From November 2009 *High Frequency Electronics*

Accurate Measurement of On/Off Time for 802.11 b/g WLAN/WiMAX LNAs

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This article compares two test methods for measuring on/off time of device enable and gain select functions in a WLAN LNA, showing their differences and potential errors

Digital Automatic Gain Control (DAGC) is used in most WLAN receivers that are compatible with the IEEE 802.11a/b/g standard, using Orthogonal Frequency Division Multiplexing (OFDM) modulation. Most WLAN Systems have a variable gain amplifier (VGA) internal to the receiver section, but some also use an external LNA in the front end section, with some systems also requiring the LNA to have a bypass function. DAGC in WLAN systems is used to automatically control both the VGA inside the transceiver and the external LNA in order to achieve better signal-to-noise ratio and hold the average power of the signal close to the desired level. The turn on and off time of the LNA enable pin and the gain gelect pin must be fast enough to comply with the fast switching time requirement from one signal level to another, so that the DAGC function remains accurate.

As an example, the RF2374 from RFMD is a switchable low noise amplifier with a high dynamic range. It is designed using a GaAs HBT technology in a small 2.2 × 2.2 × 0.6 mm QFN package, and it is an excellent choice for applications that fall between 800 to 4000 MHz such as GPS/WLAN/WiMAX. Some of the important features of this LNA are that it is a low-cost LNA, it has a high third-order intercept point (IP3), and it has programmable bias, which allows the input IP3 and supply current to be optimized for specific applications. The LNA provides up to +10 dBm input IP3 while maintaining a low noise figure (NF) of 1.3 dB and typical gain of 14 dB at 2500 MHz, and 1.6 dB NF and a typical gain of 12 dB at 3600 MHz. Furthermore, the LNA enable and gain select functions have typical turn on and off time <100 ns over the full temperature range from –40 to +85 °C, which meets most chipset time requirements for the proper DAGC function. The following pages show the setups and test results of two methods used to perform the on and off time measurement for this LNA. The first method uses spectrum analyzer video output and the second uses a diode detector. In this article we define the turn on time of the LNA enable (VREF) as the time it takes to reach 90% of its full gain from the moment it recevies the turn on command. The turn off time of the LNA enable (VREF) is the time it takes for the gain to reach <10% of the its full gain from the moment of the turn off command. The same applies for the gain select mode (bypass mode) turn on time when the LNA reached 90% of the gain while in bypass mode and 10 % of its gain.

A standard RF2374 evaluation board tuned between 2300 to 3900 MHz was used with the exception of changing the input matching capacitor from 22 nF to any value between 3 to 10 pF. (The value used for this experiment is 10 pF as shown in Figure 1.) Using a small capacitor at the input that ranges from 3 to 10 pF will result in a faster switching time, with little impact on the input third order intercept point (IIP3) of 2 to 3 dB typical. Noise figure will not be impacted but one way to recover some IIP3 is to increase the current by changing the R1 (RBais) to drive the LNA a bit harder.

In order to prevent any confusion to the reader, the information will be presented in the following three steps:

- Step 1: First method setup and test results for both LNA enable and gain select on and off time.
- Step 2: 2nd method setup and test results for both LNA enable and gain select on and off time.
- Step 3: Show the difference between the accuracy of the first method and the second method and highlight the reason.

Step 1

First method test setup (using the video output of a spectrum analyzer):

Using the first method we measured the turn and off time of the LNA enable pin (VREF) first which turns on or off the LNA and then we measured the turn on and off of the gain select pin, which switches the LNA from high gain to low gain (bypass mode). Figure 2 shows the setup and equipment used to perform this test. This setup uses the signal analyzer video output signal, which is taken to an oscilloscope to perform the accurate measurements of the on and off time. The evaluation board was biased as follows:

First Test—LNA Enable (VREF) On/Off Time:

Vcc = 3.3V, Gain Select = Low (GND), VREF (LNA enable) = pulsed from Wave Tek generator with a 50% duty cycle square waveform with a period of 360 µs with a pulse width of 180 µs and amplitude of 3.0 Vp-p. The measurement results are shown in Figures 3 and 4.

Second Test—Gain Select (Bypass Mode) On/Off Time:

Vcc = 3.3V, VREF (LNA enable) = Low (GND), Gain Select = pulsed from Wave Tek generator with a 50% duty cycle square waveform with a period of 360 µs with a pulse width of 180 µs with an amplitude of 3.0 Vp-p. Measurement results are shown in Figures 5 and 6.

