How to Select your Wi-Fi Module

Application Note

What you will learn:

- The workflow of Wi-Fi module integration.
- The typical Wi-Fi applications.
- Module selecting parameters.
- The tradeoffs when you selecting the Wi-Fi modules for your specific application.

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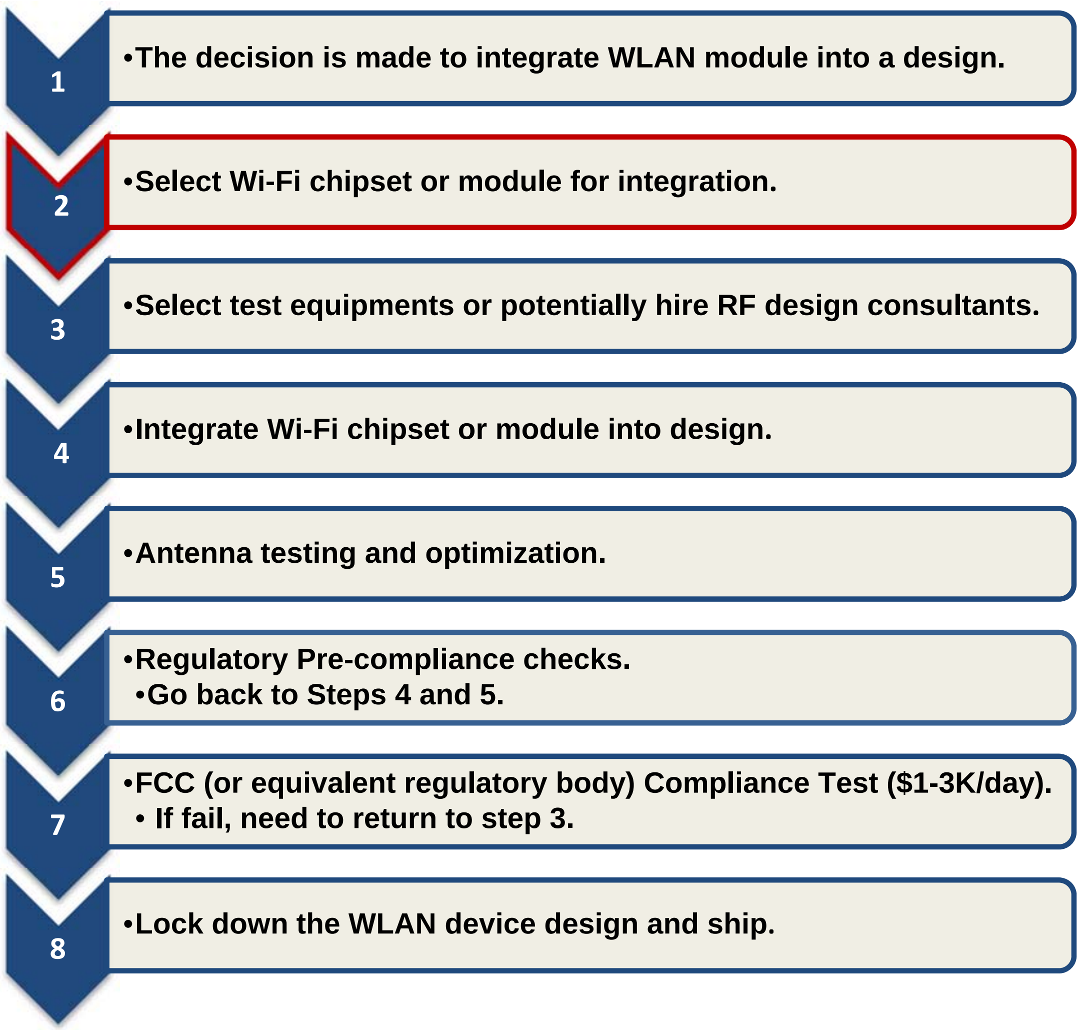
1. The Workflow of WLAN Module Integration

As we see the wireless revolution enters its next phase of deployment, we also see a large shift toward putting wireless local area network (WLAN / IEEE802.11) capabilities on a wide variety of non-traditional products like thermostats, coffee makers, and even toothbrushes. These consumer items could be controlled via an application from a smart phone or other devices connected to the internet. One advantage of using connected devices like smart phones is the applications can be developed very quickly and the end customer is presented with an integrated experience with their wireless devices. To date, this has been done with music players, GPS devices, cameras, video cameras, televisions, video games, etc. Another application driving this is the Internet of Things (IOT), where even more industrial and consumer devices are connected wirelessly.

