Research on GPS Data Frame Analysis

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Abstract. With the continuous development of GPS positioning technology and the popularization of applications, more and more GPS receivers emerge at the right moment. UM220-III supports big dipper / GPS, higher integration, excellent positioning timing function, high sensitivity design. In this paper, a low cost GPS positioning system based on STM8S is proposed, which analyzes the GPS data frame and has high positioning accuracy, the positioning information and the position accuracy factor of the observation point both obtain higher positioning accuracy.

1. Introduction
In this paper, the advanced UM220-IIIGPS receiver module is adopted to analyze GPS data frames through STM8S microcontroller, extract valuable position information and GPS signal quality parameters, and introduce the sentence pattern format and analytical thinking of GPS data frames in detail.

2. GPS data frame
GPS is an acronym for the English Global Positioning System, which is the global positioning system. GPS is mainly composed of three parts, which are composed of space segment (space satellite), control segment (ground monitoring system) and user segment (user equipment).

The user measures the delay time $t$ by comparing the received satellite transmission signal and the local reference signal, which is proportional to the distance $d$ between the satellite and the user, that is, $d = ct$. GPS can only measure one distance parameter through one satellite, and cannot obtain accurate position information, so in order to obtain position information, the number of observation satellites needs at least 3 to determine the three-dimensional coordinates. Assuming the user's position coordinates $(x, y, z)$, and the distance between the satellite and the user is $d$, the instantaneous coordinates $(X, Y, Z)$ of the GPS can be obtained from the received observation data, according to:

$$d = \sqrt{(X - x)^2 + (Y - y)^2 + (Z - z)^2}$$

As long as the data of the three satellites is obtained and put into the formula, the user position coordinates $(x, y, z)$ can be solved.

UM220-III is a big dipper / GPS dual system module launched by Hexin for vehicle monitoring / navigation, handheld devices, telecommunications / power timing, balloon sounding and other applications. It has the characteristics of complete localization, high integration and low power consumption, The UM220-III module adopts optimization algorithms such as GNSS multi-system fusion and Kalman filtering, which has excellent capture and tracking ability and reliable continuous positioning results in various complex environments, and the positioning accuracy is 2.5m.

The positioning mode can adopt single system independent positioning and multi-system joint positioning. This design uses single system independent positioning.
The GPS data frame format uses the NMEA-0183 protocol. At present, most GPS receiving devices follow this standard. This protocol defines the electrical signal requirements, data transmission protocol and time on the serial port data bus, as well as the detailed sentence pattern format.

3. System design

The system uses STM8S as the system control core. STM8S has the advantages of supporting a maximum 16MB linear address space, programmable selection of I/O pin input/output structure, strong anti-interference ability, high reliability, rich peripheral types, perfect functions, and multiple clock selections.

UM220-III, as a GPS signal receiving device, is connected to STM8S through a serial port.

The NMEA0183 protocol defines multiple language formats such as GGA, GLL, GSA, GSV, RMC, ZDA, etc. These statements start with "$", with the first two characters "GP" as the identifier, and the last three characters are statements format name is followed by the data body. The data is separated from data by ",", and the data have their own meanings, shown in Figure 1.

![Diagram](image-url)
We take the most widely used GPRMC as an example. The statement format is as follows:

$GPRMC, <1>, <2>, <3>, <4>, <5>, <6>, <7>, <8>, <9>, <10>, <11>, <12>$

$GPRMC$, statement ID, indicating that the statement is Recommended Minimum Specific GPS / TRANSIT Data (RMC)

Field <1>: UTC time, hhmmss.sss format
Field <2>: Status, A = located, V = unlocated
Field <3>: Latitude ddmm.mmmm, degree and minute format
Field <4>: Latitude N (north latitude) or S (south latitude)
Field <5>: longitude dddmm.mmmm, degree and minute format
Field <6>: Longitude E (east longitude) or W (west longitude)
Field <7>: speed
Field <8>: azimuth, degree
Field <9>: UTC date, DDMMYY format
Field <10>: magnetic declination, (000-180) degrees
Field <11>: direction of magnetic declination, E = East, W = West
Field <12>: check value

It is also important to note that $GPGSA$, which reflects the relevant parameters of the quality of the received signal, and can be used to judge the accuracy of the data.

