# IEC 62368-1 Overvoltage requirements

- Consumer electronics
- Datacenter & cloud
- Building automation
- Appliances
- Mobile & wearable

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# IEC 62368-1: Global safety standard applies to wide range of electrical and electronic equipment up to 600 V

## IEC 62368-1*

### IEC 60950-1†
(Information and communication technology equipment)

Point of Sale equipment

Banking equipment

Office equipment

Telecommunication equipment

### IEC 60065†
(Audio/Video and similar electronic equipment)

Audio, video equipment, and musical instruments

### Other equipment‡

Smart IoT appliances

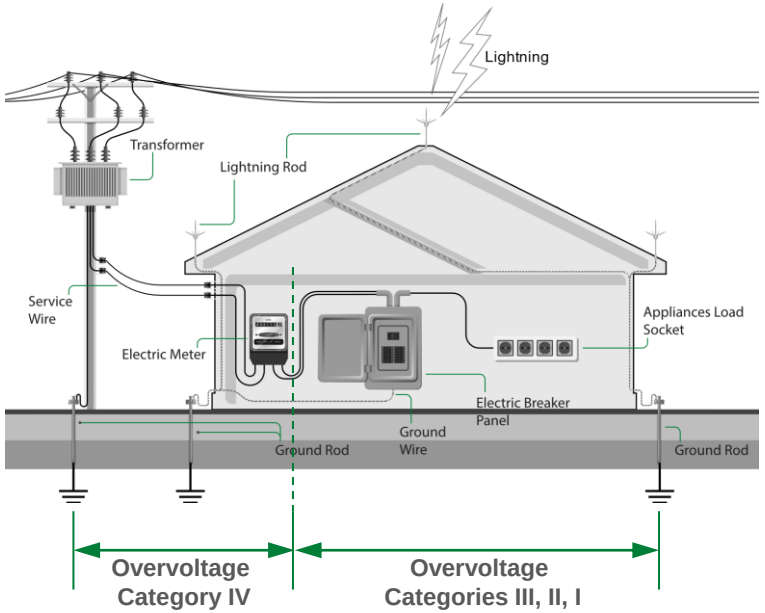
Battery powered electronic devices

* *UL/EN/CSA have created versions of 62368-1 based on IEC 62368-1*
† *Standards replaced by IEC 62368-1 starting in December 2020. All products, sub-assemblies and components previously covered under these standards are covered under UL/IEC 62368-1*
‡ *Other equipment comprises of two product types: ones not covered under any product safety standard such as smart IoT equipment and others covered under various standards such as battery powered consumer electronic devices*

# Minimum transient voltage withstand rating is determined by the AC mains voltage

| Electrical, electronic equipment, and transients |
| --- |
| Transient voltages are determined based on the system voltage and where, in a distribution system, the equipment it is connected (Overvoltage Category) |
| PCs, routers, notebooks, tablets and their power supplies fall within Overvoltage Category II (see Annex I) |
| Table 12 in section 5.4 defines the following: 120 VAC power supplies will need to withstand 1500 $V_{pk}$; 240 VAC power supplies need to withstand 2500 $V_{pk}$ |

## Overvoltage Categorization



# Additional tests included in the standard to achieve compliance when using varistors

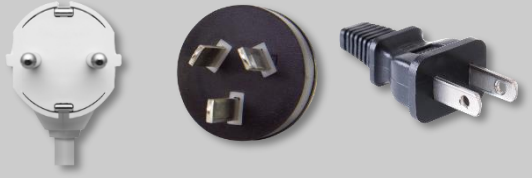
| Tests | Unreliable earth/ground bond  Non-industrial plug examples | Reliable earth/ground bond ‡  Industrial plug examples |
|---|---|---|
| Varistor overload test * (Annex G.8.2.2) | ✓ | ✓ |
| Temporary overvoltage test † (Annex G.8.2.3) | ✓ | ✓ |
| Basic insulation requirement (Clause 5.4.9.1) | ✓ | Not required |

***Table notes:*** *(Detail list of tests provided in supplementary slide)*
** Test not required if varistor voltage rating is greater than 2 x $V_R$*
*† Test not required if varistor voltage rating is (1.1 x $V_R$) + 1200 or greater*
*‡ Reliable earth: permanently connected equipment, cord connected mains equipment used in a location having equipotential bonding (restricted access area, telecommunication center and others), stationary pluggable equipment that has instructions for installation of the conductor to building by a skilled person*

