Contents

The quest for the ideal rf amplifier.

The basic function of a power amplifier is always the same: to boost a low-power signal to a higher power level, to be delivered to the amplifier load. Because that role is so fundamental, it's tempting to view amplifiers as simple black-box devices, with an input, an output, and a constant amplification factor. In many instances, the black-box approach provides an adequate picture.

It fails, however, when the demands placed on an amplifier are extreme. Hardest to satisfy is the requirement for maximum capability of two or more conflicting parameters, such as the demand for broad bandwidth and high power in the same package.

Bandwidth versus power • The demand for broadband, high-power capability has spawned a bewildering variety of amplifiers. Part of the problem is in the bandwidth limitations of power devices themselves. In any device, gain falls off at higher frequencies, largely as a function of internal parasitic capacitance. Eventually a frequency is reached where gain falls below unity, and the device stops functioning as an amplifier. To extend the bandwidth, the designer must sacrifice the size—and, with it, the power-handling capability.

Considerable effort has gone into development of output devices capable of high-frequency operation *and* power handling, but the conflict between these parameters has never been fully resolved. The amplifier designer faces a clear limit in the gain-bandwidth product and power capabilities of the devices, and the necessity for tradeoff and compromise in the circuit.

Along with device limitations, the designer must contend with another aspect of the broadband/high-power dilemma—the tendency for high-gain, untuned amplifiers to break into oscillation. This is of considerable importance in broadband amplifiers, where design calls for stable operation over a bandwidth often of several decades. Combined with this is the frequent requirement that the amplifier be stable under conditions of severe mismatch in the load.

Designing for broad bandwidth and stable operation *within device limitations* is the designer's real job—and headache. But it is exactly in this area where the designer makes a major difference in amplifier performance. Here is an opportunity to create a circuit that gets the maximum out of available devices, and a good chance to keep advancing the state of the art.

Approximately perfect • The ideal black-box device would deliver rated power—with no variation in level—over its entire bandwidth. Good designing can *approximate* this ideal; the degree to which a designer must compromise amplifier performance determines the capabilities and limitations of the amplifier. He defines these by stating the amplifier's specifications. It is here, ultimately, that the person purchasing and using the amplifier must be knowledgeable.

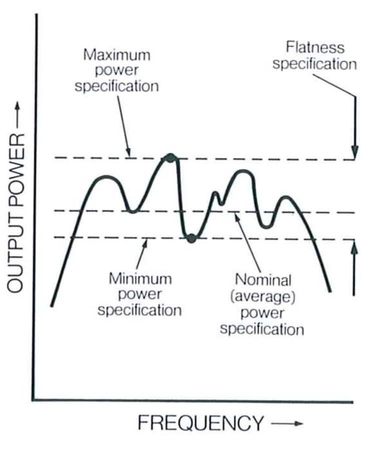
With a basic understanding of the parameters that have to be traded off in designing an amplifier, and an understanding of what the specifications mean and how they are stated, the user can select an amplifier with confidence that it will do the job it's intended for.

How broadband high-power amplifiers are rated.

The power rating • High-power rf amplifiers are usually rated for cw (continuous-wave) operation. Pulse power (see box on this page) is not an accurate indication of an amplifier's capability, simply because of the variables involved. Rating for cw operation gives the user an understandable figure on which to base his judgment—if, that is, the methods of rating are known.

A simple statement of the power output of an amplifier, expressed in watts or dBm, is not enough to describe the amplifier's capability. Output power varies with frequency in any amplifier. The degree to which it varies allows a certain flexibility in specifying output. For this reason, the user should know how the given figure was chosen, and the tolerances within which it fits.

Stated power can represent *maximum* power at a specific frequency, *nominal* power over the amplifier bandwidth, or *minimum* power available at any frequency within



the bandwidth. The graph illustrates the differences that can exist in power claims for a given amplifier.

Clearly, the way the designer rates his amplifier makes a difference. This depends to some extent on the intended use; certain ratings make more sense than others in particular applications. A *minimum* power rating guarantees availability of at least the full rated output over the entire bandwidth. This is the most desirable rating for the bulk of high-power rf applications, because it allows for headroom above a consistently predictable figure. Excess power capability is rarely a complaint.

