A VERSATILE C-BAND CRYOGENIC PARAMETRIC AMPLIFIER

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The parametric amplifier described has met several conditions which, to the writers knowledge, have not been realized heretofore in an integrated amplifier assembly suitable for system application. Some of these conditions are

- Nearly optimum noise figure is obtained under cooled or uncooled conditions
- Diodes can be easily replaced or interchanged
- Vacuum insulation of the region surrounding the diode, by use of a diode cartridge arrangement, eliminates the need for special purging or insulation of the overall amplifier structure.

Optimum cooled and uncooled noise figures were achieved by careful choice of the varactor to minimize mobility change with temperature. Best performance was achieved using a commercially available gallium arsenide diode having a cutoff frequency of approximately 170 Kmc measured at -2 volts bias. Minor adjustment of the amplifier is required when tuning from the uncooled to the cooled condition or vice versa. This amplifier has consistently yielded room temperature single sideband noise figures of 2.5 db and cooled noise figures of 1.5 db (when cooled to 80°Kelvin) including input circulator and filter. These results have been achieved with numerous similar diodes and with duplicate structures. Noise figures as low as 1.2 db have been measured on occasion under cooled conditions, and further development is expected to result in consistent noise figures below 1.4 db.

Special attention was given to the mechanical structure in the region of the diode in order to minimize contraction and expansion of the contacting surfaces. A special "star" shaped spring was employed to maintain electrical contact to one end of the diode and the other end was soldered to the cooling assembly. This assembly or "diode cartridge" is shown attached to the remainder of the parametric amplifier in figure 1. The cartridge consists essentially of a cylindrical brass shell surrounding a small copper rod and thermally insulated from the rod by thin stainless steel diaphragms. The diode is soldered to one end of the copper rod and liquid nitrogen is injected into a small hole bored in the opposite end. Vacuum integrity of the diode cartridge is completed by use of a quartz capsule which attaches to the brass shell and encapsulates the diode. This capsule also provides contact to the end of the diode which is not soldered directly to the copper cooling rod and provides a microwave window in the evacuated assembly. The above arrangement results in a compact and efficient cryogenic assembly which can be easily replaced. Furthermore, diode interchangeability is much improved by use of the evacuated cartridge.

Figure 1 also shows a typical scheme of injecting the liquid nitrogen into the diode mounting cartridge. This scheme consists of a vacuum insulated evaporator assembly which is essentially an adapter which modifies the diode cartridge to accept vacuum feeder lines.

The remainder of the amplifier consists of a short 50 ohm coaxial line which is intersected at right angles by a section of reduced height K_u-band waveguide. This waveguide is below cut-off at the idle frequency (11.6 to 12.1Gc) and above cut-off at the pump frequency of 17.5 Gc. Idle tuning is accomplished by use of a sliding short circuit located in one end of the K_u-band waveguide and the idle circuit is separated from the signal line by a low pass filter. Input coupling and signal circuit tuning are accomplished by a small "button" which comprises a part of the diode cartridge. This button makes contact with

the low pass filter through a sliding spring contact in the center conductor.

The amplifier operates at any frequency within the tuning range of 5.4 to 5.9 Gc and nominal bandwidths of 25 Mc are obtained for an amplifier gain of 16 db.

The versatility of this amplifier stems from its simple cryogenic system (primarily the vacuum insulated diode cartridge). If nitrogen consumption is unimportant, as is often the case in the laboratory, a simple fitting can be attached which allows injection of the liquid nitrogen. In installations where nitrogen consumption is an important factor each amplifier employed can be fitted with an integral dewar or several amplifiers may be fed from a single dewar by the use of vacuum insulated feeder lines. Each of the above cooling techniques has been successfully employed. Limited tests have also proven the feasibility of cooling this amplifier to temperatures well below room temperature by use of thermoelectric cooling cells. Such an arrangement can prove useful in stabilization of the amplifier gain under varying temperature conditions or in obtaining small noise figure improvements.

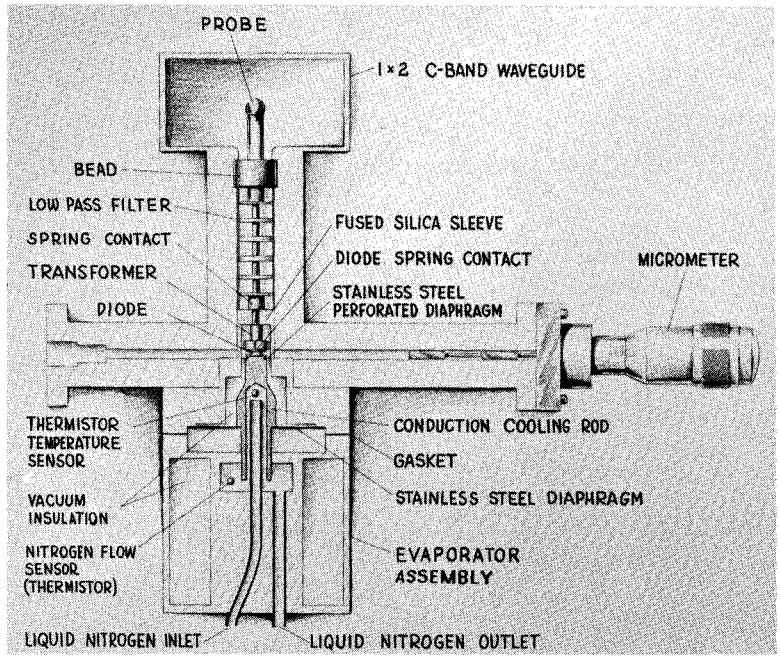

FIGURE 1. C-BAND CRYOGENIC PARAMETRIC AMPLIFIER

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