REMOTE DIAGNOSTICS FOR OFF PREMISES CABLE SYSTEMS

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ABSTRACT

Distributed intelligence in off-premises addressable CATV systems makes remote diagnostics to the module level fast and easy. Our goal in designing our system was to allow the service technician to troubleshoot a system problem within 15 minutes using a minimum of test equipment.

In order to accomplish this goal, we designed automatic tests which are performed by distributed microprocessor-based controller modules. Each module is able to test its own components, communications with the headend computer, communications and control of the tuners for each subscriber, and the subscriber interface electronics.

INTRODUCTION

Diagnosing off-premises addressable CATV systems requires the ability to interpret the diagnostic information provided by the system and to perform some simple tests. In order to understand the communications and control pathways throughout the system, an overview of the system architecture is given.

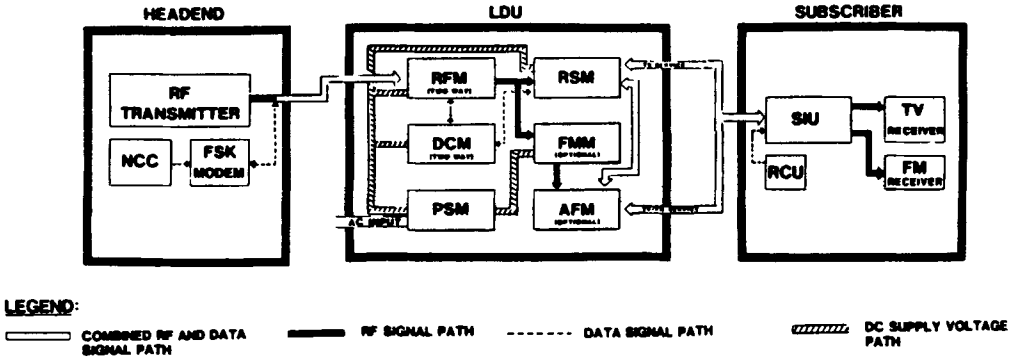
Next, the test capabilities of each system level are discussed. This section includes a description of the automatic tests performed by the distributed microprocessor-based controller modules at each hub. The remote switching modules and the subscriber equipment also provide diagnostic information which is stored in the digital control module.

System diagnostics are then described for a two-way system and for a one-way system. Special test equipment which enables test initiation and monitoring is also described. Results of the testing phases, visable via indicator lights and reports available to the field technician and directly to the operator at the headend in a two-way system, are explained.

Finally troubleshooting procedures are detailed which enable fault isolation to the defective module or communication path. There is a separate section on diagnosing problems at each system level.

SYSTEM DESCRIPTION

The CATV distribution system discussed is an off-premises star-switched system. The major components are a headend computer, the cable plant, the local distribution units, and subscriber equipment (Figure 1).



1. System Architecture

The headend computer is typically a minicomputer that contains the entire subscriber database and controls the network from a central location. The headend computer may communicate with thousands of local distribution units or hubs. It initiates all communications with the various hubs, which are individually addressable. The headend computer may also broadcast messages to all hubs simultaneously.

The power behind star-switched systems is the distributed intelligence at each local distribution unit or hub. Each hub contains a Digital Control Module and a Remote Switching Module with a tuner for each subscriber. Each hub can control the service for 8, 16, or 32 subscriber TV sets.

The Digital Control Module is a microprocessor-based control card with enough memory to keep track of subscriber service levels, diagnostic information, and special purchase information for 2-way systems. The contents of memory are super-cap backed to prevent information loss in all but extended power outages.

A one-way system means that communications travel from the headend computer to the Digital Control Module. A two-way system means that communications travel in both directions. The headend computer always initiates the communications with a particular hub.

The subscriber equipment consists of a drop cable into the home and a Subscriber Interface Unit for each TV. The Subscriber Interface Unit is a simple, low-cost microprocessor-controlled box with a keyboard and a display to allow the subscriber to access TV channels.

The Subscriber Interface Unit sends all channel requests up the drop cable to the Digital Control Module. Since the Digital Control Module contains all of the subscriber service levels, it determines whether the actual channel or a default channel will be sent to the subscriber. It then sends the appropriate information to the tuner and the signal is sent down the drop to the Subscriber Interface Unit and from there to the TV. Communication is one-way from the Subscriber Interface Unit to the Digital Control Module.

