March 17, 2016

- **in synth diy**
- **19 Comments**

Synth DIY: Gate Buffer

One of the simplest DIY utility circuits you can build is a gate buffer: you put a gate signal into one end, and get a gate signal out of the other.

Although this might sound unnecessary, there are several reasons you might want a gate buffer:

- compatibility problems between gate/trigger inputs and outputs on different equipment: see my page on the Arturia Beatstep (https://synthnerd.wordpress.com/arturia-beatstep/), for example
- the need to trigger multiple devices from one source: passive splitter cables or mults sometimes result in signal loss and therefore unreliable triggering
- tightening up the edges of gates/triggers: for various technical reasons, some trigger outputs are relatively slow to rise and/or fall; in a worst-case scenario, this can skew the timing of down-line devices. A buffer with multiple outputs can deliver a set of tight, sharp pulses simultaneously.

I offer two simple designs here, one using discrete components, the other using an op amp. Both require just a handful of parts, both will run off a wide range of DC supply, including a 9V battery, and both can be made very compact if you ever want to include them inside another piece of equipment as part of a build or mod.

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Discrete (transistor) Buffer

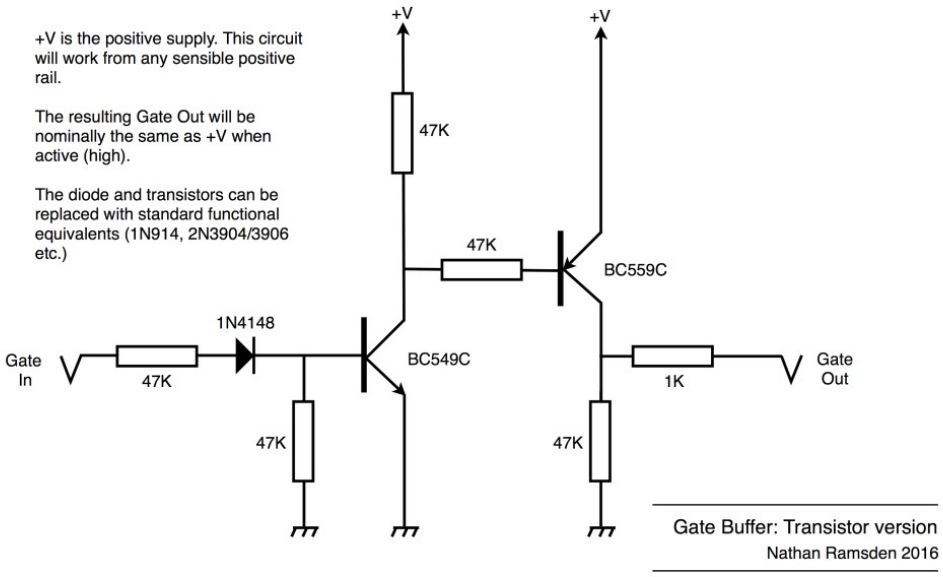
The transistor buffer is a two-stage circuit, with each stage inverting the incoming signal.

Think of a gate signal as a logic on, or a logic off. When there is no gate present, the first transistor is held off by its base resistor. The base of the second transistor is therefore tied to +V by the two 47k resistors; as it is a PNP type, it is therefore off, and the output is held low.

Conversely, when the input is high, the first transistor is switched on, and the base of the second transistor is taken low. This pushes the second transistor into conduction, and the output is taken high.

Precise voltage levels depend upon the level of the gate signal going in, and the positive supply rail. The circuit will operate on a wide range of positive DC supply: in a 5V logic circuit, from a 9V battery, a 12V or 15V rail in a Eurorack system, etc. The input resistors and diode provide input protection; so, for example, you can send a bipolar square LFO into it with no ill effects, or use it to make a reliable 9V gate from a 15V one without the impedance issues of a simple passive potential

divider. It will also allow you to increase a low gate to a high one, so you could (for example) run a 5V signal into this, powered on an existing 15V rail, and get a 15V gate out. With a standard signal diode and two normal low-power transistors, you can trigger this circuit with just a couple of volts.



