EFFECTS OF LED NAVAIDS ON CONSTANT CURRENT REGULATORS

TODAY’S AGENDA

LED-based Airfield Lighting
1. Discussion of the problems observed.
2. How to remediate them in the field.
3. How to avoid them in future.

Speaker:
Patrick Lynch
Manager Power Systems
Liberty Airport Systems Inc.
A member of the Safegate Group
Email: Pat.Lynch@LibertyAirportSystems.com
LED-BASED SOLID STATE LIGHTING (SSL)

SSL - A Burgeoning Concern on the Airfield
1. Series Circuits are no longer Resistive in nature
   - Reduced PF will mean higher energy costs
2. AFL suppliers do not design to any standard Input Impedance
   - Operational results will vary by Manufacturer
3. Regulators are becoming overloaded
   - Airside Operations impaired by equipment failure

1. Impact on New Construction Projects
   - Under sizing of CCRs, Failures during Start-up, Additional labor costs

Lost Time and Money!

CCR Technologies

SCR vs. Ferroresonant CCRs

<table>
<thead>
<tr>
<th>Type</th>
<th>Output Waveform Shape</th>
<th>1 Power Factor</th>
<th>2 Output Current Regulation</th>
<th>3 Flashing Loads</th>
<th>Total Harmonic Distortion</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCR</td>
<td>Good</td>
<td>&gt;95%</td>
<td>Good</td>
<td>Good</td>
<td>Poor</td>
<td>Lower</td>
</tr>
<tr>
<td>Ferro-Resonant</td>
<td>Better</td>
<td>&gt;95%</td>
<td>Better</td>
<td>Better</td>
<td>Better</td>
<td>Higher</td>
</tr>
</tbody>
</table>

1. PF as measured at Full Load at Brightness 5.
2. Output Regulation into a Reactive Load (Spec = max. 30% lamps out)
3. Ability to regulate the output under flashing loads (Strobes, RGLs, etc.)
**Incandescent Lighting**

Essentially a 100% resistive load (the good old days!)

- Near unity Power Factor

**LED Lighting**

No longer purely resistive – power supplies include Inductors and Capacitors to make them Reactive

Phase Shift = Power Lost
**Power Losses in the Series Circuit**

**What does this mean to the CCR and Energy Costs?**
Inductance and Capacitance will distort the CCR output waveform
- The LED load profile presented to the CCR is dynamic.
- Each LED circuit will have a different PF for each brightness step.

Series Circuit PF Calculation

\[
P.F. = \frac{KW}{KW - KVAR}
\]

\[
P.F. = \frac{Beer}{Beer + Foam}
\]

*A CCR supplies constant current, not constant kVA*

**CCR Loading**

**LED Loads - Effect on CCRs**
With LEDs, the series circuit is no longer purely resistive
- Capacitance & Inductive Reactance is introduced to the series circuit
- Circuit becomes Reactive instead of Resistive (PF < 1)

Example:
G.A. Airport – LED Signs & Edgelights with 15kW Ferro CCR

<table>
<thead>
<tr>
<th></th>
<th>4.8A</th>
<th>5.5A</th>
<th>6.6A</th>
</tr>
</thead>
<tbody>
<tr>
<td>kW</td>
<td>3.5</td>
<td>5.5</td>
<td>5.9</td>
</tr>
<tr>
<td>kVA</td>
<td>9.2</td>
<td>11.1</td>
<td>14.1</td>
</tr>
<tr>
<td>Vout</td>
<td>1,908</td>
<td>2,013</td>
<td>2,141</td>
</tr>
<tr>
<td>PF</td>
<td>0.38</td>
<td>0.50</td>
<td>0.42</td>
</tr>
<tr>
<td>CCR Loading</td>
<td>61%</td>
<td>74%</td>
<td>94%</td>
</tr>
</tbody>
</table>

*A CCR supplies constant current, not constant kVA*
LED Loads – Improving the PF

Find a lighting manufacturer that designs LED devices to appear as resistive to the series circuit.

- Use LED NA V aids that have a stable PF between B1 - B5
- Look at the PF for all brightness steps

Example: LED Signs with 20kW CCR (i.e., no other loads connected)

<table>
<thead>
<tr>
<th>A</th>
<th>W</th>
<th>PF</th>
<th>VA</th>
<th>V</th>
<th>Brightness</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.8</td>
<td>35.3</td>
<td>0.9986</td>
<td>35.3</td>
<td>12.6</td>
<td>1</td>
</tr>
<tr>
<td>3.4</td>
<td>35.8</td>
<td>0.9985</td>
<td>35.9</td>
<td>10.5</td>
<td>2</td>
</tr>
<tr>
<td>4.1</td>
<td>36.6</td>
<td>0.9983</td>
<td>36.7</td>
<td>8.9</td>
<td>3</td>
</tr>
<tr>
<td>5.2</td>
<td>37.9</td>
<td>0.9977</td>
<td>38</td>
<td>7.3</td>
<td>4</td>
</tr>
<tr>
<td>6.6</td>
<td>40.1</td>
<td>0.9967</td>
<td>40.2</td>
<td>6.1</td>
<td>5</td>
</tr>
</tbody>
</table>

CCR Loading

LED Loads – Operating Conditions Observed or Reported

- Initial Turn on of Circuit - CCR trips off on “OPEN CIRCUIT”
- Rapid rise of Voltage
- Current doesn’t get to step

- Running sign loads at lowest step – may cause CCR overloading
- Increased KVA loading
- CCR growling or loud
### CCR – CAPABILITIES - FERRORESONANT CCR

**Maximum Load Capacity of Ferroresonant type CCRs**

<table>
<thead>
<tr>
<th>Nominal Rating (KW)</th>
<th>Nominal Output (Amps)</th>
<th>Output Impedance Z Max</th>
<th>Step Setting</th>
<th>Output Current (Amps) @ step</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>6.6</td>
<td>230</td>
<td>B5 or B100</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B30</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B4</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B10</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B3</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B2</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B1</td>
<td>2.8</td>
</tr>
</tbody>
</table>

**NOTE:** Limited by Max Impedance @ Max Step B5/B100

### CCR – CAPABILITIES - THYRISTOR TYPE CCR

**Maximum Load Capacity of Thyristor type CCRs**

<table>
<thead>
<tr>
<th>Nominal Rating (KW)</th>
<th>Nominal Output (Amps)</th>
<th>Nominal Output Voltage</th>
<th>Step Setting</th>
<th>Output Current (Amps) @ step</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>6.6</td>
<td>1515</td>
<td>B5 or B100</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B30</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B4</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B10</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B3</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B2</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B1</td>
<td>2.8</td>
</tr>
</tbody>
</table>

**NOTE:** Limited by Max Nominal Output Voltage of Transformer
1 KW CCR – LOAD - MIX 4 SIGNS AND 10 TAXI EDGE

1 KW CCR – INDIVIDUAL EDGE LIGHT LOAD
LED SIGN LOAD – WITH RESISTIVE LOAD PROFILE

CCR – WITH FULL RESISTANCE LOAD
**AN ALTERNATIVE TO THE 6.6A LED**

**Saving Power – the 2A. Solution**

- AFL NAVaids manufactured to operate on both 6.6A or 2A circuits
- AFL designed to appear as resistive loads to the CCR
- Power savings are reduced by 90%

Example: 100 TWY Lights on 20,000’ series circuit with 125’ secondary cables

---

**IN CLOSING**

**To minimize the impact of SSL on the airfield …**

1. Select products with a consistent Power Factor across all brightnesses.
2. Size CCR circuits in accordance with published SCR and Ferro maximum power ratings for each output brightness level.
3. Ask what can be done to modernize FAA AC test specifications and to standardize impedance matching of AFL equipment.

Questions?