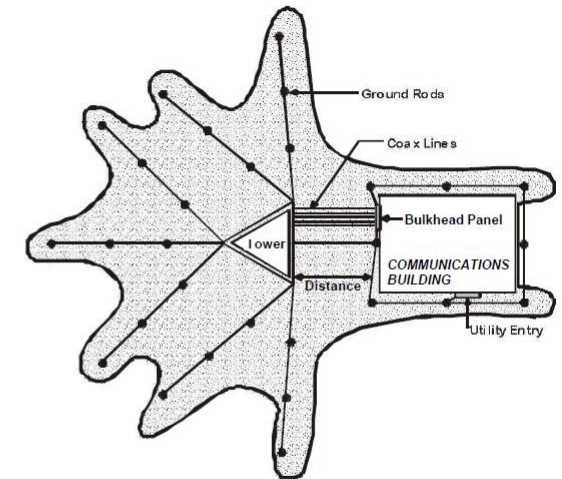
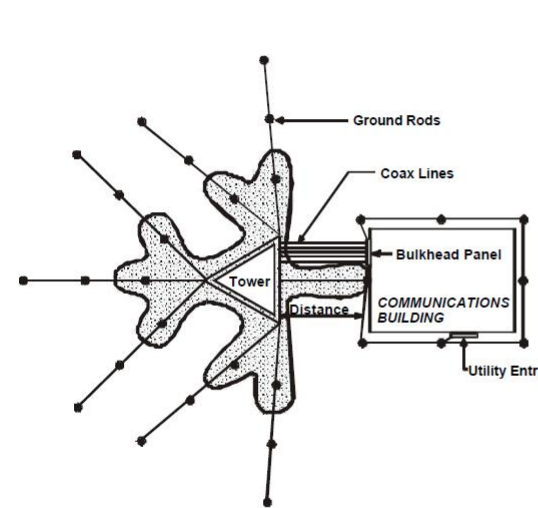
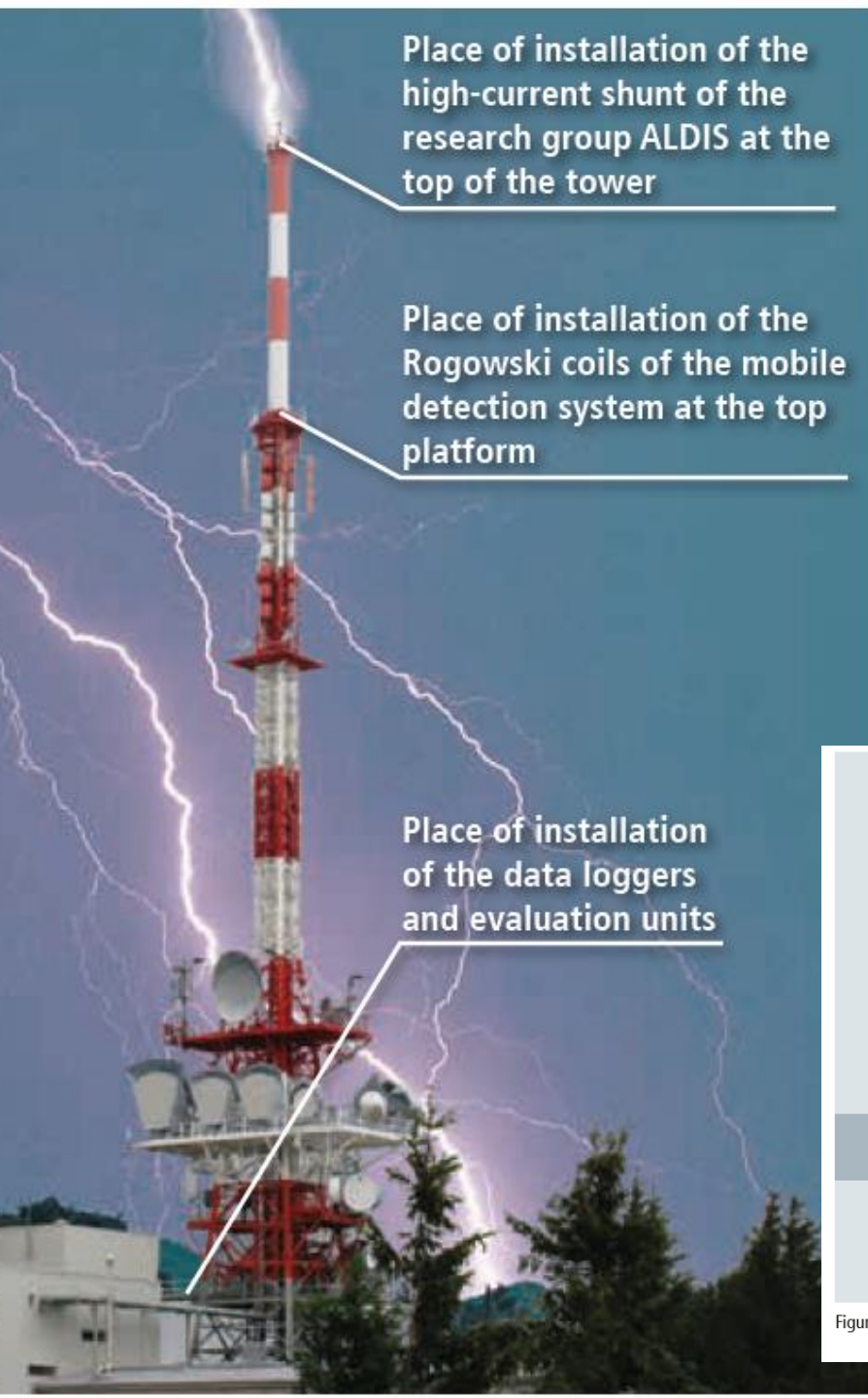


PROTECTIONS RF



Neglecting the coax currents, the strike energy moves outward from the tower base along the radial line.

As it reaches and saturates the radial system, it will traverse the building perimeter.

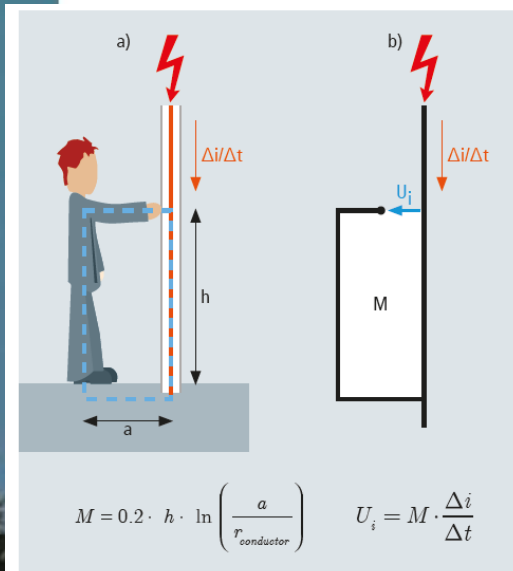
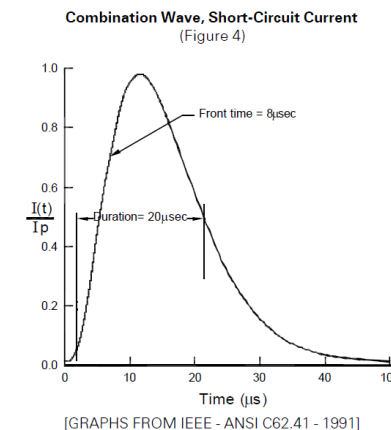


Figure 5.7.1.5 a) Loop formed by a down conductor and a person
b) Mutual inductance M and induced voltage U_i



KJ4EGU - Carlo Francescangeli

Electrical damage caused by lightning strikes results in billions of dollars in losses annually in the United States. Here are key insights based on the search results:

1. Annual Financial Impact

- Lightning strikes cause approximately *1 billion in damage to American homes each year***, with insurance claims often exceeding this amount.
- *For example, in 2022, lightning-related insurance claims totaled 1 billion in damage to American homes each year, with insurance claims often exceeding this amount. For example, in 2022, lightning-related insurance claims totaled 952 million*, while in 2023, payouts reached **\$1.2 billion**¹²¹³.
- The total economic impact on businesses and industries is even higher, estimated at **8 billion to 8 billion to 10 billion annually**, including operational downtime and asset destruction.

Erreur # 1 :

Ne pas pas **confondre** systeme de terre des electriciens (normes et reglementation installation **electriques domestiques**)

Avec les protections des pylones de transmission **signaux RF**

Malgre qu'il peut exister une certaine relation entre elles

Empêcher (en français) = **impede** (anglais)

Entraver (en français) = **impedir** (espanol)

= **impedire** (italien)

= **impedire** (portugais)

Empechance = **Impédance**

Entravance = **Impédance**

Impedance Électricité : l'opposition que presente un circuit ou une partie d'un circuit au passage du courant electrique . L'impédance inclut resistance et réactance ..et habituellement exprimée en ohms. **Symbole : Z**

Impédance mécanique : Est le rapport entre la force exercée sur un système soumis à un mouvement **harmonique** simple et la vitesse des particules dans le système.

Z = Résistance + (?) . Réactance

2 composantes



$$Z = \text{Résistance} + \cancel{(\text{?})} \cdot \cancel{\text{Réactance}}$$

La résistance **existe toujours**, aussi faible soit-elle
Elle se calcule généralement par la loi d 'ohm

$$Z = \text{Resistance} + \text{quelque chose } \textbf{éventuellement}$$

Ce n'est pas obligatoire d'avoir une réactance !

$$Z = \text{Résistance} + (j) \cdot \text{Réactance}$$

action

réaction

Pas d'action Pas de réaction

~~action~~

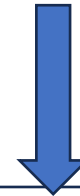
~~réaction~~

la résistance existe (presque) toujours

$$Z = \text{Résistance} + (?) . \text{Réactance}$$

Il faut comprendre d'où vient l'action

action



réaction



$$Z = \text{Résistance} + (?) . \text{Réactance}$$

$$Z = \text{Résistance} + (?) . \text{Réactance}$$

La résistance existe (presque) toujours

ACTION

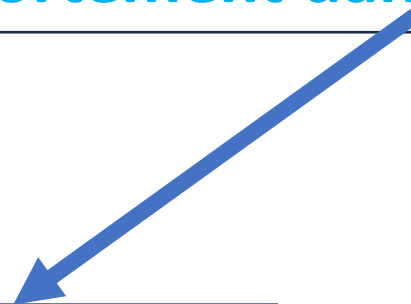


action

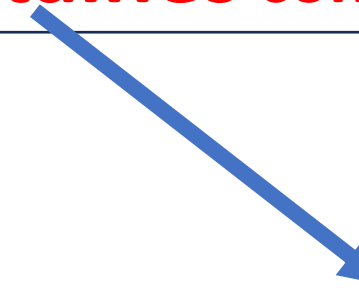


Provient du comportement dans **certaines conditions** de 2 éléments

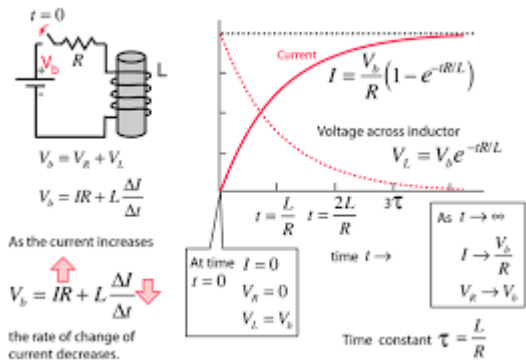
Condensateur



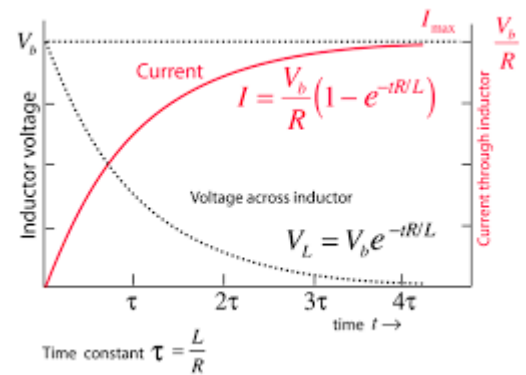
Bobine (self)



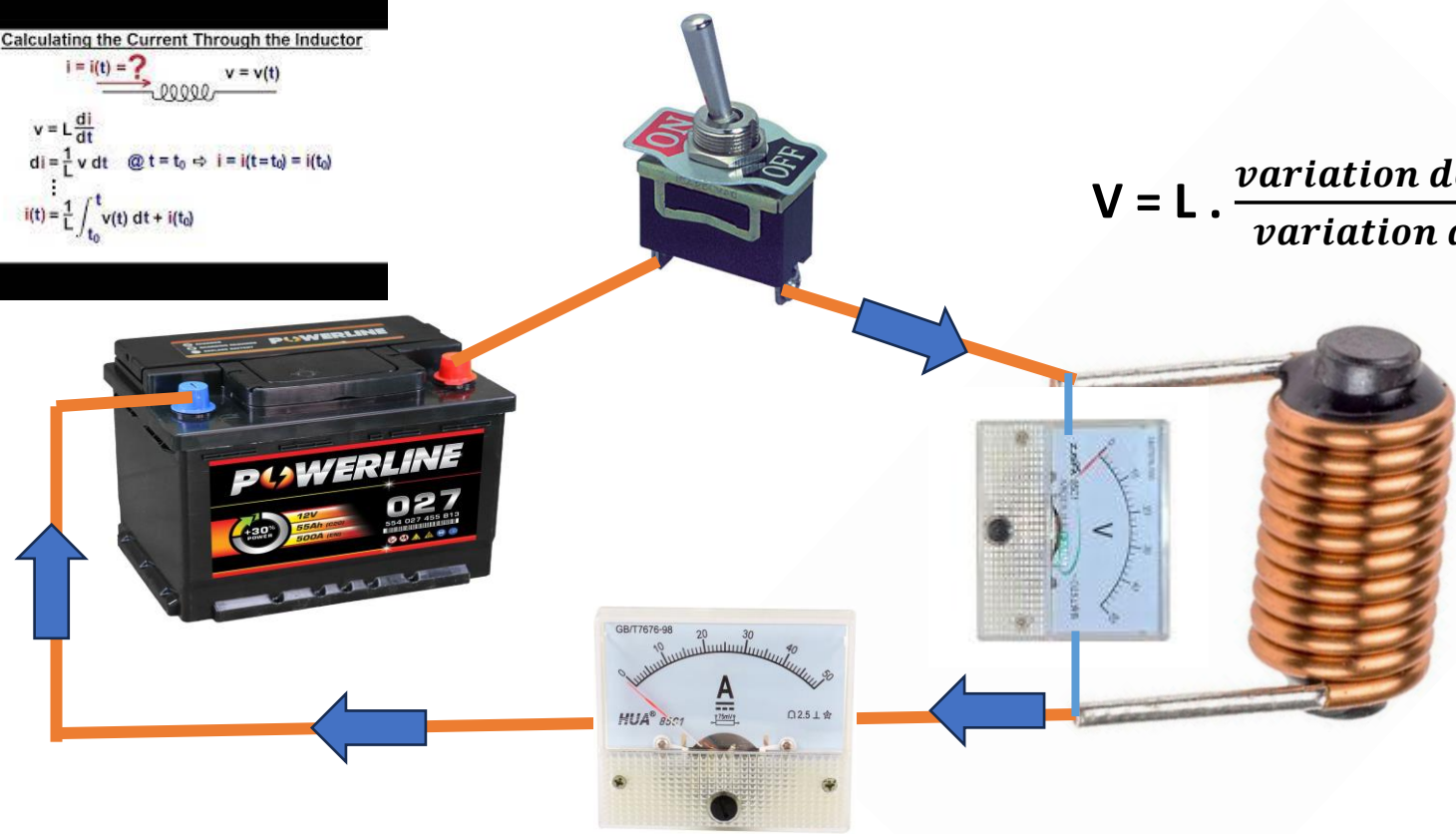
**Attention a la résonance pas de réactance !
Malgré la présence de bobine et condensateur**



Calculating the Current Through the Inductor
 $i = i(t) = ?$
 $v = v(t)$
 $v = L \frac{di}{dt}$
 $di = \frac{1}{L} v dt$ @ $t = t_0 \Rightarrow i = i(t=t_0) = i(t_0)$
 $i(t) = \frac{1}{L} \int_{t_0}^t v(t) dt + i(t_0)$



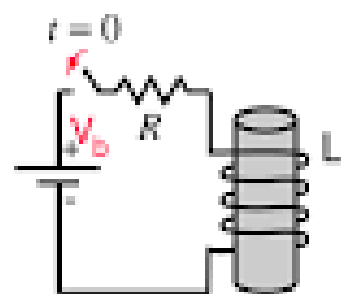
$$V = L \cdot \frac{\text{variation de courant}}{\text{variation de temps}} = L \cdot \frac{dI}{dt}$$



Le bobine (self) s'oppose a la variation de courant

Accion : la variation de courant (on/off, variation DC, impulsions, courants alternatifs , HF , etc....)

La reaction : l'opposition (reaction) a la variation de courant , qui crée une certaine résistance (ohms) d'ou le nom de réactance



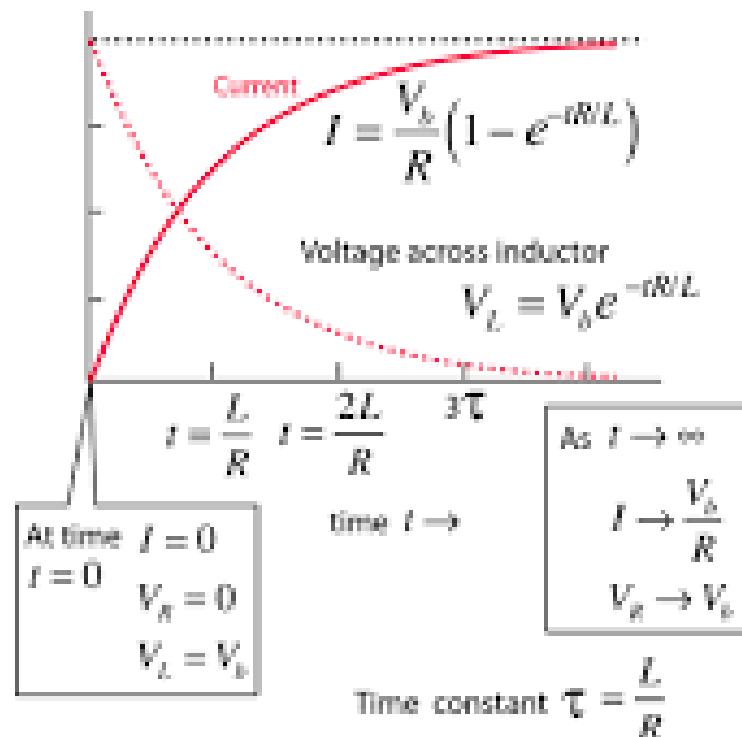
$$V_b = V_R + V_L$$

$$V_b = IR + L \frac{\Delta I}{\Delta t}$$

As the current increases

$$V_b = IR + L \frac{\Delta I}{\Delta t}$$

the rate of change of current decreases.



Calculating the Current Through the Inductor

$$i = i(t) = ? \quad v = v(t)$$

$$v = L \frac{di}{dt}$$

$$di = \frac{1}{L} v dt \quad @ t = t_0 \Rightarrow i = i(t=t_0) = i(t_0)$$

$$i(t) = \frac{1}{L} \int_{t_0}^t v(t) dt + i(t_0)$$

En mathématique, on exprime souvent :

Variation → **différence** → **différentielle**

$$I = C . \frac{\text{variation de tension}}{\text{variation de temps}} = C . \frac{dV}{dt}$$

$$V = L . \frac{\text{variation de courant}}{\text{variation de temps}} = L . \frac{dI}{dt}$$

A retenir , car il faut

1. Une inductance
2. Une variation de courant

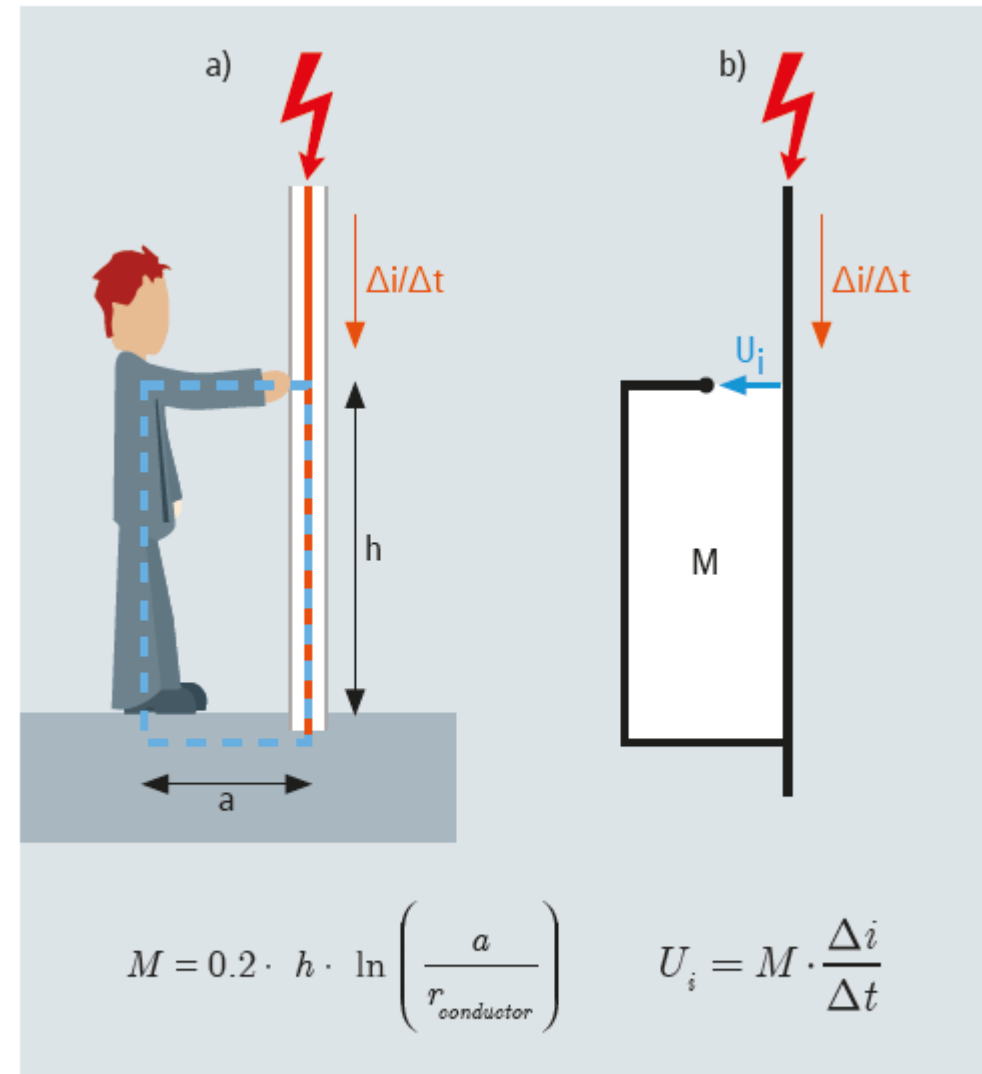
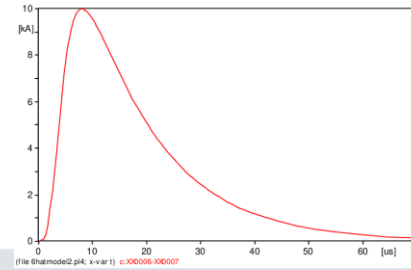
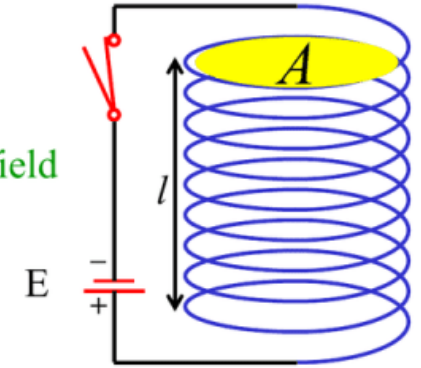


Figure 5.7.1.5 a) Loop formed by a down conductor and a person
b) Mutual inductance M and induced voltage U_i



Self Inductance

- Consider a solenoid L , connect it to a battery
 - Area A , length l , N turns
- What happens as you close the switch?
- Lenz's law – loop resists change in magnetic field
- Magnetic field is caused by the current
- “Inductor” resists change in current



$$B = \frac{\mu_0 N I}{\ell} \quad \Phi_{B1} = \frac{\mu_0 N I A}{\ell}$$

$$E_L = -\frac{d\Phi_B}{dt} = -N \frac{d}{dt} \Phi_{B1} = -\frac{d}{dt} \left(\frac{\mu_0 N^2 I A}{\ell} \right) = -\frac{\mu_0 N^2 A}{\ell} \frac{dI}{dt}$$

$$E = -L \frac{dI}{dt}$$

$$L = \mu_0 N^2 A / \ell$$

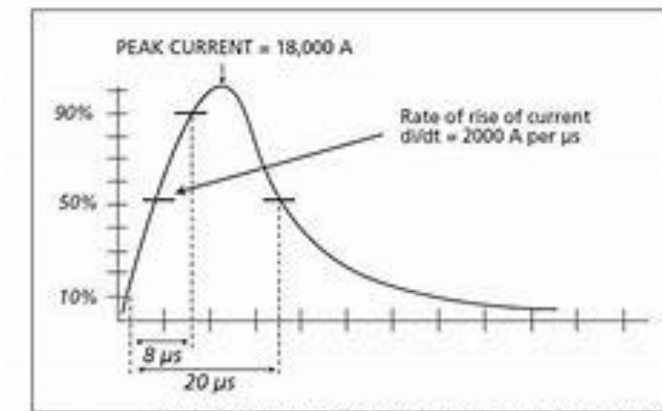
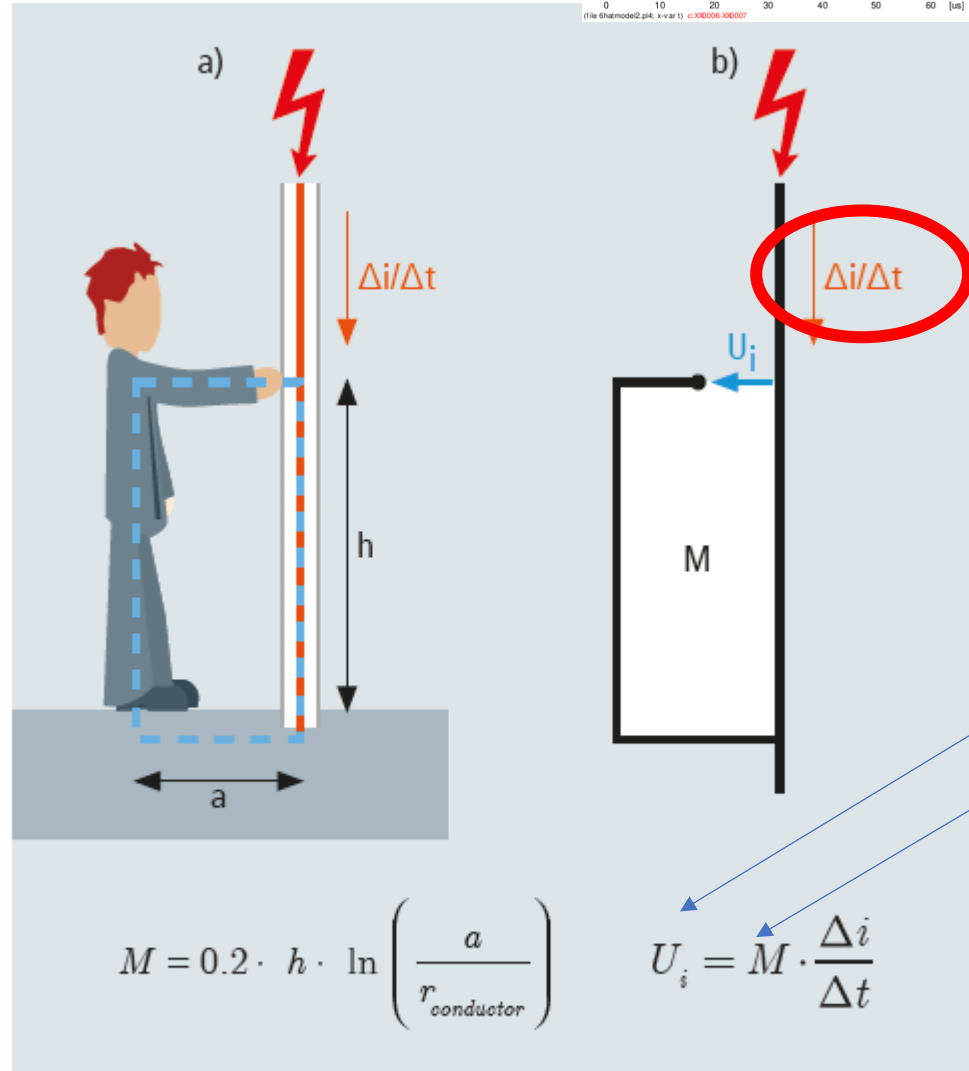


Figure 5.7.1.5 a) Loop formed by a down conductor and a person
b) Mutual inductance M and induced voltage U_i

Fig. 1: "IEEE 8/20 Model" of lightning current pulse used for specifying lightning protection devices

