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Test of DMB-T Signal Based on Software Defined Radio Technique

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Abstract

With the release of the standard, digital television terrestrial broadcasting is being gradually extended in many places. In order to speed up the extension and the application, also to evaluate the existing digital television terrestrial broadcasting system, we need a easy-to-use signal analysis and measurement system. The traditional signal measurement method is through the special hardware circuit to realize, but that method is high cost, and the system structure is complex and single function. To improve the flexibility of the system, we realize the system based on virtual instrument technology. In hardware section, this thesis described the block diagram of the system and the introduction of the NI vector signal analyzer. In software part, this thesis described the overall test system based on LabVIEW and the realization of the system features multi-threading, each step of synchronization signals achieved.

Keywords*: DMB-T NI Digital Television Test LabVIEW*

1. Introduction

Radio &TV transmission main have three categories of cable transmission, satellite transmission and ground transmission. Ground transmission channel is in the complex multipath environment, the transmission environment is the most bad of the three kinds, so the ground transmission standards must be the most complex technology. After a long time of study, DTTB technology has gone to mature, countries implement its own digital television research plan and put forward a lot of different system solutions, according to the basic principles of the ITU and their respective characteristics. The international DTTB transmission standard with the approved by the ITU mainly have three [1] of ATSC, DVB-T and ISDB-T. Chinese digital television terrestrial broadcasting standards is DMB-T(Terrestrial Digital Multimedia Television Broadcasting), a standard number is GB20600-2006. With the release of the standard, The digital TV conversion has been put on the agenda in all parts of the country. Through to the DMB-T digital signal analysis, we can measure the launch DMB-T signal quality and adjustment the transmitter accordingly [2].

Traditional radio reception system more dependent on hardware, this has brought great inconvenience to the whole development of system upgrade and maintenance [3]. And in recent years, software radio theory is increasingly being used in wireless communication field, it emphasizes that open the minimalist hardware for common platform. As far as possible to use the application software which can be upgraded and reconfiguration, that can overcome the traditional receiver to single function, expansibility poor hardware limitations as the core of the design. The basic idea of software radio is that rely on a general, standard, modular hardware platform, we can realize all the functions of the wireless radio through the software programming.

2. Research Method

The DMB-T signal testing system contains two parts, one is DMB-T digital signal hardware collection system, the other is Software testing system.

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2.1. DMB-T Digital Signal Hardware Collection System

DMB-T digital signal hardware acquisition use the NI company hardware collection equipment. The NI RF signal analyzer PXI-5661 vector and relevant interface device. As shown in Figure 1 below.

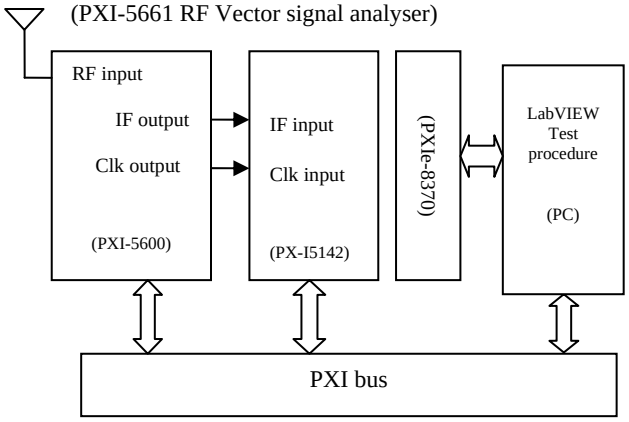

Figure 1. DMB-T digital signal hardware collection system

PXI-5661 RF Vector signal analyser has two parts of PXI-5600 down converter and PXI-5142 high-speed digital instrument. PXI-5600 down converter collection RF signal data from DMB-T channel modulator with frequency in the UHF band (470 ~ 850 MHz)and a bandwidth of 7.56MHz, it put the RF input signal frequency conversion to 5M~25MHz intermediate frequency signal, then output the intermediate frequency signal to PXI-5142 high-speed digital instrument. PXI-5142 contains two modules, OSP (onboard signal process) module and onboard RAM module. The two modules have completed of intermediate frequency signal sampling, the digital AD frequency conversion and heavy sampling filter methods. PXI-5661 exchange data and control information with the test procedure in the PC through the PXI bus. At last, the software system which is running on a PC will complete the measurement of the signal's parameters.

