# A CABLE TELEVISION SATELLITE EARTH STATION

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## Introduction

Today the cable industry is searching for ways to obtain new subscribers and additional revenues from existing subscribers. Satellite communication is a technique available today by which every cable system can significantly increase programming in order to attract these new revenues. This additional programming can be obtained with relatively small capital outlay or additional operating cost. Satellite distribution eliminates the need of reaching all cable systems by terrestrial microwave and the expense of bicycling films or cassettes from system to system.

This paper describes a satellite receiving station designed specifically for CATV systems. This system fully demonstrates the availability and simplicity of interfacing satellite signals with a typical cable system.

## Satellite Availability

Satellites in a synchronous or geostationary orbit simplify the mechanical requirements of the earth station since the satellite does not move with respect to earth. By placing the satellite in an orbit approximately 22,300 miles above the equator with an eastward speed of 7,000 miles per hour, the satellite will match the rotation of the earth and appear to be stationary. The earth station antenna needs only to be pointed at the satellite. There is no need for the antenna system to track the satellite since its total movement is less than 1 degree. The stationary satellite also reduces the operation and maintenance cost of the station since repointing will only be occasionally required.

In this system, signals from the Telesat Canada Anik satellites are used. Anik is the Eskimo word for brother. The satellite was designed by Hughes Aircraft Company and Anik I was launched in November 1972 from Cape Kennedy by NASA. Anik I is the first of three such satellites planned by Telesat. Each satellite will have the capability of relaying twelve full color TV signals. Presently the Anik is being used to distribute three TV signals to the remote stations in Canada.

The FCC has given permission for several U.S. common-carriers to lease satellite capacity from Telesat, Canada. Satellite service from at least one of these carriers will be available as early as July of this year, making CATV satellite systems a present day possibility.

## Satellite Communications System Description

Although the satellite and associated launch operations are quite complex and expensive, the overall communications system is simple in principle (see Figure 1).

The TV baseband signal to be relayed is used to modulate the 6 GHz uplink signal from the transmit earth station. The communications satellite, in synchronous orbit 22,300 miles above the earth, receives the 6 GHz signal. In the satellite, the signal is translated to 4 GHz, amplified, and is beamed to one or multiple earth stations. Both the up and down link frequency bands of satellites to be launched in the near future are in the 4 and 6 GHz terrestrial microwave bands.

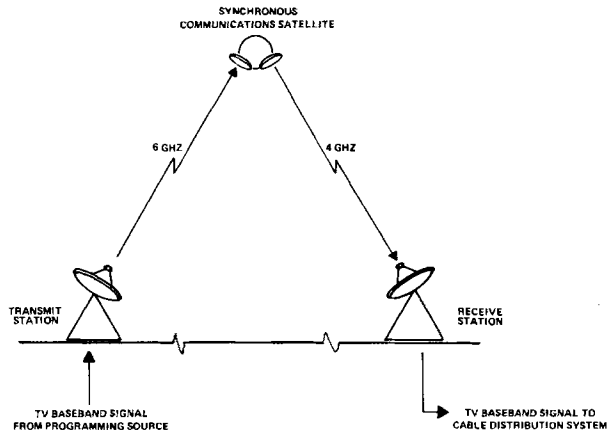


*Figure 1–Overall Satellite Communications System*

For CATV applications, up to 12 TV channels can be transmitted from the satellite within the 3.7 to 4.2 GHz band. As shown in Figure 2, each TV channel occupies a 40 MHz band (including guard bands). Wideband FM modulation is used to improve video signal-to-noise ratios and to reduce satellite power requirements.

It is the purpose of the earth station to receive the extremely weak 4 GHz signals and to restore them to a useful video and audio baseband form.

