AN-P001/15

APPLICATION NOTE

PARALLELING MINT1275A56 POWER SUPPLIES FOR LOAD SHARING

Purpose:

To provide general knowledge and guidance regarding load sharing configuration methods that facilitates paralleling of SLPE **MINT1275A56 and other MINT1275** models. Paralleling the MINT1275 can increase total system power capability or enhance system reliability through redundancy such that the failure of one or more modules can be tolerated.

Description:

Load sharing or current sharing, is the ability to manage the output current evenly across all active power supplies to reduce stresses on each power supply and allow them to run cooler which results in higher reliability of the active power supplies.

This application note covers :

1) Considerations and Limitations
2) Best Practices
3) Aid and Wiring Configurations to determine the paralleling scheme that best suits your needs.

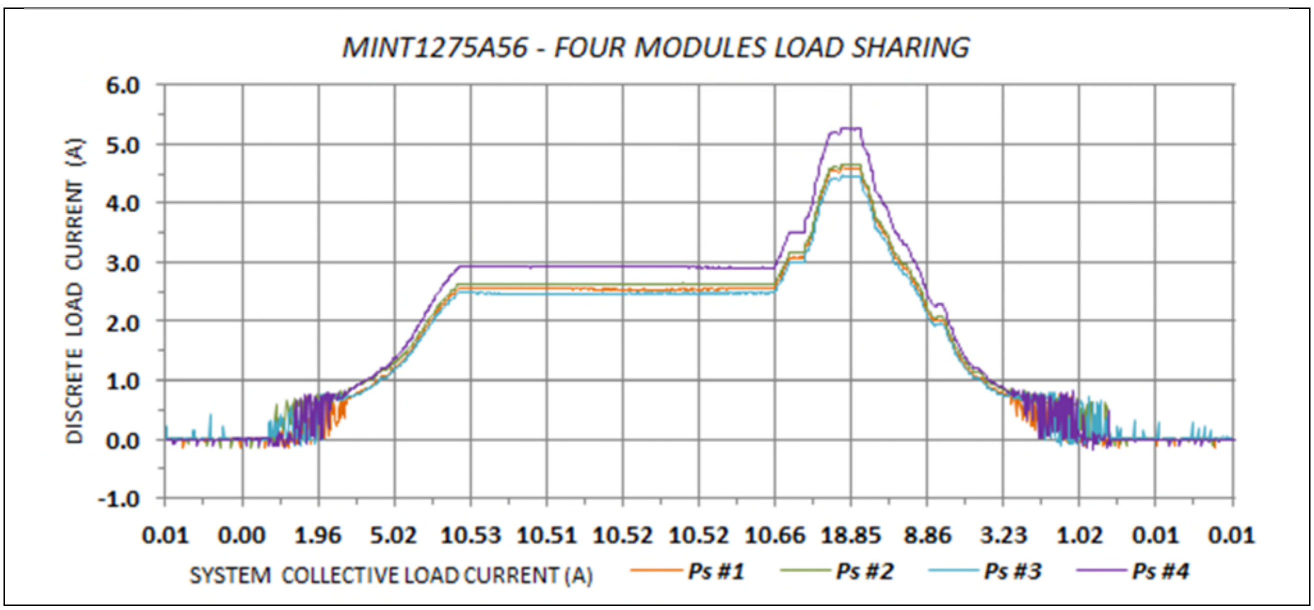
CONSIDERATIONS AND LIMITATIONS

Number of Parallel Modules Recommended:

Parallel up to four (4) compatible modules.

The SLPE model MINT1275 allows for the paralleling of up to four (4) compatible modules to increase the overall power capability in a system or for redundancy in an N+1 configuration. It is capable of actively load sharing between modules up to four (4) units in a steady state mode. The overall precision for current sharing is within 10% of each power supply's output current when the output power is above ~ 15% of the units rated load.

NOTE: for inhibit/enable performance see *"Remote Control Inhibit/Enable"*

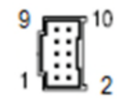


Output Voltage Adjustment:

There is no output voltage adjustment available in this particular model.