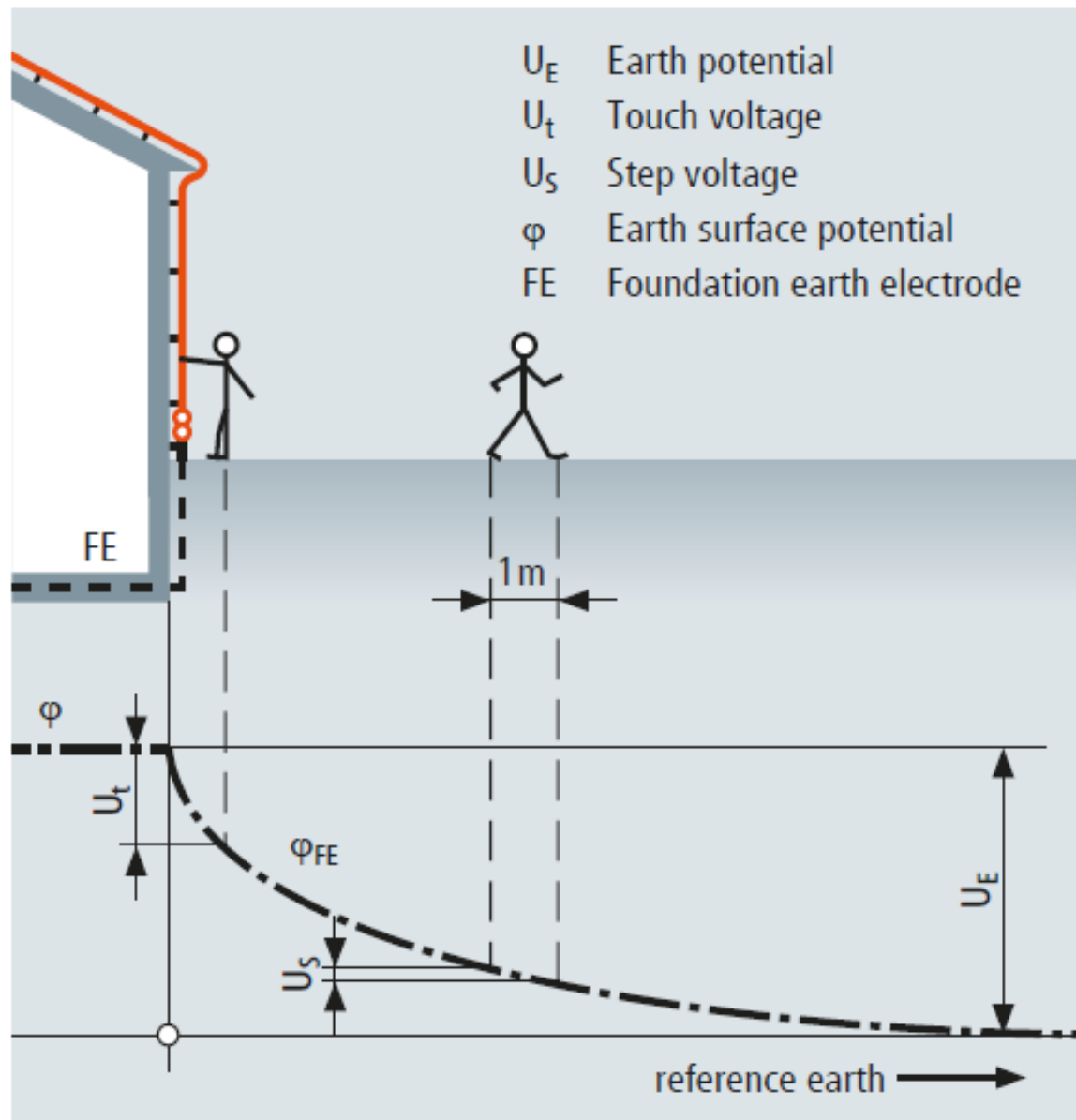


Figure 5.7.1 Step and touch voltage



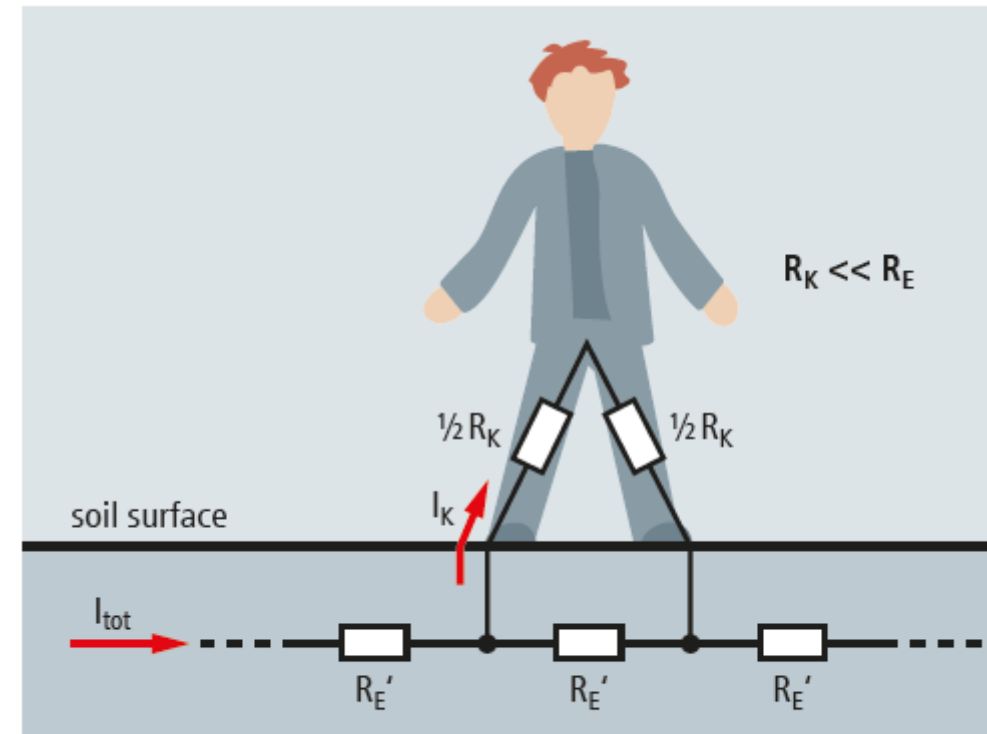
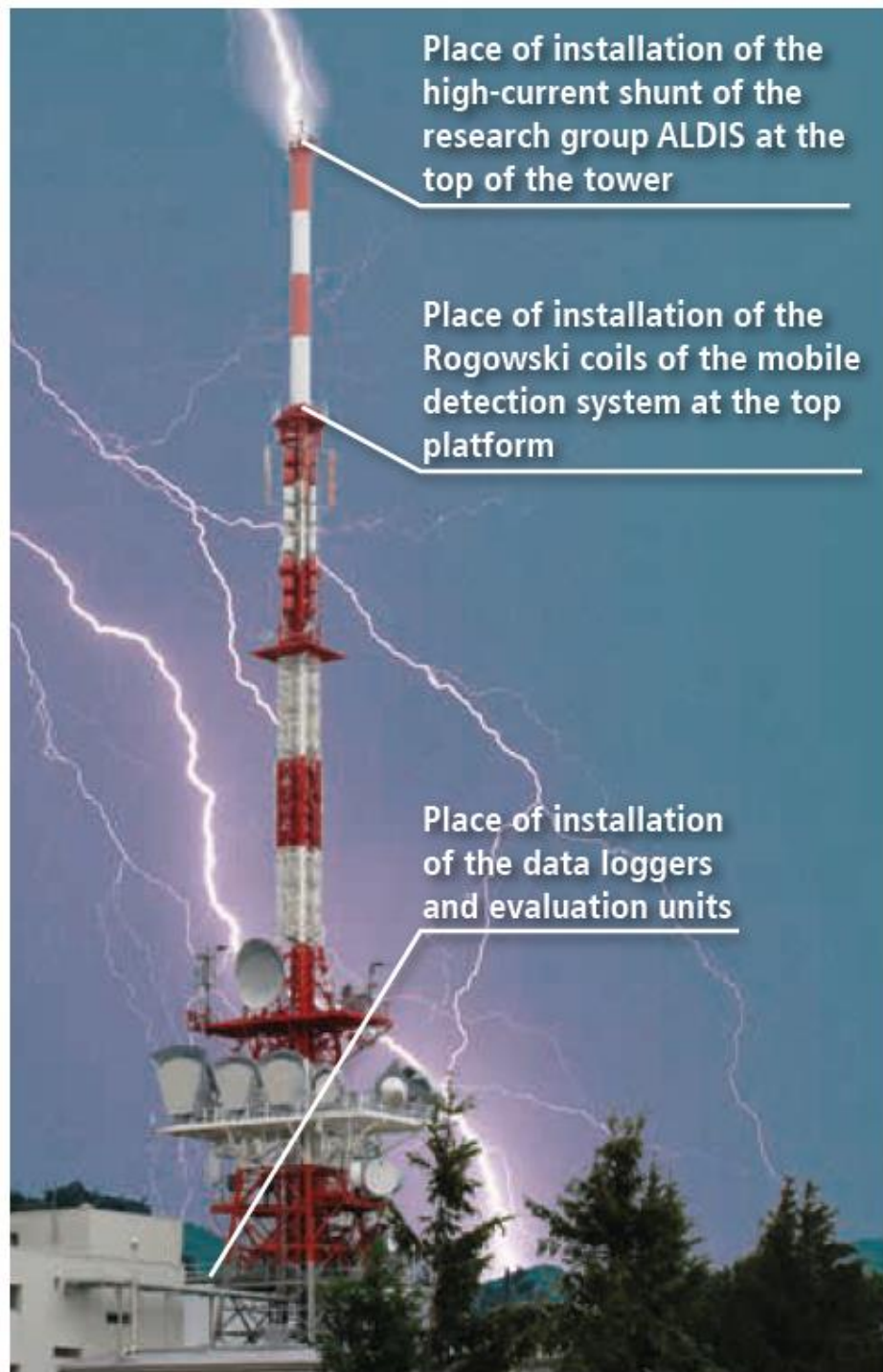


Figure 5.7.2.4 Person loading the step voltage on the soil surface

Erreur # 2 :

**Un système de terre ne protege pas necessairement les
equipements RF (TX,RX, etc....)**

**Il est possible d'avoir une protection complete de TX et RX
sans systeme de terre . Il existe un sans nombre de cas reels
qui le demontre (avions, pylones installes sur de la roche,
sommet d'un building,etc....)**

Neanmoins , cette situation n'est pas ideale

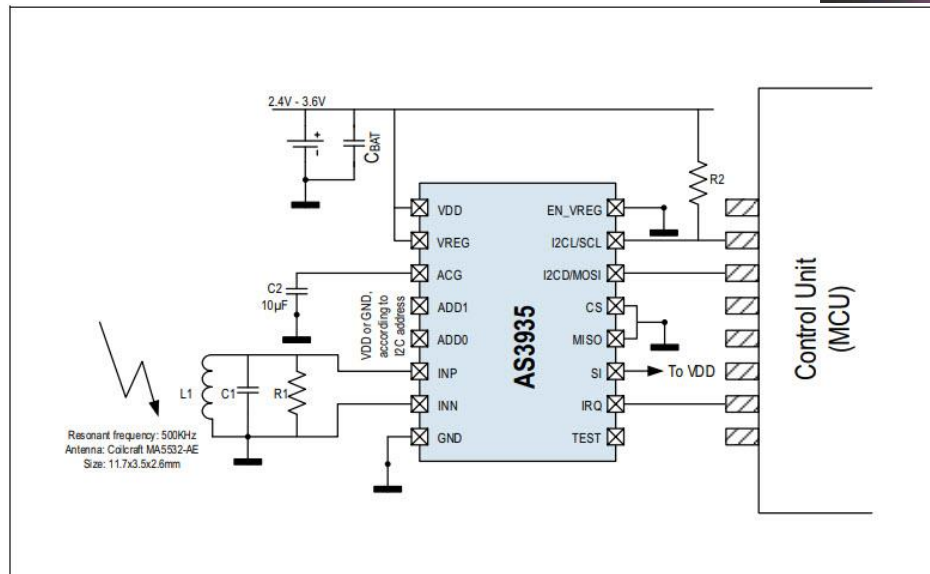
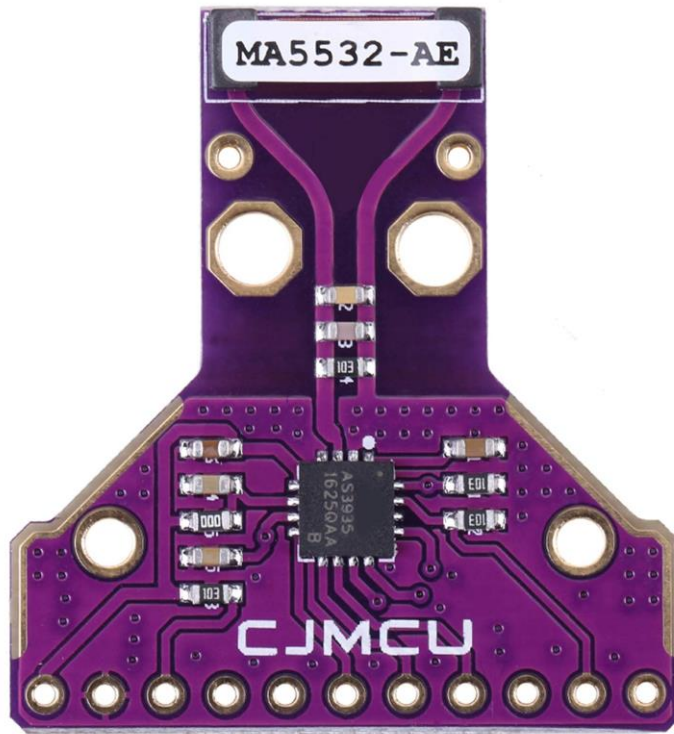
**Un Systeme de terre ne protege pas necessairement les
equipements RF**

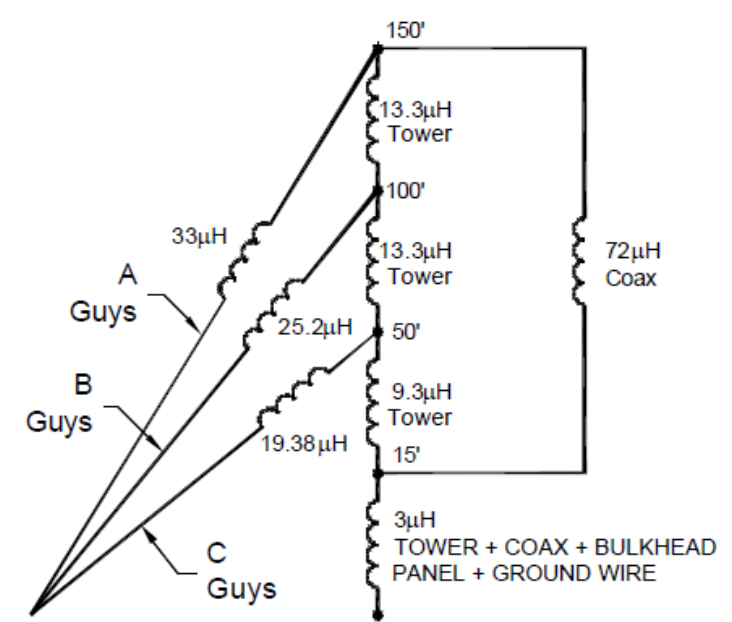
mais il protege le personnel

Elements clefs pour mieux comprendre les systemes de protection:

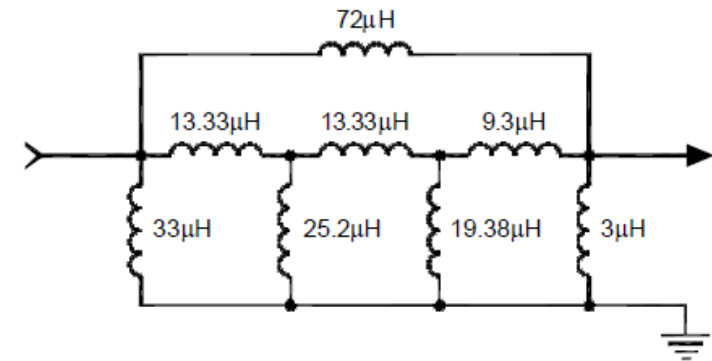
1. Notions fondamentales d'electricite (impedance , reactance, **inductance**, Resistance, capacitance,etc...)
2. Regarder les systemes de protection comme des **elements radioelectriques** (haute frequence > 100 KHz) et non pas comme des electriciens (50/60 Hz)
3. Apprendre , lire , s'instruire , se former et **non pas apprendre en detruisant des equipements** comme c'est souvent le cas .
4. **Ne surtout pas copier** los mauvais exemples d'installations existentes
5. **Les systemes de terre sont generalement utilise pour proteger le personnel**

Détecteurs charges atmospheriques

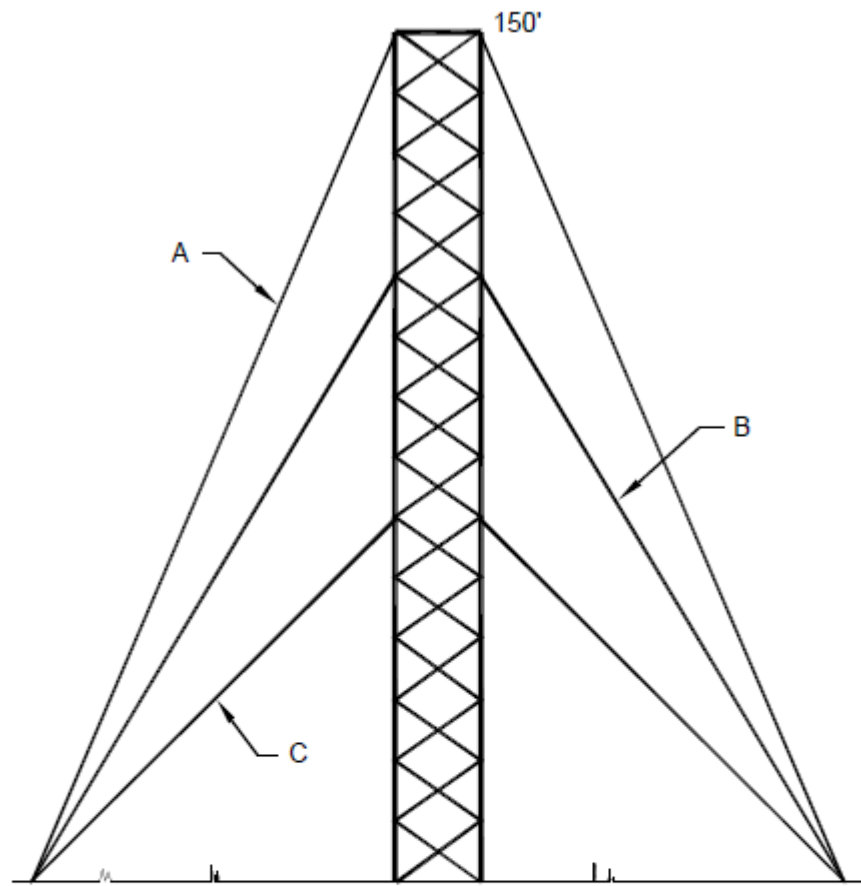




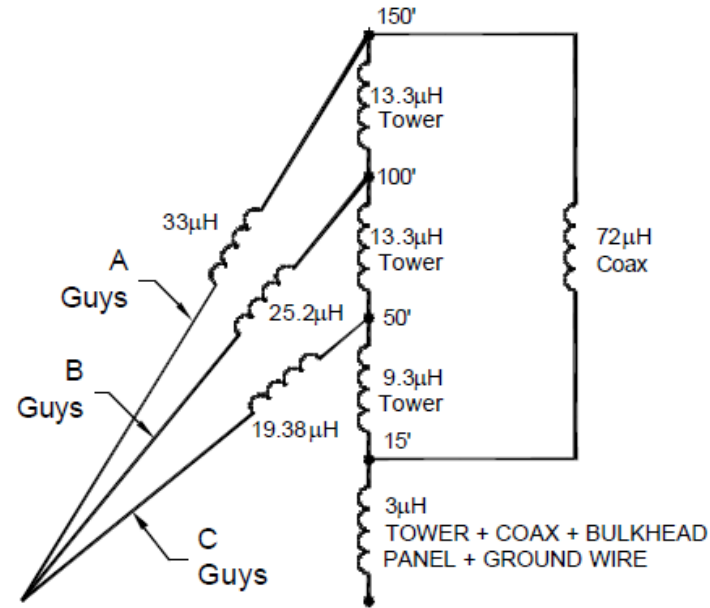
Re-drawing the tower circuit:



Resulting calculation equals about 12 μ H top to bottom.



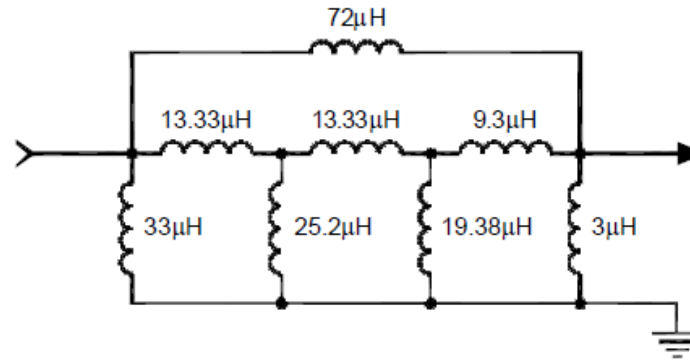
Example	Length in Feet	Inductance in μH	Inductance (μH) for 3 in Parallel
A	180.28	99.00	33.00
B	141.42	75.60	25.20
C	111.80	58.14	19.38



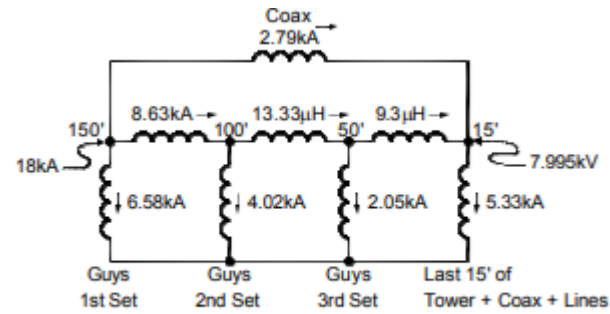
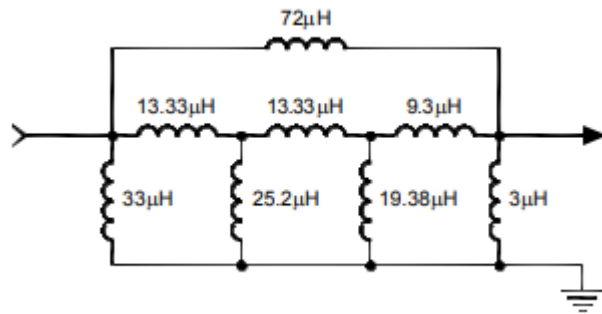
When the 18kA lightning strike occurs, it will have a voltage drop of

Re-drawing the tower circuit:

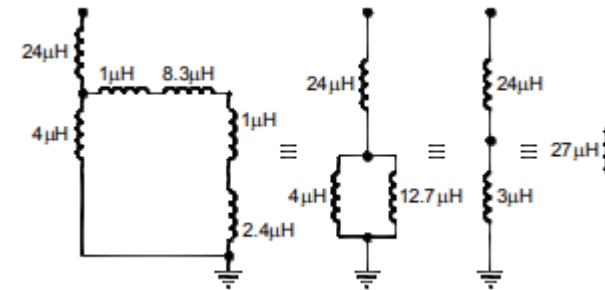
$$-E = L \frac{di}{dt} = \frac{12\mu\text{H} \times 18,000}{2\mu\text{s}} = 108\text{kV}$$



Resulting calculation equals about 12 μH top to bottom.

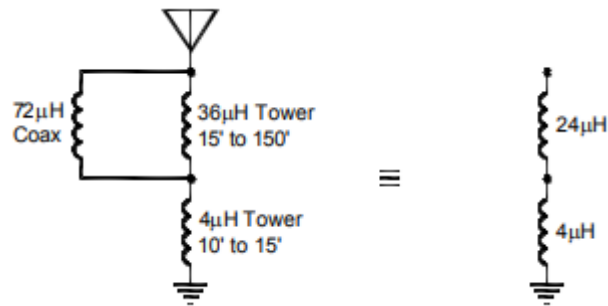


Average Coax Current is 2.79kA



when the 18kA lightning strike occurs, it will have a voltage drop of

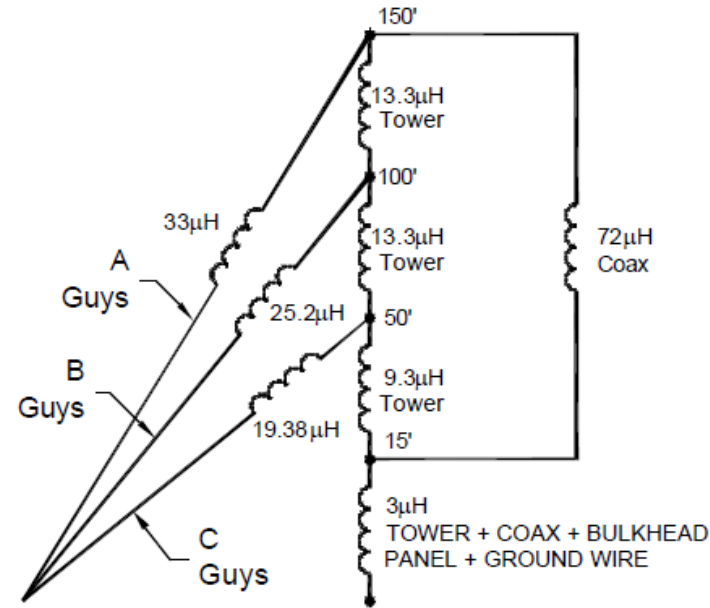
$$-E = L \frac{di}{dt} = \frac{12\mu H \times 18,000}{2\mu s} = 108kV$$



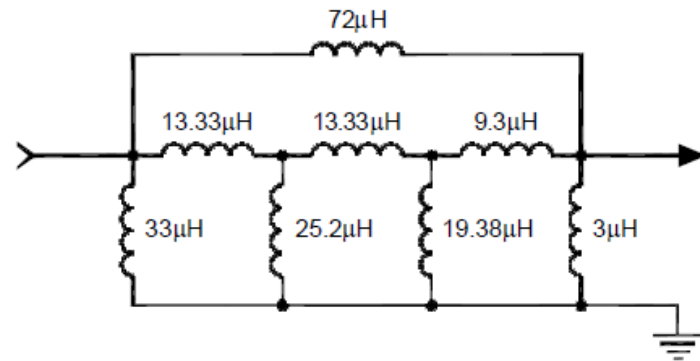
$$E = L \cdot \frac{di}{dt}$$

$$E = 28\mu H \cdot \frac{18000A}{2\mu s}$$

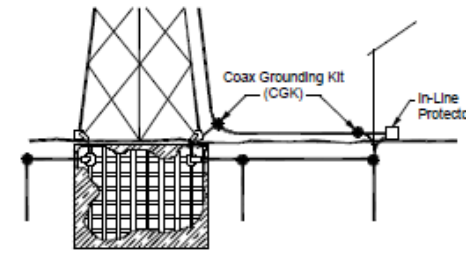
$$E = 252 kV$$



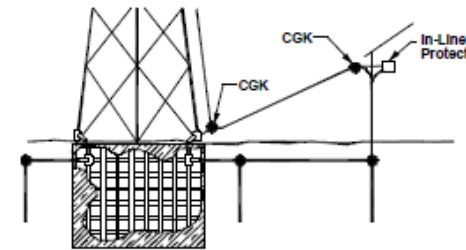
Re-drawing the tower circuit:



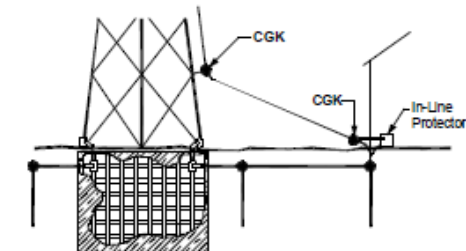
Resulting calculation equals about $12\mu\text{H}$ top to bottom.



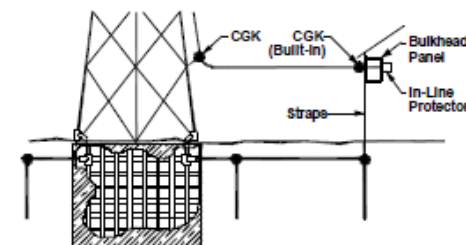
BEST



GOOD



OK



ACCEPTABLE

ADVANTAGES

DISADVANTAGES

Low $L \, di/dt$ voltage

- 1) Coax must make tight bends.
- 2) Coax enters at floor level.

Low $L \, di/dt$ at tower

- 1) Large $L \, di/dt$ for in line protector unless large grounding surface area conductor is used for building CGK and protector.
- 2) Sloped line will intercept tower mag fields.

Low $L \, di/dt$ at building

- 1) Coax must enter at floor level.
- 2) Sloped line will intercept tower mag fields.

1) Enters building high.

2) Does not intercept tower mag field.

Large straps cost more but are needed to reduce $L \, di/dt$ voltage

Il est donc impératif d'utiliser exclusivement des conducteurs a très faible inductance

$Z = \text{Resistance} +/- j \text{ reactance}$



quelques ohms



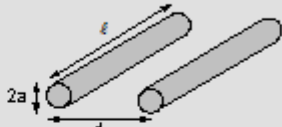
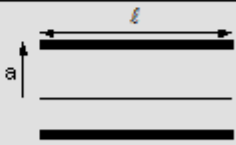
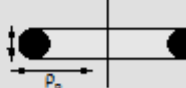
centaines voire des milliers d'ohms

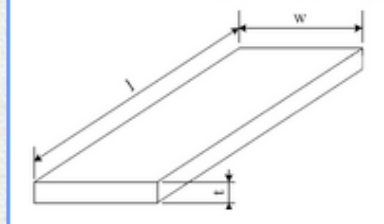
$Z = \text{Resistance} +/- j \text{ reactance (inductance)}$

$Z = \text{Inductance}$

$X_L = 2 \cdot \pi \cdot 500 \text{ KHz} \cdot 28 \mu\text{H}$

$X_L = 88 \text{ ohms}$

1. Wire $L = \frac{\mu_0 \ell}{8\pi}$	
2. Hollow cylinder $L = \frac{\mu_0 \ell}{2\pi} \left(\ln \frac{2\ell}{a} - 1 \right)$ $\ell \gg a$	
3. Parallel wires $L = \frac{\mu_0 \ell}{\pi} \ln \frac{d}{a}$ $\ell \gg d, d \gg a$	
4. Coaxial conductor $L = \frac{\mu_0 \ell}{\pi} \ln \frac{b}{a}$	
5. Circular loop $L = \frac{\mu_0 \ell}{2\pi} \left(\ln \frac{4\ell}{d} - 2.45 \right)$ $\ell = -2\pi\rho_o, \rho_o \gg d$	
6. Solenoid $L = \frac{\mu_0 N^2 S}{\ell}$ $\ell \gg a$	
7. Torus (of circular cross section) $L = \mu_0 N^2 \left[\rho_o - \sqrt{\rho_o^2 - a^2} \right]$	
8. Sheet $L = \mu_0 2 \ell \left(\ln \frac{2\ell}{b+t} + 0.5 \right)$	



Conductor material:	Copper	
σ : conductance		$\times 10^6 \text{ S/m}$
k : thermal conductivity		W/m/K
T : temperature	25	$^{\circ}\text{C}$
δ : skin depth		μm
f : frequency	100	MHz
ℓ : wire length	10	mm
w : wire width	1	mm
t : wire thickness	0.018	mm
L_{flat} : Inductance		nH
R_{dc} : DC resistance		$\text{m}\Omega$
θ : thermal resistance		K/W
Calculate!		

