The Role of Isolation Transformers in UPS Systems

Somet Integration

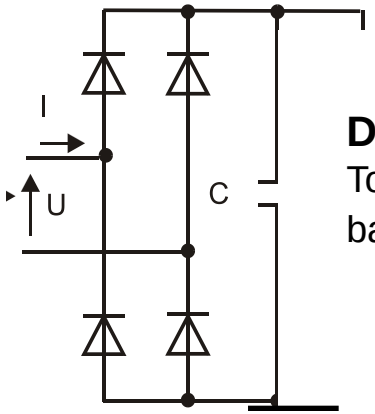
APC by Schneider Electric

Real role of a transformer (UPS output)

Output UPS Voltage adaptation

Standard SCR rectifier cannot deliver a high DC voltage

AC Input voltage
from main low voltage electrical distribution



DC output voltage
To inverter input and battery

Theoretically;
DC voltage = AC input voltage x $\sqrt{2}$
if U main = 400V
VDC = 400 x $\sqrt{2}$ = **565 V**

- **Typical DC voltage used = 450 volt**

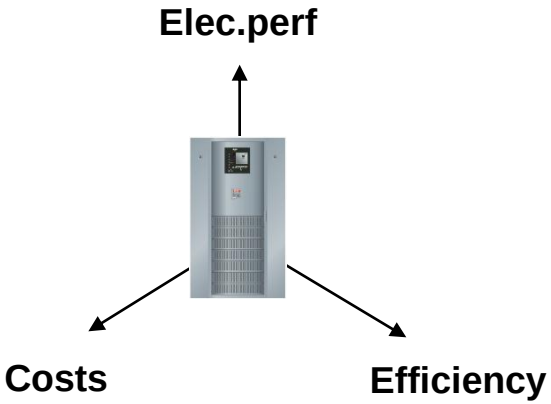
Rectifier output DC voltage is limited by AC input voltage

Transformerless topology design

Why a transformerless topography?

Technological design:

Why a transformerless topology ?



- Best solution to maximize the triptic :
  - Need of 3% thdi → Dc Bus at 800 v → no need of output transformer.
- Better electrical performances
- Total compatibility with any electrical design
- Save footprint
- Lower use of row material : environment concern
- Save cost
- Up to date topology : strong trend of current UPS design

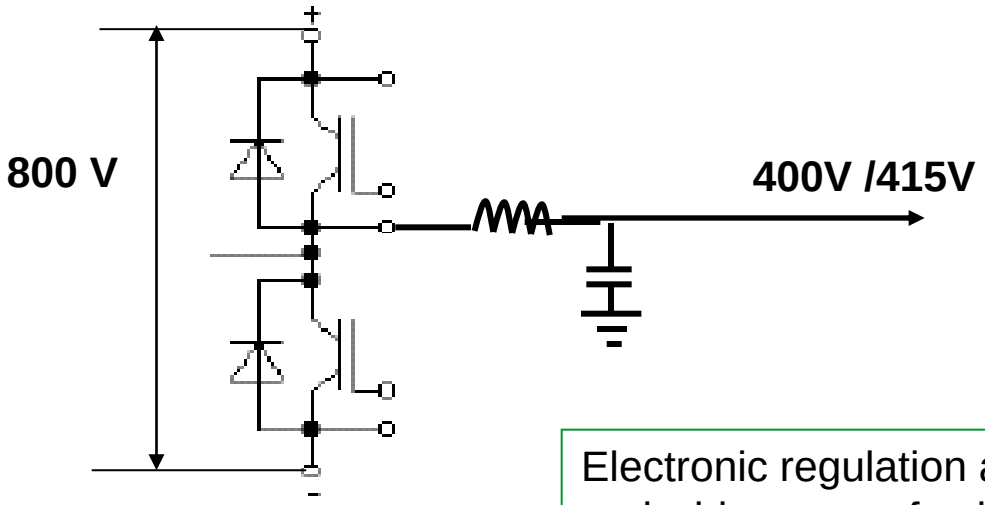
Technological design:

New generation of IGBT rectifier

Inverter output voltage accordance with 3 phase electrical distribution system :

400V, 415V

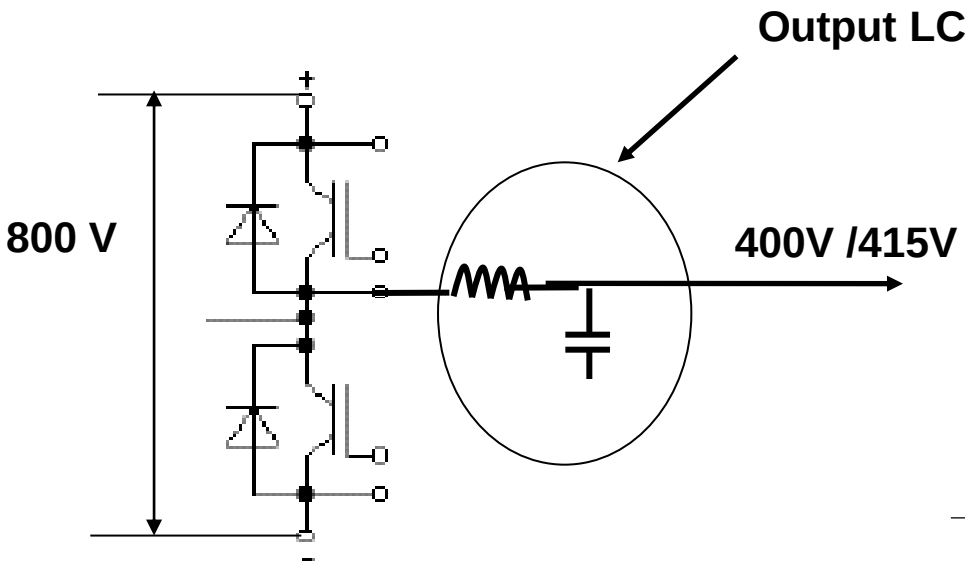
Transformer is no longer useful to adjust output AC voltage

