Bruce Trump *Mar 26, 2013*

Is it possible to parallel two op amps to get twice the output current?

We get this question periodically on our E2E forums. Though we may answer with a qualified "yes," it tends to make us shudder just a bit. It can be done… but with great care. So let me come quickly to a key point. **Don't use the simple circuit on the left.** Directly paralleling inputs and output of two op amps is sure to start a serious argument between the two. Differing offset voltages will cause them to fight over the correct output voltage. They may burn all their output current capability in the battle with one output current (sourcing) flowing into the other (sinking current).

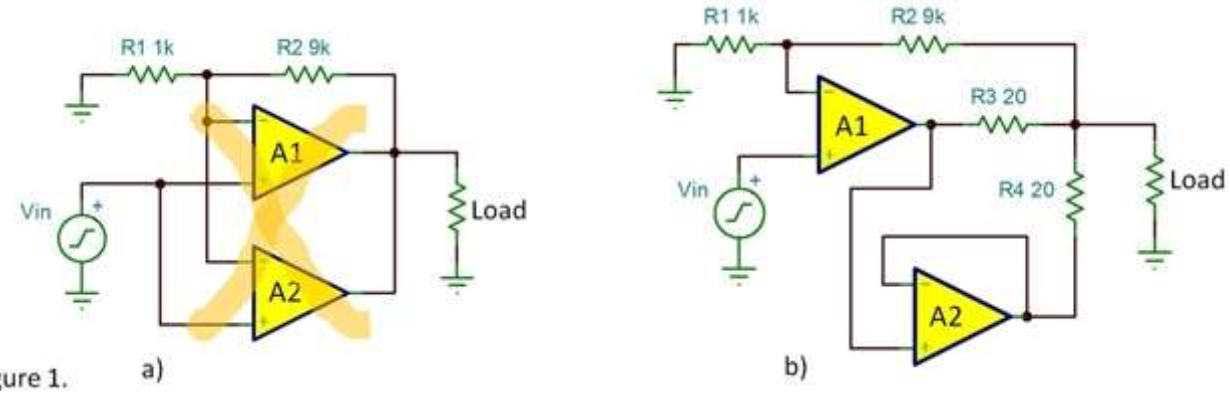

Figure 1.

Figure 1b has a chance. Op amp A1 is the "master" and A2 is the so-called "slave," replicating the output voltage of the master. R3 and R4 promote reasonably equal sharing of the load current, even though A2's output may be slightly different. Feedback is connected on the load-side of R3 and R4 so their voltage drop is corrected. You lose some output voltage swing capability in the I·R drop on these resistors so you will be tempted to make them low in value. But the offset voltage of A2 will cause extra quiescent current equal to Vos/(R3+R4). It's a tricky tradeoff.

- Be very cautious with high speed signals. You want A2 to accurately replicate the output of A1. If the signal moves too fast, the phase shift of A2 will cause differing output voltages and wasted current. It's important to avoid slewing. If necessary, add an R-C filter at the input so the fastest rate of change on the output of A1 is well below slewing speeds. The dynamic behavior of two amplifiers may not match well during slewing.

Don't use older generation op amps that have output inversion (phase reversal) behaviors. If A1 can overdrive the input common-mode range of A2 and its output inverts the result is ugly.

Above all, check the behavior of your circuit thoroughly. SPICE may tell you whether you have a basic working circuit, but op amp macro-models may not accurately predict the quirks that could befall this circuit. Build a breadboard and check all signals and conditions carefully. If your op amp is multi-sourced, consider that not all manufacturers' devices behave exactly the same. (But, of course, you have only one source for op amps, right?)

Do you think I'm a bit leery of paralleling op amps? Well, yes… call me leery. It can be successful but proceed with caution. I recommend that you consider an easier path—using an op amp with more output current. Here are a few possibilities:

- TLV4111 300mA, 6V. CMOS Op Amp.
- BUF634 G=1 buffer, 200mA, 36V. Used inside the feedback loop of standard op amps.
- OPA547 500mA, 60V Op Amp. Adjustable current limit.
- OPA564 1.5A, 24V Op Amp, 17MHz GBW.
- OPA548 5A, 60V Op Amp. Adjustable current limit.

Have you successfully paralleled op amps? Or do you have scars from trying? Comments welcome.

Thanks for reading,

Bruce email: thesignal@list.ti.com

Table of Contents… with 50+ other interesting technical topics.

Jeff Melvin *over 12 years ago*

Sam Green - Did you link to the wrong datasheet? No paralleled op-amps here.

shantanu dasgupta - your coil driver example isn't the same as it is only Hi/Lo, like logic paralleling.

Percy Williams - don't forget the problem of cross-over distortion, unless things are optimally biased.

Bruce Trump - I'd like to see further discussion, possibly with more elegant approaches, to address the problem of achieving good slew rates driving highly capacitive loads while ensuring stability.

Neil Albaugh *over 7 years ago*

My original design for parallel op amps was published in1984 in a Burr-Brown data sheet for the OPA111, a then- new dielectrically- isolated op amp. It is shown as Figure 16, 'An N-Stage Parallel-Input Amplifier for Reduced Relative Amplifier Noise at the Output." I called this approach "The Lunatic Fringe Amplifier"- but not for publication. Jim Williams and apparently a few audio folks have later promoted this paralleling idea. At the time I came up with this, my friend Mark Stitt doubted that it would actually result in lower noise but was intrigued enough with this unusual architecture to breadboard the circuit and test it. It did work.

The noise reduction takes advantage of the fact that the op amps' uncorrelated noise adds as the square root of the sums while the signal, which is correlated, adds directly. This statistical trick also applied to noise and drift reduction of summed voltage references- another idea that Mark (and maybe Bruce) breadboarded and tested long-term with success. That test PCB was stuffed full of voltage references, all summed together into one low-noise, very stable output.

Speaking of Mark Stitt, a brilliant Mechanical Engineer who became an equally brilliant electronics engineer, someone should write an article about the now- disbanded Burr- Brown "cast of characters".

Jens-Michael Gross *over 12 years ago*

This reminds me of a discussion about paralleling two batteries for double capacitance: If they don't have exactly the same output voltage and discharge curve, it will end up with wasting quite some share of the total capacity between the two.

And putting two (rechargeable) batteries of not exactly the same capacity in a row for double voltage may result in desctruction of the one with smaller capacitance - The main reason why the advertised '1000 recharge cycles' shrink to a few dozends in real-world applications.

Even if two OpAmps are of the same type, or even on the same die, they won't produce exactly the same result. Should be obvious (and so should be the implications) but is often forgotten by todays 'digital' thinking.

Thanks for bringing this to our attention.

Charles Hansen1 *over 12 years ago*

In the Oct 2012 issue of Elektor magazine, pg 14, Doug Self parallels sixteen 5532 op amps, using two parallel sets in bridge-mode per channel in his "5532 OpAmplifier". He claims 16 W/channel at 0.01% THD. The output current sharing resistors are only 1 ohm per op amp.

Sam Green *over 12 years ago*

I have done this with no ill effect at modest gain of 2 t0 4 to increase output drive current in Figure 5 of datasheets.maximintegrated.com/.../MX7543.pdf. I do the same thing with logic gates to increase fan-out. I will keep your cautions in mind in the future.

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