

# CD-PA1616S GPS patch antenna module

## Data Sheet V.04



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# 1. Functional Description

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## 1.1 Product description

The CDTop PA1616S module utilizes the MediaTek GPS Chipset MT3339 that achieves the industry's highest level of sensitivity (-165dBm) and instant Time-to-First Fix (TTFF) with lowest power consumption for precise GPS signal processing to give the ultra-precise positioning under low receptive, high velocity conditions.

The module is a revision of POT (Patch On Top) GPS Module with an extra embedded function for external antenna I/O and comes with automatic antenna switching function and short circuit protection, also features an antenna system called "Antenna Advisor" that helps with the detections and notifications of different antenna statuses, including active antenna connection, antenna open circuit and antenna shortage.

Supports up to 210 PRN channels with 66 search channels and 22 simultaneous tracking channels, Module supports various location and navigation applications, including autonomous GPS, QZSS, SBAS(note) ranging (WAAS, EGNO, GAGAN, MSAS), AGPS.

PA1616S is excellent low power consumption characteristic (acquisition 82mW, tracking 66mW), power sensitive devices, especially portable applications, need not worry about operating time anymore and user can get more fun.

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

### Application:

- ✓ Asset management
- ✓ Handheld Device
- ✓ M2M application
- ✓ Security industry
- ✓ Surveillance
- ✓ Tablet PC/PLB/MID

## 1.2 Features

- Built-in 15x15x2.5mm ceramic patch antenna on the top of module
- Ultra-High Sensitivity: -165dBm (w/o patch antenna), up to 45dB C/N of SVs in open sky reception.
- AlwaysLocate: Intelligent Algorithm (Advance Power Periodic Mode) for power saving
- EASY: Self-Generated Orbit Prediction for instant positioning fix
- GPS Consumption current(@3.3V):
  - Acquisition: 25mA Typical
  - Tracking: 20mA Typical
- High accuracy 1-PPS timing support for Timing Applications ( $\pm 20$ ns jitter)
- High Update Rate: up to 10Hz<sup>(note1)</sup>
- Logger function Embedded<sup>(note2)</sup>
- Supports QZSS, SBAS(WAAS, EGNOS, GAGAN, MSAS) ranging
- Ultra-High Sensitivity: -165dBm
- Automatic antenna switching function
- Antenna Advisor function

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

Note2: Some features need special firmware or command programmed by customer.

## 1.3 System Block Diagram

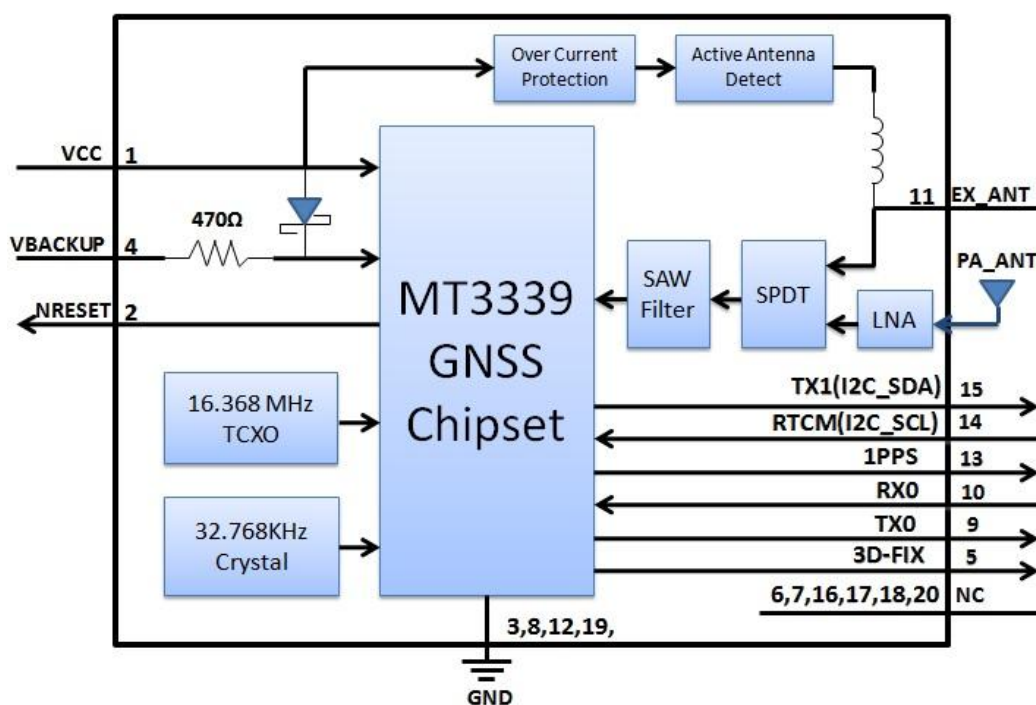


Figure 1-1: System Block Diagram.

### 1.4 Multi-tone active interference canceller

Because different application (Wi-Fi, GSM/GPRS, 3G/4G,Bluetooth )are integrated into navigation system, the harmonic of RF signal will influence the GPS reception, The multi-tone active interference canceller (abbr: MTAIC ) can reject external RF interference which come from other active components on the main board, to improve the capacity of GPS reception without any needed HW change in the design .CD-SA1209S can cancel up to 12 independent channel interference continuous wave (CW).

### 1.5 1PPS

A pulse per second (1 PPS) is an electrical signal which precisely indicates the start of a second with the accuracy of  $\pm 20\text{ns}$  RMS (Root Mean Square). The PPS signal is provided through a designated output pin for many external applications. The pulse is not only limited to being active every second but is also allowed to set up the required duration, frequency, and active high/low through a programmable user-defined setting.

### 1.6 AGPS Support for Fast TTFF (EPO™)

The AGPS (EPO™) supply the predicated Extended Prediction Orbit data to speed TTFF ,users can download the EPO data to GPS engine from the FTP server by internet or wireless network ,the GPS engine will use the EPO data to assist position calculation when the navigation information of satellites are not enough or weak signal zone .

### 1.7 AlwaysLocate™ (Advance Power Periodic Mode)

Embedded need to be executed fully all the time, the algorithm can be set by different necessary to decide the operation level of GPS function, reduce power consumption, it will suffer positing accuracy to get the target of power saving and extend the usage time of product.

