Design Considerations for DVT and Manufacturing Test of Wireless Devices
Introduction

Wireless devices are being deployed for a wide range of functions including monitoring, control, data transfer and data streaming. To perform properly, these devices need a reliable wireless connection and design engineers need to consider how the wireless performance will be tested during design verification and manufacturing. In a wireless device, design verification is critical to insure the final design meets customer expectations, and manufacturing test is critical to insure the manufacturing process produces products with consistent quality.

This technical brief provides an overview of design recommendations to help simplify and improve the accuracy of wireless performance testing of the finished device.

- Access to RF signals
- Wireless chipset control methods
- Special considerations when using pre-calibrated modules
- Testing during the production flow

Access to RF Signals

One of the most important considerations for measuring RF performance is how the RF signal will be coupled to the RF tester. There are two choices; conducted measurements with an RF connector on the DUT and high quality RF cabling to the tester, or radiated measurements where the signal is coupled over-the-air from the DUT antenna to an antenna or coupler that is attached to the tester.

Radiated measurements introduce a significant amount of measurement uncertainty and it is difficult to get repeatable results. Typical radiated measurements will have at least 20-30 db of path loss between the DUT and the tester and this value can vary by 2-3 dB or more, depending on specific placement of the device. As a result, it is very difficult to make accurate TX power or RX sensitivity measurements, which are typically specified at just 1-2 dB. In addition to the high path loss, radiated measurements require DUTs to be tested in expensive RF enclosures to minimize RF energy from other external sources.

For the most accurate and repeatable results, your design should have a direct connection to the RF signals. To achieve this, the design needs to incorporate an RF connector (with external antenna) or an RF switch (with integrated antenna). Either of these choices can easily be incorporated into almost any design and the required components are small, inexpensive, and perform very well up to 6 GHz.

Fig 1 and Fig 2 show two commercially available devices, one with and one without RF connections.
Wireless Chipset Control Methods

To test the RF performance, you’ll need some method to control the wireless chipset. The basic testing process is to put the chipset into a known TX or RX state and use a calibrated RF tester to measure the performance. Traditionally the two approaches to control the device are “signaling” and “non-signaling”. Signaling is intended for real-world usage in an actual network. It is not designed specifically for testing and therefore has limited functionality. Also, signaling is quite slow compared to the non-signaling methods which are typically 2-3x faster for RF testing. Fig 3 shows a typical 802.xx protocol stack. On the left is the signaling protocol used during normal network operation. You can see there is a significant number of software layers required to implement and conform to the full IEEE 802.xx network protocol. The drawing on the right shows a typical protocol stack used with manufacturing test software. This is significantly smaller and faster and allows direct control of the MAC and PHY layers that are used to configure the various TX and RX measurement conditions.

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<th>‘Retail’ Protocol Stack</th>
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Fig 3. Retail and Test Protocol Stacks

When using non-signaling test methods, the two things to consider are:

- The physical data connection (such as USB, UART, JTAG) between the test controller and the device being tested
- The necessary software, generally “manufacturing software”, which allows low level control of the wireless functions.

Some devices, such as the WiFi dongle shown in Fig 1, have I/O connections that are intended for customer usage. With appropriate drivers these can usually be used to directly communicate and control the wireless chipset. Other devices, such as many of the new IoT devices, do not have a customer I/O port, so the designer needs to include a data communication method such as JTAG or Serial. This connection port is used for a variety of functions such as functional test, loading firmware, programming serial numbers, and controlling the wireless chipset. The device shown in Fig 2 is a Zigbee module with a 10-pin JTAG interface (shown) that can be used to communicate directly with the wireless chipset.

Low level control of the wireless chipset requires special manufacturing software. This is provided by the chipset or module manufacturer. This software is typically loaded early in the manufacturing process and then removed when the device is “reflashed” with retail software before it ships to the end customer.
Special Consideration for Pre-calibrated RF modules

There are many excellent companies that build pre-calibrated RF modules for WiFi, BT, and Zigbee, and using one of these pre-calibrated modules is often the fastest and lowest risk method to enable wireless in your device. Pre-calibrated modules will have either embedded antennas or they will have a connector to attach to an external RF antenna.

Although these modules are pre-calibrated and have had initial testing performed, you still need to verify RF performance as part of your engineering and manufacturing process. Wireless performance is very sensitive to the environment where the module is installed and you’ll want to validate the complete system as part of your design verification. In manufacturing, even small changes in component values or the amount of solder on the PCB will impact your device RF performance. In manufacturing, you won’t need to re-calibrate the module, but you do need to run some basic TX and RX tests to insure the module does meet specification and all components are installed properly and within design tolerance.

Fig 4 shows a pre-calibrated Z-wave module installed in a typical IoT device. Notice the 6-pin digital connector which allows direct communication with the device. This module has a nicely integrated antenna, but without an RF switch it will be very difficult to get accurate and repeatable RF performance measurements.
Wireless Test in Production Flow

The product design will determine the specific test flow for RF testing.

- If the design uses a pre-calibrated RF module, the module manufacturer has already calibrated the device and has performed a basic verification. In this case, the device only requires RF verification (step 4 below). Final test verifies that the module is meeting specification and insures that it was installed correctly, without damage, as part of the manufacturing process.
- If the design is chip-on-board, the Calibration and Final Test may be performed in two stages (shown) or combined into a single step.

The important point to remember is that final RF testing is necessary after the RF and main boards have been fully assembled but before external covers and retail firmware are installed.

Summary

This document provides an overview of design recommendations that will help insure more accurate and repeatable RF testing as part of design verification and manufacturing test.

Wireless technology is a key element in many new devices and insuring proper performance is critical to a successful product. LitePoint is an industry leader in wireless test and has 1000's of testers deployed in design verification and manufacturing test. Contact us early during your design and we can help insure you have a smooth transition through design verification and into high volume manufacturing.