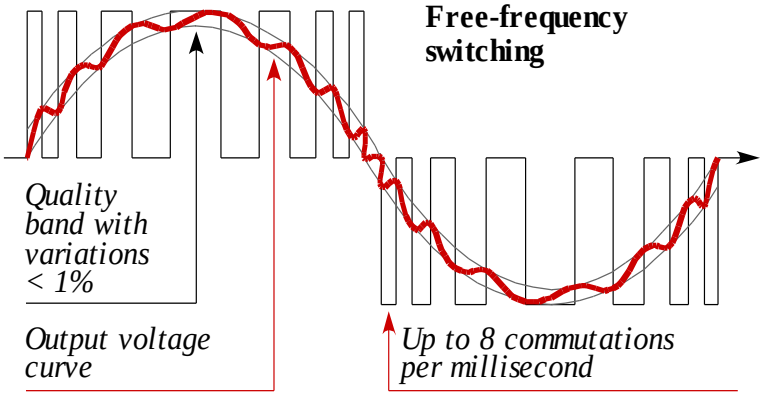


Electronic regulation allow an accurate and wide range of voltage adaptation capability

Technological design:
New generation of IGBT rectifier

Chock of the Transformer is no longer useful in the output filter





Transformerless UPS

DC voltage output : Electronic regulation

According to UPS standards, regulation and verification are separate functions from two independent devices

DC voltage at the output of the UPS

caused by a problem of electronic regulation

→ **Electronic regulates to have no DC voltage**.

If electronic trouble, control loop orders a transfer to by-pass

Transformer can supply only up till 5 % of DC current

DC current at the output of the UPS

(power supply with only one diode)

→ ***Transformerless UPS can supply up till 10% of DC Current***

UPS inverter fault between phase or on DC Bus

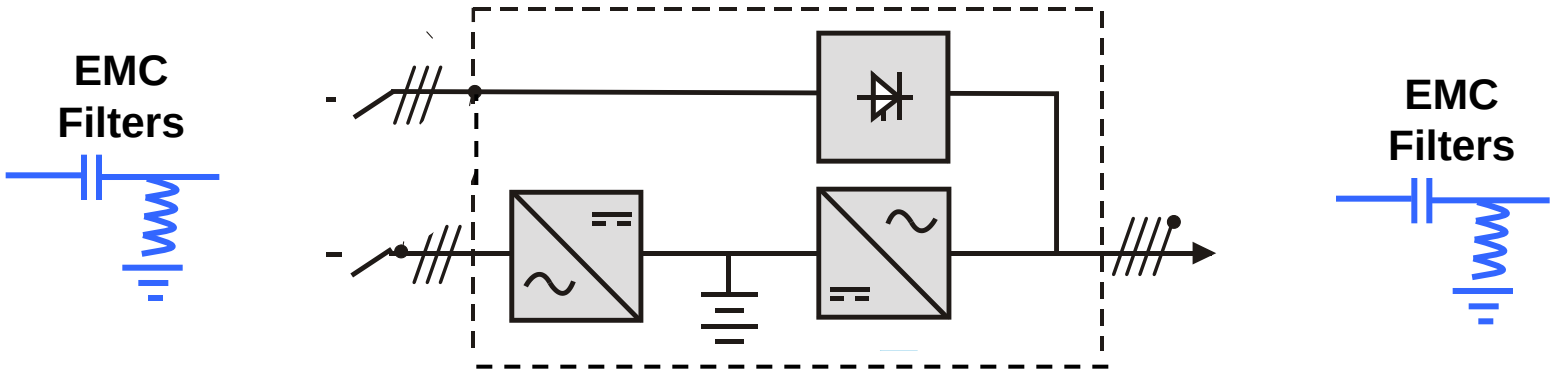
→ **Only electronic regulation can guaranty the non transmission to the load**

Transformerless UPS

EMI disturbances :

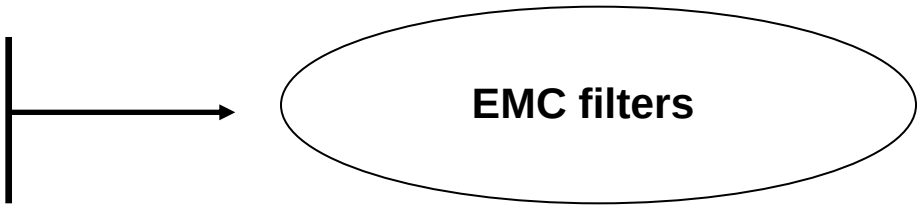
EMC of transformeless UPS doesn't change from what was done with transformer

➢**based on EMC filter installed on both Rectifier and by pass input and on UPS output**



➢Low frequency disturbances : Lightning , over voltage

➢High frequency disturbances « arcing »



Comparison between both design

Pros of Transformer based UPS design are:

- Voltage change
- Impedance
- Blocking harmonics
- Isolation of neutral from the source

Pros of Transformerless UPS design are:

- Weight, cost, resource consumption, and space usage
- Less Electrical losses and better data center efficiency

When is a Transformer really needed?

