

The Shocking Truth About Transients In Your White Space

Computer Integrated Circuits and their codes
are not “Bullet Proof!”

- I. What is a “Transient / Spike?”
- II. Where do **Transients** come from?
- III. How do **Transients** get into your Facility electrical infrastructure?
- IV. How do **Transients** get into your I.T. White Space environment?
- V. How do **Transients** “damage” your Computer Integrated Circuits?
- VI. How do **Transients** affect your Computer Data?
- VII. How can we Safeguard our White Space environment from **Transients**?
- VIII. What Operational Improvements result from eliminating **Transients**?

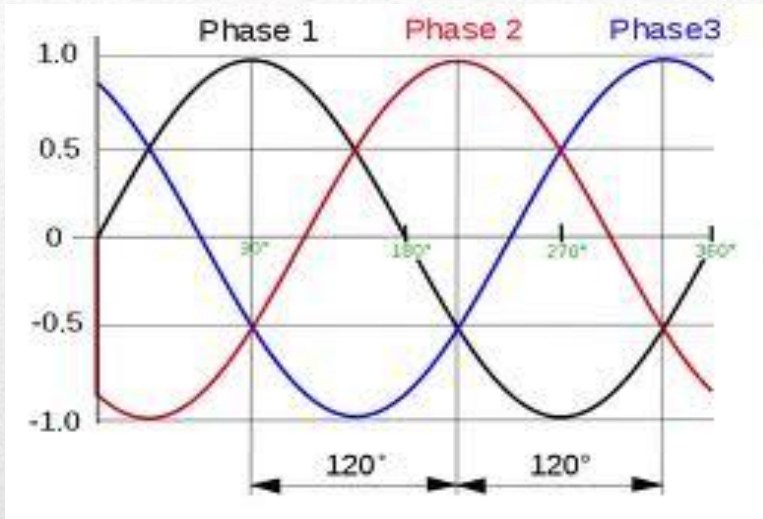
The Shocking Truth

I. What is a “Transient / Spike?”

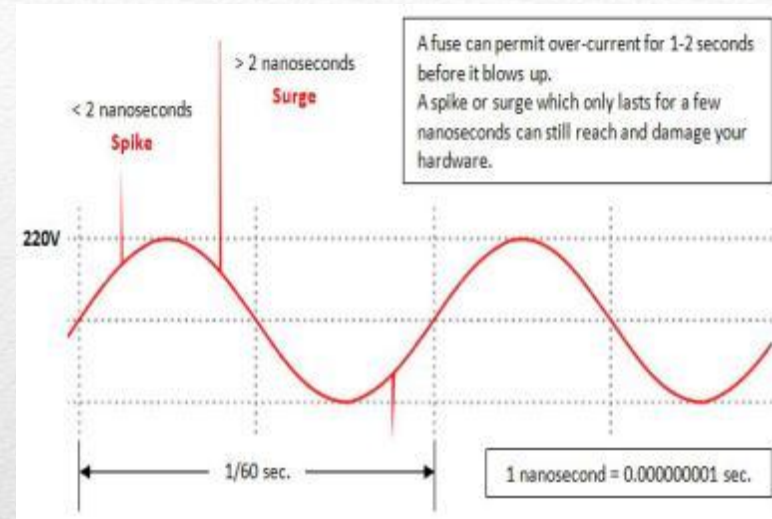
- An **external impulse of undesirable electrical energy**.
 - That is by nature either a large D.C. “spike” or
 - Is a “sliver” of a very high frequency, non-Sinusoidal A.C.
- This garbage signal “hitch hikes” a ride on the normal power 60 Cycle A.C. Sine wave.
 - Like a leech clings to its host and
 - Disrupts the clean operation of electrical equipment,
 - That eventually causes **permanent damage** to electrical equipment and/or
 - Electronic communication data!

The Shocking Truth

I. What is a “Transient / Spike?”



A Clean 3 Phase, 60 Cycle Sine Wave



A Dirty “Transient” (Spike/Surge)
Riding on a 1 Phase, 60 Cycle
Sine Wave

The Shocking Truth

II. Where do Transients *come from*?

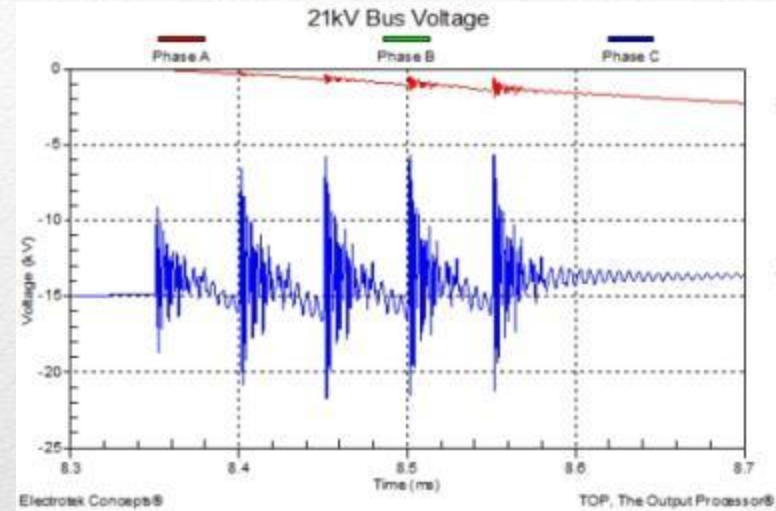
- The energy source of these “**Transients**” is generated by:
 - Lightning,
 - Utility Sub Station High Voltage (230kV, 115kV) & Medium Voltage (35kV, 15kV, 7kV) Switching,
 - Opening or closing electrical contact switching,
 - Motor noise,
 - Magnetic Solenoid Noise,
 - Inductively coupled energy, from closely oriented power cables and wires, or
 - Static electricity.

The Shocking Truth

II. Where do Transients come from?



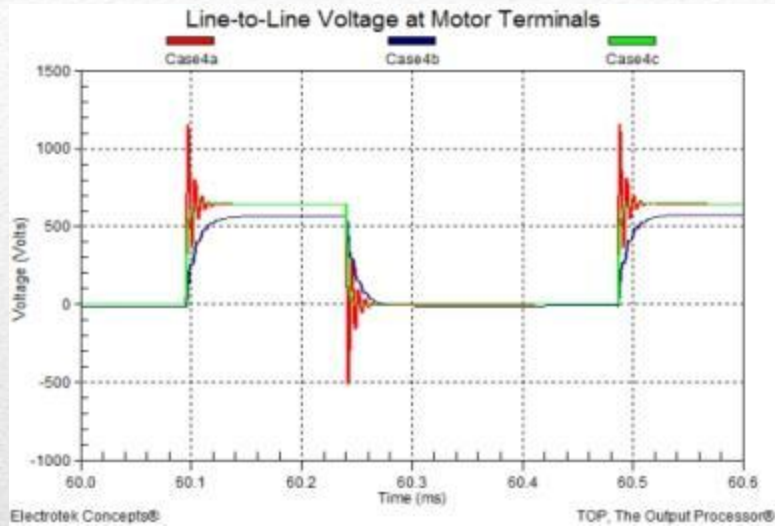
Lightning Down or Up Strikes



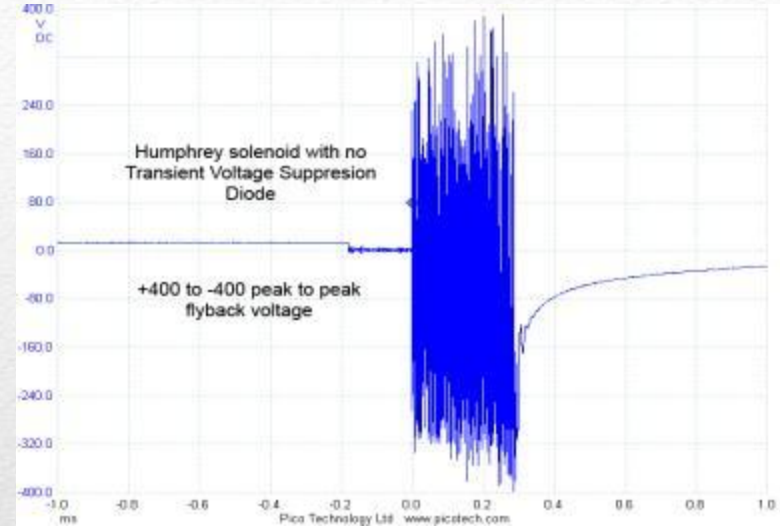
Utility Sub Station's Medium Voltage Switching

The Shocking Truth

II. Where do Transients come from?



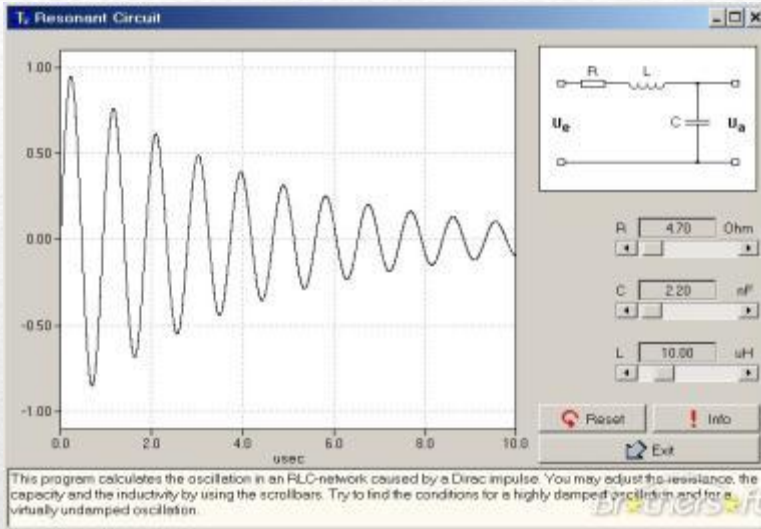
Motor Noise



E to P Solenoid Noise

The Shocking Truth

II. Where do Transients come from?



RLC Inductive Coupled “Ring Wave”

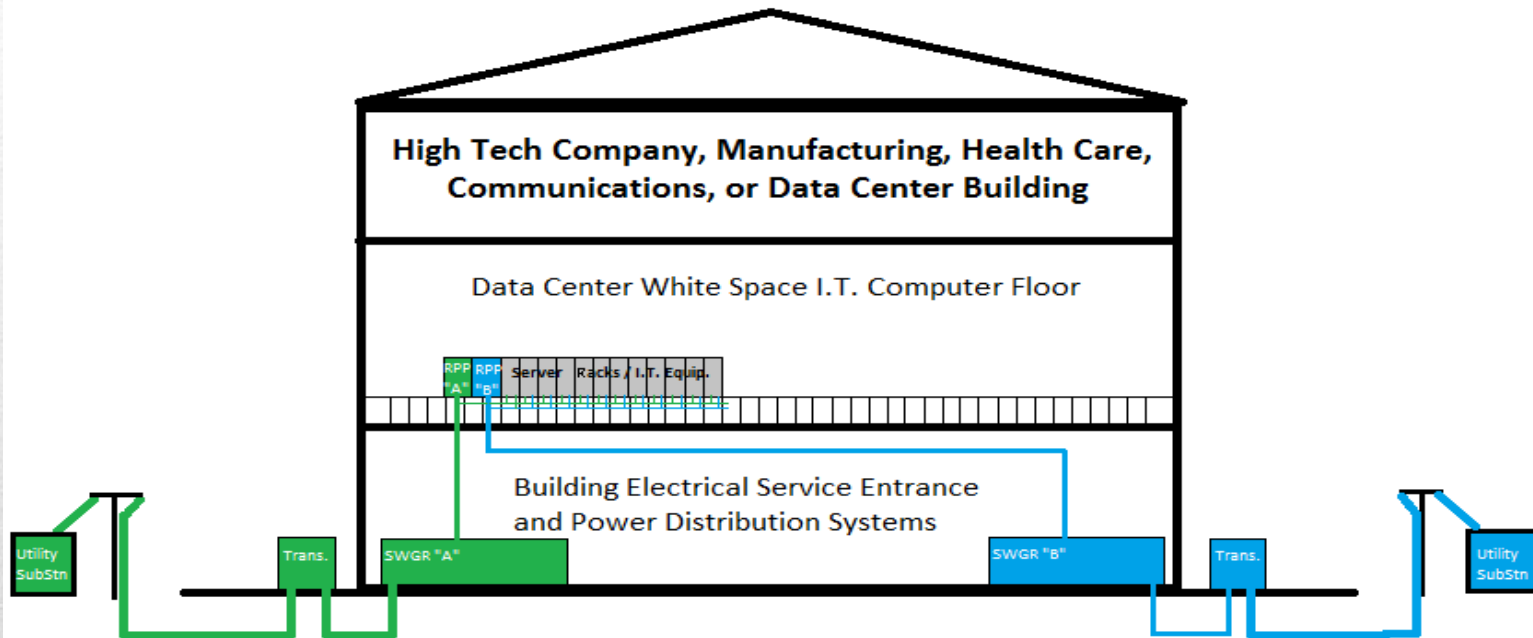
Static Electricity

The Shocking Truth

- This “**Transient**” energy enters your facility or home through:
 - The Roof/Top Door,
 - The Basement Door,
 - The Front Door, and/or
 - The Back Door!

