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Obtaining the Best PRISM II Chip Set Receiver Sensitivity

Introduction

Being the manufacturer of the PRISM® II WLAN chip set provides the rare opportunity to evaluate many PRISM based PCMCIA radios in our laboratories. This application note presents the receiver sensitivity achieved with our reference radio through the detailed description and explanation of the many circuits and networks between the antennas and the LNA's input. Furthermore, specific examples identifying performance shortcomings are identified.

Front End Architecture of the HWB3163

The path from either of the two antennas to the HFA3683A RF to IF converter includes two identical RF switches, two filters; one a low pass and the other a bandpass, and multiple impedance matching networks utilizing microstrip line, stripline, and LC circuits.
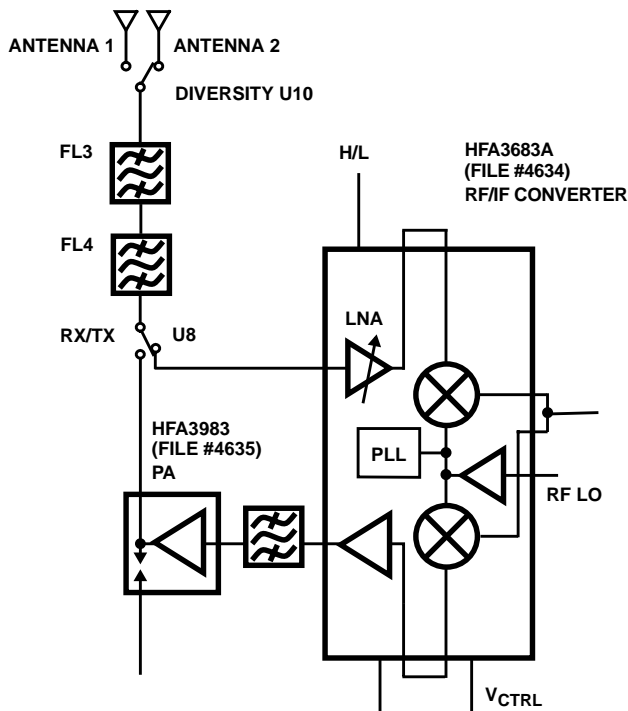

FIGURE 1. COMPONENTS BETWEEN THE ANTENNAS AND THE LNA

Components Between the Antennas and the LNA

Beginning at the number 2 antenna (Figure 1), the first series of microstrip line matching networks must adjust the antenna's characteristic 10.0Ω to U10 the UPG152TA diversity switch's 30.0Ω input impedance. Leading away from the number 2 antenna's feed point are a series of

decreasing step sized microstrip line networks. These networks are designed to be quarter-wave length impedance transforming PC traces. A sized 0402 coupling capacitor with a self-resonant frequency close to the RF operating frequency connects the number 2 antenna circuit to the Diversity switch. From the feedpoint of the number 1 antenna, both microstrip quarter-wave length transformation and a LC circuit match this antenna's impedance to the diversity switch.

The diversity switch outputs to filter FL3, the LTF3216L, a low pass filter. The network, between the diversity switch and the first filter, must impedance match the 30.0Ω switch to the 50.0Ω filter. Like preceding matching circuits, a mix of microstrip line and chip capacitance has been engaged.

The 50.0Ω microstrip interconnect between the two filters matches the 50.0Ω input and output impedances. Filter FL4, the LFSN30 a bandpass filter, outputs to the second RF switch U8, which serves to switch transmit or receive paths. Like the diversity switch, U8's input impedance is 30.0Ω and the impedance transform must occur between 50.0Ω and 30.0Ω again. This transformation is accomplished with a LC circuit using 0402 sized components. The physical size of matching components must be part of the overall optimization method as electrical characteristics due to physical size and various manufacturers vary. Another consideration often overlooked in the construction of the matching network is the component pad size and its RF electrical properties.

The TX/RX switch outputs into the last matching network before the HFA3683A RF to IF converter. The input to the HFA3683A is close to 50.0Ω and must match the 30.0Ω output impedance of U8 the RX/TX switch. Matching is accomplished with a LC network. There remain two capacitors however, one is a series coupling capacitor and the other capacitor and its position optimize input impedance for LNA noise figure.

Component Characteristics

The filter manufacturer specifies LPF insertion losses at 0.6dB, BPF insertion losses at 2dB, and the switch manufacturer specifies the RF switch insertion losses at 0.8dB. The losses attributed to the various switches, filters, and matching networks on the HWB3163 amount to a little more than 4dB. Of the various PCMCIA radios tested in Intersil's laboratory, many radios exceed this value by several dB. The losses can be and were later identified.

Receiver Sensitivity Figures

Intersil receiver sensitivity figures obtained on the HWB3163 were gathered from 77 individual radios.

The testing environment is dedicated and resides in an RF screen room and further protected from collateral RF interference by a metal box enclosure. For additional testing information please review Intersil Application Note AN9887 "Test Plan for Prism II Radio Card" by M. Culibrk. [1]

A modification designed to improve repeatability and reduce undesirable outside interference required the installation of a vertical SMA connector to U10 the diversity switch's number 1 port. The matching between the SMA and the diversity switch is accomplished with a combination of 50.0Ω microstrip and capacitors.

HWB3163 Results

With the aforementioned test environment, 11Mbps receiver sensitivity levels down to -86dB have been obtained. However, the mean sensitivity was approximately -83dB with a one sigma of approximately 1dB. Receiver sensitivity less than -92dBm have been achieved for 1Mbps data rates.

Sensitivity Losses

Following a lackluster receiver sensitivity result, a performance analysis of the various circuits was begun. Over time, a loss isolation scheme was developed. For example, using a typical HWB3163, a 50.0Ω SMA connector was properly soldered directly to the HFA3683A LNA's input. Receiver sensitivity improved by approximately 4dB. This should be the case and in some (but not all) radios that was the case. Our mean receiver sensitivity as measured at the LNA's input is -87dB. This then isolated the losses to between the LNA's input and the antenna SMA connector. Of course the switching function "Diversity" must be deactivated during these tests. The default position is the number 1 antenna in Intersil's HWB3163.

A systematic study of the networks between the LNA's input and the installed antenna SMA connector shows where the losses are. The studies required the proper RF connections to the various interdevice networks and then with a network analyzer, extract the characteristic impedances. Often the matching network was insufficient or incorrect in obtaining the optimum match. The analysis might require the substitution of a discrete 30.0Ω resistor in place of the TX/RX switch for characterization of the first filter. The loading of a given stage can be "felt" beyond the adjacent stage's I/O. Our experience suggests multiple passes through the antenna to LNA input is required to achieve optimum performance.

Those "proper" RF connectors must be locally grounded and the axial conductor's length cut to less than 0.33mm, as this is the physical length of 10.0 degrees at 2.45GHz - approximately the measurement capability of popular equipment.

The complexity of construction, due to the need to route so many signals back and forth, can lead to receiver sensitivity degradation. In one example, after an exhausting investigation revealed reasonable matching, the source was found to be coupling between PC traces. The design brought high frequency digital baseband spurs near and in parallel with the HFA3683A LNA's input causing reduced sensitivity.

Conclusion

High data rates and maximum receiver sensitivity are both desireable goals, in fact a necessity as rates and distance represent a competitive advantage. Rate and distance robbing losses have been identified in this Application Note. By reducing these losses the highest data rate and greatest distance can be achieved.

References

[1] *Application Note AN9887* "Test Plan for Prism II Radio Card", Intersil Corporation, Melbourne, FL, June, 2000, M. Culibrk. Document #99887.

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