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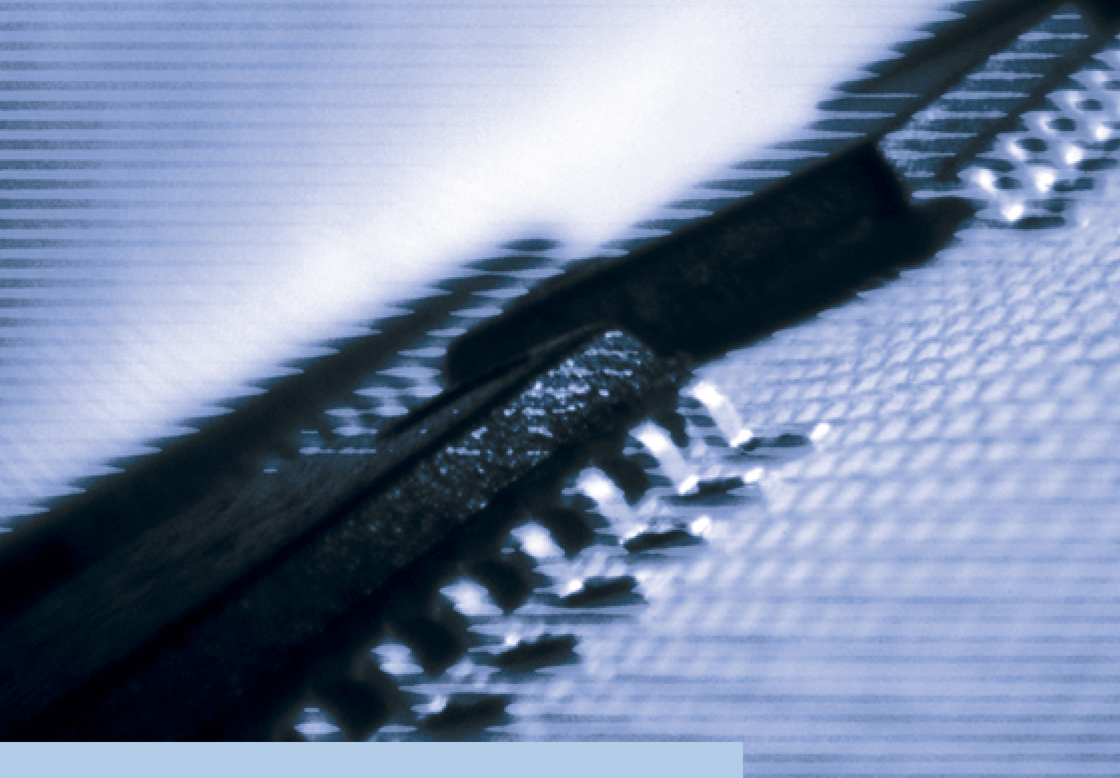
Application Note TDx510x

Loop-Antenna-Design-Recommendation

Version 1.0



Wireless Communication

Never stop thinking.

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Revision History:	**2004-01-28**	V 1.0
Previous Version:	none	

Page	Subjects (major changes since last revision)

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1.1 Introduction

The TDx510x are single chip ASK/FSK transmitters for the frequency bands at 315MHz, 434MHz, 868MHz and 915MHz. The ICs offer a high level of integration and only need a few external components. A special circuit design is used to save current consumption thus extending battery life. The devices contain a fully integrated PLL synthesizer and a high efficiency power amplifier to drive a loop antenna. A typical loop antenna design is shown below (Figure 1):

