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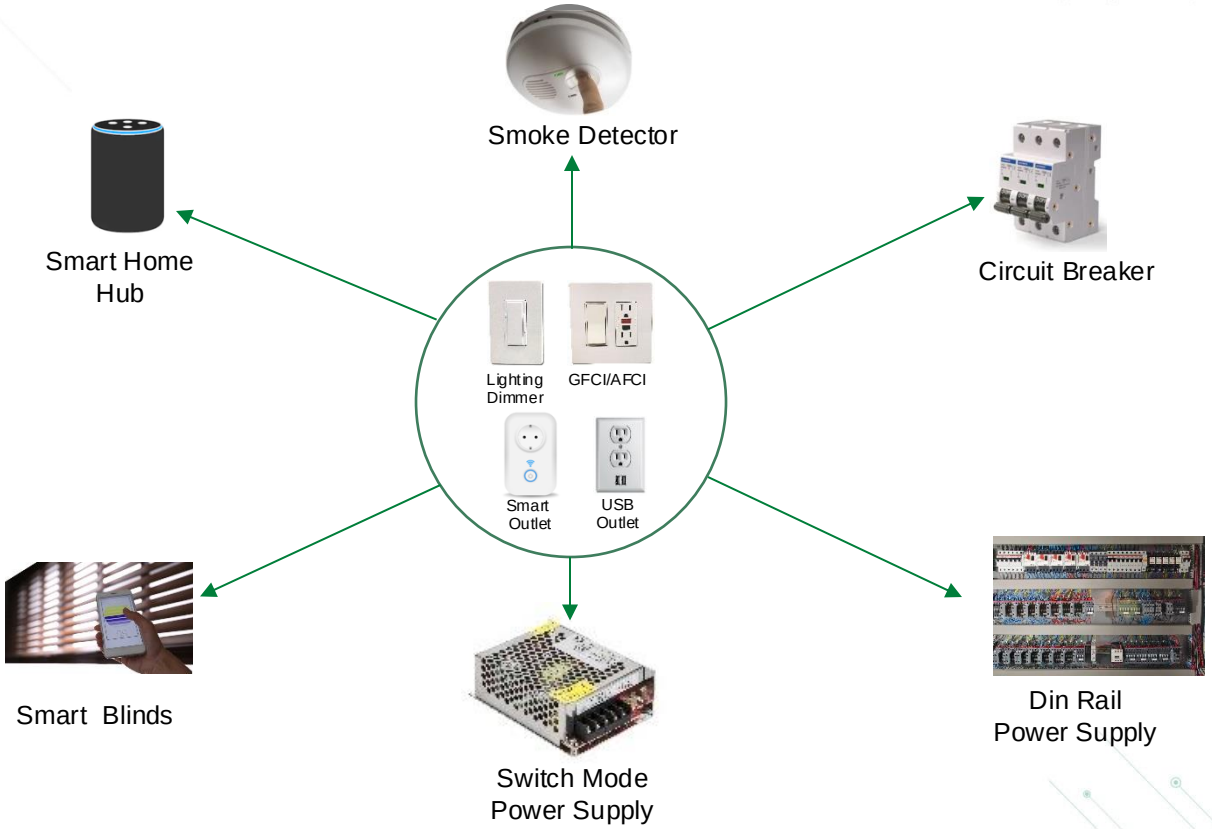
Electronic Dimmers & Smart, USB, and GFCI Outlets

Building Automation Solutions

REV0819

Many systems share functionalities with GFCI/AFCI, USB, & IoT outlets, as well as electronic light dimmers



Electronic dimmers and smart (IoT) outlet market view

Market Trends

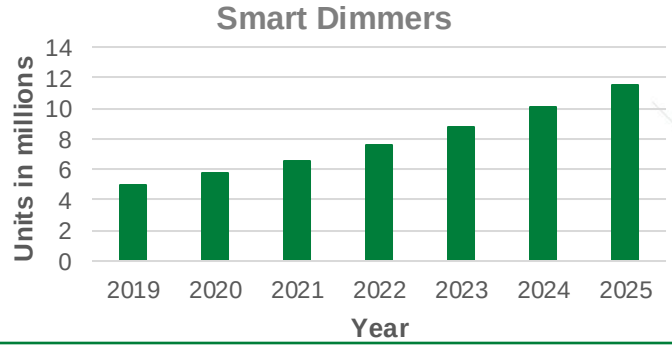
Light Dimmers:

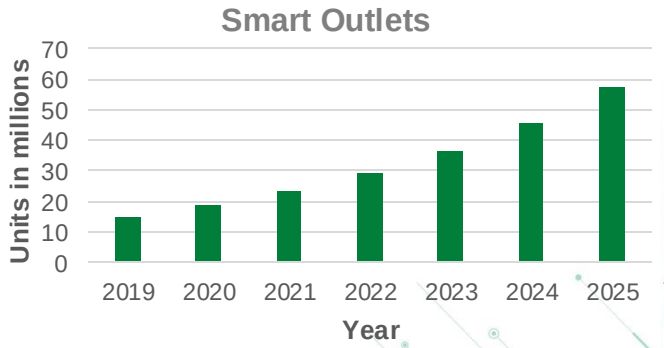
- Growing at CAGR of 5% from 2019 to 2024; 150M units/year to 200M units/year
- Smart dimmers growing at 15% from 2019 to 2024
- 5M units/year to 15M units/year
- Dimmers can reduce energy usage and increase bulb lifetime
- Some dimmers need upgrading and technology considerations to be compatible with LED luminaries

Smart Outlets:

- Growing at a CAGR of 25% from 2019 to 2024; 9M units/year to 45M units/year
- Ability to provide power usage data
- Receptacle customized for geography
- Capability to integrate smart home functionality

Smart Dimmer and Smart Outlets growing at 15% and 25%





GFCI/AFCI and USB outlets market overview

Market Trends

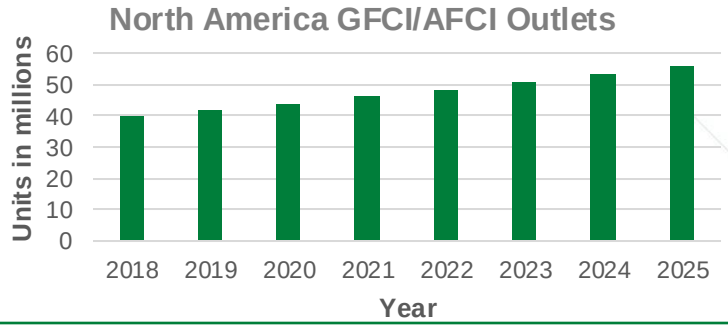
GFCI/AFCI Outlet:

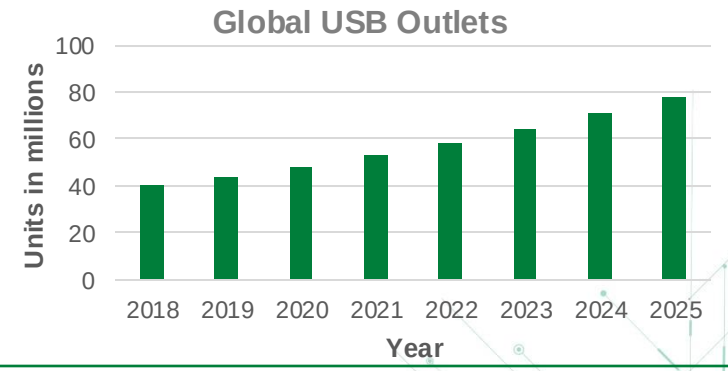
- Mature market growing at a CAGR of 5%.
- GFCI/AFCI wall receptacles almost exclusively used in NA, 60M units/year
- Other regions have residual current detector or RSD in breaker distribution panel
- Manufacturers evaluating combined GFCI and AFCI in one product

USB Outlet:

- Market growing at a CAGR of 10%
- Global market is approximately 40M units/year
- Highly fragmented market; tier-1 players hold 5 to 10% of market share
- USB-A and USB-C connection options available

GFCI/AFCI and USB outlets market





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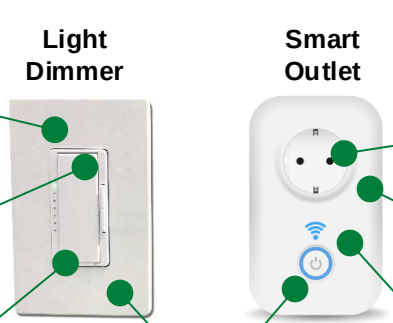
Protection and control in light dimmers and smart outlets

