Critical-Power Automatic Transfer Systems – Design and Application

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1. INTRODUCTION

An important requirement of mission-critical electric power distribution systems is the need for automatic operation. In particular, the rapid and reliable transfer of the system from one power source to another during certain system events is crucial to achieving the reliability goals for such system and the facility it serves. However, the design of such an automatic transfer system is all-too-often considered "less important" than many other aspects of the over-all power system design. The results of this can be far-reaching and, in some cases, catastrophic with respect to the reliability of the system.

This paper outlines the design considerations for automatic transfer in the mission-critical power environment, and gives recommendations as to how these considerations can be reliably implemented into an automatic transfer system.

2. BACKGROUND

2.1. The Mission-Critical Environment

In many of today's mission-critical applications, ever-increasing reliability requirements are the norm. A critical part of this reliability is the reliability of the electric power distribution system for a given facility. Among the most demanding applications is that of a data center, where the end-use equipment cannot tolerate even a momentary power outage and, further, even relatively minor disturbances in the power system can cause computer systems to re-boot, causing operational down-time. One way to illustrate the sensitivity of computer loads to system disturbances is the ITI (CBEMA) curve [1]:

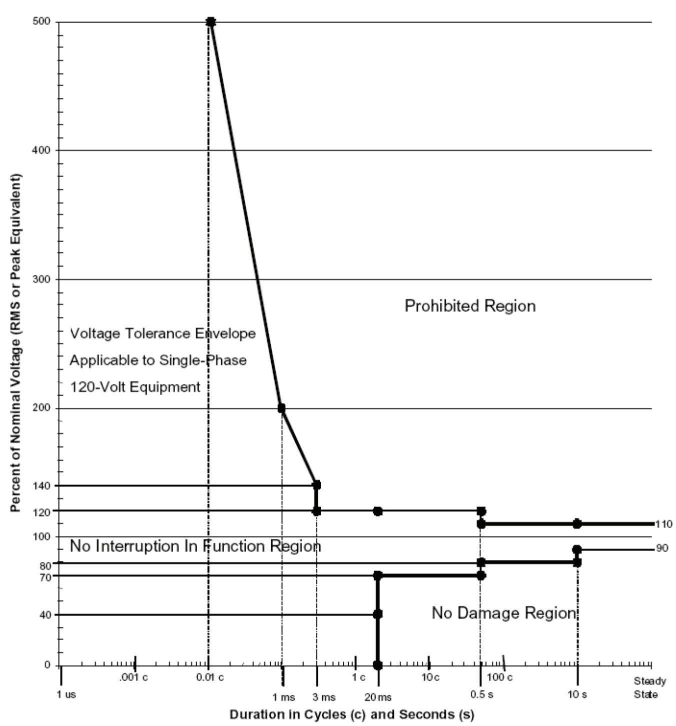


Fig. 1 ITI (CBEMA) Curve

It can readily be seen from Fig. 1 that even short-duration disturbances can cause problems. A full-scale utility failure, lasting for minutes or even hours, is therefore not tolerable for these types of systems. In fact, even the approximately 10 seconds of outage required for transfer of the system to generator power is not an option in these types of systems, a concept that will be explored in greater depth below.

That no power system component can operate with 100% reliability is a well-known fact. Another fact is that the availability of utility power is less than 100% (typically 99-99.9%) Therefore, the possibility of utility power and internal system component failure must be taken into account in the system design.

2.2. Voltage Levels

The choice of distribution voltage in a facility is largely dependent upon the size of the facility and its power system. In many cases, a medium-voltage (2.4 – 69kV) service is required by the utility for a given ampacity service. However, most utilization equipment requires voltage levels in the low-voltage range (up to 600V). The information given herein is equally applicable to automatic transfer systems for low- and medium-voltage systems.

Where multiple automatic transfer systems exist at different voltage levels, some coordination between them is typically required in order to prevent unwanted transfer operations. This will be discussed herein.

2.3. Critical Power Distribution Topologies

The choice of power system distribution topology is the first line of defense against critical-load outages. In the context of automatic transfers, the most common arrangement is the secondary-selective or “main-tie-main” arrangement. One implementation of this arrangement is as shown in Fig. 2:

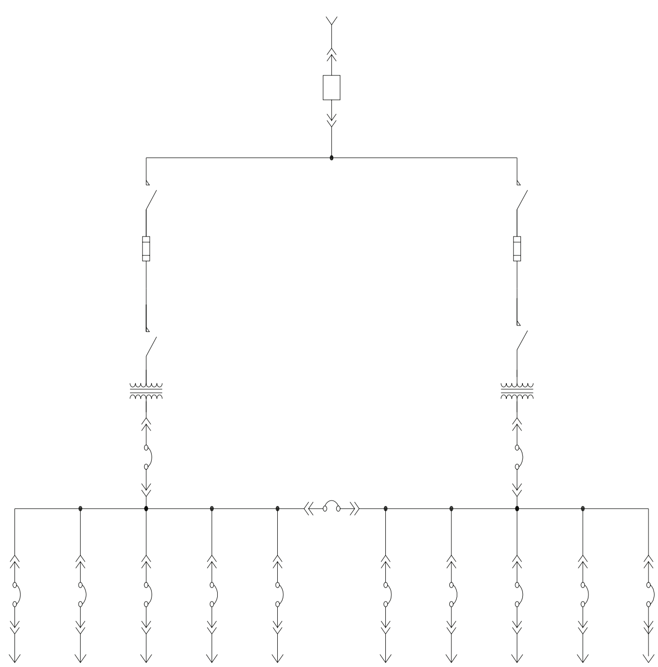
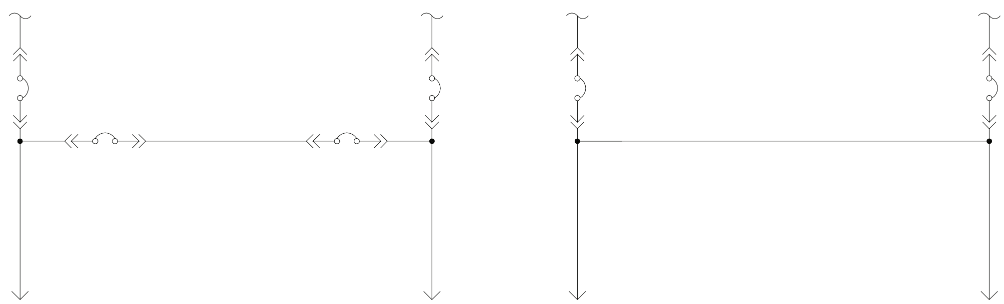


