HEWLETT PACKARD

AN-G002
ATF-10136 Demonstration Amplifier
November, 1990

Introduction

This Applications Bulletin describes a one stage low noise amplifier designed using the HP ATF-10136 GaAs FET transistor. This amplifier demonstrates the capabilities of this 0.5 dB noise figure GaAs FET as a front end device for C band Television Receive Only (TVRO) systems.

Amplifier Design And Performance

The amplifier is designed from the catalog S and noise parameters of the ATF-10136. The topology selected uses an open stub tuning elements to establish both the input noise match and the output gain match. A schematic for the amplifier is shown in Figure 1.

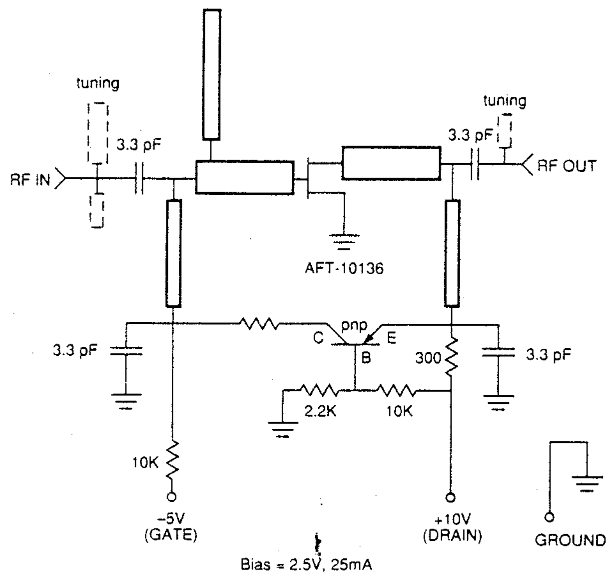

Figure 1. ATF-10136 Demonstration Amplifier schematic

The amplifier is built on 20 mil thick RT/Duroid 5880. This substrate is used for its low loss, and because 50 Ω transmission lines on this board are of a width close to that of the transistor leads. Figure 2 shows a scaled drawing of the layout.

Table 1 lists the performance of an amplifier built using this design. The data shows amplifier performance from 3.6 to 4.3 GHz in 0.1 GHz steps, giving both the noise figure in dB and the corresponding noise temperature in K. The associated gain at noise figure and total current draw are also listed.

The data shows that typical amplifier performance is 0.8 dB (60 K) noise figure at both 3.7 and 4.2 GHz, and 0.7 dB (50 K) noise figure midband. The 0.1 to 0.2 dB degradation in noise performance seen at the band edges is typical of a broadband noise match over a 10% bandwidth. This data correlates to a typical waveguide launched system noise figure performance of about .7 dB (50 K) – see SYSTEM NOISE FIGURE, below.

Table 1. ATF-10136 Demonstration Amplifier

f (GHz)	NF (dB)	NF (K)	Ga (dB)
3.6	0.81	59	12.50
3.7	0.79	56	12.20
3.8	0.72	53	11.90
3.9	0.70	52	11.80
4.0	0.65	52	11.10
4.1	0.65	55	11.05
4.2	0.65	60	10.90
4.3	0.70	68	10.00

Id = 23 mA (VD = 10.0 V, VG = –5 V)

Bias

Two external power supplies are required to bias the amplifier: a +10 V supply for the drain and a –5 V supply for the gate. The gate feed is on the same side of the amplifier as the RF input; the drain feed is on the same side as the RF output and the ground lug.

To turn the amplifier on:

1. First apply –5 V to the gate terminal "G"
2. Then apply + 10.0 V to drain terminal "D"

Altering the voltage applied to the drain terminal will change the bias point by adjusting both Vd and Id. To repeat the factory data, this voltage should be exactly 10.0 V. Only very small adjustments to bias can be accomplished by changing the voltage applied to the gate terminal because of the active bias scheme used.

Nominal bias for the demonstration amplifier is 2.5 V, 25 mA. Recent testing has shown that this bias gives slightly superior noise performance to the data sheet characterization bias of 2 V, 20 mA. The improvement varies from wafer run to wafer run, and is on the order of 0.1 dB reduction in noise figure. The S and noise parameter characterizations at 2 V, 20 mA can still be used for design, as the small bias changes discussed here do not appreciably alter device characterization.

The demonstration amplifier incorporates an active bias circuit to establish the operating point of the FET. For details on the construction and function of this bias circuit, see Applications Note AN-A002, *Design of a 4 GHz LNA for a TVRO system.* Bias is critical to performance. The variability in pinchoff voltage from device to device does not allow for a passive two supply bias with fixed voltages to be successful in production. In addition, the two supply bias will not maintain a stable bias point over temperature; an active bias will.

