IMPROVING L.D.S. MICROWAVE RELIABILITY USING REMOTE MONITORING AND AUTOMATIC CONTROL OF REDUNDANT RECEIVERS

David L. Randolph, P.E.

Complete Channel TV, Inc.
Madison, Wisconsin

With the increasing use of L.D.S. microwave systems, the use of redundant and automatic control of microwave headends becomes a necessity. As a result of technological advances in L.D.S. microwave systems, CATV companies can reduce long amplifier cascades, increase technical performance, and add CATV coverage to nearby cities. With these uses in mind, the microwave system may potentially serve thousands of cable subscribers, and the reliability of the microwave system is paramount. This article will include design parameters and practical circuits to afford remote monitoring and control of the microwave headends.

INTRODUCTION

Madison, Wisconsin, is a city of 170,000 population. Since the city is located between two large lakes, which cause the city's growth to move out in parameters around these large bodies of water, the total cable system is distributed over a large geographical area. Using standard CATV design parameters, cascades of up to 60 amplifiers would be required to provide cable reception throughout the city. In order to eliminate these large amplifier cascades and improve technical performance and reliability, L.D.S. microwave transmission is utilized.

The city is divided into four headends of roughly equal subscriber penetration. Three of the headend sites are connected to the master headend via Theta Com AML microwave. The remaining headend is connected directly to the master headend. Utilizing this city division, a maximum cascade of 22 amplifiers is realized. The headend division is illustrated in Figure #1.

The traditional reception of broadcast channels over-the-air for headend purposes was deemed less desirable since a more reliable and controlled signal can be received from each local broadcast facility via direct cable interconnection. All local Madison television channels are landline interconnected to the master headend. Using this method, direct video connections were made to each station's master control room or transmitter. As a result of these connections, not only is the signal quality improved, but cable television signals can be received when the station has transmitter difficulties and is off-the-air. This results in a continued service to cable television subscribers even at those times when transmitter failures occur at local broadcast facilities. In addition, picture degradation created when transmitting a television signal, such as ghosting caused by icing, aircraft, or local interference, is entirely eliminated providing the subscriber with the best possible reception.

As a result of the benefits of direct video connection to the local television stations, all television channels are transmitted from the master headend via L.D.S. microwave. Therefore, a high reliability microwave system had to be utilized since a malfunction of one receiver in the microwave system could potentially effect the entire reception of up to 15,000 subscribers. In order to insure minimum interruption of cable service to subscribers, a second redundant microwave receiver is utilized at each headend site. In addition, at times when a L.D.S. microwave transmitter failure might occur, a back-up off-air headend is incorporated at each headend site to allow subscribers continued reception of all local television channels This headend interconnection is diagrammed in Figure #2.

With these three levels of redundant protection available, it became desirable to incorporate an automatic switching and monitoring device to effect a rapid change of deffective equipment in order to provide minimum interruption of service. This paper will illustrate a simple method of automatic protection which has been in use at Complete Channel TV, Inc., for the past year, while allowing the method to be modified for use with other microwave systems.

AUTOMATIC CONTROL OF MICROWAVE HEADENDS

The first step in designing an automatic control system is the determination of parameters to be measured and utilized for control. The following parameters were chosen to verify correct operation of the Theta Com Wideband AML microwave receivers. The design parameters are:

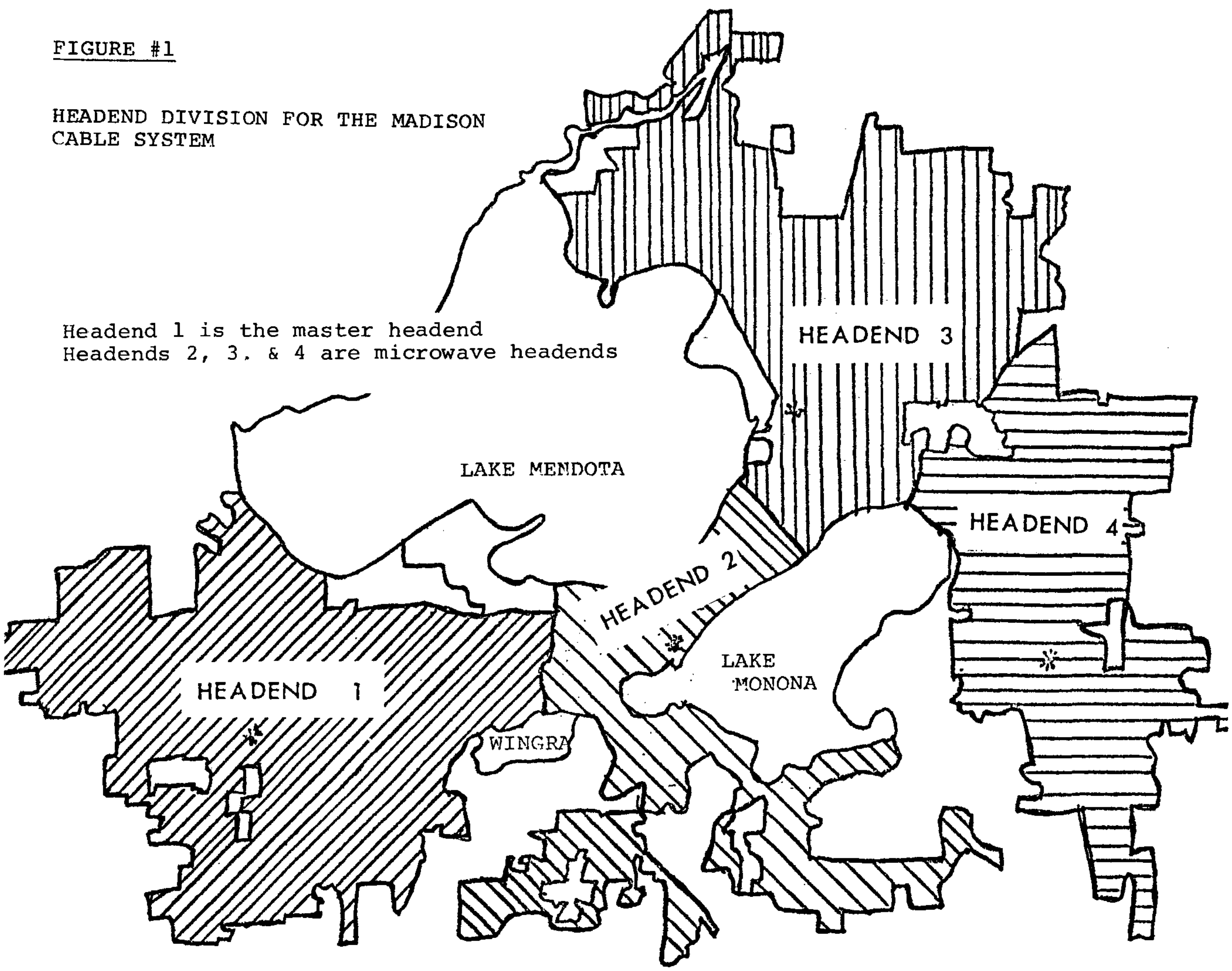
1) All microwave receiver voltages are to be isolated from the control circuit.

2) Control circuit must monitor:
   a) All power supply voltages.
   b) Solid state source lock.
   c) Phase lock condition.

3) Control unit is to be self-contained.

FIGURE #1

HEADEND DIVISION FOR THE MADISON CABLE SYSTEM



4) Control circuit should require little or no modification of microwave receiver circuitry.

5) Control circuit should allow monitoring of all receiver conditions not used for control.

6) Visual indication of microwave malfunction would be desirable.

In order to achieve the desired electrical isolation between the microwave receiver and the control circuit, optical isolators were used as interface units. In addition, the use of the optical couplers, (Motorola MOC 1000) enables different polaraties of control voltages and different control signal levels. As example of this, (See Figure #3), the +24 volt power supply is monitored by IC1, whereas the -20 volt power supply is monitored by IC2. Another feature of the optical couplers allows the device to give either a positive 1 output or zero output for any given input signal. This use is illustrated in the use of IC1 and IC2 as an inverting device in a common emitter configuration, and IC3 and IC4 as a non-inverting device in an emitter follower configuration.

Operation of the circuit is as follows: IC1 monitors the +24 volt supply and delivers an output of zero for normal operation and output of 1 for malfunction. IC2 monitors the -20 volt supply and delivers an output of zero for normal operation and output of 1 for malfunction. IC3 monitors the solid state source voltage. When a voltage is present, the solid state source is malfunctioning. Since this IC is in the emitter follower configuration, the output is not inverted. Therefore, an output of zero indicates normal operation while an output of 1 indicates a malfunction. IC4 operates in the exact same manner as IC3. The input of IC4 is connected directly to both the high and low receiver alarm. Since the phase alarm fluctuates between high and low, an additional capacitor C1 is utilized to provide a delay in device switching.

IC5, a 7402, is a quad two input NOR gate with the following logical Truth Table.