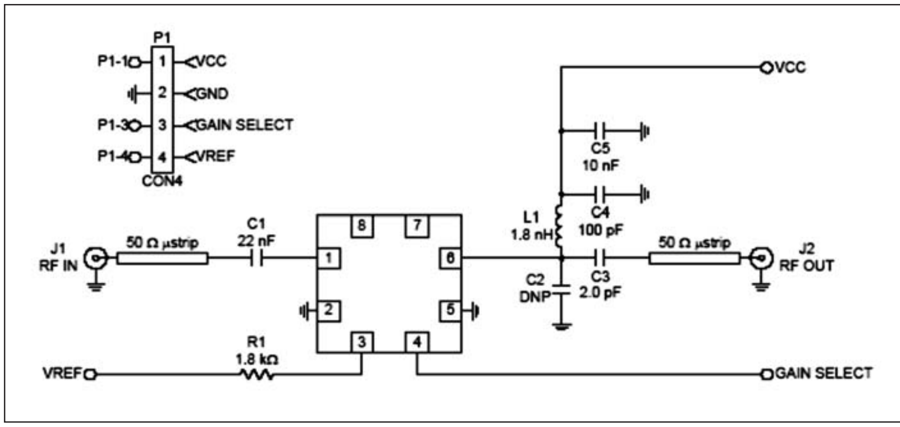

Figure 1 · Standard evaluation board schematic used to perform this test.

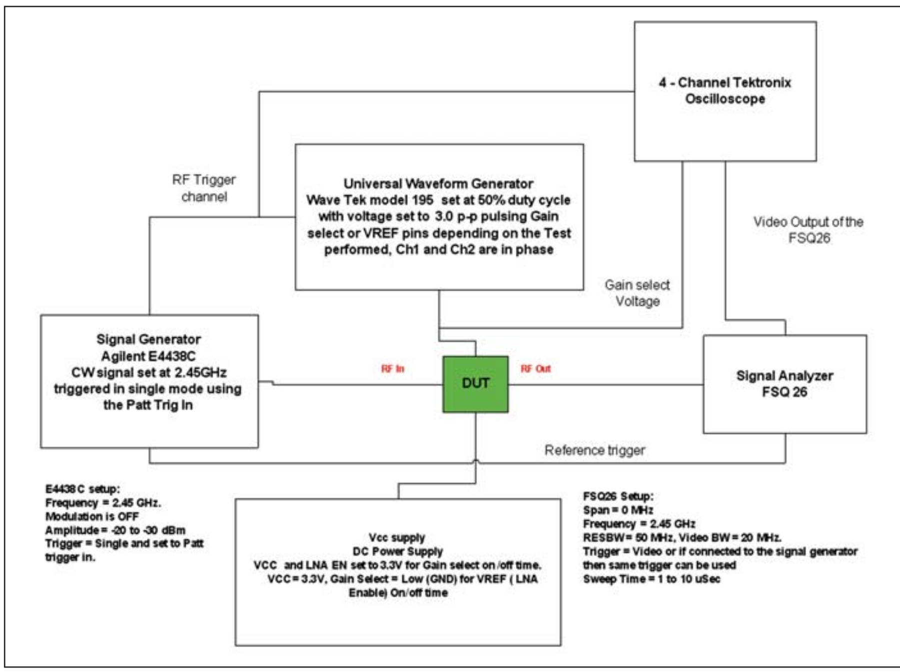

Figure 2 · Test setup using the first method to measure turn on and off time for both the LNA enable and gain select.

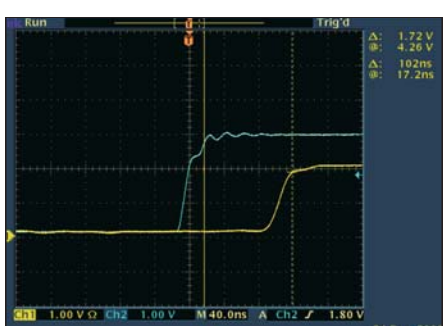

Figure 3 · This is the turn on time measurement of the LNA enable (VREF) using the first method. The typical turn on time is ~100 ns.

Figure 4 · This is the turn off time measurement of the LNA enable (VREF) using the first method. The typical turn off time is ~125 ns.

Step 2

Second Method test setup (using the diode detector chosen for this test as shown in the setup of Figure 7).

