

Direct Broadcast Satellite Applications

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One of the main reasons for the popularity of direct broadcast satellite (DBS) service is the small size of the parabolic dish antenna. The key to the small-size dish is a low-noise GaAs transistor used in the low-noise block of the DBS receiver system. One of HP's efforts in this area has been to develop an AlInAs/GaInAs device fabricated on a conventional GaAs substrate that has a lower noise figure, higher gain, and lower cost.

The first digital direct broadcast satellite (DBS) service started in June 1994. Today, DBS technology enables consumers to receive digitally modulated television signals directly from satellites. Consumers who bought digital satellite receivers are enjoying excellent high-quality pictures and more channel access. The dynamics of the DBS market are fueled by heavy competition between multiple DBS operators, who are motivated to provide better services and lower prices. This same competition also motivates receiver suppliers to reduce hardware costs.

DBS systems are now spreading at a rapid rate all over the world. Analog DBS systems have been very popular in Europe and Japan, with installations in 25 million homes since 1984. Both of these areas of the world are now switching to digital systems. In the United States, five million subscribers have already installed digital small-dish satellite systems, and the market is still growing. DBS services are just starting to be implemented in Asia and South America.



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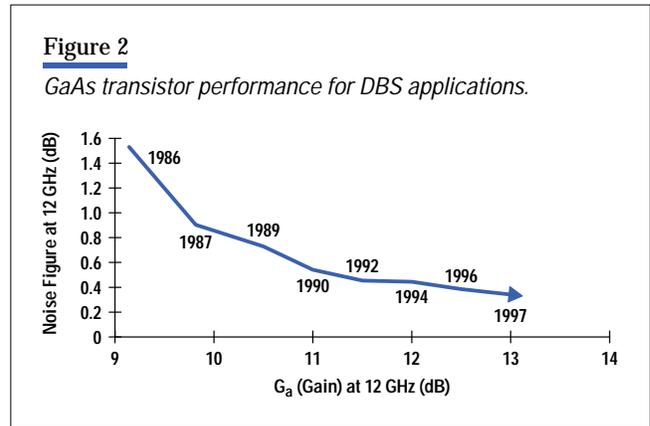
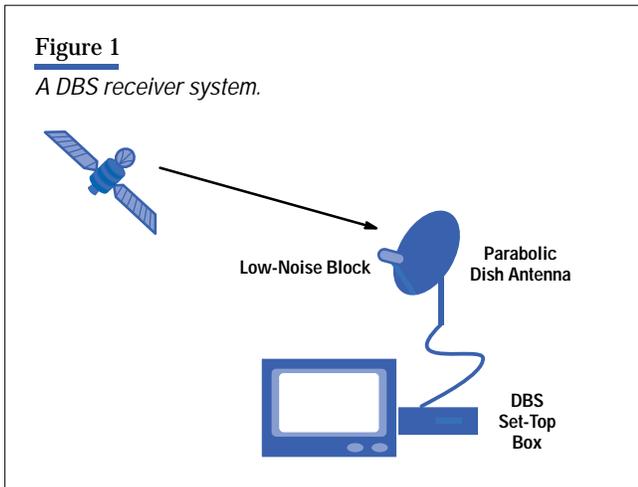
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Low-Noise Block

A DBS receiver system consists of two main components: a parabolic dish antenna with a low-noise block (LNB) down-converter and a digital set-top box (see **Figure 1**). The system receives digitally modulated video programs from high-powered Ku-band* transponders situated on satellites in a geosynchronous orbit (where the satellite is always in the same position relative to a position on earth). Using Ku-band carriers, the DBS system requires a much smaller dish antenna (18 inches or smaller) than C-band systems.



A key device that enables the use of a small-size dish is a low-noise GaAs transistor in the low-noise block. Lowering the noise figure improves the carrier-to-noise ratio for a given size of dish antenna, while still maintaining the signal quality. Therefore, the history of developing low-noise block downconverters is the same as improving the noise figure of GaAs transistors.

Typical GaAs FETs offered a noise figure of 1.2 dB to 1.5 dB for the European and Japanese DBS systems in 1985. Now, GaAs PHEMT (pseudomorphic high-electron-mobility transistor) technology has been pushing the noise figure of commercial PHEMTs down to the 0.4 dB to 0.5 dB level at 12 GHz. **Figure 2** shows these performance trends.

A typical low-noise block consists of a two- or three-stage low-noise amplifier, a downconverter mixer, a local oscillator, and a two-stage IF amplifier (see **Figure 3**). The first-stage low-noise amplifier sets the system noise figure. Therefore, the transistor with the lowest noise figure should be selected. The second and third stages should provide an appropriate gain as well as a suitable noise figure to meet the system specifications. Because of strong competitive pricing pressures, low-noise block manufacturers are forced to reduce costs each year, while at the same time improve performance. More recently, a radio architecture has eliminated the third stage low-noise amplifier and using an active mixer has become the optimal solution for lowering cost. However, the noise figure and gain per stage in the low-noise amplifier chain have become more critical.