TRUTH TABLES

7402 INPUT A	7402 INPUT B	7402 OUTPUT Y	7403 INPUT A	7403 INPUT B	7403 OUTPUT Y
0	0	1	0	0	1
1	0	0	1	0	1
0	1	0	0	1	1
1	1	0	1	1	0

During normal operation outputs of all optical couplers are zero. Therefore, for normal operation the outputs of IC5 are 1. During a malfunction of any of the four input parameters, the output of IC5 would change to zero. The additional gates in the 7402 are used to light two light emitting diodes when failure occurs One light is associated with phase lock problems, and the second indicates power supply failure. The two outputs of IC5 feed a 7403 quad two input nand gate with open collector output. Again the Truth Table illustrates that under normal operation both inputs are 1. Therefore, the normal output voltage would be a zero, and the relay would be energized. Any malfunction would cause RY1 to open.

The actual RF switching device is left to the discretion of the individual system. At Complete Channel TV, Inc., two identical control circuits were assembled, one monitoring each receiver as illustrated in Figure #4. The actual switching device is a Jerrold Model IFS Switcher. As shown in the diagram, a failure in microwave receiver 1 will automatically transfer microwave receiver 2 on line. If a failure occurs in both receivers or a transmitter failure occurs, then the back-up headend is transfered to the line out.

FIGURE 2.

Redundant headend configuration

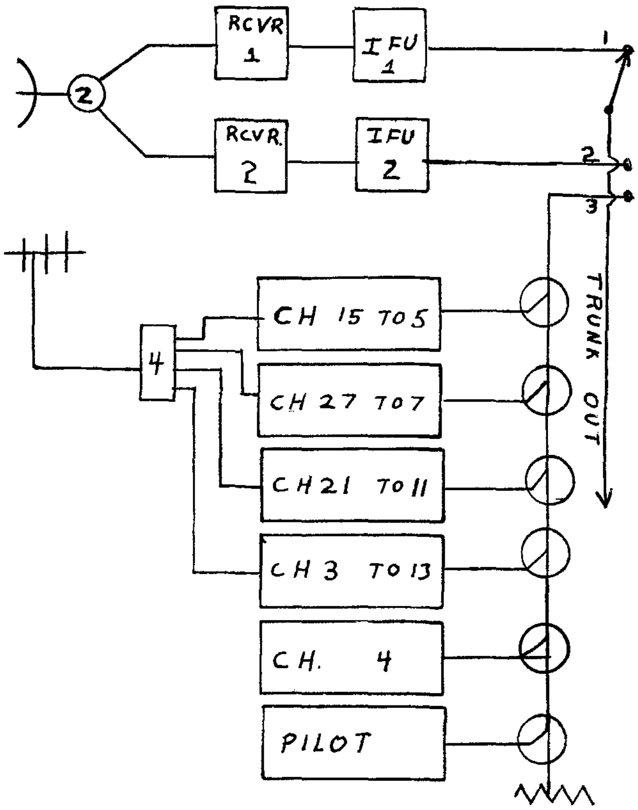
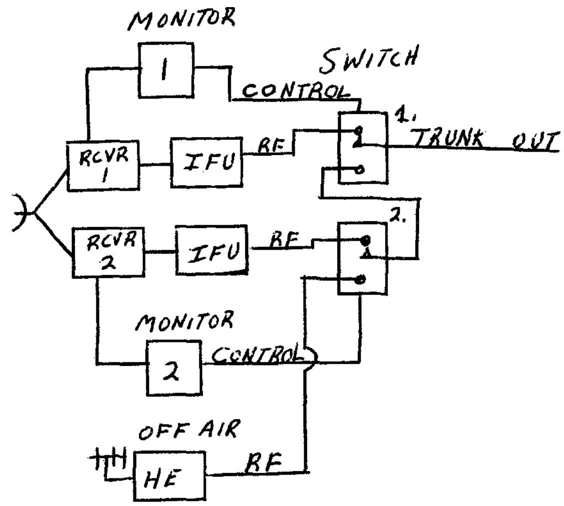


FIGURE 4.