R_{dc} : valid for $-50^{\circ}\text{C} \leq \text{temp} \leq 150^{\circ}\text{C}$

Formulas used

$$L_{flat} = 2 \times 10^{-4} \ell \left[\ln \left(\frac{2\ell}{w+t} \right) + 0.5 + 0.2235 \left(\frac{w+t}{\ell} \right) \right] [\mu\text{H}]$$

where

L_{flat} : inductance of the conductor [μH]

ℓ : length of the conductor [mm]

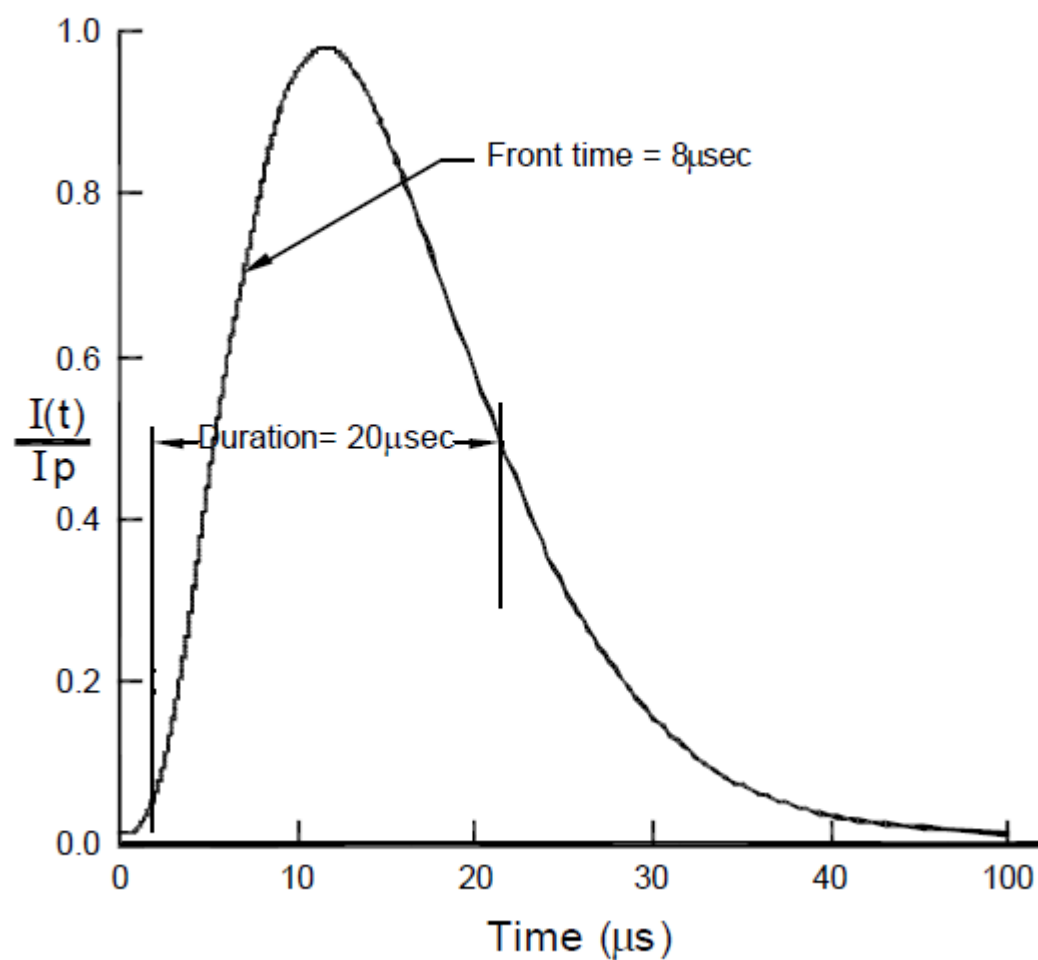
w : width of the conductor [mm]

t : thickness of the conductor [mm]



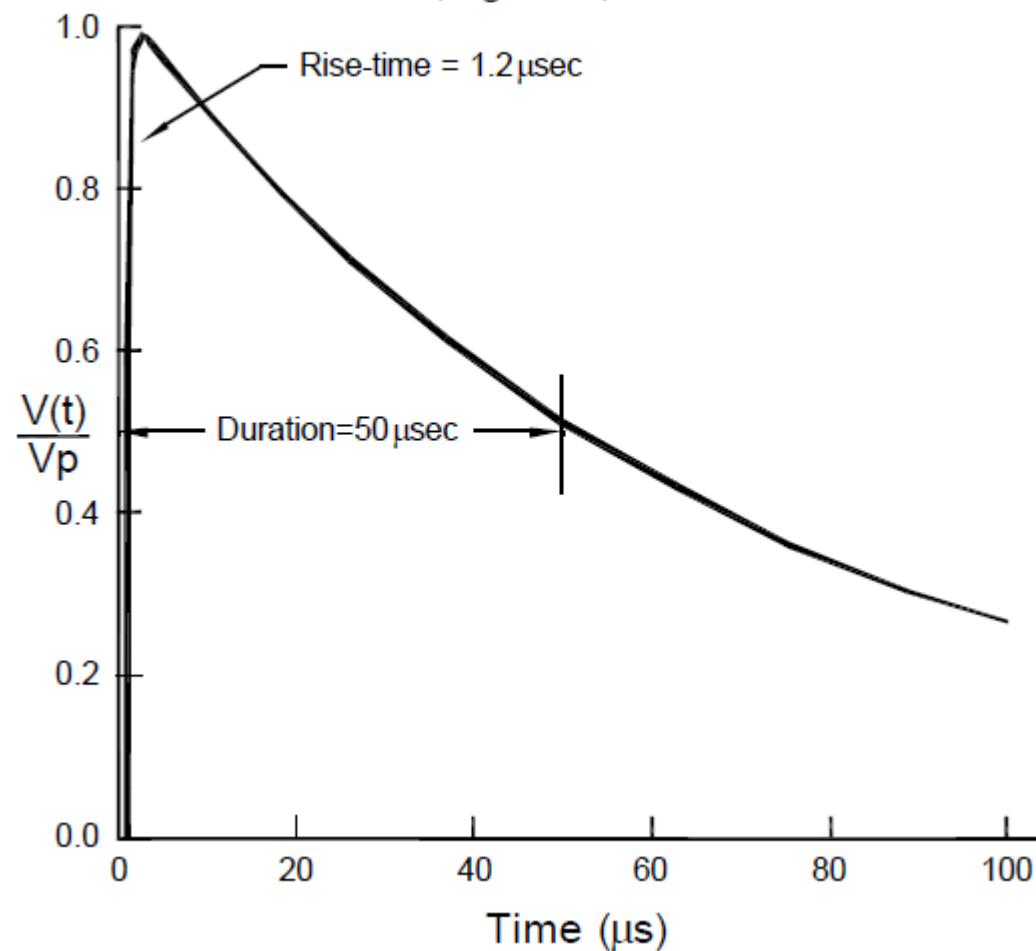


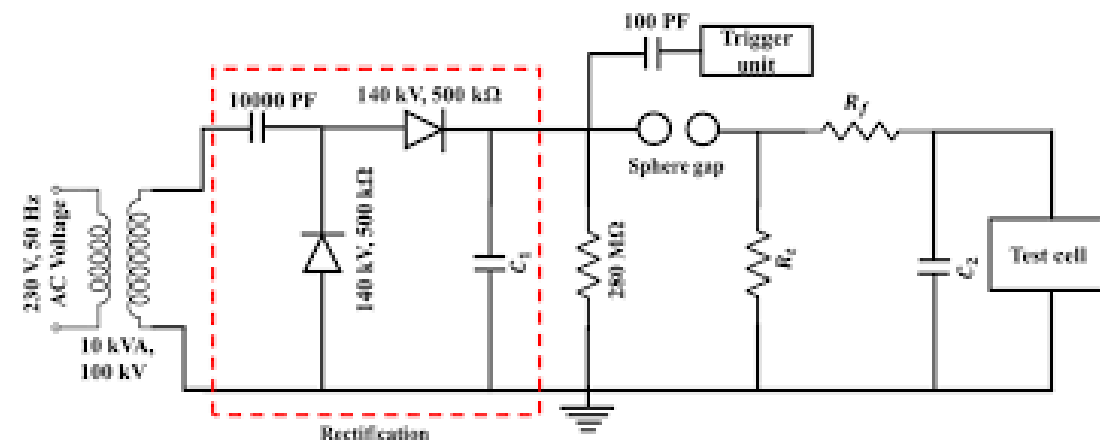
Combination Wave, Short-Circuit Current
(Figure 4)



[GRAPHS FROM IEEE - ANSI C62.41 - 1991]

Combination Wave, Open-Circuit Voltage
(Figure 3)





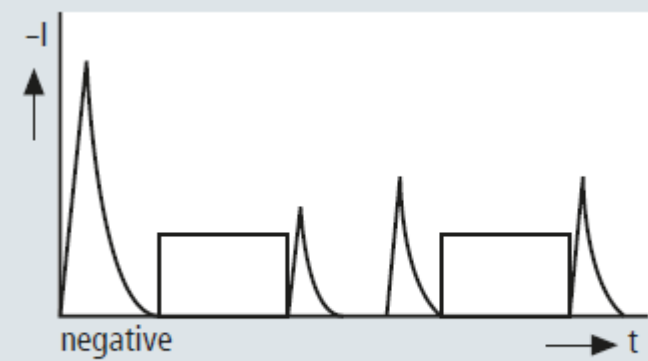
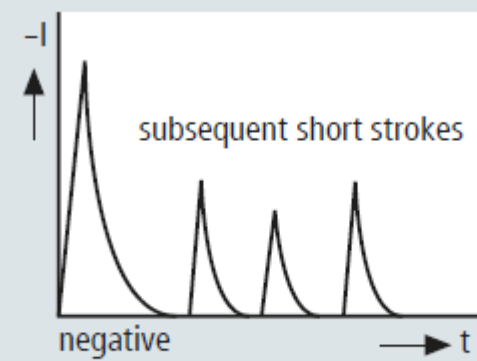
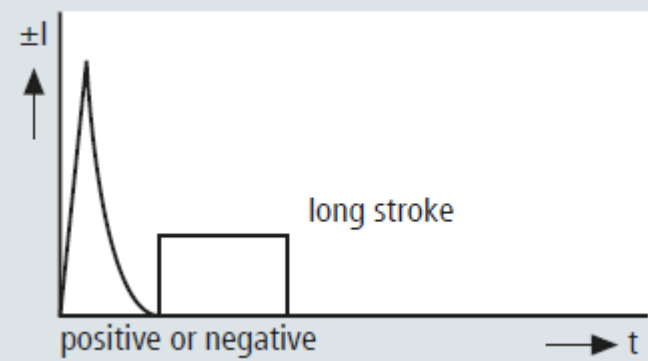
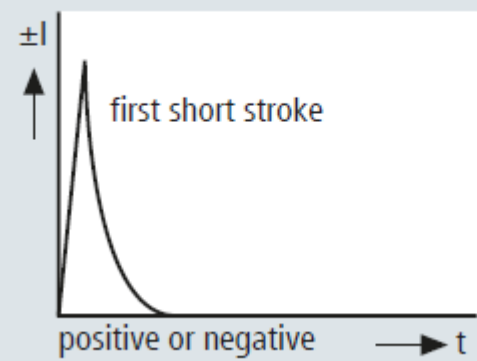
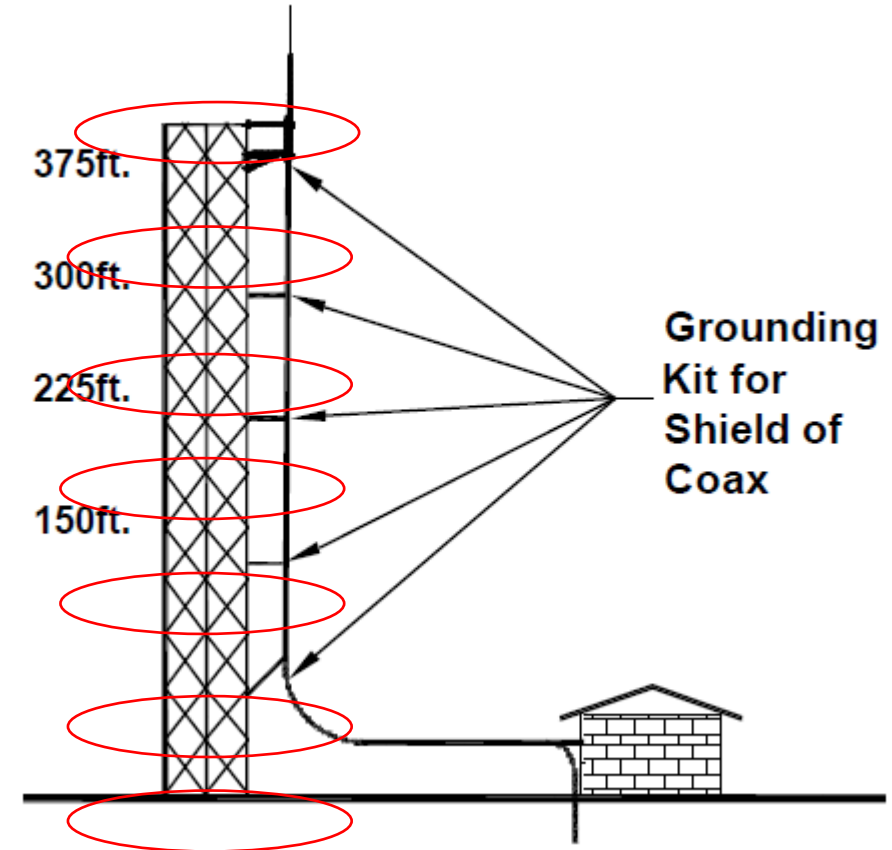


Figure 2.1.7 Possible components of a downward flash

Attention self inductance



Couplage mutuel (entre pylone et coax)

$$M = K \cdot \sqrt{L_{pylone} \cdot L_{coax}}$$

$$L_{pylone} = 40 \mu H$$

$$L_{coax} = 72 \mu H$$

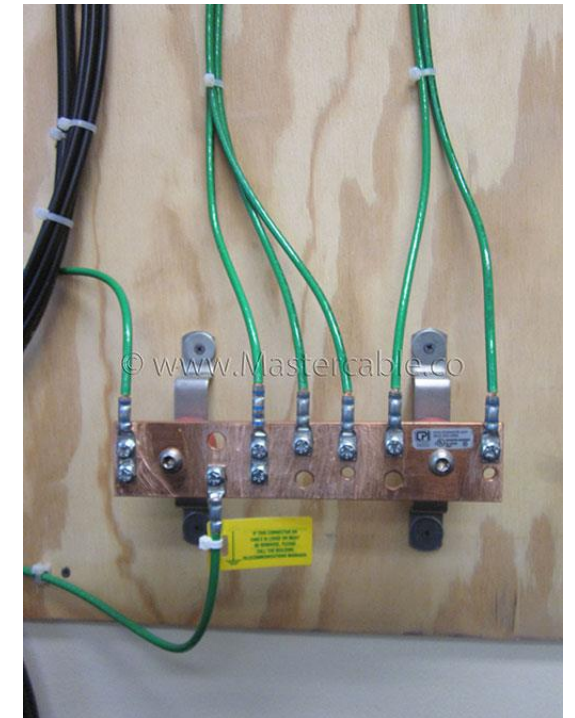
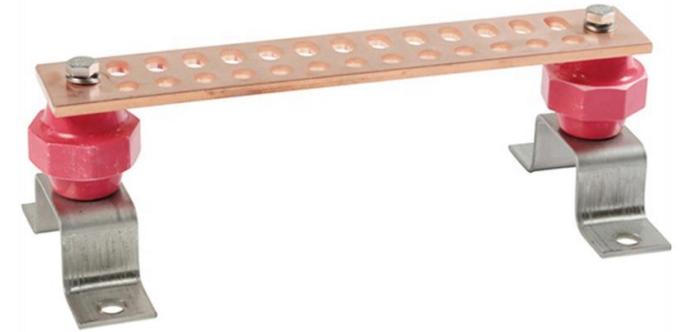
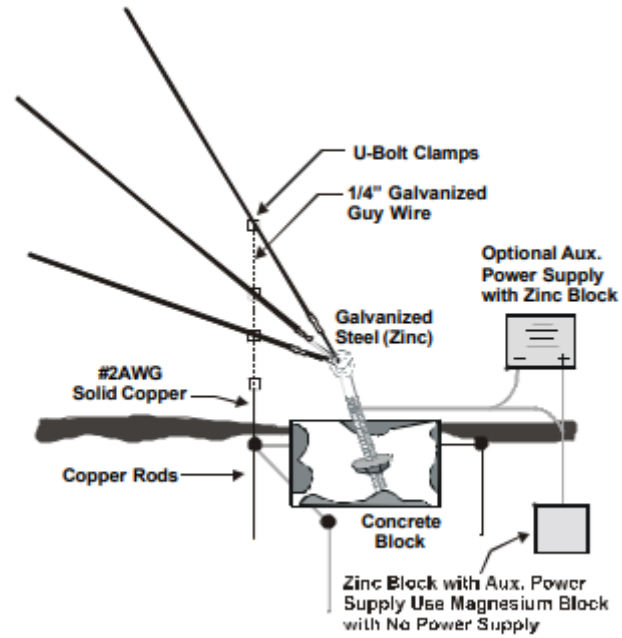
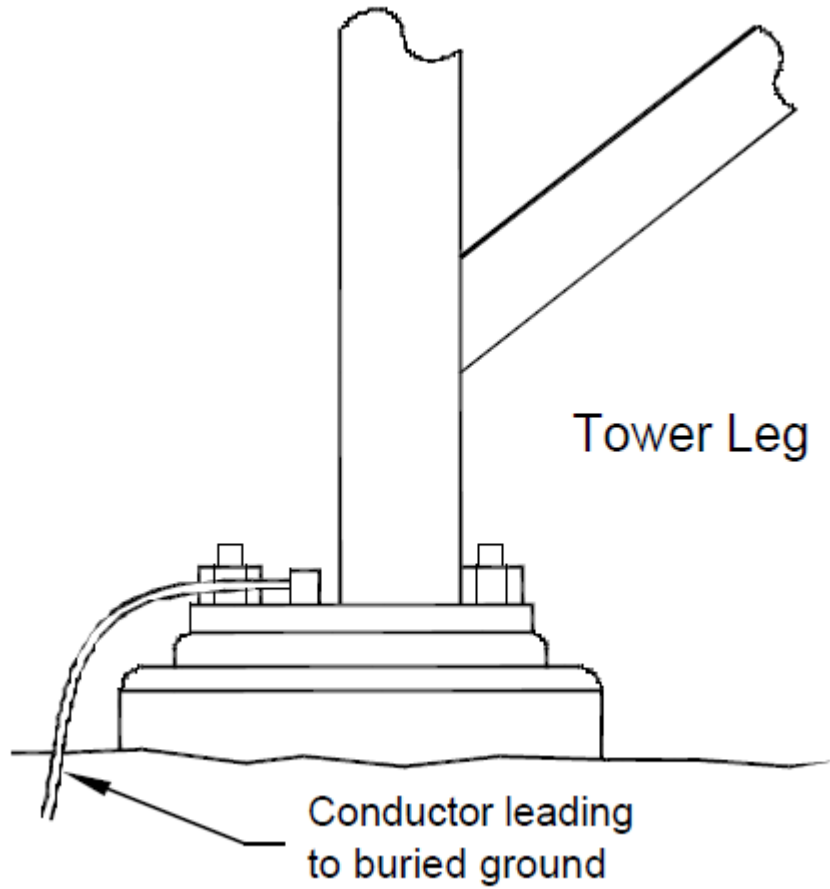
$$K=0.166$$

$$M= 8.9 \mu H$$

avec un courant de 18000 A / 2 μS

$$V = L \cdot \frac{di}{dt} = 8.9 \mu H \cdot \frac{18000 A}{2 \mu S}$$

$$V= 80.1 kV !$$



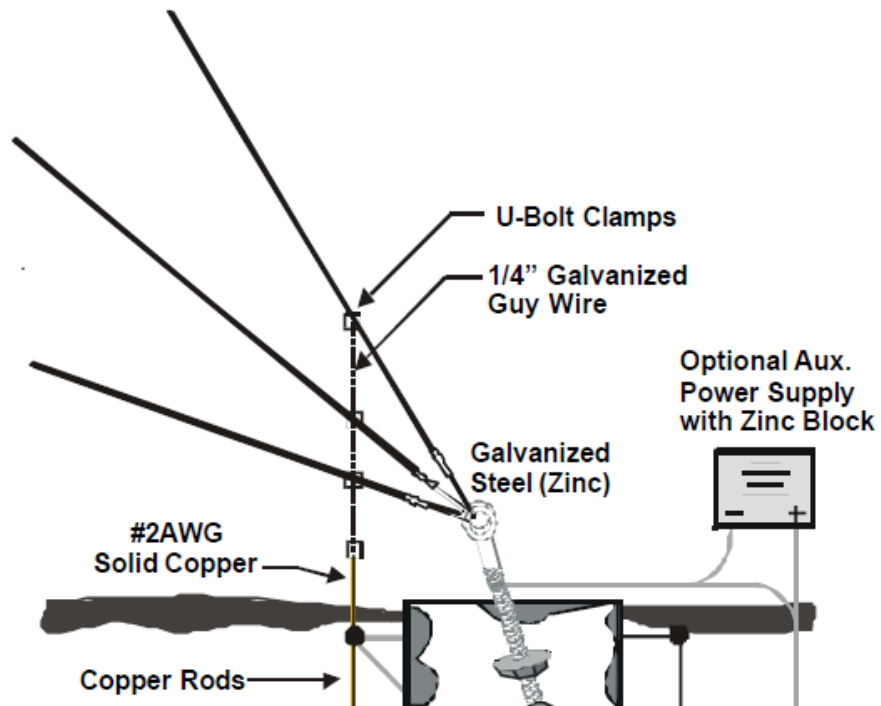
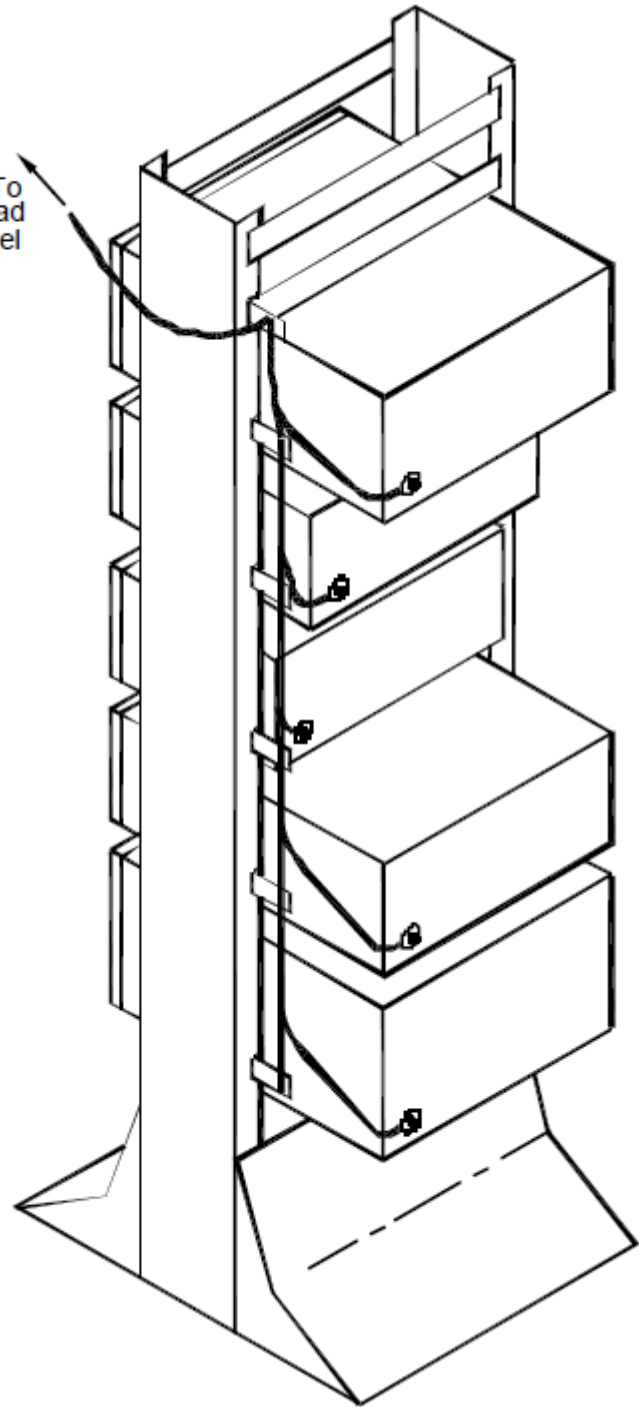
Corrosion galvanique

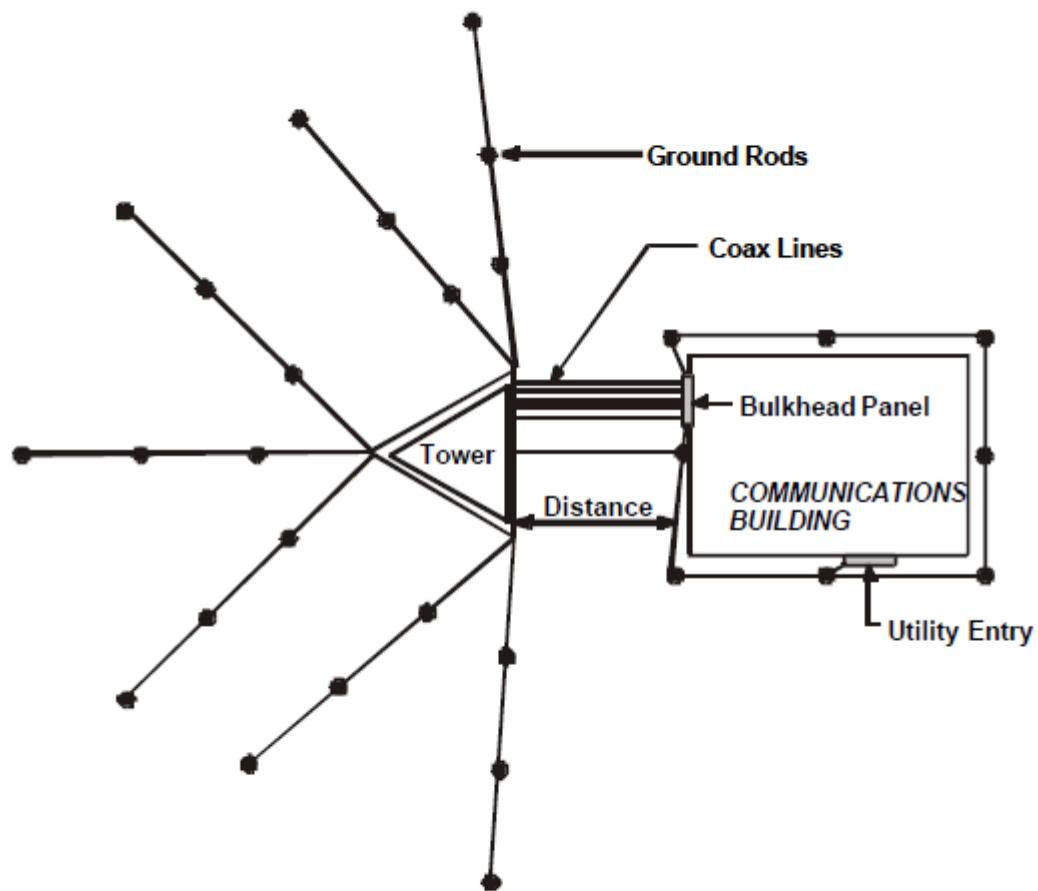


	Magnesium	Aluminum	Zinc	Iron	Cadmium	Nickel	Tin	Lead	Copper	Silver	Palladium	Gold	
↑ LESS NOBLE	MAGNESIUM	0.00	-0.71	-1.61	-1.93	-1.97	-2.12	-2.23	-2.24	-2.71	-3.17	-3.36	-3.87
	ALUMINUM	0.71	0.00	-0.90	-1.22	-1.26	-1.41	-1.52	-1.53	-2.00	-2.46	-2.65	-3.16
	ZINC	1.61	0.90	0.00	-0.32	-0.36	-0.51	-0.63	-0.64	-1.10	-1.56	-1.75	-2.26
	IRON	1.93	1.22	0.32	0.00	-0.04	-0.19	-0.30	-0.31	-0.78	-1.24	-1.43	-1.94
	CADMIUM	1.97	1.26	0.36	0.04	0.00	-0.15	-0.27	-0.28	-0.74	-1.20	-1.39	-1.90
	NICKEL	2.12	1.41	0.51	0.19	0.15	0.00	-0.11	-0.12	-0.59	-1.05	-1.24	-1.75
	TIN	2.23	1.52	0.63	0.30	0.27	0.11	0.00	-0.01	-0.47	-0.94	-1.12	-1.64
	LEAD	2.24	1.53	0.64	0.31	0.28	0.12	0.01	0.00	-0.46	-0.93	-1.11	-1.63
	COPPER	2.71	2.00	1.10	0.78	0.74	0.59	0.47	0.46	0.00	-0.46	-0.65	-1.16
	SILVER	3.17	2.46	1.56	1.24	1.20	1.05	0.94	0.93	0.46	0.00	-0.19	-0.70
	PALLADIUM	3.36	2.65	1.75	1.43	1.39	1.24	1.12	1.11	0.65	0.19	0.00	-0.51
	GOLD	3.87	3.16	2.26	1.94	1.90	1.75	1.64	1.63	1.16	0.70	0.51	0.00
	← LESS NOBLE →												

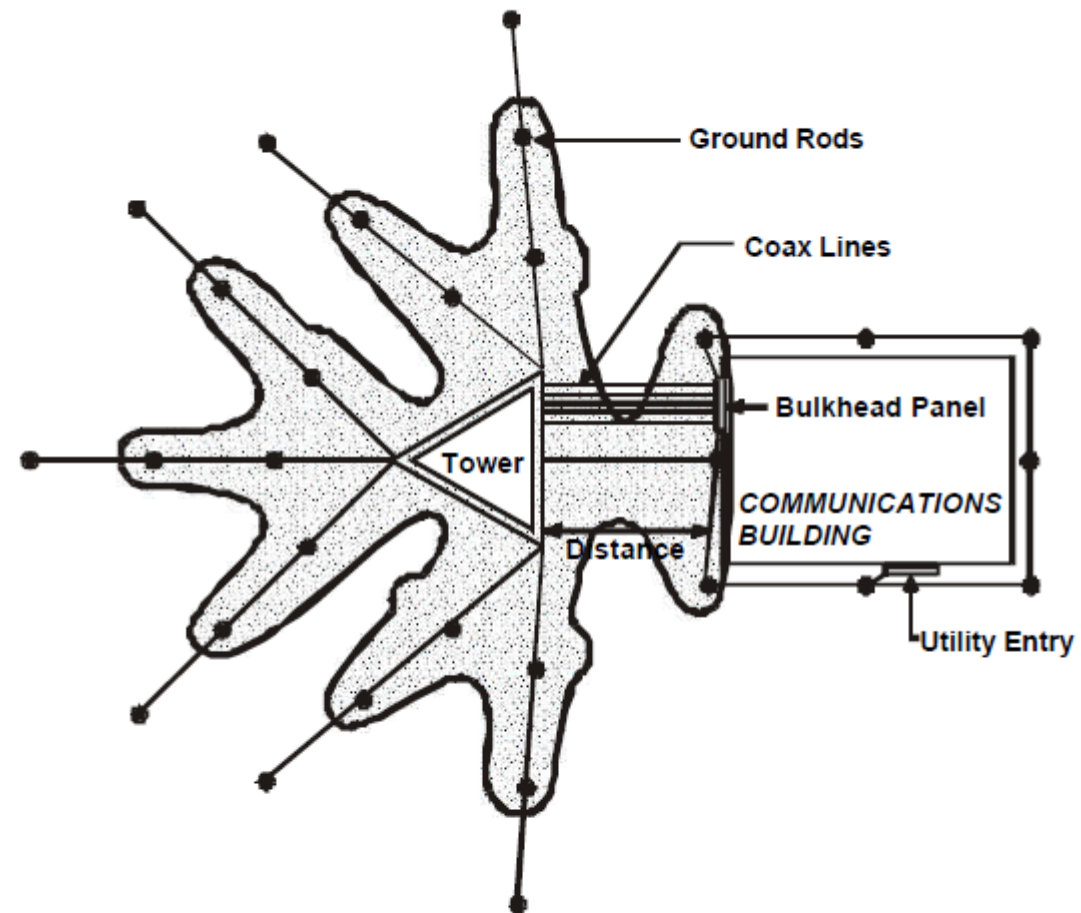
Noble Metal Table: Accelerated corrosion can occur between unprotected joints if the algebraic difference in atomic potential is greater than ± 0.3 volts.

