



Next Generation Power Solutions Solving Real World Interface Issues

Microsemi Space Forum 2015

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World Wide Sales Manager



Microsemi
SPACE FORUM

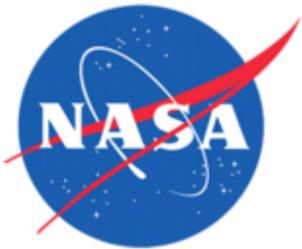
Agenda

- ISS Overview
- Impedance Matching
- Inrush Current Limiting
- Protection Circuits
- Testing
- Customizing your project
- Questions

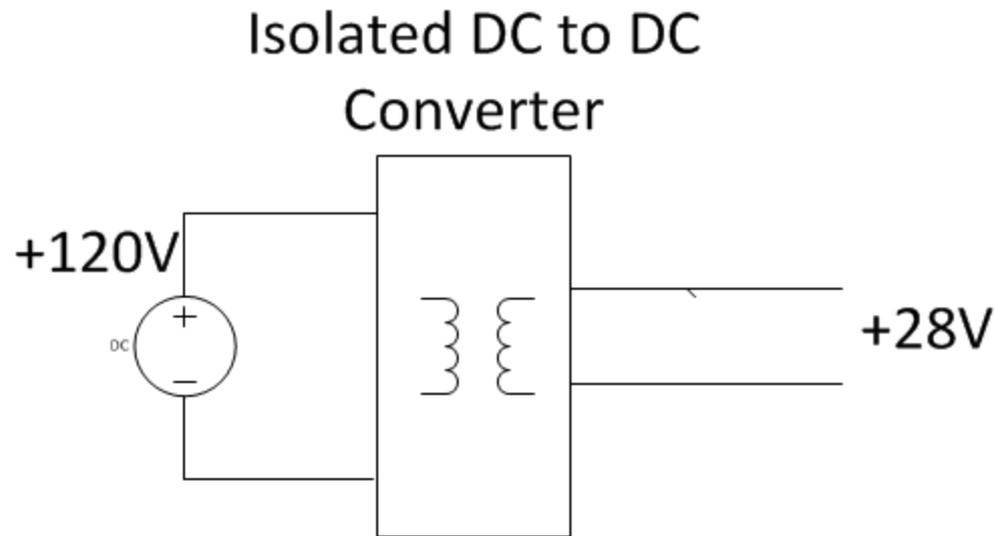


The International Space Station

- Launched in 1998, Manned since November 2000
- Pressurized volume the size of a Boeing 747
- Can support up to 84 kilowatts, 120V_{DC}
- Visited by 14 different countries
- The worlds greatest science fair
- Supported by:



A Typical Application



A typical DC to DC converter used in Space



Datasheet: SA50-120 Single Series

RADIATION HARDENED ISOLATED DC/DC CONVERTERS

SA50-120, 50 Watts Total Power, $120V_{DC IN} - 28V_{DC OUT}$ or $15V_{DC OUT}$

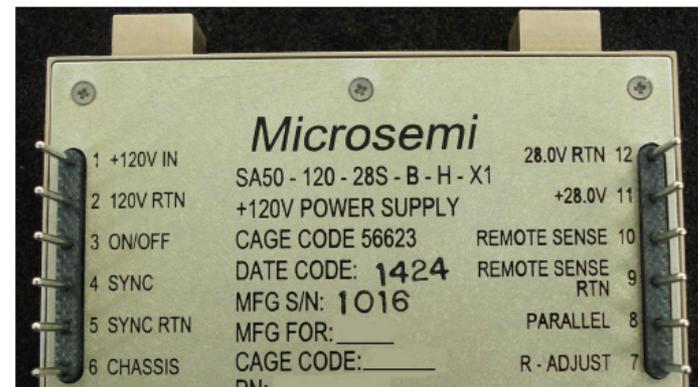
Features

- +120 VDC Satellite Input Interface
- 100kRad (Si) TID; Single Event Effect rated
- Surface Mount Construction (non-hybrid)
- 50W total power, high efficiencies 85%+
- Patented Magnetic Feedback
- Isolated Synchronization Input
- Adjustable Output
- Modules can be tied in Parallel
- Primary referenced ON – OFF command
- Over-current Protection
- Input Under-voltage lockout
- MIL-STD-1547B design de-rating criteria
- 100% Space level Environmental Screening
- Standard Mounting 2.05" x 3.05" x 0.475"
- Multiple Single Output Voltage Options
- SEE > 80 MeV•cm² /mg Version Available
- EMI Compliance to MIL-STD-461

DESCRIPTION

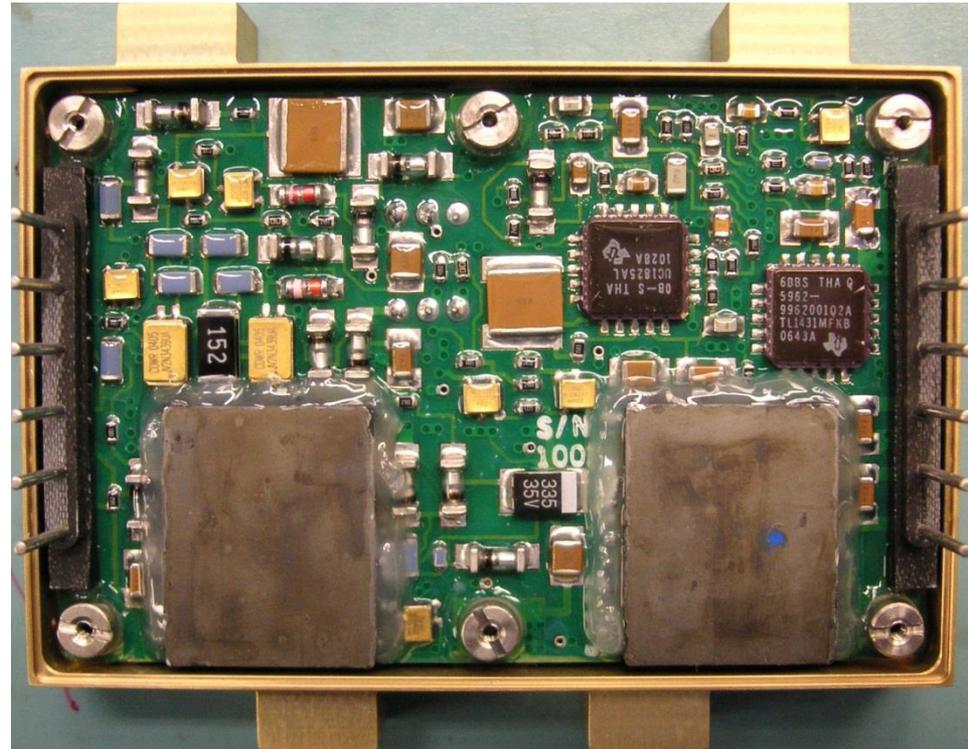
The SA series of DC-DC converters are designed for the rigors of space, characterized for Total Ionizing Dose and Single Event Effects. Operating at a fixed

Microsemi Space & Power Management (SPM) has achieved decades of flawless execution in harsh space environments. PMG's heritage, producing complex custom (radiation hardened) switching power designs and systems is now complimented with the "SA Series" Standard Radiation Hardened DC/DC converter modules. The same rigorous design methodology employed for custom designs has been applied to the SA Family of standard products. These space grade inverters are ideal choices for decades to come. Export license may be required for foreign shipments.



