

# The Implementation of Data Collection and Decoding Based on GNSS Antenna Array Receiver<sup>1</sup>

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## SUMMARY

This paper first developed the GNSS antenna array receiver which can collect data in real time, Especially studied the construction of the data collection system as well as the data decoding. Then data collection and decoding method of antenna array receiver was verified, It was proved that the GNSS antenna array receiver data collection system can be used to monitor deformation of dam, landslide etc., and it's worthy of further study.

## 1. INTRODUCTION

In the deformation monitoring field, it takes a very high cost to establish a large monitoring system if we use the traditional GNSS monitoring program because of expensive measurement-based GNSS receiver, which directly limits the application of GNSS technology in deformation monitoring, though there are many advantages. It's very necessary to develop a low-cost and effective deformation monitoring instrument. After several years' study, We developed the GNSS antenna array receiver which can reduce the cost greatly.

## 2. THE DEVELOPMENT OF GNSS ANTENNA ARRAY RECEIVER

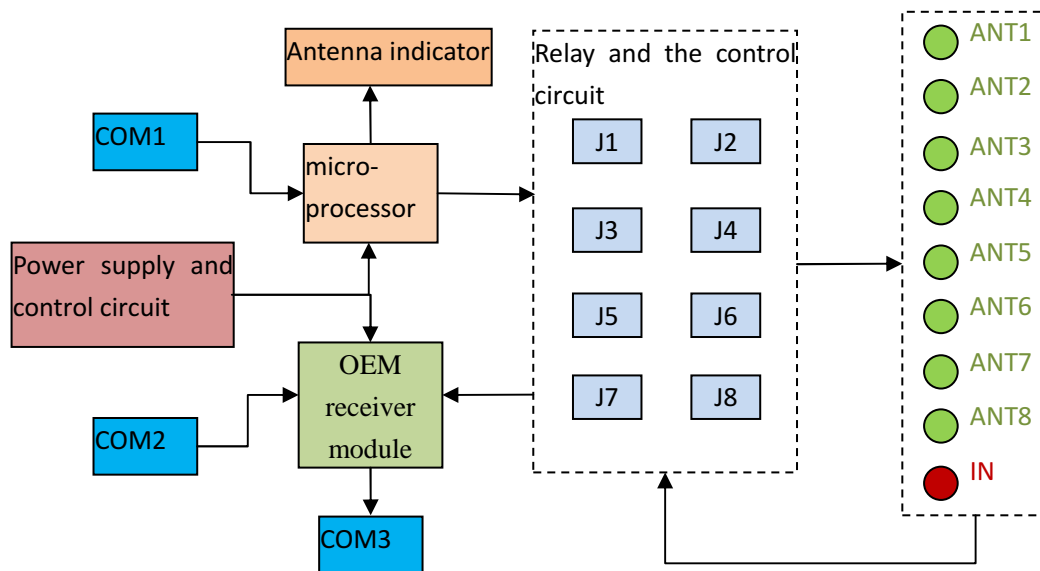
In order to realize the GNSS antenna array data collection, GNSS antenna array receiver is specially developed. The development of the receiver is divided into two steps. The first step is to develop multi-path GNSS antenna sharing device. Through the GNSS antenna sharing device, one receiver can connect more than one antenna, so that the cost in deformation monitoring using GNSS is reduced drastically. But if you buy a commercial GNSS receiver connected one antenna, especially imported receiver, the cost is very expensive. The second step is to develop GNSS antenna array receiver

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on the basis of multi-path GNSS antenna sharing device. Because the commercial GNSS receiver is very expensive, in order to further reduce the deformation monitoring cost, We integrated the antenna sharing device and the GNSS OEM receiver module, then the GNSS antenna array receiver is developed.

Overall, GNSS antenna array receiver contains a microprocessor, which controlled the circuit and multiple antennas. With further integration of OEM receiver modules, the observation of multiple antenna data collection is achieved. Figure 1 shows the design of GNSS antenna array receiver circuit diagram.



**Figure 1 Schematic diagram of the circuit design**

According to the design ideas of GNSS antenna array receiver and the actual situation, we selected Trimble BD970 OEM GNSS receiver module to develop GNSS antenna array receiver. After rigorous testing, the module can be run in harsh environments with high reliability, which not only supports a variety of satellite signals such as GPS L2C, L5 and GLONASS L1/L2 signals, but also can track the GIOVE-A and GIOVE-B test satellites for signal evaluation and test. Figure 2 shows the successfully developed GNSS antenna array receiver.



**Figure 2 GNSS antenna array receiver**

### 3. REALIZATION OF GNSS ANTENNA ARRAY DATA COLLECTION AND DECODING

After developing the GNSS antenna array receiver, a GNSS antenna array data collection system is ready to be set up. The data collection system is an integrated system, consisting of the hardware and software for remote data collection. The hardware is made up of GNSS antenna array receiver, data transmission device (e.g. GPRS or CDMA module, WLAN module) and the computer. The software consists of system controlling, data decoding and database management, etc.

