Protection of Automatic Transfer Switches

The desire for facilities to have continuous power has lead to the use of various types of generator and transfer switch combinations. The purpose of the automatic transfer switch (ATS) is to automatically start the generator and switch from the utility power feed to the power feed from the generator when the normal utility power fails. In order to complete this task, the ATS is equipped with electronic circuits that monitor the utility feed, control the starting mechanism of the generator and control the switch that transfers the power source from the utility feed to generator feed. Further, when the utility feed comes back on-line and is stable, the ATS transfers the load back to the utility feed.

Due to the electronics involved in the ATS, the ATS is susceptible to the surge environment that is common at the service entrance location where the ATS is installed. Surges from the utility feed due to lightning, load switching, etc. can be detrimental to the operation of or can destroy the ATS rendering the system useless. Also, when the generator starts up, the voltage may not yet be stabilized at the instant the ATS makes the transfer. This initial surge of not yet regulated power can damage electronic systems.

One technology available that aid in correcting these issues is surge protective devices (SPDs). This application note focuses on applying SPDs to an ATS system to mitigate the damage that can occur due to the expected surge environment.

![Diagram of a Typical ATS Layout](image_url)

**Figure 1 – One Line Diagram of a Typical ATS Layout**
Application of SPDs

To aid in the description of the application of SPDs to an ATS system, please refer to Figure 1.

This figure illustrates a typical ATS layout. The incoming power system configuration can vary greatly. As noted, there are a number of opportunities for protecting the typical ATS system – each are labeled with a circled number and are described below.

1 Utility Feed to the ATS. Protecting the input of the ATS is a necessary step in protecting the backup power system. Providing protection at this location prevents surge damage due to events propagated on the electrical system from upstream sources such as lightning and switching surges created by the utility.

Electronic circuitry is often included on the utility side of an ATS. These circuits require protection to ensure proper operation of the ATS. At this location, a parallel connected, sine wave tracking device is appropriate (includes threshold clamping as well). Sine wave tracking is recommended for this location due to the presence of switching transients that can be generated due to load switching and distant lightning events on the utility feed.

2 Generator Input to the ATS. Protecting the generator input to the ATS is also of great importance. This is especially true when the distance between the generator and the ATS is greater than 30 feet or has external wiring. In these cases, the ATS is exposed to direct lightning strikes to the wiring between the ATS and generator or is exposed to near-by strikes to the ground or structures near the wiring.

Again, due to the electronic nature of most ATS systems, a parallel connected, sine wave tracking device is appropriate (includes threshold clamping as well). Sine wave tracking is recommended for this location due to the presence of switching transients or ringing transients that are often propagate between the ATS and the loads connected to the output of the ATS.

3 ATS Output. Protecting the immediate ATS output is highly recommended. The wiring on the output of the ATS is often routed outdoors and is, therefore, exposed to direct lightning strikes to the wiring between the ATS and loads or is exposed to near-by strikes to the ground or structures near the wiring.

Due to the electronic nature of most ATS systems, a parallel connected, sine wave tracking device is appropriate (includes threshold clamping as well). Sine wave tracking is recommended for this location due to the presence of switching transients or ringing transients that are often propagate between the ATS and the loads connected to the output of the ATS.

4 Generator Low-Voltage Control Circuit. Protecting the generator low-voltage control circuit is an essential step in protecting the ATS system. This circuit is used to initiate generator startup when the utility power is absent as well as shut down after utility power returns. This circuit is usually 12-24 VDC. Providing protection at this location prevents surge damage to the control circuitry that starts the generator. Without this function, the ATS will not start the generator. If the distance between the ATS and the generator is greater than 30 feet or has external wiring, an SPD is recommended also at location 6 to prevent surge voltages from accessing the ATS electronics.

At this location, a series connected, sine wave tracking device is appropriate (includes threshold clamping as well). These circuits are often low-voltage DC circuits and could be fed by another source.

5 Utility Feed Disconnect. Protecting the utility feed disconnect is a recommended step in protecting the ATS when the disconnect is present in the system. Providing protection at this location creates a layered protection approach. With this approach the SPD on the utility feed disconnect mitigates the largest portion of incoming surges and limits the exposure of the SPD protecting the ATS utility input. The result of this action is that let-through voltage that the ATS is exposed to reduced which lessens the chance of failure or disruption of the ATS system. The need for protection at this location is emphasized if the distance between the utility feed disconnect and ATS is greater than 30 feet or has external wiring.

