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Design of Wireless Node Based on AR9341

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Abstract

In the process of news interviews, the last mile of data transmission from the reporter terminal to the system collection center has been using wired transmission. It has poor mobility and weak scalability. According to this situation, a hardware design based on the AR9341 wireless node is proposed. It makes full use of the advantages of better wireless transmission scalability and more flexible mobility. Firstly, its RF module is discussed in detail, and signal quality is ensured by Impedance Matching and Differential Routing. Secondly, its memory module is described, and the transmission performance of the system is analyzed through the eye diagram of the DDR signal lines. Finally, the Spectrum, Constellation and error vector magnitude (EVM) are measured by the spectrum analyzer to test the quality of the wireless signal and verify the feasibility of the design.

Keywords: wireless LAN; Cadence; wireless node; Eye diagram

1. Introduction

News is an important way for us to obtain information from the outside world. Traditionally, the last mile of data transmission in the news interview relies on wired connections from reporter terminals to system collection centers. However, with the surge of global emergencies, the environment of news gathering has become complicated. The shortcomings of traditional wire connections are also increasing. Firstly, it has poor mobility. Cable is used as the main medium for wired transmission. You need to re-lay the cable if the interview environment changes, which is

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time-consuming and laborious. Secondly, the expansion is weak. If you add a new device, you need to re-route, when the port reserved by the original wiring is not enough. Finally, the transmission distance is closer. The traditional cable connection has a short distance , and it is not suitable for long-distance transmission. Compare with it, the mobility of wireless transmission more stronger. If the interview environment changes, the wireless node only needs to be moved. The scalability is better, and the number of devices allowed to be accessed by the wireless node is large. We can use relay to increase the number of wireless nodes. It can achieve the aim of long-distance transmission.

Considering these points, we present to use WLAN for data transmission, as shown in Fig.1-1. The performance of data transmission relies largely on the hardware design of the underlying wireless nodes, including crosstalk between signals, the distortion, etc. We therefore proposed the hardware design of the wireless node based on AR9341. In the end, the quality of the signal is analyzed by using the spectrograms and eye diagrams.

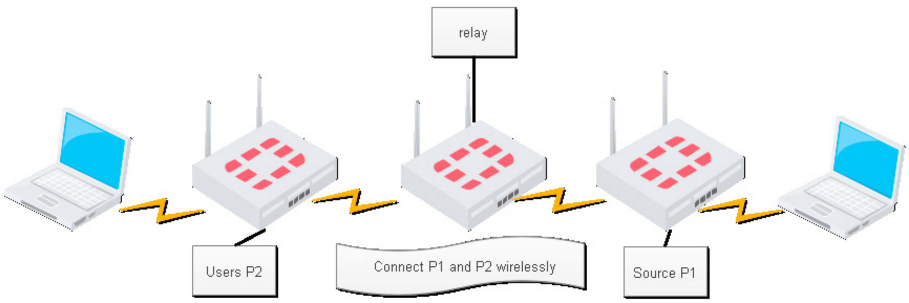

Figure. 1.Wireless transmission diagram

2.Schematic and PCB Design

The wireless node design includes CPU module, RF (antenna) module, and DDR memory module. The overall block diagram of the system is given in Fig.2[7]

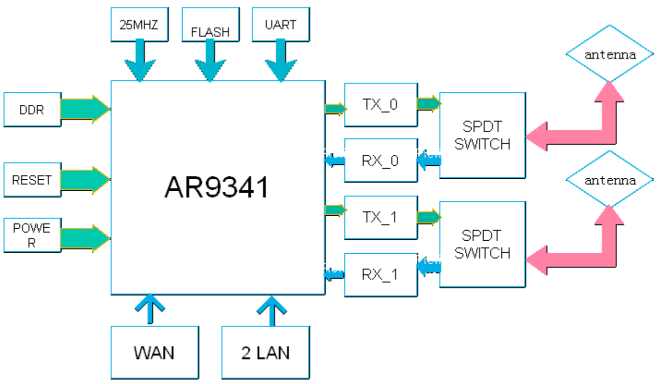

Figure. 2. System block diagram

2.1 CPU module

The design of the wireless node uses the Atheros' AR9341 as CPU. It was chosen because its uses the 802.11n wireless standard as well as 300MHz bandwidth, 2*2MIMO technology[8], 533MHz highest frequency and 25MHz external clock.

