



# DATASOCKET TECHNOLOGY AND ITS APPLICATION IN EQUIPMENT REMOTE CONDITION MONITORING AND FAULT DIAGNOSIS

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*Abstract- Virtual Instrument technology, based on DataSocket, is the product combined with computer technology, network communication technology and instrumentation technology. The paper has described some concepts about virtual instrument and LabVIEW. Now concerning the characteristic of equipment in grassroots units that equipment have diverse models and could be widespread distributed, and it could cause increasing difficulty of repair and maintenance about equipment. Thus, the paper proposed Virtual Instrument technology based on DataSocket and its application in equipment remote condition monitoring and fault diagnosis. DataSocket's properties, structure and working principle were analyzed at the same time. By developing a set of equipment remote status monitoring and fault diagnosis system, the paper has tried to verify that the use of this technology can monitor real-time data and fault diagnosis.*

**Index terms:** Virtual Instrument; DataSocket; condition monitoring; fault diagnosis.

## I. INTRODUCTION

In recent years, information technology advanced and the pace of construction in national defense information accelerated. Grassroots units were provided more new equipment, which had certain features like model diversity, wide distribution and high technology content. New features had brought new challenges for condition monitoring and fault diagnosis of equipment. Due to the limitations of space and time, it is unrealistic for experienced experts to get to the site and help repair. However, network-based remote fault diagnosis technology can provide significant technical support. By establishing condition monitoring points, we can collect status data of these equipment, send to the remote diagnostic platform and diagnose the faults timely.

Data collection, data transmission and data analysis are important parts of remote fault diagnostics. The virtual instrument technology which based on DataSocket not only changed the old ideas about traditional instrument in data collection, processing, display and storage, but also provide a wealth of on-site resources for remote monitoring and fault diagnosis<sup>[1]</sup>.

## II. VIRTUAL INSTRUMENT AND LABVIEW

### a. Virtual Instrument Technology

Nowadays computer technology and microelectronics technology penetrate through the field of measurement and control technology, signal analysis and processing would be done in the computer. The boundary between the instrument and the computer has become increasingly blurred. Virtual instrument combines general-purpose computer and hardware instrument by programming software. Traditional data acquisition and instrument control, data analysis and output processing, and results show were the three main functions which were integrated into computer software.

Users operate the computer through a friendly graphical interface, just like they operate an instrument of their own design. Therefore, the slogan like "software is the instrument" has reflected the essential characteristics of virtual instrument technology. Virtual instrument's structure is shown in Figure 1.

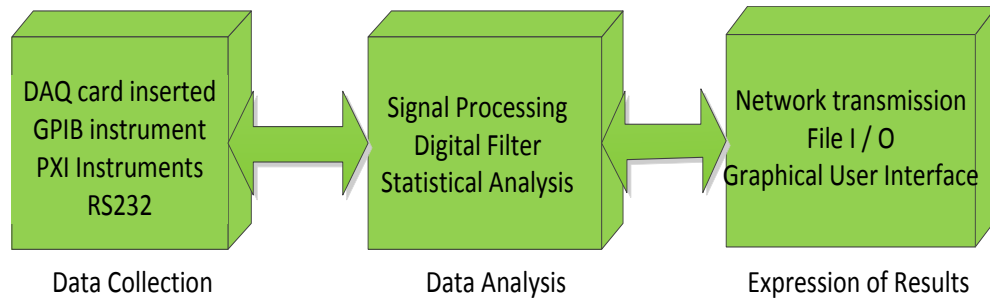


Figure 1 Virtual Instrument Structure

#### b. LabVIEW

Virtual instrument binds computer resources and instrument hardware testing capabilities in a transparent manner. Such binding became true through virtual instrument software like LabVIEW. LabVIEW is one of the most widely used and the most promising Software development platform, which is short for Laboratory Virtual Instrument Engineering Platform. It is a graphical programming tool developed by National Instruments Company. Programmers can use graphical programming language for programming, even though they are not familiar with computer languages. They could easily program just like drawing which makes programming simple and intuitive.

With the powerful library in LabVIEW, users can directly call existing functions from basic functions to advanced analysis library functions, covering all the functions needed to design together. Also, users can customize their own virtual instrument panel according to their needs. They could simulate the operation of traditional instruments on the control panel in order to achieve a variety of test functions. Currently, LabVIEW software has been widely used in data acquisition, instrument control, and automated test areas.

When using virtual instruments to test and service for remote diagnostics, users need to write LabVIEW applications programming on Engineering Control Machine (EMC) and those workstations try to complete the performance test of equipment in order to find the place where failure happened. The EMC achieves data through the DAQ card and used internal sub-VI in the software to fulfill signal analysis and processing. Besides, the software LabVIEW helps transfer those amounts of data via TCP/IP protocol or more convenient technology named DataSocket.

