The Research and Application of Array Antenna Element Detecting System

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Abstract— This paper analyzes the change of VSWR and radiation performance when the smart antenna element doesn't work. From the analysis, it is found that the damage of the antenna element has great influence on the broadcast beam, and it's not enough to just depend on the detection of VSWR. Traditional detection methods of base station antenna are studied, on the basis of above, a detecting system for array antenna element was researched and established.

1. INTRODUCTION

Array antenna is commonly used in wireless communication base station, which can form a higher gain and specific shaped electromagnetic beam Nowadays, base station antenna with more elements has become the mainstream and tendency especially in the TD-SCDMA system and LTE MIMO system [1, 5]. The arrangement of array is applied not only in one direction (e.g., vertical line array), but also in the orthogonal direction to form planar antenna array [2].

Array antenna has many elements, while one antenna element does not work properly for some reason (such as rosin joint, short circuit, destroy of mechanical structure), the reflection coefficient of the main port does not deteriorate badly, and thus the antenna will not give out a warning of the VSWR. But the array pattern will be significantly affected at this moment, such as asymmetrical antenna pattern, poor sidelobe suppression, decrease of antenna gain, etc..

The existing detection techniques only detect the VSWR [4] of the base station antenna and give out different levels of warning, and thus the abnormal situation of the internal element can't be detected. This paper proposes an antenna element detection system, which was composed of electromagnetic induction sensor and detection circuit.

2. THE INFLUENCE ANALYSIS OF DAMAGED ELEMENT

2.1. The Influence of Damaged Element on VSWR

Figure 1 shows one Vertical line array and feeding network of TD-SCDMA smart antenna. The influence of antenna element on VSWR was tested, the test chose three cases: 1. The antenna elements are in working order; 2. element 1# is damaged; 3. element 1# and element 2# are damaged. The test result is shown in Table 1.

According to test results, the VSWR is 1.21 when the antenna elements are in working order, the VSWR is 1.26 when the antenna element 1# is damaged, and the VSWR is 1.49 when the antenna element 1# and element 2# are damaged. In the three cases, the VSWR can meet the requirement (VSWR < 1.5). The test shows that it's not enough to just depend on VSWR detection in the process of finding element problems.

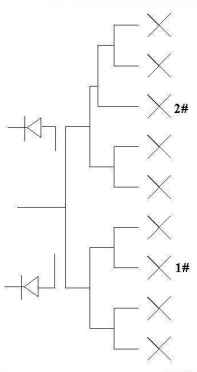

Figure 1: Vertical line array and feeding network of TD-SCDMA antenna.

Table 1: Test result of VSWR.

case	frequency band (GHz)	VSWR
the antenna elements are in working order	$1.88 \sim 2.025$	1.21
element 1# is damaged	$1.88 \sim 2.025$	1.26
element 1# and element 2# are damaged	$1.88 \sim 2.025$	1.49

2.2. The Influence of Damaged Element on Radiation Performance

The Influence of damaged element on radiation performance of broadcast beam is tested, and the results are shown in Fig. 2 and Fig. 3. The results showed that the E-plane pattern of broadcast beam changed obviously in two typical frequency points of F and A frequency band. The upper sidelobe level increase, the lower first null isn't filled, HPBW is unaltered, and front-to-rear ratio changed obviously; the H-plane pattern of broadcast beam changed obviously toward normal elements in two typical frequency points of F and A frequency band, HPBW became narrow obviously, the radiation level decreased more than 15 dB in 60-degree direction, and the pattern is significant different from the normal situation. The test results showed that the damaged element has great influence on radiation performance of broadcast beam, it is very necessary to detect the antenna element.

