



Neutral-less Smart Switch Design

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Switched Lighting: A complex binary solution

- **Evolution of switch wiring**
- **Neutral-less problem definition**
- **Load Current Path Solution**
- **Ground Current Path Solution**

Switch Wiring History

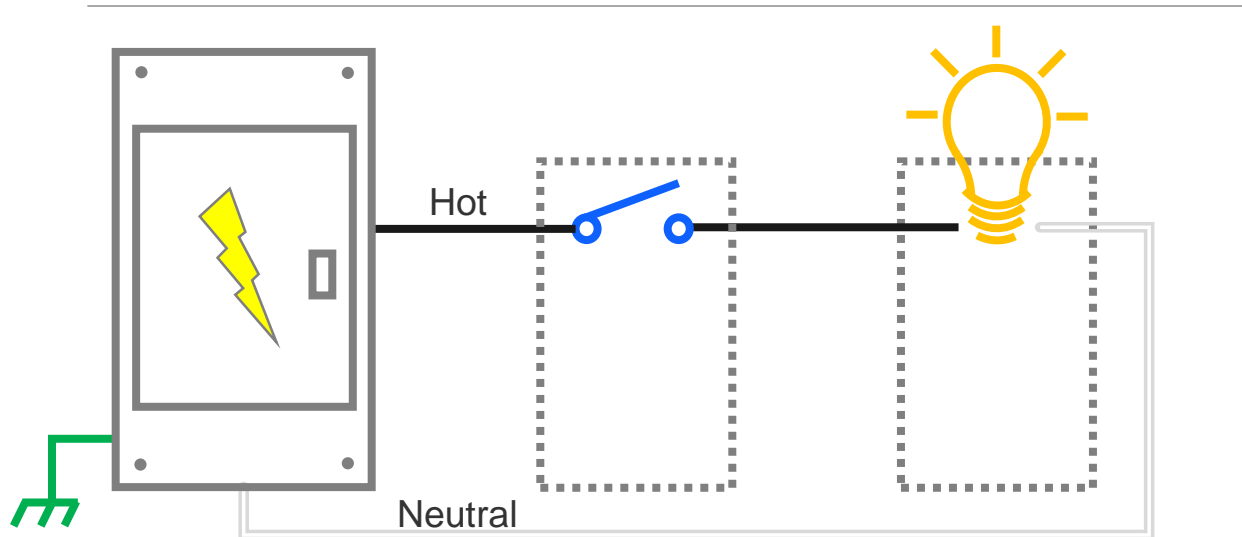
Quick Break Switch



Toggle Switch

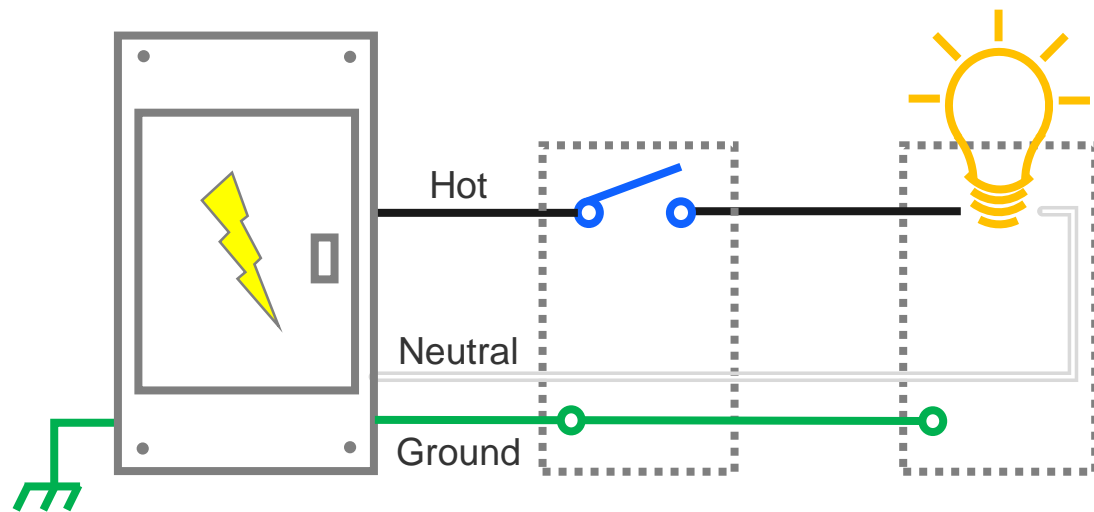
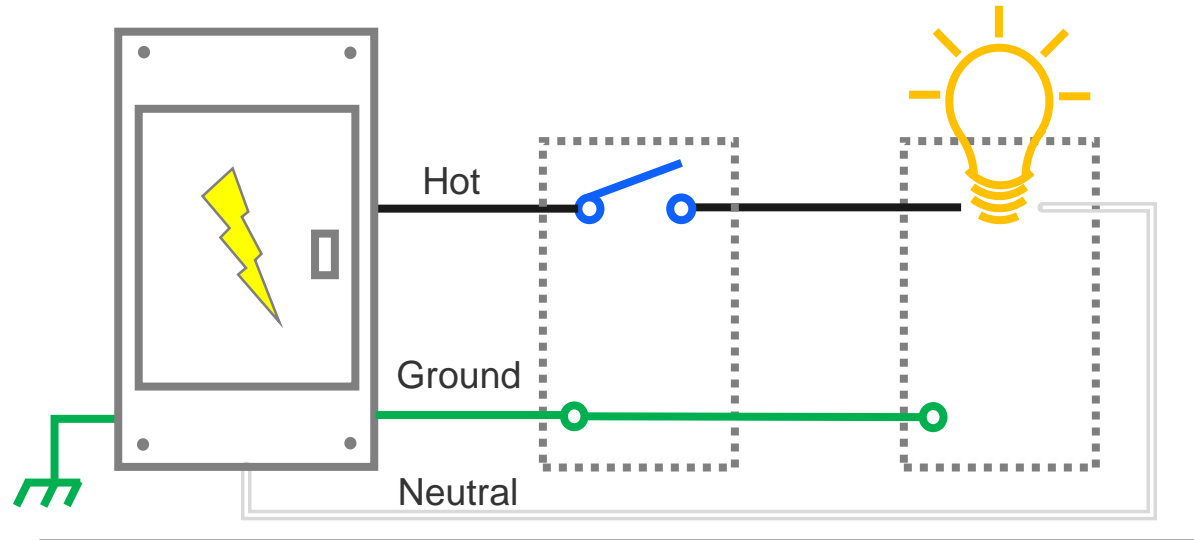


Wire and Tube Wiring system



- 1884, John Henry Holms invented the “quick break” switch
- 1916, Switch technology was further improved by William Newton’s “toggle” switch
- Early “Wire and Tube” wiring systems were a simple one wire connection path
- This continued to be the most cost effective and reliable method through the 1940s and can still be found in homes today

Evolution of Wiring Regulation



- **Ground conductor was added throughout the system for user safety**
- **Sensor control switch development prompted the need for a complete current path in the switch box**
- **2011 NEC updated to require switch box neutral for new construction**
- **3-wire switch box made smart switch design for new construction easy**
- **40% of US homes are still without a neutral wire making replacement/retrofit more challenging**

Neutral-less Home Consumer View



PROBLEM

I want smart switches, but have no neutral wire available to take advantage of 3-wire switch designs



