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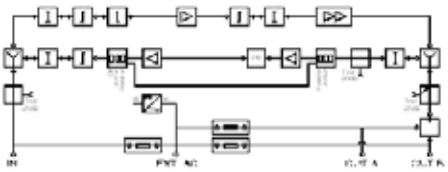
# Amplifiers in SMATV networks:

## - Appropriate gain is right. Too much is wrong !



*Amplifliers are needed to distribute TV-signals in larger areas and to ensure appropriate signal levels at all TV/radio wall outlets. But amplifiers do not improve the quality of signals.*
*On the contrary: They introduce noise, and a surplus of amplification capacity adds unnecessary noise.*

Article by Mads Dalsgaard
product manager, Triax

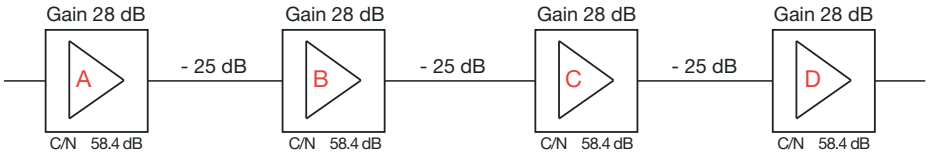
Extra power and capacity is most often an advantage in sports, in your car, in computers and in many other processes. In the handling of signals in TV/radio networks (e.g. SMATV solutions) you do however have to think differently, and this especially applies to the selection of amplifiers and their maximum gain capacity. Unnecessary amplification power adds unnecessary noise and reduces signal quality.

### A formula to consider

Carrier-to-Noise (or C/N) ratio is the value used to describe how efficiently the active components in a distribution system preserve signal quality.
More specifically, a C/N-ratio is the ratio between meaningful information (TV-signal) and background noise added by the component, and this value (measured in dB) has to be maximized.

To optimize signal quality, we need to look at the formula for calculating C/N-ratios and to understand the relationship between the different parameters. Actually the formula is fairly simple and conclusions even more so.

**Ex. 1 C/N-ratio of an amplifier is : C/N=Uout-Gain-NF-In**




| | | |
|---|---|---|
| $U_{out}$ | Amplifier's output level in line amplifiers (typically) | **95.0 dB** |
| Gain | ÷ Maximum gain of the applied amplifier, for example | **- 28.0 dB** |
| NF | ÷ Noise figures of the applied amplifier (inherent noise), typically 5-8 dB | **- 7.0 dB** |
| In | ÷ Impedance noise generated by the amplifiers 75Ω electrical resistance | **- 1.6 dB** |
| | = Amplifiers C/N-ratio | **58.4 dB** |

As in this example, amplifier gain is typically the one factor causing the largest reduction in C/N-ratio and signal quality. Additionally it is worth noticing that it is not the adjusted gain, but the maximum gain of the amplifier that counts.

As an installer or systems designer you only have very limited options to minimize the amplifier's inherent noise and impedance noise. And for reasons outlined below, an output level of more than 95-98 dBµV will start creating other problems when cascading amplifiers. So, the one important factor you can control is the amplifier's maximum gain. As the above formula shows, signal quality is improved, when you "economize" with power (and costs) and select an amplifier with the gain needed but no unnecessary amplifying capacity.

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## Keep signals at a maximum of 95-98 dBµV

Based on the formula, one can perhaps also draw the conclusion to maximize output level ($U_{out}$) and reduce the number of amplifiers needed.
This is right in respect to C/N-ratio but an output level above 95-98 dBµV will create new and different problems: Intermodulation.

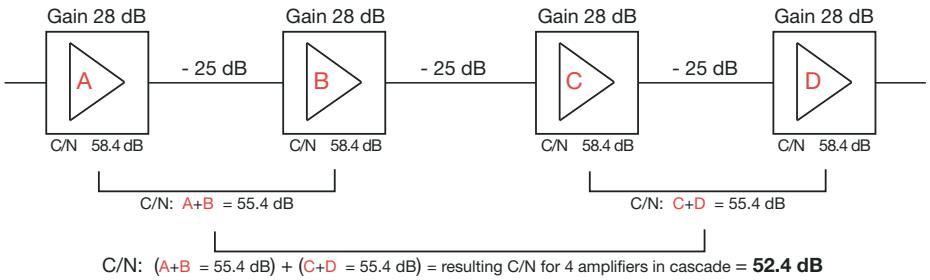
Intermodulation is the result of overdriven signals, and occurs because the amplifier radiates energy on the operating frequency as well as frequencies above and below the same assigned frequency. The result is frequency components generated by the amplifier and visible on various channels throughout the channel raster, typically in the form of undesired shadows or patterns in the TV-picture.