Using the this method we measured the turn and off time of the LNA enable pin (VREF) first which turns on or off the LNA and then we measured the turn on and off of the gain select pin, which switches the LNA from high gain to low gain (bypass mode). Figure 7 shows the setup and equipment used to perform this test. This setup uses a diode detector connected to the RF output of the LNA, which is then taken to an oscilloscope to perform the accurate measurements of the on and off time. The evaluation board was biased as follows:

First Test—LNA Enable (VREF) On/Off time:

Vcc= 3.3V, Gain Select = Low (GND), VREF (LNA enable) = pulsed from Wave Tek generator with a 50% duty cycle square waveform with a period of 360 µs with a pulse width of 180 µs an amplitude of 3.0 Vp-p.

Second Test—Gain Select (Bypass Mode) On/Off Time:

Vcc = 3.3V, VREF (LNA enable) = Low (GND), Gain Select = pulsed from Wave Tek generator with a 50% duty cycle square waveform with a period of 360 µs with a pulse width of 180 µs with an amplitude of 3.0 Vp-p.

Step 3 and Conclusions

Figures 12 through 15 show the difference between the accuracy of measuring the turn on and off time between the two methods shown above.

For a fast turn on and off time specification that is down to the 100 ns range, the accuracy of performing such measurement is critical. In this article we have shown two common methods used to perform such measurement, but it is important to note the first method introduces a delay that can vary from one signal analyz-

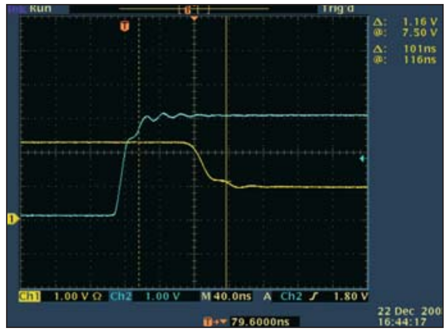

Figure 5 · This is the turn on time of the gain select (bypass mode) using the first method. When this fuction is exercised it means that the LNA is now in bypass mode and the typical insertion gain is around 3 dB. The typical turn on time is ~100 ns.

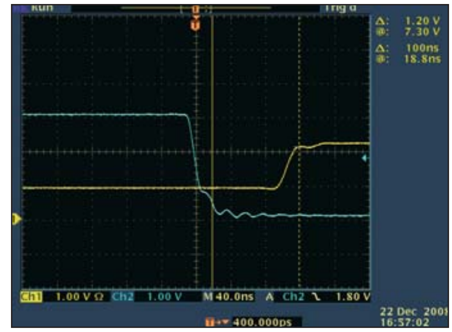

Figure 6 · This is the turn off time of the gain select (bypass mode) using the first method. When this function is exercised it means that the LNA is fully on and the typical gain is around 12 dB at 2450 MHz. The typical turn off time is ~100 ns.

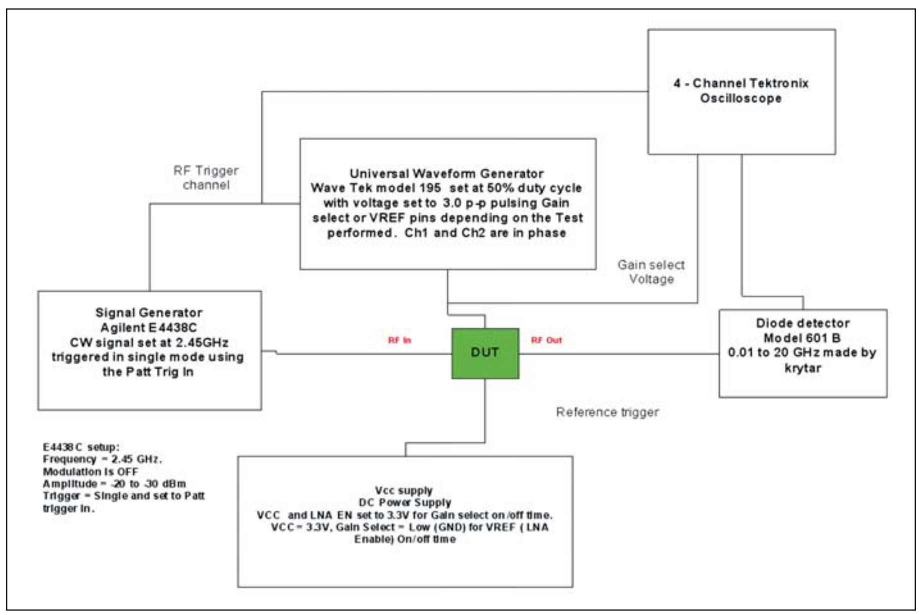

Figure 7 · Test setup using the second method to measure turn on and off time for both the LNA enable and gain select.

