Remote Terminal Monitoring Protection Surge Protection for Quasi-Grounded Low Voltage dc Circuits

Presented to Protection Engineering Group
Huntsville, AL, March 2015

Introduction - Solutions Provided by a Family of Experts

PDI

Since 1978

AC power distribution, transformation, branch chain monitoring, static switching

ONYX

Since 1979

AC, DC, custom magnetics up to 2mVA, high efficiency transformers, inverters, power distribution

PolyPhaser

Since 1979

Coaxial RF surge protection, patented DC block and DC pass technology

TRANSTECTOR

Since 1967

Specialist in non-degrading, fast-acting silicon technology
AC, DC, dataline, EMP protection, integrated cabinets, power distribution

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Problem Statement:

This topic originated from a customer protection application problem.

The customer complained of repeated damage to their monitoring stations on an oil and gas pipe line station. They provided the basic electrical block diagram this research has been based upon.

Ultimately the problem was solved through the application of normal and common mode protection across +/- polarity and from each polarity to ground.

Damage has not reoccurred at this or other customer sites.

The term “ quasi-grounded “ was coined by the customer to define their floating system with a virtual connection to ground through un-intentional paths through their equipment.

Remote Terminal Monitoring Surge Protection for Quasi-Grounded Low Voltage dc Circuits

Abstract

Common mode dielectric breakdown failure between any line to ground in low voltage dc power data and control circuits between can be mitigated with the application of surge protection. This paper describes the generic industrial control application circuits and the surge environment encountered in the range of applications allowed in NEC Article 690.35E type for ungrounded dc systems. The term quasi ground is used to describe an intentional surge protection reference .

The typical circuit diagrams are modeled in PSpice and surge stimuli are provoked at likely injection ports relative to ground. An array of installation parameters and surge conditions are compared to illustrate typical installation practices observed in process control and communications. The results will be presented through modeling and illustrations to help designers and operators find best solutions fit to their challenges.

Systems with floating dc power plant plus-minus terminals are described under common, normal and metallic mode surge conditions where ungrounded dc operation will experience dielectric faults to chassis ground.

The results of the models are overlaid onto the physical layout for remote terminal monitoring cabinets to help identify likely points of failure based on installation challenges.

The specific challenges and suggested remedial options are presented with references to best practices and electric code compliance.

Outline

Diagrams types – floating ground with intentional voltage control

dc power up the pole 48V – 30A – 2awg -6awg

control systems 48V - 1A – 18awg

Installation types

Parameters

Injection points and types

- voltage stimulus, current stimulus
- waveforms – 8/20 – 10/1000

Simulation Results

Remedial options and mitigation

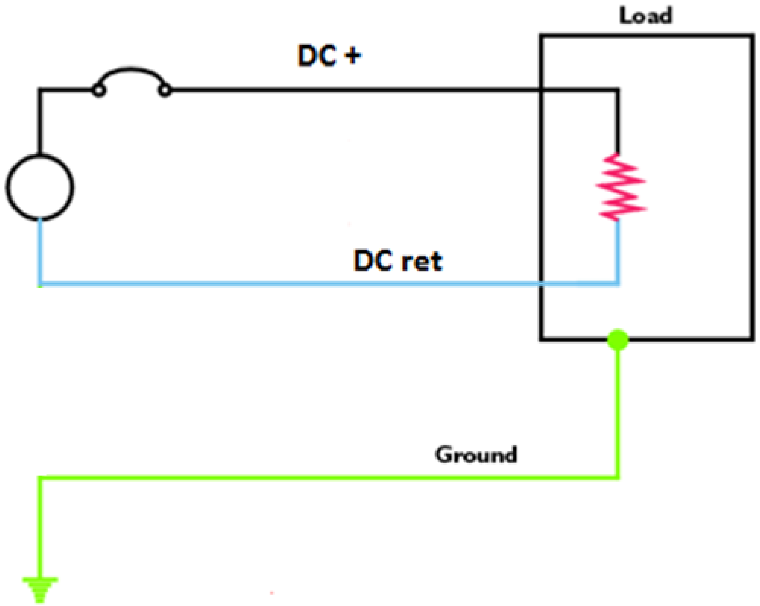
- dielectric withstand failure points, traces, connectors
- fuses, caps, solder joints

Diagram Types

NEC 690.35E closest reference for ungrounded dc battery with ground fault disconnect

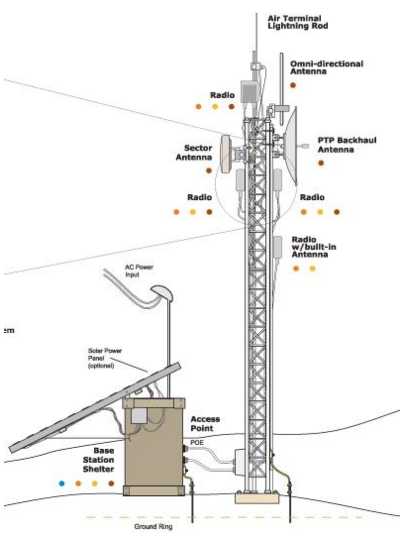
Power Up the Pole – 48Vdc @ 30A – 6awg wire, 100m, Zeq = 1.6ohm

