

- March 2001 Issue
- Editor's Scatview
- Mailbox
- Indian News
- International News
- Focus : Star's Decade
- Convergence News
- Prasar Bharati - New CEO
- 7 Star - A Shining Example
- DD Portal Off Track ?
- Star TV \$300 M For DTH
- The CTMA Show 2001
- FTV - Only If Dressed Up ?
- Digi. Comp. In Broadcasting
- Indian CATV Market -2000
- Balancing Reverse Path
- Reverse Path
- Events
- Dish Doctor
- Channel Guide

BALANCING THE REVERSE PATH

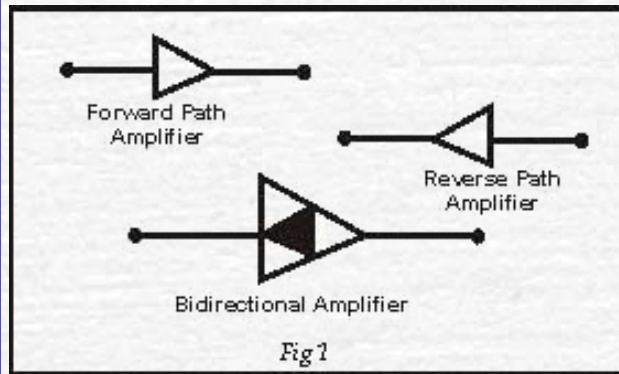
A good Reverse Path is essential for broadband delivery on a cable network. This article takes a closer look at the Reverse Path and provides tips on setting up the Reverse Path Amplifiers for optimum delivery.

INTRODUCTION

Internet and Broadband delivery provide Indian cable networks a tremendous opportunity to provide value added services. Internet delivery typically provides a revenue of Rs 1000 per month against an average of Rs 150 per month for a bouquet of 70 or more channels.

Broadband delivery also requires a fairly limited bandwidth of 2 to 8 MHz in both the forward and reverse paths. The forward path refers to signals flowing from the headend to the customers. The reverse path is the route from the customers' back to the headend. Practical experience has however shown that it is difficult to set up the reverse path for noise free operation. Unfortunately, most uninitiated cable networks believe that due to the relatively low bandwidth of 5 to 30 MHz and low cable losses at this frequency, the reverse path does not warrant particular attention. Nothing could be further from the truth. The reverse path probably demands more attention than the forward path which has, over the years already been fine tuned for TV programme delivery to customers.

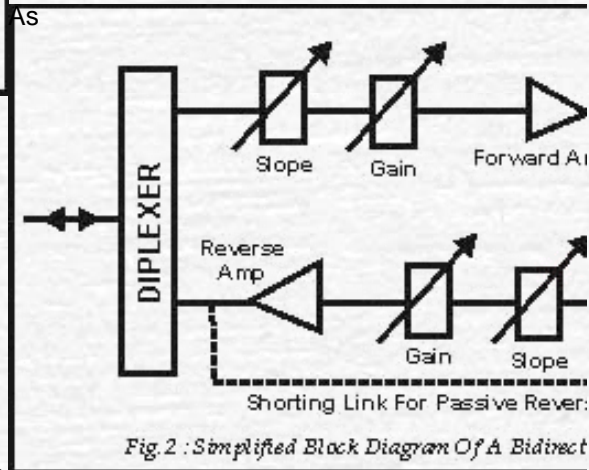
AMPLIFIER TOPOLOGY



We are all familiar with forward path amplifiers that amplify a signal flowing from the headend to the customer. Figure 1 shows the symbolic representation of a forward path amplifier, a reverse path amplifier and a bi-directional amplifier. As the name suggests, the bi-directional amplifier, amplifies signals in both, the forward and reverse paths.

indicated in Figure 2, two diplexers are used in each bi-directional amplifiers. The diplexers' function is to split or combine the in-coming and out-going signals which exists in 2 separate frequency bands. The forward path is usually allocated all frequencies above approximately 50 MHz. The reverse path is allotted frequencies from 5 MHz to approximately 40 MHz.

DIPLEXER



BAND SPLITS

Earlier Cable TV networks had practically no use for the reverse path. As a result, a relatively small frequency band of 5 MHz to 30 MHz was reserved for the reverse path. The forward path operated from 45 MHz to 860 MHz. A "Guard Band" of 31 to 44 MHz was kept aside, un-utilised, to ensure that there was no overlap or cross flow of signals between the forward and reverse paths. The traditional split was

- Reverse Path 5 MHz to 30 MHz
- Forward Path 46 MHz to 860 MHz

When modern day cable networks began exploring use of the 5 MHz to 30 MHz frequency band, earlier reserved for reverse path communications, they met with very poor results. It was observed that a large amount of noise was present on the network from 5 MHz to 15 MHz. The noise was so predominant that these frequencies were essentially unusable. Infact, the noise very often extended almost upto 20 MHz. This left, in effect, a very small frequency band of 20 MHz to 30 MHz for

carriage of reverse path signals.

Another common observation has been that noise in the reverse path diminishes at the higher end of the spectrum. Hence, the 25 MHz to 30 MHz frequency band usually provides the cleanest path. Unfortunately, this frequency span is often inadequate. As a result, Indian CATV networks have often deployed diplexers used in the US, which have been designed for the NTSC channel allocations where channel 2 is located at 52 MHz rather than 48 MHz for channel 2 in the PAL B system. Effectively, this implies that such systems in India cannot deploy TV signals on channel 2. They would commence with channel 3 in the forward path. The forward path however supports 70 or more channels and the sacrifice of a couple of band I channels is now considered quite acceptable.

The splits popularly used on Indian Cable TV networks that support Internet and Broadband delivery are:

- Reverse Path 5 MHz to 40 MHz
- Forward Path 51 MHz to 860 MHz

Some networks have gone a step further and have allocated the entire band I also to the reverse path. These networks typically use a split that provides:

- Reverse Path 5 MHz to 50 MHz
- Forward Path 70 MHz to 860 MHz
OR even
- Reverse Path 5 MHz to 65 MHz
- Forward Path 85 MHz to 860 MHz

This ofcourse implies that appropriate diplexers, providing the required frequency splits are installed in each amplifier in the network.

PASSIVE REVERSE AMPLIFIERS

Since the reverse path utilises relatively low frequency signals, the cable losses on the reverse path are usually less than 30% of the cable loss at the highest frequency in the forward path. As a result, some system engineers have not felt the need to amplify the reverse path signal at each amplifier station. They infact recommend that reverse path gain needs to be provided only at every alternate amplifier station.

This is, in practice, incorrect. Though cable losses are lower in the reverse path, the distribution losses of tapoffs and splitters are essentially the same for both, the forward and reverse paths. Hence the tapoff and splitter losses are the predominant loss and they need to be compensated.

REVERSE PATH GAIN

Another common misconception is that reverse path amplifiers do not essentially need high gain. Hence, several local manufacturers offer reverse path amplifiers with a gain of approximately 10 dB.

For a broadband network, such amplifiers are a poor choice. The loss at the two diplexers themselves typically amounts to approximately 2 dB. The gain and slope controls on the reverse path amplifier will add another 2 to 4 dB of loss. (Trunk amplifier stations with elaborate attenuator and equalisation pads often present a reverse path in / out loss of 6 dB or even 9 dB). As a result of this, the net reverse path gain finally available from an amplifier station would be approximately 6 dB.

Further, calculations will show that low gain or passive amplifiers will reduce the average signal level in the reverse path which in turn will deteriorate the noise performance of the amplifier. As a result, even though it may seem extravagant, it is recommended that a properly set up broadband network utilises high gain preferably hybrid IC based reverse path amplifier modules. These amplifier modules provide an internal gain of approximately 20 dB. After losses for diplexers, attenuators and slope equalisers are factored in, a usable reverse path gain of approximately 12 dB to 14 dB is still available. (A future article will take a close look at the requirements of high quality, bi-directional amplifier stations)

REVERSE PATH BALANCING

Figure 3 shows a line diagram of a Cable TV network with a customer's modem located some distance away from the Headend. It must be kept in mind that not just the trunk amplifiers but all amplifiers feeding signals to broadband customers, need to be bi-directional amplifiers, since the reverse path signal sent out by the cable modem must be passed right through the chain of amplifiers back to the headend. A single mal function will kill the signal.

ACCUMULATION OF REVERSE PATH NOISE

A closer look at a cable network indicates that any noise or reverse path signals fed into the system from each customer will be amplified and add up until they finally reach the headend as a large cumulative total noise. It is therefore critical that every effort is made to suppress ingress of noise from any point on the network.

CABLE MODEM OPERATION

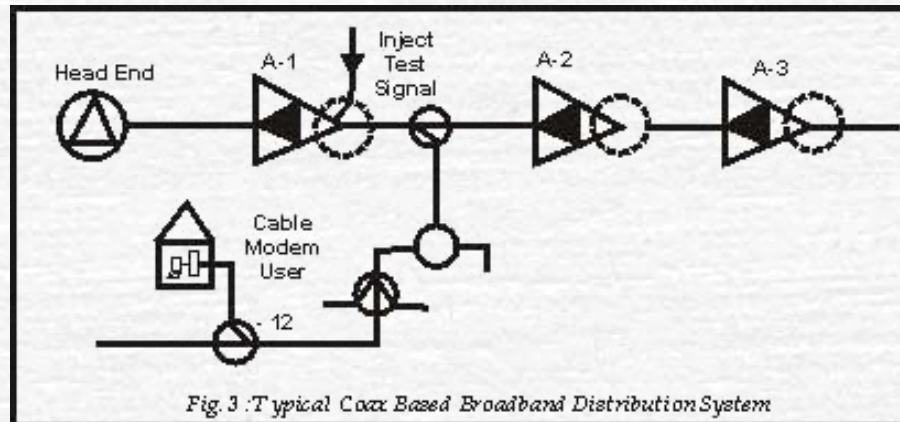


Fig. 3 : Typical Coax Based Broadband Distribution System

Let us take a quick look how a cable modem transmits and receives. The cable modem receives its signals from the headend in the forward path. It communicates back to the headend by sending out a signal in the reverse path. All cable modems incorporate essentially, sophisticated,

frequency agile modulators to generate the reverse path signal. The cable modem, at each instant, searches for an un-utilised frequency in the designated slot over which it is permitted to transmit. This output frequency may be different from instant to instant, depending on the system noise and whether another cable modem is occupying a certain frequency.

The cable modem specifications state that the cable modem will automatically vary its output signal level from 92 dBu to 112 dBu to deliver an adequately strong signal to the headend.

Let us take a closer look at Figure 3. Ignoring the cable losses, the reverse path signal loss from the cable modem to point (X) (i.e. the output of the First amplifier A-1) will be 12 dB branch loss + 2 dB in / out loss + 4 dB 2 Way splitter loss + 12 dB branch loss = 30 dB loss. Hence the cable modem will have to transmit a signal of 100 dBu if this signal is to reach point (X) as a 70 dBu signal. Add a couple of dB for cable attenuation and we realise that the cable modem is often called upon to deliver a more than 100 dB signal level! If there is a larger chain of passives, the reverse path loss will increase even further and the cable modem could very soon be called upon to put out more than its maximum specified output level of 112 dBu. A passive reverse amplifier, may sometime be the proverbial last straw!

Practical observations on a cable network have shown that cable modems are often called upon to transmit reverse path output signals of 120 dBu or even higher to ensure that their signal reaches the headend with the required Carrier to Noise (C/N) ratio. When cable modems are called upon to deliver higher than the specified outputs, they would result in a distorted signal which again will corrupt the data intended for the headend. It is not uncommon that cable modems initially installed at the customer's premises are unable to set up a reliable, loss free data path with the headend. This brings into sharp focus the need for cable networks to properly align all reverse path amplifiers on their network, for unity gain.

UNITY GAIN PROCEDURE

An external 1 Way tapoff is introduced at the output of the amplifier. (Alternatively, the amplifier output monitoring/test Point can be used for the purpose) The tapoff provides a minimal (1.5 dB) loss in its in/out path. Let us assume that the tapoff has a branch loss of 12 dB. An external test signal of 82 dBu fed into the branch will appear as a 70 dBu signal at the input of the reverse path amplifier located at that point. To generate a fixed channel or agile modulator may be used, keeping the video carrier at approximate at 25 MHz.

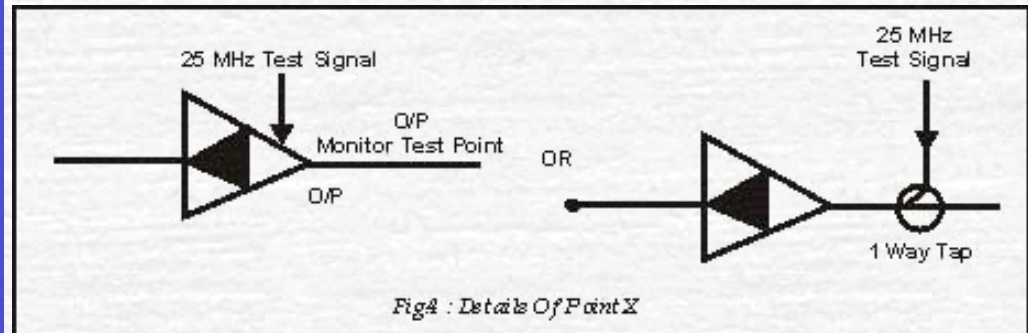
The reverse path amplifier gain now needs to be adjusted by a technician so that the test signal arrives at the headend at exactly the same level i.e. 70 dBu. For practical purposes, a spread of + / - 2 dB is permitted. This implies that the reverse path gain of amplifier A-1 should be adjusted to ensure that the headend receives the reverse path test signal at a level of 68 dBu to 72 dBu. The reverse path signal should be monitored in the control room, using a Spectra Analyser or a Field Strength Meter that can measure between 5 MHz to 40 MHz.

