CASE STUDY — IEEE WORKING GROUP REPORT —

OSCILLOGRAPHIC REPORT AND ANALYSIS

A. Thermal Power Plant

A bus transfer system is desirable for thermal power plants because it transfers all the critical auxiliaries to the healthy station source on the occurrence of a unit trip. Thus the unit can be restored quickly, reducing its overall down time. This faster recovery saves substantial losses in revenue as well as provides vital power generation and/or reserves in an expeditious manner.

The motor bus for the thermal power station auxiliaries are primarily characterized by the presence of large high-inertia fan loads such as forced draft and induced draft fans, and low inertia pump loads such as boiler feed pump, cooling water pump, etc.

The spin-down characteristics in Fig. 1 were obtained by tripping a lightly loaded unit board during normal unit operations at a 210 MW unit. It may be observed from Fig. 1 that, due to the high inertia characteristics of the motor bus, the bus voltage and phase difference decayed gradually. The motor bus took 240 ms for the bus voltage to drop to 80% of its rated voltage and 146 ms to be more than 20 degrees out of synchronism with respect to its normal source before tripping. Thus, a fast transfer can be deemed suitable for a safe and smooth bus transfer operation with no interruption to the unit auxiliaries.

A simultaneous fast transfer of the unit board is shown in Fig. 2. The dead bus time for the unit board was less than a cycle, which resulted in a safe and fast bus transfer with minimal loss of synchronism before re-energization.

B. Continuous Process Industry Auxiliaries

A bus transfer system is desirable for those continuous process industries with at least two alternate independent sources of instantaneous demand power where each plant trip results in substantial loss of material, production, and O&M.

The motor bus for continuous process industries cannot be singularly characterized, since each process demands different sets of motor configurations. However, typical installations consist of varying proportions of medium voltage (MV) and low voltage (LV) induction motor loads, compressor loads, pump loads, agitators, etc. Very often significant amounts of capacitor banks are connected to the bus for reactive power support as per utility power factor requirements. These capacitor banks provide support to the bus voltage during the spin-down of the motor bus.

The spin-down characteristics in Fig. 3 were obtained from live bus transfer trials under full-load conditions at a continuously operating PVC resin plant. The plant has two incoming 220 kV lines from different substations. The plant is susceptible to trips due to electrical faults, which are accentuated by the hilly topography and humid and rainy climactic conditions in the region.

The 10.7 MW load consisted of significant amount of low- inertia HV compressor load, along with other HV and LV pump, fan, agitator, and motor loads. An 8 MVAR capacitor bank was connected to the bus for power factor compensation. It was observed that while the capacitor banks supported the bus voltage very well during the spin-down, the low-inertia load resulted in a brisk fall in bus frequency. The bus underwent an entire slip cycle with respect to its alternate healthy source within 21 cycles. Due to this rapid loss of synchronism coupled with a sustained bus voltage, both fast transfer as well as in-phase transfer were deemed suitable.

Unlike the thermal power plant scenario where a contingency was relayed to the BTS, the BTS was required to self-detect the onset of supply contingency. Amongst several available criteria such as undervoltage, underfrequency, and df/dt, the instantaneous df/dt criterion was deemed suitable as the fastest indicator of contingency and required about 3-4 cycles for detecting supply contingency. For purposes of the live trial, the tripping of the 220 kV incoming breakers of the plant was done to induce the contingency.

A simultaneous fast transfer of this motor bus is shown in Fig. 4. The total dead bus time of about 7 cycles includes about 4 cycles for the detection of supply contingency and about 3 cycles for the closing of the alternate source breaker. The bus drifted by 60 degrees at a very high rate of approximately 10 degrees per cycle before re-energization. The bus transfer was successful in maintaining the process continuity of the plant.

An in-phase transfer of the motor bus is shown in Fig. 5. The in-phase transfer sent an advanced closing command to the breaker such that the breaker closed when the rapidly dying bus was in near-synchronism with the alternate source with 21 cycles of dead bus time before re-energization. The bus transfer was successful in maintaining the process continuity of the plant.