

A dramatic photograph of a lightning bolt striking a tall tower, likely a telecommunications tower, against a dark, stormy sky. The lightning is bright and jagged, creating a strong contrast with the dark background. The tower is silhouetted against the light from the lightning.

LIGHTNING SUPPRESSION AT TELEMETERED TRAFFIC MONITORING SITES (TTMS)

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Purpose of This Effort



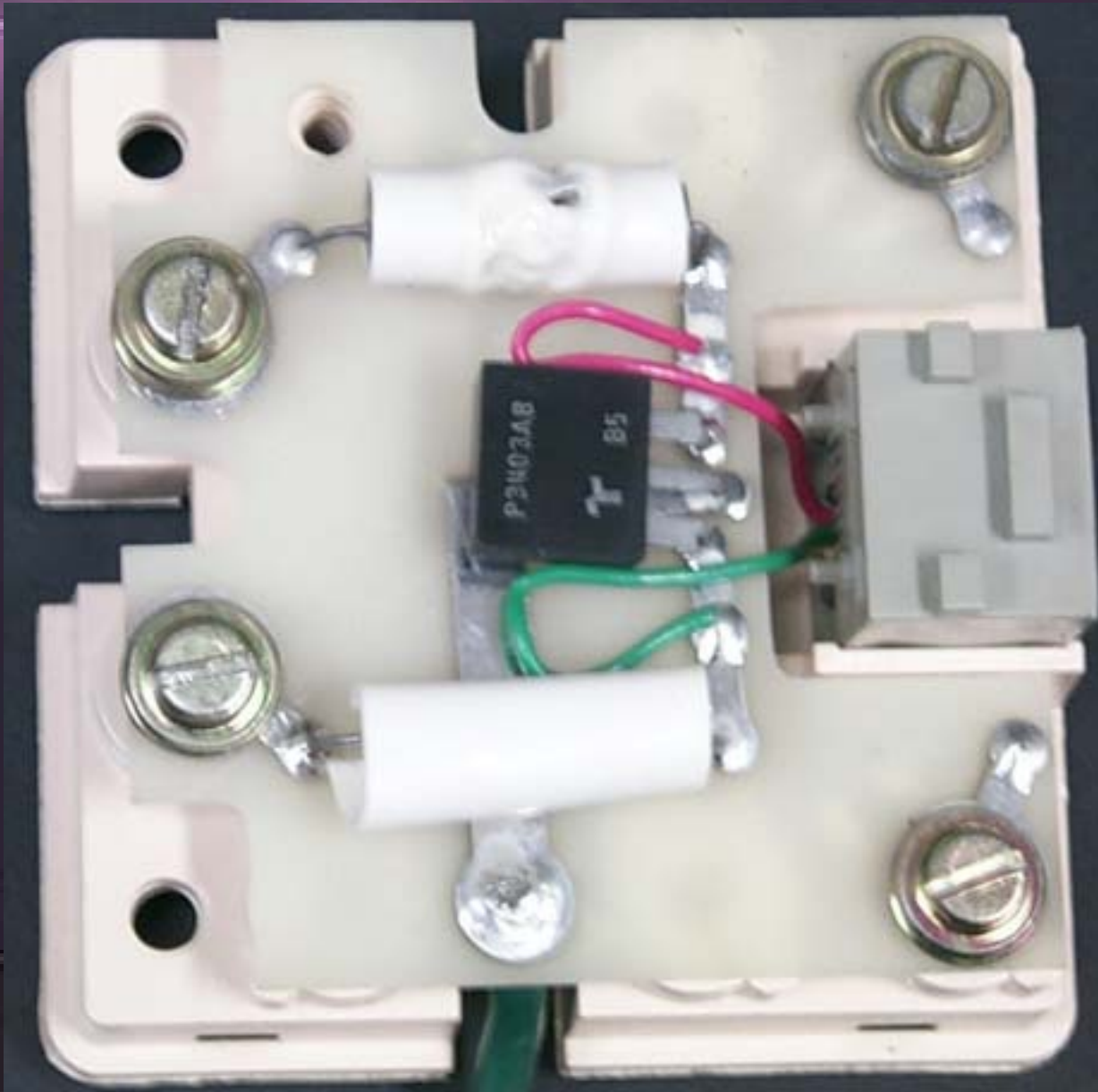
- Reduce the Number of Failed Telephone Line Surge Suppressors at TTMSs
 - Analyze Failed Devices
 - Identify Lightning Environment (Florida)
 - Test Surge Suppressors
 - Develop Standards Recommendations
- Other Surge Suppressors Not Analyzed at This Time

