

Master Divider on a Breadboard

A CD4060 THAT CLOCKS ITSELF, SEVEN OCTAVES ON SEVEN SWITCHES // BREADBOARD BUILD SHEET // MESS O' PEDALS

Build the Master Divider on a solderless breadboard: a CD4060 clocking itself off its own oscillator, seven octaves below it on seven switches, a three-way mode switch for its own clock, an outside one, or the outside one tugging its own. Forty-one steps, exact holes.

Parts

	1x CD4060 14-stage ripple counter with oscillator, DIP-16 (IC1) - spot it: sixteen legs, 4060 in the part number, a notch at one end and a dot beside pin 1. A CD4040 or CD4020 has the same family look and no oscillator; it will not run on its own
	1x LED (LED1), any color - spot it: the long leg is the plus. It blinks with the count
	7x the weighted ladder , one resistor per octave and every value different: 1M (brown-black-green), 470K (yellow-violet-yellow), 220K (red-red-yellow), 100K (brown-black-yellow), 47K (yellow-violet-orange), 22K (red-red-orange), 10K (brown-black-orange) - R1 to R7. They are what make this a mixer instead of a selector, the same ladder as the Grub
	2x 100K resistor (R8, R9) - spot it: brown-black-yellow, the same as the ladder's 100K. The RESET pull-down and the input pull-down. Three 100Ks in all; lay them out together
	1x 220K resistor (R11) - spot it: red-red-yellow, the same as the ladder's 220K. This one is Rs, the oscillator's input resistor. Two 220Ks in all
	1x 2.2K resistor (R12) - spot it: red-red-red. The floor under the pitch pot. See the note above
	1x 4.7K resistor (R13) - spot it: yellow-violet-red. Keeps the LED's current down to something the chip's output can give it
	1x 1K resistor (R10) - spot it: brown-black-red. On the output, after the cap
	1x 100pF ceramic (C4) - spot it: a tiny disc printed 101 . The SYNC cap, and the one value on this list that is a guess. See Things to try
	1x 10nF ceramic (C3) - spot it: disc printed 103 . The oscillator's timing cap. A smaller one moves everything up, a bigger one moves everything down
	1x 100nF ceramic (C1) - spot it: disc printed 104 . Supply decoupling, next to the chip
	1x 10 uF electrolytic (C2) - spot it: a small can with a stripe down one side. Blocks the DC on the way out
	1x 100K linear pot (B100K), the pitch knob - spot it: a B before the value means linear. Wired as a variable resistor , wiper tied to one outer lug
	1x 100K linear pot (B100K), the volume knob - the same part, wired as a divider , all three lugs used
	7x SPST switch - the octaves, one each. Any on-off toggle
	1x SPDT on-off-on toggle - the mode switch. spot it: three lugs, and the lever stays put in the middle. The middle position is INT , the chip on its own clock; one side is EXT , the other is SYNC
	1x momentary pushbutton - optional. Hold it and the chip stops; let go and the count starts again from the top
	2x jack - one in, one out
	A full-size breadboard , 63 columns, both banks and both rail pairs - this layout runs from column 13 to column 51 , so a half-size board will not fit it as drawn. Plus four jumpers
	9V battery and a snap. A CD4060 runs anywhere from 3V to 15V; at least two vape cells in series (7.4V; three gives 11.1V) or a 9V battery

Before you start

The 2.2K is not optional. R12 sits in series with the pitch pot. The pot is wired as a variable resistor, so at one end of its travel it is zero ohms , and with nothing in the way the oscillator's timing resistor disappears. The 2.2K is this build's version of the 1K every other pitch pot on this site gets, and it is also what sets the top of the sweep at about 20 kHz.

Two pots, wired two ways. The pitch pot is a variable resistor: wiper tied to one outer lug, 2.2K in series. The volume pot is a divider: all three lugs used, signal on one outer, ground on the other, wiper out. Wire the volume pot like the pitch pot and it will not turn anything down.

