BARITT DEVICES FOR SELF-MIXED DOPPLER RADAR APPLICATIONS*

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Abstract

The properties of X-band BARITT devices with operating voltages between 10 and 50 V have been measured. The BARITT devices are found to be superior to both IMPATT and Gunn devices for use as self-oscillating doppler detectors.

Several sets of X-band BARITT devices with operating voltages between 10 and 50 V have been fabricated and tested. Operating in the self-mixed doppler mode, these devices are superior to both IMPATT and Gunn devices in terms of minimum detectable signal, RF power required for operation, dc prime power required for operation and sensitivity to changes in bias point and RF tuning.

The circuit used for the doppler measurements is shown in Figs. 1 and 2. In the RF circuit of Fig. 1 the oscillator power is attenuated and fed through a pin modulator by means of a circulator. The signal is 100 percent square-wave modulated and returned to the oscillator after being further attenuated. At the oscillator the returned signal is mixed and the down-converted signal is picked up by a coupling capacitor and amplified. The output of the amplifier is connected to a wave analyzer with variable center frequency and bandwidth where the true rms values of signal and noise can be measured. The minimum detectable signal for a variety of BARITT devices was measured using this circuit.

The minimum detectable signal vs. doppler frequency for a 30-V BARITT device operating at approximately 10 GHz is shown in Fig. 3. These curves have several characteristics present in all of the BARITT doppler detectors tested. First, over a wide power range the minimum detectable signal is not greatly affected by the oscillator power and is not affected by the fact that the power is low. In comparison the operation of IMPATT doppler detectors is degraded at low power levels. Second, the BARITT detector has 1/f noise at low doppler frequencies. Since a complete noise model for BARITT devices has not been developed it is not known if this noise is inherent in the device or is due to the fabrication. Various changes in the fabrication have changed the frequency at which the 1/f noise starts, but it is still present in all of the devices tested. Gunn devices inherently have 1/f noise. Silicon IMPATT devices with proper care in fabrication can be made with no 1/f noise. Third, even with 1/f noise in the BARITT considered, the BARITT is superior to both Gunn and IMPATT devices as a doppler detector. A comparison of a commercial IMPATT, commercial Gunn and the BARITT of Fig. 3 is shown in Fig. 4. As can be seen from this figure the microwave power required for sensitive doppler operation is 15 to 20 dB lower in the BARITT device. Even with the lower conversion efficiency of the BARITT considered the dc power required for BARITT operation is much smaller than for either Gunn or IMPATT devices.

The minimum detectable signal vs. doppler frequency measurements for a 16-V BARITT device are shown in Fig. 5. Even though the voltage is lower in these devices and the power is 10 to 20 dB smaller than the 30-V devices of Fig. 3, the doppler detector characteristics are approximately the same. The -156 dBm minimum detectable signal from 5 to 20 kHz is the best measurement of any of the diodes tested.

The minimum detectable signal vs. doppler frequency measurements for an 11-V BARITT device are shown in Fig. 6. These devices have 1/f noise starting at approximately 20 kHz, rather than 1 to 5 kHz as in other devices, because of changes in the fabrication method. Otherwise the characteristics are similar to the 30- and 16-V devices. The -27 dBm curve was obtained with the devices operating at 11 mW dc power.

In conclusion, BARITT devices have been found to be superior to IMPATT and Gunn devices for use as self-mixing doppler detectors with the following advantages:

1. Minimum detectable signal levels 25 to 40 dB lower depending on the doppler frequency used.

2. Microwave and dc power levels much smaller.

3. Operation possible over a wide range of bias voltages.

4. Operation not sensitive to small changes in bias and microwave tuning.

It is therefore concluded that even though BARITT devices will not compete with regard to power output and efficiency, they will be extremely useful in many applications utilizing self-mixed doppler sensors.

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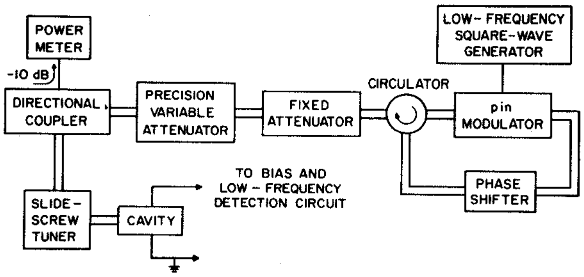

FIG. 1 RF CIRCUIT DIAGRAM.

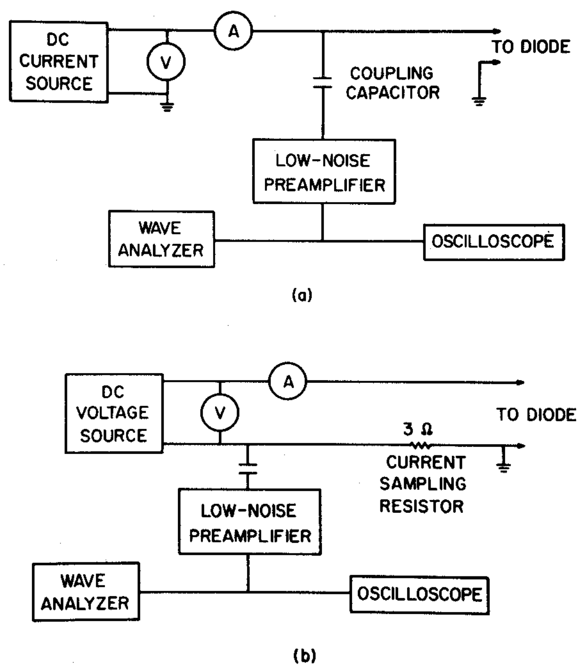

FIG. 2 BIAS AND DETECTION CIRCUITS FOR (a) BARITT AND IMPATT DEVICES AND (b) THE GUNN DEVICE.

