NXP PCF7991 - PEPS low frequency chip driven antenna

原创 JINCIEY Modified on 2025-03-06 09:39:43 Views: 916 Collection 19 Likes 14

Category: PEPS Article Tags: Embedded Hardware

1. Introduction

This article mainly introduces the configuration of NXP PCF7991 to drive the antenna, and introduces the process of MCU configuring PCF7991 to drive the antenna. Then the antenna driving current is detected by current clamp to verify that the MCU configures PCF7991 to drive the antenna successfully.

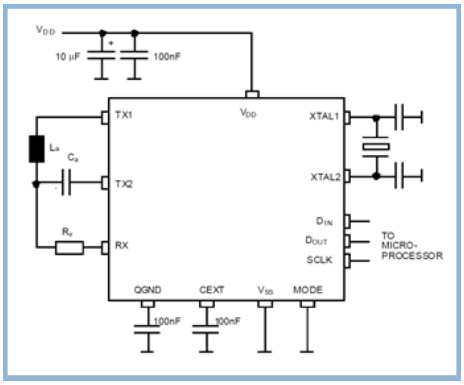
2. Basic Introduction

2.1 Overview

The PCF7991AT is a fully integrated Advanced Basestation IC (ABIC) designed for automotive engine immobilizer systems, providing read and write access to ID transponders. The device is designed to work with transponders operating at 125kHz and using ASK write and AM/PM read operations, and can be optimized according to system and transponder requirements for amplifier gain, filter cutoff frequency, etc.

The PCF7991AT is designed for easy integration into the read-write or read-only system of the engine immobilizer, featuring high integration and very few external components. The device integrates a powerful antenna driver/modulator, a low-noise adaptive sampling time demodulator, a programmable filter/amplifier and a digital converter, suitable for base stations that need to design high performance. The PCF7991AT can communicate bidirectionally with the transponder, and the three-wire interface can be configured as a two-wire interface operation by connecting DIN and DOUT.

2.2 Minimum application circuit



The figure shows the minimum application circuit of PCF7991AT. The antenna coil La and capacitor Ca form a series resonant LC circuit (f = 125kHz). The antenna voltage is attenuated by the input impedance of the RV and RX pins.

2.3 Antenna Driver

The antenna driver is a full-bridge antenna circuit that is capable of providing a square wave voltage to a serially resonant antenna, which is connected between TX1 and TX2. The full-bridge driver is characterized by low output impedance, which has a large driving voltage for the resonant antenna circuit. The standard carrier frequency of the antenna is 125KHz.

3. PCF7991 Antenna Detection

3.1 PCF7991AT Antenna Detection Overview

To detect a short or open circuit of the antenna, the chip monitors the input voltage on the receiver's RX-pin. Antenna failure is reported by the status bit ANTFAIL.

If the input voltage of the receiver does not exceed the diagnostic threshold level VDTH, the status bit ANTFAIL is set, otherwise it is cleared to 0. This status bit is updated once per antenna carrier cycle. And it can be read by GET_CONFIG_PAGE2 or GET_CONFIG_PAGE3 command. In power-down or suspend mode, during oscillator startup time, when the antenna driver is disabled, the status bit is undefined ANTFAIL.

Table 13 GET_CONFIG_PAGE mapping

BIT NO.	BIT NUMBER							
Command/Page NO.	7	6	5	4	3	2	1	0
GET_CONFIG_PAGE 0	N3	N2	N1	N0	D3	D2	D1	D0
GET_CONFIG_PAGE 1	N3	N2	N1	N0	D3	D2	D1	D0
GET_CONFIG_PAGE 2	0	0	AMPCOMP	ANTFAIL	D3	D2	D1	D0
GET_CONFIG_PAGE 3	0	0	AMPCOMP	ANTFAIL	D3	D2	D1	D0

Table 14 Status Bit description

BIT	NAME	DESCRIPTION
ANTFAIL	antenna failure 天线故障	see Section 8.5.6
AMPCOMP	amplitude comparison result 放大器比较结果	see Section 8.5.5

3.2 PCF7991AT Detects Antenna Fault Status

Detect antenna open circuit fault by sending GET_CONFIG_PAGE3 command to read the status bit ANTFAIL, and use a logic analyzer or oscilloscope to analyze the PCF7991 SCLK, DOUT, and DIN pin data.

