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Nugent et al.

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[54] **CIRCUIT FOR GENERATING A HIGH POWER RF SIGNAL HAVING LOW AM AND FM NOISE COMPONENTS**

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[73] Assignee: **Westinghouse Electric Corporation**, Pittsburgh, Pa.

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[52] **U.S. Cl.** ..... **331/75**, 331/109, 331/117 R, 331/177 V

[51] **Int. Cl.** **H03b 3/02**, H03b 5/12

[58] **Field of Search** ..... 331/74, 75, 109, 331/117 R, 167, 171, 177 V

[56] **References Cited**

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Assistant Examiner—Siegfried H. Grimm
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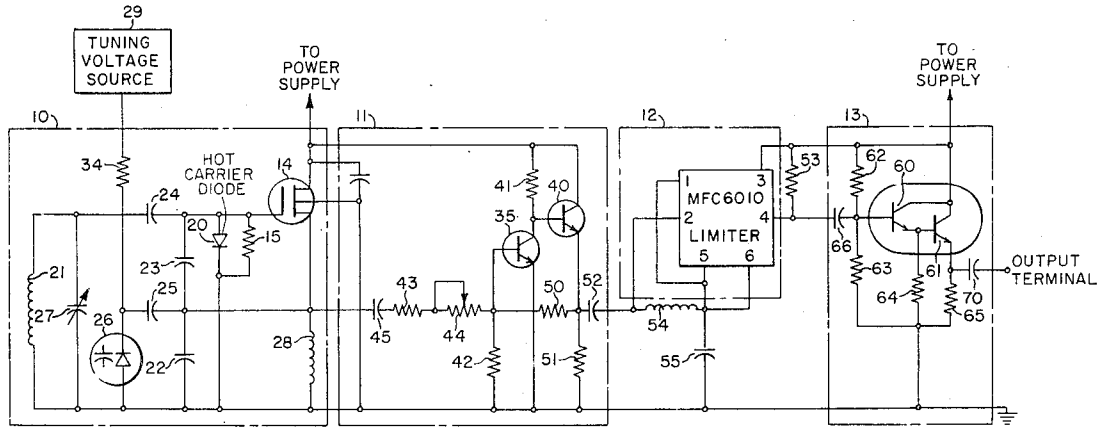
[57] **ABSTRACT**

An RF signal generator is disclosed which has low AM and FM noise and high power output. The output signal of the RF signal generator is a variable over an octave in response to a tuning voltage signal. The RF signal generator includes a low noise RF oscillator coupled to a limiter circuit through a first buffer amplifier. A second buffer amplifies the output of the limiter circuit to produce a high level RF output signal. The FM noise is reduced to a low value by a high Q resonant circuit which determines the frequency of the oscillator and by the use of components in the oscillator circuit which have low noise characteristics. The AM noise is further reduced by the limiter and the output of the limiter is amplified by a second buffer to produce a high power low noise RF signal.