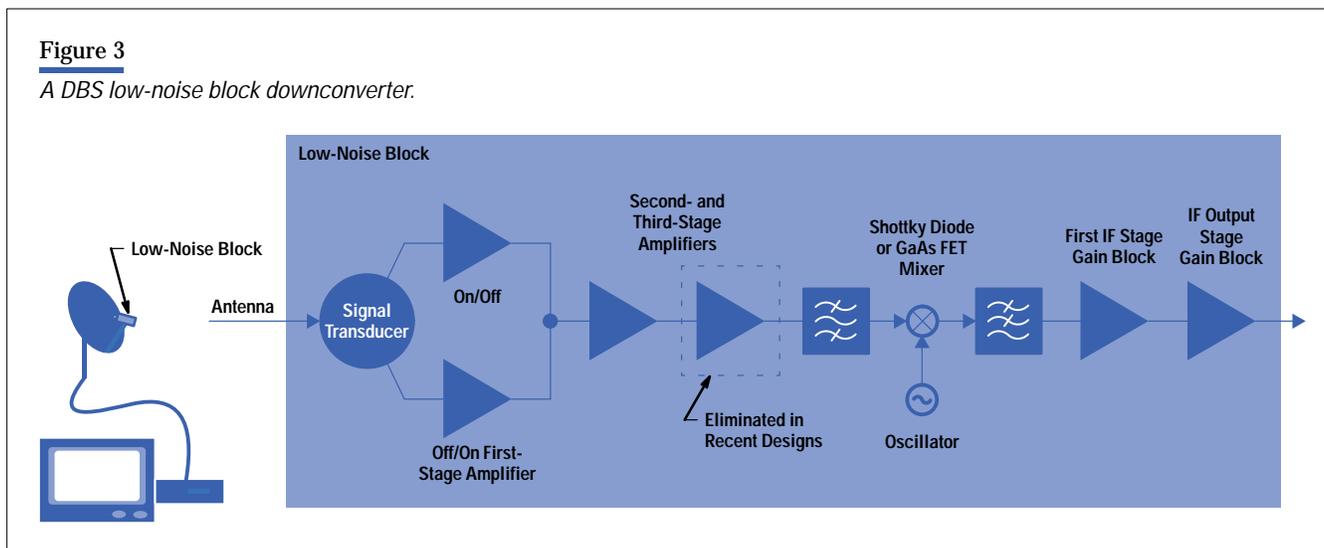
Noise Figure and Packaging

GaAs transistor suppliers have been improving the noise figures every year by modifying the device structure and fine-tuning the lithograph technology. However, GaAs material technology appears to be approaching its limits. Although InP-based devices might be required for further noise-figure improvements, this technology has higher costs. Conventional packages for these low-noise transistors are ceramic-based microstrip packages, and the cost of these ceramic packages appears to be approaching bottom. The obvious choice is a plastic package such as the SC70 (SOT-343). However, plastic material degrades the noise figure and the G_a (associated gain) at high frequencies. The plastic package

* Ku-band broadcasts are between 10.95 GHz and 12.75 GHz.

Figure 3

A DBS low-noise block downconverter.



must be designed to optimize microwave performance and keep the cost low by using standard plastic package manufacturing processes. Manufacturing capacity is an important consideration to ensure that the peak demand rate can be met. HP's solution to this manufacturing concern is based on two research-and-development projects that have the following objectives:

- Develop an AlInAs/GaInAs device fabricated on a conventional GaAs wafer to achieve a lower noise figure and much higher gain at lower cost
- Develop a surface mount plastic package optimized for microwave frequency, which is to be manufactured by standard molding processes and tested by high-volume testers (see **Subarticle 6a, Packaging**).

A transistor on the wafer made with the LGLTBL (linearly graded low-temperature buffer layer) technology typically provides a 0.10- to 0.15-dB lower noise figure and a 2-dB higher associated gain than the best GaAs PHEMT. We have developed a device, which is packaged in a plastic surface-mount package, that shows a noise figure of 0.5 dB and a G_a of 13.5 dB. This noise figure is close to the top level, and the G_a is the highest on the performance mapping.

A higher G_a effectively contributes to reducing the total system noise figure, especially for a two-stage low-noise amplifier system (assuming that the third-stage amplifier is eliminated to keep costs down). In this regard, HP provides better performance at a lower cost for the emerging DBS market. Furthermore, the high-volume production will offer a low-cost manufacturing platform for future Ka-band and millimeter-wave applications.

* Ka-band includes frequencies between 18 and 31 GHz.

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