Cause & Effects of Surge Events to Equipment

Things you may have not considered in the past

- Root cause of equipment damage
- Damage effects
- Types of protective systems and their functions
- Solutions and Advantages
Cause & Effects of Surge Events to Equipment

MT Surge Videos:
http://www.youtube.com/playlist?list=PL696F6D10382836DE
Some of the places you will see SPD’s

- ITS Traffic Cameras
- Security Cameras
- Large Bank Sorters
- ATMs
- Computers and Emergency Management
- Wireless Communication Towers
- Hazardous Areas and Process Control Facilities
- Traffic Control Signs
Some of the places you will see SPD’s

Chemical Plants

Oil Refineries

Water Treatment

Homeland Security
Some of the places you will see SPD’s

Power Plants

Manufacturing

Even Schools
Some of the places you will see SPD’s

High Tech Military Humvees

http://www.ArmyRecognition.com Army Recognition ©
Some of the places you will see SPD’s

Photovoltaic (PV) Solar Energy systems
Today’s Question is no longer: “Can I afford to protect?”
Today’s Question is: “Can I afford not to protect?”
The Sources of Surge Impulses and Their Related Problems
Understanding the Problem
Measured Ground Flash Density

Global Atmospherics, Inc.
Fault Analysis and Lightning Location System

1996-2000 Flash Density Map
10 kilometer grid
Good Grounding
Prevents Damage

Lets take a look
The Path of the Surge Current
Looking for Ground

Freeze
Resume
Surge Protection
A Controlled Path for the Surge Current
Looking for Ground
Why do Control systems need protection?

Surges can infiltrate a network 4 ways (even if a UPS has been installed)

- **Direct Coupling** — Surges conducted on lines entering from outside e.g. Telco or Network lines
- **Inductive Coupling** — Surges coupled electromagnetically onto network lines within a building
- **Transient Ground Potential** differences between buildings
- **Voltage Potential** differences between wall outlets caused by random protection applied to network devices
Surge enters the building from a direct strike to any outside copper wire.
  i.e.  Power lines
       IO Interfaces
       Telephone lines
       RF Interfaces
       Security Interfaces
Nature’s Forces
PC Board Damage
Inductive Coupling
Lightning Strikes
Ground Potential Differences
Interface Damage

Bldg. “A”

Data Line

Bldg. “B”

V = 12kV

3kV
500m

15kV
100m

200kV

Distance

Voltage
Field Transmitters

SCADA

Voltage

Distance

4-20mA

V = 12kV

15kV

100m

3kV

500m

200kV
Lightning killed 22 cows when it struck the large tree shown with the bark stripped off. Even through some of the cows were a considerable distance away from the tree, the voltage spread over the ground caused electrocuting shock between the animal’s feet.
Results of Resistive Coupling

Fig. 18. Lightning killed 504 sheep when a stroke hit the ground in this rocky pasture in Utah. A stroke to high-resistance soil can produce exceptionally high voltage in the ground and spread over an unusually large area.
Transient Propagation Theory

6kV AC Transient

Very small voltage difference

Voltage

Voltage
Transient Propagation Theory

Incoming AC Transient

6kV

1.5 kV

UPS or Surge
Transient Propagation Theory
Lightning Damage to Network Equipment

Majority of all damage

I/O Interfaces

Communication Ports
Effects to Equipment
Lightning Damage Power Supply
Why Surge Protection
Power Line Disturbances

- Oscillatory Decaying Transients: 49.0%
- Impulse Transients: 39.5%
- Voltage Outages: 0.50%
- Under/Over Voltages: 11.0%

Automation products - Failure Analysis
Causes of Short Equipment Life

Lack of maintenance: 25%
Water: 5%
Fire: 3%
Theft and vandalism: 22%
Overvoltage (lightning discharge and switching operations): 28%
Other: 15%
Storm: 1.57%

Damage in electronics: Analysis of approx. 7,737 failures

Ref: Contingency planning insurance data
What are Voltage Transients and Surges and Why should they concern me more today than yesterday?
Failure Modes of Equipment

- Catastrophic Failure
- Safe Operating Area
- Equipment Degradation
Processor Board

5 volt Signal
Logic Ground
Typical Degradation

Magnified view of 2 junctions in an IC chip

(+5 volt signal) Insulation Breakdown Point 50 volts (-) Logic ground

IC Chip Failure due to junction breakdown
- Transients between safe & outright failure levels
- Partial junction breakdown
- Repeated attack on weak link
- Unexplained clear blue day failure
Increased Rate of Equipment Failure

