Amplifier Output Power

Say we have an amplifier with gain $G = 30$ dB (i.e., $G = 1000$).

If the input power to this amplifier is 0 dBw (i.e., $P_{in} = 1W$), then the output power is:

$$P_{in} G = P_{out}$$

$$(1 W) 1000 = 1000 W$$

Or, in dB:

$$0 \text{ dBw} + 30 \text{ dB} = 30 \text{ dBw}$$

Of course, the amplifier cannot create energy.

Q: Then, where does the power come from???

A: The D.C. power supply! (Every amplifier has one).
The output power $P_{out}$ cannot exceed the power delivered by the D.C. supply.

**Q:** What happens to the D.C. power not converted to signal power $P_{out}$?

**A:**

So, if we were to plot $P_{out}$ vs. $P_{in}$ for a microwave amplifier, we would get something like this:
We notice that the output power compresses, or saturates.

Note there is one point on this curve where the amplifier output power $P_{out}$ is 1 dB less than its ideal value of $G \cdot P_{in}$. In other words, there is one (and only one!) value of $P_{in}$ and $P_{out}$ that will satisfy the equation:

$$P_{out} = G \cdot P_{in}$$

At this point, the amplifier is said to be compressed 1 dB. Therefore, a 10 dB amplifier would appear to be a 9 dB amplifier!

The output power when the amplifier has compressed 1 dB is called the 1 dB compression point $= P_{1dB}$ of the amplifier.
The 1 dB compression point is generally considered to be the **maximum power output** of the amplifier.

The input power at the 1 dB compression point is said to be the **maximum input power** ($P_{in}^{max}$) of the amplifier. We of course can put more than $P_{in}^{max}$ into the amplifier—but we won't get much more power out!

Note the equation $P_{out}(dB) = [P_{in}(dB) + G(dB)] - 1 dB$ alone is **not sufficient** to determine the 1 dB compression point, as we have two unknowns ($P_{in}$ and $P_{out}$). We need another equation!

This second “equation” is the actual **curve** or **table** of data relating $P_{in}$ to $P_{out}$ for a **specific** amplifier.
Amplifier Efficiency

We can define amplifier efficiency $e$ as the ratio of the maximum output power ($P_{1\text{dB}}$) to the D.C. power:

$$ e = \frac{P_{1\text{dB}}}{P_{\text{DC}}} \quad \text{(don't use decibels here!)} $$

For example, if $e=0.4$, then up to 40% of the D.C. power can be converted to output power, while the remaining 60% is converted to heat.

We require high power amps to be very efficient!