Lighting control technology and smart switches in the Internet of Things (IoT) era

White Paper by CMoo Systems LTD
March 2017
Written by Avi Avrahami, VP of R&D

Overview
As Internet of Things (IoT) and Smart Homes systems continue to boom on all fronts, it is astonishing that the very basic application of light control in a Smart Home is the most difficult to achieve in the vast majority of homes. Most commercial companies that develop equipment or components for Smart Homes put the bulk of their design efforts into the electronics to handle communication protocols, security, range, and so forth. However, a standard light circuit presents a much bigger problem which is overlooked – a large percentage of homes are wired using a standard that renders home automation not DIY (do it yourself) friendly. In 90% of worldwide homes, powering IoT electronics is not possible without a special and expensive re-wiring of the house. This is the number one barrier in the penetration of low-cost Smart Home systems to the mass market.

CMoo Systems offers the only product that solves this issue, allowing for the expansion of the home automation market.

The problem
The electrical power that runs in the wires of a house is called AC power (Alternate Current) and it is 220V in most of the world and 110V in US, Canada and few more countries. The AC voltage has two wires:
1. the first one (called HOT or LINE) carries the current from the electrical cabinet to the load (e.g. a light bulb)
2. the second (called NEUTRAL) carries the current back from the load to the electrical cabinet
For a load like a light bulb to be turned ON, a closed circuit is needed. Figure 1 illustrates that the light switch has only two wires: Live which is the permanent live to the switch and Switched Live that takes the Live supply to the light bulb. When the switch is closed, the Switched Live cable is live and powers the light bulb, this allows current to flow from Live through the light bulb and to Neutral - turning the light bulb on. This is a complete electrical circuit. When the switch is flicked off (wires are “open”), no current can flow and the light bulb is off. Note that the NEUTRAL wire is not present in the WALL SWITCH locations. This is the critical element that is missing to install a smart switch.

All electronic devices including IoT devices run from a low voltage DC power (Direct Current) such as a battery or from a standard power supply which converts the high voltage AC power to a low voltage DC power of 3 volts or so. All our electronic devices have such power supplies (TV, PC, Microwave oven, etc.) A power supply simply converts the AC voltage to DC voltage (Figure 2).

And here is the problem – if there is no NEUTRAL wire in the SWITCH side you cannot design a Smart Switch with electronics!

The “NO NEUTRAL” problem exists in 50% of homes in the USA and Canada, and up to 90% in the rest of the world due to different wiring standards.
Existing Solutions on the market
There are several so called “solutions” to the “NO NEUTRAL” situation in the wall switch on the market today. None of them truly solve the problem in an affordable manner.

Solution #1: Re-route the Neutral
This is not true a solution but merely a way to bypass the situation and force the user to call an electrician to pull new wires in the wall for every switch. This is very costly and messy. One example of such an approach is the BELKIN WEMO SWITCH which requires the NEUTRAL wire. However, since most switch locations do not have it and most people do not know which wires they do or do not have in their walls, it creates a lot of installation problems and dis-satisfaction as described in many online forums. Not a true DIY.

Solution #2: Switches that use the current via the bulb
There are many switches that claim to work without the NEUTRAL wire by “stealing” the current needed for the Smart Switch operation from the bulb itself. This imposes many limitations and drawbacks:
1. LED bulbs will glow even in the OFF position due to the small operating current of the switch.
2. Minimum bulb power of 25 Watts (!!!) is recommended in order for the switch to work properly.
3. Not all bulb types are supported.
4. Usually an additional “bypass” element is needed to be installed near the bulb to prevent flickering (e.g. LUTRON CASETSA, see diagram below).

Solution #3: Smart Bulb without a switch
This approach is adopted by many vendors including Philips HUE bulbs, Belkin WEMO bulbs, General Electric, and many others. This approach states the following:

Since there is no NEUTRAL in the switch and hence it is impossible to control it, put all the Smart Electronics inside the bulb and keep the mechanical switch always ON is the only way so the bulb will have constant power!

Basically, by always keeping the mechanical switch to ON, they deliver the LINE to the BULB and the Neutral is there any way (Figure 1). The user can now control the lighting remotely or from a smart phone.

This approach has 2 major drawbacks:
1. Keeping the switch ON at all times means that there is no switch anymore! The user can only use his/her smart phone for control and cannot turn the light ON or OFF from the wall switch. For most users, this is not feasible.
2. Only Smart Bulbs can be used. A legacy chandelier or other legacy light sources are not possible.

