TECHNICAL PAPER

The Digital Addressable Lighting Interface (DALI) : An Emerging Energy-Conserving Lighting Solution

Odile Ronat, International Rectifier

Digitally controlled dimming of lighting is emerging as a key energy savings system in Europe and spreading to the rest of the world. The key drivers are energy shortages, increased energy costs, and environmental concerns. The Digital Addressable Lighting Interface (DALI) standard is emerging as the preferred fluorescent controlling method due to its many advantages.

Fluorescent lighting is one of the most widespread methods of lighting due to its high energy efficiency. The DALI standard includes addressable control of individual and groups of ballasts, as well as easier installation and maintenance due to the ability to mix and match DALI components seamlessly from multiple manufacturers into complete systems.

DALI ballasts are replacing older technology analog dimming systems, which offer only hard-wired control of groups of ballasts and has a higher implementation cost. Non-DALI digital control methods are proprietary with the disadvantages of having a sole source, higher cost, and the implementation and maintenance issues of interconnecting seamlessly with other systems commonly used in a building.

Why DALI is Needed

California's energy crisis has made news all across the world. The entire western region of the United States is on the brink of an energy crisis due to increased demand and a shortage in electricity supply. Other regions are in a similar energy crisis state. For example, Brazil's lack of rain has reduced the available hydro-electric power and has forced rolling blackouts for hours each day.

Increased energy demand has been driven by an explosion in information technology and unprecedented economic growth over the past few years. The supply of energy has not increased with demand in many areas, especially in rapidly growing economies. This has led to daily outages in some areas. Europe has a strong public and government environmental awareness of the need for energy conservation. European public policies that promote conservation, including higher energy taxes, have led to high energy costs.

One area where significant energy savings can be realized without sacrificing productivity is lighting. According to John P. Kesselring of the Electric Power Research Institute, thirty to forty percent of energy used in a typical building is for lighting. While active control of a building's lighting offers the opportunity to increase productivity, save energy, reduce maintenance costs, and improve aesthetics, how does one achieve control affordably so it can be used around the world?

Enter DALI, or Digital Addressable Lighting Interface, a new proposed industry standard protocol for addressing fluorescent lighting ballasts using digital commands that promises to revolutionize the lighting industry. Because fluorescent lighting is the most widely used, energy efficient solution, the DALI standard offers increased energy savings and ergonomics through digital lighting control and has garnered a lot of interest in the lighting industry, from lighting designers and architects, to ballast manufacturers.

International
IϟR Rectifier

Using DALI for controlling building lighting offers:

- Reduced energy usage by up to 30% through "light harvesting," where lamps are dimmed in response to the changing amount of natural light and sensing when a room is occupied.
- Increased productivity through the reduction of glare and giving end users the ability to actively control their work environment.
- Reduced maintenance costs through the central monitoring of ballast and lamp status.
- Reduced implementation costs compared to analog controlled dimming due to simpler installations with less components.
- Increased lighting control by making each ballast addressable compared to the analog dimming's ability to only control hardwired groups of ballasts.
- "Plug-and-Play" implementation with component compatibility from various manufacturers.
- Avoidance of paying peak energy rate charges by lowering all lighting by 10 to 30% during peak energy usage periods. Ironically, peak energy usage usually occurs during the peak availability of natural light.

How DALI Developed

Research began midway through the 1990s spurred by high energy costs in Europe to develop a better solution to control fluorescent lighting, instead of widely used analog control methods. Analog dimming control only offers control of groups of ballasts. A group of leading lighting manufacturers decided a standard communication protocol was needed to increase the speed of adoption by customers.

Building architects and managers alike are very concerned about having to deal with the issues of different and incompatible communication protocols and equipment. For the rapid adoption of this new lighting control system architecture, the market required that equipment from different manufacturers (control systems, ballasts, sensors, controllers, switches, etc) have the ability to be mixed and matched together seamlessly into complete systems. This would reduce building system development and implementation costs, enhance availability of products, reduce maintenance issues, and reduce product development costs and risks.

Europe's leading ballast manufacturers, including Helvar, Hüco, Philips, Osram, Tridonic, Trilux and Vossloh-Schwabe, have all been involved with developing the DALI standard. A working group of the Electronic Control Gears (ECG) (IEC 929 / EN60929) was formed to study a lighing standard and incorporate the results into a draft European standard. This became the proposed DALI standard known as Annex E of the European electronic ballast standard EN60929.

As developed, DALI is an affordable "open systems architecture" that allows any manufacturer's devices to interface with any dimming, control, sensor, or fixture to create a room or area lighting system. Each DALI system consists of a maximum of 64 individual ballasts that are connected using a twisted-pair cable to a DALI controller. The DALI controller can be connected to other controllers to achieve central control of larger areas. In addition, the digital protocol enables adjustment level and functional lamp and ballast condition feedback to the DALI controller.

