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Another RF Combiner/Splitter

Combine or split any number of modules with minimal loss and great port isolation.

The use of combiners to make a higher power amp from several lower power modules is nothing new. What is new, or at least a different approach to an old design, is a combiner that will accept odd or even number of modules with minimum power loss and fault protection.

1. History

Wanting a little more power, and having a free broadcast pull, I built an 8877 tubed kilowatt amplifier for 2 meters. Since my HF amp uses eight MRF-422 transistors and four quiet muffin fans, I had forgotten about the noise from a blower adequate to cool a tube amplifier. The shack is an 80 square foot building and the blower noise was irritating at best.

The HF amplifier uses 28 volt transistors and as the power supply was already made, the choice of suitable transistors was limited.

Not wishing to re-invent the wheel, I looked for a ready to go unit, unfortunately I could find nothing on the market using 28 volts at the kilowatt level.

Checking Motorola's web site revealed they are recommending the MRF-141G for higher power at 28 volts. Rated at 300 watts, these Gemini devices are not without fault; the chief one being a lot of power dissipated in a small footprint. Application note AR-313 describes the construction of a 10 MHz to 175 MHz broadband amplifier.

This unit is also sold by Communications Concepts [1] in kit form. Four to six of these modules combined would fill the bill. The question was how best to combine them without putting a high priced transistor at risk. Also, would it be possible to make this an "add a module as finances permitted" project without losing power in a dummy load by employing an odd number of modules.

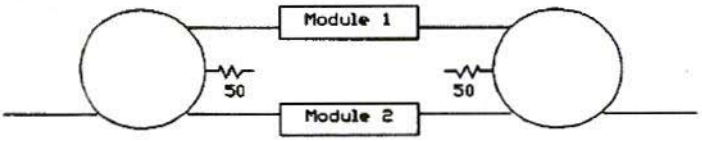


Fig.1: Hybrid Ring

2. A Study In Frustration

The most common form for safely combining power amps or modules at VHF and above is the 1-1/2 wave hybrid ring as shown in Fig 1. Theory and construction has been well documented previously [2]. Two rings are required, one to split the input power and the other to combine the outputs of the modules.

Claimed port-to-port isolation approaches 30dB with negligible loss of power. If one module is goes faulty, half of the remaining modules power is fed to the output and the other to the dummy load. The operating amp still sees 50Ω. So far so good.

Figure 2 illustrates the requirements for four amplifiers. Adding two more modules, however, has increased the number of rings from two to six. In addition, if three modules operating at full power would fulfil the requirement, the fourth would be necessary as one half of the third modules output would be dumped to the load resistor.

Several "authorities" I consulted were clueless. I was desperate.

3. The "N-Way" Combiner

Searching the web for ideas, I found Myat Engineering [3]. Among other things, they manufacture a high power multi-port combiner for FM broadcast named the E*Star (TM). Comprised entirely of 1/4 wavelength sections of transmission line and an appropriate number of loads, this combiner offers outstanding port-to-port isolation and the ability to use an odd or even number of modules without sacrificing performance.

