Mood Plush

A SQUEEZE-TRIGGERED CD4093 SYNTH THAT GETS WORKED UP, ON A BREADBOARD // BREADBOARD BUILD SHEET // MESS O' PEDALS

Build the Mood Plush on a breadboard - a piezo disc, a CD4093 and a 555 arranged so that every squeeze chirps a little higher and lights an eye a little brighter, then it calms back down on its own. One capacitor holds the mood and a home-made vactrol turns it into pitch. Forty-nine steps, no soldering but the vactrol's four leads, a printable build sheet and a troubleshooting table.

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. Three of its four gates are used: input, oscillator, eye driver
	1x NE555 timer, DIP-8 (IC2) - spot it: eight legs, half the length of the 4093, NE555 or LM555 printed on top, half-moon notch at one end
	1x 2N7000 N-channel MOSFET (Q1) - spot it: TO-92, three legs, one flat face, 2N7000 printed on the flat. Not a 2N3904 - it looks identical and it is the wrong part here, see troubleshooting
	1x piezo disc with leads (PZ1) - spot it: a brass disc with a white ceramic center and a red and a black wire. This is the thing you squeeze
	1x LDR photocell (LDR1, GL5528 or similar) - spot it: round face with a wiggly track printed across it, two legs. The same cells as the Opto Duet . It gets sealed to LED1
	1x LED , eye 1 (LED1) - spot it: any color, long leg is the anode. This one gets buried in heatshrink with the cell, so nobody sees it - but pick a bright one, because the 1K in front of it only allows a few milliamps and the cell needs all the light it can get
	1x LED , eye 2 (LED2) - spot it: the one people actually see, so pick the pretty one. Long leg is the anode
	1x 8 ohms speaker , small (SPK) - spot it: any small speaker. Expect it quiet; see the note at Power up
	2x 1M resistor (R1, R6) - spot it: bands brown-black-green. One holds the piezo at ground, the other drains the mood
	2x 100K resistor (R2, R5) - spot it: bands brown-black-yellow. One feeds the piezo into the chip, the other sets how much each squeeze adds
	1x 150K resistor (R4) - spot it: bands brown-green-yellow on a 4-band part, brown-green-black-orange on a 5-band metal film. The one-shot's timing resistor
	1x 4.7K resistor (R3) - spot it: bands yellow-violet-red. The fixed part of the oscillator's timing resistor; the photocell is the rest
	2x 1K resistor (R7, R8) - spot it: bands brown-black-red. One in front of each LED
	1x 100R resistor (R9) - spot it: bands brown-black-brown. Easy to mix up with the 1K - the third band is the difference. Speaker series resistor
	2x 100nF ceramic (C1, C5) - spot it: disc printed 104 . C1 sets the octave the whole thing lives in; C5 is supply decoupling. Either way round
	1x 10nF ceramic (C2) - spot it: disc printed 103 . Steadies the 555's control pin. Either way round
	1x 1 uF capacitor (C3) - spot it: film if you have one, a little box either way round; an electrolytic works, stripe to the minus rail. The one-shot's timing cap
	1x 22 uF electrolytic (C4) - spot it: a small can with a stripe down one side. This is the mood. The stripe marks the minus leg and polarity matters
	1x 10 uF electrolytic (C6) - spot it: a smaller can, same stripe. Speaker coupling, polarity matters
	3x 1N4148 diode (D1, D2, D3) - spot it: tiny glass body, a black band at one end - the band is the cathode. Two of them are the clamp on the piezo, the third is the one-way valve into the mood cap
	A full-size breadboard , 63 columns, both banks and both rail pairs - spot it: the long one. This layout runs from column 3 to column 50 , so a half-size board will not fit it as drawn. Plus about 20 jumpers , a few of them insulated wire rather than bare legs
	Vactrol makings : four short lengths of thin wire, and black tape or a piece of heatshrink big enough to swallow LED1 and the cell together
	9V battery and a snap. A 555 and a 4093 are both happy anywhere from 5V to 15V, but the mood voltage has to climb past the MOSFET's threshold before the vactrol does anything, so a lower supply gives it less room to climb. Untested below 9V

Before you start

The clamp diodes are not optional. A hard whack on a piezo can put out tens of volts. D1 and D2 shunt that to the rails before it reaches the CD4093. Skip them and you will eventually kill the chip.

