

# DALI Is HOK-ay

*THE INSTALLATION AND COMMISSIONING OF A DALI LIGHTING CONTROL SYSTEM AT HOK'S SAN FRANCISCO OFFICES IS A KEY STEP TOWARD LEED DESIGNATION FOR THE PROJECT*

*By Richard Miller*

Imagine the challenge—a world-class architectural firm, with a strong commitment to energy efficiency in design, moves into a landmark building in the heart of San Francisco's financial district and seeks to have LEED (Leadership in Energy and Environmental Design) designation for its offices. What lighting control system could best meet the needs? Although DALI, the Digital Addressable Lighting Interface, is still relatively new in the U.S., Hellmuth, Obata, Kassabaum (HOK) decided to

move forward with it, based on its promise of greater control, energy efficiency and occupant satisfaction. During the last 14 months a DALI lighting control system has been planned, designed, installed, commissioned and is in use for HOK San Francisco, part of its recent LEED Commercial Interiors submission.

The following article

is a case study of this pioneering project reflecting the experiences of all the major players with recommendations for future DALI installations. The participants in this installation/commissioning project consisted of: owner: HOK; design engineer: Richard Miller, RNM Engineering; electrical contractor: Daryl Dalling, Dynalectric; manufacturer: Pete Horton, The Watt Stopper; commissioner: Charles Knuffke, The Watt Stopper. This is their story.

## The Owner

The San Francisco office of HOK recently moved into new quarters at One Bush Street in the Financial District of downtown San Francisco. HOK is among the largest U.S.-based architectural firms in the US and is a leader in sustainable design. HOK wanted to pursue the LEED Commercial Interiors pilot program for this new office space and chose to implement a DALI control system to help obtain this goal.

The landmark status of One Bush Street posed several challenges for the design team. The building required the use of a concealed spline ceiling and 1x4 parabolic luminaires to maintain "the look" from the street. Additional challenges included a post "dot-com-bust" tight construction budget and a short construction time.



(top) One Bush St., HOK's new home in San Francisco's financial district.

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(right) The main conference room is perhaps the best representative of both the flexibility and complexity of this DALI installation. It has 34 DALI devices controlling the lighting, blinds, projection screen and projector lift. Manual controls operate this equipment as well as eight pre-set lighting scenes. The DALI system allows the luminaires closer to the screen to be dimmed more than those further from the screen.

**Table 1. DALI System Component Summary - HOK, San Francisco**

Total	2nd FL	3rd FL	Item	Manufacturer
376	195	181	DALI Addresses	
250	120	130	DALI Ballasts, 1F32T8	Tridonic
7	7	0	DALI Ballasts, 2F32T8	Tridonic
6	0	6	DALI Ballasts, 1F54T5HO	Tridonic
54	26	28	DALI Ballasts, 2F54T5HO	Tridonic
16	16	0	DALI Ballasts, CF	Tridonic
6	4	2	DALI Relays, 120V	Watt Stopper/Tridonic
32	17	15	DALI Relays, 277V	Watt Stopper/Tridonic
5	5	0	DALI A/V Relays	Starfield Controls
47	27	20	DALI Groups	
45	25	20	DALI 5-scene Controller	Watt Stopper
3	3	0	DALI 4-scene Controller	Starfield Controls
11	6	5	DALI Busses	
11	6	5	BusMasters: DALI-RS232	Tridonic
2	1	1	BusMaster Cabinets	Tridonic
10	5	5	277 Volt Lighting Circuits	
2	1	1	Ethernet-to-(8)RS232	Moxa
1			Palm-Dim software	Tridonic
1			DALI-Tool software	Tridonic
1			Win-Dim software	Tridonic
1			WinDimNet software	Tridonic
26,315	13,831	12,484	Connected Lighting Watts	
29,425	14,685	14,740	Square Feet per Floor	
0.89	0.94	0.85	Watts per SF	

HOK’s interior design department provided the space plan and interior design. HOK’s engineering department provided a least-cost concept design which was used for a design-build contract for the mechanical, electrical and plumbing systems. Consistent with the design approach, J.S.Nolan & Associates of San Francisco provided a lighting design that was cost effective and Title 24 compliant. Middlebrook and Louie of San Francisco provided the structural design for the stairs between the second and third floors and they are also a tenant on a portion of the second floor.

