SBE 56 Tulsa

Society of Broadcast Engineers Chapter 56 – Tulsa, Oklahoma

# Society of Broadcast Engineers

Lightning Basics – Protecting Critical Electrical and Electronic Equipment from Lightning and other Transient Voltage Surge Events

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Transtector Systems / PolyPhaser

TRANSTECTOR an INFINITE brand

PolyPhaser an INFINITE brand

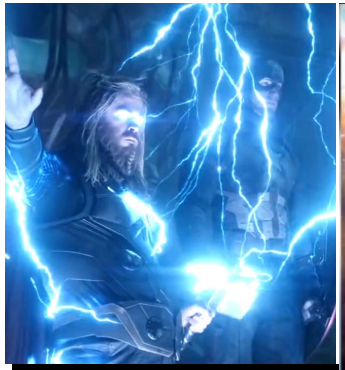
# Agenda

- How Lightning Works
  - Direct vs Near Strikes
  - Importance of Grounding
- Need for Surge Protection
  - Main Entrance Protection vs Cascading Surge Protection
  - Surge Protection Sphere of Influence
  - Series vs Parallel Connected Surge Protection
  - Surge Protection Locations (Type 1 vs Type 2)
  - Technologies Used
  - EMI / RFI Filters

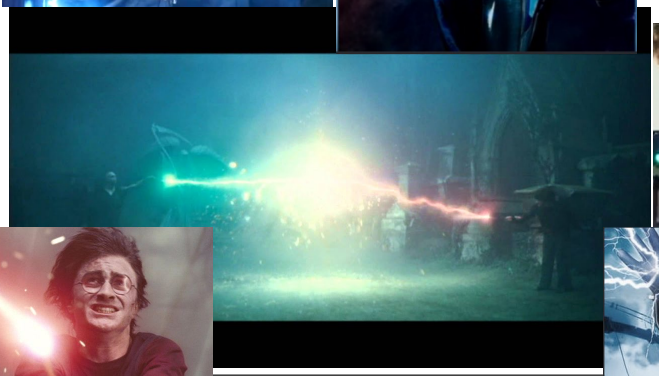
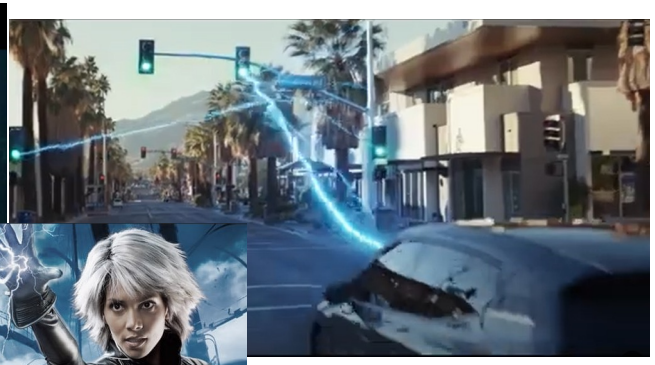
# Agenda (continued)

- Need for surge Protection (continued)
  - Motorola R56 Installation & Grounding Standard vs UL / IEEE
  - Importance of Grounding
- Common Broadcast Engineer Questions & Responses

# Lightning Basics

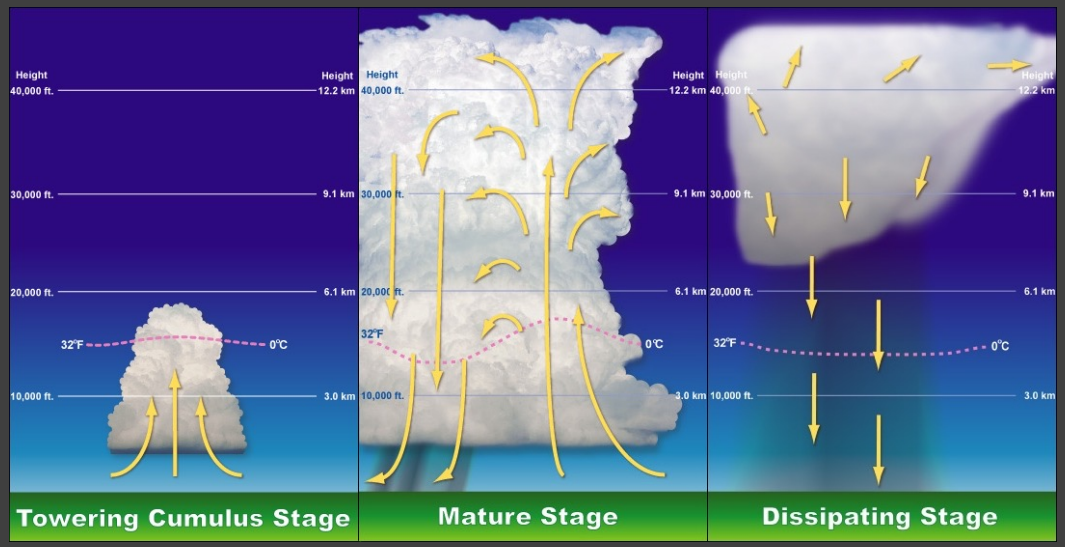



# Lightning – A Magical Super Power!

# How Lightning Really Works (Cumulonimbus)

## Lightning Cell Evolution




Size = Few Tens of Square Miles – Lasts 30 Minutes or So

- Three Stages of Development
  - Developing Stage
    - Warm Air Rises Rapidly
    - Cool Air Settles
  - Mature Stage
    - Updrafts (thru Convection) draw Water
    - Latent Heat is Released Creating Low Pressure Zone
  - Dissipating Stage
    - Downdraft is Dominate
    - Cool Air Carried to Ground thru Downburst

# How Lightning Works (continued)

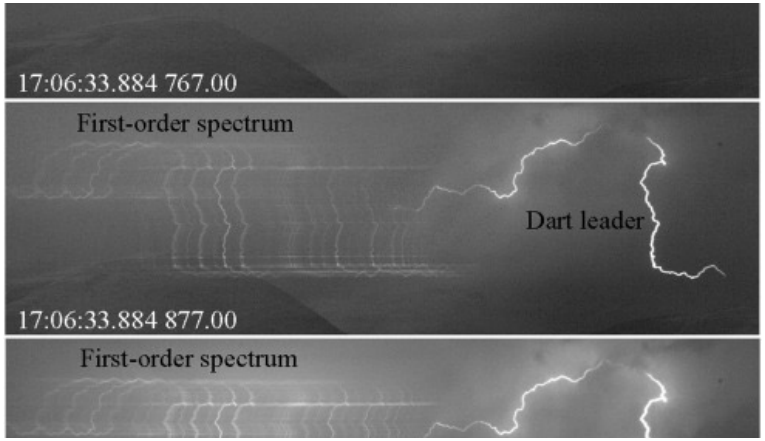
## Lightning Discharge Process

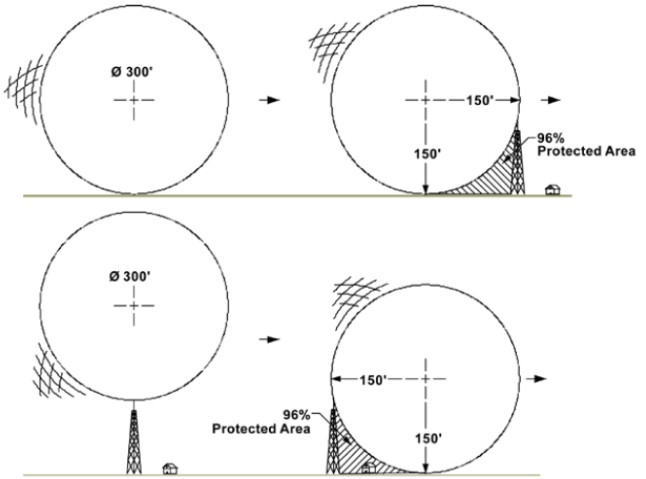
- Cloud Interaction
  - Developing Stage
    - Wind forces Ice Crystal Movement (Crashing)
    - Negative Charged Particles (Electrons) Knocked Off
    - Positive / Negative Charges Separated
    - Cloud Top Becomes Positively Charged
    - Cloud Bottom Becomes Negatively Charged
  - Opposites Attract
    - Negative Cloud Bottom wants to Link Up with Positive Charged Earth Start Moving to Positive Ground Charges Flowing Upward (Stepped Leader)
  - Lightning Return Stroke
    - Lightning Occurs when Negative Cloud and Positive Ground Currents (Stepped Leader) Meet
    - Boom! Thunderclap

Cell Size = Few Tens of Square Miles – Lasts 30 Minutes or So

# Step Leader “Rolling Ball” Theory

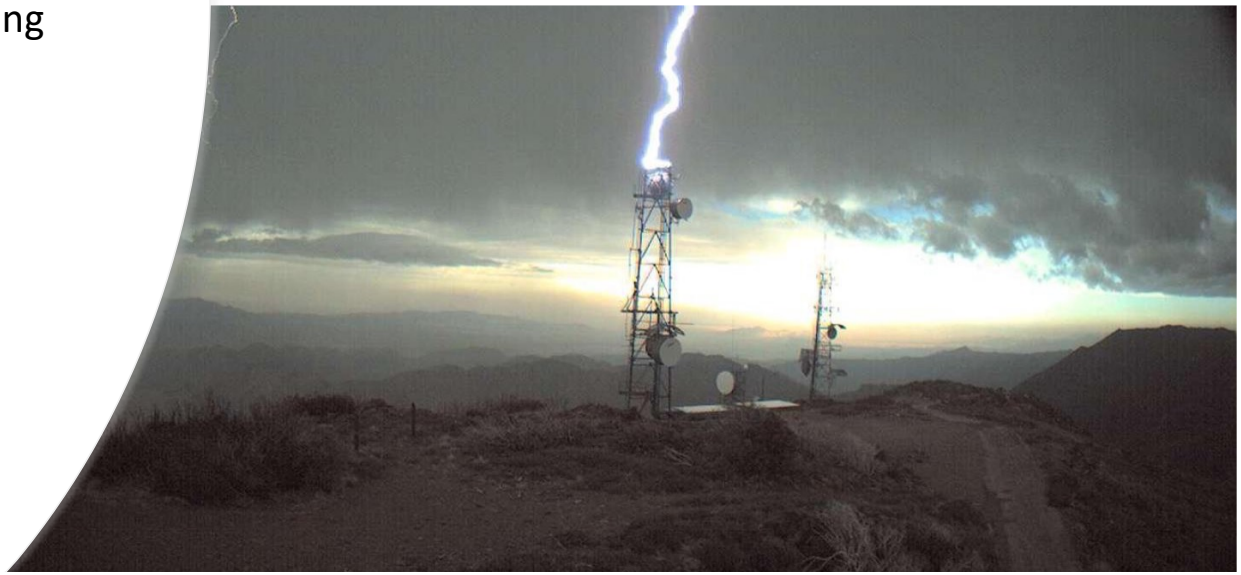
- Towers over 150’ Tall, Side-Mounted Antennas are Vulnerable to Direct Strikes.
- Tower Site with 150’ Radius Sphere (representing a Step Leader Typical Jump)
- Side-Mounted Antennas near the top, or in sections not protected by the guy wires can be hit.
  - Visualize a tower site, and imagine a 150-foot radius sphere (representing a step leader typical jump) rolling over all outlined objects, everywhere the sphere touches could be hit by lightning.
  - The sphere must be “rolled” for each compass line since the sphere is a three dimensional image.
  - When the sphere bridges between two points, the area beneath the sphere is a 96% protected zone.



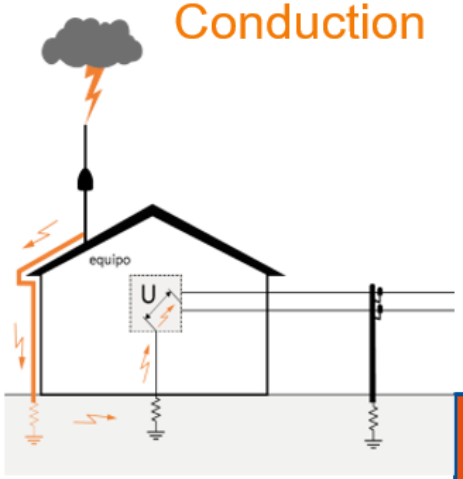
# Direct vs Near or Induced Strikes

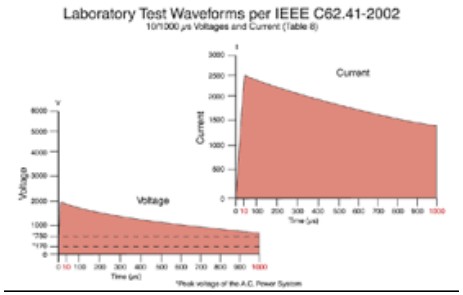
- Most Strikes are Near or Proximity (Induced) Strikes
  - Lightning hits the Tree down the street, or the Light Pole in the Parking Lot
- Direct Strikes (Conduction) are 30kA or much Stronger



