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Product name	Description	Version
TD-1612-DBX	Datasheet of TD-1612-DBX multiple GNSS module with 3D sensors	0.3

1 Introduction

The LOCOSYS TD-1612-DBX Dead Reckoning (DR) module is the perfect solution for automotive application. The TD-1612-DBX is embedded 3D accelerometer, 3D gyroscope,1-hole pressure(option) Micro-Electro-Mechanical Systems (MEMS) sensor, equipped with DR software.With adverse GNSS conditions in urban canyons, tunnels, or parking garages where DR boosts the accuracy, and the software fills the gaps. It supports three dimensional DR. This module can simultaneously acquire and track multiple satellite constellations that include GPS, BEIDOU and SBAS. It features high sensitivity, low power and ultra small form factor, and provide user the superior performance.

2 Features

- High sensitivity GNSS chip
- Support GPS, BEIDOU
- Capable of SBAS (WAAS, EGNOS, MSAS)
- Fast TTFF at low signal level
- Built-in Dead Reckoning (DR) software
- Built-in TDK MEMS sensor (3-axis Gyroscope and 3-axis Accelerometer)
- Built-in TDK pressure sensor(option)
- Support Odometer (wheel-tick pulse) input
- Support sensors data feed through the UART port
- Small form factor 16 x 12.2 x 2.4 mm
- SMD type, RoHS compliant
- IATF 16949 quality control

3 Application

- Automotive navigation, model aircraft navigation
- Fleet management
- Surveying and mapping

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4 System Block Diagram

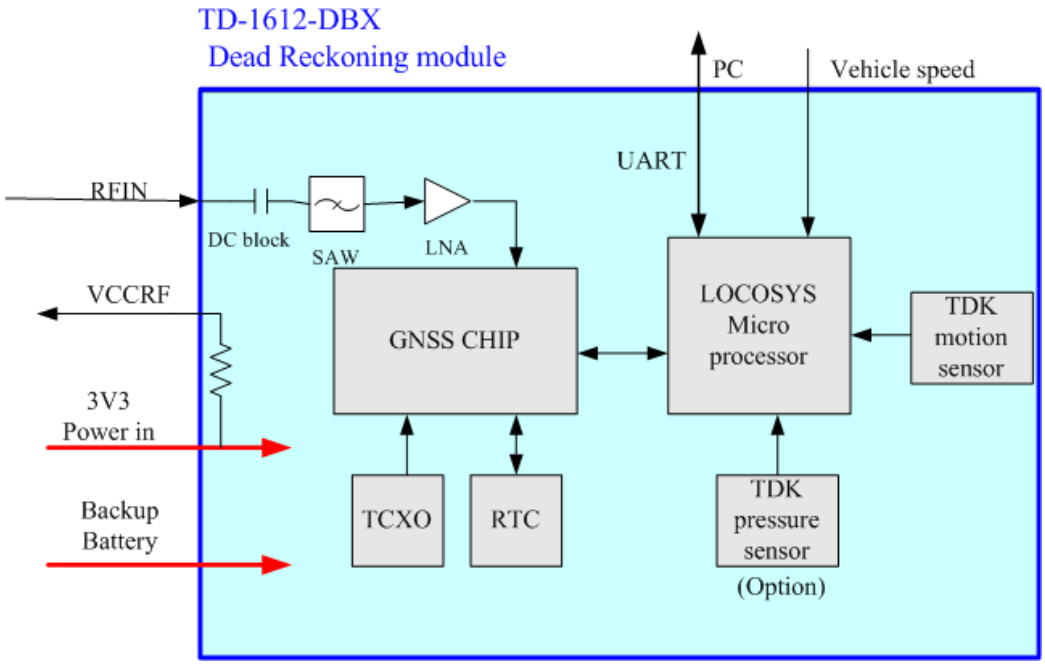
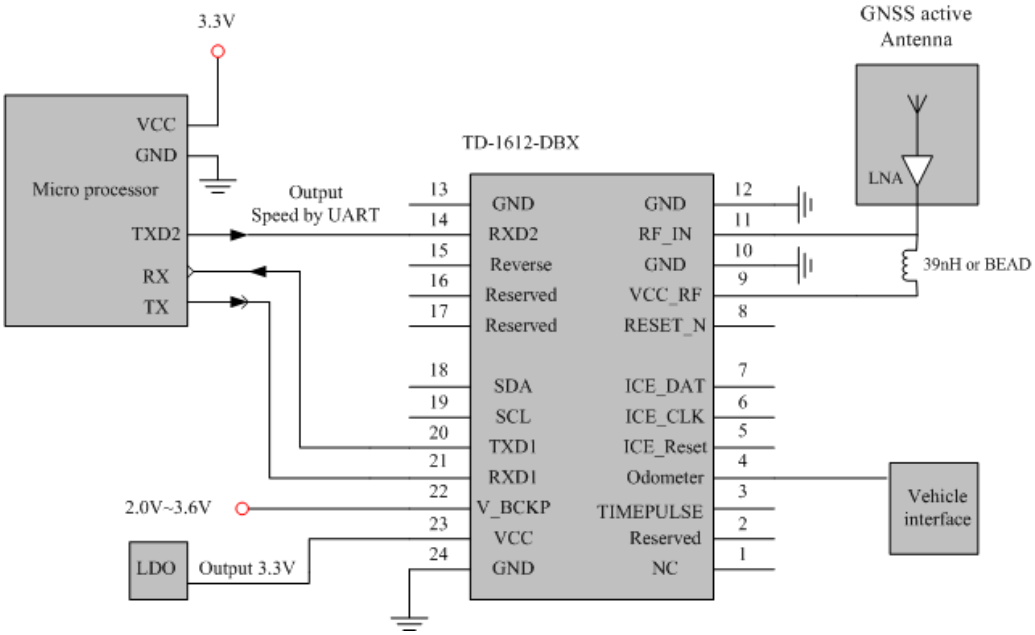


Fig 4-1 System block diagram.