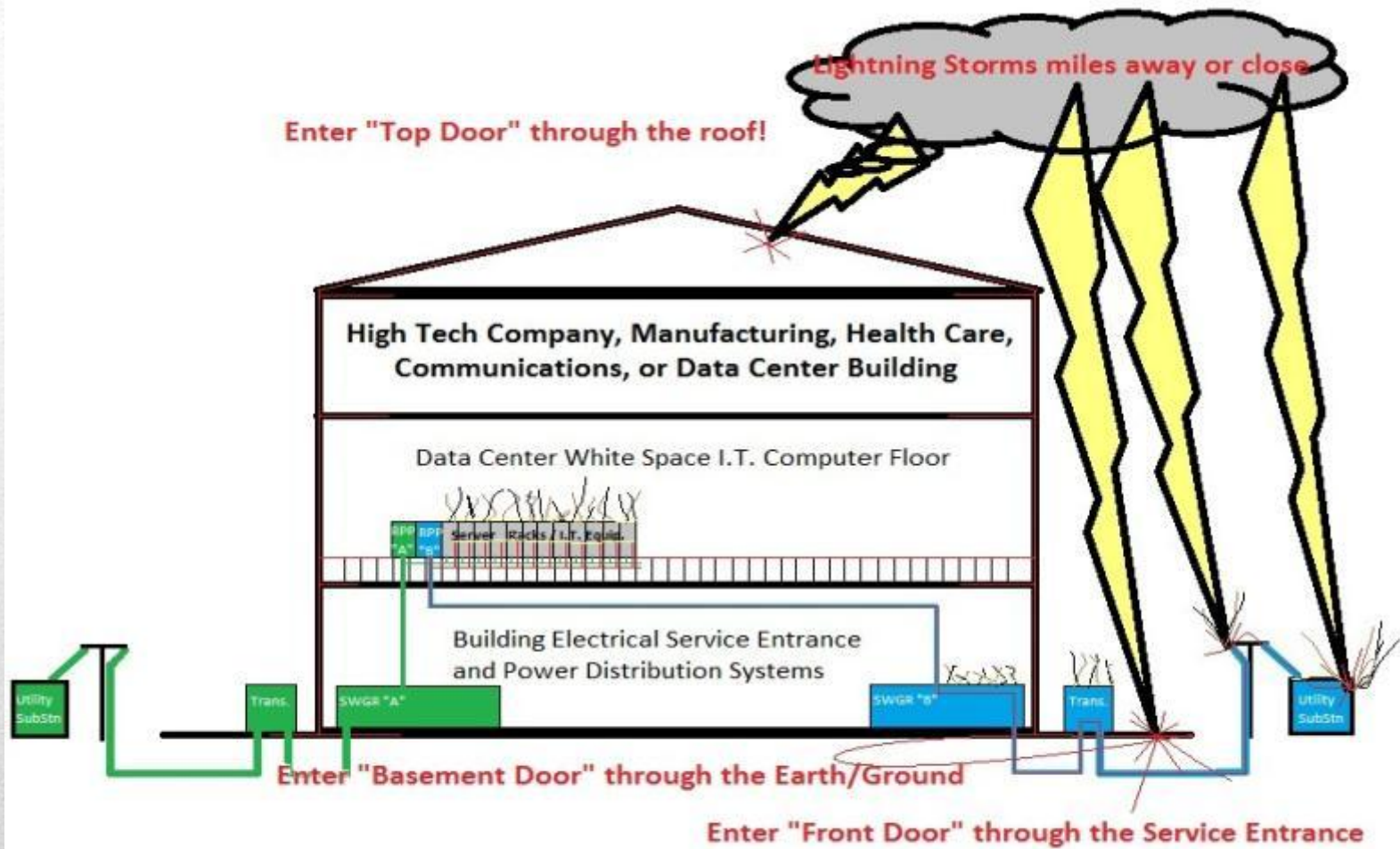
The Shocking Truth

III. How do Transients get into your *Facility electrical infrastructure*?



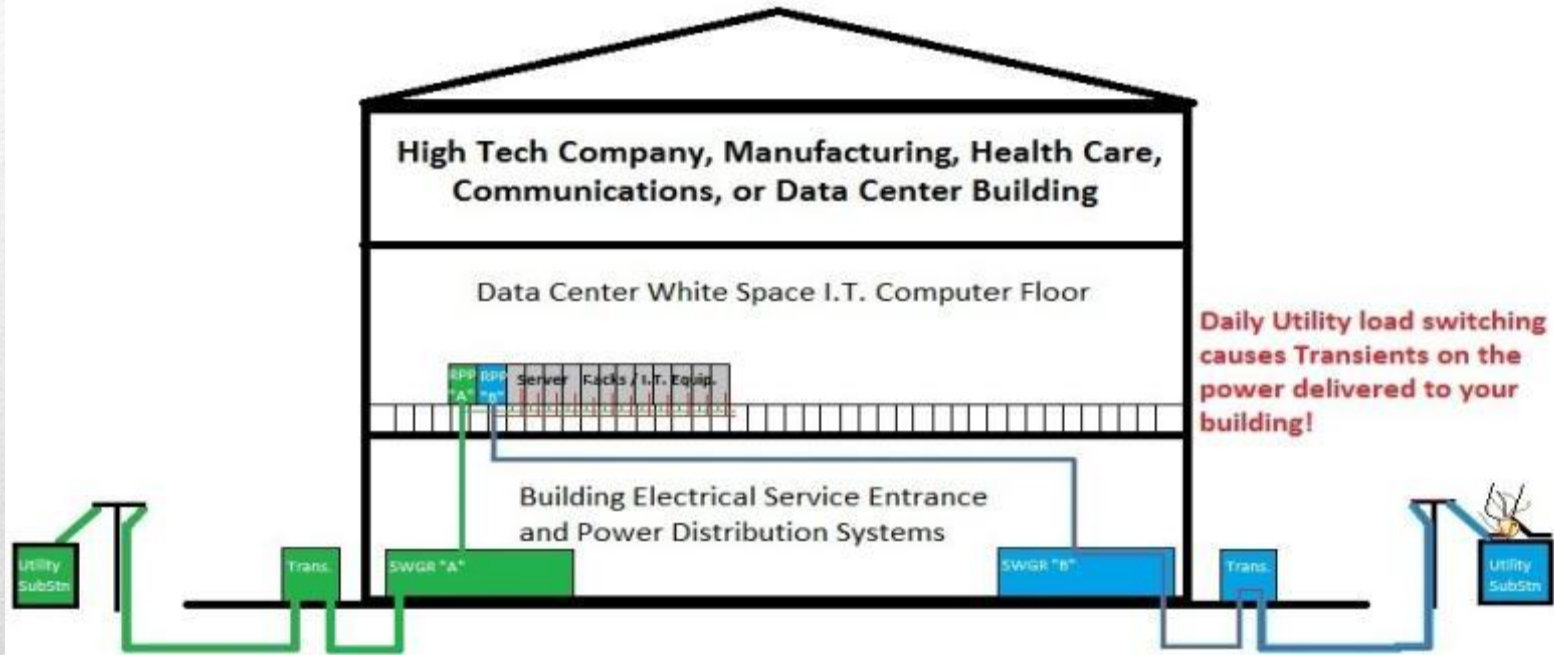
The Shocking Truth

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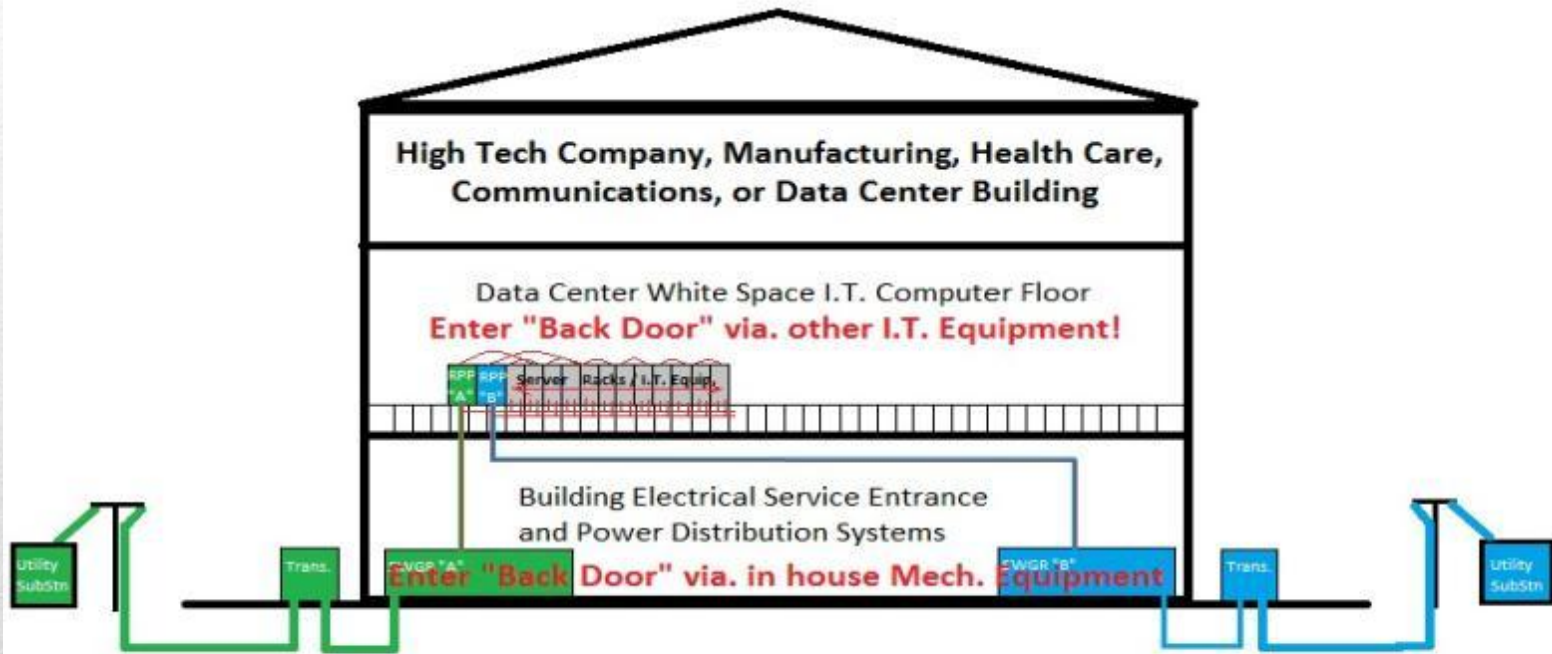
The Shocking Truth

III. How do Transients get into your *Facility electrical infrastructure*?



The Shocking Truth

III. How do Transients get into your *Facility electrical infrastructure*?



The Shocking Truth

IV. How do Transients get into your *I.T. White Space environment*?

- 5% - **Top Door**, direct Lightning strikes.
- 5% - **Basement Door**, nearby Lightning surge difference of potential.
- 10% - **Front Door**, Utility Power into the White Space but dampened by the UPS.
- 80% - **BACK DOOR**, created by the White Space I.T. Equipment themselves!

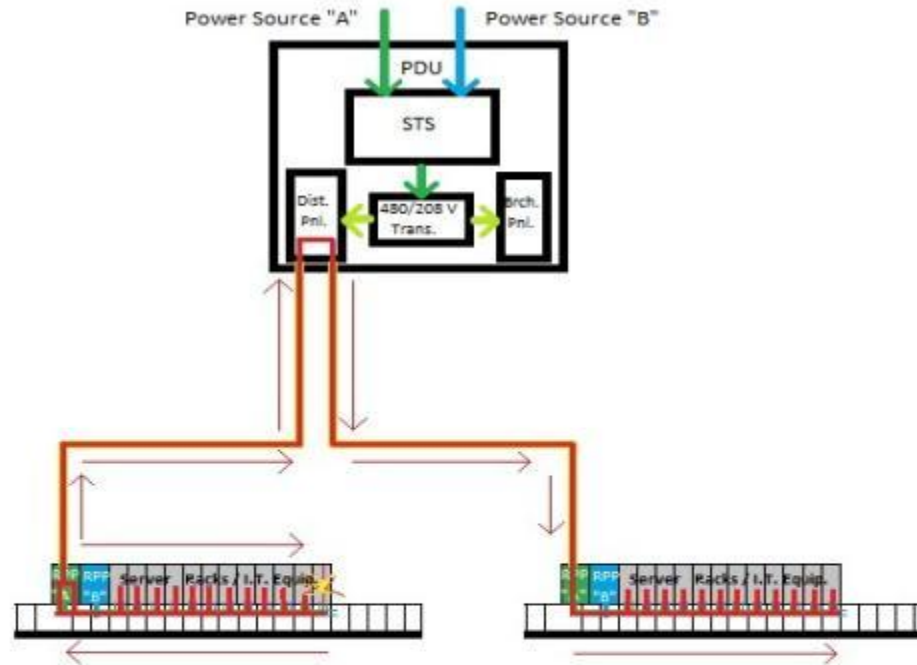
The Shocking Truth

IV. How do Transients get into your *I.T. White Space environment*?

- A. By Incoming Power events,
- B. By the PDU's "Static Transfer Switch" (STS) switching,
- C. By the PDU & RPP circuit breaker switching,
- D. By plugging & unplugging Rack VPS/PDU's,
- E. By plugging & unplugging I.T. Power Supplies in VPS/PDU's,
- F. By Network Equipment's Solid State switching,
- G. By Servers automated energy saving hibernate/shutdown/start,
- H. By Switch Mode DC Power Supply operation & failures,
- I. By Electronic-to-Light fiber optics Transducer failures and
- J. By poor humidity control & employee static electricity transfer!

The Shocking Truth

IV. How do Transients get into your *I.T. White Space environment*?



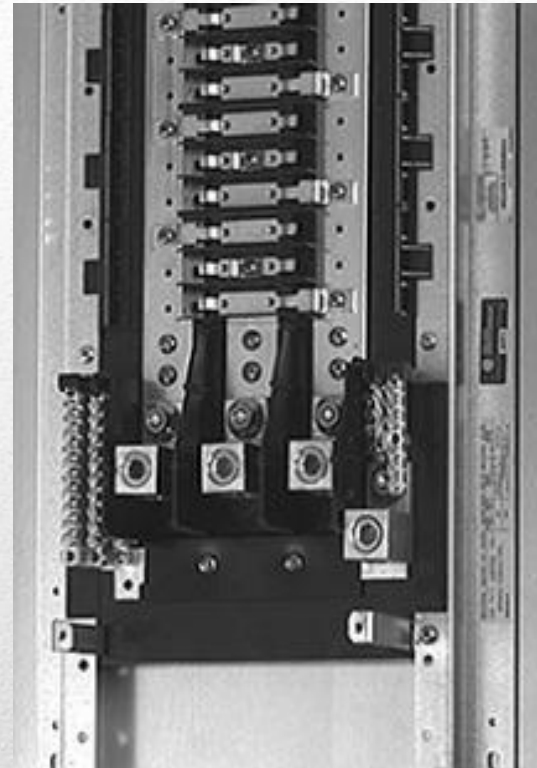
Because of the way all **Distribution Panels** and **Branch Panels** are made and interconnected, any **"Transient Event"** that may occur within that wiring system can be felt by all of the electronic components energized by that system!

The Shocking Truth

IV. How do Transients get into your *I.T. White Space environment*?



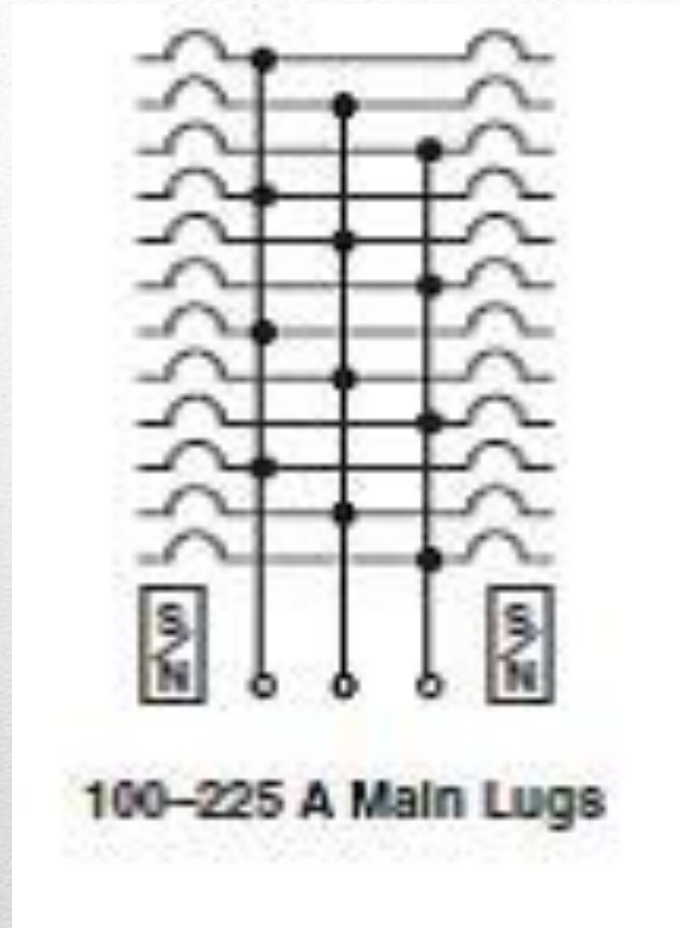
208/120 V., 3 Phase, Branch Panel
as found in PDU's & RPP's



