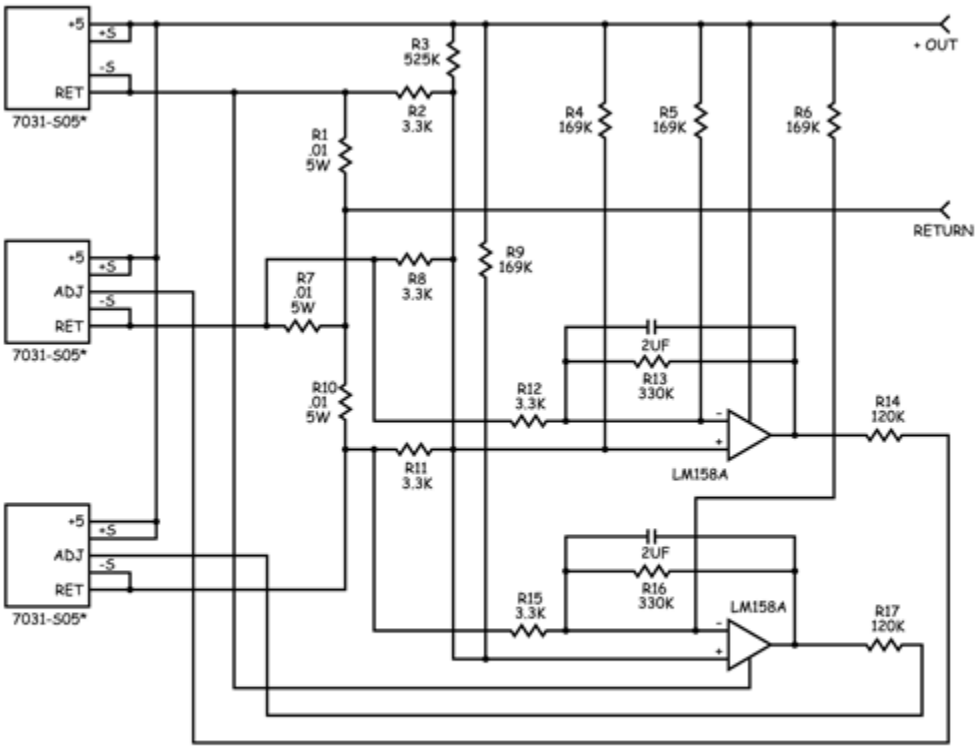
Output Considerations

Paralleling and Series Converter Connections

The outputs of like converters may be connected in parallel without damage. However, they will not share the output load to any guaranteed extent without some ballasting resistance or external circuitry. A proven active parallel circuit for forcing current sharing of three low voltage 80 watt converters is shown. This circuit may be extended to four or more converters.

When sharing power at a higher output voltage, converter outputs may be connected in series. For example, two 80 watt converters each delivering 14 VDC on their output may be connected in series to provide 160 watts at 28 VDC. Series converters always share output current. Power is shared to the extent of the (excellent) voltage regulation.



* Can be 5031, 7031, 8031, or 9031

Active Parallel Circuit

Some applications require a higher output current than a single DC-DC converter can deliver.

The figure above shows a "master - slave" active paralleling circuit that can be used to parallel two, three or more converters. In this connection, one or more "slave" converters are made to actively track the output current of a "master" converter. The diagram shows two slave converters; more may be added by repeating the circuit configuration.

The output current of the master converter is measured by current shunt R 1. The output current of the slave converters are measured by current shunts R7 and R 10. The R1, R7 and R10 shunts are connected to a common output point. It is good construction practice to construct the circuit so that the shunts are located physically close to each other, which balances the wiring drops.

The idea behind this paralleling circuit is to compare the output current of any individual converter, as measured by the shunt on each "slave" converter, with an average output current of all converters. The difference between individual and the average current is amplified and used to send a signal into the adjust pin of the "slave" converter.

The comparison is done using an operational amplifier. An LM158 or LM124 is preferred since these types can operate from a low supply voltage and their input common mode range extends down to the negative rail.

In order to avoid conflict between the DC-DC converter's main internal feedback loop and the paralleling loop, the paralleling loop is made subordinate to the main loop. This is done by lowering the bandwidth and gain of the paralleling loop.

The output of the paralleling loop controls the "slave" DC-DC converter through the slave converter's adjust pin.

Average Output current is obtained from a resistor network consisting of R2, R8 and R11.

The Individual converter actual current is fed through resistors R12 and R15.

It can be seen that the DC voltage dropped across the shunt resistors is negative with respect to the common output. While most LM158 or LM124 operational amplifiers can operate slightly below the negative rail, it is good practice to positively bias them above the rail. Biasing the op amp inputs above the rail is accomplished by connecting each op amp input to the plus rail through equal value resistors, namely R4, R5, R6 and R9. The impedances at each input are balanced at 3.3 Kohm by resistors R2, R8, R11 and R15.

With no external adjustment, the adjust pin voltage sits at 1.5 VDC. The final biasing step is to add a small positive bias to the "average" current point so that the operational amplifiers sit at 1.5 VDC when all is otherwise in balance. R3 is selected so that the positive input of the slave operational amplifiers sits at 15 mV higher. When amplified by 100, as set by R13 or R16, the operational amplifier's output is biased at 1.5 VDC.

Here are some additional practical hints. Use at least ± 1% resistors. Equalize the effects of wiring drops and use Kelvin connections for the shunt resistors. The initial set point voltage of the DC-DC converters should be close to each other, preferably within 1%. Always connect the ± sense pins locally. Always de-rate the current capacity of combined converters to prevent over-stress in the event of small unbalances; 95 percent is a good rule of thumb.

Finally, while the master-slave configuration minimizes the number of operational amplifiers needed, the circuit concept also works for a connection of all slave converters; just eliminate the master converter.