Auto-Volume Control

A clever automatic volume control for your PA System.

By C. Capel and P. Green

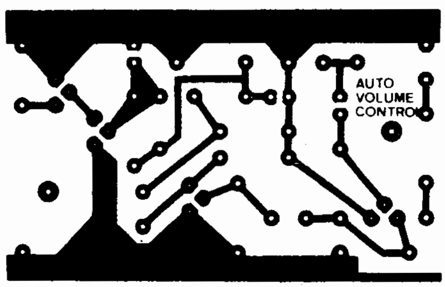
AUTOMATIC VOLUME control has been used for years in broadcast radio receivers, at least it has been termed automatic volume control although it was actually automatic gain control. AGC responded not to changes in the audio frequency output, but fluctuations in the level of the RF carrier. Part of the carrier appearing at the last IF stage was rectified, applied to a circuit having a time constant sufficient to remove audio modulations, then fed as a DC control potential to the grid circuit of the first IF stage. Thus fading was reduced and strong local carriers did not produce overloading of later stages. This illustrates the rather confused manner in which the term is used.

Expanding On Compression

Another confusing idea often encountered is between automatic volume control and volume compression. Although both are concerned with audio levels and their control, there is an important difference that dictates which feature should be used in a particular application.

With volume compression, the dynamic range is reduced and the gain of the circuit varies according to the amplitude of the signal. This reduction may take place over the whole range of signal levels, or it may start at some predetermined threshold below which the circuit behaves normally with linear gain. Above it, the signal produces an output which is proportionally less as the amplitude increases.

Volume compression is used where the dynamic range (the range between the loudest and softest signals) is too great for the equipment of system to safely handle. Either the loud signals would overload the circuit, over modulate the carrier, or introduce unacceptable distortion, or the soft signals would approach the noise level so that a poor signal-to-noise ratio would result. Broadcast radio transmissions are an example of the use of compression, and the compressed result is generally considered satisfactory for domestic listening.



The PCB artwork for the Auto-Volume Control.

Orchestral Manoeuvres

It may be worth mentioning at this point that there is often a considerable 'overkill' in the range stipulated in hi-fi circles. Some quote figures around 70 dB as the range between the quietest and loudest sounds produced by a symphony orchestra. Measurements of sound levels made by the author at public symphony concerts failed to produce anything like this. The difference between the quietest passages (whispering strings) and full-blooded climaxes with percussion, brass and everything else playing flat out was little more than 45 dBA.

The opportunity has not arisen for measurements during large scale choral and orchestral works in which a somewhat wider span could be anticipated, but from theoretical calculation it would not be a lot more. For example if a choir and orchestra each generated 45 dB, together the combined sound level would be only 48 dB.

Levelling Off

Automatic volume control does not reduce dynamic range by lessening the amplitude of loud signals more than that of quiet ones. it reduces the overall level (so that both loud and quiet sounds are affected equally) when the level is high, and increases it when the overall level is low. The operation is the same as that of a manual volume control, except it is automatically actuated by the signal.

One common use is the automatic recording level control that is incorporated in most portable cassette recorders. This permits recordings to be made without

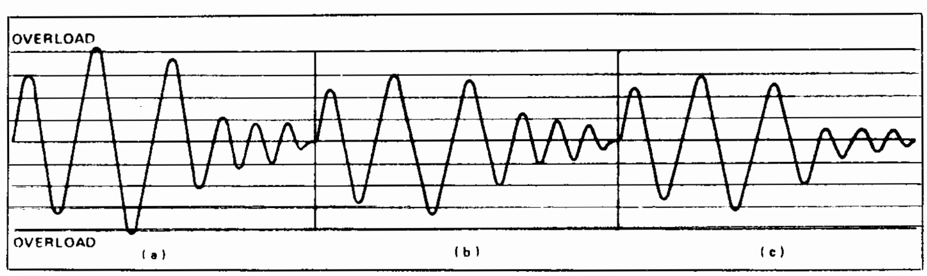


Fig. 1 A signal comprising successive loud and soft tones. The tone exceeds the overload level of the equipment (a). With volume compression, the loud tone is reduced more than the soft one, reducing dynamic range (b). With utomatic volume control, all the signals are equally reduced (c).

trial runs and careful watching of the recording level meter. Though very useful for spontaneous recordings it does have its drawbacks in being too inflexible in the form usually used. Fades, either up or down, cannot be executed as there is normally no recording level manual control. The effect is also less than satisfactory when recording music which has sudden changes of volume. The manual override which accompanied the first automatic level circuits in recorders now seems to have disappeared completely.