4 Claims, 2 Drawing Figures



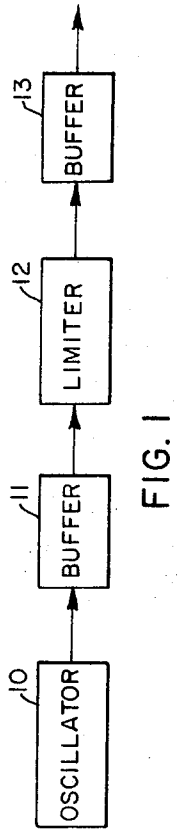
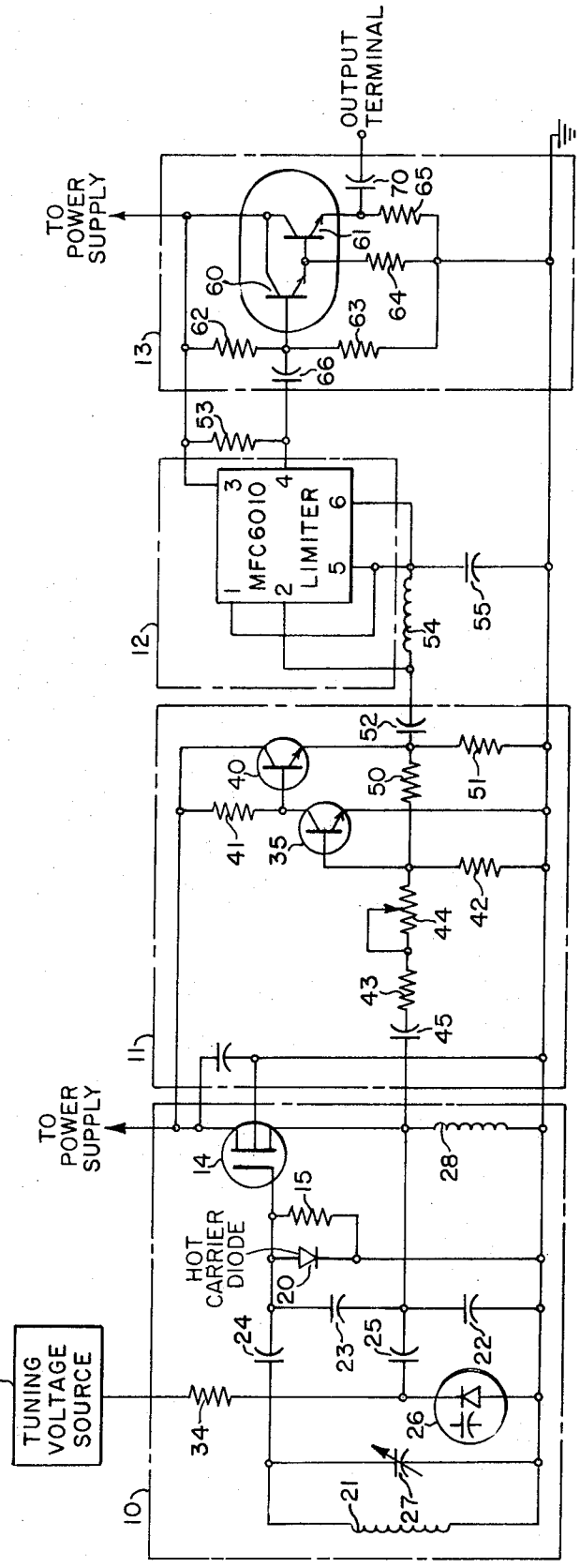

OSCILLATOR
10
BUFFER
11
LIMITER
12
BUFFER
13

FIG. 1


OUTPUT TERMINAL
TO POWER SUPPLY
TO POWER SUPPLY
TUNING VOLTAGE SOURCE
29
MFC6010 LIMITER
HOT CARRIER DIODE
10
11
12
13
14
15
20
21
22
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64
65
66
70

FIG. 2

CIRCUIT FOR GENERATING A HIGH POWER RF SIGNAL HAVING LOW AM AND FM NOISE COMPONENTS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to signal generators and more particularly to high power low noise RF signal generators.

2. Description of the Prior Art

Typical prior art RF signal generators either had a relatively limited tuning range or produced a noisy output signal. Crystal controlled oscillators were frequently used in an effort to reduce the FM noise. The active circuits of the oscillator were often designed to have a relatively constant gain in an effort to reduce the AM noise. These noise control techniques limited the frequency of prior art low noise RF signal generators to frequencies near the resonant frequency of the crystal used in the oscillator.

SUMMARY OF THE INVENTION

The preferred embodiment of the invention provides a high power, low noise RF signal generator with the frequency of the output signal being variable over at least an octave. This improved performance is achieved by combining a low noise oscillator circuit whose frequency is variable in response to a tuning voltage with an amplitude limiter and two buffer circuits. The FM and AM noise is reduced by the design of the oscillator while the AM noise is further reduced by the limiter circuit. The oscillator is isolated from the limiter by a first buffer and a second buffer amplifies the output of the limiter to produce a high power low noise RF signal. The basic circuit may be modified to provide manual tuning by using manually variable components in the frequency determining circuits.

More specifically the FM noise of the oscillator is greatly reduced by a high Q frequency determining circuit which comprises an inductor and a capacitor connected in parallel. The output of this resonant circuit is coupled to the gate terminal of an insulated gate transistor such that the loaded and unloaded Q of the circuit are substantially the same. The resonant circuit also includes a voltage controlled capacitor for varying the frequency of the oscillator over at least an octave in response to a tuning voltage.

