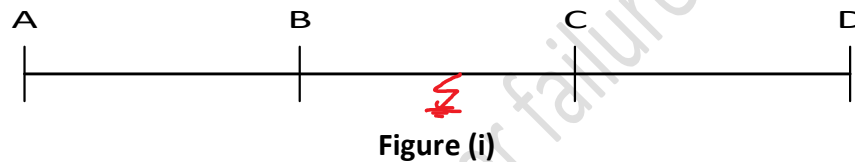


# Breaker Failure Protection/LBB/BFR (Breaker Failure Relay)

Breaker Failure Protection is also called Local Breaker Backup (LBB) Protection or Stuck Breaker Protection or Back Tripping Protection. As the name suggest, it is a back protection when circuit breaker fails to operate when a relay sense the fault and send trip signal to Circuit Breaker. ANSI code is 50BF.

Main objective of Protection System is to clear the fault with:

- Minimum Time delay. Ideally it should be 0 msec but practically it takes 2-3 cycles so that damages to power system is minimum. 0 msec means no intentional time delay.
- Minimum disruption to the Power System. It means that only faulty section should be isolated from rest of the healthy system. For example, in figure (i) as the fault is in the section BC so protection system should isolate section BC only.

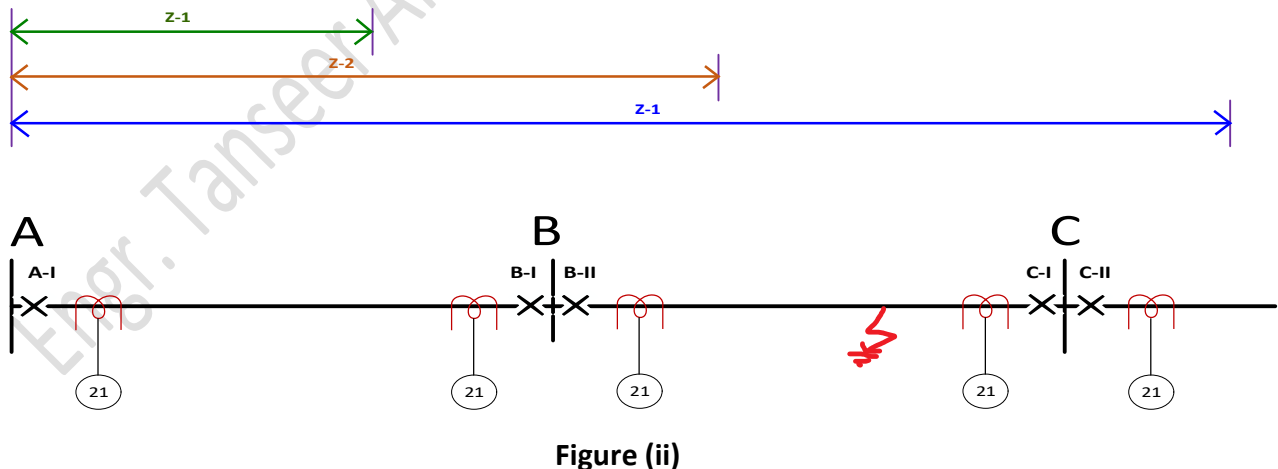


There are two kinds/forms of backup protections:

1. Remote Backup
2. Local Backup

## 1. Remote Backup Protection:

In Distance Protection/Relay, Zone-2 and Zone-3 are Remote Backup Protection.



Suppose a fault occur in section BC. For this, relay at location B-II and C-I should operate and trip their respective circuit breaker and isolate section BC.

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Let relay at C-I operates and issue trip command to its circuit breaker and it opens. But due to some reasons circuit breaker at B-II doesn't open. Possible reasons can be:

- i. Relay doesn't sense the fault.
- ii. Relay senses the fault but output contact of relay doesn't make.
- iii. Relay sense the fault and output contacts of relay also make but breaker doesn't open.

In short, CB doesn't open at B-II. So, fault will be continuously fed from the end A and will damage the system.

For the above fault, relay at A-I will also sense/pick-up the fault in Z-3 and will isolate the fault after 700 msec. Here Z-3 act as Remote Backup but it is slow which is one of the disadvantages of remote backup.

#### **Advantages of Remote Backup:**

- a) It is not affected by the local station condition. If we make backup at station B (local backup) and if there is any problem in circuit breaker itself than local backup will not work. Remote Backup is independent of local station condition.
- b) It takes care of both the failure i.e. Relay and CB failure (at station B).

#### **Disadvantages of Remote Backup:**

- a) It is slow as we have seen that Z-3 clears the fault in 700msec.
- b) It has limited discrimination as for the fault in section BC it also trips the section AB.

## **2. Local Backup Protection:**

Consider the same fault as in figure (ii). As previously discussed, let relay at C-I operates and issue trip command to its circuit breaker and it opens but circuit breaker at B-II doesn't open. We have two scenarios:

- i. Relay doesn't sense the fault. To counter this problem or to provide backup we use 2nd relay (Duplicate protection or relay backup). In grid Main-1 and Main-2 or Distance protection set-I and Set-II are used, usually of different manufacturer.
- ii. Relay sense the fault and issue trip command to CB but CB doesn't open. For this we duplicate the tripping coil of Circuit Breaker (two trip coils) and install Breaker Failure relay.

From the above discussion it is clear that two types of Local Backup can be considered:

#### **a. Relay Backup**

- Provision of duplicate main protection schemes (Distance Relay Set-I and Set-II).

#### **b. Circuit Breaker Backup**

- Cannot Duplicate the circuit breakers due to economical and technical reasons. For example, two circuit breaker in series or parallel. If one doesn't operate than other will etc.

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- We duplicate trip coils but physical mechanism (spring, pneumatic etc) for both the trip coils remains the same. Failure is still possible.
- Our problem of local backup is not solved only by the above, so we use Breaker Failure Relay.

### Advantages of Local Backup:

- It is fast as compared to Remote Backup
- It can make discrimination between the faulty section and healthy section.