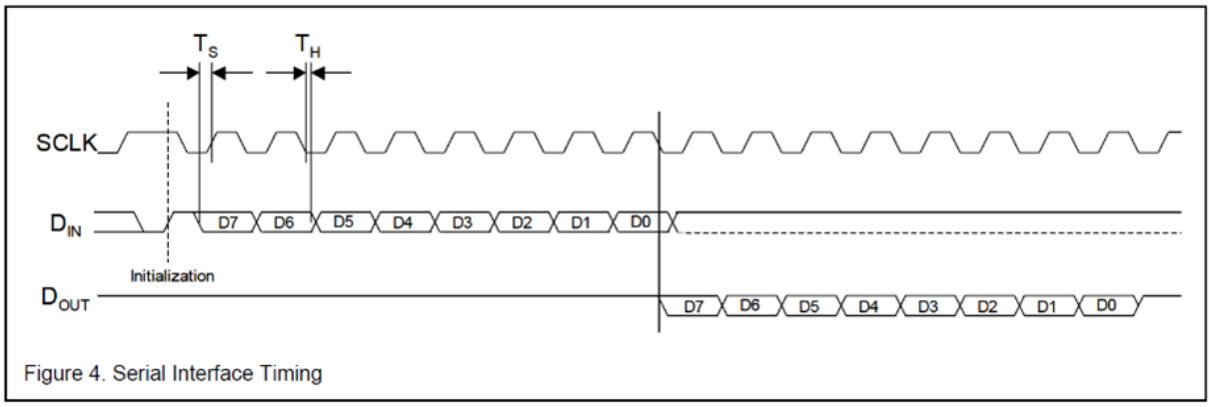
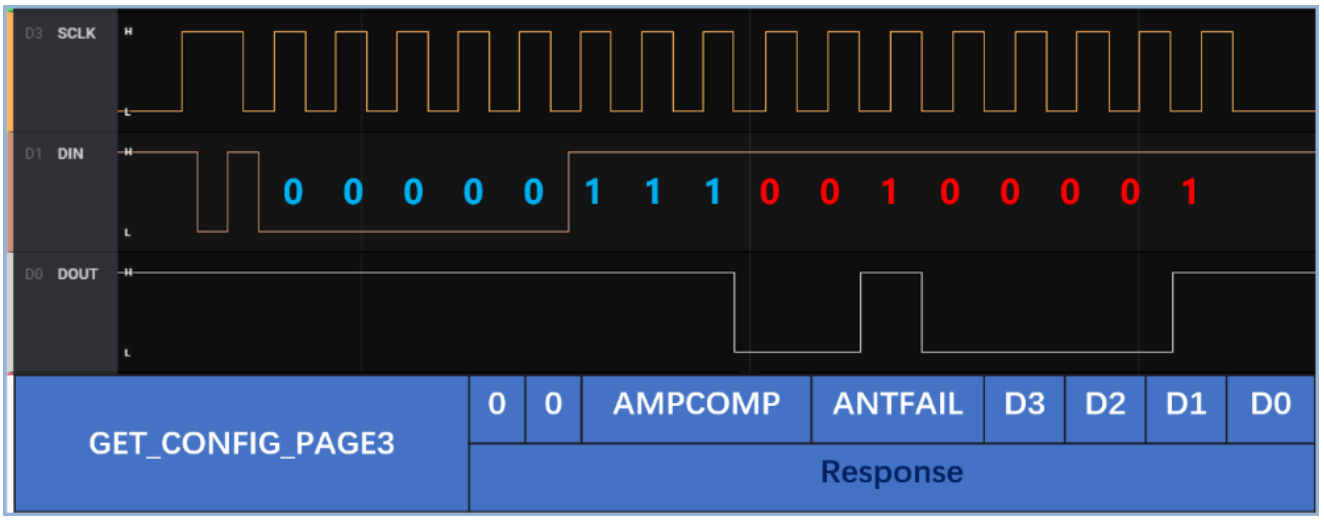


