A new International UPS Classification

by IEC 62040-3

"Method of specifying the performance and test requirements"

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Dipl.-Ing. Wilhelm Sölter

UPS Marketing Manager
AEG SVS Power Supply Systems GmbH
D 59581 Warstein, Germany
Member of the IEC SC 22H and DKE AK 331.1 (UPS)

Abstract:

There are three typical UPS circuit arrangements in use, called by their good old names
- On-line UPS or Double Conversion UPS
- Line Interactive UPS
- Off-line UPS or Passive stand-by UPS
but there are not explicit.

Competition is good in general – but in case of UPS designations some competitors are extremely creative! Terms like "quasi online UPS", "semi online UPS", true online UPS, "online-sharing technology" ...are today common. The motivation of these UPS providers are to confuse the user to believing their products are true double conversion at a much more affordable price. In reality, these products are not double conversion, do not provide the reliability that the user´s expect in receiving double conversion.

1. Motivation / Objective

Descriptive terms currently in use - e.g. for <online> – are an open invitation to misunderstandings. This is why the comment: "online UPS meaning the load is always supplied by the inverter, irrespective of the condition of the a.c. input supply. The term <online> also means "on-the-mains". To prevent confusion in definition, this term should be avoided ..." has been incorporated into the new IEC 62040-3 standard.

Accordingly, the new IEC 62040-3 standard takes a new approach - completely devoid of these old terms and no longer dependent on misunderstood designations.
The fundamental idea behind this:

- The quality of voltages to be supplied is relevant to critical applications – under all operational conditions!
- This objective is resolved by **IEC 62040-3** through the introduction of a **three step UPS classification code** that is based on the operational behavior of **UPS output voltage**.

2. The Problem - Power Line Disturbances

There are various types of power line faults and voltage deviations. The ten most frequent, which are the most important to end devices, are listed here:

Table 1

	Power Line Disturbance	**Time scale**
1.	power outage	> 10 ms
2.	voltage fluctuations	< 16 ms
3.	voltage transients	4 ... 16 ms
3.	under-voltage	continuous
4.	over-voltage	continuous
5.	lightning effects	sporadic < 1 ms
6.	voltage surges	< 4 ms
7.	frequency fluctuations	sporadic
8.	voltage bursts	periodic
9.	voltage harmonics	continuous

A UPS must provide loads with isolation from as many of these disturbances as possible, not just act as a precaution against outright power outages. It is extremely interesting to see how well the three UPS classifications are able to handle these ten types of power line disturbances; but first to the UPS classifications.

3. UPS Classification

The experts in the international standards committees have established a **three STEP** classification code:

- STEP 1: dependency of UPS output on the input power grid

- STEP 2: the voltage waveform of the UPS output

- STEP 3: the dynamic tolerance curves of the UPS output

3.1 STEP 1 Definitions

Step 1: by Output Dependency from Input supply

Code

VFI	„Where the UPS ouput is Independent of Input supply Voltage and Frequency variations“
V I	„Where the UPS output is Dependent on Input supply frequency variations, but supply Voltage variations are conditioned (Independent) ... „
VFD	„Where the UPS output is Dependent on Input supply Voltage and Frequency variations“

VFI

Output voltage is **independent** of **all** power line voltage **and** frequency fluctuations and remains regulated within the tolerances set forth by IEC 61000-2-4.

VI

Output voltage is **dependent** on power line frequency but remains within prescribed limits through active or passive regulating mechanisms.

VFD

The UPS output is dependent on changes in power line voltage and frequency when it has no corrective means, such as tapped transformers, EMC filters or varistors.

3.2 STEP 2 Definitions

Step 2 correlates the output voltage waveform into a simple structure – according to the two operational modes "normal mode " and "stored energy mode".

