What the heck's a decibel

Bels. Decibels. Centibels. Where will it all end? Here's exactly everything you may ever need to know about these fun electronic terms.

by George McCarthy

If there's any term that gets flung around the CB channels and the ham bands with reckless abandon, it's *decibel*. In fact, in typical CB jargon, decibels are usually known as *pounds*—a transformation with lineage lost in the antiquities of early CB.

But how many CB or ham operators using the term really understand its precise meaning and how it is related to radio communication?

Actually, the term was invented in the *telephone* communications industry where a standard was needed to refer to power levels existing along various lengths of telephone lines. It was noted early that the level of voice power tended to decrease in relation to the distance it had to travel over typical lines strung on telephone poles. That was quite easy to hear, but telephone engineers needed some base against which they could measure changes, so that they would be talking about the same thing when they referred to line levels.

The *bel* was too large a unit for practical measure power ratios equal to the logarithm to the base of 10 of the ratio of any two powers. The term was named after *Alexander Graham Bell,* who invented the telephone (not Don Ameche, as some early movie goers might think).

The *bel* was too large a unit for practical use, so the *decibel* is commonly used. It is a unit of power equal to one tenth of a bel. The important point to grab is that the decibel is a *comparative* unit of power. You need a given power level against which you compare a second power level, because you are going to express the *difference* in decibels.

Bels are ringing

The decibel, since it is an expression of *ratio*, can be expressed as either a *plus* or a *minus* when compared to a reference power. If a certain level of power is said to be at the zero decibel point, then any power levels that are less than that will be minus decibels (expressed as -db) and any power levels that are greater will be positive decibels, just expressed as db.

Exactly what power, in the form of voltage or current, might be chosen as the zero level depends on industry acceptance, for there has to be some *standard* or everyone would make up his own zero level.

It is commonly accepted that 1 db (one decibel) is the smallest change in audio power that can be detected by the human ear. When those commercials on television get cranked up to the point of driving you out of the room, you can be sure that the *level* has gone up a lot more than 1 db. A change of 3 db is equal to a doubling of power level. I swear that some of those tv commercials have been cranked up more than that.

Now that we have a firm grip on the fact that decibels are used to measure power changes, against some accepted standard, let's take a look at where we most commonly run into the use of the term.

CHART I

DECIBEL GAIN VS POWER RATIOS

DB	POWER RATIO
0	1.00
1	1.259
2	1.585
3	1.995
4	2.51
5	3.16
6	3.98
10	10
20	100
30	1000
40	10,000
50	100,000
60	1,000,000

Bel meter

The first one that hits us in the eye is the *S meter* on our CB or ham transceiver. Almost all of these meters are calibrated in *S units* up to a mid-range reading of *S-9* after which the readings are in decibels *above* S-9. This makes for some widely accepted readings that are duly reported to the other station. "You're coming in here like a tone of bricks, like a local, wall to wall and tree top tall," depending upon what band you are talking on. This is usually followed by a meter reading, such as "S-9 plus 20 db" or "seven pounds" or whatever.

Now, this might have some real significance to a person hearing such a report if he could be sure exactly what it meant. Unfortunately, these glowing reports are frequently followed by a few questions, such as, "could you repeat your handle and location and the report you gave me?" Hardly sounds as if you were really blowing them out of the room if they have to have a repeat on everything that you said!

In fact, there is an extremely wide variation in S meter readings among various radios. The ham station that just gave you an S-9 plus 20 db reading in Shell Rock, Iowa, on a Swan 350 might be followed by another ham from the same town telling you that you were an S-7 on his Drake TR-4.

What's going on here? Nothing unusual. Just a reflection of the fact that the Swan is a little on the generous side with the S meter, while the Drake is somewhat scotch. Actually, you are laying down exactly the same signal in that area. What you can't control, of course, is the antenna system that is being used to pick up your signal. It could be anything from a six element beam at 100 feet to a wet noodle hung out of an apartment house window.

Tough cookies

At this point you may say, "well so much for decibels," and make a pretty good case. But don't give up so easily. There is increasing acceptance of the standard of 50 microvolts of received signal to produce an S-9 reading on the meter. This at least leaves you fighting only the variables of receiver sensitivity and amplification, meter adjustment and the non-linear operation of most meters. But it would get you a little further into the ball park on having those meter readings mean something.