Figure 4. Serial Interface Timing

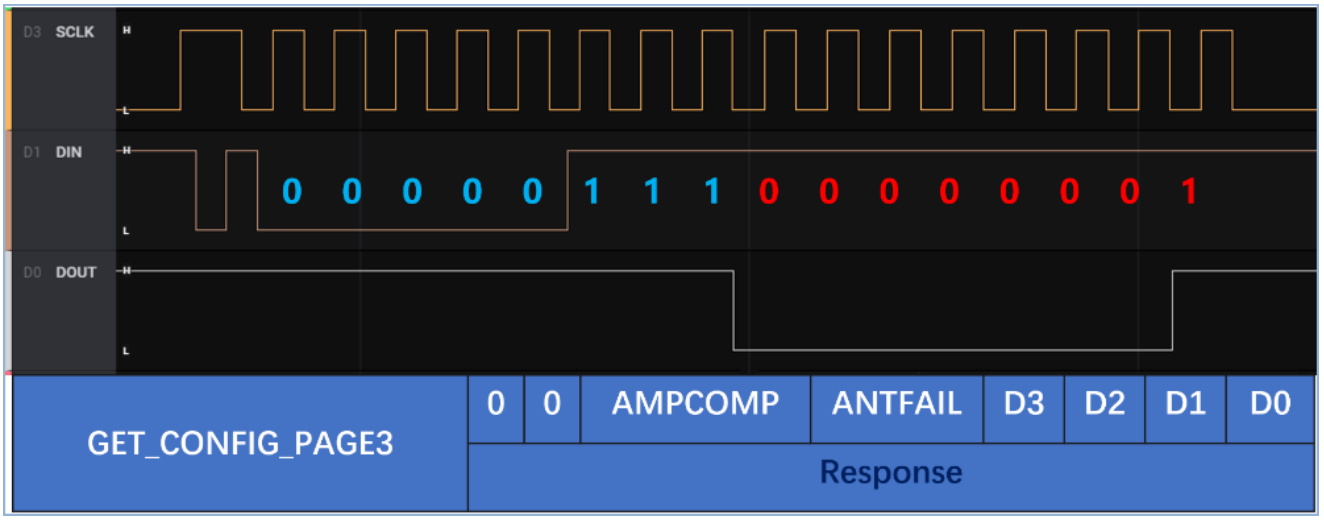
3.2.1 Reading the ANTFAIL status bit when the antenna is disconnected

Send the command SET_CONFIG_PAGE3 and capture the PCF7991 SCLK, DOUT, and DIN pin data through a logic analyzer. It can be seen that the status bit ANTFAIL read when the antenna is disconnected is set.



3.2.2 Reading the status bit ANTFAIL when the antenna is connected

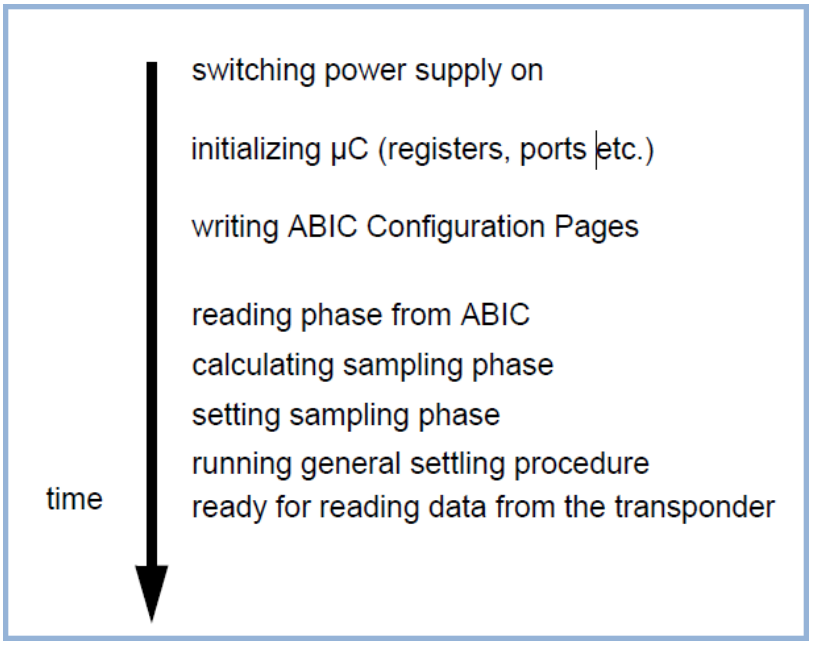
Send the command SET_CONFIG_PAGE3 and capture the PCF7991 SCLK, DOUT, and DIN pin data through a logic analyzer. It can be seen that after the antenna is connected, the status bit ANTFAIL is cleared when the antenna is disconnected.



