VOLTAGE REGULATION OF THE DISTRIBUTION GRID

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Voltage Regulation and Power Quality Track
Monday and Tuesday Sessions

SESSION 5 – How FLISR Impacts Voltage Regulation.

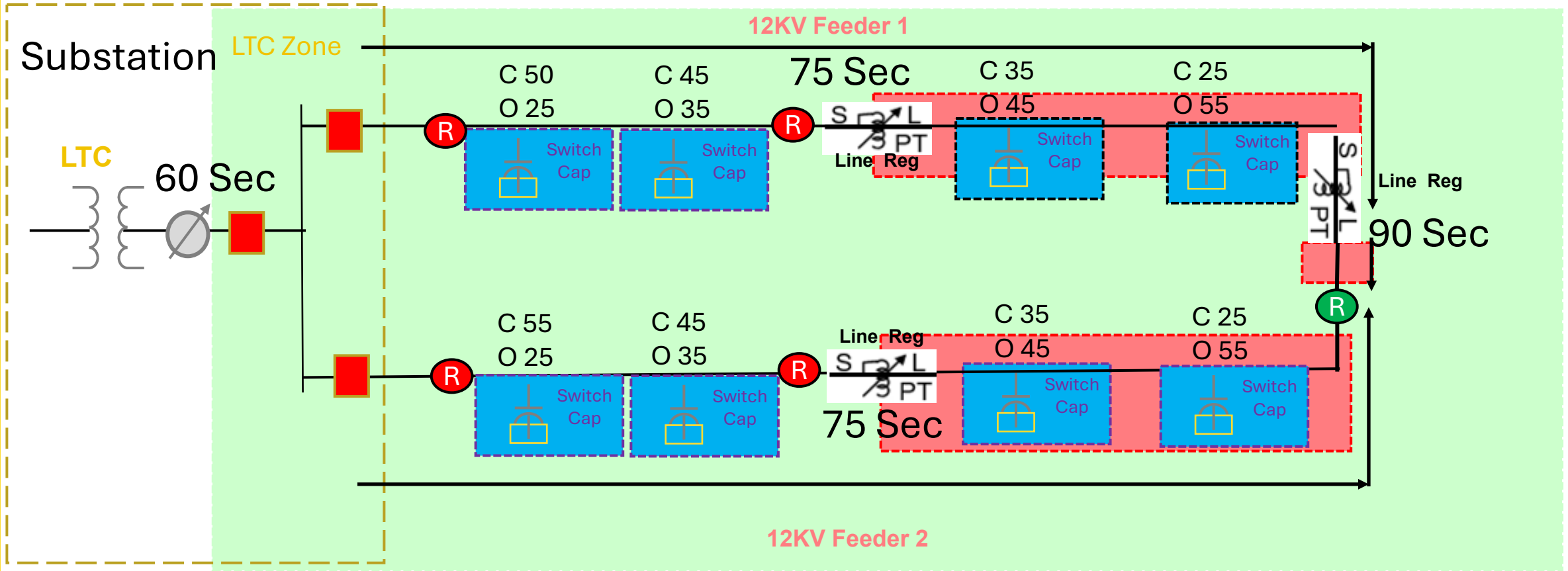
What is FLISR

Fault Location, Isolation, and Service Restoration

- Basically stated, it is the ability to place certain customer loads onto adjacent feeders for the following reasons:
  - A permanent fault is between the normal feeder and has been isolated.
  - The customer load is switched to another feeder to perform maintenance on equipment.