*Typical example of picture distorted by intermodulation and where the distortion will be visible at all channels*

## Insert amplifier for every loss of 25 - 28 dB

When output levels are kept at a maximum of 95-98 dBµV, intermodulation causes no visible problems. But signals are of course weakened in the distribution network and a next logical question could be, at what level of signal strength, you need to reinforce signals by insertion of an amplifier.

## Ex. 2 C/N-ratio in a cascade of 4 identical amplifiers




Noise is inherent in every signal, and when signal strength is reduced the relative weight of noise (and its negative visible effects) will grow.
So, it is important to keep signal strength at a level, where the intended signal dominates and the proportion of noise is insignificant and invisible.

A CATV rule of thumb is that signals in a distribution network have to be kept at a minimum of 70 dB, and to obtain this, a line amplifier (with an output level of 95-98 dBµV) has to be inserted for every loss of 25-28 dB.
The 25 dB rule of thumb is based on numerous practical installations as well as long experience. You may find installations where signal strength is allowed to drop to 65 and even 60 dB – with no visible effects.
But in other networks the same low signal strength will cause problems, including waste of installation time and subsequent exchange of network components.

## Interstage amplifiers safeguard high frequency signals

When amplification is needed, special attention has to be paid to high frequency signals and the effects of increased cable loss at higher frequencies. Equalizers are used to compensate the tilt but equalizers - when used the wrong way - will decrease C/N and introduce noise that can be critical to weakened signals. The idea in interstage amplifiers is to avoid processing of weak, high frequency signals.

In the interstage amplifier, the initial processing is signal levelling and afterwards amplification to a level where signals at all frequencies can be processed safely, i.e. where the relation between meaningful information and noise is more than acceptable. Further stages can include various processes (equalization, attenuation, amplification) but the point is

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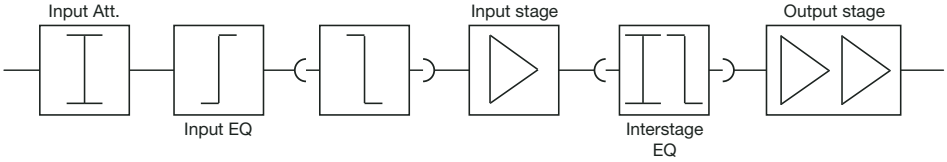
## Ex. 3

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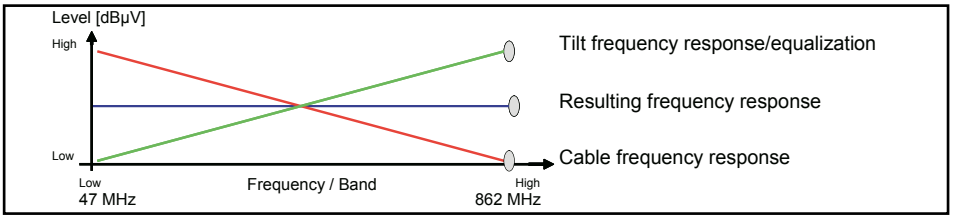
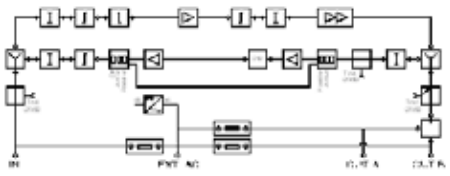
that even high frequency signals initially have been raised above the level, where the share of noise will disturb the intended signal.

