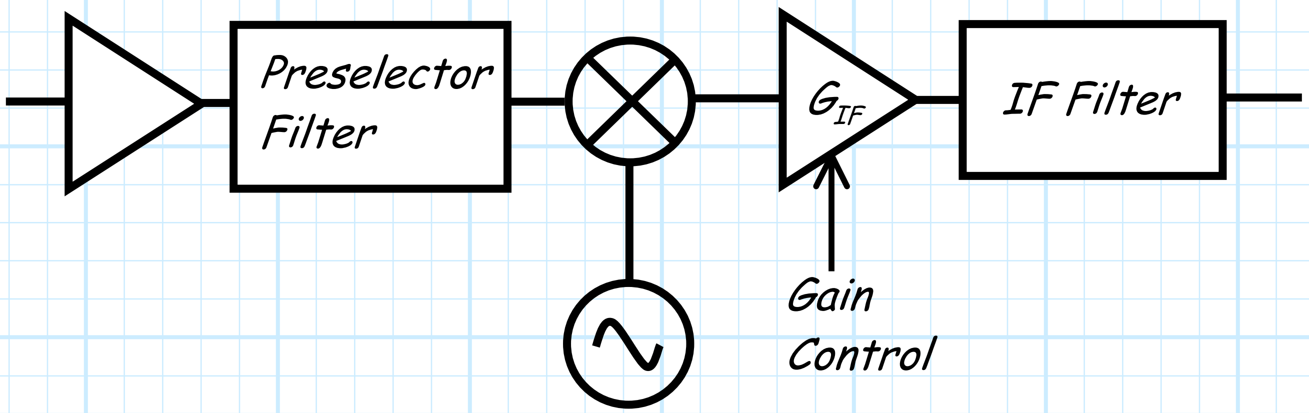
AGC

To implement **Automatic Gain Control** (AGC) we need to make the gain of the IF amplifier **adjustable**:

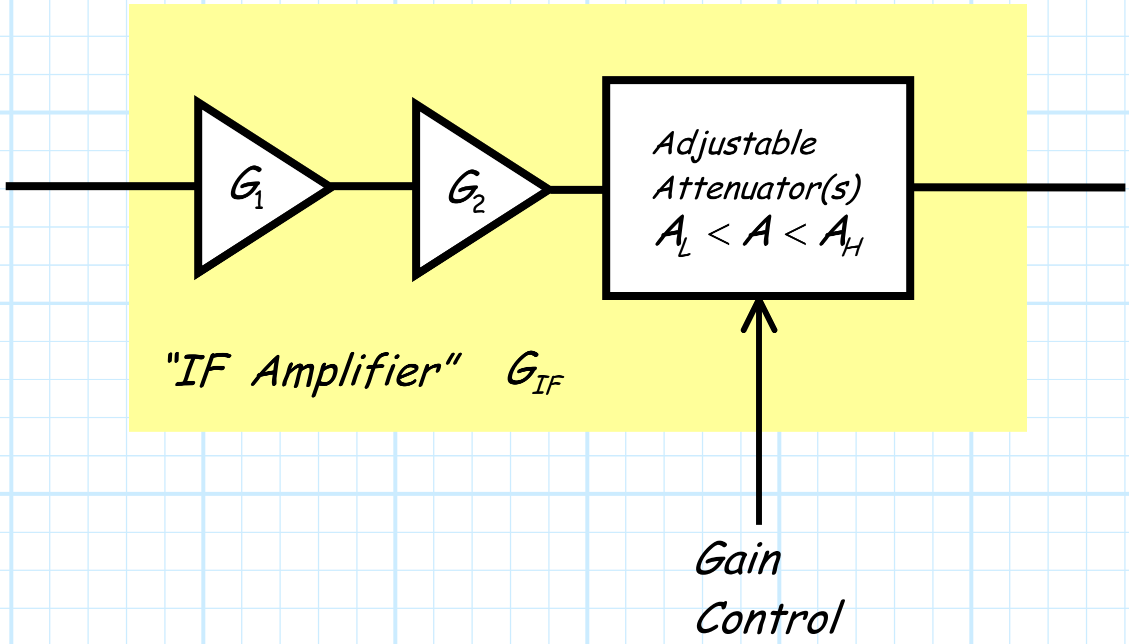


Q: ***Are** there such things as **adjustable gain** amplifiers?*

A: Yes and no.

Typically, voltage controlled amplifiers work **poorly**, have **limited** gain adjustment, or **both**.

Instead, receiver designers implement an adjustable gain amplifier using one or more **fixed gain amplifiers** and one or more **variable attenuators** (e.g., digital attenuators).



Two amplifiers are used in the design above, although one, two, three, or even four amplifiers are sometimes used.

