The Les Hall Show

Vocal Boolean Sequencer

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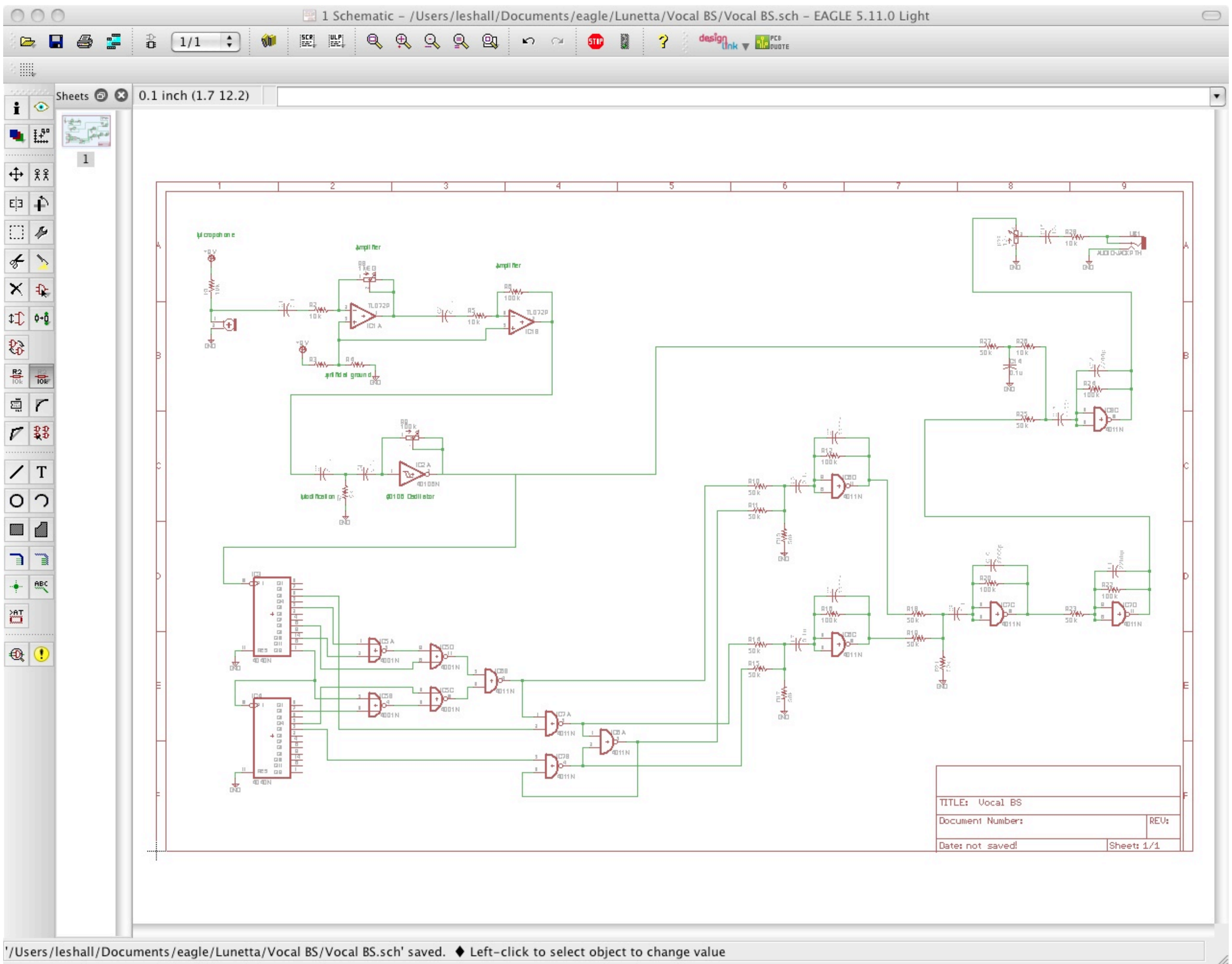
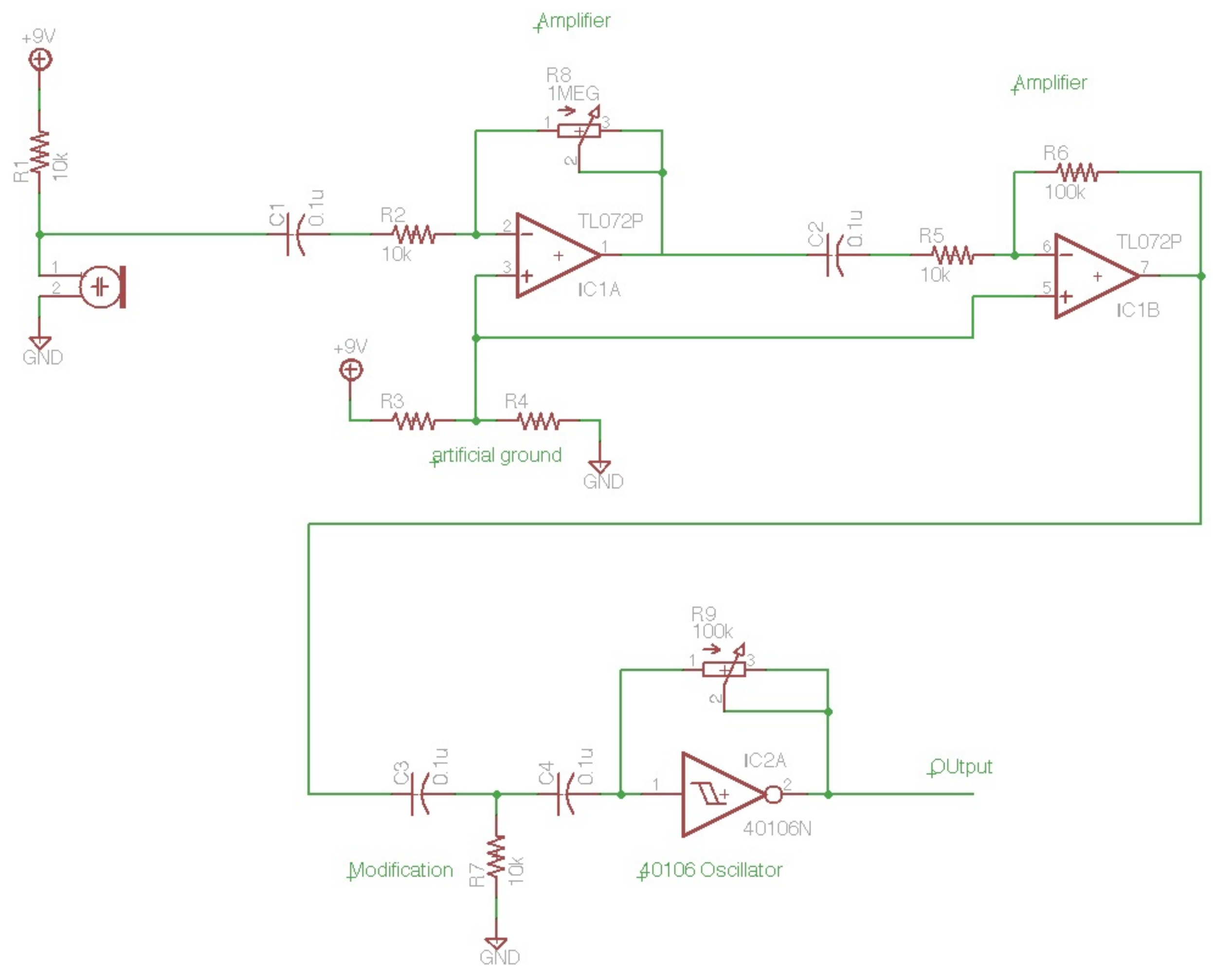
This week we will explore a voice-modulated boolean sequencer circuit with both digital CMOS and linear CMOS. The circuit, shown below, consists of the following sub-circuits: power supply starve pot, microphone amplifier, modulated 40106 oscillator, digital boolean sequencer, linear CMOS, and output driver.



