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Product name	Description	Version
LS26030-UDG	GNSS UDR module of PCIe Full-Mini card	0.2
LS26031-UDG	GNSS UDR module of PCIe Half-Mini card	

1 Introduction

LOCOSYS LS26030-UDG and LS26031-UDG are GNSS untethered dead reckoning (UDR) modules incorporated into the PCIe Full-Mini card or PCIe Half-Mini card. They not only support GPS, GLONASS, GALILEO and QZSS, but also have inertial sensors (3-axis accelerometers and 3-axis gyros) to provide dead reckoning. Besides, USB interface makes these modules easy to integrate into the industrial PC that is mounted on the bus or construction vehicles, such as trailer, truck, crane and excavator.

Both raw data of the inertial sensors and vehicle's altitude including pitch, roll and heading angles can be outputted for the driver behavior analysis. For example, the internet connected vehicles can automatically send emergency calls (e.g., 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, LS26030-UDG and LS26031-UDG 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 navigation.

2 Features

- USB interface
- Support GPS, GLONASS, GALILEO and QZSS
- Fast TTFF at low signal level
- Built-in MEMS sensor (3-axis gyroscope and 3-axis accelerometer)
- Support MEMS raw data output
- Built-in 12 multi-tone active interference canceller
- Built-in micro battery to reserve system data for rapid satellite acquisition

3 Application

- IPC with GNSS function

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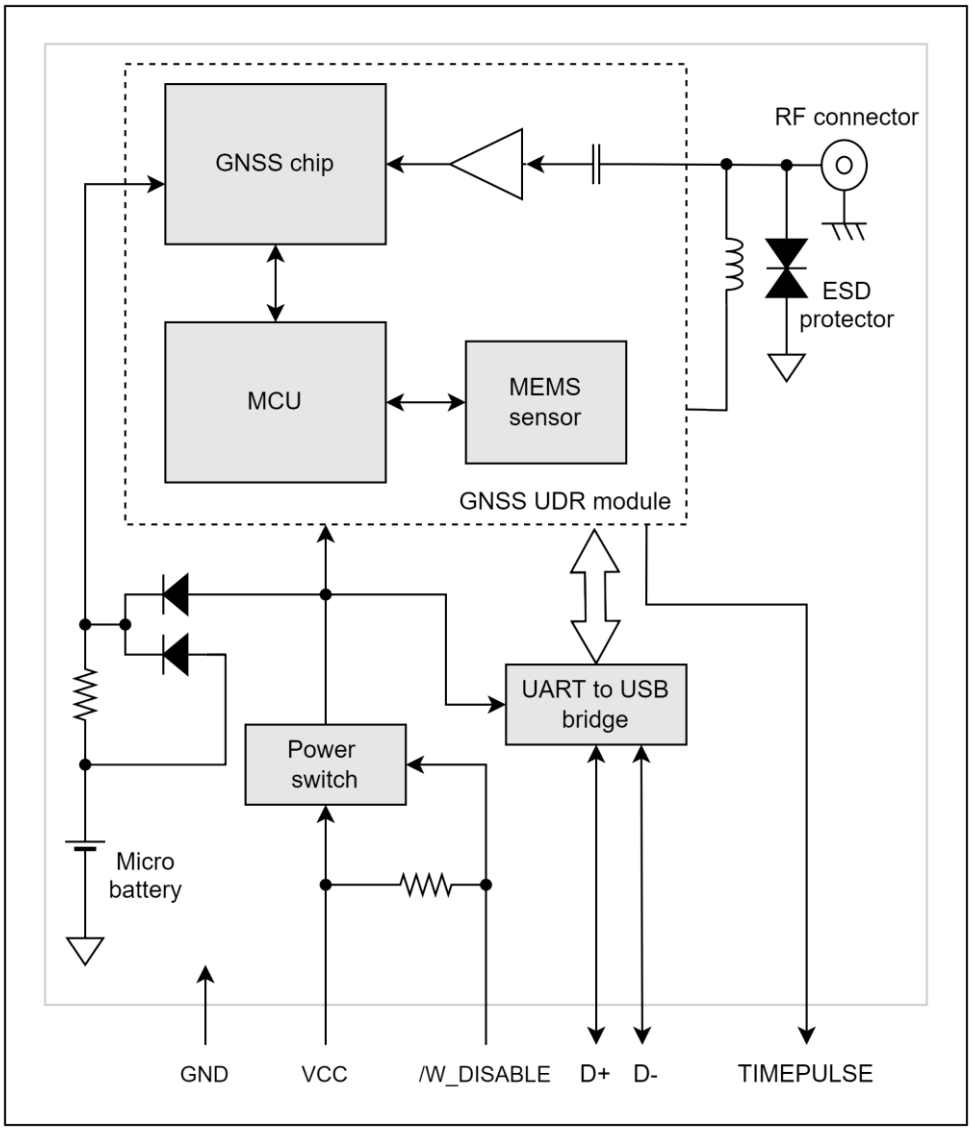

Fig 3-1 System block diagram.

