E/F نتایج مشروح محاسبات رله های

Company or Region Name = ZREC
Group or Checker Name = Group_1
Substation Name = Test_230kV_OK
Voltage = 230 / 63 kV
Calculation date & time = 2016 / 2 / 8 on Monday at 16:34:4
Transformer(s) Type = Autotransformer
S [Power Transformer(s) apparent power] = 160 MVA
Sbase = 100 MVA
Comment for this Calculation: محاسبات آزمايشي

..... Short circuit resaults : .....

Earth Fault Currents:

جریان خطای تکفاز دیده شده توسط رله فیدرهای خروجی در حالت ماکزیمم سطح اتصال کوتاه شبکه و حضور ترانس های موازی:
IE1(Substation) = 2.54 pu ===> 2327.73 A

جریان خطای تکفاز فیدرکوپلاژ در حالت ماکزیمم سطح اتصال کوتاه شبکه و حالت تک ترانسی بدون در نظر گرفتن اثر جریان تزریقی پست های مجاور متصل به فیدرهای خروجی:
IE2(Substation) = 1.296 pu ===> 1187.69 A

جریان خطای تکفاز فیدر سمت اولیه در حالت ماکزیمم سطح اتصال کوتاه شبکه بدون در نظر گرفتن اثر جریان تزریقی پست های مجاور متصل به فیدرهای خروجی:
IE3(Substation) = 32.42 pu ===> 8138.13 A

جریان خطای تکفاز فیدرهای خروجی در حالت مینیمم سطح اتصال کوتاه شبکه و حالت تک ترانسی:
IE4(Substation) = 1.228 pu ===> 1125.37 A

حاصل تقسیم جریان خطای تکفاز فیدرکوپلاژ بر تعداد ترانس ها در حالت مینیمم سطح اتصال کوتاه شبکه و حضور ترانس های موازی :
IE5(Substation) = 1.14 pu ===> 1044.73 A

جریان خطای تکفاز فیدر سمت اولیه در حالت مینیمم سطح اتصال کوتاه شبکه:
IE6(Substation) = 10.899 pu ===> 2735.89 A

جریان های اتصال کوتاه زمین مورد استفاده در محاسبات:

IeMax(1) = 2327.73 A
IeMax(2) = 1187.69 A
IeMax(3) = 1187.69 A
IeMax(4) = 1187.69 A
IeMax(5) = 8138.13 A
IeMax(6) = 1187.69 A

IeMin(1) = 1125.37 A
IeMin(2) = 1044.73 A
IeMin(3) = 1044.73 A
IeMin(4) = 1044.73 A
IeMin(5) = 2735.89 A
IeMin(6) = 1044.73 A

----------<< E/F Protection >>----------
Earth Fault Protective Relay R1(1) for 63 kV Outgoing Feeder 'A1'

Relay Type: MCGG82
Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 800 / 1
Feeder type: Line
Connected to Section Nr. 1

Direction: Line side

Ibase = 916.43 A ; Base Current
Ie1(A1) = 2.541 pu = 2328.65 A ; Maximum 1-ph short circuit at forward Line beginning, seen by this Relay
Ie2(A1) = 2.147 pu = 1967.57 A ; Maximum 1-ph short circuit at forward Line end, seen by this Relay
Ie5(A1) = 0.92 pu = 843.11 A ; Minimum 1-ph short circuit, seen by this Relay

ISR(A1) = 0.1 × Min[I1CT, I(LTR)] = 0.1 × Min[800, 549] = 54.9 A
Is = [ISR(A1) / 800] × In = 0.069 × In ; Best Norm ===> 0.1 × In
ISR(A1) = 0.1 × 800 = 80 A

Checking: Ie5(A1) / ISR(A1) = 10.54

TMS(Final) = Max [User defined TMS or Calculated TMS] = 1 ; Best Norm ===> 1

Iinst = 1 × [Ie1 / ISR(A1)] × Is = 29.11 × Is ; Best Norm ===> 29 × Is
Tinst = 0 sec; Norm ===> 0 sec
Checking: [(Ie1 - Ie2) / Ie1] × 100 = 15.5 % ; !!!!!!!! It is < 20 %