The key functions resulting from isolation are:

- Changing different mains grounding systems
- Creating a new neutral connection
- Combining two sources
- Preventing circulating currents

Definition

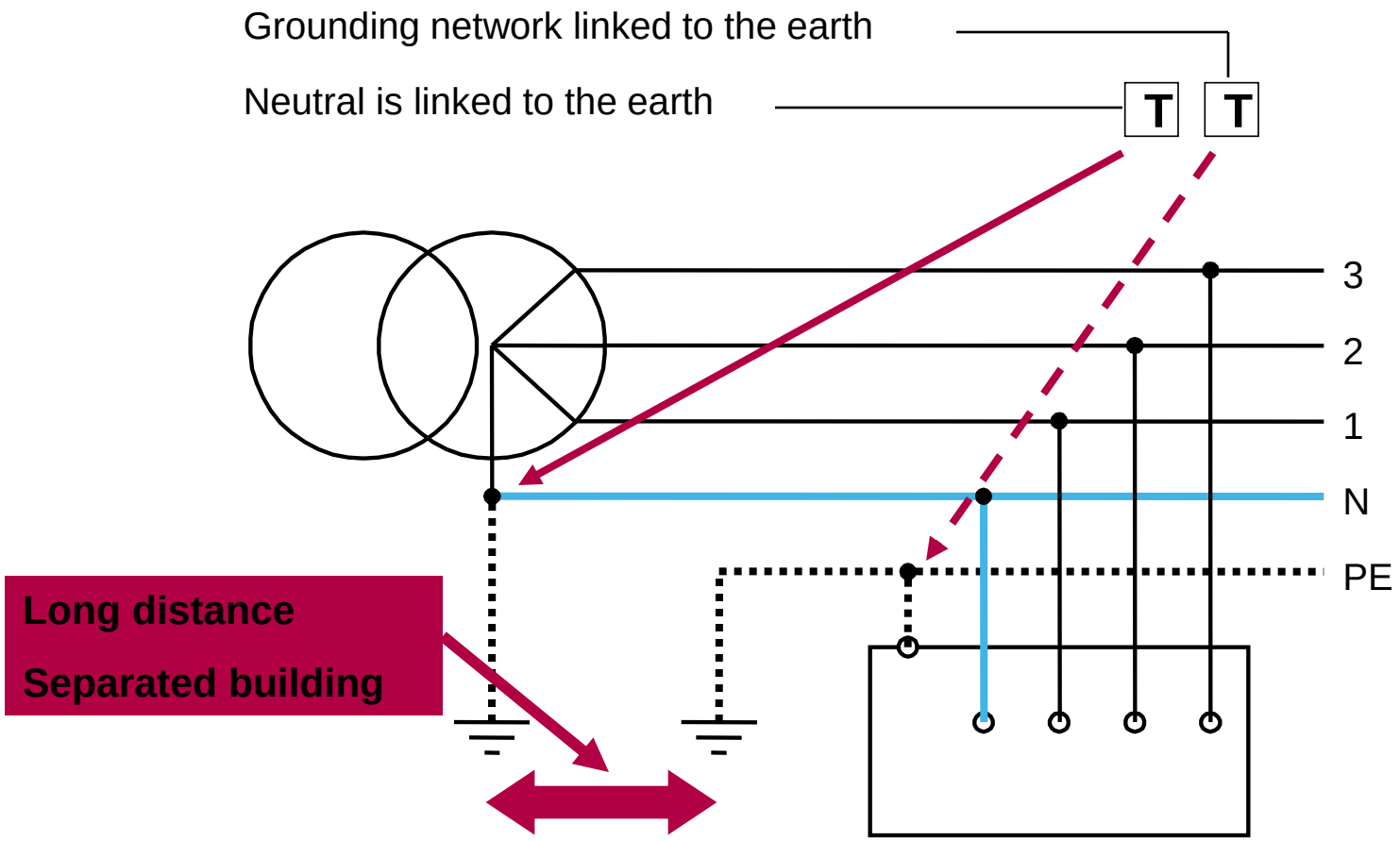
Electrical security policy

- According to IEC 60364 international standard
- The first letter defines the neutral position
  - T Neutral is linked with the local earth
  - I Neutral is isolated

