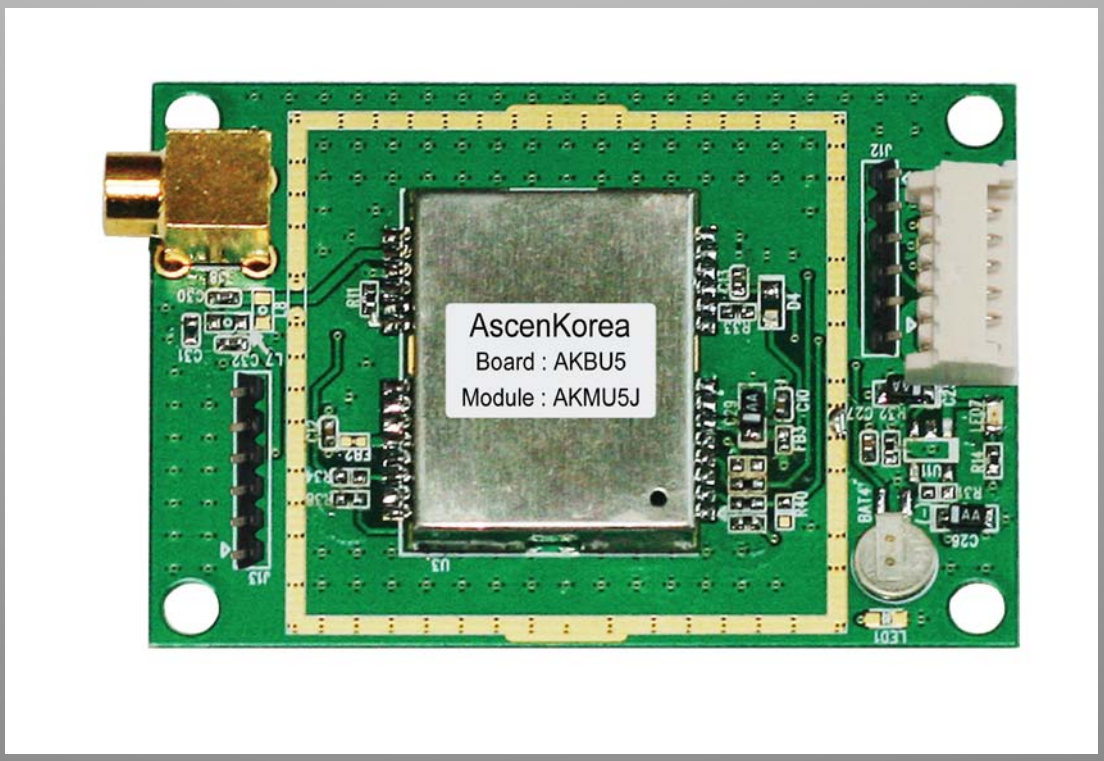
Datasheet

AscenKorea Inc.

AKBU5
GPS Module
Datasheet



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Title	**Ascenkorea AKBU5 Datasheet**
Subtitle	**GPS Module**
Doc Type	**Datasheet**
Doc Id	**AS2010-GM001**

Revision	**Date**	**Author**	Description
V0A	2012-01-25	Dennis Choi	First Release

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1. Functional Description

1.1 Overview

The Ascenkorea AKBU5 module utilizes MediaTek GPS MT 3329 solution that supports up to 66 channels of satellite searching with -165dBm sensitivity and 10Hz maximum update rate for precise GPS signal processing under low receptive, high velocity conditions.

AKBU5 comes with built-in, fully programmable GPS jammer Detect & Report System called ″Anti-JACK™”. The alarm indicator can output jammer status using UART TX output in customized NEMA string or via hardware pin voltage output once the jammer signal detected exceeds the specified level.

Anti-JACK™ is adaptable to various environments via the 2 levels of sensitivity which can be easily set through software command, and can be switched on/off as needed. An additional power saving mode for Anti-JACK™ is also available that automatically reduces power consumption used for GPS jammer detection when the GPS signal reception is above acceptable range.

AKBU5 also features an antenna system called “Antenna Advisor” that helps with detecting and notifying different antenna statuses, including active antenna connection, antenna open circuit and antenna short circuit. Antenna short circuit protection is also available to safe-gurad the module from being damaged due to DC short circuit between antenna and GND.

It is very easy to implement “Antenna Advisor” function by mounting a single additional resistor. (see application note or reference circuit)

The major advancement in jammer detection and hassle-free antenna detection/protection in a popular SMD form factor coupled with flexible GPS firmware customization makes this GPS module an ideal solution for fleet management and critical asset security.

