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Using External Amplifiers and Antennas in the License-Free Band

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Introduction
WLAN is moving outdoors: Both for fixed wireless and mobile Hot Zones. Whether or not WLAN manufacturers intended for their equipment to be used for extended range solutions, more and more people are using amplifiers to extend the range of their WLAN systems.

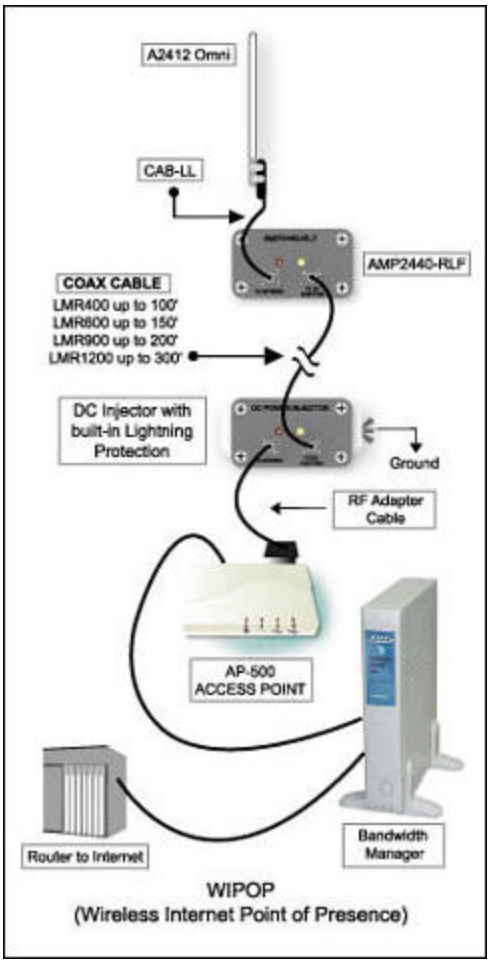
With growth in use of amplifiers comes an equal growth in misunderstandings about the sale and use of external amplifiers for the license-free bands. This article discusses some of the technical and legal issues associated with amplifiers.

To understand amplifiers, one needs to know certain technical terms. Please read thru this tutorial first:

www.ydi.com/deployinfo/wp-decibels.php

Why Use An Amplifier?
Most WLAN cards and Access Points (APs) have about +15 of dBm (32 mW) of TX power. A few claim up to +20 dBm (100mW). While this is good for indoor and short-range links of a hundred feet or so depending on obstacles, long range (miles) requires higher transmit power and/or high gain outdoor antennas. However, when you put the antenna outdoors to obtain the line-of-sight needed for long range, the coax cable from the radio to the outdoor antenna often introduces excessive attenuation to both the transmit and receive signals.

This figure shows a typical installation of an amplified single channel WIPOP (Wireless Internet Point of Presence). For best performance, the amp must be located at the antenna. This is to have minimum cable loss from the antenna to the LNA (Low Noise Amplifier) in the pole-mounted amp to minimize the



system noise figure. Likewise, to reach the full transmit power that the system is certified for requires the amp be placed right at the antenna. In effect, the amp takes the coax cable loss between the antenna and the radio out of the equation. It also allows for maximum TX power authorized and typically increases the radio receiver sensitivity by a few dB.

Amplifiers used for Time Division Duplex (TDD) radios such as FHSS and 802.11b DSSS radio must be bi-directional. Normally, the amplifier is in the receive mode and is amplifying all of the incoming signals. When the radio, AP or WLAN card transmits, it senses this RF energy and switches very quickly (less then 600 nanoseconds) into the transmit power amplification mode. When the transmitter goes off the air, the amp switches back to receive amplification mode.

Customers who use amps sometimes complain, "I don't want to use amps because they amplify noise and interference on receive." This is true; it amplifies everything across the entire band. That is what amplifiers do. However, the LNA does three very important things:

1. Boosts the received signal that the antenna pulls in before any appreciable loss in the coax cable.
2. Preserves the Signal to Noise Ratio (SNR) of the desired signal down to the radio.
3. Lowers the Noise Figure for the received system.

Field and lab tests show that these three things improve the receiver's sensitivity regardless of the coax cable loss between the antenna and the radio. ** (*See foornote.*)

FCC's Rules Regarding Transmit Power

A lot of confusion regarding the permissible use of after-market amplifiers and external antennas has risen because the FCC rules are hard to interpret at times. Not being a lawyer, I will do my best to explain the current regulations, but by no means should this be interpreted as all encompassing or legally binding. Even after getting close to 100 YDI systems FCC certified, we often go to the FCC for clarification of these rules.

Part 15.245 of the FCC rules describes the maximum effective isotropic radiated power (EIRP) that a license-free system can emit and be certified. This rule is meant for those who intend to submit a system for certification under this part. It states that a certified system can have a maximum of 1 watt (+36 dBm) of transmit power into an omni-directional antenna that has 6 dBi gain. This results in an EIRP of

+30 dBm + 6 dBi = +36 dBm (4 watts)

If a higher gain omni-directional antenna is being certified, then the transmit power into that antenna must reduced so that the EIRP of that system does not exceed +36 dBm EIRP. Thus, for a 12 dBi omni antenna, the maximum certifiable power is +24 dBm (250 mW (+24 dBm + 12 dbi = 36 dBm). ***

*** *Footnote: In practice, it is always better to use the highest possible gain antenna and the lower transmit power at the base station. This is because the higher antenna gain boosts the weak received signal from un-amplified client stations.*

For directional antennas used on point-to-point systems, the EIRP can increase by 1 dB for every 3 dB increase in gain of the antenna. For a 24 dBi dish antenna, it works out that +24 dBm of transmit power can be fed into this high gain antenna. This results in an EIRP of

+24 dBm +24 dBi = 48 dBm (64 Watts)

This is how extremely long-range certified systems can be successfully deployed. If all this math and calculations is confusing, you do not need to worry. Simply make sure that your system is installed properly with a Certified System from your vendor.