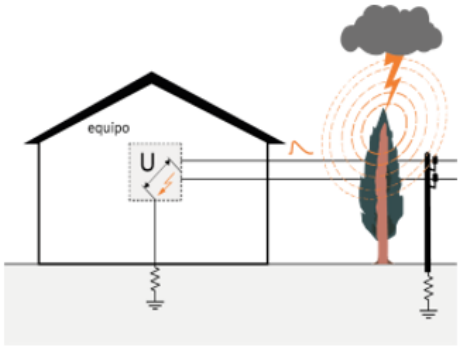
# Types of Lightning Attachment

## Conduction

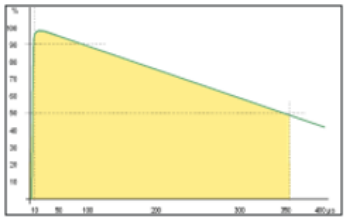


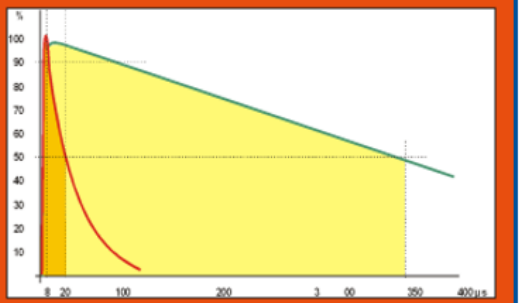

## Induction



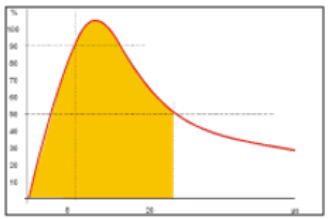

Current wave 10/350



Comparison 10/350 vs 8/20



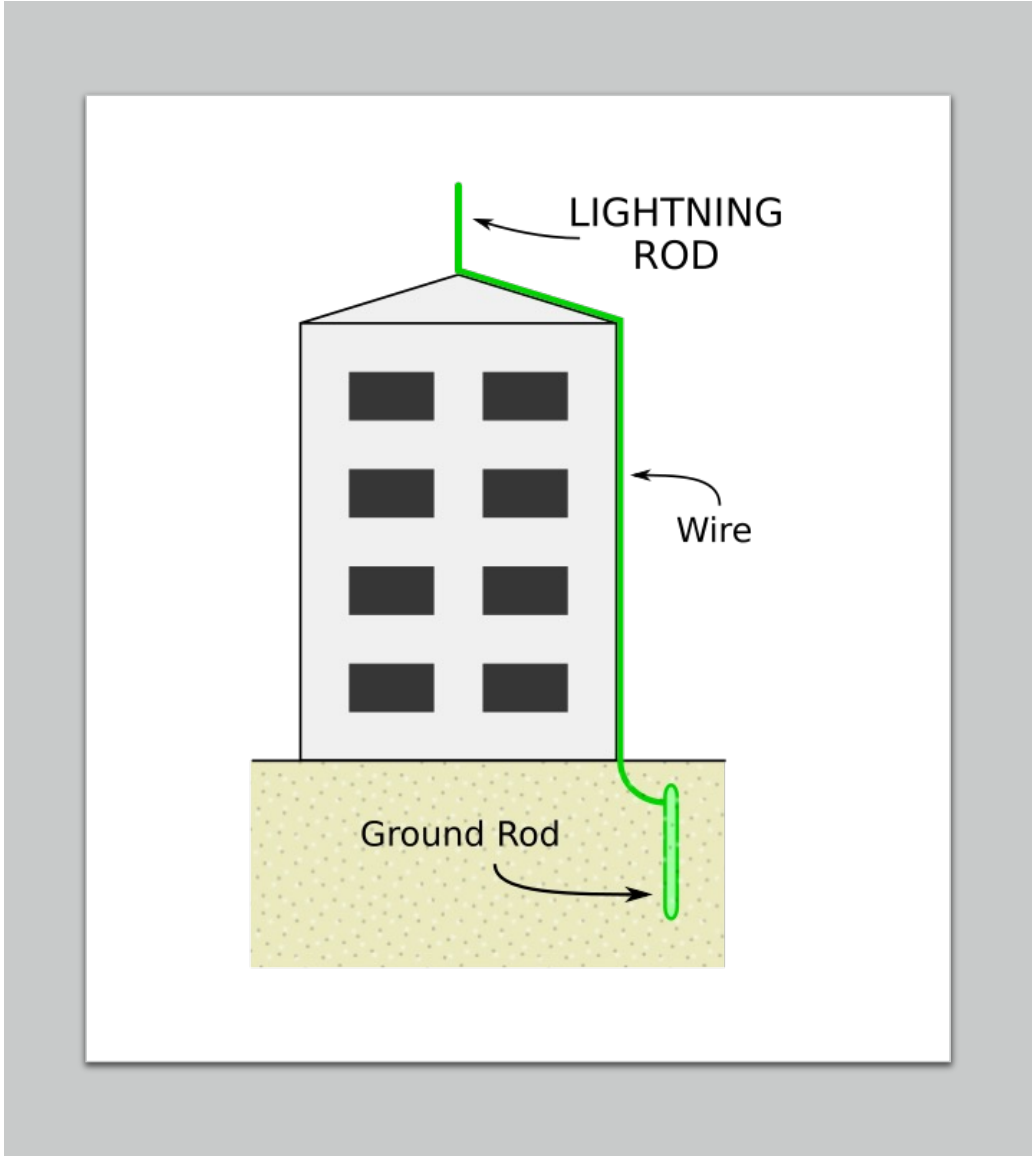
Current wave 8/20



# Lightning Protection System (LPS) vs Surge Protection Devices (SPD) Explained

- LPS Systems
  - Aerial Terminals (Lightning Rods), Copper Downleads, Dissipators, Ground Rods
  - Keeps the Physical - Architectural Facility from Catching Fire
  - Designed to Attract Lightning, then Safely Channel the Surge Current to Ground
  - Defined by the National Fire Protection Agency (NFPA 780 Standard for the Installation of Lightning Protection Systems)
  - Can Include Surge Protection Devices (SPD) for Full Systemic Protection
  - LPS Companies are Licensed & Bonded to Install & Maintain LPS Systems, and to Establish & Maintain Ground Systems if Needed to Improve Ground Resistance
    (Alltec, Lightning Master, and others)

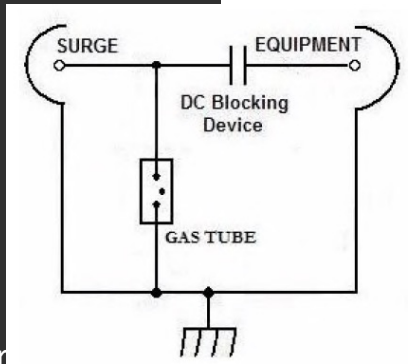
- Surge Protection Devices Mitigate Surge Current from the Electrical Infrastructure
  - Protects Electronic and Electrical Equipment, and Personnel from Electric Shock
  - Provides Sacrificial Protection for Critical Equipment



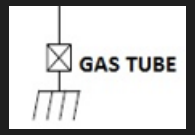
# Surge Protection Device (SPD) Basics

# Protection Technologies

# Surge Protection Technologies Used

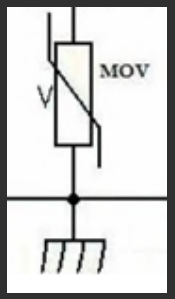



- Gas Discharge Tube (GDT) – "Good" Category, High Current Capable
  - Slower to React (Nanoseconds, Microseconds, or Milliseconds Reaction Time depending on Model
  - Normally Open, Voltage Limiting, Gas Ionizes to Short Current between Center-Pin and Coax Shield. Shorts during Surge Event, then Resets back to Open. Fail State = Open
  - Requires Dedicated Ground Path
  - Degradable Technology – Wears Out after each Surge Event
  - 20 Year Shelf Life
  - One-Time – Lifetime – 20kA Max Surge Capability – Accumulative
  - Reacts to Numerous Near Strikes, but will be fully Depleted after a Direct Lightning Strike (30kA or Much Stronger)
  - As GDT Degrades, VSWR Gets Worse.
    - Replace after VSWR Exceeds Unacceptable Levels, or after Known Direct Lightning Strike




**Gas Tube**

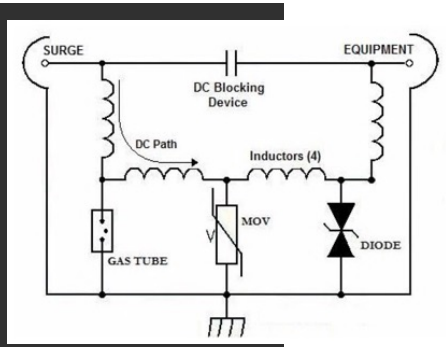
# Surge Protection Technologies Used




- Metal Oxide Varistor (MOV) – "Better" Category Handles High Energy – Inexpensive – Zinc Oxide
  - Solid State Component (Nanoseconds Reaction Time) Normally Open, Voltage Limiting, Shorts during Surge Event, then Resets back to Open. Fails Short
  - Installed Between V+ and V- (DC Voltage), or between Data+ & Data- (Ethernet, RS485, etc.), or between Line and Neutral (AC Voltage) – Parallel Connected
  - Degradable Technology – Wears Out after each Surge Event
  - Clamping (Turn-On) Voltage Increases as MOV Degrades
  - Temperature Rises (gets hotter) as MOV Degrades
  - Reacts to Numerous Near Strikes, but when fully Worn-Out, per UL 1449 2nd Edition (since then), Thermal Disconnect Ckt Disables the Surge Protector Permanently

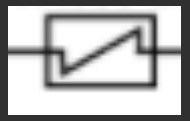

| Active Ingredients |
| --- |
| Zinc Oxide (13%) |

# Surge Protection Technologies Used

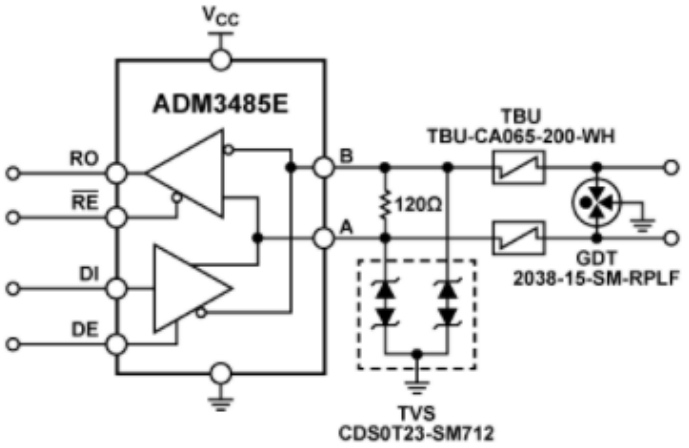



- Silicon Avalanche Suppressor Diode (SASD) – "Best" Category - Fast Reacting – Non-Degradable
  - Solid State Component (Nanoseconds Reaction Time) Normally Open, Voltage Limiting, Shorts during Surge Event, then Resets to Open. Fails Short
  - Installed Between V+ and V- (DC Voltage), or between Data+ & Data- (Ethernet, RS485, etc.), or between Line and Neutral (AC Voltage) – Parallel Connected
  - Clamping (Turn-On) Voltage is Consistently Low
  - Temperature Remains Normal
  - Higher Purchase Cost than GDT or MOV
  - Use SASD to protect Critical Electrical & Electronic Equipment Systems
- Hybrid Circuits use More than One Surge Protection Technology Together Using the Best of each for Super-Fast, Robust, and Long-Lived Protection

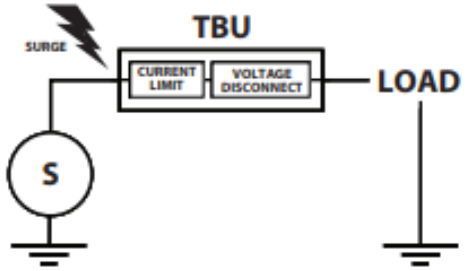
# Surge Protection Technologies Used



- Transient Blocking Unit (TBU) – Solid State
  - Current Limiting
  - TBU Circuit Increases Resistance in Proportion to Current Rise
    - As Current Increases, so does the Impedance by the TBU Circuit, Blocking the Surge Current
  - Used with another Component, such as SASD, and/or GDT to Shunt Residual Current that Leaks Thru
  - Installed in Series for each Circuit
  - Blocks both Overcurrent & Overvoltage

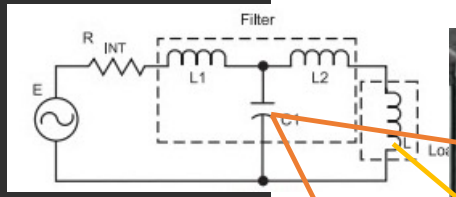


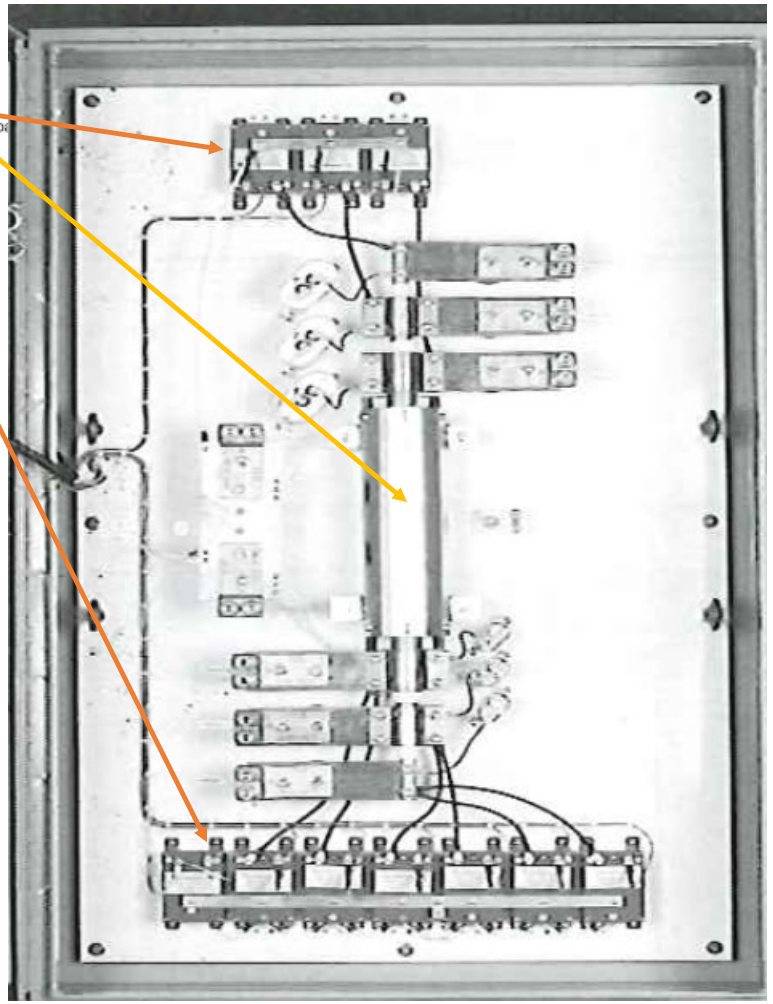

PROTECTION SCHEME 3. TVS/TBU/GDT



# Surge Protection Technologies Used

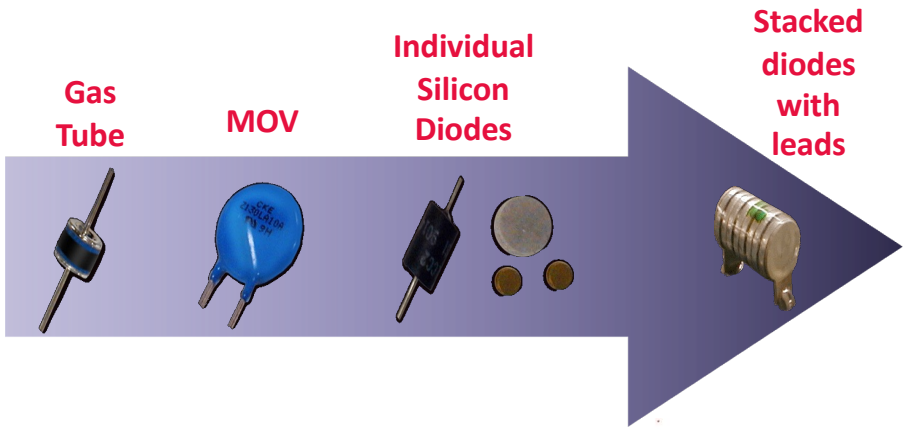
- Electromagnetic Interference (EMI) & Radio Frequency Interference (RFI) Filters
  - Inductive – Capacitive Network
  - Filters (Removes) Noise from Electrical Power – Data Cables
  - Does NOT Provide Surge Protection
  - When Used with AC Surge Protection Devices:
    - Removes Utility Generated EMI/RFI Noise from Incoming Power Lines
  - Can be Integrated with Series & Parallel Connected Surge Protection Devices

