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We Deliver.

Protection Settings Automation and Standardizing

Pedro Carvalho
Protection Engineer

Agenda

- Protection Settings
- Settings Workflow
- Standard Files
- Automation
- Q&A

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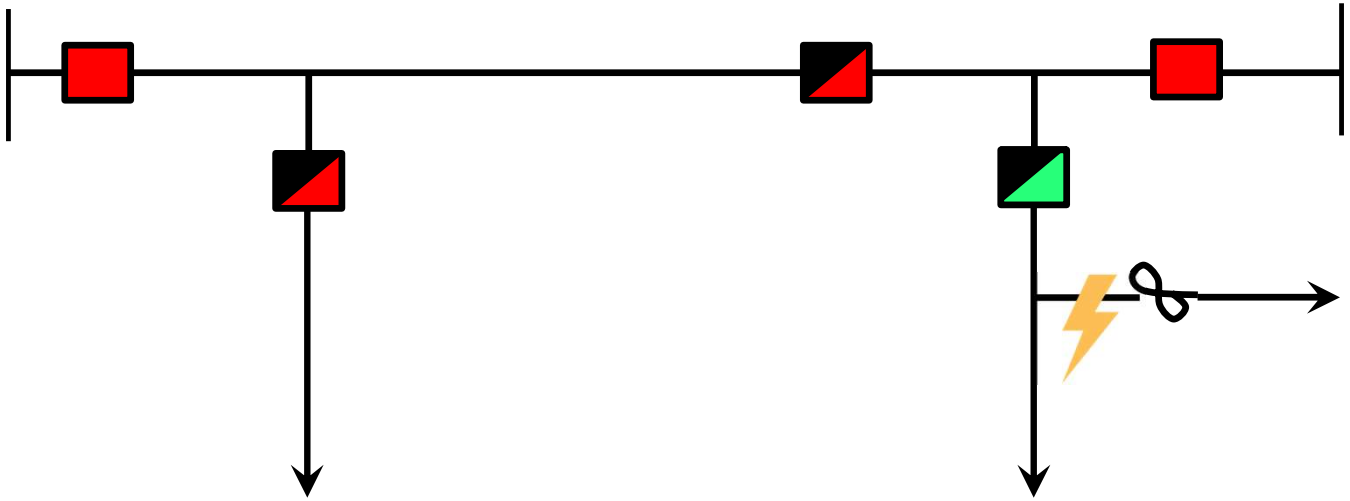
Protection Settings

A protection scheme is intended to keep the power system stable by isolating only the faulted elements, maintaining as much facilities as possible in operation as well as preventing assets from damage.



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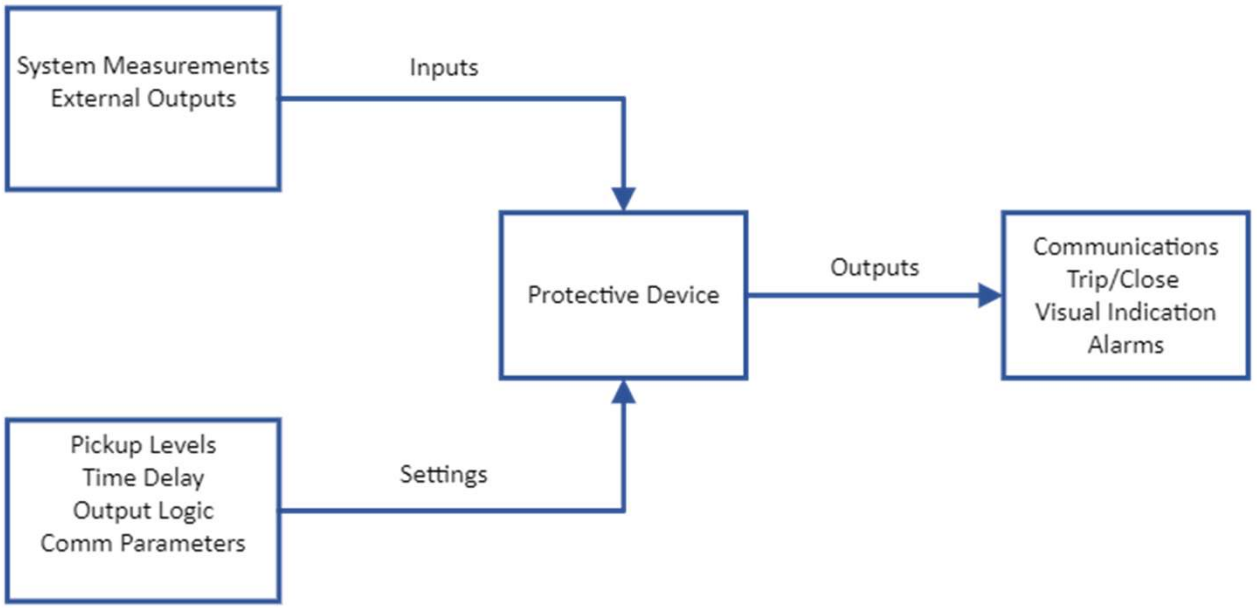
Protection Settings