Far more comforting and meaningful is the reading that does exactly what the decibel is supposed to do—give you a

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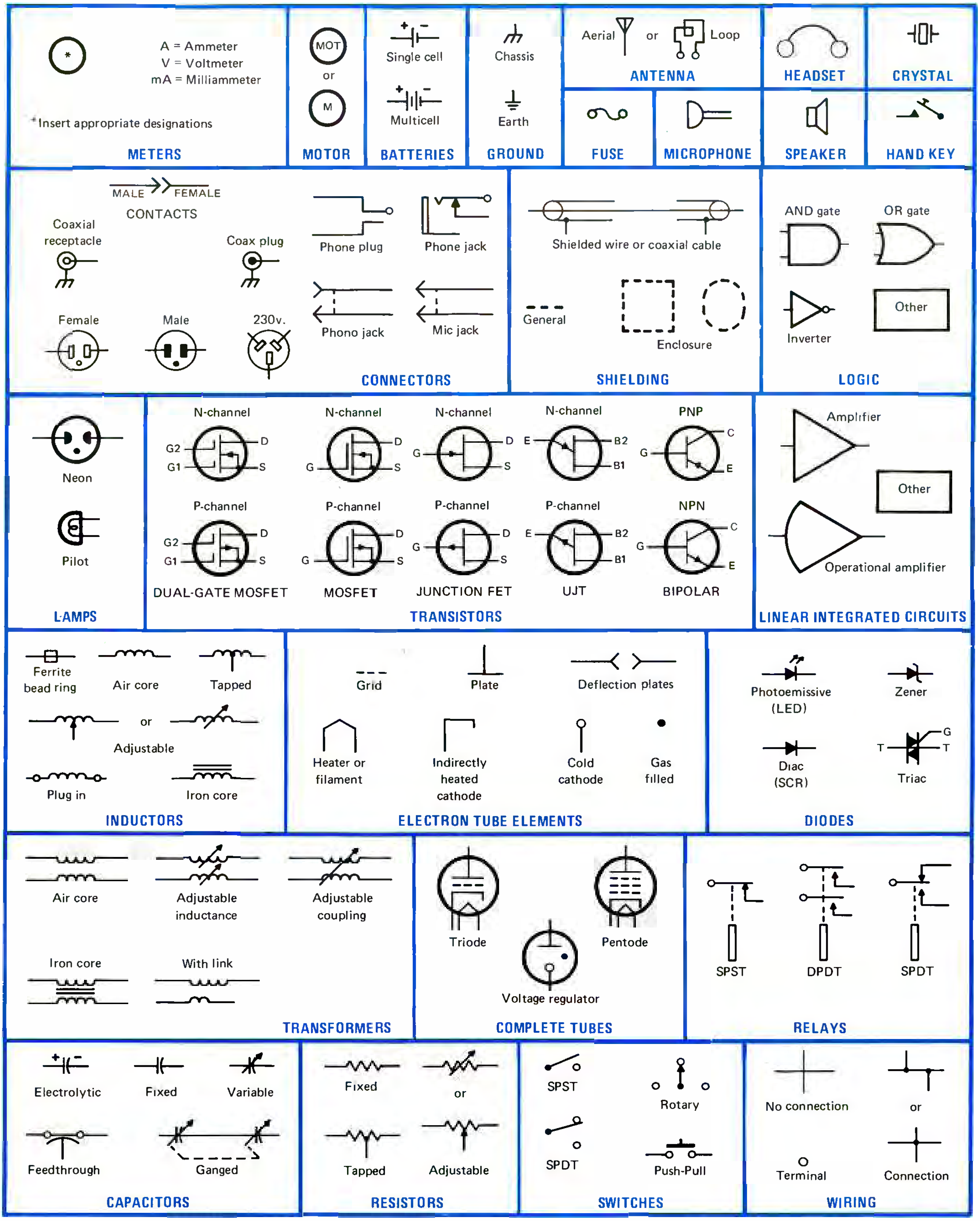
Electronic symbols
as used in Modern Electronics magazine



comparative report against some standard. The report, "you have the loudest signal that I'm hearing from the East Coast," is far more indicative of how well your rig and antenna system are working than an S-meter report.

You should know that S-meters are just measuring a small flow of current through a coil. Your radio has taken signals in the *microvolt* range (millionth of a volt) and amplified them until there is a flow of dc current that will cause the meter needle to deflect. The more current, the greater the amount of deflection.

Most radios use the meter for several functions, depending on how it is switched into the circuit. It is not uncommon for a meter to read voltage, plate current, ALC action and relative power output, in addition to the S units of received signal. Most meter circuits are adjustable, so if you think your meter's a little scotch you can make it give higher readings.

Where else do you commonly run into the term *decibel?* Why, on claims of performance, of course. This is an area where you frequently have to look to see what shell the coin is under. Unless the decibel is used in its comparative sense, it is a meaningless expression, much like the fellow who was asked, "how's your wife?" to which he replied, "compared to what?"

It is common to rate a receiver's sensitivity (ability to amplify small signals) in terms of microvolts for a signal to noise ratio expressed in decibels. Just what does this mean? You must remember that there is always random *noise* generated in both an antenna system and within a receiver itself. The level of this noise can be very important in relation to the receiver's ability to copy a weak signal.

