	0.0	degrees	Reference to “true” earth poles
Reference	T		Indicates “terrestrial”
Course over ground		degrees	Reference to “magnetic” earth poles
Reference	M		Indicates “Magnetic”
Speed over ground	0.1	knots	Speed over ground in knots
Units	N		Indicates “Knots”
Speed over ground	0.1	km/h	Speed over ground in kilometers per hour
Units	K		Indicates “Kilometers per hour”
Mode	D		A = Autonomous mode, D = Differential mode, E = Estimated (Dead Reckoning)mode
Checksum	*16		
<CR> <LF>			End of message termination

- **ZDA---UTC, day, month and year.**

Table 9.1-11 contains the values for the following example:

$GNZDA,020849.00,23,02,2017,00,00*78

Table 9.1-11 ZDA Data Format

Name	Example	Units	Description
Message ID	$GNZDA		ZDA protocol header
Timestamp	020849.00		hhmmss.ss
Day	23		Decimal, 2 digits Day of month (01 to 31)
Month	02		Decimal, 2 digits Month (01 to 12)
Year	2017		Decimal, 4 digits Year (1994 - …)
Local zone hour	00	hour	Local time zone offset from UTC (set to 00)
Local zone minutes	00	minute	Local time zone offset from UTC (set to 00)
Checksum	*78		
<CR> <LF>			End of message termination

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9.2 Proprietary NMEA input message

Table 9.2-1 proprietary input message

Software command	Command descriptions
$PSTMCOLD<CR><LF>	Perform a Cold start
$PSTMWARM<CR><LF>	Perform a Warm start
$PSTMHOT<CR><LF>	Perform a Hot start
$PSTMDRSENMSG,1	Input odometer count
$PSTMDRSENMSG,2	Input forward/reverse status
$PSTMDRSENMSG,14	Input vehicle speed

- **$PSTMCOLD---Perform a COLD start**

$PSTMCOLD,<Mask><CR><LF>

Table 9.2-2 $PSTMCOLD Data format

Parameter	Format	Description
Mask	Integer	Optional parameter to invalidate time, position, ephemeris and almanac: 0x1-clear almanac 0x2-clear ephemeris 0x4-clear position 0x8-clear time

Note: If Mask parameter is not used, default is 0xE (clear ephemeris, time and position).

Example:

$PSTMCOLD,6<CR><LF>

- **$PSTMWARM---Perform a WARM start**

Example:

$PSTMWARM<CR><LF>

- **$PSTMHOT---Perform a HOT start**

Example:

$PSTMHOT<CR><LF>

- **$ PSTMDRSENMSG,1---Input odometer count**

$PSTMDRSENMSG,1,0,<odometer><CR><LF>

The maximum input value of <odometer> is 99999. When the accumulated odometer count is bigger than 99999, it must be re-accumulated from 0. The recommended frequency of sending this message to the module is 5 times per second.

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Example:

$PSTMDRSENMSG,1,0,2000<CR><LF>

- **$ PSTMDRSENMSG,2---Input forward/reverse status**

  $PSTMDRSENMSG,2,0,<status><CR><LF>

  <status> = 0 means forward. <status> = 1 means reverse.

  The recommended initial value of sending this message to the module is 0. It needs to be sent to the module only when the vehicle's forward/revrse status changes.

Example:

$PSTMDRSENMSG,2,0,0<CR><LF>

- **$ PSTMDRSENMSG,14---Input vehicle speed**

  $PSTMDRSENMSG,14,0,<speed><CR><LF>

  The unit of <speed> is kilometer per hour. The maximum input value is 99999 km/hr. The recommended frequency of sending this message to the module is 5 times per second.

Example:

$PSTMDRSENMSG,14,0,40<CR><LF>

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9.3 Dead Reckoning (DR) output message

Table 9.3-1 DR output message

DR record	Description
$PSTMDRSENMSG <CR><LF>	Format: for Msg ID = 1、3、14、24、30、31
$PSTMDRCAL<CR><LF>	Reports the calibration status of the DR calibration parameters.
$PSTMDRGPS<CR><LF>	This message reports at 1 Hz relevant GNSS information.
$PSTMDR1<CR><LF>	This message reports at 1 Hz data that allow to understand details about ADR/UDR alignment angles, bias and sensitivity values for gyroscope and accelerometer.
$PSTMDR2<CR><LF>	This message reports at 1 Hz data that allow to understand details about ADR/UDR calibration status and availability.
$PSTMDRPVA<CR><LF>	This message reports at 1 Hz data position, velocity and attitude estimated.
$PSTMDRPVASD<CR><LF>	This message reports at 1 Hz the standard deviation of DR estimates for position, velocity and attitude.
$PSTMDRSINT<CR><LF>	This message reports at 1 Hz the result for sensors integration samples between two consecutive GNSS epochs, i.e. across 1 second.

- **$PSTMDRSENMSG,1**

Example:

$PSTMDRSENMSG,1,478872124,23556*16

Table 9.3-2 $PSTMDRSENMSG,1 Data Format

Name	Example	Description
Message	$PSTMDRSENMSG	Reports DR sensor message data, which is specific to the message id for each specific DR sensor configuration.
Message ID	1	Odometer count
cpu timestamp	478872124	microseconds
odometer	23556	unsigned odometer count
Checksum	*16	
<CR> <LF>		End of message termination

- **$PSTMDRSENMSG,3**

Example:

$PSTMDRSENMSG,3,3377701539,557802,0*0A

Table 9.3-3 $PSTMDRSENMSG,3 Data Format

Name	Example	Description
Message	$PSTMDRSENMSG	Reports DR sensor message data, which is specific to the message id for each specific DR sensor configuration.
Message ID	3	Odometer count and reverse signal input
cpu timestamp	3377701539	microseconds
odometer	557802	unsigned odometer count
Reverse	0	0 = forward, 1 = reverse
Checksum	*0A	

