

# System of Weak Signal Detection Based on TD-SCDMA Dual Polarized Antenna

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**Abstract:** In the current signal measuring equipment in measurable characteristics under the condition of weak signal, the signal measurement accuracy is not high. Therefore, this study designs and realizes a kind of equipment based on TD -SCDMA dual polarized antenna for weak signal measurement system. System uses the 2.4 GHz ISM A7105 RF transmitter sent via baud generator clock for electromagnetic wave frequency control forming the local magnetic fields, the system design includes ICL7650 AD620 chip signal amplification module, combined with a module combination based on isolation MAX275 chips, by adjusting the built-in six resistance to noise filtering, in the design of TD -SCDMA dual polarization antenna, through multiple columns of smart antenna radiation, to form the sensitivity of the dynamic contact, to strengthen the weak signal loss repair characteristic, for the synchronization of GPRS communication and AT89C51 MCU for weak signal processing; finally it realizes the weak signal accurate detection. Through the experiment testing, the system can, in complex environment, able for the accurate detection of weak signal. Compared with the traditional system, its detection accuracy by about 49%, reduced testing time by 5 seconds, has a strong practical application value.

**Keyword:** Complex environment, dual polarized antenna, network topology, weak signal.

## 1. INTRODUCTION

Currently, the detection of communication signals mostly depends on signal detecting systems, which find the position of the "signal" through the electric field generated by ultra-low frequency waves emitted by a communication signal. Equipped with special radio filters it can filter and remove frequencies, which are different from the communication signals; so the signal detection device will only sense the electric fields generated by frequencies emitted by communication signals. The detection device is equipped with two different detection rods, the long-range detection rod has detection range of up to 500 meters, and the short-range detection rod has detection range of up to 20 meters [1-3]. The ultra-low frequency electric field emitted by communication signals can be sent through the reinforced concrete walls and steel plates. The detection range will be reduced when the communication signals confront the above obstacles, but as long as moving close to the detection site, the operator can still find the precise target signal [4, 5] for searching. However, there is a problem with the current signal measurement device, that is difficult to complete a weak signal detection, that is to say, when the measurable characteristics of the signal becomes weak, the accuracy of the signal measurement is not high, which greatly limits the application of traditional detection system [6-8]. On account of this problem, this article improves the traditional system, by designing and implementing a system of weak communication signal detection based on TD-SCDMA

dual-polarized antenna to enhance the ability of weak signal detection [9, 10].

## 2. OVERALL SYSTEM DESIGNING

The detection system includes: 2.4GHzISM A7105 RF transmitter module, ICL7650-AD620 signal amplification module, MAX275 isolation defibrillation module, TD-SCDMA echo signal detection module, MAX197 digital to analog (A/D) converter module, MCU synchronous GPRS communication module, and AT89C51 single chip signal processing module. The overall system architecture of weak communication signal detection is shown in Fig. (1).

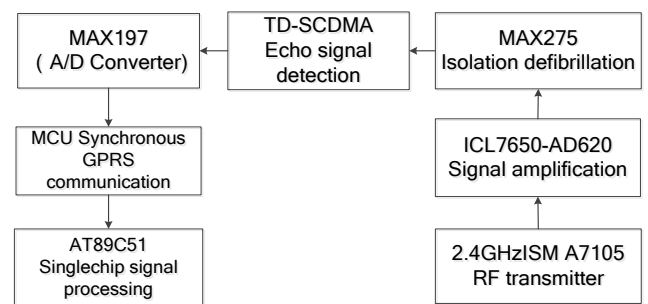


Fig. (1). System framework map.

The system uses 2.4GHz ISM A7105 RF transmitter to control the sending of electromagnetic waves through the clock frequency of baud generator, forming local magnetic

