SOLID STATE MICROWAVE GENERATOR AND POWER AMPLIFIER

RELATED APPLICATIONS

The present Application for Patent claims priority to U.S. Utility Application No. 14/732,114, entitled "Solid State Microwave Generator and Power Amplifier," filed June 5, 2015, and assigned to the assignee hereof and hereby expressly incorporated by reference herein.

BACKGROUND

Power amplifier apparatuses can utilize magnetron or other vacuum tubes to achieve an amplified power output relative to power input. Such devices can be fragile and have a limited life.

SUMMARY

At least one aspect is directed to a power amplifier system. The power amplifier system can include a first power amplifier unit that can receive an input power signal and can provide an output power signal. The output power signal has a higher power than the input power signal. The power amplifier system can include a power splitter unit that can receive the output power signal from the first power amplifier unit and can generate a plurality of split power input signals, each of the plurality of split power input signals in-phase with one another. The power amplifier system can include a second power amplifier unit that can receive the plurality of split power input signals. The second power amplifier unit can include a plurality of power amplifiers. Each of the plurality of power amplifiers of the second power amplifier unit can receive one of the plurality of split power input signals and can provide one of a plurality of split power output signals. The power amplifier system can include at least one isolator unit that can couple at least one of the plurality of power amplifiers of the second power amplifier unit with a power combiner unit. The power combiner unit can receive the plurality of split power output signals from the second power amplifier unit via the at least one isolator unit and can combine the plurality of split power output signals into a unified power

signals can include exactly four split output power signals that are substantially in phase with one another. The power combiner unit can include a polytetrafluoroethylene (PTFE) element at least partially defining a chamber, and a conductor element disposed at least in part in the chamber. The power combiner unit can be electrically coupled with an output connector and the power combiner unit can be disposed at least in part proximate to a cooling plate.

In some implementations, the first power amplifier unit receives the input power signal and provides the output power signal. The power splitter unit can receive the output power signal from the first power amplifier unit and can generate the plurality of split power input signals. The second power amplifier unit can receive the plurality of split power input signals and can provide the one of the plurality of split power output signals. The at least one isolator unit can couple the at least one of the plurality of power amplifiers of the second power amplifier unit with the power combiner unit. The power combiner unit can receive the plurality of split power output signals from the second power amplifier unit via the at least one isolator unit and can combine the plurality of split power output signals into the unified power output.

At least one aspect is directed to a microwave generator unit having a power amplifier system. The power amplifier system can include a first power amplifier unit that can receive an input power signal and provide an output power signal. The power amplifier system can include at least one power splitter unit that can receive the output power signal from the first power amplifier unit and that can generate a plurality of split power input signals, each of the plurality of split power input signals in-phase with one another. The power amplifier system can include a second power amplifier unit having four power amplifier devices that can receive the plurality of split power input signals. Each of the four power amplifier devices of the second power amplifier unit can receive one of the plurality of split power input signals and can provide one of a plurality of split power output signals. The power amplifier system can include at least one isolator unit that can couple at least one of the plurality of power amplifiers of the second power amplifier unit with a power

combiner unit. The power combiner unit can receive the plurality of split power output signals from the second power amplifier unit via the at least one isolator unit and can combine the plurality of split power output signals into a unified power output. The unified power output can have a power of substantially (e.g., +/- 25%) 1kW and a frequency of between 2.40GHz and 2.50GHz.

In some implementations, the microwave generator includes a power supply module having a phase lock loop module configured to generate the input power signal. The first power amplifier unit can receive the input power signal from the phase lock loop module. The microwave generator can include a case having a fluid cooling channel, a power supply module, a user interface, a RF digital synthesizer, and an RF output socket.

At least one aspect is directed to a method of providing microwave frequency range output power from a solid state power amplifier system. The method can include receiving, by a first power amplifier unit, an input power signal. The method can include providing, by the first power amplifier unit, an output power signal. The output power signal can have higher power than the input power signal. The method can include receiving, by a power splitter unit, the output power signal from the first power amplifier unit, and generating, by the power splitter unit, a plurality of split power input signals, each of the plurality of split power inputs signals in-phase with one another. The method can include receiving, by a second power amplifier unit, the plurality of split power input signals. The second power amplifier unit can include a plurality of power amplifiers. Each of the plurality of power amplifiers of the second power amplifier unit can receive one of the plurality of split power input signals and can provide one of a plurality of split power output signals. The method can include coupling, by at least one isolator unit, at least one of the plurality of power amplifiers of the second power amplifier unit with a power combiner unit. The method can include receiving, by the power combiner unit, the plurality of split power output signals from the second power amplifier unit via the at least one isolator unit. The method can include combining, by the power combiner unit, the

plurality of split power output signals into a unified power output having a frequency of between 2.0GHz and 3.0GHz.

CLAIMS

1. A power amplifier system, comprising:

a first power amplifier unit to receive an input power signal and provide an output power signal, the output power signal having higher power than the input power signal;

a power splitter unit to receive the output power signal from the first power amplifier unit and to generate a plurality of split power input signals, each of the plurality of split power input signals in-phase with one another;

a second power amplifier unit to receive the plurality of split power input signals, the second power amplifier unit including a plurality of power amplifiers, each of the plurality of power amplifiers of the second power amplifier unit configured to receive one of the plurality of split power input signals and to provide one of a plurality of split power output signals;

at least one isolator unit to couple at least one of the plurality of power amplifiers of the second power amplifier unit with a power combiner unit; and

the power combiner unit to receive the plurality of split power output signals from the second power amplifier unit via the at least one isolator unit and to combine the plurality of split power output signals into a unified power output having a frequency of between 2.0GHz and 3.0GHz.