Solution #4: Smart Bulb + battery
To overcome the number one problem with Smart Bulbs, vendors suggest an alternative “light switch” which is basically a remote control running on batteries. The user should “glue” it somehow over the original light switch, which can no longer be used, and then can control the Smart Bulb with the new light switch (or a smart phone). They therefore recognize that a user needs a fast way to switch ON and OFF besides using a smart phone. Philips has such a product – Philips HUE Dimmer Switch. While it may be a nice gadget for some rooms, it’s certainly not efficient for an entire home. Batteries impose a replacement and maintenance hassle and, most importantly, these devices cannot support a switch with a display, sensors or other power hungry elements.

Summary of existing “solutions”
As noted, to date there are no products on the market that provide a true solution for a simple, low
CMoo Systems’ patented solutions

CMoo Systems offer 3 modules for manufacturers of Smart Switches, Smart Bulbs, and adaptors for legacy loads like standard bulbs or motorized shades and fans. The modules are:

1. A special power supply module that delivers up to 1.5 Watts of DC power from the switch, with or without a NEUTRAL wire! With this amount of power, it is easy to design a sophisticated switch with touch display, sensors, cameras, etc. This module is referred to as “PeX” for “Power Extractor” module. The PeX extracts the DC power while constantly delivering the AC voltage to the bulb side.
2. Bulb Adaptor for legacy bulbs called “TeX” which switches the bulb ON and OFF upon command from the manufacturer’s controller
3. Miniature component called “BeX” that is integrated inside a Smart Bulb.

The CMoo solution concept

The concept behind CMoo modules is shown in Figure 3 below without diving too much into technical details. For complete information please check our web site at www.cm-oo.com or contact us at info@cm-oo.com.

![CMoo Solutions Concept](image)

The idea is to create a closed electrical circuit that will be independent from the state of the bulb (ON or OFF). The current flows through the PeX on the switch side and either the TeX on the bulb side (if using a legacy bulb) or BeX on the bulb side (if using a Smart Bulb). As shown in Figure 3, the PeX does not need the NEUTRAL wire for delivering power to the rest of the electronics in the switch.

The manufacturer should do the following:

1. Use the PeX for their wall switch product. The PeX can be treated as a standard power supply that delivers 3.3V DC and up to 1.5 Watts.
2. Use the TeX for legacy bulb adaptor products. The manufacturer’s controller will use the TeX to switch the bulb ON and OFF.
3. Use the BeX for Smart Bulb designs.

Note: The modules do not contain any wireless communication. It is up to the manufacturer to decide on their preferred method of communication, which could be z-wave, ZigBee, Wi-Fi, BT, or any other radio technology. CMoo modules are simply enablers of installation and do not impose any constraint on the manufacturer.
The advantage of the CMoo solution over existing products

1. Can be installed with or without a NEUTRAL wire.
2. Deliver significant DC power at the switch side that enables many applications from thermostat control to touch displays (see the “Beyond Lighting” section). No other solution can do that without a neutral wire. Adding a microphone and a processor to the switch can enable the entire system to be voice controlled as if you had Amazon Alexa in every room for instance.
3. Deliver constant AC power on the bulb side since a wall switch which uses a PeX module does not “break” the circuit. This opens new types of applications which cannot be done with other Smart Switches that interrupt the power. Such applications on the ceiling can be:
   a. Smoke detector
   b. IP Camera
   c. Microphone and speaker
   d. Wi-Fi range extender
   e. Alarm system

This technology is a breakthrough in bringing the Smart Home revolution to the mass market, without any constraints related to wiring or available power in the switch.

The future
Solutions like NEST, ECCOBEE and others have been successful because they are smart devices and smart devices need power. These devices are installed in the only location in the house that almost always is equipped with a neutral, mainly the place where a thermostat needs to be installed. Smart thermostats need the NEUTRAL as they need power. The only way to the future is to have smarts in switches and in the ceiling with no limitation in terms of available power, DIY and keep the old fashion way to switch off a light. Soon CPU based smart switches in every room will be needed and they require power and batteries are not an alternative

Imagine
- Amazon Alexa in every room built into a Wi-Fi enabled wall switch instead of walking around with it
- Elder care homes and hospital rooms with a multitude of sensors and 2-way voice communication in every room
- Nurseries and infants’ bedrooms with smart monitoring solutions

All of this is now possible with CMoo’s patented technology

Note: All brand names mentioned in this paper are used as a reference, belong to their respective owners, and do not in any case reflect any endorsement on their part.

Contact Avi Avrahami VP R&D
Cmoo Systems
avia@cm-oo.com
www.cm-oo.com