----------<< E/F Protection >>----------
Earth Fault Protective Relay R1(2) for 63 kV Outgoing Feeder 'A2'

Relay Type: MCGG82
Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}

alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 800 / 1
Feeder type: Line
Connected to Section Nr. 1

Direction: Line side

Ibase = 916.43 A ; Base Current
Ie1(A2) = 2.541 pu = 2328.65 A ; Maximum 1-ph short circuit at forward Line beginning, seen by this Relay
Ie2(A2) = 0.735 pu = 673.58 A ; Maximum 1-ph short circuit at forward Line end, seen by this Relay
Ie5(A2) = 0.5 pu = 458.21 A ; Minimum 1-ph short circuit, seen by this Relay

ISR(A2) = 0.1 × Min[I1CT, I(LTR)] = 0.1 × Min[800, 489] = 48.9 A
Is = [ISR(A2) / 800] × In = 0.061 × In ; Best Norm ===> 0.1 × In
ISR(A2) = 0.1 × 800 = 80 A

Checking: Ie5(A2) / ISR(A2) = 5.73

TMS according to required Relay Operating time for Faults in the Forward Line Beginning (Zone 1):
TMS1 = 0.4 × 1 / {0.14 / [(Ie1(A2) / ISR(A2)) ^ 0.02 - 1] + 0} = 0.199
TMS according to required Relay Operating time for Faults in the Forward Line End (Zone 2):
TMS2 = 0.8 × 1 / {0.14 / [(Ie2(A2) / ISR(A2)) ^ 0.02 - 1] + 0} = 0.249

TMS(Final) = Max [User defined TMS or Calculated TMS] = 0.249 ; Best Norm ===> 0.25

Iinst = 1 × [Ie1 / ISR(A2)] × Is = 29.11 × Is ; Best Norm ===> 29 × Is
Tinst = 0 sec; Norm ===> 0 sec
Checking: [(Ie1 - Ie2) / Ie1] × 100 = 71.1 %

----------<< E/F Protection >>----------
Earth Fault Protective Relay R1(3) for 63 kV Outgoing Feeder 'A3'

Relay Type: MCGG82
Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 800 / 1
Feeder type: Reactor

Connected to Section Nr. 1

Direction: Busbar side

Ibase = 916.43 A ; Base Current
Ie3(A3) = 1 pu = 916.43 A ; Maximum 1-ph short circuit at reverse Line beginning (if any)
Ie4(A3) = 1 pu = 916.43 A ; Maximum 1-ph short circuit at reverse Line end (if any)
Ie5(A3) = 0.83 pu = 760.64 A ; Minimum 1-ph short circuit, seen by this Relay

ISR(A3) = 0.1 × Min[I1CT, I(LTR)] = 0.1 × Min[800, 549] = 54.9 A
Is = [ISR(A3) / 800] × In = 0.069 × In ; Best Norm ===> 0.1 × In
ISR(A3) = 0.1 × 800 = 80 A

Checking: Ie5(A2) / ISR(A3) = 5.73

Coordination with Line E/F Relays:
T(A1) = 1 / 1 × {0.14 / [(Ie3(A3) / ISR(A1)) ^ 0.02 - 1] + 0} = 2.007 sec
T(A3) = T(A1) + 0.4 = 2.407 sec
TMS (A3) = 2.407 × 1 / {0.14 / [(Ie3(A3) / ISR(A3)) ^ 0.02 - 1] + 0} = 1.199

Coordination with Line E/F Relays:
T(A2) = 0.25 / 1 × {0.14 / [(Ie3(A3) / ISR(A2)) ^ 0.02 - 1] + 0} = 0.502 sec
T(A3) = T(A2) + 0.4 = 0.902 sec
TMS (A3) = 0.902 × 1 / {0.14 / [(Ie3(A3) / ISR(A3)) ^ 0.02 - 1] + 0} = 0.449

TMS(Final) = Max [User defined TMS or Calculated TMS] = 1.199 ; Best Norm ===> 1

Iinst = 1 × [Ie3 / ISR(A3)] × Is = 11.46 × Is ; Best Norm ===> 11 × Is
Tinst = 0 sec; Norm ===> 0 sec

----------<< E/F Protection >>----------
Earth Fault Protective Relay R1(4) for 63 kV Outgoing Feeder 'A4'