### Disadvantages of Local Backup:

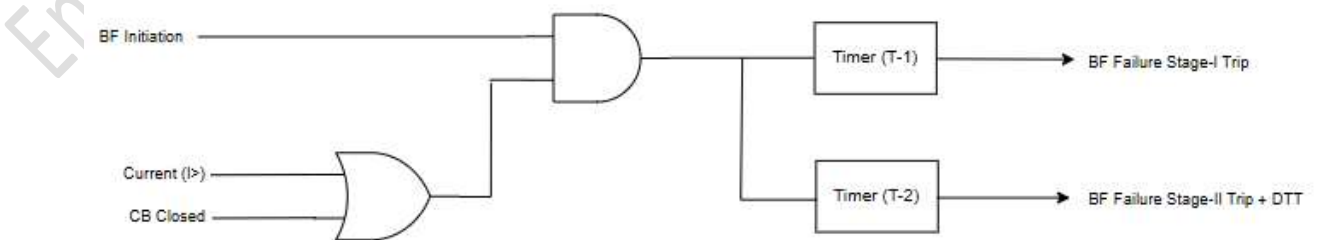
- It is affected by the local station condition. Like if Set-I doesn't sense the fault Set-II may not also sense the fault as both are affected by the local conditions.
- Accidental operation chances are there. Due maintenance work tripping may occur for example BF relay Stage-II operate.

## Breaker Failure Protection

Here we will discuss Siemens 7VK61 Breaker Failure Relay but the concept is almost same for other manufacturers as well.

When protection operates (relay send trip to CB), it sends protection operated signal to BF relay called BF or LBB initiation. Apart from initiation, BF relay also need Current (CT input) whose setting is kept as minimum as possible, normally equal to Open pole current threshold (as in some protections like Differential and Buchholz current value is minimum) and/or CB status (through auxiliary contact of CB) which will be explain in below paragraph.

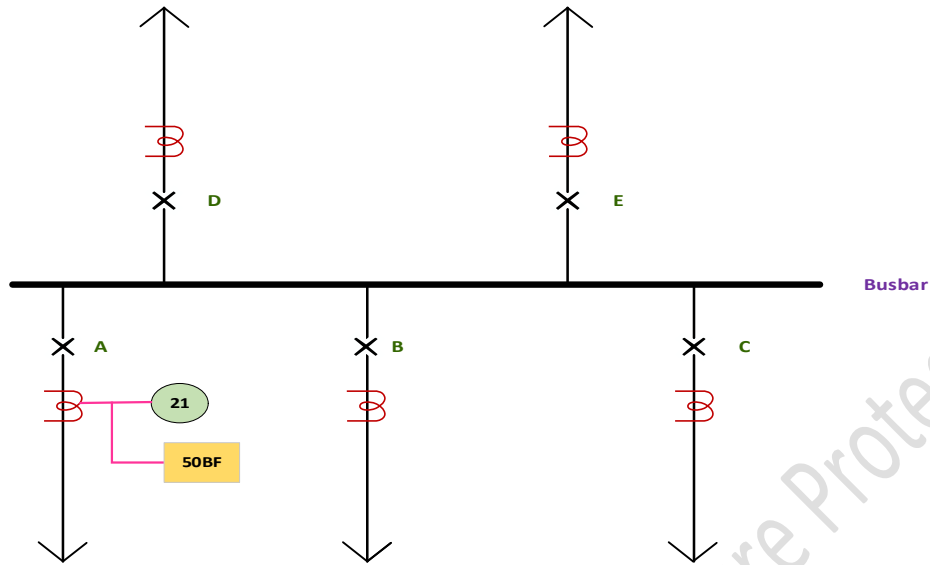
There are 2 stages in Breaker Failure Protection having Timer T-1 (150 ms) and T-2 (250 ms). After initiation, timer (T-1) starts and if in 150 ms CB is not open than BF stage-1 will operate and send re-trip to same CB. If it doesn't open again than after 100 ms (as timer T-1 and T-2 are parallel and starts at same time) it will issue back trip to all infeed breakers and send DTT (inter trip) signal to the other end station breaker (but is optional and depend on your scheme) as shown in figure (iii) – Logic diagram of two-stage breaker failure protection.



**Figure (iii) – Logic Diagram of Two-Stage Breaker Failure Protection**

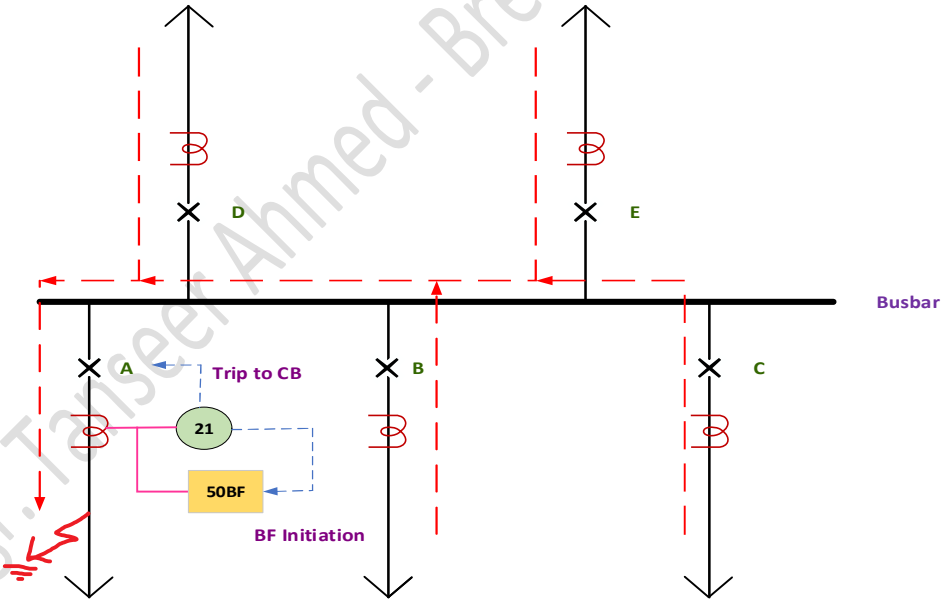
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**Explanation:**



**Figure (iv)**

For example, we have single busbar having 5 feeders. Distance relay is installed for protection of all feeders and for every breaker, there is separate Breaker Failure Relay (50BF) but for simplicity, relay on feeder A is shown only in figure (iv).



**Figure (v)**

Suppose fault occur on feeder A as shown in figure (v). Distance relay on feeder A will sense the fault and will issue trip command to Circuit Breaker A and at the same time will send BF initiation signal to BF relay of circuit breaker A as shown in figure (v)

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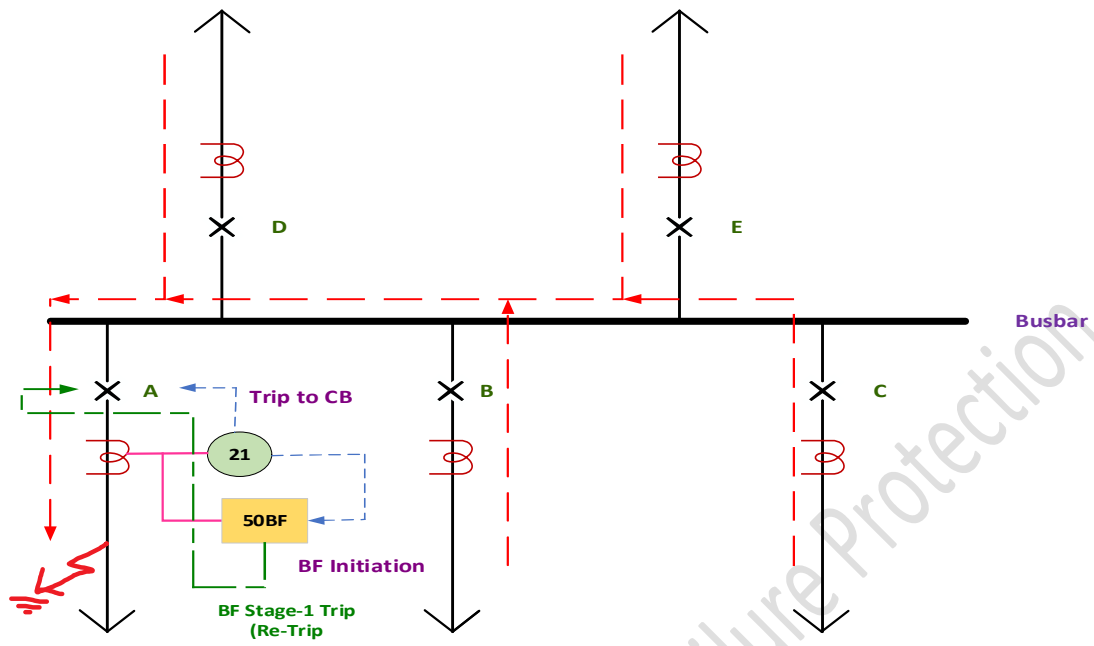


Figure (vi)

As current is greater than BF current setting (and/or CB status is closed) and there is initiation from distance relay, timer -1 and timer-2 will start. After 150 ms, if above condition sustained than BF stage-1 operate and BF relay will issue trip command to same circuit breaker (A) as shown in figure (vi).

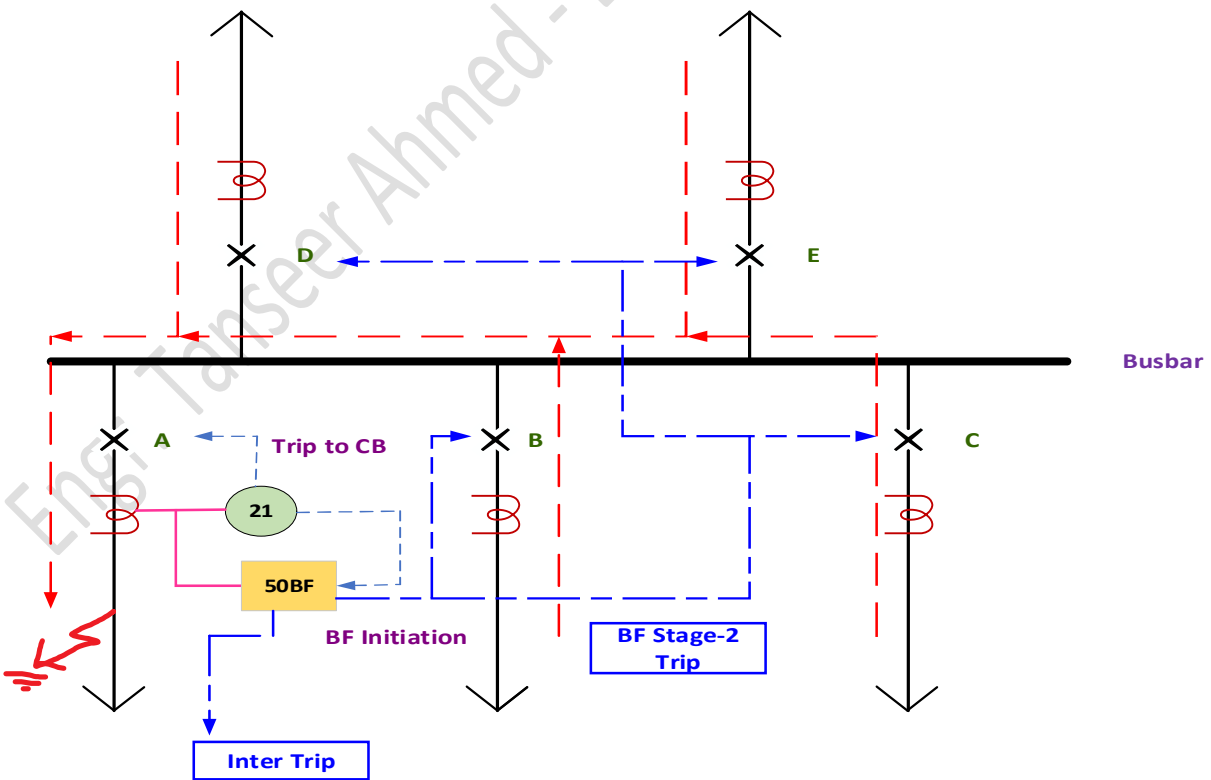


Figure (vii)

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If the breaker still doesn't open than after another 100 ms BF stage-2 operates and will issue trip command to all infeed breakers B, C, D, E and will send DTT to other end which will trip Circuit Breaker of the other end substation called Inter Trip as shown in figure (vii).

