

# The Affects of AC Transients and Lightning GPR on Remotely Powered, Remote Electronic (HSI) Equipment



Presented by:

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**The Affects of AC Transients and Lightning GPR on Remotely Powered  
Remote Electronic (HSI) Equipment.  
(Television broadcast over high speed internet)**



“Don’t mess with my TV!”

# Real-World Protection for Remote Power Feeding Telecommunications-

## Safety vs. Performance

John E. Fuller

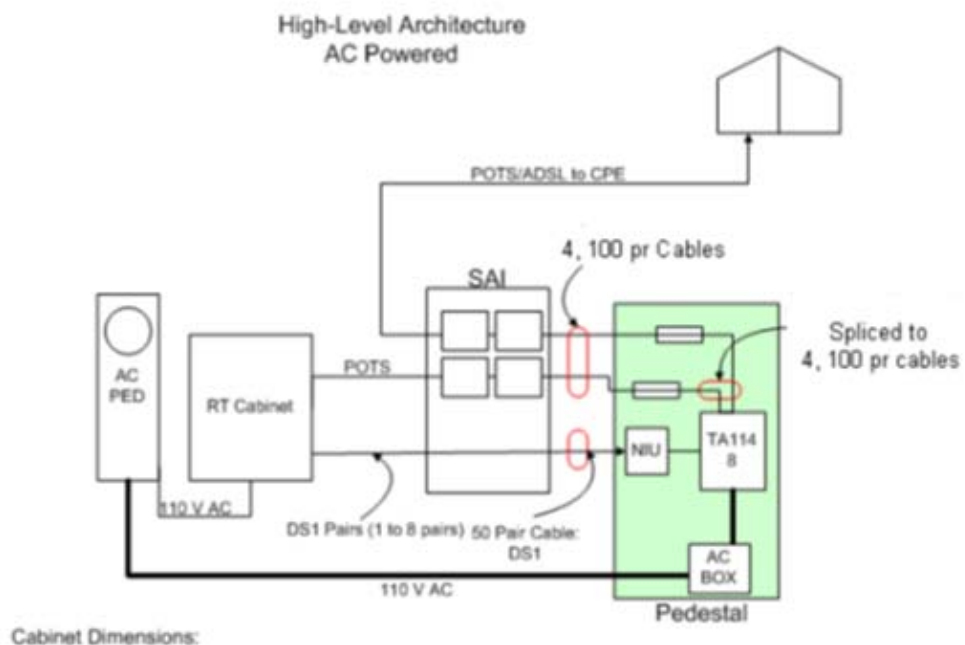
AT&T Common Systems Standards  
(see last page for contact info)

ATIS- Protection Engineer's Group  
March 17, 2011

Different story, same results.



# Standard Installation with commercial power supply.

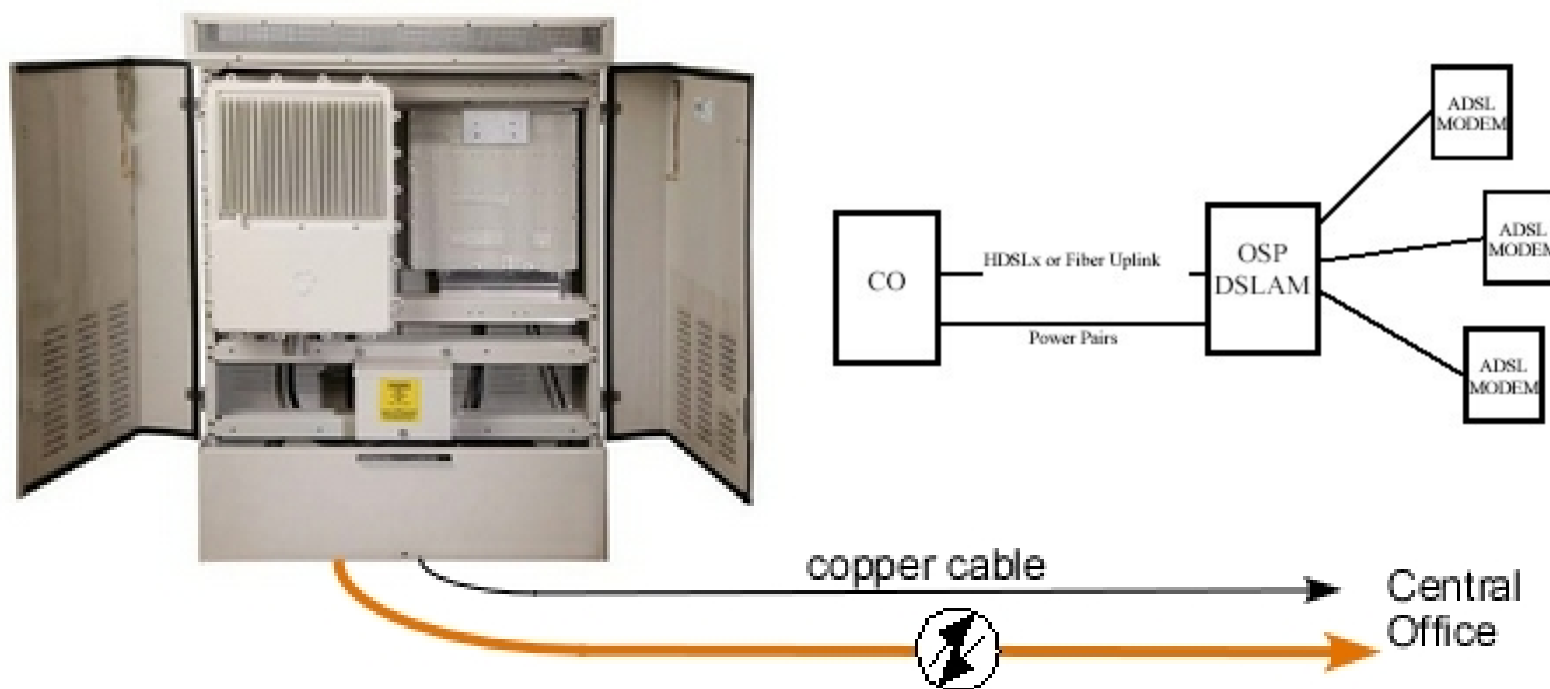


## Standard Installation with commercial power supply.

Standard site installation with commercial AC power. The broad band equipment is located in the enclosure located behind the commercial power meter assembly.