That's a lot to discuss, so we are fortunate that we have no time limit on this week's show. Let's begin with the power supply starve pot. It consists of a 100k potentiometer hooked up in series with the power supply and with a 10k resistor in parallel with it. The pot is hooked up like a rheostat, using one end and the center tap only, forming a variable resistor. The idea behind this addition is to add an interesting musical feature: supply starving.

The way that supply starving works is you put a variable resistance in series with the power supply and it serves to make the battery seem like a weak battery, in a way that you can vary. This causes all sorts of non-ideal behavior in the circuit which is actually quite good from a musical standpoint. You can add supply starving to nearly any circuit to get wild sounds out of it.

Now let's look at the microphone circuit, shown below. It consists of a microphone with supply resistor and two ac-coupled inverting amplifiers based on a TL072 opamp chip. Also shown below is the modulated 40106 oscillator.



The microphone itself works like a variable resistor of about 10k Ohms resistance, so we put it in a voltage divider with a 10k resistor to power it. It sends out a very weak signal so we have to amplify it by about 1000 times. The first amplifier has a gain of -100 and the second a gain of -10, for a total gain of 1000. The way to calculate the gain of an inverting amplifier is to divide the feedback resistance by the input resistance and multiply by minus one.

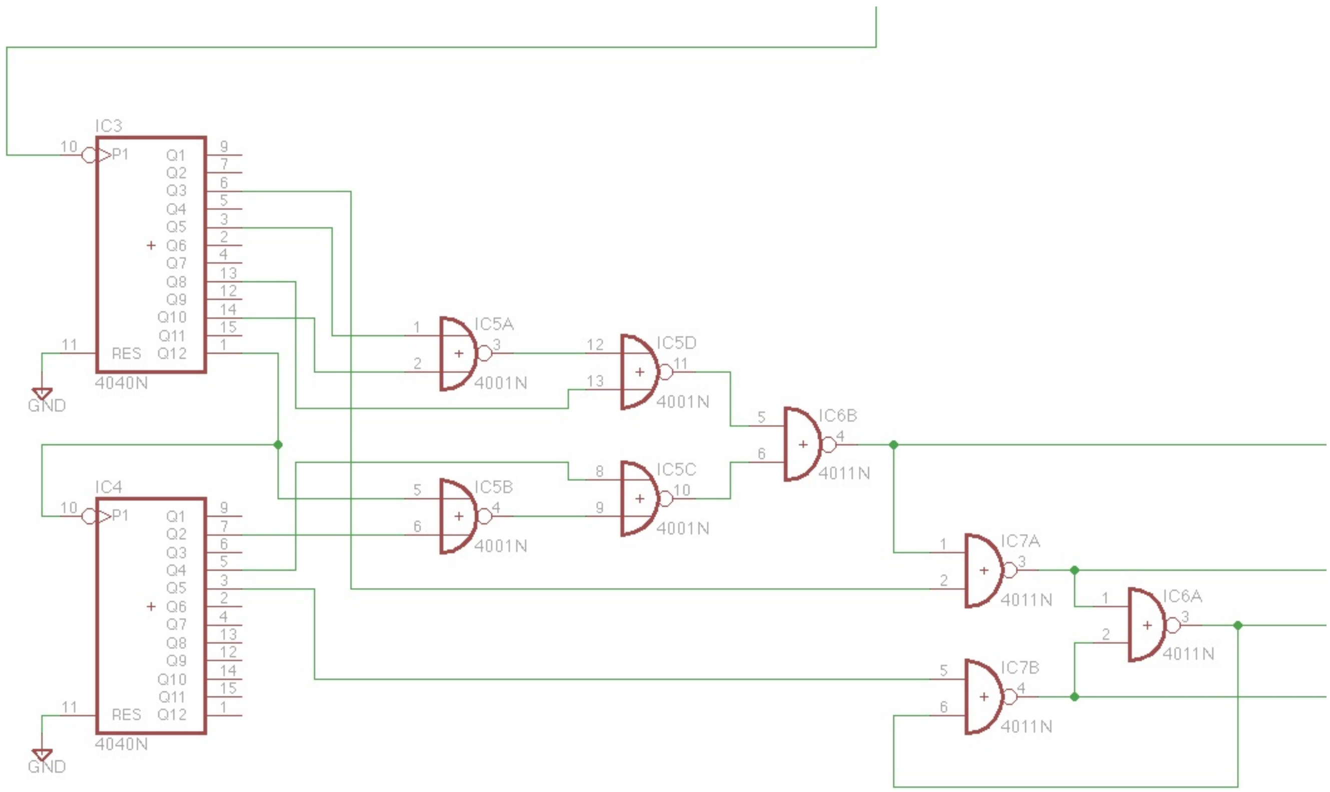
Since we are using a single supply, we must create artificial ground by dividing the power supply voltage with two equal resistors (10k each) and apply that artificial ground signal (Vdd/2) to the non-inverting inputs of the opamps. The output signal will swing above and below this artificial ground level.