Branch Panel w/o its hinged Door
and safety Dead Front Cover

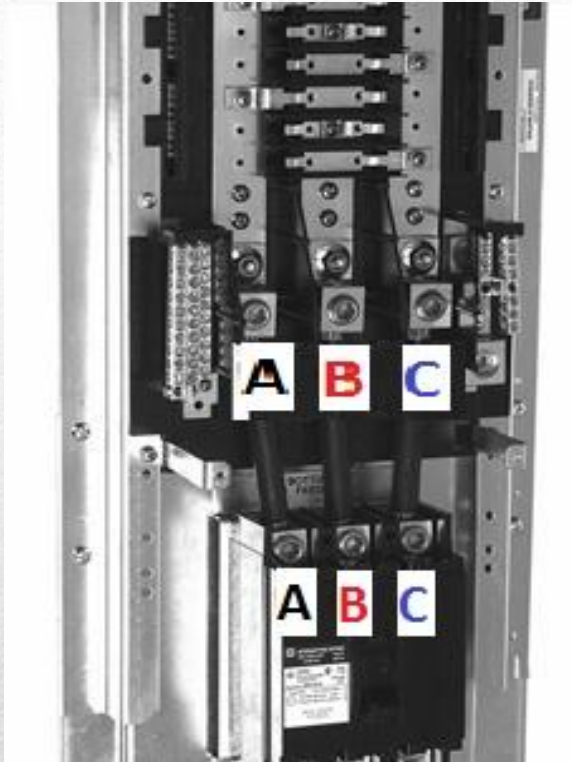
The Shocking Truth

IV. How do Transients get into your *I.T. White Space environment*?

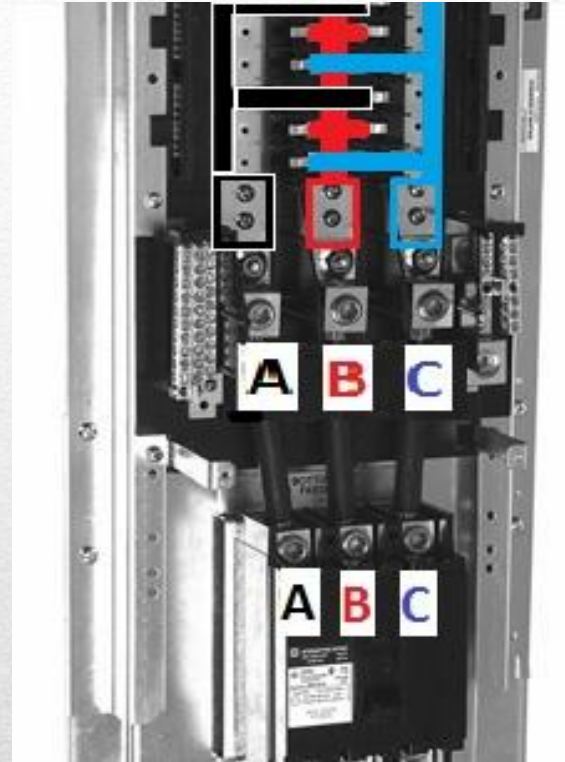


The Shocking Truth

IV. How do Transients get into your *I.T. White Space environment*?



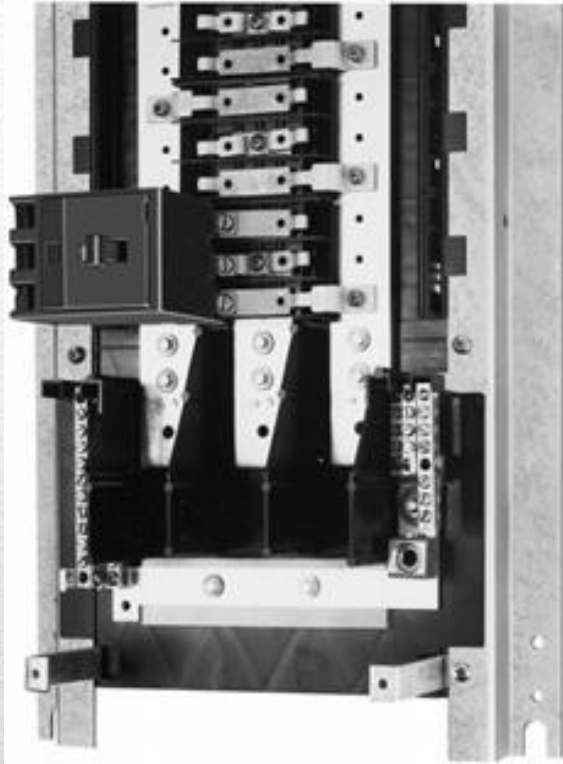
3 Phase Buses “A,” “B” & “C”



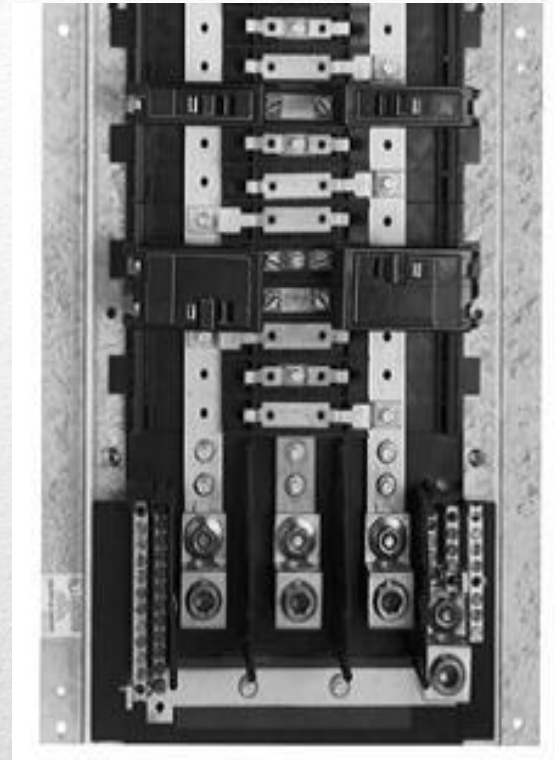
3 Phase Bus Bars connect multiple
Circuit Breaker Bus Tap points

The Shocking Truth

IV. How do Transients get into your *I.T. White Space environment*?



A 3 Pole Circuit Breaker bolted to each "A," "B" & "C" Phase Bus Tap

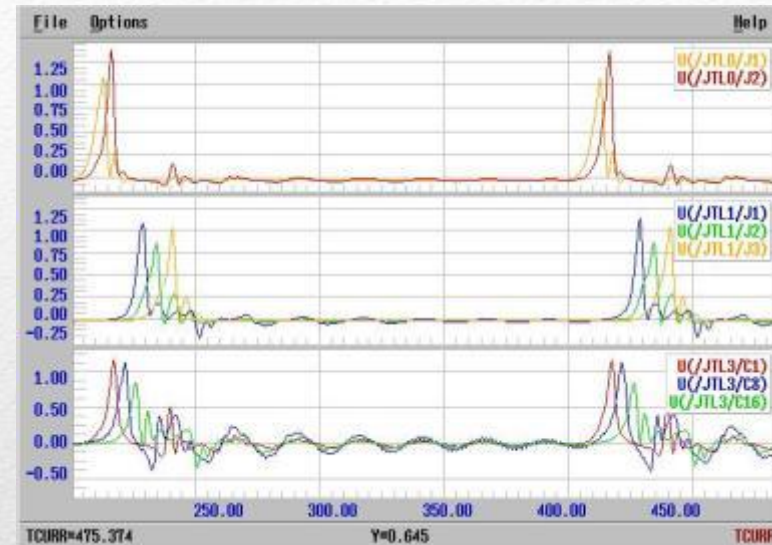


1 Pole & 2 Pole Circuit Breakers bolted to "A" Phase & "B/C" Phase Bus Taps

The Shocking Truth

IV. How do Transients get into your *I.T. White Space* environment?

Transient Categories	Spectral Component	Duration
Impulsive		
Millisecond (low frequency)	0.1 msec rise	>1 msec
Microsecond (medium frequency)	1 μ sec rise	50 nsec to 1 nsec
Nanosecond (high frequency)	5 nsec rise	< 50 nsec
Oscillatory		
Low frequency	< 5 kHz	0.3 msec to 50 msec
Medium frequency	5 kHz to 500 kHz	5 μ sec to 20 μ sec
High frequency	0.5 MHz to 5 MHz	5 μ sec

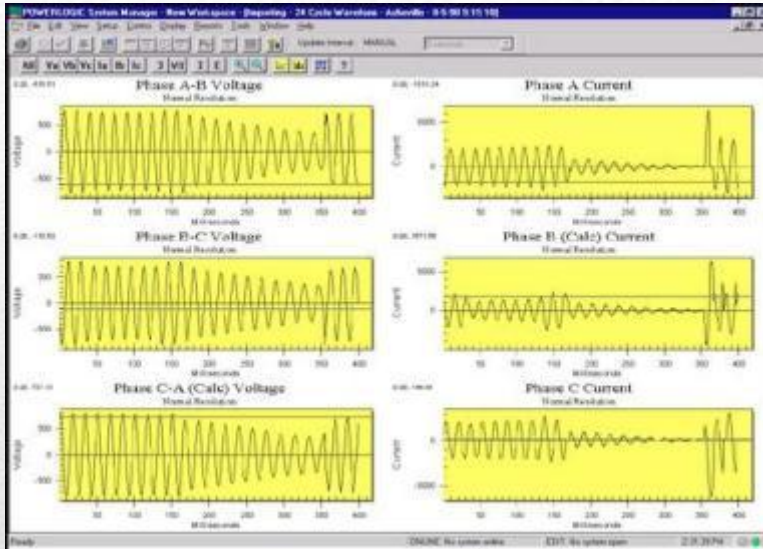


Transient Types, Frequency Speeds
and Effective Durations

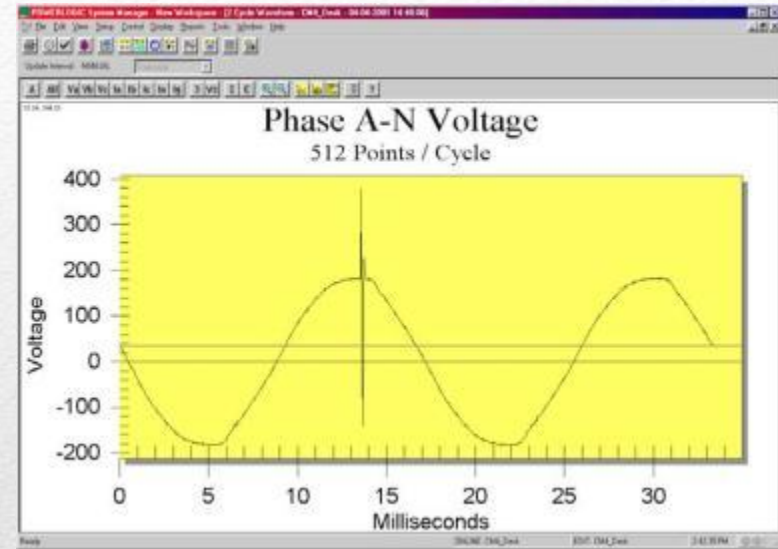
Multiple Transients of different
Types, Frequencies and Durations

The Shocking Truth

IV. How do Transients get into your *I.T. White Space* environment?



3 Phase Voltage Sag & Swell, with
“Ring Wave” event, followed by high
Frequency recovery Transients



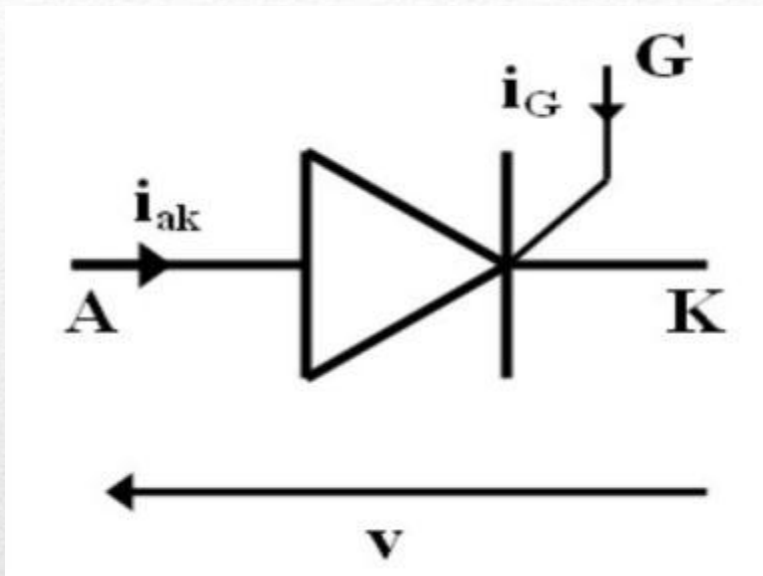
Single, high energy Transient, with a
large energy component hiding inside
of the negative Sine wave.

The Shocking Truth

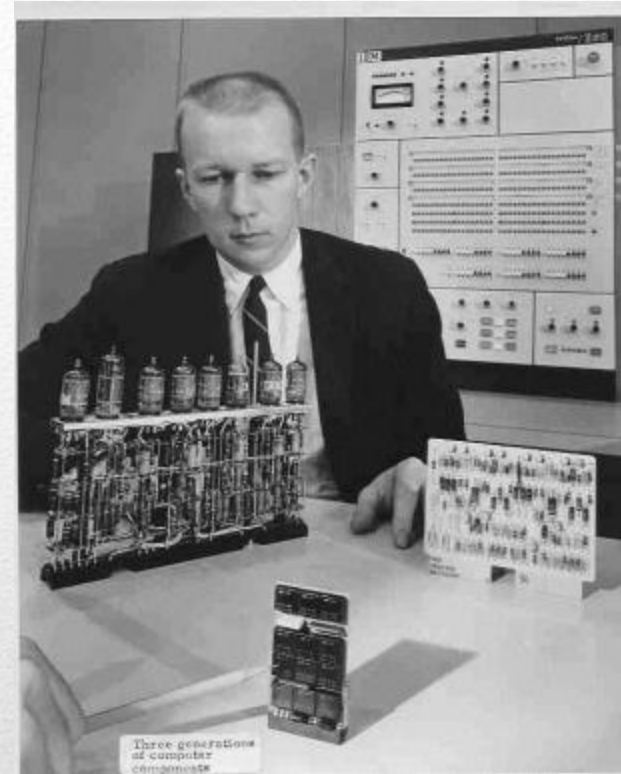
- In order to understand how **Integrated Circuits** (IC’s) are affected by **Transient**, we must understand:
 - Where did IC’s come from,
 - How are they manufactured,
 - How are they connected into electronic equipment,
 - How are they damaged, and
 - How does that damage affect the overall performance of a Data Center?

The Shocking Truth

V. How do Transients “damage” your *Computer Integrated Circuits*?



A Transistor is simply a switch that blocks and passes current flow by controlling the “Gate” with a smaller “Control Voltage” to send Codes.



In the 1950's and 1960's scientists reduced “Vacuum Tube” Transistors to “Solid State” devices and then “IC's.”

The Shocking Truth

V. How do Transients “damage” your Computer Integrated Circuits?



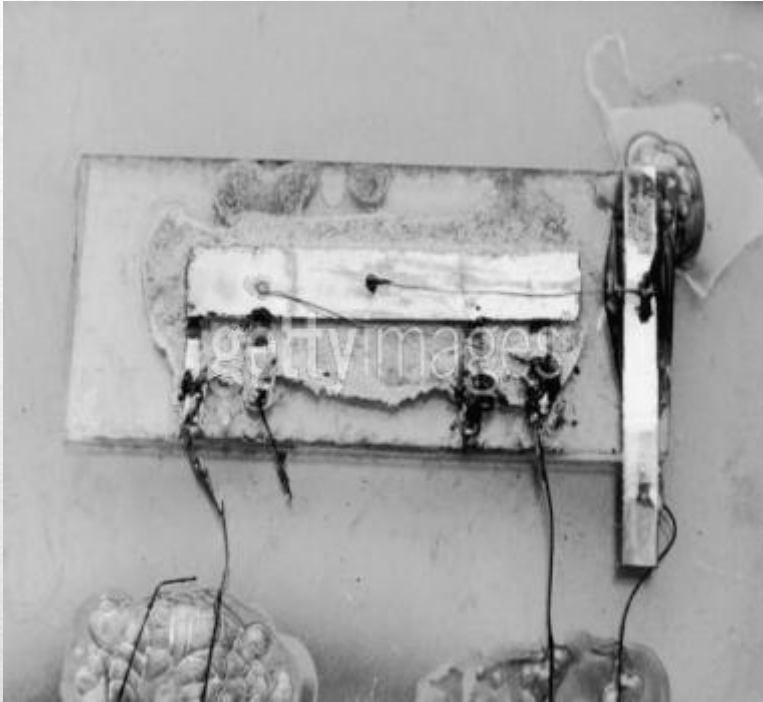
A “Solid State” discrete Transistor device that soldered onto a PC board.



Jack Kibly won the Noble Price for reducing the discrete Transistor to a “Film” of N/P/N Integrated Circuit Transistor!

The Shocking Truth

V. How do Transients “damage” your *Computer Integrated Circuits*?



Jack Kibly's 1958 “Film” of N/P/N
Integrated Circuit Transistor!



Mr. Kibly in this 2002 photo of a modern
300mm Wafer, with 108 Die/IC, each
with thousands of Transistors!

The Shocking Truth

V. How do Transients “damage” your *Computer Integrated Circuits*?



1. Just as in building a house, you need a construction plan to construct a chip. The construction plans for the chip are made and tested with a computer.



2. From the construction plans, masks with the circuit patterns are made.



3. Under precisely monitored conditions, a pure silicon crystal is grown. Circuit manufacturing demands the use of crystals with an extremely high grade of perfection.



4. The silicon is sawed into thin wafers with a diamond saw. The wafers are then polished in a number of steps until their surface has a perfect mirror-like finish



5. The silicon wafer is covered with a layer of insulating silicon oxide.



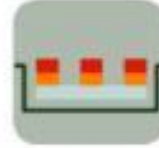
6. A covering film of protective material is put on top of the insulating silicon oxide. This material, a bit like the film in any ordinary camera, is sensitive to light.



7. UV-light is shone through a mask and onto the chip. On the parts of the chip that are hit by light, the protective material breaks apart.



8. The wafer is developed, rinsed and baked. The development process removes the parts of the protective material exposed to light.



9. The wafer is treated with chemicals in a process called “etching.” This removes the unprotected insulating material, creating a pattern of non-protected silicon wafer parts surrounded by areas protected by silicon oxide.