To achieve the wireless connection to the internet, the product manufactures have to learn how to add wireless capability to their products. The most common way to add wireless capability is to use a prepackaged WLAN module. While this approach greatly simplifies the process, it still has many challenges. This application note will outline the typical design cycle and potential pitfalls that you may encounter.

If you want to add a Wi-Fi Module to your product, what's next?



In this application note, we will take a closer look at step 2. When you search for a Wi-Fi module for your applications, you could find many different kinds of modules & solutions. In order to better match your specific RF application needs, it will be helpful to have an understanding of selection parameters and tradeoffs.

2. What Are the Typical Applications Using Wi-Fi Modules?

Wi-Fi is a popular technology that allows electronic devices to connect to the internet or exchange data wirelessly using RF radio waves. Wi-Fi refers specifically to ability for interoperability with other WLAN devices. WLAN refers to devices that comply with one or more of the IEEE 802.11 standards. These terms have different meanings, but most all WLAN devices need to be Wi-Fi compatible. Wi-Fi technology may be used in a variety of scientific, industrial, commercial and consumer applications. Many devices can use Wi-Fi, and these devices can all connect to a network resource via a wireless network access point. The example applications include:

Utility and Smart Energy
- Thermostats
- Lighting Controls
- EV-Chargers
- Smart Meters

Consumer Electronics
- Remote Control
- Internet Radio
- Home Security
- Toys

Medical, Fitness, and Healthcare
- Patient monitors
- Fitness Equipment
- Real-time location systems

Retail
- POS Terminals
- Wireless Price Tags
- Digital Remote Signage

Remote Device Management
- Location and Asset Tracking
- Automotive
- Code Update

Industrial Controls
- Chemical Sensors
- Wireless controller
- Security Systems
- M2M Communication

The Figure 1 shows the idea of the smart appliance, one of the most popular Wi-Fi module applications. With the Wi-Fi module, utilities and service providers, and their customers, have the power to directly communicate with thermostats, major appliances, heating and air conditioning systems, water heaters and every electric product in the home.