TEST CAPABILITIES

The purpose of system diagnostics is to allow the easy tracking of problems to a particular module in the system. This module can then be substituted, and the problem fixed. Each module within the system performs some kind of communications checking and/or self diagnostics.

RF Modem Diagnostics

The RF modem module, within the local distribution unit, interfaces the headend computer and the Digital Control Module. Its green indicator light is lit when the RF carrier is present. If the light is not on, communication has been lost.

Digital Control Module Diagnostics

The Digital Control Module performs diagnostics on itself upon receipt of a diagnostic command from the Local Control Computer or the headend computer or whenever its reset button is pushed. There are three LEDs on the front of the module that indicate the test in progress. The final state of the LEDs indicates whether the unit failed a test or is functioning normally.

The first series of tests checks the internal components of the Digital Control Module such as memory, timers, transmitters and receivers. Three indicator lights on the front panel indicate the component that has failed.

The next test verifies and stores the result of a communications test with each Remote Switching Module. If a Remote Switching Module fails to respond to a handshake test, its indicator light is lit.

The final test determines whether the Digital Control Module is connected to the Network Control Computer or a Local Control Computer. The current status is stored and displayed on the front panel indicators. The status is updated continuously.

The Digital Control Module also expects to receive a periodic signal from each Subscriber Interface Unit. If this signal is not received, the failure is recorded and the indicator light on the corresponding Remote Switching Module is lit until the Subscriber Interface Unit signal is restored.

Remote Switching Module Diagnostics

Each Remote Switching Module has an LED which indicates the results of a Digital Control Module to Remote Switching Module communications check as well as the status of the subscriber equipment at all times.

When a Digital Control Module is reset or receives a diagnostic command, it checks the communications path with each Remote Switching Module. This verifies the integrity of the backplane and line drivers on the Digital Control Module card as well as the functionality of the Remote Switching Module itself. If an Remote Switching Module fails this test, its LED

remains on and the failure is recorded by the Digital Control Module. The failure will then appear in later test reports.

Subscriber Interface Unit Diagnostics

When a Subscriber Interface Unit is powered up, it performs a series of self checks to verify that its modulator and IR receiver are working, that there are no stuck keys, and that all display segments may be seen. If a component fails, a corresponding message is displayed on the front panel.

Subscriber equipment testing is in operation continously in that a periodic signal must be received from every Subscriber Interface Unit to indicate that it is functioning. This signal is sent from the Subscriber Interface Unit at all times even if the TV is turned off. This signal will also demonstrate the integrity of the drop to the subscriber.

If this signal is not received for a few seconds, the LED in the corresponding Remote Switching Module is lit to indicate a subscriber communications failure and the failure is recorded in the Digital Control Module.

TWO-WAY SYSTEMS DIAGNOSTICS

Both one-way and two-way systems contain sophisticated diagnostic capabilities. In a two-way system, the headend computer can tell whether or not it is communicating with a Digital Control Module at the hub. This is done by sending a command and receiving a response.

In a two-way system, the diagnostic information may be sent directly from the Digital Control Module to the Network Control Computer located at the headend. The diagnostic reports that were stored in the Digital Control Module are available to the system operator on the headend computer. This means that most problems may be diagnosed before rolling a truck to the site. When a truck must be sent, the field technician will know which modules must be replaced to fix the problem.

The actual subscriber service levels as well as the current status of the Subscriber Interface Unit may be read from the Digital Control Module. The status indicates whether the Subscriber Interface Unit is active or failed, on or off, on cable A or B, on the default channel, or on an enabled channel. The service level check indicates which channels are enabled, disabled, or parentally locked.

With this information, a good portion of received trouble calls may be traced to errors or confusion about subscriber service levels or problems or confusion using the Subscriber Interface Unit. The operator can ask the subscriber to select a channel and verify that the subscriber actually receives it.

ONE-WAY SYSTEM DIAGNOSTICS

In a one-way system, headend to hub communications can be verified at the Local Distribution Unit, by watching the Digital Control Module perform a command such as a reset. This is because there are several lights on the hub modules which will flash during reset. In addition a light on each Remote Switching Module flashes as the handshake test is performed.

Although the indicator lights are normally sufficient to trouble shoot problems at the Local Distribution Unit, more extensive reports may be displayed and printed using a Local Control Computer. This portable, battery-operated unit is attached to the Digital Control Module where the modem is normally attached. An LED on the Digital Control Module signals that the Local Control Computer has been properly installed.

