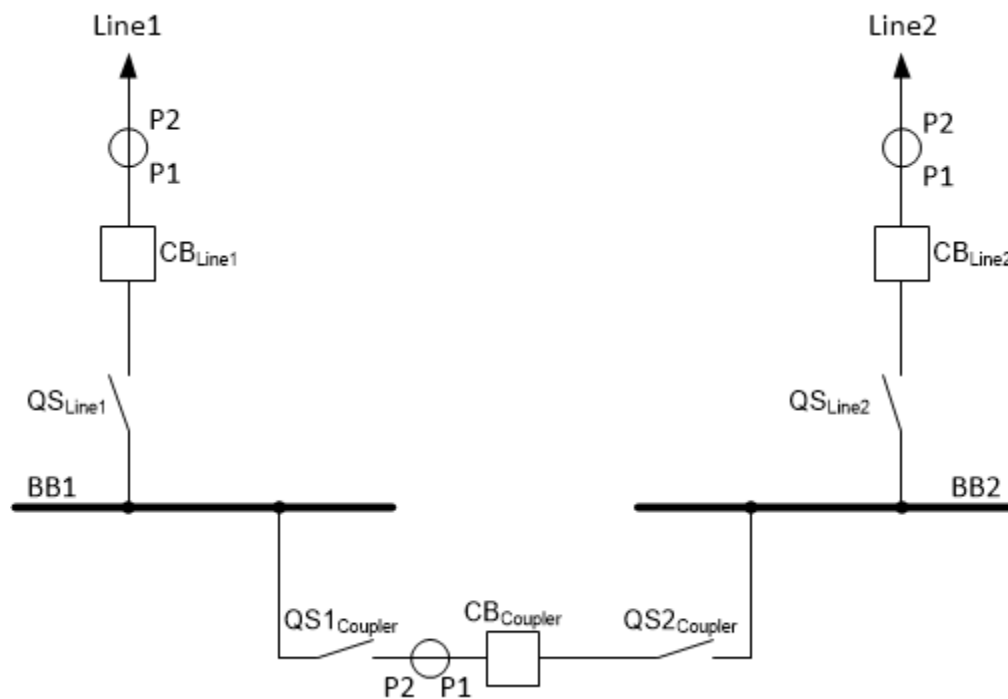




TEST PROTOCOL

Substation Topology

The tests shall be performed with single-bus H-type substation (2 lines and CB coupler for the simplification). CBs and disconnectors positions will be simulated.



Basic Parameters Settings

The thresholds given are generalized. Some of them, such as $I_{diff}(I_{bias})$ curve parameters, can be changed according to the settings of each individual manufacturer as needed.
Other relays parameters should be configured to perform the required logic.

Parameter	Setting
Line bays CT ratio	2500/5
Coupler bay CT ratio	2500/5
Transformer bays CT ratio	500/5
I_{base}	2500 A
$I_{diff.min}$	$0.6 \cdot I_{base}$
I_{s1}	$1 \cdot I_{base}$
I_{s2}	$2 \cdot I_{base}$
K_{slope1}	30%
K_{slope2}	60%
CB control	By current
CB min current for BFP	$0.2 \cdot I_{nom}$
CT supervision time delay for protection blocking	5 s
BFP first step time delay (retrip)	0.08 s
BFP second step time delay	0.2 s
BFP second step time delay in case of CB unavailability	0.1 s
End-fault time delay (line bays)	0.15 s
End-fault current (line bays)	$0.4 \cdot I_{nom}$
BFP blocking time delay (long start)	2 s
Disconnecter discrepancy time	15 s

Functional tests

Checking BBP stability during external fault currents injecting (7.3)

Signals	Values	
IA _{Line1}	3*I _{base}	180 ⁰
IA _{Coupler}	3*I _{base}	180 ⁰
IA _{Line2}	3*I _{base}	0 ⁰
CB _{Line1}	1	
CB _{Coupler}	1	
CB _{Line2}	1	
QS1 _{Line1}	1	
QS1 _{Coupler}	1	
QS2 _{Coupler}	1	
QS1 _{Line2}	0	
Expected results		
I _{diff1}	≈0*I _{base}	
I _{diff2}	≈0*I _{base}	
I _{diffCommon}	≈0*I _{base}	

Changing of substation topology (7.4)

State 1 – Normal mode

State 2 – Disconnecter of Line2 bay is opened. The relevant currents of the bay will not be calculated as part of the BB zones.

State 3 – QS_{Line2} discrepancy. With 15 s delay differential current will be calculated for zone 2 (as QS_{Line2} closed).

State 4 – Normal mode.