In some special cases it's more meaningful to specify *nominal* power. Frequency tuning of apparatus, for example, calls for "ballpark" power from the amplifier. In this application, the ballpark is the flatness specification, and the quality of the flatness specification is as important as, or more important than, the absolute power being delivered to the load. Knowing the nominal power rating and the flatness specification, the user can still safely assume a minimum figure for output. Amplifiers rated in this way will always deliver power greater than the rated power minus the total flatness specification.

While it's possible to calculate minimum power if both a *maximum* power rating and a flatness specification are given, maximum ratings tend to be deceptive figures. They sound good; they also carry the implicit admission that, over most of the bandwidth, the actual output will be less than rated output. If no flatness specification is given, minimum performance remains entirely undefined.

Amplifier Research rates most of its amplifiers by minimum power, so the user can always predict minimum performance. Ratings are also given with a flatness specification, usually ±1.5 dB; conservative ratings overall give the user an extra margin of flexibility.

One more consideration regarding output power: the drive level required to obtain rated output. This can vary widely; in the worst case, the user can find himself unable to get full use from an amplifier simply because he can't provide enough signal. All AR amplifiers are designed to require a maximum of 1 mW input for full rated output. They will withstand twenty times rated input without damage.

The amplifier bandwidth • The upper and lower frequency limits of an amplifier are defined—in Amplifier Research specifications—as the frequencies where the rated output falls below the value of the minimum power specification, or below the range of the flatness specification.

Amplifier manufacturers don't always spell out the methods they use to determine bandwidth; some amplifiers, for instance, may be rated at the "3 dB down" points. These are the upper and lower frequencies at which output falls below the rated power by more than 3 dB. Because this figure is not clearly definitive, the prospective buyer should know how the designer has arrived at his specification.

"Instant" bandwidth • One consideration which is not generally given as a part of the bandwidth specification, but which is critically important to the prospective buyer, is a factor described as "bandwidth availability." In the wide variety of rf power amplifiers on the market, there are models that have a serious limitation

(continued on page 9)

Pulse Power

The difficulty in rating an amplifier on pulse power lies in defining the pulse characteristics. Duty cycle, repetition rate, and rise time all affect amplifier performance to such a degree that it is almost impossible to state pulse-power capability without knowing the specifics of the intended application.

In general, a linear amplifier—because it operates below the output saturation level—is capable of 2 dB to 6 dB more power in pulse mode than the rated cw output. The prospective buyer should question claims for pulse power that go much higher; unless provision is made to keep the amplifier below saturated operation, a great deal of the claimed power may actually be contained in the harmonic components of the output.

Greatest bandwidth-to-power combination—dc to 1 GHz

Series W

W-Series amplifiers are ultra-broadband, solid-state units providing linear operation over the spectrum from dc to 1 GHz.

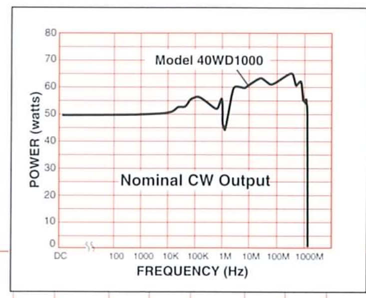
They are unconditionally stable, and can withstand infinite VSWR without damage or shutdown. Instant bandwidth and flat, predictable output make these amplifiers extremely versatile.

Model	Frequency Range	Power Output (watts), CW			Flatness (dB)	Minimum Gain (dB)
		Nominal	Minimum	Linear @ 1dB Compression		
1W1000A	100 kHz–1000MHz	3	1	1	±1.0	30
10W1000B	500 kHz–1000MHz	18	10	10	±1.5	40
25W1000	1–1000MHz	40	25	20	±1.5	45
30W1000M7	25–1000MHz	40	30	25	±1.5	45
40WD1000	DC–1000MHz	50	40	30	±1.5	47
50W1000A	1–1000MHz	70	50	40	±1.5	47
100W1000M1	80–1000MHz	130	100	60	±2.0	50
100W1000M1A	25–1000MHz	140	100	60	±2.0	50
200W1000M7A	80–1000MHz	270	200	140	±2.0	53
500W1000M7	100–1000MHz	600	500	300	±2.0	57
1000W1000M7	100–1000MHz	1200	1000	600	±2.0	60

- Input for rated output, all W-Series amplifiers, 1.0 mW maximum.
- For more detailed information, request "W" Series brochure.

500W1000M7

25W1000
200W1000M7A



New 40WD1000 extends frequency range of "W" Series down to dc.