10. The wafer is run through a process that alters the electrical properties of the unprotected areas of the wafer. This process is called “doping.” Steps 5–10 are repeated to build the integrated circuit, layer by layer. Other layers of conducting or isolating layers may also be added to make the components.

Back End – Adding the Connecting Wires



11. Finally, when all the components of the chip are ready, metal is added to connect the components to each other in a process called metalization. This is done in a way similar to the making of the components. First a conducting metal like copper is deposited over the chip.



12. On top of the metal a layer of UV-sensitive photo resist is added.

The Shocking Truth

V. How do Transients “damage” your *Computer Integrated Circuits*?



13. Next, a mask that describes the desired layout of the metal wires connecting the components of the chip is used. UV-light is shone through this mask. The light hits the photo resist that isn't protected by the mask.



14. In the next step, chemicals are used to remove the photo resist hit by UV-light.



15. Another step of etching removes the metal not protected by photo resist.



16. This leaves a pattern of metal that is the same as the one described by the mask. Now, the chip has a layer of wires that connect its different components.



17. Today, most integrated circuits need more than one layer of wires. Advanced circuits may need up to five different layers of metal to form all the necessary connections. In the last picture we have added another layer of metal to our example. As you can see, a layer of insulating material is put between the two metal layers to prevent the wires from connecting in the wrong places. Of course, to add the second layer we had to go through the same steps as when adding the first layer of metal.



18. When the final layer of connecting metal wires have been added, the chips on the silicon wafer are tested to see if they perform as intended.



19. The chips on the wafer are separated with a diamond saw to form individual integrated circuits.



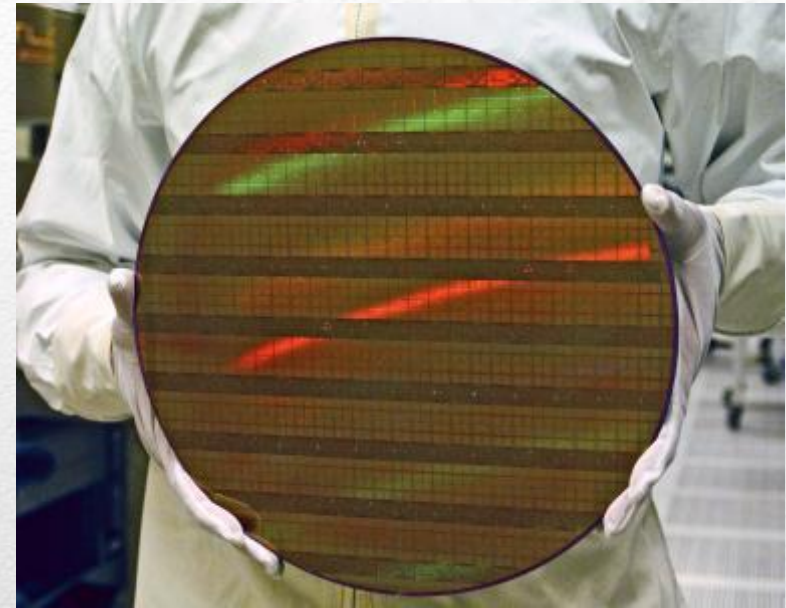
20. Finally, each chip is packed into the protective casing and subjected to another series of tests. The chip is now finished and ready to be shipped to manufacturers of digital devices around the world.

The Shocking Truth

V. How do Transients “damage” your *Computer Integrated Circuits*?



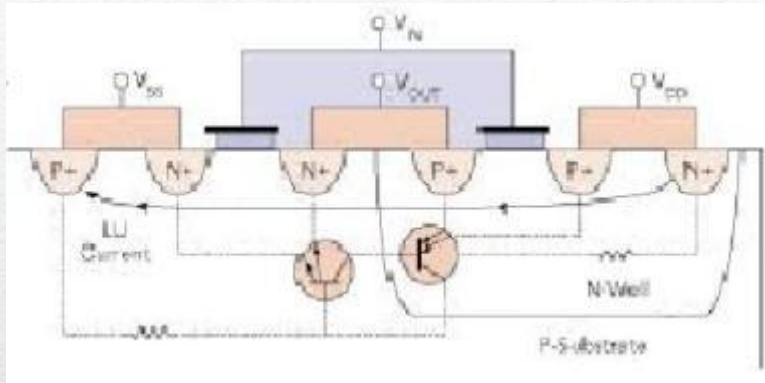
Inside of a Wafer Fab's
Photolithography Clean Room



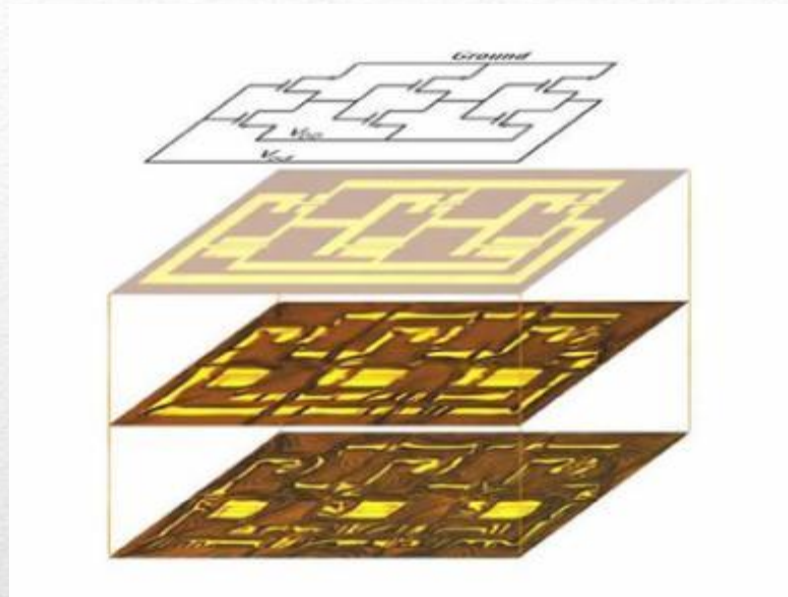
A 300mm (12") finished Wafer, that is
ready for cutting into individual “Die”
and then packaging into a PC Board IC.

The Shocking Truth

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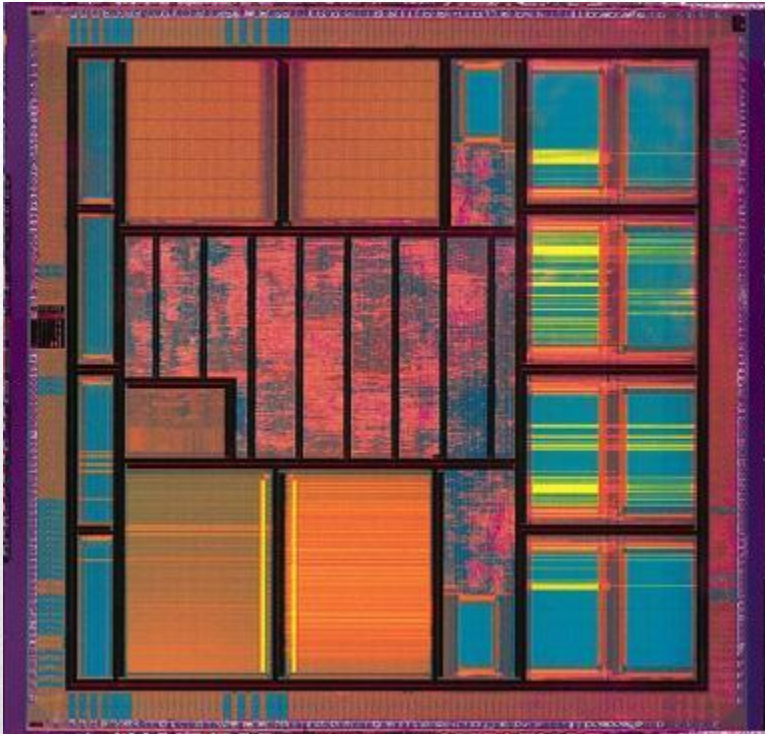
A cross section model of 1 of some 15 layers of circuits, to be “laid down” on a Wafer, to make an IC.
(Note the N/P/N portions that will form Transistors.)



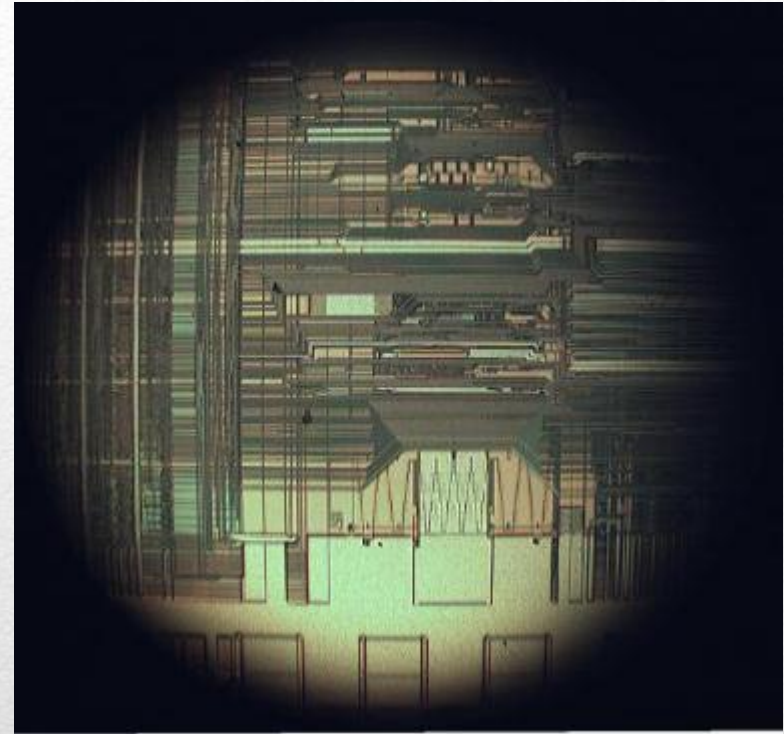
An example of the Photo negatives that are required to transfer the “Tracings” and “Doping” required to create the circuit to the left.
(Note the 6 Transistors in the top layer.)

The Shocking Truth

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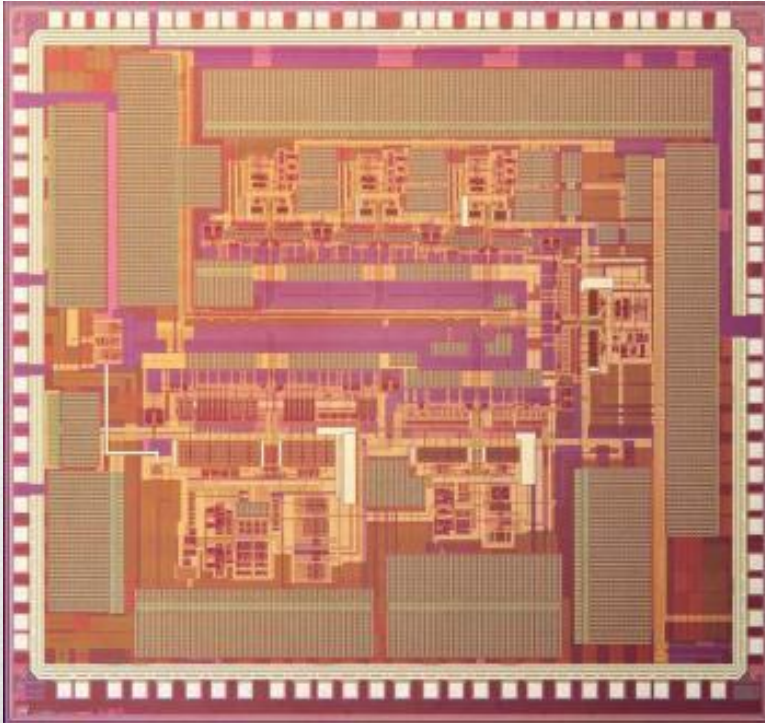
A complex Photo negative, or “Photo Mat” with thousands of wire way “tracings” that build the circuits.



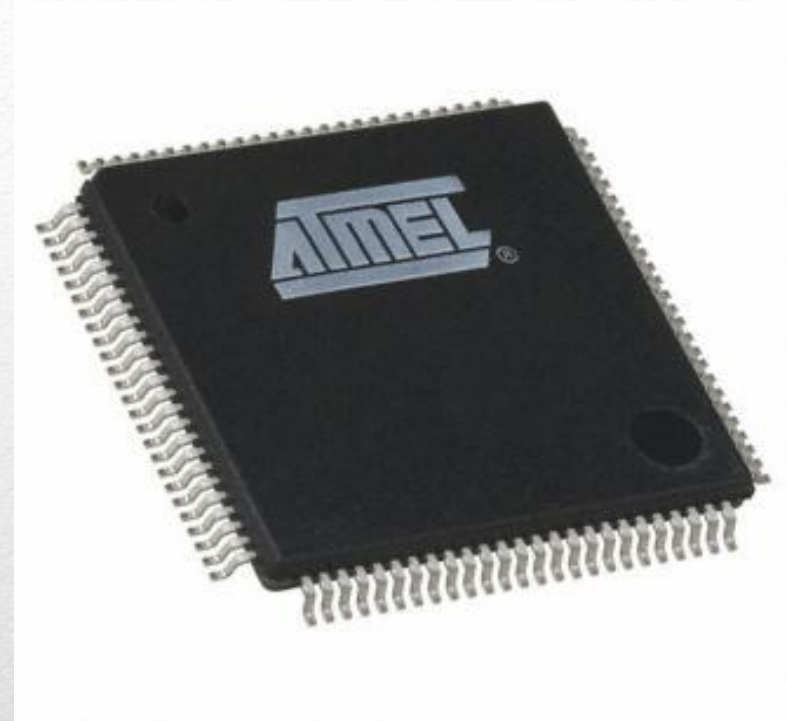
This is an inspection look at several “Mats” sandwiched together, to view their interconnections between layers.

The Shocking Truth

V. How do Transients “damage” your Computer Integrated Circuits?



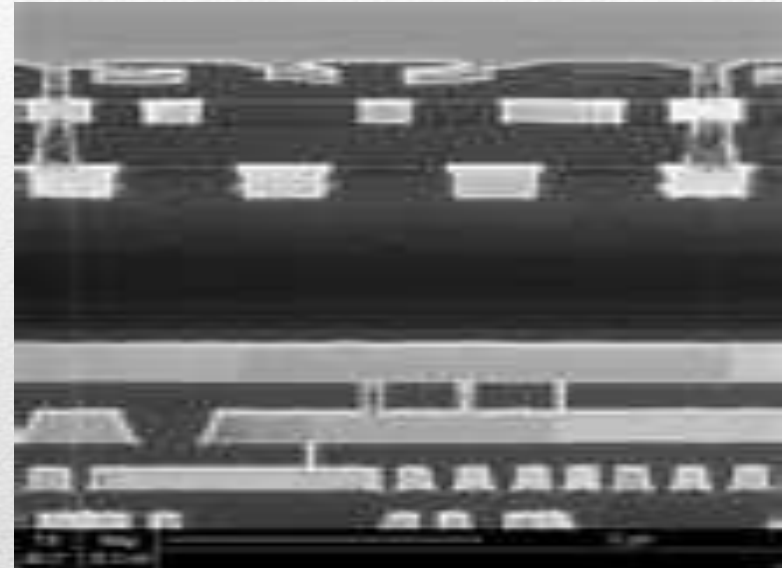
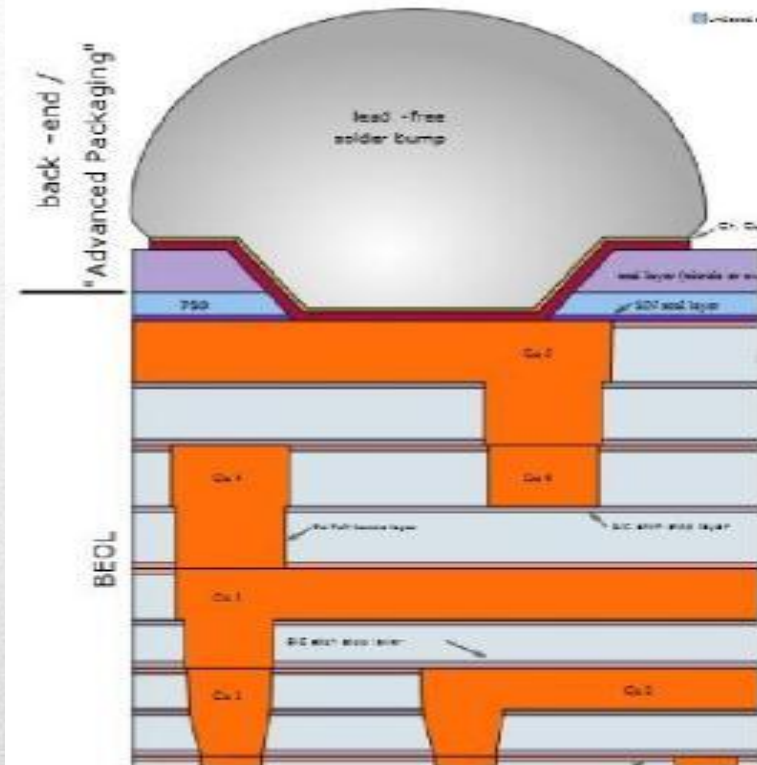
This is one “Photo Mat” of the finished IC to the right! (*Note the solder pads around the edges.*)



The “Packaged” IC is ready for final electronic testing and shipping to the customer for PC Board insertion.

