# A TECHNICAL ANALYSIS OF A HYBRID FIBER/COAXIAL CABLE TELEVISION SYSTEM

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Abstract - Improvements in the quality of the delivered NTSC signal in CATV systems may be obtained by the application of fiber backbone technology.

These signal improvements will be the result of decreased cascades of traditional cable television amplifiers following the fiber node. These improvements are measurable in terms of carrier-tonoise ratio, and intermodulation products.

The resulting improvement in system overhead may be exchanged for additional bandwidth, for increased system reach, or for improved quality of the delivered signal.

This paper presents the evaluation we performed for one of our existing systems. We show the improvements in performance which are obtained with fiber backbone. We also show how the same system can be upgraded from 270 MHz to 550 MHz, without changing trunk cable, trunk locations, or using microwave hubs. The 270-550 MHz upgrade example focuses on the exchange of performance for additional bandwidth.

### SCOPE

American Television and Communications (ATC) management directed the engineering staff to undertake the analyses described herein because of its belief that our future depends on six primary operational considerations.

- Delivery of signal quality directly comparable to present and perceived future sources, while providing economics comparable to, or better than, alternatives now available to our systems.
- 2. The ability to transport to the home, any enhancement which may be forthcoming in the art of television systems.
- 3. The ability of our systems to offer ancillary services which may become desirable to our subscribers.
- 4. The ability of our systems to meet competitive situations in a cost effective manner.
- 5. The ability of our systems to operate in a more reliable fashion.
- 6. The ability of our systems to take advantage of a more flexible evolutionary architecture.

This paper will deal only with the technical performance aspects of the application of the fiber backbone concept. Financial modeling which is an inherent part of any decision making process will be presented by other members of the ATC Engineering staff in a separate paper.

### FIBER BACKBONE

The fiber backbone concept requires that conventional amplifier cascades be reduced to a small number, such as 2, 3, 4, or 5. In order to create such short cascades, a number of "fiber nodes" must be created. Each node is connected to the headend by single mode optical fiber which transmits the optical signal from the headend to the node.

In the headend, the radio frequency (RF) signals are converted to optical frequencies, and coupled onto the fiber.

The multi-fiber cable follows traditional trunk routings and is likely to be overlashed to existing cable. As the fiber proceeds toward the furthest node point, it is split, and spliced many times. Examples of these routes are included in the appendix.

At the fiber node location, we believe the equipment required will be housed in an enclosure similar to existing trunk amplifiers. The purpose of the node is to terminate the optical fiber cable, and convert the optical signal on that fiber to RF for transmission to the home via traditional cable television trunk and line extender amplifiers.

How good must the node RF performance be?

We believe the signals recovered from the fiber must have at least 55 dB carrier-to-noise, -65 dB composite triple beat and -65 dB composite second order performance.

## **OPTICAL LINK PERFORMANCE**

ATC staff engineers began active experimentation in fiber optic transmission systems in the spring of 1987. While our focus is directed primarily at broadband amplitude modulated, vestigial sideband (AM-VSB) transmission, we also closely monitor the progress being made in the area of FM transmission on fiber. Either modulation technique (AM, or FM) may be applied to the fiber backbone approach.

Several vendors of lasers, fiber, and detectors were contacted with requests for product information and sample items. The initial results were disappointing, yielding carner-to-noise ratios of 47 dB, and composite triple beat ratios of 50 dB. With these devices, the second order performance was unacceptable. The composite second order beat products were eliminated from the band of interest by choosing an octave of bandwidth from 200-400 MHz for the initial experiments. In practical application, it may be necessary to convert the 55-550 spectrum to 605-1155 MHz prior to modulating the laser. Two advantages are expected from this process. One advantage is that all second order products will fall outside the band of interest, and may be removed by filtering. The second advantage is that this frequency range allows the laser to function in a more favorable region of its operating characteristics.

This performance was initially perceived as disappointing because it was so far from the performance required to make the fiber backbone concept a reality. The disappointments did not last very long, however.

The following graph, Fig. 1, indicates the performance improvements we have been able to observe from the various components of fiber systems to date.



The best performance observed so far produces 48 dB carrier-to-noise ratios and -65 dB composite triple beat dB with 42 channel loading, through 15 Km of fiber. A future element of the fiber experiment is to block convert the 42 channel spectrum (55-330 MHz) to 605-935 MHz. At these frequencies the signals occupy less than an octave of bandwidth and we will be better able to determine the second order performance. Experiments are presently in progress on this phase of the project, and will be reported as they produce meaningful data.

The progress made in laser technology over the past year makes us very optimistic that the required node performance goals of 55 dB carrier-to-noise, -65 dB composite triple beat, and -65 dB composite second order over 15 Km of single mode fiber are goals which will be achieved in the near future, at acceptable prices.

An especially significant item of note is that in our discussions with various manufacturers of lasers and detectors, we have learned that there are no known physical limits preventing the laser and detector manufacturers from creating devices with the parameters required to deliver the performance we expect.

Assuming that the required node performance is obtainable, we analyzed the performance improvements which can be expected in the sample 270 MHz system. We then performed an analysis on this same system to determine the performance achievable if the system were to be upgraded to 550 MHz.

In the 550 MHz upgrade, we decided to attempt to use the same trunk cable and amplifier locations, and to "drop-in" appropriate 550 MHz amplifiers, if possible.

### COMPUTER ANALYSIS

All of the analyses presented are performed with various computer programs which permit the entry of all necessary variables, and calculate performance accordingly. Several of the exhibits are the printouts from these programs. The programs require the entry of the equipment operating parameters in the area designated "Manufacturer's Specifications". The operating parameters, as the equipment is applied in the system, are entered in the "System's Specifications" area. Included in this area is the data for the number of each type of amplifier in cascade. In area labeled the "Calculated Equipment Specifications", the program calculates the performance which is expected from the contribution of each of the elements cascaded (i.e., trunk, bridger, line extender, and converter), derating appropriately for the operational parameters chosen. The "Calculated System Specifications" area indicates the expected performance of the elements in cascade, indicating end of the line" performance. Using a program simplifies the repetitive process necessary to arrive at optimum solutions to diverse system applications.

The following material represents our progress to date in the process of arriving at an optimum solution to the problem of implementing the fiber backbone concepts.

### SIGNAL QUALITY IMPROVEMENTS

As stated in the abstract, one of the goals of our project was to improve the performance of an existing 270 MHz system. The following section describes the processes we used, and the results obtained from applying the fiber backbone to this system.

The system chosen for analysis is one of ATC's older 270 MHz systems which has been in operation for more than 15 years, and which requires improved operational performance to meet competitive pressures, and market demands. The system segment analyzed consists of 375 miles of plant, serving approximately 10,000 subscribers. The longest cascade consists of 28 trunk amplifiers, one bridger, and two line extenders. The trunk spacing is 21 dB, and the cable is .750" P-3. The distribution levels are 48/41 dBmV for the bridger, and 43/37 for the line extenders. The end of the line performance of this system is: 46.7 dB carrier-to-noise, -56.2 dB composite triple beat, and -60.3 dB composite second order.

The system performance is shown in the cascade analysis, Exhibit 1 of the appendix.

Implementation of a fiber backbone in this system will yield an improvement in carrier-to-noise of 4.8 to 5.7 dB, depending on the number of amplifiers cascaded after the fiber node. In this example, the intermodulation products were slightly worse after implementing the fiber backbone. These intermodulation products are the result of the high tap levels required in the distribution portion of the system, to meet end of the line tap levels. See Fig. 2, below, and Exhibits 1, 2, 3, and 4 of the appendix.

SYSTEM END PERFORMAN	CE DATA
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	C/N	CIB	030	NODES
BEFORE FIBER BACKBONE	46.7	-56.1	-60.3	0
AFTER FIBER BACKBONE 2 TRUNK IN CASCADE	52.4	-55.2	-61.3	61
AFTER FIBER BACKBONE 3 TRUNK IN CASCADE	51.9	-55.1	-61.2	41
AFTER FIBER BACKBONE 4 TRUNK IN CASCADE	51.5	-55	-61	29

Figure 2. end of the line performance calculations based on trunk cascade and "quad power" line extenders.

Fig. 2 shows the end of line comparisons for different cascades after the fiber node. Exhibit 1

shows the present system performance. Exhibit 2 shows the performance with the fiber backbone with four trunk amplifiers cascaded after the node. Exhibit 3 shows the performance with two trunk amplifiers cascaded after the node.

