THE CHANGING CABLE-SATELLITE CONNECTION

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The delivery of television service via satellite now faces the most dramatic changes in many years. The introduction, during the last 12 months of three totally new delivery systems, and their implementation in the U.S. will affect all CATV operators. The activation of the first full encryption service, the first KU band Pay television, and the licencing of DBS, present an entirely new set of technical problem to the operator. We will examine the effect of the changes through their implementation in Canada. The lessons learned may help the transition facing the American CATV operator, when these new technologies are instituted in the U.S.

INTRODUCTION

The distribution of Pay TV via Satellite is now a well established technology. In the last few years, the system has evolved from the first telecom supplied TVRO's to the present company owned uplinks. From the first days of parametric amplifiers and 10m TVRO's to today, when a TVRO system is within the reach of the smallest cable operator. It is a well proven fact, that when the technology expands, the price and complexity comes down. This development is not always smooth, and in fact, some major obstacles have, and will lie in the way. Before we, as cable operators look back, smile and say "Well, we did it", perhaps we should peek around the next corner. Three major developments of the last 12 months will dramatically affect the equipment market and the cable operator. The changes which will result from these advances, and the interface engineering problems along the way, will lead to a very different cable satellite system in the near future. This process has begun, as two of these developments are already on line and operating in Canada, and the third is in progress in the U.S.A.

THREE MAJOR SATELLITE DEVELOPMENTS

- In May 1982, Canadian Satellite Communications Inc. (Cancom) began the delivery to cable and LPTV system of <u>fully encrypted television</u>.

- In September 1982, the Satellite Television Corporation (STC) was authorized by the FCC to construct a DBS system to cover the U.S.A. (12.2-12.7 GHz).

- In February 1983, Pay TV came to Canada via ANIK C in the KU (11.7 - 12.2GHz band).

The recent announcement by HBO that they too, will be encrypting signals, means that the same lessons learned with CSC Canada will soon apply to the U.S. The success of Pay TV delivery via KU band, and the benefits in areas such as interference, will push the US towards this type of delivery. DBS, for the first time, takes satellite communications into the area of mass consumer production.

THE TRANSITION TO ENCRYPTION

Programming in Canada is much more tightly regulated than in the U.S. The regulations are designed to control outside cultural influences, as well as to protect the local broadcaster from unfair competition. The geography however, presents a problem in that the regulations are only enforceable in the more densely populated areas. By 1981, a very embarrassing situation had developed. While cable operators in major cities were trying to get approvals to receive everyday U.S. network programming, every pothole community in the northland had a dish, and was distributing HBO illegally. Efforts to stop this activity were met with an unanswerable argument: there was nothing else available. The government decided to license the delivery of four Canadian independent stations, to which these communities could subscribe. There were, however, some initial constraints applied to the system.

FIRST : Canadian law holds strong rights for a local broadcaster. Any other service must delete all simultaneous programming. Many communities had a local CTV network affiliate, and one of the uplinked independants was a network affiliate.

SECOND : Several sports associations argued that a blacked out game in Toronto could be received on the Vancouver up-link by a Toronto tavern.

THIRD : Subscribing communities paid for the service on a monthly, per customer base. Collecting an overdue account from an operator on the Beauford Sea is only slightly easier than from a customer in Afghanistan.

THE ANSWER : Addressable encryption. CSC chose a system comprised of Multi Mode Encryption, Digitized Audio, and Computer control of Decoders.

The Problems

The initial fire up problems were quite severe and could be categorized into three distinct items:

A) The quality of the TVRO equipment

B) The new factors introduced into the signal

C) The technical operation of the link

The TVRO systems in most communities to be served by CSC had been designed to provide minimum acceptable picture quality. 10' antennas and spherical mesh antennas were common, and receive equipment was very often consumer grade or surplus gear. G/Ts of 17.5 to 18.5, and C/Ns of 8 were very common. Most systems did not even have proper accommodation, and were installed by people with little or no technical expertise.