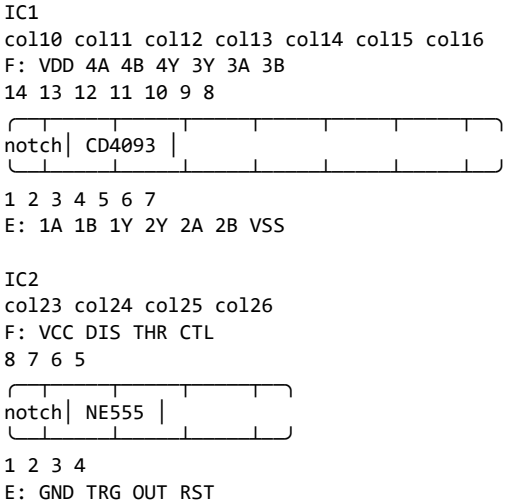
Unused CMOS inputs must be tied to a rail. Pins 12 and 13 of the CD4093 go to ground. Floating CMOS inputs oscillate, draw current, and make the whole thing misbehave in ways that look exactly like a wiring fault.

Four parts care which way round they go : C4 and C6 (the stripe marks the minus leg) and both LEDs (the long leg is the anode). The three diodes have a band at the cathode end, and every step that places one says which way the band points.

The MOSFET's legs are Source, Gate, Drain , left to right with the flat face toward you. Its gate is the one place in the circuit that draws nothing, which is the whole reason it is a MOSFET and not a transistor - see the troubleshooting table.

Make the vactrol first. Its two parts land twenty-two columns apart on the board, so they arrive as a sealed lump with four wires, not as two loose parts.

The chip, from above



Both notches point left. IC1's pin 1 goes in E10 and its pin 14 lands in F10 directly across the channel; IC2's pin 1 goes in E23 and its pin 8 in F23 . Then every other pin falls on the hole shown. Anywhere in the same bank and column is the same point, so F24 and H24 are both "pin 7". Gate 1 is the front door (piezo in at pin 1, pin 2 held high, pulse out at pin 3). Gate 2 is the voice (pin 5 is the enable from the 555, pin 6 the timing node, pin 4 the output). Gate 3 drives the eye (pins 8 and 9 tied, pin 10 out). Gate 4 is unused, its inputs grounded.

Build the vactrol first

A vactrol is an LED and a light-dependent cell staring at each other in the dark. Here it is the entire link between the mood and the pitch: the MOSFET pushes current through the LED, the LED lights the cell, and the cell is most of the oscillator's timing resistor. On this board the LED lands at column 40 and the cell at column 15, so they cannot be taped together in place - make the lump first and plug it in as four wires, exactly as the Opto Duet does.

STEP	DO
V1	Cut four lengths of thin stranded wire, about 100 mm each. Two colors if you have them - one pair for the LED, one for the cell.
V2	Solder a pair to LED1 . Mark the anode lead (the long leg) with a knot, a dot of paint, or by using red for it. Once it is wrapped up you cannot tell which is which.
V3	Solder the other pair to LDR1 . Cells are not polarized, so either way.
V4	Set the LED and the cell face to face , domes almost touching, maybe 2 mm apart. A short piece of heatshrink or a slice of black tubing round both holds them.
V5	Shrink it or tape it, then wrap the whole lump in black tape so no room light gets in and no LED light gets out. Any leak and the pitch stops following the mood and starts following the room.

V6	Test it: 9V through a 1K to the LED, meter on the cell. It should swing from megohms dark to a few k ohms lit . If it barely moves, the cell is too slow - use a different one.

Build

Steps 1-2 The chips

Both chips go 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 is measured from these two footprints.

	STEP	DO
	1	Seat the CD4093 (IC1) across the center channel, notch to the left : pin 1 in E10 , pin 7 in E16, pin 8 in F16, pin 14 in F10. The lower bank then reads E10 = 1, E11 = 2, E12 = 3, E13 = 4, E14 = 5, E15 = 6, E16 = 7, and the upper bank reads F16 = 8, F15 = 9, F14 = 10, F13 = 11, F12 = 12, F11 = 13, F10 = 14. Press it flat and check no leg folded under
	2	Seat the NE555 (IC2) across the center channel, notch to the left : pin 1 in E23 , pin 4 in E26, pin 5 in F26, pin 8 in F23. The lower bank reads E23 = 1, E24 = 2, E25 = 3, E26 = 4, and the upper bank reads F26 = 5, F25 = 6, F24 = 7, F23 = 8

Steps 3-7 The MOSFET, the diodes and the eye

The rest of the semiconductors, all from the same drawer. Every one of them has a direction, and every row says which way it points.

	STEP	DO
	3	Q1, 2N7000 : Source in A36 , Gate in A37 , Drain in A38 . With the board turned as above, numbers climbing left to right, hold it flat face toward you : the legs read Source, Gate, Drain left to right and drop straight into A36, A37, A38
	4	D1, 1N4148 : C3 to the bottom + rail , band toward the rail . Clamps a hard squeeze that swings above the supply
	5	D2, 1N4148 : bottom - rail to D3 , band toward D3 . Clamps the swing below ground
	6	D3, 1N4148 : C25 to C30 , band toward C30 . The one-way valve: the 555's pulse can pour charge into the mood cap through it, and the cap cannot drain back out when the pulse ends
	7	LED2 , the eye people see: anode (long leg) in G20 , cathode in G21

Steps 8-27 The jumpers

Twenty of them: two rail bridges, power and ground to both chips, the unused gate tied off, and then the signal wires that carry one stage's output to the next. Three of the long ones pass over a chip or run the length of the board - use insulated wire for those, not a trimmed component leg.

