Boundary Field Strength Remote Monitoring System for Radio and TV Coverage Area

Yongliang Duan

ABSTRACT

In order to change the traditional way of manpower periodic testing, the front-end device is equipped at multiple monitoring points within the coverage area of radio and television, for receiving radio and television signals. The signal frequency, field strength, name of monitoring point and other information are transmitted through the network to the processing terminal, where automatic detection and analysis of signal’s field strength at the monitoring points are conducted. This system can operate normally, and the monitoring data are accurate, convenient, reliable, time-saving, and worthy of promotion.

**Keyword:** Radio and television; Signal; Monitoring; Front-end; Terminal

Automatic monitoring system for radio and television signals utilizes automatic monitoring technology for wireless signals within the coverage area of radio and television broadcast.

1. BACKGROUND

Radio and television are important modern communication media. Broadening the coverage of radio and television signals is the primary concern of radio and television administrative authorities, especially for remote rural regions where the radio and television signals are unstable.

To assess the coverage area and population of wireless radio and television transmission, manpower is often used to the testing of signal’s field strength at the border of the coverage area and to plotting the coverage map for reception of radio and television signals. Data are collected manually at the monitoring points using vehicle-borne or portable field strength meter and then sorted out and analyzed also manually. Examples of commonly used field strength meters are “real-time monitor for wireless radio broadcast” (China patent No. 201020571782.1) and “portable monitor for AM/FM radio signal strength” (China patent No. 201020571798.2). Handheld or vehicle-borne field strength meters now in use are “vehicle-borne mobile multi-media radio signal strength road tester” (China patent No. 201110005467.1) and “digital television signal strength road tester (China patent No. 200410077400.9). The above patented inventions have been disclosed at present. However, all of them require manual testing at monitoring points, which is time- and labor-consuming (at least one testing is needed on a seasonal basis) and contains a high level of randomness.

\[1\] Yongliang Duan, Communication University of China, Nanjing
Usually two different devices are carried on one vehicle for the monitoring of radio and television signals separately. In bad weathers, this is very inconvenient for real-time monitoring.

2. SYSTEM CONFIGURATION

Automatic monitoring system for radio and television signals is composed of several front-end devices, one processing terminal and software module.

Front-end devices installed at multiple monitoring points within the coverage area are for receiving TV and AM/FM signals, which are sent to the processing terminal via the network along with the information of the monitoring points and frequency values after frequency selection and field strength conversion.

Each front-end device consist of the following: antennas, frequency selecting circuit for TV signals, frequency selecting circuit for AM/FM signals, detecting circuit for TV signals, single chip microcomputer, A/D converter, D/A converter and transreceiver, as shown in Figure 1.

Figure 1. Configuration of front-end device.

Input: TV RF Signal input, AM/FM RF Signal input
TV circuit: Frequency selecting circuit for TV signals
AM/FM circuit: Frequency selecting circuit for AM/FM signals
Detector: Detecting circuit
D/A: D/A converter
MCU: Single chip microcomputer
A/D: A/D converter
Network transceiver: Transceiver
Output: IP data output

Two groups of antennas are connected to frequency selecting circuits for TV and AM/FM signals, respectively. The antennas receive radio and TV signals of multiple frequencies and deliver them to the frequency selecting circuits for TV and AM/FM signals. Loop control is implemented by single chip microprocessor to change the receiving frequencies for frequency selecting circuits for TV and AM/FM signals in a chronological order. The intermediate-frequency signals output by the frequency selecting circuit for TV signals are first delivered to the detecting circuit for TV signals to be turned into DC signals. The output is further delivered to A/D converter...
together with the DC signal output from the frequency detecting circuit for AM/FM signals. The A/D converter is responsible for turning the analog signals into digital signals (i.e., field strength), which are sent to the transceiver along with the name and/or code of monitoring point and frequency values. The single chip microprocessor outputs the control instructions to D/A converter for controlling the selection and output of new frequency signals from the two frequency selecting circuits. This process continues until all frequency signals are sampled once within one loop.

1) Frequency selecting circuits

Under the single chip microprocessor control, the frequency selecting circuits receive the frequency signals within the monitoring area. The outputs of frequency selecting circuit for TV signals are delivered to A/D converter after passing through the detecting circuit. The outputs of frequency selecting circuit for AM/FM signals are directly delivered to the A/D converter. The frequency ranges of TV signals are 48-92MHz, 167-223MHz and 470-958MHz. The frequency ranges of AM signals are 526.5-1606.5KHz and 2.3-26.1MHz, and that of FM signals is 87-108MHz.

Frequency selecting circuit for TV signals is realized by TDG-5881 tuner, which has signal input, AGC, VT, UHF, VH, VL, 5V power supply, and IF input (pin), as illustrated in Figure 2.