To
Bulkhead
Panel

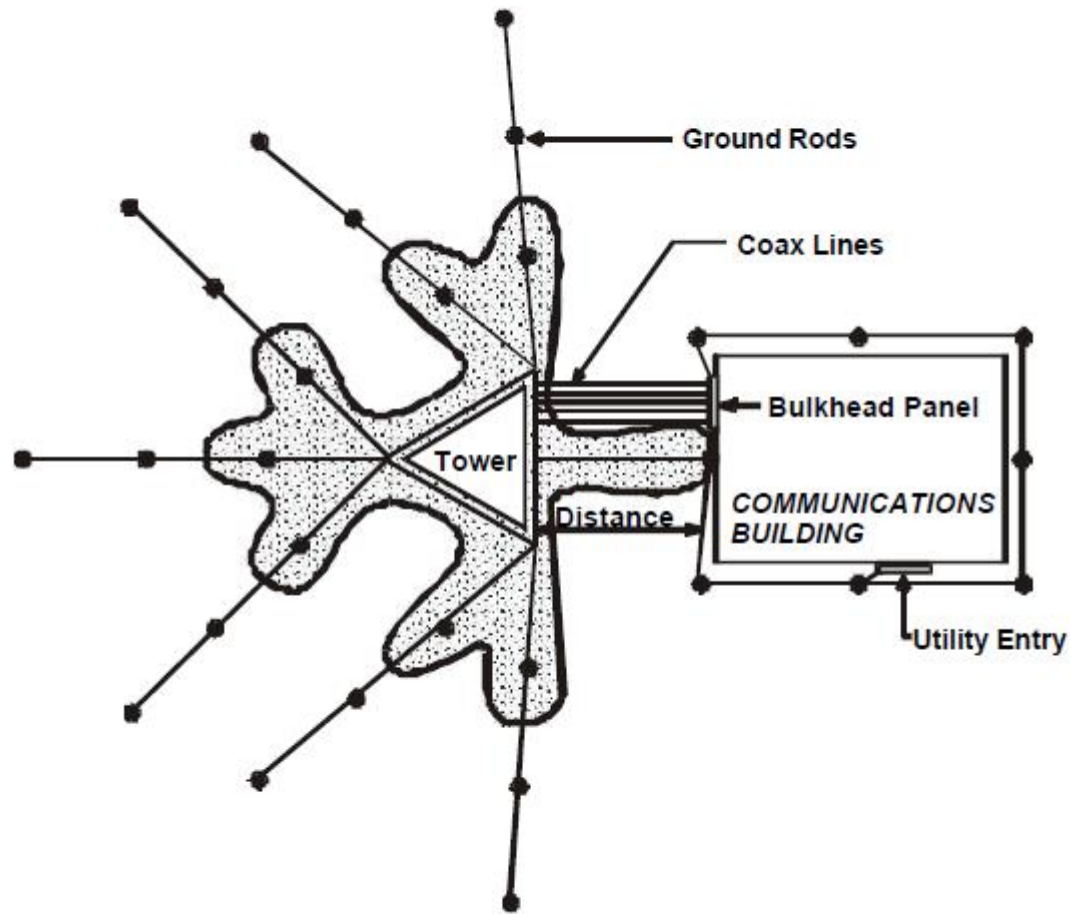




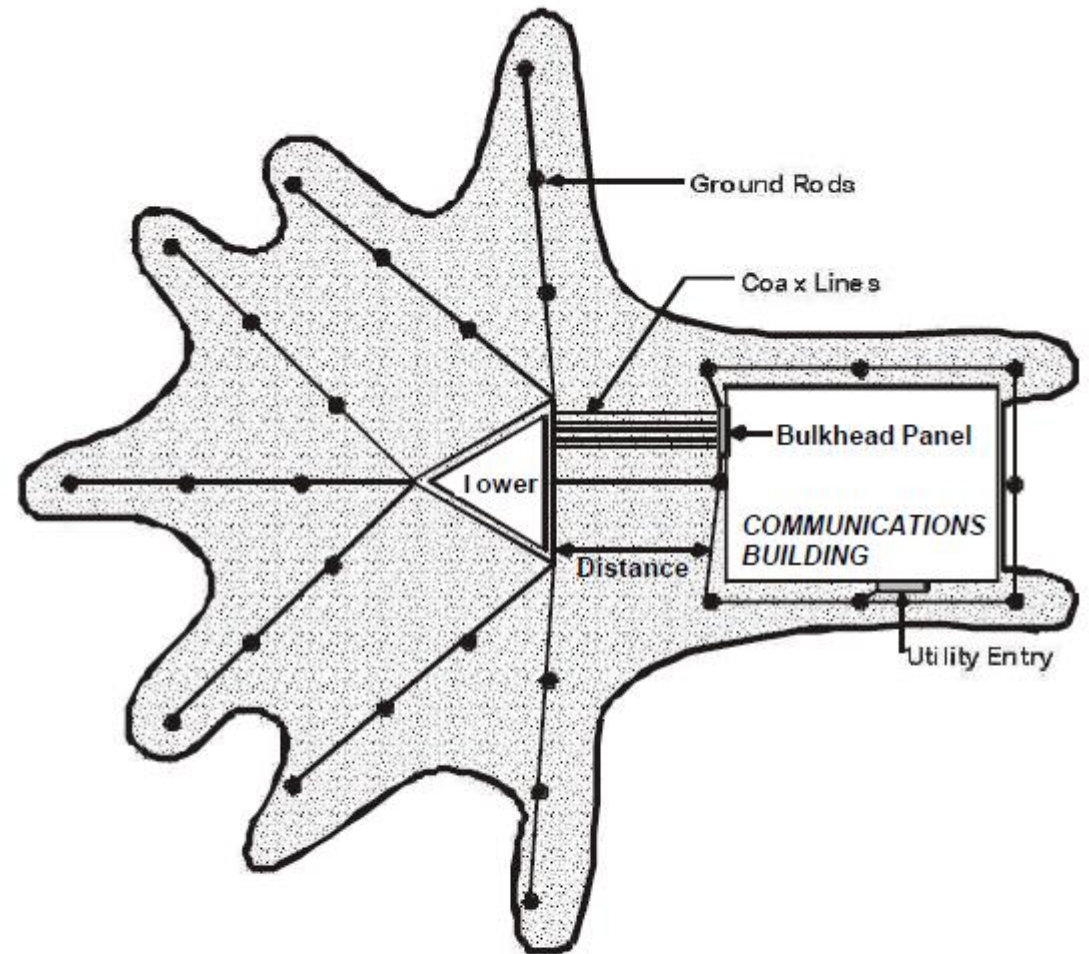
Recommended site grounding system
about to be hit by lightning.



On a well-designed ground system, the strike
energy spreads out initially from the building.

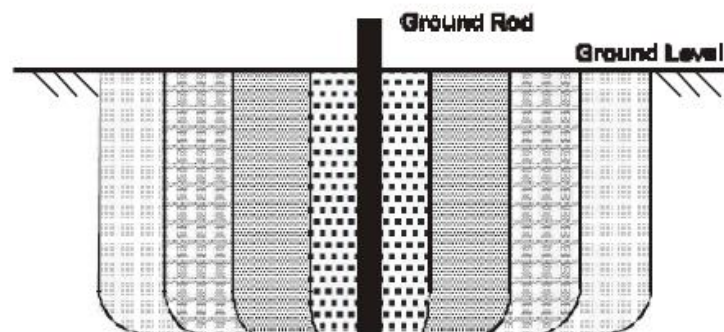


Neglecting the coax currents, the strike energy moves outward from the tower base along the radial line.

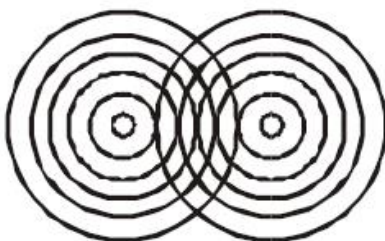


As it reaches and saturates the radial system, it will traverse the building perimeter.

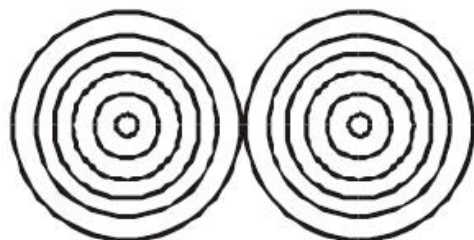
GROUND ROD SPHERE OF INFLUENCE



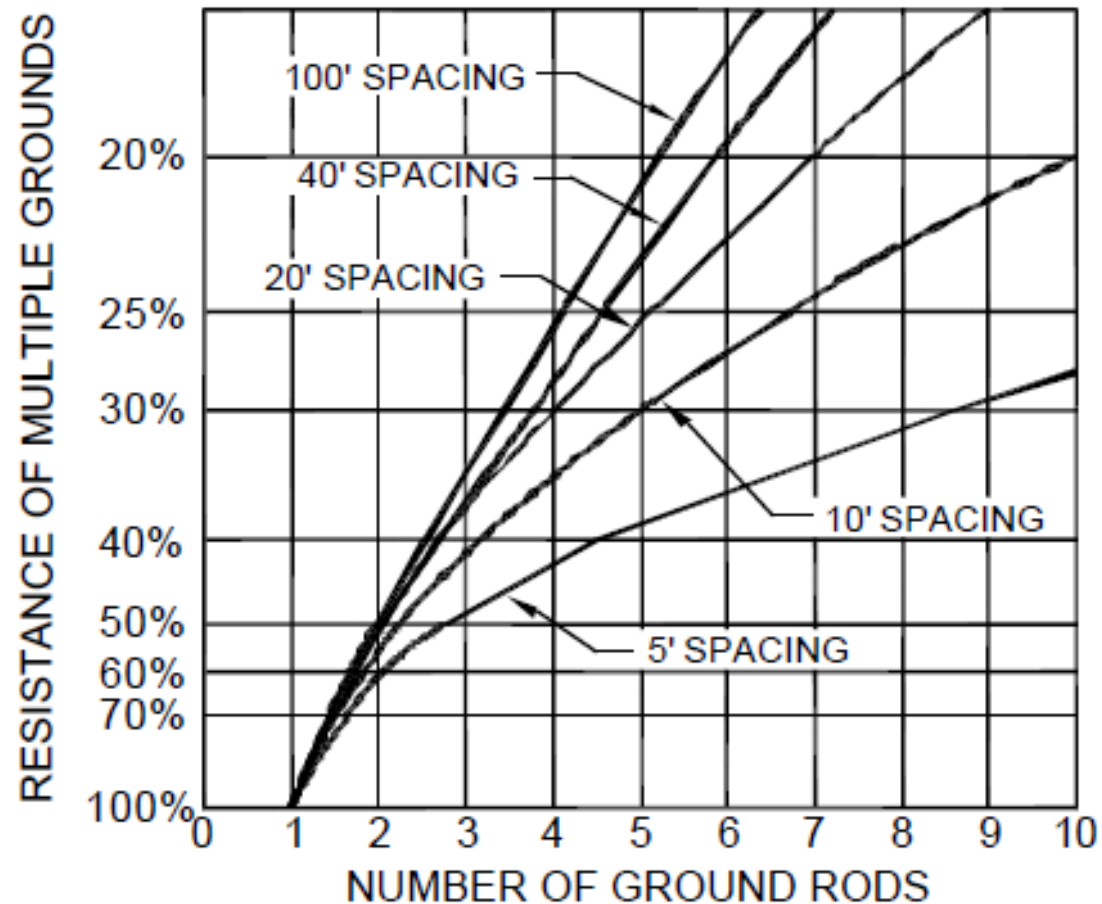
Incorrect Spacing



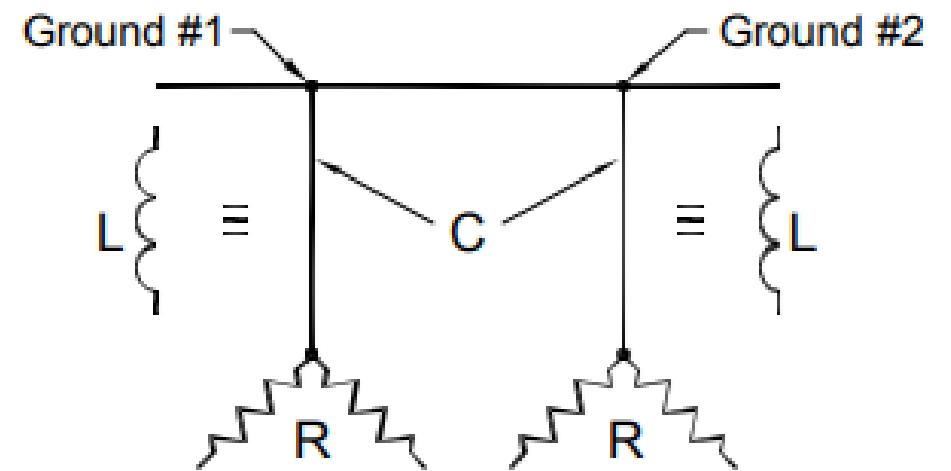
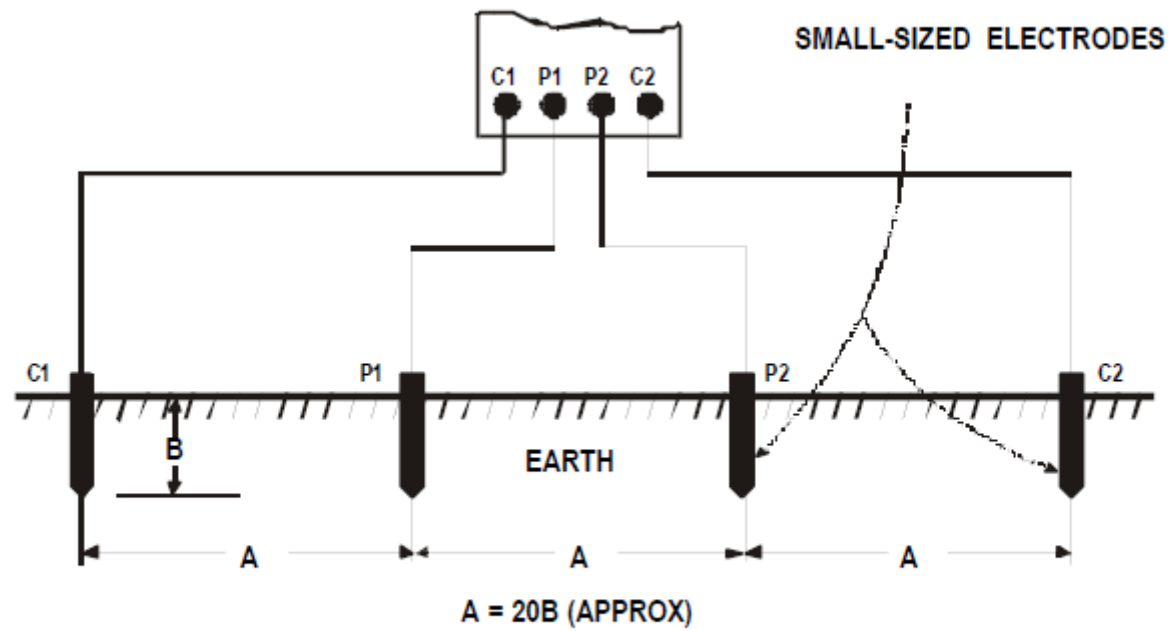
Correct Spacing



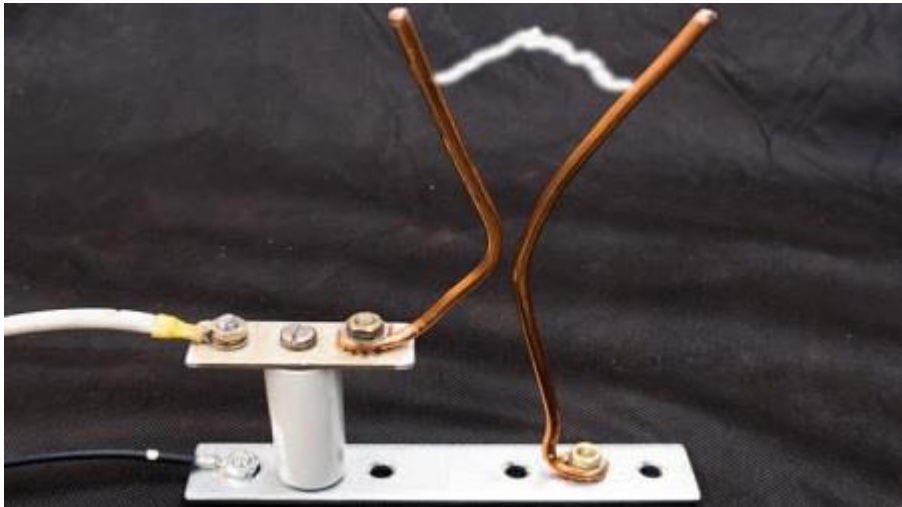
8Ft. Rod - 8Ft. Radius Influence
10Ft. Rod - 10Ft. Radius Influence



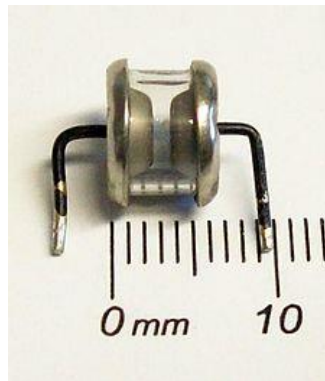
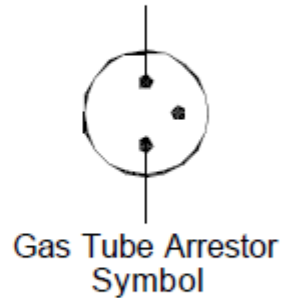
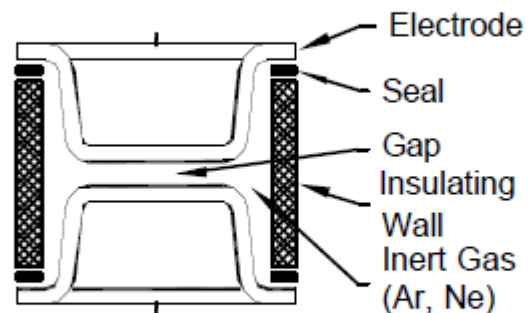
Theoretical resistance change for additionally spaced ground rods.



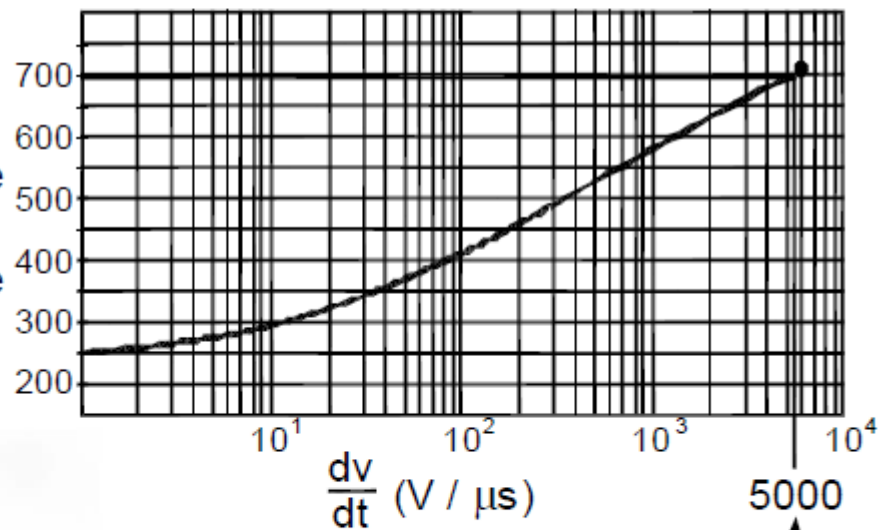
Four stake method of measuring soil resistivity.



Cut-away view of gas tube surge arrester (not to scale)



Impulse Firing Voltage (V)



ANSI C62.41, $\frac{dv}{dt} = 5000 \text{ V} / \mu\text{s}$
 $1.2 \times 50 \mu\text{s}$
 Firing Voltage $\approx 700 \text{ V}$

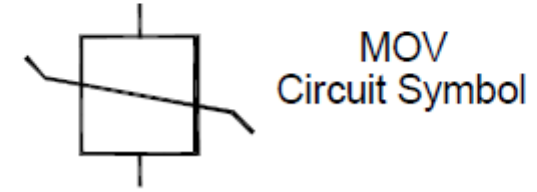
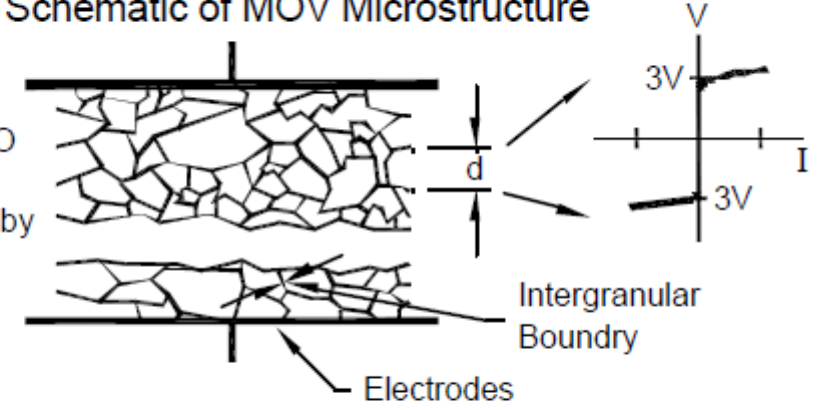




Metal Oxide Varistor (MOV)

Schematic of MOV Microstructure

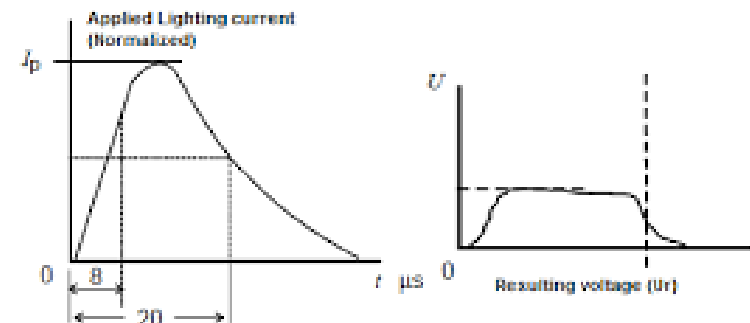
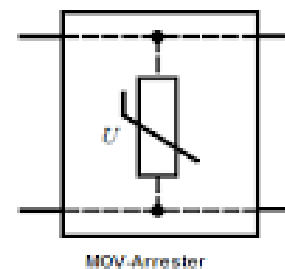
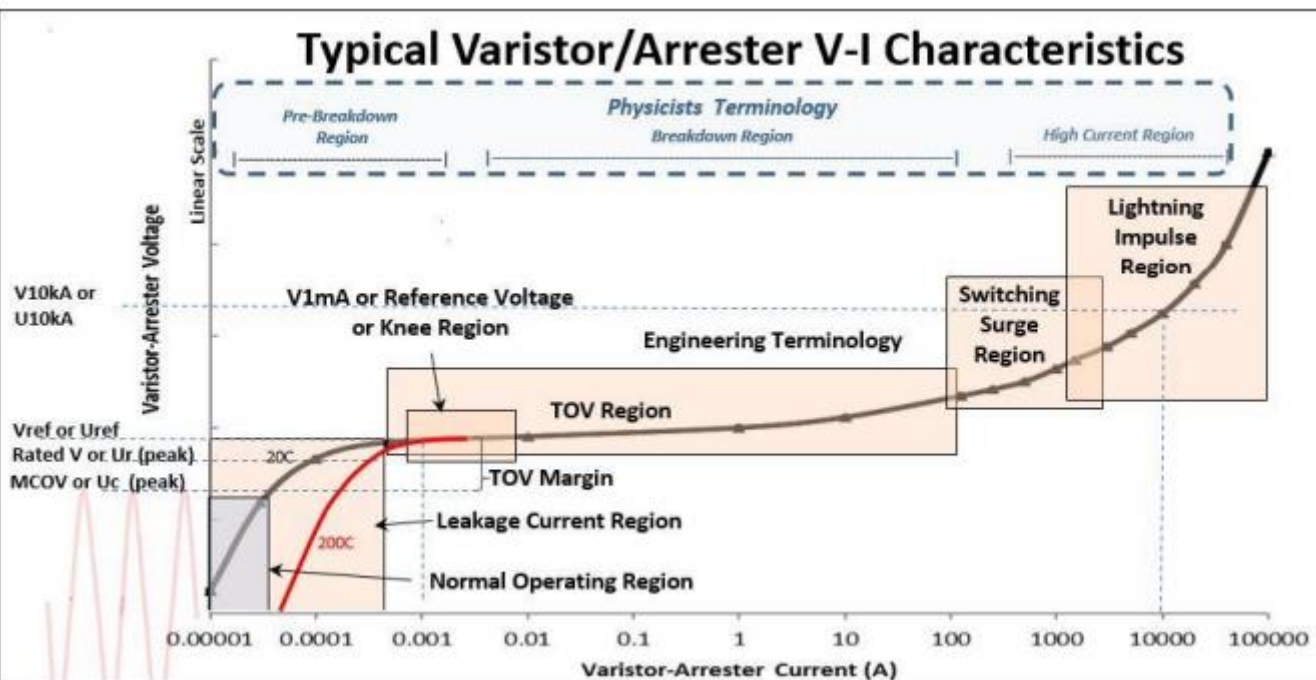
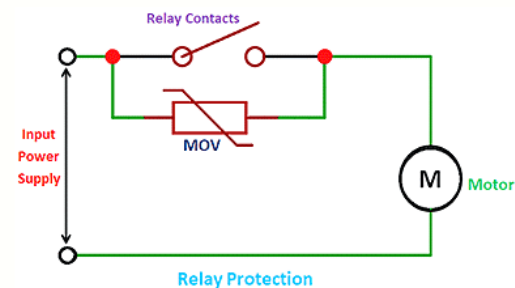
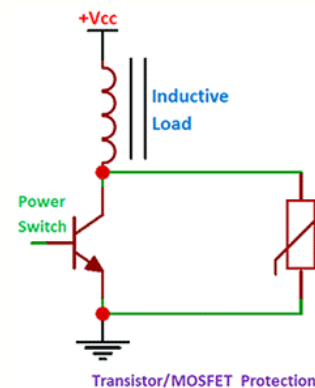
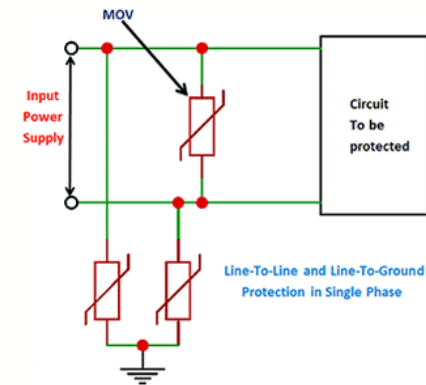
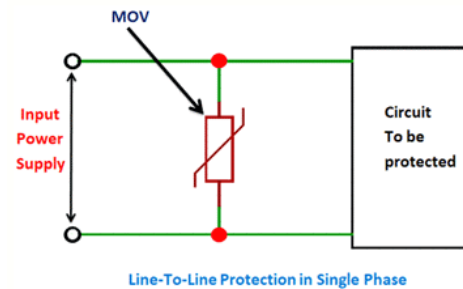
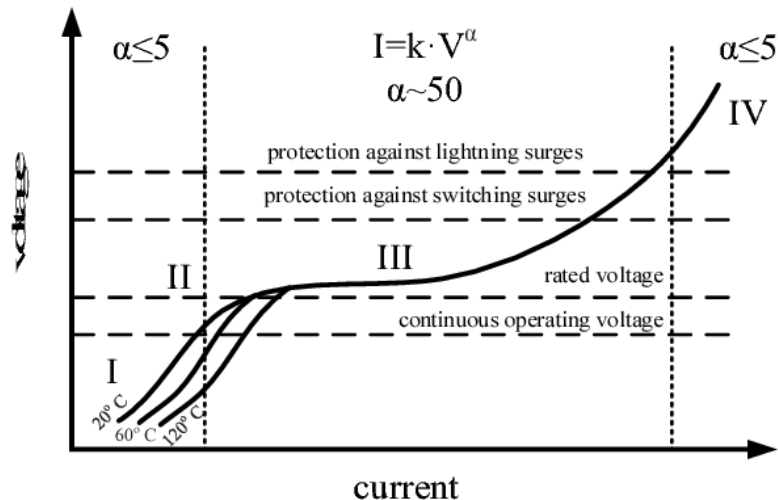
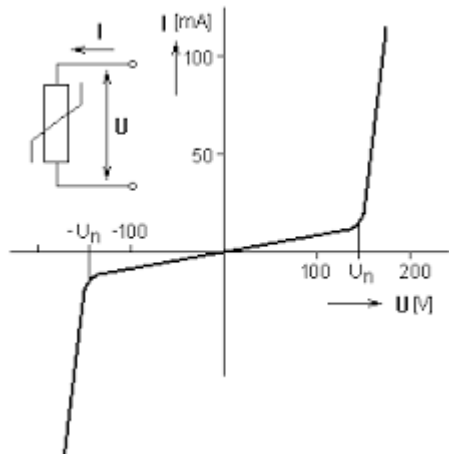
Grains of conducting ZnO (ave. size "d") are separated by intergranular boundaries

