Findings Vidanta/Cirque Du Soleil Power Issues

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***Abstract*— The power system for the venue housing the Cirque Du Soleil performance Joya is reporting power quality issues that are compromising the ability of the show to operate as intended. The sizing of the UPS devices in the system appears to be insufficient for the connected loads. Current measurements on site should be used to confirm the issue and right size UPS system to work with the connected loads and show cues. The issues with the automation system are intermittent and warrant further investigation.**

I. SYTEM SET UP

The facility is located approximately 35km northeast of the city of Playa Del Carmen in the Mexican state of Quintana Roo. The theatre complex includes the theatre itself, commercial/retail spaces, and a generator powerhouse building. According to the information provided by the technical staff, the theatre originally operated on generator power alone with utility power connection for the theatre being added afterward.

Utility power serves now serves as the primary power source with the generator power source being used for back up in cases where utility power either was not available or not reliable. The utility power and generator power are fed into a transfer switch. The output of the transfer switch in turn goes to a series of transformers each for dedicated purposes (conventional lighting, moving lights, sounds, automation, bar/kitchen areas, etc). After each transformer a double sine conversion uninterruptible power supply (UPS) is installed. Double sine wave conversion UPSes take AC power input, convert the input to DC, and create a new AC signal output. The UPSes will provide continuous power during the open transition time between loss of utility power and startup time for generators connected.

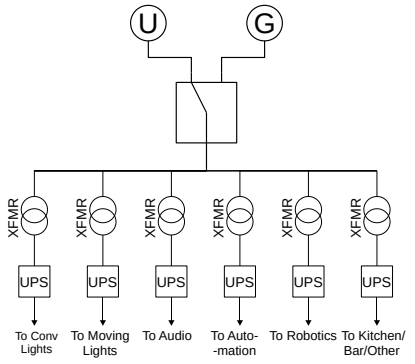

Fig. 1. Simplified 1 line diagram of input power to facility. Overcurrent devices not shown.

II. ISSUES ENCOUNTERED

A. Conventional Lighting UPS overload

The 3 phases UPS providing power to the conventional lighting loads is a CHP3100K manufactured by Sine Power of Portugal. It is rated for up to 100KVA or 80KW of power. The UPS in question is designated LX at the facility. There are 144 channels of dimmers with tungsten loads connected to the dimmer channels, and assorted control electronics associated with the conventional lighting system. The UPS unit in question is monitored remotely with a software package called SNMPView which is produced by Megatec of Taiwan. The UPS has ability to email issues to contacts set up through SNMPView

With all lights connected to the UPS set as off or zero percent on the lighting console, the UPS through the SNMPView software reported at being loaded to 11% of capacity. During certain lighting cues the lighting UPS reports overload conditions via emails while the SNMPView software shows the lighting UPS loaded at 40-45% of rated load.

While the UPS is overloaded, it will bypass the double conversion power function passing incoming AC power through and is unable to provide protection from power outages or power quality fluctuations on the incoming AC power into the facility. The head of lighting, Hector Hugo Mendez Morales, stated that issues with the lighting appear to have only started to occur after the UPSes were installed and were not present beforehand when the facility was powered off of only generator power.

B. Chain motor malfunctions

Similar to the conventional lighting loads, the automation power is protected from outages during transition periods by a UPS.

During the course of the 2+ years of operation, the head of automation on site at the facility has reported 3 chain motors have malfunctioned to the point of needing repair outside of normal maintenance. The head of automation has reported other malfunctions in the chain motors at the facility, and a correlation between the rate of malfunction and the nominal voltage measured at the motor control cabinet. There are 12 chain motors at the facility, and there are typically 5 shows a week. The chain motors change position of connected loads twice a show. The technical staff at the facility stated that issues with the chain motors occurred before and after the UPSes were installed.

III. Likely Causes

A. Conventional Lighting UPS overload

The loads connected to the lighting UPS have their intensity controlled by phase control dimmers. Each load is connected single phase between neutral and one of the phase conductors. Loads that would otherwise be linear such as lighting loads are non-linear when controlled by phase control dimmers.

For resistive or linear single phase loads on a three phase system, neutral currents tend to cancel on the neutral conductor resulting in far smaller neutral currents than found on each individual phase and neutral does not need to be considered a current carrying conductor.

In comparison, non-linear load currents tend to add on the neutral conductor resulting in larger currents on the neutral than would be present on any one phase conductor which can result in neutral currents in excess of the phase currents in the system. With lighting loads dimmed to 40-60% on all three phases, the neutral current in the system can reach 130% or more than that of the individual phase conductors. The monitoring software SNMPView is only reporting the most loaded phase while the UPS email warning system is taking into consideration the load on the neutral conductor as well, explaining why the UPS is reporting errors when the conventional lighting set up is at 45% of load with most lamps dimmed.

To demonstrate the larger neutral currents, a simplified circuit in Lex Products laboratory was setup up with 3 dimmers dimmed approximately to 50% each connected between one of the phases and neutral to illustrate the increased current on the neutral over that on any one phase. In this circuit, the neutral current was approximately 140% of the phase currents, see Table I, and Figure 2 (next page).

TABLE I. Current Draw on Phases and Neutral

Conductor	Current A RMS
A (L1)	6.17
B (L2)	5.84
C (L3)	6.35
Neutral	**8.95**

B. Chain Motor Malfunctions

The failure of 3 chain motors over the course of 2+ years may be within the realm of failure rates of the motors used, or may be outside of that range or may be outside of that window. Other motors besides the chain motor do not appear to be encountering the same issues.