2.2. Software Testing System

Test software using the company LabVIEW2009 platform development NI. LabVIEW greatly improve the efficiency of the development of virtual instrument, it provides interactive graphic development environment overturned thoroughly before those development tool with powerful development function and not may easy-to-use thought. LabVIEW contains all sorts of properties that make it a development and testing, measurement, automation and control ideal tool for application. LabVIEW can quickly develop application system, complete product design verification and automation control applications [4].

The Test software system first to demodulate the collected signals, realize the function of receiving DMB - T signal. It use the software method to realize DMB - T digital signal receiver internal function module. It is the collection of real digital signal from NI hardware equipment, to go through the Hilbert filtering get I, Q two way complex signal.Then get the I, Q two way by signal carrier recovery and down-conversion, clock recovery, DFT, channel estimation and equalization, it can get the input signal constellation diagram at last.

2.2.1. Software System Structure

The whole software system USES layered design thinking to carry on the design. The system can be divided into hardware interface part, data processing part and the user interface part. The part of the hardware interface is the data sources for system, through The article described before ,we know that the data acquisition hardware get digital signal. Data processing part contains three function modules of data processing, data analysis and data display. Data processing module collect data from hardware interface and stored part of the data in the buffer. Data analysis module will analysis the data obtained in the buffer. Data display module has got

analysis results from data analysis module. Then Data analysis module can draw up the graphics by the results and display the graphics in the user interface. Users can control the conduct of system through the user interface, and users can be monitoring hardware equipment state real-time. At the same time, the analysis results of data processing part can also be shown in the user interface.The structure of the software system as shown in Figure 2 shows.

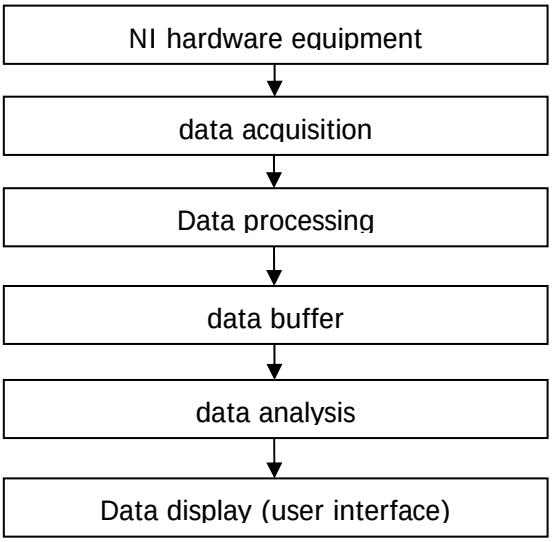

Figure 2. software system structure

2.2.2. Data Multithreading Processing

In the software system using multithreading technology to achieve data acquisition data analysis, the result shows that the output of the same. Software running on three thread above respectively operation. One acquisition thread constantly from data sources have data store in the buffer. Main thread can control analysis process, may at any time suspend or suspend analysis process. After analysis, constellation chart, channel characteristic information stored in the buffer and inside.

2.3. System Testing and Verification

This software system first to the collected signal demodulation software, and realize the DMB-T receiving signal function. This system to use the software method to realize DMB-T digital signal receiver internal function module. NI hardware equipment from the collected all the way real digital signal to go through the filter get I, Q Hilbert of two way complex signals. Then I thus gain, Q two signals recovery and the carrier frequency conversion, clock recovery, DFT, channel estimation and balanced, can get the input signal constellation chart. This software system according to the output to get after demodulation calculation DMB-T digital signal performance parameters. Related analysis diagram analysis and constellation MER, EVM parameters of the calculation. And according to the MER, EVM transmitter to send signals measured parameters such as quality.

