Communications Amplifiers: Can They Really Take You Farther and Help You Be Heard Better?

By: Chris Heavens, Vice President/General Manager, AR Modular RF

As a designer and manufacturer of RF amplifiers we have always been confident in telling our customers that the more power output you have, the "better" your communications link. Just what is "better" needs defining of course; but simplistically you can either "go farther" or "be heard better," sometimes both at once, all other things being equal. The question of just how much "better" is a lot harder to quantify.

Being heard better

Systematically, all system losses (propagation path loss, physical obstructions, coax and connector losses etc.) and antenna gains are all "reciprocal" and as such they affect both communication directions equally. However, additional transmit power affects only one end of the path, specifically the end of the path receiving the amplified signal. In many scenarios the portable location has less power than the base or vehicle mounted system. This is exactly the reason for needing a small portable amplifier system.

By using an accessory amplifier to raise the transmit power, a signal that was previously a poor copy (3/5) with noise or interference can become a full copy (5/5) signal. The amplifier's extra power (20W or more) is sufficient to raise the received signal above the detection threshold of the far end receiver with enough signal to noise margin to make the copy "in the clear". Adding a 20W amp to a system that previously ran at a 5W level means you can add 6dB to the receive signal level. If the signal was originally very broken it was probably very close to the receiver threshold or had some other interference, so the extra 6dB of signal can give you almost a full 6dB of signal to noise. That may not sound like much to audio buffs, but it is huge when you are close to a radio system threshold; enough to make the amplified signal sound relatively loud and clear. If you were to further boost the signal another 6dB (80W) it probably would not have such a dramatic effect, because now you are only improving the signal to noise of a signal that is already a solid copy so it's not perceived to be as big of an improvement. It may result in a little less background noise or if you're in a digital mode, less dropped packets or digital errors, pops etc.

Going farther distance

We are asked all the time,"So how much farther can we go with your amp**?,**" and our first answer is nearly always the same: "Well, it all depends on a lot of factors, none of which are consistent from place to place or circumstance to circumstance". This is a truthful answer, but not one that is much help in answering the question in any kind of practical way.

A simple answer is to say that doubling the distance of a link in "free space" adds 6dB to the path loss, so at best adding our 20W amplifier to a 5W system (i.e. a 6dB gain) will give you no more than twice the distance. This answer is always followed by another question: "So how far is that," and then we are back to the first answer: "Well, it all depends!!" Aside from the humorous part of this loop conversation it is frustrating not to be able to give a quantifiable answer to a very valid question.

If the path is mostly clear open country (high level site to high level site, with line of sight), then adding the amp could nearly double the path length. So if it was 5 miles with a 5W output then it could be up to 10 miles with a 20W amplifier, assuming that you are still in the clear. But how many clear open paths like that do you encounter? Probably not too many! Unfortunately doubling the distance of the path nearly always means you will encounter some new path obstruction, more trees, more terrain hills, or more buildings, so you are not likely to double the distance in reality for a relatively long path like this. We have had reports of shorter 1km paths with trees that have become usable to 2 to 3km or so when using a 2 watt SINCGARS unit fully driving our man-pack amplifier to its full 20W. Now this power increase is a 10 times or 10dB jump in power and that corresponds mathematically quite nicely to tripling the distance. From the operator's point of view this was a significant improvement and something that he really wanted to have on a daily basis under all conditions. Of course the "under all conditions" statement is the difficult part because the variable conditions are almost limitless.

The urban warfare environment is even harder. You could still run the rule of thumb, 5 blocks without the amp, 10 blocks with the amp, all things being equal. It probably won't be equal as the new buildings might be taller, might be steel structure based and so on, but it's a reasonable place to start. As the adverts say, "your mileage may vary." Plus a very important factor is whether one or both ends of the link are inside the buildings. Being inside a building is nearly always a negative condition due to the attenuation of the signal due to the structure of the building.

We've had customers tell us that they were surprised when they used a 100W amp "to burn through a long path" and didn't get quite the big boost expected. There's no denying that 100+ Watts is a lot of RF power and compared to a 20 W backpack transceiver it certainly sounds like a lot, but mathematically it's only 7dB more. So how much farther do you think it'll go………yes that's right, just over double because 6dB is double. "But only in a perfect world with free space paths" … which of course was far from the conditions in which they were operating. It's just physics and math, darn it!!

