Keywords: RF immunity, RF rejection, RF distortion

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APPLICATION NOTE 3950

A Measurement Technique for Determining RF Immunity

Abstract: The ubiquity of GSM cell phones has contributed to the steady rise in unwanted RF signals, causing electronic circuits to give distorted results unless they possess adequate RF noise-rejection capabilities. Consequently, RF-immunity testing has become imperative for ensuring the satisfactory operation of electronic circuits.

Introduction

Most of today's cell phones utilize the time-division multiple access (TDMA) standard, a multiplexing scheme that modulates the high-frequency carrier by pulsing it off and on at a rate of 217Hz. An RF-susceptible IC can then demodulate that carrier and reproduce the 217Hz signal and its harmonic frequencies. Because most of those frequencies fall within the audio band, they generate an unwanted audible buzz. Thus, a circuit with poor RF immunity can demodulate the cell phone's RF frequency and produce unwanted low-frequency audio. As a quality-assurance measure, testing should subject the circuit to an RF environment comparable to the one it will encounter during normal operation.

This article describes a general technique for measuring the RF noise-rejection capability of an integrated circuit board. RF-immunity testing subjects the board to controlled levels of RF, representing the stress likely to be encountered during its operation. The result is a standard, structured test methodology that establishes repeatable results useful in qualitative analysis. Such test results aid in the selection of ICs and circuits most resistant to RF noise.

RF susceptibility can be tested by placing the device-under-test (DUT) near an operating cell phone. However, for accurate and repeatable test results, DUTs must be tested with a consistent method and with a repeatable RF field. The solution is an RF anechoic test chamber, which produces accurately controlled RF fields comparable to those generated by a typical mobile phone.

RF-Immunity Test Setup

The following discussion compares the results of RF-immunity testing on the MAX4232 dual operational amplifiers (op amps) and a competitive part (Competitor X). The RF-immunity test circuit (**Figure 1**) shows circuit-board connections to the dual op amp under test. Each op amp is configured as an AC amplifier. With no AC signal input, the outputs sit at 1.5VDC (for V_{CC} = 3V). The inverting input is shorted to ground using a 1.5" loop of wire to emulate a PC trace at the input. This loop simulates the effect of an actual trace, which can act as an antenna at the working frequency, collecting and demodulating the RF signal. RF-noise immunity for the op amp is measured and quantified by connecting a dBV meter at its output.