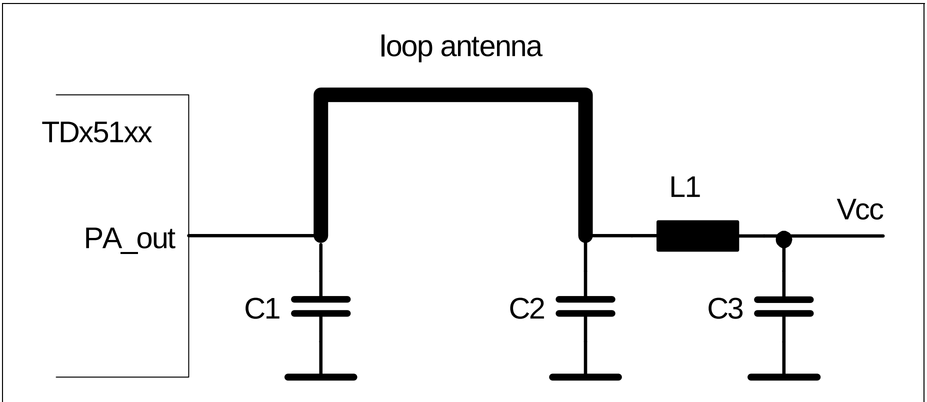

Figure 1 Typical loop antenna design

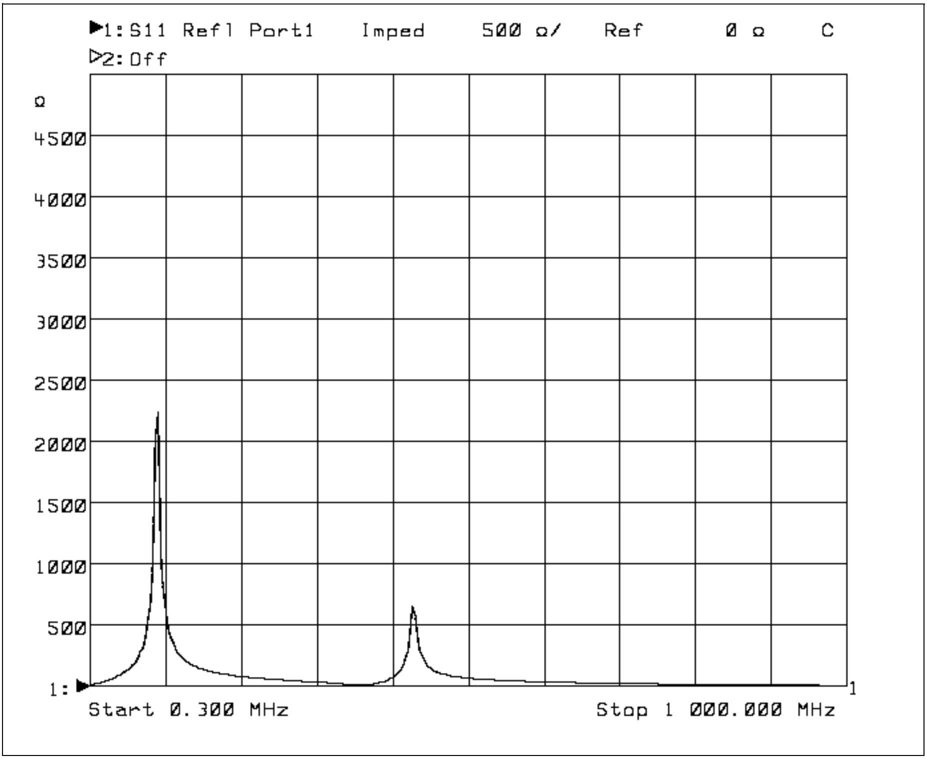

Figure 2 Frequency response at PA-out

The measured frequency response in terms of magnitude of the impedance at node PA_out is shown in graph 2 (Figure 2).

There are two high impedance resonances. The right one is desired and occurs at the operating frequency 434MHz with an impedance of about 650Ohm. The left one is not desired and is at around 90MHz with an impedance of about 2200Ohm. This unwanted resonant frequency results from tank circuits within the matching and supply network of the application and has to be suppressed.

