

Of gain and squint and tilt (Oh, my!)

When we say that an FM or TV antenna has gain, we don't really mean it—a broadcast antenna is a passive device and, so, it cannot increase overall signal power levels. (Patent-holder wannabees for perpetual motion devices should skip this part. They'll find it depressing!) What really happens is that there is an apparent increase in power in a desired direction which makes it look as if the signal level has been boosted, compared to our omni-directional or reference signal. But we must observe conservation of energy (there is no free lunch). That extra energy must be robbed from somewhere else. An AM array will tuck in your signal in some directions so as to prevent interference to neighbouring stations. A parabolic microwave antenna focuses the signal in a given direction, much like a searchlight. An FM or TV antenna will use multiple radiating elements, carefully arranged spatially, and driven with controlled phase and power levels so that a desired directional pattern is produced. Even an omni-directional multi-element antenna can have gain by focusing energy on the horizon at the expense of radiated energy up and down.

So much for the basics.

A high-gain omni antenna, then, produces a signal that is increasingly focused on the horizon. The horizontal beam gets narrower and narrower as the gain is increased. Our effective radiated power, our ERP, keeps increasing but now we can see that this is not the same as increasing transmitter power. This can become apparent when the antenna is way up high as in on a mountaintop high above our population centre. We can fall into the trap of using a high-gain antenna here, and most of our radiation will pass right over top of our market and off to the far horizon. One solution is beam tilt. By mechanically mounting our antenna at an angle from vertical, we can force the beam downwards towards our population centre. Of course, at the opposite azimuth the beam will pull up above the horizon.

This might not be what we want!

Electronic beam tilt can be used to pull the beam down a little at all azimuths at the same time. That's more common. But our beam is still very tight; we've just succeeded in aiming it a little better.

In addition to the main lobe on or near the horizon, any multi-element antenna will have nulls and lobes in its vertical radiation pattern. Again, if the antenna is up high over the target area, a null at, say, 24 degrees from straight down might fall right where we want to have some listeners. Changing the antenna design is one technique to make this problem



by Dan Roach

go away, by moving the nulls around; another more general one is called null fill. The phasing between antenna bays is jiggled a little so that the nulls are partially filled in. This also degrades the antenna gain a bit, but it's generally a small price to pay. Another solution to our problem would be to use a lower gain antenna, and bring the total power back up by using a larger transmitter. This way our beam becomes wider and easier to control. But, of course, now our power bills are going to increase (there really is no free lunch!).

Incidental lobes can be a problem, too. In addition to the main lobe, sometimes significant radiation can spill more-or-less straight up and down. The downward energy can cause problems with Safety Code Six standards. Some antenna designs are inherently better in this respect than others. And finally, high-gain antennas can be affected from a phenomenon called squint. This can happen with a narrowband design with lots of bays - say more than ten. Antennas that consist of rigid transmission line with an element every one wavelength are particularly susceptible. The problem is that as the signal is modulated, the wavelength changes, introducing an error in the (fixed) interbay spacing. As the bays are cascaded, the error keeps accumulating. It results in the antenna pattern changing with modulation, which is never a good thing. The antenna array can be centre-fed instead of end-fed, which will reduce the problem a little. If you need that much gain, it's probably better to look at a more complex (broadband) design.

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