

AUTOMATIC STATUS MONITORING FOR A CATV PLANT

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ABSTRACT

Many of the customers using the CATV Distribution System for communication require total service and continuity. Premium programming and educational requirements also mandate fast response to plant or system failures. An automatic status monitoring system can substantially improve reaction time and reduce maintenance loads. Such a system has been engineered to meet these service demands.

INTRODUCTION

The present CATV Industry is experiencing a saturation of technology which could be likened to the introduction of rectangular color television sets in the American home. The cable television industry today is positioning itself as THE mass communication medium which should take us through the turn of the century. CATV's broad influence on American lifestyles will serve to save us energy and provide better educational and entertainment opportunities to our nation and throughout the world.

As the importance of our communication increases, the reliability and the serviceability of this distribution equipment becomes a greater concern to the operators and to the consumers and subscribers themselves. The revenue producing services such as entertainment programming, information exchange, security, and educational and public service functions rely on the quality of the distribution system in their neighborhood.

We should take a moment to consider the justifications of status monitoring. Its implications of improved service, reduced down time, improved technical effectiveness and the ability to pinpoint equipment malfunctions can head up our list of benefits. Additionally an automatic system of data reporting from status monitoring equipment can be preserved for later failure trend analysis which may aid the operator in preventive maintenance service which could reduce down time even further. It has the potential to indicate areas

of the plant which may require attention on more frequent basis and presents alternatives to pole climbing and bucket trucks when it becomes necessary to do system checks. The automatic test equipment approach can provide data which has extended usefulness in a plant of any size. So the primary function becomes one of fault locating, and secondary functions enhance its value to the engineering staff responsible for plant performance.

In fact status monitoring is an edict in most new metropolitan franchises. Wide band distribution, larger plants, increased concentrations of subscribers and many physical factors increase the maintenance burden in any operation. Status monitoring has presented some alternatives to the expensive and often sporadic preventive maintenance program. There is no substitute for quality distribution components and conservative plant design. However, a well configured automatic status monitoring system would be an extremely useful service and maintenance tool as well as a trouble shooting aid in times of equipment failure. A broad based economical approach to status monitoring utilizing automatic test equipment techniques will be discussed here.

DESIGN CRITERIA

The exchange of data between remote points and a central location in the cable plant ordinarily would not be a difficult undertaking. However, the expansion of the cable spectrum leaves but few windows where data can be exchanged from points in the system and the head-end which will not complicate normal operation. The exchange of data should occupy as little spectrum room as is practical.

The environmental performance of the automatic test equipment component should exceed that of the distribution component to which it is interfaced. So environmental resistance, immunity to radio frequency interference and transients often encountered in the cable plant is imperative.

Although specifically, size is not a serious concern, a smaller component is usually more easily accommodated into a retro-fit application.

Any additional equipment in a cable plant naturally will require powering and implies additional losses which must be minimized so a component which could be considered electrically transparent would be most desirable.

Such a component configuration then begins to appear as any other common CATV component. Efficient, light weight, minimal losses, fast response and circuit integrity all become considerations in the design criteria. Not to be overlooked are the economic factors involved in producing such a device as well as the installed cost or cost per mile to the plant operator. Additionally, we would like to have our status monitoring equipment operate under adverse signal conditions as well.

SYSTEM CONFIGURATION

Let us look at a block diagram of how the system which we have configured performs. Our system components include a computer which serves as a control system, transponders which function as receiver-transmitters and data collectors, an interface or modem and a spectrum monitor which reads cable signal levels shown. In dotted line form you will see the amplifier or other components such as the power supply.

The Computer to be discussed is programmed to continuously scan and read measurements or data from each of the transponders as they are individually addressed from the program which is resident in the computer.

The Modem provides an interface between the microprocessor and the plant RF System. As a Modulator-Demodulator it converts logic levels to RF and Demodulates RF to logic levels.

The Transponder block in our diagram is comprised of an FM receiver, an addressable controller, an A to D Converter, regulated power supply, an isolation network and an FM Transmitter for returning data to the head-end.

The last block shown in our diagram is the remote spectrum monitor which is a specially configured spectrum analyzer designed to withstand the rigors of the cable environment.

SYSTEM COMPONENTS

We are all aware of the significance of the computer in process control applications. We have selected a 6502 microprocessor based computer with 48K of memory as the core of the control system. Dual disc drives, a graphics capable printer, interface cards, a clock-calendar card and a wide-band CRT round out the control system. The operating program of the control system is written in BASIC and machine code and stored on floppy disc.

The computer program is designed to analyze the data and compare it to standard data which is entered by the operator when he commissions his plant or installs the transponder. This standard data then becomes the information base within the computer to which all new data is compared. Data errors are double and triple checked by repeated interrogation and if an error persists, alert or fault alarms are generated depending on the magnitude of error. A command is also generated by the computer to print on hard copy the nature of the fault, its address, its location and at the same time all of the remaining parameters at that address are measured and recorded with date and time. These additional parameters may provide both the nature and magnitude of the fault. Besides having an audible and visual alarm presented on the CRT, hard copy print outs provide permanent record of faults as they occur and if desired a paper copy can be provided to the maintenance supervisor.

