A NEW PERSPECTIVE ON SMALLER CATV OPERATIONS

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INTRODUCTION

Both technically and economically the smaller CATV system bears little resemblance to its' urban counterpart. Yet, it is interesting to note that identical approaches in system designs are generally employed. It is as though this same approach was effective in both cases though they may be substantially different in nature.

One good example of this is in system design philosophy. The familiar trunk plus feeder technique is universally applied for 1,000 or 20,000 subscriber applications and even the amplifier gain and operating transmission levels are widely accepted without question to be optimum for both cases.

Now there's nothing sacred about these levels and gains and only a moment's review of transmission principles suggests some modifications might not only be technically acceptable, but might be significantly cost beneficial.

But for some reason the question has not been raised.

Perhaps, if we could clearly identify some requirements or problems of the small system operator we might more effectively employ today's technology in addressing those requirements and possibly produce more satisfactory solutions.

This paper reviews some smaller operation problems and proposes some alternative approaches. Some of these alternatives may be as yet unproven. Our purpose is simply to question existing methods and perhaps gain something by the discussion.

IDENTIFYING SMALL SYSTEM PROBLEMS

In the final analysis all the problems of a smaller CATV operation find root in the limited revenue base on which the operation must exist. At REA we have particularly addressed the rural applications where the density of homes per mile of plant become very inhospitable indeed, but even in systems of 1,000 to 2,000 subscribers the economic restriction is ever present.

One example, is the commonly shared costs such as program acquisition or head end. These common costs carry much different weight for a small operation. Take a satellite receiving facility at a cost of say 30 thousand dollars. With 1,000 paying subscribers that pro-rates at 30 dollars each. But with 10,000 subscribers the figure becomes a more benign 3 dollars each. The smaller operation then is under substantial pressures to expand its' subscriber base even at the cost of plant extensions out to less dense surrounding areas.

And with a smaller margin of profit the operation is limited in staff and also in the technical depth of the staff that is affordable. Thus, highly sophisticated maintenance or testing techniques are inhibited and any simplification of long term maintenance or any reduction in logistic spare equipment requirements will have a much larger impact than those same improvements in a larger operation.

SMALL SYSTEM CHARACTERISTICS

But there are some positive advantages in smaller operations also.

For example, most core communities (the central town or population cluster in a rural or small system) are located relatively close to the system point of origin or head end. Thus the length of cable plant required to reach all of this community is distinctly limited. Then the cascade of required amplifiers will also be limited and consequently a transmission engineering approach might be able to take advantage of this condition. Perhaps, cascades of 8 or so conventional trunk amplifiers might be considered typical to serve the core community alone.

In these applications the available off-air signals are usually either limited in number or marginal in quality or both. Thus operations designed for 21 channels may be quite adequate. Indeed in many cases 12 channel operation may be salable thus eliminating or at least postponing the cost plateau of subscriber set converters. In any event the small system need not construct 40 or 50 channel plant, which is no small cost reduction of itself.

The nature of the small community is a factor. Usually the population is more stable and there is less subscriber "churn" than in urban operations. This fact, and the reduced total subscriber count itself, relieves the operator of such complexities as addressable taps, etc. Even billing and accounting processes may be less expensive because of the reduction in scale.

With these facts in mind, how might we best serve the requirements with today's equipment?

INITIAL CONSTRUCTION COST REDUCTION

Obviously any reduction in initial construction cost would be most welcome.

The recent improvements in amplifiers have been very largely influenced and stimulated by CATV's entry into even larger markets. Consider an amplifier which used to produce Y intermodulation distortion at X output levels when loaded with 21 channels. Now perhaps, that unit is capable of carrying 35 or more channels while still producing Y intermod at the same X output levels.

Certainly this increased transmission capacity is presented to the small system designer, but the advantage gained is somewhat academic if that operation cannot demonstrate a need for 40 channels or can not economically support this level of programing.

