Digital drum sounds are everywhere. Now with a few parts, a few hours of your time, and some electronics savvy, you can build your own digital drums and save money too.

Build the Alpha Digital Drum

BY HOWARD W. CANO

Electronic drum sets with digitally-sampled sounds are currently the "hot" item for percussionists. Electronic drums weigh less and are much smaller than their acoustic counterparts, don't require the hassles or expense of microphones, and in the studio, assure a clean sound with no isolation problems.

If you'd like to get in on the fun, the Alpha digital drum—which plays real, digitally sampled sounds—can be built for less than $40. A variety of sounds are available on EPROM (see parts list); if there is sufficient interest, we'll describe how to record your own sounds in EPROM in a subsequent issue. The Alpha is tunable over three octaves, fully dynamic (touch sensitive), and can be triggered from sensors or pads. The parts are common and easy to obtain.

HOW IT WORKS

Referring to the schematic (**Fig. 1**), the circuit consists of eight basic blocks: peak detector, envelope generator, trigger comparator, voltage-controlled oscillator (VCO), counter, memory, digital-to-analog converter (D/A), and voltage-controlled amplifier (VCA).

The peak detector is built around IC1A (¼ of an LM324 single-supply quad op amp) and a few discrete components. VR1, the sensitivity trim pot, attenuates the transient signal generated by the pickup (a piezoceramic disc); the signal then couples into IC1A's non-inverting input through R1. R1 and D1 protect the op amp input from negative-going signals.

PARTS LIST

Integrated Circuits

IC1	LM324 quad op amp
IC2	CA3080 transconductance op amp
IC3	CD4046 CMOS phase-locked loop
IC4	CD4040 CMOS 12-stage binary ounter/divider
IC5*	2732 4K × 8 EPROM
IC6, IC7	CD4049 hex inverter

Resistors *(¼ watt, 5% tolerance except as noted)*

R1,7,12,19	220k
R2,11,18	10k
R3,13	2k2
R4	1M
R5,9	22k
R6,21,22,23	4M7
R8	150k
R10,16,17	100k
R14,15	4k7
R20	470k
R24,25,26	1M2
R27-35	301k ¼ watt 1%

Capacitors *(16 working volts DC)*

C1,7	4µ7 radial lead
C2,6,8,9-13	100n ceramic disc
C3	3n ceramic disc
C4	470p ceramic disc
C5	10n ceramic disc

Semiconductors

D1	1N34A germanium signal diode
D2,3	1N914 or equiv. silicon signal diode

Potentiometers

VR1	500k trimpot
VR2, VR3	100k linear taper

Sensor

Piezoceramic disc, approx. 1-inch dia.; Radio Shack #273-069, #273-064, or equivalent.

**The following sound EPROMs are available for $5 each from Howard Cano, 7057 Vivian Ct., Arvada, CO 80004: Snare, studio snare, high tom, mid tom, low tom, kick, studio kick, cow bell, wood block, or hand clap. An etched and drilled printed circuit board is available for $10. Include $1 postage per order.*

