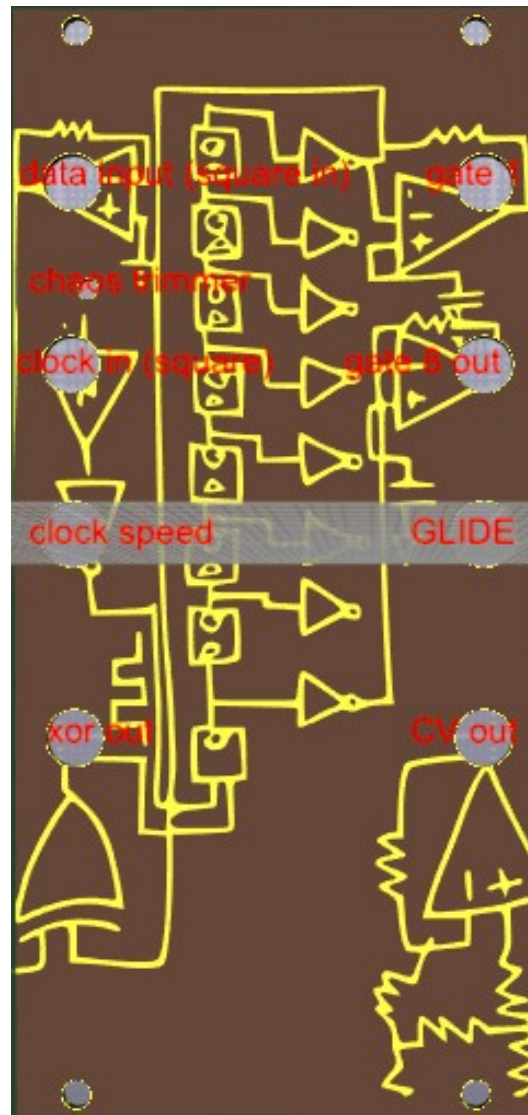# Rungler(ish) – or how to rungle two shift registers at once and be edgier than Rob Hordijk
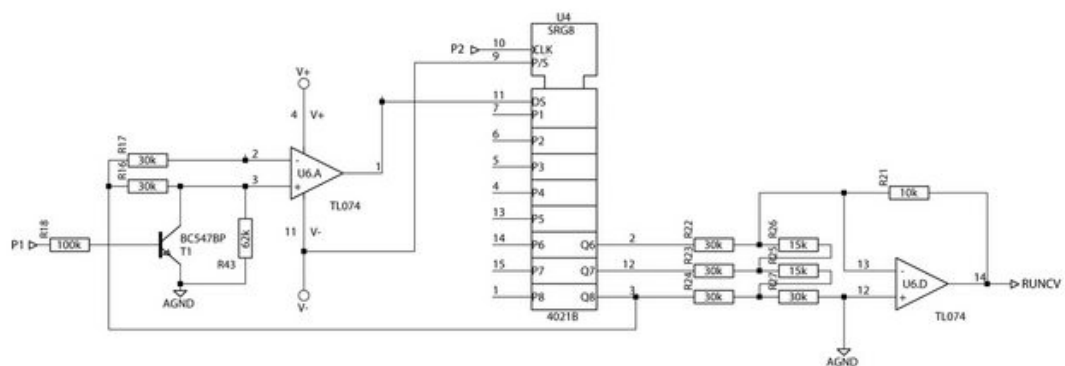

What the hell is a R U N G L E R?

- A mathematical chaos circuit (proper non-linear behaviour) invented by Rob Hordijk;

- generate 'random' or rather 'chaotic' voltage

- The circuit consists of a shift register ;

-and a basic 3-bit D/A converter (based on Resistor Ladder / R2R

- feedback loop between data input and one of the shift register outputs is the central chaotic element (since the concept of feedback or cross- modulation implies chaotic behaviour

- Blippo Box and then Benjolin contain rungler circuit:

made by Derek Holzer:

Blippo Box (precursor of Benjolin; non-eurorack format :))
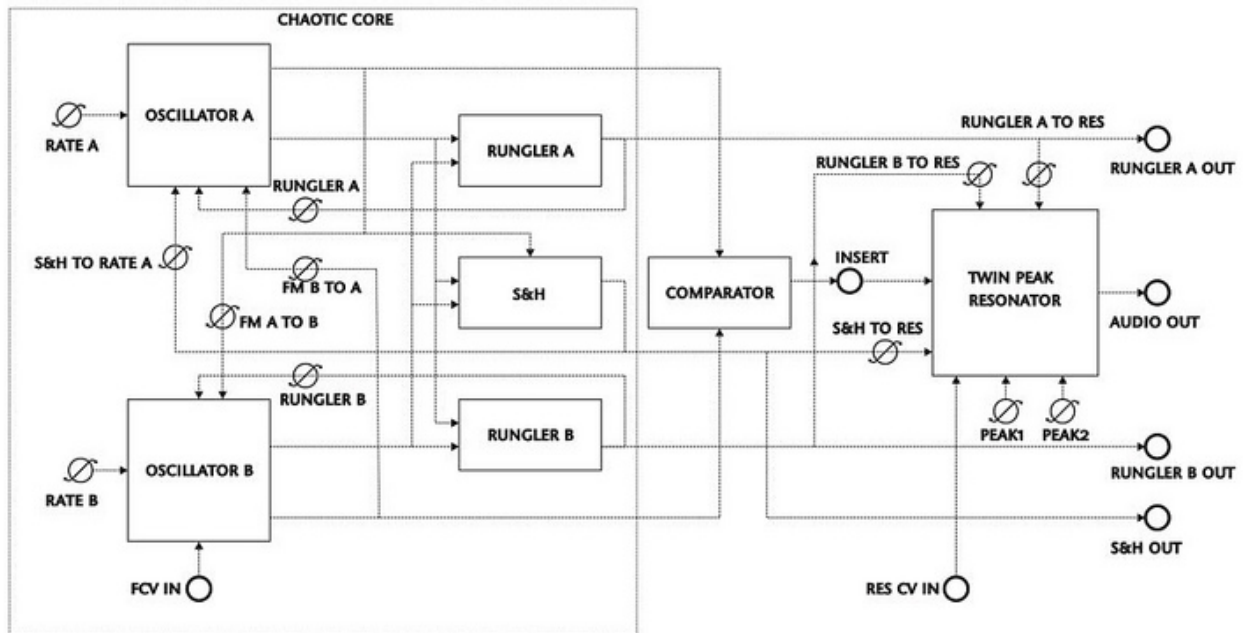
"The purpose of the rungler is to create short stepped patterns of variable length and speed. One could categorize the circuit somewhere halfway between a plain S&H and a shiftregister-based pseudorandom generator. It needs two frequency sources to work and basically creates a complex interference pattern that can be fed back into the frequency parameters of the driving oscillators to create an unlimited amount of havoc.

The rungler is basically a CMOS shift register clocked by one oscillator and receiving its data input from the other oscillator. The output bits of the shiftregister are used as a binary code 'to do something with'. E.g. in the Benjolin the last 3 stages of the shift register for a 3 bit code that is fed into a 3 bit DA converter. This DA eight level output voltage is fed back to the oscillator frequency control inputs. The output of the DA is the 'rungler CV signal'. To describe the rungler waveform in similar terms as like a sine wave or pulse wave I call it a 'stepped havoc wave'.

When the rungler signal is fed back to the frequency parameters of the oscillators it will change the triangle waveforms and pulse widths of the oscillator outputs, making other types of havoc waves, like a 'pulsed havoc wave' and a 'sloped havoc wave'. Note that it is these properties of stepped, sloped and pulsed that are of interest in the waves.

(The Dutch composer Jan Boerman formulated an idea in the 1960s about audio signals that are inbetween pitched and unpitched. Havoc waves are probably somewhere in that region, maybe a bit similar to granular synthesis stuff. I haven't really thought deeply about this myself, but Boerman has certainly always been an inspiration to me to try to go into that inbetween territory.)

The rungler will try to find a balanced state. In this way it behaves according to principle from Chaos Theory. There seems to be an unlimited amount of possible balanced states and when a balanced state is just slightly disturbed it can be noted that it takes a little time to find the next balanced state, with noticeable bifurcations, etc. Note that a new balanced state is defined by the exact position of the control knobs plus the previous state it was in.

