Cicada NAND on a Breadboard

FOUR CD4093 VOICES, EACH WITH ITS OWN PITCH KNOB AND ITS OWN MUTE // BREADBOARD BUILD SHEET // MESS O' PEDALS

Build the Cicada NAND on a solderless breadboard: four Schmitt-trigger oscillators on one CD4093, each with its own pitch knob and its own mute, mixed through a volume knob to one output. Thirty-eight steps, exact holes.

Parts

	1x CD4093 quad NAND Schmitt trigger, DIP-14 (IC1) - spot it: fourteen legs, 4093 in the part number, a notch at one end and a dot beside pin 1. It must be the 4093 and not a 4011 - the 4011 is the same pinout with no Schmitt trigger in it, and without the Schmitt trigger none of these gates will oscillate at all
	4x 1K resistor (R1, R2, R3, R4) - spot it: bands brown-black-red. One in series with each pitch pot, and the one part in here that is genuinely not optional. See the note above
	4x 10K resistor (R5, R6, R7, R8) - spot it: bands brown-black-orange. Easy to mix up with the 1K - the third band is the difference. One per voice, and they are what does the mixing: four equal resistors onto one bus is a mixer
	4x 1M resistor (R9, R10, R11, R12) - spot it: bands brown-black-green. The enable pull-ups, one per voice
	1x 1nF ceramic (C3) - spot it: disc printed 102 . Osc 3's timing cap, and the smallest cap makes the highest voice - this is the shrill one. Either way round
	1x 10nF ceramic (C1) - spot it: disc printed 103 . Osc 1, the second highest. Either way round
	2x 100nF ceramic (C2, C9) - spot it: disc printed 104 . C2 is osc 2's timing cap, the middle voice; C9 is supply decoupling and has nothing to do with any oscillator. Either way round
	5x 1 uF film capacitor (C4, C5, C6, C7, C8) - spot it: a little box, either way round. An electrolytic works for these if it is all you have, stripe toward ground. C4 is osc 4's timing cap - the biggest cap makes the slowest voice, and at 1 uF that one is a click rather than a tone. C5 to C8 carry each voice onto the mix bus
	1x 10 uF electrolytic (C10) - spot it: a small can with a stripe down one side. The output cap, and the one polarized part here
	4x 100K linear pot (B100K), the pitch knobs - spot it: a B before the value means linear, which is what you want for pitch. One per voice. Each wires as a variable resistor : wiper tied to one outer lug, and that is why every one of them needs its 1K
	1x 100K linear pot (B100K), the volume knob - the same part as the other four and wired the other way , as a divider : signal on one outer lug, ground on the other , wiper out to the jack. No 1K in front of it, and it wants none - a divider at zero ohms is silence, which is the whole point of a volume control. This is the one control the stripboard version does not have
	4x SPST switch - the mutes. Any on-off toggle. Optional: with none fitted it drones with all four voices running, which is a perfectly good instrument. They are also the cheapest thing on this list and the most fun
	1x output jack - whatever your amp takes
	A full-size breadboard , 63 columns, both banks and both rail pairs - spot it: the long one. This layout runs from column 10 to column 44 , so a half-size board will not fit it as drawn. Plus five jumpers
	9V battery and a snap. A CD4093 runs anywhere from 3V to 15V; the pitch of every voice moves with the supply, so a tired battery is a slow battery

Before you start

The 1K resistors are not optional, and this is the fault worth knowing before you start. R1 to R4 sit between each gate's output and its pitch pot. The pot is wired as a variable resistor, so at one end of its travel it is zero ohms - and with no 1K in the way that ties the gate's output straight to its own timing input. The capacitor then has nothing to charge through, and the voice does not go quiet gracefully, it dies into a dead short. Fit all four.

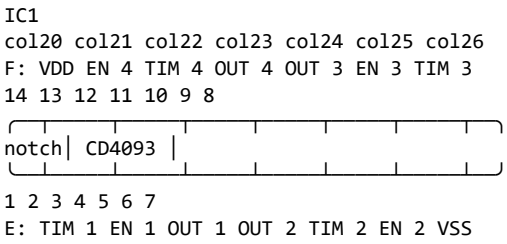
One part cares which way round it goes. C10, the 10 uF electrolytic on the output, has a stripe down one side marking the minus leg. Its plus leg goes to the board and the stripe points out toward the jack. Everything else here is a resistor, a ceramic or a film cap, and none of those care.

