Voltage Dependent Relay Coordination

Purpose and Description:

Voltage dependent overcurrent relays are used on generator circuits to achieve satisfactory generator fault clearance and coordination with local and remote downstream relays after accounting for the generator terminal fault current decrement from sub-transient to transient to steady state values unlike other remote from generator circuits where coordination is achieved using a fixed fault current at which location the fault is almost constant without decay.

In addition to voltage dependent over current protection generators have exciter field forcing for close to generator faults to allow overcurrent protection to pick up.

3 times full load current for 3 seconds is average field forcing current commonly available in generator excitation system. Longer duration field forcing (eg: 3 times FLA for 10 seconds) is attainable but needs to be customized by the vendor as per requirement.

Voltage dependent relays are of two types:

- Voltage Controlled Relay
- Voltage Restrained Relay

For both type of relays the voltage threshold setting is set above the voltage seen by the relay during a remote from generator fault separated by large impedance of transformer or cable or OHL.

Voltage Controlled Relays

If the voltage seen by the relay is below the threshold voltage, then it is identified as a close to generator fault either on the generator circuit or on the outgoing/other circuits at common bus bar fed from the generator. For such faults, the current pickup of the relay will be reduced by a factor which will be dependent on the relay model. This curve is called the fault curve of the relay.

If the voltage seen by the relay is above the threshold voltage, then it is identified as a remote fault and for such faults, the current pickup will not be adjusted. This curve is called the load curve of the voltage dependent relay.

Typically the load curve is set at 100-150% of the generator full load current and the fault curve will be shifted to a factor of 25% of the load curve current pickup.

Voltage Dependent Relay Coordination

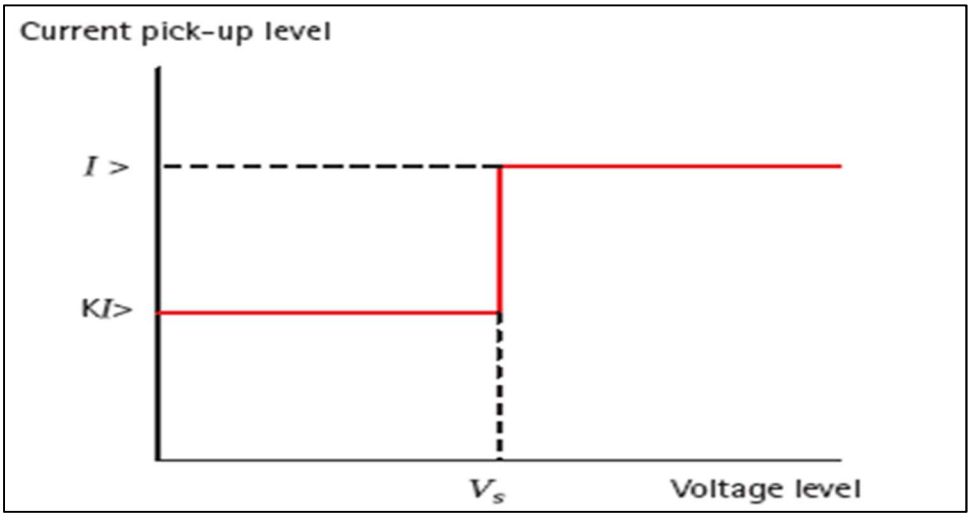

Figure: Typical Characteristics of Voltage Controlled Relay

Voltage Restrained Relays

The fundamental operation of all voltage dependent relays remain the same. The difference between voltage controlled and voltage restrained relay is that, unlike voltage controlled relays (only two possible relay curves) in voltage restrained relays the pickup values will be adjusted linearly based on the voltage seen by the relay between the threshold voltage and the rated voltage resulting in multiple possible relay curves.