5 Typical application circuit



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6 GNSS receiver

6.1 GNSS receiver

Chip	High sensitivity GNSS chip	
Frequency	GPS:L1 1575.42MHz, C/A code BEIDOU:B1 1561.098MHz, C code	
Channels	Support 56 acquisition channels	
Update rate	1Hz default	
Sensitivity	Tracking	up to -160dBm (with external LNA)
	Cold start	up to -147.5dBm (with external LNA)
Acquisition Time	Hot start (Open Sky)	< 2s (typical)
	Cold Start (Open Sky)	29s (typical)
Position Accuracy	Autonomous	3m (2D RMS)
	SBAS	2.5m (2D RMS, depends on accuracy of correction data)
Max. Altitude	< 18,000 m	
Max. Velocity	< 515 m/s	
Protocol Support	NMEA 0183 V4.10	115200 bps(1), 8 data bits, no parity, 1 stop bits (default) 1Hz: GGA, GLL, GSA, GSV, RMC, VTG, GST, SVD

Note1: Both baud rate and output message rate are configurable to be factory default.

6.2 MEMS Sensor

The TD-1612-DBX receiver support Dead Reckoning (DR) function, it composed by a 3-axis Gyroscope, 3-axis Accelerometer & pressure sensor (option). To provide optimal solution it needs to calibrate sensor parameters. The sensor parameters are initialized to default values allowing system to start up when no other better information is available, if system is started for the first time in an unknown vehicle gyroscope dedicated maneuvers are required and algorithms able to estimate these parameters.

6.3 Sensor data input

There are two methods to feed data to receiver as below descriptions.

(1) Feed through vehicle Odometer (wheel-tick pulse) input.

(2) Feed through the UART port; please refer to page 24 for more details.

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7 Pin assignment and descriptions

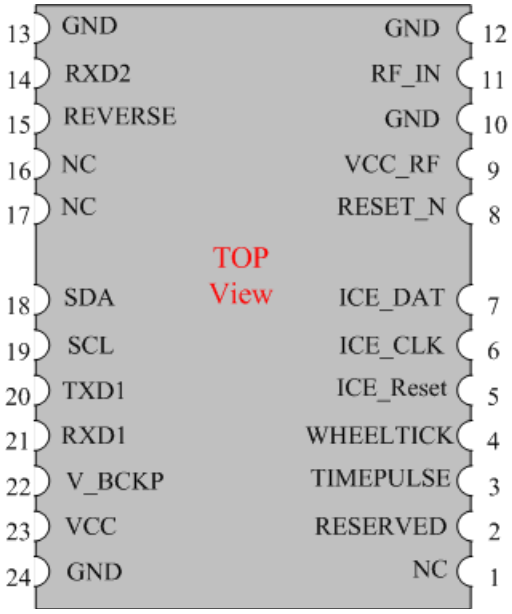

Table 7-1 Pin descriptions

Pin #	Name	Type	Description	Note
1	NC		Not connected	
2	RESERVED		Reserved, keep floating	
3	TIMEPULSE	O	Time pulse (1PPS, default 100 ms pulse/sec when 3D fix is available)	
4	WHEELTICK	I	Odometer wheel-tick input	1
5	ICE_Reset		Micro processor program only	
6	ICE_CLK		Micro processor program only	
7	ICE_DAT		Micro processor program only	
8	RESET_N	I	RESET_N	
9	VCC_RF	O	Output voltage for active antenna	
10	GND	P	Ground	
11	RFIN	I	GNSS RF signal input	
12	GND	P	Ground	
13	GND	P	Ground	
14	RXD2	I	UART, asynchronous input	
15	Reverse	I	Direction of travel relative to vehicle frame	
16	NC		Not connected	
17	NC		Not connected	
18	SDA		I2C,Sensor data output	

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19	SCL		I2C,Sensor data output	
20	TXD1	O	UART, asynchronous output (Default NMEA)	
21	RXD1	I	UART, asynchronous input (Default NMEA)	
22	V_BCKP	P	Backup battery supply voltage	2
23	VCC	P	DC supply voltage	
24	GND	P	Ground	

Note1: Pin4 and Pin15 needs external level shift circuits to meet DC electrical characteristics.
Note2: The module doesn't have hot start when this pin and VCC pin are not applied.

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8 DC & Temperature characteristics

8.1 Absolute maximum ratings

Parameter	Symbol	Ratings	Units
Input Voltage	VCC	3.6	V
Input Backup Battery Voltage	V_BCKP	3.6	V
Operating Temperature Range	Topr	-40 ~ 85	℃
Storage Temperature Range	Tstg	-40 ~ 85	℃

8.2 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		2.0		3.6	V
VCC_RF Output Voltage	VCC_RF			VCC		V
Supply Current	Iss	VCC = 3.3V, w/o active antenna, Peak Acquisition Tracking		 75 74(1)	284	 mA mA mA
Backup Battery Current	Ibat	VCC = 0V		30		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

Note1: Measured when position fix (1Hz) is available and input voltage is 3.3V with UART interface.

8.3 Temperature characteristics

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

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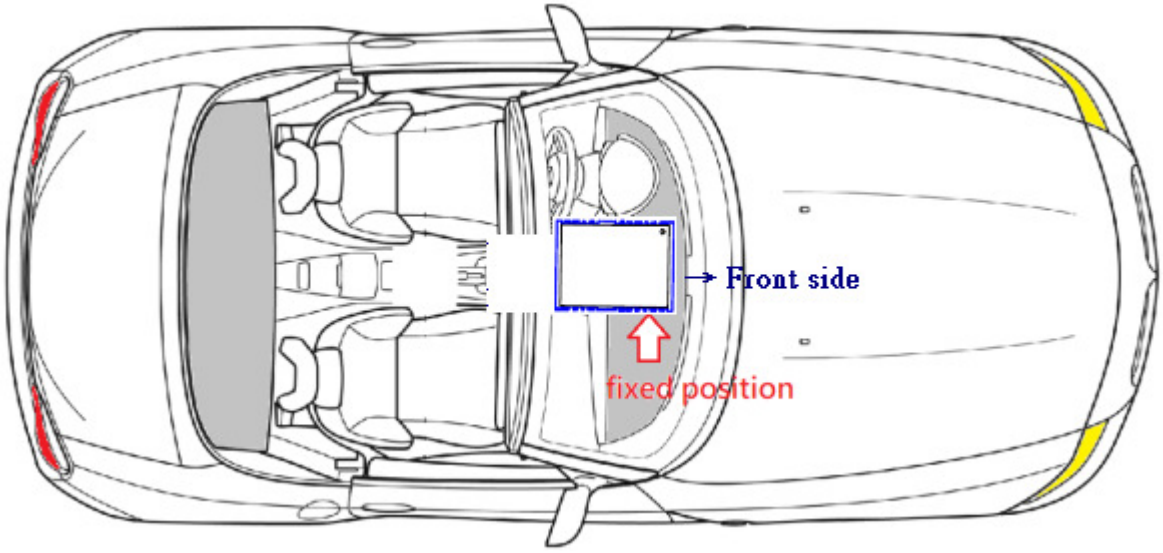
9 Mechanical specification