Application

- Asset management
- Security industry
- Surveillance

1.2 Highlights and Features

a. GPS Receiver System

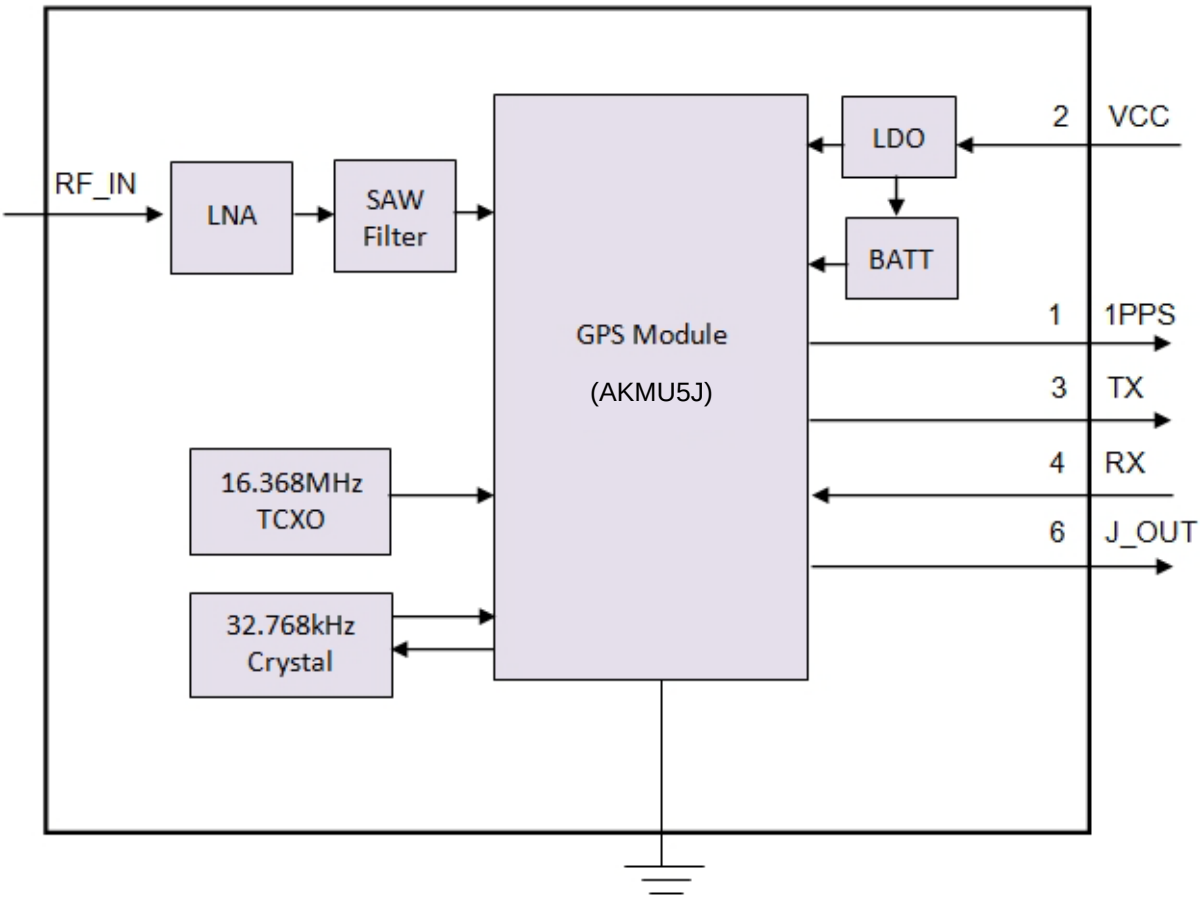
- "Antenna Advisor" –Active and Passive Antenna support with the following features and only a single additional resistor is required:
  - Active and Passive Antenna Detection & Notification
  - Open Circuit Detection & Notification
  - Short Circuit Protection & Notification
- Ultra-High Sensitivity : -165dBm(Typical)
- High Update Rate : up to 10Hz (configurable by firmware)
- DGPS(WAAS/EGNOS/MSAS/GAGAN) Support Note1
- AGPS Support for Fast TTFF
- Magnetic Variation function support (configurable by customized firmware)
- 1-PPS Support for Timing Applications
- E911, RoHS, REACH compliant
- Power Consumption
  - Acquisition : 33mA Typical
  - Tracking : 26mA Typical

Note 1 : SBAS can only be enabled when update rate is less than or equal to 5Hz.

b. Anti-**JACK**™(Anti-**J**amming **A**ssessment **C**ommand feedbac**K**) System (GPS Jammer Detect & Report)

- Jamming Sensitivity :
  -50dBm (High sensitivity) & -40dBm(Low Sensitivity) @ 1575.42MHz
- Auto Jamming Sensitivity Adjustment Based on Antenna Type (Active vs Passive)
- Customized NMEA and Hardware Pin Voltage Output Notification
- Power Saving Mode for jammer Detection
- Power Consumption :
  - operating : 16mA Typical

1.3 System Block Diagram



1.4 Antenna Advisor

"Antenna Advisor" is a brand new antenna system available exclusively for AKBU5. It is designed to detect and notify antenna status using both hardware (through pin voltage level output) and software (through proprietary protocol).

Antenna Advisor can detect and notify the following:

- Active Antenna Connected
- Active Antenna Short
- Active Antenna Open (Not Connected), or Passive Antenna Connected (Antenna Advisor cannot differentiate these two)

In addition, Antenna Advisor can protect the module against short from(external) active antenna by limiting the current drawn to a safe level. This is automatically activated whenever the system detects a load larger than 30mA at RF_IN pin.

1.5 Anti-JACK™(GPS Jammer Detect & Report)

Anti-JACK™ (Anti-Jamming Assessment Command Feedback) is a revolutionary GPS Jammer Detect & Report system available exclusively to AKBU5. It is designed to detect and notify jamming noise status using both hardware (through pin voltage level output) and software (through proprietary protocol).

By connecting this warning output to GSM/GPRS modem[1] or anti-theft system such as engine disable mechanism and siren, this system can effectively double the protection of your vehicles or assets in addition to GSM jamming protection[1].

Anti-JACK™ can also auto detect antenna type to deduce the level of jamming sensitivity, as well as supply several control command for host CPU to program the report and detect model under different conditions. Also a power saving mode is implemented that reduces power consumption of jammer detection when GPS signal reception is acceptable. It is a very flexible solution for users who wish to design GPS jamming signal detection for various applications.