### III. DATASOCKET TECHNOLOGY

The web publishing and real-time sharing of test data is one of the key technologies in equipment remote monitoring and fault diagnosis system. While the existing TCP / IP and DDE technology could make web publishing and data sharing of applications, these techniques were not convenient to be used because of their complexity of programming. When we need to transfer large amounts of field data in real-time, these techniques could not meet the actual needs. Therefore, NI company has developed a new technology for measurement and real-time exchange of network data called DataSocket.

#### a. DataSocket Profile

DataSocket is a network technology in real-time data transmission based on TCP / IP protocol. It has made a high degree of packaging for their underlying network protocol, hidden the details of the data transmission. Network programmers do not need underlying complex TCP programming, avoid writing program codes for different data formats and communication protocols. Only through a unified API programming interface, programmers could achieve the data transmission. DataSocket was designed to transmit and distribute dynamic data in the test and diagnostic applications, help to remove equipment failure and make real-time publishing and sharing of data true.

DataSocket technology locates data source through Uniform Resource Locator (URL). The prefix of URL indicates data type and transmission protocol which is used. For example, the prefix “file” represents local file protocol. “ftp” represents file transfer protocol which is used to read data in the file. “http” represents Hypertext protocol for providing data links; “opc” represents Process Control Process, specifically for sharing real-time production data. This protocol would be used when running OPC server; “dstp” shows real-time data from the DataSocket server.

DataSocket technology has been highly versatile through the use of protocol-independent, language-independent and operating system-independent API interfaces. Because it is based on URL, DataSocket not only could be used in any programming environment, but also communicate with distributed customers terminal anywhere. The architecture is shown in Figure 2.

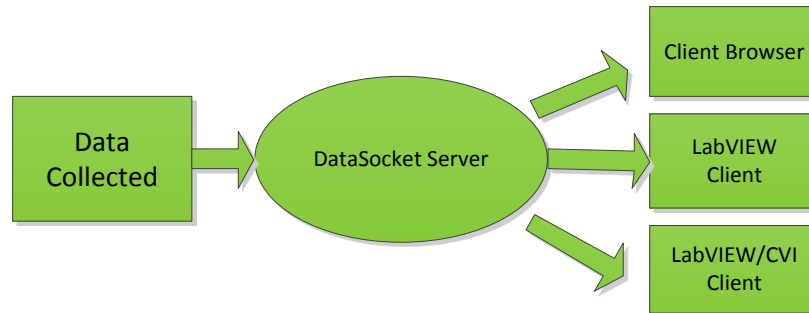


Figure 2 DataSocket Architecture

### b. DataSocket Structures

DataSocket consists of DataSocket Server Manager, DataSocket Server and DataSocket API, also includes a procedure Dstp (DataSocket Transfer Protocol), universal resource locator (URL) and file formats.

DataSocket Server Manager is a stand-alone program. By setting its MaxConnection, MaxItems and Permission Groups parameters, we can set the maximum number of clients that DataSocket Server could connect and the maximum number of data items that could be created. We could also create user groups and users, set user permissions to create data entry and read or write data items. The main parameters are as follows:

- i. MaxConnection: it indicates the number of customers could be connected. The amount of connecting clients is up to 1000 and the default is 50.
- ii. MaxItems: it indicates the number of test parameters could be displayed. The amount of parameters is up to 1000 and the default is 50.
- iii. Permission Groups: they are mainly used to set up user groups and users in order to differentiate rights between users about creating, reading and writing data items. They would help prevent network attacks from unidentified clients to the server.
- iv. Predefined Data Items: They are set to predefine data items, including the data property of the data items, the default value and access privileges.

DataSocket Server is also a stand-alone program and responsible for overseeing data exchange between clients and various privileges set in the DataSocket Server Manager. By looking the display of parameter like Processes Connected, Packets Received and Packets Sent, we can display the number of clients communicated with DataSocket Server as well as the number of packets sent and received. When network communications begins, DataSocket Server must be

run both in the server and the client, otherwise the communication would not be successful. The main parameters are as follows:

- i. Processes Connected: it primarily displays the number of clients communicate with DataSocket server side.
- ii. Packets Received: it displays the number of packets received;
- iii. Packets Sent: it displays the number of packets have been sent.

DataSocket API is a protocol-independent, language-independent and system-independent underlying communication interface. It could translate data collected in the field into the data stream, communicate with various data types in a multi-under kind of programming environment and make data publish and share. DataSocket API contains four movements: Open, Read, Write, and Close. These nodes which are shown in Figure 3 could help realize DataSocket communication.