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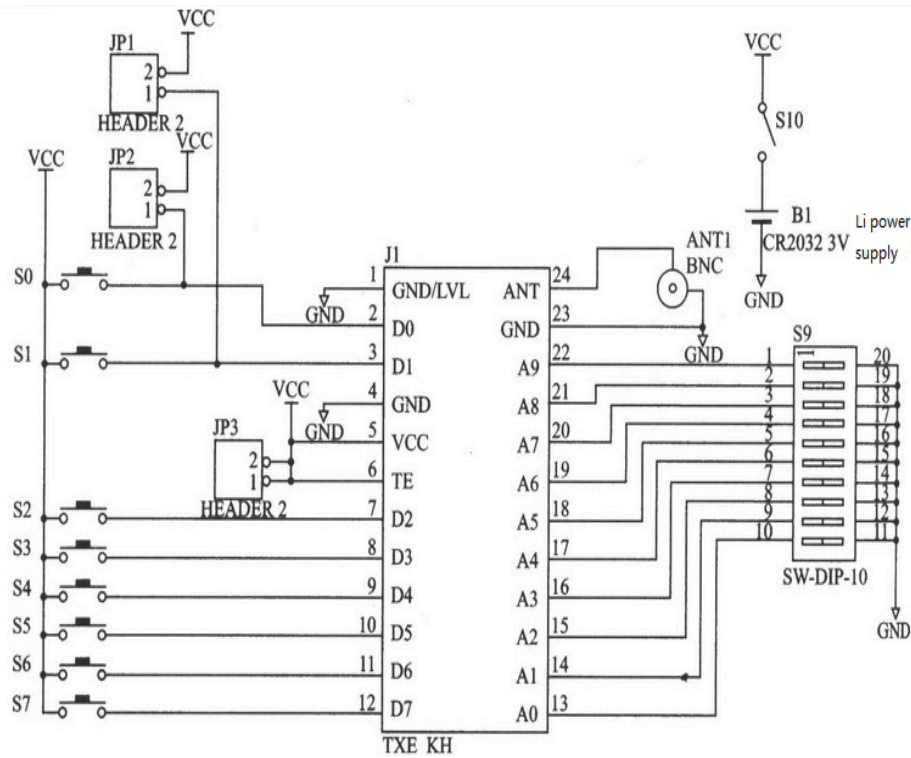


Fig. (2). Circuit diagram of 2.4GHz ISM A7105 chip.

field by emitting by the electromagnetic waves, designing ICL7650--AD620 chip module for signal amplification processing, combined with isolation defibrillation module based on MAX275 chip, by adjusting six built-in resistance to completing noise filtering, the TD-SCDMA dual-polarized antenna designed forming sensitive dynamic contact through columns of radiating elements constituted by a plurality of smart antennas, intensively repairing deletion characteristics of weak communication signals, under the processing of MCU synchronous GPRS communication and AT89C51 microcontroller to weak communication signal, and ultimately achieving accurate detection of weak communication signals.

### 3. DESIGN OF CRITICAL HARDWARE MODULES OF THE SYSTEM

#### 3.1. Design of ISM A7105 RF Transmitter

RF transmitter module is mainly used for transmitting electromagnetic waves and apperceives the weak communication signals around. When emitting electromagnetic waves, according to the design requirements of the system acquisition, the selection of RF transmitter chip should not only have appropriate precision, but also high integration and sending speed to its possible degree. At the same time, taking into account the cost of the chip, after a comprehensive consideration, this paper uses a 2.4GHzISM A7105 radio frequency transmitter, which is a low-cost wireless

applications, built-in high-sensitivity receiver, and may be working within the range of 10 meters, and the RF transmitter installs weak communication signal sensors inside the terminal, which is a linear detection device that can operate in the range of -18°C to 300°C, that is enough to cope with the detection of weak communication signals under vast majority of natural disasters. The hardware design schematics of RF transmitter 2.4GHzISM A7105 is shown in Fig. (2):

#### 3.2. ICL7650-AD620 Signal Amplification Module

The communication signal is detected when the RF transmitter is working, after the collected signals getting into the processor circuit; firstly, they should be treated with amplifier circuit, so that the characteristics of weak communication signals can be accurately detected by the corn processor named AT89C51. This article uses two level amplifying circuit for amplifying the weak communication signals: firstly, current amplification, then followed by a voltage amplification. The hardware design of the amplification circuit is shown in Fig. (3).

