Ground or Not to Ground
Ethernet Protection
(Part 2)

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Presented at
Protection Engineers Group 2013

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Ground or Not to Ground Ethernet Protection

This presentation builds on the material presented last year at this forum. Some attendees during question period had suggested we do some additional testing on the Ethernet protection and present here in the PEG conference 2013

So the question still stands “Ground or Not Ground the Ethernet Surge Protection”. Data presented in the last year’s presentation even though not comprehensive, did point to necessity of grounding Ethernet protection circuits.

During the past year we have conducted a number of surge tests with additional Network Interface Cards as well as Surge protection circuits.

A brief review of last year presentation will not be out of place to start this presentation for the sake of continuity of the topic.

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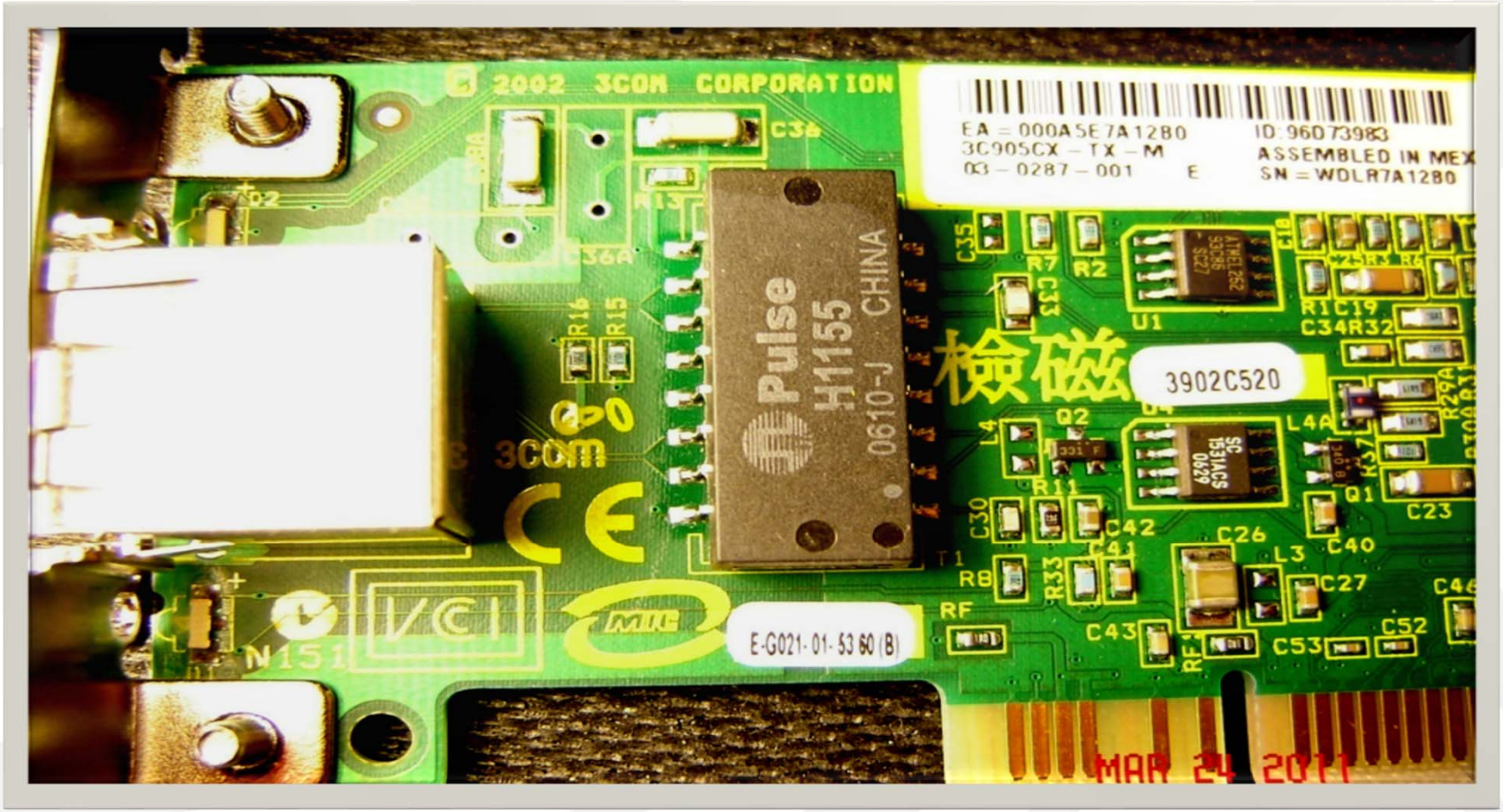
Typical NIC Card Ethernet Port – Network Side



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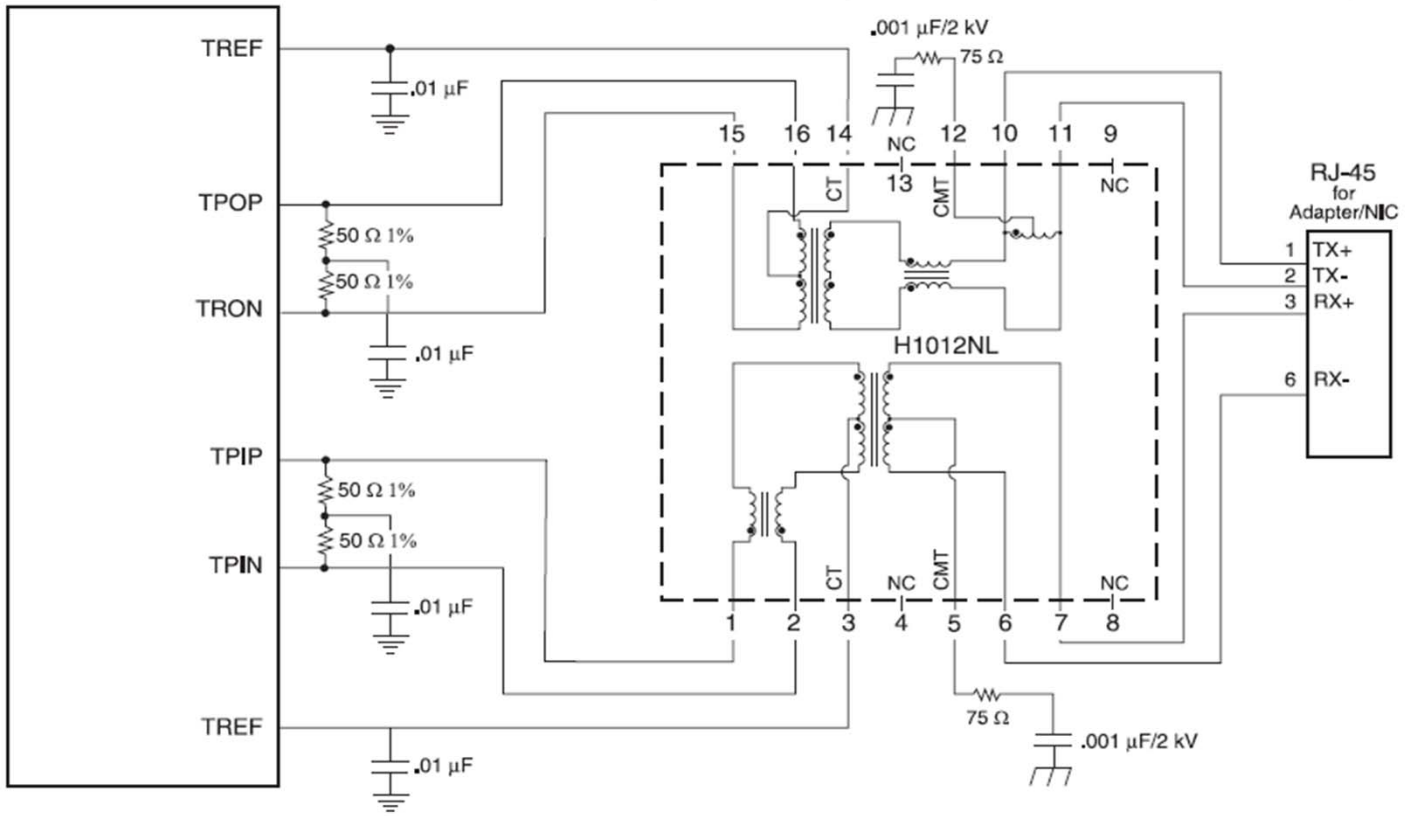
NIC Card Front End Interface with RJ 45



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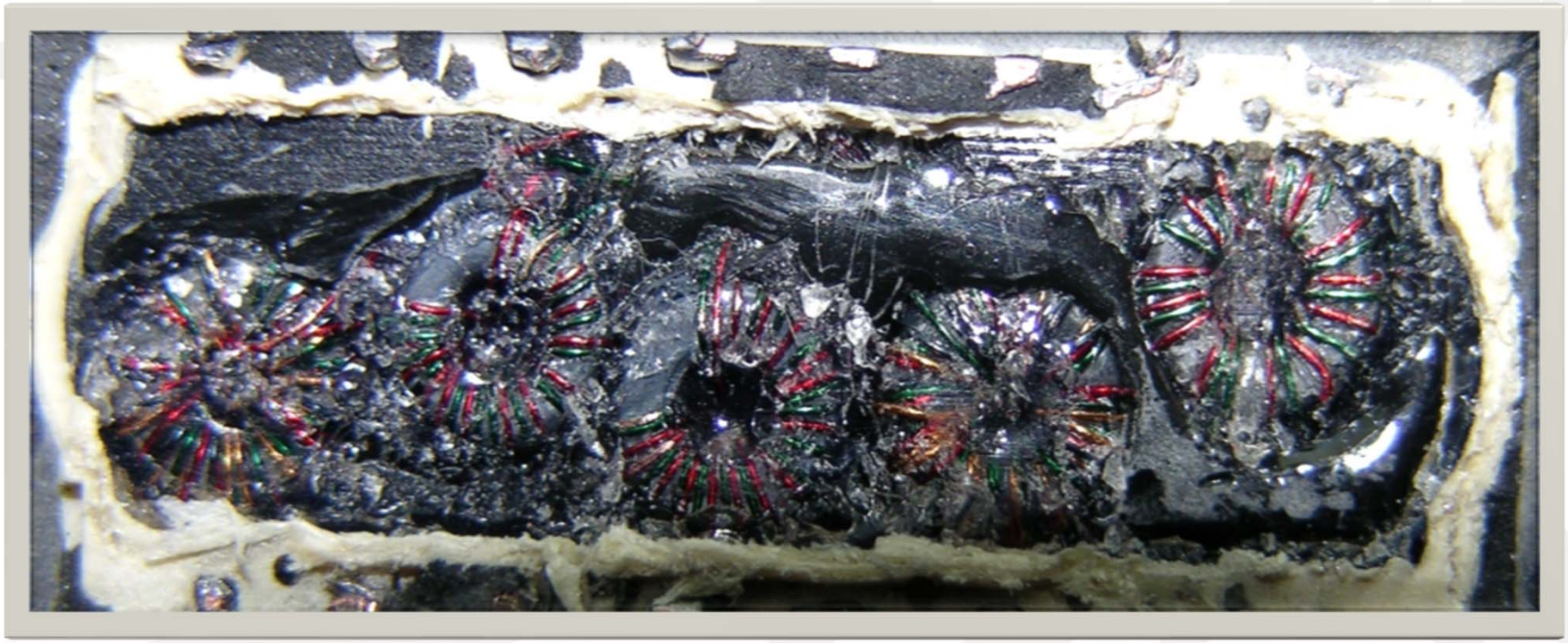
Ethernet Port – Magnetics Dissected



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Essentials for Surge Protection Evaluation

Following were considered necessary for Lab Evaluation of Ethernet Surge Protection

1. Computer Network to Verify operation of NIC cards

2. Means of inducing balanced Surges

3. Surge Generator with high enough Surge Energy and Voltage capability

4. Surge application fixture for NIC card

5. Means of measuring and recording surge events

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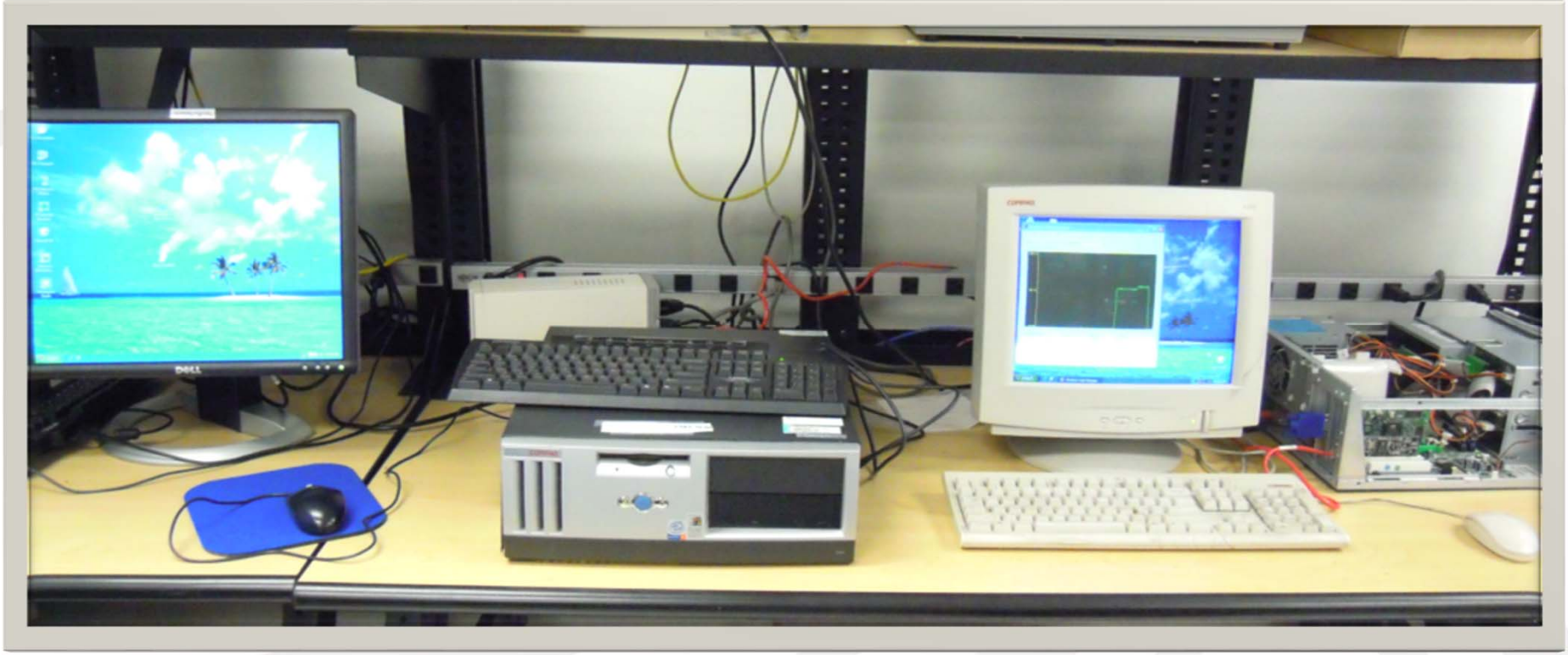
Computer Network to Verify Operation of NIC Cards



Transferring data files from one computer to another computer. Monitoring the file transfer with windows task manager. Computer # 2 opened up for NIC card insert / remove capability.

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NIC Card Installed in Computer # 2

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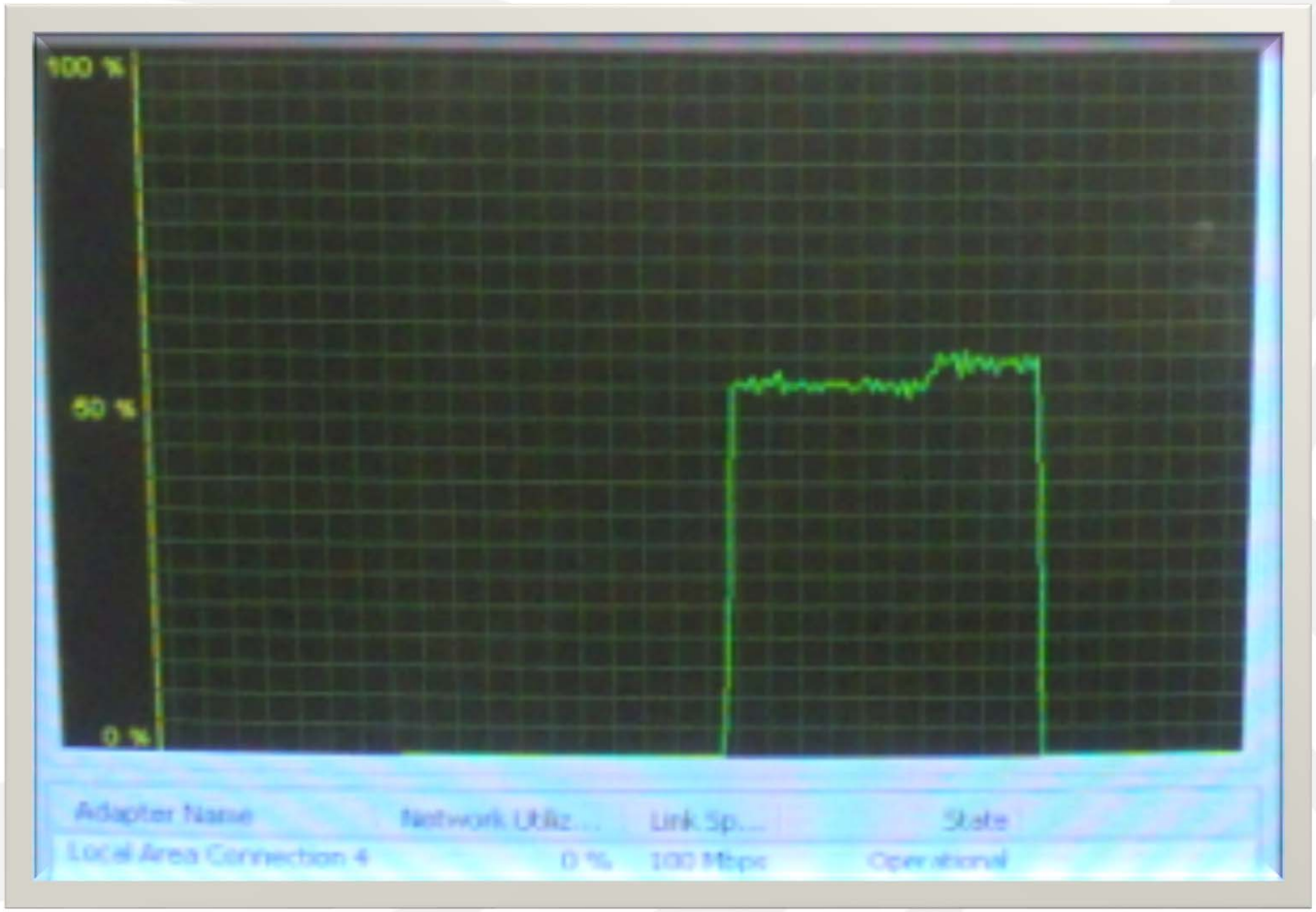
Windows Task Manager on Computer # 2



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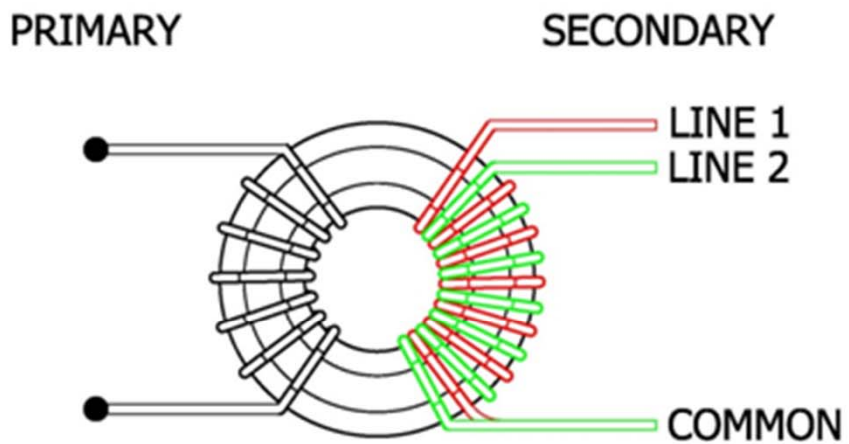
Means of Inducing Balanced Surges



TOROID

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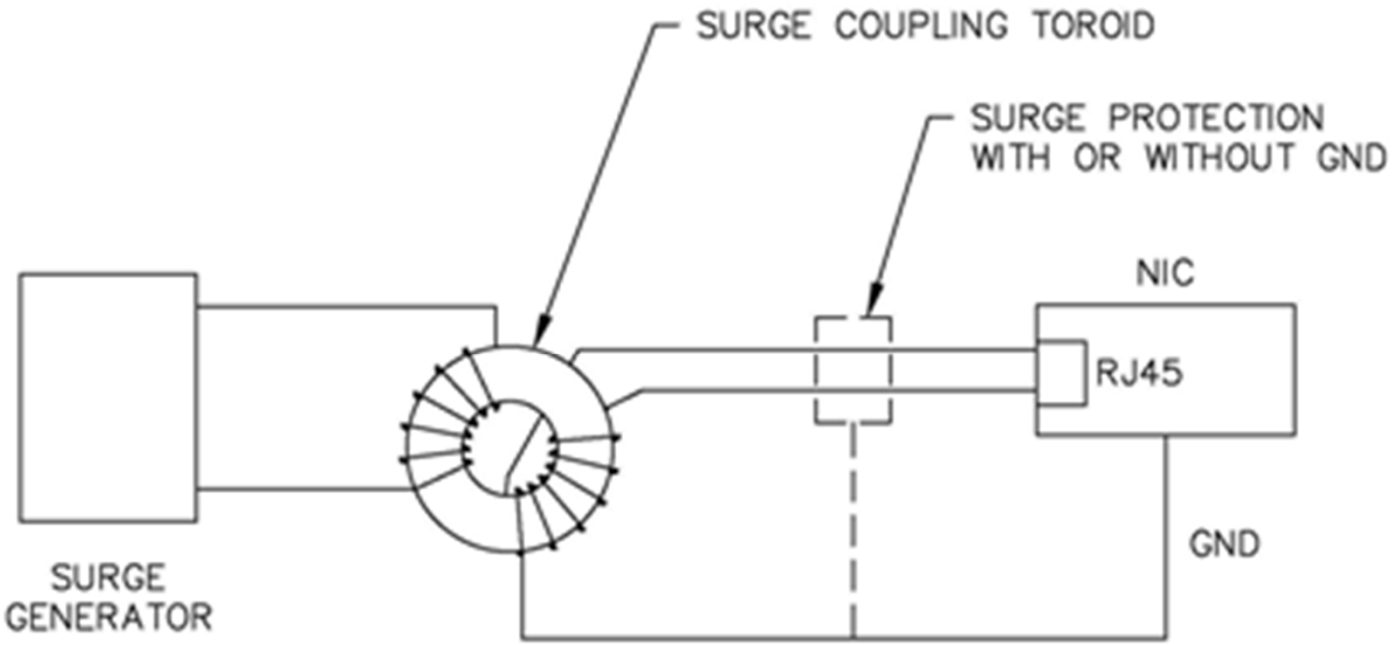
Surge Test Set-up



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6kV 8/20 uS Surge Generator KeyTek 711

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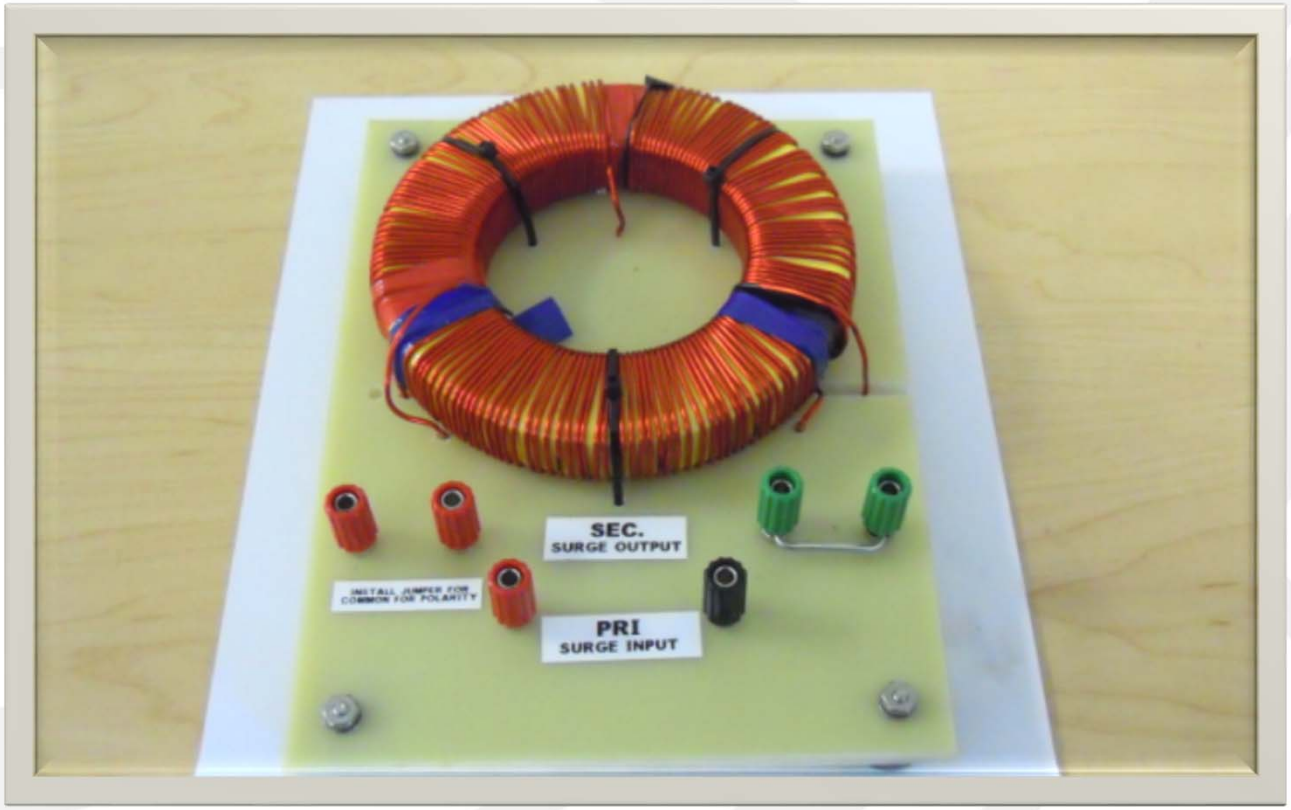
Means of Inducing Balanced Surges a Toriodal Transformer



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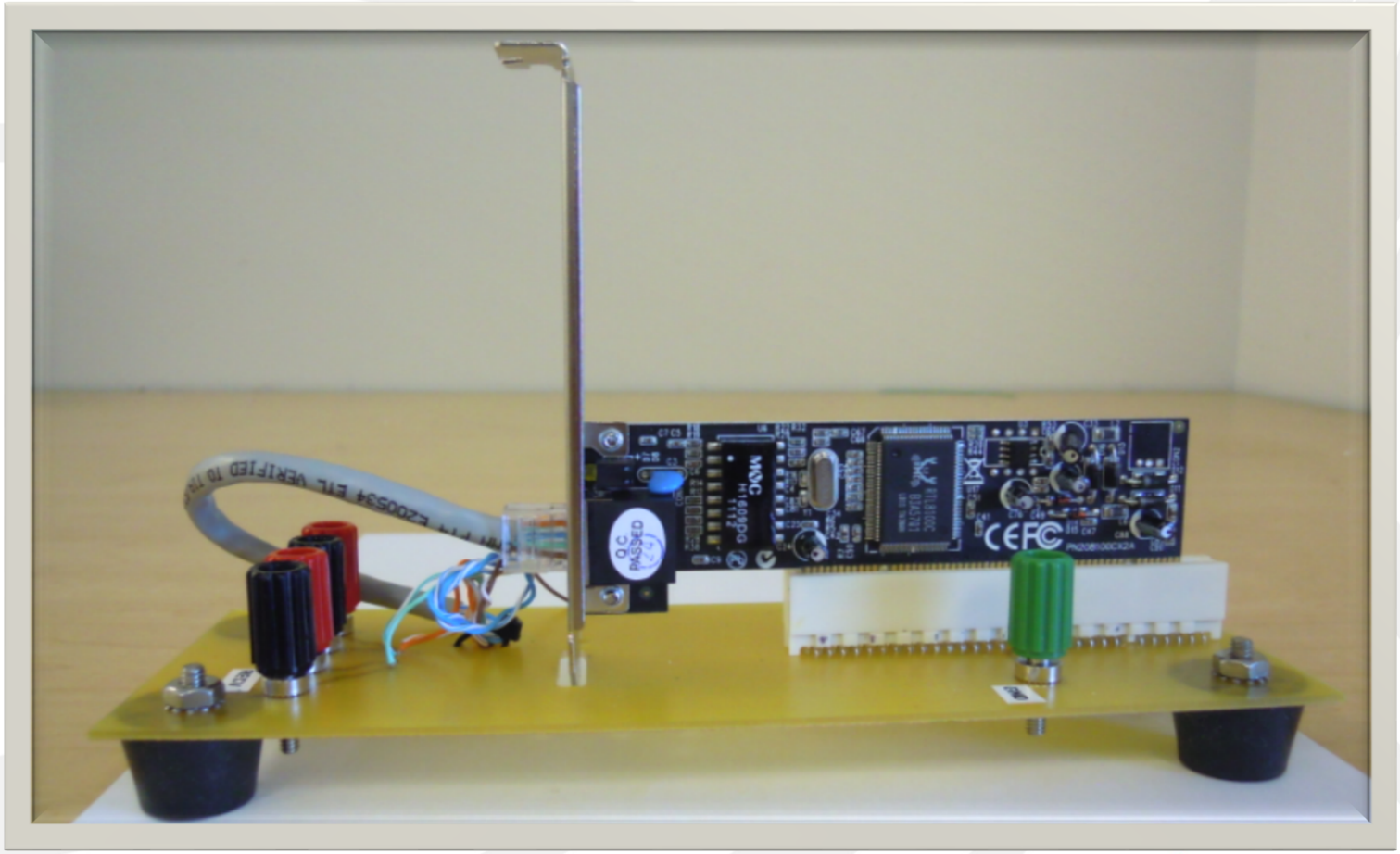
Adapter Board for NIC Card Surge Application



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Current Loop for Measuring Surge Current

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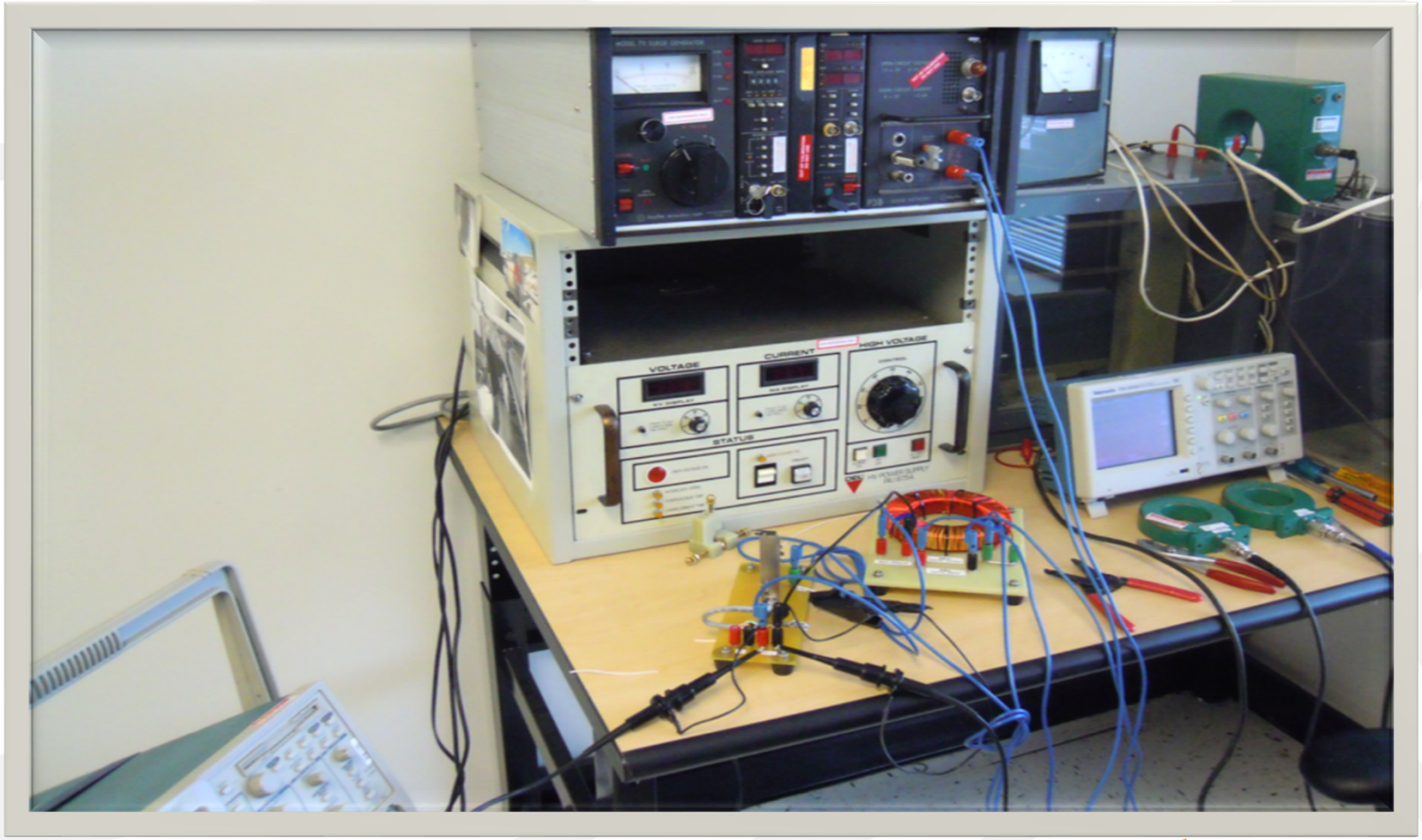
Complete Surge Testing Setup



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Surge Voltage Values vs Damage to NIC

Surge Voltages from 700 to 6000 volts were applied to the NIC cards and monitored with a scope.

Voltages in excess of 3500 volts were able to cause damage to the NIC cards

Voltages in excess of 5000 Volts caused enough damage that the NIC card stopped to connect to the network

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Conclusions to Part 1

NIC card have pretty good Isolation levels, surges up to 3500 volts did not show any damage.
Protection Circuits without ground provided partial protection, some boards continued to function even with some damage on the boards.
Protection Circuit with ground provided complete protection to the maximum level of surges available during this evaluation.
If you need good protection, the answer to question: **Ground or Not to Ground Ethernet protection** is

Ground Ethernet Protection

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Ethernet Protection
(Part 2)

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Objectives for Ethernet Protection Part 2

1. Investigate surge survival of NIC cards from various manufacturers.

2. Test additional Ethernet surge protection circuits taking into consideration of Power over Ethernet.

3. Analyze and compare transmission characteristics of the Ethernet surge protection circuits.

4. Conclusions

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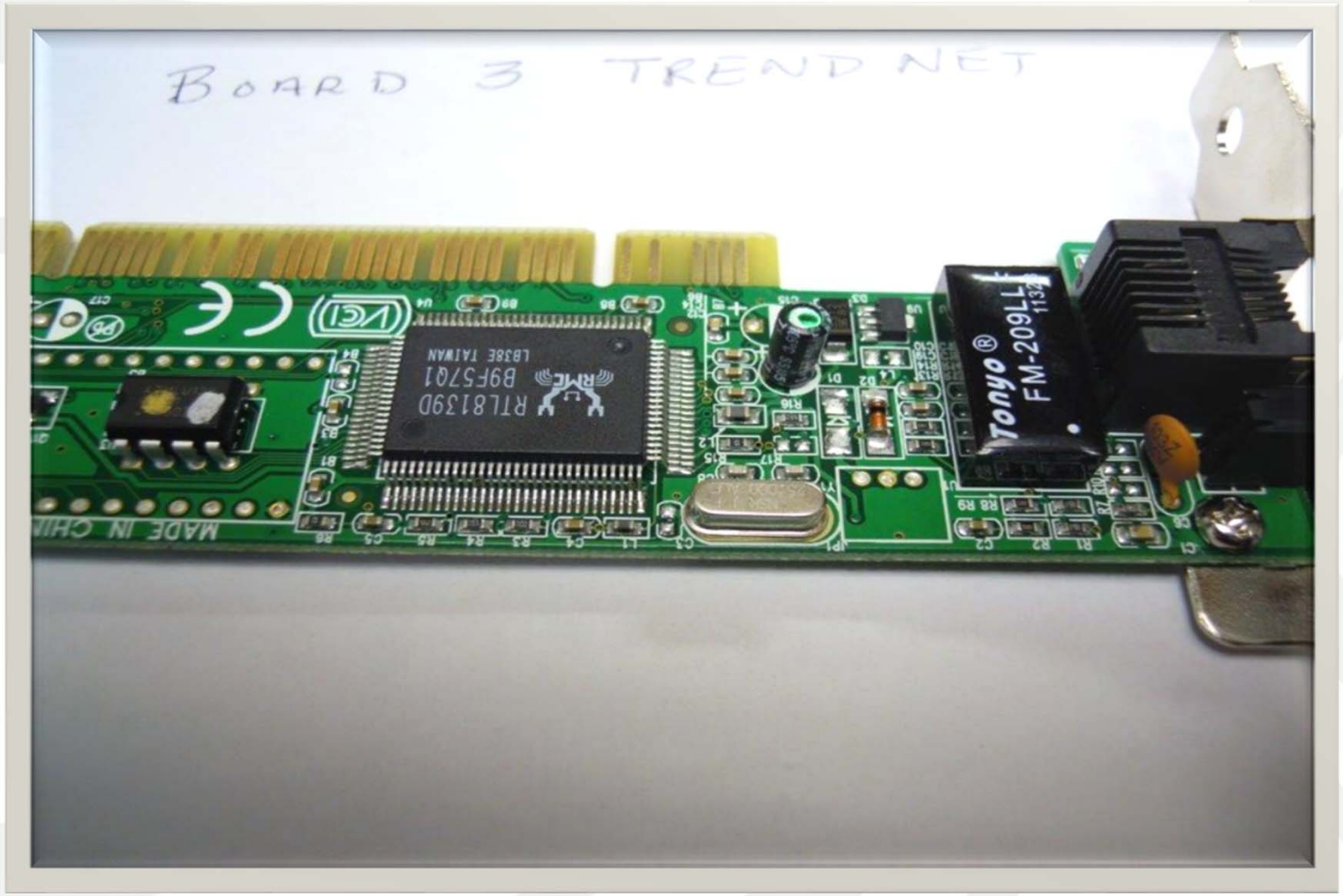

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Surge Testing Results of Various NIC Cards

Board (1) LINKSYS No protection

Surged from 3.5KV to 6KV, Board showed damage at 3.5KV but operated fully to 5.5KV. At 6KV the board although operating, Data transmission was compromised and data transfer speed was decreased.

Board (2) INTEL No protection

Board showed damage at 3.5KV components damaged. Board stopped operating at 5KV.

Board (3)TRENDNET No protection surged 3.5KV to 4KV

Board showed physical damage at 4KV and stopped operating at 4KV.

Board (4) D-LINK No protection surged from 3KV to 6KV

Board showed no damage and operated fully.

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Surge Protection Circuits Used

Circuit 1:
Consisted of two three electrode GDT protection. The GDTs selected had nominal breakdown voltage of 500 volts.

Circuit 2:
Consisted of two steering diode bridges with 12 volt bidirectional avalanche diodes, two 90 volts GDTs from pair 1 to pair 2 of the Ethernet circuit and two three electrode GDTs for surges referenced to Ground.

Circuit 3:
Comprised of steering diode bridges with two 24 volt bipolar avalanche diodes and one 3 electrode GDT of 500 volts nominal breakdown, with center electrode connected to ground.

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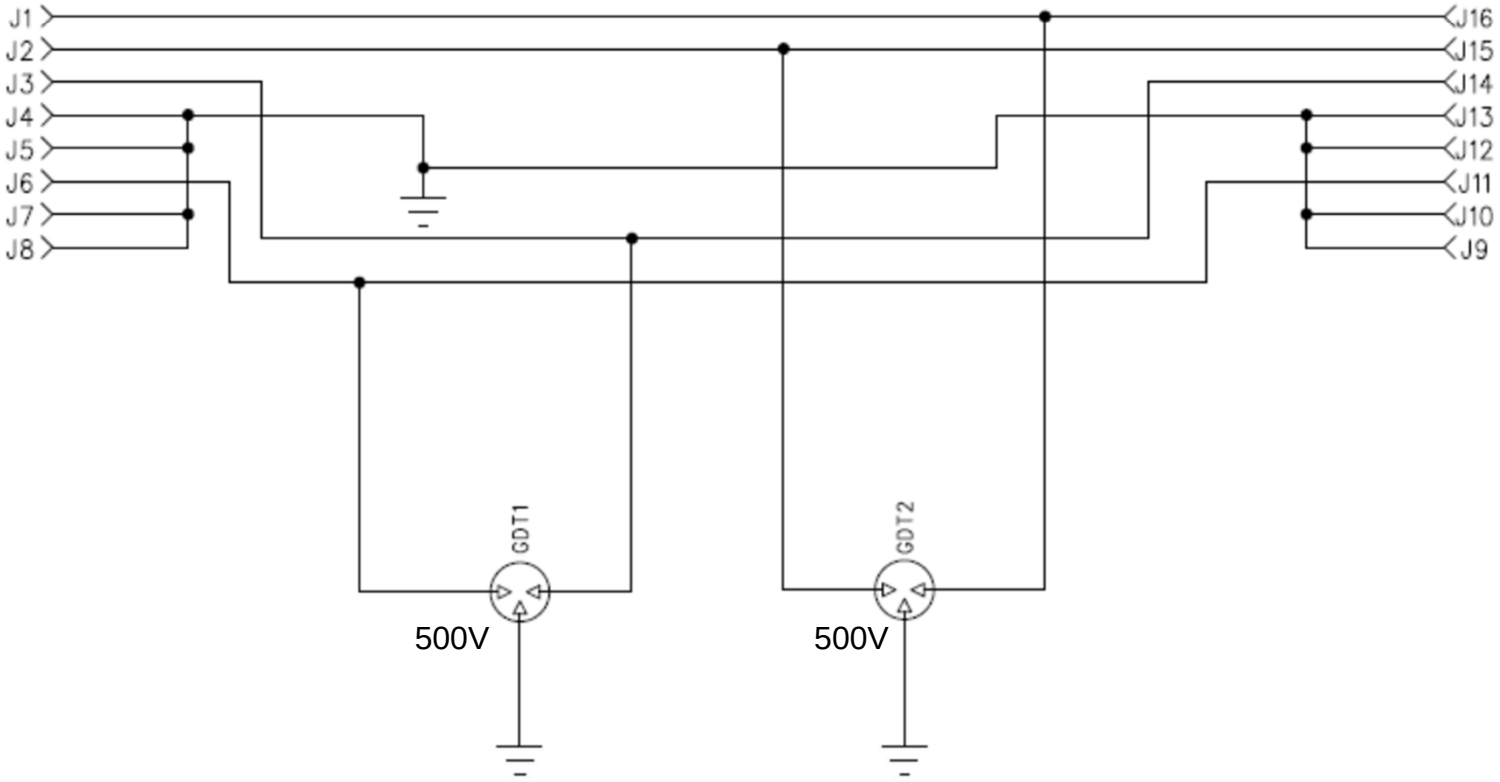
Circuit # 1



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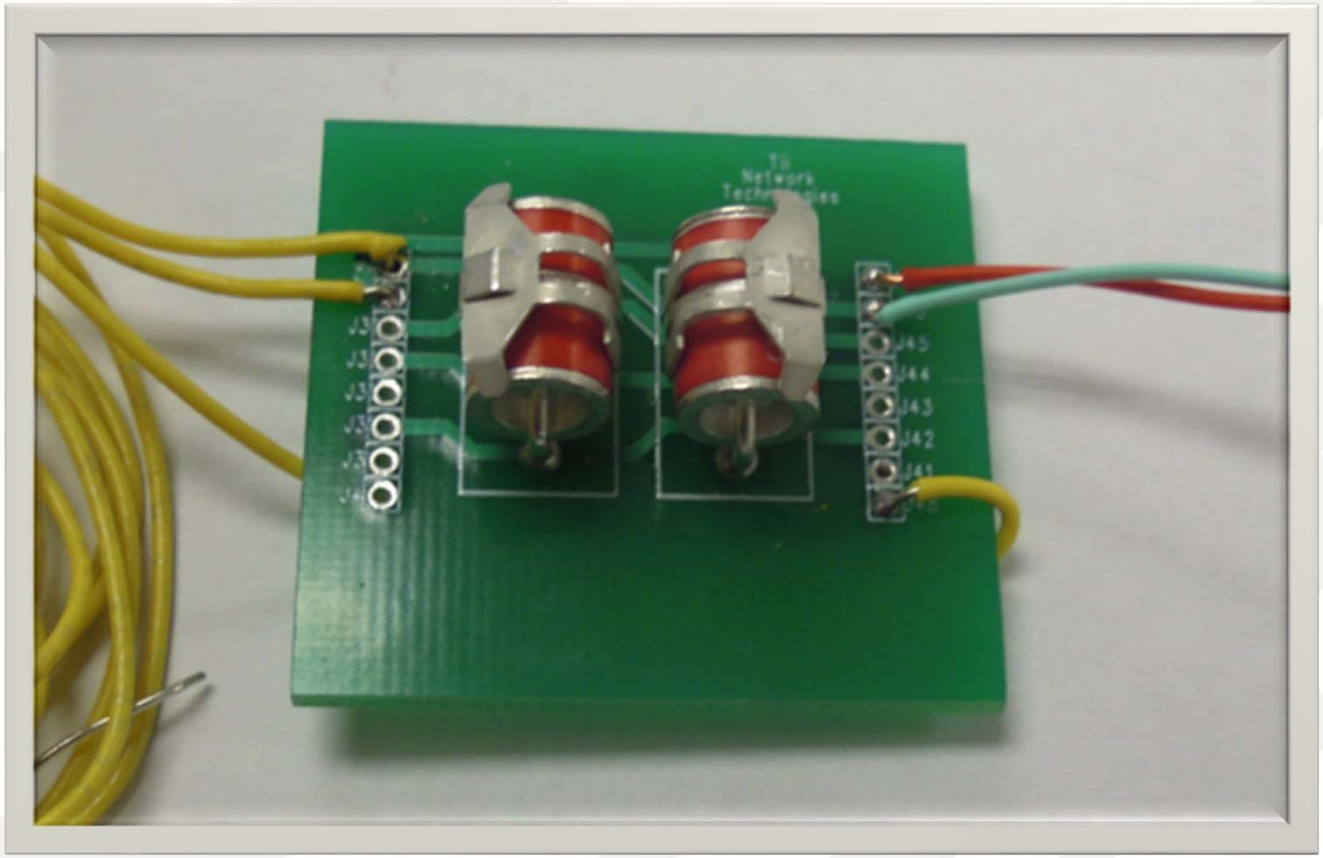
Circuit # 1Test Board