At this location, a parallel connected, threshold clamping device is appropriate. By having a sine wave tracking device at the utility feed input on the ATS, sine wave tracking is not necessary at this location.

6 Data/Control between the ATS and Generator. Some ATS systems are equipped with communication or control circuits that allow feedback from the ATS to the generator and vice-versa. These circuits can also be used to provide operational status information to operation centers often found in larger facilities. Protection at these locations is critical when this function is present in the system. This is further emphasized if the distance between the ATS and generator is greater than 30 feet or has external wiring. Often a remote annunciator panel will be used at a distant location that can replicate the data shown on the annunciator panel on the generator. This can require anywhere from four to eight 12-24 VDC circuits. In these
cases, these lines are exposed to direct and near-by lightning events.

Selecting an SPD for these locations will depend upon the type of circuit used for communication or control. If these are powered circuits, a series connected, sine wave tracking device is recommended. If these are data or communication circuits, then a data-line device is recommended. Typically, data communications for this type of circuit would be relatively low speed (< 2 Mbps).

8 **ATS Feed to Loads.** Protecting the input of the panel is a critical step in protecting the loads of the power system. Providing protection at this location provides a layered approach for the loads being protected. Although, this location is outside the scope of the ATS system, it is not any less important. Protection at this location is even more critical when the distance between the ATS and the loads is greater than 30 feet or has external wiring. In these cases, these lines are exposed to direct and near by lighting events.

Selecting an SPD for this location depends on the types of loads being protected. If the loads are electronic in nature, it is recommended to use a parallel connected, sine wave tracking device. If the loads are less critical or less susceptible to surges, then a parallel connected, threshold clamping device might be considered.

9 **Generator AC Power.** Protecting the input of the generator is an essential step in providing protection for the ATS system, especially when the distance between the ATS and generator is greater than 30 feet or has external wiring. The goal of providing protection at this location is to protect the output windings of the generator. In addition, an electrical circuit may run from a separate building power source (normally from an emergency power panel) to the generator to power a battery charger and sometimes a jacket water heater. It can be single-phase 120, single-phase 120/240, or three-phase 120/240 or 120/208.

At this location, a parallel connected, threshold clamping device is recommended. A series connected device can also be used, depending on the current level.

### Summary

<table>
<thead>
<tr>
<th>Number/ Location</th>
<th>Need for Protection</th>
<th>Type</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – ATS Utility Input</td>
<td>Critical</td>
<td>Parallel, SWT</td>
<td>ATS is electronic</td>
</tr>
<tr>
<td>2 – ATS Generator Input</td>
<td>Critical</td>
<td>Parallel, SWT</td>
<td>ATS is electronic</td>
</tr>
<tr>
<td>3 – ATS Load Output</td>
<td>Critical</td>
<td>Parallel, SWT</td>
<td>ATS is electronic</td>
</tr>
<tr>
<td>4 – Generator LV Control</td>
<td>Critical</td>
<td>Series, SWT</td>
<td>Typically low-voltage DC circuits</td>
</tr>
<tr>
<td>5 – Utility Feed Disconnect</td>
<td>Recommended, if present</td>
<td>Parallel, TC</td>
<td>Provides layered approach, less stress at #1 specifically when the distance from #5 to #1 is large</td>
</tr>
<tr>
<td>6 – Data/Control to ATS</td>
<td>Critical, if present</td>
<td>Series, SWT or Series, Data</td>
<td>Control and Data lines are highly susceptible to induced surges, propagate surges easily</td>
</tr>
<tr>
<td>7 – Data/Control from Generator</td>
<td>Critical, if present</td>
<td>Series, SWT or Series, Data</td>
<td>Control and Data lines are highly susceptible to induced surges, propagate surges easily</td>
</tr>
<tr>
<td>8 – Panel (loads)</td>
<td>Critical/Recommended</td>
<td>Parallel, SWT or Parallel, TC</td>
<td>Critical when the distance between #3 and #8 is large. Recommended to provide a layered approach and to protect all loads at this point.</td>
</tr>
<tr>
<td>9 – Generator AC Power Circuits</td>
<td>Critical/Recommended</td>
<td>Parallel or Series, TC</td>
<td>Critical when the distance between #2 and #9 is large. Recommended to protect output windings of the generator.</td>
</tr>
</tbody>
</table>

SWT = sine wave tracking
TC = threshold clamping