In Fig. (3), ICL7650 and AD620 are used to form an amplifier circuit for noise suppression and signal amplification of weak communication signals, and the calibration of the output value is magnified a million times of the input value. In order to suppress high frequency oscillation in the circuit, the input current is put in the reverse side of the amplifier ICL7650. The series capacitor C1 protects the work of ICL limiting resistor, while AD620 contains certain substrate

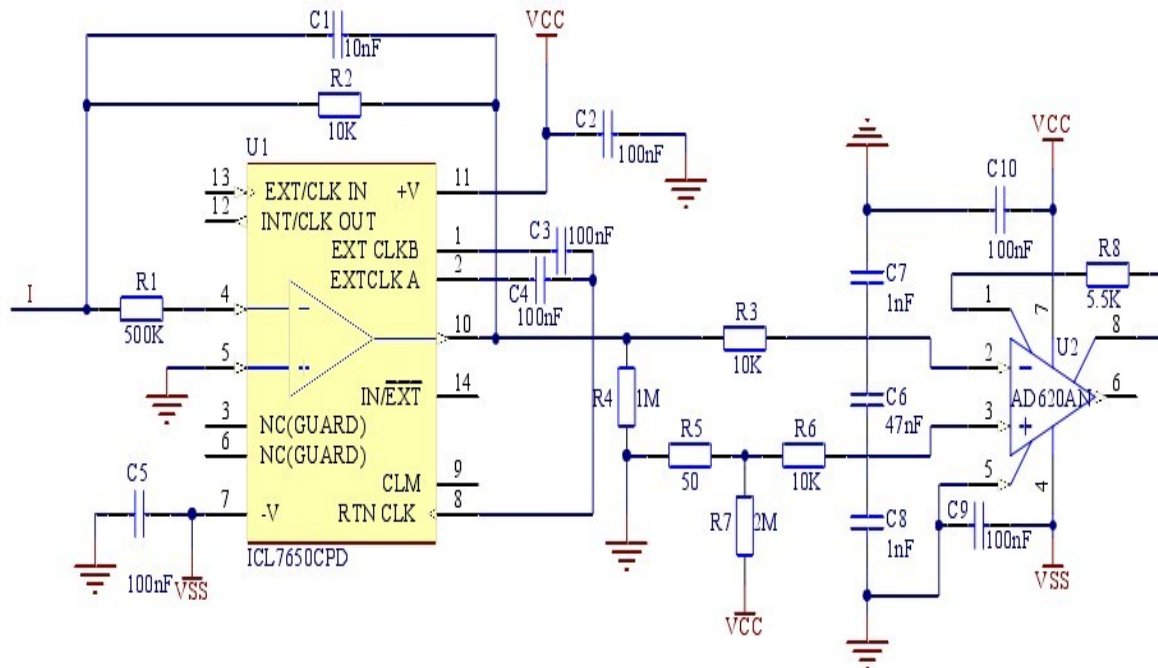


Fig. (3). Hardware design of weak signal amplification circuit.

voltage and the measured signal. After the sampling signal of the echo sensor of the communication signal is amplified, the output voltage is within the range of  $0 \sim 3.25V$ , sending into the A/D converter of LPC2148, selecting channel 0 for input, calibrating point 2, fitting together linearly to obtain the actual echo signal. The signal strength ranges from 0 to 100HZ, and the accuracy is  $\pm 1HZ$ .

### 3.3. Isolation Defibrillation Module Based on MAX275 Chip

In the presence of interference, the detection circuit of weak communication signals may be disturbed, and the pre-amplifier circuit of communication signal sensor will form electromagnetic waves. While reasonably amplifies the weak communication signal, noise is also amplified, which interferes with the characteristics testing of weak communication signals. In order to remove noise, and making the characteristics of weak communication signals reveal more obviously, we design a bandpass filter to remove noise in isolation defibrillation module, selecting MAX275 chip for the chip of MAXIM bandpass filter, the hardware design structure of filter circuit is shown in Fig. (4).

Removing the noise for weak communication signals in the image above, MAX275 can use the power supply with the power of about 5V, the maximum current can not exceed 30mA. When removing the noise for weak communication signals, suffix letters A and B in the pins represent the belonging sets of filter unit, A is the first group and B is the second group; IN represents an input; BPI means bandpass input; BPO means bandpass output; LPO means lowpass output; FC represents the work pattern and the frequency

selection. By adjusting the size of resistances R1A, R2A, R3A, R4A and R1B, R2B, R3B, R4B in the figure to control the center frequency  $F_0$  of the weak signals and the quality factor Q of complex poles, the frequency range is selected when the FC is connected, adjusting the resistance according to the need of the system to remove noise for weak signals.

