By J.R. Laughlin

An Automated Level Control

Here's an inexpensive, easy-to-build sound level control.

PHOTO 1: The finished audio level control.

This circuit contains an audio amplifier capable of driving a speaker with circuitry that automatically maintains the same relative maximum output regardless of extreme levels that are occurring at the input. It does not "compress" the peaks, but simply "turns down the volume" as you would do with your volume control (**Photo 1**).

This maintains a steady output volume for very widely varying input levels. Extremely low distortion results from the use of a self-adjusting, purely resistive voltage divider circuit to perform this action, an LDR (light dependent resistor), instead of a semiconductor device. The distortion produced by the LDR was unmeasurable with my H.P. 5L4N spectrum analyzer. I thought that the particular voltage divider used here was an interesting approach to perform this. I originally designed the circuit to be used with an old audio oscillator whose output level varied considerably with changes in frequency. It cured that problem beautifully.

I also have applied it to the following:

- regulating TV sound level (loud advertisements!)
- my front door intercom
- CB radio and amateur radio sound regulation
- a public address system
- music systems

The circuit (**Fig. 1**) is very inexpensive to build and the operational current level quite low, making battery operation feasible. Several of my friends have built their own and they have all really enjoyed putting it to use. I am certain all you readers will also.

CIRCUIT OPERATION

U1 receives the audio. It has adjustable gain with R14, which has pads to accommodate a fixed resistor or a variable one. You can use R19 to adjust input level. C10 is useful with R18 for elimination of RF (if present) and also to adjust high-frequency rolloff. You can use R26 for adjustment of input if needed.

The op amps are operated with positive supply voltage only; they must have the inputs biased to approximately half of the supply voltage. This is done using R29 and R31 to supply the half voltage, which biases pin 3 of U1 through R25. The DC output of U1 is also equal to this half voltage; because of C5, the DC gain of U1 is only 1. Note that this half DC voltage is transferred to the input of U2 through R12 and 13, providing bias for it also (U2 DC gain is 1 also, C2).

Input bias current of U1 and U2 is so very small that the resistors do not have any important effect on the DC bias level. Audio out is present at pin 6, U2, or from the output of U3, which is used as the speaker driver. You can connect the input to U3 to R5, R8, or to C1, and adjust the U3 (LM386) gain over a range of 20 to 200 using R27. It will deliver approximately 0.4W to 8Ω with an 8V supply.

You can obtain P-P output voltage close to the DC supply level from the LM386 output for resistive loads from approximately 100Ω up. Note that the power supply is very simple and conventional. You can use D3 with DC power to prevent any problems if you accidentally apply a negative supply voltage to the input terminals. Of course, it is needed for AC power input.

HOW IT WORKS

The use of U4 is optional; there is really no need for it if you use an applied voltage that is compatible with the ICs. Here is a simple explanation of how the leveling is accomplished:

1. Audio from the INPUT terminal goes through U1, with adjustable gain.
2. This audio is amplified by U2, gain set by R4.
3. If the audio amplitude is large enough from U2, it is clamped positive by C3 and D2 provided that SW1 is closed.
4. This positive clamping action can approximately double the positive amplitude value of the audio applied to D1.
5. D1 rectifies this audio, which is filtered and smoothed by C6. And, if this DC value is large enough, it will cause Q1 to begin conduction.

6. Current through Q1 causes the LED to illuminate.
7. The light from the LED falls upon the Cds cell, which causes its resistance value to decrease greatly.
8. Note that the Cds resistance and R12 form an AC voltage divider (only when the Cds cell is illuminated; otherwise, R-Cds is too large).
9. This voltage division reduces the AC voltage amplitude applied to the input of U2, reducing the voltage applied to D1 rectifier and Q1 gate.
10. The result is that when the U2 output reaches a level sufficient to turn on Q1, then further increases to the U2 input from U1 cause the LED to brighten reducing the ohmic value of the Cds cell providing more voltage division to the input of U2.
11. One way to put it simply, we have a "disagreement" going on here. U2 is supplying more voltage to a circuit that is acting to reduce U2 input.
12. So, the maximun average output of U2 is automatically adjusted to a relatively fixed level when an input level begins to turn on Q1.
13. The input amplitude at which leveling begins basically is determined by the total gain from INPUT to output of U2.
14. The purely resistive and linear characteristic of the Cds cell causes no distortion of the audio.

ADJUSTMENTS

You can adjust the low- and high-frequency rolloff characteristics of the audio with time constants of R18-C10, C5-R15/14, C8-R13, C2-R3/4, C1-C4-R5, R27-C16, C14 and speaker. R9 and C6 affect the averaging of the rectified audio and how fast the circuit responds to an increase in amplitude. R10 and C6 determine how long a rectified and smoothed DC amplitude value remain after a decrease in audio amplitude.