AC Line Protection:
- MOV
- TVS Diode
- Fuse

Switching:
- TRIAC
- MOSFET
- Gate Driver

Wireless Interface:
- TVS Diode
- Polymer ESD



Local control:
- TVS Diode

AC Input Protection:
- MOV
- Fuse
- TVS Diode

Power Supply Switching:
- MOSFET
- Gate Driver

Wireless Interface:
- TVS Diode
- Polymer ESD

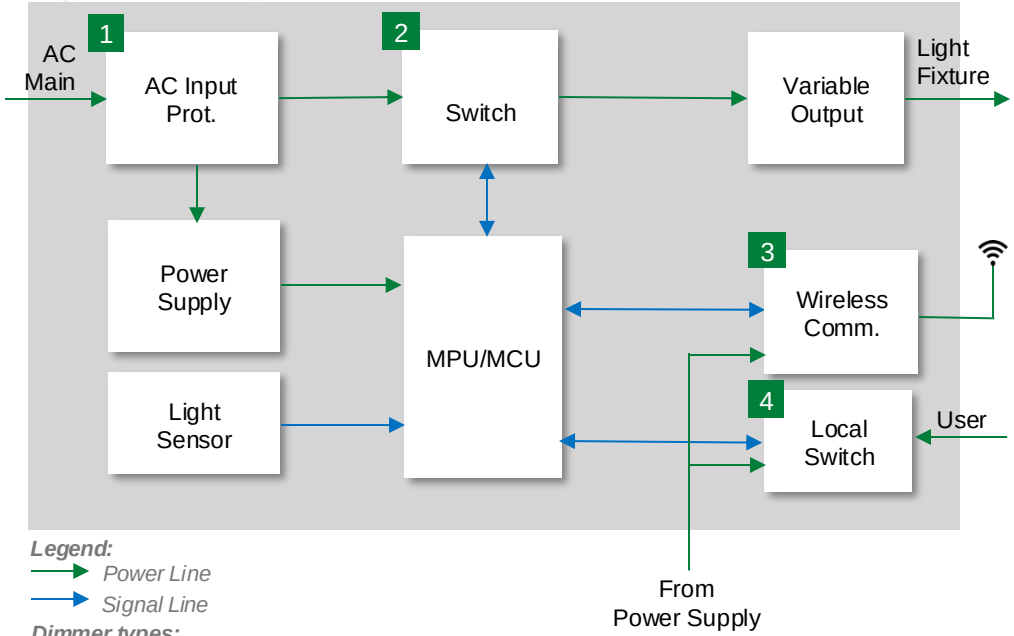
Protect Control Sense

TVS: Transient-Voltage Suppression
MOV: Metal Oxide Varistor
MOSFET: Metal Oxide Field Effect Transistor
TRIAC: Triode for Alternating Current

Functions:

- ***Light dimmers**, instead of diverting energy from the light bulb into a resistor the modern light bulb circuit is switched off many times per second around the fluctuation of household alternating current for efficiency.*
- ***Smart outlets**, are power receptacles that plugs into or replaces traditional outlets and integrates into smart home/business network and allows you to control what is plugged into it from an app on your smartphone or with your voice through virtual assistance.*

Electronic dimmer architecture



Legend:

- *Power Line*
- *Signal Line*

Dimmer types:

- *Smart (IoT) dimmer that can be remotely controlled*
- *Intelligent dimmers that can control dimmer timing and range*
- *Basic dimmer with no intelligence such as adjustable dimming rates, delays, or indicators have minimum protection requirements*

	Technology	Series
1	Fuse	Nano, Pico
	MOV	UltraMOV
	TVS Diode	SMCJ
2	TRIAC	Q6008xH1LED
	Gate Driver	IX4340
	MOSFET	650V X2 Series
	MOV	TMOV
3	Diode Array	SP3213
	Polymer ESD	PESD
4	Diode Array, Polymer ESD	SP3213, PESD

Notes:

- *Typically 250V or 300V for 120VAC applications and 650V for 230VAC applications.*
- *tMOV used with MOSFET and will be across switch*
- *MOV used with TRIAC*

