Wireless Amplifier "Mobile Test"

Jack Mayer
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678-492-1346
jackdanmayer@gmail.com

Tested Equipment

Engineering prototype of a wireless cellular amplifier. External antenna 5dbi magnetic mount omni. Internal antenna, patch panel directional. Gain unknown.

Test Location

The test was conducted in the mountains of central Colorado – the "front range" – at 8500'. The vehicle was driven away from the town of Woodland Park, into the Pike National Forest. This consisted of varied terrain, including mountain valleys with little cell phone reception.

Test Environment:

The "Mobile Test" is intended to test the performance of the device in a typical vehicle environment. The test vehicle was a Jeep Wrangler with a hardtop. The magnetic mount external antenna was mounted on the front bumper. This is about 4' off the ground. The internal patch antenna was mounted to the dash facing the passenger area in the same horizontal plane as the external antenna. The placement was near the drivers knee. It was at a 180 degree plane to the passengers and facing away from the external omni antenna. The distance between the two was 6.5'. Signal indication on the amp was no oscillation (blue light). Interestingly, moving the external omni to the fender produced oscillation. The distance was the same, but the engine was likely blocking signal when on the bumper.

The placement of the external omni was not ideal. Ideally it should be placed high on the vehicle and with 360 degrees of clear LOS away from the vehicle. It was not possible to place the omni on the roof in a position that did not produce oscillation on this vehicle. A re-test of the mobile environment will be performed with a larger vehicle. (A semi-truck with a mirror mount Maximum Cellular Super Trucker antenna will be used.)

A Motorola Droid X was used to record the results. Results were hand recorded using the phones rssi indication, and results along a selected route were recorded with an Android application – the RF Signal Tracker (http://sites.google.com/site/androiddevelopmentproject/home/rf-signal-tracker).

An Asus Eee Netbook with a Verizon 727 aircard was used to test data at each location, and continuously along the route.

Test Results

The test route was driven twice. Once with the amp off, and once with the amp on. In addition to averaging the dBm reading along the route, specific stops were made when the route was driven with the amp off. At these stops, the amp was activated and results noted. All stops were picked for various levels of "bad signal" to see the effect of the amp. The specific stops are noted in the table.

Stop	RSSI – no amp	RSSI – amp	Comments
1	-104	-78	Two bars on phone at -78; Rev A
2	-106	-91	Rev A
3	-120	-88	Rev A;
4	-120	-94	1X; deep in a mountain hollow; Nat. Access on computer, but connected. Voice connected fine.
5	-98	-65	At 10' outside vehicle, -84, @ 15'-90, @20' -95
6	-89	-57	At the edge of town

At each test location the computer data connection was tested. Stop 4 was the only stop where the connection was not Rev A – in that case it was National Access and the phone was on 1X. The netbook always connected to the Internet with the amp on. Only location 6 connected to the Internet with the amp off.

Driving the route with the amp on averaged a gain of 17dBm over driving the route with the amp off. But this can be deceiving, since the Droid X only records up to -120 dBm. Also, the external antenna placement affected the signal acquisition. In some locations the gain was truly impressive – in particular locations 3 and 4 which were in deep ravines over a hill from the known tower location.

There were no locations on this route where a voice connection could not be maintained with the amp on. With the amp off, more than half the route could not maintain a connection.

Conclusion

In this “Mobile” test the amp performed pretty much as expected. It handled both voice and data without issue. Its performance with data was very good. A continuous Ping test along the route had very few dropped packets when using the amp. That is pretty impressive considering the Verizon data coverage in this area.

The signal ”boost” area is sufficient for vehicle coverage. The one test moving outside the vehicle I would consider inconclusive for coverage results, but it did drop off rapidly beyond 10’ on that test.

Next Tests

1) Another “Mobile” test with better external antenna and better external antenna placement.
2) RV “static” test for use inside the RV. Note that a preliminary quick test inside the RV could not get the amp out of oscillation. The mag mount was on the roof on a metal plate and the panel was inside; horizontal displacement about 6’ with vertical displacement about 2.5’. I need to look at this closer.

Wireless Amplifier “Mobile Test” – Large Vehicle

22 August 2010

Test Location

Same basic location as the first mobile test. However, due to the vehicle used, the dirt road portion was not performed. Instead, equivalent signal-strength testing locations were found on paved roads.

Test Vehicle

The test vehicle was a Volvo 610 semi-truck (tractor). This contains a 61” (deep) sleeper outfitted like a motor home (refrigerator, bunks, inverter, etc). It is typical of an OTR (Over the Road) tractor used to haul freight, but has been modified for RV use.

Equipment

1. Same antenna (mag mount) and internal panel was tested with the amp – both with data and voice.
2. Mag mount antenna and WIRED Cyfre amp were tested against the wireless amp performance within the truck environment. This was a DATA-only test.