The first rungler experiments I did were back in 1980 I think, and there are quite a lot of variations possible on the rungler idea. In the Benjolin design the data input for the shiftregister is not just the pulse from the second oscillator but the XOR of this pulse and the last bit of the shift register (inspired on the pseudorandom generator). The XOR is the transistor/opamp combination that actually forms a controllable unity gain/minus unity gain amplifier, a very simple ringmodulator, so to speak.

Tip: An interesting option is to feed the three bits at the end of the shiftregister into the 3 'selection' inputs of a CMOS 4051 eight-to-one/one-to-eight analog switch and e.g. quickly switch between eight audio signals. You can take these three bits from the pins 2, 3 and 12 on the 4021.

The shiftregister used should not be too long, four to eight stages already does a perfect job. Some CMOS shiftregisters can recirculate, which would hold the pattern.

One can expand by having multiple parallel shiftregisters alternatingly clocked on positive and negative flanks of the oscillator pulse and e.g. using the triangles from the oscillators to

crossfade between multiple DAs on the multiple shiftregisters, etc. By expanding the number of oscillators and shiftregisters the number of available havoc waves explodes. Basically the rungler is an open ended circuit that can be expanded and chained into multi-rungler networks (hihi, that's what our Rungler module variation is, since we are using two shift registers... more about it l8r)

In the current issue of Leonardo Music Journal (issue 19) is an article about the Blippoo Box, the Benjolins Big Brother, and there is more on the rungler circuit in the article as well as some other thingies I used in the Benjolin as well. (I have added this pdf to rungler folder)

Imho a rungler circuit works best in an analog electronics implementation. It is definitively more alive and surprising due to the slight instabilities in the analog circuitry. I did digital implementations, but they can't beat the 'organic behaviour' of the analog versions. But this is just personal taste..."

This means if we plug the output of the rungler to X and Y of the oscilloscope we will should see something like this (strange attractor) – check out the book on chaos theory by Gleick:
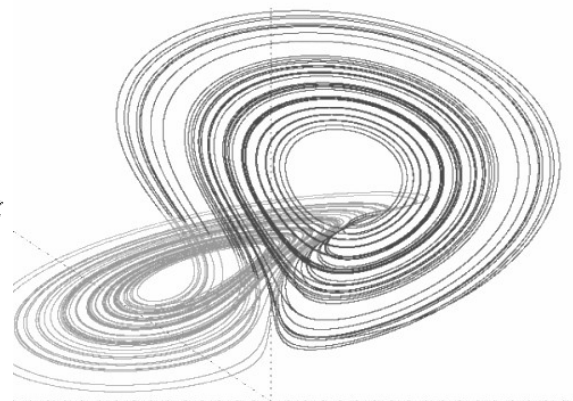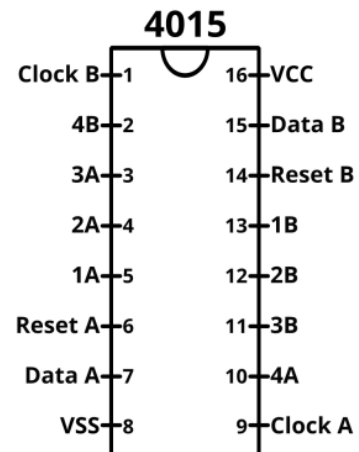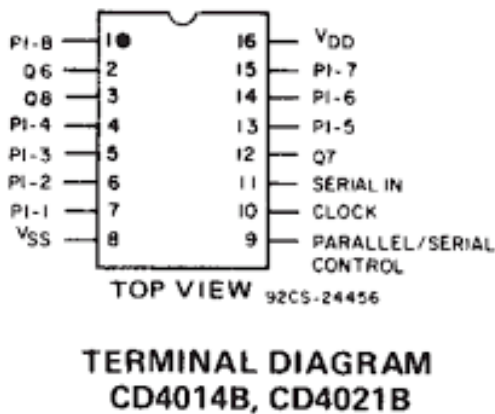
We need to talk about shift registers
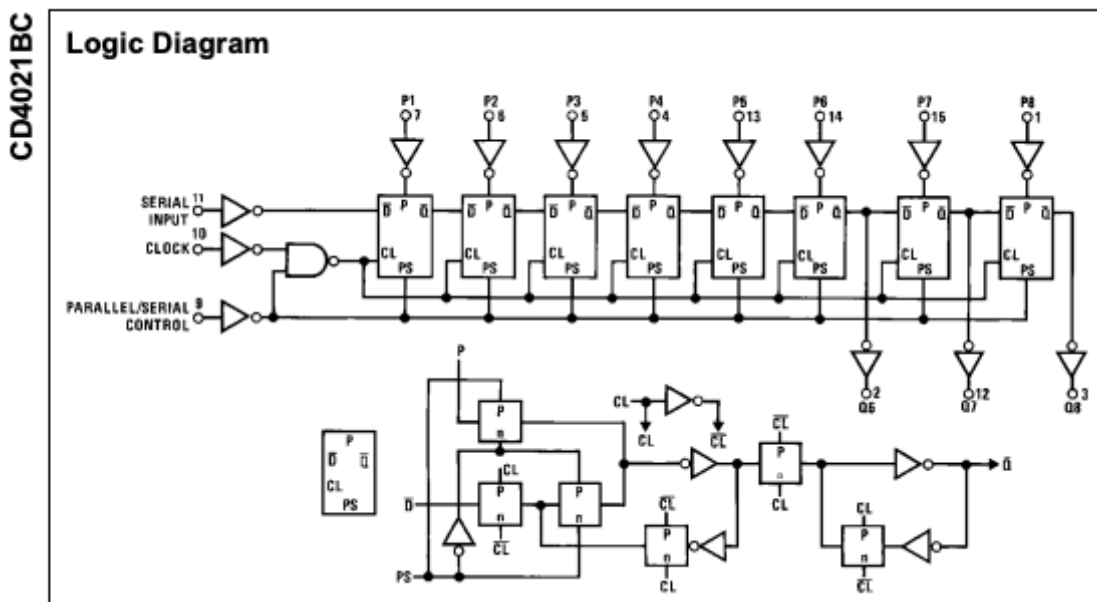
WHAT:

1) a digital circuit
2) contains daisy-chained FLIP FLOPS(bistable multi-vibrators OR simply put oscillators with two (ON/OFF-1/0) states)
3) it stores DATA, which is then being SHIFTED from one location to the next
4) a form of now obsolete DELAY-IN-LINE computer memory - when the last flip-flop is connected to the first one

SIPO VS PISO

- CD4021 is Parallel Input-Serial Output (PISO) shift register; whereas CD4015 is Serial-Input-Parallel Output
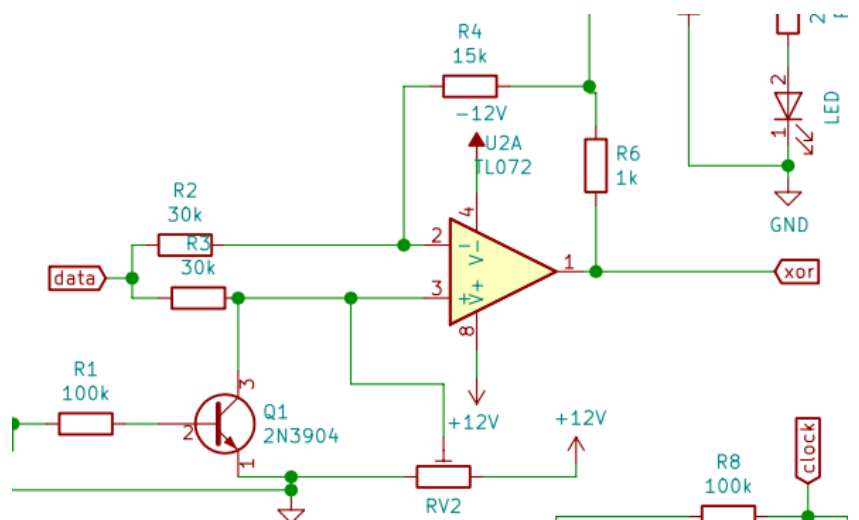


```
PI-8 ──  1 ●     16  ── V_DD
Q6   ──  2       15  ── PI-7
Q8   ──  3       14  ── PI-6
PI-4 ──  4       13  ── PI-5
PI-3 ──  5       12  ── Q7
PI-2 ──  6       11  ── SERIAL IN
PI-1 ──  7       10  ── CLOCK
V_SS ──  8        9  ── PARALLEL/SERIAL
                         CONTROL
         TOP VIEW  92CS-24456
```

