Stereo Noise Generator

An experimenter's circuit that provides noise for many applications.

Andy Flind

Noise, electrically speaking, is strange stuff. From the amount of time and effort spent in trying to control it, especially in sensitive circuits such as preamplifiers, it might be thought that it's to be found everywhere in large quantities. When one wants some noise, it comes as some surprise to find that it is, in fact, quite difficult to generate.

Why Noise?

Why should anyone actually want noise? Well, there are many possible uses for it. Amplified and fed into a loudspeaker, it produces a rushing sound, similar to a waterfall or high wind in trees. The obvious use is in sound effect generations, but the effect on its own is quite relaxing and thus of interest to people working with biofeedback and similar projects.

A soothing noise output is far better than a monotonous and irritating tone for a relaxation monitor; for example, pink noise, where higher frequency components are progressively reduced, has been used with some success to assist patients to relax in medical practice, particularly by dentists. A device is available for use in modern open-plan offices, where the sound produced reduces the chance of conversation being overheard without being too irritating for the occupants.

Noise Sources

Various circuits using noise generators have appeared in the electronics press from time to time, usually in wind and rain effects projects. The noise sources vary, but common among them are Zener diodes and other reverse-biased junctions, such as ordinary silicon diodes and the base-emitter junctions of transistors. The problem with all these sources is that their output when used in this manner varies considerably between devices, and is almost always very small. This makes them unsatisfactory for circuits intended for publication, where the performance should be readily repeatable, and the high levels of gain needed ot obtain usable output can cause problems of instability. So while they might be suitable for a one-off in the designer's workshop, they do not lend themselves well to publication. Two rather more practical noise sources are the custom sound- effects chip, and noise diodes. The chips work, but most of them have rather high quiescent currents. A standing drain of 45mA is not much use where the power supply is a single 9V battery. Noise diodes were better.

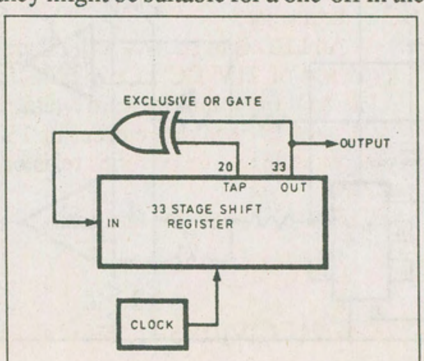

Fig. 1. Basic noise generator arrangement.

Pseudo-random

The solution eventually discovered was a pseudo-random generator, using a shift register with its output EXclusive-OR'd with the output taken from a tap partway along its length, and fed back to the input. Fig.1 shows the basic arrangement in block form. It will be seen that in this case a 33-stage register is used, with the tap at the 20th stage. The object is to obtain the longest possible apparently random output sequence before it repeats itself.

For any given number of steps in the register, there is a tapping that will give this longest sequence. The mathematics are tricky, so it's best to simply obtain the magic numbers from a reference book. The sequence repeat time obviously depends on the clock frequency, and without the arrangement shown, a 1MHz clock speed gives a repeat time of about a second, long enough to avoid any suggestion that it isn't actually random for most applications. Moving to Fig.2, the arrangement use is shown in more detail. To

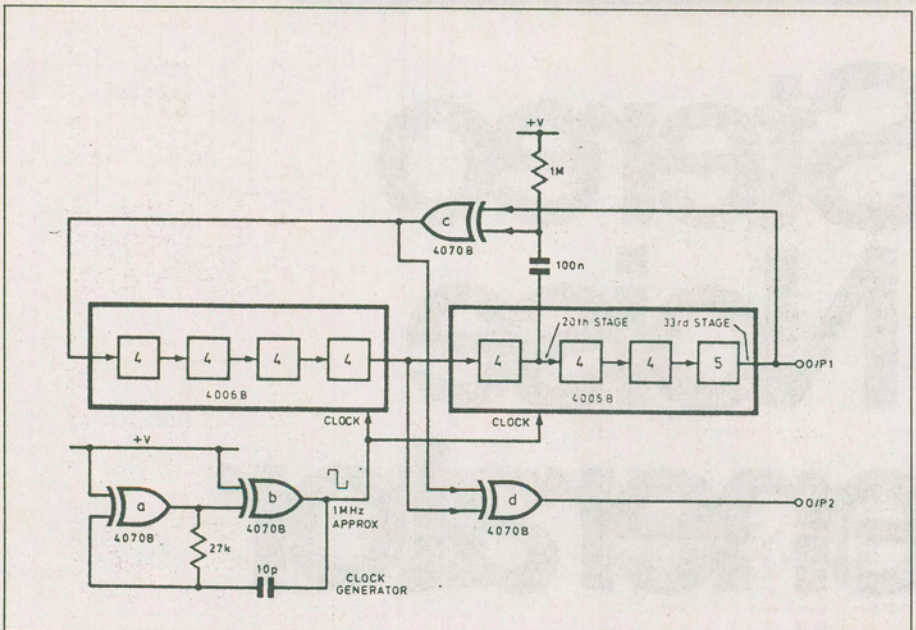

Fig. 2. Noise arrangement in more detail.