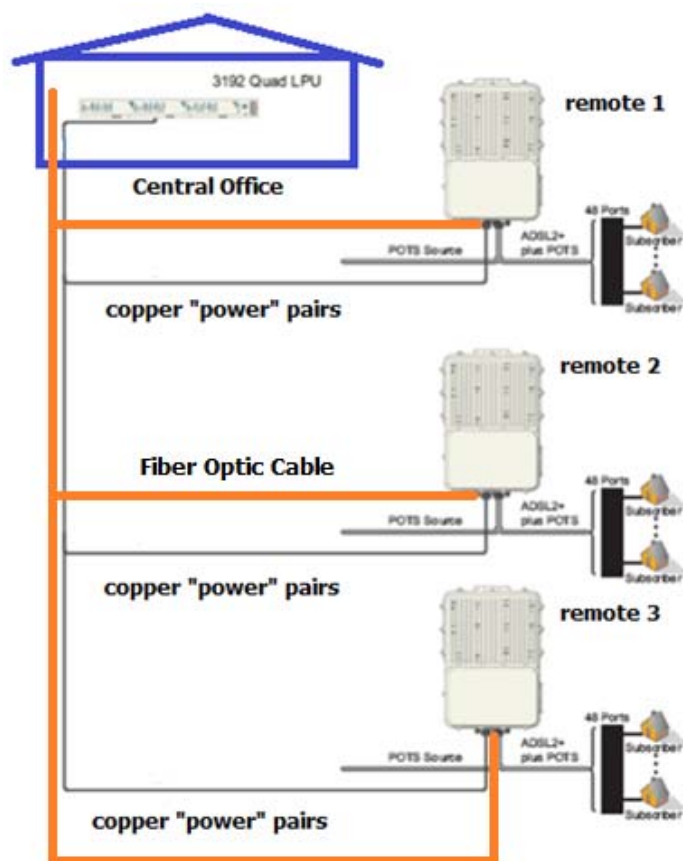


Installation with Central Office based power supply utilizing “power pairs” in the copper telecommunication cable



## Installation with Central Office based power supply utilizing “power pairs” in the copper telecommunication cable

Here is a typical layout of multiple remotes powered from the Quad- Line Power Units (LPU) located in a Central Office. HSI Bandwidth is provisioned over fiber optic cables.

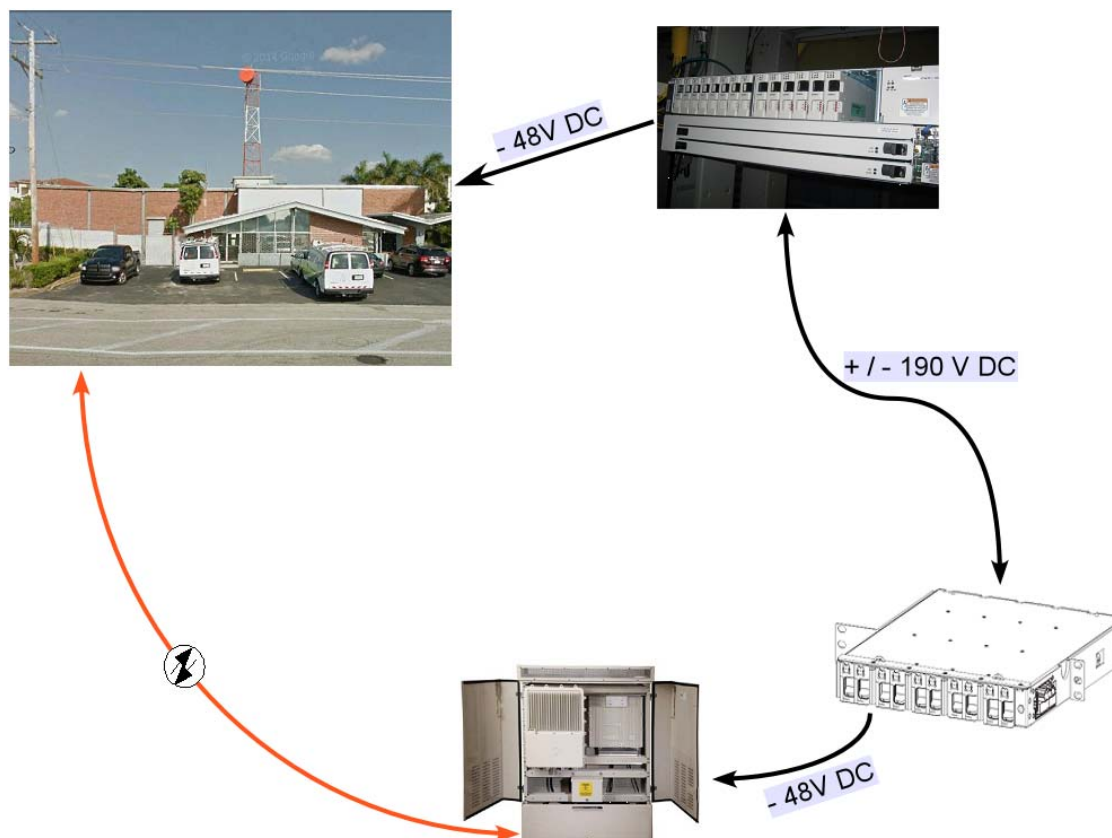




## Installation with Central Office based power supply utilizing “power pairs” in the copper telecommunication cable. Option 2

In this format, additional equipment is installed at the remote electronic equipment that converts  $\pm 140/\pm 190$  V DC to  $-48$  V DC.

HSI Bandwidth is provisioned over fiber optic cables.





## Line Powering

### The Limitations of Copper cable.

Will I Need a Ground Fault Circuit Interrupter (GFCI)?

