# DATA COLLECTION FOR STATUS MONITORING SYSTEMS

Jeffrey Cox

Magnavox CATV Systems Company

## ABSTRACT

Status monitoring is a useful tool in maintaining the high quality of service demanded by today's subscriber. Unless a two way cable system is available, it is not always possible to implement status monitoring with the available techniques. This paper examines several techniques for collecting the data from status monitoring devices. Two approaches to using the RF return path are discussed. Four techniques for gathering data when no conventional RF return is available are then discussed.

## INTRODUCTION

Cable subscribers are becoming increasingly demanding of cable service providers. With the proliferation of VCR's and satellite receivers, as well as the looming presence of High Definition Television, there is more pressure than ever before to maintain the highest possible quality in the delivery of video to the home. This pressure creates a demand for a viable status monitoring system to aid the operator in maintaining the system at its peak capability.

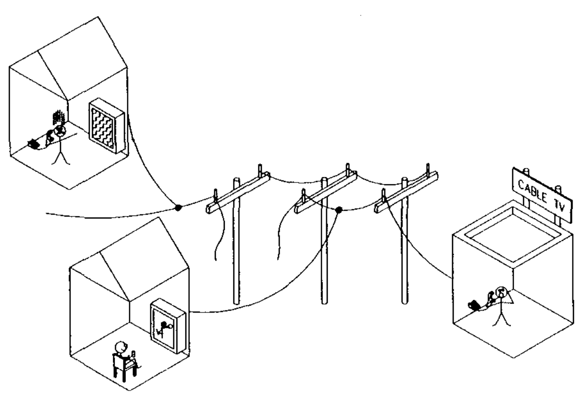



FIGURE 1
SUBSCRIBER-BASED STATUS MONITORING

Every cable operator has in place an extensive status monitoring system. This system covers every tap outlet in the system, providing feedback when picture quality degrades to unacceptable levels. There are many problems with this universal monitor system. For example, feedback is slow, often providing the first indication of problems several minutes after the problem occurs. Collecting data is also very expensive, since someone must answer the phones when all of those angry "status monitors" call in to complain about their picture quality (Figure 1).

Obviously, there is great benefit in a system that can find and report system changes before they result in subscribers becoming upset. These systems are available from all major CATV equipment suppliers. The typical status monitor product resides in the trunk amplifier. It measures the performance of one or more frequencies in the system and reports back to the headend using an RF carrier in the return band. More recently, stand alone monitor products have been introduced that offer more complete measurement capability. For the most part, these also use the RF return system for communications.

These devices work well when a return system is available, but what do you do when this luxury is not available? The advantages of status monitoring are only available when you are able to communicate in some way with the monitoring devices. Talking to the devices is easy. Any cable system can find space to squeeze in one data carrier somewhere in the forward frequency band. The trick is getting back to the operator from the devices in the field.

The easy approach may be to build an RF return system. Many systems have been built with two-way capability, even if the return amplifiers were never installed. A full return system can be expensive to install, however. This is especially painful if the only application of the return system is for end of line monitoring. The cost of all of the return amps must be divided over a very small number of monitors. Furthermore, many systems currently in operation have no facility to be upgraded for operation of a return system. How can we communicate with status monitor devices in these systems?

## LOW COST RF RETURN SYSTEMS

First, let's examine the options available for using the RF return system, when an upgrade is possible. While status monitoring will not necessarily allow a system to be maintained with fewer technicians, additional resources should not be required just to maintain the return system. Any return system that is installed solely for status monitoring, therefore, should require little or no maintenance of its own. Set up should be straight forward. The cost of the return system should be small compared to the cost of the monitoring equipment itself. We have examined two alternative return configurations that meet these requirements: the Return Data Relay system and a low cost return amplifier.

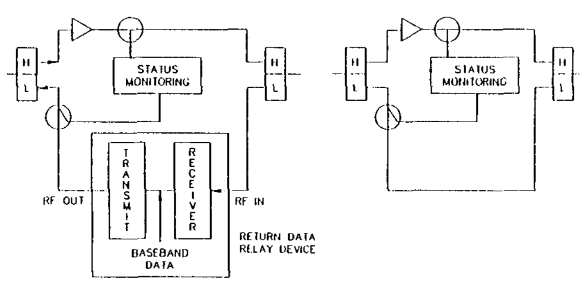
### Return Data Relay

The first RF return system we studied is what we call the Return Data Relay system. In this approach, the return data pilot is converted back to baseband, timing corrected, and retransmitted back toward the headend by intermediate relay stations in the system. These relay devices can take the place of the return amplifier in selected trunk stations (Figure 2). The distance between relay stations will vary, depending on the spacing of the amplifier stations and the amount of passive loss between stations. In general, we would expect to install a relay in every fourth or fifth station. In between the relay stations, a simple jumper arrangement allows the RF carrier to pass through the station.

