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# Understanding Geomagnetically Induced Currents and Their Impact on the Power Grid:

## Morgan Substation Neutral Isolation Device (NID)

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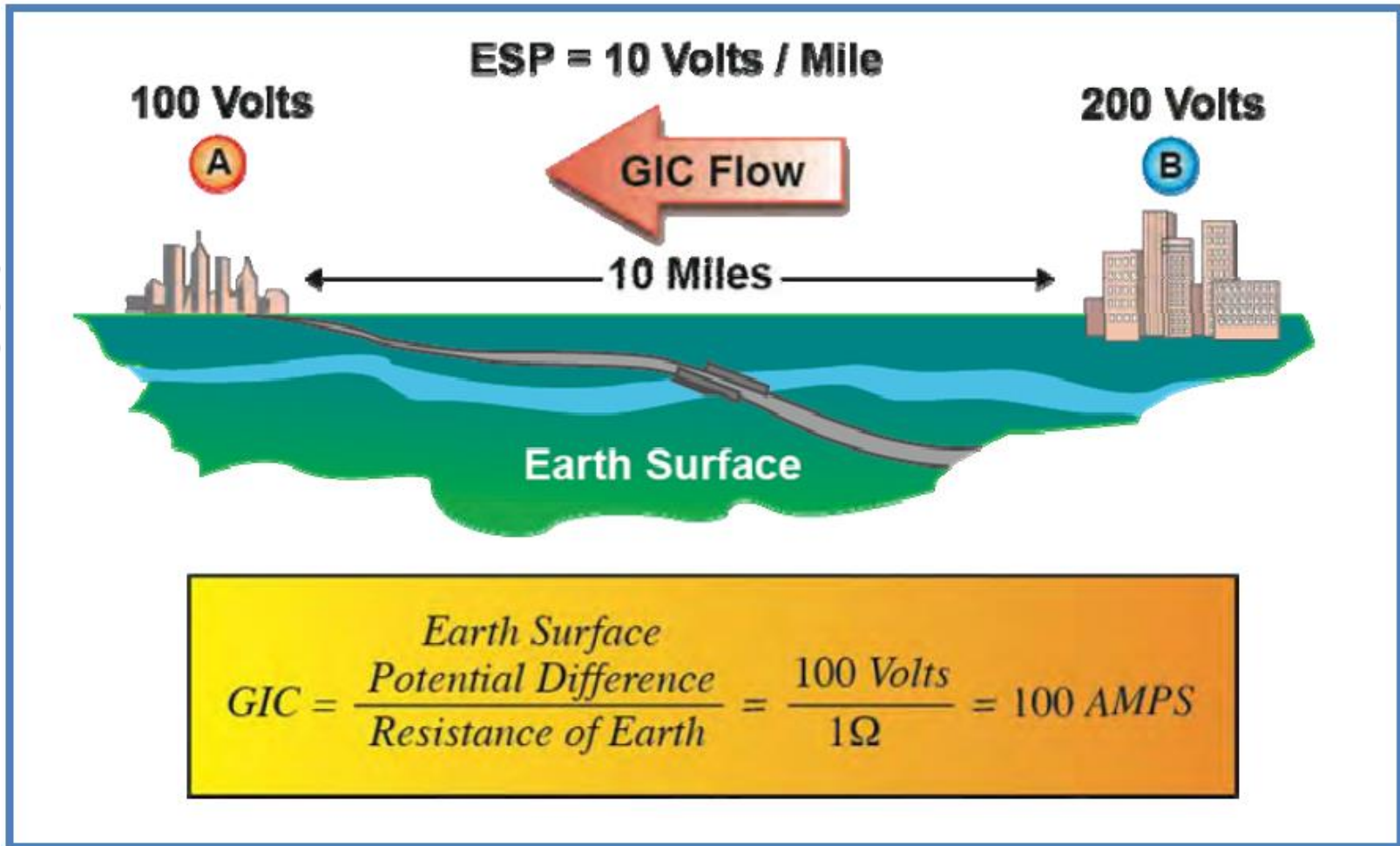
Wisconsin Public Utility Institute

