IT Power & Cooling Cheat Sheet

Version 2.0

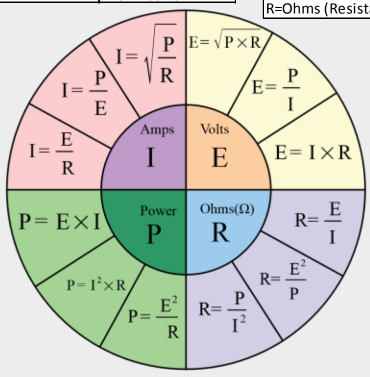
Voltages, Phasing and Calculations

Calculations & Ohm's Law Chart

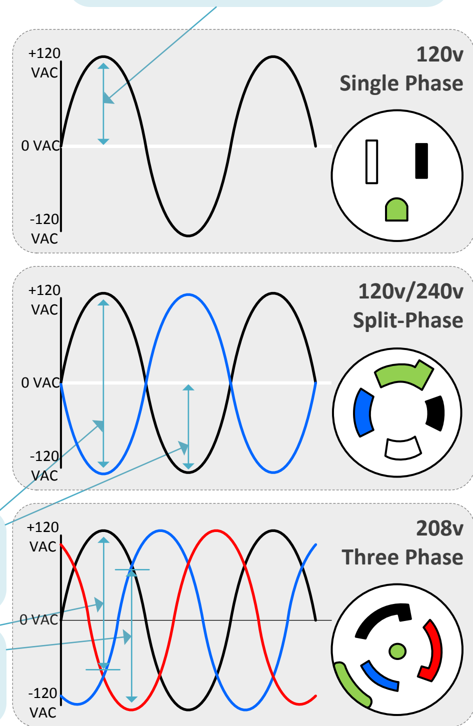
The formulas on Ohm's Law Chart can be used to calculate any measurement of an electrical circuit if two of the measurements are known.

Calculating Watts (P)	
Single Phase	Three Phase
P=E × I	P=(E × I)(√3)

Legend
I=Amps (Current)
E=Volts (Potential)
P=Watts (Power)
R=Ohms (Resistance)



Voltage potential between the hot (live) wire and the neutral wire alternates between +120 volts, 0 volts, and -120 volts.



Voltage potential between the two different hot (line) wires alternates between 240 volts and 0 volts. At its peak, the potential is always 240 volts, but the direction of current flow reverses after each peak. Voltage between a hot wire and the neutral wire alternate between +120v, 0v, and -120v. So this system provides two voltage options: 120v and 240v.

Voltage potential between any two of the three hot wires alternates between 208 volts and 0 volts. Even through all three of the waves peak at +-120v, the peak voltage potential is never greater than 208v because the phases are offset from each other by 120° of a full cycle. They never peak at the same time.

Efficiency

White Papers: Increase Server Efficiency Using High Voltage (Eaton)
Efficiency and Other Benefits of 208v over 120v (APC)
High Efficiency AC Power Distribution for Datacenters (APC)

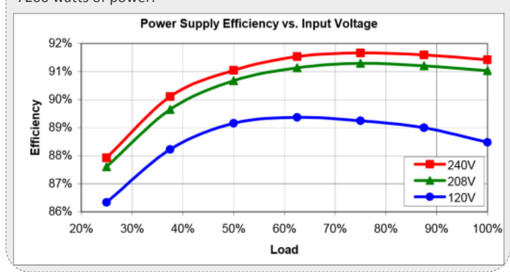
Input Voltage, Efficiency, and Density

Modern switching power-supplies are built to operate at different input voltages (usually 100v – 250v). They are built this way to allow universal operation in any power system around the world.

During the conversion of AC to DC, these power supply units (PSUs) lose some of the input power to heat. The amount of energy lost to heat depends on the current load on the PSU, the voltage of the input, and the particular PSU model.

As seen in the graph below: a PSU operates at higher efficiencies when it is:
(1). Supplied with a higher input voltage
(2). Under high load conditions relative to its maximum supported load

Using higher voltages in power distribution leads to both higher efficiencies and increased power density. For example:
--A 30 amp circuit provided at 120v uses 10AWG wire size and can supply up to 3600 watts of power.
--A 30 amp circuit provided at 240v uses the same 10AWG wire size (since wire sizing is dependent on current, not voltage) but can supply up to 7200 watts of power.