This range of improvements is made possible by the flexibility of system architecture produced by implementing the fiber backbone concept.

In this example, our goals were:

- Reuse as much of the existing plant as possible to minimize the complexity of any future upgrade which might be undertaken. Existing equipment was reused, and only direction reversals on approximately half the trunk locations were required.
- 2. Provide performance improvements which will allow this system to meet present market pressures, and permit future bandwidth expansion as necessary. The goal of improved carrier-to-noise was met. (4.8-5.7 dB).

As the system design for the quality improvement example evolved, it was necessary to consider the number of fiber node locations to be used. Several alternatives were evaluated with emphasis on the system performance with various cascades after the fiber node. An analysis of the number of nodes required is contained in Figure 3 below. It can be seen that in each of the 209 existing trunk amplifiers is a node location; the number on nodes required is 209. Similarly, if the number of amplifiers cascaded rises to 28 (the original cascade), the number of nodes is one. Between these values, we selected the numbers 2, 3, and 4 for cascade and fiber route evaluation.



NUMBER OF NODES VS CASCADE

Due to this system's architecture, and the curve from Figure 3, it appears there is no apparent advantage to continuing beyond the four in cascade point. To do so would defeat our purpose because of the buildup of noise and distortion in longer cascades.

As a preamble to the next section, two terms to be used require definition. They are: route miles, and fiber miles. A "route mile" is total linear distance which will require lashing of the fiber bearing cable to the existing plant. The "total fiber mileage" is the sum of the distances from each node to the headend, with one fiber run per node.

For each of the analyses presented we have calculated the route mileage to provide an indication of the magnitude of the overlashing required, and the fiber mileage to indicate the possible fiber costs.

The node location data, and fiber mileages for the system analyzed, are shown below.

For four in cascade after the node: (miles)

- 1. Route mileage = 43.7
- 2. Fiber mileage = 128.6
- 3. Nearest node = 1.13
- 4. Furthest node = 8.99

For three in cascade after the node:

- 1. Route mileage = 45.3
- 2. Fiber mileage = 174.6
- 3. Nearest node = .9
- 4. Furthest node = 8.61

For two in cascade after the node:

- 1. Route mileage = 50.9
- 2. Fiber mileage = 248
- 3. Nearest node = .9
- 4. Furthest node = 8.99

The fiber routings for the three cascade examples tested (2, 3, and 4 after the node) are shown in Exhibits 6, 7, and 8 respectively. These exhibits are located in the appendix.

		FIBER			FARTHEST
				100C, WII.	NODE, IVII.
2 CASCADE	50.9	248	61	.9	8.99
3 CASCADE	45.3	174.6	41	.9	8.61
4 CASCADE	43.7	128.6	29	1.13	8.99

FIBER ANALYSIS VS CASCADE

Figure 4. Fiber requirements versus cascade chosen.

Figure 4 is a tabulation of the number of nodes, fiber miles, and route miles for each cascade evaluated.

Design samples were performed to determine the architecture of the system after application of the fiber backbone. The typical trunk routings for each cascade evaluated are shown in Exhibits 8, 9, and 10 of the appendix. While it was not necessary to physically relocate any of the trunk stations, 50% of them will require reversal.

The distribution portions of the original system remain unchanged.

Another point of interest is that the same node locations will be used regardless of whether the plan is to simply upgrade the system performance, or to increase the bandwidth. This condition occurs because the same trunk locations and cascades will be used in either situation.

The preceding information shows the performance improvements which can be achieved with existing plants. As can be seen, the performance improvements in themselves are significant. Even more significant is with this performance in place, the stage is set at any time in the future to upgrade this system to 550 MHz. Not only can this system be upgraded, it can be upgraded for a relatively low cost compared to the alternative of a total rebuild.

## 270-550 Upgrade

The performance improvements generated by the fiber backbone approach and very short amplifier cascades permits an exchange of end of the line performance for expanded bandwidth. Adding improved technologies permits the upgrading of this 270 MHz system to 550 MHz, while maintaining adequate end of the line performance, with no change in trunk cable, distribution cable, or trunk locations.

The test design for the upgrade of the system was a sample of 15.8 miles of plant, with areas selected to represent an average sample of the densities in existence. Three areas of five miles each were designed, with densities ranging from less than 75 homes per mile, to densities exceeding 130 homes per mile.

### **DISTRIBUTION ANALYSIS**

The analysis process of this upgrade began with the end of the line performance criteria established for our systems. It was determined that these parameters would be met or exceeded in the 550 MHz upgrade. The major performance specifications to be met are:

- 1. 46 dB carrier-to-noise
- 2. -53 dB composite triple beat
- 3. -53 composite second order
- 4. +15/10 dBmV at the tap
- (drops are 150 ft. RG-6)

These specifications forced the levels required, and the distribution distortion values.

Various line extender and bridger technologies were evaluated to determine which would offer the most economical upgrade while meeting the performance required. It was possible to meet end of the line performance with either two "quad power" line extenders in cascade, or three power doubling line extenders. Three conventional line extenders in cascade failed to meet the required performance criteria. The use of three line extenders in cascade requires the addition of up to 147% more line extenders than the "quad power" choice, and in that case, 46% of the distribution system required the use of three line extenders in cascade.

END OF LINE PERFORMANCE	QUAD LE (2)	P.D. LE (3)	CONV LE (3)
C/N	48.4	-47.9	-48.3
СТВ	-5 <b>2.5</b>	-52.3	-49.0
CSO	59.8	-59.8	-49.0

Figure 5. End of line performance versus line extender technology.

Fig. 5 shows the distribution end of the line performance of the line extenders evaluated. Complete 550 MHz cascade analysis is shown for each of the line extender technologies evaluated. These analyses appear as Exhibits 5, 12, and 13 of the appendix.

### TRUNK ANALYSIS

The next phase of the analysis was to examine the trunk from the fiber node to the bridger input. The P-3 cable in use on the example system has a 270 MHz loss of .85 dB/100. At 550 Mhz, this same cable has 1.21 dB loss/100 ft., or 29.97 dB per span at 550 MHz. Fig. 6 shows the attenuation versus frequency for this cable.



Since 30 dB gain trunk stations are available in several technologies, it appeared possible to "drop-in" the new amplifiers in the existing locations.

Utilizing feed forward technology, trunk cascades of 2, 3, and 4 were analyzed for headroom. The headroom graphs display the carrier-to-noise and composite triple beat limits which are achieved with the output levels chosen. The graphs of these performances are shown in Fig's. 7, 8, and 9. Exhibits 5, 12, and 13 of the appendix provide full cascade analysis.

HEADROOM GRAPH FOR 2 IN CASCADE, 550 MHZ



CABLE ATTENUATION VS FREQUENCY



From the preceding graphs and exhibits, one can see that the improvement to be expected from shortening the cascade after the node is in the area of carrier-to-noise. The example system required high distribution levels and in this example, at least, it was not possible to make the usual exchange of carrier-tonoise for distortion. The distribution of this system is the limiting distortion factor, and the trunk contribution is relatively minor. Even so, it is possible to deliver a signal with 51.9 dB carrier-to-noise, to the subscriber's TV set. This performance may well be what is required to make enhanced television systems a reality.

### **ALTERNATE SOLUTIONS**

Analysis was performed to establish whether the proposed upgrade could be accomplished without the use of AML, or other hub techniques. Further headroom analysis graphs were prepared to determine what performance could be expected with "normal" 22 dB spacing after replacement of the trunk cable. The results appear in Fig's. 10 and 11.







Fig. 10 shows that performance equal to that of the fiber node was reached after a cascade of 10 feed forward trunk amplifiers.

Fig. 11 shows that performance equal to the fiber node plus four trunk amplifiers in cascade was reached after a cascade of 20.

Since replacing the trunk cable permitted the direct replacement of the amplifier locations, one can see that the "reach" is inadequate to replace the original 28 in cascade, and some sort of hub network will be required to complete the upgrade from 270 to 550 MHz.

This section of the paper shows that an upgrade from 270 MHz to 550 MHz can be accomplished using the fiber backbone concept. It has further demonstrated that this upgrade cannot be accomplished otherwise without resort to hub techniques.