<CR> <LF>		End of message termination

- **$PSTMDRSENMSG,14**

Example:

$PSTMDRSENMSG,14,1173575113,28.0*30

Table 9.3-4 $PSTMDRSENMSG,14 Data Format

Name	Example	Description
Message	$PSTMDRSENMSG	Reports DR sensor message data, which is specific to the message id for each specific DR sensor configuration.
Message ID	14	Vehicle speed
cpu timestamp	1173575113	microseconds
Vehicle speed	28.0	1 Kph resolution
Checksum	*30	
<CR> <LF>		End of message termination

- **$PSTMDRSENMSG,24**

Example:

$PSTMDRSENMSG,24,1174901488,5184,1*3D

Table 9.3-5 $PSTMDRSENMSG,24 Data Format

Name	Example	Description
Message	$PSTMDRSENMSG	Reports DR sensor message data, which is specific to the message id for each specific DR sensor configuration.
Message ID	24	Gyroscope sensor temperature
cpu timestamp	1174901488	microseconds
temperature	5184	Gyro sensor temperature
validity	1	
Checksum	*3D	
<CR> <LF>		End of message termination

- **$PSTMDRSENMSG,30**

Example:

$PSTMDRSENMSG,30,2827546184,407,-125,16522*3D

Table 9.3-6 $PSTMDRSENMSG,30 Data Format

Name	Example	Description
Message	$PSTMDRSENMSG	Reports DR sensor message data, which is specific to the message id for each specific DR sensor configuration.
Message ID	30	3D accelerometer
cpu timestamp	2827546184	microseconds
raw_x	407	407mg /LSB*0.061 = 24.827mg*0.0098 m/s^2 = 0.2433046 m/s^2

raw_y	-125	-125mg /LSB*0.061 = -7.625mg*0.0098 m/s^2 = -0.074725 m/s^2
raw_z	16522	16522mg /LSB*0.061 = 1007.842mg*0.0098 m/s^2 = 9.8768516 m/s^2
Checksum	*3D	
<CR> <LF>		End of message termination

Note: for unit mg/LSB*0.061, 1g=1000mg; 1g= 9.8 m/s^2 ; 1mg = 0.0098 m/s^2

- **$PSTMDRSENMSG,31**

Example:

$PSTMDRSENMSG,31,2827547603,360,-807,-526*17

Table 9.3-7 $PSTMDRSENMSG,31 Data Format

Name	Example	Description
Message	$PSTMDRSENMSG	Reports DR sensor message data, which is specific to the message id for each specific DR sensor configuration.
Message ID	31	3D gyroscope
cpu timestamp	2827547603	microseconds
raw_x	360	360 mdps *4.375 = 1575 mdps = 1.575 dps = 1.575 degree/s
raw_y	-807	-807 mdps *4.375 = 3530.625 mdps = 3.530625 dps = 3.530625 degree/s
raw_z	-526	-526 mdps *4.375 = 2301.25 mdps = 2.30125 dps = 2.30125 degree/s
Checksum	*17	
<CR> <LF>		End of message termination

Note: for unit mdps*4.375, 1dps = 1000mdps = 1000m degree/s

- **$ PSTMDRCAL**

Example:

$PSTMDRCAL,0,1,0,1,ff,1,1,L*0E

Table 9.3-8 $PSTMDRCAL Data Format

Name	Example	Description
Message ID	$PSTMDRCAL	Reports the calibration status of the DR calibration parameters.
dr_is_calib	0	0 = DR isn't fully calibrated 1 = DR is fully calibrated
odo_is_calib	1	0 = Odo scale isn't fully calibrated 1 = Odo scale is calibrated
gyro_gain_is_calib	0	0 = gyro gain isn't fully calibrated 1 = gyro gain is calibrated
gyro_offset_is_calib	1	0 = gyro offset isn't fully calibrated 1 = gyro offset is calibrated
imu_flag	ff	Only showing "ff" or "3f"
gyro_integrity_flag	1	1: gyro signal is healthy , 0: gyro signal is faulty
acc_integrity	1	1: acc signal is healthy , 0: acc signal is faulty
dr_calib_status	L	N: calibration Not available , L: Light calibration , F: Full calibration
Checksum	*0E	
<CR> <LF>		End of message termination

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- **$PSTMDRGPS**

Example:

$$PSTMDRGPS,25.061906389,121.645783470,0.00427,-0.00446,1.402,0.680,1.227,3.246,0.016,-0.06354,120.2*74

Table 9.3-9 $PSTMDGPS Data Format

Name	Example	Description
Message	$PSTMDRGPS	This message reports at 1 Hz relevant GNSS information.
lat	25.061906389	Decimal degrees
lon	121.645783470	Decimal degrees
vn	0.00427	Velocity’s north vector component, in meters/second
ve	-0.00446	Velocity’s east vector component, in meters/second
pdop	1.402	Position dilution of precision
hdop	0.680	Horizontal dilution of precision
vdop	1.227	Vertical dilution of precision
Rms_pos_residual	3.246	Meters
Rms_vel_residual	0.016	Meters
vv	-0.06354	Velocity’s vertical vector component, in meters/second
height	120.2	Meters
Checksum	*74	
<CR> <LF>		End of message termination

- **$PSTMDR1**

Example:

$PSTMDR1,0.329426,-1.297802,-89.500000,1.000000,-0.534401,-0.322247,0.168037,0.263500,-0.294415,0.111675,0.792870,0.000000,0.000000*1D