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4 GNSS receiver

Frequency	GPS, GALILEO (1), QZSS: L1 1575.42MHz, C/A code GLONASS: L1 1598.0625MHz ~ 1605.375MHz, C/A code	
Channels	Support 99 channels (33 Tracking, 99 Acquisition)	
Update rate	1Hz default, up to 10Hz by request	
Sensitivity	Tracking	Up to -163dBm (with external LNA)
	Cold start	Up to -148dBm (with external LNA)
Acquisition Time	Hot start (Open Sky)	1s (typical)
	Cold Start (Open Sky)	34s (typical)
Position Accuracy	Autonomous	2.5m CEP
	UDR	CEP ≤ 10% of distance travelled without GNSS (2)
Max. Altitude	< 18,000 m	
Max. Velocity	< 515 m/s	
Protocol Support	NMEA 0183 ver 4.10	115200 bps (3), 8 data bits, no parity, 1 stop bits (default) 1Hz: GGA, GLL, GSA, GSV, RMC, VTG, GST, PLSVD, PINVMSLOPE, PINVMATTIT and PINVMINR

<Note>

1. LS2603x-UDG is default configured for concurrent GPS, GLONASS, GALILEO and QZSS reception. Please contact us for different default configuration, such as concurrent GPS, GLONASS, BEIDOU and QZSS.
2. Test condition: after calibration, drive at 30 km/h for 60 seconds without GNSS signals.
3. Both baud rate and output message rate are configurable to be factory default.

5 Software interface

5.1 NMEA output message

Table 5.1-1 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

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

Table 5.1-2 contains the values for the following example:

$GNGGA,070400.00,2503.71493,N,12138.74656,E,1,14,0.73,123.83,M,15.32,M,,0000*4D

Table5.1- 2 GGA Data Format

Name	Example	Units	Description
Message ID	$GNGGA		GGA protocol header
UTC Time	070400.00		hhmmss.ss
Latitude	2503.71493		ddmm.mmmmm
N/S indicator	N		N=north or S=south
Longitude	12138.74656		dddmm.mmmmm
E/W Indicator	E		E=east or W=west
Position Fix Indicator	1		See Table 5.1-3
Satellites Used	14		Range 0 to 33
HDOP	0.73		Horizontal Dilution of Precision
MSL Altitude	123.83	meters	
Units	M	meters	
Geoid Separation	15.32	meters	
Units	M	meters	
Age of Diff. Corr.		second	Null
Diff. Ref. Station ID	0000		
Checksum	*4D		
<CR> <LF>			End of message termination

Table 5.1-3 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
6	Dead Reckoning Mode, fix valid

● GLL--- Geographic Position – Latitude/Longitude

Table 5.1-4 contains the values for the following example:

$GNGLL,2503.71493,N,12138.74656,E,070400.00,A,A*77

Table 5.1-4 GLL Data Format

Name	Example	Units	Description
Message ID	$GNGLL		GLL protocol header
Latitude	2503.71493		ddmm.mmmmm
N/S indicator	N		N=north or S=south
Longitude	12138.74656		dddmm.mmmmm
E/W indicator	E		E=east or W=west
UTC Time	070400.00		hhmmss.ss

Status	A		A=data valid or V=data not valid
Mode	A		N = No position fix A = Autonomous GNSS fix D = Differential GNSS fix R = RTK fixed F = RTK float E = Estimated/Dead reckoning fix
Checksum	*77		
<CR> <LF>			End of message termination

● GSA---GNSS DOP and Active Satellites

Table 5.1-5 contains the values for the following example:

$GNGSA,A,3,26,31,32,03,193,29,195,16,25,10,,,1.30,0.73,1.08,1*06

$GNGSA,A,3,74,,,,,,,,,,,1.30,0.73,1.08,2*0E

$GNGSA,A,3,08,30,03,,,,,,,,,1.30,0.73,1.08,3*04

Table 5.1-5 GSA Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GNGSA		GSA protocol header,
Mode 1	A		See Table 5.1-6
Mode 2	3		See Table 5.1-7
ID of satellite used	26		Sv on Channel 1
ID of satellite used	31		Sv on Channel 2
….			….
ID of satellite used			Sv on Channel 12
PDOP	1.30		Position Dilution of Precision
HDOP	0.73		Horizontal Dilution of Precision
VDOP	1.08		Vertical Dilution of Precision
System ID	1		1: GPS, 2: GLONASS, 3: GALILEO, 4: BEIDOU
Checksum	*06		
<CR> <LF>			End of message termination

Table 5.1-6 Mode 1

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

Table 5.1-7 Mode 2

Value	Description
1	Fix not available

2	2D
3	3D

● GSV---GNSS Satellites in View

Table 5.1-8 contains the values for the following example:

$GPGSV,3,1,11,194,72,048,44,32,68,103,47,26,62,243,47,193,57,151,43,0*61

$GPGSV,3,2,11,31,52,348,44,29,28,078,38,195,24,147,40,16,23,222,37,0*56

$GPGSV,3,3,11,25,21,039,38,10,17,179,41,03,12,315,35,0*5C

$GLGSV,2,1,08,71,63,169,38,72,60,322,38,74,51,338,41,73,23,031,34,1*74

$GLGSV,2,2,08,65,13,331,31,70,13,158,20,84,04,116,,83,03,062,,1*7B

$GAGSV,2,1,07,02,72,351,43,03,62,130,43,08,60,326,45,30,43,242,43,0*7A

$GAGSV,2,2,07,25,27,037,,05,11,137,,07,09,320,,0*4A

Table 5.1-8 GSV Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GPGSV		GSV protocol header GP=GPS/QZSS, GL=GLONASS, GA=GALILEO, BD=BEIDOU
Total number of messages (1)	3		Range 1 to 6
Message number (1)	1		Range 1 to 6
Satellites in view	11		
Satellite ID (2)	194		Channel 1 (Range 01 to 196)
Elevation	72	degrees	Channel 1 (Range 00 to 90)
Azimuth	048	degrees	Channel 1 (Range 000 to 359)
SNR (C/No)	44	dB-Hz	Channel 1 (Range 00 to 99, null when not tracking)
Satellite ID	32		Channel 4 (Range 01 to 196)
Elevation	68	degrees	Channel 4 (Range 00 to 90)
Azimuth	103	degrees	Channel 4 (Range 000 to 359)
SNR (C/No)	47	dB-Hz	Channel 4 (Range 00 to 99, null when not tracking)
	…		
Signal ID	0		GPS/QZSS: All signal=0, GLONASS: All signal=0, G1 C/A=1 GALILEO: All signal=0, BEIDOU: All signal=0
Checksum	*61		
<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: 01~32, SBAS: 33~64, QZSS: 193~196, GLONASS: 65 ~ 96, BEIDOU: 01~32, GALILEO: 01~32.

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● RMC---Recommended Minimum Specific GNSS Data

Table 5.1-9 contains the values for the following example:

$GNRMC,070400.00,A,2503.71493,N,12138.74656,E,0.01,0.00,061221,,,A,V*3D

Table 5.1-9 RMC Data Format

Name	Example	Units	Description
Message ID	$GNRMC		RMC protocol header
UTC Time	070400.00		hhmmss.ss
Status	A		A=data valid or V=data not valid
Latitude	2503.71493		ddmm.mmmmm
N/S Indicator	N		N=north or S=south
Longitude	12138.74656		dddmm.mmmmm
E/W Indicator	E		E=east or W=west
Speed over ground	0.01	knots	True
Course over ground	0.00	degrees	
Date	061221		ddmmyy
Magnetic variation		degrees	Null
Variation sense			Null
Mode	A		N = No position fix A = Autonomous GNSS fix D = Differential GNSS fix R = RTK fixed F = RTK float E = Estimated/Dead reckoning fix
Navigational status indicator	V		S = Safe C = Caution U = Unsafe V = Void
Checksum	*3D		
<CR> <LF>			End of message termination

● VTG---Course Over Ground and Ground Speed

Table 5.1-10 contains the values for the following example:

$GNVTG,0.00,T,,M,0.01,N,0.02,K,A*20

Table 5.1-10 VTG Data Format

Name	Example	Units	Description
Message ID	$GNVTG		VTG protocol header
Course over ground	0.00	degrees	Measured heading

Reference	T		True
Course over ground		degrees	Measured heading (null)
Reference	M		Magnetic
Speed over ground	0.01	knots	Measured speed
Units	N		Knots
Speed over ground	0.02	km/hr	Measured speed
Units	K		Kilometer per hour
Mode	A		N = No position fix A = Autonomous GNSS fix D = Differential GNSS fix R = RTK fixed F = RTK float E = Estimated/Dead reckoning fix
Checksum	*20		
<CR> <LF>			End of message termination

● GST---Estimated Position Error

Table 5.1-11 contains the values for the following example:

$GNGST,070400.00,2.3,2.4,2.1,75.1,0.67,0.69,0.81*4A

Table 5.1-11 GST Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GNGST		GST protocol header
UTC Time	070400.00		hhmmss.ss
RangeRMS	2.3	meters	RMS value of the standard deviation of the ranges
stdMajor	2.4	meters	Standard deviation of semi-major axis of error ellipse
stdMinor	2.1	meters	Standard deviation of semi-minor axis of error ellipse
Orient	75.1	degrees	Orientation of semi-major axis of error ellipse
stdLat	0.67	meters	Standard deviation of latitude error
stdLong	0.69	meters	Standard deviation of longitude error
stdAlt	0.81	meters	Standard deviation of altitude error
Checksum	*4A		
<CR> <LF>			End of message termination

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5.2 Proprietary output message

Table 5.2-1 Proprietary output message

NMEA like record	Description
$PLSVD	Velocity estimate
$PINVMINR	Calibration status
$PINVMSLOPE	Slope information
$PINVMATTIT	Attitude information
$PINVMIMU	MEMS raw data

● PLSVD--- Velocity Estimate

Table 5.2-2 contains the values for the following example:

$PLSVD,0,0,0,4,3,3*59

Table5.2- 2 PLSVD Data Format

Name	Example	Units	Description
Message ID	$PLSVD		PLSVD protocol header
VE	0	cm/s	Velocity in east (-51500~51500)
VN	0	cm/s	Velocity in north (-51500~51500)
VD	0	cm/s	Velocity in down (-10000~10000)
stdVE	4	cm/s	Standard deviation of velocity error in east
stdVN	3	cm/s	Standard deviation of velocity error in north
stdVD	3	cm/s	Standard deviation of velocity error in down
Checksum	*59		
<CR> <LF>			End of message termination

● $PINVMINR --- Calibration status

Table 5.2-3 contains the values for the following example:

$PINVMINR,1*04

Table 5.2-3 PINVMINR Data Format

Name	Example	Units	Description
Message ID	$PINVMINR		$PINVMINR protocol header
Status	1		0: wait for calibration 1: calibration is in progress 2: calibration is in progress 3: calibration is done
Checksum	*04		
<CR> <LF>			End of message termination

● $PINVMSLOPE --- Slope information

Table 5.2-4 contains the values for the following example:

$PINVMSLOPE,-3.13,-0.05,0.93,54.42,2.60,1.86*3B

Table 5.2-4 PINVMSLOPE Data Format

Name	Example	Units	Description
Message ID	$PINVMSLOPE		$PINVMSLOPE protocol header
Slope	-3.13	degree	slope + : up ; - : down
Alt_Diff	-0.05	meters	altitude difference , + : up ; - : down
Move_Dist	0.93	meters	move distance
Slope_Accu	54.42	degree	slope accuracy
Alt_Diff_Accu	2.60	meters	altitude difference accuracy
Move_Dist_Accu	1.86	meters	move distance accuracy
Checksum	*3B		
<CR> <LF>			End of message termination

<Note> The data is valid only when the calibration is done.

● PINVMATTIT --- Attitude information

Table 5.2-5 contains the values for the following example:

$PINVMATTIT,-20.652,32.265,0.000*3C

Table 5.2-5 $PINVMATTIT Data Format

Name	Example	Units	Description
Message ID	$PINVMATTIT		$PINVMATTIT protocol header
Roll	-20.652	degree	Vehicle roll.
Pitch	32.265	degree	Vehicle pitch.
Heading	0.000	degree	Vehicle heading.
Checksum	*3C		
<CR> <LF>			End of message termination

<Note> The data is valid only when the calibration is done.