PA Problems

Public address systems are another application for which auto level control is ideal. Many platform orators are notoriously bad microphone users; they turn away and often step away from the rostrum, while at other times some lean forward and shout into the microphone to emphasize a point. As the level varies according to the square of the distance between the lips of the speaker and the microphone, some pretty hefty volume changes take place. With interviews or forums there may be a variety of participants, some soft-spoken and some loud. Any of these may shift his position during the programme and wind up nearer or further from the microphone. The poor PA operator struggles manfully to compensate by rapid adjustment of the sliders, sometimes the wrong ones, and in the wrong direction. No wonder they sometimes emerge from a session as nervous wrecks!

It was for the purpose of PA control that our unit was designed, and it has proved very useful. However, there are no doubt other applications for which readers may find it practical. Being comparatively small it could be built into most existing amplifiers or mixers, drawing only a small amount of current from the power supply. However, if desired it could be mounted in a separate box with a battery supply.

Alternative Technology

Several methods were tried (and rejected) in order to achieve satisfactory auto-control. The simplest method (which has been frequently used for cassette recorder ALC circuits) is to rectify part of the output and apply it as negative bias to an early NPN transistor (or positive bias to a PNP device). This way the forward bias is reduced, reducing the collector current and also the gain of the circuit (Fig. 2).

There are several snags with this arrangement. One is that with the reduction of base current on which the signal current is superimposed, the capability of the circuit to handle large signals is also reduced. Now this occurs precisely at the time when large signals are present at the base, which are not affected by the gain of the following circuit. Therefore there is a strong possibility of overloading and distortion, the stronger the signals are, the smaller the base current becomes.

Overloading is less likely in a cassette recorder when the internal microphone is being used, as close-talking is not usual under these circumstances. But it could occur if a high sensitivity external microphone or auxiliary input were being recorded. It could certainly occur when used as a general automatic volume control for PA or other purposes.

The other drawback is that noise in a transistor is dependent on the current in the base and collector circuits; the larger the current, the greater the noise. As the current varies with the operation of the automatic control, noise will also vary. However, the current, and hence the noise, is greatest in the absence of a signal, and least when the signal is at a maximum. This of course is the opposite to what it should be, as noise is relatively unimportant in the presence of large signals which mask it.

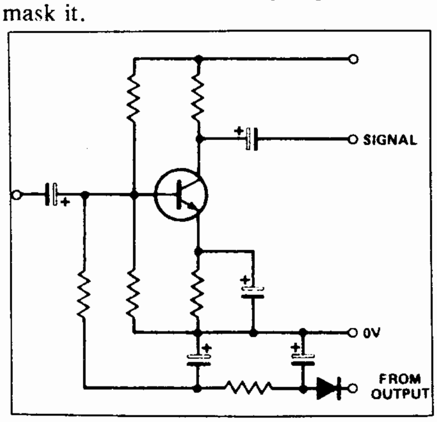


Fig. 2 A simple AVC circuit as used in some cassette recorders for recording level control. It can be overloaded as the forward bias is reduced by a strong signal.

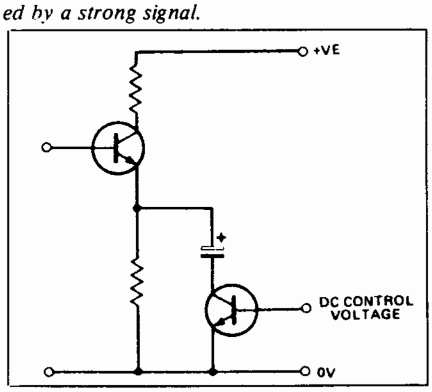


Fig. 3 Experimental circuit for controlling the gain of a stage by varying the negative feedback.

