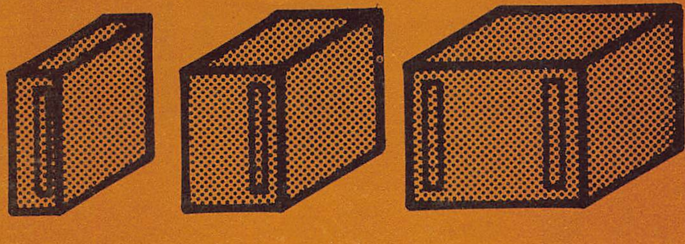

MODULAR Power Supplies

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The Current Sharing Method

A second way to accomplish redundancy is through the use of current sharing. In this scheme, N power supplies of I amps current drive a (N-1) I amp load. Figure 3 shows a current sharing redundancy circuit with a desired output of 5 volts.

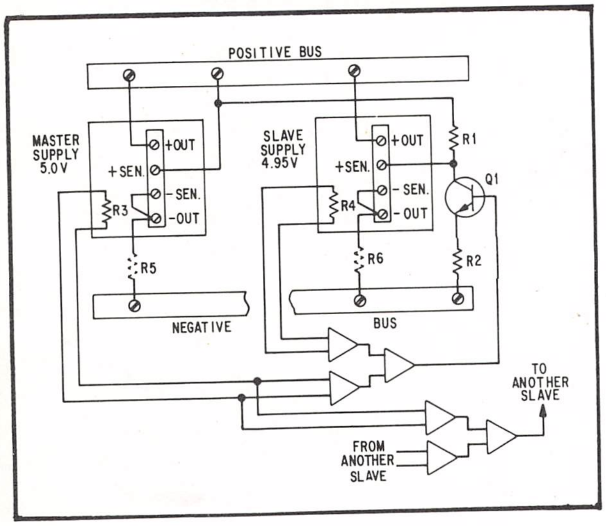


Fig. 3

The master power supply is set to 5V, with its positive sense lead monitoring the voltage on the output bus. The slave power supply is set slightly lower at 4.95V with its positive sense lead monitoring the voltage at the collector of Q1. Q1 varies the voltage divider consisting of R1, Q1, and R2 such that the drop across R1 is 0.05V. Therefore, the slave power supply senses 4.95V between its sensing terminals, and it supplies equal current to the load.

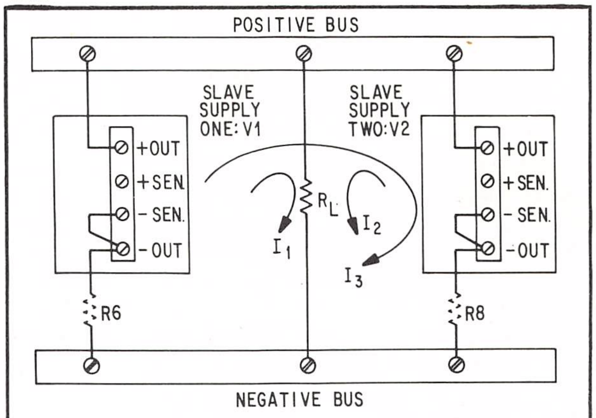
Q1 is driven by the comparator which has inputs comprised of the voltage across current sampling resistors R3 and R4. Each slave is connected in the same fashion to the master. Thus, all power supplies share load current equally.

Should a slave supply fail, the current balancing circuit continues to work in the same fashion, causing the remaining supplies to share the output current equally among themselves.

If the master power supply should fail, the current balancing circuit has no reference, and becomes inoperative (Q1 shuts off). However, the remaining supplies continue to share current and drive the load because the negative sense leads are connected to the output terminals of their supplies. If the negative sense leads were monitoring the voltage on the output bus, the slave supply whose voltage was set highest would assume the entire load, and the other slave supplies would cut back their output to zero. This action would occur because the sense leads of these supplies would be sensing an output voltage higher than their internal output voltage setting. However, the wires connecting the output terminals to the bus have a small resistance (represented by R5 and R6). Therefore, the difference in voltage between the supplies can be dropped across these resistive paths. The bus voltage is then less than or equal to the internal voltage setting of each supply, and each supply will then deliver output current.

The difference in the supplies current will depend on the magnitude, the wire resitance and the difference of the supplies setting. This relationship is demonstrated in figure 4.

In the special case where the load current is less than I_3, the slave supply with the highest output setting will provide all the load current.



$$I_3 = I_1 - I_2 = \frac{V1 - V2}{R6 + R8}$$

Fig. 4

The current sharing method has some advantages over the traditional method. These are:

1. Load transient recovery time is decreased since each power supply senses only a fraction of the load change.

2. MTBF is increased since each power supply runs at less than full output.

However, the current sharing method also has some disadvantages when compared to the traditional method. These are:

1. If no modifications are made to the individual power supplies overvoltage shutdown circuits, a bus overvoltage condition may cause all the system's power supplies to shut down.
   In order to avoid this condition, a "smart" overvoltage shutdown circuit, which shuts down only the offending power supply, must be incorporated. In this way, the system will stay up and N-1 power supplies will continue to output full system power.
2. The current sharing circuit is more complicated than the traditional redundancy circuit.
3. The current sharing circuit can only compensate for a small range of difference in output voltage settings of the individual power supplies.
   Therefore, more care must be taken in setting the output voltages of the individual power supplies than in the traditional scheme.
4. A short across the output of one of the component power supplies will short the bus, since the supplies are not diode isolated. However, this is not a significant problem with switching power supplies since there are relatively few components in the output power mesh which could short.