2.2 RF MODULE

Differential Traces and Impedance Matching are used in the RF module to keep the integrity of the signal by reducing the interference and loss between signals. The differential signal is a kind of signal with the same amplitude and opposite polarity. It has many advantages such as the strong Anti-interference ability, effectively suppress for the electromagnetic interference and accurate timing location. Impedance Matching is used in the circuit design of the Differential to Single-ended. Table 1 shows the parameter settings of the TOP layer. In this design, the Differential Impedance is 102.04ohm[1], and we can achieve the Differential Impedance we want by controlling the line width and line spacing.

Table 1. Impedance matching of top layer

Subclassname	Type	Thickness (MIL)	Dilelectric Constant	LOSS Tangent	WIDTH (MIL)	Impedance (ohm)	DIFFZ0 (ohm)
	SURFACE		1	0			
TOP	CONDUCTOR	1.4	3.66	0			
	DIELECTRIC	10	4.5	0.035	15	53.075	102.04

In this design, the wiring is in the form of Microstrip Line. The formula for calculating the Characteristic Impedance is[1]

$$Z_0 = \frac{87}{\sqrt{E_r + 1.41}} \ln\left[\frac{5.98H}{0.8W + T}\right] \tag{1}$$

Dielectric Constant E_r is 3.66, the thickness of the reference plane H is 10mil, the line width of the Microstrip Line W is 15mil, T is the trace thickness of 1.4 mil. the Characteristic Impedance is 53.075 ohm. Differential Impedance[3]

$$DIFFZ0 = 2 * Z_0 * (1 - K) = 102.04ohm \tag{2}$$

K is the Coupling Coefficient, Z_0 is the Characteristic Impedance.

2.3 DDR module

The DDR signal line includes address signals, data signals, control signals, and clock signals. DDR wiring has strict equal length requirements so that it can reduce interference between signals and ensure correct timing. Cadence's powerful constraint manager is very suitable for this design[1]. The difference routing is used in the wiring of the clock signal. The difference between the two differential routing is controlled at ±5mil. And the difference between the address signal and the clock signal line length is controlled at ±100mil. The difference between the data/control signal and the clock signal line length is controlled at ±50mil[1].

Eye diagram is one of the important ways to reflect the transmission performance of this system. As shown below, Fig. 2-4-1 and Fig.2-4-2 shows the eye diagram of the DDR control signal Sending end and Receiving end. The measurement data of the eye diagram (Table. 2-4-3 Sending end, Table. 2-4-4 Receiving end) includes Eye Cross Ratio, Q factor, etc[6]. The Eye Cross Ratio is generally required to be 50%[6]. The Q factor is the parameter which used to measure the eye signal to noise ratio,

$$Q_{factor} = \frac{P_{top} - P_{base}}{\sigma_1 + \sigma_2} \tag{3}$$

P_{base} is 0 level average, P_{top} is 1 level average, σ_1 is an effective value of 1 signal noise, σ_0 is an effective value of 0 signal noise. Generally, the Q factor of the sending end is not less than 12, and the Q factor of the receiving end is not less than 6.

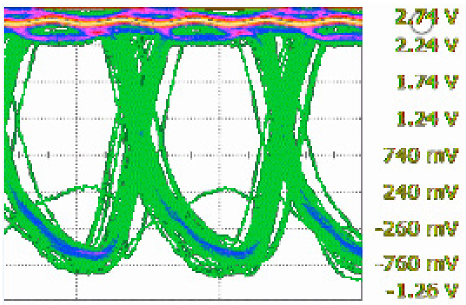

Figure. 3.Sending end.