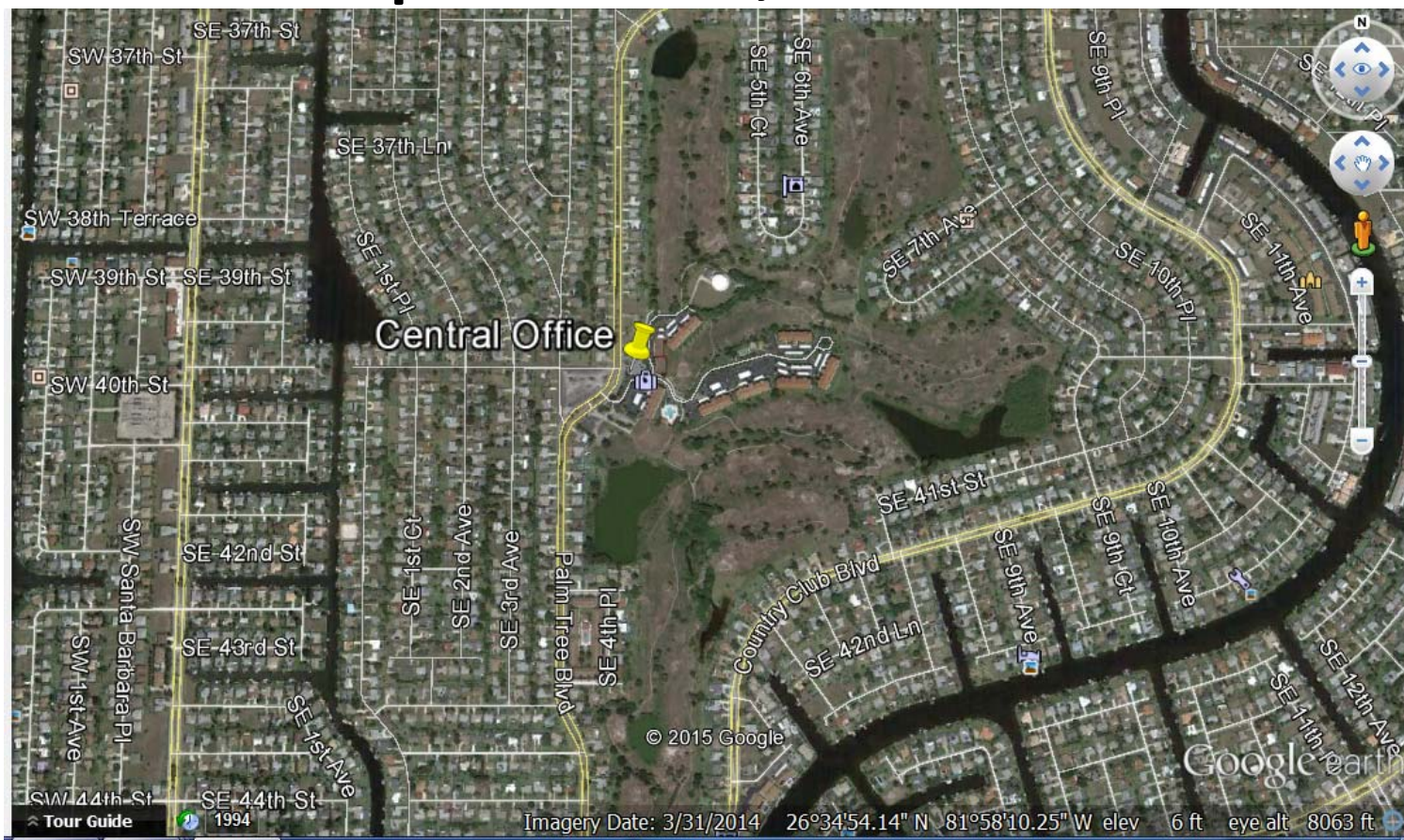
- Telecommunications networks have a long history of using line powering for various tasks, such as T-1 repeater powering, HDSL remote unit powering, FTTC powering, etc. Line powering remains popular for existing and emerging technologies because it doesn't require placement of power company meters, rectifiers, and batteries at remote locations.
- Line-powering voltages commonly found in the industry and addressed by Telcordia NEBS document GR-1089, ITU-T recommendation K.50, and UL Standards 60950-1 and 60950-21 are less than 200 V with respect to ground (e.g., nominal -48 VDC, -130, -190,  $\pm 130$ ,  $\pm 190$ , etc.).
- In addition, there are maximum power and current limits in the NEC and NESC; maximum voltage, power, and current limits in ANSI/ATIS-0600337; and additional electrical protection information for line-powering schemes in ANSI/ATIS-0600332.

