# Research on Anti-WiFi Noise Interference Technology for Display Driver IC

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## Abstract

***During high-speed signal transmission in the display system, serious identification errors occur due to Wi-Fi noise interference, resulting in subsequent decoding failures and affecting the normal display. In this paper, a CTLE circuit design method is proposed to reduce the high-frequency Wi-Fi noise while equalizing the amplitude difference of low-frequency and high-frequency transmission, and the experimental results show that the method is effective in optimizing the channel transmission. In addition, this paper proposes to optimize the signal transmission quality and improve the anti-interference ability of the system from three aspects, including improving ISI, adjusting the format of the data sent and optimizing configuration of system parameter.***

## Author Keywords

display system; Wi-Fi interference; denoising; low and high frequencies; EQ

## 1 Introduction

Display system involves a complex information transmission process, as shown in Figure 1, the relevant display data signal enters TX through the way of parallel concatenation, and is transmitted to RX by TX through differential data pairs after encoding. Before the receiving and recovering data, the inter-symbol crosstalk needs to be weakened by the EQ equalization amplifier first, and then carried out the subsequent decoding process, and finally output to the screen. In the CSPI transmission protocol, clock data is embedded in RGB data and transmitted together, thus CDR is required to recover and track the clock signal inside the system.

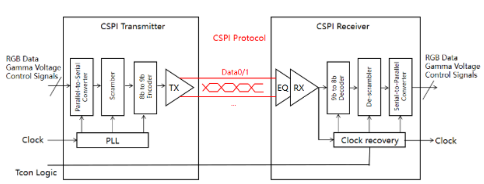


**Fig. 1.** Display system in CSPI transport protocol

When the signal changes from long 0 or long 1 to short 1 or short 0 during transmission, the changed potential cannot cross the level threshold due to transmission attenuation, resulting in an error in potential identification. At the same time, the attenuation of the high-frequency transmission signal will lead to a large ratio of eye width to eye height, a closed eye diagram and a large Jitter, so in order to obtain a clear eye diagram, it's necessary to balance the amplitude difference between low and high frequencies. There are two main methods, as shown in Figure 2, one is pre-emphasis, which balances the amplitude difference between low and high frequencies by compensating for high-frequency attenuation, the other is de-emphasis, which equalizes the amplitude difference by reducing the low-frequency amplitude, and their compensation positions and compensation objects are different.

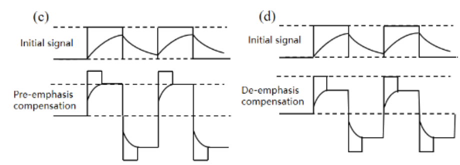


**Fig. 2.** (a) Pre-emphasis; (b) de-emphasis

## 2 Wi-Fi noise interference in the display system

Wi-Fi devices such as wireless routers and optical modems are indispensable devices in the home, but when such devices touch or are placed next to the display devices, they will interact with the display system. Taking the display system composed of UD 1G1D 120Hz TV and wireless router as an example, the TV contains the source driver chips inside, the signal sent by the wireless router will interfere with the use of TV, and in serious cases, there will be abnormal phenomenon of continuous flicker, as shown in Figure 3.


**Fig. 3.** Abnormal flickering display

Since in most cases, the wireless router is placed next to the vertical TV or under the hanging TV, so the interference of the Wi-Fi devices to the TV is unavoidable. As shown in Figure 4, observing the differential data transmission of the system when the high-frequency Wi-Fi interference noise is superimposed, it can be seen that the data waveform shows irregular changes. At the same time, the eye diagram can no longer be opened at all, the RX lose lock due to receiving errors and serious screen flicker abnormalities occur. Wi-Fi noise interference display is mainly because it affects the reception of data. The receiver of the system can only receive and identify the signal strength


ISSN 0097-996X/25/5601-0459-$1.00 © 2025

above a certain threshold, when the Wi-Fi noise interference is large, the system cannot distinguish the difference between data and noise, which will lead to the system reception errors and subsequent misjudgments. In the signal transmission, the interlock between TX and RX needs to be confirmed before the data can be sent normally, otherwise TX will send the training signal repeatedly, the screen will be flickering all the time.