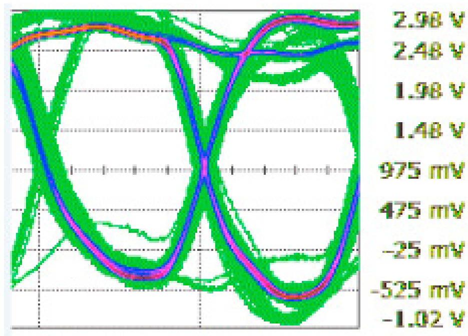

Figure. 4 .Receiving end.

Table 2.Sending end

Measurement	Curent	Mean	Min	Max	Range(Max-Min)	Std DeV
Crossing %	51.50%	67.50%	51.80%	99.00%	47.30%	27.30%
Dutcyc dist	887.67ps	887.67ps	887.67ps	887.67ps	0	0
Q-factor	17.4	12.66	4.68	17.11	12.43	6.93
Eye zero leve	-564mv	-418mv	-567mv	-124mv	443mv	255mv
Eye one leve	2.554V	2.512V	2.425V	2.555V	130mv	75mv
Eye width	3.39844ns	5.62500ns	234.38ps	15.03906ns	14.80469ns	6.47519ns

Table. 3. Receiving end

Measurement	Curent	Mean	Min	Max	Range(Max-Min)	Std DeV
Crossing %	56.70%	56.80%	56.70%	56.80%	0.07%	0.04%
Dutcyc dist	22%	22%	22%	22%	0	0
Q-factor	6.62	6.57	6.35	6.73	370m	190m
Eye zero leve	-288mv	-286mv	-289mv	-282mv	6mv	3mv
Eye one leve	2.613V	2.610V	2.605V	2.613V	8mv	4mv
Eye width	4.41406ns	8.39844ns	4.41406ns	14.53125ns	10.11719ns	5.43944ns

3.Experimental Results Show

By using the signal and spectrum analyzer, the spectrum of the wireless signal is shown in Figure 5.

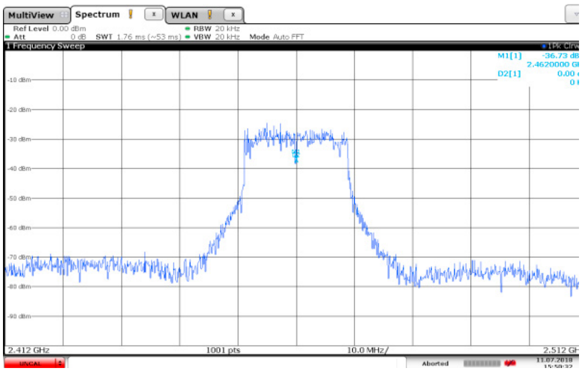

Figure. 5. Spectrum diagram

In addition, 802.11n has eight modulation modes. As shown in Table 3-2. Since the transmission speed of WIFI is affected by the modulation mode and coding rate[4], and the signal quality of WIFI is closely related to the transmission speed of WIFI. It is necessary to change the modulation mode in order to measure the signal quality. In the experimental test, we changed the modulation method by measuring the script file to measure the signal quality. The theoretical value of the Error Vector Magnitude(EVM) is shown in Table4. It is an important indicator of signal quality[2].

Table 4.802.11n modulation mode.

Spatial flow	MCS number	Modulation	Coding rate	EVM
1*1	0	BPSK	1/2	-5dB（56.2%）
	1	QPSK	1/2	-10dB（31.6%）
	2	QPSK	3/4	-13dB（22.4%）
	3	16-QAM	1/2	-16dB（15.8%）
	4	16-QAM	3/4	-19dB（11.2%）
	5	64-QAM	2/3	-22dB（7.94%）
	6	64-QAM	3/4	-25dB（5.62%）
	7	64-QAM	5/6	-27dB（4.47%）

The signal quality can be measured by comparing the EVM test value with the theoretical value. The parameter setting of the spectrum analyzer is shown in Table 5. In the experiment, the modulation Mode 4 (16-QAM, encoding rate of 3/4)[5] and modulation Mode 7 (64-QAM, encoding rate of 5/6)[5] are tested. And the Constellation Map as shown in Fig. 6 and Fig.7. The EVM values of the two modulation modes are shown in Table 5 and Table 6. The error between the test value and the theoretical value meets the design requirements.