Step 2: By generated Output waveform

Code

S S	sinusoidal: total harmonics factor D < 0.08 (IEC 61000-2-2) under all linear and under reference non-linear load or
X X	Non-sinusoidal: D > 0.08 under reference non-linear load or
Y Y	Non-sinusodial exeed the limits of IEC 61000-2-2

First character: normal mode

Second character: storage energy mode

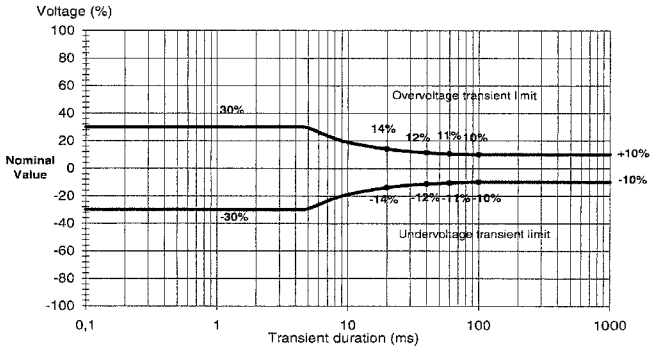
Especially the VFD-type UPS in stored energy mode may produce output voltage waveforms that may deviate considerably from a sine wave form, e.g. square or trapezoid wave shapes. Many loads will not operate properly with these voltage wave.

3.3 STEP 3 Definition

Business critical applications need a clean sine wave voltage under all conditions. Step 3 defines the maximum allowable dynamic deviations (from a clean sine wave). As such, it represents the real **"royal challenge"** to UPS classification – because this is where the “first class” UPS will be separated from the “rest”.

STEP 3: Three tolerance curves describe the output voltage limits:

Classification 1

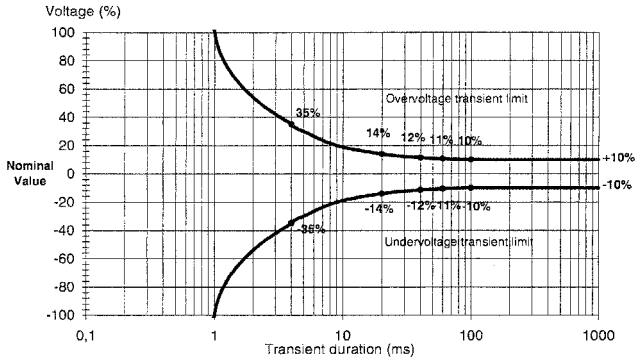


Code for Output Tolerance Curves

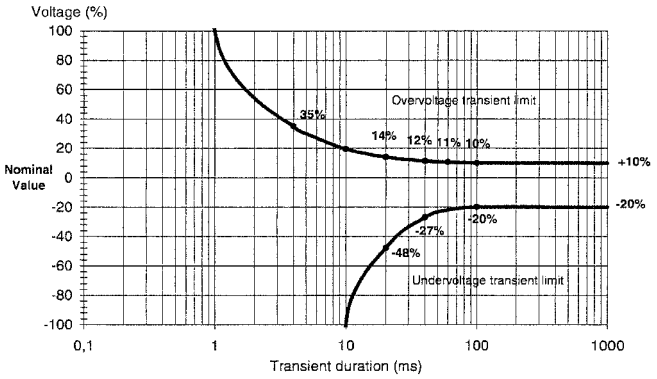
1	2	3

- first character: change of operating mode performance
  e.g. normal mode–stored energy mode – bypass mode
- second character: step linear load performance
  in normal / stored energy mode (worst case)
- third character: step **non**-linear load performance
  in normal / stored energy mode (worst case)

Classification 2



Classification 3



Only when this Step 3 part of the classification contains **three times "1" code characters** can the user be assured that his critical loads will actually be optimally protected.

