INDIA'S LARGEST MAGAZINE EXCLUSIVELY FOR SATELLITE & CABLE TV

News
Editorial
Mailbox
Indian News
International News
Convergence News
Business News
Financial News

Articles
Focus: Amplifiers Survey 2002
ESPN Scores
Free To Air Channels
A 'C' Of Change
Global Broadband Trends
DW TV Turns 10
Discovery - SET Form Alliance One
Broadcast Asia 2002
ICBF Established
Channel [V] Girl Band

Technical
Multi Stage & Trunk Amps
Past Tech Archives

Columns
Dish Doctor
New Products
SCaT Seconds

Sat Updates
Channel Changes
Channel Guide

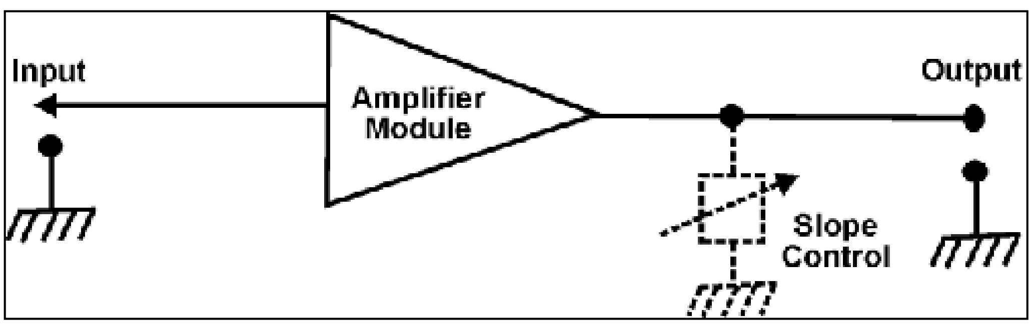
UNDERSTANDING MULTI STAGE & TRUNK AMPLIFIERS

INTRODUCTION

A variety of CATV Amplifiers are now available. Each type of CATV Amplifier offers a compromise between its technical specifications and price. An ideal CATV Amplifier should amplify the cable TV signal without adding any distortion or noise to the signal. While this definition may seem simple, it is almost impossible to implement.

TYPES OF AMPLIFIERS

The most basic type of commercial CATV Amplifier is the Transistorised Amplifier. These Amplifiers do not use a Hybrid IC. They use multiple amplifying stages implemented with discreet transistors. These low cost amplifiers are strictly speaking appropriate for Master Antenna TV applications rather than CATV applications. However, in India, they are often used in small cable TV networks, which deliver upto 24 channels for frequencies upto 300 MHz. Some manufacturers even offer transistorised amplifiers for operation upto 550 MHz. These low cost amplifiers are unsuitable for output levels above 90 dBU, with 67 channels driven simultaneously.



The line extender amplifier is a Hybrid IC based, single stage amplifier that offers reasonable performance at an attractive price. Ideally, it should only be used on the branch and last mile paths. It does not offer the lowest level of distortion or noise and hence its use should be avoided on the trunk line. Bridger Amplifiers are usually Hybrid IC based amplifiers that offer high output levels to a branch, for distribution. Some times the Bridge Amplifier; as a module; is housed within the trunk amplifier enclosure.
Trunk amplifiers typically offer the highest level of performance and also cost the most.
A trunk amplifier approaches the ideal amplifier i.e. it offers amplification with the least distortion and noise. Let us take a closer look at how this is achieved.

A SIMPLE AMPLIFIER

The block diagram of a simple amplifier is shown in Figure 1. The active electronics i.e. the section which actually amplifies the signal is clubbed together in the block diagram, as the amplifier module.

INPUT CONTROL

Since some means of varying the output signal level is required, a gain control is a must. The gain control is shown as a variable resistance connected across the input signal.
For lower output levels, the gain control is lower i.e. a smaller signal is fed into the amplifier module. Unfortunately, the setting of the external gain control does not reduce the noise generated inside the amplifier module. Hence small input signals will be adversely affected by the internal noise from the amplifier module. As a result, the Carrier to Noise ratio (C/N) deteriorates rapidly for low gain control settings, if the topology of Figure 1 is used. All practical CATV

Amplifiers need some extent of slope equalisation. This is shown as a box in Figure 1 and will add a further attenuation at the input, for lower frequencies. As a result, the slope control at the input further degrades the C/N performance at lower frequencies.

