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(54) **ROBUST WAVEGUIDE MILLIMETER WAVE NOISE SOURCE**

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(51) **Int. Cl.**
H03B 29/00	(2006.01)
H01P 1/203	(2006.01)
H01P 5/107	(2006.01)
H01P 9/00	(2006.01)

(52) **U.S. Cl.**
CPC *H03B 29/00* (2013.01); *H01P 1/2039* (2013.01); *H01P 5/107* (2013.01); *H01P 9/00* (2013.01)

(58) **Field of Classification Search**
CPC H03B 29/00; H01P 5/02; H03H 11/02; H03H 1/0007
See application file for complete search history.

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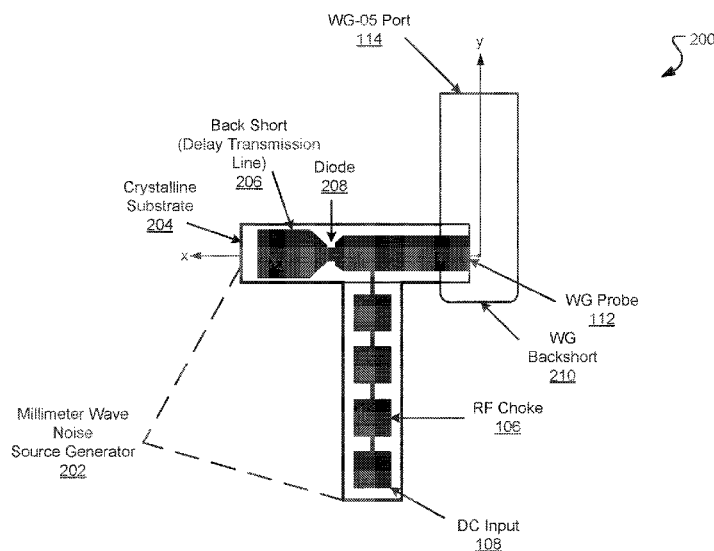|				
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(57)   **ABSTRACT**

Aspects of the present disclosure involve a system and method for generating noise waves at millimeter wave frequencies. A noise source generator is designed to be connected to a crystalline structure for efficient heat transfer and compatibility with millimeter wave receivers. The use of crystalline structure coupled to the noise source generator allows heat from a biasing device, such as a diode, to be carried away such that the diode is able to generate noise waves while being reversed biased without compromising the device. In another embodiment, the noise source generator includes the use of a backshort transmission line with vias that is connected to the biasing device for heat transfer from the biasing device to the backshort.
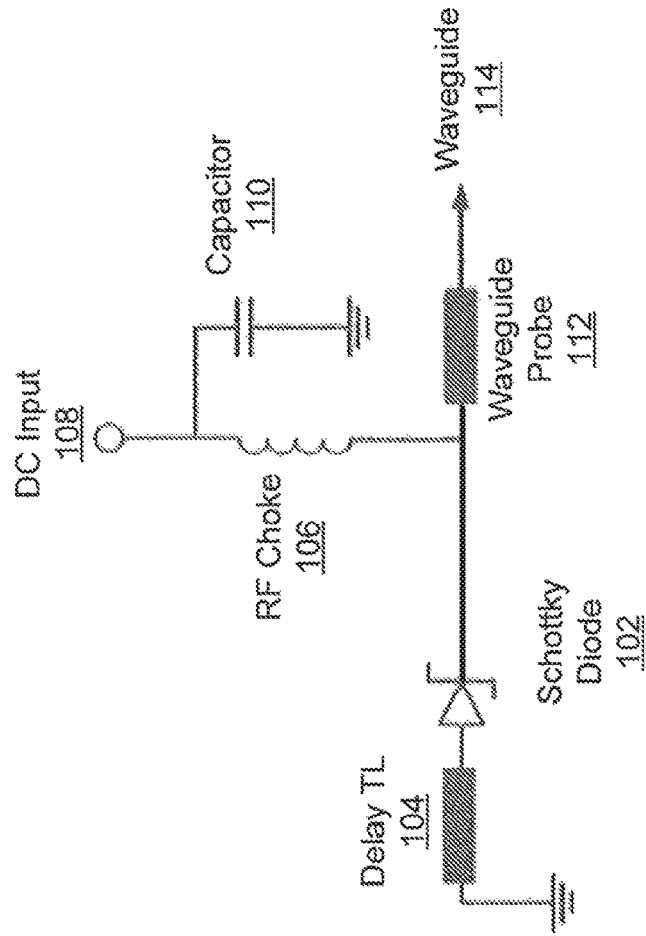
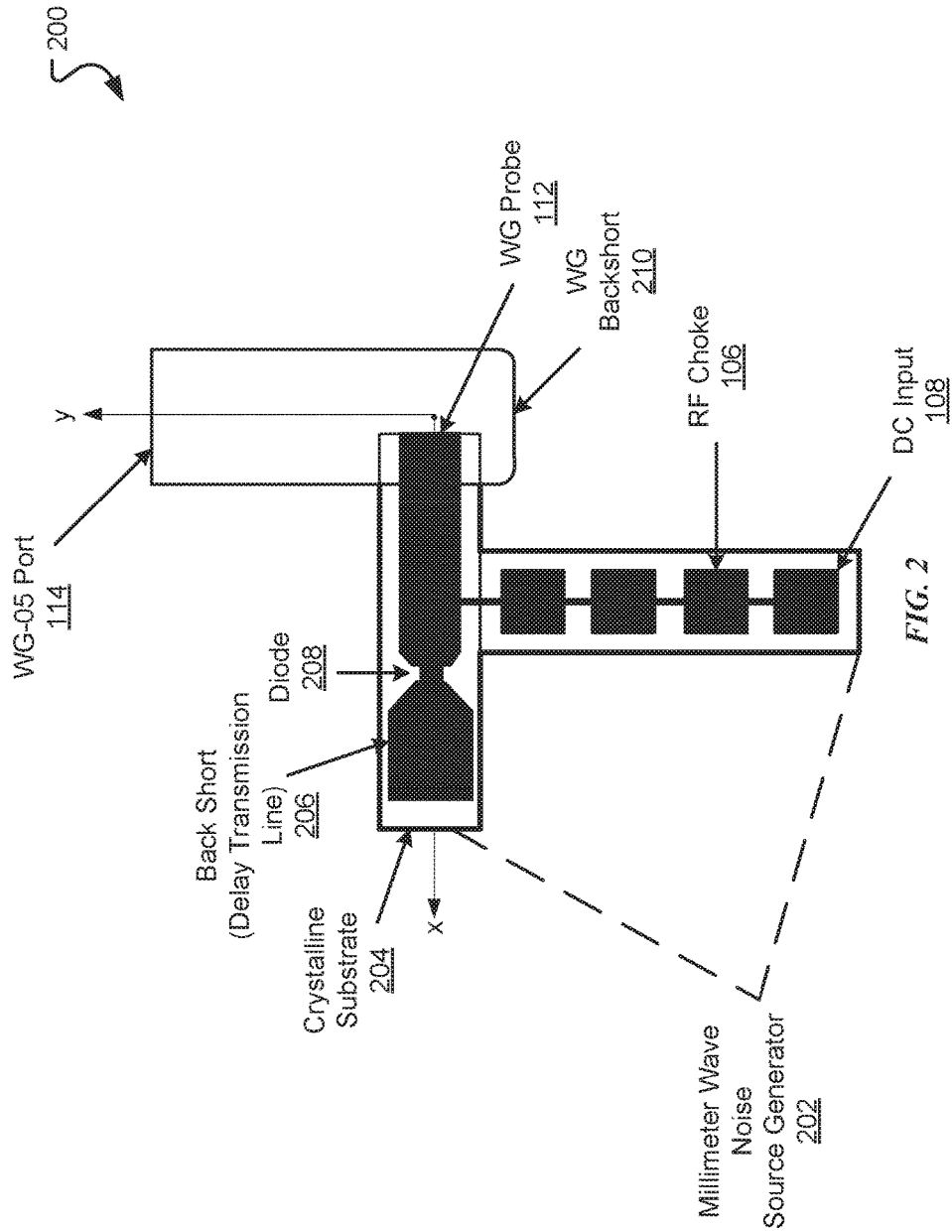**20 Claims, 5 Drawing Sheets**

