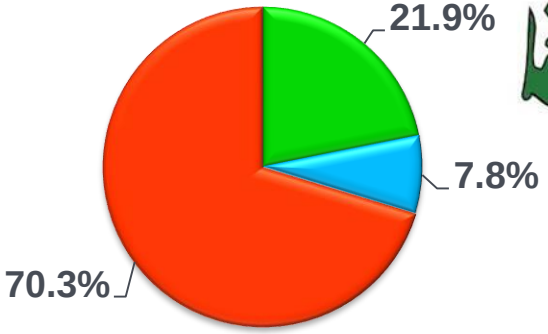
Time Delay Technique for Pinpointing PD Noise on Combined Cycle Systems

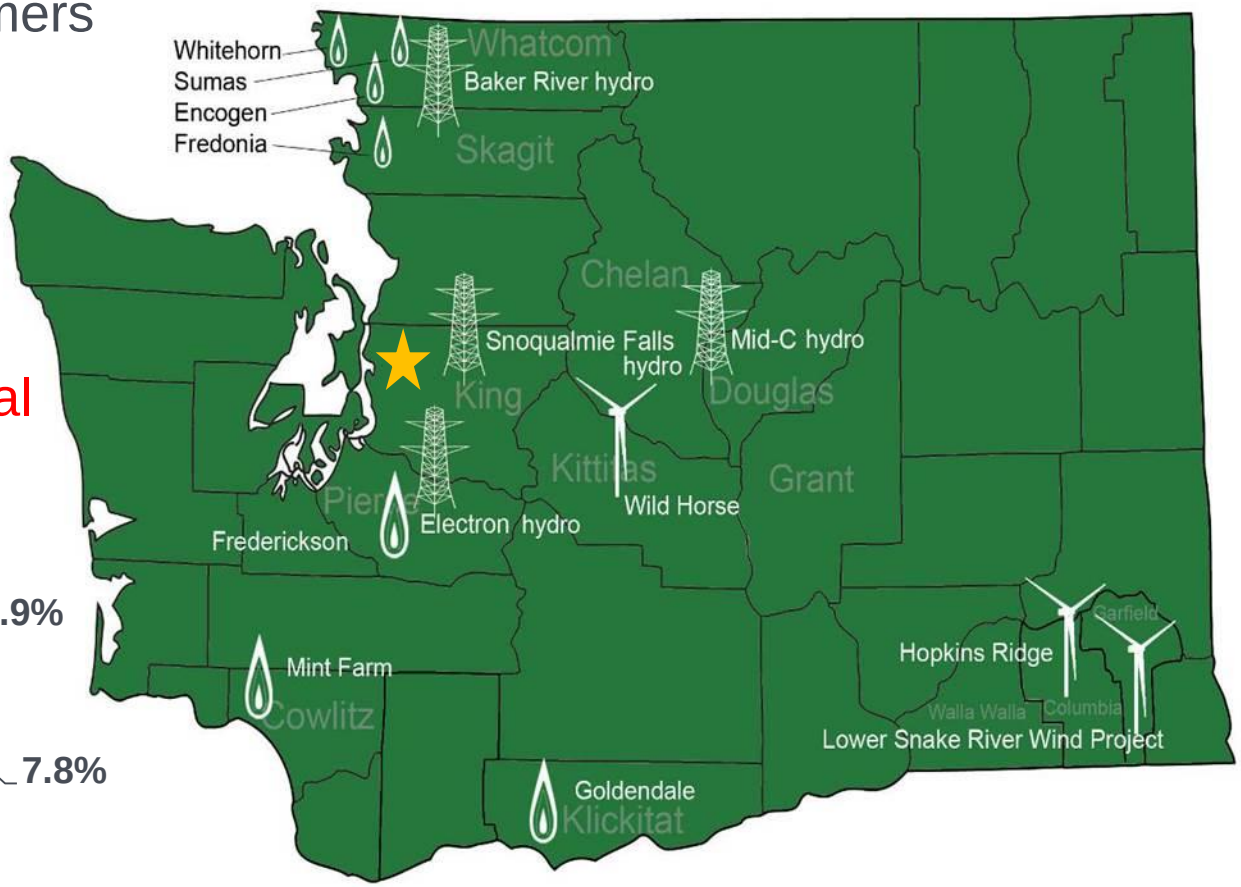
Troy Coleman, Plant Technical Services

PSE PUGET SOUND ENERGY

Puget Sound Energy

- >1 Million Customers
- 772 MW Wind
  - 3 Farms
- 276 MW Hydro
  - 2 Projects
- 2481 MW Thermal
  - 11 Sites
- 3529 MW Total

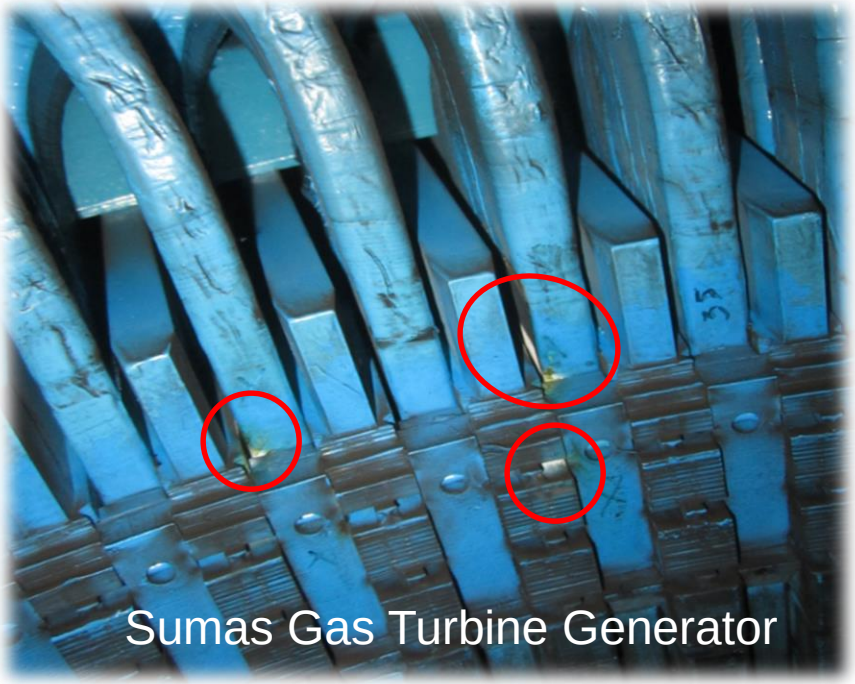


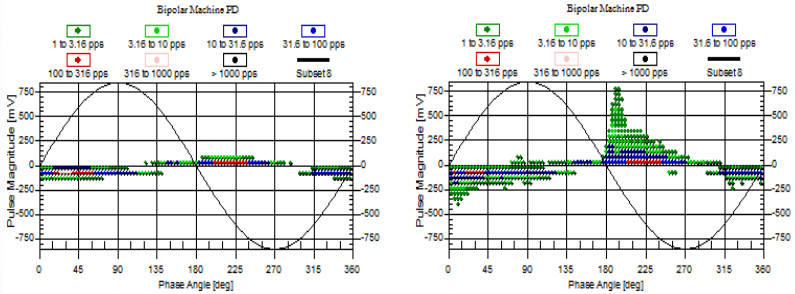


PUGET SOUND ENERGY

Generator Stator Partial Discharge

- Record data every 6 months → TGA-BP
- Pulse Qm (Magnitude) and NQN (Quantity)
- Check for changes in PD over time
- Doubling of PD in 6 months → Severe





PUGET SOUND ENERGY

Goldendale, 1:1 Combined Cycle

GE 7FA Gas Turbine

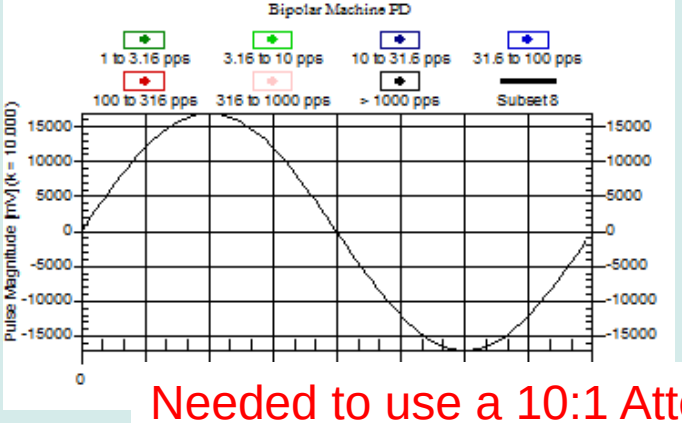
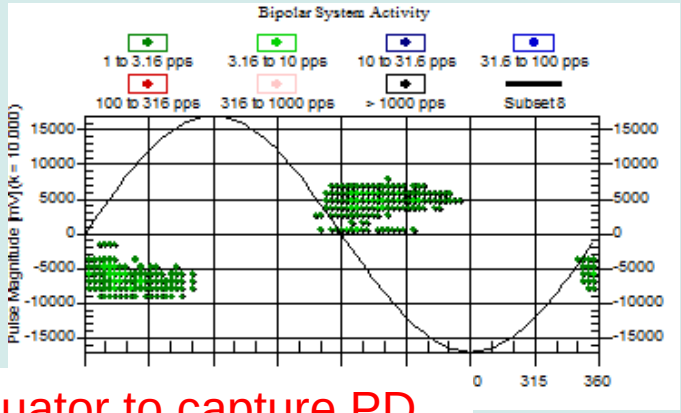
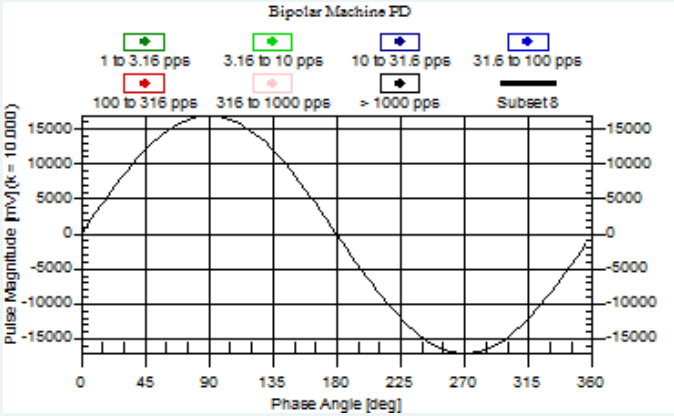
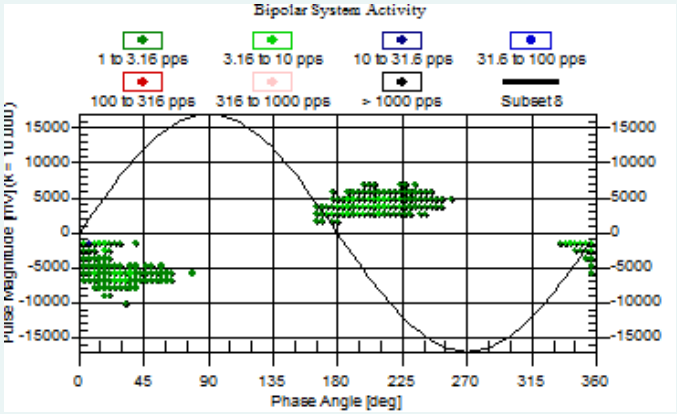
- 168 MW
- 18 kV