2.3.1. Constellation Chart Analysis

In a constellation chart all the I and Q signals possible combined with the performance for the grid shape, which makes it easy to explain things cause interference, constellation graphs can imagine with the box for arrays, each box represents a state or symbol, in an ideal data transmission cases each accepted transmit code should fall in the center of the box, but in fact, invade interference and noise reflection can let transmission theory to the center of symbols from adjacent box of boundary, the dividing line between adjacent box called judge threshold, and transmit signal if be interference across the threshold pushing, it would be wrong

to adjacent box as belonging to the symbols, therefore, is an error code, or it will be considered normal symbols [5]. Constellation chart can be thought of as digital signal of a "two dimensional eye chart" array, the symbols in the picture the position that should have reasonable limit or court boundary, represent each receiving symbols in the picture more close to point zero point, signal quality is high. Because the screen is corresponding to the extent of the graphics and phase, and the shape of the array can be applied to analyze and determine the system or the channel's many defects and distortion, and help find the cause. Constellation chart is a very good troubleshooting auxiliary tool, it can provide the source of interference with the kinds of clues, through the constellation chart easy to find amplitude noise and phase noise, phase error, error and modulation problems than modulation.

2.3.2. Performance Parameters are Calculated

The system USES the measure of the main parameters of the signal quality for MER and EVM[6]. Modulation error rate MER baseband signal is similar to the SNR, its computation formula is:

$$MER_{dB} = 10 \times \log_{10} \left\{ \frac{\sum_{j=1}^{N} (I_j^2 + Q_j^2)}{\sum_{j=1}^{N} (\delta I_j^2 + \delta Q_j^2)} \right\} dB \quad (1)$$

The definition of EVM for the effective value of margin for error and the amplitude of the peak of the vector than: its computation formula is:

$$EVM = \frac{\sqrt{\frac{1}{N} \sum_{j=1}^{N} (\delta I_j^2 + \delta Q_j^2)}}{S_{\max}^2} \times 100\ \% \quad (2)$$

3. Results and Analysis

System testing and verification work is mainly aimed at the actual DMB-T signal. Data sources for the actual DMB-T digital signal transmitter. The system through the connected to PC of data acquisition system to hardware NI collection DMB-T digital signal transmitter to send the digital TV signals. Software system in PC operation, users can be directly observed PC measurement result.

3.1. Spectrum Analysis

Time domain measurement and frequency domain measurement are two different methods of measuring the same signal . The spectrum analysis of the signal are able to provide the information that cannot be watched in time domain analysis. In this test system, the radio frequency signal power spectrum and intermediate frequency signal spectrum were test. Intermediate frequency signal analysis is to sample in the radio frequency signal after frequency conversion, and then draw its spectrum through the FFT transform. Figure 3 shows the radio frequency signal power spectrum when the carrier frequency is 666 MHz, bandwidth for 8 MHz. Figure 4 shows the intermediate frequency signal spectrum when the carrier frequency is 15 MHz.

3.2. Constellation Diagram Analysis

In system testing process, for QPSK, 16 QAM and 64 QAM in different protection interval are tested. Constellation diagram is that the data flow into two road of I and Q, and then two way signal are modulated with phase difference of 90 degree after quantification, mapping with the modulation signal, and the other for transverse the modulation signal for longitudinal axis, this makes signal in the graph has a corresponding position. In this test system, the constellation diagram analysis is analysis in PC buffer storage baseband signal I, Q demodulation of constellation diagram, at this time the formation of constellation diagram mainly reflects the mistakes that transmission channel have made .

