AGC/ASC DESIGN

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Abstract

A unique AGC/ASC design which is capable of being cascaded in every amplifier in a CATV system without the problems associated with conventional AGC/ASC design is discussed. A conventional AGC/ASC design is compared to the new design by use of block diagrams and each function of the AGC/ASC is discussed. Finally, the measured results of the cascade performance is given.

Introduction

CATV systems require automatic gain and slope controls to compensate for cable changes due to temperature variations. The AGC in an amplifier samples the level of a reference carrier and corrects the gain of the amplifier to compensate for any level change. Over the past years, the cable industry has switched from using CW carriers for these reference carriers, to video modulated carriers and back again. There are some problems that can be encountered by using cascaded AGC/ASC's, which have caused this indecision on the use of CW or modulated pilot carriers and also whether AGC/ASC should be used in every position, every other, or every third position.

This paper discusses some of these problems associated with cascaded AGC/ASC's and presents an AGC/ASC design which overcomes these problems.

AGC/ASC

A conventional AGC/ASC design used in the cable industry is shown in Figure 1. The RF signal is sampled at the output of the RF amplifier by a directional coupler and filtered by a bandpass filter. The RF signal is then amplified, detected, and compared to a DC reference voltage to provide a correction voltage to the voltage controlled attenuator. A low pass filter after the DC amplifier filters any low frequency components which might modulate the control voltage. The low pass filter is usually a single pole filter (one capacitor to ground) to ensure stability of the AGC loop. If a CW pilot carrier is used, the filter capacitor does not have to be very large as long as the pilot filter on the input of the AGC is sharp enough to reject the adjacent channels. If modulated pilot carriers are used, the filter capacitor must be large enough to reject the low frequency components that are present in the modulated video (transfer modulation) of the pilot carrier or adjacent channels. Increasing this filter capacitor causes the time constant of the AGC/ASC loop to increase. This large time constant makes the system AGC difficult to set up and results in a long settling time for the system following a transient in this pilot signal or an adjustment of the AGC controls. In order to overcome this problem, systems using this conventional type of AGC/ASC will compromise by minimizing the number of AGC/ASC's, placing them in every other, or every third trunk station.

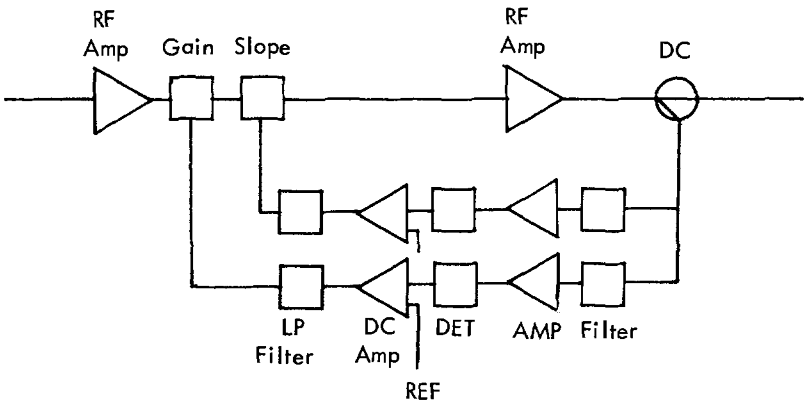

FIGURE 1

A cost savings is also claimed for this type of system using a minimum number of AGC/ASC's. The opposite is true in cases where the temperature change is large. In order to achieve the same performance with AGC/ASC in every amplifier, the system with AGC/ASC in every other position would have to operate at a lower level to allow for the variations due to temperature in the non-AGC amplifiers The lower output level would result in more amplifiers per mile at a total system cost exceeding the cost differential between AGC/ASC in every trunk station versus every other station.

RCA-AGC/ASC

RCA has designed an AGC/ASC which minimizes cascade instability resulting from a long time constant and minimizes the transfer modulation resulting from low frequency components of the video modulation. This design allows for maximum utilization of AGC/ASC's in a system for maximum performance. A block diagram is given in Figure 2 of the RCA-AGC/ASC.

RCA's AGC/ASC is designed using video detection techniques which eliminate the need for the large filter capacitor in the low pass filter. This design allows for a relatively fast time constant, excellent filtering for adjacent channel rejection and provides a high detector voltage for stability. The following is an explanation of the block diagram in Figure 2:

Hybrid Amplifiers A1 and A2 -

The hybrid amplifiers are wideband RF gain blocks within the CATV amplifier.

Gain and Slope Controls -

The signal, after being amplified by hybrid #A1, passes through a gain and slope control. These controls are a voltage controlled attenuator and variable equalizer, respectively. The AGC/ASC provides the required voltage for controlling the gain and slope of the amplifier.

Directional Coupler -

A high value directional coupler samples the level of a reference carrier at the output of the second hybrid module. A high value (15 dB) DC is used to minimize insertion loss in the output of the amplifier and to isolate the AGC/ASC from the main trunk line.

