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Product name	Description	Version
LS20026	Stand-alone GPS smart antenna module/SS3LP,9600BPS	1.1

Datasheet of stand-alone GPS smart antenna module, LS20026

1 Introduction

LS20026 is a complete stand-alone GPS smart antenna module, including embedded patch antenna and GPS receiver circuits, dedicated designed for cellular phones that are going to integrate GPS function. The module is powered by SiRF Star III and can track up to 20 satellites at a time while providing fast time-to-first-fix, one-second navigation update and low power consumption. Besides, it can provide you with superior sensitivity and performance even in urban canyon and dense foliage environment.

It is easy to install without both RF connector and coaxial cable that are needed in a separated active antenna. In other words, reduce the cost and size. Also, speed up the time to market by eliminating R&D efforts on RF matching and stability between separated GPS antenna and module. Furthermore, it can be directly powered by a lithium battery without any external voltage regulars. A built-in hardware enable pin provides the convenience to turn on/off the module. Therefore, LS20026 of miniature size and brilliant performance is the best choice to be integrated into your slim cellular phones.

2 Features

- Optimal RF design for cellular phone
- Easy to install (SMT process capable)
- SiRF Star III high sensitivity solution
- Support 20-channel GPS
- Fast TTFF at low signal level
- Capable of SBAS (WAAS, EGNOS, MSAS)
- Pin-to-pin compatible with LS20036 (MediaTek solution) and LS20056 (u-Nav solution)

3 Application

- Cellular phones with GPS function
- GPS personal tracker
- Mobile internet device with GPS function

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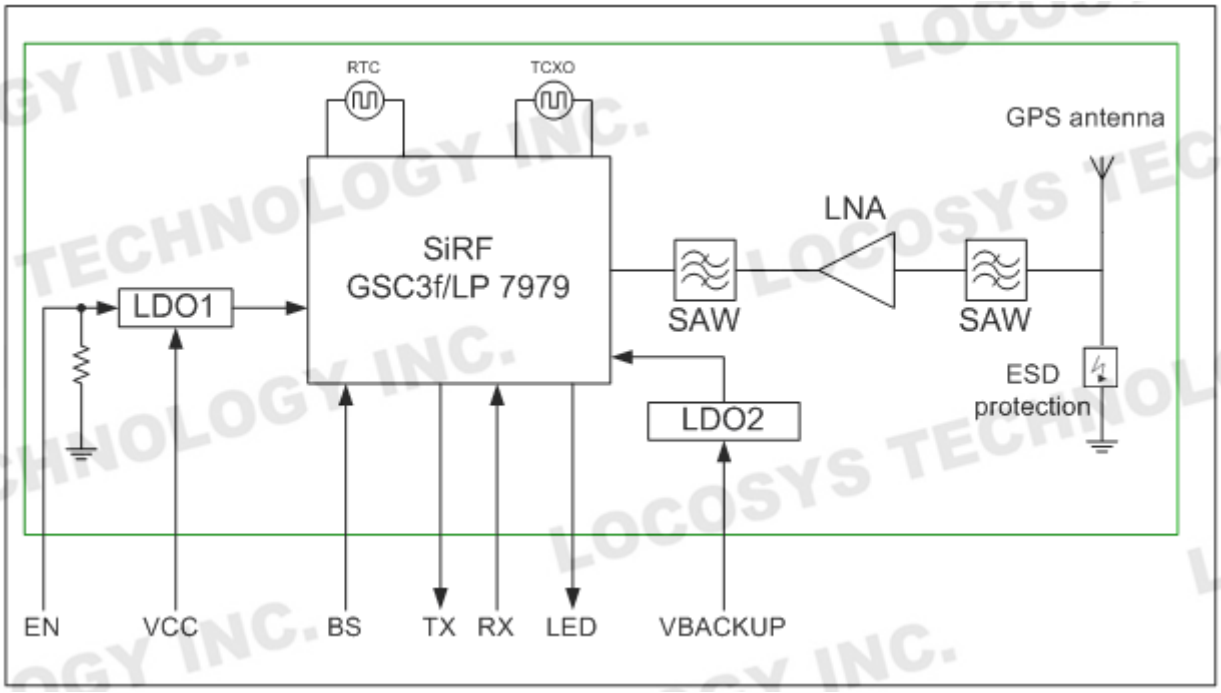