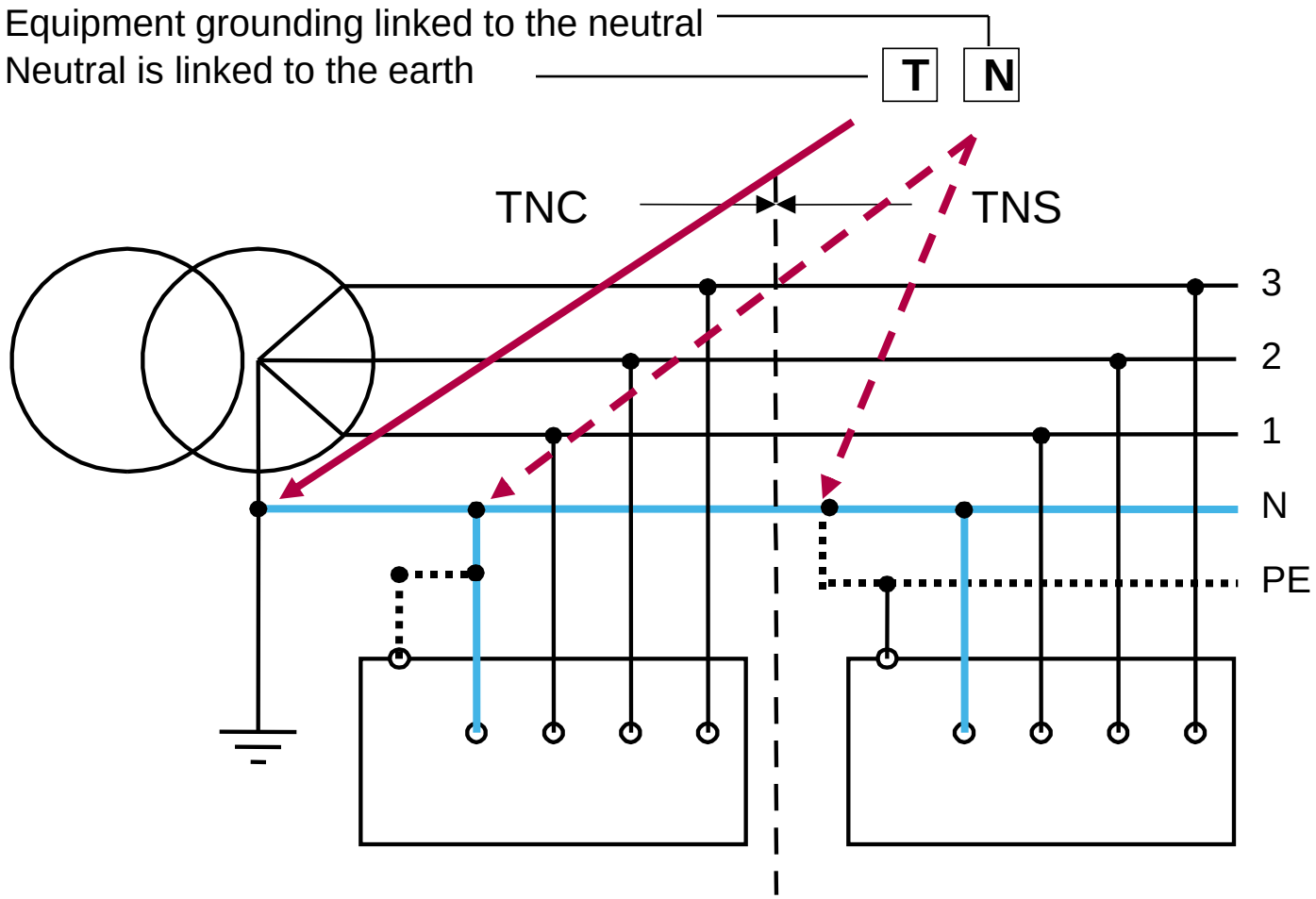
- The second letter defines the ground position
  - T Ground are linked to earth
  - N Ground are linked to the Neutral

- The third letter defines the neutral position within TN mode
  - C Neutral and Ground are Common
  - S Neutral and Ground are Separated

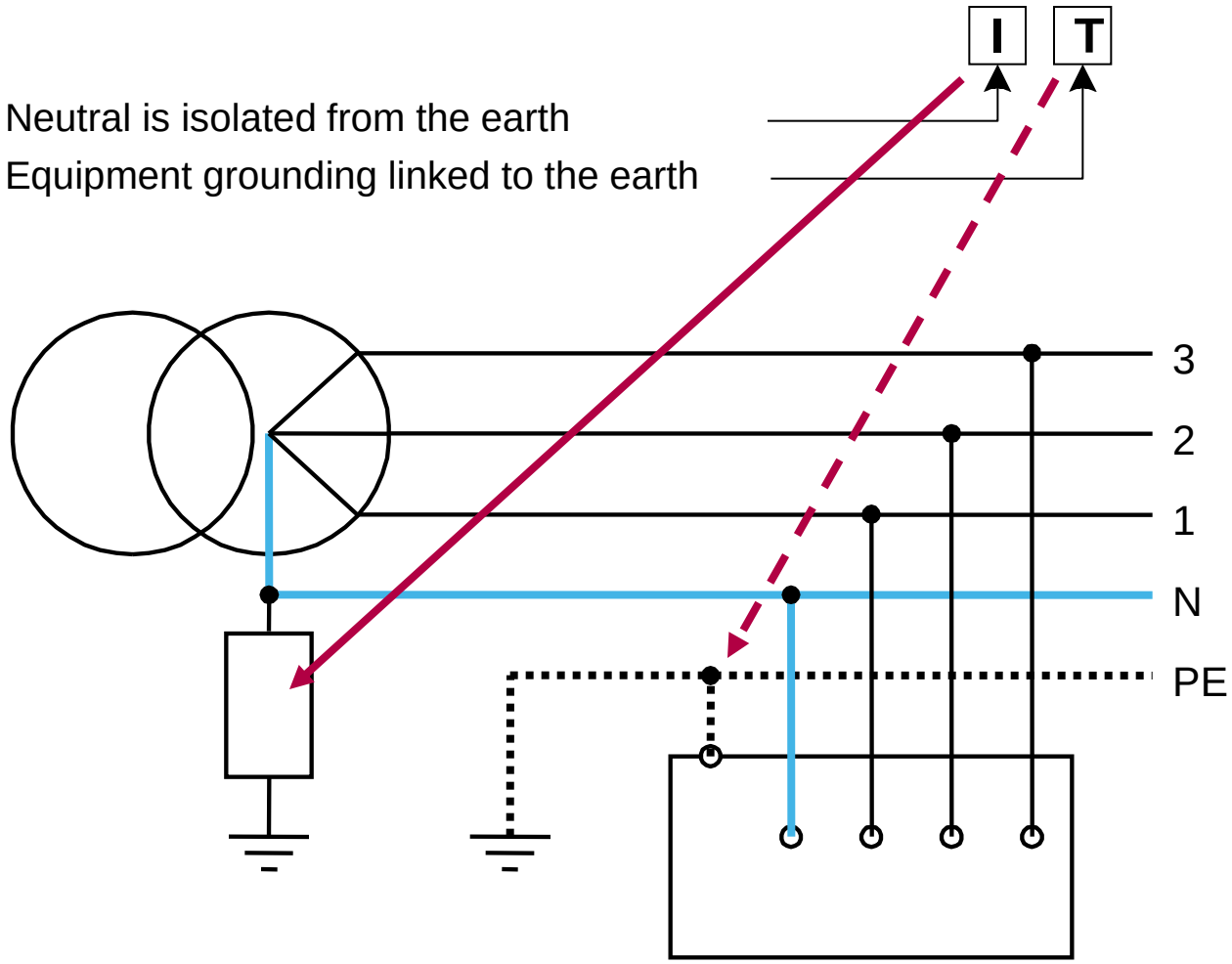
TT system


Grounding network linked to the earth
Neutral is linked to the earth
T
T
3
2
1
N
PE
Long distance
Separated building

TN system


Equipment grounding linked to the neutral
Neutral is linked to the earth
T
N
TNC
TNS
3
2
1
N
PE

IT system
industrial environment.



