Advancing The Power Curve

Series Operation of SynQor Converters

Application Note 07/13/11 Rev. A

Summary

Voltage requirements often do not match standard component voltage specifications, particularly in the industrial markets, making a power implementation with standard board-mounted DC-DC power converters more challenging. A wide range of output voltages for unique system requirements are often achievable with series connections of standard isolated power converters.

Introduction

A series connection of SynQor isolated DC-DC converters is straightforward, and takes advantage of the high-voltage isolation characteristics of isolated DC-DC converters. This note details the simple interconnections needed to operate and protect these converters connected in series. For series operation, the modules must be isolated converters, since the output return of one will be tied to VOUT(+) of another module. Multiple different output voltages may be connected to provide the desired non-standard output voltage.

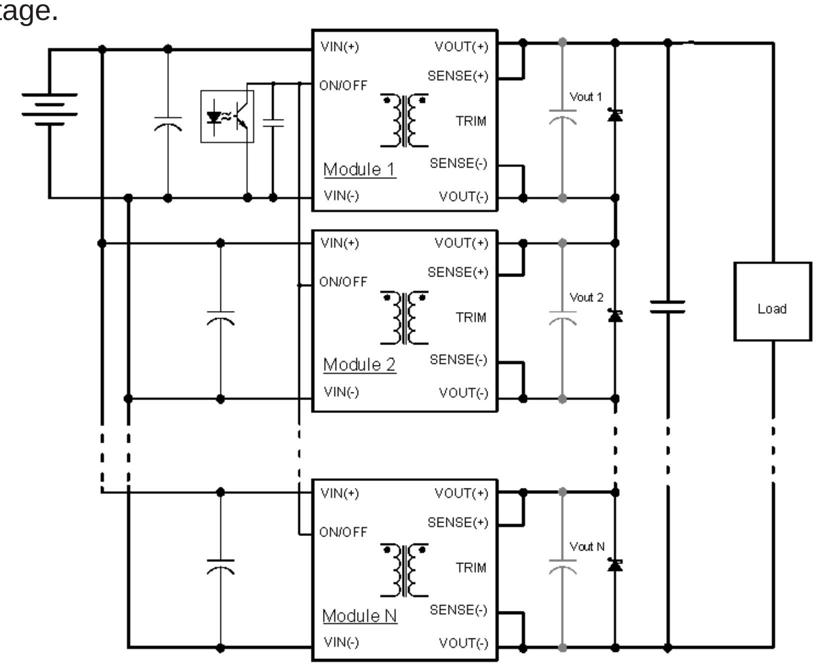

Figure 1: *Suggested wiring diagram for converters in series with a single input power supply*

Schottky Diode

We recommend a Schottky diode be connected across the output of each series connected converter, so that if one converter shuts down for any reason – over-temperature for example – then the output stage won't be thermally overstressed. Without this external diode, the output stage of the shut-down converter could carry the load current provided by the other series converters, with its MOSFETs conducting through the body diodes. The MOSFETs could then be overstressed and fail. The external diode should be capable of handling the full load current for as long as the application is expected to run with any unit shut down.

Input Connection

All inputs should be in parallel (see Figure 1). They can possibly be powered from different sources, possibly with different ground references, but inputs cannot be connected in series (see Figure 2).