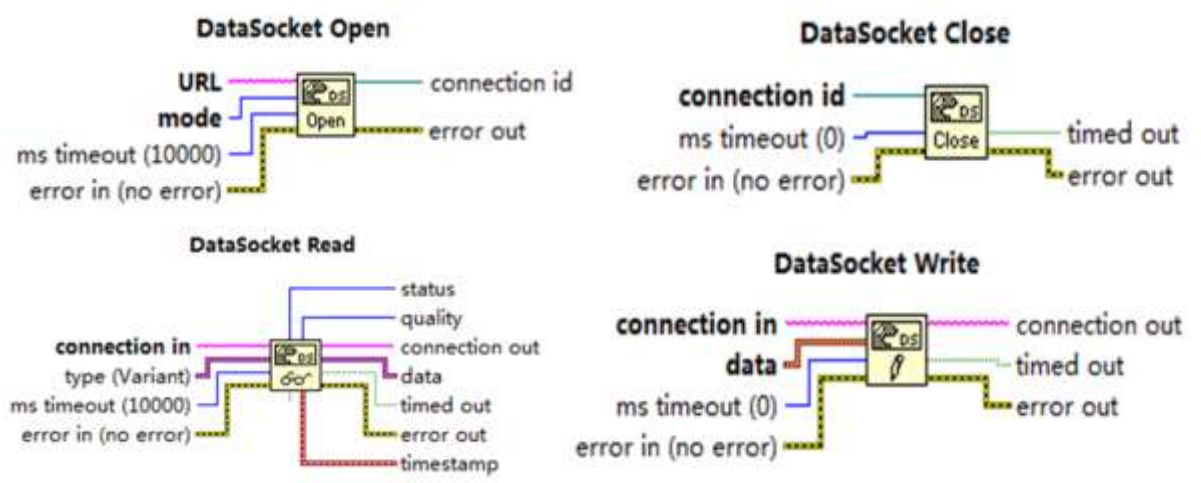


Figure 3 API nodes

### c. DataSocket Working Principle

DataSocket realizes Network communication by using DataSocket library. DataSocket publish data by three elements called Publisher, DataSocket Server and Subscriber. When publishing data, the publisher use DataSocket API Interface to transmit data into DataSocket Server. When receiving data, the subscriber utilizes the API interface to read data from DataSocket Server. Communication process is shown in Figure 5.

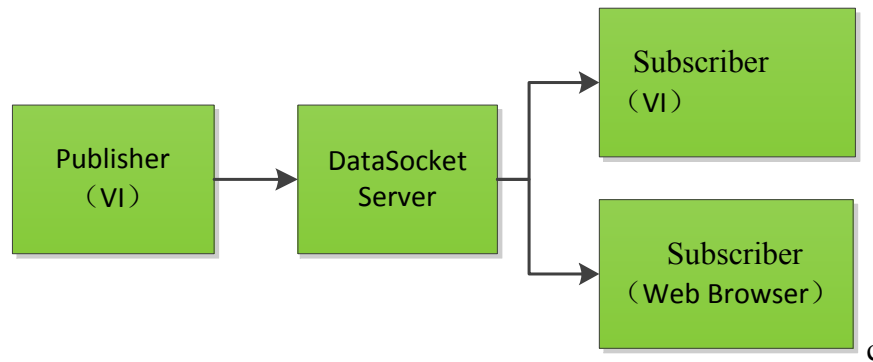


Figure 4 DataSocket Communication Process

DataSocket server plays a middleware role in the whole network communication test platform. DataSocket has two ways for data transmission, including the way by connecting the control panel and the other way by writing agreement program based on DataSocket. The way via the control panel only needs to set the DataSocket Connection dialog box of the data display controls. When filling the same URL on DataSocket Connection dialog of local and remote control, local control can be real time transmitted to the remote control in the same URL, without programming, simple and practical.

While needing transparent data transmission and data processing, we can write DataSocket protocol program. Write and Read operation in DataSocket library directly shows the operations of writing and reading data: Signal data which has been collected could be written into DataSocket server by using writing node and the data could also be read through reading node. The data could be a single character, string Boolean or data rows and the data receiving side could process and analyze the data. Resource Locator (URL) helps locate the final destination of the data transmission and realize remote monitoring as well as on-line, real-time, high-speed data exchange.

#### IV. REMOTE MONITORING AND FAULT DIAGNOSIS SYSTEM

Remote monitoring and fault diagnosis system consists of three parts, including the field test systems, the server and remote fault diagnosis client.

##### a. Field Test Systems Structure

The field test part locates in the front of the whole system, directly drives these devices working. This part consists of field instruments, control equipment and hardware interface components, mainly responsible for the implementation of on-site data collection and control functions. Field Intelligent sensors pick up the original information and provide information, which would be processed by the signal processing circuits, to the data acquisition card. The computer would select PXI, USB, GPIB and other bus modes to connect external data acquisition devices with instruments function hardware in order to realize data acquisition and instrument control. The structure of the field test part has been shown in Figure 5.