Bias for the insulated gate transistor is produced by a low noise diode coupled between the gate and source terminals of the insulated gate transistor. This diode is a hot carrier diode. The hot carrier diode has low noise characteristics as compared to diodes commonly used for this purpose. The low noise characteristics of this diode reduces both the AM and FM noise components of the oscillator output signal. The output signal of the oscillator circuit is coupled to a first buffer. The output of the first buffer is coupled to a limiter which removes substantially all of the AM components from the RF signal. The output of the limiter is further amplified by a second buffer to produce a low noise high power RF signal.

The above-described RF signal generator typically has a noise figure of at least −136 db/hz at a frequency of 3 kilohertz removed from the carrier. The FM noise of the RF signal generator is substantially determined by the noise characteristics of the oscillator circuit while the AM noise is substantially determined by the characteristics of the limiter circuit. This separation of the AM and FM noise determining circuits permits the system to be more easily optimized in order to achive a minimal noise figure. Typical RF signal generators of the type disclosed by this invention have a noise figure of at least 25 db better than typical prior art RF signal generators having a similar tuning range and power output.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a functional block diagram of the RF signal generator.

FIG. 2 is a detailed schematic diagram of the RF signal generator.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 is a functional block diagram of the RF signal generator which is the subject of this invention. The RF signal generator includes an oscillator **10** coupled to a firt buffer **11.** The output of the first buffer **11** is coupled to a limiter circuit **12** with the output of the limiter coupled to a second buffer **13.**

The first buffer **11** isolates the oscillator **10** from the limiter **12** and provides an RF signal to the limiter **12** having an amplitude sufficient to assure proper limiting action. The buffer **11** may be eliminated in specific designs depending on the output signal capabilities of the oscillator **10** and the input signal requirements of the limiter **12.** The second buffer **13** further amplifies the output of the limiter circuit **12** to produce a high level low noise RF signal. This buffer may also be eliminated if the output of the limiter is sufficient for the intended application.

A detailed schematic diagram of the low noise RF signal generator illustrated functionally in FIG. **1** is shown in FIG. **2.** The oscillator **10** includes an active circuit comprising an insulated gate transistor **14,** a tuned circuit and a bias network. The bias network comprises a resistor **15** and a diode **20** connected in parallel with the resistor **15.** The diode **20** conducts on the positive peaks of the RF signal to produce a bias voltage at the gate terminal of the insulated gate transistor **14.** The resonant circuit which determines the frequency of the oscillator includes an inductor **21** and capacitors **22** through **27.** Capacitor **24** isolates the DC bias voltage produced at the gate terminal of the insulated gate transistor **14** so that it is not shorted out by the inductor **21.** The remainder of the capacitors form the frequency determining capacitive elements of the resonant circuit. Manually variable components can be used in the resonant circuit, if manual tuning is desirable.

An inductor **28** is connected between the source terminal of the insulated gate transistor **14** and the ground terminal of the oscillator. The junction of capacitors **22** and **23** is connected to the junction of inductor **28** and the source terminal of the insulated gate transistor **14** to form a feedback path which causes the circuit to oscillate.

Capacitor **26** is a varactor diode whose capacitance has a predetermined relationship to the output voltage of the tuning voltage source **29.** By varying the output voltage of the tuning voltage source **29** the frequency of the oscillator **10** can be changed over its operating range. The junction of capacitors **25** and **26** is isolated

from the tuning voltage source **29** by an isolation resistor **34.**

The RF output signal of the oscillator **10** is available at the junction of inductor **28** and the source terminal of the insulated gate transistor **14.** This signal is coupled to the input of the first buffer **11.**