***Abbreviation:***
*$V_R$: rated voltage of AC mains or upper voltage of AC mains voltage range*

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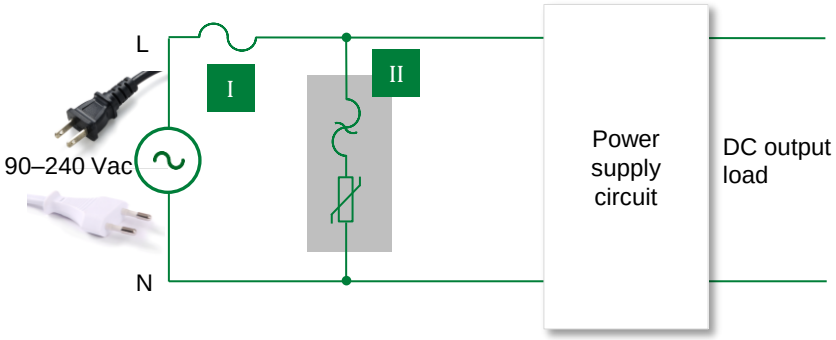
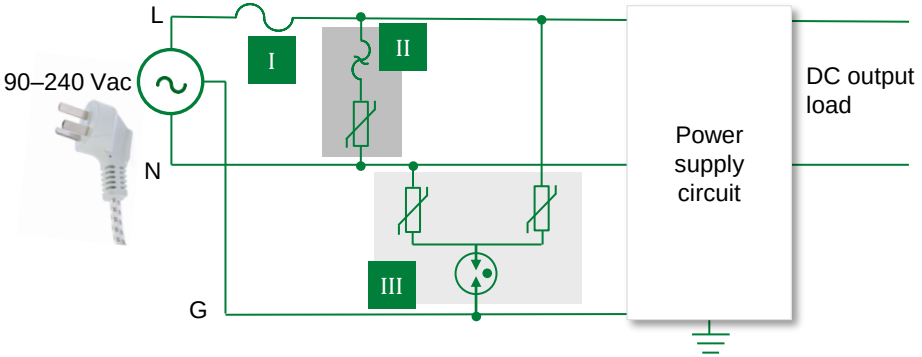
# Solution recommendations for universal power adapters with two-prong & three-prong plugs

## Differential mode protection




## Differential & Common mode protection

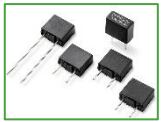



| | Technology | Product series | Function in application | Benefits and considerations |
|---|---|---|---|---|
| I | Fuse | 2153.15* | Protects the power stage from overcurrent events | Small, through-hole device with high breaking capacity and high surge withstand capability |
| | | 39213150000 | | Multiple ampere ratings in compact design |
| II | TMOV | TMOV14RP300E* | Protects the power supply unit from voltage transients and lightning. Meets minimum allowable MCOV (1.25 x 240 V). Exceeds minimum surge requirements of Overvoltage category II | Integrated thermal protection avoids overheating caused during abnormal voltage events; low energy let-through and clamping voltage |
| | MOV | V10E420P | | Smallest form-factor, higher clamping voltage than other solutions |
| | SIDACtor® + MOV | P2300 + V10E300P | | Lowest leakage current (nA) |
| | TVS Diode | AK3-380C-Y | | Best clamping and surge life |
| III | MOV + GDT | V10E300P + CG3 3.3* | Protects the power supply unit from voltage transients and lightning. Meets requirements for common mode protection. | Only permitted solution for common mode protection; lowest leakage current |

** This is the primary recommendation. Other products shown can be considered based on design requirements*

# Fuse selection

- Purpose
  - Prevent damage due to overcurrent events
  - Helps pass fault testing
- Requirements
  - Achieves purpose in circuit
  - Avoids nuisance trips
    - Must not open during normal operation
    - Should not open during surge pulse testing
  - Voltage rating ≥ system voltage
  - Safely interrupt max available fault current
  - Fit available space
  - Meet required 3rd party certifications (e.g. UL, IEC, etc)

| Item | Example System | 215 Series | 392 Series |
|---|---|---|---|
| Part # | - | 2153.15  | 39213150000  |
| Voltage (Vac) | 240 | 250 | 250 |
| Current (A) | 0.5 | 3.15 | 3.15 |
| Max fault current (A) [1] | 100 | 1500 | 130 [2] |
| $I^2t$ [3] ($A^2s$) | 15 | 43 | 78 |
| Size [4] (mm) | - | 20 x 5.2 | 8.5 x 4 |