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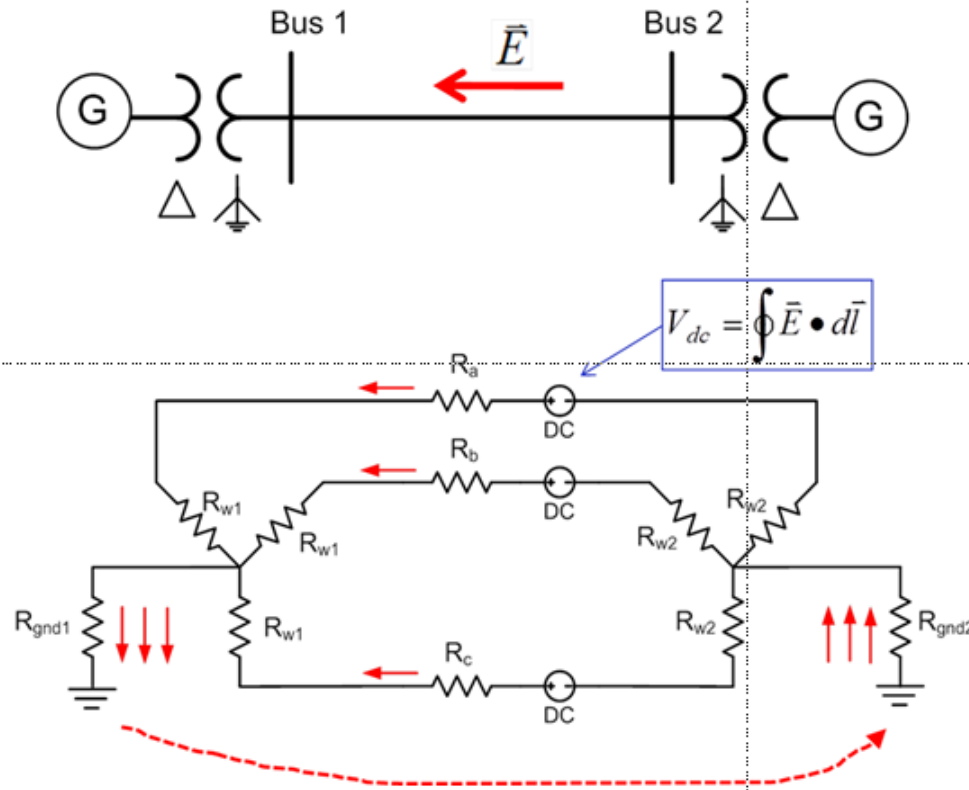
[atcllc.com](http://atcllc.com)

# Quick Review of where Geomagnetically Induced Currents (GIC) Come From

# Geomagnetic Induced Currents



# Geomagnetically Induced Currents (GICs)



The impact of the electric field variation is modeled as dc voltages superimposed on the transmission lines. The GIC calculation then just involves solving a linear dc circuits problem



# Possible Effects of GIC on ATC System and Equipment

- **Transformer saturation**
  - Additional heating in transformers--likely
  - Transformer aging/failure--unlikely
- **Additional VAR (Volts-Amps-Reactive) requirements on system**
  - Depressed voltages--likely
  - Voltage collapse on system--depends
- **Harmonics**
  - Relay misoperation--unlikely
  - Generator heating--possible but small
  - Power quality problems--likely but small

# GIC Isolation Device at Morgan Substation



# Morgan Neutral Isolation Device



One ohm power resistor rated for continuous current of 200 amperes. This is to handle neutral unbalanced current.

Capacitor bank of (14) 400 kVar 2.4 kV rated capacitors. One ohm impedance at 60 Hz.

Shunt located in this enclosure. 0.001 ohm shunt. Geomagnetic quasi-DC current is measured across this shunt.

Conduits with control conductors enter into the bottom of the terminal cabinet.

# Morgan Neutral Isolation Device cont'd



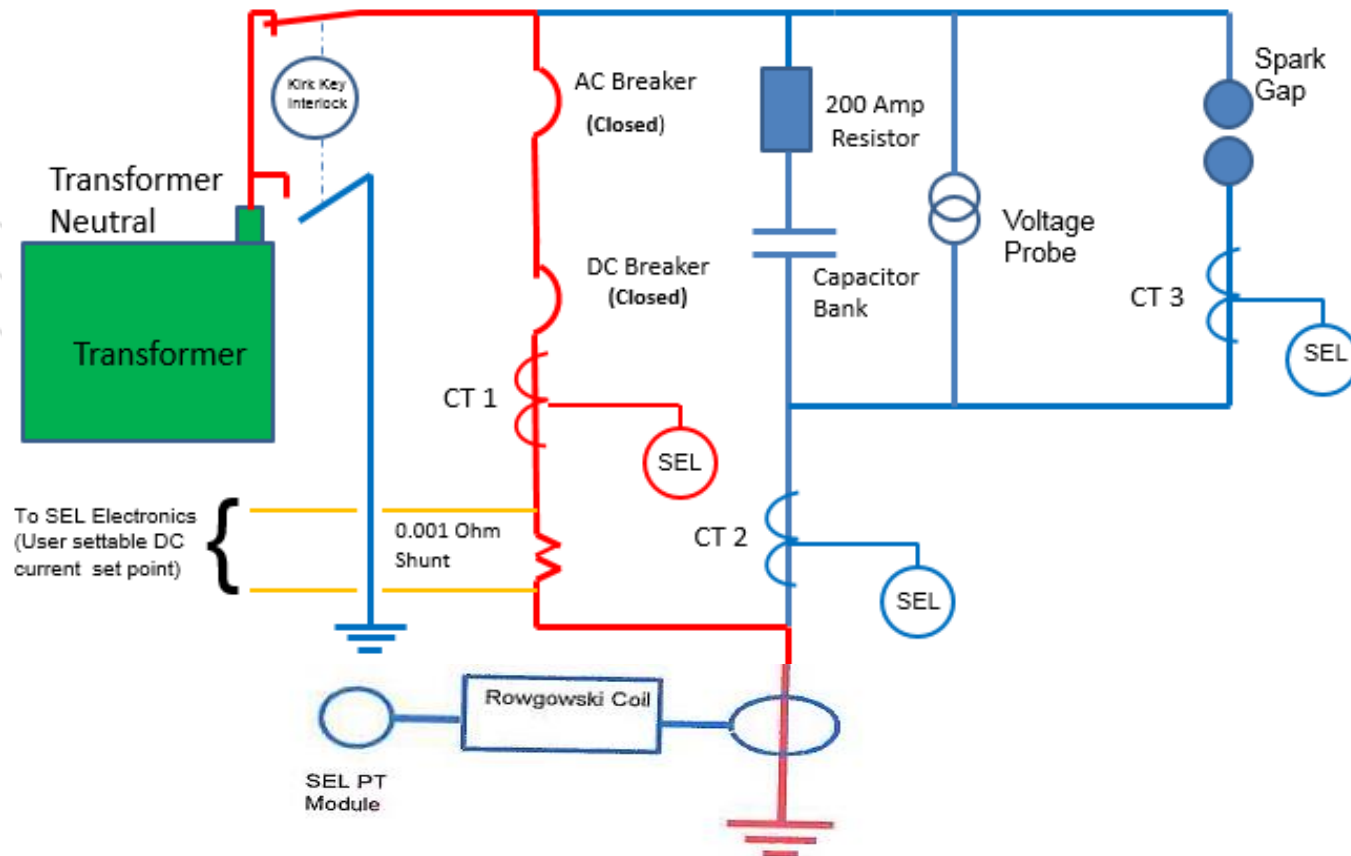
Maintenance switches allow for the unit to be taken out of service without interruption of the the connection. Kirk key used to assure proper operation of switch operation.

Auxiliary switches monitor the position of the maintenance switches.