Fig 3-1 System block diagram of LS20026

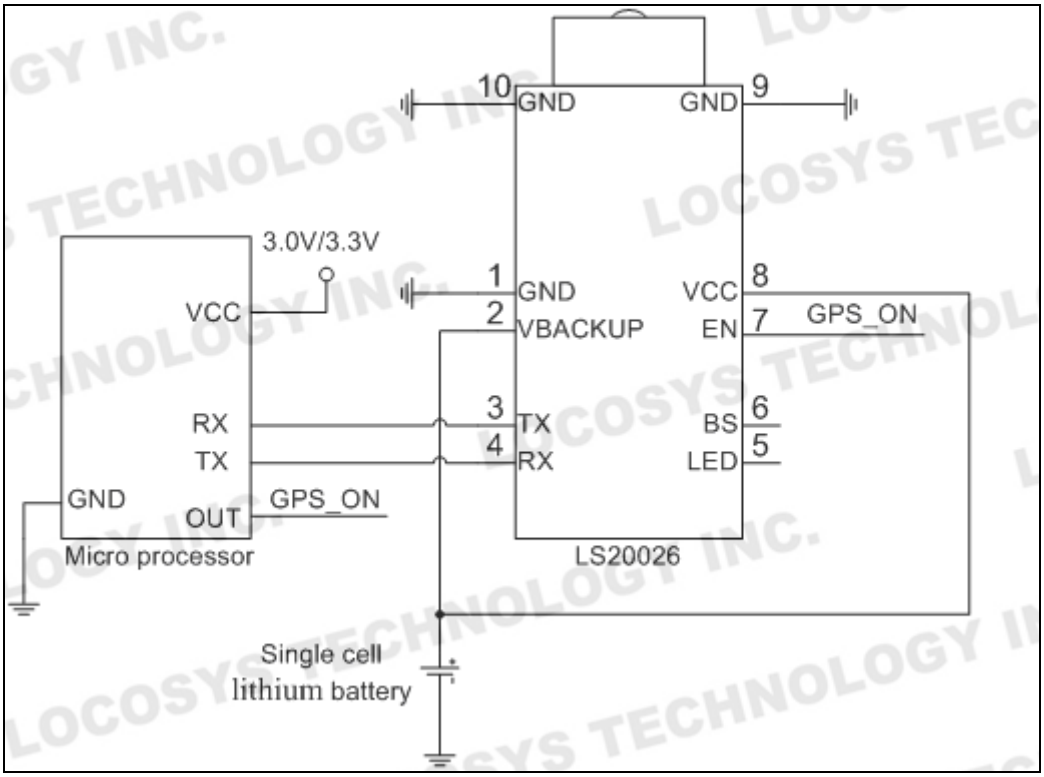

Fig 3-2 Typical application circuit (1)

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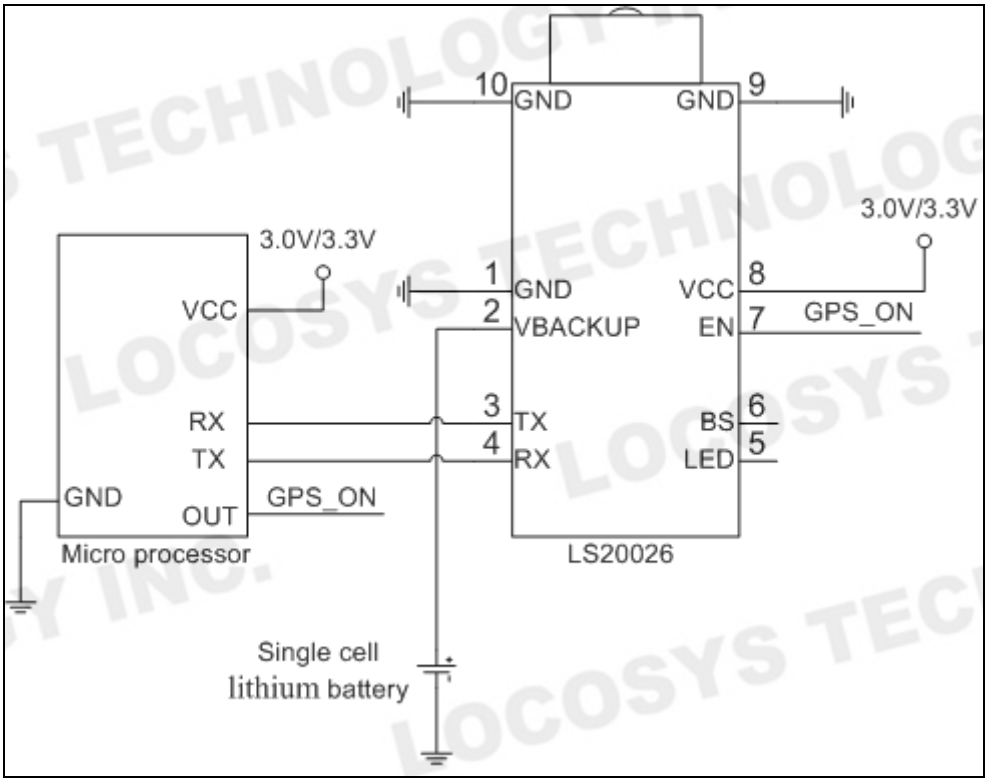

Fig 3-3 Typical application circuit (2)

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4 GPS receiver and antenna

4.1 GPS receiver

Chip	SiRF Star III, GSC3f/LPx 7989	
Frequency	L1 1575.42MHz, C/A code	
Channels	Support 20 channels	
Update rate	1Hz	
Acquisition Time	Hot start (Open Sky)	< 2s
	Cold Start (Open Sky)	35s (typical)
Position Accuracy	Autonomous	< 10m (2D RMS)
	SBAS	< 5m (2D RMS)
Datum	WGS-84 (default)	
Max. Altitude	< 18,000 m	
Max. Velocity	< 515 m/s	
Protocol	NMEA 0183 ver 3.0	9600 bps (1), 8 data bits, no parity, 1 stop bits 1Hz: GGA, GLL, GSA, GSV, RMC, VTG

Note 1: Both baud rate and output message rate are configurable.

4.2 GPS antenna

Antenna type	Patch antenna
Polarization	RHCP
Frequency Range	1575.42MHz ± 1.023MHz (1)
Gain	-2 dBic Typ. @zenith (1)
Axial ratio	Max 4.0dB @zenith (1)

Note 1: This value is measured with evaluation board and must be fine tuned when installed into your device.