### SUMMARY

In this paper, we demonstrated the following:

- 1. The improvement in signal quality which may be obtained by application of the fiber backbone concept to an existing 270 MHz system.
- The potential to upgrade our example system to a greater bandwidth, by trading improved performance for that bandwidth.
- The upgrade of a 270 Mhz system to 550 MHz while preserving trunk cable and trunk locations, and without resorting to AML or other hub techniques.
- The application of the fiber backbone concept will provide new opportunities for the cable television community to take advantage of performance technologies as they occur.
- 5. As will be seen in the financial models to be presented later, the expense of the fiber backbone is less than a total rebuild, and it appears possible that this technology will permit upgrades which are not possible with any amplifier technology available today, or in the foreseeable future.

It is the authors' opinion that the ideas and concepts set forth in the abstract have been proven. We have shown that quality improvements can be attained; and that these improvements are not only measurable, but substantial; and we have shown a working upgrade example from 270 to 550 MHz which in the worst case not only betters original system performance, but a 550 MHz system which has the performance to transport enhanced television systems or other services. Our peers, in a parallel effort, have shown that the fiber backbone concept is economically viable as we have proven its technical feasibility.

We must stress that while there is, today, no equipment commercially available which supplies all the desired performance at the price necessary to transform the fiber backbone concept into reality, the authors' are confident that the performance predicted herein will be attainable in the foreseeable future.

### ACKNOWLEDGEMENT

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### APPENDIX

#### CATV SYSTEM DISTORTIONS

SYSTEM NAME.	1 Mar 1	099	FWD. BW	4.0	FWD. NOISE		-59.2
MANE FACTURED	1-Mari	300	HEV. DW	4.000	HEV. NUISE		-59.2
SPECIFICATIONS				TRUNK	BRIDGER	L.E.	
NOISE FIGURE				9.5	10.5	11.0	
CTB OUTPUT CAP	· · · · ·			33.0	50.0	50.0	
CTB RATING(-de	3mv) į			-93.0	-59.0	-59.0	
XMOD OUTPUT CA	AP			33.0	50.0	50.0	
XMOD RATING(-	dBmv) j			-92.0	-59.0	-59.0	
2nd OUTPUT CAP	1			33.0	50.0	50.0	
2nd RATING(-dE	3mv) (			-85.0	-70.0	-70.0	
CHANNEL CAPACI	TY į			42.0	35.0	35.0	
MANUFACTURER	TILT			3.0	6.0	6.0	
HUM SPECIFICAT	ION			-70.0	-70.0	-70.0	
SYSTEM							
SPECIFICATIONS				TRUNK	BRIDGER	L.E.	
AMPLIFIER INPU	π ι			12.0	13.0	17.0	
GANORBROCLO	oss i			21.0	-20.0	26.0	
DESIRED TILT				6.0	6.0	6.0	
AMPLIFIER OUTP	ί τυ			33.0	48.0	43.0	
CHANNEL LOADIN	a i			35.0	35.0	35.0	
CASCADELENGTH	i i			30.0	1.0	2.0	
CALCULATED	<b>`</b>						
EQUIPMENT							
SPECIFICATIONS				TRUNK	BRIDGER	L.E.	
	C/N1	•••••		-46.9	-61.7	-62.2	
	СТВ			-67.6	-63.0	-67.0	
	хмо і			-66.2	-63.0	-67.0	
LOG., 15.0	2ND			-62.8	-72.0	-72.5	
	HUM			-40.5	-70.0	-64.0	
CALCULATED		FWD,	FWD.	FWD.			
SYSTEM	i	TRUNK	TRUNK	SYSTEM			
SPECIFICATIONS	í		PLUS	TR+BR			
	i		BRIDGER	+LE(S)			
	C/N	-46.9	-46.8	-46.7			C/N
	СТВ ј	-67.6	-59.0	-56.1			CTB
	хмо ј	-66.2	-58.4	-55.7			XMO
	2ND	-62.8	-61.4	-60.3			2ND
	HUM	-40.5	-40.2	-39.6			HUM
NOTES: CUBB	ENT OPER	ATING PERF	ORMANCE				