Block diagram of system interconnection



EQUIPMENT UTILIZED

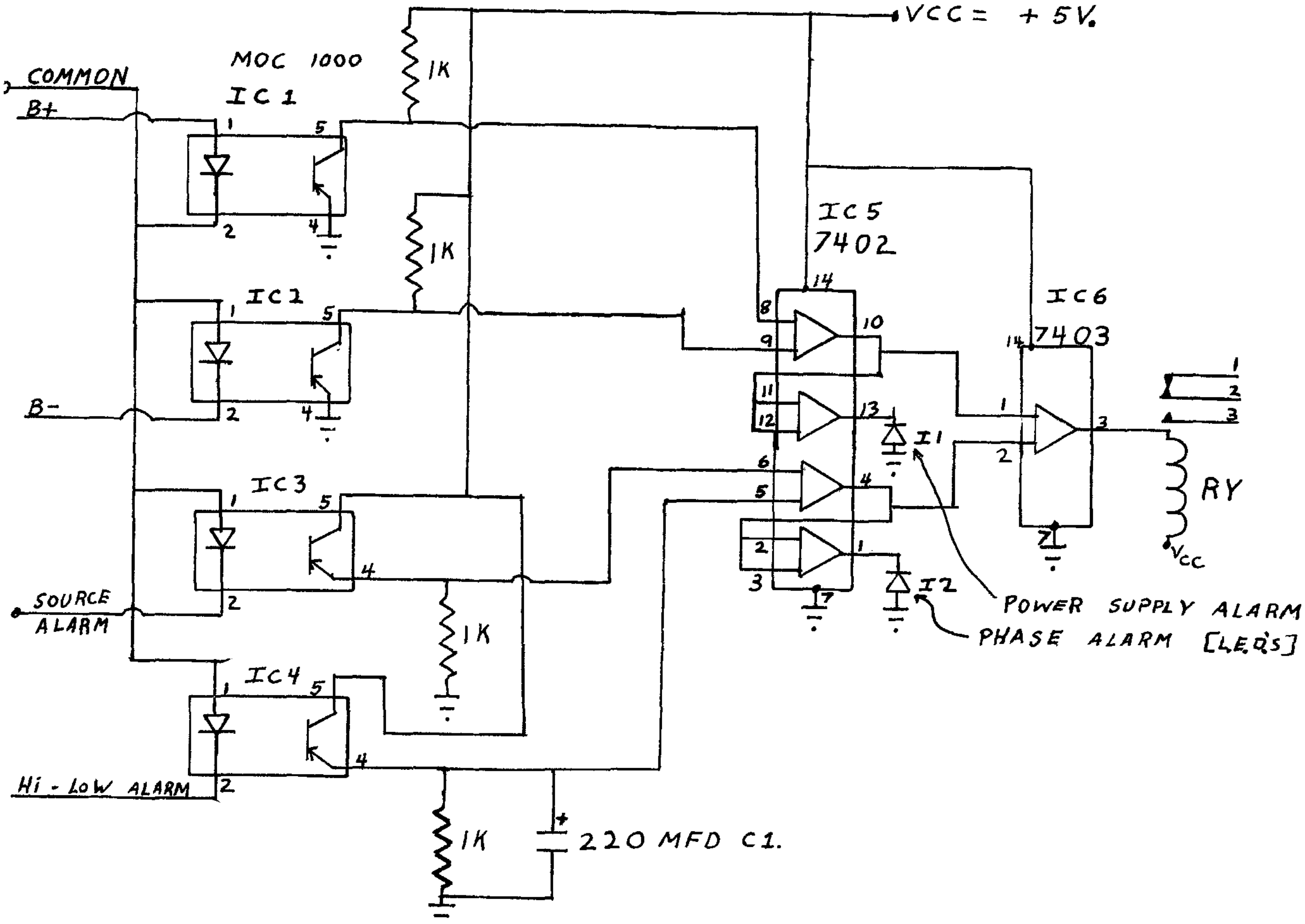
1 Andrew 6' Dish
3 3' Andrew Flex Waveguide
1 Theta Com Magic Tee
2 Theta Com AML Wideband Receivers
2 Theta Com Interface Units with Pilot Carrier
4 Jerrold Channel Commanders
1 Jerrold Modulator Channel 4
1 UHF-VHF Yagi Antenna
1 Jerrold Pilot Carrier Unit
Various Taps and Double Shielded Cable

MONITORING

The microwave receivers in use at Complete Channel TV are equipped with the Theta Com external metering. Therefore, all connections to the receiver are made through the entrance connection for the meter box. The only change in the receiver was the change in power values of the isolating resistors in the receiver. Each resistor in the monitoring circuit was changed to a 1/2 watt carbon resistor. In addition, a duplicate type mode switch was installed with two poles. One pole of the switch was utilized for the first microwave receiver and the second pole is utilized for the second receiver This connection is illustrated in Figure #5 The use of this monitoring arrangement allows direct comparison of each receiver.