Variable Variation

Another circuit which at first seemed promising (Fig. 3) consisted of a transistor used as a variable resistor. This was controlled by a rectified voltage derived from the output, which was connected in series with an emitter bypass capacitor. The signal developed over the emitter resistor by the collector current is in opposition to the applied signal between base and emitter, thereby providing a form of negative feedback. When bypassed with a capacitor having a low reactance compared to the emitter resistor, the feedback disappears. Continued on page 38

How It Works

The signal is sampled from the output of the mixer or some other convenient high-level point, and is applied to the potentiometer PR. This permits the amount of AVC to be preset. SW1 shorts the preset wiper to ground, which allows the circuit to be switched out without disturbing the control setting.

Q1 amplifies the control signal and the output is applied to Q2; this is an emitter follower with a low impedance output and high current sourcing. The purpose of this is to ensure that the capacitors C4 and C5 charge rapidly at the onset of a sudden loud sound and so achieve a quick reaction. The capacitance of these components has been limited for the same reason.

After rectification by D1, the DC control signal charges C5 through D2 which offers a low impedance path. However, the capacitor cannot discharge back through D2 because of reverse polarity, but does so through R8 and R7. Thus the discharge is considerably slower than the charge, so the control signal doesn't fluctuate with every change in amplitude of the original signal (which would result in volume compression). Instead it maintains a level which corresponds with the average level of the incoming signal; thus if a quiet signal follows immediately after a loud one, the same dynamic range is maintained and the gain drifts back only slowly to the previous level. Small changes in signal amplitude as in normal speech have little effect.

The rapid initial response greatly reduces the devastating effect of the explosive consonants P and B when spoken too close to the microphone. But because the general overall level is governed by the average input signal, the circuit evens out longer variations which arise when a speaker turns his head away from the microphone to address one section of his audience.

Transistor Q3 drives the control transistor Q4, which behaves as a variable resistor and is connected as the bottom leg of a potentiometer across the signal source. The upper leg is a fixed resistor, and the tap between them is the variable point for feeding the following amplifier. A shunt resistor is connected across Q4 to maintain the load on the source when the transistor is cut off.

When a large signal is received, Q4 is made conductive and the resistance of the bottom leg reduced, changing the ratio between it and the top leg. When the signal is small the opposite happens and Q4 becomes less conductive, increasing the lower leg resistance. Thus the circuit operates in the same manner as a manual volume control, by reducing the signal applied to the controlled stage rather than changing the gain of the stage itself. Therefore it can't be overloaded and self-generated noise remains the same. Noise from earlier stages is reduced along with the signal, so the drawbacks of other control circuits are eliminated.

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A variable resistor in series with the capacitor enables the gain of the stage to be varied in sympathy with the signal amplitude by changing the total impedance across the emitter resistor and also the amount of negative feedback.

Unfortunately, the circuit proved unsatisfactory in practice because the DC charge in the capacitor changed according to the value of the series resistance.

into existing mixers or amplifiers, the top leg resistor of can be inserted in series with the main volume control at its 'high' end. The transistor is connected across the control which therefore serves as the shunt described in the 'How It Works' section. The value of the top leg resistor should be about a tenth of that of the volume control, so a 25k control would need a 2k2 resistor. This will reduce the gain of the

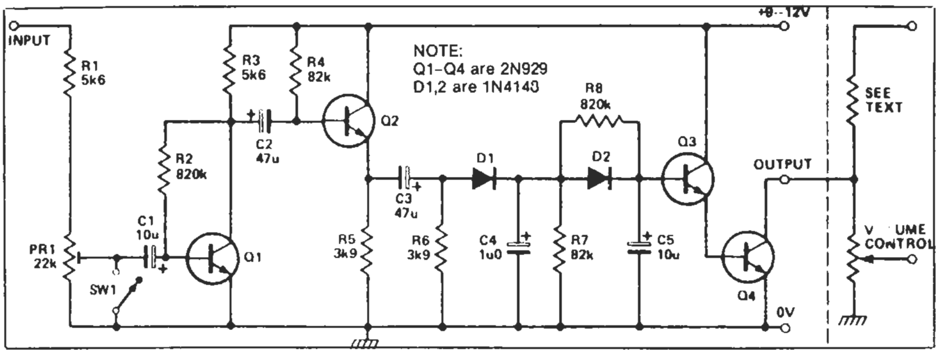

Fig. 4 The circuit of the AVC unit, showing the connections required when it's built into existing equipment.