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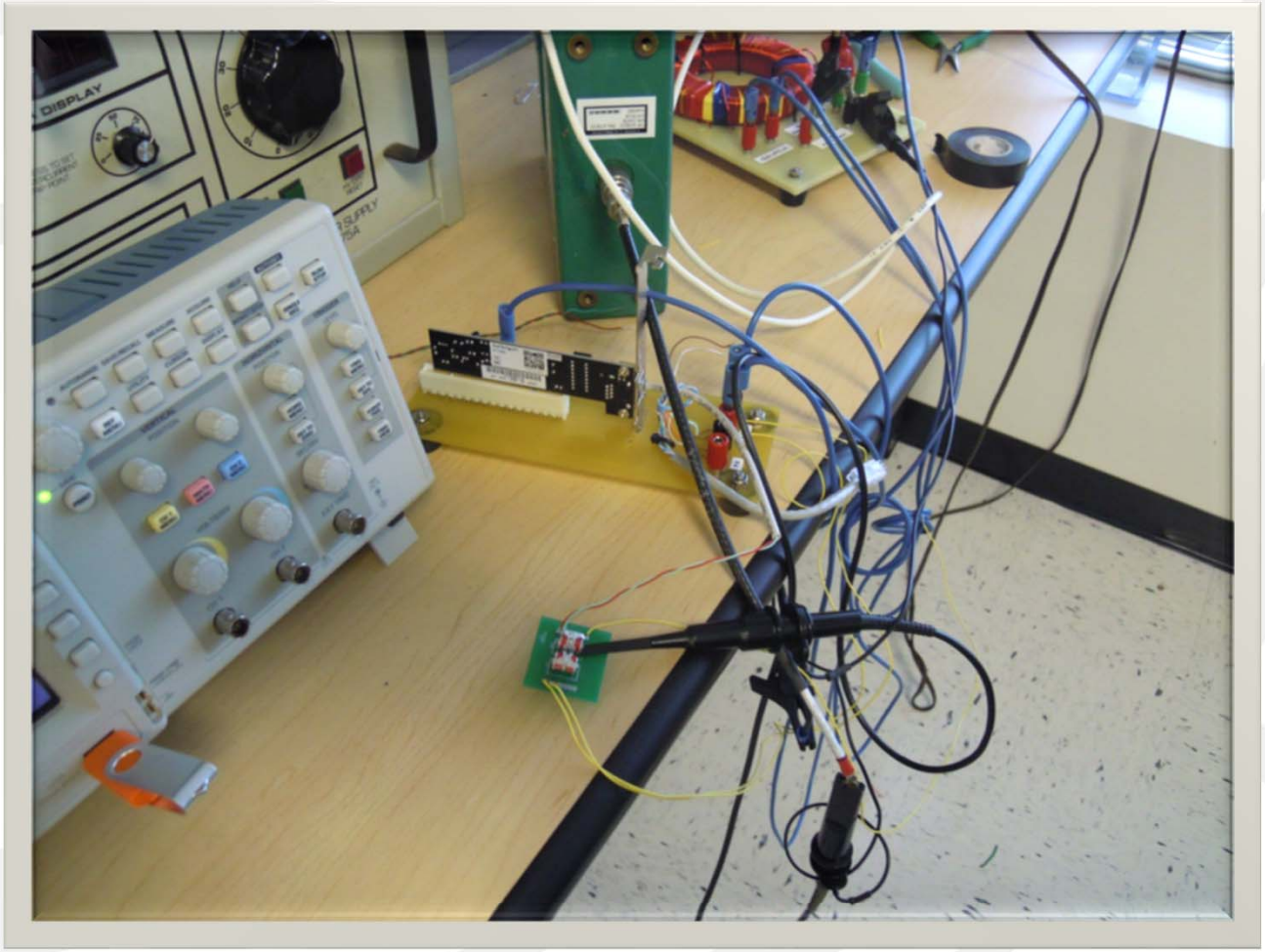
Circuit # 1Test Configuration



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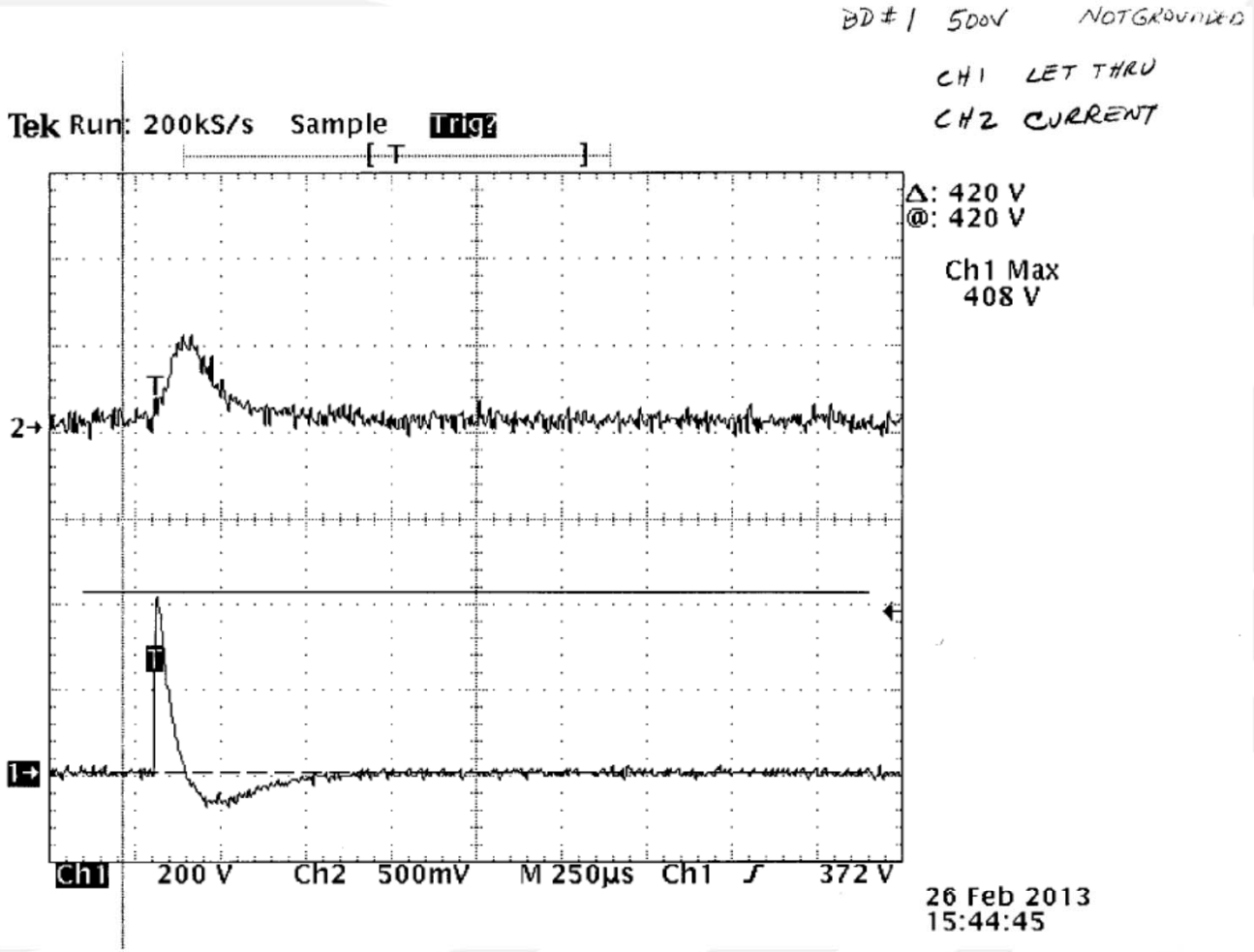
Surge Waveform – 500V without GND



Ch2: 1V = 100 Amp

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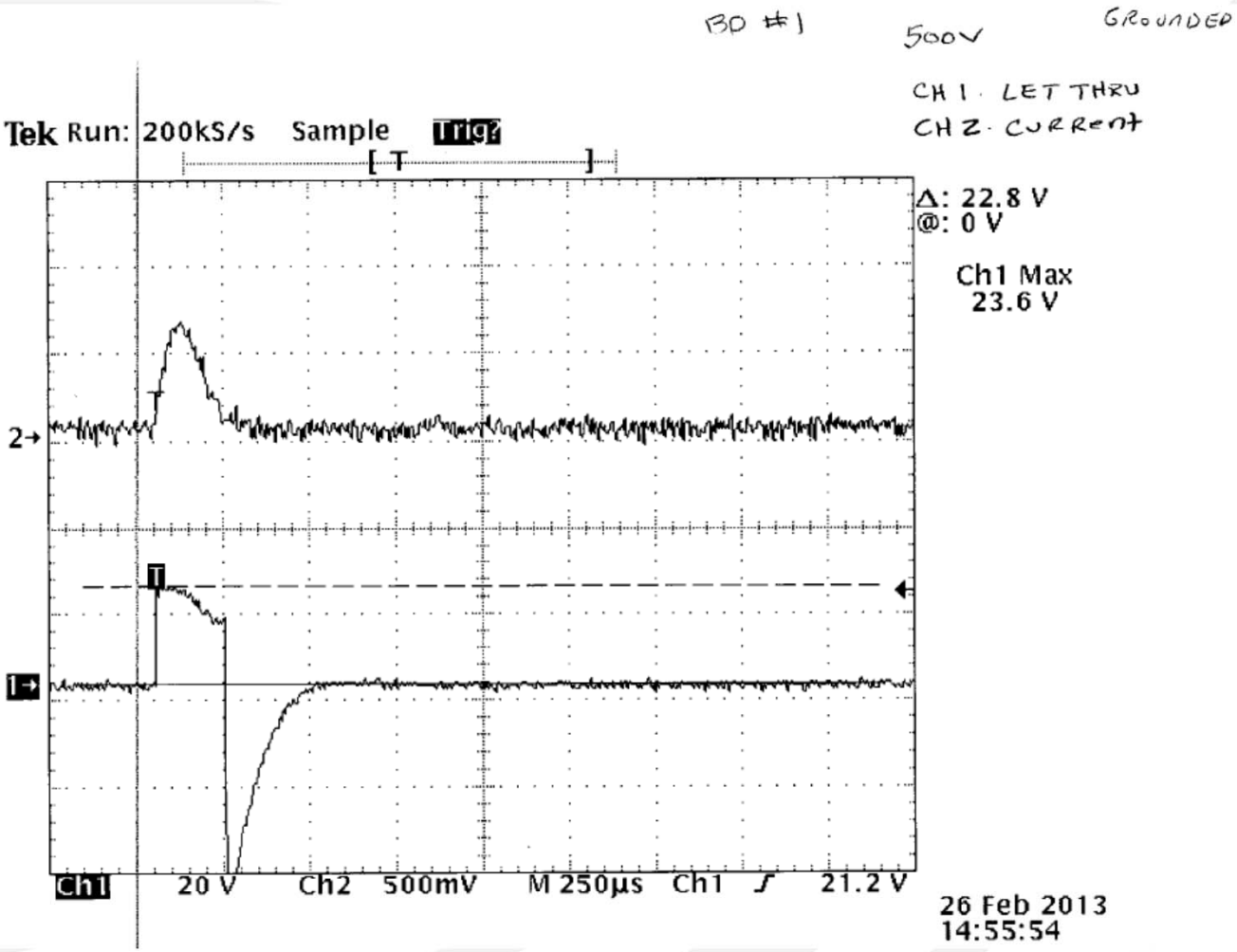
Surge Waveform – 500V with GND



Ch2: 1V = 100 Amp

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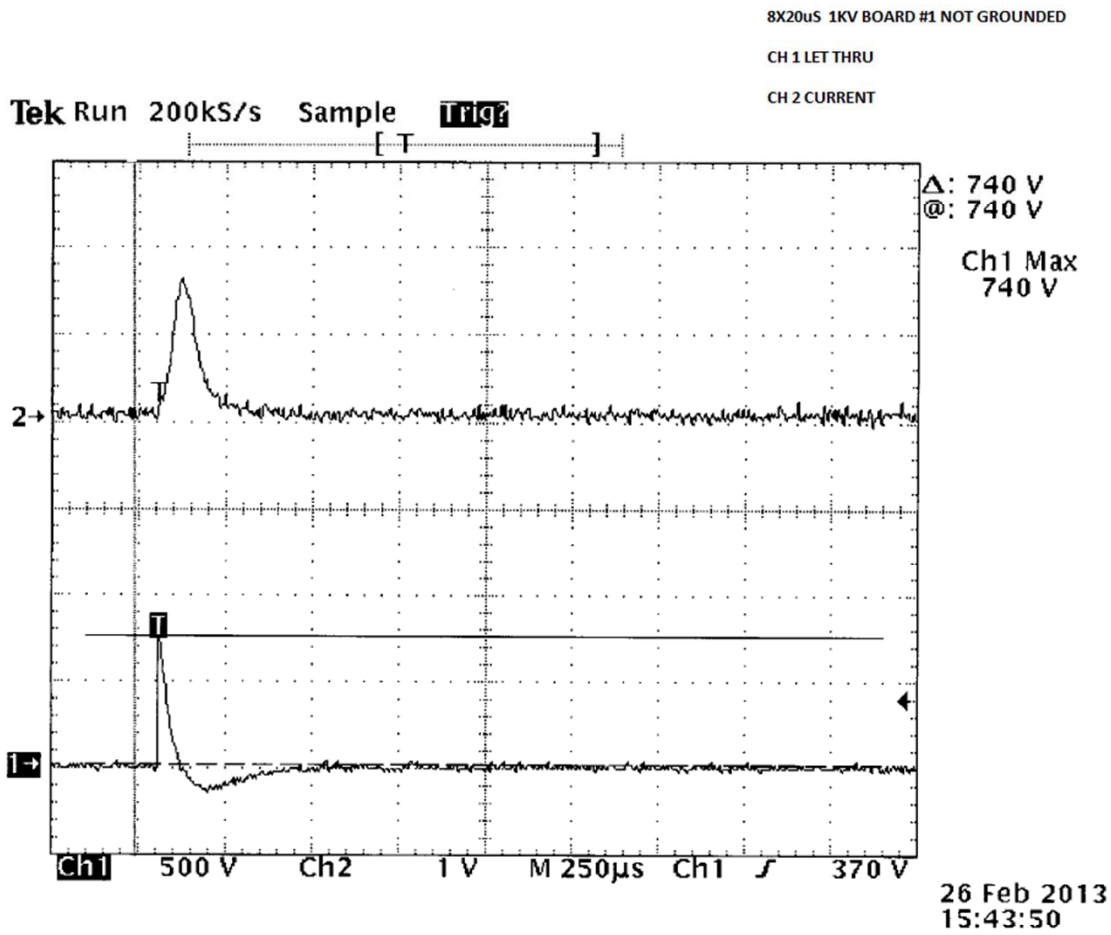
Surge Waveform – 1kV without GND



Ch2: 1V = 100 Amp

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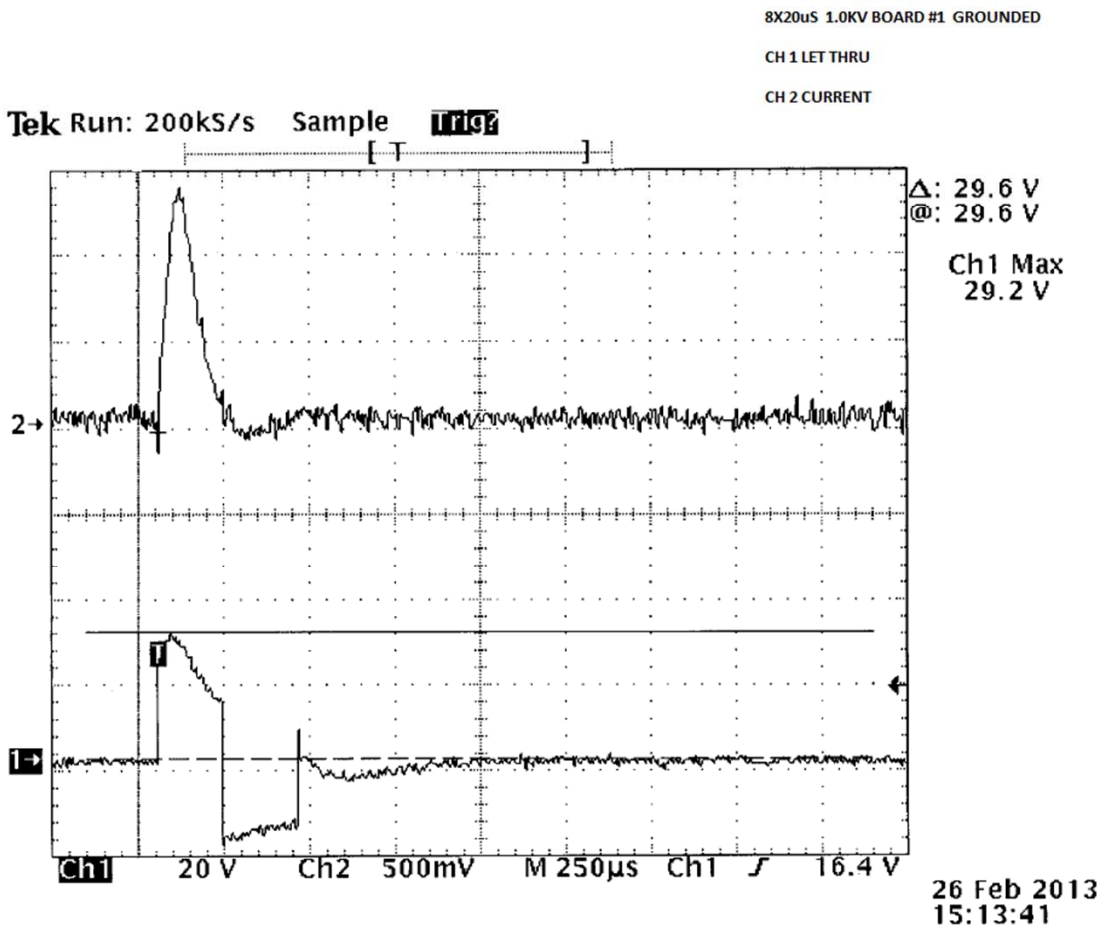
Surge Waveform – 1kV with GND



Ch2: 1V = 100 Amp

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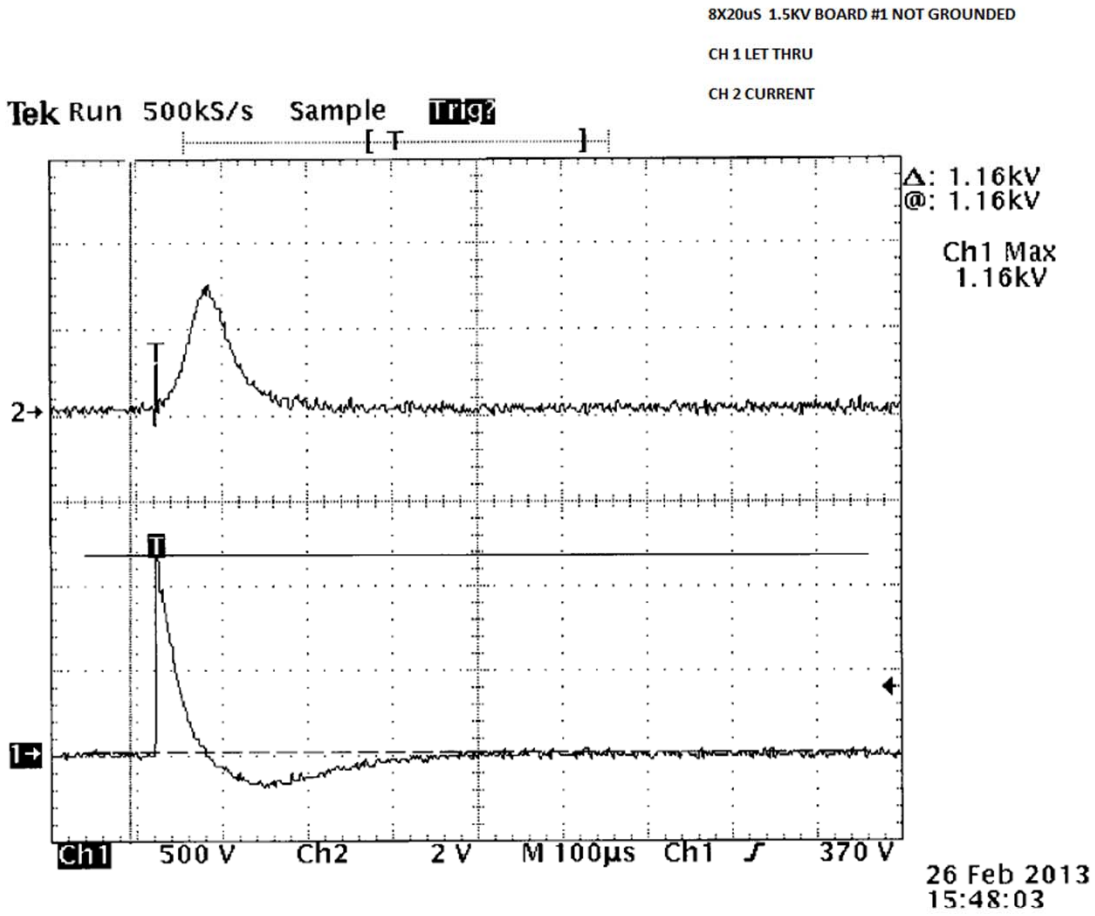
Surge Waveform – 1.5kV without GND



Ch2: 1V = 100 Amp

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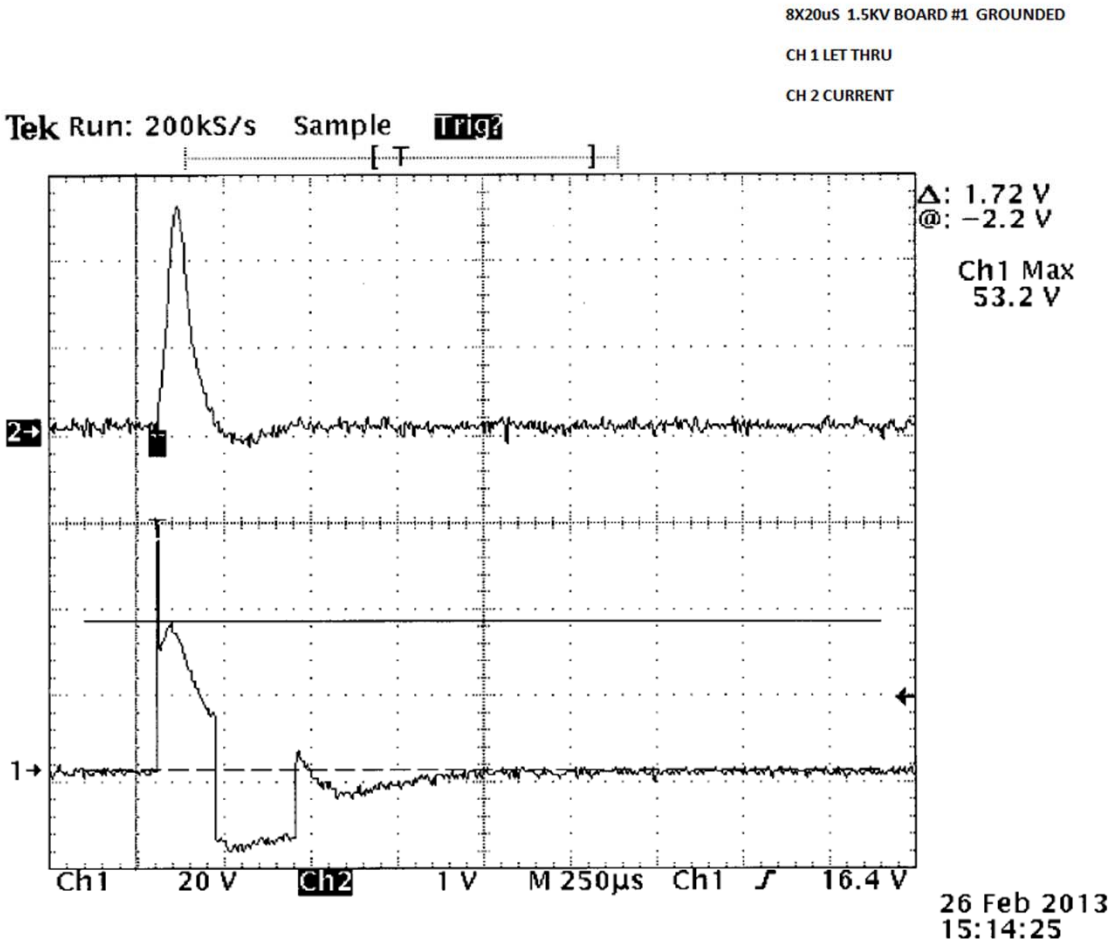
Surge Waveform – 1.5kV with GND



Ch2: 1V = 100 Amp

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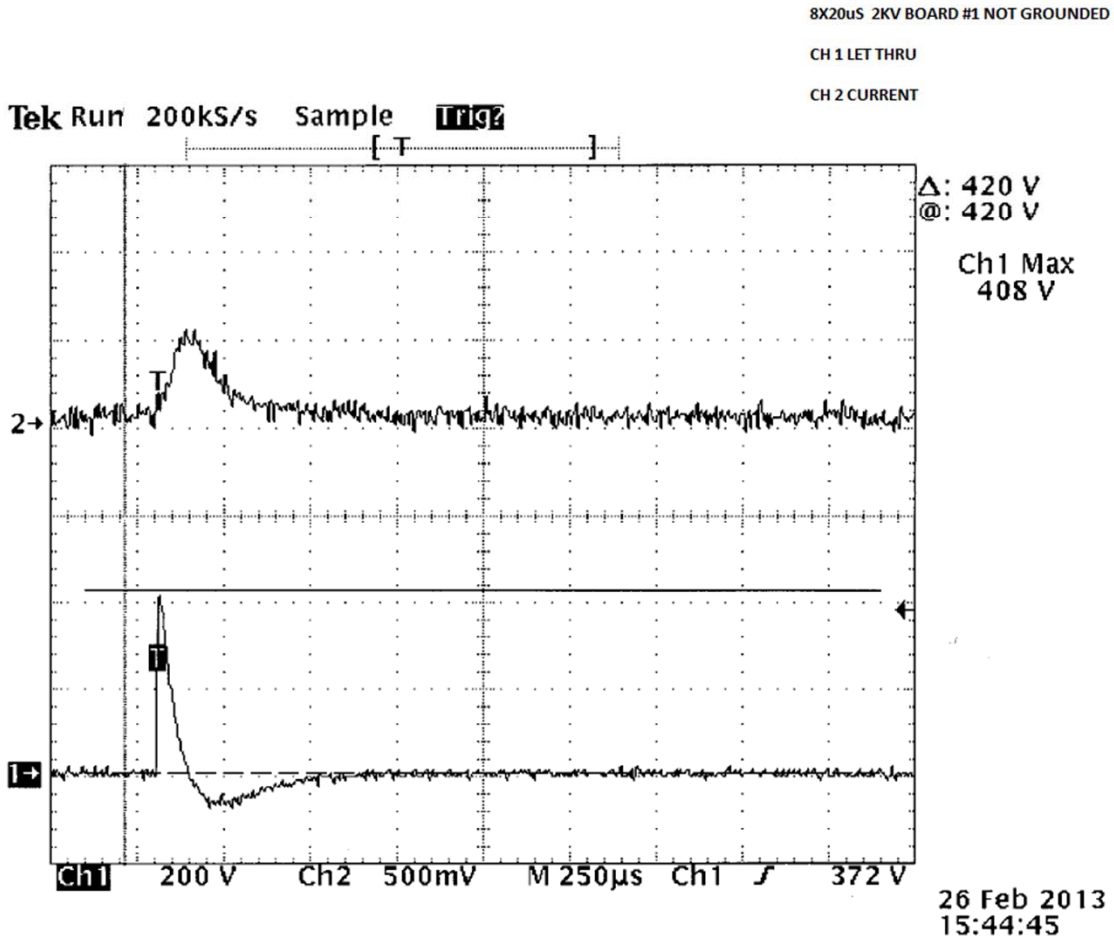
Surge Waveform – 2kV without GND



Ch2: 1V = 100 Amp

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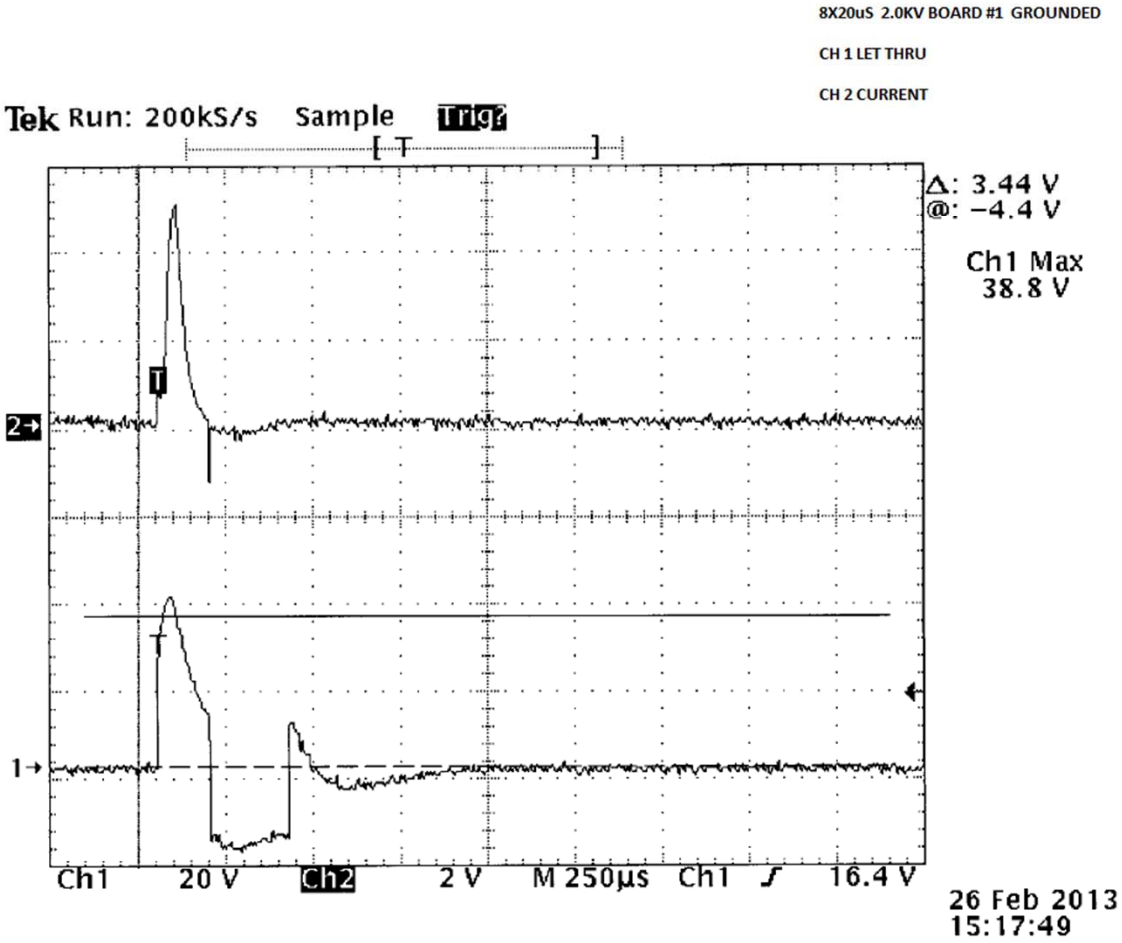
Surge Waveform – 2kV with GND



Ch2: 1V = 100 Amp

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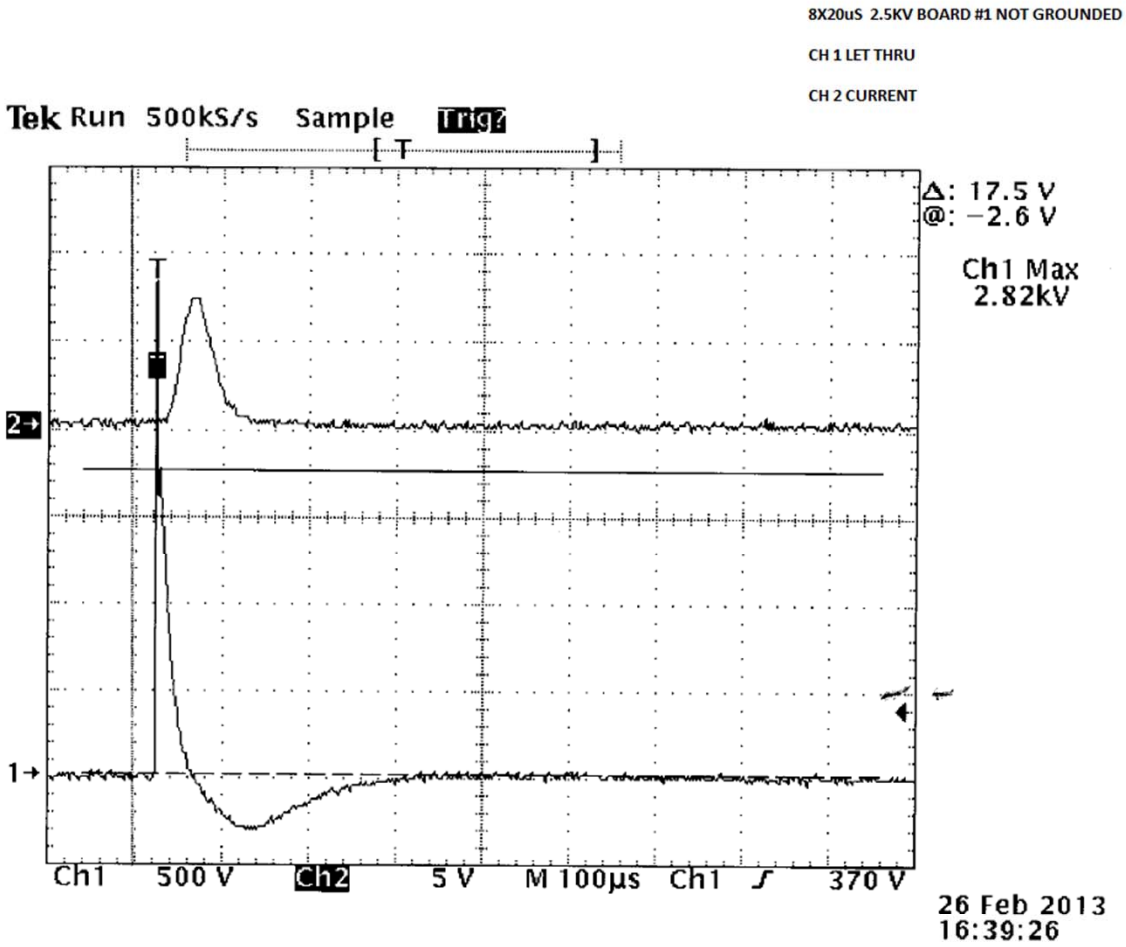
Surge Waveform – 2.5kV without GND



Ch2: 1V = 100 Amp

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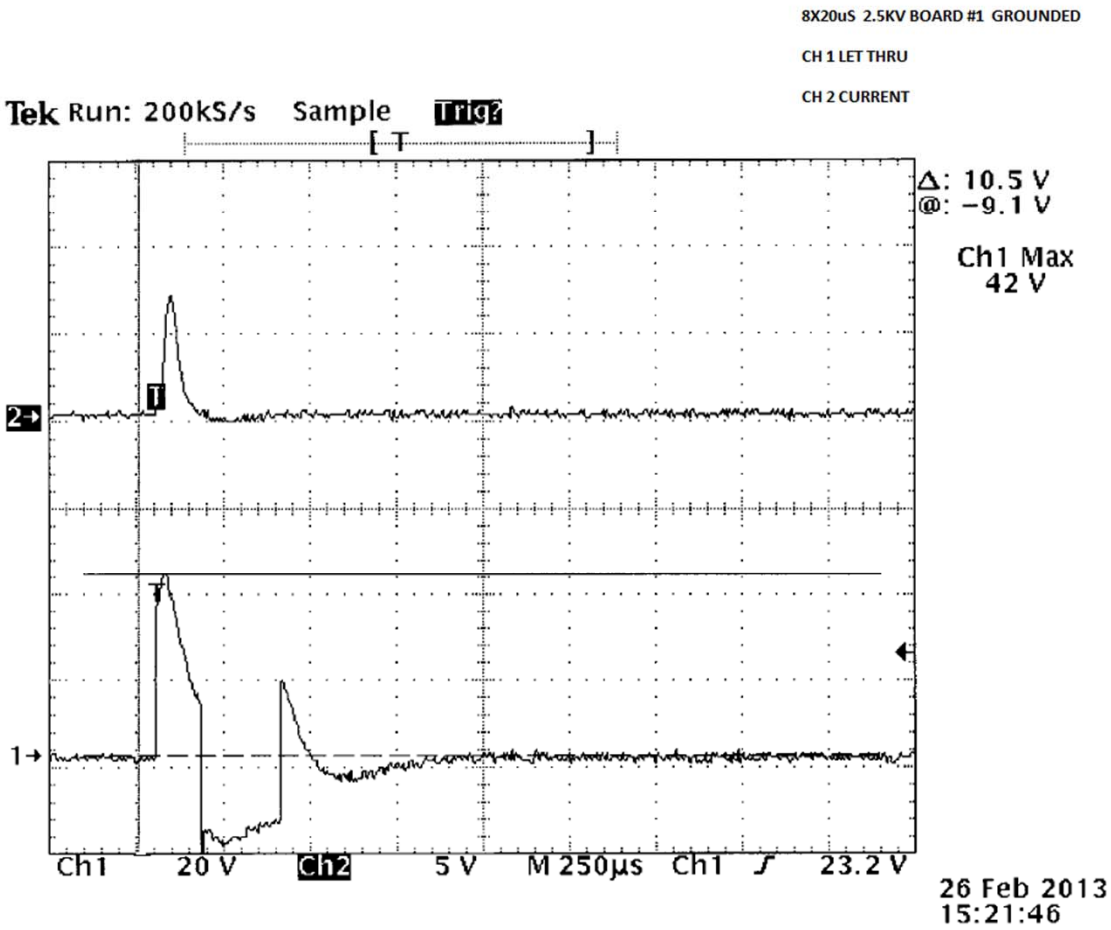
Surge Waveform – 2.5kV with GND



Ch2: 1V = 100 Amp

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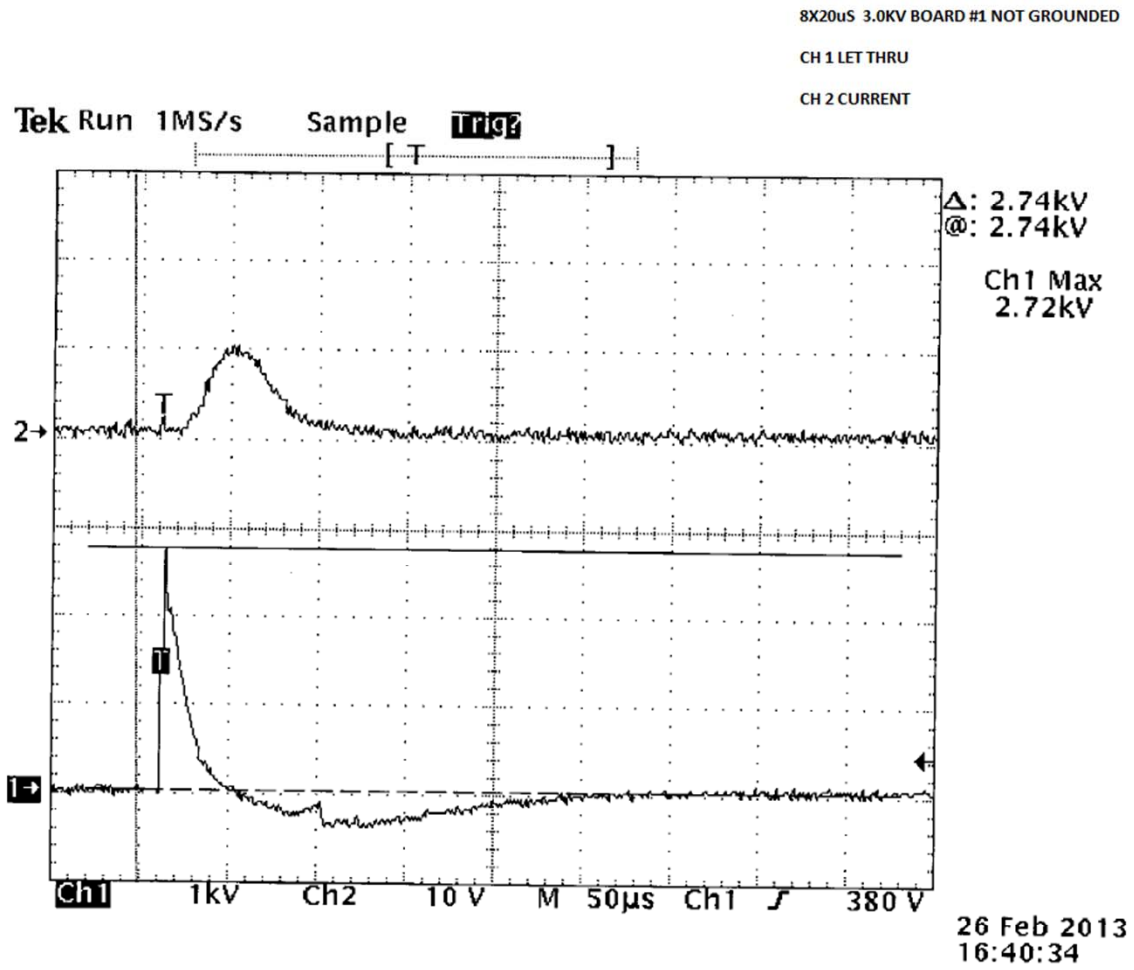
Surge Waveform – 3kV without GND



Ch2: 1V = 100 Amp

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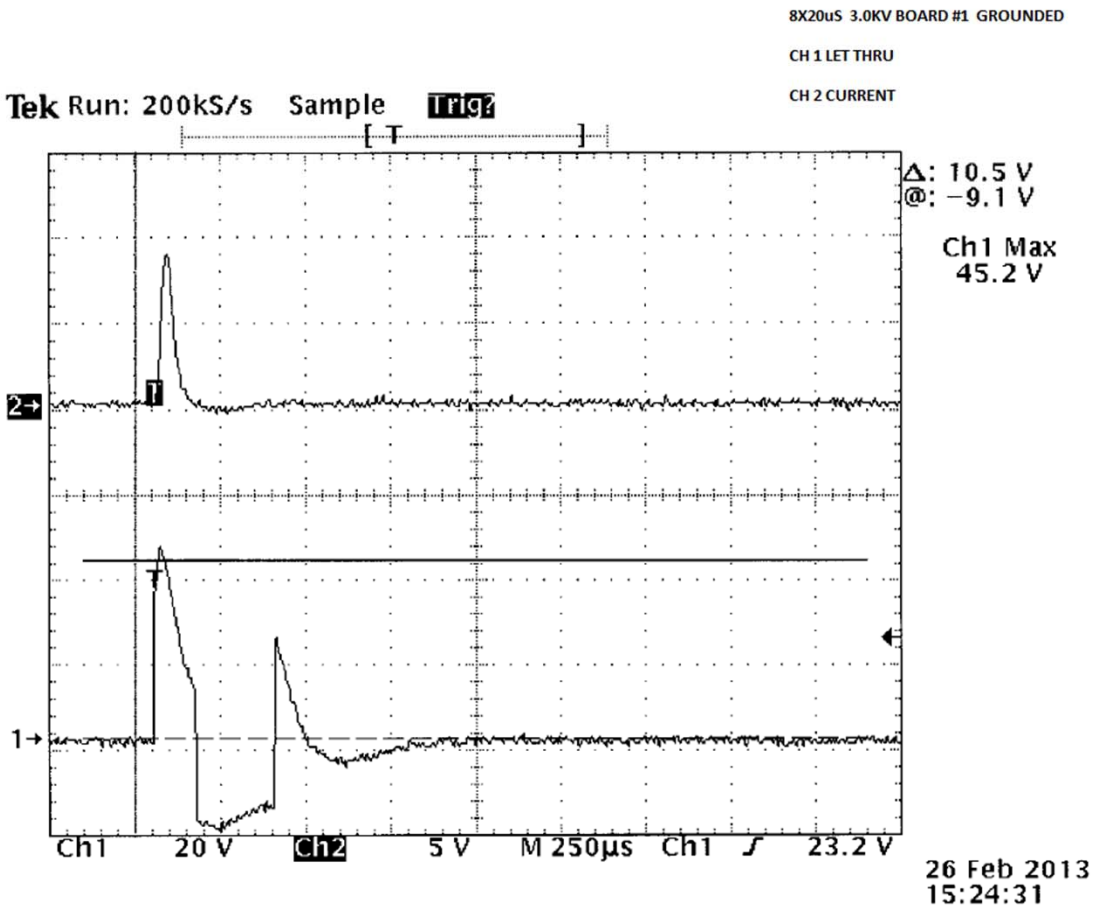
Surge Waveform – 3kV with GND



Ch2: 1V = 100 Amp

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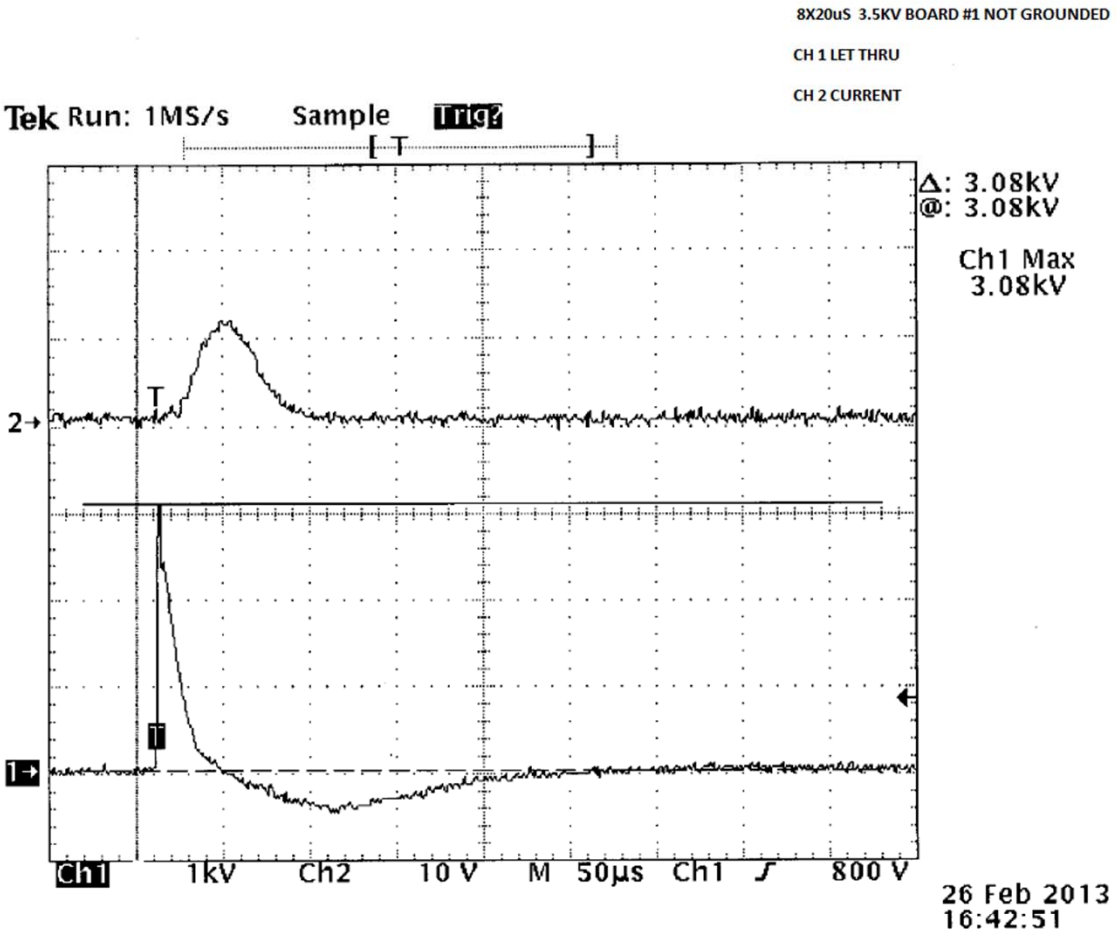
Surge Waveform – 3.5kV without GND