It does no good at all to have an extremely sensitive receiver if it is just boosting every bit of voltage around. So, we are interested in the ratio of the strength of the *received* signal to the strength of the *random* noise. Now that we are dealing with power ratios, the old decibel is right at home.

A receiver with a sensitivity of ½ microvolt to a S/N ratio of 10 db will be able to take a signal of only one half of a millionth of a volt and amplify it to a point of ten times the power level of just the ambient noise level! That's a specification that means something.

Where else do we see those decibels being tossed around? In *antenna* performance claims. There are a multitude of glowing promises made by most antenna manufacturers, but all of the adjectives in the world are just so much puffing compared to a correct decibel rating. I wish that I could report that I put great faith in most of the claims that I see made for CB antennas. I know that most of them really do work real well, but I sure wish that they were a little less liberal with how they use the db when describing antenna performance.

CHART II

RATIO OF DECIBEL TO VOLTAGE

0 db	1 microvolt
20 db	10
40 db	100
60 db	1000
80 db	10,000
100 db	100,000
120 db	1,000,000

Firepower

Let's take a look at some of the parameters that really are a natural for the use of the decibel. Two of the major performance factors that we ought to be interested in when looking at an antenna are *gain* and *rejection*. Both terms can use decibels to describe performance.

Now you've got a firm grip on the relative principle when someone flings a db at you, right? "This antenna has a gain of 4 db," the ad says. "Compared to what?" you ask. You will not always find the basis of comparison listed. You may see a very small asterisk after the db. Look for the answer. If it says, "compared to an isotrophic antenna," the manufacturer is comparing his antenna to a theoretical antenna that actually doesn't exist. The so-called isotrophic antenna would radiate energy equally in every direction and plane. If it were inside of a giant bulb, it would light up all areas equally.

Squirting planes

Now, any antenna that is located in a typical installation is going to have a great deal of its radiated power squirting out in some planes and very little in others. Thus a typical vertical antenna pushes a lot more energy out of its sides than off the top or bottom. The energy that is radiated along the ground plane is partly composed of energy that isn't radiated from the top and bottom.

Therefore, compared to the isotrophic antenna, it will have more gain. A half wave dipole in free space has a gain of 2.1 db over an isotrophic antenna. A good vertical almost 3 db. Hey, that's equal to twice the power of an isotrophic antenna if 3 db is a doubling, right? That's correct. But is it really a useful figure for you?

It's a lot easier to dig if we compare things against some known value. Comparison against the half wave dipole is much better, but it doesn't produce quite the impressive figures, does it?

A beam antenna should not only have *forward gain* expressed against a specified standard, but should also list the *front-to-back ratio*, a natural for our friend the db again. In this case there should be no doubt, for we are talking about measuring a signal with the antenna pointing right at the signal source and then turning the antenna 180° around and taking another measurement off the back. The difference is a power ratio. It is expressed in dbs. A two element beam may have a front-to-back of up to 25 db and a four element up to 35 db. Much more claimed than that might cause a little suspicion among most antenna buffs.

Now that we've kicked the term decibel around a bit and shown a few areas in which it is commonly used, let's see just what those power ratios really are. Are they really significant? One look at the chart ought to make a believer out of you. It shows that every time you double power it represents an increase of 3 db. Might not sound like much, but it is doubling every time. When we talk about a 10 db increase we are referring to a power increase of 10 times! But the next time we jump another 10 db we are talking about an increase to 100 times the starting power!

Back from the front

Let's put this in terms that we can deal with and relate to some specific experience. We can use this information to really dig what a front-to-back ratio can mean to a CB or ham station.

Suppose we have an antenna that has a 20 db front-to-back ratio? In terms of power that means that a station behind our antenna will have to be 100 times as strong as one in front of our antenna to be putting in the same level of signal to our receiver. Now, that's a lot of extra power. If we are copying a station running a legal four watts on a CB channel, then one in back will have to run 400 watts to be as loud.

The *rejection* off of the sides of a beam antenna is frequently much greater than off the back, as much as 50 db in some cases. What does this mean? Look at the power chart. A signal off the side would have to be 100,000 times as strong as off the front to be equal! A 400,000 watt linear hooked up to a CB set? Not likely!

It may have occurred to some of you that a beam antenna could be a handy thing to have when the *skip* is really rolling in. Not to pick it up, but to *reject* it so that you can hear your buddy down the street and not have him drowned out by a signal coming from a couple of thousand miles away.

If you would like to relate decibels to some specific unit of measurement, look at our second chart which shows the ratio of decibels to microvolts. We choose 1 microvolt as the zero db level. By the time we get to 10 microvolts we have a 20 db change. At 60 db we are looking at 1000 microvolts! Now that's a respectable change in anyone's ball park. Double those db to 120 db and you don't double the microvolts to 2000, but now are looking at one million microvolts, or one big whole volt! ■