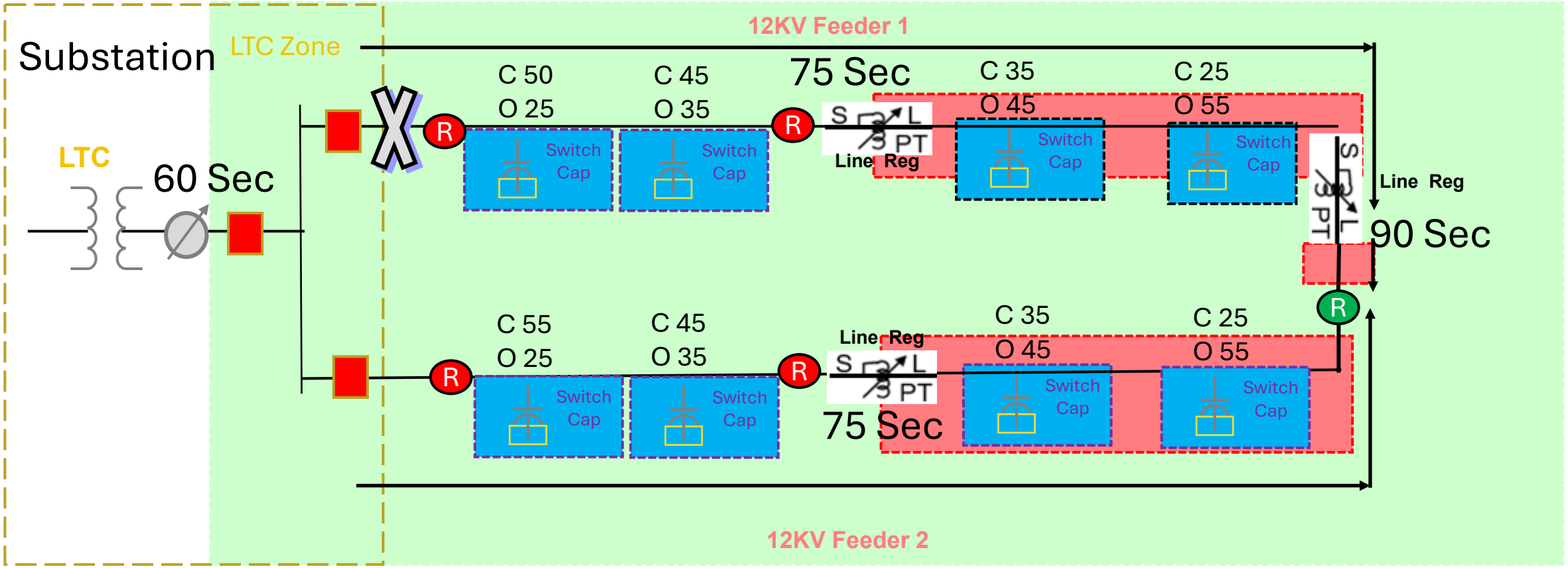
Normal Configuration

This is a typical layout with feeders from different substations and a normal Open Tie point between them.



Abnormal Configuration

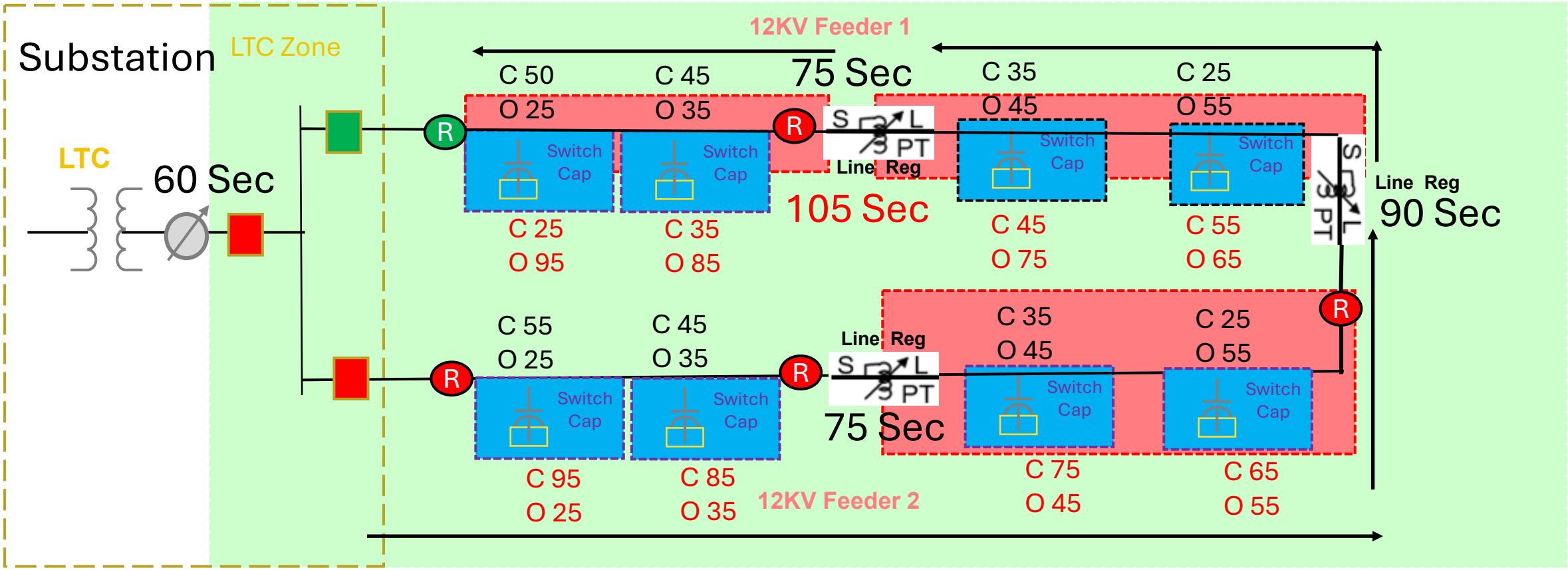
There is a fault close to the substation of feeder 1. The feeder breaker and closest recloser operate to isolate the fault. The NO Bus-Tie is closed and customers that were fed from feeder 1 are know being fed from feeder 2.



