ISSN: 2664-9640

Design of Control System of Intelligent Digital FM Transmitter

Huishi Gao, Longxi Jiang, Sijia Liu

Wenzhou Polytechnic, Wenzhou 325200, China

Abstract

In order to realize the intelligence of the FM transmitter control system, the team developed the second generation of intelligent digital FM transmitter, the modulation control board is integrated FM signal modulation and power control functions. The closed-loop precision control (AGC) is realized by inputting frequency and power information to the MCU through the rotary coding switch. The MCU controls the liquid crystal display to display various status information at the same time, and the modulation signal is sent from the control board to the RF power amplifier to achieve amplified output. The closed-loop precision control includes the MCU intelligent control platform, which connects the LCD display, rotary coding switch, PCC modulated signal transmitter, power controller, and power monitoring feedback on the MCU intelligent control platform. The power monitor sends and feeds the acquisition frequency, asynchronous AM signal-to-noise ratio, and synchronous AM signal-to-noise ratio, and then sends the information to the MCU intelligent control platform. After calculation and analysis, the MCU outputs the PCC adjustment signal to the power control module to form precise power output control. In addition, the MCU intelligent control platform can also detect its own working status, fault type and fault location, etc., to ensure the safety, stability and reliability of various control functions.

Keywords

Smart digital FM, broadcast FM, control system, smart FM, FM transmitter.

1. Introduction

In order to further improve the computer real-time monitoring system of the TV FM transmitter room, we have designed an intelligent control system for the FM main and standby transmitters at the three frequency points of 94.9MHz, 98.5MHz and 103.5MHz in the computer room. The programming of the programmable controller (PLC) realizes a series of intelligent operation functions such as timing start-up, timing shutdown of the FM transmitter, and automatic back-up of the main and standby machines. In the design process, we took the safe, stable and reliable operation of various intelligent control functions as the design principles and inspection standards [1]. For different control functions, we carried out the setting of different constraint conditions and the design of flowcharts. The relevant design and technological transformation are described as follows.

2. The structural principles and characteristics of the system

2.1. System structure principle

The network diagram of the transmitter control system is shown in Figure 1. It can be seen from Figure 1 that the control system is mainly composed of two parts: the upper computer system and the lower computer system [2]. The lower computer system completes the acquisition and storage of the transmitter analogy and switch values, such as temperature, voltage, power, current, frequency, etc., and displays them in real time on the LCD screen. The occurrence of faults will be alarmed and displayed, and the control quantity will be output to protect the transmitter at the same time. The main function of the upper computer is to communicate with the lower computer through RS485232 to achieve remote modification of the system time of the lower computer and remotely turn on and off the transmitter.