Table 9.3-10 $PSTMDR1 Data Format

Name	Example	Description
Message	$PSTMDR1	This message reports at 1 Hz data that allow to understand details about ADR/UDR alignment angles, bias and sensitivity values for gyroscope& accelerometer.
M pitch	0.329426	Misalignment sensor vs. vehicle frame saved in memory- Pitch angle [deg]
M roll	-1.297802	Misalignment sensor vs. vehicle frame saved in memory- Roll angle [deg]
M yaw	-89.500000	Misalignment sensor vs. vehicle frame saved in memory- Yaw angle [deg]
gsz	1.000000	Gyro z axis sensitivity [adimensional]
gbx	-0.534401	Gyro x axis bias [dps]
gby	-0.322247	Gyro y axis bias [dps]
gbz	0.168037	Gyro z axis bias [dps]
abx	0.263500	Accelerometer x axis bias [m/s^2]
aby	-0.294415	Accelerometer y axis bias [m/s^2]
abz	0.111675	Accelerometer z axis bias [m/s^2]
odometer_scale	0.792870	Meters/pulse

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Res1_baro	0.000000	Reserved for barometer
Res2_baro	0.000000	Reserved for barometer
Checksum	*1D	
<CR> <LF>		End of message termination

- **$PSTMDR2**

Example:

$PSTMDR2,NC,AA,1,0,1,0.00,0.00,1*32

Table 9.3-11 $PSTMDR2 Data Format

Name	Example	Description
Message	$PSTMDR2	This message reports at 1 Hz data that allow to understand details about ADR/UDR calibration status and availability.
IMU cal	NC	6-axes IMU calibration status. Char #1: accelerometer Char #2: gyroscope A: Not Available (sensor not supported) N: Not calibrated C: Calibrated
AS cal	AA	Additional sensors calibration status. A: Not Available (sensor not supported) N: Not calibrated C: Calibrated
Motion status	1	Motion status indicator. 0: Unclassified 1: Stopped 2: Straight 3: No straight no turn 4: Turning 5: Accelerating 6: Braking 7: Reverse
Err code	0	FW error code. 00: No Error 01: Gyro Failure 02: Accelerometer Failure 03: Odometer failure 04: GNSS Failure 05: Pressure Sensor Failure 06: Magnetometer Failure 07: Misalignment Failure 08: Acc KF Failure 09: Gyro KF Failure 10: Generic SW Failure
sr	1	System Ready Flag. 0: System not ready (GNSS-only PVT out) 1: System ready (PVT is GNSS sensors fusion)
Cross_track_error	0.00	Cross track error vs GNSS [m]
Along_track_error	0.00	Along track error vs GNSS [m]
sa	1	System aligned Flag. 0: System not aligned (The Full Free Mounted procedure is not finished) 1: System aligned (The Full Free Mounted procedure completes successfully)
Checksum	*32	

<CR> <LF>		End of message termination

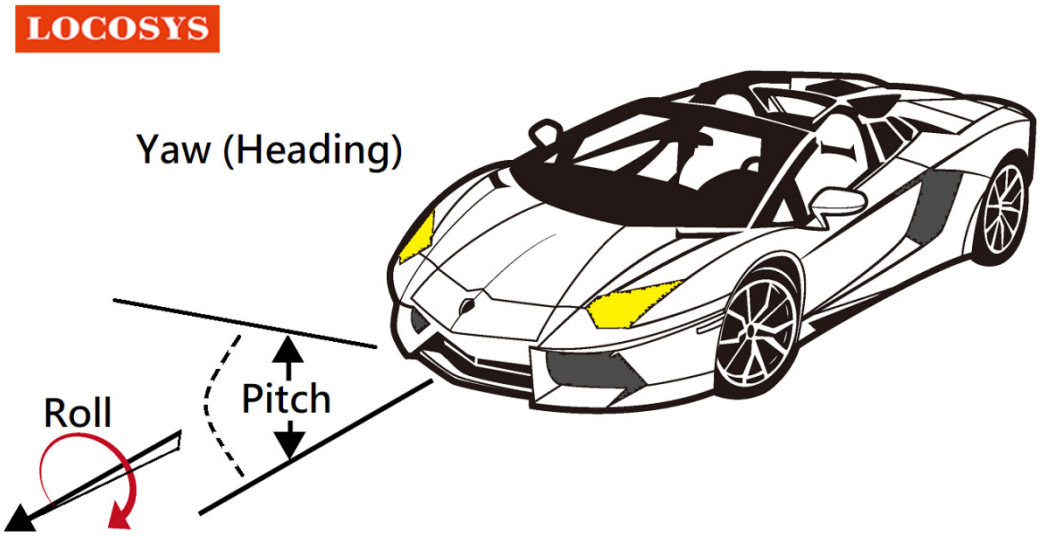
- **$PSTMDRPVA**

Example:

$PSTMDRPVA,033234.000,874446223,25.0621174,121.6450876,43.4,0.00,0.00,0.01,1.05,-0.00,45.51*71

Table 9.3-12 $PSTMDRPVA Data Format

Name	Example	Description
Message	$PSTMDRPVA	This message reports at 1 Hz data position, velocity and attitude estimated.
Timestamp	033234.000	Fix timestamp in UTC hh: hours (Fixed two digits) mm: minutes (Fixed two digits) ss: seconds (Fixed two digits) .sss: decimal fraction of seconds
CPU time	87446223	Time of DR estimation [CPU ticks]
Latitude	25.0621174	DR latitude [deg]
Longitude	121.6450876	DR longitude [deg]
Height	43.4	DR height [m]
V north	0.00	DR velocity north component [m/s]
V east	0.00	DR velocity east component [m/s]
V up	0.01	DR velocity up component [m/s]
Pitch	1.05	DR pitch angle [deg]
Roll	-0.00	DR roll angle [deg]
Heading	45.51	DR heading angle [deg]
Checksum	*71	
<CR> <LF>		End of message termination



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- **$PSTMDRPVASD**

Example:

$PSTMDRPVASD,033234.000,874446223,5.0,7.0,236.5,0.00,0.00,0.35,0.29,0.29,180.76,1.9,1.4,3.0,0.00,0.00,0.00*4B

Table 9.3-13 $PSTMDRPVSD Data Format

Name	Example	Description
Message	$PSTMDRPVASD	This message reports at 1 Hz the standard deviation of DR estimates for position, velocity and attitude
Timestamp	033234.000	Fix timestamp in UTC hh: hours (Fixed two digits) mm: minutes (Fixed two digits) ss: seconds (Fixed two digits) .sss: decimal fraction of seconds
CPU time	874446223	Time of DR estimation [CPU ticks]
Latitude sd	5.0	DR latitude standard deviation [m]
Longitude sd	7.0	DR longitude standard deviation [m]
Height sd	236.5	DR height standard deviation [m]
V north sd	0.00	DR velocity north component standard deviation [m/s]
V east sd	0.00	DR velocity east component standard deviation [m/s]
V up sd	0.35	DR velocity up component standard deviation [m/s]
Pitch sd	0.29	DR pitch angle standard deviation [deg]
Roll sd	0.29	DR roll angle standard deviation [deg]
Heading sd	180.76	DR heading angle standard deviation [deg]
P_ne_sd	1.9	DR position north east standard deviation [m]
P_nu_sd	1.4	DR position north up standard deviation [m]
P_eu_sd	3.0	DR position east up standard deviation [m]
V_ne_sd	0.00	DR velocity north east standard deviation [m/s]
V_nu_sd	0.00	DR velocity north up standard deviation [m/s]
V_eu_sd	0.00	DR velocity east up standard deviation [m/s]
Checksum	*4B	
<CR> <LF>		End of message termination

- **$PSTMDRSINT**

Example:

$PSTMDRSINT,15,15,0,0,1.000,1.000,0.000,-0.55,-0.32,0.17,0.44,-0.30,9.90,0.00*15

Table 9.3-14 $PSTMDRSINT Data Format

Name	Example	Description
Message	$PSTMDRSINT	This message reports at 1 Hz the result for sensors integration samples between two consecutive GNSS epochs, i.e. across 1 second.
gyro sample count	15	Number of gyro samples received
acc sample count	15	Number of acc samples received
pres sample count	0	Number of pressure samples received
Odometer count	0	Number of odometer pulses received

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gyro int time	1.000	Time elapsed between 1st and last gyro sample received [s]
acc int time	1.000	Time elapsed between 1st and last acc sample received [s]
pres int time	0.000	Time elapsed between 1st and last pressure sample received [s]
gyro x avg	-0.55	Average of x gyro samples received [dps]
gyro y avg	-0.32	Average of y gyro samples received [dps]
gyro z avg	0.17	Average of z gyro samples received [dps]
acc x avg	0.44	Average of x acc samples received [m/s^2]
acc y avg	-0.30	Average of x acc samples received [m/s^2]
acc z avg	9.90	Average of x acc samples received [m/s^2]
pressure avg	0.00	Average of pressure samples received [hPa]
Checksum	*15	
<CR> <LF>		End of message termination

9.4 STAGPS autonomous solution

STMicro provide "STAGPS" autonomous solution works using the past real ephemeris (downloaded from the sky and stored in its internal database) to extrapolate the parameter of future ephemeris (up to 5 days of prediction).

For these reason the STAGPS autonomous performances (in terms of position accuracy using predicted ephemeris) are strictly dependent on the real ephemeris database content. In normal usage of STAGPS autonomous, the system automatically uploads the real ephemeris into its module database as soon as new ephemerides are downloaded from the sky.