The Return Data Relay system offers two significant advantages over traditional return systems. The first is the lack of setup and maintenance required to operate the system. Noise buildup is limited to the span between relay stations. Even with trunk branching, the noise floor will be very low at the input to the receiver. The low noise floor allows the receiver to accept a wide range of input levels without the noise overpowering the signal. Variations in level due to thermal changes are minimal over the short cascades as well. Adjustments for transmit and receive levels can be simplified or even eliminated.

A second advantage of the Return Data Relay is cost. It is not difficult to make a wide dynamic range receiver circuit that will operate in a low noise environment. There are integrated circuit receivers that will perform the job very nicely for either AM or FM data systems. In a system using traditional trunk based status monitors, the transmitter of the transponder can be used as the transmitter of the relay, thus the cost of the transmitter can be eliminated from the repeater. The cost of a repeater station will be considerably less than the cost of a standard return amplifier, and we do not even need one in every amplifier location.

The primary argument against the Return Data Relay system as the RF product of choice is that it is strictly a single use device. It does not allow the return path to accommodate any service other than a single status monitor data pilot. This is not a serious drawback, since our only application for the return path is the monitoring system itself. We have, however, also considered the possibility of a more general purpose system that will provide for services beyond the status monitoring system.




A) TYPICAL AMPLIFIER STATION WITH RETURN DATA RELAY DEVICE

B) AMPLIFIER STATION WITH RETURN PATH JUMPER INSTALLED

FIGURE 2

TRUNK AMPLIFIER STATION CONFIGURATION FOR RETURN DATA RELAY SYSTEM

## Low Cost Return Amplifier

Most return amplifier modules assume that video signals will be sent to the headend on a return channel and retransmitted to subscribers on the forward system. To operate properly in the system, this application requires a fairly expensive amplifier module and extensive setup. If we limit our application to narrow band data communications, the performance requirements of the amplifier module can be relaxed considerably. While a typical sub-split return system operates from 5 to 30 MHz, only a small portion of that bandwidth is required for data. Several data pilots can operate in a single 6 MHz video channel assignment. It is easy to implement a return amplifier to accommodate a narrow-band, data only, return system using any of a number of integrated circuit RF amplifiers. A single IC can provide up to 20 dB of gain at a very low cost. No slope control is necessary for the narrow bandwidth required. All that is needed is a gain control for the purists who insist on setting levels and possibly a simple thermal compensation network to limit the level variations due to temperature changes.

Here is an example of how this system might work: Assume a 300 MHz system spaced at 22 dB at the highest carrier. If we use a return data frequency of 11 MHz, there is about 4 dB of loss per span for the return data. This will increase when passive devices such as trunk couplers are used, but will be less for short spans. For a cascade length of 30 amplifiers, the total loss at 11 MHz will be about 120 dB. For operation over a temperature range of -20 to +120 degrees Fahrenheit, the change in attenuation is estimated by the following equation:

$$Ac= ((t1-t2)/10) \times .01 \times Anom=$$

$$((120+20)/10) \times .01 \times 120 = 12 \text{ dB}$$

where Ac is the change in attenuation due to temperature change, t1 and t2 are the temperature extremes, and Anom is the nominal attenuation of the cable.

The receiver in the hub must accommodate input signals that vary as much as 12 dB over temperature variations. Any variations in the nominal transmit levels must also be accommodated. If we provide a level control for the transmitters, it is feasible to provide a receiver that will track the level variations expected. The system will, therefore, operate reliably with no thermal compensation in the return amplifiers. The lack of compensation simplifies the setup and maintenance of the system substantially.

This does not necessarily provide a system that will be usable by any other data services, however. In order to provide a reliable data path for other services, thermal compensation is required. This still presents an appreciable cost savings over traditional return amplifiers, but loses the advantages of simplified set-up.