Analysis of Failed Telephone Line Surge Suppressors

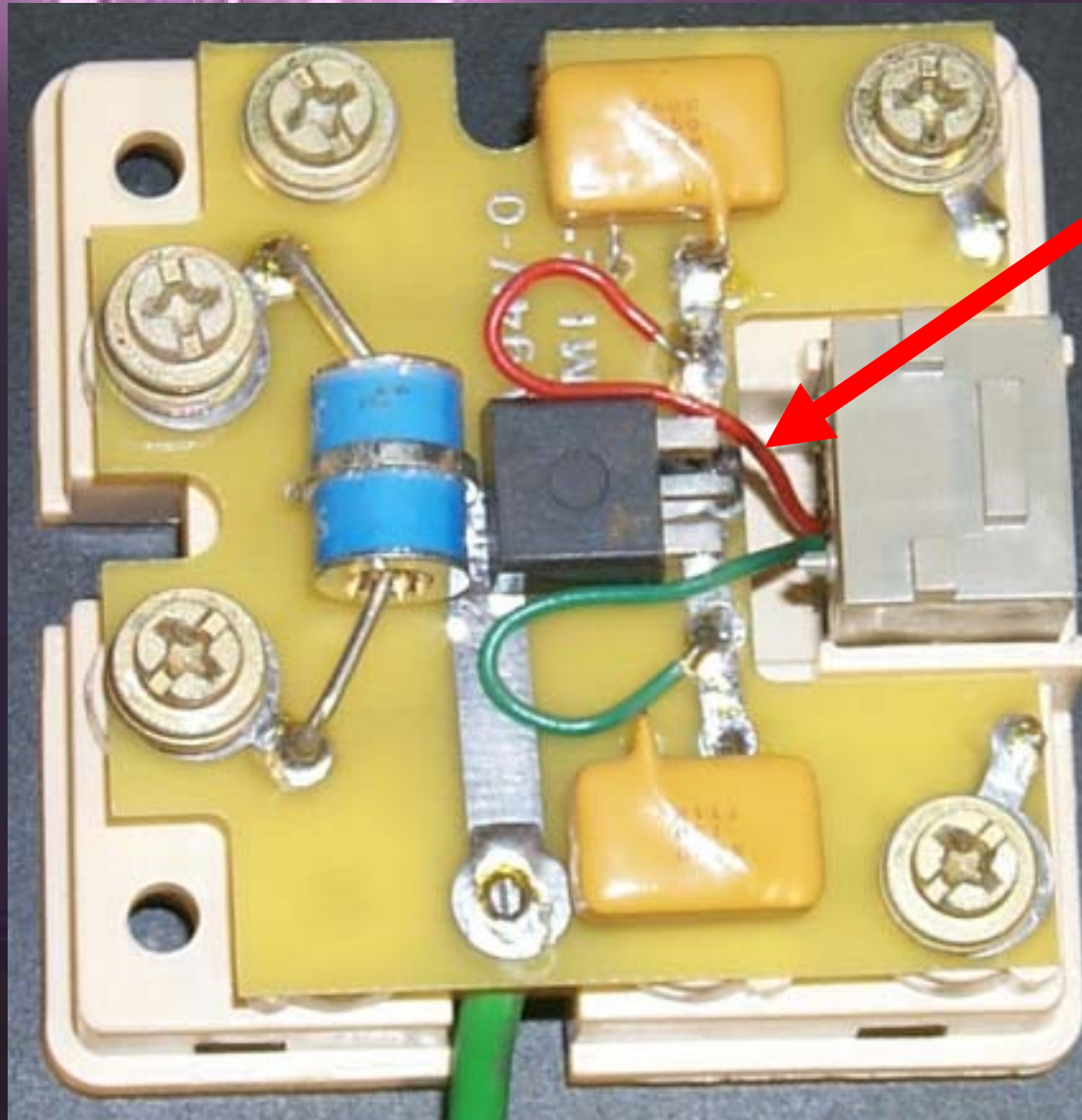


- Florida DOT Collected a Number of Failed Surge Suppressors
- Suppressors Analyzed Through
 - Visual Inspection
 - Component Testing
- Goal: Determine Mode of Failure

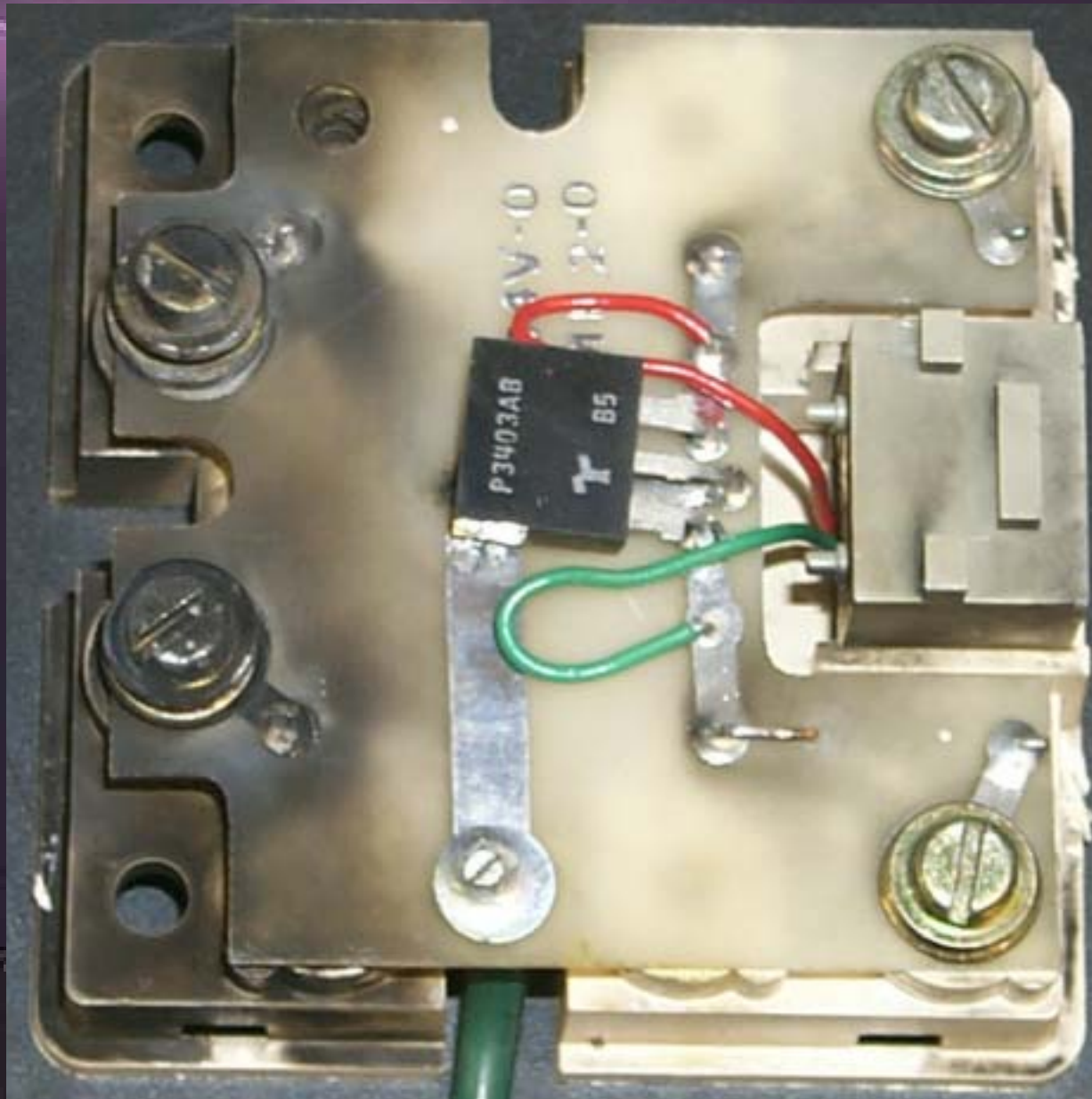
Typical Failed Surge Suppressor



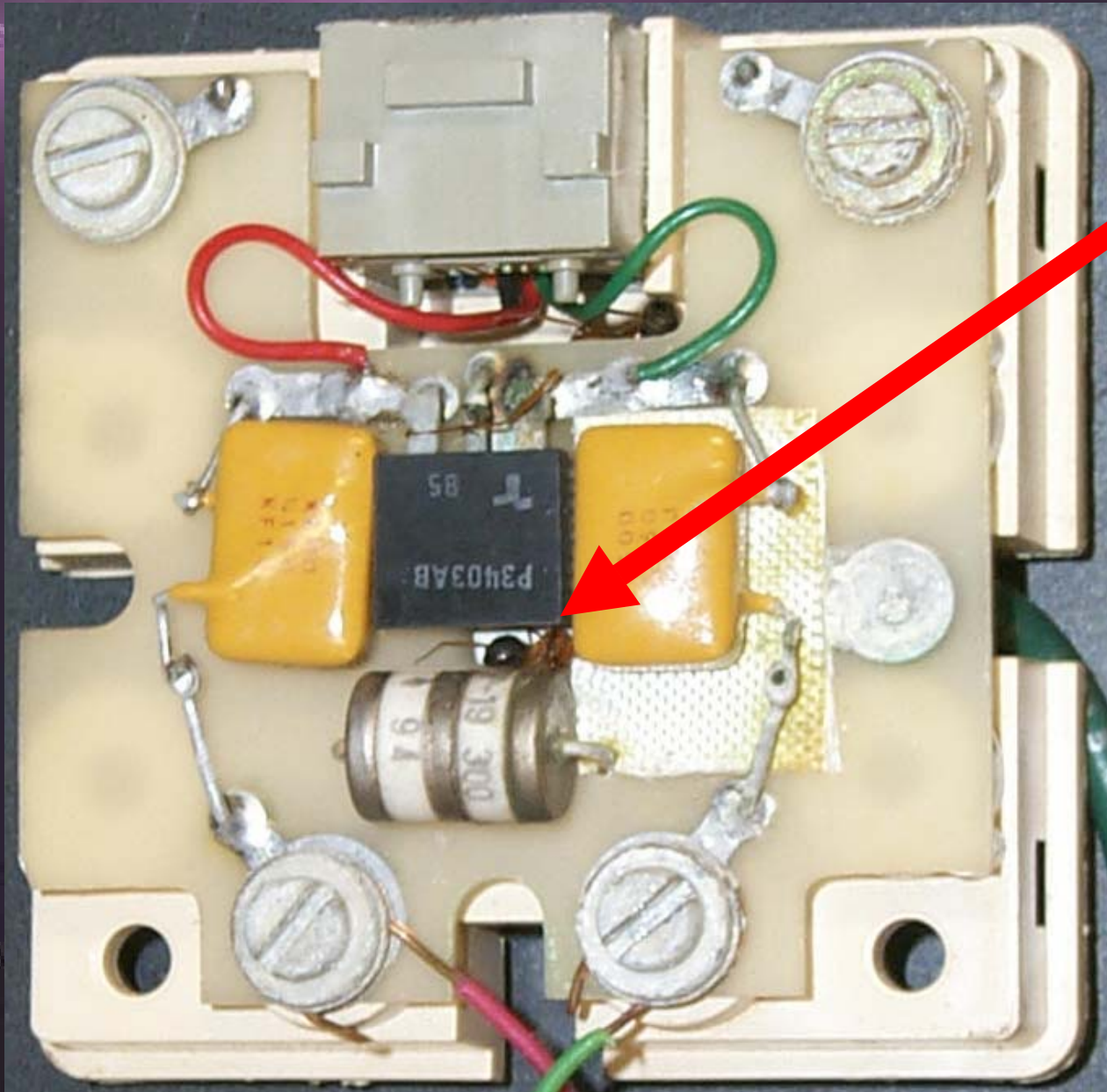
Typical Failed (?) Surge Suppressor



Atypical Failed Surge Suppressor



Other Surge Suppressor Hazards

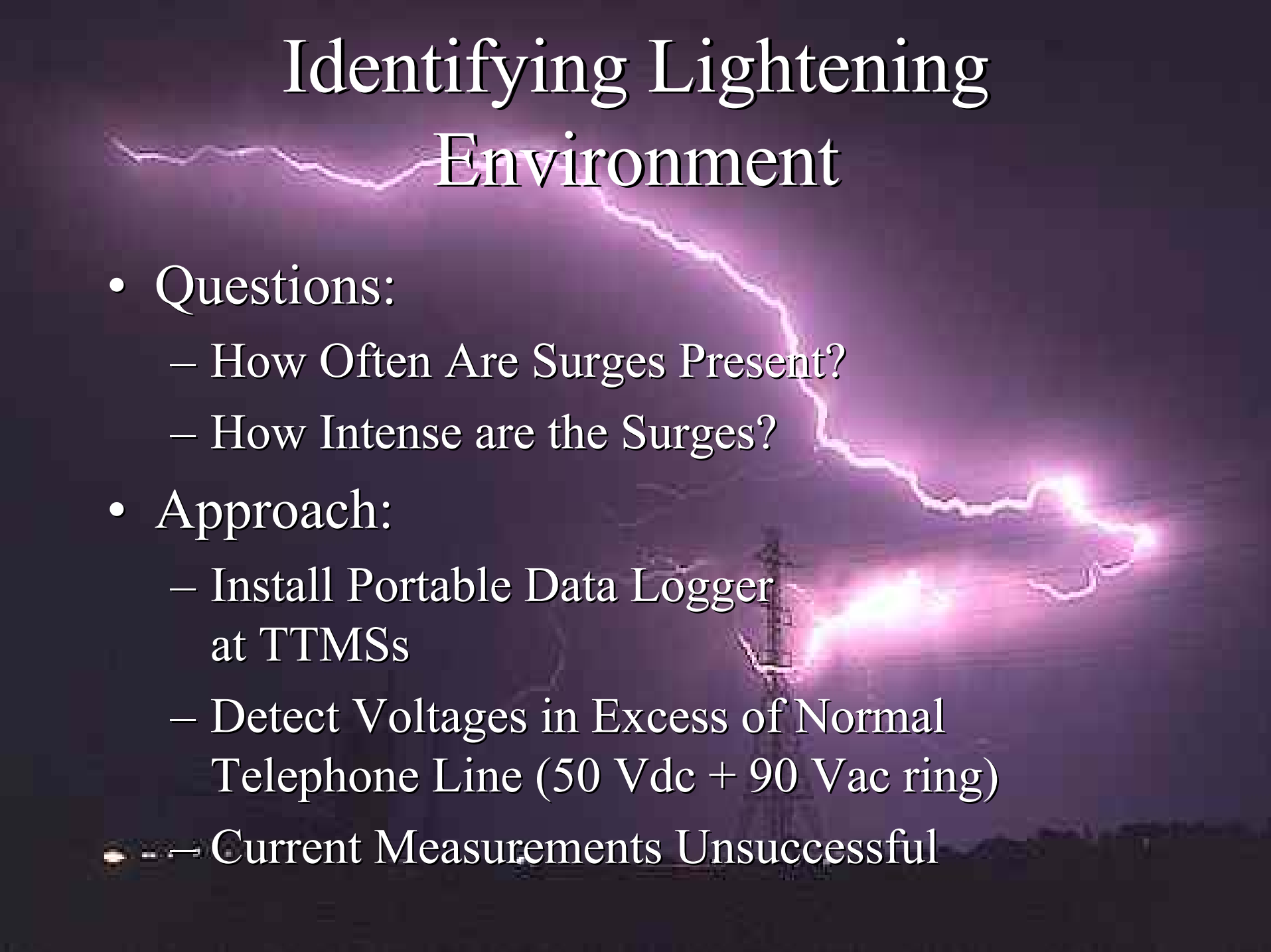


Analysis of Failed Surge Suppressors

The background of the slide features a dramatic lightning storm. A bright, jagged lightning bolt strikes from the upper left towards the center. In the lower right, another lightning bolt is visible, illuminating a power line tower. The sky is dark and filled with the glow of the lightning.

- Early Surge Suppressors had Fuses Blown
- Most Times the Blown Fuse was the Only Damage Noted (>75% Failures Due to Fuse)
- Occasionally Catastrophic Damage
- Newer Devices:
 - Gas Tubes – More Reliable than Fuses, Fast
 - Resettable Fuses – Slow, for Safety
 - Sidactor – Solid-State Voltage Limiter, Very Fast
Now the Likely “Weakest Link”
- None of the Newer “Failed” Suppressors Not Working

Identifying Lightning Environment

