



THE ISRAEL ELECTRIC CORPORATION LTD.

ENGINEERING PLANNING DIVISION

SUBSTATION PLANNING SECTOR

STR-1949 SPECIFICATION FOR BUSBAR AND BREAKER FAILURE PROTECTION FOR SUBSTATIONS
--

APPENDIX NO. 3

Busbar and Breaker Failure Protection
Acceptance Test Programs
(For tests in Purchaser's Laboratory)

Busbar and Breaker Failure Protection
Acceptance Test Programs
(For tests in Purchaser's Laboratory)
as a part of Specs STR-1949

General Notes:

- The POC will take place at Purchaser's facility in Haifa – Israel.
- The testing will be performed with doble F6150 or ISA DRTS66 instrument.
- The bidder can provide their own test equipment for POC.
- The communication with relays will be by bidder's PC.
- Before the beginning of the tests, bidder should provide the pre-test protocol as described in Appendix 3.1.

Test	Acceptance Criteria	Note
1. Visual check 1.1. Packing reliability and marking 1.2. Absence of broken parts and no signs that relay has been damaged during transportation 1.3. Checking of nameplates 1.4. Inspection of internal relay construction, including internal power supply, overvoltage protection of logical inputs, trip relays, auxiliary relays, etc. and examination accordance to Spec, Standards and manufacturer Data Sheets	Accordance to Specifications, Standards and manufacturer's Data Sheets	
2. Communications ports checks Examination functioning of all communication ports, connected to PC	Ability for communication by Ethernet and/or USB	Annex B 10.3.5.1.6

Test	Acceptance Criteria	Note
3. Power supply 3.1. Measurement of relay consumption from power supply at minimal (176 VDC) and maximal (253 VDC) operating voltage 3.2. Testing relay withstanding to minimal and maximal operating voltage for 5 hours each. During testing relay placed in thermos-insulation enclosure 3.3. Testing relay functioning at minimal and maximal supply voltages Testing relay functioning at supply voltage sags	Less than 30 W Subject to manufacturer's approval No influence of voltage level to accuracy of current measurement function No failures on relay, no tripping with voltage interruption during 40 ms on power supply	Annex B 10.3.5.1.13.20
4. Binary inputs tests Activation/deactivation voltage measurement of relay binary input		Annex B 10.3.5.1.16.1
5. Binary outputs tests 5.1. Closing time measurement of relay binary outputs Checking alarm output at losing of power supply voltage 220V DC	Alarm contact is closed at switching OFF and opened at switching ON power supply 220 VDC	Annex B 10.3.5.1.16.2 10.3.5.1.16.3
6. Checking rated burden for current circuits Measurement of voltage drop on current input at nominal current 5A	Less than 0.1 V	Annex B 10.3.5.1.16.4

Test	Acceptance Criteria	Note
7. Functional tests		
7.1. Checking function of analog signals level measurement	Ability for currents measurements on analog inputs with required accuracy	Annex B 10.3.5.1.16.4
7.2. Checking of phase differential current measurement	Ability to segregate phase measurement of differential currents on analog inputs	Annex B 10.3.4.1.5
7.3. Checking differential protection (BBP) stability during external fault currents injecting	Differential current is close to 0	Annex B 10.3.4.1.1
7.4. Changing of substation topology	Ability to correct differential current calculation while changing disconnectors position	Annex B 10.3.4.1.6 10.3.4.1.7 10.3.4.1.15
7.5. Checking $I_{diff}(I_{bias})$ characteristic		Annex B 10.3.4.1.19
7.6. Checking of BBP operating time at different pick-up levels	Less than 0.025 s	Annex B 10.3.4.1.3
7.7. Checking of CT supervision function		Annex B 10.3.4.1.17
7.8. Checking of breaker failure protection for each bay in different configurations, including CB unavailability		Annex B 10.3.4.2
7.9. Checking of dead-zone function	Ability to detect fault between coupler CT and CB	Annex B 10.3.4.1.13