## The laws of physics cannot be bent

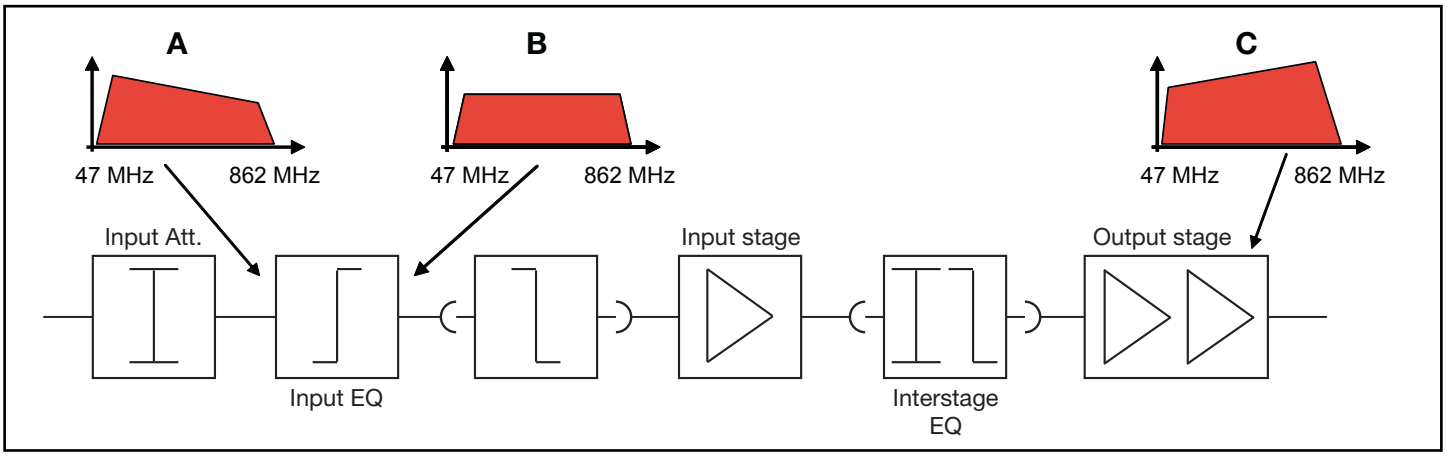
When a new SMATV network does not perform as planned, troubleshooting can require hours and days of extra work, and the necessary modifications will often result in extra costs.
One thing is certain: You can't change the physical laws influencing signals in a cabled network. In this article, we have however tried to outline a few basic rules of thumb that can help you operate efficiently within the laws of physics.




*The purpose of tilt is to compensate cable high frequency losses. When frequency is increased the cable loss is increased.*
*The tilt has it is pivot point at the highest frequency and attenuates lower frequencies at approximately the same rate as cable attenuates higher frequencies.*
*This way the resulting frequency response will be flat, with even levels at all frequencies.*
*Tilt compensation is done at the amplifier input, to get even levels at the input and prevent low frequency signals overdriving the amplifier input stage.*
*Line amplifiers often feature interstage tilt, making it possible to precompensate losses further down the line.*



*The input EQ, protects the input stage from being overdriven by strong low frequency signals (**A**), attenuating the low frequencies and by these means supplying the input stage with a flat spectrum (**B**).*




*The purpose of the inter stage EQ is to compensate cable high frequency loss further downstream. The technology used to build the output stage (**C**) ensures a minimum of distortion even though the spectrum after EQ is no longer flat.*

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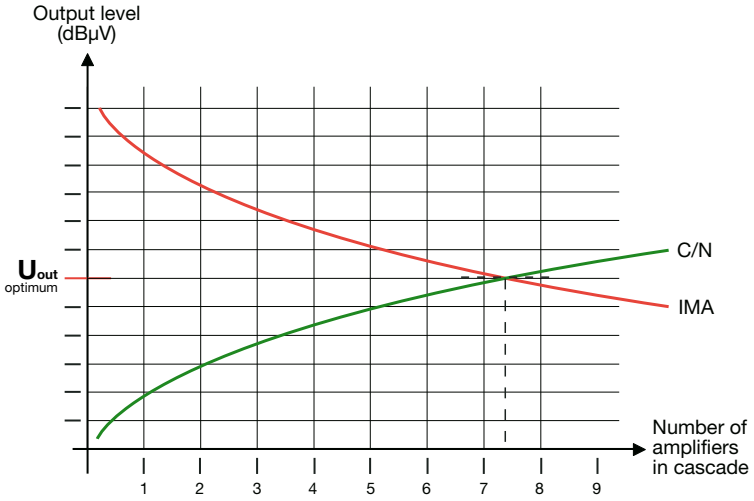
## Typical components in an SMATV network

| Component | Application | |
|---|---|---|
| Line amplifier | Used to keep signals at appropriate levels (95-98 dBµV) in the main distribution network. Typically a broadband amplifier. | Broadband amplifier |
| End-of-line or D3 amplifier<br>- last active device before passive distribution | Broadband amplifier. Ensures adequate signal levels (107-110 dBµV) for distribution to a number of outlets. | Distribution amplifier |
| Attenuator | Reduces signal strength.<br>Usually placed at the amplifier input stage to avoid overdriving the amplifier. | Fixed attenuator<br>Adjustable attenuator |
| Equalizer | Used to compensate high frequency losses. Amplifies high frequencies and attenuates lower frequencies resulting in even levels at all frequencies. | Fixed equalizer<br>Adjustable equalizer |
| Cable simulator | Used to ensure a flat input signal to amplifiers and inserted, if and when a signal for some reason has to much tilt. Influences signals in the way as cables | Fixed cable simulator<br>Adjustable cable simulator |

## Calculation of number of cascaded amplifiers in an SMATV network

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