

November 2023

Fault Managed Power Systems / Class 4 Power

In this brief:

Fault Managed Power Systems (FMPS), also referred to as Class 4 Power in the 2023 National Electrical Code developed by the National Fire Protection Association (NFPA), represent a new power distribution technology that was standardized by UL through collaboration with Panduit and other leaders. Read on to learn about how FMPS work, and the opportunities they unlock for safely and efficiently distributing significant power across long distances.

NEC Power Classes at a Glance

First published in 1897 by the National Fire Protection Association (NFPA) and regarded as the authoritative standard for safe electrical practices, the National Electrical Code (NEC) is a set of standards for the safe installation of electric systems for preventing fires and other electrical accidents. Until recently, the NEC specified three classes of electrical power, with each representing a distinct characteristic of the voltage and power threshold through a circuit.

Class 1 Power

Class 1 is a non-power-limited circuit with a 600-volt limit. As the most deployed class of power, it can go long distances and does not adhere to any power limits. All residential and commercial buildings run Class 1 electrical power. Despite not adhering to a power limit, the use of Class 1 Power carries risks of fire or electrical shock, and, therefore, a licensed electrician must do the installation following strict installation requirements using conduit.

Class 2 Power

Class 2 is a power-limited circuit with 60-volt and 100-watt power limits, making it safer from a fire initiation standpoint and providing acceptable protection from electric shock. It has no stringent installation requirements, covered in Article 725 of NFPA 70, and may be installed by non-electricians, depending on local jurisdiction rules. “Power” in Power over Ethernet (PoE) is considered Class 2, making PoE the most common and widely used Class 2 today.

Class 3 Power

Class 3 is a power-limited circuit with 150-volt and 100-watt power limits, like Class 2. The primary uses of Class 3 are for home theatre and sound systems. While it is safe from a fire initiation standpoint, the risk of a shock hazard remains present. For this reason, wiring practices that are more stringent than Class 2 require installations by licensed electricians.

The Call for Class 4 Power

In 2020, Underwriters Laboratory (UL) formed a group of interested industry members, including Panduit, to collaborate on developing a new safety standard to govern existing and future power delivery systems that operate in a grey area, where they do not fit into the existing three classes of power mentioned above. UL and the industry now refer to these systems as Fault Managed Power Systems (FMPS). Through the efforts of Panduit and the leading members of this group, two standards have been published:

1. UL 1400-2: Outline of Investigation for Fault Managed Power Systems, Part 2: Cable Requirements; published on August 4, 2022
2. UL 1400-1: Outline of Investigation for Fault Managed Power Systems, Part 1: Safety Requirements; published on December 19, 2022

In 2023, the NEC added a new class of power for the first time in 45 years: Class 4 Fault Managed Power Systems (FMPS). Based on the two published standards, UL 1400-1 and UL 1400-2, Article 726 of NFPA 70 covers Class 4 power.

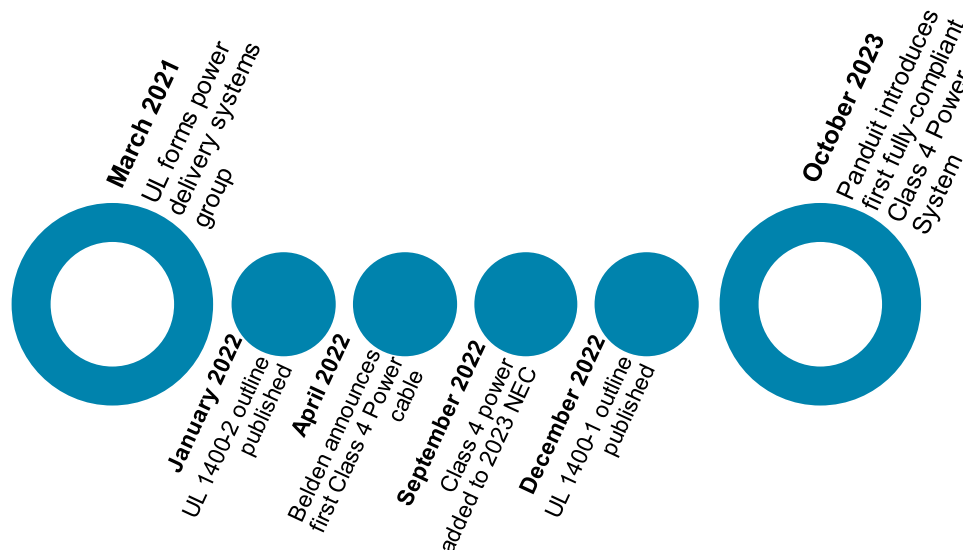


Figure 1: Development timeline for Class 4 Power / Fault Managed Power Systems.