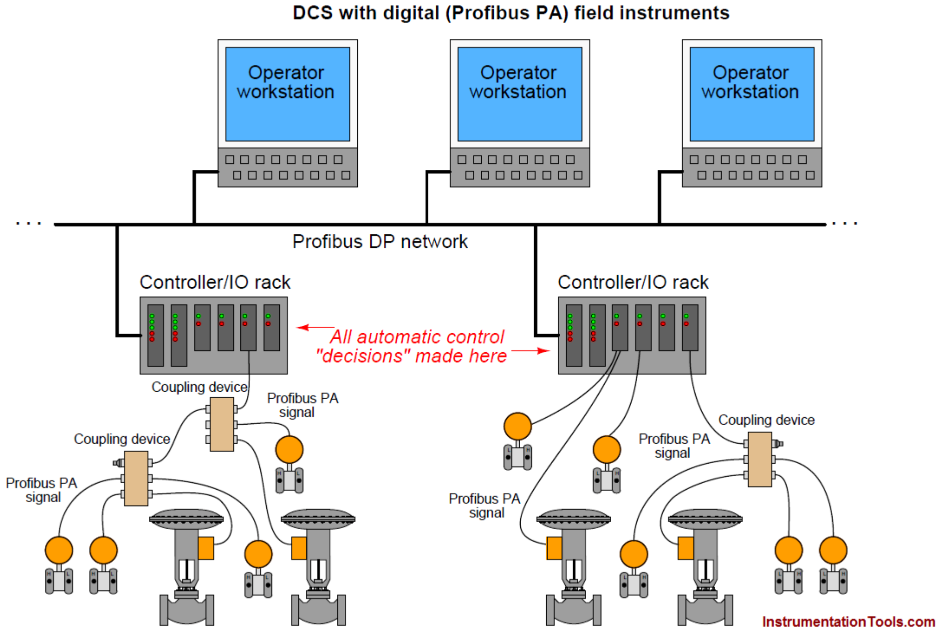

Figure 1. Transmitter control system network

2.2. Hardware structure

The power supply adopts the PS3075A power module, which converts 120 or 230V AC voltage into 24V DC working voltage, and supplies power to the CPU and actuators. Various parameters of the transmitter system are detected by setting 6 sets of SMM331 analogy quantity acquisition modules and 11 sets of SM321 switch quantity acquisition modules. Among them, the acquisition signal of the cooling system in the analogy quantity acquisition is 4-20mA, and the rest are 0-5V. A group of SM322 control signal output modules control the transmitter accordingly. Use IM360/361 interface module to connect between each rack [3]. In order to communicate with the host computer, it is equipped with a CP343-1 module, which supports industrial Ethernet communication, and is connected to the host computer through a twisted pair and a router. The upper computer selects the TPC series touch panel computer, using the latest HMI (Human Machine Interface). In addition to supporting the Windows CE platform, its x86-based system also supports the Windows XP operating system and embedded platform. The system uses a low-power processor, no need to install a fan, and is equipped with a serial port, RS-485 port, Ethernet port and USB interface, easy to communicate with other devices.

2.3. Software design

2.3.1 Data collection. Data collection adopts a unified collection and unified processing method. The function blocks FC11 and FC2 are responsible for collecting and monitoring 41 analogy quantities and 173 switching quantities of the transmitter, sampling once every 0.5s, and storing the data in the data block. In addition, the function block FC22 cooperates with the cyclic interrupt organization block OB35 to realize the filtering of the analogy quantity. The average filter is performed every 4 times of acquisition, and an interrupt is triggered every 100 ms.

2.3.2 Switch machine control. The power on/off control includes the start-up process, shutdown process, and the processing and state preservation of the power on/off failure. Through the on/off control of the exciter and the main power supply, the transmitter can be turned on and off. The program design idea is realized by the state machine, that is, only the condition of this step can trigger the next action in the process of switching on and off. If the condition is not reached or overtime, it is judged as the failure of switching on and off. The process is shown in Figure 2.

