Opto Duet on a Breadboard

TWO 555S, CHAINED BY LIGHT INSTEAD OF COPPER. // BREADBOARD BUILD SHEET // MESS O' PEDALS

The Opto Duet built on a solderless breadboard: two NE555 astables chained by a home-made vactrol, so the slow one bends the pitch of the fast one. Exact hole coordinates, a home-made vactrol, and no soldering except its four leads.

Parts

	2x NE555 timer, 8-pin DIP - spot it: eight legs, NE555 or LM555 printed on the back, and a half-moon notch at one end. The notch is the only thing that tells you which way round it goes
	2x 1k resistor (R1, R3) - spot it: brown - black - red, then a gold band
	2x 100R resistor (R2, R4) - spot it: brown - black - brown, then gold. Easy to mix up with the 1k - the third band is the difference
	1x 10uF electrolytic (C1) - spot it: small can with a pale stripe down one side. The stripe marks the minus leg, and that leg is the shorter one
	2x 10nF ceramic (C2, C5) - spot it: little disc marked 103 . Not fussy about which way round
	3x 100uF electrolytic (C3, C6, C7) - spot it: the fat cans. Stripe = minus, same as C1
	1x 100nF ceramic (C4) - spot it: disc marked 104 . This one sets the pitch range - keep a few other values nearby to swap
	1x LDR , the tempo eye (GL5528 or similar) - spot it: round face with a wiggly track printed across it, two legs. Mounted so it looks out of the box
	1x LDR , the pitch eye, same type - spot it: as above. Which cell you fit here decides everything - see the note under Before you start
	1x bright LED , any color, for A22 - spot it: the brighter the better. This is the one that wakes the whole circuit up, not an indicator
	1x vactrol : one LED and one LDR, sealed, on flying leads - spot it: you make this yourself before you start. It arrives at the breadboard as a little black lump with four wires
	1x 8 ohms speaker , or a jack to an amp - spot it: any small speaker. A jack lets you feed a real amp instead
	9V battery or supply - spot it: regulated or unregulated, it does not mind. 5V off a breadboard power module works too, in a bright enough room - see the note at Power up
	Solderless breadboard , 30 columns, plus solid-core jumper wire - spot it: this layout runs from column 5 to column 26, so it needs the full length

Before you start

The 555s go in dry. Nothing plugged in, no power, chips seated first. If you push a 555 into a board that already has wires round it you will bend a leg under the body and spend an hour looking for a fault that is not there.

Power off for every change. Pulling a leg out of a live board is how you kill a 555.

The stripes matter. C1, C3, C6 and C7 are polarised. The stripe goes to the hole this guide marks minus. Backwards electrolytics get hot and then get loud.

Which LDR you fit is not a detail. The cell's resistance range is the frequency range. Fit a cell that stays high in the dark and the audio 555 drops out of hearing and starts ticking like a metronome instead of chirping. If your Opto Duet clicks when it should sing, change the cell before you change anything else - this cost me a whole evening once.

Make the vactrol first. It has to be finished and dry before the board makes sense.

The chip, from above

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NE555 on the board, notch left:
+---\__/---+
GND 1 -| |- 8 V+ upper island F 8 7 6 5
TRG 2 -| |- 7 DIS =========
OUT 3 -| |- 6 THR channel ---------
RST 4 -| |- 5 CTL =========
+----------+ lower island E 1 2 3 4
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IC1 pin 1 in E5 -> pins run E5 E6 E7 E8 / F5 F6 F7 F8
IC2 pin 1 in E17 -> pins run E17 E18 E19 E20 / F17 F18 F19 F20
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Build the vactrol first

A vactrol is an LED and a light-dependent cell staring at each other in the dark. You can buy one, but a home-made one is better here because you get to pick the cell , and the cell is the whole character of the thing. Make it now and let it set; it plugs into the board as four wires.

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 the LED . 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 the LDR . Cells are not polarised, 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 tempo properly.
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.

If it does not work

Two 555s, both wired as astables. IC1 is the slow one - its timing resistor is a light-dependent cell you point at the room, so covering it slows the pulse and brightening it speeds up. Its output drives an LED, and that LED is sealed face to face with a second cell in a light-tight tube. That second cell is the timing resistor for IC2, the audio oscillator . So every pulse from the slow half bends the pitch of the fast half.