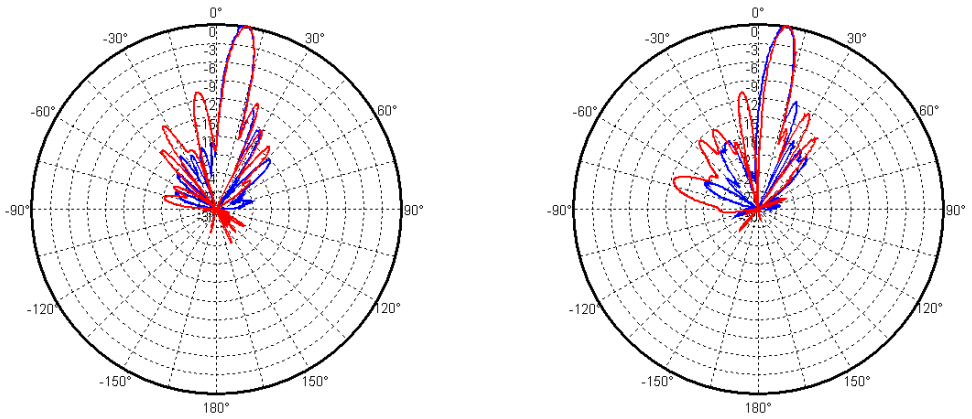

Figure 2: comparison on the E-plane pattern between normal situation and damaged situation of element 1#, 2# (blue line represent normal situation, red line represent damaged situation). (a) 1900 MHz. (b) 2018 MHz.

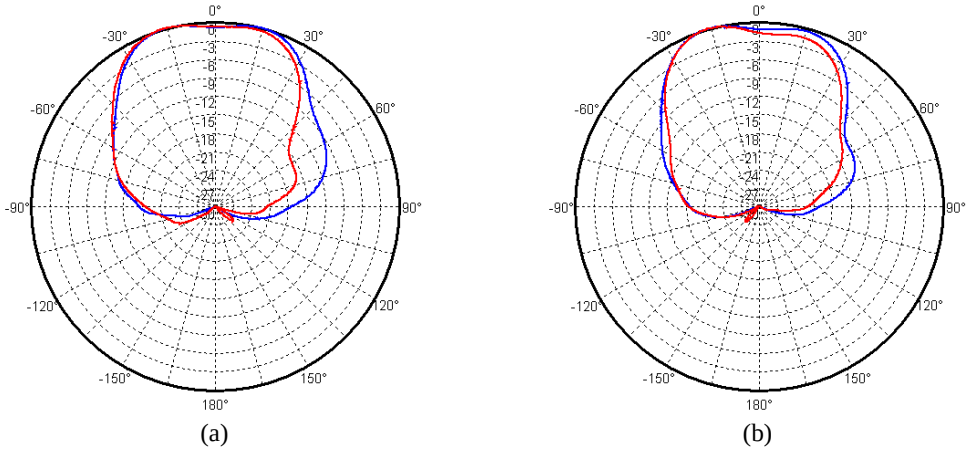

Figure 3: Comparison on the H-plane pattern between normal situation and damaged situation of element 1#, 2# (blue line represent normal situation, red line represent damaged situation). (a) 1900 MHz. (b) 2018 MHz.

3. DETECTION METHODS OF ANTENNA ELEMENT

3.1. Traditional Detection Methods of Antenna and Cable Systems

The failure of antenna and cable system occurs mainly on the antenna, cables and connectors. The detection of antenna and cable system is implemented by measuring the standing wave ratio (VSWR) or the value of return loss and isolation; we can determine the equipping quality and operation state from the detection results. The VSWR alarm of base station antenna is usually set to 1.5, and different types of base stations have different requirements on isolation between antennas.

There are mainly three types of instrument for antenna detection: spectrum analyzer, TDR, and Site Master. When the spectrum analyzer is used to detect the VSWR, the return loss is obtained after the test of the forward and reverse power, and the VSWR is obtained by checking the comparison table of return loss and VSWR; TDR can only roughly observe the waveform of antenna and cable system to determine the problem position; The VSWR and antenna isolation can be measured directly by Site Master, and the fault location is rapid.