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10 Product handling

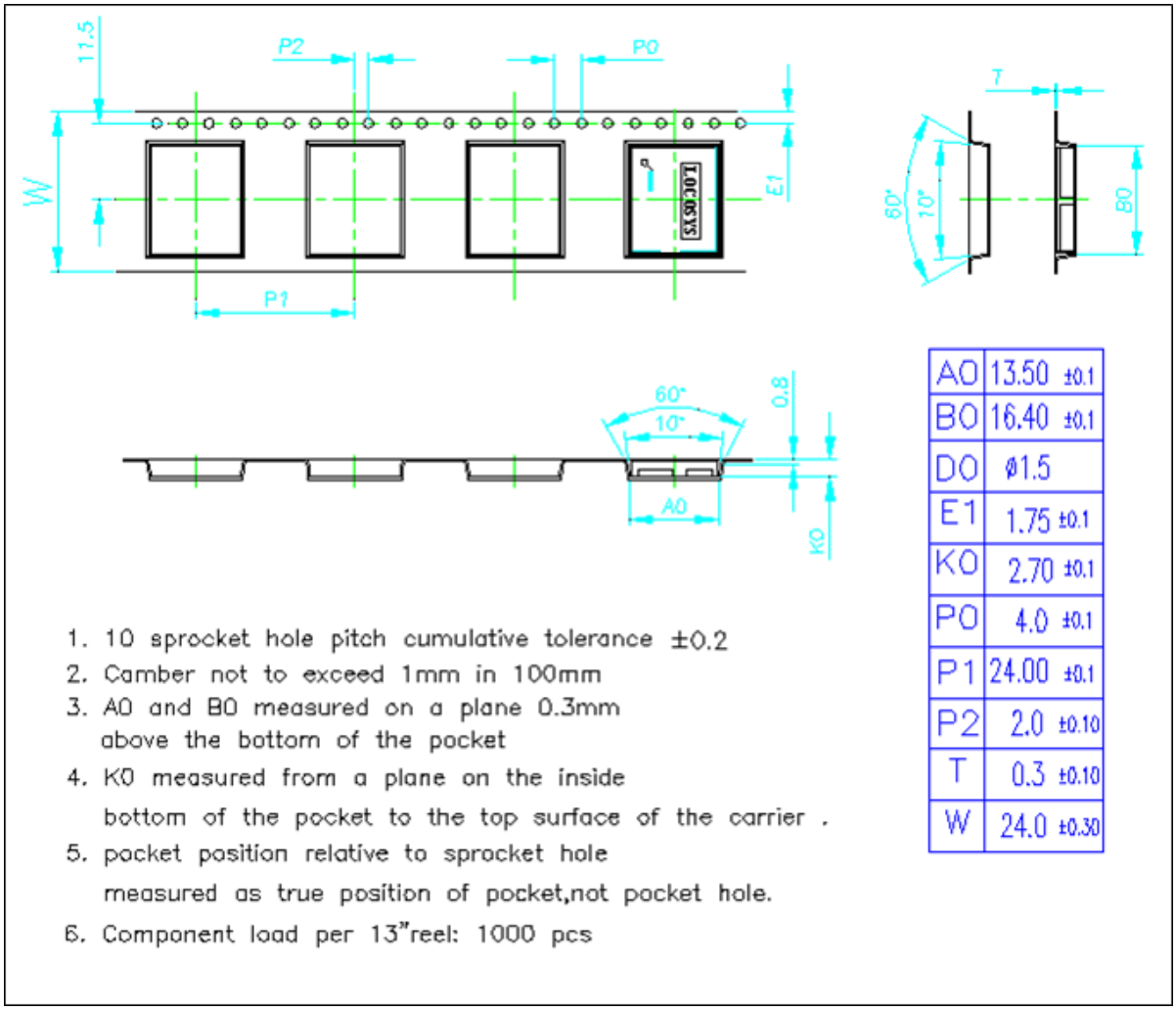
10.1 ESD precaution

GNSS modules are electrostatic sensitive devices. Handling the modules without proper ESD protection may result in severe damage to them. ESD protection must be implemented throughout the processing, handling and even when the modules are being returned for repair.

10.2 Packaging

The modules are sealed in a moisture barrier ESD bag with the appropriate units of desiccant and a humidity indicator card. It should not be opened until the modules are ready to be soldered onto the application.

10.2.1 Tape and reel packaging



A0	13.50 ±0.1
B0	16.40 ±0.1
D0	ø1.5
E1	1.75 ±0.1
K0	2.70 ±0.1
P0	4.0 ±0.1
P1	24.00 ±0.1
P2	2.0 ±0.10
T	0.3 ±0.10
W	24.0 ±0.30

1. 10 sprocket hole pitch cumulative tolerance ±0.2
2. Camber not to exceed 1mm in 100mm
3. A0 and B0 measured on a plane 0.3mm above the bottom of the pocket
4. K0 measured from a plane on the inside bottom of the pocket to the top surface of the carrier .
5. pocket position relative to sprocket hole measured as true position of pocket,not pocket hole.
6. Component load per 13"reel: 1000 pcs

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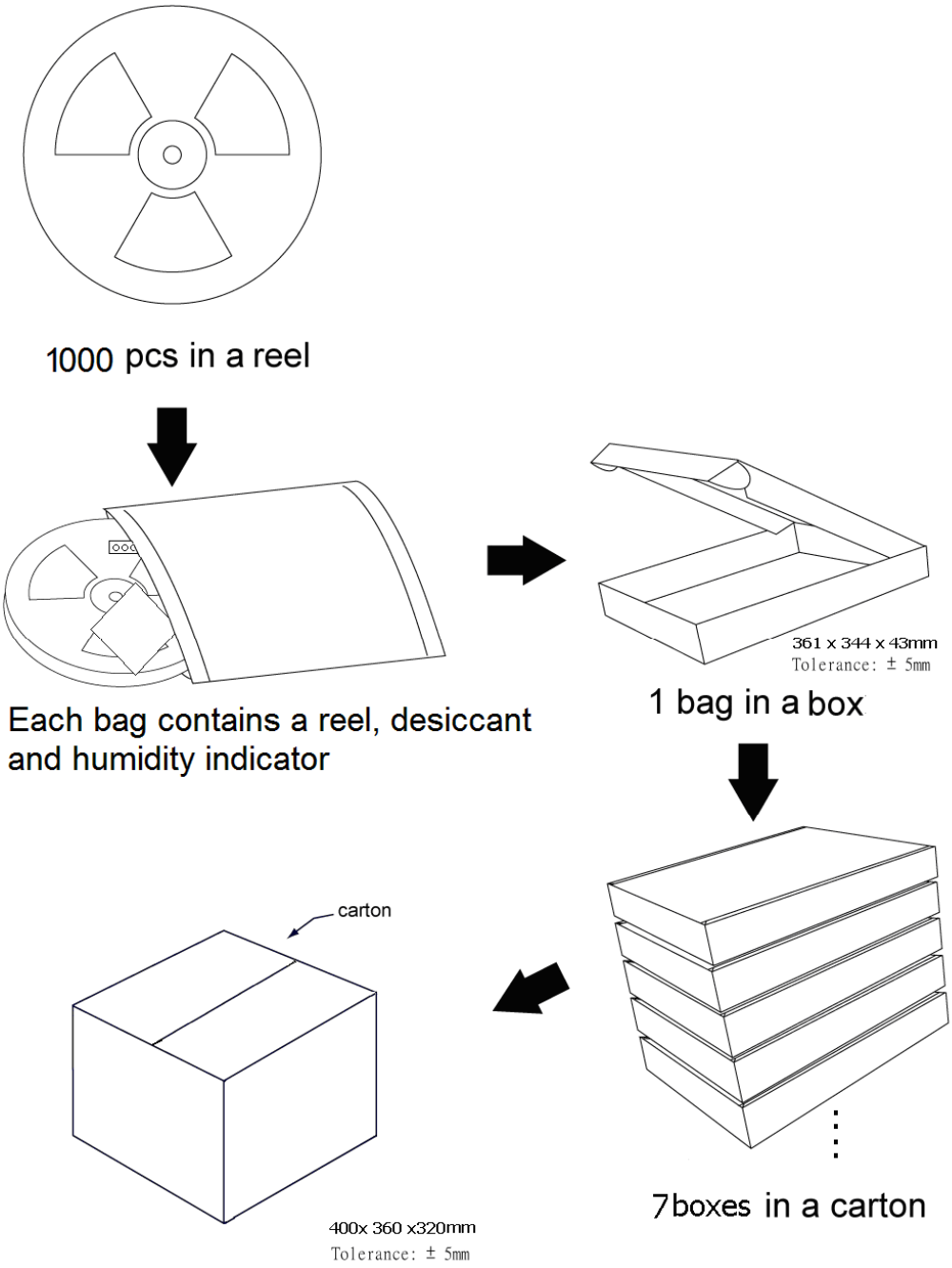
10.2.2 Box packaging