Cooling

White Papers: Calculating Datacenter Cooling Requirements (APC)
Datacenter Power and Cooling (Cisco)

Calculating Cooling

An optimal datacenter environment resides at 65°f (18°C) - 80°f (27°C) with a relative humidity of 40% - 60%

Effectively, all power consumed by IT equipment is turned into heat and is dissipated into the air in the datacenter. So once the total Wattage draw of the IT equipment in the datacenter is known, cooling capacity for that equipment is known.

NOTE: You can exclude any power drawn as POE if the POE devices using the power are outside the scope of the cooling system being sized.

You will also want to consider other sources of heat in your calculations. In these calculations, I will use "ITP" to represent the total Wattage consumed by the IT equipment. Since Watts are also usable as a measurement of heat, we will use them to calculate heat generated by these other sources:

(1) UPS Inefficiencies (.04 x UPS Watt Rating) + (.05 x ITP)
(2) Power Distribution (.01 x UPS Watt Rating) + (.02 x ITP)
(3) Lighting (22 Watts x Floor Area in m²) (2 Watts x Floor Area in ft²)
(4) People (100 Watts x max number of people)

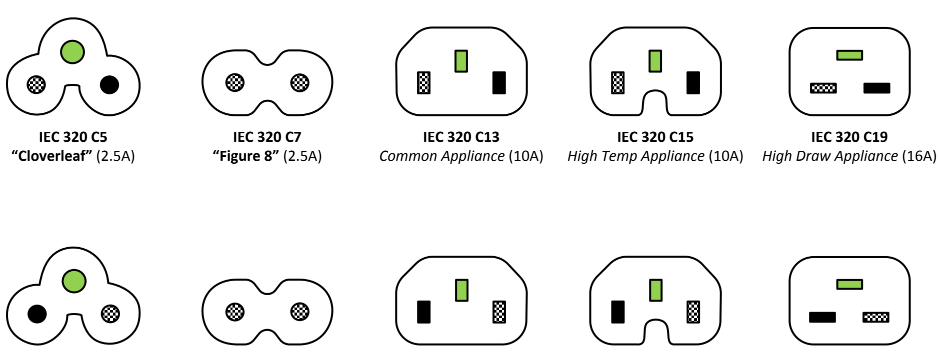
Once these calculations have been made, you will need to determine if this environment will be affected by external sources of heat (sunlight through windows, heat from roof, etc). This heat will also need to be factored into the cooling of the room. If this data room is within an already controlled environment (ie: a data closet in an office), these external factors can likely be ignored.

Legacy Unit	Formula	Example
British Thermal Units (BTU)	W=3.41 BTU/hr	1200 Watts = 4092 BTU/hr
Tons (Cooling)	W=.000283 Tons	1 Ton = 3533 Watts

International Connector Standards

Appliances (IEC 60320)

More Info: https://en.wikipedia.org/wiki/IEC_60320
IEC 60320 Reference Chart



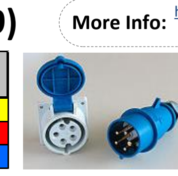
Female (Receptacle): IEC 320 C5 "Cloverleaf" (2.5A); IEC 320 C7 "Figure 8" (2.5A); IEC 320 C13 *Common Appliance* (10A); IEC 320 C15 *High Temp Appliance* (10A); IEC 320 C19 *High Draw Appliance* (16A)

Male (Plug or Appliance): IEC 320 C6 "Cloverleaf" (2.5A); IEC 320 C8 "Figure 8" (2.5A); IEC 320 C14 *Common Appliance* (10A); IEC 320 C16 *High Temp Appliance* (10A); IEC 320 C20 *High Draw Appliance* (16A)

Supply and Distribution (IEC 60309)

More Info: https://en.wikipedia.org/wiki/IEC_60309
Industrial and Multiphase Power Plugs

Earth Pin Location	3 Wires P+N+E or 2P+E	4 Wires 3P+E	5 Wires 3P+N+E
120° | 4h	100-130V AC	100-130V AC	57-75/100-130V AC
180° | 6h	200-250V AC	380-415V AC	200-240/346-415V AC
270° | 9h	380-415V AC	200-250V AC	120-144/208-250V AC

