1. Hardware

PK-1000 is a cm-level accurate positioning / distance measuring kit with independent intellectual property rights. It is featured with a scheduling system based on clock synchronization. This in-house developed scheduling system, combined with traditional UWB positioning technology, has enabled PK-1000 with the ability to solve the biggest problem in usual TOA (time of arrive) based UWB positioning method -- poorly configurable mesh network. This deficiency means that global positioning in a large complex environment cannot be achieved by usual UWB, while with PK-1000, it is possible. PK-1000 is suitable for research, as well as for integrating with any third-party products. Following the specification and manual of PK-1000, you can set up the kit by yourself, make use of it or further develop it freely.

1.1 Product images

Figure 1 PK-1000 tag

Figure 2 PK-1000 anchor

1.2 Hardware components

1.2.1 The tag

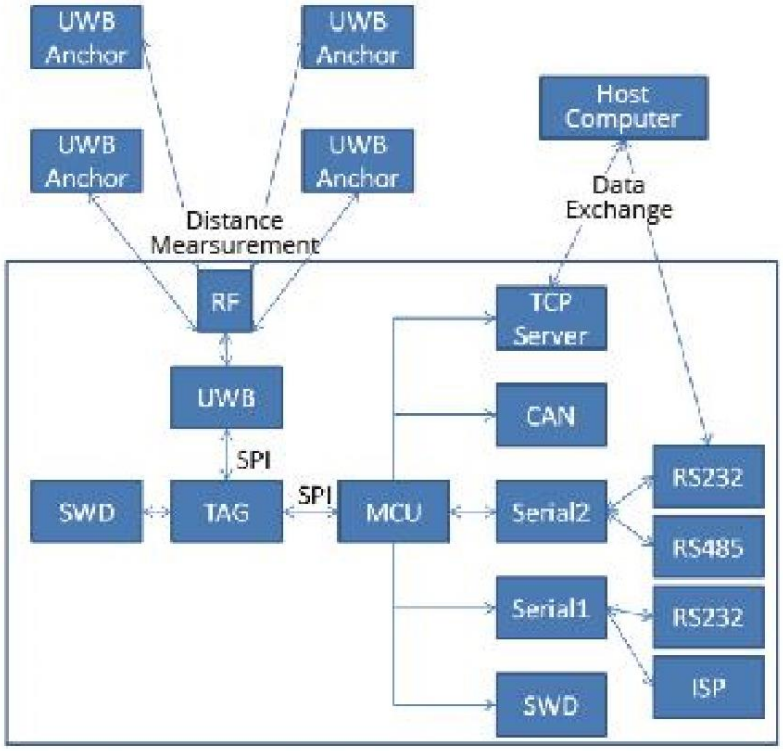

Figure 3 Hardware system of PK-1000 tag

As illustrated inFigure 3,the hardware system of PK-100 tag includes 5parts:

- MCU acquires the distance data measured by TAG, calculates the absolute coordinates of TAG, and processes data exchanged with outer processors through interfaces like Serial,CAN, and TCP.
- TAG communicates with IR-UWB chip, controls the operative mode of IR-UWB,and communicates with Anchors within range.
- TCP Server, Serial and CAN interfaces transmit data and receive order wirelessly.
- SWD and ISP are interfaces for code upgrade.
- TAG is powered through micro USB or independent 5V DC socket.

1.2.2 The anchor

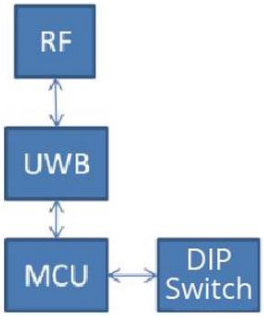

Figure 4 Hardware system of PK-1000 anchor

As illustrated in Figure 4, the hardware system of PK-100 anchor includes 3 parts:

- MCU communicates with IR-UWB chip, controls the operative mode of IR-UWB,and communicates with Tags within range.
- Anchor ID can be set with DIP switch. For detailed instruction, please look into PK-1000 User Manual.
- Anchor is powered by 5v micro USB.

1.3 Definition of interfaces

Please look into PK-1000 User Manual.

1.4 Performance index of the hardware modules

IR-UWB chip provided by Decawave has the following data rates:

No.	Datarates	Preamblelength
1	110Kbps	3.042m
2	850Kbps	380.3us
3	6.8Mbps	103.3us

IR-UWB chip provided by Decawave has the following channels:

No.	Center frequencies (MHz)	Bandwidth(MHz)
1	3494.4	499.2

2	3993.6	499.2
3	4492.8	499.2
4	3993.6	1331.2
5	6489.6	499.2
6	6489.6	1081.6

By default, PK-1000 kit operates on channel 2, center frequencies is 3.994GHz, data rateis6.8Mbps.