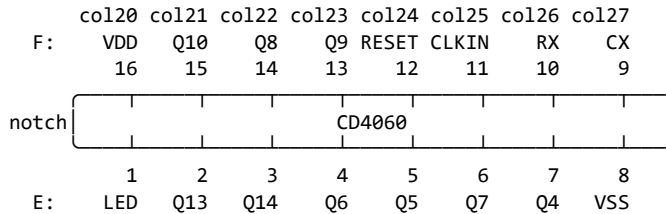
Two parts care which way around they go. The 10 uF electrolytic has a stripe down one side marking the minus leg, and the LED's long leg is the plus. Everything else is a resistor or a ceramic and does not care.

The 100K on pin 12 is not optional either. Pin 12 is RESET, and on this chip RESET held high does two things: it clears the count and stops the oscillator. Left floating it picks up whatever is nearby and the whole thing stutters or goes silent. The 100K holds it low so it runs.

Meter your rails before you wire anything. This layout runs from column 13 to column 51, straight across the midpoint where plenty of full-size boards break their rails, and it uses both rail pairs. A split rail is the single most common reason a breadboard build does nothing at all.

The chip, from above

IC1



The notch points left and pin 1 goes in E20, so pin 16 lands in F20 directly across the channel. The octave outputs are scattered around the chip in no order at all - Q4 to Q7 in the lower bank, Q8 to Q10 in the upper - which is the datasheet's doing, not this layout's. Q13 and Q14 are outputs left unconnected, which is fine; an unused output needs nothing.

Build

Step 1 The chip

It goes in dry, before a single wire. Sixteen legs is two more chances than usual to fold one under the body, and every other part on the board is measured from this footprint.

STEP	DO
1	Seat the CD4060 (IC1) across the center channel, notch to the left : pin 1 in E20, pin 8 in E27, pin 9 in F27, pin 16 in F20. The lower bank then reads E20 = 1 through E27 = 8, and the upper bank reads F27 = 9 back to F20 = 16. Press it flat and check no leg folded under

Step 2 The LED

The other semiconductor, so it goes in with the chip.

STEP	DO
2	LED1 : long leg in A13, short leg in the bottom - rail. Its resistor arrives at step 19

Steps 3-6 The jumpers

Four wires, all plumbing. The chip takes its supply from the top rails and its ground from the bottom ones, so the two rail ties are not optional.

STEP	DO
3	J1 : bottom + rail to top + rail. Ties the two positive rails together
4	J2 : bottom - rail to top - rail. Ties the two negative rails together
5	J3 : J20 to the top + rail. This is pin 16, the chip's supply
6	J4 : A27 to the bottom - rail. This is pin 8, the chip's ground

Steps 7-19 The resistors

Thirteen of them. The first seven are the ladder, one per octave in pitch order, and every value is different - check the bands on each one rather than trusting the one before it. The highest octave gets the biggest resistor, so it sits quietly on top of the low ones

instead of burying them.

STEP	DO
7	R1, 1M (brown-black-green): B26 to B34 . Q4, the clock divided by 16 - the highest octave and the quietest
8	R2, 470K (yellow-violet-yellow): D24 to D30 . Q5, divided by 32
9	R3, 220K (red-red-yellow): D23 to D17 . Q6, divided by 64. This one runs left, the others in the lower bank run right
10	R4, 100K (brown-black-yellow): C25 to C32 . Q7, divided by 128
11	R5, 47K (yellow-violet-orange): I22 to I19 . Q8, divided by 256. Upper bank now
12	R6, 22K (red-red-orange): G23 to G17 . Q9, divided by 512
13	R7, 10K (brown-black-orange): H21 to H15 . Q10, divided by 1024 - the lowest octave and the loudest. At most settings of the pitch knob this one is a tick, not a note
14	R8, 100K (brown-black-yellow): J24 to the top - rail . Holds RESET low so the chip runs
15	R9, 100K : J38 to the top - rail . The input pull-down, so an empty input jack is quiet rather than random
16	R10, 1K (brown-black-red): B47 to B51 . On the output, after the cap
17	R11, 220K (red-red-yellow): G25 to G30 . Rs, from the oscillator's input pin to the timing node at column 30
18	R12, 2.2K (red-red-red): I30 to I35 . The floor under the pitch pot. Not optional
19	R13, 4.7K (yellow-violet-red): B20 to B13 . From Q12 to the LED's long leg

Steps 20-22 The ceramic caps

None of these care which way around they go.