Abnormal Configuration – Cap Banks

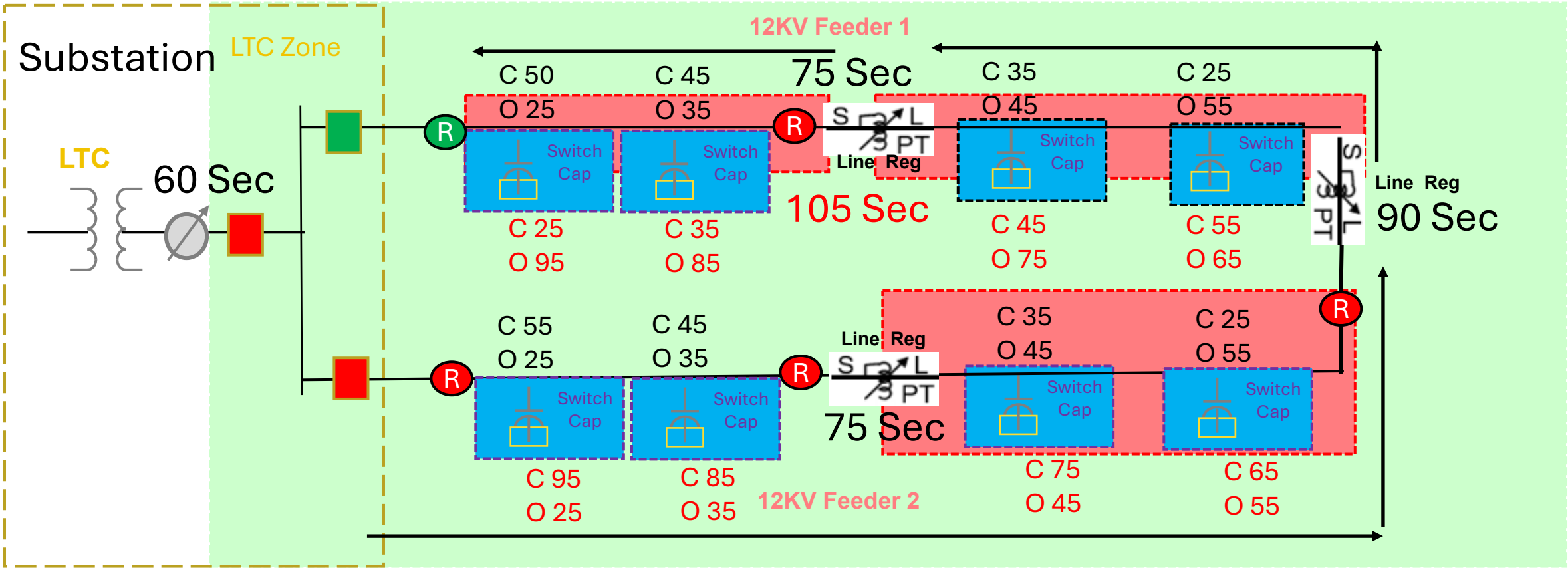
In the original configuration each feeder had 4 cap banks. In this configuration feeder 2 has gained three cap banks.