The signal power spectral density that PK-10000 transmits is -41Bm/MHz. With a bandwidth of 500MHz, the power of signal of PK-1000 is -14dBm, which is far below that of WIFI and Bluetooth.

The average power of both PK-1000 tag and anchor is roughly 0.925w.

1.5 Specification for physical layer

1.5.1Dimensions

The diameter of all four location holes on both PK-1000 tag and anchor is 3.1mm. Use M3 screws to fix PK-1000.

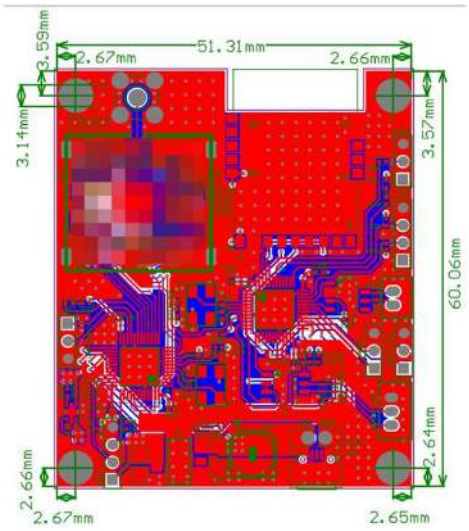

Figure 5 PK-1000 tag dimension

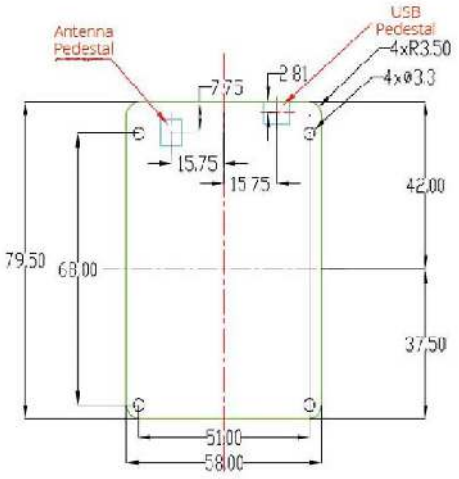

Figure 6 PK-1000 anchor dimension

1.5.2 Operating temperature range

The operating temperature range of PK-1000 is from -40℃ to +85℃, this performance is guaranteed by TCXO (Temperature Controlled Crystal Oscillator).

2. Software

2.1 Software of the microcontroller

2.1.1 Distance measurement

2.1.1.1 Theory of distance measurement

The theory of PK-100 measuring distance is:

Distance = Vl * Ttof

(**Vl** is the velocity of light, Ttof is the duration of electromagnetic wave transmission)

In order to restrain the influence of crystal oscillator deviation on Ttof, PK-1000 is using Symmetric double-sided two-way ranging (SDSTWR) method, as illustrated in Figure7:

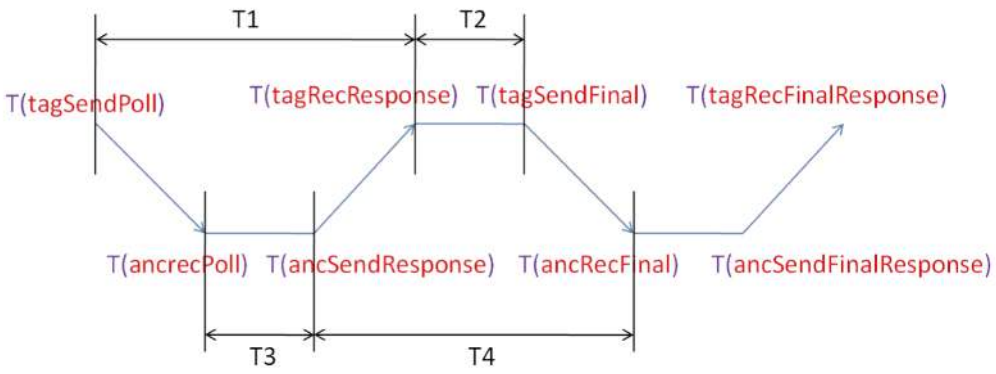

Figure 7 SDSTWR diagram

2.1.1.2 Measurement systems

PK-1000 supports 3 different distance measurement systems, all of which are based on UWB TOF method. You can choose among these systems according to your own application scenario.