2. The system of claim 1, comprising:

a directional coupler configured to receive the unified power output from the power combiner unit and to provide the unified power output as output of the power amplifier system.

3. The system of claim 1, comprising:

the first power amplifier unit including three power amplifier devices.

4. The system of claim 1, wherein the first power amplifier unit comprises at least two power amplifiers connected to each other in series.

5. The system of claim 1, wherein the power amplifier system is part of a microwave generator.

6. The system of claim 1, wherein the power splitter unit includes a first power splitter device coupled to both a second power splitter device and a third power splitter device, comprising:

the first power splitter device configured to receive the output power signal from the first power amplifier unit;

the second power splitter device configured to provide a first of the plurality of split power output signals to a first of the plurality of power amplifiers of the second power amplifier unit, and to provide a second of the plurality of split power output signals to a second of the plurality of power amplifiers of the second power amplifier unit; and

the third power splitter device configured to provide a third of the plurality of split power output signals to a third of the plurality of power amplifiers of the second power amplifier unit, and to provide a fourth of the plurality of split power output signals to a fourth of the plurality of power amplifiers of the second power amplifier unit.

7. The system of claim 1, wherein:

the first power amplifier unit includes exactly three power amplifier devices configured in series;

the power splitter unit includes exactly three power splitter devices;

the second power amplifier unit includes exactly four power amplifiers configured in parallel;

the at least one isolator unit includes exactly four isolator devices; and

the power combiner unit includes exactly three power combiner devices.

8. The system of claim 1, comprising:

the power amplifier system disposed in a shielded metal case, the shielded metal case having a fluid cooling channel.

9. The system of claim 1, wherein the unified power output is at least 800W and has a frequency of between 2.40GHz and 2.50GHz.

10. The system of claim 1, wherein the plurality of split output power signals includes exactly four split output power signals that are substantially in phase with one another.

11. The system of claim 1, comprising:

the power combiner unit including a polytetrafluoroethylene (PTFE) element at least partially defining a chamber; and

a conductor element disposed at least in part in the chamber.

12. The system of claim 11, wherein the power combiner unit is electrically coupled with an output connector and the power combiner unit is disposed proximate to a cooling plate.

13. The system of claim 1, wherein:

the first power amplifier unit receives the input power signal and provides the output power signal;

the power splitter unit receives the output power signal from the first power amplifier unit and generates the plurality of split power input signals;

the second power amplifier unit receives the plurality of split power input signals and provides the one of the plurality of split power output signals;

the at least one isolator unit couples the at least one of the plurality of power amplifiers of the second power amplifier unit with the power combiner unit; and

the power combiner unit receives the plurality of split power output signals from the second power amplifier unit via the at least one isolator unit and combines the plurality of split power output signals into the unified power output.

14. The system of claim 1, wherein a combining section of the power combiner unit has a length of substantially half of a wavelength of any one of the plurality of split power input signals.

15. The system of claim 1, wherein the power combiner unit includes a chamber, the chamber including air as a first dielectric and a polytetrafluoroethylene (PTFE) element as a second dielectric.

16. A microwave generator unit comprising a power amplifier system, the power amplifier system comprising:

a first power amplifier unit to receive an input power signal and provide an output power signal;

a power splitter unit to receive the output power signal from the first power amplifier unit and to generate a plurality of split power input signals, each of the plurality of split power input signals in-phase with one another;

a second power amplifier unit having four power amplifiers to receive the plurality of split power input signals, each of the four power amplifiers of the second

power amplifier unit configured to receive one of the plurality of split power input signals and to provide one of a plurality of split power output signals;

at least one isolator unit to couple at least one of the four power amplifiers of the second power amplifier unit with a power combiner unit; and

the power combiner unit to receive the plurality of split power output signals from the second power amplifier unit via the at least one isolator unit and to combine the plurality of split power output signals into a unified power output, the unified power output having a power of at least 750W and a frequency of between 2.40GHz and 2.50GHz.

17. The microwave generator of claim 16, comprising:

a power supply module having a phase lock loop module configured to generate the input power signal, the first power amplifier unit configured to receive the input power signal from the phase lock loop module.

18. The microwave generator of claim 16, comprising:

a case having a fluid cooling channel;

a power supply module;

a user interface;

a RF digital synthesizer; and

a RF output socket.

19. A method of providing microwave frequency range output power from a solid state power amplifier system, comprising:

receiving, by a first power amplifier unit, an input power signal;

providing, by the first power amplifier unit, an output power signal, the output power signal having higher power than the input power signal;

receiving, by a power splitter unit, the output power signal from the first power amplifier unit;

generating, by the power splitter unit, a plurality of split power input signals, each of the plurality of split power input signals in-phase with one another;

receiving, by a second power amplifier unit, the plurality of split power input signals, the second power amplifier unit including a plurality of power amplifiers, each of the plurality of power amplifiers of the second power amplifier unit configured to receive one of the plurality of split power input signals and to provide one of a plurality of split power output signals;

coupling, by at least one isolator unit, at least one of the plurality of power amplifiers of the second power amplifier unit with a power combiner unit;

receiving, by the power combiner unit, the plurality of split power output signals from the second power amplifier unit via the at least one isolator unit; and

combining, by the power combiner unit, the plurality of split power output signals into a unified power output having a frequency of between 2.0GHz and 3.0GHz.

20. The method of claim 19, comprising:

providing the unified power output as output from a microwave generator.

21. The method of claim 19, comprising:

providing the solid state power amplifier system in a case having a fluid cooling channel.

22. The method of claim 21, wherein the plurality of power amplifiers of the second power amplifier unit includes exactly four power amplifiers, comprising:

providing the four power amplifiers in a parallel configuration and electrically coupled between the power splitter unit and the at least one isolator unit.