Research on integration of Beidou Positioning and RFID antenna module

Chuanfu Xia¹,a, You Li²,b, Lili Zhang³,c, Wei Liu⁴,d, Baoquan Liao⁵,e, Yonghui Zhang⁶,f, Lingfeng Zheng⁷,g

¹State Grid Sijishenwang Location Based Service (Beijing) Co., Ltd., Beijing, China
²State Grid Sijishenwang Location Based Service (Beijing) Co., Ltd., Beijing, China
³State Grid Sijishenwang Location Based Service (Beijing) Co., Ltd., Beijing, China
⁴State Grid Sijishenwang Location Based Service (Beijing) Co., Ltd., Beijing, China
⁵State Grid Sijishenwang Location Based Service (Beijing) Co., Ltd., Beijing, China
⁶State Grid Sijishenwang Location Based Service (Beijing) Co., Ltd., Beijing, China
⁷Fuzhou University, Fuzhou, Fujian, China

axiachuanfu@sgitg.sgcc.com.cn, bliyou@sgitg.sgcc.com.cn, czhanglili@sgitg.sgcc.com.cn, dliuwei@sgitg.sgcc.com.cn, eliaobaoquan@sgitg.sgcc.com.cn, fzhangyonghui@sgitg.sgcc.com.cn, g011801143@fzu.edu.cn

Abstract—RFID radio frequency identification technology has been carried out on the grid assets life cycle management all the various levels of application, the technical implementation model is the physical label paste on the assets, equipment information storage, contactless batch read and data transfer. This design studies the long-distance ultra-high RF technology and designs the integrated ultra-high frequency module through the RFID asset physical electronic identification; the design studies the high-precision Beidou Positioning Technology and designs the integrated high-precision positioning module. According to the above two modules, the peripherals integrating Beidou Positioning and RFID are designed to connect the mobile terminals of various business departments.

1. Introduction
Satellite navigation system is an important space and information infrastructure, which can provide high-quality positioning, navigation and timing services to regional or global users. It plays a very important role in various fields of national defense security and national economic construction. However, the traditional satellite navigation technology and its application mainly rely on the GPS system of the United States [1], which seriously restricts the military security [2] and economic lifeline [3] of other countries and regions. In order to break the monopoly of GPS in the United States, Russia, the European Union and other countries and regions have also been committed to developing their own satellite navigation systems, such as GLONASS of Russia and Galileo system of EU. China is also vigorously developing Beidou satellite navigation system (Beidou or BDS) with independent intellectual property rights. As early as 2000, China has built the Beidou navigation test system (Beidou...
Since 2010, Beidou has entered a period of intensive launching. By the end of 2012, the Beidou regional satellite navigation system (Beidou II), which consists of four medium orbit (MEO) satellites, five inclined orbit (IGSO) satellites and five earth synchronous (GEO) satellites, was initially completed, which officially provides positioning, navigation, timing and short message communication services to the Asia Pacific region. At present, the one belt, one road, is being launched in the global network stage. It is expected to launch the three generation satellite in the end of 2017. In 2018, it was the first to provide basic services for the countries along the belt and the whole world satellite navigation system composed of 5 synchronous satellites and 30 medium orbit satellites (i.e. the three generation of the Beidou) was built in 2020. Obviously, satellite navigation has entered the era of multi-system cooperation from a single system monopoly, and presents a new pattern of multipolar competition and complementary advantages. At present, more than 80 on orbit GNSS (GNSS is the general name of GPS, GLONASS, BDS and Galileo) satellites have provided more than 10 satellite signals with different frequencies to global users. These new satellite navigation systems and abundant frequency resources bring new development opportunities and challenges to navigation and positioning. BDS can be used for mobile phones [4], UAVs [5], ships [6] and other positioning.

From 1940 to 1950, RFID technology was derived from the development and progress of radar technology. In 1948, the theoretical basis of RFID was born; from 1950 to 1960, people began to explore RFID technology, but it was not separated from laboratory research; from 1960 to 1970, the relevant theories developed continuously, and the system began to be used in practice; from 1970 to 1980, RFID technology was constantly updated, product research gradually deepened, and the test of RFID began to accelerate further. From 1980 to 1990, RFID technology and related products were developed and applied in the market, and a variety of fields were used. From 1990 to 2000, people began to pay attention to the standardization of RFID, and RFID system can be seen in many fields of life. After 2000, people generally realized the importance of standardization The variety of RFID products has been further enriched and developed. Both active, passive and semi-active electronic tags have begun to develop. The related production costs have further decreased and the application fields have gradually increased.