9.1 Recommended Mounting

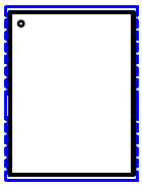
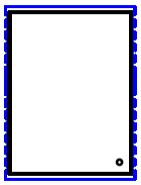
Please refer to the following figure to mount TD-1612-DBX on vehicle. The module should be securely mounted to a stable part of the vehicle.



Note1: Default TD-1612-DBX module MUST mount horizontally on vehicle (when the vehicle is on a level surface) and toward the front of vehicle.

Note2: We provide any mount method for customer but the roll angular of module placement will affect DR performance.

Please below chart to choose best mount:

		
Best for mount	Best for mount	Best for mount
		
Best for mount	Best for mount	Nice for mount

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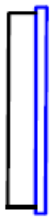
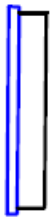
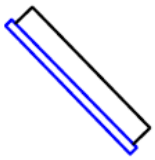
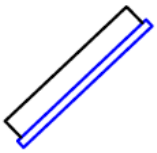
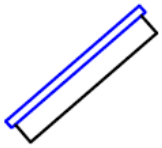
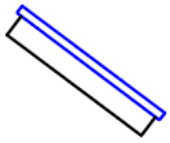
		
Nice for mount	Nice for mount	Roll angular ≧45, Not recommend
		
Roll angular ≧45, Not recommend	Roll angular ≧45, Not recommend	Roll angular ≧45, Not recommend

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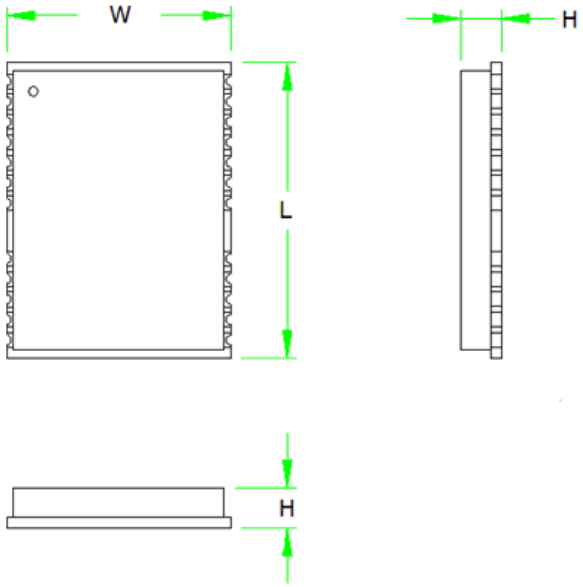
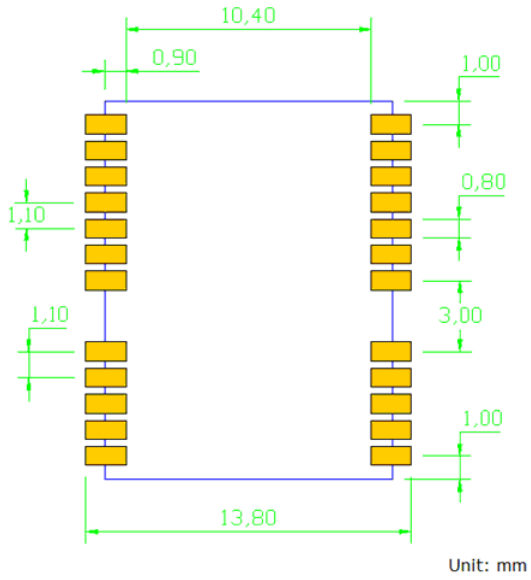
10 Outline dimensions



Symbol	Min. (mm)	Typ. (mm)	Max. (mm)
W	12.1	12.2	12.3
L	15.7	16.0	16.4
H	2.2	2.4	2.6

10.1 Recommended land pattern dimensions



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

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11 Software interface

11.1 NMEA output message

Table 11.1-1 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
GST	Estimated Position Error
SVD	3D velocity & deviation information

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

Table 11.1-2 contains the values for the following example:

$GNGGA,062948.00,2503.46437,N,12137.23014,E,2,18,0.75,16.5,M,19.3,M,,0000*76

Table 11.1- 2 GGA Data Format

Name	Example	Units	Description
Message ID	$GNGGA		GGA protocol header
UTC Time	062948.00		hhmmss.ss
Latitude	2503.46437		ddmm.mmmmm
N/S indicator	N		Latitude Direction: North or South
Longitude	12137.23014		dddmm.mmmmm
E/W Indicator	E		Longitude Direction: East or West
Position Fix Indicator	2		See Table 11.1-3
Satellites Used	18		Satellites in use
HDOP	0.75		Horizontal Dilution of Precision,max:99.0
MSL Altitude	16.5	meters	Height above mean sea level
Units	M	meters	Reference Unit for Altitude (“M” = meters)
Geoidal Separation	19.3	meters	Geoidal Separation measure in “M” = meters
Units	M	meters	Reference Unit for Geoidal Separation (“M” = meters)
DGPS Age			Not supported
DGPS Reference	0000		
Checksum	*76		

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<CR> <LF>			End of message termination

Table 11.1-3 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 11.1-4 contains the values for the following example:

$GNGLL,2503.46437,N,12137.23014,E,062948.00,A,D*77

Table 11.1-4 GLL Data Format

Name	Example	Units	Description
Message ID	$GNGLL		GLL protocol header
Latitude	2503.46437		ddmm.mmmmm
N/S indicator	N		Latitude Direction: North or South
Longitude	12137.23014		dddmm.mmmmm
E/W indicator	E		Longitude Direction: East or West
UTC Time	062948.00		hhmmss.ss
Status	A		Validity of Data; A=data valid or V=data invalid
Mode	D		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 11.1-5 contains the values for the following example:

$GNGSA,A,3,05,13,15,21,24,29,02,20,50,42,,,1.28,0.70,1.07,1*05

$GNGSA,A,3,09,13,01,02,03,04,06,08,07,,,,1.28,0.70,1.07,4*08

Table 11.1-5 GSA Data Format

Name	Example	Units	Description
Message ID	$GNGSA		GSA protocol header
Mode 1	A		See Table 11.1-6
Mode 2	3		See Table 11.1-7

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ID of satellite used	05		Sv on Channel 1
ID of satellite used	13		Sv on Channel 2
….			….
ID of satellite used			Sv on Channel 12
PDOP	1.28		Position Dilution of Precision,max:99.0
HDOP	0.70		Horizontal Dilution of Precision, max:99.0
VDOP	1.07		Vertical Dilution of Precision, max:99.0
GNSS System ID	1		1: GPS, 2: GLONASS, 3: GALILEO, 4: BEIDOU, 5-F: Reserved
Checksum	*05		
<CR> <LF>			End of message termination

Table 11.1-6 Mode 1

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

Table 11.1-7 Mode 2

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

● GSV---GNSS Satellites in View

Table 11.1-8 contains the values for the following example:

$GPGSV,3,1,10,02,20,151,42,05,37,076,44,13,44,029,46,15,64,324,49,0*60

$GPGSV,3,2,10,20,10,304,34,21,33,316,44,24,48,176,46,29,26,235,46,0*60

$GPGSV,3,3,10,42,51,134,35,50,51,134,34,0*66

$BDGSV,4,1,13,01,53,143,42,02,40,242,37,03,58,204,43,04,38,119,39,0*71

$BDGSV,4,2,13,05,17,259,33,06,62,329,44,07,14,171,43,08,59,185,42,0*7B

$BDGSV,4,3,13,09,48,278,43,10,03,193,,13,70,259,44,14,11,079,21,0*74

$BDGSV,4,4,13,16,58,310,,0*4E

Table 11.1-8 GSV Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GPGSV		GSV protocol header (GPGSV & BDGSV)
Total number of messages[1]	3		Range 1 to 8
Message number[1]	1		Range 1 to 8
Satellites in view	10		Total number of satellites in view

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Satellite ID	02		Channel 1 (Range 01 to 330)
Elevation	20	degrees	Channel 1 (Range 00 to 90)
Azimuth	151	degrees	Channel 1 (Range 000 to 359)
SNR (C/No)	42	dB-Hz	Channel 1 (Range 00 to 99, null when not tracking)
…..			…..
Satellite ID	15		Channel 4 (Range 01 to 330)
Elevation	64	degrees	Channel 4 (Range 00 to 90)
Azimuth	324	degrees	Channel 4 (Range 000 to 359)
SNR (C/No)	49	dB-Hz	Channel 4 (Range 00 to 99, null when not tracking)
Signal ID	0		See Table 11.1-9
Checksum	*60		
<CR> <LF>			End of message termination

Note1: Depending on the number of satellites tracked multiple messages of GSV data may be required.

Table 11.1-9 GNSS Identification:

System	System ID	Satellite ID	Signal ID	Signal Channel
GPS	1 (GP)	1 - 32 is reserved for GPS 33 - 64 is reserved for SBAS 65 - 99 is undefined	0 1	All signals L1 C/A
BDS	4 (BD)	1 - 37 is reserved for BDS 38 - 99 is undefined	0 1	All signals B1I

● RMC---Recommended Minimum Specific GNSS Data

Table 11.1-10 contains the values for the following example:

$GNRMC,062949.00,A,2503.46969,N,12137.22962,E,19.939,-4.54,231018,,,D,V*1E

Table 11.1-10 RMC Data Format

Name	Example	Units	Description
Message ID	$GNRMC		RMC protocol header
UTC Time	062949.00		hhmmss.ss
Status	A		A=data valid or V=data invalid
Latitude	2503.46969		ddmm.mmmmm
N/S Indicator	N		Latitude Direction: North or South
Longitude	12137.22962		dddmm.mmmmm
E/W Indicator	E		Longitude Direction: East or West
Speed over ground	19.939	knots	Speed over ground in knots
Course over ground	-4.54	degrees	

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Date	231018		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
Navigational status	V		S= safe, C= caution, U= unsafe, V=Navigational status not valid
Checksum	*1E		
<CR> <LF>			End of message termination

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

Table 11.1-11 contains the values for the following example:

$GNVTG,-4.54,T,,M,19.939,N,36.927,K,D*0C

Table 11.1-11 VTG Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GNVTG		VTG protocol header
Course over ground	-4.54	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	19.939	knots	Speed over ground in knots
Units	N		Indicates “Knots”
Speed over ground	36.927	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	*0C		
<CR> <LF>			End of message termination

- **GST ---Estimated Position Error**

Table 11.1-12 contains the values for the following example:

$GNGST,062948.00,1366,,,,1.1,1.2,2.8*43

Table 11.1-12 GST Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GNGST		GST protocol header
UTC Time	062948.00		hhmmss.ss

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RMS value of the standard deviation of the ranges	1366		
Standard deviation of semi-major axis of error ellipse		meters	0~9999999.99
Standard deviation of semi-minor axis of error ellipse		meters	0~9999999.99
Orientation of semi-major axis of error ellipse		degree	
Standard deviation of Latitude error	1.1	meters	
Standard deviation of Longitude error	1.2	meters	
Standard deviation of altitude error	2.8	meters	
Checksum	*43		
<CR> <LF>			End of message termination

● SVD ---3D velocity & deviation information

Table 11.1-13 contains the values for the following example:

$PLSVD,-61,942,-3,11,10,22*57

Table 11.1-13 SVD Data Format

Name	**Example**	**Units**	**Description**
Message ID	$PLSVD		PLSVD protocol header
True east velocity	-61	cm/s	-51500~51500
True north velocity	942	cm/s	-51500~51500
True down velocity	-3	cm/s	-10000~10000
Deviation of east velocity	11	cm/s	
Deviation of north velocity	10	cm/s	
Deviation of down velocity	22	cm/s	
Checksum	*57		
<CR> <LF>			End of message termination