Note that the power amplifier is operating in Class C-mode. (For further details see “TDA5100, Application Note, Version 1.2, March 2000”, chapter 4.1 Antenna). In Class C-mode, the PA produces narrow current pulses at its output in such a way that the start-up transients of such pulses cause oscillations at both resonant frequencies. The effect is sustained by the non-linear behavior of the class C amplifier operating (as specified) in overcritical mode. Another prerequisite of such an effect is a high Q-factor of the parasitic tank-circuit.

Oscillation at the undesired resonance frequency is most likely at following conditions:

-high impedance at operating frequency

-high impedance at undesired resonance

-low temperature of the IC

-supply-voltage = 2.4 V

The result would be spurious radiation.

1.2 Testing of existing applications

The application has to be tested at the lowest specified temperature of the IC in a climatic chamber at a supply voltage of 2.4 V. An external power-supply has to be used. Ferrite-beads have to be used in series to VCC and GND-leads directly at the application board for RF-decoupling. Since no battery is present during this test it has to be substituted by 10nF in series to 2.7 Ohms. This network is an RF-model of a lithium coin cell.

In mass-production the resonant frequency of the antenna-matching will vary due to tolerances of the components in the antenna-matching circuit. This results in a different magnitude of impedance at the operating frequency. The worst case for parasitic oscillation is at the maximum magnitude of impedance at the operating frequency. Since it is hard to tune the resonant frequency of the antenna matching in a climatic chamber, the output frequency of the transmitter has to be varied around the nominal transmit frequency in order to ensure that the maximum magnitude of the impedance of the antenna matching is tested. This is most easily done by forcing the crystal oscillator with an external signal generator using an RC network. This network and the complete test-setup are summarized in graph 3. The capacitor is used for DC-decoupling. The resistors are used for generation of a high impedance current source and for RF-decoupling of the connecting leads.

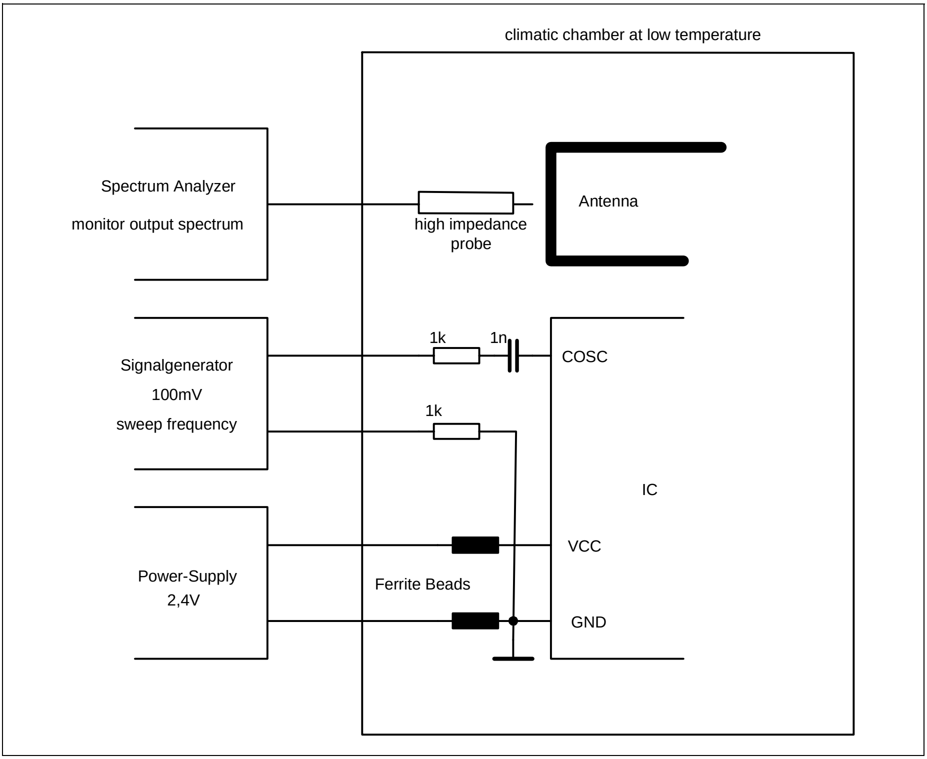

Figure 3 Test setup

During variation of the output frequency of the signal generator the output spectrum of the transmitter is monitored using a high-impedance-spectrum-analyzer-probe placed close to the antenna. If no spurious emissions occur at the parasitic resonance, the design is OK. If there are some spurious emissions at the parasitic resonance, a redesign is necessary.