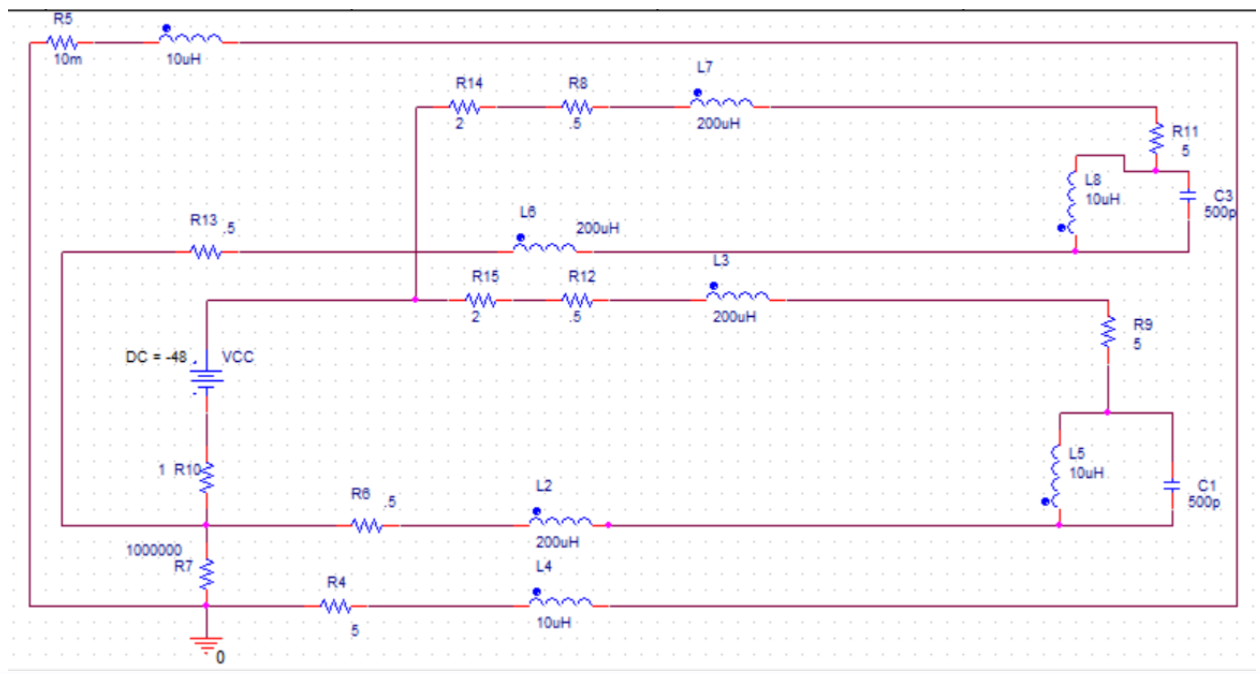
Low power Control I/O – 48Vdc @ 1A – 18awg wire, 100m, Zeq = 50ohm



Installation Types

The typical installation type described exhibits these features
Large gauge wire, Long cable runs
Floating ground reference
Multiple circuit power feeds through breakers
Vulnerable wire exposure points
Failure Points