Fig. 2 Secondary-Selective “Main-Tie-Main” Arrangement

In this arrangement, there are two busses, each of which serves approximately 50% of the load but is sized to carry the entire load. In Fig. 2, this means that each transformer, secondary main circuit breaker, and secondary equipment bus is sized to carry the entire load. Should a transformer fail, the entire load may be transferred to the other transformer and its associated secondary bus via the bus tie circuit breaker.

There are many variations on this arrangement. In critical-power applications the most common variation is to use two bus tie circuit breakers, and have the two secondary busses separated into two different pieces of equipment. Another variation is the main-main arrangement, which omits the bus tie circuit breaker and simply has the two secondary busses connected all the time. In this arrangement, one power source normally carries the entire load, and the other is strictly a standby power source should the normal source fail. In this way the main-main arrangement is analogous to an automatic transfer switch (ATS). Both of these variations are shown in Fig. 3.



a.) *b.)*

Fig. 3 Variations on the "Main-Tie-Main" topology a.) "Main-Tie-Tie-Main" b.) "Main-Main"

It should be noted that the main-tie-main topology is also commonly used at the medium-voltage level.

Other arrangements exist, however none are as popular in the critical-power distribution environment as the secondary-selective "main-tie-main" and its variants. One other arrangement, however, has been used with great success is the ring bus, as illustrated in Fig. 4:

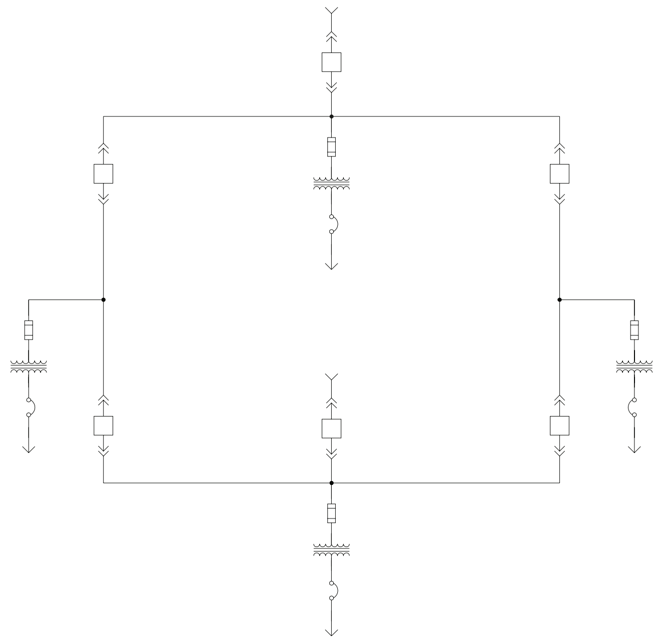


Fig. 4 Ring Bus Arrangement

The ring bus arrangement allows the flexibility of supplying multiple loads using multiple busses. It is most often used at the medium-voltage level, and usually in a “closed loop” arrangement with all of the bus tie circuit breakers closed.

A variation on the ring-bus is the primary loop arrangement shown in Fig. 5:

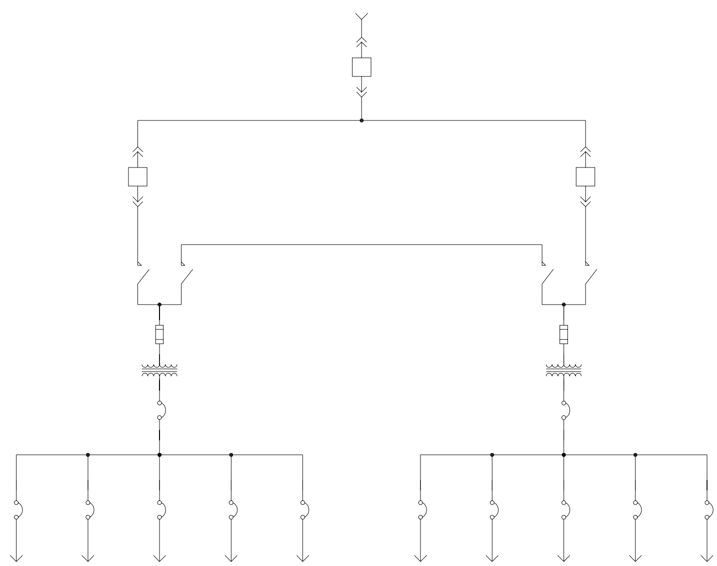


Fig. 5 Primary Loop Arrangement

A primary loop arrangement typically uses load-interrupter switches for switching on the loop, and is more economically justifiable than a full ring-bus system. Typically, the loop is operated in an “open-loop” arrangement, but still gives the ability to supply all loads from either side of the loop.

Extreme flexibility and increased reliability are obtained by combining topologies. An example of this is the composite primary loop/secondary-selective arrangement shown in Fig. 6. Here, multiple failure contingencies are addressed in a generally economically-feasible manner.