The adjustable **attenuator** can likewise be implemented in a number of ways. Recall the attenuator can be either **digital** or **voltage controlled**. Likewise, the attenuator can be implemented using either **one** attenuator, or with **multiple** cascaded attenuator components.

However it is implemented, the **gain** of the overall IF amplifier is simply the **product** of the fixed amplifier gains, **divided** the total attenuation *A*. Thus, for the example above:

$$G^{IF} = \frac{G_1 G_2}{A}$$

Now, the key point here is that this gain is **adjustable**, since the attenuation can be varied from:

$$A_L < A < A_H$$

Thus, the IF amplifier gain can **vary** from:

$$G_L^{IF} < G < G_H^{IF}$$

Where G_L^{IF} is the **lowest** possible IF amplifier gain:

$$G_L^{IF} = \frac{G_1 G_2}{A_H}$$

And G_H^{IF} is the **highest** possible IF amplifier gain:

$$G_H^{IF} = \frac{G_1 G_2}{A_L}$$

Note the **gain** is the **highest** when the **attenuation** is the **lowest**, and vice versa (this should make **perfect** sense to **you**!).

However, recall that the value of the **lowest attenuation** value is **not equal to one** (i.e., $A_L > 1$). Instead A_L represents the **insertion loss** of the attenuators when in their minimum attenuation state.

Recall also that the **total receiver gain** is the product of the gains of **all** the components in the receiver chain. For example:

$$G = G_{LNA} G_{preselector} G_{mixer} G^{IF} G_{IFfilter}$$

Note, however, that the only **adjustable** gain in this chain is the **IF amplifier** gain G^{IF}, thus the remainder of the receiver gain is **fixed**, and we can thus define this **fixed gain** G_{fixed} as:

$$G_{fixed} = \frac{G}{G^{IF}}$$

Thus, G_{fixed} is simply the gain of the entire receiver, with the **exception** of the IF amplifier.

Since the gain of the **IF amplifier** is adjustable, the gain of **entire receiver** is likewise adjustable, varying over:

$$G_L < G < G_H$$

where:

$$G_L = G_{fixed}\, G_L^{IF}$$

and:

$$G_H = G_{fixed}\, G_H^{IF}$$

Thus, a receiver designer must design the "IF Amplifier" such that the **largest possible** receiver gain G_H **exceeds** the minimum gain requirement (i.e., $G_H > G_{min}$)—a requirement that is applicable when the receiver input signal is at its **smallest** (i.e., when $P_{in} = MDS$).

To accomplish this, we find that:

$$
\begin{aligned}
G_H &> G_{min} \\
G_{fixed} G_H^{IF} &> G_{min} \\
G_H^{IF} &> \frac{G_{min}}{G_{fixed}}
\end{aligned}
$$

Thus, since $G_{min} = P_D^{min} / MDS$ we can conclude that the **highest possible** gain G_H^{IF} of our "IF amplifier" **must** exceed:

$$G_H^{IF} > \frac{P_D^{min}}{G_{fixed}\, MDS}$$

or

$$G_H^{IF}(dB) > P_D^{min}(dBm) - G_{fixed}(dB) - MDS(dBm)$$

Additionally, a receiver designer must design the "IF Amplifier" such that the **smallest possible** receiver gain G_L is **less** that the maximum gain requirement (i.e., $G_L < G_{max}$)—a requirement that is applicable when the receiver input signal is at its **largest** (i.e., when $P_{in} = P_{in}^{sat}$).

To accomplish this, we find that:

$$G_L < G_{max}$$

$$G_{fixed} G_L^{IF} < G_{max}$$

$$G_L^{IF} < \frac{G_{max}}{G_{fixed}}$$

Thus, since $G_{max} = P_D^{max} / P_{in}^{sat}$ we can conclude that the **lowest possible** gain G_L^{IF} of our "IF amplifier" must be **lower** than:

$$G_L^{IF} < \frac{P_D^{max}}{G_{fixed}\, P_{in}^{sat}}$$

or

$$G_L^{IF}\left(dB\right) < P_D^{max}\left(dBm\right) - G_{fixed}\left(dB\right) - P_{in}^{sat}\left(dBm\right)$$

Q: *I'm still a bit confused. Now what is the* ***difference*** *between G_{min}, G_{max} and G_L, G_H?*

A: The values G_{min} and G_{max} are in fact **requirements** that are placed on the receiver designer. There **must** be some IF gain setting that will result in a receiver gain greater than G_{min}, and there **must** be some IF gain setting that will result in a receiver gain less than G_{max}.

In contrast, the values G_L and G_H are the **actual** minimum and maximum values of the receiver gain. They state the performance of a **specific receiver design**.

Properly designed, we will find that $G_H > G_{min}$, and $G_L < G_{max}$. However, this is true **only** if we have properly design our "IF Amplifier"!