keep current consumption to a minimum the active devices are CMOS types, the most useful shift register for the purposes being the 4006B device. This is internally organized as four independent registers, two of which are four stages long and two either four or five, depending on connection. The first provides a total of sixteen stages and with the first four-stage of the second gives the twenty stages to the tap. The remaining stages, used as two fours and a five, take the total to thirty-three. A 4070B provides the EXclusive-OR function, and since it has three more gates available, two of these has three more gates available, two of these serve as the clock generator.

It is possible for this circuit to enter a state where, if output and tap are both low, the output of the EX-OR gate will also be low so it will have nothing but low states circulating around it and the resulting output will appear to be a continuous low condition. To prevent this a simple self-starter has been added, using the 1M resistor and 100n capacitor at one input to the gate. If the output from the tap is continuously low, the resistor will soon pull the gate

Parts List

Resistors

R1	27k
R2	1M
R3-6	22k
R7-10	10k
R11,12	33k
R13-16	47k
R17,18	47k

All metal film types

Capacitors

C1	10p
C2,6	100n
C3,4	470p
C5	100u 25V

Semiconductors

TR1,2	2N3904, BC184
IC1	4070B EX-OR gate
IC2,3	4006B shift register
IC4,5	CA3080 transconductance amp

Miscellaneous

PCB, 3 14-pin DIP sockets, 2 8-pin DIP sockets

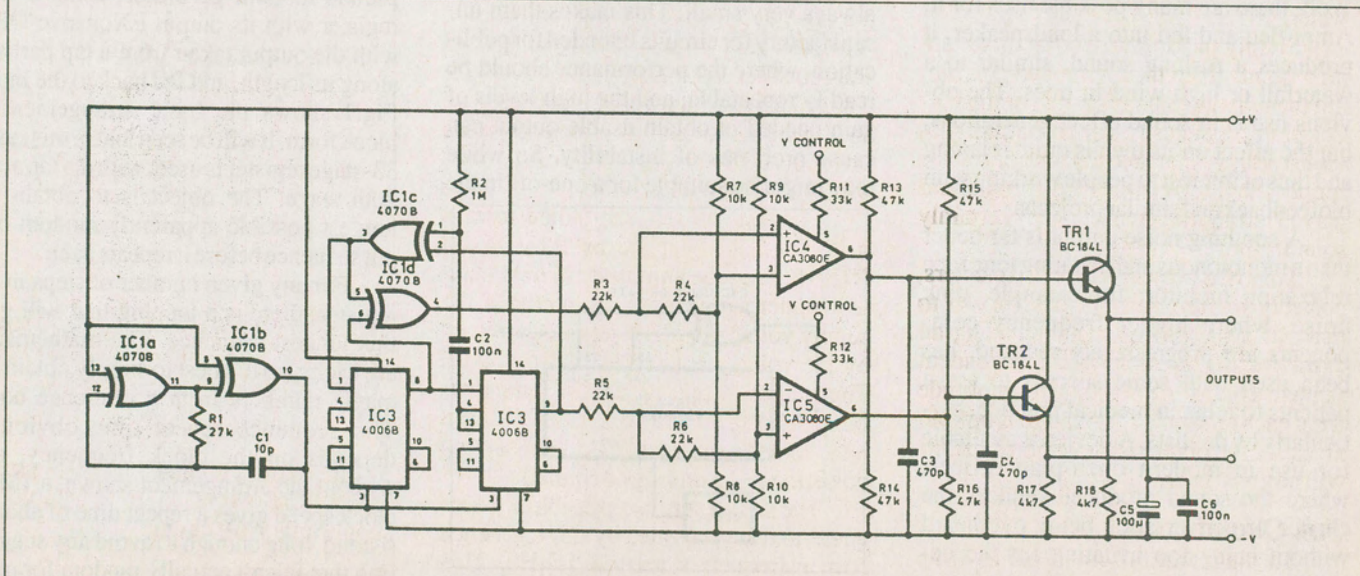

Fig. 3. Full circuit of the Stereo Noise Generator.