EXHIBIT 1

### CATY SYSTEM DISTORTIONS

MANUFACTURER SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     NORSE FIGURE   9.5   10.5   11.0     CTB CUTPUT CAP   33.0   50.0   50.0     CTB CUTPUT CAP   33.0   50.0   50.0     XMOD CATING(-dBmw)   -93.0   59.0   -59.0     XMOD CUTPUT CAP   33.0   50.0   50.0     ZMOUTPUT CAP   33.0   50.0   50.0     ZMOD RATING(-dBmw)   -92.0   -59.0   -50.0     ZMOD RATING(-dBmw)   -92.0   50.0   50.0     ZMOD RATING(-dBmw)   -85.0   -70.0   -70.0     CHANNEL CAPACITY   42.0   35.0   35.0     MANUFACTURER TILT   3.0   6.0   6.0     ILMI SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     AMPUIFIER INPUT   12.0   13.0   17.0     GAIN OR BR DCLOSS   21.0   -20.0   26.0     DESIRED TILT   6.0   6.0   6.0     CASCADELENGTH   4.0   1.0<	SYSTEM NAME. DATE 1-Mar	1988	fwd. Bw Rev. Bw	4.0 4.000	FWD. NOISE REV. NOISE		-59.2 -59.2
NORSE FIGURE   9.5   10.5   11.0     CTB CUTPUT CAP   33.0   50.0   50.0     CTB RATING(-dBmw)   -93.0   59.0   59.0     XMOD OUTPUT CAP   33.0   50.0   50.0     XMOD CUTPUT CAP   33.0   50.0   50.0     XMOD ATING(-dBmw)   -92.0   -59.0   50.0     ZMOUTPUT CAP   33.0   50.0   50.0     ZMOUTPUT CAP   33.0   6.0   6.0     CHANNEL CAPACITY   42.0   35.0   35.0     MANUFACTORER TILT   3.0   6.0   6.0     SYSTEM   FIBER   TRUNK   BRIDGER   L.E.     AMPLIFER INPUT   12.0   13.0   17.0     GAINOR BR DCLOSS   21.0   20.0   26.0     CHANNEL LOADING </td <td>MANUFACTURER SPECIFICATIONS</td> <td></td> <td>FIBER</td> <td>TRUNK</td> <td>BRIDGER</td> <td>L.E.</td> <td></td>	MANUFACTURER SPECIFICATIONS		FIBER	TRUNK	BRIDGER	L.E.	
CTB CAUTPUT CAP   33.0   50.0   50.0     CTB RATING(-dBmw)   -93.0   -59.0   -59.0     MACD CUTPUT CAP   33.0   50.0   50.0     2nd CHANGER TIL   3.0   6.0   6.0     HWAUFACTMER TIL   3.0   6.0   6.0     HUM SPECIFICATION   -70.0   -70.0   -70.0     SYSTEM   SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     AMPLIFER OUTPUT   33.0   48.0   43.0   CHANNEL LOADING   35.0   35.0     CALCULATED   4.0   1.0   2.0   CALCULATED   CTB   -65.0   -55.7   61.7   62.2   CTB	NOISE FIGURE	1		9.5	10.5	11.0	
CTB RATING(-dBmv)   -93.0   -59.0   -59.0     XMOD QUTPUT CAP   33.0   50.0   50.0     Zad RATING(-dBmv)   -85.0   -70.0   -70.0     CHANNEL CAPACITY   42.0   35.0   35.0     MANUFACTURER TILT   3.0   6.0   6.0     HUM SPECIFICATION   -70.0   -70.0   -70.0     SYSTEM   SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     AMPLIFIER INPUT   12.0   13.0   17.0   GAN OR BRO DCLOSS   21.0   -20.0   26.0     DESIRED TILT   6.0   6.0   6.0   6.0   AMALIFIER NUTPUT   33.0   48.0   43.0     CHANNEL DADING   35.0   35.0   35.0   35.0   2.0   CALCULATED   EQUIPMENT   SECIFICATIONS </td <td>CTBOUTPUT CAP</td> <td>1</td> <td></td> <td>33.0</td> <td>50.0</td> <td>50.0</td> <td></td>	CTBOUTPUT CAP	1		33.0	50.0	50.0	
XMOD CUTPUT CAP   33.0   50.0   50.0     XMOD RATING(-dBmv)   -92.0   -59.0   -59.0     2nd CUTPUT CAP   33.0   50.0   50.0     2nd RATING(-dBmv)   -85.0   -70.0   -70.0     2nd RATING(-dBmv)   -85.0   -70.0   -70.0     2nd RATING(-dBmv)   -85.0   -70.0   -70.0     CHANNEL CAPACITY   42.0   35.0   6.0     MANUFACTURER TILT   3.0   6.0   6.0     HUM SPECIFICATION   -70.0   -70.0   -70.0     SYSTEM   SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     AMPLIFIER INPUT   12.0   13.0   17.0     GAIN OR BR DCLOSS   21.0   -20.0   26.0     DESIRED TILT   6.0   6.0   6.0     AMPLIFIER OUTPUT   33.0   48.0   43.0     CHANNEL LOADING   35.0   35.0   35.0     CALCULATED   FIBER   TRUNK   BRIDGER   L.E.     CTB   -65.0	CTB RATING(-dBmv)	1		-93.0	-59.0	-59.0	
XMOD PATING(-dBmv)   -92.0   -59.0   -59.0     2nd CUTPUT CAP   33.0   50.0   50.0     2nd RATING(-dBmv)   -85.0   -70.0   -70.0     CHANNEL CAPACITY   42.0   35.0   35.0     MANUFACTMER TILT   3.0   6.0   6.0     HUM SPECIFICATION   -70.0   -70.0   -70.0     SYSTEM   SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     AMPLIFIER INPUT   12.0   13.0   17.0   GAIN OR BR DC LOSS   21.0   -20.0   26.0     DESIRED TILT   6.0   6.0   6.0   AMPLIFIER OUTPUT   33.0   48.0   43.0     CHANNEL LOADING   35.0   35.0   35.0   35.0   CASCADE LENSTH   4.0   1.0   2.0     CALCULATED   FIBER   TRUNK   BRIDGER   L.E.   CTB	XMOD OUTPUT CAP	1		33.0	50.0	50.0	
2nd GUTPUT CAP   33.0   50.0   50.0     2nd RATING(dBmv)   -85.0   -70.0   -70.0     CHANNEL CAPACITY   42.0   35.0   35.0     MANUFACTURER TILT   3.0   6.0   6.0     HUM SPECIFICATION   -70.0   -70.0   -70.0     SYSTEM   -70.0   -70.0   -70.0     SYSTEM   -70.0   -70.0   -70.0     SYSTEM   SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     AMPLIFIER INPUT   12.0   13.0   17.0   GANOR BRO DCLOSS   21.0   -20.0   26.0     DESIRED TILT   6.0   6.0   6.0   6.0   Adv.0   CASCADE LENGTH   4.0   1.0   2.0   CALCULATED   CALCULATED   EQUIPMENT   SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     C/N   -55.0   -55.7   -61.7   -62.2   CTB   CTB   -70.0   -58.0   -70.0   -52.7   C1.7   -62.2   CTB   CCM	XMOD RATING(-dBmv)	1		-92.0	-59.0	-59.0	
2nd RATING(-dBmv) -85.0 -70.0 -70.0   CHANNEL CAPACITY 42.0 35.0 35.0   MANUFACTURER TILT 3.0 6.0 6.0   HUM SPECIFICATION -70.0 -70.0 -70.0   SYSTEM -70.0 -70.0 -70.0   SPECIFICATIONS FIBER TRUNK BRIDGER L.E.   AMPLIFIER INPUT 12.0 13.0 17.0   GAIN OR BR DCLOSS 21.0 -20.0 26.0   DESIRED TILT 6.0 6.0 6.0   AMPLIFIER OUTPUT 33.0 48.0 43.0   CHANNEL LOADING 35.0 35.0 35.0   CASCADE LINGTH 4.0 1.0 2.0   CALCULATED FIBER TRUNK BRIDGER L.E.   CTB -65.0 -85.1 -63.0 -67.0   CTB -65.0 -88.7 -63.0 -67.0   XMO -65.0 -78.0 -72.0 -72.5   CTB -70.0 -58.0 -70.0 -64.0   CMU -70.0	2nd OUTPUT CAP	1		33.0	50.0	50.0	
CHANNEL CAPACITY   42.0 35.0 35.0 HUM SPECIFICATION   70.0 -70.0 -70.0 SYSTEM SYSTEM SPECIFICATIONS FIBER TRUNK BRIDGER L.E. AMPLIFIER INPUT   12.0 13.0 17.0 GAIN OR BR DC LOSS   21.0 -20.0 26.0 DESIRED TILT   6.0 6.0 6.0 AMPLIFIER OUTPUT   33.0 48.0 43.0 CHANNEL LOADING   35.0 35.0 35.0 CASCADE LENSTH   4.0 1.0 2.0 CALCULATED EQUIPMENT SPECIFICATIONS FIBER TRUNK BRIDGER L.E. C/N   -55.0 -55.7 -61.7 -62.2 CTB   -65.0 -85.1 -63.0 -67.0 XMO   -65.0 -85.1 -63.0 -67.0 XMO   -65.0 -76.0 -72.0 -72.5 HUM   -70.0 -58.0 -70.0 -64.0 CALCULATED   FWD. FWD. SYSTEM   TRUNK TRUNK SYSTEM SPECIFICATIONS FIBER	2nd RATING(-d8mv)	1		-85.0	-70.0	-70.0	
MANUFACTURER TILT   3.0   6.0   6.0     HUM SPECIFICATION   .70.0   .70.0   .70.0     SYSTEM   .70.0   .70.0   .70.0     SAMPLIFIER INPUT   12.0   13.0   17.0     GANOR BR DCLOSS   .21.0   .20.0   26.0     DESIRED TILT   .6.0   6.0   6.0     AMPLIFIER OUTPUT   .33.0   48.0   43.0     CHAINEL LADONG   .35.0   .35.0   .20.0     CALLATED   EOUIFMENT   .0   1.0   2.0     CTB  65.0   .88.1   .63.0   .67.0     LOG15.0   2ND   .65.0   .76.0   .72.0   .72.5     HUM   .70.0   .58.0   .70.0	CHANNEL CAPACITY	1		42.0	35.0	35.0	