Notes:

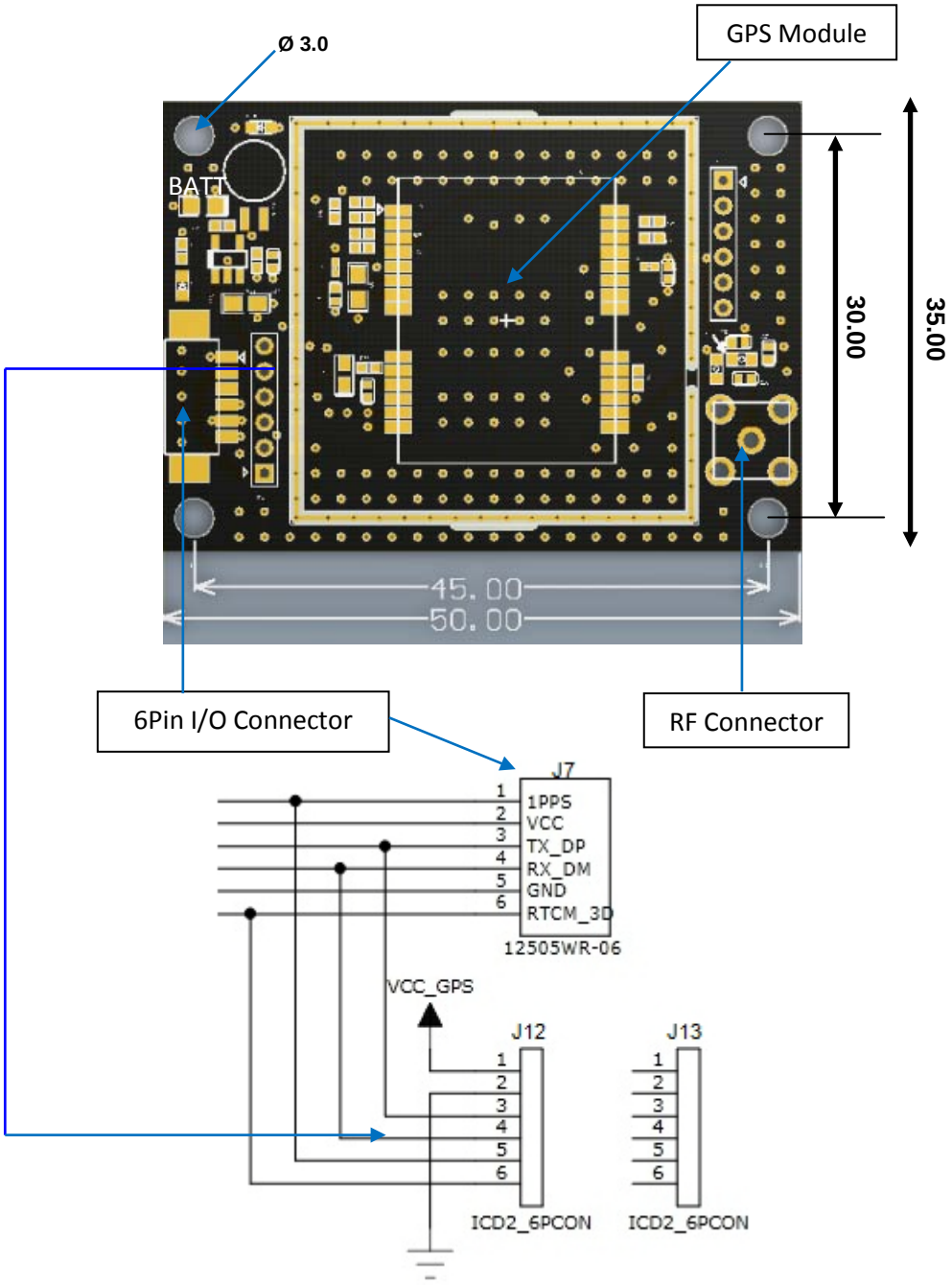
[1] Not Included in AKBU5

2. Specifications

Unit: mm

Mechanical (Dimension)

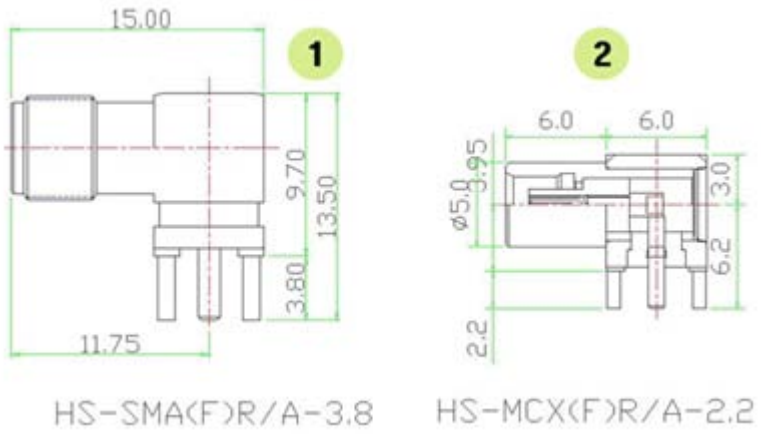
Board Ass'y



Item	Model Name	Description
1	AKBU5-SM	6 Pin I/O Connector, SMA Type Connector
2	AKBU5-MC	6 Pin I/O Connector, MCX Type Connector

RF Connector (SMA / MCX)

Unit: mm



HS-SMA(F)R/A-3.8　　HS-MCX(F)R/A-2.2

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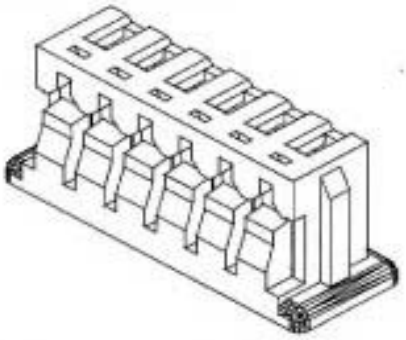
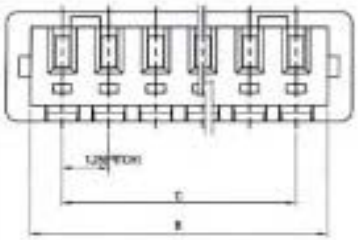
6 Pin connector

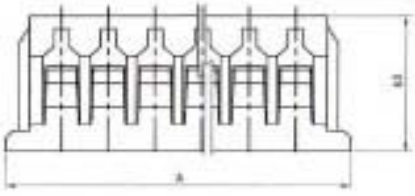
Wire to Board Wafer: http://yeonho.com/pdf/12505WR.pdf 12505WR-06A00
Wire to Board Housing: http://yeonho.com/pdf/12505HS.pdf 12505HS-06000

