Understanding 802.11a Technology and Testing Requirements - Part II

As WLAN standards emerge, test solutions will play a crucial role in the success of long-term end-user acceptance.

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Editor's Note: This article represents Part Two of a two-part article. Click here [1] to read part one.

Testing Requirements

Having discussed the details of 802.11a and OFDM, we can now take a look at the testing requirements associated with this technology.

Testing WLAN components and systems requires both transmitter and receiver tests. Traditionally, these tests are run separately from each other. They can be further broken down into complete system tests or individual component tests. Further, both production and engineering tests for 802.11a will require that the test equipment be able to test modulation related and RF parameters that meet the 802.11a standard itself and the design goals of the product in question. To address this broad range of tests, the test equipment must be quite flexible. It must possess the ability to properly format the individual fields within the packet and provide the speed and convenience of predefined tests. Additionally, test equipment performance must surpass the performance of the device or system under test so that accurate test measurements can be made.

Transmitter Tests: Measuring the Modulation and Spectral Performance

The 802.11a standards specify many tests that measure both the modulation and spectral performance of the transmitter. In order to make the modulation measurements, an RF spectrum/signal analyzer with wide IQ bandwidth is required. Additionally, if the 802.11a measurement and analysis is not built into the analyzer, a controller (typically a Windows(computer driving the instrument via GPIB or Ethernet) is used to capture the IQ data and the software running on an external PC is used to perform the measurement and analysis of the 802.11a signal.

Because of the wide bandwidth of the 802.11a signal, a spectrum analyzer capable of capturing an IQ bandwidth of at least 20 MHz is required in order to perform the demodulation. Once the data is demodulated, the modulation performance of the transmitter can be analyzed. One of the most important

measures of the transmitter performance is the Error Vector Magnitude (EVM). The specification is given in dB in the standard but most engineers refer to EVM in percentage. Item 'A' of Figure 1 shows a software tool that displays the EVM performance in both formats. Another important transmitter measurement is modulation accuracy. This test measures such things as IQ offset, IQ imbalance and Quadrature mismatch. Item 'B' in Figure 1 summarizes the results of a modulation accuracy test.

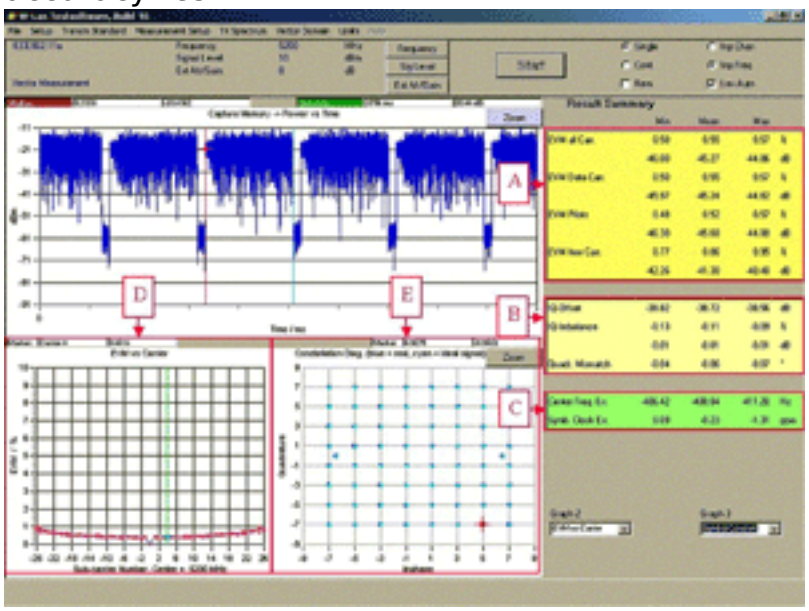

Figure 1: Results summary display of an 802.11a measurement and analysis software used with a spectrum analyzer. A.) EVM results given in percentage and dB, B.) Modulation Accuracy results, C.) Center Frequency and Symbol Clock Error results, D.) EVM vs. sub-carrier plot, and E.) Constellation Diagram of the data and pilot sub-carriers.