$GPGSA, <1>, <2>, <3>, <4>, <5>, <6>, <7>$

Field <1>: mode, M manual, an automatic
Field <2>: positioning type, 1 = unlocated; 2 = two-dimensional positioning; 3 = three-dimensional positioning
Field <3>: PRN number, 01 to 32 indicate the satellite number used in the sky, receive up to 12 satellite information
Field <4>: PDOP position accuracy factor, 0.5 ~ 99.9
Field <5>: HDOP horizontal accuracy factor, 0.5 ~ 99.9
Field <6>: VDOP vertical accuracy factor, 0.5 ~ 99.9
Field <7>: Check bit

We can parse out the three important measurement parameters used to measure the signal quality from the GPGSA sentence, PDOP, HDOP, VDOP, and the number of satellites that measure the accuracy of the signal. Figure 2 shows the circuit design block diagram.

4. Programming design
The program design mainly includes: initialization, serial port data reception, and GPS data analysis, signal quality identification, etc. Here we mainly discuss the ideas of GPS data analysis. The program detects the comma to determine the content of the received data to implement GPS data analysis as shown in Figure 3.
Figure 3. The program flow chart

Program code:
```
Switch (ReceiveData) 
{
    case '$': mode=1; // mode
        byte_count=0; // Received digits
        break;
    case ','. comma_count++; // The comma plus 1
        byte_count=0;
        break;
    default: if(mode==1) // Type judgment
        {
            cmd[byte_count]=ReceiveData;
            if(byte_count>=4)
            {
                // If the type data is received, determine the type and add other types
                if(strcmp(cmd,"GPRMC")==0)
                {
                    flag=1;
                }
                mode=2;
                comma_count=0;
                byte_count=0;
            }
        }
        else if(mode==2) //Receiving data processing
        {
```

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```
}```
switch(comma_count)
{
    case 1:  //Time processing
        if(byte_count<6)
        {
            time[byte_count]=tmp;
        }
        break;
    case 2:  //Positioning judgment
        if(byte_count<1)
        {
            if(ReceiveData =='V')
            {
                lock=0;
            }
            else
            {
                lock=1;
            }
        }
        break;
    case 3:  //Latitude processing
        if(byte_count<9)
        {
            WD[byte_count]= ReceiveData;
        }
        break;
    case 4:  //Latitude direction processing
        if(byte_count<1)
        {
            WD_dir= ReceiveData;
        }
        break;
    case 5:  //Longitude processing
        if(byte_count<10)
        {
            JD[byte_count]= ReceiveData;
        }
        break;
    case 6:  //Longitude direction processing
        if(byte_count<1)
        {
            JD_dir= ReceiveData;
        }
        break;
    case 7:  //Speed processing
        if(byte_count<5)
        {
            speed[byte_count]= ReceiveData;
        }
        break;
    case 8:  //Azimuth processing
        if(byte_count<5)
        {
            //Code continues here...
        }
}
angle[byte_count] = ReceiveData;
}
break;

case 9:  //Azimuth processing
if (byte_count < 6)
{
    date[byte_count] = ReceiveData;
}
break;

byte_count++;  //Receive digit plus 1
break;

5. Measurement results
Perform the test to obtain the original experimental data, as follows:
$GPRMC,144022.000,A,2450.157172,N,10252.006770,E,0.075,137.102,260915,,E,A*21
$GPRMC,144023.000,A,2450.157162,N,10252.003444,E,0.416,137.102,260915,,E,A*2E
$GPRMC,144024.000,A,2450.157510,N,10252.000454,E,0.211,137.102,260915,,E,A*2A
$GPRMC,144025.000,A,2450.157986,N,10252.006605,E,0.090,133.818,260915,,E,A*2C
$GPRMC,144026.000,A,2450.157277,N,10252.006438,E,0.026,133.818,260915,,E,A*24
$GPRMC,144027.000,A,2450.157402,N,10252.006299,E,0.053,133.818,260915,,E,A*20
$GPRMC,144028.000,A,2450.157550,N,10252.006135,E,0.125,133.818,260915,,E,A*22
$GPRMC,144029.000,A,2450.157704,N,10252.006038,E,0.164,133.818,260915,,E,A*20

After the data is analysed by the program, the results are shown as follows (Figure 4):

Figure 4. The operation result display

6. Conclusion
The introduced GPS positioning system based on STM8S has simple hardware circuits and low prices. Using the UM220-III high-precision GPS receiver module, it can obtain accurate time and position information. The system through data parsing has realized the GPS three-dimensional coordinate information, the key information such as the signal quality, afterwards, the obtained relevant basic information can be used to improve the positioning accuracy through various filtering algorithms.

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