REAL WORLD TESTING

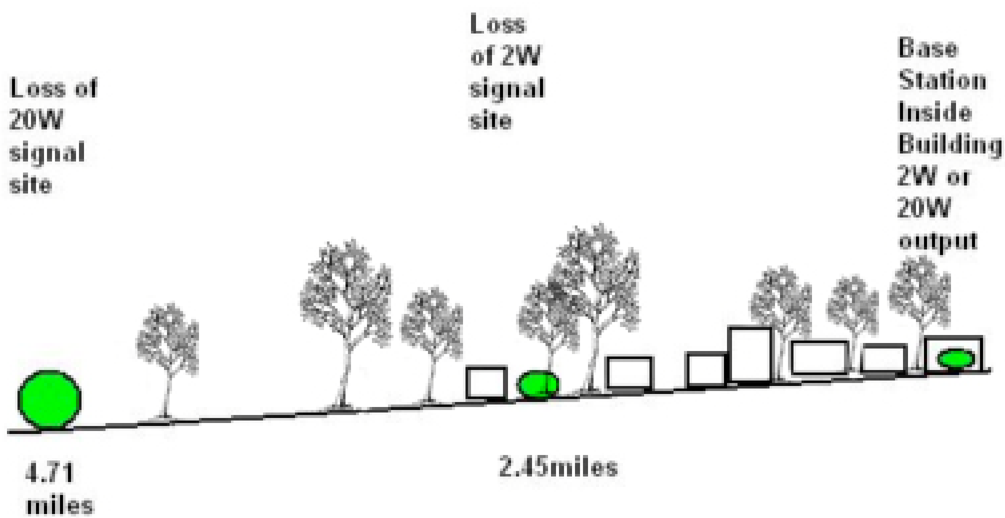
Having quoted the propagation theory, tests were made in the urban environment surrounding our manufacturing facility to see what happens in the real world. The area around our factory in Bothell WA is a demanding area from an RF propagation point of view, very hilly and heavily wooded with Pine and Poplar trees of up to 100ft tall in many places. Most of the industrial park area is comprised of 2-story 25 ft. tall tilt-up concrete structures surrounded by 30 to 40-foot trees.

THE PATHS UNDER CONSIDERATION

Two paths were considered in these tests.

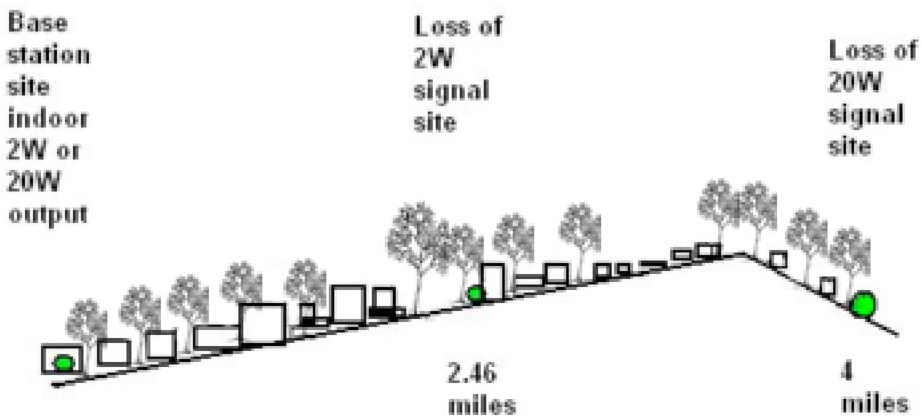
1. The first was a path to the south from our business along the course of a river/slough in a valley area. The path is essentially flat with buildings and a small city center along the first 1 mile of the path; after that it's a mixture of single story buildings, open land and dense intermittent wooded areas, with trees up to 75ft tall.

   a. **PATH ONE GROUND PROFILE PICTURE**



2. The second path was to the north across a densely built business park area on mostly flat but steadily rising ground that becomes residential buildings surrounded by heavy pine trees up to 100 ft. tall. The path rises to a ridge about 4 miles away and then rapidly falls away causing additional ground obstruction losses on the path.