SA50-120 Family

- $V_{IN} = 120V_{DC}$ (86V to 158V)
 - 165V for 10 seconds
- Outputs isolated from the inputs
- Outputs isolated from each other
- Isolated chassis
- Space grade PWB (IPC-2221 and IPC-2222)
 - Trace to trace hi-pot test to 250V
- Built in EMI filter



For a simple system

- Connect the input to the power bus
 - A small capacitor can be placed across the input
- If large step currents on the output, place a few hundred μF across the output(s)
- Use remote sense if load is a distance from the output of the SA50
- Use trim (on single output version) if V_{OUT} adjustment of up to +/- 10% is required
- Parallel two or more modules for increased output power
- All of the converter analysis and testing is done for you
- Pretty Simple implementation

The ISS – A more complicated system

- Dual 120V buses
- Power source may be a distance from the DC to DC converter
- Long cables to the System Power supply
- Solar storms can cause spikes in the power supply
- There are many other loads connected to the same bus
- Isolation from the 120 volt supply a critical safety issue

The ISS – the Designer must

- Design an Impedance matching Network
- Design for Inrush Current Limiting
- Add input protection circuitry

Applicable Documents for ISS / Orion

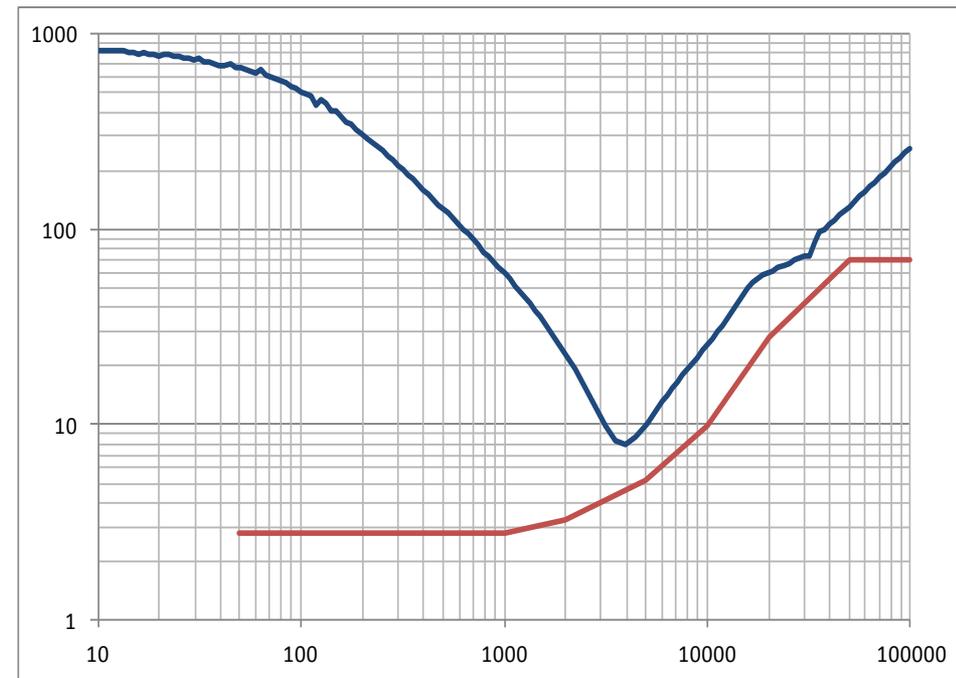
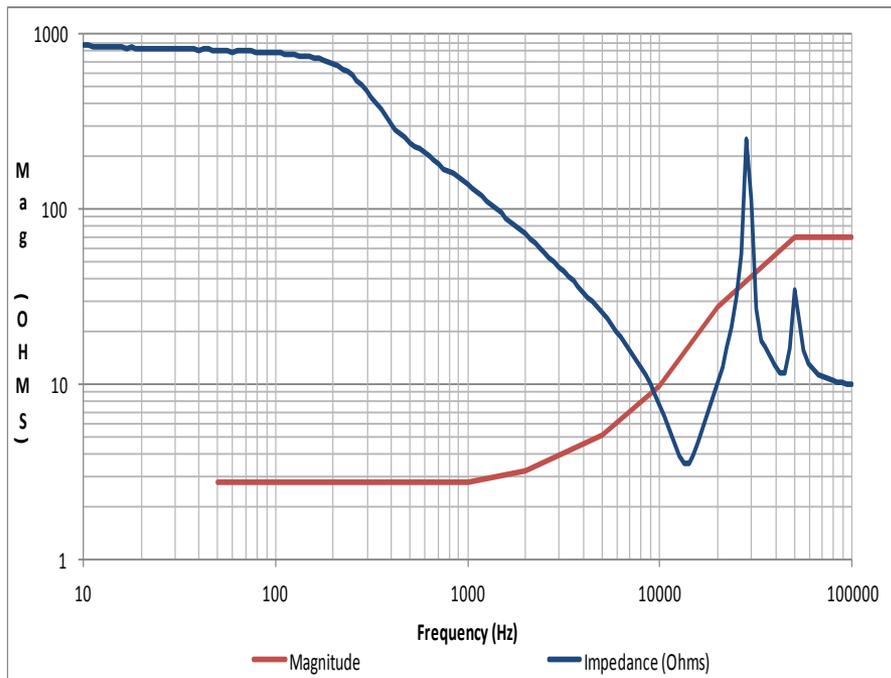
- SSP 30237 Revision F: Space Station Electromagnetic Emission and Susceptibility Requirements
- SSP 30238 Revision D: Space Station Electromagnetic Techniques
- SSP 30240 Revision D: Space Station Grounding Requirements
- SSP 30243 Revision G: Space Station Requirements for Electromagnetic Compatibility
- SSP 30312, Revision H: Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program
- SSP 30425 Revision B: Space Station Program Natural Environment Definition for Design
- SSP 30482 Volume 1, Revision C: Electric Power Specifications and Standards Volume 1 - EPS Electrical Performance Specifications
- SSP 30482 Volume 2, Revision A: ELECTRIC POWER SPECIFICATIONS AND STANDARDS: VOLUME 2 - CONSUMER CONSTRAINTS
- SSP 30512 Revision C: Space Station Ionizing Radiation Design Environment
- SSP 41172 Revision U: Qualification and Acceptance / Environmental Test Requirements
- SSP 41173 Revision C: Space Station Quality Assurance Requirements
- SSP 42004, Part 2, Revision A: Mobile Servicing System to User (Generic) Interface Control Document
- SSP 52051 Vol. 1: User Electric Power Specifications and Standards - 120Volt DC Loads
- NASA-STD-4003A: ELECTRICAL BONDING FOR NASA LAUNCH VEHICLES, SPACECRAFT, PAYLOADS, AND FLIGHT EQUIPMENT

Impedance Matching Network

- The Source can be a significant distance from the load.
- The power cable is inductive
- The load impedance increases with frequency
- For stable operation $Z_{\text{LOAD}} > Z_{\text{SOURCE}}$