Having looked into two different approaches to a RF return system, what conclusions have we made? Each system has some advantages. The relay system eliminates any need for complicated set-up procedures. It also prevents any build-up of noise, which makes the monitoring of the distribution system much easier. The low-cost amplifier approach, on the other hand, provides a less expensive approach to a trunk-only monitor system. It also provides an easier upgrade path to accommodate other data services. Both systems also suffer from one other problem. The devices need to fit into the trunk station in the return amplifier. This means that each unique amplifier product line needs to have a device designed to fit it. A large engineering effort would be required to package the system for the many different types of trunk equipment installed in the field. The low cost amplifier is the preferred solution due to its more universal nature.

## THE ONE WAY TICKET

Two alternatives have been identified for implementing a return data system when the return path is usable. In many systems, however, there is no provision at all for using the return band. How can we retrieve status data in these cases?

### Visual Reading

One concept we have considered for extracting data from the monitor modules is the use of a visual indicator on the outside of an amplifier station. This could be as simple as a pair of colored lights, a green light to indicate normal operating status and a red light for a trouble alert. This system eliminates the need to climb the pole and open a test port to determine if signals are present in the system. A system of this type may work to speed system diagnostic time when a major outage occurs, but will not do much to allow us to find problems before they become major. Only go/no-go data is available, and collecting even that data is a labor-intensive process. Due to the limitations of this type of device, we have focused our studies elsewhere.

Power Band Communications

Every cable system passes AC voltage between stations to power the amplifiers. To pass the power required, stations contain bypass circuitry that blocks RF signals above 5 MHz, but passes lower frequencies, from DC to as high as 1 MHz (Figure 3). Using this band for data transmission is not a new idea, but is intriguing. More and more devices are becoming available to perform similar functions over shorter distances, in home and office applications. It seems that this technique can be applied successfully in a CATV environment.

At least one vendor in the CATV arena has a product that communicates in the power band. Carriers from 100 KHz to 150 KHz are used. Data repeaters are used to extend the reach of the system so that a full cascade can be covered. Test systems are installed and operating, showing the viability of the technique. Repeaters are installed at the locations of the 60 volt power supply stations. No extra passives are required. The trunk stations that do not pass power must be modified to pass the communications frequencies while preventing the 60 Hz supply voltage from passing through them.

A power band communications system, then, has a large appeal due to its minimum impact on the system architecture. It is a generic system, in that it requires no significant modification to the existing equipment.

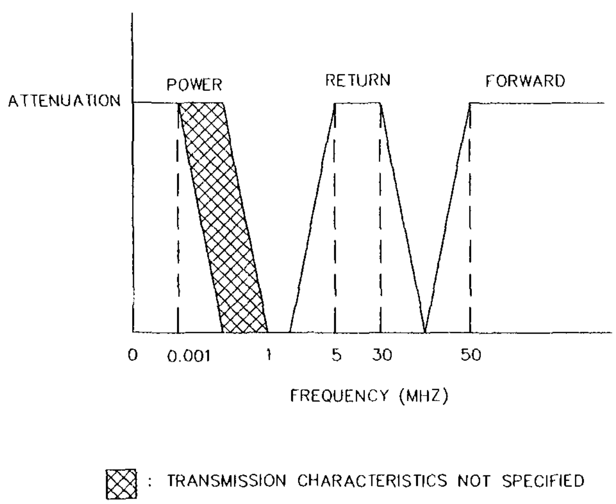



FIGURE 3
CATV FREQUENCY UTILIZATION

Installation of a power band communication system in a CATV network can be quite complicated, however. Although the frequencies around 100 KHz are generally passed through the power system, the characteristics vary greatly within a system. Manufacturers do not specify the operation of their equipment in this region. Not only do products from different manufacturers differ greatly in their response in this range, but also supposedly identical equipment from a single vendor can vary greatly. Setting up a system demands that the characteristics of the particular section of the system be analyzed to determine the optimum frequency to use for the communications channel. This analysis is currently being performed manually by sweeping the frequencies in the 100 KHz range for each repeater span to find the best frequency to use. Equipment is currently being developed to automate the setup process.

The noise generated by switching power supplies, coupled with the low impedance to ground presented by the power system, requires a significant amount of power from the transmitters in this system. It is still not clear whether power band communications is a completely universal system. There may be some installations that will not pass the frequencies desired,making this system unusable.

