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Test & Measurement is our Knowledge,
Supporting customers our Business

# How to choose the right AC power supply for your application?

*André Handgraaf*

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# How to choose the right AC power supply for your application?

How hard can it be?

1) Voltage range determination
2) Frequency range
3) Required power

And that's it.

# How to choose the right AC power supply for your application?

Unfortunately, we know from practical experience that there are many more parameters to consider.

- Maximum voltage
- Frequency range
- Maximum current
- Maximum power at a given voltage
- Single phase or three phase
- Crest factor
- Inrush current
- The power factor
- Output impedance
- Harmonic distortion
- Others....

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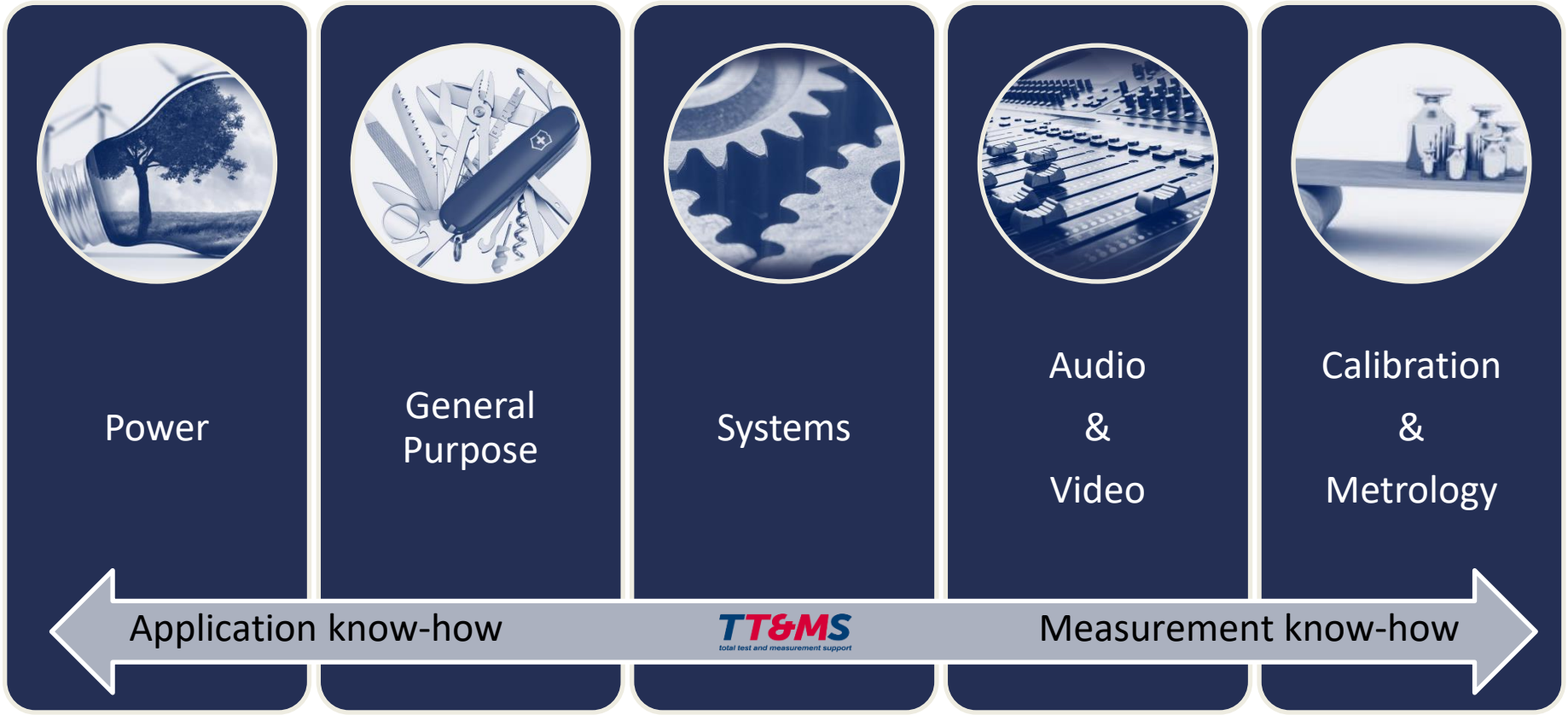


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# Power division

Programmable DC Power Supplies
Bi-directional DC Power Supplies
4Q DC Grid emulator
High Voltage DC Power Supplies >600Vdc
Battery, Solar Emulator, Power Hardware in the Loop
Programmable AC Sources
AC Grid emulators
2Q,4Q Bipolair Amplifiers
Programmable DC Loads
Programmable AC loads
2Q, 4Q regenerative loads
Power Measurement and analysis


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# Maximum Voltage

With single-phase systems, this is simple:

220V-230V-240V 50 or 60Hz
110V-120V 50 or 60Hz

Exceptions:
127V/220V
100V

For more details:
https://www.worldstandards.eu/nl/elektriciteit/landenoverzicht-stekkers-voltage/

WAARSCHUWING.