Ch2: 1V = 100 Amp

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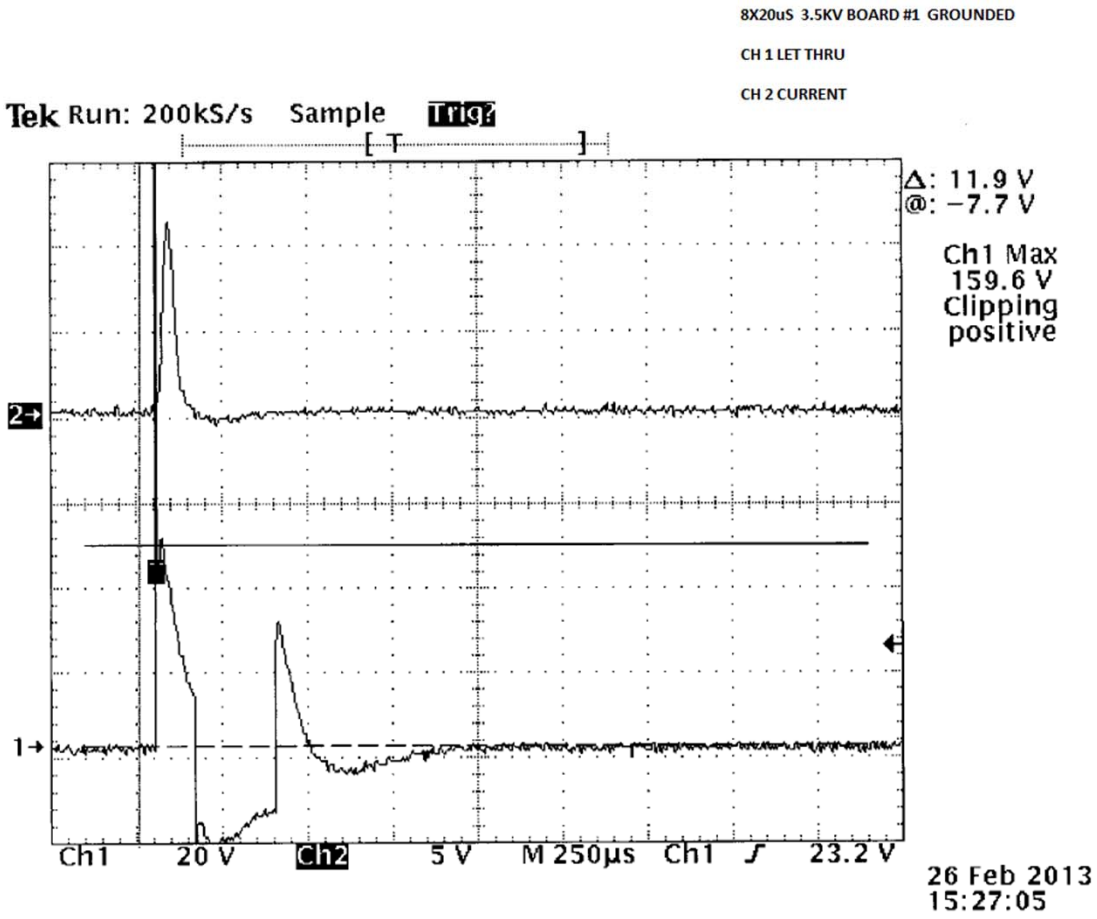
Surge Waveform – 3.5kV with GND



Ch2: 1V = 100 Amp

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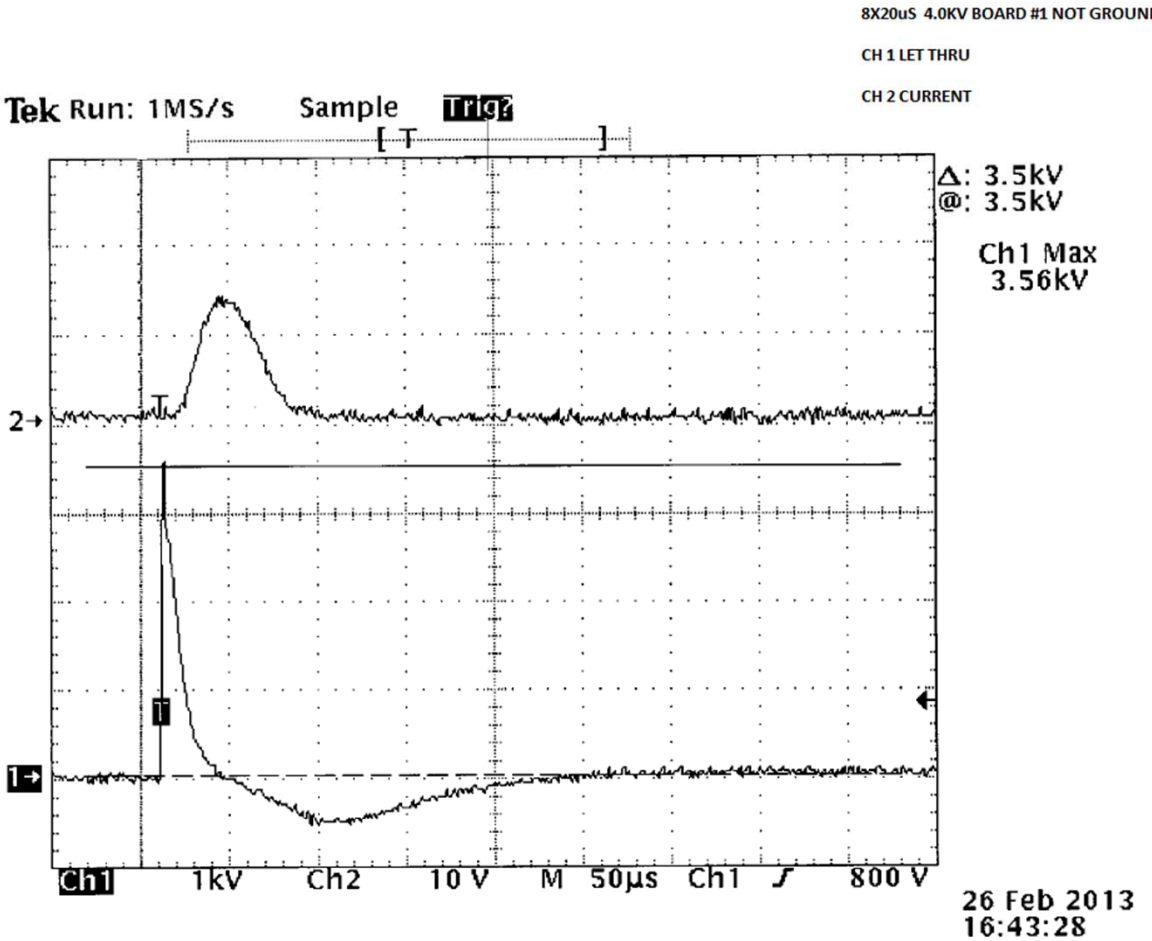
Surge Waveform – 4kV without GND



Ch2: 1V = 100 Amp

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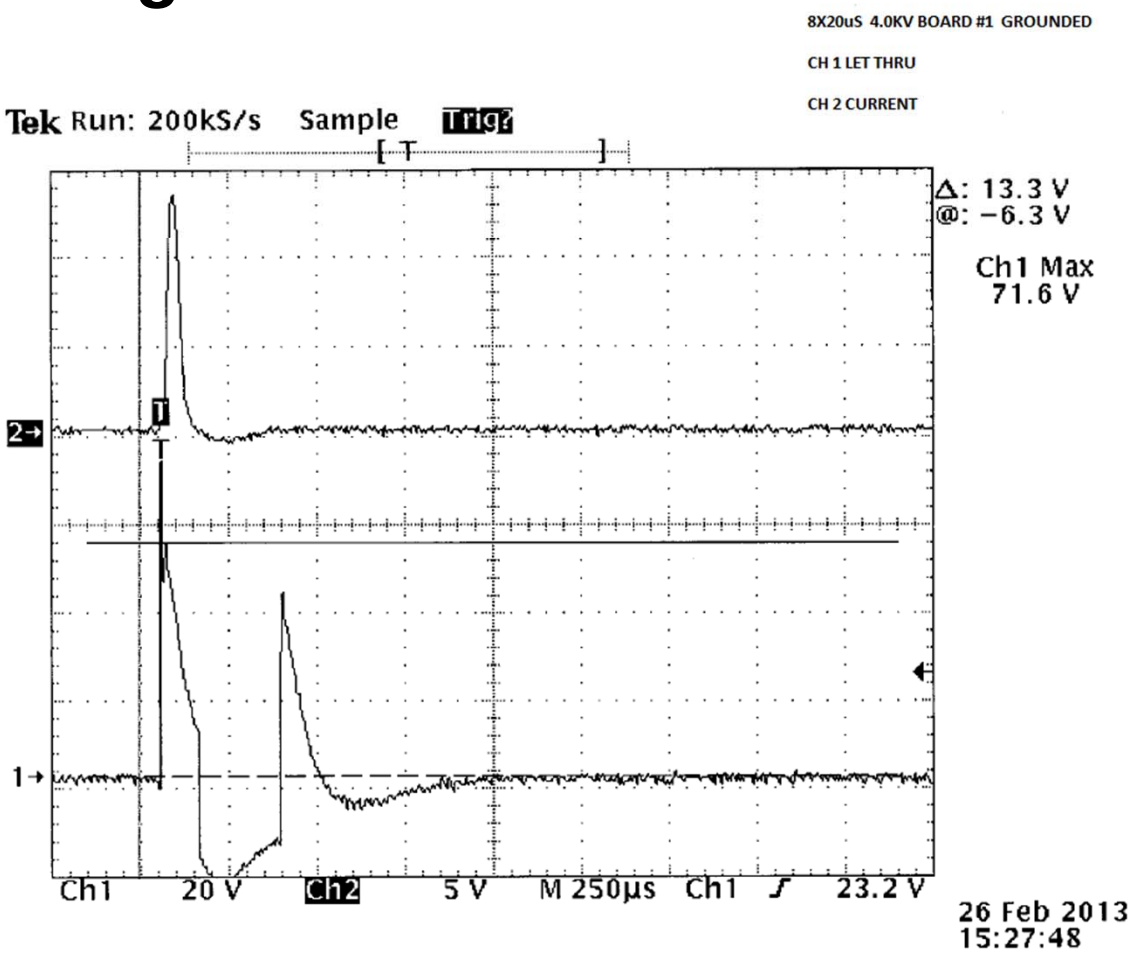
Surge Waveform – 4kV with GND



Ch2: 1V = 100 Amp

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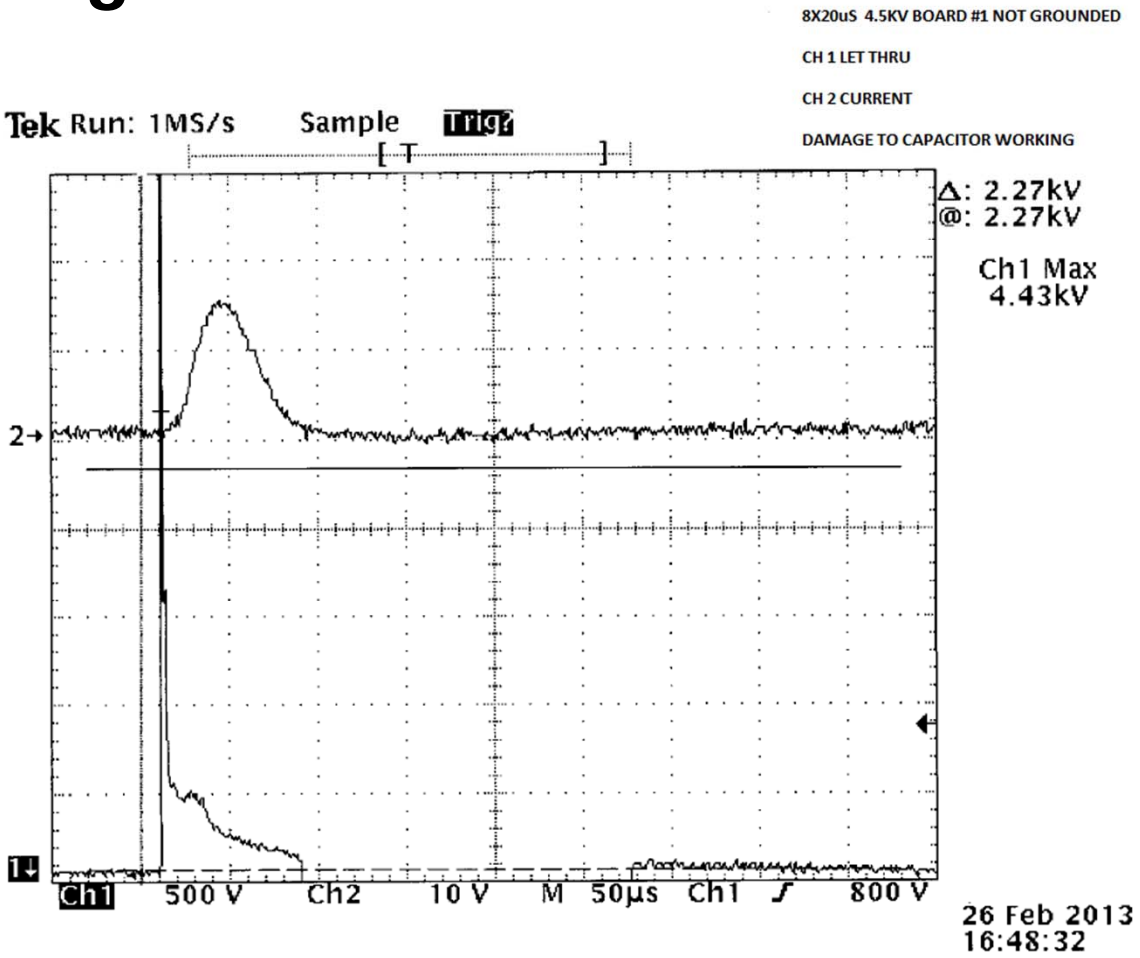
Surge Waveform – 4.5kV without GND



Ch2: 1V = 100 Amp

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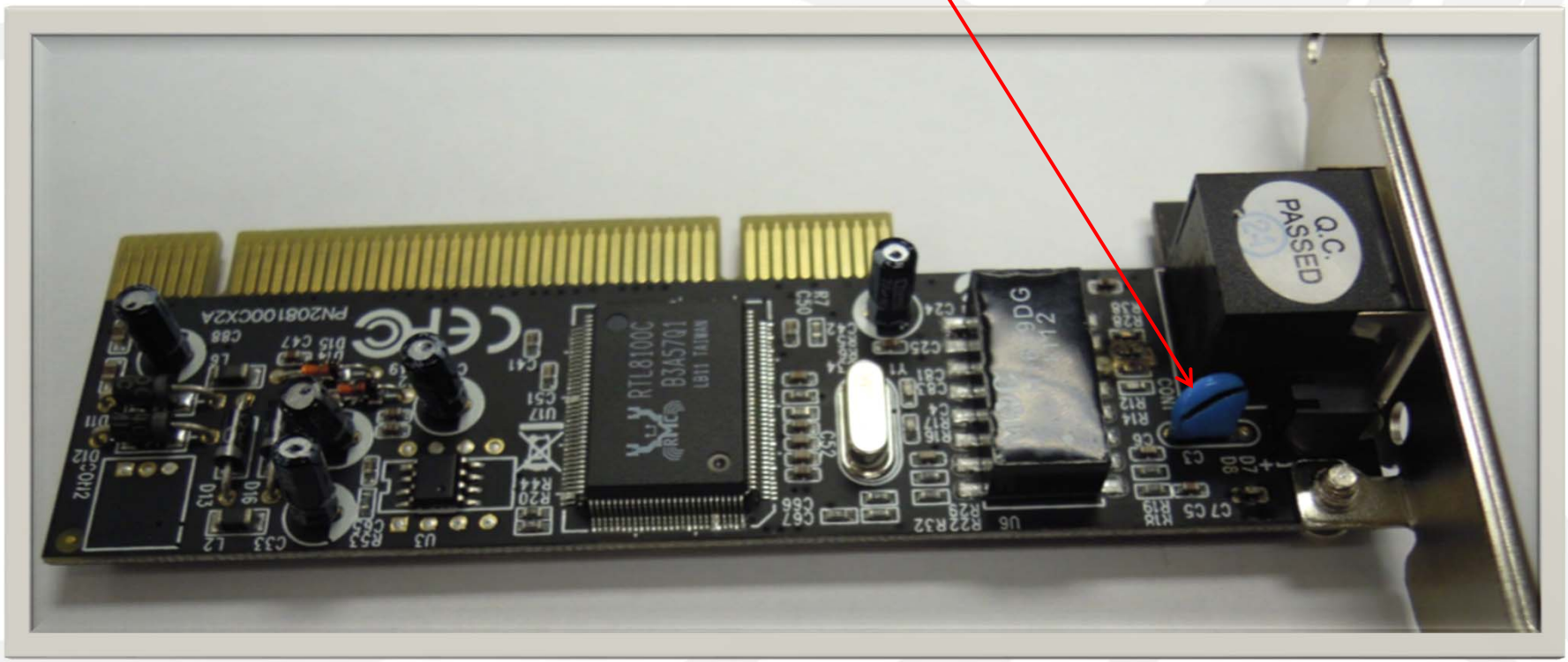
Surge Waveform – 4.5kV without GND

Damage to Capacitor C3



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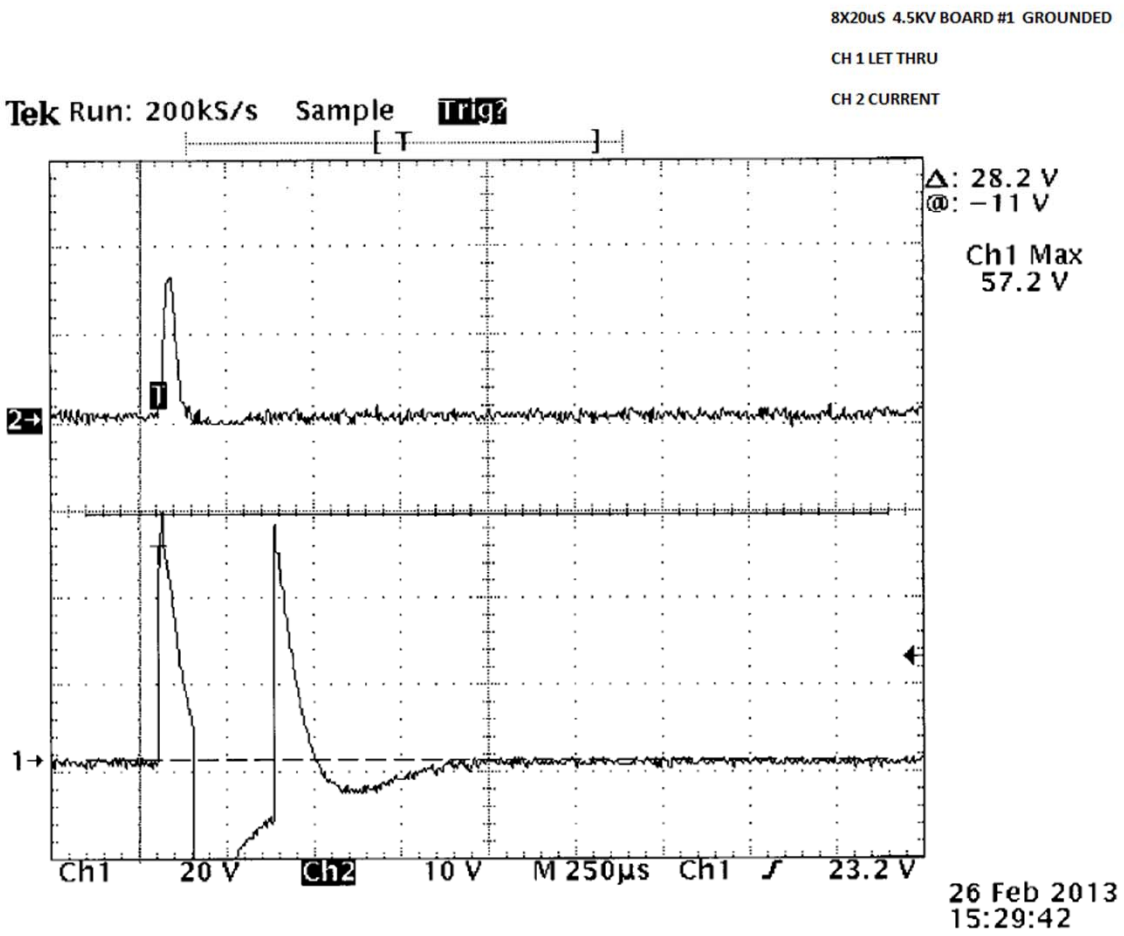
Surge Waveform – 4.5kV with GND



Ch2: 1V = 100 Amp

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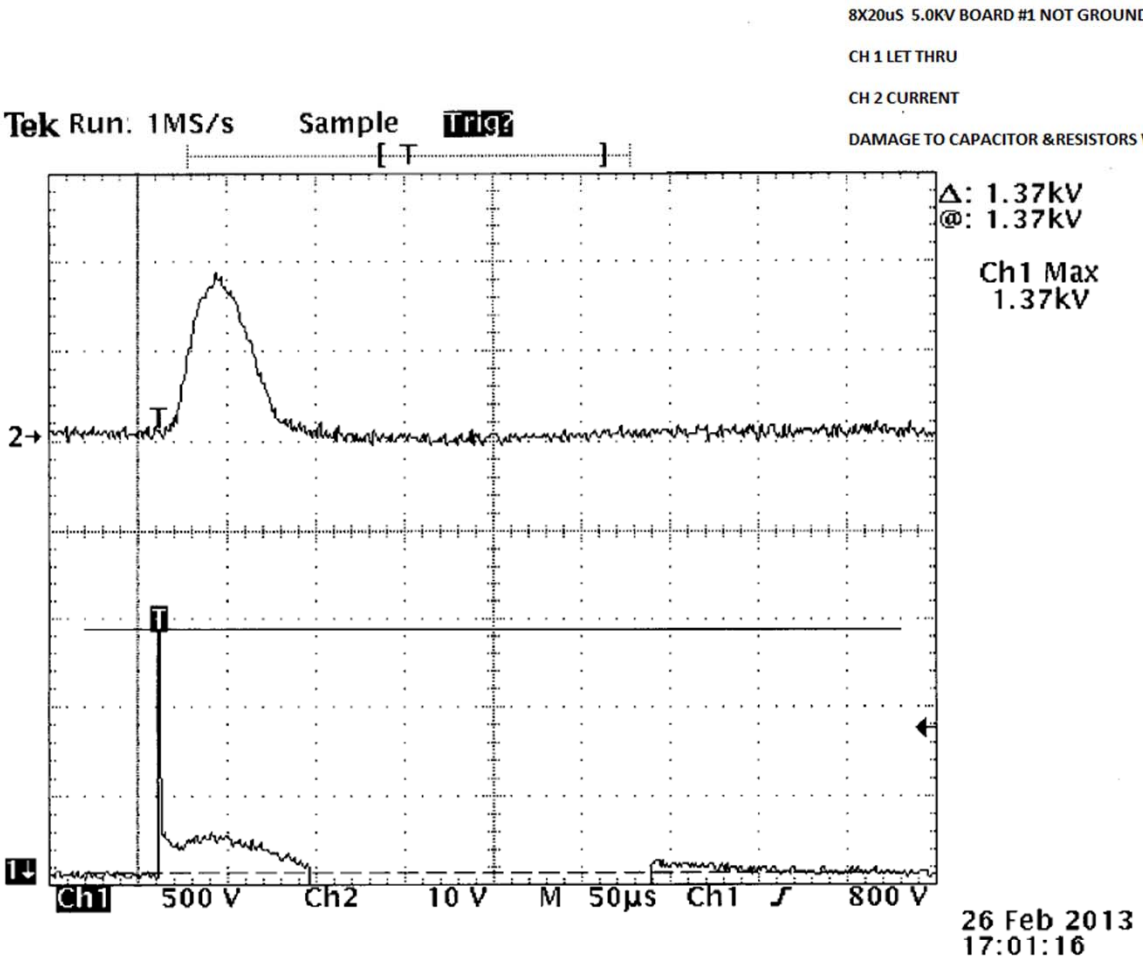
Surge Waveform – 5kV without GND



Ch2: 1V = 100 Amp

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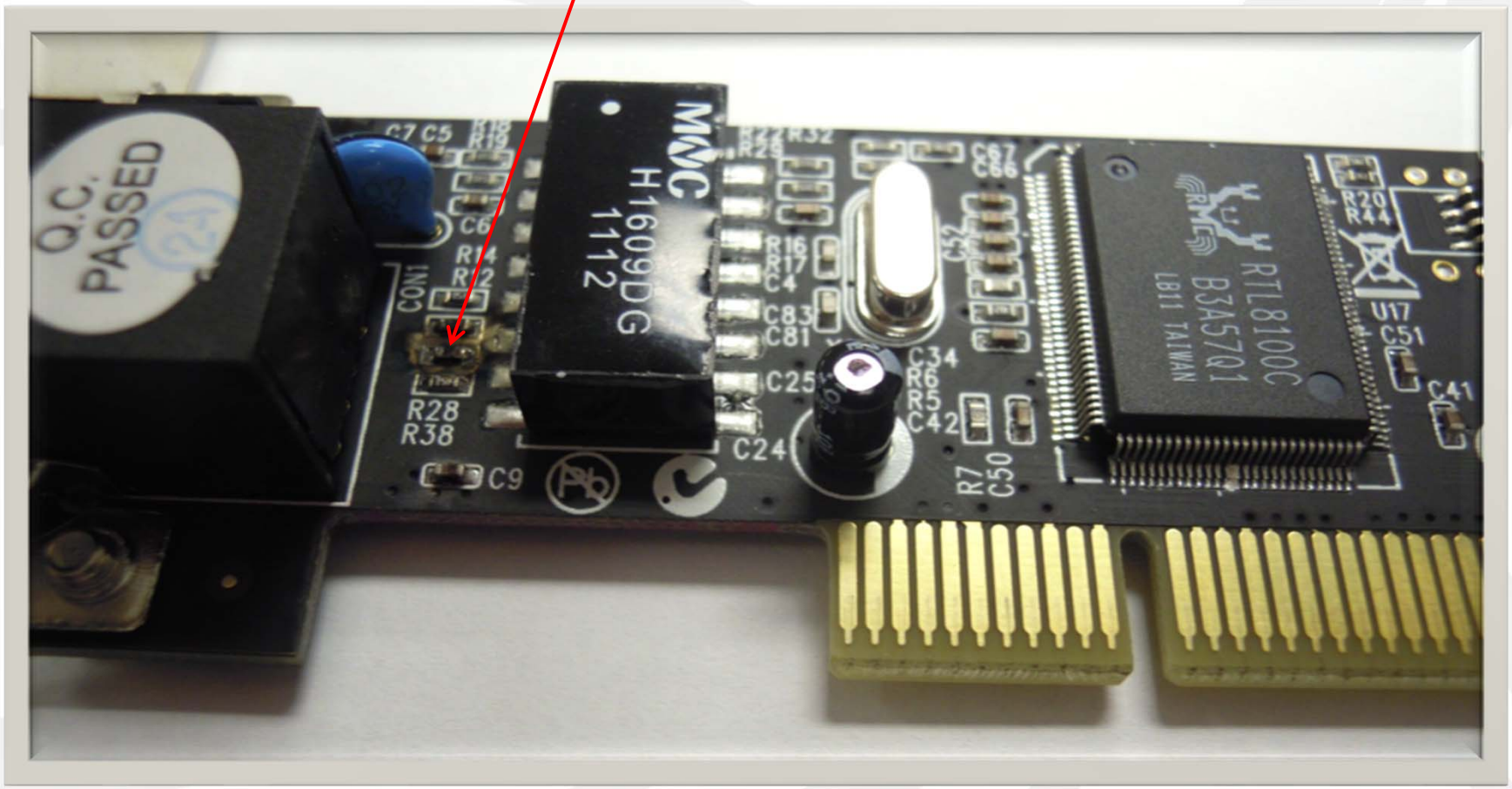
Surge Waveform – 5kV without GND

Damage to Resistor R28



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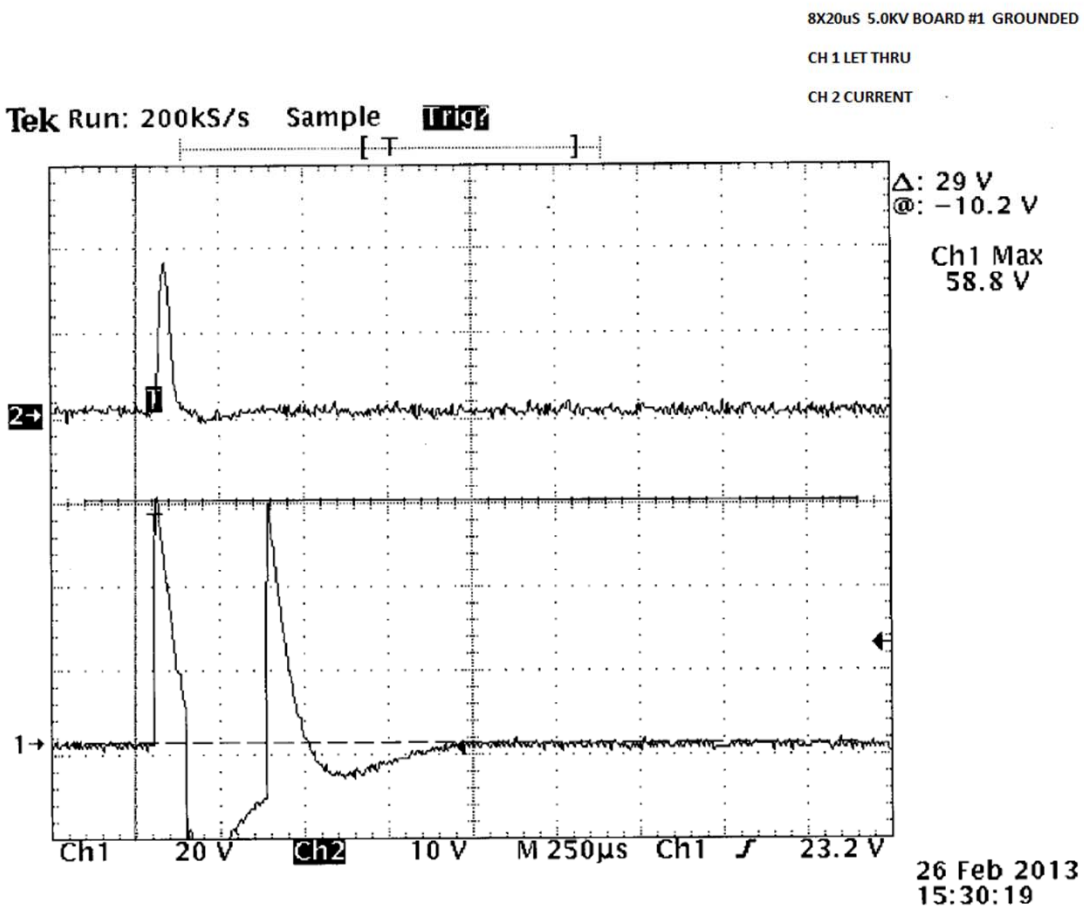
Surge Waveform – 5kV with GND



Ch2: 1V = 100 Amp

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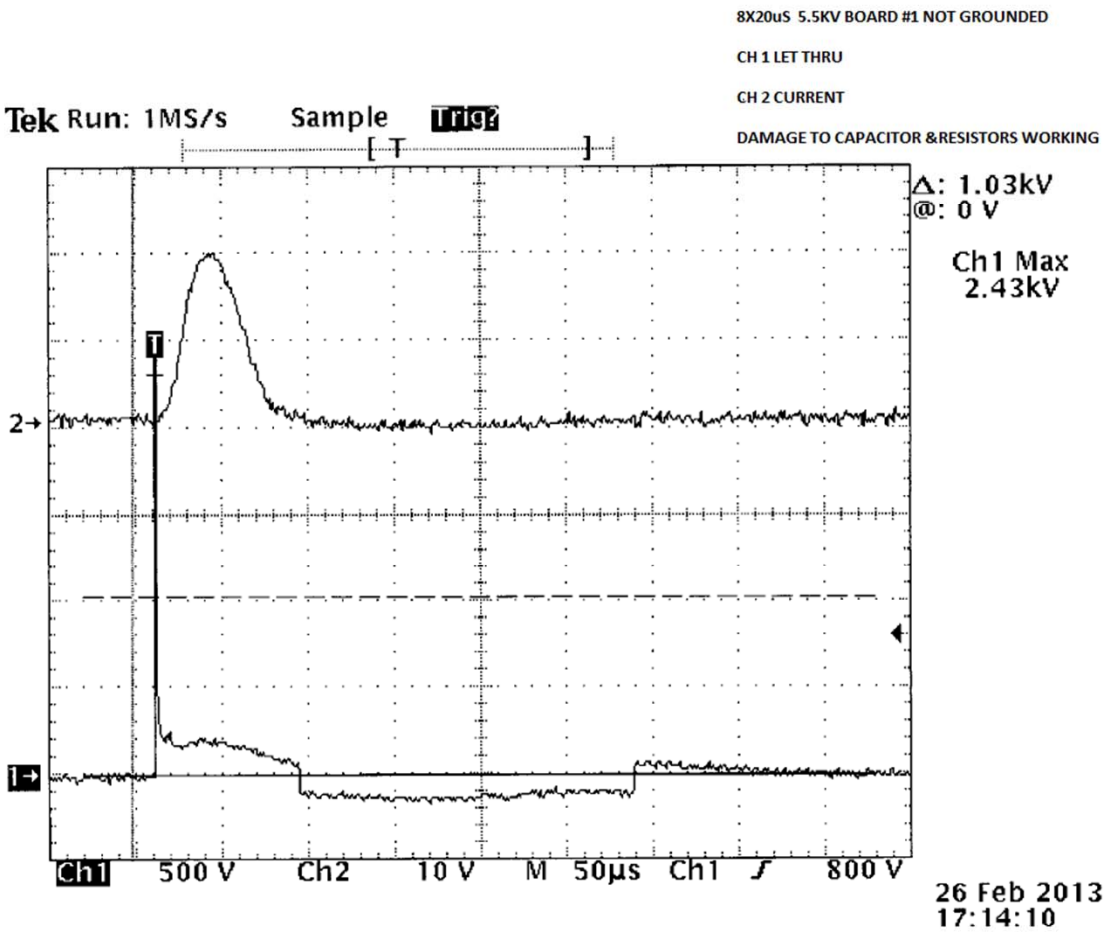
Surge Waveform – 5.5kV without GND



Ch2: 1V = 100 Amp

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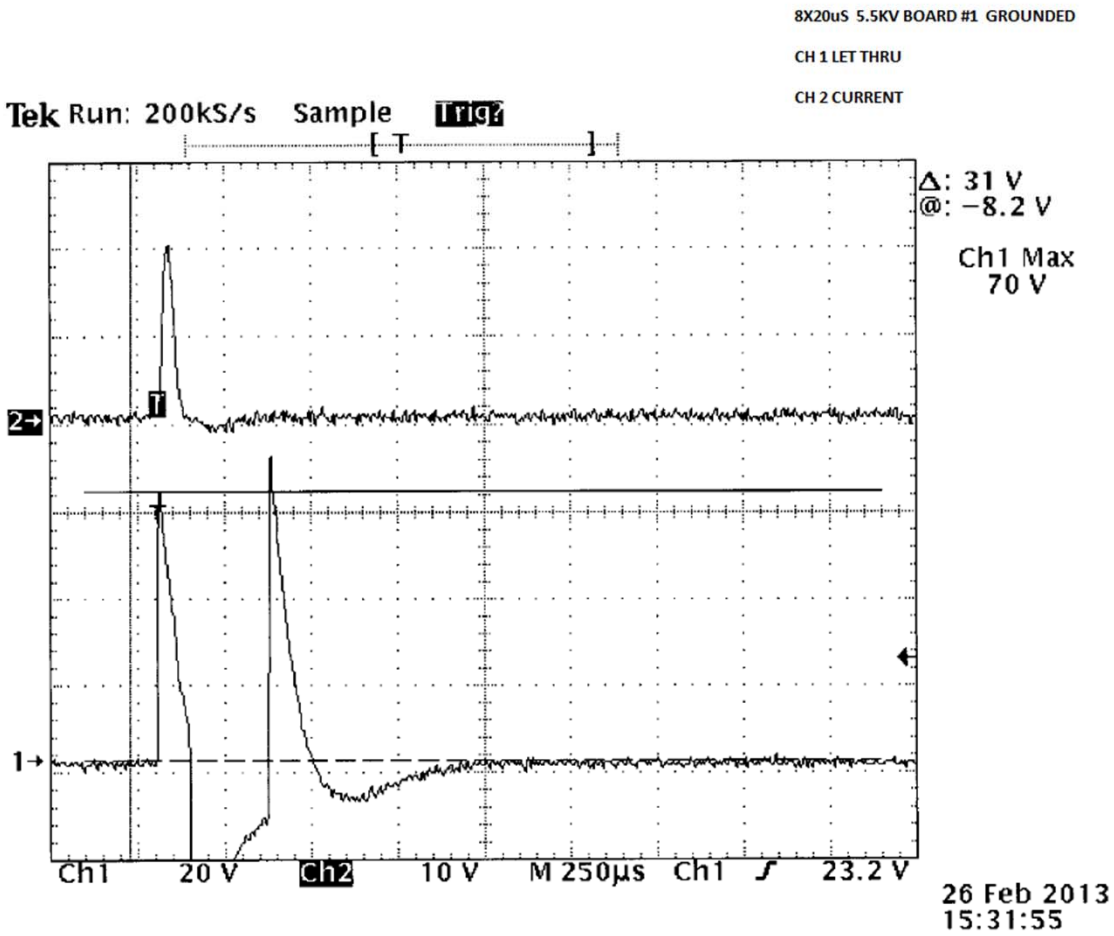
Surge Waveform – 5.5kV with GND



Ch2: 1V = 100 Amp

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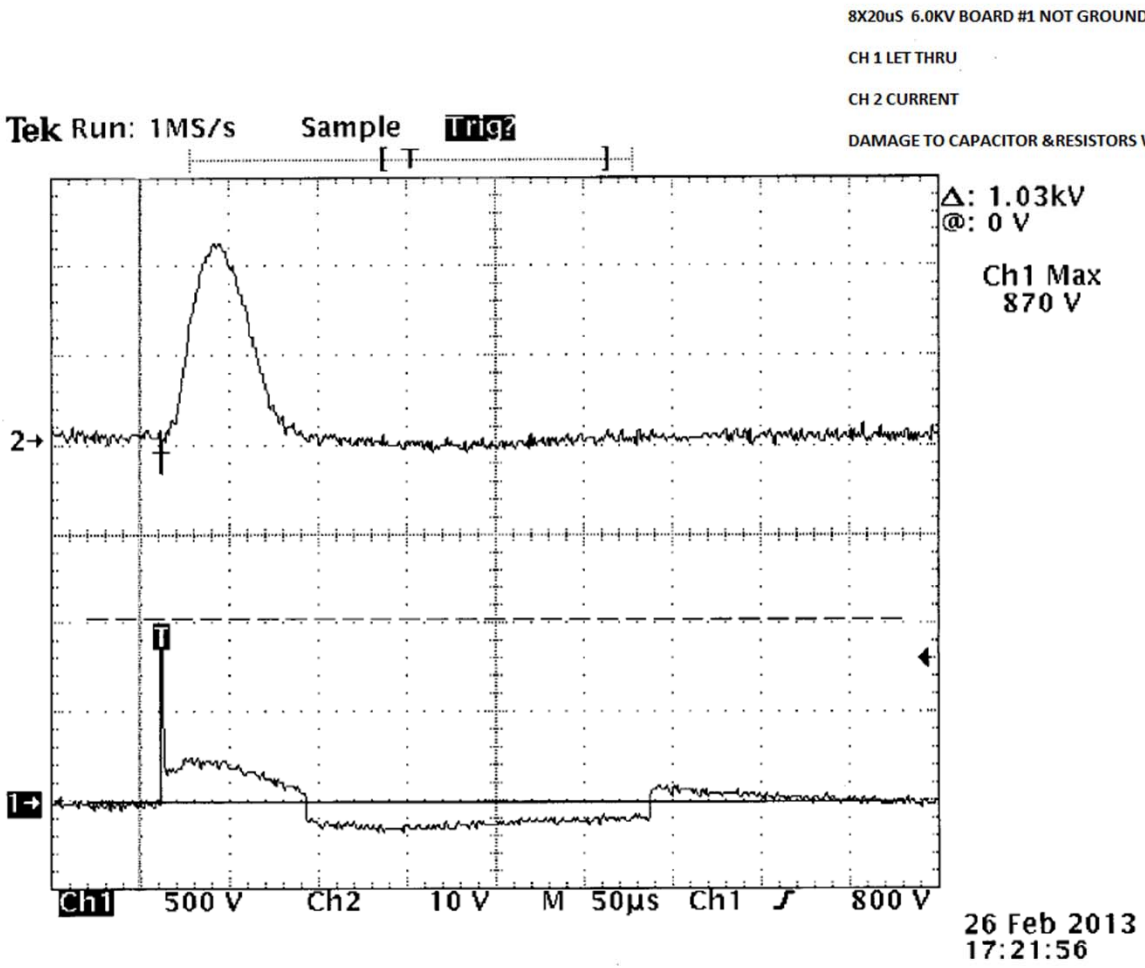
Surge Waveform – 6kV without GND



Ch2: 1V = 100 Amp

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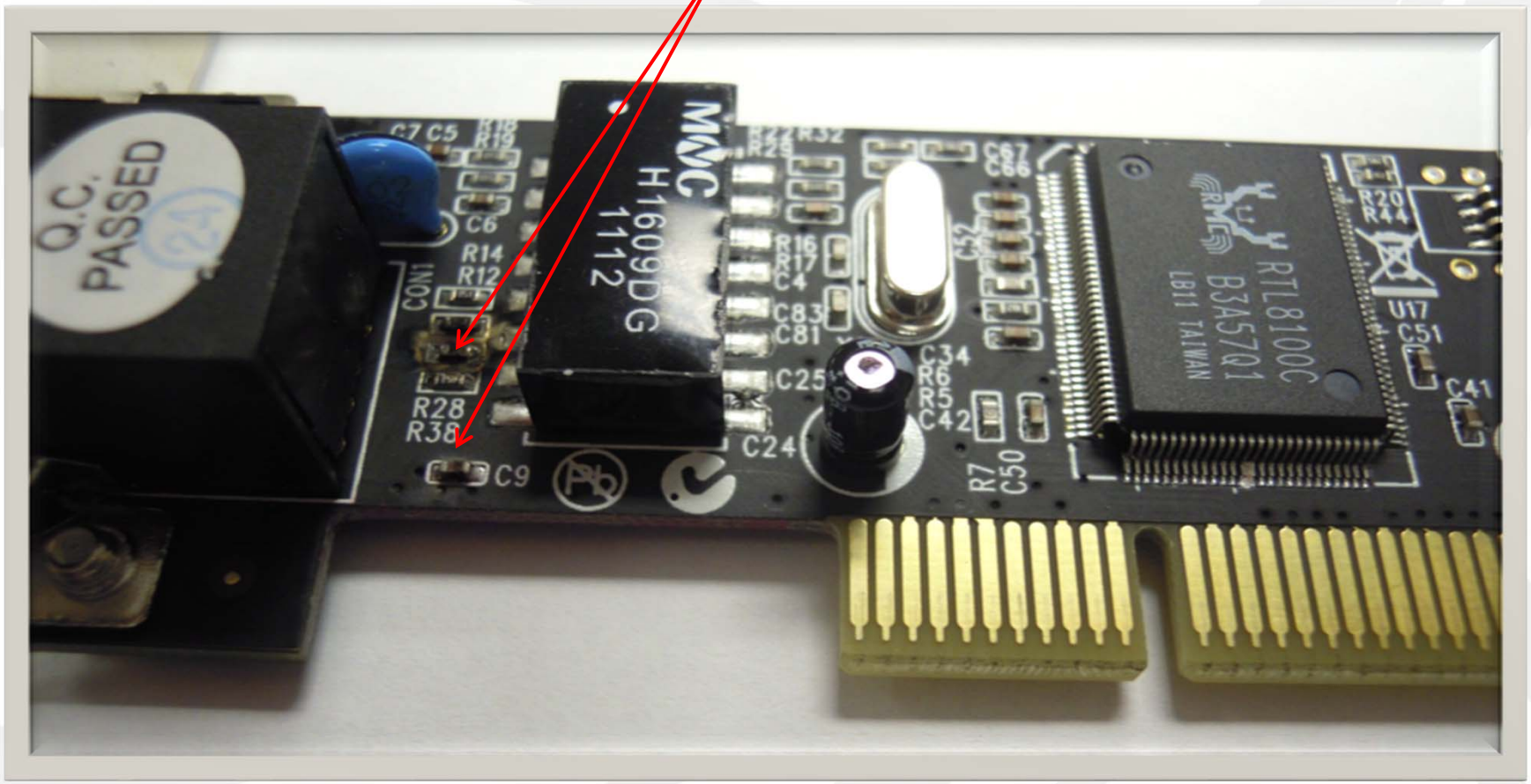
Surge Waveform – 6kV without GND

Damage to R28 and C9



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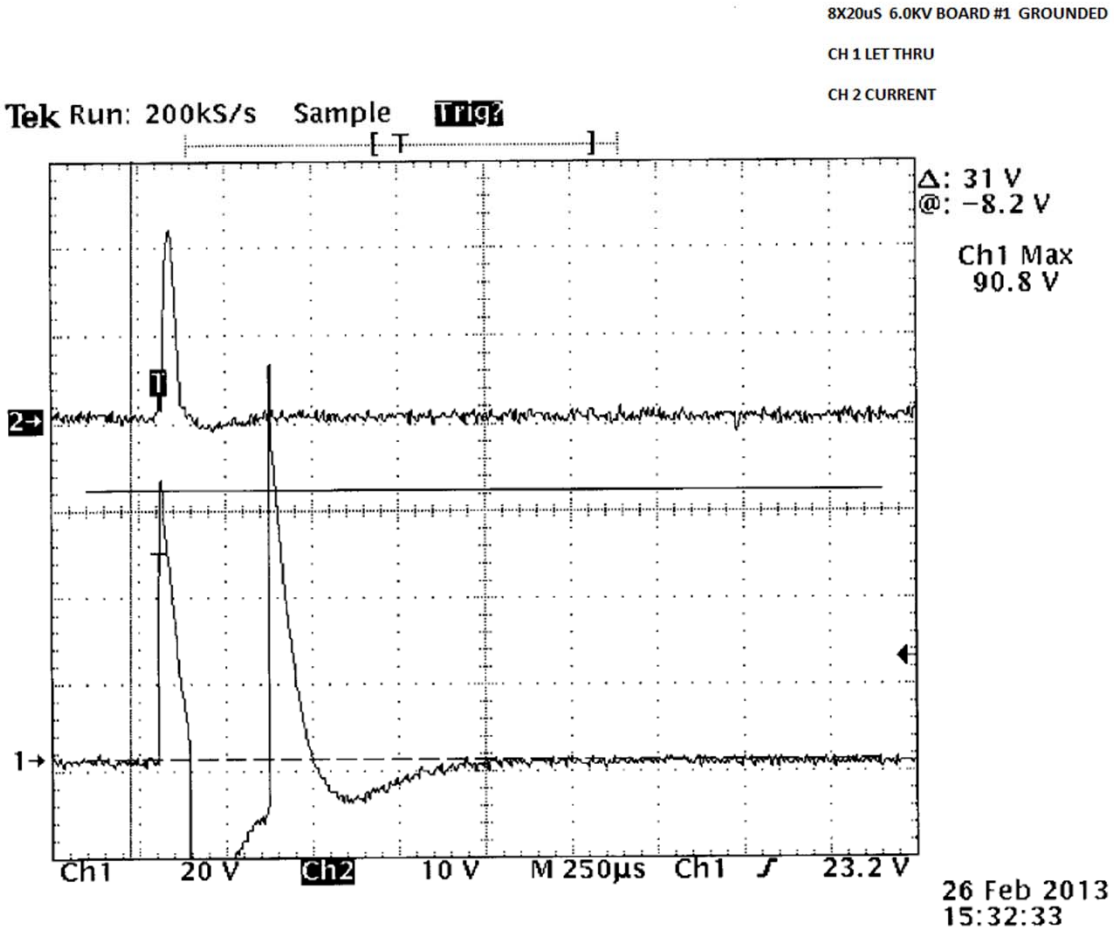
Surge Waveform – 6kV with GND



Ch2: 1V = 100 Amp

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Protection Circuit 1 Test Results

No Ground Connection:

NIC cards started showing damage when surge voltage levels were increased beyond 4000 volts.

With Ground Connection:

NIC cards showed no damage when ground connection was present and the GDT allowed surge energy to be diverted to ground.