TERMINAL DIAGRAM
CD4014B, CD4021B

```
              4015
Clock B ─┤1        16├─ VCC
   4B  ─┤2        15├─ Data B
   3A  ─┤3        14├─ Reset B
   2A  ─┤4        13├─ 1B
   1A  ─┤5        12├─ 2B
Reset A ─┤6        11├─ 3B
Data A ─┤7        10├─ 4A
  VSS  ─┤8         9├─ Clock A
```

We are using CD4015 to :
- run LEDs and generate gate signals (two out of 8 0 first one and the last one (8th)

-whereas CD4021 is generating CV signal

XOR GATES (Exclusive OR)

A —⊐
B —⊐ XOR ⟩o— Q   is

XOR logic gate 0 0
XOR logic gate 0 1
XOR logic gate 1 0
XOR logic gate 1 1

Only science nibbas will find it funny

- the output of the XOR is true if the inputs are not alike otherwise the output is false. A way to remember XOR is "must have one or the other but not both".

- the op-amp and transistor section functions here as comparator:

"Operational amplifier in which one terminal is connected to reference signal (in our case its the "data" label, which is the last output of CD4021) and input signal (external square wave input). Comparator compares (LOL) the input applied to this terminal with reference voltage. When ever the input signal crosses the reference then the output of opamp changes. Additionally the chaos trimmer changes the range of the reference signal since its middle leg is connected to non-inverting input (+) and two opposite legs go to GND and +12V.

It also scales any kind of signal to the right range for CMOS which is +12V / 0V (GND). You don't want to fry them !!!

USING CMOS ONLY FOR DIGITAL CIRCUITS

INTEGRATION OF ANALOG AND DIGITAL CIRCUITS

INTEGRATION OF ANALOG, RF AND DIGITAL CIRCUITS

INTEGRATION OF DNA, RF, ANALOG AND DIGITAL CIRCUITS

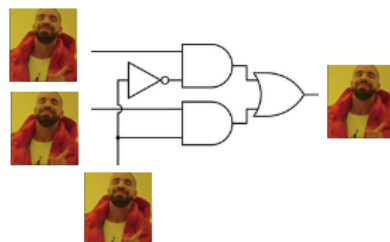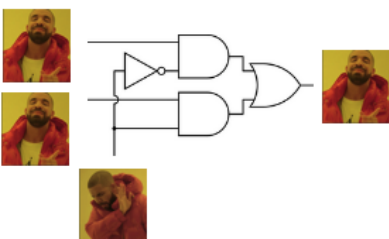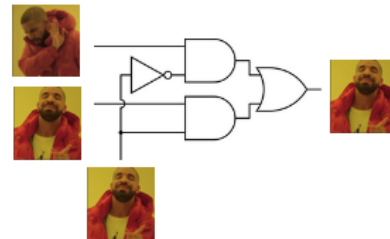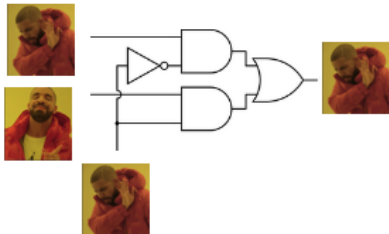INTEGRATION OF HUMANS, DNA, RF, ANALOG AND DIGITAL CIRCUITS

CMOS
O NO CMOS
memegenerator.net

To be

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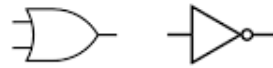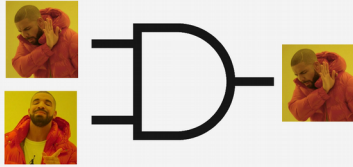
to be