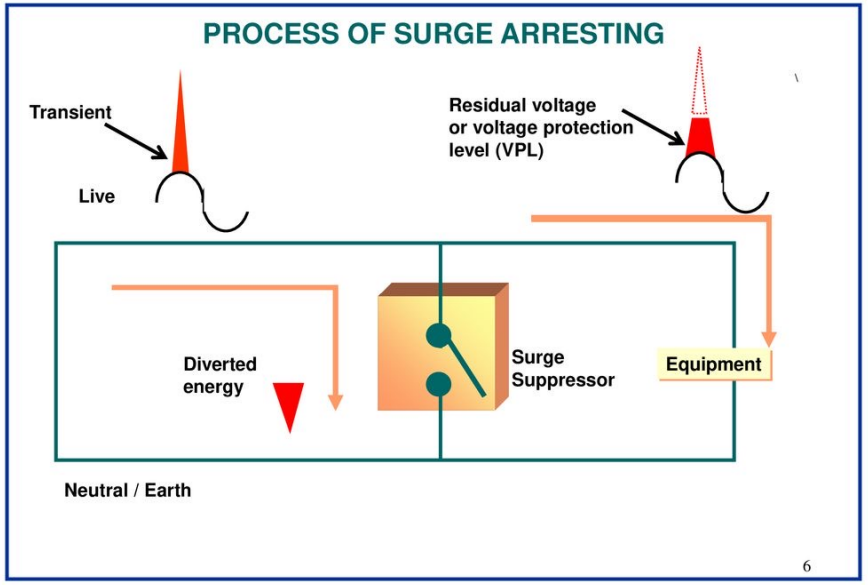


# Surge Protection Technologies Function

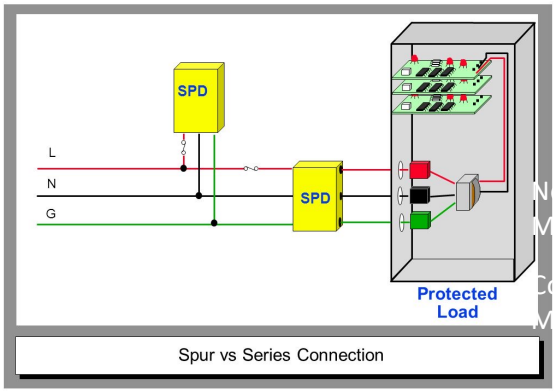
- **Surge Protection Components Act Like Switches**
  - Reaction Time = Nano or Micro Seconds
  - Normally Open Devices
  - Voltage Limiting
    - Reacts to Sudden Rise Time in Voltage
    - Shorts to Shunt Surge Current
    - Resets to Open State

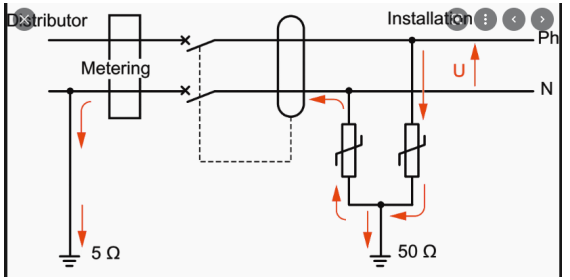


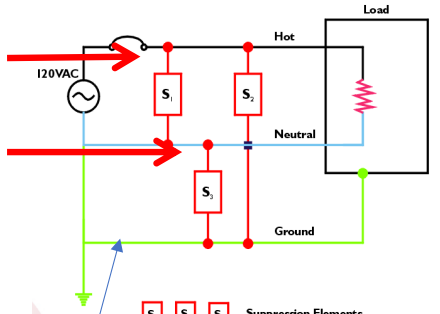



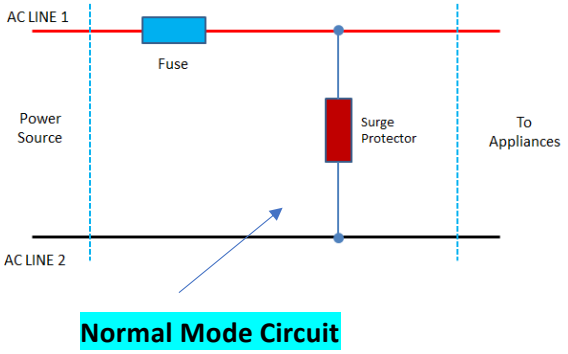
# Parallel or Series Connected SPDs

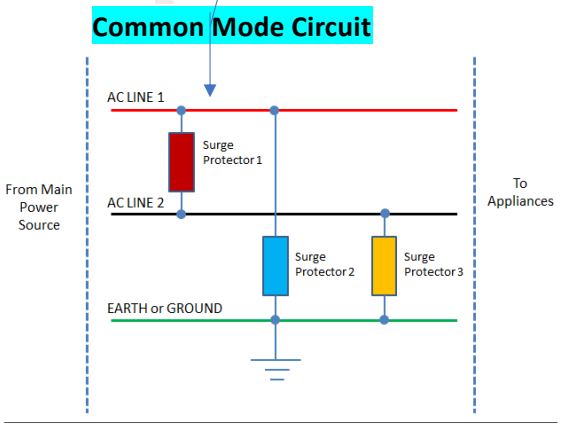
- Voltage or Current Limiting?
  - **Parallel Connected** SPDs Provide Over-Voltage Protection for Critical Electrical and Electronic Equipment
    - Reacts to the Sudden Rise-Time in Voltage (Microsecond Duration Power Spikes) then Shunts the Surge Current to Ground, keeping the Surge Current away from & Protecting the Electrical Equipment
    - If Self-Sacrificing from a Direct Strike, still protects Electrical Equipment in Death ( like a Fuse )
    - Less Costly to Replace an SPD than the Electrical Equipment ($100's to $Thousands for SPD vs $100ks+ for Equipment)
    - Some Parallel SPDs also provide Electromagnetic Interference (EMI) & Radio Frequency Interference (RFI) Filtering
  - **Series Connected** SPDs also Provide Over-Voltage Protection but must be designed to support the Max Current Rating of the Breaker Panel.
    - Also provides EMI/RFI Filtering, a Standard Feature with Series Connected SPDs
  - Normal Mode Protection
    - Surge Protection Components between Hot & Neutral (or DC+ & DC-, or between Data+ & Data-)
    - L-L, L-N Only
    - NO TO GROUND COMPONENTS
  - Common Mode Protection
    - Surge Protection Components between Hot & Neutral (or DC+ & DC-, or between Data+ & Data-, and L-G, or N-G)
    - L-L, L-N, L-G, N-G (Also called All Mode Protection)
    - INCLUDES TO GROUND COMPONENTS



# Industry Standards

- **Underwriter's Laboratory** (UL) 1449 4th Edition - SPD Safety and Performance
  - UL 1283 – EMI Filtering
  - UL 96A – Master Lightning Protection System

    The Standard for Installation Requirements for Lightning Protection Systems (LPS), addresses the minimum requirements for installation of Air Terminals, Cable Conductors, Fittings, Connectors and Fasteners used in quality LPS's.
  - UL 497 is a family of three safety standards
    - Provides requirements for Protection Devices.
    - Used in Low-Voltage circuits (DC Voltage & Data). ex. RS422, RS485, 4.20ma Loops
- **National Electric Code** (NEC) 285 – SPD Installation Considerations.
- **Telecordia** GR-1089-CORE - Data Line Lightning Protection Test Levels
- **Information Technology Industry Council** (ITIC) & CBEMA - AC input voltage envelope which typically can be tolerated (no interruption in function) by most Information Technology Equipment (ITE).
  **CBEMA** = Computer & Business Equipment Manufacturer's Association.
- **National Fire Protection Agency** (NFPA) 780
  - Provides Lightning Protection System (LPS) Installation Requirements to Safeguard People and Property from Fire Risk
- **Motorola** R56 (Chapter 7 – Surge Protection Devices)
  - Land Mobile Radio (Public Safety) Installation & Grounding Standards (911 Call Centers)
- **Atmosphères Explosibles** (ATEX) = Refers to Hazardous Locations (Explosive Environments) Requirements (Intrinsically Sage – No Sparks)
- **Intertek** (IN – ETL) – Provides Multinational Assurance Inspection, Product Testing & Certification (also provides Hazardous Location Certification, as does UL and ATEX)









# Industry Standards

- **Institute of Electrical and Electronics Engineers** (IEEE)
  - 802.3xx Ethernet Standard defining Protocol, DataRate, Power over Ethernet Characteristifcs
  - ANSI/IEEE C62.41-1991 Guide for Surge Voltages in Low Voltage (<600Vac)
- **American National Standards Institute** (ANSI)
  - ANSI and IEEE are often listed as: ANSI/IEEE
- **Consumer Electronics** (CE) – Conformité Européenne (French), which means European conformity – CE Compliance means the Manufacturer proves Compliance with EU Health, Safety & Environmental Protection Legislation, and that the product meets relevant requirements
- **International Electrotechnical Commission** (IEC) – International Standards Organization for all Electrical, Electronic & Related Technologies
- **National Electrical Manufacturer Association** (NEMA) – Defines Types of Environments in which an Electrical Enclosure can be used. NEMA 3R, NEMA 4, NEMA 4X
- **Ingress Protection** (IP) – Similar to NEMA for International Standards (ENB 60529, or IEC 60509) Defining levels of Sealing Effectiveness of Electrical Enclosures (part of IEC)

CE

IEEE
Advancing Technology for Humanity

ANSI

INGRESS PROTECTION SOLID WATER
IP 65

IEC

NEMA ENCLOSURES

# SPD Location – Where to Install Surge Protectors?

# Type 1, 2, 3 SPD Locations

- Location – Location – Location!!!

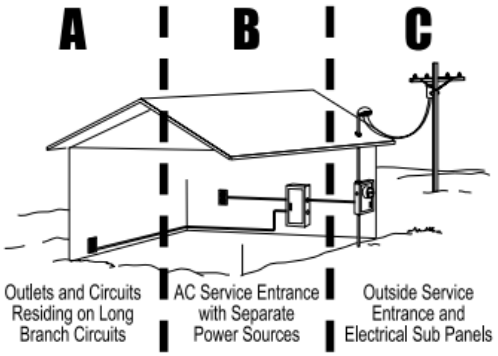
- Cascading Surge Protection Device (SPD) Scheme
  - Divide & Conquer
  - SPD Sphere of Influence (30 to 40 Feet)

- **UL / IEEE Defines Locations as Type 1, 2, or 3**
  - TYPE 1 = Between the Power Meter and Main Breaker Panel (Same as C High)
  - Type 2 = At the Main Breaker Panel or at any Subpanel Down-Leg of the Main Breaker Panel (Same as C Low & B)
  - Type 3 = Point-of-Use (Usually Plug-In Protection (Same as A)
    - 19" Rack Surge Strips
    - Single Outlet or Multi-Outlet Surge Strips

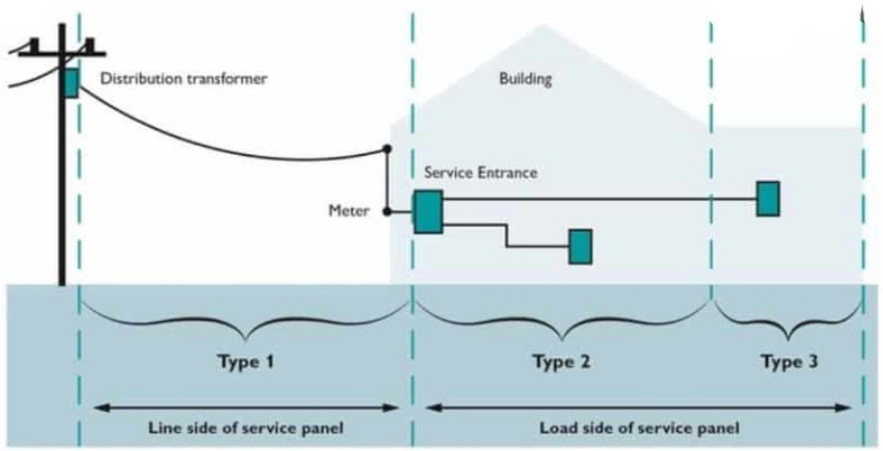
- IEC 61643-11 Class I & Class II
  - Class I = Same as Type 1
  - Class II = Same as Type 2

- Motorola R56 Type 2A / 2B
  - 2A = Hybrid SASD/MOV – Type 2
  - 2B = MOV Only – At Main Breaker Panel Only (Type 2, but only at the Main)

## IEEE/ANSI Chart ANSI/IEEE Standard C62.41 (2002)

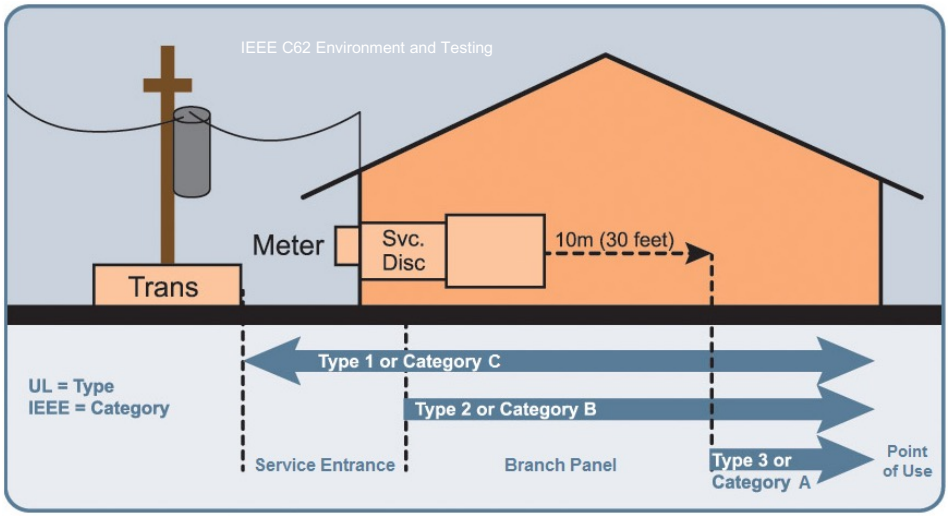



| | Ringwave (0.5µs/100kHz) | Impulse (1.25/50µs) | Impulse (8/20µs) |
|---|---|---|---|
| **A** | 6kV/200A | 6kV | 500A |
| **B** | 500A/6kV | 6kV | 3kA |
| **C** Low | - | 6kV | 3kA |
| **C** High | - | 10kV | 10kA |



# SPD Sphere of Influence

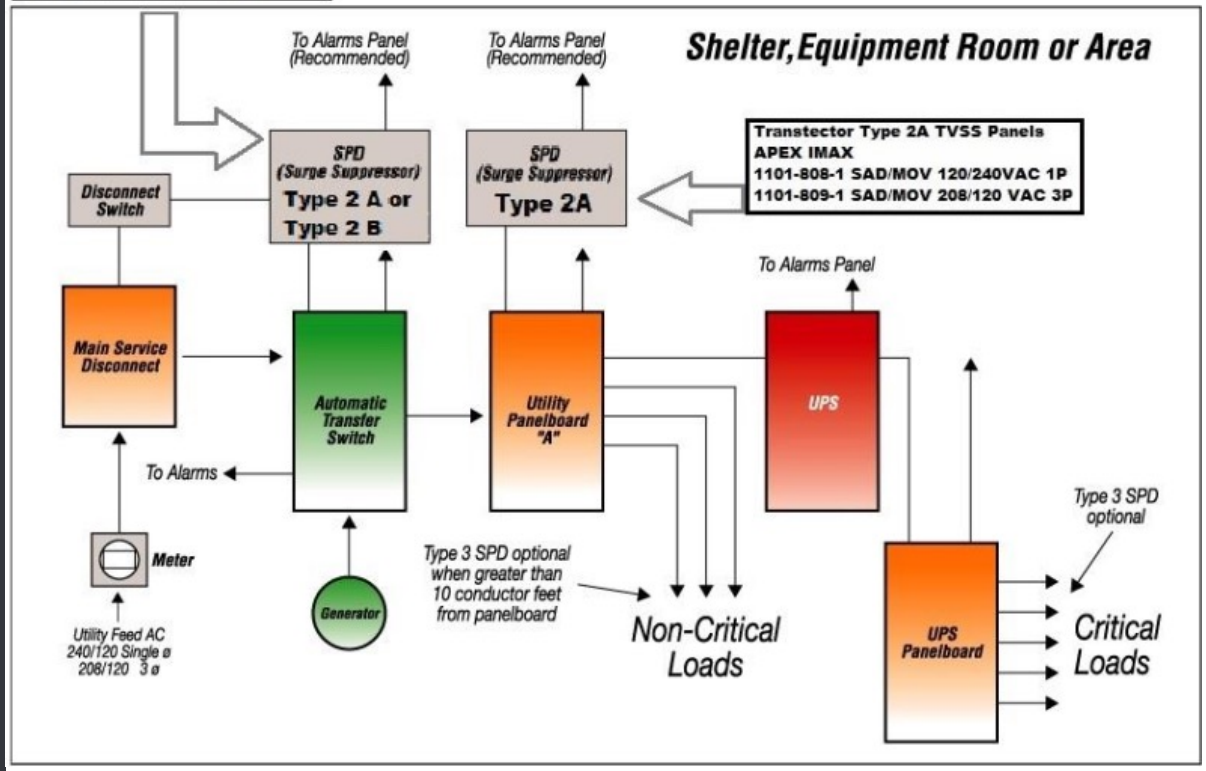
- Surge Protectors have a Sphere of Influence: 30’ to 40’
  - SPD Location is Critical
  - Install SPD close to Protected Equipment
- Lightning Surge Current is Induced to Conductive Cables
  - Cables Longer than 40’ Act like Antennas
- Cascading SPD Approach Mitigates Damage from Induced Surge Current to Conductive Cables longer than 50’