De spanning van het Haagsche lichtnet is:
125 VOLT
LET OP of op de huls der „zoogenaamd" goedkoope lampen, die dezer dagen in de dagbladen werden aangeboden
110 VOLT
of eenig andere spanning dan 125 VOLT gestempeld is.

Lampen die op hoogere spanning branden dan waarvoor zij gemaakt zijn geraken zeer spoedig defect.

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# Maximum Voltage

The minimum and maximum voltage on the mains are defined by local standards. In the Netherlands, this is the NEN EN50160:2010 with some additions in 2015 and 2019.

In general, we see that the mains voltage may vary by +10% and -15%.
(Standard in 2010, now it is +10% and -10%).
For the Netherlands, this means between 195.5V and 253V.
For universal AC power supplies, we see specifications such as 187V to 264V or even 85V to 265V.

Most AC power supplies therefore have two voltage ranges;
0-300Vac
0-150Vac
With a double current capability in the low voltage range.

| SPECIFICATIONS | | |
|---|---|---|
| Model | 61601 | 61602 |
| Output phase | 1 | 1 |
| Output Rating - AC | | |
| Power/Phase | 500VA | 1000VA |
| Voltage | | |
| Range/Phase | 150V/300V/Auto | 150V/300V/Auto |
| Accuracy | 0.2%+0.2%F.S. | 0.2%+0.2%F.S. |
| Resolution | 0.1V | 0.1V |
| Distortion (*1) | 0.3% @ 50/60Hz<br>1% @ 15~1kHz | 0.3% @ 50/60Hz<br>1% @ 15~1kHz |
| Line Regulation | 0.1% | 0.1% |
| Load Regulation (*2) | 0.2% | 0.2% |
| Max. Current/Phase | | |
| r.m.s. | 4A/2A (150V/300V) | 8A/4A (150V/300V) |
| peak | 24A/12A (150V/300V) | 48A/24A (150V/300V) |
| Frequency | | |
| Range | DC, 15~1kHz | DC, 15~1kHz |
| Accuracy | 0.15% | 0.15% |
| Resolution | 0.01 Hz | 0.01 Hz |

# Maximum Voltage

But against which voltages should you test?

LED drivers for outdoor lighting often have a universal input between 90V and 305V.

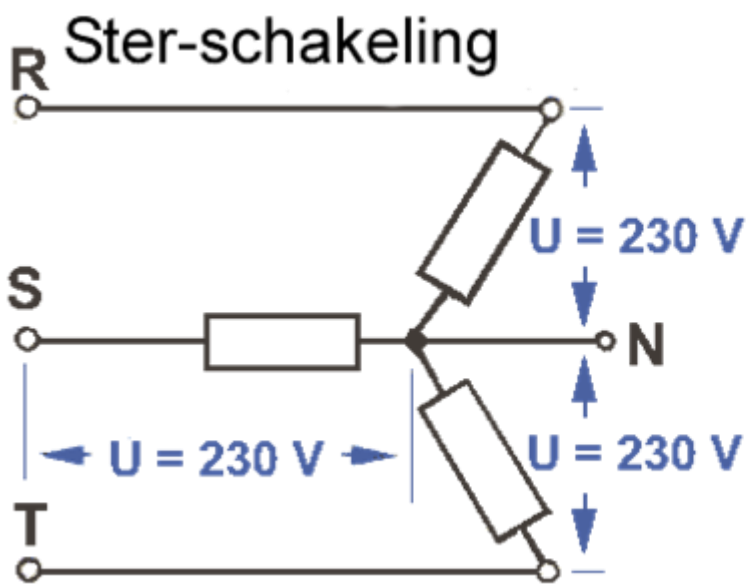
Datasheet 11/19-LC435-6
LED Driver Universal Wide Voltage (UNV)100

