Parallel connection / operations and current share application note

Overview

This document will examine method for active load sharing, basic criteria and performances of such a function on Glary UH and PS module series.

This application note provides also a brief summary about some general guidelines to help accomplishing the task.

System requirements and premises

The basic requirements of a power supply system, consisting of a number of paralleled sources, to increase the total load current are:

-to maintain a regulated output voltage under variations in line or load;

-to control the output current of each supply just to share the total load current equally;

To maximize reliability of the system there are the following features:

-Achieve redundancy, so that a failure of any one supply can be tolerated as long as there is sufficient current capacity available from the remaining power units;

-Implement a load sharing method without any external control system.

In addition, these are the following desirable features:

-to have a common, low bandwidth share bus interconnecting all power units;

-to achieve good load sharing transient response;

-the ability to margin the system output voltage with one control.

In other words, the combination of power supplies behaves like one large supply with equal stress on each of the units. Also, reliability can be better secured by taking advantage of load sharing to incorporate modular redundancy.

Load sharing techniques

There are a number of schemes to achieve load sharing.

Six methods are possible: the following method is passive method while all the rest are active methods.

O-ring diode method

This is the most passive common method of paralleling power modules by using an O-Ring diode on each unit. By using power modules with adjustable outputs, it is possible to 'Balance' the current sharing of the units. By taking a 'differential' voltage measurement at the anodes of the O-Ring diodes current will be shared more equally the closer the differential voltage is to zero. This method has the disadvantage of an additional power loss in the diodes and dissipation of the heat generated in the diodes.

The droop method

The Droop method programs the output impedance of the power supplies to achieve load sharing. It is a simple open loop method, but is not accurate.

The dedicated master

This approach is to select a master module to perform the voltage control and force the remaining modules (slaves) to act as current sources. A dedicated Master approach with current mode supplies will facilitate current sharing but it does not achieve redundancy.

External controller

This method is to use an external controller to perform the load sharing. This is achieved by comparing all loads sharing signals from the individual power units and adjusts the corresponding feedback signal to balance the load currents. This system does perform well but requires an additional controller and multiple connections between the controller and each supply.

Automatic current sharing – average current method

For automatic current sharing no external controller is required and a single share bus interconnects all the supplies. This requires an adjustment amplifier that compares a current signal from the share bus to the individual units current and adjusts the reference of the voltage amp until equal load current distribution is achieved.

The average Current method is a patented technique where each power module's current monitor drives a common share bus via a resistor. While this scheme performs accurate current sharing, it can result in a specific application problem. An example is when a supply runs into current limit, causing the share bus to be loaded down and the output voltage to regulate to the lower adjust limit. A similar failure mode will exist if the share bus is shorted or if any unit on the share bus is inoperative.

Automatic current sharing – highest current method

This technique for automatic current sharing shown compares the highest current module to each individual current, and adjusts the reference voltage accordingly to correct the imbalance of load current.

This technique is similar to the average current method except that the resistor is replaced with a diode, allowing only one unit to communicate on the share bus. This method provides for excellent sharing among the slaves with an error in the master's load current contribution because of the diode.

Internal IC Load Share Regulator has improved this function by replacing the diode with a unidirectional buffer to reduce the master's error. An inoperative or insufficient capacity supply will not effect the sharing of the operational units.

A shorted share bus will disable the reference adjustment section used for load sharing, making the units operate as stand-alone.

A generic load share system with the basic bus connections required performing accurate output voltage control and load sharing is shown in Fig 1. The output voltage is sensed with a fully differential, high-impedance voltage amplifier.

Each individual power supply current is sensed with a differential current amplifier, and it is used for the load share portion of the circuit.