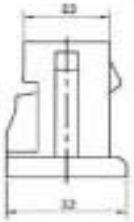
1.25mm (0.049") PITCH CONNECTOR

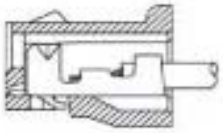
Wire-to-Board Housing — *12505HS Series*

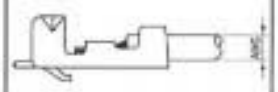












Material

NO	DESCRIPTION	TITLE	MATERIAL
1	HOUSING	12505HS	PA66, UL 94V Grade

Available Pin

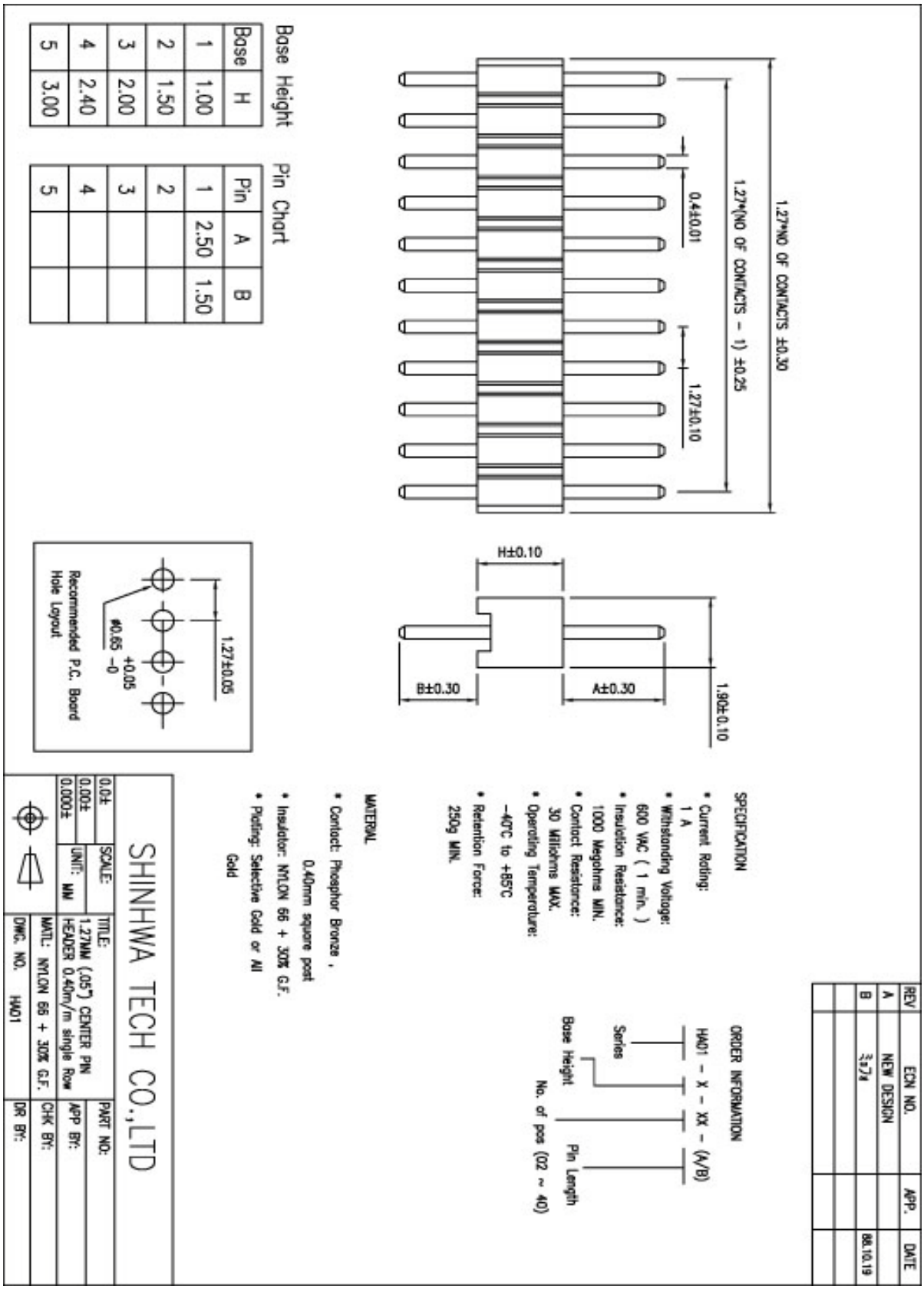
PARTS NO.	A	B	C
12505HS-02000	4.25	2.95	1.25
12505HS-03000	5.50	4.20	2.50
12505HS-04000	6.75	5.45	3.75
12505HS-05000	8.00	6.70	5.00
12505HS-06000	9.25	7.95	6.25
12505HS-07000	10.50	9.20	7.50
12505HS-08000	11.75	10.45	8.75
12505HS-09000	13.00	11.70	10.00
12505HS-10000	14.25	12.95	11.25
12505HS-11000	15.50	14.20	12.50
12505HS-12000	16.75	15.45	13.75
12505HS-13000	18.00	16.70	15.00
12505HS-14000	19.25	17.95	16.25
12505HS-15000	20.50	19.20	17.50

Specification

ITEM	SPEC
Voltage Rating	AC/DC 125V
Current Rating	AC/DC 1A
Operating Temperature	-25℃~+85℃
Contact Resistance	30mΩ MAX
Withstanding Voltage	AC250V/1min
Insulation Resistance	100MΩ MIN
Applicable Wire	AWG #28~#32
Applicable P.C.B	-
Applicable FPC/FFC	-
Solder Height	-
Crimp Tensile Strength	-
UL FILE NO	E106706

Application Terminal : 12505TS (22 Page)