There are quite a few potentiometers and components put into this circuit for experimental purposes, if you desire to do so. You can use R23 to alter the slope of the output versus input level. **Table 1** graphs the equalization for a U1 gain of 1 and U2 gain of 5 with a value of R23 = 0, 330, and 1K.

Table 3 gives a listing for **Table 1**. **Table 2** shows various AC voltage levels for two different input levels at T1 (level 2, equalization has started). I never use R21, but it is available if desired. R20 was originally used with a Darlington transistor and is not needed with the FET. Any of the variable pots can be panel mounted. You can use R22 to reduce input to U3 if needed.

There are nine pads located on the circuit board where you can place vertical posts to serve as easily available test points if desired (T1 through T9). These pads are numbered on the top of the circuit board. I used some very small brass nails for these test points. Refer to the *aX* website, www.audioXpress.com, to see the printed circuit boards and component placement.

I was interested to see how test results showed what a small amount of LED current would cause such a large amount of resistance change in the LDR (**Table 1**). Measuring the LED current (T4 and T5), I noticed on my unit that the audio voltages at C8 and T2 were the same

Table 1: Cds resistance vs. LED current (an average of several units).

20µA	600K
30	320
40	250
50	180
60	140
70	120
80	100
90	80
100	70
200	30
400	13
500	10
100	4.5
200	2.2
4000	1.2

Table 2: Audio voltage measurements.

2 input levels at T1, RMS		
	level 1	**level 2**
	.100	.288
Resulting levels at T3, RMS		
	.450	.597
T6	.734	1.21
Clamped peaks at T7		
	+.936	1.42
	-.232	-.262
LED current (R24)		
	.16mA	.28mA

Table 3

R23-	0	330	1kΩ
Ein(T1)mV		Ec(T3)mV	
100	450	450	450
200	584	597	619
300	600	623	665
700	625	680	775
1200	640	726	866
1400	645	741	896

level when the LED current was zero. When the LED current reaches approximately 0.03mA on my unit, the audio voltage at T2 is 10-20% lower than that at C8, showing that this small amount of current through the LED has started the process of reducing the LDR resistance, which is beginning to control the output from U2. These numbers will vary, depending upon the particular LED and LDR used.

The input from your application will determine what gain is appropriate for U1 and/or U2 or what attenuation at the INPUT terminal will be needed to begin the leveling at your desired amplitude. Of course, you can set the gains for small signal operation and adjust the input with R19 for larger inputs. Pads are provided for all potentiometers so that you can easily use a fixed resistor or two in place of any one.

R18 and R26 can serve in place of the potentiometer R19. Vertical mounting for R5 replacement and for R22 is required. Actually, for practically any application I can think of, unless the input is extremely small, you can permanently set the gain of U1 to 1 and use R19 and U2 gain to produce the desired amount of signal. The approach here is very flexible. This circuit works nicely as a speaker driver or as an input device to any other piece of equipment.

CONSTRUCTION

This is easy and typical. In the event, for some reason, that you might prefer a single-sided board, you can use four wire jumpers to provide the traces on the top-side of the board; nothing else on top is vital or necessary to the operation, only convenient. To me it is vital to provide easy removal and installation of parts you may want to experiment with. I really like the female "machine contact" (**Fig. 2**, sockets—Jameco # 102201, for instance). You can carefully clip the plastic from the edge of each one to free it. A 1/16″ drill bit will allow easy insertion into the circuit board.

I also prefer to use male and female crimp terminals for easily disconnecting wires. **Figure 3** shows how I prefer to do this. A bit of silicone grease really makes insertion of connectors easier. You can see in **Photo 2** several wires provided with these connectors.

In the parts list (**Table 4**) I suggest several hardware components, but your choice of these is wide open. I used the small die cast case; if you do likewise, you'll need to be very careful about hardware mounting because of the tight fit. The circuit board has a mounting pad on each corner; these

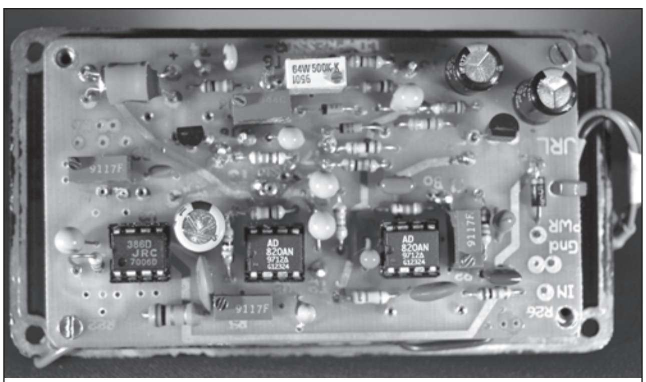

PHOTO 2: PC board.