Phone Line Communications

A conventional means of communicating with remote devices uses the telephone network. If full time communications is desired, leased lines are required. This is an expensive proposition. A voice-grade dedicated line that runs between telephone switching centers can cost over $100 per month, even for a short connection, and over $300 per month for a longer run. This cost would prove difficult to justify.

An easier sell is the installation of a standard dial-up line. This would eliminate the surcharge for connecting between local switching centers. Base rates may run as low as $30 per month, with an additional charge based on the number of calls made from each location.

In a dial-up telephone system the control computer dials into the monitor devices, one at a time, to determine the status of a particular point in the system. The speed of the system is limited by the time it takes to place a call to each station in the system. At best, it takes about 5 seconds to make a dial-up connection. Only 12 stations per minute can be polled using this scheme. Even the slowest conventional status monitoring system can poll over 200 stations in a minute. Thus, the dial-up system is less useful than a conventional system as an aid in rapidly finding major system problems. It still provides the most important feature of status monitoring, however. Data is accumulated over time that will track the performance of the system and indicate areas where performance is beginning to degrade and maintenance is required.

## Ride The Air Waves

The FCC has recently allocated a frequency band at about 900 MHz for over-the-air data communications. The hardware required to take advantage of this space is now becoming available. This system is capable of communicating over the distances required by most CATV systems. Since it is a line-of-sight system, the reach that can be obtained depends on the height and location of the master antenna as well as the physical terrain of the installation (Figure 4). This system is considered a microwave product by the FCC due to the high frequencies involved.

This over-the-air system accommodates full-time communications. The monitoring stations can be polled just as if data was running through a two way cable system. If a loss of power takes down a monitoring node, the control system will "know" almost immediately, since it is continually polling the devices in the field. A cable break or a failed amplifier will not impede communications at all, unlike a traditional cable-based system.

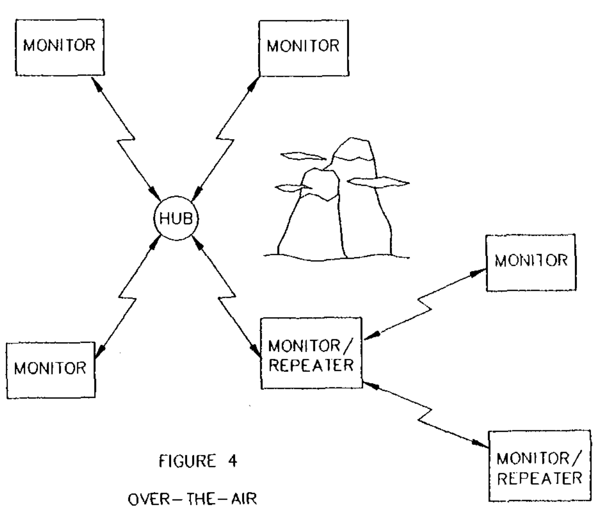



FIGURE 4

OVER-THE-AIR
MICROWAVE COMMUNICATIONS

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The hardware to implement an over-the-air data system is not cheap by any means. The transmit/receive stations alone cost about $1500, for a unit that is not rugged, and around $3000 for a unit set in a rugged NEMA type enclosure. That level of expense makes this over-the-air approach unreasonable, except for a few key points in a system. Lease arrangements will allow the operator to obtain this over-the-air service without a large initial expense. The cost of a lease will make this technology cost competitive with a dial-up system, while providing a dedicated, full-time, data link.

The 900 MHz over-the-air concept has not been shown to be appropriate for a CATV status monitoring system, but it holds promise. The spectrum is available. Equipment is becoming more readily available. Magnavox is looking seriously into this technology to determine the problems and advantages that it brings us. Stay tuned.

## SUMMARY

We have looked briefly at six techniques for collecting data from status monitor systems. The low cost return amplifier and Return Data Relay systems use the traditional RF return path of the cable network. The low cost amplifier appears to provide a more complete and general solution to the problem at hand. Visual indicators provide too little communication too late to be acceptable for most applications. Using the power band for communications holds promise as a technique that applies in almost any system, but the problems of setting it up for individual systems must be resolved. Telephone communications are certainly viable and can be implemented today. A new high-frequency, over-the-air, data system allows full time, rapid communications at a cost that is comparable to monthly charges for phone service.

The CATV community has not yet determined which of these systems will be accepted for status monitoring qpplications. With the diversity of the applications and personalities involved, it is likely that most of them will be used to some extent.

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