The Local Control Computer can gather the same diagnostic information available to the headend computer in a two-way system. These diagnostic reports show the functionality of the Digital Control Module itself, the status of the remote switching modules, whether they have failed or may be disabled, the status of the Subscriber Interface Units and the communication path integrity between the various modules.

The diagnostic information sent to the local control computer is displayed on a screen and may also be printed via the self-contained printer. This is one of the reports which can be produced (Figure 2).

```
     DIAGNOSTIC
       REPORT
 01/10/86 15:46:42
ADDR :  300
DCM II
LED CODE:  1
  DIAGNOSTIC MODE
DF CHAN =  10
FAILED RSMS:

ENABLED RSMS:
 1  2  3  4  5  6  7
  8  9  10  11  12
 13  14  15  16
REMOTES:
 6
FAILED SIUS:
 1  5  7  8  9  11
 13  14  15  16
INOPER SIUS:

MODEM STATUS:
  DSR ABSENT
PROM CRC = 37C3hex
TBL A CRC = 48F2hex
TBL B CRC = 48F2hex
COMMAND? /PR
```

2. Local Control Computer Diagnostic Report

This report allows a technician to easily locate and document the trouble. The site address and date and time are at the top of the report.

Another report, called a subscriber service level check, displays current service levels and the enabled/disabled status of the equipment that provides service to the selected subscriber (Figure 3).

```
   SERVICE FOR
     RSM# 6
    01/10/86
    15:44:18

ADDR :  300
POWER ON
CABLE A
DESCRAMB DISABLED
RELAY OFF
STU ALIVE
HANDSHAKE LOW
FM  ENABLED
RBG ENABLED
RSM ENABLED
BSM ENABLED

 <-CHANNEL STATUS->

  1- 10:LLLLLEEEEE
 11- 20:EEEEEEEEEE
 21- 30:EEEEEEEEEE
 31- 40:DDDDDDDDDD
 41- 50:DDDDDDDDDD
 51- 60:DDDDDDDDDD
 61- 70:DDDDDDDDDD
 71- 80:DDDDDDDDDD
 81- 90:DDDDDDDDDD
 91-100:DDDDDDDDDD
101-110:DDDDDDDDDD
111-120:DDDDDDDDDD
121-130:DDDDDDDDDD
131-140:DDDDDDDDDD
141-150:DDDDDDDDDD
151-160:DDDDDDDDDD
REMOTE ENABLED
PAR CODE =  4 5 3 6
COMMAND? /PR
```

3. Local Control Computer Subscriber Service Report

This report allows a technician to easily verify discrepancies in subscriber service levels. The site address and date and time are at the top of the report.

TROUBLESHOOTING PROCEDURES

Specific troubleshooting techniques enable the quick determination of faulty modules. The following procedure is tailored for our star-switched system.

Standard diagnostic tools such as a Field Strength Meter, a field Subscriber Interface Unit, a Multimeter and the diagnostic LEDs provided on the modules should enable the service technician to troubleshoot most problems occurring within the system. Some percentage of problems will require the technician to use a Local Control Computer.

At the Office

Before the technician leaves the office, the database should be checked to ensure that the hub has been initialized properly. If the database at the headend computer is correct, then proceed. Otherwise, correct the problem at the headend and transmit the new information to the hub.

If the system is two-way, establish communications with the hub. Verify that all of the modules are working via a diagnostic command. Check the actual status of the Subscriber Interface Unit.

If the problem remains, or if the system is one-way only, go to the Local Distribution Unit where the subscriber's off-premises electronics are located. If the subscriber's complaint is relative to the reception of a particular tier, skip to the section covering headend computer to Digital Control Module communications problems.

At the Local Distribution Unit

Check out the power supply, modem, and the RF levels at the test points provided. Check for terminations or unauthorized connections. Inspect the Digital Control Module, Remote Switching Module, and interconnect cables for any obvious physical or mechanical problems. Look at the LEDs on the Digital Control Module; they should be in the normal running state.

Digital Control Module Diagnostics

Reset the Digital Control Module by pressing the reset button. Do the lights go through a sequence ending with all lights off on the Digital Control Module? If not, do the following steps.

1. Reseat the Digital Control Module in the back plane connector.
2. Check that the connector from the modem is correctly installed on the Digital Control Module connector.
3. Reseat the power supply on the backplane.
4. Repeat the reset command.

If the lights still do not sequence, then replace the Digital Control Module.