3.2. Detection Methods of Antenna Element

Chapter 3.1 shows that the existing antenna detection technology just tests the VSWR and gives different levels of alarm signal, and thus cannot detect the abnormal situation of the internal element of the antenna array However, Chapter 2 of this paper shows that the antenna element testing is necessary; therefore this paper proposes an antenna element detection system, which was composed of electromagnetic induction sensor and detection circuit, this system can realize the detection of smart antenna element.

Figure 4 is a schematic diagram of the antenna element detection system The detection circuit has independent power supply (12 V), which is similar to the RCU (Remote control unit). The signal collected by the detection circuit is transmitted to the base station server by AISG cable [3]; the adapter is mainly used to implement the connection between RS485 and RS232 RS485 has a smaller transmission loss, and it is easy to realize long-distance signal transmission. RS232 interface can be easily connected with PC to facilitate the control of this system.

Based on the comparison of the coupling signal and the reference standard signal, you can achieve the detection of antenna element station.

As shown in Figure 5 the coupling signal acquisition process can be explained by an ordinary 2×8 dual-polarized planar array The antenna has 2 columns, each column has eight elements, and each element has two cross-feed ports to support dual-polarized mode, so that each column has four main ports. The primary port is divided into two sub-ports; the power of two sub-ports is further distributed to the four ports, and different polarization element of eight antenna element is feeded separately.

The coupled signal 1 represents sub-port of the left upper column, once one or some elements does not work the reflection coefficient of port 1 is inevitably abnormal, and the output RF signal of port A must change. The control unit indicates the working status of the element by checking the variation of the coupling signal of port 1 in a similar way, 8 channel signals of ports 1, 2, ..., 8 can be collected to detect the element status of the 16 antenna elements.

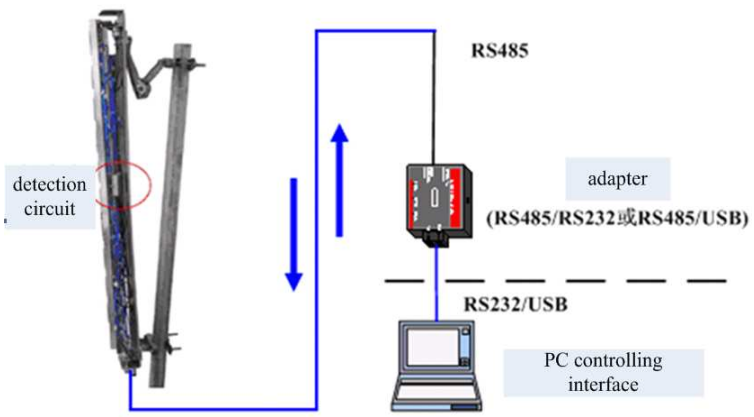

Figure 4: Antenna element detection system schematic.

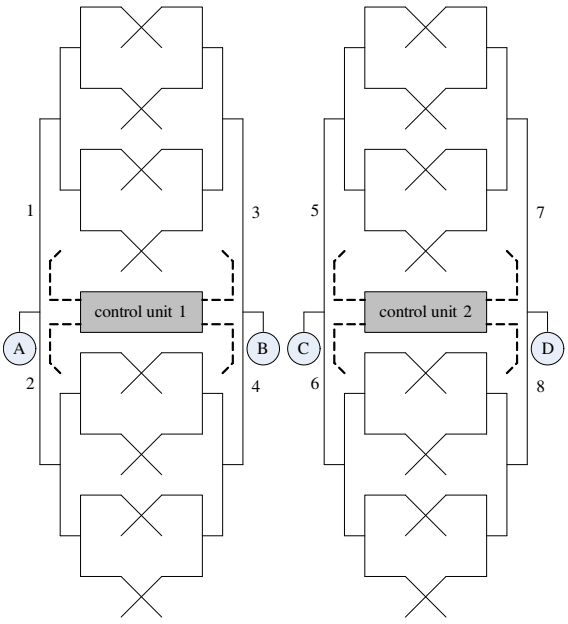

Figure 5: Collection of the coupling signal.