### 3.4. Hardware Design of the Echo Signal Detection Module

In order to overcome the problem that some characteristics of the weak communication signal are missing after isolation defibrillation, TD-SCDMA dual-polarized antenna and the network topology structure are designed in echo detection module to enhance the weak communication signal which has missing features. Detection network is constructed by multiple smart antennas, which include multiple independent columns radiating element (currently there are 8,6 and 4 columns), forming interconnected detection networks between each antenna, in which the smart antenna adopts bipolar smart antennas, to build a more sensitive dynamic relationship between the antennas. So, a weak communication signal with some missing characteristics discovered by a node discovery can be transferred quickly to the entire network, then repairing and strengthening the weak communication signal with missing characteristics.

At the same time, we design a small-zone dividing method, completing filtering of weak communication signals with missing features in the detection network that accurately reproduces the characteristics of faint communication signals. Strong isolation exists between the dual-polarized antennas, which are used to divide area across the antennas in

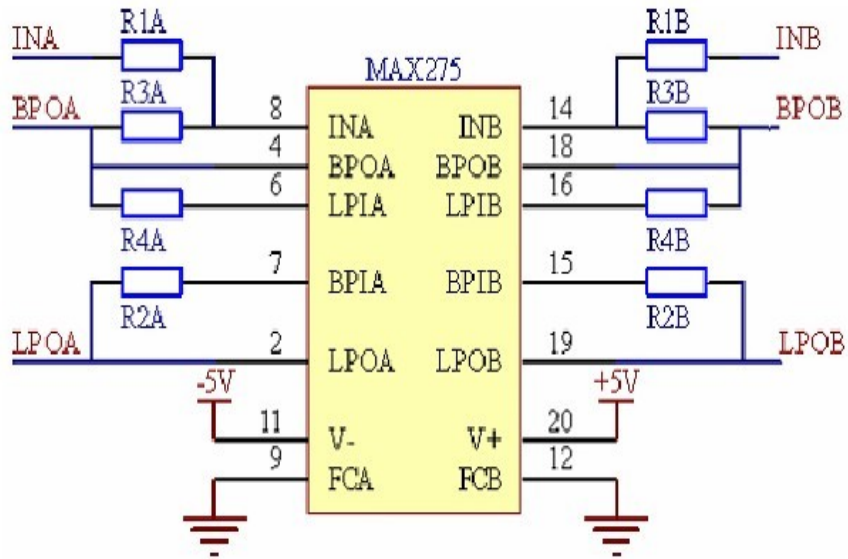


Fig. (4). Hardware design of filtering circuit for weak signals.

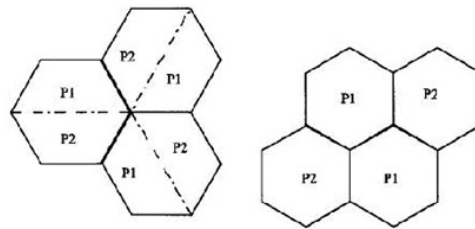


Fig. (5). Network topology design of dual-polarized smart antenna.

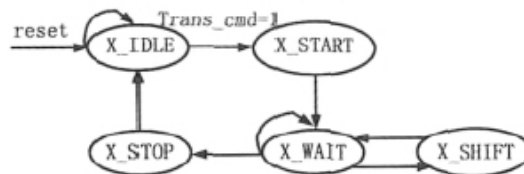


Fig. (6). Transmit state machine.

entire communication network, and communication signals are detected by each small area. The network topology design of intelligent dual-polarized antennas is shown in Fig. (5):

**4. SOFTWARE DESIGN OF SYSTEM**

**4.1. Software Design of RF Transmitter Module**

RF transmitter transmits electromagnetic waves to generate a local magnetic field for sensing weak communication signals, 2.4GHzISM A7105 RF transmitter built-in baud rate generator which controls the entire process with a clock frequency, because the frequency of the clock signal baud rate that the generator generates is 8 times of the baud rate of actual speed serial interface, thus sending a valid bits every

eight clock cycles. Sending module uses the approach of finite state machine and divides the whole process into five states: X\_IDLE (free), X\_START (start), X\_WAIT (shift waiting), X\_SHIFT (shift), and X\_STOP (stop). The design of transmit state is shown in Fig. (6).

Implementation process: after power-on reset in a radio transmitter, the state machine enters into X\_IDLE state. When idle, the state machine has been waiting for the data to send commands trans\_cmd, when trans\_cmd = 1, the state machine shifts into X\_START state, ready to send the start bit.

