GNSS Dead Reckoning Module Datasheet

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This document applicable to the following products：

Product name	Type number	Product status
SKG121D	SKG121D	Mass production

Contents

1.General Description

SKG121D is a single receiver module integrating GPS, BeiDou, GLONASS and Galileo systems. It is able to achieve the industry's highest level of sensitivity, accuracy and TTFF with the lowest power consumption in a small-footprint lead-free package. The embedded flash memory provides capacity for storing user-specific configurations and allows for future updates.

The SKG121D module supports multiple positioning and navigation systems including autonomous GPS, BeiDou, GLONASS, Galileo, SBAS (including WAAS, EGNOS, MSAS and GAGAN), QZSS, DGPS, and AGPS.

The SKG121D module supports Dead Reckoning (DR) function, and it is embedded with a 3-axis Gyroscope and 3-axis Accelerometer. Dead Reckoning (DR) is the process of estimating the module current position based upon a previously determined position or "fix", and estimating that position based upon course and speed. The SKG121D module provides the user with accurate estimates of a vehicle's position and speed, even during interruptions in GNSS information, combining the best features of GNSS and Sensor navigation.

SKG121D module is an SMD type module with a compact 12.2mm ×16.2mm ×2.3mm form factor. It can be embedded in customers' applications through the 24-pin pads with 1.1mm pitch. It provides necessary hardware interfaces for connection with the main PCB.

The module is fully compliant with EU RoHS directive.

Figure 1: SKG121D Top View

2.Applications

- LBS (Location Based Service)
- PND (Portable Navigation Device)
- Vehicle navigation system
- Mobile phone
- Main chip pass AEC-Q100 certification
- IATF16949 quality control system

3.Features

- GPS/GLONASS/BDS/ GALILEO/QZSS reseiver
- Ultra high sensitivity: -162dBm
- Extremely fast TTFF at low signal level
- Supports Dead Reckoning (DR) function
- ±25ns high accuracy time pulse (1PPS)
- SBAS (WAAS,EGNOS,MSAS,GAGAN)
- Embedded with a 3-axis Gyroscope and 3-axis Accelerometer
- UART0: Supports baud rates from 4800bps to 115200bps; 115200bps by default
- UART0 port is used for NMEA output and firmware upgrade
- Small form factor: 16.2 x 12.2 x 2.4mm
- FCC compliance
- RoHS compliance (Lead-free)
- CE certificated

4 Pin Assignment

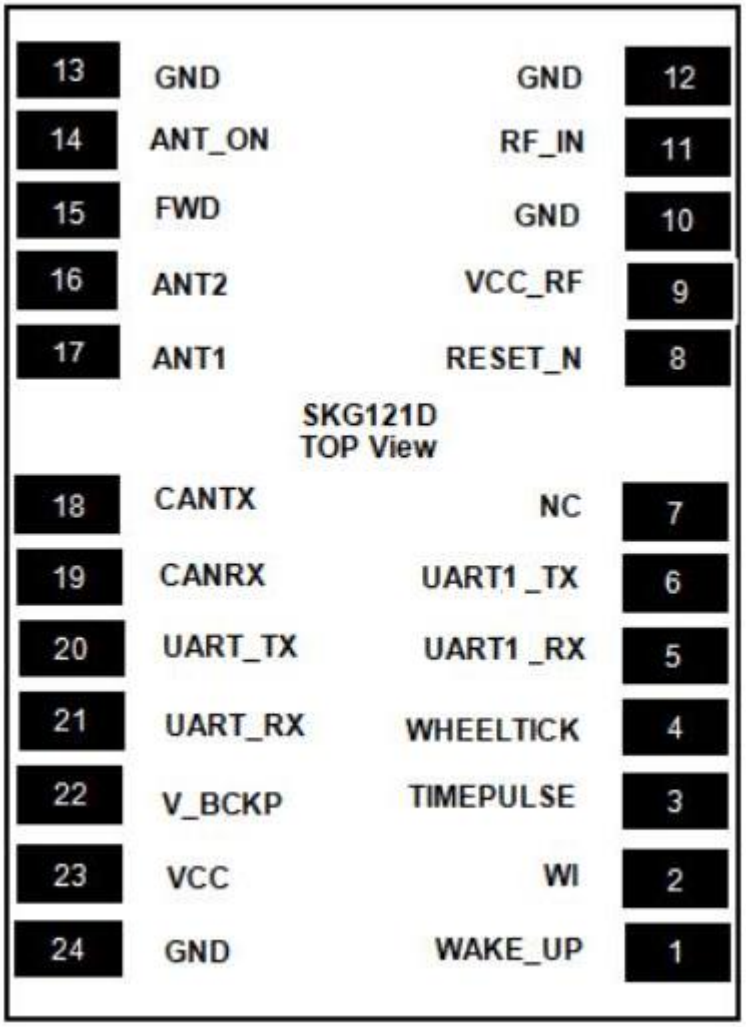


Figure 2: Pin Assignment

5 Pin Description

Pin No.	Pin name	I/O	Description	Remark
1	WAKEUP	DI	WAKEUP from STANDBY mode	If unused, keep this pin open
2	WI*	DO	Warning indicator	When the vertical Angle of the car deviates greatly, the output indicator signal.

