FIBER OPTICS AND UHF IN A CATV NETWORK

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INTRODUCTION

This paper describes a system that utilizes the extremely wide bandwidth of a fiber optic network by applying only UHF carriers in the range of 470 to 850 MHz. Such a system has many advantages and few disadvantages and would suffice as an international amplifier system.

DESCRIPTION

A fiber/UHF network will consist of the fiber network, an optical receiver with UHF amplification, and UHF trunk and distribution amplifiers.

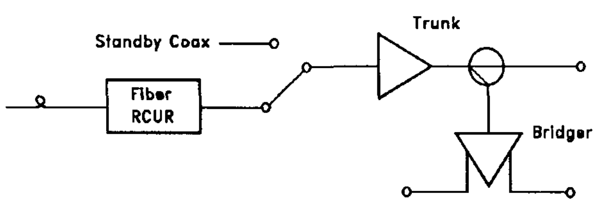

Figure 1 Fiber Optic Receiver Station

The performance of lasers and detectors is essentially constant over the band up to 1 GHz. That is, the lasers and detectors have the same distortion performance for modulation frequencies from 47 MHz to 850 MHz. The distortion performance is only sensitive at this time to the number of carriers being used. Therefore, no improvement in optics is needed for operation up to 1 GHz other than that which is desired for use up to 550 MHz.

The UHF spectrum is single-octave, and therefore, no second-order distortion is generated in the band of interest. The amplifiers could, in fact, be single-ended (i.e., no push-pull). Given a bandwidth of 470 to 850 MHz, all second order beats fall outside this passband. The sum beats fall above 940 MHz and the difference beats fall below 380 MHz. Since the push-pull hybrids are so commonly used and since they provide some improvement in third-order distortion, it is likely that the amplifiers will contain push-pull units. For either single-ended or push-pull amplifiers, good hybrid modules to 850 MHz do not exist and will have to be designed.

The ALSC attenuator circuits may be much simpler than VHF amplifiers, since the cable footages are shorter, the bandwidth is narrower, and the slope differential (i.e., tilt between 470 and 850 MHz) is smaller.

The tilt in cable attenuation from 470 to 850 MHz is about 6.4 dB in a 22 dB span at 850 MHz. Over the temperature range of ±70° F, this tilt would vary less than ±0.7 dB. With an ALSC module at every station (a current trend), the slope control attenuator needs only ±0.7 dB range, thus simplifying the slope circuitry.

Cable Loss		Loss	Slope	Gain
850 MHz	470 MHz	Diff.	Range	Range
24 dB	16.8 dB	7.2 dB	1.2 dB	0 dB
22 dB	15.4 dB	6.6 dB	0.6 dB	-2 dB
20 dB	14.0 dB	6.0 dB	0.0 dB	-4 dB
18 dB	12.6 dB	5.4 dB	-0.6 dB	-6 dB
16 dB	11.2 dB	4.8 dB	-1.2 dB	-8 dB

Figure 2 Gain and Slope Range with ALSC at Every Second Amplifier

The gain control attenuator requires a ±2.5 dB range (or a total of 5 dB) which is fortunate, as it allows the attenuator to track better over the frequency range. Again, since the bandwidth is less than one octave, good tracking will be easier to obtain.

Cable Loss 850 MHz	Cable Loss 470 MHz	Loss Diff.	Slope Range	Gain Range
24 dB	16.8 dB	7.2 dB	0.6 dB	0 dB
22 dB	15.4 dB	6.6 dB	0.0 dB	-2 dB
20 dB	14.0 dB	6.0 dB	-0.6 dB	-4 dB

Figure 3 Gain and Slope Range with ALSC at Every Station

ADVANTAGES

There are many advantages to using only UHF in a fiber system. If single-ended circuits are used, the cost and power consumption is lower. There are no second-order beats or CSO.

There are NO CLI PROBLEMS, since there are no other radio services in this band and particularly, no aircraft frequencies. The only worry about signal leakage is theft of service. There are no FCC regulations on signal leakage in this band in the U.S.

Return filters will be extremely simple. The current usage of return signals exists in a relatively narrow bandwidth. If these return carriers are left in the 5 to 30 MHz band, very little filtering is required to separate the bands. Zero ripple Butterworth filters would work very nicely instead of the complex elliptic filters in use today.

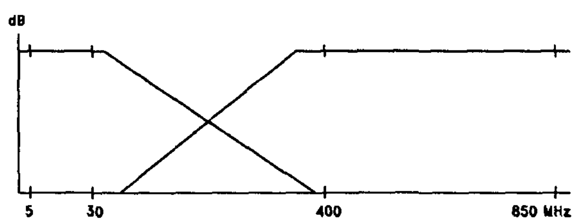

Figure 4 Forward and Reverse Filter Passbands

Equalizers are easier to design in single-octave applications because of the narrower bandwidth. It is likely that few, if any, control adjustments would be necessary. Again, due to the single octave bandwidth, response ripple will be more easily controlled.

DISADVANTAGES

UHF channels would mean UHF converter/descramblers for pay channels. In the U.S., TV tuners have inadequate stability, signal handling capabilities, and selectivity. The UHF tuners in Europe have satisfactory stability and signal handling capability, but also suffer from poor adjacent channel selectivity. In a 20 channel system with carriers spread every second or third space, the selectivity may be adequate.

A major problem at this time is the fact that hybrid modules do not exist that can handle over 10 or 20 channels. However, these few channels may be adequate for many applications.

Hi-Q pilot carrier filters will be more difficult to design; however, helical filters are smaller and readily available. SAW filters may also be usable, but their insertion loss is high.

Passives and taps in the UHF region are in common use in Europe, but would have to be developed for use in the U.S.

Drop cable would, no doubt, be RG-6 or equivalent because of its lower attenuation at UHF compared to RG-59 type drop cable. Type 6 cable has an attenuation of about 5.9 dB at 850 MHz and type 59 cable has an attenuation of 7.4 dB. The difference is 1.5 dB.

Trunk amplifier spacing will be relatively short. Assume 22 dB trunk spacing with 0.750 cable. At 850 MHz, the spacing will be about 1375 feet or roughly 4 amplifiers per mile. (Running miles not strand miles). Using 0.875 cable will increase the spacing about 14 % or to 1570 feet in this example.

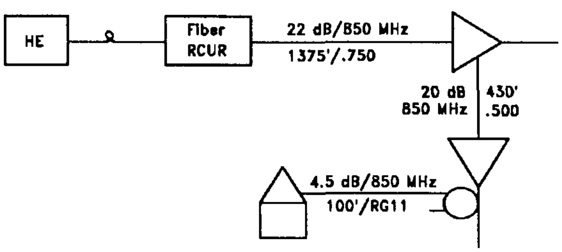

Figure 5 System Diagram

With a typical line extender gain of 20 dB (probably higher in the future) and a typical span of 10 dB of cable and 10 dB of loss due to taps and passives, feeder spans will average about 430 feet with 0.500 cable.

Typical cable losses per 100 feet at 850 MHz are:

0.875	1.4 dB
0.750	1.6 dB
0.500	2.3 dB
Type 6	5.9 dB
Type 59	7.4 dB

HYBRIDS

There are currently only two hybrid amplifier modules available from two manufacturers, respectively, that are designed for 850 MHz, but they were designed for a different application. The distortion performance of these devices is marginal for this application. It is anticipated that with the demand for this kind of product, a suitable device will be produced by the hybrid vendors.

Be that as it may, one can calculate (actually estimate, since hard data is not available) the system performance with currently available technology. Figure 6 lists estimated system performance for the fiber link, fiber receiver, one trunk, one bridger, and one line extender. The operating levels were chosen for best dynamic range with, hopefully, reasonable levels.

Note that the carrier-to-noise ratio (C/N) is set by the fiber link at about 51 dB and the composite triple beat (CTB) for 20 channels is set by the bridger and line extender at about 55 dB. C/N is adequate, but CTB is marginal, depending on the application.

Two trunk amplifiers would degrade the CTB by about 1 dB (i.e., -54 dB instead of -55 dB) and would not appreciably alter the C/N.

	FO Link	Trunk Ampl	Bridger	1 LE	EOL
Level (dBmV)Flat		+30	+40	+40	--
C/N (dB)	51	60	66	66	50
CTB (dB)	71	-80	-63	-63	-55

Figure 6 Estimated performance analysis with 20 channels

Sixty channel applications will require a 9.5 dB improvement in hybrid CTB performance. Perhaps some of this improvement can be gained by changing the transistor die to a current generation. The remainder could be achieved by designing a power doubling version. Alternatively, suitable devices could be obtained by pushing current 550 MHz units to 850 MHz and optimizing performance between 470 and 850 MHz.

COSTS

No cost figures are available, since some of the key items are not yet available. It is anticipated that individual equipment costs would not be significantly greater than an equivalent VHF system. Some costs would be greater, but some savings would also result as described above. However, as discussed, the shorter spacing will require more equipment than an equivalent VHF system.

CONCLUSION

A single-octave fiber/UHF system has many advantages; however, all of the technology is not yet available. The missing technology is within reach, but some work remains to achieve it. All that is needed is the desire to build it. The first practical application would probably be in Europe where UHF TV channels are more prevalent and in widespread use.