A dramatic night sky with a bright purple lightning bolt striking a utility tower. The lightning bolt is the central focus, with its jagged path leading from the top left towards the bottom right, where it strikes a tall, dark utility tower. The background is a dark, stormy sky with other faint lightning bolts visible in the distance. The overall color palette is dominated by deep purples, blues, and blacks, with the bright white and purple of the lightning providing a stark contrast.

- Questions:
 - How Often Are Surges Present?
 - How Intense are the Surges?
- Approach:
 - Install Portable Data Logger at TTMSs
 - Detect Voltages in Excess of Normal Telephone Line (50 Vdc + 90 Vac ring)
 - Current Measurements Unsuccessful

Equipment for Monitoring Surges

A dramatic night sky with a bright purple lightning bolt striking a power line tower. The lightning bolt is the central focus, with its energy radiating outwards. The power line tower is silhouetted against the dark sky, and the lightning bolt appears to be striking it. The overall scene is dark and atmospheric, with the purple light of the lightning providing the main source of illumination.

- MetraHit 29S Multimeter
 - Can Record Pulses $\geq 5 \mu\text{sec}$ and Over 200 V
 - Event Recorder to Store Events (Pulses) with Magnitude and Time/Date
 - Current Probe had Insufficient Magnitude for Pulse Detection
 - Sampling Rate (non-pulse) $\geq 5 \text{ msec}$ (too slow)
- 12V Battery and Voltage Regulators for Monitoring over 1 Week
- Installed at 3 TTMS Locations (2 successful)

Results of Surge Monitoring

- Site 245: Hwy 59 LLoyd, FL
 - Monitored for 37 days (6/28 to 8/3/2001)
 - Total Surges: 26 (9 ring surges)
 - Average: 0.7 per day
 - Peak: 9 Surges on 6/29/2001
- Site 192: Hwy 20 Youngstown (N. of Panama City)
 - Monitored for 92 days (7/3 to 10/2/2001) inc. T.S. Barry
 - Total Surges: 4460 (556 ring surges)
 - Average: 48.5 per day (6 ring surges)
 - Peak: 461 Surges on 8/16/2001
- Site 906: I-4 Deltona
 - Monitoring Problems (voltage dropouts): 2 successful days
 - Total 90 Surges (3 ring surges) all on 9/4/2001

Conclusions From Environmental Studies

- “Killer Surges” NOT the Most Troublesome
 - Newer Devices Rated to 10 kA typical
 - Older Devices Rated Much Lower
 - Consistent with Analysis of Failed Suppressors
- Problem Appears to be Frequency of Lightning Surges
 - Need Devices With Greater Endurance Rather Than Higher Peak Current Capability
 - **May Need More Resilient Solid-State Dev.**