HUM SPECIFICATION   -70.0   -70.0   -70.0   -70.0     SYSTEM   SYSTEM   FIBER   TRUNK   BRIDGER   L.E.     AMPLIFIER INPUT   12.0   13.0   17.0     GAIN OR BR DCLOSS   21.0   -20.0   26.0     DESIRED TILT   6.0   6.0   6.0     AMPLIFIER OUTPUT   33.0   48.0   43.0     CHANNEL LOADING   35.0   35.0   35.0     CASCADE LENGTH   4.0   1.0   2.0     CALCULATED   FIBER   TRUNK   BRIDGER   L.E.     CTB   -55.0   -55.7   -61.7   -62.2     CTB   -65.0   -85.1   -63.0   -67.0     XMO   -65.0   -78.0   -72.0   -72.5     HUM   -70.0   -58.0   -70.0   -64.0     CALCULATED   FWD.   FWD.   FWD.   SYSTEM     SYSTEM   TRUNK   TRUNK   SYSTEM   SYSTEM	MANUFACTURER TILT			3.0	6.0	6.0	
SYSTEM   SYSTEM     SYSTEM   FIBER   TRUNK   BRIDGER   L.E.     AMPLIFIER INPUT   12.0   13.0   17.0   GANOR BR DCLOSS   21.0   -20.0   26.0     DESIRED TBLT   6.0   6.0   6.0   6.0   AMPLIFIER OUTPUT   33.0   48.0   43.0     CHANNEL LOADNG   35.0   35.0   35.0   35.0   CASCADE LENSTH   4.0   1.0   2.0   CALCULATED     EQUIPMENT   SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     CR   -55.0   -55.7   -61.7   62.2   CTB     CTB   -65.0   -85.1   -63.0   -67.0     LOG15.0   2HD   -65.0   -76.0   -72.0   -72.5     HUM   -70.0   -58.0   -70.0   -64.0     CALCULATED   FWD.   FWD.   SYSTEM   SYSTEM     SYSTEM   TRUNK   TRUNK   SYSTEM   SYSTEM	HUM SPECIFICATION			-70.0	-70.0	-70.0	
AMPLIFIER INPUT   12.0   13.0   17.0     GAINOR BR DCLOSS   21.0   -20.0   26.0     DESIRED TIL   6.0   6.0   6.0     AMPLIFIER OUTPUT   33.0   48.0   43.0     CHANNEL LOADING   35.0   35.0   35.0     CASCADE LENGTH   4.0   1.0   2.0     CALCULATED   2.0   CALCULATED   2.0     EQUIPMENT   SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     CTB   -65.0   -85.7   -61.7   -62.2   CTB     CTB   -65.0   -83.7   -63.0   -67.0     XMO   -65.0   -78.0   -72.0   -72.5     HUM   -70.0   58.0   -70.0   -64.0     CALCULATED   FWD.   FWD.   FWD.   SYSTEM     SYSTEM   TRUNK   TRUNK   SYSTEM   SYSTEM	SYSTEM SPECIFICATIONS		FIBER	TRUNK	BRIDGER	L.E.	
GAIN OR BR DC LOSS   21.0   -20.0   26.0     DESIRED TRUT   6.0   6.0   6.0     MPLIFER OUTPUT   33.0   48.0   43.0     CHANNEL LOADING   35.0   35.0   35.0     CASCADELENSTH   4.0   1.0   2.0     CALCULATED   EQUIPMENT   SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     CTB   -55.0   -55.7   -61.7   -62.2   C     CTB   -65.0   -83.1   -63.0   -67.0     XMO   -65.0   -78.0   -72.0   -72.5     HUM   -70.0   -58.0   -70.0   -64.0     CALCULATED   FWD.   FWD.   FWD.   SYSTEM     SYSTEM   TRUNK   TRUNK   SYSTEM   SYSTEM		1		12 0	13.0	17 0	
DESIRED TILT   6.0   6.0   6.0     AMFLIFER OUTPUT   33.0   48.0   43.0     CHANNEL LADONG   35.0   35.0   35.0     CASCADE LENGTH   4.0   1.0   2.0     CALCULATED   EQUIPMENT   SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     C/N   -55.0   -55.7   -61.7   -62.2   CTB     CTB   -65.0   -85.1   -63.0   -67.0     XMO   -65.0   -88.1   -63.0   -67.0     ZMO   -70.0   -58.0   -72.0   -72.5     HUM   -70.0   58.0   -70.0   -64.0     CALCULATED   FWD.   FWD.   FWD.   SYSTEM     SYSTEM   TRUNK   TRUNK   SYSTEM   SYSTEM	GAINOR BROCLOSS	i		21.0	-20.0	26.0	
AMPLIFER OUTPUT   33.0   48.0   43.0     CHANNELLOADING   35.0   35.0   35.0     CASCADE LINGTH   4.0   1.0   2.0     CALCULATED   2.0   2.0   2.0     CALCULATED   55.0   -55.7   -61.7   -62.2     CTB   -55.0   -85.1   -63.0   -67.0     XMO   -65.0   -83.7   -63.0   -67.0     XMO   -70.0   -78.0   -72.0   -72.5     HUM   -70.0   58.0   -70.0   -64.0     CALCULATED   FWD.   FWD.   FWD.   SYSTEM     SYSTEM   TRUNK   TRUNK   SYSTEM   SYSTEM	DESIRED T# T	i		6.0	6.0	6.0	
CHANNEL LOADING   35.0   35.0   35.0     CASCADELENSTH   4.0   1.0   2.0     CALCULATED   4.0   1.0   2.0     EQUIPMENT   SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     CTB   -55.0   -55.7   -61.7   -62.2   C     CTB   -65.0   -85.1   -63.0   -67.0   XMO     LOG15.0   2ND   -65.0   -76.0   -72.0   -72.5     HUM   -70.0   -58.0   -70.0   -64.0     CALCULATED   FWD.   FWD.   FWD.     SYSTEM   TRUNK   SYSTEM   SYSTEM     SPECIFICATIONS   FULS   FH-BR   FH-BR	AMPLIFIER OUTPUT	í		33.0	48.0	43.0	
CASCADE LENGTH   4.0   1.0   2.0     CALCULATED   EOURMENT	CHANNEL LOADING	i		35.0	35.0	35.0	
CALCULATED   FIBER   TRUNK   BRIDGER   L.E.     C/N   -55.0   -55.7   -61.7   -62.2     CTB   -65.0   -85.1   -63.0   -67.0     XMO   -65.0   -83.7   -63.0   -67.0     LOG15.0   2ND   -65.0   -76.0   -72.0   -72.5     HUM   -70.0   -58.0   -70.0   -64.0     CALCULATED   FWD.   FWD.   FWD.     SYSTEM   TRUNK   SYSTEM   SYSTEM	CASCADE LENGTH	i		4.0	1.0	2.0	
EQUIPMENT SPECIFICATIONS FIBER TRUNK BRDGER L.E. C/N   -55.0 -55.7 -61.7 -62.2 CTB   -65.0 -85.1 -63.0 -67.0 XMO   -65.0 -85.1 -63.0 -67.0 LOG15.0 2ND   -65.0 -78.0 -72.0 -72.5 HUM   -70.0 -58.0 -70.0 -64.0 CALCULATED   FWD. FWD. SYSTEM   TRUNK TRUNK SYSTEM SPECIFICATIONS   FLUS FR+BR	CALCULATED						
SPECIFICATIONS   FIBER   TRUNK   BRIDGER   L.E.     C/N   -55.0   -55.7   -61.7   -62.2     CTB   -65.0   -85.1   -63.0   -67.0     XMO   -65.0   -83.7   -63.0   -67.0     LOG15.0   2ND   -65.0   -76.0   -72.0   -72.5     HUM   -70.0   -58.0   70.0   -64.0     CALCULATED   FWD.   FWD.   FWD.   FWD.     SYSTEM   TRUNK   SYSTEM   SYSTEM   SYSTEM	EQUIPMENT						
C/N   -55.0   -55.7   -61.7   -62.2     CTB   -65.0   -85.1   -63.0   -67.0     XMO   -65.0   -83.7   -63.0   -67.0     LOG15.0   2ND   -65.0   -76.0   -72.0   -72.5     HUM   -70.0   -58.0   -70.0   -64.0     CALCULATED   FWD.   FWD.   FWD.     SYSTEM   TRUNK   TRUNK   SYSTEM     PLUS   TR-BR   -70.0   -58.1	SPECIFICATIONS		FIBER	TRUNK	BRIDGER	L.E.	
C/N   -55.0   -55.7   -61.7   -62.2     CTB   -65.0   -85.1   -63.0   -67.0     XMO   -65.0   -83.7   -63.0   -67.0     LOG15.0   2ND   -65.0   -76.0   -72.0   -72.5     HUM   -70.0   -58.0   -70.0   -64.0     CALCULATED   FWD.   FWD.   FWD.     SYSTEM   TRUNK   TRUNK   SYSTEM     SPECIFICATIONS   PLUS   TR+BR							• • • • •
CTB	C/N	!	-55.0	-55.7	-61.7	-62.2	
XMO   -65.0   -83.7   -63.0   -67.0     LOG15.0   2ND   -65.0   -76.0   -72.5     HUM   -70.0   -58.0   -70.0   -64.0     CALCULATED   FWD.   FWD.   FWD.   FWD.     SYSTEM   TRUNK   TRUNK   SYSTEM     PECIFICATIONS   FULS   TR+BR	C18	• !	-65.0	-85.1	-63.0	-67.0	
LOG.15.0 2ND	XMO	·!	-65.0	-83.7	-63.0	-67.0	
HUM   -70.0   -58.0   -70.0   -64.0     CALCULATED     FWD.   FWD.   FWD.   SYSTEM   SYSTEM   1 TRUNK TRUNK SYSTEM     SPECIFICATIONS     FLUS   FULS   TR+BR	LOG15.0 2ND	•	-65.0	-76.0	-72.0	-/2.5	
CALCALAIED   FWD. FWD. FWD. SYSTEM   TRUNK TRUNK SYSTEM SPECIFICATIONS   PLUS PLUS TR+BR	HUM		-70.0	-58.0	-70.0	-64.0	
STSTEM THUNK THUNK STSTEM SPECIFICATIONS PLUS PLUS TR+BR	CALCOLATED	FWD.	FWD.	FWU.			
SPECIFICATIONS I FLUS FLUS I H+DH	STSTEM	THUNK		STSIEM			
	SECOLOGICATIONS	I FIREP	RDICCED				
	C/N	1 .52 9	51 0	+LE(3)			L C/M
CTB 1 -64 2 -57 6 -55 0	сля ств	52.3	51.0	-55.0			CTP
XMO 1 -64.0 -57.5 -55.0 XMO	YLLO	64.0	-57 5	-55.0			XMO
2ND   -63.9 -62.2 -61.0   2ND	240	-62 9	-62 2	-61 0			200
	HUM	-56.0	-54.4	-51.9			HUM