4. PCF7991 configuration drive antenna process

4.1 Typical Power-On Sequence

Typical power-on sequence of a PCF7991 ABIC base station system. The time required to complete the power-on sequence depends on the parameters of system components such as the power supply, MCU, base station antenna, and transponder.



4.2 General Setting Procedure

After the clock is stable after power-on or power-off, the µC should execute the following sequence.

SET_CONFIG_PAGE 2, 1011b; THRESET=1, FREEZE1=1, FREEZE0=1

Delay of 5 ms to allow for accelerated filter and demodulator configuration.

SET_CONFIG_PAGE 2, 1000b; THRESET=1, FREEZE1=0. FREEZE0=0

The delay is 1 ms, waiting for the normal filter and demodulator to operate for one millisecond.

SET_CONFIG_PAGE 2, 0000; THRESET=0, FREEZE1=0 FREEZE0=0)

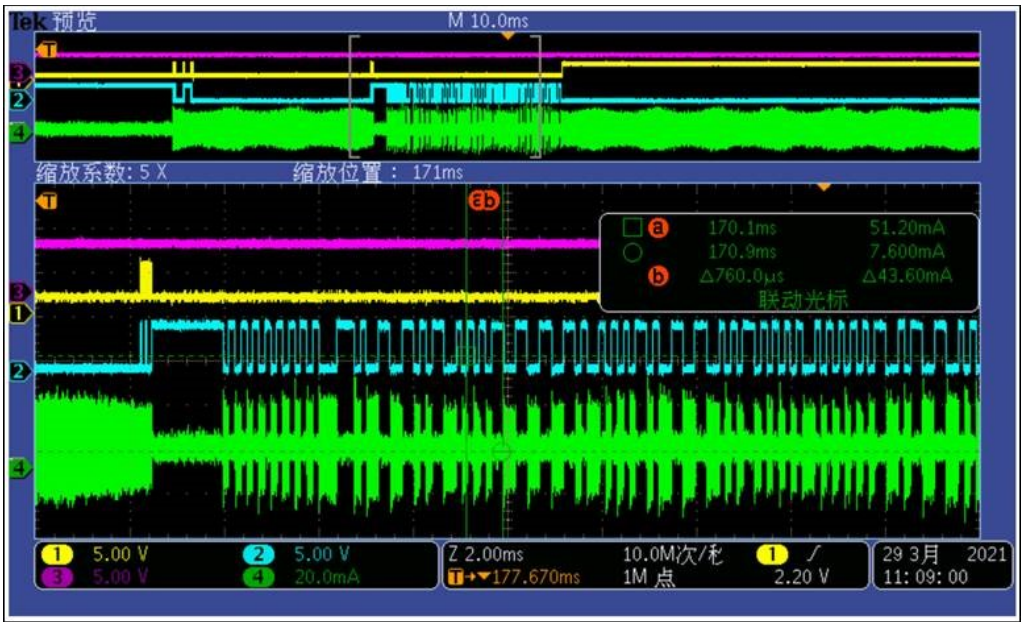
READ_TAG( );

Waiting for data and waiting for the threshold, filter, and demodulator to work properly. The given time is a safe basis for starting the system design.

