Continuous, uninterrupted power supply is demanded by all process plants. To meet this demand, different schemes are adopted by consultants and end users. These schemes essentially need two or more sources of supply to the busbar system. One of the simple schemes commonly followed by the users is manual changeover of supply from one source to the other by switching OFF-ON desired switches/circuit breakers. This manual changeover demands continuous attentive manning of substation and yet interruption of supply for at least some minutes is inevitable. In this scheme, safety and fool proofness is incorporated by adding mechanical interlock between the switches/circuit breaker.

In case where interruption of supply is very critical, and time delay needs to be brought down to a few seconds, automatic changeover of supply to the affected bus is implemented. In such cases, the affected incomer is switched off and under healthy bus conditions, the load is transferred to the other bus/incoming source.

Since in this case monitoring of conditions/parameters is carried out by relays and interlocks/permisives are connected electrically, the changeover takes place in a few seconds. Electrical control circuit is normally developed considering various interlocks and safety features. So operations are more reliable and independent of operator's skills. Chances of error get eliminated.

While conceiving such interlocked schemes, different variations are followed by users. Depending on previous experience, probable conditions are added for more reliable and safe operations. Good engineering practices followed by some consultants/end users are not incorporated by many other users. To attempt standardisation of such logic and benefit entire user sector with good engineering practices, L&T has incorporated a comprehensive auto-changeover logic with the facility of manual paralleling in the Advanced Feedervision relays of the Supervision Series.

Apart from brining advantages of a vast experience in this field, the package offers economy in terms of space, lesser component count, lesser engineering and testing time. The operations are simplified due to user friendly features of the system.

In this issue of L&T Current Trends, we bring you a curtain raiser on this subject. Though logic covered here is mainly discussing a typical two incomer and one buscoupler scheme, the same can be extended to three incomers and two buscouplers or two incomers without a bus sectionaliser.
Normally, at distribution voltage (6.6 kV) and low voltage (415V) levels, switchgear has two or more bus sections, for reliable operations. This arrangement ensures availability of supply to the critical drives/feeders even if the incomer on that bus is not feeding them.

The normal sequence of events in such cases is as follows:

In healthy condition, the respective incomer is ON and feeds the bus section connected to it.

In case there is sustained under voltage (about 75%) on the line side (for about 2 - 2.5 sec.), the incomer trips. This tripping is initiated by the line VT circuit. In this case, incomer tripping is not carried out by the lockout relay.

When the bus voltage is down to 20% and if the other bus section is healthy, (having a voltage above 80%), the buscoupler closes and the supply on the affected bus is restored. This sequence is true for either of the incomers on both sides of buscoupler. Bus VT circuit carries out this sequence. Closing permissive of buscoupler checks healthiness of the lockout relay of the open incomer.

In a two incomer and a buscoupler scheme, each incomer has a line VT circuit and each bus has a bus VT circuit to carry out this operation.

Under voltage on line side or bus side is sensed by the line VT circuit and it initiates tripping of the respective incomer and auto closure of the buscoupler.

To prevent false undervoltage alarm/signal being generated by the blowing of fuse in the VT circuit, healthiness of the VT fuses (both primary and secondary) needs to be monitored. Conventional relays are connected only across the secondary fuses of the VT circuit. With the availability of fuse monitoring MCCBs (which can withstand upto 50kA), the primary and secondary fuses in the VT circuits can be replaced with such MCCBs. (e.g. L&T's MCCB type DF) and the healthiness of line or bus VT circuit can also be monitored for initiating the auto changeover.

In the above-mentioned sequence, tripping of the incomer (due to undervoltage) is unplanned and restoration of supply occurs only after a break. This necessitates tripping of larger motors (controlled by circuit breakers) on undervoltage of the bus, so that back emf of these motors does not delay residual voltage reaching no volt level on the busbar. For this purpose, a separate undervoltage relay with a time delay is provided on the busbar.

After the closing of buscoupler and revival of healthy voltage, the essential drives in a process plant must start automatically without the need to do so intentionally from a control room. For this purpose, a re-acceleration scheme is added in the starter circuit of such drives. To prevent all such drives from starting simultaneously, time grading is done in groups, so that the changeover bus dip is controlled.

This is only one part of the events.

However auto changeover is not desirable in all circumstances. Instances when auto changeover is stalled or delayed are as follows:

1) At distribution voltage level, the time delays for sensing sustained undervoltage are shorter compared to the delays on low voltage level. This facilitates changeover first at distribution voltage without tripping incomer of low voltage switchgear.