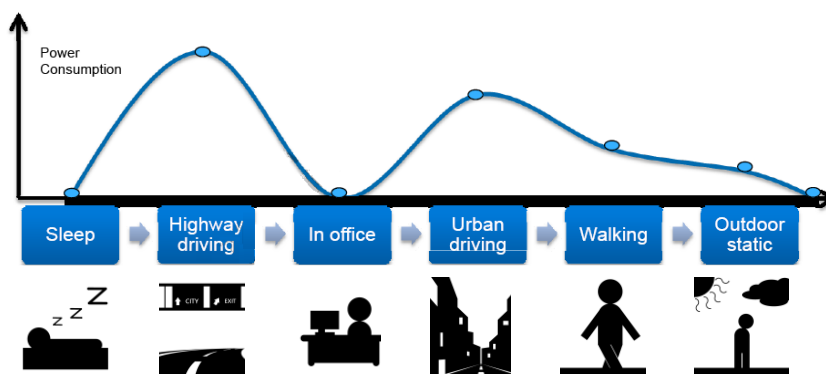


Figure 1-2: Always Locatie

### 1.8 EASY™

The EASY™ is embedded assist system for quick positioning, the GPS engine will calculate and predict automatically the single ephemeris (Max. up to 3 days) when power on, and save the predict information into the memory, GPS engine will use these information for positioning if no enough information from satellites, so the function will be helpful for positioning and TTFF improvement under indoor or urban condition, the Backup power (VBACKUP) is necessary.

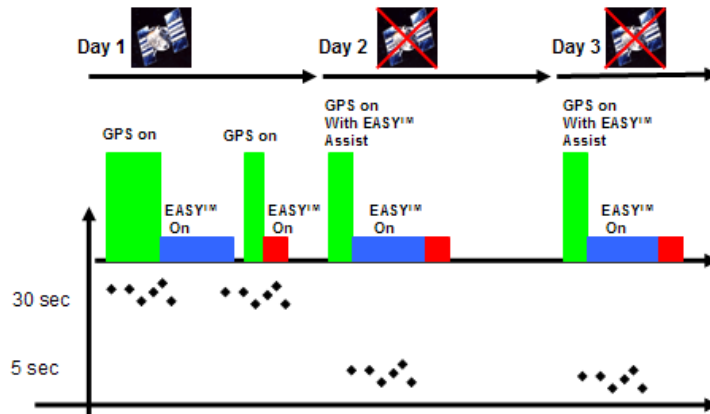


Figure 1-3 EASY System operation

Please refer to the Fig 1-3, When GPS device great the satellite information from GPS satellites, the GPS engine automatically pre-calculate the predict orbit information for 3 days.

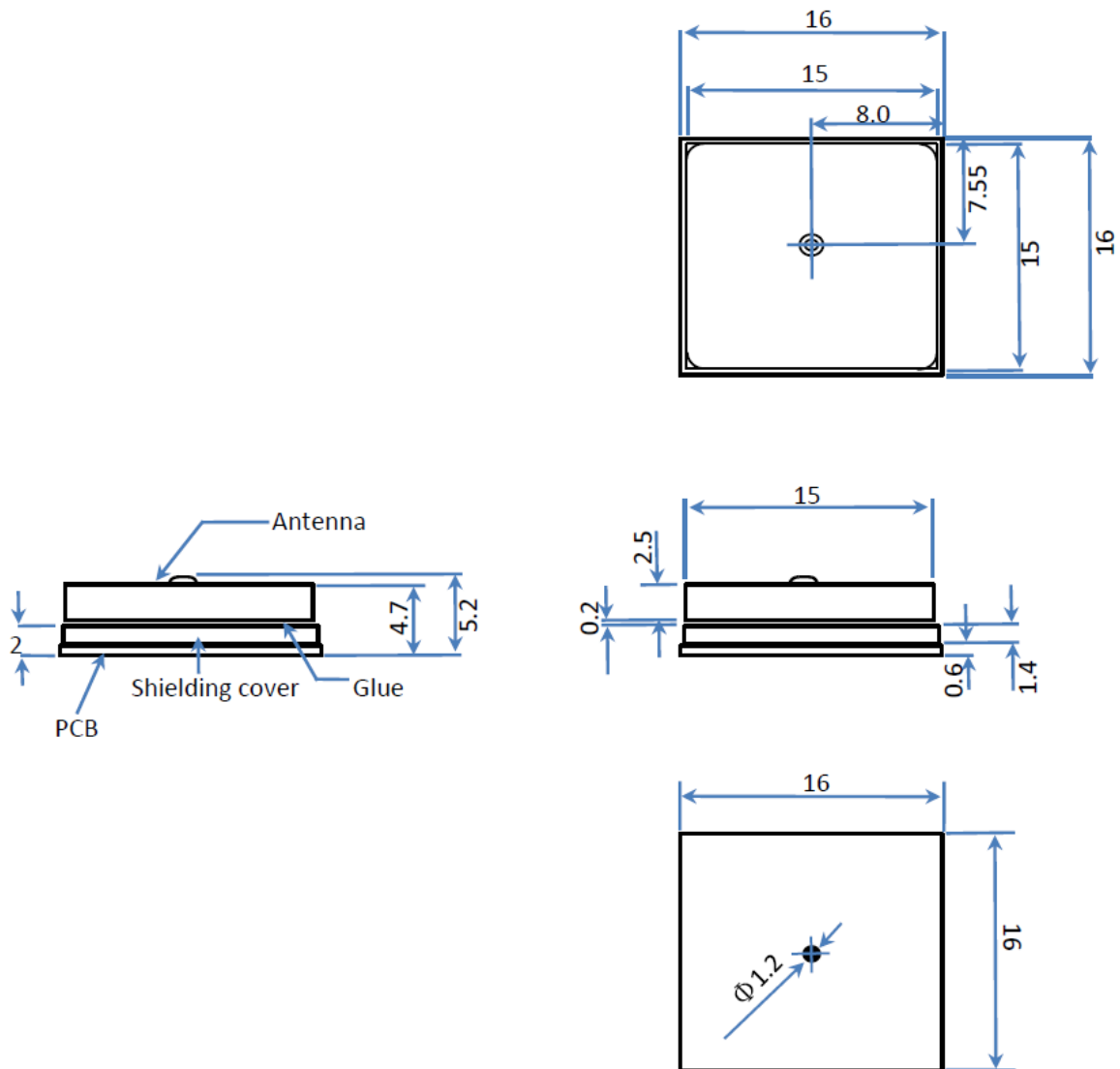
The GPS device still can quickly do the positioning with EASY™ function under weak GPS signal.