There are numerous other features of the computer program which enhance the overall system versatility and allow the operator to select specific functions, alter his data base, customize his measurement parameters/formats and do other housekeeping chores including updating files, expansion, and deletion of certain stations which may be undergoing maintenance.

The control system is linked via RS-232 to the modem or interface. The digital data from the computer is sent serially at 4800 Baud (BPS). This serial data is applied as frequency modulation to an oscillator which operates at video carrier levels as a substitute for a normal CW pilot, or as a data carrier alone operating at -15 dBc to -20 dBc. The FSK Data then is summed with the video signals for distribution in the forward trunk. The interface or modem also receives the replies from each of the individual transponders in the reverse trunk.

The above discussed applications, if you will, are well known in the industry. The transponder, however, represents an advance in automatic test equipment techniques as applied to measurements in the CATV Distribution Plant.

[illegible]

CS = uP Control System
PPI - Processor - Plant Interface
RTDM = Remote Transponder Data Module
RSM = Remote Spectrum Monitor
TA - Trunk Amp

The block diagram illustrates the internal architecture of the 1500 MHz Transceiver. A central horizontal line represents the 75 Ohm Xmsn Line (15), which is connected to IN/OUT ports at both ends. The internal components are numbered 1 through 15, with some having sub-labels (13a, 14a, 7a, 8a). The components are interconnected as follows:

- IN/OUT** ports connect to the **75 Ohm Xmsn Line (15)**.
- The **75 Ohm Xmsn Line (15)** is connected to **13** (Guardian Comp.) and **1** (20 dB Isolation).
- 13** is connected to **14** (Reg DC/Ref).
- 1** is connected to **2** (Diplex-Match).
- 2** is connected to **3** (RF Amp).
- 3** is connected to **4** (Osc-Mixer).
- 4** is connected to **5** (Xtal Filter).
- 5** is connected to **6** (2nd Conv.-IF-Det.).
- 6** is connected to **7** (Controller).
- 7** is connected to **8** (Mux-A/D Conv.).
- 8** is connected to **8a** (Input Dividers).
- 8a** is connected to **10** (TX Switch).
- 10** is connected to **11** (TX FSK Gen.).
- 11** is connected to **12** (TX Oscillator).
- 12** is connected to **2** (Diplex-Match).
- 12** is connected to **9** (Output Stage).
- 9** is connected to **7** (Controller).
- 7** is connected to **13a** (Bulk DC Supply).
- 13a** is connected to **14a** (Reg DC/Ref).
- 14a** is connected to **10** (TX Switch).
- 10** is connected to **11** (TX FSK Gen.).
- 11** is connected to **12** (TX Oscillator).
- 12** is connected to **2** (Diplex-Match).
- 2** is connected to **3** (RF Amp).
- 3** is connected to **4** (Osc-Mixer).
- 4** is connected to **5** (Xtal Filter).
- 5** is connected to **6** (2nd Conv.-IF-Det.).
- 6** is connected to **7** (Controller).
- 7** is connected to **8** (Mux-A/D Conv.).
- 8** is connected to **8a** (Input Dividers).
- 8a** is connected to **10** (TX Switch).
- 10** is connected to **11** (TX FSK Gen.).
- 11** is connected to **12** (TX Oscillator).
- 12** is connected to **2** (Diplex-Match).
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- 4** is connected to **5** (Xtal Filter).
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- 6** is connected to **7** (Controller).
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- 10** is connected to **11** (TX FSK Gen.).
- 11** is connected to **12** (TX Oscillator).</

The Transponder block contains a number of special circuits which will be described briefly. A very narrow band FM Receiver utilizes an adjustable RF gain stage and a very high sensitivity high linearity PLLFM Detector. The detected data or address and command are sent to a controller which interprets the address and command and cycles the A to D converter. Upon completion of the measurement cycle the data is returned to the controller. It again is converted to serial form and applied as FM modulation to a crystal oscillator. Data is keyed through a transmitter circuit and coupled finally to the trunk line through an isolation network. The transponder module is isolated by a minimum of 20 DB from the trunk thereby minimizing loading effects in both forward and reverse directions. The transponder also contains a very stable power supply/reference section and divider networks which adjust scaling of the A to D convertor for full scale values appropriate to the parameters being measured. The selected measurement parameter, after input scaling, is converted to an 8 bit word which is latched into the transmitter portion of the control chip. The control chip then serializes this data, keys the transmitter and FM modulates the oscillator. A one shot multi-vibrator which is keyed upon receipt of a valid address and command, provides fail-safe operation of the transmit output stage.

The accuracy of the data (which is sent to the control system processor for reduction is plus or minus 3%. However, its stability is better than .5% over temp. Since the control system can log data from each transponder individually, the actual accuracy of the measurement is not as important as the stability of repeated measurement over the temperature range. The reference supply has a stability of better than .1% over the temperature range. This is four times better than the resolution of an 8 bit convertor.