Next we shall examine the modulated 40106 oscillator. The standard 40106 oscillator has just the feedback potentiometer and a cap to ground from the input node. I wondered if we could apply a signal to the ground side of the cap, would it modulate the square wave? Sure enough it did cause frequency modulation.

The way I hooked up the input signal was to lift the ground side of the oscillator's capacitor and add an AC coupled input signal with resistor reference to ground. Actually the first thing I tried was to directly drive the capacitor's ground side by lifting it from ground and connecting it straight to the output of the microphone amplifier circuit. This did not work because the signal was referenced to Vdd/2, not ground. So then I figured out how to do it properly with the series capacitor and shunt resistor creating ac coupling and ground reference. At first I tried 100k for the resistor value, but that was too much so I tried 10k and it worked.

This is the type of experimentation that I encourage you to do - imagine what might work and then try it and mess around with it until you get something interesting. You can't be afraid to fail when experimenting like this.

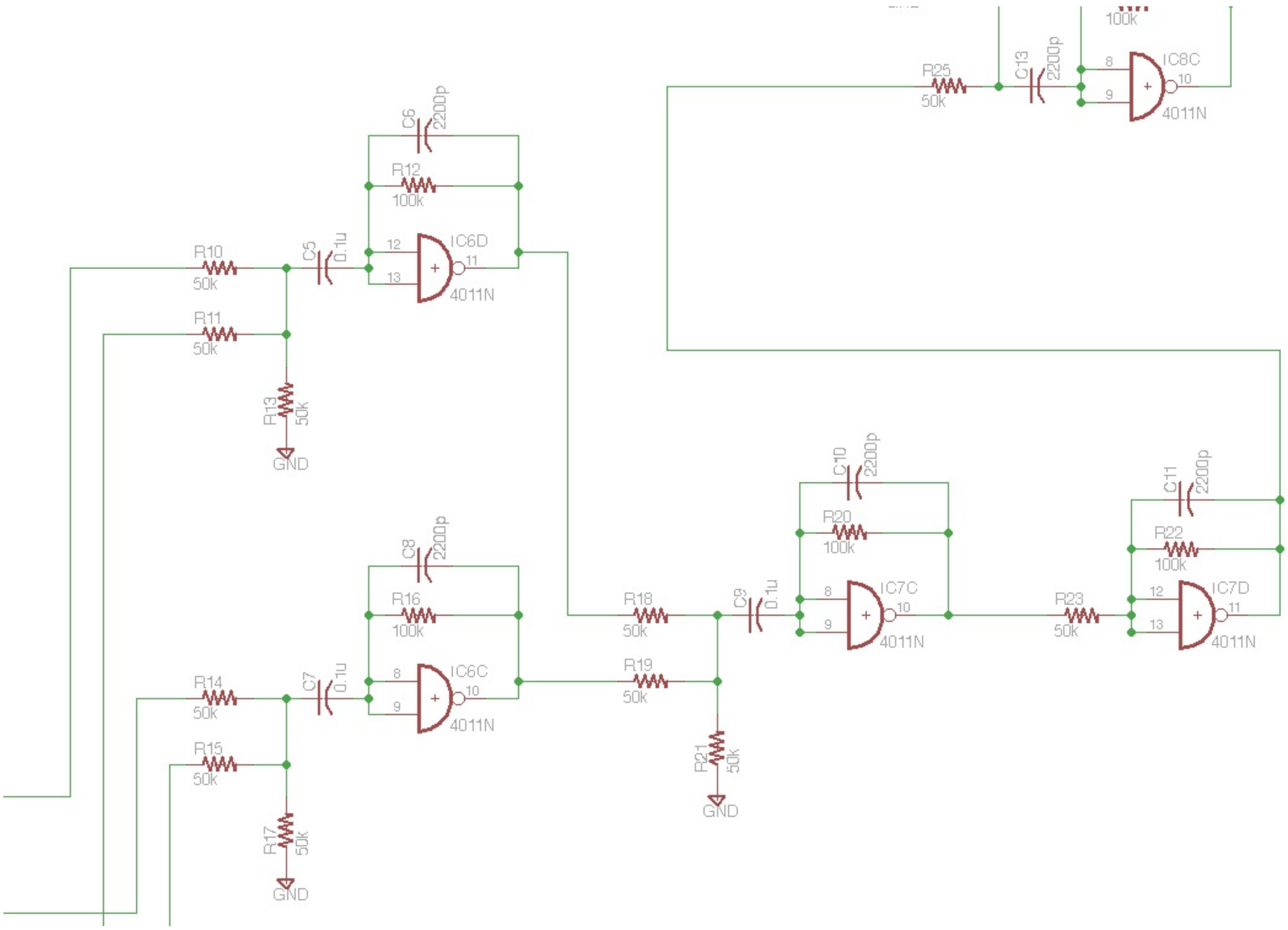
Next let's take a look at the digital boolean sequencer. It consists of two 4040 counter chips connected together forming a 24 bit counter. We tap a random selection of those output bits as inputs to our logic cloud, shown to the center and right part of the schematic below. Then we choose some of the logic outputs to feed into our next circuit.



