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By: Brian Wilson and Joe Witkowski

EMI Profile of Ephesus Stadium Lighting System

Abstract: ***All stadiums have an abundance of equipment that introduce Electromagnetic Interference (EMI), or electrical noise into the environment. The Ephesus Stadium Light Solution produces minimal EMI in stadium environments and does not interfere with any other RF operating frequencies. This Bright Paper examines how the Ephesus Stadium Light, and its control system, impacts the stadium environment at University of Phoenix Stadium in Glendale, AZ, and how it's advantageous over the old system during game-day operations.***

Ephesus Lighting provides a wireless control system for the Stadium luminaires that can perform and coexist along with other communication systems in a FCC approved frequency band.

Introduction

The Ephesus Lighting Stadium System installed at University of Phoenix Stadium consists of 312, 1000 Watt Ephesus Stadium Light Fixtures, mounted in locations around the pre-existing lighting. This installation resulted in an average of 277fc delivered to the playing surface. The system is controlled by wired DMX which gives the venue the ability to individually control each fixture. The Ephesus Stadium system replaced 780, 1500 Watt Metal Halide fixtures.

Over the past few years there has been an increase of interest in LED lighting. One concern that has evolved, due to increased electronic components, is how these fixtures will impact the surrounding environment. This is known as Electromagnetic Interference (EMI), which has the ability to interrupt, obstruct, or degrade the performance of other systems or frequencies within the stadium. As many stadiums push to improve the fan experience, they have begun to implement increased accessibility to wifi, cell phone repeaters, more advanced scoreboards, ribbon boards, etc. All these devices produce both desired and unwanted frequencies into the stadium. To ensure the Stadium is operable to its fullest capabilities, the Ephesus Stadium Solution is designed to operate at frequencies that do not interfere with these, or other RF systems.

Methods

In order to observe the frequencies present within University of Phoenix Stadium a Tektronix MD03104 Mixed Domain Oscilloscope with a Spectrum Analyzer module was used. An RF antenna with a wideband receive frequency range was also used to detect the electrical noise within the environment. A "peak hold" command was used to measure the largest magnitude of the frequencies from 0 Hz to 1 GHz.

Various tests were performed in order to find the impact of the Ephesus Stadium Lighting System on the electrical noise in the stadium. While taking all the readings, the scoreboard and ribbon boards were on. To obtain a baseline measurement, AC voltage was cut to both the Ephesus System and the pre-existing system. Then, the

AC voltage was turned on to the Ephesus fixtures and readings were taken at dim settings of 0%, 20%, 50%, and Game Mode. Then, the Ephesus fixtures were dimmed down to 0%, and the pre-existing 1500 Watt Metal halides were turned on. Prior to taking an EMI reading, the Metal Halide fixtures were allotted 15 minutes to warm up and were under the same conditions as the readings taken for the Ephesus System. To ensure that the frequencies obtained didn't interfere with any frequencies during the game, multiple measurements were taken every half hour, starting 1.5 hours before the game.

Results & Discussion – Wired DMX Control System

The measurement taken when AC power was cut to both the Ephesus and the pre-existing lighting systems is seen in Figure 1. The most prominent tones seen above the noise floor are between: 90-110 MHz, 450-550 MHz, 575-625 MHz, 675-700 MHz, 725-750 MHz, 850-900 MHz, and 920-940 MHz.

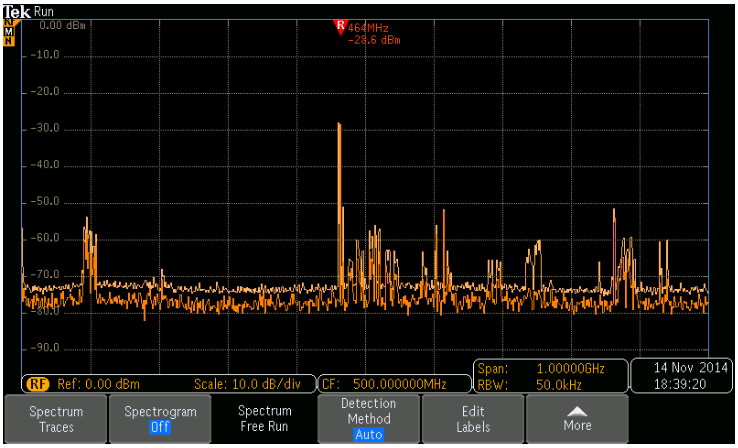

Figure 1: The EMI results when both Ephesus and pre-existing systems were off.

EMI readings were also taken during the game to determine which additional frequencies were present in the stadium environment, and can be seen in Figure 2. As one can see there are multiple additional frequencies seen during the game. The frequencies range, now, predominantly from 450 MHz-940 MHz.