2. Beidou Positioning

2.1 Static positioning.
Also known as absolute positioning, the user antenna is fixed in the process of tracking the navigation satellite. The satellite receiver measures the propagation time of the navigation satellite signal with high precision, and calculates the three-dimensional coordinates of the fixed user antenna according to the known position of the navigation satellite in orbit.

2.2 Dynamic positioning.
It refers to the use of navigation satellite receiver to determine the trajectory of a moving object. The moving object on which the navigation satellite receiver is located is called carrier. It can be land vehicle, river ship, air plane, space vehicle and so on. According to the running speed of these carriers, the dynamic positioning is divided into three forms: low dynamic with the speed of several meters to tens of meters per second, medium dynamic of 100 meters to hundreds of meters per second, and high dynamic of several kilometers per second. The so-called "dynamic positioning" means that the antenna of the navigation satellite receiver on the carrier moves relative to the earth in the process of tracking the navigation satellite. The navigation satellite receiver uses the navigation satellite signal to measure the state parameters of the moving carrier in real time.

Both GPS and Beidou II are passive pseudo code one-way ranging three-dimensional navigation. The 3D positioning data can be calculated independently by the user equipment. Beidou-1 adopts active two-way ranging. The three-dimensional positioning data of users is solved by the ground center control system. Thus, the device must contain a transmitter, so it is at a disadvantage in terms of size, weight, price and power consumption. In addition to the global coverage, the performance and
reliability of beidou-3 system will be greatly improved. At the same time, the relevant performance will be further improved on the basis of retaining the short message function of beidou-2. In terms of positioning accuracy, it will improve the performance of the existing Beidou II system by one to two times. In terms of data link, the integrated design of inter satellite transmission and ground-based transmission functions is adopted to realize the link interworking of high orbit, low orbit satellites and ground stations.

3. High precision and miniaturization Beidou Positioning

3.1 Overall framework of miniaturized Beidou high precision positioning module

Therefore, Beidou single second satellite positioning module and prtk module can be used as the core of high-precision positioning data. In addition, the hardware circuit of the module also includes DC-DC power chip and relevant peripheral resistance and capacitance to form RC filtering network to ensure the stability of power supply voltage. In addition, with the necessary satellite signal receiving antenna interface and satellite signal input line, the high-precision positioning module structure block diagram as shown in the above figure is formed. Beidou Positioning chip / module outputs and inputs data with DSP unit through serial port. The input content is mainly configuration instruction, which is used to configure the relevant working state of the module and the opening or closing of some additional functions. In the configuration, considering the data storage and convenience of post-processing, the format of module output data (observation data and ephemeris file) is configured as After receiving Ubx file and RTCM data, DSP unit makes RTK settlement and outputs high-precision positioning results.

3.2 Data processing of single frequency RTK high precision positioning algorithm

In order to facilitate data processing, the output data format of Beidou positioning module is set as hexadecimal Ubx protocol, and the original observation data and ephemeris file are provided to DSP processor for RTK calculation. The data to be used in the process are aid.alm, rxm-sfrbx and rxm-rawx under Ubx protocol. The first one is ephemeris file, the second is navigation data subframe, The third is the observation data. The data corresponding to these three kinds of information are continuously output in the process of positioning operation. Considering that the high data output frequency is conducive to improving the positioning accuracy, the data output frequency is set to 10 Hz. After positioning, the DSP processor reads the stored Ubx file, and then imports the Ubx file into rtk-lib to obtain the o file and N file in renix format of a single module. The o file is the observation file, which mainly contains the carrier phase, C / a code pseudo range, Doppler frequency and signal-to-noise ratio of the satellite signal observed by the module. N file is the navigation file, which is used to provide the orbit parameters of the satellite observed by the module. Combined with the time, the specific position of the satellite can be determined at this time. At the same time, because the satellite orbit changes slowly, it can also predict the position of the satellite in a period of time after this time point. The distance between the receiver and the satellite and the position of the corresponding satellite can be obtained by combining the contents of O file and N file, so the approximate position of the receiver can be obtained according to the positioning principle shown in equation (2), and the positioning accuracy can be improved by combining Kalman filtering

4. Long range UHF radio frequency

4.1 Implementation scheme of RF chip technology circuit.

The reader design needs to consider supporting Mifare card, typea CPU card and TypeB Based on these functions, the CPU card is selected from several semiconductor manufacturers which provide RF chips at home and abroad, such as NXP, Ti, AMS and so on. Finally, tm2130 is selected as the RF chip scheme of this design. The judgment basis for the selection is as follows:
With all the radio frequency card protocols listed above, it can fully support the reading and writing of these cards.