![Figure 2. TV tuner.](input)

Input:TV Signal input

Functions fulfilled by each interface are described below:

Signal input: TV signal input end; AGC: voltage input end of automatic gain control; VT: harmonic voltage input end. If imposed with a voltage value in the range of 0-33V, VT will select the signals of a certain channel in sympathy with wave band controlling circuit; UHF: UHF wave band selecting and controlling end. If imposed with a voltage of 5V, UHF can receive high-frequency TV signals above channel 13. If UHF band is not selected, the voltage at this end will be 0V. VH: VH wave band selecting and controlling end. If imposed with a voltage of 5V, VH can receive high-frequency TV signals of channel 6-12 and complementary channel Z8-Z37. If VH band is not selected, the voltage at this end will be 0V. VL: VL wave band selecting and controlling end. If imposed with a voltage of 5V, VL can receive high-frequency TV signals of channel 1-5 and complementary channel Z1-Z7. If VL band is not selected, the voltage at this end will be 0V. 5V: internal circuit power input end; IF: intermediate frequency output end, for outputting intermediate frequency signals of 38MHz TV images and for delivering signals to the detector. IF is the only signal output end of the tuner.

The frequency selecting circuit for AM/FM signals is realized by single-chip tuner IC, which contains AM/FM local oscillation circuit, damping circuit, AGC,
frequency discrimination circuit and muting circuit. The working voltage range is from 1.8V to 7V, corresponding to small working current. When the working voltage is 3V, the working current is 11mA for FM signals and 7mA for AM signals, which produce low power and low heat. This makes it highly ideal under low-voltage working environment as shown in Figure 3.

![Figure 3. Frequency selecting circuit for AM/FM signals.](image)

Functions of each pin in SP2104 are described below:

① Radiofrequency ground; ② FM radiofrequency signal input; ③ Low-frequency switching for AM signals; ④ Mixed signal output; ⑤ Circuit current source Vcc; ⑥ AM intermediate frequency signal input; ⑦ FM intermediate frequency signal input; ⑧ Ground; ⑨ AGC external; ⑩ 10.7MHz crystal oscillator; ⑪ Output of right sound channel; ⑫ Output of left sound channel; ⑬ Low-pass filter 2; ⑭ Low-pass filter 1; ⑮ Stereo input; ⑯ Detector output; ⑰ Intermediate frequency; ⑱ Stereo indicator; ⑲ Oscillator output; ⑳ Oscillation for AM signals; ㉑ Oscillation for FM signals; ㉒ AM radiofrequency signal input; ㉓ Radiofrequency power source; ㉔ Output of FM radiofrequency signals

(2) Detecting circuit for TV signals

Detecting circuit for TV signals converts the intermediate signals from the frequency selecting circuit into DC output signals.

Detecting circuit for TV signals contains opamp A1 and A2, capacitor C, diode VD, and reset switch (SW). Opamp A1 utilizes high-speed opamp AD8038, which satisfies the requirement on passband and converting speed. A2 utilizes dual-channel opamp LM358, which contains two independent, high-gain dual opamp with internal frequency compensation. This is fit for either single or dual power with wide voltage range. Diode 2AP1, featured by small forward resistance and fast rise of forward current, is used. It can start linear detection of large signals even at small trigger signals, as shown in Figure 4.
TV circuit: Frequency selecting circuit for TV signals
MCU: Single chip microprocessor

(3) A/D converter

A/D converter is for converting the analog DC signals from the frequency selecting circuit to digital signals recognizable and processable by the single chip microprocessor.

Converter AD1674, which is a 12-bit successive approximation converter, is used. It contains a sampling holder, 10V reference voltage source, clock source and a cache/three-state buffer that directly interface with buses of the microprocessor, as shown in Figure 5.

The pins of AD1674 are divided into four types based on function: logic control, parallel data output, analog signal input and power source.

There are 6 logic control interfaces: 12/8 — data output bit selection end. At high-level input, the output is single 12-bit byte; at low-level input, the output is double 8-bit byte. CS—chip select signal input end, activated at low level. R/C—
read/conversion state input end. In complete control mode, it is read state at high-level input and conversion state at low-level input. In independent working mode, conversion state corresponds to the falling edge of input signal. CE—operational enabling end; A0—bit addressing/short-cycle switching and selection input end; STS—conversion state output end.

Other interfaces are parallel data output interfaces (DB11-DB8, DB7-DB4), analog interfaces (10VIN, 20VIN), power supply interfaces (REFIN, REOUT and BIPOFF are reference voltage input/output interface and bipolar voltage adjustment interface; VCC, VEE and VLOGIC are analog voltage input interfaces; AGND and DGND are ground terminals).

(4) D/A converter

D/A converter is for turning digital signals output from the single chip microprocessor into analog signals that control the selection of frequencies in frequency selecting circuit.

Converter D/A AD558, a V-type 8-bit converter, is used. It contains reference voltage source and high-speed output amplifier and realizes unipolar or bipolar output of analog voltage. Without external devices or fine tuning, this D/A converter can be connected to the 8-bit buses of the single chip microprocessor, as shown in Figure 6.

![Figure 6. D/A converter](image)

AD558 has four functional modules, logic control, latch, DAC and reference source, and the interface circuits are simple.

