

Design and Implementation of a Portable FM Broadcasting Duty Monitoring Alarm Device Postprint

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Abstract

Through analysis of waveform diagrams under diverse broadcast conditions and employing DDS technology for extraction of audio characteristic parameters, a portable FM broadcast duty monitoring alarm device has been designed. This apparatus achieves alarming functionality under power on/off, broadcast cessation, and no-audio states, thereby ensuring real-time monitoring of broadcast transmitter station operational status under the “staffed but unattended operation” mode, facilitating timely fault detection and remediation, and enhancing broadcast quality. Characterized by compact dimensions and portability, the device enables on-site personnel to identify fault conditions at the earliest opportunity and undertake immediate corrective actions, thus minimizing broadcast interruptions and substandard transmissions to the maximum extent possible.

Full Text

Preamble

Design and Implementation of a Portable FM Broadcast Duty Monitoring and Alarm Device

Abstract: By analyzing waveform patterns under different broadcast states and employing DDS technology to extract audio characteristic parameters, this paper presents the design of a portable FM broadcast duty monitoring and alarm device. The device achieves alarm functionality for power-on/off, broadcast interruption, and audio loss conditions, enabling real-time monitoring of broadcast transmitter status under an “attended 留守, unmanned 值机” operational model. This ensures timely fault detection and handling, thereby improving broadcast quality. With its compact size and portability, the device allows attendant staff to immediately identify and address faults, minimizing broadcast interruptions and degraded transmission.

Keywords: Safe broadcasting; FM broadcast; Duty monitoring; Alarm device

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With the advancement of automation technology and rising labor costs, traditional broadcast duty models no longer meet modern operational requirements. This project was initiated to address duty monitoring challenges at our FM broadcast station, where the small equipment room located on a mountaintop makes 24-hour staffing impractical. To enhance broadcast safety, we implemented automated switching for power supplies, transmitters, and program signals, establishing an “attended 留守, unmanned 值机” model that reduces manpower requirements. To enable attendant staff to monitor broadcast status while performing other duties, we developed this portable FM broadcast duty monitoring and alarm device. Compact and lightweight like a mobile phone, the device provides audible and visual alarms for power status changes, broadcast interruptions, and audio loss, allowing staff to monitor broadcasts anywhere without continuous audio monitoring. This eliminates fatigue from prolonged listening, significantly reduces fault detection and recovery times, and improves both duty efficiency and broadcast safety.

Our station’s official broadcast hours are 6:30–24:00. Following automation upgrades, the transmitter automatically powers on at 6:20 and off at 0:10. Based on program schedules, we categorize the transmitter’s 24-hour operation into three states: shutdown, powered-on but not broadcasting, and powered-on and broadcasting, as illustrated in the four phases shown in Figure 1 [Figure 1: see original paper].

1. Functional Design

Based on operational requirements, we designed the alarm device with six primary functions: (1) **Alarm function**—the core capability to detect faults and trigger alerts; (2) **Configuration function**—adjustable monitoring frequency, time parameters, and alarm thresholds for universal applicability; (3) **Monitoring function**—real-time program audio monitoring; (4) **Fault indication**—color-coded visual alerts for different fault types; (5) **Display function**—LCD screen showing device status; and (6) **Charging function**—lithium battery power supply for portability.

1.1 Transmitter Operation State Detection

This function comprises two aspects. First, **power status detection** monitors transmitter on/off states, including early morning automatic startup, abnormal shutdown during broadcast, and proper shutdown after evening programs. Using our station’s schedule (6:20–0:10 powered on), the device must trigger an alarm if the transmitter fails to start after 6:20 or shuts down due to power loss or equipment failure. During 0:10–6:20 (scheduled shutdown), any automatic startup must also trigger an alarm.

Second, **program broadcast state detection** addresses common faults during normal operation (6:30-24:00), including program interruption, audio loss, or excessively low volume. The device must detect these conditions and generate appropriate alerts.

1.2 Alarm Type Indication

To facilitate quick fault identification, different alarm types are assigned distinct indicator lights. When an alarm sounds, the corresponding fault indicator flashes. Staff can silence the alarm while the light continues flashing, enabling immediate fault type recognition.

1.3 Monitoring Function

To verify broadcast quality, the device includes a program listening function with adjustable volume control.

1.4 Display Function

An LCD displays signal strength, battery level, clock, frequency, and device status.

1.5 Configuration Function

For universal applicability, the device supports configuration of broadcast frequency, on/off times, signal thresholds, audio thresholds, and alarm sound settings.

1.6 Charging Function

Portability requires compact size, convenient power supply, long battery life, and charging capability. The device uses a single 4.2V high-capacity rechargeable battery instead of multiple dry cells, with an integrated charging circuit. A shared speaker for program monitoring and alarms further reduces size.

2. Key Technical Principles

Among the device's functions, transmitter state detection represents the core technical challenge. While modern facilities use PLCs for parameter sampling and computer-based monitoring, these solutions are fixed in place. Network-based transmission to PDAs offers mobility but remains expensive and network-dependent. Drawing on years of fault-handling experience, we propose a novel receiver-side monitoring approach: acquiring audio waveforms under different broadcast states, extracting characteristic features, and implementing detection-based alarms.