215 recommended due to breaking capacity

*[1] For system, this is determined by equipment design. For fuse, this is the breaking capacity*
*[2] Per UL 248-1 and UL 248-14*
*[3] Pulse $I^2t$ for system. Melting I2t for fuse*
*[4] Length x Width*

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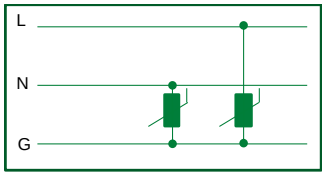
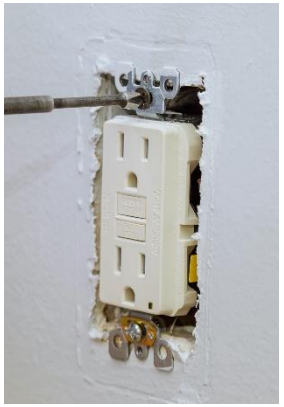
# Surge protection requirements: Section 5.5.7

- Multiple technologies possible (varistors, TVS diodes, protection thyristors, gas discharge tubes)
- Varistor & GDT specifically mentioned & most widely used
- Varistors
  - Allowed between mains and protective earth if ground is reliable
  - Must comply with G.8

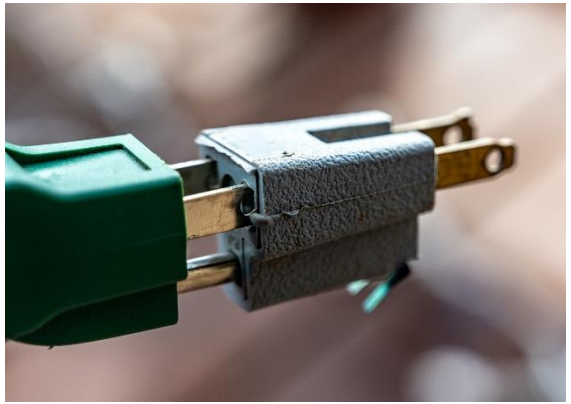


# Clause 5.5.7 SPDs
# Examples of non-reliable earthing

- Loose earth connection in wall socket or damaged earthing terminal in plug



- Plug terminal reducers/adapters
  - From 3 terminals to 2 terminals
  - Essentially removing the ground terminal



Our example, the universal power supply has unreliable ground

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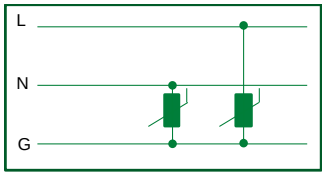
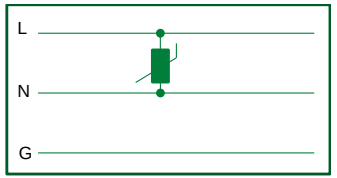
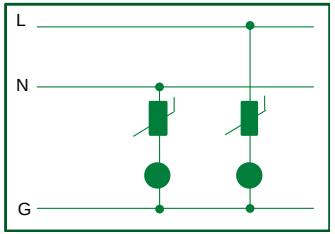
- Multiple technologies possible (varistors, TVS diodes, protection thyristors, gas discharge tubes)
- Varistor & GDT specifically mentioned & most widely used
- Varistors
  - Allowed between mains and protective earth if ground is reliable
  - Must comply with varistor requirements in section G.8
  - Allowed between line and neutral & between lines (L-N & L-L)
- GDTs
  - If ground is unreliable; between mains and PE (G), use a varistor with a GDT
  - Comply with Electric strength tests, clearances and creepage distances (sections 5.4.9.1, 5.4.2, and 5.4.3)