STEP	DO
20	C1, 100nF (printed 104): top + rail to top - rail , as close to column 20 as you can get it. Supply decoupling. It does nothing useful far away from the chip
21	C3, 10nF (printed 103): H27 to H30 . The timing cap, from pin 9 to the timing node. This and the pitch knob set the speed of everything
22	C4, 100pF (printed 101): I25 to I28 . The SYNC cap, from pin 11 to the SYNC lug's column. It does nothing until the mode switch selects it

Step 23 The electrolytic

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

STEP	DO
23	C2, 10 uF electrolytic : plus leg in C44 , the volume wiper's column, stripe leg in C47 . The stripe points away from the chip, toward the jack

Steps 24-38 Off the board: the knobs, the switches and the jacks

Everything with a wire on it. The octave switches are one step each, in pitch order, so you can tick them off as you go.

The PITCH pot is a variable resistor. Tie the wiper to one outer lug and run that pair to J26; the other outer lug goes to J35. The 2.2K you fitted at step 18 is what protects the fast end.

The VOLUME pot is a divider. 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 resistor in front of it, because a divider at zero should be silent.

The mode switch is an on-off-on , and its middle lug is the common . Middle position, nothing connected: the chip runs on its own oscillator. Flip it one way and the input jack goes straight to pin 11; flip it the other and it goes through the 100pF. Which side is EXT depends on how you mount it, so label it once you have heard it.

STEP	DO
24	Power in : 9V snap red to the bottom + rail , black to the bottom - rail . Leave it unplugged until step 40

25	The pitch pot , wired as a variable resistor : wiper and one outer lug together to J26 , the other outer lug to J35 . If the knob turns the wrong way for you, swap which outer lug is tied to the wiper
26	Octave switch 1 (Q4, ÷16): one side to A34
27	Octave switch 2 (Q5, ÷32): one side to A30
28	Octave switch 3 (Q6, ÷64): one side to C17 , lower bank
29	Octave switch 4 (Q7, ÷128): one side to A32
30	Octave switch 5 (Q8, ÷256): one side to J19
31	Octave switch 6 (Q9, ÷512): one side to J17 , upper bank. Not the same point as C17
32	Octave switch 7 (Q10, ÷1024): one side to J15
33	The bus : wire the other side of all seven switches together , off the board, and run one lead from that chain to A40 . This is the mixer - seven octaves arriving through seven resistors onto one point
34	The volume pot , wired as a divider - all three lugs used. One outer lug to B40 , the bus; the other outer lug to the bottom - rail ; wiper to D44 , the plus side of the 10 uF. If it runs backwards, swap the two outer leads
35	Output jack : tip to A51 , sleeve to the bottom - rail
36	Input jack : tip to H38 , sleeve to the top - rail
37	The mode switch , on-off-on: middle lug to I38 ; one outer lug to H25 , which is EXT, straight to pin 11; the other outer lug to J28 , which is SYNC, through the 100pF
38	The retrigger , optional: a momentary between H24 and the top + rail . Hold it and pin 12 goes high, which clears the count and stops the oscillator; let go and it starts again from the top. Leave it out and nothing changes

Steps 39-41 Check, then power up

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

Start with the volume knob down. Seven CMOS outputs summed onto one bus is a hot square wave by the standards of anything expecting a guitar. Turn it up into the amp rather than the other way around.