(https://synthnerd.wordpress.com/wp-content/uploads/2016/03/gate-buffer.jpg)
Gate Buffer: Transistor version

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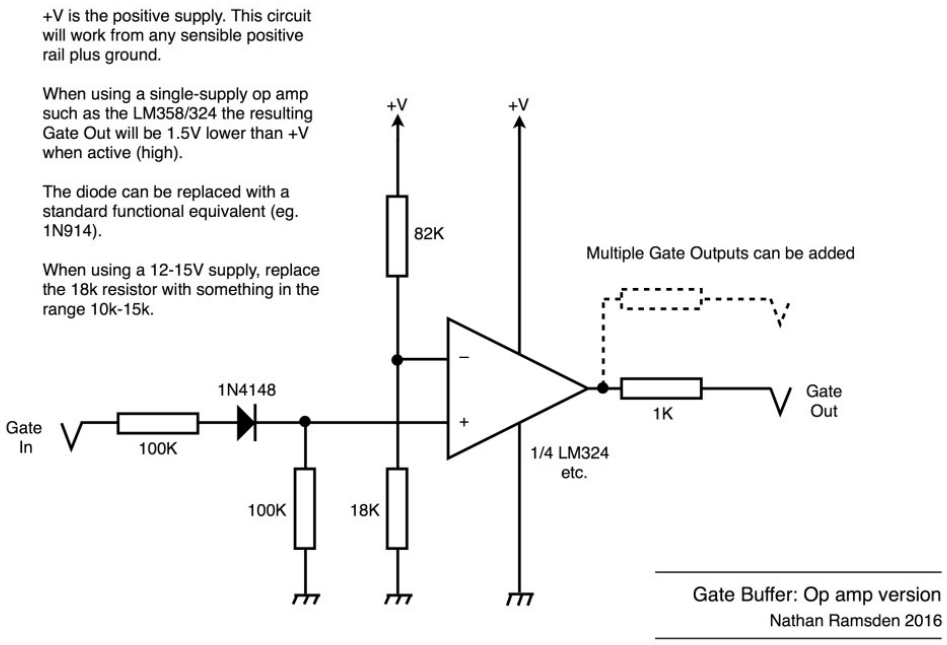
Op Amp Buffer

The op amp version of this gate buffer circuit consists of a single op amp stage set up as a comparator: one voltage is compared to another, and the output goes high or low depending which input is the higher.

The potential divider at the inverting input provides our reference voltage. The non-inverting input takes the external gate signal we want to buffer.

When there is no gate signal, or it is low, the inverting input is higher, and the output is therefore low. When the gate signal is high, the non-inverting input is higher, and the output is high.



(https://synthnerd.wordpress.com/wp-content/uploads/2016/03/op-amp-gate-buffer.jpg)
Gate buffer: op amp version

The circuit is designed to run from a single-sided supply, ie. ground and positive. For this purpose, an op amp such as the LM158/358/324 (single, dual, and quad versions respectively) is suitable as the low output state goes to the 0V rail. Their high output state is around 1.5V below positive supply.

The voltage reference provided by the potential divider at the inverting input should be adjusted for purpose: using a 9V supply, the values given will trigger the comparator at around 1.6V; even with a low battery, this circuit should trigger around 1.2V. With a 12V or 15V supply, replace the 18k resistor with something in the region of 10k-15k. This would keep the trigger level around 2V or a little lower, which is high enough to be a clear 'on' signal, but not so low as to be confused with a slightly high 'off' signal (the Arturia Beatstep 'off' gate signal hovers around 0.6V, for example).

It would be possible to use a dual-rail op amp just as well, which would require the addition of a diode on the output to clip the negative-going signal.

I have used an op amp here rather than a dedicated comparator; devices such as the 311 cannot be directly substituted in this circuit.