### 1.9 Embedded Logger function(LOCUS)

The Embedded Logger function(LOCUS) don't need host CPU (MCU) and external flash to handle the operation, GPS Engine will use internal flash (embedded in GPS chipset) to log the GPS data (Data format: UTC, Latitude, longitude, Valid,Checksum), the maximum log duration is up to two days under AlwaysLocate™.

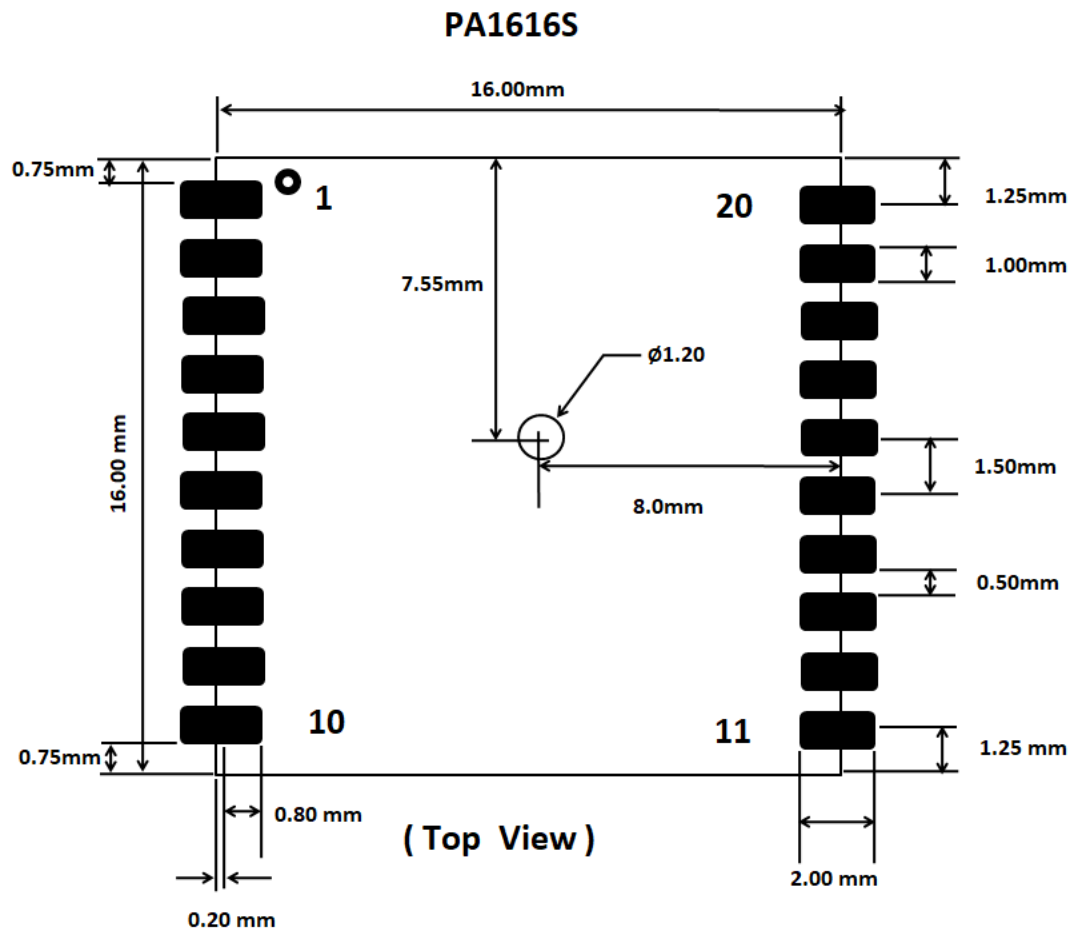
## 2. Specification

### 2.1 Mechanical Dimension

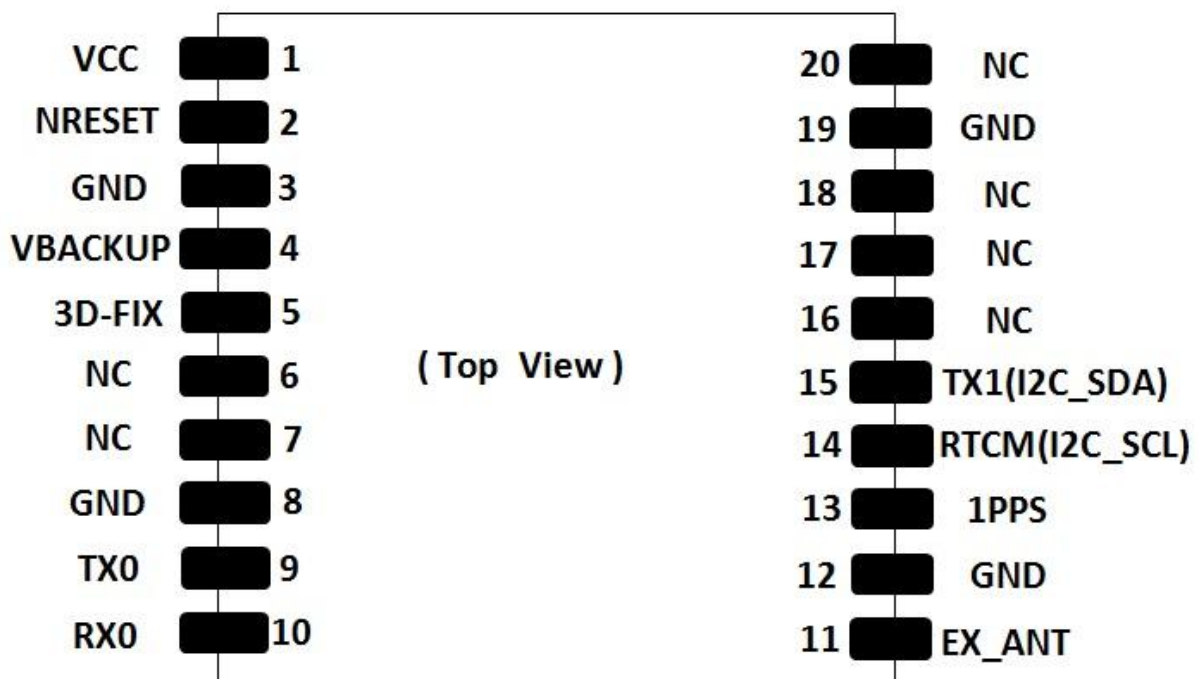


Dimension: (Unit: mm, Tolerance: +/- 0.2mm)