Neutral system comparison

TT system

Home/low power

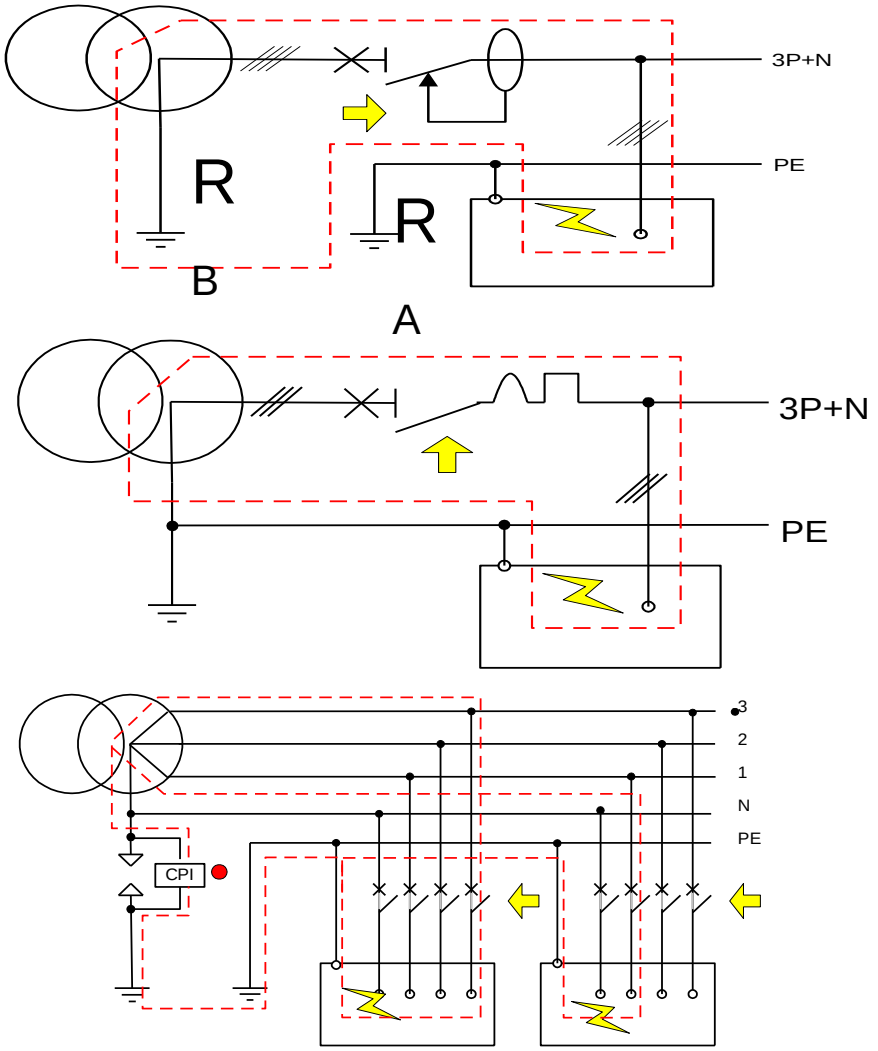
TN system

Tertiary

IT system

Industrial/Hospital

CB control after 2 faults



Grounding systems arrangement:
The different cases

			UPSTREAM UPS			
			TNC	**TNS**	**TT**	**IT**
DOWNSTREAM UPS	**TNC**	**2%** - If long cables, save costs on number of wires. Grounding system change if necessaru at down strem electrical panel.	**No transformer**	**1 compulsory** transformer at the ouput **or 2** upstream (Mains 1 and 2) transformers	**1 compulsory** transformer at the ouput **or 2** upstream (Mains 1 and 2) transformers	**1 compulsory** transformer at the ouput **or 2** upstream (Mains 1 and 2) transformers
	TNS	**85% - recommanded for IT loads**	**No transformer** (separate cables upstream or downstream UPS)	**Recommandation** of 1 tansformer at the ouput or 2 upstream transformers (Mains 1 and 2)	**1 compulsory** transformer at the ouput **or 2** upstream (Mains 1 and 2) transformers	**1 compulsory** transformer at the ouput **or 2** upstream (Mains 1 and 2) transformers
	TT	**3% -** Public buildings	**1 compulsory** transformer at the ouput **or 2** upstream (Mains 1 and 2) transformers	**1 compulsory** transformer at the ouput **or 2** upstream (Mains 1 and 2) transformers	**Recommandation** of 1 tansformer at the ouput or 2 upstream transformers (Mains 1 and 2)	**1 compulsory** transformer at the ouput **or 2** upstream (Mains 1 and 2) transformers
	IT	**10% -** Industry environment or non IT loads	**1 compulsory** transformer at the ouput **or 2** upstream (Mains 1 and 2) transformers	**1 compulsory** transformer at the ouput **or 2** upstream (Mains 1 and 2) transformers	**1 compulsory** transformer at the ouput **or 2** upstream (Mains 1 and 2) transformers	**Recommandation** of 1 tansformer at the ouput or 2 upstream transformers (Mains 1 and 2)