What is a Class 4 Fault Managed Power System and Circuit?

Class 4 FMPS are end-to-end power delivery systems that transmit power from a power transmitter over cables to a receiver, all listed for Class 4. A Class 4 transmitter is an energy-limited power source constantly monitoring for faults over the Class 4 wire. If a fault occurs, the transmitter detects it and quickly isolates the power by limiting the fault energy to a safe level based on UL 1400-1 requirements. By limiting the fault energy, these systems mitigate against risk of fire or shock and, therefore, allow for the exact wiring methods afforded to Class 2 circuits.

The diagram below shows the components that make up a Class 4 FMPS. A listed Class 4 transmitter takes power from a power supply and converts it to a Class 4 circuit. A listed Class 4 receiver converts the Class 4 circuit into the power form of power needed by the powered devices. The receiver can either be a standalone device, or integrated into the powered device, as shown in Figure 2 below.

Fault Managed Power Systems / Class 4 Power

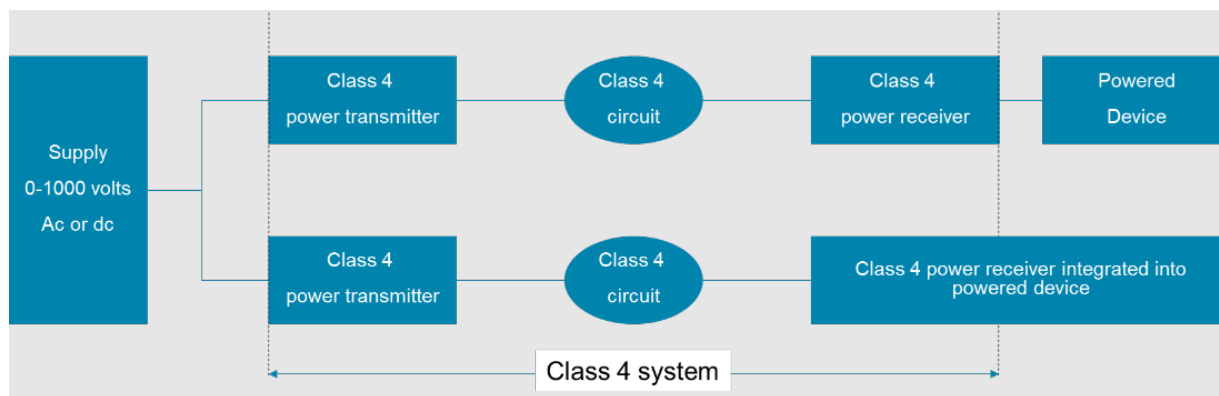


Figure 2: Components of a Class 4 / Fault Managed Power System.

In summary, a Class 4 circuit is an energy-limited fault condition circuit with a voltage limit of 450 volts. Unlike Class 2 or 3, Class 4 circuits do not have any power limits. Therefore, Class 4 circuits provide the best of both worlds: no power limit like a Class 1 circuit, with non-stringent installation requirements like Class 2 circuits. With a voltage limit of 450 volts and no power limit, Class 4 circuits can deliver hundreds and even thousands of watts over significantly long distances safely and efficiently. To have a listed Class 4 transmitter and receiver, they must be tested and compliant with UL 1400-1. In the next section, we explore the faults and requirements of UL 1400-1.

Table 1: Characteristics of Power Delivery Classes

	Class 1	Class 2	Class 3	Class 4 / Fault-Managed Power Systems
Power Limit	High power levels	100 W	100 W	High power levels – Up to 600W per copper pair (Typical)
Voltage Limit	600 V	60 V	150 V	450 V
Common Uses	- Building wiring - Portable applications without a class rating	- Power over Ethernet (PoE) - Wireless radios - Doorbells	Home theatre and sound systems	- Outdoor wireless - In-building wireless - Lighting - Digital signage - Gigabit passive optical networks (GPONs) - Smart buildings
Installation/Wiring	Electrician required	Low-voltage technician	Electrician required	Low-voltage technician
Wire Gauge	Large wire gauge	Gauge is Power and Distance Dependent	24 AWG	Small wire gauge (16-18 AWG Typical)
Distance	Long range – No Limit	Limited Range (300 m Typical)	Short distance	Long range – No Limit (2 km Typical)

*Class 4 Power, also known as Fault Managed Power Systems, was added to the NEC code in 2023.

