BDA's
BI-DIRECTIONAL AMPLIFIERS:

AN ARTICLE
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If ever you could get tired of a commercial asking "Can you hear me now" Paul Macarelli was traumatized by a cellular provider for tormenting us with this question that unfortunately gets to be more truth of a problem that not. These days with cellular system densities changing, frequency plans on the move and modulation schemes in total chaos, we add to the problem of R.F. proof buildings with the new move by many municipalities that require Public Safety radio systems to have man down coverage on the floor of every sub basement bathroom and boiler room in the universe. This seemingly good idea when pinned down by smoke, flames, or gun fire to be able to key your mic, or dial 911 and have a meaningful conversation while lead is zipping by means well but in the real world, this kind of want and the reality of get are often two very disparate things.

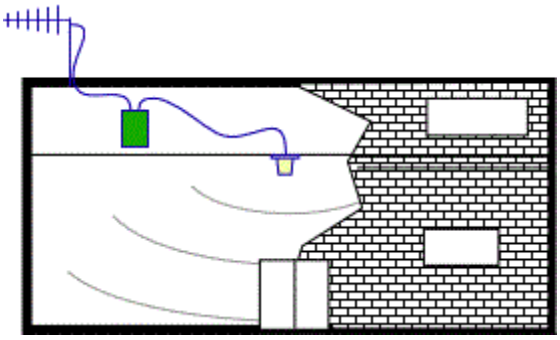
New companies are popping up that perform these tests and having been a part of some of this creative fluff, coverage in the deepest darkest janitor closet is great, but even when systems are designed by quote,,, Professionals, the systems often leave a lot to be desired from many aspects. With the cellular systems being so spread out frequency wise and the Public Safety systems encompassing everything under the sun from 700mc through 940mc with little gaps in between, then they throw this new charge toward 5G in to the cellular pile, and being told or being forced into installing one of these heinous BDA systems can be a life sentence of on-going maintenance costs along with the initial ransom of the installation price.

NETWORK	3G BANDS	3G FREQUENCIES	4G LTE BANDS	4G LTE FREQUENCIES
GSM/HSPA+	2, 5	1900, 850	2, 4, 5, 12, 17, 30	1900, 1700/2100, 850, 700, 2300
CDMA	0, 1	850, 1900	2, 4, 5, 13	1900, 1700/2100, 850, 700
GSM/HSPA+	2, 4	1900, 1700/2100	2, 4, 12, 66, 71	1900, 1700/2100, 700, 600
CDMA	2, 10	1900, 800	25, 26, 41	1900, 850, 2500
CDMA	2, 5	850, 1900	2, 4, 5, 12	1900, 1700/2100, 850, 700

The companies that perform the measurements AND try to sell you an installation need a good looking at. I was just involved in a 4th party check of a new building where the owner was told that he needed to install a BDA system and it was going to run him over $250,000.00 just for the installation with an annual maintenance cost of $2500.00 per year to continually re-certify the system.

Needless to say, this test was quite revealing. While the very central core of his building did fail the receive test, he did not need the system complexity that the surveying party recommended.

Often systems are over blown and even if they are not, due care needs to be observed when trying to either keep the costs reasonable, or even if you DIY (do it yourself) and get away with it, there are things you need to watch out for. BDA system design is a very complex subject but here are some basic things to look at.



ANTENNA SPACING AND DIRECTION:
Donor antennas are often directional and can be panel or Yagi type antennas. These antennas pick up the signal from a specific direction that is pointed away from the building to be served, opposite the Host antenna(s) as shown in the drawing so that the Host antenna inside of the building and the Donor antenna do not get in to a feedback loop and cause interference that will hamper communications in the area around the building. This feedback can also often affect the supported service such as the Public Safety system, or the cellular carriers in the area.

COAXIAL CABLE TYPES:
The right kind of Coaxial Cable is critical. Not only is the selection of the cable important from