Analog Control Signals:

The MINT1275 Series is equipped with a 10 pins control signal header **(J201)** that provides analog control interface and standby power interface.



Voltage Remote Sense:

The main output of the MINT1275 is equipped with a Remote Sensing capability control that will compensate for a voltage drop of up to **250mV** between the main output terminals and the sensed voltage point at the system load. Implementation of this control feature is accomplished by connecting S+ Remote Sense (J201 pin 1) and the S– Remote Sense (J201 pin 3) terminals to the positive and negative rails of the main output respectively, at the system load or point of regulation

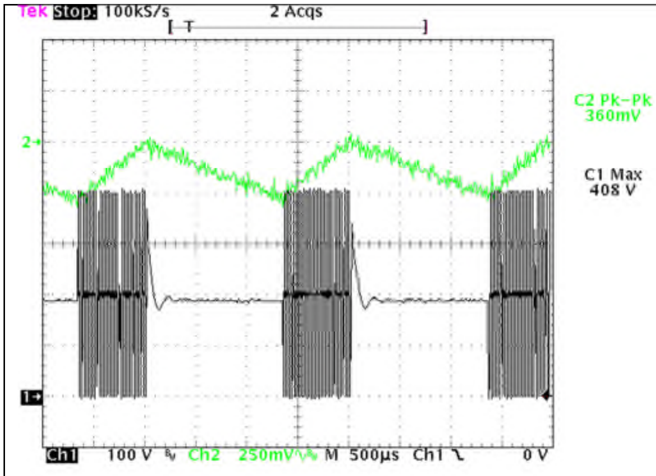
Load Share Bus (LSB):

The MINT1275 Series features a load-share controller that supports active current sharing through a single wire connection between the paralleled power supplies. The “LSB” **J201 pin4** allows up to 3 additional units to be paralleled to increase the overall power capability or for a configuration of N+1 for redundancy purposes. Care should be taken in the routing of J201 pin 4 from one unit to the J201 pin 4 of another unit as noise sources may affect to the stability of the supplies.

Minimum Load Sharing Performance:

Due to the inherent high efficiency conversion topology of the MINT1275 Series, under low load conditions, approximately 18% combined rated load, the units operate in a quasi-burst mode. The energy is provided in bursts and since the parallel power supplies will do this asynchronously, ***it is typical*** for some current flow between units as well as to the load. At very light load, some units will not provide current but will remain in regulation redundantly ready to share any rising demand of load current. Above 18% of the combined rated load, all active parallel units will be operating in a continuous output load sharing mode.

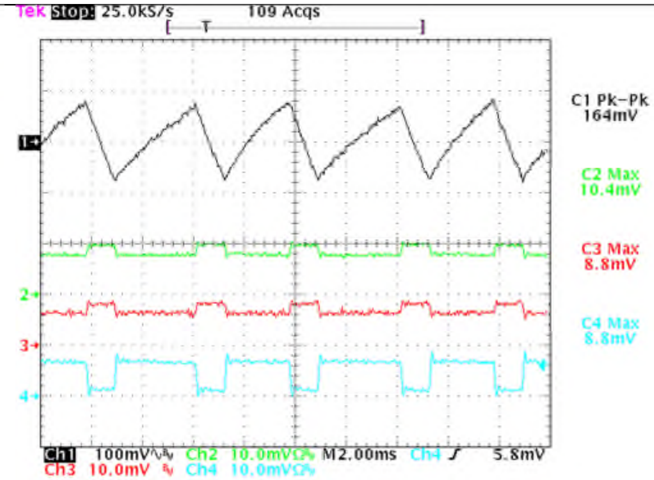
Minimum Load Sharing Performance



Quasi-burst mode

Ch1: Main Q302 d-s, Ch2: Output Ripple Voltage

Figure1a: No - Very Low load current sharing



Typical Min Load Sharing Performance _ (N+1)