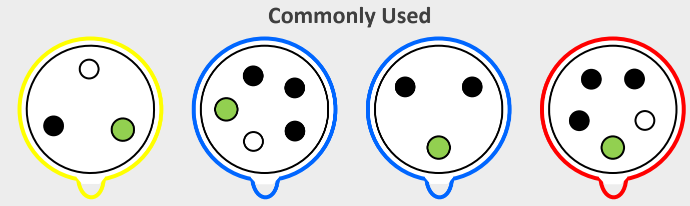


IEC 60309 receptacles can be read using three pieces of information:
1. Number of pins (conductors)
2. Position of "Earth" (ground) pin in relation to the "keyway" (notch).
3. Color of housing

The IEC standard allows for 12 positions of the Earth pin relative to the keyway, so the position is named in hours as it would be seen on a clock. Furthermore, the keyway is always facing down, and the receptacle (female) side of the connector is the one referenced for Earth pin positioning.

The name of the plug is assembled as [<line or pole count>P+<N for neutral if existent>+E<Earth pin> <Earth pin position as hour or degree>

Commonly Used



- P+N+E 4h (100-130V) *Earth at 4 o'clock* *16A & 32A Versions*
- 3P+N+E 9h (120/208V – 144/250V) *Earth at 9 o'clock* *16A & 32A Versions*
- 2P+E 6h (200-250V) *Earth at 6 o'clock* *16A & 32A Versions*
- 3P+N+E 6h (200/346V – 240/415V) *Earth at 6 o'clock* *32A Version*

North America (NEMA Standards)

Nomenclature

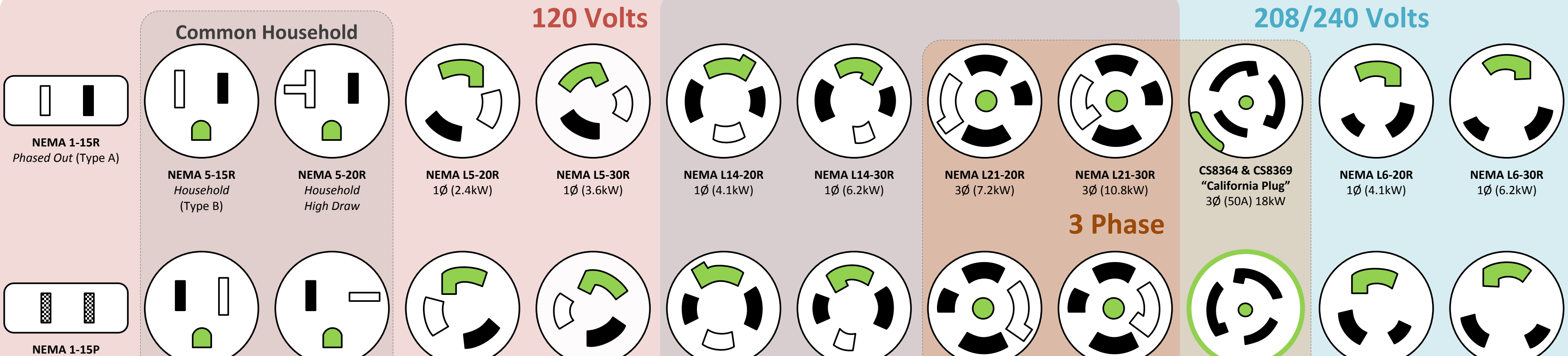
Code	Voltage(s)	Phases, Conductors
5	125V	1Ø, 2 Pole, 3 Wire
6	250V	1Ø, 2 Pole, 3 Wire
14	125V & 250V	1Ø, 3 Pole, 4 Wire
15	250V	3Ø, 3 Pole, 4 Wire
21	120V & 208V	3Ø, 4 Pole, 5 Wire

Code	Meaning
<none>	Non-locking, straight-blades
L	Twist-Lock Blades

N E M A X 5 – 15 P

Code	Meaning
P	Plug (Male)
R	Receptacle (Female)

