LOW COST RURAL CATV SYSTEMS

RICHARD KIRN

WIRE TELEVIEW CORP.

ABSTRACT

Substantial economies may be achieved in the electronics of trunk and distribution systems by the use of high gain line extender amplifiers. Additional savings may be found in the head end design, reduction of dual trunk/distribution cabling, and labor saving construction.

INTRODUCTION

Many system operators have towns within 20 miles or so of their system, and/or small communities or groups of homes within a few miles of their cable. However, when the system designer has made an estimate of the cost of cabling these areas, it is just not economically possible using conventional construction techniques. What alternatives do we have that will allow us to profitably cable these outlying areas?

ELECTRONICS

First, the high cost of trunk amplifiers can be substantially reduced by utilizing line extender amplifiers as trunk amplifiers. This "mini trunk" approach may bring to mind cheap and inferior construction to some operators. This is just not so. There is a wide selection of high quality line extender amplifiers, using the same quality components found in the best trunk amplifiers. Table I provides price comparison for the twelve amplifier cascade illustrated in Figure I.

	UNIT COST	NO. IN CASCADE	COST	COST OF 12 AMP CASCADE
Trunk Station (Manual) 2000/152	$1000	9	$9000	
Trunk Station (Automatic) 2000/152	$1150	3	$3450	$12,450
Mini Trunk (Manual) 3000/152	$ 482	9	$4338	
Mini-Trunk (Automatic) 1000/152	$ 766	3	$2298	$ 6,636

TABLE I

Using list pricing for the amplifier cascade, the "mini-trunk" approach results in amplifier costs approximately one-half the cost of full sized trunk stations with no degradation in capability.

Now, remember that we are dealing with small communities which translates to short amplifier chains. Conventional trunk amplifiers have gains around 25 dB and are designed for maximum cascadability. Modern high quality line extender amplifiers are available with performance characteristics as shown in Table II.

With short cascades we can operate the amplifiers with 0 to + 3dBmV input, which corresponds to about a + 40dBmV output. In a well-behaved amplifier, the cross modulation/composite triple beat expressed in dB will increase 2 dB for each dB increase in the output level. Applying this principle to the data in Table II, results in the data in Table III.

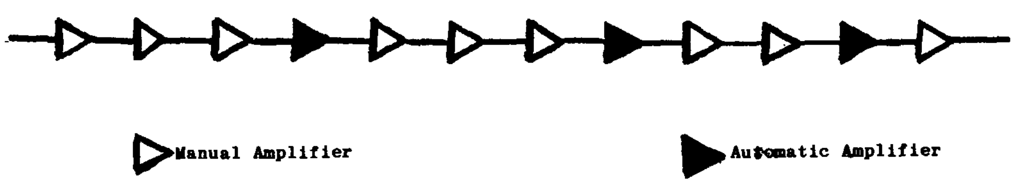

FIGURE I

MODEL	NOISE FIGURE	GAIN	OUTPUT LEVEL	CROSS MOD TRIPLE BEAT	CHANNEL CAPACITY
231	8 dB	31-38 dB	33 dBmV	-89 dB	30 (270 MHZ)
	7.5 dB	31-38 dB	34 dBmV	-91 dB	21 (220 MHZ)
	8 dB	38-43 dB	33 dBmV	-89 dB	30 (220 MHZ)
241	7.5 dB	38-43 dB	34 dBmV	-91 dB	21 (220 MHZ)

TABLE II

MODEL	NOISE FIGURE	GAIN	OUTPUT LEVEL	CROSS MOD TRIPLE BEAT	CHANNEL CAPACITY
	8 dB	31-38 dB	40 dBmV	-75 dB	30 (220 MHZ)
231	7.5 dB	31-38 dB	40 dBmV	-77 dB	21 (220 MHZ)
	8 db	38-43 dB	40 dBmV	-75 dB	30 (270 MHZ)
241	7.5 dB	38-43 dB	40 dBmV	-77 dB	21 (220 MHZ)

TABLE III

Again, keep in mind that we are dealing with small rural communities and super channel capacity is not required, and is probably cost prohibitive. Typically, we are dealing with 21 channel 220 MHZ or 30 channel 270 MHZ systems. Now, where does all this lead us? Table IV shows that with 40dB spacing and limiting our system to 21 channels, amplifier spacings a mile apart are possible. This reduces the number of amplifiers by one-half.

TRUNK CABLE AMPLIFIER SPACING (.750 CABLE)

	22 dB	40 dB
21 ch (220 MHZ)	1900 ft.	5300 ft.
30 ch (270 MHZ)	2500 ft.	4700 ft.
36 ch (300 MHZ)	2400 ft.	4500 ft.