3	TIMEPULSE	DO	One pulse per second	If unused, keep this pin open.
4	WHEELTICK*	DI	Odometer wheel-tick input	If unused, keep this pin open.
5	UART1_RX*	DI	Receive data	If unused, keep this pin open.
6	UART1_TX*	DO	Transmit data	If unused, keep this pin open.
7	NC			Keep these pins open.
8	RESET_N	DI	Reset the module	Active low. If unused, keep this pin open.
9	VCC_RF	PO	Power supply for external RF components	Usually supply power for the external active antenna or the LNA. VCC_RF≈VCC If unused, keep this pin open.
10	GND	G	Ground	
11	RF_IN	AI	RF signal input	50Ω characteristic impedance.
12	GND	G	Ground	
13	GND	G	Ground	
14	ANT_ON	DO	External LNA control pin and active antenna power control pin	If unused, keep this pin open.
15	FWD*	DI	Forward/Backward signal input	If unused, keep this pin open.
16	ANT2*	AI	Antenna detection 2	If unused, keep this pin open.
17	ANT1*	AI	Antenna detection 1	If unused, keep this pin open.
18	CANTX	DO	CAN transmit data output	
19	CANTX	DI	CAN receive data input	
20	UART_TX	DO	Transmit data	UART port is used for NMEA output and firmware upgrade.
21	UART_RX	DI	Receive data	UART port is used for NMEA output and firmware upgrade.
22	V_BCKP	PI	Backup power supply	Supply power for RTC domain when VCC is powered off.
23	VCC	PI	Module Power Supply	Assure load current not less than

				150mA.
24	GND	G	Ground	

6 Interfaces Configuration

Power Supply

VCC pin supplies power for BB, RF and RTC domains. The load current of VCC pin varies according to the VCC level, processor load and satellite acquisition. Typical VCC peak current is TBD during GNSS acquisition after power-up, so it is important to supply sufficient current and make the power clean and stable. It is recommended to choose an LDO with minimum output current of 150mA as the power supply and add a 10uF and a 100nF decoupling capacitor combination as well as a TVS near the VCC pin.

The V_BCKP pin supplies power for RTC domain. A cell battery with the combination of a 4.7uF and a 100nF capacitor is recommended to be placed nearby V_BCKP pin. The voltage of RTC domain ranges from 1.8V to 3.6V. In order to achieve better Time to First Fix (TTFF), RTC domain should be valid all the time so as to supply power for SRAM memory which contains all the necessary GNSS information for quick start-up and a small amount of user configuration variables.

The module's internal power construction is shown as below. VCC not only supplies power for PMU but also for RTC domain, while V_BCKP supplies power for RTC domain only. When the power supply voltage of VCC is within the normal range, use VCC; otherwise, use V_BCKP.

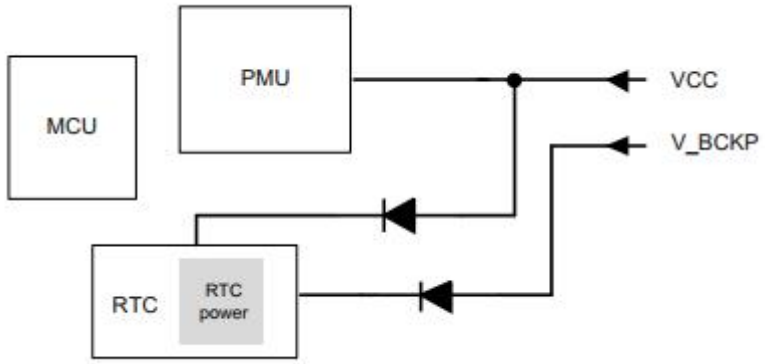


Figure 3: VCC Input Reference Circuit

7 Operation Modes

The table below briefly illustrates the operation mode switching of SKG121D module.

Table 5: Module Mode Switching

Current Mode	**Current Mode**	
	Backup	**Standby**
Full on	NA	Refer to ***Chapter 7*****：** Standby Mode
Standby	Refer to ***Chapter 7*****：** **Full on Mode**	NA

Full on Mode

Full on mode comprises tracking mode and acquisition mode. Acquisition mode is defined as the mode in which the module starts to search satellites, and to determine the visible satellites, coarse carrier frequency as well as code phase of satellite signals. When the acquisition is completed, it will automatically switch to tracking mode. Tracking mode is defined as the module tracking satellites and demodulating the navigation data from specific satellites.

When both VCC and V_BCKP pins are valid or only VCC is valid, the module will enter into full on mode automatically and follow the default configuration as below. Please refer to ***Chapter 7*** about internal power construction for better comprehension.

Standby Mode

Standby mode requires lower power consumption mode. In this mode, the module stops acquiring and tracking satellites. UART is not accessible. But the backup memory in RTC domain which contains all the necessary GNSS information for quick start-up and a small amount of user configuration variables is alive. The current consumption in this mode is about 35uA.

There is only one way to enter into backup mode and back to full on mode.

- Send “$PSTMFORCESTANDBY, <duration>” Command to enter into standby mode. Duration of the standby time in seconds, Decimal, 5 digits. The module will automatically wake up at the end of the

countdown.

For a better understanding, please refer to ***Chapter 7*** for details about the internal power construction. The V_BCKP pin can be directly powered by an external capacitor or battery (rechargeable or non-chargeable). Please refer to the following figure for RTC backup reference design.

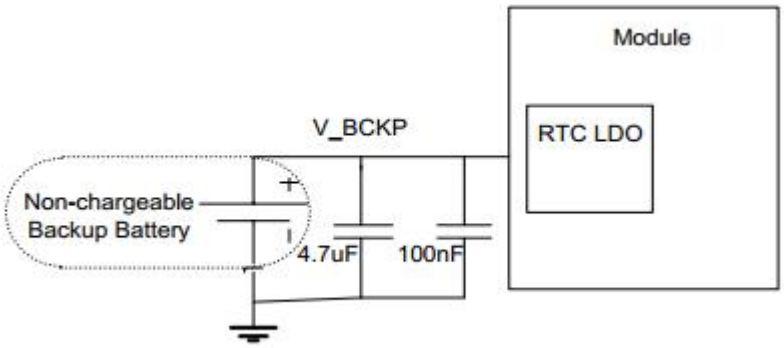


Figure 4: RTC Supply from Non-chargeable Battery

With a charging circuit, V_BCKP will support battery charging function. Please see the reference charging circuit in the figure below.