(1) 1 tag, 1anchor

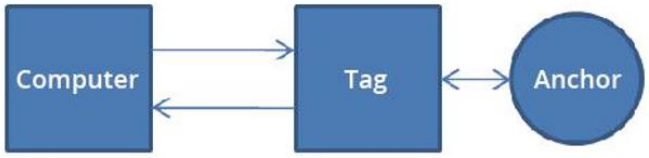

Figure 8　Application framework for 1 tag, 1 anchor

(2) 1 tag, Nanchors

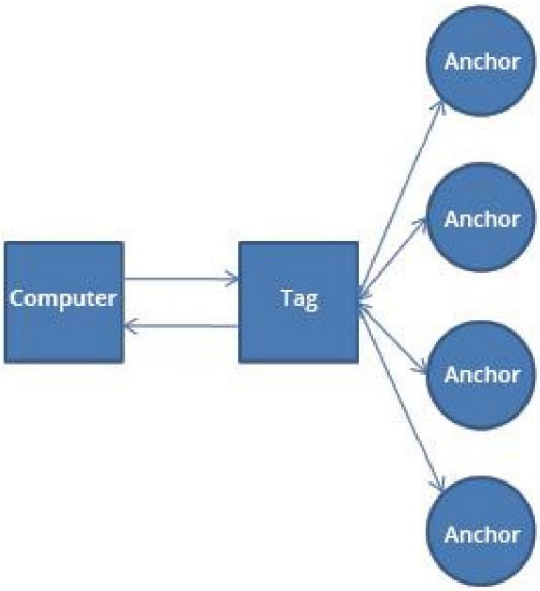

Figure 9　Application framework for 1 tag, N anchor

(3) Mtags, Nanchors

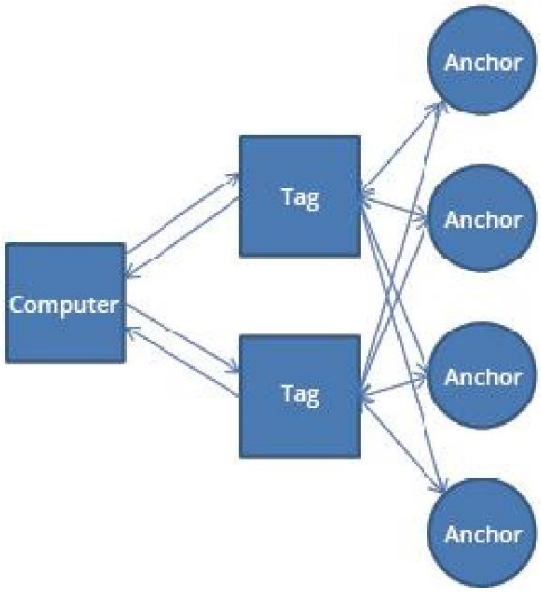

Figure 10 Application framework for 1 tag, N anchor

PK-1000 is based on the in-house developed clock synchronization scheduling system, which is compatible for the aforementioned systems in both hardware and software. But for system 3 (M tags, N anchors), to assure the measuring frequency stays at 10Hz when all the tags are being measured, we advise you to use no more than 10 tags in the same system. There's no restrains on the number of anchors.

Attention:

1. The clock synchronized scheduling system is an important feature of PK-1000. The excellent network capability of PK-1000 is owned to this feature. The positioning accuracy in a large and complex space is 20cm.

2. There's no restrains on the number of anchors. It means that a random tag can communicate with any four anchors, this random tag can choose and change the anchors it communicates with at any time.

2.1.2 Coordinates calculation

The positioning of PK-1000 refers to 2D positioning with X, Y coordinates.

2.1.2.1 Calculation theory

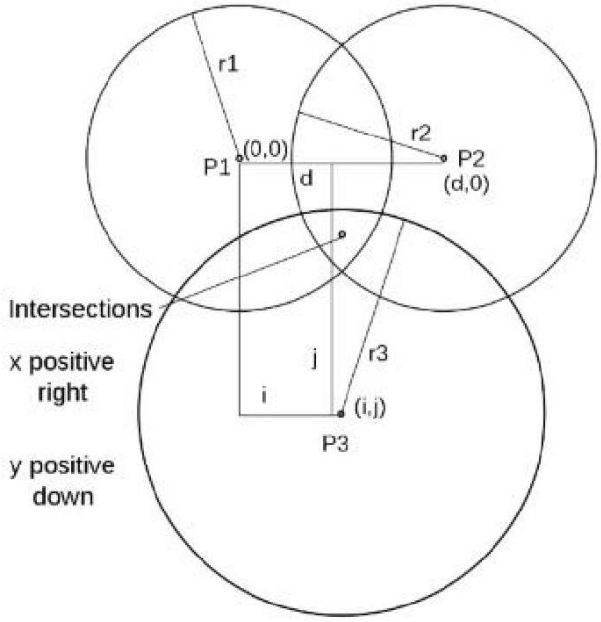

Figure 11 Coordinates calculation theory

PK-1000 positioning system is operational with only 3 anchors. The fourth anchor provides more distance data for the user, and therefore improve the accuracy and robustness of the system.