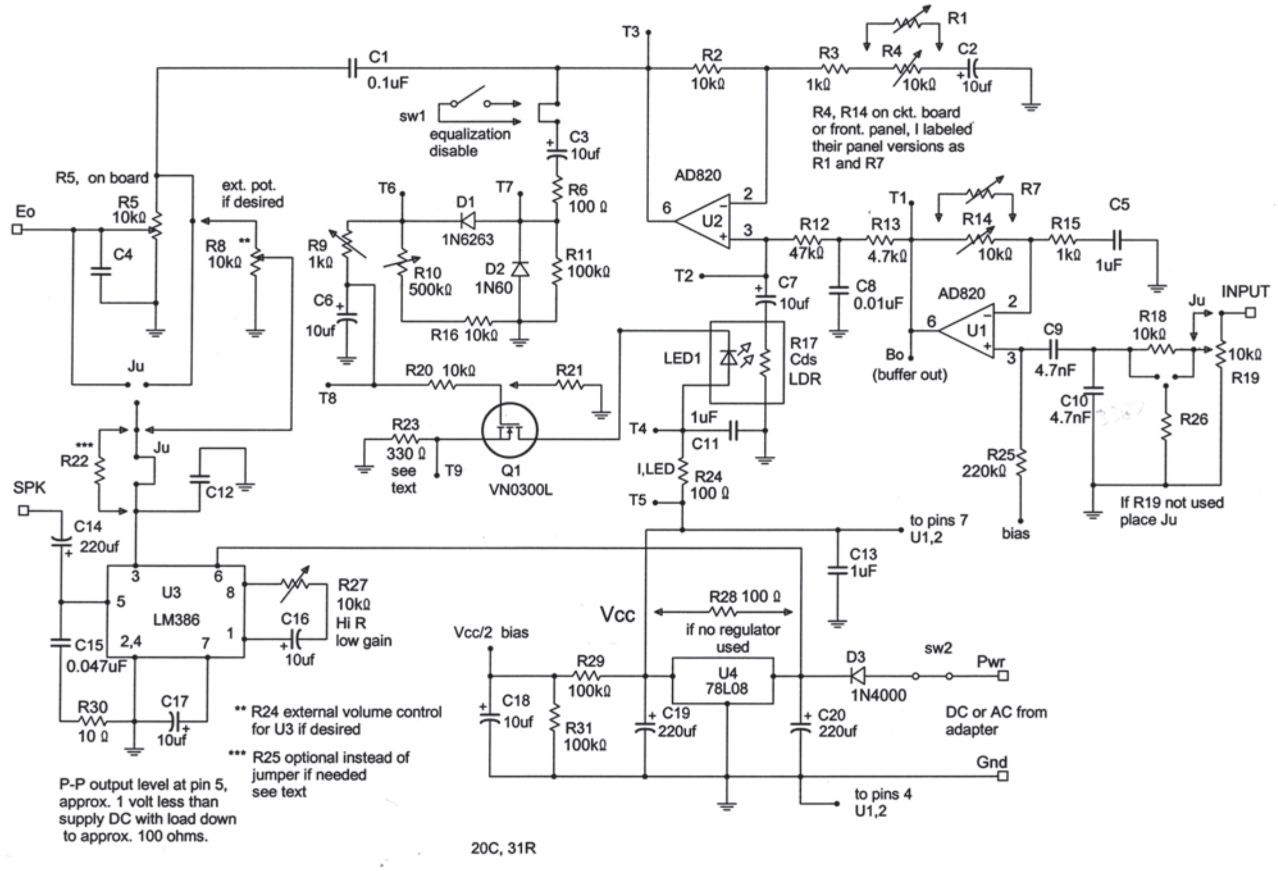

FIGURE 1: Audio level control circuit.

were basically designed for #2 bolts and standoffs to fit your cabinet. When you obtain the CDS cell/cells, test their resistance in *total* darkness; it should be over a megohm.

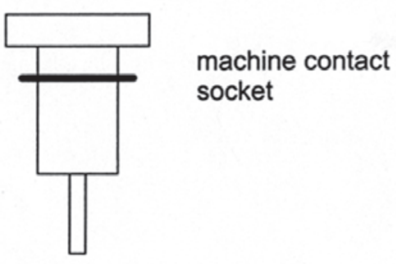

FIGURE 2: Sample socket.