Ch1: Output Ripple, Ch2,3,4: 1A/10mV

Figure 1b: Low load current sharing

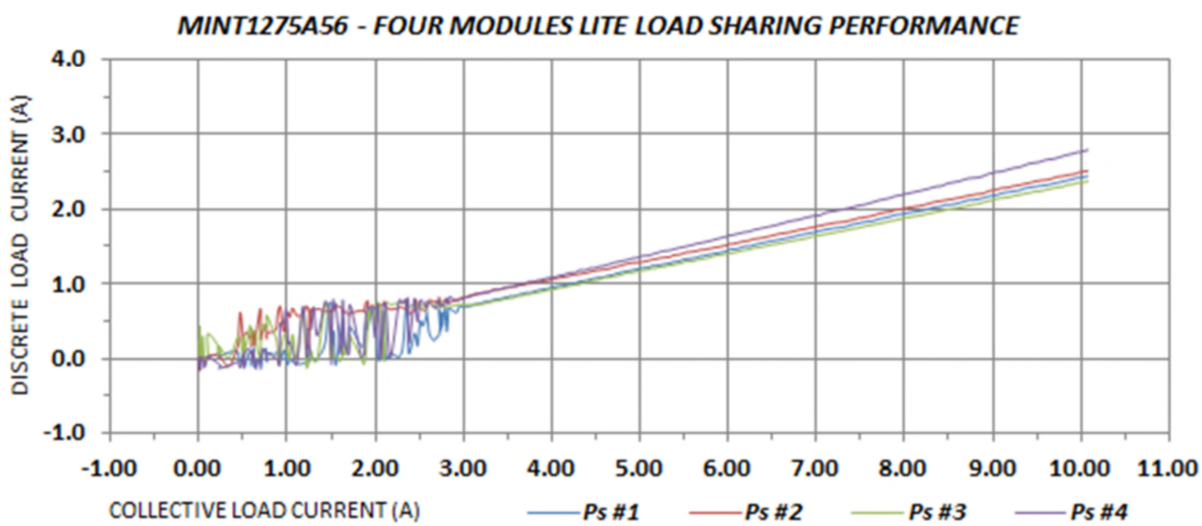
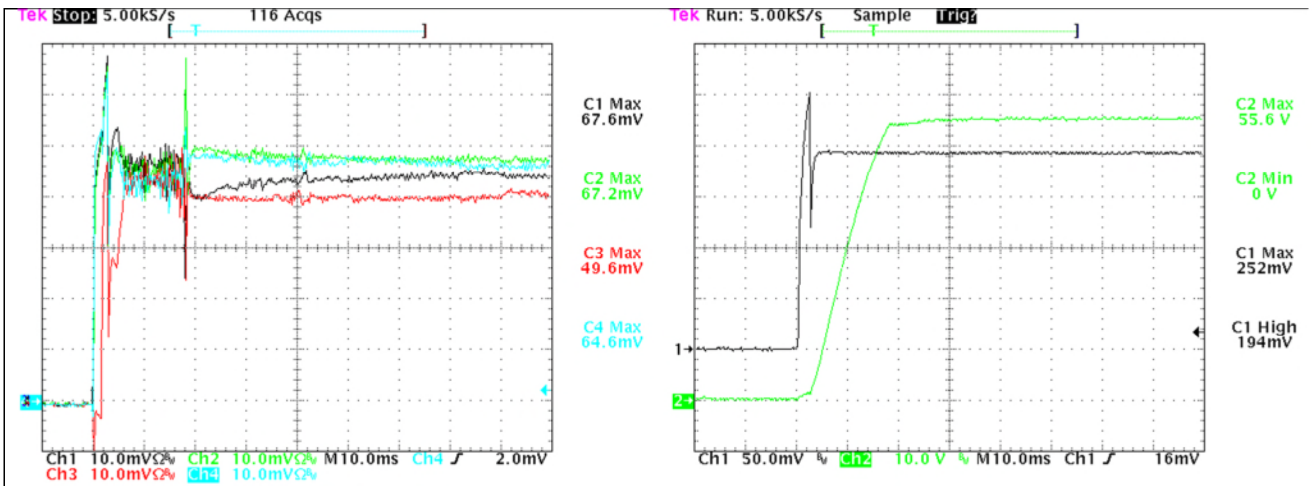


Figure 2: *Typical Lite Load Share with four MINT1275's in parallel*

Start-up Behavior: The MINT1275 Series responds to unusual operating conditions during start up in a moderate rate ensuring a uniform engagement in sharing the load current.