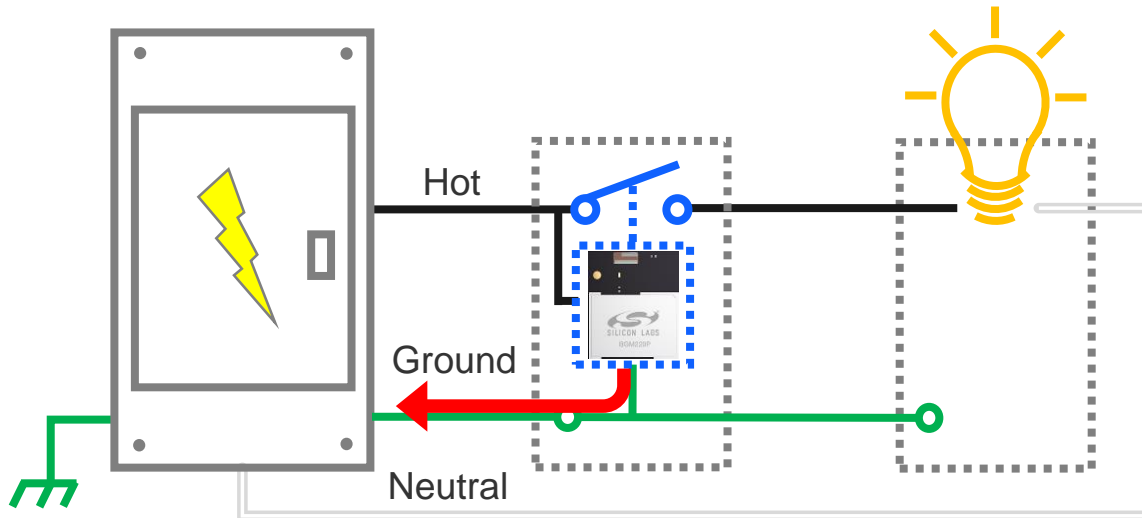
SOLUTIONS

Hire an expensive professional electrician to add neutral wiring to my home

Purchase a "one-wire" neutral-less smart switch design

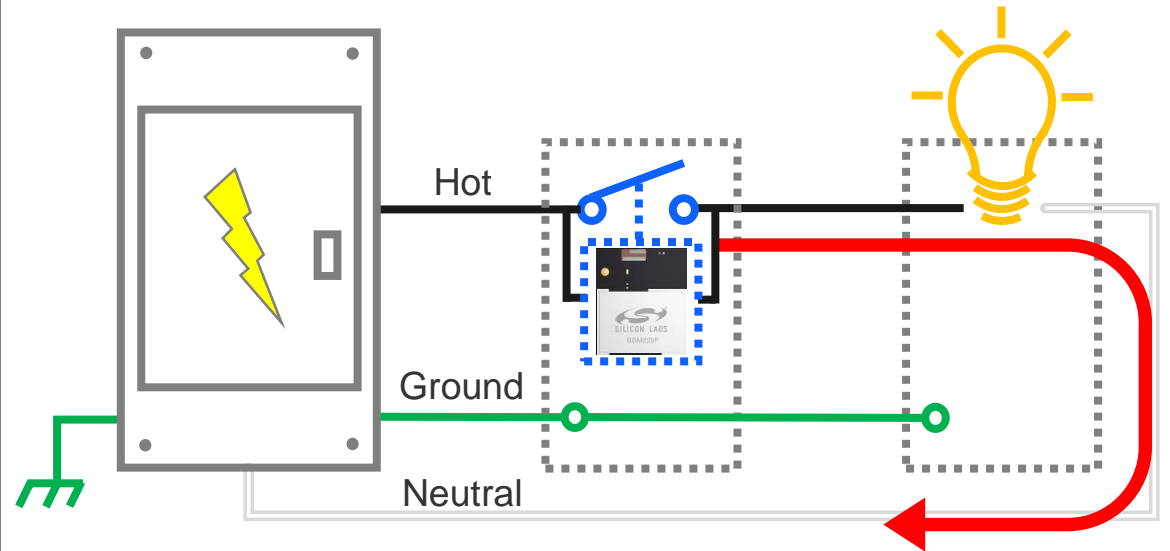
Neutral-less Switch Design Options

GROUND CURRENT PATH (2-WIRE)



