DIFB CL
The most economical solution for busbar protection of all types of electrical substations

Why protect electrical substation busbars?

The consequences of an electrical short circuit in the busbar of a production, distribution or transmission network may be very serious as much to the quality of the service provided as the damage incurred by the electrical equipment. To limit the risks resulting from such faults, operators resort to various solutions, such as the creation of independent sections so that if the fault affects one of them it is then possible to switch the load into the remaining healthy sections. However these preventive measures are only effective if there is also busbar protection equipment which meets a number of criteria such as:

- Speed
- Selectivity
- Sensitivity to internal faults
- Stability during all external fault conditions

More and more electrical companies who manufacture, transmit and distribute energy commit themselves to the provision of high quality energy supplies. This commitment cannot exist without a high availability of substations. Ultra-rapid busbar protection relays contribute towards the reduction in downtime of substations in cases of internal fault.

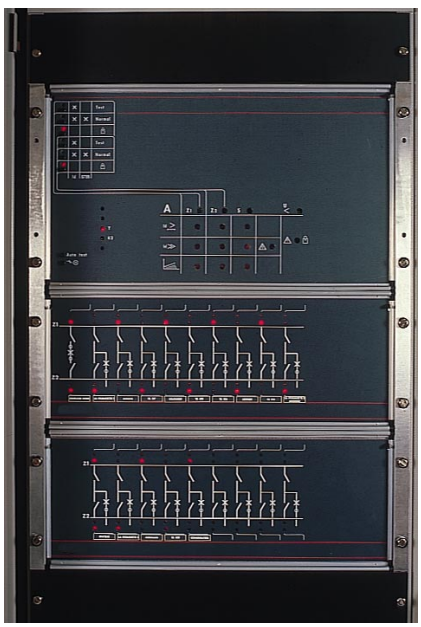
Why choose the DIFB CL?

To meet these requirements, ALSTOM has designed the DIFB CL busbar protection relay

The DIFB CL is a summation current differential busbar protection relay that combines extremely fast measurement (1ms) with high sensitivity to busbar internal fault. This can be achieved thanks to a facility to differentiate between phase-to-earth and phase-to-phase faults. The over sensitivity to phase-to earth faults does not compromise stability in the event that isolators' positions are incorrectly transmitted to the relay; a *check zone* supervision unit guarantees operational stability.

Application notes

The DIFB CL currently offers the best *value for money* technical performance. At a reduced total cost it can be used in place of high impedance equipment and has the added advantage of being compatible with various ratios CTs. It can also be used with existing equipment (refurbished substation). It can also be used for EHV networks provided that the phase selection option is utilised.
This busbar differential protection relay includes most of the features present in the segregated phase DIFB protection cubicle used to protect EHV substations, and in particular its easy commissioning, reliability and performances with very saturated CTs.
The DIFB CL can be recommended in a wide variety of substations as it is not limited by voltage level.
The following non comprehensive list indicates a few application examples:



DIFB CL Rack (2 zones)

- MV and HV distribution substations
- HV and EHV transmission substations
- Railway networks specific substations for 2-phase feeders.
- Directly or impedance-earthed substations.
- Reversible hydroelectric generating substations
- Shielded substations with 2-phase compartments

Positioning

The DIFB CL is a percentage medium impedance protection equipment which switches to low impedance upon detection of a busbar fault.

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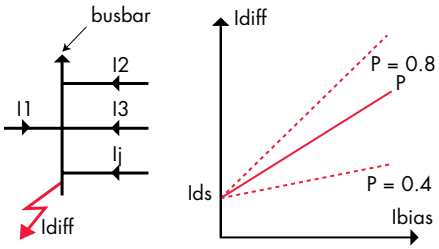


The operating condition of the protection is given by the following equation:

$$Idiff \geq Ids + p.Ibias$$

- p: biased characteristic settable between 0.4 and 0.8
- Idiff = $|\sum I_j|$: absolute value of differential current or image of busbar fault current before CT saturation.
- Ibias = $\sum |I_j|$: bias current.
- Ids = 0.125 In: fixed start condition.

The DIFB CL differs from other busbar protections on two fundamental points:

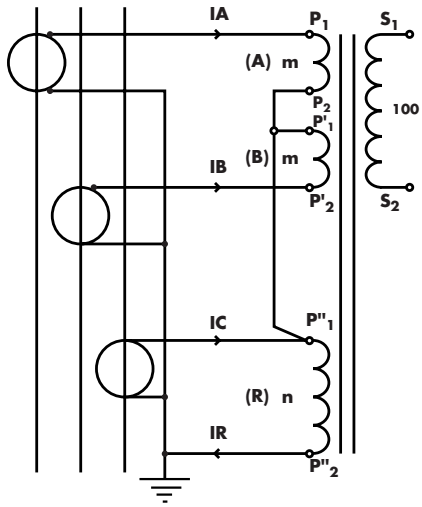
1. It uses a linear summation principle to calculate the input values from the three phases currents with separate sensitivity for the zero-sequence current. Therefore the DIFB CL can be used with all types of neutral earth connections.
2. Virtually instantaneous busbar tripping decision before any CT saturation occurs.

