Design of a Broadband Electromagnetic Signal Monitoring and Evaluation System

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Abstract. Communication signal reconnaissance and evaluation is the basis for the implementation of communication anti-interference. The design of broadband electromagnetic signal monitoring and evaluation system realizes the function of communication signal reconnaissance and evaluation through the monitoring, collection, analysis and storage of complex electromagnetic signals, providing a basis for the effective implementation of communication anti-interference. The wideband electromagnetic signal monitoring and evaluation system can monitor, collect, analyze and store complex electromagnetic signals, and has the function of communication signal reconnaissance and evaluation.

1. System Composition
The broadband electromagnetic signal monitoring and evaluation system completes the monitoring, acquisition, analysis and storage of complex electromagnetic signals, and realizes the direction finding and positioning functions of signal sources. It mainly includes communication signal sources, direction finding antennas, multi-channel receiving units, high-speed acquisition oscilloscope units, monitoring antenna arrays, real-time spectrum analysis units, ultra-wideband acquisition storage units, high-performance processing computers, electromagnetic monitoring and situation analysis software and other instruments and equipment composition. The system composition is shown in Figure 1.
Complex Electromagnetic Signal Monitoring and Analysis Receiver

Electromagnetic signal radio frequency receiving unit

High-speed acquisition unit

Real-time spectrum analysis unit

Clock unit

Power unit

Software for electromagnetic signal production, monitoring, analysis, and evaluation

signal display

graphic display

signal direction indication

Interference Display
Generation

Interference Playback and Performance evaluation

High-performance processing computer unit

Electromagnetic signal radio frequency receiving unit: It consists of low noise amplifier module, radio frequency attenuator module, radio frequency pre-selection filter module, frequency mixing module, local oscillator module, intermediate frequency module and so on.

High-speed acquisition unit: analog-to-digital conversion module for intermediate frequency signals, digital signal processing and signal acquisition.

Real-time spectrum analysis unit: with real-time spectrum analysis function.

Ultra-wideband acquisition storage unit: It consists of a disk array controller and storage. The storage array is a top-speed high-speed solid-state disk array.

High-performance processing computer unit: High-performance industrial computer.

Software for electromagnetic signal production, monitoring, analysis, and evaluation: It is mainly composed of function modules such as parameter setting, status display, and external control. It can complete the statistical analysis of monitoring signals, and realize signal display, graphic display, signal direction indication, and situation display.

2. Working Principle
The organization diagram of the communication signal receiving subsystem is shown in figure 2, which consists of low-noise amplifier module, radio frequency attenuator module, radio frequency pre-selected frequency filter module, mixing module, local oscillator module, intermediate frequency module, analog-to-digital conversion module, and digital signal processing module.
Electromagnetic signals are converted into time-domain digital signals by mixing and IF sampling. The real-time spectrum analysis of digital signals is mainly accomplished by digital domain modules including ADC interface module, digital down conversion module, decimation filter module, FFT module, data processing module, and output interface module. Domain signal to frequency domain deceleration, windowing, decimation, conversion and other calculations.

3. System Implementation Scheme.

3.1 Electromagnetic Receiving Subsystem

3.1.1 Implementation of Communication Signal Reception. The main function of the communication signal receiver is to select and amplify the signal sent by the antenna or the signal combiner system, and provide an intermediate frequency signal with suitable amplitude and phase characteristics for subsequent signal processing equipment. The specific implementation of receiving is shown in Figure 3.

- Low-noise amplifier module: Amplifies the input signal, improves the link noise figure, and increases the system sensitivity;
- RF attenuator module: adjust the gain of the link according to the power value of the input signal;
- RF pre-selection filter module: according to the test frequency, multiple channels are filtered in parallel to filter signals outside the expected bandwidth;
- Mixing module: down-convert the RF signal to the desired intermediate frequency signal;
- Local oscillator module: provides the local oscillator signal required by the mixer;
- IF module: IF filtering and amplification, used to filter out undesired signal frequencies after mixing;
- Analog-to-digital conversion module: performs analog-to-digital conversion on IF signals;
- Digital signal processing module: The digital signal performs mathematical operations.
3.1.2 Analysis and Implementation of Complex Spectrum Environment. The real-time spectrum analyzer is used to process and calculate the signal sent by the receiver, and extract the bearing information from the signal. At the same time, coordinate the work of each part of the system (antenna, receiver, output interface, etc.), control the array element conversion of the antenna, the receiver's local oscillator and channel, the selection of the working mode, and the setting of other working parameters.

ADC interface module: used for format and clock domain conversion of ADC output data;
Orthogonal digital down-conversion module: includes NCO (digitally controlled oscillator), multiplier, and LPF (low-pass filter). NCO is used to generate orthogonal digital carrier frequency. Multiplier is used for frequency mixing. The output of the orthogonal digital down conversion module is two orthogonal signals of IQ;
Decimation and filtering module: used to reduce the data rate of the output signal of the orthogonal digital down-conversion module;
FFT module: The FFT module is used to perform a fast Fourier transform on the IQ signal and convert the time domain signal from the time domain to the frequency domain;
Delay module: used to delay the time domain signal so that the time domain signal is aligned with the frequency domain result of the FFT calculation;
Data processing module: used for logarithmic conversion of the output data of the FFT module;
Output interface module: used to output the calculation result of the hardware unit to the system board.

3.1.3 High-Speed Uwb Acquisition and Storage Implementation. It is mainly composed of PCIe interface, disk array controller and storage. The storage array is the top high-speed solid-state disk array as shown in Figure 4.
3.1.4 High-Performance Processing Computer. Adopt high-performance industrial computer motherboard. The interface between the system board and the data acquisition module, signal processing module and storage array controller is PCIe interface. The high-speed data acquisition record storage playback system virtualizes the on-board memory into FIFO, allowing the collected data to be buffered. Continuously transmitted to the host memory or hard disk through the bus, as shown in Figure 5:

3.2 Electromagnetic Monitoring, Analysis, and Evaluation Software Subsystems
The electromagnetic monitoring, analysis, and evaluation software is loaded on a high-performance processing computer. The software functional block diagram is shown in Figure 6:
The software is mainly composed of function modules such as parameter setting, status display and external control. Each module and function are as follows:

1) Parameter setting: Set related parameter settings, such as signal frequency setting, bandwidth setting, interference signal frequency, bandwidth, modulation mode, etc.;
2) Status display: signal positioning and trajectory display, signal strength display, and statistical analysis of signal data;
3) External control module: provides external application access control interface.
4) Main control unit

The main control unit is composed of a main control computer and control software. When the initialization is completed, the configuration of each parameter is issued, the command is issued, the process is controlled, suspended, terminated, and so on. And complete the management and scheduling of the various resources of the system, the coordination, management and control of the follow-up interference execution and post-mortem analysis, organically integrate all parts of the system to achieve system function integration and management control integration Automation is the control and management center of the entire inspection system.

The task of the control software is to provide a human-computer interaction interface. As an integrated operating environment for the user's system, it is responsible for completing user management, resource maintenance, resource management, interference signal generation and emission, interference implementation management and monitoring.

4. Conclusion
The broadband electromagnetic signal monitoring and evaluation system is integrated with monitoring and evaluation to meet the needs of spectrum situation analysis. It can be widely used in civil and military information and communication fields. The system uses plug-in module design to facilitate subsequent function expansion. Demand, develop application software flexibly, and improve application benefits.

5. References
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