## 2.2 Recommended PCB pad Layout



## 2.3 Pin Configuration





## 2.4 Pin Assignment

Pin	Name	I/O	Description & Note
1	VCC	PI	Main DC power input
2	NRESET	I	Reset Input, Low Active
3	GND	P	Ground
4	VBACKUP	PI	Backup Power Input for RTC & Navigation Data Retention
5	3D-FIX	O	3D-Fix Indicator
6	NC	--	Not Connect
7	NC	--	Not Connect
8	GND	P	Ground
9	TX <sub>0</sub>	O	Serial Data Output for NMEA Output (UART TTL)
10	RX <sub>0</sub>	I	Serial Data Input for Firmware Update (UART TTL)
11	EX_ANT	I PO	External active antenna RF input. DC power from VCC and provide for external active
12	GND	P	Ground
13	1PPS	O	1PPS Time Mark Output 2.8V CMOS Level
14	RTCM (I2C_SCL)	I I	Serial Data Input for DGPS RTCM Data Streaming I2C Serial clock (by custom firmware)
15	TX <sub>1</sub> (I2C_SDA)	O O	Serial Data Output 1 I2C Serial data (by custom firmware)
16	NC	--	Not Connect
17	NC	--	Not Connect
18	NC	--	Not Connect
19	GND	P	Ground
20	NC	--	Not Connect

## 2.5 Description of I/O Pin

### **Pin1, (VCC)**

The main DC power supply of the module, the voltage should be kept between from 3.0V to 4.3V. The Vcc ripple must be controlled under 50mVpp (Typical: 3.3V)

### **Pin2, (NRESET)**

With a low level, it causes the module to reset. If not used, keep floating.

### **Pin3, 8, 12, 19, (GND)**

Ground1

### **Pin4, (VBACKUP)**

This connects to the backup power of the GPS module. Power source (such as battery) connected to this pin will help the GPS chipset in keeping its internal RTC running when the main power source is removed. The voltage should be kept between 2.0V~4.3V, Typical 3.0V.

**If VBACKUP power was not reserved, the GPS module will perform a lengthy cold start every time it is powered-on because previous satellite information is not retained and needs to be re-transmitted.**

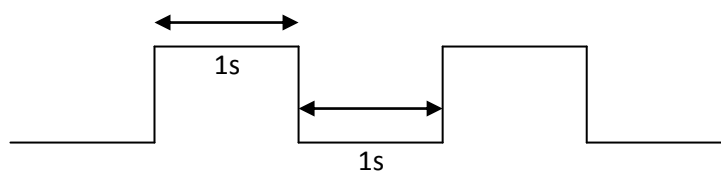
If not used, keep floating.

### **Pin5, (3D-FIX)**

The 3D\_FIX is assigned as a fix flag output. The timing behavior of this pin can be configured by custom firmware for different applications (Example: waking up host MCU). If not used, keep floating.

- Before 2D Fix

The pin should continuously output one-second high-level with one-second low-level signal



- After 2D or 3D Fix

The pin should continuously output low-level signal

Low



### **Pin6, 7, 17, 18, 20, (NC)**

This pin is not connected, keep floating.

### **Pin9, (TX<sub>0</sub>)**

This is the UART transmitter of the module. It is used for aiding. If not used, keep floating.

### **Pin10, (RX<sub>0</sub>)**

This is the UART receiver of the module. It is used for aiding. If not used, keep floating.



### ***Pin11, (EX\_ANT)***

DC power from VCC and provide for external active antenna (Recommendation: 3.3V).

When a 4mA or higher current is detected, the detect circuit will acknowledge the external antenna as being present and uses external antenna for reception.

In the event of short circuit occurring at external antenna, the module will limit the drawn current to a safe level.

**The 3.0V for the GPS external antenna is limited to 25mA.**

**The 3.3V for the GPS external antenna is limited to 28mA.**

**The 3.6V for the GPS external antenna is limited to 31mA.**

### ***Pin13, (1PPS)***

This pin provides one pulse-per-second output from the module and synchronizes to GPS time.

Keep floating if not used.

### ***Pin14, (RTCM) or (I2C\_SCL)***

This pin receive DGPS data of RTCM protocol (TTL level), if not used keep floating.

RTCM is not enabled by default, please consult CDTop support to enable this feature.

This pin can be modified to I2C\_SCL through firmware customization, it received the clock for I2C application, if not used keep floating.

### ***Pin15, (TX<sub>1</sub>) or (I2C\_SDA)***

This is the UART1 transmitter of the module. It is used for aiding. If not used, keep floating

This pin can be modified to I2C\_SDA through firmware customization, it output GPS information for I2C application, if not used please keep floating.

## 2.6 Specification List

Item	Description
GPS Solution	MTK MT3339
Frequency	GPS L1, 1575.42MHz
Sensitivity(GPS portion)	Acquisition: -148dBm, cold start Reacquisition: -163dBm Hot start Tracking: -165dBm
TTFF (No. of SVs>4, C/N>40dB, PDop<1.5)	Hot start: 1 second typical Warm start: 33 seconds typical Cold start: 35 seconds typical, 60 seconds Max
Position Accuracy	Without aid:3.0m (50% CEP) DGPS(SBAS(WAAS,EGNOS,MSAS)):2.5m (50% CEP)
Update Rate	1Hz (default), maximum 10Hz
Baud Rate	9600 bps (default)
Velocity Accuracy	Without aid : 0.1m/s DGPS(SBAS(WAAS,EGNOS,MSAS,GAGAN)):0.05m/s
Timing Accuracy(1PPS Output)	±20 ns RMS within 100ms in one pulse
Altitude	Maximum 18,000m (60,000 feet)
Velocity	Maximum 515m/s (1000 knots)
Acceleration	Maximum 4G
DGPS	SBAS(default) [WAAS, EGNOS, MSAS,GAGAN]
Power Supply	VCC : 3.0V to 4.3V ; VBACKUP : 2.0V to 4.3V
Current Consumption @ 3.3V,1Hz Update Rate	Acquisition: 25mA,Tracking: 20mA
Working Temperature	-40 °C to +85 °C
Dimension	16 x 16 x 5.2 mm, QFN
Weight	4g

## 2.7 Absolute Maximum Ratings

The voltage applied for VCC should not exceed 4.3VDC.