When putting together the LED/CDS unit (**Fig. 4**), be sure to do a good polishing job on the flattened LED front. Also, be certain that the clear epoxy glue is completely distributed all over the space between the two surfaces of the LED and CDS. It is important that no light be able to enter the casing and affect the CDS cell. I used a drop of nonconducting silver paint placed into each end of the unit after the shrink tubing is in place. **Table 2** shows an average of measurements I made on several CDS units.

TESTING

My measured power supply current is approximately 6mA using an 8V regulator. Using a 100Ω resistor in place of the regulator, my current level is approximately 4mA with input supply voltage from 5 to 15V. This can depend upon the op amps used. My LM386 uses about 3mA of this total, so obviously if you do not need the LM386 or voltage regulation, do not use either and the static current drain will only be around 1mA for battery operation.

I suggest that you measure the output pins of U1 and U2. This voltage should be close to half of the supply voltage, which is determined basically by R29 and R31. **Table 2** has voltage listings for two different input levels of 1kHz sine wave

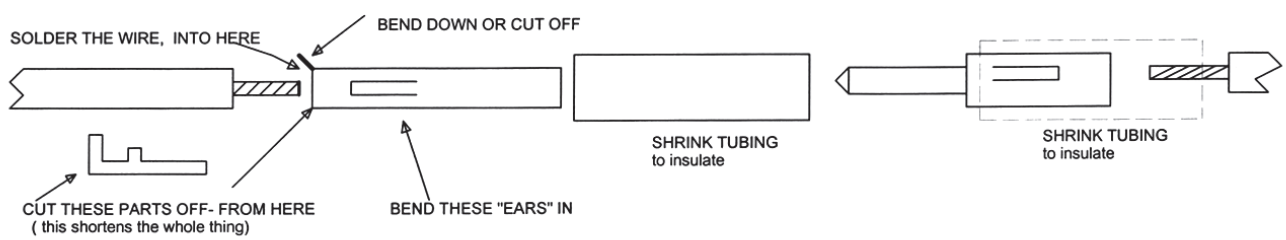

FIGURE 3: Preparing crimp terminals for connecting two wires.

starting at T1. Level 1 shown is below the level where Q1 begins to conduct, so all circuit voltages are the same as though SW1 is open. Level 2 is high enough so that the equalization process is in effect. Run a test as shown in **Fig. 2** and compare the results.

Test with varying sine wave input levels (1kHz) and observe when the equalization level begins. Test with music and voice over many amplitude levels of input while turning SW1 on and off noting the difference in output. I used a value of 330Ω for R23. This causes U1 to turn on a bit more smoothly and seemed to make the voice and music sound better. See what you think. *aX*

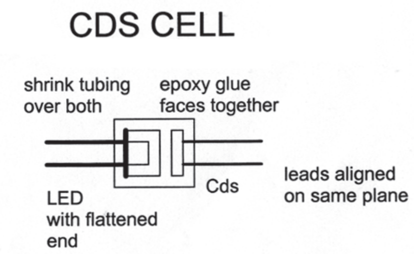

FIGURE 4: LED/CDS connection.

Table 4: Parts List

Capacitors	
C1	0.1µF
C2, 3, 6, 7, 16-18	10µF
C4, 12	see text
C5, 13	1µF
C8	0.01µF
C9, 10	.0047µF
C11	not needed
C14, 19, 20	220µF
C15	.047µF
Semiconductors	
U1, 2	AD820 or similar
U3	LM386
U4	78L08
D1, 2	any small Schottky diode
D3	1N4000 series or most any silicone diode
LED1	yellow hi intensity
Q1	VN0300L FET or similar
Hardware	
Switch 1,2	small SPST
Cabinet	Die cast LM Heeger 3421 or Jameco 11965, wide choice here
Audio connectors	RCA jacks, panel mount, available many places
Power connector	many options, Jameco 281851, 297529 or similar
Panel knobs and labels	custom
Power module	similar to Radio Shack 273 1767, wide choice on this
Machine contact sockets	Jameco 78642
Crimp terminals	Jameco 224581 male, 224573 female
Resistors	
R1, 2, 4, 5, 7, 8, 14, 16, 18, 20, 27	10K
R3, 9, 15	1K
R6, 24, 28	100
R10	500K
R11, 29, 31	100K
R12	47K
R13	4.7K
R17	Cadmium sulfide LDR–Radio Shack 276-1657 or equivalent
R21, 22, 26	see text
R23	330 (*Fig. 2*)
R25	220K
R30	10