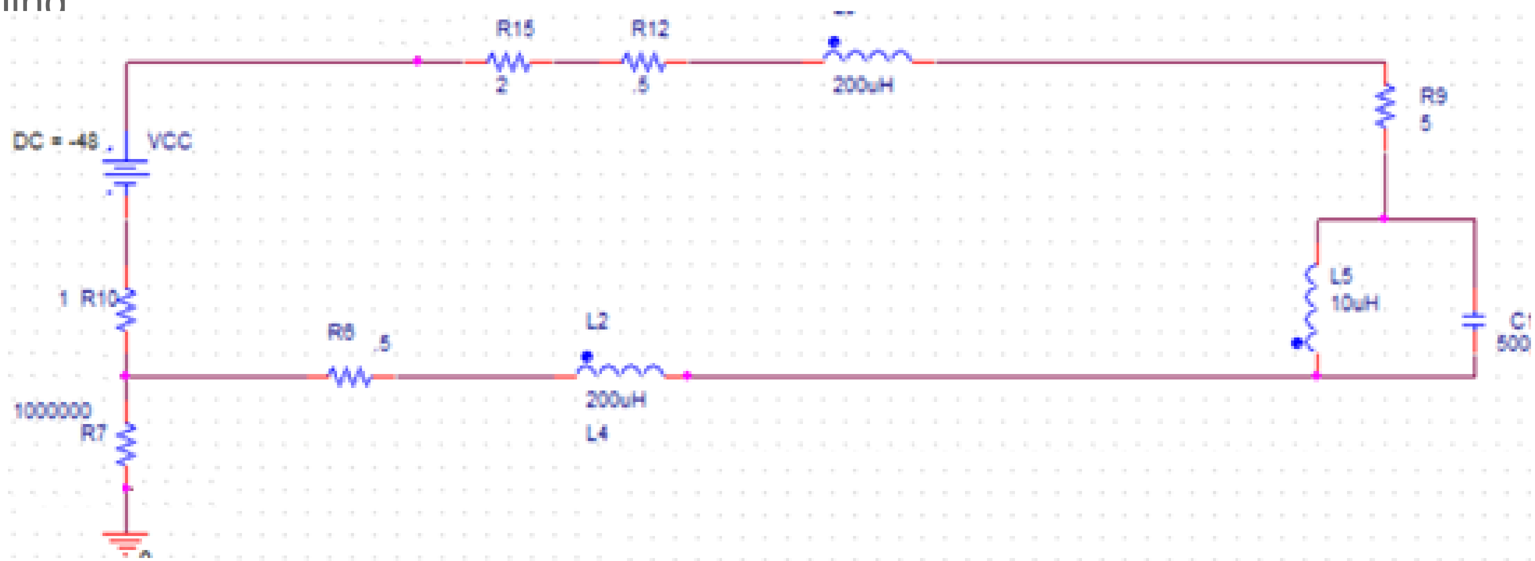




Parameters

Table of Parameters Estimations Based on Typical Installations

Cable Inductance – L1, L2, L3, L4 was derived from typical 30m cable runs for 4awg
Cable Resistance – R3, R4, R5, R6 was derived from typical 30m cable runs for 4awg
Load Values for R9, L5 and C1 are selected at 5ohms with low parasitic inductance and capacitance.
Ground Resistance R7 is selected at 1Mohm to imply floating ground.
R15 is selected at 2ohms as a substitute for a breaker to allow multiple surge path decoupling