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

## 2.8 Operating Condition

	Condition	Min.	Typ.	Max.	Unit
Operation supply Ripple Voltage	—	—	—	50	mVpp
RX0 TTL H Level	V <sub>CC</sub> =3.0~4.3V	2.0	—	V <sub>CC</sub>	V
RX0 TTL L Level	V <sub>CC</sub> =3.0~4.3V	0	—	0.8	V
TX0 TTL H Level	V <sub>CC</sub> =3.0~4.3V	2.4	—	2.8	V
TX0 TTL L Level	V <sub>CC</sub> =3.0~4.3V	0	—	0.4	V
Current consumption @3.3V, 1Hz update rate	Acquisition	—	25	—	mA
	Tracking	—	20	—	mA
Backup power consumption @ 3V	25°C	—	7	—	μA

## 2.9 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	3.0 to 3.6V
DC Current	4 ~ 20 mA at 3.3V
Total Gain	>+ 15dBi(Two-stage LNA)
Output VSWR	< 2.5
Impedance	50Ω
Noise Figure	< 1.5dB

## 3. Protocols

### 3.1 NMEA Output Sentences

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

Table-1: Each of the NMEA output sentences	
Option	Description
<b>GGA</b>	Time, position and fix type data.
<b>GSA</b>	GPS receiver operating mode, active satellites used in the position solution and DOP values.
<b>GSV</b>	The number of GPS satellites in view satellite ID numbers, elevation, azimuth, and SNR values.
<b>RMC</b>	Time, date, position, course and speed data. Recommended Minimum Navigation Information.
<b>VTG</b>	Course and speed information relative to the ground.

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

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

\$GPGGA,091626.000,2236.2791,N,12017.2818,E,1,10,1.00,8.8,M,18.7,M,,\*66

Table-2: GGA Data Format			
Name	Example	Units	Description
Message ID	\$GPGGA		GGA protocol header
UTC Time	091626.000		hhmmss.sss
Latitude	2236.2791		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12017.2818		dddmm.mmmm
E/W Indicator	E		E=east or W=west
Position Fix Indicator	1		See <b>Table-4</b>
Satellites Used	10		Range 0 to 14
HDOP	1.00		Horizontal Dilution of Precision
MSL Altitude	8.8	meters	Antenna Altitude above/below mean-sea-level
Units	M	meters	Units of antenna altitude
Geoidal Separation	18.7	meters	
Units	M	meters	Units of geoids separation
Age of Diff. Corr.		second	Null fields when DGPS is not used
Checksum	*66		
<CR> <LF>			End of message termination

Table-3: Position Fix Indicator	
Value	Description
0	Fix not available
1	GPS fix
2	Differential GPS fix

### GSA—GPS DOP and Active Satellites

**Table-4** contains the values for the following example :  
`$GPGSA,A,3,01,11,07,18,30,193,22,08,28,03,,,1.32,1.00,0.87*3A`

Table-4: GSA Data Format			
Name	Example	Units	Description
Message ID	\$GPGSA		GSA protocol header
Mode 1	A		See <b>Table-5</b>
Mode 2	3		See <b>Table-6</b>
Satellite Used	01		SV on Channel 1
Satellite Used	11		SV on Channel 2
....	....	....	....
Satellite Used			SV on Channel 12
PDOP	1.32		Position Dilution of Precision
HDOP	1.00		Horizontal Dilution of Precision
VDOP	0.87		Vertical Dilution of Precision
Checksum	*3A		
<CR> <LF>			End of message termination

Table-5: Mode 1	
Value	Description
M	Manual—forced to operate in 2D or 3D mode
A	2D Automatic—allowed to automatically switch 2D/3D

Table-6: Mode 2	
Value	Description
1	Fix not available
2	2D (< 4 SVs used)
3	3D ( $\geq$ 4 SVs used)



**GSV— Satellites in View**

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

```
$GPGSV,4,1,15,01,83,048,45,11,67,006,42,07,58,234,42,18,56,039,42*71
$GPGSV,4,2,15,30,51,284,42,42,51,129,35,193,33,140,38,22,32,120,41*48
$GPGSV,4,3,15,08,31,041,34,28,29,326,38,03,25,147,37,17,13,270,*7C
$GPGSV,4,4,15,09,03,206,22,16,02,119,,27,01,066,*4B
```

Table-7: GPGSV Data Format			
Name	Example	Units	Description
Message ID	\$GPGSV		GSV protocol header
Number of Messages	4		Range 1 to 4 <i>(Depending on the number of satellites tracked, multiple messages of GSV data may be required.)</i>
Message Number1	1		Range 1 to 4
Satellites in View	15		
Satellite ID	01		Channel 1 (Range 1 to 32)
Elevation	83	degrees	Channel 1 (Maximum 90)
Azimuth	048	degrees	Channel 1 (True, Range 0 to 359)
SNR (C/No)	45	dBHz	Range 0 to 99,(null when not tracking)
....	....	....	....
Satellite ID	18		Channel 4 (Range 1 to 32)
Elevation	56	degrees	Channel 4 (Maximum 90)
Azimuth	039	degrees	Channel 4 (True, Range 0 to 359)
SNR (C/No)	42	dBHz	Range 0 to 99, (null when not tracking)
Checksum	*71		
<CR> <LF>			End of message termination

## RMC—Recommended Minimum Navigation Information

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

*\$GPRMC,091626.000,A,2236.2791,N,12017.2818,E,0.32,172.25,160418,,,A\*62*

Table-8: RMC Data Format			
Name	Example	Units	Description
Message ID	\$GPRMC		RMC protocol header
UTC Time	091626.000		hhmmss.sss
Status	A		A=data valid or V=data not valid
Latitude	2236.2791		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12017.2818		dddmm.mmmm
E/W Indicator	E		E=east or W=west
Speed over Ground	0.32	knots	
Course over Ground	172.25	degrees	True
Date	160418		ddmmyy
Magnetic Variation		degrees	
Mode	A		A= Autonomous mode D= Differential mode E= Estimated mode
Checksum	*62		
<CR> <LF>			End of message termination

**VTG—Course and speed information relative to the ground**

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

`$GPVTG,172.25,T,,M,0.32,N,0.59,K,A*33`

Table-9: VTG Data Format			
Name	Example	Units	Description
Message ID	\$GPVTG		VTG protocol header
Course	172.25	degrees	Measured heading
Reference	T		True
Course		degrees	Measured heading
Reference	M		Magnetic
Speed	0.32	knots	Measured horizontal speed
Units	N		Knots
Speed	0.59	km/hr	Measured horizontal speed
Units	K		Kilometers per hour
Mode	A		A= Autonomous mode D= Differential mode E= Estimated mode
Checksum	*33		
<CR> <LF>			End of message termination

**Note:** when inputting the command `$PMTK353,0,1,0,0,0*2A` , \$GNVTG will change to \$GLVTG(For GLONASS). When inputting the command `$PMTK353,1,0,0,0,0*2A` : \$GNVTG will change to \$GPVTG (For GPS).