NOTE: Current spike on Ch1 due to electronic CC load

***Start-up Behavior** – four modules discrete load current share of a total 19A system load*	***System total load** – four modules, 19A total load share*
Ch1: PS#1, Ch2: PS#2, Ch3: PS#3, Ch4: PS#4, (1A/10mV)	*Ch1: Collective System Load Current, Ch2: Voltage at the system load*

Figure 3 Typical Start-up behaviors

Remote Control Inhibit/Enable:

Remote Inhibit is a TTL compatible active low input signal that allows the system or user to control the operating state of the MINT1275. During application of an inhibit condition, the main output will be disabled however the 5VSB and the +12V Fan output will continue to be available. The Remote Inhibit input is referenced to the common - J201 pins 2 and 6. It is recommended to Inhibit/Enable all units at the same time.

Inhibiting individual units: Consideration should be taken when inhibiting any of the load sharing parallel modules while the others remain operational. It is prudent not to re-enable any of the inhibited modules when the total active (operating system) load exceeds 130% (~6.0A)of the output rated current of a single module (fig. 4). If enabling occurs, the modules will engage in a hiccup mode that they may only recover from if the load is reduced to ~ 130% of a single unit or the input power is recycled.

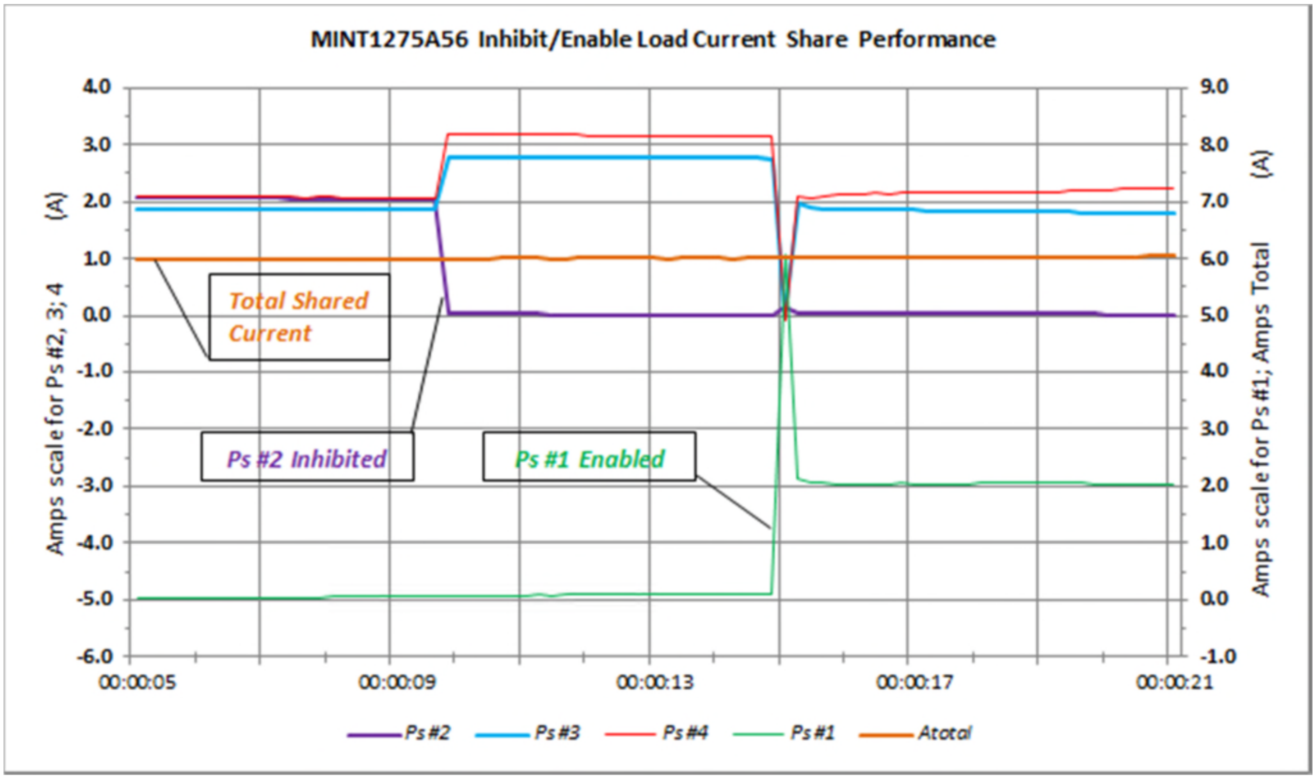


Figure 4 Inhibit / Enable Load Share Behavior

Figure 4 above exhibits the total load current of 6 Amps being shared by three (3) active modules plus one in standby mode (Ps #1), and their load sharing performance when Ps #2 is inhibited and Ps #1 is enabled. This inhibit /enable characteristic performance is typical with any combination of parallel modules.

Best Practices:

With any of these optional load sharing methods, it is considered a good practice to arrange the wiring from each paralleled power supply to the system/load so that the cable lengths from each supply are similar to each other. Also, besides a comparable wire length, it is as important to consider the wire gauge vs. the load current it has to carry in order to reduce conduction losses and voltage drops. Ensure that the voltage drop (Current x Cable Resistance) along the cable is not out of range of the remote sense control specified for the power supply being used.