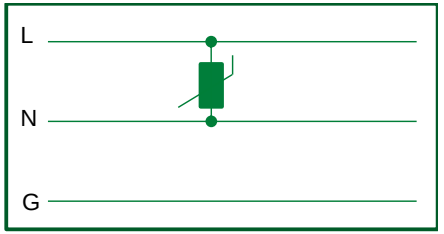



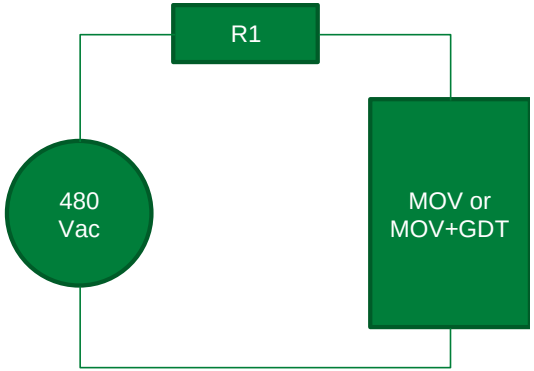




Next: select MOV for L-N and MOV+GDT for mains to PE

# Select varistors for differential mode protection according to Annex G.8

- Comply with a varistor component standard
  - IEC 61051-1 or IEC 61643-331
- MCOV ≥ 1.25 x rated voltage of equipment
  - Example (240 Vac power supply)
    - 240 x 1.25 = 300 V
- Withstand multiple strikes as defined by 2.3.6 of IEC 61051-2 or 8.1.1 of IEC 61643-331
  - Example (240 Vac power supply)
    - 10 pulses of 2.5 kV / 1.25 kA combination wave of 1.2/50 µs voltage and 8/20 µs current
    - 10 mm* or larger varistor diameter required
- Pass varistor overload test (G.8.2.2)
  - If used in series with other devices, G.8.2.2 applies to series combination
  - Example (240 Vac power supply)
    - Apply 2x rated voltage = 2 x 240 = 480 V
    - R1 of test one = 3.84 kΩ
    - Subsequent tests, halve the R value until circuit opens
  - 300 V thermally protected varistor passes
  - 420 V or higher required for non-thermally protected varistor
    - Clamping voltage is higher than 300 V MOV




Recommend 14mm* 300 V TMOV

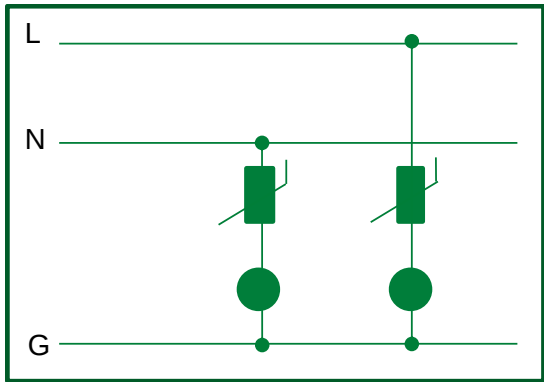
Note:
* Multiple strike surge may be different for specific part series. Check manufacturers spec before finalizing selection

# Varistor and GDT for common mode protection

- Varistor (MOV)
  - Minimum MCOV = 1.25 x rated voltage of equipment
    - Example (240 Vac power supply)
      - 240 x 1.25 = 300 V
  - Same surge requirements → 10 mm* MOV (UltraMOV – series)

- Gas Discharge Tube (GDT)
  - Pass electric strength test of 5.4.9.1
    - Withstand voltage of slide 3 (2500 V) → Vbr of GDT ≥ 2500 V
  - Comply with clearance and creepage of 5.4.2 and 5.4.3

- MOV and GDT
  - Pass overload test from G.8.2.2
  - Pass temporary over-voltage tests from G.8.2.3
  - 300 V MOV and 2500 V GDT pass




Recommend 10 mm 300 V MOV and CG33.3 GDT

Note:
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# Surge protection solutions compared

| Features | TMOV | MOV | SIDACtor™ + MOV | High Power TVS Diode | GDT + MOV |
|---|---|---|---|---|---|
| Suggested Protection Modes<br>(When ground is unreliable) | L-L<br>L-N | L-L<br>L-N | L-L<br>L-N | L-L<br>L-N | L-G & N-G<br>(Mains to PE) |
| Continuous voltage withstand rating | 300 V | 420 V | 480 V<br>(180 V + 300 V) | 380 V | 2940 V<br>(2640 V + 300 V) |
| Clamping voltage<br>(combination surge: 6 kV/3 kA) | 1.18 kV | 1.66 kV | 1.3 kV* | 520 V | 1.3 kV |
| Let-through energy during surge event | ↯↯ | ↯↯↯ | ↯↯ | ↯ | ↯↯ |
| Leakage current | Medium<br>(µA) | Medium<br>(µA) | Low<br>(nA) | Medium<br>(µA) | Very low<br>(pA) |
| Lifetime after multiple surge events | Good | Fair | Very Good | Excellent | Good |
| PCB footprint surface area | ■ | ■ | ■ | ■ | ■ |
| Price | $$ | $ | $$$ | $$$$ | $$ |

- TMOV recommended for most differential mode protection applications
- GDT + MOV is the recommended solution between mains and protective earth (per IEC 62368-1, clause 5.5.7)