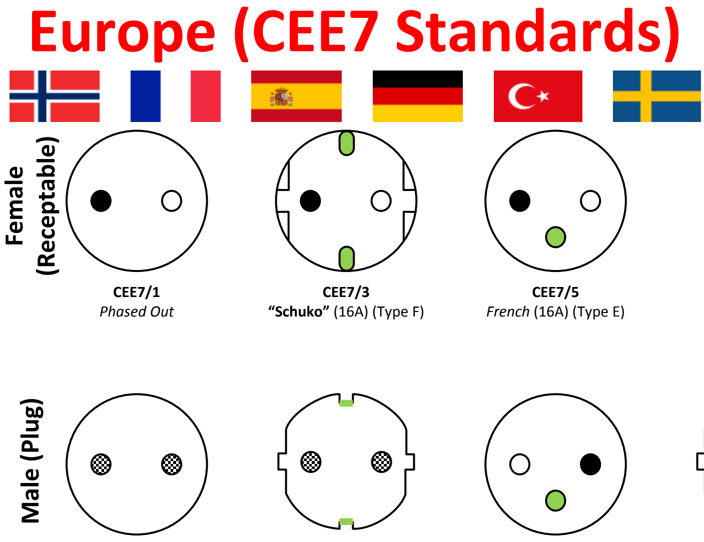
Code	Current
15	Amps
20	Amps
30	Amps
50	Amps
60	Amps



Female (Receptacle):
- NEMA 1-15R *Phased Out (Type A)*
- NEMA 5-15R *Household* (Type B)
- NEMA 5-20R *Household* *High Draw*
- NEMA L5-20R 1Ø (2.4kW)
- NEMA L5-30R 1Ø (3.6kW)
- NEMA L14-20R 1Ø (4.1kW)
- NEMA L14-30R 1Ø (6.2kW)
- NEMA L21-20R 3Ø (7.2kW)
- NEMA L21-30R 3Ø (10.8kW)
- CS8364 & CS8369 "California Plug" 3Ø (50A) 18kW
- NEMA L6-20R 1Ø (4.1kW)
- NEMA L6-30R 1Ø (6.2kW)

Male (Plug):
- NEMA 1-15P *Phased Out (Type A)*
- NEMA 5-15P *Household* (Type B)
- NEMA 5-20P *Household* *High Draw*
- NEMA L5-20P 1Ø (2.4kW)
- NEMA L5-30P 1Ø (3.6kW)
- NEMA L14-20P 1Ø (4.1kW)
- NEMA L14-30P 1Ø (6.2kW)
- NEMA L21-20P 3Ø (7.2kW)
- NEMA L21-30P 3Ø (10.8kW)
- CS8365 "California Plug" 3Ø (50A) 18kW
- NEMA L6-20P 1Ø (4.1kW)
- NEMA L6-30P 1Ø (6.2kW)

Europe (CEE7 Standards)



Female (Receptable): CEE7/1 *Phased Out*; CEE7/3 "Schuko" (16A) (Type F); CEE7/5 *French* (16A) (Type E)

Male (Plug): CEE7/2 *Phased Out*; CEE7/3 "Schuko" (16A) (Type F); CEE7/6 *French* (16A) (Type E); CEE7/7 *Schuko & French* (16A); CEE7/16 "Europlug" (2.5A) (Type C)

Interchangable

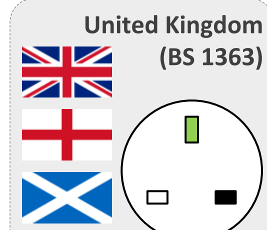
IRAM 2073
Argentina (10A) (Type I)

AS/NZS 3112
Australia, New Zealand (10A) (Type I)

CPCS-CCC
China (10A) (Type I)

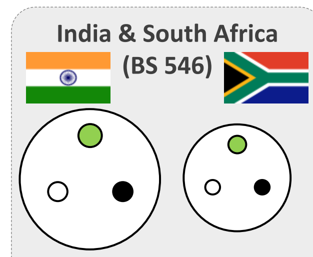
Other Standards

United Kingdom (BS 1363)



BS 1363 (13A)
Britan (Type G)

India & South Africa (BS 546)

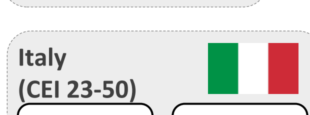


BS 546 (15A) (Type D)
BS 546 (5A) (Type M)

Switzerland (SEV 1011)

SEV 1011 Typ 13 (10A) (Type L)

Italy (CEI 23-50)



CEI 23-50 (10A) (Type L)
CEI 23-50 (16A) (Type L)

Legend

- Neutral Conductor
- Hot Conductor (Line)
- Grounding Conductor (Earth)
- Hot or Neutral (usually reversable)

Created by John W Kerns

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