(Drake's Multiplexer)
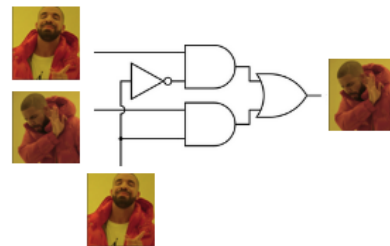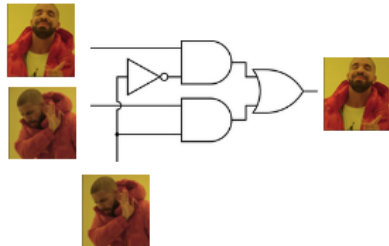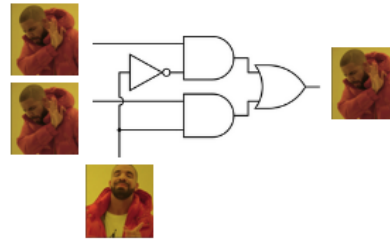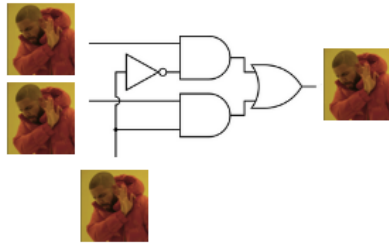
Drake's Logic Gates

'And' gate &	'Or' Gate |	'Not' Operator ~
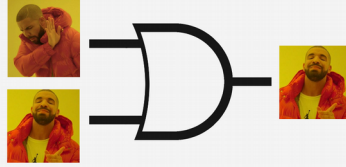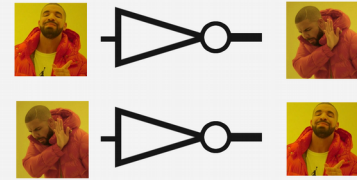
- R = half the value of 2R (OR, to show my interpretative genius: 2R = twice the value of R! Who would have guessed that??!?!?! HEEEE??
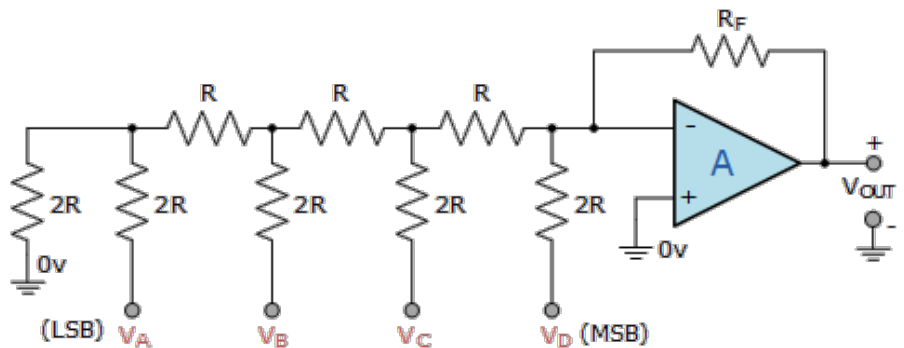
- resistors act as voltage dividers between the referenced voltages (our Q outputs from shift registers)

- each tap of the string generates a different voltage (0V-10V) depending on which bits (Q outs puts) are set to 0 (LOW/0V) and which are set to 1 (HIGH/5V) -since CMOS output signal range is from 0V to 5V

Resources:

https://youtu.be/gls5eug9P9M

https://thehordijkmodular.blogspot.com/2018/02/the-blippoo-box-ah-fabled-blippoo-box.html

https://electronicmusic.fandom.com/wiki/Rungler

https://modwiggler.com/forum/viewtopic.php?t=92049

https://en.wikipedia.org/wiki/Shift_register#:~:text=A%20shift%20register%20is%20a,one%20location%20to%20the%20next.

https://hackaday.com/2015/05/04/logic-noise-taming-the-wild-shift-register/

https://www.redrok.com/CMOS_CD4021BC_8-StageStaticShiftRegister_Fairchild.pdf

https://en.wikipedia.org/wiki/XOR_gate

http://www.zpag.net/Electroniques/CirLogiques/xor_gate_using_op_amplifier.html

https://www.quora.com/What-is-the-difference-between-comparator-and-logic-gate

https://www.electronics-tutorials.ws/opamp/op-amp-comparator.html

https://www.electronics-tutorials.ws/combination/r-2r-dac.html