The Shocking Truth

V. How do Transients “damage” your *Computer Integrated Circuits*?

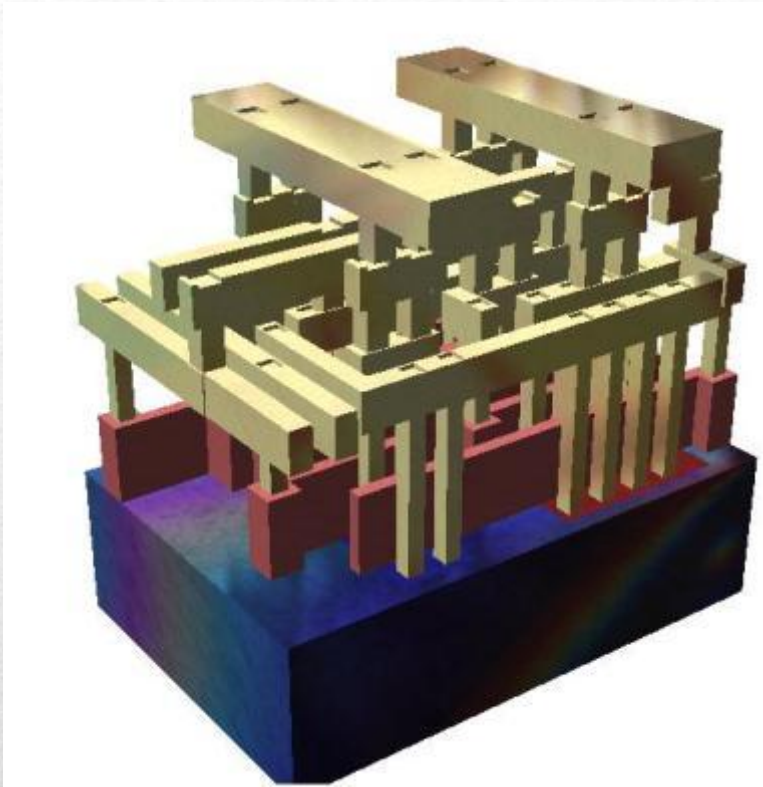


The actual layers are negated if they cannot interconnect exactly.

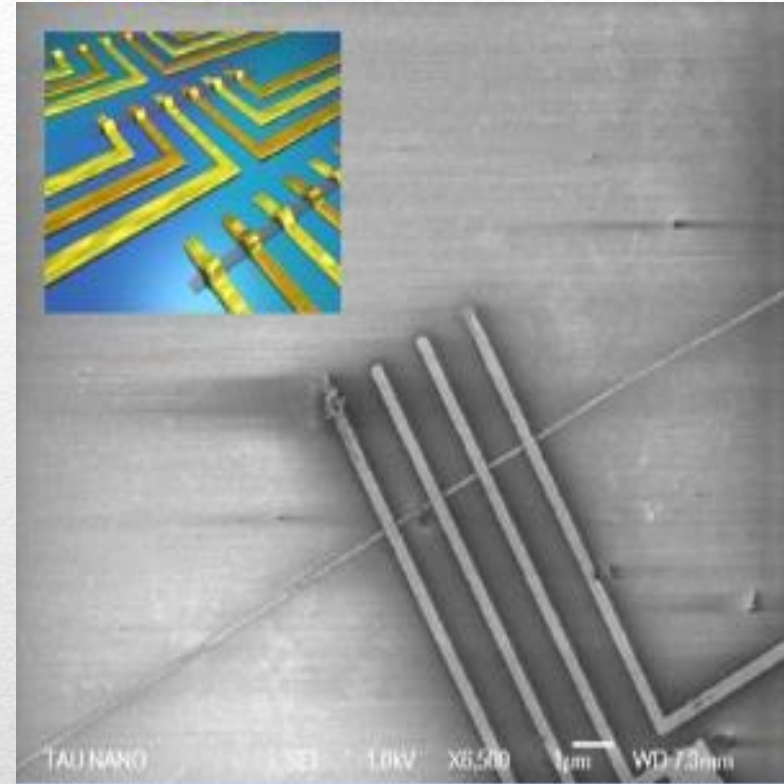
A Scanning Electron Microscope (SEM) cross section image of interconnecting layers.

The Shocking Truth

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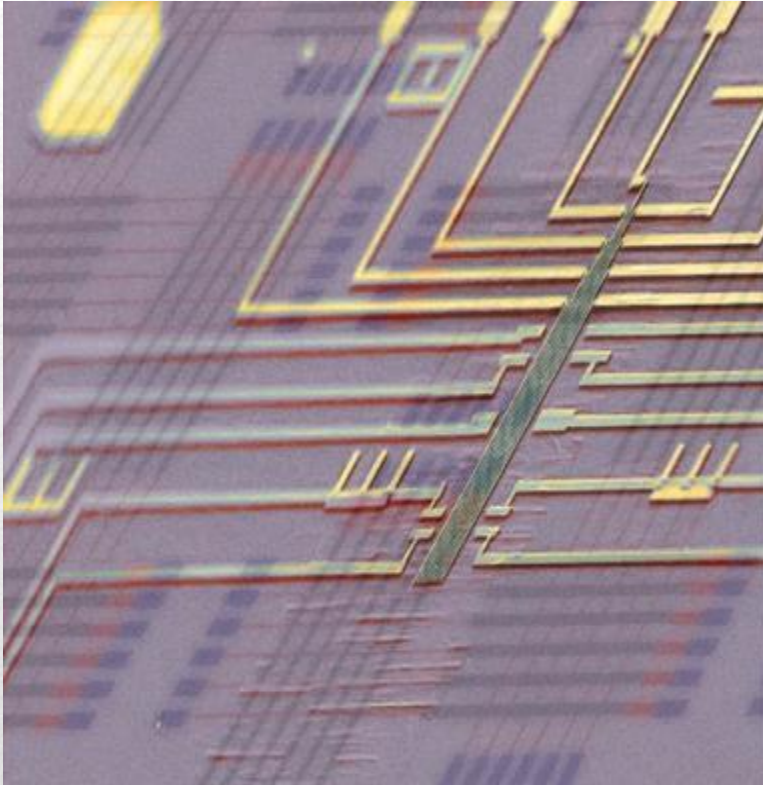
A 3D computer model of the metal “Tracings” & “Bus Work” in 8 layers.



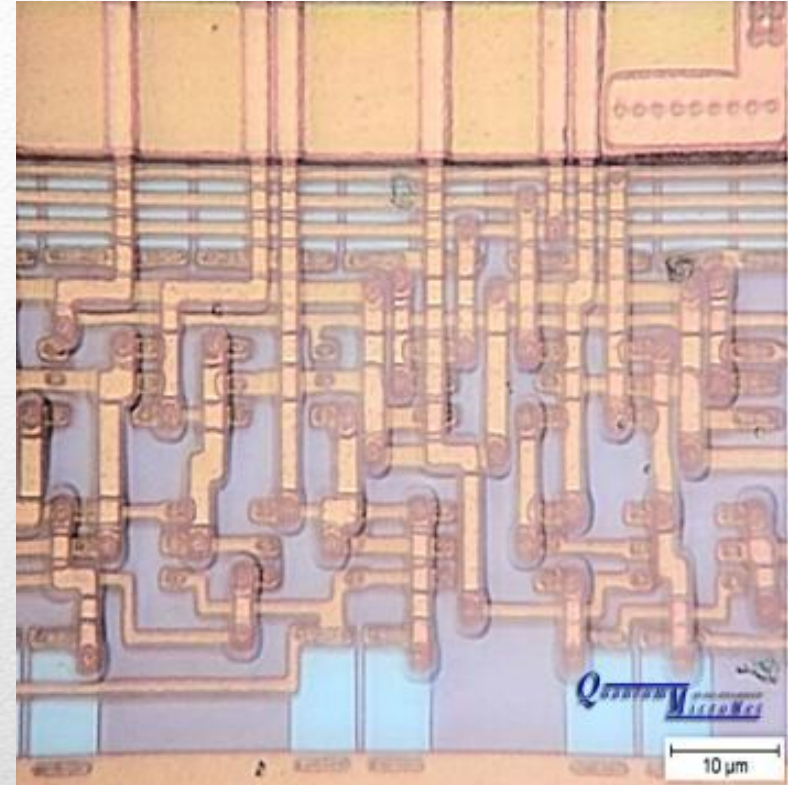
Color model of “Wire Ways” & a B&W SEM of wires that are 10 times smaller than a human hair!

The Shocking Truth

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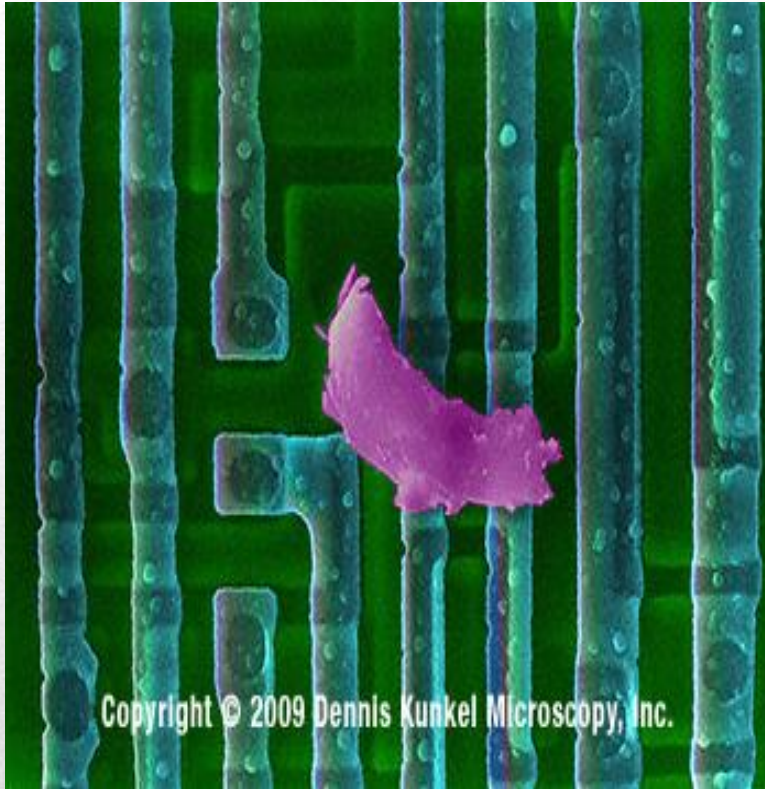
SEM inspection of a “Wire Ways” layer before the next layers are applied. (*Note the layers below.*)



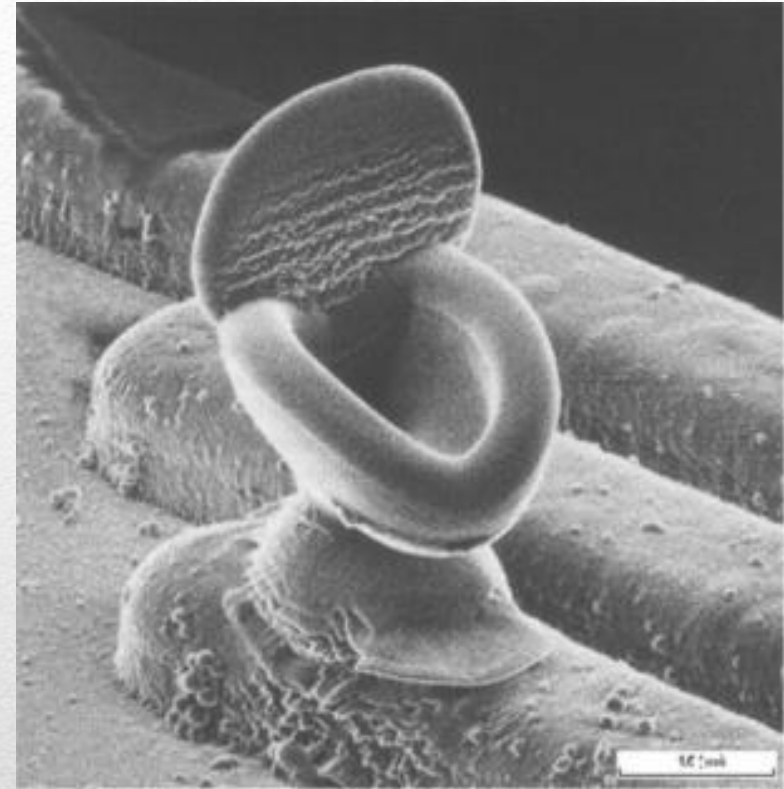
SEM Photo of multi layers of “Wire Ways” & their vertical connections between layers. (*Note pin point accuracy!*)

The Shocking Truth

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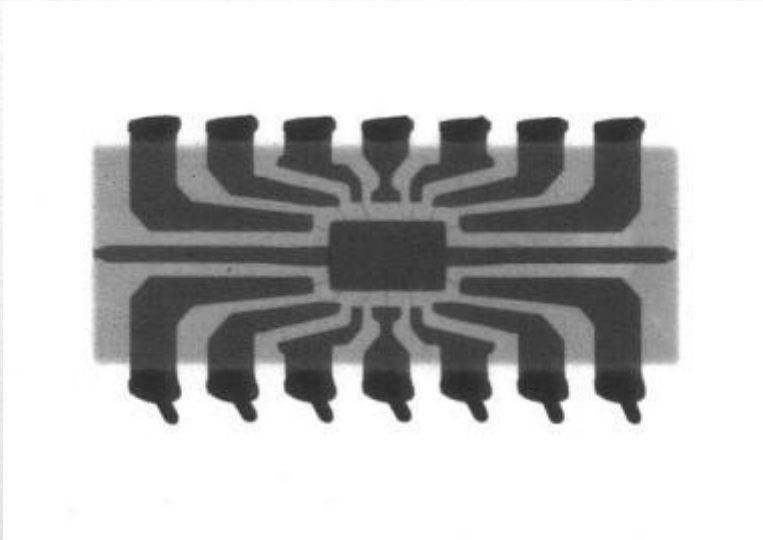
Contamination/dirt between layers destroys the following layers. (*Note the flake of skin, 3/10th hair width.*)



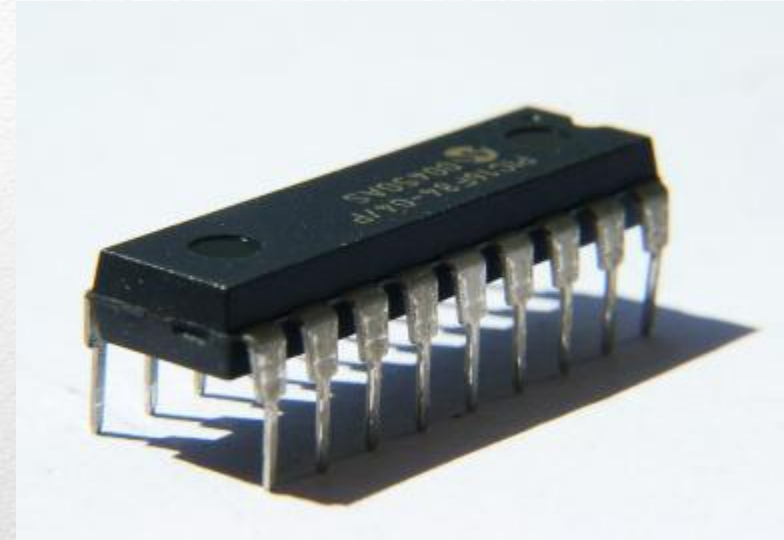
Famous Japan SEM Photo “The Toilet,” that depicts the unwanted “trash” between layers. (*Note wires at 1/10th hair width.*)

The Shocking Truth

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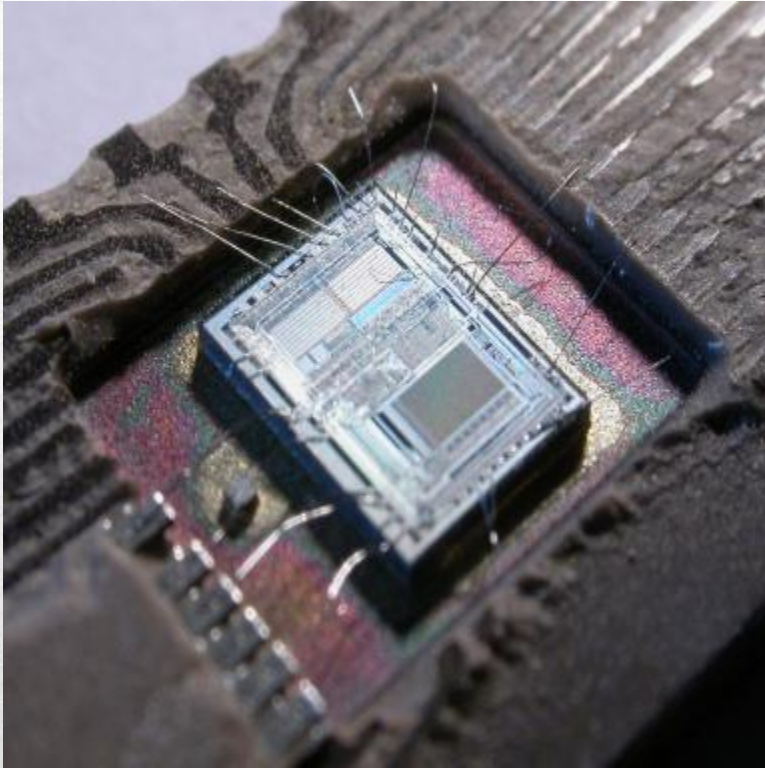
Top X-ray: “Die” in the center, with gold “Wires” bonded to external pins, for PC Board female socket insertion.