HUM.... | -56.0 -54.4 -51.8 NOTES: PERFORMANCE IMPROVEMENT ONLY. FOUR TRUNK AMPLIFIERS IN CASCADE FROM FIBER NODE.

EXHIBIT 2

### CATV SYSTEM DISTORTIONS

SYSTEM NAME.	1.Mar	088	FWD. BW	4.0	FWD. NOISE		-59.2
MANI IFACTI IDED	1-141.001		1124.000	4.000	TLY. NONL		
SPECIFICATIONS			FIBER	TRUNK	BRIDGER	LE.	
NOISE FIGURE				9.5	10.5	11.0	• • • • •
CTBOUTPUTCAP				33.0	50.0	50.0	
CTB RATING(-dB	imv)			-93.0	-59.0	-59.0	
XMOD OUTPUT CA	P			33.0	50.0	50.0	
XMOD RATING(-	Brnv)			-92.0	-59.0	-59.0	
2nd OUTPUT CAP				33.0	50.0	50.0	
2nd RATING(-dB	mv)			-85.0	-70.0	-70.0	
CHANNEL CAPACIT	IY I			42.0	35.0	35.0	
MANUFACTURER	TILT			3.0	6.0	8.0	
HUM SPECIFICATI	ON			-70.0	+70.0	-70.0	
SYSTEM SPECIFICATIONS			FIBER	TRUNK	BRIDGER	L.E.	
							• • • • •
CANLOD DD DD LO	<u></u>			12.0	13.0	17.0	
GAIN OR BROCLU	500			21.0	-20.0	26.0	
UESINEU TILI				6.0	6.0	6.0	
AMPLIFIER OUTP				33.0	48.0	43.0	
CHANNEL LOADING	i i			35.0	35.0	35.0	
CASCADE LENGIH				3.0	1.0	2.0	
CALCULATED							
SPECIFICATIONS			FIBER	TRUNK	BRIDGER	LE.	
	C/N		-55.0	-56.9	-61.7	-62.2	••••
	CTB		-65.0	-87.6	-83.0	-67.0	
	XMO		-65.0	-86.2	-63.0	-67.0	
LOG15.0	2ND		-65.0	-77.8	-72.0	•72.5	
	HUM		-70.0	-60.5	-70.0	-84.0	
CALCULATED		FWD.	FWD.	FWD.			
SYSTEM		TRUNK	TRUNK	SYSTEM			
SPECIFICATIONS	i	PLUS	PLUS	TR+BR			
	i	FIBER	BRIDGER	+LE(S)			
	C/N	-52.9	-52.3	51.9			C/N
	СТВ	-64.4	-57.6	-55.1			CTB
	ХМО	-64.3	-57.8	- 55.1			jXMO
	2ND	-64.2	-62.4	-61.2			j2ND
	HUM	-58.0	-56.0	- 53.1			jHUM
NOTES DEDEODA	ANN'S ME	CONCERENT					

THREE TRUNK AMPLIFIERS IN CASCADE FROM FIBER NODE.

EXHIBIT 3

### CATV SYSTEM DISTORTIONS

SYSTEM NAME.	1-Mar 1		FWD. BW	4.0	FWD. NOISE		-59.2
MANI ICACTUDED	1	800	HLV. DW	4.000	HEV. NOISE		-58.2
SPECIFICATIONS			FIBER	TRUNK	BRIDGER	L.E.	
NOREERCHDE					10.5	11 0	••••
CTROITEITCAR				22.0	50.0	50.0	
CTR RATING/JdB				.93.0	-59.0	-59.0	
XMOD OLITPUT CAL	, i			33.0	50.0	50.0	
XMOD BATING(-d	Brnv) İ			-92.0	-59.0	- 59.0	
2nd OLITPLIT CAP	,			33.0	50.0	50.0	
2nd BATING(-dBr	ו (יית			-85.0	-70.0	-70.0	
CHANNEL CAPACIT	Ϋ́Υ			42.0	35.0	35.0	
MANUFACTURER	rilt i			3.0	6.0	6.0	
HUM SPECIFICATK	ON I			-70.0	-70.0	-70.0	
SYSTEM							
SPECIFICATIONS			FIBER	TRUNK	BRIDGER	L. <b>E</b> .	
AMPLIFIER INPUT				12.0	13.0	17.0	••••
GAIN OR BR DC LO	SS			21.0	-20.0	26.0	
DESIRED TILT	1			6.0	6.0	6.0	
AMPLIFIER OUTPL	л ј			33.0	48.0	43.0	
CHANNEL LOADING	i			35.0	35.0	35.0	
CASCADE LENGTH				2.0	1.0	2.0	
CALCULATED							
EQUIPMENT							
SPECIFICATIONS			FIBER	TRUNK	BRIDGER	L.E.	
	C/N		-55.0	-58.7	-61.7	-62.2	
	СТВ		-65.0	-91.1	-63.0	-67.0	
	XMO		-65.0	-89.7	-63.0	-67.0	
LOG15.0	2ND		-65.0	-80.5	-72.0	-72.5	
	HUM		-70.0	-64.0	-70.0	-64.0	
CALCULATED		FWD.	FWD.	FWD.			
SYSTEM	l	THUNK	THUNK	SYSTEM			
SPECIFICATIONS	ļ	PLUS	PLUS	TR+BR			
		FIBER	BRIDGER	+LE(S)			
	C/N	-53.5	-52.9	-52.4			C/N
	018	64.6	- 57.7	- 55.2			L.CIB
	XMU	04.5	-57.7	- 55.1			
	2ND	64.4	-62.7	-61.3			12ND
	HUM	-60.5	-58.0	54.4			jHUM

NOTES: PERFORMANCE IMPROVEMENT ONLY. TWO TRUNK AMPLIFIERS IN CASCADE FROM FIBER NODE.

EXHIBIT 4

### CATV SYSTEM DISTORTIONS

SYSTEM NAME:	FIBER TEST	1087	FWD. 8W	4.0	FWD. NOISE		-59.2
MANI JEACTHOED	/-Mar	1901		TDUNK	BDICED	1.5	-38.2
SDECIEICATIONS			FIDEN	EE		YOLE.	
SPECIFICATIONS				п	<b>u</b> -	ALL:	
NOISE FIGURE	1			11.5	9.5	12.0	
CTB OUTPUT CAP	1			38.0	48.0	47.0	
CTB RATING(-de	3mv) į			-85.0	-65.0	-69.0	
XMOD OUTPUT CA	VP			38.0	48.0	47.0	
XMOD RATING(-	dBrnv)			-85.0	-65.0	-69.0	
2nd OUTPUT CAP	i i			38.0	48.0	47.0	
2nd RATING(-dB	imv) İ			-87.0	-71.0	-73.0	
CHANNEL CAPACI	τγ' i			77.0	77.0	77.0	
MANUFACTURER	TILT İ			6.0	10.0	10.0	
HUM SPECIFICAT	юм i			-70.0	-70.0	-70.0	
SYSTEM							
SPECIFICATIONS			FIBER	TRUNK	BRIDGER	L.E.	
AMPLIFIER INPU	т і			8.0	18.0	19.0	
GAINORBRDCLO	oss i			30.0	-20.0	29.0	
DESIRED TILT	i			6.0	9.0	9.0	
AMPLIFIER OUTP	υτ i			38.0	48.0	48.0	
CHANNEL LOADIN	Ġ i			77.0	77.0	77.0	
CASCADE LENGTH	i i			4.0	1.0	2.0	
CALCULATED							
EQUIPMENT							
SPECIFICATIONS			FIBER	TRUNK	BRIDGER	L.E.	
	C/N		-55.0	-49.7	-67.7	-63.2	
	C1B		-65.0	-73.0	-64.3	-60.3	
	XMO		-65.0	-73.0	-64.3	-60.3	
LOG15.0	2ND		-85.0	-78.0	-71.0	-87.5	
	_ <u>HUM</u>		-70.0	-58.0	-70.0	-64.0	
CALCULATED	1	FWD.	FWD.	FWD.			
SYSTEM	1	TRUNK	TRUNK	SYSTEM			
SPECIFICATIONS	1	PLUS	PLUS	TR+BR			
		FIBER	BRIDGER	+LE(S)			
	C/N	-48.6	-48.5	-48.4			C/N
	СТВ	-62.1	-57.1	-52.5			CTB
	XMO	-62.1	-57.1	-52.5			XMO
	2ND	-64.2	-62.2	-59.8			2ND
	HUM	-56.0	- 54.4	-51.9			HUM

NOTES: 550 MHz UPGRADE/FIBER BACKBONE. FOUR TRUNK AMPLIFIERS IN CASCADE FROM FIBER NODE.

EXHIBIT 5





EXHIBIT 8, NODE LOCATION AND FIBER ROUTING FOR FOUR IN CASCADE

EXHIBIT 6, NODE LOCATION AND FIBER ROUTING FOR TWO IN CASCADE



EXHIBIT 7, NODE LOCATION AND FIBER ROUTING FOR THREE IN CASCADE



EXHIBIT 9, TYPICAL TRUNK DIAGRAM FOR FIBER NODE PLUS TWO IN CASCADE







### CATV SYSTEM DISTORTIONS

SYSTEM NAME:	FIBER TES	Т	FWD. BW	4.0	FWD. NOISE		-59.2
DATE	7-Mar 1	988	HEV. BW	4.000	HEV. NOISE		-59.2
MANUFACTURER			FIBER	THUNK	BHIDGER		
SPECIFICATIONS				H-	QP	XUE	
NOISE FIGURE				11.5	9.5	12.0	
CTROITEUTCA	>			38.0	48.0	47.0	
CTB BATING/-d	Rmv)			-85.0	-65.0	69.0	
XMODOLITERITO				38.0	48.0	47.0	
XMOD BATING	-dBmv)			-85.0	-65.0	-69.0	
2nd OUTPUT CAP	,			38.0	48.0	47.0	
2nd RATING(-d	Brmv) İ			-87.0	-71.0	-73.0	
CHANNEL CAPAC	πγ i			77.0	77.0	77.0	
MANUFACTURE	атат і			6.0	10.0	10.0	
HUM SPECIFICA	NON I			-70.0	-70.0	-70.0	
SYSTEM							
SPECIFICATIONS			FIBER	TRUNK	BRIDGER	L.E.	
					<b>.</b>		
AMPLIFIER INPU	л і			11.0	21.0	19.0	
GAINORBROCL	oss i			30.0	-20.0	29.0	
DESIRED TILT				6.0	9.0	9.0	
AMPLIFIER OUT	рот і			41.0	48.0	48.0	
CHANNELLOAD	KG I			77.0	77.0	77.0	
CASCADE LENGT	- i			2.0	1.0	2.0	
CALCULATED							
EQUIPMENT							
SPECIFICATIONS	;		FIBER	TRUNK	BRIDGER	L.E.	
	CAL				70.7		
	CTR		-55.0	.73.0	.64.9	-60.2	
	VIID		-65.0	-73.0	-04.0	.60.3	
100.150	200		-05.0	-79.5	-71.0	-67.5	
LOG. 15.0			-70.0	-78.5	-70.0	-64.0	
CALCULATED	NOM	EWD	FWD	EWD	-70.0	-04.0	
SVSTEM		TRUNK	TRUNK	SYSTEM			
OFCIERCATIONS							
SPECIFICATIONS	•	FIRER	BRINGER	LIE(S)			
	C/N	-52.3	.52.2	-51.9			L C/N
	CTB	-62 1	-57 1	-52.5			CTB
	XMO	-62 1	-57 1	-52.5			I. XMO
	2ND	-64.3	-62.3	-59.9			2ND
	HUM	-60.5	-58.0	-54 4			HUM

EXHIBIT II, TYPICAL TRUNK DIAGRAM FOR FIBER MODE PLUS FOUR IN CASCADE

NOTES: 550 MHz UPGRADE/FIBER BACKBONE. TWO TRUNK AMPLIFIERS IN CASCADE FROM FIBER NODE.

### EXHIBIT 13

#### CATV SYSTEM DISTORTIONS

SYSTEM NAME:	FIBER TES	т	FWD. BW	4.0	FWD. NOISE		-59.2
DAIE	<u>7-Mar 19</u>	288	HEV. BW	4.000	REV. NOISE		-59.2
MANUFACTURER			FIBER	TRUNK	BRIDGER	L.E.	
SPECIFICATIONS				FF	QP 	PD	
NOISE FIGURE				11.5	9.5	13.0	
CTB OUTPUT CAP	1			38.0	48.0	45.0	
CTB RATING(-dB	mv) İ			-85.0	-65.0	-67.0	
XMOD OUTPUT CA	PÌ			38.0	48.0	45.0	
XMOD RATING(-c	iBmv) (			-85.0	-65.0	-67.0	
2nd OUTPUT CAP	1			38.0	48.0	45.0	
2nd RATING(-dB	mv) i			-87.0	-71.0	-73.0	
CHANNEL CAPACIT	nvi i			77.0	77.0	77.0	
MANUFACTURER	TILT İ			6.0	10.0	10.0	
HUM SPECIFICATI	<u>on</u> i			-70.0	-70.0	-70.0	
SYSTEM			5050		PDDCCD		
SPECIFICATIONS				110NK	DRILLAGR	L.E.	
AMPLIFIER INPUT	r i			8.0	18.0	15.0	
GAINORBRDCLO	ss i			30.0	-20.0	29.0	
DESIRED TILT	i			6.0	9.0	9.0	
AMPLIFIER OUTPI	л і			38.0	47.0	44.0	
CHANNEL LOADING	a i			77.0	77.0	77.0	
CASCADE LENGTH				4.0	1.0	3.0	
CALCULATED							
EQUIPMENT							
SPECIFICATIONS			FIBER	TRUNK	BRIDGER	L.E.	
	C/N E	• • • • • • •	.55.0				
	CTB I		-65.0	.73.0	-66.3	58 8	
	YMO I		-65.0	-73.0	-66.3	- 50.0	
106 15 0	200		-65.0	.78.0	- 72 0	- 30.0	
204	HUM		-70.0	-58.0	-70.0	-60.5	
CALCULATED	1	FWD.	FWD.	FWD.			
SYSTEM	i	TRUNK	TRUNK	SYSTEM			
SPECIFICATIONS	i i	PLUS	PLUS	TB+BB			
	i i	FIBER	BBIDGER	+1 F(S)			
	C/N	-48.6	-48.5	-47.9			IC/N
	CTB	-62.1	-57.9	-52.3			CTB
	XMO	-62.1	-57.9	-52.3			XMO
	2ND	-64.2	62.5	-59.8			12ND
	HUM	-56.0	-54.4	-50.9			I. HUM
NOTES, FEAMUR	LIDCDADE		OD UNE E	VIENDEDE			1

HUM..... -58.0 -58 NOTES: 550 MHz UPGRADE/FIBER BACKBONE THREE TRUNK AMPLIFIERS IN CASCADE FROM FIBER NODE.

FWD.

PLUS

FIBER

-50.3

-62.1

-62.1

-64 2

TRUNK

C/N..... CTB..... XMO..... 2ND.....

HUM.

C/N....

СТВ..... ХМО.....

2ND.

EXHIBIT 12

FOUR AMPLIFIERS IN CASCADE FROM FIBER NODE.

### EXHIBIT 14

#### CHANNEL LOADING CASCADE LENGTH CALCULATED EQUIPMENT TRUNK BRIDGER SPECIFICATIONS FIBER

-55.0

-65.0 -85.0

-65.0

FWD

TRUNK

BRIDGER - 50.3 - 57.1

-57.1

-62.3

70.0

# CATV SYSTEM DISTORTIONS FWD. BW

FIBER

FIBER

4.0

4.000

11.5

38.0 85.0

38.0

85.0 38.0

87.0 77.0

6.0

70.0

9.3 30.0

6.0 39.3 77.0

3.0

-52.2 -73.0 -73.0 -78.6

60.5

FWD

SYSTEM

TR+BR

LE(S) - 50.1

.52.5

-52.5

-59.8

53

TRUNK

FF

FWD. NOISE

REV. NOISE

BRIDGER

œ

9.5

48.0

65.0 48.0

48.0 -65.0 48.0 -71.0 77.0 10.0

70.0

19.3 -20.0 9.0 48.0 77.0

-69.0 -64.3 -64.3 -71.0

70.0

BRIDGER

-59.2

-59.2

I F

XOLE

12.0 47.0

-69.0

-69.0 47.0 -73.0 77.0

10.0

70.0

19.0 29.0

9.0 48.0 77.0

2.0

L.E.

-63.2 -60.3 -60.3 -67.5

64.0

(...C/N

.XMO

HUM

L.E.

SYSTEM NAME: FIBER TEST

7-Mar

987

DATE MANUFACTURER SPECIFICATIONS

. . . . . NOISE FIGURE

NORSE FIGURE CTB OUTPUT CAP CTB RATING(-dBmv) XMOD OUTPUT CAP XMOD RATING(-dBmv) 2nd OUTPUT CAP

2nd RATING(-dBmv) CHANNEL CAPACITY

MANUFACTURER TILT HUM SPECIFICATION SYSTEM

AMPLIFIER INPUT GAIN OR BRDC LOSS

DESIRED TILT AMPLIFIER OUTPUT

LOG..15.0

CALCULATED

SYSTEM SPECIFICATIONS

SPECIFICATIONS

# CATV SYSTEM DISTORTIONS

SYSTEM NAME:	FIBER TES	Т	FWD. BW	4.0	FWD. NOISE		-59.2
DATE	7 • Mar 19	88	REV. BW	4.000	HEV. NOISE		-59.2
SPECIFICATIONS			FIBER	FF	BRIDGER OP	L.E.	
NOISE FIGURE	1			11.5	9.5	9.5	
CTBOUTPUT CAP	i			38.0	48.0	46.0	
CTB RATING(-dB	Bmv) j			-85.0	-65.0	-59.0	
XMOD OUTPUT CA	P			38.0	48.0	46.0	
XMOD RATING(-	dBrmv) ∣			-85.0	-65.0	-59.0	
2nd OUTPUT CAP	1			38.0	48.0	46.0	
2nd RATING(-dB	lmv)			-87.0	-71.0	-70.0	
CHANNEL CAPACI	TY			77.0	77.0	78.0	
MANUFACTURER	TILT			6.0	10.0	10.0	
HUM SPECIFICAT	ION 1			-70.0	-70.0	-70.0	
SYSTEM							
SPECIFICATIONS			FIBER	TRUNK	BRIDGER	L.E.	
	T 1				18.0	16.0	
CAIN OF BE DOLL				30.0	-20.0	28.0	
	~~ !			50.0	-20.0	20.0	
AMBHEIER OF THE	•m -			38.0	47.0	44.0	
CHANNELLOADIN				77.0	77.0	77.0	
CASCADELENGTH	ĭ			4.0	1.0	3.0	
CALCULATED							
EQUIPMENT							
SPECIFICATIONS			FIRER	TOI INK	DDIVCED		
				Inolan	DHUGEN	с.е.	
	C/N 1					L.E.	
	C/N		-55.0	-49.7	-67.7	-60.9	
	C/N   CTB		-55.0 -65.0	-49.7 -73.0	-67.7 -66.3	-60.9 -52.9	
100 15 0	C/N   CTB   XMO		-55.0 -65.0 -65.0	-49.7 -73.0 -73.0	-67.7 -66.3 -66.3	-60.9 -52.9 -52.9	
LOG15.0	C/N   CTB   XMO   2ND		-55.0 -65.0 -65.0 -65.0	-49.7 -73.0 -73.0 -78.0	-67.7 -66.3 -66.3 -72.0	-60.9 -52.9 -52.9 -64.8	
LOG15.0	C/N  CTB  XMO  2ND  HUM	EWD	-55.0 -65.0 -65.0 -65.0 -70.0	-49.7 -73.0 -73.0 -78.0 -58.0	-67.7 -66.3 -66.3 -72.0 -70.0	-60.9 -52.9 -52.9 -64.8 -60.5	
LOG15.0	C/N   CTB   XMO   2ND   HUM	FWD.	-55.0 -65.0 -65.0 -65.0 -70.0 FWD. TRUNK	-49.7 -73.0 -73.0 -78.0 -58.0 FWD.	-67.7 -66.3 -66.3 -72.0 -70.0	-60.9 -52.9 -52.9 -64.8 -60.5	
LOG15.0 CALCULATED SYSTEM SEFERICATIONS	C/N   CTB XMO 2ND HUM	FWD. TRUNK PLUS	-55.0 -65.0 -65.0 -65.0 -70.0 FWD. TRUNK PULIS	-49.7 -73.0 -73.0 -78.0 -58.0 FWD. SYSTEM TBABB	-67.7 -66.3 -66.3 -72.0 -70.0	-60.9 -52.9 -52.9 -64.8 -60.5	
LOG15.0 CALCULATED SYSTEM SPECIFICATIONS	C/N  CTB  XMO  2ND  HUM	FWD. TRUNK PLUS FIBER	-55.0 -65.0 -65.0 -65.0 -70.0 FWD. FWD. TRUNK PLUS BRDGER	-49.7 -73.0 -73.0 -78.0 -58.0 FWD. SYSTEM TR+BR +LE(S)	-67.7 -66.3 -66.3 -72.0 -70.0	-60.9 -52.9 -52.9 -64.8 -60.5	
LOG15.0 CALCULATED SYSTEM SPECIFICATIONS	C/N CTB XMO 2ND HUM	FWD. TRUNK PLUS FIBER -48.6	-55.0 -65.0 -65.0 -70.0 FWD. TRUNK PLUS BRIDGER -48,5	-49.7 -73.0 -73.0 -58.0 FWD. SYSTEM TR+BR +LE(S) -48.3	-67.7 -66.3 -66.3 -72.0 -70.0	-60.9 -52.9 -52.9 -64.8 -60.5	C/N
LOG15.0 CALCULATED SYSTEM SPECIFICATIONS	C/N CTB XMO 2ND HUM C/N	FWD. TRUNK PLUS FIBER - 48.6 - 62.1	-55.0 -65.0 -65.0 -65.0 -70.0 FWD. TRUNK PLUS BRIDGER -48.5 -57.9	-49.7 -73.0 -73.0 -78.0 -58.0 FWD. SYSTEM TR+BR +LE(S) -48.3 -49.0	-67.7 -66.3 -66.3 -72.0 -70.0	-60.9 -52.9 -52.9 -64.8 -60.5	C/N  CTB
LOG15.0 CALCULATED SYSTEM SPECIFICATIONS	С/N СТВ 2ND HUM С/N СТВ XMO	FWD. TRUNK PLUS FIBER -48.6 -62.1 -62.1	-55.0 -65.0 -65.0 -70.0 FWD. TRUNK PLUS BRIDGER 5 -48.5 -57.9 -57.9	-49.7 -73.0 -73.0 -78.0 -58.0 FWD. SYSTEM TR+BR +LE(S) -48.3 -49.0	-67.7 -66.3 -66.3 -72.0 -70.0	- 60.9 - 52.9 - 52.9 - 64.8 <u>- 60.5</u>	C/N  CTB  XMO
LOG15.0 CALCULATED SYSTEM SPECIFICATIONS	C/N   CTB   XMO   2ND   HUM   C/N   CTB   XMO   2ND	FWD. TRUNK PLUS FIBER -48.6 -62.1 -62.1 -62.4	-55.0 -65.0 -65.0 -70.0 FWD. TRUNK PLUS BRIDGER -48.5 -57.9 -57.9 -62.5	-49.7 -73.0 -73.0 -78.0 -58.0 FWD. SYSTEM TR+BR +LE(S) -48.3 -49.0 -59.0	-67.7 -66.3 -66.3 -72.0 -70.0	-60.9 -52.9 -52.9 -64.8 -60.5	C/N  CTB  XMO  2ND

NOTES: 550 MHz UPGRADE WITH THREE PD LINE EXTENDERS. FOUR AMPLIFIERS IN CASCADE FROM FIBER NODE.

EXHIBIT 15