*This expression signifies the **quality of output voltage** under all operational conditions. It has **nothing** to do with an expression relative to the **availability** of an UPS. If availability requirements are very high, e.g. greater than 99.99%, then redundant UPS units must be installed, e.g. in an N+1 configuration.*

The complete UPS classification code is:

STEP 1 **Output** Dependency	STEP 2 **Output** Waveform	STEP 3 **Output** Tolerance
from line	distortion*	tolerances*
VFI	SS	111
VI	SX	122
VFD	SY	333

* examples

The complete three-Step code is detailed and, at first glance, complex but it becomes readily clear and – as promised under Point 2 – very interesting when the 10 power disturbance types are correlated to these three UPS classes.

4 UPS Classes and Grid Disturbances

4.1 VFI Classification

Output voltage is independent of all changes to line **voltage amplitude**.

In order to achieve the required independence also from **line frequency** there is a physical prerequisite to completely regenerate the output voltage from an intermediate d.c. circuit[1)] while operating under normal mode conditions. The complete independence of the UPS output voltage from the input supply makes this type of UPS a

VFI type

VFI Dynamics: This type of UPS also meets the most stringent requirements for dynamic voltage deviations as imposed by Class 1. Even during the change of operation mode or sudden load steps!

The triple "Classification 1" rating is only possible with this type of UPS. Therefore,

VFI : UPS Classification 1

A solution to all 10 line disturbances

[1)] The UPS technique employed here is the double conversion (previously: online).
Mode: UPS continuous operation.

4.2 VI Classification

Line power voltage failures can be regulated within certain limits:

- voltage amplitude: about +/- 20%
- time window: line disturbances of up to about 8 ms will **not** be suppressed by regulation

Output voltage is **dependent** on the **line frequency** during normal operation. Line frequency errors and phase errors reach connected loads. This type of UPS does not require a direct current intermediate circuit.[2)]

[2)] The UPS technique employed here is the line interactive.
Mode: UPS line interactive operation.

VI Dynamics: Classification 1 tolerances cannot be maintained by this type of UPS during switchover between operational modes (supply gaps)! Every minor line failure also causes this type of UPS to electrically cut off the line and switch over to battery operation to isolate connected loads from the failed line. Such UPS arrangements rarely comply with Class 1 tolerance limits. *[This method of operation causes frequent stress to the battery and is thereby a cause of premature battery aging.]*

Therefore,

VI : UPS Classification 2

A solution to 5 of the 10 line disturbances

4.3 VFD Classification

The UPS output is **dependent** on changes to line voltage and frequency. Its layout permits almost all line failures that occur during normal "mode operation" to reach the connected loads. Some degree of performance improvement can be achieved with the aid of tapped transformers, EMC filters or varistors.[3)]

[3)] The UPS technique employed here is the "passive line parallel technique" (previously "offline").
Mode "UPS passive stand-by operation".

VFD Dynamics: When a line outage is detected, a mechanical switch causes a switchover to the battery-driven inverter – with a typical gap of 4 ... 8 ms. Clearly, this type of UPS will only be capable of meeting tolerances specified for Class 3.

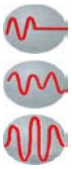
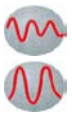
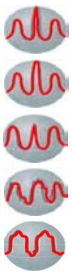
VFD : UPS Classification 3

A solution to 3 of the 10 line disturbances

Grid disturbances and UPS Classes

On the basis of their dependencies, the three UPS types are graphically correlated below as differentiated solutions to the 10 types of grid disturbances. The **Table 2** below provides an overview that should help the user with his decision-making process.