A demonstration of the receiver capability is presented in Figure 1 and Figure 2 below. A video carrier spectrum of 330 MHz modulated 100%, and an interfering CW carrier were combined with the data carrier set 30db down. This spectrum was applied to a hybrid amplifier and the overall input level to the hybrid was adjusted to yield Xmod distortion of -40db or worse. The distorted spectrum was attenuated and applied to the cascade @ +28dBmV. See figure (1). Both data carrier and the interfering signal can be seen on the 3rd graticule line from the left in Figure 1. The interfering signal is but 75 KHz higher than the data carrier which is at -30dbc. Figure 2 shows the response of the outbound and return signals during this demonstration. These cascade tests were conducted with staggered reverse

amplifiers. In one test case only reverse passives were installed through a 4 amplifier cascade spaced 20db at 270 MHz. The same performance characteristics are retained over the temperature range of -30°C to +85°C.

NOTE: The two carriers of interest appear super-imposed at the arrow due to 200kHz B/W of the spectrum analyzer.

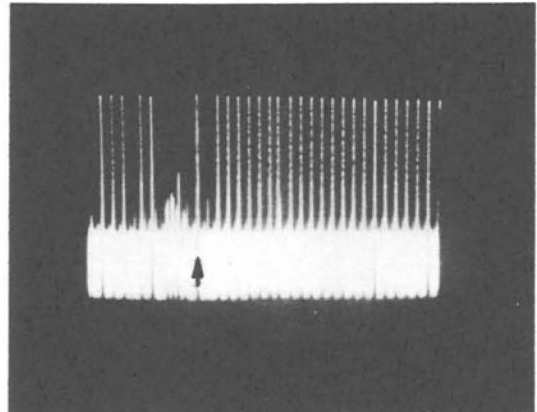


Figure 1

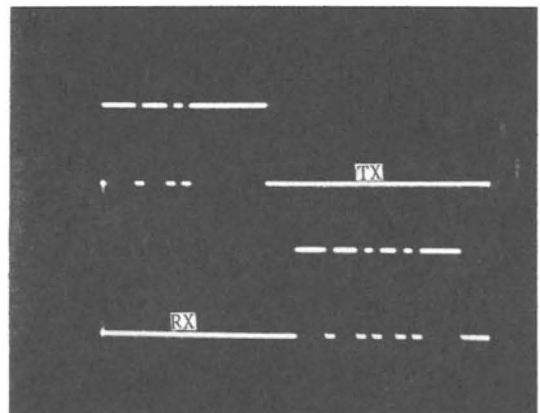


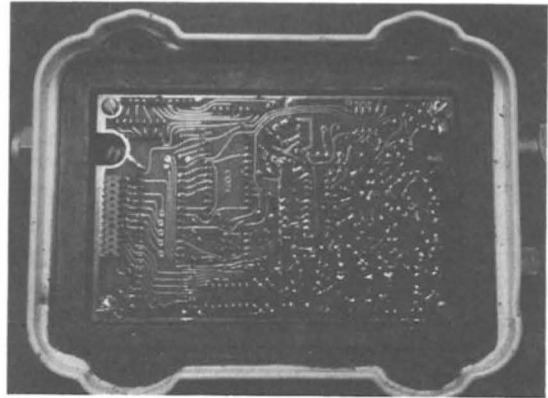
Figure 2

The block diagram shows the integral parts of the transponder module and the interface with the trunk station under test. The transponder/data module is quite small in itself, measuring 5.5x3.5x.75 inches. But most amplifiers if they are fully loaded have little interior room for additional components. So a remote version has been designed which is powered from the cable AC and draws less than one watt.

This remote version of the transponder exhibits less than 1db insertion loss from 5 to 450MHz and maintains input and output return losses at better than 20 db. The special power supply within the remote housing includes over voltage protection from a gas-tube surge suppressor as well as a version of the guardian compensator circuit utilized in CATV power supplies. This special circuit pre-regulates the primary voltage applied to the transformer by sensing a rise in the secondary and feeding back an error signal instantly which reduces the applied primary voltage. The circuit is designed to minimize the effects of sheath-current-applied over-voltage. In cascade tests the power supply has successfully operated at extended inputs of greater than 150 volts AC with no measureable effect on the regulated DC supply.

We feel then that the power supply incorporated in the remote transponder/data module may exceed the performance standards of many of the line amplifiers presently installed in the field. This provides a measure of reliability greater than the amplifiers themselves.

A unique umbilical cable assembly links the remote transponder to the amplifier under test. The components of the umbilical include the same pressure-tight fittings used throughout the industry. The umbilical is terminated in a customized adapter harness which isolates RF and taps the measurement points within the amplifier.



CONCLUSION

Two independently operating systems are configured in separate cascades at the Texscan/Theta-Com facility. These systems are regularly temperature cycled during the course of other engineering work. The reliability of the equipment and data returned thus far exceeds specified BER (Bit Error Rates) margins of <1 ppm. Data verification in the resident program aids in these judgments. We feel that progressive engineers and operators will appreciate these latest and significant advances of CATV Test Equipment; Automatic Status Monitoring, a system management tool.

ACKNOWLEDGMENT

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