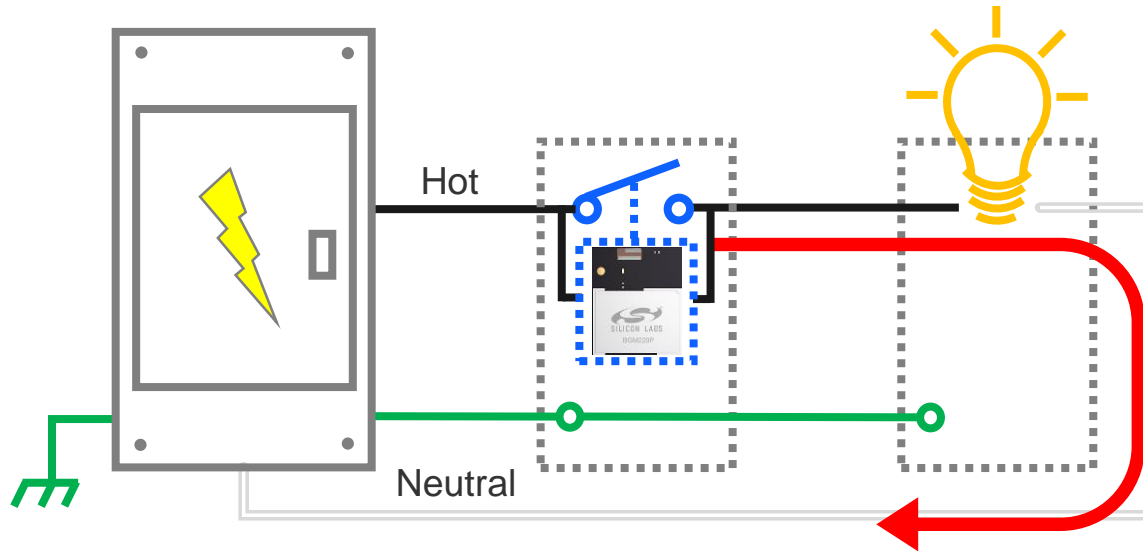
- Uses equipment ground for current return path
- Limited by electrical standards for leakage current
- Good for low power automation devices

LOAD CURRENT PATH (1-WIRE)



- Trickle current through the load circuit to complete circuit for switching controls
- Works well with higher load wattages

Load Current Path Solution



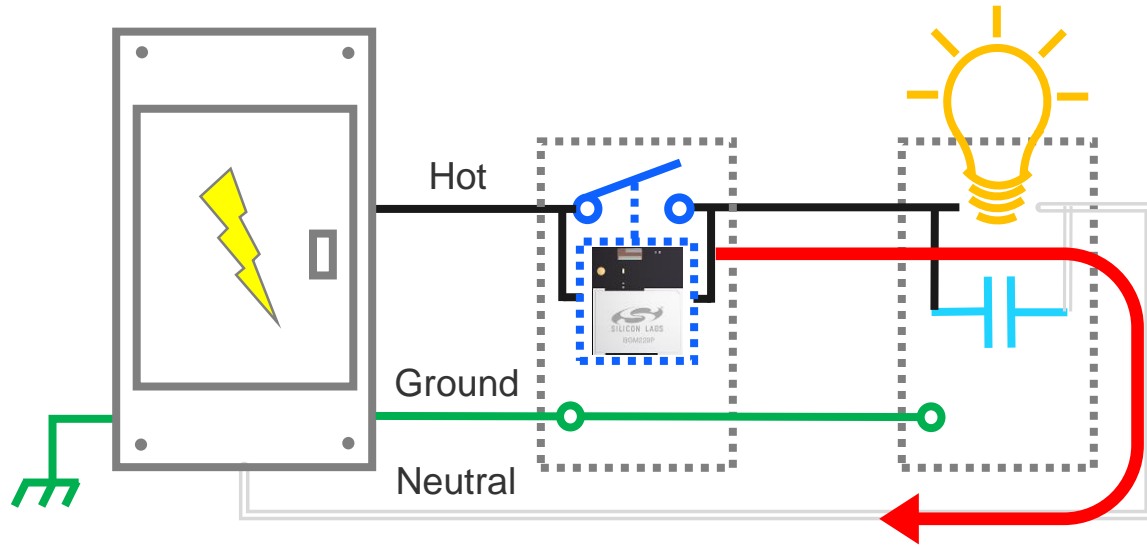
- Higher power budget to enable wireless connectivity
- Manufacturers must use workarounds for compromised load behavior
- Users must install these workarounds which reduce desire to purchase

High Power Dimmer



- **Jasco has had a No Neutral Dimmer product that uses this method for almost 10 years**
- **It was exclusively marketed toward high output lighting such as BR30 can lights that could often be 100 Watts per bulb**
- **When the bulb filament failed, the circuit was cut and the consumer had to guess what the problem might be**