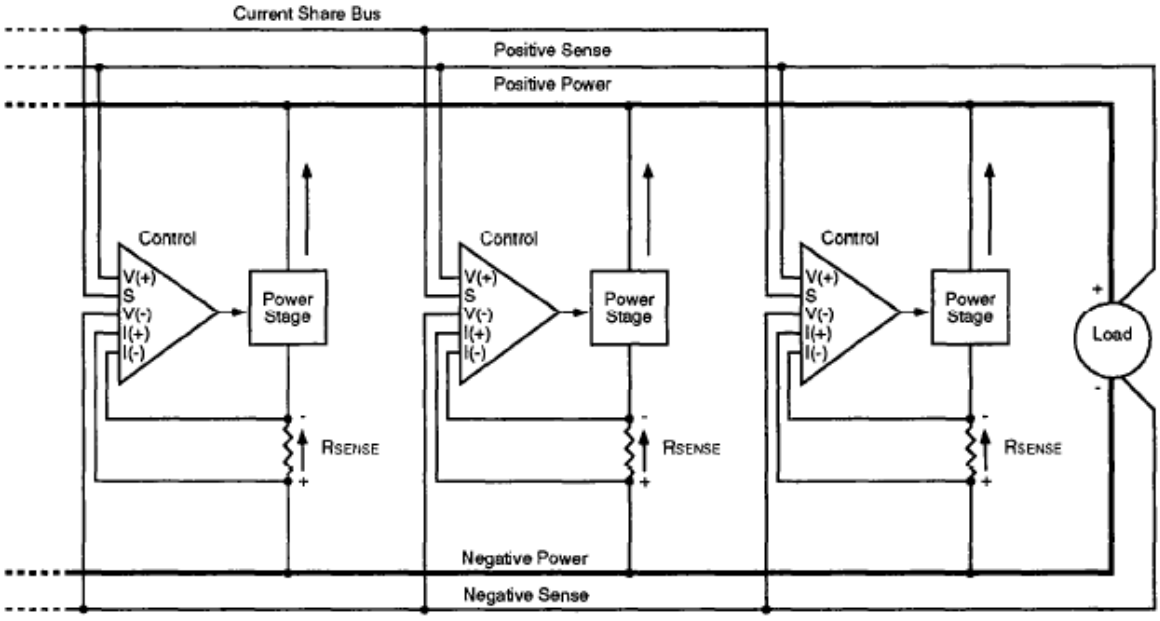

Fig. 1. Basic bus connections required performing accurate output voltage control and load sharing

The share bus signal interconnecting all the paralleled modules is a low-impedance, noise insensitive line. The connection diagram is shown in FIG 2. The following discussion of the voltage and current sharing loops should help the user to understand the operation and features of this technique.