2.1.2.2 Calculation result

You can find the result in the host computer RLKit. For more information please look into PK-1000 User Manual.

2.2 Software of the host computer

2.2.1 Code upgrade

Please look into PK-1000 User Manual.

2.2.2RLKit

The host computer RLKit has the following functions:

(1) Setup the connection between PK-1000 and RLKit.

(2) Setup tag ID, its corresponding anchors' ID and coordinates.

(3) Display the distances between tags and anchors, and the calculated coordinates of the tags in real-time.

Please look into PK-1000 User Manual for more in formation.

2.3 PK-1000 default parameters

2.3.1 The default parameters of UWB

Content	Default value
Channel	Channel 2, Center frequency: 3.994GHz, Bandwidth: 500MHz
Data rate	6.8MHz
Measuring frequency	10Hz
PANID	DECA

2.3.2 The default parameters of PK-1000 tag WIFI module

Content	Default value
Operating mode	TCP Server
SSID	BeiLa
Password	12345678
IP address	192.168.0.19
Server port	8080

2.3.3 ThedefaultparametersofPK-1000tag serialports

Content	Default value
Baud rate	115200
Data bit	8
Stop bit	1
Check bit	None

3. PK-1000 performance demonstration

3.1 Error performance of outdoor measurement (0-20m)

True Value	Avg. Measured Value	Errors
124	118	6
173	171	2
235	226	9
282	277	5
339	334	5
390	388	2
462	460	2
507	503	4
583	580	3
615	613	2
715	715	0
751	752	−1
877	876	1
930	929	1
999	998	1
1119	1119	0
1124	1123	1
1290	1289	1
1350	1348	2
1529	1529	0
1663	1659	4
1856	1858	−2
2014	2008	6