Design Developed

Finally, the circuit shown in **Fig. 4** was developed, and with some minor modifications over a period of use has proved to be very effective. When the device is built

amplifier by an eleventh or less than 1 dB. If the unit is constructed in a separate control box, the shunt resistor can be 47k and the upper one less than a tenth at 3k3.

Parts List

Resistors (all 1/4W, 5%)

R1,3 . . . . . 5k6
R2,8 . . . . . 820k
R4,7 . . . . . 82k
R5,6 . . . . . 3k9
PR1 . . . . . 22k potentiometer

Capacitors

C1,5 . . . . . 10u 16V PCB elect.
C2,3 . . . . . 47u 16V PCB elect.
C4 . . . . . 1u0 16V PCB elect.

Semiconductors

Q1-4 . . . . . 2N929
D1,2 . . . . . 1N4148

Miscellaneous

SW1 . . . . . SPST or SPDT (see text)

Manual Mode

The AVC control is shown as a preset mounted on the circuit board, but if desired it could be an ordinary manual control fitted either to the control panel of the mixer or on the case of a separate unit.

A manual control is useful as different conditions call for different degrees of control. In the lowest positions, operation of the control automatic circuit is not noticeable to an audience, but the

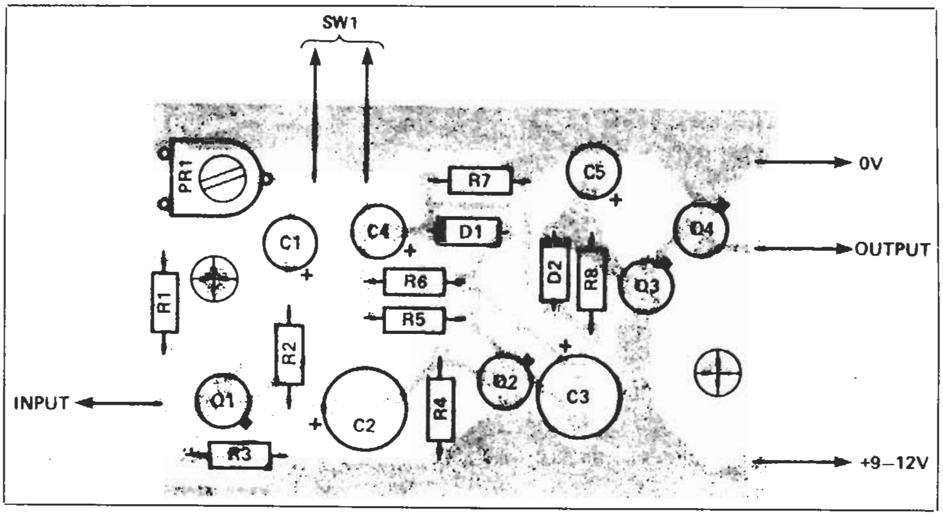

Fig. 5 Component overlay for the AVC unit.

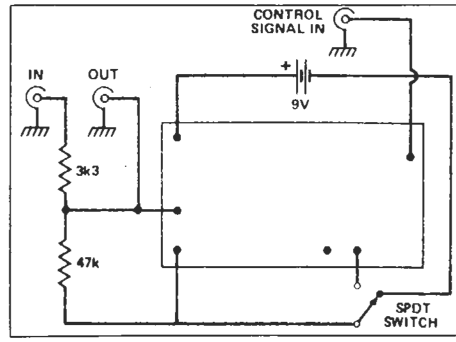

Fig. 6 Board connections to peripheral components when used as a separate control box. PR1 can be replaced by a manual control on the panel if desired.

operator can see form his output meters that the loudest signals are restrained and kept within the range of the equipment. At the other extreme, if turned fully up, the loud sounds come out quieter than the soft ones. This degree of control would obviously never be used, and the setting will be somewhere well below that.

Modifications

A switch can be incorporated, if desired, to short the wiper of the control to ground. The same effect is obtained by turning down the control to zero, but the separate switch enables a particular control setting to be preserved when the circuit is switched out. Another optional feature is that the switch can be a double pole type with the second pole arranged to switch a LED on and off as an indication that the automatic circuit is in operation. ■