There are five identical pots here and they are not wired alike. The four pitch pots are variable resistors: wiper tied to one outer lug, third lug empty, 1K in series. The volume pot is a divider: all three lugs used, signal on one outer, ground on the other, wiper out, and no 1K anywhere near it. Wire the volume pot like a pitch pot and it will not turn anything down; wire a pitch pot like the volume pot and you ground its timing node.

The mute switches are optional; the 1M resistors are not. R9 to R12 hold each gate's enable input high so the voice runs. Leave the switches off and it simply drones with all four going. Leave a 1M off and that input floats, which on a CMOS chip means the voice does whatever it likes and draws current doing it.

Meter your rails before you wire anything. This layout runs from column 10 to column 44, straight across the midpoint where plenty of full-size boards break their rails. A split rail is the single most common reason a breadboard build does nothing at all.

The chip, from above



The notch points left and pin 1 goes in E20 , so pin 14 lands in F20 directly across the channel. Then every other pin falls on the hole shown. Anywhere in the same bank and column is the same point, so F24 and I24 are both "pin 10". Read the card in pairs and the layout explains itself: each voice's timing pin, enable pin and output sit side by side , which is why every voice is three adjacent columns and nothing has to cross anything.

Build

Step 1 The chip

It goes in dry, before a single wire. Push a chip into a board that already has jumpers round it and you will fold a leg under the body and spend an hour chasing a fault that is not there. Every other part on the board is measured from this one footprint.

	STEP	DO
☐	1	Seat the CD4093 (IC1) across the center channel, notch to the left : pin 1 in E20 , pin 7 in E26, pin 8 in F26, pin 14 in F20. The lower bank then reads E20 = 1, E21 = 2, E22 = 3, E23 = 4, E24 = 5, E25 = 6, E26 = 7, and the upper bank reads F26 = 8, F25 = 9, F24 = 10, F23 = 11, F22 = 12, F21 = 13, F20 = 14. Press it flat and check no leg folded under

Steps 2-6 The jumpers

Five wires, and four of them are plumbing. Do the two rail ties first: the upper bank needs power and ground as much as the lower one does, and on most boards the two rail pairs are not connected to each other at all.

	STEP	DO
☐	2	J4 : bottom + rail to top + rail . Ties the two positive rails together
☐	3	J5 : bottom - rail to top - rail . Ties the two negative rails together
☐	4	J1 : H20 to the top + rail . This is pin 14, the chip's supply
☐	5	J2 : C26 to the bottom - rail . This is pin 7, the chip's ground
☐	6	J3 : E40 to F40 . Bridges the two halves of the mix bus across the channel, so the two upper voices and the two lower voices end up on one node. Nothing else on this board crosses the channel

Steps 7-18 The resistors

Twelve of them, in three groups of four - one trip to each drawer. The 1K group and the 10K group look alike and the third band is the only difference, so do them as groups rather than voice by voice and you will not mix them up.

	STEP	DO
☐	7	R1, 1K (brown-black-red): B22 to B10 . Voice 1's feedback limiter - the floor under its pitch pot
☐	8	R2, 1K : B23 to B14 . Voice 2
☐	9	R3, 1K : G24 to G10 . Voice 3, upper bank. Same column 10 as voice 1, other side of the channel, not the same point

	10	R4, 1K : G23 to G14 . Voice 4
	11	R5, 10K (brown-black-orange): D22 to B32 . Voice 1's mix resistor
	12	R6, 10K : D23 to B36 . Voice 2
	13	R7, 10K : I24 to G32 . Voice 3
	14	R8, 10K : I23 to G36 . Voice 4
	15	R9, 1M (brown-black-green): A21 to the bottom + rail . Holds voice 1's enable high so it runs
	16	R10, 1M : A25 to the bottom + rail . Voice 2
	17	R11, 1M : H25 to the top + rail . Voice 3
	18	R12, 1M : H21 to the top + rail . Voice 4

Steps 19-27 The ceramic and film caps

None of these care which way round they go. Four of them are the whole reason the four voices sound different from each other: a bigger timing cap is a slower voice , and these run from 1nF to 1 uF, which is a thousand to one.