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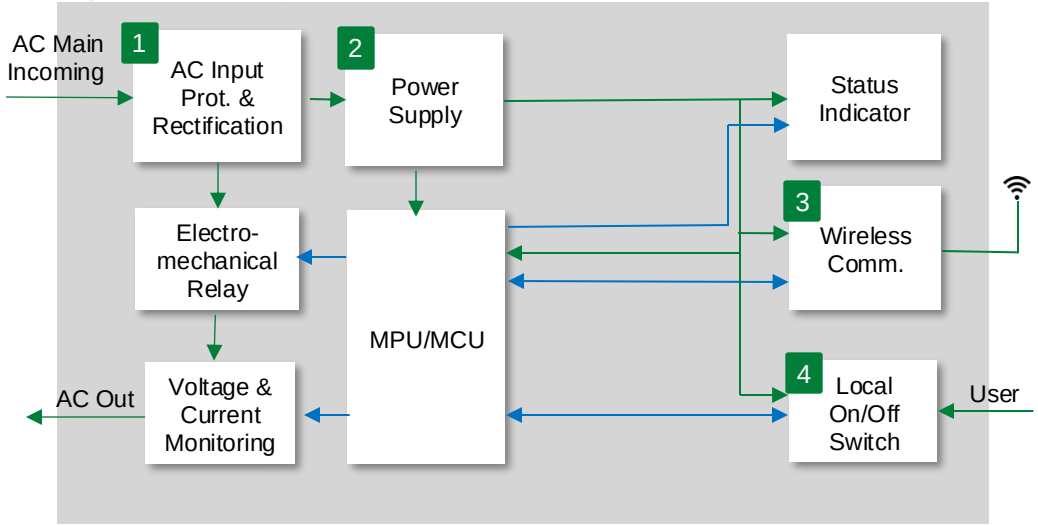
Benefits of Littelfuse components in electronic dimmers

	Technology	Function in Application	Series	Benefits	Features
1	Fuse	Protects input power stage and downstream components from faults due to overcurrent	Nano, Pico	Reduces customer qualification time by complying with third party safety standards such as UL/IEC	Third party compliance UL/IEC, low internal resistance, shock safe, and vibration resistant
	MOV	Protects power supply from line voltage surges and fulfils regulatory requirements	UltraMOV	Reduces customer qualification time by complying with third party safety standards such as UL/IEC	High peak surge current rating up to 10KA and high operating temperature range up to 125°C
	TVS diode	Protects sensitive electronic components from voltage transients	SMCJ	Improves system reliability by protecting downstream components from transients on power lines	1500W peak pulse capability and compatible with lead-free solder reflow temperature profile
2	Triac	AC switching for dimming light	Q6008xH1LED	Allows for efficient energy conservation and compact design	UL recognized to UL 1557, provides full control of light output at extreme low end of load conditions
	Gate Driver	High-side and low-side gate driver for power MOSFETs	IX4340	Enables fast MOSFET switching	Capable of sourcing and sinking up to 5A
	MOSFET	Turns power supply units on and off	650V X2 Series	Fast response time and lower heat signature	Low Rds (on) and dv/dt ruggedness
	MOV	Protects power supply from line voltage surges and fulfils regulatory requirements	TMOV	Reduces customer qualification time by complying with third party safety standards such as UL/IEC	Integrated thermal protection device and high peak surge current rating up to 10KA
3	TVS diode array	Protects wireless chipsets from ESD induced by user	SP3213	Smaller form-factor and multi-line protection enables ease of design	Space efficient 0201 form-factor, third party compliance, and low capacitance
	Polymer ESD	Protects wireless chipsets from ESD induced by user	PESD	Smaller form-factor and multi-line protection enables ease of design	Fast response (<1nS), low leakage current, and very low capacitance of 0.25pF per I/O
4	Diode Array, Polymer ESD	Protects IC from ESD induced by user	SP3213, PESD	Smaller form-factor and multi-line protection enables ease of design	Low capacitance of 1.0pF per I/O

Smart outlet architecture



Legend:

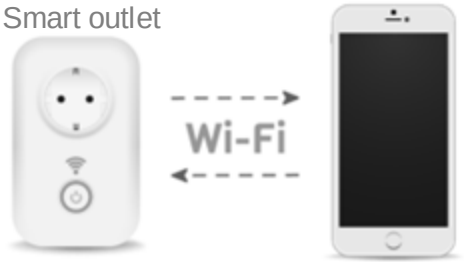
- *Power Line*
- *Signal Line*

	Technology	Series
1	Fuse	Nano, Pico
	MOV	UltraMOV
	TVS Diode	SMCJ
2	Schottky Rectifier	DST
3	TVS Array	SP3213
	Polymer ESD	PESD
4	TVS Array, Polymer ESD	SP3213, PESD