The encryption manufacturer had specified a minimum G/T of 20.4 and a minimum C/N of 11dB. The difficulties in trying to explain why a system delivered good pictures from Satcom, and poor pictures in the encrypt/decrypt mode, to untrained operators were enormous. The adamant operator view of "it was OK before, so it must be the scrambling", was a major problem. In reality, any system which delivered cable quality pictures without the use of limited bandwidth or threshold extention was probably suitable for encrypted traffic. The use of low quality antenna systems and low cost receivers (PLL) etc. is not confined to the Canadian North. Indeed many small American cable operations have cut a few corners in this way. It is safe to assume that the problems will occur in much the same way when HBO and others begin encryption.

The encryption system introduced several new factors to satellite transmission. Most significant among these were sync suppression/restoration, and high rate data traffic. These two factors caused significant difficulties for receive equipment in the field. In order to handle this signal, the typical receiver required the following changes:

All sync handling circuitry had to be disabled. Any residual clamping action would act on the data streams rather than on the non existant sync. In addition, the lack of sync makes level setup quite confusing.

Increased video headroom and response were required to handle the high data rate. The combination of pre-emphasis, and data overshoot, often makes the data the highest peak to peak content of the signal. A typical example of what may happen in these cases is shown in Fig. 1 and Fig. 2. Fig. 1 shows a data burst riding in a sync location, and being affected by a sync clamping circuit. Fig. 2 shows the peak to peak video as normal, and with the addition of data and dispersal. We can see that, not only is the peak to peak level handling requirement much higher, but the item most likely to run out of headroom is the data train.

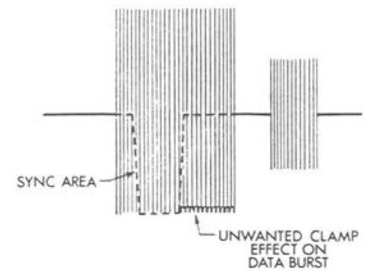

FIG.1

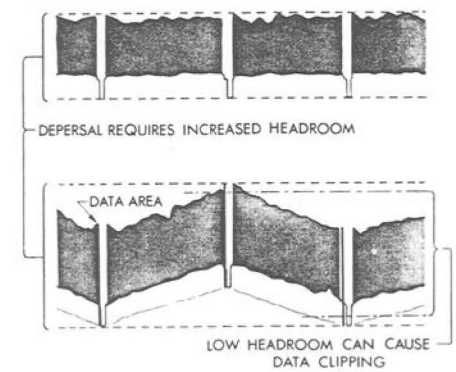

FIG.2

Solutions

One of the more successful approaches to these problems lies in the application of FM compression/EDW feedback. The application of this technique allowed both major problems to be addressed simultaneously (Fig. 3). A typical FM compression receiver operates in the following manner. After demodulation, a sample of the energy dispersal waveform is extracted, and fed back to the front end. It then drives a tuning element which corrects the input tuning in time and out of phase with tne dispersal. The result is that the entire dispersal deviation is removed before IF filtering and video demodulation.

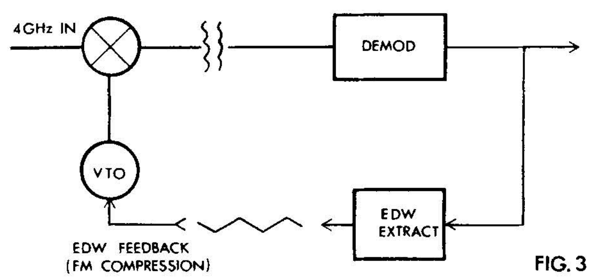

FIG. 3

The immediate effects are a) the peak to peak deviation and the peak to peak video level are reduced before processing; b) the removal of the dispersal eliminates the need for any kind of clamping circuit, and therefore any clamping distortion. Because the dispersal rejection is active, no correction is required for different dispersal levels. A receiver of this type is highly transparent to any form of data/video combined signal. A side benefit is that the FM compression, by reducing truncation noise in the IF filter, provides an immediate, dramatic improvement in dynamic threshold. FM compression receivers can operate with encrypted signals well below the encryption manufacturers' minimum G/T and C/N requirements and allow satisfactory performance with many of the 10' remote systems.