	STEP	DO
	19	C3, 1nF (printed 102): H26 to the top - rail . Voice 3's timing cap. Smallest cap, highest voice - this is the shrill one
	20	C1, 10nF (printed 103): A20 to the bottom - rail . Voice 1. Second highest
	21	C2, 100nF (printed 104): A24 to the bottom - rail . Voice 2. The middle of the four
	22	C9, 100nF : bottom + rail to bottom - rail , as close to the chip's end of the board as you can get it. This one is supply decoupling and belongs to no voice. It does nothing useful far away from the chip
	23	C4, 1 uF : H22 to the top - rail . Voice 4's timing cap. Biggest cap, slowest voice - at 1 uF this one is a click rather than a tone, and that is what it is for
	24	C5, 1 uF : D32 to A40 . Carries voice 1 onto the mix bus
	25	C6, 1 uF : D36 to B40 . Voice 2
	26	C7, 1 uF : I32 to G40 . Voice 3
	27	C8, 1 uF : I36 to H40 . Voice 4. All four now meet at column 40, which J3 already bridged across the channel

Step 28 The electrolytic

One part, and the only one on the board with a direction.

	STEP	DO
	28	C10, 10 uF electrolytic : plus leg in C40 , the mix bus side, stripe leg in A44 . The stripe marks the minus leg and it points away from the board, toward the jack

Steps 29-35 Off the board: the knobs, the mutes and the jack

Everything with a wire on it. Each voice is one pot and one switch, so wire them a voice at a time and test your way along if you like - a voice works on its own.

The four PITCH pots are variable resistors. Tie the wiper to one outer lug and run that pair to the WIPER hole; the remaining outer lug goes to the LUG hole. The third lug is not left floating, it is tied to the wiper - that is what stops the pot going open circuit and killing the voice at one end of its travel. The 1K you fitted at steps 7 to 10 is what protects the other end.

The VOLUME pot at step 31 is the opposite, a divider , and it is the only pot here wired that way. All three lugs do a job: signal in on one outer, ground on the other, wiper out. Nothing is tied together and there is no 1K, because a divider at zero ohms should be silent - that is what turning it down means. A divider is also why this one can sit on the output at all: its ground leg is what gives the node behind C10 a path to ground.

	STEP	DO
	29	Power in : 9V snap red to the bottom + rail , black to the bottom - rail . Leave it unplugged until step 37

	30	Output jack sleeve to the bottom - rail
	31	The volume pot , wired as a divider - all three lugs used. One outer lug to C44 , the free leg of the 10 uF; the other outer lug to the bottom - rail ; wiper to the output jack tip . Which outer lug is which only decides whether the knob turns up clockwise or counter-clockwise, so wire it, listen, and swap the two outer leads if it runs backwards
	32	Voice 1 : pot wiper and one outer lug together to D10 ; the other outer lug to C20 . Then the mute switch between C21 and the bottom - rail - closed mutes the voice
	33	Voice 2 : wiper pair to D14 , other lug to C24 , mute switch between C25 and the bottom - rail
	34	Voice 3 : wiper pair to I10 , other lug to J26 , mute switch between J25 and the bottom - rail . Upper bank now, so all three land in the F to J rows
	35	Voice 4 : wiper pair to I14 , other lug to J22 , mute switch between J21 and the bottom - rail

Steps 36-38 Check, then power up

Now, and not before. Everything above goes in with the supply disconnected.

Start with the volume knob down. Four CMOS outputs swinging the full supply, summed and coupled to a jack, is a hot signal by the standards of anything expecting a guitar - the pot is there to tame it, so use it before you find out how much it was needed. Turn it up into the amp rather than the other way round. Even wide open this is a line-level-ish square wave, not a pickup.