# Sequence of Operation Normal Mode

Normal Mode of Operation (Red = Current Flow)

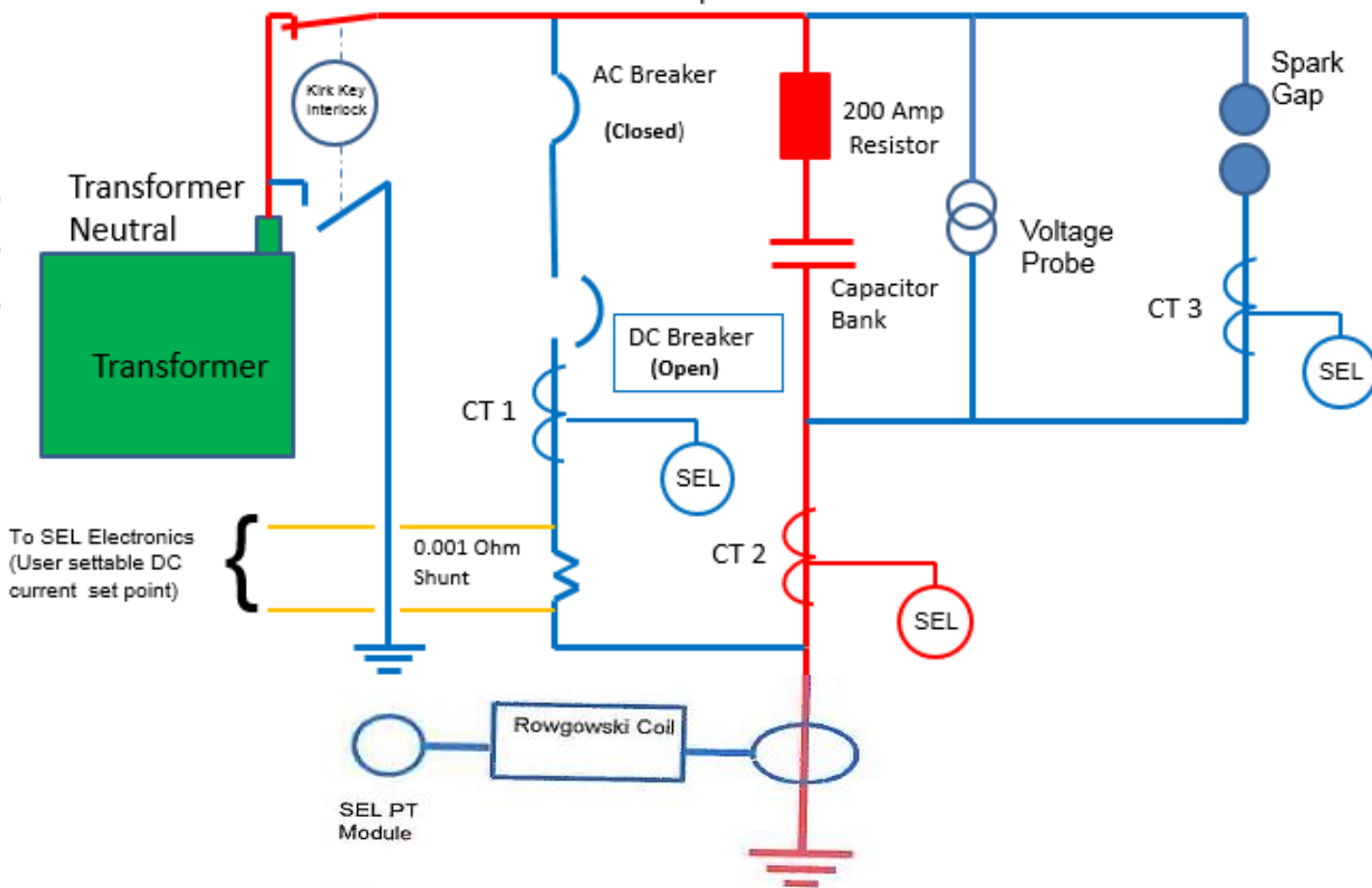


# Sequence of Operation Transitioning to GIC Isolation

## Going into the GIC Mode (Red = Current Flow)

(GIC= Geomagnetic Induced Current)

SEL Electronics sense quasi-DC current above set point value and calls for the DC breaker to open.