Relay Type: MCGG62
Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 800 / 1
Feeder type: Cap-Bank
Connected to Section Nr. 2

Direction: Non Directional

Ibase = 916.43 A ; Base Current

Ie1(A4) = 2.5 pu = 2291.07 A ; Maximum 1-ph short circuit at forward Line beginning, seen by this Relay
Ie2(A4) = 1.7 pu = 1557.93 A ; Maximum 1-ph short circuit at forward Line end, seen by this Relay
Ie3(A4) = 1 pu = 916.43 A ; Maximum 1-ph short circuit at reverse Line beginning (if any), seen by this Relay
Ie4(A4) = 1 pu = 916.43 A ; Maximum 1-ph short circuit at reverse Line end (if any), seen by this Relay
Ie5(A4) = 0.9 pu = 824.79 A ; Minimum 1-ph short circuit, seen by this Relay

ISR(A4) = 0.1 × Min[I1CT, I(LTR)] = 0.1 × Min[800, 549] = 54.9 A
Is = [ISR(A4) / 800] × In = 0.069 × In ; Best Norm ===> 0.05 × In
ISR(A4) = 0.05 × 800 = 40 A

Checking: Ie5(A2) / ISR(A4) = 11.46

Coordination with Line E/F Relays:
T(A1) = 1 / 1 × {0.14 / [(Ie3(A4) / ISR(A1)) ^ 0.02 - 1] + 0} = 2.801 sec
T(A4) = T(A1) + 0.4 = 3.201 sec
TMS (A4) = 3.201 × 1 / {0.14 / [(Ie3(A4) / ISR(A4)) ^ 0.02 - 1] + 0} = 1.478

Coordination with Line E/F Relays:
T(A2) = 0.25 / 1 × {0.14 / [(Ie3(A4) / ISR(A2)) ^ 0.02 - 1] + 0} = 0.7 sec
T(A4) = T(A2) + 0.4 = 1.1 sec
TMS (A4) = 1.1 × 1 / {0.14 / [(Ie3(A4) / ISR(A4)) ^ 0.02 - 1] + 0} = 0.508

TMS(Final) = Max [User defined TMS or Calculated TMS] = 1.478 ; Best Norm ===> 1

Iinst = Infinity
Tinst = 0 sec; Norm ===> 0 sec

----------<< E/F Protection >>----------
Earth Fault Protective Relay R2(1) for 63 KV at Buscoupler feeder 'Bus_LV_1'

Relay Type: MCGG82
Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 2000 / 1
Feeder type: Bus-Coupler
Connected to Section Nr. 1

In(Transformer 63 kV side) = 160000 / (63 × 3^0.5) = 1466.29 A

ISR(Bus_LV_1) = 0.1 × In(Transformer 63 kV side) = 146.63 A

Is = [ISR(Bus_LV_1) / 2000] × In = 0.073 × In ; Best Norm ===> 0.1 × In
ISR(Bus_LV_1) = 0.1 × 2000 = 200 A

IeMax(A3) = 1187.69 A
TR(A3) = TMS(A3) / 1 × {0.14 / [(IeMax(A3) / ISR(A3)) ^ 0.02 - 1] + 0} = 2.525 sec ; Operating time for the Slowest Relay from lower layers
TR(Bus_LV_1) = TR(A3) + 0.4 = 2.925 sec

TMS = TR(Bus_LV_1) × 1 / {0.14 / [IeMax(A3) / ISR(Bus_LV_1)) ^ 0.02 - 1] + 0} = 0.758 ; High Norm ===> 0.775

Iinst = Infinity
Tinst = 0 sec; Norm ===> 0 sec

----------<< E/F Protection >>----------
Earth Fault Protective Relay R4(1) for 63 KV at L.V Side feeder 'Trans_1'

Relay Type: MCGG22
Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 600 / 1
Feeder type: Trans.
Connected to Section Nr. 1

ISR(Trans_1) = 0.1 × ISR(Bus_LV_1) = 20 A
Is = [ISR(Trans_1) / 600] × In = 0.033 × In ; Best Norm ===> 0.1 × In
ISR(Trans_1) = 0.1 × 600 = 60 A