### 3.2 Antenna Status Command Protocols(Antenna Advisor)

**PCD—Status of antenna**

Table-10 contains the values for the following list:

**\$PCD,11,value\*checksum**

**Example:**

\$PCD,11,1 \*66 \$PCD,11,2 \*65 \$PCD,11,3 \*64

Value: 1=> Using Internal Antenna

2=> Using Active Antenna

3=> Active Antenna Shorted

Table-10 PCACK Data format			
Name	Example	Units	Description
Message ID	\$PCD		Protocol header
Command ID	11		Function Type
Reference	3		True

**Enable Antenna Status command:**

\$CDCMD,33,1\*7C

**Disable Antenna Status command:**

\$CDCMD,33,0\*7D

### 3.3 MTK NMEA Command Protocols

**Packet Type:**

103 PMTK\_CMD\_COLD\_START

**Packet Meaning:**

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

**Example:**

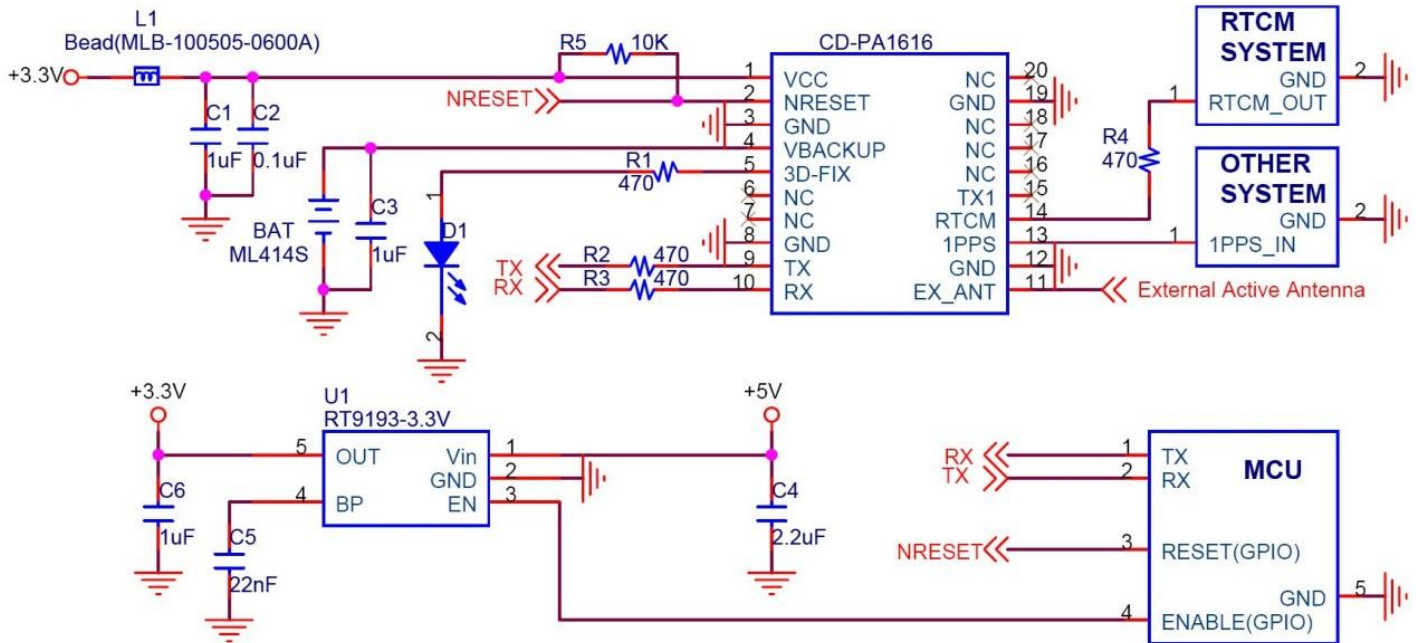
\$PMTK103\*30<CR><LF>

## 4. Reference Design

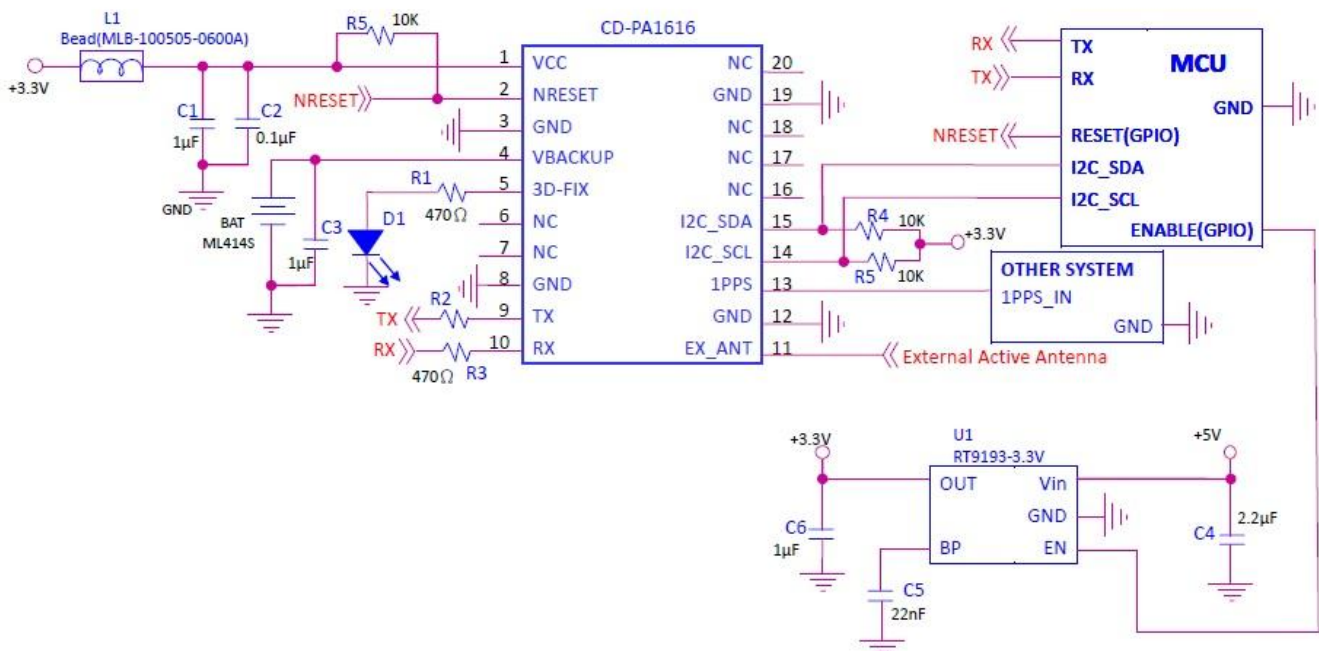
This chapter introduces the reference schematic design for the best performance. Additional tips and cautions on design are well documented on Application Note, which is available upon request.