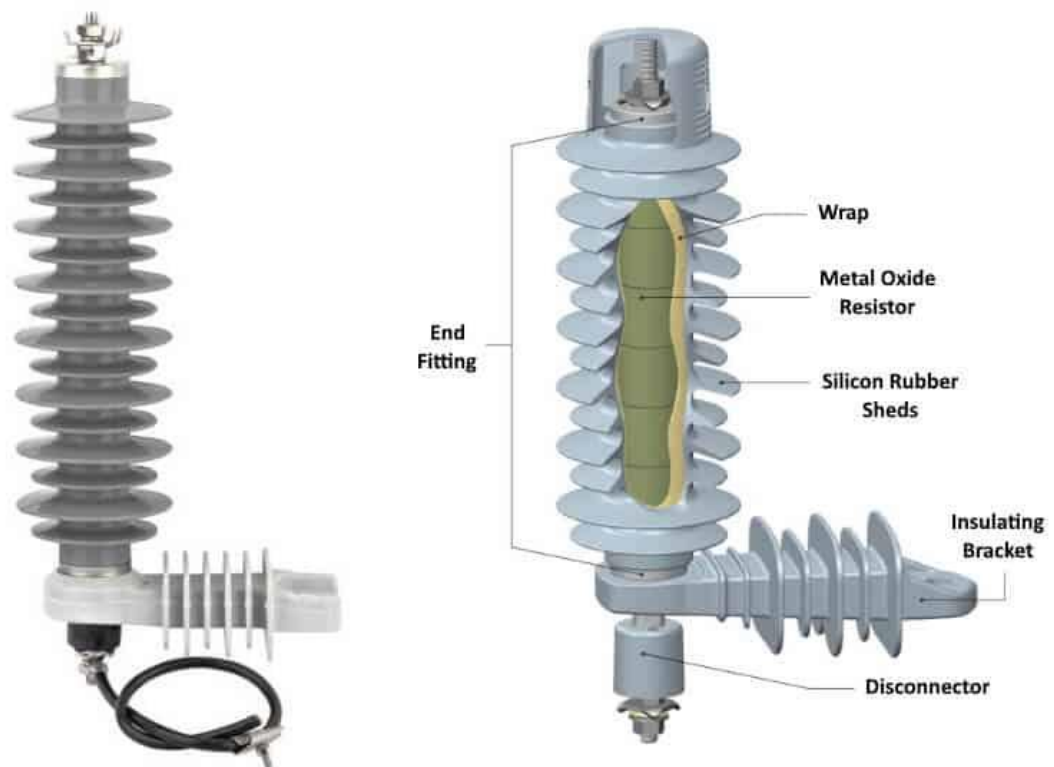


EL VARISTOR

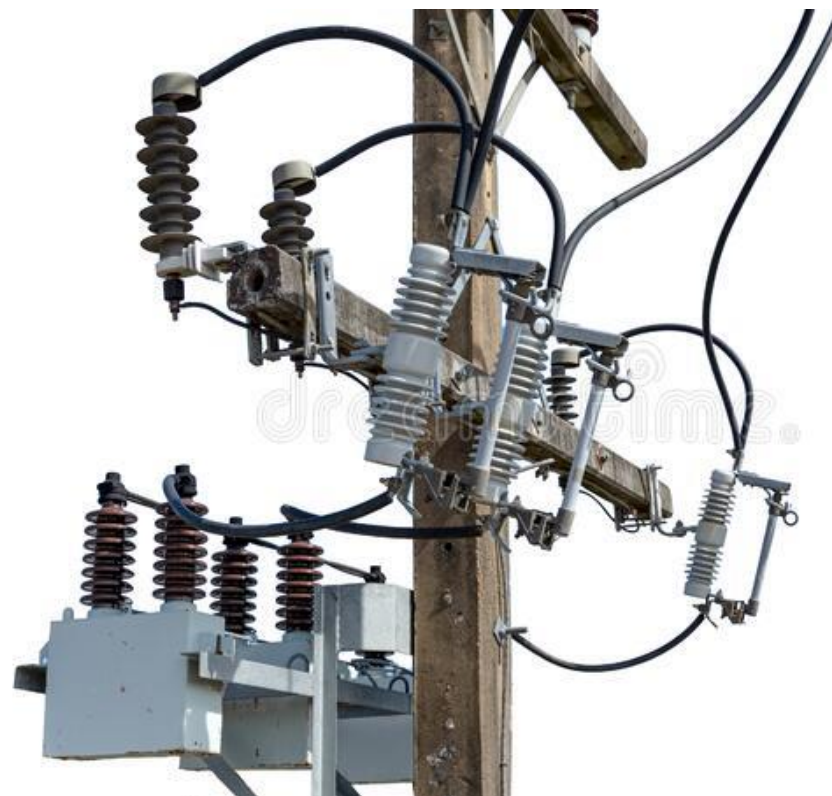
PARA QUE SIRVE,
COMO FUNCIONA Y TIPOS

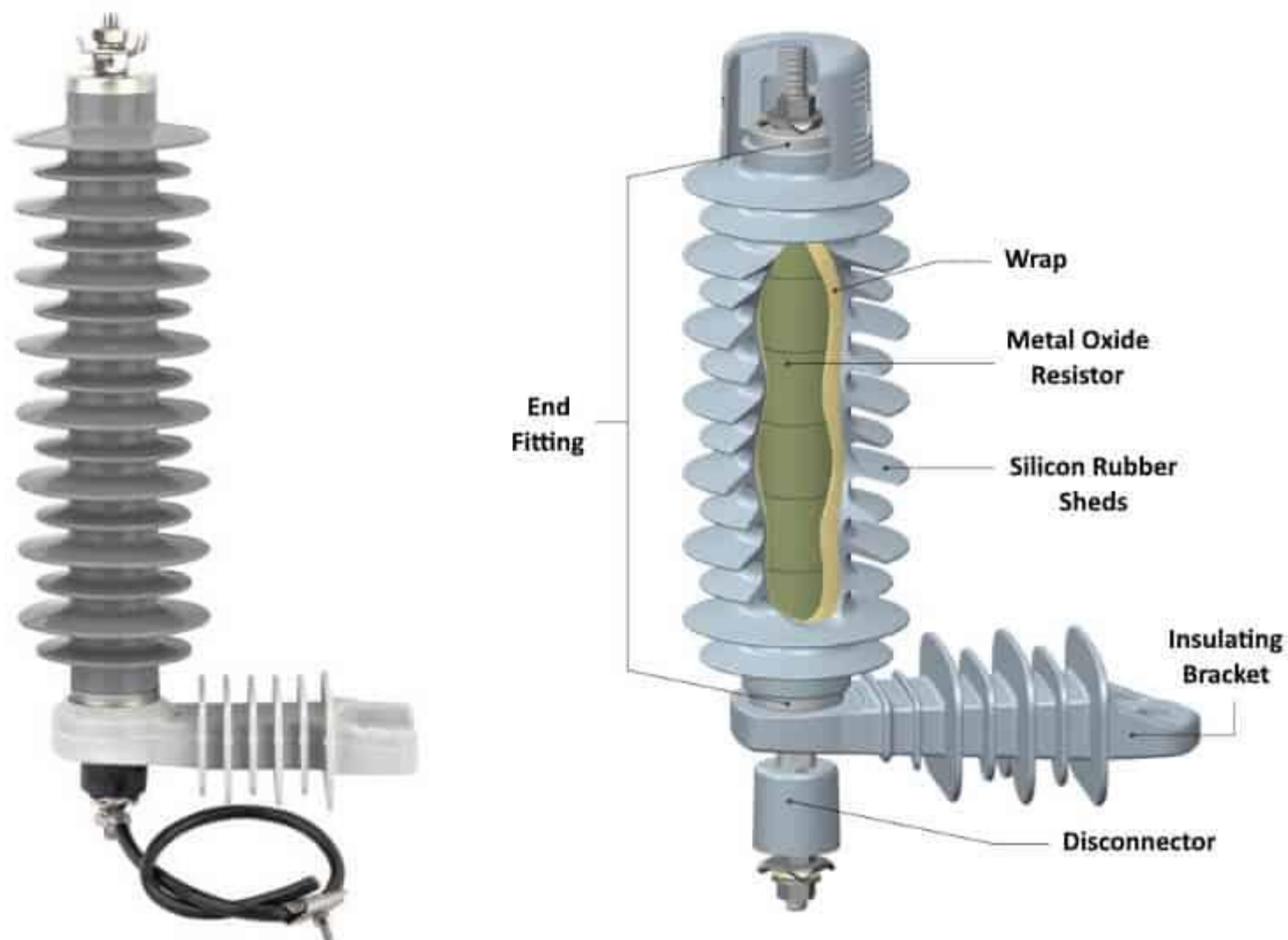






Surge Arrester





Surge Arrester



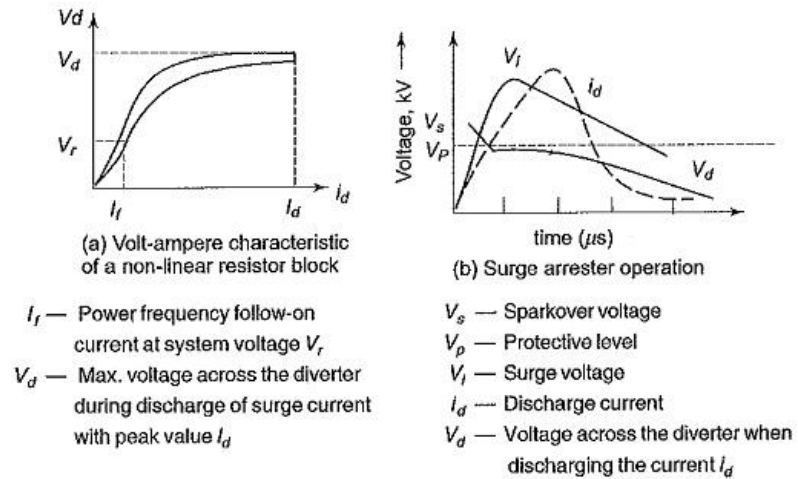
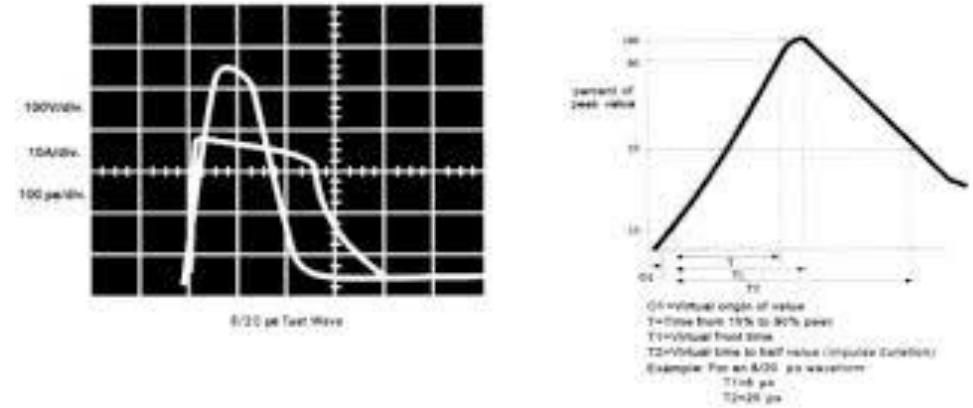
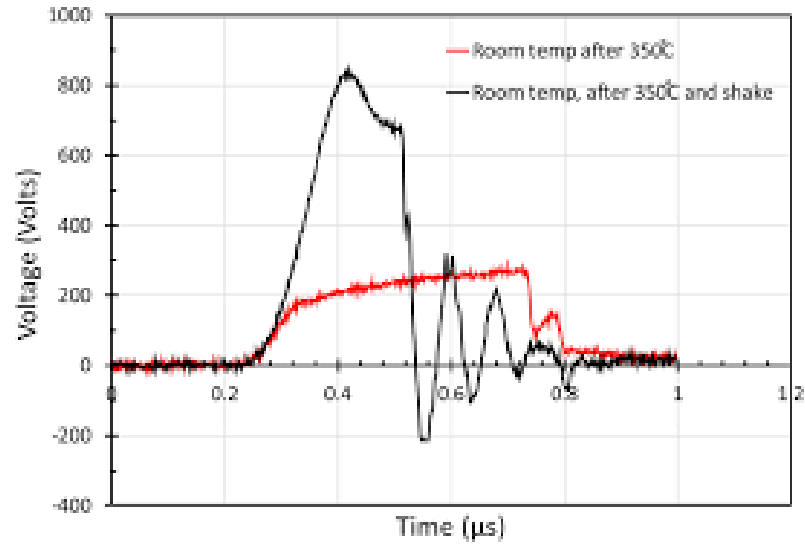
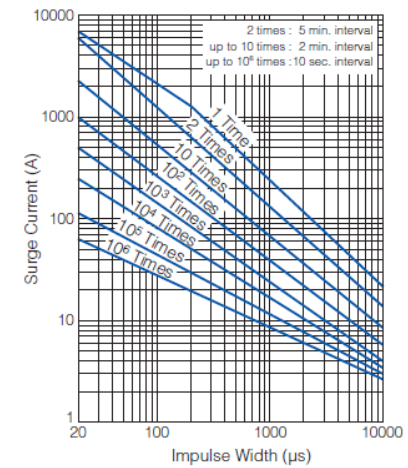


Fig. 8.25 Characteristics of a surge arrester

ERZV20D561 to ERZV20D112



**Comment combiner tube a gas y
varistors ?**

..... Pour tirer les avantages de chaque dispositif ?

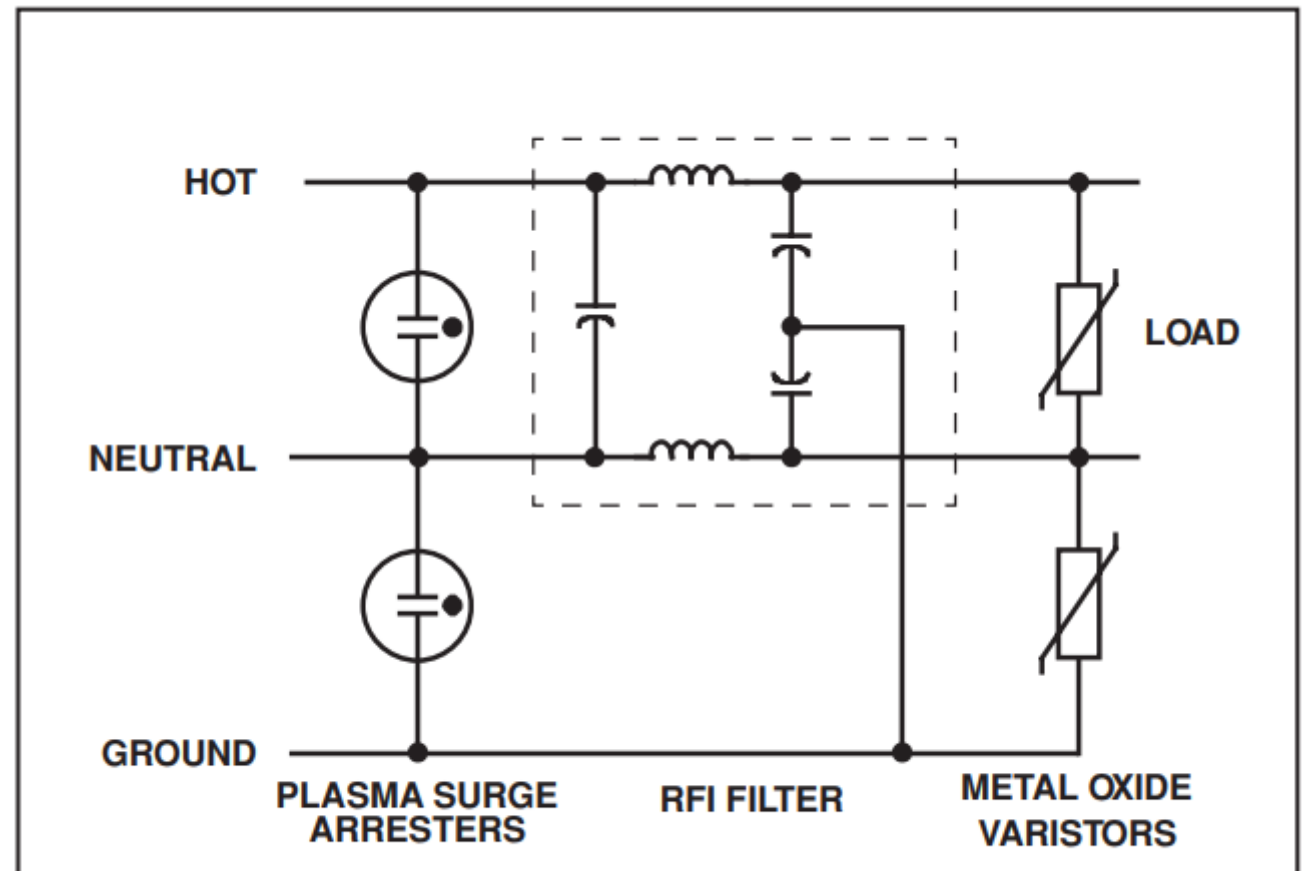
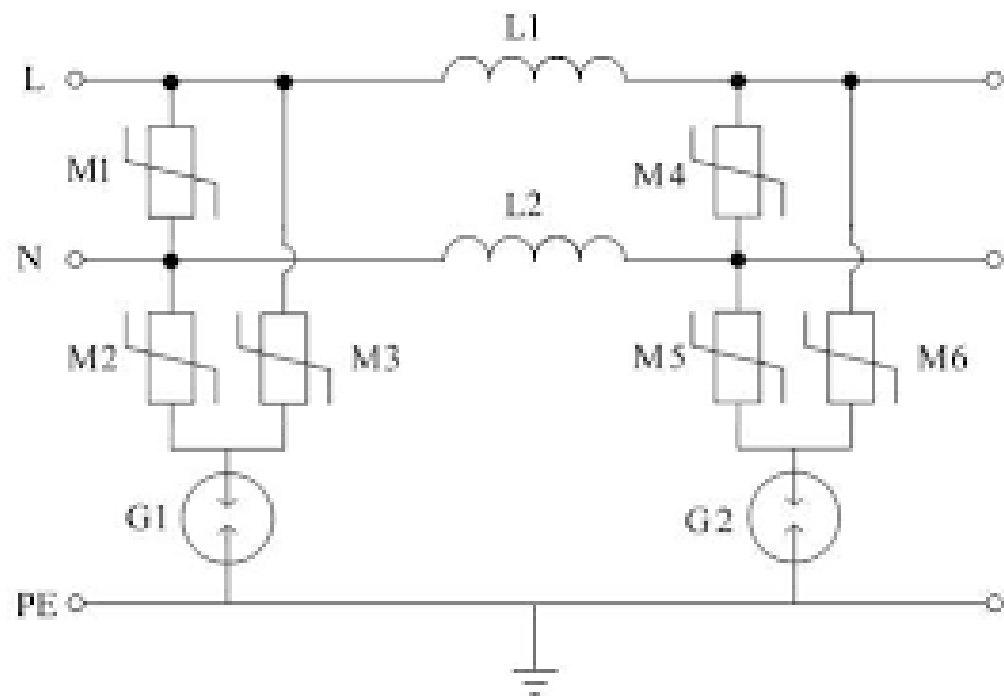
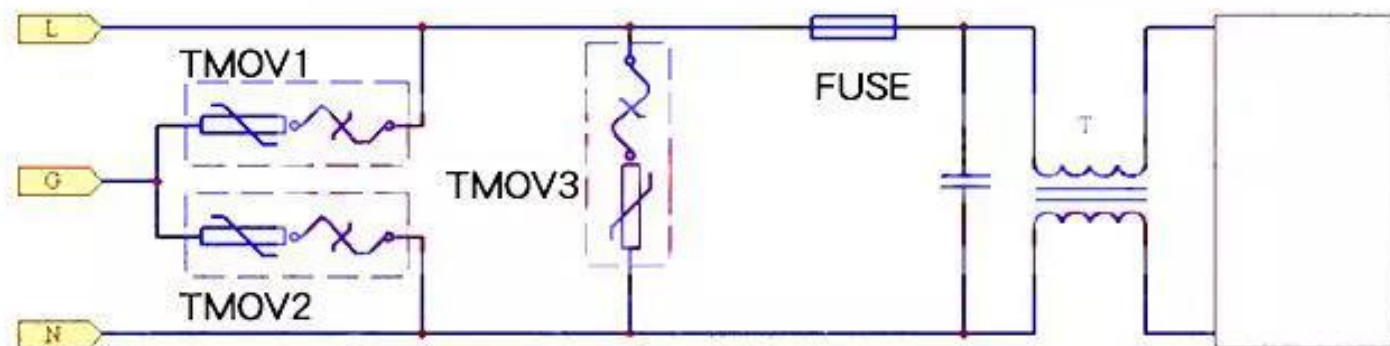
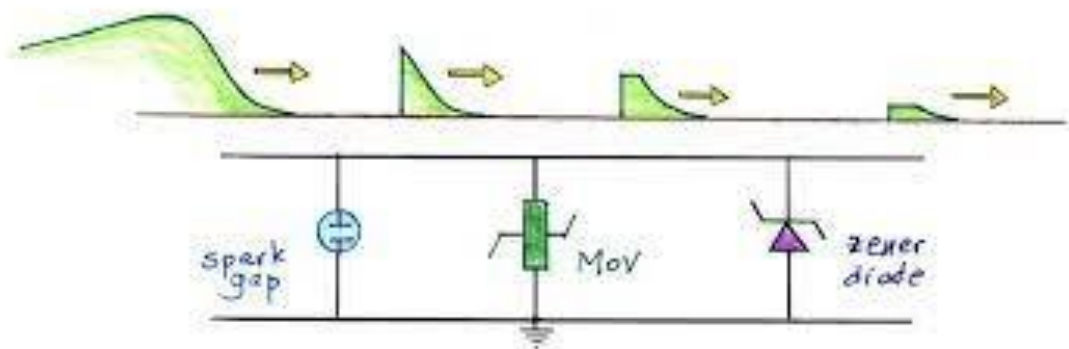
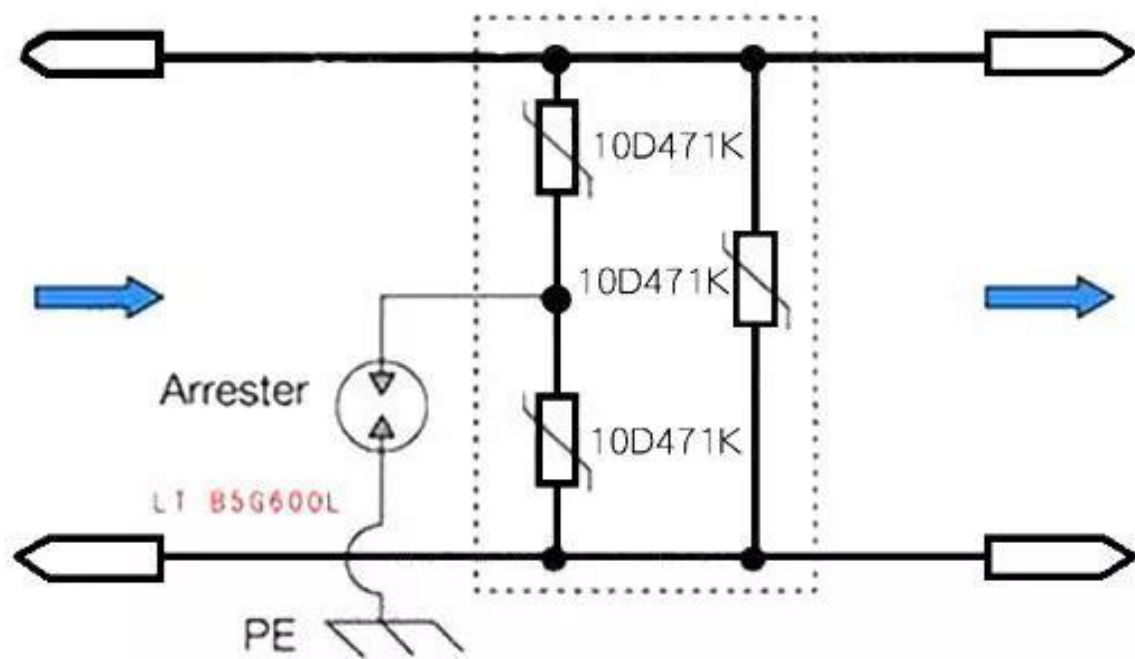
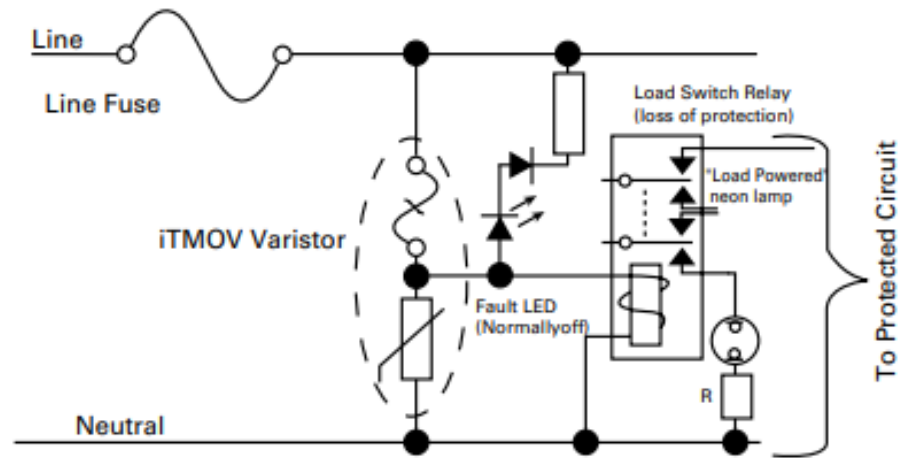
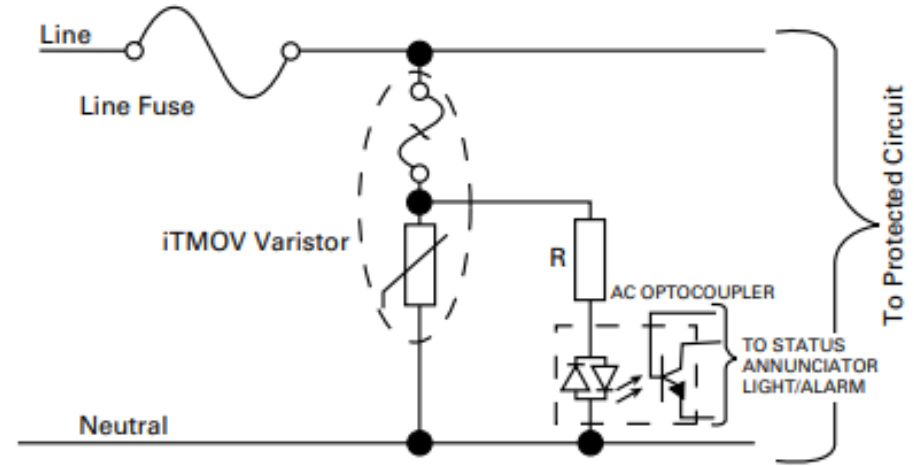
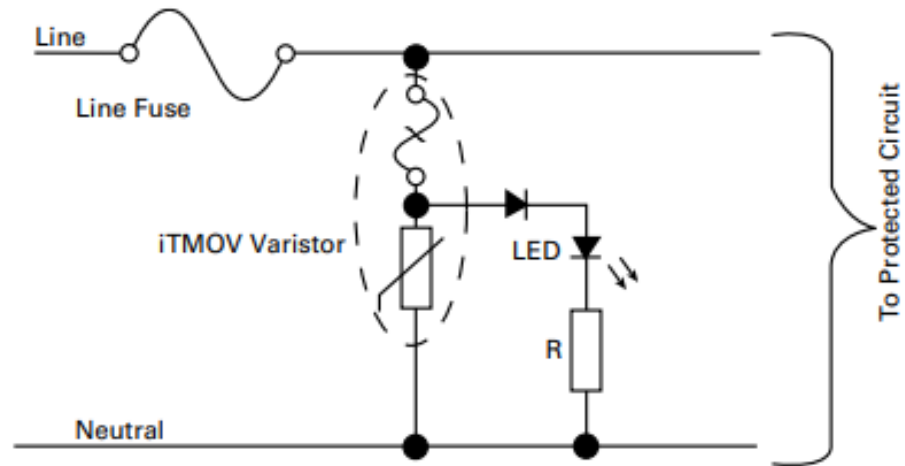