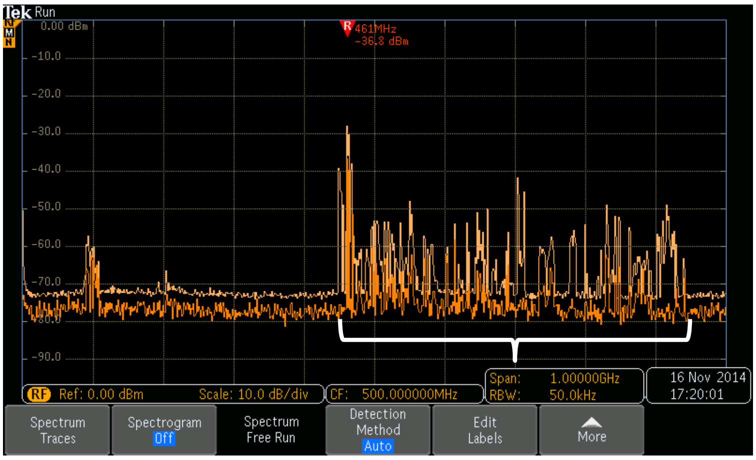

Figure 2: The EMI results during kick-off of the Detroit Lions at Arizona Cardinals, with the Ephesus System in Game Mode.

The next measurements were taken with AC power applied to the Ephesus System set at 0%, 20%, 50%, and Game Mode (~80%) intensity, with the pre-existing lighting system powered off. The detected frequencies at these intensity settings can be seen in Figure 3. There is an apparent 780 MHz RF tone at the 0% intensity setting, but this tone is not caused by the Ephesus system. This tone is believed to be a random communication frequency because it is not apparent at other 0% intensity measurements (see Figure 6) and is more prominent during the football game when lights are in game mode (see Figure 2). The one additional RF tone during Game Mode is at 820 MHz. Again this tone is believed to be a random communication frequency because it is not detected at certain times during the football game when the lights were in Game Mode (see Figure 4). The tone also becomes more prominent at other times during the football game (see Figure 5).

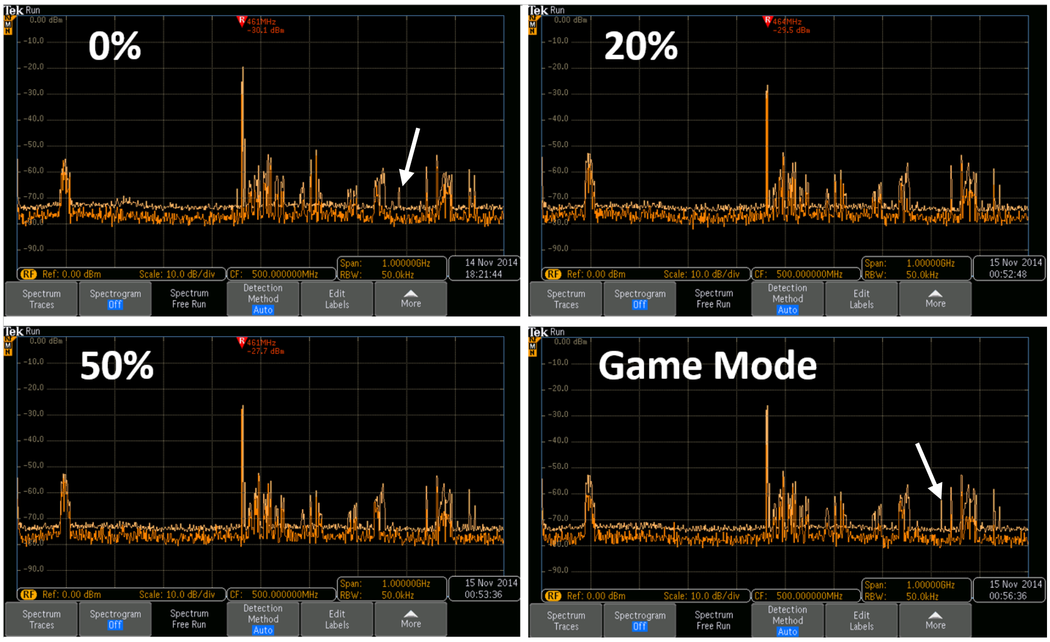

Figure 3: The EMI results with the pre-existing lighting system off, and the Ephesus System set to multiple settings: 0%, 20%, 50%, and Game Mode. When comparing these results to the baseline measurements, seen in Figure 1, one can see a few minor frequency differences at 0% and Game Mode. At 0%, there is a new tone at 780 MHz (noted in the top-left image), and in Game Mode, there is a new tone present at 820 MHz (noted in the bottom-right image). These tones are believed to be random communication frequencies and are not caused by the Ephesus system.