● $PINVMIMU --- IMU raw data

Table 5.2-6 contains the values for the following example:

$PINVMIMU,1114.106,-0.36990,1.51074,9.81383,0.67139,0.61035,-0.30518*22

Table 5.2-6 PINVMIMU Data Format

Name	Example	Units	Description

Message ID	$PINVMIMU		$PINVMIMU protocol header
Time_Second	1114.106	sec	Time stamp
Accel_X	-0.36990	m/s^2	Accel_X output data of MEMS sensor
Accel_Y	1.51074	m/s^2	Accel_Y output data of MEMS sensor
Accel_Z	9.81383	m/s^2	Accel_Z output data of MEMS sensor
Gyro_X	0.67139	degree /s	Gyro_X output data of MEMS sensor
Gyro_Y	0.61035	degree /s	Gyro_Y output data of MEMS sensor
Gyro_Z	-0.30518	degree /s	Gyro_Z output data of MEMS sensor
Checksum	*22		
<CR> <LF>			End of message termination

<Note> The raw data is 100Hz.

5.3 Proprietary input command

Table 5.3-1 Proprietary input message

NMEA like record	Description
$PINVCRES	Clear DR NVM data
$PINVCSTR	Restart DR calibration
$PLSC,MEMS	Enable/disable output MEMS raw data
$PMTK101	Perform GNSS hot start
$PMTK102	Perform GNSS warm start
$PMTK103	Perform GNSS cold start
$PMTK104	Perform GNSS full cold start
$PLSC,VER	Query firmware version

- **$PINVCRES ---Clear DR NVM data**

Table 5.3-2 contains the values for the following example:

$PINVCRES,0*1A

Table 5.3-2 PINVCRES Data Format

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

- **$PINVCSTR --- Restart DR calibration**

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Table 5.3-3 contains the values for the following example:

$PINVCSTR,14*3E

Table 5.3-3 PINVCSTR Data Format

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

- **$PLSC,MEMS --- Enable/disable output MEMS raw data**

Table 5.3-4 contains the values for the following example:

$PLSC,MEMS,1*2B

Table 5.3-4 PLSC,MEMS Data Format

Name	Example	Units	Description
Message ID	$PLSC,MEMS		$PLSC,MEMS protocol header
Enable/Disable	1		1: enable. The response is “$PLSR,MEMS,1,OK*12”. 0: disable. The response is “$PLSR,MEMS,0,OK*13”.
Checksum	*2B		
<CR> <LF>			End of message termination

- **$PMTK101 --- Perform GNSS hot start**

Table 5.3-5 contains the values for the following example:

$PMTK101*32

Table 5.3-5 PMTK101 Data Format

Name	Example	Units	Description
Message ID	$PMTK101		$PMTK101 protocol header
Checksum	*32		
<CR> <LF>			End of message termination

- **$PMTK102 --- Perform GNSS warm start**

Table 5.3-6 contains the values for the following example:

$PMTK102*31

Table 5.3-6 PMTK102 Data Format

Name	Example	Units	Description
Message ID	$PMTK102		$PMTK102 protocol header
Checksum	*31		
<CR> <LF>			End of message termination

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● $PMTK103 --- Perform GNSS cold start

Table 5.3-7 contains the values for the following example:

$PMTK103*30

Table 5.3-7 PMTK103 Data Format

Name	Example	Units	Description
Message ID	$PMTK103		$PMTK103 protocol header
Checksum	*30		
<CR> <LF>			End of message termination

● $PMTK104 --- Perform GNSS full cold start

Table 5.3-8 contains the values for the following example:

$PMTK104*37

Table 5.3-8 PMTK104 Data Format

Name	Example	Units	Description
Message ID	$PMTK104		$PMTK104 protocol header
Checksum	*37		
<CR> <LF>			End of message termination

● $PLSC,VER --- Query firmware version

Table 5.3-9 contains the values for the following example:

$PLSC,VER*61

Table 5.3-9 PLSC,VER Data Format

Name	Example	Units	Description
Message ID	$PLSC,VER		$PLSC,VER protocol header
Checksum	*61		
<CR> <LF>			End of message termination

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6 Pin assignment and descriptions