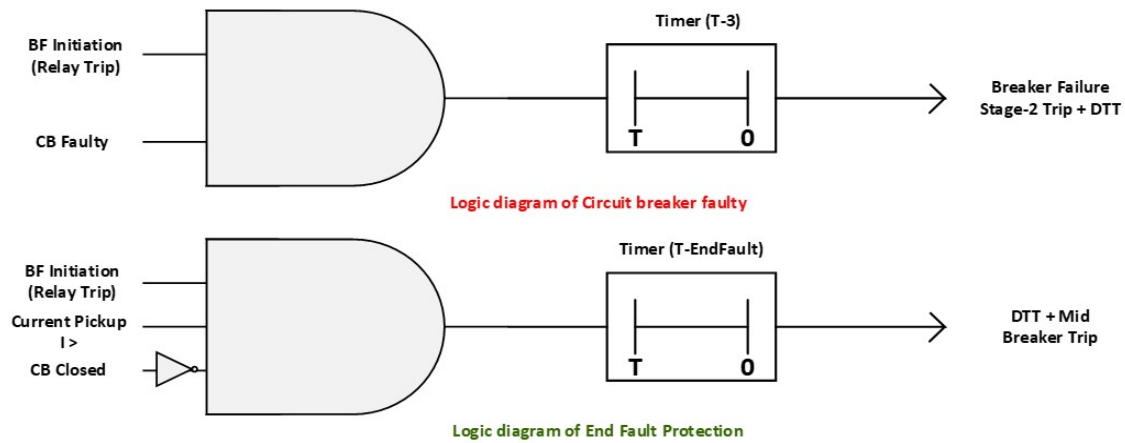


Figure (viii)

Apart from T-1 and T-2 timers, there are 2 more timers i.e. T-3 (For CB defective) and T-End fault. Both Timers are normally set at 100 msec. Logic diagram of both are shown in figure (viii).

If we already known that our CB is faulty (e.g. low SF6 Lockout) than there is no need of BF stage-I. BF stage-II will operate and will issue trip command to all infeed breakers and inter trip signal (DTT) to other end substation CB.

Now we will discuss the 4<sup>th</sup> timer which is for End fault. End fault can be defined as the fault at the end of a section/line between Circuit Breaker and Current Transformer.

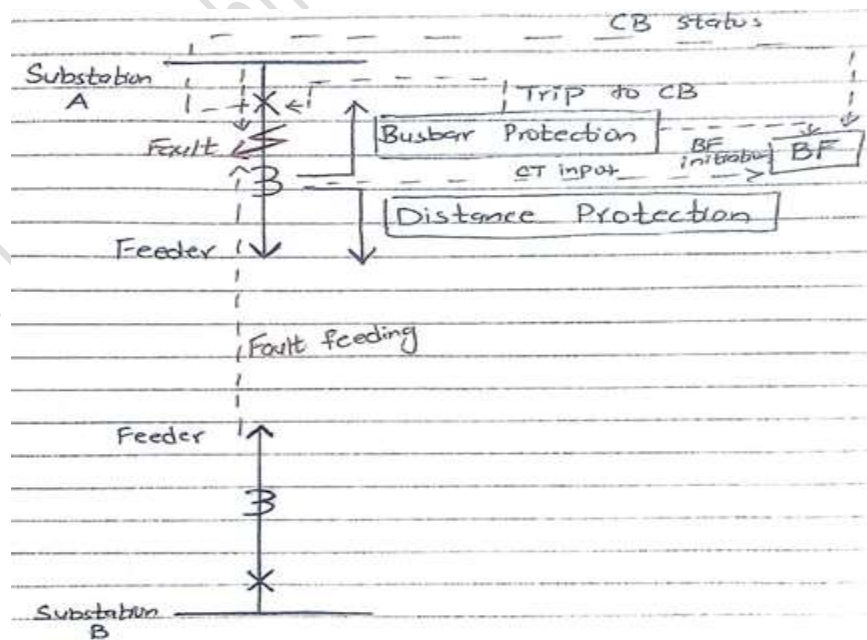


Figure (ix)

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The fault shown in figure (ix) is an End fault. For this, Busbar Protection will operate (as this fault is in busbar protection zone) and will trip the Circuit Breaker as shown in figure (ix) and will send BF initiation to BF relay. But Distance Relay will remain silent as this is reverse zone fault (reverse zone is normally inactive in our system and also its time is about 800ms).

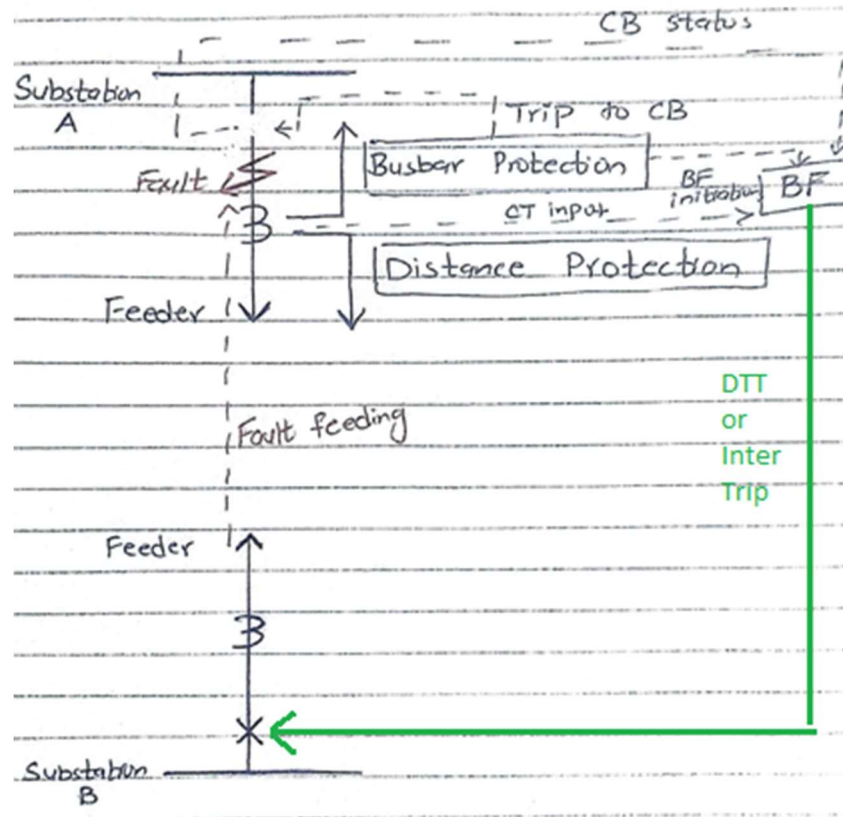


Figure (x)

As Busbar protection trip the circuit breaker but still fault is fed from the other end. As seen from the logic diagram of End fault figure (viii), we need three quantities for End Fault logic to be activated.