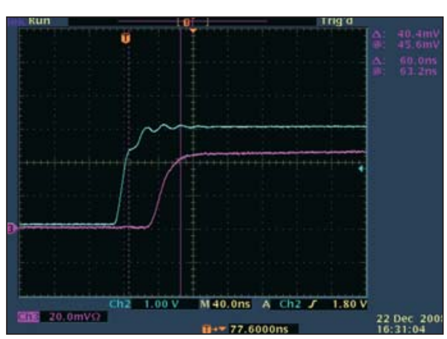

Figure 8 · This is the turn on time of the LNA enable (VREF) using the second method (diode detector). The typical turn on time is ~27 ns.

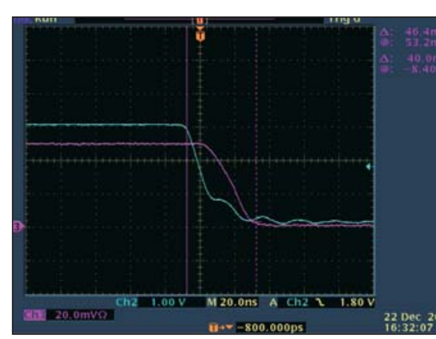

Figure 9 · This is the turn off time of the LNA enable (VREF) using the second method (diode detector). The typical turn off time is ~40 ns.

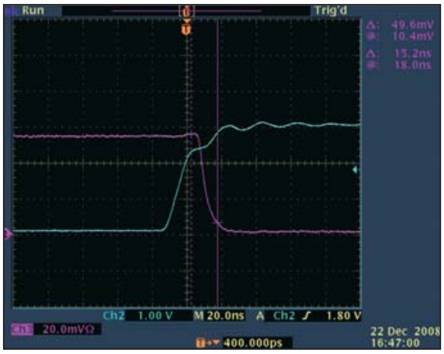

Figure 10 · This is the turn on time measurement of the gain select (bypass mode) using the second method. When this function is exercised it means that the LNA now in bypass mode and the typical insertion gain is around 3 dB. The typical turn on time is ~ 15 ns.

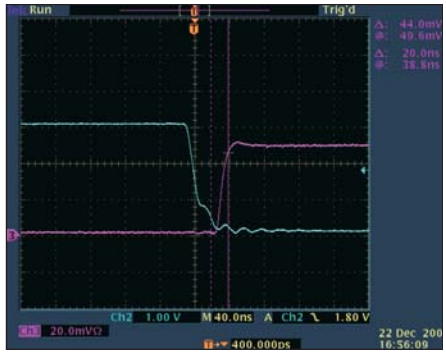

Figure 11 · This is the turn off time measurement of the gain select (bypass mode) using the second method. When this function is exercised it means that the LNA now in fully on and the typical gain is around 12 dB at 2450 MHz. The typical turn off time is ~ 100 ns.

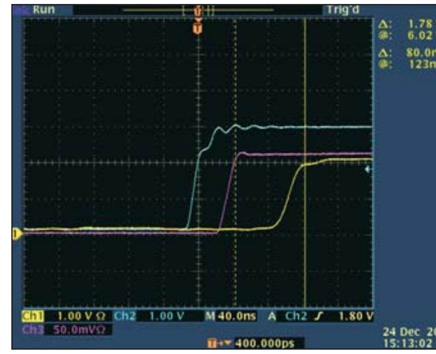

Figure 12 · This is the difference in turn on time of the LNA enable between first and second method. It is clear that first method introduces a typical delay of ~80 ns.

er or spectrum analyzer to another. When performing this type of measurement it is important to at least use two different methods to double check the accuracy of the results.