# Motorola R56
# Cascade Approach

- Location – Location – Location!!!
- Motorola R56 Type 2A / 2B (Ch. 7)
- Type 2A Technology Requirements
  - SASD Primary / MOV Secondary –Modular
  - Can be used at the Main and Sub Panels
  - UL/IEEE Type 2 Locations
  - Normal Mode Only
- Type 2B Technology Requirements
  - MOV Only – Modular
  - Can only be used at the Main Breaker Panel
  - UL/IEEE Type 2 Location but only at the Main Panel
  - Normal Mode Only
- Type 3 Technology Requirements
  - 100% SASD
  - R56/UL/IEEE Type 3 Location – Point-of-Use
  - Normal Mode Only

**Transtector Type 2 A TVSS Panels**
**APEX IMAX**
**1101-808-1 SAD/MOV 1P**
**1101-809-1 SAD/MOV 3P**
**OR**
**Type 2 B TVSS Panels**
**1101-808-MM-1 MOV Only 1P**
**1101-809-MM-1 MOV Only 3P**



# Lightning Protection System (LPS) vs Surge Protection Devices (SPD) Explained

- Need for Surge Protection

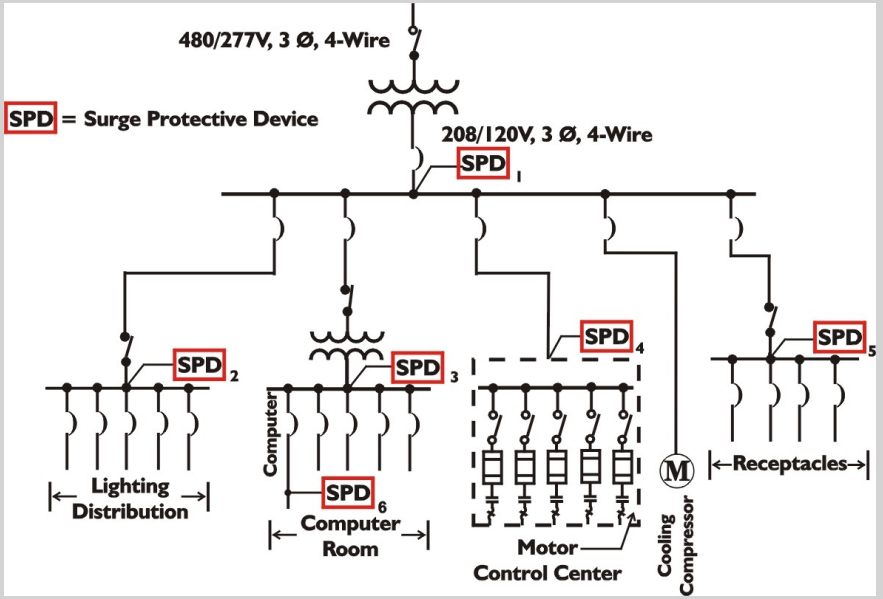
- SPDs Protect the Electrical Infrastructure from Transient Voltage Surge Events
  - Lightning Strikes, Power Spikes from the Utility, Spikes Caused by Industrial Machinery, HVAC Systems, etc., when Turned On-Off (Motors Controlling Equipment for example)
  - Safely re-directs Surge Current to Ground, removing Surge Current from Electrical, Data, Coaxial Radio Frequency (RF), and other Current Conducting Cables & Wires.
  - Controlled by Institute of Electrical & Electronics Engineers (IEEE) – IEEE C62.41, and Underwriter's Laboratory (UL) Standards (UL 1449 4th Edition), and the National Electric Code (NEC 2020 Latest Edition)
  - Also, Motorola R56 (2017 Latest Edition) – Standards & Guidelines for Communication Sites, Chapter 7 (Surge Protection Devices).

Potential Surge Current Ingress Threats

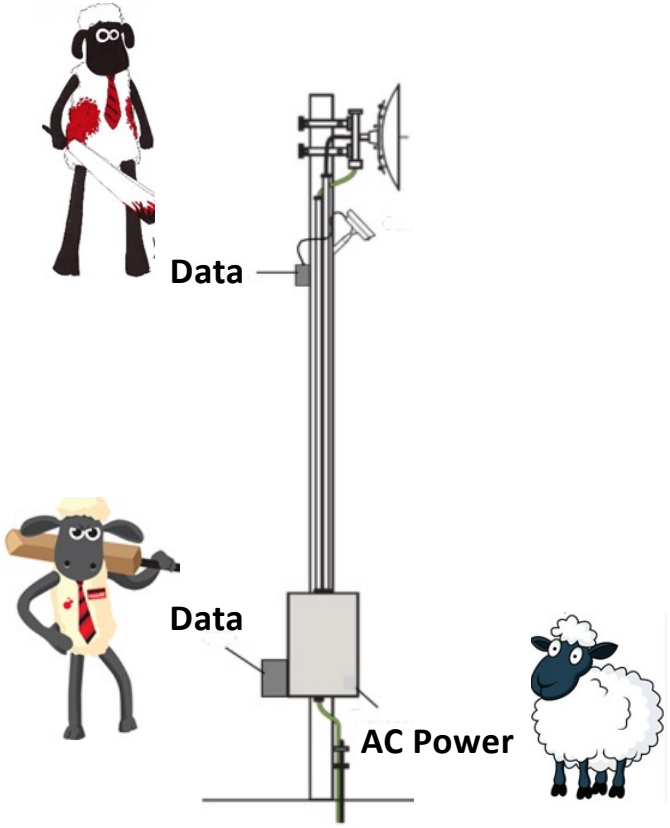
All Conductive Power – Data – Coaxial Cables & Wires, Including Chain Link Fences

# SPD Sphere of Influence

- Surge Protection Sphere of Influence: 30’ to 40’
  - SPD Location is Critical
  - Install SPD close to Protected Equipment
- Type 1 Location



# SPD's Save Equipment – Are Sacrificial lambs




- SPDs in outdoor applications help to ensure the continuous transmission of data.
- Not using SPDs results in problematic data loss issues.
- Another major benefit is also missed:
  - **Under extreme power quality events SPDs will sacrifice protecting expensive electronics.**

# Fixed Wireless Broadband Solutions

## Tower Top Electronic Protection

4 **Backhaul Antenna** Parabolic

1 **DC**- Protection

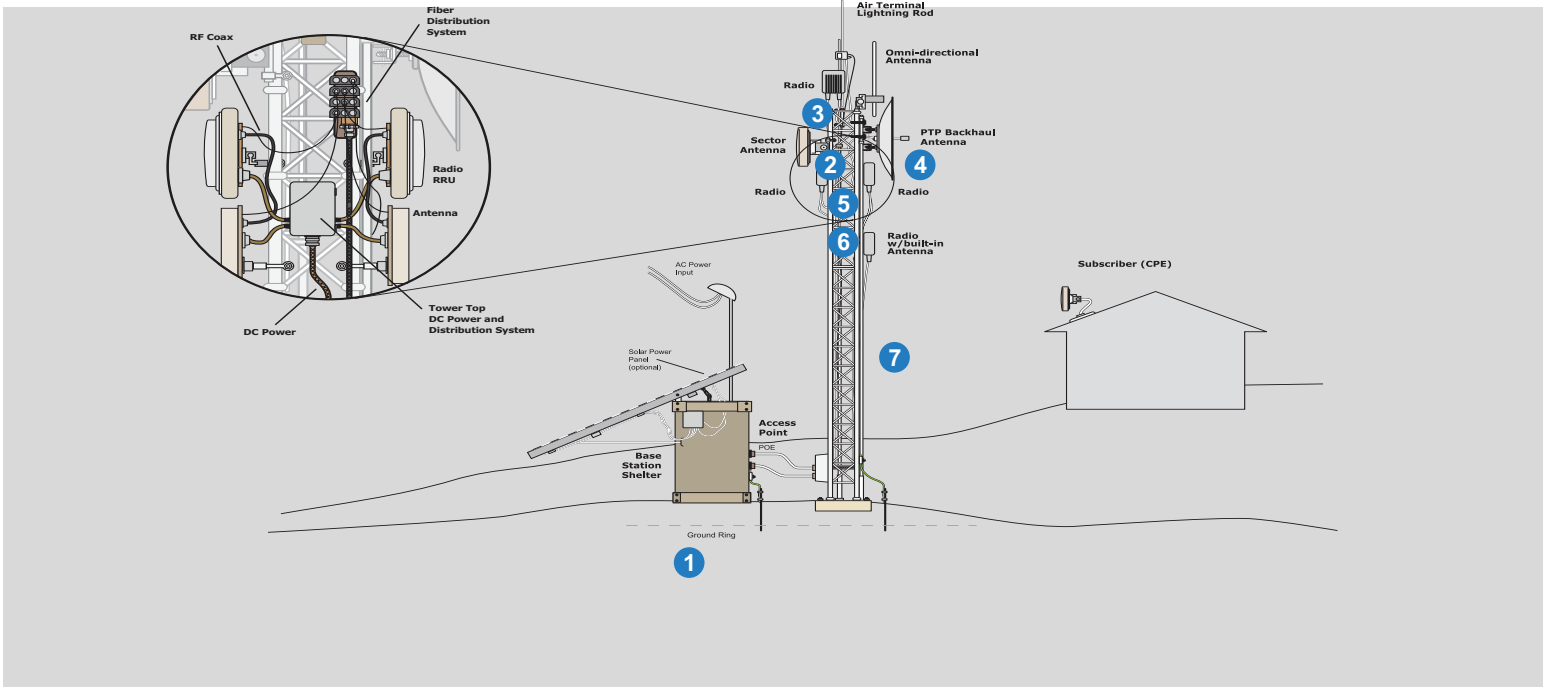
2 **RF**- Protection

3 **TMA**- Tower Mounted Amplifiers

5 **Data**- Protection

6 **DC**- PRotection

7 **Combiners** Dual Band



# Telecommunications- Cellular Backhaul Solutions

1 **RF-** Protection

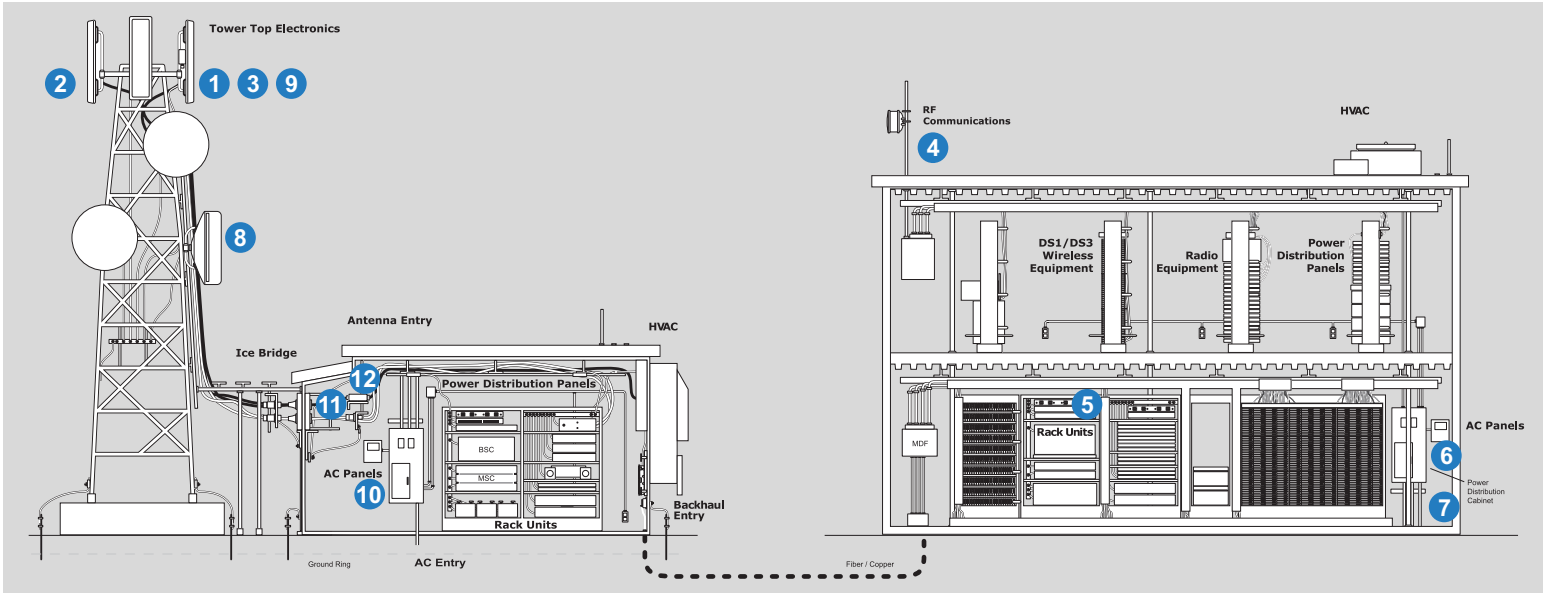
2 **TMA- Tower Mounted Amplifiers**

3 **Outdoor Data-** Protection

4 **RF-** Protection

5 **Indoor Data-** Protection

6 **AC-** Protection




7 **PPC Cabinet- Integrated Protection**

8 **Backhaul Antenna-** Parabolic

9 **DC-** Protection

10 **AC-** Prote4ction

11 **Combiner-** Prot4ection

12 **RF Filter-** Protection

# Significance of Surge Protection for Radios

**Initial Performance Check**

DUT 1

DUT 2

- Device Under Test (DUT)
  - DUT 1: Fluidmesh FM-3200-ENDO radio
  - DUT 2: Fluidmesh FM-4200-MOBI radio
- Power and signal strength checked (Table 1)
- Ensure throughput, continuity and absence of shorts
- Functionality of Transtector ALPU-F140 SPD (Table 2) checked