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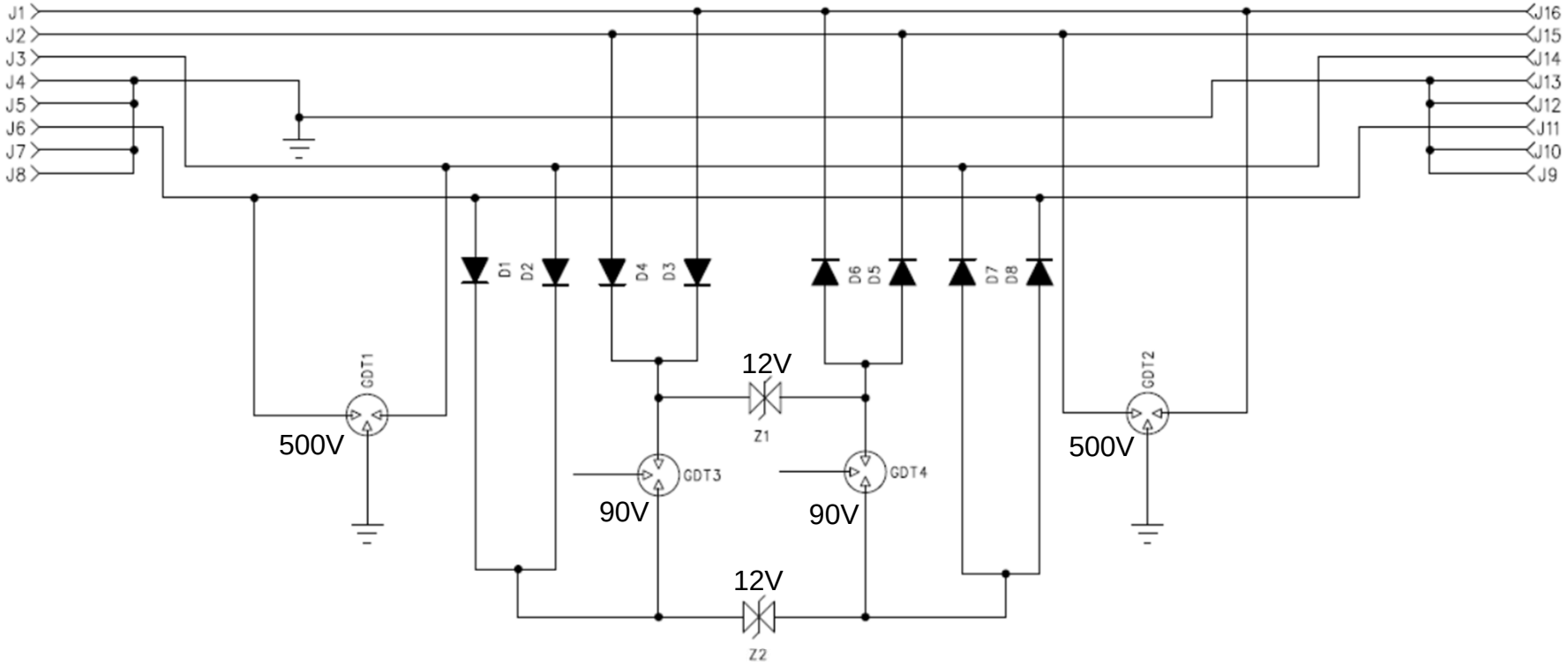
Circuit # 2



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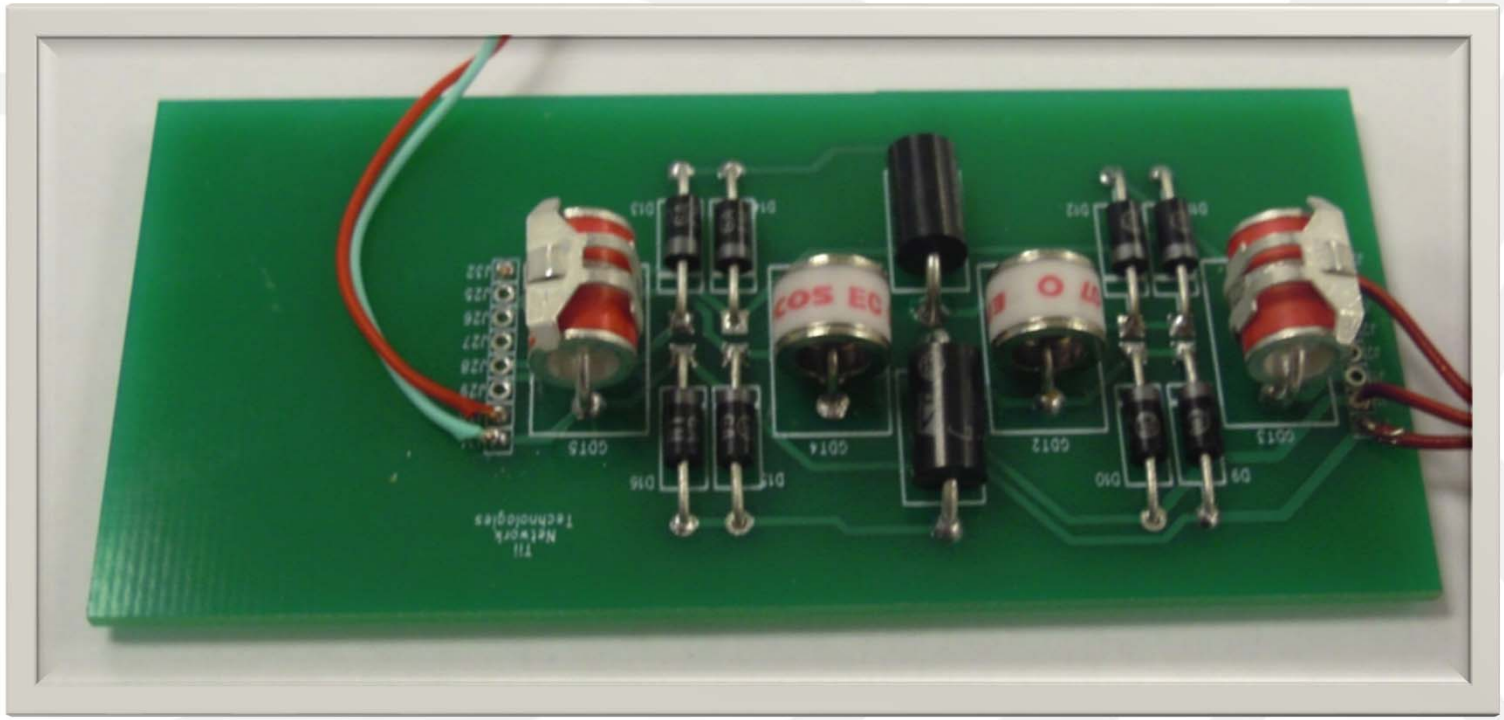
Circuit # 2Test Board



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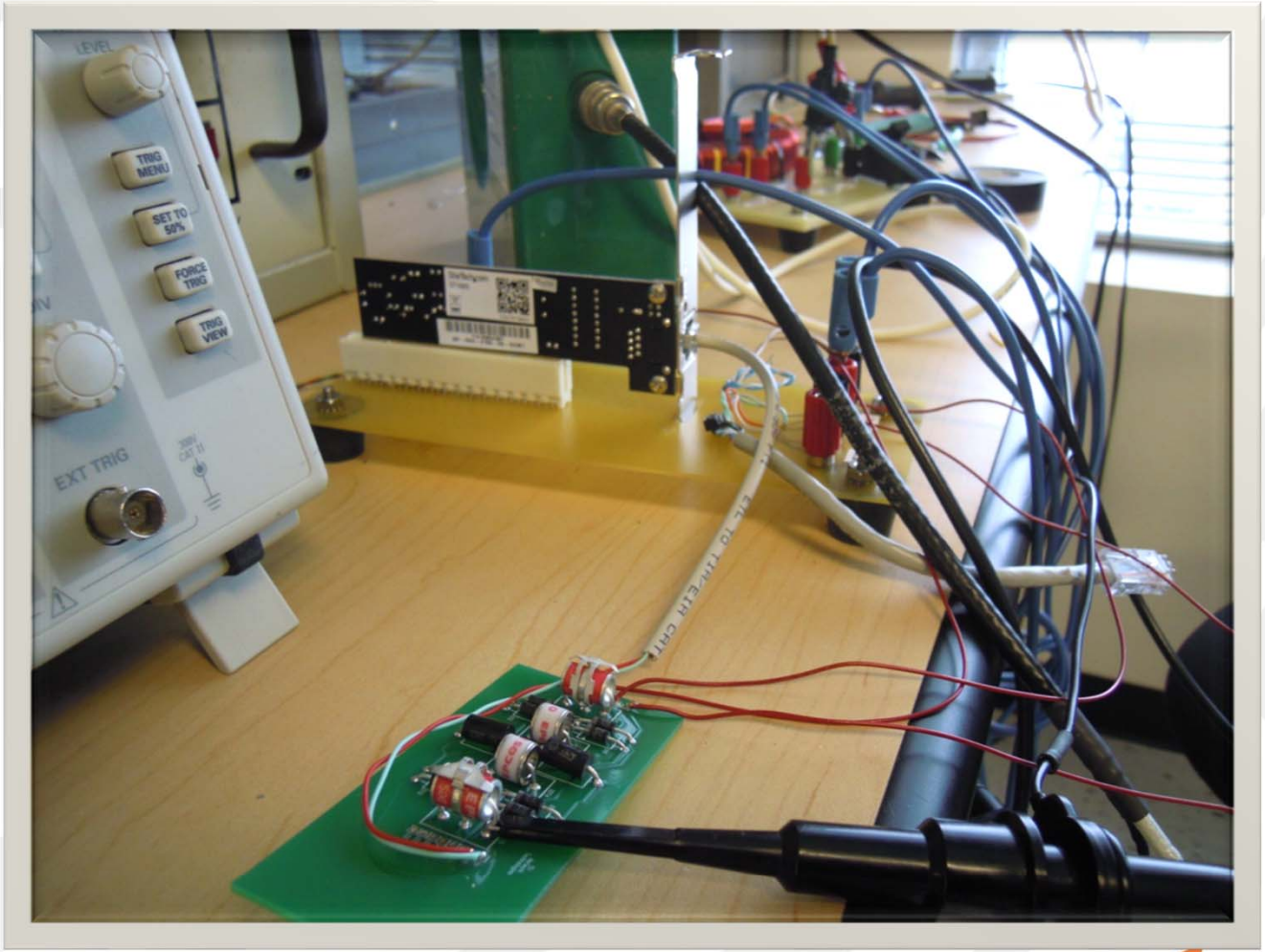
Circuit # 2Test Configuration



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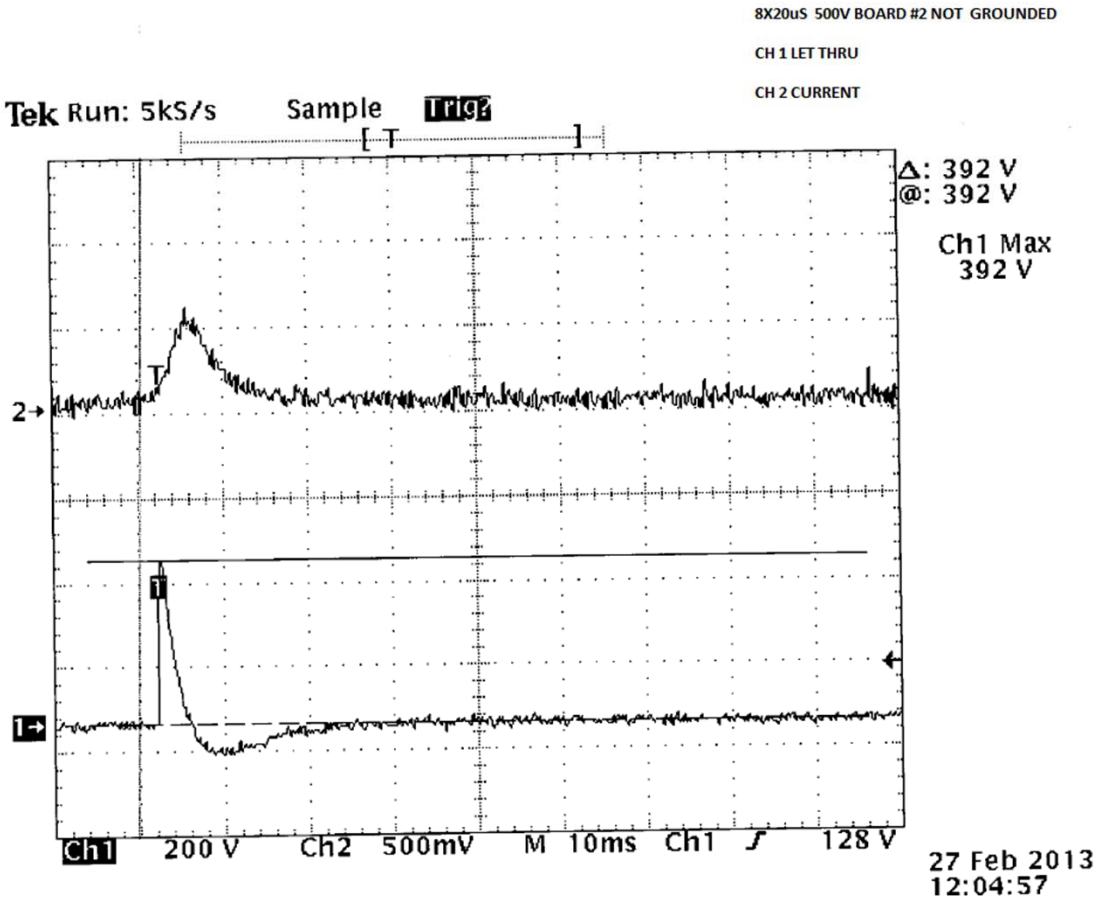
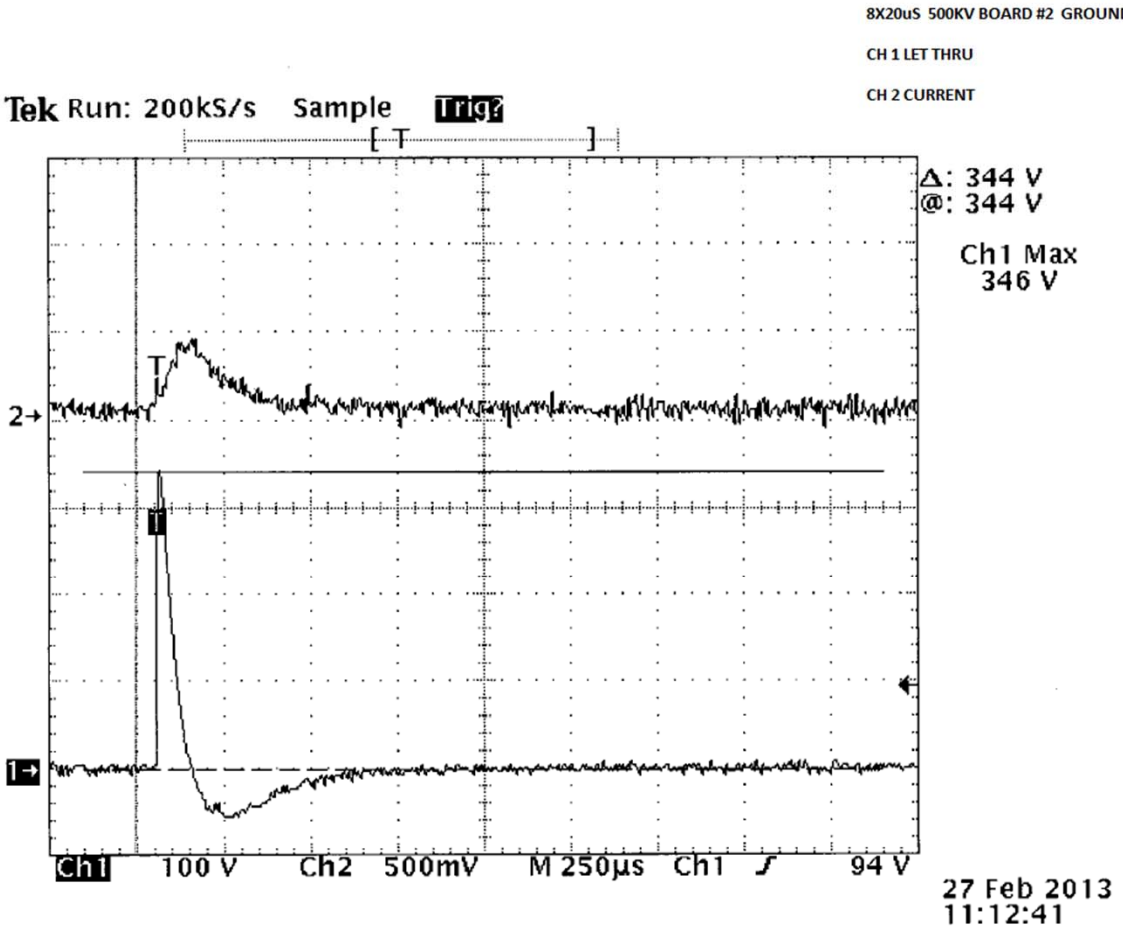
Surge Waveform – 500V without GND



Ch2: 1V = 100 Amp

tii network technologies

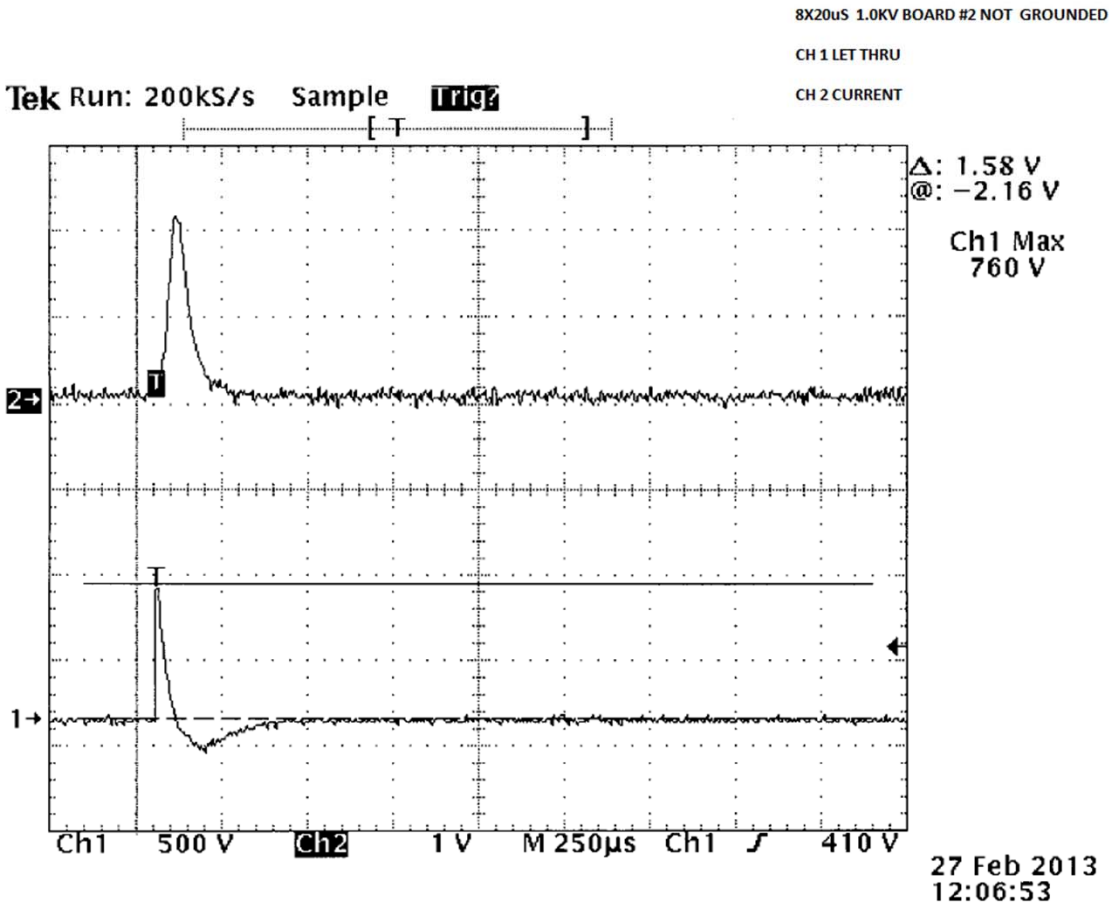
Surge Waveform – 500V with GND



Ch2: 1V = 100 Amp

tii network technologies

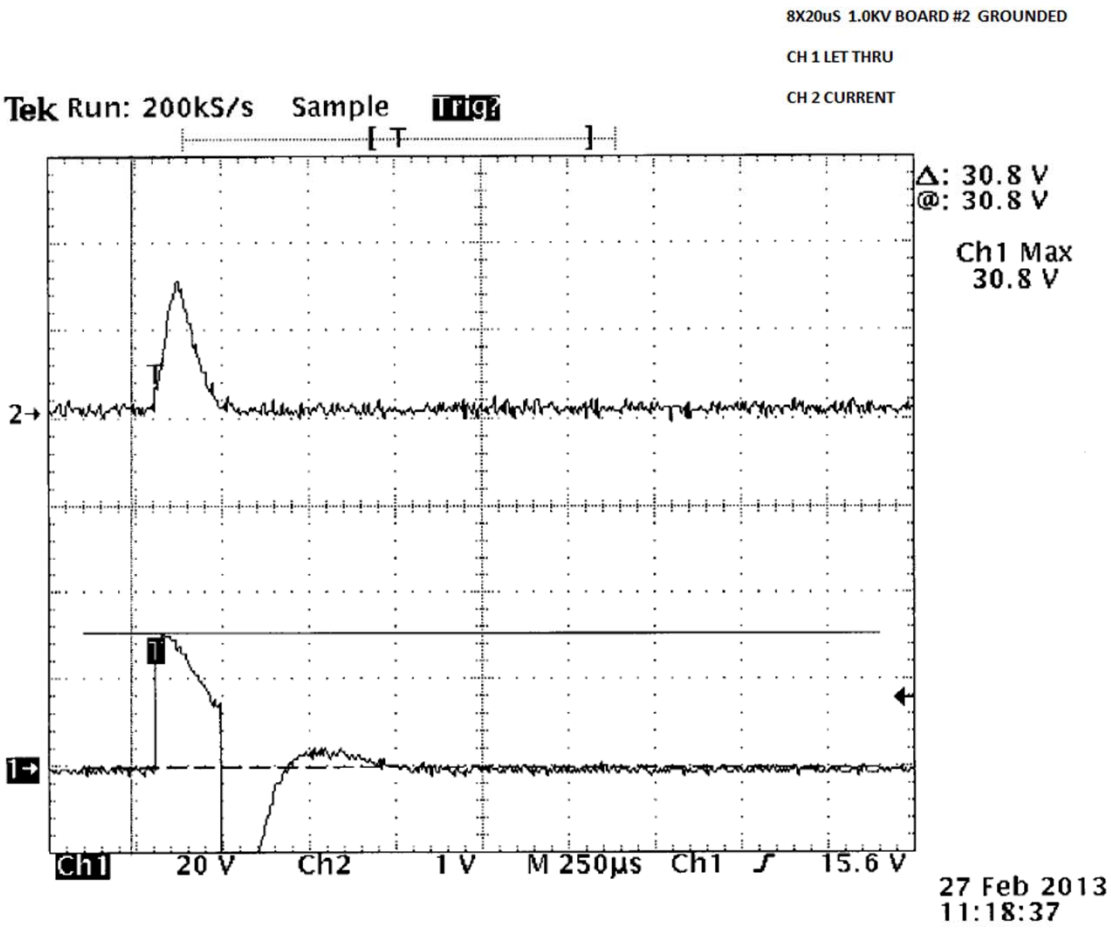
Surge Waveform – 1kV without GND



Ch2: 1V = 100 Amp

tii network technologies

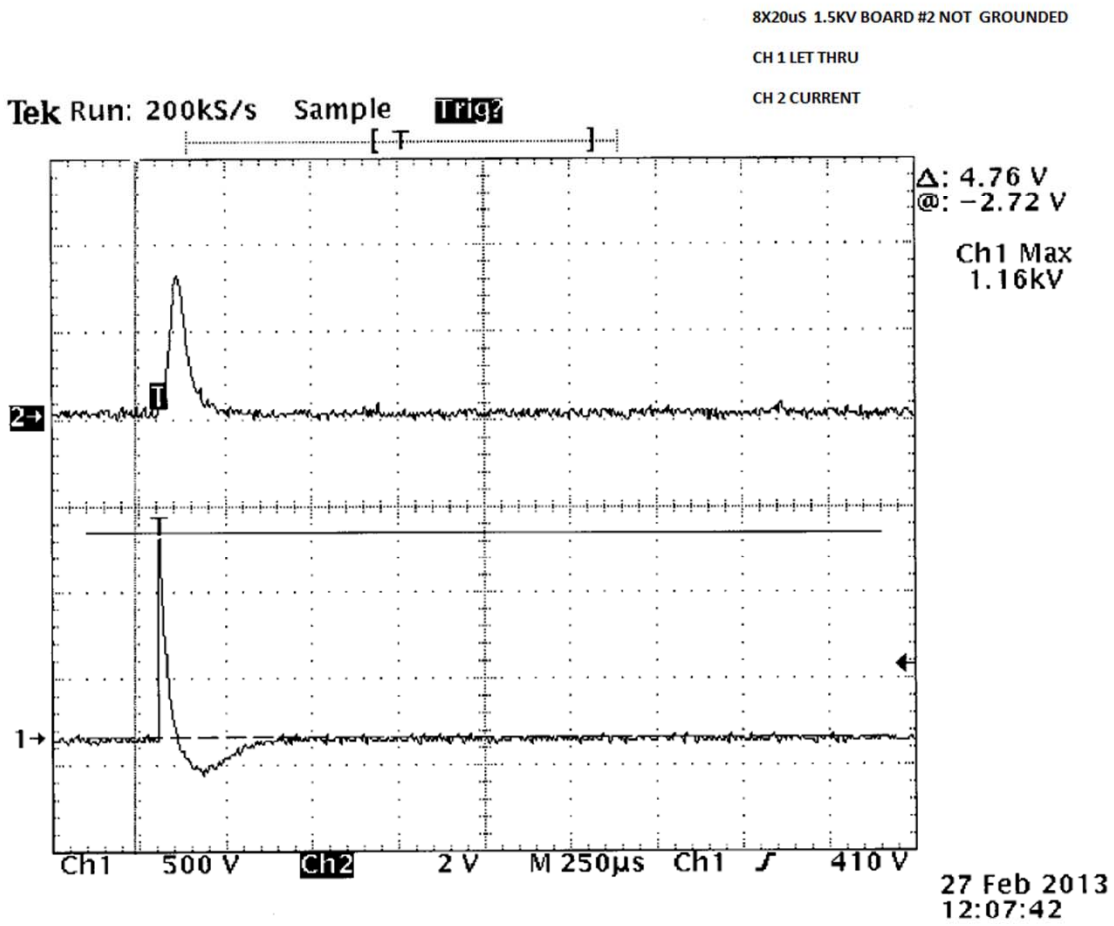
Surge Waveform – 1kV with GND



Ch2: 1V = 100 Amp

tii network technologies

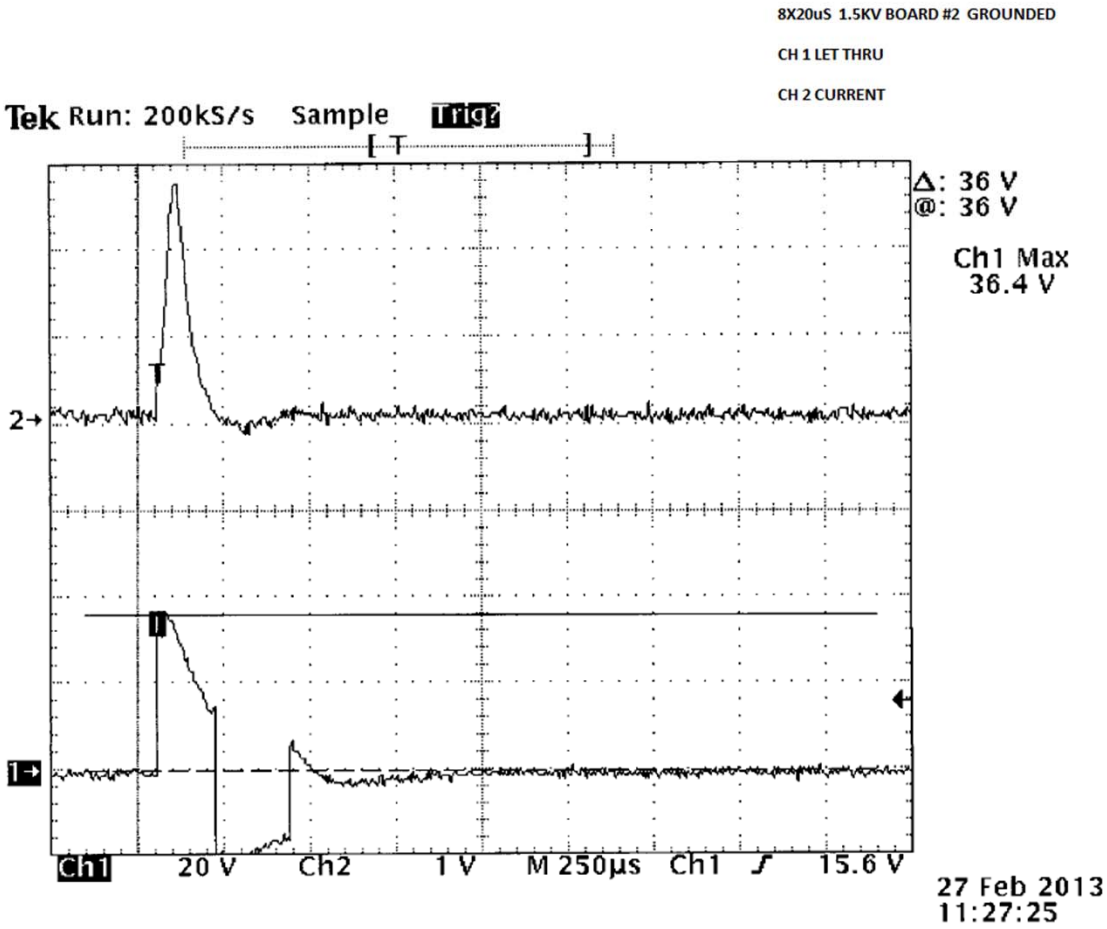
Surge Waveform – 1.5kV without GND



Ch2: 1V = 100 Amp

tii network technologies

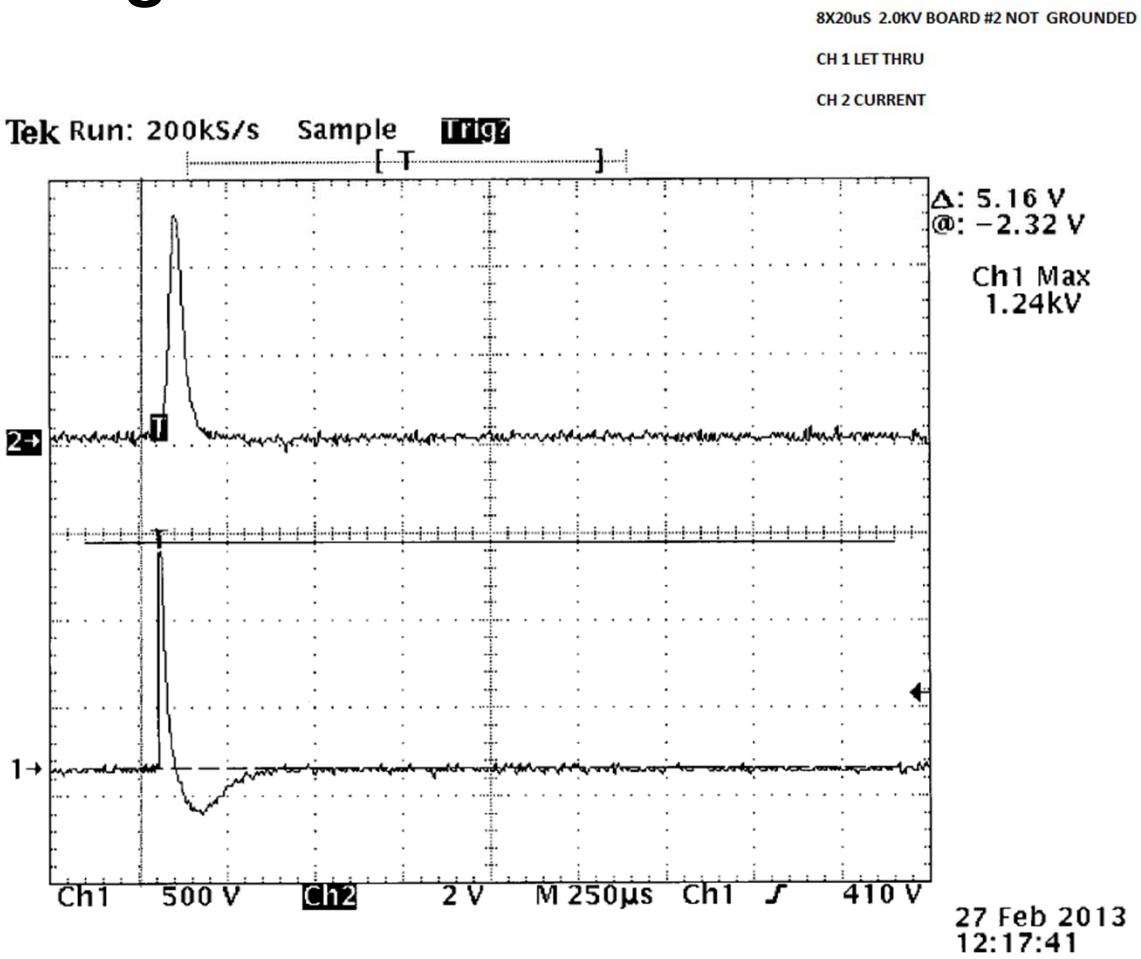
Surge Waveform – 1.5kV with GND



Ch2: 1V = 100 Amp

tii network technologies

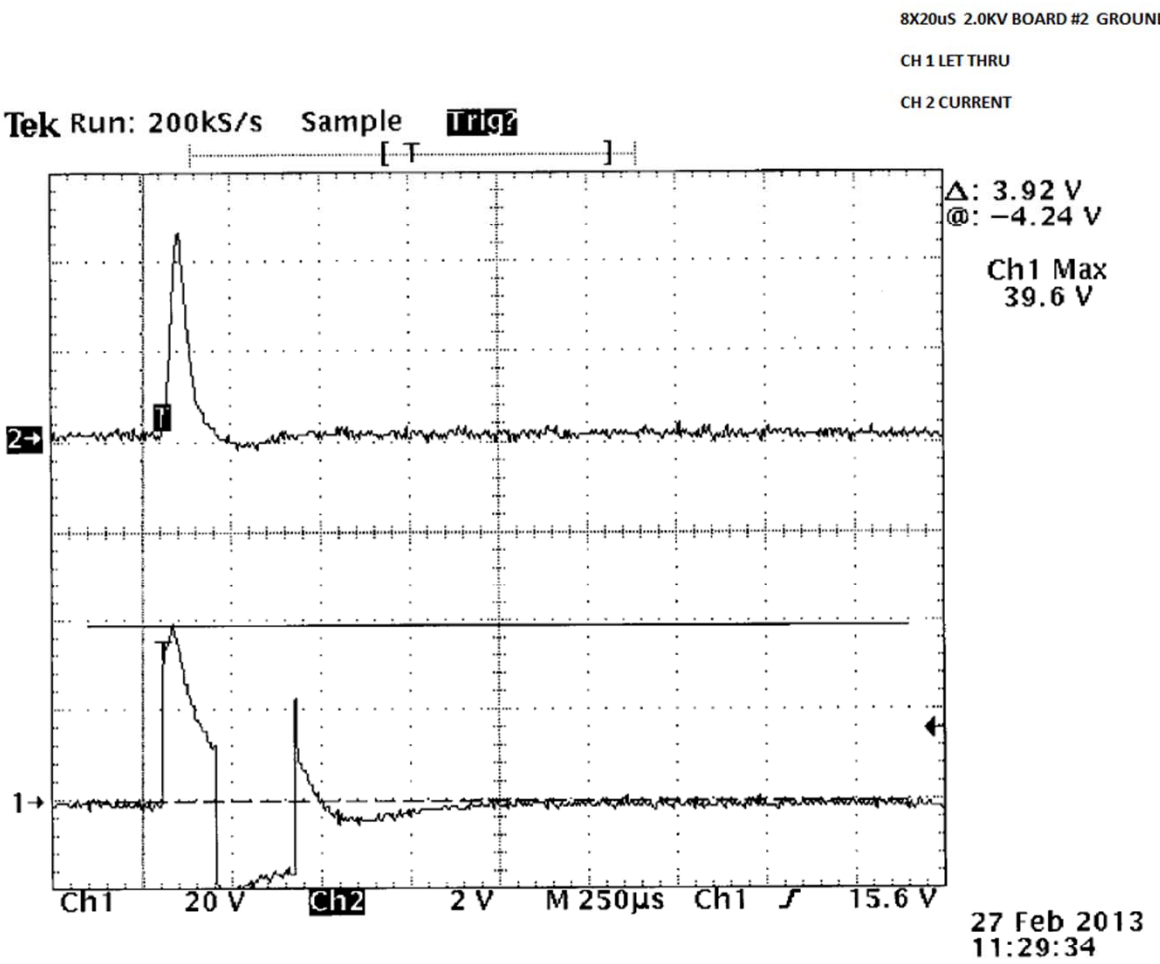
Surge Waveform – 2kV without GND



Ch2: 1V = 100 Amp

tii network technologies

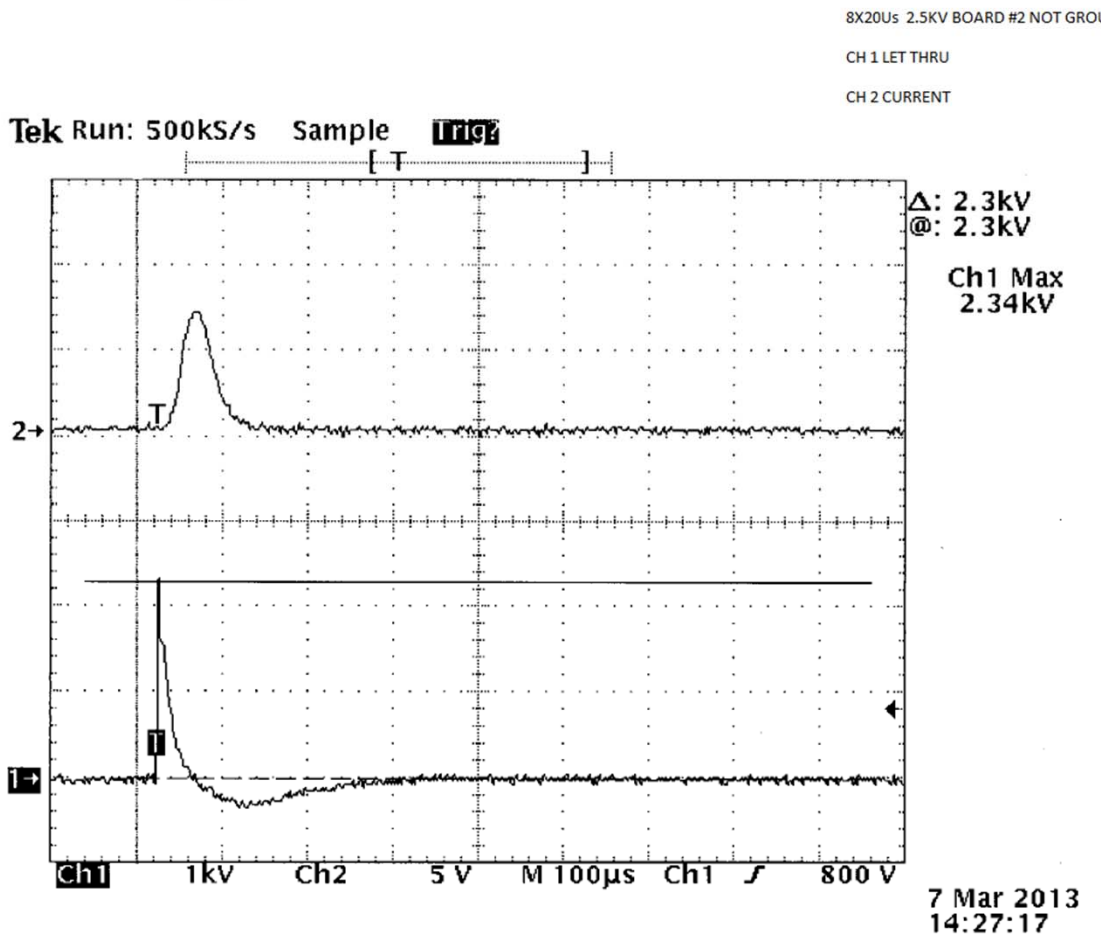
Surge Waveform – 2kV with GND



Ch2: 1V = 100 Amp

tii network technologies

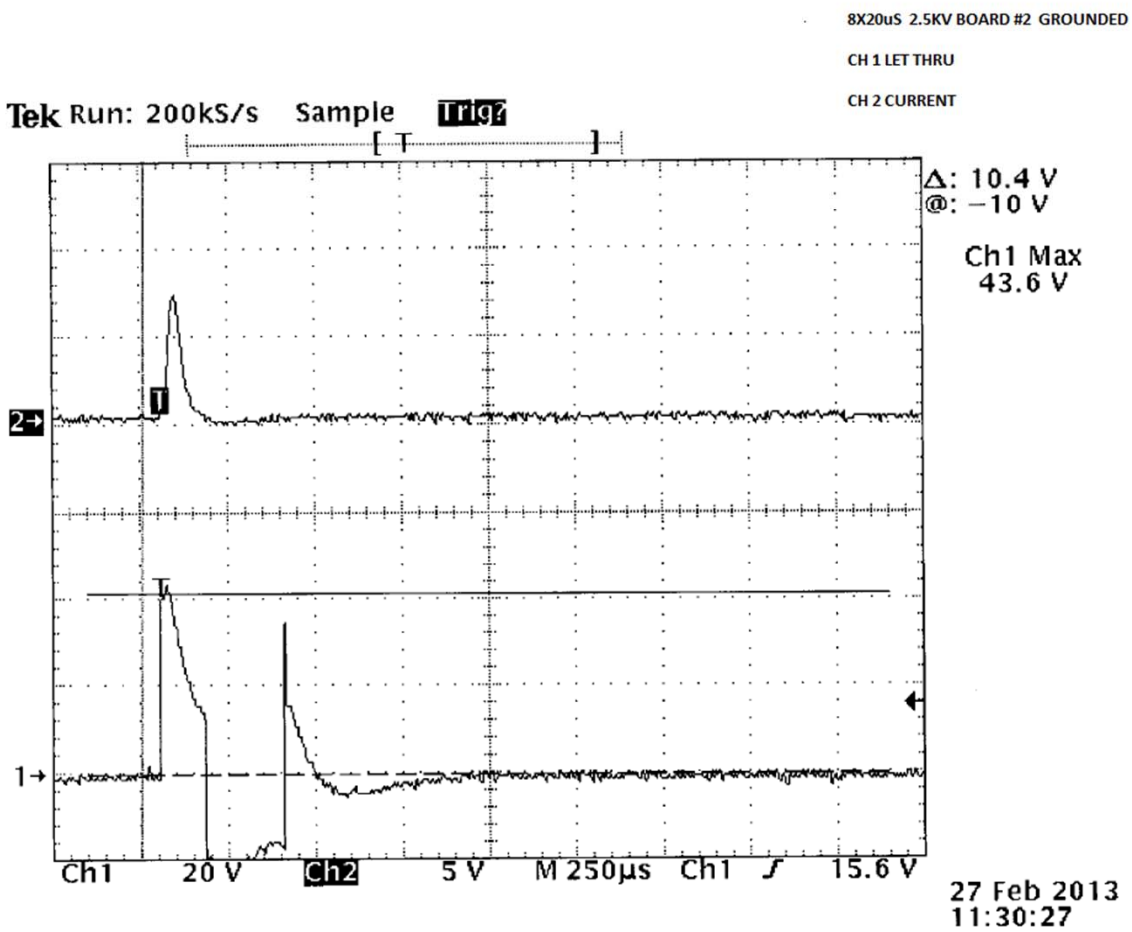
Surge Waveform – 2.5kV without GND



Ch2: 1V = 100 Amp

tii network technologies

Surge Waveform – 2.5kV with GND



Ch2: 1V = 100 Amp

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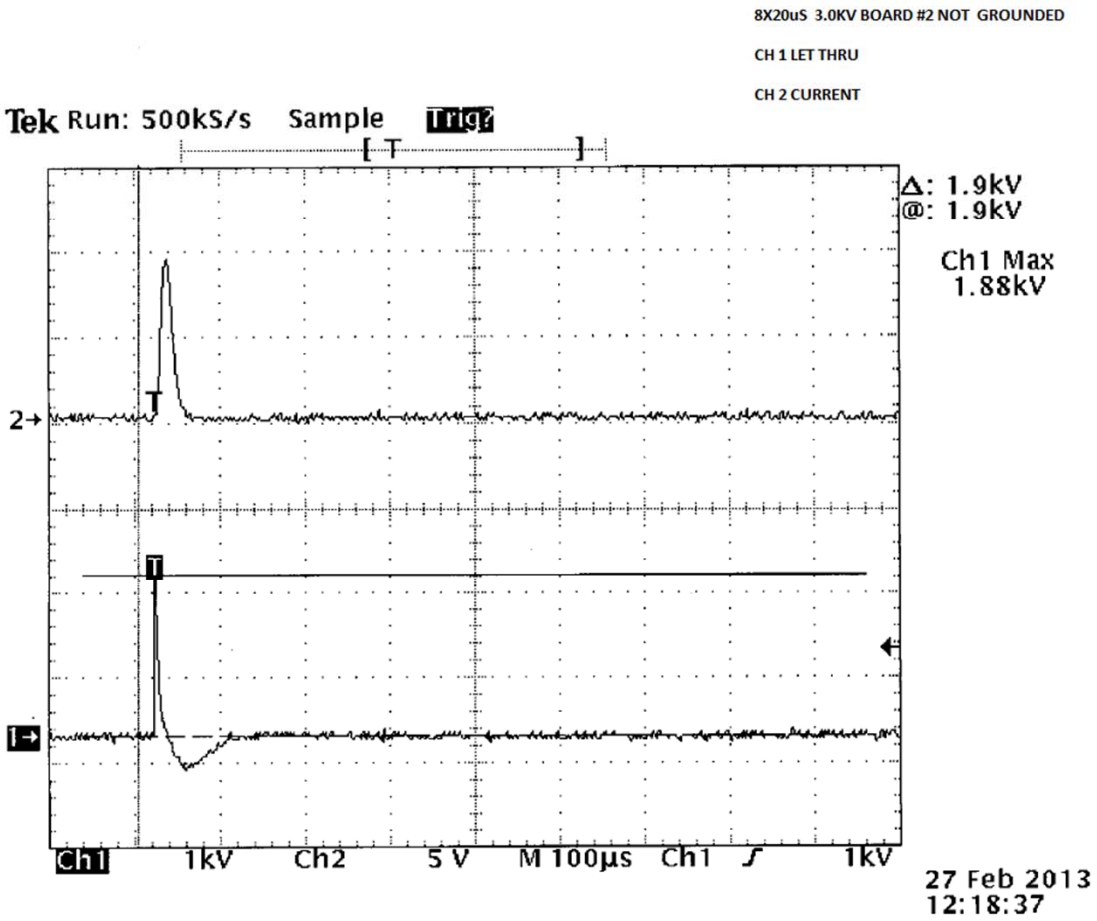
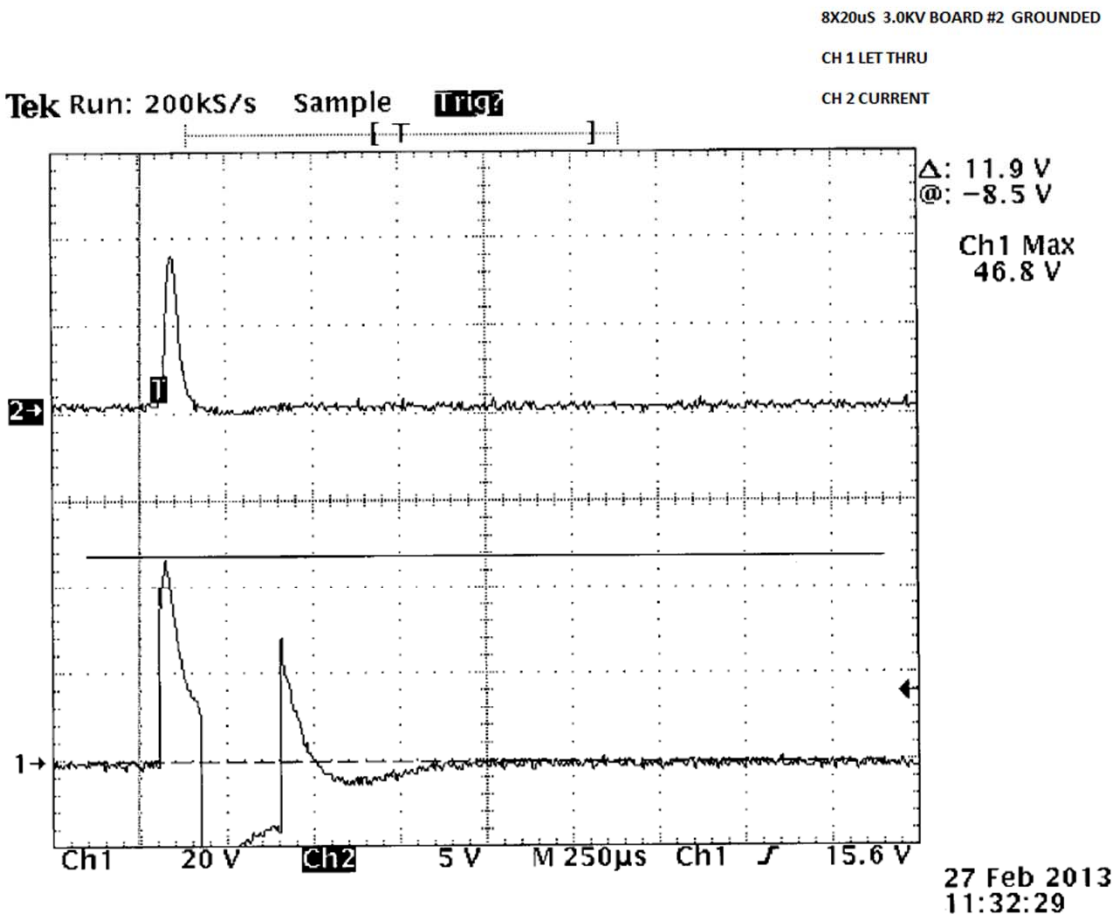
Surge Waveform – 3kV without GND