The microprocessors devices used to protect the power systems from faults are normally programmed via settings files. These files are loaded to the device for any given configuration change.



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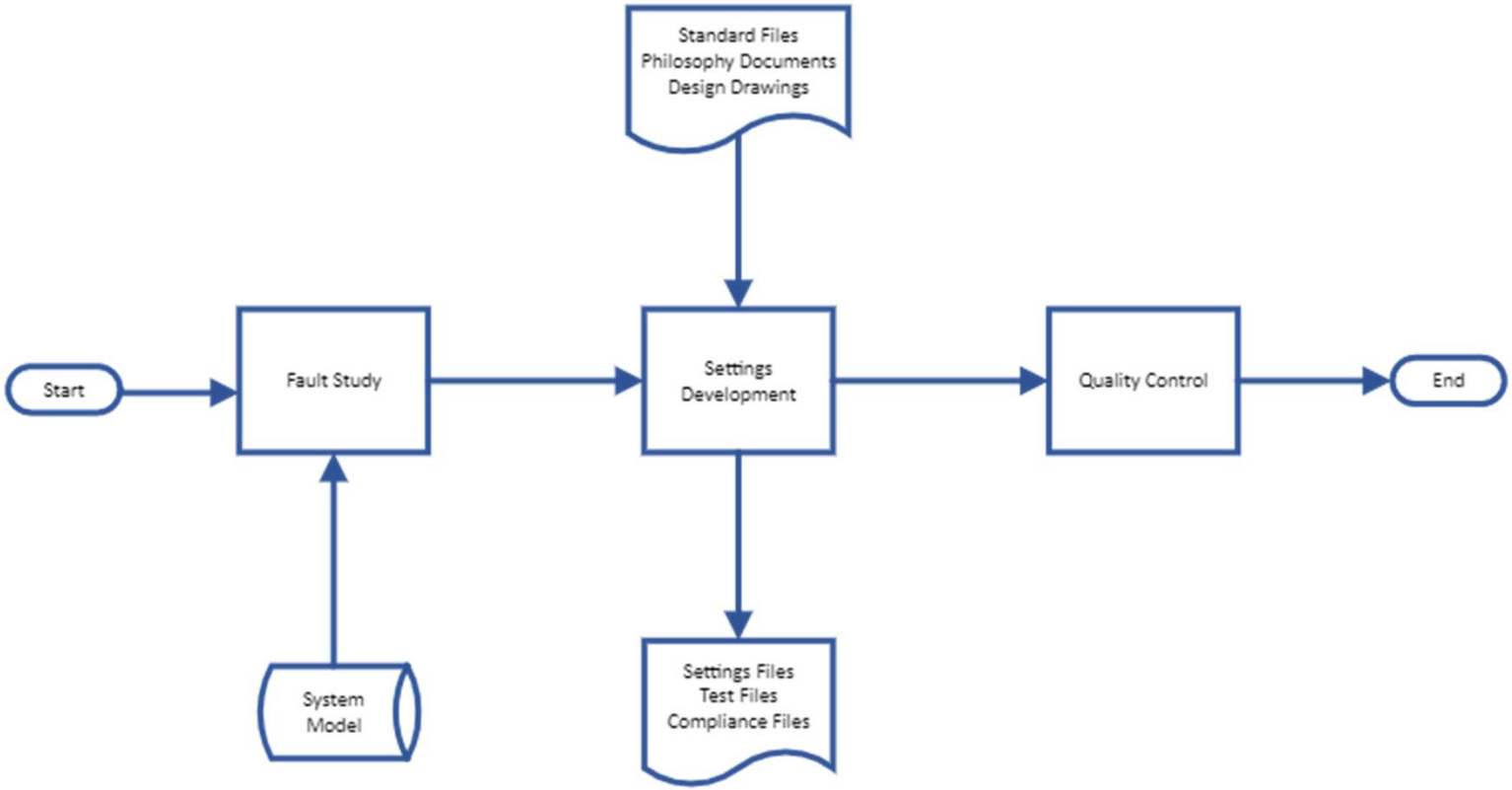
Settings Workflow