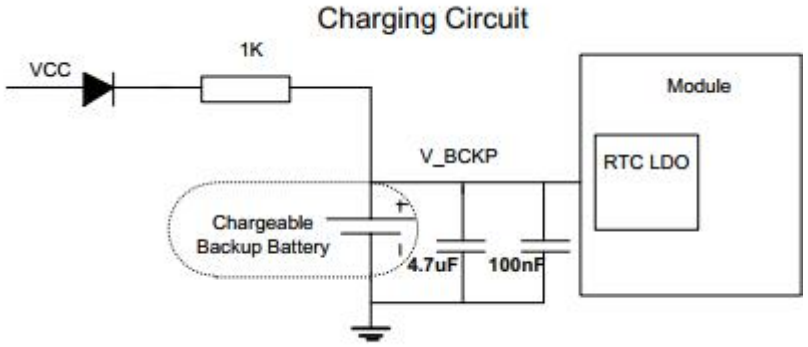


Figure 5: Reference Charging Circuit for Rechargeable Batteries

The coin-type rechargeable capacitor from Seiko (http://www.sii.co.jp/en) can be used as an alternative to the chargeable backup battery. And the Schottky diode from ON Semiconductor (http://www.onsemi.com)

is recommended to be the choice of diode for its low voltage drop.

Reset

SKG121D module can be reset by driving RESET to a low-level voltage for at least 10ms and then releasing it. Please note that the resetting will possibly force the loss of volatile RAM data, while non-volatile backup RAM content is not cleared so that fast TTFF is still possible. An OC driver circuit shown as below is recommended to control the RESET.

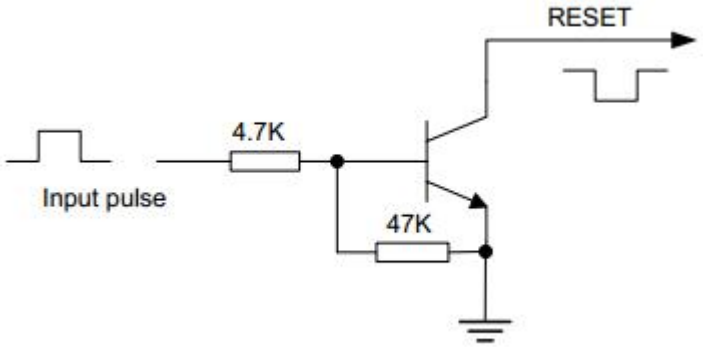


Figure 6: Reference OC Circuit for Module Reset

The following figure shows the reset timing of SKG121D module.

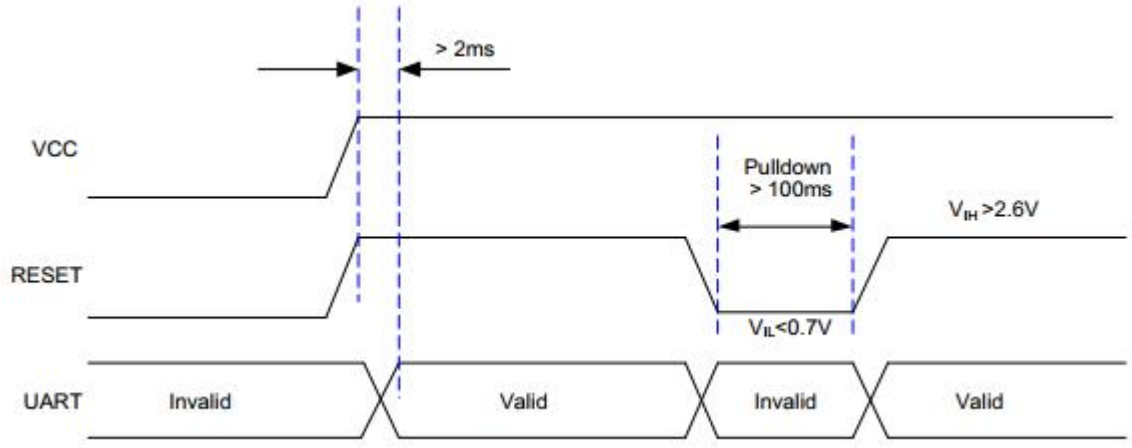


Figure 7: Reset Timing

UART Interface

SKG121D provides two universal asynchronous receiver & transmitter serial ports.

UART0

The module is designed as DCE (Data Communication Equipment), following the traditional DCE-DTE (Data Terminal Equipment) connection. The module and the client (DTE) are connected through the signals shown in the following figure. It supports data baud-rate from 4800bps to 115200bps, 115200bps by default.

UART0 port:

- UART0_TX: Send data to the RXD signal line of DTE
- UART0_RX: Receive data from the TXD signal line of DTE

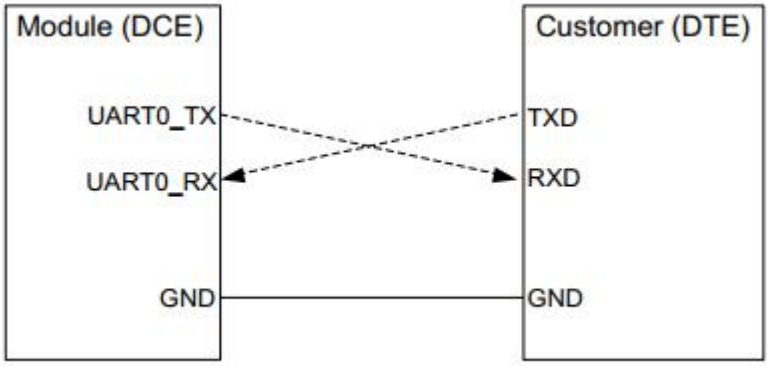


Figure 8: Reference Design for UART Port

This UART0 port has the following features:

- UART0 port can be used for NMEA output and firmware upgrade.
- The default output NMEA type setting is RMC, VTG, GGA, GSA, GSV.
- UART port supports the following data rates: 4800bps, 9600bps, 14400bps, 19200bps, 38400bps, 57600bps, 115200bps.

- The default setting is 115200bps, 8 bits, no parity bit, 1 stop bit.
- Hardware flow control and synchronous operation are not supported.