But that same amplifier improvement might be translated to higher gain, higher output level operation if the channel loading remained at 21 channels. And higher gain translates to longer spacings and reduced system costs.

Let's examine the typical trunk system design as it is almost universally applied today in both the largest and the smallest systems.

Usually operated at + 10 dBmV input and + 32 dBmV output the typical trunk amplifier is spaced 22 dB or so. These levels may be increased by a dB or so for lower channel loading application.

Under these parameters the trunk system would be cascadable to perhaps approximately 25 units and at the end of that cascade could still accommodate an extension through a bridger amplifier and perhaps two line extenders. These feeder amplifiers operate at higher transmission levels to improve subscriber tapping effeciency, but the higher levels impose higher intermodulation distortion contributions also. The higher distortion is tolerable because of the limited cascade of feeder units (2 or 3 typically) and the low distortion trunk contribution due to the low trunk operating levels.

But our smaller system will probably never require anything like a 25 trunk amplifier cascade, at least not to serve the core community itself. Perhaps, we could operate our trunk amplifiers at substantially higher gain and still produce "in spec" end of system performance through the usual 3 amplifier feeder leg.

In effect, if the small system designer simply applies urban trunk parameters, the end result will be better than necessary transmission quality at higher than necessary construction costs.

We examined many small system designs that were examples of this. One, I recall was a total of five amplifiers deep in the head end to system extremity, but the design dutifully (and extravagantly) used 3/4 inch trunk cable and 22 dB spaced trunk amplifiers.

Quite obviously this was designed by rote, not reasoning.

If the rationale is that some long rural extensions may be required later and thus trunk quality must be preserved at the initial extremities of the system, that is a different thing entirely and should be addressed separately.

RURAL SYSTEMS AND SYSTEM EXTENSIONS

The demographics of a rural system or an "out of town" extension of the smaller system are not particularly suitable for trunk plus feeder designs.

Usually the cable route is quite long, and the nominal subscriber tap load is distributed along this entire length. At the same time, side lead or lateral cable runs may be of quite significant length in themselves.

If we apply conventional trunk plus feeder designs we will find a majority of the feeder simply paralleling the trunk cable for tapping purposes. This is not particularly cost effective. We might consider eliminating the second cable and its associated second level of bridger and line extender amplifiers. Perhaps, we could simply insert all required taps into the main cable itself.

If we consider the side lead runs as pure feeder cable, we will find that often the length of such runs will require AGC or thermal compensation anyway and may require a cascade of so many high distortion feeder amplifiers imposing out of specification distortion at the end of the side lead cable runs.

The conventional feeder system technique is simply not compatible with long, lightly loaded cable runs, particularly if little of the feeder plant is located "off" the main trunk cable route.

In the rural extensions we do not anticipate any cluster or group tap loads or a large number of service points at the end of the extension. Rather than apply the trunk and feeder philosophy, which allocates some limited intermodulation distortion to the trunk system and reserves some substantial intermodulation distortion for the feeder sub-system, we might redistribute distortion along the entire length of a single cable system.

We could then accept higher intermod from each individual amplifier, since we expect no subsequent large distortion contribution from feeders. If we can accept higher distortion from each unit, we are free to operate them at higher output levels with higher amplifier gain. This translates to longer amplifier spacing which may be usefully employed in overcoming the tap insertion losses or in using lower cost, higher loss cable or a combination of both.

In any event, the effect can significantly reduce construction costs.

There is no "free lunch", and the effects of many taps inserted into a single cable may have limitations or present problems. Obviously, just introducing a larger number of cable connectors is undesirable, but careful workmanship and a short "debugging" period should make this acceptable.

Such devices will introduce echoes and reflections, of course. Ultimately, these may become limiting, but despite some extensive study we have not, as yet, been able to positively determine the point at which this becomes totally inhibiting. We have a field project under construction which will produce some useful data and, of course, there is the experience of long urban feeders. In many cases, three line extenders have been cascaded and certainly as many as 30 or 40 taps have been included and in this respect the urban feeder is essentially like the rural single cable design.