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11.2 Proprietary Dead Reckoning input/output messages

Table 11.2-1 The table below summarizes the set of proprietary command sets for the TD-1612-DBX

NMEA record	Description
$PINVMINR	Calibration status
$PINVMVGS	Speed message info.
$PINVCRES	Clear the NVM data
$PINVCSTR	Start session
$CCSIR	Perform a Cold start or a Warm start or a Hot start

- **$PINVMINR --- Calibration status**

Table 11.2-2 contains the values for the following example:

$PINVMINR,1*04

Table 11.2-2 $PINVMINR Data Format

Name	Example	Units	Description
Message ID	$PINVMINR		$PINVMINR protocol header
Status	1		0:not initialized 1:calibrating/initializing 2:calibration done
Checksum	*04		
<CR> <LF>			End of message termination

Note: When GNSS positioning is valid, the message appears at NMEA sentence.

- **$PINVMVGS --- Speed Message info.**

Table 11.2-3 contains the values for the following example:

$PINVMVGS,2392.893,12.30,F*5C

Table 11.2-3 $PINVMVGS Data Format

Name	Example	Units	Description
Message ID	$PINVMVGS		$PINVMVGS protocol header
Time stamp	2392.893		microseconds
Current speed	12.30	Km/h	Speed over ground in kilometers per hour
Direction	F		Direction of travel relative to vehicle frame (1) F = Forward (2) R = Reverse (3) U = Unknown
Checksum	*76		
<CR> <LF>			End of message termination

Note: When vehicle speed is received, the message appears at NMEA sentence.

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- **$PINVCRES ---Clear the NVM data**

Table 11.2-4 contains the values for the following example:

$PINVCRES,0*1A

Table 11.2-4 $PINVCRES Data Format

Name	Example	Units	Description
Message ID	$PINVCRES		$PINVCRES protocol header
Value	0		Clear the NVM data
Checksum	*1A		
<CR> <LF>			End of message termination

Note: The command need collocation start session command.

- **$PINVCSTR --- Start session**

Table 11.2-5 contains the values for the following example:

$PINVCSTR,14*3E

Table 11.2-5$PINVCSTR Data Format

Name	Example	Units	Description
Message ID	$PINVCSTR		$PINVCSTR protocol header
Value	14		Start session
Checksum	*3E		
<CR> <LF>			End of message termination

Note1: The command need collocation clear NVM data command.

Note2: First time to use needs to do DR calibration, please follow below chart.

A Command example for DR recalibration :

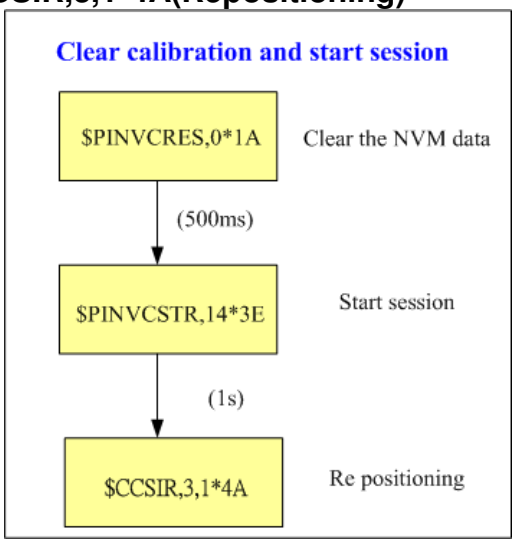
$PINVCRES,0*1A

↓

$PINVCSTR,14*3E

↓

$CCSIR,3,1*4A(Repositioning)



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- **$CCSIR --- Perform a Cold start or a Warm start or a Hot start**

Table 11.2-6 contains the values for the following example:

$CCSIR,3,1*4A
$CCSIR,3,2*49
$CCSIR,3,3*48

Table 11.2-6$CCSIR Data Format

Name	Example	Units	Description
Message ID	$CCSIR		$CCSIR protocol header
Satellite	3		GPS+BDS
Action	1		1:cold start 2:warm start 3:hot start
Checksum	*4A		*4A or *49 or *48
<CR> <LF>			End of message termination

- **PSTMDRSENMSG --- Sensor data over UART**

Customer needs get vehicle speed from the micro processor and follow the table's data format to input TD-1612-DBU module.

Table 11.2-7 contains the values for the following example:

$PSTMDRSENMSG,14,0,31*16

Table 11.2-7 $ PSTMDRSENMSG Data Format

Name	Example	Units	Description
Message ID	$PSTMDRSENMSG		$PSTMDRSENMSG protocol header
MSG ID	14		Data type
MSG ID	0		Data type
Microprocessor output speed	31	Km/h	Speed over ground in kilometers per hour
Checksum	*16		
<CR> <LF>			End of message termination

Note: Default recommend input up to 5Hz to module pin14.

12 Ordering Information

Model	Interface
TD-1612-DBO	Odometer signal input
TD-1612-DBU	Sensor data over UART input