#### 3.1 The System Architecture of GNSS Antenna Array Data Collection

According to the demands of deformation monitoring, the measuring points are divided into base points and monitoring points. During the monitoring process, we fix the GNSS receivers on the base points which one receiver connected with one antenna, and fix the GNSS antenna array receiver on the monitoring points which one antenna array receiver connected with multiple antenna. An appropriate data transmission method is chosen according to the actual situation to realize remote data collection, i.e. WLAN or GPRS/CDMA wireless transmission etc.

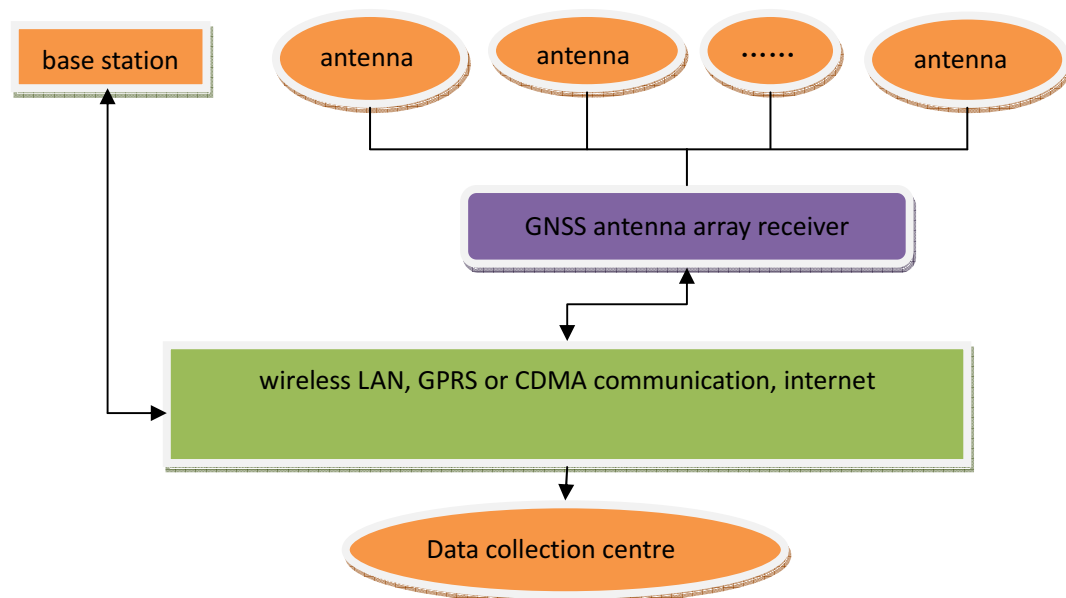


Figure 3 System architecture

#### 3.2 The Implementation of Antenna Array Data Collection and Decoding

The crucial part of GNSS antenna array data collection system is to decode the static observation data into standard RINEX data format for the convenience of data processing. The GNSS antenna array receiver in this system not only receives GPS data, but also GLONASS data as well. When performing static control surveying, only RT17-format data will be outputted if the receiver only gets GPS data. If the data contains GLONASS data as well, the RT27-format data will be outputted. Both of which are original binary data, but vary greatly in format. So the static data collection

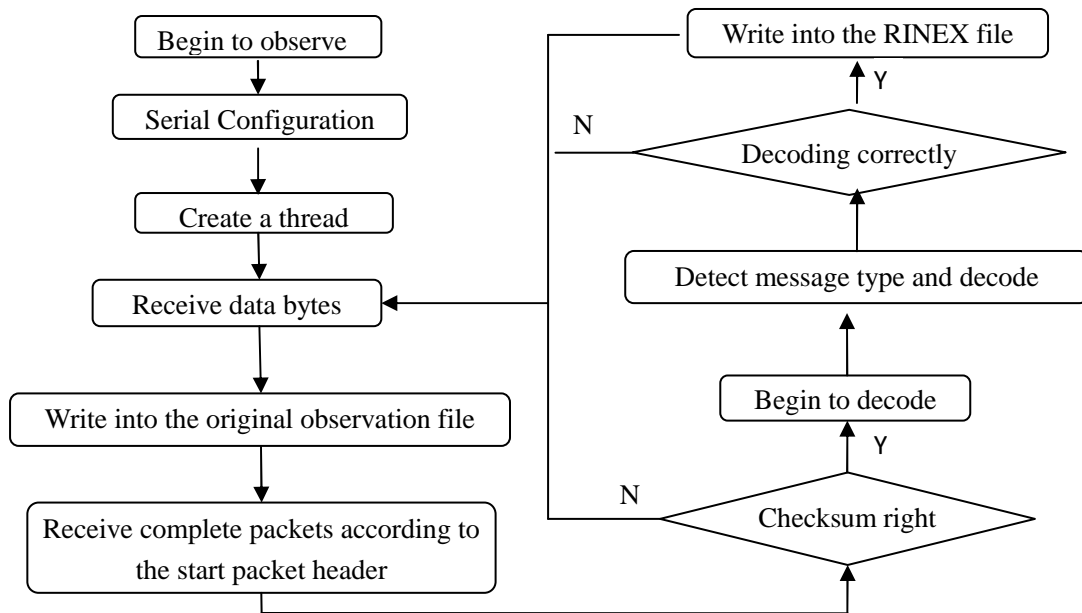
module of the system must be able to detect the data format and call for the corresponding decoding module. In order to achieve the correct decoding result for static observation data, it is necessary to examine the original data format on top of understanding standard RINEX data format.