## Line Power vs. Local AC Power

### The Economic Factors

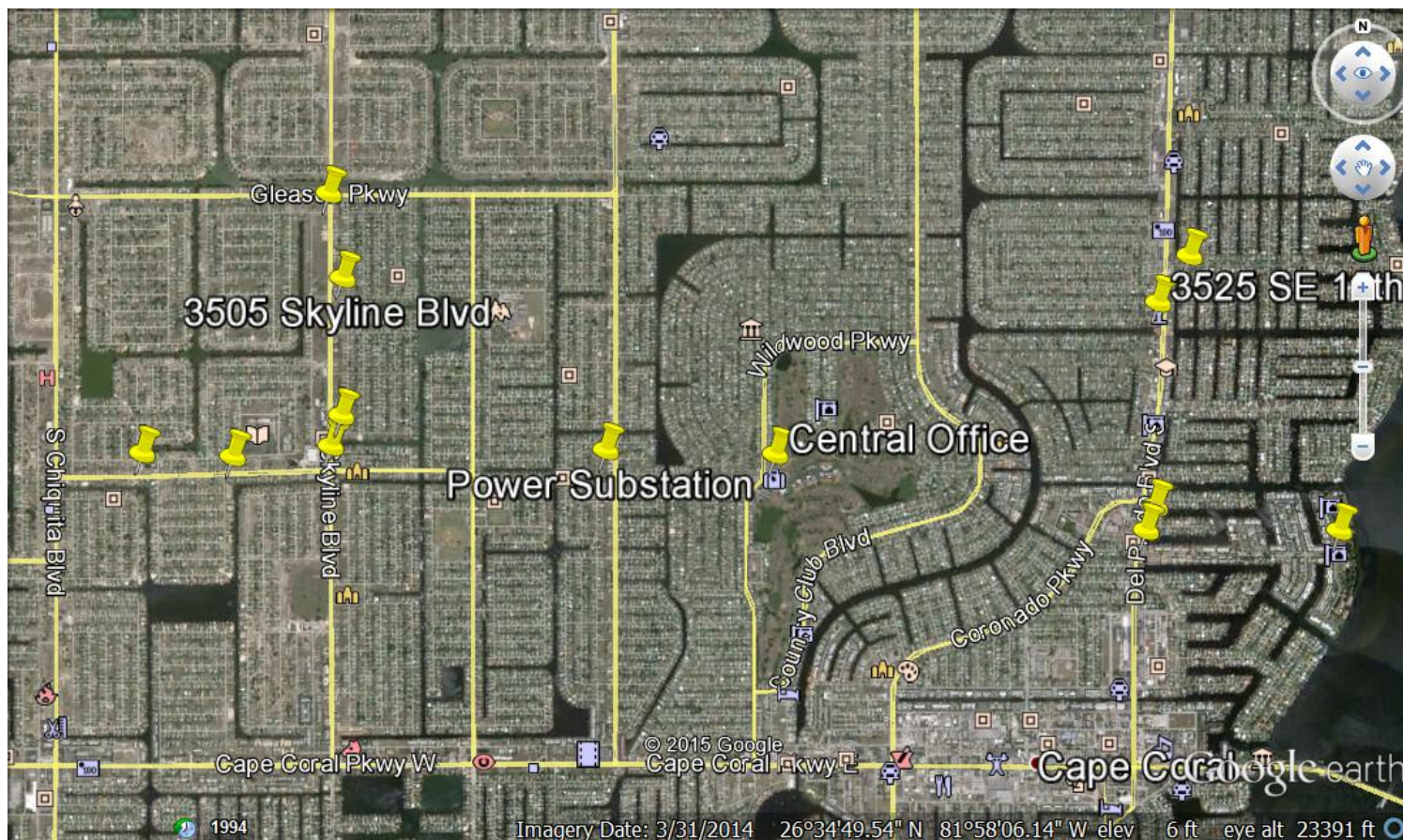
- Installing a commercial AC power supply to power remote broadband equipment can cost approximately \$5K per site. (not including battery back-up)
- Installing equipment for Central Office based line powering, depending on configurations, can cost \$2K to \$3K per site.
- In 100 sites, this can save \$200K to \$300K.

# Cape Coral, Florida





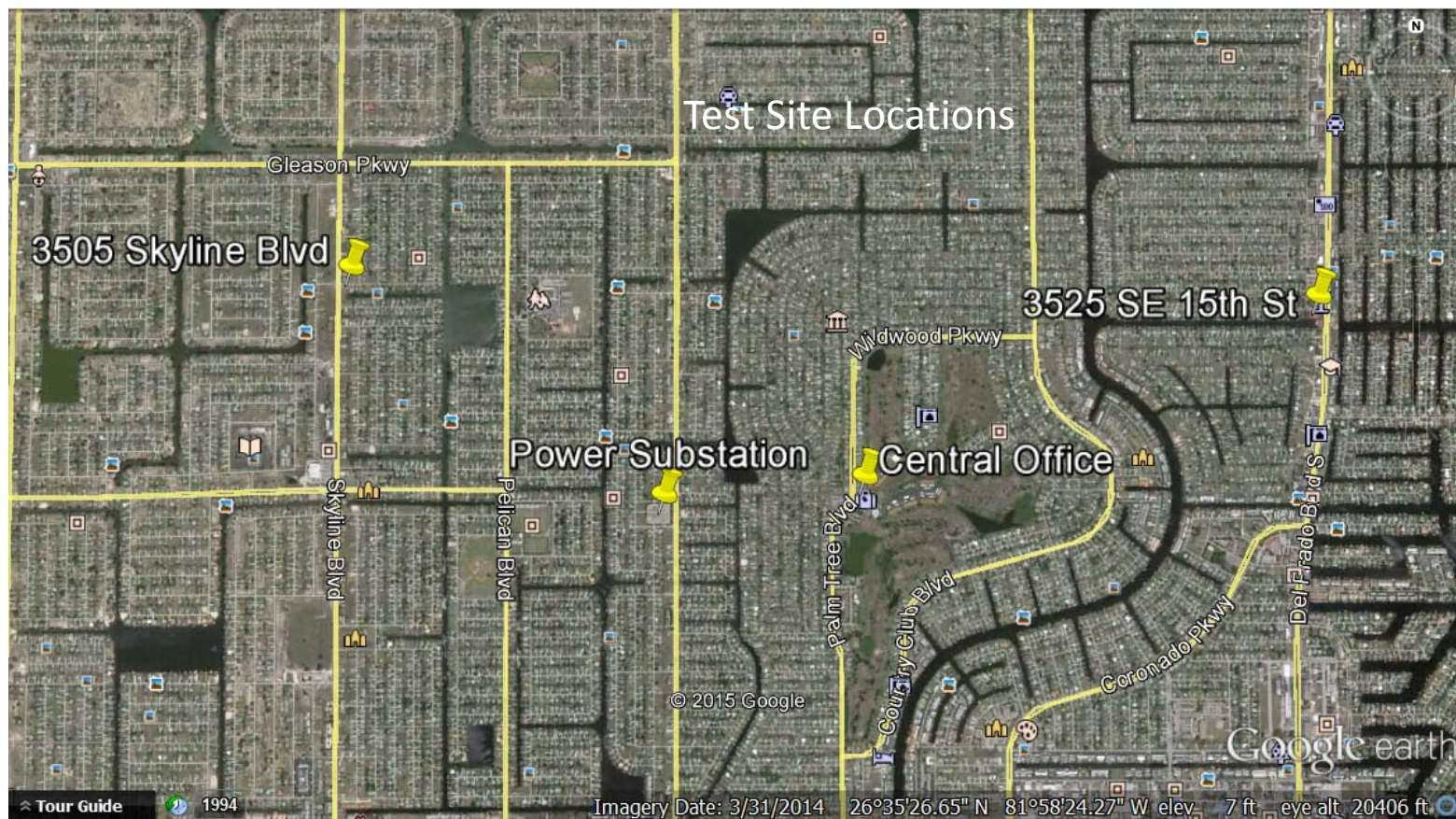
# Cape Coral, Florida



Analyzing issues made more complex by diversity of site locations



# Cape Coral, Florida



## Maintenance History

- Cable pairs where tested for insulation quality
- Cable pairs where spliced using single conductor splices and tagged as “power pair”
- Cable shield continuity was checked and bonds to additional low impedance ground sources were established. (MGN, manhole grounding system etc.)

# Data Collection

- TID: CAPECORAL-LPU-1 Total Access System 08/20/12 11:02
- Unacknowledged Alarms: MAJOR Unit Number: 1

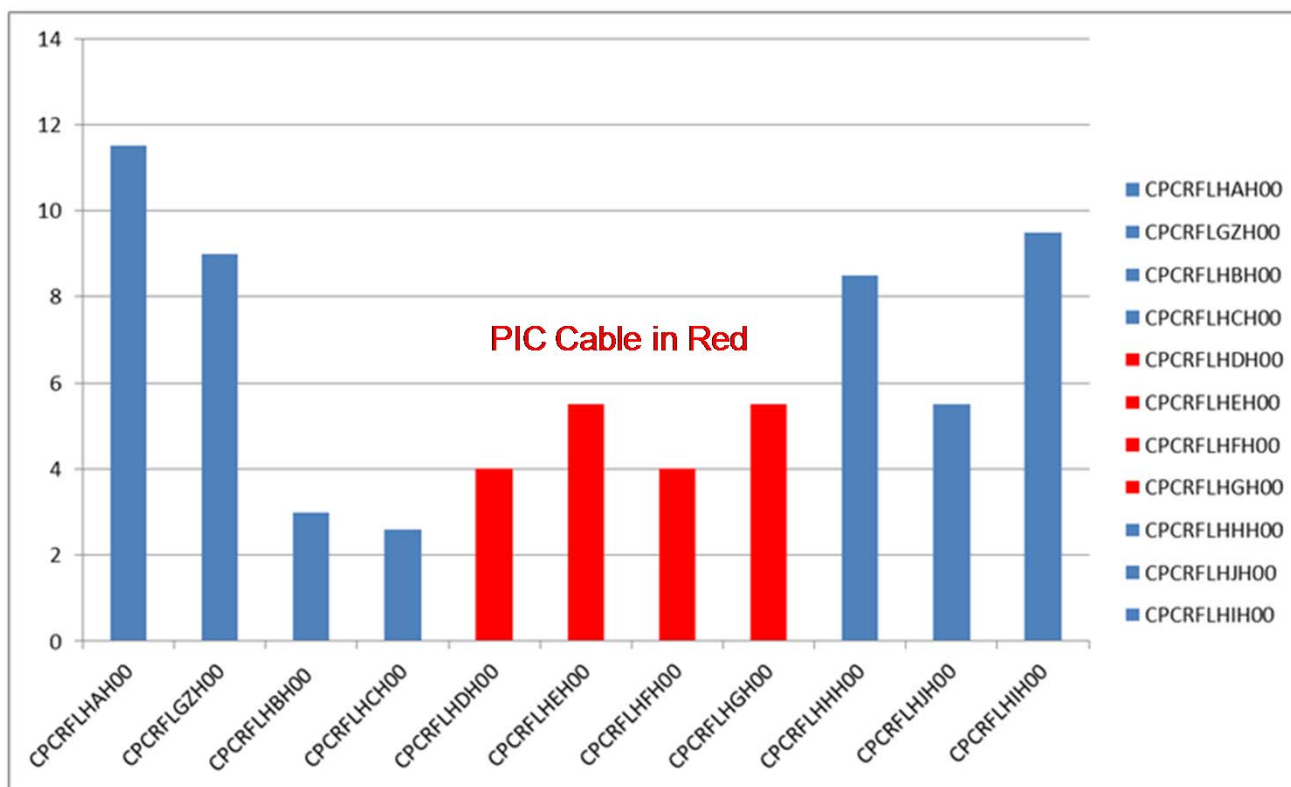
- Alarm Log - Master Alarms Alarms 1 to 14 of 82 Page 1 of 6

Date	Time	Pos	Type	Port	Level	Description	Status
08/16/12	11:26:38	11	LPU	Power	Major	Ground Fault	*Cleared
08/16/12	11:26:30	11	LPU	Power	Major	Ground Fault	*Active
08/14/12	04:18:27	03	LPU	Power	Major	Ground Fault	*Cleared
08/14/12	04:18:20	03	LPU	Power	Major	Ground Fault	*Active
08/14/12	04:18:17	03	LPU	Power	Major	Ground Fault	*Cleared
08/14/12	04:18:07	03	LPU	Power	Major	Ground Fault	*Active
08/14/12	04:17:16	03	LPU	Power	Major	Ground Fault	*Cleared
08/14/12	04:17:07	03	LPU	Power	Major	Ground Fault	*Active
08/14/12	04:16:16	03	LPU	Power	Major	Ground Fault	*Cleared
08/14/12	04:16:08	03	LPU	Power	Major	Ground Fault	*Active
08/14/12	04:15:33	03	LPU	Power	Major	Ground Fault	*Cleared
08/14/12	04:15:26	03	LPU	Power	Major	Ground Fault	*Active
08/10/12	02:54:18	05	LPU	Power	Major	Ground Fault	*Cleared
08/10/12	02:54:18	03	LPU	Power	Major	Ground Fault	*Cleared

## Alarm History



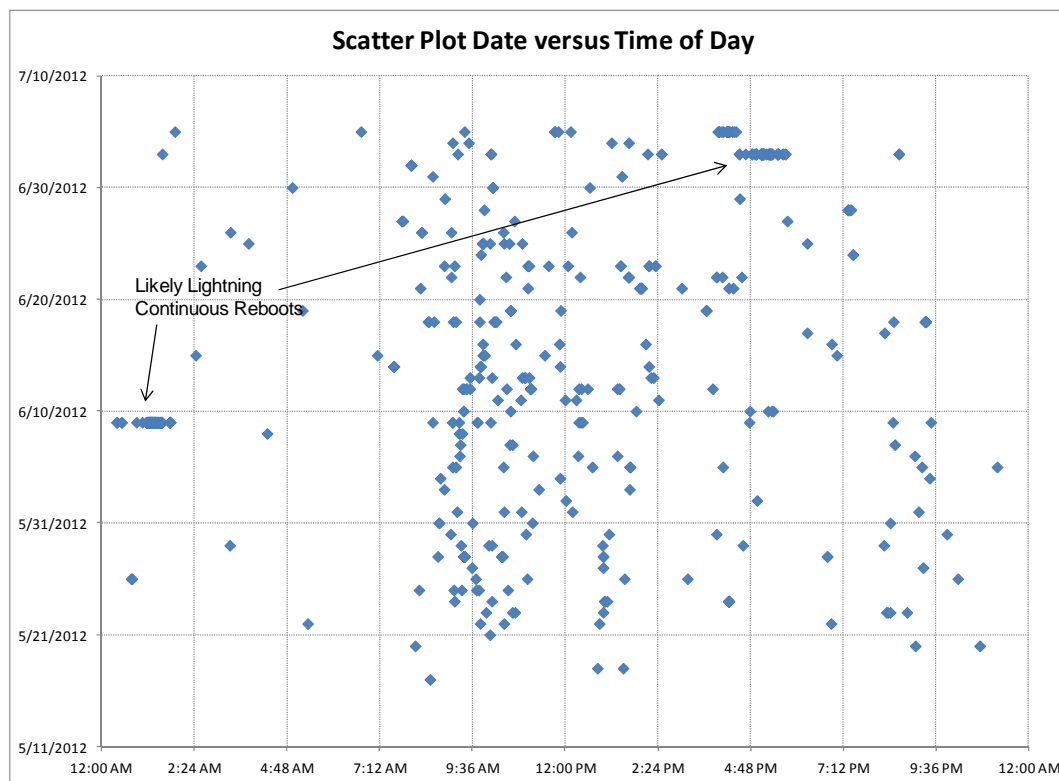
# Data Collection



PIC and PULP Cable powering pair reboot frequency for 1 month

# Data Collection

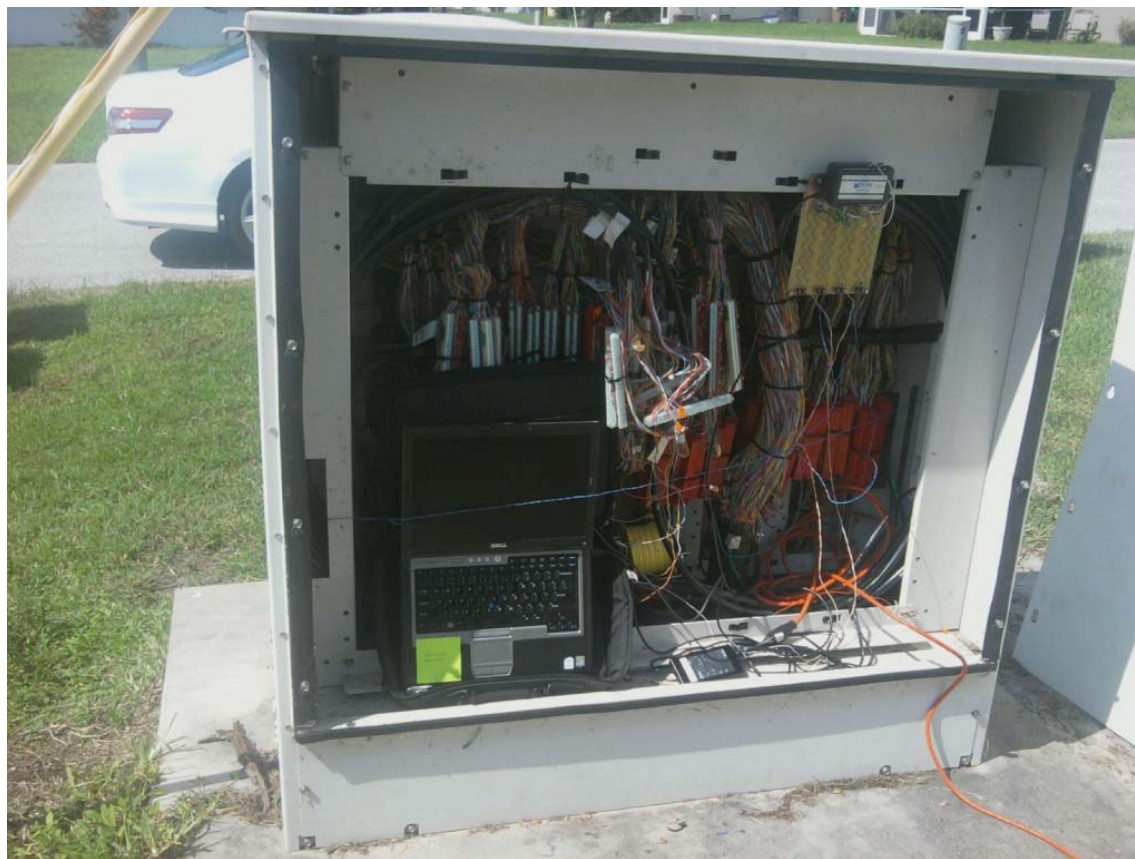
The initial field assessment that was that the events were random throughout the day. This was challenged by plotting the date versus time of day which clearly identified lightning related reboots as well as a strong correlation of reboots to daytime hours. The heavy lightning events of 3 separate days dominated the total amount of reboot events vs. day.