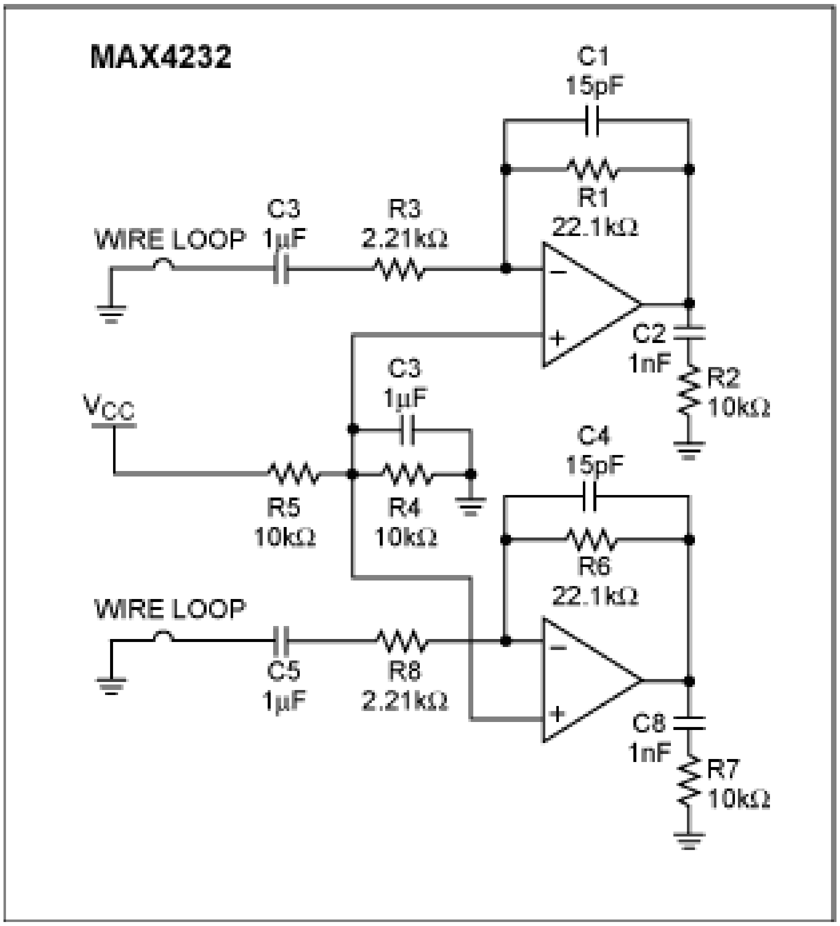

Figure 1. Test-circuit connections for RF noise-immunity testing of the MAX4232 dual op amp.

Maxim's RF test setup (**Figure 2**) generates the RF field necessary for RF-immunity testing. The anechoic test chamber has a shielded body similar to that of a Faraday cage, with access ports for connecting supply voltages and output monitors. The test setup is formed by concatenating the following equipment:

- Signal generator: 9kHz to 3.3GHz (Rhode & Schwarz SML-03)
- RF power amplifier: 800MHz to 1GHz, 20W (OPHIR 5124)
- Power meter: 25MHz to 1GHz (Rhode & Schwarz)
- Parallel-wired cell (anechoic chamber)
- Electric field sensor
- Computer (PC)
- dBV meter

