THE DESIGN, CONSTRUCTION, COST AND PERFORMANCE THE FIRST 400 MHz CABLE TELEVISION SYSTEM

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Orland Park, Illinois was the first 400 MHz system to be designed, built and operated with a full compliment of 51 phase-locked, harmonically related coherent carrier television channels. When completed, the system will have a total of 100 miles of CATV plant, with a maximum cascade of 18 main line amplifiers, one bridger amplifier and two line extenders.

The main line was designed for a spacing of 22 dB at 400 MHz using 3/4" cable for trunk and ½" cable for feeder. This design resulted in a feeder-to-trunk ratio of 3:1 with 5.5 actives per mile. The plant design was maximized to withstand the temperature extremes the system will experience and because of the then many unanswered questions concerning the performance of a 400 MHz system, every main line amplifier position was designed for AGC and ASC operation.

After completing the design, we found the cost for electronics increased approximately 34%, due primarily to the higher usage rate per mile. The cable increased approximately 20% because of the feeder-to-trunk ratio change from 4:1 at 300 MHz to 3:1 for 400 MHz design. All other costs have remained virtually the same, when inflation is accounted for, resulting in a net increase of 13%.

INTRODUCTION

Over the past year and a half to two years, there has been considerable rhetoric, industry-wide, as to whether 400 MHz cable television systems can be built and operated successfully. First, there was the issue of the availability of 400 MHz equipment. Then, after equipment deliveries began, the cry went out that it was a whole new design, that it was not proven and would not be reliable. We hope to show: 1) that equipment is readily available; 2) that 400 MHz technology is not a new technology, such as the move to transistor and integrated circuits was, but that it is simply an extension of a proven technology; and 3) that the technology meets or exceeds expectations concerning distortions and that it has proven to be very reliable. The issue of whether or not additional channel capacity is needed will be left for other discussions.

CONSTRUCTION

Construction of the first 400 MHz system began on June 5, 1980. This state-of-the-art system was designed, constructed and is operated by Cox Cable Communications, Inc. When construction began, approximately twenty miles of 400 MHz equipment was in inventory. Commensurate with plant construction, installation of the Master Telecommunications facility with all the towers, TVRO antennas and processing equipment began. Since construction of the office and MTC complex had not commenced, a 10 x 50 foot trailer was brought on sight to house the ten racks of equipment that were required for a system of this size. At present, 100% of the aerial plant is built and approximately one-half of the 60% underground plant is completed. Rather than equipment, as many had predicted, our major obstacle was the age-old problem of make ready and right-of-way clearances.

SYSTEM DESCRIPTION AND DESIGN

On June 30, 1980, the first fully loaded, 400 MHz CATV system was turned on and began serving subscribers in Orland Park, Illinois.

The Master Telecommunications Center (MTC), or headend, design includes two 4.5-meter dual polarized Andrews satellite TVRO antennas - one receiving signals from SATCOM I, the other receiving signals from COMSTAR D-2. Scientific Atlanta 5500 satellite receivers are used on both antennas. The MTC processes 51 channels of television information in a harmonically related coherent (HRC) format using Scientific Atlanta 6350 TV modulators and 6150 TV processors.

The 100-mile cable plant design anticipated and incorporated the capacity for two-way communications. However, the upstream amplifier modules were not installed with the initial construction. The design of the system specified ComScope PIII+ 3/4" trunk cable and ComScope PIII+ 1/2" feeder cable. Scientific Atlanta Model 6500 trunk amplifiers are spaced 22 dB apart with a maximum cascade of eighteen amplifiers, one bridger and two line extenders. With our design philosophy, the 400 MHz system yielded a 3:1 feeder-to-trunk ratio with an active ratio of 5.5 amplifiers per mile.

The system was intentionally overdesigned because of the many unknown and unanswered questions regarding 400 MHz. For instance, we designed the system for AGC and ASC operation at every trunk amplifier. Because of the superior performance experienced to date, we have operated the system with every other amplifier in AGC/ASC mode and find that the system is still performing well beyond expectations, even with the severe temperature variations. The operating levels are: trunk input +11 dBmV, output +33 dBmV; bridger output +45 dBmV; line extender output +43 dBmV. Lectro automatic standby power supplies are provided at every power supply location.