OUTPUT CONTROL

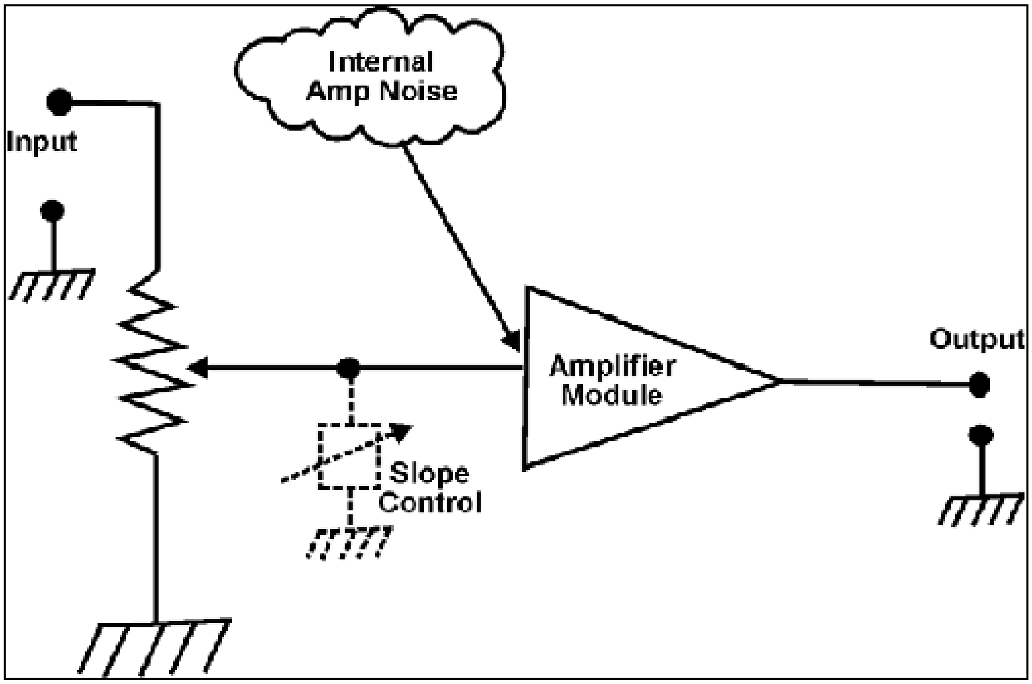


Figure 2 shows an alternate block diagram where the output signals are varied by the use of an attenuator across the output of the CATV Amplifier. This layout has the disadvantage that the amplifier module is constantly providing the highest output. Only a part of this output signal is utilised, as required. Readers who have read our earlier articles will recall that distortion increases very rapidly with output levels. A 5 dB increase in output level will increase the output distortion by 10 dB !

The slope control will have to be added across the output, as shown in Figure 2. This will present an increased attenuation or burden on the amplifier at lower frequencies, which will result in increased distortion at lower frequencies. If the ideal amplifier characteristics of zero distortion are to be achieved, the output signal level must be maintained to the lowest level actually required. Clearly, a line extender amplifier if based on Figure 1, will produce an increased level of noise (poor noise figure). Alternately, if Figure 2 is implemented, the distortion will suffer.

MULTI STAGE AMPLIFIERS

A much better performance level would therefore be achieved if the amplifier gain was split into 2 or more stages and the signal level attenuated partially over the first and second stages so that the input stage does not see too low a signal level. At the same time the output stage is not forced to operate at excessive output levels.
Figure 3 shows a block diagram of a practical trunk amplifier (Forward Path Only). The total amplifier gain of approximately 32 dB is divided over 2 sections.

PRE AMPLIFIER

As the name suggests, the Pre Amplifier is the first amplifying stage. The input signal after passing through the forward / reverse path diplexer passes through an external plug-in attenuator. In some products, this plug-in input attenuator can either be a fixed attenuator or a Thermal Equaliser. The pre amplifier receives relatively low level signals and is therefore designed to operate with low noise, at relatively modest output levels. Since output levels are not large, the pre amplifier section does not generate significant distortion.