The original data for the GNSS antenna array receiver is binary message format, which is received by the OEM receiver module. The BD970 OEM receiver module used in this research has defined many binary message data packets with a specific function for every packet. The binary message structure is strictly defined, consisting start packet header, data bytes, checksum and terminator identification. Message format is defined as table1. This type of definition satisfies the need for asynchronous serial communication, which is convenient for the communication between GNSS antenna array receiver and computers.

**Table 1 Data Collector Format Packet structure**

Byte #	Message	Description
		Start packet header
0	STX(02h)	Start transmission
1	STAUS	Receiver status code
2	PACKET TYPE	Hexadecimal code assigned to the packet
3	LENGTH	Single byte# of data bytes limits data to 255 bytes
4-Length 3	DATA BYTES	Data bytes
		Begin packet trailer
Length + 4	CHECKSUM	(status+type+lengths+data bytes)modulo 256
Length + 5	ETX(03h)	End transmission

Real time data collection and decoding works at the same time when the system is running. During data collection, original data is collected through serial ports, which makes debugging easier during the process. The process of static data collection and decoding is introduced as below in Fig 4.



**Figure4 Static data collection and decoding flow chart**

In order to attain correct static data decoding result, it is vital to make sure that the original data are collected properly. Therefore, the system consist a specialized communication serial which adopts multi thread technology to make sure no interferences happened between the stations during data collection and decoding. Once the serial port is open, the port is initialized and monitoring begins. The message response function OnCommunication() is called when data collection begins. The function also calls for the decoding module automatically to collect and decode the data for the specific station. The functions and their functions are described in table2.

If observation data are sent to the local computer through the internet, we only need to setup a correspondence between the local computer internet port and the virtual serial port to realize regular data collection and data decoding.

**Table2 The main function of serial interface communication**

Function name	The role of the function
InitPort()	Initialization serial
StartMonitoring()	Begin monitoring
StopMonitoring()	Stop monitoring
RestoreCom()	Release port resources
Close()	CloseComm
ReceiveChar()	Receive data bytes
WriteToPort()	Write data from a serial port

The realization of data transmission to the local computer is described above. In fact,

to guarantee the data is correct and reliable, a further checking of the received data is needed before decoding. Only the data which passes the check will be decoded. During decoding, data packets will go through identification check, such as page check, data identification check etc, and the packet will be denied if any check is not passed. The decoding result will not be written into the RINEX file if any irregular data is found.

In the system, static data decoding are divided into RT17 and RT27 data decoding, The system will automatically decide the specific decoding type according to the data. Static data decoding function is shown as table 3.

**Table 3 The main function of static decoding**

<b>Function name</b>	<b>The role of the function</b>
ReadTRIMTSIP()	Read data packet
Get_cs()	Checkout checksum
DecodeEph()	Decode the data packets of ephemeris
DecodeGpsObs()	Decode the observation data packets
GetRAWDATA()	Decode RT17 observation data
GetRT27DATA()	Decode RT27 observation data
WriteRinexObsEpochFile()	Write epoch data into observation file
WriteRinexNavSatFile()	Write data into GPS navigation file
WriteGRinexNavSatFile()	Write data into GLONASS navigation file

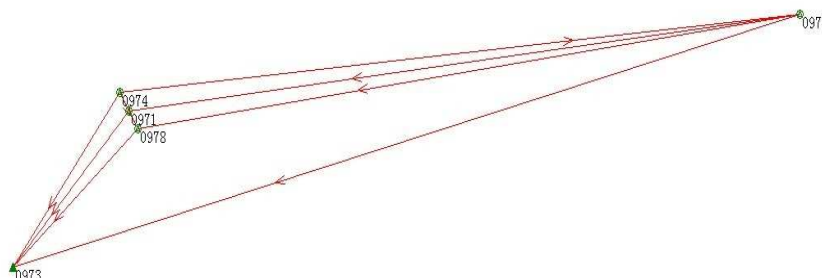
During observing period, the system receives messages from the port and starts storing data into the buffer array after the start identification of the packet is checked and confirmed by ReadTRIMTSIP() function. This is done until the whole packet is received and passed through the function. If all checks are passed then decoding starts and each station starts real-time data decoding and storage.

#### **4. THE EXPERIMENT OF DATA COLLECTION AND DECODING**

The experiment of the GNSS antenna array data collection and decoding was done on the roof of Building No.4 of Information Technology Campus, Wuhan University. The experiment was done as following: connect the GNSS antenna array receiver to two Trimble antennas for static observation. Output data is set as RT27 format during the experiment, the collected data includes GPS and GLONASS data, with the elevation angle set as 10deg, collection rate as 5s, antenna-switching is 30min. The output RINEX file contains the observation file, GPS navigation file and GLONASS navigation file.

Through several static observation tests, the system is able to output RINEX file stably. The correctness of the collected data is proved by the system static decoding

module. In the test, the original data is transmitted to the local computer, and in order to check the correctness of the data, we also used another data collection software to collect the data apart from the decoding module. The RINEX files were compared afterwards, and it has shown that the observation data was same for every epoch, which proves the reliability of the static decoding module. The monitoring network is show as Figure 5:



**Figure 5 Static monitoring network diagram**

The network consists of 5 measuring points. No.0973 is the base point in the stable area, 0976 is a monitoring point beside a small hill near the dam, the rest of the three monitoring points are on the dam. The original coordinate for monitoring network is the WGS84 coordinate. Deformation calculation starts with this point, coordinates is shown as Table 4:

**Table 4 Monitoring network original coordinates**

	<b>X</b>	<b>Y</b>	<b>Z</b>
0971	-1762473.4665	5584950.1967	2518799.9117
0973	-1762323.8186	5585154.1127	2518627.8272
0974	-1762454.9050	5584945.2911	2518824.0568
0976	-1763584.8240	5584548.5841	2518925.7819
0978	-1762491.2676	5584955.0112	2518776.9327

Deformation monitoring mainly adopts automatic monitoring method, i.e. using the automatic collection mode of the static measuring module. During the monitoring period, two different collection intervals were used, for the test the time was mostly one hour, and two hours for later period. The longest was a six hour monitoring test, which proved the data collection module was stable enough to collect and decode the data and output standard RINEX files. To analyze the reliability of the collected data, the third period data was chosen. The processing software was LGO, monitoring result is calculated using least restrictive least squares with 0973 as the starting point. Result is shown as Table 5.

**Table 5 The data processing of static measurement collection results unit:mm**

Dot mark	X coordinate	Y coordinate	Z coordinate	$\Delta X$ (mm)	$\Delta Y$ (mm)	$\Delta Z$ (mm)
The first phase						
0971	-1762473.4670	5584950.2003	2518799.9136	-0.5	2.6	1.9
0974	-1762454.9060	5584945.2962	2518824.0589	-1.0	1.1	2.1
0976	-1763584.8229	5584548.5823	2518925.7816	1.1	-1.8	-0.3
0978	-1762491.2692	5584955.0155	2518776.9321	-1.6	1.3	-0.6
The second phase						
0971	-1762473.4676	5584950.1992	2518799.9114	-1.1	2.5	-0.3
0974	-1762454.9049	5584945.2903	2518824.0565	0.1	-0.8	-0.3
0976	-1763584.8240	5584548.5834	2518925.7809	0.0	-0.7	-1.0
0978	-1762491.2696	5584955.0128	2518776.9322	-2.0	1.6	-0.5
The third phase						
0971	-1762473.4632	5584950.1959	2518799.9099	2.3	-0.8	-1.8
0974	-1762454.9009	5584945.2904	2518824.0548	1.1	-0.7	-2.0
0976	-1763584.8186	5584548.5846	2518925.7822	1.4	0.5	0.3
0978	-1762491.2671	5584955.0136	2518776.9305	0.5	2.4	-2.2

The last 3 columns of the table displays the deformation amount compared to the original data. We can see that the deformation in three coordinate components is within 3.0mm, which doesn't exceed the limited error. Thus it can be derived that there is very little or no deformation and the dam is safe. For the one hour observation, precisions are usually in millimeters, which are the normal circumstance, that means the dam has no obvious deformation during the monitoring period.

## 5. CONCLUSION

GNSS antenna array data collection system can greatly reduce the cost of the application of GNSS technology in deformation monitoring. Using suitable data transmission technology can realize the remote data collection and decoding of GNSS. Through many experiments, the data which are collected by the GNSS antenna array data collection system is reliable and can be used for deformation monitoring.

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