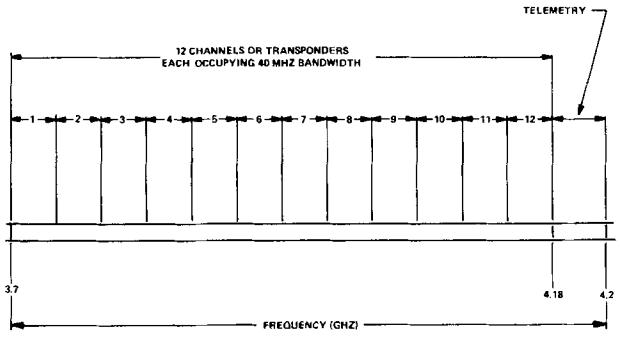


*Figure 2–Satellite Signal Characteristics*

## CATV Earth Station Description

A transportable CATV satellite earth station is shown in Figure 3. The configuration for operational cable systems will be similar in appearance to this one, but will not require the trailer and cab assembly.

The system as equipped for two channels of TV reception consists of a 25-foot diameter microwave antenna, an extremely sensitive preamplifier called a low noise receiver (LNR) and two TV receivers, each capable of receiving any one of three desired channels. See Figure 4. Each receiver provides a video output and three audio outputs. In the Telesat satellite system, one program audio channel accompanies the video, and the two additional audio channels are provided to carry cue and radio broadcast signals.

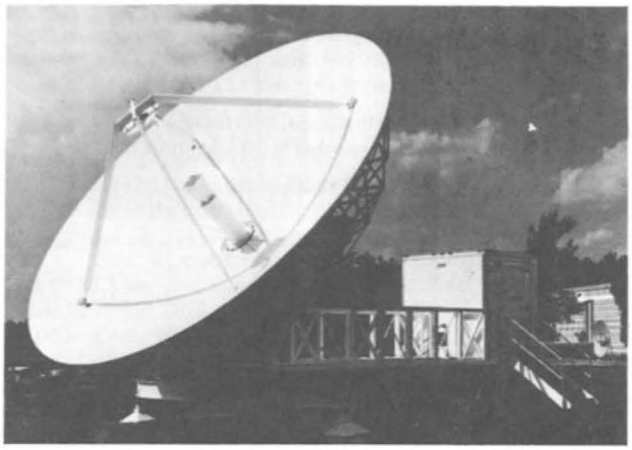

*Figure 3–Transportable CATV Satellite Earth Station*

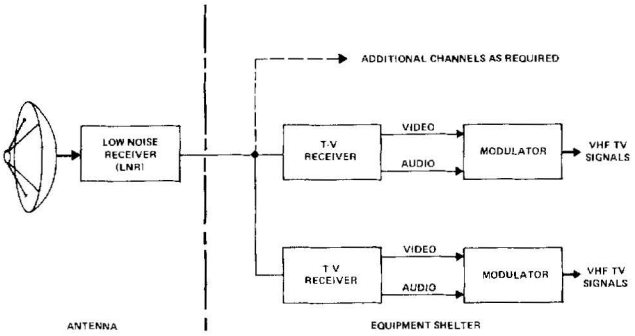


*Figure 4–System Block Diagram*

## Antenna and Feed System

The antenna system used is a 25-foot diameter reflector with a Cassegrain configuration feed system. In this system (see Figure 5) energy received by the main reflector is reflected to the subreflector and then reflected again, where it is focused on the horn feed located at the center of the reflector.

The Cassegrain configuration is used because it is highly efficient, and it receives very little energy from surrounding terrestrial microwave stations. It also receives very little signal from the ground, which in sensitive satellite earth stations, can also be a source of interfering noise.

The feed horn may be manually rotated about its axis to provide optimum alignment in polarization. It is pressurized with dry air to keep moisture from accumulating on the interior.

## Low Noise Receiver

The Low Noise Receiver (LNR) is a parametric amplifier to provide low-noise amplification of signals over the entire 3.7 to 4.2 GHz band. It is mounted directly to the back of the antenna feed horn to reduce losses

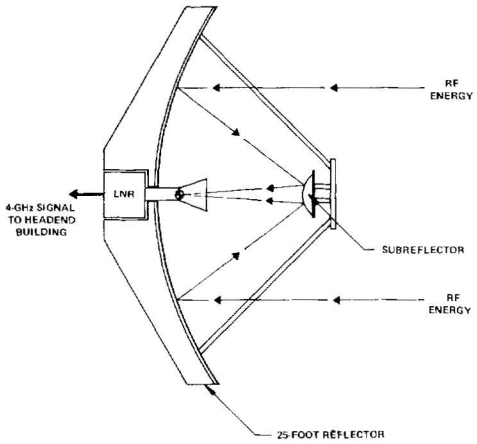


*Figure 5–Antenna Geometery*

to an absolute minimum. As mentioned before, this system is so sensitive that even energy radiated by the earth is a source of interference. For this reason, it is necessary to exercise extreme care in the antenna and LNR design.