Injection Points

Stimulus Mode

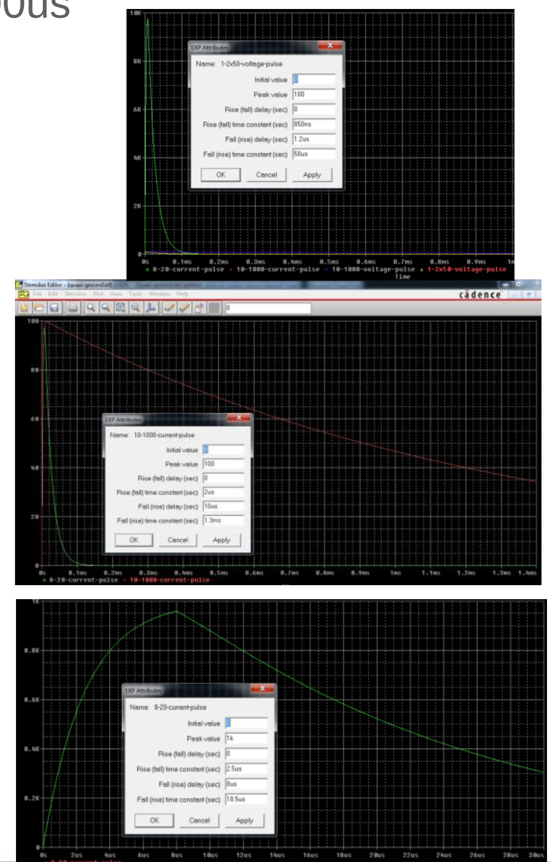
Voltage Source

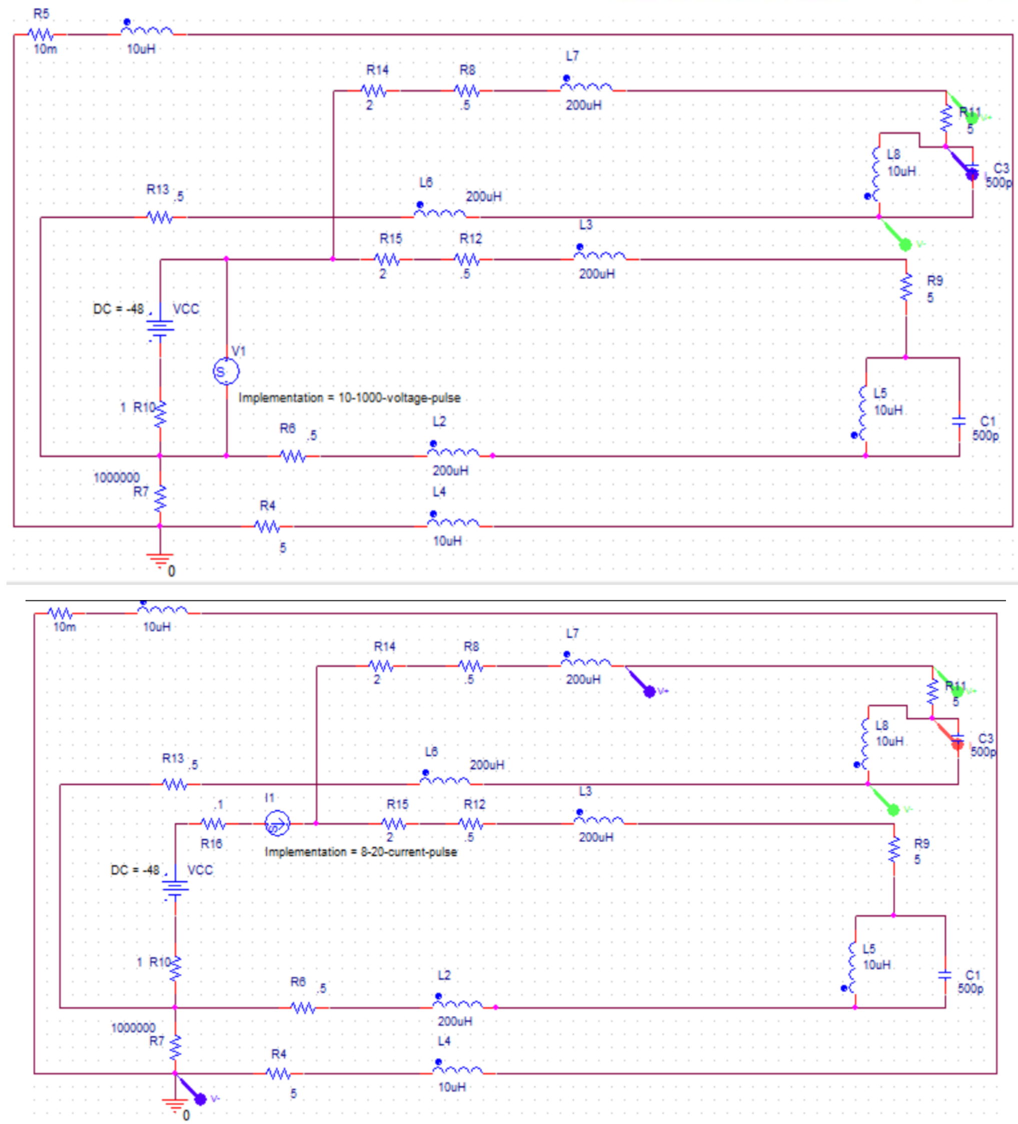
Current Source

1.2 / 50us

10/1000us

8/20us

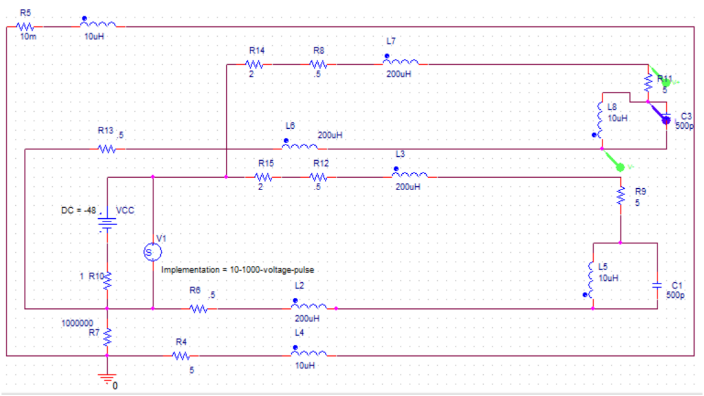