Type	Material	Coverage [%]
Braid	BC - Bare Copper	95 %

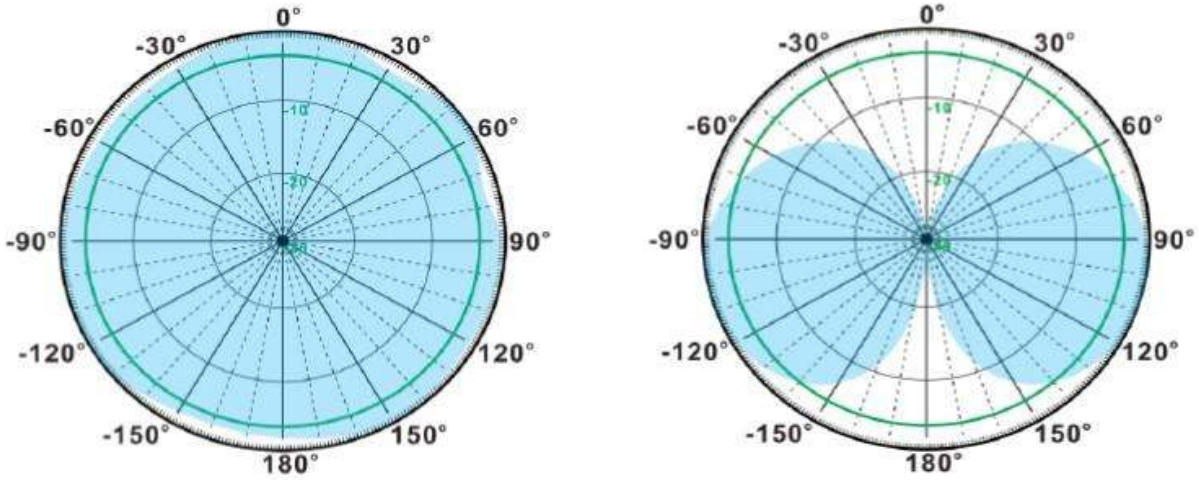
a system efficiency and loss factor, the leakage of signal through the shield of the cable is a huge problem. Many BDA systems use an inferior grade of Coaxial Cable.

Type	Layer	Material	Material Trade Name	Coverage [%]
Tape	1	Aluminum/Polyester/Aluminum	Bonded Duofoil®	100 %
Braid	2	TC - Tinned Copper		95 %

I personally frown on most types of Braided or Taped shield cables due to their leakage or aging issues. The table excerpts from some known manufacturers show that while some coax can have between 95% and 100% shielding, this shielding is directly related to the quality of the installation, age of the cable, temperatures of use, quality of the connector installation and frequencies involved. Heliax style coaxial Cable with a solid copper outer shield has no stated leakage percentage. When you call the various manufacturers they laugh at the question and ask if you are running near or over the power rating cuz this stuff just don't leak.

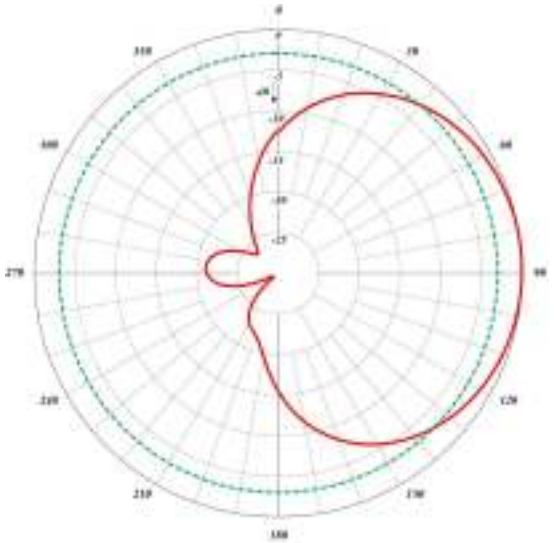
ANTENNA PATTERNS:
Selecting the proper antennas for both Donor and Host is perhaps the most critical trick other than the over all gain of both the up-link (toward the master system) and the down-link