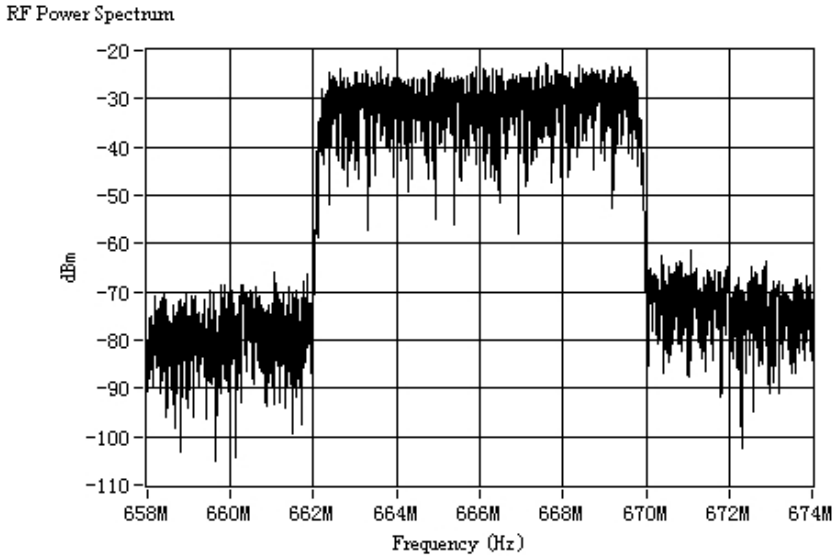

Figure 3. the radio frequency signal power spectrum

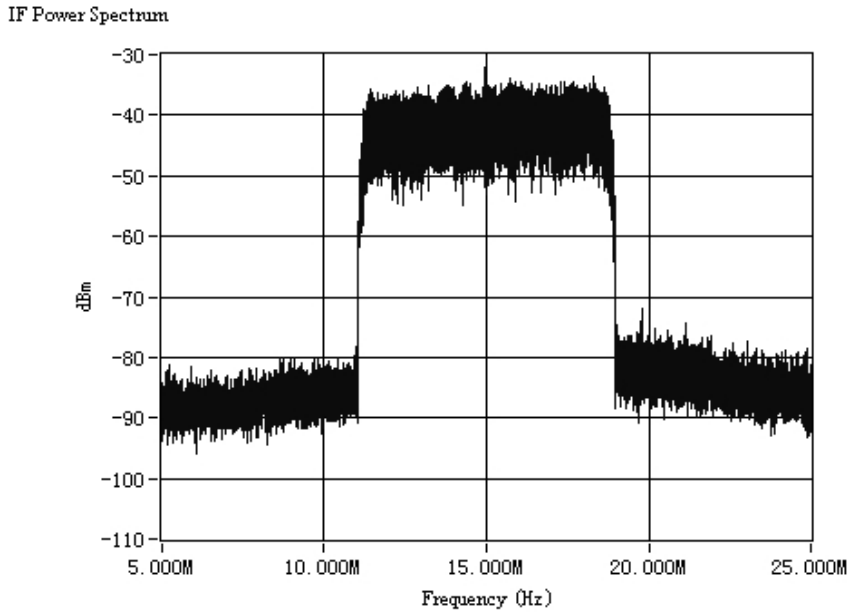

Figure 4. the intermediate frequency signal spectrum

3.3. Modulation Error Rate MER_{dB}

According to computation formula(1) and the I, Q component value calculation of system actual measuring. In this experiment system conditions, when work state parameter for: carrier number=3780; FEC=0.8; Protection interval=1/9; Time domain mixed: 720; Modulation mode=64 qam; Radio frequency bandwidth=8 MHZ; Radio frequency level=+ 10 db, the MER_{dB} value is measured about 42 db. In other parameters in the working state of the measured value is no longer list.

Test results close to hardware measuring equipment measurement result. This shows that the system can meet the needs of engineering measurement.