	STEP	DO
	8	Jumper: bottom + rail to top + rail , out past column 50 where nothing else lives
	9	Jumper: bottom - rail to top - rail , same end
	10	Jumper: J10 to the top + rail - IC1 pin 14, supply
	11	Jumper: A16 to the bottom - rail - IC1 pin 7, ground
	12	Jumper: J23 to the top + rail - IC2 pin 8, supply
	13	Jumper: A23 to the bottom - rail - IC2 pin 1, ground
	14	Jumper: J11 to the top - rail - IC1 pin 13, an unused input, tied off
	15	Jumper: J12 to the top - rail - IC1 pin 12, the other unused input
	16	Jumper: A11 to the bottom + rail - IC1 pin 2 held high, which turns gate 1 into an inverter
	17	Jumper: A12 to A24 - gate 1's output into the 555's trigger, pin 2. It runs past the chip on the A row, so use insulated wire
	18	Jumper: H24 to H25 - IC2 pin 7 to pin 6, discharge to threshold, which is what makes a 555 a one-shot

	19	Jumper: A26 to the bottom + rail - IC2 pin 4, reset held high
	20	Jumper: B25 to B14 - the 555's output, pin 3, back to IC1 pin 5, the oscillator's enable. Insulated wire; it runs eleven columns
	21	Jumper: B33 to B37 - the mood voltage to the MOSFET's gate
	22	Jumper: B38 to the bottom + rail - the MOSFET's drain to supply
	23	Jumper: E41 to the bottom - rail - LED1's cathode to ground
	24	Jumper: A13 to J15 - the oscillator's output, pin 4, across the channel to gate 3's input at pin 9. This one passes over the chip: insulated wire
	25	Jumper: G15 to G16 - IC1 pin 9 to pin 8, so gate 3 is an inverter
	26	Jumper: H21 to the top - rail - LED2's cathode to ground
	27	Jumper: B13 to B46 - the oscillator's output out to the speaker stage. The longest wire on the board: insulated

Steps 28-36 The resistors

Nine. The two 1Ms and the two 100Ks are pairs doing different jobs, so the placement column matters more than usual - a 1M in the piezo's spot and the mood never drains, a 1M in the mood's spot and the piezo never settles.

	STEP	DO
	28	R1, 1M (brown-black-green): B3 to the bottom - rail - holds the piezo at ground between squeezes
	29	R2, 100K (brown-black-yellow): E3 to A10 - the piezo into IC1 pin 1
	30	R3, 4.7K (yellow-violet-red): C13 to C18 - the oscillator's output out toward the cell. This plus the cell is the timing resistor
	31	R4, 150K (brown-green-yellow): J24 to the top + rail - the one-shot's timing resistor; with C3 it makes the pulse about 165 ms
	32	R5, 100K (brown-black-yellow): D30 to D33 - sets how much each squeeze adds to the mood
	33	R6, 1M (brown-black-green): E33 to the bottom - rail - sets how fast it forgets
	34	R7, 1K (brown-black-red): C36 to C40 - the MOSFET's source to LED1
	35	R8, 1K (brown-black-red): H14 to H20 - gate 3's output to LED2
	36	R9, 100R (brown-black-brown): C46 to C48 - in series with the speaker

Steps 37-39 The ceramic caps

Three discs, none of them fussy about which way round they go. One is decoupling, one steadies the 555, and one decides what octave the whole thing lives in.

	STEP	DO
	37	C5, 100nF (printed 104): straight across the top + rail and top - rail , near column 12, right by the chips. Supply decoupling
	38	C1, 100nF (104): B15 to the bottom - rail . This is the oscillator's timing cap - it sets the octave, and it is the first thing to swap when you want a different voice
	39	C2, 10nF (103): J26 to the top - rail - IC2 pin 5, control voltage, decoupled

Steps 40-42 The electrolytics

Two of these care which way round they go, and the third does if it is an electrolytic. The stripe down the can marks the minus leg. Backwards electrolytics get hot and then get loud.

	STEP	DO
	40	C3, 1 uF : G25 to the top - rail - the one-shot's timing cap. A film cap goes either way; an electrolytic goes stripe to the rail
	41	C4, 22 uF , the mood: + leg in C33 , stripe leg to the bottom - rail
	42	C6, 10 uF : + leg in D48 , stripe leg in D50 - speaker coupling

Steps 43-46 Off the board: the piezo, the vactrol and the speaker

Everything that leaves the board. The vactrol you made at the start plugs in here as four wires: its LED on the MOSFET, its cell on the oscillator's timing node. That is the whole link between the mood and the pitch, and it is made of light.