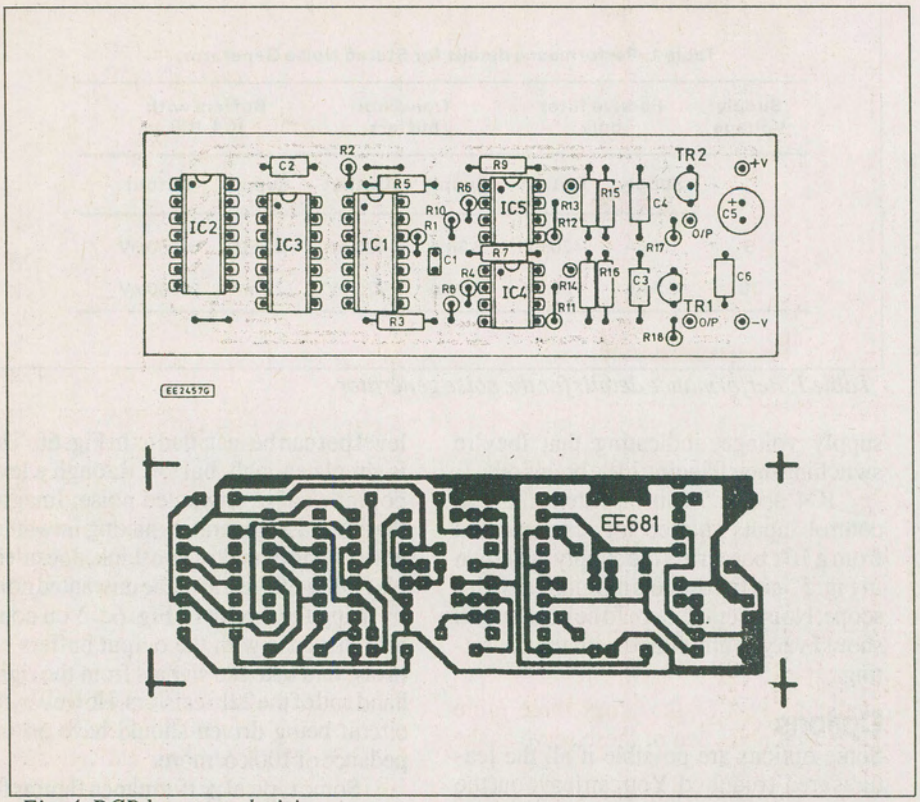

Fig. 4. PCB layout and wiring.

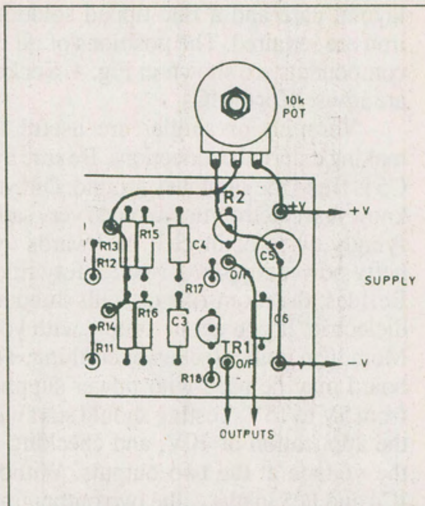

Fig. 5. Connections for testing the unit.

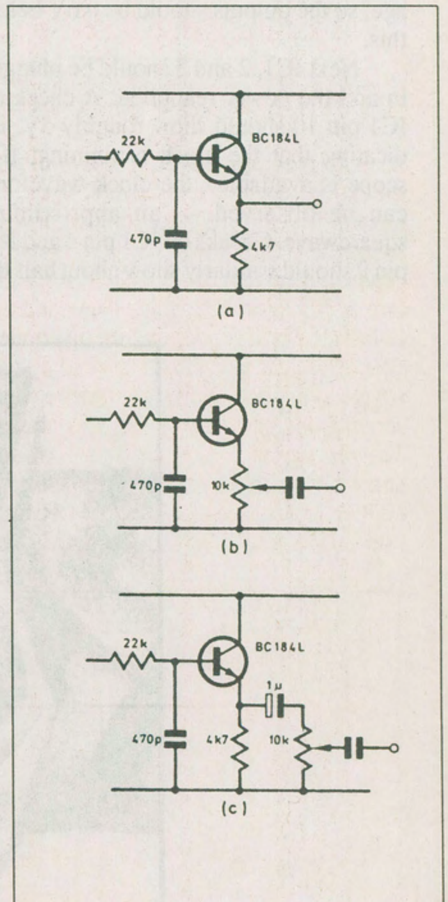

Fig. 6(a). Simple output circuit. (b) Output circuit with simple gain control. (c) Improved output with gain control.

input high, setting the circuit into correct action.