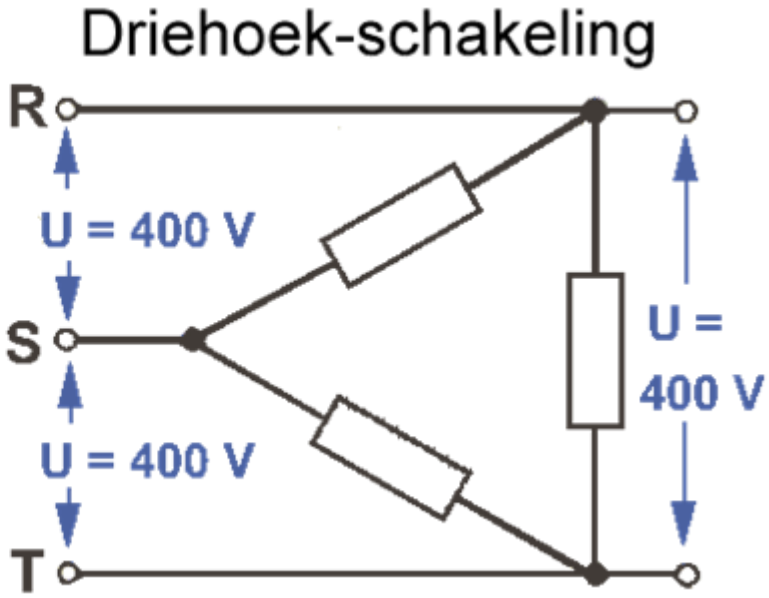
Technical data:
Rated supply voltage 100V - 277V
AC voltage range 90V - 305V

| Power Rating | | 500VA | 1000VA | 2000VA | 3000VA |
|---|---|---|---|---|---|
| Output Voltage | | 0 ~ 155Vrms, 0 ~ 310Vrms | | | |
| Output Frequency | | 45.00 ~ 500.0 Hz | | | |
| Max. Current(rms) *1 | 0 ~ 155 Vrms | 4.2A | 8.4A | 16.8A | 25.2A |
| | 0 ~ 310 Vrms | 2.1A | 4.2A | 8.4A | 12.6A |
| Max. Current (peak) | 0 ~ 155 Vrms | Peak value which is four times of the maximum current(rms) | | | |
| | 0 ~ 310 Vrms | | | | |
| OPT. APS-003(rms) | 0 ~ 600 Vrms | 1.05A 2.1A 4.2A 6.3A | | | |
| OPT. APS-003(peak) | 0 ~ 600 Vrms | Peak value which is four times of the maximum current | | | |

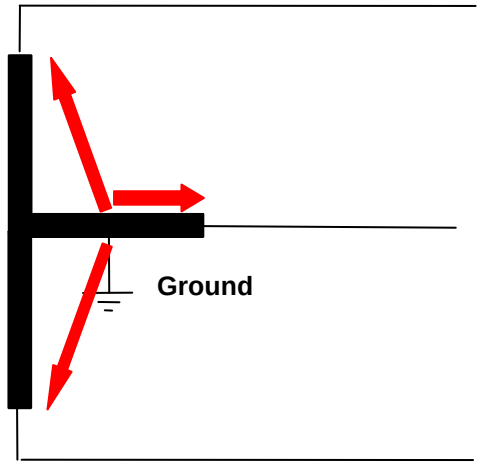
# Single-phase or three-phase AC power supply

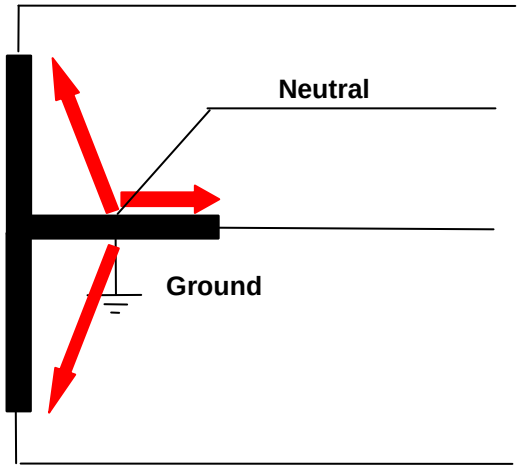
With this, we have largely clarified the voltage ranges in single-phase systems.
But what about three-phase systems?