Notes:

- *Some smart outlets have USB power outlet. See Slide 13 for additional protection.*
- *Some designers choose to use large caps and transformers which reduces protection requirements*

Smart outlet



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Benefits of Littelfuse components in smart (IoT) outlets

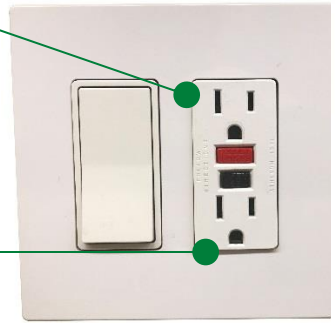
	Technology	Function in Application	Series	Benefits	Features
1	Fuse	Protects input power stage and downstream components from faults due to overcurrent	Nano, Pico	Reduces customer qualification time by complying with third party safety standards such as UL/IEC	Third party compliance UL/IEC, low internal resistance, shock safe, and vibration resistant
	MOV	Protects power unit from voltage surges such as lighting and transients	UltraMOV	Reduces customer qualification time by complying with third party safety standards such as UL/IEC	High peak surge current rating up to 10KA and high operating temperature range up to 125°C
	TVS diode	Protects sensitive electronic components from voltage transients	SMCJ	Improves system reliability by protecting downstream components from transients on power lines	1500W peak pulse capability and compatible with lead-free solder reflow temperature profile
2	Schottky Diode	Rectification and blocking in power supply units	DST	Enables the design of high efficiency power supplies	Ultra low forward voltage drop and high frequency operation
3	TVS diode array	Protects wireless chipsets from ESD induced by user	SP3213	Smaller form-factor and multi-line protection enables ease of design	Space efficient 0201 form-factor, third party compliance, and low capacitance
	Polymer ESD	Protects wireless chipsets from ESD induced by user	PESD	Smaller form-factor and multi-line protection enables ease of design	Fast response (<1nS), low leakage current, and very low capacitance of 0.25pF per I/O
4	Diode Array, Polymer ESD	Protects IC from ESD induced by user	SP3213, PESD	Smaller form-factor and multi-line protection enables ease of design	Low capacitance of 1.0pF per I/O

Protection and control in GFCI/AFCI and USB outlets

AC Line Protection:
- Metal Oxide Varistor (MOV)
- Transient-Voltage Suppression (TVS) Diode

Trip circuit:
- Silicon Controlled Rectifier (SCR)

GFCI/AFC Receptacle



USB Receptacle

AC Input Protection:
- Metal Oxide Varistor (MOV)
- Fuse
- TVS Diode

Power Supply Switching:
- MOSFET
- Gate Driver

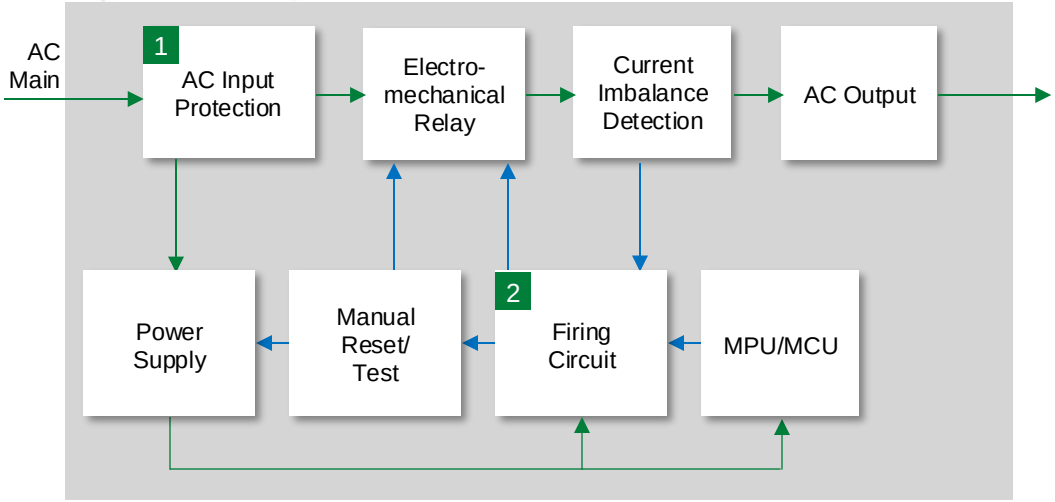
SCR: Silicon Controlled Rectifier
TVS: Transient-Voltage Suppression
MOV: Metal Oxide Varistor

