

In-Home Amplifiers

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Introduction

Most CATV networks are designed to deliver a signal level to each home that is sufficient for the cable modem and one TV-set. In homes where there are several TV-sets it is then necessary to amplify the signal in order to compensate for the losses in the in-home distribution network. This white paper describes the requirements to these in-home amplifiers, and the considerations when selecting the right choice for the subscribers for maximum customer satisfaction. Also, recommendations are given on how to make the in-home network for DOCSIS 3.1 services.

Conclusion

When there is a need for several TV sets in the home there is typically also a need for an in-home amplifier. This amplifier must have sufficient gain to compensate for the in-home distribution losses, and on the same time it must have a large window of linearity to preserve the signal quality, even in the case of a fully loaded DOCSIS 3.1 spectrum. Automatic Gain Control is a suitable functionality to ensure this. For DOCSIS 3.1 services it is recommended to place the modem at the entry to the home, ensuring a controlled signal path between the modem and the CMTS and protecting the distribution network from any in-home generated noise. MoCA might then be a secure and stable alternative to standard WiFi broadband distribution within the home.

Identifying the need for an amplifier

In homes with more than one TV-set the signal delivered from the MSO might not be sufficient to ensure the signal quality for all TVs; simply because additional losses in cables, splitters and outlets lower the signal level. The ability to provide quality TV services to in-home devices often requires appropriate signal amplification from the point of demarcation. As a rule-of-thumb whenever there is more than one system outlet in the home there is a need for an amplifier. There might be local and national variation to this.

Understanding an amplifier's critical features and restrictions

The ability to provide sufficient signal strength with amplifier hardware requires that such equipment satisfy certain technical criteria. This ensures, for example, that noise amplification and signal linearity, do not adversely affect the user experience. In addition, it is a must that it is easy to make the installation of the in-home amplifier, both for professionals and for Do-It-Yourself hobbyists. Then the risk of network

failures and loss of customer satisfaction is minimized. Figure 1 shows an example on how the in-home network can be made.

- **Forward Amplifier Gain**

As the signal level of the signal delivered to the home has a suitable level for proper TV reception the amplifier gain has to compensate for the losses in the in-home network. These losses consist of the losses in the signal distribution (typically a tap), the in-home cables, and the insertion losses in the wall outlets. Typically, a 4-way tap has 12 dB tap loss, 20-30 meters of cables add about 3-5 dB, and the wall outlet has 1-2 dB loss, so in this example the amplifier gain has to be approximately 19dB. The frequency dependent attenuation in the cables may contribute with 2-4 dB variation in the losses from 200 MHz to 862 MHz, so it is an advantage to have 2-4 dB equalization in the amplifier forward gain.

- **Forward Amplifier Linearity**

The number of TV channels in CATV networks can span from a few channels to complete occupation of the TV frequency range. In addition broadband services are also present filling up part of the forward frequency spectrum.

For trouble-free TV reception of PAL or analogue channels, the amplifier must offer adequate linearity to ensure that second (CSO) and third (CTB) order intermodulation products are suppressed by at least 60 dB relative to the desired signal on the output. For DVB-C channels the amplifier must have a sufficient linearity to avoid suppression in the constellation diagram that the MER value exceeds 40dB.

The requirements to the linearity limit the maximum signal output level from the amplifier, and with a fixed gain this directly limits the signal input power. Adding more signal power to the amplifier, e.g. by increasing the number of TV-channels, enhancing the frequency range for the downstream broadband services, or if there are upgrades in the distribution network, might then drive the amplifier outside its window of linearity. This can be avoided by automatically controlling the amplifier gain, so the gain is decreased as the input power increases. Manually adjusting the gain is a second alternative but then the subscriber has to change the amplifier settings each time there are changes in the distribution network.

- **Return Path**

In DOCSIS 3.0 networks it is common practice to place the modem behind the in-home amplifier and therefore the amplifier must have a return path. As for the forward gain the return path gain must compensate for the in-home losses. The cable losses in the return path frequency range (5-65 MHz) are quite small, so the return path gain has to be approximately 15 dB. According to EN60728 the IMA3 levels must be sufficiently suppressed in the return path.

In DOCSIS 3.1 networks it is recommended not to have an in-home amplifier in front of the modem. Instead there should be a signal

path from demarcation point directly to the modem, and a second signal path to the amplifier for the in-home distribution of the TV signals. This solution has two very important benefits: The signal path from the distribution network to the modem is well defined with respect to the attenuation both in the forward and the return path directions; second any noise picked up by the in-home network can be blocked in a filter to the benefit of the upstream signal quality to the CMTS (even if the amplifier has an active return path). This filter can e.g. be built into the device at the demarcation point splitting the signal between broadband services and TV. Also, the total transmitted power from the modem in the upstream channel might saturate an in-home amplifier leading to signal degradation, and the noise figure of the amplifier decreases the CNR of the upstream signal.