Transformer Isolation

Changing Different Mains Grounding Systems is an essential function

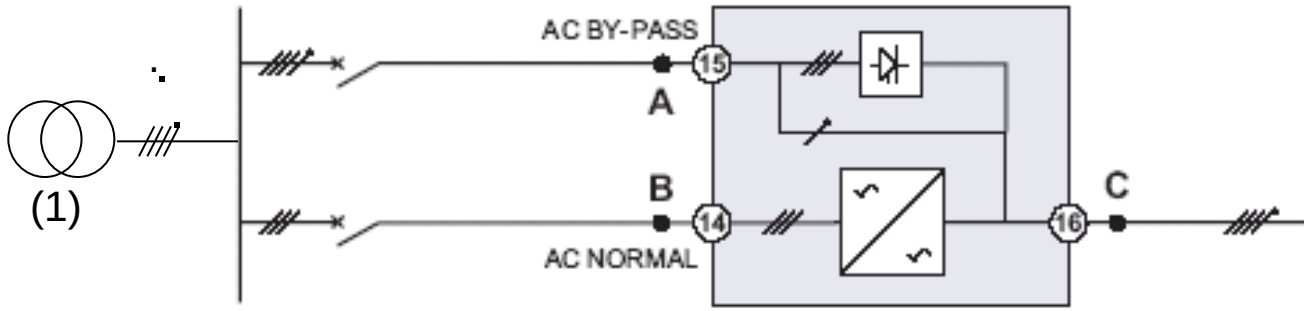
TT/IT require conversion to TN-S

transformer

IT equipment = TN-S

Earthing system arrangement

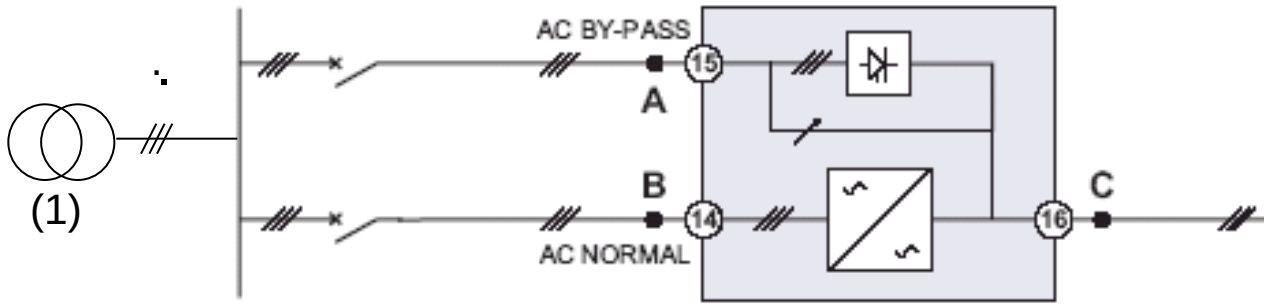
AC normal	AC By-Pass	Upstream UPS	downstream UPS
Separated		Same earthing system arrangement	
Come from same source (1)		Neutral distributed	



Earthing system arrangement

AC normal	AC By-Pass
Separated	
Come from same source (1)	

Upstream UPS	downstream UPS
Same earthing system arrangement	
Neutral **not** distributed	



Comments

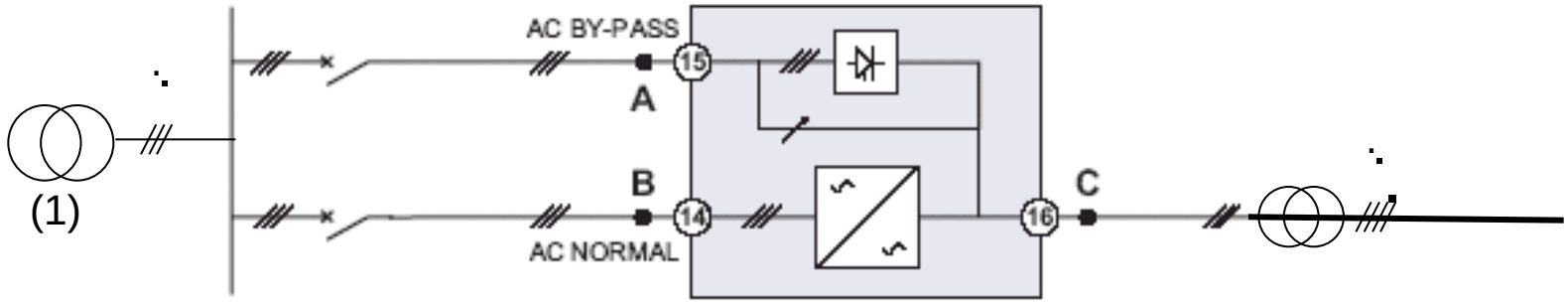
Transformerless UPS can work without neutral

Application : 3 phases loads

Earthing system arrangement

AC normal	AC By-Pass
Separated	
Come from same source (1)	