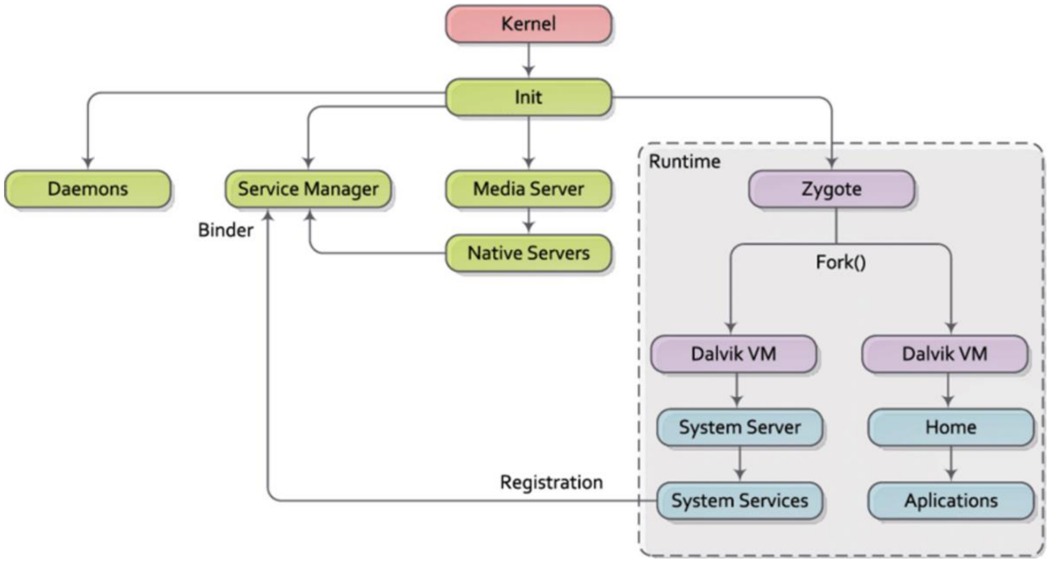

Figure 2. Boot process

2.3.3 Failure analysis and processing. From the fault handling method, the fault types are divided into cascading faults, blockage excitation and shutdown faults. Among them, the cascading faults are only handled during the start-up process, and the blocking excitation and shutdown faults are permanently detected, but they are only handled in the system running state. The global monitoring module is responsible for extracting the points that need fault judgment [4]. When a fault occurs, the function block FC4 is used to save the fault information, the blockage excitation fault information is saved to DB40, the shutdown fault is saved to DB42, and then the function block FC5 is used. Perform lockout fault handling and shutdown fault handling with FC6. In addition to the above-mentioned troubleshooting methods, in order to reduce broadcast, stop accidents, a one-key reset function has also been added. When a fault occurs, after pressing a key to reset, all fault information will be cleared to "0", and when a fault occurs again, only record and alarm will be performed without blocking excitation or shutdown processing.

2.4. Features

1) Humanized digital LCD display panel, rotary coding switch control. 2) All system parameters of the integrated LCD display: transmitter frequency, stereo and mono, volume, power amplifier tube temperature, audio signal UV meter, forward power, reflected power, modulation mode, pre-emphasis, etc. 3) The standard 19-inch 1U thick all-aluminium alloy chassis is not only sturdy but also excellent in heat dissipation. 4) Accurate PLL frequency generation system, to ensure that the frequency does not drift for 10 years, built-in high-quality stereo encoder. 5) Excellent power AGC balance control system, the power output can be adjusted from 0 to 50 watts, with automatic gain power control, to maintain the output power within the set range without drifting. 6) The signal input not only supports XLR and RCA audio input, but also uses BNC connector AUX to input SCA signal and RDS signal. 7) The RF amplifier part uses LDMOS transistors, which can withstand severe load mismatch exceeding 65:1 standing wave ratio at the 5dB compression point. Figure 3 shows the precise closed-loop control flow chart.