The LNR offers about 50 dB of signal gain, so that the cabling losses between it and the TV receivers become relatively noncritical. The LNR is protected by the hub of the reflector and is additionally enclosed in a weatherproof enclosure. Figure 6 is a photograph of the LNR.

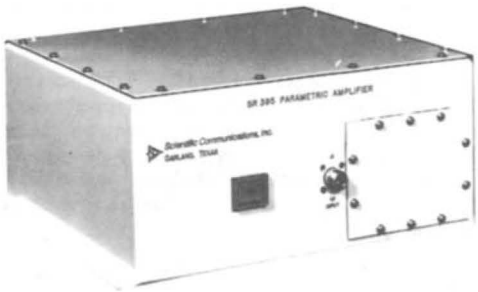

*Figure 6–Low-Noise Receiver*

## TV Receivers

Two of the TV receivers are shown in Figure 7. One receiver is used for each TV channel. Additional channels may be added simply by adding TV receivers to the system. This receiver is very compact in nature and has been designed specifically for use in CATV headends. It differs drastically from other receivers previously used for satellite reception.

Each receiver is modular in construction and uses solid-state devices throughout. A front-panel switch allows the selection of one of three channels within the 3.7 to 4.2 GHz band. This may be readily expanded to obtain up to 12 switch selected channels.

Front-panel metering is provided for display of signal-to-noise levels as well as power supply, audio and video signal level checks. These functions can be monitored for remote alarms if desired.

It should be pointed out that this receiver is electronically tuned, which permits it to be remotely tuned at very little additional cost.

For rapid troubleshooting, the circuit modules are replaceable from the front panel without removing the receiver from the rack. A built-in module test slot is provided for maintenance procedures. The video output levels are standard 1V peak-to-peak, 75 ohms. Audio outputs are 0 dBm, 600 ohms.

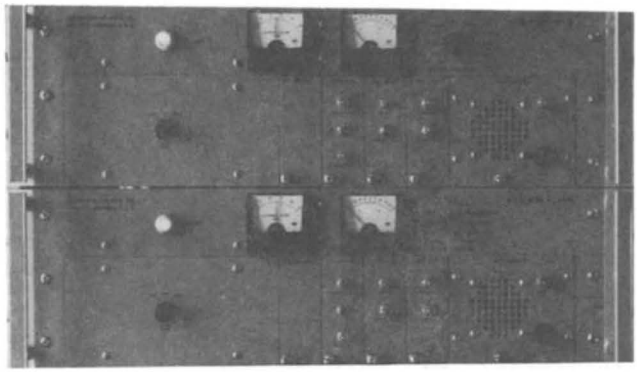

*Figure 7–TV Receivers*

## Location of the CATV Satellite Earth Station

Siting for the typical CATV satellite earth station differs from a normal headend antenna installation or a terrestrial microwave system. In the case of the satellite earth station, it is desirable to locate the antenna in a low spot where natural terrain or surrounding buildings provide shielding from terrestrial interference. In many cases the satellite earth station will operate without degradation, where terrestrial line-of-sight systems might exhibit interference effects.