10.3 Moisture sensitivity level

The moisture sensitivity level of the module is 3. After the sealed bag is opened, modules should be mounted within 168 hours at factory conditions of ≦ 30℃ and 60% RH or stored at ≦ 20% RH.

The modules require baking before mounting if above conditions are not met. If baking is required, the modules may be baked for:

a. 192 hours at 40℃ + 5℃ / -0℃ and < 5% RH
b. 24 hours at 125℃ + 5℃ / -0℃

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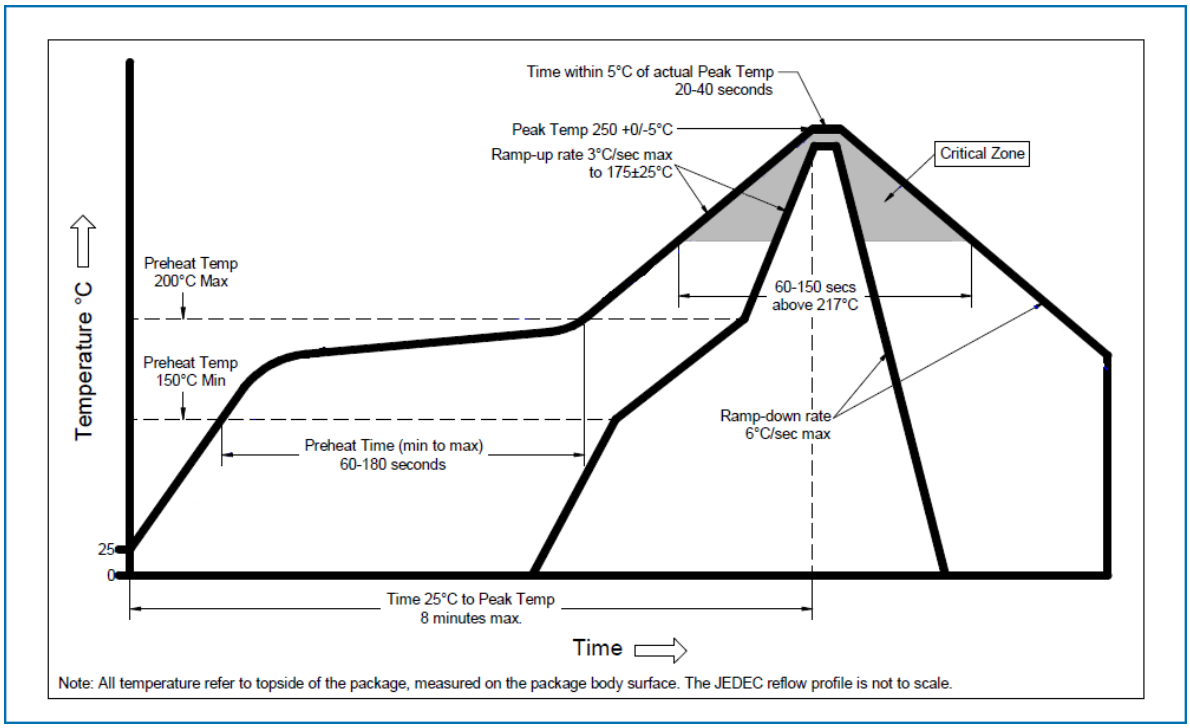
10.4 Reflow soldering



Note the module mounted to the top side (first reflow side) may fall off during reflow soldering of the bottom side.