The system may be provided either as separate elements that can be easily assembled by the customer or as a ready-to-operate integrated cubicle.

Linear current summation

The auxiliary CTs combine two identical windings for phases A and B and one winding for the residual current. For each winding, input and output terminals to insert the DIFB CL ancillary CTs between the primary CTs and any other existing relays are provided.

It should also be noted that earth fault sensitivity can be modified independently from phase-to-phase fault sensitivity.



Auxilliary CTs

The primary windings of the auxiliary CTs are wound in such a way to make it possible for them to be inserted within the existing relays circuits.
The DIFB CL inputs are tested against HF disturbances, allowing the auxiliary CTs to be installed in an external cubicle and more particularly in the feeder panel (line or transformer feeder).

Stability

Stability is assured with highly saturated CTs upon external faults Through fault stability is assured by the addition of through load bias. It is independent from short circuit current magnitude as well as from the level of CT saturation. It is obtained through the well known *Merz-Price* circulated current principle.
Stabilisation occurs simultaneously with the lowering of the magnetising impedance and instantaneously vanishes upon desaturation.
This operation principle being based upon the actual physical state of the CT as opposed to the estimated value of the magnetic flux guarantees unequalled performances.

Operational dependability

When there is a busbar fault, the short-circuit currents can cause a very high CT saturation.
This level of saturation can be very important when all the fault current goes through one transformer which is often the case with CTs in the busbar coupling area, especially when there is a combination of an aperiodic condition of fault current appearance with a residual magnetic flux due to a previous fault.
The DIFB CL is fitted with ultra-high speed detection elements able to operate within 1 ms, i.e., always before CT saturation.

Speed

The length of the voltage dip created by a busbar fault depends on this performance.
It is an essential factor of stability for transmission networks and of a guaranteed quality service for the distribution networks' consumer.
The DIFB CL differential busbar protection relay provides a tripping order within 7 to 15 ms. This typical operating time is not affected by the fault current DC component.

Reliability

Its operating principle allows the DIFB CL to have a very simple construction. In particular, it does not require complex signal processing circuits on each input, and therefore the risk of failure is minimum.

Regular self test

This function avoids the use of difficult manual operations to verify the relay's ability to trip on a true busbar fault. Taking into account the reliability of the tested sub-assemblies, these operations could be comparatively spaced out.
The time interval between self tests is adjustable and can be daily.

The result of a self test can be included in the event recorder's log.

Check zone supervision

One of the most frequent causes of a busbar differential protection relay's operational failure is the transmission of reception error of the actual position of a disconnector that produces a differential current in some measurement elements.
However, if only *incoming* and *outgoing* currents of the whole substation are taken into account, their vectorial sum will remain null in faultless conditions whatever the possible repeat errors on the partial sections. In this way the tripping order of a busbar section is submitted to the operation of a check zone sensitive only to global values.