Upstream UPS	downstream UPS
Different earthing system	



➢AC By-Pass and AC normal come **from same source : 94%**

➢Changes of grounding system arrangement upstream/downstream : **30%**

⟶ **28%**

Comments

Add one output transformer

Transformer reliability is high : not a single point of failure

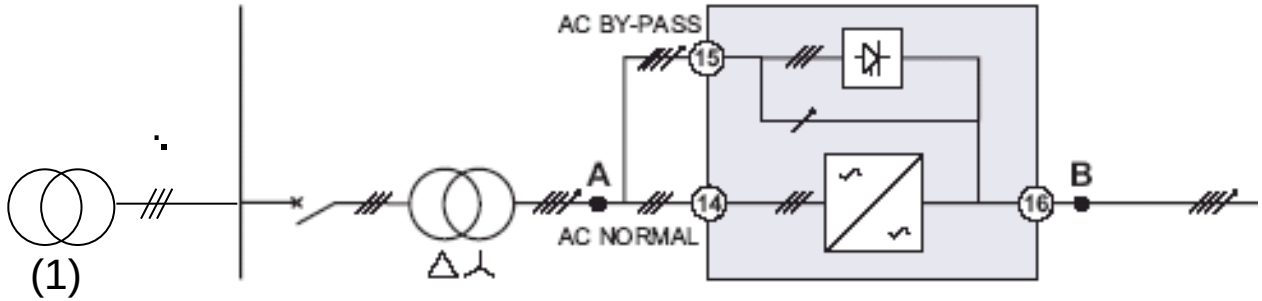
TFO MTBF = 2 millions hours

UPS MTBF = 475,000 hours

Earthing system arrangement

AC normal	AC By-Pass
Common	

Upstream UPS	downstream UPS
Different earthing system	



- AC By-Pass and AC normal come **from same source : 94%**
- Changes of grounding system arrangement upstream/downstream : **30%**

→ **28%**

Comments

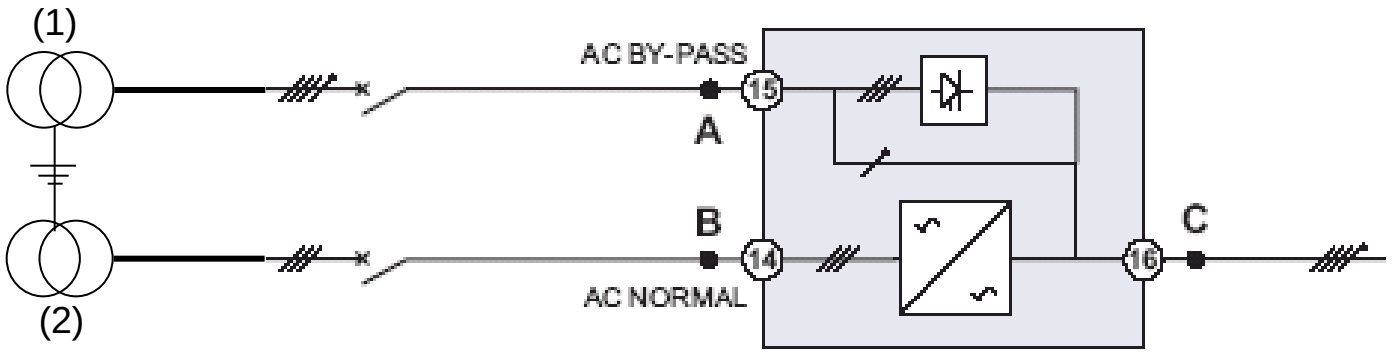
Add one input transformer I

Efficiency is lower by 1%

Size of the transformer : Pn

Earthing system arrangement

AC normal	AC By-Pass	Upstream UPS	downstream UPS
Separated		Same earthing system arrangement	
Come from 2 sources (1) & (2)		Neutral distributed	
Common earth for the 2 sources			

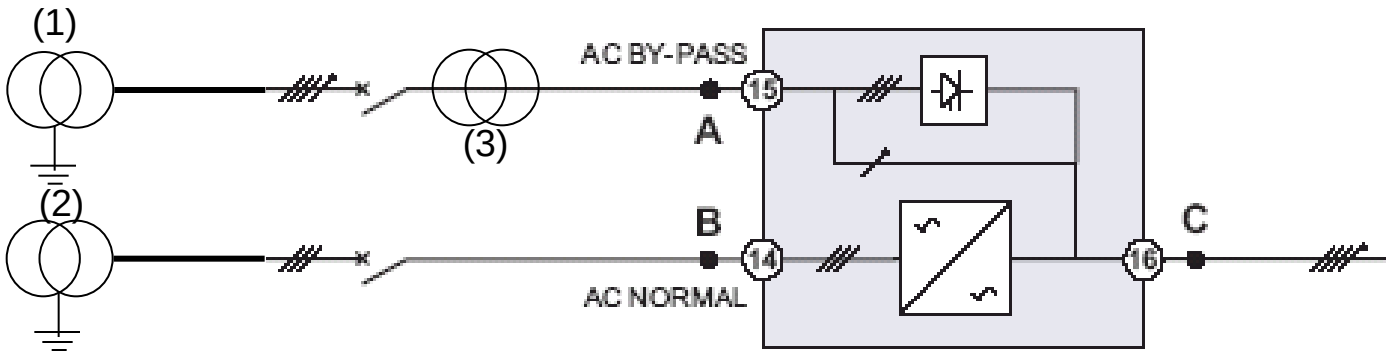


Comments

Necessary to have common earth for the 2 sources

Earthing system arrangement

AC normal	AC By-Pass	Upstream UPS	downstream UPS
Separated		Same earthing system arrangement	
Come from 2 sources (1) & (2)		Neutral distributed	
Different earth for the 2 sources			