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The following table (Table 1) below is an aid to select wire gauge according to its ampacity, or the voltage drop can be calculated using the resistance and length to select an appropriate wire size.

AWG Size	Number of Strands	Ohms Per 1,000 ft	Circular Mils	Ampacity 250mils per Amp	LOAD WIRE LENGHTS VS. ITS VOLTAGE DROPS @ RATED AMPACITY							
					4.0 "	8.0 "	12.0 "	16.0 "	20.0 "	24.0 "	28.0 "	32.0 "
18	16/30	6.61	1600	6.4	0.0141	0.0282	0.0423	0.0564	0.0705	0.0846	0.0987	0.1128
16	26/30	4.07	2600	10.4	0.0141	0.0282	0.0423	0.0564	0.0705	0.0847	0.0988	0.1129
14	41/30	2.58	4100	16.4	0.0141	0.0282	0.0423	0.0564	0.0705	0.0846	0.0987	0.1128
12	65/30	1.63	6500	26.0	0.0141	0.0283	0.0424	0.0565	0.0706	0.0848	0.0989	0.1130
10	105/30	1.01	10500	42.0	0.0141	0.0283	0.0424	0.0566	0.0707	0.0848	0.0990	0.1131
8	133/29	0.635	16983	67.9	0.0144	0.0288	0.0431	0.0575	0.0719	0.0863	0.1007	0.1150

Table 1 Load Wire Selection Guide

The terminations of the wires and their contact connection losses are not accounted for in the figures of the table (Table 1) above. They may develop additional voltage drops that need to be considered.

To calculate the voltage drop per unit length, use the Ohms per 1,000 ft data and multiply by the load current to determine mV/ft of voltage drop.

Example: A load current of 4 amps is expected and the cable length is 24". What is the expected voltage drop on the load cable if a #18 AWG cable is used:

18 AWG resistance is 6.61 ohms/K Ft., IxR = 4 x 6.61 =26.44V/Kft or 26.44mV/ft.

Total feed and return length = 2FT (24") x 2 (Feed and return) = 4ft. : 4 x 26.44 = 105.76mV

This is below the 0.25V (250mV) remote sense compensation hence is an acceptable cable option.

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WIRING COFIGURATIONS

Basic Connections - Star Wiring Scheme:

Although there may be more than one way to wire load sharing with parallel power supplies, the star wiring method is typically the one most recommend. In the proceeding figures herein, it is demonstrated three star wiring schemes that provide options for any desirable level of redundancy.