Commissioning tools

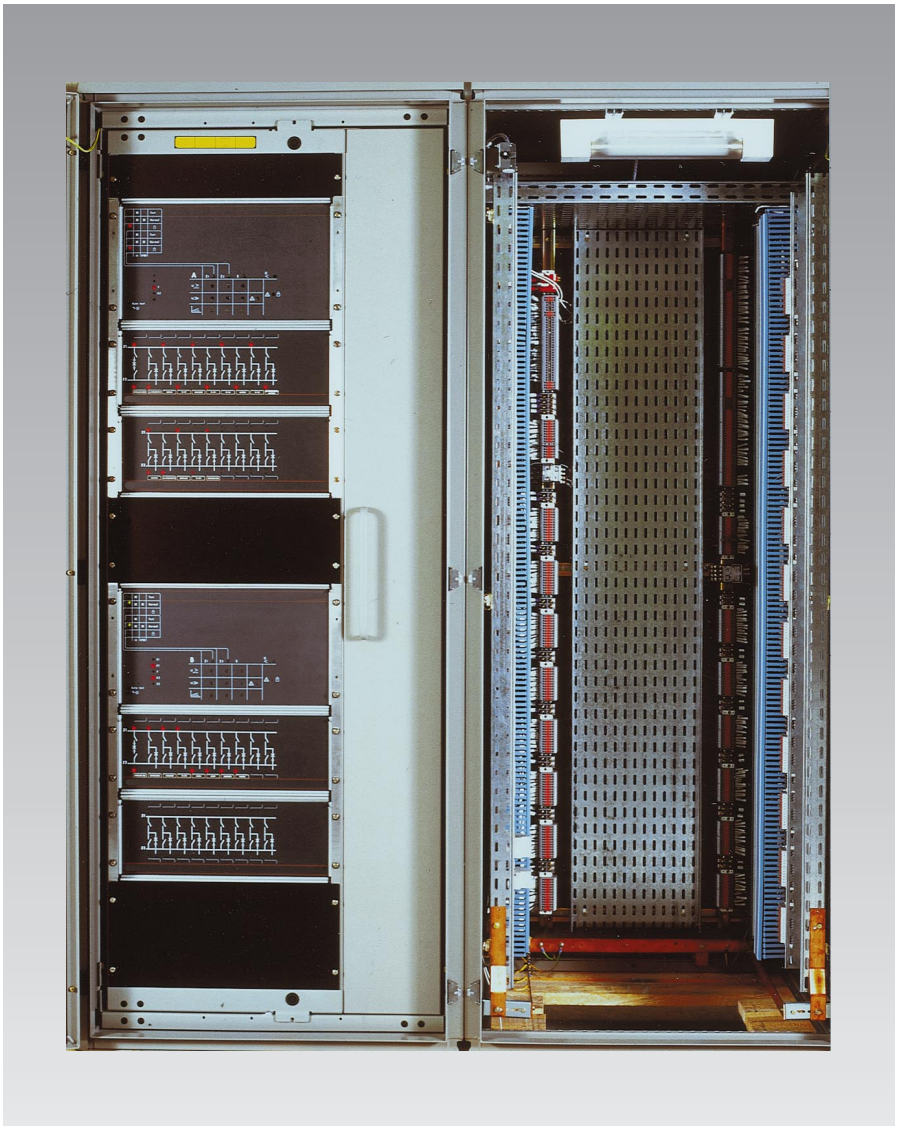
The DIFB CL is fitted with the following commissioning and operating tools:

- ENERTEST test plugs for secondary injections.
- Per zone in service/out of service switch.
- Simple mimic diagram of the substation with continuous display of selectors with disconnectors.
- Possibility to force the state of the isolators' position repeater relays.
- Per zone tripping indication LEDs.
- Threshold crossing indication LEDs.

Simple settings

The settings are made on the measurement boards through micro-switches. There are only 4 parameters to set:

- Bias slope characteristic: 40% to 80%. This parameter defines the stability of the relay in case of CT saturation on an external fault.



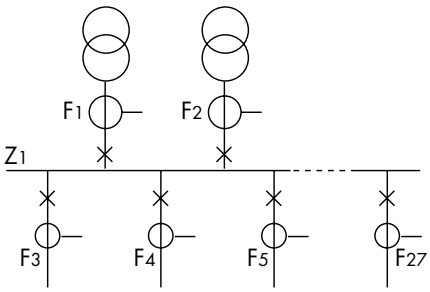
DIFB CL cubicle prepared for a 4-zone substation

- Id >> threshold: 0.25 to 2.5 In. This parameter sets a minimum differential current that will allow the relay to trip. Provided it is set at a value higher than the load current of the most loaded feeder (generally couplings and incoming generators), it avoids any risk of unwanted tripping upon an isolator position repeat error (wiring defect). In the DIFB CL this risk is kept to a minimum by this supervision function that is redundant with the check zone supervision.
- *Wiring defect* supervision Id > threshold: 0.05 to 0.5 In. This function is aimed at providing an alarm and a blocking command when there is permanent and significant differential current due to repeat error. The alarm threshold is generally set at a value sufficiently low to detect the anomaly even on a low burden feeder.
- *Wiring defect alarm* time delay TF: it is set at a sufficiently high value to avoid any unnecessary alarm and blocking on transient differential currents appearing inevitably upon external faults.

CT dimensions

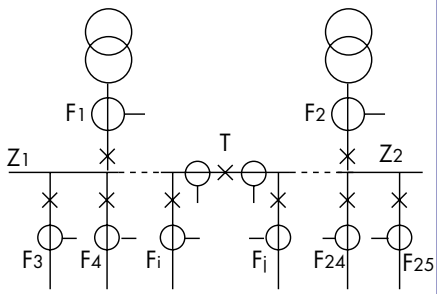
Current transformers are specified in load to guarantee internal fault detection before saturation occurs. Generally, X or Y class will be specified with a load of 20 VA and an IP20 factor.