The logic is just a randomly connected set of whatever gates you have on hand and you can experiment with different wiring to get different sounds. Note also that on the lower right I accidentally created state information by using logic feedback. This was unintentional but it serves to create more variety in the sound, so feel free to do this.

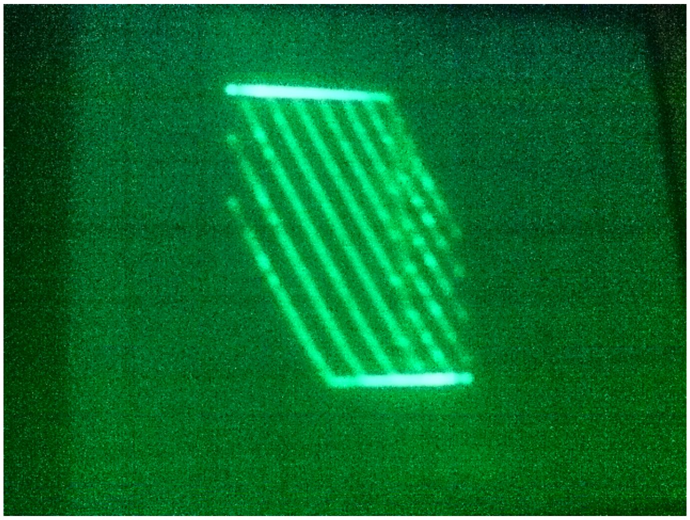
The connections from the counter to the logic cloud are made with longer arcs of wire so that I can easily reconnect them during the show to create different musical sequences. That way you will hear different types of sounds throughout the show.

The circuit shown below is the linear CMOS section which adds a lot to the sound quality by creating intermediate values of logic level. The feedback capacitors provide compensation so that the circuit does not oscillate and also filters the audio somewhat, creating smooth edges in the signal which adds to the musical quality.