Class 4 FMPS Fault Management and the Requirements of UL 1400-1

Per the NEC Article 726, the following conditions are considered faults for which a Class 4 transmitter must interrupt an energized circuit if they occur:

1. A short circuit
2. A line-to-line fault condition
3. A ground-fault condition
4. An overcurrent condition
5. A malfunctioning of the monitoring or control system
6. Any other condition that presents an unacceptable risk of fire or electric shock

The above conditions are general guidance; however, for the details of testing and listing a Class 4 system, Article 726 requires systems to test and comply with UL 1400-1, which is concerned with ensuring that a Class 4 FMPS adequately mitigates against shock or fire hazards. Below, we explore the definition of these hazards and the possible faults to prevent.

Fire Hazard:

A Class 4 system must prevent fire hazards by mitigating against any ignition mechanism like arcing and short circuits. There are five faults listed in UL 1400-1 to test for, illustrated in Figure 3:

- Line-to-Line Resistive Fault
- Short Circuit
- Series Arc
- Line-to-Line Arc
- Series Resistance (Optional)

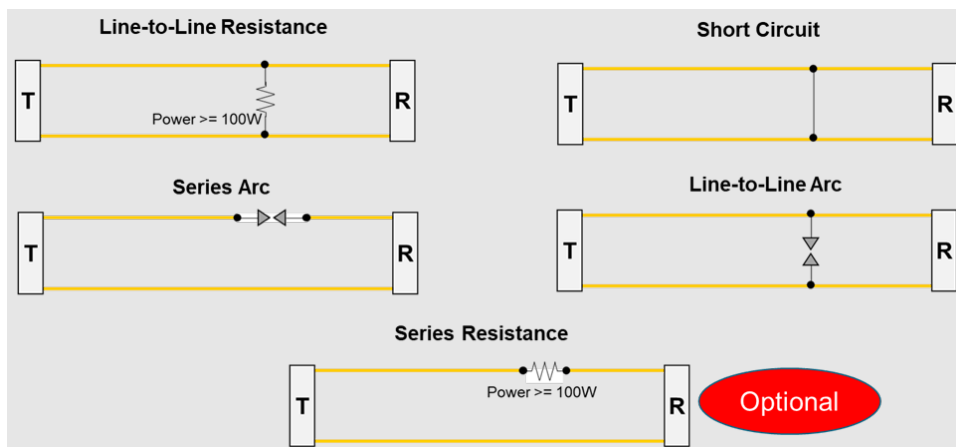


Figure 3: Fire hazard faults that are tested for with Class 4 power systems;
T=Transmitter, R=Receiver.

Within milliseconds, a Class 4 system detects and interrupts the flow of electricity in all the faults listed above. Like Arc Fault Interrupters (AFI), Class 4 Systems limit the energy going into a series arc fault or line-to-line arc fault to limit the fire risk. Class 4 systems also detect line-to-line resistive faults above 100W to limit the amount of heat generated between the lines to the limits of a Class 2 circuit. In the case of limiting the risk of fire from a series resistive fault, Class 4 systems can limit a series resistance fault to 100W or use connectivity with the proper voltage rating for a Class 4 circuit.

Shock Hazard:

A Class 4 system must prevent a shock to a person that could arise from multiple contacts, all to ensure the safety of the person engaged with these systems. Illustrated in Figure 4 are three shock conditions to test for as listed in UL 1400-1:

- Line-to-Ground
- Line-to-Line
- Line Pair 1 to Line Pair 2

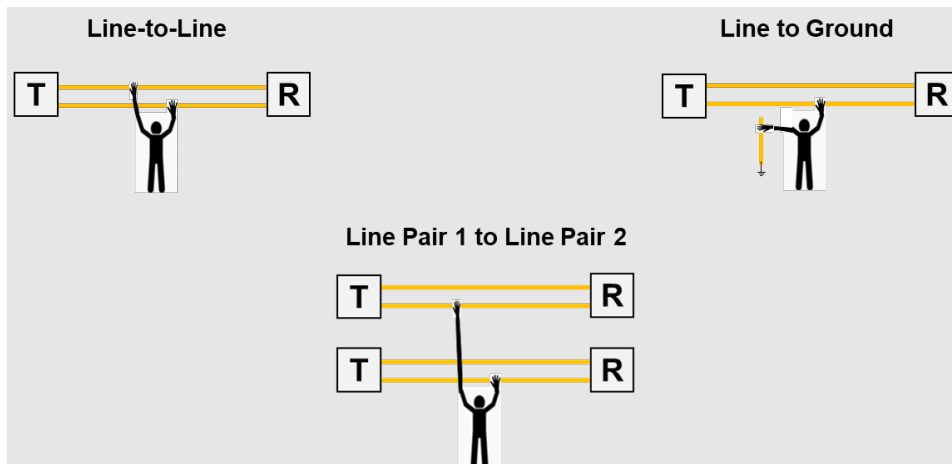


Figure 4: Shock hazard faults that are tested for with Class 4 power systems;
T=Transmitter, R=Receiver.

Line-to-ground is a familiar fault. Residential outlets near wet locations such as bathrooms and kitchens are called Ground Fault Circuit Interrupters (GFCI) or Ground Fault Interrupters (GFI). They interrupt a fault when a line-to-ground fault is detected. If a person accidentally touches one of the wires while grounded, the person will feel a shock, but the outlet will interrupt the current flow and close the circuit to avoid any harm to the person. However, if the person touches both lines of the circuit, the GFI outlet cannot distinguish between the person and a load, such as your phone charger or a microwave. Therefore, it could cause harm to the person that comes into contact with the wires.

Class 4 systems can detect ground faults and line-to-line defects, such as someone coming into contact with two wires. If the system detects any faults, it limits the amount of energy going into the fault by turning it off within milliseconds to avoid harm to the person touching the circuit. For this reason, Class 4 circuits differ from Class 1 circuits we have in our homes and offices in the ability to detect and limit the energy going into all shock hazard scenarios, making Class 4 circuits a safer way to deliver electricity, as shown in Table 2.

Table 2: Power systems and safety hazard scenarios

Class 4 Systems are Safer across the board!				
Hazard	Fault Type	GFCI	AFCI	Class 4
Shock	Line-to-Earth	✓	✓	✓
	Line-to-Line	⚡	⚡	✓
Fire	In-Line Arc	🔥	✓	✓
	Parallel Arc	🔥	✓	✓
	Line-to-Line resistive	🔥	🔥	✓
	In-line Resistive	🔥	🔥	✓
Source: BICSI 2022 Speaker Section 23: Class 4 Power				

In addition to all the fault requirements discussed above, the UL 1400-1 standard dictates that a Fault Managed Power System shall also comply with the following:

1. The relevant requirements of the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1
2. IEC 61508-1 for functional safety requirements for electrical, electronic, and programmable electronic safety-related systems
3. FCC 47 CFR PART 15 SUBPART B:2023
4. ICES-003 ISSUE 7:2020

The First Fully Compliant Class 4 Fault Managed Power System

The Panduit Fault Managed Power System is the first Class 4 System in the industry based on NFPA 70 Article 726 requirements. It is the first system certified to UL 1400-1 and IEC/UL 62368-1 and meets the functional safety requirements of IEC 61508.

The Panduit FMPS combines the best of both worlds, Class 1 and Class 2, delivering higher voltages safely. It delivers significant power over long distances, while protecting against any shock or fire hazards per the requirements of UL 1400-1 requirements. This protection enables the safety benefits of a low-voltage installation, making it a safe, reliable, and easy-to-install power delivery system that provides substantial time and cost savings.

How it Works

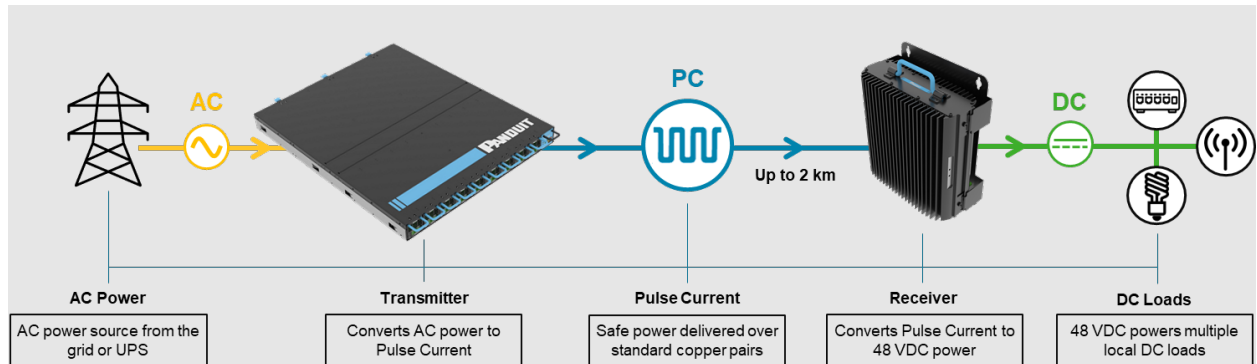


Figure 5: How the Panduit Fault Managed Power System works.

