USER STORY

Philips Lighting and Its Partners Use MATLAB® to Ensure the Performance of High-Intensity Discharge Lighting Systems

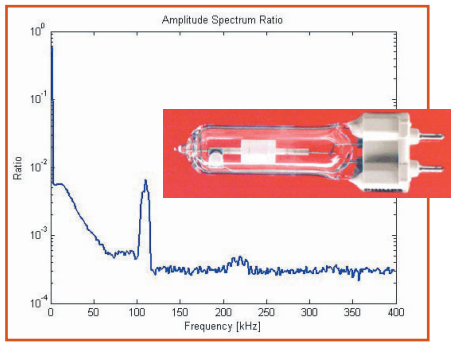
From the Eiffel Tower to the Sydney Opera House, high-intensity discharge (HID) lamps illuminate some of the most recognizable landmarks in the world. Such large areas typically require more light than can be provided by conventional incandescent or fluorescent lamps. HID lamps are optimal for lighting vast outdoor spaces because they deliver high light output. For indoor applications, HID lamps are primarily used for accent and decorative lighting.

A division of Royal Philips Electronics, Philips Lighting, together with partners in the European Lamp Manufacturers Association in the Preparation of Standards (ELMAPS), have taken a leadership position in delivering HID lighting solutions and ensuring safety and performance through industry standards for electronic ballasts. Philips Lighting engineers use MATLAB® to enable other lighting component manufacturers to verify that a key performance critical aspect of electronic HID ballasts, ripple power, is within acceptable limits.

"We wanted to create a widely available tool to help companies ensure compliance with this standard," says Don Couwenberg, global HID consultant at Philips Lighting. "Working from a sophisticated mathematical description of the problem, we used MATLAB to build a standalone tool that everyone can use easily."

THE CHALLENGE

HID lamps incorporate a ballast, circuitry that delivers a high-voltage pulse during startup and limits lamp current once it is in steady state. The ballast is a switch-mode power supply that transforms power from the main power source and produces the voltages and



MATLAB application for calculating ripple power of high-intensity discharge lamps.

nominal current needed by the lamp. As a byproduct, the ballast typically also produces a ripple current at frequencies higher than 10 kHz. When the associated power with this ripple current exceeds 1.5 percent of the nominal power of the lamp, the lamp can become unstable and potentially fail.

Philips Lighting, Osram, GE, and Sylvania agreed on a method of computing the ripple current in a lamp based on measured lamp voltages and current over time. Warren Moskowitz of Osram proposed the method, which was presented in 2004 at the Lighting Conference LS10 in Toulouse, France. While acquiring the data required for this computation is fairly straightforward, the process for determining the ripple current is complex. Philips Lighting needed a tool to calculate ripple power from measured data. They also needed the tool to be easily distributed to and employed by ballast manufacturers.

"We want to promote this standard so that our next generation of products can incorporate components from other vendors. We need specifications so that there are no incompatibilities, the lamps perform optimally and safely, and our customers get the full benefits of standardization," says Couwenberg.

THE CHALLENGE

To develop a standard tool for measuring ripple power and ensuring standards in high-intensity discharge lamps

THE SOLUTION

Use MathWorks tools to implement a standards validation tool that can be used throughout the lighting industry

THE RESULTS

- Ripple current testing simplified
- Deeper analysis facilitated
- Project initiated quickly

> *At Philips Lighting, MATLAB and Simulink are key tools for mathematical analysis and computation. For HID lamps, MATLAB plays an important role in measuring ripple power and ensuring that performance standards are met in the industry.*
>
> Don Couwenberg, Philips Lighting

THE SOLUTION

Using MATLAB and the MATLAB Compiler, Philips Lighting created a standalone application for calculating ripple current and ensuring compliance with industry standards.

Couwenberg started by engaging MathWorks Consulting to develop a first proof-of-concept version of the application using MATLAB. Working from this version, Philips Lighting engineers continued using MATLAB to develop a full-featured version.

The engineers used MATLAB to implement an algorithm that analyzes a series of lamp voltages and lamp current measurements taken at periodic intervals to determine the harmonics of the ripple current.

The group used the Signal Processing Toolbox to perform the fast Fourier transform and perform sensitivity analysis by evaluating various windows, such as Blackman and Hamming windows.

They also used MATLAB development tools to create a graphical user interface that displays the harmonics as well as a test pass/fail indicator that verifies ballasts are within acceptable standards when the computed ripple power is less than 1.5 percent of the nominal power.

Engineers then used the MATLAB Compiler to create a standalone executable version of the tool that can be run outside MATLAB, saving them time in rewriting the application.

Philips Lighting is in the final stages of prerelease testing of the tool. They are also using Simulink® and additional MathWorks tools to model sophisticated control loops for the switch mode power supply of lamps to enhance color performance and light quality.

THE RESULTS

- **Ripple current testing simplified.** "Availability and accessibility are key advantages of using MATLAB for this project," says Couwenberg. "By creating an executable file that provides authorized compliance test results, we have removed all barriers for manufacturers to ensure their electronics meet the industry standard for ripple current."
- **Deeper analysis facilitated.** In addition to providing a standalone application, ELMAPS is releasing the MATLAB code to enable vendors to determine how the end results are obtained. "If someone wants to look in more detail or perform further analysis, they can use MATLAB and the code to get more insight," says Couwenberg.
- **Project initiated quickly.** "After we had agreed on the mathematical description of how to calculate the ripple current, I contacted MathWorks Consulting," says Couwenberg. "One of the specialists created the first version of the tool for us, which was a great help in getting the development started."

To learn more about Philips Lighting, visit **www.lighting.philips.com**

APPLICATION AREAS

- Algorithm development
- Application development and deployment
- Data analysis
- Signal processing

PRODUCTS USED

- MATLAB
- Simulink
- MATLAB Compiler
- Signal Processing Toolbox

www.mathworks.com

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