nRF24AP1 RF Coupling Effect Reduction Guidelines

ABSTRACT

Poor RF coupling of the nRF24AP1 can reduce or possibly terminate its RF functionality. To minimize this coupling effect, keep the serial lines short and place a series RF block inductor close to the TXD/SOUT pin.

TABLE OF CONTENTS

1 Introduction

PCB layout and application environment of the nRF24AP1 Single Chip 2.4GHz RF Transceiver can impact its RF functionality. When the output power is optimized on an nRF24AP1 design, it is possible to couple 2.4GHz radio signals back into the transmit serial line of the nRF24AP1 causing small shifts in the carrier frequency. The magnitude of the carrier frequency shifts are environment specific and small shifts may not be noticeable by the user. Small changes in the environment can cause the carrier shift to increase and the demodulation of the message to fail. This document describes the recognition and prevention guidelines of this coupling effect.

2 Recognition of the Problem

Typically, this problem occurs on devices that have been highly optimized for output power. A typical symptom of the problem is the output power of the antenna is more than adequate to establish a link but a connection is not possible at any range or the message error rate is unusually high. However, by reducing the RF power, a link would be established and/or the message error rate would drop.

3 Quantifying the Problem

Small shifts in the carrier frequency can be monitored using a Vector Spectrum Analyzer that demodulates FSK signaling.

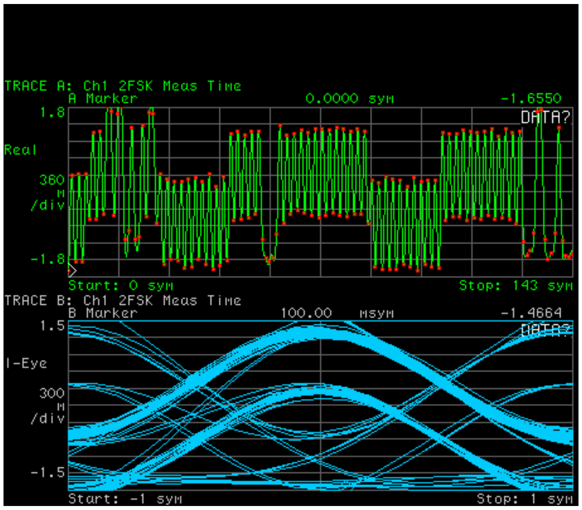

Figure 1: Top - Demodulated Magnitude vs. Time, Bottom - Demodulated Eye Diagram

Figure 1 shows the demodulated message of an asynchronous nRF24AP1 device exhibiting an excessive amount of RF coupling effect using an HP 89441A Vector Spectrum Analyzer. The serial message baud rate of the device is 50000, and the frequency shift correlates directly to the serial message transitions. The figure shows that there are distinct shifts in the carrier when the TXD line is high or low as apposed to the VCO drifting over time due to the PLL being released.

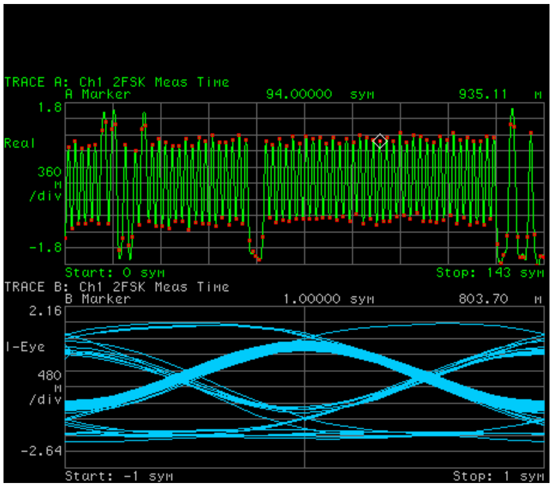

Figure 2: Top - Demodulated Magnitude vs. Time, Bottom - Demodulated Eye Diagram

Figure 2 shows an nRF24AP1 device that does not exhibit the RF coupling effect.

During GFSK demodulation, the receiver will choose a threshold point to decide if a bit should be a 1 or 0. When the magnitude of the frequency shift approaches the magnitude of the bit threshold, the bits cannot be decoded correctly and the demodulation breaks down. The following sections deal with guidelines that can be used to help prevent the coupling effect.

4 Serial Line Layout Guidelines

In addition to following the recommended RF layout guidelines provided by Nordic Semiconductor, it is recommended that the serial lines be kept as short as possible between the nRF24AP1 and its host controller. This is to prevent RF coupling into the nRF24AP1.

5 Using a TXD/SOUT RF Block

A series inductor can be used as a RF block on the TXD/SOUT line to prevent RF from coupling back into the nRF24AP1. It should be placed as close as possible to the TXD/SOUT pin. For convenience, the same value of inductor that is used as a RF block in the match between the VDD_PA pin and ANT1/ANT2 can be used.

6 Reduction of RF Power

Limiting the output power can reduce or eliminate the coupling effect. If the problem has already presented itself and range is not an issue, a possible solution is to reduce the RF power output of the nRF24AP1 through software or by detuning the antenna match.

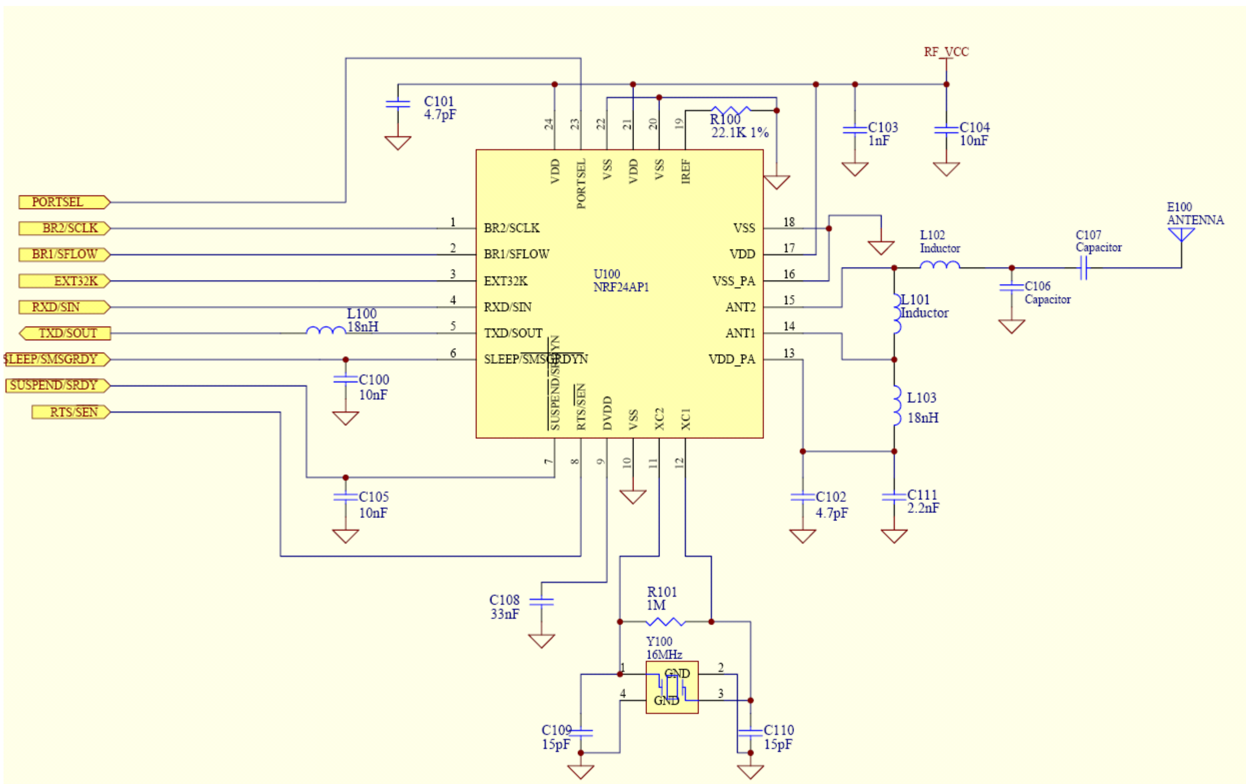

Figure 3: nRF24AP1 schematic for nRFAP1 Layout

Component	Description	Value	Tolerance	Footprint
R101	Resistor	1M	±1%	0402
C103	Capacitor	1nF	±10%	0402
C111	Capacitor	2.2nF	±5%	0402
C107	Capacitor	Tuning Capacitor		0402
C102	Capacitor	4.7pF	±0.25pF	0402
C101	Capacitor	4.7pF	±0.25pF	0402
L101	Inductor	Tuning Inductor		0402
L102	Inductor	Tuning Inductor		0402
C100	Capacitor	10nF	±5%	0402
C104	Capacitor	10nF	±5%	0402
C105	Capacitor	10nF	±5%	0402
C109	Capacitor	15pF	±5%	0402
C110	Capacitor	15pF	±5%	0402
Y100	Crystal CL = 9pF	16MHz	±50ppm	4.0x2.5
L100	Inductor	18nH	±5%	0402
L103	Inductor	18nH	±5%	0402
R100	Resistor	22.1K	±1%	0402
C108	Capacitor	33nF	±10%	0402
E100	Antenna	ANTENNA	NA	ANTENNA
C106	Capacitor	Tuning Capacitor		0402
U100	nRFAP1	NRF24AP1	NA	QFN24/5x5

Table 1: nRF24AP1 Design Component Values