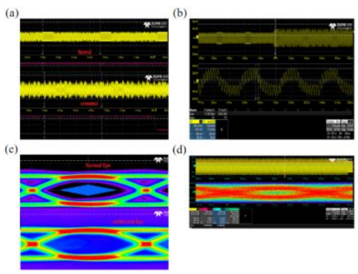

**Fig. 4.** (a) Data transmission waveform; (b) data transmission detail; (c) eye diagram; (d) eye diagram detail.

In order to avoid this, one of the methods is to increase the voltage difference between the DATAP and the DATAN, that is, to expand the Swing=$V_{id}$=$V_{datap}$-$V_{datan}$ in TX, and even if the transmission signal is lost in the case of interference, the value of $V_{ip}$-$V_{in}$ can still be correctly judged in the voltage comparator, so as to output the correct potential and improve the anti-interference ability of data.

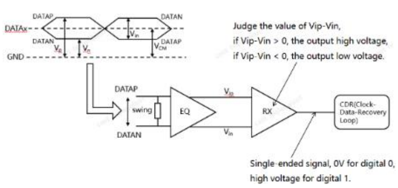


**Fig. 5.** Increase the differential amplitude to optimize data transmission

## 3 Experiment and discussions

### 3.1 Experimental results

Taking two SD ICs applied to UD 60Hz and UD 120Hz as examples to build the experimental platform separately, as shown in Figure 6, in order to maintain the consistency of input impedance, the PCB layout, TCON and PMIC models are consistent, and Wi-Fi interference emitted by the wireless router is added to the system.

When Wi-Fi noise interference is added to the two experimental systems, the results are as follows, the UD 60Hz screen is normal, while the UD 120Hz screen has abnormal flickering. The CT waveforms of the two systems are measured separately to further confirm the presence of Wi-Fi noise as shown in Figure 7. There is indeed Wi-Fi noise interference in the two systems and the CT waveforms are distorted to a certain extent, but the display screens show different results.

**Fig. 6.** Experimental platforms composed of panels for UD 60Hz and UD 120Hz, 1G1D Column, RGB

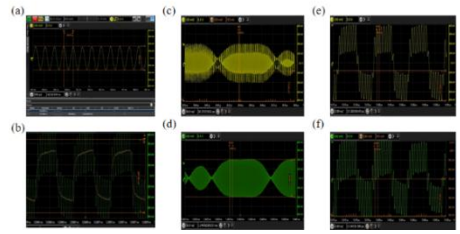

**Fig. 7.** (a) Normal transmission waveform; (b) 2.4G WiFi waveform; (c) CT waveform in UD 60Hz system; (d) CT waveform in UD 120Hz system; (e) waveform details in UD 60Hz system; (d) waveform details in UD 120Hz system

### 3.2 Experimental results analysis

The fundamental reason for the different display results in the same application environment is that the operating data rate of the two ICs are different. The operation rate range of SD $IC_1$ applied to UD 60Hz is 0.6-1.8Gbps, while the operating rate range of SD $IC_2$ applied to UD 120Hz is 1.2-3.0Gbps. Therefore, the Wi-Fi noise outside the operating range will not be amplified in the UD 60Hz application system, and the UD 120Hz application system will amplify the transmission signal and Wi-Fi noise of 2.4G at the same time, the latter receiver cannot use the amplitude difference to distinguish between data and noise, resulting in both being received.

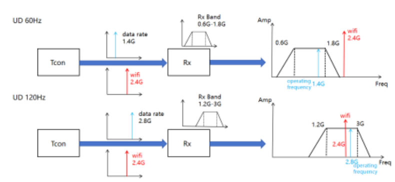


**Fig. 8.** The UD 60Hz and UD 120Hz systems display differences analysis

### 3.3 Experimental verification

In order to further verify the conjecture, 5G Wi-Fi noise is added to the original UD 120Hz system, and the rest of the conditions are kept unchanged. The relevant data and waveforms are also measured in Figure 9, and it was found that although the transmission data waveform is disturbed to a certain extent, the eye diagram is still open at this time and the screen is displayed normally. The above results show that the interference frequency band is strongly correlated with the RX receiving frequency band, and the Wi-Fi noise of the system can be further reduced by controlling the RX amplification band away from the Wi-Fi interference band or reducing the amplification gain value in the Wi-Fi interference band.