**Establish Test Parameter**

Test Set Up

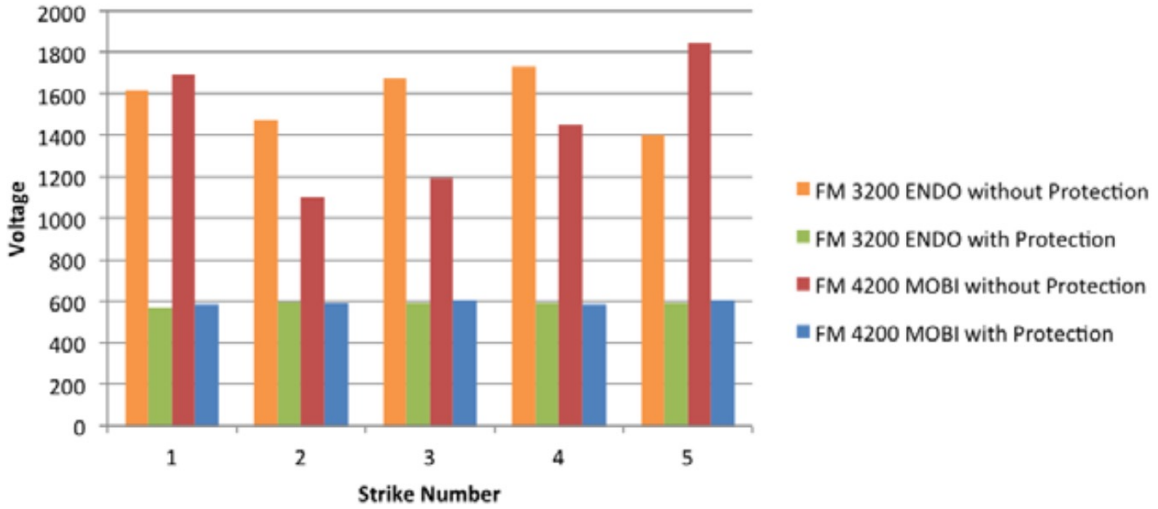
Setup 1 (No SPD)

Setup 2 (SPD)

- Two test setup established for each radio model (DUT) and included:
  - Setup 1: Each Fluidmesh radio model (DUT) was not protected (no SPD was connected in the setup)
  - Setup 2: One ALPU-F140 dataline SPD connected to each Fluidmesh radio model (DUT)

DUT = Device Under Test

**Graph 1: Peak Voltage Comparison of DUT Setup 1** (without protection) **vs DUT Setup 2** (with protection)

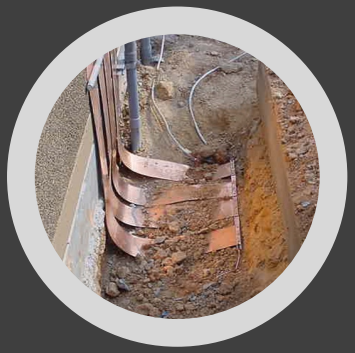


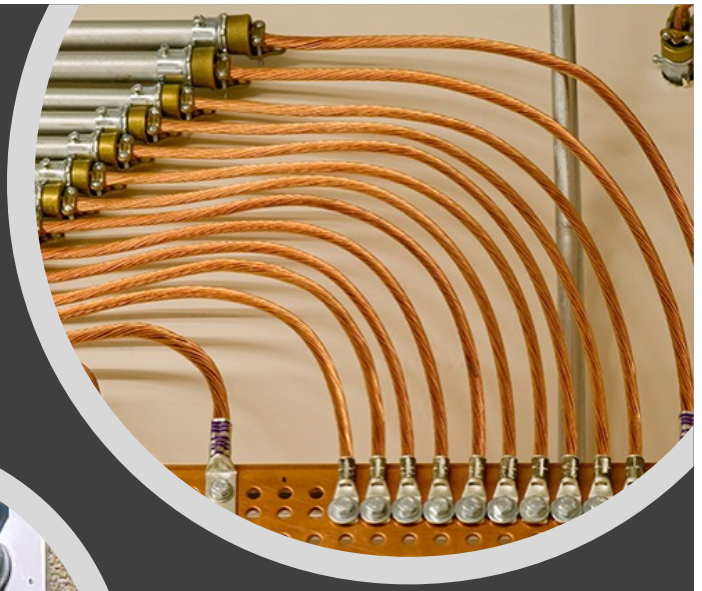

*The graph shows setup with protection consistently limits over voltage condition.*

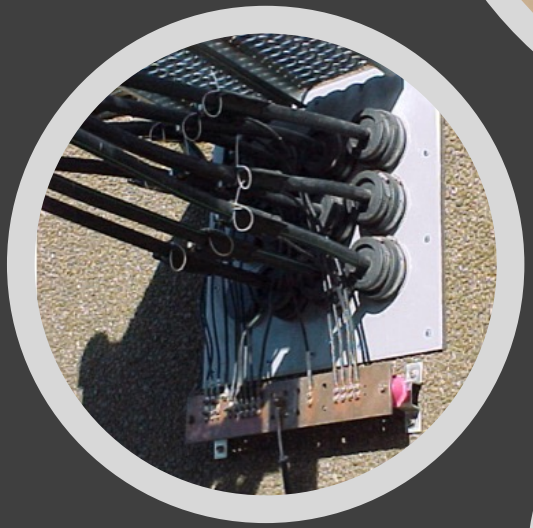
# Importance of Grounding: Installation Criteria

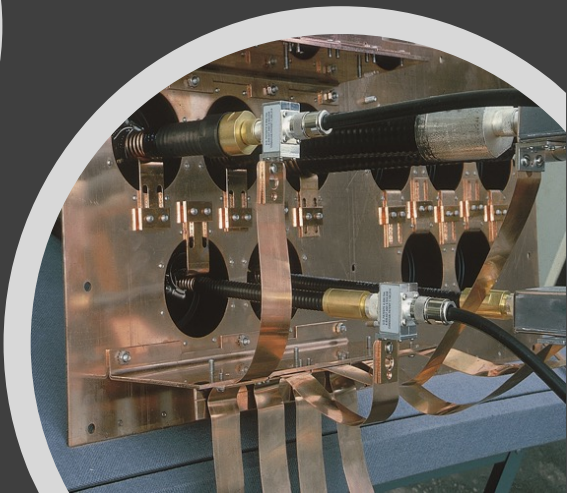
- **Proper Installation Impacts Suppressor Performance**

- Lead Length (18” Optimal) for parallel units. Clamp Voltage increases 100V per foot of wire.
- Wire Bends (NO 90º bends). Excessive wire bends increase ground impedance.
- Grounding (NEC - 25 ohms or less). SPD fails to function optimally with inadequate grounding. 4 ohms or less is Ideal
- Verify voltage configurations – 3Y, 3D, SP etc.
- Enclosures must be weatherized if mounted on the exterior of a structure or otherwise exposed to climatic conditions.







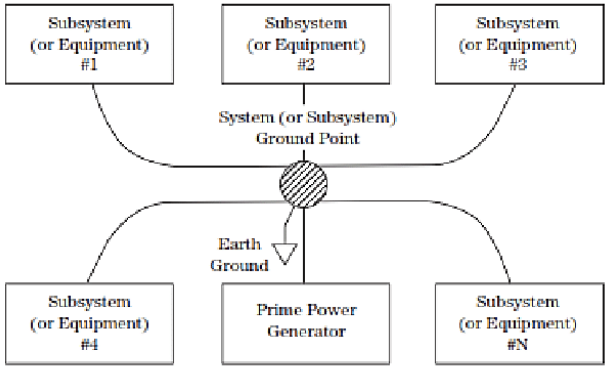
# Grounding Methods

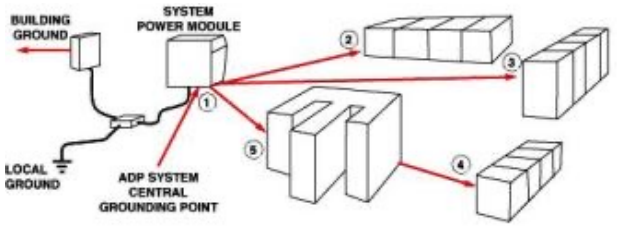
**Grounding is Foundational to Surge Protection and To a Safe Electrical Infrastructure!!!**

- All Grounds at a Single Facility Tie Together to the **Single Point Ground System**:
  - Ensures all Voltages at the Facility Rise-Fall Together
  - Mitigates Ground Loops

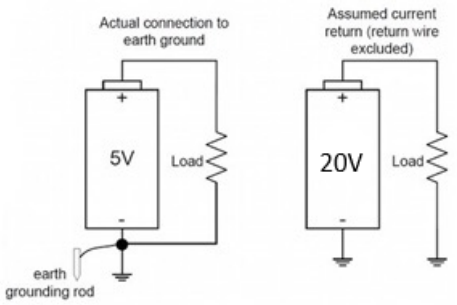
- Ground Loops
  - Prematurely Damage Electrical-Electronic Systems
  - Causes Human Electrical Shock Safety Hazards

**5V with 0V Ground Potential, Measures 5V**




*A "single point ground" in an ADP system prevents unwanted ground loops by providing only one conducting path between it and all external grounds.*




20V

**5V with 15V Ground Potential, Measures 20V**

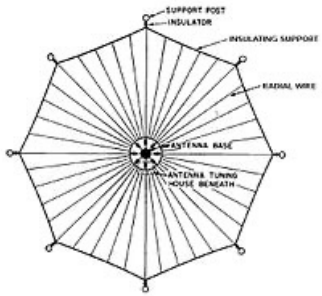
# Grounding Methods

Motorola R56 (and NEC 250.8) Allows
Two Grounding Methods:

- Irreversible (Permanent) Crimp
  - Using Crimp Sleeves
  - For Copper Conductors Only
  - Do Not Mix Aluminum & Copper Conductors

- Exothermic Welding (Cadweld) – Preferred Method
  - Molecular Mixing-Joining of Two Metal Surfaces (Cable to Ground Rod, or Ground Plate Surface)
  - If Repairing an Antenna Counter-Poise, use Exothermic Welding Method

Antenna Counterpoise




Permanent Crimp Method

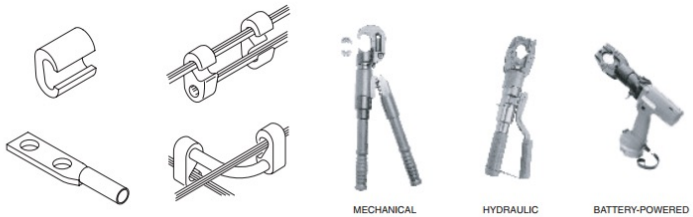
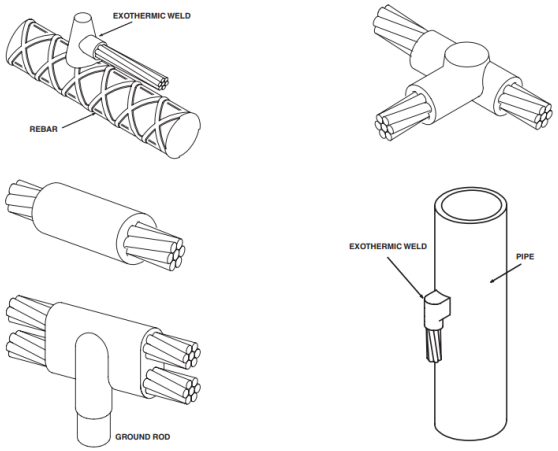
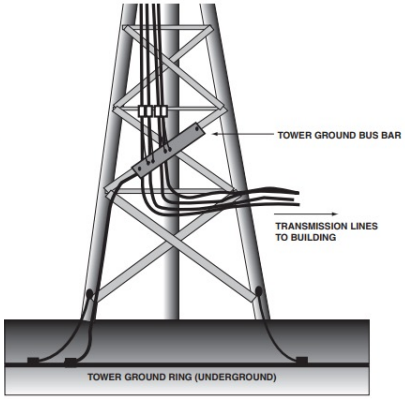
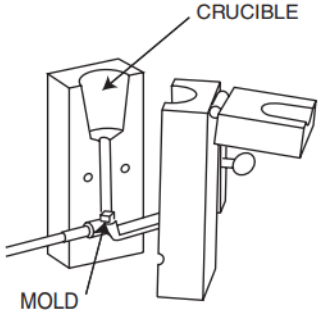



**FIGURE 4-30** HIGH-COMPRESSION CONNECTORS AND TYPICAL CRIMPING TOOLS

Exothermic Weld Method



# Grounding Methods

Prepare Metal Surfaces when Joining Surge Arrestor or Ground Wire to other Metal Surfaces:

- Remove all Paint and other Conformal Coatings
  - Must have Metal-to-Metal Contact
    - by Surge Arrestor to Metal Ground Plate
    - By Ground Conductor to Ground Rod

- Use Electrically Conductive Joint Compound (Anti-Seize) between Metal Surfaces before Joining (if using Jam Nut with Surge Arrestor to Ground Plate for example)

  - Ensures Excellent Ground Conductivity
  - Prevents Corrosion from Settling Between Surfaces
  - Helps Mitigate Dissimilar Metals (Electrolysis) Issues

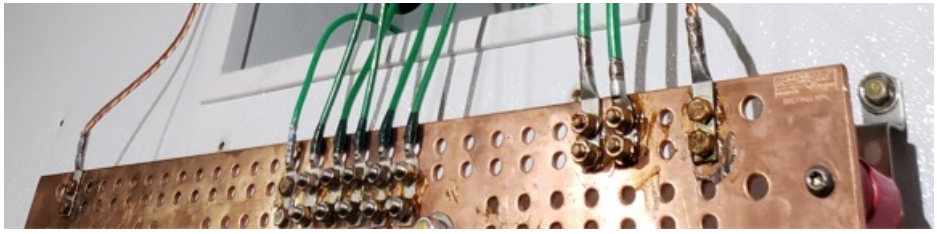




**TABLE 4-7** SUITABILITY OF METALS FOR BONDING

| Metal assumed to have the Larger Surface Area | Electrode metal or item assumed to have the Smaller Surface Area | | | |
|---|---|---|---|---|
| | **Steel** | **Galvanized Steel** | **Copper** | **Tinned Copper** |
| **Galvanized Steel** | Suitable | Suitable | Suitable | Suitable |
| **Steel in Concrete** | Not Suitable | Not Suitable | Suitable | Suitable |
| **Galvanized Steel in Concrete** | Suitable | * | Suitable | Suitable |
| **Lead** | Suitable | * | Suitable | Suitable |

**Key:**
Suitable = Materials suitable for bonding.
Not Suitable = Materials not suitable for bonding.
* = Materials suitable for bonding, but the galvanizing on the smaller surface may suffer.
This table is based on Table 8 of BS 7430:1998.