If the goal is to obtain absolutely the lowest noise LNB possible with the ATF-10136 each first stage FET should be individually set to its empirically determined optimum bias (Vd between 2.0 and 3.0 V, Id between 15 and 30 mA). The improvement in noise figure from the nominal bias (2.5 V, 25 mA) to the true optimum bias for any given ATF-10136 is typically 0.1 dB.

Rf Matching And Tuning:

"Tabs" are used to fine tune amplifier performance, as shown in the schematic in Figure 1 . The stub at the input sets the noise figure vs frequency response. Adding length to this tuner improves noise performance at the low end of the band at the cost of high end noise performance. Adding length to this tuner also rolls off the gain of the amplifier at high frequencies due to increased input mismatch. Typically this tuner is set so that the best noise performance is slightly above mid-band. The small stub at the output of the circuit improves the high frequency gain response by approximately 0.5 dB.

System Noise Figure:

For convenience of testing, the demonstration amplifier uses SMA connectors instead of the waveguide launch found in most production systems. The measured loss of a pair of these connectors is 0.25 dB at 4 GHz. Thus the demonstration amplifier has at least 0.1 dB of noise contribution from the input connector. Use of a waveguide launch would also permit the removal of the input blocking capacitor. Th is component, even though high Q, contributes an additional 0.05 dB to the noise figure of the demonstration amplifier due to its associated loss.

Note that the minimum in-band noise figure of the amplifier is 0.7 dB. Correcting 0.1 dB for the input connector, 0.05 dB for the blocking capacitor, and allowing 0.05 db loss for the input portion of the pc matching structure, we arrive at a minimum device noise figure of 0.5 dB. This confirms the 0.6 dB maximum, 0.5 dB typical noise specification of the ATF-10136

In an actual LNB, the observed noise figure should be the same or slightly better than what is displayed by the demonstration amplifier. A waveguide launch with approximately 0.05 dB loss will replace the input connector and allow the removal of the input blocking capacitor from the design. Although there will be a noise contribution from the latter stages of the system, for a second stage with a 0.9 dB maximum noise figure and 11 dB of gain, a third stage with a 1.3 dB noise figure and 12 db of gain, and assuming a 8 dB noise figure for the mixer, this noise contribution is calculated to be 0.09 dB. Thus systems with noise figures around 0.69 dB (50 K) can be achieved with the ATF-10136 in the 3.7 to 4.2 GHz band.

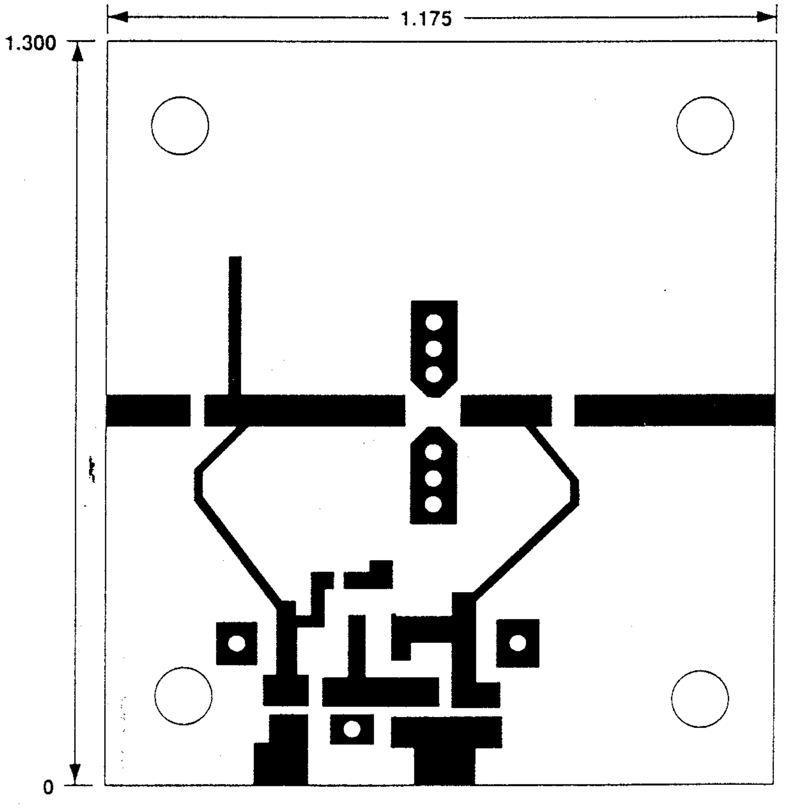

Figure 2. ATF10136 Demonstration Amplifier
3x scale drawing
pc board = 20 mil RT/Duroid (k = 2.5)

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