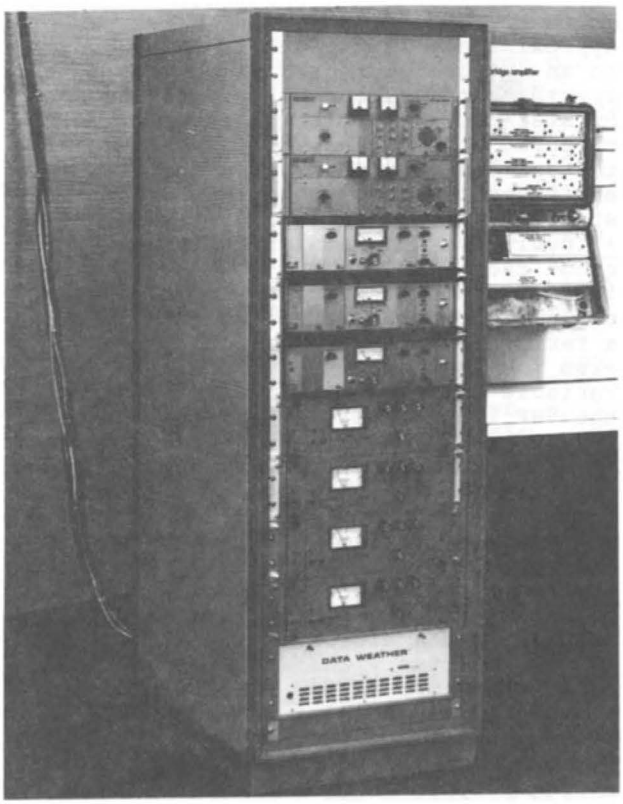

*Figure 8–Typical Headend Rack with TV Receivers and Modulators Installed*

In most locations, the 25-foot diameter Cassegrain antenna will provide 50 dB or better rejection of interfering terrestrial 4 GHz signals. Natural terrain or buildings can provide an additional 20-40 dB of shielding.

It should be pointed out that one of the important considerations of the design is that future satellites may be parked in orbit at a spacing of 5 degrees. The antenna system is capable of reducing those interfering signals to a negligible level.

## CATV System Interconnect

It is felt that despite potential interference from terrestrial microwave stations, most CATV satellite stations can be located close to the headend system. In this case, the audio and video signals are processed by cable system modulators and enter the system as any conventional VHF TV signal.

Figure 8 is a photograph of a headend system including both satellites and off-the-air electronics. The headend electronics are complicated only by the addition of the TV receivers and modulators.

When terrestrial 4 GHz interference is severe, it may be necessary to remotely locate the satellite earth station. In this case, the remote signal may be relayed either by cable or by terrestrial microwave.

## Overall Satellite Earth Station Performance

Television transmission requires special design considerations, because the equipment must be capable of passing broadband FM transmissions. In the overall system design, bandwidth, interference rejection, crosstalk, thermal noise and nonlinear effects have been very carefully considered in light of the application for CATV systems.

In color TV transmission work, nonlinearity effects are quite rapidly evaluated by differential phase and differential gain measurements. The receiver, which measured at less than 1 degree for differential phase and 0.5 dB for differential gain at 10-90% average picture levels, insures negligible degradation in picture quality. When compared to the off-the-air reception of UHF and VHF signals, satellite transmission realistically offers remarkable picture quality improvement as well as the programming potential previously mentioned.

A summary of the overall system performance specifications is given below:

| Characteristic | Specification |
|---|---|
| Antenna Size | 25-foot diameter |
| Operating Frequency | 3.7 to 4.2 GHz |
| Antenna Gain (4.0 GHz) | 48 dB |
| G/T (4.0 GHz) | 27 dB |
| Video Signal-to-Noise (Clear Sky) | |
| Canadian Satellite | 50 dB nominal at Anaheim |
| U.S. Satellite | 54 dB minimum throughout U.S. |
| Video Response | 10 Hz - 4.25 MHz (±0.5 dB) |
| Differential Gain | 0.5 dB maximum, 10-90% APL |
| Differential Phase | 1 degree maximum, 10-90% APL |
| Video Outputs | 1 per receiver, 1V peak-to-peak, 75 ohms |
| Audio Outputs | 1 program, 1 cue, 1 broadcast (Telsat) at 0 dBm, 600 ohms |
| Operating Temperatures | 20 degrees F to 100 degrees F (indoors)<br>-20 degrees F to 160 degrees F (outside) |
| Power | 115V, 50/60 Hz, 12 amps |