As we are aware, Data and RF are two very different sciences. Video is in itself a specialized science, and not one which is fully understood by most Data or RF technicians.

In most cases the RF people are unaware of the video baseband of their system, and the data people assume that the video will be well maintained.

The encryption system may be designed to regenerate sync at the decoder, and if so, it will be perfect in both level and form. If the video provided to the encryption unit or to the decoder, varies in level or content from ideal, difficult situations arise. It may sound like a simple matter to control, but, how do you measure video level with sync removed, data added, and video content altered for security? Problems in this area have and do arise, and usually result in much finger pointing and yelling. Point of note: a cable operation receiving encrypted video had better have someone available with the equipment and expertise to handle baseband video.

12 GHz PAY TV

The transition to KU band for pay television, which began with ANIK C, has been brought about by several factors. Because the 11.7-12.2GHz band is dedicated to television downlink, there is no prolem with terrestrial interference. Because there are no terrestrial links to be interfered with, higher downlink powers are possible.

The shorter wavelength allows smaller receive antennas as well as more control of beam shaping. ANIK C operates 16 transponders, each capable of carrying two channel simultaneously one half transponder format. These transponders are arranged to transmit 8 transponders (16 channels) to the western half of the country on vertical polarization, and 8 transponders east on horizontal (Fig. 4). The online date for this service and format, was preceded by about two weeks of occasional test patterns, making for a terrific scramble on "PAY" day. There were three reception methods available, in limited supply, to the cable operators, and many systems are not yet activated. The available hardware consists of:

A) some experimental 12GHz LNC receivers (single channel per down converter)

B) new block downconversion receivers (LNB) which require all new equipment to be purchased.

C) 12GHz to 3.7-4.2MHz block converters which allow the reuse of existing 4GHz receivers.

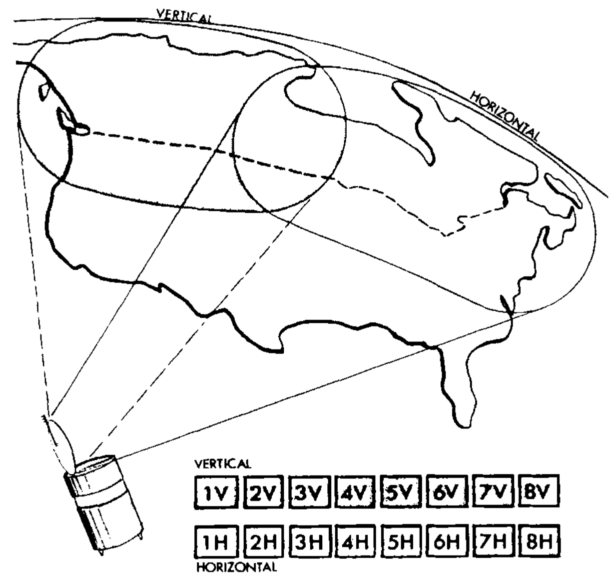

FIG.4

The supply and cost of this equipment presented the major problem, particularly when many operators were acquiring a 12GHz TVRO as their first TVRO. Each type of receive system had its peculiarities and required adjustments both in equipment, and in the way we think about TVRO systems.

The first item of concern was the antenna. Surface tolerance at 12GHz is quite critical, and many existing 3.5-4.5M C band antennas do not perform as well at KU band as a properly designed 1.5M 12GHz antenna. In order to provide margin and high G/T, most cable operators opted to purchase new 12 GHz antennas in the 3.5-4M size, but some tried to use whatever they had available. From the antenna, there are three systems available to recover the 12GHz signal (Fig. 5). The LNC system could be used by operators wanting only one Pay Channel. The LNC consists of a 12GHz low noise stage, followed by an image reject mixer, and a tunable local oscillator. The oscillator is remotely tuned from the receiver, and converts the desired channel to a low IF (i.e. 70 or 140MHz) which is transported to the receiver on low cost coaxial cable.