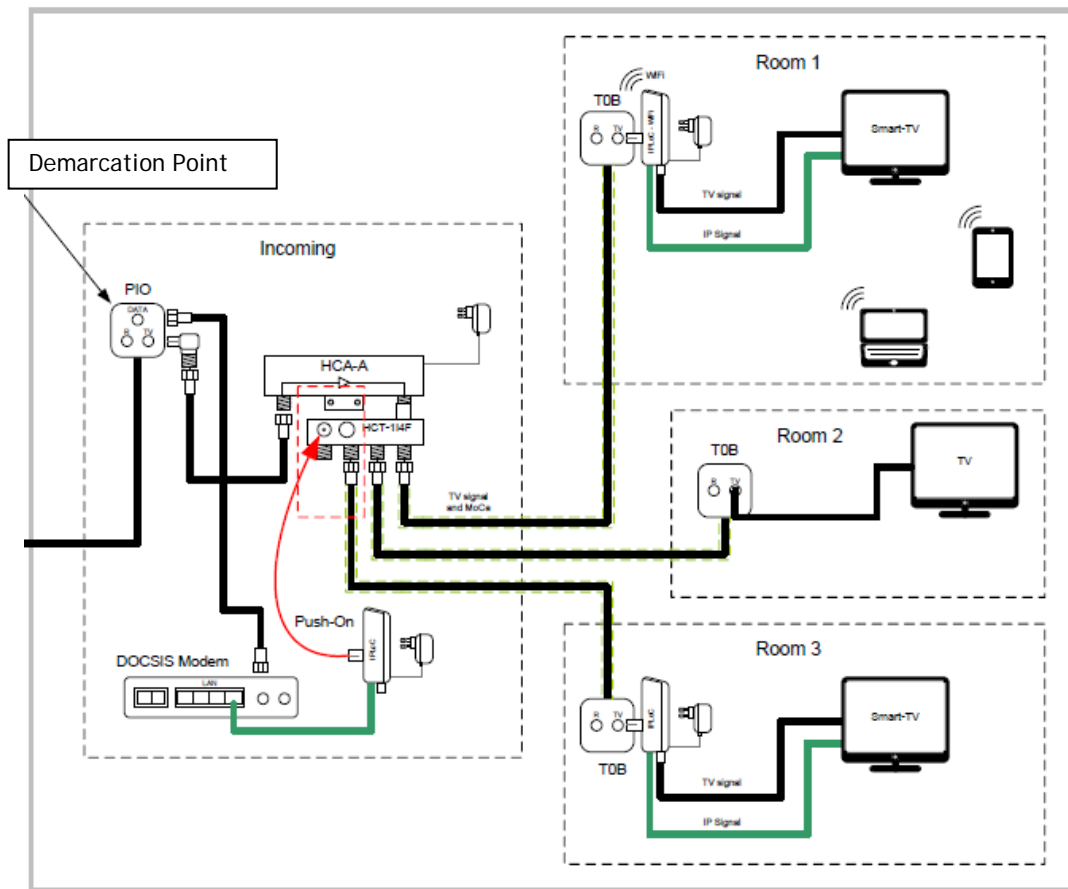


Figure 1 In-home network. The modem is connected directly to the demarcation point, and the TV signals are amplified in the HCA-A amplifier before being distributed to the outlets in the rooms around the house. Broadband services are being distributed through the same network using MoCA.

Understanding amplifier and tap solution from DKT

With all the features and restrictions listed above in mind, DKT is providing a series of amplifiers to satisfy these. The DKT Home Connect Amplifier series is modular, consisting of the amplifier unit, an external power supply, a tap unit, and a decoration cover, see Figure 2. For details of the complete series please refer to the DKT webpages: <http://dktcomega.com/product-home-network/amplifiers>





Figure 2 The DKT HCA amplifier and HCT-114F tap with the decorative HC-C cover.

There are two versions of the amplifier unit; one with and one without an active return path. HCA-A65 has an active return path with 16dB gain in the frequency range 5-65MHz. This amplifier is recommended for maintenance of DOCSIS 3.0 networks only. The HCA-A amplifier has no return path and it is recommended for DOCSIS 3.1 networks. The amplifier unit is described in more details in the following section. There are also two versions of the tap unit; one with 4+1 tap ports and one with 8+1 tap ports. In addition the amplifier can be used as a stand-alone unit, which can be connected to an existing in-home network. The two tap units allows for easy enhancement of the in-home number of outlets. The "+1" tap port can be used to connect a TV-set directly, as a test port, or as an entry port for broadband in-home distribution via MoCA.

The decorative HC-C cover allows for installation of the amplifier in visible places like the living room.

The HCS family of amplifiers is shipped with Tap mounted and HC-C cover included.

The forward gain of the amplifier unit is 21.5 dB at 87.5 MHz to 25.5 dB at 862 MHz, so the amplifier has sufficient gain to service up to 9 outlets, and has 4 dB equalization to compensate for the frequency dependent cable losses.

To ease the installation and provide safety for any future distribution network changes the amplifier has an automatic gain control (AGC). The amplifier only has to be installed and the input and output cables connected, and it is ready for operation; no adjustments are need. The amplifier monitors the total incoming power and adjusts the gain accordingly. The threshold for the AGC is 80 dB μ V in the full frequency range 87.5 MHz to 1218 MHz. If the input power exceeds this threshold the gains is reduced to keep the output power level constant, refer to Figure 3.