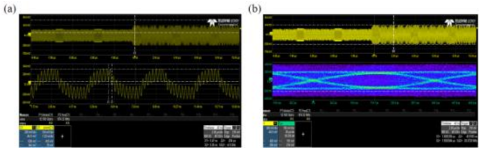


**Fig. 9.** (a) 5G Wi-Fi interference waveform; (b) disturbed eye diagram in UD 120Hz system

## 4 Anti-WiFi noise interference solutions

### 4.1 Increase the thicker physical shield

Generally, the EMC interference problem are solved from the three elements of EMC, namely the interference source, the interference path and the interfered source. From the perspective of interference path, a shielding layer can be added to the transmission path to shield more noise from entering the system and being amplified. For example, using a double-layer FPC or adding absorbers nearby prevents Wi-Fi noise from coupling to the system through transmission devices, such as PCBs, FFCs and FPCs, which can interfere with the operation of the SD IC and generate unexpected direct current (DC) voltages that can drive the output drift of the panel-driven buffer op amp (OPAMP), as shown in Figure 10.

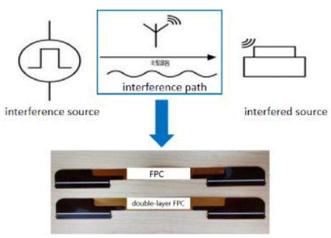


**Fig. 10.** Physical shield of a double-layer FPC

### 4.2 Improve the internal circuit design of the EQ

The main role in the EQ equalizer is the CTLE circuit. CTLE increases the channel capacity by increasing the bandwidth, which is essentially equivalent to a high-pass filter. From the perspective of circuit design, to obtain a high-pass filter, a negative feedback circuit with low-pass filter can be connected to the circuit. In the CTLE linear equalizer, the source degenerated CML structure design is often adopted, as shown in Figure 11.

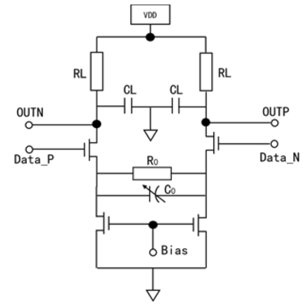


**Fig. 11.** Physical shield of a double-layer FPC

The circuit transfer function and the zero-pole formula are derived as follows:

$$H(s) = \frac{V_{out}(s)}{V_i(s)} = \frac{g_m}{C_L} * \frac{S + \frac{1}{R_0 C_0}}{S + \frac{1 + g_m R_0}{R_0 C_0}} * \frac{1}{S + \frac{1}{R_L C_L}}$$

$$wz(zero) = \frac{1}{R_0 C_0}$$

$$wp_1(pole1) = \frac{1 + g_m R_0}{R_0 C_0}$$

$$wp_2(pole2) = \frac{1}{R_L C_L}$$

$$DC\ gain = \frac{g_m R_L}{1 + g_m R_0}$$

In the CTLE design in this paper, the resistive load array and the capacitive load array are added to the original circuit respectively, as shown in Figure 12, where the values of the resistor array $R_A = \sum_{n=1}^{N} = 1/(R_n|Q_n)$, n=1,2,3,4, and the values of the capacitor array $C_A = \sum_{n=1}^{N} = (R_n|Q_{nn})$, n=1,2,3,4, $Q_n$ =1 and $Q_{nn}$ =1 represent the corresponding MOS tube closure, and the pole and DC gain of the converted circuit can be obtained as follows:

$$wp_2(pole2)' = \frac{1}{R_L//R_A + (C_L + C_A)}$$

$$DC\ gain' = \frac{g_m R_L//R_A}{1 + g_m R_0}$$

The increase of resistance and capacitive load array leads to the decrease of the effective output resistance and the increase of the effective output capacitance of the circuit. The gain waveform diagram before and after the circuit change are shown in Figure 14(a), from which it can be seen that the DC gain of the changed circuit decreases and the frequency of the second pole changes greatly. Select the appropriate resistor array and capacitor array values to add to the circuit, so that the pole close to the high-frequency Wi-Fi interference frequency band moves to the low frequency and suppress the amplification of Wi-Fi noise. At the same time, the gain at the zero low-frequency position is reduced, and the high-frequency compensation is achieved by reducing the amplitude of the low-frequency signal, so as to improve the anti-interference ability of the circuit. Finally, we carry out experimental verification of the new CTLE circuit design proposed in this paper, and the result is shown in Figure 13. In the same application environment (panel, PCB layout, TCON and PMIC models remain the same), the color bar is displayed in its entirety without flickering or blurring of boundaries, which shows that the method of pulling down the circuit pole design is indeed effective in resisting external Wi-Fi interference.