IeMax(Bus_LV_1) = 1187.69 A
TR(Bus_LV_1) = TMS(Bus_LV_1) / 1 × {0.14 / [(IeMax(Bus_LV_1) / ISR(Bus_LV_1)) ^ 0.02 - 1] + 0} = 2.991 sec ; Operating time for the Slowest Relay from lower layers
TR(Trans_1) = TR(Bus_LV_1) + 0.4 = 3.391 sec

TMS = TR(Trans_1) × 1 / {0.14 / [IeMax(Bus_LV_1) / ISR(Trans_1)) ^ 0.02 - 1] + 0} = 1.49 ; Best Norm ===> 1

Iinst = Infinity
Tinst = 0 sec; Norm ===> 0 sec

----------<< E/F Protection >>----------
Earth Fault Protective Relay R4(2) for 63 KV at L.V Side feeder 'Trans_2'

Relay Type: MCGG22
Selected Characteristic: SI

Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 600 / 1
Feeder type: Trans.
Connected to Section Nr. 2

ISR(Trans_2) = 0.1 × ISR(Bus_LV_1) = 20 A
Is = [ISR(Trans_2) / 600] × In = 0.033 × In ; Best Norm ===> 0.1 × In
ISR(Trans_2) = 0.1 × 600 = 60 A

IeMax(Bus_LV_1) = 1187.69 A
TR(Bus_LV_1) = TMS(Bus_LV_1) / 1 × {0.14 / [(IeMax(Bus_LV_1) / ISR(Bus_LV_1)) ^ 0.02 - 1] + 0} = 2.991 sec ; Operating time for the Slowest Relay from lower layers
TR(Trans_2) = TR(Bus_LV_1) + 0.4 = 3.391 sec

TMS = TR(Trans_2) × 1 / {0.14 / [IeMax(Bus_LV_1) / ISR(Trans_2)) ^ 0.02 - 1] + 0} = 1.49 ; Best Norm ===> 1

Iinst = Infinity
Tinst = 0 sec; Norm ===> 0 sec

----------<< E/F Protection >>----------
Earth Fault Protective Relay R5(1) for 230 KV at Trans. Primary Side feeder 'HV_1'

Relay Type: MCGG22
Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 600 / 1
Feeder type: Trans.
Connected to Section Nr. 1

In(Transformer 230 kV side) = 160000 / (230 × 3^0.5) = 401.63 A

ISR(HV_1) = 0.2 × In (Transformer 230 kV side) = 80.33 A
Is = [ISR(HV_1) / 600] × In = 0.134 × In ; Best Norm ===> 0.15 × In
ISR(HV_1) = 0.15 × 600 = 90 A

IeMax(Trans_1) = 1187.69 A
I'eMax(Trans_1) = IeMax(Trans_1) × 0 = 0 A

IeMin(Trans_1) = 1044.73 A
I'eMin(Trans_1) = IeMin(Trans_1) × 0 = 0 A

Checking: I'eMin(Trans_1) / ISR(HV_1) = 0
TR(Trans_1) = TMS(Trans_1) / 1 × {0.14 / [(IeMax(Trans_1) / ISR(Trans_1)) ^ 0.02 - 1] + 0} = 2.275 sec ; Operating time for the Slowest Relay from lower layers
TR(HV_1) = TR(Trans_1) + 0.3 = 2.575 sec

TMS = TR(HV_1) × 1 / {0.14 / [I'eMax(Trans_1) / ISR(HV_1)) ^ 0.02 - 1] + 0} = -18.393 ; Best Norm ===> 0.05

Iinst = Infinity
Tinst = 0 sec; Norm ===> 0 sec

----------<< E/F Protection >>----------
Earth Fault Protective Relay R5(2) for 230 KV at Trans. Primary Side feeder 'HV_2'

Relay Type: MCGG22
Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 600 / 1
Feeder type: Trans.
Connected to Section Nr. 1

In(Transformer 230 kV side) = 160000 / (230 × 3^0.5) = 401.63 A

ISR(HV_2) = 0.2 × In (Transformer 230 kV side) = 80.33 A
Is = [ISR(HV_2) / 600] × In = 0.134 × In ; Best Norm ===> 0.15 × In
ISR(HV_2) = 0.15 × 600 = 90 A