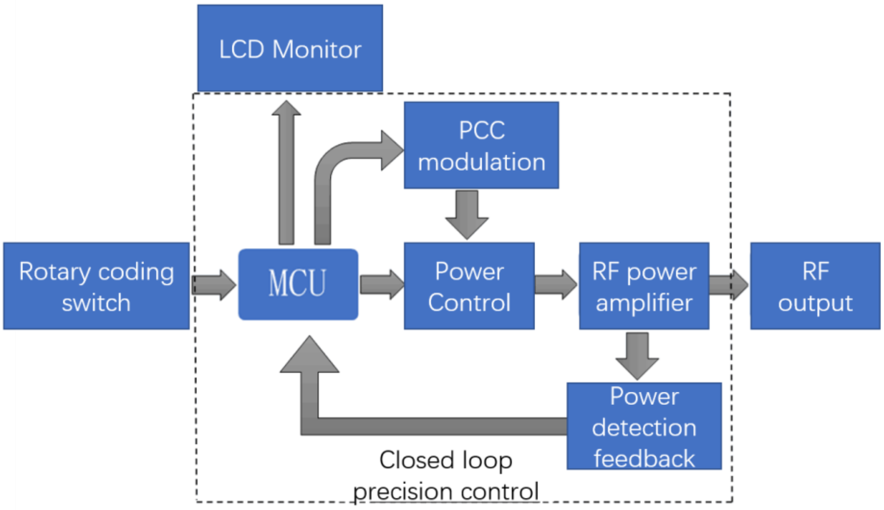

Figure 3. Flow chart of precise closed-loop control

Compared with traditional broadcasting equipment, the intelligent digital FM transmitter developed by our team has great advantages: 1) The price is moderate, and the price of the same power level is only about 1/5 of traditional broadcasting equipment, which is a developing country at this price. Most of the schools can afford it. 2) The product quality is stable and reliable, with temperature protection, standing wave protection and PLL frequency locking functions. Compared with traditional broadcasting equipment, the internal modular structure of the intelligent FM transmitter of Ailian Electronics makes the later maintenance very convenient and the maintenance cost is relatively low. 3) Under the current situation of being affected by the epidemic and the "Belt and Road", the smart digital FM transmitter we developed can enter the Southeast Asian market smoothly, and gradually expand the market along the "Belt and Road" direction.

3. System Test

Using traditional methods to measure the operating technical indicators of FM broadcast transmitters is completed by multiple test instruments with different functions. A single instrument cannot cover all measurement items, and this system can replace multiple measurement instruments at the same time to complete different Project testing [5]. The test board is equipped with multi-stage amplifiers, filters and related circuits. Its test block diagram is shown as in Fig. 4. The specific test principle and method are as follows.

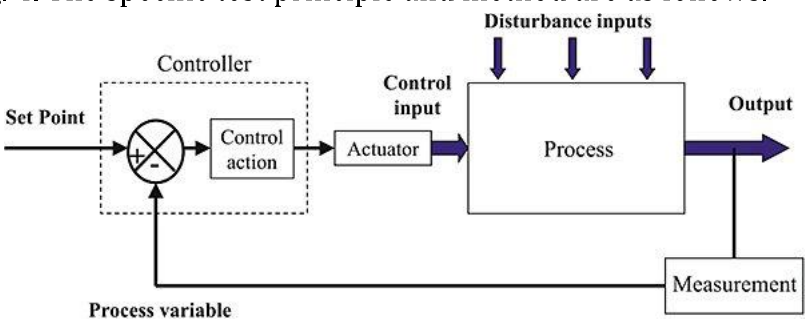

Figure 4. Test schematic

ISSN: 2664-9640

3.1. Signal-to-noise ratio

According to the national standard, the signal-to-noise ratio is the decibel value of the ratio of the signal level to the noise level measured at the output of the demodulator after modulating a 1kHz signal and removing the 1kHz signal, that is:

$$S/N = 20\lg\frac{V_1}{V_2} \tag{1}$$

Where: V_1 is the signal level (with modulation); V_2 is the noise level (without modulation).

$$V = \sqrt{\frac{1}{N}\Sigma_{k=1}^{N}x_k^2} \tag{2}$$

In the formula: x_k is the sampling data value; N is the total number of sampling points. For the noise level, according to relevant regulations, the test of the signal-to-noise ratio of the FM transmitting equipment should add a band-pass filter with a 3dB bandwidth of 19-31.5Hz (low end) to 16-25kHz (high end) to ensure the standardization of the noise measurement bandwidth. We use a combination of analogy filtering and digital filtering to limit the noise bandwidth and ensure the accuracy of the signal-to-noise ratio test.