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

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

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

$GPGGA,053740.000,2503.6319,N,12136.0099,E,1,08,1.1,63.8,M,15.2,M,,0000*64

Table5.1- 2 GGA Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GPGGA		GGA protocol header
UTC Time	053740.000		hhmmss.sss
Latitude	2503.6319		ddmm.mmmm
N/S indicator	N		N=north or S=south
Longitude	12136.0099		dddmm.mmmm
E/W Indicator	E		E=east or W=west
Position Fix Indicator	1		See Table 5.1-3
Satellites Used	08		Range 0 to 12
HDOP	1.1		Horizontal Dilution of Precision
MSL Altitude	63.8	mters	
Units	M	mters	
Geoid Separation	15.2	mters	
Units	M	mters	
Age of Diff. Corr.		second	Null fields when DGPS is not used
Diff. Ref. Station ID	0000		
Checksum	*64		
<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:

$GPGLL,2503.6319,N,12136.0099,E,053740.000,A,A*52

Table 5.1-4 GLL Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GPGLL		GLL protocol header
Latitude	2503.6319		ddmm.mmmm

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N/S indicator	N		N=north or S=south
Longitude	12136.0099		dddmm.mmmm
E/W indicator	E		E=east or W=west
UTC Time	053740.000		hhmmss.sss
Status	A		A=data valid or V=data not valid
Mode	A		A=autonomous, D=DGPS, E=DR
Checksum	*52		
<CR> <LF>			End of message termination

● GSA---GNSS DOP and Active Satellites

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

$GPGSA,A,3,24,07,17,11,28,08,20,04,,,,,2.0,1.1,1.7*35

Table 5.1-5 GSA Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GPGSA		GSA protocol header
Mode 1	A		See Table 5.1-6
Mode 2	3		See Table 5.1-7
ID of satellite used	24		Sv on Channel 1
ID of satellite used	07		Sv on Channel 2
….			….
ID of satellite used			Sv on Channel 12
PDOP	2.0		Position Dilution of Precision
HDOP	1.1		Horizontal Dilution of Precision
VDOP	1.7		Vertical Dilution of Precision
Checksum	*35		
<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

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

$GPGSV,3,1,12,28,81,285,42,24,67,302,46,31,54,354,,20,51,077,46*73

$GPGSV,3,2,12,17,41,328,45,07,32,315,45,04,31,250,40,11,25,046,41*75

$GPGSV,3,3,12,08,22,214,38,27,08,190,16,19,05,092,33,23,04,127,*7B

Table 5.1-8 GSV Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GPGSV		GSV protocol header
Total number of messages[1]	3		Range 1 to 3
Message number[1]	1		Range 1 to 3
Satellites in view	12		
Satellite ID	28		Channel 1 (Range 01 to 32)
Elevation	81	degrees	Channel 1 (Range 00 to 90)
Azimuth	285	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	20		Channel 4 (Range 01 to 32)
Elevation	51	degrees	Channel 4 (Range 00 to 90)
Azimuth	077	degrees	Channel 4 (Range 000 to 359)
SNR (C/No)	46	dB-Hz	Channel 4 (Range 00 to 99, null when not tracking)
Checksum	*73		
<CR> <LF>			End of message termination

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

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

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

$GPRMC,053740.000,A,2503.6319,N,12136.0099,E,2.69,79.65,100106,,,A*53

Table 5.1-9 RMC Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GPRMC		RMC protocol header
UTC Time	053740.000		hhmmss.sss
Status	A		A=data valid or V=data not valid
Latitude	2503.6319		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12136.0099		dddmm.mmmm
E/W Indicator	E		E=east or W=west
Speed over ground	2.69	knots	True
Course over ground	79.65	degrees	
Date	100106		ddmmyy

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Magnetic variation		degrees	
Variation sense			E=east or W=west (Not shown)
Mode	A		A=autonomous, D=DGPS, E=DR
Checksum	*53		
<CR> <LF>			End of message termination

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

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

$GPVTG,79.65,T,,M,2.69,N,5.0,K,A*38

Table 5.1-10 VTG Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GPVTG		VTG protocol header
Course over ground	79.65	degrees	Measured heading
Reference	T		True
Course over ground		degrees	Measured heading
Reference	M		Magnetic
Speed over ground	2.69	knots	Measured speed
Units	N		Knots
Speed over ground	5.0	km/hr	Measured speed
Units	K		Kilometer per hour
Mode	A		A=autonomous, D=DGPS, E=DR
Checksum	*38		
<CR> <LF>			End of message termination

5.2 Proprietary NMEA input message

Table 5.2-1 Message Parameters

Start Sequence	Payload	Checksum	End Sequence
$PSRF<MID>[1]	Data[2]	*CKSUM[3]	<CR><LF>[4]

1. Message Identifier consisting of three numeric characters. Input messages begin at MID 100.
2. Message specific data. Refer to a specific message section for <data>…<data> definition.
3. CKSUM is a two-hex character checksum as defined in the NMEA specification, *NMEA-0183Standard For Interfacing Marine Electronic Devices.* Use of checksums is required on all input messages.
4. Each message is terminated using Carriage Return (CR) Line Feed (LF) which is \r\n which is hex 0D0A. Because \r\n are not printable ASCII characters, they are omitted from the example strings, but must be sent to terminate the message and cause the receiver to process that input message.

Note: All fields in all proprietary NMEA messages are required, none are optional. All NMEA messages are comma delimited.

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Table 5.2-2 Proprietary NMEA input messages

Message	MID[1]	Description
SetSerialPort	100	Set PORT A parameters and protocol
NavigationInitialization	101	Parameters required for start using X/Y/Z[2]
SetDGPSPort	102	Set PORT B parameters for DGPS input
Query/Rate Control	103	Query standard NMEA message and/or set output rate
LLANavigationInitialization	104	Parameters required for start using Lat/Lon/Alt[3]
Development Data On/Off	105	Development Data messages On/Off
Select Datum	106	Selection of datum to be used for coordinate transformations

1. Message Identification (MID).
2. Input coordinates must be WGS84.
3. Input coordinates must be WGS84

● 100---SetSerialPort

This command message is used to set the protocol (SiRF binary or NMEA) and/or the communication parameters (Baud, data bits, stop bits, and parity). Generally, this command is used to switch the module back to SiRF binary protocol mode where a more extensive command message set is available. When a valid message is received, the parameters are stored in battery-backed SRAM and the Evaluation Receiver restarts using the saved parameters.