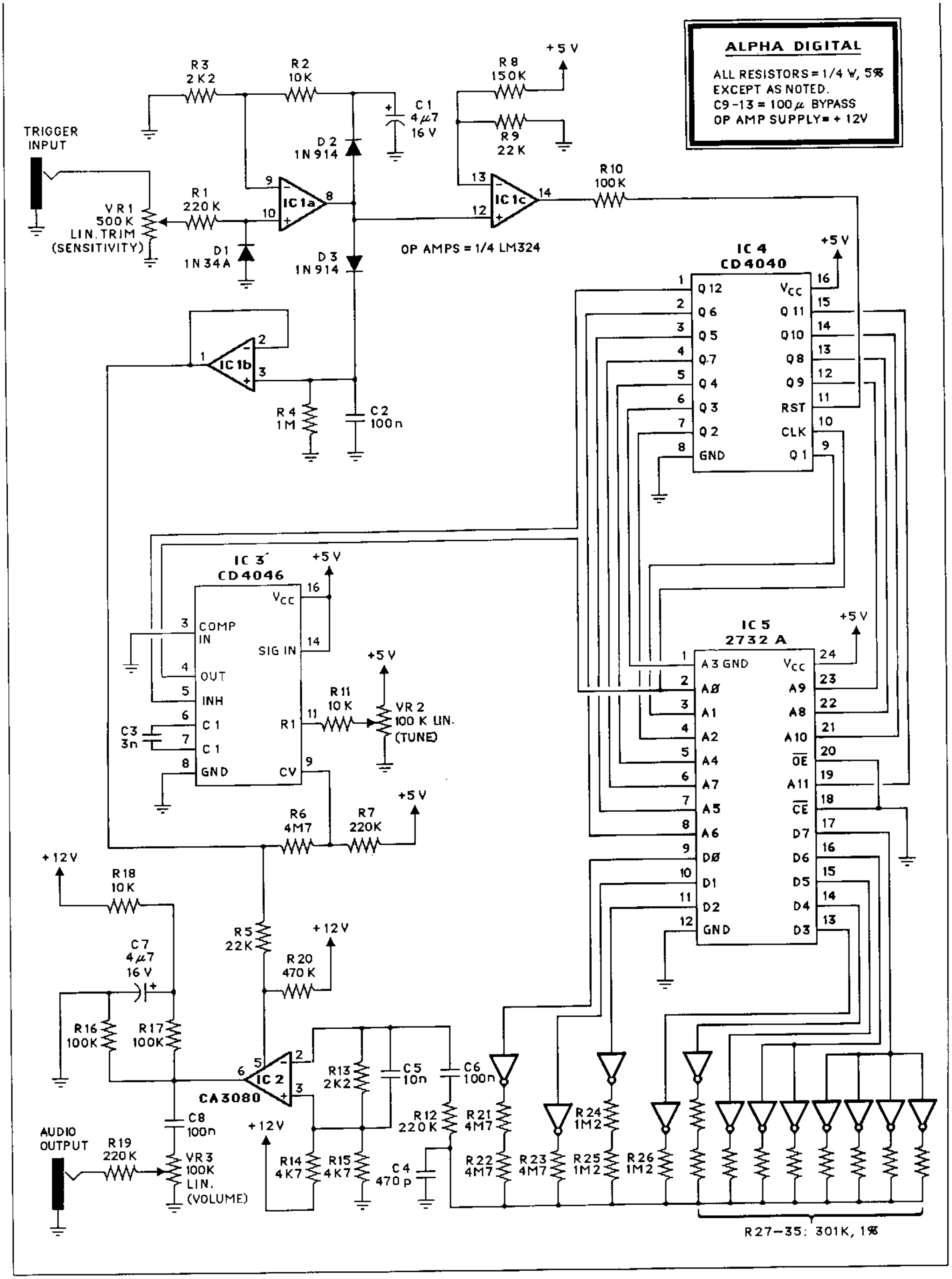


Fig. 1 *Circuit diagram for Alpha Digital Drum*

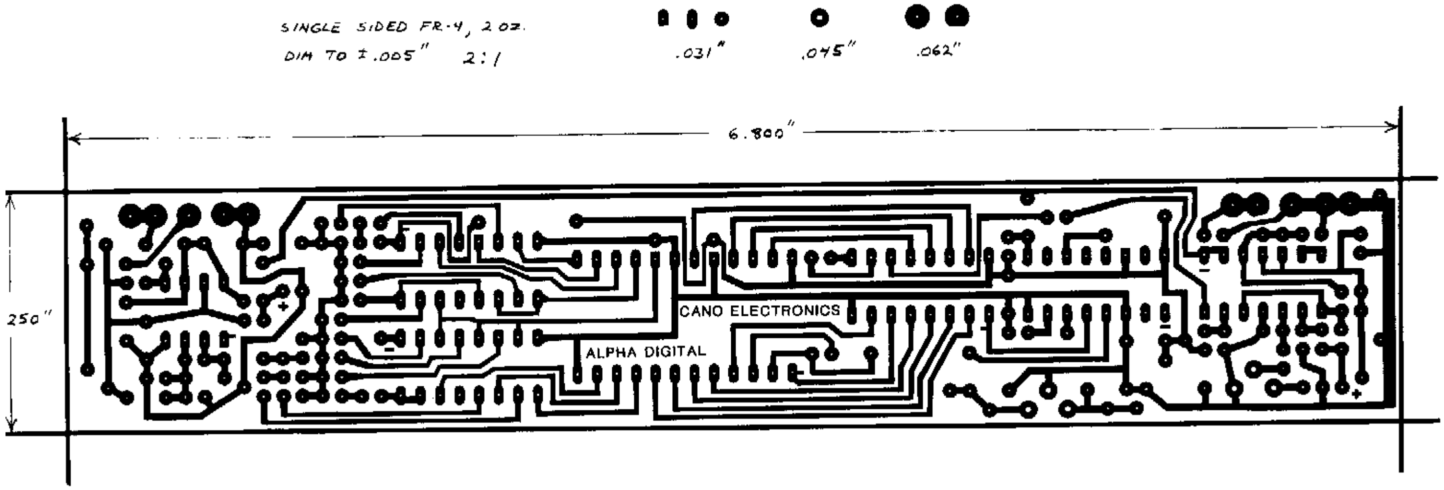
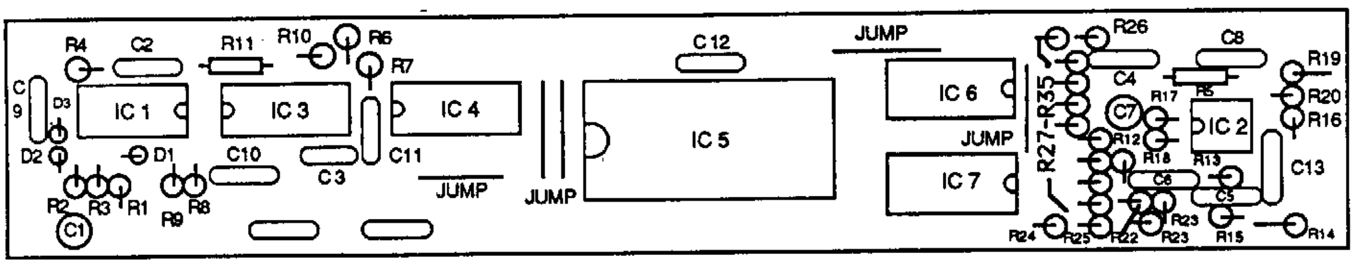


Fig. 2 *(above): foil side of Alpha Digital Drum PC board.* **Fig. 3** *(below): parts placement.*



IC1A charges C1 through D2 during the input signal's positive-going peaks until both inputs of IC1A are at the same instantaneous potential. C1 holds this voltage during more negative input signals. The charge slowly bleeds away through R2 and R3; this particular choice of resistor values also gives the peak detector some gain.

When IC1A swings positive, it also charges C2 through D3. These components, along with R4 and IC1B, form the envelope generator. It may seem redundant to have two RC networks, but it is necessary. The shorter time constant of (R2 + R3) × C1 permits the peak detector to respond to rapid playing, such as a drum roll, and the longer time constant of R4 × C2 doesn't cut short the longer drum sounds—yet still reacts quickly enough to give a good dynamic response. ICB1 buffers the exponential envelope and drives the control input of the VCA (IC2 and associated components) through R5. The envelope, attenuated by R6 and R7, also modulates the VCO (IC3) so that striking the sensor harder increases the frequency slightly, thus giving a more natural sound.