100

Capacitor
110

DC Input
108

RF Choke
106

Waveguide
114

Waveguide
Probe
112

Schottky
Diode
102

Delay TL
104

FIG. 1

200

WG-05 Port
114

WG Probe
112

WG Backshort
210

Back Short
(Delay Transmission Line)
206

Diode
208

RF Choke
106

DC Input
108

Crystalline Substrate
204

Millimeter Wave Noise Source Generator
202

y

x

FIG. 2

FIG. 3

400

402 — REVERSE BIAS DIODE(S) TO GENERATE NOISE WAVES

404 — COMPENSATE DIODE REACTANCE USING A BACK SHORT COUPLED TO DIODE

406 — CARRY HEAT OUT USING HEAT SINK/ VIAS IN THE BACK SHORT

408 — BLOCK NOISE WAVE LEAKAGE USING RF CHOKE
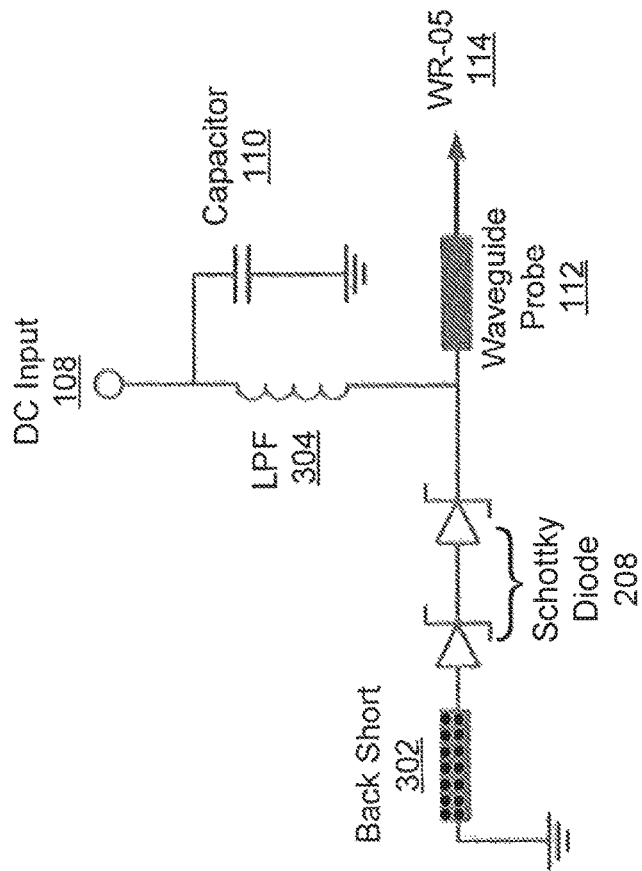
410 — PROVIDE SIGNAL PATH FOR NOISE WAVES TO WAVEGUIDE USING WAVEGUIDE PROBE
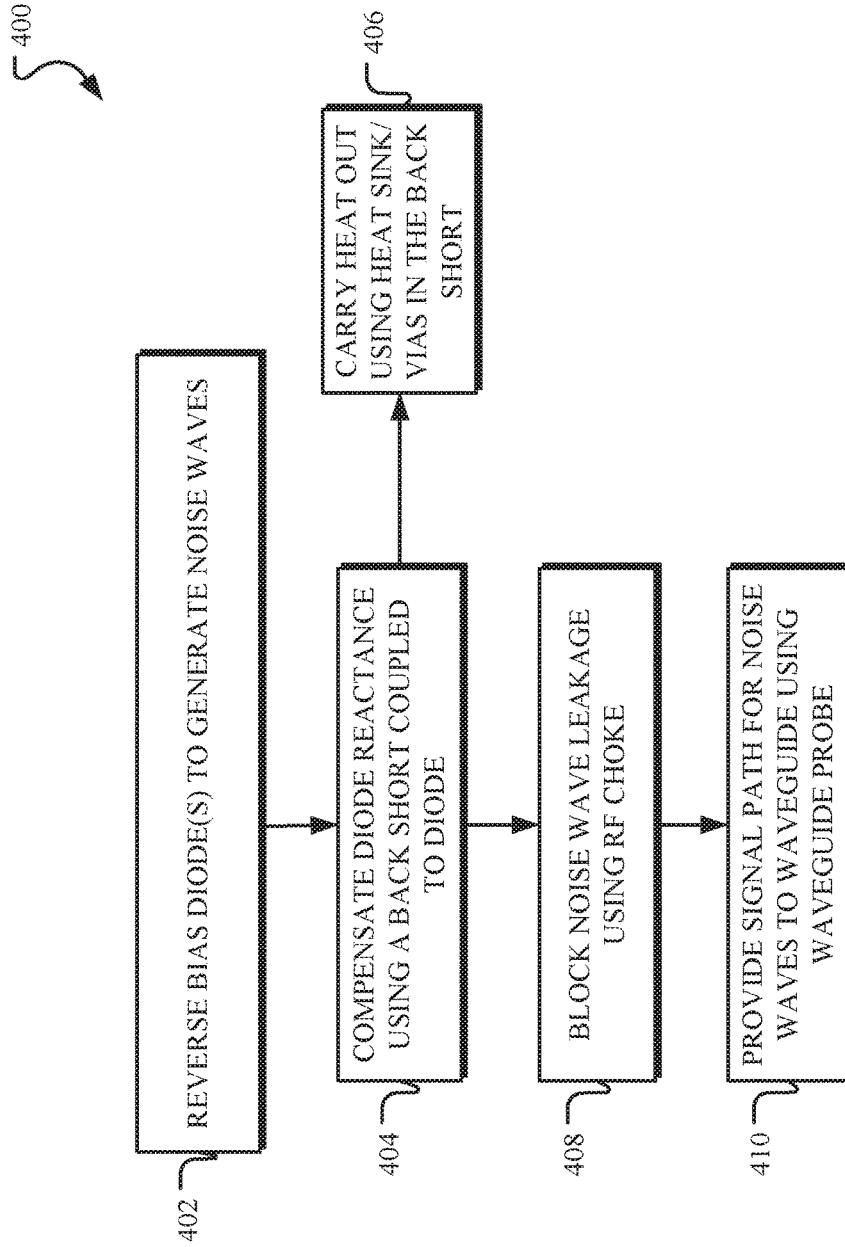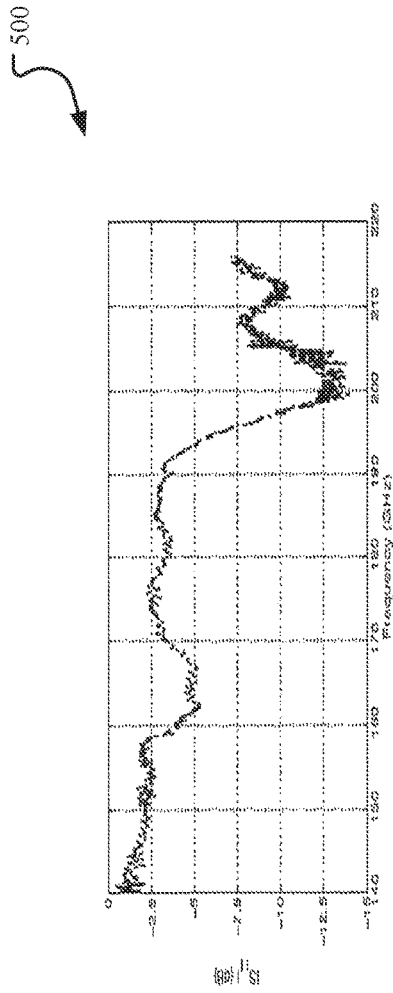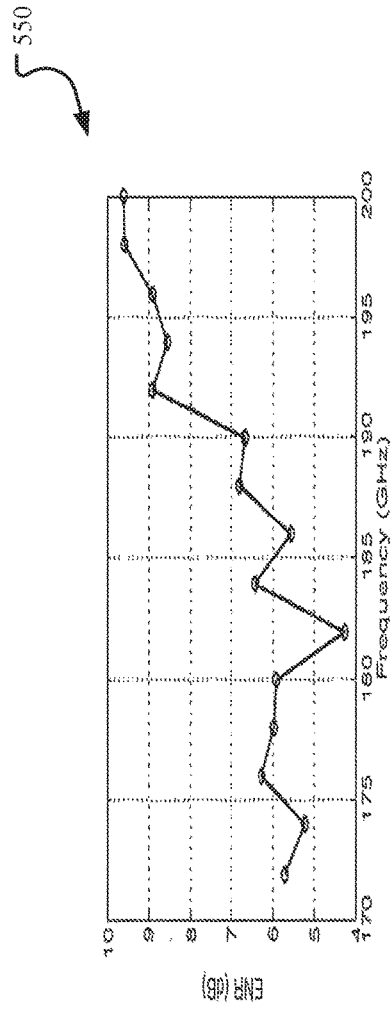
FIG. 4