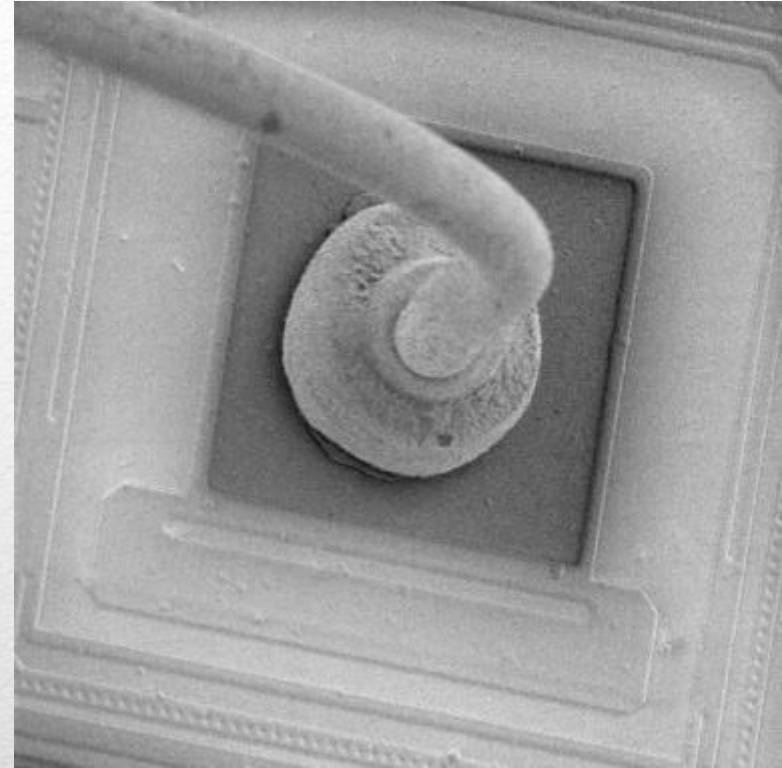
The finished “Packaged” IC ready to be inserted into its PC Board female socket.

The Shocking Truth

V. How do Transients “damage” your *Computer Integrated Circuits*?



A “Failure Analysis” Photo of the “Packaging” top & metal pins removed, showing IC & gold wires.



SEM Photo of the gold wire bonded to the IC’s aluminum “Pad,” as seen to the left w/o magnification.

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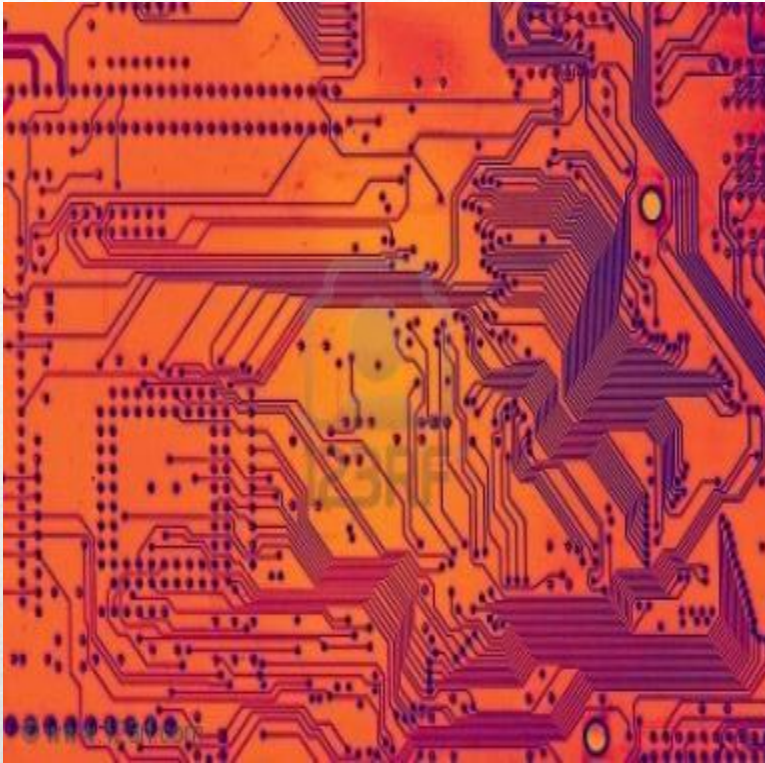
Today our world is strewn with Integrated Circuits/Chips in nearly everything we use!



Printed Circuit Boards are the platform for smart IC's & discrete electronic power components.

The Shocking Truth

V. How do Transients “damage” your *Computer Integrated Circuits*?



A light table Photo of a complex PC Board with multiple layers of tracings and layer-to-layer vertical connections.



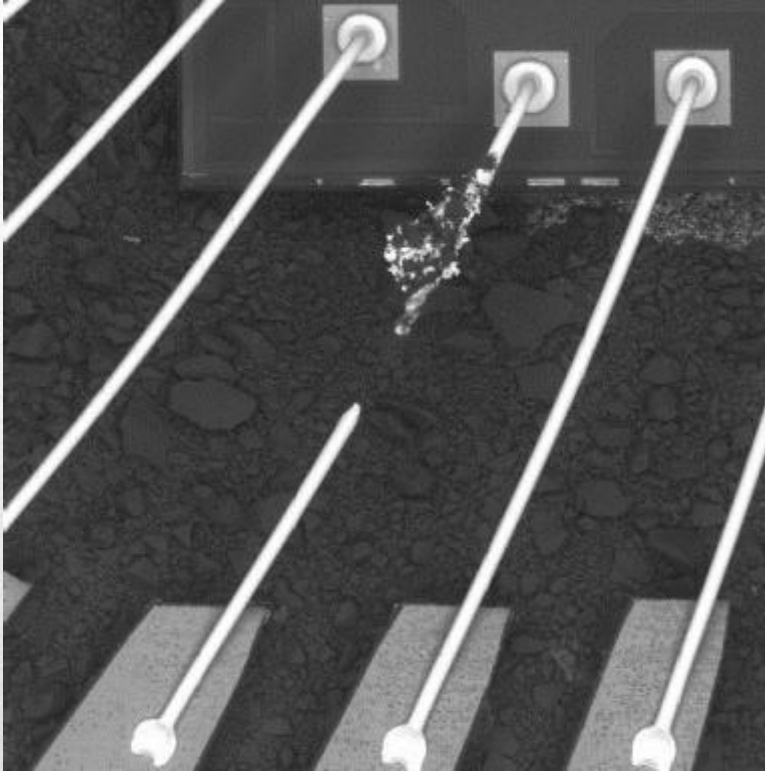
The same type of complex PC Board after component insertion & wave soldering to a completed plug-in board.

The Shocking Truth

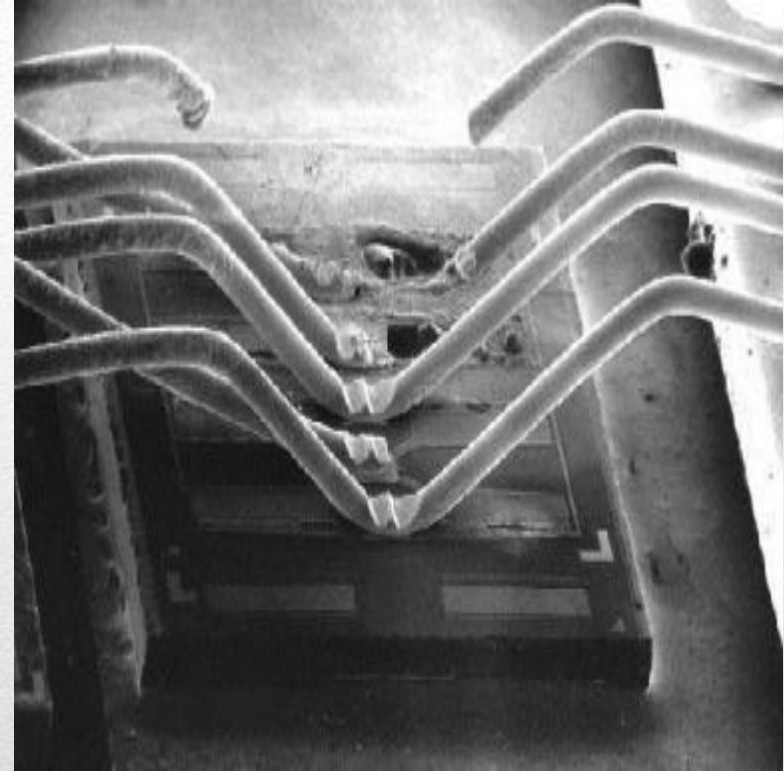
- In the Electronic world of microscopic “Integrated Circuits,”
Transients and their damage are classified as:
 - “Electrical Over Stress” (**EOS**) and
 - “Electro Static Discharge” (**ESD**).

The Shocking Truth

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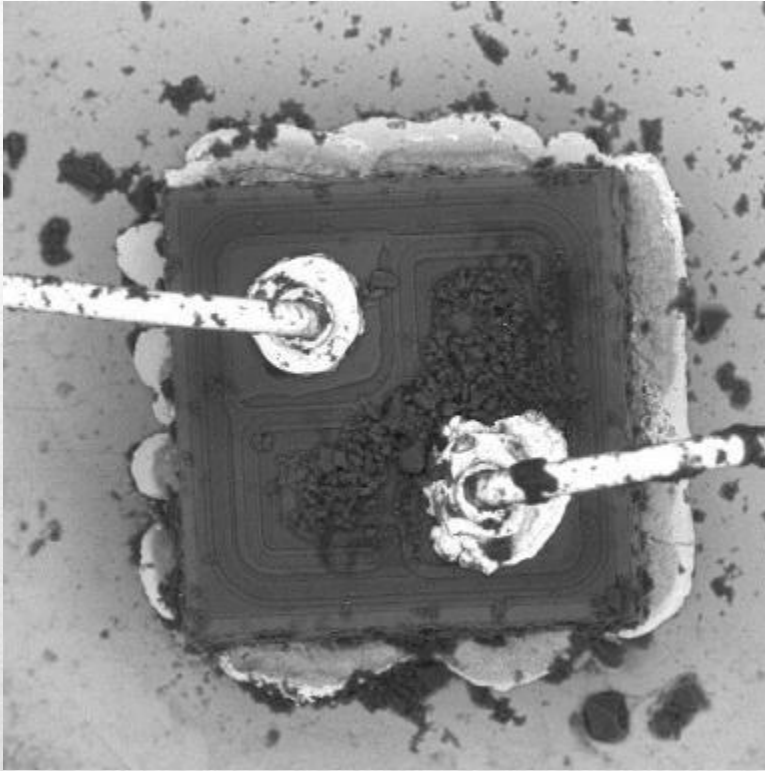
EOS severed this wire bond from its power sources weld pad!



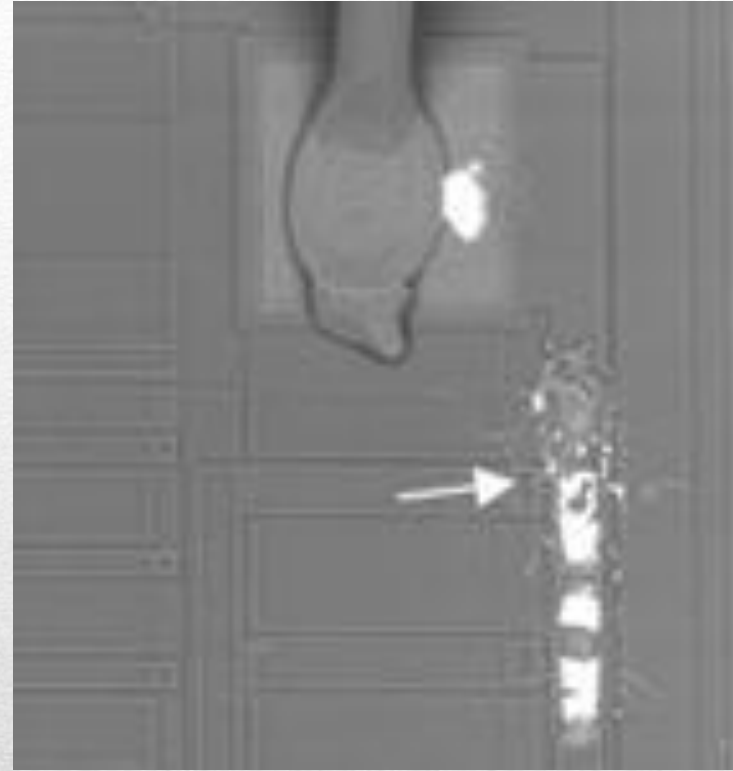
EOS fried the Power Transistor's welded (+) wire lead and its case!

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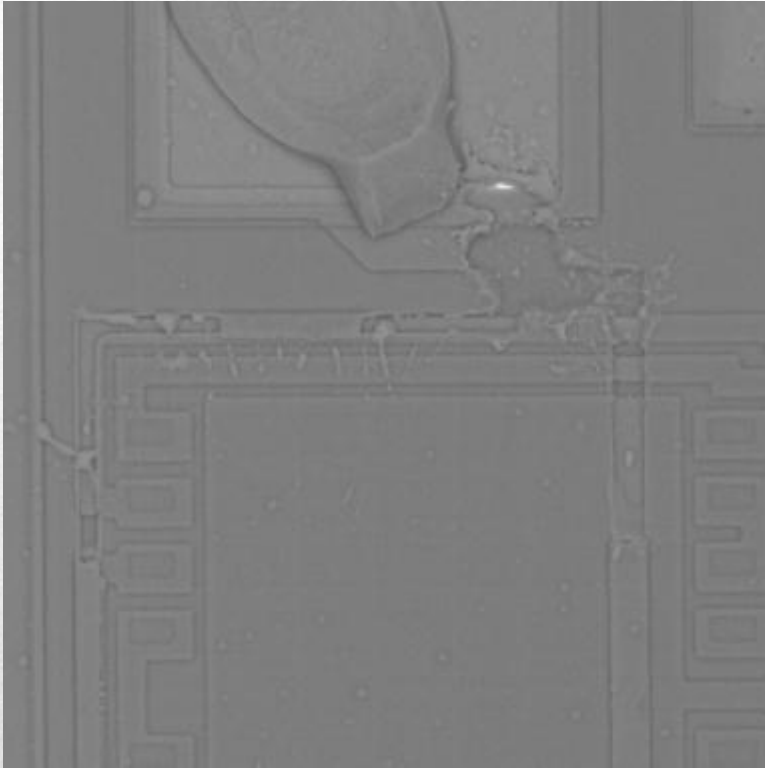
EOS destroyed this discrete diode inside of its case on a PC Board!