Stereo Noise

Mono noise, while more useful than simple tone for many applications, can still lack that certain something. Stereo, given by a separate noise source for each channel, gives an immediate impression of depth, like wind in tall trees or rushing water.

Simply picking off two or more tapping points from the circuit and combining them in the remaining gate of the EX-OR chip produces a second output. Obviously this is related to the first, but on the scope they look totally different and played through an amplifier they certainly sound right.

This is a project for experimenters, possibly for use in other designs, so to make it more useful and interesting an extra feature is included: independent voltage control of the output amplitude from each channel. This feature is optional, as are the output buffers; notes on this will be given later.

Full Circuit

Turning to the full circuit of Fig. 3, the clock consists of IC1a and IC1b, connected as a simple astable running at approximately 1MHz. This drives the clock inputs, pin 3 on IC2 and IC3. The output from the first four stages in IC2 is taken from pin 8 straight to the input of IC3, pin 1.

The output from IC3 is taken from pin 9 and EX-OR'd with the output from the 20th stage tap, from pins 4 and 13 by IC1c. The output from this gate is passed back to IC2's input, pin 1. It also goes to IC1d, where it is EX-OR'd with a tap from stage 16, pin 8 of IC1 to give the second output. Variable gain is provided by a pair of transconductance op amps, IC4 and IC5. The polarity of output of these depends on the input, but the output current depends on the bias current fed to pin 5, in this case, through R11 and R12.

The outputs are also pulled toward half the supply voltage by R13/14 and R15/16. Thus the amplitude of the output is symmetrical around the centre of the supply voltage, with amplitude governed by the voltage applied to R11 and R12. The output at this point still jumps between two levels, however. To shape it into something more like true analog noise, lowpass filtering is required.

The simplest filters possible are adequate, and are provided by C3/4, giving a corner frequency around 15kHz. This gives a noise bandwidth covering the full audio band. Finally, since the outputs have a fairly high impedance, they are buffered by transistors TR1 and TR2, here used as emitter followers. C5/6 decouple the supply rails to the circuit.

Construction

Construction is straightforward, though this project does have a fairly compact layout; care and a fine-tipped soldering iron are required. The positions of all the components are shown in Fig. 4. Sockets are advised for the ICs.

Veropins or similar are useful for making external connections. Be sure that C5 is fitted the right way around. Did you know that electrolytics explode very satisfyingly when connected backwards to a hefty power supply? Listen: safety rules. Besides, the room fills up with shredded dielectric. If you get in trouble with your Mom, I'm going to deny everything. The board may be used with power supplies from 5V to 15V. Testing should start with the application of 10V, and checking of the voltage at the two outputs. Without IC4 and IC5 in place, the two output transistor bases will be at half the supply voltage, so the outputs should be 0.6V below this.

Next IC1, 2 and 3 should be plugged in and the power reapplied. A check on IC1 pin 10 should show roughly 5V, indicating that the clock is running. If a scope is available , the clock waveform can be observed — an approximate squarewave. Checks on IC1 pin 4 and IC3 pin 9 should similarly show about half the supply voltage, indicating that they're switching their frigging little brains out.

IC4 and IC5 can be fitted, the two control inputs shorted together and fed from a 10k pot across the supply as shown in Fig. 5, and the outputs monitored with a scope. Noise signals should be present and should vary in amplitude with the pot setting.

Options

Some options are possible if all the features aren't required. You can leave out the op amps, shorting pins 2-6 on each amp. This gives the simple output of Fig. 6a. A level pot can be installed as in Fig. 6b. This is simple enough, but DC through a level pot may cause unwanted noise. Imagine that. A noise generator making unwanted noise. Kind of makes you think, doesn't it? No? Oh, well, get rid of the unwanted noise by using the circuit of Fig. 6c. You could also dispense with the output buffers entirely, and take the signals from the right-hand end of the 22k resistors. However, the circuit being driven should have an impedance of 100k or more.

Some typical performance figures for the circuit for different supply voltages and configurations are shown in Table 1.

Table 1. Performance details for Stereo Noise Generator.

Supply Voltage	Passive filter only		Transistor buffers		Buffers with IC4, IC5	
	Supply	Output	Supply	Output	Supply	Output
5	1.5mA	420mV	2.3mA	430mV	2.5mA	0-280mV
10	5.5mA	760mV	7.2mA	770mV	7.6mA	0-660mV

Table 1. Performance details for the noise generator.