Test	Acceptance Criteria	Note
7.10. Checking of end-fault function	Ability to detect fault between line bay CT and CB	Annex B 10.3.4.1.9
7.11. Checking events and fault recording	Ability to correct recording and retrieving of the events and faults simulations	Annex B 10.3.4.3.12
7.12. Self-monitoring		Annex B 10.3.4.3.9.1
8. Checking fiber-optic channel 8.1. Checking of fiber-optic transmission channel	At closed optical loop: - propagation time delay not more than 3 ms; - no error messages; - no degradation messages; - no alarm signals. At opened optical loop: - propagation time delay not available; - code of error message; - code of degradation message; - alarm signal appears	
9. Cyber security		W.r.t. cyber security annexure
10. Software - Licensing and silent installation - Proper displaying of software screens on IECo operational computers - Connection to the relay - Set file and logic file upload and download to and from the relays - Data models import and update settings ranges - Programmable logic - I/O programming	HMI, installation functionality	Annex B 10.3.4.3.10
11. IEC 61850 communications		Annex B 10.3.4.3.13

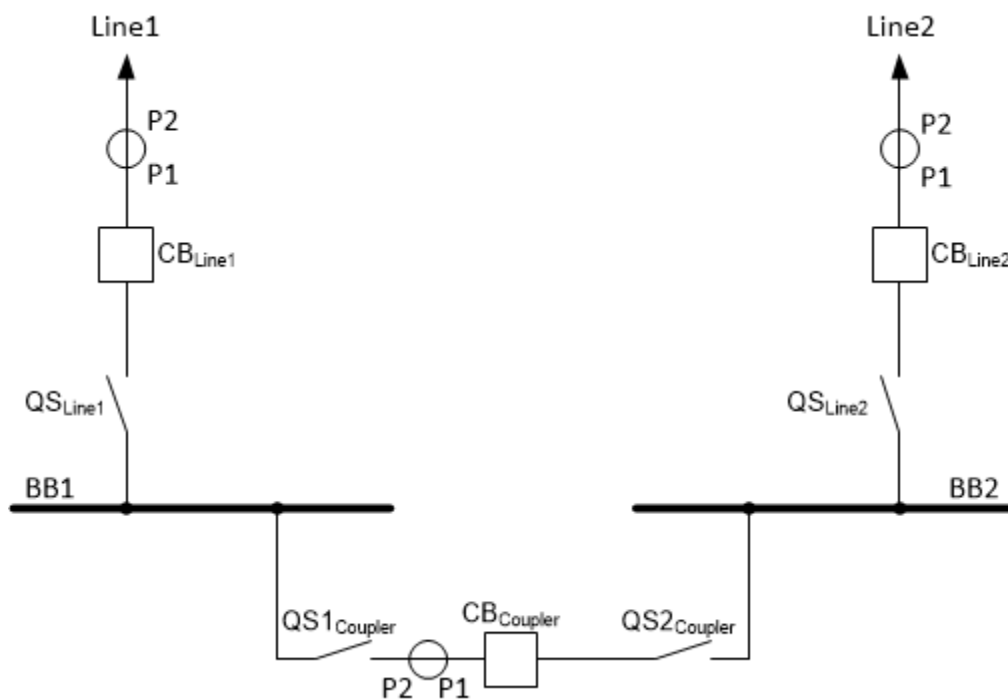
APPENDIX 3.1

TESTING PLAN

All these tests should be performed before the beginning of POC.
The test protocol should be provided.

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 1s		State 2 0.3s or BB2 Trip		State 3 0.3s or BB1 Trip		State 4 1s		State 5 0.3s or BB2 Trip		State 6 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												
<i>Relay outputs monitoring</i>												
ReTrip	0		0		1		0		0		1	
BB1 Trip	0		0		1		0		0		1	
BB2 Trip	0		1		1		0		1		1	
<i>Testing device timers</i>												
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		State 2	
	1s		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 disconnectors 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			