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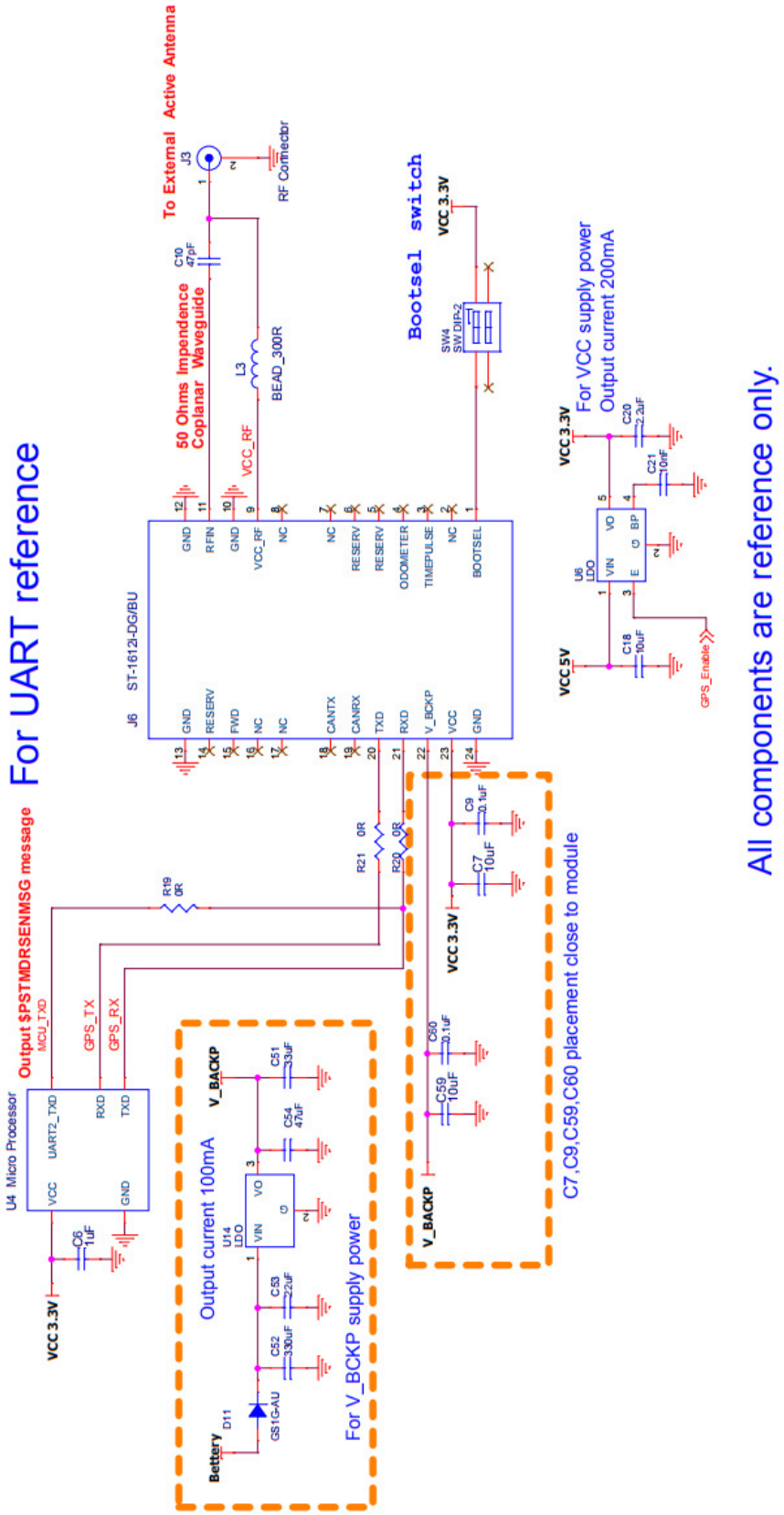
11 Reference circuit

11.1 Vehicle speed input from UART port



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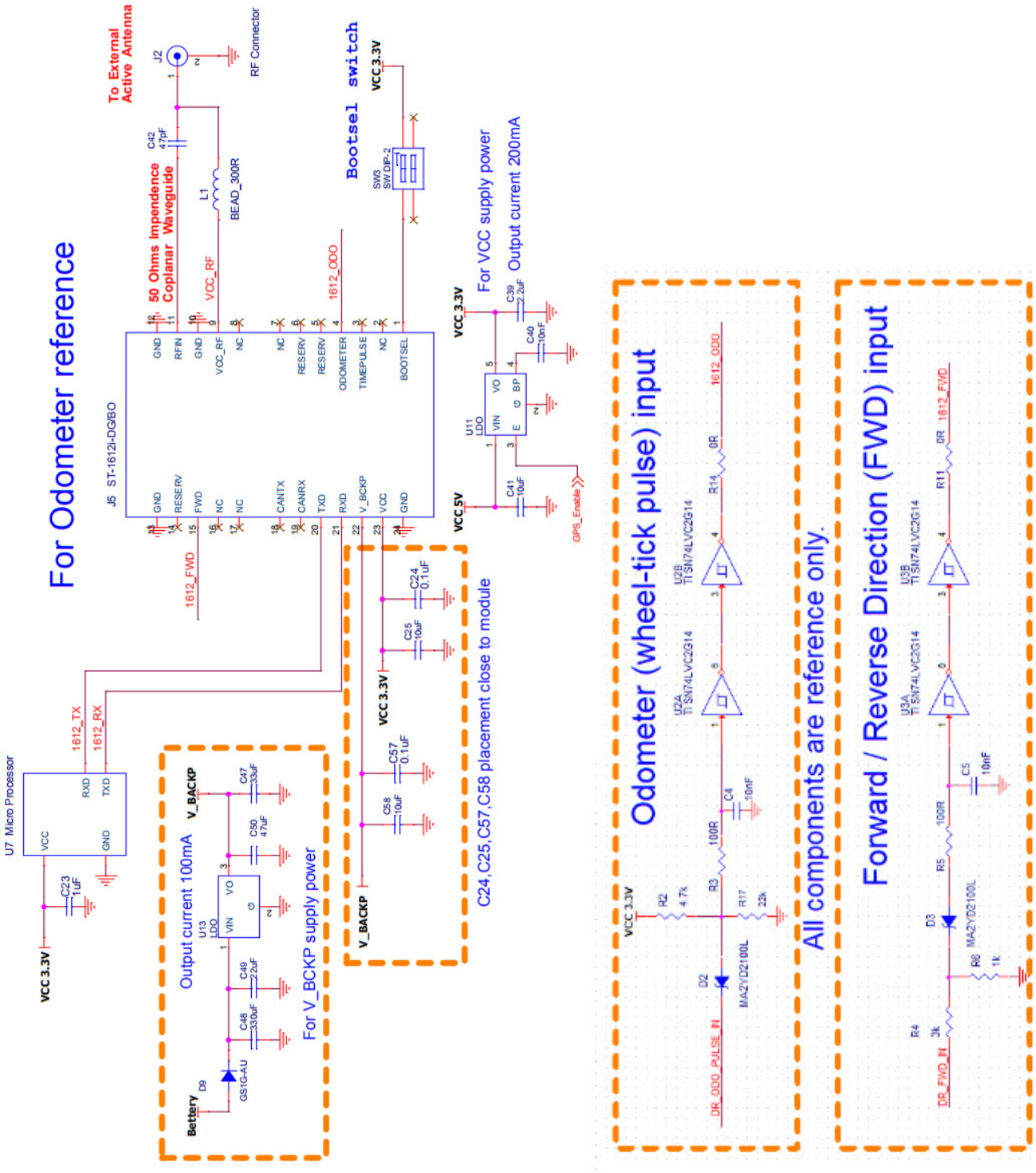
11.2 Odometer (wheel-tick pulse) and forward/reverse signal input