### 4.1 Reference Design Circuit

#### a. UART + RTCM application



#### b. UART + I2C application



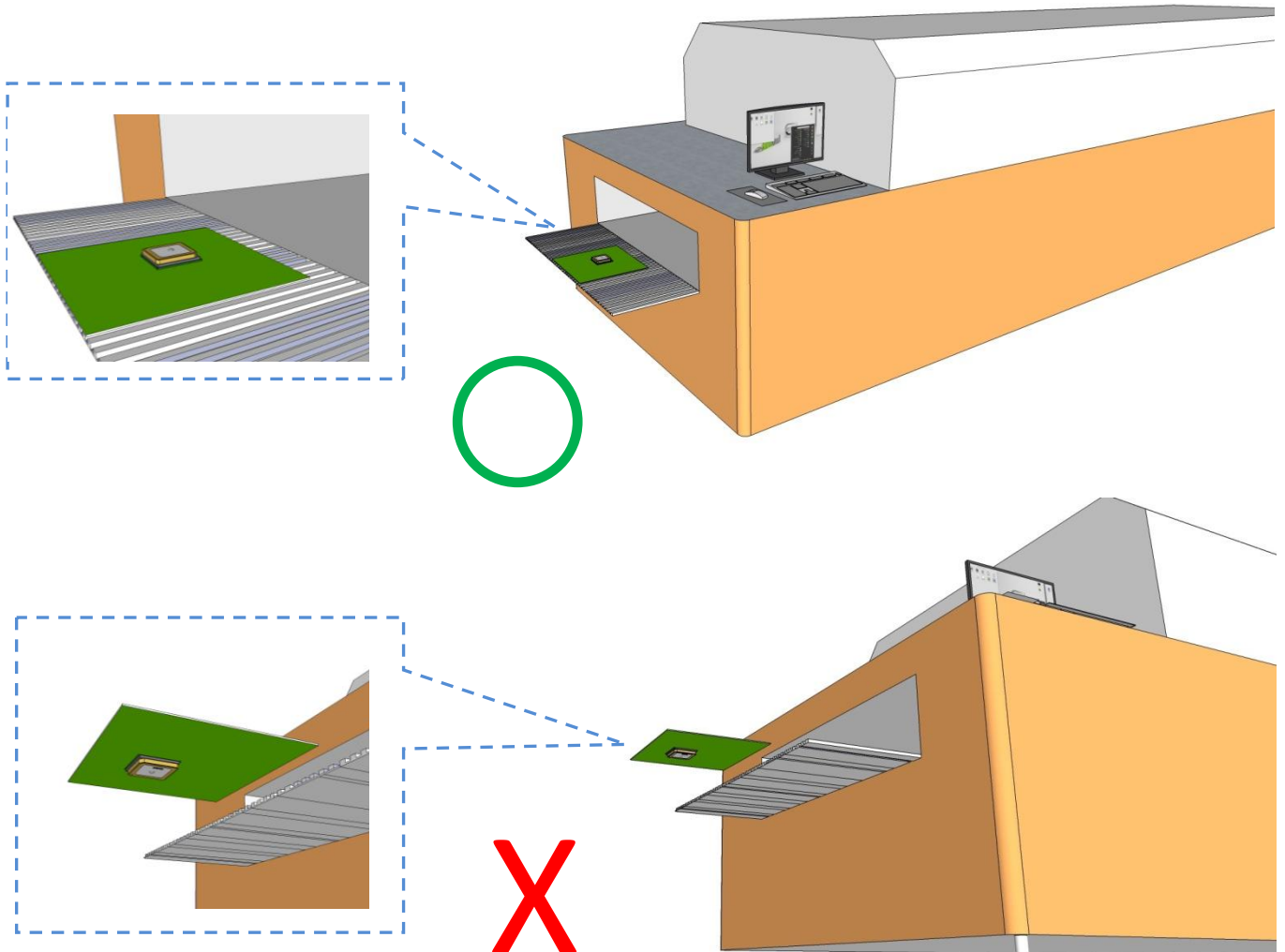
#### Note:

1. Ferrite bead L1 is added for power noise reduction.
2. C1 and C2 bypass should be put near the module.
3. Damping resistors R2, R3, R4 could be modified based on system application for EMI.
4. If you need more support and information on antenna implementation, please directly contact us at [info@cdtop-tech.com](mailto:info@cdtop-tech.com) for further services.