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Standard Files

Standard Settings Files

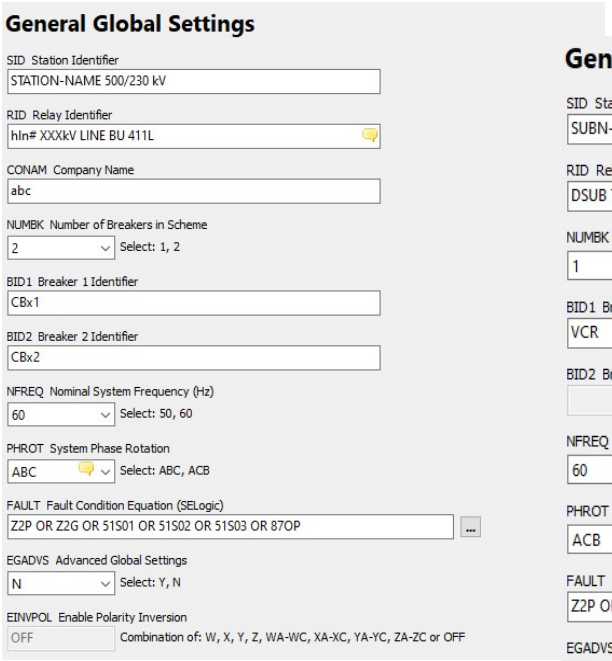

Figure 1: SEL-411L Standard Global Settings

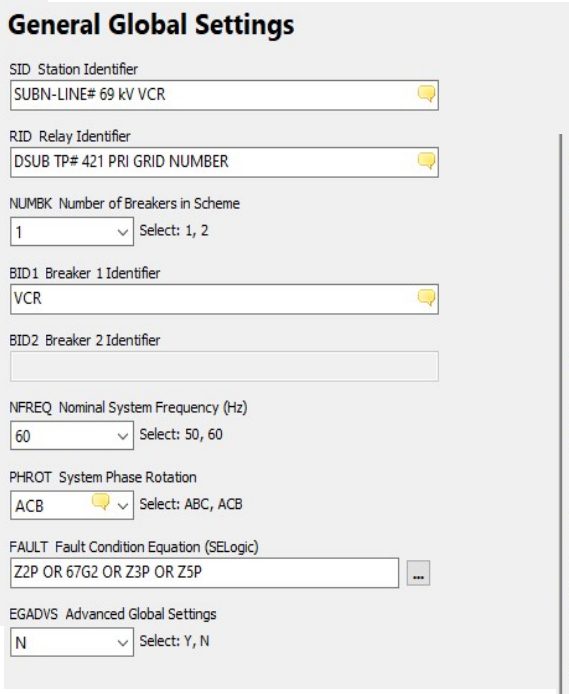

Figure 2: SEL-421 (VCR) Standard Global Settings

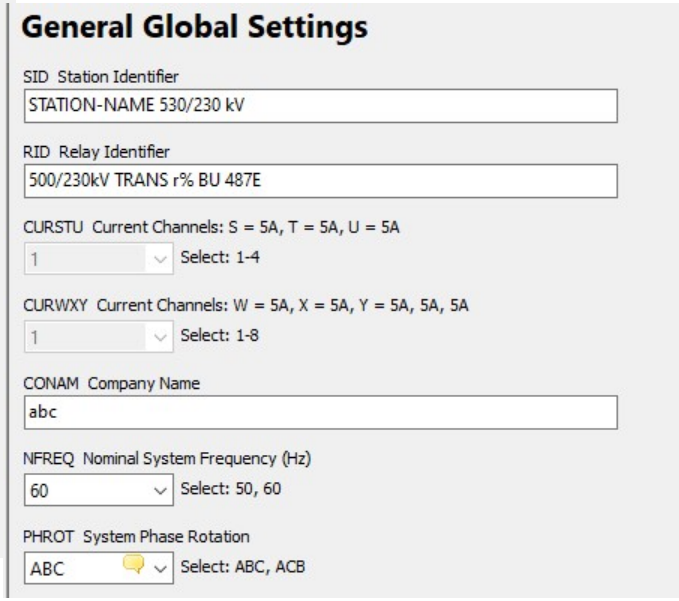

Figure 3: SEL-487E Standard Global Settings

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Standard Files

Protection Philosophy Documents

- Transmission Line Protection Philosophy
- Transformer Protection Philosophy
- Bus Protection Philosophy
- Capacitor Protection Philosophy
- Circuit Breaker Philosophy