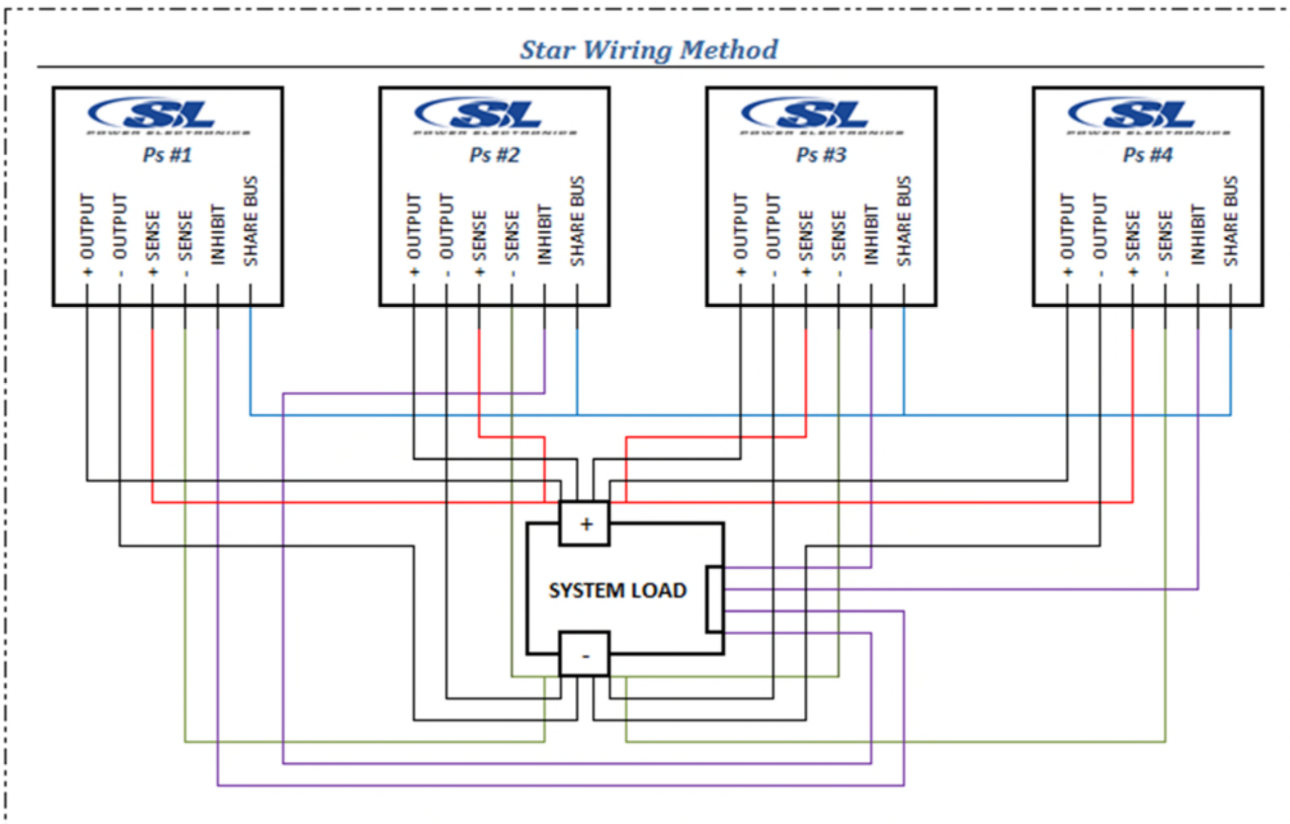

Figure 5

The method above in figure 5 demonstrates a basic star wiring scheme that offers a basic level of redundancy without the inclusion of extra components that are not strictly necessary for a load sharing function.

Advanced Connections - Diode ORing Wiring Scheme:

Many safety-critical systems demand a reliability that necessitates an advanced redundancy that requires additional components. This can be seen in the load share wiring scheme as demonstrated in figure 6.