The Time Delays are not correct for cap banks. The time delays in Red are what they should be to maintain coordination.



Abnormal Configuration – Cap Banks – Delta Voltages

Remember that the Delta Voltage (the amount the voltage changes when a cap bank is operated) is proportional to the size of the bank (they are all 600 KVAr) and impedance back to the source. The Delta V will change on the cap banks that have changed circuits. The one that is currently at the end of feeder 2 was originally the first on feeder 1.

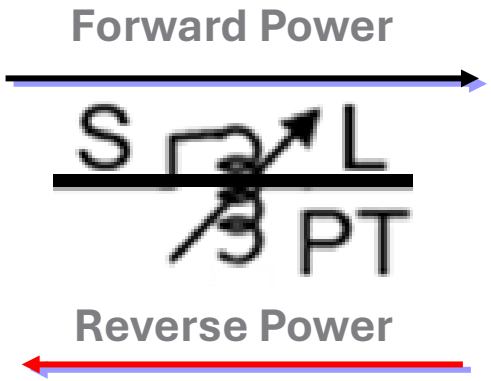


Abnormal Configuration – Regulators – Voltage Sense

- Most regulators only have one sense voltage and it is monitoring the load bushing.

- This is because regulators are unidirectional and only change the voltage on the load side of the regulator. When the voltage is out of band the regulator taps, which changes the voltage on the load side and the monitoring detects the new voltage.

- In reverse power mode cause by the change in source, the source is now on the load-side of the regulator. When the regulator taps it is changing the voltage on the source side. The control can't see the change in voltage because it is measuring the side that doesn't change. This will cause the control to continue to either raise or lower the voltage until it hits full 16R or 16L and will cause either high or lower voltages.

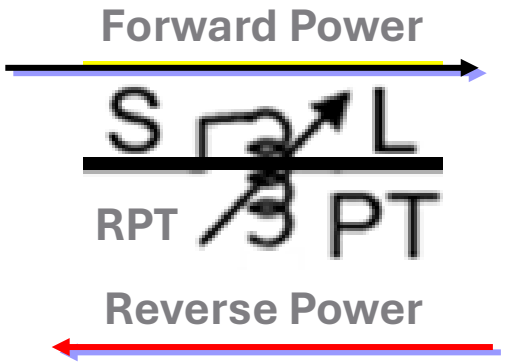


Abnormal Configuration – Regulators – Voltage Sense

- One solution to this problem is to add a PT to the source side of the regulator. In the normal direction the control will monitor the normal load PT and if it detects reverse power, it will switch and monitor the new RPT as this is now the load side of the regulator. This requires and extra PT and input into the control.

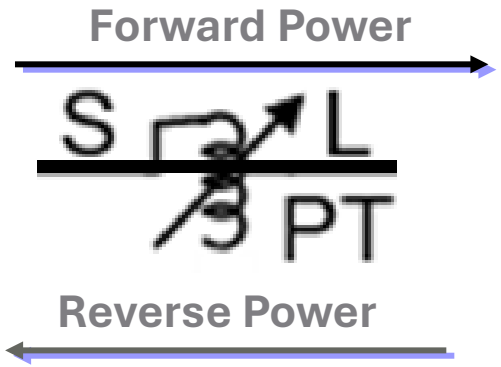
- The other solution is to use the only PT, now on the source side. The measured value is used to calculate the voltage on the Load side by knowing the tap position (and impedance) of the regulator. Regulators change the voltage by 0.75 volts per tap on a 120 V AC base.

- This works as long as the tap position is correct. If not, customers can experience high or low voltages.