Attenuator -

The sampled signal is then passed through an attenuator. With normal signal levels in a system, this attenuator is not used. The purpose of the attenuator is to provide a wide dynamic range to the AGC/ASC for special applications. If the amplifier should be used as a transportation trunk, carrying a few channels, the levels in the trunk could be raised to improve the carrier-to-noise ratio. The sampled signal to the AGC/ASC may then be reduced by the input AGC/ASC attenuator for proper operation.

Buffer Amplifier -

The sampled signal is amplified by a wideband RF amplifier. This amplifier provides a portion of the required loop gain while increasing the isolation between the AGC/ASC filters and the main trunk line.

Pilot Filters - No. 1 and No. 2 -

The pilot filters select the pilot frequencies that will be processed to control the gain and slope of the amplifier.

RF Amplifier -

The pilot signals are further amplified by a wideband amplifier before a second set of pilot filters separate the gain and slope frequencies into separate paths. From this point, the AGC and ASC circuits are almost identical, so this description will be of the lower AGC circuit in the schematic.

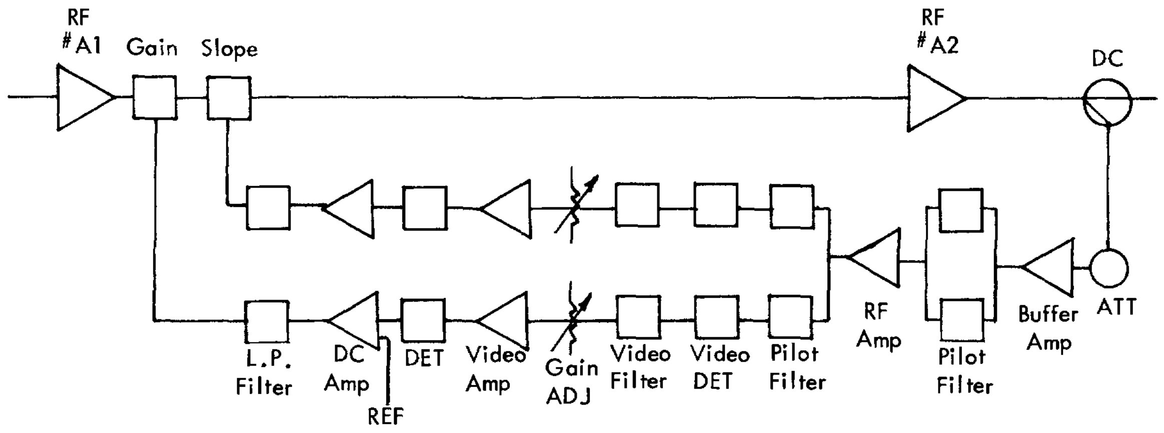

FIGURE 2

Video Detector -

If the pilot signal is a CW signal, the output of the video detector will be a DC voltage that is proportional to the amplitude of the RF signal. If the pilot signal is a modulated television channel, the video detector output will be a sync-positive video signal with the DC level of the sync-tips proportional to the level of the RF signal.

Video Filter -

The video filter limits the video bandwidth and filters out any RF components. Filtering in the video domain minimizes the effects of adjacent channels on the pilot channels with a relatively small filter capacitor. As a result, excellent filtering is provided with greatly increasing the time constant of the AGC loop.

Gain Adj -

The "Gain Adj" selects the required video level to produce the module AGC output voltage that is required by the trunk module.

Video Amplifier -

The video signal is amplified by an integrated circuit video amplifier to provide a high voltage (6 volts) to drive the following peak detector. By amplifying the AGC signal in the video domain, a more stable amplifier relative to RF gain, can be achieved. The high voltage driving the peak detector assures that the detector diode is operating in the most linear and stuble region, and the amplified sync-tips minimize the effect of the video information on the AGC loop.

Peak Detector -

The peak detector detects the peak of the video signal, or the sync-tips, in the case where the pilot frequency is modulated. It passes the DC signal resulting from a CW pilot frequency.

DC Amplifier -

The detected signal is then compared to a reference voltage and amplified.

Low Pass Filter -

With the filtering and processing done on the video, the requirement for a large filter capacitor to filter the modulated signal is not necessary. A nominal amount of filtering is used to attenuate any frequency components above the DC control voltage. The resulting DC control voltage drives the gain control to correct for any level change in the system.

Cascade Performance

A cascade of RCA Model 151 Amplifiers was tested to verify the stability and practicality of using AGC/ASC in every amplifier position for maximum performance and economy.

Figure 3 is a plot of the amplifier reaction time when the pilot level was stepped $\pm$ 2 dB. The figures show that overshoot and undershoot are present in cascaded AGC's when pulsed, but the time constant of this transient is 50 to 100 times faster than conventional AGC/ASC's (0.3 sec). This fast time constant minimizes any system instability due to transients or field set up adjustments and allows AGC/ASC to be used in every amplifier station.

The pilot signals for gain and slope were also turned off and on with settling times being the same as shown in Figure 3.

