Interconnected Equipment
Fault Ground Current
History

- The technological evolution of 90’s and introduction of personal computing and internet brought us at the footsteps of Information Age, also commonly known as the Computer Age or Digital Age.
History cont.

- The two decades transitioning from simple one-piece setup to multitasking workstation has some implications.
History cont.

- As number of devices used on our desk has significantly grown from 1 or 2 to 10 or more we have been forced to use other not task related devices such as power strips, power extension cords, splitters, UPS and etc. to distribute the power which often results in us of more than one wall outlet.
Background

• **Ground Current:**
  - Electric current that flows in the Protective Earth (PE) as a result of a difference in the potential between points of a PE system.

• **Issue:**
  - Two or more products with three-wire power cords providing functional ground connected to two different AC outlets and interconnected by a signal cable.
  - The voltage differences between two PE grounds may drive large currents (fault current) through the products’ functional ground path.
  - The voltage differences are usually caused by miswire of one of the AC outlets in setup wiring or the building wiring.
  - The fault current may cause components and traces in the products to overheat and fail. The voltage differential ranges from a few volts to the full value of the AC mains depending on type of “miswiring”.

• **Result:**
  - The customer experience will range from: continued operation (least extreme) – sparking cables – warm cables - smoke from damaged components - tripping circuit breakers – exposure to electric shock – possible risk of electrically caused fire–(most extreme).
Equipment connected by a USB cable

Normal Operation

120/240 VAC

Circuit breaker

Line

Neutral

PE Ground

AC Outlet 1

Product 1 Chassis

Product 2 Chassis

Ground wire & Interconnect Cable (USB)

Normal

To other outlets

AC Outlet 2
Equipment connected by a USB cable

Normal Operation - PE Ground reversed with Neutral

120/240 VAC

AC Outlet 1

Circuit breaker

Line

Neutral

PE Ground

AC Outlet 2

Product 1 Chassis

One PE Ground connection reversed with Neutral & Interconnect cable (USB) with Neutral Current

To other outlets

Product 2 Chassis
Equipment connected by a USB cable
Non-Operational - PE Ground reversed with Line

120/240 VAC
Neutral
PE Ground

AC Outlet 1
AC Outlet 2

Product 1 Chassis
Product 2 Chassis

One PE Ground connection reversed with Line & Interconnect Cable (USB) with Line Fault Current

Fault Current

To other outlets

Circuit breaker
Line

Fault Current

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Equipment connected by a USB cable

Operational without USB & Non-Operational with USB - 2-wire system Line & Neutral reversed

120/240 VAC

Circuit breaker

AC Outlet 1

(“L” N)

Product 1 Chassis

(N) PE Ground

Product 2 Chassis

AC Outlet 2

(L)

To other outlets

PE Ground

Fault Current

#1 Outlet, Line & Neutral connections reversed & Interconnect Cable (USB) with Line Fault Current
Options

1. Utilize a Class II power supply. A Class II power supply is not grounded therefore will not provide a path for the ground current to flow.

2. Enable power supply to limit a fault current (short circuit current) and disable it when miswiring is taking place, it might not prevent all possible system failures.

3. Require a “robust” functional ground path, between the power supply ground and any cable shields e.g. USB or parallel ports which may be connected to grounded equipment.
   - “Robust” is defined as capable to withstand 25A, 60 Hz for at least 1 minute. The intent is to survive until a building circuit breaker trips, or force a failure onto other parts of the setup other than the product.
     • USB Robustness Test
Results of house miswire

Damaged power adapter’s RTN/ground conductor =>
Results of house miswire

Damaged USB connector area

Damages may vary from arced connector, open traces or damaged components (e.g. ASIC, etc.).
Q & A

Thank You