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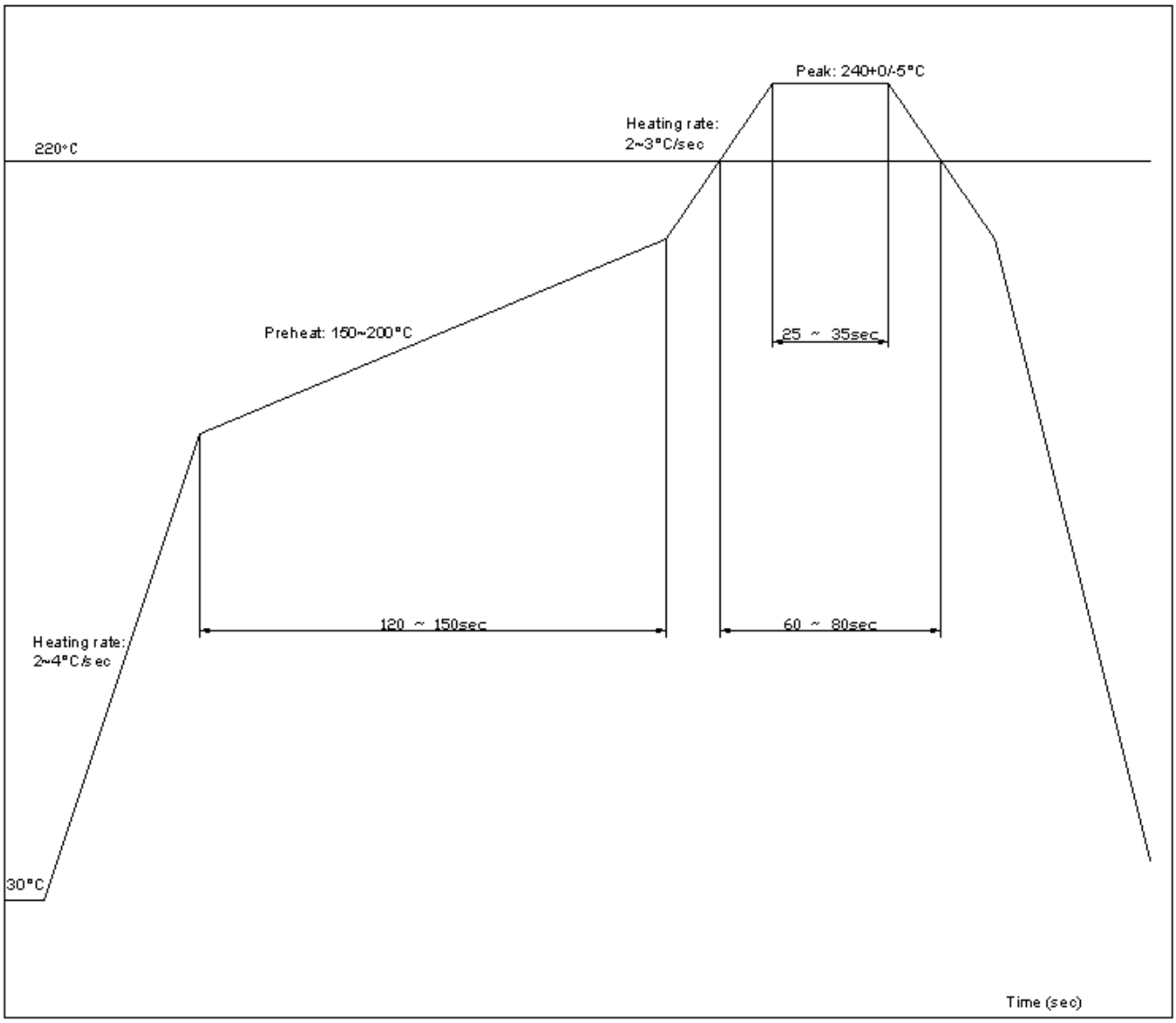
13 Recommended soldering reflow profile

The module belongs to RoHS device. The maximum of reflow temperature, real on top of PCB, is not over 240 Celsius.

Lead-free Processes



Lead –Free Solder Paste (Sn 96.5-Ag 3.0-Cu 0.5) Cycle Interval: 300 sec

Note: The TD-1612-DBX module should be soldered on the topside in the soldering process to prevent from falling down.

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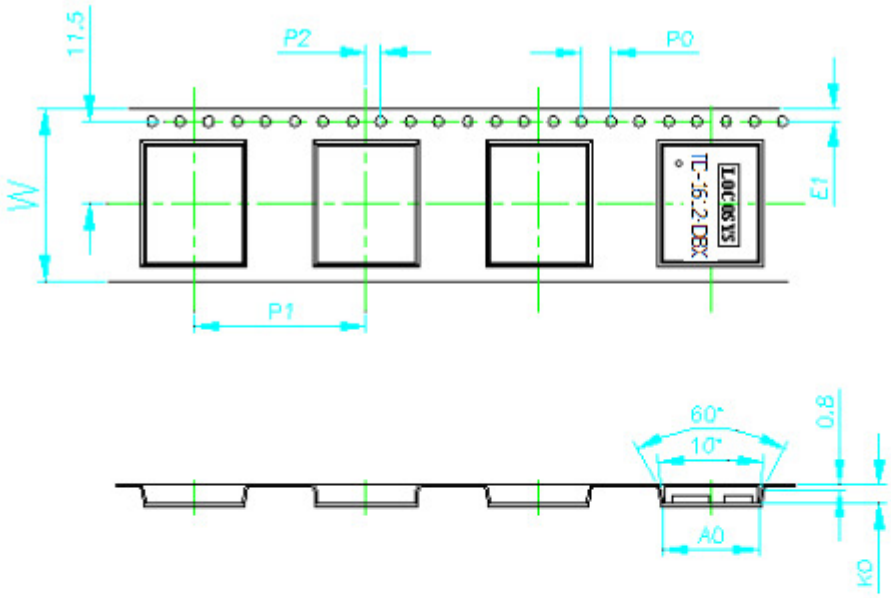
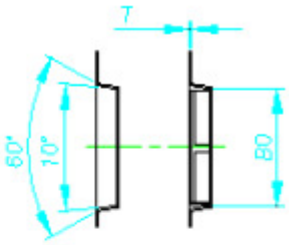
14 Reel packing information





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
7. Packimg length per 22"reel: 75 M

