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REPORT

# 31.4 GHz Parametric Amplifier

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**16. Abstract**

A degenerate parametric amplifier for 31.4 GHz was studied, designed and constructed. Good mechanical stability and a wide bandwidth of about 800 MHz have been achieved using Schottky barrier varactors mounted in specially designed Sharpless wafers and a fixed tuned amplifier mount.



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## 1. Preface

The objective of this contract was to develop, construct and test a parametric amplifier for 31.4 GHz with the following design goal:

3 db instantaneous bandwidth - 800 MHz

gain - 18 db

second stage noise temperature - 1000° (DSB)

Input VSWR - 1.25:1

IF Range - 10 to 500 MHz

Pump Frequency - 62.8 GHz

Noise temperature (DSB) of amplifier including mixer preamp - T = 190K.

In agreement with theoretical predictions a bandwidth of over 800 MHz for a gain of 18 db, an input VSWR of 1.25:1 and a degenerate operation at 31.4 GHz were achieved. The noise temperature of the amplifier was measured to be in excess of 400K (DSB) and could not be reduced to the design goal within the existing time limits and with the limited equipment supplied by GSFC to the contractor. Based on significantly better performance achieved by our group with a 47 GHz paramp radiometer[1-3] it is evident that significantly lower noise can be accomplished for a wide band amplifier with sufficient high-quality test equipment being available.

## 2. 31.4 GHz Parametric Amplifier Design

### 2.1 Varactor Diode Development

Initial theoretical work on the amplifier design indicated that a junction diameter of 3 to 5 μm would give the best compromise between low pump power, low noise temperature and wide bandwidth for a degenerate paramp with a center frequency of 31.4 GHz. In order to minimize the stray capacitance $C_S$ and the loss of the whisker contacting the Schottky barrier junction, and to maximize the mechanical rigidity of the diode structure, the optimum length, diameter, and taper length of the electrically pointed phosphor bronze whisker was found to be 0.25, 0.025 and 0.3 μm, respectively.

Shaping the whisker in form of an L was also found to result in improved stability and reproducibility. Problems associated with non-uniform etching of the whisker tips were overcome by an optimized chemical composition of the etching fluid and a better mechanical movement of the micrometer jig holding the whisker post. A varactor wafer of this design was thereafter constructed, tested and finalized.

### 2.2 Circulator

Theoretical studies on the overall amplifier system led to a circulator specification of 0.6 db max. insertion loss and 40 db minimum insertion loss in front of the amplifier. This way the specified noise, bandwidth and match can be accomplished. Subsequently, such a device was purchased, received, tested and found to meet the above specifications.

### 2.3 Amplifier Circuits

First work on the amplifier mount centered on the search for an optimum way for a broadbanded interaction of the junction with pump and signal circuits. An equivalent circuit modeling the junction-whisker structure as a capacitively loaded post in a rectangular waveguide proved to be a good tool for studying the overall frequency response of the amplifier. Based on these studies an amplifier mount including its associated pump and signal circuits was designed and constructed. Subsequently, rf testing of the amplifier also incorporating the varactor and the circulator was started.

## 2.4 Amplifier Test Results

First rf tests of the amplifier showed an excellent bandwidth of 800 MHz with electronic gain of 18 db. However, the midband frequency was too high. Retuning of all circuits involved resulted in a significant reduction of the bandwidth, probably caused by undesirably stagger tuning of the signal and pump circuits. Later on this effect was eliminated; however, the noise level was relatively high (> 500K DSB).

While trying to reduce this noise the pump klystron which was supplied by GSFC deteriorated to the point that it was no longer usable. After consulting with the Technical Officer it was returned to Varian for warranty repair. This equipment failure delayed the work on the project almost one year.

Another equipment problem was caused by a sweeper main frame; it was not provided for by GSFC and therefore had to be obtained for several short term loans from NBS allowing only short laboratory tests with frequent long waiting periods. Our own solid state sweeper (provided from other fund sources of the University) arrived late and therefore was not available before the end of this contract.

## 2.5 New Technology

None.

## 2.6 Bibliography


1. "A Cryogenically Cooled Two-Channel Paramp Radiometer for 47 GHz," IEEE Trans. MTT-25, No. 4, pp. 280-285, April 1977.

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