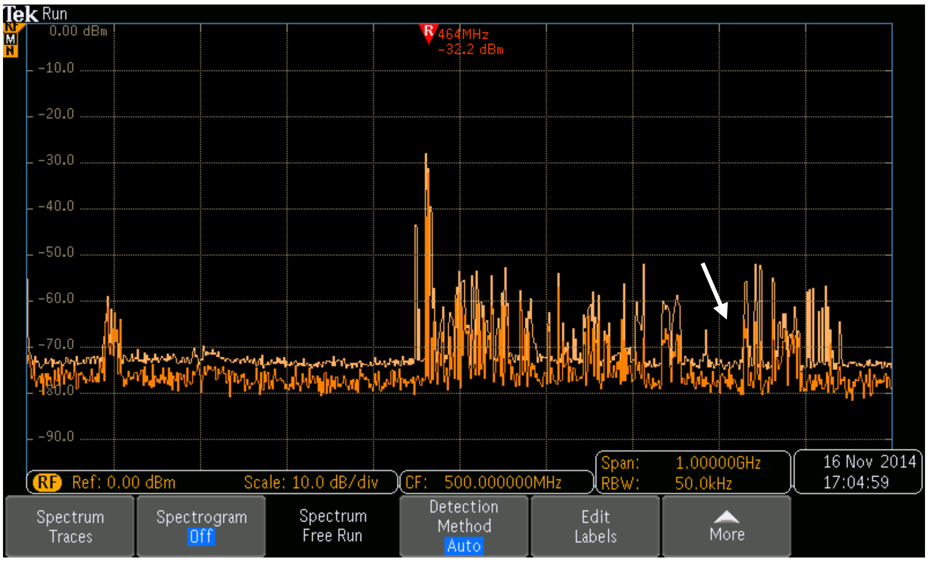

Figure 4: Measured EMI results taken 15 minutes before kickoff. This data proves the absence of the 820 MHz RF tone when the Ephesus system was set to Game Mode.

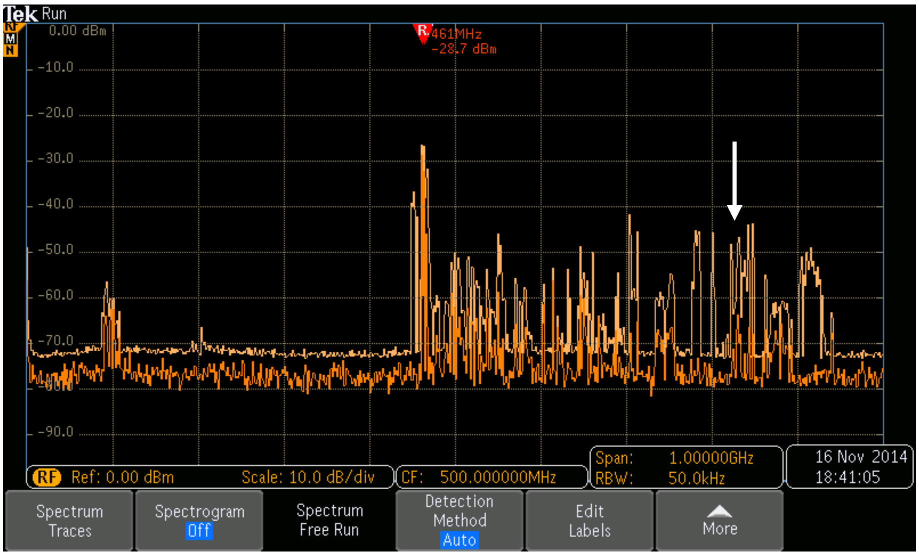

Figure 5: Measured EMI results taken at the end of the first half. This data shows how the 820 MHz RF tone becomes more prominent during the football game when more communication devices are running.

After characterizing the EMI of the Ephesus System, the EMI for the pre-existing metal halide system was also measured. The EMI results can be seen in Figure 6. These frequencies were evaluated with the Ephesus System on at 0%. When comparing the EMI of the metal halides (Figure 6) to that of the Ephesus System (Figure 3, top-left image), there are two additional RF tones at 575 MHz, and 650 MHz that rise 14 dB above the noise floor. These tones are significant because they exist at the same frequencies detected during the game (Figure 2). If the metal halide fixtures were on during game-day operations, they could have interfered with devices that operated at these two frequencies. This can create non-favorable conditions for other electronics and communication systems in the stadium.