Note:
* Lower clamping is possible with use of a lower voltage MOV and higher rated SIDACtor. Requires review with agency providing certification to the standard

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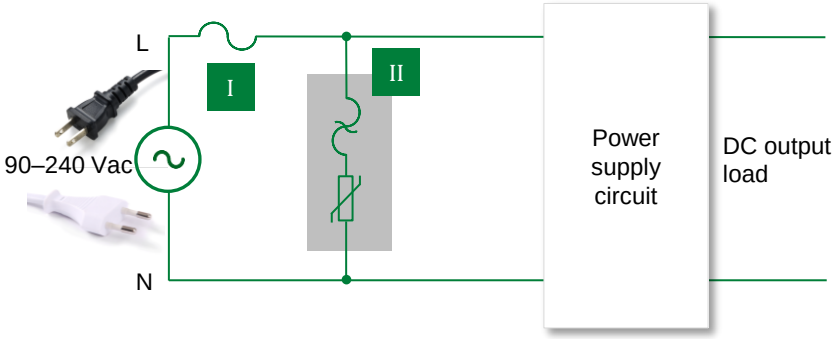
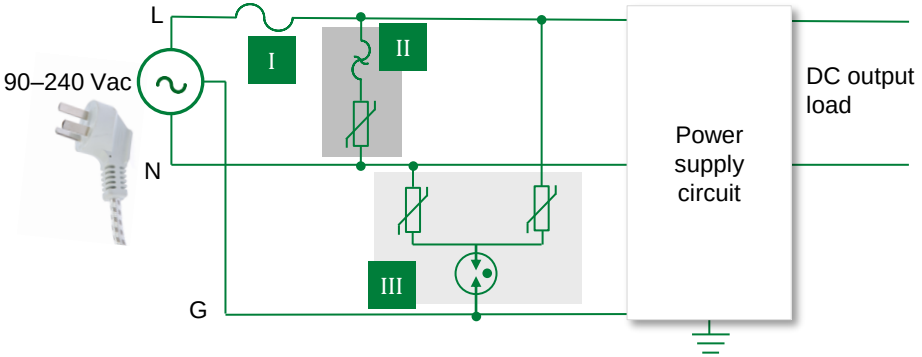



## Differential & Common mode protection

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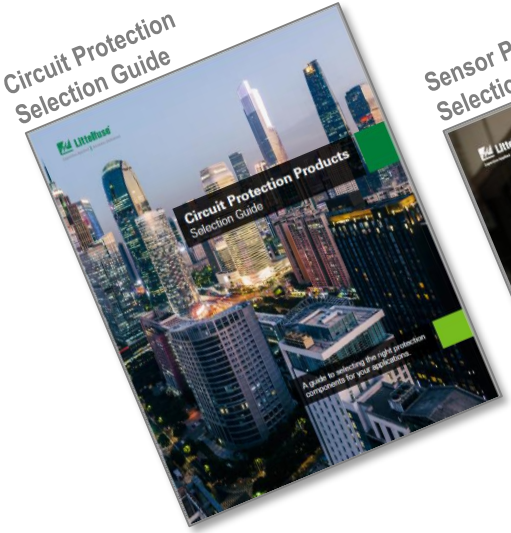
# Summary

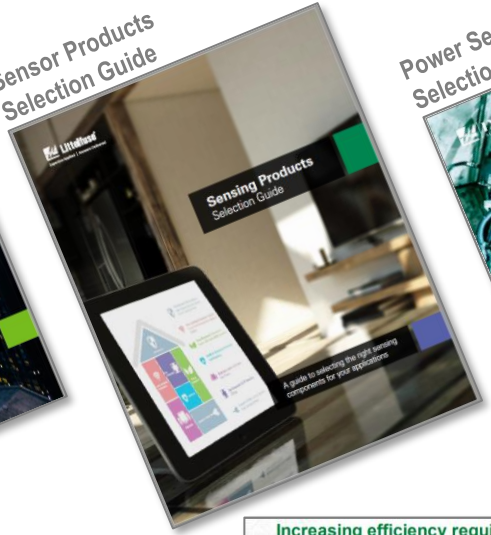
- IEC 62368-1 superseded IEC 60950-1 and IEC 60065 as of December 2020
- Additional tests may apply for compliance
- IEC 62368-1 can seem complicated at first but allows for greater safety and design flexibility