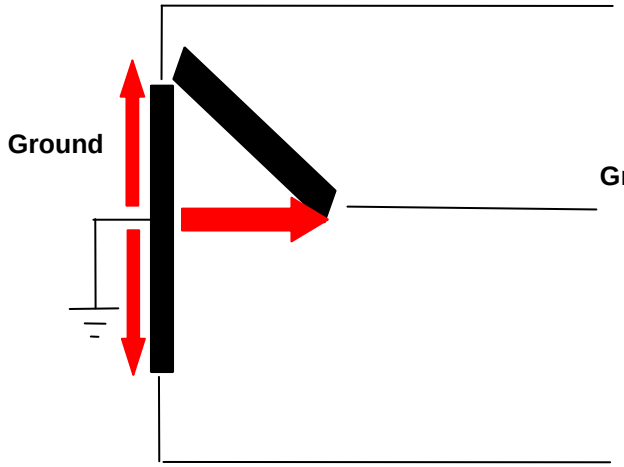


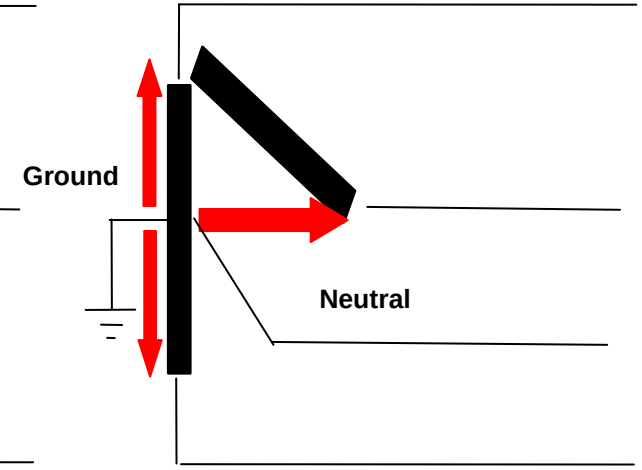



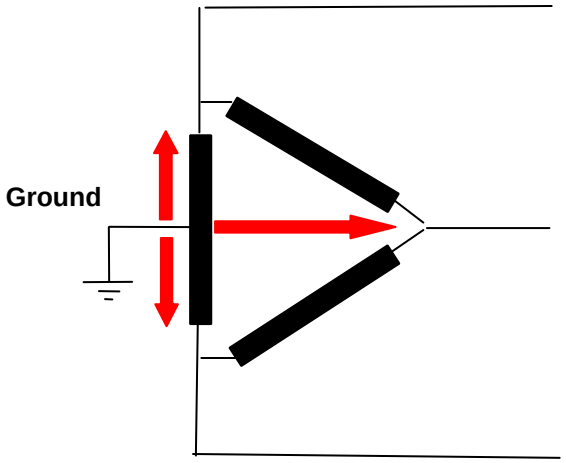
# Single-phase or three-phase AC power supply