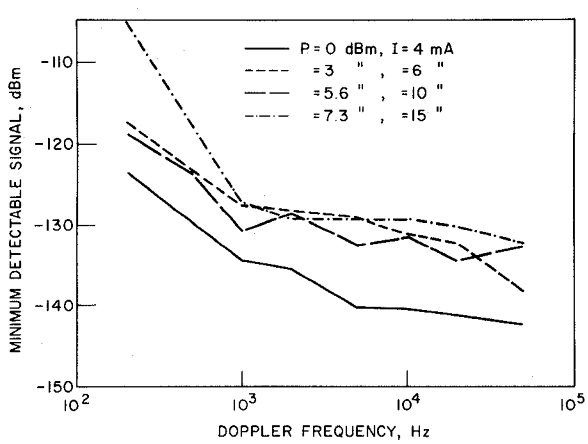

FIG. 3 MINIMUM DETECTABLE SIGNAL VS. DOPPLER FREQUENCY IN A BARITT DEVICE. (V = 30 V, f_o = 10 GHz)

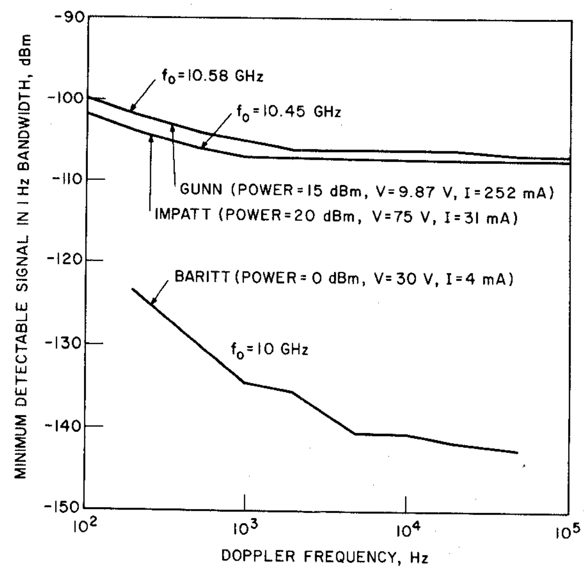

FIG. 4 COMPARISON OF BARITT, IMPATT AND GUNN DEVICES AS DOPPLER DETECTORS.

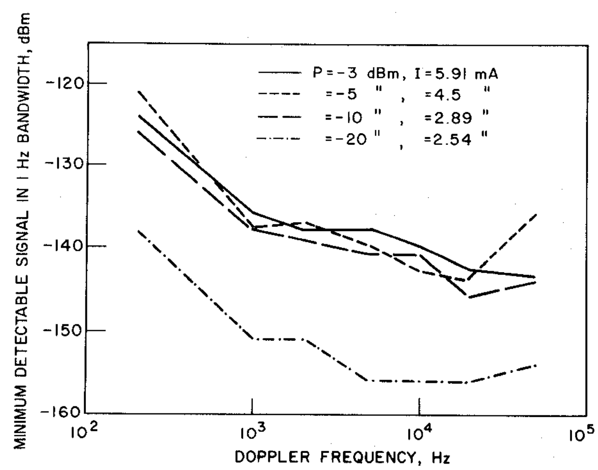

FIG. 5 MINIMUM DETECTABLE SIGNAL VS. DOPPLER FREQUENCY FOR A BARITT DEVICE. (V = 16 V, f_o = 9 GHz)

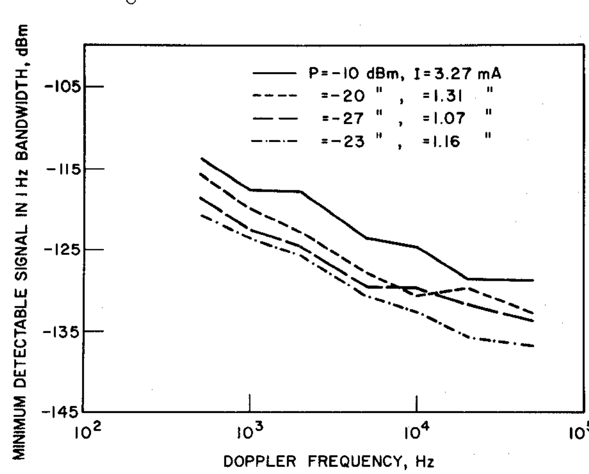

FIG. 6 MINIMUM DETECTABLE SIGNAL VS. DOPPLER FREQUENCY FOR A BARITT DEVICE. (V = 11 V, f_o = 11 GHz)