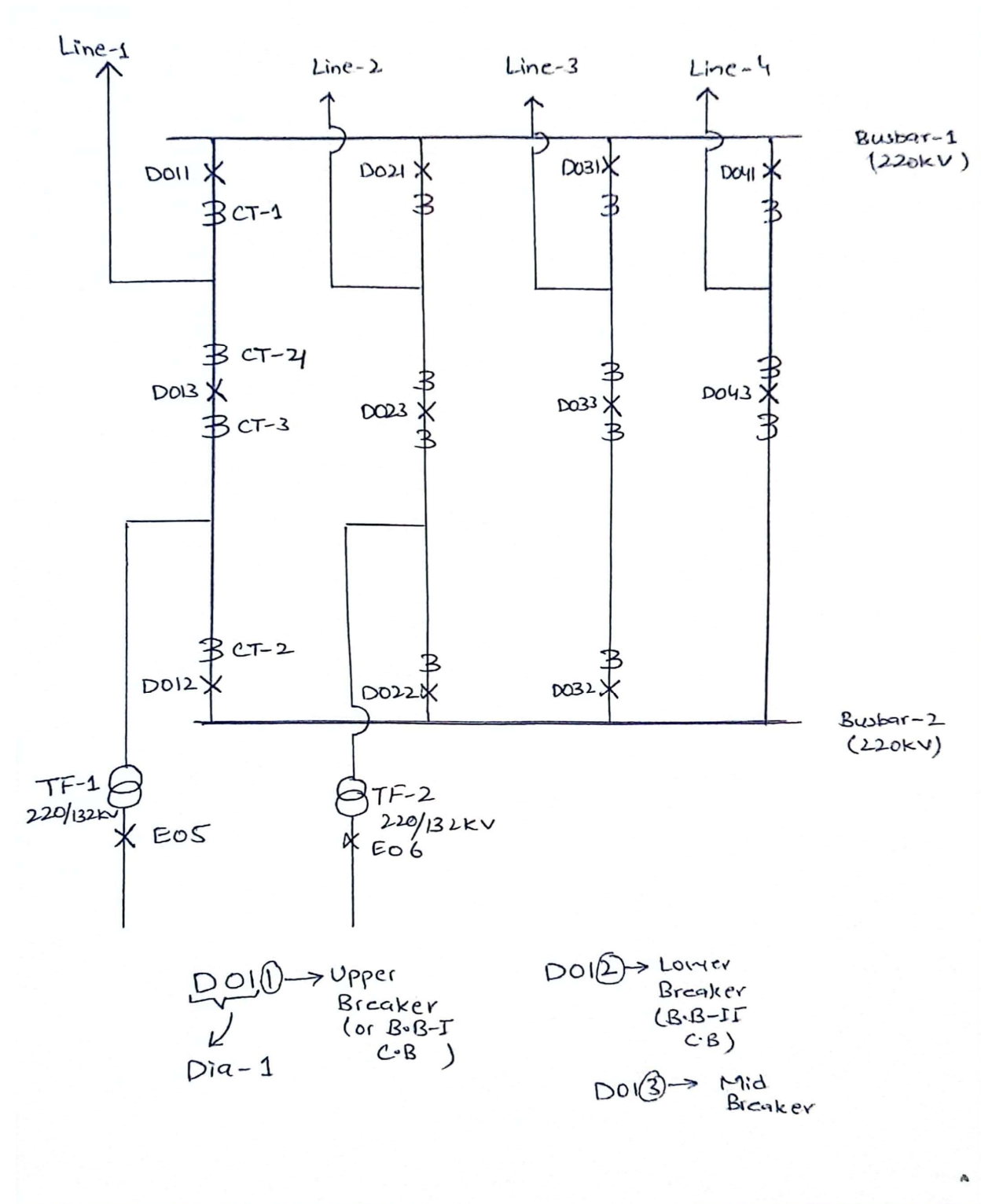
- BF initiation – given by the Busbar protection relay when it is operated.
- Current (CT) – Current is still there as fault is fed from the other end.
- CB open status – from CB auxiliary contacts at Binary Inputs of BF relay.

To summarize the End fault logic, CB is open but current is still there along with BF initiation, will activate the End Fault Protection (Binary Output will close which is marshalled for End fault) and will send DTT to trip the other end CB. In one and half breaker scheme, trip signal should also be sent to mid breaker to completely isolate the fault.

### Complete Breaker Failure Protection Scheme Example:

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Single Line Diagram (SLD) is shown in figure (xi). For every CB there is separate BF Relay. Masking of BF Relay is shown above.

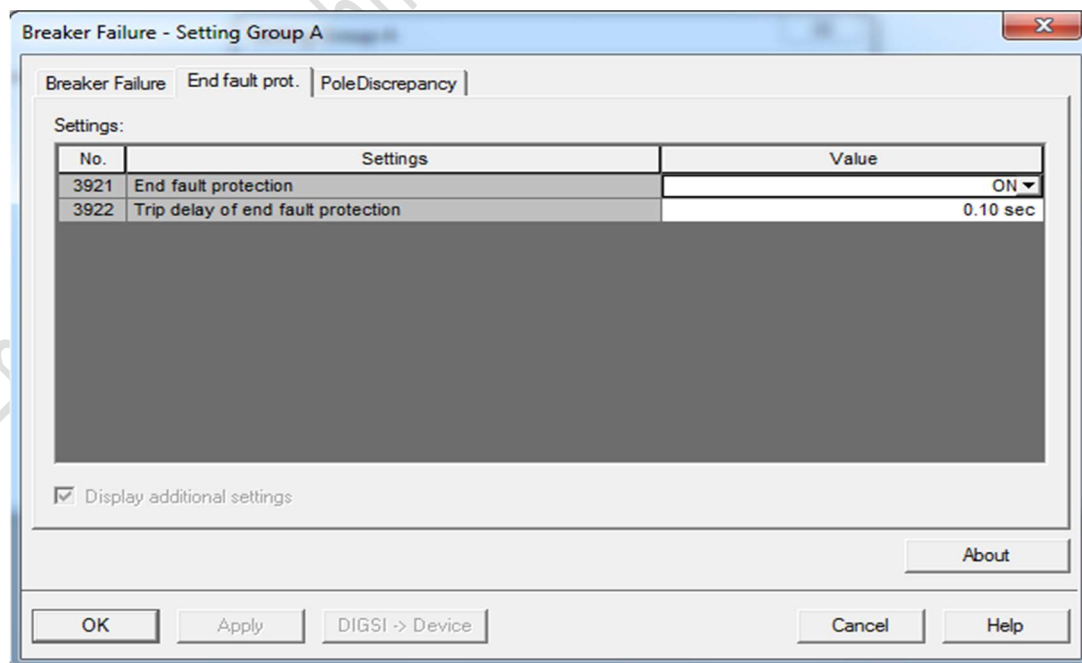
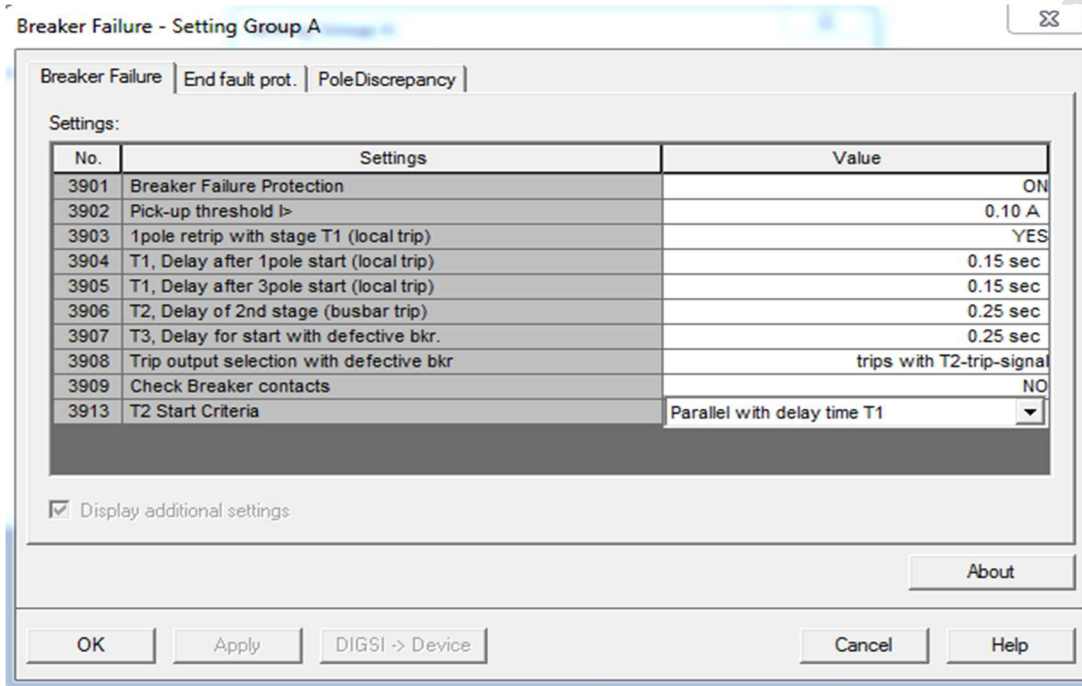


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Here BF scheme for Dia-1 will be explain. For CB D011 Breaker Failure is BF-1, D012 is BF-2 and D013 is BF-3. CT used for BF-1 is CT-1, BF-2 is CT-2 and BF-3 is CT-3 (CT adjacent to CB is used for BF).

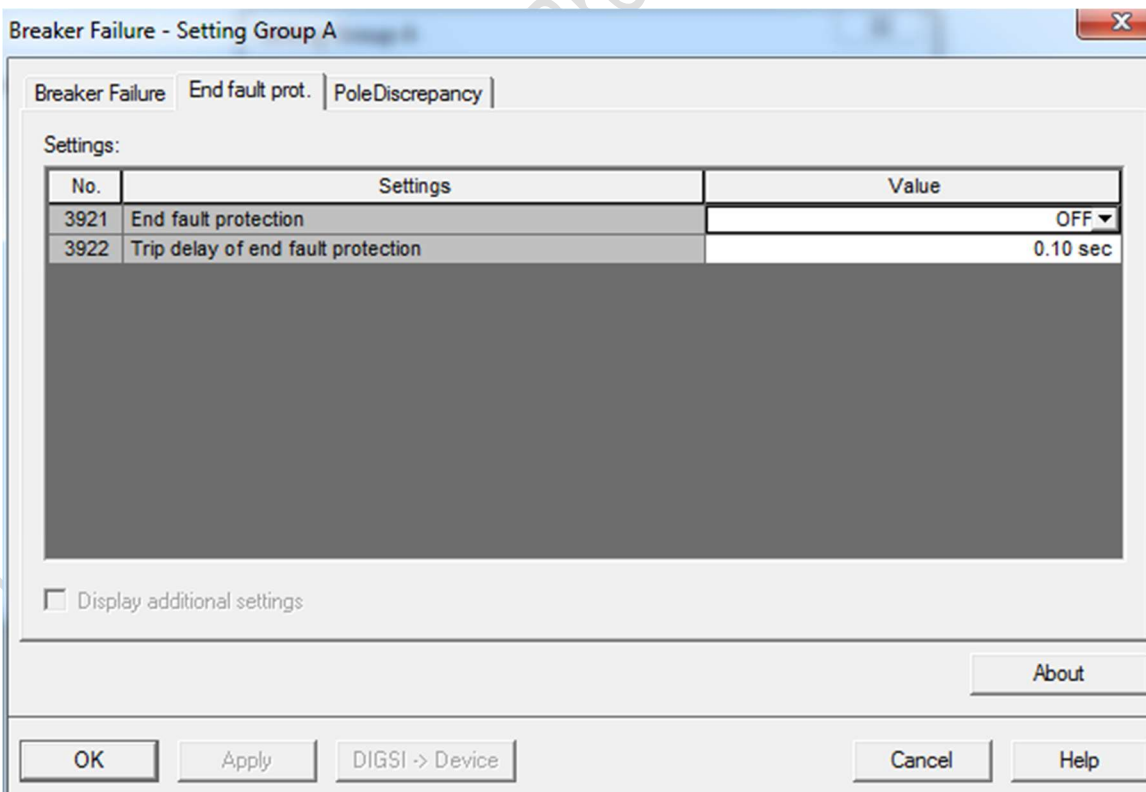
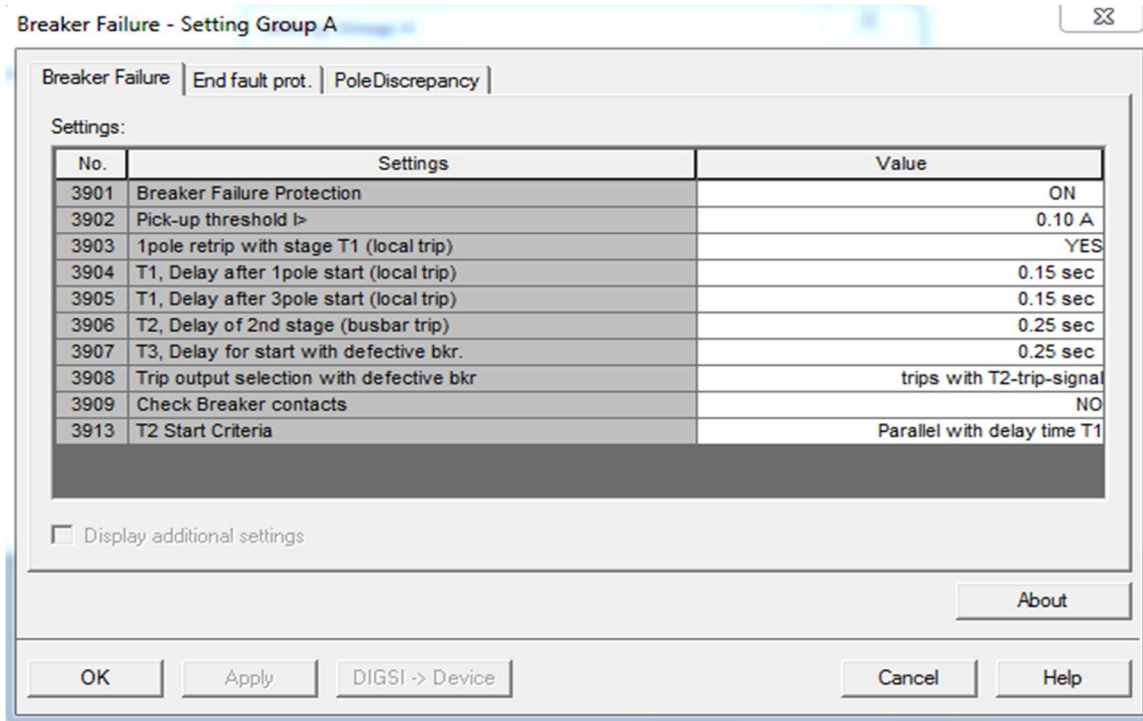
**Settings in Siemens 7VK61 Breaker Failure Protection:**

**a. BF-1 & BF-3**



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b. BF-2



Please note that T-3 timer is normally 100 ms but in above setting it is 250 ms.

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Now, we will discuss Initiation of BF-1, BF-2 and BF-3. For initiation one thing should be kept in mind:

*“Those protections/relays which give trip to CB, must also initiate its BF Relay.”*

### **Initiation of BF-1:**

Following are the Protections/Relays which will initiate BF-1 of CB D011.

1. Distance Relay Set-1 Trip.
2. Distance Relay Set-2 Trip.
3. O/C & E/F Relay Trip (back-up Protection of Line).
4. Busbar-1 Protection Trip.
5. D013/D021/D031/D041 BF Stage-II Trip.
6. DTT Receive from the other end Substation.

### **Initiation of BF-2:**

Following are the Protections/Relays which will initiate BF-2 of CB D012.

1. Busbar-2 Protection Trip.
2. D013/D022/D032/D043/E05 BF Stage-II Trip.
3. Transformer Protection
  - a. **Set-I:**
    - i. Main Differential Protection Trip.
    - ii. LV O/C Protection Trip.
    - iii. HV O/C Protection Trip.
    - iv. REF Protection Trip.
    - v. Thermal Overload Protection Trip.
    - vi. Over-flux Protection Trip.
    - vii. Buchloz Protection Trip.
    - viii. HV winding temperature relay/gauge Protection Trip.
    - ix. LV winding temperature relay/gauge Protection Trip.
    - x. HV Oil Temperature relay/gauge Protection Trip.
    - xi. LV Oil Temperature relay/gauge Protection Trip.
  - b. **Set-II:**
    - i. Rough Balance Differential Protection Trip.
    - ii. LV connection Protection Trip.
    - iii. HV connection Protection Trip.
    - iv. Neutral E/F Protection Trip.
    - v. Tap Changer Protection Device Trip.

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- vi. PRD Protection Trip.
- vii. Tap Changer PRD Protection Trip.

**Initiation of BF-3:**

Following are the Protections/Relays which will initiate BF-3 of CB D013.

- 1. Distance Relay Set-1 Trip.
- 2. Distance Relay Set-2 Trip.
- 3. O/C & E/F Relay Trip (back-up Protection of Line).
- 4. D011/D012/E05 BF Stage-II Trip.
- 5. DTT Receive from the other end Substation.
- 6. Transformer Protection
  - a. Set-I:
    - Mentioned above
  - b. Set-II:
    - Mentioned above

**Binary Inputs/Binary Outputs in Siemens 7VK61 Breaker Failure Protection:**

**1. Binary Inputs:**

**a. BF-1**

	Information				Source																			
	Number	Display text	Long text	Type	BI																			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Device																								
P. System Data 1																								
Osc. Fault Rec.																								
P. System Data 2	00351	>CB Aux. L1	>Circuit breaker aux. contact Pole L1	SP				H																
	00352	>CB Aux. L2	>Circuit breaker aux. contact Pole L2	SP					H															
	00353	>CB Aux. L3	>Circuit breaker aux. contact Pole L3	SP						H														
	00378	>CB faulty	>CB faulty	SP										H										
	00501	Relay PICKUP	Relay PICKUP	OUT																				
Measurem. Superv																								
Breaker Failure	01432	>BF release	>BF: External release	SP																				
	01415	>BF Start 3pole	>BF: External start 3pole	SP																				
	01435	>BF Start L1	>BF: External start L1	SP		H																		
	01436	>BF Start L2	>BF: External start L2	SP			H																	
	01437	>BF Start L3	>BF: External start L3	SP				H																
	01493	BF TRIP CBdefec	BF Trip in case of defective CB	OUT																				
	01495	BF EndFlt TRIP	BF Trip End fault stage	OUT																				
		BF S-I	BF S-I	SP																				
	BF S-II	BF S-II	SP																					