Since the signal received at the headend is exactly the same level as the test signal injected, the link from A-1 to the headend is a unity gain link. A-1 has now been properly set up for reverse path transmission.

The test signal generator is now shifted one amplifier down the line and A-2 is similarly equalised.

The same procedure is followed for A-3 and all other bi-directional amplifiers in the chain.

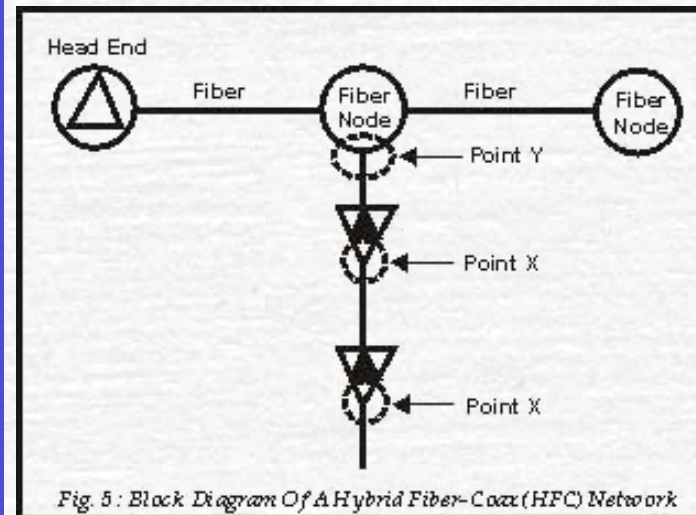
It must be noted that adjusting the reverse amplifiers, will require two technicians simultaneously in touch with each other. One technician will be at the amplifier A-1 while an associate will be at the headend. The two technicians need to communicate with each other through a walkie-talkie or mobile phone to properly adjust the amplifier levels. Other schemes of communication which require just one technician have been devised but their discussion is beyond the scope of this article.



The test signal should be representative of the actual frequencies used in the reverse path by the cable modem. A frequency of 23 MHz or

25 MHz is ideal. In systems that employ a very wide reverse path - say upto 70 MHz, it may be better to utilise two test frequencies, one at 25 MHz and another at 50 MHz to properly correct for even the reverse path slope.

REVERSE PATH WITH FIBER



Most modern day systems now incorporate fiber optics for the trunk line. As a result, the system will consist of several "nodes". Each fiber optic node essentially consists of 2 parts viz. a fiber optic receiver for the forward path signals and a fiber optic transmitter for the reverse path signals. A simplified block diagram is indicated in Figure 5. The procedure to balance a fiber optic path is exactly the same as that detailed for the coaxial network. For fiber, each fiber optic node (Point Y in Fig 5) will be injected with a 70 dBu test signal @ 25 MHz and the fiber optic node gain adjusted so that the test signal is received at 70 dBu at the headend.

After all fiber nodes are equalised for unity gain reverse path transmission, the copper distribution system consisting of reverse path amplifiers can then be corrected for reverse path gain.

CONCLUSION

It is hoped that this article provides a practical insight into the reverse path and a simple, logical method for equalising the reverse path for unity gain signal transmission. The unity gain concept ensures that a signal arriving at the input of any reverse path active device (whether a fiber node or bi-directional amplifier) is replicated at the headend. Practical implementation, though simple, is tedious but absolutely essential.

CREDIT



This article has been written by SCaT with the essential contents provided by Mr. Arvinder Singh Sahni - CEO, Spacecom Broadband Networks. SBN offers cable modem systems and all associated hardware to execute broadband delivery on existing or new networks. SBN has been involved in the successful commissioning of several broadband networks in the country and have acquired extensive experience in all aspects of implementing a broadband project.

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