Signals	State 1		State 2		State 3		State 4	
IB _{Line1}	0.2*I _{base}	180 ⁰	0.2*I _{base}	180 ⁰	0.2*I _{base}	180 ⁰	0.2*I _{base}	180 ⁰
IB _{Coupler}	0.3*I _{base}	180 ⁰	0.3*I _{base}	180 ⁰	0.3*I _{base}	180 ⁰	0.3*I _{base}	180 ⁰
IB _{Line2}	0.4*I _{base}	0 ⁰	0.4*I _{base}	0 ⁰	0.4*I _{base}	0 ⁰	0.4*I _{base}	0 ⁰
CB _{Line1}	1		1		1		1	
CB _{Coupler}	1		1		1		1	
CB _{Line2}	1		1		1		1	
QS _{Line1}	1		1		1		1	
QS1 _{Coupler}	1		1		1		1	
QS2 _{Coupler}	1		1		1		1	
QS _{Line2}	0		0		01		1	
Expected results								
I _{diff1}	0.1*I _{base}		0.1*I _{base}		0.1*I _{base}		0.1*I _{base}	
I _{diff2}	0.1*I _{base}		0.3*I _{base}		0.1*I _{base} (15s delay)		0.1*I _{base}	
I _{diffCommon}	0.2*I _{base}		0.2*I _{base}		0.2*I _{base} (15s delay)		0.2*I _{base}	

Checking I_{diff}(I_{bias}) characteristic (7.5)

Automatic test. Testing device protocol shall be provided.

Checking of BBP operating time at different pick-up levels (7.6)

State 1 – Normal mode

State 2 – Low current BB1 fault

State 3 – Tripped mode

State 4 – Normal mode

State 5 – High current BB1 fault

Signals	State 1 1s		State 2 0.3s or BB1 Trip		State 3 1s		State 4 1s		State 5 0.3s or BB1 Trip	
IC _{Line1}	0.4*I _{base}	180 ⁰	0.4*I _{base}	180 ⁰	0*I _{base}	180 ⁰	0.4*I _{base}	180 ⁰	3*I _{base}	180 ⁰
IC _{Coupler}	0.4*I _{base}	180 ⁰	0.4*I _{base}	0 ⁰	0*I _{base}	0 ⁰	0.4*I _{base}	180 ⁰	3*I _{base}	0 ⁰
IC _{Line2}	0.4*I _{base}	0 ⁰	0.4*I _{base}	180 ⁰	0*I _{base}	0 ⁰	0.4*I _{base}	0 ⁰	3*I _{base}	180 ⁰
CB _{Line1}	1		1		0		1		1	
CB _{Coupler}	1		1		0		1		1	
CB _{Line2}	1		1		1		1		1	
Expected results										
I _{diff1}	≈0*I _{base}		≈0.8*I _{base}		≈0*I _{base}		≈0*I _{base}		≈6*I _{base}	
I _{diff2}	≈0*I _{base}		≈0*I _{base}		≈0*I _{base}		≈0*I _{base}		≈0*I _{base}	
I _{diffCommon}	≈0*I _{base}		≈0.8*I _{base}		≈0*I _{base}		≈0*I _{base}		≈6*I _{base}	
Relay outputs monitoring										
BB1 Trip	0		1		0		0		1	
CB _{Line1} AR block	0		1		0		0		1	
Testing device timers										
BB1 Trip			<0.025s						<0.025s	

Checking of CT supervision function (7.7)

CT supervision function is activated for this test only.

State 1 – Normal mode

State 2 – CT fault

State 3 – BB1 fault during CT fault

State 4 – Normal mode

State 5 – BB1 fault

Signals	State 1 1s		State 2 5.5s		State 3 0.3s		State 4 1s		State 5 0.3s or BB1 Trip	
IA _{Line1}	0.4*I _{base}	180 ⁰	0*I _{base}	180 ⁰	0.4*I _{base}	180 ⁰	0.4*I _{base}	180 ⁰	0.4*I _{base}	180 ⁰
IA _{Coupler}	0.4*I _{base}	180 ⁰	0.4*I _{base}	180 ⁰	0.4*I _{base}	0 ⁰	0.4*I _{base}	180 ⁰	0.4*I _{base}	0 ⁰
IA _{Line2}	0.4*I _{base}	0 ⁰	0.4*I _{base}	0 ⁰	0.4*I _{base}	180 ⁰	0.4*I _{base}	0 ⁰	0.4*I _{base}	180 ⁰
CB _{Line1}	1		1		1		1		1	
CB _{Coupler}	1		1		1		1		1	
CB _{Line2}	1		1		1		1		1	
CTSV reset	0		0		0		1		0	
Expected results										
<i>Relay outputs monitoring</i>										
CTSV	0		1		1		0		0	
BB1 Trip	0		0		0		0		1	
<i>Testing device timers</i>										
CTSV			5s							
BB1 Trip									<0.025s	

Checking of breaker failure protection for each bay in different configurations, including CB unavailability (7.8)