Siemens Steam Turbine

- 84 MW
- 13.8 kV

PUGET SOUND ENERGY

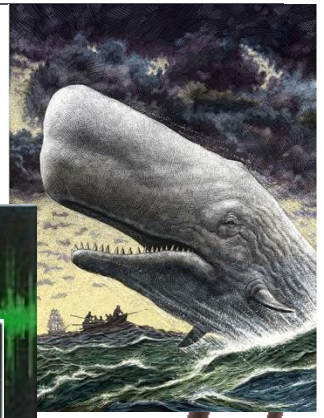
High System PD (1000-17000 mV)

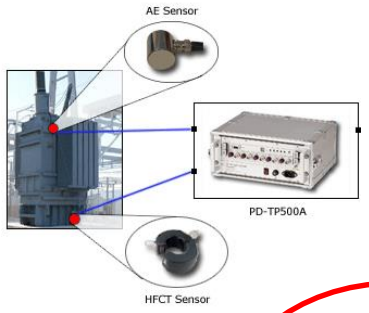
Date	Machine (A phase)	System (A phase)
2011		
2016		

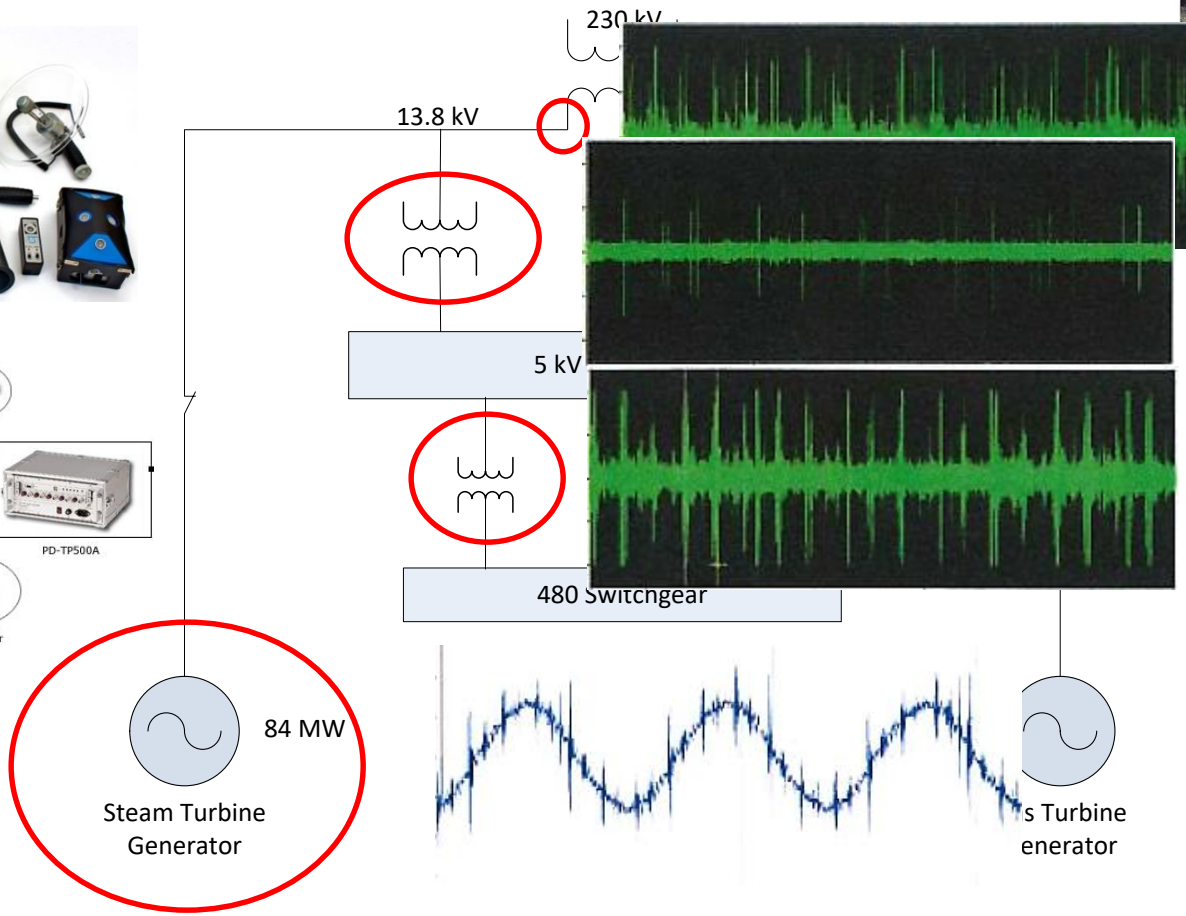
Needed to use a 10:1 Attenuator to capture PD.

