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COUNTING CHANNELS

By RON HRANAC

The cable system in which I got my industry start in 1972 boasted a 220 MHz upper frequency limit. The network was based on a tree-and-branch architecture that used Vikoa's Futura 12 series of amplifiers. Those amps were single-ended devices, which meant that despite their roughly 50 to 220 MHz bandwidth, the usable downstream channel capacity was limited to 12: VHF low band Ch. 2-6 and VHF high band Ch. 7-13. The theoretical channel capacity was higher, of course, but single-ended amplifiers were distortion-limited to carrying just the 12 broadcast-equivalent VHF TV channels and maybe a few FM stations in the 88-108 MHz range.

How can one sort out the channel capacity of a cable network? The first step is to define what a channel is. Unless otherwise indicated, I'm calling a channel a 6 MHz bandwidth chunk of the RF spectrum used to carry a single analog NTSC TV signal.

Count 'em up

If we look at those old 220 MHz systems - technically 54-216 MHz - the theoretical channel capacity is (216 - 54)/6 = 27 channels. Subtracting the 4 MHz band between Ch. 4 and 5 and the 20 MHz-wide FM band gives us a more practical number: [(216 - 54) - (4 + 20)]/6 = 23 channels. But we couldn't use the VHF midband (108-174 MHz) in single-ended amplifiers - pictures would have been full of interfering beats. With the introduction of push-pull amplifier technology, a so-called 220 MHz system's channel capacity really was 23. Well, sort of. In most instances, what we now call Ch. 98 and 99 (formerly known as channels A-2 and A-1 respectively) weren't counted, so the number of 6 MHz-wide channels was said to be 21. The available channels were 2-6, A-I (now called 14-22), and 7-13.

Over the years, the channel capacity of cable networks increased as technology improvements allowed expansion of the upper frequency limit. Some of the more common numbers that I recall include 270 MHz, 300 MHz, 330 MHz, 400 MHz, 450 MHz, 550 MHz, a brief stop at 600 MHz, 750 MHz, 860~870 MHz, and finally 1 GHz. Even though we often said the bandwidth of a system was 270 MHz, 300 MHz, and so on, that's technically incorrect. The total available downstream bandwidth actually is the applicable upper frequency limit minus the lower frequency limit, the latter typically in the 50 to 54 MHz range. While Ch. 2 (54-60 MHz) is the lowest TV channel used in these examples, a bit of usable spectrum is available just below Ch. 2. That extra few MHz was and still is sometimes used for non-video purposes such as telemetry signals for system sweep equipment. (The 4 MHz slot between Ch. 4 and 5 occasionally sees telemetry and other non-video signals, too.)

Depending on how one counts channel capacity, the numbers of usable channels seemed to vary a bit among manufacturers. For instance, 270 MHz networks were said to support 30 channels, but if Ch. A-2 and A-1 are included, the tally jumps to 32 channels. The 300 MHz systems could carry 35 channels (37 channels with A-2 and A-1), and 330 MHz bumped the total channel capacity by another five. After 330 MHz, the numbers get a little more interesting.

Where's the top?

For instance, what we called 400 MHz systems had a somewhat nebulous upper frequency limit. How's that possible? Well, Ch. PP (52) ends at 396 MHz, and Ch. QQ (53) ends at 402 MHz. I remember hearing 400 MHz systems' channel capacity referred to most often as either 52 channels or 54 channels, depending on the manufacturer. If we assume that Ch. PP (390-396 MHz) was the highest used, the channel capacity is 53 channels, or 51 channels without A-2 and A-1. If Ch. QQ (396-402 MHz) is the highest channel, then the capacity is 54 channels with A-2 and A-1, or 52 channels without those two in the total.

For quite a few years, the industry continued to use the old letter designations for channels other than 2-6 and 7-13 up through about 450 MHz. Systems designed and built for 450 MHz operation were called 60 channel capable, though when A-2 and A-1 are included, the total is 62 channels. Sneaking the last lettered channel into the lineup - Ch. ZZ (Ch. 62, or 450-456 MHz) - bumps the count up one.

The 550 MHz upper frequency limit also is a bit nebulous. Like 450 MHz, there isn't a clean channel break right at 550 MHz. Ch. 77 is 540-546 MHz, and Ch. 78 is 546-552 MHz. If we use Ch. 78 as the highest channel, the capacity is [(552 - 54) - (4 + 20)]/6 = 79 channels, including good ol' A-2 (98) and A-1 (99). Drop those two channels, and the capacity is 77 channels. Interestingly, I've heard references to 77 channels, 78 channels, and 79 channels in 550 MHz networks. Where does 78 channels come from? Let's look at some possibilities.

One plausible but unlikely scenario is that the highest channel - Ch. 78 - was mistakenly assumed by someone to be equal to the channel capacity. Oops. The channel count starts with Ch. 2, not Ch. 1. The more likely explanation is that Ch. 77 (540-546 MHz) was considered the highest channel, making the capacity 78 channels with A-2 and A-1 in the total. Without A-2 and A-1, the channel capacity is 76 channels. So which is correct? The answer is clearly "it depends," but my vote is for 79 channels.

A bit easier

A 600 MHz network is a little easier. Channel capacity is [(600 - 54) - (4 + 20)]/6 = 87 channels, again including A-2 and A-1. Or 85 channels without A-2 and A-1.

At 750 MHz, it works out to [(750 - 54) - (4 + 20)]/6 = 112 channels with A-2 and A-1, or 110 channels without.

More recent 860 MHz networks are in the same ballpark as 550 MHz networks, sort of. First, one has to decide just where the upper frequency limit really is: 858 MHz? 860 MHz (no clean channel break at this frequency)? 864 MHz? Or 870 MHz? The latter seems to be the offering du jour. An 870 MHz upper frequency limit gives us a channel capacity of [(870 - 54) - (4 + 20)]/6 = 132 channels, here, too, with A-2 and A-1 in the count.

And then ...

And then there's 1 GHz. This is also one of those problematic frequencies, because there is no clean channel break at 1,000 MHz. Indeed, Ch. 158 ends at 1,002 MHz. So, the upper frequency limit may be generically referred to as 1 GHz, but to be technically correct the actual frequency limit is 2 MHz higher. So, a 1,002 MHz upper band edge gives us a channel capacity of [(1,002 - 54) - (4 + 20)]/6 = 154 channels with our old friends A-2 and A-1 included, or 152 channels without. Frankly, it doesn't make sense to leave out those two channels considering the value of RF bandwidth these days, so let's call it what it is: 154 channels.

Muddying all of this up somewhat is the fact that a handful of cable operators have opted to use some of the FM band for carriage of TV signals, upping the channel capacity by another three: Ch. 95 (A-5), 96 (A-4), and 97 (A-3). These three channels are assigned to 90-96 MHz, 96-102 MHz, and 102-108 MHz respectively. The primary challenge using these three allocations is ingress from over-the-air FM broadcast stations.

Not easy

Who said counting channels was easy? Now you know why those of us in the engineering side of the business swapped our slide rules for scientific calculators and computer-based spreadsheets.

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