BB1 fault with CB coupler failure

State 1 – Normal mode

State 2 – BB1 fault

State 3 – BB1 disabled with CB coupler failure, successful retrip

State 4 – Normal mode, BB1 disabled

State 5 – BB1 fault

State 6 – BB1 disabled with CB coupler failure, unsuccessful retrip, BB2 trip

State 7 – Normal mode, BB1 and BB2 disabled, CB coupler unavailable

State 8 – BB1 fault with CB coupler unavailable, BB2 trip

Signals	State 1 1s		State 2 0.3s or BB1 Trip		State 3 0.3s or ReTrip		State 4 1s		State 5 0.3s or BB1 Trip		State 6 0.3s or BB2 Trip		State 7 1s		State 8 0.3s or BB2 Trip	
IA _{Line1}	0.4*I _{base}	180°	2*I _{base}	180°	0*I _{base}	180°	0*I _{base}	180°	2*I _{base}	180°	2*I _{base}	180°	0*I _{base}	180°	2*I _{base}	180°
IA _{Coupler}	0.4*I _{base}	0°	2*I _{base}	0°	2*I _{base}	0°	0*I _{base}	0°	2*I _{base}	0°	2*I _{base}	0°	0*I _{base}	0°	2*I _{base}	0°
IA _{Line2}	0.4*I _{base}	180°	2*I _{base}	180°	2*I _{base}	180°	0.1*I _{base}	180°	2*I _{base}	180°	2*I _{base}	180°	0*I _{base}	180°	2*I _{base}	180°
CB _{Line1}	1		1		0		0		1		0		0		1	
CB _{Coupler}	1		1		1		0		1		1		0		1	
CB _{Line2}	1		1		1		1		1		1		0		1	
CB _{Coupler} unavailable	0		0		0		0		0		0		1		1	
Expected results																
<i>Relay outputs monitoring</i>																
CB _{Coupler} ReTrip	0		0		1		0		0		1		0		0	
BB1 Trip	0		1		1		0		1		1		0		1	
BB2 Trip	0		0		0		0		0		1		0		1	
<i>Testing device timers</i>																
CB _{Coupler} ReTrip					0.08s						0.08s					
BB2 Trip											0.2s				<0.025s	

Line1 fault with CB failure

State 1 – Normal mode

State 2 – Line1 fault with CB failure, successful retrip

State 3 – Normal mode, CB_{Line1} disabled

State 4 – Line1 fault with CB failure, unsuccessful retrip, BB1 trip + DTT

State 5 – Normal mode, BB1 disabled, CB_{Line1} unavailable

State 6 – Line1 fault with CB unavailable, BB1 trip + DTT

State 7 – BB1 disabled, CB_{Line1} BFP start for more than 2 s

State 8 – BB1 enabled, Line1 fault with continuous BFP start, no BB1 trip

Signals	State 1 1s		State 2 0.3s or ReTrip		State 3 1s		State 4 0.3s or DTT		State 5 1s		State 6 0.3s or DTT		State 7 3s		State 8 0.3s	
IA _{Line1}	0.4*I _{base}	0 ⁰	2*I _{base}	0 ⁰	0*I _{base}	0 ⁰	2*I _{base}	0 ⁰	0*I _{base}	0 ⁰	2*I _{base}	0 ⁰	0*I _{base}	0 ⁰	2*I _{base}	0 ⁰
IA _{Coupler}	0.4*I _{base}	180 ⁰	2*I _{base}	180 ⁰	0.1*I _{base}	180 ⁰	2*I _{base}	180 ⁰	0*I _{base}	180 ⁰	2*I _{base}	180 ⁰	0*I _{base}	180 ⁰	2*I _{base}	180 ⁰
IA _{Line2}	0.4*I _{base}	180 ⁰	2*I _{base}	180 ⁰	0.1*I _{base}	180 ⁰	2*I _{base}	180 ⁰	0.1*I _{base}	180 ⁰	2*I _{base}	180 ⁰	0*I _{base}	180 ⁰	2*I _{base}	180 ⁰
CB _{Line1}	1		1		0		1		1		1		0		1	
CB _{Coupler}	1		1		1		1		0		1		0		1	
CB _{Line2}	1		1		1		1		1		1		1		1	
CB _{Line1} BFP Start	0		1		0		1		0		1		1		1	
CB _{Line1} unavailable	0		0		0		0		1		1		0		0	
Expected results																
<i>Relay outputs monitoring</i>																
ReTrip	0		1		0		1		0		0		0		0	
BB1 Trip	0		0		0		1		0		1		0		0	
CB _{Line1} AR Block	0		0		0		1		0		1		0		0	
Line1 DTT	0		0		0		1		0		1		0		0	
<i>Testing device timers</i>																
ReTrip			0.08s				0.08s									
Line1 DTT							0.2s				0.1s					

