POWERLINE COMMUNICATED LOAD CONTROL

How it Works

PCLC uses power wiring to communicate information based on US patents 8,716,882 and 9,544,017 Powerline Communicated Load Control, by selectively imposing small, brief, voltage drops on the power line with a Transmitter. These drops occur only during the brief period when new information must be sent. PCLC enabled Receivers decode the signaling as digital information and command light levels to a driver or perform other desired functions.

PCLC signaling does not directly cause dimming the way phase cut / TRIAC dimmers reduce the power delivered to incandescent lights. This avoids the severe power quality problems when dimming and the flickering problems encountered between some dimmers and some LEDs. Instead, the Transmitter sends commands much like DALI or zero to ten volts that signal to dimmable drivers but without the need for control wiring. PCLC is digital like DALI instead of analog like zero to ten volts so that it is repeatable between devices and does not require individual tweaking to match the controller to the light.

In a typical scenario the Transmitter replaces the room's light switch. The Receivers are built into LED drivers or TLEDs in each luminaire in the room that are powered by the AC power passed through the Transmitter. Depending on the load current, the Transmitter may require a small heat sink similar to those used by phase cut / TRIAC dimmers. Transmitters that don't need to interface to sensors or building networks can be wired with only Line in and switched Line out without the need for a Neutral or Earth Ground in the wall switch box. Just like a light switch.

The signaling voltage drops are small and brief enough that they don't significantly reduce the AC power delivered to the loads. There are tradeoffs between the size of the voltage drop, the power dissipated in the Transmitter and the sophistication of the Receiver. We are using combinations of 0, 3, 6 and 9V drops applied to one of the AC line polarities in our latest testing which gives us 2 bits per AC cycle with good reliability. There is negligible degradation of power quality because the signaling is small in amplitude and very infrequent in time.

The same design of Transmitter and Receiver can be used for the common lighting power standards of 50 or 60Hz and 100 to 277V.

The signal coming out of the Transmitter is AC power of either full amplitude or slightly reduced amplitude during signaling. In both cases, the AC wiring is designed to transmit this "signal" and the lighting loads do not try to filter it out. AC wiring is optimized to deliver the PCLC signal from the Transmitter to the loads. It has insignificant inductance at 60Hz and low resistance. More sophisticated Transmitters using Neutral power wires can monitor their output and see the same thing the Receivers will see. When extremely high reliability is needed this can be used to re-transmit messages when the Transmitter knows that a power glitch has randomly simulated PCLC signaling and will cause an error.

In contrast, high frequency signaling used by competing power line communication systems can have reflections, attenuation and emission problems on AC wiring which was not designed to pass them. Their frequencies typically fall within the frequency range of the EMI filters of the lighting loads which also reduces their amplitude. This typically requires complicated network design to overcome the uncertain signal reception.

A low cost general purpose microprocessor with an analog to digital converter can easily detect the presence of PCLC signaling on a per-phase basis. The Transmitter's microprocessor does not even need the A/D, but needs to be low power if used in a design with no Neutral connection. You don't need an expensive custom chip from a company that can discontinue the part or go out of business. Because PCLC is intended for small systems with short addresses, if any, sending bits once per AC cycle phase is enough baud rate to make user commands appear to be executed instantaneously and allows trade-offs of signaling redundancy for easier error detection and recovery. Signaling for an entire AC cycle phase allows simple filtering that averages out the high frequency noise typically injected onto the AC lines by the switching power supplies or power factor correction front ends of dimmable lighting loads. Those noise sources can be in-band interference for competing high frequency power line systems.

The PCLC encoding voltage drops are applied only to the output of the Transmitter, so the communication is one way. The Transmitter sends light level commands and other control information over the AC power line that can only be seen by the devices it powers and can not interfere with other PCLC systems powered through different Transmitters. This eliminates the need to network the entire building together. An electrician or maintenance person can plan and install the system without the need for a trained expert. This is identical in concept to how phase cut / TRIAC dimmers are wired to control their loads and just as simple to install.

Some codes like California's Title 24 2013 require multiple type of daylit zones to be controlled independently from non-daylit zones. PCLC can accomplish this either by independently wiring those zones to their own PCLC Transmitter / switch as is presently done for non- dimming systems, or through zone addressing on a common circuit from a Transmitter with multiple user control switches. Multi-way switching is also possible by wiring multiple Transmitters in series.

To eliminate low voltage sensor wiring to the Transmitter in the wall switch box or to a Transmitter in the ceiling, the Receivers can make use of inexpensive light sensors and short range occupancy sensors embedded in each luminaire to meet energy code requirements. A microprocessor capable of decoding PCLC signals can also handle daylighting regulation and occupancy timeouts. Demand Response signals can be introduced at the Lighting Panel by a Transmitter hooked to an off the shelf DR receiver with a dry contact output. That Transmitter can signal all lighting loads powered by that panel to shed load with PCLC replacing the otherwise needed DR control wiring.

We built and tested a first generation proof of concept system to demonstrate the use and reliability of the technology. The proof of concept system was demonstrated in the lab, a demo box set and an office Alpha site. We performed 6 months of nearly continuous signaling for error rate testing with real world AC power during the development of our hardware and encoding and decoding software. At the end we achieved 11.5 million successful transmissions over about a month before the first error occurred, which means it is very unlikely that a user command will be missed by the system. We believe our signaling robustness and error recovery far exceeds the real world needs, allowing room to cost optimize the system while still achieving acceptable reliability. We are now refining the design of pre-production versions of standalone Transmitters and Receivers that give a good idea of the size, cost and performance that can be expected. Testing is ongoing.

Products that advertise using PCLC signaling will need to meet a common signaling specification for interoperability. This standard is extensible to cover requirements we have not thought of. We are defining relative commands like increase the light level as well as absolute commands like Demand Response On or send an absolute light level percentage. This allows the licensee to use push buttons or sliders or rotary knobs for the user's continuous dimming control. Step diming is also supported. We have demonstrated Transmitter switches using an On/Off paddle next to Up and Down buttons in a Decora form factor, and a toggle switch with center return with an Off detent that replaces a typical light switch. The Transmitters are the size of typical TRIAC dimmers and fit common light switch boxes. The Transmitter can physically cut power to the loads or signal On and Off for loads that should remain powered.

5/17/19