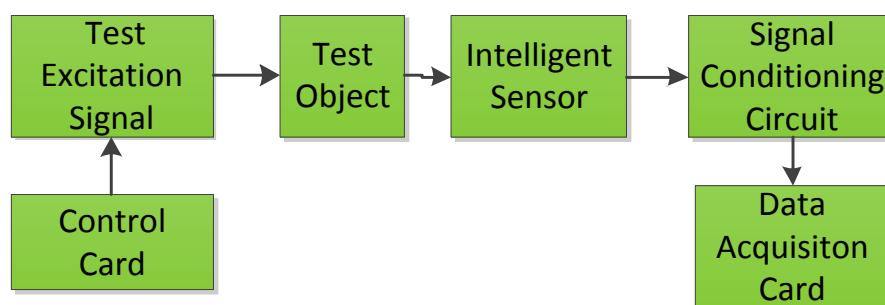


Figure 5 System Structure

#### b. The Server Structure

The server locates in the heart of the entire platform and generally uses high-performance IPC. As link port between field and remote troubleshooting communications, on the one hand it provides a specific operating environment for virtual instrument software and completes on-site data acquisition, instrument control and management. On the other hand it provides data and network services to the remote fault diagnosis center, and receives control commands to complete the control operation to on-site equipments. Through the instrument hardware interface installed on the IPC, the virtual instrument software based on LabVIEW can control the data acquisition card to collect the original signal. It also could use LabVIEW's DAQ technology to enables field devices to input and output analog quantity, realize digital I / O and timing count function. At the same time, DataSocket technology could help server-side control device collect data and transfer raw data to remote diagnostics clients.

The server includes a network communication module, data acquisition card module, the controller module and instrument management module which has been shown in Figure 6.



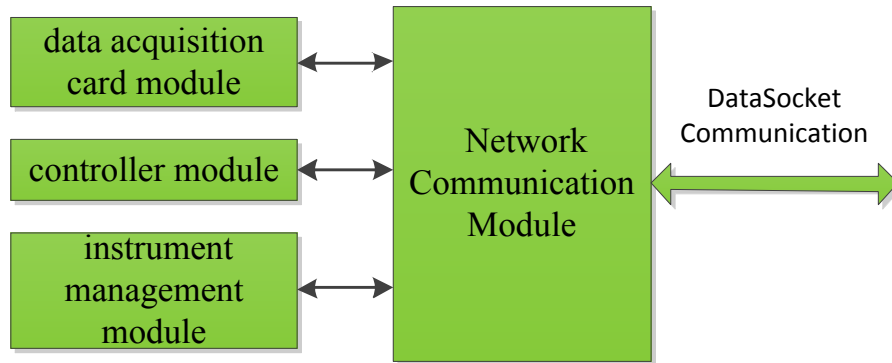


Figure 6 The Server Structure

The server would communicate with the client through network communication module and provide serve to the client, including helping to translate the information from customers to programming languish which could control instrument operation, the acquisition card, the controller as well as send the data from the acquisition card to the client display.

Data acquisition card module controls the card to acquire electrical signal which has been adjusted and send these signals to the client. The client could analyze and processing the signals for fault diagnosis.

The controller module could accept control commands sent by the client as well as program control instructions provided by the instrument controllers.

The instrument management module could ensure reliable employment of shared resources. It could help to test and monitor the equipment status and provide alarm to the failures and errors.

#### c. Remote Fault Diagnosis Client

Remote fault diagnosis client provides human-computer window for monitoring and diagnosis. The client uses DataSocket technique to read field data, and utilizes LabVIEW signal analysis module to complete signal processing. The ultimate goal of signal processing is to clearly exhibit a characteristic signal curve and extract feature information. Combined with years of expert diagnosis experience, it could help complete fault diagnosis.

Remote fault diagnosis client includes input and output module, human-computer interaction module, data analysis and processing module and network communication module etc. The simple structure could be shown in Figure 7.

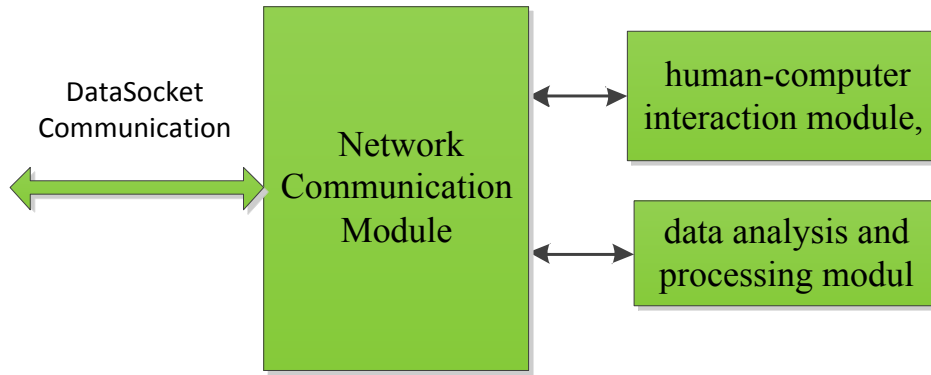


Figure 7 the Client Structure

### V. EXAMPLE OF DIAGNOSIMS

To further verify the DataSocket technology in remote monitoring and fault diagnosis, we will collect sine wave signal mixed with white noise for example. Power failures are common failure of equipment and electrical equipment are typically powered by an alternating current. To solve the problem of AC power failure, we could detect and analyze sinusoidal AC signal mixed with white noise to determine what the fault is. We can see the complete structure of diagnosis in Figure 8 and some classic instruments in Figure 9-10.