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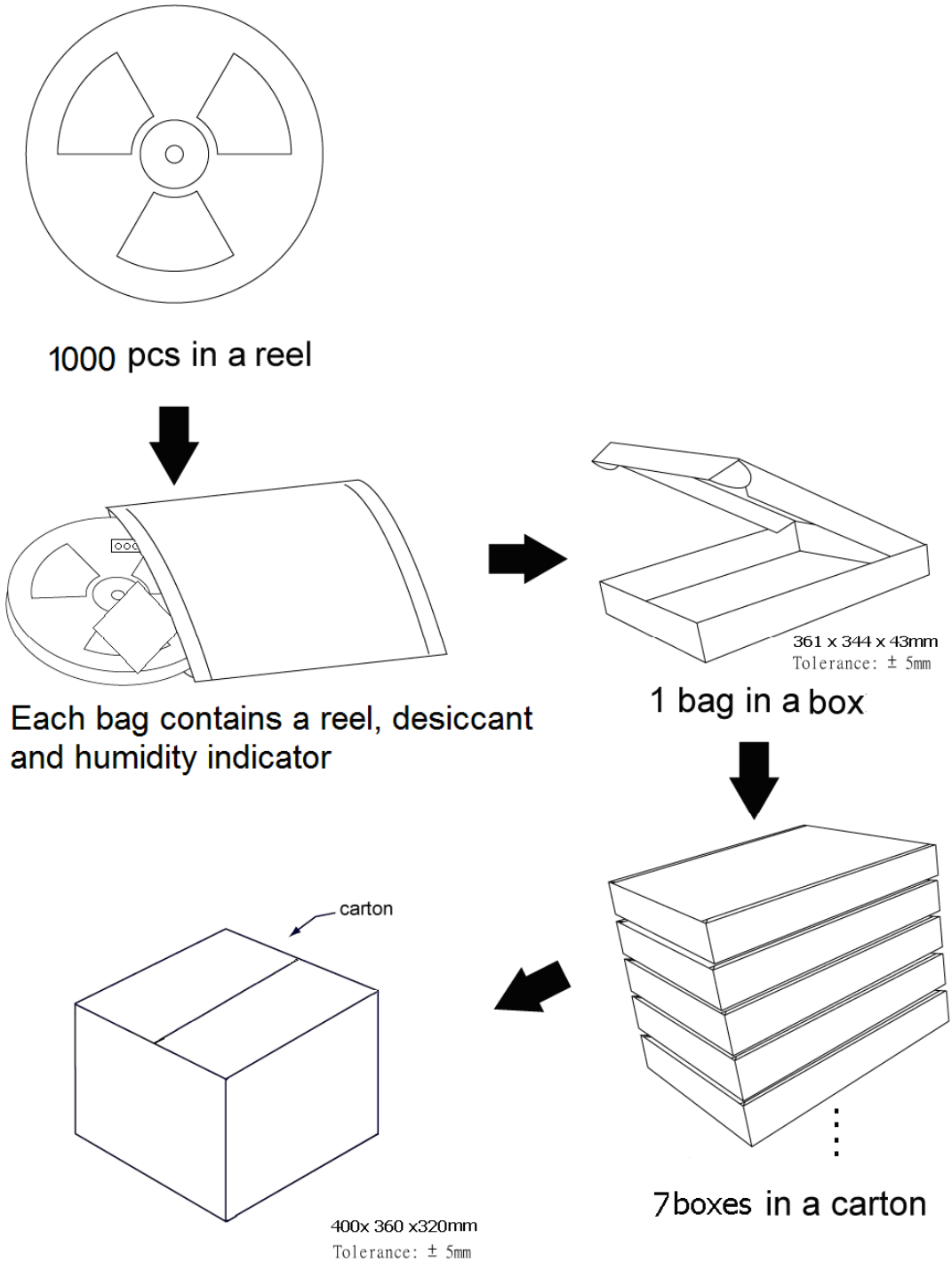
15 Packing and Handling

GNSS modules, like any other SMD devices, are sensitive to moisture, electrostatic discharge, and temperature. By following the description sketched in the document for LOCOSYS GNSS module storage and handling, it is possible to reduce the chances of them being damaged during production.

15.1 Packing



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15.2 Moisture Sensitivity

The module belongs to moisture sensitive device (IPC/JEDEC J-STD-020C Level III). If it is not used by then, we strong recommended storing the GNSS modules in dry places such as dry cabinet. The approximate shelf life for LOCOSYS GNSS modules packages is 6 months from the bag seal date, when store in a non-condensing storage environment (<30°C/60% RH)

15.3 ESD Handling

Please carefully follow the following precautions to prevent severe damage to GNSS modules.

LOCOSYS GNSS modules are sensitive to electrostatic discharges, and thus are Electrostatic Sensitive Devices (ESD). Careful handling of the GNSS modules and in particular RFIN pin must follow the standard ESD safety protections:

- Unless there is a galvanic coupling between the local GND and the PCB GND, then the first point of contact when handling the PCB shall always be between the local GND and PCB GND.
- Before working with RFIN pin, please make sure the GND is connected.
- When working with RFIN pin, do not contact any charges capacitors or materials that can easily develop or store charges such as patch antenna, coax cable, soldering iron.
- When soldering RFIN pin, please make sure to use an ESD safe soldering iron (tip).