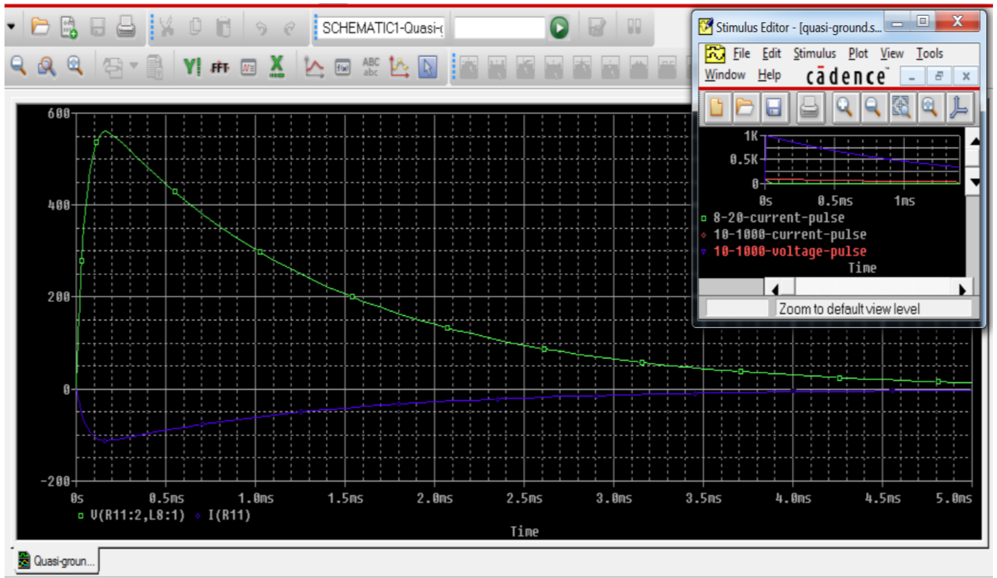


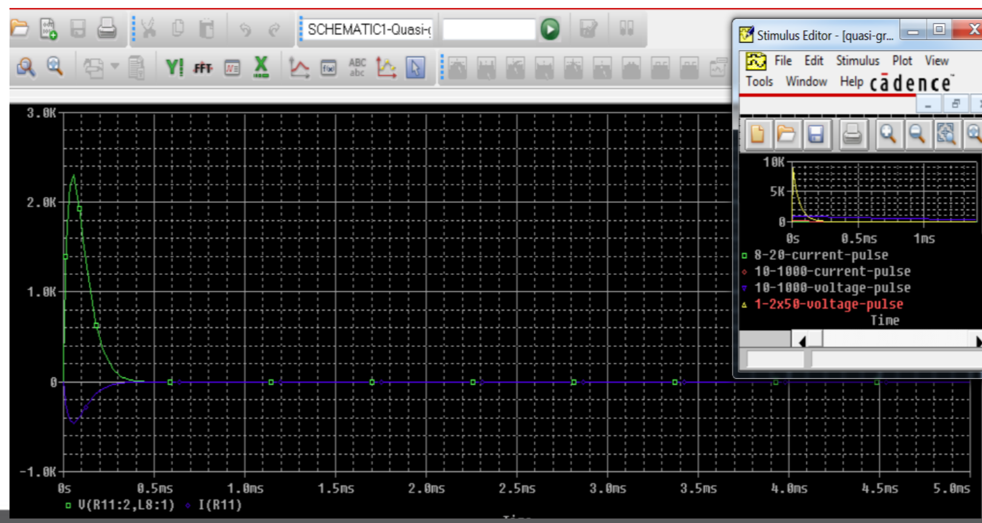
smiths power

Simulation Results – Voltage Source

Peak levels







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