Before

After



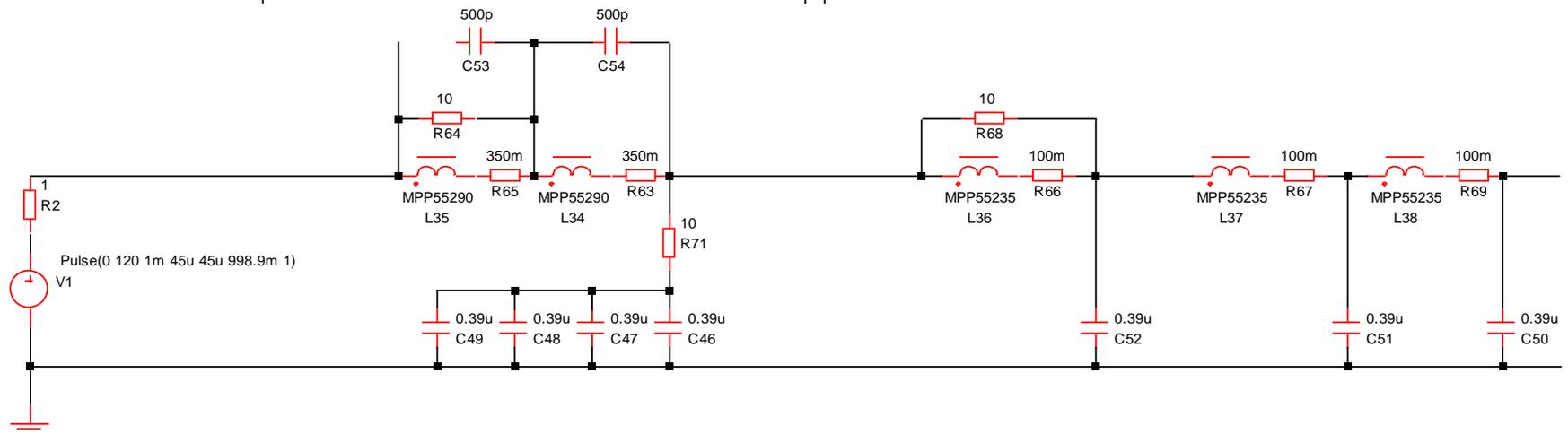
Impedance Matching Network

- The Impedance presented to the source is higher than the required source impedance curve.
- The impedance matching network should present an inductive impedance.
- A passive network is typically used for this function