International
IƐR Rectifier

The protocol enables cost-effective implementation for digital control of both individual DALI ballasts as well as of numerous segments interconnected to the building' s automation bus. Typical applications include offices, universities, factories, warehouses, convention centers, classrooms, and other facilities requiring both flexibility in lighting adjustments and energy savings.

The DALI Standard

DALI is exclusively designed for lighting and fills the needs beyond the more complex bus systems found in many building controls. DALI is designed for low cost due to the large number of lighting system nodes. Reaching up to 300 meters (984 feet or a maximum of 250 mA drive current or 2 volt drop), each DALI interface is suitable for mid-size rooms and stand-alone systems. DALI becomes a sub-system to large building management systems, communicating in both directions via a gateway or transmitter.

Wiring is simplified with DALI. Each individual device, control, dimmer, or ballast has only a power input and digital control input. Since each device is wired to these common buses, groups can be defined and adjusted without rewiring – something not possible with analog control. Groups of ballasts are used to set lighting scenes. This way, individual lights do not need to be manually adjusted. In addition, one DALI system allows up to 16 groups to be created with individual luminaries having multiple group memberships. Ballasts can be assigned to groups at any time. Each group can also have up to 16 scenario settings. Non-polarized control input wiring eliminates costly installation errors due to reversing control wiring at ballast or control terminals.

DALI is a Software Solution

The key to the DALI standard is the definition of the software' s core commands. DALI messages include error detection and consist of an address part and a command part. The address part determines which DALI module the message is intended to. All modules execute commands with "broadcast" addresses. Sixty-four unique and sixteen group addresses are available. A particular module can belong to more than one group at the same time.

Light levels are defined in DALI messages using an 8-bit number with zero (0) being off. The DALI standard defines light levels on a logarithmic regulation curve from 0.1% to 100% with Level 1 corresponding to 0.1%. All DALI ballasts and controllers must adhere to this curve regardless of their absolute minimum level so the human eye will observe light changes in a linear fashion.

Table 1 lists typical software commands. Operating parameters can be changed and stored dynamically within the ballast memory including sixteen different light levels with fade time and rate. Light level settings include minimum light level, maximum light level, actual light level, fade time and rate. Diagnostics include the status of each ballast and lamp.

Typical DALI Message	Description
Go to light level xx	Sets light level from 0.1% to 100.0%
Go to minimum level	Set light level defined as lowest for this situation or setting
Turn lamp off	Turns the light off
Go to level compliant with situation xx	Sets light level at a predefined level
Query: What light level are you on?	Returns a number from 0.1% to 100.0%
Query: What is your status?	Returns a variety of status messages

Table 1: Sample communication messages

DALI - A Lighting Control System with many applications

Control flexibility, ease of installation, and low cost are the key factors behind the growing acceptance of the DALI standard in Europe, the US, and the rest of the world. At a minimum, a DALI system consists simply of ballasts and a controller. Using sensors with a DALI system offers benefits such as constant light control, motion-detection and infra-red remote operation. Ballast to controller communication gives the operating status of lamps and ballasts. This information can be used to generate reports showing the location of failed lamps and ballasts.

More complex distributed solutions operating as a subsystem to the master building control are just as easily created. The DALI control unit or gateway acts as the "master" for local communications to and from any ballast. It passes status and responds to commands from the building' s master control system. In this scenario, whole floors or warehouses would have predefined lighting settings with local sensor overrides that would allow for the most energy efficient control of lights. Each local DALI controller would query the dimming status from the ballasts it controls and compare it to the current light level measured by local sensors and calculate the difference. The appropriate ballasts or groups of ballasts are adjusted simultaneously, or over a period of time for an unperceivable change in lighting.

Simpler controls for individual room light scenes are also easily created. For example, a conference room may have tree lighting scenes - one for audiovisual presentations, another for general meetings, and another to check if the room is occupied. Instead of manually turning various lights on and off to set the lighting in a room for an audiovisual presentation, this could be pre-set as a DALI lighting scene. A DALI system user would simply select the audiovisual presentation scene, and all the lights would automatically adjust. After the presentation, another DALI lighting scene could be selected that turned on all the lights to full brightness. After the meeting, users could leave, and the room lights would turn off or dim, saving energy.

International
IΩR Rectifier

Designing a DALI Ballast

Digital lighting controls offer many advantages over traditional analog controls, but implementation has been traditionally seen as very challenging technically and costly. Designing an analog dimming (1-10Volts) ballast has been the common means of dimming fluorescent lighting. However, analog control is complex to implement because control logic is hard wired and thus lacks flexibility if needs change. Additional issues with analog systems are the additional components needed, such as relays, and voltage drops in the control lines. Voltage drops in the control lines can result in differing luminance settings for each ballast.