2.1 Feature Analysis and Extraction

We used an oscilloscope to capture 10ms waveform samples from a radio receiver tuned to our frequency across three states: shutdown, powered-on without audio, and powered-on with broadcast. Figures 2 [Figure 2: see original paper] through 4 [Figure 4: see original paper] reveal distinct waveform patterns for each state, enabling unique feature extraction. The process involves: FM signal demodulation by the radio module, appropriate filtering, processing by a Microchip PIC16F917 high-performance microcontroller, AD sampling to obtain discrete values, and calculating deviations to determine operational state.

2.2 Signal Detection Principle

After ADC conversion by the PIC16F917, 256 discrete values are acquired every 1ms. Calculating the deviation of these values yields large results during strong signal conditions (transmitter on) and small, stable values during weak signal conditions (transmitter off). This deviation serves as a reference; an appropriate signal threshold is set based on actual conditions. When the deviation falls below threshold, a weak signal is indicated. To prevent false alarms, a buffer time is implemented, significantly improving accuracy. The detection flow is shown in Figure 5 [Figure 5: see original paper].

2.3 Audio Detection Principle

When the signal-to-noise ratio is adequate, voice activity can be distinguished by comparing input signal energy against a speech energy threshold. Implementation: The radio module's analog signal undergoes internal filtering for stable linearity. The program scans the input every 1ms; when input exceeds the set threshold, a counter resets; otherwise, it increments. Upon reaching the set time threshold, an alarm triggers. The no-audio alarm detection flow is shown in Figure 6 [Figure 6: see original paper].

3. Design Implementation

3.1 Hardware Composition

The monitoring alarm comprises a PIC16F917 microcontroller, FM radio module, audio amplifier, PCF8563 clock chip, buttons, and LCD module. The PIC16F917 serves as the core component, connecting all modules and managing data exchange. Its high performance, precision, and low power consumption suit the intensive scanning requirements. The radio module outputs signals to the microcontroller for detection. Audio output routes through a single 8-channel CD4051 analog switch, with the microcontroller selecting inputs via binary control lines B and C, feeding the amplifier module and speaker. The PCF8563 clock chip manages time for multi-period alarms, alarm delays, and complex timing services. A single 4.2V rechargeable battery powers the system, with

an integrated charging circuit. The design is shown in Figure 7 [Figure 7: see original paper].

3.2 Implementation Technology

The radio module's signal passes through resistor R9, converting current to voltage for input to the PIC16F917's pin 25 (ADC port). This port consists of an analog integrator with input switch, comparator, and counter unit, employing dual-slope conversion to transform analog voltage into a proportional time interval based on its average value. The converted signal is estimated to obtain 256 10-bit digital values, then averaged. The absolute deviation of each value from the mean is calculated; strong signals yield large deviations, weak signals small deviations. All deviations are summed and divided by sample count to obtain the SNR. When SNR falls below the threshold of 5 for less than 2 seconds, an alarm triggers. The C implementation is as follows:

```
unsigned int Data[255]; // Acquire 255 data points
unsigned long SUM_{DATA}; // Sum of 255 data points
unsigned int AVG_{DATA}; // Average of 255 data points
bit S_{IF}; // Data acquisition complete flag

AVG_{DATA} = SUM_{DATA} >> 8; // Calculate average
SUM_{DATA} = 0;
unsigned long GC_{DATA}; // Sum of absolute deviations
GC_{DATA} = 0;
unsigned char ik;

// Calculate total absolute deviation
for(ik = 0; ik < 255; ik++) {
    if(Data[ik] > AVG_{DATA}) {
        GC_{DATA} = GC_{DATA} + Data[ik] - AVG_{DATA};
    } else {
        GC_{DATA} = GC_{DATA} + AVG_{DATA} - Data[ik];
    }
}

SNR = GC_{DATA} >> 8; // Calculate SNR
```

3.3 Main Technical Parameters

The device offers extensive parameter configuration for universal applicability: receivable frequency, power on/off times, program start/end times, signal threshold, audio threshold, and mute interval. These settings enable monitoring of any FM broadcast station. Key specifications include: dimensions 10cm×6cm×2cm; frequency range 87MHz-107MHz; time settings 0:00-23:59; signal threshold 5-45; audio threshold 5-99; mute buffer time 5-99; voltage 3.7-4.2V; battery life 48 hours (monitoring off) or variable (monitoring on).

4. Deployment and Performance

Since deployment, the portable broadcast duty monitoring alarm has proven highly effective. Staff can easily carry the device and enable speaker monitoring during normal operations. During meetings or other tasks, silencing the speaker still allows alarms to sound for broadcast anomalies. Two indicator lights enable immediate distinction between audio program faults and transmitter faults. The device provides intuitive display, accurate alarming, and stable operation, meeting all design requirements. Under the “attended 留守, unmanned 值机” model, it accelerates fault detection, reduces recovery time, alleviates staff workload, and enhances broadcast safety. The device features mature technology, stable performance, high detection sensitivity, portability, and broad applicability. With simple parameter configuration, it can be deployed at any FM broadcast station, making it suitable for mass production and nationwide deployment in broadcast systems.

References: [1] Liu Kun, Song Ge, Zhao Hongbo. *51 Microcontroller C Language Application Development Technology*[M]. Beijing: People’ s Posts and Telecommunications Press, 2008: 176-464. [2] Zhang Hongrun, Sun Rui, Zhang Yafan. *Microcontroller Principles and Applications*[M]. Beijing: Tsinghua University Press, 2008: 223-302.

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Note: Figure translations are in progress. See original paper for figures.

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