3.2. Distortion test

The distortion test is to measure the fundamental wave and each harmonic voltage value according to the harmonic analysis method, and obtain it according to the following formula:

$$D = \frac{\sqrt{U_2^2 + U_3^2 + \ldots + U_n^2}}{U_1} \times 100\% \tag{3}$$

Here, the fundamental wave and harmonic voltage are obtained by FFT spectrum analysis on a batch of collected data. For a signal with N sampling points, the discrete Fourier transform pair formula is as follows:

$$x(n) = \Sigma_{k=0}^{N-1}x(k)e^{-j2\pi nk/N}, n = 0,1,\ldots,N-1 \tag{4}$$

$$x(k) = \frac{1}{N}\Sigma_{k=0}^{N-1}X(n)e^{j2\pi nk/N}, k = 0,1,\ldots,N-1 \tag{5}$$

Among them, $X(n)$ is the nth frequency domain component in the discrete spectrum, and $x(k)$ is the kth time domain component in the time domain sampled value. n is the sample number in the frequency domain, and k is the sample number in the time domain. Take: $W = e^{j2\pi nk/N}$, called the rotation factor. According to the connection method in Figure 4, the distortion degree D1 of the audio signal is first measured during the test, and then the distortion degree D2 of the audio signal output by the modulation and demodulation is measured. The distortion degree D of the transmitter can be obtained by the following mathematical derivation formula:

$$D = \sqrt{\frac{D_2^2 - D_1^2}{1 + D_1^2}} \tag{6}$$

The passband fluctuation of the filter can be adjusted to the best state, and in the calculation of FFT, 16-bit block floating point calculation method is adopted, and the transfer function calculation uses floating point calculation, the dynamic range can reach 100dB, which ensures the calculation accuracy. All these make the introduced distortion of the system reach below 0.01%.

3.3. Other index tests

The system can also test other operational technical indicators of the transmitter in accordance with the provisions of the national standard. Among them, the left and right signal level difference, separation degree, pre-emphasis, pilot frequency deviation and sub-carrier suppression are five indicators. Analogy switches and relays can automatically switch the frequency and frequency of the signal source. For the corresponding test points, run the software programs of each special test, measure the corresponding indicators and draw the curve [6]. The pilot frequency and pilot signal phase difference test are realized by using the shaping, phase-voltage conversion and other circuits on the test board to take advantage of the software and hardware advantages of the C80.

4. Conclusion

The FM control system designed by the team has achieved the intended purpose and ensured the FM transmitter through relevant design and technical transformation, through the setting of control conditions and the design of flow charts for different functions, and the programming of related PLC programs. The stability, accuracy and reliability of the intelligent control function lays a solid foundation for the safe and high-quality transmission of FM broadcast signals.

References

[1] Chauhan, K., & Chauhan, R. K. Design and development of two levels electronic security and safety system for buildings. International Journal of Electronic Security and Digital Forensics, 12(3) (2020) 279-292.
[2] Smadi, T. A., & Al-Maitah, M. Artificial intelligent technology for safe driver assistance system. International Journal of Computer Aided Engineering and Technology, 13(1-2) (2020) 183-191.
[3] Dawood, Y. S., Almaged, M., & Mahmood, A. Autonomous Model Vehicles: Signal Conditioning and Digital Control Design. International Journal of Engineering and Innovative Technology (IJEIT), 8(3) (2018) 18-24.
[4] Pisoni, G., Díaz-Rodríguez, N., Gijlers, H., & Tonolli, L. Human-Centred Artificial Intelligence for Designing Accessible Cultural Heritage. Applied Sciences, 11(2) (2021) 870-875.
[5] Mappatao, G., Bautista, I. M. Z., Orsos, M. K., Ribo, M. A., & Castillo, J. Development of a remote tending system for analogy broadcast transmitters. Indonesian Journal of Electrical Engineering and Computer Science, 15(3) (2019) 1474-1484.
[6] Zungeru, A. M., Mangwala, M., Chuma, J., Gaebolae, B., & Basutli, B. Design and simulation of an automatic room heater control system. Heliyon, 4(6) (2018) 655-679.