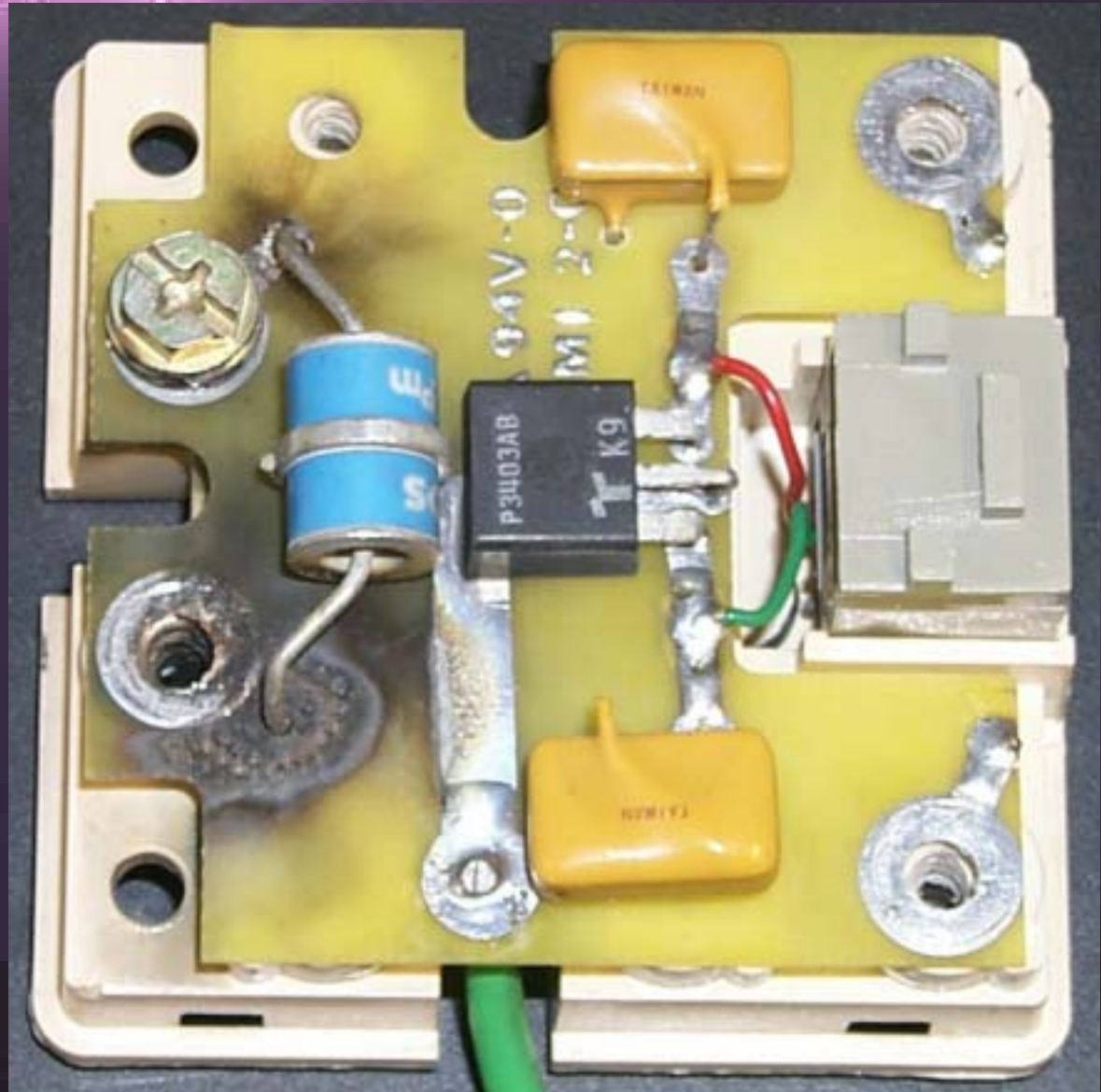
Surge Suppressor Lab Testing

A dramatic photograph of a lightning bolt striking a power line tower at night. The lightning is bright yellow and white, illuminating the dark sky and the tower. The background is a dark, stormy sky with other faint lightning bolts visible.