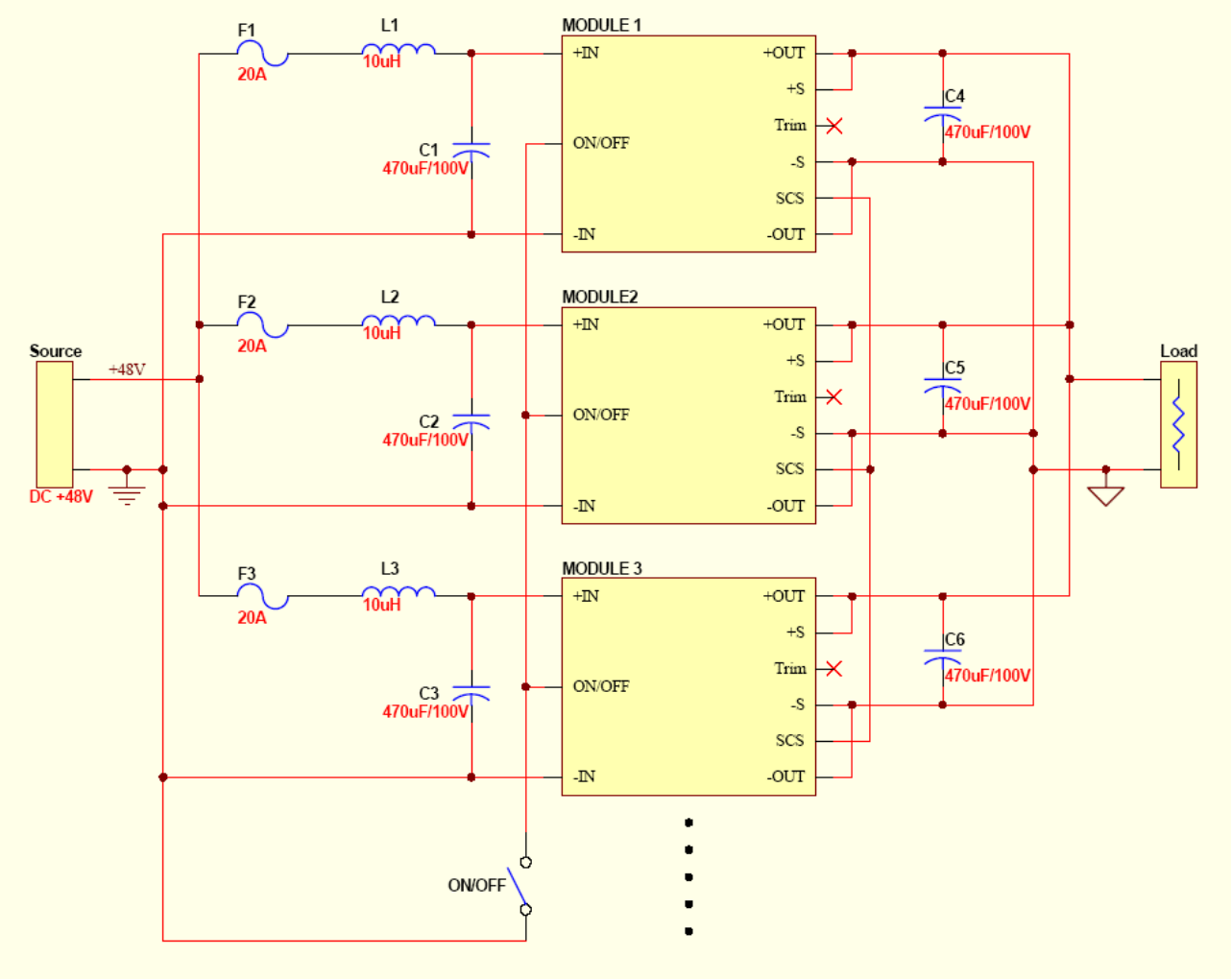

Fig. 2. System connections for modules with independent load sharing

External design basic criteria, design rules, suggestions and reached performances

Layout considerations

It is quite imperative to adopt a symmetrical and “star node” layout of the power circuit with minimum loop area and impedance for each PCB track between modules and load. This basic criterion is also to avoid loop noise generation.

Basic connection diagram to be followed is shown on Fig. 2.

When using units connected in parallel, best suggestion is to not connect **sense pins** unless load is far away from output pin’s module; basic criteria to decide about this issue is related to voltage drop across PCB tracks that is suggested to be less than 0,5% of the output voltage; just in case output voltage drop is higher than what is suggested, sense pins can be conveniently connected to load as shown on Fig. 2

Important issue is: **do not connect trim pins and circuitry** when parallel configuration is adopted in order to not defeat parallel performances.

Electrical ratings and thermal suggestions of power modules connected in parallel

All modules connected in parallel are suggested to be mounted on the same heat sink in order to achieve the best possible thermal coupling. It is the best to space the modules apart over the whole surface of the heat sink to avoid creation of hot spots on the heat sink and to minimize heat density.

The current rating of the whole assembly must not exceed 80% to 90% of the total current capability of the modules just to compensate for unavoidable parameter variations between the modules.

Modules must have very symmetrical designs with very short connections both for power and control terminals. Parasitic resistance of connections has to be very low in order to facilitate a parallel module layout with minimum loop impedance.

Additional external components

External delayed fuse type is suggested to be connected on each output DC/DC lines as close as possible to output pins. This suggested solution is to prevent any burns on the system just in case one module goes on hypothetical short circuit failure and so may sink all the current of the entire system. Alternative or equivalent solution to fuse is OK.

A suggested alternative active solution can be implemented by using the Linear Technology IC LTC4357 (Positive High Voltage Ideal Diode Controller) driving N-channel MOSFETs placed in parallel as substitution of above fuse.

This simple solution enhances system reliability and prevents hazard situations.

The suggested best current trip value of fuse could be around 160% of the maximum output current of each module.

General considerations

Paralleling of power modules with good current sharing can be achieved by following some important guidelines. The above recommendations and greater care and maximum precautions are necessary if the number of paralleled modules increases and become very high.

Theoretically speaking the **maximum number of paralleled modules limitation does not exist; however the maximum quantity suggested is over 16-18 pieces**; the only precaution that is necessary to adopt is a safe and reliable design for the entire system and particular attention to electrical power point of view.

Overall electrical Performances for parallel

-Current share tolerance: **+/-5%**

-Voltage tolerance with current share: **+/-1%**