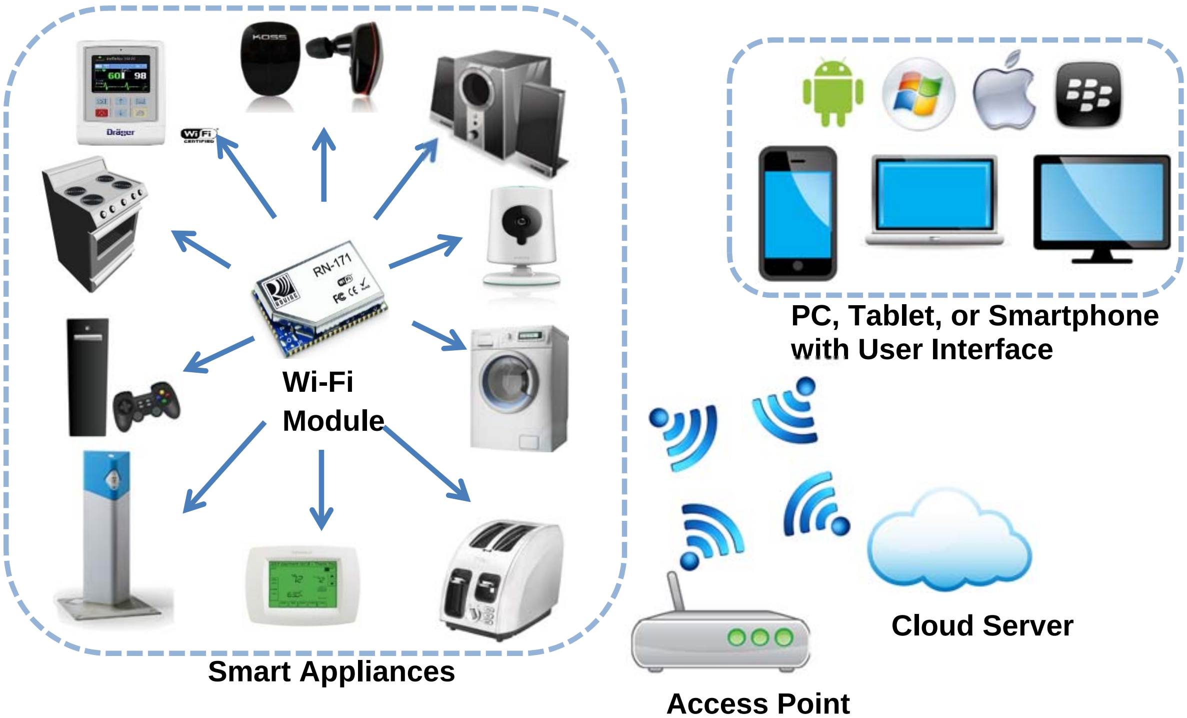


Figure 1: Integrating Wi-Fi in Smart Appliances.

3. What Are the Parametric Filters for Your Module Search?

Wi-Fi module is a functional unit, and can only run while embedded in the system. When choosing the Wi-Fi module for your applications, you need to consider both software and hardware aspects. Figure 2 shows a simplified block diagram of a Wi-Fi module.

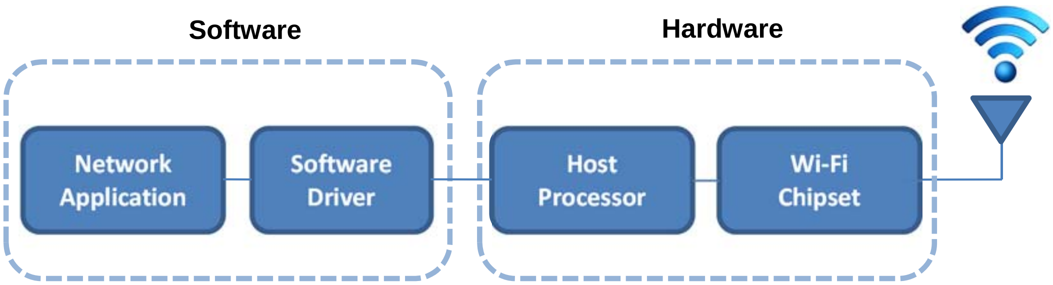


Figure 2: Simplified Block Diagram of a Typical Wi-Fi Module

The hardware of the Wi-Fi module contains two main parts: a Wi-Fi chip and an application host processor. For more stand-alone Wi-Fi applications, engineers can select from Wi-Fi modules from makers like Laird Technologies, Quatech, and Roving Networks that combine the signal chain with a complete embedded processor core. The application host processor has internal or external flash, ROM, and RAM. A number of I/O's are available to allow a wide range of applications. These include timers, serial communication interfaces, analog comparators, ADC, DAC, crystal oscillators and a debug interface, etc.

The specialized software is required by some applications to deliver the security, trouble-free operations, and manageability that customers require. The Wi-Fi software usually includes a device driver, an integrated 802.11 security supplicant, and a full-featured management and monitoring utility.

There are many different kinds of Wi-Fi Modules & Solutions available when you do your search. The vendors or module makers usually categorize the modules by many parameters including data rate, range, RF band, certification and packaging type, etc. The parametric filters will allow you to refine your search results according to the required specifications.

Selecting Parameters	Description
Protocol/ Standard Supported	There are a number of different wireless standards that are available on the market today. The benefits of wireless networking depend on the standard employed. The modern wireless LAN standards that are in use today include: 802.11 a/b/g/j/n/p/ac/ad,… Each standard has different specification requirement, and you need to consider the tradeoff, like the data rate and power consumption, depends on your applications. The newer modulation methods and coding rates are generally more efficient and sustain higher data rates, but older methods and rates are still supported for backwards compatibility. Some Wi-Fi modules also have the embedded Bluetooth (also operate in 2.4 GHz) for robust audio and data connectivity, enabling rapid time to market for portable, battery powered devices.
Operating Frequency Band	2.4 GHz (2.4 - 2.483 GHz) - 802.11b/g/n 5 GHz (5.15 - 5.725 GHz) - 802.11a/h/j/n/ac 5.9 GHz (5.85 - 5.9 GHz) - 802.11p Each range is divided into a multitude of channels. Countries apply their own regulations to both the allowable channels, allowed users and maximum power levels within these frequency ranges. Some Wi-Fi modules are Dual-Band Support, for example, while 802.11g solutions operate only in the 2.4 GHz frequency band, 802.11n solution supports both the 2.4 and 5 GHz bands, maximizing flexibility in how mobile devices are deployed and managed.
Transmit Range	Wi-Fi networks have limited range. It depends on the number and type of routers and/or wireless access points being used. Factors that determine a device's range are: • the specific 802.11 protocol employed • the overall power of the transmitter • the nature of obstructions and interference in the surrounding area Wi-Fi in the 2.4 GHz frequency block has slightly better range than Wi-Fi in the 5 GHz frequency block which is used by 802.11a, 802.11n, and 802.11ac.
Transmit Power Output, Operating Supply Current or Voltage	Higher data rate and longer transmission distance requires higher transmit power output for the Wi-Fi module. However, the high power consumption of Wi-Fi makes battery life in mobile devices a concern, and it is also limited by local regulations, such as FCC Part 15 in the US.