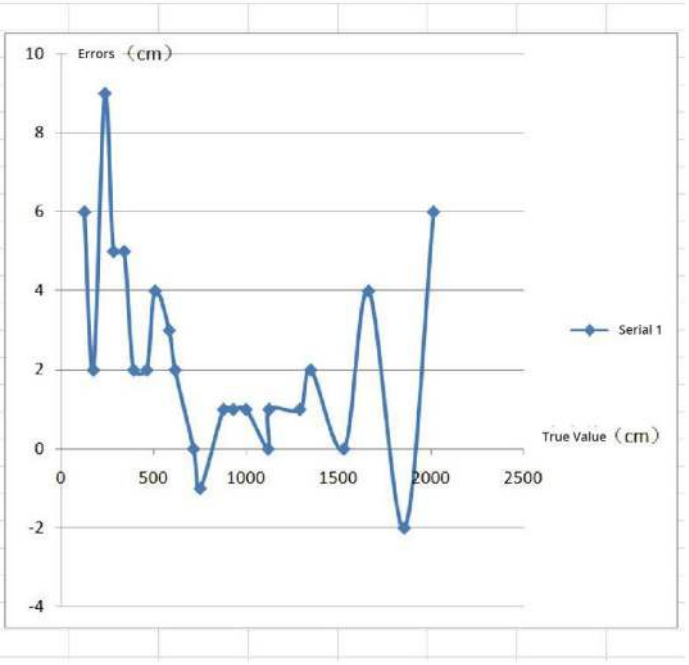

Figure 12 Error performance of outdoor measurement

3.2 Volatility performance of indoor measurement

(1) True value 679cm

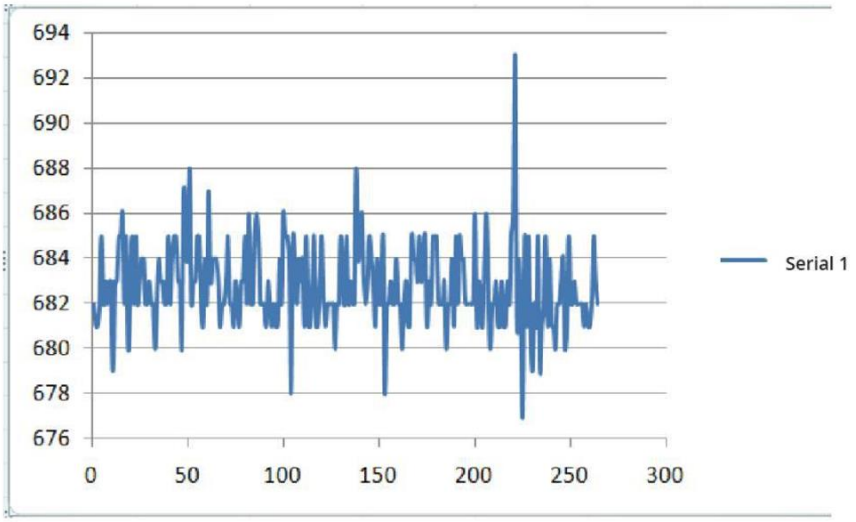

Figure 13 Measuring volatility when true value is 679cm

(2) True value 423cm

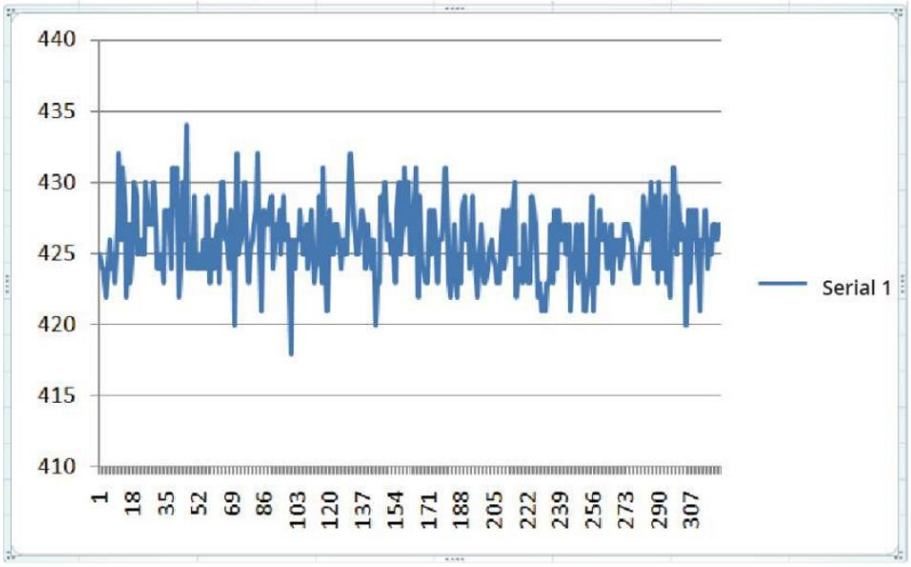

Figure 14 Measuring volatility when true value is 423cm

(3) True value 179cm

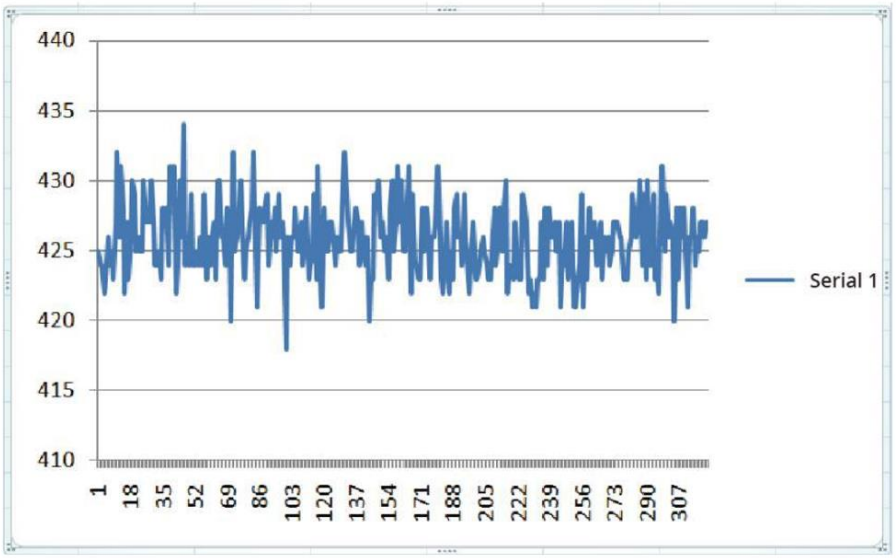

Figure 15 Measuring volatility when true value is 179cm

Attention:

1. PK-1000 UWB distance measuring performance differs between indoor and outdoor environments. This is caused by the indoor multi-path effect, the indoor measurement error is slightly bigger than outdoor, and the stability poorer. But this deviation won't have big impact on the positioning.