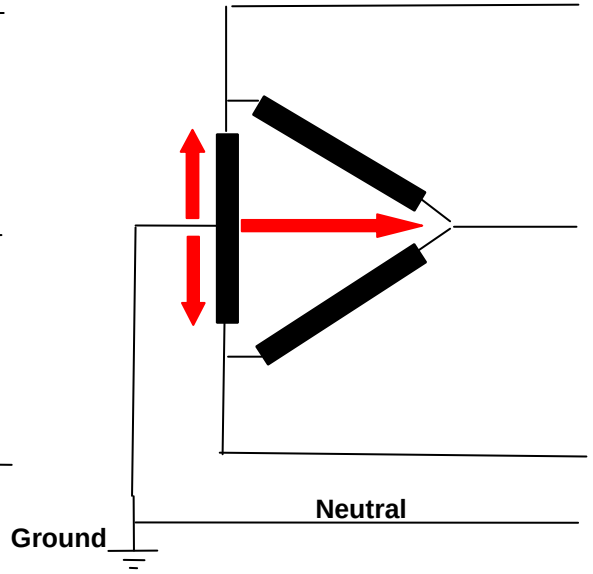


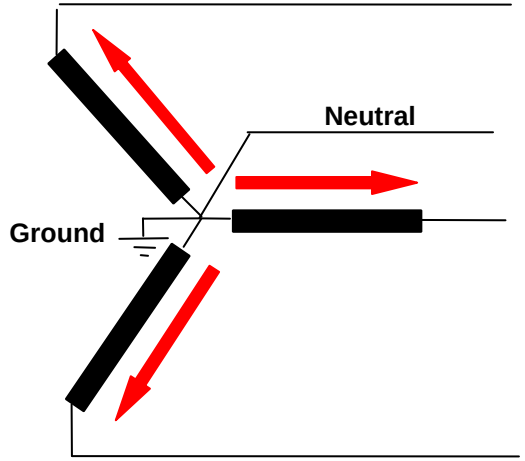

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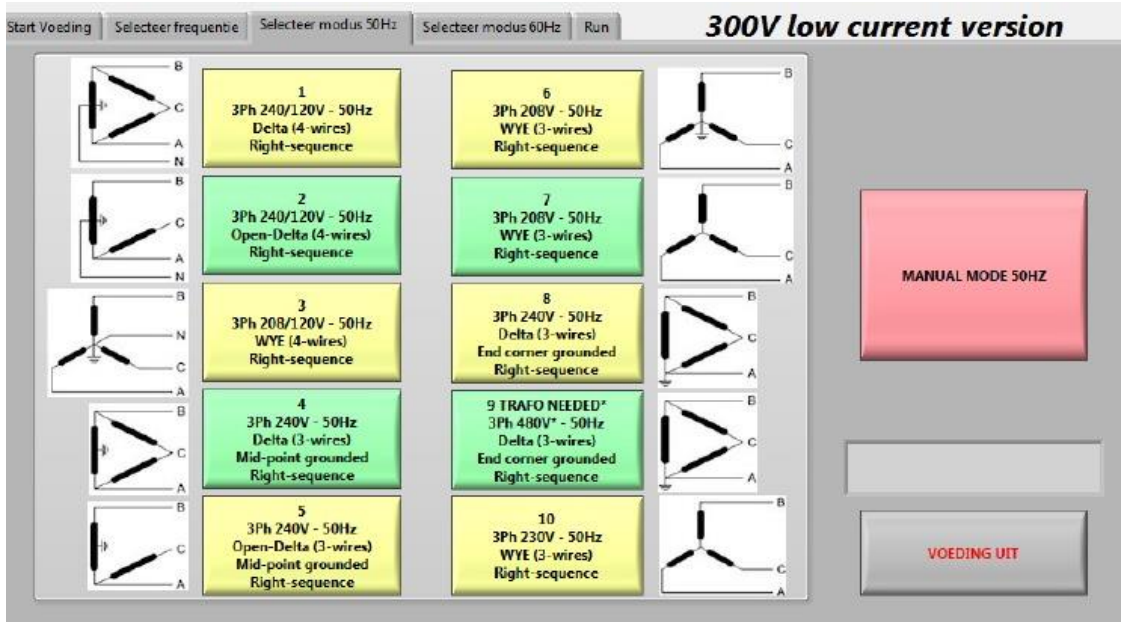
# Single-phase or three-phase AC power supply





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# Frequency range / resolution

Normally 50Hz or 60Hz

In the aircraft industry 400Hz or 800Hz to 1200Hz

In trains we sometimes see 16.66Hz.

Here too we have the NEN EN50160:2010 standard:

Frequency between 49.5Hz and 50.5Hz
In 2015 this was changed to 49.9Hz and 50.1Hz

The resolution and accuracy of the frequency setting of your AC power supply play a role in the testing

| *SPECIFICATIONS* | | |
|---|---|---|
| **Model** | **61601** | **61602** |
| **Output phase** | 1 | 1 |
| **Output Rating - AC** | | |
| Power/Phase | 500VA | 1000VA |
| **Voltage** | | |
| Range/Phase | 150V/300V/Auto | 150V/300V/Auto |
| Accuracy | 0.2%+0.2%F.S. | 0.2%+0.2%F.S. |
| Resolution | 0.1V | 0.1V |
| Distortion (*1) | 0.3% @ 50/60Hz<br>1% @ 15~1kHz | 0.3% @ 50/60Hz<br>1% @ 15~1kHz |
| Line Regulation | 0.1% | 0.1% |
| Load Regulation (*2) | 0.2% | 0.2% |
| **Max. Current/Phase** | | |
| r.m.s. | 4A/2A (150V/300V) | 8A/4A (150V/300V) |
| peak | 24A/12A (150V/300V) | 48A/24A (150V/300V) |
| **Frequency** | | |
| Range | DC, 15~1kHz | DC, 15~1kHz |
| Accuracy | 0.15% | 0.15% |
| Resolution | 0.01 Hz | 0.01 Hz |

# Maximum Current

| SPECIFICATIONS | | |
|---|---|---|
| Model | 61601 | 61602 |
| Output phase | 1 | 1 |
| Output Rating - AC | | |
| Power/Phase | 500VA | 1000VA |
| Voltage | | |
| Range/Phase | 150V/300V/Auto | 150V/300V/Auto |
| Accuracy | 0.2%+0.2%F.S. | 0.2%+0.2%F.S. |
| Resolution | 0.1V | 0.1V |
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| Frequency | | |
| Range | DC, 15~1kHz | DC, 15~1kHz |
| Accuracy | 0.15% | 0.15% |
| Resolution | 0.01 Hz | 0.01 Hz |

| Power Rating | | 500VA | 1000VA | 2000VA | 3000VA |
|---|---|---|---|---|---|
| Output Voltage | | 0 ~ 155Vrms, 0 ~ 310Vrms | | | |
| Output Frequency | | 45.00 ~ 500.0 Hz | | | |
| Max. Current(rms) *1 | 0 ~ 155 Vrms | 4.2A | 8.4A | 16.8A | 25.2A |
| | 0 ~ 310 Vrms | 2.1A | 4.2A | 8.4A | 12.6A |
| Max. Current (peak) | 0 ~ 155 Vrms | Peak value which is four times of the maximum current(rms) | | | |
| | 0 ~ 310 Vrms | | | | |
| OPT. APS-003(rms) | 0 ~ 600 Vrms | 1.05A | 2.1A | 4.2A | 6.3A |
| OPT. APS-003(peak) | 0 ~ 600 Vrms | Peak value which is four times of the maximum current | | | |