Pin header



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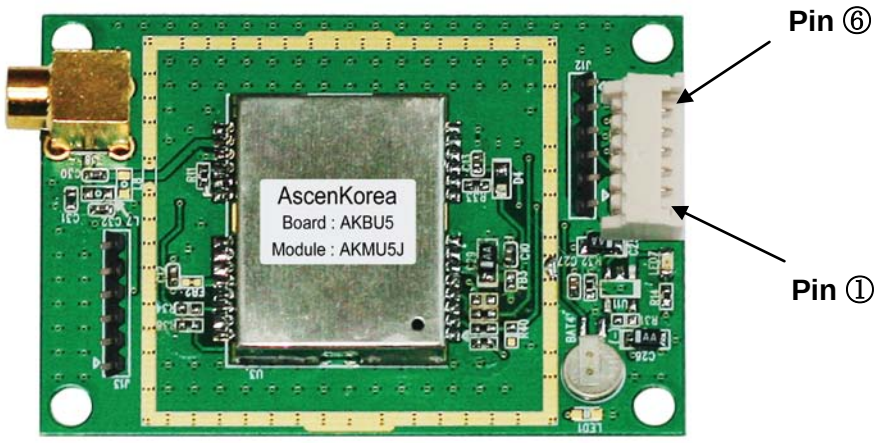
2.1 Pin Assignment (6 Pin connector)

Pin	Name	I/O	Description & Note
1	1PPS	O	1PPS Time Mark Output 2.8V CMOS Level (Default)
2	VCC	PI	Main DC power input (Default)
3	TXDA	O	Serial Data Output for NMEA output (Default)
	DP	I/O	USB port D+ (Optional)
4	RXDA	I	Serial Data Input for Firmware update (Default)
	DM	I/O	USB port D- (Optional)
5	GND	P	Ground (Default)
6	J_OUT	O	Jamming detecting status out (Default)



2.2 Description of I/O Pin

1PPS, Pin1

This pin provides one pulse-per-second output from the module, which is synchronized to GPS time. If not used, keep floating; default duration 100ms

VCC, Pin2

The main DC power supply for the module. The voltage should be kept 5.0V.

The ripple must be controlled under 50mV$_{pp}$ (Typical: 3.3V)

TXDA, Pin3 (Default)

This is the UART transmitter of the module. It outputs the GPS information for application

DP, Pin3 (Optional)

USB Port DPLUS signal (Differential Signal +)

RXDA, Pin4 (Default)

This is the UART receiver of the module. It is used to receive commands from system

DM, Pin4 Optional)

USB Port DMINUS signal (Differential Signal －)

GND, Pin5

Ground

ENABLE, Pin6 (Default)

Keep open or pull high to Power ON. Pull low to shutdown the module.

Enable (High): 1.6V<= V_{enable}<=VCC

Disable (Low): 0V<= V_{enable}<=0.3V

J_OUT, Pin6

Indicate the status of jamming signal detected. A “High” level indicates a jamming signal Has been detected nearby the module, and a “Low” level indicates no jamming signal has Been detected.

2.3 Specification List

Parameter	Description
GPS Solution	MTK MT3329
Frequency	L1, 1575.42MHz
Sensitivity[1]	Acquisition -148dBm, cold start Reacquisition -160dBm Tracking -165dBm
Channel	66 channels
TTFF[1]	Hot start: 1 second typical Warm start: 33 seconds typical Cold start: 35 seconds typical
Position Accuracy	Without aid:3.0m 2D-RMS DGPS(RTM,SBAS(WAAS,EGNOS,MSAS)):2.5m 2D-RMS
Velocity Accuracy	Without aid : 0.1m/s DGPS(RTM,SBAS(WAAS,EGNOS,MSAS)):0.05m/s Without aid:0.1 m/s^2
Acceleration Accuracy	Without aid:0.1 m/s^2 DGPS(SBAS(WAAS,EGNOS,MSAS)):0.05m/s^2
Timing Accuracy (1PPS output)	100 ns RMS
Altitude	Maximum 18,000m (60,000 feet)
Velocity	Maximum 515m/s (1000 knots)
Acceleration	Maximum 4G
Update Rate	1Hz (default), maximum 10Hz
Baud Rate	9600 bps (default)
DGPS	SBAS(defult) [WAAS, EGNOS, MSAS,GAGAN] (≤5Hz update rate)
AGPS	Support
Power Supply	VCC : 3V to 3.6V / VBACKUP : 2.0V to 4.3V
Current Consumption	33mA acquisition, 26mA tracking
Working Temperature	-40 °C to +85 °C(without Battery) -20 °C to +60 °C(with Battery)
Dimension	50 X 37 x 9.7(SMA) [mm]
Weight	9 g

[1] Reference to GPS chipset specification

Anti-JACK™(GPS Jammer Detection and Report) Specification)	
Jamming Sensitivity	**-50dBm (High sensitivity) & -40dBm(Low sensitivity)**
Jamming Detection	**Built-in high gain and band selection device for detection**
Power Supply	**VCC : 3V to 3.6V**
Current Consumption	**16 mA(operating)**

2.4 Absolute Maximum Ratings

The voltage applied for VCC should not exceed 4VDC;

Parameter	Symbol	Min.	Typ.	Max.	Unit
Power Supply Voltage	VCC	3.0	3.3	3.6	**V**
Backup battery Voltage	VBACKUP	2.0	3.0	4.3	**V**

2.5 Operating Conditions

Parameter	Condition	Min.	Typ.	Max.	Unit
Operation supply Ripple Voltage	—	—	—	50	**mVpp**
RX0 TTL H Level	VCC=3.3V	2.0	—	VCC	**V**
RX0 TTL L Level	VCC=3.3V	0	—	0.9	**V**
TX0 TTL H Level	VCC=3.3V	2.4	—	2.8	**V**
TX0 TTL L Level	VCC=3.3V	0	—	0.4	**V**
RTCM TTL H Level	VCC=3.3V	2.1	—	VCC	**V**
USB D+	Standard	—	—	—	**V**
USB D-	Standard	—	—	—	**V**
RTCM TTL L Level	VCC=3.3V	0	—	0.9	**V**
Current Consumption @ 3.3V	Acquisition	43	48	53	**mA**
	Tracking	32	37	42	**mA**
Backup Power Consumption@ 3.0V	25℃	—	20	—	**uA**

2.6 GPS External Antenna Specification (Recommended)

It is important that the antenna gets a clear view of the sky and is positioned on a surface level to the horizon for best results. The following specification has to meet for the use reference design.