Time of Day scatter plots with all activity (with likely lightning activity)

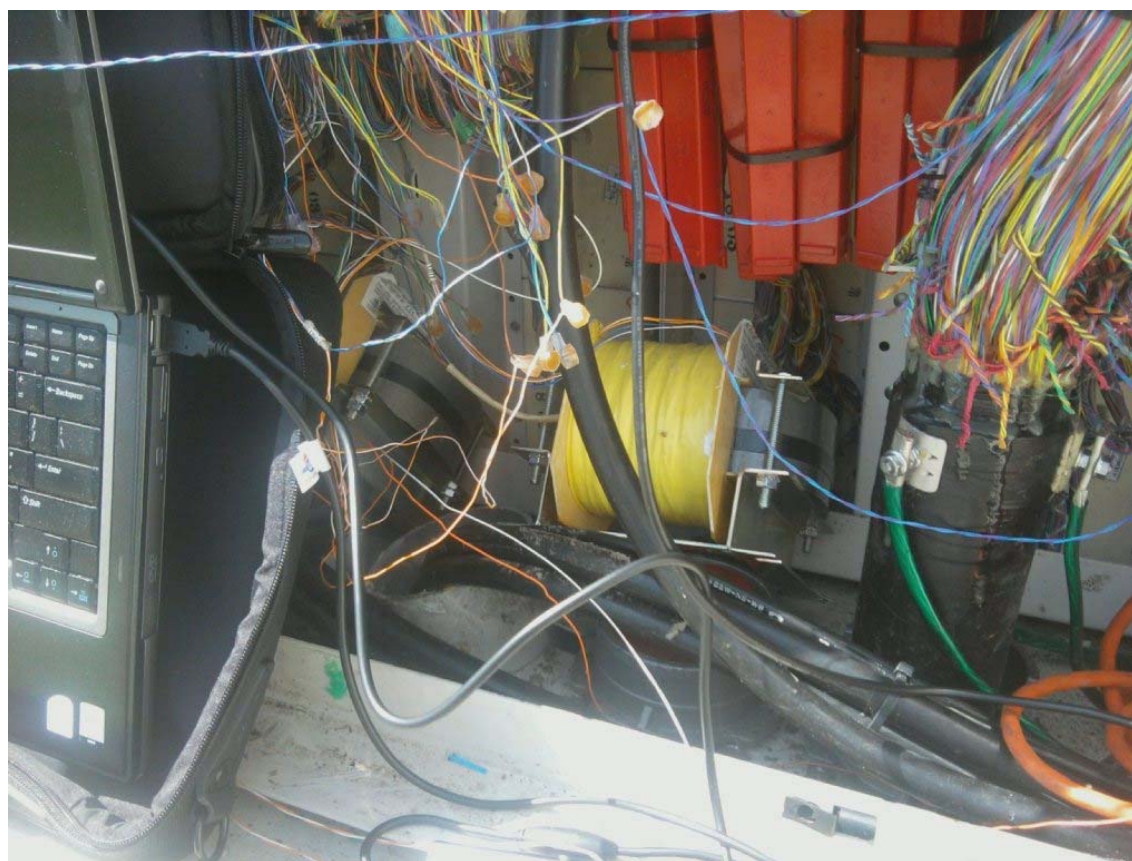
# Data Collection

Field collecting “real time” data of AC voltage anomalies on DC power pairs using a purpose built circuit board with a commercial data acquisition device.



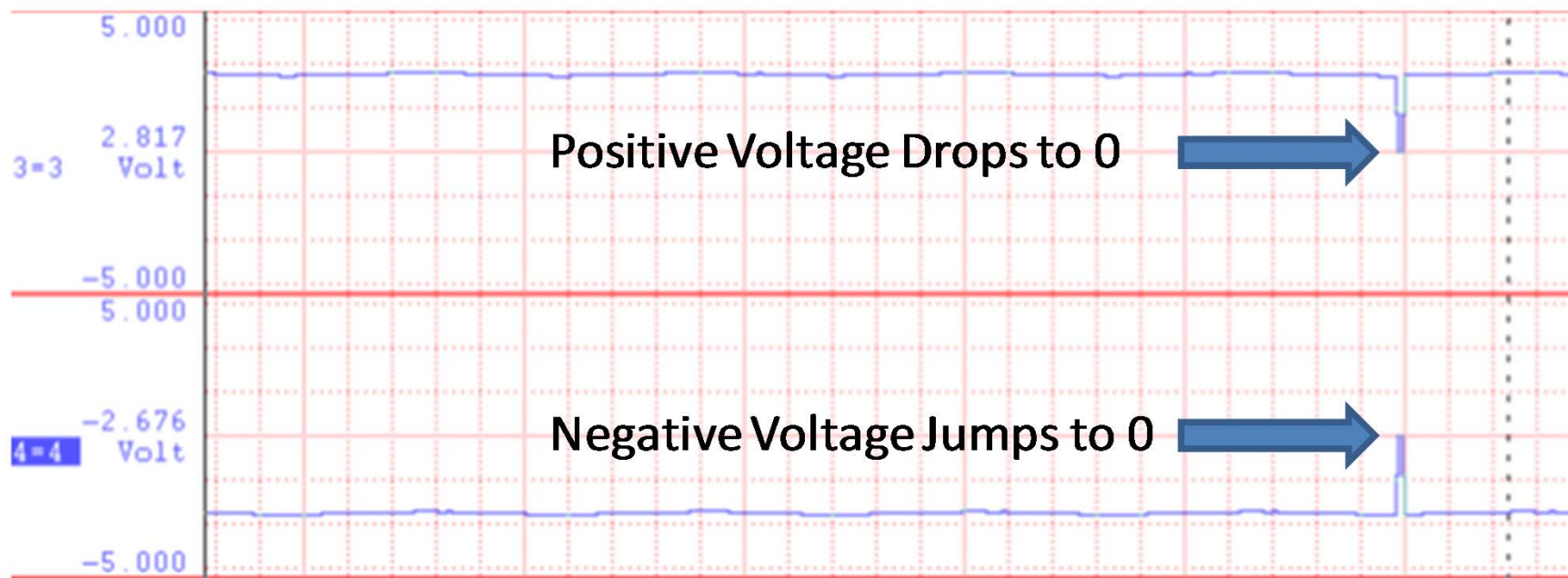
# Data Collection

For testing purposes, one of the monitored power pairs was wired through an induction neutralizing transformer. Monitors were left in place for 12+ hours.