FIG. 5A

FIG. 5B

ROBUST WAVEGUIDE MILLIMETER WAVE NOISE SOURCE

PRIORITY

The present application claims priority to Provisional Application 62/349,241, filed Jun. 13, 2016 which is herein incorporated by reference.

TECHNICAL FIELD

This disclosure relates generally to millimeter wave noise source generators, and more specifically to a system and method for generating noise waves using a biasing device operational at millimeter wave frequencies.

BACKGROUND

Millimeter- and submillimeter wave remote sensing has atmospheric applications ranging from atmospheric sounding to precipitation and ice cloud measurements. Over the past few decades extensive research has been performed related to the development of receiver components at millimeter- and submillimeter wave frequencies that enable such atmospheric applications. Most research has focused largely on the development of local oscillators, mixers, and the like, that are operational at the millimeter wave frequency range. However, corresponding advances in integrated noise sources are minimal and as such larger, more complex, and costly noise sources are often used for atmospheric applications.

BRIEF SUMMARY

The present disclosure is directed to a millimeter wave noise generating apparatus and method for generating such millimeter wave noise waves. The millimeter wave noise generating apparatus can include a biasing device having a first terminal and a second terminal, the biasing device defined to generate noise waves. The millimeter wave noise generating apparatus can include a backshort transmission line connected to the first terminal. The backshort transmission line defined to compensate a reactance of the biasing device. The millimeter wave noise generating apparatus can further include a crystalline structure connected to the biasing device and the backshort transmission line, wherein the crystalline structure transfers heat from the biasing device to the backshort transmission line. The millimeter wave noise generating apparatus can include a filtering component connected at the second terminal, wherein the filtering component prevents the noise waves from leaking out of the apparatus. The millimeter wave noise generating apparatus can also include a probe connected to the second terminal for providing a path for the noise waves to a wave-guiding structure.

The method for generating millimeter wave noise waves including a diode for generating the noise waves in reverse bias mode. The method compensating a reactance of the diode created when generating the noise waves using a backshort transmission line. The method for generating millimeter wave noise waves transferring, by a crystalline structure, heat accumulated on the diode to the backshort transmission line. Also, the method for generating the millimeter wave noise waves blocking the noise waves to keep them from leaking out of an apparatus by a radio frequency (RF) choke and guiding the blocked radio waves to a wave-guiding structure.

The millimeter wave noise generating apparatus can include a biasing device with two terminals used for generating noise waves. The millimeter wave noise generating apparatus can also include a backshort transmission line that is connected to one of the biasing terminals to compensate a reactance of the biasing device, wherein the backshort transmission line comprises vias for transferring heat from the biasing device to the backshort transmission line. The millimeter wave noise generating apparatus including a filtering component coupled to the other terminal to prevent the noise waves from leaking out of an apparatus. The millimeter wave noise generating apparatus can also include a probe for providing a path for the noise waves to a wave-guiding structure.

BRIEF DESCRIPTION OF THE DRAWINGS

The description will be more fully understood with reference to the following figures and data graphs, which are presented as various embodiments of the disclosure and should not be construed as a complete recitation of the scope of the disclosure, wherein:

FIG. 1 is a diagram illustrating a noise source generator.

FIG. 2 is a diagram illustrating a simulated millimeter wave noise source generator with on-chip circuitry designed on a crystalline substrate.

FIG. 3 is a diagram illustrating the millimeter wave noise source generator with a backshort heat sink.

FIG. 4 is a flow chart of a method for using the millimeter wave noise source generator including the backshort heat sink.

FIG. 5A is a graph illustrating the measured return loss, S_{11} of the millimeter wave noise source generator.

FIG. 5B is a diagram illustrating the measured Excess Noise Ratio (ENR) of the millimeter wave noise source generator over a range of millimeter wave frequencies.

DETAILED DESCRIPTION

Aspects of the present disclosure involve systems, methods, devices and the like for generating noise waves at millimeter wave frequencies. In one aspect, a noise source generator is designed to be connected to a crystalline structure for efficient heat transfer and compatibility with millimeter wave receivers. The use of crystalline structure coupled to the noise source generator allows heat from a biasing device, such as a diode, to be carried away such that the diode is able to generate noise waves while being reversed biased without compromising the diode function or reliability.