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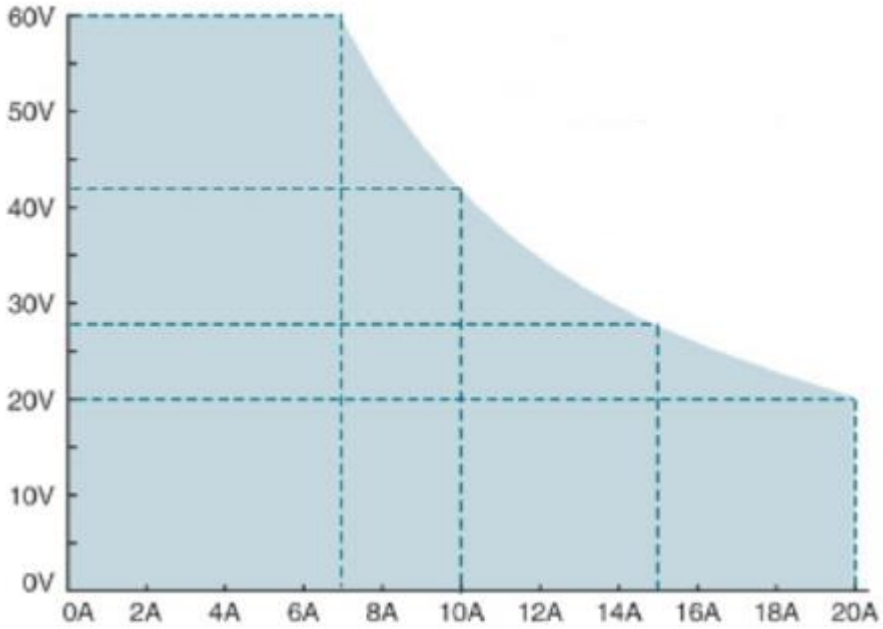
# Maximum Current

Maximum voltage 300Vrms
Maximum current 4.A
Maximum power 1000VA

300V x 4.A = 1200VA
1000 / 4 = 250V
So at a voltage higher than 250Vrms, full power can be delivered.

So at 230Vrms, you have a maximum power of 920VA
At 270Vrms you have a maximum power of 828VA

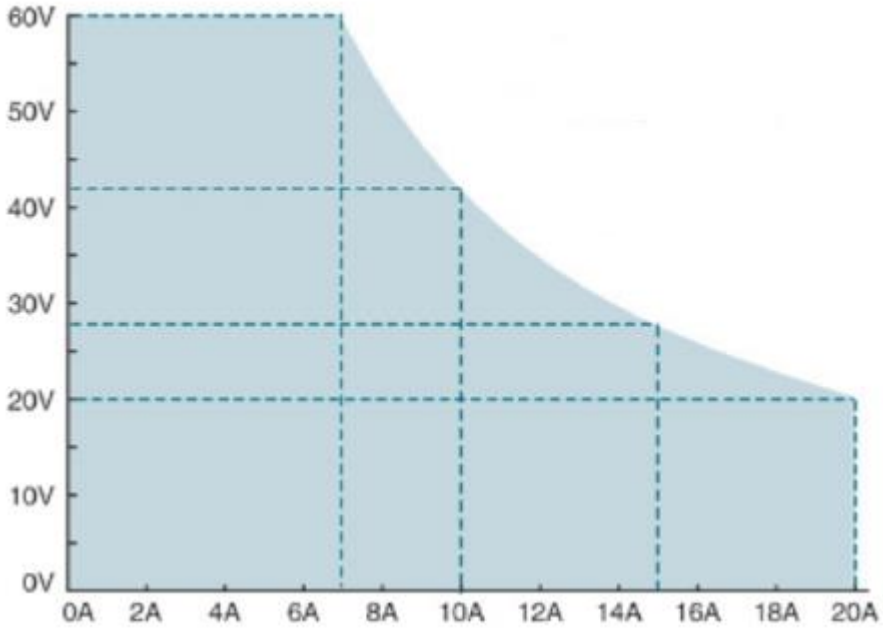


# Maximum Current

Maximum voltage 310Vrms
Maximum current 4.2A
Maximum power 1000VA

310V x 4.2A = 1302VA
1000 / 4.2 = 238,1V
So at a voltage higher than 238.1Vrms, full power can be delivered.

So at 185Vrms, you have a maximum power of 777VA (185V x 4.2A)



# Maximum Current

| Power Rating | | 500VA | 1000VA | 2000VA | 3000VA |
|---|---|---|---|---|---|
| Output Voltage | | 0 ~ 155Vrms, 0 ~ 310Vrms | | | |
| Output Frequency | | 45.00 ~ 500.0 Hz | | | |
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| | 0 ~ 310 Vrms | 2.1A | 4.2A | 8.4A | 12.6A |
| Max. Current (peak) | 0 ~ 155 Vrms | Peak value which is four times of the maximum current(rms) | | | |
| | 0 ~ 310 Vrms | | | | |
| OPT. APS-003(rms) | 0 ~ 600 Vrms | 1.05A | 2.1A | 4.2A | 6.3A |
| OPT. APS-003(peak) | 0 ~ 600 Vrms | Peak value which is four times of the maximum current | | | |

# Maximum Current

Maximum voltage 310Vrms
Peak current 4.2A x 4 = 16.8A
Maximum power 1000VA

So at 185Vrms we can still deliver 1000VA, right?