VOLTAGE SOURCE
SIMULATING VARIOUS dV/dT

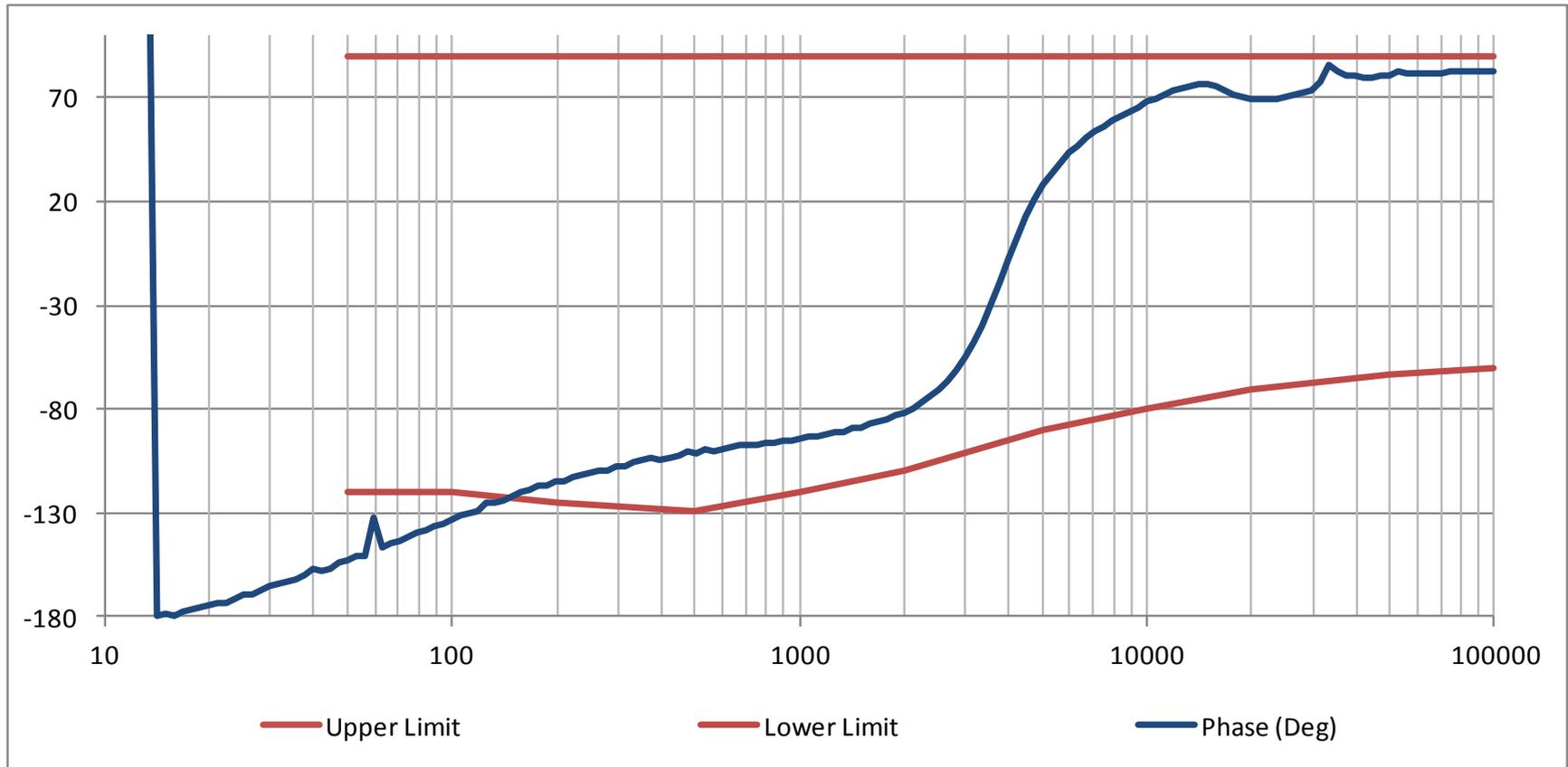
ADDED EXTERNAL COMPONENTS

INTERNAL TO SA50 POWER SUPPLY



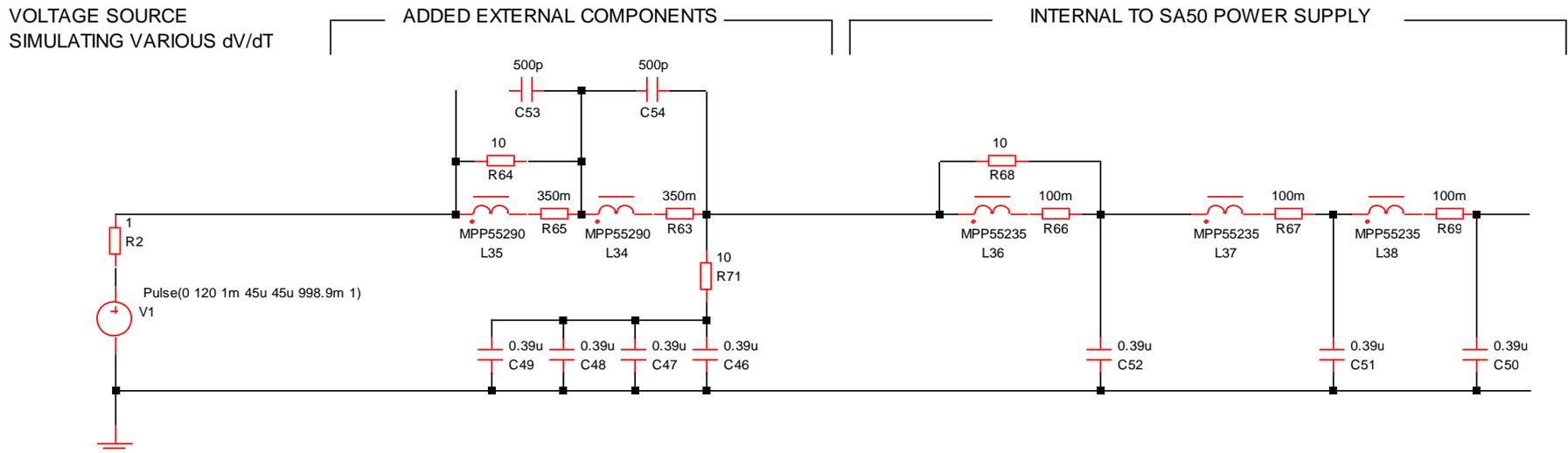
Impedance Matching Network

- The Phase (current leads or lags the voltage) must be within defined upper / lower limits

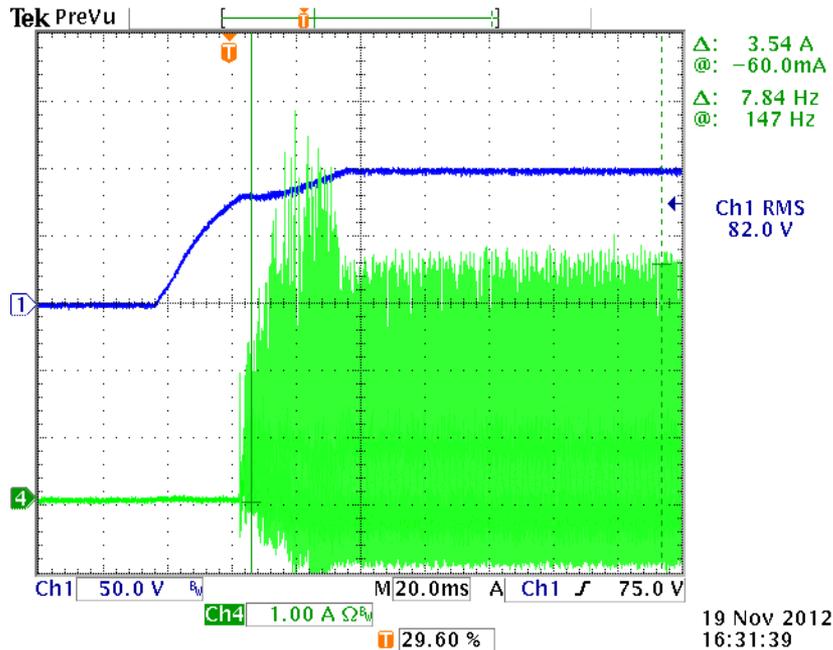


Inrush Current Limiting

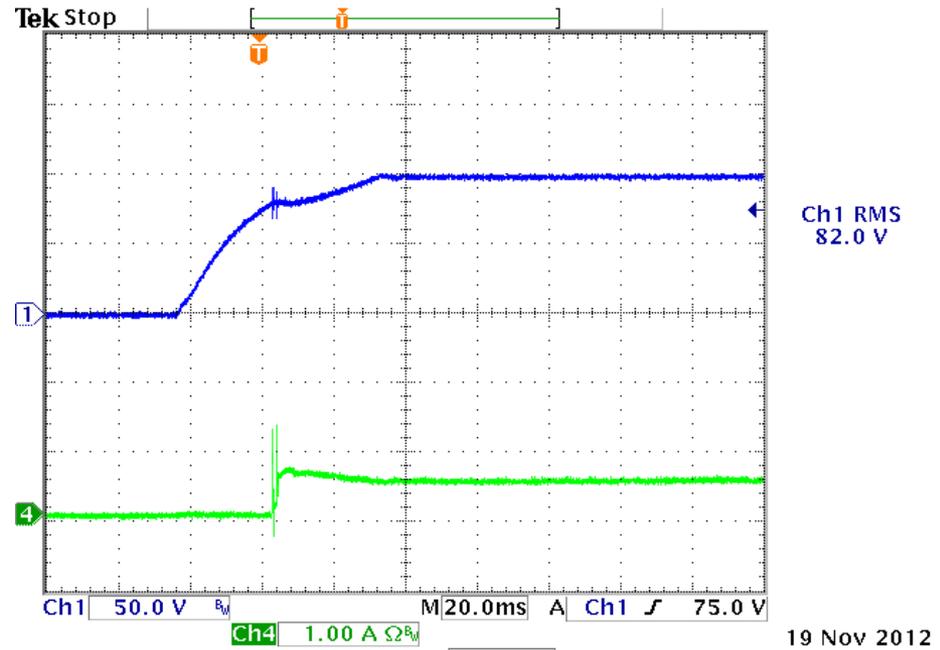
- When a remote device is turned on, the system may place limits on how much instantaneous current is allowed at the load
- The input current dramatically increases if the inductors saturate
- The input filter elements limit the current into the capacitors