**The Engineer**

The most significant engineering and lighting design challenge was the landmark status requirement to use 1x4 parabolic luminaires. The existing luminaires were F40T12 over/under two-lamp with magnetic ballasts. After extended negotiations with the landlord, the design team was allowed to use a one-lamp T8 1x4 parabolic luminaire with electronic ballast. This decision reduced the lighting power density from 1.35 W per sq ft to a connected lighting load of 0.89 W per sq ft, well below the Title 24 requirement of 1.2 W per sq ft. This decision also provided an opportunity to install a DALI lighting control system to further enhance the energy efficiency of this project.

In designing the DALI lighting control system, RNM Engineering took advantage of the new construction to

have the DALI low-voltage control wires installed as Class 1 signal wires in the conduit along with the 277-volt lighting branch circuit conductors. This then required that all the DALI wires be installed in conduit even where the 277-volt conductors were not present.

The process of designing a DALI lighting control system requires the calculation of five parameters. Those being: 1) The connected load of the lighting branch circuit; 2) The count of DALI addressable ballasts on a DALI bus (maximum of 64); 3) The count of control groups (maximum of 16 control groups on a DALI bus); 4) The amperage of DALI current ( maximum of 250 milliamps of DALI current; each ballast consumes 2 ma and some scene controllers can consume as much as 15 ma each); 5) The length of wire runs (maximum wire length of 1000 ft between any control and any ballast). The design is documented on lighting plans

together with selection of components.

Working toward the owner’s sustainability goals, Title 24 compliance provided one point towards the LEED Commercial Interiors pilot program certification, while the DALI lighting control system design garnered four additional points.

**The Contractor**

The design-build contract allowed the electrical contractor, Dynalectric of San Francisco, some opportunities in cost reduction but also provided many challenges. The specified concept design provided only an outline of expectations and quality. The landmark status and the landlord also dictated requirements, such as luminaires, luminaire set-back restrictions, lamp colors, Building Management System (BMS), and lighting control interface. Also, the tight budget limited the selection of lighting products.

The selection of a lighting package was a significant item in the contractor’s process. “Package” is the key word and the key resource is the lighting product representative. The representative must understand the specs and scope of the project, must understand the budget to match the dollars with the requirements and must communicate these understandings to the client in order to have a successful package.

This project required every type of standard control—

individual room switching, dual level switching, dimmers, dimmer systems, occupancy sensors, low voltage lighting control panel and the BMS interface.

The introduction of DALI to the project was initially overwhelming and the contractor team members were all skeptical, but the power of the DALI ballast to do all the

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required switching functions: individual switching, multi-level switching, dimming single room or fixture and dimming to a scene sequence, won them over.

The contractor working with lighting representatives next brought in Watt Stopper, providing solutions to the interface issues with non-DALI fixtures, as well as furnishing all switching devices, relays and software to control the ballast. The Watt Stopper representative actually worked hand-in-hand with the field electricians to educate and resolve installation issues as they came up.

The simplicity and ease of installation impressed the contractor team. The DALI backbone consists of just two components: The line voltage lighting circuit (not a switch leg), straight from the breaker panel, and The Busmaster cabinet which provides the multiple DALI busses. These together with 3 #12 AWG line-voltage conductors (green, gray, [brown, orange or yellow]) along with 2 #16 AWG DALI bus conductors (black and red), create a lighting circuit. This group of wires can be pulled in the same conduit through all junction points without the need of adding switch legs or travelers. This design aids the wireman in his lighting rough-in.

When questioned, all of the electricians involved would do another DALI project. All were impressed and thought this project was a good education. They look forward to the growth and expansion of the DALI system in the future.

### The Manufacturer

One of the key benefits of an open standard protocol such as DALI is that multiple manufacturers can provide interoperable products. This is also known as the “play nice” requirement. The HOK San Francisco DALI installation utilized components from three different manufacturers, but The Watt Stopper, Inc lighting control group out of Birmingham AL provided the overall systems integration for this project. This included

arranging for the shipment of the DALI ballasts from Tridonic to the luminaire manufacturers, securing the Busmaster power supplies and DALI cabinets from Tridonic, securing of the installation, commissioning and operating software from Tridonic, securing of the control stations from Watt Stopper and Starfield Controls, and the fabrication of custom relays. So Watt Stopper is our “manufacturer.” (See the DALI Schematic Diagram for a complete description of all the interoperable devices.)

Some of the key components include single gang, five-button switches for individual and open office control as well as single gang, four-button switches for control of the conference room lights. Additionally, DALI relay controls are utilized for ON/OFF control off of non-DALI lighting loads, such as groups of compact fluorescent downlights and wallwashers. Groups of CFL downlights and wallwashers in the lobbies and offices are switched via DALI/PowerPack relay modules as a cost reduction measure. Manual/DALI control relays are used for audio-video equipment, shades and blinds, the projector lifts and screen control.

Tridonic, the ballast manufacturer, also provided the software utilized in the commissioning process (described below) as well as the software required for operating the system after installation. The operating software (WinDimNet) runs on both PCs and servers and can manage both single and multiple DALI buses. On a PC, it allows monitoring and control of a single DALI bus. On a server it provides scheduling, multi-bus communication and allows employee workstations to interface to the DALI network. This software also allows central storage of ballast settings and archival of historical data.

Tridonic provided the system configuration of the WinDimNet operating software on the server. They also provided the correlation between the DALI level and the power consumption for each of the ballast types for the energy monitoring portion of the software.

HOK provided the computer for running the server soft-

### Words From The Job Site

The following are comments from the electrical foremen involved in the HOK DALI installation.

- Electricians were worried about mixed voltage and make-up in common boxes. As it turned out this was no problem for the electricians, and it is acceptable by most codes.
- There would be no labor savings on a non-conduit installation, such as MC cable. This is not really true because MC cable is available in five conductors.
- Call backs could be confusing to service people if they are not aware or knowledgeable of the DALI installation.
- Layout is simple. All five wires connect to every ballast.
- Smaller pipe to install and fewer wires to pull.
- Quicker lighting control installation.
- DALI wiring is more forgiving. All switching options are always available.
- Changes or added switches are easy to install.
- Change order friendly for both owner and contractor.
- Troubleshooting is easier due to fewer wires and make-ups.
- Ballast is self-addressing. There are no dip switches.
- The programming is non-electrical. Programming is software based.

ware, the Ethernet system hardware and cabling and the Ethernet-to-RS232 gateways, coordinated the IP addresses for the Ethernet system, and loaded the frequent software updates on the server.

All involved learned that there is a significant amount of IT work involved in a DALI installation and that it takes more than one manufacturer to provide a DALI system.

### The Commissioner

The goal of the commissioning process is to confirm that all aspects of the lighting control system are installed correctly and working as specified, and that the system documentation matches the “as built” installation and meets the owner’s needs. This project was jointly com-

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missioned by a representative of the controls manufacturer (Watt Stopper) and the design engineer (RNM Engineering) with contributions by the electrician and the owner’s representative.

While a commissioning process is important for any large, multi-vendor system, it is absolutely critical for the success of a DALI installation. Since DALI systems provide more capability, they have more complexity, including significantly more control points. DALI also uses a communication protocol and commissioning of the system includes assigning all of the digital addresses to the ballasts and loading the group assignments and intensity settings into the ballasts. The commissioning process uses several software tools, some special purpose and some general purpose, such as Microsoft Excel. Since DALI is new, the special software still had a few “bugs” that were found on this project.

Prior to starting the actual commissioning, all the system components must be completely installed. This includes the line voltage wiring, DALI communication bus, all ballasts and fixtures and any DALI override devices. While this seems obvious, in many systems it is possible to “fake” missing components, but not with DALI. It should also be noted that if electrical power is cut off to the DALI bus, all lamps return to their default state—100per-

cent intensity. So if there are occupants in the space, the commissioning process may be disruptive to their work environment, so they must become part of the “team.” The HOK San Francisco DALI commissioning took over 60 hours of setup time in 12 visits and the space was fully occupied, so close cooperation and the patience of the owner was necessary for success.