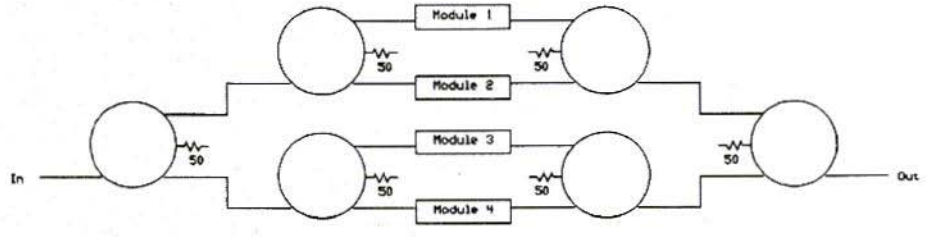


Fig.2: Four Amplifier Combiner

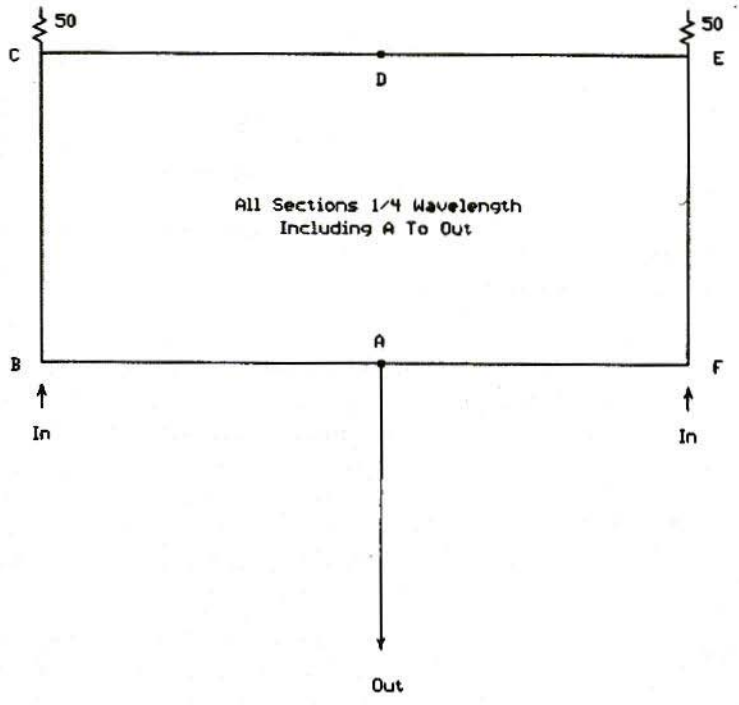


Fig.3: Two Module Combiner

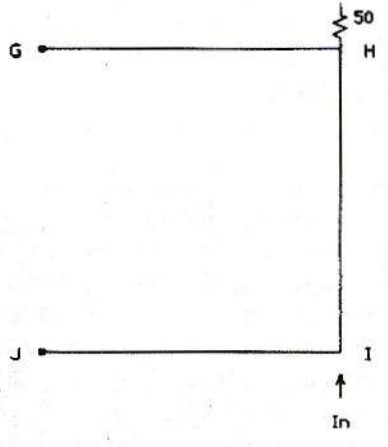


Fig.4: Adding an Additional Port

Figure 3 illustrates the concept based on two modules. Like the hybrid ring, port-to-port isolation is accomplished by RF arriving 180° out of phase from the opposite port. Here again, faulting one port allows continued operation at half power.

Unique to this design is the ability to add a third, fourth, fifth or sixth port without significant loss of power.

One additional port is shown in Fig.4. Connections G and J are tied to D and A (Fig.3) respectively to add the third port. Duplicating Fig.4 again would allow the fourth port to added and so on. The quarter wave section from A to Out is used for matching to a 50Ω load.

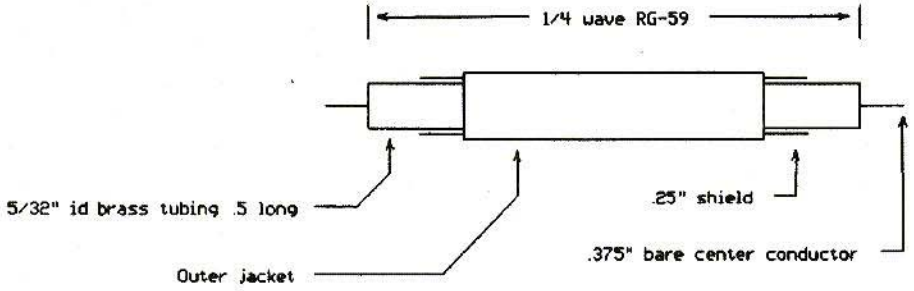


Fig.5: 1/4-wave Stub Construction Details

The impedance of this section is determined from the formula (A*50) where A=50/# of ports.