In another embodiment, the noise source generator includes the use of a backshort transmission line that is thermally coupled to the biasing device for heat transfer from the biasing device to the backshort. The backshort, designed to include vias, provides a pathway for heat to be transferred from the biasing device, enabling a more efficient temperature control and permitting the biasing device to operate with continuous power.

FIG. 1 is a diagram illustrating a noise source generator 100. Noise source generators 100 are devices used to produce electrical noise used to test signals. In remote sensing, noise source generators 100 can be used to calibrate receivers. A noise source generator 100 is generally configured to include a device that generates the noise. The device can be active or passive and can include resistors, diodes, tubes, etc. Biasing devices or diode(s) 102 are most commonly used to generate noise waves and biased using a DC input 108.

Additionally, noise source generators **100** can include other components such as, but not limited to, a delay transmission line **104**, RF choke **106**, and a waveguide probe **112**.

Conventionally, noise source generators **100** have been designed with components that operate at lower frequencies. However, in atmospheric remote sensing and other applications, submillimeter and millimeter wave sensing is desired. In particular, the G-band (160-210 GHz range), is often targeted for these atmospheric applications due to the water vapor absorption line at 183 GHz. Therefore, the design and integration of a millimeter noise source generator is advantageous for its ability to reduce cost, instrumentation, and complexity. Further, an integrated noise source operational at the millimeter and submillimeter wave can enable relative radiant power calibration of the receiver which could reduce and/or eliminate the need for a clear view to cold space in atmospheric applications. In addition, calibration using this approach can take place on a faster timescale and thus improve overall stability and fidelity achieved by the receiver.

As indicated, traditionally the diode **102** has been used as an active component for generating noise waves. The diode **102** can be biased to create noise waves that are provided to a waveguide **114** used for calibrating the front end receivers. Various types of diodes have been conventionally used for noise generation. For example, Zener diodes, temperature-limited vacuum diodes, PIN diodes have been used in noise generation applications, however, the life expectancy of such diodes is often compromised or diminished at millimeter wave operation. Recently, Schottky diodes have been proposed for use in millimeter wave applications for their ability to perform at higher frequencies. A Schottky diode is a semiconductor diode formed by the junction of a semiconductor with a metal with low forward voltage drop and fast switching action. Generally, the Schottky diode has been used with mixers, multipliers and the like in forward bias mode.

However, to enable noise wave generation for millimeter wave applications, the operability of the Schottky diode is reversed. In one embodiment, the Schottky diode is reversed biased into avalanche breakdown to generate the noise waves. In avalanche breakdown, holes and electrons in the depletion region of a reversed-biased pn junction acquire sufficient energy to create hole-electron pairs by colliding with silicon atoms. In other words, noise current arises from collision-induced ionization via free carriers colliding with and knocking free new carriers in the semiconductor. In some instances, diodes **102** can include the two or more Schottky diodes placed in series. For example, the diodes **102** can include two GaAs Schottky diodes (two in series, on one chip). As another example, the diodes **102** can include two GaAs Schottky diodes in series with each diode being 148 μm×45 μm×20 μm in dimension. Note that the values used are exemplary and the use of the diode(s) **102** is not so limited as other dimensions, compositions, and arrangements may be contemplated.

In noise source generator **100**, since the diode **102** is being biased, noise wave and RF leakage can occur. To compensate for this noise and/or RF leakage, the noise source generator **100** can be designed to include components that counter it. For example, an RF choke **106** can also be used as part of the biasing circuit to ensure the passage of the direct current from the DC input **108** arrives at the diode **102** while blocking any energy from leaking out. In some instances, the RF choke **106** can be an inductor. In other instances, the RF choke can be a filter. Still in other instances, the RF choke **106** can include a capacitor **110** for

blocking RF leakage. For blocking noise, a transmission line (e.g., delay transmission line (TL) **104**) can also be added in proximity to the diode **102** to counteract any backpath flow created by the diode **102**.

Noise source generators **100** also include waveguide probes **112**. A waveguide probe **112** is a component that provides an interface and/or pathway from the diode **102** to the waveguide **114**. The waveguide **114** can be any structure that can be used to guide the noise waves toward a device while enabling propagation with minimal loss of energy by restricting the waves to propagating in one or two dimensions.

Operation of the integrated noise source generator **100** at submillimeter and millimeter frequencies can lead to the generation of heat, which can cause components (e.g., diode **102**) to rapidly degrade, overheat, or burnout. To prevent compromising the lifetime of the components, a crystalline substrate **204** can be appropriately attached to the component (e.g., diode **102**) such that the crystalline substrate **204** provides good heat transport. FIG. **2** is a diagram illustrating a simulated chip-waveguide noise source **200** with the millimeter wave noise source generator **202** designed on a crystalline substrate **204**. In one embodiment, the simulated millimeter wave noise source generator **202** of FIG. **2** may be the noise source generator **100** of FIG. **1** mounted on the crystalline substrate **204** to combat heat.

By mounting the millimeter wave noise source generator **202** on a crystalline substrate **204** (e.g., quartz, floatzone silicon, sapphire, diamond, etc.), heat on the components is minimized and the integrity of the components is maintained. For example, diode **102** can be appropriately attached to the crystalline substrate **204** to ensure the diode **102** runs at a reasonable temperature, such that the diode is not damaged or its lifetime compromised. The crystalline substrate **204** can act as a thermal conductor allowing heat to be carried away from the component (e.g., diode **102**) and enabling the component to function under reasonable temperatures. Similarly, the other components on the noise source can also benefit from being mounted on the crystalline substrate **204** such that the heat on the components is minimized. As illustrated in FIG. **2**, the crystalline structure **204** extends through the area of the simulated millimeter wave noise source generator **202**. Note that the crystalline substrate **204** can be any material with good heat transfer properties. In one embodiment, the crystalline substrate can be diamond, sapphire, etc. In a preferred embodiment, the crystalline substrate can be quartz, which has good conductivity and is easily integrable with other chip devices including standard waveguide flanges operational in the G-band (e.g., WR-05 **114**).

As illustrated in FIG. **2**, the millimeter wave noise source generator **202** can include the standard components e.g., diode **102**, bias circuitry (e.g., RF choke **106** and DC input **108**), delay transmission line, and waveguide probe **112** described above and in conjunction with noise source generator **100** of FIG. **1**. The diode **102** can therefore be one or more Schottky diode (s) **208** (e.g., two Schottky diodes **208** placed in series) for noise wave generation. The Schottky diode(s) **208** can generate noise when operating in reversed biased mode at a high voltage, forcing the Schottky diode **208** into avalanche breakdown. The biasing circuitry can include a low pass filter including an RF choke **106** and/or a capacitor **110** (not shown) for blocking the RF, and a DC input **108**. In addition, the delay transmission line **104** can include a backshort **206** designed to reflect the noise from the Schottky diodes **208**. A backshort **206** can be a tuning element that can compensate for reactance of the Schottky

diodes **208**. More simply put, a Schottky diode **208**, when operational in reverse-bias mode, generates noise waves from both terminals ends and thus in both directions on the microstrip guide with 180° phase difference. To direct all of the noise to the desired RF path, an RF short or backshort **206** can be designed to reflect the noise from the Schottky diode **208** in the other direction and thus add in-phase with the outgoing noise.

In one embodiment, chip-waveguide noise source **200** is operational at 160-210 GHz. The millimeter wave noise source generator **202** is designed on quartz and implemented into a waveguide housing. The noise generators are Schottky diodes **208** with a low pass filter **106** as part of the bias circuit for biasing the Schottky diodes **208** with an alternating high/low impedance configuration for blocking RF, and a feed-thru (electromagnetic interference (EMI) filter) that connects the filter **106** to bias line with an internal capacitor **110** to short any RF noise coming from the DC path. The backshort **206**, used for suppressing reflected noise, is designed with a center frequency at 183 GHz and a microstrip-to-waveguide probe **112** transition is used for coupling to the waveguide **114**. In addition, a waveguide backshort **210** may be included or attached to the waveguide prove **112**. The waveguide **114** is a WG-05, for G-band operability with a longitudinal probe configuration. Note that design is not so limited and other configurations, components, and substrates may be contemplated.

Further to the chip-waveguide noise source **200** design of FIG. **2**, FIG. **3** is presented to provide additional heat transfer features that will allow for improved millimeter wave noise source generator **202** functionality. Specifically, FIG. **3** is a diagram illustrating the millimeter wave noise source generator **202** with a backshort heat sink **302**. As previously indicated, the backshort **302** is a tuning element that compensates for the reactance in the Schottky diodes **208**. The backshort **302**, can further be configured to provide a pathway that enables the transfer of heat from the diode **102** to the backshort **302**. The backshort **302** as illustrated in FIG. **3** can be designed to include vias. Vias are metal filled conduits that permit the electrical connection between layers in a circuit. Vias can be used to carry heat away from power devices. In one embodiment, the backshort **302** can be designed to include vias to aid in the heat-sinking of the Schottky diodes **208**. By enabling heat sinking of the Schottky diodes **208**, the Schottky diodes **208** can be powered continuously (e.g., continuously biased) rather than pulsed powered. In one embodiment, the millimeter wave noise source generator **300** of FIG. **3** can include a backshort as a capacitive delay transmission line including vias with phase delays of 180° at 184 GHz, 160° at 191 GHz, and −160° at 176 GHz.

FIG. **4** is a flowchart of the various operations of the presently disclosed technology. Specifically, FIG. **4** is a flow chart of a method for using the millimeter wave noise source generator **300** including the backshort heat sink **306**. Method **400** begins with operation **402**, where one or more diodes **102** are reversed biased to generate the noise waves. As previously indicated, millimeter wave noise source generators **202** play a significant role in remote sensing related to atmospheric applications. Noise waves generated by the millimeter wave noise source generators **202** enable the calibration of the RF front-end receivers and can eliminate the need for a clear view of cold space in atmospheric applications. At high frequencies, Schottky diodes **208**, due to the low junction capacitance, have been identified as

promising noise sources when reversed biased to avalanche breakdown. The Schottky diodes **208** can be biased using a direct current input.

When the diode **102** is powered/biased, power can leak from both terminals of the diode. To reflect the leakage or reactance of the diode, method **400** continues to operation **404**, where a backshort **306** reflects the noise in the other direction so that the reflected noise adds in phase with the outgoing noise in the opposite direction. In some instances, the backshort can be designed to operate at center frequency of 183 GHz and is a delayed transmission line.

In operation **406**, in addition to reflecting the noise generated by the diodes **102**, the backshort **306** is also used to carry heat out of the diode **102**, to which the backshort is thermally coupled or connected. The heat can be carried out using a built in heat sink (e.g., vias) in the backshort **306**, which allows the heat to be transferred from the powered diodes **102** to the backshort **306**. The use of vias provide constant heat sinking, which enables the diodes **102** to be continuously powered as opposed to being pulsed powered as generally done.

In operation **408**, the RF choke or low pass filter **106** is used to ensure the passage of the direct current from the DC input to the diode **102** while blocking any energy from leaking out. The RF choke **106** can include a built in capacitor **110** as part of the biasing circuit to block any RF from leaking out. Note that operation **408** can occur prior to and simultaneously with the compensation by the backshort **306** in operation **408**.

In operation **410**, the noise waves generated by the Schottky diodes **102** are guided to the waveguide **114** using a waveguide probe **112**. The waveguide probe **112** can be added to the noise source generator **100** to couple and provide an interface and/or pathway for the noise waves from the diodes **102** to the waveguide **114**. In some instances, the waveguide probe **112** can include a longitudinal probe configuration. Once attached to the waveguide **114**, the noise waves can be used for calibrating the frontend of the receiver.

To ensure proper functionality of the noise source generator **100**, performance measurements were taken with FIGS. **5A** and **5B** providing exemplary performance results. Specifically, FIG. **5A** includes a graph illustrating the measured return loss, S_{11} of the millimeter wave noise source generator **202**. While FIG. **5B** is a diagram illustrating the measured Excess Noise Ratio (ENR) of the millimeter wave noise source generator **202** over a range of millimeter wave frequencies.

For the performance measurements, a G-band receiver can be set-up to include any configuration and instrumentation including antennas, waveguides, couplers, amplifiers, and the like. In one embodiment, the measurement system can include a circular G-band horn, an E-plane bend, a 4" waveguide, an 8 dB coupler to couple the noise from the noise source, a second-harmonic mixer from VDI, a ×6 multiplier, a synthesizer, an intermediate frequency (IF) low-noise amplifier (LNA), a bandpass filter centered at 250 MHz with 140 MHz bandwidth, and a power meter.

For the return loss measurement illustrated in graph **500** of FIG. **5A**, the circuit was designed to match 50Ω. Return loss is generally the ratio of reflected to incident power in decibels (dB) at a specific reference plane. Therefore, return loss can often be used as a convenient way to characterize an input and output signal source. Return loss can occur when a mismatch exists and is important to be understood as a "return loss" signal may mix with subsequent signals

compromising the quality of the received signal and possibly creating errors in the subsequent signal received.

In one embodiment, to verify the transition between the microstrip and the waveguide, return loss measurements were obtained. For example, the microstrip-to-waveguide transition on quartz that was fabricated, and packaged on a back-to-back structure was tested for such measurement. FIG. 5A illustrates the measured return loss, which includes a set of WR-5.1 extension heads and a network analyzer to measure the noise source generator's 100 S-parameters. The extension heads are calibrated. In some instances, to calibrate the extension heads, the short, load, offset short, offset load, and thru (SLOSOLT) calibration method can be used. As illustrated in FIG. 5A, the return loss measurement verifies the performance of the transition from microstrip to waveguide with a return loss is 10 dB up to 210 GHz. As illustrated in FIG. 5A, the return loss results further indicate that the biasing device (e.g., Schottky Diode 306) is well-matched to 50Ω as a −12 dB return loss is achieved at 200 GHz. Bill was measured at bias points from Vd=0.12 V to Vd=0.16:4 V, and no sensitivity to bias voltage was noted. Still further, reanalysis of measurement results indicated that indeed the diode was matched as the input impedance Schottky diode 306 indicated that Schottky diode 306 is capacitive with series resistance on the order of C_j=12 fF.

FIG. 5B illustrates the measured Excess Noise Ratio (ENR) of the noise source generator 100. ENR is generally a way of describing the power spectral density of noise with respect to a thermal noise floor. In other words, ENR is a normalized measure of how much the noise source generator 100 is above thermal in its power. ENR can generally be described by the equation below.

$$ENR = 10\log\left(\frac{T_{NS}}{290} - 1\right)$$

To perform the ENR measurements, the thermal noise of the noise temperatures (ON/OFF) of the noise source should be determined. In one embodiment, to obtain the noise source temperature measurements, Y-factor measurement of two targets was identified, one at 77 K and the other at room temperature. The measurement was performed for two cases at each frequency: the diode OFF and the diode ON. For the "ON" state the diode was reverse-biased at Vd=16:39 V and Id=6 mA. The synthesizer frequency was swept to measure the noise at different frequencies. All the front-end losses (waveguide E-plane bend, transmission lines, and the coupler) were measured as an assembly using waveguide extension heads and a performance network analyzer, and used to correct the response. To extract the ENR from the measurements taken, the following equations were calculations that were used:

$$Y_{on} = \frac{P_{onHot}}{P_{onCold}} \tag{1}$$

$$Y_{off} = \frac{P_{offHot}}{P_{offCold}} \tag{2}$$

$$T_{on} = \frac{T_{Hot} - Y_{on} \times T_{Cold}}{Y_{on} - 1} \tag{3}$$

$$T_{off} = \frac{T_{Hot} - Y_{off} \times T_{Cold}}{Y_{off} - 1} \tag{4}$$

-continued

$$T_{NS} = (T_{on} - T_{off}) \times C \times \frac{L_2}{L_1} \tag{5}$$

$$ENR = 10\log\left(\frac{T_{NS}}{290} - 1\right), \tag{6}$$

where P_{onHot} and P_{onCold} are the measured powers with the noise diode on looking at the room temperature target and at the cold target, respectively. P_{offHot} and $P_{offCold}$ are the measured power when the noise diode is off looking at the room temperature target and cold target, respectively. L1 is the loss from the bend, 4" transmission line between the antenna and the coupler, and the coupler; C is the coupling factor, and L2 is the loss of the transmission line from the noise source to the coupler.

FIG. 5B illustrates that the measured ENR 550 of the millimeter wave noise source generator 202 is consistent with the return loss measurements of FIG. 5A. As illustrated in the figure, the millimeter wave noise source generator 202 generates approximately 10 dB ENR at 200 GHz which corresponds with a return loss that is best at 200 GHz.

The noise source generators 100, 202, 300 of FIGS. 1-3 are possible examples of a millimeter wave noise source generator that may be employed or be configured in accordance with aspects of the present disclosure. It will be appreciated that other configurations may be utilized.

In the present disclosure, the methods disclosed may be implemented as sets of instructions in hardware or software. It may be further understood that the specific order or hierarchy of steps in the methods disclosed are instances of example approaches. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the method can be rearranged while remaining within the disclosed subject matter. The accompanying method claims present elements of the various steps in a sample order, and are not necessarily meant to be limited to the specific order or hierarchy presented.

While the present disclosure has been described with reference to various implementations, it will be understood that these implementations are illustrative and that the scope of the present disclosure is not limited to them. Many variations, modifications, additions, and improvements are possible. More generally, embodiments in accordance with the present disclosure have been described in the context of particular implementations. Functionality may be separated or combined in blocks differently in various embodiments of the disclosure or described with different terminology. These and other variations, modifications, additions, and improvements may fall within the scope of the disclosure as defined in the claims that follow.

What is claimed is:

1. An apparatus comprising:
a biasing device comprising a first terminal and a second terminal, the biasing device generating noise waves;
a backshort transmission line thermally coupled to the first terminal, the backshort transmission line compensating a reactance of the biasing device;
a crystalline structure connected to the biasing device and the backshort transmission line, wherein the crystalline structure transfers heat from the biasing device to the backshort transmission line;
a filtering component connected at the second terminal, wherein the filtering component prevents the noise waves from leaking out of the apparatus; and

a probe connected to the second terminal for providing a path for the noise waves to a wave-guiding structure.

2. The apparatus of claim **1**, wherein the biasing device is reverse biased.

3. The apparatus of claim **1**, wherein the backshort transmission line comprises vias for transferring heat from the biasing device to the backshort transmission line.

4. The apparatus of claim **1**, wherein the filtering component is a low pass filter.

5. The apparatus of claim **4**, wherein the low pass filter comprises an RF choke and a capacitor.

6. The apparatus of claim **2**, wherein the biasing device operates in avalanche breakdown mode when reverse biased.

7. The apparatus of claim **1**, wherein the crystalline structure is a quartz structure.

8. The apparatus of claim **1**, wherein the biasing device is a Schottky diode operating at millimeter wave frequencies.

9. The apparatus of claim **1**, wherein the backshort transmission line is in-phase with the noise waves.

10. A method comprising:

generating, by a diode, noise waves wherein the noise waves are generated by reverse biasing the diode;

compensating, by a backshort transmission line, a reactance of the diode created when generating the noise waves;

transferring, by a crystalline structure, heat accumulated on the diode to the backshort transmission line;

blocking, by a radio frequency (RF) choke, the noise waves to keep them from leaking out of an apparatus; and

guiding, by a waveguide probe, the blocked noise waves from the apparatus to a wave-guiding structure.

11. The method of claim **10**, wherein the backshort transmission line comprises vias for transferring heat from the diode to the backshort transmission line.

12. The method of claim **10**, wherein the RF choke is a low pass filter.

13. The method of claim **10**, wherein the diode operates in avalanche breakdown mode when reverse biased.

14. The method of claim **10**, wherein the crystalline structure is a quartz structure.

15. The method of claim **10**, wherein the diode is a Schottky diode operating at millimeter wave frequencies.

16. The method of claim **10**, wherein the backshort transmission line is in-phase with the noise waves.

17. An apparatus comprising:

a biasing device comprising a first terminal and a second terminal, the biasing device generating noise waves;

a backshort transmission line connected to the first terminal, the backshort transmission line compensating a reactance of the biasing device, and wherein the backshort transmission line comprises vias for transferring heat from the biasing device to the backshort transmission line;

a filtering component connected at the second terminal, wherein the filtering component prevents the noise waves from leaking out of an apparatus; and

a probe connected to the second terminal for providing a path for the noise waves to a wave-guiding structure.

18. The apparatus of claim **17**, wherein a crystalline structure thermally couples the biasing device and the backshort transmission line, wherein the crystalline structure transfers heat from the biasing device to the backshort transmission line.

19. The apparatus of claim **17**, wherein the low pass filter comprises an RF choke and a capacitor.

20. The apparatus of claim **18**, wherein the crystalline structure is a quartz structure.

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