The first buffer amplifier **11** includes two bi-polar transistors **35** and **40.** The first bi-polar transistor **35** is a voltage gain stage which includes a load resistor **41** and a bias resistor **42.** The base terminal of transistor **35** is coupled to the output of the oscillator **10** by two resistors **43** and **44,** and a capacitor **45** connected in series. Resistor **44** is variable to adjust the gain or the first buffer amplifier **11** so that the output signal of this buffer amplifier has the desired value. The second transistor **40** is an emitter follower stage and is included to provide power gain. The emitter terminal of the second transistor **40** is coupled to the base terminal of the first transistor **35** through a feedback resistor **50** to stabilize the gain of the first buffer emplifier **11.** An emitter resistor **51** is coupled between the emitter terminal of the second transistor **40** and the ground terminal of the first buffer amplifier **11** and the output signal is coupled to the limiter **12** through a capacitor **52.**

The limiter **12** may be a standard integrated circuit sold by Motorola which is identified by Motorola part Number MFC6010. This circuit is shown properly connected in FIG. **2.**

The output signal of the above-described limiter circuit is available at terminal **4** of the integrated circuit and is coupled to the input terminal of the second buffer **13.** Resistor **53,** an inductor **54** and a capacitor **55** provides bias signals to the limiter circuit **12.**

The active elements of the second buffer amplifier **13** comprise two Darlington connected transistors **60** and **61.** The output signal of the limiter **12** is coupled to the base terminal of the first transistor **60** by a capacitor **66.** Bias is provided to these transistors by two resistors **62** and **63.** The emitter of the first transistor **60** is returned to the ground terminal of the second buffer **13** by a resistor **64.** The emitter of the second transistor **61** is similarly returned to ground by a second resistor **65.** A coupling capacitor **70** is coupled to the junction formed by the emitter of the second transistor **61** and a resistor **65** which couples the emitter of this transistor to the ground terminal of the second buffer **13.** The coupling capacitor **70** isolates the DC voltage present at the emitter of transistor **61** from the output terminal to assure that only the RF signal is coupled to the output terminal of the RF signal generator.

In selecting components for the above-described RF signal generator the inductor **21** should have a high Q and capacitors **22** through **27** should have low losses to assure that the resonant circuit has a high Q. The input impedance of the insulated gate transistor **14** is relatively high thereby assuring that the loaded and unloaded Q of the resonant circuit are substantially the same. This assures a high loaded Q for this circuit resulting in low FM noise. The bias diode **20** is preferably a Hewlett Packard hot carrier diode. This diode has the lowest 1/F noise of any diode currently available on the market. The value of the various tuning capacitors are chosen such that the oscillator will have the proper frequency and tuning range. Using currently available components the disclosed oscillator will successfully oscillate at a frequency range of between **1** and **500** megahertz and be variable over at least an octave. It should be emphasized however that these limits are imposed by the availability of suitable components and that the basic design of the RF signal generator is not so limited.

The system as disclosed in detail in FIG. **2** typically has a noise figure of −136 db at 3 KHz removed from the carrier and has a power output of at least +12 dbm into a 50 ohm load. This is a noise figure at least 25 db better than prior art voltage controlled RF signal generators having a similar tuning range.

What is claimed is:

1. A low noise RF signal generator comprising, in combination:

a. an active circuit comprising an insulated gate transistor having a gate terminal, a source terminal and a drain terminal, a bias network including a resistor and a hot carrier diode connected in parallel therewith, a load impendance, said bias network being coupled between said gate terminal of said insulated gate transistor and the ground terminal of said active circuit, said drain terminal being connected to a power supply, said load impedance being coupled between said source terminal of said insulated gate transistor and the ground terminal of said active circuit with the junction of said source terminal and said load impedance forming the output terminal of said active circuit;

b. a parallel tuned circuit comprising an inductor and a capacitor connected in parallel, said tuned circuit being coupled to the gate terminal of said transistor and to the ground terminal of said active circuit;

c. a feedback circuit coupling the output of said active circuit to the gate terminal of said transistor to form an oscillator circuit; and

d. a limiter coupled to receive the output signal of said oscillator and generate therefrom a low noise RF signal.

2. The RF signal generator of claim **1** wherein said parallel tuned circuit includes a voltage controlled capacitor permitting the frequency of said oscillator to be varied in response to a voltage signal.

3. The oscillator of claim **1** further including a buffer amplifier disposed between said active circuit and said limiter.

4. The oscillator of claim **3** wherein said buffer amplifier includes a gain control thereby permitting the input signal to said limiter to be adjusted.

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