Table 6-1 Pin descriptions of PCIe Mini card

Pin #	Name	Type	Description	Note
1	NC			
2	NC			
3	NC			
4	GND	P	Ground	
5	NC			
6	NC			
7	NC			
8	NC			
9	GND	P	Ground	
10	NC			
11	NC			
12	NC			
13	NC			
14	NC			
15	GND	P	Ground	
16	NC			
17	NC			
18	GND	P	Ground	
19	NC			
20	/W_DISABLE	I	Power control input pin. Internal pull-up resistor. High: power on; Low: power off	
21	GND	P	Ground	
22	NC			
23	NC			
24	NC			
25	NC			
26	GND	P	Ground	
27	GND	P	Ground	
28	NC			
29	GND	P	Ground	
30	NC			
31	NC			
32	NC			

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33	NC			
34	GND	P	Ground	
35	GND	P	Ground	
36	USB_D-		USB D- line	
37	GND	P	Ground	
38	USB_D+		USB D+ line	
39	NC			
40	GND	P	Ground	
41	NC			
42	NC			
43	GND	P	Ground	
44	NC			
45	NC			
46	NC			
47	NC			
48	NC			
49	TIMEMARK	O	Time pulse (1PPS, default 100 ms pulse/sec when 3D position fix is available)	
50	GND	P	Ground	
51	NC			
52	VCC	P	Power input	

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7 DC & Temperature characteristics

7.1 DC Electrical characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Input Voltage	VCC		3.0		3.6	V
Supply Current	Iss	VCC = 3.3V, Peak Acquisition Tracking Power off		 108 97 (1) <1 (2)	230	 mA mA mA uA
High Level Input Voltage	V_{IH}	/W_DISABLE pin	1.3		VCC	V
Low Level Input Voltage	V_{IL}	/W_DISABLE pin			0.25	V
High Level Input Current	I_{IH}	/W_DISABLE pin	-5		1	uA
Low Level Input Current	I_{IL}	/W_DISABLE pin	-5		1	uA

<Note>

1. Measured when position fix (1Hz) is available and input voltage is 3.3V.
2. Measured when /W_DISABLE pin is at low level.

7.2 Temperature characteristics

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

Note: The operating and storage temperature of the built-in micro battery are -20 ~ +60 ℃ and -40 ~ +60 ℃ respectively. GNSS module will still work even the battery is broken or short due to temperature or other issues.

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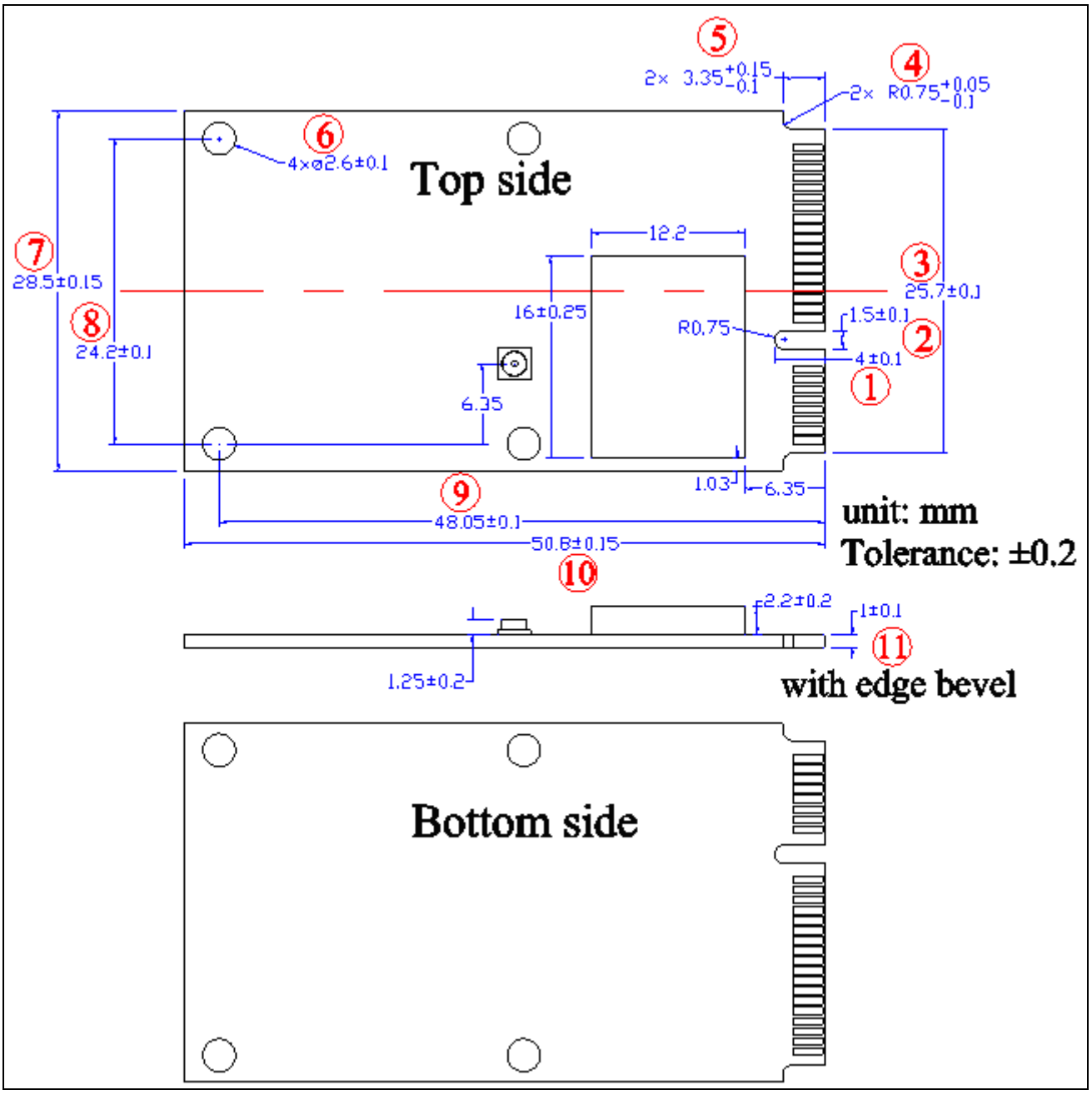
8 Mechanical specification