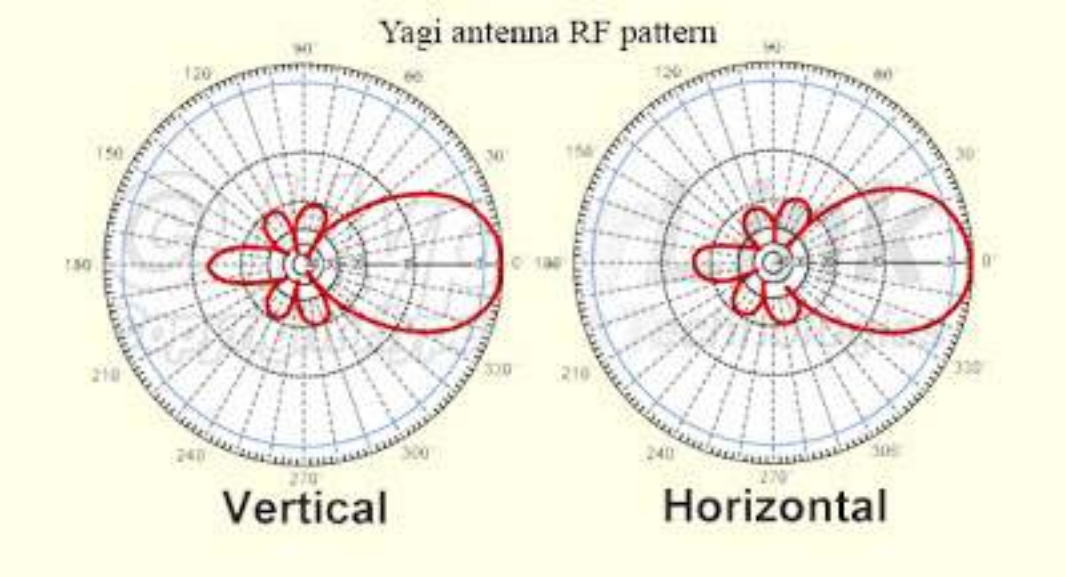
(toward the users) in the building. Donor antennas and Host antennas are selected for each location of use for their pattern and gain characteristics. The common antennae are the Omni, the Panel, and the Yagi. I won't say the word obviously but certainly the omni or Omnioid antenna shown in this figure,



like all antennas, comes in several flavors. Low gain Omni antennas are often used in BDA systems so that the broad shotgun approach to signal spewing in a controlled area is taken advantage of. The H plane is simply round and the V plane is like a 3D doughnut. The patterns shown here are a very low gain or near unity gain antenna. Notice that the V plane exhibits no beam squishing or "gain" effect though in this model due to the lack of a decent ground plane, there is some apparent down-tilt.

Panel antennas are a directional illuminator that often allows for wide to narrow coverage patterns that can emulate a Yagi. The image here exhibits about a 120 degree pattern spread which in the right circumstance, can be quite useful. The green dash line is a reference to unity for an Omni radiation pattern. No directional antenna is perfect. The little dribble to the rear of the pattern is typically the connector. There are minor circulating currents that run along the grounded surfaces and you can see from the radial gradients that the level of the energy on the connector is very low. If this were a Corner Reflector type of antenna with a side fed Di-pile, the dribble would typically be off to the 200 degree to 330 degree azimuth.


Vertical radiation pattern



Lastly for our example the Yagi as it is abbreviated, has similar pattern abilities to the panels antenna but the rear radiation of the Yagi is higher and less controlled though the gain can vary from only a few dB to over 26dB in some cases. Notice how the horizontal and vertical patterns are very similar. The number of fingers or lobes is usually directly related to the gain of the Yagi.

SYSTEM GAIN:

Many BDA designers take the stand that just because the system has 30 or 50 dB of gain in one direction or both that they should lett'r rip. This could not be further from the truth. In all my years of interference hunting for a major cellular carrier, the number of BDA interference problems that manifested themselves due to crazy high open loop gain, or super high automatic gain settings was the number one problem child. Even systems with high fixed gain levels of unknown amounts from off-shore manufacturers, the poor installations, leaky coax and feedback from Donor to Host or vice versa was the bane of trouble. Often inserting a simple 3dB or 6dB attenuator in to the Donor antenna line would cure the feedback issue. Many offenders really don't want to be offenders. They just want some signal and the want to be able to call their girlfriends after they get off the phone with the wifey telling them how late they are working.

If you are approached by a governmental agency who insists that you get on the wagon for measurements and then you get the bad news that your tomb needs some sort of assistive amplification, be smart. Be aware of what you are being told and what kind of system you are being sold. Do you really want to have a full service BDA for cellular, 5G and Public Safety? If you do, hang on to your fountain pen because it is going to be an ink leaking adventure. If you only need a Public Safety BDA, be sure that the system that gets recommended for you is ONLY what you need and not something that covers from DC to Gamma particles. Get in touch with the liaison for the agency that is serving your area and read the document that they must provide to you that lays out the terms of the change in the code. The document should be between 5 and 30 pages depending on the complexity.

Be sure that you have someone on your side that knows their way around this goat roping and can insure that you are not going to get taken to the cleaners. The system that I 4th party inspected should have had more than enough signal in their deepest darkest tomb but the multiple multi-story structures in between them and the prime site for the County along with some crazy dense foliage just trashed all hope of sliding by on this one. Be informed and don't take anyone's word for it. Your check book will thank you.