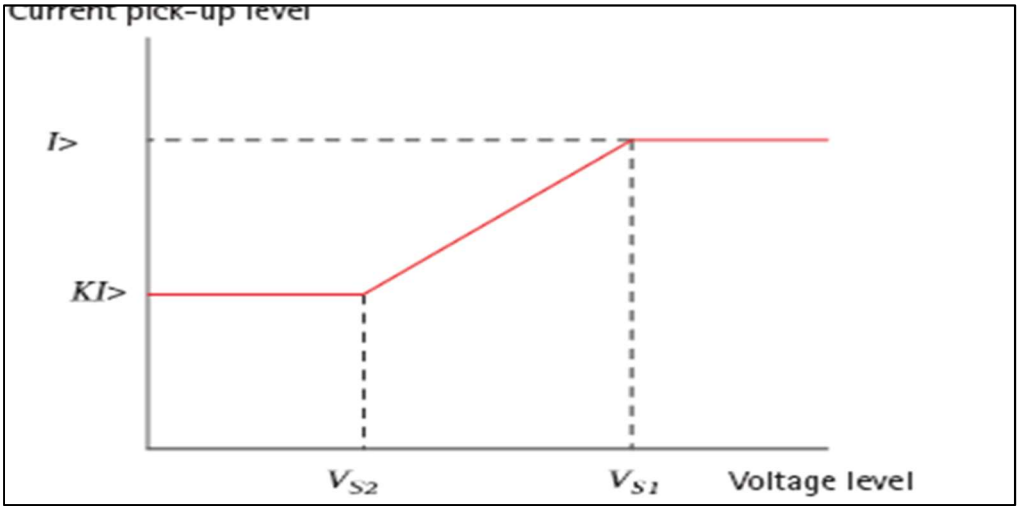

Figure: Typical Characteristics of Voltage Restrained Relay

In this exercise, only voltage restrained relay is considered.

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Procedure:

1) Open the ETAP File – 51V Exercise.OTI
   Library Location – C: -> ETAP 1610 -> lib -> etaplib1610.lib

i) The transformer primary relay is assumed to be set after coordination with downstream relays.

ii) Hence, select the entire system (excluding transformer) for coordinating the generator voltage restrained overcurrent relay with outgoing relay and click on "Create Star View"  .

ii) Zoom in on the selected system by clicking on the "Zoom in – Star One-Line" icon  in the Star View and place the network to the right hand side of the TCC.

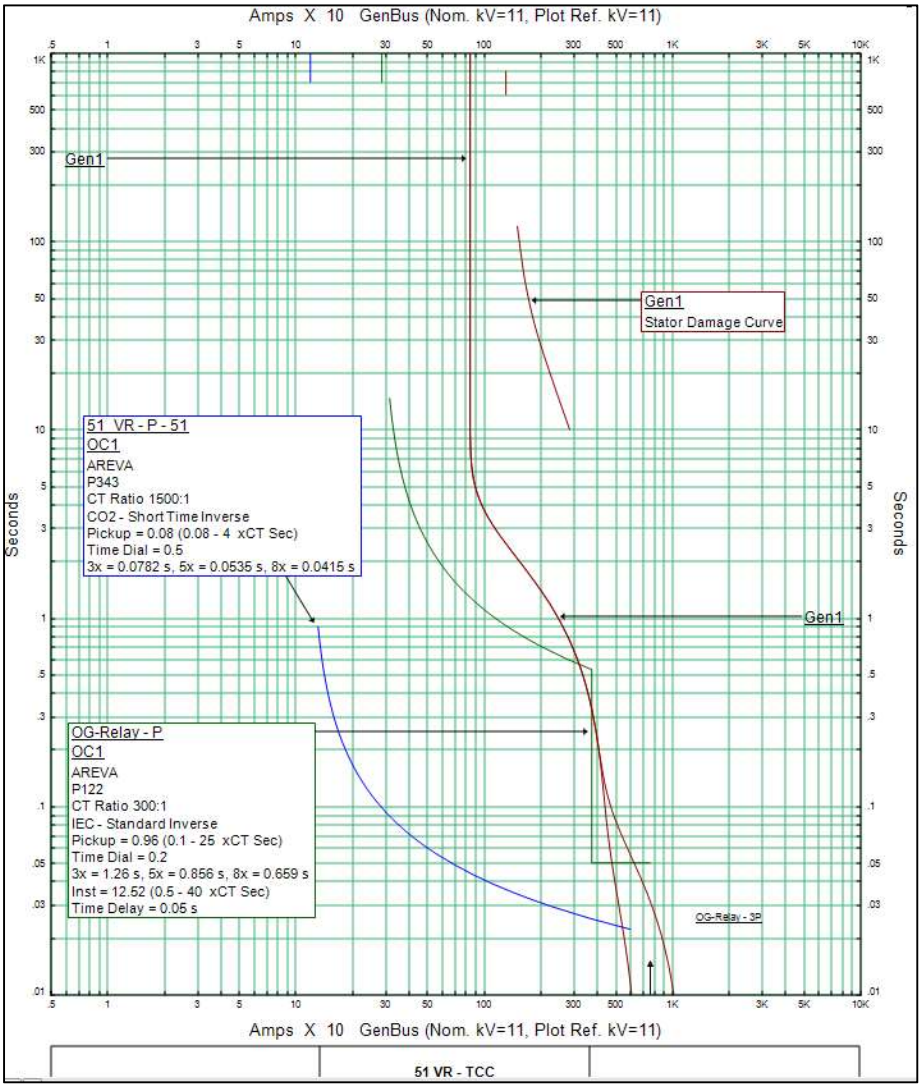
iii) Display the settings of the relays in the TCC by right clicking on the relay curves.

