MINIMAL BANDWIDTH UPGRADES

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Abstract

The operational bandwidth of a cable television system is normally limited to something at or near it's designed bandwidth. The designed bandwidth of a system frequently is more perceived than actual. The ability to accurately analyze the factors at play in an existing system may provide the understanding necessary to embark on a very cost effective bandwidth upgrade.

A clear understanding of how these factors interrelate and their economic burden can frequently result in the planning and execution of a project that provides bandwidth enhancement and additional revenue.

HURDLES TO HAPPINESS

Minimal expansion of bandwidth in a system depends on the condition of several elements in the plant. These elements may be thought of a hurdles. Each hurdle must be cleared or the project can not be completed. The cost in work hours and dollars associated with each hurdle must also be clearly understood. If every hurdle is high and it's associated cost large, then the system may not be a candidate for "MBUing". Accurate investigation, costing, and planning is essential or you may find yourself trapped. The major subsections of a system are: 1) Trunk Amplification, 2) Bridgers and Line Extenders, 3) Taps and Passives, 4) Cable.

The amount of effort which must be expended in each of these areas is a direct result of the overall bandwidth expansion desired. Beyond a certain expansion bandwidth, which is different in each system, the costs and effort will soar.

A way of maintaining perspective in exploring MBU options is to equate the impact of the project as cost per channel per subscriber. In this way, pushing beyond the economic knee will be reflected in raising costs per channel per subscriber . A separate important analysis not provided here is the revenvue production capability of newly created channels.

WHAT TO EXPECT

At the end of this paper we will look at some actual MBU information on real systems. MBUs adding 6 to 10 channels in systems with 300 to 450 MHz as the current upper band limits are reasonable expectations.

HURDLE ONE

The bandwidth and number of trunk amplifiers in cascade is the first concern. Many systems have trunk modules that are capable of full performance above their specified upper frequency limit. The principal band limiting element in a trunk station is the equalizer. Selection of an equalizer with a higher top frequency will solve this problem. Before you rush out for a bag of new equalizers, let's look at the other problems. Most trunk/bridger stations pass AC power. This is accomplished by a series of several power passing chokes and bypass capacitors that provide a directable power path through the amplifier which is independent of the RF function(s). Power passing chokes are selected by the designer to be highly reactive within the design frequency range. When properly sized they are essentially invisible to the RF path. Once you explore the band beyond the upper design limit you run the risk of entering a region where the power passing chokes absorb RF energy and hence influence Gain/Frequency response. This "choke notch" when encountered will be pronounced and set a practical absolute limit to the bandwidth that can pass through a station. Some hard core RF Engineers may talk about moving this notch by bending or "knifing" coils. It can be done, but, it's well beyond the scope of this paper. A couple of other factors also get in the way: As you go up in frequency the attenuation of coaxial cable increases. The expected attenuation between stations must be accounted for. It may range from an inconsequential amount to several dB. Maintaining operational levels at higher frequencies also becomes a problem when the gain of the station drops off a few tenths of a dB and internal passives manifest a little extraordinary loss. These factors together eat into residual operating margins. Careful bench testing of a sample of stations at the newly proposed upper frequency and actual inventory of the trunk stations in the field to ascertain pad values, (that's gain you can use), will address these concerns.

Don't plan on faking any of this. Careful deliberate steps are the difference between success and failure in MBU's.

Before we leave trunk amplifiers, a couple of operational comments. Most systems are noise based, this is, they are positioned within their operational level window toward the noise side. This is because until recently we have lacked high quality low cost field equipment for making cross modulation and composite triple beat measurements. (*such as the Hewlett Packard 8591C*). This omission resulted in "staying as far away as possible" from coherent distortions. The reason is simple! The onset of coherent distortion in subjective analysis is abrupt and most observers will see it within a couple of dBs of one another. On the other hand, noise is more gradual and highly subjective. It was easier to sell noise than beats.

Today, their is no excuse for not being well positioned within the operating range; this generally happens through raising the levels. It may be counter intuitive to think about adding channels and raising levels, but it may turn out that way!

Finally, if you have applied any glass to your system to reduce cascades and enhance reliability the reduction of cascades not only relaxes noise/distraction objectives, but also relaxes gain/frequency considerations in that the cumulative impact is lessened.

HURDLE TWO

The performance of the bridger and the line extenders in a distribution leg set not only the performance but the tap levels, as well, hence drop levels for the individual subscribers. The impact of changing levels must be thought through as to how it relates to drop levels and the Commissions (FCC 76.605) requirements. Changing pads and equalizers to reach a higher bandwidth is a good investment, dropping in higher gain modules may be a good investment. Changing out line extender stations may not make economic sense for an MBU.

When the design bandwidth of a bridger or a line extender is slightly exceeded, the signals will start to fall off on the higher channels, that right where you need it to overcome tap losses that are also increasing as they approach their performance limits. A practical way of quantifying the impact of many of these factors is to test a selected sampled that picks up a few representative distribution legs.

