GATE TO TRIGGER CONVERTER

- It consists of two distinct sections- first, a high pass filter with a pretty steep cut-off frequency and second, an op-amp based comparator.
- When we apply a gate signal to the input capacitor, we get a voltage spike on the other side that quickly dies down as the capacitor fills up and stops passing the signal.
- For the split second this spike crosses its threshold voltage, the comparator will then push out an extremely short 12 volts gate. also called a trigger
- //// Those 12 volts are then scaled down to around 1.4 volts by the voltage divider at the kicks trigger input. /////
- The diode pointing up from ground at the op-amp's non-inverting input is necessary because some op-amps will glitch out if they read a very negative input voltage in this scenario.
- This is an issue because once the gate goes low, we'd normally see a big negative spike as the capacitor discharges. The diode mitigates that by allowing the capacitor to discharge instantly.
- One more issue is that during the comparator's low state, it'll set its output to -12 volts simply because that's what we give it as a low supply voltage.
- This is not ideal because remember our oscillator will swing around the voltage we apply to the non-inverting input.
- For audio signals that voltage should be zero volts ground level so we fix this by placing a diode after the comparator's output.
- This way the trigger can pass through but the comparator's low state is blocked and the voltage gets pinned to ground level via the voltage divider instead.
- Here's how this works out in practice I'm feeding the sequences gate output into the gate to trigger converter which I've then hooked up to the oscillators trigger input and yeah we now get a single kick hit instead of two per gate.

BRIDGE T OSCILLATOR

- We want to make a short, punchy sine wave that sounds like a kick drum- that's our goal.
- To do this, we start with an op-amp, which always tries to make the voltage at its –ve input match the +ve input.
- We give a quick voltage pulse (like pressing a button) to the +ve input. Now, this sudden change makes the op-amp react and kick things off.
- Next, we add two capacitors:
    - One (C1) from the op-amp's output to a middle point (Node X).
    - The other (C2) from Node X to the –ve input of the op-amp.
    - These two form a path that reacts slowly (because caps charge/discharge), which creates the delay needed for oscillation.
- But if there's no way for current to leave that middle point, nothing really happens and the capacitors just sit there.
- So we add a resistor (R1) from Node X to ground.

- Now, when the op-amp pushes out voltage, C1 charges and some current leaks to ground through R1.
    - That causes voltage at the –ve input to drop.
    - The op-amp tries to fix that by increasing its output even more- a kind of feedback loop starts.
- If we stop here, the op-amp keeps pushing up harder and harder, and eventually hits its maximum limit (the supply voltage).
    - Once this happens, it can't respond smoothly anymore. it leaves its linear region, which is where it behaves like a proper amplifier.
    - In the linear zone, it adjusts output gently to keep the +ve and –ve inputs equal.
    - Outside that zone, it gets stuck at max or min which ruins the clean sine wave we want.
- To stop that from happening, we add a large resistor (R2) between the op-amp's output and the -ve input.
    - This is called the bridge resistor.
    - What it does is clever, it lets a small amount of current sneak into C2 from the other side.
    - That slowly raises the voltage at the –ve input again, so the op-amp now sees it's gone too far and starts pulling its output back down.
    - Now the whole swing reverses.
- This back-and-forth motion makes the op-amp's output form a sine wave that gradually dies out, a low, thumpy sound.
- But with every swing, some energy is lost (through the resistors), so the sine wave gets smaller and smaller.
- To get the right frequency and decay, we use:
    - C1 = C2 = 15nF
    - R1 = 10kΩ to ground
    - R2 = 1MΩ as the bridge
    - This gives around 50 Hz with a nice fast decay.
- To trigger the sound, we add a push button that connects from the power supply to the +ve input.
    - When we press it, the voltage at +ve input jumps and kicks off the oscillation.
- We also use a voltage divider (like 100k and 14k resistors) to set the resting voltage at the +ve input, so the op-amp starts from a known point.
- But here's the thing, we hear a second bump when we release the button too.
    - That's because letting go drops the voltage at the +ve input, which again looks like a trigger to the op-amp.
- If we want to trigger this circuit using a sequencer (which sends gate signals that stay high for a while), we'll also get two thumps, one when it goes high, one when it drops.
- To fix that, we use a gate-to-trigger converter, which turns a long gate into a short pulse, so we only get one clean hit.