Inrush Current Limiting – Actual Example



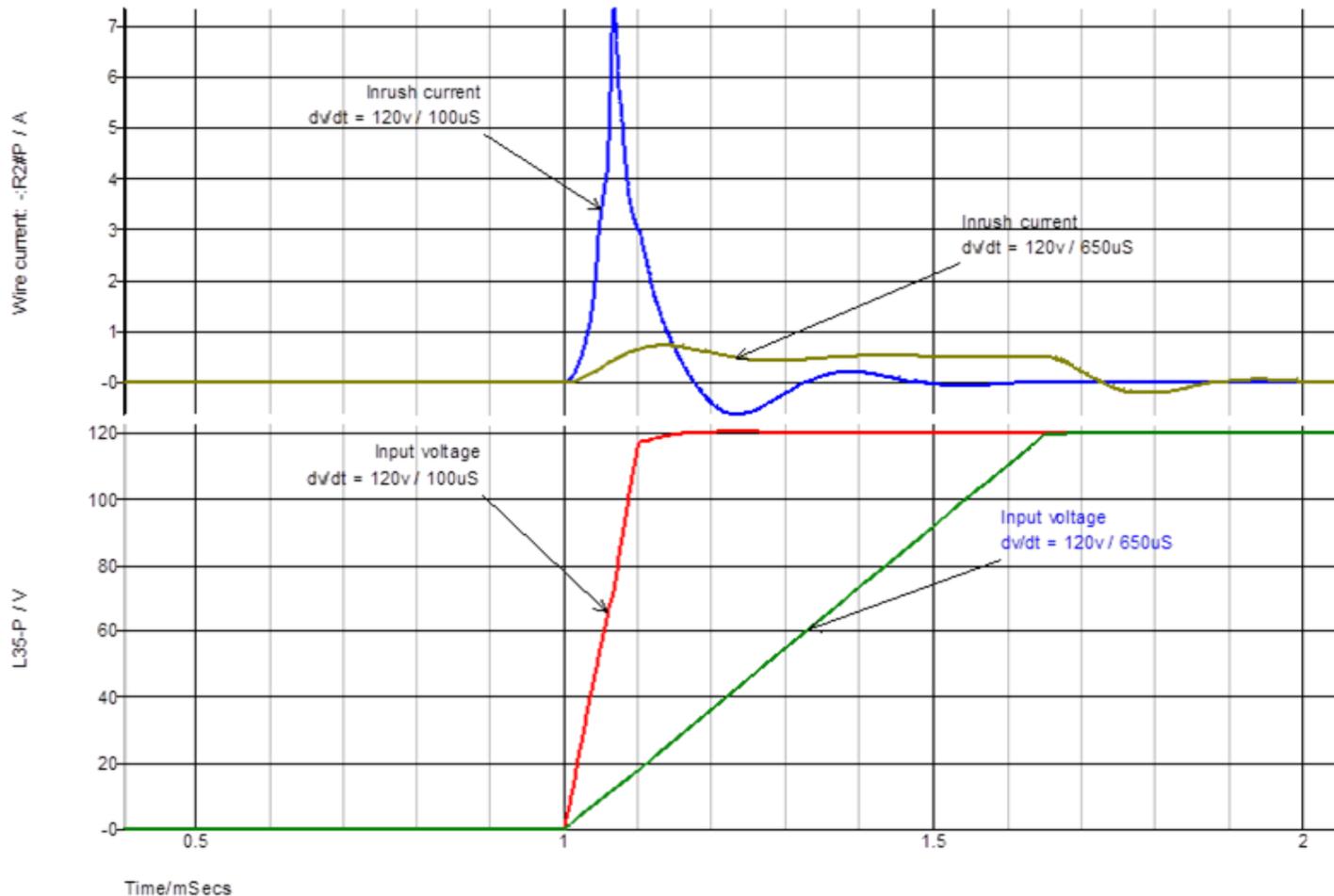
Inrush Current at 100% Load
(Vin Rise \approx 40mSec)



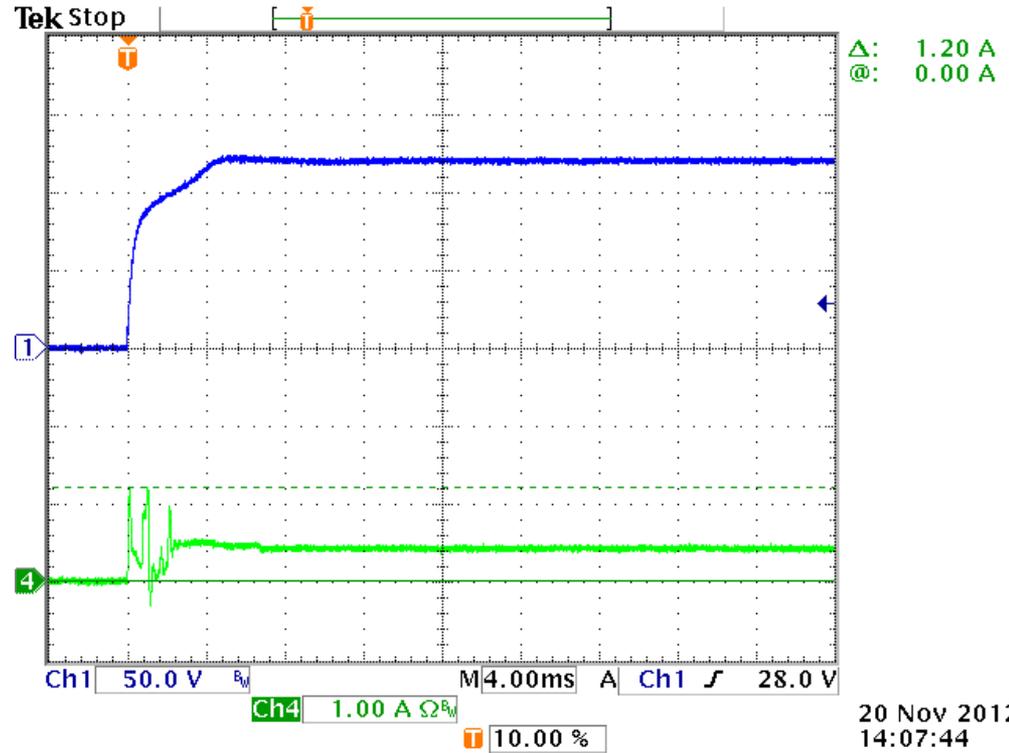
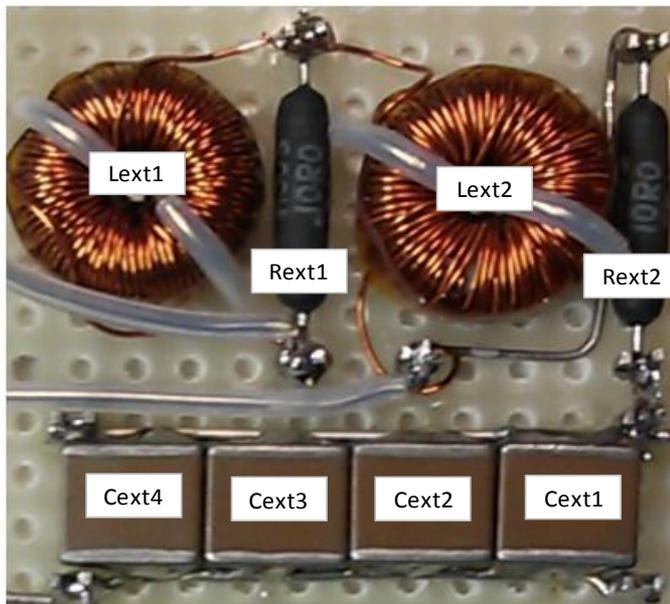
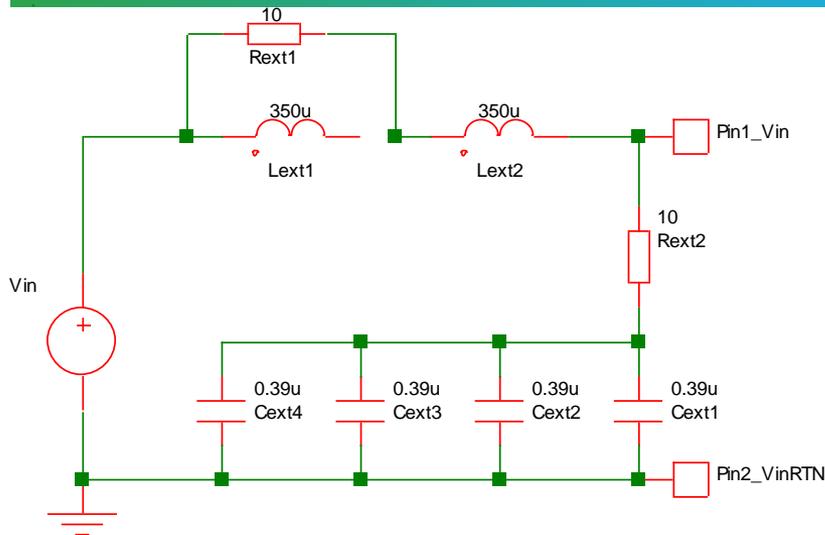
Inrush Current at 100% load with additional
External EMI Filter