Figure 3a. Hybrid surge protection circuit

line



TMOV Thermally Protected Metal Oxide Varistor

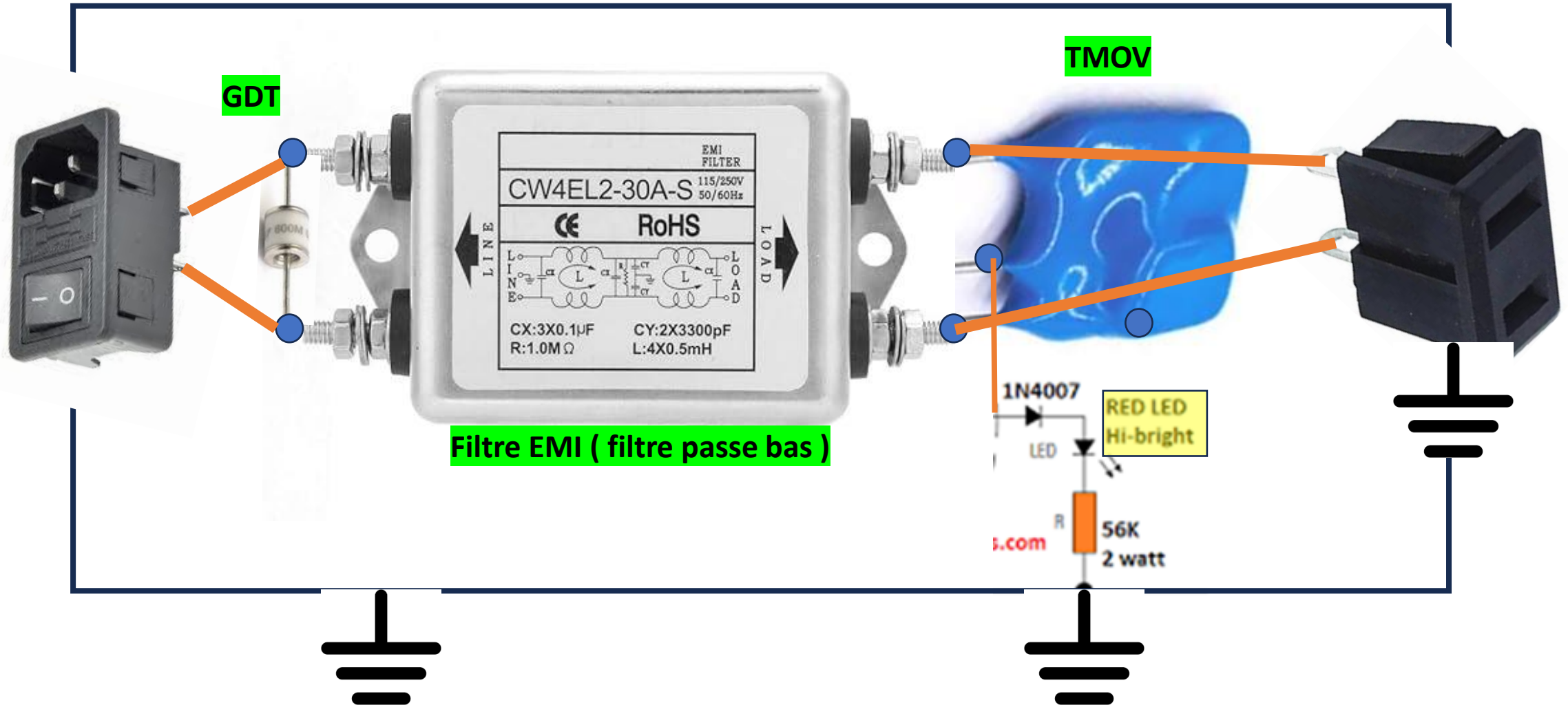


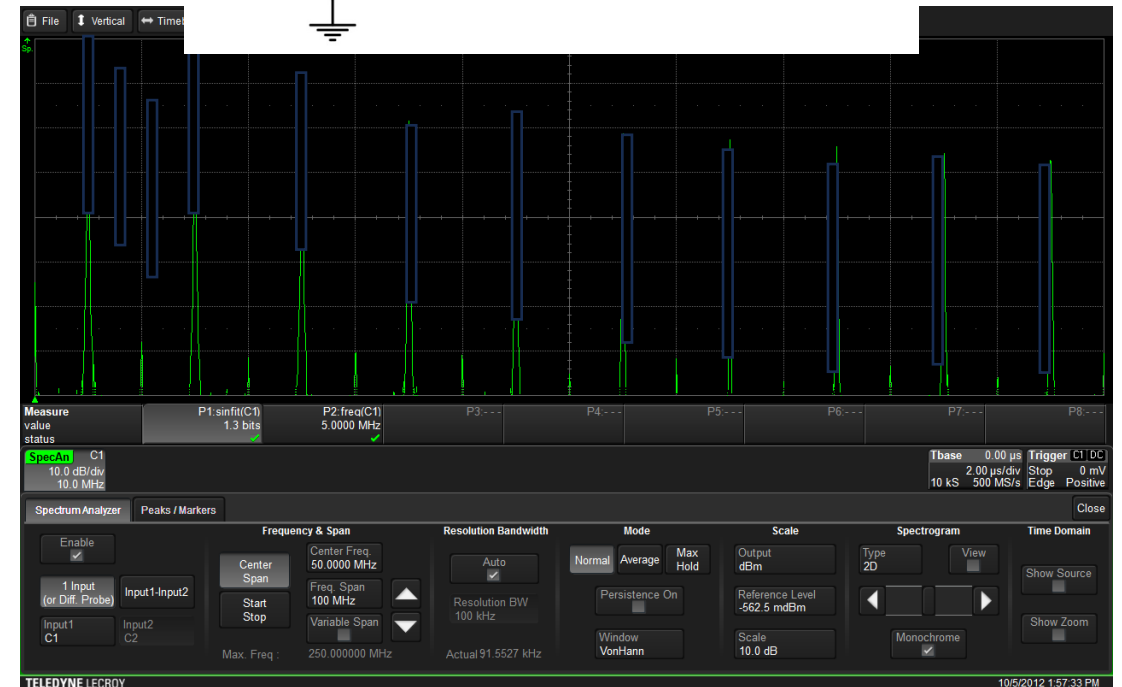
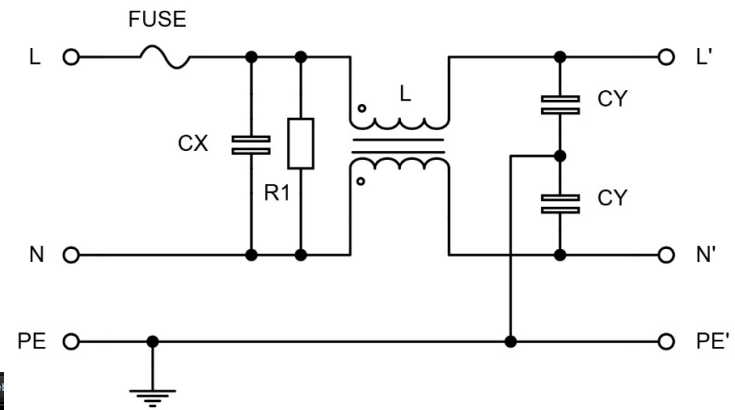
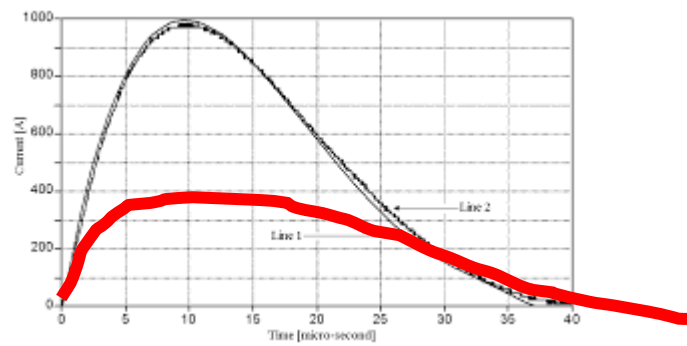
Excellent supprimeur de transistors – 15 A – 220 V

Tester a 1600 V – 800 A

impulsion : 8/20 uS

Surge generator : teste personnellement avec Velonex 587





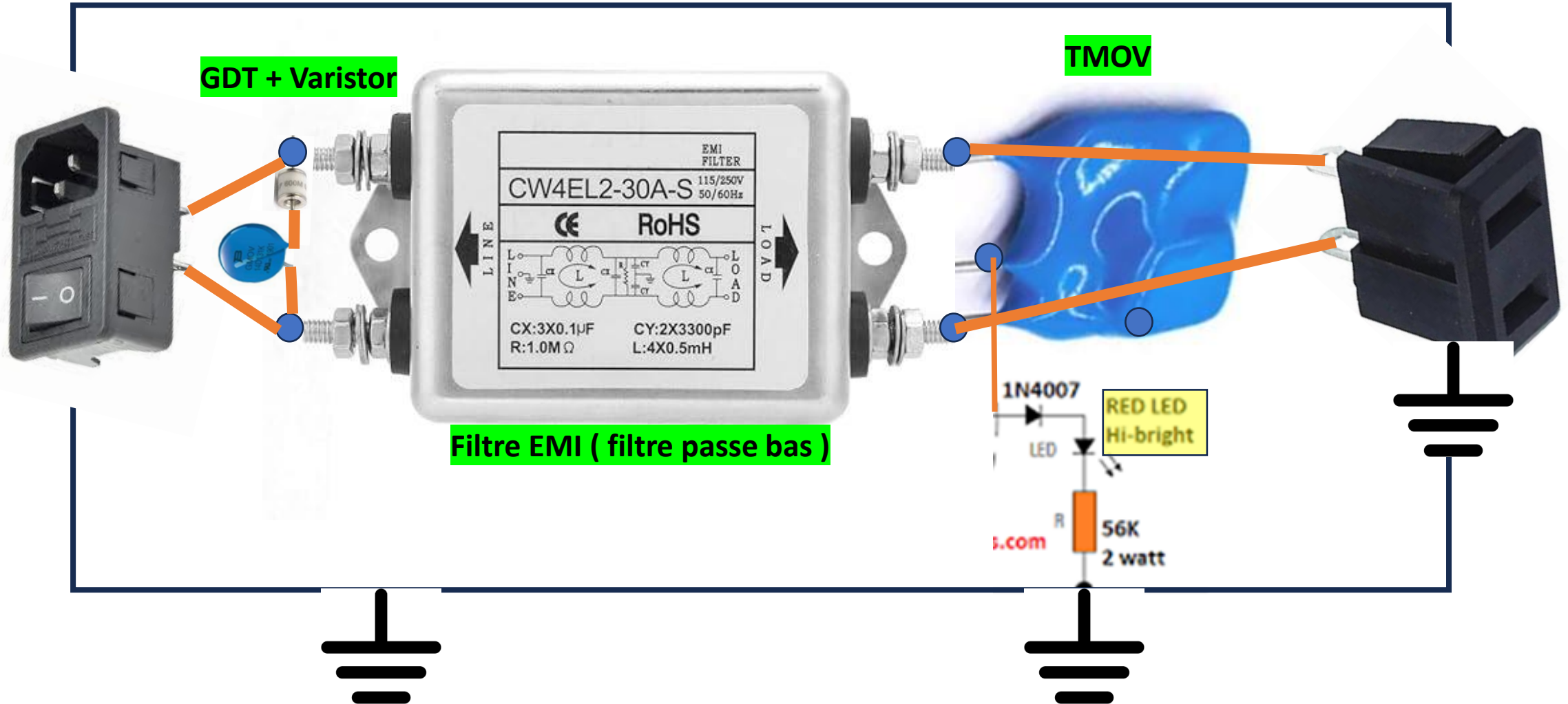
Filtre EMI est en fait un filtre passe bas

Excellent supprimeur de transistors – 15 A – 220 V

Tester a 1600 V – 800 A

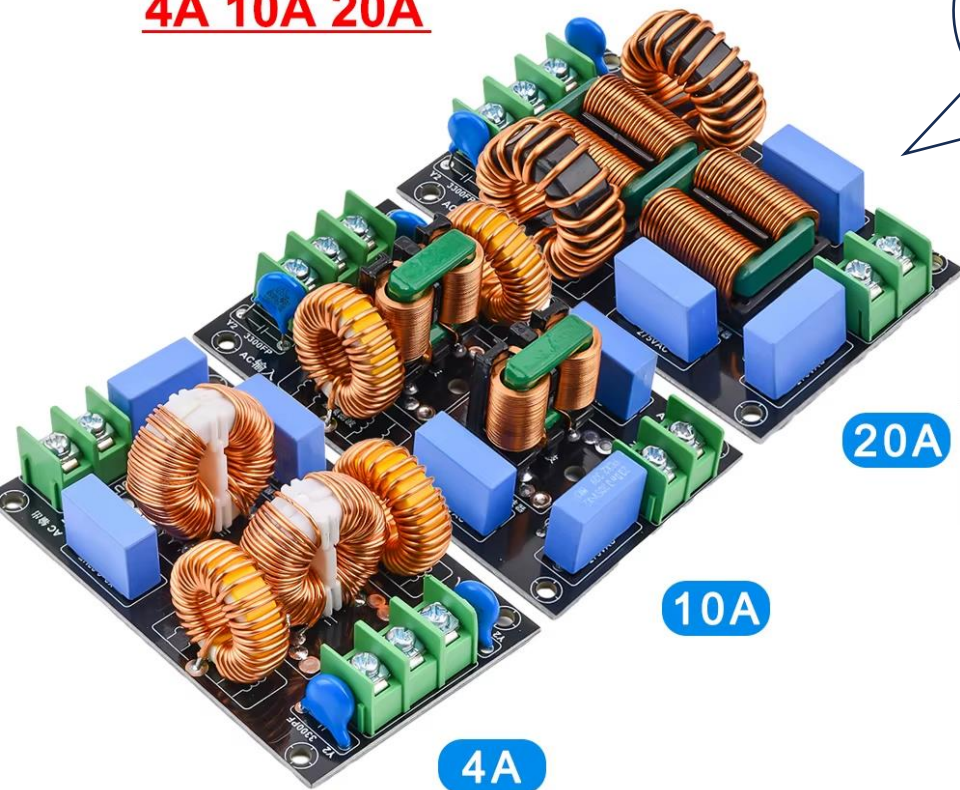
impulsion : 8/20 μ S

Surge generator : Velonex 587

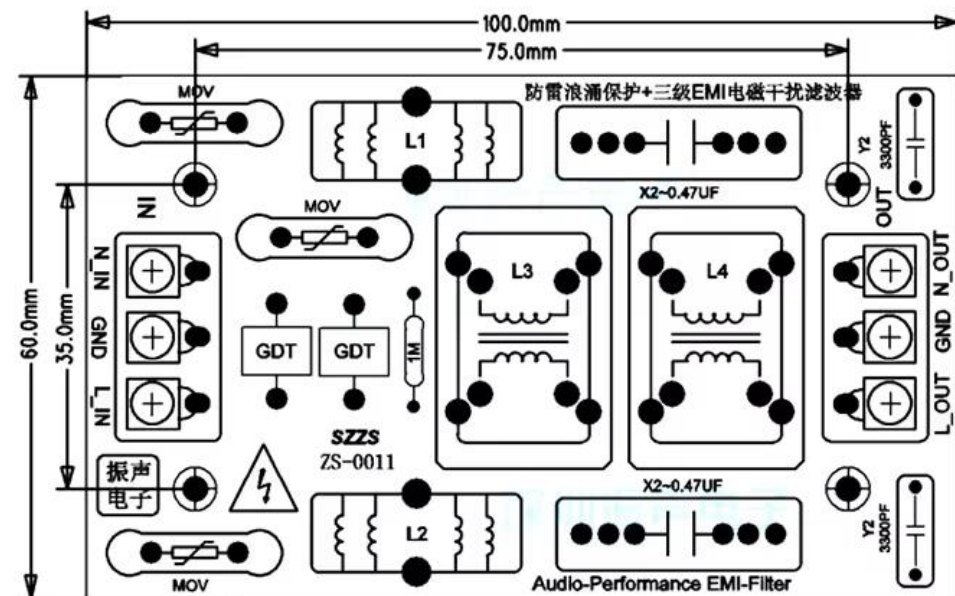
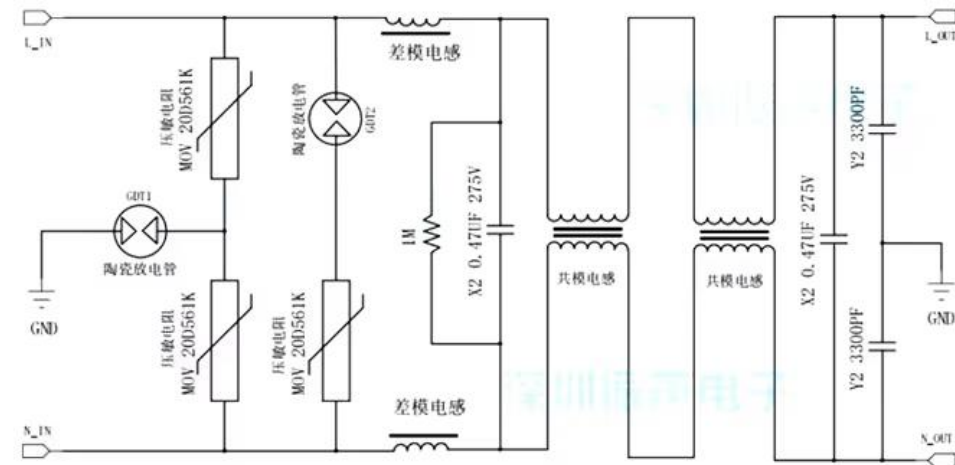


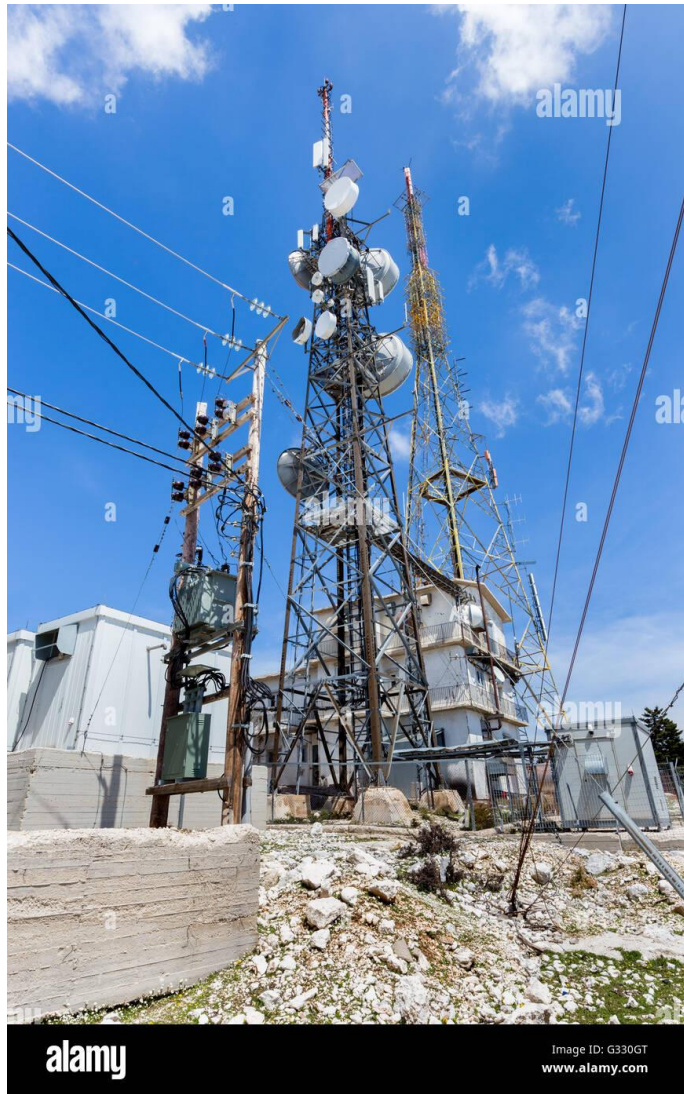
EMI Power Filter

4A 10A 20A



15 USD
aliexpress





KTNV's transmitter building

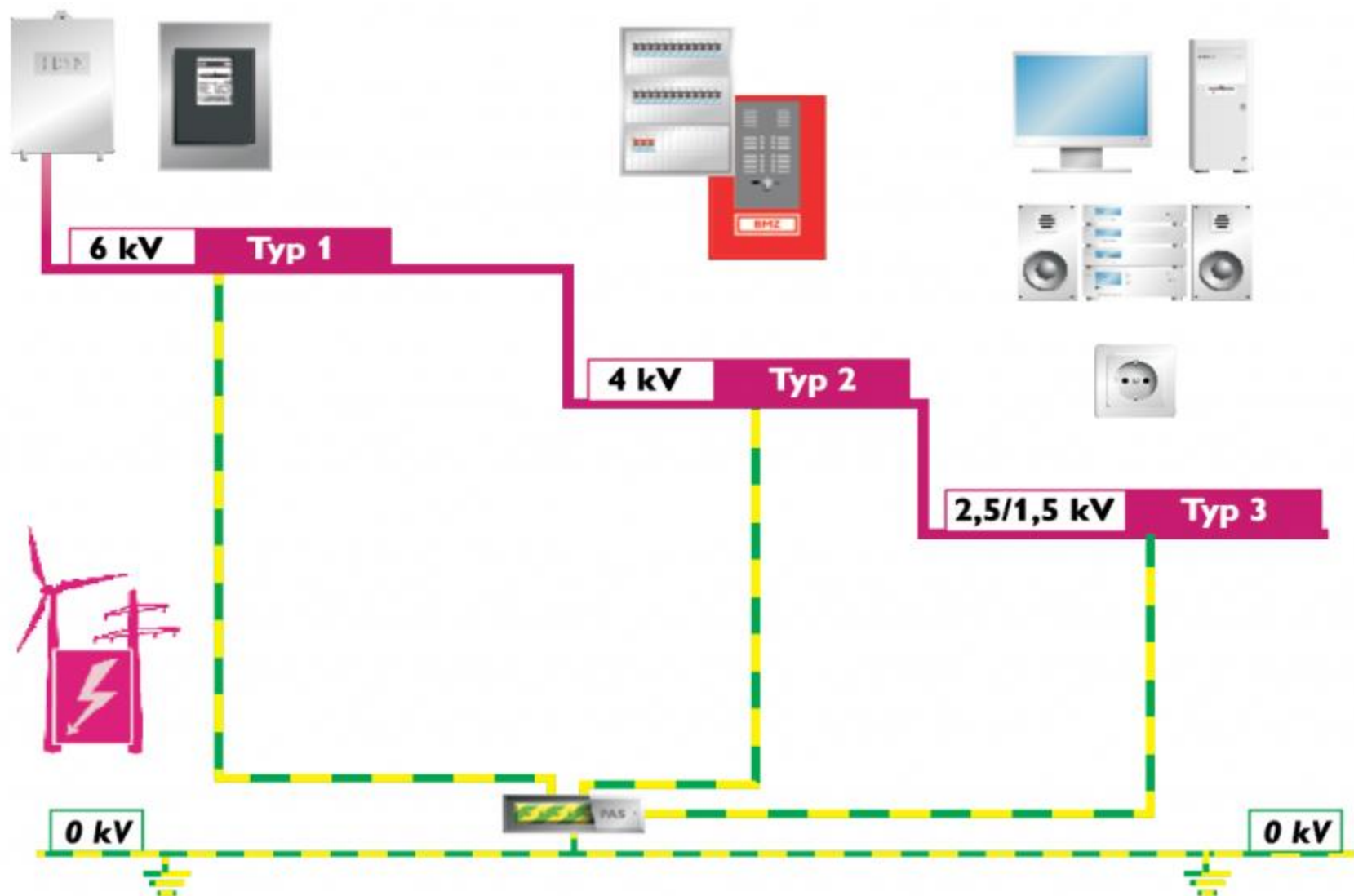
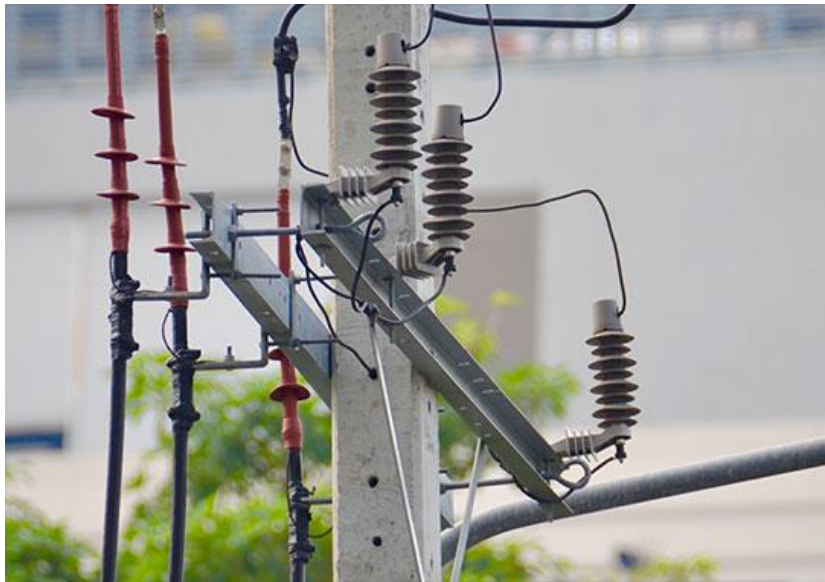
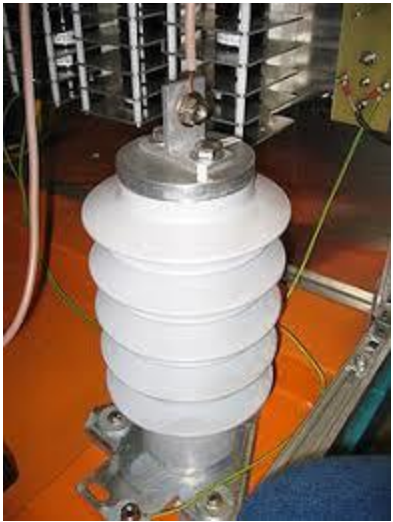
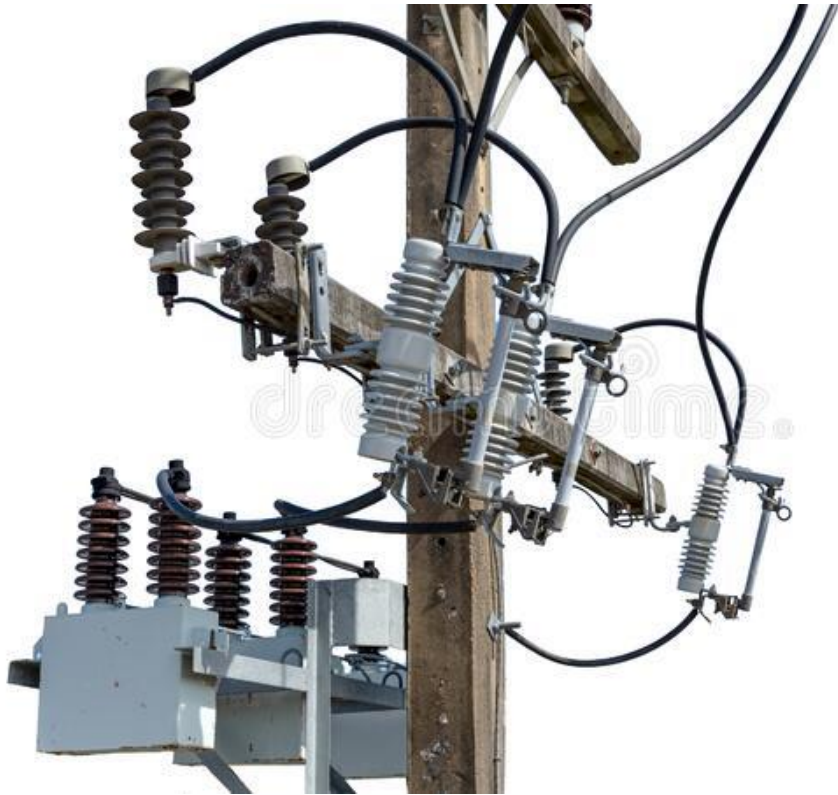
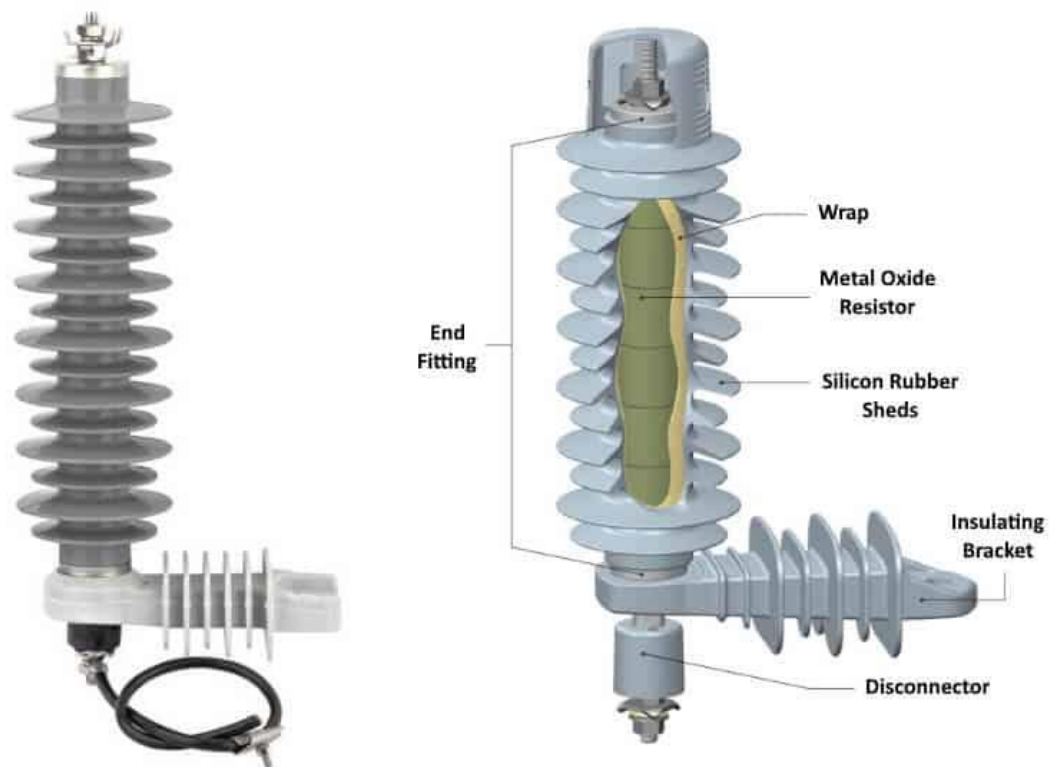
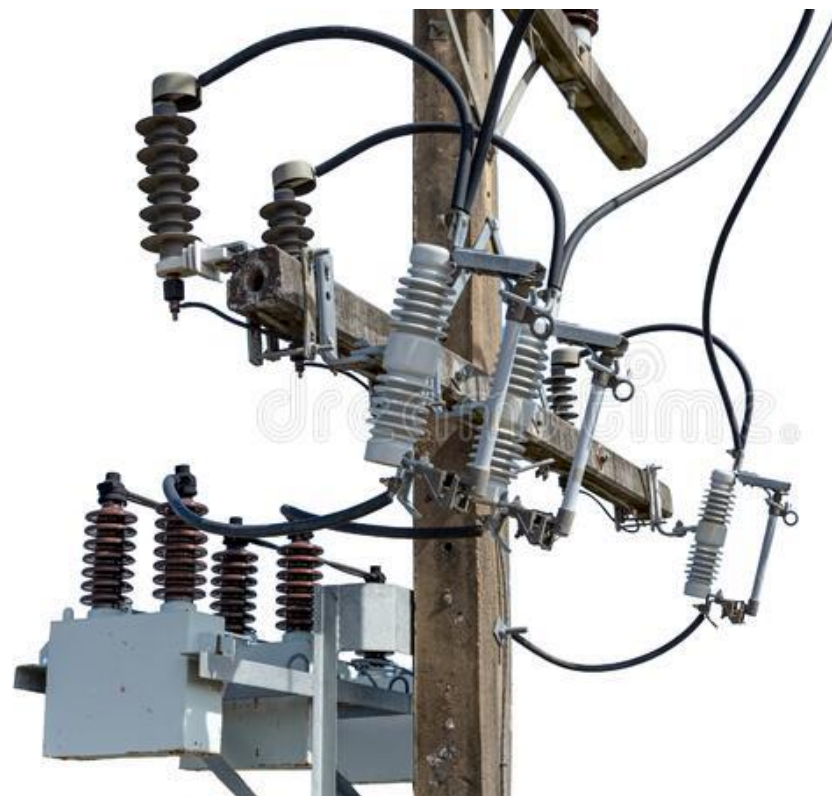