TABLE IV

Now our electronic's cost has been reduced to one-quarter of a conventional system. But what about performance? The cross modulation at the output of a cascade of identical amplifiers increases 6 dB each time the number of amplifiers is doubled. This rule can be applied to a cascade of any number of amplifiers by using Table V as follows:

> To find system cross-mod, add the value from the column (20LOGm) opposite the number of amplifiers in the cascade to the cross-mod for one amplifier.

Using the data in Tables III and V, we can calculate the cross-modulation at the end of our 12 amplifier cascade and find it to be -56 dB. This is approximately the industry system design standard of -57 dB and well below the -46 dB for perceptible interference.

It should be noted that good thermal equalization is essential for proper operation. The use of thermal equalization will compensate for the variable cable loss between two amplifiers over the temperature range from -20° to 120° F with approximately ± 1dB flatness from 50 MHZ to the highest frequency used in the sys-

10 LOGm NOISE	NO. OF AMPS IN CASCADE	20 LOGm CROSS MOD	10	NO. OF AMPS IN CASCADE	20	10	NO. OF AMPS IN CASCADE	20	10	NO. OF AMPS IN CASCADE	20	10	NO. OF AMPS IN CASCADE	20
0	1	0	10.41	11	20.82	13.22	21	26.44	14.91	31	29.82	16.13	41	32.26
3.01	2	6.02	10.79	12	21.58	13.42	22	26.84	15.05	32	30.10	16.23	42	32.46
4.77	3	9.54	11.14	13	22.28	13.62	23	27.24	15.18	33	30.36	16.33	43	32.66
6.02	4	12.04	11.43	14	22.86	13.80	24	27.60	15.31	34	30.62	16.43	44	32.86
7.00	5	14.00	11.76	15	23.52	13.98	25	27.96	15.44	35	30.88	16.53	45	33.06
7.78	6	15.56	12.04	16	24.08	14.15	26	28.30	15.56	36	31.12	16.63	46	33.26
8.45	7	16.90	12.30	17	24.60	14.31	27	28.62	15.68	37	31.36	16.72	47	33.44
9.03	8	18.06	12.55	18	25.10	14.47	28	28.94	15.80	38	31.60	16.81	48	33.62
9.54	9	19.09	12.79	19	25.58	14.62	29	29.24	15.91	39	31.82	16.90	49	33.80
10.00	10	20.00	13.01	20	26.02	14.77	30	29.54	16.02	40	32.04	17.00	50	34.00

TABLE V

tem. If an automatic gain/slope amplifier is used at every fourth amplifier location, an economical trunk cascade with excellent level control can be achieved.

Another area of savings is the use of long distribution cascades. The tradeoffs of this approach are as follows:

Advantages

1. Elimination of double (trunk/distribution) cabling.

2. Reduce the number of bridger amplifiers.

3. Allows the extensive use of integrated messenger (figure 8) cable.

Disadvantages

1. Possible disruption of service for a large portion of the system if a tap fails.

2. Degradation due to an unterminated drop or feedback from a TV receiver.

3. Tap discontinuities.

4. Degration from amplifier cascade.

5. Powering problems.

The key to reducing the disadvantages to a level that will result in reliable service, is the modern quality tap. Using today's high quality directional taps, with seized center conductors, provides high reliability and isolation coupled with 5 to 6 amps through current at low hum-modulation levels. Figure II shows a typical directional tap. Note that it has one important distinquishing feature, reverse path isolation.

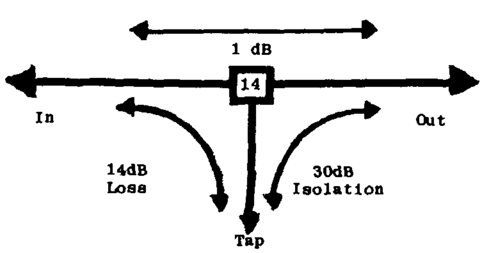

FIGURE II

This isolation helps us in two important ways. First, it reduces signals coming back down the distribution cable (reflected ghost, etc.) from getting into the subscribers drop; and secondly, keeps subscriber generated signals from feeding back into the downstream direction.

A directional tap can cause hum modulation. The power passing AC coil is a very high impedence to RF, the coil may have a ferrite, powdered iron, or air core. At some point, as current is drawn through this coil, the field will collapse. When the field collapses the coil no longer presents a high impedence to the RF. Now the power passing coil field does not just collapse and remain collapsed. As the AC current passes back through the zero point, it re-establishes itself, and then recollapses, as the current increases again. All this at a rate of 60 cycles per second. This 60 cycle rate is, in effect, a form of modulation and will appear in the RF signal. Directional taps are current rated and it is important not to exceed that rating, not because the tap will fail but because of the collapsing field and the resultant hum modulation. Keep in mind, that if a core is defective, hum modulation may begin at very low currents. Hence, there are some advantages to using directional taps with air core coils.