IeMax(Trans_2) = 1187.69 A
I'eMax(Trans_2) = IeMax(Trans_2) × 0 = 0 A

IeMin(Trans_2) = 1044.73 A
I'eMin(Trans_2) = IeMin(Trans_2) × 0 = 0 A

Checking: I'eMin(Trans_2) / ISR(HV_2) = 0
TR(Trans_2) = TMS(Trans_2) / 1 × {0.14 / [(IeMax(Trans_2) / ISR(Trans_2)) ^ 0.02 - 1] + 0} = 2.275 sec ; Operating time for the Slowest Relay from lower layers
TR(HV_2) = TR(Trans_2) + 0.3 = 2.575 sec

TMS = TR(HV_2) × 1 / {0.14 / [I'eMax(Trans_2) / ISR(HV_2)) ^ 0.02 - 1] + 0} = -18.393 ; Best Norm ===> 0.05

Iinst = Infinity

Tinst = 0 sec; Norm ===> 0 sec

----------<< E/F Protection >>----------
Earth Fault Protective Relay R7(1) for 230 kV side Line Bay 'Abhar'

Relay Type: MCGG62
Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 1200 / 4
Feeder type: Line
Connected to Section Nr. 1

Direction: Line side

Ibase = 251.02 A ; Base Current
Ie1(Abhar) = 24.68 pu = 6195.22 A ; Maximum 1-ph short circuit at forward Line beginning, seen by this Relay
Ie2(Abhar) = 12 pu = 3012.26 A ; Maximum 1-ph short circuit at forward Line end, seen by this Relay
Ie5(Abhar) = 5 pu = 1255.11 A ; Minimum 1-ph short circuit, seen by this Relay

ISR(Abhar) = Max [Ie5(Abhar) / 4 , 0.3 × CT.Rating] = 360 A
Is = [ISR(Abhar) / 300] × In = 1.2 × In ; Best Norm ===> 1.2 × In
ISR(Abhar) = 1.2 × 300 = 360 A

Checking: Ie5(Abhar) / ISR(Abhar) = 3.49

TMS according to required Relay Operating time for Faults in the Forward Line Beginning (Zone 1):
TMS1 = 0.4 × 1 / {0.14 / [(Ie1(Abhar) / ISR(Abhar)) ^ 0.02 - 1] + 0} = 0.167
TMS according to required Relay Operating time for Faults in the Forward Line End (Zone 2):
TMS2 = 0.8 × 1 / {0.14 / [(Ie2(Abhar) / ISR(Abhar)) ^ 0.02 - 1] + 0} = 0.248

TMS(Final) = Max [User defined TMS or Calculated TMS] = 0.248 ; High Norm ===> 0.25

Iinst = 0.9 × [Ie1 / ISR(Abhar)] × Is = 15.49 × Is ; Best Norm ===> 15 × Is
Tinst = 0 sec; Norm ===> 0 sec
Checking: [(Ie1 - Ie2) / Ie1] × 100 = 51.4 %

----------<< E/F Protection >>----------
Earth Fault Protective Relay R7(2) for 230 kV side Line Bay 'Eshragh'

Relay Type: MCGG22

Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 1200 / 1
Feeder type: Reactor
Connected to Section Nr. 1

Direction: Busbar side

Ibase = 251.02 A ; Base Current
Ie3(Eshragh) = 24.68 pu = 6195.22 A ; Maximum 1-ph short circuit at reverse Line beginning (if any)
Ie4(Eshragh) = 12 pu = 3012.26 A ; Maximum 1-ph short circuit at reverse Line end (if any)
Ie5(Eshragh) = 3.8 pu = 953.88 A ; Minimum 1-ph short circuit, seen by this Relay

ISR(Eshragh) = Max [0.3 × CT.Rating , 1.1 × (Max Is(all of E/F Relays that are Line side or Non Directional))] = 396 A
Is = [ISR(Eshragh) / 1200] × In = 0.33 × In ; Best Norm ===> 0.35 × In
ISR(Eshragh) = 0.35 × 1200 = 420 A

