AGC- Automatic Gain Control

Overview

The AGC is a smart programmable gain amplifier (PGA). The amplifier gain is adjusted based upon the input signal level so that the output is at a specified Target Gain. The AGC can be configured to be either a mono or stereo input / output component. For illustration purposes, the following discussion will highlight the stereo configuration. Figure 1 illustrates a typical AGC response curve.

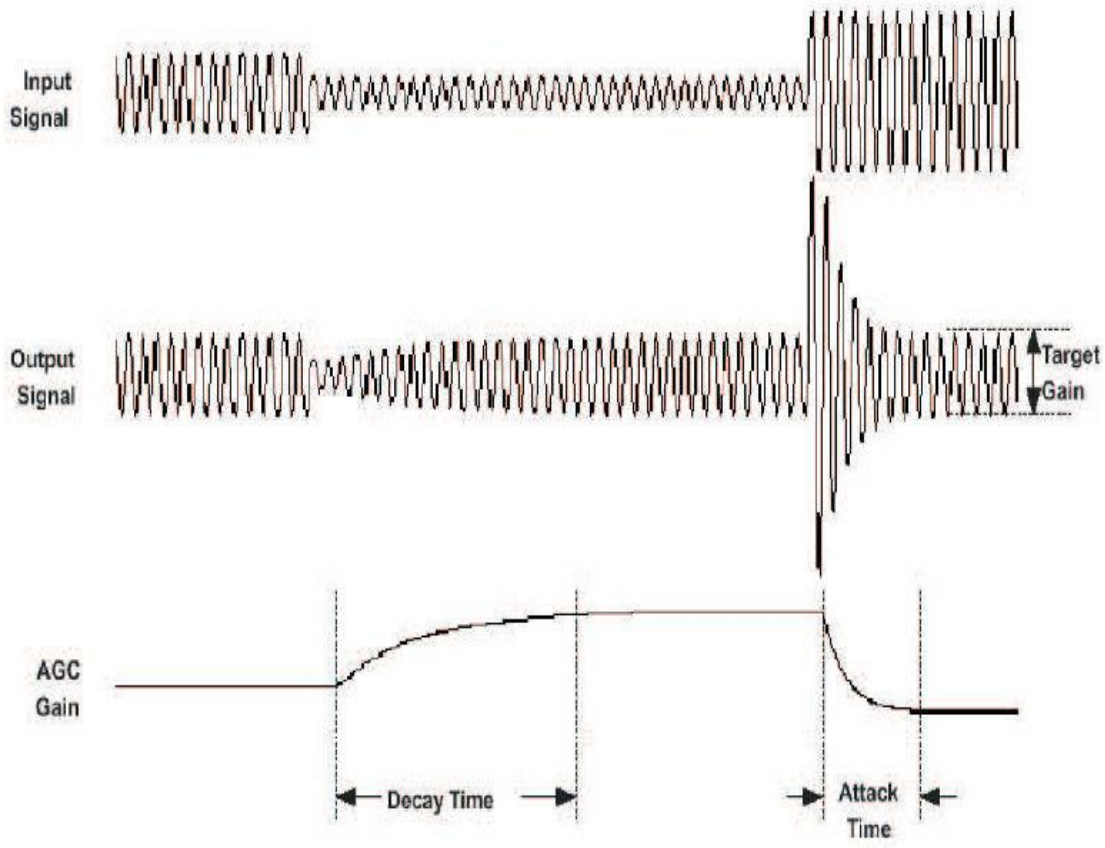

Figure 1 AGC Response Curve

There are three elements comprising the AGC:
(1) an ABS mean energy estimator,
(2) a gain control engine, and
(3) an attack / decay controller.

Figure 2 illustrates the AGC architecture.