RFMD delivers a broad portfolio for multiple market segments with offerings for all 802.11a/b/g/n and 802.16d/e applications. Utilizing proven design expertise and its Optimum Technology Matching® strategy, RFMD's portfolio reduces

RFMD Product Notes

The following is a list of some of the low noise amplifiers offered by the Wireless Components Business Unit at RFMD, along with their key specifications:

Part #	Description	Freq(MHz)	Gain (dB)	NF (dB)	P_{1dB} (dBm)	OIP3 (dBm)	Vd(V)	Id (mA)	PackageStyle	Status
RF2374	Broadband LNA W/Bypass mode	900 - 4000	14	1.3	–5	7	3.3	10	QFN-8 2X2	Production
RF2370	Broadband LNA	900 - 4000	14	1.3	–5	7	3.3	4	SOT-6 Lead	Production
RF2373	Broadband LNA	400 - 3000	15	1.3	–3.5	9.3	3.3	10	SOT-5 Lead	Production
RF2472	Broadband LNA	DC - 6000	14	1.5	–10	22	2.7 - 3.6	6	SOT-5 Lead	Production
SGA 8343	Broadband LNA	DC - 4000	18	1.2	9	27	3.3	10	SOT 343	Production
RF5501	2.5 GHz LNA w/Bypass + SP3T switch	2400 - 2500	12	1.9	30 (SW)	21	2.3 - 5.0	9	QFN-12 2x2xX0.5 mm	Production
RF5611	2.5 GHz LNA w/ Bypass + SP3T switch	2400 - 2500	12	2.2	30 (SW)	21	2.3 - 5.0	9	QFN-12 2x2x0.5 mm	Production
RF5511	2.5 GHz LNA w/ Bypass + SP3T switch	2400 - 2500	12	1.8	30 (SW)	21	2.3 - 5.0	9	Flip Chip 0.99x0.98x0.4 mm	Production
RF5515	5 GHz LNA	4900 - 5900	11	1.6	–2 (IP_{1dB})	22	2.3 - 4.8	12	QFN-8 2.2x2.2x0.45 mm	Production
RF5601	5 GHz LNA W/Bypass	4900- 5900	11	1.6	–2 (IP_{1dB})	22	2.3 -4.8	13	QFN-8 2.2x2.2x0.45 mm	Production
RF5521	2.5 GHz LNA w/ Bypass + SP3T switch	2400 - 2500	12	1.8	30 (SW)	21	2.3 - 4.8	7	QFN-10 1.75x1.75x0.5 mm	Production

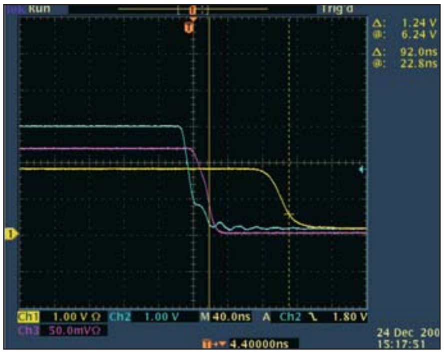

Figure 13 · This is the difference in turn off time of the LNA enable between first and second method. It is clear that first method introduces a typical delay of ~76 ns.

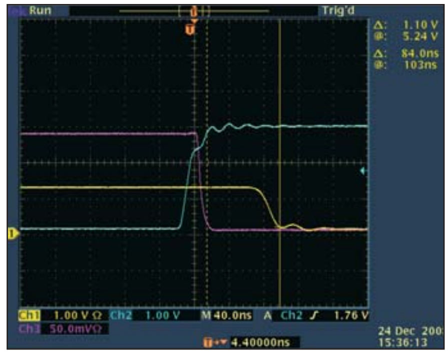

Figure 14 · This is the difference in turn on time of the gain Select (LNA is in bypass mode) between first and second method. It is clear that first method introduces a typical delay of ~84 ns.

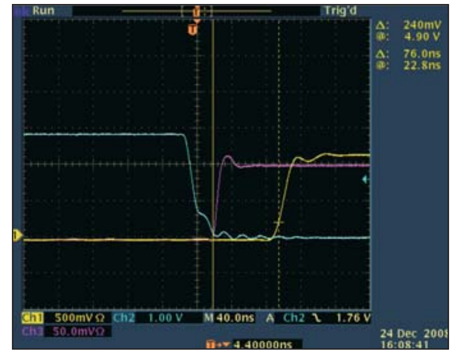

Figure 15 · This is the difference in turn off time of the gain select (LNA is not in bypass mode) between first and second method. It is clear that first method introduces a typical delay of ~76 ns.

engineering complexity for straightforward implementation and faster time to market while delivering best-in-class performance.

For more information on a specific product that could fit your need please visit the RFMD Web site at www.RFMD.com.

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The author would like to thank everyone who made a contribution to this article.