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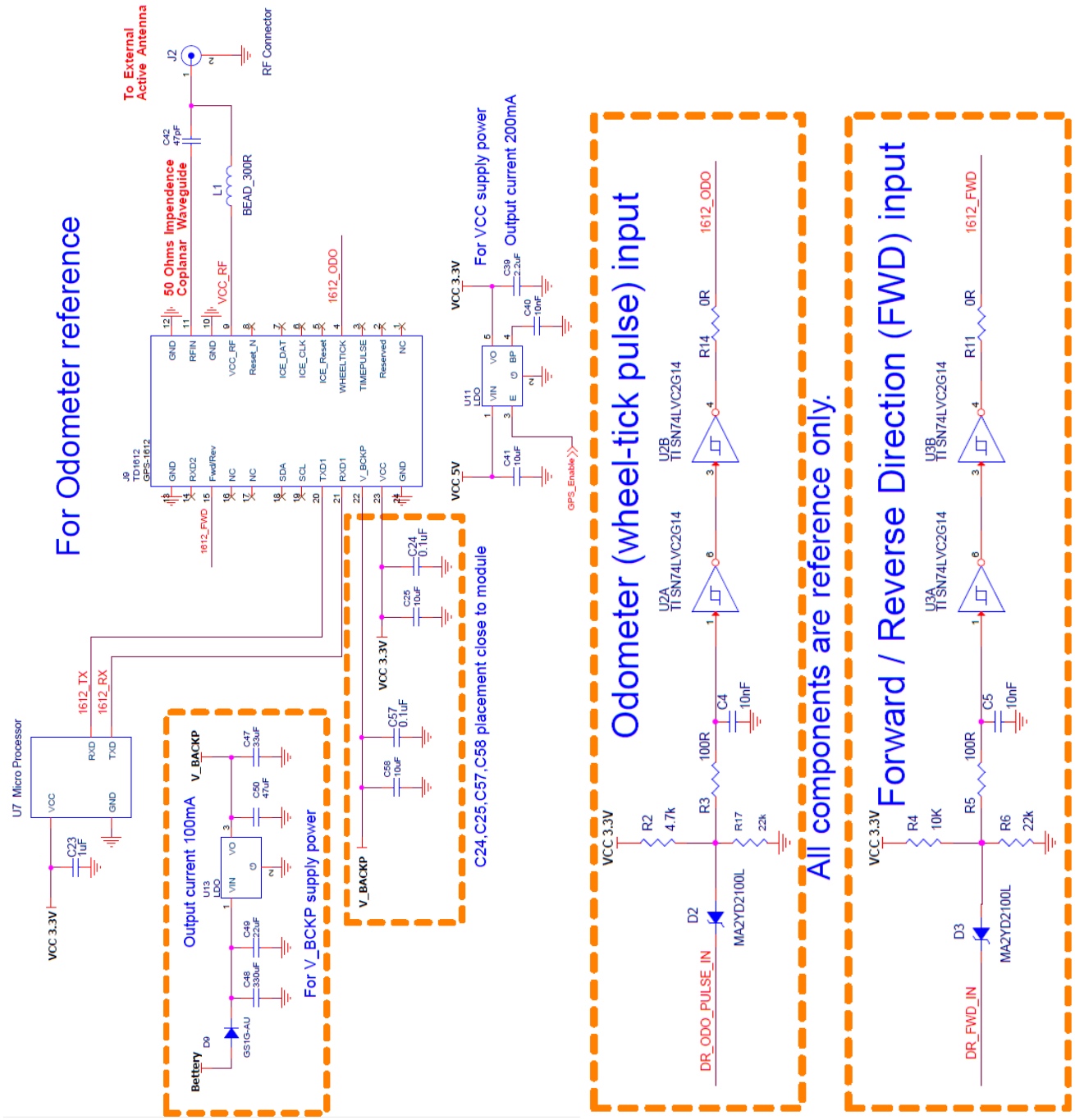
16 Reference Circuit

16.1 For Odometer (wheel-tick pulse) input reference



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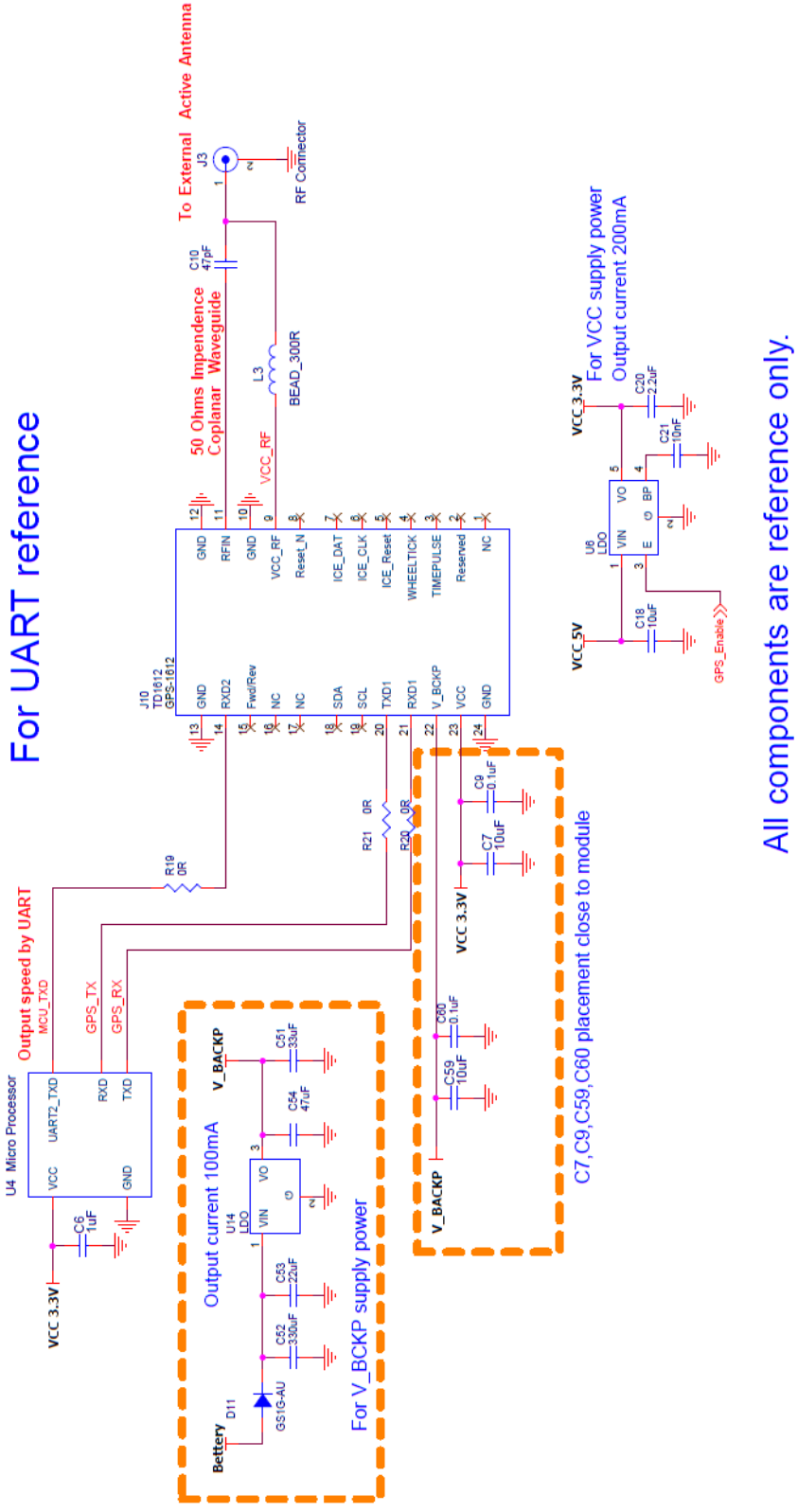
16.2 For UART input Reference



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Document change list

Revision 0.3

- Draft release on Mar. 15, 2019.

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