Only Systems Can be Certified

Many users, operators and installers typically buy an antenna from Vendor A, an amp from Vendor B and a radio from Vendor C. They do some power/loss/gain computations and figure their EIRP and summarize that since it does not exceed the power limitations set forth in the FCC's rule, their system is compliant. This is not true. Compliance with FCC transmit power limitations does ***not*** equal compliance with FCC regulations.

According to another FCC rule, Part 15.204, which governs the use of amplifiers and external antennas, you cannot use an amplifier with a Part 15 device - unless it is part of an FCC-certified system. Part 15.204 states:

> *(a) Except as otherwise described in paragraph (b) of this section, no person shall use, manufacture, sell or lease, offer for sale or lease (including advertising for sale or lease), or import, ship, or distribute for the purpose of selling or leasing, any external radio frequency power amplifier or amplifier kit intended for use with a Part 15 intentional radiator.*
>
> *(b) A transmission system consisting of an intentional radiator, an external radio frequency power amplifier, and an antenna, may be authorized, marketed and used under this part. However, when a transmission system is authorized as a system, it must always be marketed as a complete system and must always be used in the configuration in which it was authorized.*

If a system (radio, amp and antenna) has been certified, paragraph (b) states that you can't take parts of that system and use them separately. One must deploy a complete system that not only complies with the EIRP specified in Part 15.245, but the radio, coaxial cable, amplifier and antenna must be tested and certified together. From a legal standpoint, you cannot simply "roll your own" system in the field and expect it to meet the FCC's rules.

Even if you do not use an amp, you cannot attach an external antenna to any certified Part 15 radio unless that antenna has been tested and certified by the FCC. As stated in paragraph (c) of Part 15.204:

> *(c) Only the antenna with which an intentional radiator is authorized may be used with the intentional radiator.*

In other words, you cannot remove the antenna that came with an access point or client device, attach a coax cable and put a higher gain antenna on it in the field - unless the manufacturer had this system FCC certified with that antenna.

FCC Starts Enforcement

In early 2002, the FCC started enforcing these rules. In most cases, FCC inspections occur after someone complains. Complaints typically come from WISPs getting hammered with interference—perhaps from a competitor using high-power, uncertifiable amplifiers. In other cases, the FCC Inspector may learn of a license-free system from the media or other means and take it upon himself to inspect it while he is in the area doing other radio inspections. Typically, the Inspector is an FCC Field Engineer from a one of the several FCC field offices located throughout the US.

When the FCC Inspector visits, he takes note of all equipment used in the base installation. He asks the operator for documentation to show that the system is certified. He is not interested in the operator's calculation of how his EIRP does not exceed Part 15.247. He just wants to see evidence that the system deployed has been certified by the Commission. If it is not, the operator will likely get an Official Notice of Violation in the mail. He then has 10 days to reply with a list of "specific actions to correct the violation and to preclude its reoccurrence".

Conclusion

FCC compliance is imperative throughout the equipment supply line. Obviously, equipment manufacturers must offer FCC compliant systems but some seem to thumb their noses at the regulations. Always demand to see proof of FCC compliance for the specific system from your vendors. A sample of the type of information you need can be found at: *www.ydi.com/FCCinfo*

To find out if a system from a specific manufacturer is certified, get the Grantee Code from the vendor and go to: *www.fcc.gov/oet/fccid*. It will show all the certified systems for that company. For example, you can try the YDI Grantee Code: NM5.

Systems integrators and professional installers must ensure that the systems that they design and install are FCC certified. Imagine your embarrassment if one of your customers is found to be operating an uncertified system and you are the "professional" that designed and installed a non-compliant system. You just made a lawyer happy somewhere!

Finally, the operator must ensure that all of their systems have been FCC certified since he is ultimately responsible. The FCC is clearly stepping up enforcement. You don't want an a visit from the FCC to turn into an enforcement proceeding that could jeopardize your WISP business. As the operator of the system, you have primary responsibility should you be found to be in non-compliance. Further, it just makes business sense to be a good neighbor and make sure that you only use compliant systems so to reduce the probability of interfering with other WISP systems in the area, including your own. Many WISPs plan to sell their networks or company sometime in the future. Smart buyers will demand proof that the entire network is FCC compliant. If the seller cannot demonstrate proof of compliance, the buyers are either walking from the deal or demanding steep discounts in price.

*** Footnote: You cannot expect to improve the radio's receiver sensitivity by the dB gain of the LNA. This is because it amplifies signal and noise, plus introduces it's own noise. If you could, then amps would be made with 30 or even 50 dB receive gain allowing us to receive signals from the moon! But after a certain point, more receive gain only results in raising the noise level. The optimum receive gain for an amp (after taking out cable loss) is somewhere between 8 and 12 dB. More than that does little good. A lot more than that will swamp the receiver with noise making it deaf to the desired signals.*