Bypass Cap Remedy



- Bypass capacitor can eliminate LED bulb flicker as well as power the switch during a bulb change
- Installed in parallel to load from hot to neutral

- Some are installed inside the fixture housing
- Others are screw-in adapters for a single bulb

Load Current Path Solution



- The Silicon Labs Z-Wave 700 series modules for instance has reduced power consumption significantly
- We have been able to redesign our No Neutral Dimmer (attached images 52252) to accept a minimum load as low as 5.5 Watts LED/CFL as rated by UL, but have tested it to work as low as 2 watts
- This allows the switch to not only work with high output Incandescent lighting, but with as little as 1 low wattage LED bulb

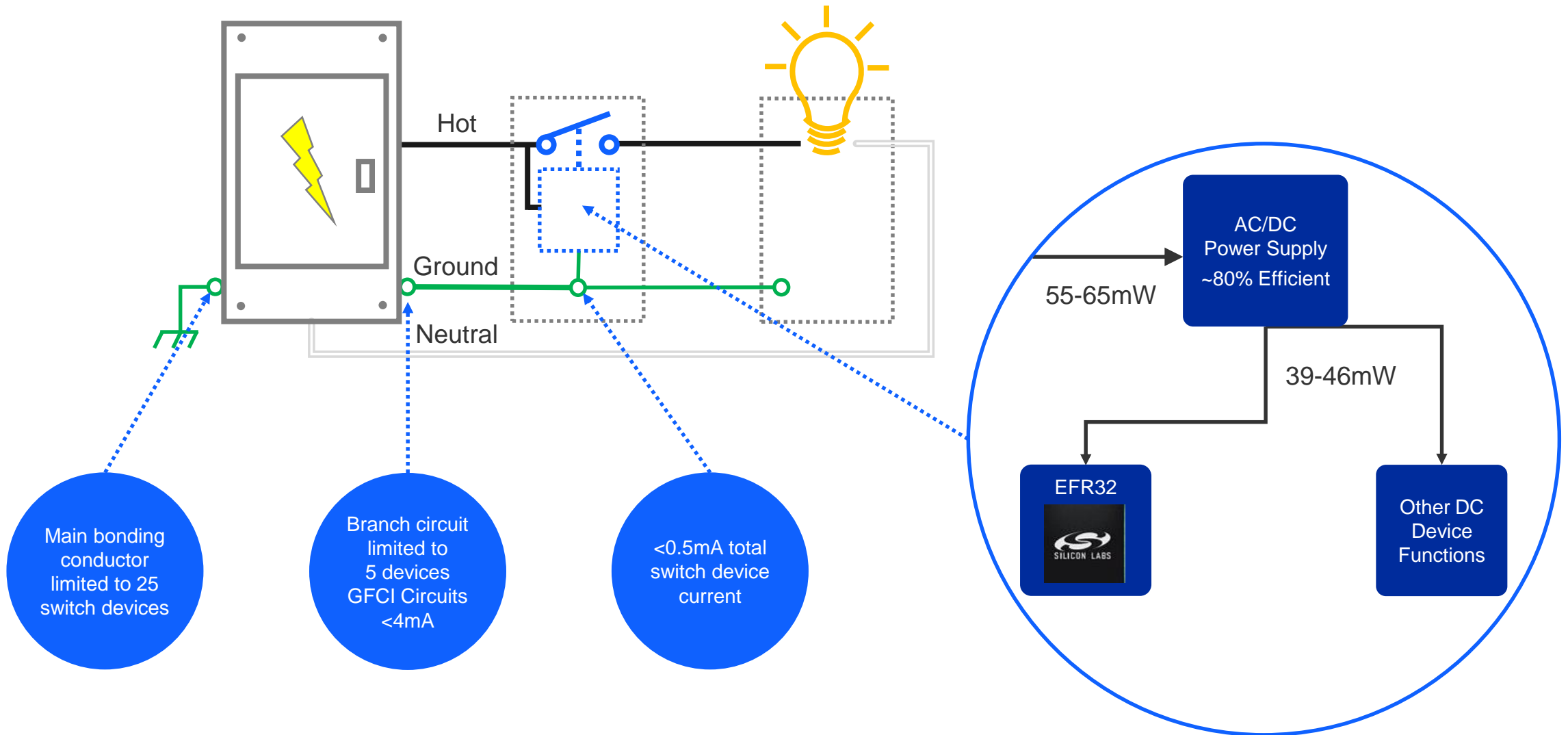
Jasco – Product Video

- Video Placeholder

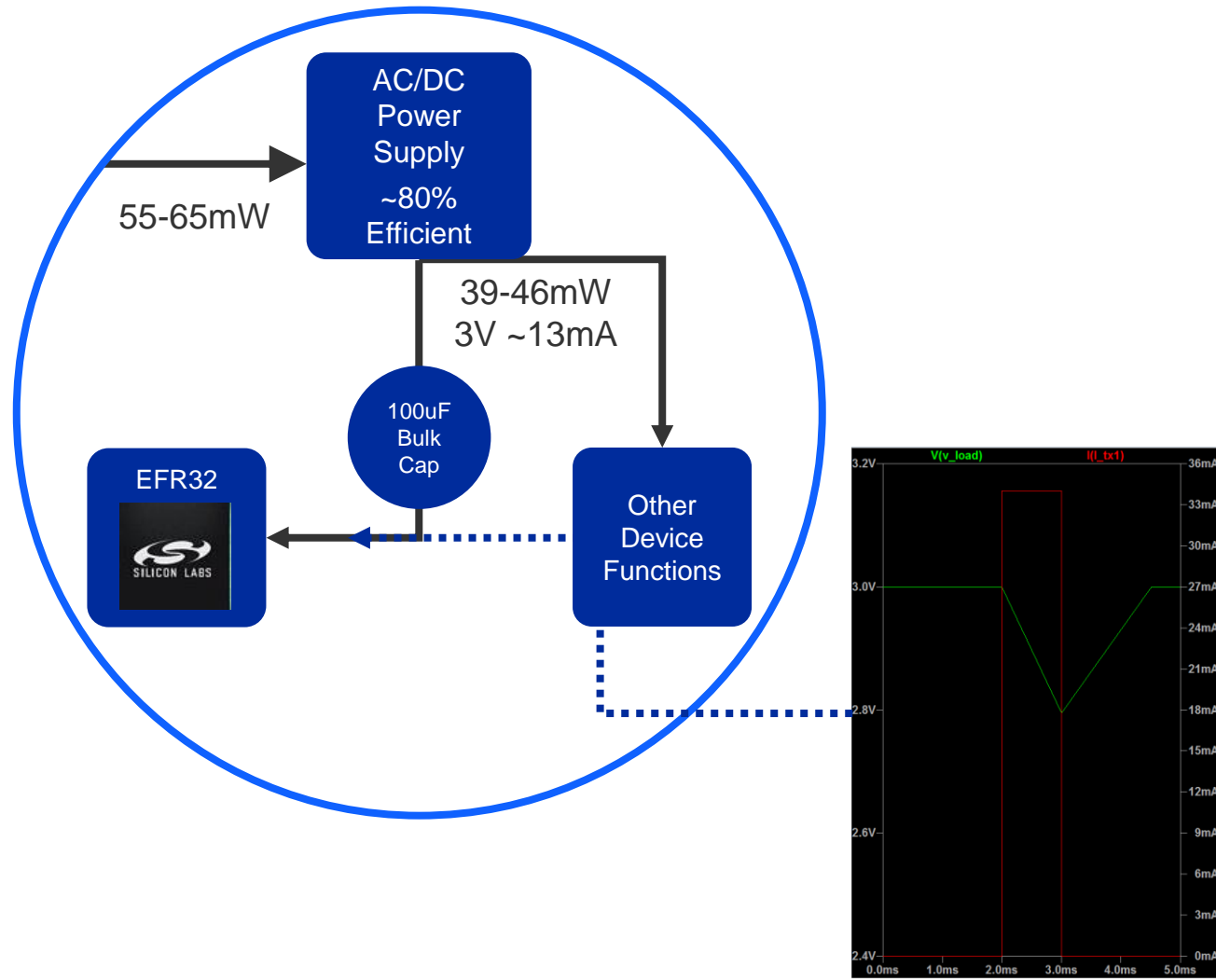
Ground Connection Regulatory Standards

Regulation	Requirement	Exception Summary