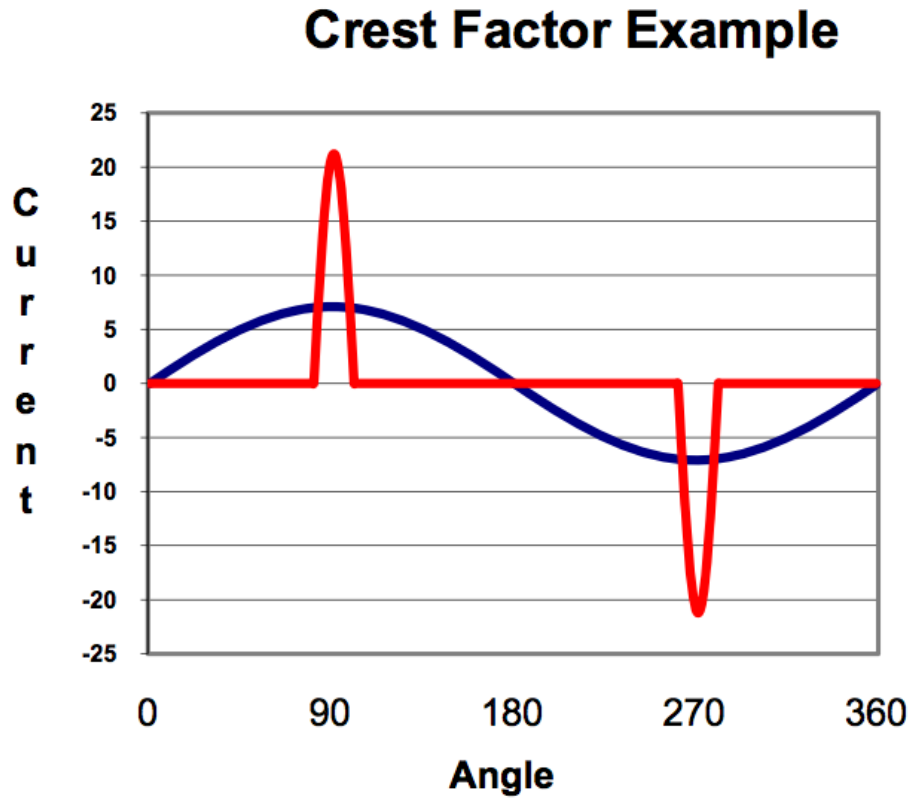
# Crest factor

The Crest factor of an AC current is the ratio of the peak value of the waveform to its rms value:

Crest factor = peak current / rms current

With a pure resistive load and a sinusoidal voltage, the current will also be sinusoidal.
The Crest factor is then 1.414 of the rms value.