Data Rate (Max Throughput)	Wi-Fi supports varying levels of performance depending on which technology standards it supports. Each Wi-Fi standard is rated according to its maximum theoretical throughput. The data rate of Wi-Fi networks practically never approaches these theoretical maximums due to higher layer overheads. The theoretical maximum data rate of a Wi-Fi module could be from 1 Mbps (802.11 b) to 6.75Gb/s (802.11 ac). Higher date rate is not always better, and you need to choose the best option based on your application. For example, 802.11n and 802.11ac have been defined for higher data throughput applications such as TV multimedia. This data rate is not required for embedded applications and also is not sustainable if large numbers of clients of any type (even more 802.11n) are on the network.
Microcontroller/ Microprocessor	The microcontrollers or microprocessors act as the brain of the module, provide the optimum hardware platform around which wireless network nodes can be designed, combining high-performance processing and radio communications. One of the major selection criteria is the cost. Additional criteria are the size of its program and data memory, its power consumption, the availability of peripherals, and its processing speed.
Operating System (Driver Support)	Android, iPhone/iPad, Linux, WinCE, or other Embedded systems support: Now more and more Wi-Fi modules on the market allow users to quickly configure their wireless security and network options using either PC (web browser) or smartphone and tablet (iOS or Android based). If you need build in this feature into your product, you need to check the driver level support, and configuration and management support from the Wi-Fi module.
Antenna and Connector	There are two main types of Wi-Fi antennas, Omni directional and Directional. • Omni directional antennas provide a 360° donut shaped radiation pattern to provide the widest possible signal coverage in indoor and outdoor wireless applications. The typical applications are the wireless coverage providing connectivity to Wi-Fi device an inside office, home, warehouse, or even an outdoor café. • Directional antennas, as the name implies, focus the wireless signal in a specific direction resulting in a limited coverage area. The typical applications are wireless connection from one building to another building. Through use of directional antennas, the connection can be extended with many kilometers between stations. The antenna connectors are mainly classified as on-board chip antenna and U.FL connector for external antenna option. The tiny chip antenna is the latest entry into the antenna field. They are surface mount devices that are typically 8 by 5 by 2.5 mm, making them the smallest design available. The U.FL connectors are commonly used in applications where space is of critical concern and the external antenna is needed. A list of antennas and cables that the Wi-Fi Module was certified with may be found in the modules' datasheet. If the module is certified, use of these antennas does not require additional certifications.