iv) Rename the TCC as "51 VR - TCC"

v) Disable all the protection function available in the generator incomer relay except overcurrent.

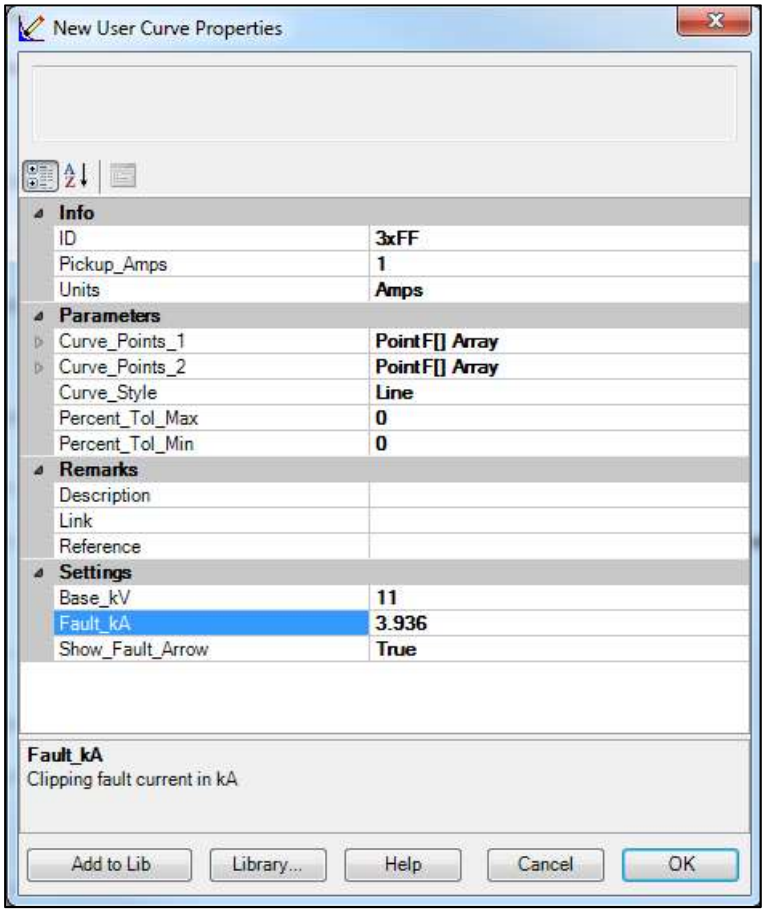
vi) Prior to the coordination, the TCC will look as shown below,

Voltage Dependent Relay Coordination



vii) Create a new "User Curve"  named 3xFF to indicate the field forcing current as shown below,

Voltage Dependent Relay Coordination



viii) Extend the newly created user curve 3xFF above 3 seconds.

ix) Double click on the 51_VR relay and revise the setting as given in the below table,