FIGURE #3

Schematic Diagram of Control Circuit



<u>PARTS LIST</u>

Part	Qty	Description
R1 Thru R4	4	1 kΩ 1/2 watt carbon resistor
C1	1	220 MFD at 50V
IC1 Thru IC4	4	MOC-1000 IC
IC4	1	7402 IC
IC6	1	7403 IC
I1, I2	2	LED Diodes
RY1	1	Coil (6VDC, 500Ω, 12Ma) SPDT

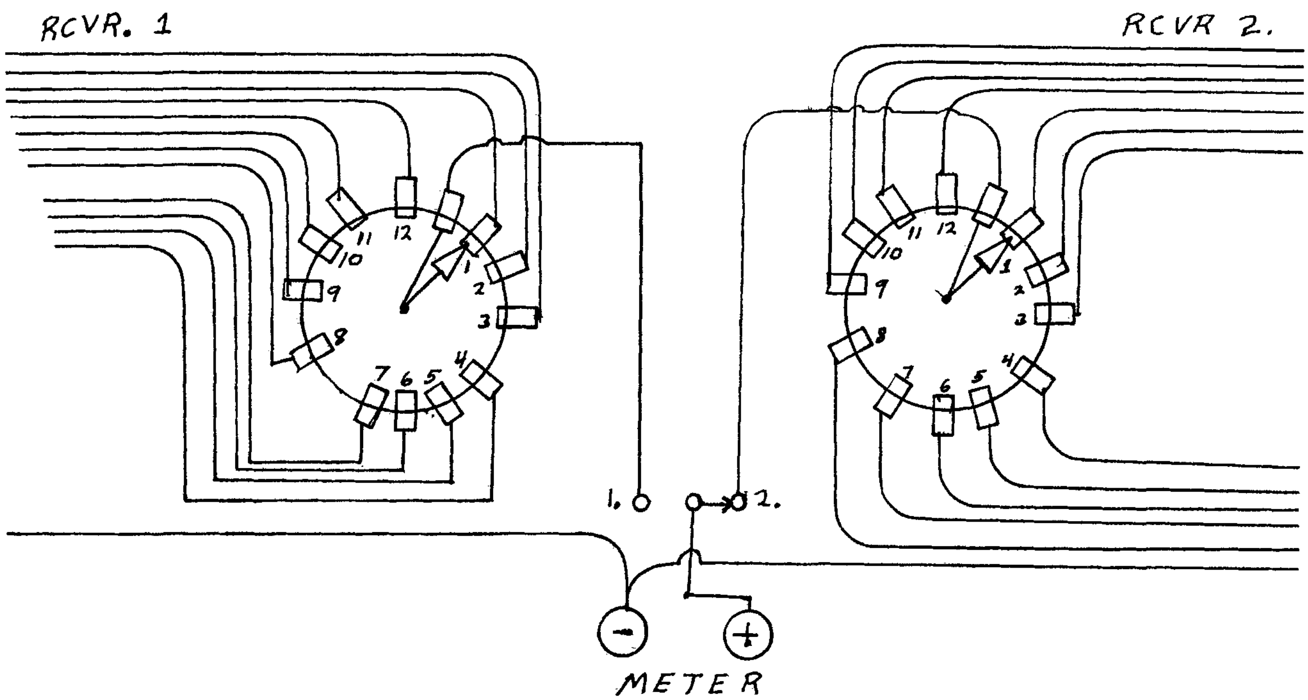
CONCLUSION

The control circuit as described has been in use at Complete Channel TV for the past year It has proven to be a very reliable device as it continues to provide the least interruption of reception to subscribers. The power supply required for the control circuits is best provided by a rechargable battery such as a nickle cadmium battery. The battery should be constantly trickle charged by the standard 110 VAC line.

Future additions to this system are contemplated by using telephone lines to control the microwave receivers. This would allow the change of receivers at any remote point for signal comparisons. Also, using standard voltage variable oscillators, it would be possible to use the standard telephone line to provide actual microwave receiver parameter measurements. Using the basic approach, it is possible to modify the circuit for other microwave systems and different signal parameters.

FIGURE #5

Monitoring of Microwave Receivers Equipped With External Monitoring



METER POSITIONS

1) Temperature calibrate
2) Temperature
3) Solid State Source Lock
4) Solid State Source Alarm
5) Phase Lock Voltage
6) High Alarm
7) Low Alarm
8) A.G.C. Voltage
9) +24 Volt Supply
10) -20 Volt Supply
11) 60 Volt A.C.
12) Meter Short