Tags: analogue, circuit bending, CV, discrete buffer, Gate, gate buffer, op amp buffer, synth diy, synth mods, Synthesizer, synthesizer circuits, synthesizer diy, Trigger, trigger buffer

19 responses to "Synth DIY: Gate Buffer"

CJ says : September 20, 2016 at 10:37 pm
Hi. Could I use this transistor gate buffer to send synth gates into a micro-controller? My DC supply would be 3.3V so the micro-controller could accept it at a pin-in. The synth gate would be +5V.

Also, is this circuit protected from maybe a -30V or +30V going into the gate-in jack? Just in case someone accidentally sticks in a CV signal.

Thanks for the help!

REPLY

synthnerd says : September 22, 2016 at 10:50 am
Yes, you could do that. If you power this gate buffer from 3.3V, a 5V input from a synth will cause no trouble at all. The input diode protects against negative voltages, and the transistors won't saturate above the 3.3V supply. With the component values shown, the gate will activate at inputs above something like 1.4V, give or take a little.

REPLY

instantknut says : April 24, 2018 at 8:17 pm
Hi, I have built your Op Amp buffer to sync an OB-8 arpeggiator with a TR606. Strange thing is, that it does only work, when I skip the 1k resistor at the output of the Op Amp (LM358). I can replace it with max 100 Ohm, anything above and the OB-8 won't process any triggers.

The triggers look good on a (cheap) oscilloscope, though.

But even without the resistor the OB-8 misfires some arp steps. Do you have an idea what the problem might be and how to improve?

Anyway big thanks!

REPLY

synthnerd says : April 26, 2018 at 8:23 pm
I don't have an OB-8 here to look at, but from the schematic I'd say this should work. The OB's arp clock input looks like it should go high from any reasonable positive input, though the way it's put together looks like it also expects to be pulled down to ground unless there's a positive voltage present. There's a 33k resistor between the input and positive, which means that if a trigger output (like the 606's) also have a resistor to ground, the level at the OB's input won't reach zero and it will be permanently high. However, the op-amp circuit I posted (which is nothing more than a basic comparator) only has a 1k resistor that means the voltage at the OB's trigger should fall low enough to pull it down and permit low/high transitions.

There is also an engineering note for the OB-8 that shows a change was made to the trigger input during production. This added a resistor and capacitor, and it's described as to "avoid missing pulse on arpeggiator external clock". Perhaps yours lacks this mod.

My first question would be: what are you using to power your buffer circuit? There may also be some fault with your OB trigger input. I've also had trouble with bad cables in situations like this, so double check everything that is part of this chain to make sure it's correct and functioning fully. I'd also want to measure the output voltage of the buffer, just to make sure it's reaching ground when low. Measure this with respect to the buffer's supply, and with respect to the OB's ground (you can use the shield of a jack for this).

It could be, perhaps a different design would work better here.

REPLY

instantknut says : April 26, 2018 at 9:28 pm
Thanks for your comprehensive research and reply! Meanwhile I have tested other clock sources like Eurorack sequencers and a new TR-08 and while they are able to trigger the OB-8, it's never perfect (mostly double glitches/triggers).

> There is also an engineering note for the OB-8 that shows a change was made to the trigger input during production. This added a resistor and capacitor, and it's described as

to “avoid missing pulse on arpeggiator external clock”. Perhaps yours lacks this mod.

That can be very true, I have one of the very first models with Pratt-Read keyboard and without the Page 2 functions labeled on the synth.

Out of ideas I changed the Op Amp Buffer design with a simple S-trigger conversion I found here: http://www.doepfer.de/faq/gen_faq.htm#S-Trig

That seems to work! May be that has something to do with the expected pull down to ground you mentioned? I don’t know if that might damage the OB-8 in the long run, though.