Of course, several techniques for "shedding" tap loads are available, particularly for clusters or groupings of taps. For example, back feed or forward feed cables, even with some cost penalty for limited parallel cable runs, offer some relief.

Improving the return loss of the inserted devices themselves, either by redesign or simply by production selection, would substantially reduce the potential problem.

In any event, we do not see the limitation as unmanageable. The single cable technique can reduce the amount of larger, more expensive cable required, and reduce or eliminate much of the inefficient parallel cable placement. It could completely eliminate a second level of amplifiers such as bridgers or extenders.

We believe a 36 dB gain amplifier, operated at + 8 dBmV input and + 40 dBmV output with 32 dB transmission loss spacing for 21 channel applications, compromises between cost and system "reach" for rural extensions. Using ½ inch size cable only, and including the typical tap loads along the route, this amplifier can provide rural extensions on the order of 17 to 18 miles depending on the tap and splitting loads.

That is pretty good area coverage if you include side lead and lateral cable runs and at a substantial reduction in cost, anywhere from 30 to 40 percent less than conventional trunk plus feeder designs as shown by our studies.

How might this design be incorporated into the core community design comfortably?

A COMPOSITE DESIGN FOR SMALL SYSTEMS

In our earlier examination of trunk plus feeder designs for core commuities, we raised the question of conventional trunk amplifier gain and operating levels as being less cost effective than we would like. But we had not presented any specific alternatives.

In our rural extension discussion we have introduced higher gain and higher operating level figures. Quite obviously, we might consider these figures when applied to the core community design. In effect, we may have optimized a trunk design for the core community which is completely compatible with the long rural extensions and presents initial construction economies in both applications.

This sounds great, but what of the higher intermodulation distortion introduced by these amplifiers when they are in the trunk portion of the core community system? In this case, our intention is to follow this cascade with a conventional 3 amplifier feeder leg, which contributes a substantial amount of distortion itself.

But, you will recall that our demographic profile of the core community showed a relatively limited distance from head end to core community extremities, thus the cascade of the rural amplifiers to the point of feeder system connection would be distinctly limited. Our studies show that a cascade of 8 or 10 amplifiers operating at + 40 dBmV output (the rural extension optimum) can be followed by a bridger plus two line extenders operating at standard levels and still produce - 52 dB of Cross Modulation at the last service point or better. That would seem quite acceptable.

Let us review what we have:

We have a single, low cost, small size cable, equipped with high gain amplifiers and operating at transmission levels somewhat above the inefficient, conservative, urban trunk levels, but somewhat below the high distortion, high transmission level urban feeder system.

Throughout this single cable, amplifiers are working with + 8 dBmV input and + 40 dBmV output with 32 dB transmission loss spacing for 21 channel operation.

In the "in town" portion of the system this single cable is not tapped for service drop feeds, but is split and tapped by directional couplers to feed conventional feeder type line extenders or bridger amplifiers.

In the rural sections of the system this single cable is directly tapped for service drop feeds and extensions out to 17 miles or so using ½ inch cable. The ultimate extension length will reflect the end of system performance specifications, of course. One might relax the specifications somewhat, since only a small number of subscribers is actually fed at the ends of these extensions.

The identical amplifier is used throughout this single cable and all output levels are identical at all stations. This significantly reduces logistic support and maintenance problems. And any or all amplifiers are capable of AGC (closed loop) thermal regulation as required.

The amplifier we have reference to is not a new design or development. In fact, it is not a unique product of any specific supplier. This unit, or an equivalent, is available off-shelf from several sources. All we are doing is configuring the equipment differently in the system and operating it at different transmission levels.

So far, we have confined our discussion to cost reduction, but earlier we had identified some other unique problems of small system operations. Can we respond to these more effectively through system design or operation?