SYMPTOM	CHECK
Nothing at all, dead silent	Split rails - jumper both halves. Then check every chip has pin 1 to -, pin 8 to +, pin 4 to +. Then check the notches both point left. Then look under both chips for a folded leg.
A steady tone, no pulsing	The tempo half is not running. C1's stripe should be on the - rail, not in B12 . Check the tempo eye's leads really are in D12 and G12 - one leg on each island, not both on the same one.
Pulses, but the pitch never moves	The vactrol. Either the LED is in backwards (anode in C10) or the wrap is leaking light. Cover the whole lump with your hand in a dark room - if the sound changes, it is leaking.
Ticking or clicking instead of a note	The audio 555 has fallen below hearing. Your pitch cell's dark resistance is too high. Swap it for a faster cell, or drop C4 from 100nF to 10nF to lift the whole range.
A note, but it will not get low	The opposite problem - the cell never gets resistive enough. Put a 100k trimmer in series with it, or go up to 1uF for C4.
Very quiet	Check the second LED is in A22 first - without it this build is much quieter. After that: R2 and R4 throw most of it away by design. Feed an amp instead of a speaker, or drop them to 47R - do not go below that or the two halves start modulating each other through the mixer.
Hum under everything	Check C7 is actually across the rails and its stripe is on -. If it is a mains supply, the cells may also be reading the flicker off your room lights - try it on a battery to tell the two apart.

Hot chip	Power off immediately. A 555 that gets warm has pin 1 and pin 8 swapped, or an electrolytic in backwards nearby.

Build

Steps 1-2 The chips

Both 555s 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.

	STEP	DO
☐	1	Seat the first NE555 across the center channel with pin 1 in E5 , notch pointing left. Its legs sit in E5-E8 and F5-F8 . Press it flat and check no leg folded under. This one is IC1 , the tempo half
☐	2	Seat the second NE555 the same way with pin 1 in E17 , notch left. Legs in E17-E20 and F17-F20 . This one is IC2 , the audio half

Steps 3-15 The jumpers

Thirteen wires, and six of them are just feeding the chips. The other seven carry each 555's timing node out to a column with room around it, so a light-dependent cell can straddle the channel without fighting the chip for space.

	STEP	DO
☐	3	Jumper: A5 to the A-side - rail - IC1 pin 1, ground
☐	4	Jumper: J5 to the J-side + rail - IC1 pin 8, supply
☐	5	Jumper: A8 to the A-side + rail - IC1 pin 4, reset held high
☐	6	Jumper: A17 to the A-side - rail - IC2 pin 1
☐	7	Jumper: J17 to the J-side + rail - IC2 pin 8
☐	8	Jumper: A20 to the A-side + rail - IC2 pin 4
☐	9	Jumper: D6 to G7 - IC1 pin 2 to pin 6, across the channel. Tying those two together is what makes a 555 free-run
☐	10	Jumper: C6 to C12 - carries IC1's pin 2/6 node out to column 12
☐	11	Jumper: H6 to H12 - carries IC1 pin 7 out to column 12
☐	12	Jumper: D18 to G19 - IC2 pin 2 to pin 6
☐	13	Jumper: C18 to C24 - IC2's pin 2/6 node out to column 24
☐	14	Jumper: H18 to H24 - IC2 pin 7 out to column 24
☐	15	Jumper: D13 to D26 - brings IC1's leg of the mixer across to join IC2's. This is the only wire that connects the two halves electrically

Steps 16-19 The resistors

Four, in two pairs, and they are easy to mix up: the 1k reads brown-black- red and the 100R reads brown-black- brown . The third band is the only difference.

	STEP	DO
☐	16	R1, 1k : I6 to the J-side + rail - keeps IC1's discharge pin from seeing a dead short when the tempo eye is in bright light
☐	17	R3, 1k : I18 to the J-side + rail - the same job on IC2
☐	18	R2, 100R : C10 to C13 - IC1's leg of the mixer
☐	19	R4, 100R : C22 to C26 - IC2's leg of the mixer

Steps 20-22 The ceramic caps

Three discs, none of them fussy about which way round they go. Two are decoupling and the third is the one that decides what octave the whole box lives in.

	STEP	DO
	20	C2, 10nF (marked 103): J8 to the J-side - rail - IC1 pin 5 decoupling
	21	C5, 10nF (103): J20 to the J-side - rail - IC2 pin 5 decoupling
	22	C4, 100nF (104): A24 to the A-side - rail . This is the audio timing cap - it sets the octave, and it is the first thing to swap when you want a different voice

Steps 23-26 The electrolytic caps

All four care which way round they go. The stripe down the can marks the minus leg, and it is the shorter one. Backwards electrolytics get hot and then get loud.