Figure 2 : Equipment withstand categories in a typical installation





Surge Arrester





IEC 60364-5-53

Edition 3.0 2015-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

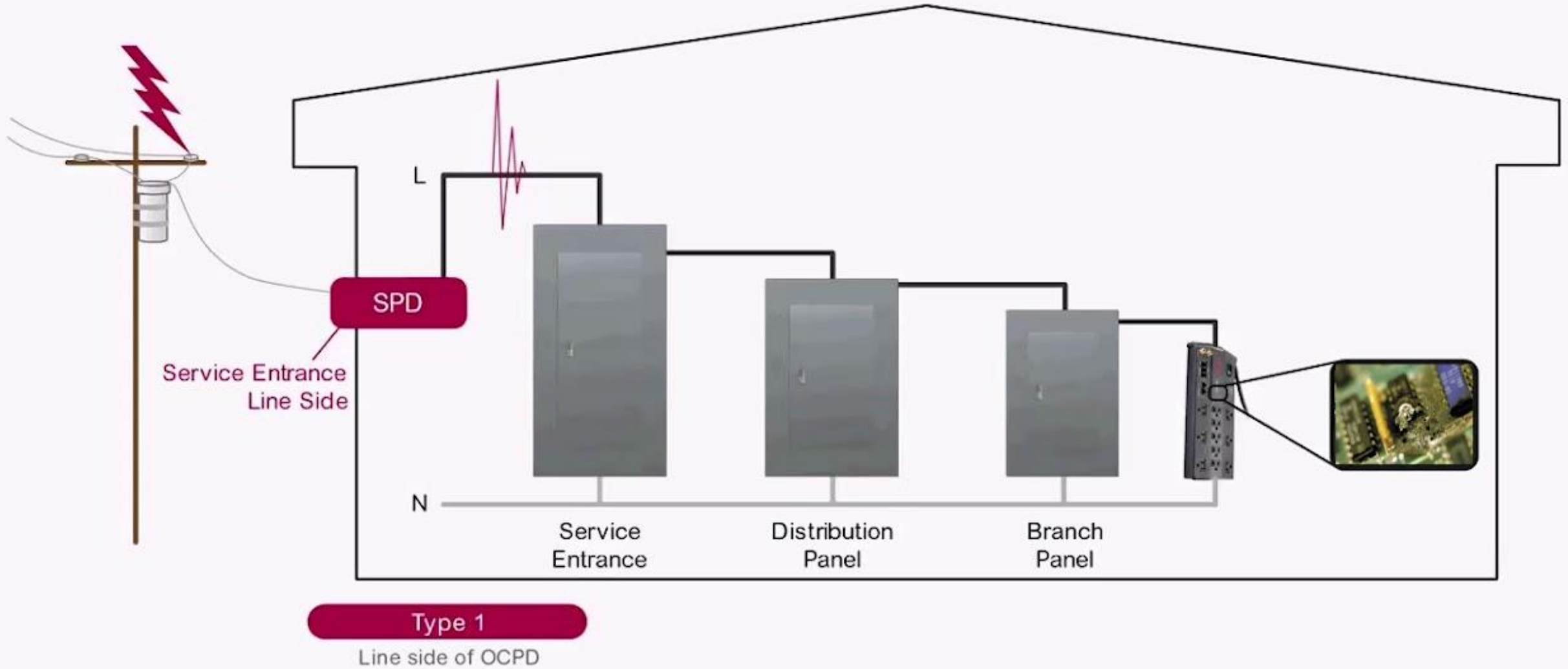


AMENDMENT 2
AMENDEMENT 2

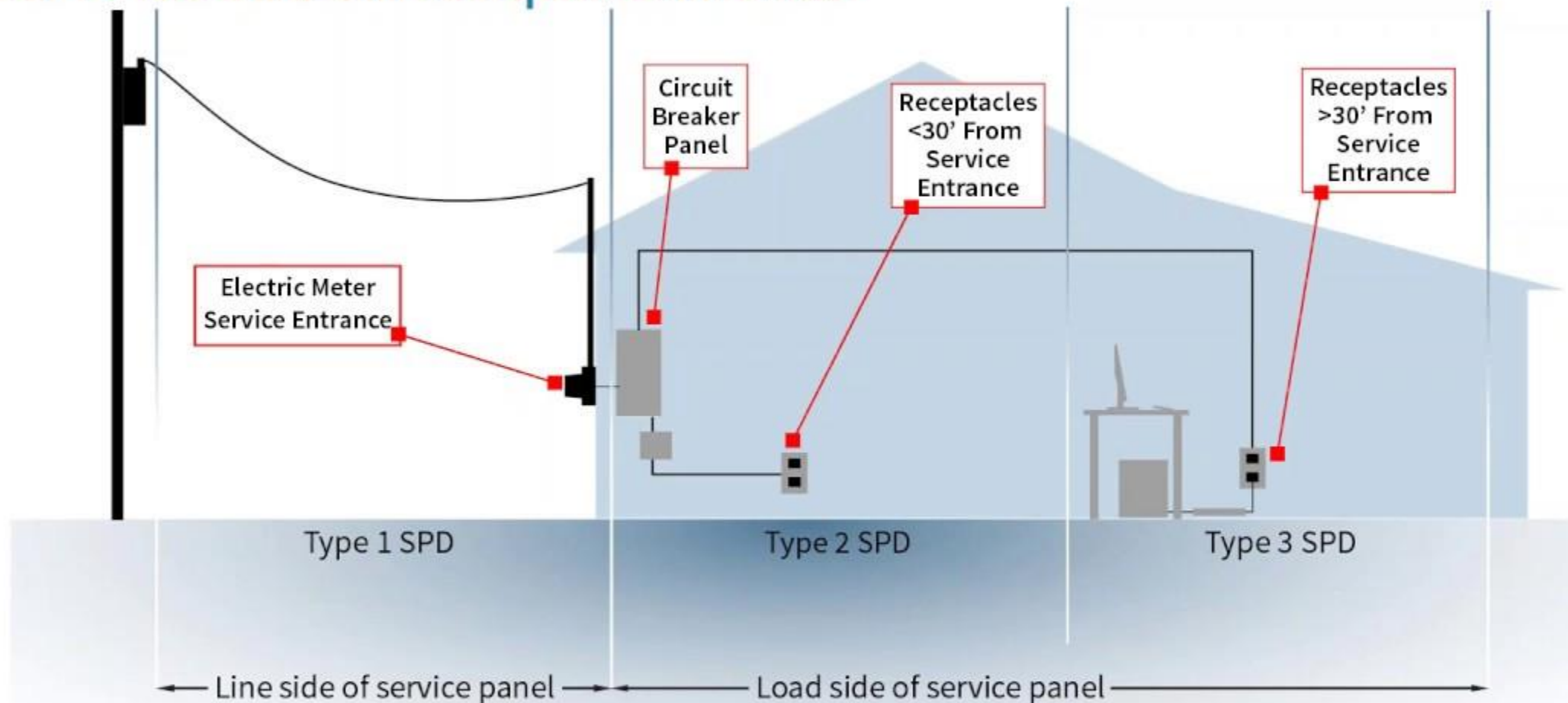
**Electrical installations of buildings –
Part 5-53: Selection and erection of electrical equipment – Isolation, switching
and control**

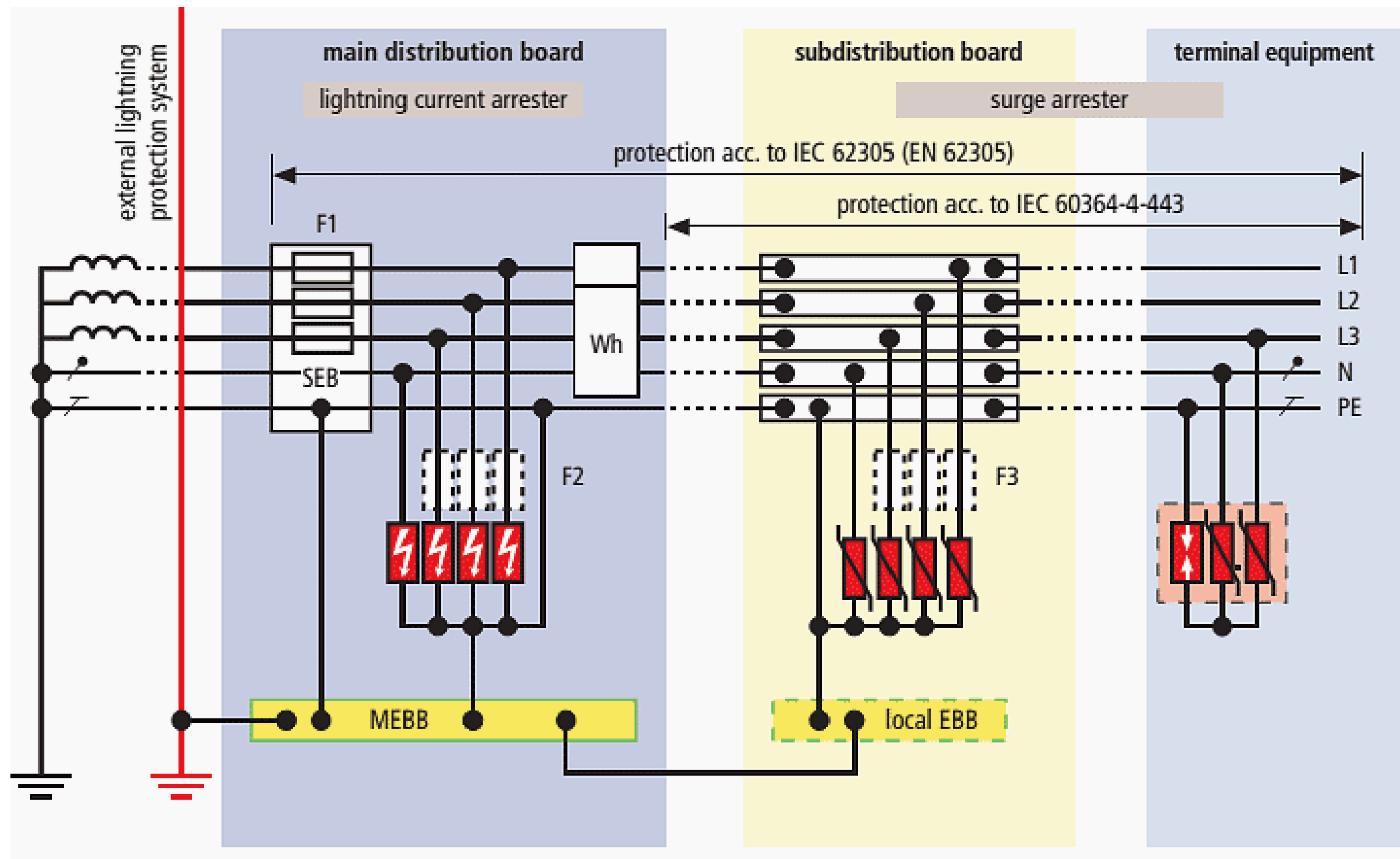
**Installations électriques des bâtiments –
Partie 5-53: Choix et mise en oeuvre des matériels électriques – Sectionnement,
coupure et commande**

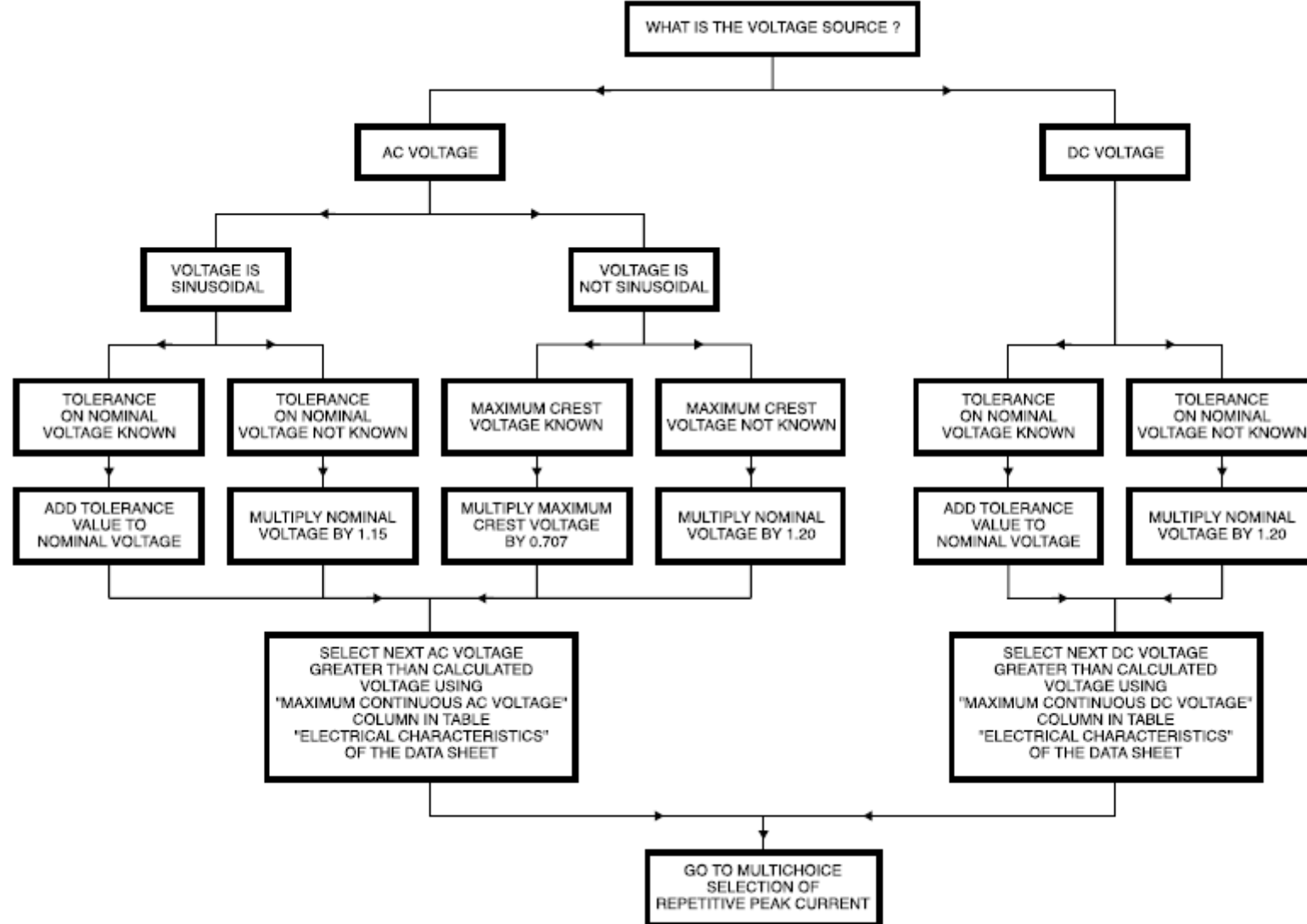
SPD Types per NEC Article 285 and UL1449 3rd Edition

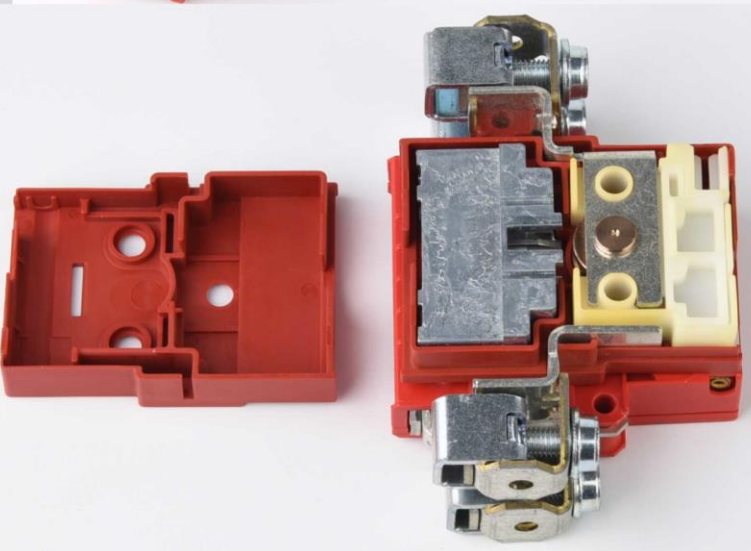
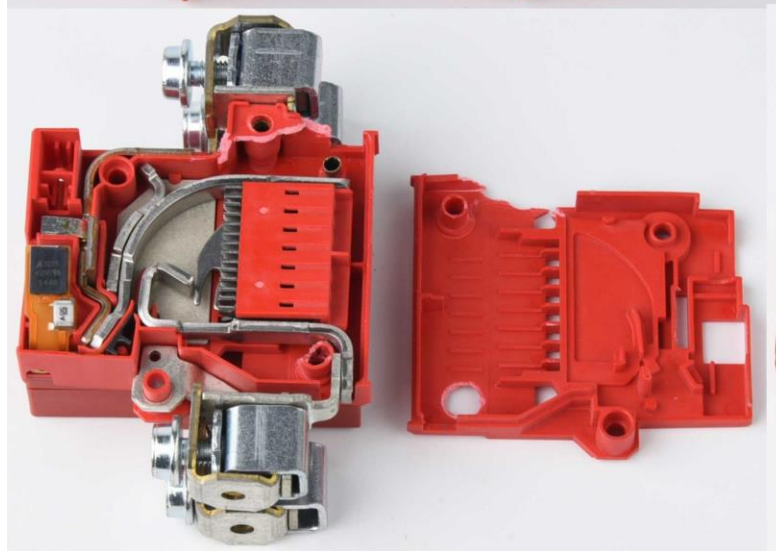
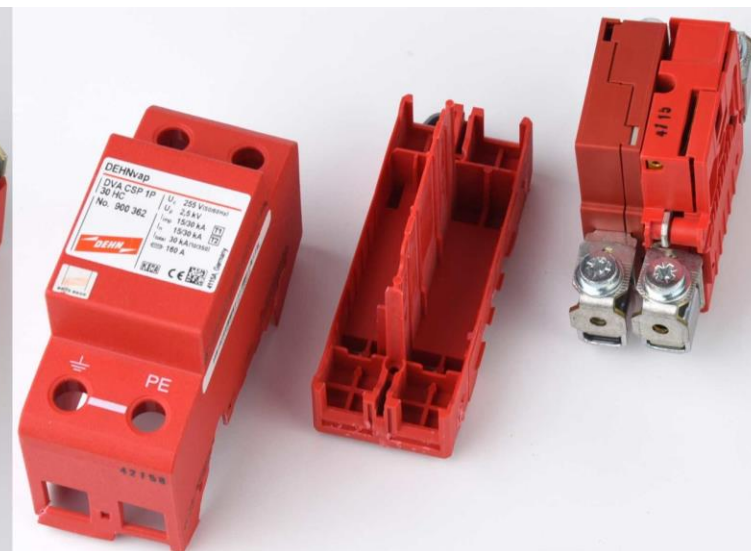


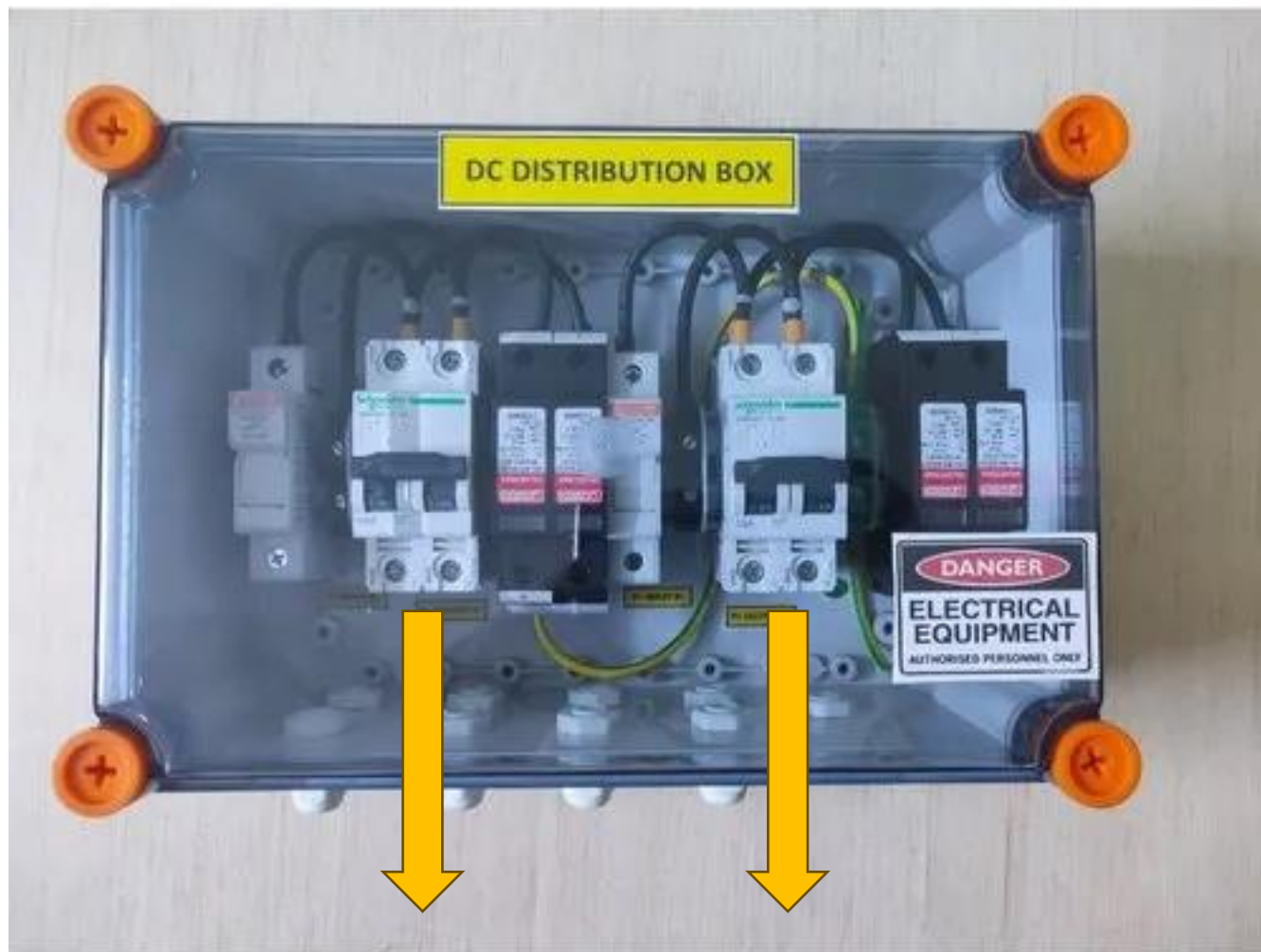
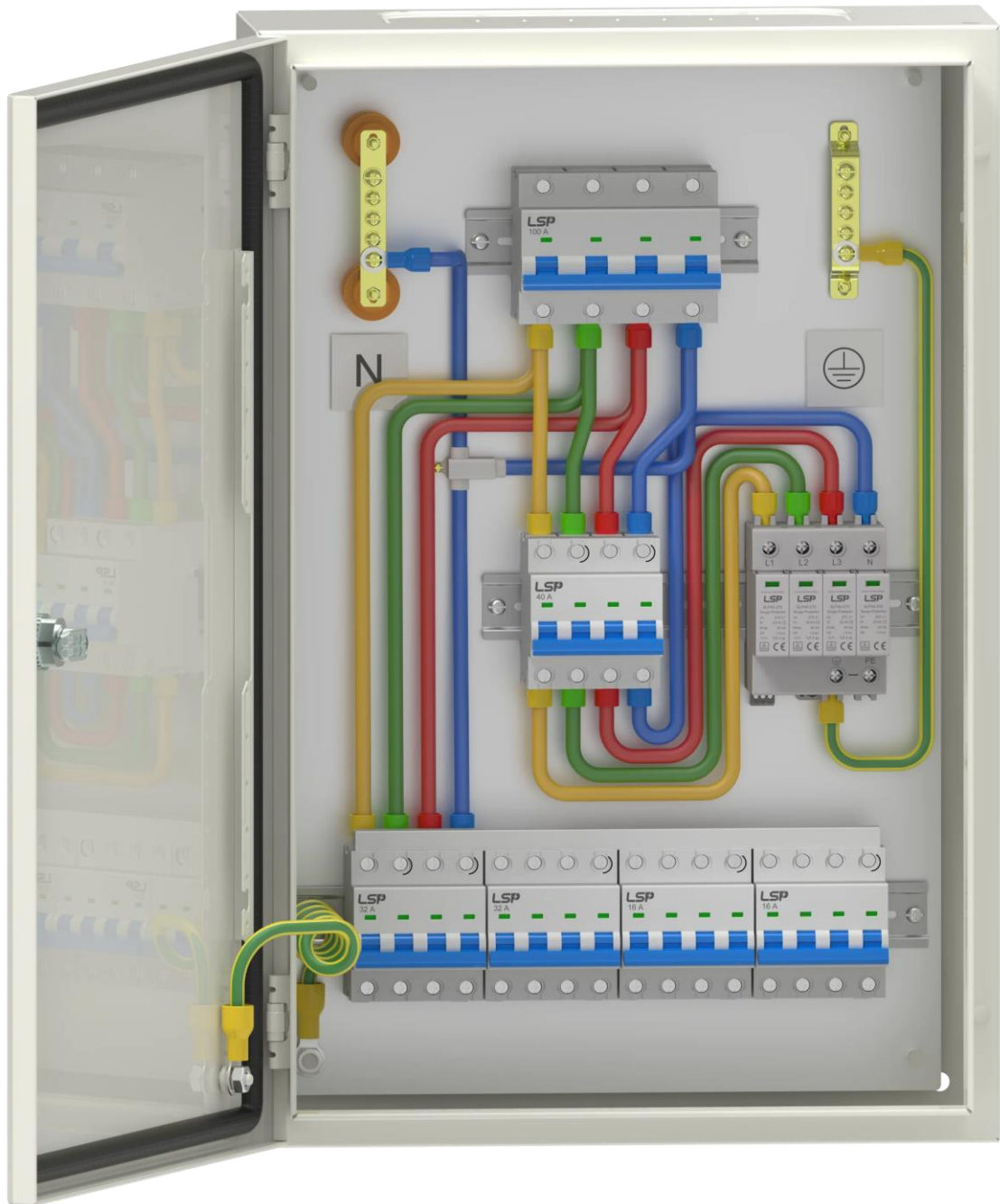
SPD Location Requirements