# Data Collection Results



One of the data acquisition devices captured a few millisecond voltage transient event which appears to be representative of the powering related issues in the area. This particular data capture was on a powering pair at the Skyline (west) location and appears as a common mode event. This transient was too fast to trip the GFCI due to the low pass filtering on the GFCI detector input.

# Cause and Affect



Primary protectors  
It's not about color



Classic telephone company employees tend to look at the world as color coded. "Should we use the "blue" one or the "red" one?"

# Cause and Affect

Technicians were instructed to look at the model number, not the color of the primary protectors to determine the correct protection for this application.



Primary protectors



Primary protection devices deployed in Cape Coral were changed from the fast response hybrid protection device to the slower reacting “gas tube only” protectors which were recommended by the equipment manufacturer.

**NOTE:** It appears that these slower reacting protection devices improved on the relative frequency of the induced power transient caused GFCI “trips”.



# Cause and Affect

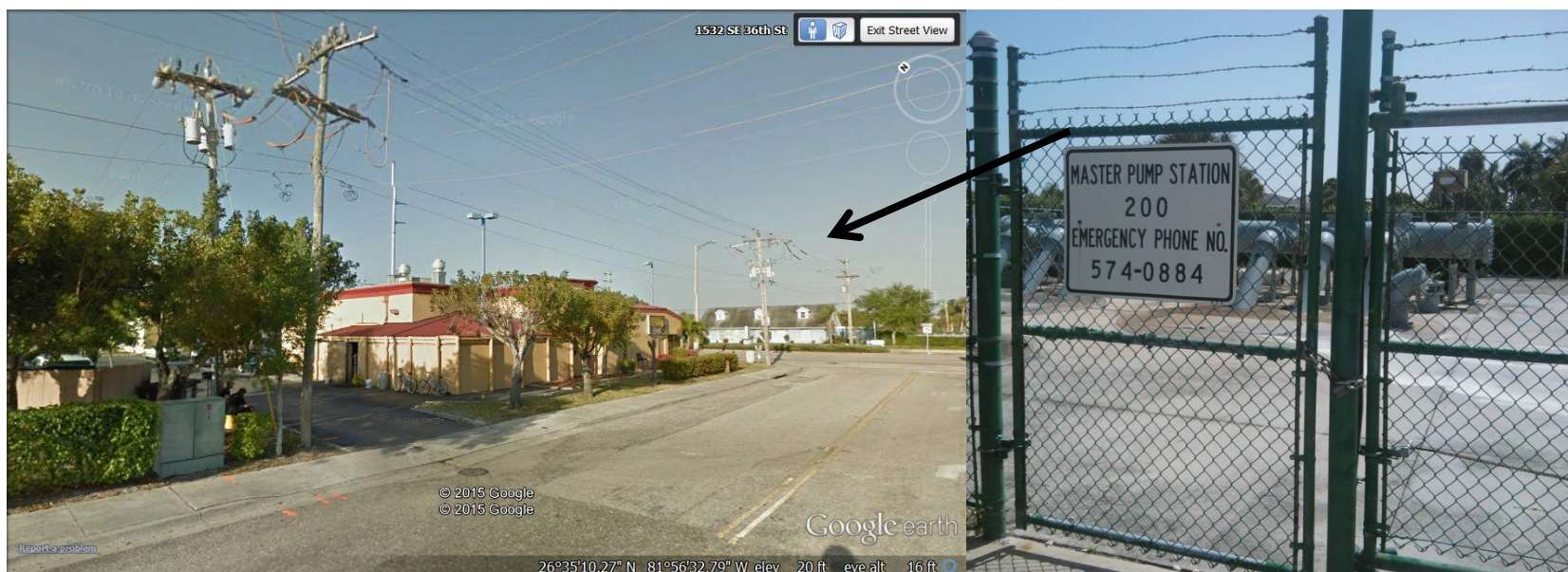
## Substation ground potential rise (GPR)

The GPR voltages and zone of influence (ZOI) were calculated using the electrical data (X/R ratio, total earth return current, ground grid impedance to remote earth and grid size) provided by the local power company. GPR calculated voltages ranged from 1554V AC RMS to 4098V AC peak asymmetrical with a ZOI of 425 feet. The affects of any line to ground fault produced GPR at this substation on the copper telecommunications cable in close proximity would be minimal.



# Cause and Affect

## Other Possible factors



There is an Industrial pump station located in close proximity to several remote sites. “Could the pump cycling create large transients in the commercial AC system?”

# Cause and Affect

## Other Possible factors

The local power company uses capacitor banks through out their distribution system. During periods of high lightning activity, a large number of these banks had blown fuses on one or two of the phase wires. This would have created a large system imbalance during periods of high loads in the AC distribution system. The unbalance not only increases the total amount of AC voltage induced into the copper communication cables in parallel, it may also add to the affects of any transients induced into the cables as well.





# Summary

- The use of line powering is a cost affective method for powering certain types of remote equipment.
- Engineering must take into account not only the physical cable plant make up but also the environmental factors that may influence the over all remote power system.
- Installation and maintenance work forces should be trained and properly equipped with the correct procedures and materials to install and maintain the line power system.
- High lightning areas such as Florida may not be well suited for line powering technology unless additional steps are taken to enhance the power system to mitigate a loss of power during a GFCI caused power failure.

# Questions?