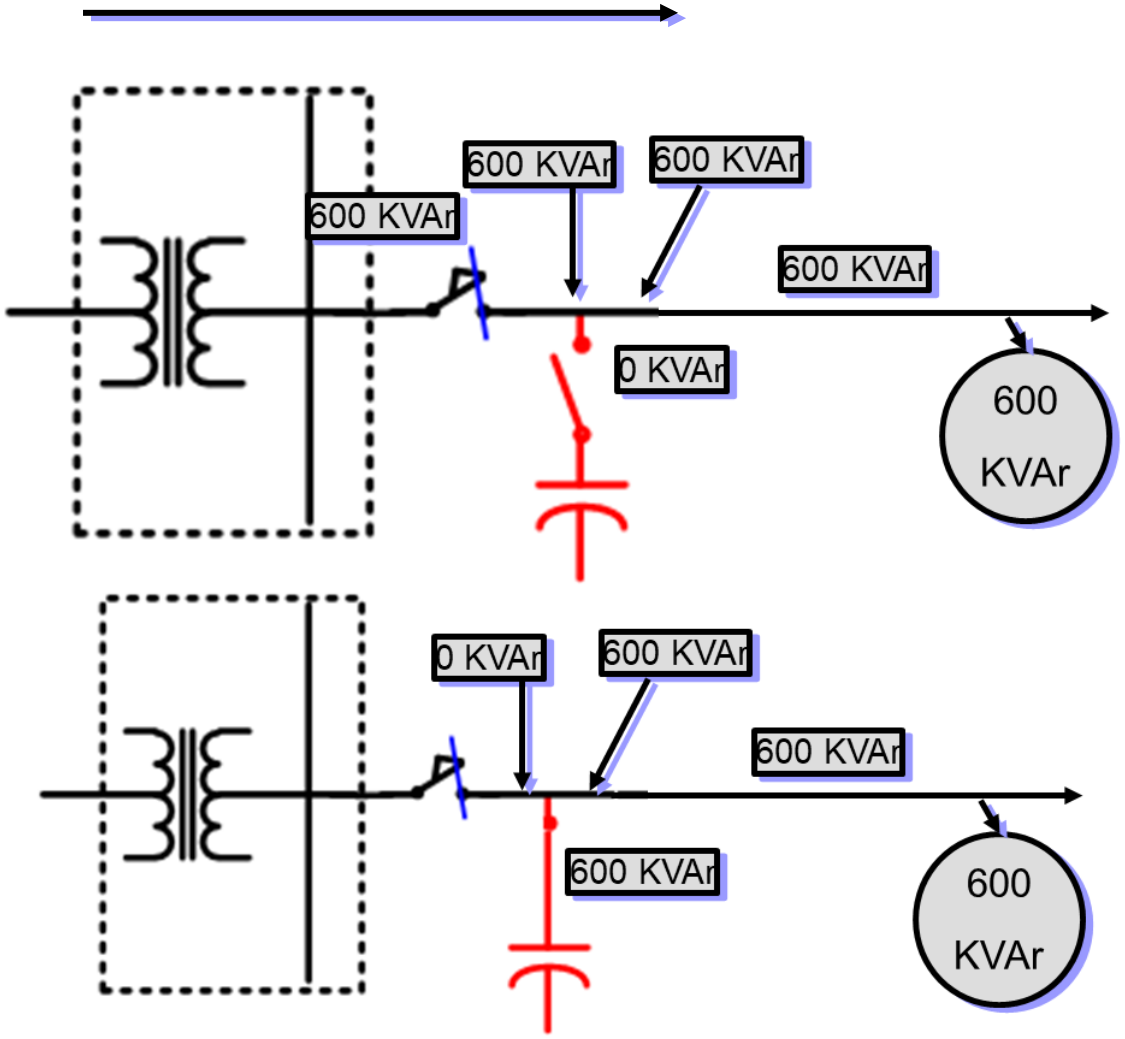
Abnormal Configuration – Regulators – Voltage Sense

To further complicate things, when the source has changed and the regulator is in reverse power, a lower will actually raise the voltage on the source (now load-side) side of the regulator and raise will lower the voltage. The control must send the opposite command to get the desired response.