The pins of AD558 are divided into the following types based on function: DB0-DB7—digital quantity input; CE—choice enabling end, working in synergy with CS; CS—chip select end, working in synergy with CE; VCC—circuit current source (5-15 V); GND—ground terminal; A(VOUT SENSE)—output voltage selection end (0-2.56V); B(VOUT SELECT)—output voltage selection end (0-10V).

(5) Transreceiver

The transreceiver is responsible for converting digital data (field strength, name of monitoring points and/or code, frequency values) into digital signals to be sent via the network.

The transreceiver is based on DM9000A Ethernet controller, initialized by the single chip microprocessor. The data to be sent is encapsulated in the Ethernet data frame format by the single chip microprocessor and sent to the DM9000A Ethernet controller, which is connected to the network via the RJ45 interface (by wires). In this way, the encapsulated data are sent to the processing terminal as shown in Figure 7.
MCU: Single chip microprocessor
Isolator: Network physical separator

Between the DM9000A Ethernet controller and RJ45 interface there is a network physical separator.

Other types of transceivers are also available for use. For example, the Ethernet controller based on IEEE Standard can realize wireless connection of front-end devise. By wireless connection into the network, this Ethernet controller is linked to the processing terminal for data exchange.

(6) Processing terminal

The processing terminals include bench-top, lap-top or pocket PC.

The processing terminals receive the encapsulated data via the Internet, unpack and store the data (real-time field strength, name and/or code of monitoring point, frequency values), which are displayed on the screen.

The processing terminals are also responsible for analyzing the real-time field strength data sent by the front-end devices at each monitoring point. The field strength measurements at different frequencies are compared against the allowable field strength specified by national standards, the design values and the values corresponding to high signal quality. Low measured field strength may be related to the influence of shields; high field strength is related to multipath interference; field strength measured during the power-off period of the monitored transmitter is the background noise or co-channel interference; field strength signals beyond the monitored frequency range are interferences, including adjacent channel interference, clutter from other transmitting stations, out-of-band interference and interference from pirate radio stations.

The processing terminals are also installed with an alarm module, for giving alarms (flashes and/or acoustic) based on the field strength analysis result.

Alarms may be given for the following reasons: the measured field strength values are lower or higher than the national standard, design values or the values corresponding to high-quality signals by certain margins. For example, the measured values exceed the preset tolerance range or signals beyond the monitored frequency range are detected.

Alarms are given as flickering of abnormal field strength values at the monitoring points or the name/code of the monitoring points with the abnormal values. Voice prompts that “the field strength of the monitoring point xx is abnormally higher or low” and “there are interferences” may be given.
Each processing terminal has an electronic map and the longitude and latitude of the front-end devices at each monitoring point. After the analysis of the received data, the processing terminals will generate the field strength distribution over the electronic map for each monitoring point.

The steps of data transmission and analysis and report processing at the processing terminals can be described as follows: number the monitoring points, look up the longitude and latitude of each monitoring point (presented in baiduAPI format), design a table that contains two fields for monitoring point No. and latitude & longitude, respectively. The information of the monitoring points stored in the data table should satisfy the following requirements. First, the data tables are real-time data tables (the data table has the data record number as the primary key, and increment data and data table can be used). Second, the data tables are the latest of the monitoring points (using monitoring point No. as the primary key). The monitored data are uploaded to the server in the national standard format for the radio and television industry. Generally GPS is used for uploading the data with stable performance and low cost. At the server side, communication software is programmed for data receiving and storage in the database. There are two data tables to be stored: one is real-time data table which contains all pieces of data received, including monitoring point No., monitored data and monitoring time. The other is the latest data table, where the previous data are replaced by the new data. Therefore, the data contained in this table area always those at the last rewriting step. For programming of the communication software, the following problems should be considered. If huge amounts of data are updated at the same time, buffer overflow will occur. To deal with large amounts of received data, concurrent processing should be allowed. Packet loss and verification also deserve attention during data connections. The protocols are those generally used for communications. BaiduAPI provides an open interface and application tools. Here two steps are needed for application programming. First the monitoring points are located on the map. By traversing the array, the locations are done via the API. Next, the data are displayed at the located points. A form will pop up after clicking in API, and data are displayed in the form. The procedures for data display are consistent with those of annotation on the map. Depending on the specific needs, it is determined whether multi-table manipulation is necessary for the display results. Journal function is designed for the background software, among many other functions, such as data operation management (adding, deleting and revising the operations). During this process, information such as previous data of operation, post-operation data, who does the operation and when is stored in the data table and then presented on the page. User management module is also designed with multiple functions. Different authority is allocated to different users. Report processing function is for graphic representation of the data. However, pagination may be an inconvenient form of display, so query function based on time period for each monitoring point is designed and the results are exported to Excel. The report contains the information on monitoring time, monitoring site, frequencies and field strength. Other functions related to the report such as statistics, query and printing are also ready for use.
3. CONCLUSION

The automatic monitoring system for radio and television signals proposed in this study can realize simultaneous field strength measurements of radio and television signals. This represents a great innovation as compared with manual detection. The monitoring data is accurate, and the system can run normally, conveniently stably and save time and human labor.

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