Ch2: 1V = 100 Amp

tii network technologies

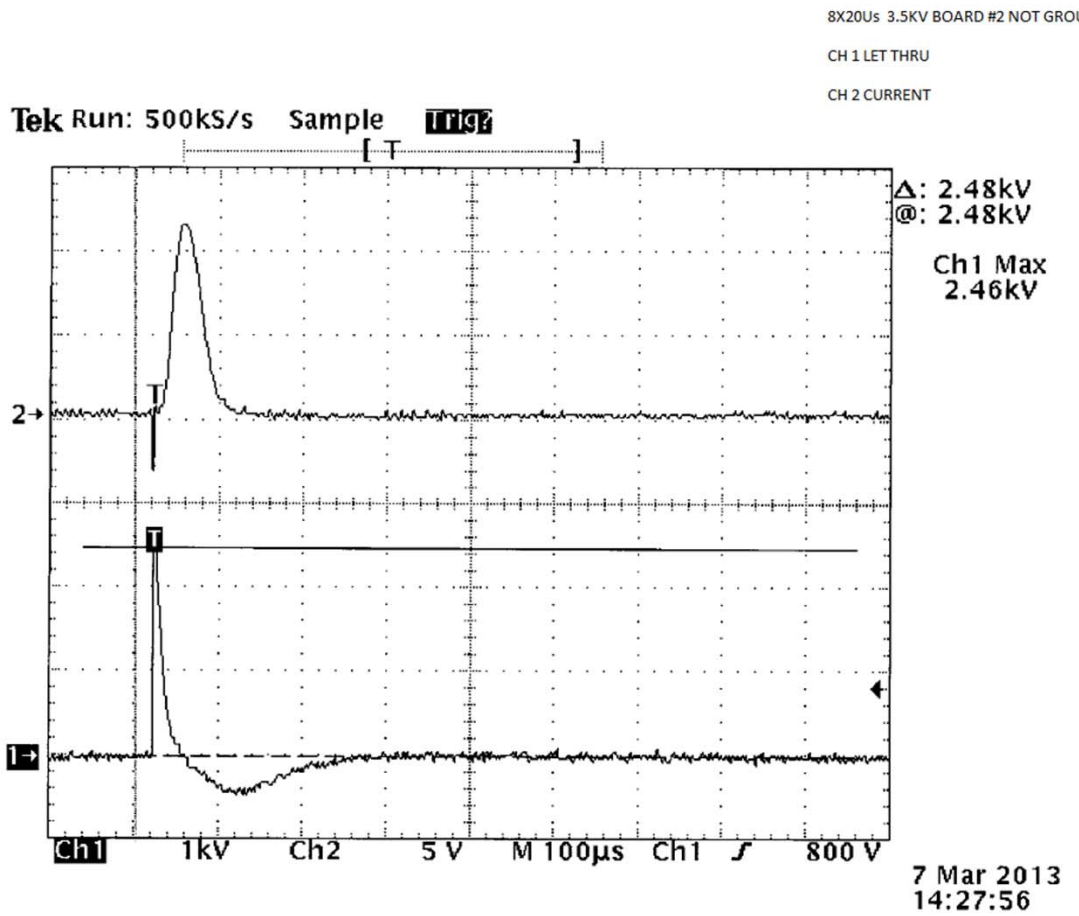
Surge Waveform – 3kV with GND



Ch2: 1V = 100 Amp

tii network technologies

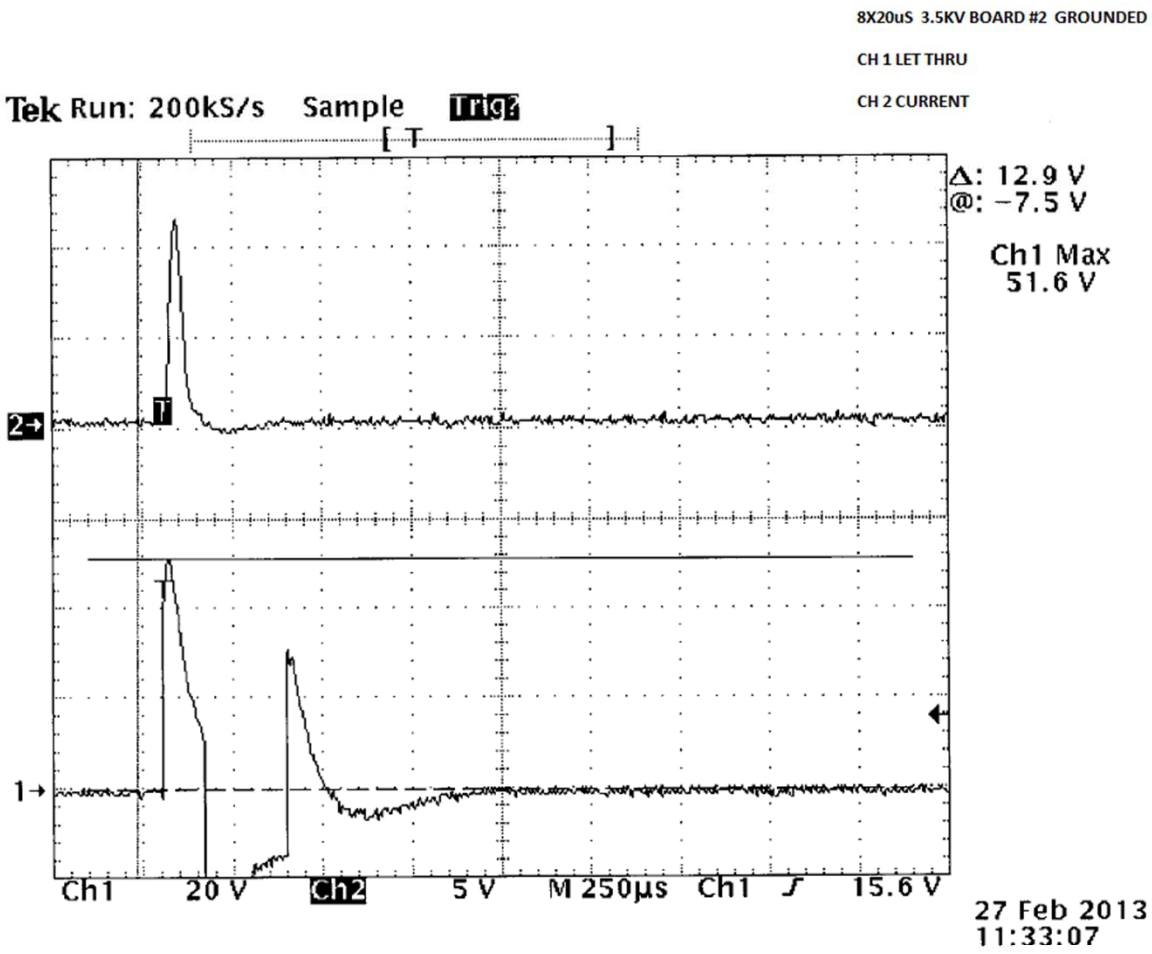
Surge Waveform – 3.5kV without GND



Ch2: 1V = 100 Amp

tii network technologies

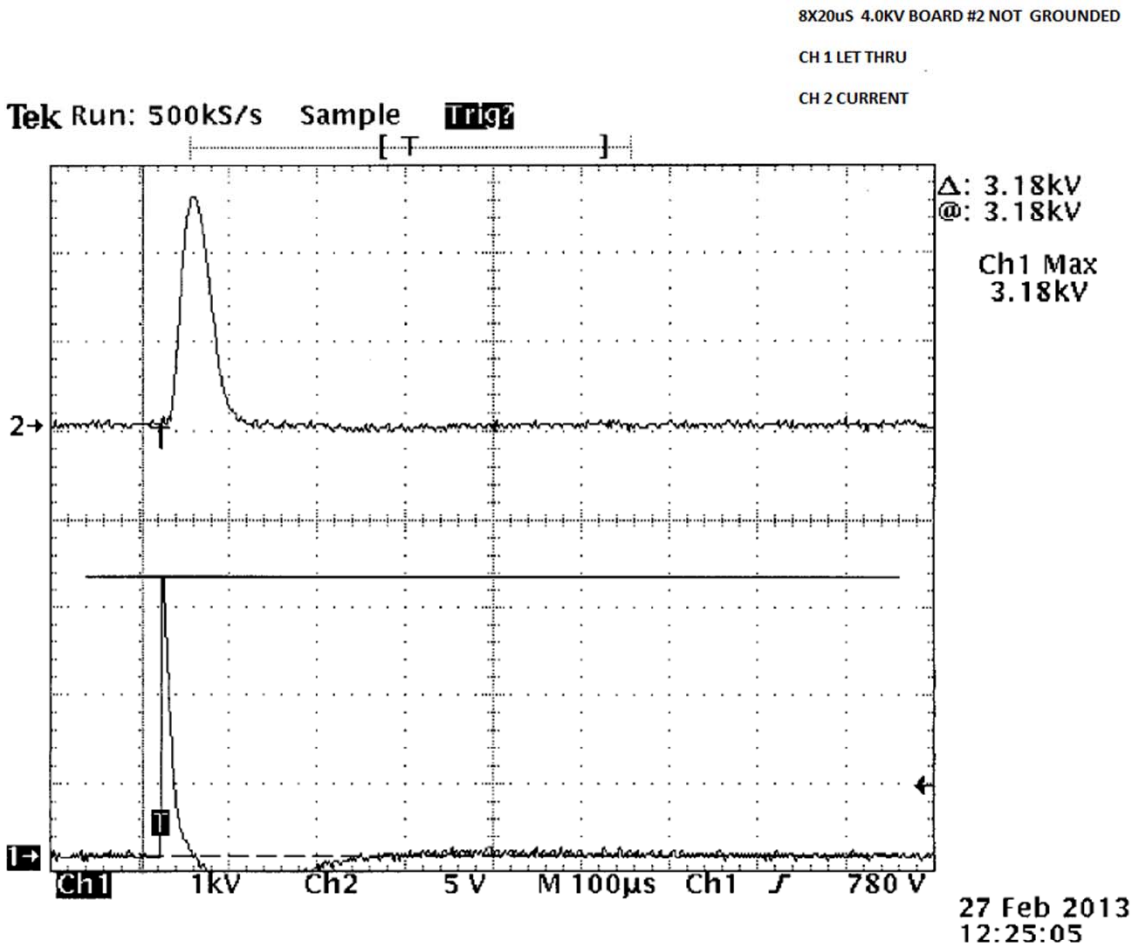
Surge Waveform – 3.5kV with GND



Ch2: 1V = 100 Amp

tii network technologies

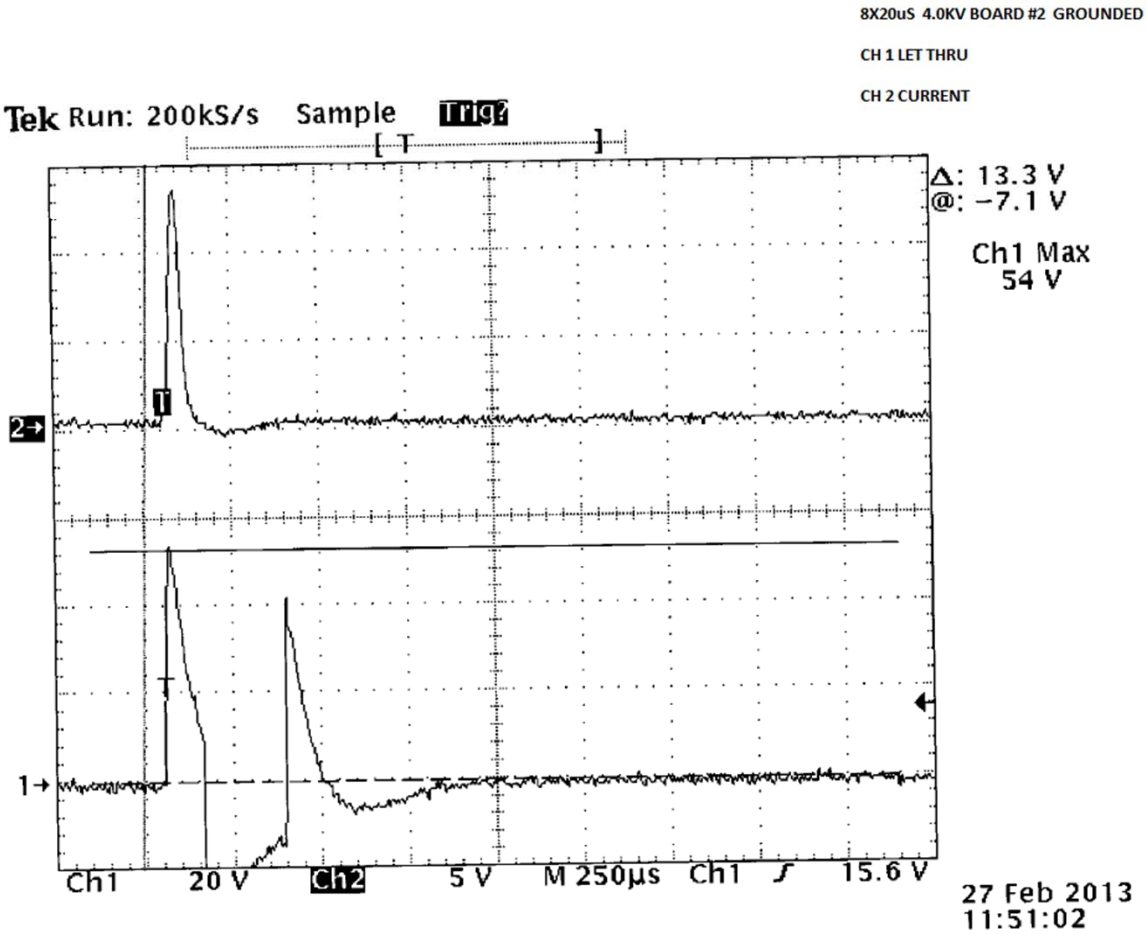
Surge Waveform – 4kV without GND



Ch2: 1V = 100 Amp

tii network technologies

Surge Waveform – 4kV with GND



Ch2: 1V = 100 Amp

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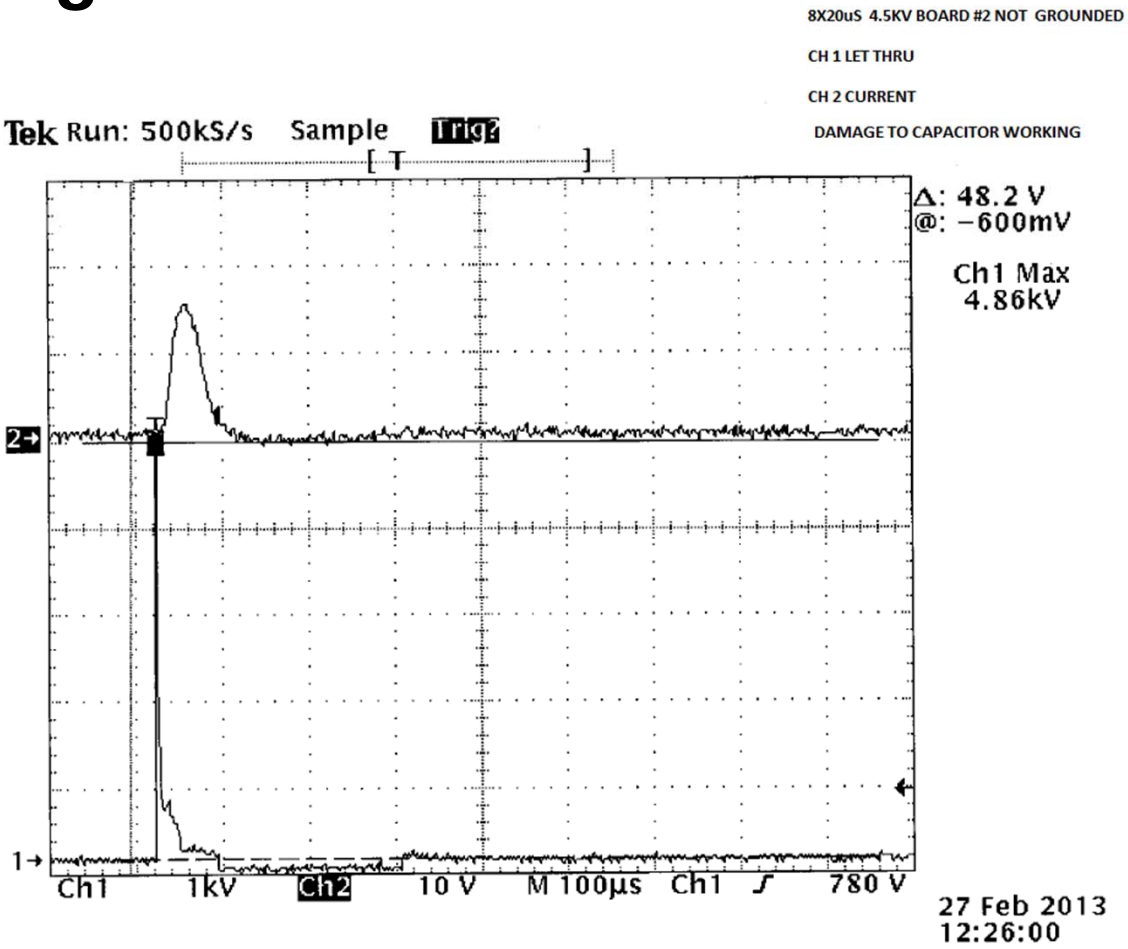
Surge Waveform – 4.5kV without GND

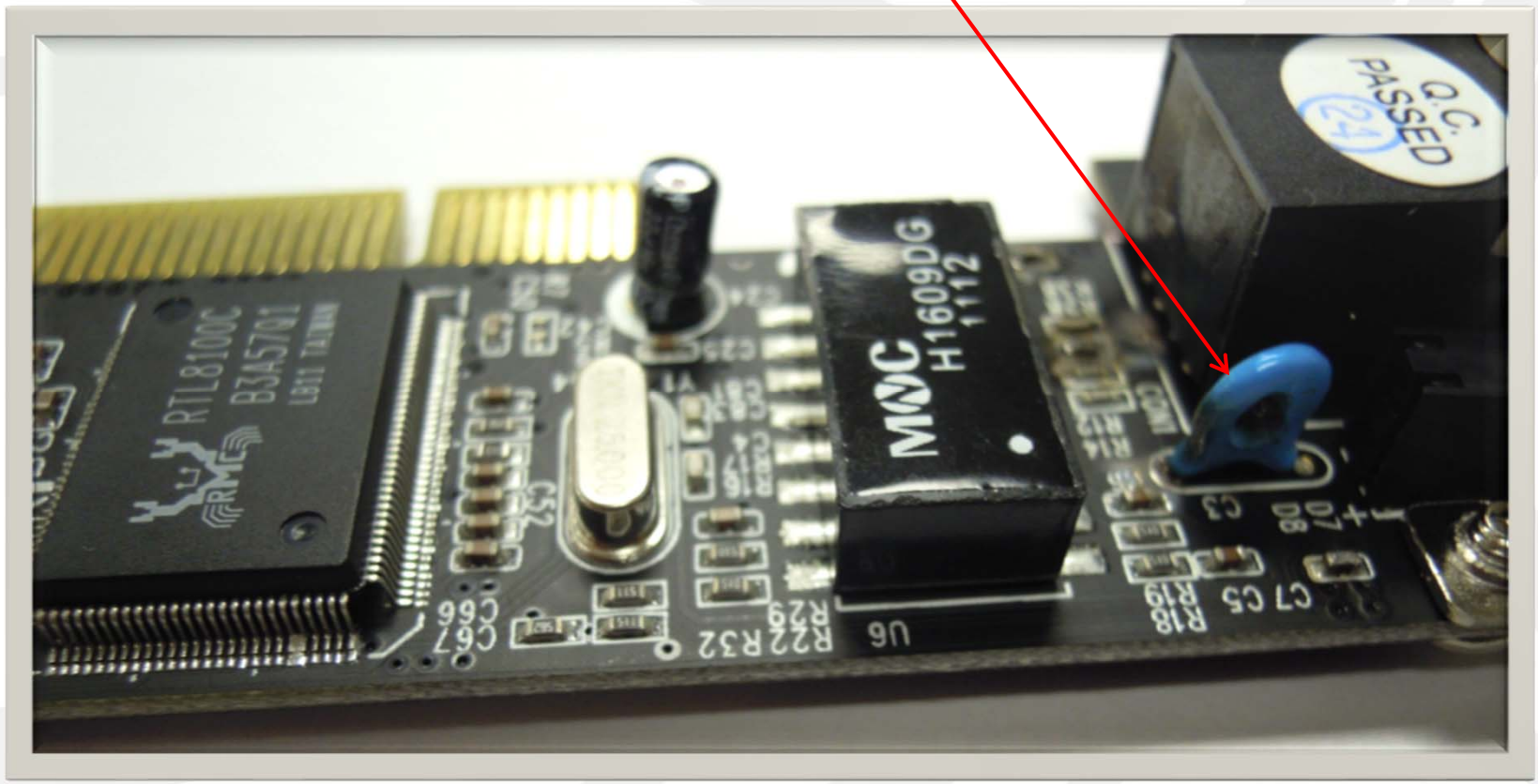


Ch2: 1V = 100 Amp

tii network technologies

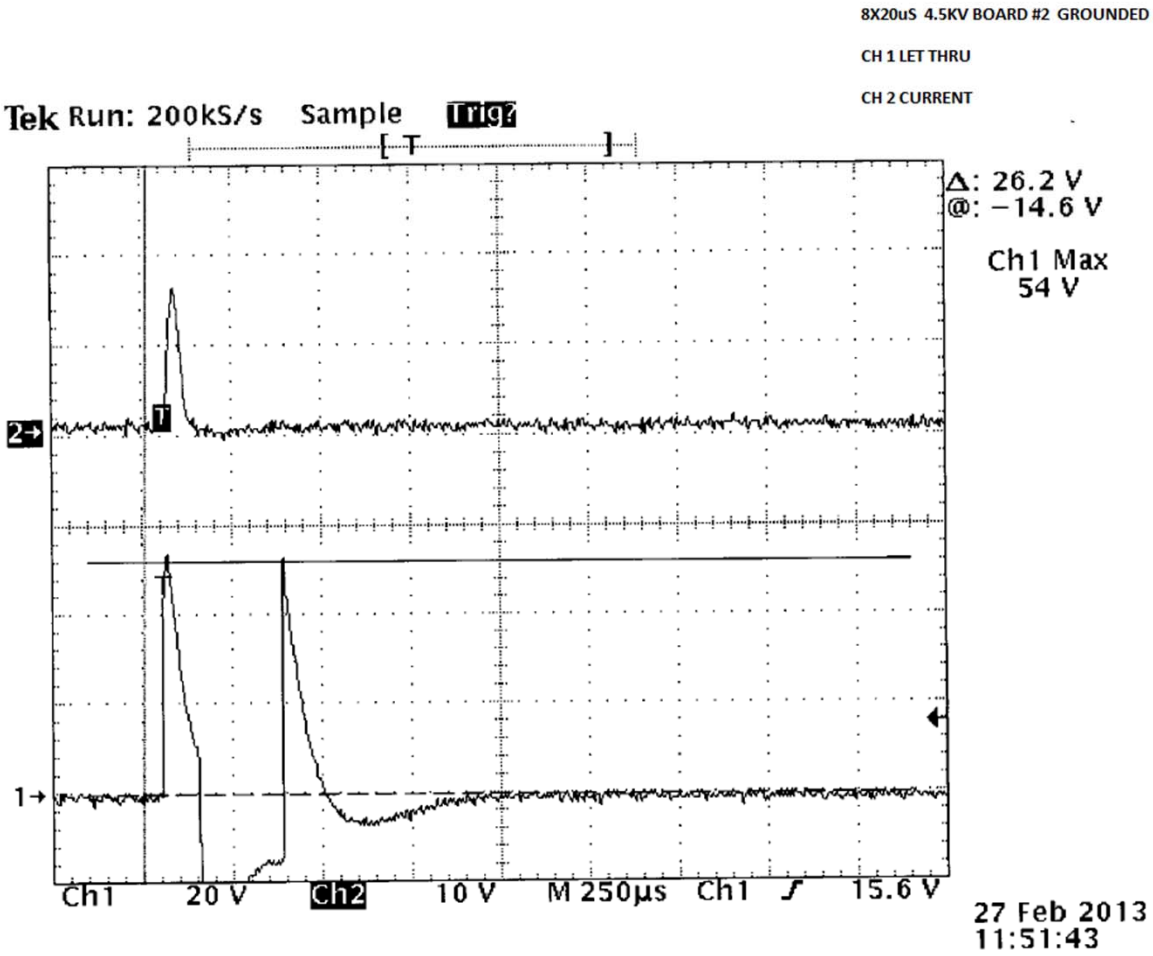
Surge Waveform – 4.5kV without GND

Damage to Capacitor C3



tii network technologies

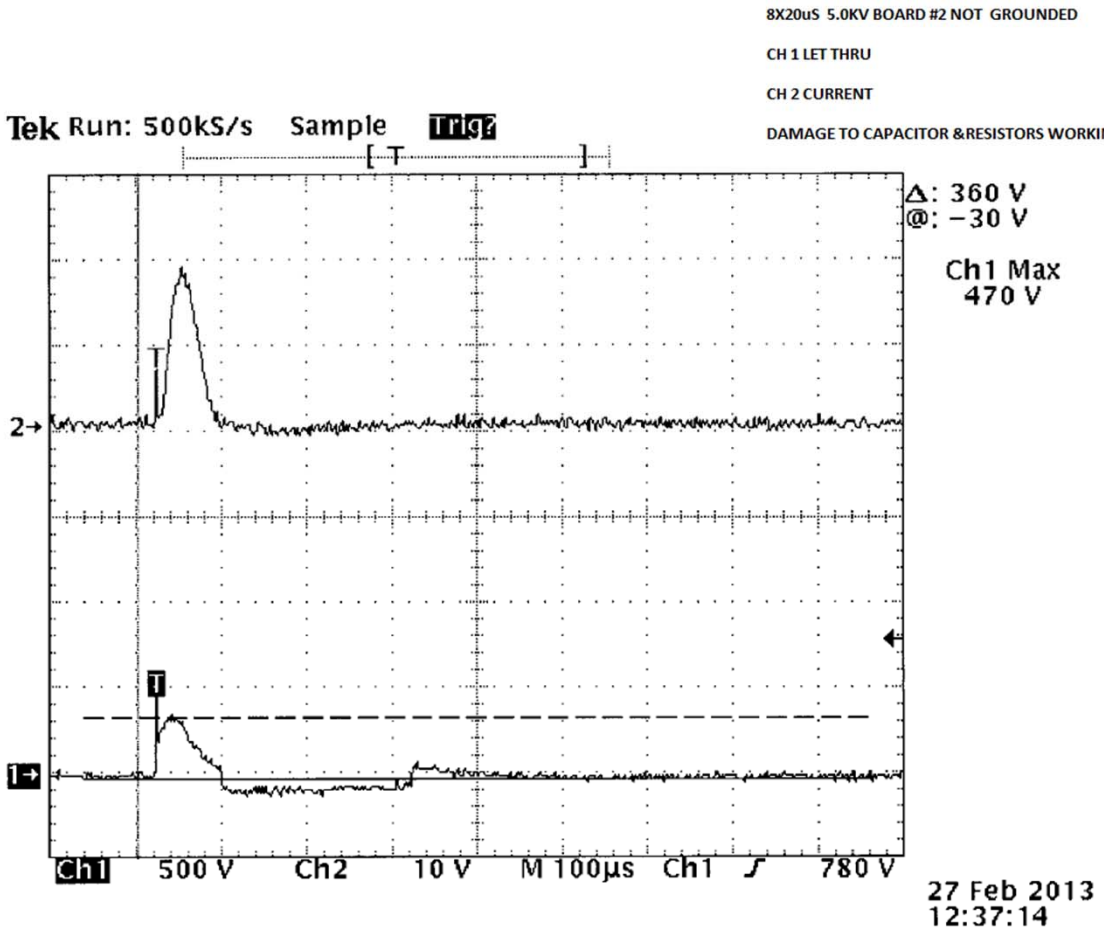
Surge Waveform – 4.5kV with GND



Ch2: 1V = 100 Amp

tii network technologies

Surge Waveform – 5kV without GND

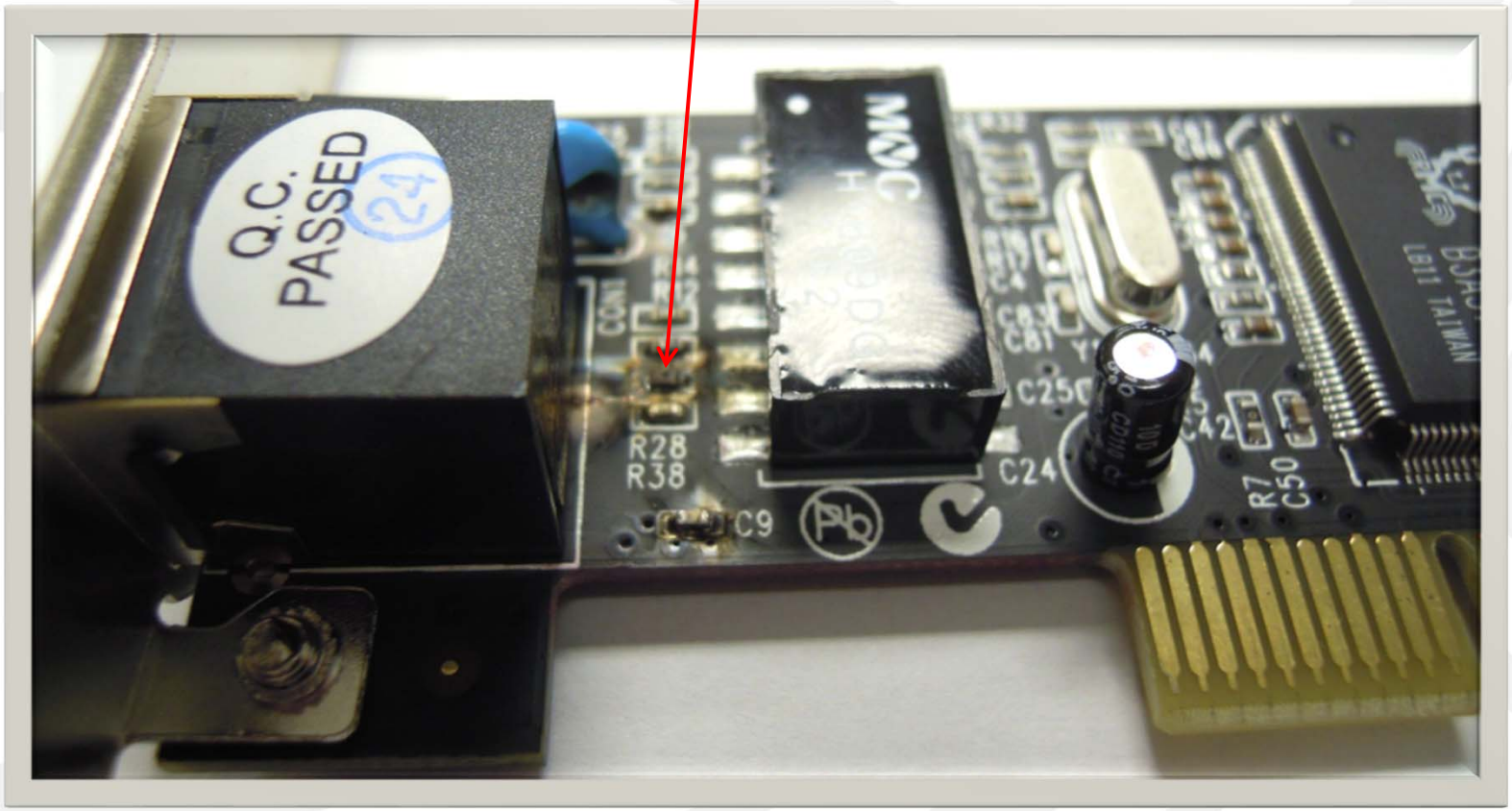


Ch2: 1V = 100 Amp

tii network technologies

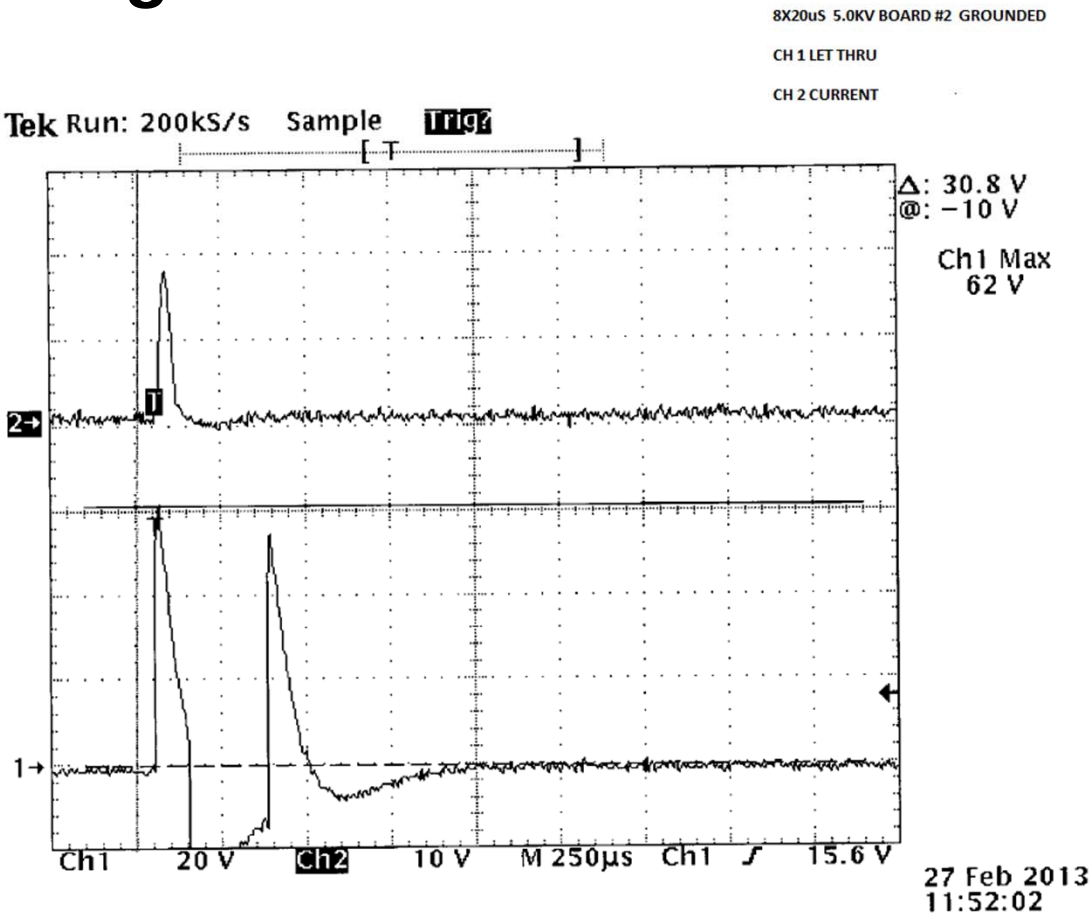
Surge Waveform – 5kV without GND

Damage to Resistor R28



tii network technologies

Surge Waveform – 5kV with GND



Ch2: 1V = 100 Amp

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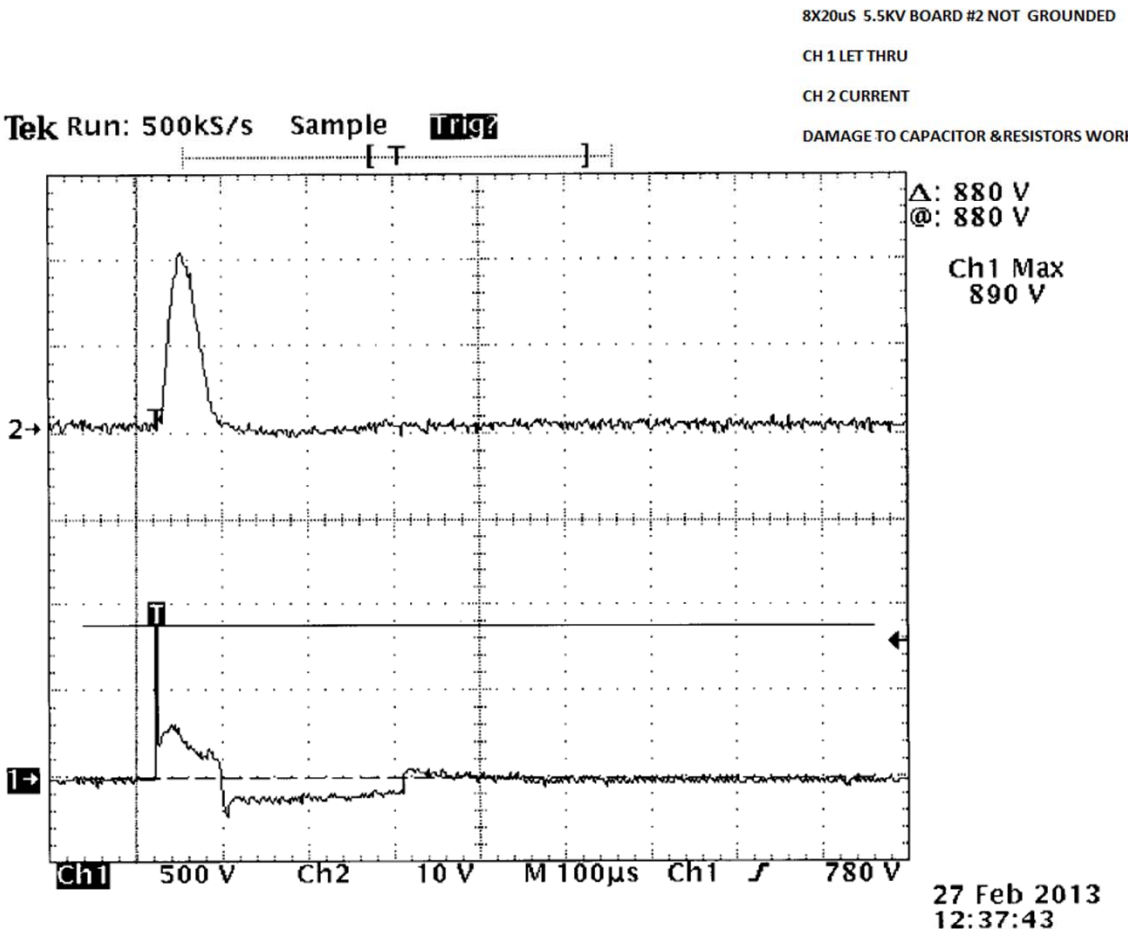
Surge Waveform – 5.5kV without GND



Ch2: 1V = 100 Amp

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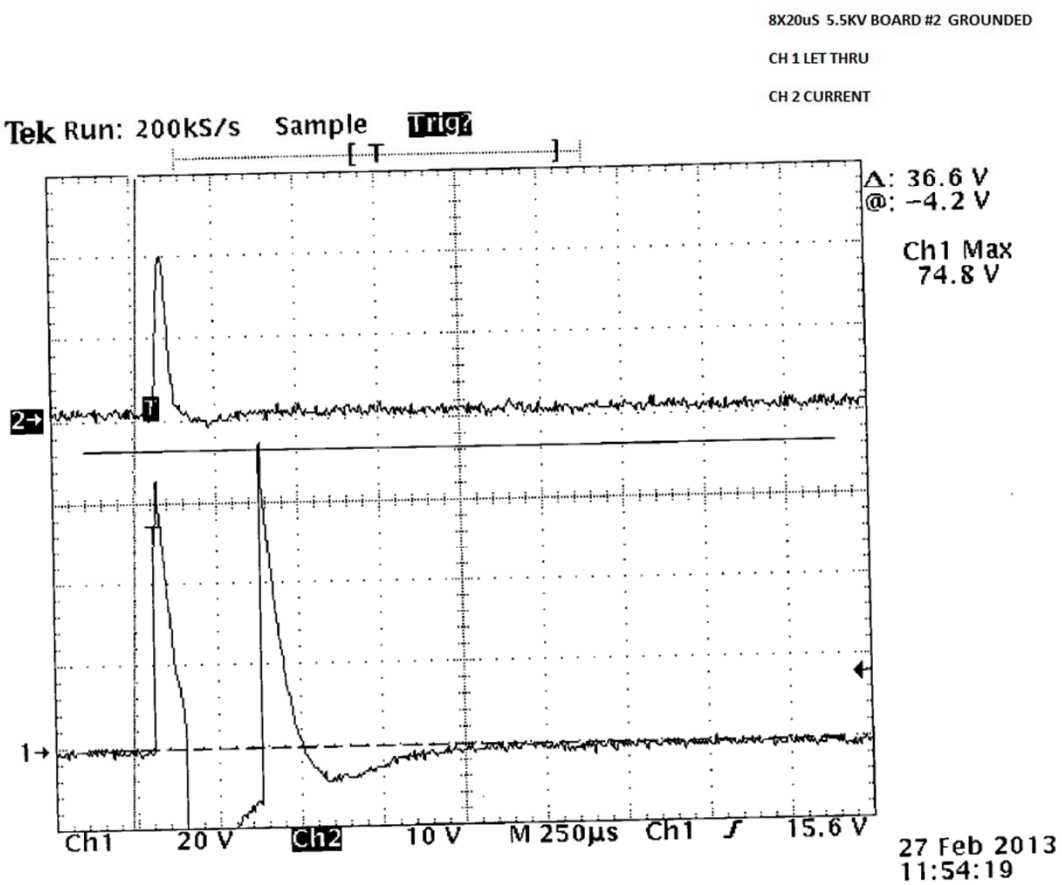
Surge Waveform – 5.5kV with GND



Ch2: 1V = 100 Amp

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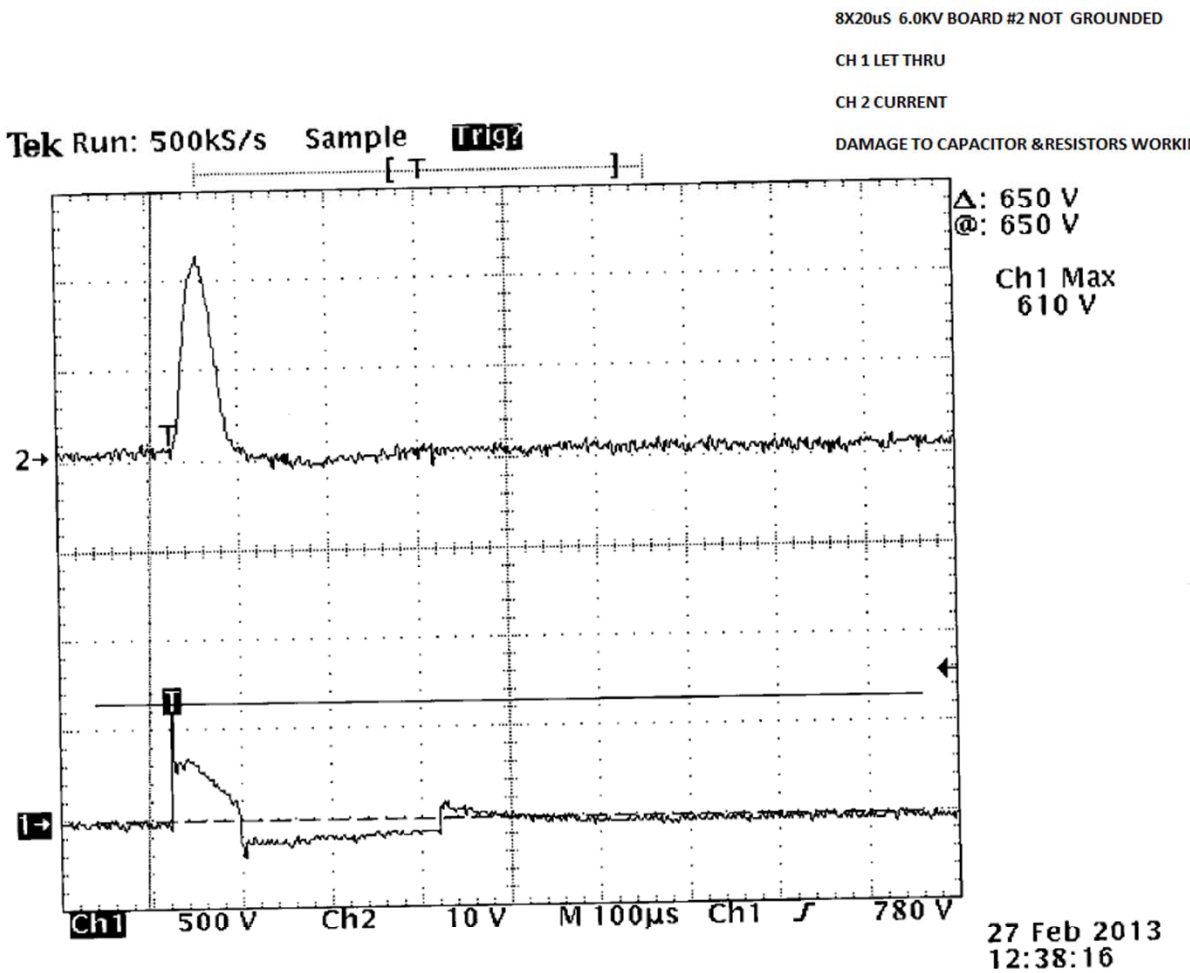
Surge Waveform – 6kV without GND

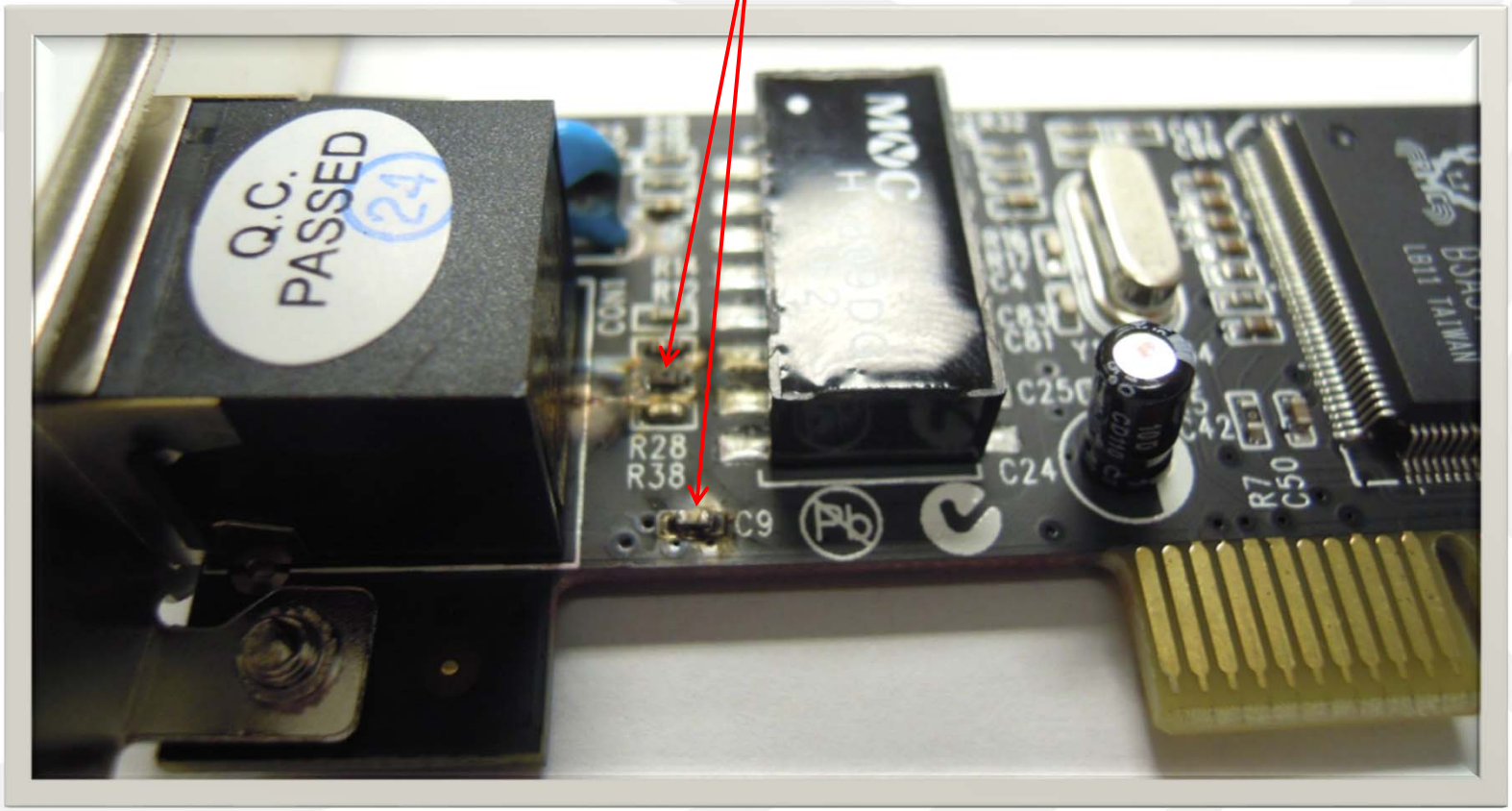


Ch2: 1V = 100 Amp

tii network technologies

Surge Waveform – 6kV without GND

Damage to R28 and C9



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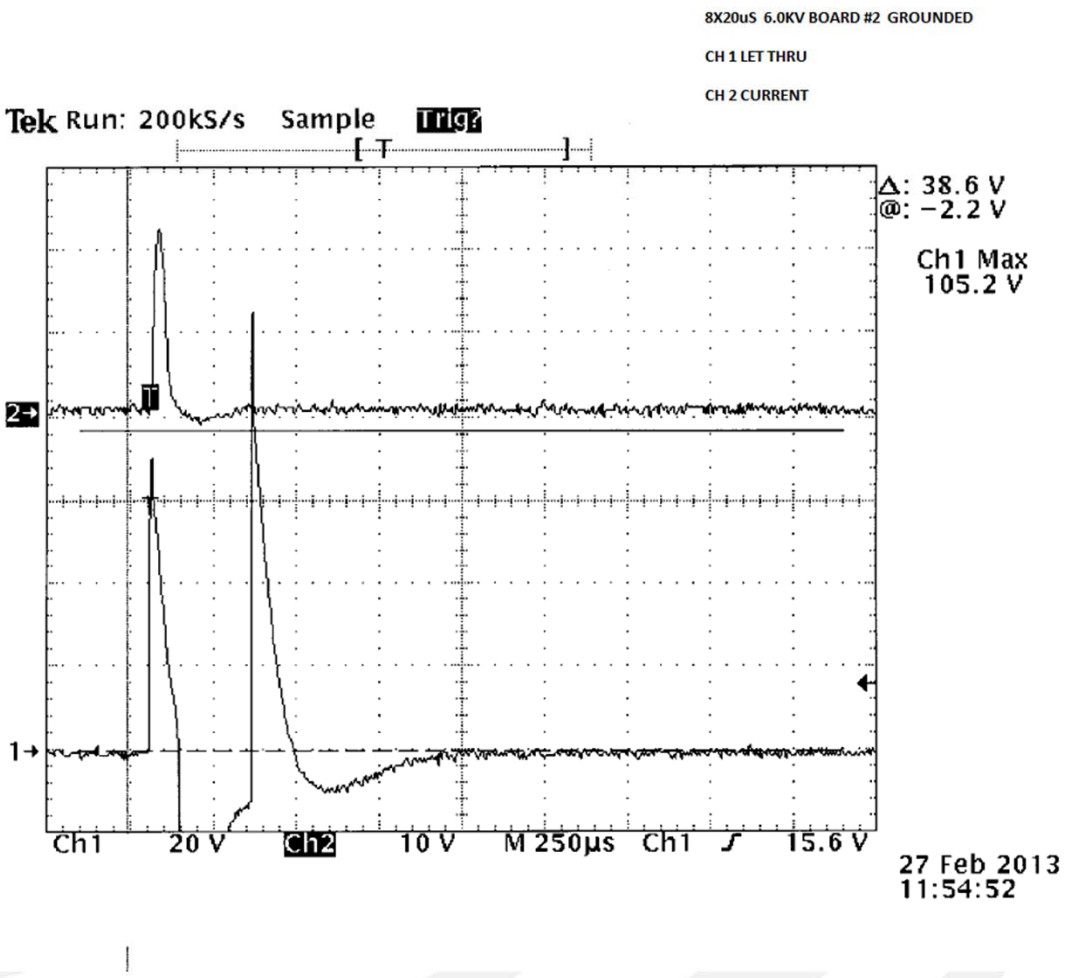
Surge Waveform – 6kV with GND



Ch2: 1V = 100 Amp

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Protection Circuit 2 Test Results

No Ground Connection:

NIC cards got damaged when surge voltages approached 4000 volts or higher.