Inrush Current Limiting

- Simulated result for selected dV/dT

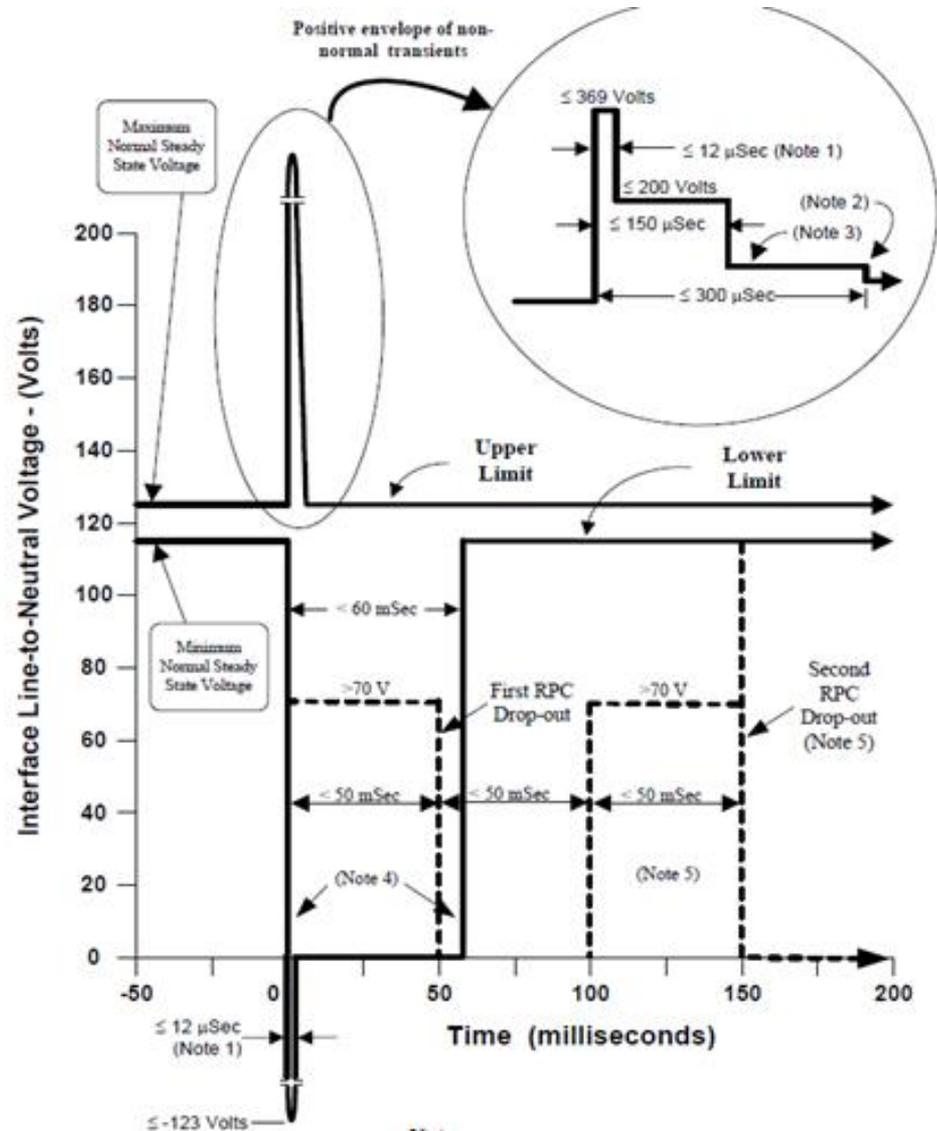


Breadboard the solution



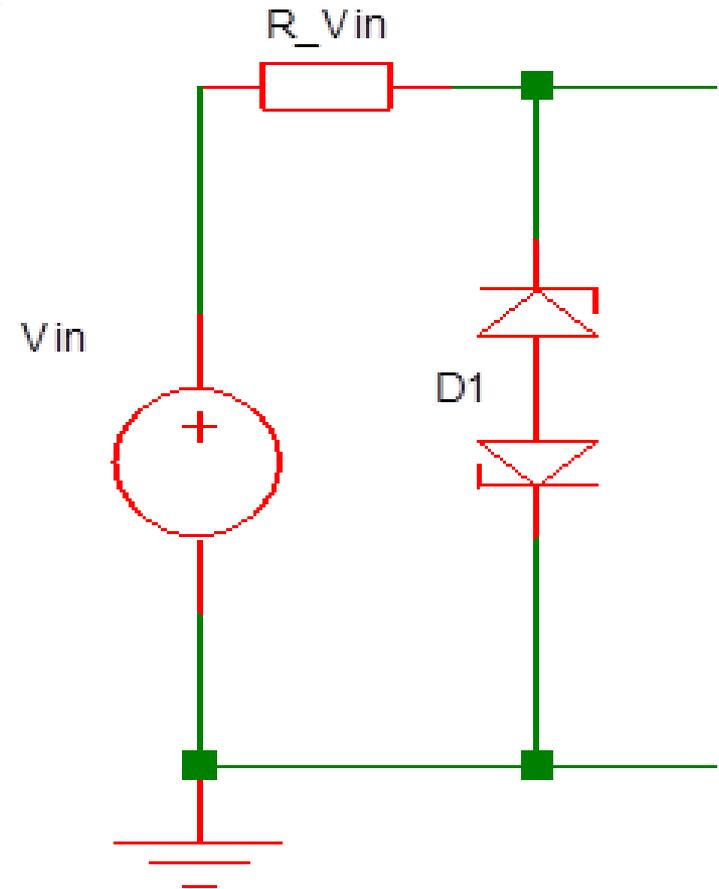
Input Protection

- The power converter must operate in a hostile environment
- 320V spike for 10 μ S
- External suppression circuitry is necessary