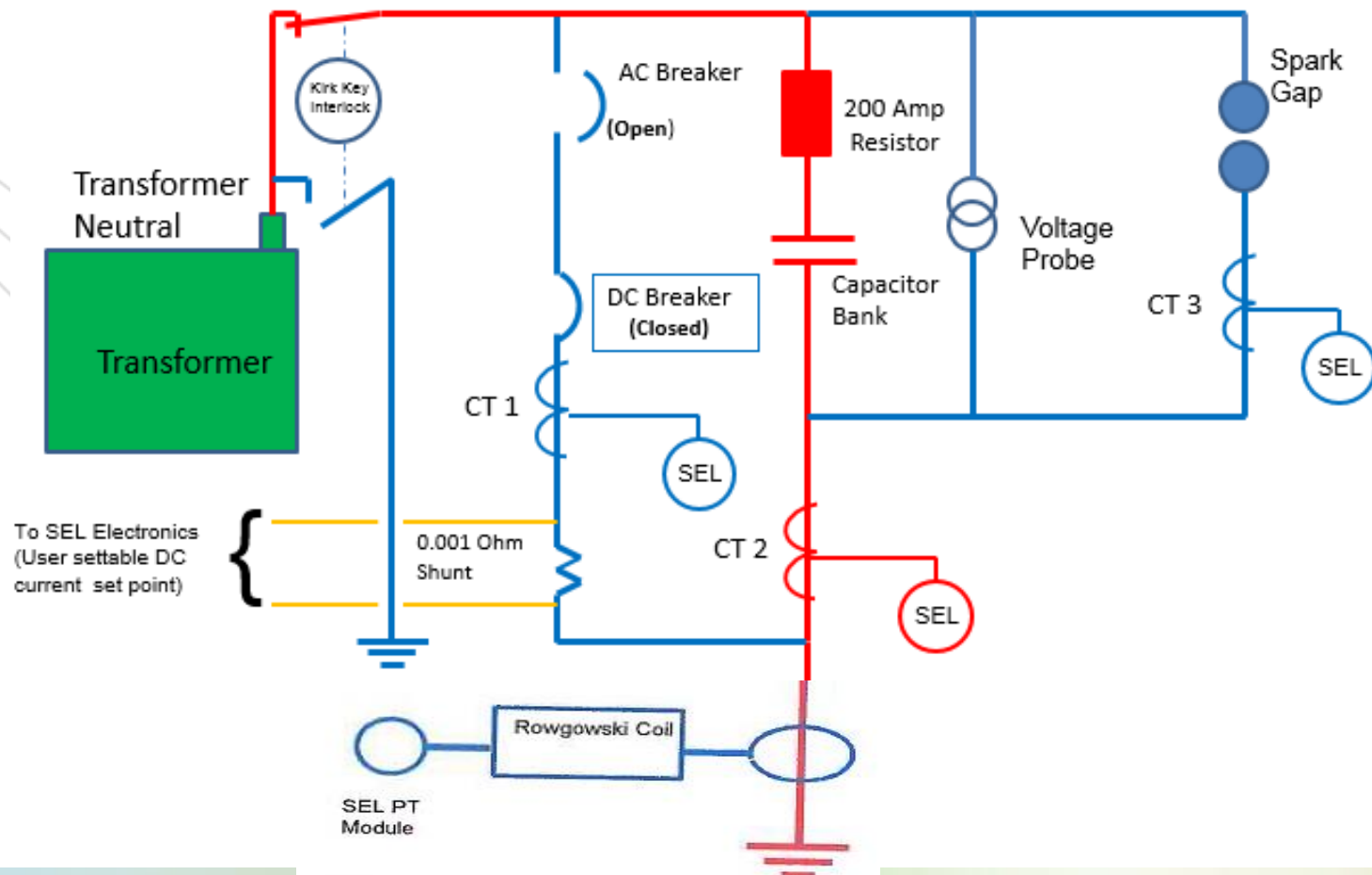
# Sequence of Operation In GIC Mode

## IN the GIC Mode (Red = Current Flow)

(GIC= Geomagnetic Induced Current)

SEL Electronics senses quasi-DC current above set point value.