In addition to the EVM and modulation accuracy measurements shown in the result summary of Figure 1, center frequency error and symbol clock error are displayed (see item 'C'). This is necessary because the standard allows for some tolerance in the transmit center frequency and the symbol clock frequency. The analysis tool used for transmitter measurements should be able to demodulate the 802.11a signal despite the imperfections of the reference oscillator and measure these frequency errors.

Although the results summary given in Figure 1 is sufficient for determining if the device under test passes or fails, another viewpoint of the results can be helpful in troubleshooting. Item 'D' of Figure 1 shows a plot of EVM vs. sub-carrier and item 'E' displays the constellation diagram of all of the sub-carriers and pilots overlaid. The device used for the measurement results displayed in Figure 1 was very good. If, however, an upper adjacent channel interferer had been present, the EVM performance of the higher frequency sub-carriers would have been significantly degraded and would have been easy to see with this plot. In addition to EVM vs. sub-carrier and constellation diagrams, the 802.11a demodulation tool used may provide other plots such as constellation vs. sub-carrier or EVM vs. symbol for analyzing and troubleshooting the 802.11a device performance.

Besides measuring the modulation performance of the transmitter, spectral performance needs to be tested. The standard specifies several transmit spectrum tests. One of them is spurious emissions that should be measured to ensure compliance with national regulations. Furthermore, transmitter spectral flatness and

the transmitted spectrum need to be measured. As the name implies, spectral flatness is measured to ensure that average energy of each sub-carrier does not deviate more than a specified amount from the average energy of all of the sub-carriers. The transmit spectrum test measures the spectral density in frequency bands defined relative to the center frequency with limit lines given in units of dBr (dB relative to the maximum spectral density of the signal). For details on the limit lines for 802.11a, see figure 120 of the IEEE 802.11a standards document.

In theory, all of these spectral tests could be performed with any mid range spectrum analyzer since it is not necessary to capture a wide I/Q bandwidth. However, since the transmit spectrum mask is given in units of dBr, the absolute value of the mask will change over time. A spectrum analyzer or analysis tool that will calculate the maximum spectral density of the signal and adjust the transmit spectrum mask accordingly will simplify testing.

Receiver Tests: Accurate Simulation of an 802.11a Signal

In order to test a receiver system (or component) a known 802.11a signal needs to be generated. A typical test equipment configuration for 802.11a consists of an I/Q simulation software package to create a baseband signal and an RF signal generator to convert the baseband signal to an RF signal. As explained in earlier sections, before the user's data in an 802.11a signal is transmitted over the physical channel, it is first put into a PLCP frame with a preamble and header. It is then scrambled, encoded, and interleaved onto the 48 data sub-carriers and mapped according to the appropriate modulation for the selected data rate. Then an inverse FFT is performed, a guard zone is added and then the signal is finally transmitted. A signal source must be capable of performing all of these steps according to the specifications so that the receiver can be accurately tested.

There are five receiver tests defined in the 802.11a standard: CCA sensitivity, receiver maximum input level, receiver minimum input level, adjacent channel rejection and non-adjacent channel rejection. The CCA test measures the receiver's ability to detect the presence of other RF signals in the receiver band and to notify higher protocol layers to delay transmission. Here, the signal source sends an 802.11a signal and provides a marker output to indicate when data is active. An oscilloscope can then be used to observe the CCA signal from the device under test and the data active signal from the signal generator to verify the timing required in the standard. The receiver minimum and maximum input level tests the receiver's ability to demodulate with varying input levels. The adjacent and non-adjacent channel rejection tests measure the receiver's ability to demodulate the desired 802.11a signal in the presence of an interfering 802.11a signal in another channel. Because of the wide bandwidth of the 802.11a signals, the output of two signal generators may need to be combined to accurately measure the receiver's ability to reject the interfering signal.

Conclusion:

Communication methods are becoming more complex over time, using higher order modulation techniques and wider bandwidths. The WLAN standards,

especially 802.11a, are a perfect example of this. As this market continues to grow and the standard evolves, fast, efficient test solutions for the design and production of WLAN devices will play a crucial role in the success of long-term end-user acceptance.

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