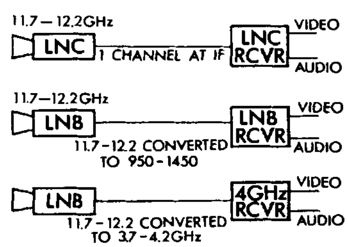

FIG.5

LNBs to high IF or to 4GHz were available, and both are widely used. The LNB to 4GHz converts the 11.7-12.2 band to 3.7-4.2GHz. A standard 4GHz receiver is realigned for the narrow IF requirements of half transponder transmission. The audio circuits must be realigned to the telesat frequencies (5.41, 6.17MHz) and the channel tuner must be realigned to accommodate the ANIK C frequency plan. The signal is carried to the receiver on microwave cable and can be split with regular 4GHz dividers to feed as many as required. This system is still rather expensive, because the block converter is a telecom/military product, and is not yet mass produced for cable.

The most successful method appears to be the LNB receiver designed for cable television. The primary features are a low noise front end (3-4dB), followed by a mixer, and driven with a dielectrically stabilized oscillator (DSO). The 11.7-12.2GHz band is block converted to an IF of approximately 1GHz. Design frequencies vary, with 270-770 and 950-1450 being the most common. There is pressure from the FCC to standardize on 950-1450, but many manufacturers are stocked with components for other bands. The signal can be transported on regular 75 ohm CATV cable and fed to as many receivers as required. The receiver can be essentially any LNB compatible receiver which operates in the proper input band; however some retuning may be necessary. The channel allocations for 12GHz and 4GHz, when converted to 950-1450 do not fall on the same frequencies. Receivers must be rechannelized depending on the block converter employed. Block converters of this type, for 12GHz are also in short supply, with very few manufacturers involved in the market. The price remains high, and delivery, slow.

Anik C Broadcast Format

The delivery via KU band on Anik C presented to the operator a new channel format as well as a new frequency band. The downlink band consists of two banks of eight transponders (eight vertical and eight horizontal). Each transponder is 54MHz wide with a 7MHz guard band, and each contains two similarly polarized channels at ±13MHz from center frequency (Fig. 6). The receivers employed on this service must meet two new operating requirements. The receiver must be able to select one 27MHz portion of the transponder while rejecting the adjacent. Remember that Satcom III's channels are 20MHz spaced and cross polarized alike. The receiver must also be able to tune transponders which are not incremented: that is, the space between channels is not equal and consistant.

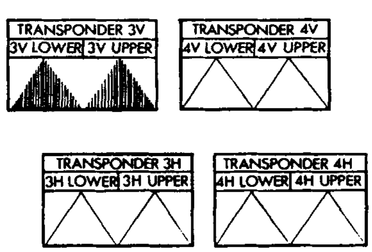

FIG.6

The problems are not too severe with receivers sold as part of a KU system, but do occur when conversion of existing C band equipment to KU is performed.

DIRECT BROADCAST SATELLITE

The licensing of STC to carry DBS in the near future has been met with negative views by the cable industry. In fact, DBS can not, and will not adversely affect cable. The delivery of a relatively small number of channels via antenna can easily be outdone by cable in any built-up area. The low delivery cost of cable combined with the high channel capacity, and, not to be forgotten, the low capital outlay from the customer, is an unbeatable combination. DBS will, contrary to popular belief, open a whole new dimension in the cable/satellite connection. The requirement for high volume KU band receivers will provide the thrust needed for developments in a relatively new science: GaAs MMIC.

Gallium Arsenide Monolithic Microwave Integrated Circuits (GaAs MMIC)

Today, LNAs, DSOs and other microwave circuits, are manufactured with a technique known as Hybrid MIC (Fig. 7). In a hybrid, part of the circuit such as couplers, resistors and stripline conductors are deposited on a dielectric substrate. Transistor and diode dies, as well as other components, are bonded to the conductors and connected with fine wire jumpers.