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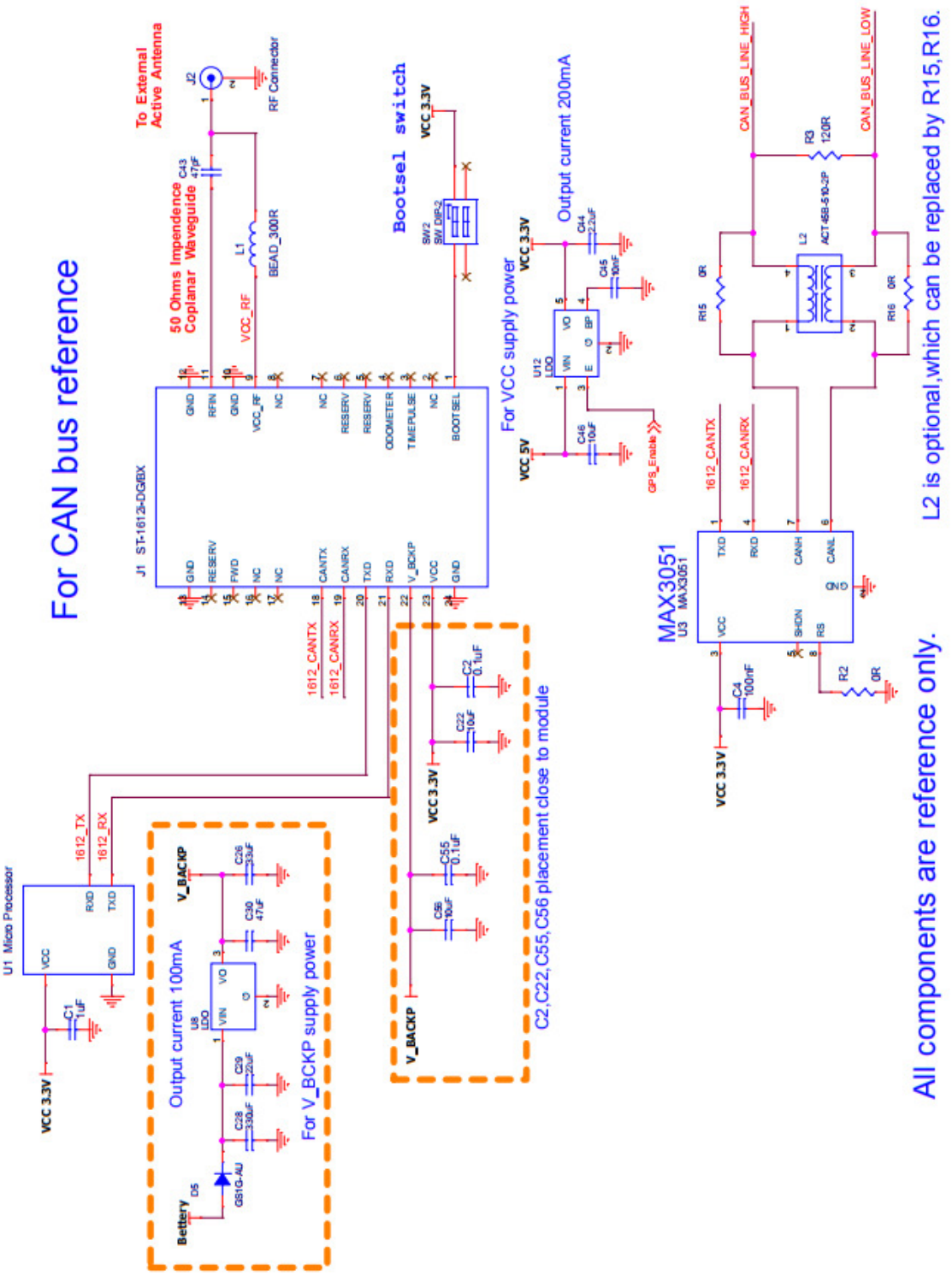
11.3 Vehicle speed input from CAN Bus



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12 Product marking and ordering Information

12.1 Product marking

The marking of the module is engraved on the metal shielding that has product information, such as LOCOSYS logo, product name and manufacturing date.

12.2 Ordering Information

Model	Description	Remark
ST-1612r-DGU	Multi-constellation GNSS UDR/ADR module (vehicle speed input from UART port)	GPS, GLONASS, GALILEO, QZSS
ST-1612r-DGO	Multi-constellation GNSS UDR/ADR module (vehicle speed from odometer)	GPS, GLONASS, GALILEO, QZSS
ST-1612r-DBU	Multi-constellation GNSS UDR/ADR module (vehicle speed input from UART port)	GPS, BEIDOU, GALILEO, QZSS
ST-1612r-DBO	Multi-constellation GNSS UDR/ADR module (vehicle speed from odometer)	GPS, BEIDOU, GALILEO, QZSS

Note: For the vehicle speed input from CAN bus, please contact us.

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Document change list

Revision 0.1

- Draft release on March 27, 2020

Revision 0.2 (April 7, 2020)

- Changed maximum MEMS raw data output to 100Hz in section 2.
- Changed max. altitude to 50,000m in section 4.
- Added the sampling rate of the peak current in section 6.2.
- Changed max. acceleration from 2g to 4g in section 7.3.

Revision 0.3 (April 16, 2020)

- Added “support AGPS autonomous solution “in section 2.
- Added the max current in section 6.2.
- Added section 8.4 “STAGPS autonomous solution“.

Revision 0.4 (October 20, 2020)

- Added application description in section 3.