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

Switch to SiRF binary protocol at 9600,8,N,1

$PSRF100,0,9600,8,1,0*0C

Table 5.2-3 Set Serial Port Data Format

Name	**Example**	**Units**	**Description**
Message ID	$PSRF100		PSRF100 protocol header
Protocol	0		0=SiRF binary, 1=NMEA
Baud	9600		4800,9600,19200,38400,57600
DataBits	8		8,7[1]
StopBits	1		0,1
Parity	0		0=None, 1=Odd, 2=Even
Checksum	*0C		
<CR><LF>			End of message termination

1. SiRF protocol is only valid for 8 data bits, 1 stop bit, and no parity.

● 101---NavigationInitialization

This command is used to initialize the Evaluation Receiver by providing current position (in X, Y, Z coordinates), clock offset, and time. This enables the Evaluation Receiver to search for the correct satellite signals at the correct signal parameters. Correct initialization parameters enable the Evaluation Receiver to acquire signals quickly.

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

Start using known position and time

$PSRF101,-2686700,-4304200,3851624,96000,497260,921,12,3*1C

Table 5.2-4 Navigation Initialization Data Format

Name	**Example**	**Units**	**Description**
Message ID	$PSRF101		PSRF101 protocol header
ECEF X	-2686700	meters	X coordinate position
ECEF Y	-4304200	meters	Y coordinate position
ECEF Z	3851624	meters	Z coordinate position
ClkOffset	96000	Hz	Clock Offset of the Evaluation Receiver[1]
TimeOfWeek	497260	seconds	GPS Time Of Week
WeekNo	921		GPS Week Number
ChannelCount	12		Range 1 to 12
ResetCfg	3		See Table 5.2-5
Checksum	*1C		
<CR><LF>			End of message termination

1. Use 0 for last saved value if available. If this is unavailable, a default value of 96000 is used.

Table 5.2-5 Reset Configuration

Hex	Description
0x01	Hot Start – All data valid
0x02	Warm Start – Ephemeris cleared
0x03	Warm Start (with Init) – Ephemeris cleared, initialization data loaded
0x04	Cold Start – Clears all data in memory
0x08	Clear Memory – Clears all data in memory and resets the receiver back to factory defaults

● 102---SetDGPSPort

This command is used to control the serial port used to receive RTCM differential corrections. Differential receivers may output corrections using different communication parameters. If a DGPS receiver is used that has different communication parameters, use this command to allow the receiver to correctly decode the data. When a valid message is received, the parameters are stored in battery-backed SRAM and the receiver restarts using the saved parameters.
Table 5.2-6 contains the input values for the following example:

Set DGPS Port to be 9600,8,N,1.

$PSRF102,9600,8,1,0*12

Table 5.2-6 Set GPS Port Data Format

Name	**Example**	**Units**	**Description**
Message ID	$PSRF102		PSRF102 protocol header

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Baud	9600		4800,9600,19200,38400
DataBits	8		8,7
StopBits	1		0,1
Parity	0		0=None, 1=Odd, 2=Even
Checksum	*12		
<CR><LF>			End of message termination

Note: RTCM is not supported.

- **103---Query/Rate Control**

This command is used to control the output of standard NMEA messages GGA, GLL, GSA, GSV, RMC, and VTG. Using this command message, standard NMEA messages may be polled once, or setup for periodic output. Checksums may also be enabled or disabled depending on the needs of the receiving program. NMEA message settings are saved in battery-backed memory for each entry when the message is accepted.

Table 5.2-7 contains the input values for the following example:

1. Query the GGA message with checksum enabled

   $PSRF103,00,01,00,01*25

2. Enable VTG message for a 1 Hz constant output with checksum enabled

   $PSRF103,05,00,01,01*20

3. Disable VTG message

   $PSRF103,05,00,00,01*21

Table 5.2-7 Query/Rate Control Data Format (See example 1)

Name	**Example**	**Units**	**Description**
Message ID	$PSRF103		PSRF103 protocol header
Msg	00		See Table 5.2-8
Mode	01		0=SetRate, 1=Query
Rate	00	seconds	Output – off=0, max=255
CksumEnable	01		0=Disable Checksum, 1=Enable Checksum
Checksum	*25		
<CR><LF>			End of message termination

Table 5.2-8 Messages

Value	**Description**
0	GGA
1	GLL
2	GSA
3	GSV

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4	RMC
5	VTG
6	MSS (If internal beacon is supported)
7	Not defined
8	ZDA (if 1PPS output is supported)
9	Not defined

- **104---LLANavigationInitialization**

This command is used to initialize the Evaluation Receiver by providing current position (in latitude, longitude, and altitude coordinates), clock offset, and time. This enables the receiver to search for the correct satellite signals at the correct signal parameters. Correct initialization parameters enable the receiver to acquire signals quickly.

Table 5.2-9 contains the input values for the following example:

Start using known position and time.