Table5.Spectrum Analyzer Parameters.

Sample Rate Fs	40.0MHz	Standard	IEEE802.11n	Capt Time/Samples	5ms/200000
PPDU/MCS Index/GI	HT-MF20/4/S8	Meas Setup	1 Tx 1 Rx:Simultaneous	Data Symbols	1/10000

Table 6. EVM values (64—QAM, 5/6)

NO.of PPDUs-Recognized:21 Analyzed:21 Analyzed Physical Channel:21						
PPDUs:	Min	Mean	Limit	Max	Limit	Unit
Pilot Bit Error Rate	---	---	0.00	---	0.00	%
EVM All Carriers	2.43	2.72	4.47	2.99	4.47	%
	-32.28	-31.32	-27.00	-30.49	-27.00	dB
EVM Data Carriers	2.45	2.73	4.47	3.00	4.47	%
	-32.23	-31.27	-27.00	-30.45	-27.00	dB
EVM Pilot Carriers	2.13	2.52	56.23	2.94	56.23	%
	-33.44	-31.98	-5.00	-30.64	-5.00	dB
Center Freq Error	-32876.44	-32911.03	±61550.00	-32939.57	±61550.00	Hz
Symbol Clock Error	-11.00	-12.97	±25.00	-16.47	±25.00	ppm

Table 7. EVM values (16—QAM, 3/4)

NO.of PPDUs-Recognized:18 Analyzed:17 Analyzed Physical Channel:17						
PPDUs:	Min	Mean	Limit	Max	Limit	Unit
Pilot Bit Error Rate	---	---	0.00	---	0.00	%
EVM All Carriers	3.80	3.96	11.22	4.13	11.22	%
	-28.41	-28.05	-19.00	-27.69	-19.00	dB
EVM Data Carriers	3.82	3.99	11.22	4.13	11.22	%
	-28.35	-27.99	-19.00	-27.68	-19.00	dB
EVM Pilot Carriers	3.23	3.59	56.23	4.07	56.23	%
	-29.81	-28.89	-5.00	-27.82	-5.00	dB
Center Freq Error	-32578.32	-32595.88	±61550.00	-32607.66	±61550.00	Hz
Symbol Clock Error	-11.55	-13.06	±25.00	-14.39	±25.00	ppm

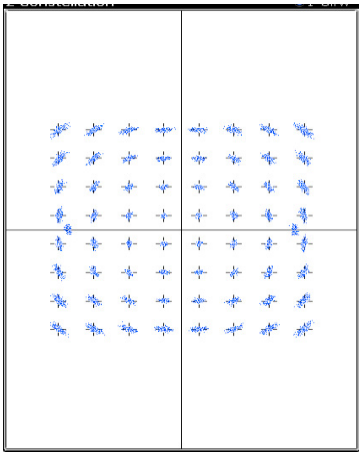

Figure. 6 .(64—QAM, 5/6)

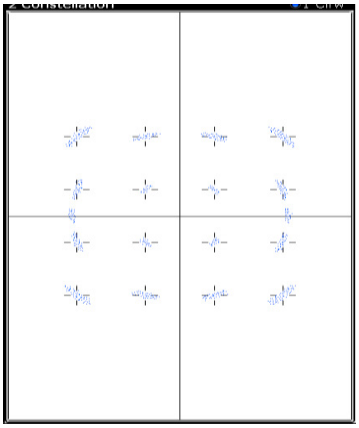

Figure. 7. (16—QAM, 3/4)

4.Conclucion

The purpose of this paper is to develop the underlying hardware design of the wireless node based on AR9341 so that it can solve the problem of poor scalability and weak mobility faced by the use of wired connections for news interview data transmission. Firstly，The composition of the underlying hardware modules is analyzed .Secondly, the technical specifications of each module are tested through the Spectrum Analyzer and Oscilloscope. Finally, the feasibility of the design was verified by the PCB board in practice. It is found that the last kilometer data transmission of news interview using WLAN has better expansibility and more flexible movement. It is visible to see that it has important practical significance for the data transmission of the last one kilometer news interview.

Acknowledgement

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