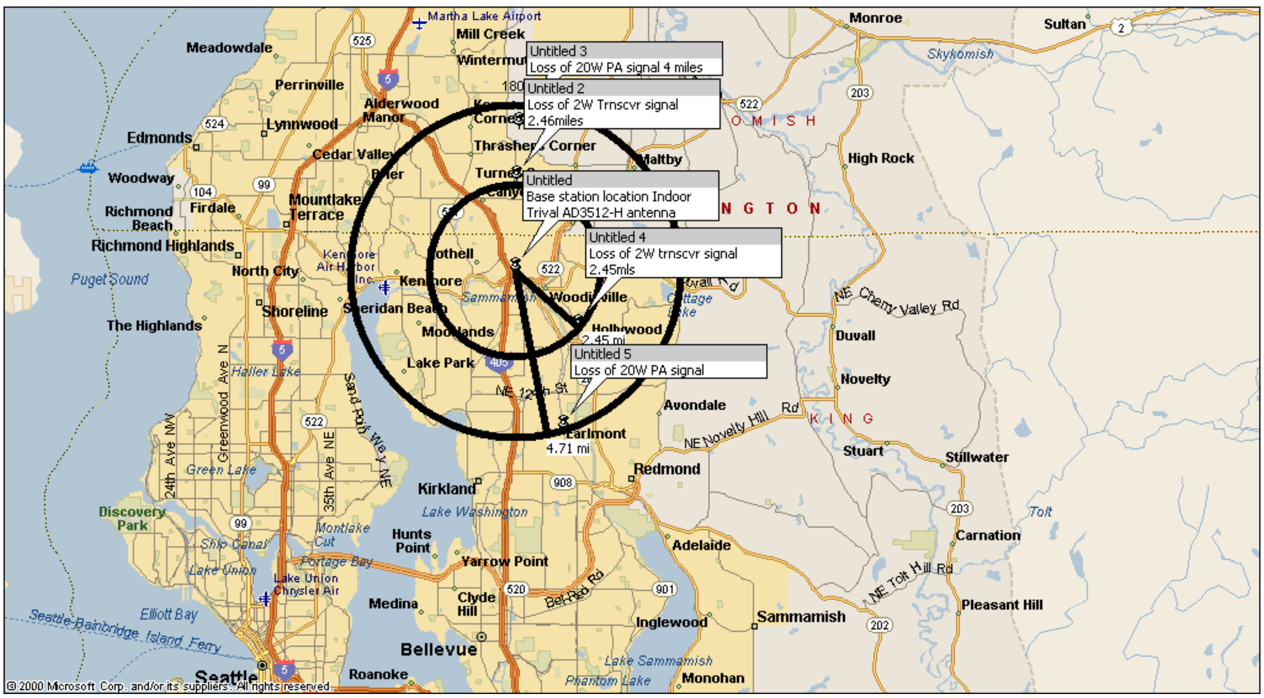
   a. PATH TWO GROUND PROFILE PICTURE



   b. TYPICAL ON PATH TREE OBSTRUCTIONS

In order to give a "worst case" urban situation, the base station was set up inside our facility with a 2W transceiver running in the middle of the VHF band driving a KMW1031 20W PA on which we mounted a Trival 30-512 "gooseneck" backpack antenna. The two paths were driven and receive levels monitored until the communications link failed due to squelch action on the mobile receiver. At that point the base station PA was turned on to give a 10dB increase in output power (nominal 20W) and then we continued to drive the path until communications failed again.

At no time was either path a "clear line of sight" condition. There was considerable above ground obstruction from buildings and trees across the whole length of the path. Our 10dB of PA gain essentially gave us nearly double the transmission distance or about 2/3 of the theoretical improvement, which considering the extensive above ground obstruction loss was better than expected. The path to the north was shortened due to the effect of the ridge at about the 4 mile distance. The additional losses due to that ground obstruction as well as the above ground tree losses made the path fail more quickly than the fairly flat ground path to the south.



ADDITIONAL LOSSES

Tree losses can be substantial and CCIR (International Radio Recommendations) cite tree losses as follows

- 200MHz at 0.05dB loss per meter
- 500MHz at 0.1dB loss per meter

So it's easy to add 10dB of path loss if you are in a heavily wooded area like urban Seattle, WA!

Building losses vary based on the type of construction and can easily add 6dB or more dependent on the frequency being used. If the building has a steel structure and/or mesh floors it can act like a screened room and essentially prevent radio communications from within the building other than through windows.

MANAGING LOSSES
Managing losses is an important part of operation of a radio system. Military operation of radios is usually done under less than ideal conditions and usually little can be done to improve performance. However, we reviewed a number of operator antenna set-ups to see what kind of performance variation occurs in real world situations.

The general rule should be, "use the highest gain antenna (in broadband antenna this often really means less loss!!), wear it as high on the body as possible, DO NOT shorten the antenna by folding it up and keep it away from walls and the ground. It should be noted that many systems reduce the output power when operated into a high VSWR (mismatch) as can exist when an antenna is tight against the body, or a wall or the ground. Antenna performance varies from vendor to vendor. We noted a 5dB variation in VHF signals when comparing 3 different 30-512MHz antennas. Using a less broadband antenna or one designed specifically for a sub-band (low band SINCGARS, AIRBand VHF) or high band VHF/UHF can make a dramatic improvement in received signals of 6dB or more.

The AR man-portable booster systems do not have this power management system and will attempt to transmit full power in spite of the high VSWR. When copy is poor, try to orient the body such that the antenna isn't shielded (obstructed) by the body. Here is a quick guide to how user configuration can affect the system performance based on actual measurements on our system

1. **REFERENCE CONDITION**: Full antenna height, at shoulder level, facing the line of sight to the distant site
2. Additional losses (vary with frequency and type of antenna so these are "averaged numbers")
    a. Antenna worn within the webbing vest close to the body and below shoulder level, 2 to 3 dB
    b. Antenna shortened by folding tape, single fold 2dB, double or multiple folds 6dB or more depending on frequency
    c. Antenna shielded by body due to orientation, 1-2dB

SUMMARY:
Adding a booster amplifier to your portable system such as the KMW1031 will give the user a significant improvement in "readability and/or operational distance" as shown by this report. Defining what that actual range is ahead of time is only possible after significant engineering effort with advance knowledge of the path conditions and isn't really appropriate for the kind of dynamic use environment in which these systems operate.