2020 NEC 404.2(C) – Switches Controlling Lighting Loads	The grounded conductor shall be extended to any switch location as necessary and shall be connected to switching devices that require line-to-neutral voltage to operate the electronics of the switch in the standby mode and shall meet the requirements of 404.22.	The requirement shall not apply to replacement or retrofit switches installed in locations prior to local adoption and where the neutral conductor cannot be extended without removing finish materials. Electronic lighting control switch quantity shall not exceed 5 on a branch circuit and 25 on the main bonding jumper.
2020 NEC 404.22 - Electronic Control Switches	Electronic control switches shall not introduce current on the equipment-grounding/bonding conductor during normal operation.	Electronic control switches that introduce current on the equipment grounding conductor shall be permitted for applications covered by 404.2(C), Exception.
UL 1472 - Solid- State Dimming Controls	4.6.5 - Circuitry shall be arranged such that an equipment-grounding/bonding connection or conductor does not carry current.	Leakage current not exceeding 0.5mA through an equipment-grounding/bonding conductor or connection is permitted if a neutral connection is not provided.

Regulatory Limitation Impact



Peak Current Solution

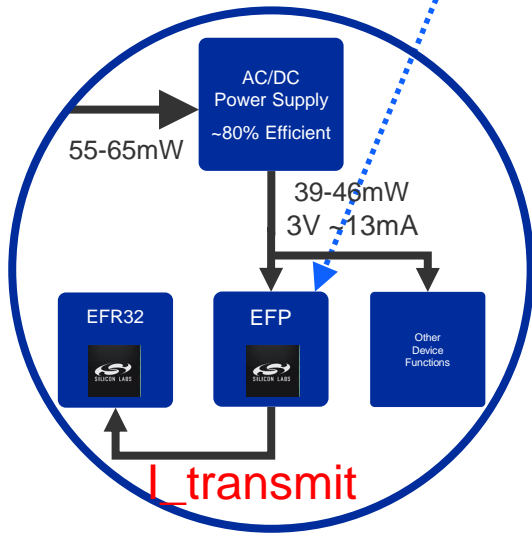
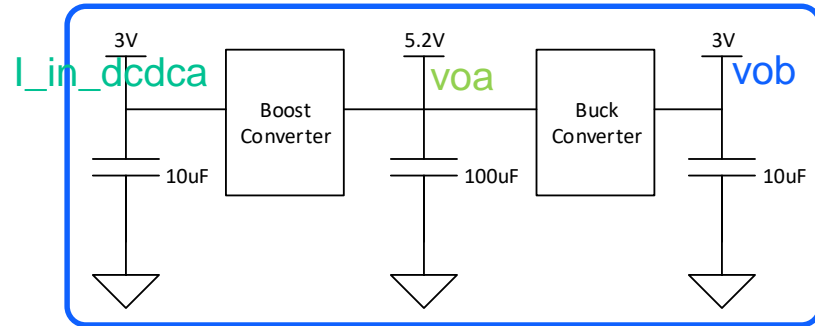


- Available power leaves little room for Tx/Rx current peaks
- EFR Series 2 0dBm low power radios will function within the limits while leaving room for other device functions
- Adding 100uF bulk capacitance can provide peak buffering to support 10dBm transmit pulses while not dipping below 2.8V

EFR32MG21 Current @ 3.0V

RX – Active 2Mbit/s	9.4mA
RX – Listen 2Mbit/s	9.8mA
TX – Active @ 0dBm	10.5mA
TX – Active @ 10dBm	34.0mA

EFP0111 Boost Bootstrap



- Higher transmit peaks require active current management
- Simulations show the EFP0111 paired with a 100uF Bulk cap can stay within our budget using active current limiting to support a 20dBm peak transmit draw
- Wi-Fi feasibility investigations underway

EFR32MG21 Current @ 3.0V

RX – Active 2Mbit/s	9.4mA
RX – Listen 2Mbit/s	9.8mA
TX – Active @ 10dBm	34mA
TX – Active @ 20dBm	185mA



works with
BY SILICON LABS
VIRTUAL CONFERENCE



Thank you