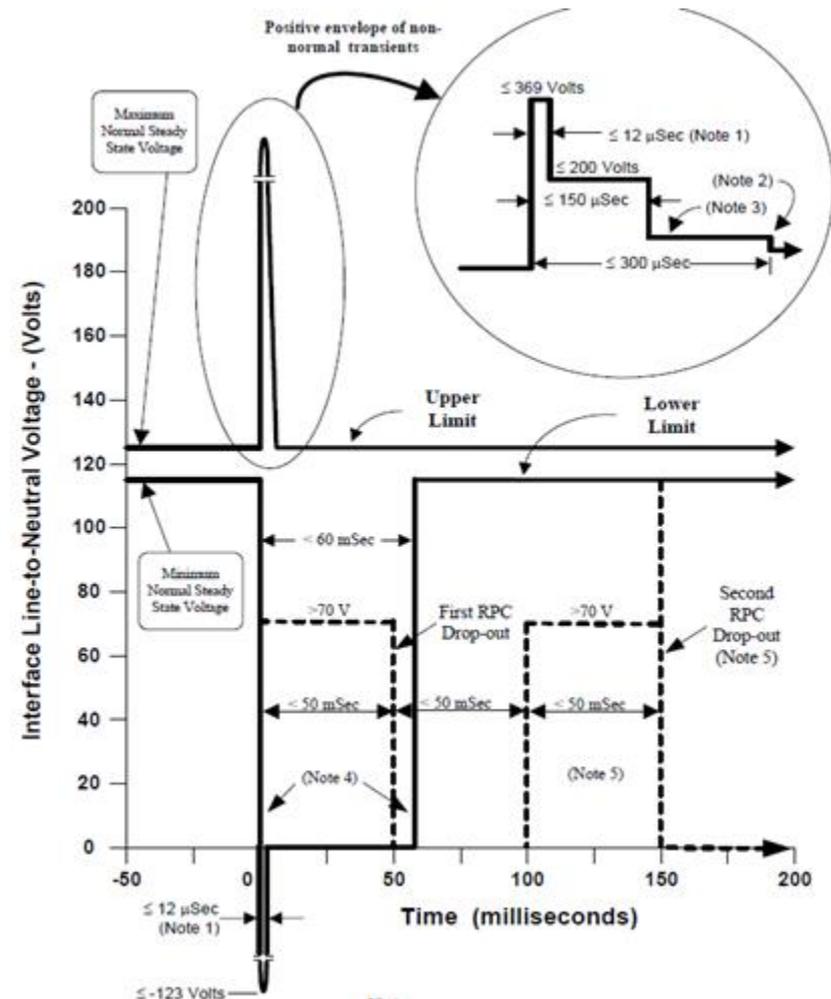
Input Protection

- Transorbs limit input voltage spike maximum voltage
- R_{vin} limits current

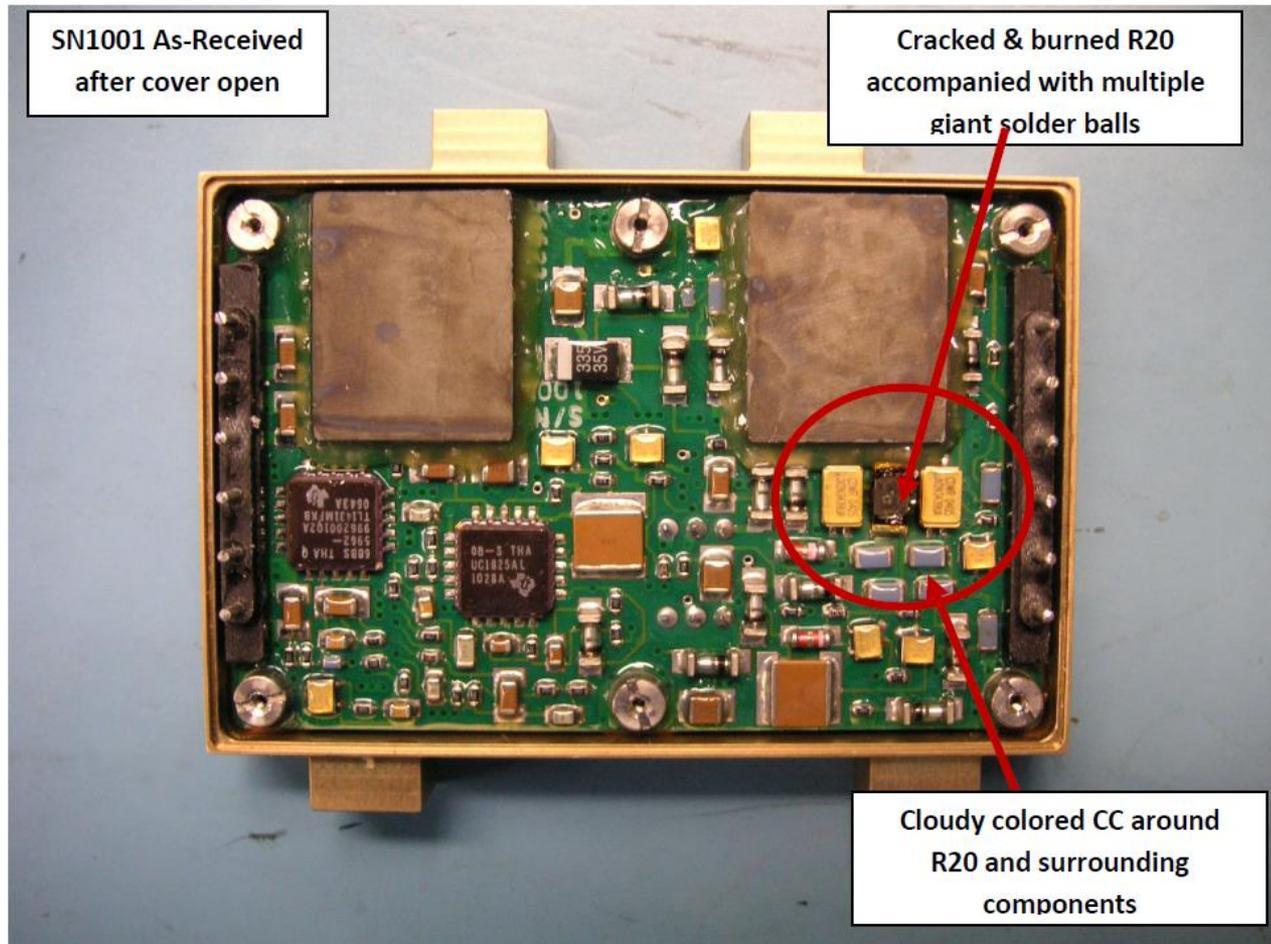


Testing at Johnson Space Center

Inrush Current
Inrush Current with RPCM
compatibility
Surge Current
Impedance
Large Signal Stability
Over and Under Voltage Transient
Envelope
Fault Clearing & Protection
CE01 and CE03
CE07
Common Mode Transient Spike
Voltage
Common Mode Current
Common Mode Isolation
CS-01 and CS-02
CS-06
Non-normal Voltage
Reverse Current



The result of insufficient protection



Application note for the ISS



The SA50-120 and the International Space Station

ISS Overview

The International Space Station has been occupied since November of 2000. Bigger than a football field, with a pressurized volume as large as a Boeing 747, it is capable of supporting an electrical load of 84 kilowatts. The main power bus on the ISS is 120 VDC NOMINAL. Before a vendor is allowed to connect to the power bus, equipment intended for the ISS must go through a rigorous testing and certification process¹. While it is beyond the scope of this application note to address all the issues involved in this certification, the most common electrical interface concerns will be addressed.

SA50-120 Overview

The SA50-120 is a family of 50 watt, fully isolated DC to DC converters with single or triple outputs. The input voltage is typically 120V which is ideally suited to the International Space station. The SA50-120 has a built in MIL-STD 461 compliant EMI filter. It is fabricated using radiation hardened, hermetically sealed, fully tested and burned-in semiconductor devices² and space-grade passive devices assembled onto a PWB³.

Remote Sense Function

For single or parallel operation, the Remote Sense pin can provide accurate regulation at the point of loading.

