A REMOTE STATUS MONITORING SYSTEM FOR ONE WAY PLANT

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ABSTRACT

A system for transmitting data in an upstream direction on broadband cable plant equipped only with downstream transmission is described.

A multiple-frequency repeater technique allowing transmission of low frequency signals over long cascades in an upstream direction is used. This technique overcomes the need to undertake any significant modifications to existing plant and eliminates the problems of crosstalk and attenuation occurring in a single-frequency approach.

The resulting modem designs facilitate simple and economic addition of remote monitoring capability to any cable system using existing software and power supply interfaces.

INTRODUCTION

With increasing system bandwidths, complexity and operating costs there is a growing need to optimize maintenance procedures to reduce system downtime. Remote status monitoring has been a valuable adjunct to organized maintenance programs for over ten years. Status monitoring capability has been developed for the broadband industry by the major manufacturers of broadband amplifiers and standby power supplies.

The power supply monitoring systems designed and developed by Alpha Technologies during the early eighties included a complete system dedicated to power supply monitoring and a second system designed to interface Alpha's power supplies to the major amplifier monitors.

Alpha's system, like the others, required a two-way plant, hardware interfaces, transponders (or data modems), head-end controllers and dedicated monitoring software. Given that the installed base of two-way plant is a very small fraction of total CATV plant, few systems could hope to implement these techniques. Clearly a system which could function as a monitor in a one-way plant would have applicability to all CATV systems currently in use.

In early 1986 a decision was made by Alpha Technologies to proceed with a project to investigate the feasibility of two-way data transmission in one-way plants. A technique was proposed for use of a low-frequency return signal using the broadband system's power path and product development work was initiated.

BACKGROUND

A proprietary power supply monitoring system had been developed years earlier by Alpha Technologies, allowing CATV operators to implement a completely separate ('stand-alone') monitoring system for standby power-independent of any other monitoring system already operating in the system. The monitoring of power system status and the ability to remotely test or exercise critical power supply functions can expose power supply and battery malfunctions which affect large amounts of plant simultaneously.

The Alpha system, known as "RSM", incorporates a head end computer, head-end modem, local power supply modems, addressable power supply interfaces, and requires two-way plant. This well established system provides the following capabilities:

1. Automatic, constant scanning of up to 4095 locations, and

2. 'Single-unit mode' allowing detailed interaction with a single power supply,

3. Choice of up to eight operator-configurable test sequences for each address, with up to 14 selectable test parameters per test.

4. Automatic alarm functions configured by the user around locally defined fault conditions.

5. Stored or printed records of fault data by location and time.

6. Remote access to battery voltage values, charger operating modes, failure modes, inverter status, standby times, a.c. line status, and tamper switch status.

7. Remote control of battery charge modes, test function, test reset, alarm modes, and single or multiple unit scanning.

The development of the one-way plant communications technology is intended to take advantage of Alpha's existing monitoring technology - utilizing the same power supply interfaces, the

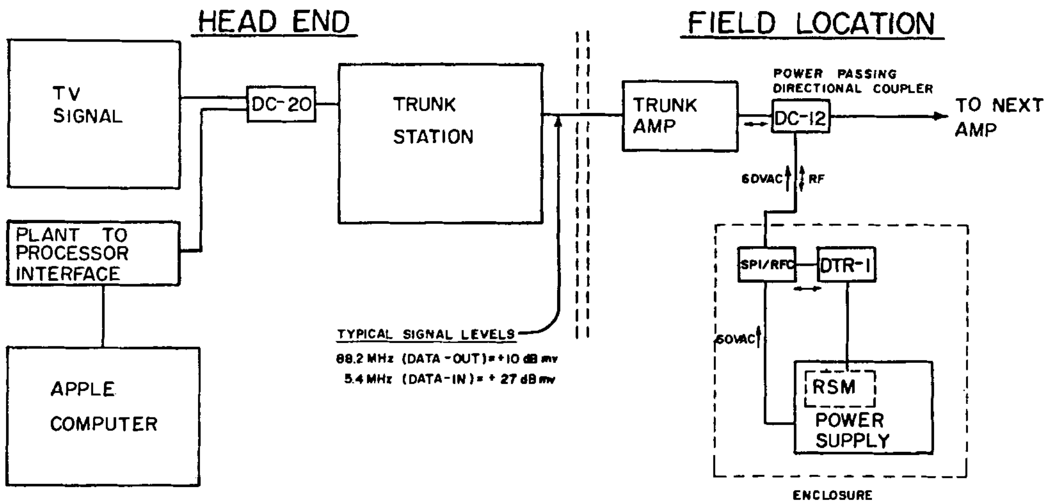


Figure 1. Alpha RSM System Layout

same software and the same physical characteristics. (Fig. 1.)