# Grounding Methods

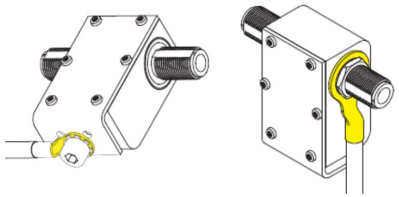
Wire Size (Gauge) Recommendations

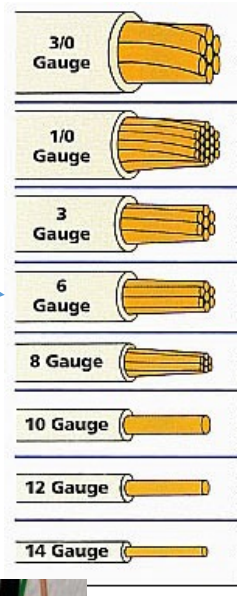
- Use No Smaller Diameter than 6AWG Stranded Ground Wire (Not Solid) Between Single Surge Arrestor & Ground Plate (or to Single Point Ground System), if Not attached to a Metal Ground Plate

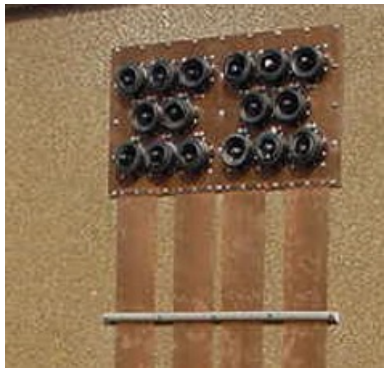
  Surge Current Flows on Conductor's Surface
  - **There is More Surface Area with Stranded, than Solid, Ground Wire**
  - More Surge Current Transfers to Ground via Stranded Ground Wire
  - Can also use 1 ½" Wide Solid Copper Strap (Equal to 6AWG Stranded)

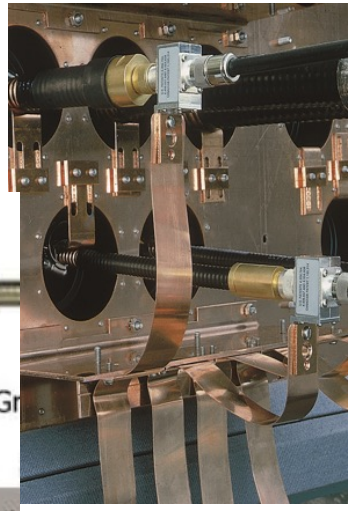
- Use 4AWG or 2AWG Ground Wire, or 3" to 6" Wide Solid Copper Strap between Metal Ground Plate and to the Single Point Ground System

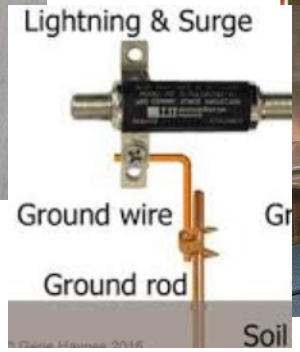
  - Metal Ground Plates Have Multiple Surge Arrestors Mounted to them, therefore, they carry more Surge Current
  - Needs Larger Ground Pipe (Wire – Strap) than a Single Surge Arrestor Ground Conductor





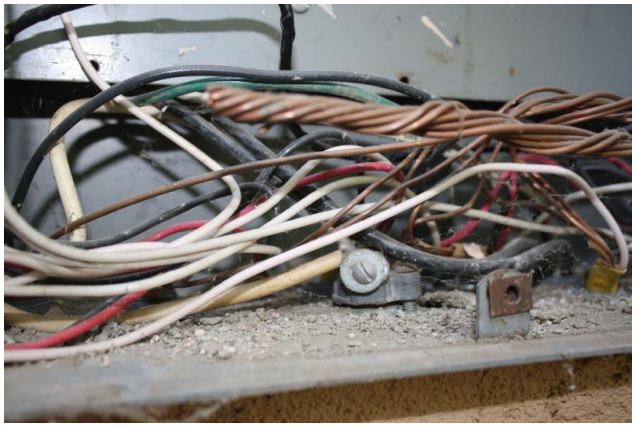




# Grounding Methods

Ground Wire Management

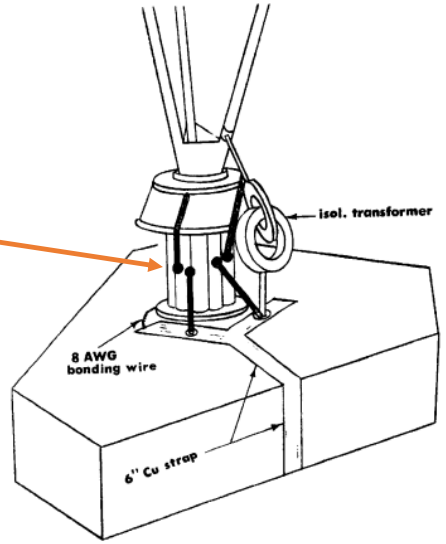
- Keep the 6AWG or 4AWG/2AWG Ground Wire as Straight and Short as Possible
    - No Bends or Kinks in the Ground Wire
- The Ground Wire needs to be the Path of Least Resistance
    - Bends and Kinks add Impedance
    - Surge Current will find a Lesser Resistive Path to Ground thru the Equipment if the Ground Wire has severe Bends or Kinks
    - Keep Un-Avoidable Bends to a Gentle 8” Arc



# Tower Grounding Methods

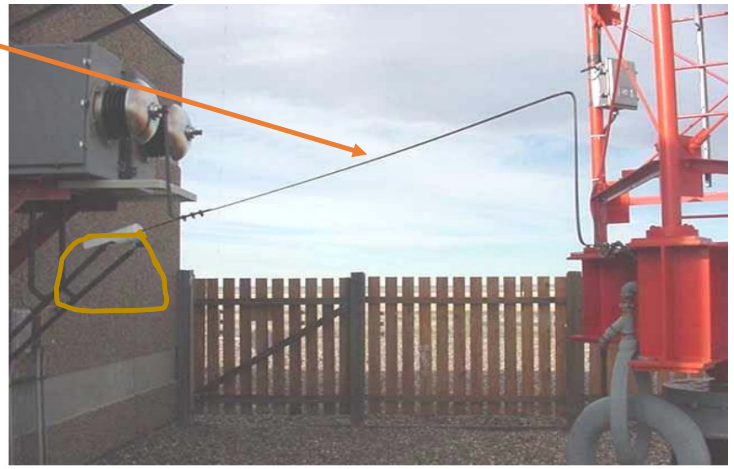
Spark Gaps needed for Hot Guyed Towers

- Hot Towers need a Spark Gap to channel Lightning Surge Current to Ground thru (with Air Gap)




Z-Feed (Used by US Coast Guard LORAN for RF Path to 1M Watt Transmit Tower from Antenna Coupler)

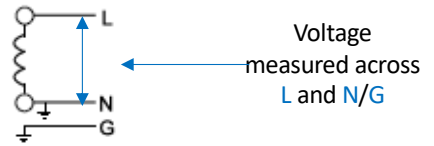
- The RF Path Z-Feed has two 90 Degree or more Severe Bends adding Impedance to Surge Current
- Surge Current Finds the Least Path of Resistance, thru the Spark Gaps, Not thru the RF Path



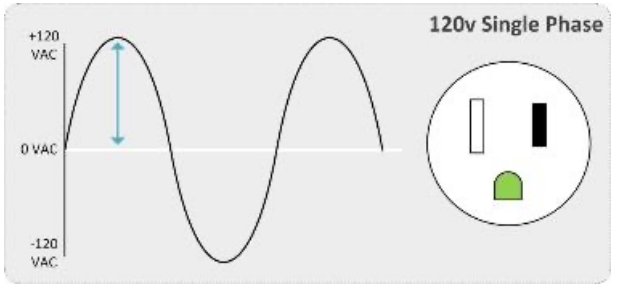
# Voltage Configurations – Single phase wiring diagram

- Single phase wiring is 1 hot line measuring XXX V to neutral or ground
- Requires 3 connections
  - Line/Hot
  - Neutral
  - Ground
- Single phase wiring is building block for various other voltage configurations
  - Split phase
  - 3 wire Delta
  - 3 wire Wye (pronounced as - *why* or *Y*)

| 120 Single Phase | 220 - 277 Single Phase | 480 Single phase |
|---|---|---|



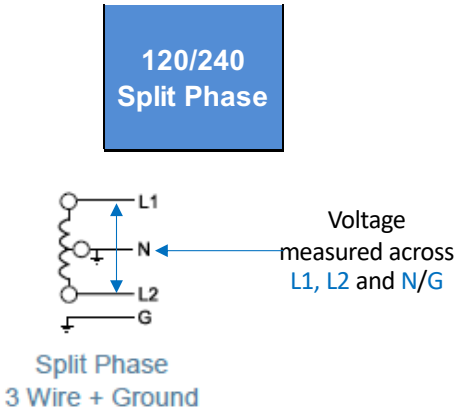

Single Phase
2 Wire + Ground

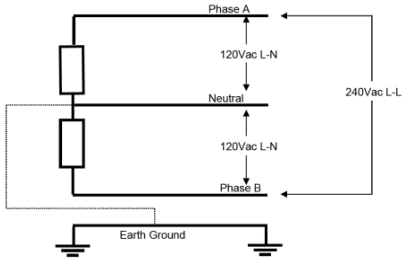


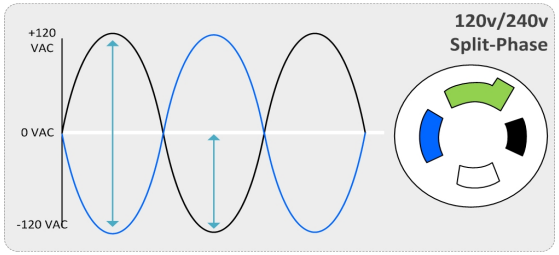
# Voltage Configurations – Split/Dual phase wiring diagram

- Split phase wiring is 2 hot line measuring 240V, and 120V from L1 & L2 to neutral or ground
  - (L1 – N) + (L2 – N) = (L1 – L2)
  - L1 – L2 = 240V
  - L1, L2 - N/G = 120V

- Requires 4 connections
  - Line/Hot (L1, L2)
  - Neutral
  - Ground



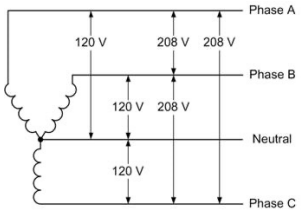



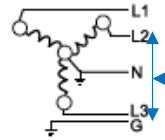



# Voltage Configurations – 3 phase Wye (Y) wiring diagram

- 3 phase wiring is 3 hot lines measuring 120V to neutral or ground and 208V line to line *(for 120/208 configuration)*
  - (L1 – N) + (L2 – N) = (L1 – L2)
  - L1 – L2, L1 – L3, L2 – L3 = 208V
  - L1, L2, L3 - N/G = 120V

| 120/208 Wye | 127/220 Wye | 220/380 Wye | 230/400 Wye | 240/415 Wye | 277/480 Wye | 347/600 Wye |
|---|---|---|---|---|---|---|



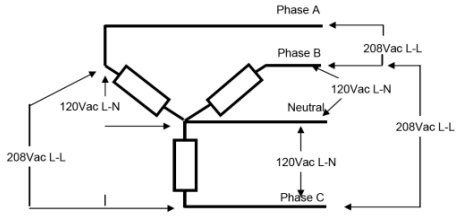



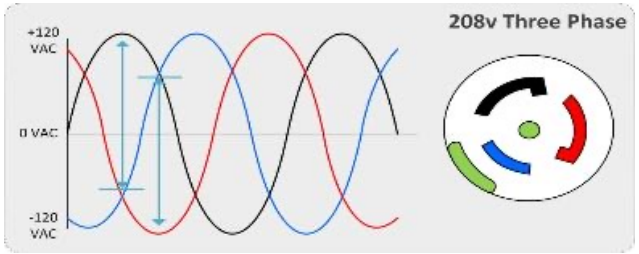

Voltage measured across L1, L2, L3 and N/G

3 Phase Wye
4 Wire + Ground

- Requires 5 connections
  - Line/Hot (L1, L2, L3)
  - Neutral
  - Ground

- 3 Phase Wye wiring enable application to use both voltages (120V and 208V)

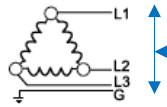


# Voltage Configurations – 3 phase Delta (Δ)wiring diagram

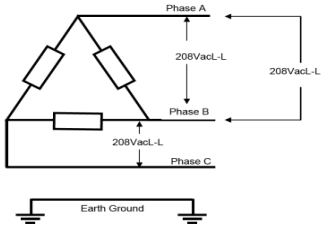
- 3 phase wiring is 3 hot lines measuring 208V line to line *(no split configurations)*
  - L1 – L2, L1 – L3, L2 – L3 = 208V
  - L1, L2, L3 - N/G = 120V
- Requires 4 connections
  - Line/Hot (L1, L2, L3)
  - Ground
- 3 phase Delta wiring offers reliability, and does not have neutral connection

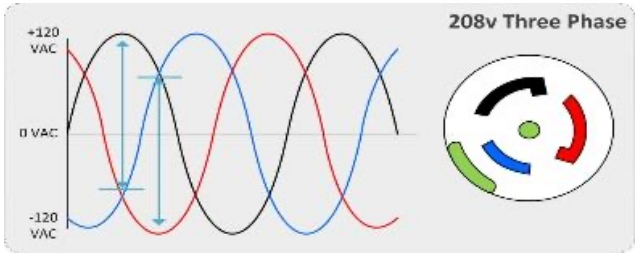
| 240 Delta | 480 Delta | 600 Delta |
|---|---|---|




Voltage measured across L1, L2, L3 and G *(no N in delta)*

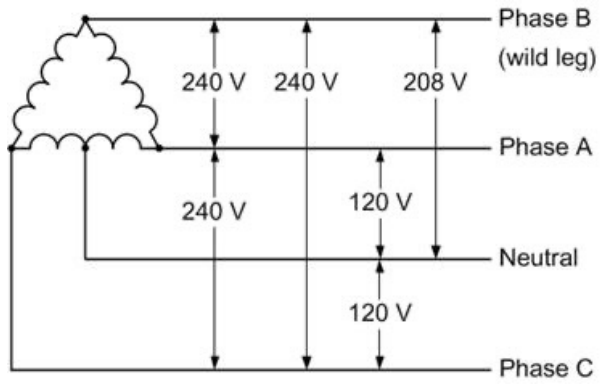
3 Phase Delta
3 Wire + Ground



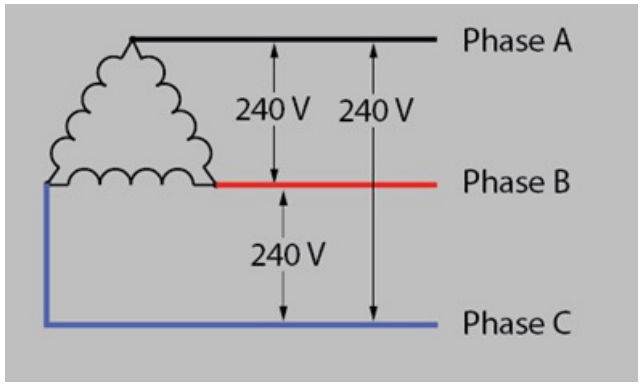



# Differences between 3Phase Delta and 3Phase High Leg Delta or Center-Phased Ground

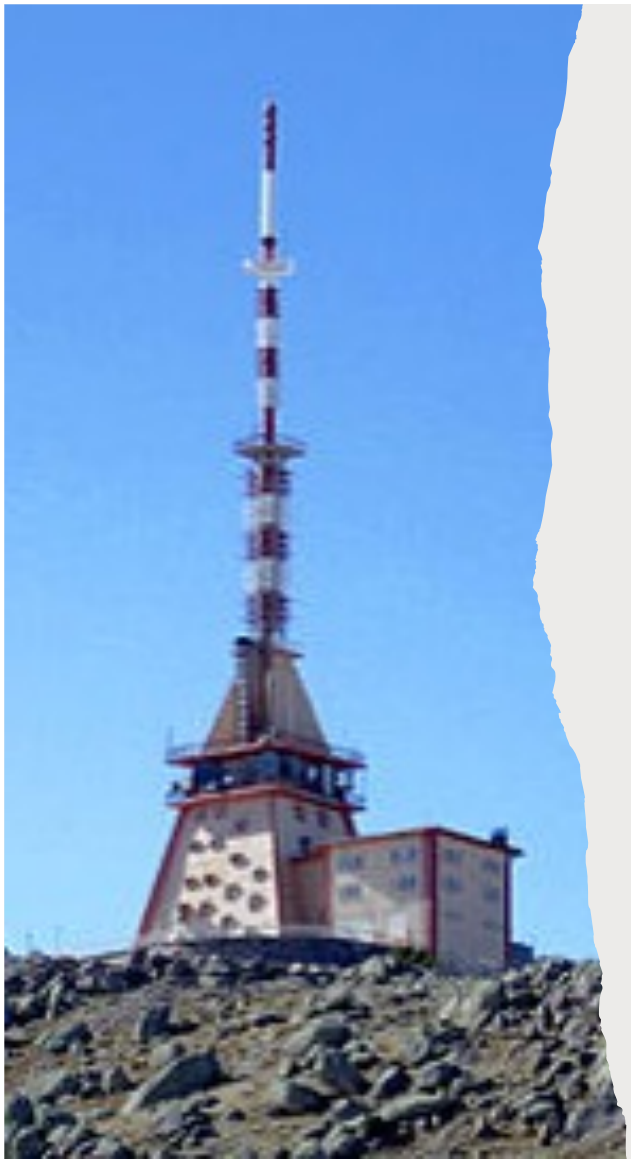
Three Phase High-Leg Delta, or Center Phased Ground