Checking: Ie5(Boein Zahra) / ISR(Eshragh) = 2.27

Coordination with H.V side or Relays in Lower layers:
TR(HV_2)= 0.05 / 1 × {0.14 / [(Ie3 (Eshragh) / ISR(HV_2)) ^ 0.02 - 1] + 0} = 0.079 sec
TMS5 =(TR(HV_2) + 0.3) × 1 / {0.14 / [(Ie3 (Eshragh) / ISR(Eshragh)) ^ 0.02 - 1] + 0} = 0.15

TMS according to required Relay Operating time for Faults in the Reverse Line beginning (Zone 1):
TMS3 = 0.4 × 1 / {0.14 / [(Ie3(Eshragh) / ISR(Eshragh)) ^ 0.02 - 1] + 0} = 0.158
TMS according to required Relay Operating time for Faults in the Reverse Line End (Zone 2):
TMS4 = 0.8 × 1 / {0.14 / [(Ie4(Eshragh) / ISR(Eshragh)) ^ 0.02 - 1] + 0} = 0.23

Coordination with Line E/F Relays:
T(Abhar) = 0.25 / 1 × {0.14 / [(Ie3(Eshragh) / ISR(Abhar)) ^ 0.02 - 1] + 0} = 0.598 sec
T(Eshragh) = T(Abhar) + 0.4 = 0.998 sec
TMS (Eshragh) = 0.998 × 1 / {0.14 / [(Ie3(Eshragh) / ISR(Eshragh)) ^ 0.02 - 1] + 0} = 0.394

TMS(Final) = Max [User defined TMS or Calculated TMS] = 0.394 ; High Norm ===> 0.4

Iinst = 0.9 × [Ie3 / ISR(Eshragh)] × Is = 13.28 × Is ; Best Norm ===> 13 × Is
Tinst = 0 sec; Norm ===> 0 sec

----------<< E/F Protection >>----------
Earth Fault Protective Relay R7(3) for 230 kV side Line Bay 'Boein Zahra'

Relay Type: MCGG22
Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 1200 / 1
Feeder type: Reactor
Connected to Section Nr. 2

Direction: Non Directional

Ibase = 251.02 A ; Base Current
Ie1(Boein Zahra) = 13.23 pu = 3321.02 A ; Maximum 1-ph short circuit at forward Line beginning, seen by this Relay
Ie2(Boein Zahra) = 8.04 pu = 2018.22 A ; Maximum 1-ph short circuit at forward Line end, seen by this Relay
Ie3(Boein Zahra) = 24.68 pu = 6195.22 A ; Maximum 1-ph short circuit at reverse Line beginning (if any), seen by this Relay
Ie4(Boein Zahra) = 12 pu = 3012.26 A ; Maximum 1-ph short circuit at reverse Line end (if any), seen by this Relay
Ie5(Boein Zahra) = 3.8 pu = 953.88 A ; Minimum 1-ph short circuit, seen by this Relay

ISR(Boein Zahra) = Max [Ie5(Boein Zahra) / 4 , 0.3 × CT.Rating , 1.1 × (Max Is(all of E/F Relays that are Line side or Non Directional))] = 396 A
Is = [ISR(Boein Zahra) / 1200] × In = 0.33 × In ; Best Norm ===> 0.35 × In
ISR(Boein Zahra) = 0.35 × 1200 = 420 A

Checking: Ie5(Boein Zahra) / ISR(Boein Zahra) = 2.27

Coordination with H.V side or Relays in Lower layers:
TR(HV_2)= 0.05 / 1 × {0.14 / [(Ie3 (Boein Zahra) / ISR(HV_2)) ^ 0.02 - 1] + 0} = 0.079 sec
TMS5 =(TR(HV_2) + 0.3) × 1 / {0.14 / [(Ie3 (Boein Zahra) / ISR(Boein Zahra)) ^ 0.02 - 1] + 0} = 0.15

Coordination with Line E/F Relays:
T(Abhar) = 0.25 / 1 × {0.14 / [(Ie3(Boein Zahra) / ISR(Abhar)) ^ 0.02 - 1] + 0} = 0.598 sec
T(Boein Zahra) = T(Abhar) + 0.4 = 0.998 sec
TMS (Boein Zahra) = 0.998 × 1 / {0.14 / [(Ie3(Boein Zahra) / ISR(Boein Zahra)) ^