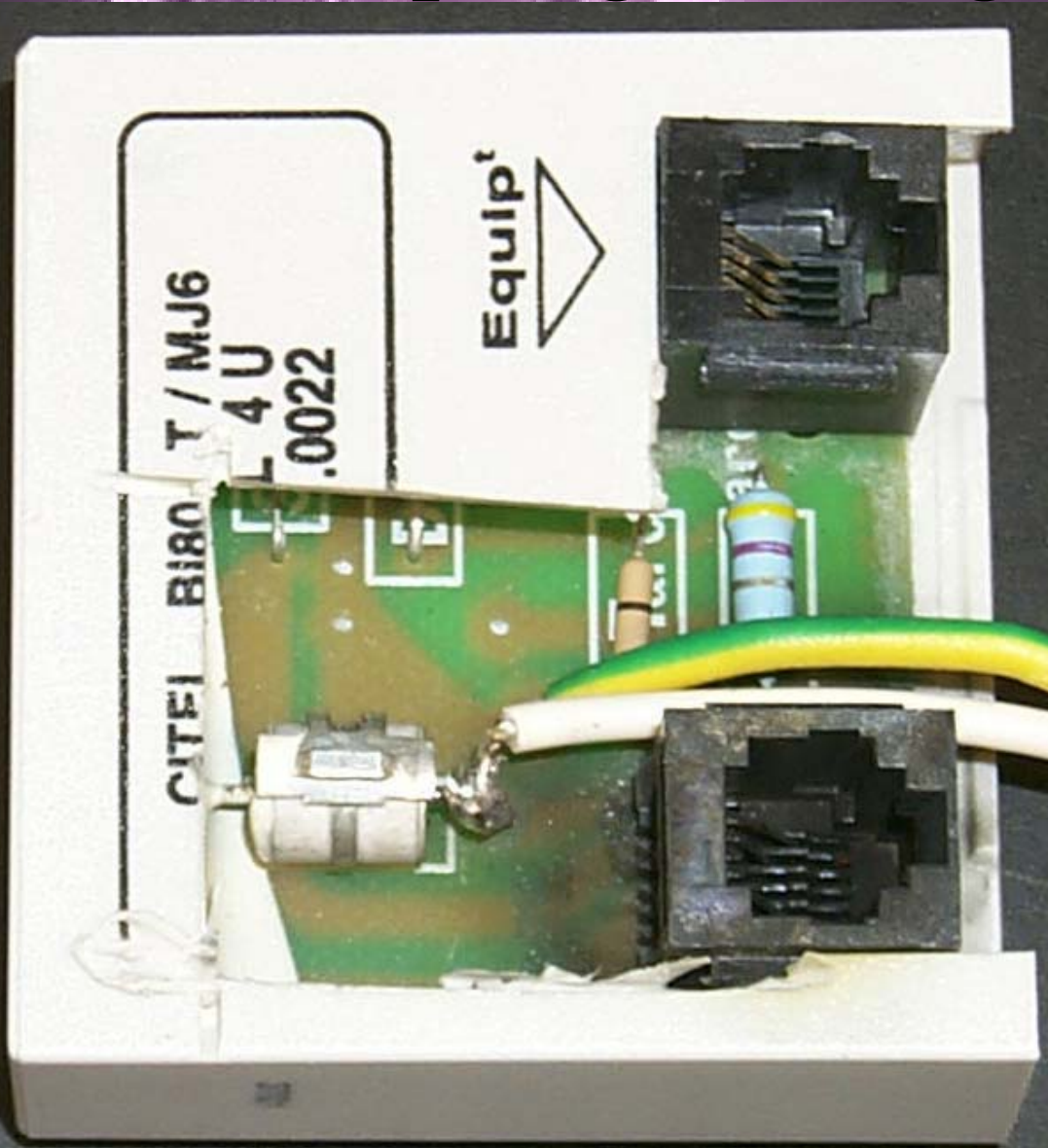
- Purchased Lightning Surge Generator
 - MIG 0606 (HV Technologies)
 - Impulse Current: 0.5 to 6 kA (8/20 μ sec)
- Purpose: Endurance Tests of Surge Suppressors
 - Repeated Surges at Various Current Levels
 - Identify Failure Modes
 - Verify Damage with Experiences in Field

Coupling of Surges Critical

- Wire Not Secured Tightly Between Washers
- Surges Destroyed Circuit Traces
- NOT Typical of Devices Failed in Field



Coupling of Surges Critical



- Surge Mode
 - Line-to-Line
 - Destroyed Connector
- NOT Typical of Field Experience