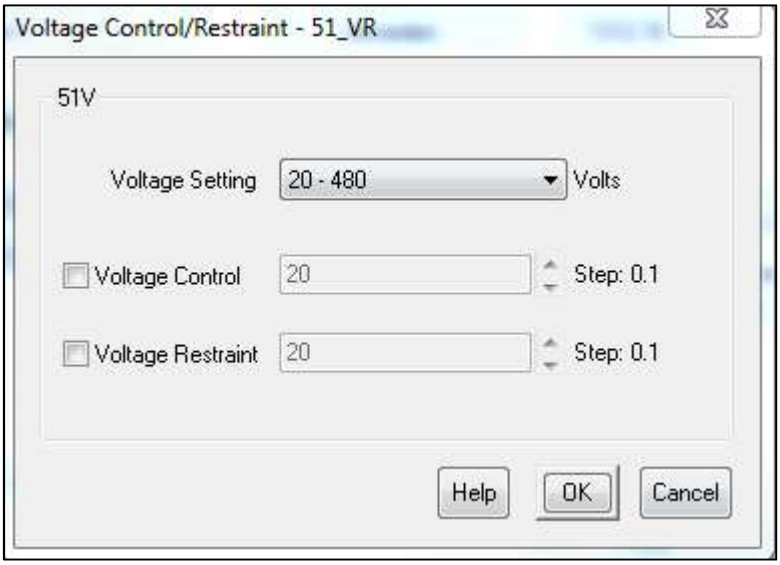
Curve Type	IEC Standard Inverse
Pickup (set as 150% of FLA)	1.31

x) Enable the checkbox 

and click the tab 

to open the following page,

Voltage Dependent Relay Coordination



xi) Check Voltage Restraint and set the threshold voltage as 60 (above the voltage seen by the relay for a remote fault) and enter the TMS as 0.25 (this value is arrived at ensuring coordination between the outgoing relay and the fault curve of voltage restrained relay). Now the TCC would look as shown below,

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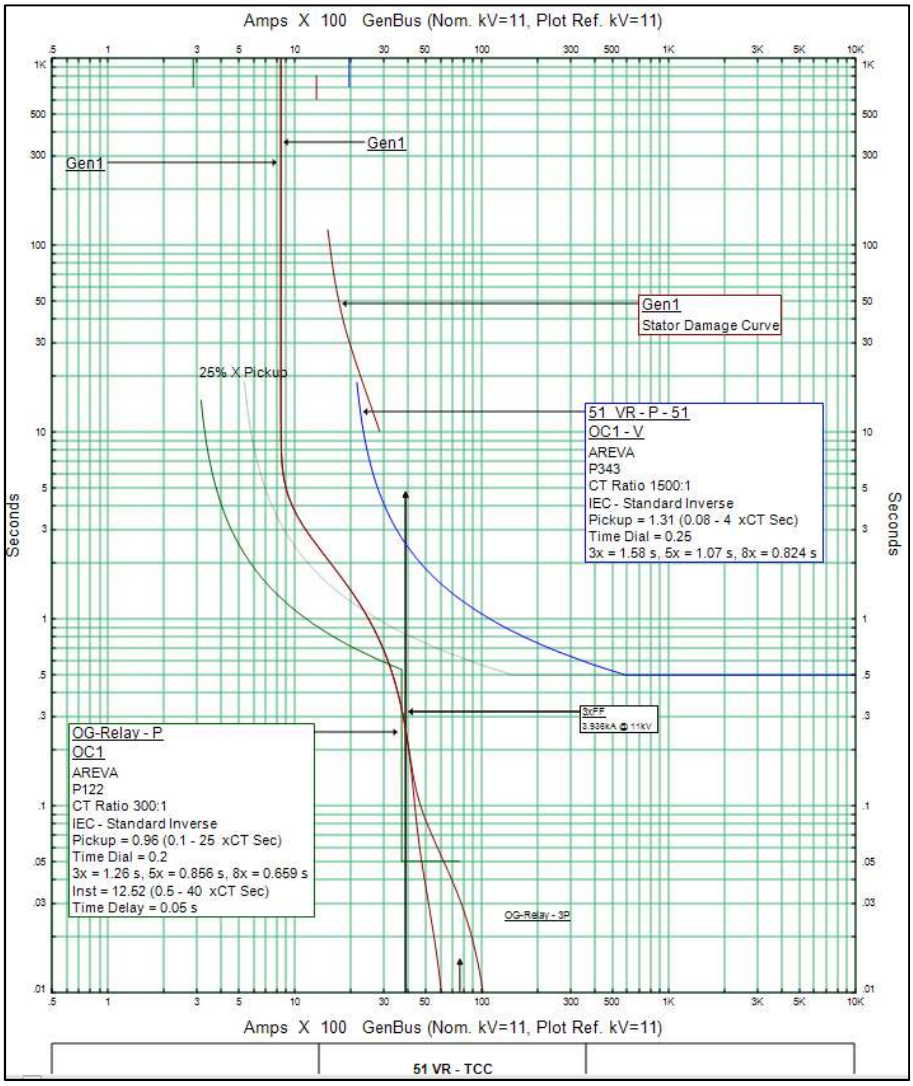

xii) From the above TCC, both the fault curve (25% x pickup) and the load curve can be seen.

xiii) The difference in operating time and the shifting in pickup for a close in outgoing fault and remote fault can be seen in the following normalized TCC.