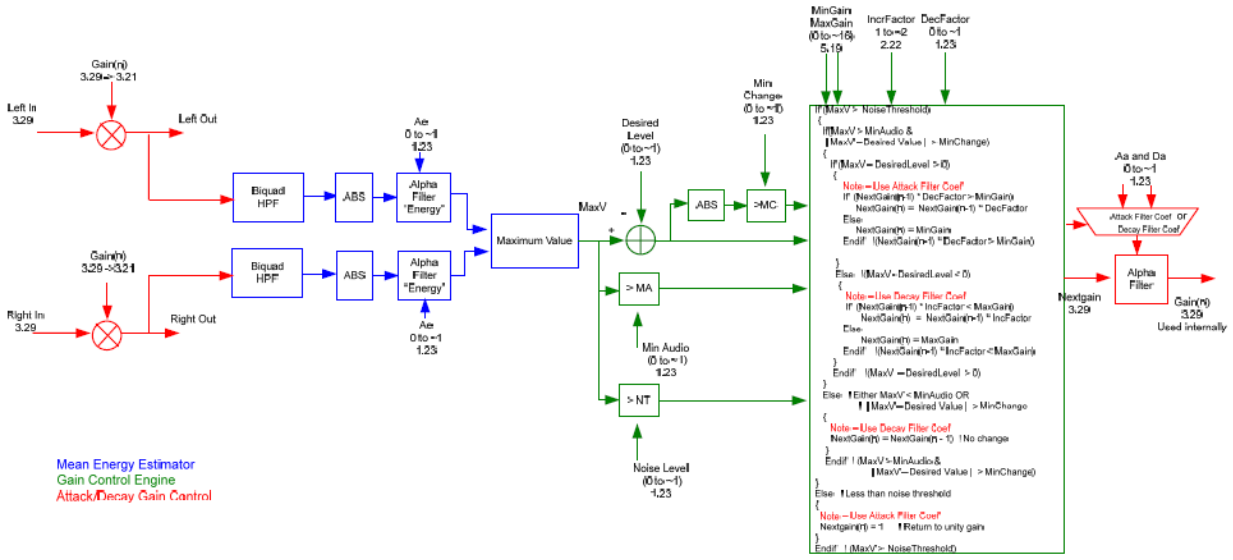

Figure 2 AGC Architecture

Absolute Value Mean Estimator

This AGC element derives an estimate of the average absolute value of the audio data stream into the AGC. For stereo AGC block, the individual channel energy estimates are computed. The outputs of the estimators are then compared, sample-by-sample, and the larger value sample is forwarded to the compression / expansion coefficient computation engine. Two programmable parameters, a_e and $(1 - a_e)$, set the effective time window over which the average absolute value estimate is made. The time window over which the average absolute value estimation is computed can be determined by:

$$t_{window} = \frac{-1}{Fs \ln(1 - a_e)}$$

The Gain Control Engine

This AGC element uses the output of the average absolute value estimator plus level and other control inputs to generate a next gain control output. The Gain control engine has three gain regions. When signal is above the minimum signal level (**AGC_MIN_AUDIO**), the signal level can be adjusted to approach a desired level by changing a gain factor that is applied to the signal. In computing the gain level, a Minimum Change threshold is used to provide hysteresis to the control when the signal level is close to the desired level. This prevents low level noise in the measured signal level from causing the system to alternately increase and decrease gain when the value is close to the desired level. This threshold is the Minimum Change value (MC, **AGC_MIN_CHANGE**). The signal level is adjusted by a Gain signal. The gain signal is produced by smoothing the output of a digital control signal, NextGain, with an alpha filter. When the input signal level is below (Desired level - MC), NextGain is increased by multiplying its previous value (NextGain (n-1)) by IncrFactor (**AGC_INC_FACTOR**). When the signal level is above (Desired level + MC), NextGain is decreased by multiplying its previous value (NextGain (n-1)) by DecFactor (**AGC_DEC_FACTOR**). When the signal is between these two levels (desired level – MC < signal level < desired level + MC) the NextGain value is unchanged. The maximum NextGain value is MaxGain (**AGC_MAX_GAIN**). The minimum NextGain value is MinGain (**AGC_MIN_GAIN**). When the signal is between the Noise level and the Min Signal level the gain is held at the last gain setting. This is a hysteresis zone to prevent rapid switching the large boost that will be applied for low signals and a gain of 1 that will be applied for signal that are below the noise threshold. A ***Noise Threshold***

(**AGC_NOISE_LEVEL**) is a level or threshold for AGC to distinguish noise from a small signal, so that noise lower than the threshold cannot be amplified. For the AGC, a signal lower than the noise threshold is considered as *noise*, and a signal higher than the noise threshold is considered to be the *signal* or *normal*. When the input is below the Noise Level, the NextGain is set to 1.

Attack / Decay Control - This AGC element controls the transition time of changes in the coefficient computed in the Gain Control Engine. Four programmable parameters define the operation of this element. Parameters a_d and (1 - a_d) set the decay or release time constant to be used for signal amplitude boost (expansion). Parameters a_a and (1 - a_a) set the attack time constant to be used for signal amplitude cuts. The transition time constants can be determined by:

$$t_a = \frac{-1}{Fs \ln(1-a_a)}$$

$$t_d = \frac{-1}{Fs \ln(1-a_d)}$$

Configurable Properties

Properties	Scaling	Default Value	Description
AGC_B0	1.23	0.9999998807907104492187 5	Biquad coefficient
AGC_B1	1.23	0.0	Biquad coefficient
AGC_B2	1.23	0.0	Biquad coefficient
AGC_A1	1.23	0.0	Biquad coefficient
AGC_A2	1.23	0.0	Biquad coefficient
AGC_ENERGY	1.x	0.00188779830932617187 5 (12 ms.)	a_e = 1- exp(-1/(Fs*t_window))
AGC_ATTACK_COEF	1.x	0.00565278530120849609375 (15 ms.)	a_a = 1- exp(-1/(Fs*ta))
AGC_DECAY_COEFF	1.x	0.00151050090789794921875 (4 ms.)	a_d = 1- exp(-1/(Fs*td))
AGC_DESIRED_LEVEL	1.x	0.25 (-12 dB)	Desired gain level
AGC_MIN_AUDIO	1.x	0.000998973846435546875 (-60 dB)	Minimal signal level
AGC_NOISE_LEVEL	2.x	0.0000998973846435546875 (-80 dB)	Noise threshold
AGC_MIN_CHANGE	1.x	0.006249904632568359375	Minimum change value (MC)
AGC_MIN_GAIN	5.x	0.0625 (-24 dB)	Minimal NextGain value
AGC_MAX_GAIN	5.x	15.9999980926513671875 (+24 dB)	Maximal NextGain value
AGC_INC_FACTOR	2.x	1.0000782012939453125 (+30 dB/sec.)	NextGain increase factor
AGC_DEC_FACTOR	2.x	0.99979114532470703125 (-80 dB/sec.)	NextGain decrease factor