AN INTEGRATED X-BAND PARAMETRIC AMPLIFIER

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Abstract

To be reported in this paper are the results of a program for the design and development of an all solid state integrated circuit microwave parametric amplifier. This is a room temperature device with a design stressing low cost and high reliability.

Summary

This paper describes the results of a program for the design and development of an integrated circuit room temperature microwave (X-band) parametric amplifier. The paramp is of hybrid (truly integrated) form. It contains distributed element microstrip ferrite circulators, microstrip transmission lines, distributed terminations, microstrip signal impedance transformers, coplanar line-slot line hybrid junctions for balanced semiconductor diode modulations, broadband transitions from slot line to microstrip, and a high Q cavity for frequency stabilization of the solid state pump oscillator. The paramp design stresses low cost and high reliability, and is suitable for use in any microwave system where low noise performance is important.

The performance goals of this paramp are given in the table below.

Table 1

Center Frequency	9.3 GHz
Bandwidth (1 dB)	1.0 GHz
Noise Figure	2.0 dB
Gain	15 dB
Gain Stability	$< \pm 0.5$ dB/hr
1 dB Gain Compression Point	-10 dBm(output)

Photographs of the top and bottom views of the paramp are given in Figures 1 and 2. In order to facilitate initial testing of the paramp all major functions were separated onto four substrates. A block diagram is given in Figure 3. Substrate S-1 contains a 5 port signal ferrite circulator to ensure satisfaction of the VSWR, gain and phase stability. Measurements of the circulator have shown an insertion loss of 0.5 - 0.6 dB, input VSWR < 1.25, and an isolation > 33 dB across a band of 8.8 - 9.8 GHz. Substrate S-2 contains a microstrip transformer for signal impedance matching to the varactors. This effects the double tuning necessary for broadband operation. Substrate S-3 contains a coplanar line-slot line junction and the special varactor chip developed for this application. The chip contains a pair of high f_{co} GaAs Schottky barrier varactors so arranged as to facilitate bonding to the coplanar line-slot line junction. The signal inputs on microstrip and transitions to the coplanar line via a coupling pin through the substrate. Capacitive elements, C_T, are included at this transition for tuning the varactors to the center signal frequency. The coplanar line is a quarter wavelength at the signal frequency. Pump energy at 37.2 GHz enters S-3 on microstrip and passes through a broadband transition to slot line. Matching of the pump to the varactor chip is accomplished with a dielectric chip positioned along the slot line. Also on S-3 are the idler and pump isolation filters, F_i and F_p respectively. Substrate S-4 contains the pump ferrite isolator (terminated circulator). The pump oscillator uses a commercially available silicon IMPATT diode. The fundamental resonance is obtained by the use of a radial disc resonator on the IMPATT diode package. To ensure frequency stability and spectral purity, a high Q stabilizing cavity has been included. This is in the form of an $n\lambda/2$ short circuited section of reduced height rectangular waveguide machined into the base plate of the paramp directly below S-4. Pump power is coupled from the stabilizing cavity to the isolator microstrip input by use of a small section of coax and a probe extension into the waveguide resonator high electric field position. This pin can be seen adjacent to S-4.

A varactor bias regulator and pump leveling circuit has been designed and is contained in a box mounted on the back of the paramp base plate. This can be seen in Figure 1. The circuit is in a hybrid microelectronic form. Since the paramp gain and phase characteristics are both sensitive functions of pump power and varactor bias voltage, we have included a voltage regulator to ensure varactor bias stability (and compensation) and a varactor current sampling circuit and feedback amplifier to regulate RF pump power.

Acknowledgment

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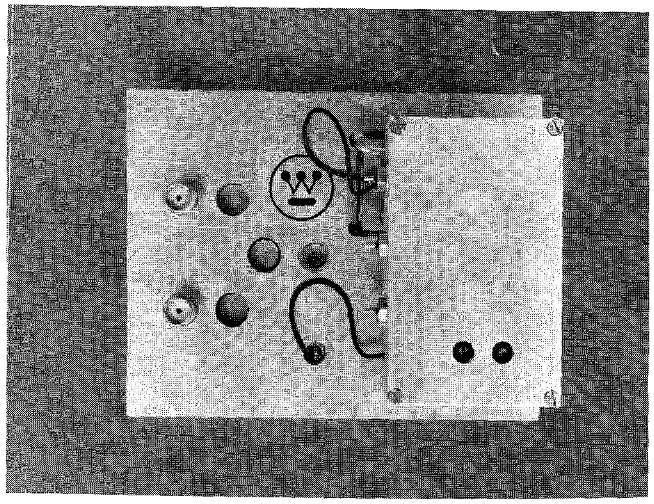

Figure 1 - Paramp top view.