Characteristic	Specification
Polarization	Right-hand circular polarized
Frequency Received	1.57542GHz +/- 1.023MHz
Power Supply	3V to 3.6V
DC Current	3mA <IDC < 30mA at 3.3V
Total Gain	+ 25dBi
Output VSWR	< 2.5
Impedance	50 ohm
Noise Figure	< 1.5dB

3. Protocols

NMEA Output Sentence

Table-1 lists each of the NMEA output sentences specifically developed and defined by MTK for use within MTK products

Table-1: NMEA Output Sentence	
Option	**Description**
GGA	Time, position and fix type data.
GSA	GPS receiver operating mode, active satellites used in the position solution and DOP values.
GSV	The number of GPS satellites in view satellite ID numbers, elevation, azimuth, and SNR values.
RMC	Time, date, position, course and speed data. Recommended Minimum Navigation Information.
VTG	Course and speed information relative to the ground.
GLL	Geographic Position, Latitude / Logitude

Table-2 lists each of the custom NMEA output sentences specifically developed and defined by MTK for use within MTK products

Table-2: Custom NMEA Output Sentence	
Option	**Description**
PGACK	The status of antenna.

GGA—Global Positioning System Fixed Data. Time, Position and fix related data

Table-3 contains the values for the following example：

$GPGGA,064951.000,2307.1256,N,12016.4438,E,1,8,0.95,39.9,M,17.8,M,,*65

Table-3: GGA Data Format

Name	Example	Units	Description
Message ID	$GPGGA		GGA protocol header
UTC Time	064951.000		hhmmss.sss
Latitude	2307.1256		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12016.4438		dddmm.mmmm
E/W Indicator	E		E=east or W=west
Position Fix Indicator	1		See **Table-3**
Satellites Used	8		Range 0 to 14
HDOP	0.95		Horizontal Dilution of Precision
MSL Altitude	39.9	meters	Antenna Altitude above/below mean-sae-level
Units	M	meters	Units of antenna altitude
Geoidal Separation	17.8	meters	
Units	M	meters	Units of geoid separation
Age of Diff. Corr.		second	Null fields when DGPS is not used
Checksum	*65		
<CR> <LF>			End of message termination

Table-4 Position Fix indicator

Table-4: Position Fix Indicator

Value	Description
0	Fix not available
1	GPS fix
2	Differential GPS fix

GSA—GNSS DOP and Active Satellites

Table-5 contains the values for the following example：

$GPGSA,A,3,29,21,26,15,18,09,06,10,,,,,2.32,0.95,2.11*00

Table-5: GSA Data Format			
Name	**Example**	**Units**	**Description**
Message ID	$GPGSA		GSA protocol header
Mode 1	A		See **Table-5**
Mode 2	3		See **Table-6**
Satellite Used	29		SV on Channel 1
Satellite Used	21		SV on Channel 2
....	....	....	....
Satellite Used			SV on Channel 12
PDOP	2.32		Position Dilution of Precision
HDOP	0.95		Horizontal Dilution of Precision
VDOP	2.11		Vertical Dilution of Precision
Checksum	*00		
<CR> <LF>			End of message termination

Table-6: Mode 1	
Value	**Description**
M	Manual—forced to operate in 2D or 3D mode
A	2D Automatic—allowed to automatically switch 2D/3D

Table-7: Mode 2	
Value	**Description**
1	Fix not available
2	2D (＜4 SVs used)
3	3D (≧4 SVs used)

GSV—GNSS Satellites in View

Table-8 contains the values for the following example：

$GPGSV,3,1,09,29,36,029,42,21,46,314,43,26,44,020,43,15,21,321,39*7D

$GPGSV,3,2,09,18,26,314,40,09,57,170,44,06,20,229,37,10,26,084,37*77
$GPGSV,3,3,09,07,,,26*73

Table-8: GSV Data Format

Name	Example	Units	Description
Message ID	$GPGSV		GSV protocol header
Number of Messages	3		Range 1 to 3 *(Depending on the number of satellites tracked, multiple messages of GSV data may be required.)*
Message Number1	1		Range 1 to 3
Satellites in View	09		
Satellite ID	29		Channel 1 (Range 1 to 32)
Elevation	36	degrees	Channel 1 (Maximum 90)
Azimuth	029	degrees	Channel 1 (True, Range 0 to 359)
SNR (C/No)	42	dBHz	Range 0 to 99, (null when not tracking)
....	….	….	....
Satellite ID	15		Channel 4 (Range 1 to 32)
Elevation	21	degrees	Channel 4 (Maximum 90)
Azimuth	321	degrees	Channel 4 (True, Range 0 to 359)
SNR (C/No)	39	dBHz	Range 0 to 99, (null when not tracking)
Checksum	*7D		
<CR> <LF>			End of message termination

RMC—Recommended Minimum Navigation Information

Table-9 contains the values for the following example：

$GPRMC,064951.000,A,2307.1256,N,12016.4438,E,0.03,165.48,260406,,,A*55

Table-9: RMC Data Format

Name	Example	Units	Description
Message ID	$GPRMC		RMC protocol header
UTC Time	064951.000		hhmmss.sss
Status	A		A=data valid or V=data not valid
Latitude	2307.1256		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12016.4438		dddmm.mmmm
E/W Indicator	E		E=east or W=west
Speed over Ground	0.03	knots	
Course over Ground	165.48	degrees	True
Date	260406		ddmmyy
Magnetic Variation		degrees	E=east or W=west **(Need Ascenkorea Customization Service)**
Mode	A		A= Autonomous mode D= Differential mode E= Estimated mode
Checksum	*65		
<CR> <LF>			End of message termination