1 Introduction and Protection Overview 9
1.1 Consideration for BES and non-BES Facilities 10
1.2 Line Loadability Requirements 12
1.3 Arc Resistance Calculations 13
1.3.1 230, 138 and 69 kV 13
1.3.2 500 kV 13
2 High-Speed Pilot Protection 14
2.1 Directional Comparison Schemes 14
2.1.1 Permissive Overreach Transfer Trip (POTT) 14
2.1.2 Direction Comparison Blocking (DCB) 15
2.2 Current Comparison Schemes 16
2.2.1 Data Synchronization and Communications Considerations 17
2.2.2 Percentage Differential Protection 18
2.2.3 Alpha Plane Differential Protection 19
2.2.3.1 Phase Differential Element Settings 20
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2.2.3.3 Zero-Sequence Differential Element Settings 22

Figure 1: Table of Contents from Line Protection Philosophy

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Standard Files

Calculation Sheets

- Line SEL-421, 411L
  - TP&C Calc Sht Line SEL-421&411L_PR&BU_20220906.xlsm
- Bus Section CB SEL-451
  - TP&C Calc Sht Bus Section CB SEL-451_CN_20201202.xlsm
- Bus SEL-487B
  - TP&C Calc Sht Bus SEL-487B_PR&BU_20190909.xlsm
- Cap Bank SEL-487E
  - TP&C Calc Sht Cap Bank 5-String SEL-487E_PR_20201102.xlsm
  - TP&C Calc Sht Cap Bank 9-String SEL-487E_PR1&2_20161207.xlsm
  - TP&C Calc Sht Cap Bank Double Wye SEL-487E_PR_20201218.xlsm
  - TP&C Calc Sht Cap Bank Neutral CT Only SEL-487E_PR_20201218.xlsm
- Transformer SEL-487E
  - TP&C Calc Sht Transformer SEL-487E_PR&BU_20200922.xlsm
- Cap Bank SEL-487V
  - TP&C Calc Sht Cap Bank 5&9-String SEL-487V_BU_20201112.xlsm
  - TP&C Calc Sht Cap Bank Double Wye & Neutral CT Only SEL-487V_BU_20201214.xlsm
- Line SEL-T401L
  - TP&C Calc Sht Line SEL-T401L_PR&MON_20221031.xlsm