Under X\_START state, the sending module sends a signal with the start bit 0 to the TXD. Then the state machine goes into X\_WAIT state.

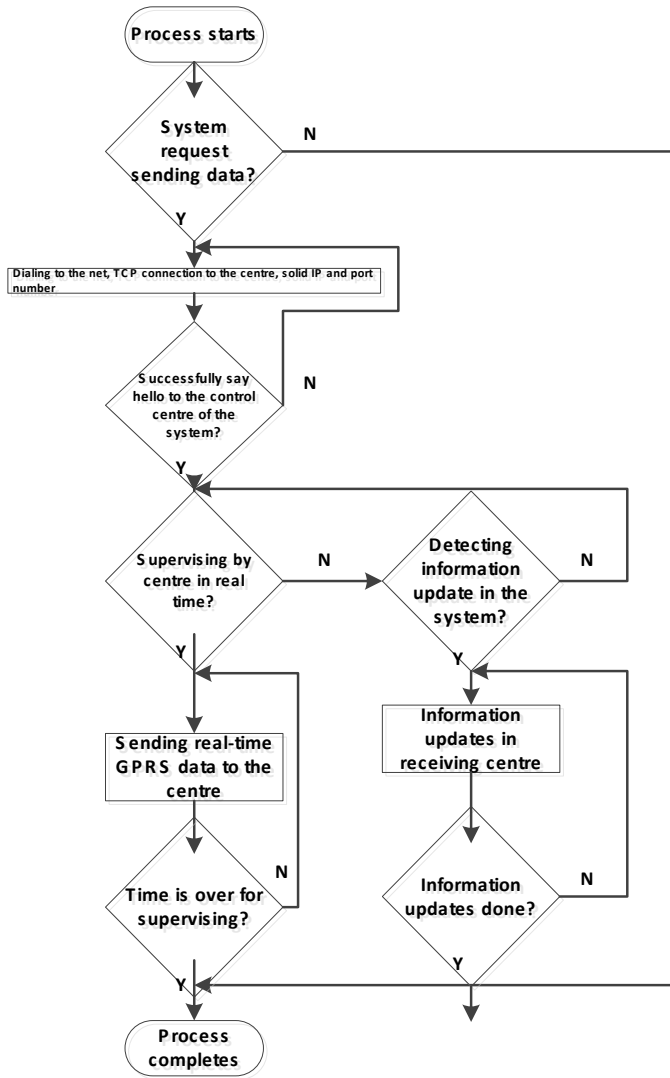


Fig. (7). Software design diagram of GPRS sending workflow.

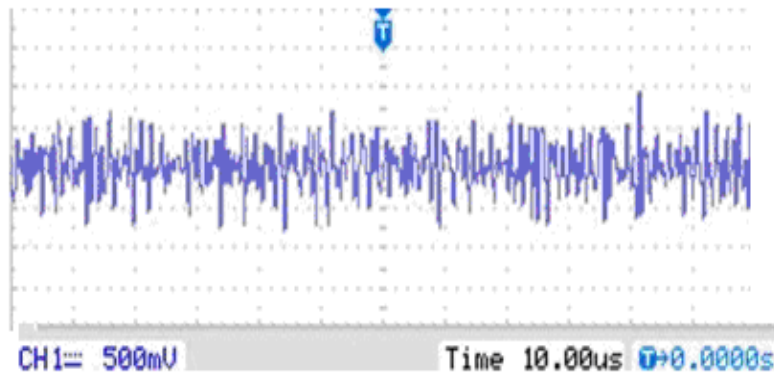


Fig. (8). Weak communication signal distribution detected by present system.

Under X\_WAIT state, firstly expire to eight baud rate generator clock to complete a full start bit transmitting, and begin to enter X\_SHIFT state in the ninth baud rate generator clock for shifting and sending the data, at the same time determining whether a character data has been sent com-

pletely, if a character data is sent completely, entering to X\_STOP state.

Under X\_SHIFT state, achieving string conversion of the data, immediately return X\_WAIT state after sending one bit of data.