VTG—Course and speed information relative to the ground

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

$GPVTG,165.48,T,,M,0.03,N,0.06,K,A*37

Table-10: VTG Data Format			
Name	**Example**	**Units**	**Description**
Message ID	$GPVTG		VTG protocol header
Course	165.48	degrees	Measured heading
Reference	T		True
Course		degrees	Measured heading
Reference	M		**Magnetic (Need Ascenkorea Customization Service)**
Speed	0.03	knots	Measured horizontal speed
Units	N		Knots
Speed	0.06	km/hr	Measured horizontal speed
Units	K		Kilometers per hour
Mode	A		A= Autonomous mode D= Differential mode E= Estimated mode
Checksum	*06		
<CR> <LF>			End of message termination

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

$GPGLL,2305.91626,N,12017.06438,E,051817.00,A,A*61

Table-11: GLL Data Format			
Name	**Example**	**Units**	**Description**
Message ID	$GPGLL		GLL protocol header
Latitude	2305.91626		ddmm.mmmmm
N/S Indicator	N		N=north or S=south
Longitude	12017.06438		ddmm.mmmmm
E/W Indicator	E		E=east or W=west
UTC Time	064951.00		hhmmss.ss
Status	A		A=data valid or V=data not valid
Mode	A		A=Autonomous mode D=Differential mode E=Estimated mode
Checksum	*61		

Antenna Status Protocol (Antenna Advisor)

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

$PGACK,13,3*6F

Table-12: PGACK Data Format			
Name	**Example**	**Units**	**Description**
Message ID	$PGACK		PGACK protocol header
Command ID	13		The id of command
Reference	3		Value of antenna status

Example :

$PGACK,13,value*checksum

Value : 1=>Active Antenna Short

2=>Passive Antenna Connected or Active Antenna Open

3=>External antenna active

Antenna Status Protocol (Antenna Advisor)

The complete MTK NMEA Command list document is available by request. Contact Ascenkorea for more details.

Packet Type :

103 PMTK_CMD_COLD_START

Packet Meaning :

Cold Start : Don't use Time, Position, Almanacs and Ephemeris data at re-start.

Example :

$PMTK103*30<CR><LF>

Antenna and GPS Jammer Status Report Protocol (Antenna Advisor and Anti-JACK™)

Table-13: PGACK 100 Data Format		
Name	**Value**	**Description**
Message ID	$PGACK	PGACK protocol heade
Command ID	100	The id of command for status
Parameter 1	1, 2, or 3	Antenna connecting status: 1. Active Antenna Short 2. Passive Antenna Connected of Active Antenna Open 3. Active (external) antenna active
Parameter 2	0, 1, or 2	Jamming sensitivity setting status: 0. Jamming detect function is disabled 1. Current setting is “High Sensitivity” for Jamming detector. 2. Current setting is “Low Sensitivity” for jamming detector.
Parameter 3	0 or 1	Value of jamming status: 0. No jammer detected. 1. Jammer detected.
Checksum	*checksum	
<CR><LF>		End of message termination

Example :

$PGACK,100,2,1,1*5D<CR><LF>

Parameter 1 : 2=>Passive Antenna Connected of Active Antenna Open

Parameter 2 : 1=>the current setting is “High Sensitivity” for jamming detector.

Parameter 3 : 1=>Jammer detected

Checksum : 5D

Anti-JACK: GPS Jammer Detection Mode Selection Protocol

Anti-JACK™ offers four flexible GPS jammer detect modes that users can select via UART RX depending on their applications.

Example :

$PGCMD,23,Mode*checksum<CR><LF>

Mode 0 : $PGCMD,23,0*6C<CR><LF> Mode 1 : $PGCMD,23,1*6D<CR><LF>

Mode 2 : $PGCMD,23,2*6C<CR><LF> Mode 3 : $PGCMD,23,3*6F<CR><LF>

Table-14: Command mode Format

Mode	Jammer Detector disabled	Power Saving Mode	SW UART Protocol Output	HW JDET_OUT (Pin 2) Output	AJSS[1]	Description
0	√					**Disable Jammer Detect function**
1			√	√	√	**Jammed Detect & Report on UART and Pin 2 Voltage Output, AJSS is enabled.**
2		√	√	√	√	**Power Saving Mode Active in Jammer Detect**
3 (default)		√	√	√		**AJSS is not active, set to high sensitivity.**

[1]AJSS=Auto Jamming Sensitivity Setting

AJSS : Auto Jamming Sensitivity Setting

AJSS will automatically adjust the sensitivity of jammer detection based on the following:

- The auto sensitivity switch will set to “low sensitivity” if an active antenna was connected.
- The auto sensitivity switch will set to “high sensitivity” if a passive antenna is connected to **RF_IN(Pin16).**
- If GPS Jammer Detect Mode 3 (default) is selected, the sensitivity will be always at high sensitivity.

When you finished selecting GPS Jammer Detection Mode with the appropriate command, you will receive an ACK after the command is processed. Please refer to **Table-14** for the detail of ACK packet.