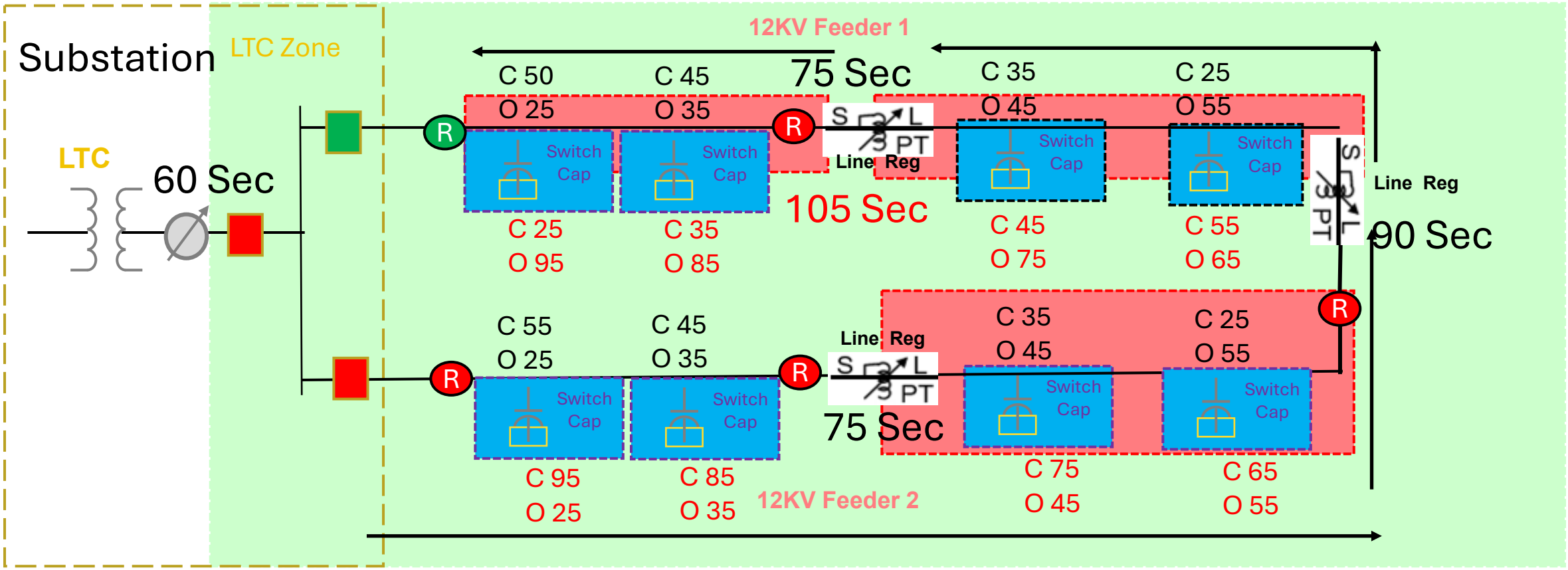
Advanced Capacitor Issues

- Line Post Sensors should be mounted between source and cap bank.
- Like regulators in reverse, capacitor banks on the new source will have power flowing in the opposite direction and they will not be able to see their contribution to the Vars.
- If the controller is operating in Var mode it may switch to voltage in reverse power.



Advanced Regulator Issues

- The regulator above the normal open tie will have any issue. In the normal operation there is no load on the regulator as it is next to the NO recloser.
- In reverse power when the NO recloser is closed it has load in the reverse direction.
- When the circuit is returned to normal the regulator should operate in the forward direction but there is not enough load to inform it is back in the forward direction.



Abnormal Configuration Summary

- When part of one circuit is switched to a new source the following conditions can occur that can create high or low voltages.

- For capacitors, the coordination is lost unless new tie delays are assigned. The impact each Capacitor has on the voltage may change. Capacitors that are further from the new source than the previous will create more voltage rise to the point it may lockout the bank or cause high voltages.

- For regulators, the ones that remain in forward power may pick up additional load and impedance. The ones that are now operating in reverse power have had the load and source swapped and if this is not accounted for the regulator will run away.

- Likewise, regulators in reverse power due to the source change will have to inverter the raise and lower commands while operating in reverse direction.

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