DALI systems eliminate these problems. Wiring is simplified by having each ballast on the same two-wire digital bus and a power circuit, this lowering implementation costs. To simplify product development, new DALI chip sets are available that reduce component count, development time and cost, yet increase the control and flexibility of the system. For instance, International Rectifier, in partnership with Microchip Technology, offers the IRPLDIM2 reference design (See Fig. 1) that incorporates all dimming ballast control and digital interface functions with full DALI compatibility. The reference design required only 92 components on a single board, compared to several hundreds of components on several boards for a discrete solution. The IRPLDIM2 reference design uses a ballast control IC with a patent-pending phase control method that allows 256 dimming levels for smooth variation of lighting that is very pleasing to the eye. The reference design also includes Microcode, a GUI for control of the ballast using a PC, full board documentation (BOM, Gerber file, application notes, user manual), and RS-232 serial-to-DALI interface. This reference design allows manufacturers to bring digital addressable ballasts to market more quickly by providing an integrated solution that combines advanced dimming ballast control technology with a microcontroller.
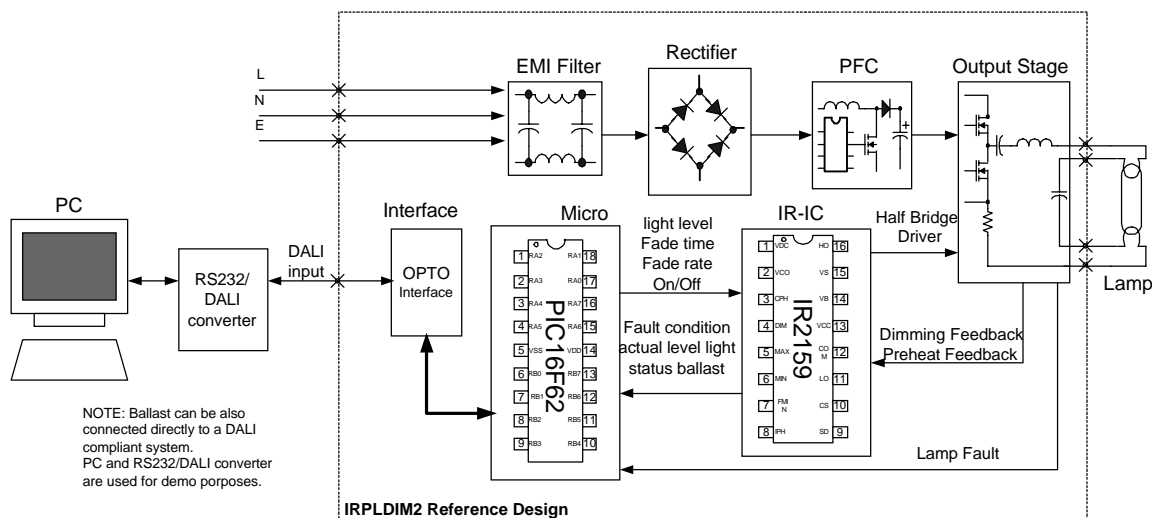

Figure 1: Reference designs make a DALI interface simple

International
IƆR Rectifier

Conclusion

DALI, recognized and supported by leading global ballast manufacturers, is making strides to become a global lighting communication standard. Developed to provide easy-to-install, digital lighting control solutions, DALI applications interface with universal building management systems like EIB, LON, LUXMATE or BATIBUS to provide complex lighting solutions with a high degree of integration to other building functionalities.

DALI controls enable increased productivity by making lighting an active part of the work environment, deliver a 20 to 30 percent reduction in energy use, reduce maintenance costs, and improves building aesthetics. DALI provides significant advantages over existing analog control systems including:

- Two-way communications for obtaining operating status and performance of luminaries. This ability to generate reports showing location of failed lamps and additional fixture performance items helps reduce maintenance and energy costs.

- Individual fixture addressing of up to 64 addresses provides cost-effective control of individual fixtures and allows re-configuring space lighting groups without re-wiring.

- With 16 programmable scenes and groups stored in the ballast, the user can define lighting scenes based on occupant tasks while groups provide the ability to control individual fixtures included in multiple control zones.

- Control compatibility across multiple suppliers letting users to mex and match and obtain consistent control operation.

- Simple control wiring allowing maximum flexibility, ease of installation, and convenience

A number of ballast manufacturers are offering DALI solutions today. Through the use of pre-packaged design solutions and reference designs, more ballast and lighting manufacturers will be able to offer energy-efficient, DALI-compatible lighting control to their customers. As architects, designers, users and building owners begin to demand better lighting control, DALI solutions will become more prevalent, offering easy installation, high levels of controls, and more energy efficient lighting.

International
IƆR Rectifier