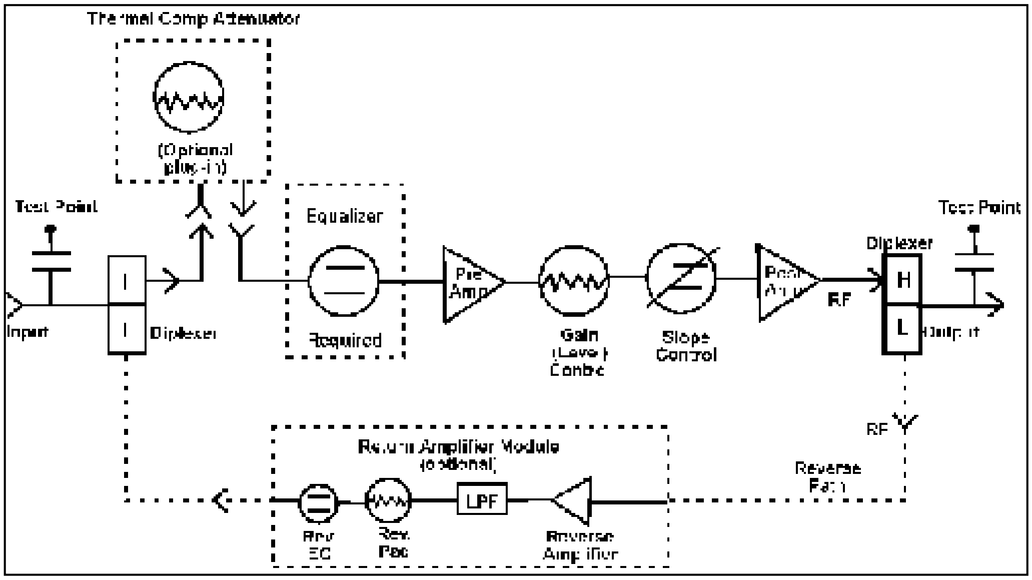
THERMAL EQUALISER

The thermal equaliser is basically an attenuator whose attenuation changes with the temperature. Since cable attenuation increases with temperature, the thermal attenuator is designed so that that its impedance decreases with temperature. As a result, the thermal attenuator compensates for cable attenuation with temperature and presents an approximately constant input signal, despite changes in ambient temperatures.
If high gain is required, without Thermal Compensation, this stage can be simply bypassed, with a shorting link.

FIXED EQUALISER

The optional attenuator / thermal equaliser is followed by a fixed equaliser. This partially compensates for the cable slope. Hence the signal to the pre amplifier is equalised in two stages viz. an optional, external attenuator or thermal equaliser and subsequently a fixed equaliser. It is important to note that only partial cable equalisation is performed prior to the pre amplifier. This ensures that low frequency signals are not overly attenuated when a large equalisation slope is required. As a result, the pre amplifier maintains a superior low frequency C/N ratio.

GAIN & SLOPE



The signal partially amplified by the pre amplifier section now passes to the main gain and slope controls. As the name suggests, the gain control allows user setting of the output signal level. The slope control permits setting of the overall slope required by the system. While some products maintain fixed pads for specific, plug-in gain and slope control values, others offer a variable potentiometer for more versatile, on site control. The advantages and disadvantages of fixed pads versus potentiometers is elaborated a little later.

POST AMPLIFIER

After the signal has been corrected for its level and slope, it is fed through the post amplifier. The post amplifier is designed to provide maximum output with the least possible distortion. Since the post amplifier already receives an input signal of fairly high signal levels, it is not necessary to optimise the post amplifier for low noise performance.

Ideally, the post amplifier should be a "Power Doubler" or "Power Quadrupler". The power doubler configuration offers double the output level (3 dB higher), with equivalent distortion compared to an ordinary push-pull Hybrid IC. The power quadrupler offers 4 times the output level (6 dB higher) than an ordinary push-pull Hybrid IC. The output of the post amplifier is fed to the output diplex filter of the amplifier.

AGC / ALC

Most trunk amplifiers offer the option of providing an automatic gain control or an automatic level control facility. The AGC / ALC module is usually offered as an optional extra. A detailed explanation on the function of the AGC / ALC circuit has been provided in earlier articles and therefore not included in this write up.

It would however suffice to inform readers that the AGC / ALC module automatically compensates for 6 to 12 dB of variation in the input signal. These variations could occur not only due to changes in cable temperature but also some times due to permanent changes such as the insertion of a one way tap off at some point in the trunk line, before the amplifier. An AGC specification of +/- 4 dB would imply a total AGC range of 8 dB.

FIXED PADS & VARIABLE ATTENUATORS

Most of the budget priced line extenders offer a variable control for adjusting the gain and slope of an amplifier. The continuous variable controls offer tremendous flexibility and ease of set up. Their operation is however, relatively unstable. The setting value tends to drift over a period of time. The settings can also be inadvertently disturbed by a mechanical movement of the spindle. Fixed pads on the other hand, offer extremely high stability as well as reliability. The fixed pads are offered in a range of values and are easily plugged in or removed at site. Gold plated contacts are used to ensure that the contacts do not tarnish or deteriorate due to the adverse outdoor ambient conditions.

The disadvantage for fixed pads ofcourse is that a large inventory needs to be maintained to cater to the specific requirement of each amplifier in the network. A good system design would typically dictate that each trunk amplifier should receive an input signal of 70 dBU to 75 dBU and provide an output signal of 95 dBU to 100 dBU. The specific figures would depend on the number of amplifiers in cascade, the distance between each amplifier, the gain of each amplifier and ofcourse whether the output stage uses power doubling technology. However an output signal level of 95 dBU to 100 dBU will generally be ideal. Once such a logical and consistent system design has been implemented, most amplifiers in the system will require a similar set of fixed value equaliser and attenuation pads. A bulk of the inventory needs to accommodate values of only about 3 dB above and below the typical value. It must be noted that fixed pads are available not only for gain control but also for equalisation.
Often even the signal path between the pre and post amplifiers incorporate both, fixed and variable control. The fixed pads provide a bulk of the compensation while the variable controls are used to simply "trim" or optimise to the exact required characteristic.

THE REVERSE PATH AMP

While the above discussions have been restricted to the forward path amplification section, the reverse path amplifier can also benefit from a similar circuit topology. The reverse path typically caters to signals from 5 MHz to 50 MHz. Manufacturers often provide a variety of diplexer options to cater to different forward and reverse path frequency splits. While a range of 5 to 50 MHz may not seem large, it must be noted that these frequencies represent a 1:10 ratio i.e. a 1 decade frequency range. Slope compensation over this one decade is often desirable particularly if the entire reverse path is to be utilised. However, most Indian networks use less than adequately shielded cable. (e.g. 60% braid RG11). Also connectoring practice is shabby. As a result, noise ingress is very substantial over the 5 MHz to 20 MHz frequency range. Due to this, most Indian CATV networks do not transmit signals in the 5 to 20 MHz range. Hence utilised reverse path is just 20 to 50 MHz. In this case, reverse path slope compensation is often not necessary.

THE TRUNK STATION

A trunk amplifier unit often houses several amplifiers and modules. As an example, the unit may house 1 Forward Path Amplifier Module + 1 Bridger Amplifier Module + 1 Reverse Path Amplifier Module and ofcourse a built in power supply. Other modules such as AGC, status monitoring, etc may also be incorporated. A unit consisting of 2 or more amplifier modules in a single housing is often referred to as a "Trunk Station".

THE FUTURE

India has rapidly absorbed 40 years of international trends and technology in cable TV in less than 10 years. Our systems have moved on from the initial primitive installations using MATV amplifiers to those currently offering 106 channels & 860 MHz operation. For these higher bandwidth systems, fiber optics provides an ideal alternate, particularly for the trunk route. Infact, preliminary cost analysis shows that a fiber optic distribution system for the trunk line may actually work out cheaper for a trunk length of 6 to 8 kilometers or longer.

In larger systems, the trunk amplifier is therefore being replaced by a fibre optic backbone, making the trunk station redundant. Alternately, smaller CATV networks that do not have a large number of cascaded amplifiers may not feel the need to deploy expensive trunk stations. The RF only trunk station is beginning to now make way for the fibre optic era.