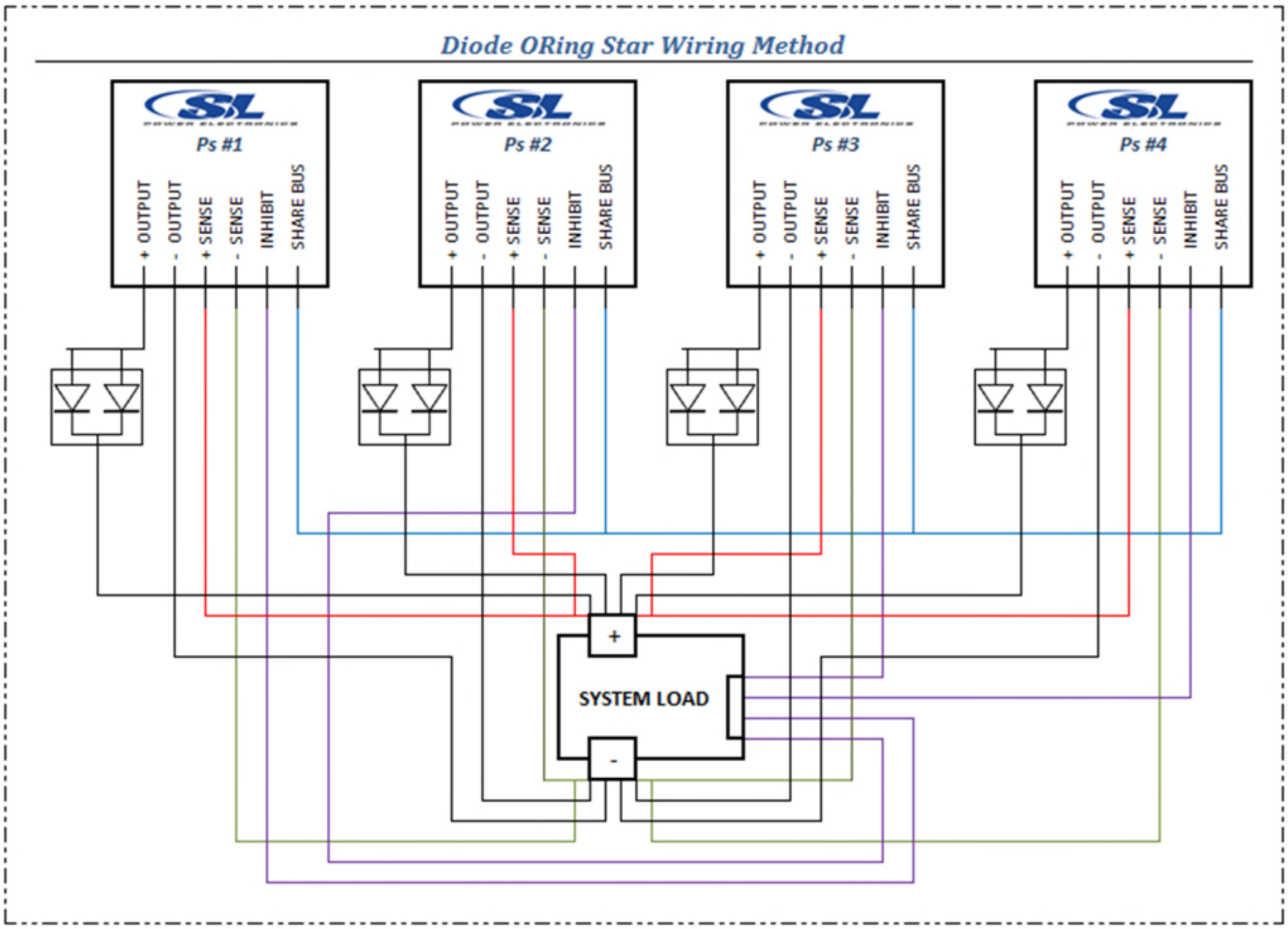

Figure 6

The diode ORing configuration above in figure 6 is an advanced scheme that presents a redundancy option that is simple and reasonable.

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Lower Power Loss Connections - MosFet ORing Wiring Scheme:

OR ing diodes are commonly used for lower current Oring applications. As the current increases, there can be significant power losses due to the voltage drop of the diode. A more efficient Oring method is to use of ORing FET's. This method has more complexity and may have higher costs associated with it. A trade-off analysis should be conducted to determine if thisa suitable alternative to ORing diodes.