Checking of dead-zone function (7.9)

State 1 – Normal mode

State 2 – Fault between CB_{Coupler} and it's CT

State 3 – BB2 disabled, CB_{Coupler} failure, unsuccessful retrip, BFP

State 4 – Normal mode, BB1 and BB2 disabled

State 5 – Fault between CB_{Coupler} and it's CT

State 6 – BB2 disabled, CB_{Coupler} opened, dead-zone logic operation

Signals	State 1		State 2		State 3		State 4		State 5		State 6	
	1s		0.3s or BB2 Trip		0.3s or BB1 Trip		1s		0.3s or BB2 Trip		0.3s or BB1 Trip	
IA _{Line1}	0.4*I _{base}	180 ⁰	2*I _{base}	180 ⁰	2*I _{base}	180 ⁰	0*I _{base}	180 ⁰	2*I _{base}	180 ⁰	2*I _{base}	180 ⁰
IA _{Coupler}	0.4*I _{base}	180 ⁰	2*I _{base}	180 ⁰	2*I _{base}	180 ⁰	0*I _{base}	180 ⁰	2*I _{base}	180 ⁰	2*I _{base}	180 ⁰
IA _{Line2}	0.4*I _{base}	0 ⁰	2*I _{base}	180 ⁰	0*I _{base}	180 ⁰	0*I _{base}	180 ⁰	2*I _{base}	180 ⁰	0*I _{base}	180 ⁰
CB _{Line1}	1		1		1		0		1		1	
CB _{Coupler}	1		1		1		1		1		0	
CB _{Line2}	1		1		0		0		1		0	
Expected results												
Relay outputs monitoring												
ReTrip	0		0		1		0		0		1	
BB1 Trip	0		0		1		0		0		1	
BB2 Trip	0		1		1		0		1		1	
Testing device timers												
ReTrip					0.08s						0.08s	
BB1 Trip					0.2s						≈0.1s	
BB2 Trip			<0.025s						<0.025s			

Checking of end-fault function with disconnecter opened (7.10)

State 1 – Normal mode, CB_{Line2}, QS_{Line2} opened

State 2 – Low current fault between CB_{Line2} and it's CT, end-fault logic operation

Signals	State 1 1s		State 2 0.3s or DTT	
IA _{Line2}	0*I _{base}	0 ⁰	0.5*I _{base}	180 ⁰
CB _{Line1}	1		1	
CB _{Coupler}	1		1	
CB _{Line2}	0		0	
QS _{Line1}	1		1	
QS1 _{Coupler}	1		1	
QS2 _{Coupler}	1		1	
QS _{Line2}	0		0	
Expected results				
Relay outputs monitoring				
DTT	0		1	
Testing device timers				
DTT			0.15s	

Checking of end-fault function with disconnecter closed (7.10) (optional)

State 1 – Normal mode

State 2 – Fault between CB_{Line2} and it's CT

State 3 – BB2 disabled, CB_{Line2} failure, unsuccessful retrip, BFP

State 4 – Normal mode, BB2 disabled

State 5 – Fault between CB_{Line2} and it's CT

State 6 – BB2 disabled, CB_{Line2} opened, end-fault logic operation

Signals	State 1 1s		State 2 0.3s or BB2 Trip		State 3 0.3s or DTT		State 4 1s		State 5 0.3s or BB2 Trip		State 6 0.3s or DTT	
IA _{Line1}	0.4*I _{base}	180°	2*I _{base}	180°	0.1*I _{base}	180°	0.1*I _{base}	180°	2*I _{base}	180°	0.1*I _{base}	180°
IA _{Coupler}	0.4*I _{base}	180°	2*I _{base}	180°	0*I _{base}	180°	0*I _{base}	180°	2*I _{base}	180°	0*I _{base}	180°
IA _{Line2}	0.4*I _{base}	0°	2*I _{base}	180°	2*I _{base}	180°	0*I _{base}	180°	2*I _{base}	180°	0.5*I _{base}	180°
CB _{Line1}	1		1		1		0		1		1	
CB _{Coupler}	1		1		0		0		1		0	
CB _{Line2}	1		1		1		1		1		0	
QS _{Line1}	1		1		1		1		1		1	
QS1 _{Coupler}	1		1		1		1		1		1	
QS2 _{Coupler}	1		1		1		1		1		1	
QS _{Line2}	0		0		0		0		0		0	
Expected results												
<i>Relay outputs monitoring</i>												
ReTrip					1						1	
BFP Trip					1							
DTT					1						1	
BB2 Trip			1		1				1		1	
<i>Testing device timers</i>												
ReTrip					0.08s						0.08s	
BFP Trip					0.2s							
DTT					0.2s						0.15s	
BB2 Trip			<0.025s						<0.025s			