- BI 01/02/03 is for single pole BF initiation from Distance Relay Set-I & II.
- BI 04/05/06 is for CB D011 RYB pole Status (Auxiliary contacts).
- BI 07 is for 3-pole initiation (all protection except distance).
- BI 08 for external release (security purpose).
- BI 9 is for CB faulty (Logic diagram already discussed)

**b. BF-2**

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	Information				Source																			
	Number	Display text	Long text	Type	BI																			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Device																								
P.System Data 1																								
Osc. Fault Rec.																								
P.System Data 2	00351	>CB Aux. L1	>Circuit breaker aux. contact: Pole L1	SP	H																			
	00352	>CB Aux. L2	>Circuit breaker aux. contact: Pole L2	SP		H																		
	00353	>CB Aux. L3	>Circuit breaker aux. contact: Pole L3	SP			H																	
	00378	>CB faulty	>CB faulty	SP						H														
	00501	Relay PICKUP	Relay PICKUP	OUT							H													
Measurem.Superv																								
Breaker Failure	01432	>BF release	>BF: External release	SP					H															
	01415	>BF Start 3pole	>BF: External start 3pole	SP				H																
	01493	BF TRIP CBdefec	BF Trip in case of defective CB	OUT																				
		BF S-I	BF S-I	SP																				
	BF S-II	BF S-II	SP																					
EN100-Modul 1																								
Testing																								
Cntrl Authority																								
Control Device																								
Process Data																								
Measurement																								
Set Points(MV)																								
Energy																								

- BI 01/02/03 is for CB D012 RYB pole Status.
- BI 04 is for 3-pole initiation (all protection except distance).
- BI 05 for external release.
- BI 06 is for CB faulty.

### c. BF-3

	Information				Source																			
	Number	Display text	Long text	Type	BI																			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Device																								
P.System Data 1																								
Osc. Fault Rec.																								
P.System Data 2	00351	>CB Aux. L1	>Circuit breaker aux. contact: Pole L1	SP					H															
	00352	>CB Aux. L2	>Circuit breaker aux. contact: Pole L2	SP						H														
	00353	>CB Aux. L3	>Circuit breaker aux. contact: Pole L3	SP							H													
	00378	>CB faulty	>CB faulty	SP										H										
	00501	Relay PICKUP	Relay PICKUP	OUT											H									
Measurem.Superv																								
Breaker Failure	01432	>BF release	>BF: External release	SP												H								
	01415	>BF Start 3pole	>BF: External start 3pole	SP													H							
	01435	>BF Start L1	>BF: External start L1	SP		H																		
	01436	>BF Start L2	>BF: External start L2	SP			H																	
	01437	>BF Start L3	>BF: External start L3	SP				H																
	01493	BF TRIP CBdefec	BF Trip in case of defective CB	OUT																				
	01495	BF EndFR TRIP	BF Trip End fault stage	OUT																				
	BF S-I	BF S-I	SP																					
	BF S-II	BF S-II	SP																					
EN100-Modul 1																								
Testing																								
Cntrl Authority																								
Control Device																								

- BI 01/02/03 is for single pole BF initiation from Distance Relay Set-I & II.
- BI 04/05/06 is for CB D013 RYB pole Status.
- BI 07 is for 3-pole initiation (all protection except distance).
- BI 08 for external release (security purpose).
- BI 9 is for CB faulty.

## 2. Binary Outputs:

### a. BF-1

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- Trip Command to CB D012 Trip Coil-2.
- BO 010 BF Stage-2 Trip/ BO 08 CB defective Trip.
  - Trip command to CB D013/D022/D032/D043/E05 Trip Coil-1.
  - Trip command to CB D013/D022/D032/D043/E05 Trip Coil-2.
  - CB D013/D022/D032/D043/E05 BF initiation.
  - CB D013/D043 A/R-2 Block.
  - CB D012/D013/D022/D032/D043/E05 lockout.

**c. BF-3**

Device	Information				Source				BO																			
	Number	Display text	Long text	Type	BI	F	S	C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
	P.System Data 1																											
Osc. Fault Rec.																												
P.System Data 2	00351	>CB Aux. L1	>Circuit breaker aux. contact: Pole L1	SP																								
	00352	>CB Aux. L2	>Circuit breaker aux. contact: Pole L2	SP																								
	00353	>CB Aux. L3	>Circuit breaker aux. contact: Pole L3	SP																								
	00378	>CB faulty	>CB faulty	SP																								
	00501	Relay PICKUP	Relay PICKUP	OUT																								
Measur. Superv																												
Breaker Failure	01432	>BF release	>BF: External release	SP																								
	01415	>BF Start 3pole	>BF: External start 3pole	SP																								
	01435	>BF Start L1	>BF: External start L1	SP																								
	01436	>BF Start L2	>BF: External start L2	SP																								
	01437	>BF Start L3	>BF: External start L3	SP																								
	01493	BF TRIP CBdefec	BF Trip in case of defective CB	OUT																	U							
	01495	BF EndFR TRIP	BF Trip End fault stage	OUT																	U							
		BF S-I	BF S-I	SP			X			U	U	U									U		U	U		U	U	
		BF S-II	BF S-II	SP			X															U						
EN100-Modul 1																												
Testing																												
Ctrl Authority																												
Control Device																												

- BO 01/02/03/09/11/12/15/17 Stage-1 Trip.
  - BF Stage-I trip CB D013 Trip Coil-1.
  - BF Stage-I trip CB D013 Trip Coil-2.
  - CB D013 A/R-2 Block.
- BO 010 Stage-2 Trip/ BO 08 CB defective Trip.
  - BF Stage-II trip CB D011/D012/E05 Trip Coil-1.
  - BF Stage-II trip CB D011/D012/E05 Trip Coil-2.
  - CB D011/D012/E05 BF initiation.
  - CB D011/D012/D013/E05 lockout.
  - CB D011 A/R-1 Block
- BO 07 End Fault Trip.
  - DTT send to the other end station.