The UART0 port does not support the RS-232 level but only CMOS level. If the module's UART0 port is connected to the UART port of a computer, it is necessary to add a level shift circuit between the module and the computer. Please refer to the following figure.

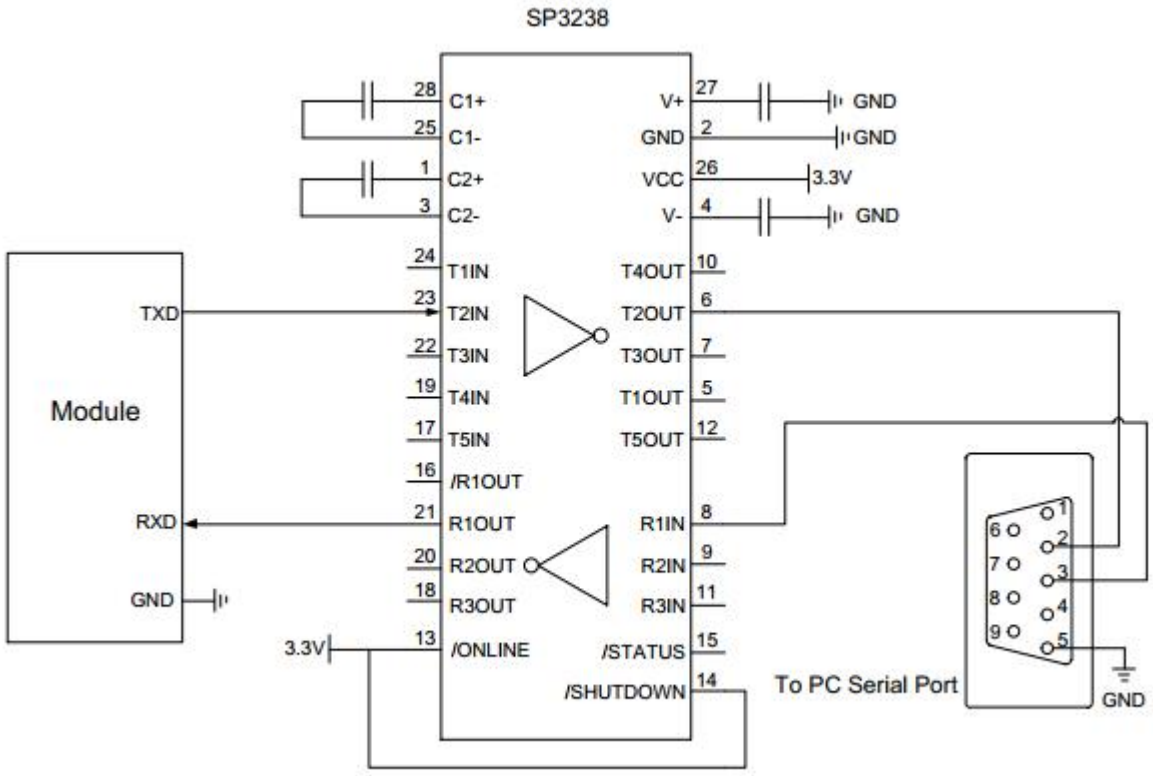


Figure 9: RS-232 Level Shift Circuit

NOTES

GNSS modules output more data than single GPS systems. The default baud rate (115200bps) of SKG121D is enough to transmit GNSS NMEA. If the baud rate has to be set to 4800bps, then it is recommended to decrease NMEA output types so as to avoid possible data loss.

CAN Interface

SKG121D provides one CAN Bus interface. An additional can transceiver is required to connect to the can bus of the car. Its main function is to obtain the speed signal of the car.

FWD Interface*

Forward/Reverse signal input of car.

WHEELTICK Interface*

Odometer wheel-tick input of car.

8 Performance Specification

Parameter	Specification	
Receiver Type	GPS L1 C/A (1575.42MHz) BeiDou B1 C/A (1561.098MHz) GLONASS L1 C/A (1602.5625MHz) Galileo E1 C/A (1575.42MHz)	
Sensitivity	Tracking Reacquisition Acquisition	-163dBm Typical -156dBm Typical -147dBm Typical
Accuracy	Position Velocity Timing (PPS)	<1.8m CEP* @-130dBm 0.1m/s without SA 25ns RMS
Acquisition Time	Cold Start Warm Start Hot Start Re-Acquisition	<32s(Typical Open Sky) <25s <1.5s <1s
Assisted GPS support	Support	
Power Consumption	Tracking Acquisition	TBD TBD
Navigation Data Update Rate	Max 10Hz	Default 1Hz

Operational Limits	Altitude	Max 18,000m
	Velocity	Max 515m/s
	Acceleration	4.5G

9 Electrical Characteristics

Absolute Maximum Rating

Parameter	Symbol	Min	Max	Units
Power Supply				
Power Supply Volt.	VCC	-0.3	4.8	V
Input Pins				
Input voltage on any input connection	VIO	-0.2	VCC+0.3V	V
Backup Battery	V_BCKP	-0.3	4.8	V
RF input power	RF_IN		15	dBm
Human Body Model ESD capability	RF_IN		2000	V
Machine Model ESD capability	RF_IN		100	V
Environment				
Storage Temperature	Tstg	-40	125	°C
Peak Reflow Soldering Temperature <10s	Tpeak		260	°C
Humidity			95	%

Note: Absolute maximum ratings are stress ratings only, and functional operation at the maxims is not guaranteed. Stress beyond the limits specified in this table may affect device reliability or cause permanent damage to the device. For functional operating conditions, refer to the operating conditions tables as follow.

