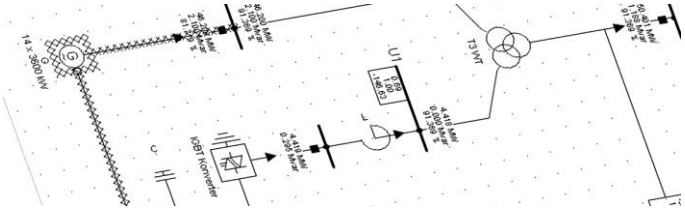

DIgSILENT Technical Documentation

ABB REG 216
PowerFactory
V001 Relay model description

DIgSILENT GmbH
Heinrich-Hertz-Strasse 9
D-72810 Gomaringen
Tel.: +49 7072 9168 - 0
Fax: +49 7072 9168- 88
http://www.digsilent.de
e-mail: mail@digsilent.de

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1 Model general description

The ABB REG 216 is a modular relay and the number and the type of the protective functions can be defined by the customer by configuring the relay software. The ABB REG 216 PowerFactory relay model has been implemented trying to mock up the more common protective functions used in a typical large generator protection scheme.

The ABB REG 216 PowerFactory relay model consists of a main relay model and 8 subrelays:

- REG 216 overcurrent (F50/51)
- REG 216 voltage elements (F27/59)
- REG 216 frequency (F81)
- REG 216 reverse power (F32)
- REG 216 differential (F87)
- REG 216 underimpedance (F21)
- REG 216 underreactance (F40)
- REG 216 Pole slip

The main relay contains the measurement and acquisition units, the output logic and all other subrelays:

1.1 Measurement and acquisition

1.1.1 Available Units

The voltage and the current are measured by two current transformers ("Ct" and "Neutral Ct" blocks) and one voltage transformer ("Vt" block). Two additional current transformers are used by the differential elements: the "Remote Ct" block represents the Cts located at the generator/motor ground terminals. The "Remote Ct Transf" block represents the Cts located at the CSU transformer terminals.

Six measurement units ("Measure", "Delta Measure" , "Measurement Seq", "Meas Neutral I", "Remote Measurement" and "Remote Measurement Transf" blocks) are fed by these CTs and the VT.

1.1.2 Functionality

The input signals are sampled at 12 samples/cycle; a DFT filter operating over a cycle calculates then the voltage and current values used by the protective elements.

1.1.3 Data Input

Please note that the nominal current and the nominal voltage values MUST be entered in all the measurement units.

1.2 Output logic

1.2.1 Available Units

The output logic is implemented by the "Logic" block.

1.2.2 Functionality

This block is operating the breaker. Please disable the "Logic" block to disable the relay model ability to open the power circuit.

The signal operating the breaker is "yout". Eleven additional output signals ("OUT1"… "OUT11") freely configurable are available.

1.3 REG 216 Overcurrent (F50/51) subrelay

1.3.1 Available Units

- Three 3 phase definite time overcurrent elements ("3ph Current DT 1", "3ph Current DT 2" and "3ph Current DT 3" block)
- Three ground current definite time overcurrent elements ("3I0 Current DT 1", "3I0 Current DT 2" and "3I0 Current DT 3" block)
- Three 3 phase definite time directional overcurrent elements ("3ph DirCurrent DT 1", "3ph DirCurrent DT 1 angle", "3ph DirCurrent DT 2", "3ph DirCurrent DT 2 angle", "3ph DirCurrent DT 3" and "3ph DirCurrent DT 3 angle" block)
- Three ground current definite time directional overcurrent elements ("3I0 DirCurrent DT 1", "3I0 DirCurrent DT 1 angle", "3I0 DirCurrent DT 2", "3I0 DirCurrent DT 2 angle" ,"3I0 DirCurrent DT 3" and ,"3I0 DirCurrent DT 3 angle" block)
- Three neutral current definite time directional overcurrent elements ("IN DirCurrent DT 1", "IN DirCurrent DT 1 angle", "IN DirCurrent DT 2", "IN DirCurrent DT 2 angle" ,"IN DirCurrent DT 3" and ,"IN DirCurrent DT 3 angle" block)
- Two 3 phase inverse time directional overcurrent elements ("3ph DirCurrent Inv 1", "3ph DirCurrent Inv6 1 angle", "3ph DirCurrent Inv 2" and "3ph DirCurrent Inv 2 angle" block)
- Two ground current inverse time directional overcurrent elements ("3I0 DirCurrent Inv 1", "3I0 DirCurrent Inv 1 angle", "3I0 DirCurrent Inv 2" and "3I0 DirCurrent Inv 2 angle" block)
- Two neutral current inverse time directional overcurrent elements ("IN DirCurrent Inv 1", "IN DirCurrent Inv 1 angle", "IN DirCurrent Inv 2" and "IN DirCurrent Inv 2 angle" block)

- One phase current peak value time defined element with frequency block ("3ph Current-Inst" and "3ph Current-Inst Frequency limit" block)
- One ground current peak value time defined element with frequency block ("3I0 Current-Inst" and "3I0 Current-Inst Frequency limit" block)
- One neutral current peak value time defined element with frequency block ("IN Current-Inst" and "IN Current-Inst Frequency limit" block)
- Two negative sequence inverse time overcurrent elements ("NPS-Inv 1" and "NPS-Inv 2" block)
- Two negative sequence time defined overcurrent elements ("NPS-DT 1" and "NPS-DT 2" block)
- Two phase undercurrent elements("3ph Current DT MIN 1" and "3ph Current DT MIN 2" block)
- One stator overload element ("OLoad-Stator", "OLoad-Stator IB", "tmax", "tmin", and "tg" block)
- One voltage restrained/controlled element ("V dep OC I>" and "V restraint" block). To select which voltage logic is enabled, the restraint factor ("V Dep OC k Set" variable) and the restraint voltage levels ("V Dep OC V<1Set" and "V value derived from the phase voltages or the value measured by the open delta VT) is used can be set in the "logic" tab page of the "VPol Measured or Derived" block.

1.3.2 Functionality

The model contains a full choice of phase, zero sequence ("Holmgreen's connection internally calculated), and neutral current overcurrent elements. There is a set of directional and a set of no directional elements. There is one instantaneous (peak) phase element, one instantaneous (peak) zero element sequence, one instantaneous neutral element which can be set to be blocked when the frequency is falling below a given threshold.

The inverse time overcurrent elements support the following trip characteristics:

- "IEC extremely inverse"
- "IEC very inverse"
- "IEC inverse"
- "Long time earth fault" (neutral and ground current elements only)

1.3.3 Data input

To configure the "OLoad-Stator" protective functions please insert:

- The relay "IB" setting in the "OLoad-Stator IB" block in the "Logic" tab page.
- The relay "I-Start" setting in the "Oload-Stator" block as "Current setting".
- The relay "k1-Setting" setting in the "Oload-Stator" block as "Time dial".
- The relay "t-min" setting in the "tmin" block as "Time setting".
- The relay "t-max" setting in the "tmax" block as "Time setting".
- The relay "tg" setting in the "tg" block as "Time setting".

To configure the "Voltage controlled Overcurrent" protective functions please insert:

- The relay "Current" setting in the "I>Ucontrol Current" block as "Current setting".
- The relay "Delay" setting in the "I>Ucontrol Delay" block as "Time setting".
- The relay "Hold-Voltage" setting in the "I>Ucontrol Voltage" block as "Voltage".
- The relay "Hold-Time" setting in the "I>Ucontrol HoldTime" block as "Time setting".

1.4 REG 216 Voltage elements (F27/59) subrelay

1.4.1 Available Units

- Two phase-ground time defined undervoltage elements ("27P 1" and "27P 2", "27P 1Inst" and "27P 2 Inst" block)
- Two phase-phase time defined undervoltage elements ("27PP 1" and "27PP 2", "27PP 1 Inst" and "27PP 2 Inst" block)
- Two phase-ground time defined overvoltage elements ("59P 1" and "59P 2", "59P 1 Inst" and "59P 2 Inst" block)
- Two phase-phase time defined overvoltage elements ("59PP 1" and "59PP 2", "59PP 1 Inst" and "59PP 2 Inst" block)
- Two zero sequence time defined overvoltage elements ("59G 1" and "59G 2", "59G 1 Inst" and "59G 2 Inst" block)
- Two negative sequence time defined overvoltage elements ("59Q 1" and "59Q 2", "59Q 1 Inst" and "59Q 2 Inst" block)
- Two positive sequence time defined overvoltage elements ("59V1 1" and "59V1 2", "59V1 1 Inst" and "59V1 2 Inst" block)
- Two positive sequence time defined undervoltage elements ("27V1 1" and "27V1 2", "27V1 1 Inst" and "27V1 2 Inst" block)

1.4.2 Functionality

The more common over/undervoltage protection elements have been implemented. For each protective element two blocks are available: one fed by the voltage RMS values, one fed by the voltage instantaneous values. Please notice that the protective elements fed by the voltage instantaneous values must be used only for the EMT simulations.

1.5 REG 216 Frequency (F81) subrelay

1.5.1 Available Units

- Four over/under frequency elements with voltage restraint ("Frequency 1", "Frequency 2, "Frequency 3" and "Frequency 4" block, for the voltage restraint: "Block Voltage 1", "Block Voltage 2", "Block Voltage 3" and "Block Voltage 4" block)
- Four rate of change of frequency elements with frequency and voltage restraint("dfdt1", "dfdt2", "dfdt3" and "dfdt4" block, for the voltage restraint: "Block Voltage dfdt 1", "Block Voltage dfdt ", "Block Voltage dfdt 3" and "Block Voltage dfdt 4", for the frequency restraint: "dfdt Frequency block 1", "dfdt Frequency block 2", "dfdt Frequency block 3" and "dfdt Frequency block 4")
- Two over fluxing elements with inverse characteristic ("U/F inv1" and "U/F inv1" block, the U/f value is calculated by the "V/Hz calculator" block)

1.5.2 Functionality

The restraint logic of the change of frequency elements can be customized using the equation present in the "Logic" tab page of the "dfdt1logic", "dfdt3logic", "dfdt3logic" and "dfdt4logic" block. Please notice that in such equation the "win1" input is coming from the voltage restraint block ("Block Voltage dfdt x" with x = 1,2,3,4) and the "win2" input is coming from the frequency restraint block ("dfdt Frequency block x" with x = 1,2,3,4)

1.6 REG 216 Reverse power (F32) subrelay

1.6.1 Available Units

- Two active underpower elements ("32P1" and "32P2" block)
- One output block opening the associated breaker ("Output logic" block)
- One block calculating the active power ("Power Calculator" block)

1.6.2 Functionality

The subrelay implements two elements tripping when the active power is smaller than the given thresholds.

1.7 REG 216 Differential (F87) subrelay

1.7.1 Available Units

- One transformer differential element with up to three 3ph current inputs ("Transformer Differential" and "Winding 1 Adapter", "Winding 2 Adapter", "Winding 3 Adapter" block).
- One generator differential element ("Generator differential" block)

1.7.2 Functionality

The transformer differential feature has a current restraint threshold and an unrestraint threshold ("Differential current base threshold" and "Unrestrained differential threshold" setting in the "Transformer differential" block). The 2nd harmonic blocking is available as well ("Harmonic blocking" tab page). Please notice that in the provided relay scheme only two sets of 3ph current inputs are connected. The relay ability to adapt the CT ratio and connection type can be mocked using the "Winding 1 Adapter", "Winding 2 Adapter", "Winding 3 Adapter" block.

1.7.3 Data input

Please notice that that the "a1", "a2" and the "a3" relay settings cannot be inserted directly but they must be converted in terms of "Current transformer ratio" and "Terminal Line-Line Voltage" to insert inside the "Winding 1 Adapter", "Winding 2 Adapter", "Winding 3 Adapter" block. Inside the same block the "s1", "s2" and the "s3" relay settings can be inserted directly as "Current transformer connection".

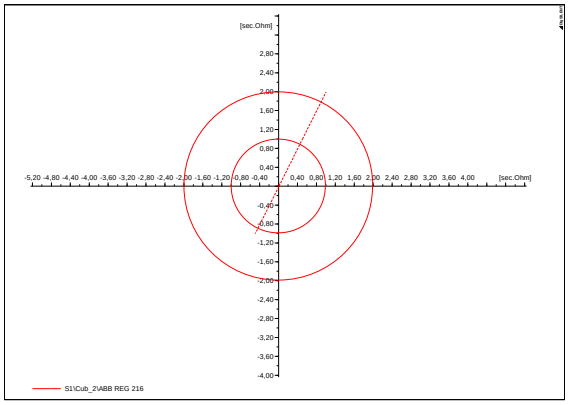
1.8 REG 216 Underimpedance (F21) subrelay

1.8.1 Available Units

- Two under impedance elements ("Underimpedance 1" and "Underimpedance 2" block).
- Two timers ("Underimpedance 1 Delay" and "Underimpedance 2 Delay" block)
- One polarizing block ("Polarizing" block)
- One minimum current supervision element ("Sup IN" block)
- One output block opening the associated breaker ("Output logic" block)

1.8.2 Functionality

The subrelay implements two circular (in the R-X diagram) operating characteristics centred in the axis origin with adjustable time delay and three phase measurement.



1.8.3 Data input

Please notice that in the underimpedance elements the impedance value ("Z-Setting" setting) must be inserted in secondary Ohm instead of pu ("UN/IN"). For this reason a very large secondary Ohm range has been set.

No user input is required is the "Polarizing", in the "Sup IN" and in the "Output Logic" block.

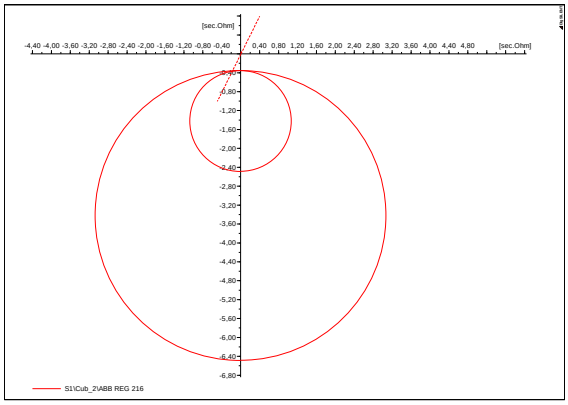
1.9 REG 216 Undereactance (F40) subrelay

1.9.1 Available Units

- Two under impedance elements ("Underreactance 1" and "Underreactance 2" block).
- Two timers ("Underreactance 1 Delay" and "Underreactance 2 Delay" block)
- One polarizing block ("Polarizing" block)
- One minimum current supervision element ("Sup IN" block)
- One output block opening the associated breaker ("Output logic" block)

1.9.2 Functionality

The subrelay implements two circular (in the R-X diagram) operating characteristics with selectable impedance offset, adjustable time delay and three phase measurement.



1.9.3 Data input

Please notice that in the underreactance elements the "Replica impedance" and the "offset impedance" impedance values must be calculated from the relay "XA-Setting" and "XB-Setting" setting value and must be inserted in secondary Ohm instead of pu ("UN/IN"). For this reason very large secondary Ohm ranges have been set.

No user input is required is the "Polarizing", in the "Sup IN" and in the "Output Logic" block.

1.10 REG 216 Pole slip (F78) subrelay

1.10.1 Available Units

- Three blinders mocking up the slip lines ("Za", "ZB" and ZC" block)
- One OOS element ("Out Of Step Outer-Inner" block)
- One timer to delay the OOS trip ("OOS PickUp Delay" block)
- One minimum current supervision element ("I supervision" block)
- One output block opening the associated breaker ("Output logic" block)

1.10.2 Functionality

This subrelay implements a simplified model of the OOS logic present in the relay; the simplified model consists of two slip zones and the OOS logic where the number of slips can be entered. No "WarnAngle", "TripAngle" or "t-Reset" setting is available in the model.

1.10.3 Data Input

The "ZA", "ZB", "ZC" relay settings must be entered in the "ZA", "ZB", "ZC" model block as "Reactance" setting. The relay "phi" angle setting is the "Relay angle" setting. Please notice that "Relay angle" must be "phi"+ 90°.

The number of slip is the "OOS, No. of crossing" in the "Out Of Step Outer-Inner" model block.

No user input is required is the "Polarizing" and in the "I supervision" block.

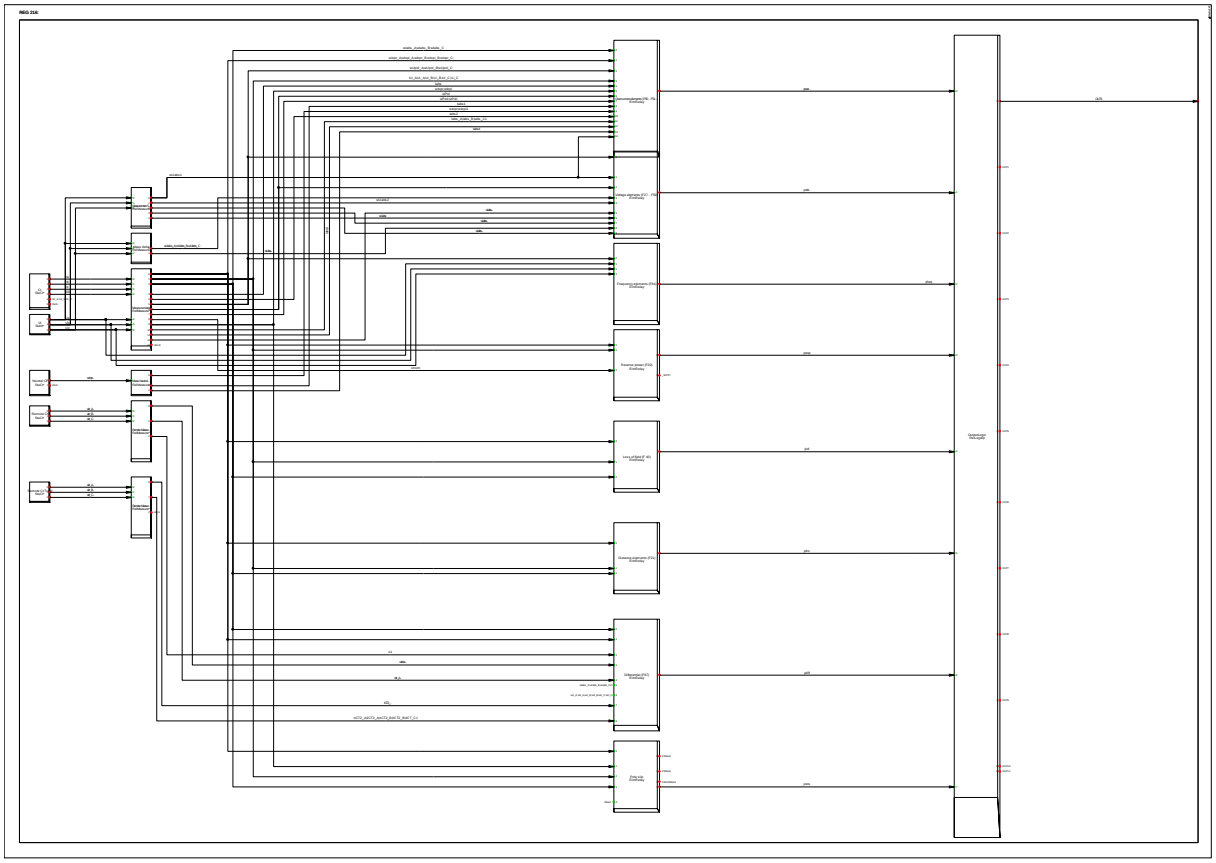
2 Relay not supported features

The following features are not supported:

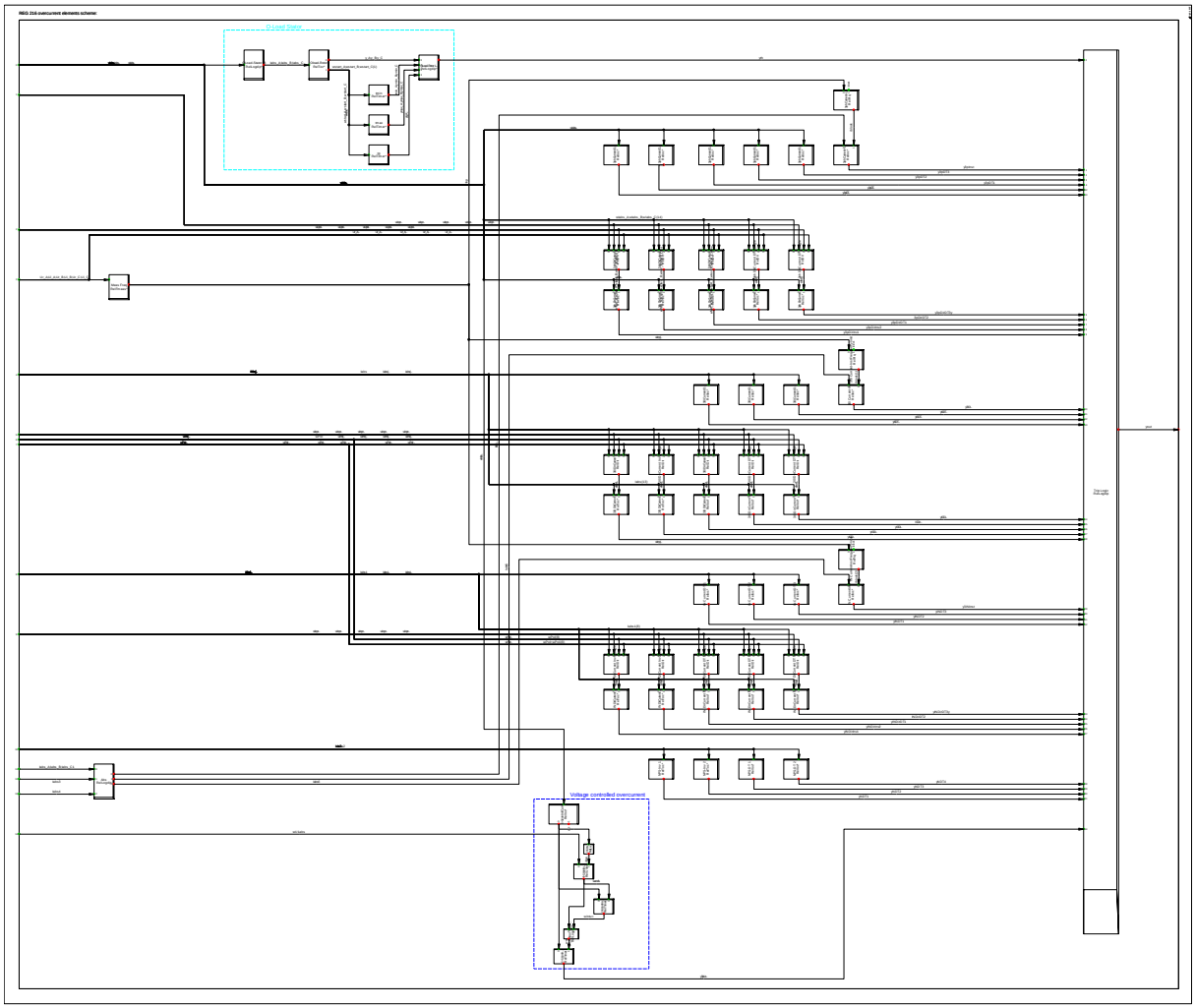
- Transformer differential: "g-High", "Inrush Time"
- Rotor overload function
- Single phase trip
- Check synchronization functions.
- Circuit breaker failure protection.
- 100% stator earth fault protection (3rd harmonic method) (27TN/59TN)
- 100% stator earth fault protection (low frequency injection method) (64S)
- Thermal element alarm thresholds
- Negative sequence thermal element minimum & maximum tripping time
- Dead machine
- Active overpower
- Reactive over and underpower
- Sensitive earth fault protection for ungrounded system and system with Petersen coil

3 Model schemes

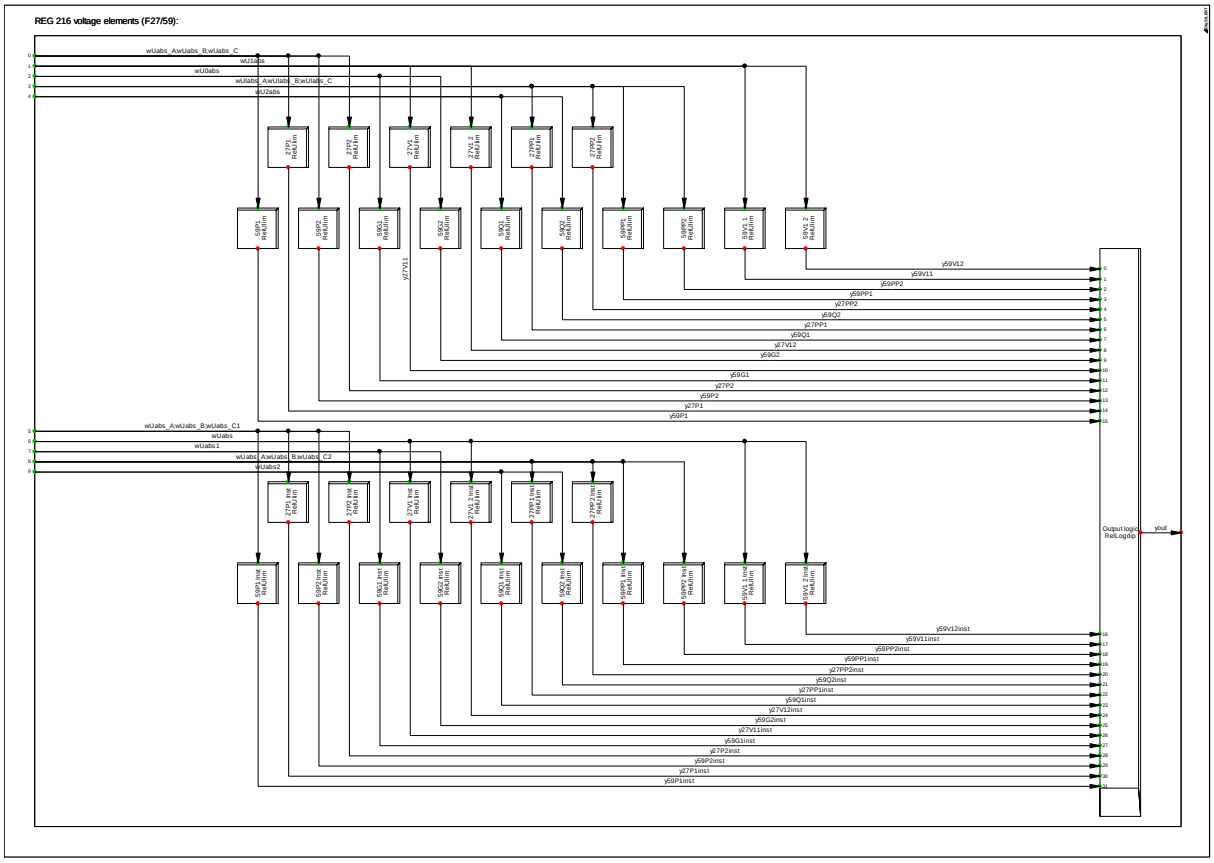
3.1 Main relay



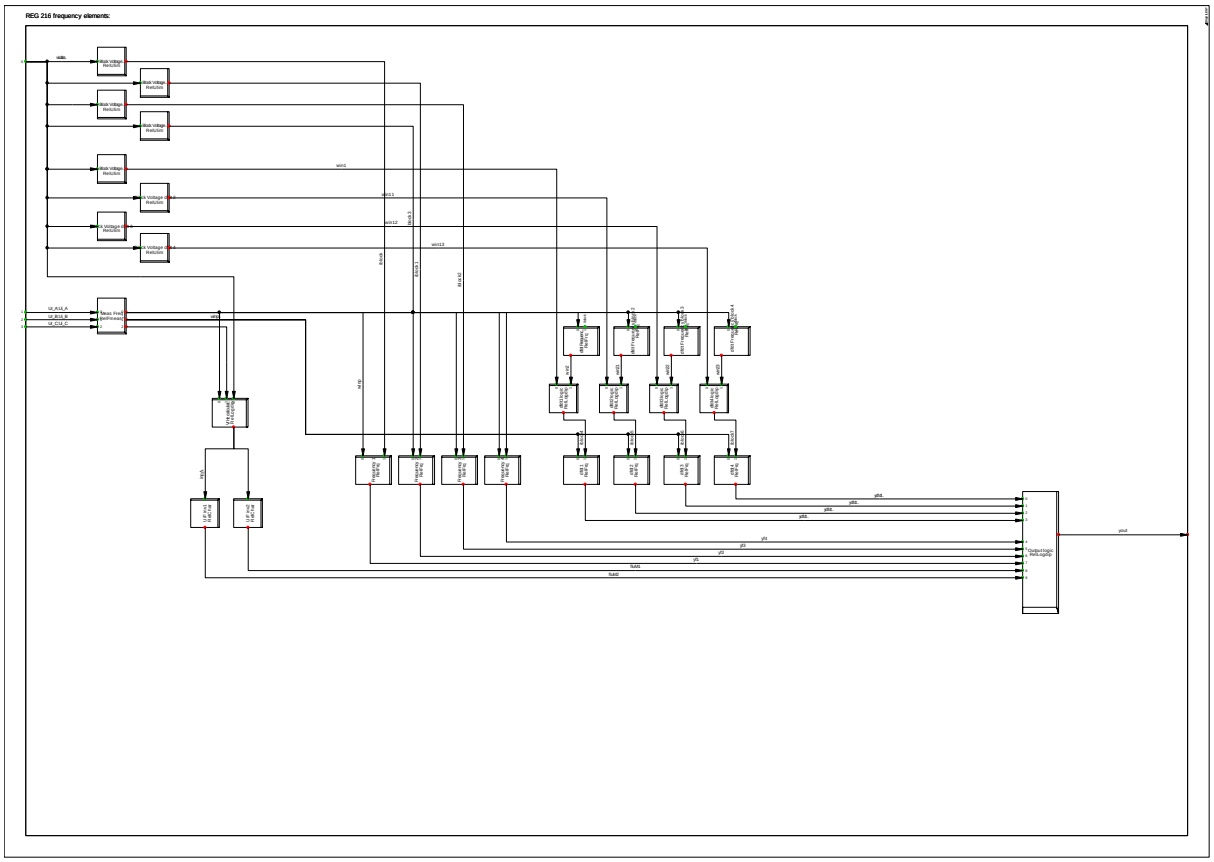
3.2 Overcurrent



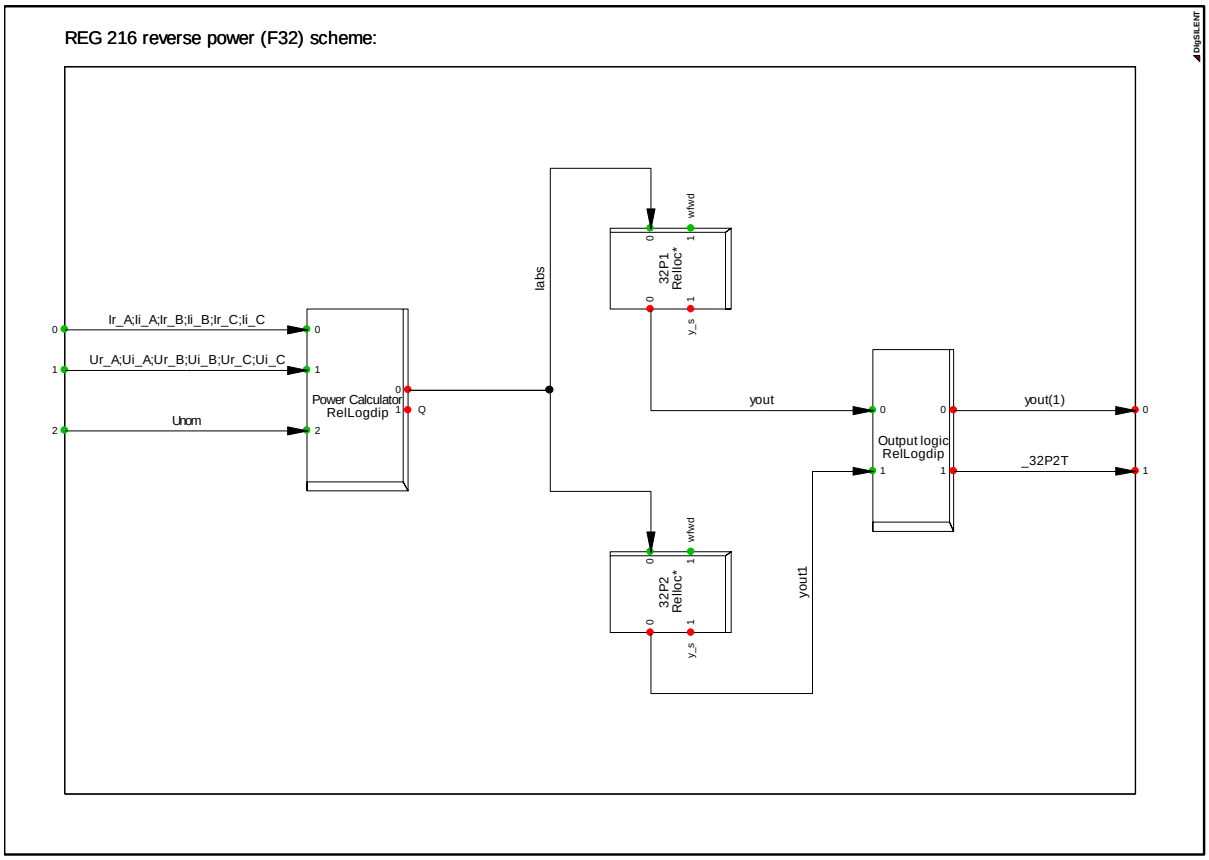
3.3 Voltage


REG 216 voltage elements (F27/59):
wUabs_AwUabs_BwUabs_C
wU1abs
wU0abs
wUabs_AwUabs_BwUabs_C
wU2abs
27P1 ReUnm
27P2 ReUnm
27V1 ReUnm
27V1 2 ReUnm
27PP1 ReUnm
27PP2 ReUnm
59PP ReUnm
59PP2 ReUnm
59Q1 ReUnm
59Q2 ReUnm
59Q ReUnm
59PP1 ReUnm
59PP2 ReUnm
59V1 ReUnm
59V1 2 ReUnm
y27V11
y59V12
y59V11
y59PP2
y59PP1
y27PP2
y59Q2
y27PP1
y59Q1
y27V12
y59G2
y59G1
y27P2
y59P2
y27P1
y59P1
wUabs_AwUabs_BwUabs_C1
wUabs
wUabs1
wUabs_AwUabs_BwUabs_C2
wUabs2
27P1 Inst ReUnm
27P2 Inst ReUnm
27V1 Inst ReUnm
27V1 2 Inst ReUnm
27PP1 Inst ReUnm
27PP2 Inst ReUnm
59PP Inst ReUnm
59PP2 Inst ReUnm
59Q1 Inst ReUnm
59Q2 Inst ReUnm
59Q Inst ReUnm
59PP1 Inst ReUnm
59PP2 Inst ReUnm
59V1 Inst ReUnm
59V1 2 Inst ReUnm
Output logic RelLogdip
yout
y59V12inst
y59V11inst
y59PP2inst
y59PP1inst
y27PP2inst
y59Q2inst
y27PP1inst
y59Q1inst
y27V12inst
y59G2inst
y27V11inst
y59G1inst
y27P2inst
y59P2inst
y27P1inst
y59P1inst

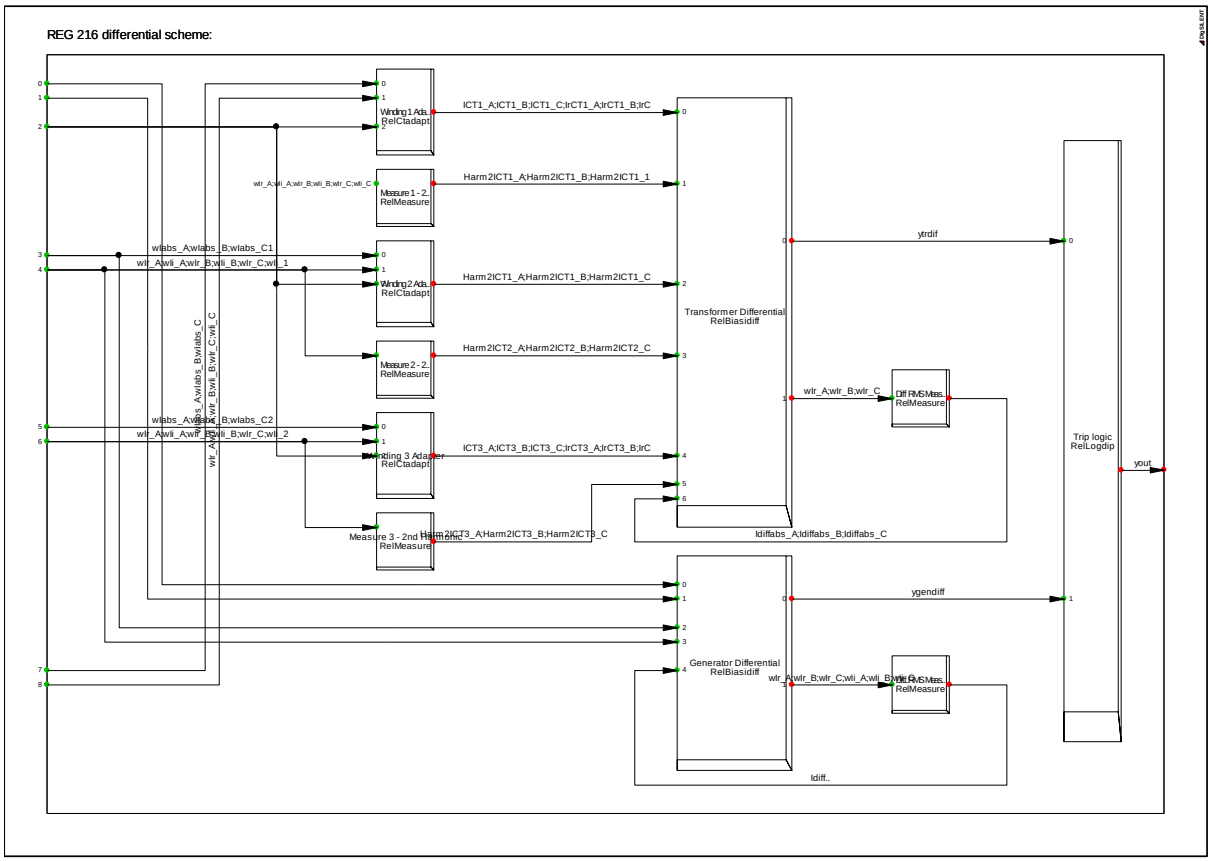
3.4 Frequency



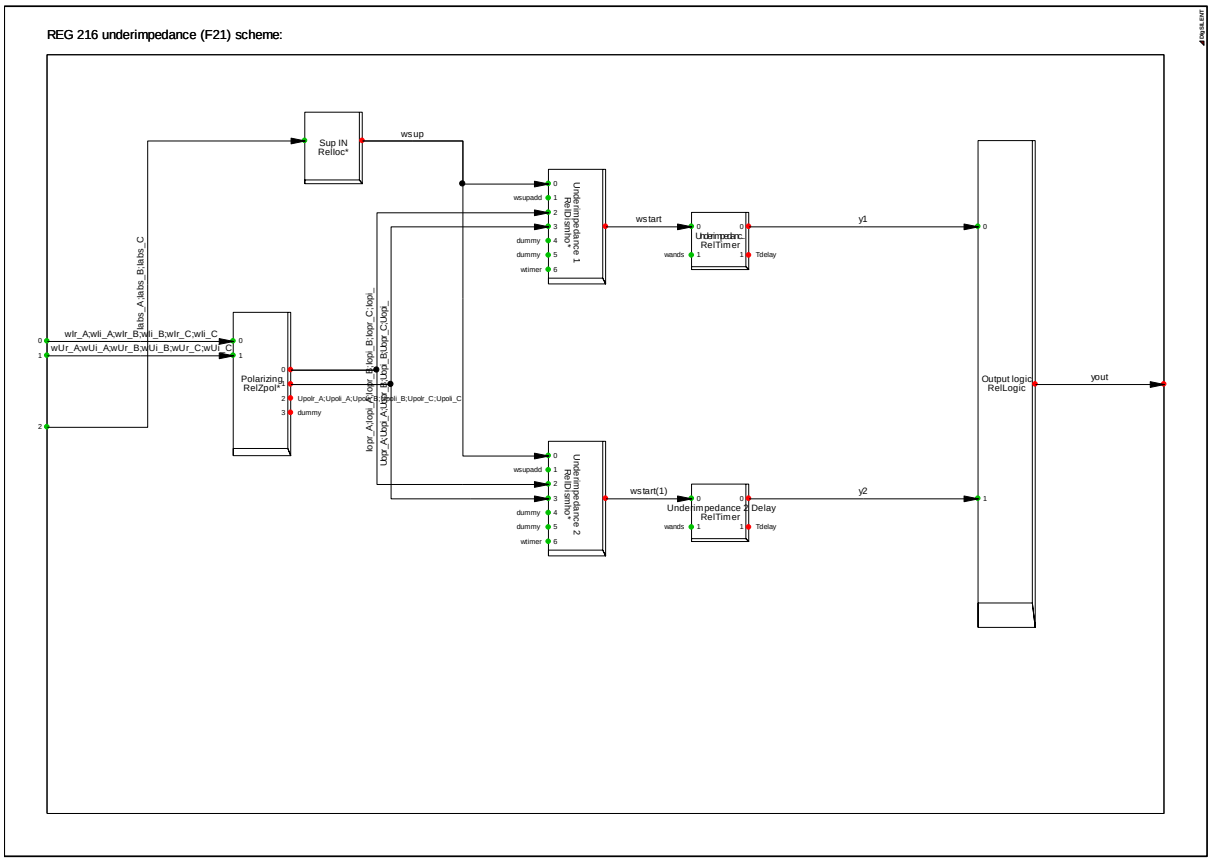
3.5 Reverse power



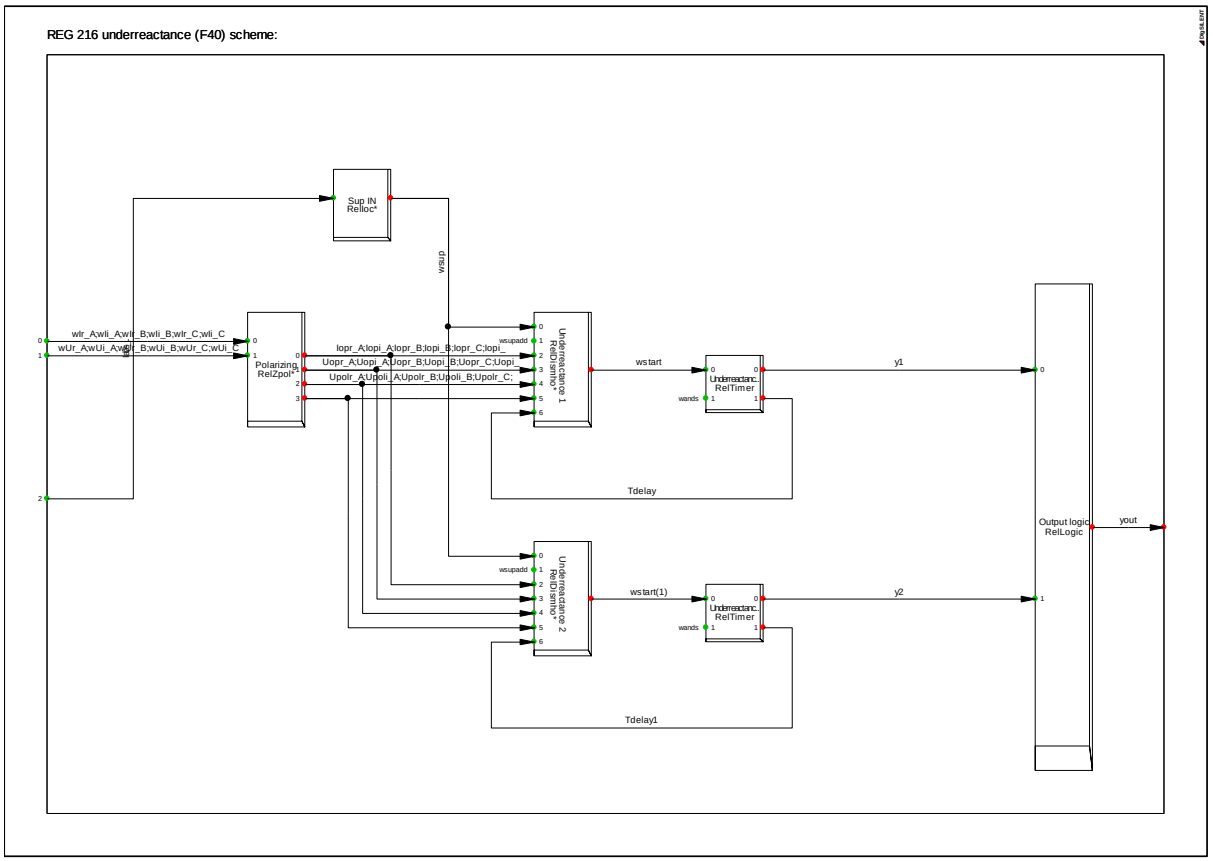
3.6 Differential



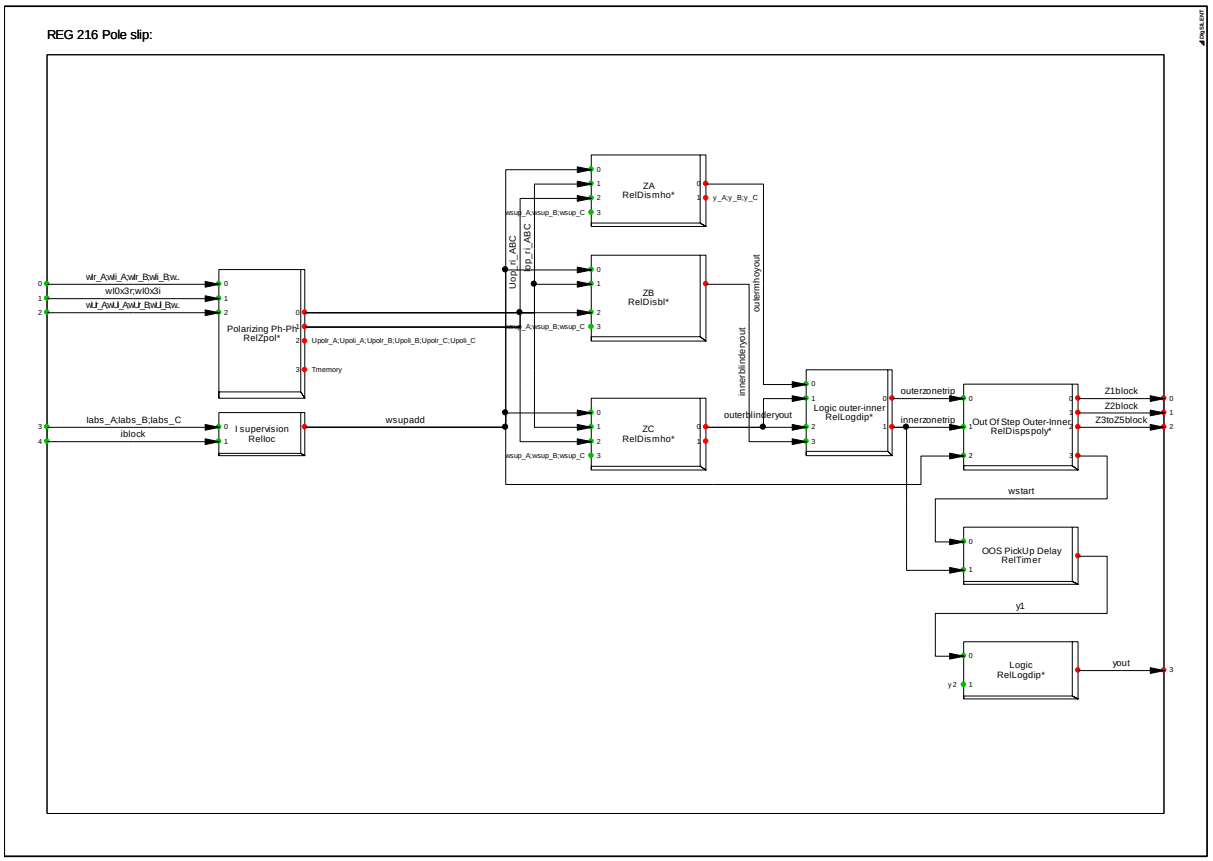
3.7 Underimpedance



3.8 Underreactance



3.9 Pole slip


REG 216 Pole slip:
wlr_Awli_Awlr_Bwli_Bw..
wl0x3r;wl0x3i
wlJ_AwlJ_AwlJ_BwlJ_Bw..
Polarizing Ph-PH
RelZpol*
Upolr_A;Upoli_A;Upolr_B;Upoli_B;Upolr_C;Upoli_C
Tmemory
labs_A;labs_B;labs_C
iblock
I supervision
Relloc
wsupadd
Upp_ri_ABC
Upp_ri_ABC
wsup_A;wsup_B;wsup_C
ZA
RelDismho*
y_A;y_B;y_C
ZB
RelDisbl*
ZC
RelDismho*
outerblinderyout
innerblinderyout
outerzonetrip
innerzonetrip
Logic outer-inner
RelLogdip*
Out Of Step Outer-Inner
RelDispspoly*
Z1block
Z2block
Z3toZ5block
wstart
OOS PickUp Delay
RelTimer
y1
Logic
RelLogdip*
y2
yout

4 References

The model implementation has been based on the information available in the "REG216, REG216 Compact REC216 Numerical Generator Protection Numerical Control Unit Operating Instructions 1MDU02005-EN/3/Rev. 1 Edition March 2001" document.