Hunting the elusive PD signal

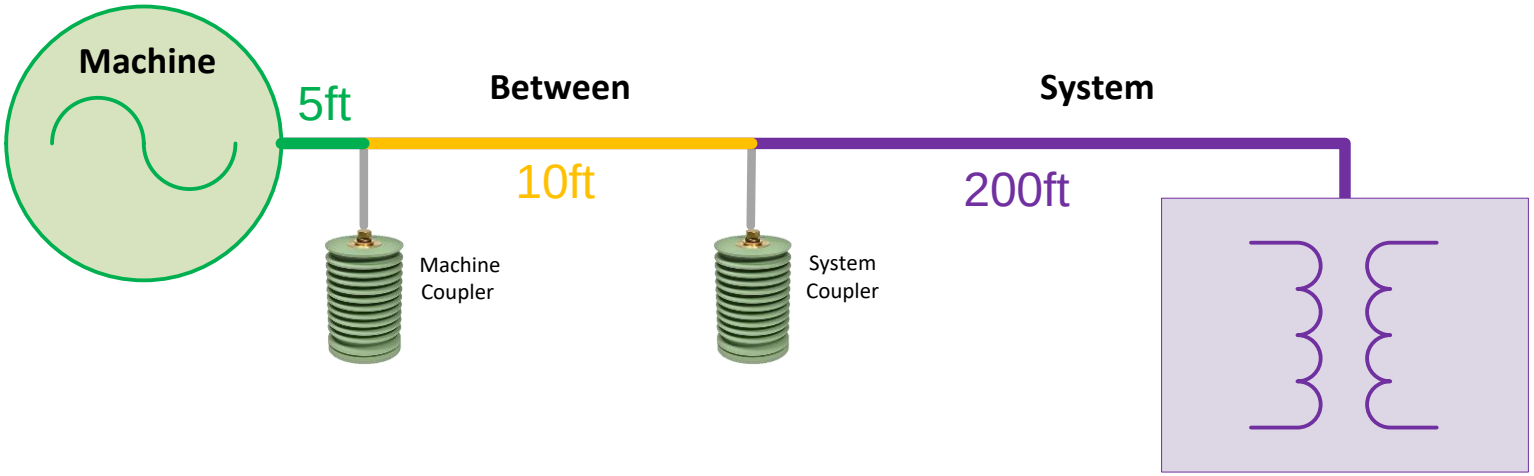
- High System PD throughout plant





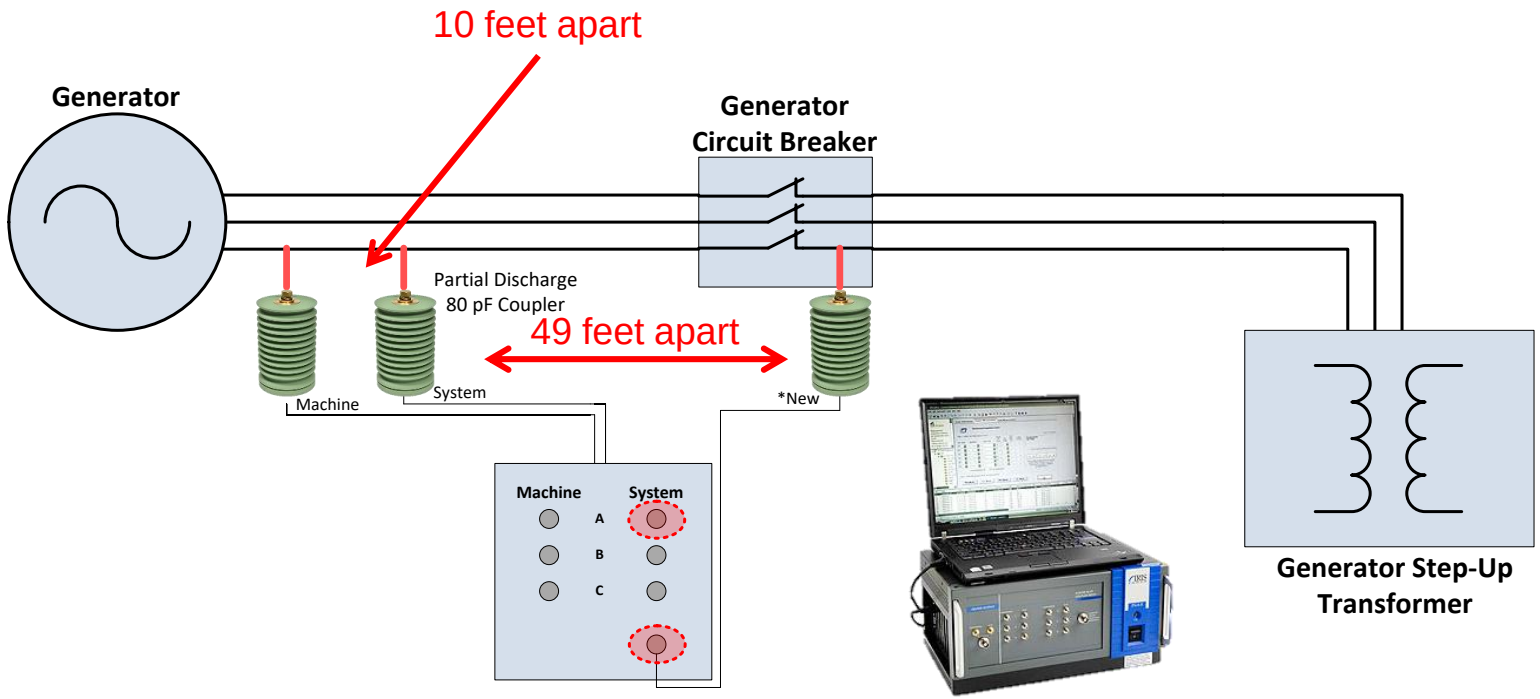


Need distance between both couplers

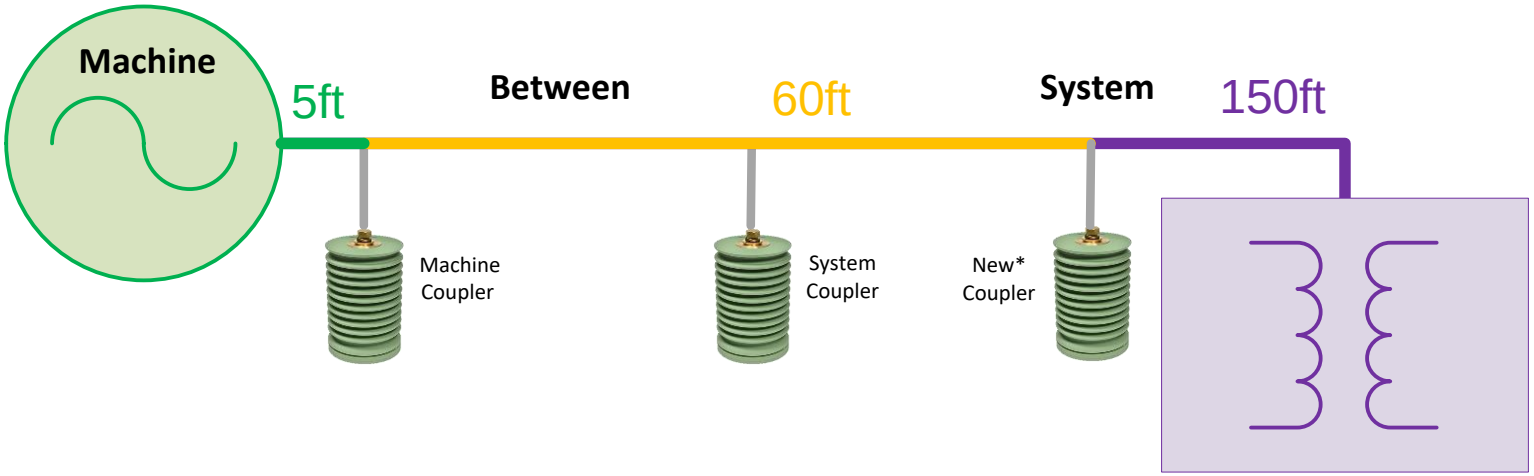


PUGET SOUND ENERGY

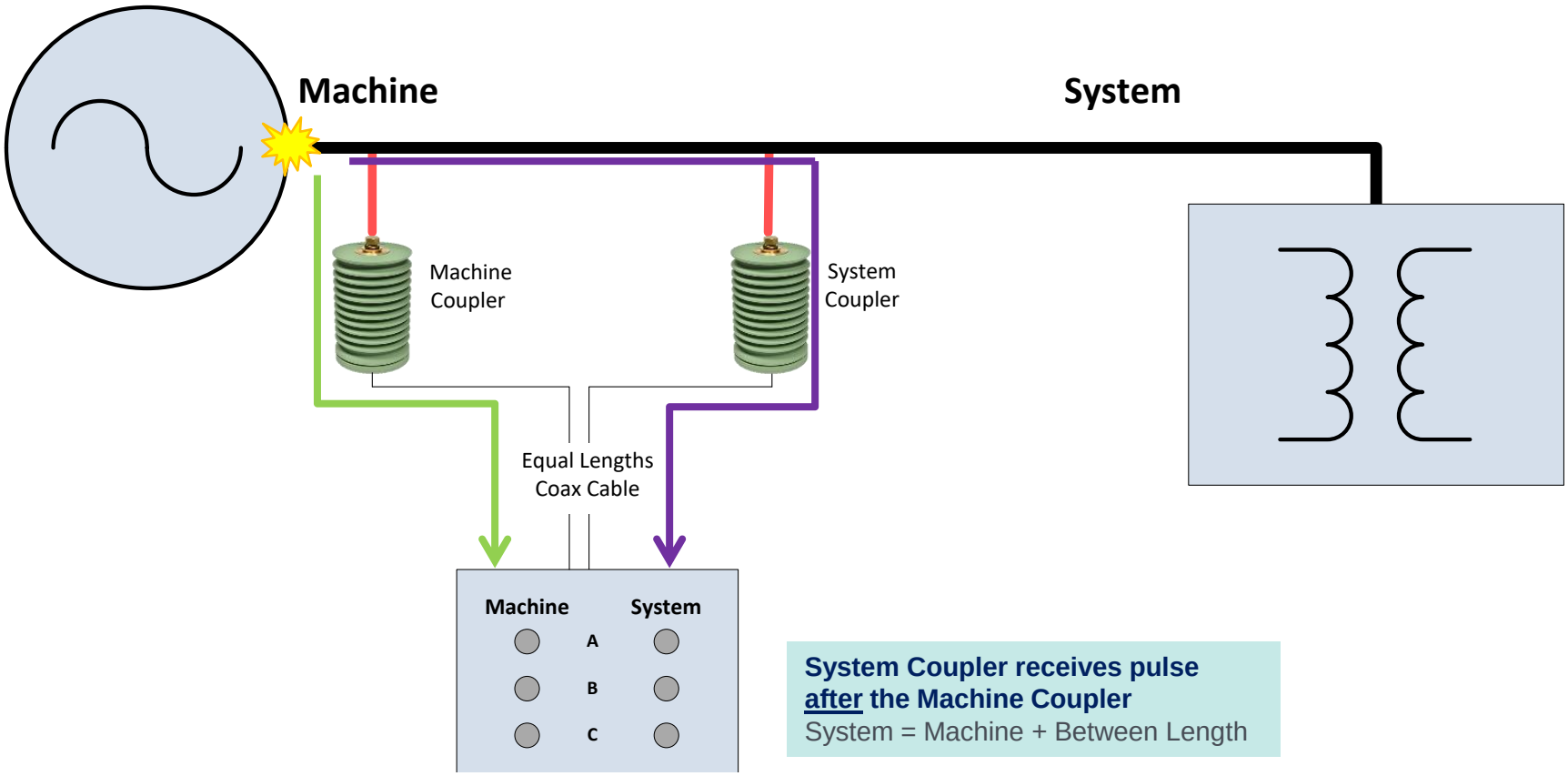
Adding Additional Coupler



New distance between couplers

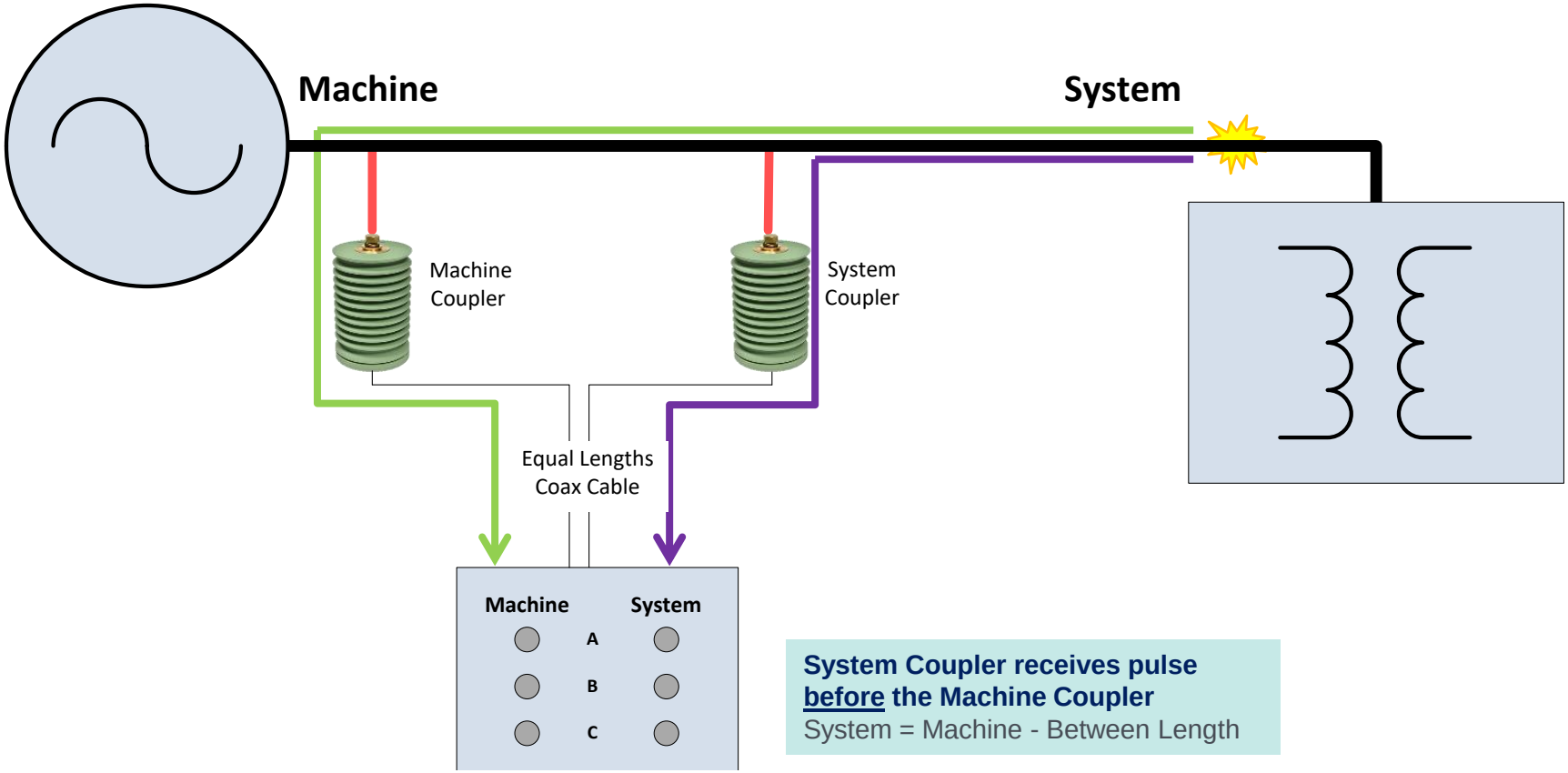


Machine PD



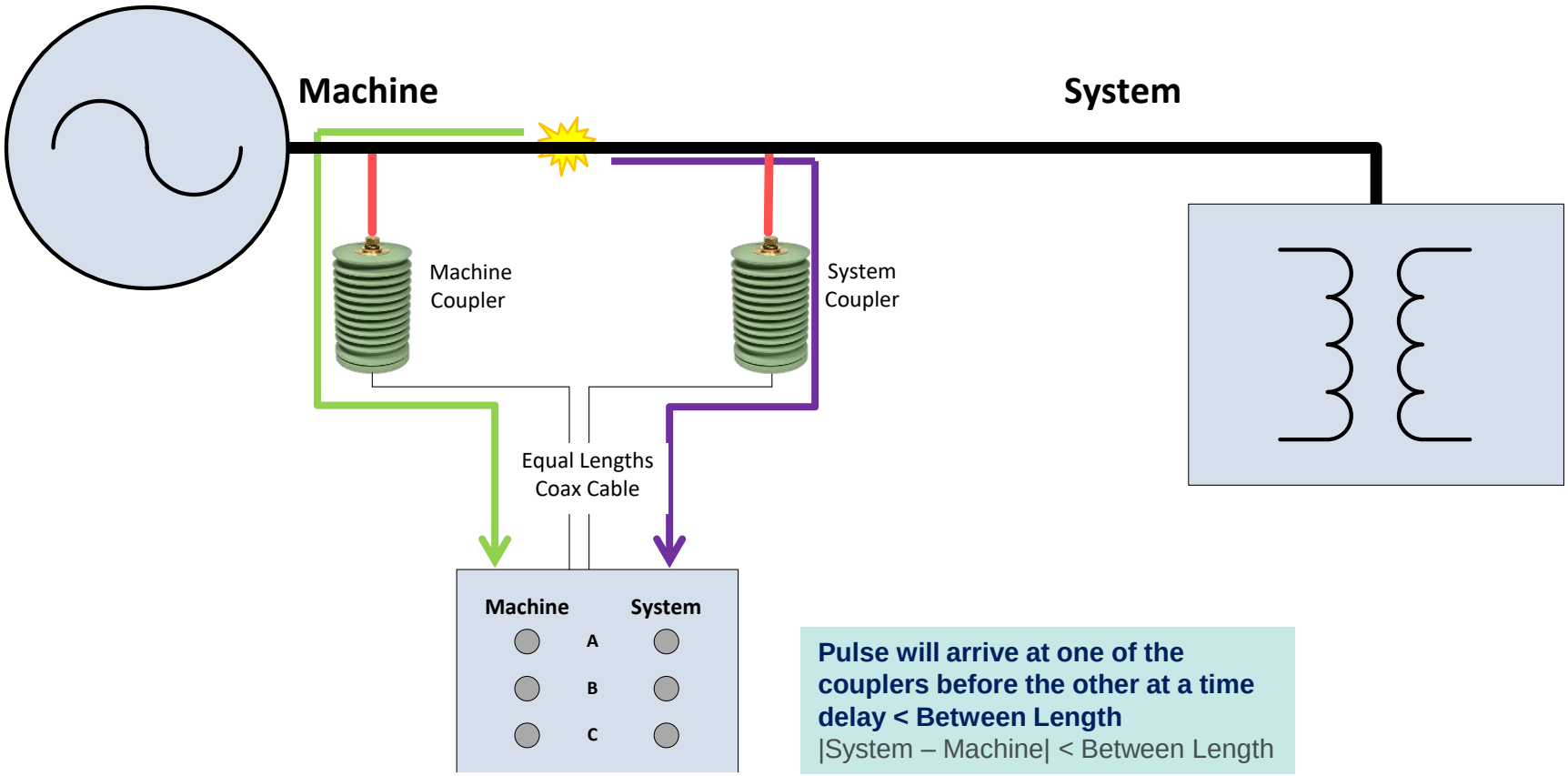
System Coupler receives pulse <u>after</u> the Machine Coupler
System = Machine + Between Length

System PD



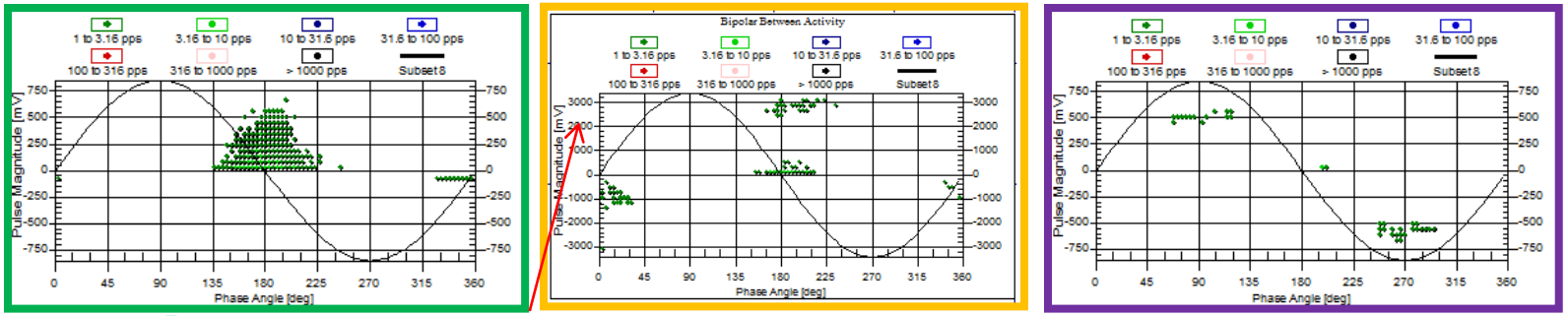
System Coupler receives pulse <u>before</u> the Machine Coupler
System = Machine - Between Length

Between PD

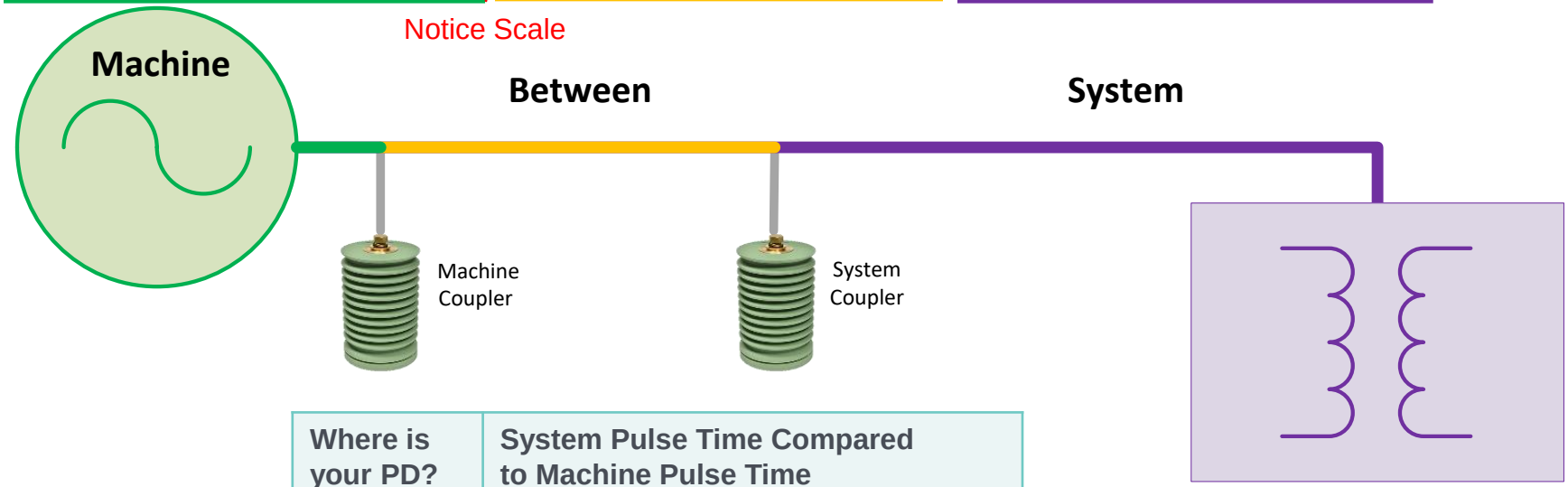


Pulse will arrive at one of the couplers before the other at a time delay < Between Length
|System – Machine| < Between Length

PDView Between Plot Technique!



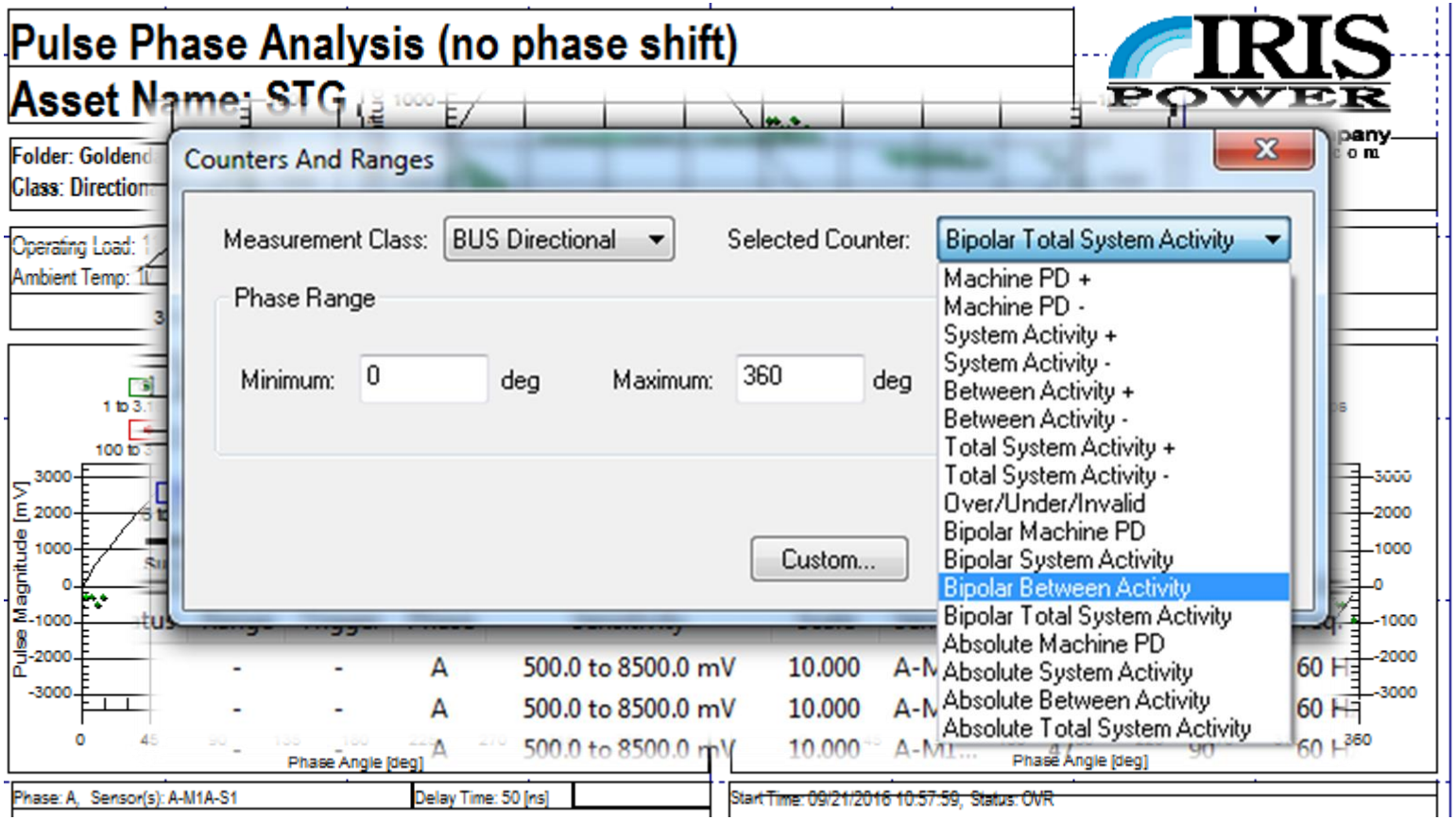
Notice Scale



Where is your PD?	System Pulse Time Compared to Machine Pulse Time
Machine	System = Machine + Between Length
System	System = Machine - Between Length
Between	|System – Machine| < Between Length

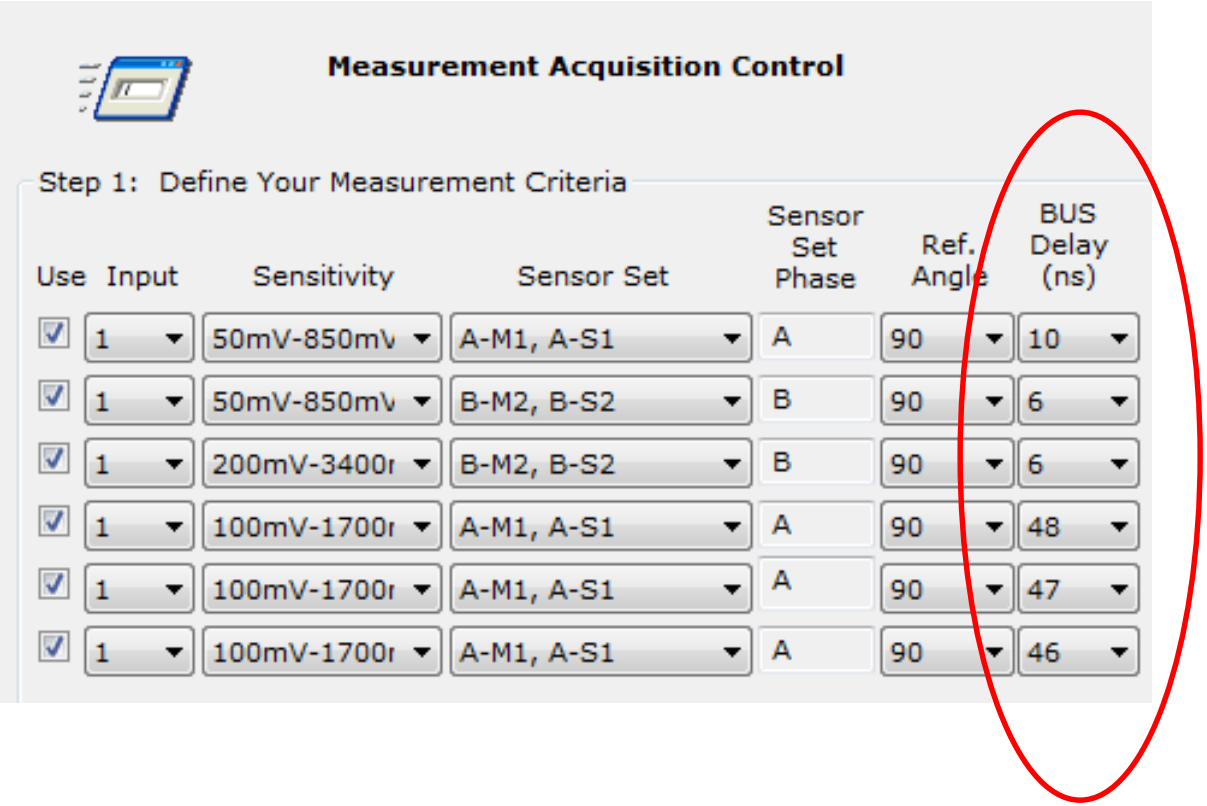
PUGET SOUND ENERGY

PDView Plots



Source: Iris PDView

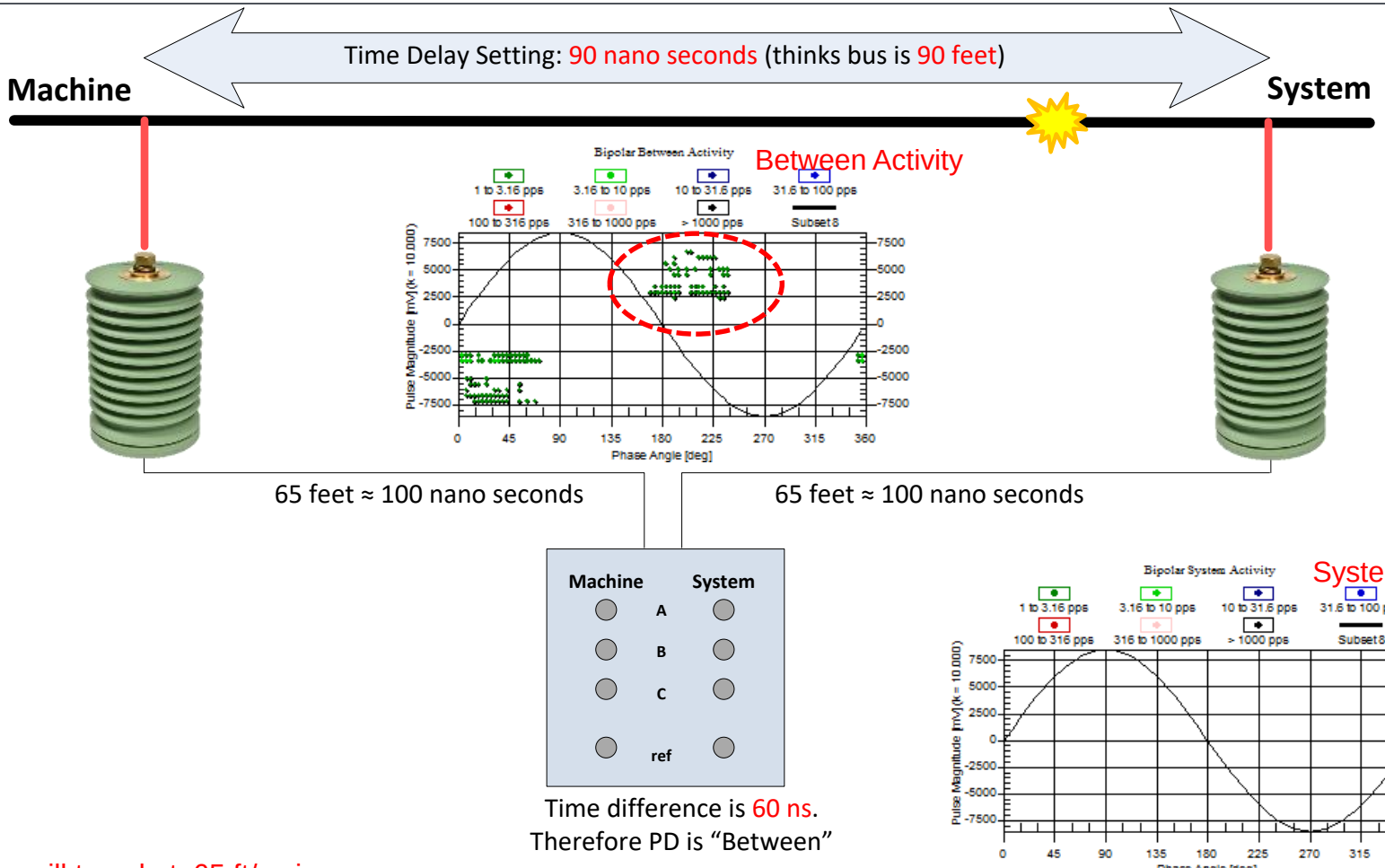
Changing Time Delay Setting



Source: Iris PDView

PUGET SOUND ENERGY

Adjusting Time Delay Settings

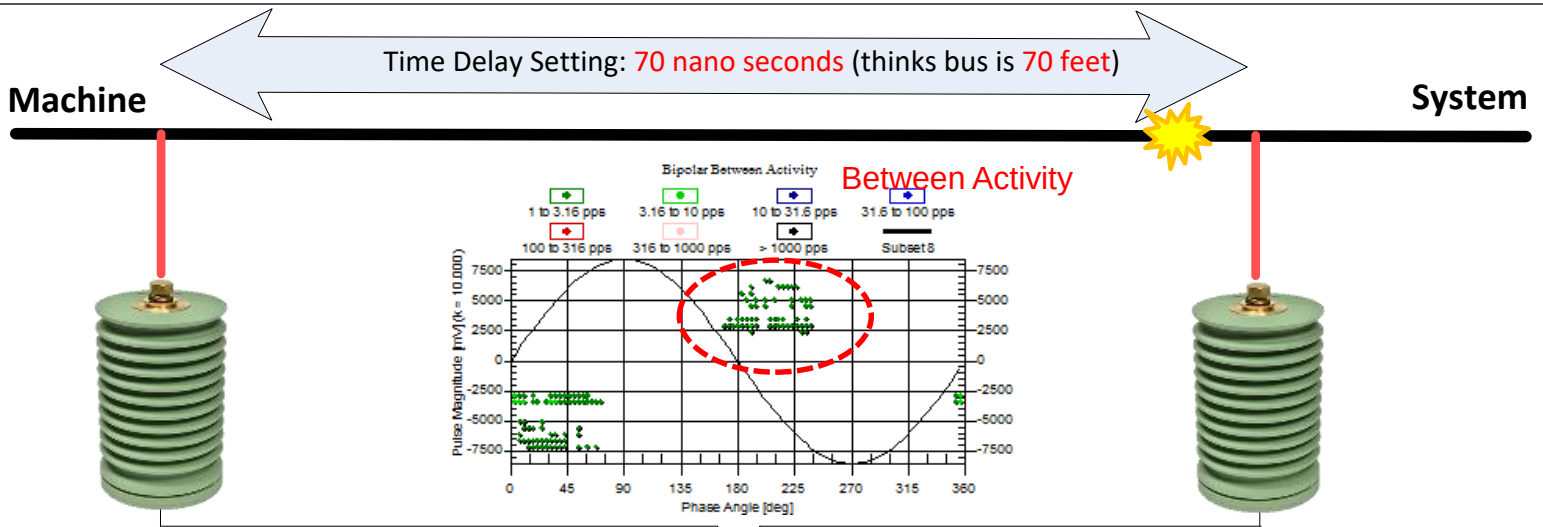


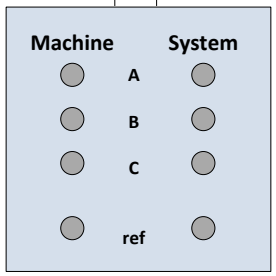
Time difference is 60 ns.
Therefore PD is "Between"

Pulses will travel at .65 ft/ns in coax
Pulses will travel at 1 ft/ns in bus

PUGET SOUND ENERGY

Adjusting Time Delay Settings





Difference is 60 ns.
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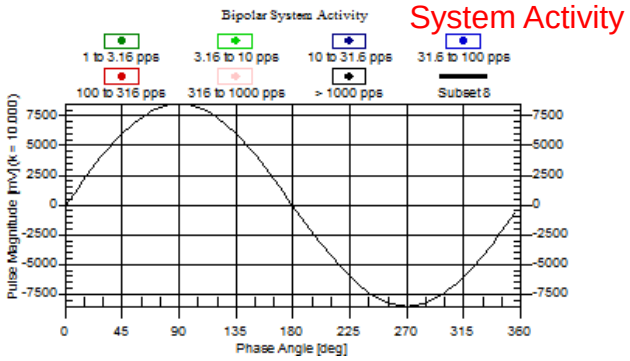
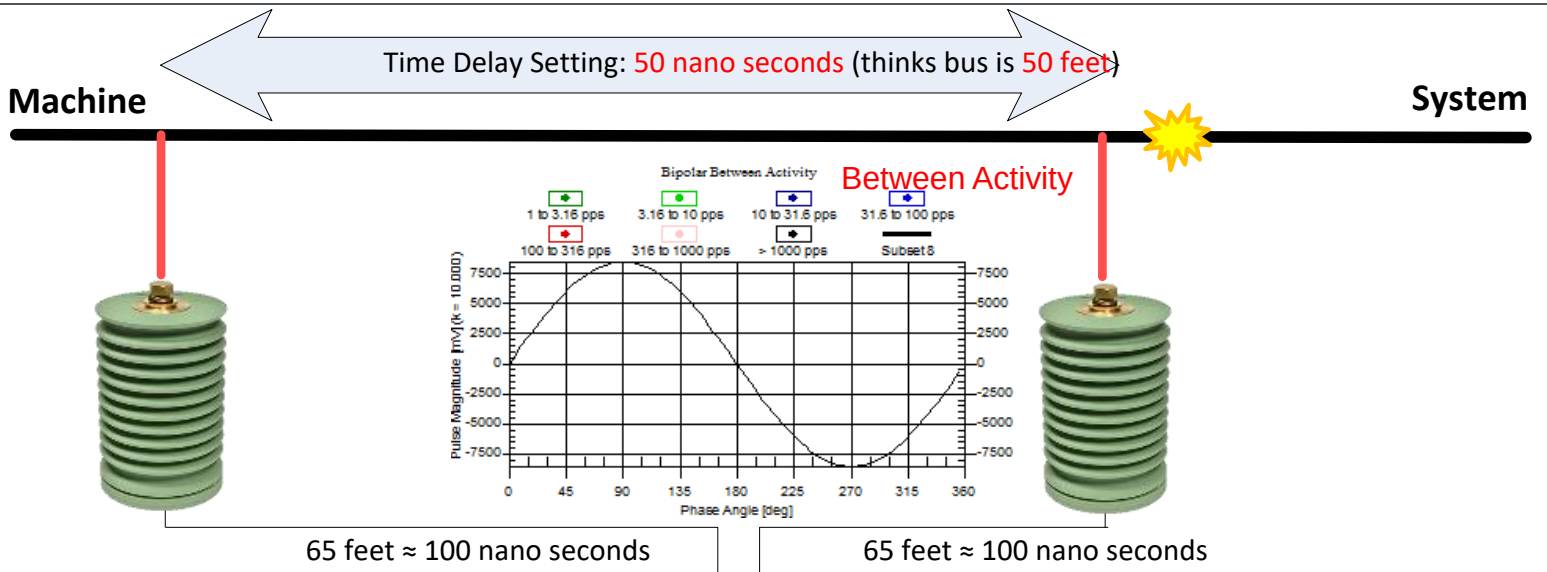
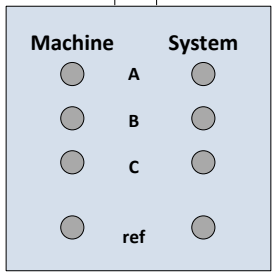


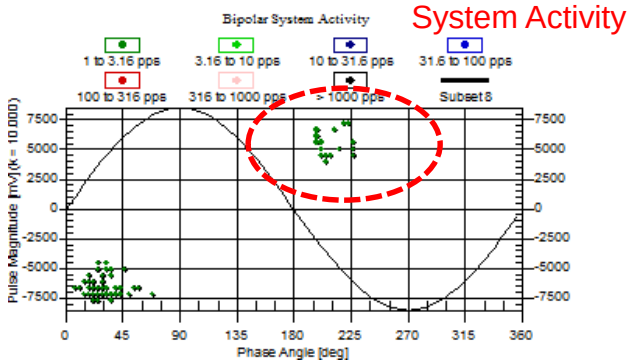
PUGET SOUND ENERGY

Adjusting Time Delay Settings



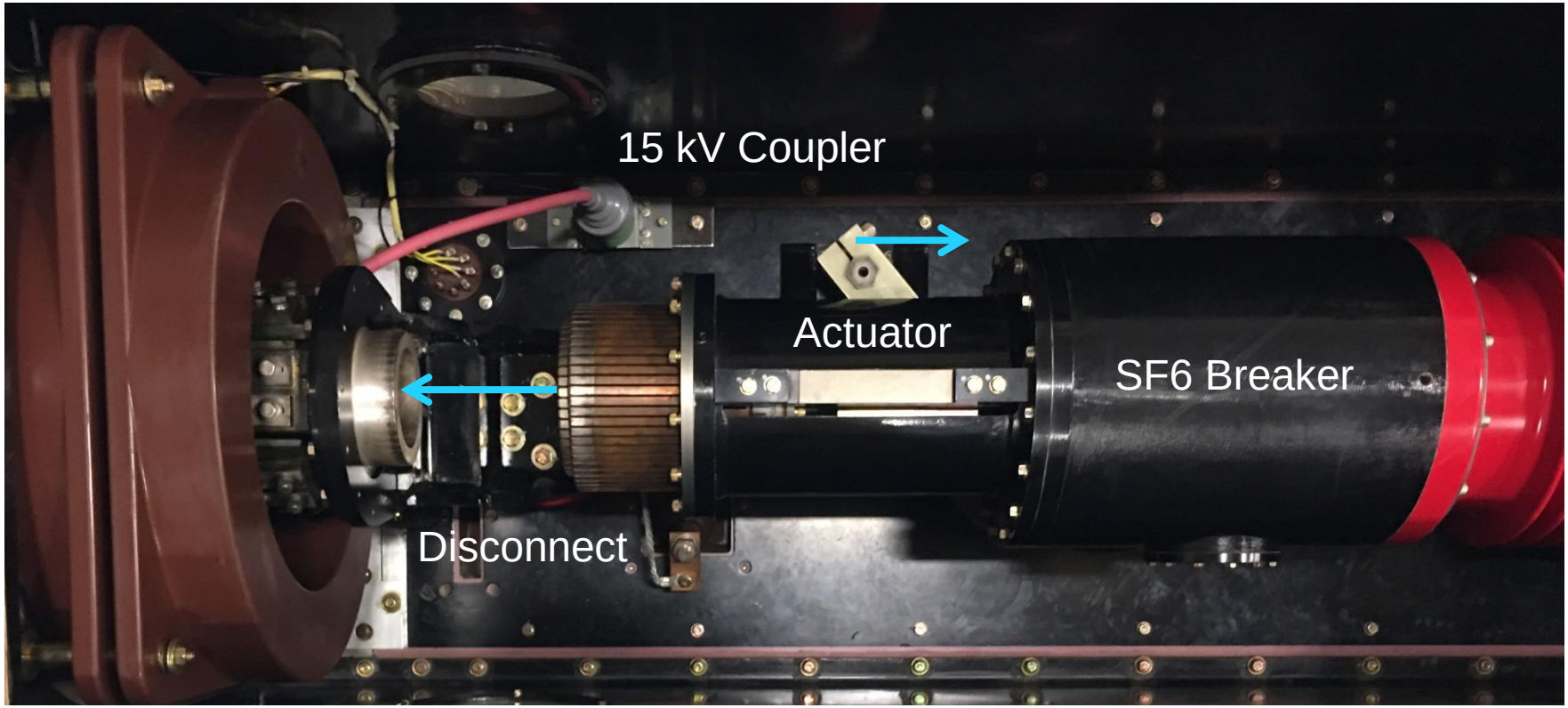


Difference is 60 ns.
Therefore PD is "System"



PUGET SOUND ENERGY

Adding Additional System Coupler



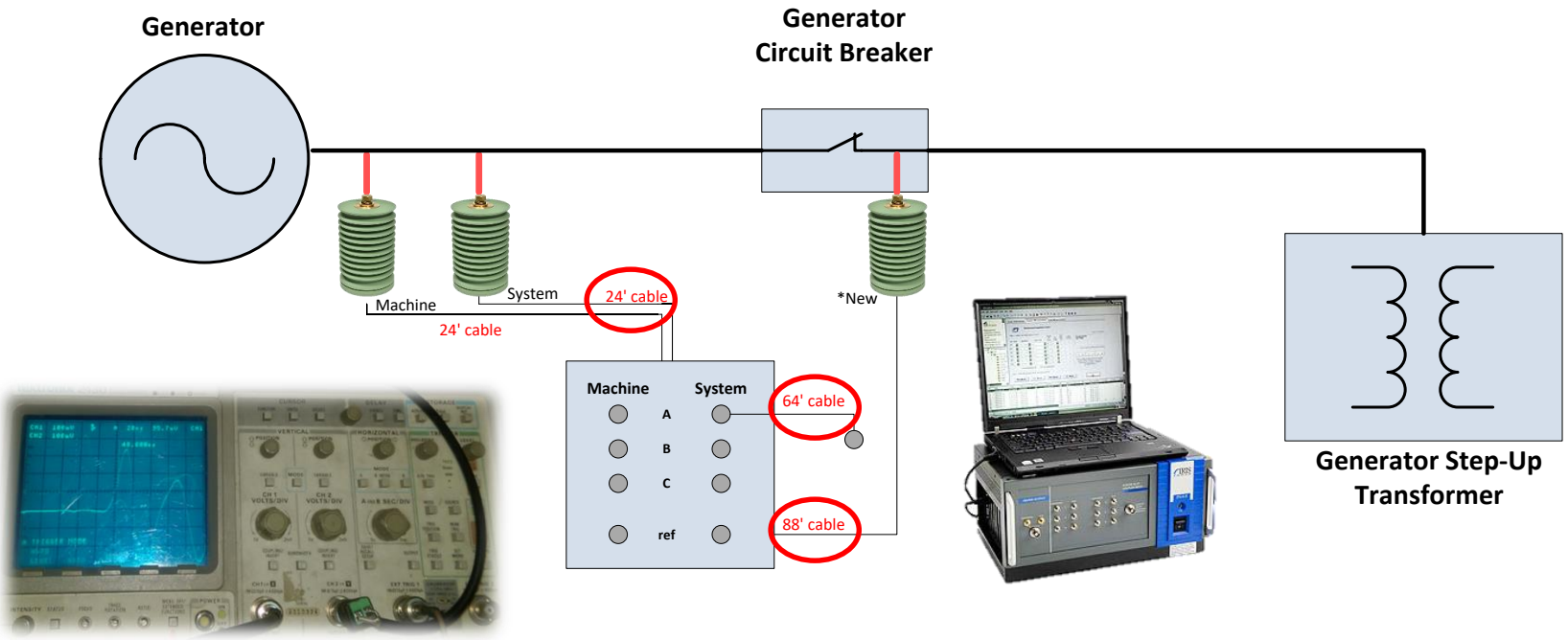
PUGET SOUND ENERGY

Adding Additional System Coupler

PUGET SOUND ENERGY

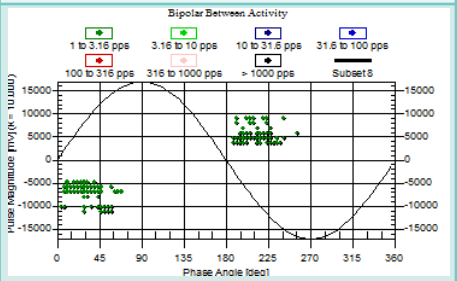
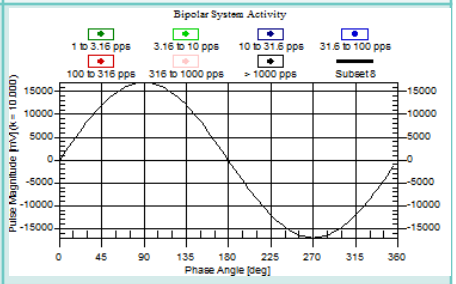
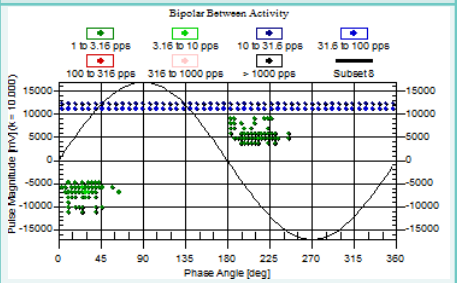
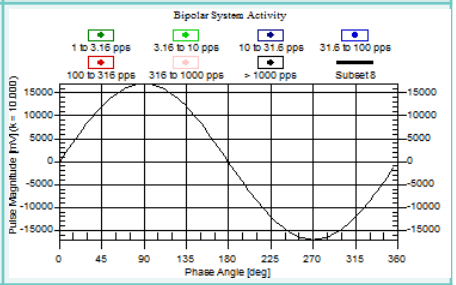
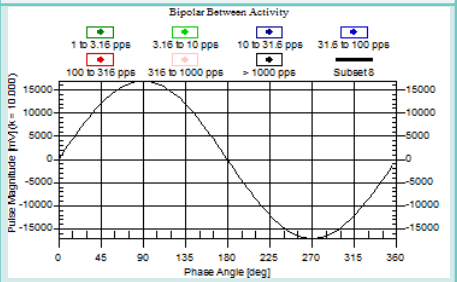
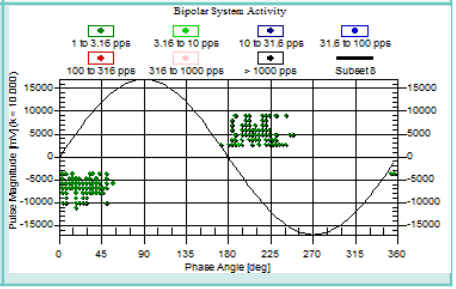
Creating Equal Lengths

- Existing couplers had 24’ coax cables.
- Our new* system coupler had a 88’ coax cable.
- To create “equal” lengths, we needed a temporary 64’ coax cable.



