RTISS™ Operation

Real-Time Illumination Stability System for phase-control dimmers

Bob Newman
Consultant

Technical white paper
June 1999 version 2

LUTRON
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I. Introduction

Lutron, the world leader in dimming products for nearly 40 years, has faced many technical challenges in its history. Recently, Lutron engineers have addressed the issue of international power quality, specifically power line noise, and its negative effect on dimmers.

Poor quality power can cause lights to change rapidly as power source integrity changes. This can manifest itself as an occasional flash, a strobe effect, or a roller coaster or "breathing" effect.

This paper outlines the basic concepts of dimming, power line noise, and successful dimming in the presence of poor power quality. It identifies probable causes of poor power quality and describes how Lutron has integrated a patented design enhancement – RTISS™ – that filters out line noise to the dimmer to ensure consistent, quality dimming performance.

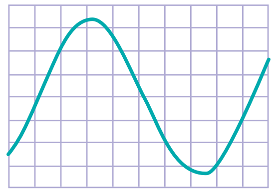

Figure 1A – On

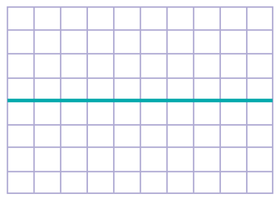

Figure 1B – Off

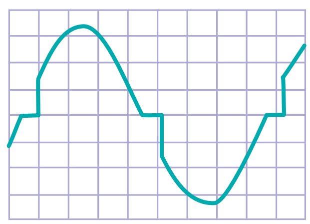

Figure 2A – High Intensity

Figure 2B – Moderate Intensity

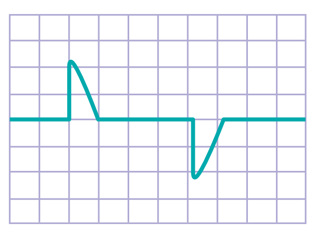

Figure 2C – Low Intensity

II. Switches vs. Dimmers

In applications, a dimmer is used in place of a conventional toggle switch.

Toggle switches provide a load with one of only two power levels: On and Off. Voltage condition diagrams for these are shown to the left.

On the other hand, dimmer switches provide a virtually infinite number of power levels to a load based on the position of the slider or dimmer control mechanism. Several load voltage diagrams for different dimming levels are shown in Figures 2A, 2B, and 2C.

Most industry standard dimmers operate using one of four basic devices: Triac, SCR, FET, or IGBT. These devices are made into either phase-control or reverse-phase-control dimmer switches. The triac is used in this discussion for simplicity purposes; however, the issues and solutions covered in this paper affect all of these devices, not just triacs.

A phase-control dimmer controls the power to the load through a solid state switch or triac. The triac turns on and off at regular intervals based upon the AC power source, for example, 120 times per second on a 60 Hz line and 100 times per second on a 50 Hz line.

Using a slider, rotary knob, or other device, a user sets a light level that tells the dimmer, through a potentiometer or microcontroller, to provide a specific intensity level. The dimmer translates this level into a triac conduction time. Conduction time is defined as the time between “turn-on” and “turn-off” of the triac.

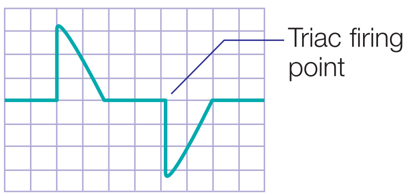

Figure 3 – Triac Conduction Time

Figure 3 –

A phase-control dimmer is synchronized to the AC line. Timing software internal to the microcontroller synchronizes the dimmer with the AC power line. The timing software measures the line frequency and the time at which the AC line crosses through zero. Stable, consistent phase-control dimming requires accurate line frequency and clean zero cross information.

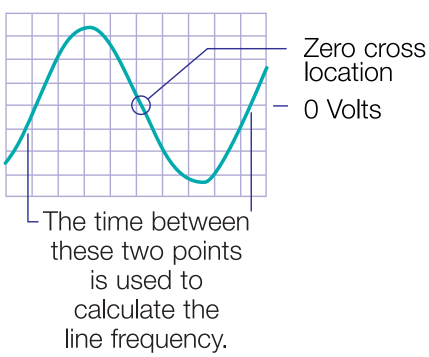

Figure 4 – Zero Cross and Line Frequency

Figure 4 –

The microcontroller uses the zero cross information and the calculated conduction time to compute when to activate the triac. Based on the AC powerline frequency, the timing circuit calculates the time that the triac remains active. After it has stayed on for the calculated time, the triac automatically turns itself off just as the AC current crosses zero. This sequence provides the exact amount of conduction time; therefore, provides the requested light level.