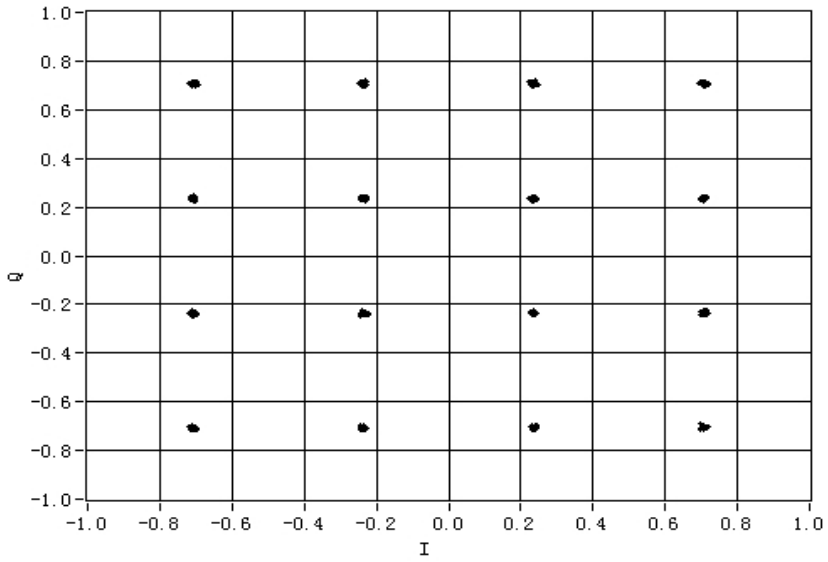

Figure 5. 16QAM constellation chart

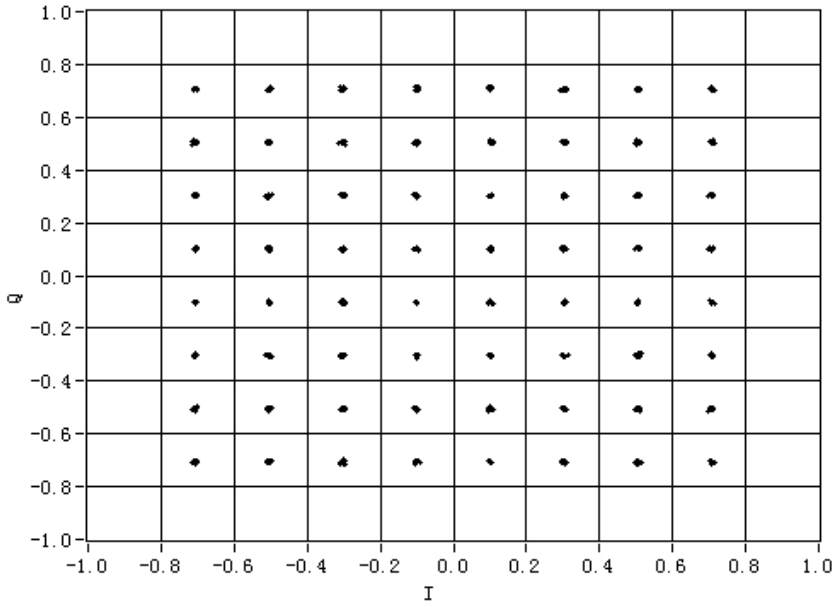

Figure 6. 64QAM constellation chart

4. Conclusion

This article introduced the DMB-T digital signal measuring system, and based on the DMB-T digital signal receiver principle of work, through the software to achieve the digital signal measurement process. This system has obvious more advantages than other traditional measure in simple structure , high flexibility, easy to use, and so on. In addition, the system used by the hardware conditions, enough to complete other kinds of digital radio signal measurement. Therefore, the future research work will also on how to improve the shortcoming of the test to DMB-T signals and how to development a measurement software system which suitable for other standard signal, such as DVB-T, etc. Make full use of the advantages of good software radio, we can complete the test of many kinds of signals with one hardware equipment.

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