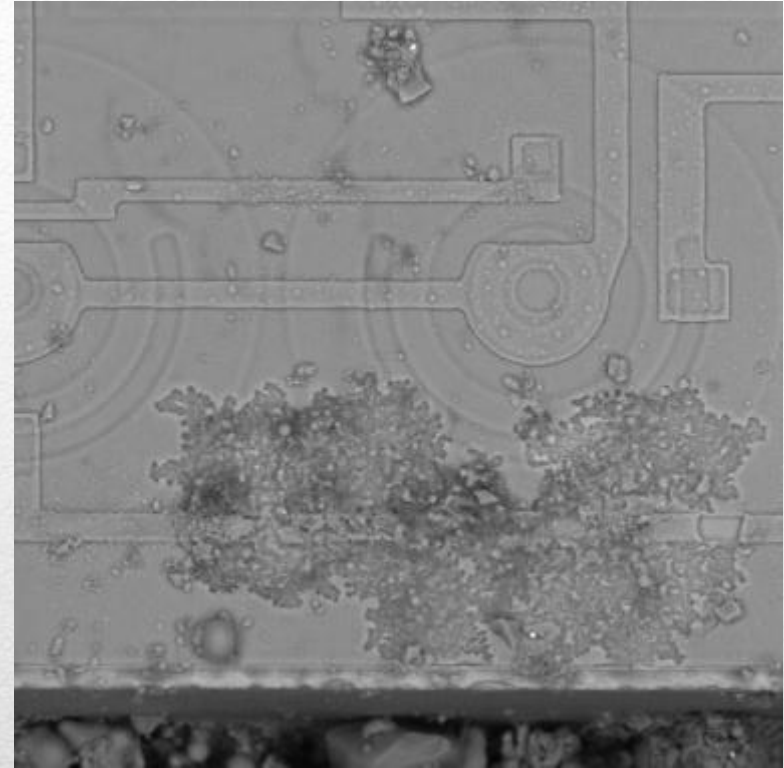
EOS hot spots on a poor wire pad weld and the related IC's power bus!

The Shocking Truth

V. How do Transients “damage” your *Computer Integrated Circuits*?



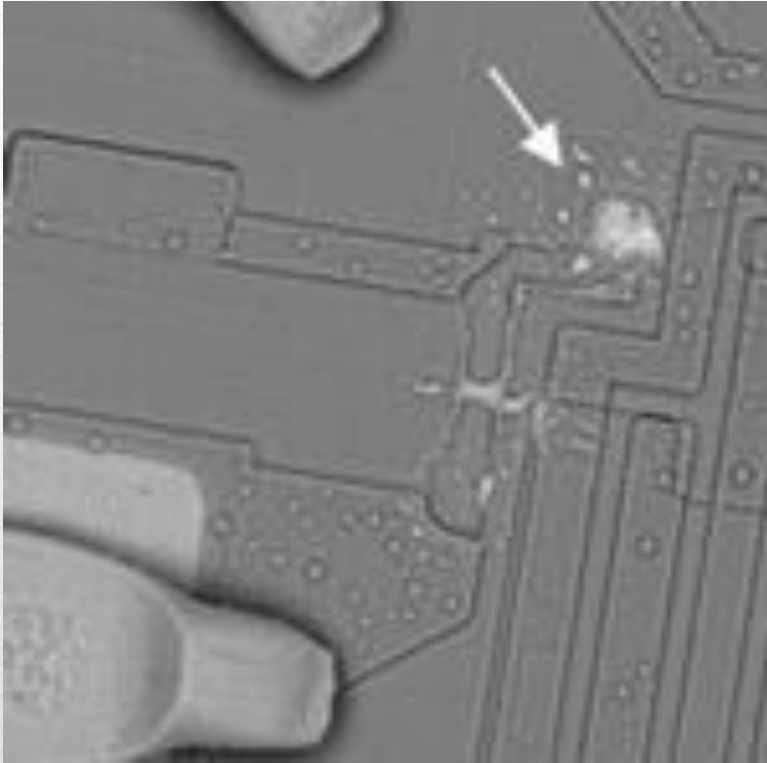
EOS burned the IC's power bus connection to its welded wire pad!



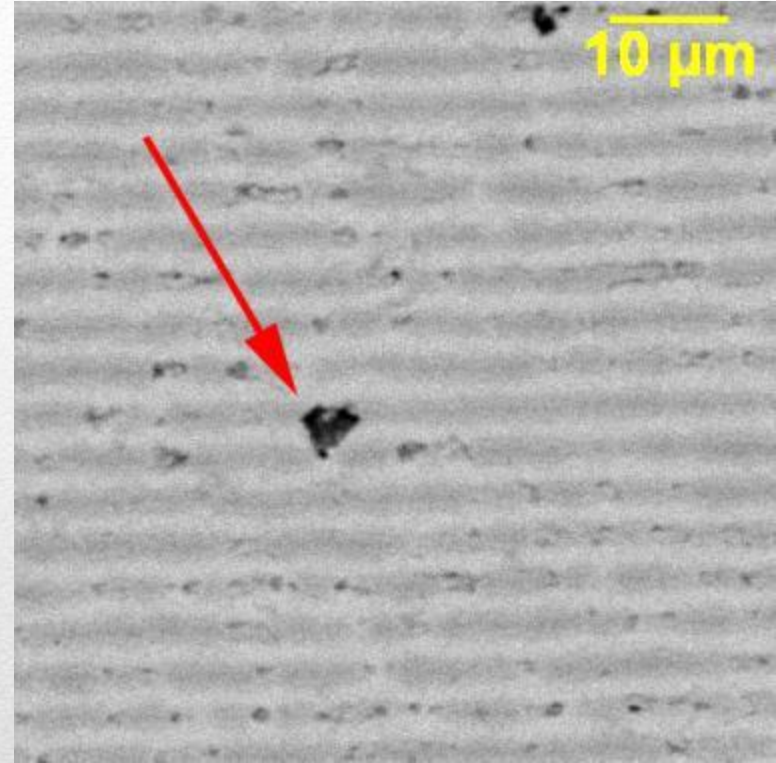
EOS so overheated this IC tracing that it eroded the dielectric around it and splattered the metal substrate!

The Shocking Truth

V. How do Transients “damage” your *Computer Integrated Circuits*?



ESD between two wire pads
“Zapped” the IC’s wire & dielectric!



ESD punched hole through the
insulating dielectric material layer

The Shocking Truth

- An I.T. piece of equipment has a 200-220 (208) Volt AC Power Supply to create a 38 & 5 Volt DC Power Source to operate the entire electronics (IC's) inside that piece of equipment.
- When a Transient is riding on that 208 Volt AC Sine wave, this Power Supply does not stop it and it translates right on through to the “flat” 38 & 5 Volt DC Power output!
- This corrupt DC power is then used inside of the IC's to write the Computer Language and Message Code.

The Shocking Truth

- These computer “Morse Codes” are a series of 1’s and 0’s and spaces that represent all messages, calculations, memory, and actions.
- These Codes are later translated into Fiber Optic Light Frequency Codes and shipped to other devices, processes, Data Centers, and customers.

The Shocking Truth

VI. How do Transients affect your Computer Data?

- My name is Dale Pickering

- ..- - -. - .- - - - - .-.. . . - -
- - - .- - .- - - -

- 001 110 101 11 111 0100 0 0 11
1 1101100 1 1

- My name is Dale Pickering

A	.-	M	---	Y	-. -	6	-----
B	N	-. .	Z	--- .	7	-----
C	- . - .	O	---	A	.- .	8	-----
D	... -	P	-. - .	O	--- -	9	-----
E	.	Q	--- -	U	.. -	,	-----
F	.. - .	R	.- .	Ch	--- -	,	-----
G	- . . .	S	0	-----	7	-----
H	T	-. -	1	-----	7	-----
I	..	U	.. -	2	-----	:	-----
J	.- . -	V	... -	3	-----	'	-----
K	- . -	W	-. . -	4	-----	'	-----
L	.- . .	X	-. - .	5	-----	=	-----

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The Shocking Truth

VI. How do Transients affect your *Computer Data*?

- My name is Dale
Pickering
- ..- - -. - .- - - - - .-.. . . - -
- - -. - -. . . - -
- 001 1110 1 101 1111111 0100 010
11 11 1101100 1 1111
- mY naim iz Dali
Demurring

Data Corruption
(*False "Morse Code"*)



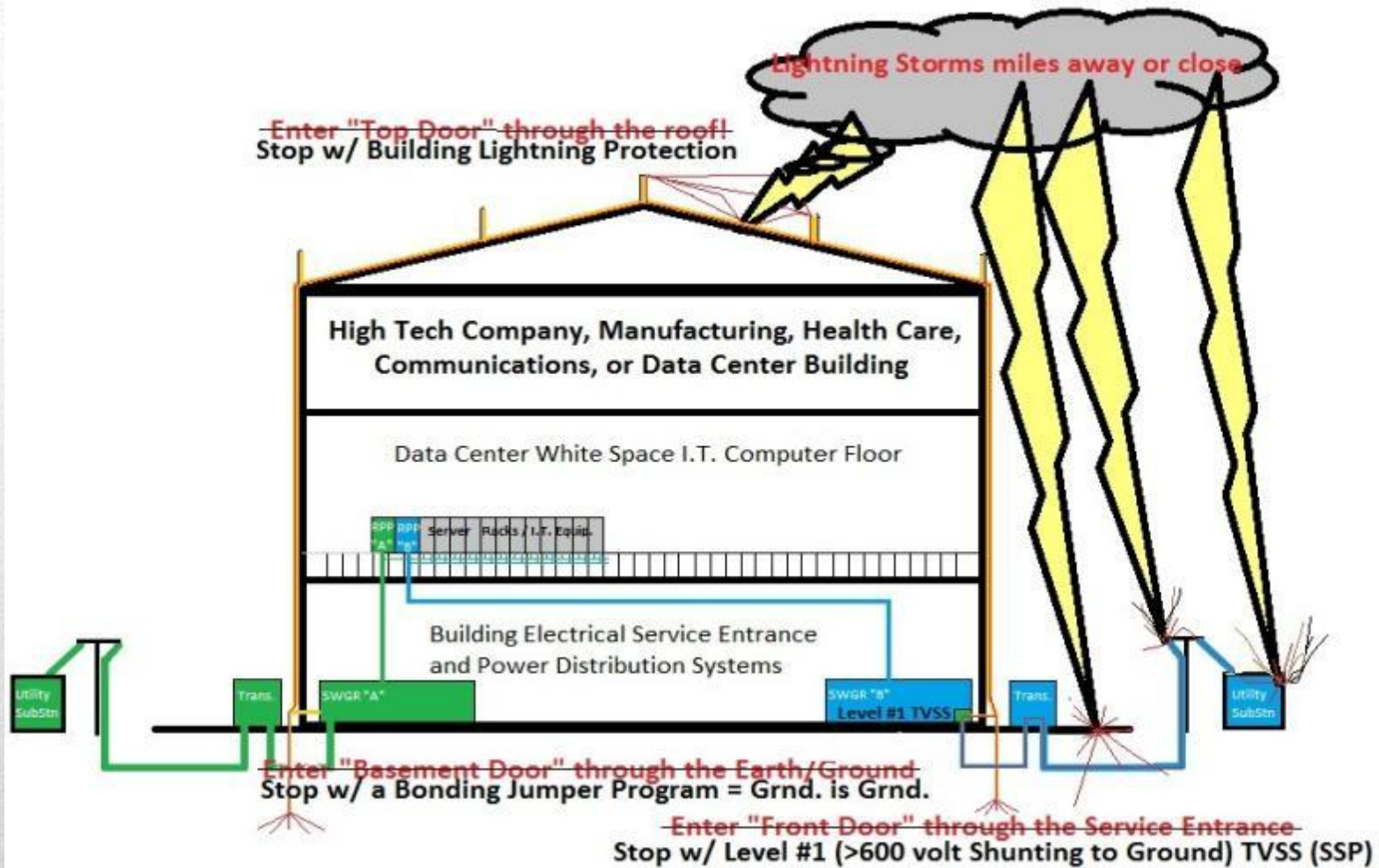
Antique Morse Code Transmitter that
is replaced by modern Computer
language.

The Shocking Truth

- Eliminate Lightning Strikes from entering your Roof.
 - *Lightning Umbrella (1MV)*
- Eliminate Lightning Strikes from entering your Basement.
 - *Grounding and Bonding (Delta Potential)*
- Eliminate Lightning Strikes from entering your Front Door.
 - *Service Entrance Switchgear (12kV, 7kV, 480V)*
- Eliminate Transients from your Business's Back Door.
 - *I.T. White Space, Manufacturing, Services (Static, Noise, Switching, etc.)*