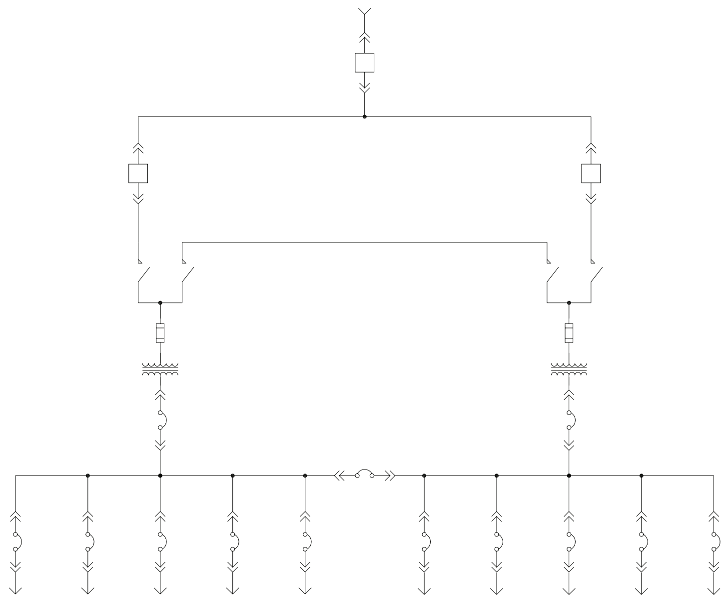


Fig. 6 Composite Primary Loop/Secondary Selective Arrangement

2.4. On-Site Generation

As mentioned above, utility power typically has 99% - 99.9% availability. In a given year, this equates to 9 – 90 hours per year when utility power is not available. For this reason, it is essential that an alternate source of power be available to power the system when utility power is unavailable. Typically, this alternate source of power is in the form of standby engine-generator sets, typically diesel-powered.

The interface of generation with the system can be in one of several forms. One form is *grouped generation/single transfer*, an example of which is shown in Fig. 7:

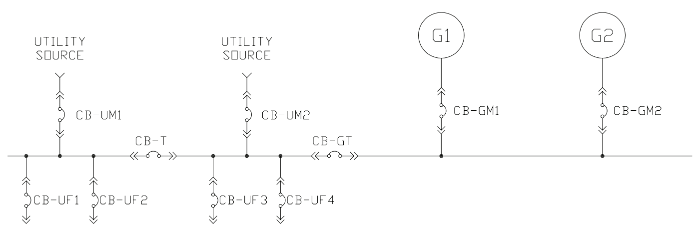


Fig. 7 Grouped Generation/Single Transfer

As the name implies, the generation is grouped (electrically, if not always physically) onto one bus, and the critical loads can be transferred to generator power using one circuit breaker. Care must be taken not to block-load the generators to a higher level than will produce acceptable system performance (frequency and voltage excursions will occur on block-loaded generators, the severity of which is dependent upon the engine-generator set design and the level of block loading). Also, the single bus tie breaker is a single point of failure which may not be acceptable. Multiple generators are provided, usually at least one more than is necessary to supply the entire load (i.e., N+1), due to engine-generator set reliability concerns.

While the grouped generation/single transfer arrangement may be utilized effectively for smaller systems, larger systems typically require a more robust arrangement. By far the most popular such arrangement is the *grouped generation/distributed transfer* arrangement, as shown in Fig. 8. Here, generators are grouped onto one electrical bus, but the electrical loads are segregated into different groups, each of which is served by a "main-main" transfer pair. Such an arrangement has the advantage of eliminating the single point of failure associated with the grouped generation/single transfer arrangement, and also allows the loading of the generators to be staggered in order to minimize block-loading concerns.

Another arrangement is to have generators distributed throughout the system. Such an arrangement is called *distributed generation*, and it is shown in Fig. 9. Here, each generator supplies its own local loads, independent of any other generation in the system. Only one generator at each load group is shown; supplying N+1 redundancy for each engine-generator set typically makes this arrangement economically unfeasible. It is the least popular arrangement for this reason.

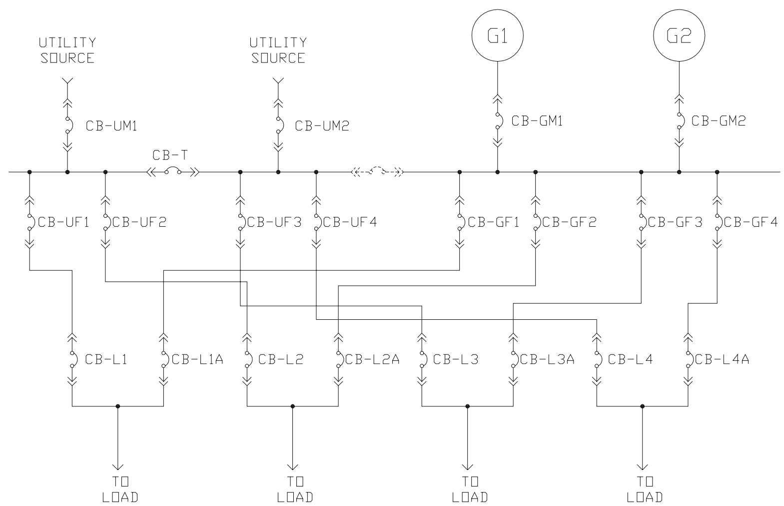


Fig. 8 Grouped Generation/Distributed Transfer

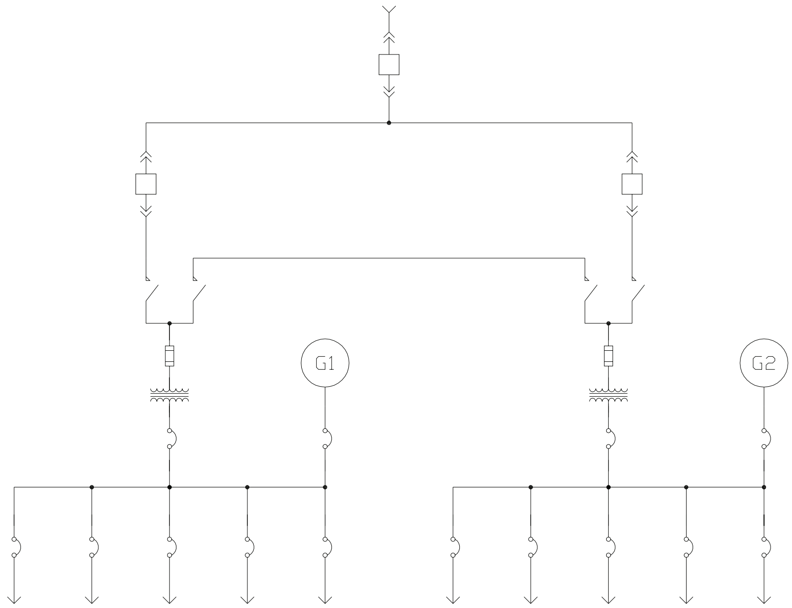


Fig. 9 Distributed Generation

2.5. Uninterruptible Power Supplies (UPS)

As stated above and shown graphically in Fig. 1, computer loads are extremely sensitive to power system anomalies. As has also been stated, bringing backup generation on-line can take several seconds – far too long to allow continuity of operation for these types of loads. For these two reasons, uninterruptible power supplies are used to provide continuous, conditioned power to these loads.