	STEP	DO
	23	C7, 100uF : straight across the rails, + leg to the + rail , stripe leg to the - rail . Put it near where the power comes in
	24	C1, 10uF : + leg in B12 , stripe leg to the A-side - rail . This is the tempo timing cap - bigger is slower
	25	C3, 100uF : + leg in B7 (IC1 pin 3, the output), other leg in B10
	26	C6, 100uF : + leg in B19 (IC2 pin 3), other leg in B22

Steps 27-32 The eyes, 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 IC1's output, its cell on IC2's timing node. That is the entire link between the two halves, and it is made of light rather than copper.

	STEP	DO
	27	Tempo eye (LDR): flying leads into D12 and G12 . It bridges the channel, so one leg on each island. Face it out of the box
	28	Vactrol LED : anode into C10 , cathode to the A-side - rail . This is the lead you marked when you built it - backwards, the LED never lights and the pitch never moves
	29	Vactrol cell : its other pair of leads into B24 and I24
	30	Pitch eye (LDR): flying leads into D24 and G24 , alongside the vactrol cell. Face it out of the box. Two cells share this node - whichever is letting more light through wins
	31	Speaker : hot lead into A26 , return to the A-side - rail . Or run A26 and - to the tip and sleeve of a jack and feed an amp
	32	Second LED , and make it a bright one: anode into A22 , cathode to the A-side - rail . That is the same place on the audio half that the vactrol's LED has on the tempo half - behind the 100uF coupler, before the mixer resistor. It is not decoration; see the note under Power up

Step 33 Power up

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

The second LED is not decoration. With a bright one in A22 the whole box gets louder, the pitch range opens up and it stops needing a bright room. Without it, the same build at 5V is quiet and wants a lot of light on the cells. Fit it.

Five volts is enough. The build in the photo runs a 9V battery into a breadboard power module, so the rails sit at 5V rather than 9V, and with the second LED in it plays in ordinary room light. A 555 keeps oscillating down to 4.5V, so the chips are not what runs out first. Why one LED does all that is not settled. A bright LED beside the cells is itself a light source, and an LED across that node also clamps it the way the vactrol's does. Both are plausible, neither has been measured, and the stripboard version carries the same LED in the same place as standard.

	STEP	DO
	33	9V in : + to the + rail , - to the - rail . You should get a pulse - a repeating chirp or swoop, one per flash of the vactrol. A hand over the tempo eye changes the rate; a hand over the pitch eye bends the note

Things to try

- A switch across the tempo eye (on my board) . A jumper and a toggle in parallel with it - any free hole in column 12 on each island, which is the same node the eye sits on. Closed, it shorts the eye out and the tempo half runs so fast that the pulsing stops being a pulse and turns into a steady tone. Open, the ticking comes back. Two fairly different instruments on one toggle. I put a second cell in parallel there first and then took it out again; the switch is the better version of the same idea.
- A 1k pot in the supply, after the power switch (on my board) . A crude power starve. Wind it up and the whole rail sags: the pitch drops, the LEDs dim, and past a point they stop lighting while the box is still making noise. That is the same order of failure the stripboard build showed on a dying battery, so if you fit this, expect the LEDs to be the first thing to go.
- An amplifier board (on my board) . A little LM386 module instead of running the mixer node straight at a speaker. It is louder and it stops the two 555s being asked to drive a load on their own.
- A mini mixer with a line in (on my board) . So something else can play through the same speaker alongside it.
- A touch bend on a flying lead (on my board) . This one hangs off the mixer above rather than off the Opto Duet itself. The mixer's third channel was going spare, so I soldered a bare wire onto the end of its mixing resistor and brought it out through the lid. Hold the probe and the bare metal of the tin at the same time and it squeals - your own skin is part of the path, so it is never quite the same twice. Touch the probe against one of the toggle switches instead and it growls. I found this one by fiddling with it, not by planning it.
- Swap C4. 10nF for a thin whistle, 100nF as drawn, 1uF for a growl. This is the single biggest change you can make and it is one component.
- Swap C1. Take the tempo capacitor down to 1uF and the tempo half climbs into audio range - the two 555s start beating against each other and it goes ring-mod.
- Put a pot in series with R1. A 100k linear gives you a manual tempo control on top of the light.
- Trimmer in series with each cell. The proper fix for a cell whose range is in the wrong place. 100k trimmer, set it once, forget it.
- Long leads on the pitch eye. Get it out on 300 mm of wire and you can play it away from the box.
- Second LED on the mixer node. Straight off A26 through a 1k to - and you get a flicker that follows the sound.
- Run it into a filter. An envelope filter after this thing is worth the trouble. It stops sounding like a circuit and starts sounding like it is talking back.