STEP	DO
39	Supply off. Check the chip's notch points left , the 10 uF 's stripe is in C47, the LED's long leg is in A13, and the 2.2K really is red-red- red . Check the ladder against step 7 to step 13 one band at a time. Then meter the bottom + rail to the bottom - rail : it should read high, not near zero
40	9V in , with the mode switch in the middle , all seven octave switches off , the pitch pot at mid travel and the volume down . The LED should start blinking - that is the chip counting, before you have heard anything. Turn the pitch knob and the blink speeds up and slows down
41	Play it. Switch on octave 1 and bring the volume up: a square wave that follows the pitch knob. Add octaves one at a time and each one lands an octave under the last, quieter ones on top, louder ones underneath. With the knob low, the bottom switches stop being notes and start being a pulse. Then try the mode switch with something plugged into the input - the Atari Punk Console is the obvious thing to feed it

If it doesn't work

SYMPTOM	CHECK
Nothing at all, and the LED is dark.	Split rails - jumper both halves of each, then check J1 and J2 really tie the two pairs together. Then the chip: pin 16 to + at J20, pin 8 to - at A27, notch pointing left. Then look under the chip for a folded leg. Then the LED itself: long leg in A13, short leg in the - rail.
The LED is dark but the switches make sound.	The LED is in backwards, or the 4.7K is not reaching B20. The chip is fine; this is cosmetic.

The LED is lit solid, or dark, and nothing changes with the pitch knob.	The oscillator is not running. Check the mode switch is in the middle. Then the three oscillator parts: the 220K from G25 to G30, the 10nF from H27 to H30, the 2.2K from I30 to I35, and the pitch pot from J26 to J35. All three meet at column 30 and nowhere else. Then RESET: the 100K from J24 must reach the - rail, because a high pin 12 stops the oscillator dead.
It stutters, or stops when you touch the board.	RESET is floating - the 100K at J24 is missing or on the wrong rail. Or the retrigger button is wired to - on one side and + on the other.
One octave is silent.	That octave only: its ladder resistor and its switch. Check the switch hole is in the same column and bank as the resistor's far leg, and that the switch's other side made it onto the bus chain.
The bottom octaves sound broken - clicks, not notes.	Working as intended. Q10 is the clock divided by 1024; at most knob settings it is below the bottom of hearing and you hear the individual edges. Turn the pitch up and they become notes.
The pitch knob does almost nothing, or only works at one end.	It is a linear pot driving a frequency, so most of the speed change is crowded into the fast end - that much is normal. If it does nothing at all, it is wired as a divider: the wiper must be tied to one outer lug, and that pair goes to J26.
The pitch jumps or the top of the sweep sounds rough.	Not yet known whether this happens. The 220K is only two to ten times the timing resistor at the slow end of the knob, which is what TI asks for; at the fast end it is a hundred times. If the top of the sweep misbehaves, try a 47K or 100K there and say so.
EXT is silent with something plugged in.	The 4060 needs its input to swing most of the way from ground to the supply. A small or AC-coupled signal may not get there - this is the same complaint the Grub has, and a gain stage in front is the same answer. Watch the LED: if it blinks in EXT, the chip is counting and the problem is downstream.
EXT works but everything is very low.	Correct. The first switch is the input divided by 16, so a 1 kHz tone comes out at about 62 Hz. Feed it something high.
Volume works backwards.	The two outer lugs are swapped. Harmless.
It is horrible.	Good.

Things to try

- Change the SYNC cap. 100pF is a starting guess. Bigger kicks harder, up to the point where SYNC is just EXT; smaller lets the oscillator ignore the input. Try 47pF and 1nF and see which end is more interesting.
- Swap the timing cap. 1nF moves everything up ten times, so the bottom switch becomes a note and the top one becomes a whistle. 100nF moves everything down ten times and the whole board becomes a rhythm.
- Move the LED. Pin 2 (Q13) blinks half as fast as pin 1 and pin 3 (Q14) a quarter as fast. Move the 4.7K's leg from B20 to B21 or B22.
- Gate it from outside. RESET held high stops the oscillator, so a slow square wave from another build, wired into H24 in place of the button, chops the whole thing into bursts. Share the grounds.
- Feed it the Atari Punk Console. It is the source that made the Grub sound best, and it is high enough that dividing by 16 still leaves a note.
- Solder it down. The stripboard Master Divider is this circuit drawn in Copper Bottom , part for part.