Figure 1: List of Calculation Sheets

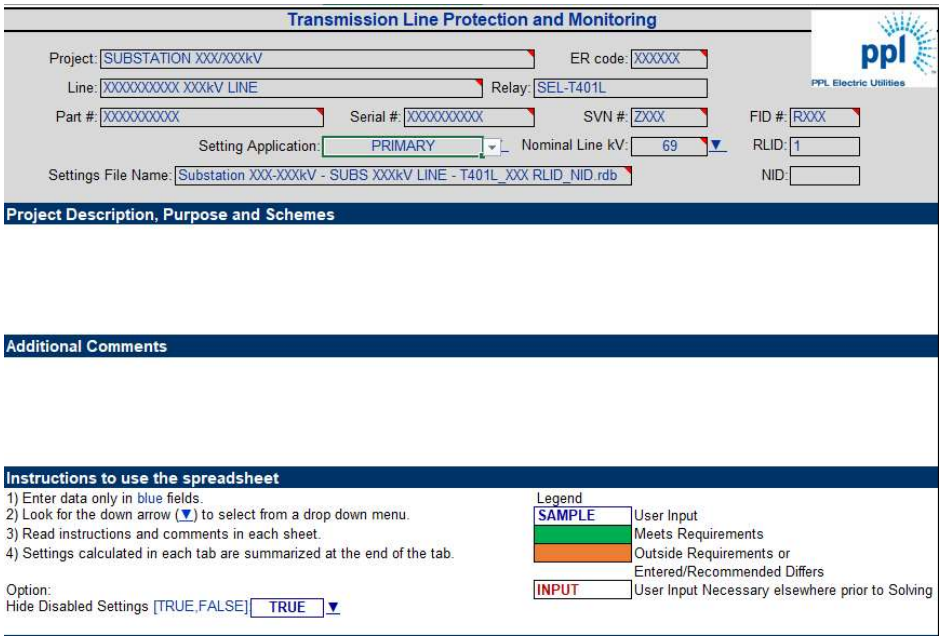

Figure 2: T401L Calculation Sheet Cover Page

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Standard Files

Quality Assurance/Control Checklist

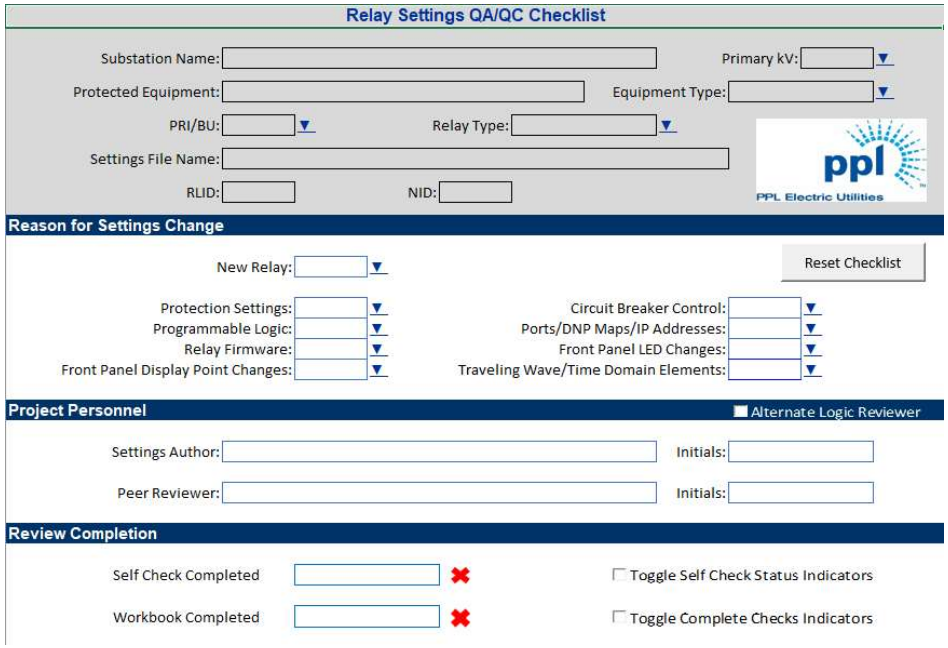

Figure 1: QA/QC Checklist Cover Page

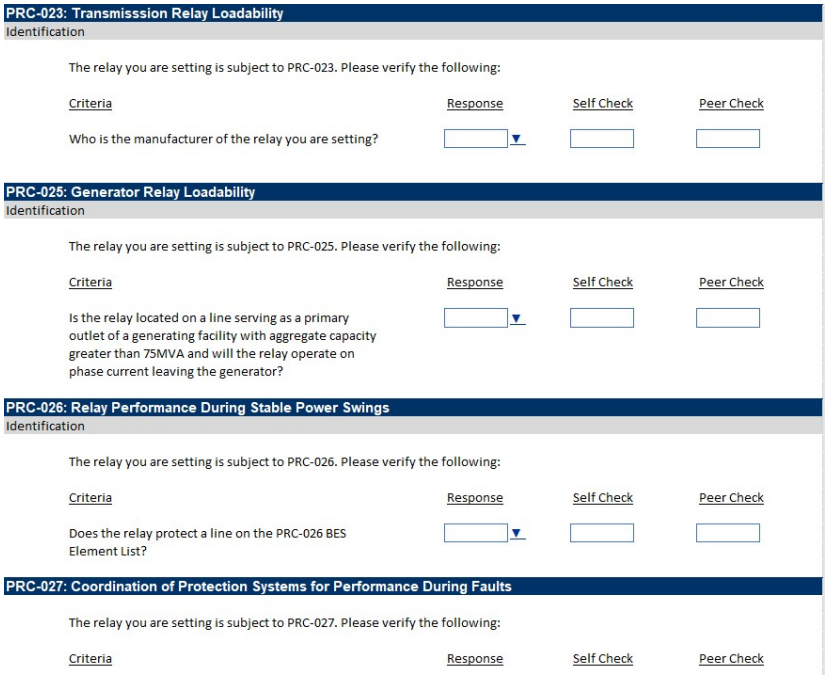

Figure 2: QA/QC Checklist Compliance Section

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Automation

Settings Calculations

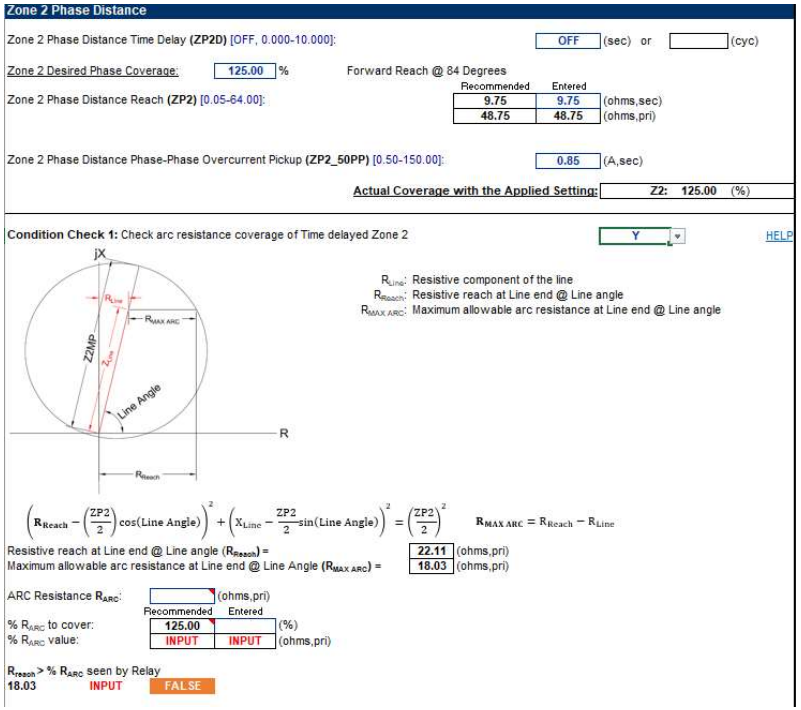

Figure 1: Arc Resistance Check

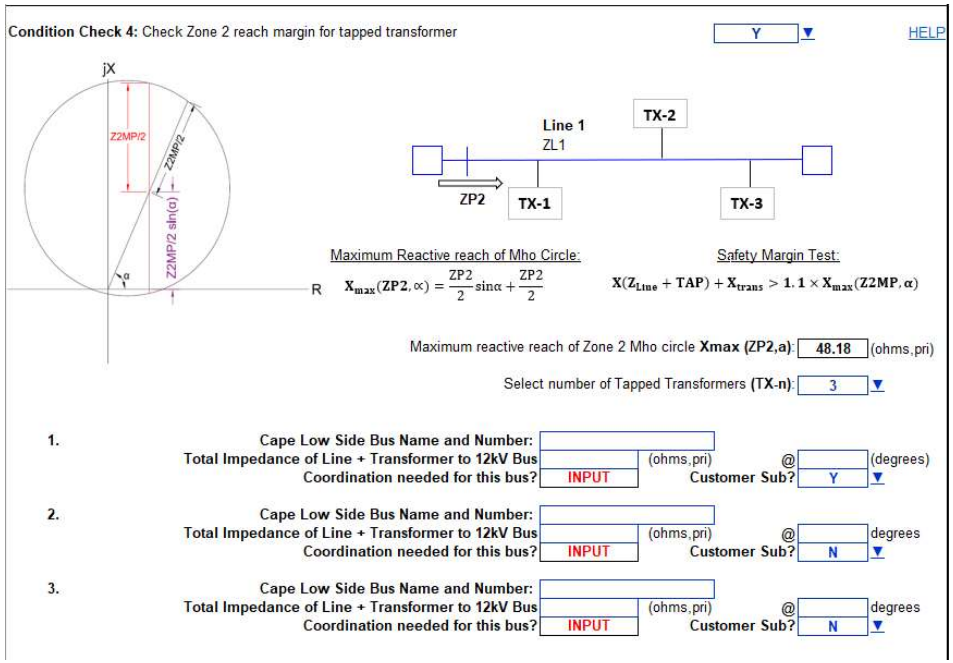

Figure 2: Tapped Transformer Coordination Check

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Automation

Settings File Update

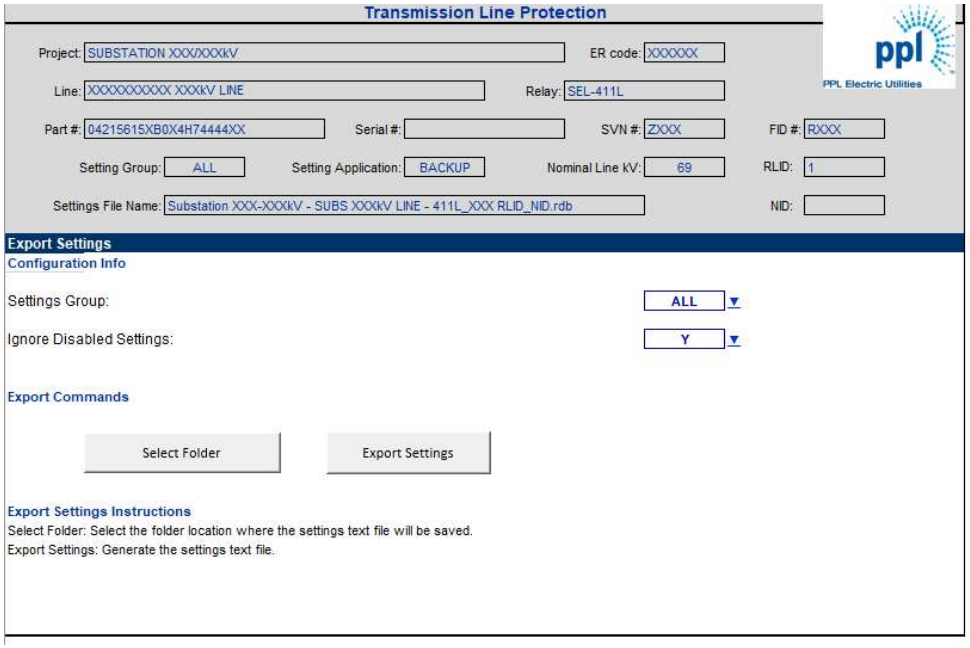

Figure 1: Calc Sheet Settings Export Feature

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Automation

Fault Study Macro

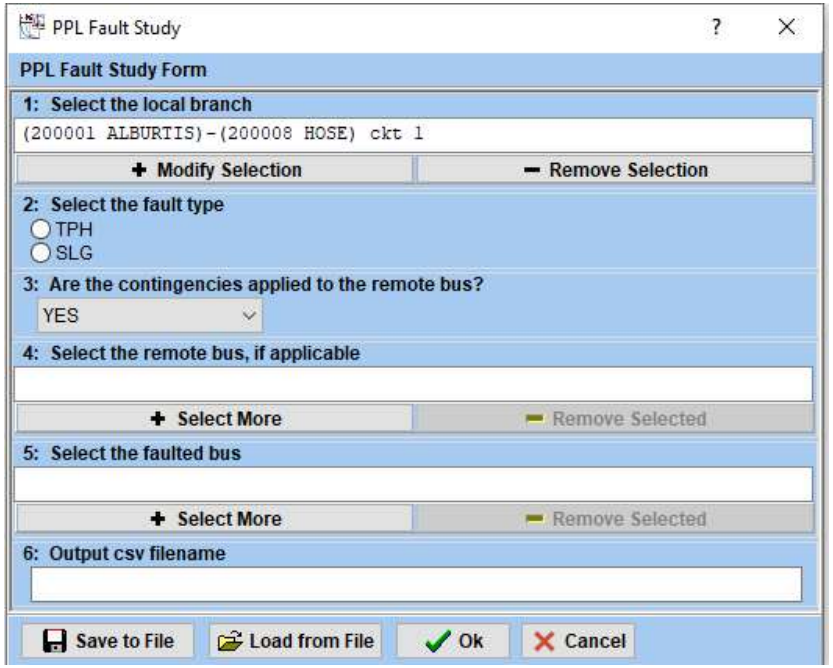