# Additional information can be found on Littelfuse.com

Circuit Protection Selection Guide



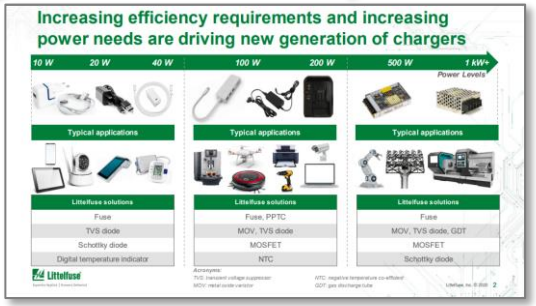

Sensor Products Selection Guide




Power Semiconductor Selection Guide


Designing with TMOV Application Note


Power Supply Spotlight

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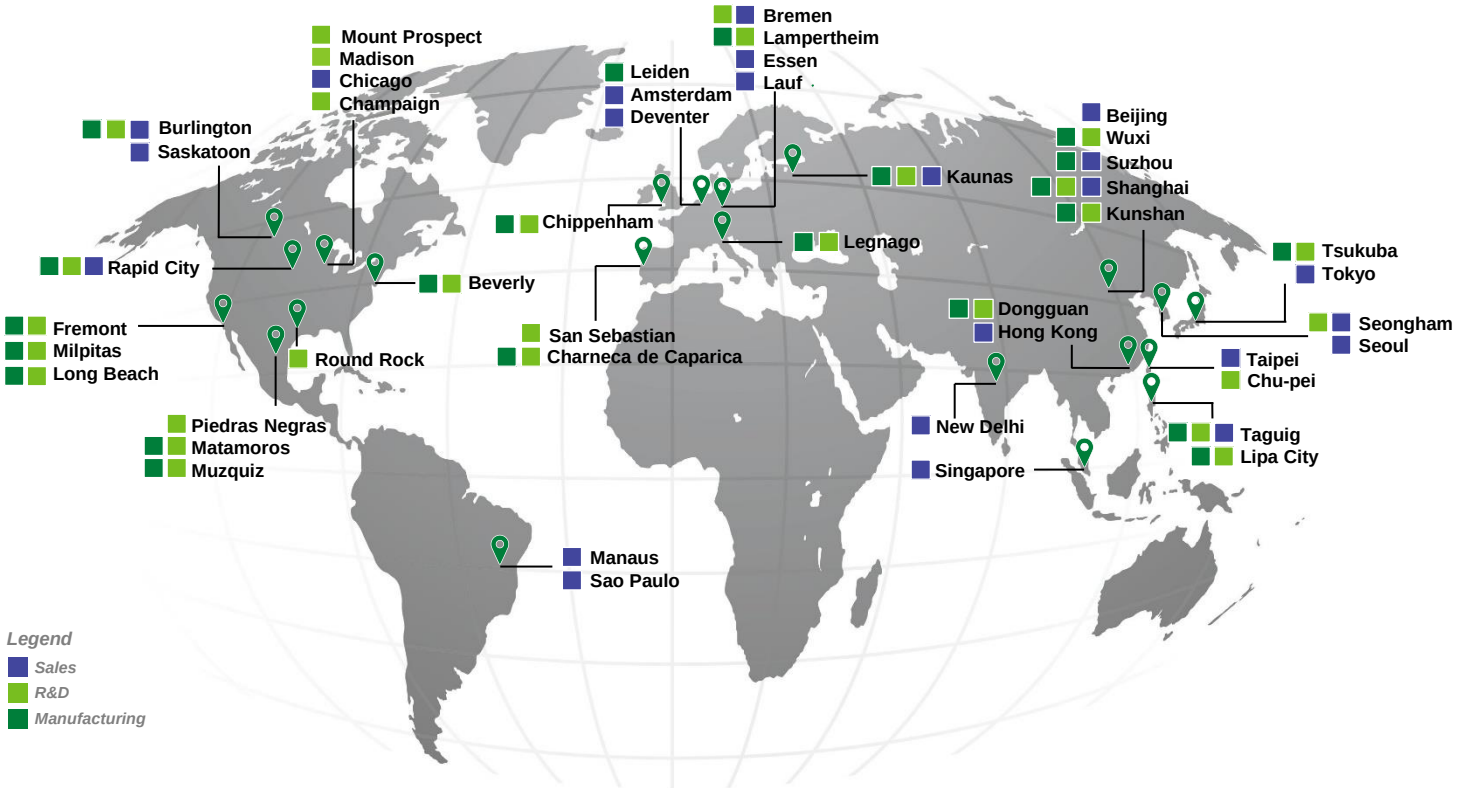


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