UPS's use stored energy, usually chemical energy in the form of batteries or mechanical energy in the form of a rotating flywheel, and use it to "bridge the gap" from the time the normal source of power (i.e., the utility) fails and the time the alternate source of power (i.e., the standby generators) can be brought on-line. In addition, many UPS topologies provide power conditioning, further isolating the computer loads from disturbances on the system. However, the UPS stored energy source cannot operate indefinitely, and typically requires re-charging from the system normal or alternate power source.

There are several UPS topologies currently on the market and a general discussion of these is beyond the scope of this paper, however UPS's are important in the over-all context of automatic transfer systems.

2.6. The Role of the Automatic Transfer System

Using the basic building blocks of utility power, system topology, on-site generation, and uninterruptible power supplies, the basic role of the automatic transfer system may now be defined. Simply stated, *the role of the automatic transfer system is to provide the automatic transfer of power for its associated load group from a normal power source, such as a utility service, to an alternate power source, such as standby generation, in the event the normal source fails*. This is shown diagrammatically in Fig. 10:

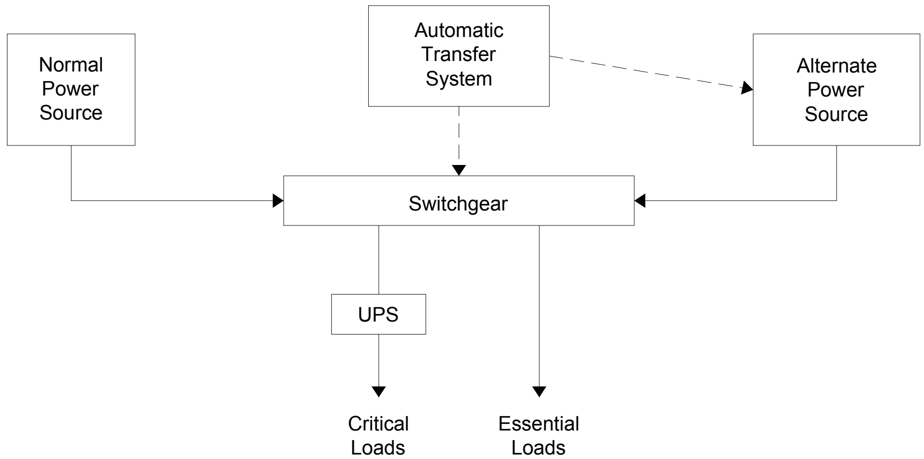


Fig. 10 Critical Power System Functional Block Diagram

In Fig. 10, the role of the automatic transfer system is to direct the operation of the switchgear in such a way as to accomplish transfer from the normal power source to the alternate power source, should a failure occur on the normal power source. The automatic-transfer-equipped switchgear then supplies two classes of loads: Essential loads, which can tolerate the unavoidable few seconds of outage that will occur during transfer operation, and Critical loads, which cannot. The Critical loads use UPS's to allow load power continuity during transfer.

In this role, the Automatic Transfer System must display the following characteristics:

1.) Robustness – it must operate as intended, even under abnormal power system conditions, without human intervention. Just as importantly, it must be able to distinguish when a system condition does <u>not</u> warrant transfer to the alternate power source.

2.) It must be able to control the switchgear as required and, additionally, must be able to pass the proper signals to the alternate power source if necessary (for example, to signal a generator when to start.

3. OPERATIONAL REQUIREMENTS

3.1. Example System Description

To fully illustrate the operational requirements of a typical automatic transfer system, a more detailed representation of the system is required. For this purpose, the main-main arrangement of Fig. 3b.) used, but with the details of the automatic transfer system shown:

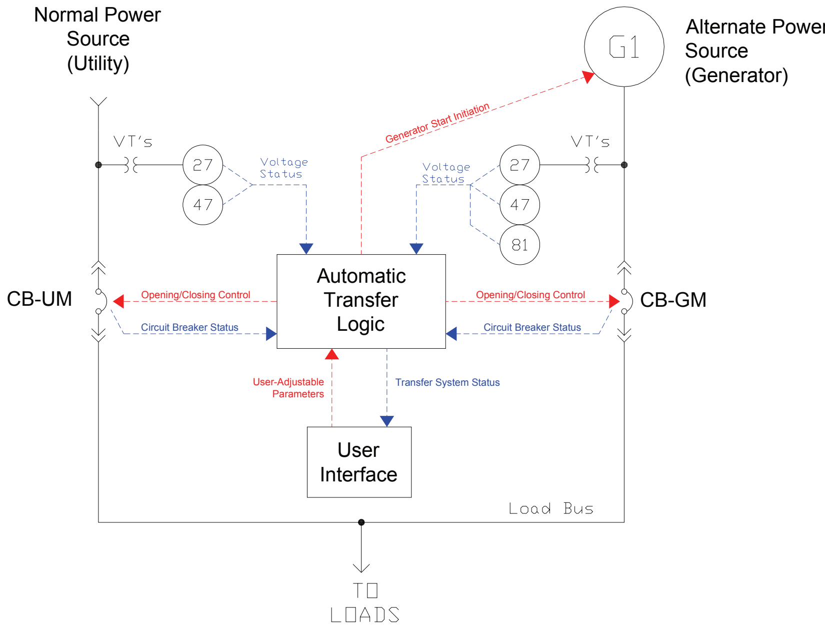


Fig. 11 Main-Main Automatic Transfer Scheme Detail

In Fig. 11, the automatic transfer logic provides the decision-making for what automatic operations are to happen, and when. It controls the operation of the two transfer circuit breakers, CB-UM and CB-GM, and receives status inputs from those breakers. It also can initiate generator startup for the alternate power source. Undervoltage (device 27) and negative-sequence voltage (device 47) relays on each power source give the transfer logic indication of their condition. In addition, a frequency relay (device 81) is present for frequency indication of the alternate power source. Voltage transformers, or VT's, step the system voltages down to instrumentation levels that can be used by these relays. A user interface allows the adjustment of certain operating parameters of the system, and updates the user on the status of the system.