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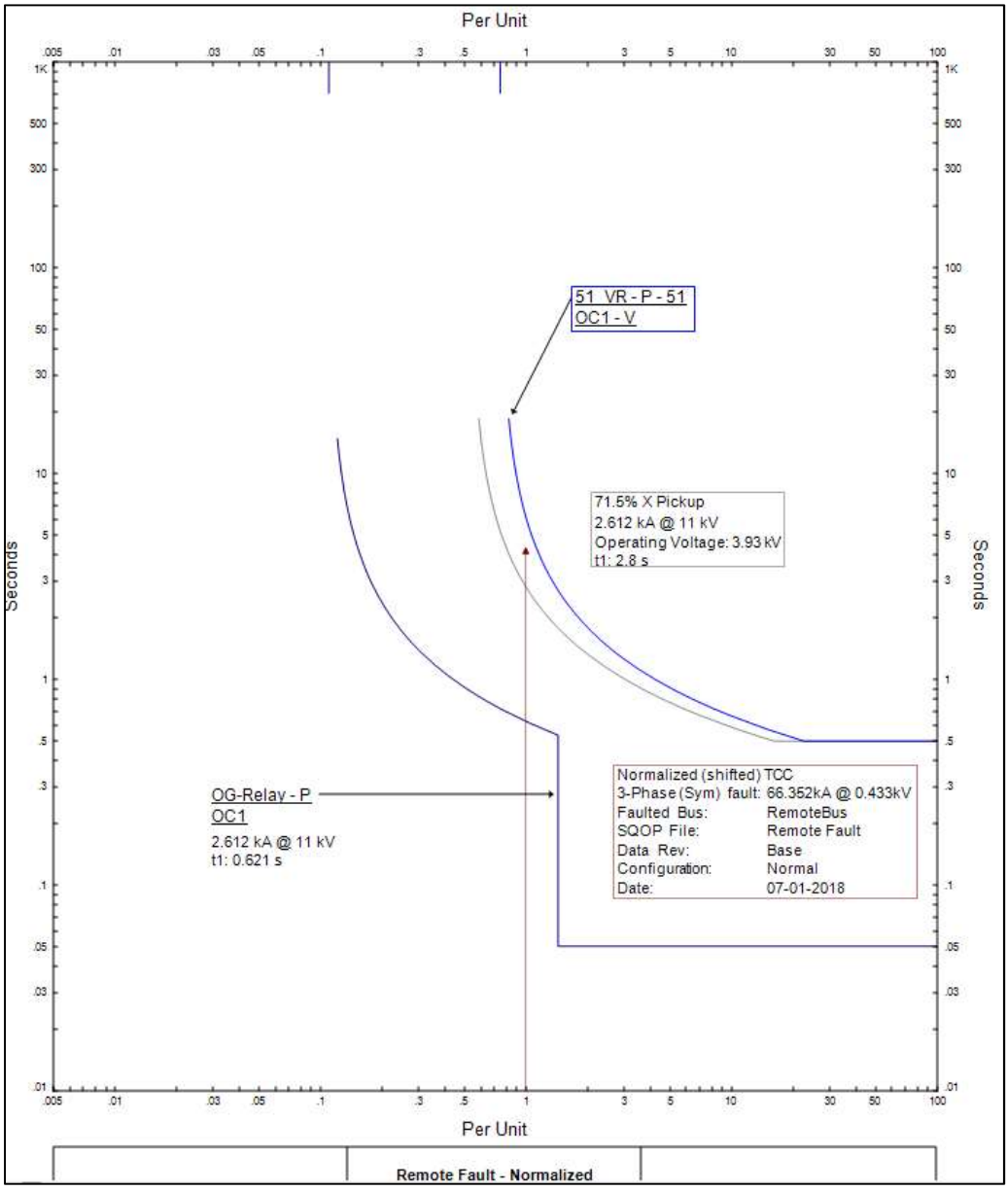