DC breaker aux contacts opens AC breaker, SEL then closes DC breaker

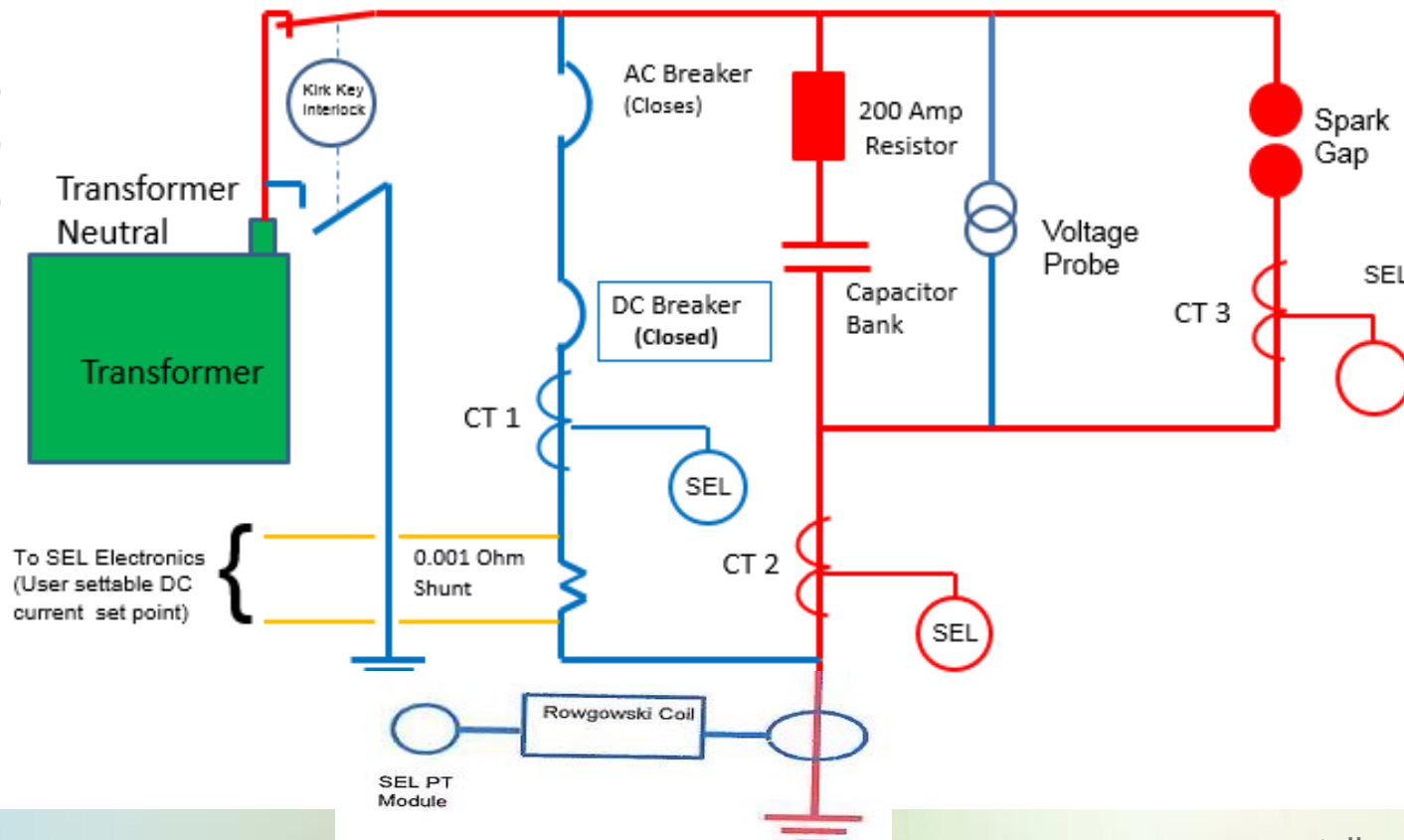


# Sequence of Operation Ground Fault in GIC Mode

## Ground Fault in the GIC Mode (Red = Current Flow)

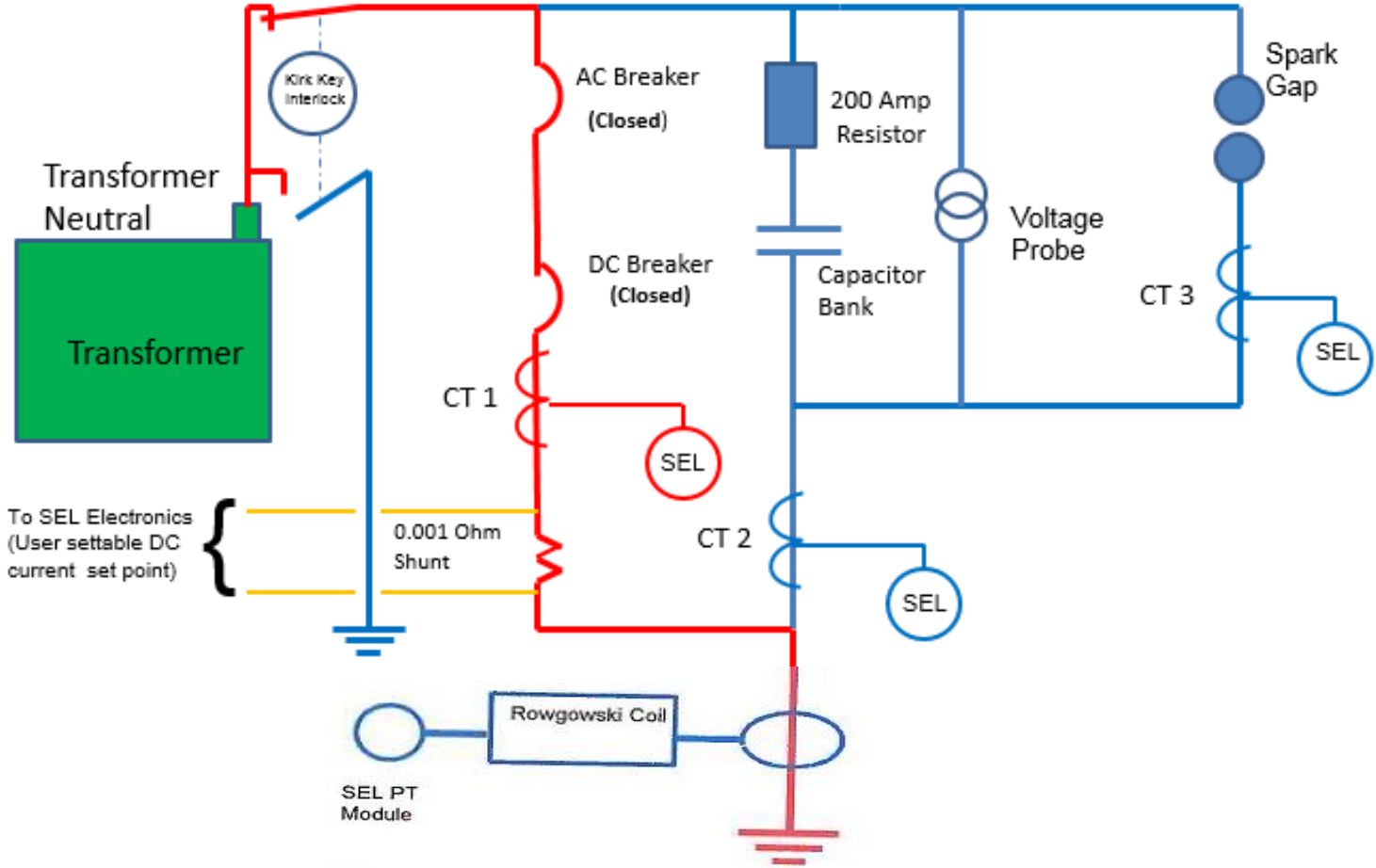
(GIC= Geomagnetic Induced Current)

When a ground fault occurs, spark gap protects capacitor and transformer from overvoltage. The spark gap assembly can handle many ground faults. Normal operation will cause the AC breaker to close to reset to stand-by mode (see next slide). If AC breaker fails to close a major alarm will be generated.