<u>PITCH MOD</u>

- Our kick's pitch depends mostly on the resistance to ground (R1) in the feedback loop of the op-amp.
- So we remove the fixed 10kΩ resistor that was going from Node X to ground.
- In its place, we put a 100kΩ potentiometer. This means:
    - Turning the knob changes the pitch.
    - Less resistance = higher pitch (faster charge/discharge)
    - More resistance = lower pitch (slower charge/discharge)
- Now we have a wide pitch range, but we need to be careful that it shouldn't go too high.
- For a kick drum, we want to stay in the low frequency zone, so it sounds like a thump.
- To fix that, we add a 10kΩ resistor in series with the potentiometer.
    - Now the total resistance to ground is:
        - At minimum: 10kΩ (when pot = 0)
        - At maximum: 110kΩ (when pot = 100k)
- This works as follows:
    - The pitch gets higher when resistance is lower.
    - Without the 10k, the pot could go down to 0 an could end up giving super high pitch.
    - With the 10k, we set a minimum limit, so the pitch never goes above a kick range.

<u>DECAY</u>

- the default decay was way too short, and we wanted to make it longer without changing the pitch
- tried thinking in terms of energy, either lose less each cycle or add more in
- skipped the "lose less" approach, i.e. increasing the bridge resistor, because:
    - it affects pitch, lowers it
    - there's an upper limit to how much decay we can get this way
    - we were already near that limit with the bridge and grounding resistors being quite different
- instead, we chose to add momentum back in using positive feedback
- to do this, we added an inverting buffer using an op-amp:
    - input of the buffer, output of the kick
    - output of the buffer, connected to the midpoint between the two capacitors through a large resistor
- what this did:
    - when kick output rises, buffer output falls, pulls down on cap midpoint, kick op-amp responds by pushing harder, more motion
    - same thing happens in reverse when the kick output falls
    - result, system gets pushed both ways, reinforcing oscillation, longer decay
- at this point, the oscillation didn't die out, so we needed a way to control decay length
- added a potentiometer in the feedback loop of the buffer op-amp to control gain:
    - gain depends on the ratio of feedback resistor to input resistor
    - higher gain, stronger feedback, longer decay

    - lower gain, weaker feedback, shorter decay
- issue we ran into:
    - turning the knob didn't feel smooth, decay jumped suddenly from short to long
    - realized the decay responds exponentially to gain, but the pot was linear
    - linear resistance, exponential decay = uneven feel
- fix:
    - added a 47k resistor in parallel with the pot, this mimics a reverse-log potentiometer
    - now as we turn the knob, the change in decay feels much smoother and easier to control
- result, full control over decay from short to long, without messing up the pitch.

ENVELOPE

1. **Pitch Control Voltage(CV):**
    - The goal is to add a pitch envelope to control the kick drum's pitch using a voltage.
    - To do this, the circuit needs to be modified so the pitch can be adjusted with a voltage, which wasn't the original design.
    - The oscillation frequency of the kick depends on the resistance between the two capacitors and ground.
    - The faster current can be pushed into or out of the capacitor on the right, the faster the mechanism will oscillate.
    - We need a component that can control the resistance with a voltage to change the pitch, and an NPN transistor seems to fit the bill.
    - The NPN transistor works by controlling the current flow between the collector and emitter based on the voltage applied to the base.
    - When the transistor is off (no voltage at the base), it behaves like a resistor. When voltage is applied to the base, it opens up, allowing more current to flow, which changes the pitch.
    - A 100k resistor is added in series to prevent the transistor from short-circuiting when the base voltage is too high.
    - The control voltage (CV) from the sequencer is connected to the base of the transistor through the 100k resistor. This allows pitch to be adjusted as the CV level changes.
    - Without the CV, the oscillator produces a clean sine wave.
    - When the CV is applied, the waveform becomes a rounded sawtooth due to the asymmetry in the transistor's current flow.
    - In forward active mode, the transistor allows 400 microamps of current to flow, but in reverse active mode, only 15 microamps flow.
    - This difference in current flow causes the waveform distortion.
    - The distortion is mild, and for this application, it's acceptable because it doesn't overpower the sound.
    - Overall, this modification allows for voltage-controlled pitch for the kick drum.

2. **Pitch Envelope**
    - The 220nF capacitor is used in the envelope generator circuit to store charge when a trigger is applied. The cap charges instantly when the trigger pulse hits, and then discharges gradually when the pulse disappears.
    - The diode at the very beginning of the circuit allows current to flow into the capacitor when the trigger pulse is applied, causing the capacitor to charge quickly.
    - After the trigger pulse disappears, the charge inside the capacitor starts to drain through a resistor to ground. The rate of discharge depends on the resistance, controlled by a potentiometer. This resistance determines how quickly the voltage drops, shaping the envelope's curve.
    - To isolate the capacitor's discharge path from the rest of the circuit and avoid interference, an NPN transistor is used instead of an op-amp buffer for efficiency.
    - The emitter follower configuration is used with the NPN transistor. The collector is connected to the positive rail (supply voltage), and the emitter is connected to the output node where we need the envelope's output. The transistor copies the voltage from the capacitor and passes it into the 100k resistor, ensuring the capacitor's discharge process isn't disturbed.
    - When tested, the pitch sounds too high because the transistor allows too much current to flow, causing the oscillation frequency to increase too much.
    - To fix this, a 2k resistor is added between the transistor and ground. This resistor limits the current, setting a maximum frequency of about 250Hz, preventing the pitch from rising too high.
    - A 10k potentiometer is added in series to adjust the pitch envelope's depth, allowing fine-tuning of how much the pitch changes over time.
    - Although the resistor and potentiometer help with controlling the pitch envelope's depth, the pitch transition is still abrupt. The envelope curve drops quickly at first, but the transition back to the bass pitch is not smooth. To smooth this out further, we'd need to modify the envelope curve, but due to the simplicity of the circuit, only limited adjustments can be made.
3. **Smoother Envelope**
    - We start by adding a capacitor after the envelope's output and before the oscillator's CV input. The other side of the capacitor connects to ground through a diode and to the node between the oscillator's capacitors via a 1-megaohm resistor.
    - When the envelope is triggered, the buffer transistor sends a burst of current into the new capacitor, pushing charge into it. The diode allows current to flow to ground on the other side of the capacitor.
    - As the envelope's output voltage drops, the new capacitor doesn't immediately discharge into the oscillator's CV input. This happens because current can't flow back from ground into the capacitor. Instead, the current must pass through the large 1-megaohm resistor.
    - The 1-megaohm resistor slows down the discharge process significantly, which helps to smooth out the envelope curve, especially in the tail end.
    - The 1-megaohm resistor needs to be connected to the transistor's **collector**, not directly to ground. If connected to ground, the resistor wouldn't provide

    the required voltage push to allow current flow through the capacitor in certain voltage conditions.
    - When the transistor is in forward active mode, the emitter voltage stays slightly above zero volts, so a higher base voltage is required for current to flow. In reverse active mode, the collector goes below zero volts, which allows current to flow even with a slightly higher base voltage.
    - Connecting the resistor to the transistor’s collector ensures that when the collector voltage is high, the capacitor gets a little push, helping the base voltage rise enough to allow current to flow. When the collector voltage drops, it restrains the capacitor, preventing excess current use.
    - This setup ensures that the drop to the base pitch is smoother, reducing the harsh transition in the envelope.
    - If we want to intensify the smoothing effect, we can increase the size of the added capacitor.

<u>**TONE AND DISTORTION**</u>

- The purpose of adding a "tone" knob is to tame the initial, clicky transient that happens at the start of the kick drum sound.
- This clicky transient is a sharp high-frequency component, and sometimes it can be too aggressive or intrusive in a mix.
- To address this, we implement a low-pass filter after the kick's output. The low-pass filter allows only lower frequencies to pass through while filtering out higher frequencies.
- The "tone" knob, in this case, works by adjusting the cutoff frequency of the filter. At the highest setting, the cutoff is around 220Hz, which eliminates most of the clickiness by removing those higher frequencies.
- However, as we lower the cutoff frequency, the volume can drop significantly, because the passive filter affects the circuit’s output impedance.
- To solve this, we add an op-amp-based distortion stage, which also buffers the signal. This setup ensures that we retain the signal strength while adding tone-shaping capabilities.
- The distortion stage works in conjunction with the filter. When the potentiometer is set to the lowest setting, the op-amp simply acts as a buffer, providing a clean signal. As we increase the resistance, it starts introducing distortion.
- The diodes in the feedback path of the op-amp create the distortion, clipping the signal when it exceeds certain thresholds (around ±600mV).
- To control the intensity of this distortion, a small capacitor is added in parallel with the diodes and potentiometer. This capacitor smooths out the distortion by acting as a low-pass filter, allowing rapid changes in the signal to pass while filtering slower changes.
- The capacitor size determines the smoothness of the distortion. A smaller capacitor results in a harsher distortion, while a larger one makes the distortion warmer and more rounded.