Figure: Normalized TCC for 3 Phase Fault at Remote Bus

Voltage Dependent Relay Coordination

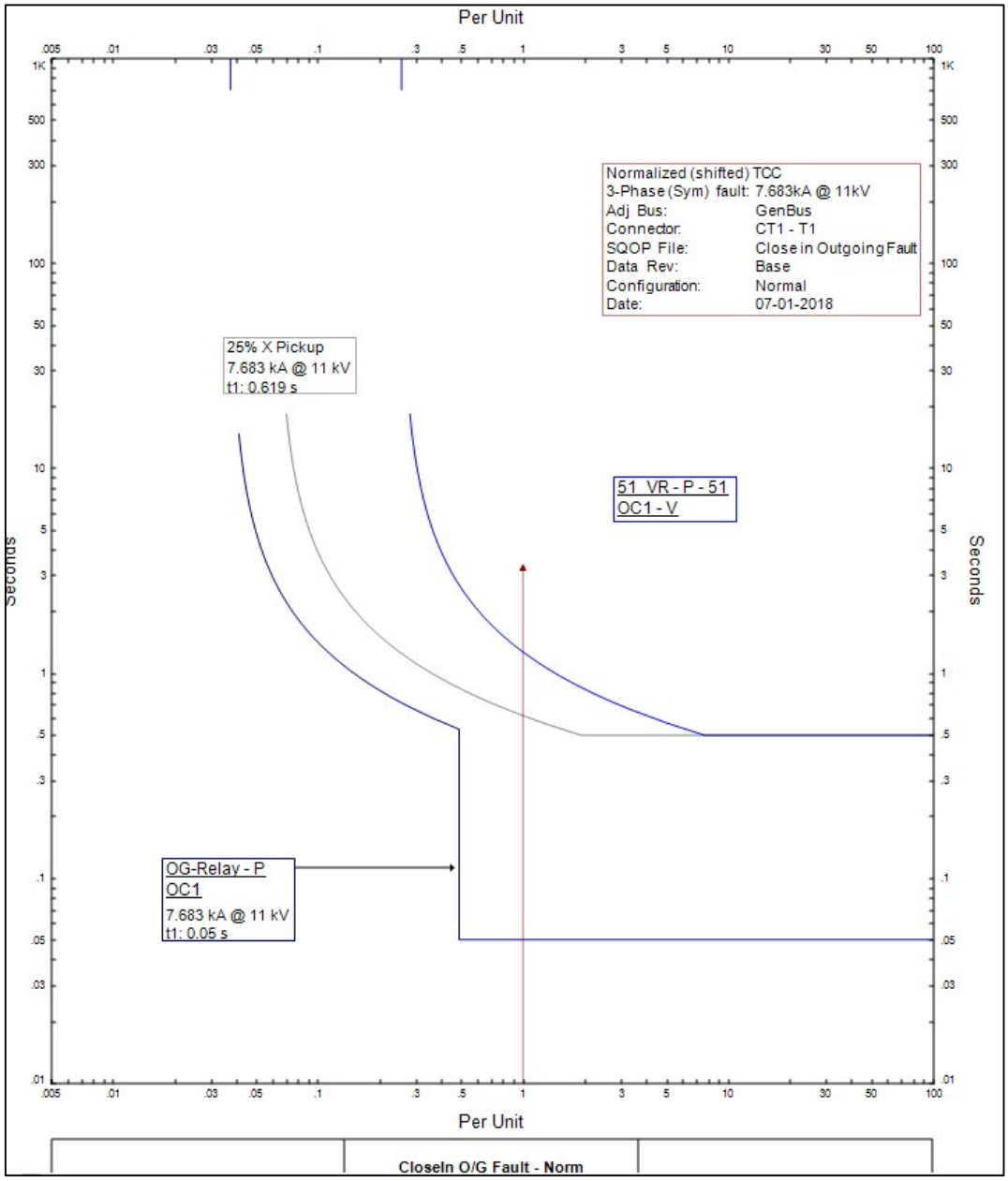

Figure: Normalized TCC for 3 Phase close-in fault at outgoing feeder from GenBus