IC3, a 4046 phase-locked loop, serves as the basis of the VCO. VR2 tunes the sampled sound's pitch over more than three octaves. The inhibit input (pin 5) gates the oscillator on and off. Other sections of the 4046 are not used.

IC1C is the trigger comparator. When the output of the peak detector goes more positive than the reference voltage set by voltage divider R8/R9, this comparator resets the 4040 12-stage binary divider. R10 protects the 4040's reset input, as IC1C can swing higher than the 5V supply used on the 4040.

When the counter (IC4) is reset, Q12's output goes low and enables the VCO (IC3). The VCO clocks the counter, and the counter sequentially recalls the digital sound samples stored in memory chip IC5, a 2732 EPROM. The samples are read out of memory until counter output Q12 goes high. The VCO is then inhibited, and remains so until the sensor is struck again. The counter may be reset at any time during this sequence by multiple sensor strikes.

The D/A converter, which consists of two 4049 hex inverters (IC6 and IC7) and a binary weighted resistor string (R21 through R35), translates the 2732's digital data into an analog voltage. C4 and C5 filter out high frequency hash and clock glitches from the analog waveform.

The D/A feeds the VCA through an attenuator (R12 and R13), as the CA3080 is susceptible to overload. The CA3080 is a transconductance amplifier whose output current is proportional to the differential input voltage multiplied by the control current flowing into pin 5. The ratio of R16 and R17 sets a bias voltage for the CA3080 output, and their parallel resistance (along with VR3) determines the VCA gain, which is set just low enough to avoid clipping. R18 and C7 keep power supply noise out of the audio output. C8 couples the output signal to volume control VR3. R19 permits multiple drum outputs to be paralleled if no mixer is available; however, if you're feeding a typical PA or recording mixer, it's probably better

Howard Cano *is an electronics engineer and currently designs high accuracy laboratory equipment. He has manufactured several types of musical equipment; his "Modulus Electronic Drums" are played and endorsed by Ed Shaughnessy on the NBC Tonight Show. His hobbies include playing guitar and other instruments, flying radio-controlled airplanes, and driving red sports cars.*

to lower the value to around 10k. R20 helps overcome the 0.6V diode drop at the control pin input, which would otherwise cause a "dead" spot in the drum response at low dynamic levels.

CONSTRUCTION NOTES

IC5's pinout allows for a single-sided printed circuit board layout (see **Fig. 2**, the circuit board foil artwork). The diodes stand banded-end up, and most of the resistors stand on end to save space (see **Fig. 3**, component layout). Even so, construction is not particularly tight or difficult. . .just keep an eye out for solder bridges.

I strongly recommend using sockets on all ICs. A socket on the EPROM is, of course, mandatory if you want to change sounds—a ZIF (zero insertion force) socket is best here.

The circuit requires +5V at approximately 75 mA and +12V at approximately 3 mA. There is room on the board for a 5V regulator, which with proper heatsinking could run five or more drums. The +12V must be well-filtered, but not necessarily regulated. The analog and digital grounds should be kept separate and tie together only at the power supply.

VR1, the sensitivity trim pot, can mount on the board or go someplace more accessible if you anticipate using different types of triggers.

The piezoceramic sensor may be mounted in or on a practice pad, acoustic drum, or even a thin piece of plywood with rubber on top. Place the sensor where it won't take a direct impact, and use shielded cable between the sensor and circuit board. Pickup phasing is normally not important. If your particular sensor pad construction doesn't give quite enough output, you can increase the peak detector gain by reducing R3's value (halving R3 gives about twice the gain).

USING THE ALPHA DRUM

To use the drums for practicing or playing a small gig, you'll need an amplifier with at least 100 watts RMS of power. For proper reproduction, most drum sounds require excellent bass and transient response from the amp and speaker system. The Alpha drum output is line level, so pad it down if you're using a guitar amp.

Although most people think of digital drums as pretty high-tech, they're not really all that difficult to build. So grab your soldering iron and have fun! **EM**