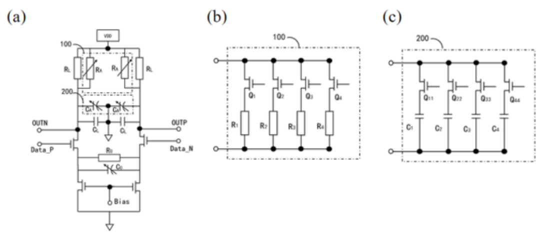


**Fig. 12.** CTLE circuit consisting of the improved CML structure

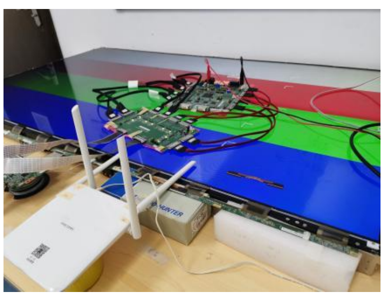

**Fig. 13.** Normal display in the new CTLE circuit design

In addition, in higher frequency display applications with that the amplification gain value cannot avoid the Wi-Fi noise band, and the circuit design method can be adopted to reduce the gain value near the interference frequency, as shown in Figure 14(b), that is, to change the zero point and first pole of the circuit. Or adopt the circuit design of multi-zero point and multi-pole point, so as to further amplify the amplitude difference between the interference noise and the received data, and use the threshold receiving property of the receiver to filter out the noise.

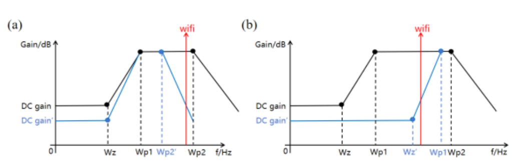


**Fig. 14.** The gain waveform in two different CTLE circuit designs

## 5 Optimize channel transmission quality

Wi-Fi noise often leads to abnormal screen display, which fundamentally interferes with the information transmission process and reduces the transmission quality of the system. To improve the channel transmission from the aspect of the interfered source, the system can be optimized from the following three aspects, such as optimizing the equalization technique to improve the ISI, reasonably adjusting the transmitted data and reasonably adjusting the RX EQ value.

In terms of ISI improvement, the use of three types of equalizers is involved, including FFE, CTLE, and DFE. The transmission quality can be greatly optimized by improving the design of three types of equalizers.

As for adjusting the format of the transmitted data, the TX can use a higher carrier frequency band to send data, so that the data can be sent at a higher rate away from the Wi-Fi interference band. Or TX sends more empty packets at the interference frequency band and the effective data is arranged to be sent in other frequency bands. Finally, the corresponding data reading mode and band-pass filter centered on the Wi-Fi interference frequency are designed to cooperate with the SD IC, so as filter out noise and improve the signal-to-noise ratio of the entire signal reception.

In addition, select the EQ gear in a near-small and far-large way on the X board, but at this time, if the specific transmission link length and path impedance matching degree are not referenced, the situation of insufficient EQ or over-compensation EQ will result, which may cause poor eye diagram and data decoding errors. In order to improve the signal reception and channel transmission quality, smart EQ and Auto EQ can also be used to optimize the rational configuration of system parameters.

## 6 Conclusion and prospects

To sum up, this paper proposes a novel CTLE circuit design, which aims to reduce the frequency of the second pole of the circuit to suppress Wi-Fi interference. Experimental results have shown that this method is effective and greatly improves the display quality. In addition, this paper focuses on reducing Wi-Fi noise interference and optimizing channel transmission quality inside the display system, and proposes solutions from the following aspects:

1) Optimize the internal circuit design. For low-speed display applications, noise interference can be suppressed by amplifying the bands away from Wi-Fi interference, and for high-speed display applications, interference can be suppressed by decreasing the gain value of the interference band.

2) Use physical shielding measures to prevent more interference from entering the system and being further amplified.

3) Optimize the equilibrium technique to improve the inter-symbol crosstalk.

4) Adjust the data transmission format to improve the anti-interference ability of the system.

5) Use smart EQ and Auto EQ to improve parameter rationalization and find the best EQ settings for the system.

In addition, it can also provide ideas for the overall optimization of the future display system from the aspects of optimizing the automatic swing design of the TX terminal, improving the impedance matching of the transmission link, and increasing the input voltage to improve the anti-interference ability of the circuit.

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