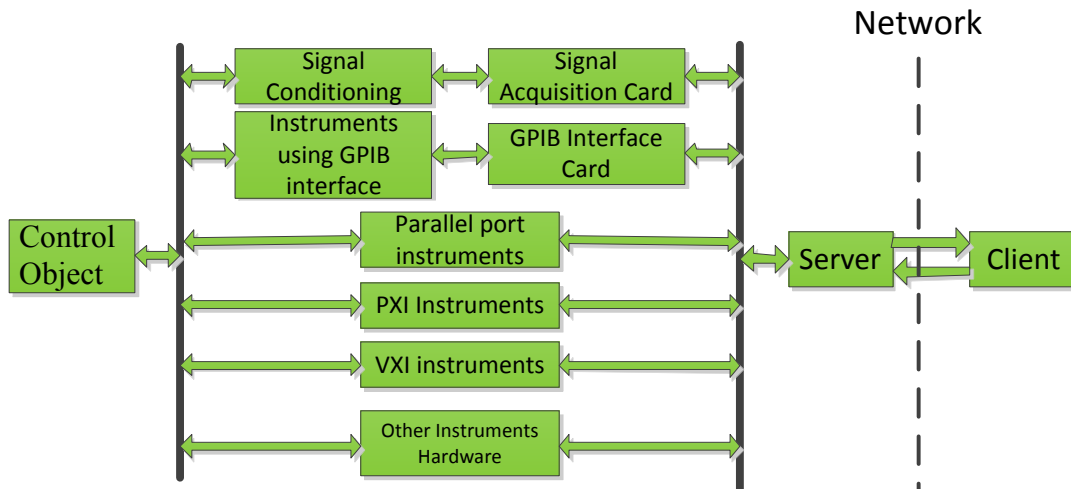


Figure 8 System Structure



Figure 9 ATE Main Cabinet



Figure 10 Control device and its cards

#### a. Synchronous and high-speed data sampling with DAQ

Remote test system has high requirements for signal acquisition and the data acquisition technique based on the software called LabVIEW could be provided with the advantages which others do not possess. We could write powerful signal acquisition program by using DAQ module in LabVIEW and with that we users could not only meet on the basic need of high-speed acquisition but also could design a convenient and friendly acquisition program according to our

own favor. The experiment in this paper relies on current laboratory equipment and has selected the PXI-5114 digitizer type in NI Company. This card shows powerful features. It could achieve real-time sampling at the rate of 250MS/s and equivalent-time sampling at the rate of 5GB/s respectively. PXI-5114 also has the ability of dual-channel synchronous sampling with its input value ranging from 40mV to 40V and the 125MHz bandwidth. When using the card to acquire the waveform data, we could make use of 256 MB onboard memory on each channel to store those great amounts of waveform data. In addition, PXI-5114 also has a series of trigger functions including SDTV / HDTV. This card could connect to the computer through PXI bus and we users could be convenient to program by using more than 50 built-in measurement and analysis functions. Detailed specifications would be shown in the table1.

Table 1: Performance parameters on PXI-5114

Bus Type	PXI
Operating System	Real-Time Systems、Linux、Windows
LabVIEW RT Support	YES
Trigger mode	Digital, analog, video
External Clock	YES
I / O connector	BNC connectors, SMB male side
Sampling Rate	250MS/s
bandwidth	125MHz
Minimum voltage range	-20mV, 20mV
Frequency Range	0~125MHz
The maximum analog input voltage	-20V, 20V
Board storage	256MB/Channel
Number of Channels	2

After installing DAQ-mx software in the internet, we could open the software and detect this card. We could carry out a series of execution like viewing the card pin information, configuring virtual channels, setting the measurement mode before performing system testing and diagnostic.

b. Example

Sine wave can be detected in power extension module or generated directly by the signal generator. We generated directly is the sine-wave signal mixed uniformly white noise by the virtual instrument signal generator module. The sine signal has the amplitude of 5V and the frequency of 10HZ. The signal data was collected through Virtual Instrument DAQ board and would be stored in a computer database. The number of device is 1, the channel is 0, the sampling rate is 1000 and the sampling buffer was set 5000. The sampling program was written in LabVIEW and the front panel and block diagram are shown in Figure 11-12.