Stop	RSSI – no amp	RSSI – amp	Comments
1	-102	-82	Rev A
2	-106	-94	Rev A
3	-120	-91	Rev A;
4*	-120	-98	Rev A
5*	-98	-65	At 10’ outside vehicle,

			-91, @ 15'-96, @20' -99
6	-87	-59	At the edge of town

Note: locations 4,5 are not the same locations as in the first table (Mobile Test – Small Vehicle). All other locations are the same.

Observations

- It was difficult to mount the antennas on this vehicle. The typical mirror mount location on large trucks produced oscillation no matter where the interior patch panel was located. As a result, the Super Trucker antenna already present on this truck could not be used for a second set of tests (with a better antenna than the mag mount).

  The final location of the mag mount was on a right visor strut above the windshield, with the patch on the lower left dash facing the rear. Vertical separation was 7',and horizontal separation was 7'.
- Data always connected with the amp, although speeds in the weak reception areas were slow. Only sites 5 and 6 would pass data without the amp, and site 5 was so slow as to be useless. The amp provided significant improvement for data.
- Test site 5 showed that the radius of signal boost in this larger vehicle was not as impressive as in the smaller vehicle. Basically, there was little-to-no boost outside of the vehicle. This "may" be due to the higher location of the patch, relative to the ground (higher vehicle). There WAS boost present in the rear of the vehicle (bunk area), but it was generally an order of magnitude (-3 dBm) less than sitting in the drivers seat closer to the patch. I would have hoped that the boost would have been the same within the confines of the cab.
- Data tested with the wired amp vastly outperformed the wireless amp. I can guess that the reason is better signal gain, but the data is not sufficient to prove that, since rssi levels could not be collected from the aircard. With the wireless amp, an average of 5 speed tests (Speedtest.net to a local server) at location 4 (-98dBm on voice) was 345 kbps. With the wired amp (same mag mount antenna) the average of 5 speed tests was 624 kbps. This is a significant difference.

  For completeness: this one set of data tests was run through a Cradlepoint 350 router with the USB 727 aircard attached to it. The location relative to the patch antenna was 4' during the wireless test, so the rssi should have been similar to the voice test – at least in theory. All other data tests were run with the aircard directly connected to the computer USB port – including at Site 4. These extra sets of tests were the only ones run

through a router.

There are too many variables to determine the cause of the difference with certainty, but the end-user data experience is certainly better with the wired amp. However, without any amplification, no data could be effectively passed, although a connection was established. So the wireless amp is sure better than no amp.

Wireless Amplifier “RV Test”

22 August 2010

Test Location

Diamond Campground, Woodland Park, CO. This location does have “OK” voice and data without amplification. Voice rssi on the Droid X is an average of -86 dBm without the amp. Because of this, conclusions may be suspect.

Test Environment

Interior test environment viewed from the patch antenna location. Data testing was performed on the island countertop.

The test was conducted in a 42’ 5th wheel. The mag mount antenna was on the roof, on a 12”x12” metal plate. The internal patch antenna was inside, facing away from the omni on a

wall at 7’ height. It was slightly pointed “downward” so that the main radio beam should have been focused on the living area. The vertical distance between antennas was 3.5-4’, and the horizontal distance was 8’. Having the horizontal distance any closer produced oscillation after about 2 minutes. (For example, horizontal 5’, vertical 5’ produced oscillation)The seating area of the RV was 10-15’ from the patch. The location of the data pickup (aircard) was 5’ from the patch, and 3’ below it.

Observations

- At 5’ the average rssi was -76 dBm
- At 10’ the average rssi was -83 dBm
- At 15’ the average rssi was -86dBm
- Data: at the 5’ distance data speeds improved slightly from 620 kbps with no amp, to 757 kbps with the wireless amp. (10 tests to speedtest.net averaged for each sample.) At 10’ the amp had no measureable improvement on data throughput (5 tests of each sample).

I was somewhat disappointed in the 15’ results. There seems to be no improvement at this distance. But that may be a side effect of the original signal strength in the area. There was significant improvement around 10’, but beyond that it simply drops off. It would be interesting to see the data where the unamplified signal is in the -90 to -105 range, but I have no way to obtain that at this location (inside the RV). If you extrapolate the Small Vehicle test results from test 5 you might expect similar performance inside the RV (although that test was open-air). It is simply not clear from these results if the small panel is sufficient for Large RV interiors, but I suspect that a better antenna is required inside (although I do not know the specs on this panel, so it is hard to say…).

It should be noted that on the 2.4 GHz band there are MANY broadcasts in this area. Spectrum analysis shows at least 12 wifi access points with signal under -90 dBm. But that frequency should not interfere with the cellular frequencies. Motorola Canopy also blankets this area.

I do not view the requirement for data improvement to be close to the antenna to be a big deal, since use of a cellular router rebroadcasting local WiFi is the norm in this environment. Handheld devices like an iPod Touch or iPad can use the WiFi link and get a speed boost, as can laptops.

Antenna location proved to be difficult on this RV. Oscillation occurred when I would not have expected it. In my opinion this needs a closer look, since many RVs have limited mounting

locations that are convenient to wire. Mounting instructions are going to have to be clear, and detailed.