Operating Conditions

Parameter	Symbol	Condition	Min	Typ	Max	Units
Power supply voltage	Vcc		3	3.3	3.6	V

Backup Battery	V_BCKP		1.8	3.0	3.6	V
Power supply voltage ripple	Vcc_PP	Vcc=3.3V			30	mV
Peak supply current	Icc	Vcc=3.3V		110		mA
Supply current, Tracking	Icc	Vcc=3.3V		TBD		mA
Supply current, backup state	Ibckp	Vcc=3.3V		15		uA
VCC_RF Antenna bias supply	VCC_RF			VCC		V
Input high voltage	V_{IH}		2		3.6	V
Input low voltage	V_{IL}		-0.3		0.8	V
Output high voltage	V_{OH}		2.4		3.1	V
Output low voltage	V_{OL}		-0.3		0.4	V
Operating temperature	Topr		-40	25	85	°C

10 Mechanical Specification

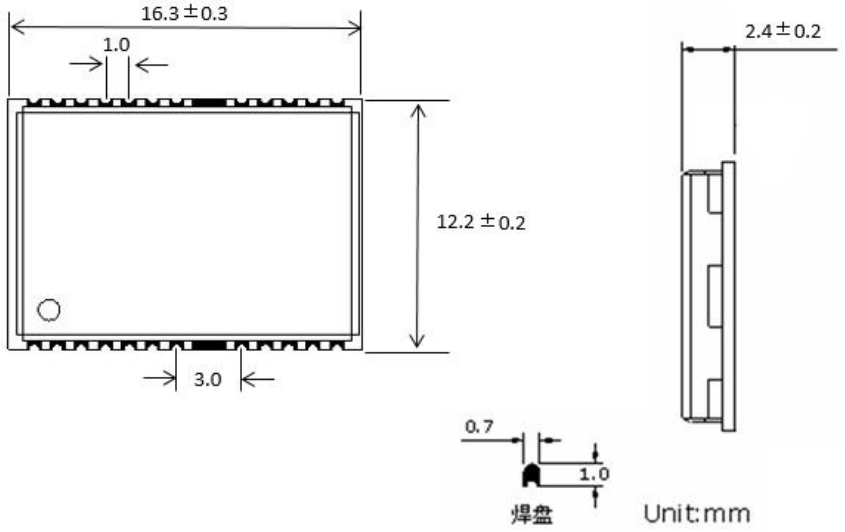


Figure 10: SKG121D Dimensions

Recommend Layout

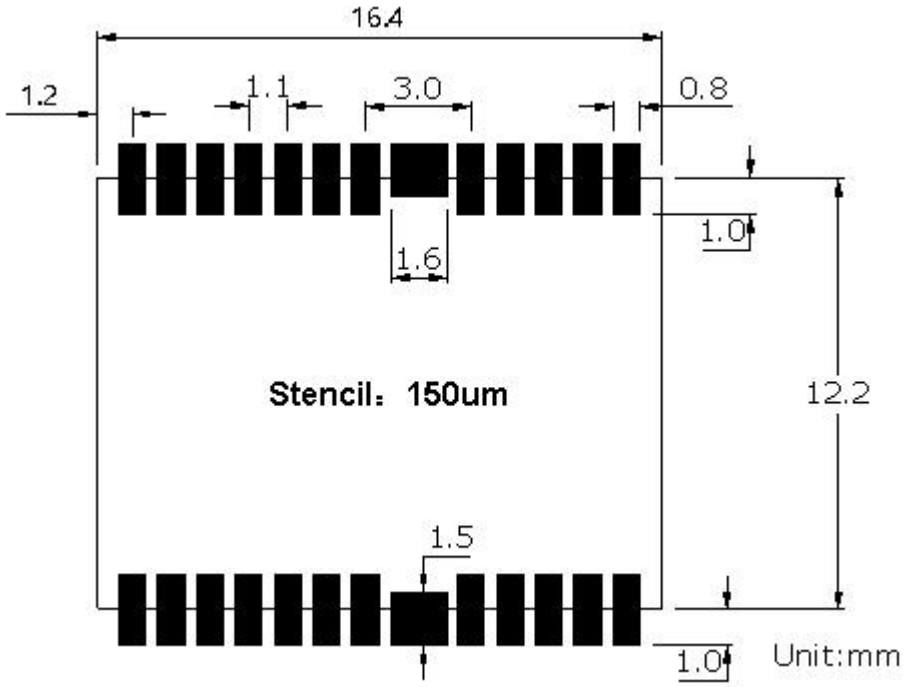


Figure 11: SKG121D Footprint

11 Recommended Mounting

Please refer to the following figure to mount SKG121D module on vehicle. The module should be securely mounted to a stable part of the vehicle.