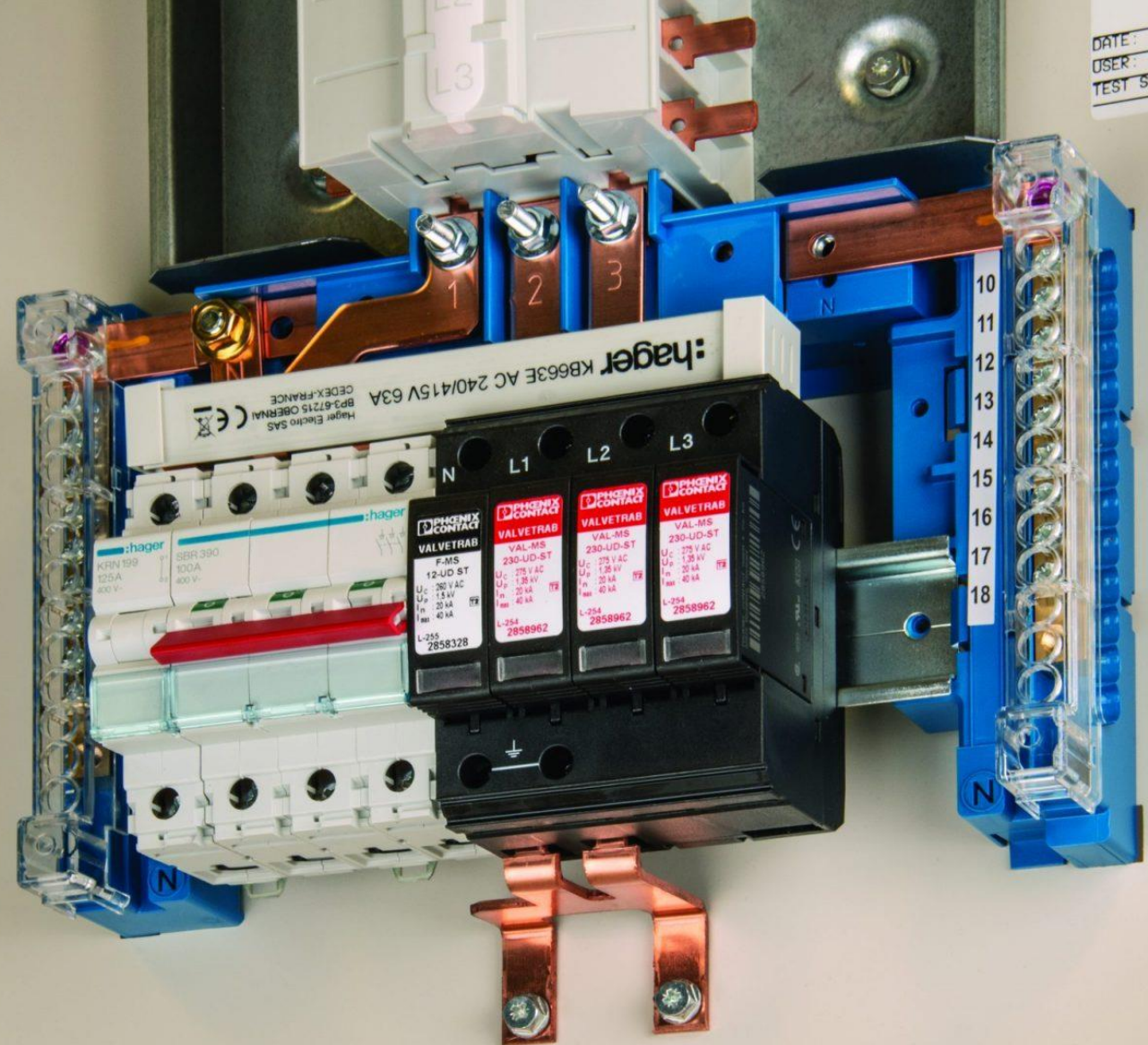




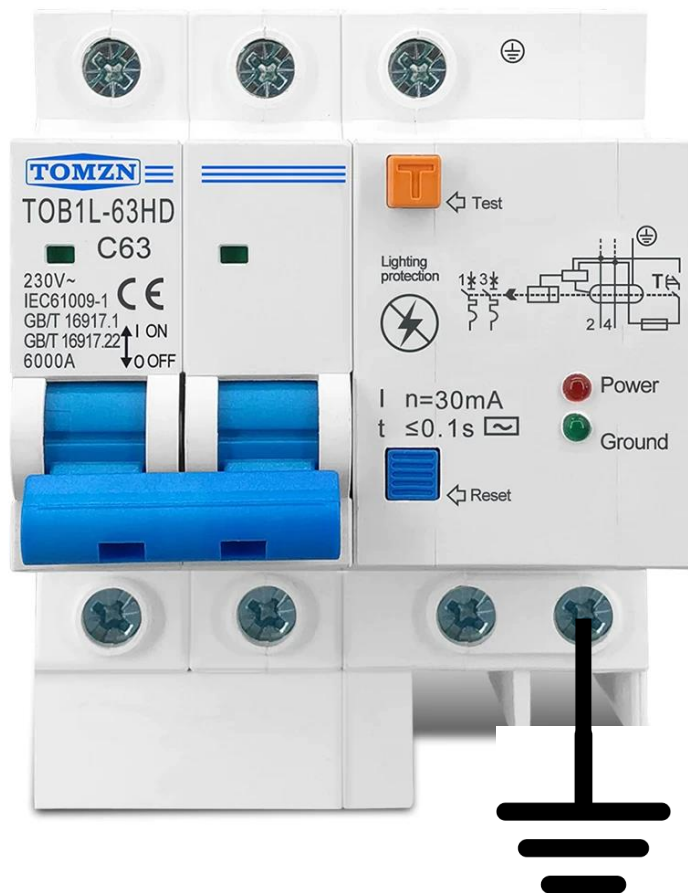
Station 1

Station 2

22/11/2019
DATE: _____
USER: _____
TEST STATUS: _____
PRODUCTION
PASS

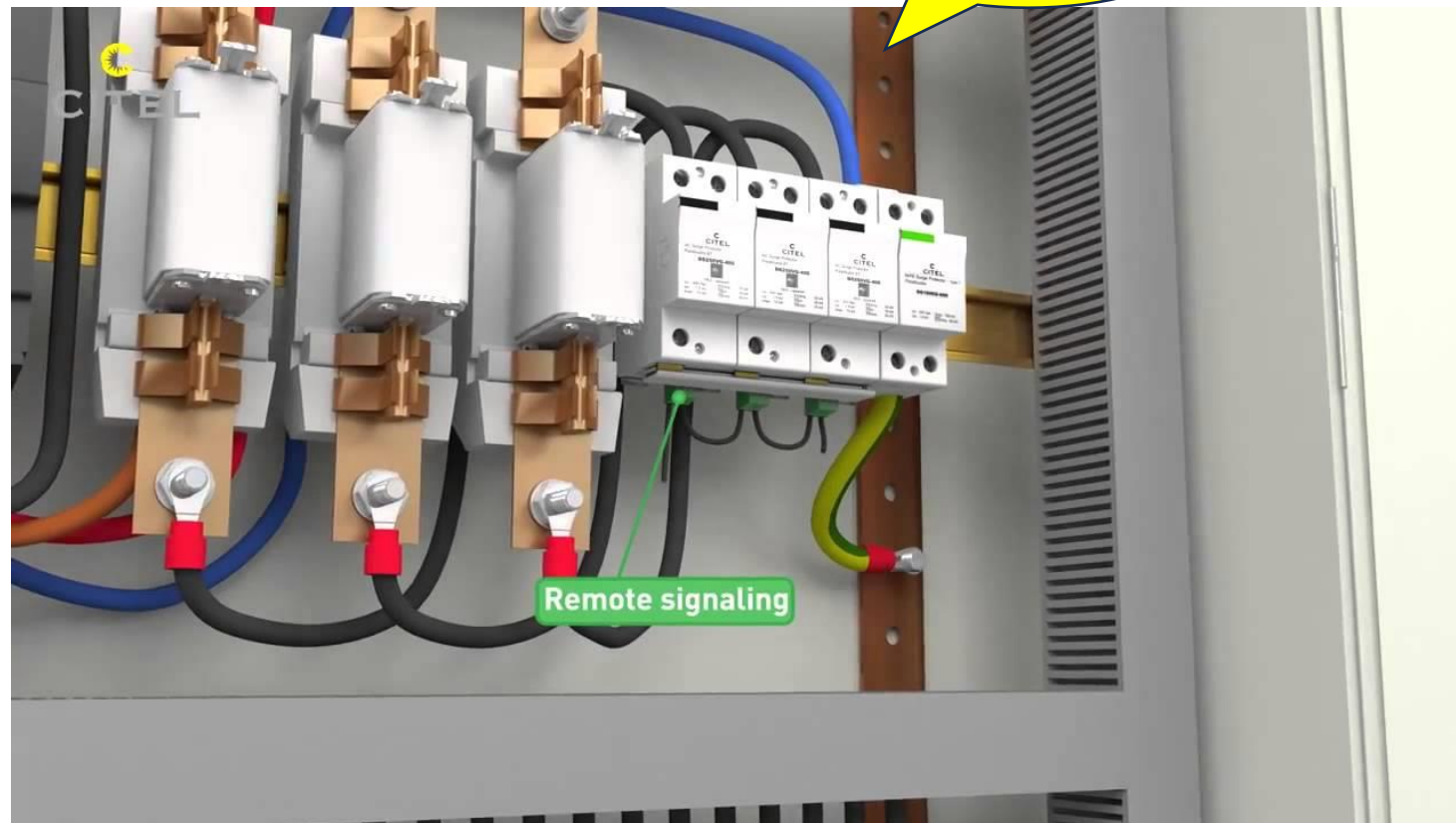


E
B1
B2
B3
1
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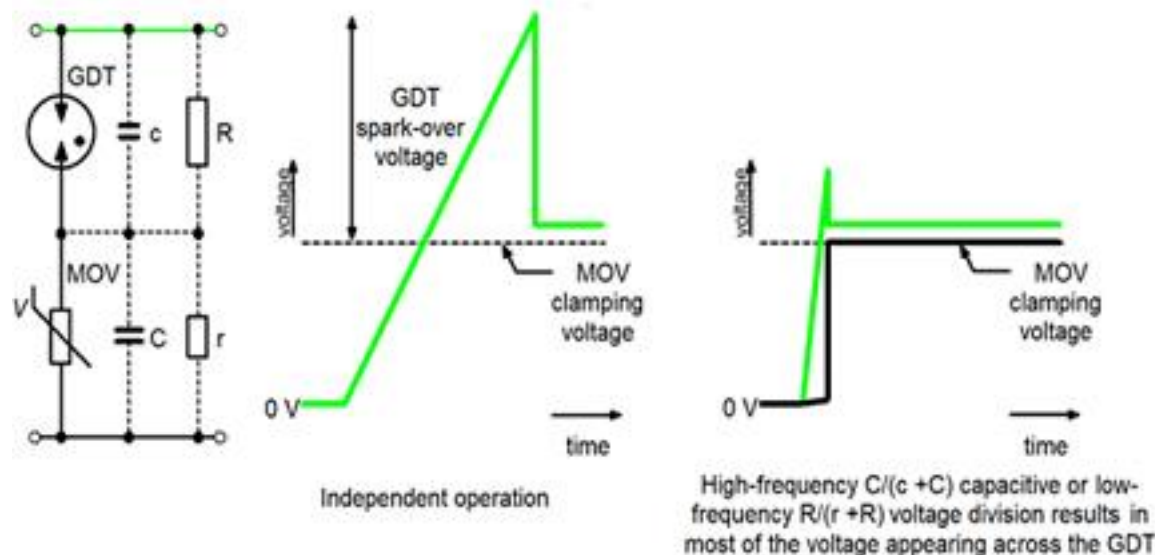


Protection pour le personnel , afin
d'éviter de possibles électrocutions
Fonctionne a 50/60 HZ

Faible inductance



How does a GMOV™ Component Protect?



- Under normal operating conditions, the line voltage appears largely across the extremely low leakage GDT

- essentially disconnecting the MOV from the line

- smaller transients and TOV can damage MOVs over time.

- During a surge event, due to capacitive coupling, all voltage appears across the GDT

- because the GDT turns on first, it clamps the voltage and allows voltage to appear across the MOV.

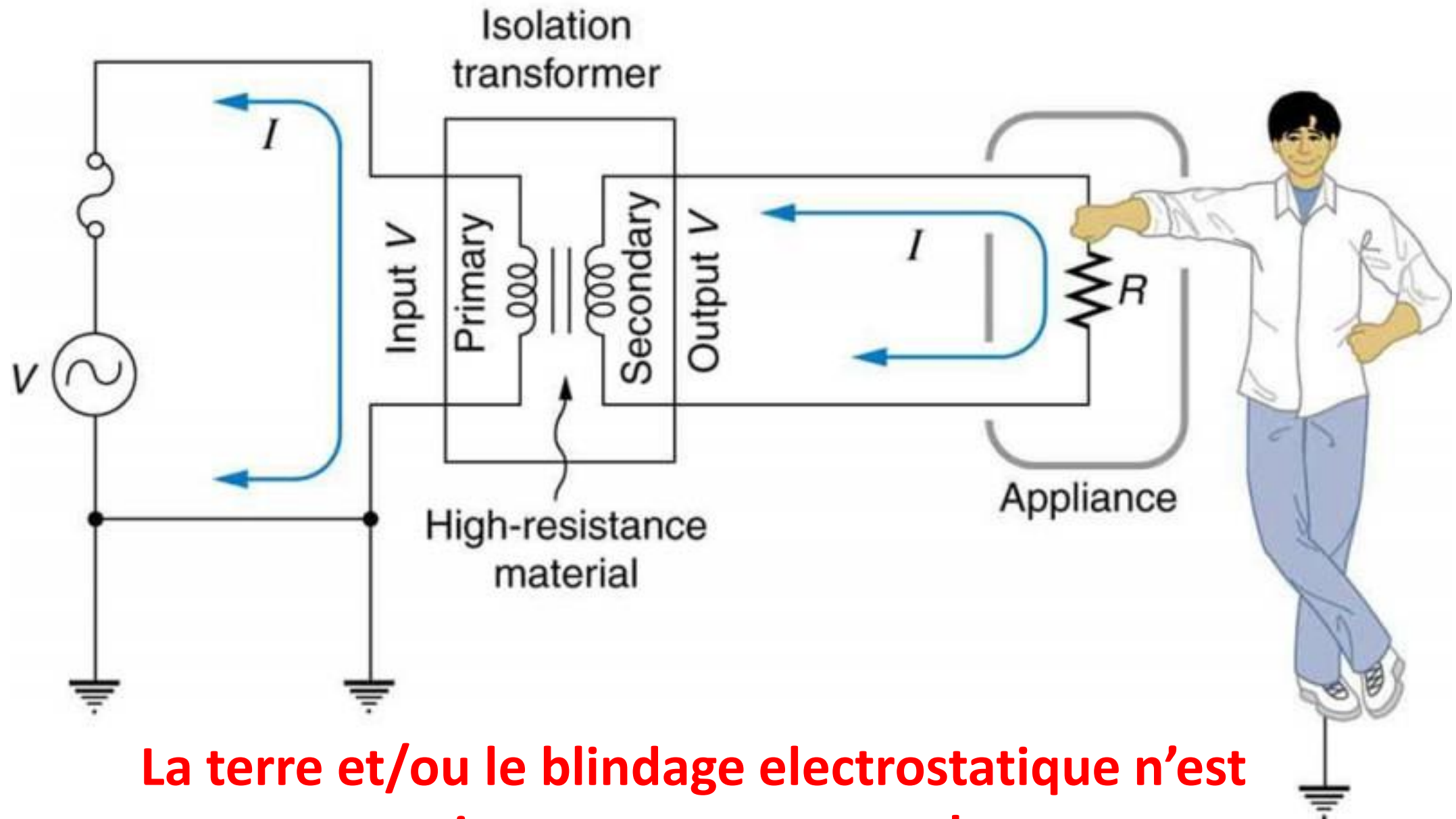
- the MOV then begins to conduct -- fully clamping and dissipating the surge event.

- When the transient event subsides, the current limiting MOV allows the GDT to reset

- this even occurs under extreme AC follow-on current conditions.

- Once the GDT turns-off, the MOV is then isolated again from the line voltage.

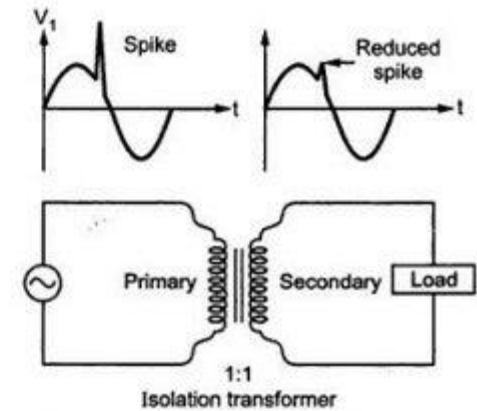
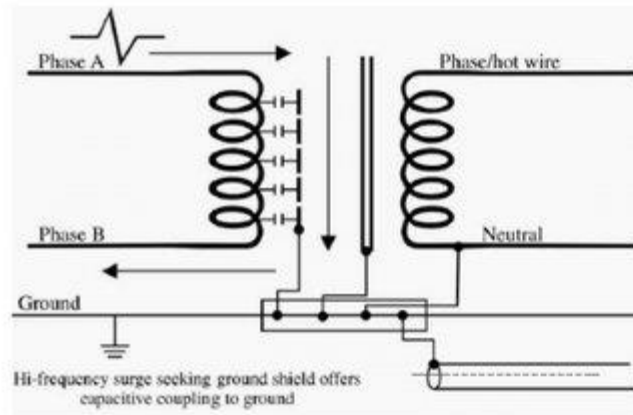
- The GDTs low capacitance means the GMOV won't interfere with high speed data run over AC or DC power lines.



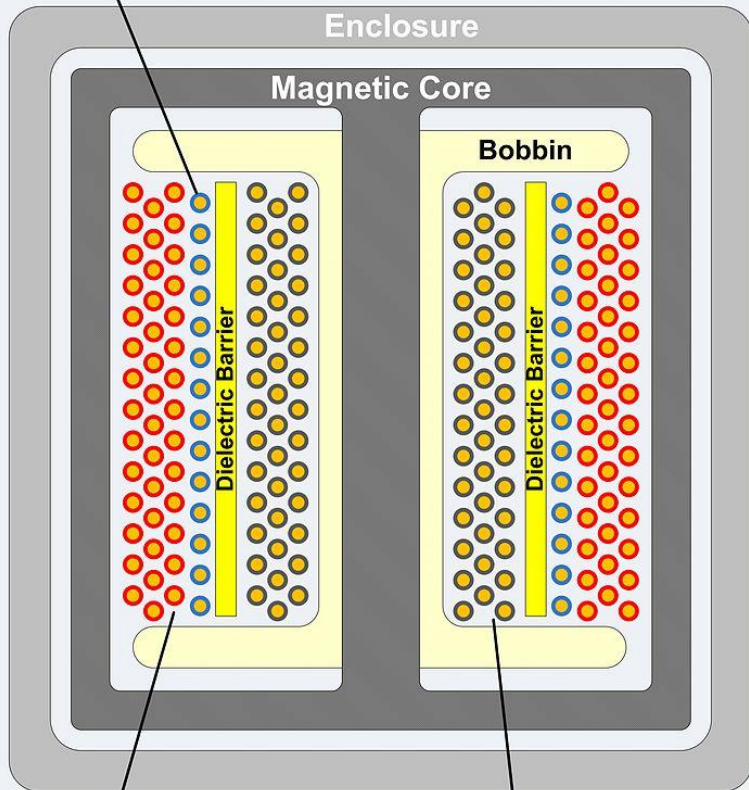
La terre et/ou le blindage electrostatique n'est pas necessairement conncter a la terre c'est l'utilisateur qui le choisit



What is Isolation Transformer?



Single layer winding used as electrostatic shield

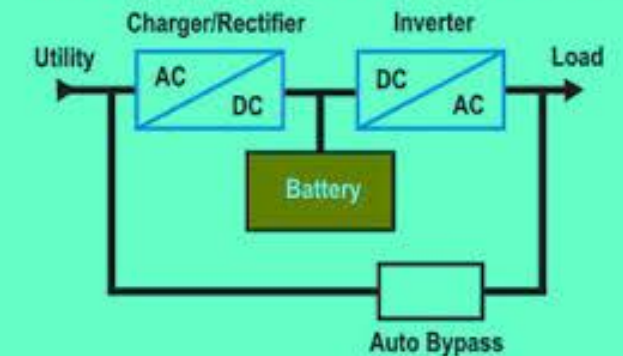


secondary winding

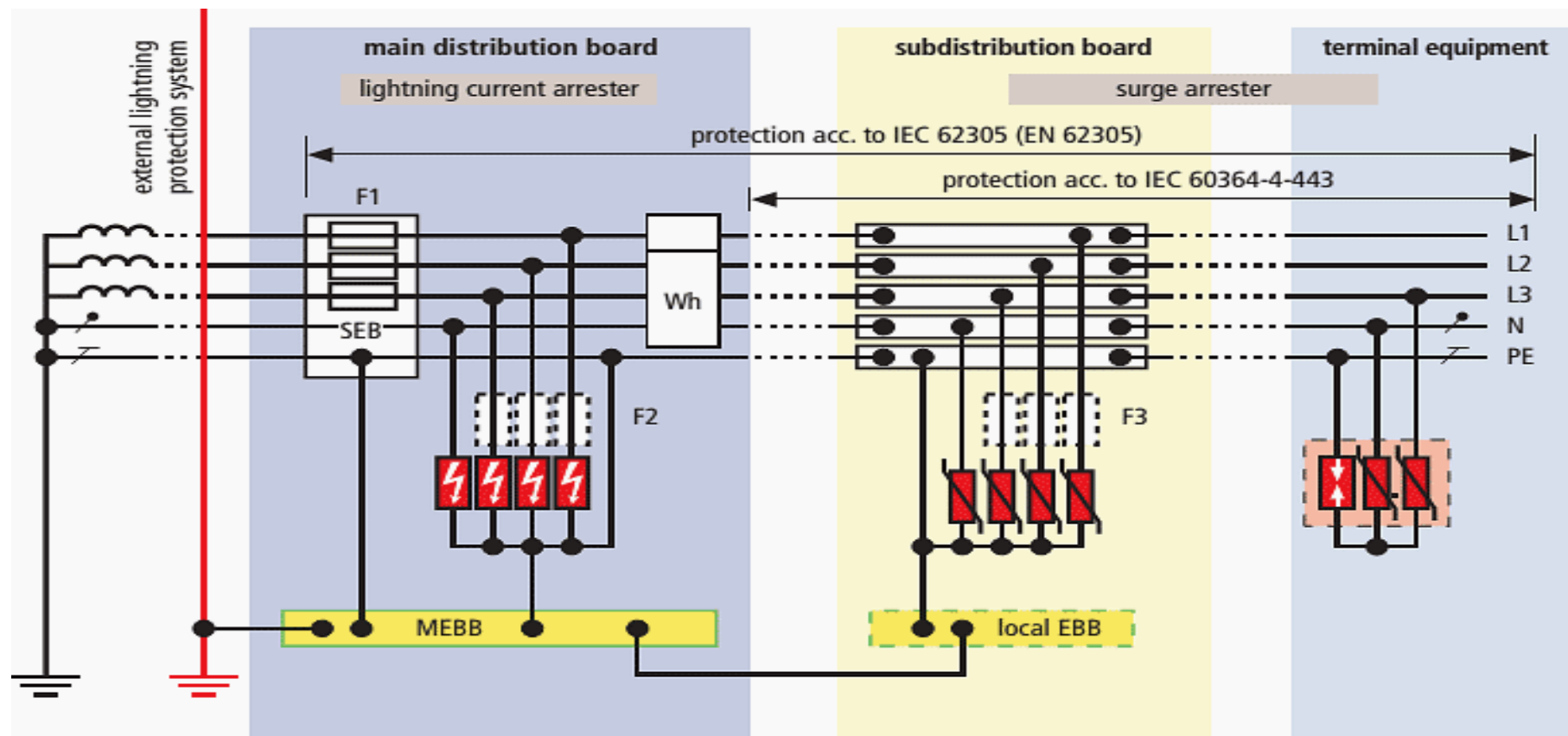
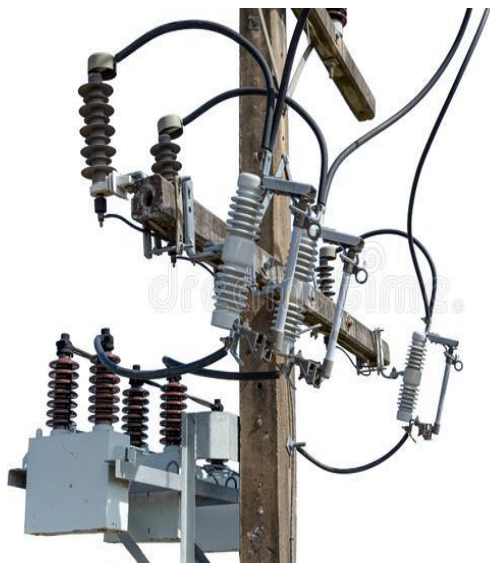
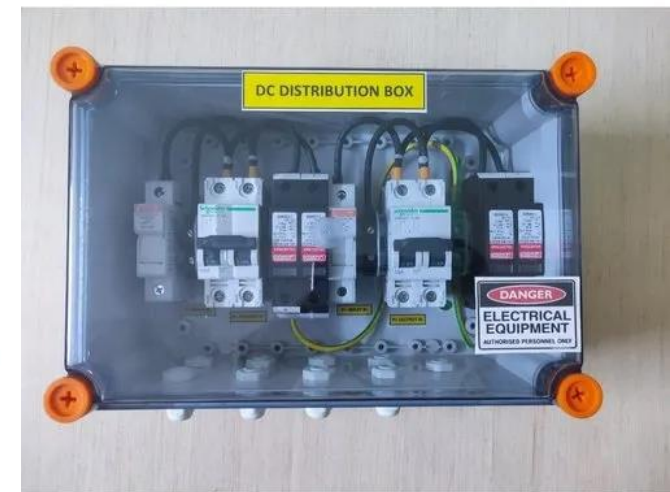
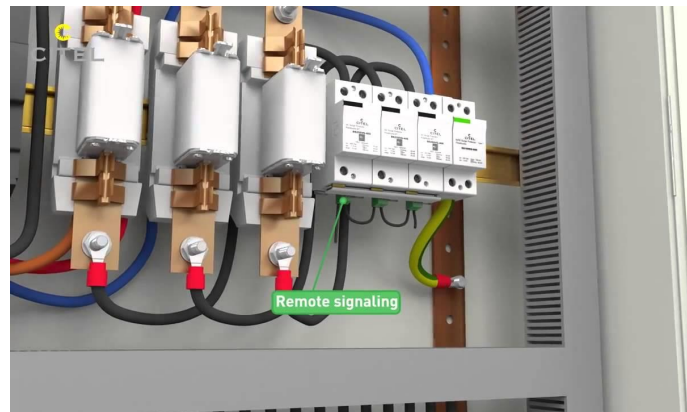
primary winding



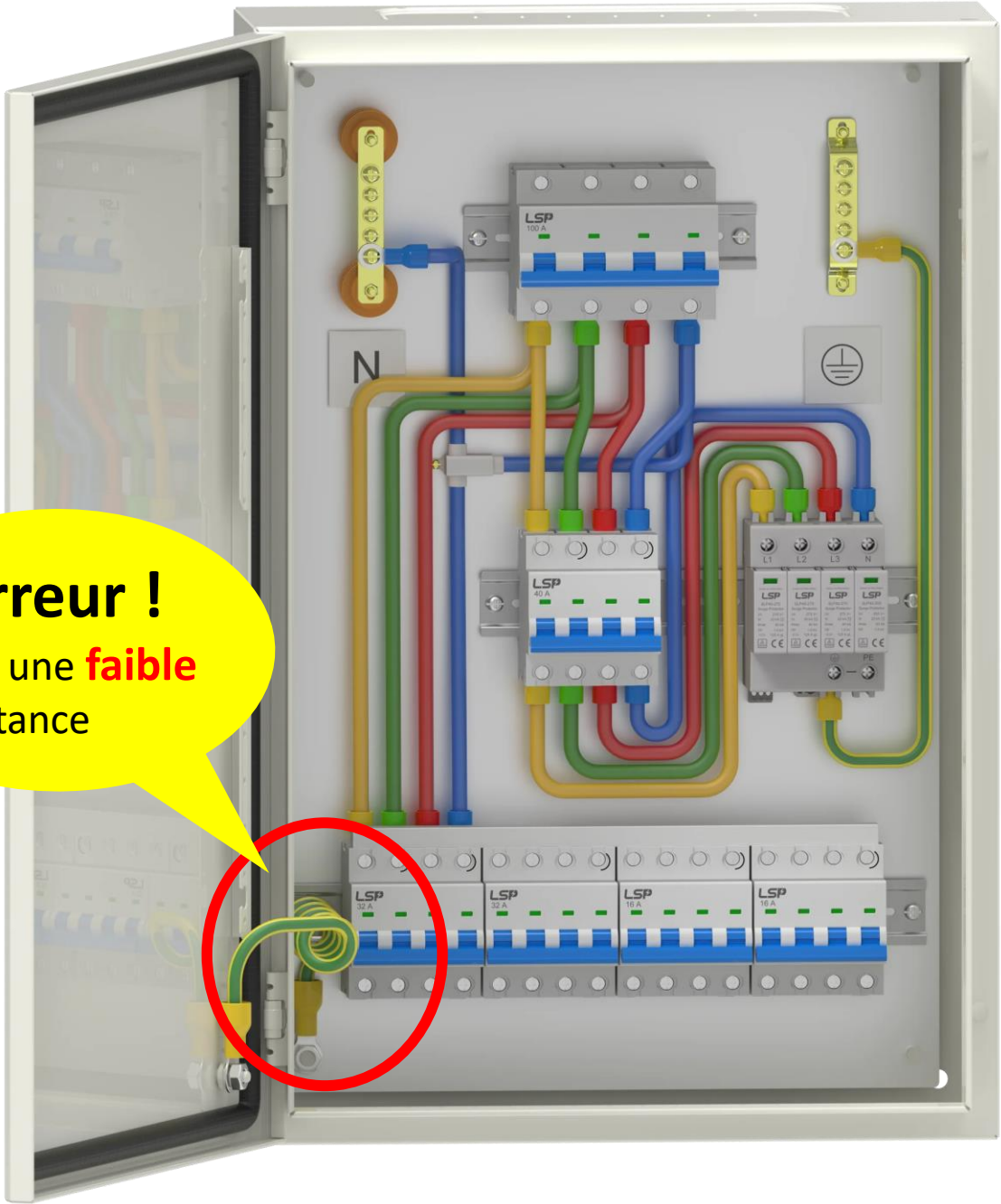
On Line Double Conversion UPS



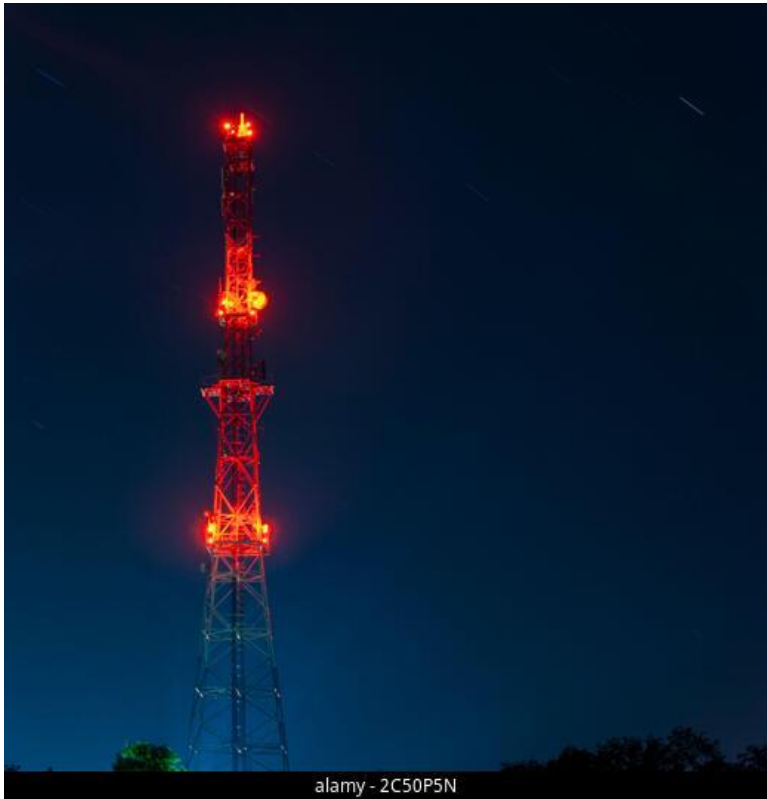
UPS = Attention attention La terre est commune entree/sortie



Erreur !
Il faut une **faible**
inductance



BALISAGES = probleme !





Examples, using the following values:

Mains voltage = $220 \text{ V}_{\text{RMS}}$;

allowable peak voltage = 340 V

Line inductance: $L = 20 \text{ } \mu\text{H} = 20 \times 10^{-6} \text{ H}$

Line capacitance: $C = 300 \text{ nF} = 0.3 \times 10^{-6} \text{ H}$

Line resistance: $0.68 \text{ } \Omega$

In the event of a short circuit:

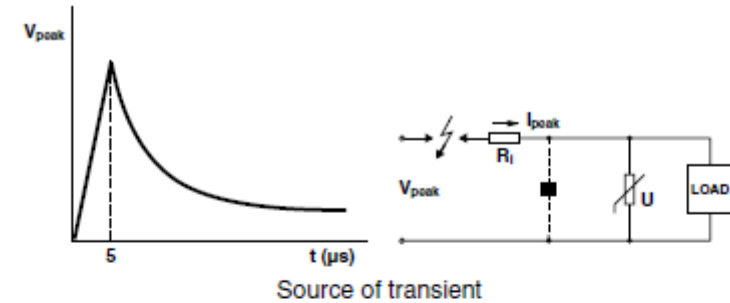
$$\text{Load current: } I_L = \frac{V}{R} = \frac{340 \text{ V}}{0.68 \text{ } \Omega} = 500 \text{ A}$$

$$\text{Energy stored: } E = \frac{1}{2} \times 20 \times 10^{-6} \times 25 \times 10^4 = 2.5 \text{ J (Ws)}$$

In the event of a fuse going open circuit:

The energy goes from inductance L towards line capacitance:

$$V_C = \sqrt{\frac{2E}{C}} = \sqrt{\frac{2 \times 2.5}{0.3 \times 10^{-6}}} = 4082 \text{ V}$$



The line impedance becomes high when the fuse goes open circuit (resistance against high voltage peak in a very short time).

$$R_i = \omega L = 2 \pi f L$$

Since the rise time of the pulse is $5 \text{ } \mu\text{s}$, the frequency $f = 50 \text{ kHz}$.

$$R_i = 6.28 \text{ } \Omega \times 50 \times 10^3 \times 20 \times 10^{-6} = 6.28 \text{ } \Omega$$

$$Z_i = 6.28 \text{ } \Omega + 0.68 \text{ } \Omega = 6.96 \text{ } \Omega$$

$$V_{Ri} = 6.96 \text{ } \Omega \times 500 \text{ A} = 3480 \text{ V}$$

$$V_{\text{VDR}} = 4082 \text{ V} - 3480 \text{ V} = 602 \text{ V}$$

*merci pour votre
aimable attention*



KJ4EGU

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