0.02 - 1] + 0} = 0.394

TMS(Final) = Max [User defined TMS or Calculated TMS] = 0.449 ; High Norm ===> 0.45

Iinst = 1.3 × [Ie1 / ISR(Boein Zahra)] × Is = 10.28 × Is ; Best Norm ===> 10 × Is
Tinst = 0 sec; Norm ===> 0 sec
Checking: [(Ie1 - Ie2) / Ie1] × 100 = 39.2 %

----------<< E/F Protection >>----------
Earth Fault Protective Relay, R8(1) for 230 kV side Buscoupler feeder 'Bus_HV'

Relay Type: MCGG82
Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 2000 / 1
Feeder type: Bus-Coupler
Connected to Section Nr. 1

Ibase = 251.02 A ; Base Current
Ie1Max(Bus_HV) = 32.42 Pu = 29710.63 A ; Maximum 1-ph short circuit at Line beginning, seen by this Relay
Ie2Max(Bus_HV) = 14 Pu = 12830.01 A ; Maximum 1-ph short circuit at smallest Line end, seen by this Relay
Ie3Min(Bus_HV) = 7 Pu = 6415 A ; Minimum 1-ph short circuit, seen by this Relay

ISR(Bus_HV) >= 0.2 × I1ct(H.V)= 400 A
ISR(Bus_HV) >= 360 A ; According to Current setting of Abhar
ISR(Bus_HV) >= 420 A ; According to Current setting of Boein Zahra
ISR = Maximum all of ISRs = 420 A
Is = [ISR(Bus_HV) / 2000] × In = 0.21 × In ; Best Norm ===> 0.2 × In
ISR(Bus_HV) = 0.2 × 2000 = 400 A

Checking: Ie3min(Bus_HV) / ISR(Bus_HV) = 16.04

TMS(Final) = Max [User defined TMS or Calculated TMS] = 1 ; High Norm ===> 1

Iinst = Infinity
Tinst = 0 sec; Norm ===> 0 sec

----------<< E/F Protection >>----------
Earth Fault Protective Relay R9(1) for 230 kV side Neutral Protection at feeder 'HV_Neutral_1'

Relay Type: MCGG22

Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 1200 / 1
Feeder type: Trans.
Connected to Section Nr. 1

Ibase = 251.02 A ; Base Current
Ie1Max(HV_Neutral_1) = 32.42 Pu = 29710.63 A ; Maximum 1-ph short circuit at Line beginning, seen by this Relay
Ie2MAx(HV_Neutral_1) = 1 Pu = 916.43 A ; Maximum 1-ph short circuit at smallest Line end, seen by this Relay
Ie3Min(HV_Neutral_1) = 1 pu = 916.43 A ; Minimum 1-ph short circuit, seen by this Relay
IL(H.V) = 160000 / (230 × 3^0.5) = 401.63 A ; Trans. Nominal Current at 230 kV side

ISR(HV_Neutral_1) >= 0.3 × IL(H.V)= 120.49 A
Is = [ISR(HV_Neutral_1) / 1200] × In = 0.1 × In ; Best Norm ===> 0.1 × In
ISR(HV_Neutral_1) = 0.1 × 1200 = 120 A

IeMax(Trans_1) = 1187.69 A
I'eMax(Trans_1) = IeMax(Trans_1) × 0 = 0 A

IeMin(Trans_1) = 1044.73 A
I'eMin(Trans_1) = IeMin(Trans_1) × 0 = 0 A

Checking: I'eMin(Trans_1) / ISR(HV_Neutral_1) = 0
TR(Trans_1) = TMS(Trans_1) / 1 × {0.14 / [(IeMax(Trans_1) / ISR(Trans_1)) ^ 0.02 - 1] + 0} = 2.275 sec ; Operating time for the Slowest Relay from lower layers
TR(HV_Neutral_1) = TR(Trans_1) + 0.4 = 2.675 sec

TMS = TR(HV_Neutral_1) × 1 / {0.14 / [I'eMax(Trans_1) / ISR(HV_Neutral_1)) ^ 0.02 - 1] + 0} = -19.107 ; High Norm ===> 0.05

Checking: Ie3min(HV_Neutral_1) / ISR(HV_Neutral_1) = 7.64

Coordination with Remote substation's Relay or Fuse (You may deactivate this option):
Time of Extra Relay or Fuse = 2 sec ; Slowest Relay Operating time for Ie6
TR6(HV_Neutral_1) = 1 + 2 = 3 sec
Ie6(HV_Neutral_1); Maximum common current with Extra Relay, seen by this Relay = 2 pu = 502.04 A
TMS6 = 3 × 1 / {0.14 / [(Ie6(HV_Neutral_1) / ISR(HV_Neutral_1)) ^ 0.02 - 1] + 0} = 0.622

TMS(Final) = Max [User defined TMS or Calculated TMS] = 0.622 ; High Norm ===> 0.625

Iinst = Infinity
Tinst = 0 sec; Norm ===> 0 sec

----------<< E/F Protection >>----------
Earth Fault Protective Relay R9(2) for 230 kV side Neutral Protection at feeder 'HV_Neutral_2'

Relay Type: MCGG22
Selected Characteristic: SI
Generic Formula: T = (TMS/1) × {K / [(I/Is)^alfa -1]^Gama + Beta} = (TMS/1) × {0.14 / [(I/Is)^0.02 -1]^1 + 0}
alfa = 0.02 ; Beta = 0 ; Gama = 1 ; K = 0.14 ; M = 1

In = 1 A ; Relay Nominal Current

C.T Ratio = I1CT / I2CT = 1200 / 1
Feeder type: Trans.
Connected to Section Nr. 2

Ibase = 251.02 A ; Base Current
Ie1Max(HV_Neutral_2) = 32.42 Pu = 29710.63 A ; Maximum 1-ph short circuit at Line beginning, seen by this Relay
Ie2MAx(HV_Neutral_2) = 1 Pu = 916.43 A ; Maximum 1-ph short circuit at smallest Line end, seen by this Relay
Ie3Min(HV_Neutral_2) = 1 pu = 916.43 A ; Minimum 1-ph short circuit, seen by this Relay
IL(H.V) = 160000 / (230 × 3^0.5) = 401.63 A ; Trans. Nominal Current at 230 kV side

ISR(HV_Neutral_2) >= 0.3 × IL(H.V)= 120.49 A
Is = [ISR(HV_Neutral_2) / 1200] × In = 0.1 × In ; Best Norm ===> 0.1 × In
ISR(HV_Neutral_2) = 0.1 × 1200 = 120 A

IeMax(Trans_2) = 1187.69 A
I'eMax(Trans_2) = IeMax(Trans_2) × 0 = 0 A

IeMin(Trans_2) = 1044.73 A
I'eMin(Trans_2) = IeMin(Trans_2) × 0 = 0 A

Checking: I'eMin(Trans_2) / ISR(HV_Neutral_2) = 0
TR(Trans_2) = TMS(Trans_2) / 1 × {0.14 / [(IeMax(Trans_2) / ISR(Trans_2)) ^ 0.02 - 1] + 0} = 2.275 sec ; Operating time for the Slowest Relay from lower layers
TR(HV_Neutral_2) = TR(Trans_2) + 0.4 = 2.675 sec

TMS = TR(HV_Neutral_2) × 1 / {0.14 / [I'eMax(Trans_2) / ISR(HV_Neutral_2)) ^ 0.02 - 1] + 0} = -19.107 ; High Norm ===> 0.05

Checking: Ie3min(HV_Neutral_2) / ISR(HV_Neutral_2) = 7.64

TMS according to required Relay Operating time for Faults in the Forward Line Beginning (Zone 1):
TMS1 = 0.5 × 1 / {0.14 / [(Ie1(HV_Neutral_2) / ISR(HV_Neutral_2)) ^ 0.02 - 1] + 0} = 0.416
TMS according to required Relay Operating time for Faults in the Forward Line End (Zone 2):
TMS2 = 1 × 1 / {0.14 / [(Ie2(HV_Neutral_2) / ISR(HV_Neutral_2)) ^ 0.02 - 1] + 0} = 0.296

TMS(Final) = Max [User defined TMS or Calculated TMS] = 0.416 ; High Norm ===> 0.425

Iinst = Infinity
Tinst = 0 sec; Norm ===> 0 sec