Another prerequisite is to be fully knowledgeable about all the devices on the system and their various power requirements. Reviews by the commissioner of the specific hardware and switches are essential. A clean reflected ceiling diagram and a sharp red pencil are also necessary.

The first “real” step is to assign a digital address to each ballast. This is currently accomplished using one or more of four proprietary software tools provided by the ballast manufacturer, in this case Tridonic. These tools range from a Palm-based product to an NT-server based system level product and each has a role in the process, but they do not yet provide a complete software commissioning solution. To pull all the information together, Microsoft Excel was used as an “electronic notebook.” The actual address is loaded into the ballast by the proprietary software “wizard” and is not easily accessible to the commissioner. So the second step is to identify the address a specific fixture and note it on the lighting plan. This was accomplished by two members of the team with walkie-talkies and a laptop running Excel, cycling through the addresses until the appropriate optical feedback was received from the actual fixture. This is currently a relatively cumbersome, manual process that can take several minutes per bus and may impact the building occupants, so careful coordination is required. The third setup step is to assign ballasts to groups and set intensity levels for the various scenes. Software commands allow device communication in broadcast (all devices), group or address mode.

As with any large project, all did not go smoothly, so troubleshooting was required. The electrician had to verify that 16VDC was on the DALI bus to the ballasts and that the ballast wiring was correct. The proprietary software packages were used to detect failures and send override commands. Two testing features of the Dataline switch were particularly helpful—Broadcast on/off and raise/lower an entire group. Troubleshooting tools for the commissioner are an area for additional improvement.

Key lessons learned include the need for the commissioning team to be very familiar with the bus wire runs as well as all the equipment interfacing to the system. The project electrician who had installed the wiring provided this critical system knowledge. In setting up the system, it is important to keep the busses manageable and create obvious control groups to reduce complexity. Until there is more open third party software specifically for the commissioning of DALI projects, using an ‘electronic notebook’, such as Microsoft Excel is strongly recommended. Another key lesson learned is the need to coordinate the commissioning with the owner and occupants of the

building. Both setup and checkout impacted the occupants since re-initialization was required to connect each bus, dropping all lights to a low level. Of the 60 hours spent on commissioning, about one-third of the time was related to wiring problems, one-third to “new technology issues” and one-third to meeting specific owner requirements, such as revising setpoints.

While all involved are very pleased with this installation, it is worth remembering that DALI is still in the “early adopter” stage and will need to continue to evolve if it is to fulfill its promise.

## System Operational

In 2002 when HOK San Francisco decided to install a DALI system in its new offices, it was on the promise of greater control, energy efficiency and occupant satisfaction. Now that that this system is operational, it is only appropriate to ask how well the promises and goals were met. The main conference room at HOK San Francisco is perhaps the best representative of both the flexibility and complexity of this DALI installation. It has 34 DALI devices controlling the lighting, blinds, projection screen and projector lift. Manual controls operate this equipment as well as eight pre-set lighting scenes. The DALI system allows the luminaires closer to the screen to be dimmed more than those further from the screen. This room can easily be used in both blinds open and blinds closed mode.

The DALI system also allows dimming of groups and zones of luminaires in response to individual manual commands, group commands and time-of-day commands, giving both occupant and building managers significant control. The DALI system proportionally dims the luminaires to “harvest” the daylight. The lighting component of the calculated daylight energy savings at HOK San Francisco is 11,000 KWH per year. DALI equipment cabinets on each floor connect to a computer for master control, and preparation of energy and maintenance reports.

Now that the project has been completed, HOK San Francisco is the owner of one of the most comprehensive DALI installations in the U.S. HOK is pleased with the DALI lighting con-

trol system and with its submission for LEED Commercial Interiors Pilot program designation, has met its goals.



**About the Author:** Richard N. Miller, PE, LC, IESNA, been a member since 1967 and has been active in several local sections, including serving as president of the Chicago Section on two separate occasions and has just completed a term as president of the Golden Gate Section. Rick chaired the Education Materials Committee, leading the revision of ED100. He is president of RNM Engineering Inc., providing electrical engineering services to the lighting design and construction communities. He is actively involved in lighting control systems design and installation, especially DALI systems, and lectures and sponsors a vendor-neutral website—[www.DALIbyDesign.us](http://www.DALIbyDesign.us).