Protect Control Sense

Functions:

- ***GFCI Outlet****, ground fault circuit interrupter, is a circuit breaker which shuts off an internal circuit breaker when it senses an imbalance between outgoing and incoming circuit. The main purpose is to protect people from electrical shock. The U.S. National Electric Code defines when required.*
- ***AFCI Outlet****, arc fault circuit interrupter, is a circuit breaker that detects electrical arcs and protects against electrical fires. In the U.S. over 40,000 fires are attributed to home electric wiring which results in 350 deaths and 14,000 injuries on average each year according to U.S. Product Safety Commission.*
- ***USB Outlet*** *can combine receptacles with USB charging ports. The charging ports operate as switch mode power supplies.*
- ***Conventional circuit breakers*** *only respond to overloads and short circuits.*

GFCI/AFCI outlet architecture



Legend:
- *Power Line*
- *Signal Line*

	Technology	Series
1	Fuse	Nano, Pico
	MOV	UltraMOV
	TVS Diode	SMCJ
2	SCR	SJxx08xSx/SJxx08xx

GFCI/AFCI outlet

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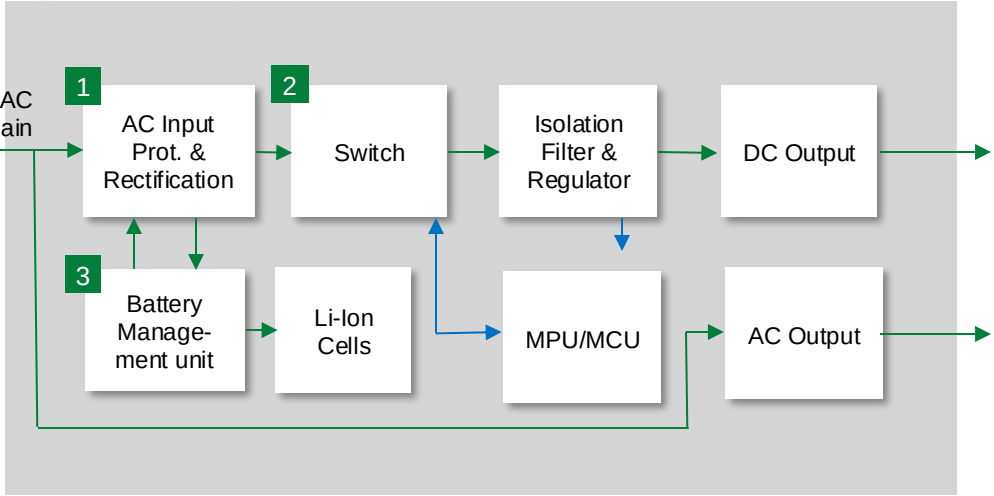
Benefits of Littelfuse products in GFCI/AFCI outlet

	Technology	Function in Application	Series	Benefits	Features
1	Fuse	Protects input power stage and downstream components from faults due to overcurrent	Nano, Pico	Reduces customer qualification time by complying with third party safety standards such as UL/IEC	Third party compliance UL/IEC, low internal resistance, shock safe, and vibration resistant
	MOV	Protects power unit from voltage surges such as lighting and transients	UltraMOV	Reduces customer qualification time by complying with third party safety standards such as UL/IEC	High peak surge current rating up to 10KA and high operating temperature range up to 125°C
	TVS diode	Protects sensitive electronic components from voltage transients	SMCJ	Improves system reliability by protecting downstream components from transients on power lines	1500W peak pulse capability and compatible with lead-free solder reflow temperature profile
2	SCR	Triggers electro-mechanical relay to disengage electrical contacts during fault	SJxx08xSx/SJxx08xx	Allows for efficient and compact design due to simple control circuit and quick turn on	Up to 600V capability and high surge capability up to 100A

USB outlet architecture



USB outlet operates as a switch mode power supply

Legend:

Power Line

Signal Line

	Technology	Series
1	Fuse	Nano, Pico
	MOV	UltraMOV
	TVS Diode	SMCJ
2	Schottky Rectifier	MBR, DST
	Gate Driver	IX4340
	MOSFET	650V X2 Series
3	NTC	UPS16673

Notes:

Some designers choose to use large caps and transformers which reduces protection requirements.

