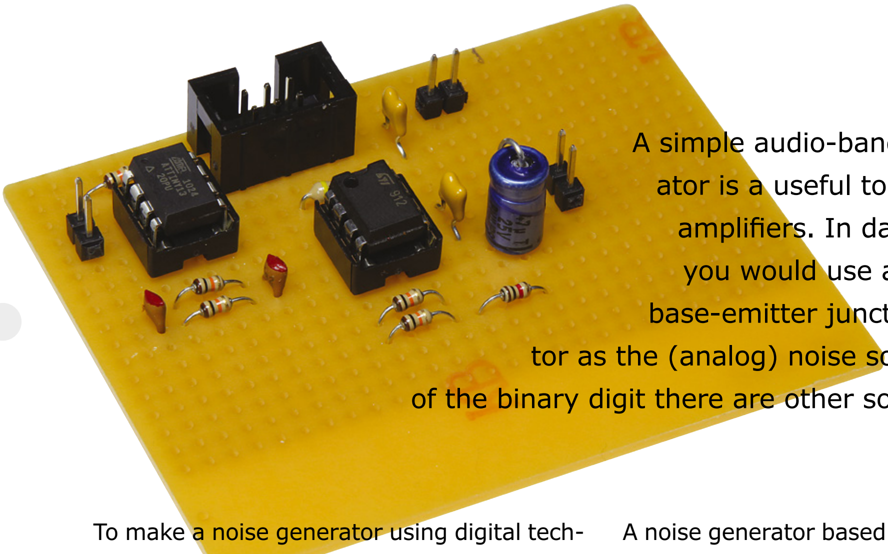
Mini Noise Generator

Check that frequency response



A simple audio-band noise generator is a useful tool for testing amplifiers. In days gone by, you would use a diode or the base-emitter junction of a transistor as the (analog) noise source, in the age of the binary digit there are other solutions…

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To make a noise generator using digital technology you can start with a long shift register made up of a chain of D-type flip flops. The logic value of the last flip flop in the register together with some selected flip flops along the chain (taps) are then logically gated together to produce the (feedback) signal which forms the input to the shift register. **Figure 1** shows the basic configuration of a typical Linear Feedback Shift Register (LFSR) using XOR logic gates to generate the feedback logic signal.

A Linear Feedback Shift Register

The register's output waveform looks like a random sequence of ones and zeroes, but in truth (since there is no truly chaotic behavior like the noise generated in a base-emitter junction) the sequence is deterministic. The bit sequence generator also has uses as a pseudo-random number generator or for encrypted stream ciphers. The bit sequence is made up of many discrete frequencies which extend to one half of the clock frequency. When a chain of n=8 cells is used with a primitive feedback polynomial (here 1+V8+V6+V5+V4), it generates a total of 2^8-1 different frequencies. A large value of n is important for noise generator applications because it creates a flat noise characteristic across the spectrum. More information on the theory and math behind this technique can be found at [1].