To achieve smooth, flicker-free dimming, the microcontroller’s timing circuit needs valid, highly accurate, zero cross information. Corrupt zero cross information could impact the turn-on points and conduction time of the solid-state switch which ultimately affects dimming quality. This information is dependent upon the quality of the power line.

These two requirements, zero cross information and accurate line frequency, are unique to dimming. Other equipment that uses electricity is not concerned with these two factors. A common misconception is that computer equipment is just as sensitive to power line anomalies. In fact, because dimmers do not store energy as power supplies in computers do, they can be more sensitive to power line quality problems.

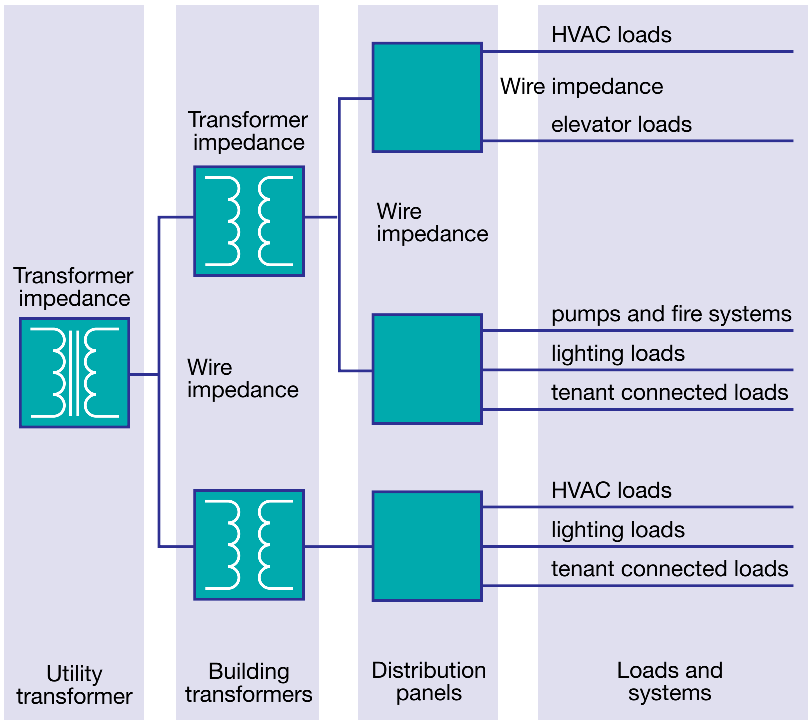

Figure 5 – Building Power Distribution System

III. Research

Throughout its research, Lutron has identified six different types of power line anomalies:

- High-frequency noise
- Impulse noise
- Low-frequency non-harmonics and signaling systems
- Notches and low-frequency noise
- RMS (Root Mean Square) voltage changes
- Variable fundamental frequency

These specific conditions are the result of the various building power distribution systems that exist. A typical system is shown in Figure 5. Wire and transformer impedance as well as disparate loads/systems fed from a common distribution panel will affect the severity of the conditions.

Figure 5 –

Lutron isolated these conditions after reviewing over 150 samples from a multinational installation base. All samples reviewed were gathered in facilities where problems were occurring regularly and noted by knowledgeable personnel.

Up to this point, Lutron equipment was well-suited to handle any one of the six conditions individually. (For example, if the RMS voltage changed up to 2%/line cycle, the dimmer operated properly.) However, when multiple conditions occur simultaneously, poor quality problems could result in poor dimming performance.

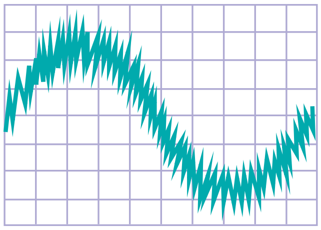

Figure 6 – High Frequency Noise >5kHz
Caused by: Variable-speed motor drives, on-line UPS systems

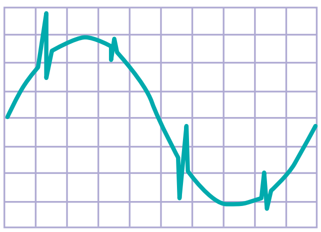

Figure 7 – Impulse Noise
Caused by: Switch arcing (loads switching on/off)

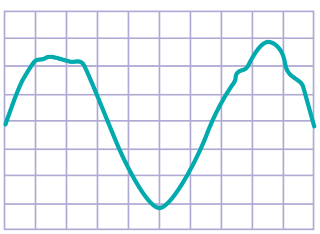

Figure 8 – Low Frequency Non-Harmonics and Signaling Systems
Caused by: Signaling systems, power line carrier communications