4.3 WRITE_TAG_N Mode

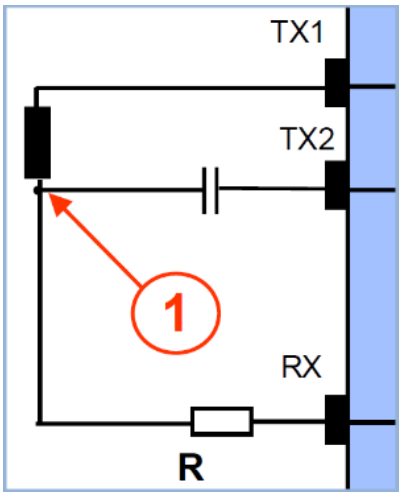
After the typical power-on sequence configuration, send the WRITE_TAG_N command to enter the WRITE_TAG_N mode. The high level on DIN is equivalent to the antenna driver being turned off, and the low level is equivalent to the antenna driver being turned on. If N3-N0 is set to 0, the signal on DIN will be switched to the driver similar to transparent transmission.

The figure below shows the current clamp collecting the current flowing through the antenna. The antenna has not been modified by the antenna hardware (tuning, adjusting the Q value). It can be seen that there is a subtle problem with the antenna current.

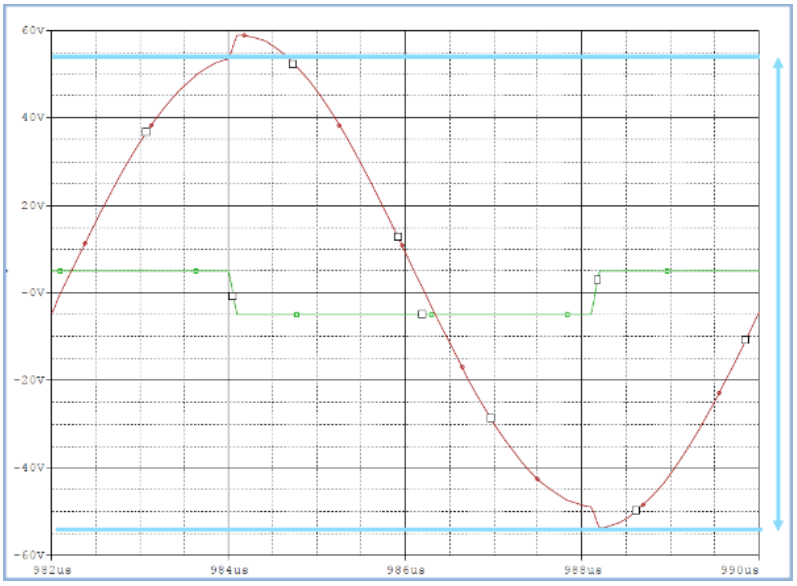


5. PCF7991 adjusts the resonant capacitor

5.1 Oscilloscope measurement ① Point voltage



The waveform should be as shown below. When these 5V sudden edges are at the maximum and minimum of the sine wave, the system is tuned. If not, the system can be adjusted by changing the resonant capacitor. Measure the peak voltage of the antenna. The antenna voltage amplitude Vant (peak value) is half of the measured voltage.



The quality factor Q of the antenna is calculated from the measured voltage, and the value of Q is preferably between 5 and 15.

$$Q = \frac{\hat{V}_{ant} \cdot \pi}{5V \cdot 4}$$

5.2 Tuning Overview

The figure below is the equivalent circuit of the driver and antenna. A vector network analyzer can be used to analyze the impedance of the antenna. The purpose of tuning is to match the impedance of the antenna with that of the driver. This is done by adjusting the capacitance of the tuning capacitor to eliminate the imaginary part of the impedance. The stability of capacitors made of different materials is also different. Try to use capacitors that are not easily affected by temperature to ensure the stability of the circuit.

