The Design of Ultra Narrow-Band Amplifiers for High Sensitivity Receiver Front-Ends Using Negative Resistance Devices for ESM, ECM, ECCM, ELINT, Radar, Satellite & Telecommunication Applications

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In order to design and construct very highly sensitive Receiver Front-Ends for Electronic Warfare, Radars, RWR's (Radar Warning Receivers), Direction Finding (DF) Telemetry, Satellite Communications, Telecommunication, Radio Astronomy and Communication application it requires the need to control and select proper narrow fixed or tunable filter bandwidths, noise figure, losses and temperature in the front-end amplifier that is applied and used in the system.

A conventional receiver requires narrowband front end to reject unwanted signals at frequencies in proximity to the operating frequency as well as to reduce the noise content for high sensitivity. Conventional filter designs have bandwidths greater than five percent.

To achieve ultra-low losses, high Q filters and ultra narrow bandwidth in the front-end amplifiers in many systems applications use is made of using superconductor filters or cryogenic cooling technics.

Various topology block diagrams of Receivers used in Electronic Warfare, Satellite Communications, Telecommunication, Transceiver, Radar Warning Receiver(RWR), Direction Finding (DF) systems are reviewed and comparison is made to show key importance role of the receiver front end low noise amplifier in each application. The equations that determine and derive the receiver sensitivity and noise levels are also reviewed and discussed in this paper.

In this paper the authors present design techniques, analysis and experimental results of how Negative Resistance devices and circuits can be used to achieve bandwidths of 0.75% to 0.004% at room temperatures with theoretical amplifier gain of 25db by use of a Tunnel diode at 2.9 GHz as an example. Analyzes of the gain of the amplifier as a function of frequency is made using computer analysis. Similar design techniques can be used for higher microwave & millimeter wave frequencies by use of proper tunnel diodes in chip or beam lead format.

This paper presents the design of a negative resistance amplifier using 3 dB Hybrids and matched tunnel diodes instead of circulators. Circulators are generally magnetic(ferrite) devices and are often larger and heavier than hybrid couplers so they are not used for space or airborne applications. Diodes produced from same wafer are very closely matched and the value of the negative resistance can be fine-tuned by tweaking the bias voltage. MMIC miniature 3db Hybrids have been developed and readily available and their small footprints makes these amplifiers very suitable for space warfare, satellite, 5G, 6G, cell phones, and other handheld communications or defense applications.