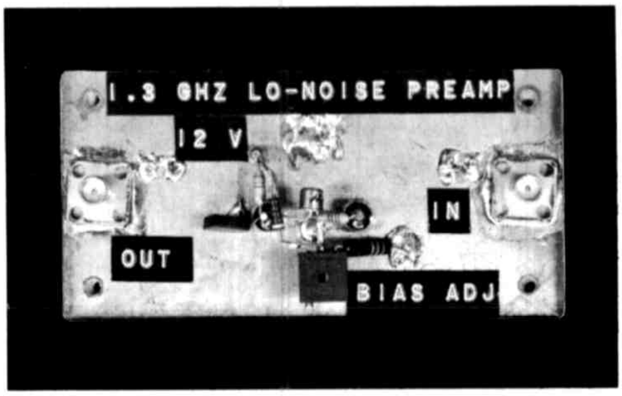
which results in a range of values for X_{out} of between +j34.9 and +j40.9 ohms. The required values for the trimmer capacitor, from $C = 1/2\pi f X_c$, is 3 to 3.5 pF at 1296 MHz. Allowing for variations between devices and imperfections in the micro-striplines, a 1 to 5 pF trimmer will assure cancellation of any of the transistors' shunt reactive



Ground-plane side of the preamplifier stage. Note that component placement in the dc bias circuitry is not critical but the feed-through capacitors make convenient stand-offs. The transistor mounting hole is covered with copper foil to promote good rf shielding.

components. The resulting compromise output circuit is used in the circuits of **figs. 1** and **3**.

input matching

This discussion applies only to the second stage as a complex conjugate match into the first stage is not desired. From **table 1**, the input shunt reactance values for the two different transistors are found to be +j38.5 and +j325.6 ohms. As these values are positive (inductive), a shunt variable capacitor directly at the base will provide reactive matching. The capacitance range required is 0.38 to 3.2 pF. To provide sufficient tuning range, a 0.35 to 3.5 pF capacitor was chosen.

With the shunt reactive component thus disposed of, input matching now amounts to transforming 50 ohms to the required equivalent parallel resistance, R_p. The geometric mean of the R_p values for the two transistors is

$$R_p \text{ (mean)} = \sqrt{12.77 \times 13.11} = 12.94 \text{ ohms}$$

The required quarter-wave matching section has a desired characteristic impedance of

$$Z_o = \sqrt{12.94 \times 50} = 25.4 \text{ ohms}$$

Fig. 3 reflects these values. The resulting amplifier input impedance, as shown in **table 3**, yields an input vswr of better than 1.1:1.

noise-matching the first stage input

A parameter frequently specified for low-noise microwave transistors is the source reflection coefficient for optimum noise figure, Γ_s opt, or simply Γ_o, optimum source reflection coefficient. Either designation is an indication of the *source* impedance seen by the transistor input terminals when matched for optimum noise figure. The reference plane is at the edge of the transistor package, perpendicular to the input lead. The optimum source reflection coefficient, Γ_o, is often plotted as a function of frequency on a Smith chart, as indicated in **fig. 13**. It is important to realize that the impedances read from the Γ_o Smith chart are those looking back toward the source, *not* the transistor's input impedance.

If the input impedance to the amplifier (typically 50 ohms non-reactive) can be transformed to appear at the transistor input as Γ_o, optimum noise

table 3. Actual input impedance and input vswr of Hewlett-Packard and NEC transistors in the circuit of fig. 3.

device	$Z_{in} = 25^2/R_p$	vswr
HP 35826E	48.9 ohms	1.02:1
NEC V021	47.7 ohms	1.05:1