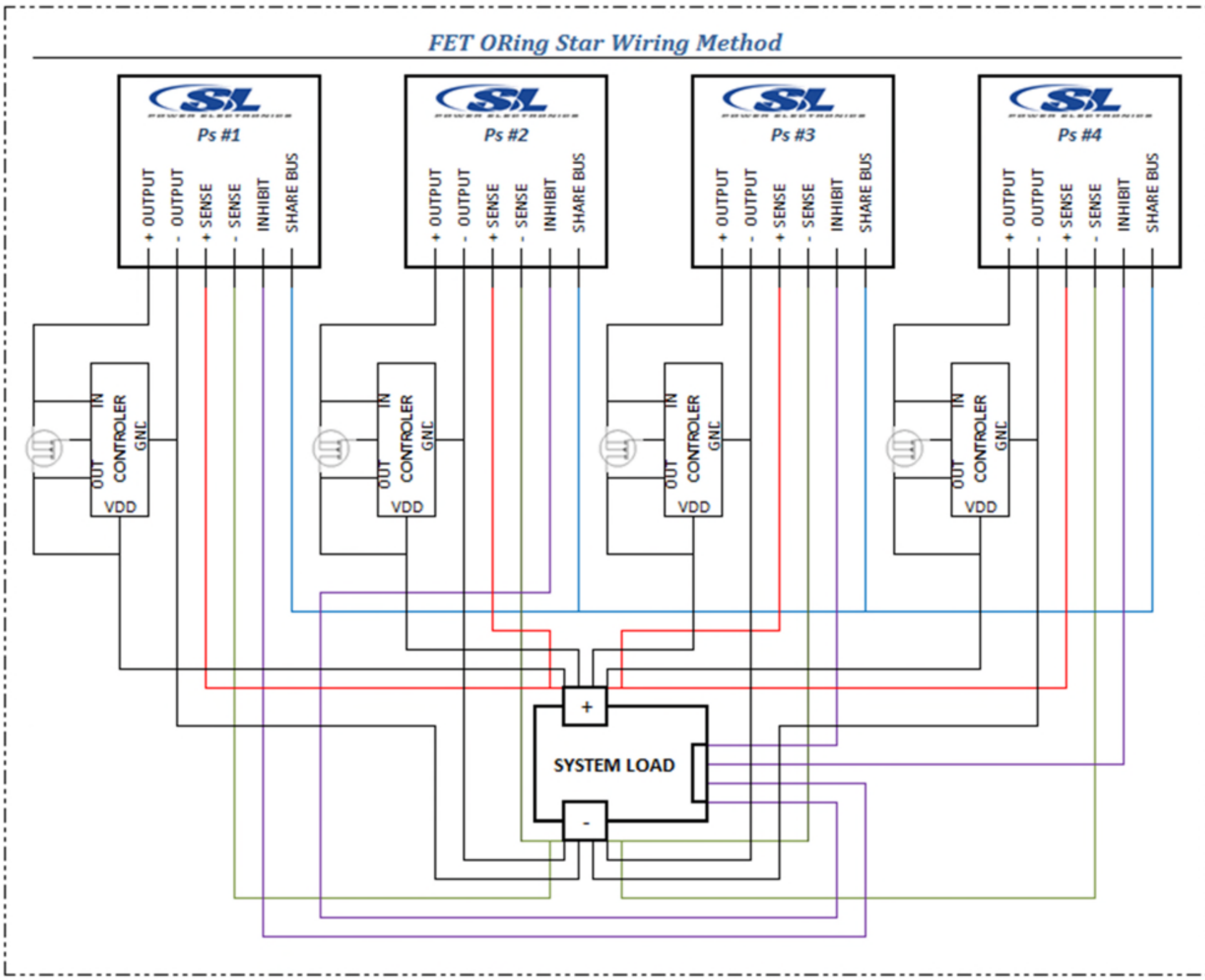

Figure 7

Figure 7 shows a typical arrangement using ORing FET's and FET drivers. This scheme consists of the same basic ORing star wiring method however, it is considerably more efficient and is well suited for <24V output voltages with higher currents. The voltage limitation is linked to the availability of suitable ORing FET driver IC's. At higher voltage levels the efficiency impact is less of an issue. Current Share Testing with OR'ing FET's was done using a Linear Technology LTC4357 controller.

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Notes: