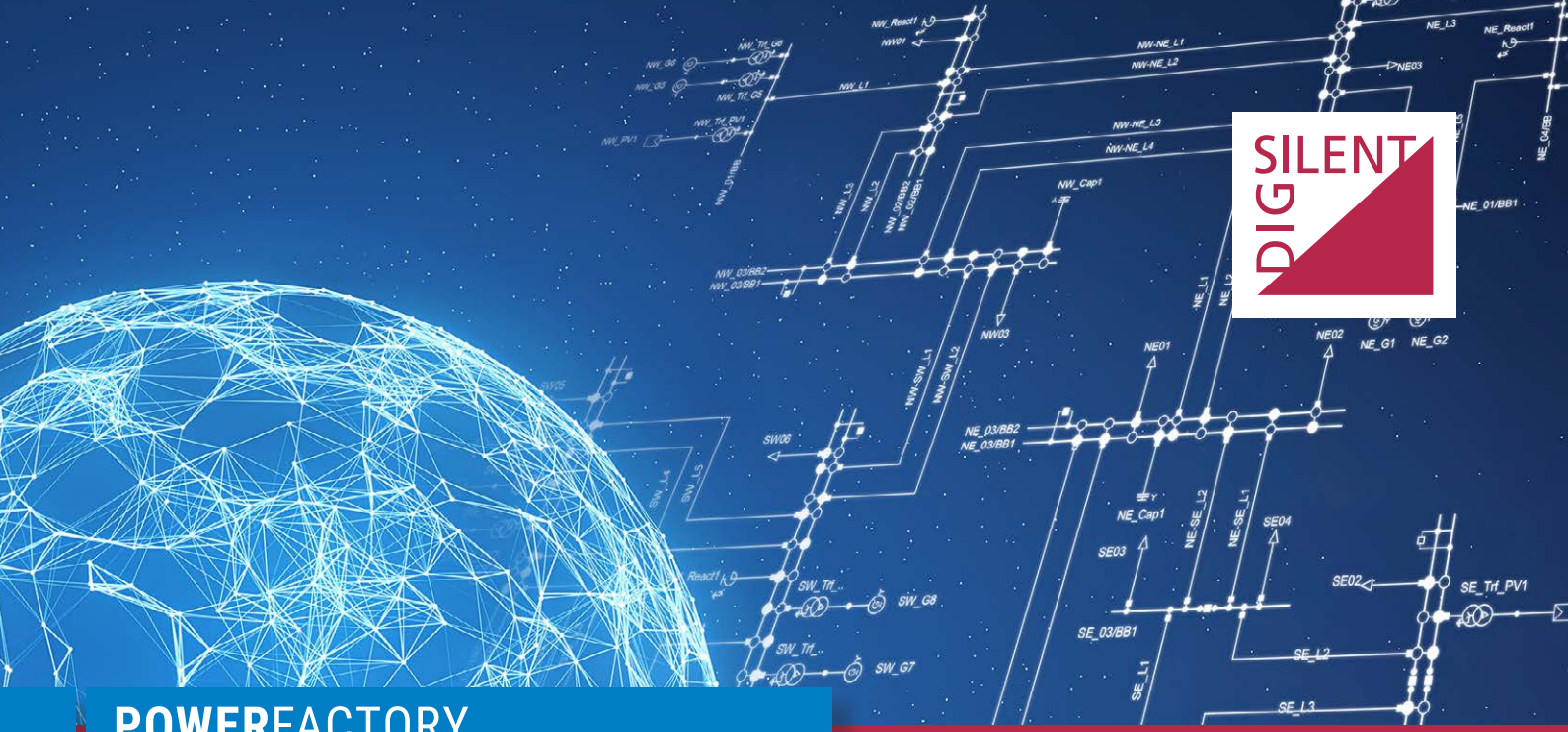

POWERFACTORY

PowerFactory 2021

Technical Reference

Alstom EPAC

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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Contents

1 Model information

Manufacturer Alstom

Model EPAC

Variants The Alstom EPAC PowerFactory relay model can be used to simulate any version of the Alstom EPAC relay. However please consider that the model has been implemented with the features available in the V6E firmware version.

2 General description

The Alstom EPAC line distance protection terminal is a protective relay for HV and EHV line distance protection applications. Additional protection functionality includes phase overcurrent, directional residual current and phase over/undervoltage elements.

The Alstom EPAC PowerFactory relay model consists of a main relay model which contains all elements. Two model subversions are available, one for each available rated current:

- EPAC 1A
- EPAC 5A

The Alstom EPAC PowerFactory relay model has been implemented to simulate the most commonly used protective functions.

The main relay contains the measurement and acquisition units, the starting element, the polarizing elements, the distance elements, the directional element for the distance elements, the overcurrent elements, the over/under voltage elements, and the output logic .

The model implementation has been based on the information available in the relay manual [1].

3 Features supported

3.1 Measurement and acquisition

The voltage and the current are measured by one three phase current transformer (”Ct” block) and one three phase voltage transformer (”Vt” block).
Two measurement units (”Measure” and ”Delta Measure” block) are fed by this CT and this VT.

One relay input signal (’yExt”) is present and can be used to implement a Transfer Trip logic (like ”PUTT” or ”POTT”). The distance block trip signals and the starting signals (not including the directional logic) are available as relay output signals.

3.1.1 Available Units and Input Signals

- One three phase current transformer (”Ct” block).
- One three phase voltage transformer (”Vt” block).
- One three phase measurement block calculating both the phase and voltage values (”Measurement” block).
- One three phase measurement block calculating the phase to phase currents and the phase to phase voltages (”Delta Measure” block).
- One relay input signal (”’yExt” signal).

3.1.2 Functionality

The input signals are sampled at 80 samples/cycle; for each signal the average values are calculated using groups of 4 samples; the average values are processed by a DFT filter operating over a cycle which calculates then the voltage and current values used by the protective elements. The ”Delta Measure” block is calculating the current and voltage ph-ph values used by the phase loop distance elements.

3.1.3 Data input

The nominal current and the nominal voltage values MUST be entered in all the measurement blocks.

3.2 Main Relay protective elements

The starting element, the polarizing elements, the directional element, the reclosing feature and the distance elements work together to simulate the Alstom EPAC distance functionalities. The distance elements can be controlled by the reclosing feature. Additionally some ancillary overcurrent and over/under voltage elements are also available.

3.2.1 Available Units

- One starting element implementing the fault detection logic (”Starting” block).
- One directional element (”Dir-Z” block).
- Two polarizing elements (”Polarizing Z1”, and ”Polarizing Z2-Z5” block).
- Six distance trip zones processing both the phase and the ground loop impedances(”Z1”, ”Z2”, ”Z3”, ”Z4”,”Z5”, and ”Z1b” block).
- Six timers associated with the distance trip zones (”ZT1”, ”ZT2”, ”ZT3”, ”ZT4”, ”ZT5” and ”ZT1b” block).
- One thermal image inverse characteristic element (”Overload” block).
- Two time defined phase overcurrent elements (”I>” and ”I>>” block).
- One inverse time ground current element (”IE>” block).
- One time defined ground current elemnet (”IE>>” block).
- One 3 phase definite time overvoltage element (”OverV” block).
- One 3 phase definite time undervoltage element (”UnderV” block).
- One reclosing element (”Reclosing” block).

3.2.2 Functionality

Starting element The Alstom EPAC relay model starting element simulates the relay fault detection function and is set to use the following criteria:

- Overcurrent fault detection (*Overcurrent I>* option).
- Impedance fault detection (*Impedance Z* option).

Separate settings are available for the earth fault detection (”Ground detection” tab page). Loop determination rules can be set with inside the ”Phase Preference Logic” tab page.

Directional element The directional element is based on the use of the polarizing voltage and of the operating current calculated by the polarizing block. The 3 phase loops and the 3 ground loops are evaluated separately.

Polarizing elements The polarizing elements calculate the voltage vectors used by the directional element taking care of the zero sequence current and of the *Earth Factor*. ”Polarizing Z1”calculate the impedance values used by zone 1, by the directional element and by the starting element. ”Polarizing Z2-Z5”calculate the impedance values used by the other the distance zone elements.

Distance trip zones The polygonal distance elements monitor both the phase and the ground loops; each loop is evaluated separately. All distance elements are directional and the direction can be set for each distance element. Independent timers are available for each distance element. All the distance zone shapes are represented in terms of positive sequence impedances.

The ”Z1b” block can be used to implement an acceleration trip zone (the ”Reclosing” block should be set to enable the ”Z1b” element only during the first trip operation)

Reclosing element The reclosing element can be set to trigger a variable number of reclosing attempts. Different dead times during the first reclosing attempt can be set depending upon the type of fault (single phase-grnd fault or other types of fault). Different dead times can be set for the first reclosing attempt and for the following attempts.

Overcurrent elements Some ancillary overcurrent elements have been implemented in the model to simulate the overload element, the two time defined phase overcurrent elements and the two ground overcurrent elements. The earth fault inverse time element (”IE>” block) supports the following inverse characteristics:

- ANSI Extremly Inverse
- ANSI Inverse
- ANSI Moderately Inverse
- ANSI Very Inverse
- IEC extremly inverse
- IEC inverse
- IEC very inverse

All the inverse time element trip characteristic equations comply with the IEC 60255-3 standards.

3.2.3 Data input

The relationships between the relay settings and the model parameters can be found in the following tables (the relay model parameter names are listed between brackets):

Starting element :

Address	Relay Setting	Model block	Model setting	Note
1003	LIN	Starting	Line length (linelen)	
1007	LIN Known Char	Starting	System Grounding (ineutrearth)	
100E	LIN Rd	Starting	R1 (R1)	
100F	LIN Xd	Starting	X1 (X1)	
1010	LIN R01	Starting	R01 (R01)	In the ”Underimpedance” tab page
1011	LIN X01	Starting	X01 (R01)	In the ”Underimpedance” tab page
1012	LIN R02	Starting	R02 (R02)	In the ”Underimpedance” tab page
1013	LIN X02	Starting	X02 (X02)	In the ”Underimpedance” tab page
1801	ISO Iso Network	Starting	Enabled (ienabled)	In the ”Phase Preference logic” tab page
1803	ISO Loop Sel	Starting	Phase preference for Ph-Ph-E Faults (PhasePref)	In the ”Phase Preference logic” tab page
1804	ISO IR>	Starting	Residual current Threshold (SIr)	In the ”Ground Detection” tab page
1805	ISO VR>	Starting	Residual voltage Threshold (SUr)	In the ”Ground Detection” tab page
1806	ISO Ph/Gnd Trip	Starting	Tripping on maximum residual voltage (iutripen)	In the ”Ground Detection” tab page
1807	ISO tTRIP	Starting	Tripping time delay (Temp)	In the ”Ground Detection” tab page

NOTE: the impedance reach of the starting zone is equal to the Z4 zone reach for the forward direction and to the Z5 zone for the reverse direction. Different angles can be set for the phase, and the ground starting parallelogram angle. Moreover a different angle can be defined for the ground starting parallelogram used to control distance zone 1.(see 2-15 at [1])
The phase starting parallelogram angle is
$\alpha = atan(\overline{(R1, X1)})$
The ground starting parallelogram angle for zone 1 is
$\alpha = atan(2 * \overline{(R1, X1)} + \overline{(R01, X01)})/3)$
The ground starting parallelogram angle for zone 2, 3, 4, 5 is
$\alpha = atan(2 * \overline{(R1, X1)} + \overline{(R02, X02)})/3)$

Directional element :

No user input is required.

Polarizing element :

Address	Relay Setting	Model block	Model setting	Note
100A	LIN Z01	Polarizing Z1	k0 (K0)	Setting visible only when *Show as a complex number* is set
100B	LIN Phi01	Polarizing Z1	Angle (phiK0)	Setting visible only when *Show as a complex number* is set
100C	LIN Z02	Polarizing Z2-Z5	k0 (K0)	Setting visible only when *Show as a complex number* is set
100D	LIN Phi02	Polarizing Z2-Z5	Angle (phiK0)	Setting visible only when *Show as a complex number* is set

Address	Relay Setting	Model block	Model setting	Note
1014	LIN K01r	Polarizing Z1	Re / Rl (ReRl)	Setting visible only when *Show as a complex number* is not set
1015	LIN K01x	Polarizing Z1	Xe / Xl (XeXl)	Setting visible only when *Show as a complex number* is not set
1016	LIN K02r	Polarizing Z2-Z5	Re / Rl (ReRl)	Setting visible only when *Show as a complex number* is not set
1017	LIN K02x	Polarizing Z2-Z5	Xe / Xl (XeXl)	Setting visible only when *Show as a complex number* is not set

Distance trip zones :

Address	Relay Setting	Model block	Model setting	Note
1101	ZON Z1	Z1	Z Reach (Zmax)	
1102	ZON Z1Overreach	Z1b	Z Reach (Zmax)	
1103	ZON T1	ZT1	Time Setting(Tdelay)	
1104	ZON Z2	Z2	Z Reach (Zmax)	
1105	ZON T2	ZT2	Time Setting(Tdelay)	
1106	ZON Z3	Z3	Z Reach (Zmax)	
1107	ZON T3	ZT3	Time Setting(Tdelay)	
1106	ZON Z4	Z4	Z Reach (Zmax)	
1107	ZON T4	ZT4	Time Setting(Tdelay)	
1106	ZON Z5	Z5	Z Reach (Zmax)	
1107	ZON T5	ZT5	Time Setting(Tdelay)	
1108	ZON Dir. Z3	Z3	Tripping Direction (idir)	
110F	ZON Ph/Gnd RZ1	Z1	+R Resistance (PH-E) (REmax)	
		Z1b	+R Resistance (PH-E) (REmax)	
1110	ZON Ph/Ph RZ1	Z1	+R Resistance (Rmax)	
		Z1b	+R Resistance (Rmax)	
1111	ZON RLim Z2	Z2	+R Resistance (Rmax)	
1112	ZON RLim Z3	Z3	+R Resistance (Rmax)	
1113	ZON RLim Starter	Z4	+R Resistance (Rmax)	
		Z5	+R Resistance (Rmax)	

Note: the angle of the phase distance parallelogram is
$\alpha = atan(\overline{(R1, X1)})$.
The ground distance parallelogram angle for zone 1 is
$\alpha = atan(2 * \overline{(R1, X1)} + \overline{(R01, X01)})/3)$
The ground distance parallelogram angle for zone 2, 3, 4, 5 is
$\alpha = atan(2 * \overline{(R1, X1)} + \overline{(R02, X02)})/3)$
Where $R1, X1, R01, X01, R02, X02$ are parameters of the ”Starting” element.

Reclosing :

Address	Relay Setting	Model block	Model setting	Note
1701	ARC t1PFASTDEAD	Reclosing	Reclosing int 1 1Ph-Grnd faults (recltime11ph)	
1702	ARC t3PFASTDEAD	Reclosing	Reclosing Interval 1 (recltime1)	
1703	ARC tSLOWDEAD	Reclosing	Reclosing Interval 2 (recltime2)	
		Reclosing	Reclosing Interval 3 (recltime3)	
		Reclosing	Reclosing Interval 4 (recltime4)	

Address	Relay Setting	Model block	Model setting	Note
1704	ARC Recl Time	Reclosing	Closing command duration (closingcomtime)	
1705	ARC tRECLAIM	Reclosing	Reset Time (resettime)	

Overcurrent :

Address	Relay Setting	Model block	Model setting	Note
110D	ZON T>>	I>>	Time Setting (Tset)	
110E	ZON T>	I>	Time Setting (Tset)	
1114	ZON I>> Acti.	I>>	Out of Service (outserv)	
1115	ZON I>>	I>>	Pickup Current (Ipset)	
1117	ZON I> Acti.	I>	Out of Service (outserv)	
1118	ZON I>	I>	Pickup Current (Ipset)	
1A0E	OVL Curves	Overload	Chracteristic (pcharac)	
1A0F	OVL IEC Curves	Overload	Chracteristic (pcharac)	
1A10	OVL ANSI Curves	Overload	Chracteristic (pcharac)	
1A11	OVL I Factor	Overload	Current Setting (Ipset)	
1A12	OVL I>	Overload	Time Dial (Tpset)	
1601	DEF Def	IE>	Out of Service (outserv)	
		IE>>	Out of Service (outserv)	
1602	DEF VR>	Earth Dir	Polarizing Voltage (upolu)	In the ”Voltage Polarizing” tab page
1603	DEF Forward IR>	IE>	Current Setting (Ipset)	
160A	DEF tOPERATE	IE>>	Time Setting (Tset)	
160D	DEF IR>>	IE>>	Pickup Current (Ipset)	
160E	DEF I Factor	IE>	Time Dial (Tpset)	
1610	DEF Curves	IE>	Characteristic (pcharac)	
1611	DEF IEC Curves	IE>	Characteristic (pcharac)	
1612	DEF ANSI Curves	IE>	Characteristic (pcharac)	

Voltage :

Address	Relay Setting	Model block	Model setting	Note
1A01	OVL V« & V»	UnderV	Out of Service (outserv)	
		OverV	Out of Service (outserv)	
1A02	OVL V«	UnderV	Pickup Voltage (Uset)	
1A03	OVL V« tTRIP	UnderV	Time Delay (Tdel)	
1A04	OVL V»	OverV	Pickup Voltage (Uset)	
1A05	OVL V» tALARM	OverV	Time Delay (Tdel)	the ”OverV” block generates always a trip command
1A06	OVL Trip on V»	OverV	Out of Service (outserv)	

3.3 Output logic

The output logic is the interface between the relay and the power system. A set of relay output signals can be used to simulate the control logics.

3.3.1 Available Units and Output Signals

The trip logic is implemented by the ”Logic” block located in the main relay. The ”Closing Logic” block controlled by the reclosing feature (”Reclosing” block) has the purpose of generating a closing command for the power breaker when a reclosing attempt is triggered.

Fourteen relay output signals are available:

- *ys_z1b* The extension distance zone starting signal.
- *ys_z5* The fifth distance zone starting signal.
- *ys_z4* The forth distance zone starting signal.
- *ys_z3* The third distance zone starting signal.
- *ys_z2* The second distance zone starting signal.
- *ys_z1* The first distance zone starting signal.
- *y_z1b* The extension distance zone tripping signal.
- *y_z5* The fifth distance zone tripping signal.
- *y_z4* The forth distance zone tripping signal.
- *y_z3* The third distance zone tripping signal.
- *y_z2* The second distance zone tripping signal.
- *y_z1* The first distance zone tripping signal.
- *yout* The ”Logic” block output signal.
- *yClose* The ”Closing Logic” block output signal.

3.3.2 Functionality

The ”Logic” block located in the main relay is operating the breaker.
The relay output signal which is used to operate the breaker is ”yout”.

Moreover it implements the Permissive Underreach Transfer Trip logic (”PUTT”).
For this purpose the ”yExt” relay input signal is used in accordance with the following logic:

A PUTT condition is declared and the breaker is operated when

- The PUTT logic is active (”PUTT” parameter).
- The PUTT input signal (*yExt*) is on.
- The relay has started (the *Starting* element picked up).

3.3.3 Data input

Please disable the ”Logic” block in the main relay to disable the relay model’s ability to open the power circuit.

To enable the PUTT logic set the ”PUTT ” parameter in the ”Logic” tab page of the ”Logic” block dialog equal to TRIP. This is disabled (NOTRIP) by default.

4 Features not supported

The following features are not supported:

- Synchronism and voltage check.
- Permissive Overreach Transfer Trip and other teleprotection scheme. (POTT scheme, directional comparison, unblocking etc.).
- Single phase trip - single phase reclosing.
- Week infeed.
- Tee line logic scheme.
- Power Swing.
- Fuse failure detection.
- High speed algorithm.
- Fault locator.

5 References

[1] ALSTOM P and C HV Product Line, Marketing Department Avenue de Figuières F-34975 LATTES CEDEX. *EPAC 3100/EPAC 3500 Versions V5E-V6-V6E Numerical Distance Relay Commissioning and Maintenance Guide 09/00 MS/M 1.6882-D*.