Three Phase Delta



# Common Broadcast Engineer Questions & Responses

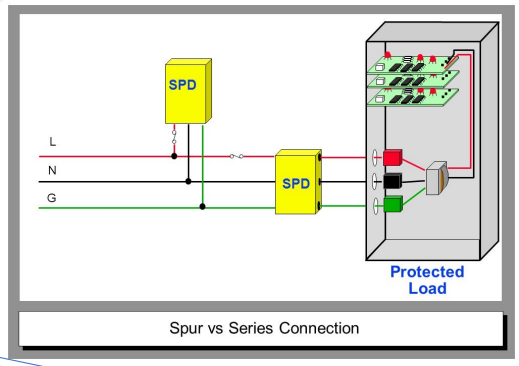


# Question:

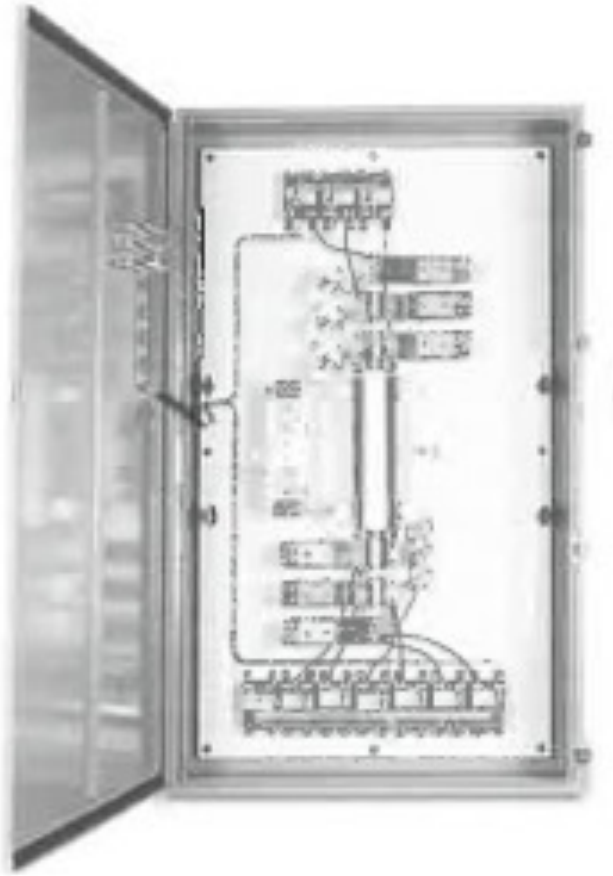
- **We're installing a new Transmitter. I need a Surge Protector for it. What should I use?**
  - Use a Surge Protector with EMI/RFI Filtering to Remove Incoming Noise from the Utility Input Power Lines
  - LEA International PowerVantage (PV) Series
  - Parallel Connected. Comes in:
    - 120/240 Split Phase
    - 120/208Vac 3Phase Wye
    - 277/480Vac 3Phase Wye
    - 480Vac 3Phase Delta

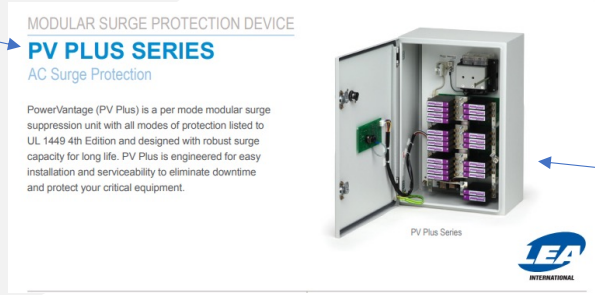
# Question:

- “I have a 20 year old Dyna System Series Connected SPD. None of the MOV Modules seem to have any life in them. Do you have replacement Modules for this Surge Protector?”
  - No. Obsolete.
  - Keep In Place for EMI/RFI Filtering.
  - Install Parallel Connected SPD to Restore Protection.



Spur vs Series Connection

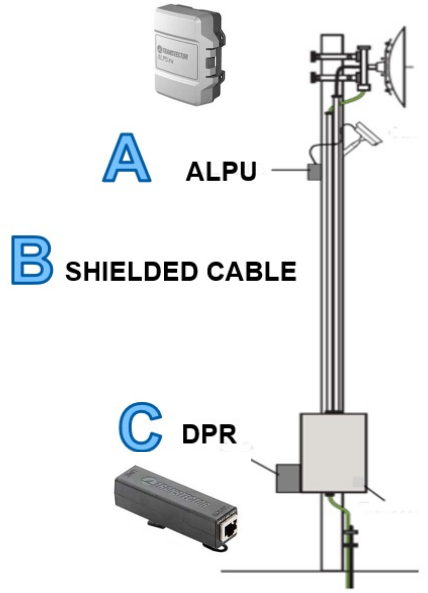


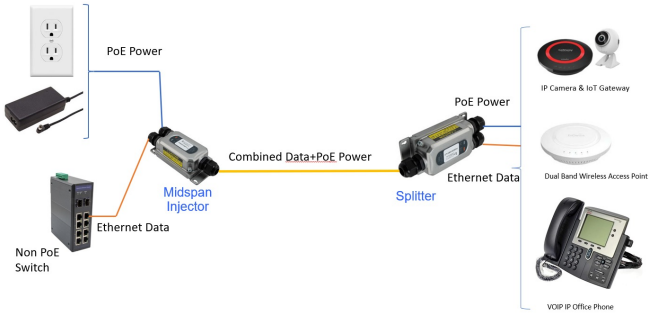



PV Plus Series is Modular, and has EMI/RFI Filtering (UL 1449 Listed)
Uses 100% MOV Technology

# Question:

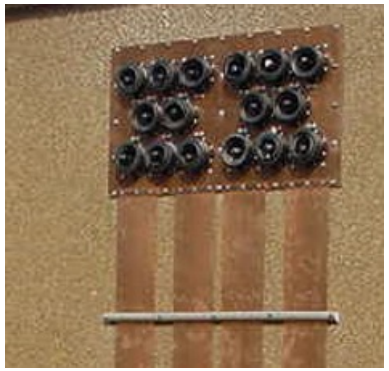
- **I have 48Vdc Powered CAT/Fiber Cable Equipment on the Towers. What do we use for Protecting 48Vdc on Tower Tops?**
  - For Power-over-Ethernet or 48vdc, Use an Indoor Surge Protector at Switch End (Indoors) and Outdoor Rated Surge Protector for Tower-Top Equipment; one Protector at both ends of the Same Data Cable.
  - Fiber Media Converters typically use a Negative Grounded (-48Vdc) Input Power Surge Protector that protects DC+ to DC- and DC+ to Ground, and DC- to Ground for 'All Mode' Protection.
  - Transtector has Premium GigaBit PoE++ (100 Watts) Indoor-Outdoor Protectors & Input Voltage +/- 48Vdc Surge Protection Solutions for Tower Top Equipment. An Outdoor 10GigaBit PoE++ Protector is now Available also.
- **Follow-Up Question, When do I need an Ethernet Injector?**
  - Injectors are used to extend or boost Ethernet Signals on long CAT Cable Installations (beyond 100 meters or 328~ish feet).
  - Also, some Switches provide separate Data and PoE Power Output Ports. Use an Injector Surge Protector to combine Data+Power allowing One CAT# Data Cable Run up the Tower where the Data & PoE Power can be broken out by a 2nd Injector Protector to the Tower Top Equipment using separate Data & PoE Ports.

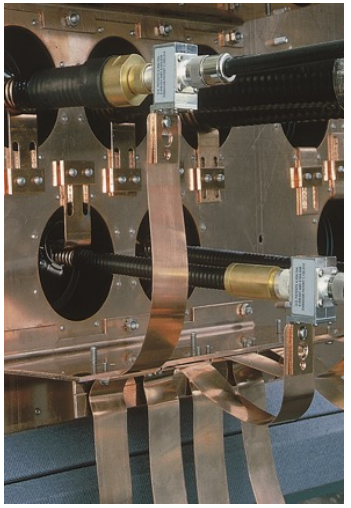


# Question:

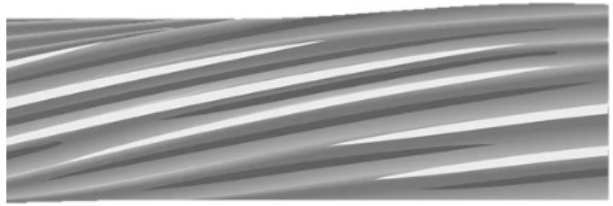
- **Do Surge Protection Devices Mitigate Demand Sags and Switching Surges, or Sustained Over-Voltage Scenarios?**
  - No, Surge Protection Devices react to momentary, microseconds duration Transient Voltage Surge events, like from Lightning, or Power Spikes from the Utility, or from Equipment that Turn-On/Off (Switching), or HVAC Motors Turning On-Off, etc..
  - Surge Protectors will be destroyed from Sustained Over-Voltages (minutes or longer duration).
  - Surge Protection Devices are NOT Voltage Regulators!!!





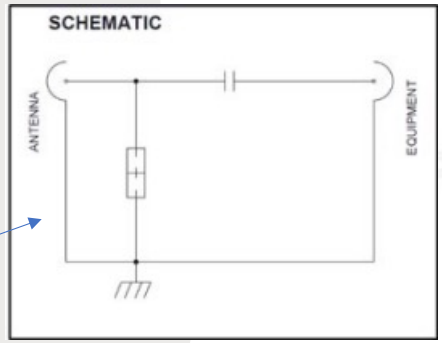
# Question:

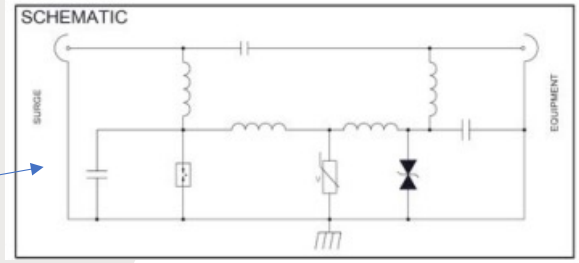
- **How Do we Protect from Copper Theft at Un-Attended Remote Transmitter Tower Sites?**
  - No Magic Wand helps here.
  - One best method is to use Tinned-Copper Grounding Conductors.
  - Metal Recycling folks want pure metal materials, and will not likely accept alloys, like Tinned-Copper.

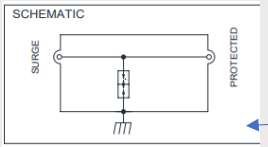


# Question:

- **What Is the Difference Between a DC Block and a DC Pass RF Coaxial Surge Arrestor?**
  - DC Block RF Coaxial Surge Arrestors Block the DC Component of a Lightning Strike
    - A Capacitor is Installed in Series on the Center-Pin
    - Use DC Block Surge Arrestors on Passive Antennas
      - Whips, Yagis, Di-Poles
  - DC Pass Surge Arrestors Pass DC to Active Antennas
    - GPS Antennas are Active Because they have a Pre-Amplifier in them with a Circuit Board and Components that needs a DC Voltage to Function, Supplied by the Radio via the Coax Antenna Cable
    - Anything Installed in Series on the GPS Coax Cable must Pass DC or the Antenna Does Not Work



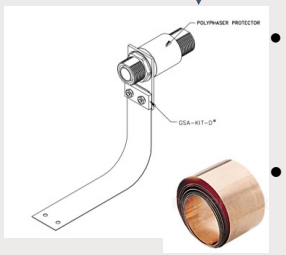



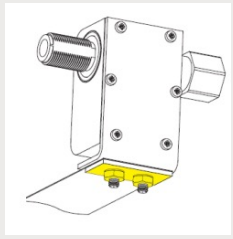



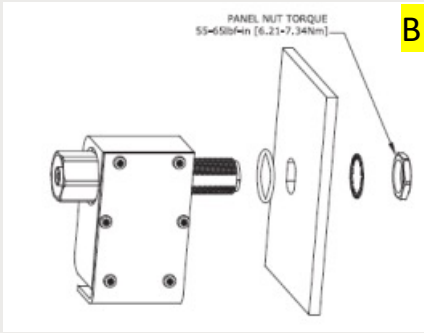

# Question:

- **How do I Attach Ground to an RF Coaxial Surge Arrestor?**
  - Bulkhead Mounting
    - Attach the Ground Wire / Strap to the Metal Ground Plate
    - Ensure Bare Metal-to-Metal Contact by the Surge Arrestor to the Ground Plate
    - Use 4AWG or 2AWG from Metal Plate to Single Point round System
  - Flange Mounting (to Flat Surface, or to Metal Ground Plate
    - Attach Ground Wire-Strap to Flange Bracket or to Metal Ground Plate
  - Directly to the Surge Arrestor (if Hanging the Surge Arrestor on the Coax – Not Mounting to a Ground Plate
    - Use Ring Terminal to Attach Ground Wire to Female Coax Connector on Surge Arrestor
  - Use No Smaller Diameter than 6AWG Stranded Ground Wire (or 1 ½" Wide Solid Copper Strap) when Connecting a Ground Wire Directly to the Surge Arrestor