# Sequence of Operation Reset to Normal Mode

Normal Mode of Operation (Red = Current Flow)



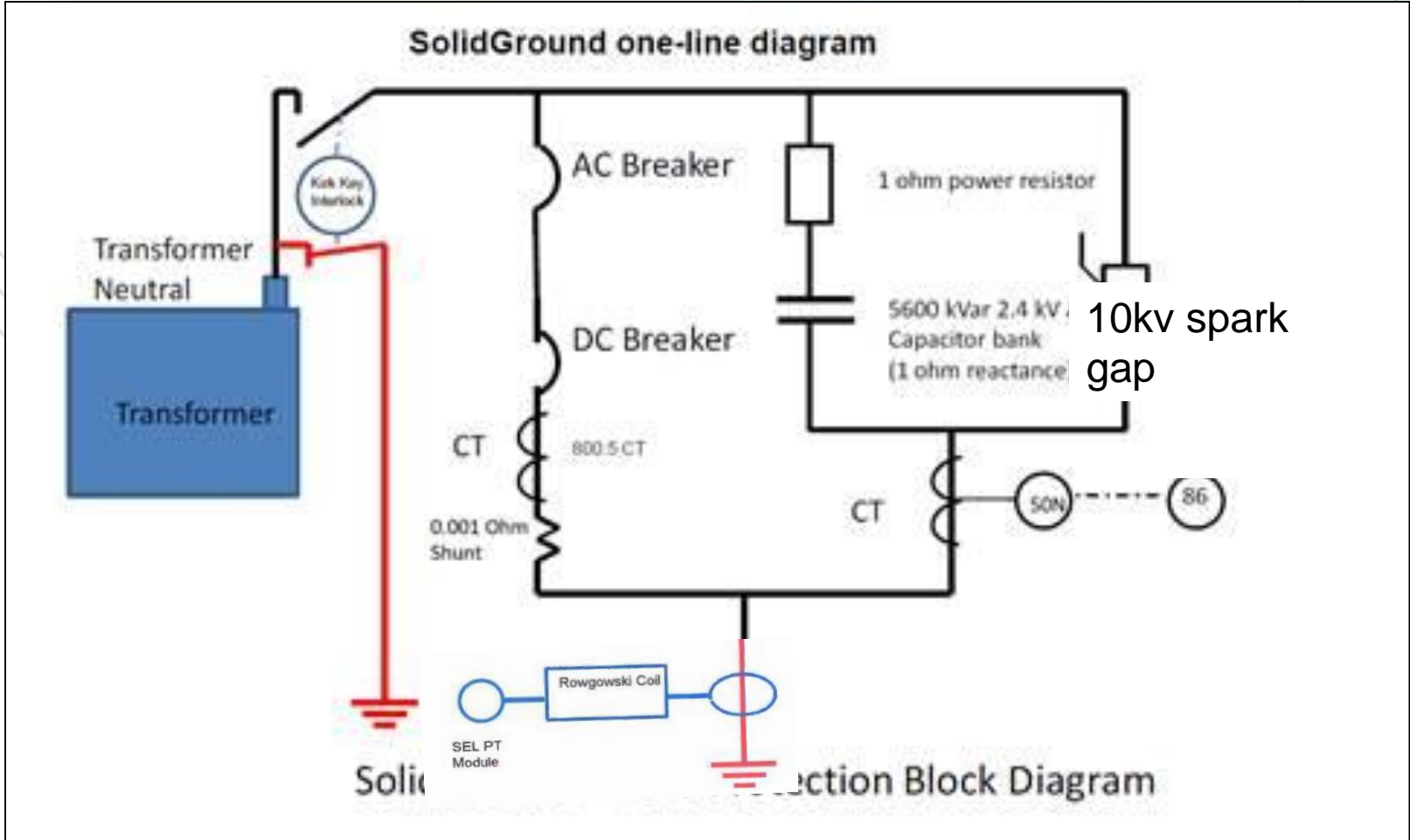
## *The Transformation*

- Fail Safe Resilience
  - Spark Gap
    - Non consumable
    - Repeatable
    - Inspected after 10 events
  - Rogowski Coil (N-G path proof)

Located on neutral bar heading to ground



# Morgan NID in "By-Pass" Mode



# Questions?