	STEP	DO
	36	Supply off. Check the 10 uF 's stripe is in A44 and not C40, the chip's notch points left , and all four 1K resistors are actually 1K (brown-black- red) and not 10K (brown-black- orange). Check the volume pot has all three lugs wired and one of them really does reach the - rail. Then meter the bottom + rail to the bottom - rail : it should read high, not near zero. Anything near zero is a short and the chip should not see power until you find it
	37	9V in , with all four mute switches open , the four pitch pots at mid travel and the volume down . Bring the volume up and you should get four tones at once: a shrill one, two in the middle, and a slow lumpy click under them
	38	Play it. Mute three voices and sweep the fourth end to end - that is how you learn what each knob does. Then bring them back in one at a time. Voice 4 at 1 uF is the one that sounds broken; it is not, it is the rhythm

If it doesn't work

SYMPTOM	CHECK
Nothing at all, dead silent.	Split rails - jumper both halves of each, then check J4 and J5 are actually tying the two pairs together. Then the chip: pin 14 to + at H20, pin 7 to - at C26, notch pointing left. Then look under the chip for a folded leg.
Dead silent, but the volume knob is new to you.	The volume pot is a divider and it has three lugs wired: signal from C44, ground to the - rail, wiper to the jack tip . A pot with the jack on an outer lug instead of the wiper gives you nothing at any setting.
The volume knob does almost nothing, or only works at the very end.	It is wired like a pitch pot - wiper tied to an outer lug, third lug floating. That is a variable resistor, not a divider, and with nothing to divide against it barely attenuates. Untie the lugs and take the third one to ground.
Volume works backwards.	The two outer lugs are swapped. Harmless; swap them back, or leave it and remember.
Three voices work, one is silent.	That voice only. Its 1M pull-up (R9 to R12) reaching the + rail, its timing cap reaching the - rail, and its mute switch actually open. A mute switch wired to + instead of - holds the voice off permanently.
A voice is silent at one end of its knob and fine at the other.	Its 1K is missing, or it is a 10K read as a 1K in bad light. At zero ohms on the pot there is nothing between the gate's output and its own timing cap. Brown-black-red.
A voice does not change pitch at all.	The pot is wired as a divider rather than a variable resistor. The wiper must be tied to one outer lug, and that pair goes to the WIPER hole. If the wiper is on its own, sweeping it does almost nothing.
Voice 4 clicks instead of playing a note.	Working as intended. C4 is 1 uF, a hundred times bigger than voice 2's cap, so it runs below the bottom of hearing and you hear the individual edges. Swap it for 100nF if you want four tones instead of three and a pulse.

All four voices change pitch when you turn one knob.	They share a supply and a mix bus, so a little of this is normal and is part of how it sounds. A lot of it means C9 is missing or is nowhere near the chip - that is the cap whose whole job is to stop one voice's current pulses moving another voice's pitch.
It gets slower and duller as the evening goes on.	The battery. Every voice's pitch moves with the supply on this chip, so a tired 9V is a whole instrument going flat. It is also a genuinely nice effect if you let it happen.
A voice sounds like a different voice.	Two timing caps swapped. They go 102, 103, 104, 1 uF on voices 3, 1, 2, 4 in that order, which is deliberately not the order the voices are numbered in - check each against step 19 to 23 rather than against the one next to it.
It is horrible.	Good.

Things to try

- Try an A100K for the volume instead of the B100K. An audio taper spreads the useful part of a volume control across the whole sweep; a linear one does most of its work in the last quarter turn. The B is in the parts list because it is the same part as the other four and that keeps the list short, not because it is better here.
- Swap the timing caps. Anything from 100pF to 10 uF does something. Four caps of the same value is a different instrument entirely: four voices that nearly agree, beating against each other.
- Make a mute switch a momentary instead of a toggle, and that voice becomes a key you play rather than a drone you allow.
- Feed one voice into another's mute. Run a wire from a gate output into another voice's enable hole instead of its switch, and the slow voice starts chopping the fast one. Voice 4 at 1 uF is the obvious one to chop with. This is the trick the Locust is built on.
- Give it a proper output. An LM386 Hornet stage and a speaker and it needs nothing plugged into it at all.
- Solder it down. The stripboard Cicada NAND is the same board on 18 by 20 holes, built and working, with a drill template for a 125B box. It has no volume pot - add this one to it the same way, off the board between the output cap and the jack.