The dimension and pin definition are compliant with PCI Express Mini Card Revision 1.2.

8.1 Outline dimensions of LS26030-UDG



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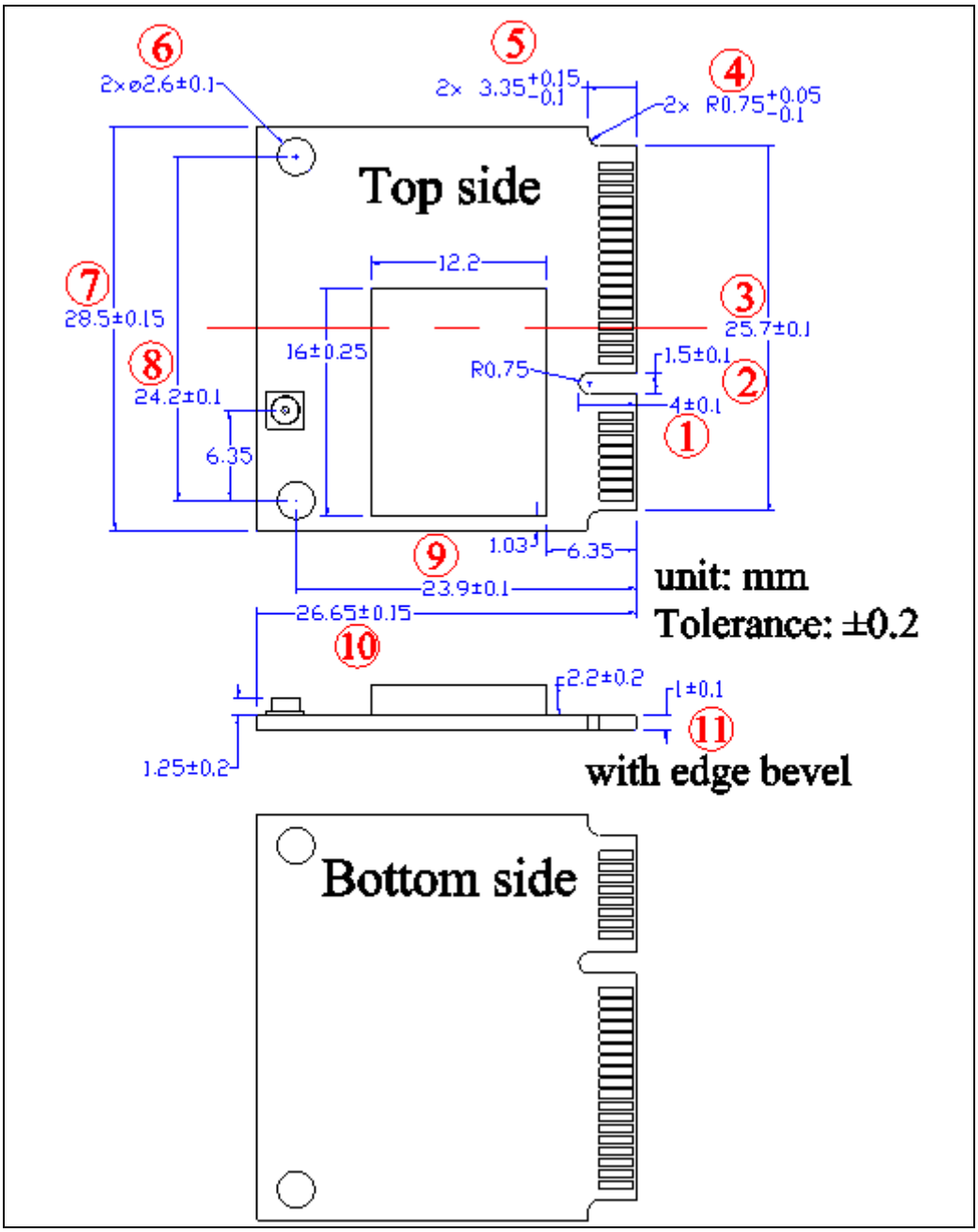
8.2 Outline dimensions of LS26031-UDG