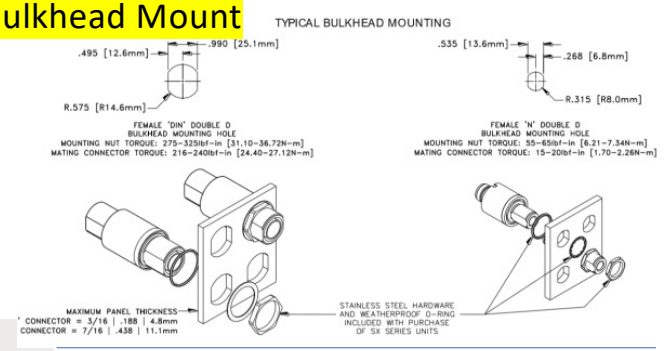
Direct Grounding With Strap

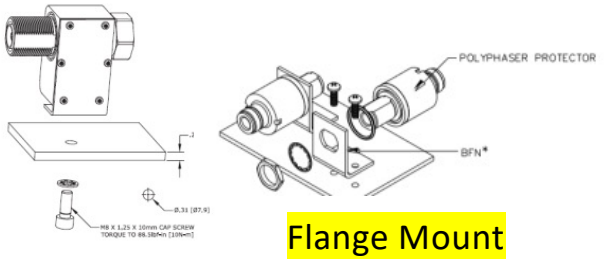




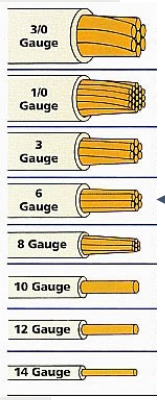



Bulkhead Mount

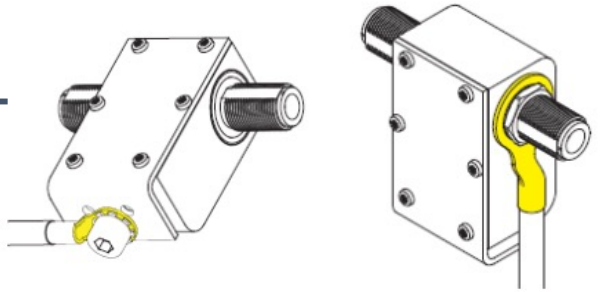



Flange Mount

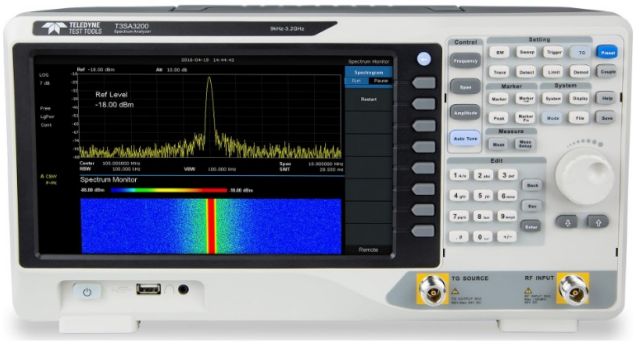



Direct Grounding with Stranded Wire



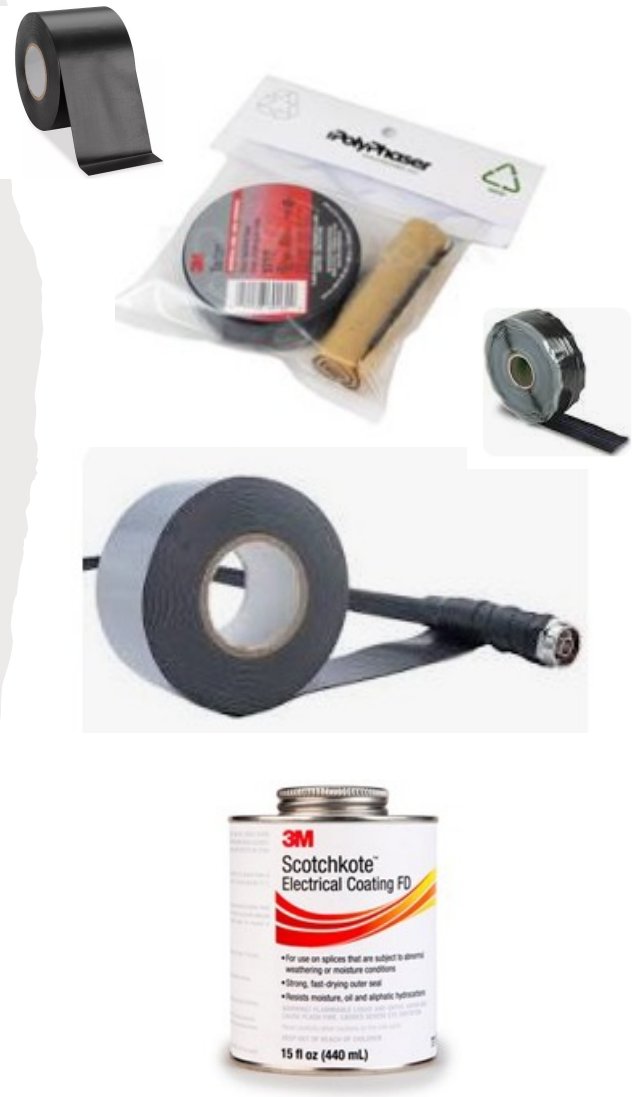
# Question:

- **How Can I Field Test Gas Discharge Tube (GDT) Based RF Coaxial Surge Arrestors to Know When to Replace Them?**
  - Perform Consistent VSWR Testing
  - As the GDT Degrades, VSWR Gets Worse
  - When VSWR Degrades Beyond Point of Not Good (Subjective), Replace the Surge Arrestor
    - Assumes Coax Cable is in Good Shape – Connectors are Clean, The Antenna is in Good Shape, etc.
    - Recommend Replacing Surge Arrestor with Barrell Pass-Thru for Troubleshooting (Eliminate Other Sources of Bad VSWR)
    - If VSWR Still Bad with Surge Arrestor Removed, Troubleshoot Coax Cable-Connectors-Antenna and Resolve. Then, Re-Test with the Surge Arrestor Re-Installed for True GDT VSWR Impact
    - If VSWR Improves with Surge Arrestor Removed, Replace Surge Arrestor

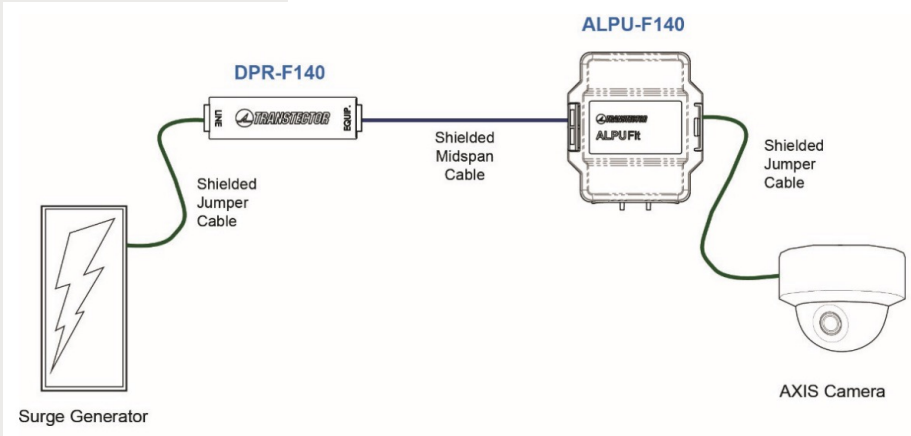
# Question:

- **How do I Weatherize an RF Coaxial Surge Arrestor?**
  - Two Tape Method
    - Self-Vulcanizing (Rubbery) Tape – First Layer
    - Sticky Electrician's Tape – Second Layer (Overlap 1st Layer)
    - Scotchkote (3M ®) Electrical Coating – Third Layer (Paint Over Tape Layers)
      - Hardens in 24 Hours to UV and Water Resistant Shell
      - Specifically Designed to Paint over Vinyl Cable Splices for Underwater Submersion
      - https://www.gordonelectricsupply.com/p/3M-Scotchkote-Fd-15-Oz-Can/5679982?text=5679982&gclid=EAIaIQobChMI8Z256M_g2wIVioF-Ch3grAp7EAYYASABEgL-QPD_BwE
  - Three Layer Method Employed by US Coast Guard
  - Scotchkote Not Sold by PolyPhaser - Is Available Online
  - Brush Attached to Lid. Remove Lid, Paint Goo over Tape
  - Don't get Scotchkote on Clothes – Will Never Come Out!!!!



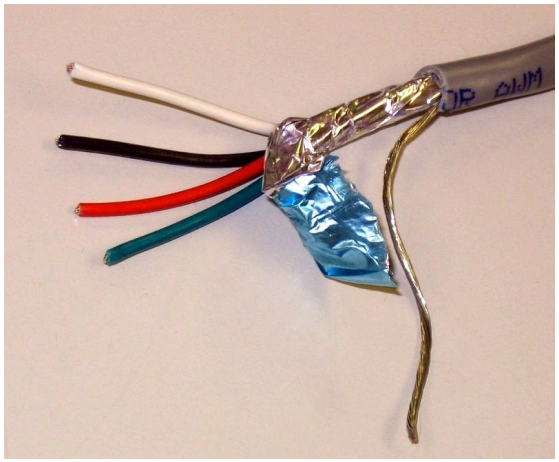
# Question:

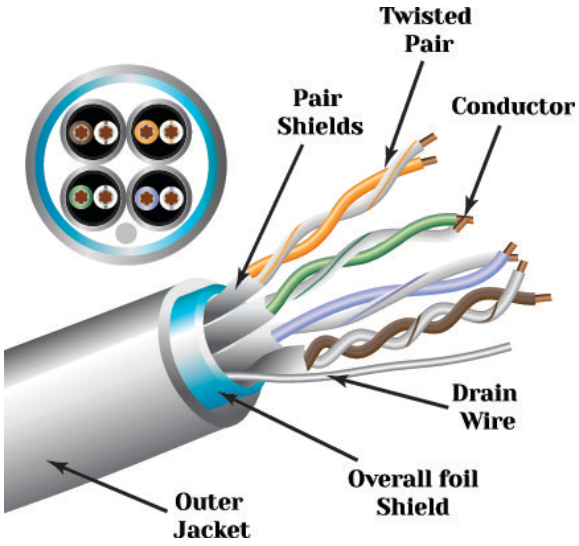
- **I have a Data (Ethernet) Surge Protector. Where do I Install It? (For both a Radio, and for a Security Camera on a Tall Pole Outside)**
  - Install Close to Equipment
  - Two Data Surge Protectors; One at Both Ends of Data Cable
  - Ground One End of Data Cable Only (Prevents Ground Loops)
    - Ground Data Cable at Data Cable End Closer to Ground, Not at Tower Top (Water and Trons Runs Down-Hill) Make It Easy



# Question:

- **Do I ground Both ends of a CAT6 Data Cable?**
  - **No.** Only Ground One End of a Data Cable
    - Grounding Both Ends Causes Ground Loops! BAD!!!
    - Ground the Data Cable at the 'Closer-to-Ground' End of the Data Cable, NOT the Tower Top End
    - Use Shielded CAT5 or CAT6 Data Cable
      - Shielded Data Cable Helps Mitigate EMI/RFI
  - Long Data Cables Are the Source of the Surge!
    - Align 'Surge' End of Surge Protectors to Face Each Other (Equipment Ends of Surge Protector Faces The Equipment (Switch at one End, Radio at the Other End)
  - Grounding Cable Shield Grounds Out EMI/RFI and Static
    - Cable Shield Ground is NOT Surge Protection Ground for the Surge Protector which is Separate. **Always Ground the Surge Arrestors (Both ends of Data Cable)**





# Question:

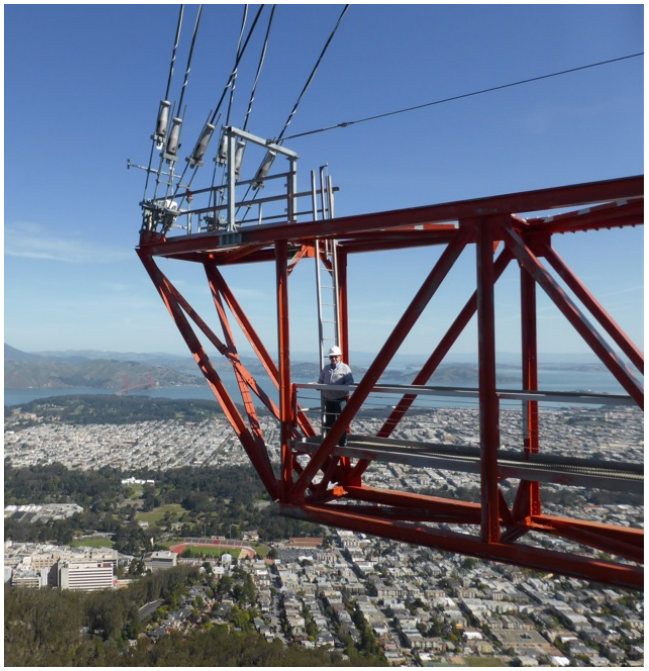
- **I have a UPS System with Built-In Surge Protection. Do I Still Need a Surge Protection Device?**
  - **YES!!!**
  - **Repeat After Me! UPS Systems are NOT Surge Protection Devices!!!**
  - UPS Systems with Built-In Surge Protection means that when the Integrated Surge Protection Circuits Fail, so does the UPS.
  - Protect UPS Systems with Appropriate Surge Protection Devices so that the UPS Systems can Do What They are Designed To Do
  - **The Proper Tool for the Job!!!**

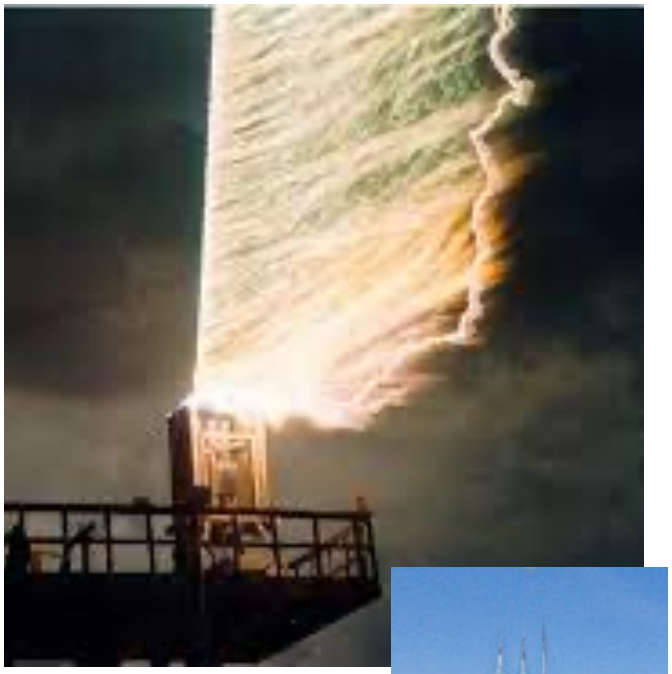
A UPS delivers second-level protection against surges; **it should never be considered a primary surge protection device.**

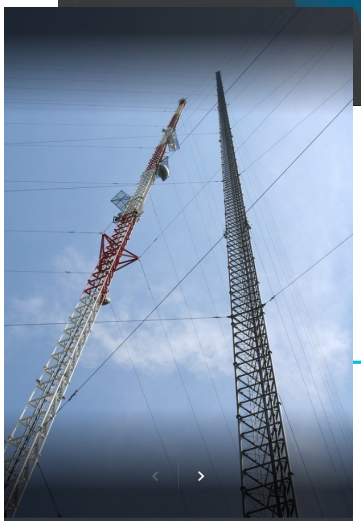
The UPS also continually regulates incoming voltage and provides an internal battery that allows connected equipment to continue running even if the power supply is cut.

~~Use a UPS to Regulate Voltage~~ and Provide Backup Power which IS NOT WHAT SPDs do

Use an SPD to Protect a UPS from Transient Voltage Surge Events, not from Sustained Over-Voltage (SPDs go Boom when Exposed to Sustained Over-Voltage)







# Lightning Is a Real Pain!!

2nd Tallest Structure in Western Hemisphere – 8th Tallest Structure in the World. What Radio Station? Where?

Where am I?