$PSRF104,37.3875111,-121.97232,0,96000,237759,1946,12,1*07

Table 5.2-9 LLA Navigation Initialization Data Format

Name	**Example**	**Units**	**Description**
Message ID	$PSRF104		PSRF104 protocol header
Lat	37.3875111	degrees	Latitude position (Range 90 to –90)
Lon	-121.97232	degrees	Longitude position (Range 180 to –180)
Alt	0	meters	Altitude position
ClkOffset	96000	Hz	Clock Offset of the Evaluation Receiver[1]
TimeOfWeek	237759	seconds	GPS Time Of Week
WeekNo	1946		Extended GPS Week Number (1024 added)
ChannelCount	12		Range 1 to 12
ResetCfg	1		See Table 5.2-10
Checksum	*07		
<CR><LF>			End of message termination

1. Use 0 for last saved value if available. If this is unavailable, a default value of 96000 is used.

Table 5.2-10 Messages

Hex	**Description**
0x01	Hot Start – All data valid
0x02	Warm Start – Ephemeris cleared
0x03	Warm Start (with Init) – Ephemeris cleared, initialization data loaded
0x04	Cold Start – Clears all data in memory

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0x08	Clear Memory – Clears all data in memory and resets receiver back to factory defaults

● 105---Development Data On/Off

Use this command to enable development data information if you are having trouble getting commands accepted. Invalid commands generate debug information that enables you to determine the source of the command rejection. Common reasons for input command rejection are invalid checksum or parameter out of specified range.

Table 5.2-11 contains the input values for the following example:

1. Debug On

   $PSRF105,1*3E

2. Debug Off

   $PSRF105,0*3F

Table 5.2-11 Development Data On/Off Data Format

Name	**Example**	**Units**	**Description**
Message ID	$PSRF105		PSRF105 protocol header
Debug	1		0=Off, 1=On
Checksum	*3E		
<CR><LF>			End of message termination

● 106---Select Datum

$PSGPS receivers perform initial position and velocity calculations using an earth-centered earth-fixed (ECEF) coordinate system. Results may be converted to an earth model (geoid) defined by the selected datum. The default datum is WGS 84 (World Geodetic System 1984) which provides a worldwide common grid system that may be translated into local coordinate systems or map datums. (Local map datums are a best fit to the local shape of the earth and not valid worldwide.)

Table 5.2-12 contains the input values for the following example:

Datum select TOKYO_MEAN

$PSRF106,178*32

Table 5.2-12 Development Data On/Off Data Format

Name	**Example**	**Units**	**Description**
Message ID	$PSRF106		PSRF106 protocol header
Datum	178		21=WGS84 178=TOKYO_MEAN 179=TOKYO_JAPAN 180=TOKYO_KOREA 181=TOKYO_OKINAWA
Checksum	*32		
<CR><LF>			End of message termination

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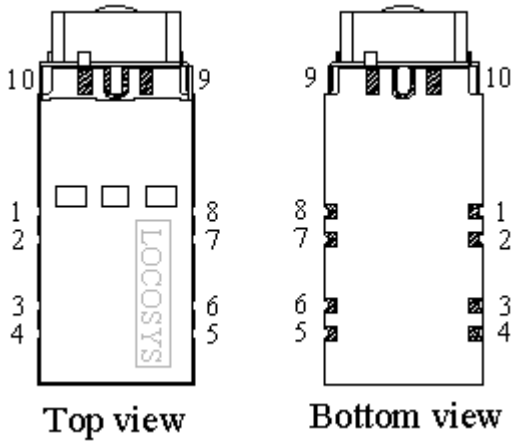
6 Pin assignment and descriptions



Pin #	Name	Type	Description
1	GND	P	Ground
2	VBACKUP	P	Backup battery supply voltage. This pin must be powered to enable the module.
3	TX	O	Serial data output
4	RX	I	Serial data input
5	LED	O	LED indicator (1). Internal pulled down via 100KΩ resistor. Default input at reset.
6	BS	I	Boot mode selection (2). Internal pulled down via 115KΩ resistor. Do not connect in normal operation.
7	EN	I	Enable pin (3). High active with internal pull-down resistor.
8	VCC	P	DC supply voltage
9	GND	P	Ground
10	GND	P	Ground

<Note>

1. When GPS position fix is available, it outputs 50ms high per second, otherwise it outputs low.
2. When this pin is low at system reset, the module will boot in normal operation. Otherwise, it will boot in internal mode.
3. This pin only controls the main power through VCC pin, not apply to VBACKUP pin.

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7 DC & Temperature characteristics

7.1 Absolute maximum ratings

Parameter	Symbol	Ratings	Units
Input Voltage	VCC	5.5	V
Input Backup Battery Voltage	VBACKUP	7	V
Operating Temperature Range	Topr	-30 ~ 85	℃
Storage Temperature Range	Tstg	-40 ~ 85	℃

7.2 DC Electrical characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Input Voltage	VCC		3.0		4.3	V
Input Backup Battery Voltage	VBACKUP		1.3		6.0	V
Supply Current	I_{VCC}	Full operation		31(1)	49	mA
		EN = Low		< 0.1		uA
Backup Battery Current	I_{BAT}	EN = Low		5.8		uA
High Level Input Voltage	V_{IH}		2.1		3.6	V
		For EN pin	1.3		VCC	
Low Level Input Voltage	V_{IL}		-0.3		0.8	V
		For EN pin			0.25	
High Level Input Current	I_{IH}		-10		60	uA
		For EN pin	-0.2		10	
Low Level Input Current	I_{IL}		-10		60	uA
		For EN pin	-0.2		1	
High Level Output Voltage	V_{OH}		2.0			V
Low Level Output Voltage	V_{OL}				0.73	V
High Level Output Current	I_{OH}			2		mA
Low Level Output Current	I_{OL}			2		mA

Note 1: Measured when position fix is available and input voltage is 3.3V.

7.3 Temperature characteristics

Parameter	Symbol	Min.	Typ.	Max.	Units
Operating Temperature	Topr	-30	-	85	℃
Storage Temperature	Tstg	-40	25	85	℃

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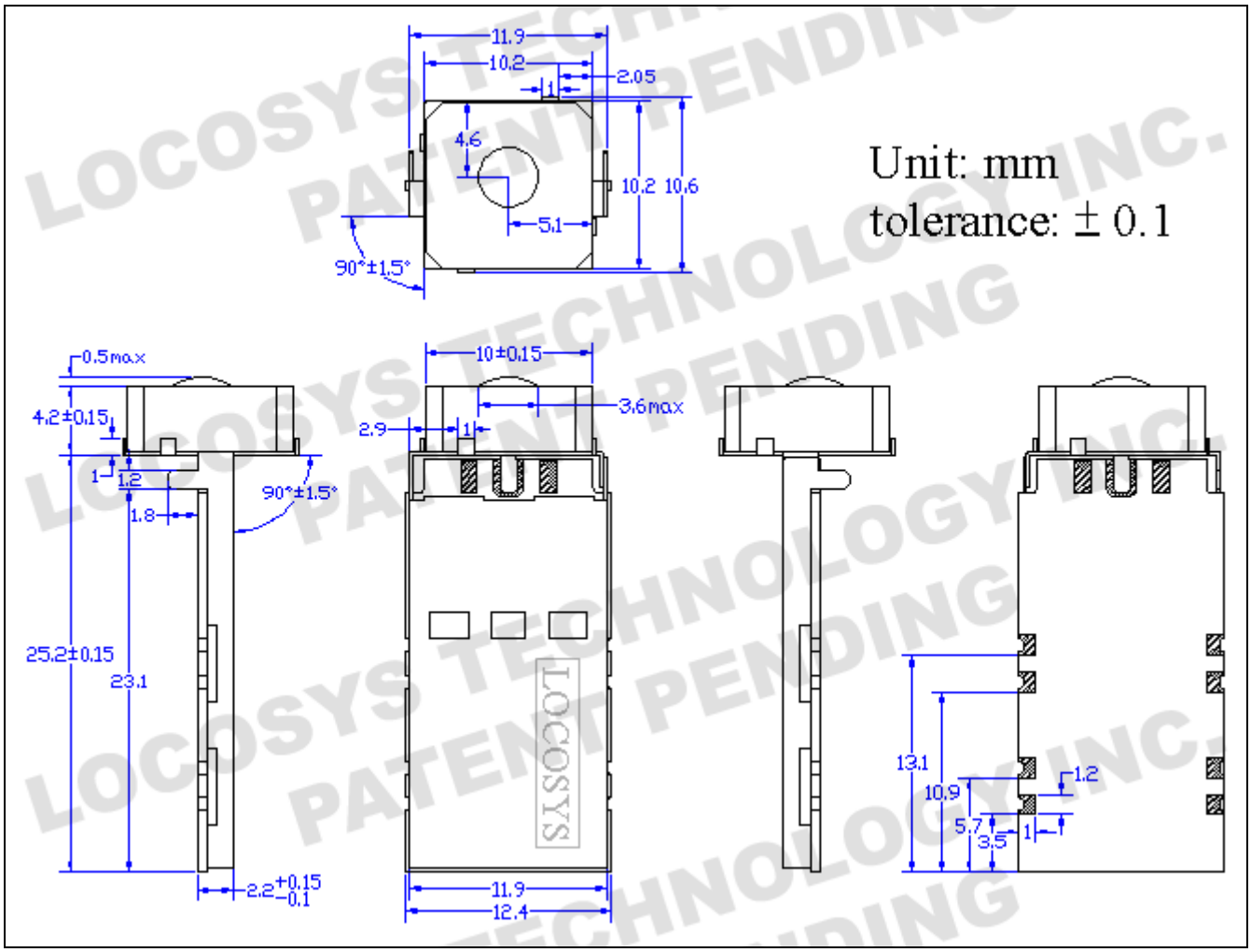
8 Mechanical specification

8.1 Outline dimensions



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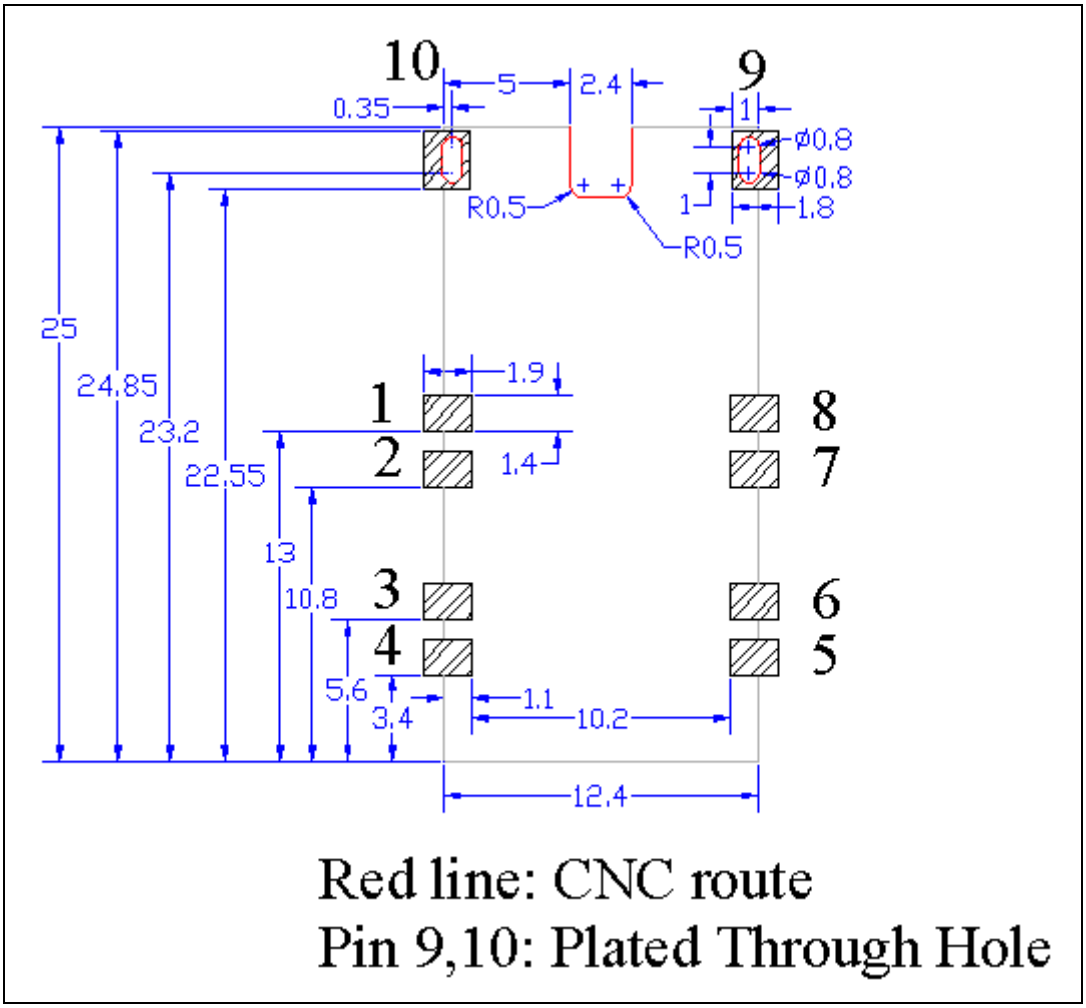
8.2 Recommended land pattern dimensions



