Noisemaker Workshop

Attack of the Oscillator

April 22, 2009

Outline

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Workshop Overview

What's the plan?

- Today: Oscillators and a basic amplifier.
  Driving speakers with interesting noise.
- Next week: Modulation.
  Making stranger noises.
- Third week: Sequencers and rhythm generators.
  Architecting the noise.
- Fourth week: Open lab. Special topics.
  Digital oscillators? Voltage control? Serious modular synthesis?

Today: Building Simple Oscillators

What not to expect

- *Not* building what you probably think of as a synthesizer
- Not making something musical (yet).
  (If by "musical" you mean sound that's based on melodies.)
- No keyboards

What to expect

- Many of the basic ideas of serious 1970's analog synthesis, in a stripped-down form
- Some electronics
- A lot of experimentation
- Bugs. Hardware bugs galore.

"There is no wrong way to do this..."

...is a complete lie

- This is not finger-painting, this is audio engineering.
- There are a couple of right ways and an infinity of wrong ways.
- The wrong ways are often interesting.
- Art is doing it the wrong way,
  influenced by having practiced the right way.
- Hacking is just doing it, not worrying about right or wrong.
- We'll be starting out doing a number of things wrong.
- "There is no *wronger* way to do this?"

Quick Demo

Outline

Electricity as Water

Two slide overview

- Electrical pressure (that can be used to get stuff done) is like water pressure.
  Voltage = Pressure
- Electrical current (flowing electricity) is like flowing water.
  Current = Current
- Skinny pipes reduce the flow of water *and* the pressure downstream of the skinny pipe.
  Resistor = Skinny Pipe
- Pumps increase water pressure (and thus flow, through a pipe of given size).
  (Voltage) Amplifier = Pump

Electricity as Water

The other slide: the strange bits

- A pipe with a rubber wall in the middle blocks the flow of water, but lets small variations in water pressure through:
  Capacitor = Rubber wall in pipe section
- There's no good water analogy for a speaker. A surface that moves back and forth in response to changing water pressure?
  Speakers have cones that move back and forth in response to changes in voltage.
- One-way valves let water flow through one way, but not the other.
  Diode = one-way valve

Outline

Oscillation...

... brought to you by Hysteresis

- Hysteresis is the property of devices that turn on at one point, but off at a different point
- Thermostats have hysteresis:
  Set for 65 degrees, turn on at 63 degrees, turn off at 67 degrees
- What if it didn't have hysteresis?
- (Your heater/thermostat system is a very low frequency oscillator!)
- Like thermostat, many digital circuits use hysteresis
- "On" is a voltage above 5 * 2/3 volts.
  "Off" is a voltage below 5 * 1/3 volts.
- In between? Stays in whichever state it was in last.

Oscillation

Hysteresis *and* Feedback

- Thermostat controls heater. Heater heats air. Air temperature controls thermostat. Thermostat controls heater...
- Negative feedback: heating the air turns off the heater, vice versa
- This negative feedback plus hysteresis keeps the temperature bouncing up and down between the two temperature set points
- We're going to do the same with electricity.
- Inverting amplifier with hysteresis (inverting is the negative feedback part)

Oscillator Chip

74HC14: Hex Inverter with Schmitt Trigger

- Hex = 6
- Inverter = Inverting amplifier. Given 5v input, sends 0v out.
- Amplifier is like a pump. This one's a pressure-controlled pump.
- Schmitt Trigger is the *hysteresis*.
- Input $>$ 5v * 2/3: input is read as high, so output goes low (0v)
- Input $<$ 5v * 1/3: input is read as low, so output goes high (5v)
- In-between: doesn't change state

Oscillator

The plan

- Use one inverter from the HC14
- Feed its output back into its input
- Hysteresis will make sure that it stays between 5*2/3 and 5*1/3 volts
- Need to slow it down: skinny pipe and some way to store up the water for a while

The Circuit

How it works

- Imagine input starts low, output high
- Current flows through resistor, pushes on capacitor
- As capacitor gets more and more displaced, it pushes back more and more
- Eventually the pressure/voltage gets enough to trip the input high
- Then the output goes low
- Then current flows through the resistor in the opposite direction
- This relieves pressure on the capacitor
- Until...

Buffering

So can we just hook it up?

- Not yet!
- If we put the speaker in the circuit, all of our current would just flow out the speaker
- Use an intermediate stage: a buffer
- Used LM386 amplifier as buffer
- (Note: This is not ideal. In the future, I'll just use a stage from the 74HC14 or maybe a 74HC04.)
- Then to the speaker?

Output Capacitor

Now to the speaker

- Want to limit the current flowing through the speaker
- But want changes in pressure to pass through (to make sound)
- The job for a big capacitor
- Remember: stretchy rubber membrane in a pipe

Draw Pinout and Circuit on the Board

- Play!

The End

The End

Outline