With Ground Connection:

No damage suffered by the NIC cards when Ground connection was present.

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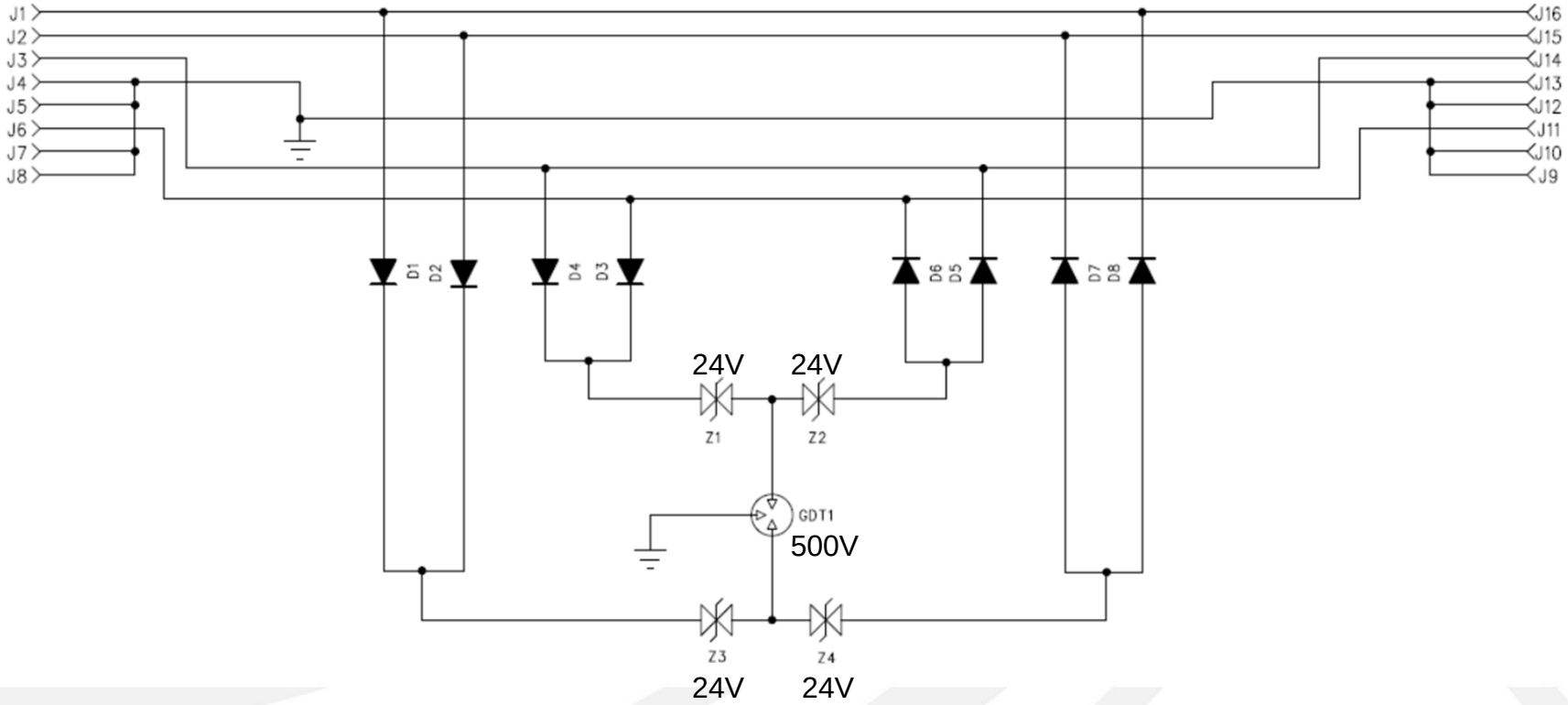
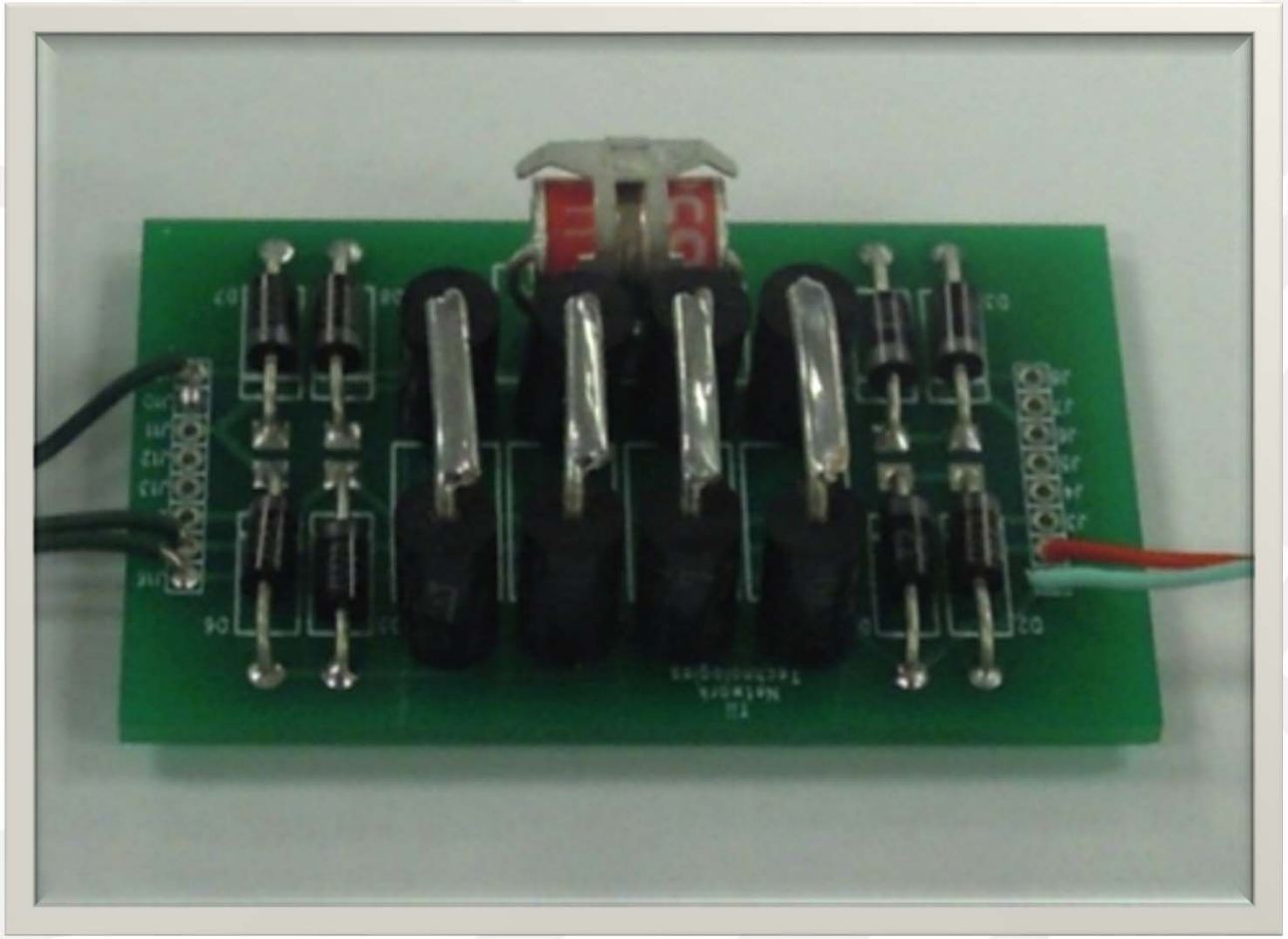
Circuit # 3