- Rate of Surge Damage
- 1950 to 2010
- VLSIC
- LSIC
- IC

VLSIC
Interesting Growth Comparisons

Number of Transistors in one chip

1993 – Intel Pentium – 3.1 million
2000 – Intel Pentium IV – 43 million
2006 – Intel Montecito Itanium – 1.7 billion

2004 - More transistors produced in 1 year than the number of rice grains grown (and cost less)

Today – There are 100 transistors per every ant in the world

1978 – The cost of a commercial flight between Paris and New York was about $900 and took about 7 hours
If the principle above were applied to the flight industry, the same flight today would cost one cent and would take less than one second.
Conventional Protection Systems

- Structural lightning protection system
- Earthing
- Plant earth bonding
- IS Barrier/Galvanic Isolators
- Isolation transformer
- UPS
Control System

150M
Problems Occur
Improved Earthing & Bonding

- 30kA
- 27kA
- 3kA

Control System
Improved Earthing & Bonding

Better than 27kV; but good enough?
An appropriate protection needs:

- Structural lightning protection system
- Earthing
- Plant earth bonding
- Galvanic Isolators/Isolation Transformer
- IS Barrier (hazardous area)
- UPS

- Surge Protection Devices
How they work
Main Panel
No Protection

Incoming transient

The transient wants to get to earth by the path of least resistance

Main Panel
120/240 split phase

Electrical wires going out to equipment

Ground
Ground Over voltage impulses are diverted to Ground

Incoming transient

The transient wants to get to earth by the path of least resistance

Main Panel 120/240 split phase

Surge protector Parallel device Minimal resistance

Over voltage impulses are diverted to Ground

Main Panel Panel Protection

Electrical wires going out to equipment

Ground
The **TWO** Functions of a Surge Protector

**Divert and Equalize**

- **L1**
- **L2**
- **N**
- **G**

6,000 V

400V

LOAD
Path of Surge Diversion Through an SPD

- SPD
- Differential mode limiting voltage
- Common-mode limiting voltage
- Divert to ground
- Protected equipment
Incoming Surge

SPD

DC Power
Protection of Transmitters

SPD

Surge Diversion

Incoming surge
Applying Effective Protection
Zoned Protection

Zone 0
- 20,000 V
- 10,000 A

Zone 1
- Controlled Environment

Zone 2
- Controlled Environments

Zone 3
- Controlled Environment
- MA15 & SD’s

Insignificant
Divert energy and equalize voltage potential differences

1,000V Impulse

120V

N

G

MA15 AC Protector

Cabinet Reference Rises
Divert energy and equalize voltage potential differences

New Problems
Adding IO

IO Devices at a difference reference

1,000V Impulse

120V

MA15

AC Protector

Cabinet Reference Rises

4-20mA

N

G
Divert energy and equalize voltage potential differences

1,000V Impulse

MA15
AC Protector

Cabinet Reference Rises

Protecting IO and Interfaces

120V

N

G

SD Series

4-20mA

TP Series
Installation

Grounding and Bonding

1000 Volt Spike

120 AC

Neutral

Ground

Transmitter

Tied to

Installation

Grounding and Bonding

MTL Instruments
Transmitter case is normally ground

Damage occurs either between the pair or from the wires to ground

The TP48 grounds to the ground connection inside the transmitter and protects between the pair and each wire to ground

Transmitter case is normally ground
Plant Protection Considerations

Plant Security

- Camera Power
- Coaxial Cable
- PTZ (Pan, Tilt, Zoom)
- POE (Power over Ethernet)
Power Supplies – Control Panels

MA15
Incoming Power
Signal and Control Lines

SD Series
Signal and Control Lines

MA15
Incoming Power
Signal and Control Lines

SLP Series
Signal and Control Lines

SD Series
Signal and Control Lines

MA15
Incoming Power
TP Series

- Exceptional 20kA Surge Capacity
- Does not require dedicated ground wire
- Easily installs in spare conduit fitting
- Unique design does not add resistance in the loop
Benefits of using surge protection

- Higher integrity
- Safer
- Increased reliability
- Reduced spares inventory
- Reduce recovery costs
- Reduce downtime
Thank you!