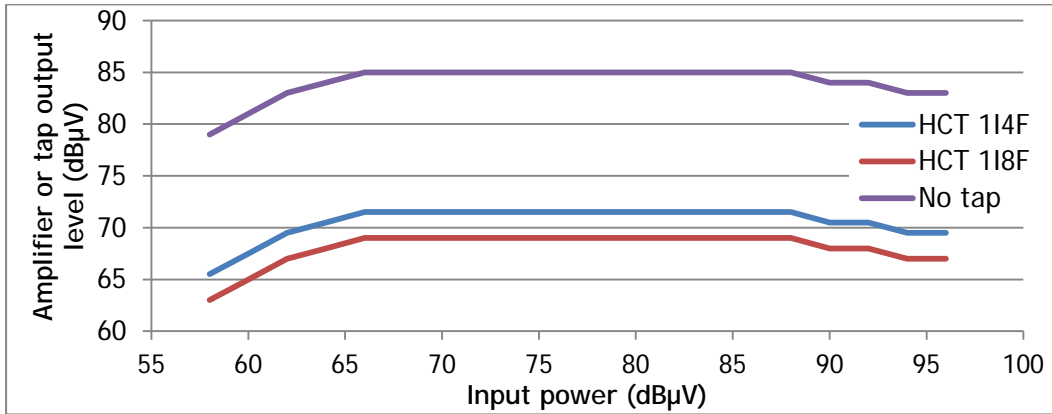


Figure 3 Amplifier output as function of the input power level for 41 PAL TV channels. “No tap” is the gain characteristic of the amplifier unit, and “HCT 114F” and “HCT 118F” are with a 4+1 and 8+1 tap unit connected, respectively.

In addition to the obvious benefit of keeping the power level in the in-home network constant the AGC also ensures the linearity of the amplifier. For analogue TV channel, as shown in Figure 4, the CSO and CTB values remain above 60 dB in the whole window of input power. In Table 1 measurements using DVB-C channels are summarized. As shown the signal quality in MER stays well above 40 dB. This test has also been made with a full load of DOCSIS 3.1 signals in the frequency range 838 MHz to 1218 MHz with similar results. Thus the amplifier preserves the signal quality in any case.

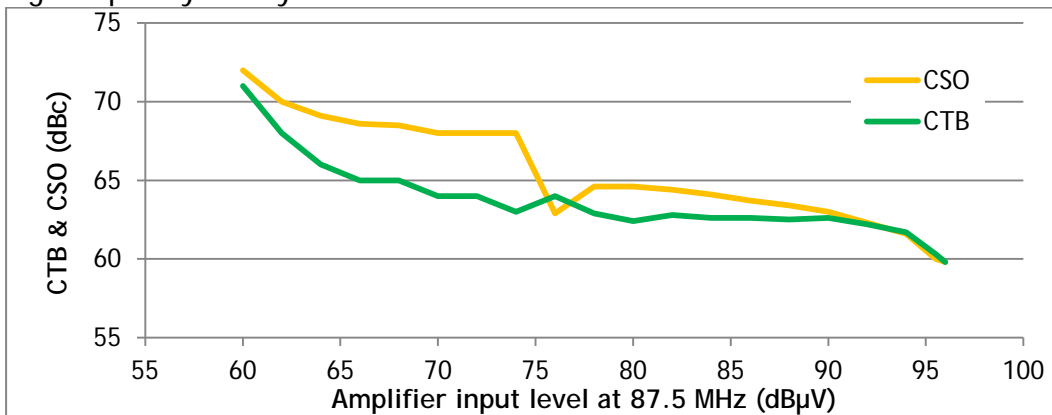


Figure 4 CTB and CSO for the HCA-A amplifier with 41 PAL TV channels.

Input Power (dBµV)	Output Power (dBµV)	Gain (dB)	BER	MER (dB)
61,8	83,5	21,7	0	43
71,8	84,6	12,8	0	44
81,8	84,5	2,7	0	46
91,8	83,4	-8,4	0	46

Table 1 Output power level, amplifier gain, BER, and MER measured with 90 QAM256 DVB-C channels. The power level is measured at 108MHz.

Conclusion - repeated

When there is a need for several TV sets in the home there is typically also a need for an in-home amplifier. This amplifier must have sufficient gain to compensate for the in-home distribution losses, and on the same time it must have a large window of linearity to preserve the signal quality, even in the case of a fully loaded DOCSIS 3.1 spectrum. Automatic Gain Control is a suitable functionality to ensure this.

For DOCSIS 3.1 services it is recommended to place the modem at the entry to the home, ensuring a controlled signal path between the modem and the CMTS and protecting the distribution network from any in-home generated noise. MoCA might then be a secure and stable alternative to standard WiFi broadband distribution within the home. The DKT HCA-A series of amplifiers contains an AGC and among other features is prepared for MoCA services.

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