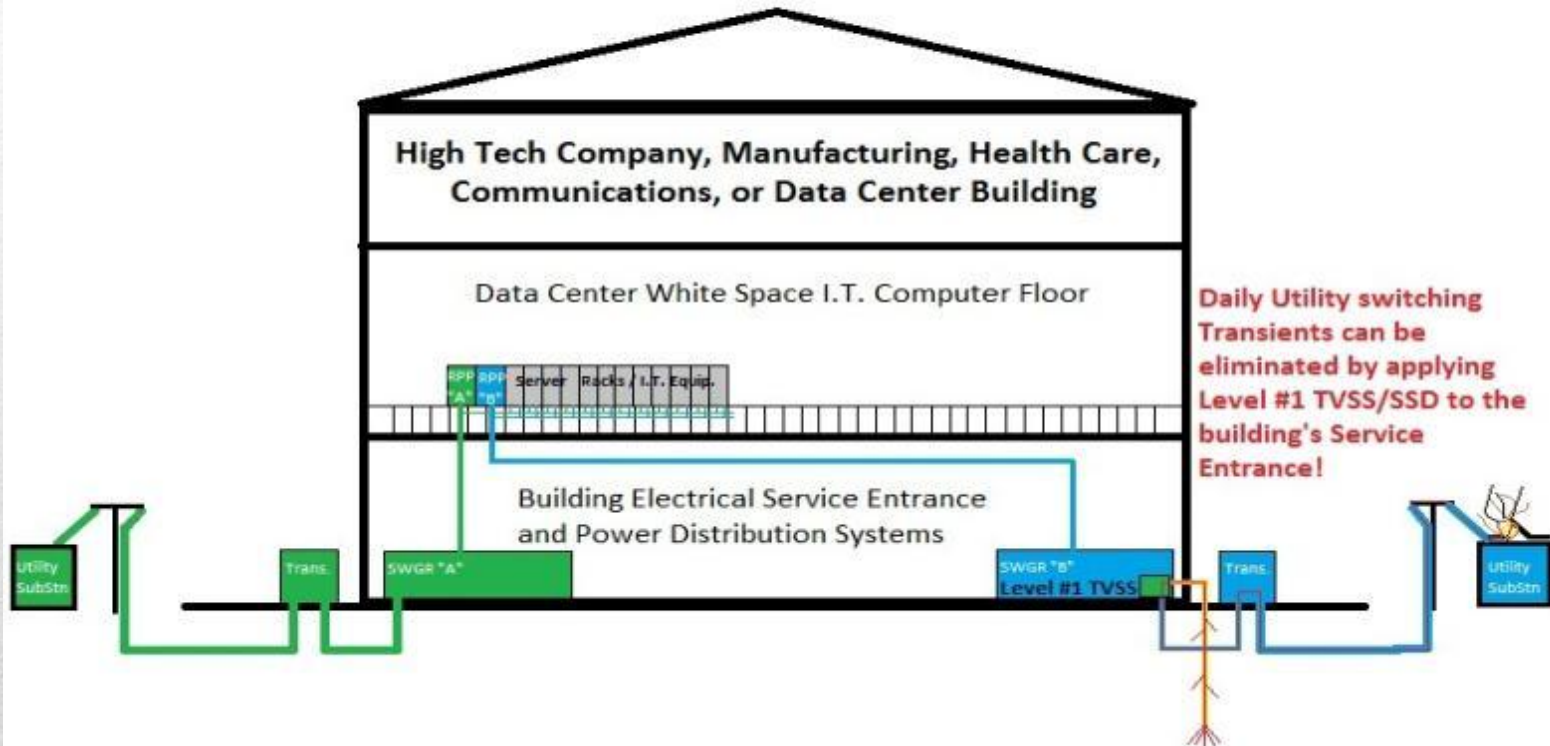
The Shocking Truth

VII. How do we Safeguard our White Space environment from Transients?



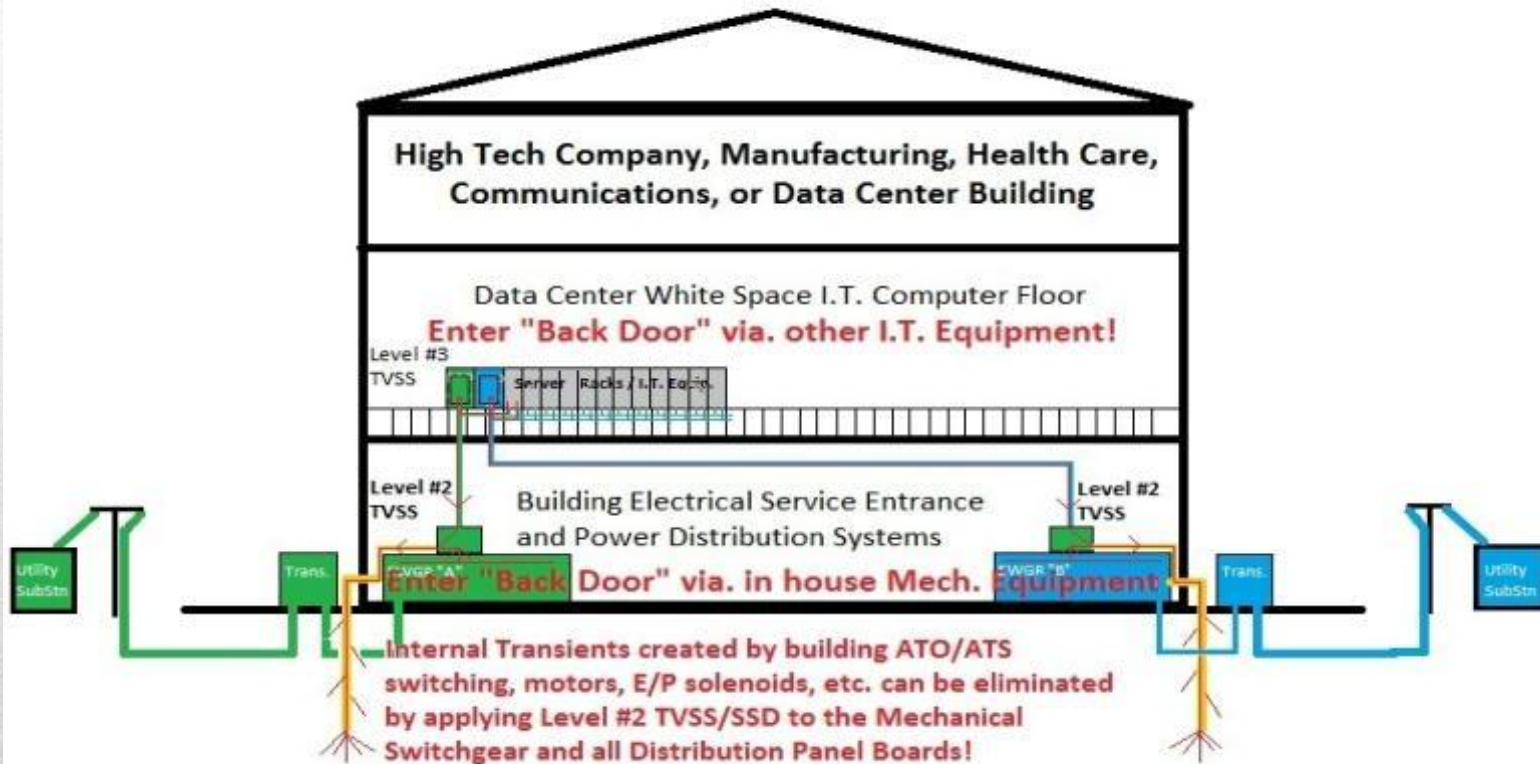
The Shocking Truth

VII. How do we Safeguard our White Space environment from Transients?



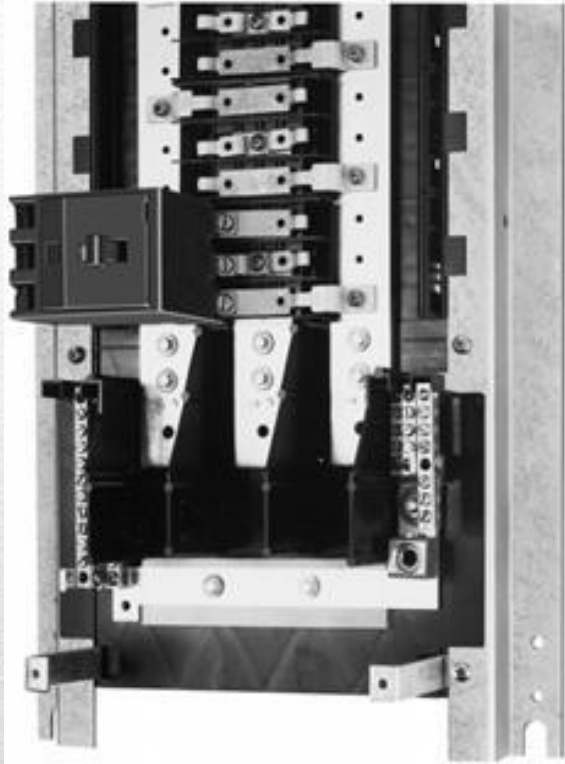
The Shocking Truth

VII. How do we Safeguard our White Space environment from Transients?

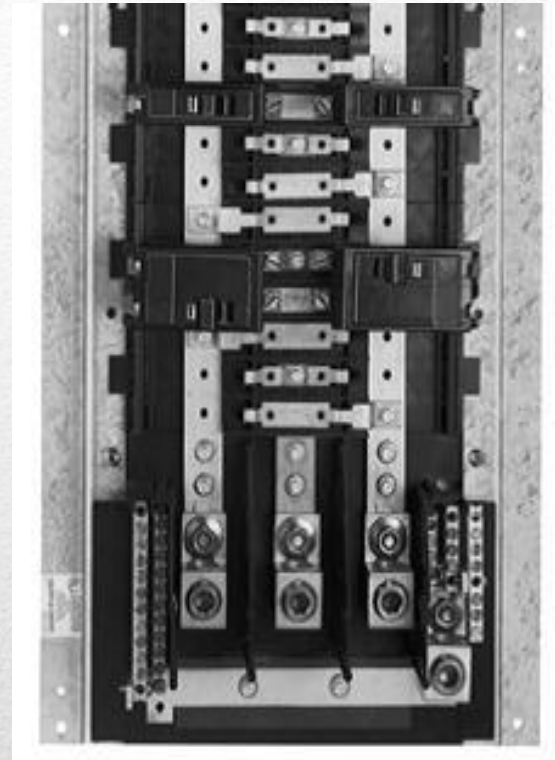


The Shocking Truth

VII. How do we Safeguard our White Space environment from Transients?



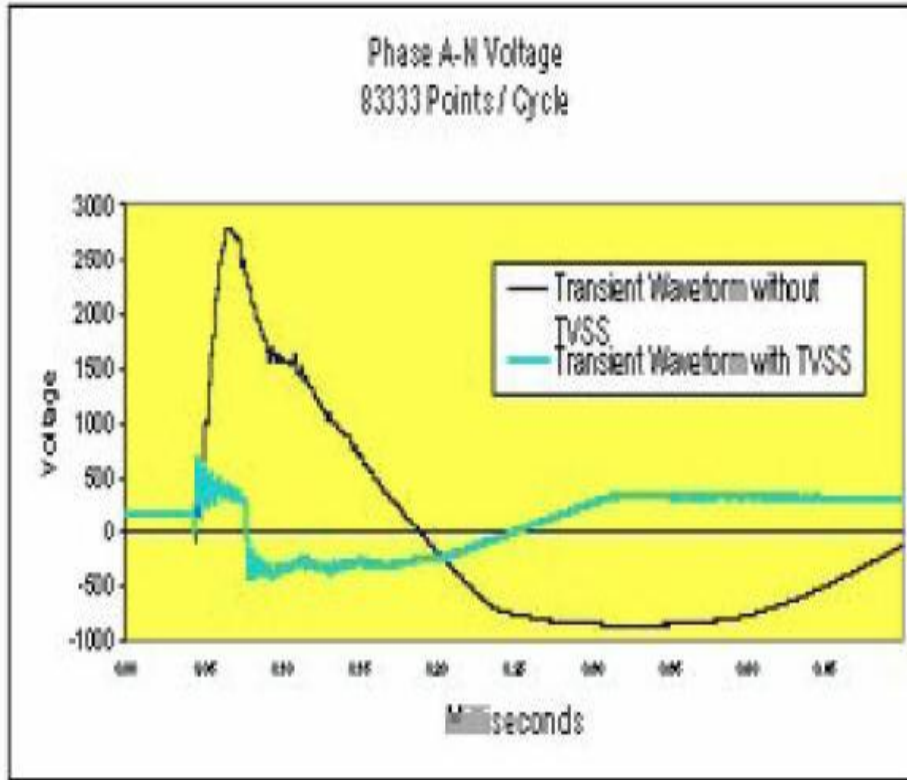
A 30 Amp., 3 Pole Circuit Breaker is used to attach a Level #3 TVSS/SSD to protect all circuits going & coming.



All Branch Circuits now have any noise or Transients safely shunted away to ground, leaving CLEAN Power!

The Shocking Truth

VII. How do we Safeguard our White Space environment from Transients?



A 2,850 Volt Transient w/o & clamped to 500 Volts w/ Level #1 TVSS

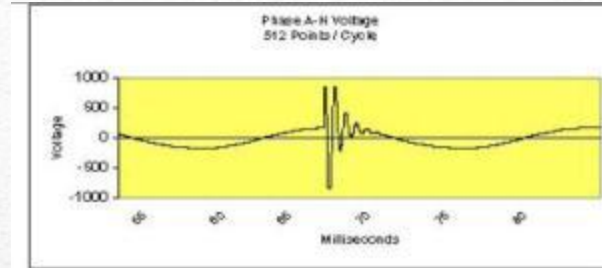


Figure C: Event captured using the 512 sample/cycle monitor (without a TVSS on the load)

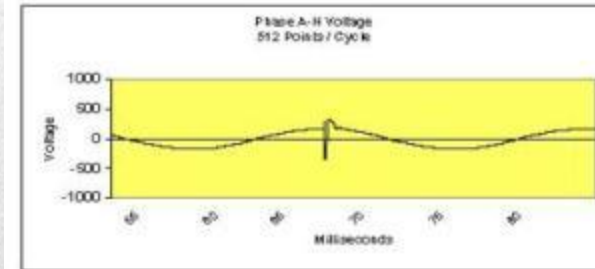
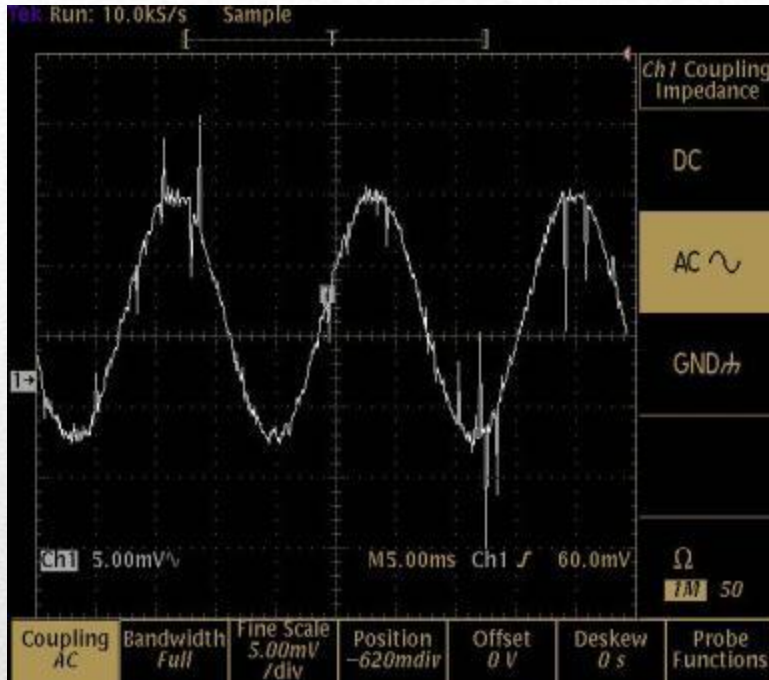


Figure D: Event captured using the 512 sample/cycle monitor (with a TVSS on the load)

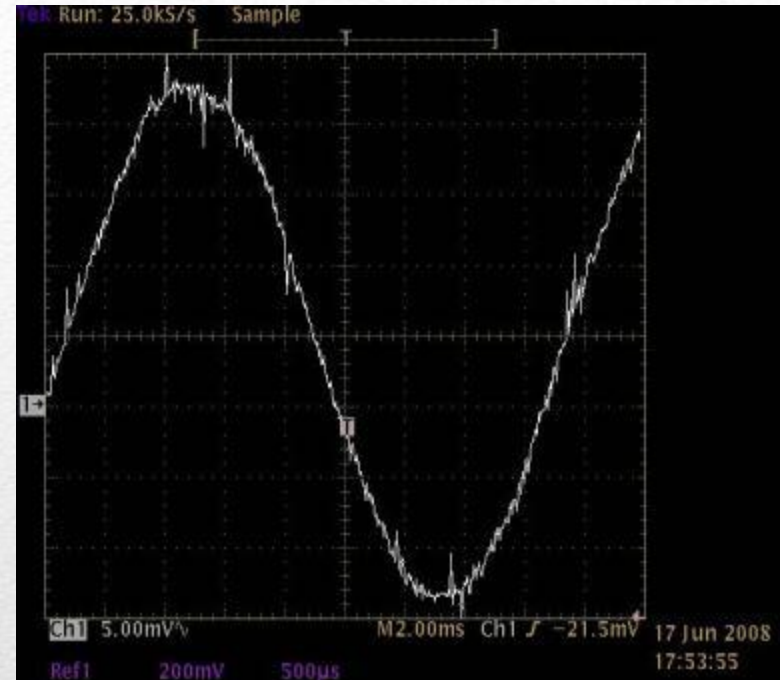
A 900 Volt Transient w/o & clamped to 300 Volts w/ Level #2 TVSS

The Shocking Truth

VII. How do we Safeguard our White Space environment from Transients?



A 50 Volt Transient on a 120 Volts
Sine wave w/o TVSS



The same 50 Volt Transient that is
clamped to only 5 Volts w/Level #3
Sine wave tracking TVSS!

The Shocking Truth

VIII. What *Operational Improvements* result from eliminating Transients?

- Data Corruption (*False “Morse Code”*)
- Software Lockup (*What was that, better re-calculate*)
- Late...Late...Latency (*Hang on...I’m coming*)
- ROI missed targets (*Capital Depreciation erosion*)
- MTBF short cycle (*Electronic component failure, Warranty Issues*)
- EOLC repetition (*Funerals in your Prime*)
- System Down Time (*Who breached the reservoir*)
- Lost Revenue (*Who drained the reservoir*)
- Lost Business (*Closed doors...R.I.P.*)

The Shocking Truth

CONCLUSION!

- **Transients** and their damage are very real!
- **Transients** are generated every day and are unseen to the human senses.
- **Transients** roam through your electrical and electronic systems like “Bank Robbers” looking for an easy pay day!
- You may think that you are at 100% productivity and your Data Center is operating at its full potential, but in reality, **Transients** are robbing you of some 10% to 20% efficiency!

The Shocking Truth

CONCLUSION!

- **Transients** may be unseen, but their effects on our Data Centers are seen in:
 - Equipment lock ups,
 - I.C. latch ups,
 - Damaged equipment,
 - Down time, data corruption,
 - Data extended latencies,
 - Shortened MTBF,
 - Lost of ROI,
 - Business impacts,
 - Lost Revenue, and
 - Lost Customers
- Once **Transients** are dealt with, all of the above negative business impacts disappear!
- Sleep at night with the security of **Transient Voltage Surge Suppression** protection!

The Shocking Truth

Thank you for your time and interest
in eliminating **Transients!**

- *Dale G. Pickering, BSEE* -

The Shocking Truth