## 5. Reflow Soldering Note

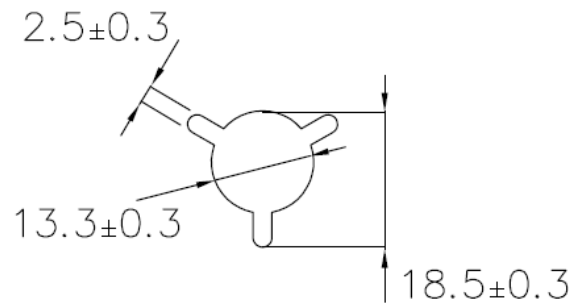
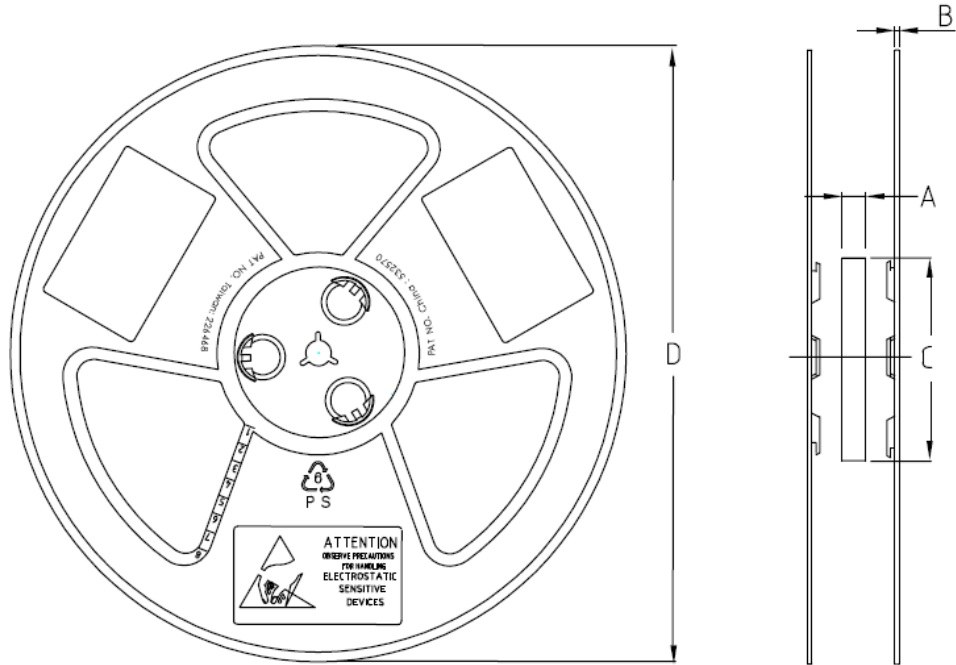
### Cautionary Notes on Reflow-Soldering Process:

1. Module must be pre-baked **before** going through SMT solder reflow process.
2. The usage of solder paste should follow “First-in-First out” principle. Opened solder paste needs to be monitored and recorded in a timely manner (refer to IPQC standards for related documentation and examples).
3. Temperature and humidity must be controlled within SMT production line and storage area. Temperature of 23°C, 60±5% RH humidity is recommended. (please refer to IPQC standards for related documentation and examples)
4. When performing solder paste printing, please notice if the amount of solder paste is in excess or insufficient, as both conditions may lead to defects such as electrical shortage, empty solder and etc.
5. Make sure the vacuum mouthpiece is able to bear the weight of the GNSS module to prevent positional shift during the loading process.
6. Before the PCBA is going through the reflow-soldering process, the operators should check with his/her own eyes to see if there are positional offset to the module.
7. The reflow temperature and its profile data must be measured before the SMT process and match the levels and guidelines set by IPQC.
8. If SMT production line is running a double-sided process for PCBA, please process GNSS module during the second pass only to avoid repeated reflow exposures of the GNSS module. Please contact CDTop beforehand if you must process GNSS module during the 1<sup>st</sup> pass of double-side process.

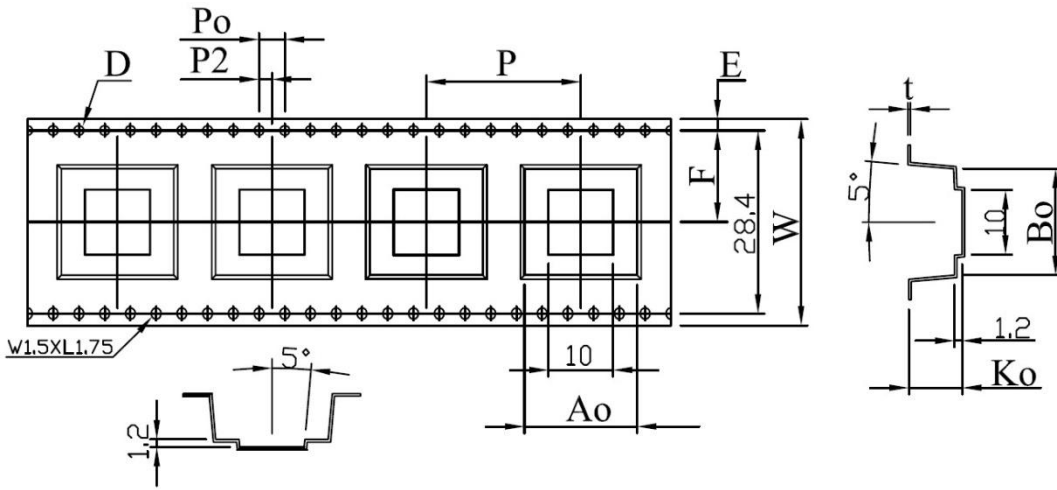


## 6. Tape Reel Packing Information

One Reel : 250pcs



SPEC	13" REEL W: 32 mm				
	Material: HIPS				
ITEM	A	B	C	D	Surface Resistivity
DIM	$32.5 \pm \begin{matrix} +1.0 \\ -0.1 \end{matrix}$ mm	$2.2 \pm 0.2$ mm	$100 \pm 1.0$ mm	$330 \pm 1.5$ mm	$< 10^{11} \Omega/\square$
ALTERNATE					



ITEM	SPEC
<b>W</b>	$32.0^{+0.30}_{-0.30}$
<b>Ao</b>	$17.5^{+0.10}_{-0.10}$
<b>Bo</b>	$16.5^{+0.10}_{-0.10}$
<b>Ko</b>	$8.30^{+0.10}_{-0.10}$
<b>P</b>	$24.0^{+0.10}_{-0.10}$
<b>F</b>	$14.2^{+0.10}_{-0.10}$
<b>E</b>	$1.75^{+0.10}_{-0.10}$
<b>D</b>	$1.50^{+0.10}_{-0.00}$
<b>D1</b>	$0.00^{+0.10}_{-0.10}$
<b>Po</b>	$4.00^{+0.10}_{-0.10}$
<b>P2</b>	$2.00^{+0.10}_{-0.10}$
<b>t</b>	$0.40^{+0.05}_{-0.05}$
Impedance	$<10^7 \Omega$