Table-14 contains the values for the following example:

$PGACK 23,Mode*checksum<CR><LF>

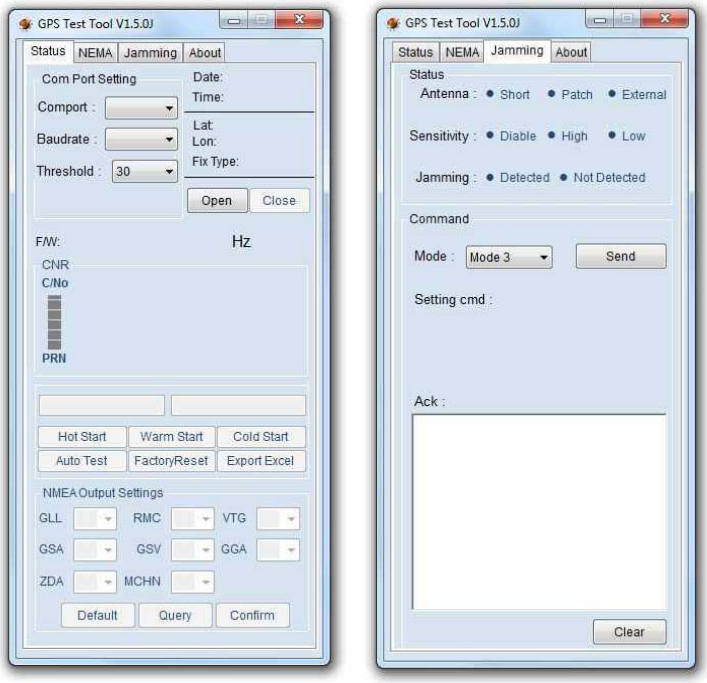
Table-15: PGACK 23 Data Format			
Name	**Example**	**Units**	**Description**
Message ID	$PGACK		PGACK protocol header
Command ID	23		The id of command
Mode	3		The mode of jammer function setting
Checksum	*6C		
<CR> <LF>			End of message termination

Example :

$PGACK,23,3*6C<CR><LF>

Anti-JACK: GPS Jammer Detection Test Program

A simple GPS test tool is available for AKBU5 which allows the testing of various jammer detection and control commands with statues report, including firmware version, NMEA output and CNR. This test tool is for Windows OS based PC and is available for download from AscenKorea website at http://www.ascenkorea.com



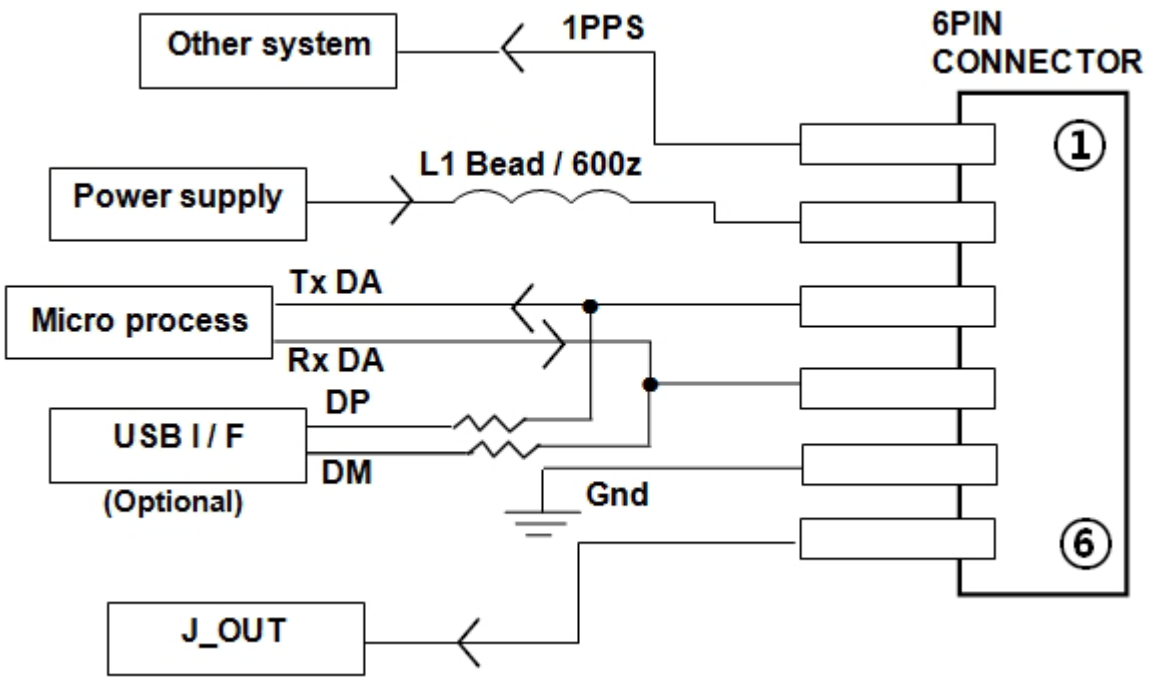
4. Application

4.1 Description

This chapter introduces the reference schematic design for the best performance.

4.2 Reference Design Circuit

External Antenna Application



Notice:

Ferrite bead L1 was add for power noise reduction.

5. Packing and Handling

GPS modules, like any other SMD devices, are sensitive to moisture, electrostatic discharge, and temperature. By following the standards outlined in this document for Ascenkorea GPS module storage and handling, it is possible to reduce the chances of them being damaged during production set-up. This document will go through the basics on how Ascenkorea packages its modules to ensure they arrive at their destination without any damages and deterioration to performance quality, as well as some cautionary notes before going through the surface mount process.

⚠ **Please read the sections II to V carefully to avoid damages permanent damages due to moisture intake**

⚠ **GPS receiver modules contain highly sensitive electronic circuits and are electronic sensitive devices and improper handling without ESD protections may lead to permanent damages to the modules. Please read section VI for more details.**

5.1 ESD Handling

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

Ascenkorea GPS modules are sensitive to electrostatic discharges, and thus are Electrostatic Sensitive Devices (ESD). Careful handling of the GPS modules and in particular to its patch antenna (if included) and RF_IN pin, must follow the standard ESD safety practices:

- ✓ 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 RF_IN pin, please make sure the GND is connected

- ✓ When working with RF_IN pin, do not contact any charges capacitors or materials that can easily develop or store charges such as patch antenna, coax cable, soldering iron.
- ✓ Please do not touch the mounted patch antenna to prevent electrostatic discharge from the RF input
- ✓ When soldering RF_IN pin, please make sure to use an ESD safe soldering iron (tip).

6. Contact

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