	STEP	DO
☐	43	Piezo disc : red wire into A3 , black wire to the bottom - rail . Column 3 is now full - the piezo, the 1M, both clamp diodes and the 100K all share it, which is the point
☐	44	Vactrol LED (LED1): anode into D40 , cathode into D41 . This is the lead you marked when you built it - backwards, the LED never lights and the pitch never moves
☐	45	Vactrol cell (LDR1): its other pair of leads into D18 and D15 . Either way round
☐	46	Speaker : one wire into A50 , the other to the bottom - rail . Or run A50 and the bottom - rail to the tip and sleeve of a jack and feed an amp, which you will probably want - see the note below

Steps 47-49 Check, then power up

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

Nobody has built this yet, so this is what the circuit says should happen. The vactrol's LED does not light until the mood voltage on C4 climbs past the MOSFET's threshold, a couple of volts, and each squeeze adds well under a volt. So expect the first few taps to come out low and clicky rather than as a chirp - the cell is still dark and the oscillator is running at a few hertz. Keep tapping and it should wake up and climb. If that turns out to be true, this note stays; if it does not, the page gets corrected.

Expect it quiet. The speaker hangs straight off a CD4093 output through 100R, and a 4093 can only push a few milliamps. It will make a noise on the bench, but not a loud one. A jack to an amp, or an LM386 stage between A50 and the speaker, is the fix, not a fault.

	STEP	DO
☐	47	Supply off. Check C4 and C6 have their stripes where the steps say, both LEDs have their long legs in the anode holes, all three diode bands point the way their steps say, and the MOSFET has Source in A36. Then meter column 3 in the lower bank to the bottom - rail : about 1M, the piezo's pull-down. Anything near zero is a short
☐	48	9V in : positive to the + rail , negative to the - rail , with both rail pairs bridged. Nothing should light and nothing should make a noise
☐	49	Tap the piezo. One short chirp, or a click if it is still cold, and LED2 flashes with it. Keep tapping: the pitch climbs, and the vactrol lump warms up inside its tape. Stop, and over half a minute or so it settles back to silence

If it doesn't work

SYMPTOM	CHECK
Nothing at all, dead silent, no flash.	Split rails - jumper both halves of each. Then both chips: pin 14 of the 4093 and pin 8 of the 555 to +, pin 7 and pin 1 to -, both notches pointing left. Then look under both chips for a folded leg.
Constant tone, never stops.	The 555's output is stuck high. Check R4 (J24 to the top + rail) and C3 (G25 to the top - rail), and that pin 4 is tied to + at A26.
One squeeze gives a burst of chirps.	The one-shot is too short for the piezo's ringing. Raise R4 or C3.
Nothing at all on tap.	Probe IC1 pin 3 (E12) while tapping. No pulse there means the piezo network - check D1 and D2 point the right way, the piezo's red wire is in A3, and R1 is actually to the bottom - rail.
Chirps but the pitch never changes.	Vactrol light leak, or C4 never charging. Cover the LED and cell pair properly, then meter C33 as you tap: the voltage should build a little on each squeeze. If it does not, check D3's band is toward C30 and the 555 output really reaches C25.
Chirps but very quietly.	Expected - a bare CD4093 output into a speaker. Feed a jack to an amp, or put an LM386 stage between A50 and the speaker. See the note at Power up.
The first several taps are clicks, not chirps.	Also expected, if the circuit does what it says: the cell is dark until the mood climbs past the MOSFET's threshold. Keep tapping. If it never climbs, see the row above.
The vactrol's LED glows at rest, or the pitch sits high with nobody touching it.	Q1 leaking or C4 not draining. Confirm R6 is 1M (brown-black-green, not brown-black-yellow) and that it actually connects E33 to the bottom - rail.

The mood decays too fast.	The MOSFET's gate should draw nothing. If you substituted a 2N3904, its base current is draining C4 - that is the trade. Raise R6, or go back to a MOSFET.
Pitch swings but it sounds bad.	Good.

Things to try

- Swap C1 (100nF) for 10nF and the whole voice jumps up an octave or so.
- A pot in series with R6 and you can dial how long it stays worked up.
- Replace R5 with a pot to change how much each squeeze adds. Low, and one squeeze maxes it out, which is a very different animal.
- A second cell across LDR1 - any free hole in column 15 and column 18 - poking out through the fur, and it reacts to light as well as touch. That is the Chubbles trick.
- Use the spare gate. Gate 4 is sitting there with its inputs grounded. Wire it as a slow oscillator and mix it into the timing node for a wobble that gets faster as it gets more agitated.
- Give it a voice. An LM386 Hornet stage between A50 and the speaker, and it stops whispering.