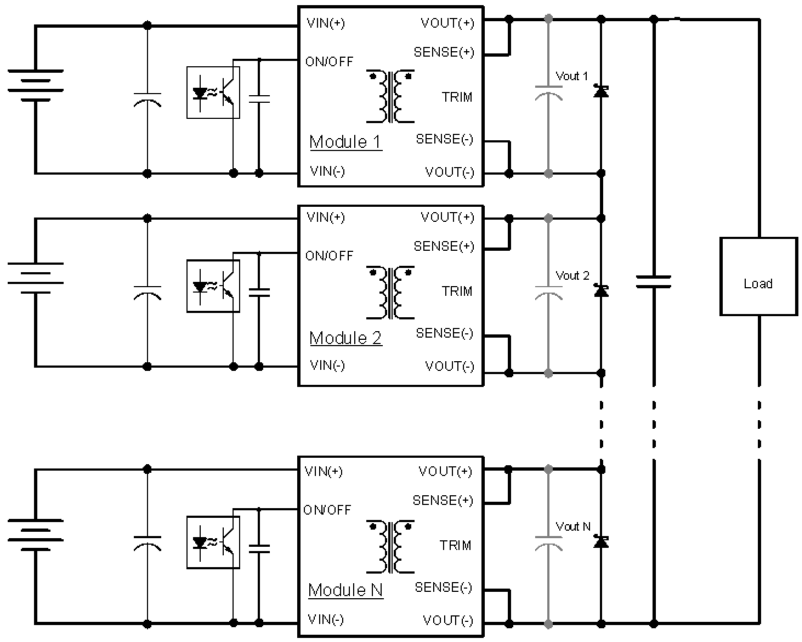

Figure 2: *Suggested wiring diagram for converters in series with multiple input power supplies*

Be aware that there is input-to-output capacitance on each converter that can create displacement currents under transient conditions, for example when one converter is shorted. When many units are stacked in series, this capacitance is charged to the voltage seen between VIN(-) and VOUT(-) for that individual converter.

Output Voltage Trim

Each converter output can be trimmed with a resistor or active circuit, but the reference net for each trim is the SENSE(-) pin of that converter. Only one of them will be at the load's return potential, so care must be exercised in trimming modules that are in series. If only a very small trim is needed, trimming only the bottom converter in the stack is the best approach.

Remote Sense

Remote sensing is not generally effective for series stacks of converters since each module can only adjust its own output voltage, not the overall stack voltage.

Output Capacitance

At power-up, many SynQor converters require their output voltage to reach approximately 75% of their nominal rated output voltage within a 10ms window following the start of the output voltage risetime. Failure to achieve this condition can result in a failure to start and automatic re-try in a hiccup mode that can go on indefinitely. While this causes no damage, it nonetheless is not a desirable mode of operation.

As output voltage and/or external output capacitance increase, so does the risk of the converters entering current limit mode on startup. The risk is aggravated by any load current being drawn during the risetime of the output voltage. If the total current from charging external output capacitance and load exceeds the current limit threshold of any one converter during the startup waveform, then that module will enter current limit mode and the ramp-up of the output voltage will slow. If any single module voltage fails to reach ~75% of Vout(nominal) within 10ms of the start of the voltage ramp, the module may fail to start, causing a delay followed by a re-start attempt.

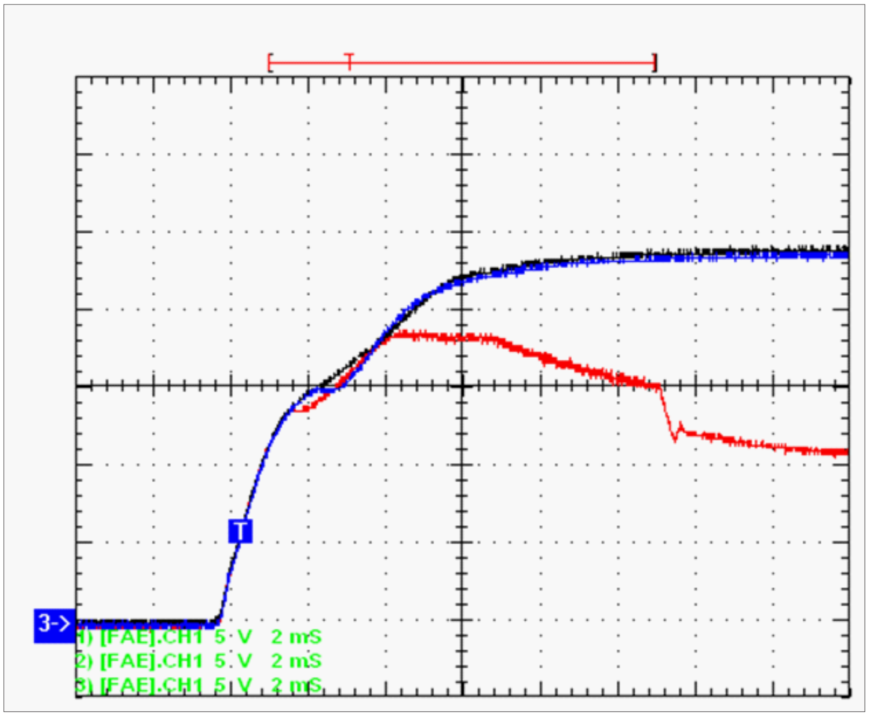

Figure 3: 2 x PQ48120QGA08 in series
Black Trace = Starting into 1000uF capacitive load only
Blue Trace = Starting into 1000uF capacitive load and 8A constant resistance
Red Trace = Starting into 1000uF and 8A constant current load (failed initial start up)