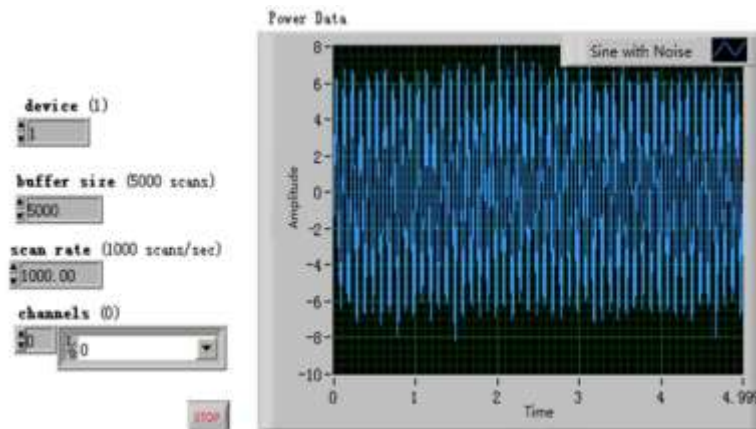


Figure 11 Sample of Front Panel

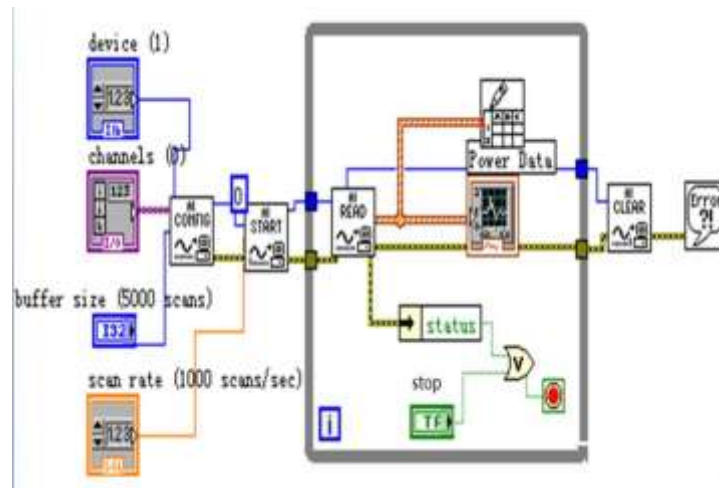


Figure 12 Sample of Block Diagram

The server side wrote virtual instrument program in LabVIEW. Through built-in DAQ board driver, it could control device to capture the signal measured and save to the database within a computer. When entering the server's computer address on the URL panel, we could write data through DateSocket Writer node. The server's default address is its local host. Figure 11 has

shown sinusoidal signal mixed with the white noise. The signal was written and displayed on the oscilloscope instrument.

The treatment of sampling and analyzing measured signal would provide data basis to determine the place where the fault happened. It is an important means of dealing with the sampled data to send sample data to the remote diagnostics clients. We could realize the telecommunications by writing DataSocket communications-server program. Users could design friendly transmission interface as their own favor and enter the URL address of the local server on the display panel. In addition, users can enter 'ipconfig' via 'cmd' window to view the local IP address or directly default as 'localhost' which would reach the same effort. DataSocket server-side program would write the data which needs to transmit by DateSocket Writer node. Here we also realize transmission sinusoidal signal mixed with white noise and could view the signal transmitted in the local scope meter. The consequence has been shown in Figure 13-14.

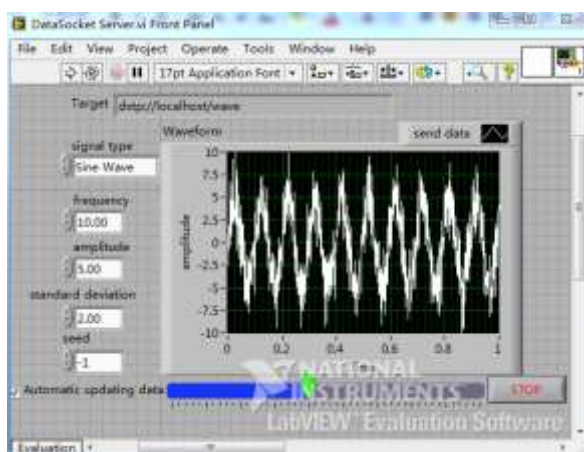


Figure 13 Front Panel of Server fault signal

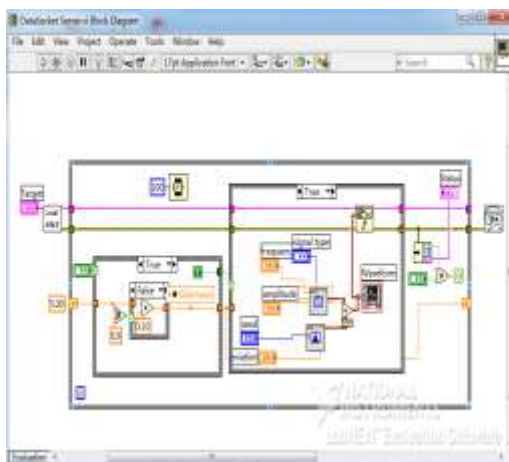


Figure 14 Block Diagram of Server fault signal

The client read out data from the URL specified location by DataSocket Reader node and displayed on the client oscilloscope as shown in Figure 15.

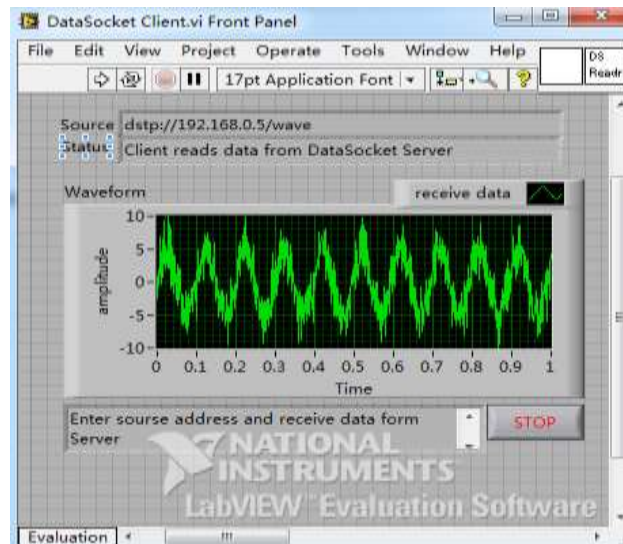


Figure 15 Client reception monitoring signal

In order to analyze the data which has been received, we have used signal analysis sub-module provided by LabVIEW to make spectral analysis. Therefore, the characteristic frequency of sinusoidal signal would be obtained. Then through a filter (using anti-Schiff filter) we would filter white noise and get frequency and amplitude by time domain analysis. Based on analysis operations to the received signal, we could compare the fault characteristic curve database which has been established to monitor device status and realize fault diagnosis. The result has been shown in Figure 16-17.

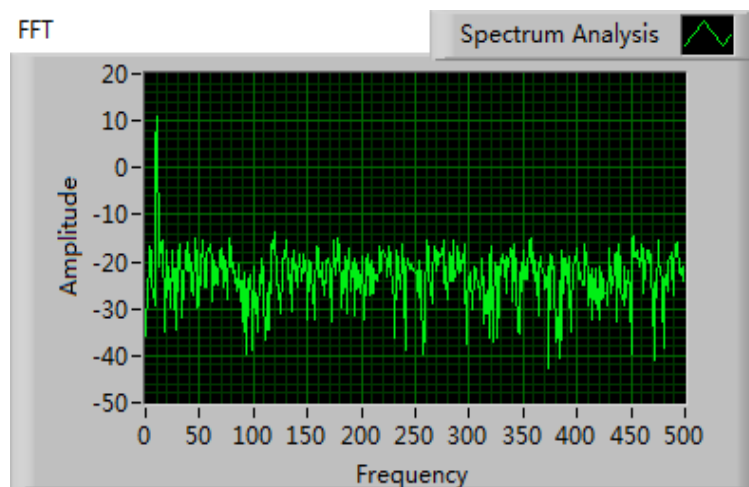


Figure 16 Fault signal spectrum analysis

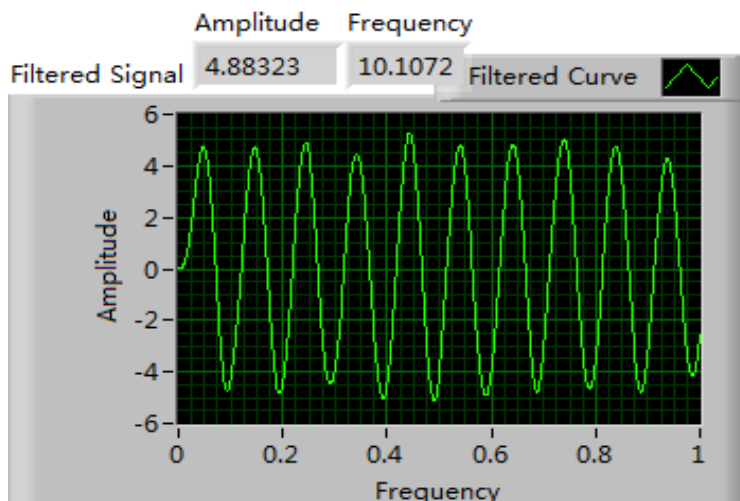


Figure 17 Fault signal filtering

## VI. CONCLUSION

In summary, the virtual instrument technology based on networks makes full use of its own advantages in software and hardware. For the reality of monitoring equipment condition and fault diagnosis in grass-roots units, this technique has provided one cost-effective mean of supporting equipment. By using DataSocket to help network transmission, we have overcome inefficiencies in the underlying network programming, poor real-time data transmission and other shortcomings. DataSocket technique has truly helped make network programming simple and quick and make test data transmit in real-time. From the instance to transmit sine wave signal mixed with white noise, we can see that experts will not need to visit the site and can monitor equipment status at the remote site in real time. Besides, experts can analyze and process fault signals to achieve the purpose of fault diagnosis.

## REFERENCES

- [1] LiFengbao, LiLing, WangXiaodong. Networked Measurement and Control System Based on Virtual Instrument [J]. Scientific Instrument, 2004, 25(4): 295-297
- [2] ChenGuoshun, Yuhanwei. Test Engineering and LabVIEW Applications [J]. 2013.
- [3] MoHuifang, Raominghui. Motor Audio Remote Fault Diagnosis System Based on DataSocket Technology [J]. Automation and Instrumentation, 2013 (3): 175-176.



- [4]DataSocket Transfer Protocol Overview.[Http://www.ni.com](http://www.ni.com).
- [5] JiangWei, ZhangXiaobo, LaiQinggui. Instrument Communication Technology Based on LabVIEW [J]. Computer Measurement & Control, 2013, 21(4): 1030-1032.
- [6] WangJiping, ZhaoZhe, TianKechun. Communication Measurement Technology Based on LabVIEW [J]. Automation and Instrumentation, 2011, 26(1): 29-31.
- [7]Yan He and Benxian Xiao, “Research of The Forklift Power-Assisted Steering System Based on Safety Steering Speed Control” International Journal On Smart Sensing and Intelligent Systems. vol. 8, no. 1, March 2015 .
- [8]. J. H. Liu, Y. F. Chen, T. S. Lin, C. P. Chen, P. T. Chen, T.H. Wen, C. H. Sun, J. Y. Juang<sup>2</sup>, and J. A. Jiang, “ An air Quality Monitoring System for Urban Areas based on the Technology of Wireless Sensor Networks,” International Journal on Smart Sensing and Intelligent Systems, vol. 5, no. 1, march 2012 page 192-217.
- [9]. N. Samanta, A. K. Chanda, C. RoyChaudhuri , “An Energy Efficient, Minimally Intrusive Multi-Sensor Intelligent System for Health Monitoring of Elderly People,” International Journal on Smart Sensing and Intelligent Systems vol. 7, no. 2, June 2014, page no 762-780.
- [10]. J. Yang, W. Chen, Z. Fu, W. Wu, and Z. Xie,” Research of Multi Sensor Intelligent System Signal Fusion and Reconstruction,” International Journal on Smart Sensing and Intelligent Systems, vol. 7, no. 4, December 2014 page 1701-1716.
- [11]WangLin,ZhengZhengqi, Design of radar ranging data transmission system based on DataSocket[J], Electronic Measurement Technology, 2011.34(1):99-101
- [12]Bai JinPeng, The speed research of transferring images through DataSocket[J], Electronic Measurement Technology, 2015.38(12):49-53
- [13] Chen Zheng, WangYing, Asynchronous motor test system based on LabVIEW and OPC[J], Industrial Communication,2015.10:68-71
- [14] ZhangFeng, WangYu, Remote data acquisition system based on C/S Mode in the LabVIEW environment, Industrial & Science Tribune,2014(7)
- [15] XuJie, Chencheng,ZhaoGuowei. Design of Remote Data Acquisition System Based on LabVIEW[J], Microcomputer Information 2007(28):62-63.
- [16] XU Fuxin , LUO Ming, CHEN Fang, HE Jishan, Design and Implementation of Video Acquisition in a Remote Measurement and Control System Based on LabVIEW[J], Computer Engineering & Science, 2009, 31(5):24-26.

[17] Yao Juan,Zhang Zhijie,Li Lifang, Data Acquisition System Design and Implementation based on LabVIEW and TCP[J], Application of Electronic Technique, 2012(7):72-74.

[18] ZHANG Zhi-jun,XU Xiao-li,WU Guo-xin, Wireless data technology Acquisition System based on LabVIEW and Wi-Fi [J]. Control and Instruments in Chemical Industry, 2013, 40(3):367-371.

[19] LI Ning, YUE Weiwei, Implement remote control technology based on LabVIEW [J], Equipment Manufacturing Technology, 2014(11):250-251.

[20] Jiang Chaoyang, Zhu Chen. Virtual Instrument applies in Equipment Remote Monitoring and Fault Diagnosis Based on DataSocket Technology [J]. Digital Technology & Application, 2012(5):63-64.