Detailed testing including the net impact on distribution end performance will answer these questions.

HURDLE THREE

Taps and passives while they look and work about the same, their impact on the cost of an MBU can be significant. If passives restrict bandwidth because of extraordinary loss or more likely power passing choke notches, they can simply be replaced. Passives are cheap and about a dozen or less per plant mile. Taps on the other hand are everywhere; underground, down everybody's street and up your alley. Taps generally degrade gracefully and pushing bandwidth by perhaps 10% (330 from 300 or 440 from 400) should not present a problem. Beware, however, the dreaded power passing chokes. Some taps are into the power passing choke notch at even 10% above the upper frequency limit. this is an area in which good attention to detail is necessary.

Different taps within from the same manufacturer and same series may behave quite differently. If a few values are found to be a problem, they can probably be changed out economically, however reaching every tap in a system to achieve an MBU makes no sense. An inventory of the type and value of taps used within the system and their performance at the MBU frequencies will provide the needed information. All taps have power choke notches, passive sweep testing of a tap cascade in the field is a good way to accelerate this understanding. Testing of a tap or two on the bench may provide misleading data. Generally, all devices of the same manufacturer and tap values will behave the same. As mentioned earlier, a few problematical taps can be exchanged in the pursuit of an MBU.

HURDLE FOUR

The coaxial cable used in a system frequently is the highest hurdle. Cable can be a disappointment in two ways: 1) It's original design performance fall short of a new expectation, or, 2) It is defective and fails to meet it's original performance specification.

If you think taps are everywhere how about cable: "Gee, that's why they call it Cable TV!" Occasionally one may encounter a style cable that will express some unusual behavior, in a frequency range. This is generally due to mechanical properties of the cable, repetitive structures or damage in a cable can set up a circumstance where a notch or "suck out" can occur. These properties can be tested for by sweeping. The writer has had some experience with a cable no longer in manufacture called Seal-a-Matic. This cable had an outer conductor made of aluminum foil and over folded against itself logitiutionally. While this cable was blamed for many sins, including signal leakage, the reality was that with good connectors is was and is capable of operation at 450 MHz.

The message here is that older cable should not be rejected out of hand for expanded bandwidth projects. There is no substitute for sample testing. A more frequent problem is one of cable that is bad for a variety of reasons and all the margin is used up; *even at the old bandwidth*. Sample testing and extrapolating results into the overall project will generally prove that only some fraction of the total miles of a plant suffers from bad cable and at some price it can found and fixed.

MBU POLITICS

Bringing together a successful MBU or bigger still a series of them can result in adding channels to existing systems. These channels can generate new revenue sources, as well as taking permissive rate increases through channel expansion. The prospects of adding channels through MBU can easily be misunderstood: *MBU is not an alternative to system rebuild, it is an interim step that provides more channels sooner. MBU is not risking arrest. It is not speeding to do 330 MHz in a 300 MHz zone. MBU is not bad engineering, in fact it is just the opposite, sound proven engineering is what makes it work.*

The close interchange of ideas, and expectations between management and engineering is absolutely necessary to make MBU successful. The overall number of channels than can be achieved is dependant on a number of variables. While some systems may be similar in their MBU needs, no two will be exactly alike. Trying to force too aggressive an MBU into a system will result in high costs per channel. Alternatively, adding channels with only minimum preparation runs the risk of poor performance, problems with subscribers and /or the Commission at proof time.

Here is some actual MBU information and a broad estimate of the cost of implementation in various type systems. You may find this information helpful in ranking a prospective MBU project.

TYPICAL MBU PROJECTS

System	System Current Upper Limit	MBU Upper Band	Cost/ Channel Sub	Notes
A	300	400	$2.83	Small, similar in size and age.
B	300	400	$3.03	
C	300	400	$2.50	
D	300	400	$2.56	
E	400	460	$9.00	
F	400	450	$3.40	
G	340	380	$7.67	Previously expanded from 300 340 MHz.
H	270	330	$3.40	
I	300	330	$5.24	
J	300	330	$6.24	
K	300	330	$5.21	
L	400	450	$2.77	
M	300	366	$23.62*	Extensive .412 Dist.
N	330	330	$15.28*	.412 Dist. Band limited taps.
O	270	330	$14.95*	Needs taps & cable.
P	300	330	$16.22*	Needs taps & cable.
Q	330	450	$6.25	450 L/E & taps in place.

Average unweighed cost per channel per subscriber, is $4.62 excluding projects not undertaken shown by * above.

CONCLUSION

Points to ponder:

- Every system is different, the price of an MBU varies.

- The number of channels that can be economically obtained varies.

- Not every system is an MBU candidate.

- Some aspects of the capital and labor expenditures of an MBU may be useful in a subsequent rebuild.

- MBU projects which can be finished quickly provide revenue that is otherwise lost or delayed until a rebuild.

Additional channel capacity may be falow in your system, why not put it to work soon?