For example:

In a two port device, A=25

$\sqrt{(25*50)} = 35.36\Omega$

A three port would be A=16.67

$\sqrt{(16.67*50)} = 28.87\Omega$

Four ports = 25Ω

Five ports = 22.36Ω and

Six ports = 20.41Ω

4. Construction

RG-59 coax is used throughout with the exception of the output matching line. Each 1/4 wave section is made as shown in Fig.5. I used solid dielectric cable and found 1/4 wave at 144.2 MHz equalled 13.5 inches. I chose to make my combiner rack mountable as shown in the photos.

Any layout should work well as long as the shields are connected close to the connectors. The output matching section is constructed in the same fashion. Two parallel connected 75Ω lines (37.5Ω) seem to work well with two ports. Similarly, a 50 and 75Ω line yield 30Ω for a three port and a pair of 50Ω cables equal 25Ω for a four port.

Closer impedances can be obtained by constructing the matching line from copper pipe at the expense of making the unit larger.

5. Bench Test

When construction is complete, terminate the output and all input ports except two inputs into 50Ω low power loads. Apply a signal generator to one input and a receiver to the other. Measure isolation between all ports in this fashion. I measured about 38dB with a Cushman CE-3 and an FM receiver set at critical squelch. A quick check with the engineers at Myatt confirmed this is a correct number for their units. Lacking lab equipment, I

cannot state mine is an absolute obtainable number, but it is reasonably close.

Next, terminate the inputs with dummy loads of appropriate power and apply power to the output port. The power should be evenly divided at the input ports with < 2% loss. Once you have obtained good port to port isolation and equal power division, the project is complete.

6. Conclusion

This approach to combining lends itself well to easy expansion. By simply adding three quarter wave sections and changing the output matching line impedance, additional modules can be added as finances permit. Remember, as with any combiner, the coax from the modules to the combiner inputs MUST be of equal length.

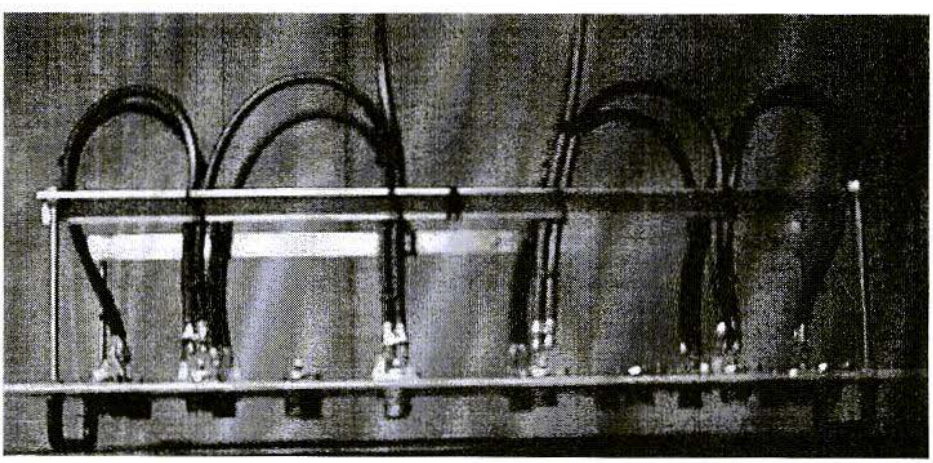
Also, if a module is pulled from service, the input port must be terminated in 50Ω. That's it. Enjoy being able to run an odd or even number of modules without wasting power or worrying about frying expensive transistors should a module fail. If you are unfamiliar with combiners, I strongly urge you to visit Myatt's web site. They have an excellent tutorial on the subject.

7. References

[1] Communications Concepts, 508 Millstone Dr, Beavercreek, OH 45434-5480

[2] HY-brid HI-power, Tom Pettis, QEX, January 1990

[3] Myat Engineering, Norwood, NJ 07648-0425 (www.myat.com)



A Completed Combiner