IV. Next Steps

A. Conventional Lighting UPS overload

There are two ways to approach resolving the conventional lighting UPS issue. Option (1) Change the UPS to match the required demand to properly protect the show, or option (2) modify the show to fit within the available capacity.

Option 1: To change the UPS to match the capacity, the neutral currents will need to be measured during a run through of the lighting cues for the show to determine peak current and UPS size. Network power loggers from a variety of companies may be used. Lex Products can recommend a specific model if needed.

After determining the largest neutral current present, the UPS size needed is best determined by working with the UPS manufacturer. An approximation of what size UPS can be estimated by using the below formula where I_n is the neutral current, V_{ln} is the nominal voltage between line and neutral.

$$KVA\ Rating\ of\ UPS\ Needed = I_n * 3 * V_{Ln} * 1.25$$

Option 2: Similar to option 1 a network power logger will be needed to log the neutral currents during a run through of the lighting cues. Each cue that causes the UPS to send error messages will need to be modified to reduce neutral current and saved in its new state. Keep in mind that at times increasing intensity of lamps can reduce neutral currents. This may not be ideal is it will change the intended look of the show.

B. Chain Motor Malfunctions

Whether there is a power issue affecting the chain motors is not apparent. The failure rate experienced is within the range of failures seen in other locations. To verify the chain motor failures are not due to power quality a network power logger that can calculate total harmonic distortion (THD) should be placed on the power feed to the motor control cabinet. If the voltage stays consistent and the THD in the waveform is less than 3%, power quality will be ruled out as a potential cause of the motor issues encountered.

V. Conclusion

Power measurements taken during a show or run through of cues for the show using equipment capable of measuring and logging voltage, and current waveforms will provide the data needed to determine UPS size changes or show modifications. Power quality issues with the chain motors may or may not be present. Only taking measurements will rule out the possibility.

Lex Products can arrange for further onsite evaluation with specialty test equipment and personnel to evaluate power quality during the show as outlined in the next steps section, or the work can be done internally at the Vidanta facility with remote assistance from Lex or other industry experts.

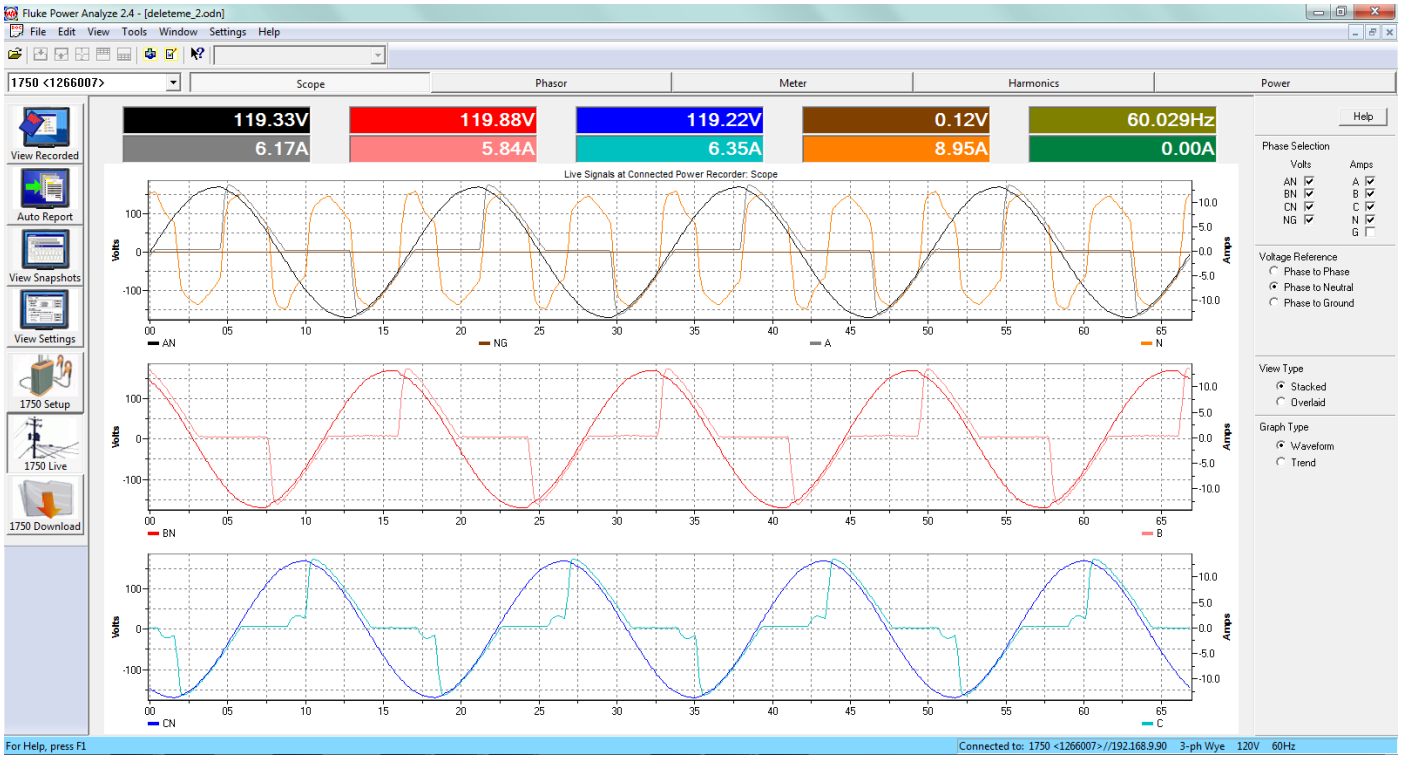

Fig. 2. Screenshot of Data from Table I