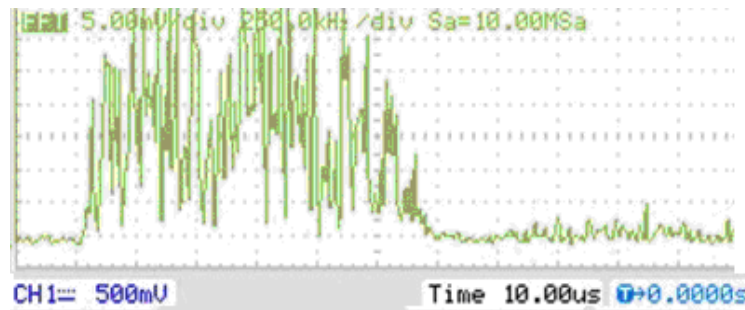


Fig. (9). Weak communication signal distribution detected by a conventional system.

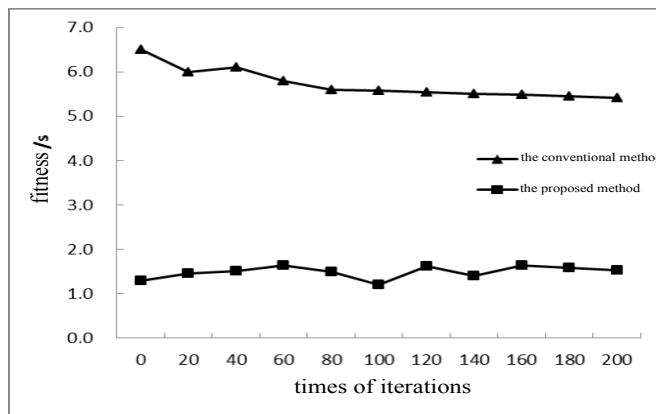


Fig. (10). Changing map of fitness with the times of iterations.

Once the data has been transmitted, enter into the X\_STOP state, the stop bit of state machine 1 to TXD, then back to X\_IDLE state, waiting for the sending of the next character.

#### 4.2. Software Design of GPRS Communication Module

After the completion of detection of the communication signals coordinated by the radio transmitter, the communication signals pass to the signal processing module via GPRS wireless network for signal analysis and display.

GPRS communication uses MCU (micro control unit) synchronization method, making communication synchronous with the A/D converter module, and configure its baud rate, the format of short message, coding mode, then read AT commands in the receive buffer module in real time. Software design flow is shown in Fig. (7).

### 5. EXPERIMENT AND ANALYSIS

In order to verify the effectiveness of the proposed design of the system, the following experiments are carried out. The subjects are 20 weak communication signals under chaotic environment with natural disasters. In the computer simulation circumstance, acquire echo information of communication signals at different ranges. The feature extraction results of central moment verify the effect of the characteristics of communication signals entering into analog bipolar network in this experiment.

Detect the echo data in two different detection ranges, and establish a training sample template library of weak communication signals. At the same time the echo data to be classified is also the measured data. 180 times testing for each detected target to obtain the experimental results in different systems, the communication signal detection results obtained are shown in Fig. (8).

Through comparison, it is observed that weak signal noise obtained by this proposed system is small, has a higher detection accuracy and obvious optimization effect, while the weak signal fluctuations achieved by the traditional system is larger and the average detection accuracy is not high. Specific statistical results are shown in Table 1.

As we can see from Table 1, this proposed method is better able to complete the detection of a weak communication signal, the detection time reduces approximately 5 seconds than traditional systems, and the detection accuracy of the weak signal is increased by about 49%.

To further verify the performance of the system, we experiment the fitness of the system. Results are shown in Fig. (9).

As we can be see from the Fig. (10), the optimal fitness of the legacy system is 1.744s, and fitness of the system in this article is 6.566s, thereby improving 73.4% than the traditional design of the system, which indicates strong adaptability of the proposed system that is suitable for large-scale fields.

**Table 1. Results of Experimental Comparison.**

Feature Extraction	Average Detection Time	Detection Range	Average Detection Accuracy
Conventional system detection	13s	100~150 meters	28%
Present systems detection	5s	100~150 meters	77%

## CONCLUSION

This paper proposes a design method of weak communication signal detection based on TD-SCDMA dual-polarized antenna. It can be seen from the test results of the system that the accuracy of weak signal detection improves about 49% and reduces by approximately 5 seconds the detection time than traditional systems, showing great advantages.

## ABOUT AUTHOR

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## CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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