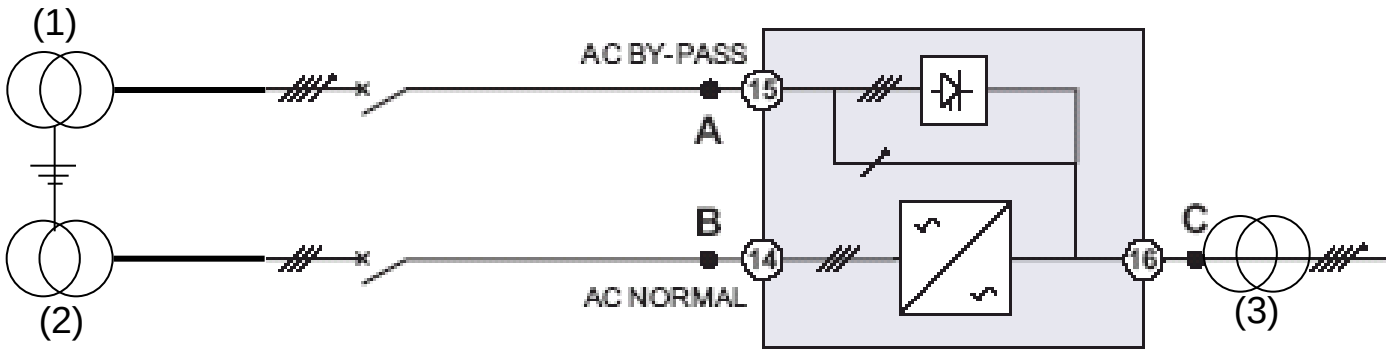
Comments

Add one transformer (3)

Not different from PW ?

Earthing system arrangement

AC normal	AC By-Pass	Upstream UPS	downstream UPS
Separated		**Different earthing sys. arrangement**	
Come from 2 sources (1) & (2)		Neutral distributed	
Common earth for the 2 sources			



- AC By-Pass and AC normal come from 2 different sources : **6%**
- Changes of grounding system arrangement upstream/downstream : **30%**

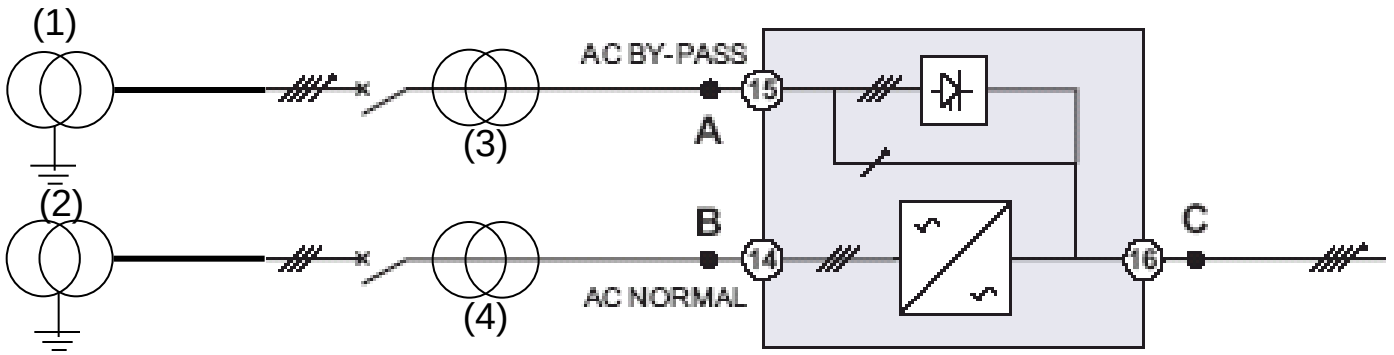
→ **1.8%**

Comments

Add 1 transformers (3)

Earthing system arrangement

AC normal	AC By-Pass	Upstream UPS	downstream UPS
Separated		Different earth. system arrangement	
Come from 2 sources (1) & (2)		Neutral distributed	
Different earth for the 2 sources			

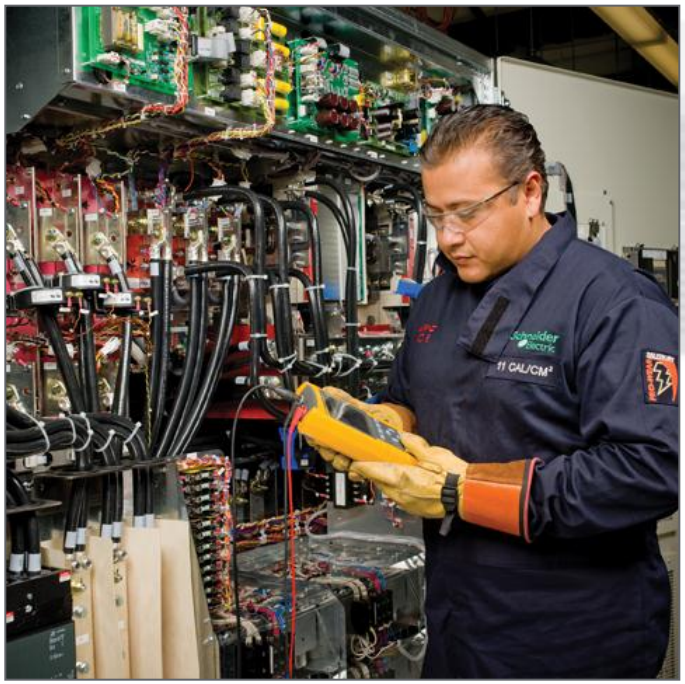


Comments

Add 2 transformers (3) and (4)

Transformer Isolation

Creating a New Neutral Connection



Shared with other customers

Generated a distance from the data center

Deemed unreliable

Transformer Isolation

Creating a New Neutral Connection

In developed countries and most large, new buildings:

- TN-S neutral source is within the customer premises and close to the data center
- Excellent quality

In other situations:

- Neutral-to-ground bond may be outdoors, possibly distant, shared, and part of a degraded/ overloaded system
- Significant offset or noise voltage
- Loss of ground connection or interruption

Conclusion

In summary:

- Transformer-based and transformerless UPS installations include transformers.
- Transformers provide for important functions.
- Transformers are still, but not always, necessary in system design.
- Transformer-based UPS systems do not usually have an optimally placed transformer.
- Transformer-less UPS systems allow for the omission or movement to the best location of transformers.