Table 2 Grid disturbances and UPS Classes publicated by ZVEI: UPS Guide

	Voltage Phenomenon	Time	e. g.	IEC 62040-3	UPS-Solution	
1.	Outage - blackouts ...	> 10 ms		**VFD** Voltage + Frequency Dependent	Classification 3 **Offline**	
2.	Sags / brownouts	< 16 ms				
3.	dynamic overvoltage	< 16 ms				
4.	undervoltage	continuous		**VI** Voltage Independent	Classification 2 **LineInteractive**	
5.	overvoltage	continuous				
6.	Lightning	sporadic		**VFI** Voltage + Frequency Independent	..... Classification 1 **(true) Online real Double-Conversion**	by additional lightning arrestors
7.	transients (Surge)	< 4 ms				
8.	frequency variations	sporadic				
9.	voltage distorsion Hf (Burst)	periodically				
10.	voltage harmonics	continuous				

5. Summary

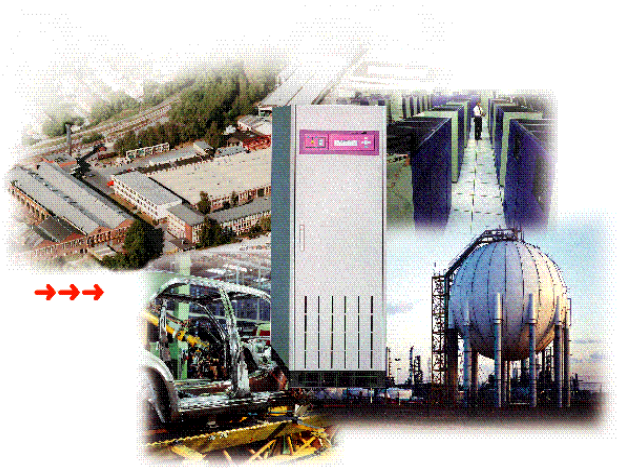
As a result of term diversity and nomenclature misuse and the confusion that these have caused among users, the three Step classification code, as set forth by IEC 62040-3, has been explained. The 10 most significant line disturbances have been presented and the performance characteristics of the three UPS types have been outlined.

This permits the three types of UPS systems to be correlated to the 10 line disturbances (Table 2).

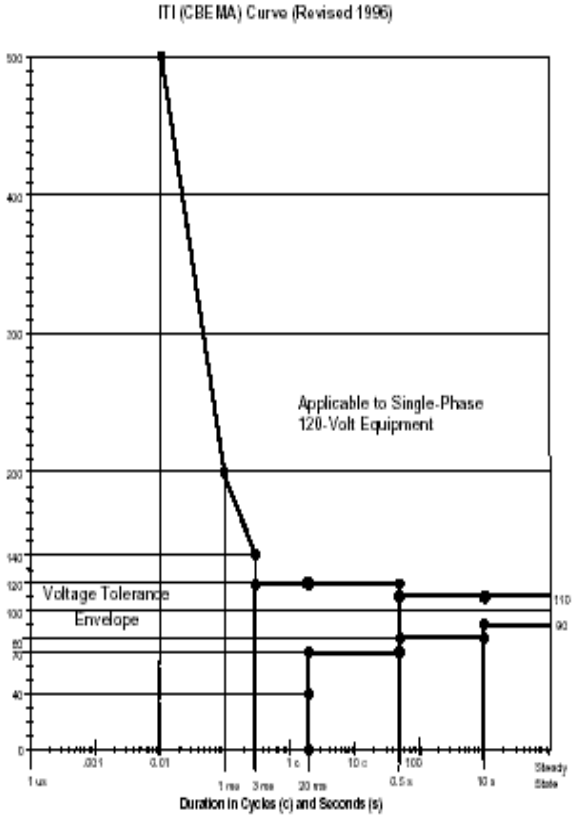
Together with Table 2, the new classification code serves as an excellent instrument for evaluating specific performance characteristics of the various UPS types – in a manner that is not clouded by misleading terms and names.

Users should generally avoid suppliers who make no, or only sketchy, reference to the new UPS classification scheme.

A **product example** of the top classification
VFI SS 111
is PROTECT 3.33: 10 kVA to 1 MVA
by **AEG / SAFT** SVS Power Systems



Annex
Comparison between
ITI (CBEMA)
and
IEC 62040-3 by Step 3 tolerances:



IEC 62040-3: Dynamics /
Classification 3