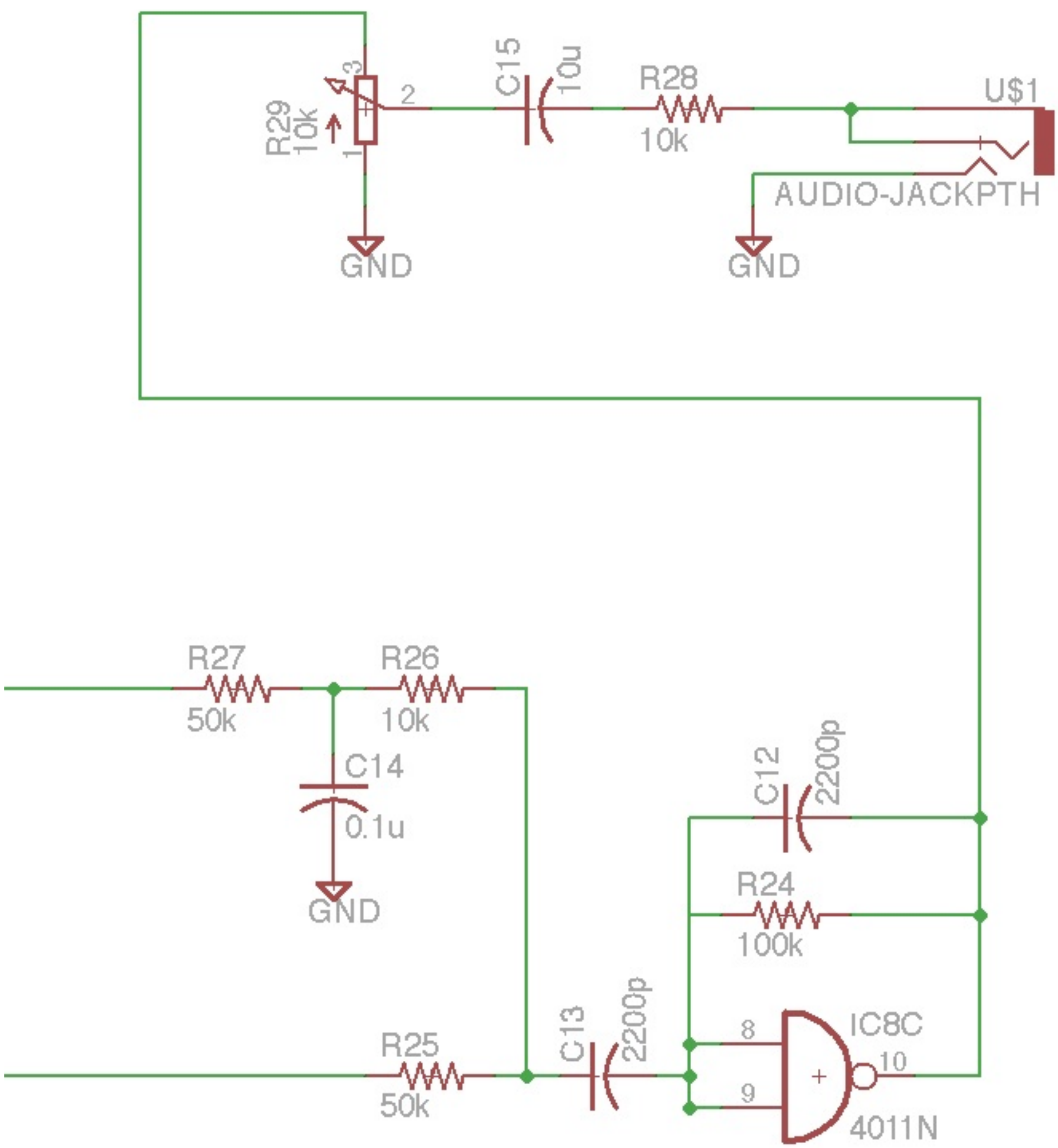
We have two input gates with two inputs each, a second gate combining the outputs of the first two, and finally a gain stage to boost the audio levels. This is another circuit that I recently designed for the purpose of creating this week's show.

Let’s have a look at an oscilloscope trace of a circuit very similar to the linear CMOS circuits. Shown below is a photograph of an oscilloscope XY plot that I created. I used the ChucK music programming language as a function generator to create sweeping input signals that put the thing through it’s paces, so to speak. These were ramp signals, one running ten times slower than the other.



The plot is very nice for music applications because it has smoothly varying mid-level signals and sharply changing upper and lower signals. In effect, it mixes the digital inputs to create analog levels. To really make good sound, however, we need a few layers of such a circuit. I got away using only two layers but more would have been better.

Finally, we have the output drive which consists of a filtered input for the voice and a non-filtered input for the audio. The potentiometer acts as a volume control and output is sent through a DC blocking cap and a source resistor to the audio jack which has left and right connected together.



This circuit is a lot of fun to play around with and it has a lot of creativity in it. I had a great time developing it and I'm happy to share it with you. If you decide to make your own version of this circuit, I recommend that you not just simply copy what I have done - which is OK for starters - but rather, try to use the principles that I've described and create your own unique circuit.

Also one good thing to do is to build the output circuit first, specifically just the potentiometer and the capacitor, resistor, and jack. That way as soon as you build the next part you can listen to it. In fact, I find that I don't need any test equipment at all in developing these types of audio circuits, I just use my ears! So listen to each little part as you build it using a long wire as a probe and you'll have a ton of wacky sounds to enjoy along the way.

Les Hall