Conclusion

Each of the redundancy circuits discussed here have inherent advantages and disadvantages. The choice of a proper redundancy scheme depends upon the trade-offs best suited to a particular application.

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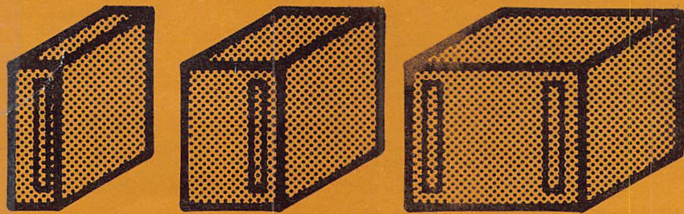

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Application Note 236-2

Two Power Supply Redundancy Schemes

In many systems a redundant power supply configuration may be desirable. This is particularly true in systems where down time must be avoided, such as live broadcast equipment, life support systems, and on line computers.

This application note will examine two methods of accomplishing redundancy.

The Traditional Method

Traditional methods are those in which one power source is active and supplying power to the load, while another power source is in stand-by and not supplying system power.

A traditional method of accomplishing redundancy is shown in figure 1. Each power source is connected to the load with a series blocking diode. The power source which has a higher output voltage will supply current to the load, while the power supply with the lower output setting will have its series diode back biased, preventing it from supplying load current. Should the active power supply fail, the situation is reversed and the standby power supply takes over.

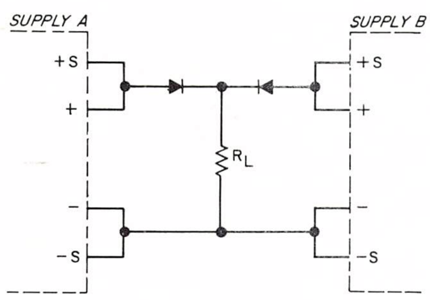

Fig. 1

This simple arrangement results in a reduction in load regulation which may be unsatisfactory for some applications. The degradation is caused by the varying voltage drops of the series diodes which are both temperature and load current dependent.

A more sophisticated traditional redundancy scheme without these disadvantages is shown in figure 2. In order to understand the operation of this redundancy configuration, we must consider the circuit from two perspectives:

1. power supply A is delivering power to the load
2. power supply B is active but in a standby mode

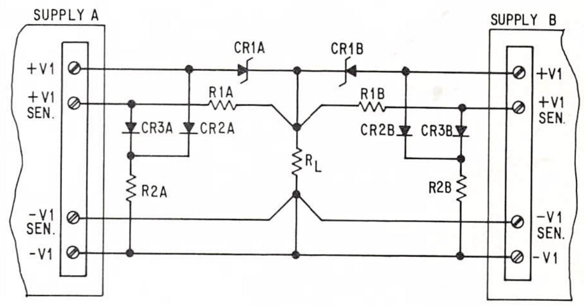

Fig. 2

1. Power Supply A is Delivering Power to the Load. If both supplies are functioning and supply A has a higher output voltage setting, it will deliver power through CR1A, while supply B is in standby with its output diode CR1B back biased. Supply A sees a voltage across its sensing terminals equal to the load voltage minus the current voltage drop across R1A. However, power supply A has its output voltage adjustment set lower to compensate for this constant voltage difference. Thus a sensing voltage reflects the load voltage, making the supply's output voltage greater than the sensing voltage by the sum of the output diode drop and the drop across R1A. Although diode CR2A is conducting it has no effect on circuit operations at this time.

2. Power Supply B is in Standby. When Supply A is providing power, supply B is in standby. Diodes CR2B and CR3B provide a sensing path for power supply B because in the standby supply, both diodes are conducting. CR2B conducts current from the output of supply B, and CR3B conducts current from the output of supply A. Since both diodes are conducting, their voltage drops are equal and supply B's positive output voltage is equal to the voltage at its positive sensing terminal. The voltage divider composed of R1B, CR3B, and R2B, establishes the sensing terminal voltage.

While this traditional scheme accomplishes redundancy, it suffers from two disadvantages:

1. When used with small voltage power supplies (e.g. a 5V supply) the voltage drop across the series diodes is a significant percentage of the output voltage, and subsequently a significant percentage of the output power is dissipated in the diodes. This results in an inefficient power system and heat dissipation which may not be acceptable for some applications.
2. If the series diodes require a heat sink, the effective volume of the power system is increased.