Figure 12: Recommended Mounting

12 Reference design schematic

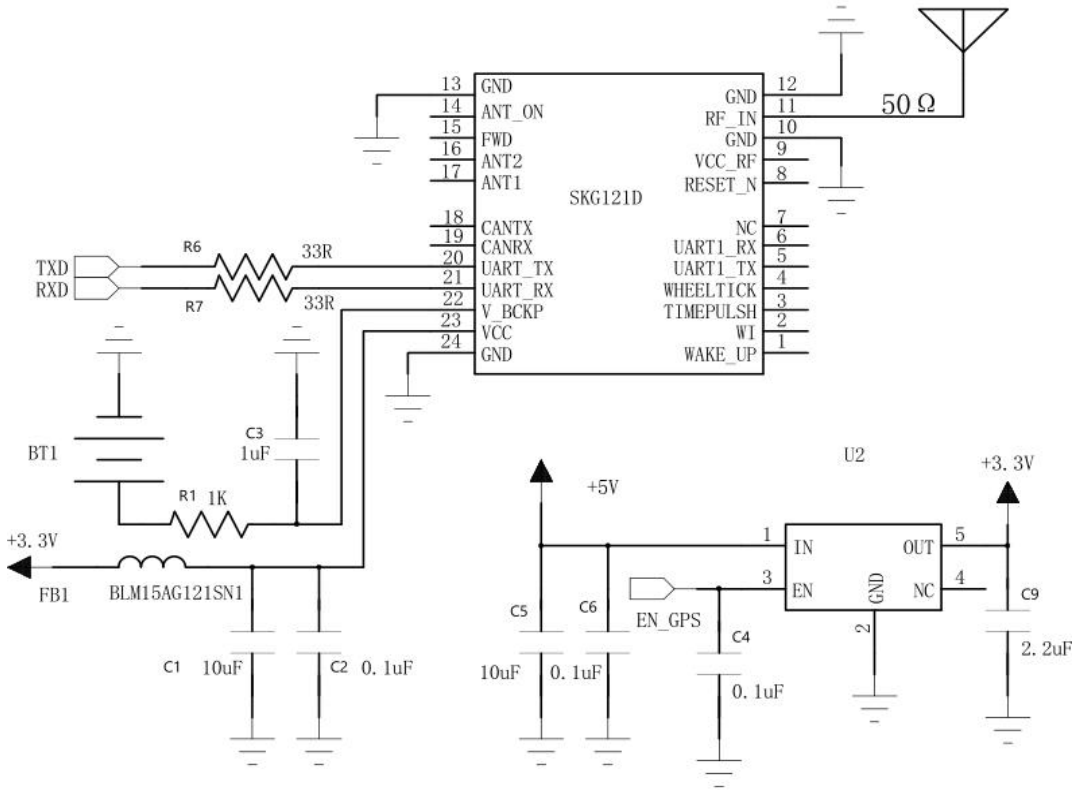
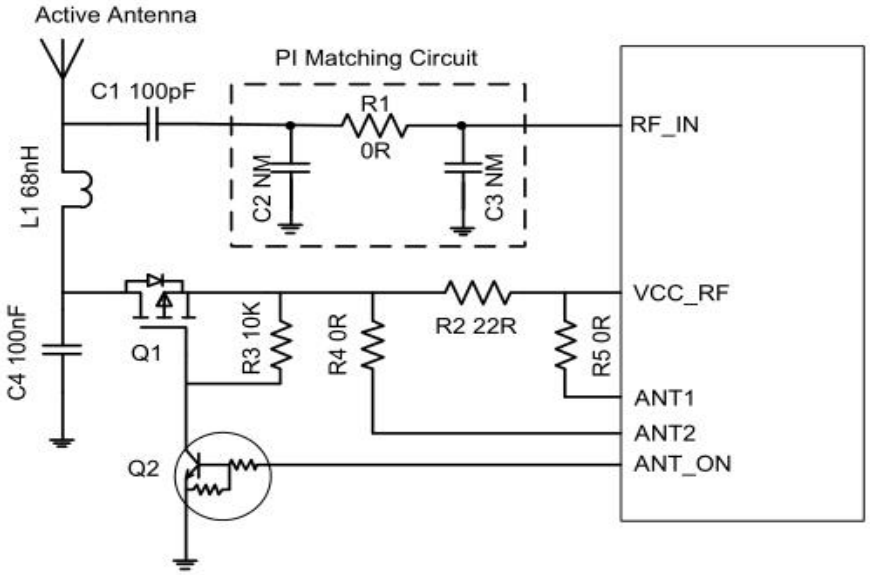


Figure 9: SKG121D Typical Reference design schematic

The following figure is a typical reference design for active antenna with Antenna Detection.



13 Packaging Specification

SKG121D modules are shipped in reel and with 1200 units per reel. Each tray is ‘dry’ package.