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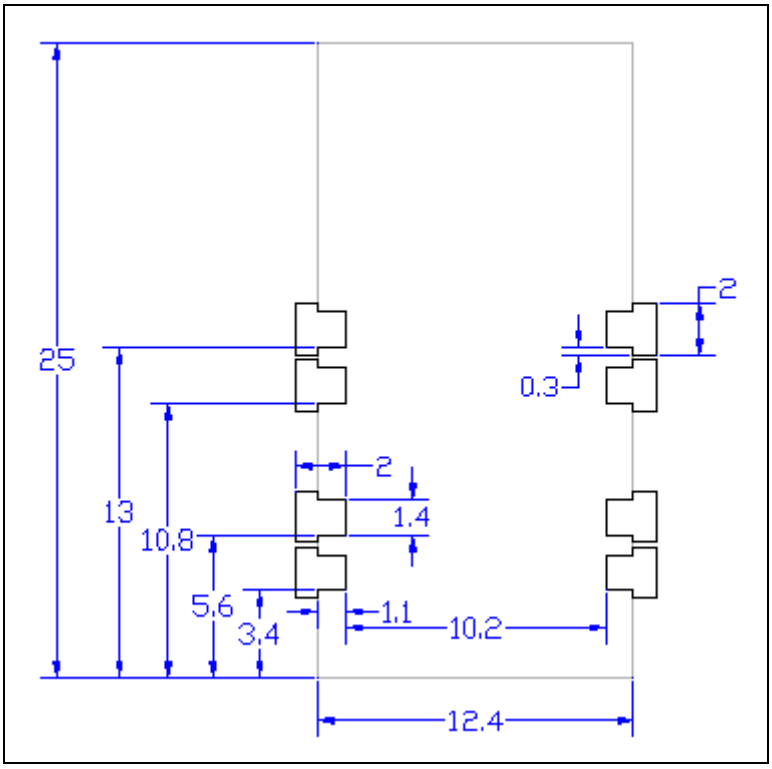
8.3 Recommended solder paste stencil dimensions



LS20026 can be soldered by SMT process. But please note that if your PCB is double sided components and has to go into reflow oven twice, LS20026 must be designed to be secondary reflow process. Otherwise LS20026 has to be hand soldered.

Pin number 9 and 10 of LS20026 are designed for hand soldered in order to tightly fix onto your PCB.

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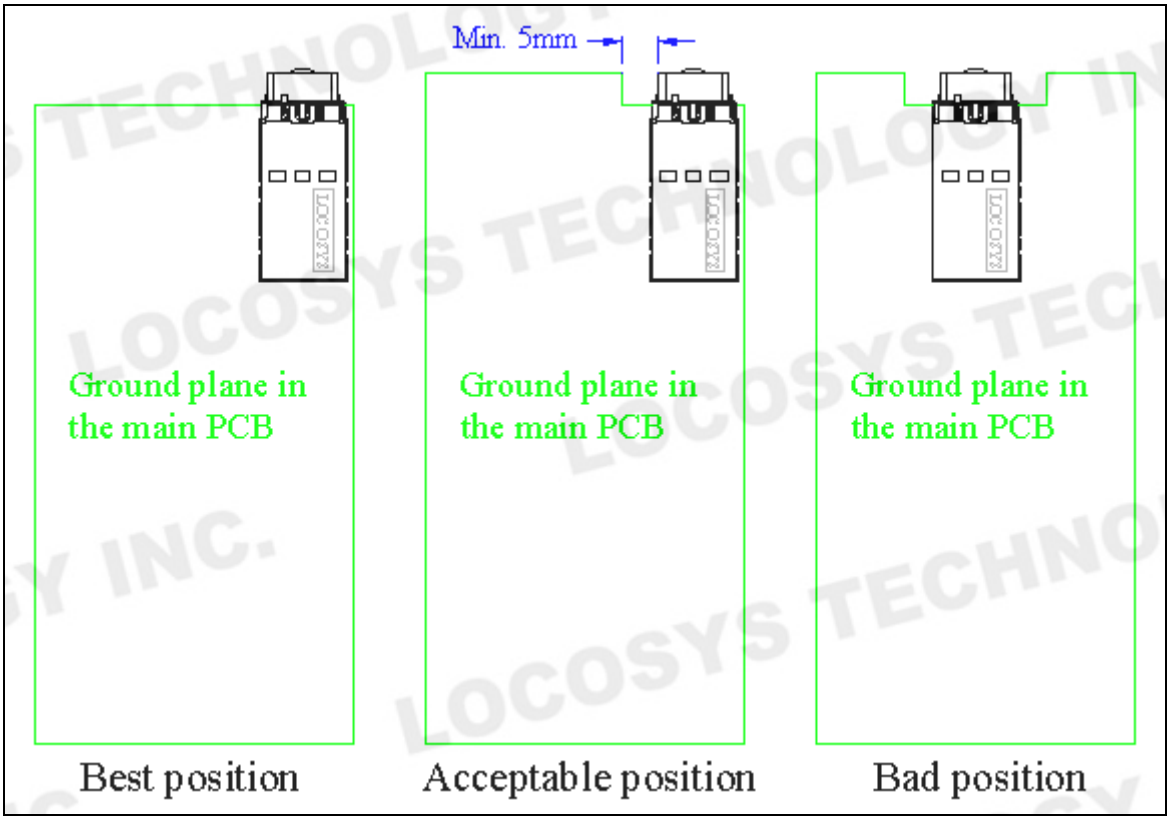
8.4 Installation position on the main PCB