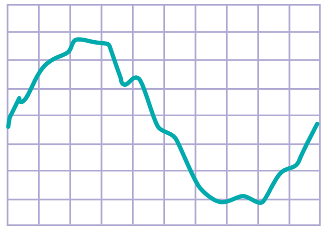

Figure 9 – Notches and Low Frequency Noise 100 - 5kHz
Caused by: Elevators and large industrial loads

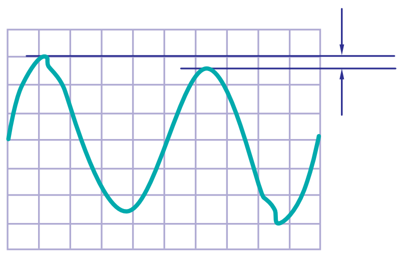

Figure 10 – RMS Voltage Changes
Caused by: Heavy loads switching on/off

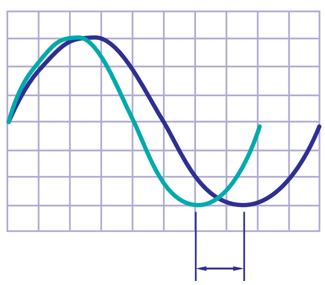

Figure 11 – Variable Fundamental Frequency
Caused by: Backup generators, relatively small power grids

The figures to the left illustrate the six power line anomalies. These conditions can exist individually or in combination. They are dynamic and can disappear and re-appear over time as loads on the power line change. To properly recreate and analyze the conditions, Lutron developed a method for bringing exact field conditions into the engineering lab. Lutron invented a recording method that uses a digital audio platform.

This method records several hours of line voltage onto digital cassette. Using these cassettes, Lutron engineers are able to recreate exact field conditions in a lab environment. Lutron continues to compile a library of power line conditions from around the world, which provides authentic testing grounds for proposed product changes.

IV. Solution

Lutron's original solution for filtering out single instances of power line anomalies was a digital filter called a phase locked loop (PLL). Through constant monitoring of the zero cross location, the PLL would average any noise presented to the dimmer. Adjusting the system meant enabling or disabling the PLL or changing how quickly it tracked noise.

The PLL system worked well when only one power line anomaly existed. If two or more existed simultaneously, the PLL became inadequate. To accommodate instances of multiple simultaneous anomalies, Lutron developed its next generation zero cross filter, RTISSTM – Real Time Illumination Stability System. The development effort resulted in an analog filter used by the microcontroller's timing circuit.

The filter was designed to eliminate any frequency content that has the potential to corrupt the timing circuit. It provides stable sync pulses for the micro-controller in the presence of poor power quality.

Figure 12 illustrates how the filter operates. The top waveform shows an unstable, distorted input voltage. The bottom waveform shows the result of the filter circuit – what is actually provided to the microcontroller timing circuit.

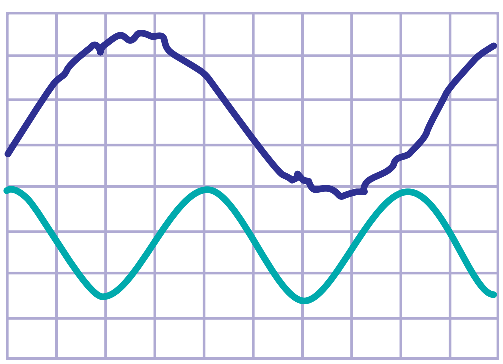

Figure 12 - Input Voltage and Filtered Voltage

Note: The RTISS filter circuit is not a power conditioner to the dimmer. It does not affect the power profile out to the load, it only provides a clean signal to the timing circuit so accurate zero cross and frequency information is available for the triac.

VI. Conclusion

Incorporating the zero cross filter into microcontroller-based products allows Lutron's products to continue to provide superior performance. It helps to ensure that Lutron's customers will not experience inconsistent or unreliable dimming simply because power conditions at the installation vary or are of poor quality.

Continuing its commitment to providing exceptional lighting controls, Lutron is incorporating the recording tools it developed into the design verification process for all its products. Lutron's products are tested under worst-case, real-world conditions before they leave the lab. This process ensures that Lutron products not only meet, but exceed customer expectations now and in the future.

Tel: 610.282.3800
International: +1 610.282.3800

For more information about choosing the best lighting control system for your stadium or arena project, contact your local Lutron representative:

World Headquarters
Lutron Electronics Co., Inc.
7200 Suter Road
Coopersburg, PA
18036-1299 USA

Barcelona +34 93 496 5742
Beijing +86 10 8525 1867
Berlin +49 30 9710 4590
Hong Kong +852 2104 7733
London +44 (0) 207 702 0657
Madrid +34 91 567 8479
Paris +33 1 44 70 71 86
Shanghai +86 21 6288 1473
Tokyo +81 3 5575 8411

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