Off by 48.6 ns
(Bus Length)

Changing Time Delays (59 feet apart)

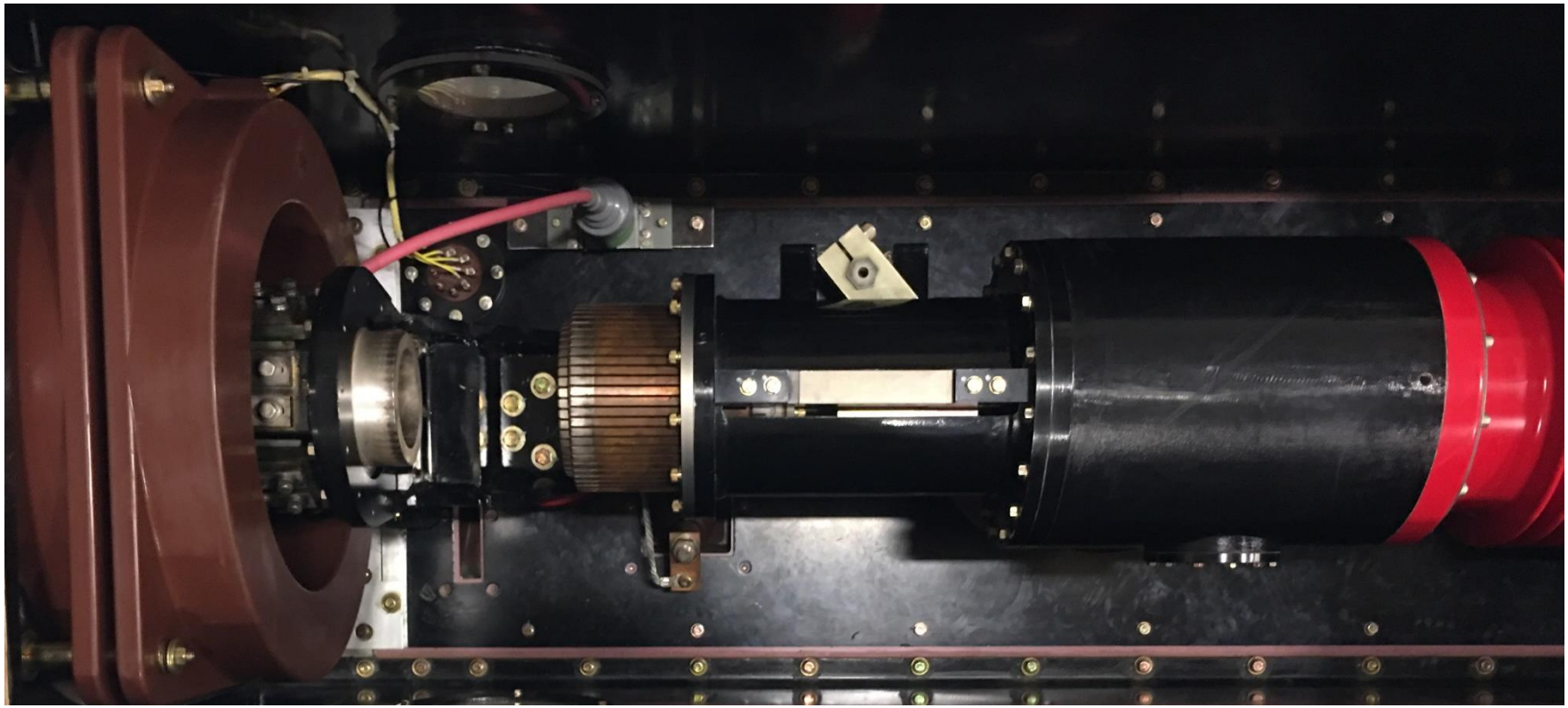
Time Delay	Between	System
56 ns		
55 ns		
54 ns		

Shifted the Time Delay by 5ns.

The noise is occurring a few feet from the coupler, which puts us in the circuit breaker

PUGET SOUND ENERGY

Source in Circuit Breaker?

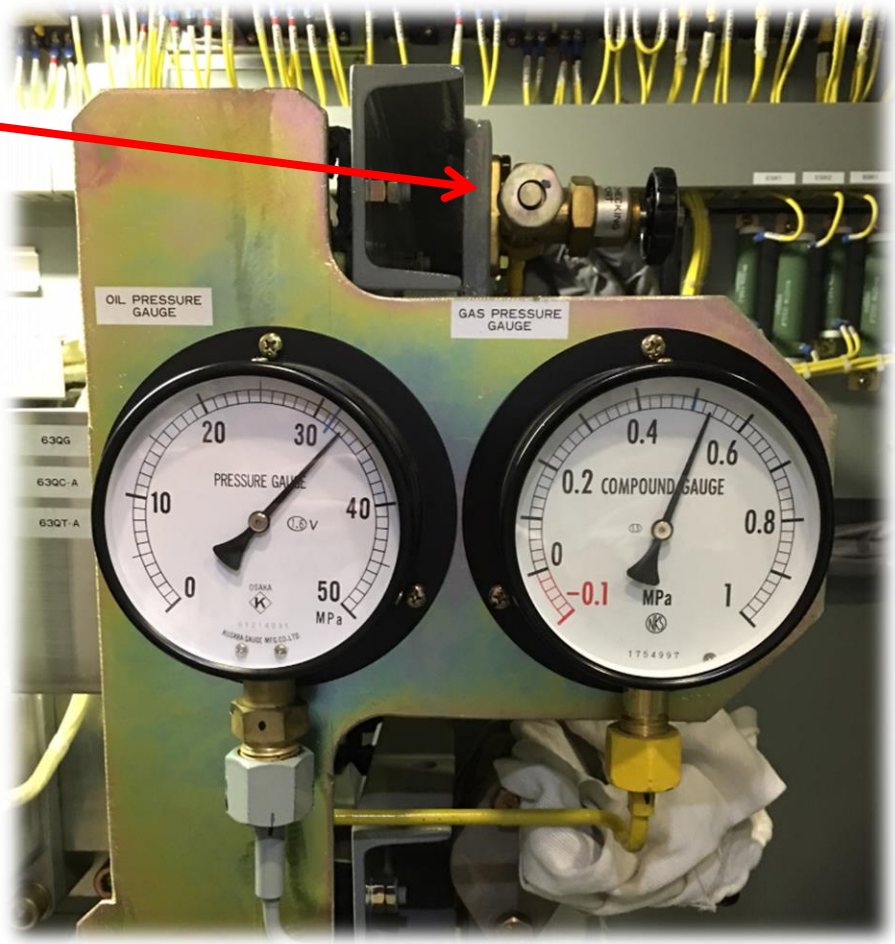


PUGET SOUND ENERGY

SF_6 Gas Testing

The gas tested normal:

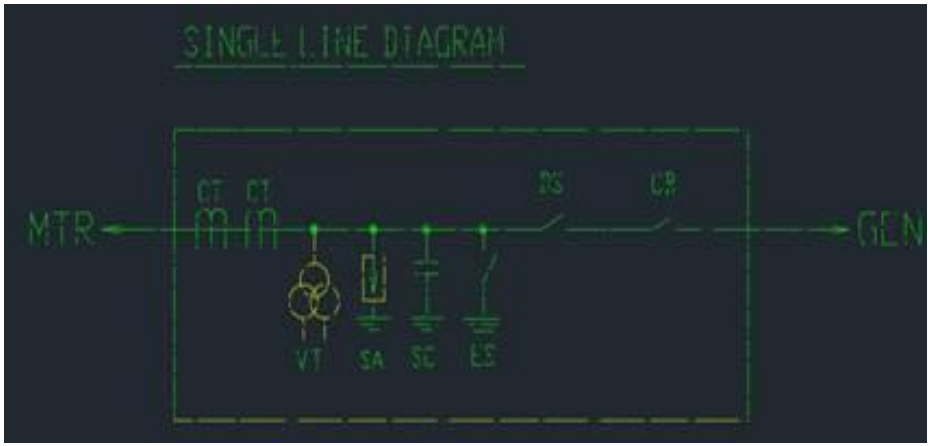
- 99.9% Purity
- < 200 ppm dew
- 0 ppm SO_2
- 71.3 PSI



Visual Inspection – Aux Equipment

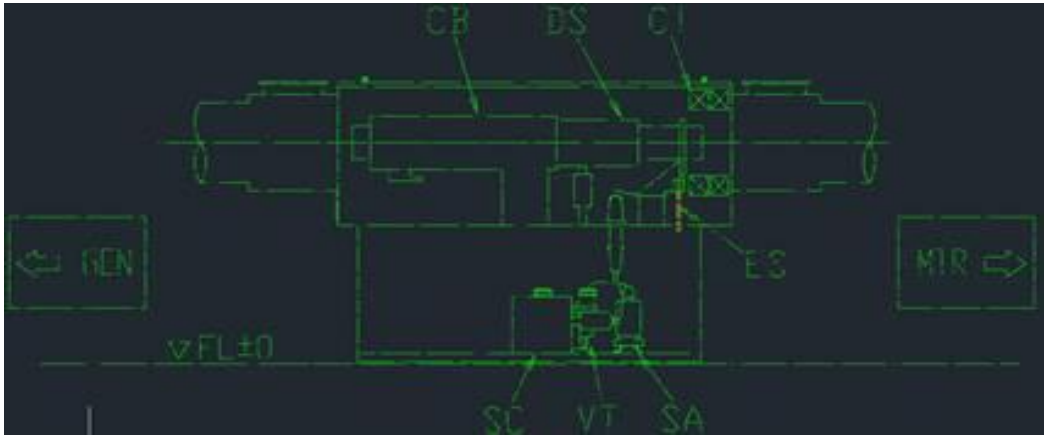
Tested all the auxiliary equipment:

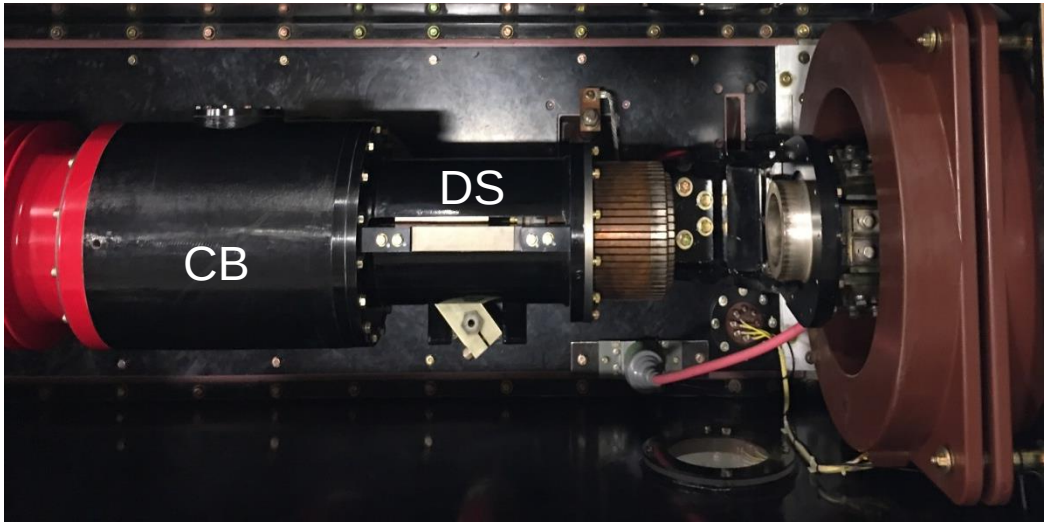
- Disconnect Bushing
- Surge Arrester
- Capacitor
- Voltage Transformer