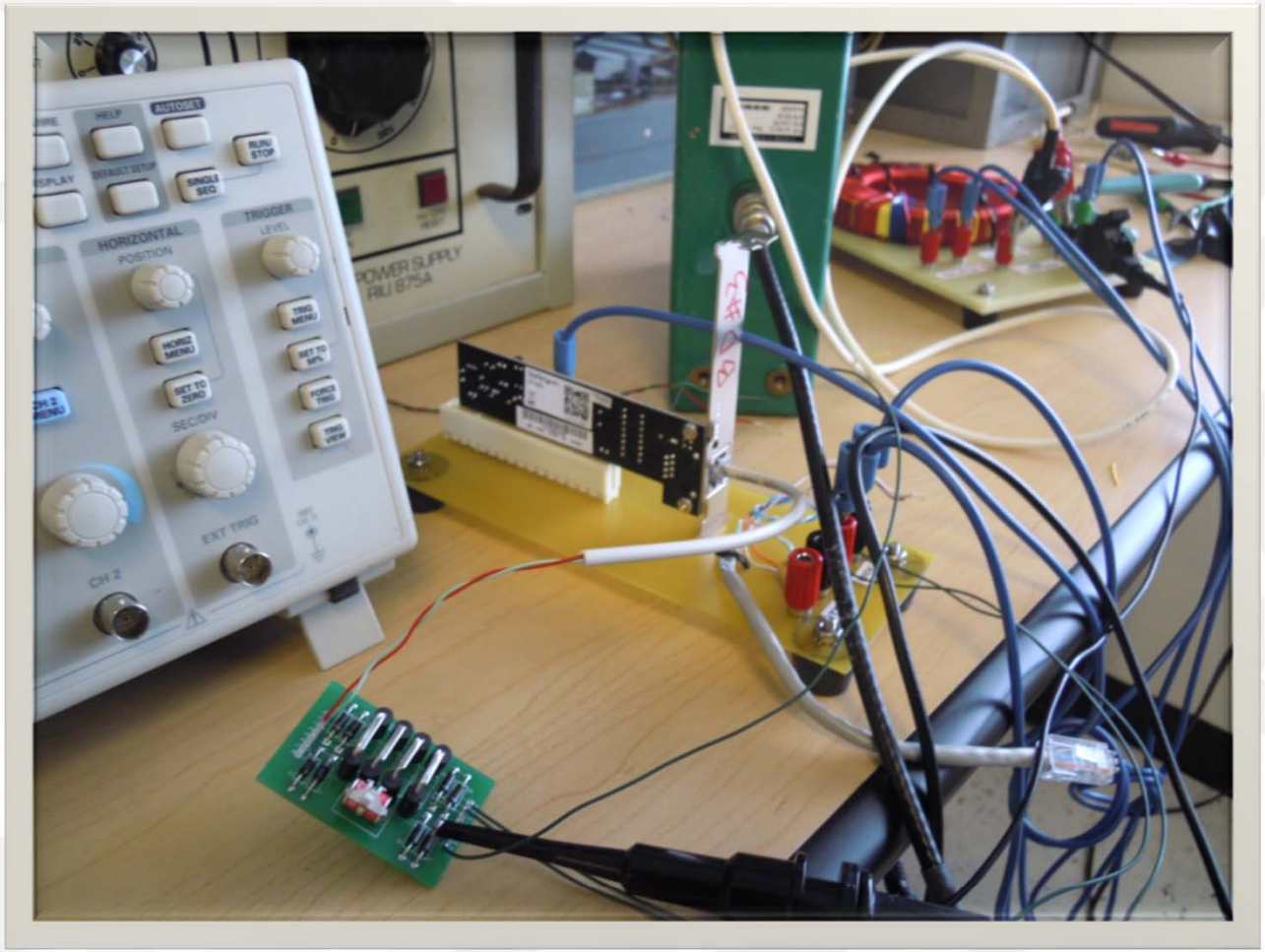
tii network technologies

Circuit # 3Test Board



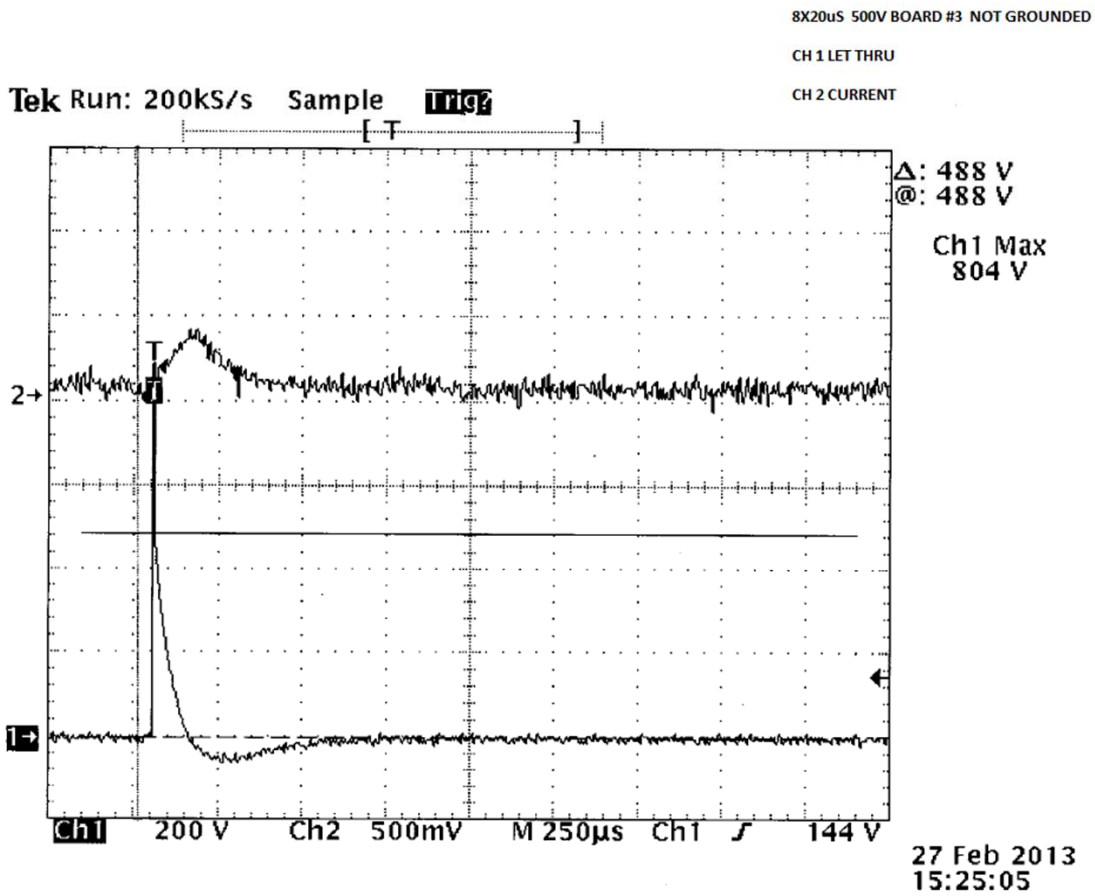
tii network technologies

Circuit # 3Test Configuration



tii network technologies

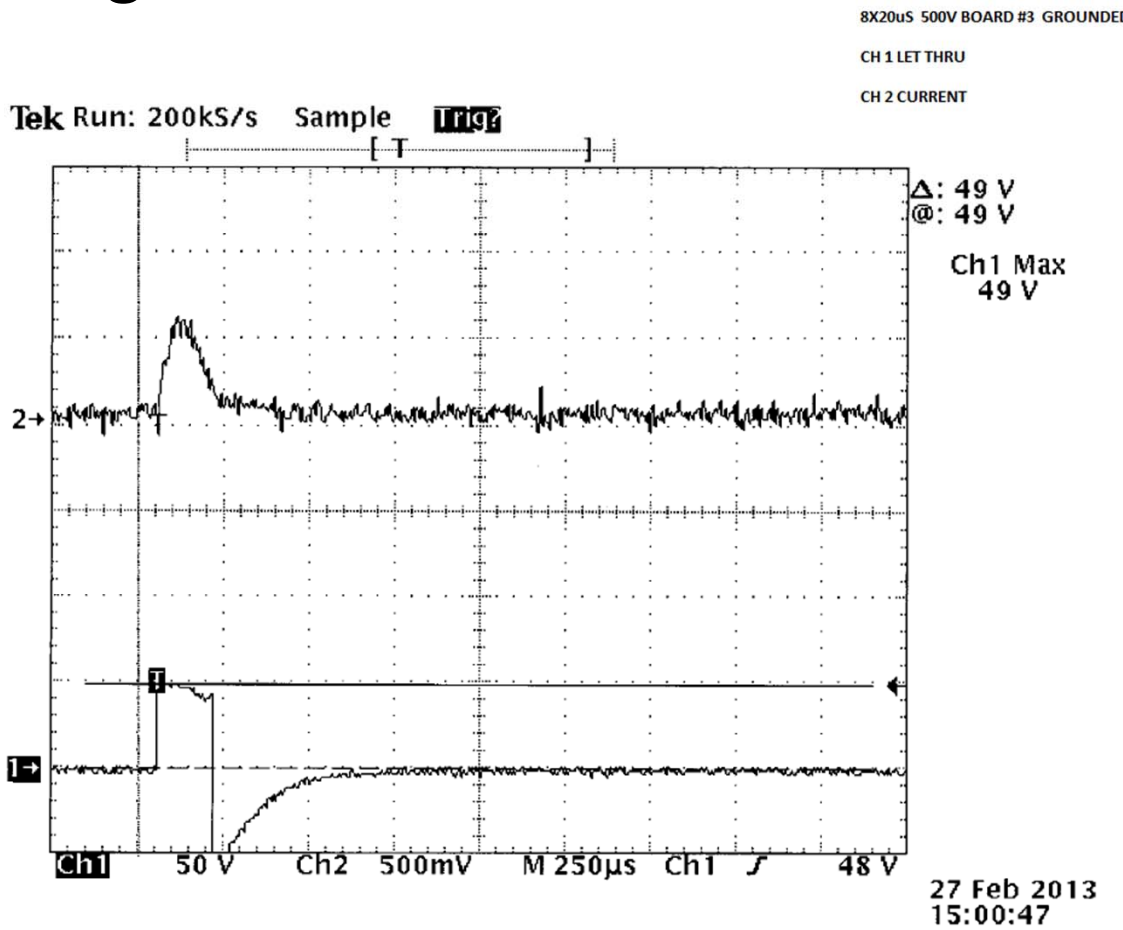
Surge Waveform – 500V without GND



Ch2: 1V = 100 Amp

tii network technologies

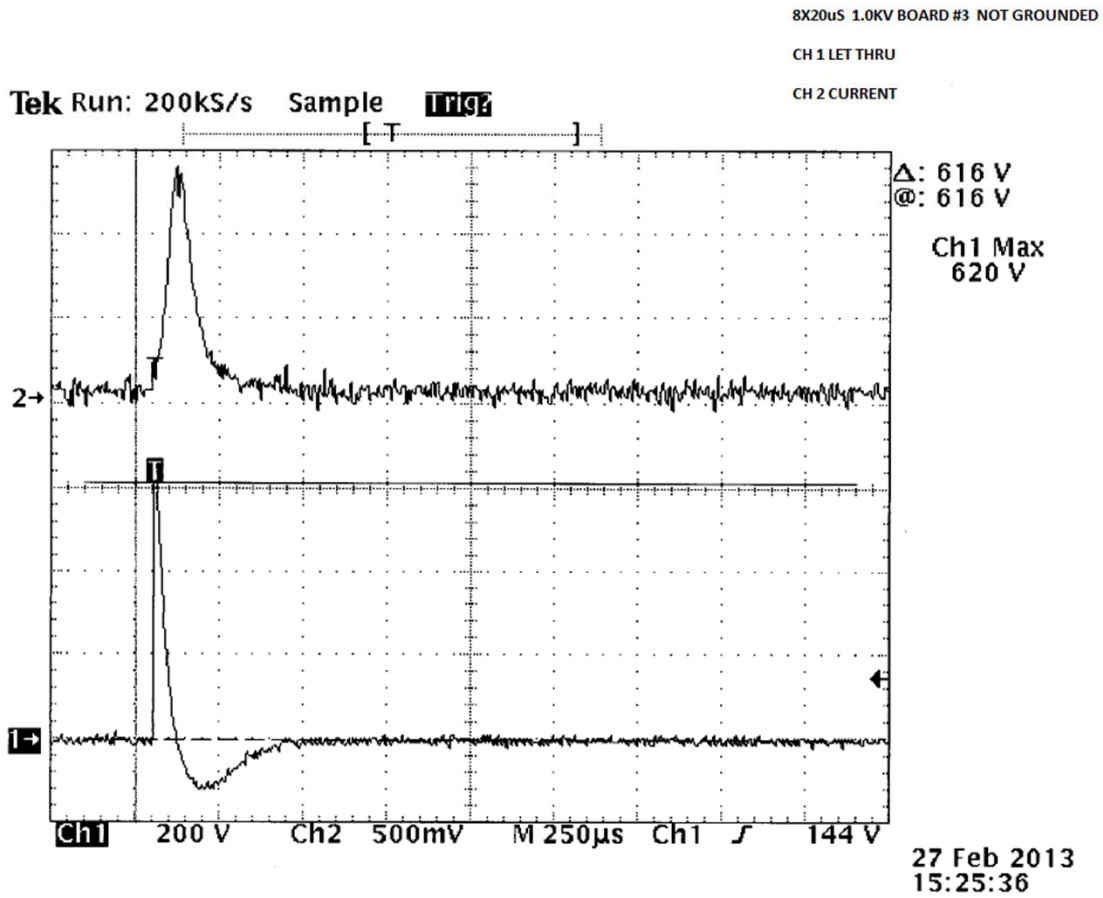
Surge Waveform – 500V with GND



Ch2: 1V = 100 Amp

tii network technologies

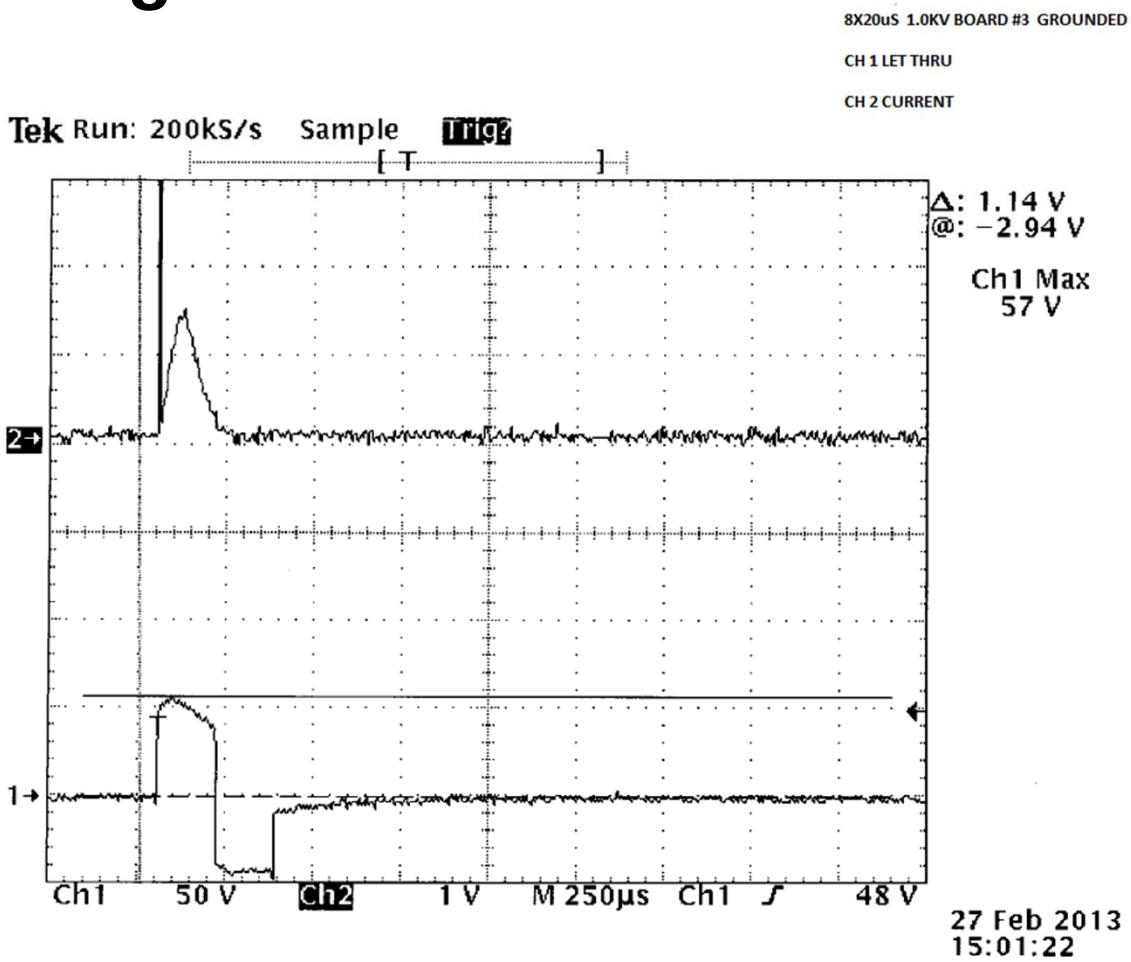
Surge Waveform – 1kV without GND



Ch2: 1V = 100 Amp

tii network technologies

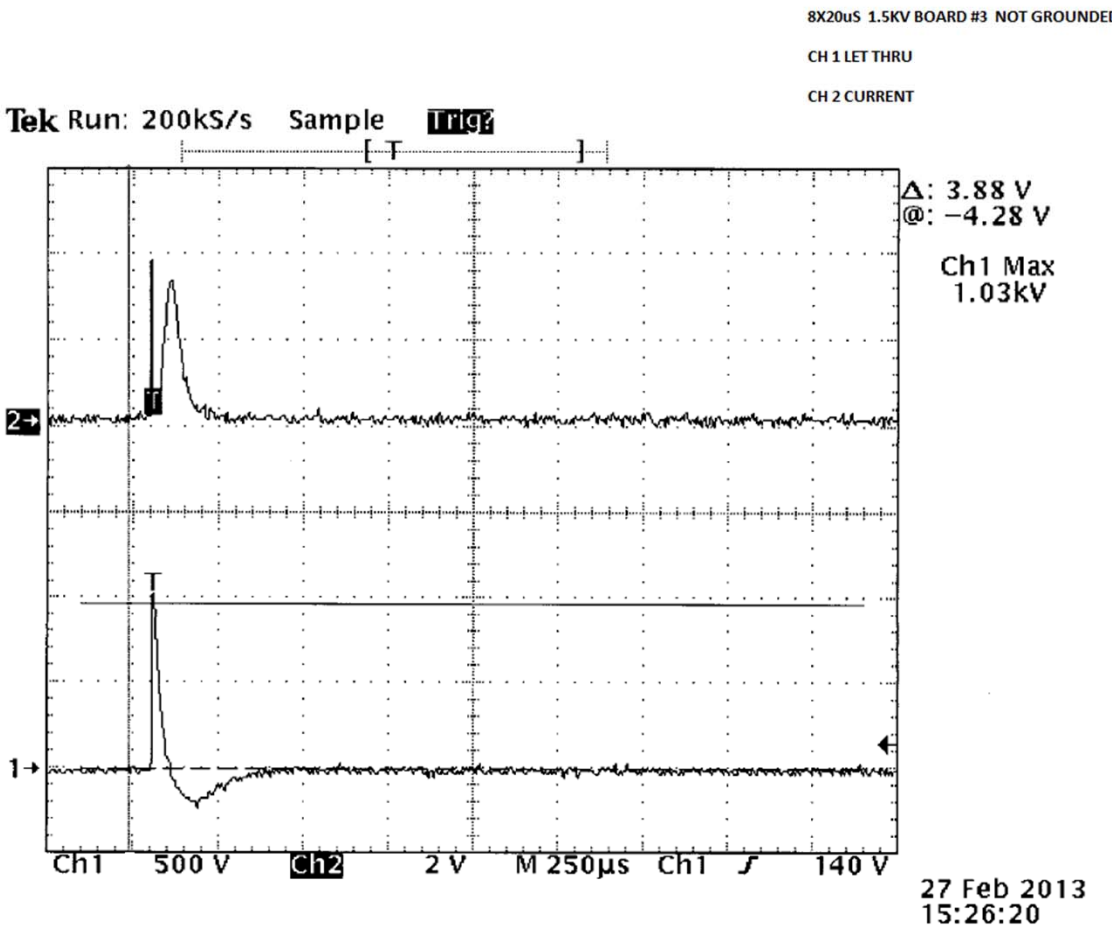
Surge Waveform – 1kV with GND



Ch2: 1V = 100 Amp

tii network technologies

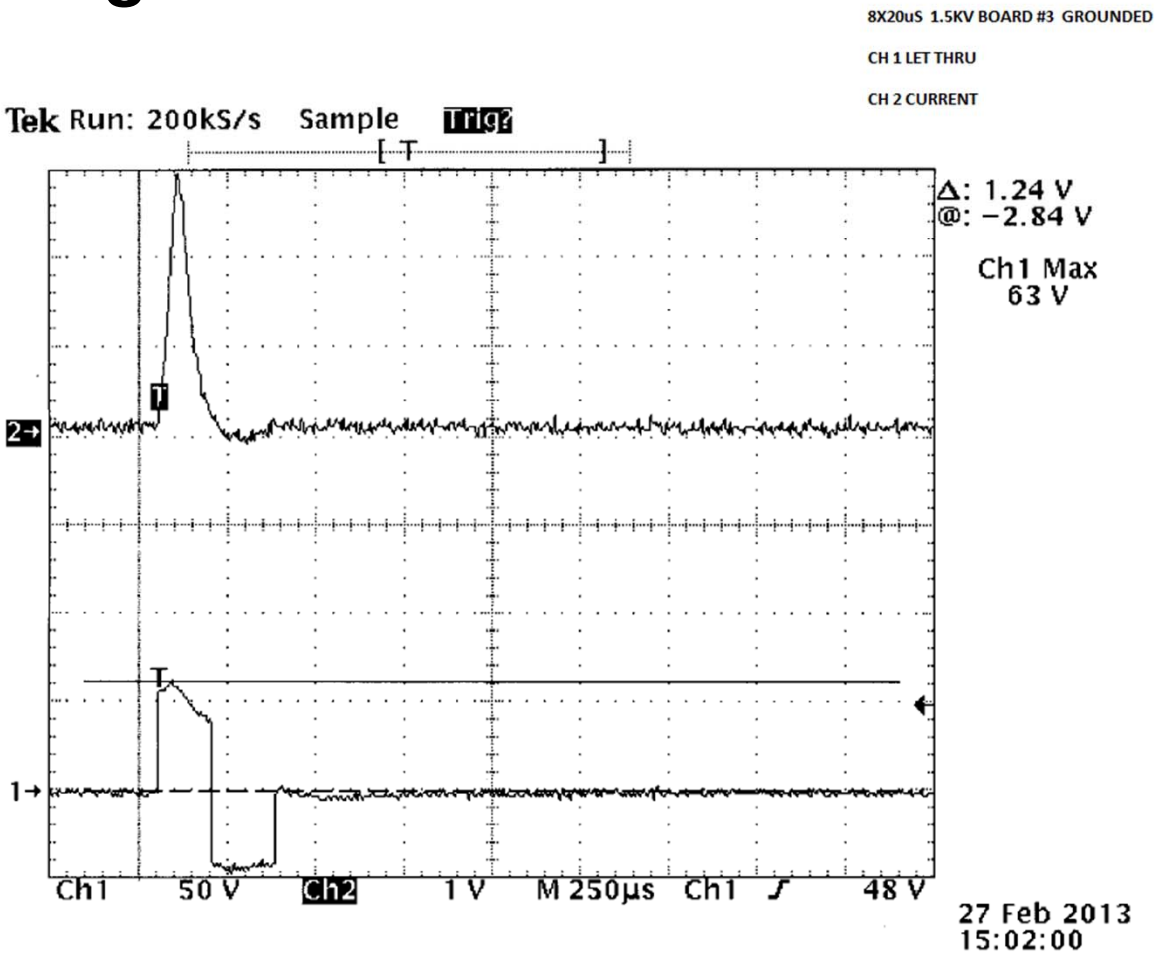
Surge Waveform – 1.5kV without GND



Ch2: 1V = 100 Amp

tii network technologies

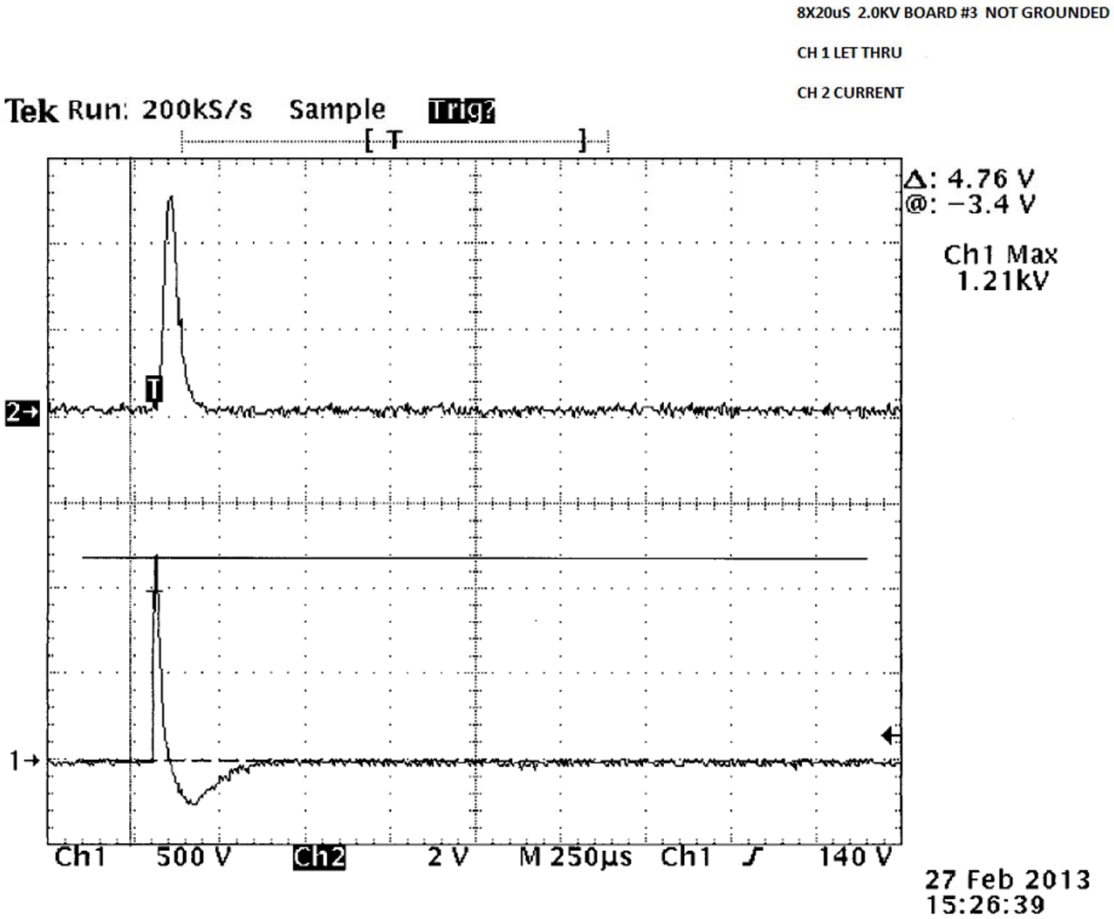
Surge Waveform – 1.5kV with GND



Ch2: 1V = 100 Amp

tii network technologies

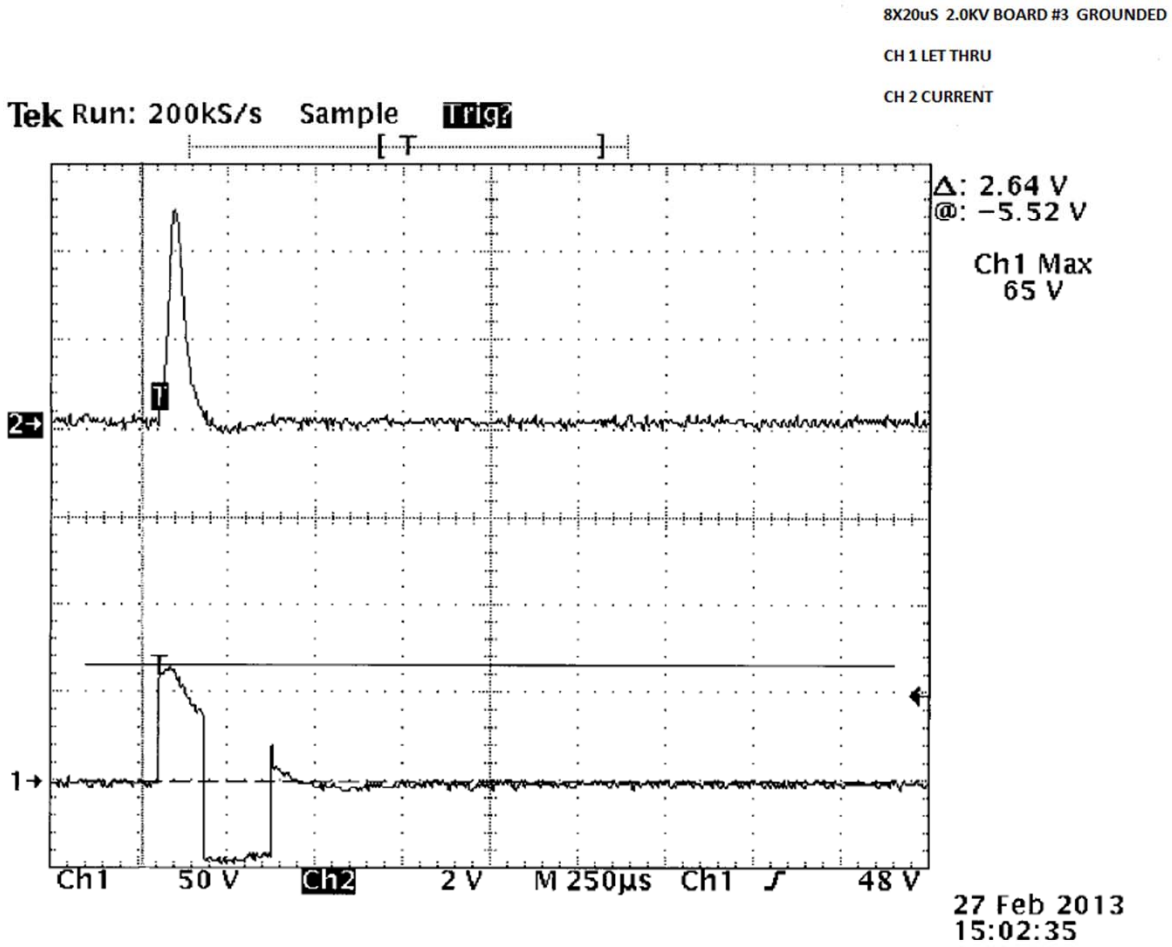
Surge Waveform – 2kV without GND



Ch2: 1V = 100 Amp

tii network technologies

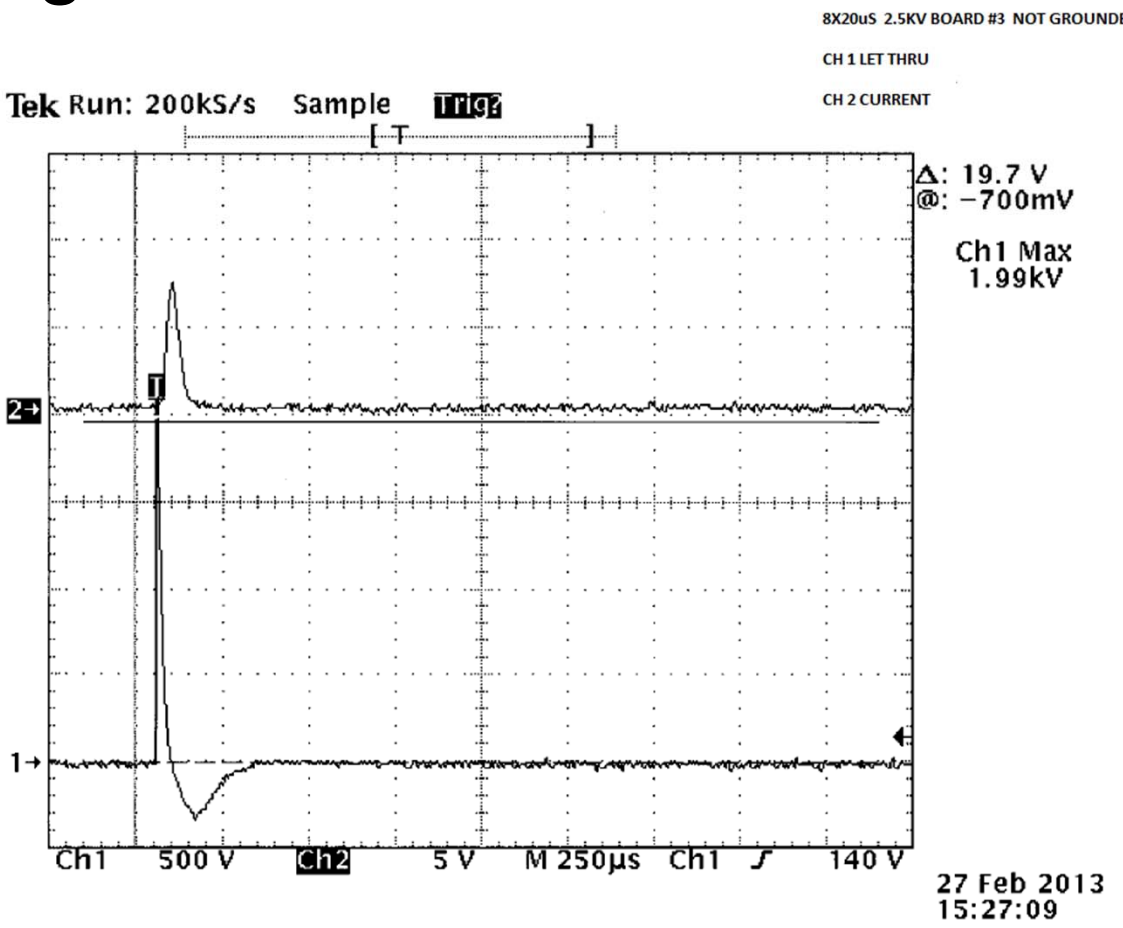
Surge Waveform – 2kV with GND



Ch2: 1V = 100 Amp

tii network technologies

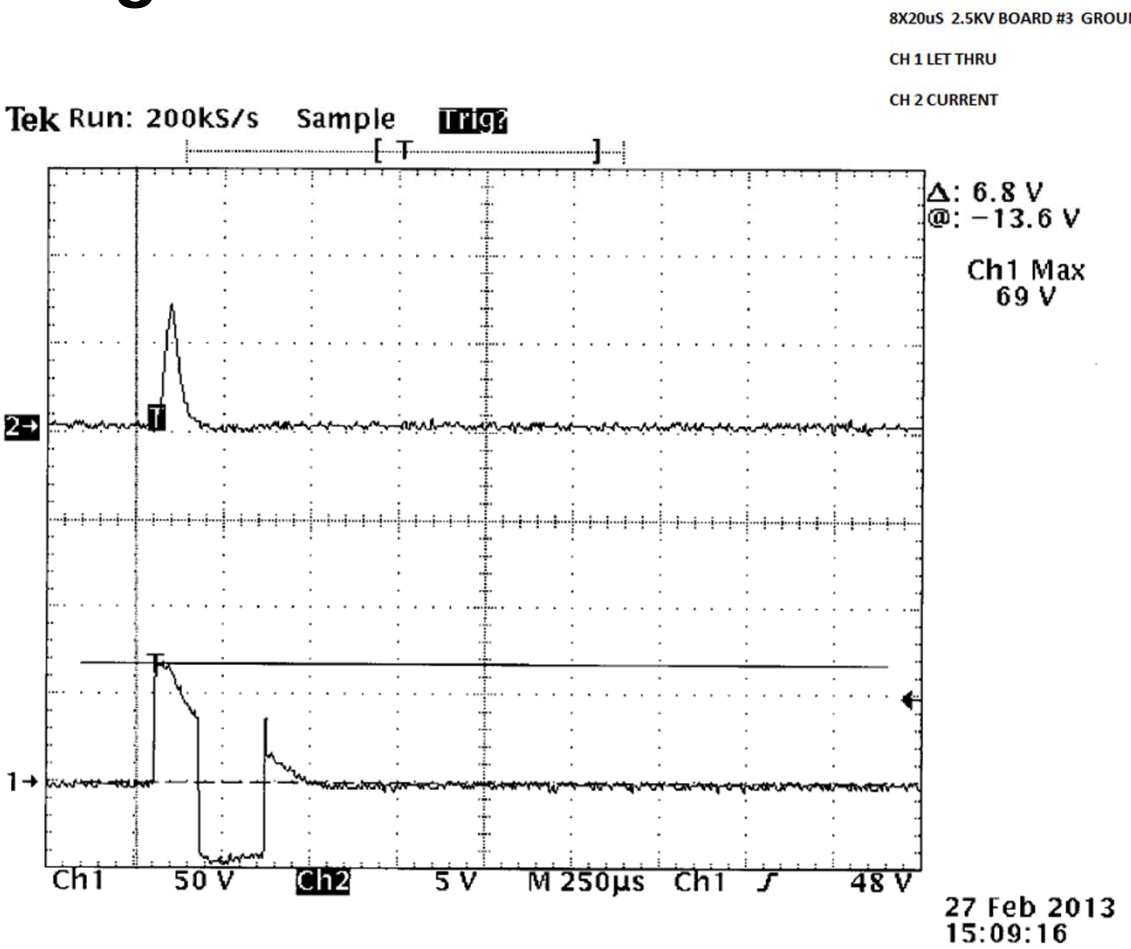
Surge Waveform – 2.5kV without GND



Ch2: 1V = 100 Amp

tii network technologies

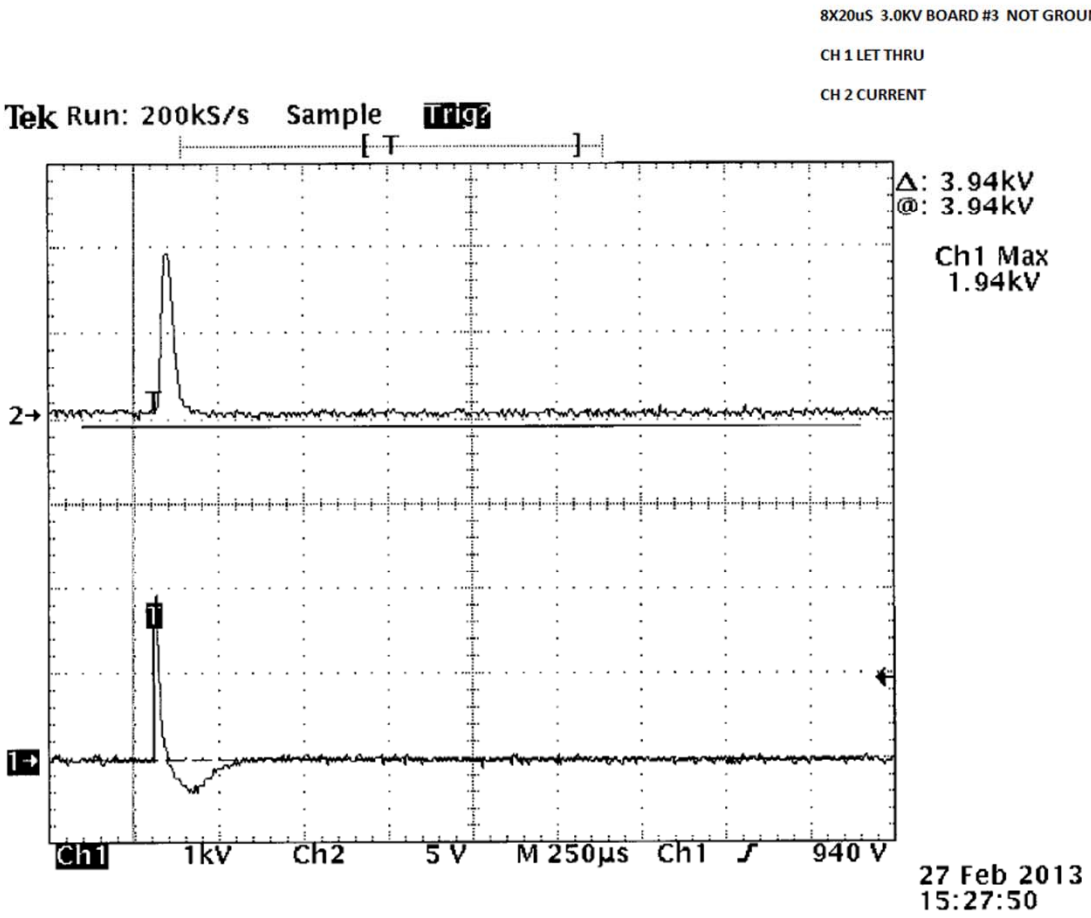
Surge Waveform – 2.5kV with GND



Ch2: 1V = 100 Amp

tii network technologies

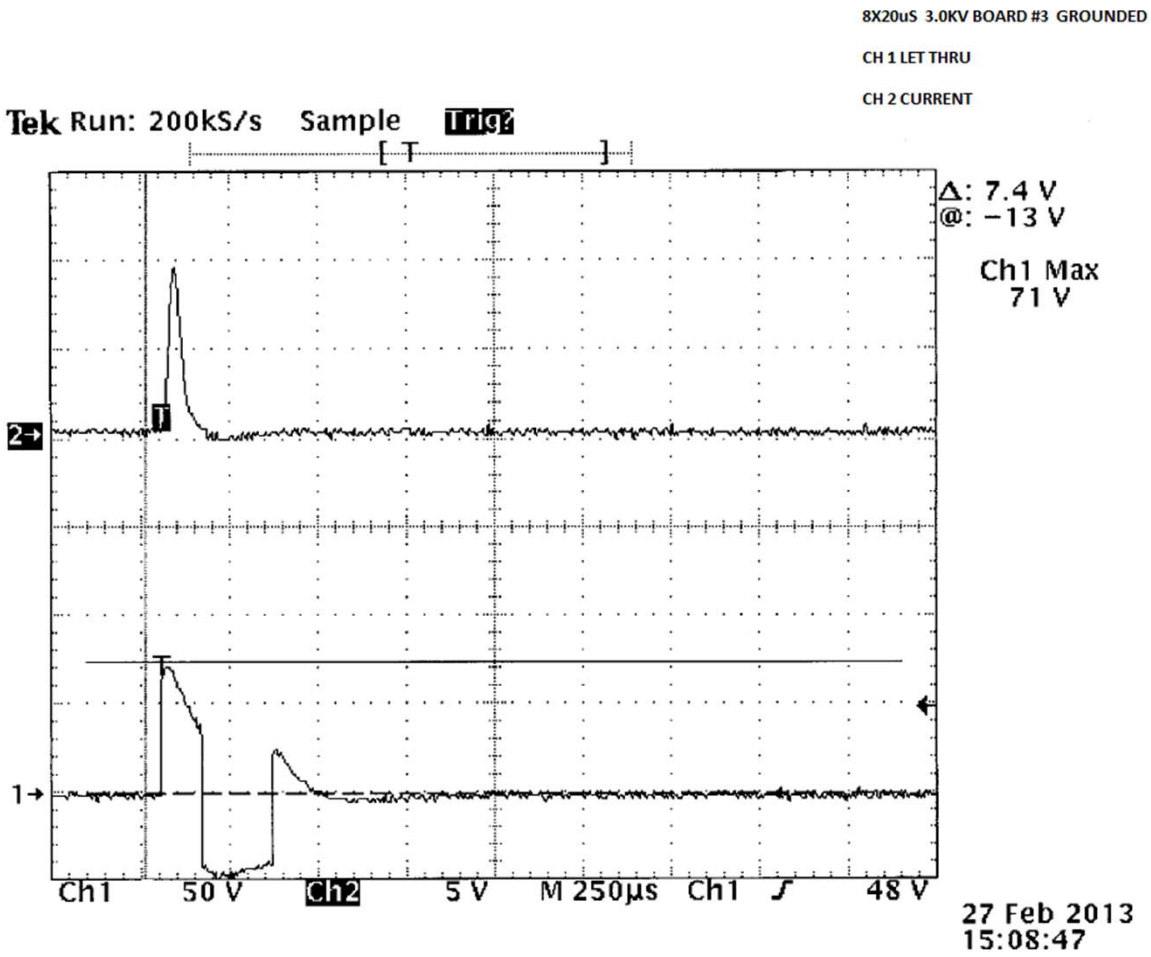
Surge Waveform – 3kV without GND



Ch2: 1V = 100 Amp

tii network technologies

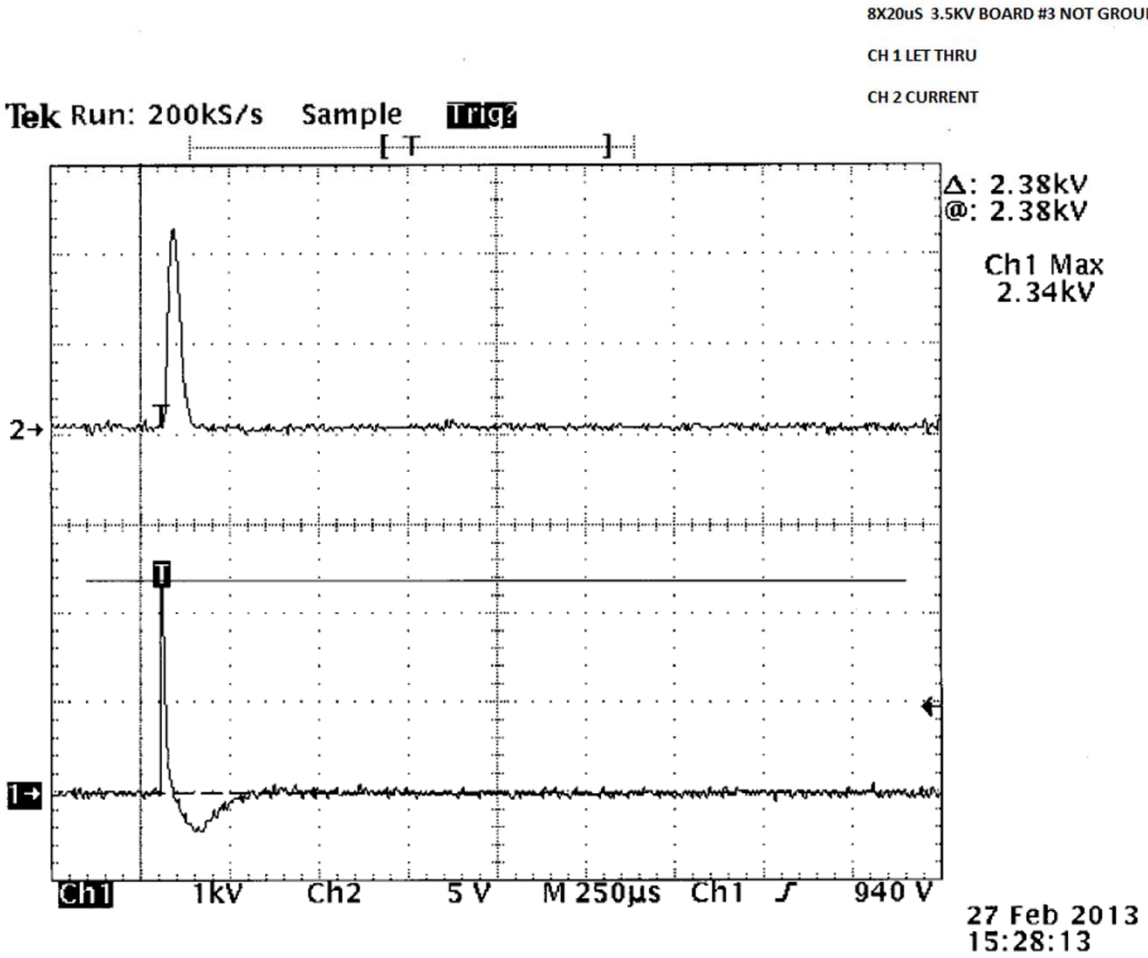
Surge Waveform – 3kV with GND



Ch2: 1V = 100 Amp

tii network technologies

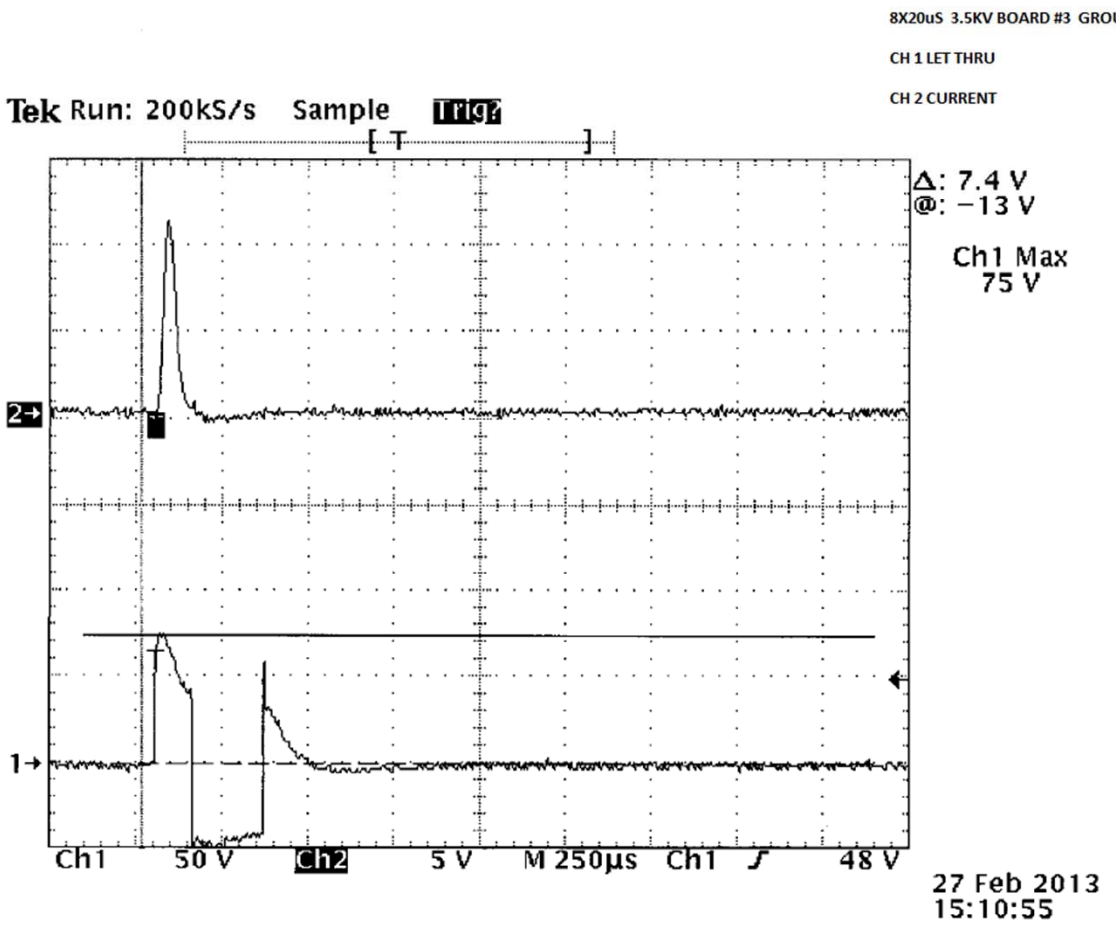
Surge Waveform – 3.5kV without GND



Ch2: 1V = 100 Amp

tii network technologies

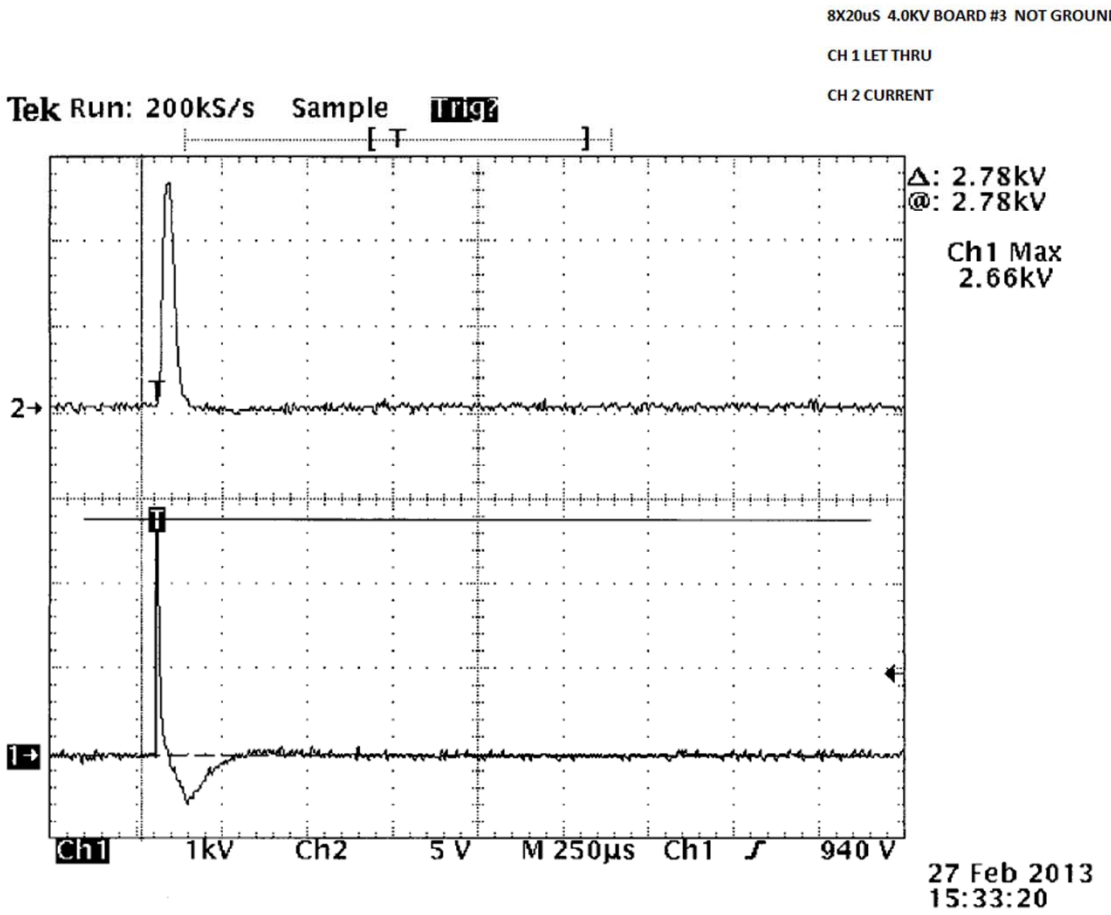
Surge Waveform – 3.5kV with GND



Ch2: 1V = 100 Amp

tii network technologies

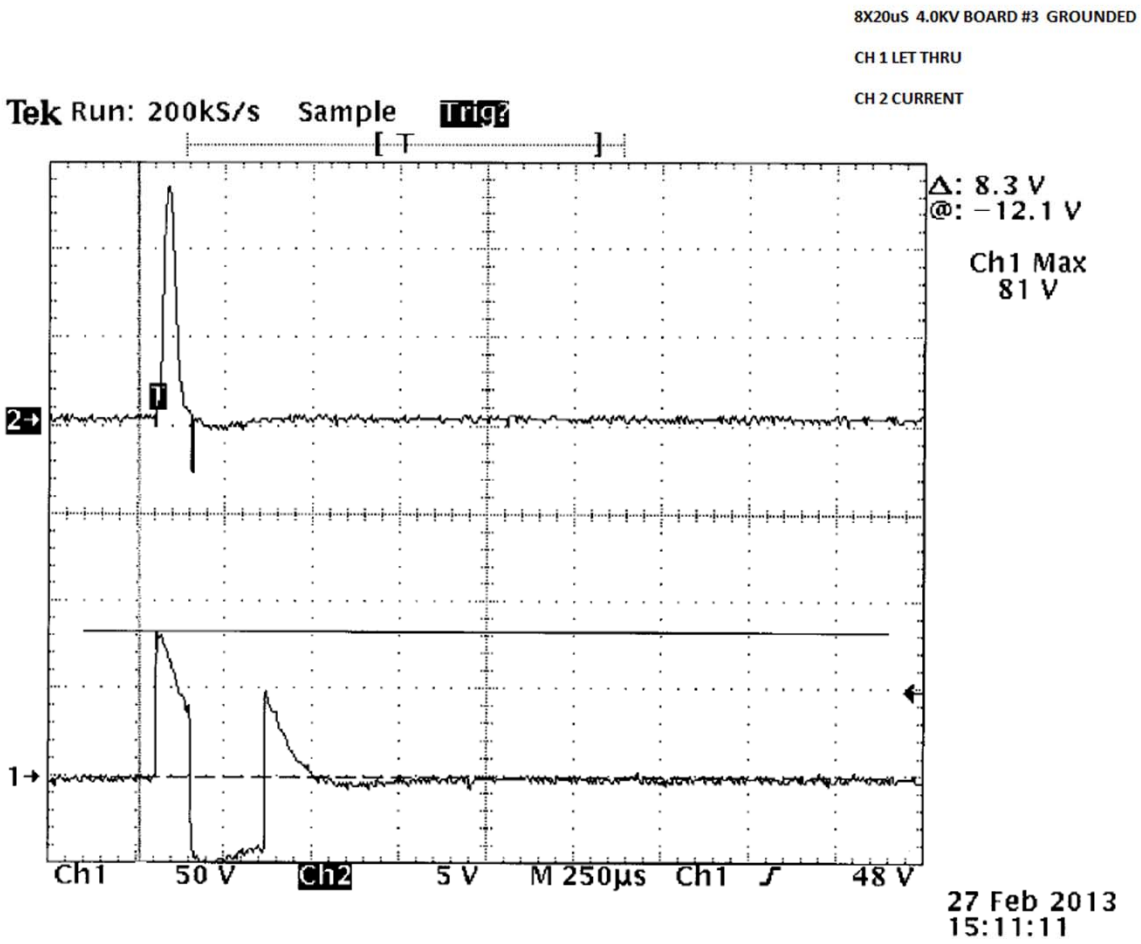
Surge Waveform – 4kV without GND



Ch2: 1V = 100 Amp

tii network technologies

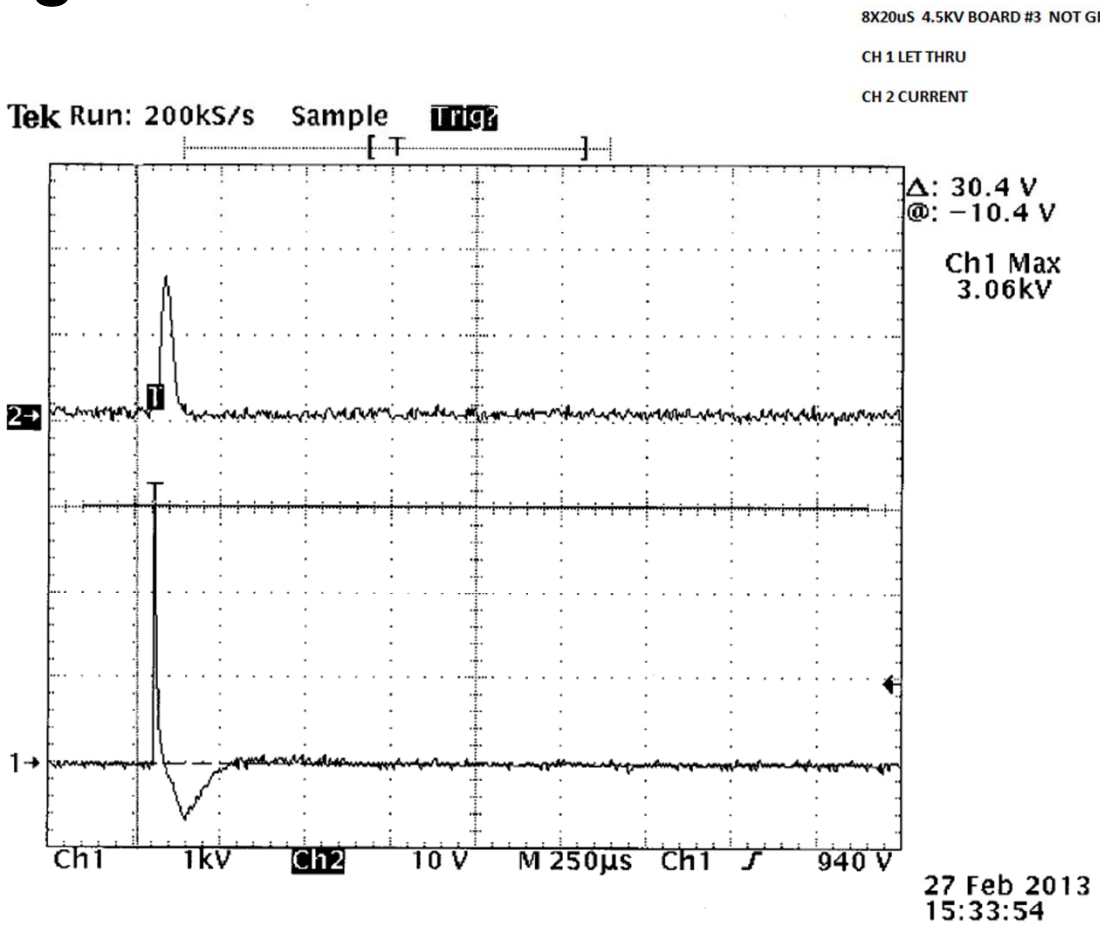
Surge Waveform – 4kV with GND



Ch2: 1V = 100 Amp

tii network technologies

Surge Waveform – 4.5kV without GND

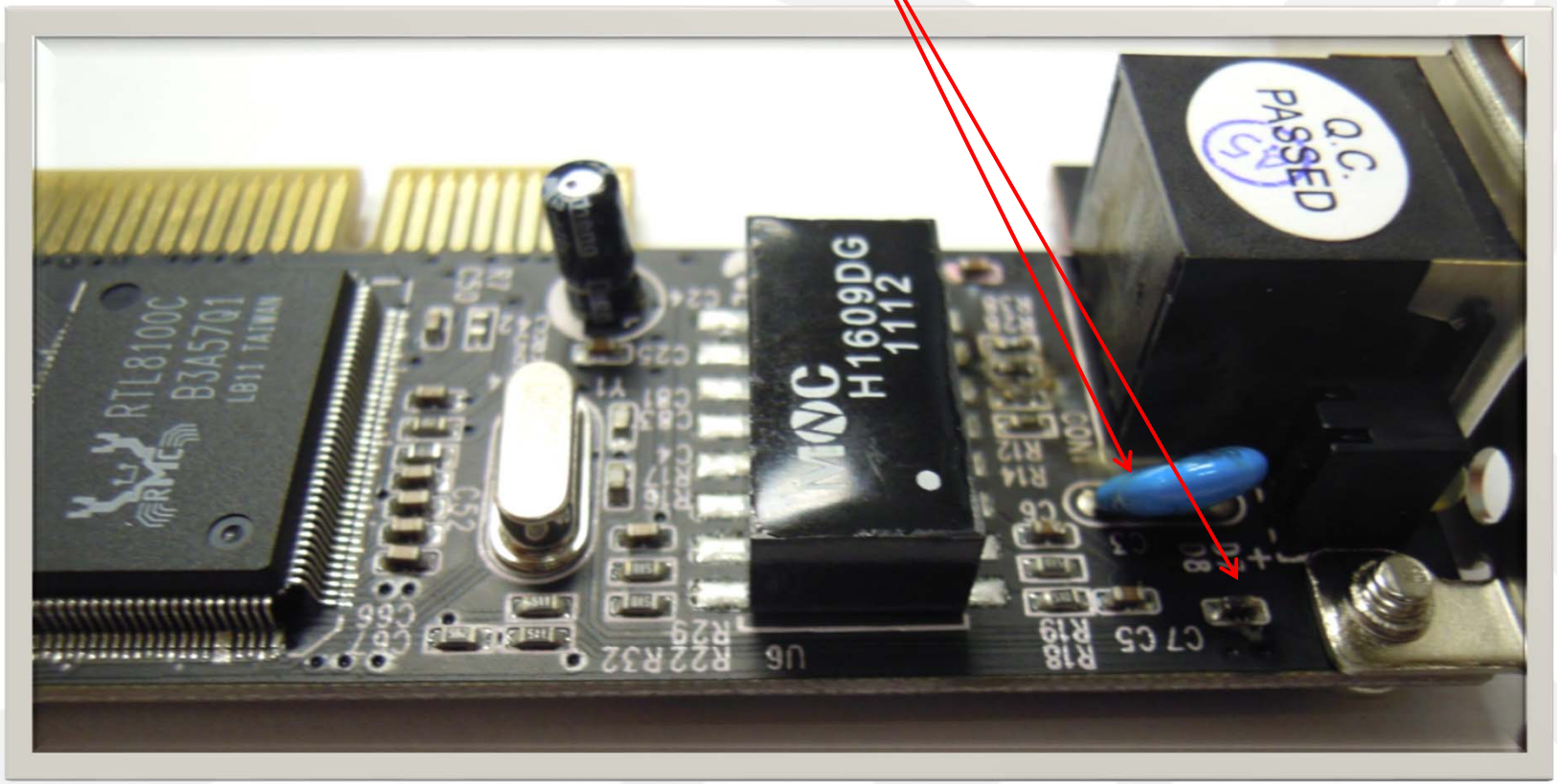


Ch2: 1V = 100 Amp

tii network technologies

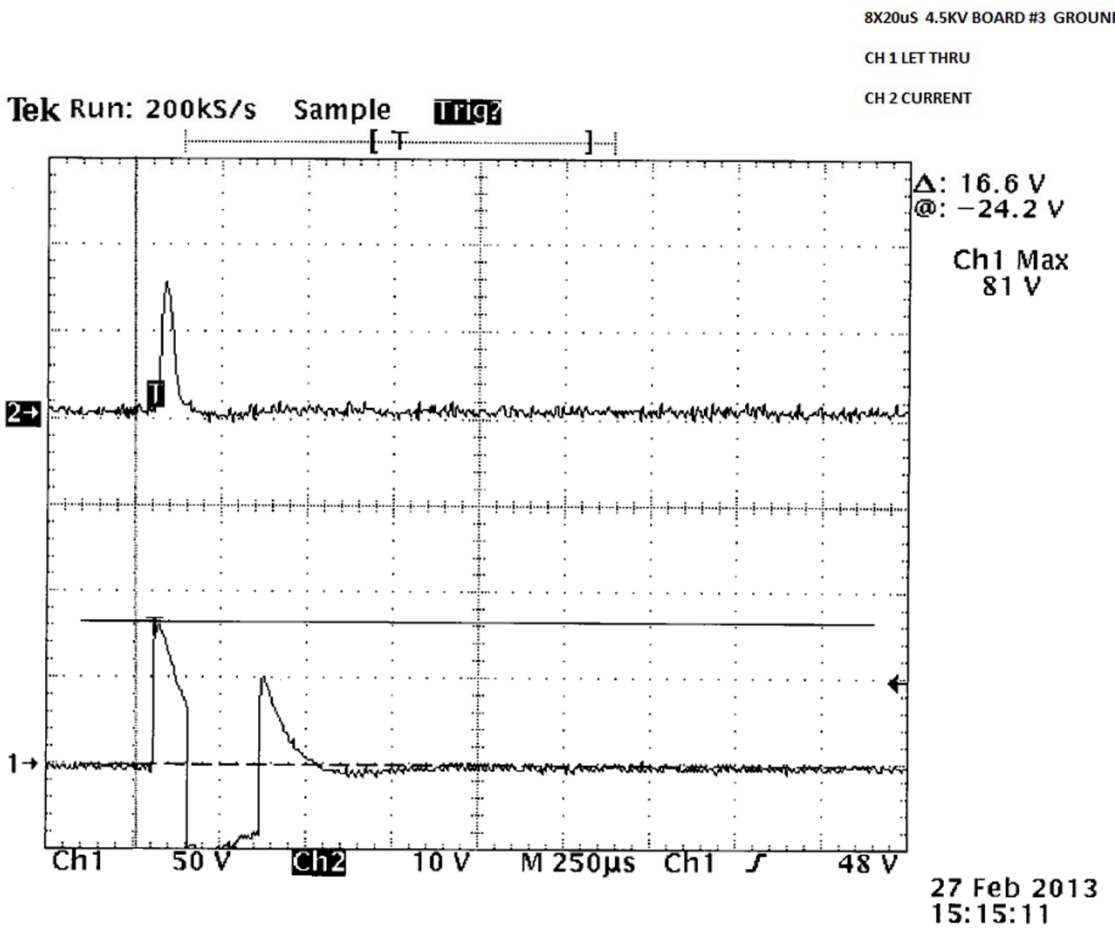
Surge Waveform – 4.5kV without GND

Damage to C3 and C7



tii network technologies

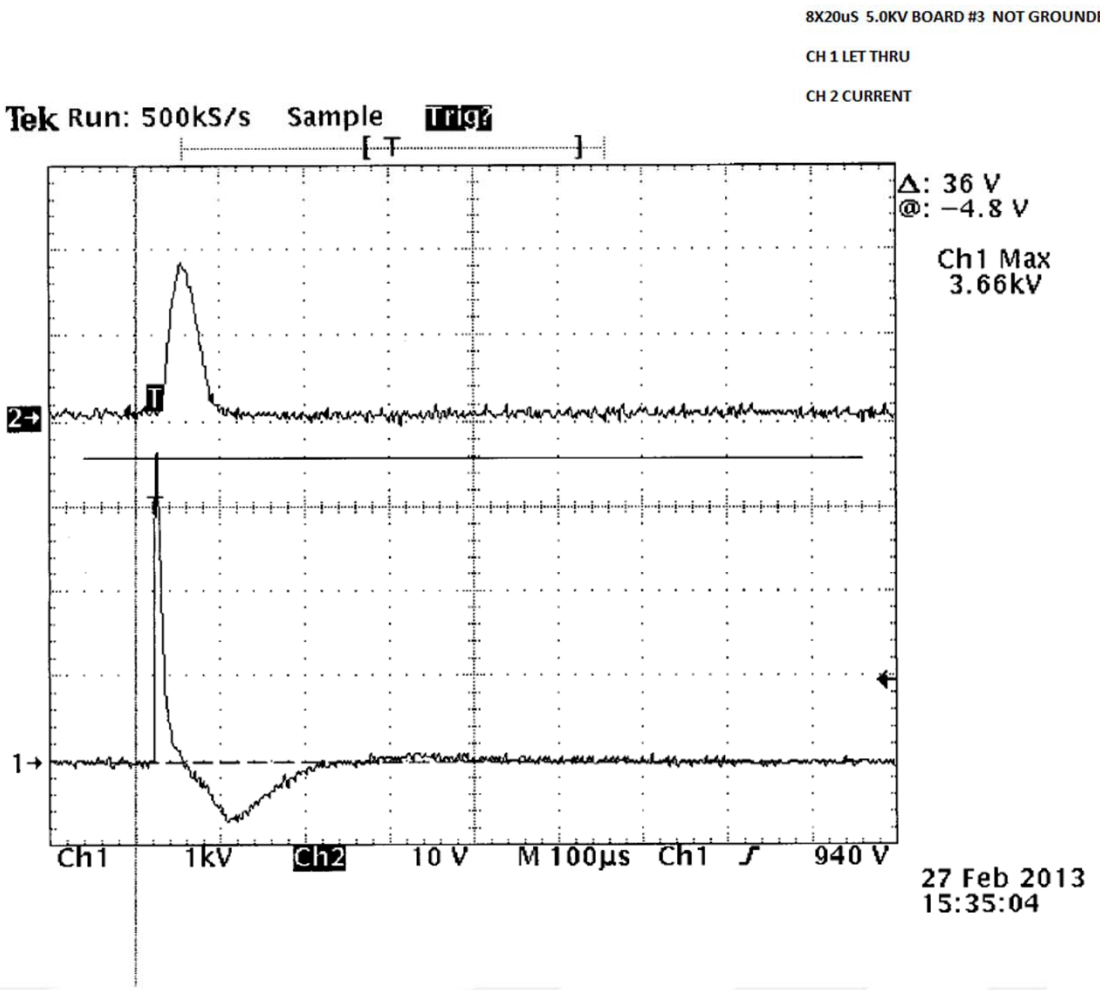
Surge Waveform – 4.5kV with GND



Ch2: 1V = 100 Amp

tii network technologies

Surge Waveform – 5kV without GND

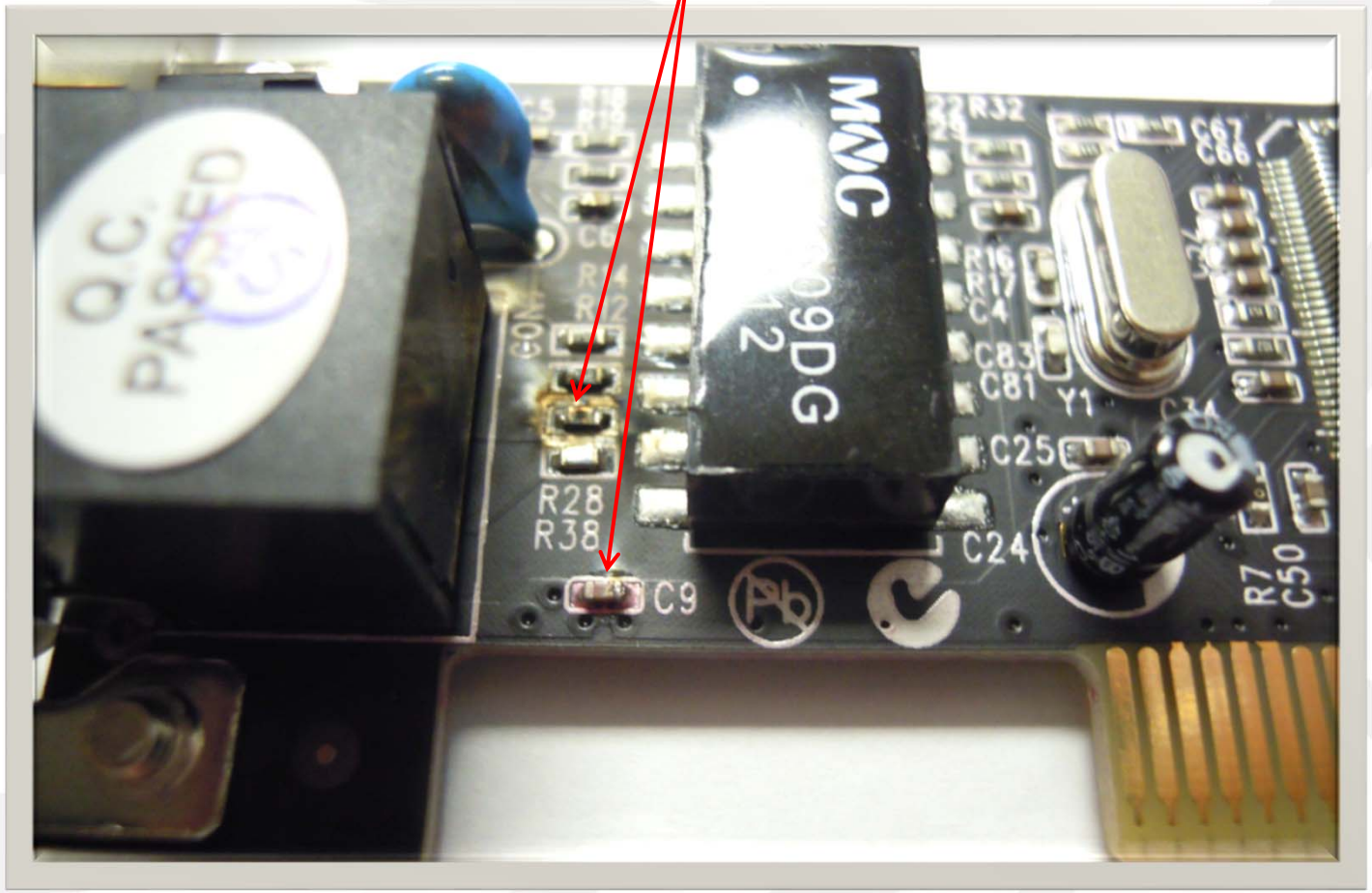


Ch2: 1V = 100 Amp

tii network technologies

Surge Waveform – 5kV without GND

Damage to R28 and C9



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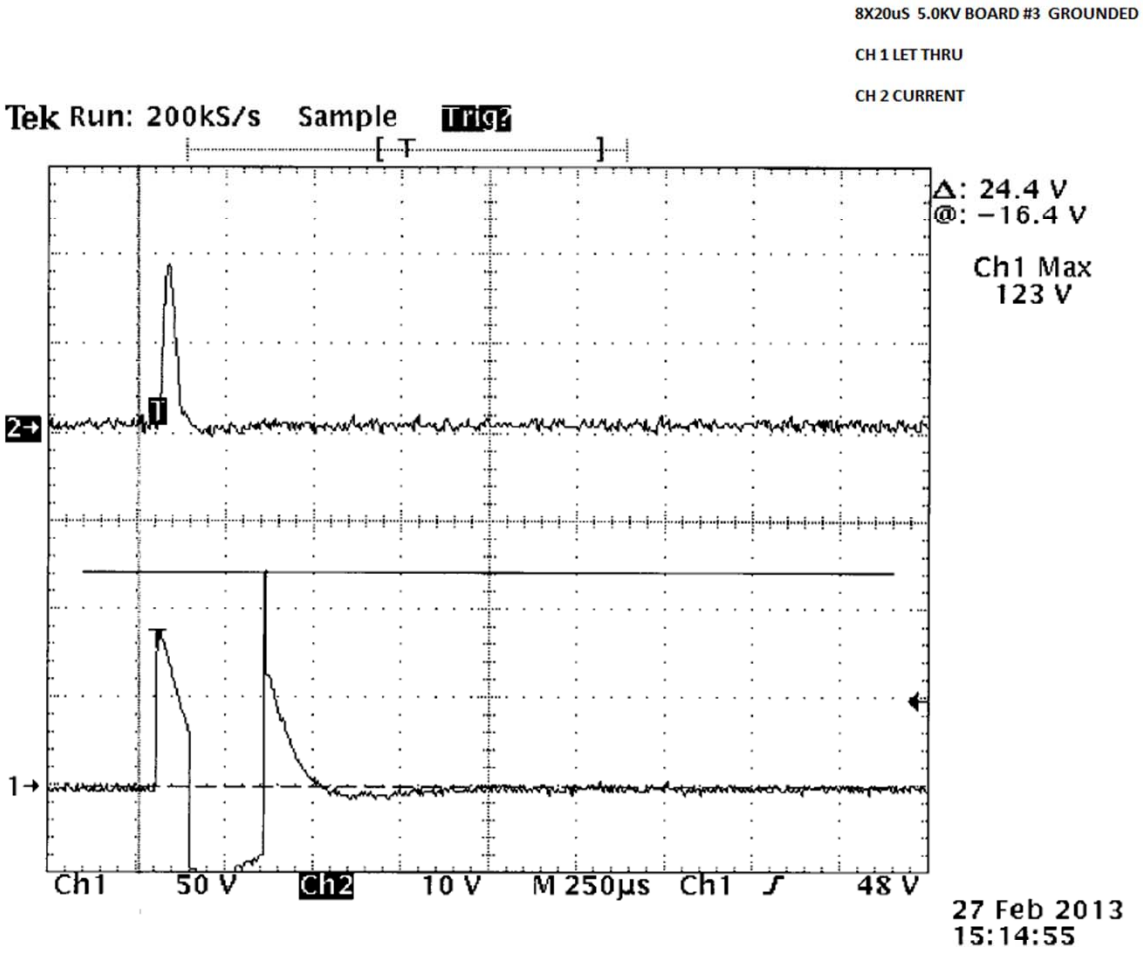
Surge Waveform – 5kV with GND



Ch2: 1V = 100 Amp

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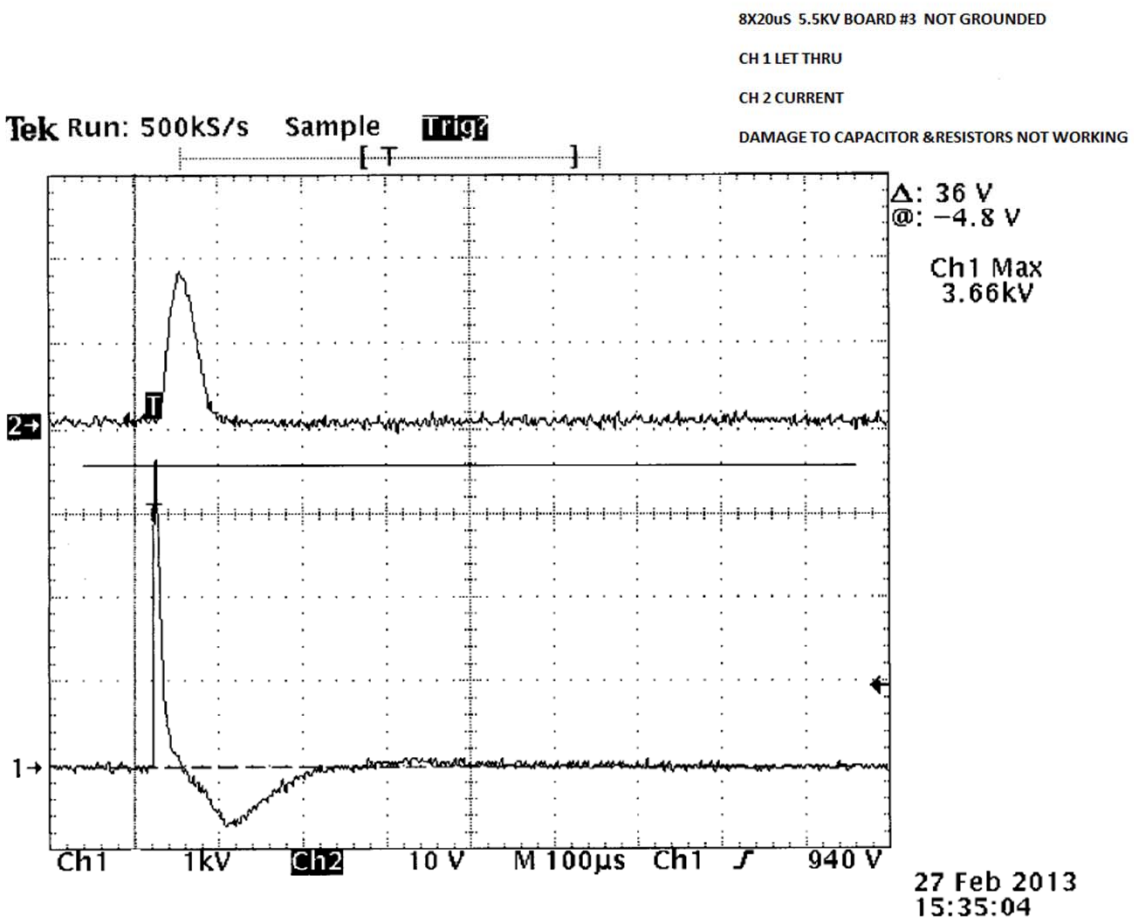
Surge Waveform – 5.5kV without GND