Ongoing Test of EDCO and Citel Surge Suppressors

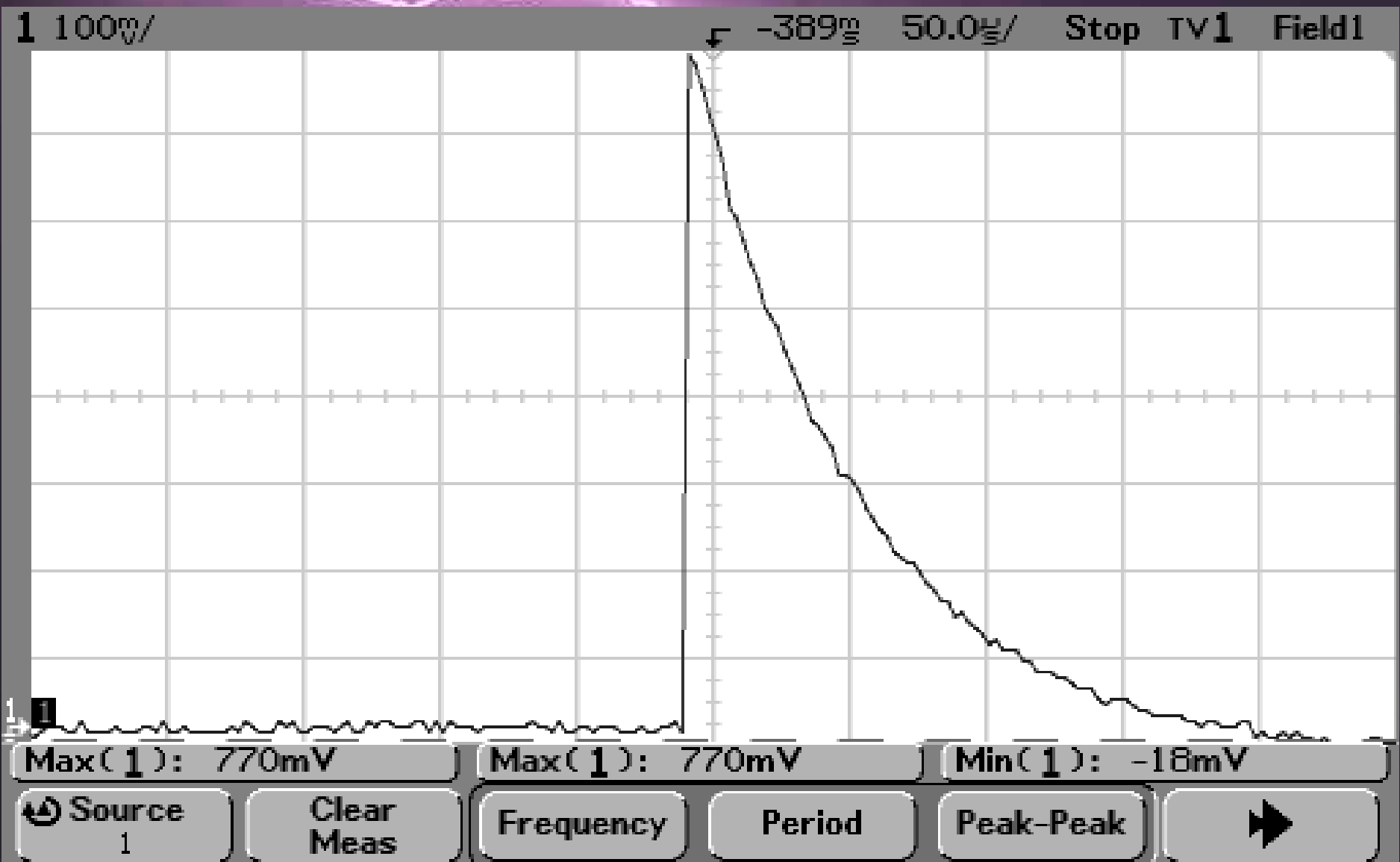
- Current Telephone Surge Suppressors Based on Gas Tubes with Supporting Electronics
- Much More Resilient to Surges (up to 10 kA)
- Multiple Surges from 500 A to 6 kA Have Been Applied ; None Have Failed
- Older (Fuse Based) Suppressors Had Catastrophic Failures at 6 kA
- Endurance Tests Not Yet Completed

Gas Tubes Very Resilient

- None Have Failed Even With Repeated 6 kA Surges
- One Gas Tube has been Subjected to Over 1000 Surges – STILL WORKS!
- Clamping Voltage $\geq 90V$ typically



1 kA Current Surge (1 V = 1 kA)



1 kV Voltage Surge (2V = 1 kV)



Undo
Autoscale

Conclusions

A dramatic night sky with a bright purple lightning bolt striking a power line tower. The lightning bolt is the central focus, with a bright white core and a purple glow. The power line tower is silhouetted against the dark sky. The background is a dark, stormy sky with some clouds.

- Surge Environment in Florida
 - High Number of Surges (poss. near 100/day)
 - Direct Strikes Unlikely and Impossible to Protect Against
- Surge Protectors Necessary to Protect More Expensive Equipment
 - Very Few Modems Damaged By Lightning
- Older Fuse-Based Suppressors Protect Well, But Require Replacement Often (\$\$\$)

Conclusions & Recommendations



- Telephone Line Surge Suppressors Should Use Gas Tubes as Primary Protection
- Current Rating of 10 kA is Sufficient
- High Endurance Chosen Over Current Rating
 - Over 100 Strikes at 5-10 kA
 - Over 1000 Strikes at ~1 kA

Future Work



- Continuing Endurance Tests on EDCO and Citel Surge Suppressors
- Other Suppressors with Higher Endurance Ratings Possibly Added
- Decide on Specification for FDOT
- Investigate Lower Voltage Suppressors for Loops and Piezo Sensors
 - Gas Tubes Likely Not Useful