Using this example system, the operational requirements of a typical automatic transfer system will be examined.

3.2. Modes of Operation

An essential requirement of any automatic transfer system is the ability to have different *modes of operation*. In a given mode of operation, the transfer system will respond in a given way to changing system conditions. For a different mode of operation, the transfer system will respond differently. Two basic modes of operation, which any automatic transfer system must have, are:

1.) Manual Mode

2.) Automatic Mode

In the manual mode, the automatic transfer system does not perform any automatic operations, i.e., it does not respond to changing system conditions. All circuit breaker operations must be manually performed. Conversely, in the automatic mode of operation all operations, with a few emergency exceptions, are automatic, and the system will respond automatically to changing system conditions.

On the surface, this appears to be a simple arrangement, and to some extent this is true. However, good automatic transfer system design has well-thought-out mode logic that answers the following questions:

a.) Can the system be placed into automatic mode if system conditions are not correct (for example, if an automatically-controlled circuit breaker is in the withdrawn position or not present in the circuit breaker cell)?

b.) What manual operations are allowed in automatic mode (for example, manual opening of circuit breakers)?

c.) What happens if an allowed manual operation is performed on an automatically controlled device (for example, if an automatically-controlled circuit breaker is manually tripped or trips due to a fault)

Such questions are not always easy to answer. In fact, they necessitate, in a well-designed automatic transfer system, the inclusion of a third mode of operation, typically known as *auto mode failure.* The three modes of operation then typically work as follows:

1.) Manual Mode – Selected via a selector switch position or other pre-determined user input via the user interface. No automatic operations occur.

2.) Automatic Mode – Selected via a selector switch position or other pre-determined user input via the user interface. Attempting to enter automatic mode if the system conditions are not correct places the system into Auto Mode Failure. In Automatic Mode, operations for certain circuit breakers (such as main and tie circuit breakers) are automatic, however manual tripping (or breaker trip due to a fault) of automatically-controlled circuit breakers is allowed. Such manual or fault-driven operations will result in the system being placed into Auto Mode Failure.

3.) Auto Mode Failure – No automatic operations occur. For automatically-controlled circuit breakers, only manual tripping (or trip due to a fault) is allowed. To leave this mode of operation, the system must be placed into manual mode.

This arrangement provides a high level of security for the transfer scheme, i.e., undesired or "nuisance" operations are minimized, enhancing safety, maintainability, and reliability of the system.

Of necessity, to make this mode logic arrangement function properly the breaker status must consist both of breaker open-closed indication <u>and</u>, for drawout circuit breakers, circuit breaker cell switch indication. Circuit breaker cell switches are a feature which must not be overlooked as they are essential for the proper function of an automatic transfer scheme with drawout circuit breakers. For the same reason overcurrent trip switches for low-voltage circuit breakers or lockout relays for medium-voltage circuit breakers are also required.

Another question that frequently arises is that of a "test" mode of operation. While this could be made into a separate mode of operation, this is usually most expediently handled via voltage failure simulation test switches while the system is the automatic mode.

3.3. Initiation of Transfer

In the automatic mode, the transfer system must be able to react to source failure by initiating transfer. For this purpose, it is necessary for the mode logic to know the condition of the normal and alternate power sources. This is typically accomplished via undervoltage (device 27) and negative-sequence voltage (device 47) relays, as shown in Fig. 11. Frequency relaying is usually not required for utility sources as the frequency is quite stable, and not affected by changing load conditions within the facility. For standby generators, however, although they are typically controlled via isochronous governors there is a limit to the amount of power (and to sudden changes in power) that they can supply without frequency changes. Also, at the beginning of the startup cycle of a generator the frequency is zero, and will ramp up to the nominal frequency (typically 60Hz) as part of the startup process. For these reasons, under- (and possibly over-) frequency relays (device 81) are used for generator sources in addition to the under- and negative-sequence voltage relays. Because overvoltage can be an issue when operating on generator power (for example, if the voltage regulator fails or the generator is called upon to absorb an excessive amount of reactive power), overvoltage (device 59) relays are occasionally used as well (not shown in Fig. 11).

The pickup and time delay levels for these relays are functions of the system itself and the amount of time that abnormal conditions can be tolerated. For example, the undervoltage relays are typically set to pick up when the voltage level falls to 80% of nominal. The negative-sequence voltage relays are typically pre-set to respond to loss of a single phase, but may be adjustable. Frequency relays must be set very carefully to avoid nuisance operations on normal load swings. It should be noted that these relays are typically for use by the automatic transfer system only, and are separate from the relays or generator control package functions which provide protection for the generator. Careful coordination is required to insure that the automatic transfer relays will always react before generator protective relays.

The indication from these relays to the automatic transfer logic is typically in the form of a single binary input, i.e., “source normal” or “source abnormal”. Upon receipt of a “source abnormal” signal when operating on utility power, the automatic transfer logic must respond. Typically, this response is delayed to insure that the abnormality is not a transient condition, in order to prevent an unnecessary transfer. When the system is supplied via utility power this will allow the utility system to attempt clear the fault through reclosing. The time delay, known as a *source failure delay,* may be via inverse-time characteristics built into the relays or, more typically, via a time delay built into the automatic transfer logic. This delay is typically 5-10 seconds and is a function of what type of utility reclosing is used and how long the abnormal voltage condition can be allowed to persist.