<u>Tolerances of components:</u>

In order to avoid spurious radiations at unwanted frequencies designers have to verify that their design will always work in mass production. Tolerances of C1, C2, L1 and the PCB cause variations of the resonant frequency, resulting in changes of magnitude of impedance at the operating frequency. Therefore a single verification-board should be prepared with worst case component values which results in the highest possible magnitude of impedance. This is realized by using minimum values for C1 and maximum values for C2 and L1. An LCR-Meter is a useful tool for determination of the exact component values imparted on the board. L1 can be increased by soldering another small inductance in series. C2 can be increased by soldering another small capacitor in parallel. Since it is hard to decrease the capacitance of C1, C2 can be increased instead which also results in an even further increased magnitude of impedance.

Example:

The nominal value of L1 is 100nH +/-2nH. The measurement of L1 of the verification-board yields a value of 99,3nH. So an inductor of 2,7nH has to be soldered in series to L1 in order to get an inductance of 102nH, which is the maximum value of L1 in mass production. This should be done for all other components.

The test above has to be repeated with this worst-case-PCB.

1.3 Solution

In order to avoid spurious radiations at unwanted frequencies designers have to look for both wanted and unwanted resonant impedances when designing a matching network. Lowering both impedances results in a more stable design.

Graph 4 shows the loop antenna design from above with a resistor added in series to L1, which damps the unwanted resonance:

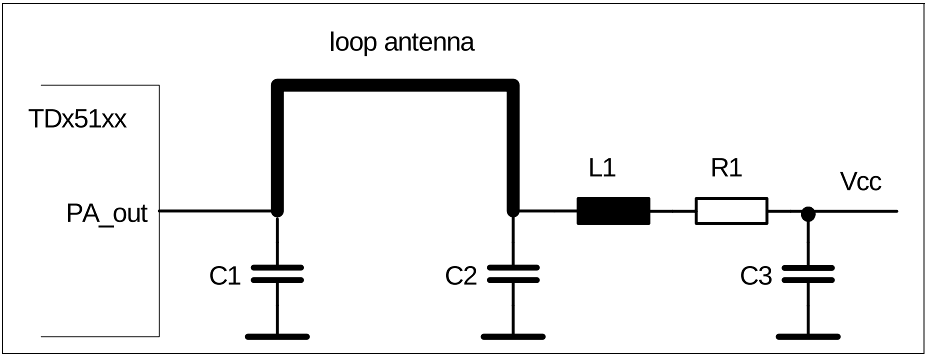

Figure 4 Example of an improved layout

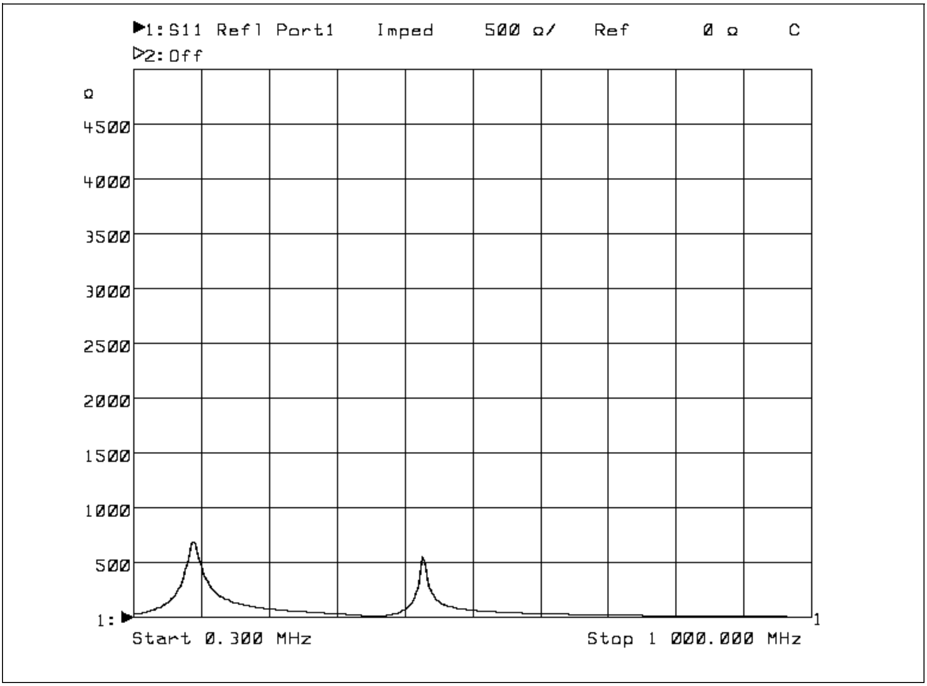

Figure 5 Damped unwanted resonance

The improved design results in a desired resonance at 434 MHz with an impedance of 550Ohm and in an unwanted (but damped) resonance at 90Mhz with an impedance of 700Ohm. Graph 6 shows the point (x=650Ohm, y=2200Ohm) for the original layout (without resistor) and the point (x=550Ohm, y=700Ohm) for the improved design (with series resistor).

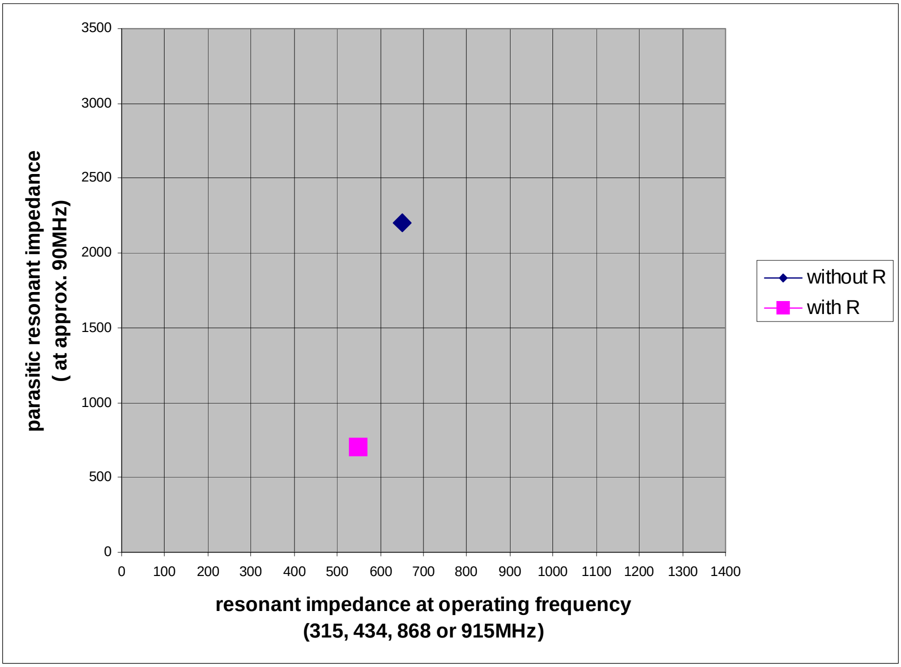

Figure 6 parasitic resonant impedance over resonant impedance at operating frequency

However, the impedance at the operating frequency should not go below 500Ohm in mass production in order to operate the PA in overcritical Class C-mode which results in low tolerances of the delivered output power of the IC itself.

The above described procedure is mandatory after implementation of any redesign.

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