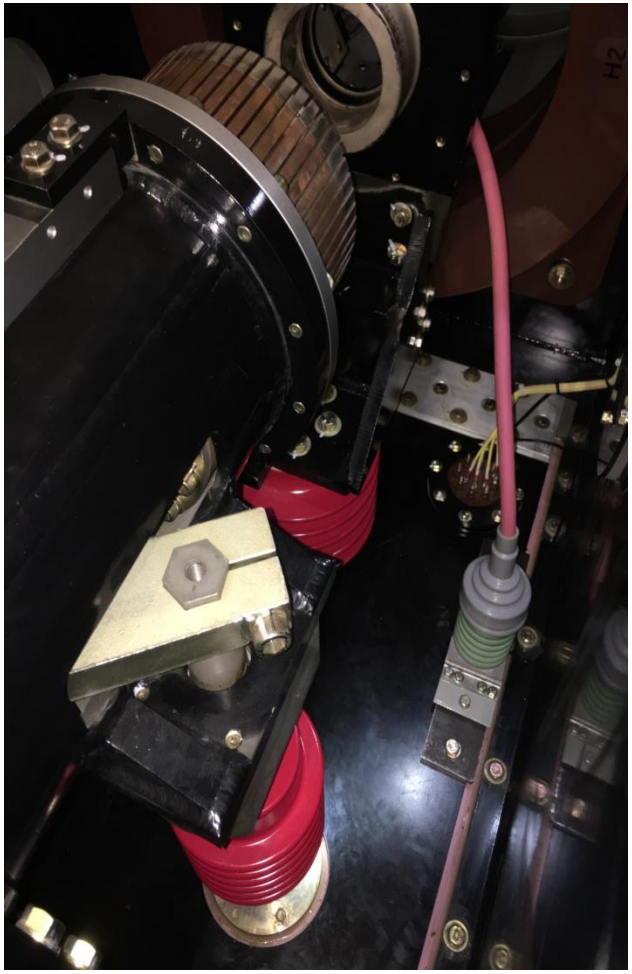


PUGET SOUND ENERGY

Visual Inspection – Inside Breaker

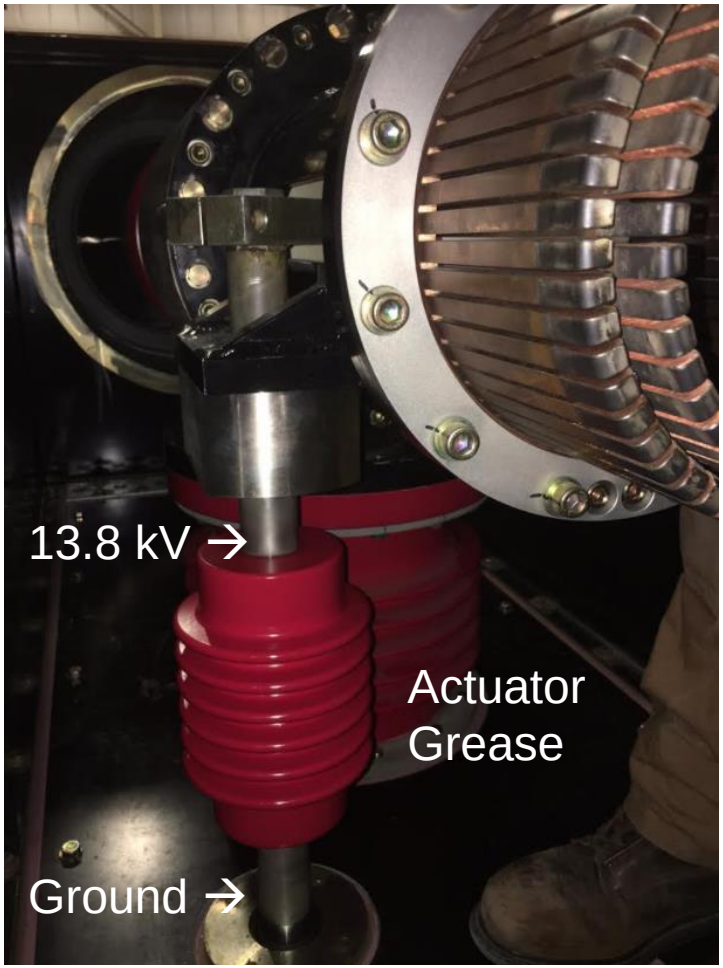


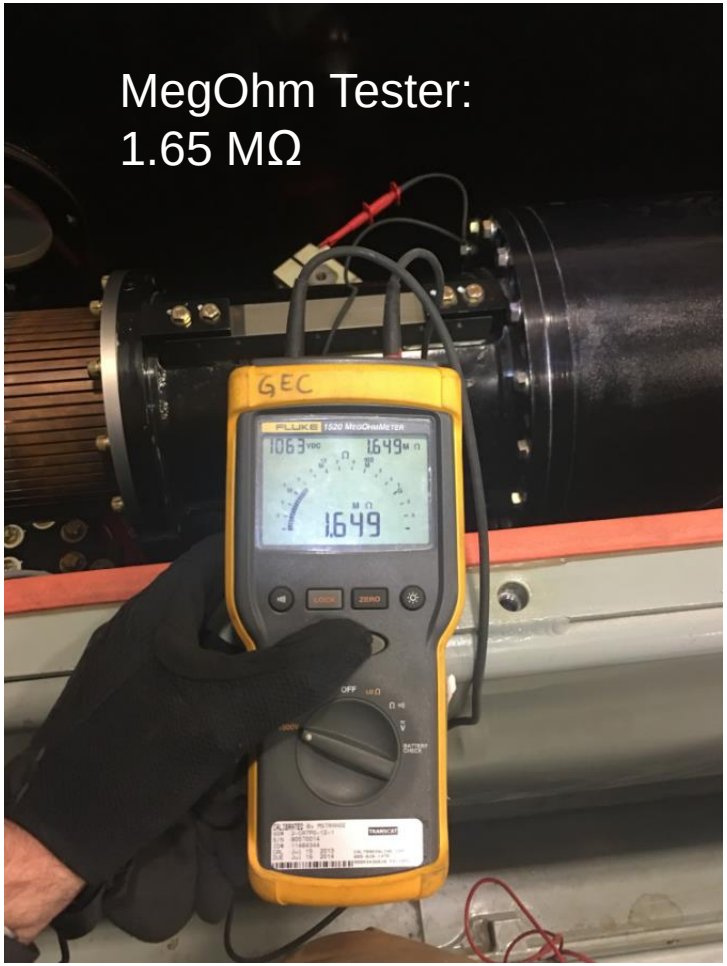




PUGET SOUND ENERGY

Source of Partial Discharge?





PUGET SOUND ENERGY

Next Steps

1. Contacted manufacturer
2. Consulted other engineers
3. Cleaned actuator grease off
4. Put unit back in service
5. Re-perform PD testing
6. Re-inspect on next outage

PUGET SOUND ENERGY

Mint Farm, 1:1 Combined Cycle

GE 7FA Gas Turbine

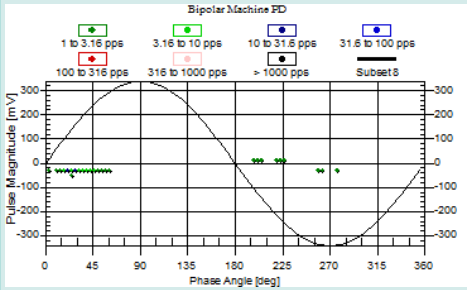
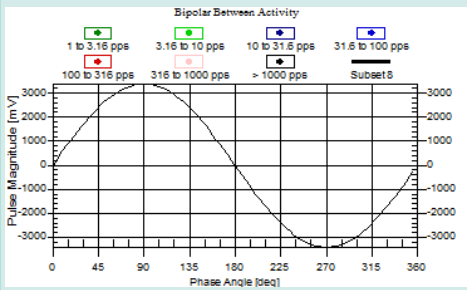
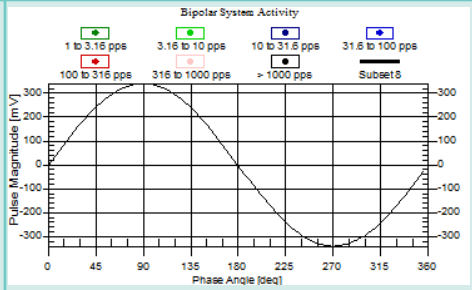
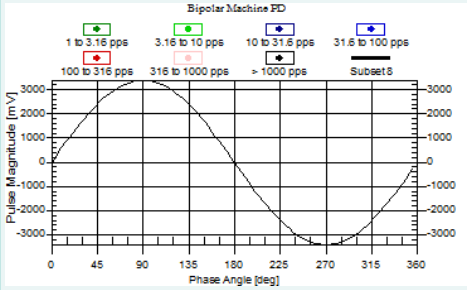
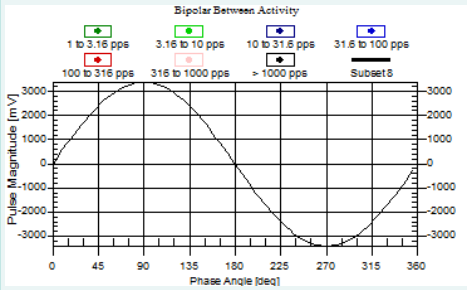
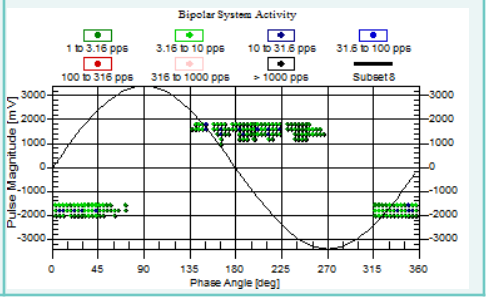
- 174 MW
- 18 kV

Fuji Electric Steam Turbine

- 86 MW
- 13.8 kV

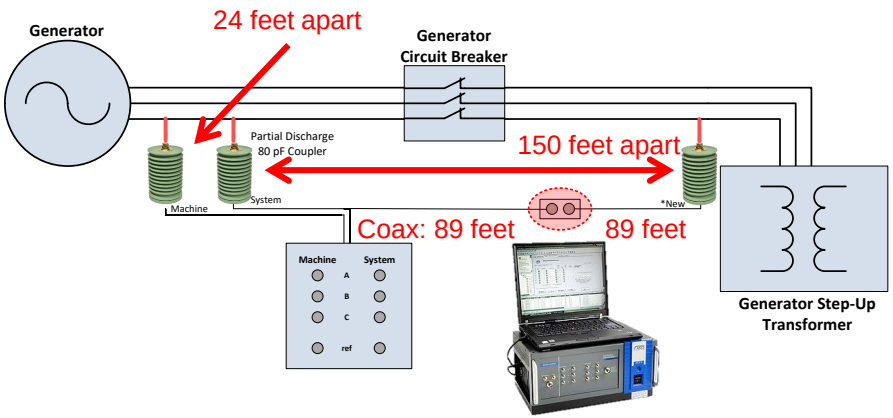
PUGET SOUND ENERGY

Hunting for Discharge

Date	Machine (C phase)	Between (C phase)	System (C phase)
June 1st 2015 (**rain**)			
June 9th 2015 (**dry**)			

No Machine or Between PD, so we decided to add an additional coupler further down the bus to increase our “Between” distance.

Adding Coupler



Next Steps

1. Wait for the end of the outage when the unit is back in service.
2. Perform PD testing at earliest convenience, on a dry day.
3. Adjust time delay settings until the “Between” signal switches to a “System” signal.

PUGET SOUND ENERGY

Thank you! Questions?