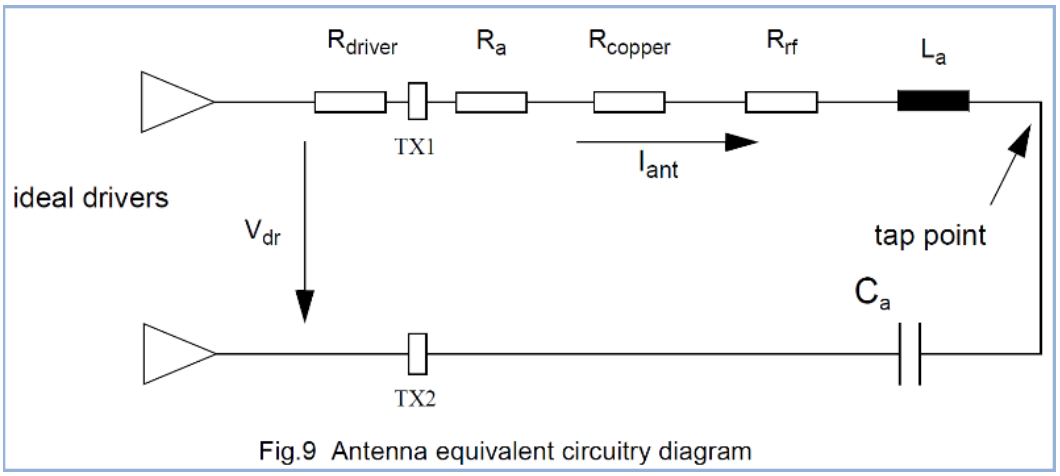
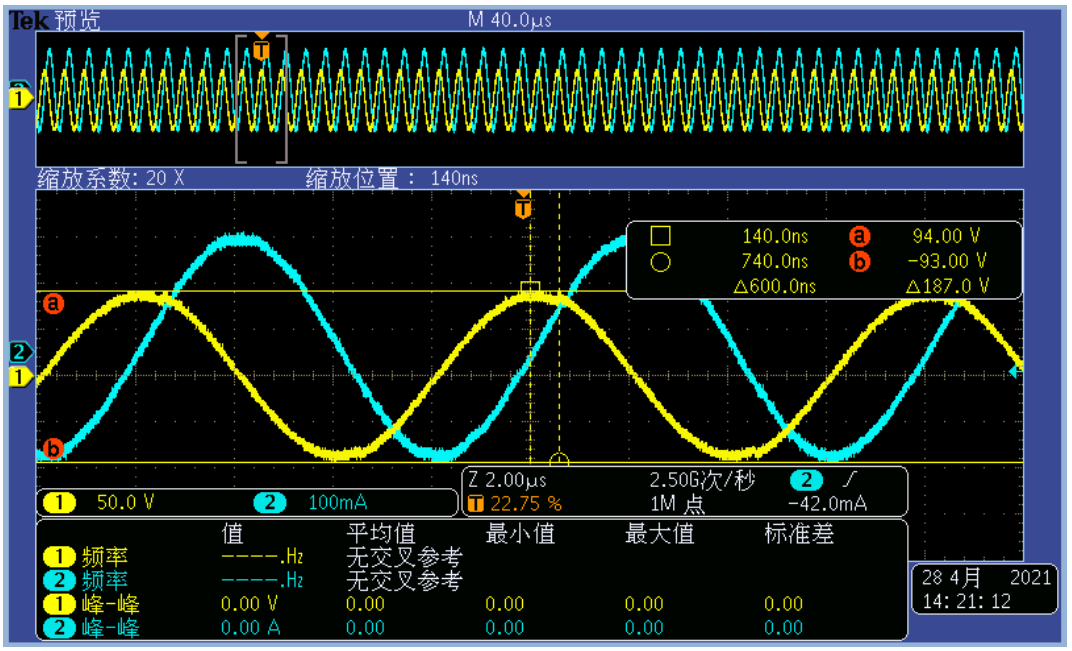


Fig.9 Antenna equivalent circuitry diagram

The instrument shown in the figure below is a vector network analyzer

5.3 Comparison before and after tuning

By changing the resonant capacitor to adjust the system, the figure below shows the voltage and antenna current at point ① before tuning. The 5V mutation edge is on the right side of the peak.



After adjusting the system by changing the resonant capacitor, the voltage and antenna current at point ① and the 5V mutation edge are at the peak value.