Once the source failure time delay has expired, the automatic transfer system opens the circuit breaker for the affected source, starting the automatic transfer process.

3.4. Dead-Bus Considerations

Once a transfer operation has been initiated and the system has been disconnected from its normal source of supply, a suitable time delay must be given to allow the residual voltage from spinning motors to decay before the system is transferred to the alternate source. This time delay is known *dead-bus time*, and it is vital that this be taken into account in the transfer scheme design. If this is not done, there is a significant risk of both shaft and winding damage to connected motors due to the energy transfer that can occur. For the example system of Fig. 11, this will almost always be inherently be accounted for due to the generator start-up time, however the logic should incorporate controls to insure this. In general, any time a system bus is de-energized due to automatic transfer action a dead-bus delay should be coded into the transfer logic. Typical dead-bus delays are 2 – 5s.

3.5. Generator Starting

For the example system of Fig. 11, a signal is provided to initiate generator starting. In general, this will be a requirement any time one of the sources of power is a generator or generators, unless the generator(s) is used for cogeneration as well as standby power. Typically, this signal is a contact closure; once the contact is closed the generator(s) will start up and will run until the contact is opened, at which time the generator will begin a cool-down cycle. Other variations exist, however in general the management of the generator cool-down cycle should remain under control of the generator(s) control system rather than the automatic transfer system.

3.6. Completion of Transfer

After the alternate source is available and the required dead-bus delay has expired, the transfer system must close the alternate-source circuit breaker to supply the system from the alternate source. In the example system of Fig. 11, the alternate-source circuit breaker is CB-GM. For a main-tie-main system as shown in Fig. 2, the secondary bus tie circuit breaker would be the circuit breaker that is closed. For a main-tie-tie-main system such as shown in Fig. 3b.), one of the bus tie circuit breakers would normally remain closed all of the time, and the second tie circuit breaker would be the circuit breaker that is closed to complete the transfer.

3.7. Re-Transfer to Normal Source

The normal source, when it returns, typically starts a timer in the automatic transfer system. This timer is present so that re-transfer will not occur until the normal source has been shown to be stable. The time delay is known as a *return of source time delay* and is typically set from 5 – 15 minutes. Once the time delay has expired the return to the normal operating condition may be *open-* or *closed-transition*, and may be manually or automatically initiated.

3.7.1. Open-Transition Re-Transfer

As its name implies, open-transition re-transfer entails de-energizing the system prior to re-energizing it with the normal source. This requires a dead-bus delay as discussed above. In the example system of Fig. 11, the circuit breaker CB-GM would open, a dead-bus delay would transpire, and circuit breaker CB-UM would close to complete the re-transfer.

The disadvantage to this method of re-transfer is that it requires the system to take a second outage in order to be restored to the normal source. However, it does not require additional equipment to accomplish.

3.7.2. Closed-Transition Re-Transfer

Closed-transition re-transfer requires the paralleling of the normal and alternate power sources for a brief time period prior to separation from the alternate power source. Where a generator(s) is involved, this requires synchronizing the generator(s) with the normal power source. This synchronization may be accomplished passively, by simply waiting for the generator(s) to fall into synchronism with the normal source, or actively, by driving the generator(s) into synchronism with the normal source. In general, passive synchronization is less expensive and can be accomplished with a simple synchronism checking relay (device 25), however the generator is not guaranteed to fall into synchronism with the utility source and the resulting energy transfer during the transition can damage the generator and other system components. Active synchronization avoids these problems, but is more expensive since an generator synchronizer and additional control signals between the automatic transfer system and generator control system are required.

The time period during which the sources are paralleled is usually very brief, no more than 2 -3 cycles, in order to keep the heightened exposure of the system which occurs to as brief a time as possible. This heightened exposure results from the elevated fault-current levels that exist with the sources in parallel, and also due to the exposure of the system to supply a fault on the normal source via the alternate source. If both the normal and alternate sources are separate utility services the utility may have restrictions on the ability to perform closed-transition re-transfer.

The advantage of closed-transition re-transfer is that the system does not have to experience another outage during re-transfer. For the example system of Fig. 11, circuit breaker CB-UM would close once synchronization is achieved (passive or active), then circuit breaker CB-GM would open to complete the re-transfer.

3.8. Unusual Conditions

Unusual conditions can occur during the automatic transfer process. For example, the normal power source could fail, only to be restored during the dead-bus time delay before the alternate source is connected to the system. How the automatically transfer system responds during such conditions has traditionally been a function of the skill of the transfer system designer and the requirements of the facility. The basic philosophy for automatic transfers in mission-critical environments is to transfer the system if the condition of the normal source is in doubt, so long as the alternate power source is known to be available and it is safe to do so, and most automatic transfer systems for these environments are designed with this goal in mind.

4. EQUIPMENT SPECIFICATION

Although the basic operational requirements of any automatic transfer system are as given in section 3 above, the equipment which is used to implement the automatic transfer system can vary. The following is a list of commonly encountered variations regarding the automatic transfer system equipment.

4.1. Switchboard or Switchgear?

The power equipment used to facilitate the transfer, for low-voltage systems, is commonly either a UL 891 switchboard or ANSI C37.20.1 low-voltage power switchgear. Which is used is dependent upon the system design and where in the over-all power system the equipment is located, however the following general guidelines apply:

1.) For automatic transfer “higher” in the system (closer to the service), ANSI low-voltage switchgear is generally preferred due to is compartmentalization and the use of drawout low-voltage power circuit breakers, which have short-time withstand capabilities. An alternative is a “hybrid” UL 891 switchboard which uses drawout insulated-case circuit breakers with characteristics similar to low-voltage power circuit breakers, but with less compartmentalization.

2.) For automatic transfer “lower” in the system (farther from the service), a UL 891 switchboard may suffice. However, drawout circuit breakers should be considered even if a UL 891 switchboard is used. Lack of short-time withstand on molded-case circuit breakers is a big factor here.