1. 1-zone substation



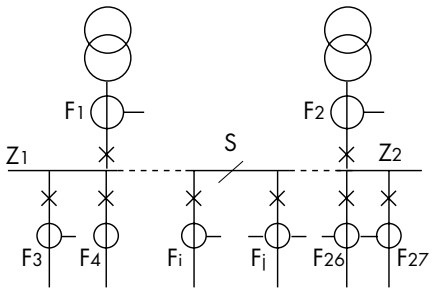
DIFB CL 1101

2. 2-zone substation with 1 BSCB (2)



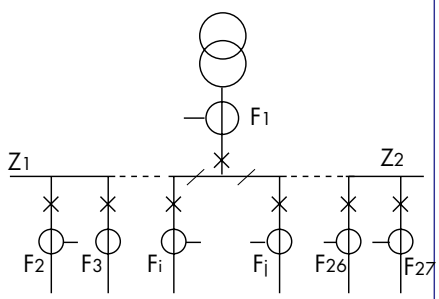
DIFB CL 2201

3. 2-zone substation with 1 BSI (1)



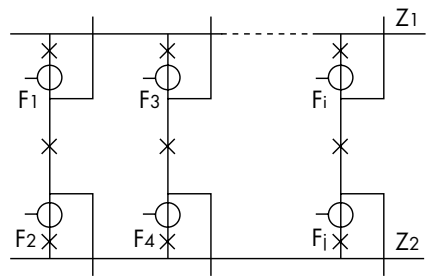
DIFB CL 2201

4. 2-zone substation with central incoming and double routing by isolators



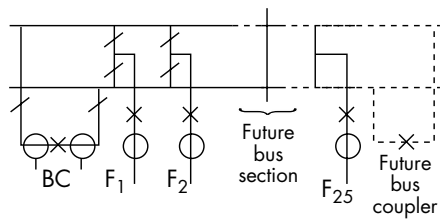
DIFB CL 2201

5. 2-zone substation with 1+1/2 circuit breaker per feeder



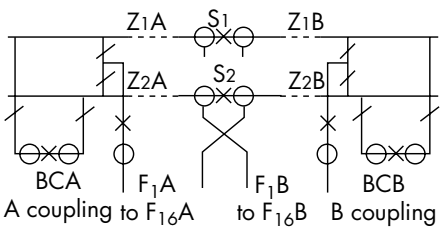
DIFB CL 2201

6. 2-zone substation, 1 bus coupler, 1 circuit breaker per feeder Busbar routing by isolators



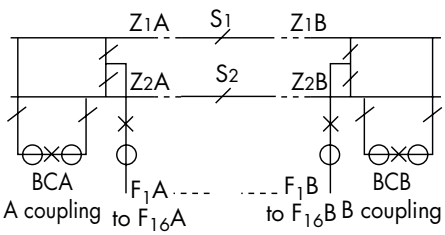
DIFB CL 2201

7. 4-zone substation with 2 BS-CB
2 bus couplers
1 circuit-breaker per feeder



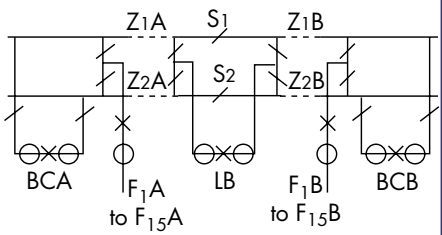
DIFB CL 4405

8. 4-zone substation with 2 BSI
2 bus couplers
1 circuit breaker per feeder



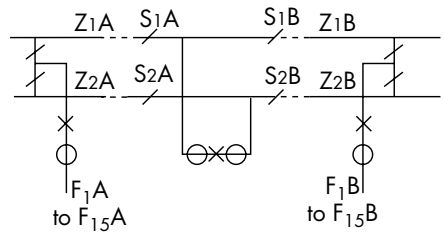
DIFB CL 4405

8-1. Architectural variants, 4 zones can be used with the standard configurations of a DIFB CL, type 4405 or DIFB 4450



In this architecture the S1 and S2 isolators are operated by a bus link (LB) which is used to create a shunt for the operating isolator by a circuit breaker. The link is considered to be a combination of one bus coupler circuit breaker and two feeders.

8-2.



The specific feature of this architecture is that the bus coupler is central and can be assigned to the following:
A busbars, or
B busbars, or
A and B busbars simultaneously.

The DIFB switching system must be organized in such a way that the coupling section currents can be routed either separately via the A or B frame, or simultaneously (see fig. 8).

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