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.

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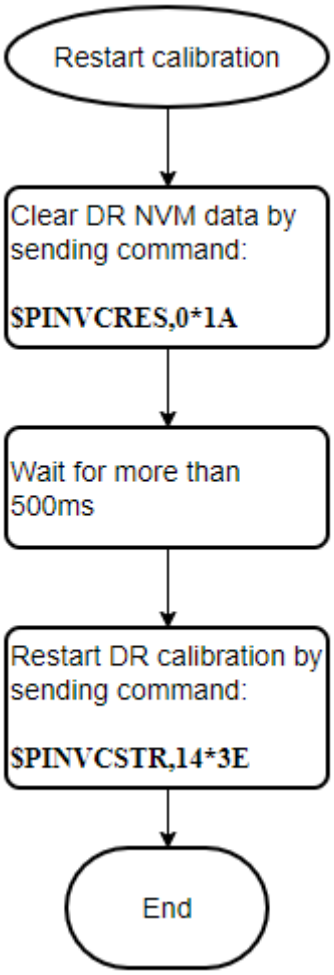
3. Drive in the straight road at the speed above 30km/h for more than 5 minutes in the open sky environment.
4. Accelerate and decelerate linearly more than 5 times in the open sky environment.
5. Complete 2 or more 90-degree turns in the open sky environment.
6. The calibration status in the message "**$PINVMINR**" shows if the calibration is done.

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 flowchart. Then the module will restart the initialization and calibration.



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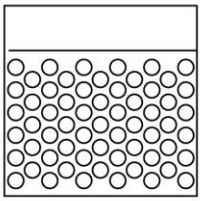
9 Packing information

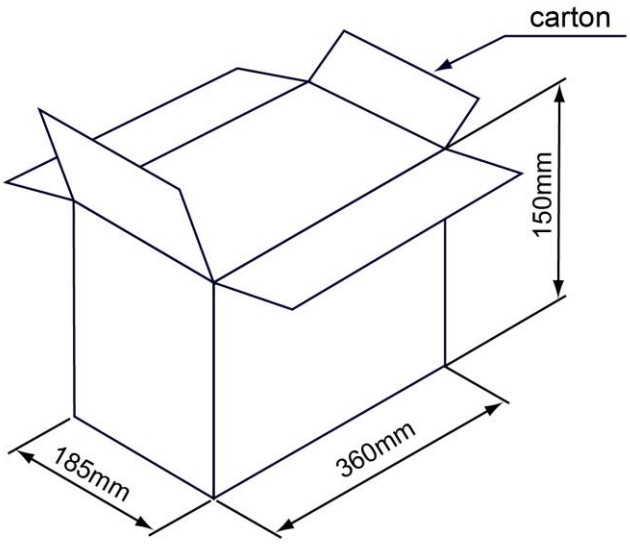
Both LS26030-UDG and LS26031-UDG use the same package.

1pcs in an antistatic bag



6pcs in a bubble bag

30 bubble bags in a carton
(180pcs)



Tolerance: ±10 mm

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Document change list

Revision 0.1

- Draft release on December 7, 2021.

Revision 0.2 (December 22, 2021)

- Changed the packaging in section 9.