4.2. Logic Platform

The automatic transfer logic may be supplied by either discrete control relays or a programmable logic controller (PLC), as shown in Fig. 12. In times past, this was generally a choice of flexibility (the PLC) vs. robustness (discrete relays). In recent years, however, PLC’s have undergone significant improvements in reliability and robustness, to the point that they are now the preferred method for implementing automatic transfer scheme logic.

The flexibility given by the use of PLC’s lies in the fact that the automatic transfer logic is coded into software, rather than hard-wired. This makes some on-the-fly changes, if required, possible without hardware or wiring modifications to the equipment. It also allows more complex decision-making logic to be implemented without excessive wiring. Discrete control relays, on the other hand, must be re-wired to make changes to the automatic transfer logic, and more complex logic generally requires more control relays and wiring.

Another advantage of a PLC is its ability to communicate digitally with external devices. This makes more sophisticated user interfaces possible, as will be discussed below. It also allows remote access to the transfer system if required.

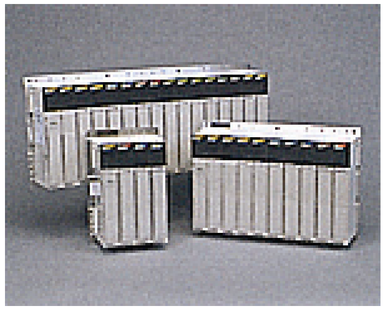


Fig. 12 PLC for Automatic Transfer System Logic Implementation

4.3. Circuit Breaker Control and Interlocking

Interlocking is the restriction of operation of devices, usually for safety reasons. For an automatic transfer system, the most common interlocking required is interlocking to prevent out-of-synchronism paralleling of power sources (or prevention of paralleling at all in many cases). When the automatic transfer system logic is provided by a PLC, this interlocking may be implemented in a *hard-wired* fashion, that is, outside of the PLC or as part of the PLC program. In general, use of hard-wired interlocking is preferred, to allow an extra measure of safety should the PLC fail.

Similarly, manual control for automatically operated circuit breakers may be implemented in a hard-wired fashion or via the PLC. It is generally recommended that at least the circuit breaker tripping function be implemented outside the PLC. Manual control for automatically-operated circuit breakers is generally implemented via an external control switches, with the manual close control (and often trip control) on the circuit breaker access-restricted via a cover to force use of these control switches.

4.4. User Interface

This is the most customizable part of the automatic transfer system equipment. In general, two options are available: discrete controls or touch screen.

4.4.1. Discrete Controls

Discrete controls take the form of control switches and pilot lights mounted on the equipment. An example of this is given in Fig. 13:

1. Auto/Man Keyed Switch
2. White Indicator Light
3. Blue Indicator Light
4. Amber Auto Mode Fail Light
5. Preferred Source Selector Switch (Optional)
6. Auto Retransfer Switch (Optional)

Fig. 13 Discrete Controls

In Fig. 13, "AUTO", "MANUAL", and "AUTO FAIL" pilot lights indicate the three modes of operation described in section 3.2 above. A keyed auto/manual mode selector gives control of the operating mode, a keyed automatic retransfer on/off switch provides a means to enable or disable automatic retransfer, and a keyed preferred source selector allows either power source to be considered as the normal source. The use of keyed switches should be carefully evaluated to insure that the end-user achieves the maximum benefit from such an arrangement.

In addition to the controls shown in Fig. 13, the following are also commonly available:

1.) Open/Closed Transition re-transfer selector
2.) Source Available Indicators
3.) PLC low-battery indicator
4.) Transfer in Process indicator
5.) Source Failure Test Switches

Like discrete relay control logic, discrete controls must be planned to the last detail early in the specification process and provide limited flexibility for change.

4.4.2. Touch screen

When a PLC is used for the automatic transfer logic, a touch screen is an option for the user interface. A touch screen can provide a wealth of detail regarding the automatic transfer system status, and adjustability in several areas which aren't typically available with discrete controls. An example of a touch screen interface is shown in Fig. 14:

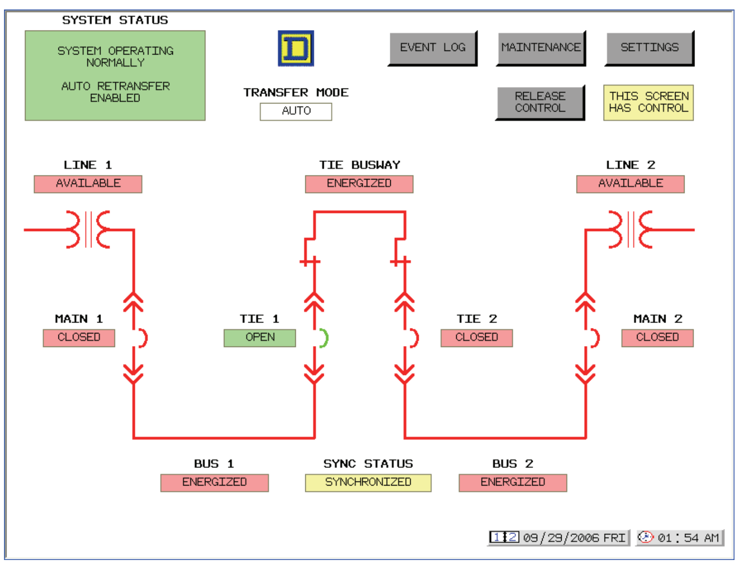


Fig. 14 Touch screen Interface

The touch screen interface in Fig. 14 includes:

1.) An active mimic one-line diagram which changes color to denote energization of system components
2.) Source available indicators
3.) Breaker status indicators,
4.) A transfer system status summary

5.) The ability to change numerical settings such source failure, dead bus, and source restore timers

6.) Quick manual transfer of the system from one source to the other in manual mode

7.) An event log which captures automatic transfer events for diagnostic purposes.

Such sophisticated control is simply not feasible with discrete controls, but is easily achieved with a touch screen.

