

Application Note #57 The Pros and Cons of Dual-Band RF Amplifiers

By: Jason Smith, Manager Applications Engineering and Pat Malloy, Sr. Applications Engineer

In an effort to cover the relatively broad frequency ranges mandated by most modern EMC immunity standards, some amplifier vendors have resorted to combining two amplifier modules within a common enclosure. These so called dual-band amplifiers use frequency band switching to achieve an overall broader frequency band than either amplifier module could cover by itself. This application note will highlight both the benefits and drawbacks of this technique.

The most obvious benefit of a dual-band amplifier is the apparent simplification and possibly, the cost savings. Two amplifiers are replaced with one “box” with a single RF input and output and a bandwidth broader than either one of the amplifiers it has replaced. While on the surface the system may seem to have been simplified, a closer look within the “box” reveals a different story. While the two amplifier modules in a dual-band amplifier share a common power supply, the overall system is complicated by the fact that it now consists of not one, but two fairly complex amplifier modules. Furthermore, as can be seen in Fig. 2, additional RF switching, cabling and connectors are required which will adversely affect the RF output of both amplifiers. All of the additional components add insertion loss that may not present a problem at lower frequencies but can account for significant losses at higher frequencies.

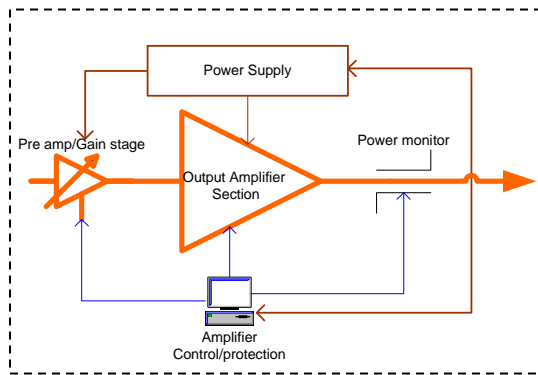


Figure 1: Basic diagram of a single-band amplifier

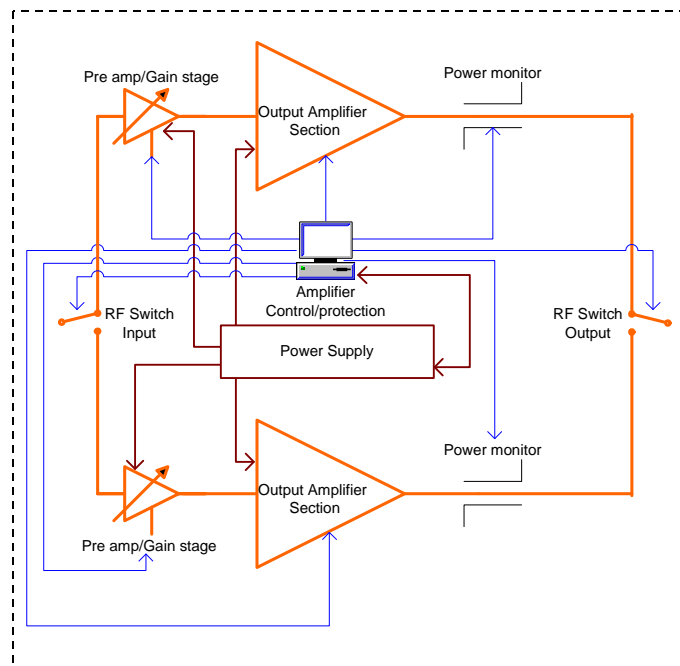


Figure 2: Basic diagram of a dual-band amplifier

For example, a relatively small RF insertion loss of 0.5 dB will result in a 12% loss in output power which may very well negate the ease of use and cost savings gained by opting for a dual-band amplifier. Another concern is that a failure of the common power supply will affect both amplifier modules rendering both inoperable. Finally, with additional complexity comes additional risk of failure and a failure of any one of the common components will take the entire amplifier system down.

If on the other hand a single-band amplifier is available that has the same frequency coverage as the dual-band amplifier, the choice is clear. The single band product will most likely be far less complicated and will thus be inherently more robust and reliable.