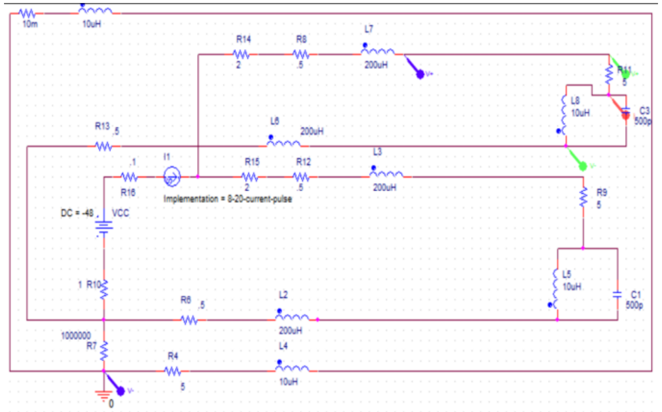
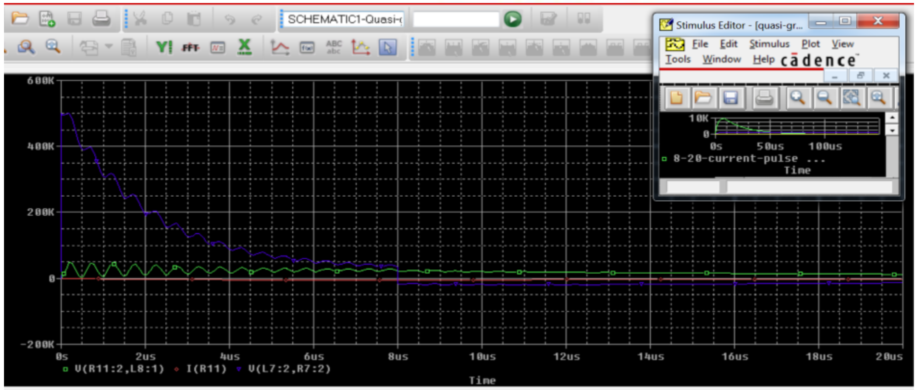
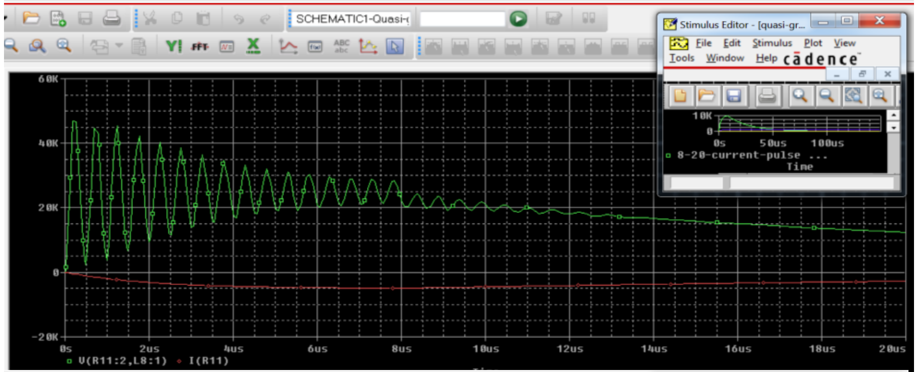
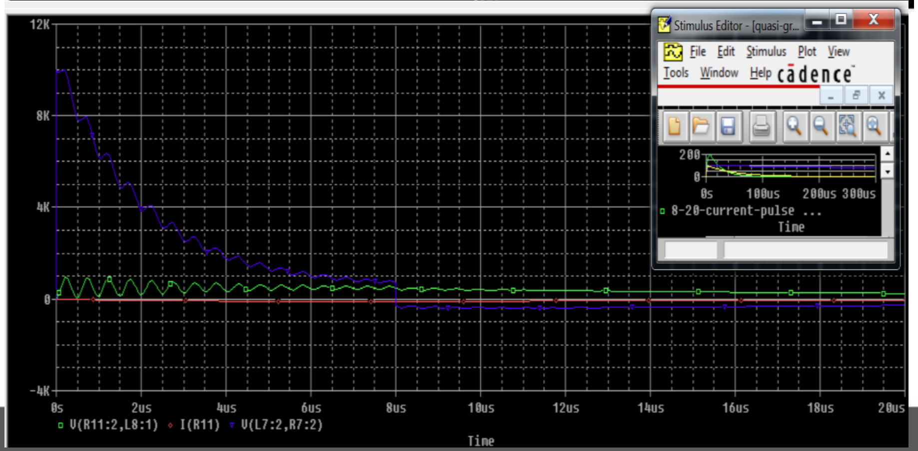
Simulation Results – Current Source

Peak and Moderate

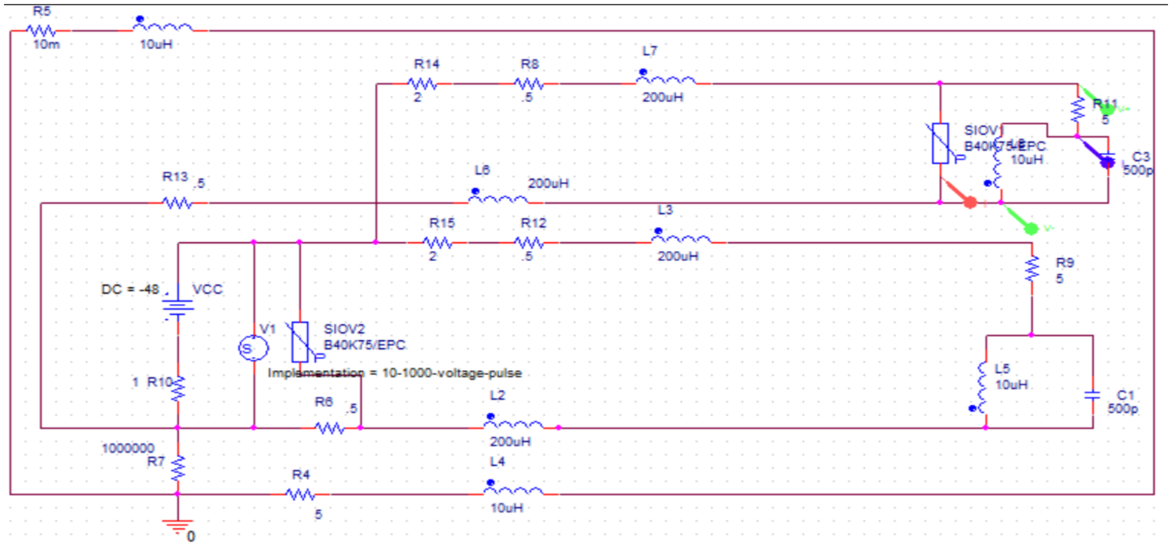


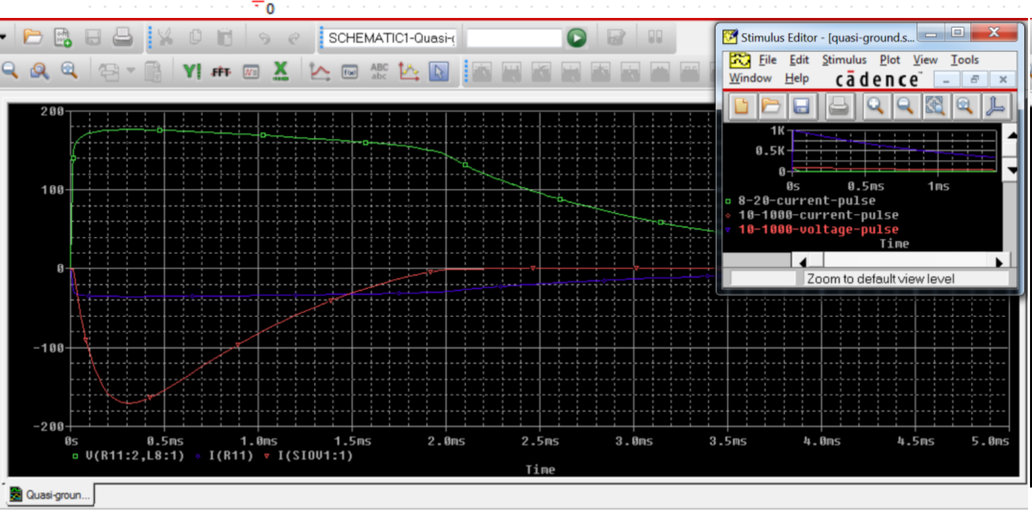


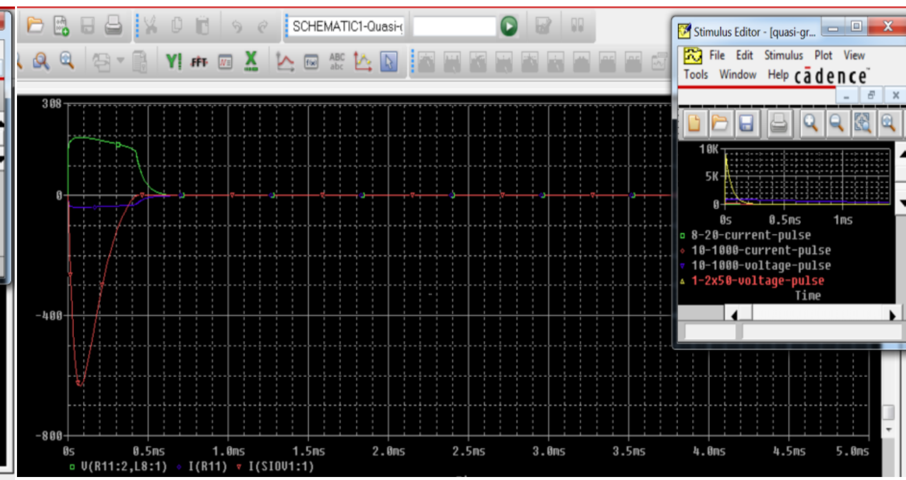




Remedial Options and Mitigation – Voltage Source







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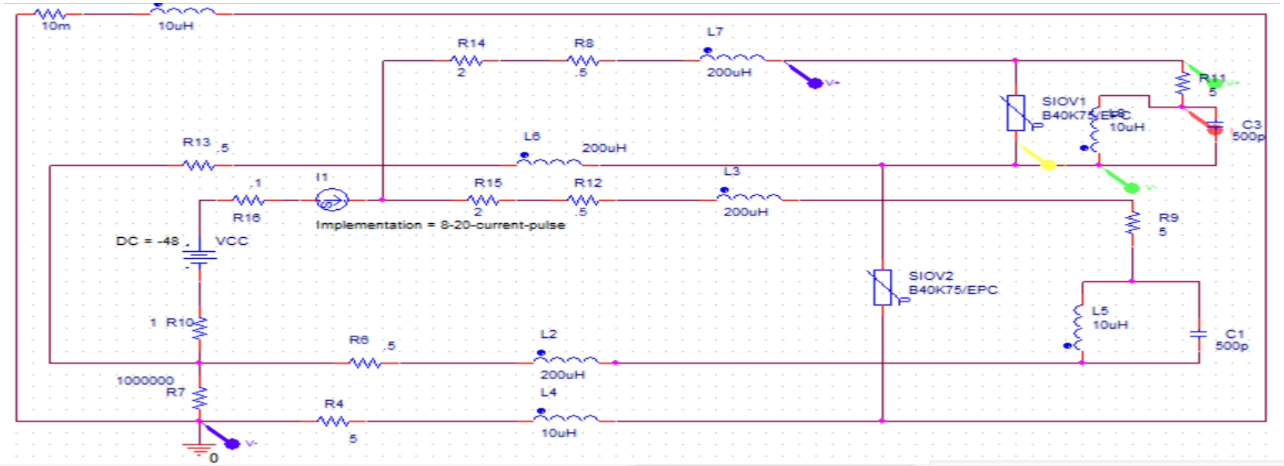
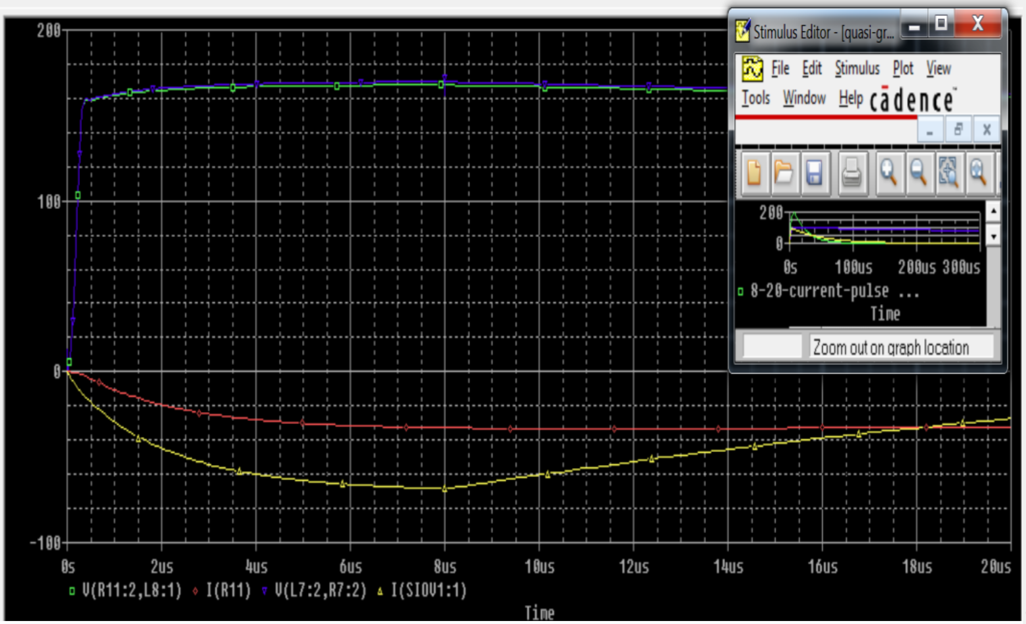
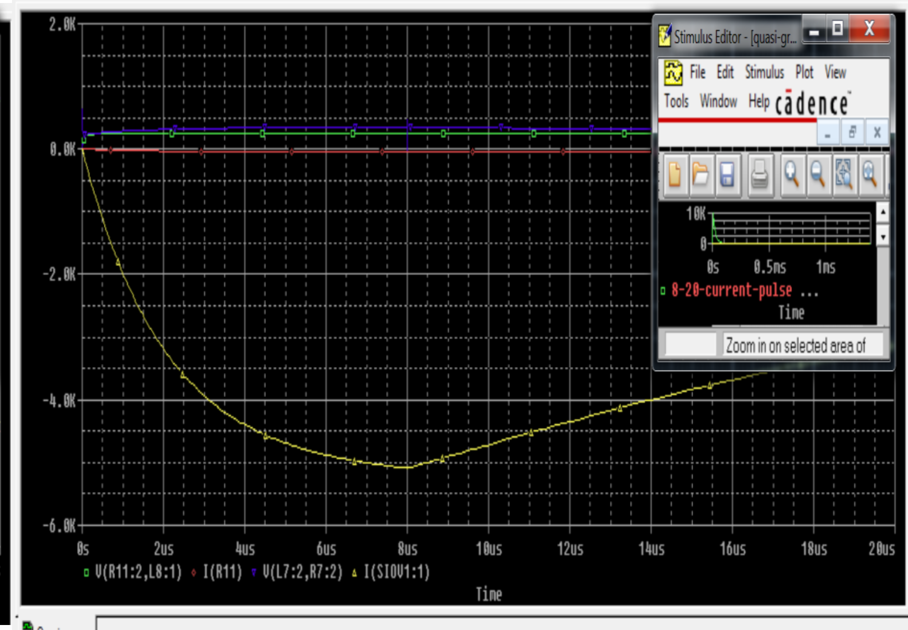
Remedial Options and Mitigation – Current Source







P-Spice Simulation Results

IEEE/IEC reference	surge volts	surge amps	Waveform	Simulation Peak Value Load	Simulation Peak Value to Ground	With Epcos B40K75
IEEE C62.41		**10kA**	8/20us	**47kV**	**500kV**	350V
		200A	8/20us	1kV	10kV	160V
IEEE C62.41	10kV		1.2 / 50us	2.3kV		200V
GR 1089	1kV		10/1000us	560V		175V
	500V		10/1000us	380V		155V

Summary

If an electrical system is not grounded, the electrical network can seek to create path to equalize transient energy. This quasi-ground connection is like a bond.

Voltage source stimulus and low-level current source stimulus results are consistent to a reasonable level across different wave forms.

Simulation results indicate exceptionally high induced voltage conditions when subjected current injection levels over 200Amps 8/20us.

In particular the 8/20us 10kAmp injection provokes over 40kV across the victim load, which would could cause dielectric faults.

Surge protection measures could control this, by applying SPD’s across the victim load, and relative to Ground

Additional P-Spice simulation and suitable test experimentation with “real world” setup is encouraged to reconcile exceptional high common mode surge voltages.

Bibliography

Cadence Orcad Capture CIS 16.2 p001 with Pspice A/D Simulation Software

General Cable Handbook, 2nd edition, Table 11 Wire resistance and Reactance Values

IEEE Std C62.41.2TM-2002 Surge Waveforms

GR-1089 CORE Table 4.2 First Level Lightning Waveforms

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