Touch screen control interfaces for automatic transfer systems do usually include at least one discrete switch and indicators, namely the auto/manual mode selector and its associated indicators.

4.4.3. Multiple User Interfaces

The use of multiple user interfaces is possible. Such an arrangement may be desirable due to the need for remote control of the system. In planning such an arrangement, careful consideration should be given to the number of interfaces and which interface overrides if control is attempted by more than one interface at a time.

5. COMMON MISCONCEPTIONS

Several common misconceptions regarding automatic transfer systems exist. Some of these are addressed here.

5.1. "I need a complex automatic transfer scheme at every voltage level"

This may or may not be true, but in general if more than one automatic transfer scheme is present, the farther downstream it is, the less complex it has to be. For example, consider the system of Fig. 15:

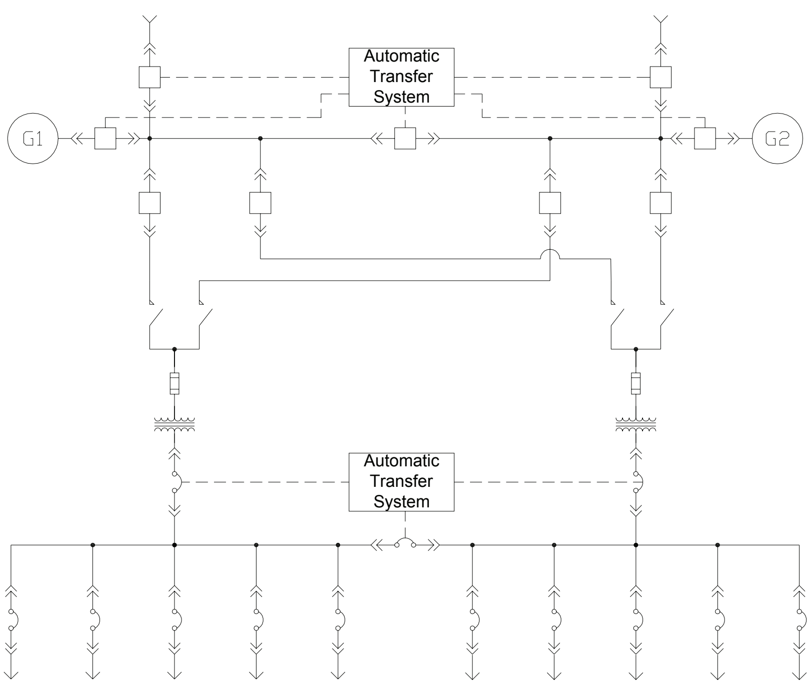


Fig. 15 Two Automatic Transfer Systems at Different Voltage Levels

In Fig. 15, two automatic transfer systems exist, one at the medium-voltage level and one at the low-voltage level. The automatic transfer system at the low-voltage level must be coordinated so that it does not transfer unless the reason for transfer is not addressed by a transfer on the system at the medium-voltage level. For example, should one of the utility sources fail, the medium-voltage system will transfer to the other utility source. In that case, the low-voltage transfer scheme should not transfer at all. However, should a fault occur on one of the medium-voltage feeders, the low-voltage system must transfer to restore power to the loads. Typically this coordination between automatic transfer systems is achieved by making the time delays for source failure and re-transfer longer on the low-voltage system than on the medium-voltage system.

Further, in Fig. 15 the generation is at the medium-voltage level, so the low-voltage automatic transfer system does not have to consider operation of the generators. It is therefore less complex than the medium-voltage automatic transfer system and will, in general, transfer less frequently.

5.2. "AC Control Power for my automatic transfer PLC can be handled by the system UPS's"

On the surface, this is true. However, initial system start-up will require a power source other than the system UPS's, which are devices downstream from the automatic transfer system. And, if a UPS is taken off-line for maintenance the availability of the control power can be compromised.

In reality, automatic transfer PLC's have control power reliability requirements that are similar to microprocessor-based protective relays. Where those devices are used, the preferred power source is a DC battery system, and this is true for an automatic transfer PLC also. Typically, a 24V battery system is sufficient, although care should be used to isolate the PLC from the battery voltage via a DC-to-DC converter to avoid exposing the PLC power supply to the voltage variations that will occur on the battery system. Alternatively, a small UPS, supplied by a control transformer in the switchgear/switchboard, could be used. In either case, maintenance requirements apply to insure that the power is available when called upon. In this case, a control power throwover is advisable, with one source being the switchgear/switchboard UPS, and the other being a system UPS or other reliable source.

AC control power for low-voltage switchgear/switchboards used for automatic transfer is generally provided via a control power throwover supplied by control transformers in the equipment. Energy to trip circuit breakers when no control power is available (i.e., after source failure but before standby generators are up and running) is provided via capacitive energy-storage devices. For medium-voltage switchgear, the protective relays will have similar control power reliability requirements similar to those of the automatic transfer PLC, and DC batteries are typically used, but usually at the 48VDC or 125VDC level.

Many variations exist on switchgear/switchboard/PLC control power design, and this is an issue must be carefully considered to achieve the desired results.

5.3. "Since my automatic transfer system was tested in the factory, it doesn't need field testing"

Like any other engineered system, factory testing for an automatic transfer system is no substitute for field testing. Field testing takes into account shipping damage and installation errors that may have occurred, as well as testing the system's response to actual system conditions rather than simulated test conditions. In many cases the specified time delays, such as source failure delays, are found to need adjustment when applied under real-world conditions.

This is doubly important in the mission-critical environment, where reliable equipment operation is crucial.

6. SUMMARY

In this paper, many aspects of automatic transfer systems for the critical power environment have been examined. In general, the manufacturer's experience with these types of systems, along with proper specification, are the keys to successful transfer system design and implementation. When properly designed and implemented, automatic transfer systems provide a vital function in the reliable operation of critical power systems. Working in conjunction with alternate power sources and UPS's, automatic transfer systems help to insure that critical system loads receive the reliable power they require in order to function.

7. REFERENCES

[1] "ITI (CBEMA) Curve Application Note," The Information Technology Industry Council, Washington, DC, 2000