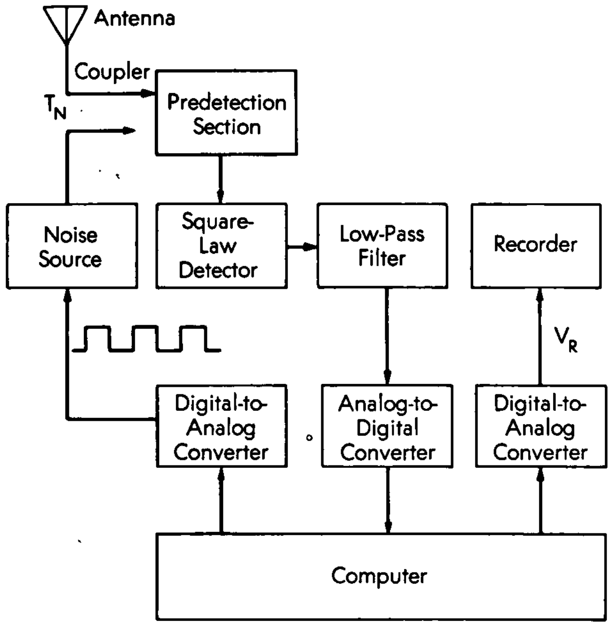
NASA TECH BRIEF

NASA Pasadena Office

Improved Noise-Adding Radiometer for Microwave Receivers

The problem:

To provide a means for utilizing high sensitivity receivers for radioastronomy applications with greater confidence in the stability of the radiometer. A gain compensation scheme is necessary in order for the power output indication to be quantitatively significant. Most gain compensation techniques commonly used, such as the Dicke scheme wherein the receiver input is switched to a reference, would degrade the very low noise-temperature front end of the receiver. For example, a microwave switch in the front end can add about 7°K to the system noise-temperature. This in turn will cause a significant decrease in the radiometer and/or communications sensitivity of the receiver.



The solution:

Avoid the use of an input switch and noise reference standard by using a noise-adding technique wherein the excess noise from a solid state noise-diode is coupled into the receiver through a directional coupler and square-wave modulated at a low rate by computer control.

How it's done:

The ratio of the system input temperature with added noise to the system input temperature alone is given by the ratio of the output voltages of the square-law detector with and without the noise source. This requires a square law detector and linear IF amplifiers. The ratio of the system temperature plus added noise to the system temperature alone is quantized by an analog-to-digital converter and is fed into a computer which is programmed to solve for the ratio using the sampled states; in this manner, the gain terms are canceled. Additionally, the computer performs the functions of bookkeeping and recording.

Referring to the diagram, control and sampling-rate functions are programmed into the computer; the output may be analog recording, printout, and magnetic tape. A solid-state diode (noise temperature 400,000°K) is driven by a constant current source. The input current to the diode is square-wave, shorted by computer control at a low-frequency keying rate ($\approx$11Hz). The resulting square-wave noise is coupled ($\approx$−40 db) into the receiver input. This is a noise temperature increase, T_N, of about 40°K

(continued overleaf)

added into the receiver input at an 11-Hz square-wave rate. By essentially eliminating the gain term, increased radiometer sensitivity is achieved.

Salient to the operation of the noise-adding radiometer is a good, wideband square-law detector. The computer periodically samples the output of the square-law detector and forms a voltage ratio, V_R, which is (neglecting gain changes during the cycle) used to solve for the system operating noise temperature. Noise calibration of the system is accomplished by injecting a separate noise source signal into the receiver input. The value of the calibration source is, for example, 1° to 4°K referenced to the antenna.

Experimental data has indicated that a total power radiometer has lower short-term jitter and is most useful for short-term measurements (seconds), but that the noise-adding radiometer has less drift and is most useful for long-term measurements (minutes). The noise-adding technique of achieving a gain-insensitive radiometer has been demonstrated to be a powerful technique which is ideally suited to application at a deep-space network station. However, a good square-law detector is required, the usual problem of gain linearity must be controlled throughout the system, and the stability of the keyed noise source is critical.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
NASA Pasadena Office
4800 Oak Grove Drive
Pasadena, California 91103
Reference: TSP 73-10345

Patent status:

NASA has decided not to apply for a patent.

Source: Paul D. Batelaan, Richard M. Goldstein, and Charles T. Stelzried of Caltech/JPL under contract to NASA Pasadena Office (NPO-11706)