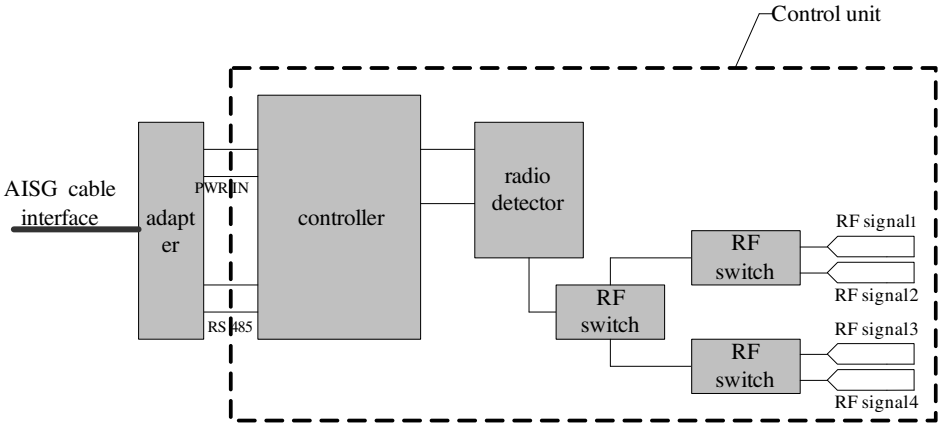

Figure 6: The principle block diagram of the detection circuit.

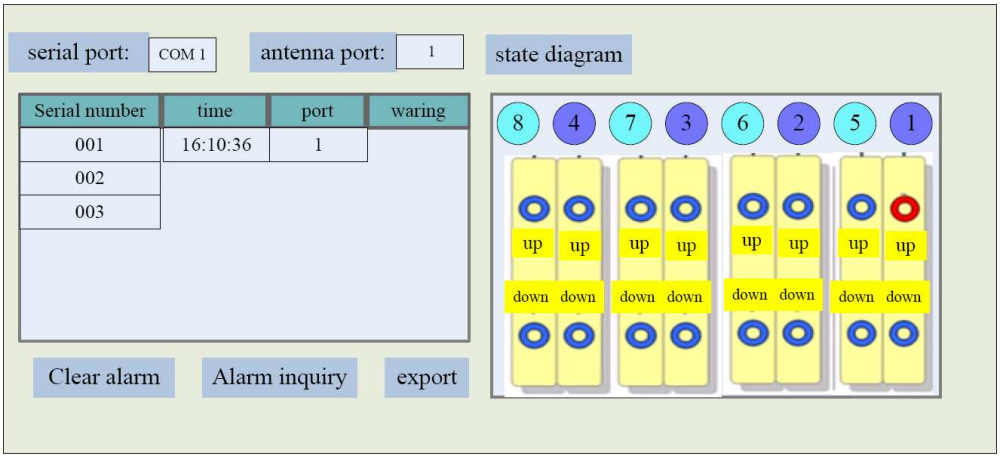

Figure 7: PC controlling interface.

Figure 6 shows the principle block diagram of the detection circuit, the four RF signals can be detected by the RF switch; the radio detector is used to convert radio frequency (RF) signal to the corresponding DC voltage. The DC voltage is converted to digital information by the A/D module

of the controller and then the antenna working condition can be obtained by comparing the digital information with the reference value.

The antenna working condition is monitored by PC controlling interface. Fig. 7 shows the interface of the antenna element condition, the blue light indicates that the elements are normal, and the red light indicates that the elements are failure.

4. SUMMARY

Array antenna has many elements, while some antenna elements don't work properly, the antenna will not often give out a warning of the VSWR. But the array pattern will be significantly affected at this moment. Therefore this paper proposes an antenna element detection system, and the next step is to improve the accuracy of antenna element detection system.

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