The realizability is simple. The external communication interface of RF chip is SPI mode, which has the advantages of fast communication speed and strong anti-interference ability. The RF matching circuit is relatively simple, and supports two antenna connection modes of differential and coaxial.

4.2 Implementation scheme of microprocessor selection.
The armv7 architecture of cortex series defines three series with clear division of labor, which correspond to the applications with different requirements respectively: a series is for discontinuous virtual memory based operating system and user application; R series is for real-time system; m series is for cost and power sensitive microprocessors. As the reader function is relatively simple, we choose M series. At present, most semiconductor manufacturers in the world, such as NXP, TI and ST, have this series of microprocessors. At present, ST company has the most abundant product line and relatively advantageous price.

After a lot of consideration and comparison, this design is determined as ST company in the selection of main control microprocessor manufacturer, and finally selected stm32f072c8u6 as the final model. This microprocessor uses cortex M0 core. Compared with the popular m3 core, it has a greater cost advantage in handling simple operation, and eliminates many remaining problems in the M3 core processor design of ST company.

- It has rich functions and meets the requirements. It has a maximum frequency of 48mhz, 64K flash, 16K ram, 9 timers, 2 SPI, 1 and I2C, 4 UARTS, 1 USB, 1 can, and 37 io. These resources can fully meet the needs of reader design.

- Small size. Vfqfn48 package can realize the miniaturization of card reading device and facilitate the integration of more portable devices.

There are two communication modes under USBL. 1 protocol: full speed mode (speed is 12MB / s) and low speed mode (1.5MB / s). Corresponding to these two modes, nuf2221w12t2 has two connection modes in circuit design, mainly RUP connection mode of pull-up resistor inside the chip. The connection mode of full speed mode and low speed mode are shown in the figure 1.

![Figure 1. USB principle at full speed and low speed mode](image)
5. Internet of things, mobile Internet and other communication technologies
The implementation scheme of Internet of things and mobile Internet can be based on GPRS technology. GPRS technology, namely general packet radio service, is a kind of mobile packet data service developed from the second generation communication technology GSM mobile communication technology. It is also a transition technology from the second generation mobile communication technology to the third generation mobile communication technology. It upgrades the software and hardware on the basis of GSM. GPRS technology follows the frequency band, wireless debugging mode, frequency hopping rules, burst architecture and frame structure of GSM. Compared with GSM technology, the biggest advantage of GPRS is the introduction of packet switching mode to complete data transmission, which greatly improves the data transmission speed.

6. Result
According to the above description, we use FR-4 material to design RFID antenna simulation experiment. The influence of coupling feed position on S parameters is shown in Figure 2.

![Figure 2. Influence of feeding position on S-parameters](image)

![Figure 3. Smith chart](image)
As can be seen from Figure 3, when other variables remain unchanged, changing the feeding position will have a greater impact on the S-parameter. As the feeding position is far away from the center point, the center frequency point moves to high frequency, and the depth of S-parameter will gradually deepen (Smith chart shows that the matching degree is getting better and better, and further away, it will get worse and worse).

References

[1] Jin S, Zhang T. Terrestrial water storage anomalies associated with drought in southwestern USA from GPS observations[J]. Surveys in Geophysics, 2016, 37(6): 1139-1156.

[2] Perugu P. An innovative method using GPS tracking, WINS technologies for border security and tracking of vehicles[C]//Recent Advances in Space Technology Services and Climate Change 2010 (RSTS & CC-2010). IEEE, 2010: 130-133.

[3] Kaplan C, Loyer E, Daniels E C. Precision Targets: GPS and the Militarization of Everyday Life[J]. Canadian Journal of Communication, 2013, 38(3).

[4] Zuo W, Guo C, Liu J, et al. A police and insurance joint management system based on high precision bds/gps positioning[J]. Sensors, 2018, 18(1): 169.

[5] Chen C, Tian Y Y, Lin L, et al. Obtaining World Coordinate Information of UAV in GNSS Denied Environments[J]. Sensors, 2020, 20(8): 2241.

[6] SUN Z, ZHAO J, WANG S, et al. A study on the control of BDS/GPS self-phase quadrifilar helical antenna for ship[J]. Journal of Shipping and Ocean Engineering, 2017, 7: 108-111.