Figure 1: Custom Macro Guide User Interface

Fault Typ	Faulted B	Faulted B	Local Bus	3I0 (A)	/_3I0	Iph_fault	/_Iph_fau	System Condition	Tested Line
SLG	208040	MONT	GLBR	1591.57	-77.205	31661.2	-86.53	MONT TR 230/24kV	MONT-GLBR
SLG	208040	MONT	GLBR	1583.8	-77.2	31506.6	-86.525	MONT TR 230/24kV	MONT-GLBR
SLG	208040	MONT	GLBR	1478.9	-76.685	40771	-87.164	MONT-MONTSCR1	MONT-GLBR
SLG	208040	MONT	GLBR	1478.75	-76.683	40772.3	-87.164	MONT-MONTSCR2	MONT-GLBR
SLG	208040	MONT	GLBR	1445.96	-76.752	39427.1	-87.173	MONT-GLBR 230kV	MONT-MILT 2
SLG	208040	MONT	GLBR	1445.96	-76.752	39427.1	-87.173	MONT-MILT 230kV	MONT-GLBR
SLG	208040	MONT	GLBR	1445.87	-76.753	39427.9	-87.172	MONT-GLBR 230kV	MONT-MILT 2
SLG	208040	MONT	GLBR	1445.87	-76.753	39427.9	-87.172	MONT-MILT 230kV	MONT-GLBR
SLG	208040	MONT	GLBR	1428.99	-76.721	41219.4	-87.156	MONT-GLBR 230kV	None
SLG	208040	MONT	GLBR	1413.99	-76.58	40139.9	-87.142	MONT-GLBR 230kV	MONT-SAEG
SLG	208040	MONT	GLBR	1413.99	-76.58	40139.9	-87.142	MONT-SAEG 230kV	MONT-GLBR