The remote sense terminals may remain unconnected. For best output voltage regulation however, the remote sense terminal of the SA50 should be connected to a single point, as close as possible to the positive load terminal or point where the voltage regulation is desired to be maintained. For parallel operation, all remote sense pins should be connected together and tied to the remote point. In the same way, the remote sense return terminal of each SA50 module should be connected to a single point, as close as possible to the negative load terminal.

Parallel Operation

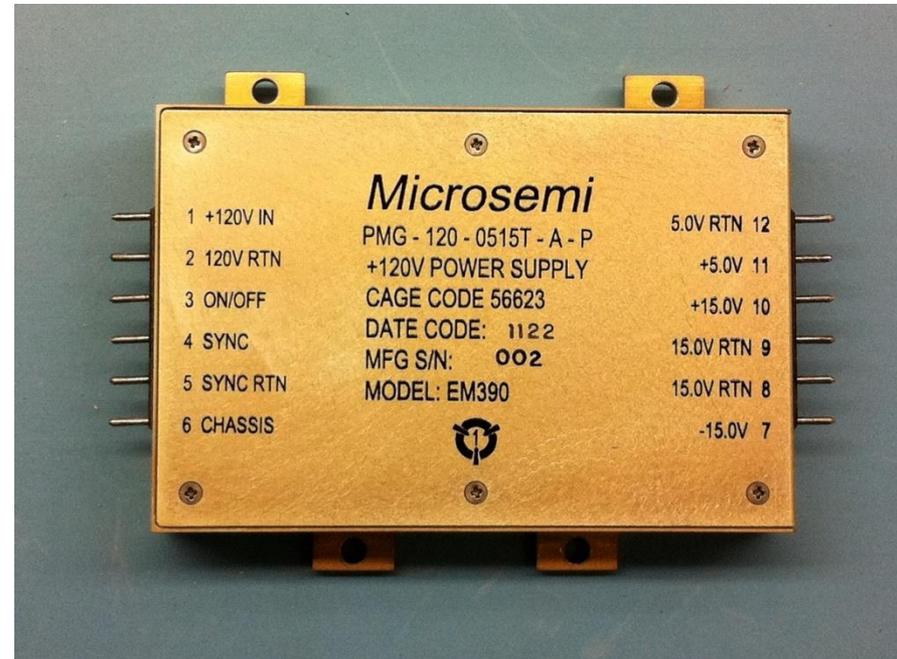
Up to five modules may be connected in parallel.

To insure current sharing, the Parallel terminal of every Power Supply module must be connected together to form a common bus. These connections should be made relatively short, but can be made in any configuration.

The expected current sharing accuracy is 10%

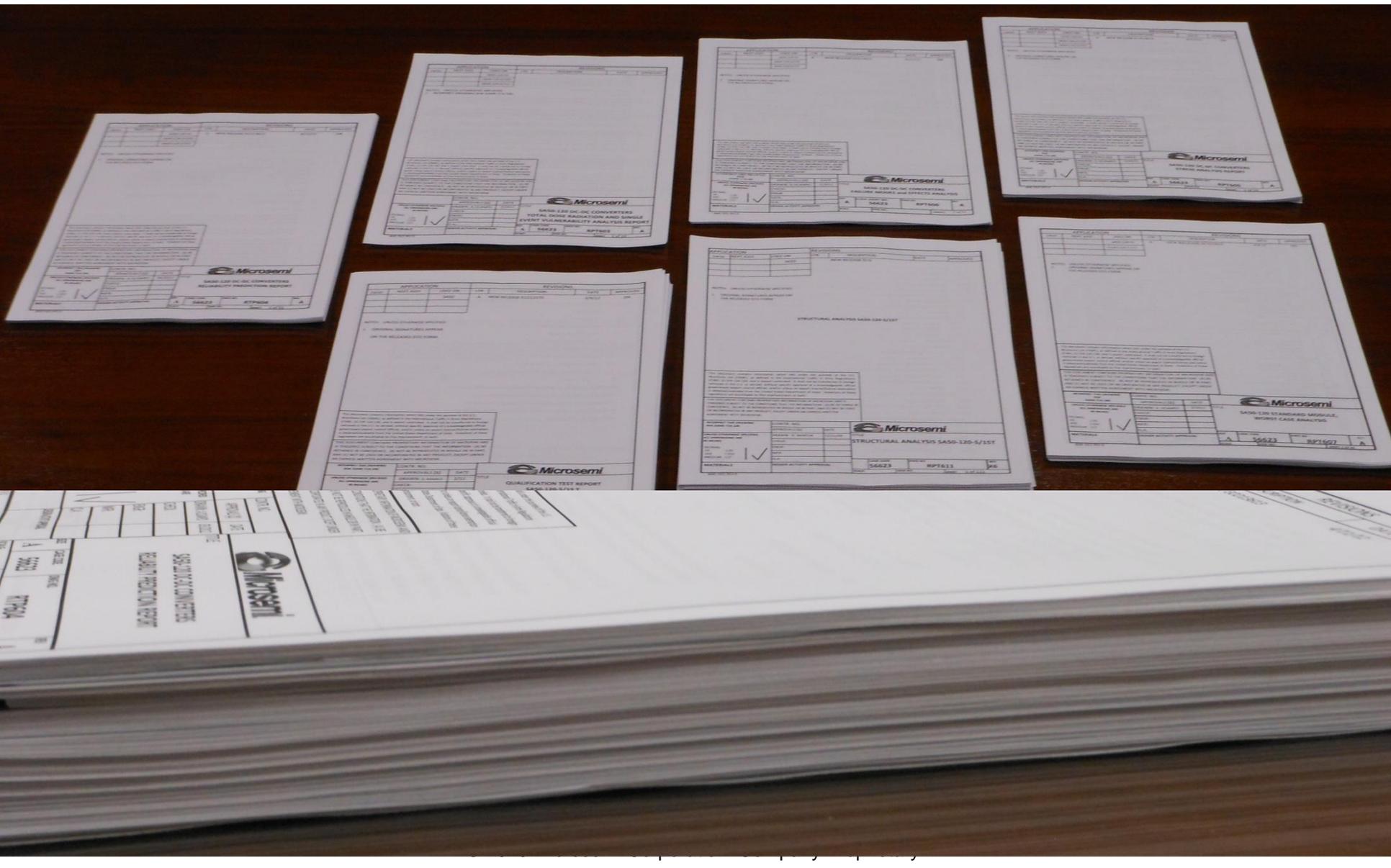
Customization Capabilities

- Typical Customizations:
 - Input Voltage
 - Output voltage (combinations)
 - Package / Mounting
 - Customer Marking
 - Current / Power Limit settings
 - Power Up / Power Down profiles
 - Enhanced Traceability
 - Custom material control
 - Special Process Control
 - Assembly
 - Screening



Standard Module First Prototype

Why should you buy a Module, when you can design your own?



Customization Capabilities

- Microsemi PMG in Garden Grove, CA can support your needs with a design that includes Impedance Matching, Inrush Current Limiting and Input Protection circuitry in one package.
- From a few watts to thousands of watts
- Time and cost are dependent on the complexity
- Our core business for the past 30+ years is space grade custom power supplies.

Summary

- DC to DC converters may need additional circuitry depending on the application
- Read the specs to understand the environment
- Use AN 101 as a guide
- If you want to modify or customize your design:
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Thank You



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Power Matters.™

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