COSTS

The design constraints resulting from the new engineering requirements, with all other factors remaining the same, produced an overall increase in system cost of 13% to build a 400 MHz system versus a 300 MHz system. The design criteria resulted in an increased cost of approximately 34% in electronics. Cable cost increased approximately 20% due to the feeder-to-trunk ratio change, requiring more trunk cable and more loop-back design. In addition to the increase in length, a premium was being charged for 400 MHz cable, at that time. This net cost increase of 13% yields a 48.5% increase in channel capacity, so the cost per channel actually decreases.

PERFORMANCE

On February 16, 1981, Cox Cable Communications, Inc. and Scientific Atlanta performed a proof of performance on the system, one line of which consisted of seventeen trunk amplifiers, one terminating bridger and two line extenders. The following test equipment was used for perform the measurement:

Wavetek Sweep	Gen.	Model 1855	S/N 270346
Wavetek Swepp	Rec.	1865	270347
Dix Hills Signal	Gen. (matrix)	SX16	181
Six Hills Distortion	Anl. (matrix)	RHi2	102
Spectrum	Anl.	8854B	2002A02611
Wavetek Freq. Sig.	Gen.	3001	280261
Wavetek Freq. Sig.	Gen.	3001	319245
Mid State	FSM	SAM-1	5126
SA 7dB true tilt	NET.	T	----
Texscan	BFP	75XX-35	
Texscan	BFP	75XX-37	
Texscan	BFP	75XX-38	
Texscan	BFP	75XX-39	
SA Pre Amp		SA-1	18 dB gain

All tests were performed using accepted NCTA test measurement procedures. Temperature at the time of the tests as +20 degrees Fahrenheit. The following are the results of the tests as compared to the calculated predictions:

Ch.	CTB Pred.	CTB Meas.	C/N Pred.	C/N Meas.	Cross Mod. Pred.	Cross Mod. Meas.	
2	-50.07	-57.5	46.17	47	-52.77	-63.5	dB
E	"	-57	"	47	"	-67.5	dB
12	"	-55	"	49	"	-67	dB
P	"	-56	"	47	"	-61	dB
R	"	-52	"	48	"	-59	dB
W	"	-55	"	47	"	-57.5	dB
QQ	"	-54	"	46	"	*	dB

* QQ cross mod was not measured because, at that time, a receiver was not available for that channel.

With this comparison, it can be readily seen that system performance far exceeds the predicted distortion levels. The overall system response, at the output of the 17th amplifier, had a peak-to-valley of 3.32 dB with an almost Gaussian shape 2dB peak near 210 MHz. Discounting this one peak, the response at the output of this amplifier would easily be within 1.4 dB peak-to-valley. The first line extender output exhibited a peak-to-valley of 4.22 dB with the output of the second line extender yielding a 6.4 dB peak-to-valley. At the output of the first line extender, between 50 MHz and 300 MHz, the response is well within 3 dB peak-to-valley. This response is not as tight as we would like to see, and we are continuing to work with Scientific Atlanta to improve the overall response. The major contributor to the poor response at the end of the second line extender appears to be the accumulative effects of roll-off on feed through loss exhibited by the directional taps between 300 MHz and 400 MHz.

RELIABILITY

With over 2,000 subscribers now being served by this 400 MHz system, and increasing at approximately 40 subscribers per day, it is worthy to note that in the past five months, not one service call has been attributed to the distribution system. The system has now successfully performed through summer and winter and has exhibited level stability of $\pm$ 3 dB over wide ambient temperature variations. The only outage experienced thus far occurred when the system was purposely shut down to allow the processing equipment to be moved from its temporary facilities in the trailer to its permanent facilities in the Cox Cable of Orland Park office complex. It is certainly note-worthy that, at this time, there have been no distribution equipment failures of any type. Our people on site report that this is the most stable and reliable system that they have ever worked with.

CONCLUSION

Our experience with 400 MHz systems in Orland Park, Illinois with over 2,000 subscribers and Jacksonville Teach, Florida with over 1,000 subscribers gives us great confidence that 400 MHz systems are not something of the future, but are deliverable, workable and reliable - today. Judging by the noise and distortion figures measured, we see no reason why at least a twenty amplifier cascade could not be designed and operated successfully. Our confidence in 400 MHz cable TV systems utilizing 400 MHz technology is evidenced by our commitment to the following systems, which are either under construction, or in the design phase: Michigan City, Indiana; Cranston, Rhode Island; Great Neck, New York; North Shores, New York; Maywood, Illinois; Park Forest, Illinois; Libertyville, Illinois; Mundelime, Illinois; Wauconda, Illinois; Grayslake, Illinois; Omaha, Nebraska; New Orleans, Louisiana.