Secure Wi-Fi Authentication Schemes	Before allowing your devices to connect to the networks using Wi-Fi, those responsible for information security must be confident that the Wi-Fi networks and your devices that use them will protect sensitive information that are transmitted over Wi-Fi or stored on the networks. WEP, WPA, WPA2, WPA2-Enterprise, WPS, WMM, WMM-PS are typical Wi-Fi security types, each has advantages and disadvantages.
Shape & Size	One of the main criteria for Wi-Fi module selection is the size of the module, especially when the product you want to add Wi-Fi module in is quite compact such as portable devices.
Operating Temperature Range	The common operating temperature range is from -40°C to 85° C. Most Wi-Fi modules today are designed as “commercial design without the verification on extreme low or high temperature range.” In practice, even the module makers indicate their modules are “Extended Temperature Wi-Fi”, it is assumed the Wi-Fi module will be placed in an enclosure with miniature heater and fan that attempts to maintain temperate conditions similar to the indoors environment.
Packaging Type	Surface mount (SMT) and Through-hole are two most common module packaging type. When comparing both, SMT surpasses Through Hole in advantages, which clearly define and SMT justify the majority (90%) use of this technology in board assemblies. Through Hole however is anticipated to remain in use in testing and prototype applications that may need manual adjustments and replacements.
PCB Layout	The recommended PCB land patterns for the modules are detailed in manufactures’ data sheets. The number of layers in the PCB is dictated by the host processor. A minimum of 4 layers will be required, with 6 or 8 layer PCB layout common.
Hardware Interfaces	The digital interface is typically a serial UART connection, Secure Digital (SDIO), Serial Peripheral Interface (SPI) or USB. The SDIO, SPI or USB connection will be required to support high data throughput applications. The digital interface will be connected to the system processor in the device.
Other Features & Consideration	Real-time clock for time-stamping, auto-sleep, and auto-wakeup modes, Supports Soft access point, Over the air firmware upgrade, evaluation kits, Onboard TCP/IP stack, Receive Sensitivity, Frequency References, User programmable (I/O), Manufacturer, Price
Certification/ Compliance	Some Wi-Fi module makers announce their products are fully Certified Modules. A commonly asked question is, “**if I use a pre-certified WLAN module in my design, do I need to perform regulatory compliance testing?”** The short answer is **YES**. Most of the regulatory bodies in the world like ETSI/CE rules in Europe have no provision for a modular approval. All approvals and certifications must exist at the device, rather than the radio module level. If you need more detail about the compliance/pre-compliance test, please check the Tektronix application note “Spectrum Pre-compliance for Wireless LAN Regulatory Testing”.

4. What Are the Tradeoff When You Are Selecting the Module?

There are three key factors to consider when evaluating wireless technologies: Data rate, range, and power requirements. Improving the data throughput and spectrum efficiency has been a key driver for the wireless communication research for the past 10-20 years. This focus has resulted in more complex channel coding and modulation methods with the higher cost and more power for signal processing. When you compare different Wi-Fi protocols, 802.11n and 802.11ac has the advantage of the higher data throughput, while 802.11b/g has the advantage in compatibility and power requirements.

802.11n provides operational advantages of higher data throughput, greater range and robust link quality, and enables greater network utilization. 802.11ac builds on high bandwidths over extended ranges by offering 2x the bandwidth for the 600 Mbps via 802.11n. It enables Wi-Fi solutions to meet today's demand for high capacity and high quality mobile real-time applications like video and voice. Using multiple antennas (MIMO technology) further increases the data rate and the range. These extended features, however come at a price through the use of multiple antenna structures, increased BOM design complexity, and the use of more power.

The embedded market has connected clients such as buildings, industrial and home automation products, sensors, Machine to Person (M2P) and Machine to Machine (M2M) data and control devices. These markets need and are driven by low power consumption and low data rate solutions. These markets are not concerned with bandwidth, but with battery life and compatibility. The data rates supported with b/g will be sufficient for most M2M applications. The 802.11b/g modules are ideally suited for the embedded space as the b/g protocol is still best for fully Wi-Fi compatible, low power applications.

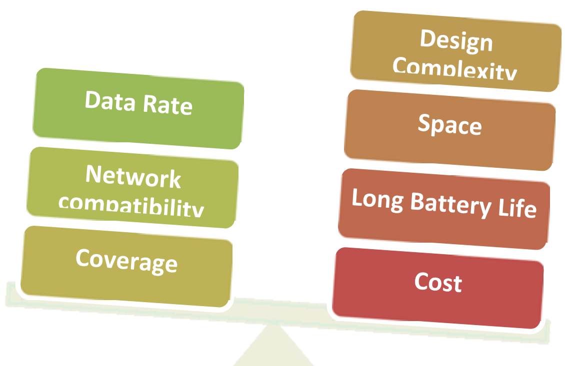


Figure 3: Typical Tradeoffs when selecting a Wi-Fi module.

There are some tradeoffs other than the protocol selection. Taking antenna selection for example, the Omni Directional antenna and Directional antenna are two main types of Wi-Fi antenna. An Omni Directional antenna has the advantage of being incredibly easy to setup as once it is mounted in a high position there is very little adjustment required, but the tradeoff is that the signal is being sent in all directions and is not being concentrated at the source. A directional antenna has the benefit of focusing a narrow beam of energy in one direction and thus greatly increasing the possible distance you can achieve a connection over. The tradeoff for this is that a little more time is required to manually rotate the antenna through 360 degrees and connect to the desired hotspot.