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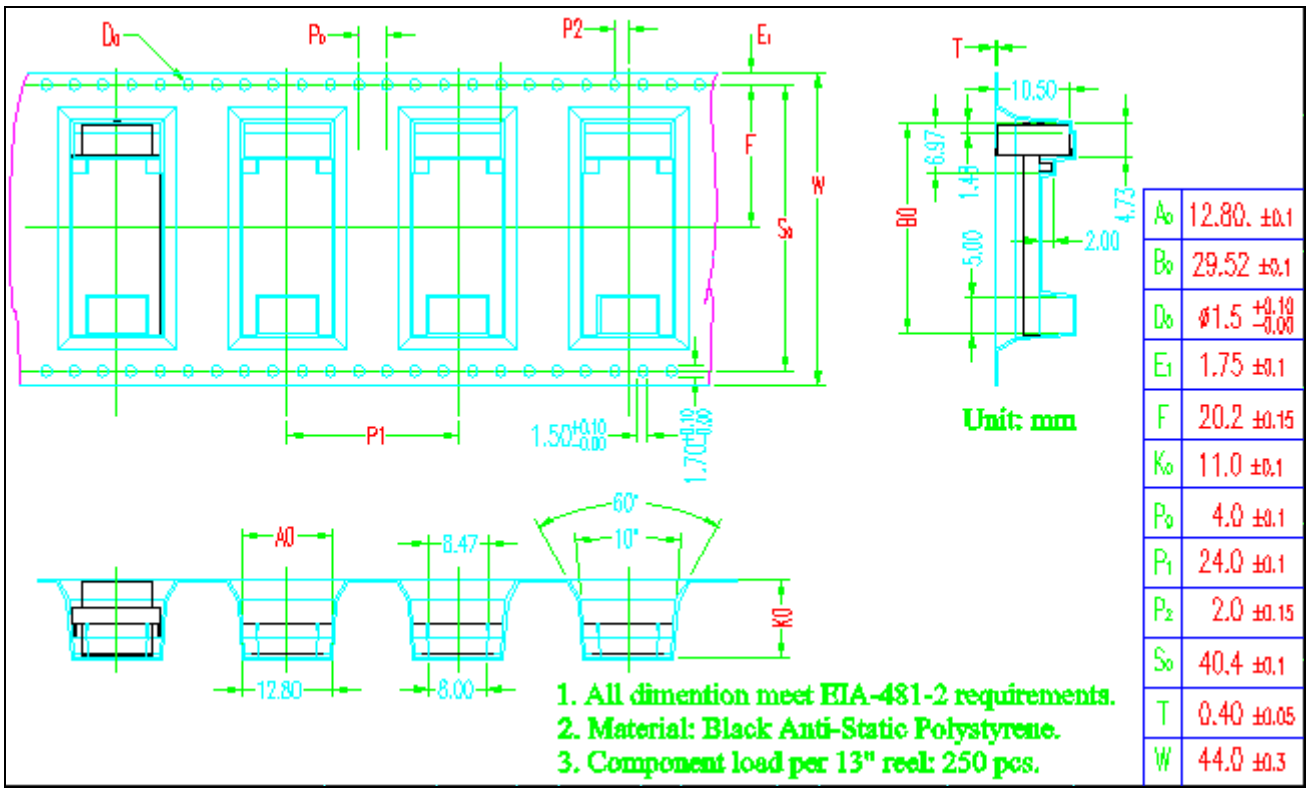
9 Reel packing information



A_0	12.80 ±0.1
B_0	29.52 ±0.1
D_0	ϕ1.5 +0.10 −0.00
E_1	1.75 ±0.1
F	20.2 ±0.15
K_0	11.0 ±0.1
P_0	4.0 ±0.1
P_1	24.0 ±0.1
P_2	2.0 ±0.15
S_0	40.4 ±0.1
T	0.40 ±0.05
W	44.0 ±0.3

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Document change list

Revision 1.0

- First release on Feb. 19, 2008.

Revision 1.0 to Revision 1.1 (June 24, 2008)

- Changed GPS chip from GSC3f/LP 7979 to GSC3f/LPx 7989 on page 4. The units with date code after 0827 were changed to new chip.
- Changed typical cold start time from 38s to 35s on page 4.
- Changed the minimum voltage of VBACKUP from 1.6V to 1.3V on page 15.
- Changed the typical supply current from 40mA to 31mA on page 15
- Changed the maximum supply current from 69mA to 49mA on page 15