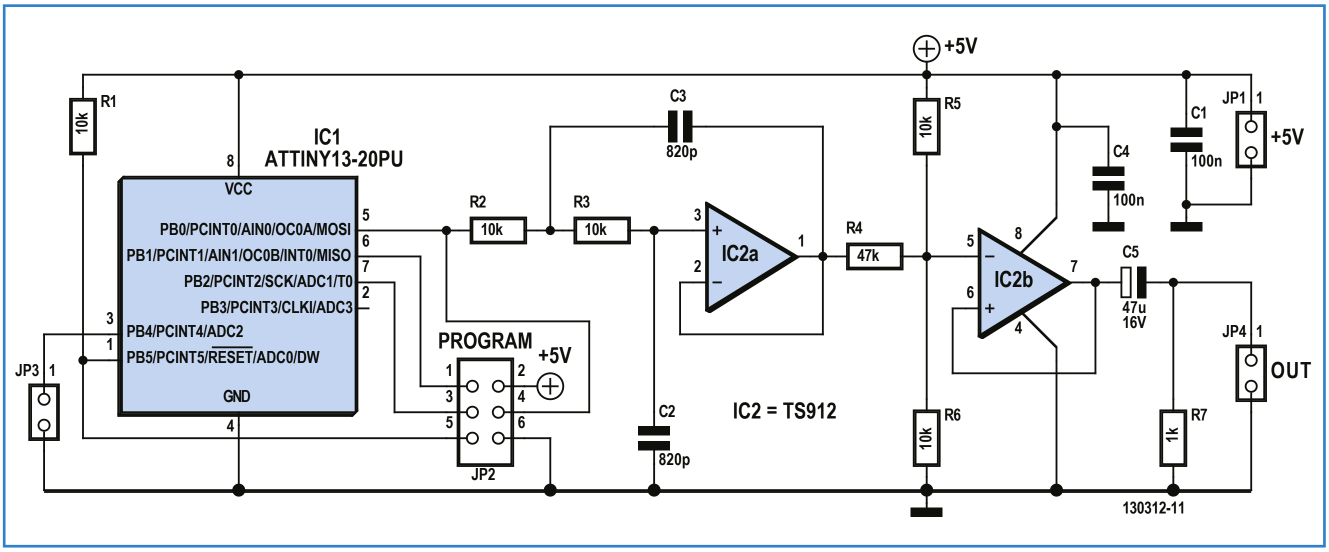
A noise generator based on this principle was described in an old Elektor article [2]. It used a 16-bit long shift register with XNOR gates to generate the feedback signal using a polynomial of 1+V2+V3+V5+V16. Testing this design it was apparent that the noise characteristics across the audio spectrum were not very linear; with audible rumbles and chirps. In an effort to improve the characteristics two versions of the LFSR named after the Italian mathematician Leonardo Fibonacci were implemented.

- 16 bit Fibonacci-LFSR : feedback 1 + V11 + V13 + V14 + V16 with XOR and
- 24 bit Fibonacci-LFSR: feedback 1 + V20 + V21 + V23 + V24 with XOR.

Both of these examples were shown to generate a consistently flat output across the audio spectrum.

A Controller and Filter

The LFSR can of course be built using a dedicated shift register IC such as a 74HCT174 plus some additional logic [2] but all those naked digital gates look so 20th century. Surely a more elegant and contemporary solution is to use a small 8-pin Atmel ATtiny13 microcontroller and emulate the feedback register function in an (Assembler) program (**Figure 2**). Jumper JP3 shown on the cir-



cuit connects to the controller pin PB4 and allows the register length to be changed from 16 memory cells (jumper fitted) to 24 cells (jumper removed).

The microcontroller is clocked at 9.6 MHz by its built-in clock generator and produces a new value in the LFSR every 10 µs (100 kHz). The distance between the generated frequencies is either 100 kHz/2^{16}–1 ≈ 15.5 Hz or 100 kHz/2^{24}–1 ≈ 0.006 Hz, the upper frequency limit is $f_{Clk}/2$ = 50 kHz. The output signal from V1 (the shift register output) is at pin PD0 of the ATtiny microcontroller. In 24-cell mode the sequence takes almost 3 minutes!

The assembler program for this project can be downloaded from [3]. The Atmel AVR-Studio 6 was used for program development. Fuses should be set to HIGH 0xFF and LOW 0x7A. The circuit diagram shows the connection of a standard-layout ISP connector for programming but if a ready-programmed controller is used [3] J2 can be left out.

IC2A is configured as a simple Sallen-Key low-pass filter with a cut off frequency of 19.4 kHz [4], all frequency components above the audio band (including the 100 KHz clock frequency) will be attenuated by its 12 dB/Octave characteristic. The signal is then simply buffered by IC2B and because the opamp is powered from a single +5 V supply any DC component in the signal is decoupled by C5 and the resulting output signal taken to JP4. IC2 is a dual opamp type TS912 with rail-to-rail capability. The complete circuit is so small it fits neatly onto a small square of breadboard.

(130312)

Figure 1.
The noise generator uses an ATtiny to produce the LFSR function in software.

Web Links

[1] http://en.wikipedia.org/wiki/Linear_feedback_shift_register

[2] Noise Generator, Elektor December 2002, ref. no. 014118

[3] www.elektor-magazine.com/130312

[4] https://en.wikipedia.org/wiki/Sallen%E2%80%93Key_topology

Figure 2.
The 8-memory element Fibonacci linear feedback shift register.