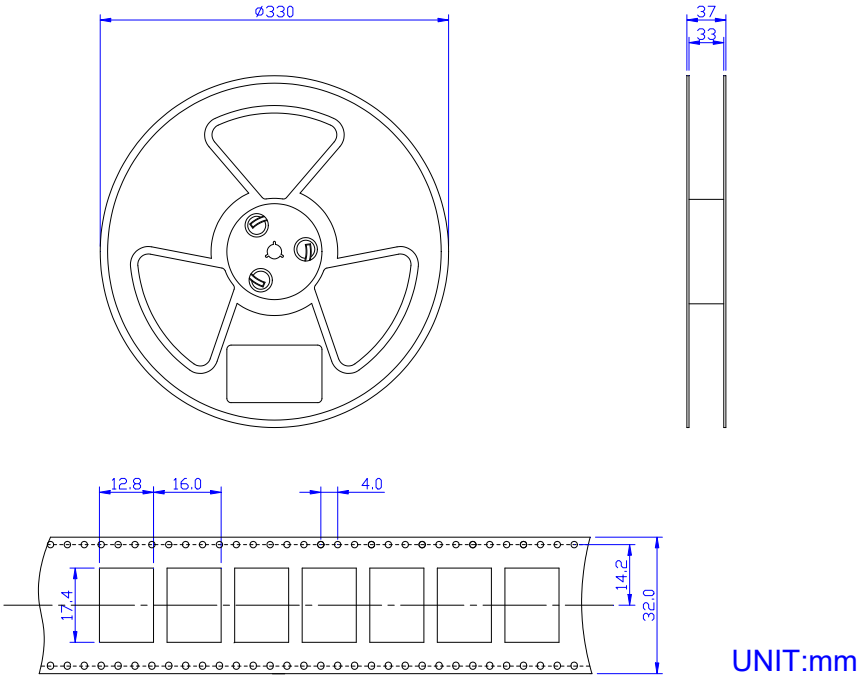


Figure 13: SKG121D Packaging

14 Manufacturing Process Recommendations

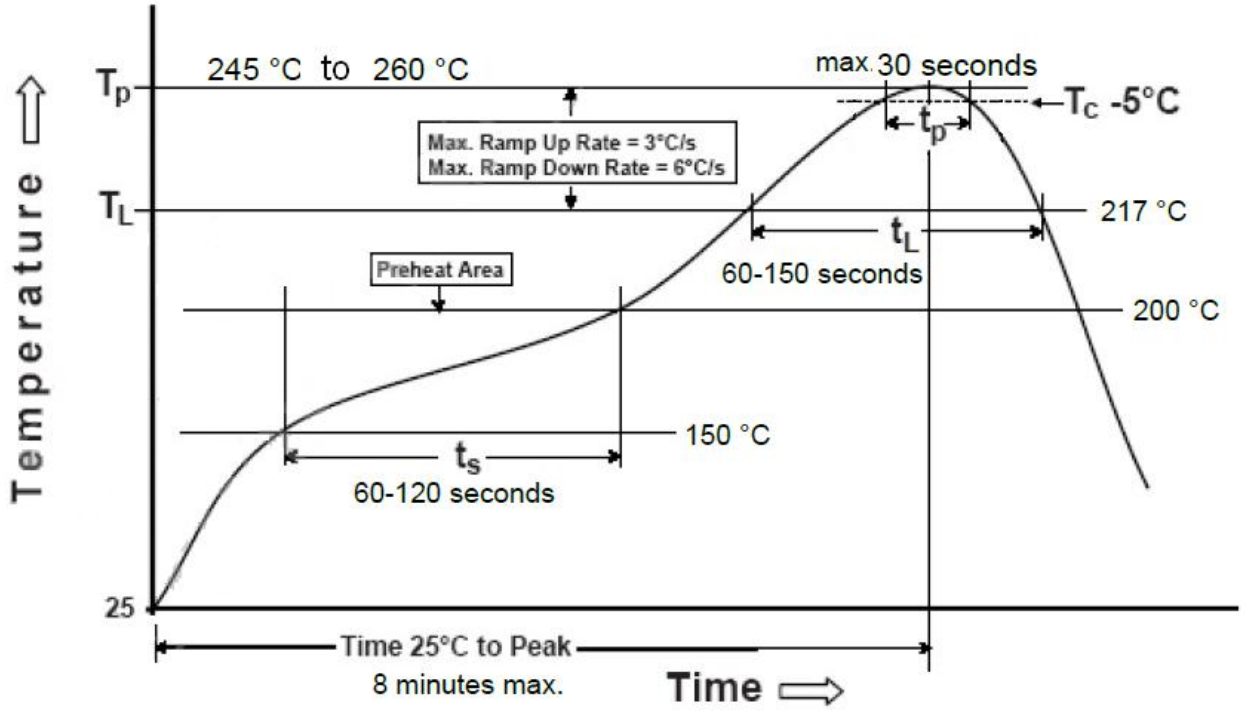


Figure 14: SKG121D Typical Leadfree Soldering Profile

Note： The final soldering temperature chosen at the factory depends on additional external factors like choice of soldering paste，size，thickness and properties of the baseboard，etc. Exceeding the maximum soldering temperature in the recommended soldering profile may permanently damage the module.

Soldering Paste: OM338 SAC405 / Nr.143714 (Cookson Electronics)

Alloy specification: Sn 95.5/ Ag 4/ Cu 0.5 (95.5% Tin/ 4% Silver/ 0.5% Copper)

Melting Temperature: 217 °C

Stencil Thickness: 150um

15 Software Protocol

NMEA 0183 Protocol

The NMEA protocol is an ASCII-based protocol, Records start with a $ and with carriage return/line feed. GPS specific messages all start with $GNxxx where xxx is a three-letter identifier of the message data that follows. NMEA messages have a checksum, which allows detection of corrupted data transfers.

The Skylab SKG121D supports the following NMEA-0183 messages: GGA, GLL, GSA, GSV, RMC VTG, ZDA. The module default NMEA-0183 output is set up GGA、GSA、RMC、GSV , GLL、GSA and default baud rate is set up 115200bps.

Table 1: NMEA-0183 Output Messages

NMEA Record	Description	Default
GNGGA	Global positioning system fixed data	Y
GNGLL	Geographic position—latitude/longitude	Y
GPGSA	GNSS DOP and active satellites for GPS	Y
GLGSA	GNSS DOP and active satellites for GLONASS	Y
BDGSA	Beidou DOP and active satellites for BD	N
GPGSV	GNSS satellites in view for GPS	Y
GLGSV	GNSS satellites in view for GLONASS	Y
BDGSV	Beidou satellites in view for BD	N
GNRMC	Recommended minimum specific GNSS data	Y
GNVTG	Course over ground and ground speed	Y
GNZDA	Date and Time	N

GGA-Global Positioning System Fixed Data

This sentence contains the position, time and quality of the navigation fix.

See RMC for Fix Status, Fix Mode, Fix Date, Speed, and True Course.

See GSA for Fix Type, PDOP, and VDOP.

$GNGGA,021514.000,2232.1799,N,11401.1823,E,1,6,1.25,84.0,M,-2.2,M,,*6A

Table 2: GGA Data Format

Name	Example	Units	Description
Message ID	$GNGGA		GGA protocol header
UTC Position	021514.000		hhmmss.sss
Latitude	2232.1799		ddmm.mmmm
N/S indicator	N		N=north or S=south
Longitude	11401.1823		dddmm.mmmm
E/W Indicator	E		E=east or W=west
Position Fix Indicator	1		See Table 2-1
Satellites Used	6		Range 0 to 12
HDOP	1.25		Horizontal Dilution of Precision
MSL Altitude	84.0	meters	Altitude (referenced to the Ellipsoid)
AltUnit	M	meters	Altitude Unit
GeoSep	-2.2	meters	Geoidal Separation
GeoSepUnit	M	meters	Geoidal Separation Unit
Age of Diff.Corr.	<Null>	second	Null fields when it is not Used
Diff.Ref.Station ID	<Null>		Null fields when it is not Used
Checksum	*6A		
EOL	<CR> <LF>		End of message termination

Table 2-1: Position Fix Indicators

Value	Description
0	Fix not available or invalid
1	fix valid
2	Differential GPS, fix valid

GLL-Geographic Position – Latitude/Longitude

This sentence contains the fix latitude and longitude.