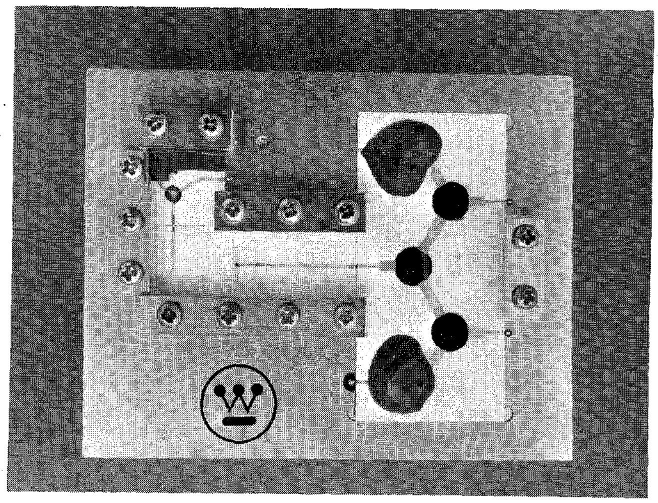

Figure 2 - Paramp bottom view.

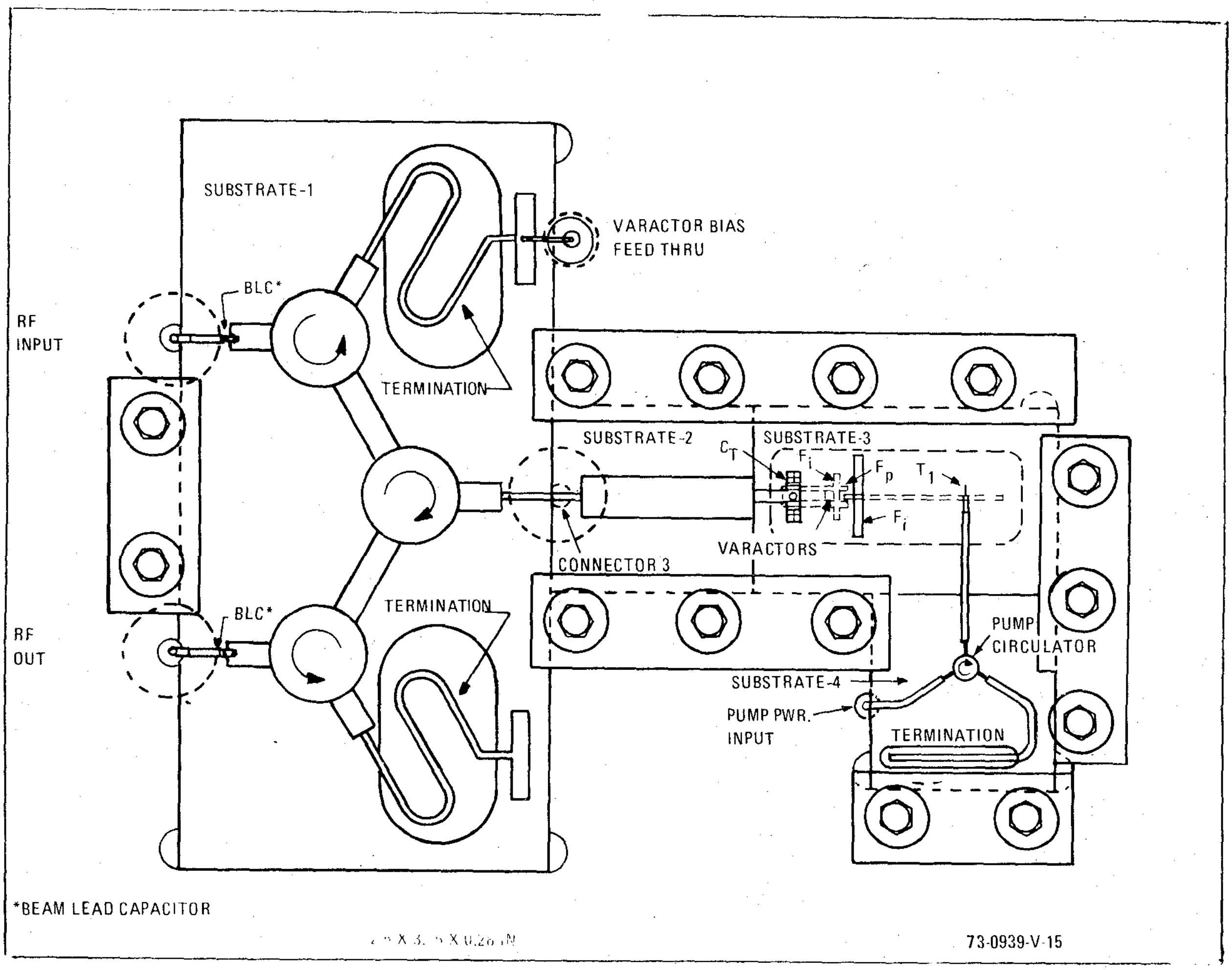

Figure 3 - Block diagram indicating the individual substrates and major functions of the paramp.