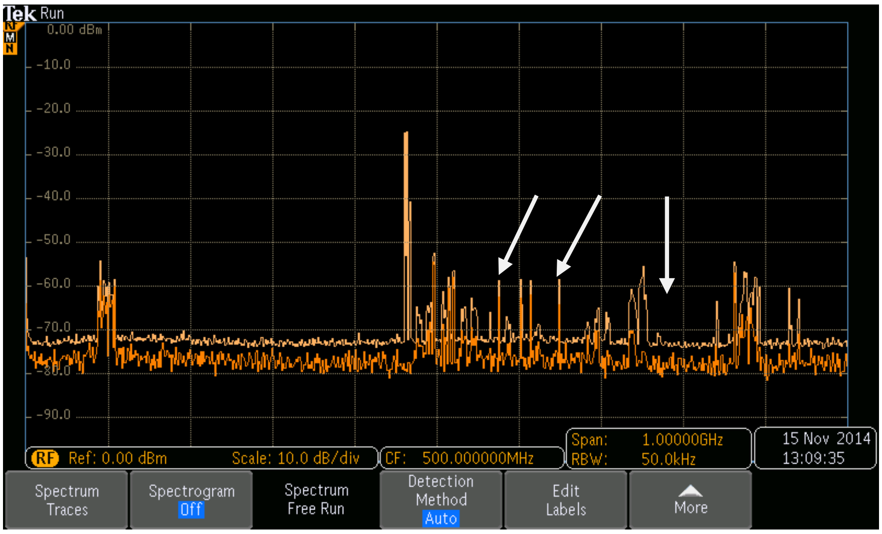

Figure 6: The EMI results of the pre-existing metal halide fixtures on, and the Ephesus Fixtures at 0%. When comparing these tones to the ones at 0% in Figure 3, one can see that there are added frequencies at 575 MHz, and 650 MHz (noted in image above). This data also proves the absence of the 780 MHz RF tone when the Ephesus system is set to 0% intensity.

Discussion – Ephesus Wireless Lighting Control System

Ephesus Lighting has partnered with Anaren Microwave to design a wireless control system for Stadium luminaires. Although the wireless system was not used in the University of Phoenix Stadium, it is the recommended standard to control the Stadium series luminaires. Advantages of this wireless system include reduced installation cost due to lack of control cable wiring, increased reliability, and ease of use.

The operating frequency of the Ephesus wireless control system resides in the frequency range shown in Figure 7. Although there appears to be a lot of RF traffic in that frequency range, the Ephesus wireless control system was designed to coexist in that FCC approved band. The system uses FCC/IC approved techniques to monitor RF activity in the environment and make adjustments to avoid collisions.

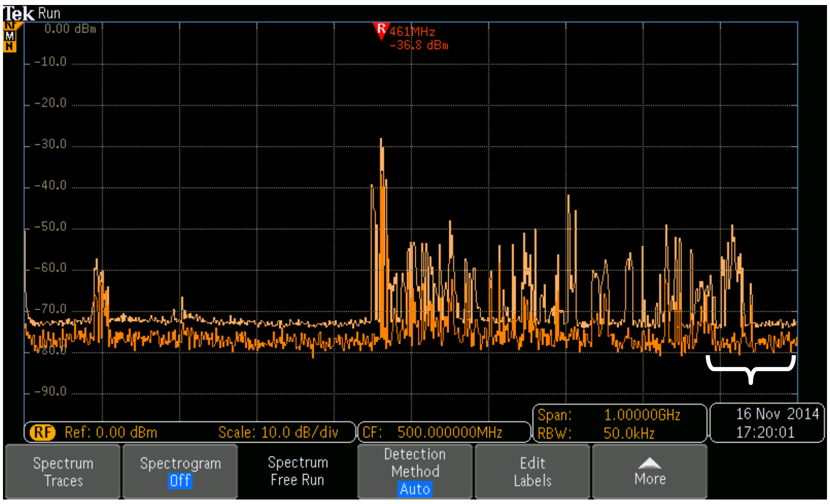

Figure 7: Shows the operating frequency band of the Ephesus wireless system.

Conclusion

The Ephesus Stadium lighting solution with wired controls does not emit any significant EMI within University of Phoenix Stadium during game-day operations. The Ephesus Stadium lighting solution has proven to be an upgrade over the pre-existing metal halide lighting system. The metal halides create two RF frequency tones that exist during the game-day environment (Figure 6). If the metal halide fixtures were on during a game, they could have interfered with other devices, causing non-favorable conditions for other electronics and communication systems within the stadium.

Ephesus recommends using our wireless control system to control our Stadium luminaire in future Stadium applications. The Ephesus wireless control system was designed to perform and coexist within a FCC approved frequency band. It achieves this without any detrimental effects to the performance of other systems within the same frequency band.