$GNGLL,2232.1799,N,11401.1824,E,021513.000,A,A*4E

Table 3: GLL Data Format

Name	Example	Units	Description
Message ID	$GNGLL		GLL protocol header
Latitude	2232.1799		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	11401.1824		dddmm.mmmm
E/W Indicator	E		E=east or W=west
UTC Position	021513.000		hhmmss.sss
Fix Status	A		A=data valid or V=data not valid
Fix Mode	A		A=autonomous, N = No fix, D=DGPS, E=DR
Checksum	*4E		
EOL	<CR> <LF>		End of message temination

GSA-GNSS DOP and Active Satellites

This sentence contains the mode of operation, type of fix, PRNs of the satellites used in the solution as well as PDOP, HDOP and VDOP.

GPS GSA message: $GPGSA,……

$GPGSA,A,3,28,20,04,17,10,193,08,,,,,,1.14,0.75,0.85*31

GLONASS GSA message: $GLGSA,……

$GLGSA,A,3,67,81,80,66,82,79,,,,,,,1.14,0.75,0.85*11

BD GSA message: $BDGSA,……

$BDGSA,A,3,10,,,,,,,,,,,,1.54,1.26,0.88*17

Table 4: GSA Data Format

Name	Example	Units	Description
Message	$GPGSA		GSA protocol header

Mode 1	A		See Table 4-2
Mode 2	3		See Table 4-1
ID of satellite used	28		Sv on Channel 1
ID of satellite used	20		Sv on Channel 2
…	…		…
ID of satellite used	<Null>		Sv on Channel 12 (Null fields when it is not Used)
PDOP	1.14		Position Dilution of Precision
HDOP	0.75		Horizontal Dilution of Precision
VDOP	0.85		Vertical Dilution of Precision
Checksum	*31		
EOL	<CR> <LF>		End of message termination

Table 4-1: Mode 2

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

Table 4-2: Mode 1

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

GSV-GNSS Satellites in View

This sentence contains the PRNs, azimuth, elevation, and signal strength of all satellites in view.

GPS GSV message: $GPGSV,……

$GPGSV,4,1,14,28,86,009,35,193,70,056,38,04,44,258,29,17,44,338,44*48

GLONASS GSV message: $GLGSV,……

$GLGSV,3,1,10,79,42,239,15,66,40,076,31,67,37,143,29,81,33,025,14*66

BD GSV message: $BDGSV,……

$BDGSV,1,1,03,10,46,329,31,08,43,161,,09,40,217,*52

Table 5: GSV Data Format

Name	Example	Units	Description
Message ID	$GPGSV		GSV protocol header
Number of Message	4		Total number of GSV sentences (Range 1 to 3)
Message Number	1		Sentence number of the total (Range 1 to 3)
Satellites in View	14		Number of satellites in view
Satellite ID	28		Channel 1
Elevation	86	degrees	Channel 1(Range 00 to 90)
Azinmuth	009	degrees	Channel 1(Range 000 to 359)
SNR(C/NO)	35	dB-Hz	Channel 1(Range 00 to 99, null when not tracking)
…			…
Satellite ID	17		Channel 4
Elevation	44	degrees	Channel 4(Range 00 to 90)
Azimuth	338	degrees	Channel 4(Range 000 to 359)
SNR(C/NO)	44	dB-Hz	Channel 4(Range 00 to 99, null when not tracking)
Checksum	*48		
EOL	<CR> <LF>		End of message termination

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

RMC-Recommended Minimum Specific GNSS Data

This sentence contains the recommended minimum fix information.

See GGA for Fix Quality, Sats Used, HDOP, Altitude, Geoidal Separation, and DGPS data.

See GSA for Fix Type, PDOP and VDOP.

$GNRMC,023345.000,A,2232.1767,N,11401.1953,E,0.18,151.55,100410,,,A*76

Table 6: RMC Data Format

Name	Example	Units	Description
Message ID	$GNRMC		RMC protocol header
UTS Position	023345.000		hhmmss.sss
Status	A		A=data valid or V=data not valid
Latitude	2232.1767		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	11401.1953		dddmm.mmmm
E/W Indicator	E		E=east or W=west
Speed Over Ground	0.18	Knots	
Course Over Ground	151.55	Degrees	True Course
Date(UTC)	100410		ddmmyy
Magnetic variation	<Null>	Degrees	Null fields when it is not Used
Magnetic Variation Direction	<Null>		E=east or W=west (Null fields when it is not Used)
Fix Mode	A		A=autonomous, N = No fix, D=DGPS, E=DR
Checksum	*76		
EOL	<CR> <LF>		End of message termination

VTG-Course Over Ground and Ground Speed

This sentence contains the course and speed of the navigation solution.

$GNVTG,148.81,T,,M,0.13,N,0.24,K,A*23

Table 7: VTG Data Format

Name	Example	Units	Description
Message ID	$GPVTG		VTG protocol header
Tcourse	148.81	Degrees	True Course
Reference	T		T = True
Mcourse	<Null>	Degrees	Magnetic Course (Null fields when it is not Used)
Reference	M		M = Magnetic (Null fields when it is not Used)
Speed over ground	0.13	Knots	Nautical Miles per Hour
Units	N		Knots
Speed over ground	0.24	Km/hr	in Kilometers per Hour
Units	K		Kilometer per hour
Mode	A		A=Autonomous, N=No fix, D=DGPS, E=DR
Checksum	*23		
EOL	<CR> <LF>		End of message termination

ZDA-Date and Time

This sentence contains UTC date & time, and local time zone offset information.

$GNZDA,023345.000,10,04,2010,,*4D

Table 8: ZDA Data Format

Name	Example	Units	Description
Message ID	$GPZDA		ZDA protocol header
UTC Time	023345.000		hhmmss.sss
Day	10		UTC time: day (01 ... 31) dd

Month	04		UTC time: month (01 ... 12) mm
Year	2010		UTC time: year (4 digit year) yyyy
local zone hours	<null>		Local Time Zone Offset Hours (Null fields when it is not Used)
local zone minutes	<null>		Local Time Zone Offset Minutes (Null fields when it is not Used)
Checksum	*4D		
EOL	<CR> <LF>		End of message termination

16 Contact Information

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