SLG	208040	MONT	GLBR	1413.99	-76.58	40139.9	-87.142	MONT-SAEG 230kV	MONT-GLBR
SLG	208040	MONT	GLBR	1407.94	-76.341	38921.1	-87.243	MONT-GLBR 230kV	MONT-COLU
SLG	208040	MONT	GLBR	1407.94	-76.341	38921.1	-87.243	MONT-COLU TR2 2	MONT-GLBR
SLG	208040	MONT	GLBR	1053.55	-75.175	32010.9	-86.369	MONT TR 230/24kV	MONT-MILT 2
SLG	208040	MONT	GLBR	1053.46	-75.176	32012.1	-86.368	MONT TR 230/24kV	MONT-MILT 2
SLG	208040	MONT	GLBR	1048.76	-75.171	31865.3	-86.365	MONT TR 230/24kV	MONT-MILT 2
SLG	208040	MONT	GLBR	1048.67	-75.172	31866.5	-86.364	MONT TR 230/24kV	MONT-MILT 2
SLG	208040	MONT	GLBR	1026.73	-75.078	33818.9	-86.418	MONT TR 230/24kV	None
SLG	208040	MONT	GLBR	1024.01	-74.64	31597.4	-86.506	MONT TR 230/24kV	MONT-COLU
SLG	208040	MONT	GLBR	1022.23	-75.074	33670.6	-86.413	MONT TR 230/24kV	None
SLG	208040	MONT	GLBR	1019.22	-74.634	31449.4	-86.501	MONT TR 230/24kV	MONT-COLU
SLG	208040	MONT	GLBR	1018.72	-74.908	32790.3	-86.4	MONT TR 230/24kV	MONT-SAEG