Remote Switching Module Diagnostics

Press the reset button on the Digital Control Module. Do all of the Remote Switching Module lights flash? If no lights flash on any Remote Switching Module, then perform the following steps.

1. Reseat the power supplies in the backplanes.
2. Replace the Digital Control Module.
3. Reset the Digital Control Module.

If still no lights flash, then replace the backplane. If only one or a few (less than all) of Remote Switching Module LEDs fail to flash, then do the following.

4. Replace those Remote Switching Modules.
5. Repeat the Digital Control Module reset.

If a Remote Switching Module light still does not flash then replace the backplane in which it is located. The Remote Switching Module was probably good.

Subscriber Interface Unit Diagnostics

Wait for a few minutes after the Digital Control Module is reset. Look at the LED(s) on the Remote Switching Module(s) for the subscriber. Did the light(s) come on? If so, then the Remote Switching Module(s) have powered down due to a lack of "keep alive" signal from the Subscriber Interface Unit(s). Do the following.

1. Check that the subscriber cable is securely fastened to the Remote Switching Module.
2. Disconnect the subscriber's Subscriber Interface Unit and connect a known working, battery-powered field Subscriber Interface Unit.
3. Use the field Subscriber Interface Unit to change channels making sure that it is properly set for first or second-set mode.

Does the Remote Switching Module light flash? If the light flashes, then verify the correct RF operating level. If the light does not flash, replace the Remote Switching Module and repeat the Subscriber Interface Unit diagnostics.

Headend Computer - Digital Control Module Diagnostics

Although the database shows the proper tiering levels for the subscriber, the information may not have reached the Digital Control Module from the headend computer. To verify the communications path:

1. Check that the green LED on the RF modem is on.

If the LED is on, check that the interconnect cable between the RF modem and the Digital Control Module is correctly installed. If the LED is not on, verify the presence of modem carrier by using a spectrum analyzer. If the RF modem carrier level is measured to be within specification and the green LED does not light, then replace the modem.

2. Ask the office to send a reset command to the Digital Control Module.

If the reset occurs, verified by the lights sequencing on the Digital Control Module and all Remote Switching Modules, then communications are intact. If the lights do not sequence then do the following.

1. Replace the Digital Control Module/RF modem interconnect cable.
2. Ask the office to send a reset command to the Digital Control Module.
3. If the lights do not sequence then check the right angled F connector and the RF modem.

If the Digital Control Module does not respond, then go to the Digital Control Module Diagnostics section. If the Digital Control Module responds, then replace the modem and the interconnect cable.

If problems still persist, the Local Control Computer may be used for more extensive tests as follows.

Local Control Unit Problem Verification and Diagnosis

1. Connect the Local Control Computer to the Digital Control Module.
2. Send a transmit address command to the Digital Control Module from the Local Control Computer using the Digital Control Module address or a global address.

If the Digital Control Module responds to a global command but not to its own address, then replace the address PROM.

3. Perform a diagnostic command making sure to produce a hard copy with the printer.
4. Perform a subscriber service check command making sure to produce a hard copy with the printer.
5. Check that all of the headend computer database service levels for the subscriber are the same as those in the Digital Control Module based on the readings just collected.

If not, go to the Headend - Digital Control Module Diagnostics section. If the service level is correct, verify the complaint with the subscriber using the subscriber's Subscriber Interface Unit or the field Subscriber Interface Unit and an Field Strength Meter.

Diagnosis of Equipment at Subscriber's Premises

To determine if the Digital Control Module is responding to Subscriber Interface Unit commands from the subscriber, perform the following.

1. Unplug the TV from the Subscriber Interface Unit and plug it into the wall.
2. Turn the Remote Switching Module off and on from the Subscriber Interface Unit. When the Subscriber Interface Unit is off, the TV should go to white noise or to a blank screen.
3. If the ON/OFF commands work but channel

change commands do not, then change the video and check the tiering information again for accuracy.

4. If the ON/OFF commands do not work, do the following.

   1. Check for Subscriber Interface Unit problems by substituting a known working Subscriber Interface Unit.
   2. Repeat the ON/OFF commands.

If the ON/OFF commands still do not work then the problem is in the drop cable.

CONCLUSION

In conclusion, star-switched CATV distribution systems are easily maintained due to the troubleshooting capabilities inherent with distributed microprocessor intelligence. Most problems are solved within the 15 minute timeframe to the module level using simple tools and without entering the subscriber's premises.