1. The Power Transmitter accepts standard AC power from a grid or UPS
2. The Transmitter converts standard AC power from a grid or UPS into higher voltage DC power, then into a pulsed current waveform, or Class 4 circuit
3. Class 4 cable delivers safe power to the Receiver (Class 4 Cable is detailed in NPFA Article 722)
4. The Receiver converts the pulsed current (Class 4 circuit) into 48-volt DC power to multiple end devices; Each pulse provides a safe duration, where touching or shorting the cable is automatically detected

How Quickly it Responds

The Pulse Current (Class 4 circuit) Panduit FMPS used for power delivery consists of 3 millisecond periods: 2 milliseconds of power ON and 1 millisecond of power OFF. The system constantly checks for faults required by the UL 1400-1 standard. If any fault occurs, the Panduit FMPS Transmitter limits the amount of energy going into a fault by turning power OFF within 2 milliseconds.

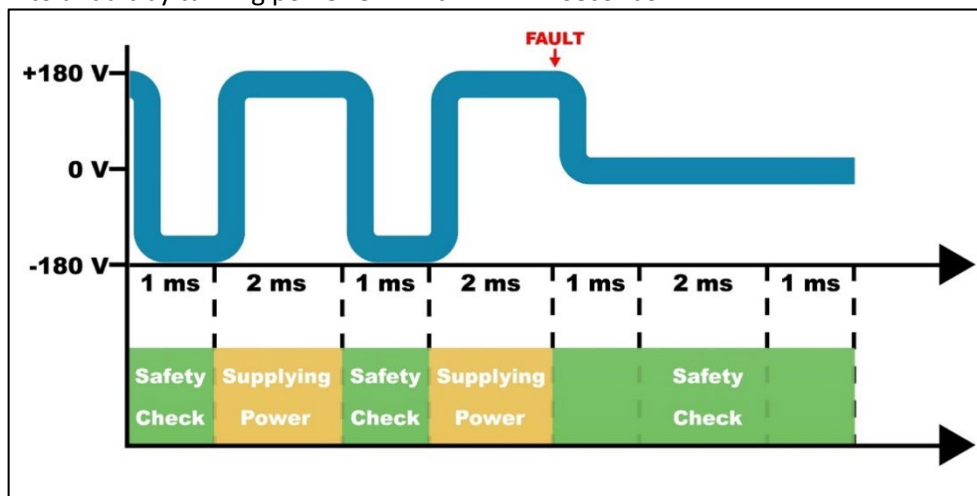


Figure 6: The Panduit Fault Managed Power System responds to faults within 3 milliseconds.

Key Benefits

Safety:

The Panduit FMPS is a safe and reliable Class 4 system, thoroughly tested to comply with UL 1400-1 and the requirements of NEC Article 726 for Class 4 systems, offering peace of mind for all users. It is an easy-to-install power delivery system using low-voltage wiring methods. In addition to monitoring the circuit for faults and limiting the energy transmitted into the fault, the Panduit FMPS automatically turns back ON after a fault is cleared, making it easier to manage remotely.

Savings:

The Panduit FMPS is more efficient and cost-effective than alternative methods of delivering power greater than 100W. For example, a pair of 16 AWG wires can transport 520 watts for 500 meters or 250 watts for 2000 meters. Back up all endpoints on a single UPS and save on UPS costs and valuable real estate in any environment with multiple send devices at the edge.

Sustainability:

The Panduit FMPS technology offers unparalleled power delivery, providing up to 30 times the power and distance of traditional Class 2 power systems while utilizing fewer copper pairs and thinner wire gauges. This groundbreaking approach transforms how power is transmitted and notably contributes to a more sustainable world.

The Panduit FMPS enables up to 60% savings on cable costs, by maximizing power efficiency and minimizing resource usage. These impressive figures represent our [environmental stewardship](#). With the Panduit FMPS, we are meeting the demands of today while building a greener tomorrow – one innovation at a time.

Learn More about the Panduit Fault Managed Power System

For more information about the Panduit Fault Managed Power System, visit our [website](#).