2) In the event incomer trips on operation of a protection relay (say overcurrent or earthfault), the lockout relay on respective incomer prevents the buscoupler from closing and feeding the faulty bus.
3. Intentional opening/tripping of the incomer is distinguished by a memory contact (lost motion device contact in conventional schemes) and it also prevents closing of buscoupler.

4. In the event that both incomers on the two bus sections experience simultaneous undervoltage on their line side, none trips and the system hangs on till the time any one or both supplies restore.

The above auto changeover sequence covers situation of undervoltage on the line side and interruption in the bus supply. There can be a requirement for maintenance to take outage on any one of the transformers/incomer circuit breakers. In this event, it is desired to feed the respective bus from the other healthy bus - obviously without interruption of the supply. This situation is "Planned outage of the desired circuit breaker' and it necessitates paralleling both the incomers - momentarily - and then tripping the desired circuit breaker. As a prerequisite, obviously synchronization of the supplies needs to be checked before paralleling the sources. Normally, using line side supply, check synchronization function is added on to the bus-coupler.

In most of the cases, "close" permissive is given to the circuit breakers only from the control room, when they are in service position. In case the control logic is desired to be tested, the circuit breakers need to be drawn in test position (out of service position) and then the operation can be tested, without affecting other circuit breakers, which are in service position and feeding the bus. However, for momentary paralleling and planned outage, the close command may be given from the control room or from the switchgear.

When wired with conventional electromechanical devices, all these logical requirements demand extensive wiring between the Incomers and Buscoupler circuits, in addition to a large number of auxiliary contactors and timers. Electrical antipumping feature is desired in both incomers and buscouplers.

**Protection**

Normally on distribution voltage (6.6/11kV) and low voltage (415V), incomers are provided with the following protections:

- 51 - Inverse overcurrent (2 elements)
- 51N - Earth fault
- 50 - Highset overcurrent
- 64S - Standby earthfault
- 64R - Restricted earthfault

There is a lockout relay (86) for all these protective functions.

To monitor voltage on line and bus side, undervoltage (27u) and no-volt relays (27n) with timers (2) are provided in the line VT and Bus VT modules. Trip circuit healthiness (95) is monitored using a separate relay.

Buscoupler have normally 51, 51N protections with lockout relay (86) and trip circuit supervision (95).

**Metering**

For Incomers, metering requirement includes current, voltage, power factor and energy. For Buscoupler, normally it is only current that is measured and displayed. For remote metering, transducers are used.

**Annunciation and Indication:**

Apart from feeder status, lamps and annunciators are used for various alarms and faults. For this purpose, auxiliary circuit needs some auxiliary relays, specially to announce transformer faults and alarms.

**Single line diagram and panel layout**

A typical single line diagram with all these requirements is shown in Fig. 1. For simplicity, only 2:Incomers and 1:Buscoupler are shown.

A typical switchboard layout for 3200A ACBs, using conventional electromechanical relays is shown in Fig. 2. It is clear that dummy panels are to be added to accommodate meters / relays in the switchboard. Additional relays / timers are to be...
Considered for "Autochangeover occurred" and "Autochangeover Failed" annunciations whenever desired.

**Using Integrated Protection Controllers:**
L&T has introduced a concept of Integrated Protection Controller, combining protection and control with metering and indication in Supervision series relays. These integrated protection controllers have been developed for total flexibility in protection and control of feeders and motors. Keeping specific application in mind, a sophisticated and powerful controller in the form of Advanced Feedervision is developed incorporating the complex Autochangeover logic of Incomers and Buscouplers mentioned above. Its software is developed such that in addition to current and voltage inputs, digital inputs/status inputs are taken by the relay as hard wired signals and the entire logical operation is carried out by software similar to a PLC. It not only eliminates large number of function specific devices and auxiliaries but also offers the benefit of a foolproof logic and standardisation to the user. L&T's experience, merged with internationally acclaimed good engineering practices followed by leading consultants in the world is incorporated in this software.

The single line diagram giving a comprehensive list of functions carried out by the respective Advanced Feedervision relays is shown in Fig. 3. Switchboard layout with Advanced Feedervision Relays incorporated is shown in Fig. 4. Comparing Fig. 2 with Fig.4, it is obvious that Integrated Protection Controllers simplify the switchboard layout and wiring. In addition, they also reduce engineering, commissioning, testing and trouble shooting time.

Capability to record fault history facilitates fault analysis.

**Conclusion**
In today's context, cost of space and interruption in production are very important issues. An Integrated Protection Controller, offering a comprehensive package and occupying less space, offers a economical solution in terms of :-
- reduced time for system design, commissioning and trouble shooting
- lesser number of failures and lower downtime
- saving in space.

In addition, features of microprocessor based relays viz. Self diagnostic feature, data logging, fault history add further value to the package.

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