TO BUILD OR NOT TO BUILD©

By

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Radio Astronomy Supplies
Society of Amateur Radio Astronomers (Founder)

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Partial material from: Robert M. Sickels (ARA Pioneer) Deceased

ABSTRACT

Attempts to successfully build microwave modules, by home builders, have had mixed results. Not like low frequency RF circuitry, microwave technology requires special knowledge of RF, micro-strip technology, shielding as well as packaging.

Historically, experimental hobbyists such as, HAM radio operators and electronic enthusiasts have always been at the for-front of design and construction of electronic circuitry.

Circuitry construction was mainly done in the VLF, HF and UHF bands with available schematics and readily available components. Microwave circuit construction was rare and only attempted by a select few.

To successfully construct a circuit of any type, one must have some expertise in soldering techniques, general knowledge of electronics and the expected performance. In addition, specific test equipment is a “MUST” to complete and optimize the project.

Test equipment may include a signal generator, oscilloscope, noise figure meter, power meter, DVM or a spectrum analyzer. All of these require a significant dollar outlay. Also, the knowledge of operation of such equipment.

For example, the Society of Amateur Radio Astronomers (SARA) was motivated to supply a 408 MHz radio telescope kit for a nominal fee to the membership. This idea was to try and standardize a system for the masses. This kit was designed by a very gifted engineer. To capsulize this project, the kits were sold to about eight members. The results were, it was too intimidating and, parts were very small and hard to handle! Needless to say, the author has not seen or heard of any of these kits being assembled or used.

Robert M. Sickels, Radio Astronomy pioneer (deceased) attempted to try marketing kits to some of his customers. The results were not good! Due to the improper handling of static sensitive parts, overheating during the soldering and the overall lack of test equipment, most of the kits sold were returned, resulting in negative feelings towards the seller. Also, some were so frustrated that they decided not to further their hobby.

In the following paragraphs, Mr. Sickels details some of the pitfalls and thoughts. (Information was taken from *the "Radio Astronomy Handbook", 1989. R.M. Sickels).*

NOTE: In some cases, the circuitry or components described are dated but, still relevant. The following is only for educational knowledge.

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[1]"Practical Methods for the Building of Low Noise Amplifiers"
By
R.M. Sickels (1989)

During the past few years, many hours have been spent in our lab, in experimentation with the new low noise components and the building of low noise antenna and line amplifiers. The experiences of others through publications and personal contact have also been reviewed, and this article is a summation of these experiences with recommendations for the most efficient use of these components.

GaAsFET TRANSISTOR AMPLIFIERS

The following design procedures must be considered:

1. Optimum gain and noise figure can usually be achieved by tuning the input circuit only. The most stable designs appear to be accomplished by making the output stage only broadly resonant. The output stage may take the form of a broadly series resonant circuit consisting of a 1/4 wave choke and appropriate output feed capacitor. Alternately, designs terminate the output into an inductive bifilar device to assure good load impedance match. These terminations too, are also made broadly resonant to the frequency of interest.

2. In radio astronomy applications, the best tuning procedure for antenna preamps appears to be accomplished by attaching the LNA input to the antenna feed to be used, and taking it remote to the radiated test signal into the far-field pattern of the feed (10 wavelengths or more). An audio modulated test signal is then radiated to the assembly with the LNA output

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[1] Radio Astronomy Handbook, R.M. Sickels, 1989

being read by an oscilloscope terminated to the appropriate load impedance. This test and alignment procedure assures the best impedance match from the feed to the LNA input when the assembly is finally located at its permanent site.

3. Though small signal GaAsFET transistors are designed for 5 volt Station, the best low noise results appears to be realized by reduction of the drain potential to about 4 volts. This may be accomplished with a 100 ohm resistor in the feed line (properly decoupled). Professionally built GaAsFET amplifiers show a typical current through the device on the order of 8 to 10 milliamperes. If the amateur's current reading is made by inserting a milliampere meter in series with the B+ line, one should also allow about 5 additional ma. For the current drain of the miniature 5 volt regulator usually associated with these amplifiers. (Total amplifier current typically is on the order of 13 to 15 milliamperes.

4. Tests of professionally built LNAs that have been checked out on noise figure meters show that the best optimum noise figure does not normally occur at maximum tuned gain, but rather at a point typically about 1 dB down from this maximum.

5. In radio astronomy applications, and in Instances where the local oscillator mixer is located very close to the LBA output, a single - stage LNA gain of 18 dB appears to be adequate. (This assumes of course, that the mixer itself is not unduly noisy). In applications where the LO/mixer is situated remotely to the LNA output, an additional booster amp. may be needed to overcome coaxial line loss. This is typical of interferometers series cascading of low noise amplifiers can be an iffy business, and the amateur is cautioned to be alert for possible oscillation in these stages, whenever this procedure is used. An equally serious defect can also occur with such GaAsFET applications If these input stages appear to be operating normally, but are In fact an the *oscillation*. In these instances, any strong local pulse can drive the input system into oscillation with the result that spurious results are logged by the observer. The same problem may hold true if the observation frequency is very near a very strong local broadcast station. In such cases as these, the GaAsFET system maybe saturated by strong local signals and output strong unwanted harmonics rendering it useless for radio astronomy observations.

6. In examination of the engineering of LNA systems used in TVRO satellite work, it has been discovered that as much as 36 to 40 dB pre-mixer gain is commonly used. This is normally accomplished by the use of 4 broadly tuned GaAsFET stages, carefully shielded and de-coupled from each other and the power supply line. Tuned stages in these amplifiers have been observed to have 10 K resistors acres the inductances to broaden the bandwidth and to keep the GaAsFET from 'taking off' into oscillation with the reception strong local pulses.

7. Though GaAsFET transistors have many desirable qualities, they still remain <u>prone to the outlined above, and are also subject to serious long term radiometer drift with changes in ambient temperature</u>.

8. In the design and building of these amplifiers one should not try to economize by selection of poor quality associated components (all must be temperature stable). Metal boxes should house while not detuning the amplifier. This will turn into a resonant cavity rather than an amplifier. Care should also be given to water and condensation!

9. <u>Knowledge of *Static Sensitive* components and how to handle the device or module.</u>

10. <u>Knowledge of Grounding and Shielding techniques</u>.

As we have read in the above paragraphs, there are many points that have to be addressed when attempting to design and build a modern state-of-the-art circuit. This includes IF amplifiers as well as all associated circuitry.

After reading the above, ***<u>consider the time, your expertise, proper tools and, most important, optimizing your project using the latest test equipment</u>***.

<u>Conclusion-</u>

- ***<u>What can you save as far as cost and time?</u>***

- ***<u>Do you have the knowledge and expertise?</u>***

- ***<u>Do you have the proper tools, test equipment etc.?</u>***

<u>Should you build or buy? That is the question!</u>