Both adjacent channels to the pilot channels, were switched on and off with less than a 0.1 dB change in the pilot level. The modulation was also switched on and off the pilot channel with less than 0.1 dB change in pilot level. This stability in the pilot level is a result of the video processing and peak detection in the AGC/ASC as discussed above.

SUMMARY:

1. AGC/ASC should be used in every trunk amplifier in a system to achieve excellent performance and economy.

2. Video processing and peak detection in the AGC/ASC minimizes the effects of adjacent channels, modulation, and other low frequency components.

3. Short time constant allows system to be easily set up because of the fast settling time and greatly reduces the duration of any transients.

4. Reliability of the total system is improved with AGC/ASC in each amplifier. If an AGC/ASC module should fail, the system will have the AGC/ASC range to make up for the failure before the system experiences any overload distortion.

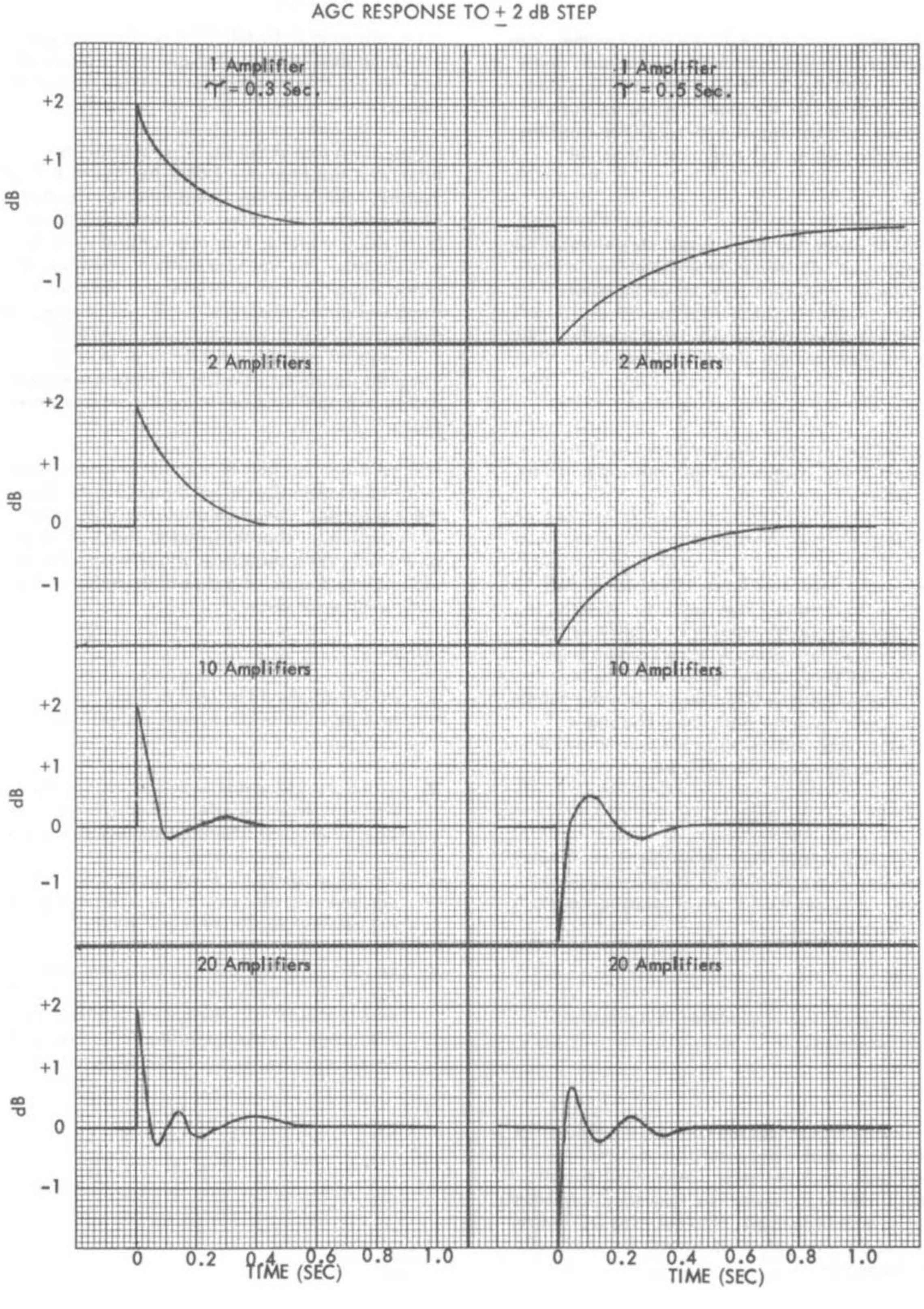
AGC RESPONSE TO ± 2 dB STEP
1 Amplifier
ϒ = 0.3 Sec.
1 Amplifier
ϒ = 0.5 Sec.
2 Amplifiers
2 Amplifiers
10 Amplifiers
10 Amplifiers
20 Amplifiers
20 Amplifiers
+2
+1
0
-1
dB
0
0.2
0.4
0.6
0.8
1.0
TIME (SEC)
TIME (SEC)

FIGURE 3