Dual-Band Amplifiers

Pros	Cons
<ol style="list-style-type: none"> 1. Extended frequency range 2. Single box configuration 3. Share control/protection circuitry (less redundancy, less cost) 4. Share Power supply (less redundancy, less cost) 5. Supports different output power levels for different frequency ranges. 6. Connecting RF modules internally will reduce cable lengths which <u>should</u> result in lower losses than if switched externally (see Annex A for more details). 7. Manufacturer can develop simpler narrower band modules instead of one more complex wide band module. 	<ol style="list-style-type: none"> 1. Added complexity of overall system <ol style="list-style-type: none"> a. Low power RF switch on input, [less likely to fail] b. High power RF switch on output, [more likely to fail] c. Shared power supply d. Shared control e. If any one of the above fails the whole amplifier is out of commission and needs to be repaired 2. The need to control the amplifier manually or with software to switch frequency bands 3. As power increases so does the size. Fitting both amplifiers into one box becomes increasingly difficult. 4. Two amplifier modules will consume more power since both amplifiers will always be powered while the system is on. 5. Extended hours running; when the “Box” is on both amplifier sections will be on whether being used or not. This will escalate aging of the amplifiers and needlessly nibble away at the system MTBF. (reliability concern) 6. Loss of RF output power do to signal routing and RF switching (see Annex A)

How to tell if an amplifier has band switching

Sometimes it is not apparent whether an amplifier contains a single RF range or has multiple ranges requiring band switching. Some key words to look for are *hybrid*, *dual-band*, and *frequency-switched amplifiers*. Another sign that an amplifier may have band switching is when some specifications are separated into frequency bands, such as frequency response and power ratings. If an amplifier’s data sheet states a frequency range and uses the word **instantaneous**, this means there is no band switching in this frequency range. If there is no clear statement of this sort, then it is questionable how the amplifier will perform. Data sheets should clearly state the nature of the amplifier design. If not, definitely ask the question.

External Switch Matrix

One can achieve most of the benefits of a dual-band switching amplifier while minimizing or eliminating its drawbacks by using two discrete amplifiers and an external switching matrix. At first glance one might think this is a more complicated setup but after weighing all the pros and cons it is shown to be elegant in its simplicity. Application Note #48 provides details on how a system with a switch matrix can be configured. The one difference between the external switch matrix and internal switching (dual-band amplifier) that seems to favor a dual-band amplifier is that RF losses are minimized since the amplifier stages are physically closer in a dual-band amplifier. While this is true, the benefits realized are not as significant as one might think. Please refer to Annex A for a side by side comparison.

Conclusion

This application note has contrasted dual-band amplifiers with two separate amplifiers combined via a switch matrix. On the surface, the dual-band amplifier seems to be a viable option, but when thoroughly scrutinized, the approach using two amplifiers plus a switch matrix is the clear winner. The most obvious benefits are the versatility of having two discrete amplifiers plus a switch matrix that can combine not only the amplifiers, but also signal generators, directional couplers, power meters, and loads. In addition, the inherent simplicity of this automated system translates to enhanced reliability. No matter which approach is selected; one must always consider product quality as well as the manufacturer's reputation and ability to support their products. Finally, as with any system, the sum of the parts is only as good as its weakest link.

Annex A

Comparison of RF output losses between a dual-band amplifier and two externally switched amplifiers

Assumptions:

Frequency range: 1 – 6 GHz

Amplifier break point: 2.5GHz

Basic module power output: 50 watts

Find worst case losses: @6GHz

One directional coupler is used to span both amplifiers

Product A: Dual-band amplifier

Use semi-rigid coax for all connections: SR250 best from manufacture (see references)

Coax lengths: a: Amplifier modules to switch (estimate best case) 0.3 meters x 2
 b: Switch to directional coupler (estimate best case) 0.1 meters
 c: Directional coupler to back of cabinet (estimate best case)
 0.1 meters

Other components in RF path to evaluate: RF Switch and directional coupler

Product B: Two amplifiers coupled to a switch matrix

Use high power, high quality coax: AR's CC100000 Series coax cables (see references)

Coax lengths: A: Amplifiers to switch (estimate worst case) 1 meter x 2
 B: Switch to directional coupler (estimate worst case) 0.5 meters

Since the RF output is available at the coupler with this setup, there is no additional cable loss to consider.

Product A: Dual-band amplifier		Product B: Two amplifiers plus a switch matrix	
Semi-rigid coax A and connectors	0.315 dB	coax A and connectors	0.53 dB
Switch	0.3 dB	Switch	0.3 dB
Semi rigid coax B and connectors	0.185 dB	coax B and connectors	0.32 dB
Directional coupler	0.45 dB	Directional coupler	0.45 dB
Semi rigid coax C and connectors	0.185 dB		
Total	1.435 dB	Total	1.6 dB
Available Power after losses	35.93 Watts	Available Power after losses	34.59 Watts

Only a 0.16dB difference!

Clearly there is not a significant difference in losses between the two configurations. However, the external switch matrix provides a great deal of flexibility for future expansion. Additional amplifiers and loads can be added or a complete reconfiguration of the system is possible by merely adding additional switches.

References:

Semi-ridged cable losses <http://www.megaphase.com/system05.html>

High power high quality coax cable http://www.arww-rfmicro.com/post/CC100000_Series.pdf