The black trace in figure 3 shows a no-load startup into a high capacitance load of 1000μF, showing the default, or voltage-controlled startup waveform. The blue trace shows the same waveform, this time representing an 8A resistive load (3.0Ω) as well as the 1000μF capacitive load. This startup is also closed-loop since it matches the no-load waveform.

In third case (red trace), with a constant-current load and the same 1000μF capacitance, the loop opens during the startup waveform at the point where the voltage waveform had an upward inflection point, where charging the capacitance requires more current than is available. At this point, the current limit loop engages and because of the constant-current load, the voltage actually decreases, diverting some of the capacitor charge to the load. The loop response of both the converter and the electronic load contribute to the exact shape of the waveform after ~4ms. Since the voltage is below the 18V point (about 75% of Vout nominal) at 10ms after the starting point, the module does not start and turns off at this point. It will re-try the startup after the 200ms startup inhibit period.

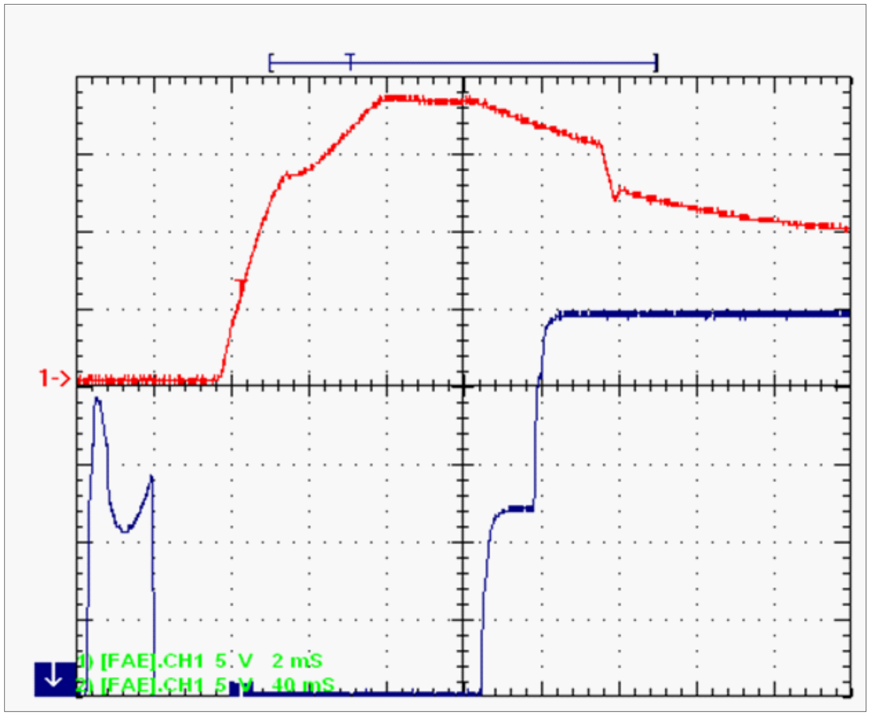

Figure 4: 2 x PQ48120QGA08 in series
Red Trace = Starting into 1000uF and 8A constant current load (failed initial start up) 2ms/div
Blue Trace = Starting into 1000uF and 8A constant current load (failed initial start up, eventually starts after approximately 200ms) 40ms/div

Figure 4 is a combination view showing the failed startup waveform (top trace) at 2ms/division and a zoomed-out view (bottom trace) at 40ms/division showing the hiccup-mode off period and the re-start after 200ms. This re-start was successful, meaning that some charge was retained by the capacitors and the startup was marginal enough that the second attempt was successful.

Reference

SynQor Application Note: *Input System Stability*
http://www.synqor.com/documents/appnotes/appnt_System_Instability.pdf

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