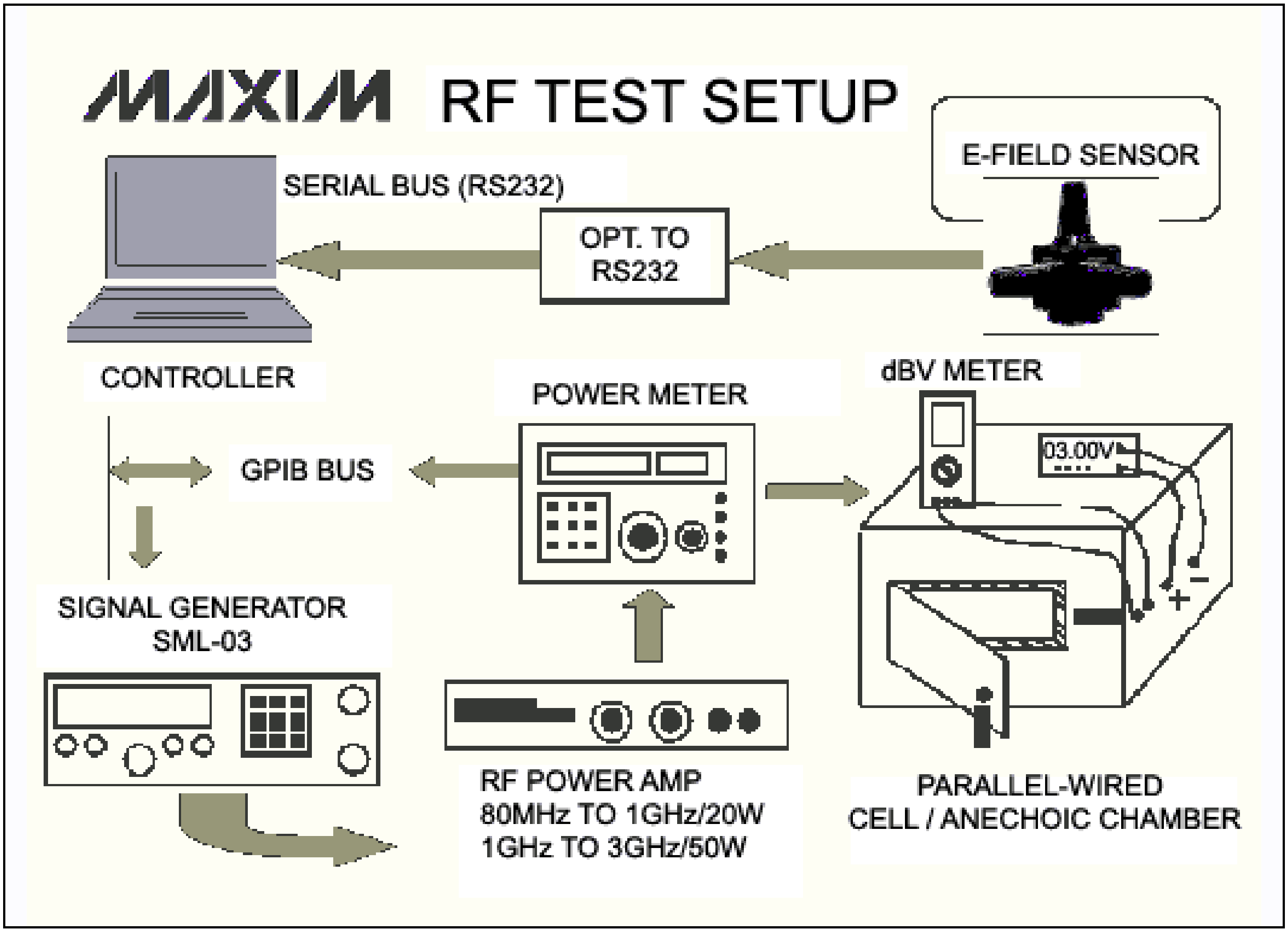

Figure 2. Equipment setup for RF noise-immunity testing.

The signal generator produces an RF signal of the desired frequency and modulation, and feeds it to the power amplifier. The power-amplifier (PA) output is measured and monitored with a directional coupler in conjunction with a power meter. The computer establishes the desired RF field by controlling the range of frequencies at the signal-generator output, the type of modulation, the modulation percentage, and the PA's power output. The field is radiated inside the shielded anechoic chamber using an antenna (Planer type) that produces a uniform, accurately calibrated, and consistently repeatable electric field.

The RF field near a typical cell phone is approximately 60V/m at 4cm from the phone's radiating antenna; the RF field decreases as one moves away from the phone to about 25V/m at 10cm from the phone. The chamber therefore generates a uniform field strength of 60V/m, emulating the RF environment experienced by a DUT (60V/m is also low enough to keep receiving devices below the clipping level and avoid measurement errors). An RF sinewave, varied between the cell-phone frequencies of 800MHz and 1GHz, is 100% modulated with an audio frequency of 1000Hz. Modulation with 217Hz produces similar results, but the more common audio frequency of 1000Hz is chosen for convenience. Access ports on the side of the chamber provide power to the DUT and also give access for connecting the dBV meter, which is set for dBV readings (dBs relative to 1V). The RF field can be accurately calibrated by adjusting the DUT location within the chamber, using the field sensor.

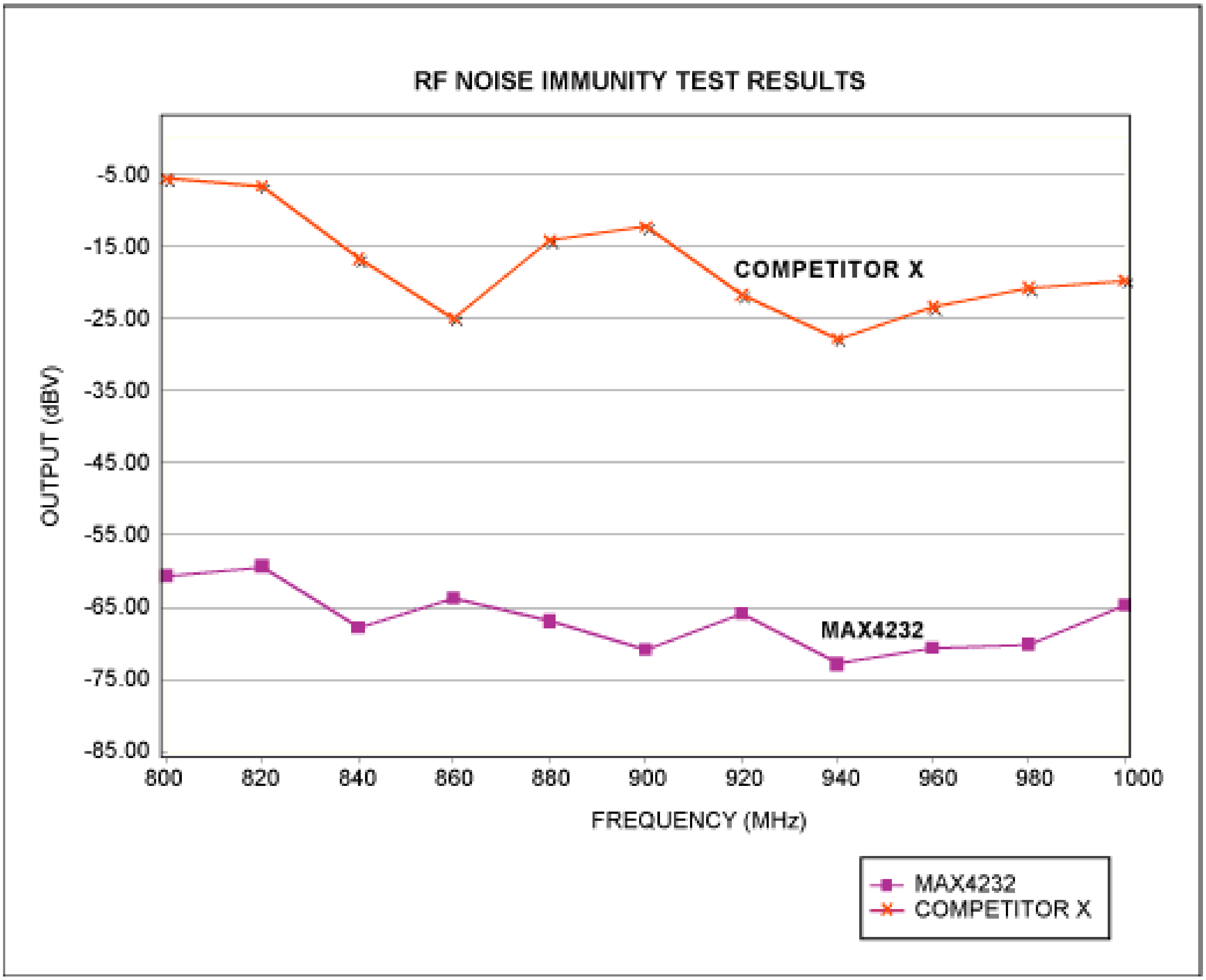

Figure 3. RF noise-immunity test results for two dual op amps, using the Figure 2 setup.

Test Results

Test results for the two dual op amps (MAX4232 and Competitor X) show the average outputs in dBV (**Figure 3**). In response to an RF-frequency variation of 800MHz to 1Ghz, with a uniform electric field of 60V/m, the average MAX4232 output is about -66dBV (500µV RMS with respect to 1V) and the average for Competitor X is about -18dBV (125mV RMS with respect to 1V). In the absence of any RF signal, the dBV meter reads -86dBV.

Thus, the MAX4232 output changes by only -20dB (-86dBV to -66dBV). That is, the RF environment causes its output to change from 50µV RMS to 500µV RMS. We can say that the MAX4232 output changes by a factor of only 10 in response to the imposed RF environment. Hence, the MAX4232 has an excellent RF immunity of -66dBV and would not produce any noticeable output distortion.

The average reading for Competitor X is only -18dBV, which means its output changes 125mV RMS (with respect to 1V RMS) when subjected to RF. This increase is 2500 times greater than normal (50µV RMS). Thus, Competitor X can be said to have poor RF immunity (-18dBV); it is more likely to cause problems when in close proximity to a cell phone or other RF source. Clearly, the MAX4232 is a better choice for audio-processing applications such as headphone amplifiers and microphone amplifiers.

Summary

In conclusion, RF-immunity testing is an indispensable step for board and IC manufacturers concerned about maintaining quality performance in an RF environment. The RF chamber setup provides an economical and flexible method for accurate RF-immunity testing.

A similar article appeared as a Design Tip in the October 2005 edition of *RF Design*.

Application Note 3950: www.maxim-ic.com/an3950

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