Perhaps i will look into that engineering note and see if I can do the mod myself, but for now everything looks to work pretty well. Thanks again!

synthnerd says : April 28, 2018 at 4:46 pm
You won’t cause any damage to the OB by using that pull-down S-trig circuit, but you should bear in mind that shorting the OB’s input to ground is what it expects as the *off* state, not *on*. If you feed a short S-trig pulse, the OB will respond on the upward edge at the end of that pulse, so will be slightly behind. Whether that’s noticeable is another matter.

instantknut says : April 29, 2018 at 9:21 pm
> so will be slightly behind. Whether that’s noticeable is another matter.

yes, I have noticed that. The gates of the 606 are 20ms wide, I guess that is the delay I am hearing? Sigh, I have to look into change order 432 (http://www.synthfool.com/docs/Oberheim/ECOS/OB8/OB8_ECO432.jpg) it seems …

synthnerd says : April 30, 2018 at 7:50 am
Perhaps. What are you using to power your buffer circuit? A Battery, or something else?

instantknut says : April 30, 2018 at 10:01 am
I was using a 9V block. But as other clock sources had problems too to sync the OB, I think your circuit is fine and the problem is on OBs side. Btw. what do you think is the more reliable circuit: the discrete one with the transistors or the one with the opamps?

synthnerd says : April 30, 2018 at 3:55 pm
In this case, the op amp circuit. My transistor buffer would have the same problem as the 606 trigger output because it uses the same arrangement at the output. However, I’ve sketched out another design for you, which you can see running in the online simulator here: http://tinyurl.com/y9mktjze

It’s battery powered (9V), and you can use pretty much any standard small signal NPN transistors (2N3904, BC547, etc.). Resistor values are not critical, so there’s some flexibility there.

instantknut says : May 1, 2018 at 11:27 am
I have no idea what you did there, all I can say is: it freakin works! The OB does not miss one beat and syncs tight to the TR-606. Also this online sim is pure wizardry.
If I may stress your patience once more I have another question : for convenience I like to power the circuit from a 12V Pedal Power supply. Does that change the values of the resistors?
Thanks a ton for everything!

synthnerd says : May 1, 2018 at 6:56 pm
No problem! I might make a new page for this circuit, in case it's useful to others. You should be able to run it off 12V without any changes. Glad to be of assistance

instantknut says : May 1, 2018 at 8:23 pm
Perfect! Your circuit on a perfboard in a deck of cards box. Added a LED for dramatic reasons. https://photos.app.goo.gl/cFCYzVDmGS7gT3vj8

REPLY

synthnerd says : May 1, 2018 at 8:46 pm
Excellent! Enjoy

REPLY

Leon Cornelisse says : September 18, 2018 at 4:48 pm
Hi, thanks a lot for the schematic. It's pretty hard finding 9v schematics. One question: is there a maximum of outputs that's possible? I'm thinking of using this for my main clock and split it into 7 outputs.

REPLY

synthnerd says : October 14, 2018 at 8:21 pm
Apologies for the late reply! That's a very good question, and the answer is "it depends" You should be OK paralleling outputs with either of these designs, but it can lead to problems in some situations. Try it and see, and if you run into trouble, ask again!

REPLY

Rob Kam says : January 18, 2019 at 11:35 am
Discrete components vs. op amp, what if any are the advantages/disadvantages of one over the other?

REPLY

synthnerd says : January 18, 2019 at 8:49 pm
That's a very good question! The transistor version can be made very compact and squeezed into odd gaps on a busy board if needed. The part types and component values are not critical in this transistor circuit, and it will give a good voltage level output for any positive gate input level. Getting a supply-level output in the op-amp version requires selecting parts correctly. On the other hand, the op-amp circuit here can be tweaked to have a higher threshold, and the simple comparator can be easily changed into a Schmitt trigger, which might prove useful with unstable gate inputs. It might also provide a better source for multiple parallel triggers. For most purposes, I think it comes down to personal choice, and most of the time these days I'd prefer the transistor circuit unless I had an op-amp stage spare somewhere already.

REPLY

Cameron says : September 7, 2024 at 2:13 pm
I enjoyed readiing your post

REPLY