5. Do Wi-Fi Modules Eliminate the Need for RF Engineers?

Lots of manufacturers are wanting to build M2M devices by integrating a Wi-Fi module into their products. The biggest hurdle for those traditional non-wireless manufacturers, such as those making stoves and refrigerators, simply lack the RF expertise required to build the network devices. Fortunately, a number of RF module manufacturers, who design and build the Wi-Fi modules specifically for the embedded M2M market, can be your RF consultants during your integration design.

Some of the Wi-Fi Module Manufacturers

Atmel	Fasttrax	Nordic Semiconductor	RFM
B&B Electronics	Freescale	NXP	Roving Networks
Bluegiga	Infineon	Omron	Silicon Laboratories
CEL	Intel	Panasonic	ST Micro
Connect One	Laird Technologies	Parallax	Taiyo Yuden
Cypress Semiconductor	Lantronix	Phoenix Contact	Texas Instruments
Digi International	Linx Technologies	Powercast	Wi2Wi
DLP	Microchip	Rabbit Semiconductor	
EPCOS	Murata	Redpine Signals	

However, it is unpractical for the product development engineers to rely on the RF module manufacture to solve all of their RF problems. You may still need to hire an RF consultant, or look for help from a professional test and measurement company, like Tektronix.

In order to meet your test needs for both today and tomorrow’s 802.11 specifications, Tektronix offers a suite of tools to meet your particular needs. With the MDO4000B Series, the world's first oscilloscope with a built in spectrum analyzer, and capture time-correlated analog, digital and RF signals for a complete system view of your device. Engineers universally use oscilloscopes to debug analog and digital circuits in their embedded designs but may have limited or no experience with WLAN and RF test equipment. With the MDO4000B engineers can turn to a single tool to validate and debug complex components and system level issues that is familiar, easy to use and available at a much lower price point than using multiple instruments.

- For the first stage of testing, the MDO3000 can help with the first turning on of the radio, to do things like checking the power supplies and buses.
- For the second stage of testing, the MDO4000B + SignalVu PC can help with the Regulatory Compliance Testing.
- For debug, the MDO4000B can easily correlate time domain signals with frequency domain signals. Time domain signals could include the power supply lines, PLL’s, and serial buses. Frequency Domain information would be the Spectrum or Spectrogram to show signal history over time.
- Finally, SignalVu-PC could be used for WLAN signal demodulation to investigate problems with data throughput. The MDO worlds only Oscilloscope with an integrated Spectrum Analyzer. This powerful combination can help resolve hardware issues and identify software problems.

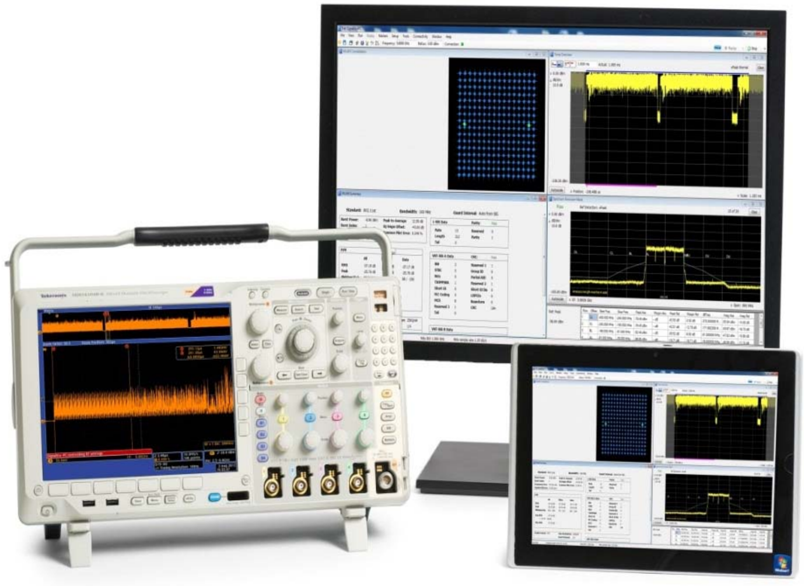


Figure 4: Tektronix MDO4000B Paired with SignalVu-PC to Analyze 802.11ac Signals

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