USB outlet

Potential Littelfuse products for USB outlets

	Technology	Function in Application	Series	Benefits	Features
1	Fuse	Protects input power stage and downstream components from faults due to overcurrent	Nano, Pico	Reduces customer qualification time by complying with third party safety standards such as UL/IEC	Third party compliance UL/IEC, low internal resistance, shock safe, and vibration resistant
	MOV	Protects power unit from voltage surges such as lighting and transients	UltraMOV	Reduces customer qualification time by complying with third party safety standards such as UL/IEC	High peak surge current rating up to 10KA and high operating temperature range up to 125°C
	TVS diode	Protects sensitive electronic components from voltage transients	SMCJ	Improves system reliability by protecting downstream components from transients on power lines	1500W peak pulse capability and compatible with lead-free solder reflow temperature profile
2	Schottky Diode	Rectification and blocking in power supply units	MBR, DST	Enables the design of high efficiency power supplies	Ultra low forward voltage drop and high frequency operation
	Gate Driver	High-side and low-side gate driver for power MOSFETs	IX4340	Enables fast MOSFET switching	Capable of sourcing and sinking up to 5A
	MOSFET	High switching speed in power supply units	650V X2 Series	Fast response time and lower heat signature	Low Rds (on), dv/dt ruggedness
3	NTC	Temperature sensing	UPS16673	Provides accurate temperature (component/ambient) for enabling safe device operation	Tight tolerance, ultra thin, and customizable

Industry Standards

	 **Lighting Dimmer**	 **GFCI/AFCI**	 **Smart Outlet**	 **USB Receptacle**
Safety	▪ UL 1472 ▪ IEC 63036	▪ UL 943 – GFCI ▪ IEC 61008 Series - RCD ▪ UL 1699 – AFCI ▪ IEC 62606 - AFDD	▪ UL 231	▪ UL 498
ESD	Electrostatic Discharges – IEC 61000-4-2 Electrical Fast Transient – IEC 61000-4-4 Surge Immunity – IEC 61000-4-5			

Standards and compliances

Standard	Title	General Scope	Region
UL 1472	Solid State Dimming Control	Covers dimmers (non-touch) rated <600 vs touch rated <120 volts ac and electric s/ws minimum power rating of 300 watts incandescent or 300 volt-amp	North America
IEC 63036	Standard for Automatic Electric Controls for household	Specifies the electrical interface and test procedures for the control by mains voltage phase-cut dimming	Global
UL 943	Standard for Safety for GFCI	Class A, single and three-phase GFCI intended for personnel protection	North America
IEC 61008	RCCB without integral overcurrent protection for household	Protection against safety hazard (RCCB rated <440V, 125A)	Global
UL 1699	Standard for Safety for Arc-Fault Circuit-Interrupters	Covers AFCIs maximum rating of 20A and are intended for use in 120-Vac, 60-HZ circuits; cord AFCIs are rated up to 30A	North America
IEC 62606	General requirements for arc fault detection devices	Applies to arc fault detection devices (AFDD) for household and similar uses in AC circuits	Global
UL 231	Standard for Power Outlets	Cover power outlets, with or without integral mounting posts or pedestals	North America
UL 498	Standard for Attachment Plugs and Receptacles	Covers attachment plugs, receptacles, cord connectors, inlets, current taps provided with wiring terminals for flexible cord, and flatiron and appliance plugs	North America
UL 1310	Standard for Class II Power Units	Safety requirements covering indoor and outdoor use Class II power supplies and battery chargers	North America
UL 916	Standard for Energy Management Equipment	Covers energy management equipment and associated sensing devices rated 600V	North America
IEC 61000-4-2	Testing – Electrostatic Discharge (ESD)	Checks capability of the equipment to survive repetitive electrical fast transients and bursts	Global
IEC 61000-4-4	Electrical fast transient/burst immunity test	Evaluating the immunity of equipment when subjected to electrical fast transient/bursts on supply, signal, control, and earth ports	Global
IEC 61000-4-5	Fast Transient Surge Test	Evaluate the immunity of equipment when subjected to surges	Global

Why choose Littelfuse

- Global leader with broad product portfolio covering every aspect of protection, sensing, and control
- Application expertise combined with product designed guidelines to help you determine best component for your application
- Testing capabilities and assistance to support confirmation of product selection
- Standards compliance expertise including product compliance to many standards and approval support
- High-volume manufacturing, committed to the highest quality standards
- Global company with local support

We are committed to supporting your success

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