SLG	208040	MONT	GLBR	1014.09	-74.903	32641.1	-86.395	MONT TR 230/24kV	MONT-SAEG
SLG	208040	MONT	GLBR	961.273	-74.547	41267.8	-87.069	MONT-MONTSCR1	MONT-MILT 2
SLG	208040	MONT	GLBR	961.212	-74.548	41268.8	-87.069	MONT-MONTSCR1	MONT-MILT 2
SLG	208040	MONT	GLBR	961.178	-74.545	41269.3	-87.07	MONT-MONTSCR2	MONT-MILT 2
SLG	208040	MONT	GLBR	961.117	-74.546	41270.3	-87.07	MONT-MONTSCR2	MONT-MILT 2
SLG	208040	MONT	GLBR	945.517	-74.519	43031.3	-87.066	MONT-MONTSCR1	None
SLG	208040	MONT	GLBR	945.428	-74.517	43032.7	-87.067	MONT-MONTSCR2	None
SLG	208040	MONT	GLBR	938.197	-74.137	40811.2	-87.153	MONT-MONTSCR1	MONT-COLU

Figure 2: Custom Macro Output

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Future Enhancements

- Relay Settings Maintained in CAPE
- Automated Settings Adequacy Check
- Automated Compliance Checks

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Questions?

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