Ch2: 1V = 100 Amp

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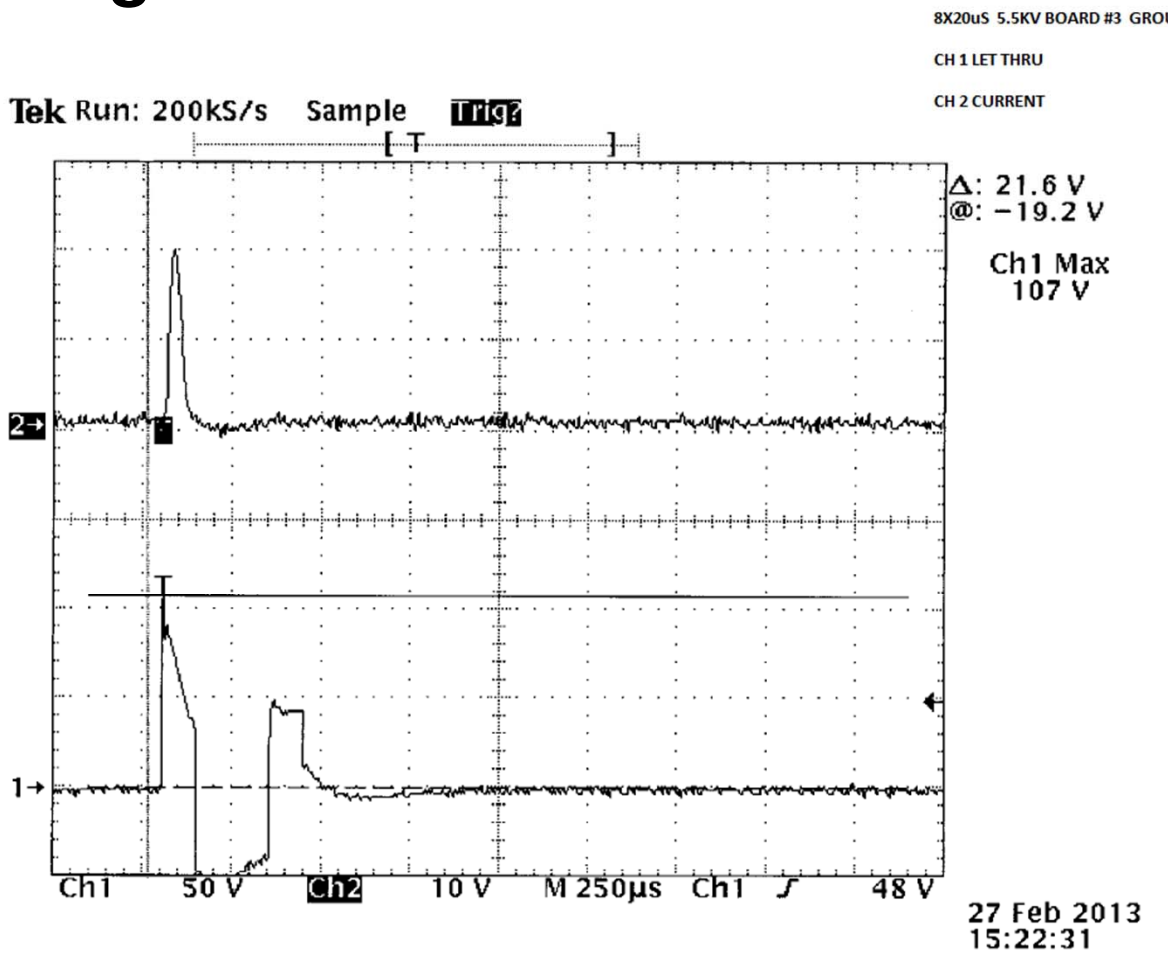
Surge Waveform – 5.5kV with GND



Ch2: 1V = 100 Amp

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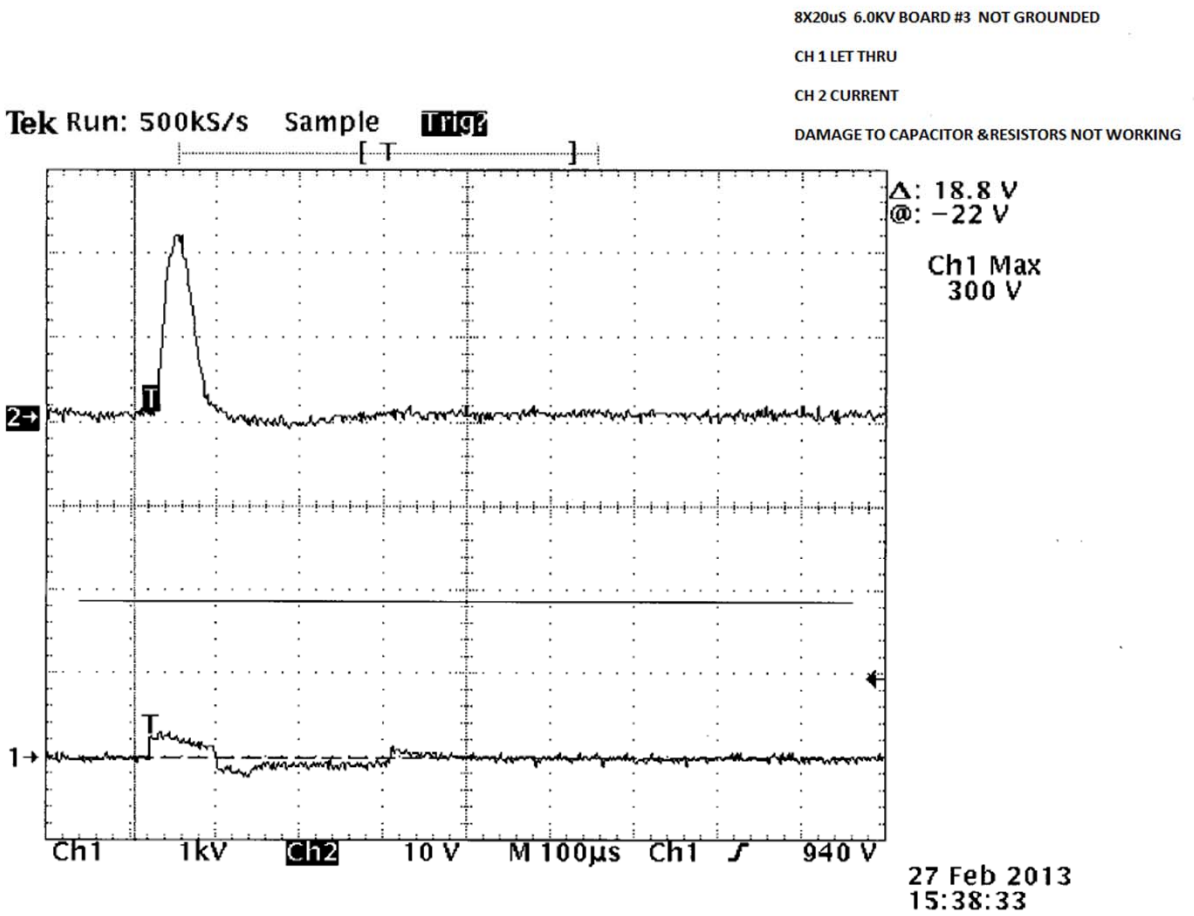
Surge Waveform – 6kV without GND



Ch2: 1V = 100 Amp

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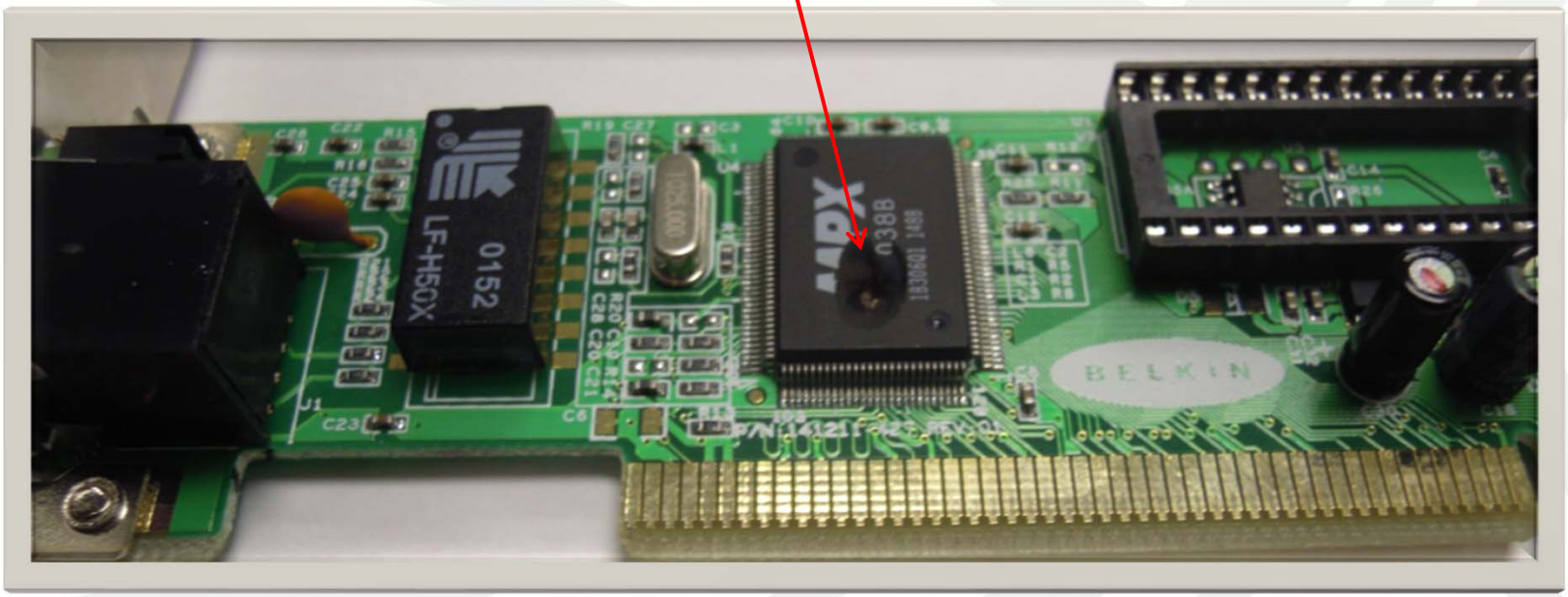
Surge Waveform – 6kV without GND

Damage to Ethernet Controller



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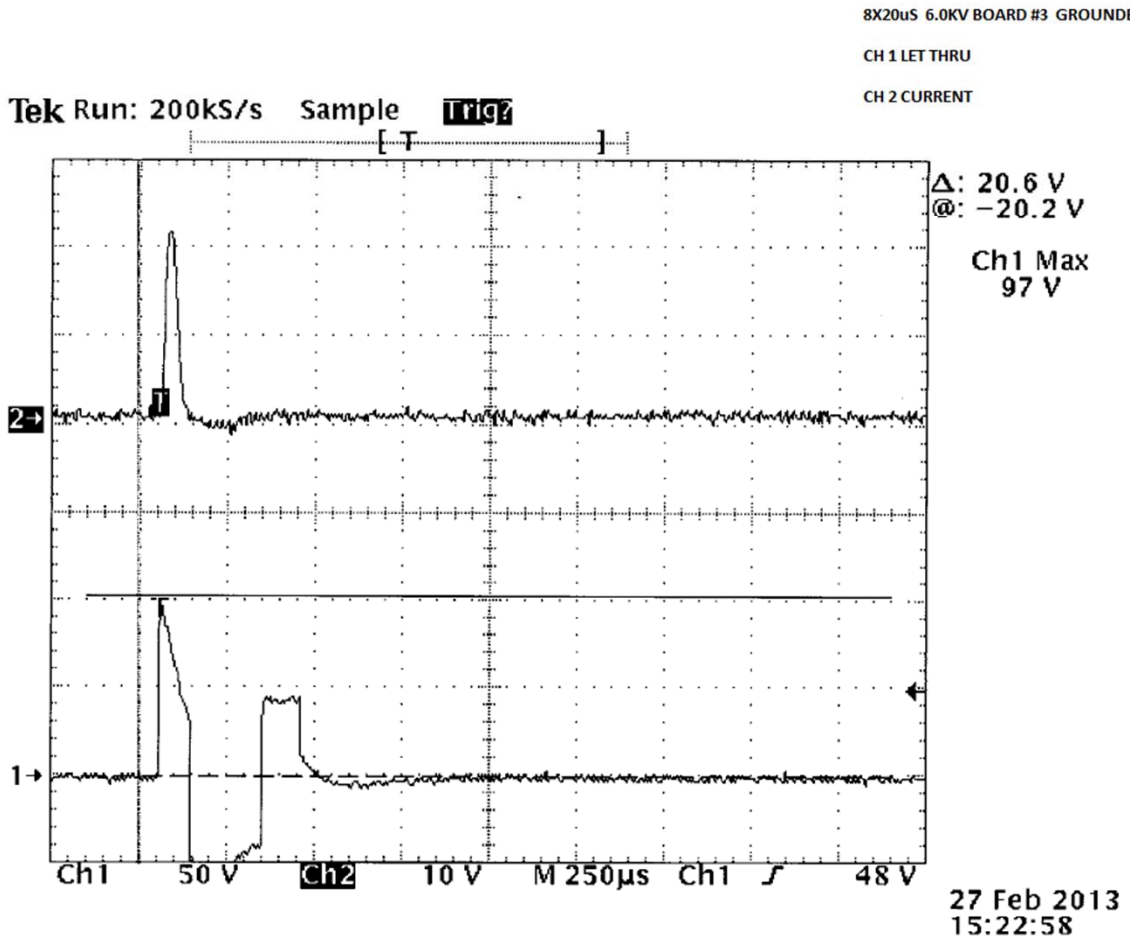
Surge Waveform – 6kV with GND



Ch2: 1V = 100 Amp

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Protection Circuit 3 Test Results

No Ground Connection:
Damage to NIC cards when surge voltage exceeded 4000 volts.

With Ground Connection:
No Damage to the NIC cards when tested up to 6000 volts of peak surge voltage.

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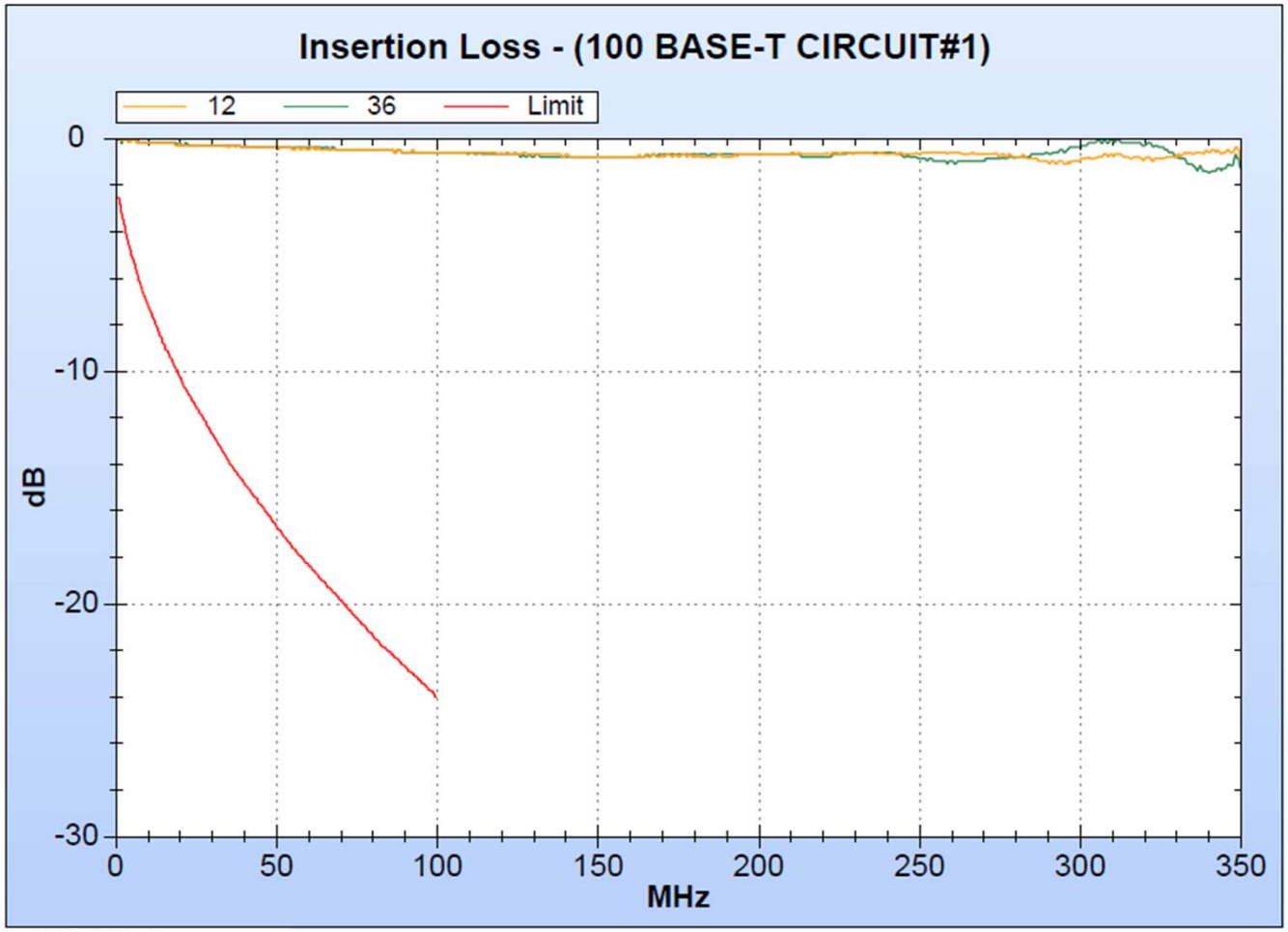
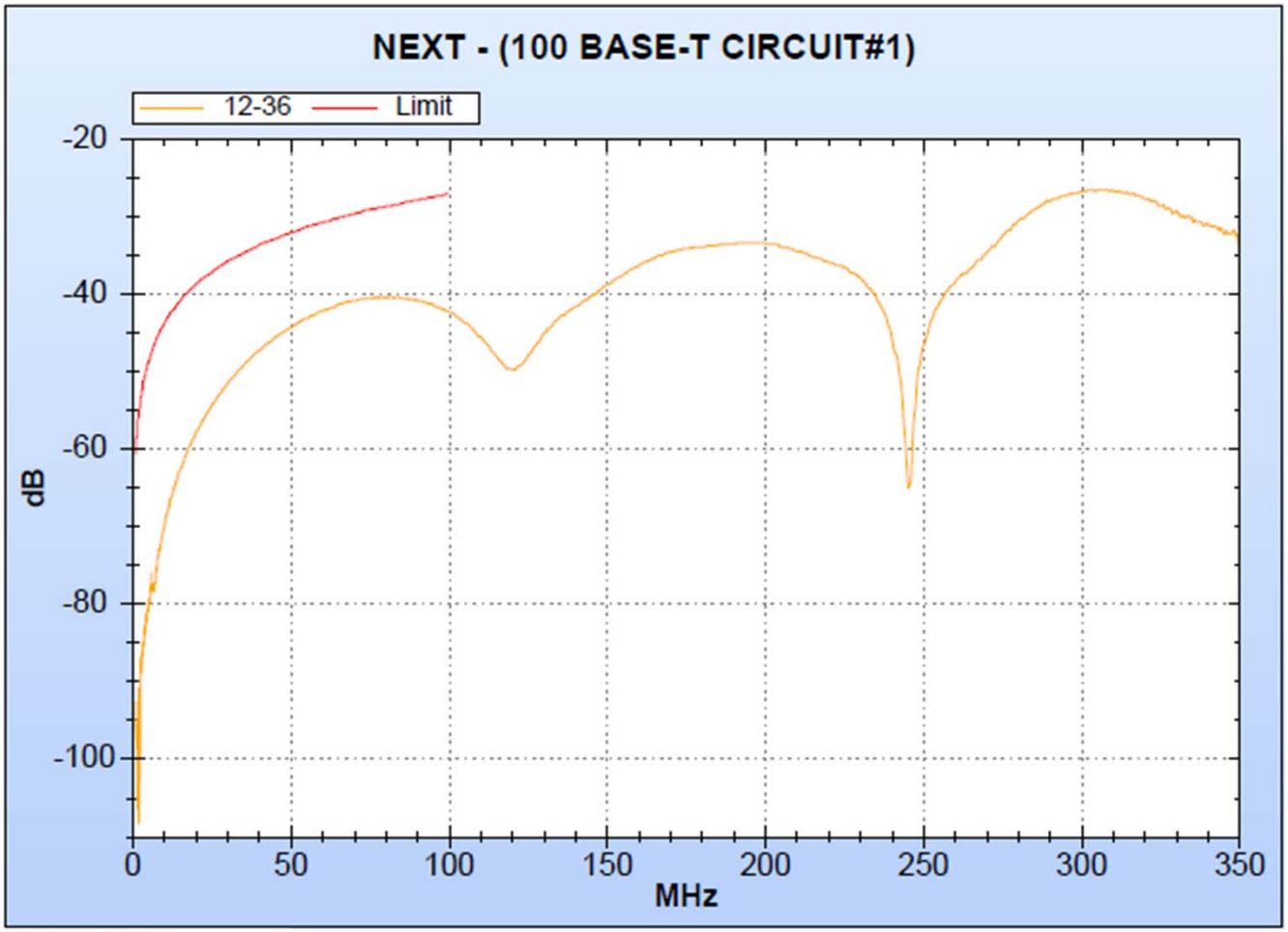


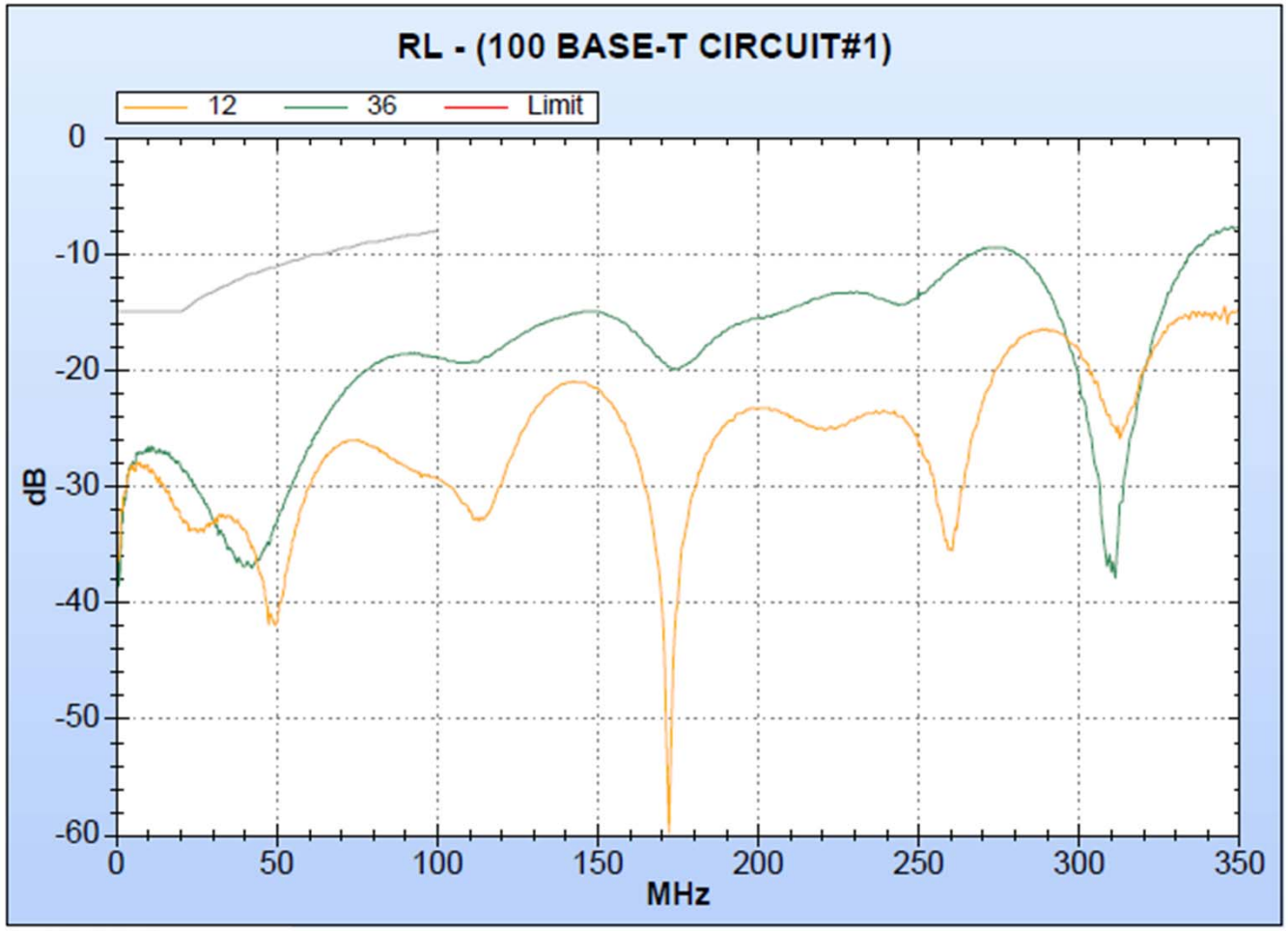
FLUKE networks

tii network technologies



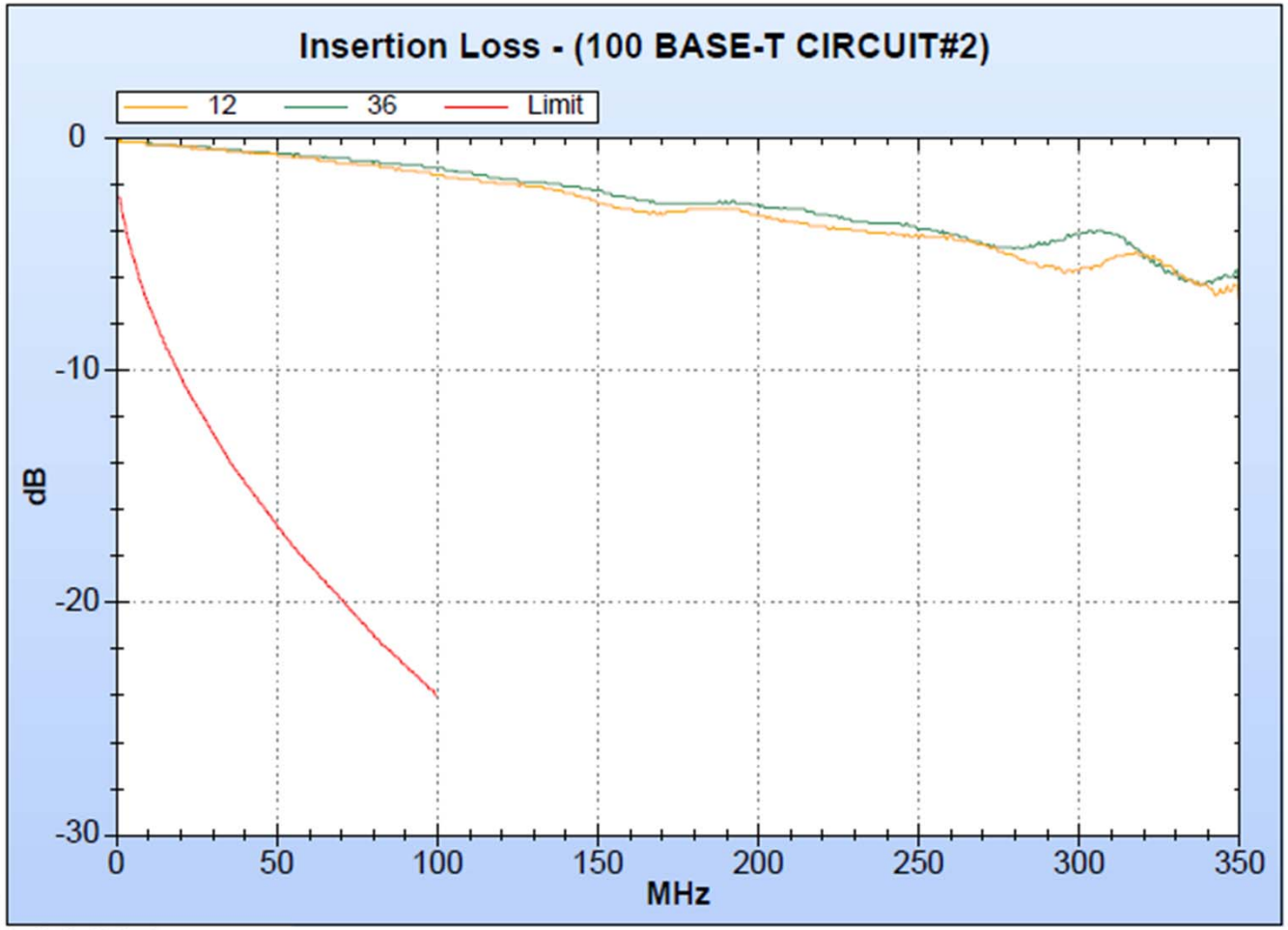
FLUKE networks

tii network technologies



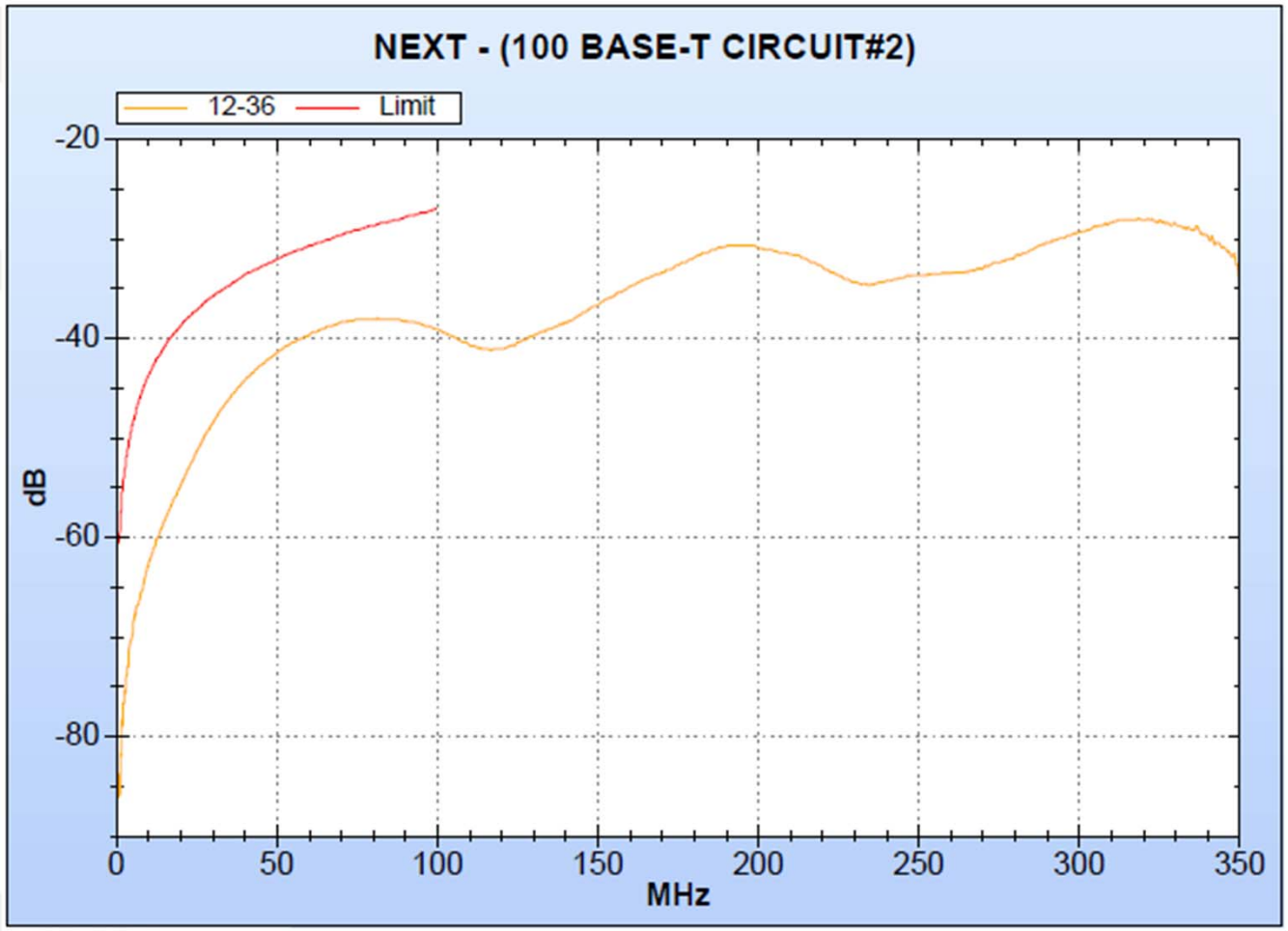
FLUKE networks

tii network technologies



FLUKE networks

tii network technologies



FLUKE networks

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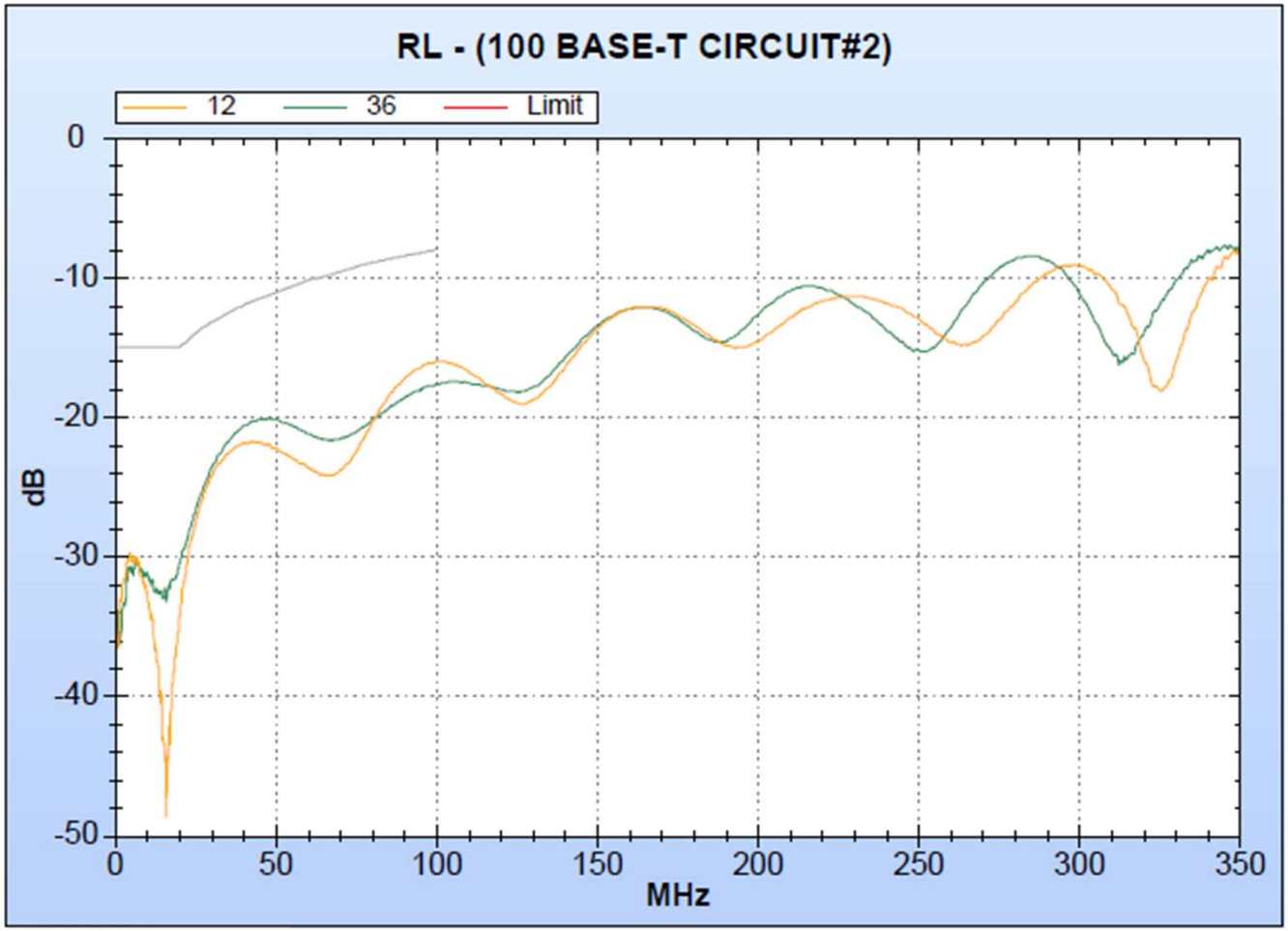

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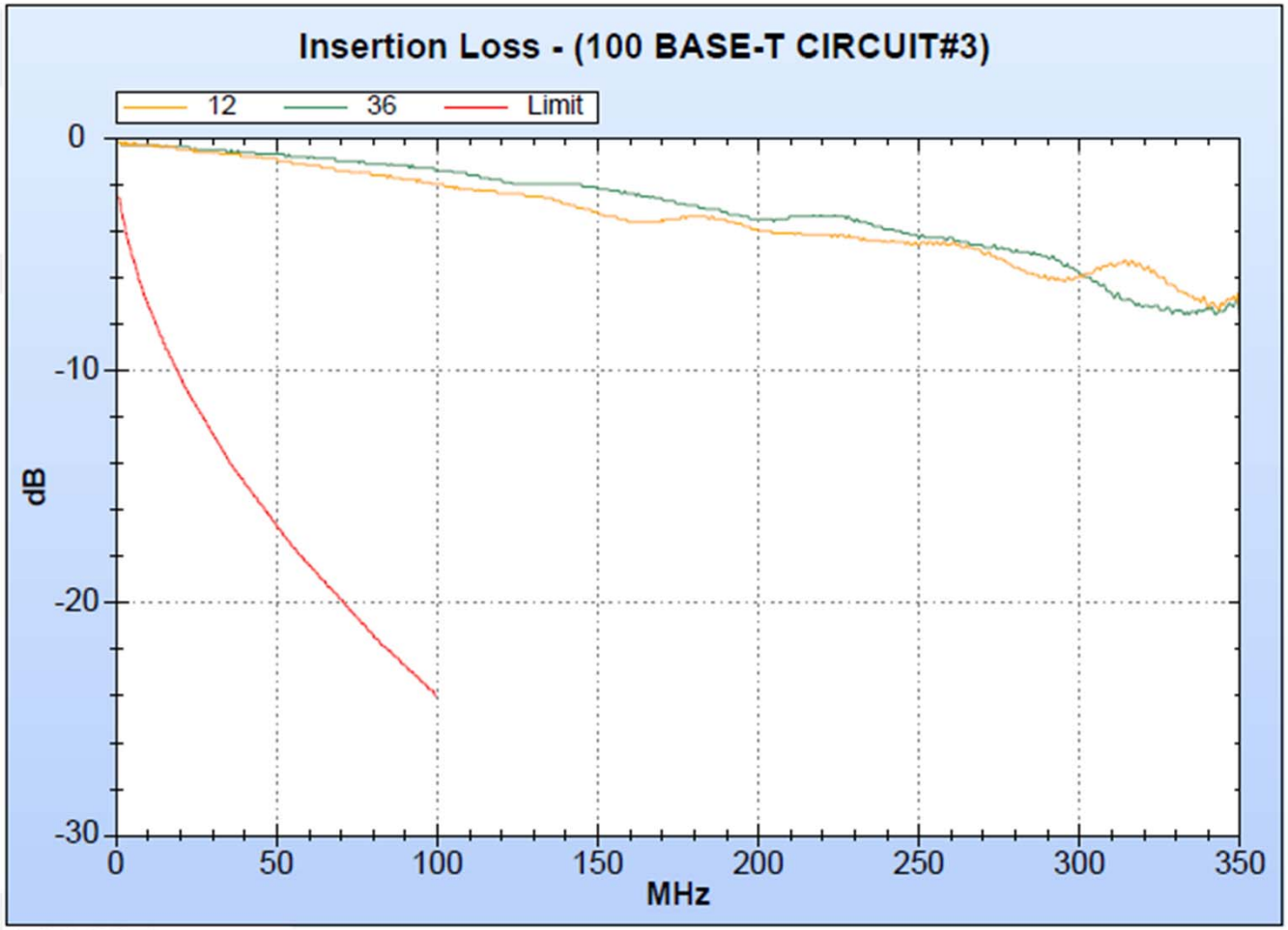

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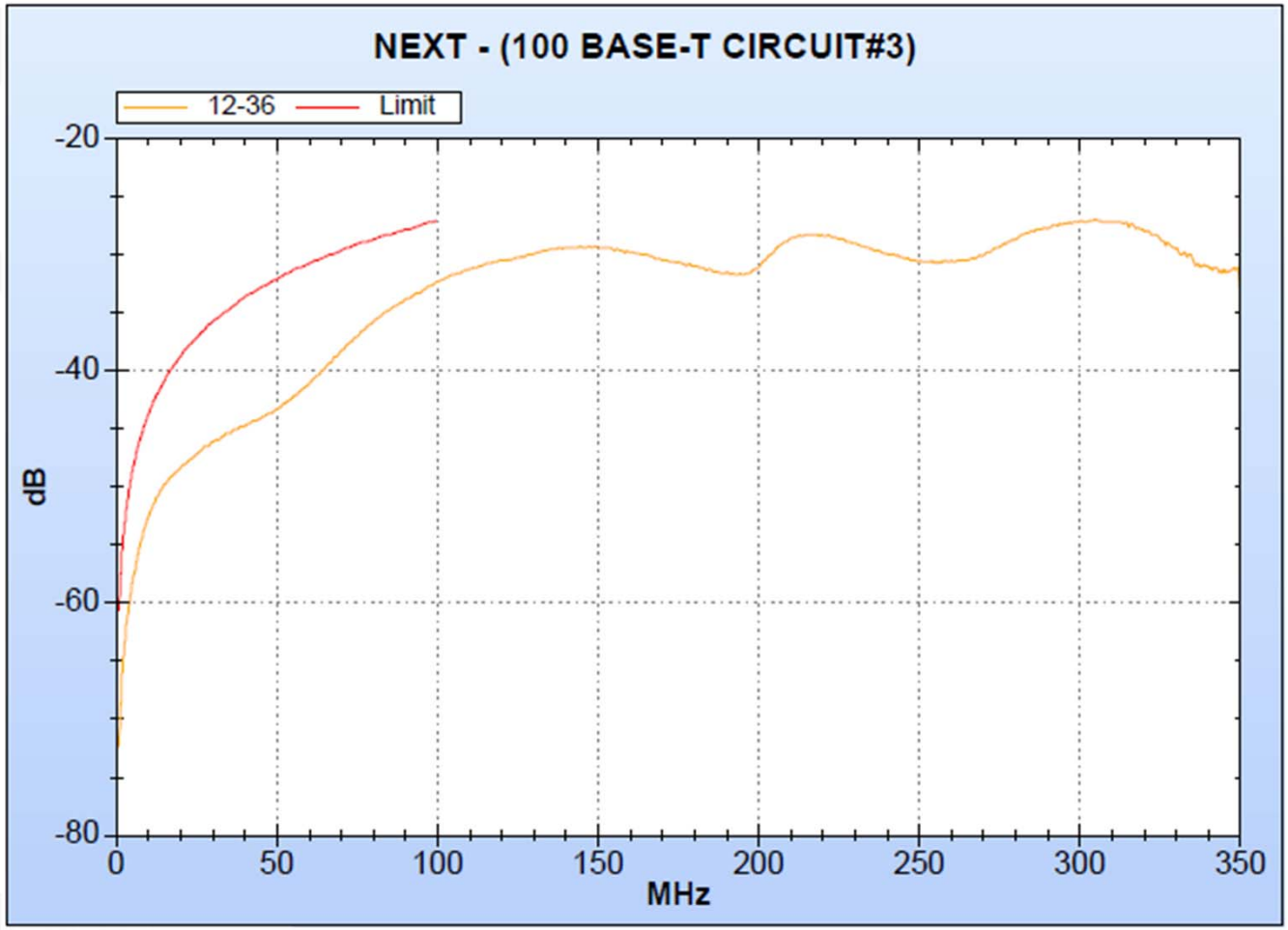

FLUKE networks

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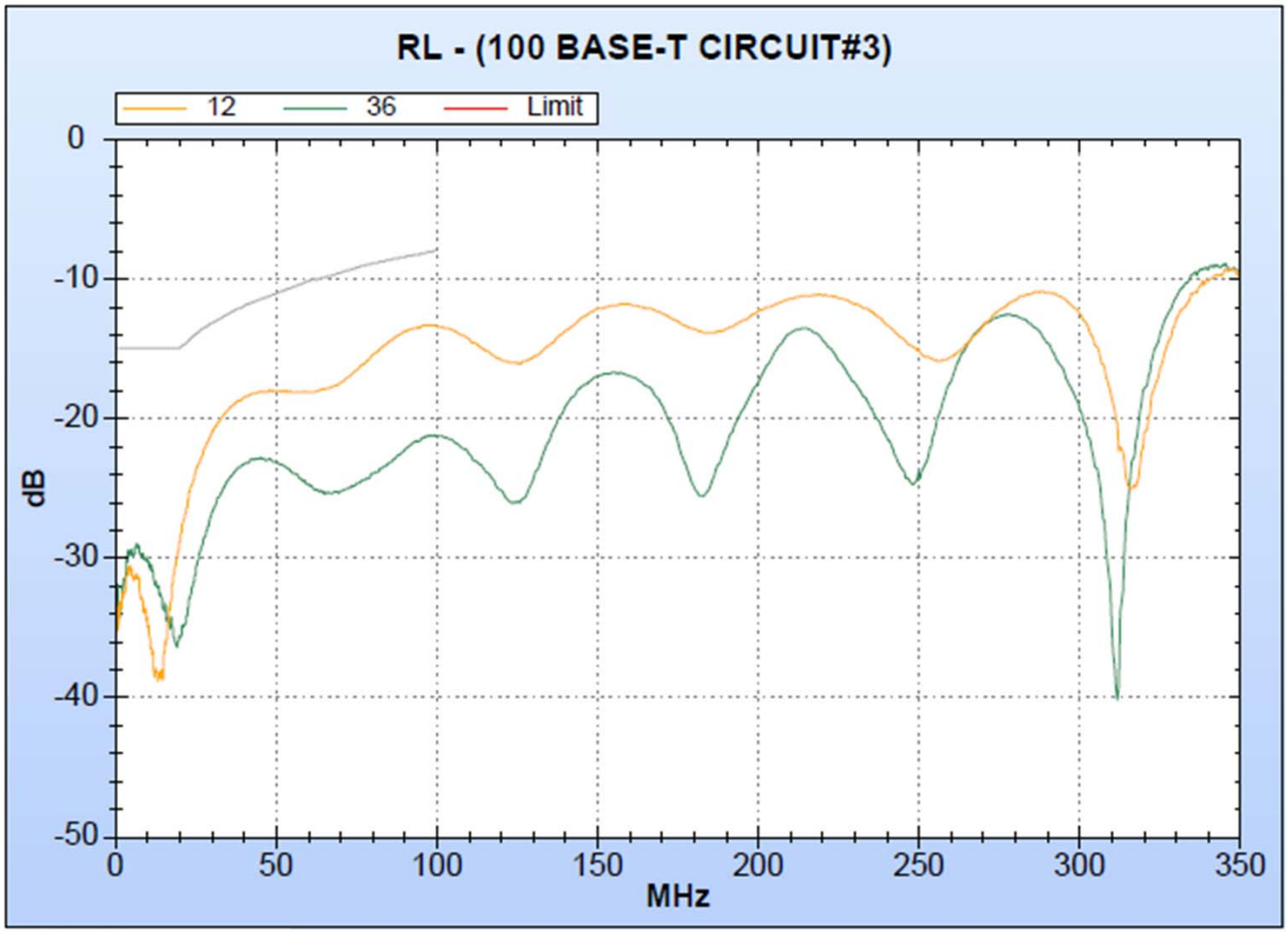

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Conclusions

Surge Protection Circuits with ground provide complete protection to the maximum level of surges tested.

Some NIC cards made with higher breakdown voltage caps and higher isolation voltage levels can survive without any surge protection.

Improved surge protection circuits could affect data transmission rate. Surge protection device design must meet transmission requirements of the Ethernet circuit.

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Any Questions

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