PROJECT "LIFELINE" IMPLEMENTED FOR LOW FREQUENCY RETURN

Selection of suitable return frequencies for data transmission is restricted to the range between 40KHz and 200KHz. This is based on the bandpass characteristics of typical plant components as illustrated in Figure 2. The power pass band below 40KHz is particularly noisy, so current channels begin in the 50KHz range and go up.

Initial designs for the low-frequency return were based on a single return frequency in the 115KHz range. This approach required adding a second semi-rigid cable to the power inserters used at standby locations. The two cables provided low frequency signal paths to and from the power-supply mounted repeater module. See Fig. 3.

The single-frequency design required change to or extensive modification of the power inserters, in addition to the modification of the power supply enclosure and 60VAC output circuitry. Further, adequate isolation between the two signals was difficult to achieve.

It was concluded that a multiple frequency approach was needed, providing the advantage that no power inserter change was required and no modifications were necessary to the power supply. In addition, repeaters may be implemented at any open distribution port between any widely-spaced powering locations. Open power directors require shunting with fairly large capacitors (between .22 and .47 microfarad) to complete the return path. This is the only system modification required.

SIX FREQUENCIES PER SYSTEM

Typically, six frequency pairs can be used to cover a complete system. Adjacent repeater stations use adjacent low-frequency channels with the last frequency before the head-end using the same frequency as the head-end receiver. See Figure 4.

Eight channel frequencies have been designated between the horizontal sync pulse harmonics. Adjacent channel rejection is approximately 66dB. Frequency pairs would be assigned as 1-3, 3-5, 5-7, 7-1, and so on, or 2-4, 4-6, 6-8, 8-2, etc.

Systems long enough to require more than three frequency pairs would repeat the same group of three as the duplicated frequencies would be sufficiently far apart so as not to interfere. The alternate channels are used to connect branches to the trunk.

Each power supply location supports a modem/repeater combination connected to the cable directly, via the 60 Volt power connection. At the power insertion point, four signals are multiplexed into and out of the cable:

1. *60Hz power at 60VAC*
2. *The downstream VHF data carrier*
3. *The low-frequency signal received from adjacent downstream repeater*
4. *The remodulated low frequency transmission to the next upstream repeater.*

The multiplexing network is a proprietary transformer hybrid network, mounted in the modem housing and is connected directly in line with

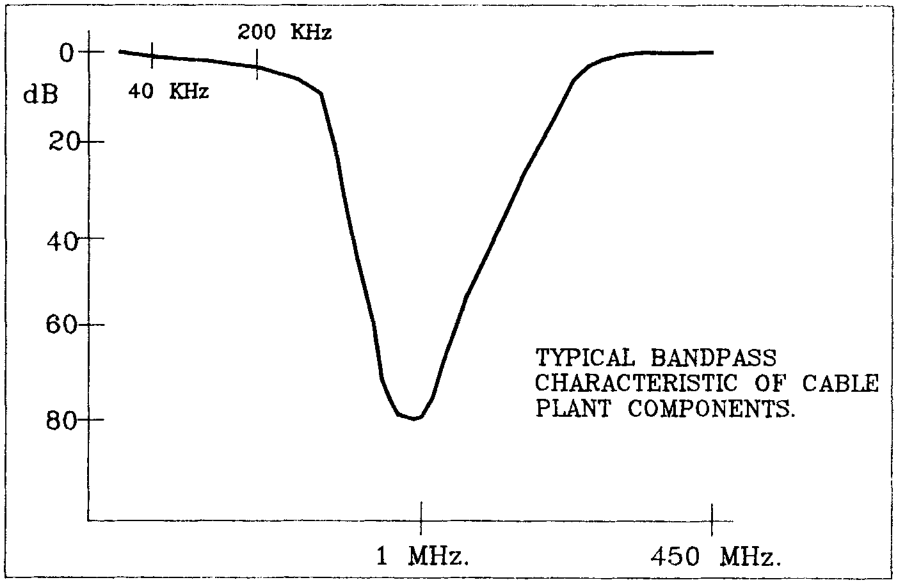


Figure 2. Typical Bandpass of Cable Plant Components

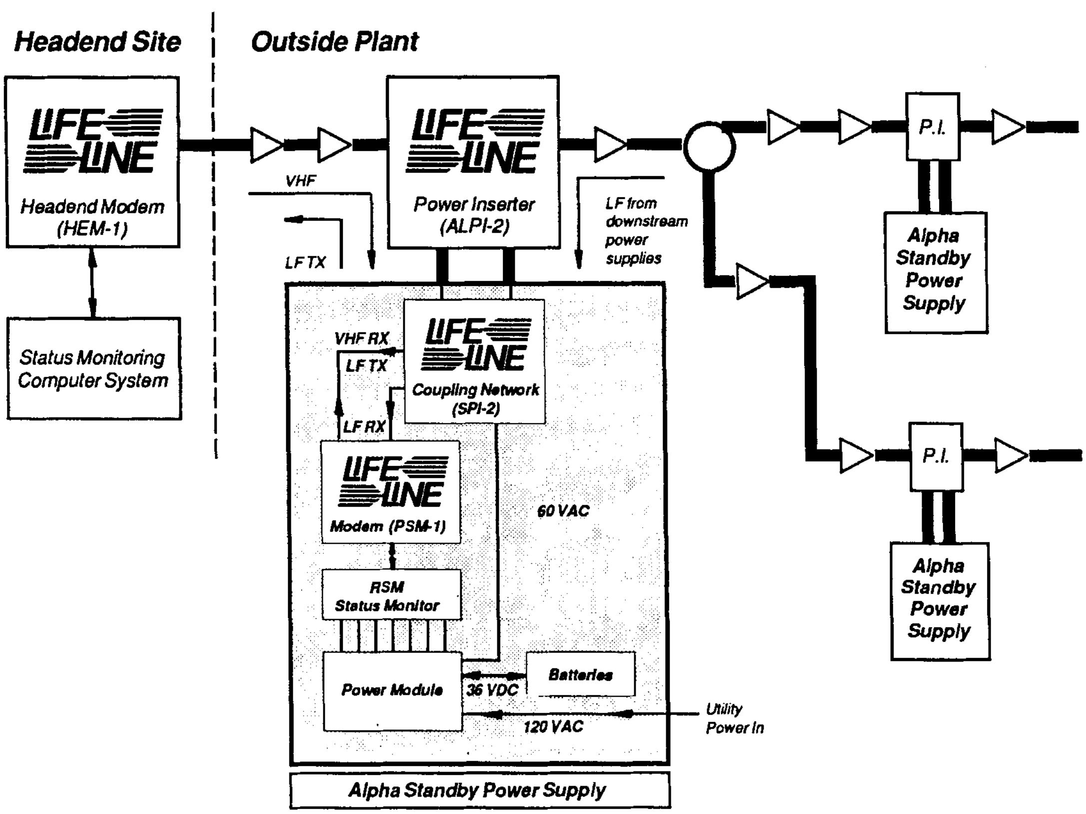
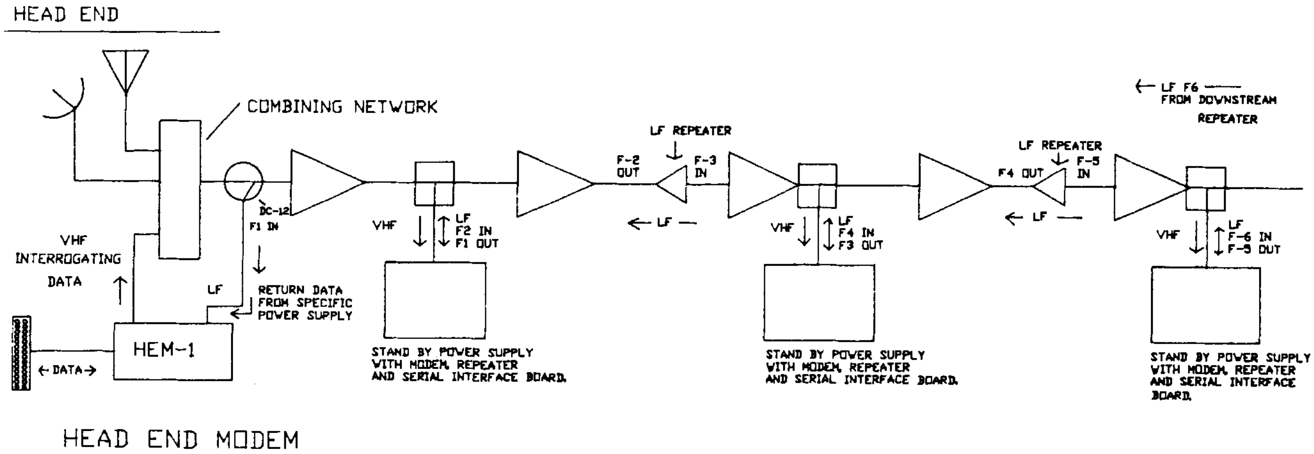


Figure 3. Single Frequency Lifeline Architecture



NOTE: LF REPEATERS BETWEEN TRUNK STATIONS ARE ONLY USED WHEN LF SIGNAL IS ATTENUATED SEVERELY BY TRUNK STATION MOTHER BOARDS. OTHERWISE, REPEATERS ARE LOCATED ONLY IN THE POWER SUPPLY ENCLOSURE.

Figure 4. Typical Monitored One-Way Plant

the 60VAC output of the standby power supply. The addition of the modem to the powering location can be effected without interruption in power to the cable. See Figure 6.

Low frequency carriers are transmitted at approximately 70dBmV. With maximum attenuation between powering locations of 60dB, 10dBmV minimum signal is available to each receiver. For wider separations, an in-line repeater is added at any convenient open distribution port. These units are housed in standard line-extender hardware.

The power supply modems are full duplex, handling the downstream VHF carrier from the head-end and the upstream low-frequency carrier. Modems contain both VHF and LF circuits in the same housing, with the multiplexing circuitry needed to combine the three signals with the 60Hz power feed as described above.

When polled by the head-end computer, the addressed modem will begin a transmission by initializing the upstream repeaters. Carrier-detect circuitry in each demodulator turns on the repeater transmitters and data is passed upstream. Data is FSK encoded on the LF carriers, which are frequency-synthesized from a crystal reference. Data speeds up to 4800 BPS can be supported.

Once the repeater structure is installed in a CATV trunk, this "party-line" system enables extension of the same frequency pairs into any system branch.

CONCLUSION

The low-frequency return system implemented in the Alpha PSM-1 and HEM-1 modems will allow complete power supply monitoring in one-way plant. Use of existing controllers, software, and power-supply interfaces is facilitated, and no significant system modifications are required other than capacitive shunting of open power directors.

The technique may be used for any data communications in an upstream direction on broadband cable, including amplifier monitoring and control, alarm or security systems or subscriber services, without the need for expensive, power-hungry return electronics.

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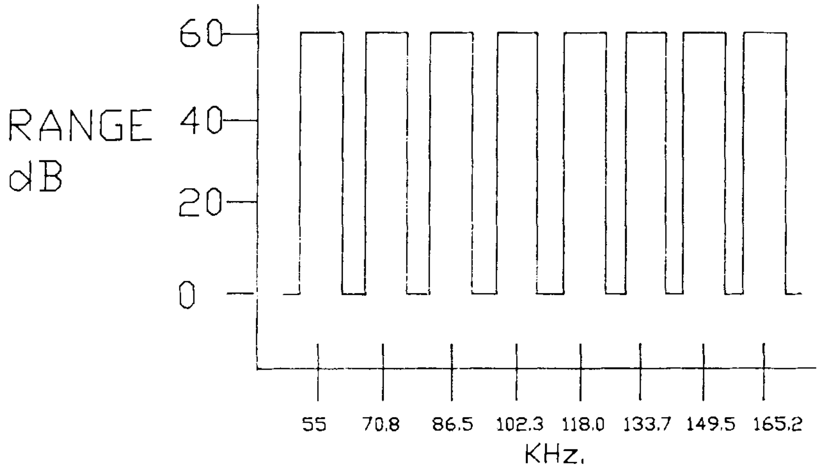

Figure 5. Lifeline Channel Frequencies in a Multiple Frequency Repeater System.

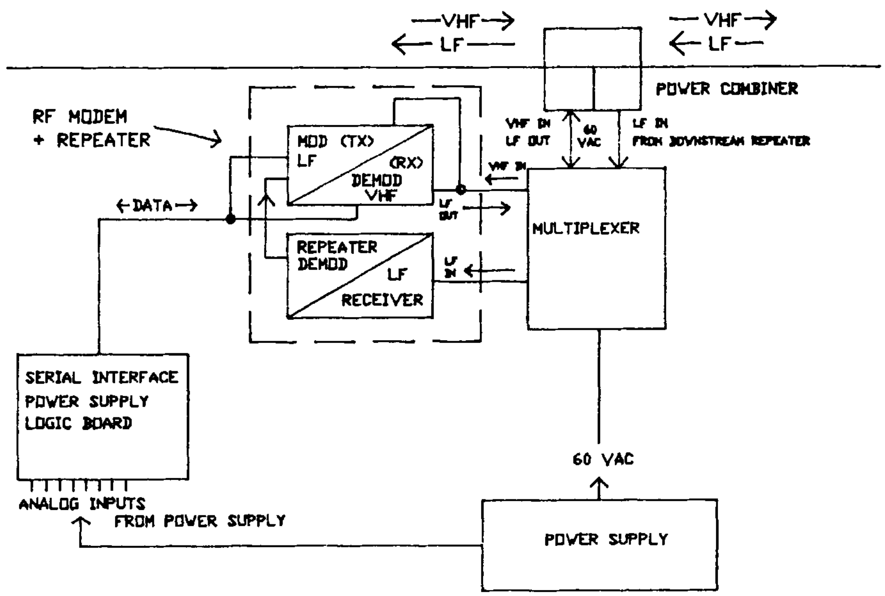

Figure 6. Signal Multiplexing at Power Inserter

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