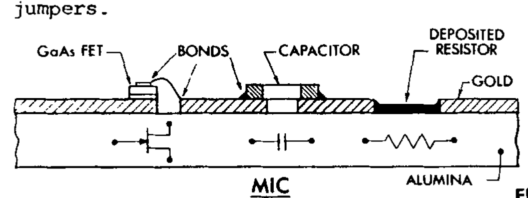

FIG. 7

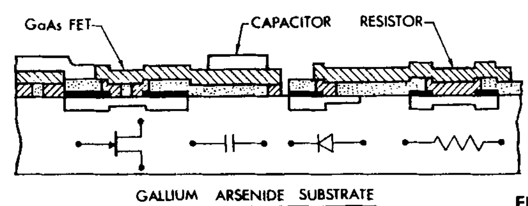

FIG. 8

This circuit involves a high degree of hand micro assembly, and the result is high cost.

The GaAs MMIC is a multi-layer construction which begins with a Gallium Arsenide substrate. In the manufacturing process, the transistors (FETs) and diodes are built up along with the other circuit components. We are able to build an integrated circuit (Fig. 8) almost totally by machine, with very few hand connections or extra components.

The DBS receiver could consist of (Fig. 9) two integrated circuits: one GaAs MMIC incorporating KU low noise input to IF output, and one conventional monolithic circuit incorporating an IF amplifier, demodulator and baseband processor.

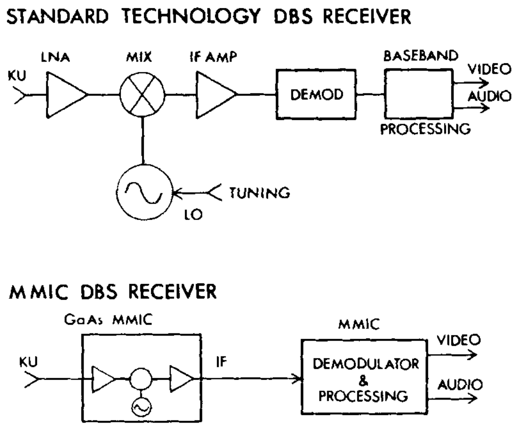

FIG.9

Influence of DBS Technoloy on Cable

Once implemented, this technology could reduce the average receiver cost to well below $200.00 including low noise amplifier. While this technology is initially being applied to high KU (12.2-12.7GHz) for DBS, it will probably spin off into the cable KU band (11.7-12.7GHz). One major potential could be realized when the KU band traffic becomes established for cable services. GaAs MMIC receivers could make it possible to build a system of multi head ends, at lower cost than a supertrunk or AML Hub system. We can forsee, in the future, that a 20 channel satellite receiver head end could cost less than 2 miles of trunk. Many small population pockets could now be served with individual mini-satellite hubs, occupying not much more space than a conventional AML receiver. This will not happen overnight! We will be employing conventional receive equipment for many years to come, but the potential for change is there. We must remember, the DBS traffic will probably consist of lighter loading than cable traffic. The services received by the cable operator, even today, include many non television components. The inclusion of multiple subcarriers, teletext and other services leave a wide performance margin between DBS and CATV quality receive equipment. Indeed, the major problem will probably not be the GaAs MMIC, but the receive process MMIC design.

CONCLUSION

The events of the last year will have significant effects on the cable/satellite connection. Within the next six months, we will probably all be having our first experience with satellite encryption. KU band input sources are not far behind. In general, the changes that will affect the cable operator are itemized as follows:

Today

-Encryption will require an improvement in system G/T as well as general receive equipment quality.

-Encryption will require improved video performance, and in many cases, will require that the operator have more comprehensive understanding of video, as well as more video test equipment.

Tomorrow

-Conversion to 12GHz band will require more accurate antennas and extensive modification to existing equipment.

The Future

-DBS will probably reduce the actual equipment cost, and result in new system design possibilities for the operator.

The future of the Pay TV Satellite/Cable system may have a few rough moments, and will require that some operators learn some very big lessons in a very short time. The end result, whether C or KU band, will be higher performance systems and higher performance equipment. We will not, in the age of KU encrypted signals, get away with previous bad habits and corner cuts. We must grow with the system.