Figure III is a typical rural town distribution line with 150 foot spacing of 4-way taps on .500 inch cable. In the distribution system, the signal level must be maintained high enough to feed the last tap; thus, the block loss will not be as great as in our trunk example, and an amplifier gain of about 35 dB is required. Amplifier spacing of about 2000 feet is practical with these parameters.

How far can we go using this technique? Going back to Table V, we can calculate that at 40 dBmV out, we can go a maximum of 12 amplifier cascades. Remember, that this is the maximum cascade chain. In a real situation, we are not running a single straight line, but more like a grid design or possibly using a hub type distribution. Thus, the total number of amplifiers could be many times the twelve amplifier maximum cascade, and cover substantial areas. Conversely in some small communities, the maximum cascade may be less than twelve and we could operate at even higher output levels.

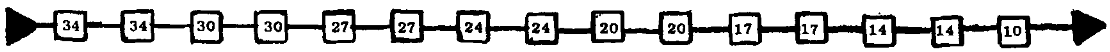

FIGURE III

INTEGRATION

How can we integrate these techniques into an existing or area-wide rural system? First, we may extend a short trunk, to a cluster of homes, or small community, or just distribution from an existing system using low cost techniques to serve an area that would not otherwise be economical.

A rural area is normally made up of a number of small communities, clusters of homes, and scattered individual homes, farms, etc. While it may not be practical to provide service to everyone, it may be feasible to design a system consisting of a large number of small "low cost systems," as we have described, interconnected by a super trunk. The super trunk may be 1.00 inch cable, and, may use a conventional or "mini trunk" technique, depending upon the overall complexity of the system.

The cross modulation of two dissimilar systems may be calculated using Table VI as follows:

1. Determine the cross-mod level for each system.

2. Compare these levels to obtain their difference.

3. Using this difference, find the derate value in the chart.

4. Derate the worst cross-mod level by this factor to obtain the combined cross-mod level.

DIFF. IN dB	CROSS MODULATION COMBINING DERATE: FOR DISSIMILAR AMPLIFIERS						
0.0	6.02	Diff.		Diff.		Diff.	
1.0	5.53	11.0	2.16	21.0	0.74	31.0	0.24
2.0	5.08	12.0	1.95	22.0	0.66	32.0	0.22
3.0	4.65	13.0	1.75	23.0	0.59	33.0	0.19
4.0	4.25	14.0	1.58	24.0	0.53	34.0	0.17
5.0	3.88	15.0	1.42	25.0	0.48	35.0	0.15
6.0	3.53	16.0	1.28	26.0	0.42	36.0	0.14
7.0	3.21	17.0	1.15	27.0	0.38	37.0	0.12
8.0	2.91	18.0	1.03	28.0	0.34	38.0	0.11
9.0	2.64	19.0	0.92	29.0	0.30	39.0	0.10
10.0	2.39	20.0	0.83	30.0	0.27	40.0	0.09

TABLE VI

CONSTRUCTION

Once the decision is made to utilize long distribution cascades (up to 8-10 amplifiers), a sizable portion of our cable plant is now single cable. Integrated messenger (figure 8) cable, with its associated hardware, and, installation labor savings, may be used for a sizable portion of the system. About a 30% reduction in the cost of cable and labor will be achieved by the reduction of dual trunk/feeder, and the use of figure 8 cable.

HEAD END

For the system that must stand alone, the head end represents considerable cost for the system planner. Signal processors for off-air channels, and modulators are available from at least one manufacturer (Triple Crown) in an economy version at one-third the cost of more conventional equipment. While not having all the fancy options, and not quite as good specifications, they will provide satisfactory performance in most cases.

Antenna and pre-amplifier economies may be achieved where several signals are received from the same direction. Heavy duty all-channel antennas (Jerrold J283-X); or hi/lo band logs, combined with a low noise broad band (customed to a specific bandwidth) pre-amplifier (Q-Bit Corp.) may be used to receive a number of channels at the cost of one antenna and one pre-amplifier. Of course, this technique will not work in all cases, depending upon the severity of the reception problems, so a careful analysis should be made for each situation.

CONCLUSION

The classic cable system with which we are all familiar, is designed for maximum cascadeability; which is all right providing we are cabling New York City, but for Centerville USA, do we need that? The techniques presented here to provide service to subscribers in rural areas at a reasonable cost, hopefully will start you thinking about how you can save money without sacrificing service quality. While not everyone will agree with the approach presented, I believe it is worth considering.