AN ALTERNATIVE DESIGN FOR SMALLER SYSTEMS

Perhaps we might consider system designs from the standpoint of long term system operation.

Let us suppose that every amplifier in a system, no matter if it were in the trunk or in the feeder sub-system, were identical. That is, the housing and gain module, would in every respect be identical.

What might the long term advantages be in such a case?

Obviously, the logistics of spare amplifiers for maintenance would be much simpler and perhaps a lower level of staff would be able to handle the entire system.

Test and maintenance procedures might be significantly reduced.

For example, suppose instead of designing closed loop AGC into a system as periodic, lumped increments of correction, we were able to incorporate some AGC into every amplifier. The required range of the AGC would reduce, of course, but the cost per unit would not be much improved by this. Then we would expect, from a construction cost only point of view, that total AGC could be somewhat more expensive and perhaps unnecessarily so.

But from a long term operations point of view some cost penalty might be quite acceptable.

In effect, we would have a system with a very high level of self-regulation, and, consequently, a much lower vulnerability, not only to thermal variations, but to maladjustments of the system by low level personnel.

Carried a bit further this might make possible the use of non-adjustable or fixed gain amplifier modules.

The maintenance process might be reduced to the level of, "Go-No Go" indicators simply to isolate the service interruption of failed unit. Restoration of service might be the straight, plug-in substitution of a replacement with no measurements or adjustments.

Perhaps, this is a bit too much to hope for at the moment, but if practical, such a technique might even find application in feeder plant maintenance in the very largest, major market systems eventually. These systems are becoming more and more difficult to staff and maintain and since the majority of the plant involved is limited length feeder legs, the impact on operating costs of reduced maintenance complexity in feeders might be very attractive.

From this blue sky point of view we might look to the small system and its' rural extensions again.

Perhaps the basic amplifier which we have suggested might be equally cost-effective in the single cable extensions and in the core community trunk itself, could also be usefully employed in the core community feeder sub-system. It is already operating well above conventional trunk amplifier levels and might actually be operated at line extender or bridger output levels also.

But, we are feeding this core community feeder plant from some limited, but higher distortion trunk plant, so actually going up to typical line extender outputs may not be possible. But, we are free to operate somewhat higher and this would improve the cost effectiveness of this unit when compared to a conventional bridger or bridger plus line extender combination.

We were operating the basic amplifier at + 40 dBmV output in 21 channel systems. By increasing the input and output by only 5 dB, this unit starts to compare quite favorably in system layouts using the typical line extender. A study we did at REA indicates a cascade of 8 amplifiers, operating at + 40 dBmV output (as trunk units), can be followed by a cascade of 3 amplifiers operating at + 45 dBmV output (as feeder units) and still deliver a - 52 dB Cross Modulation distortion or better.

It is not necessary that every unit in the feeder plant be fully AGC equipped, but the option is available. Thus unusually long feeder legs could be accommodated by operating the first two or three units at the lower + 40 dBmV level and the last two units perhaps at + 45 dBmV.

An ACG could be provided in this feeder leg as required by simply inserting the appropriate additional AGC modules. The field trial previously mentioned includes some plant constructed in this manner and we will be reporting the results and system costs to the industry at large as soon as possible.

SUMMARY

Much of what we have discussed here is yet to be proven to have practical merit, but much of it surely needs no proof. For example, raising operating levels in a limited cascade of a small system trunk and using higher gain amplifiers in that trunk is neither radical nor innovative. Unquestionably it would be economically beneficial and it certainly would appear technically sound.

Yet we continue to find 22 dB spacings and high cost 3/4 inch trunk cables in systems that are designed only ten amplifiers deep and less.

Technology changes-inevitably and inexorably--and it is incumbent upon engineers to not only stay abreast of these changes but to effectively apply them in practice when advantageous to do so.

That's what good engineering is all about, isn't it?