In this case a rms value of 5A (blue line) or a peak current of 7.07A



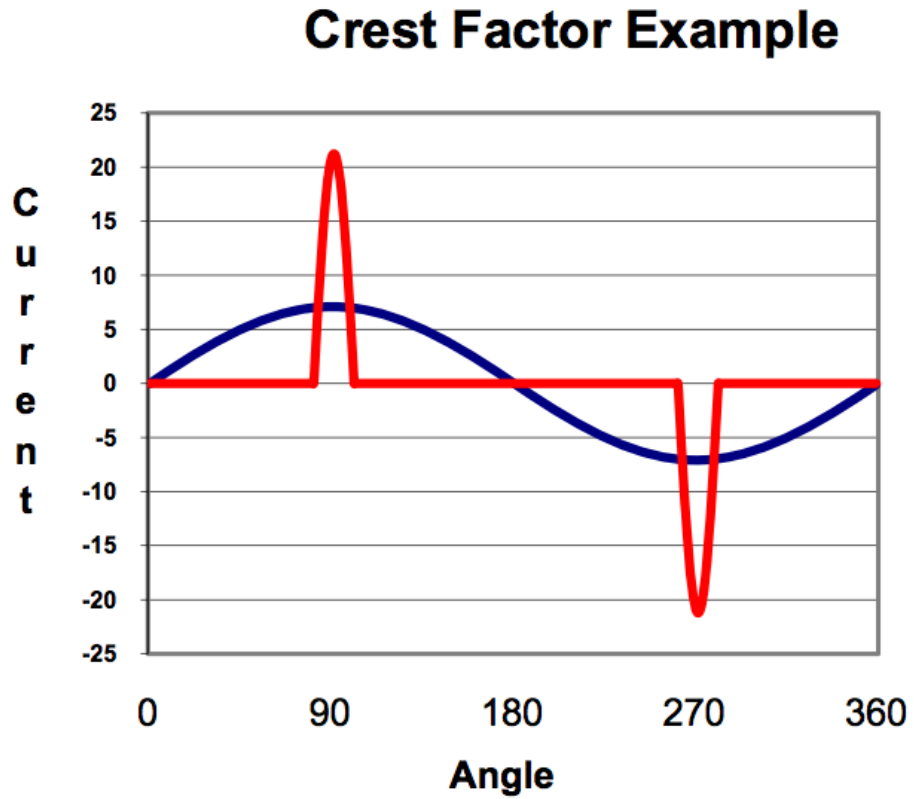
# Crest factor

However, there are also loads with a non-sinusoidal current.

Think of switching power supplies but also of specific lamps where the Crest factor can be particularly high.

In this case, the red line with a peak value of 21A (Crest factor of 3).

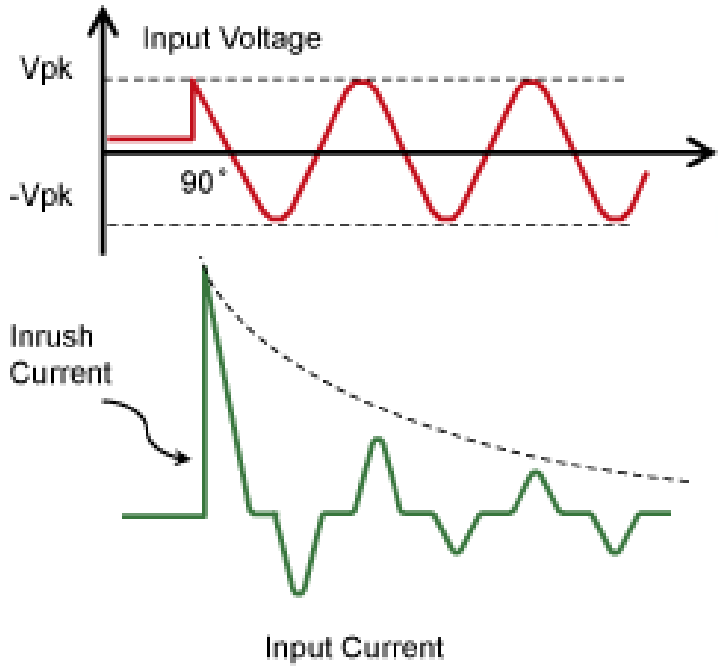
When selecting the right AC power supply, it is therefore very important to measure the peak current in your application.



# Inrush Current

The maximum inrush current is measured at the maximum voltage.

In many applications, it is a requirement to measure the maximum inrush current.



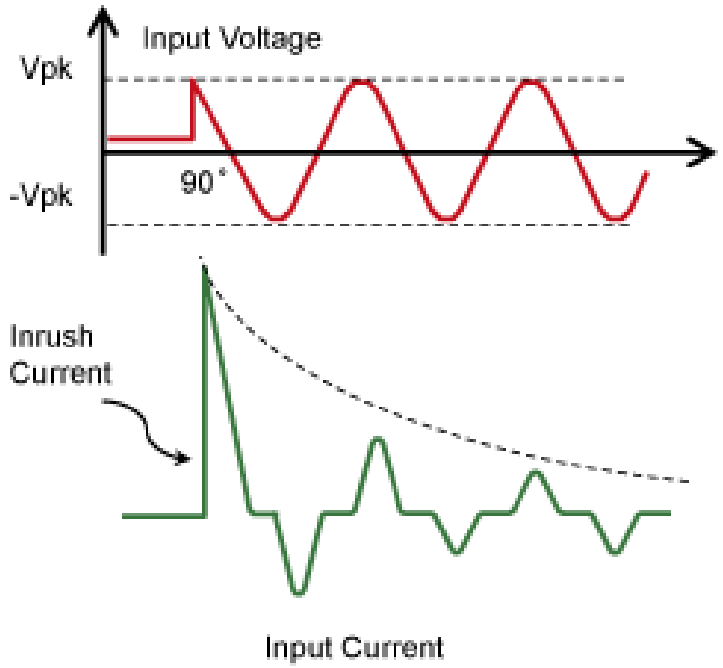
# Inrush Current

An inrush current that is too high regularly causes the AC power supply to go into protection (OCP) and the output to be switched off.

How can we prevent this?

Switching on the zero crossing.

Let the AC voltage increase slowly
(For example, within 10 seconds from 0 to 230Vac)

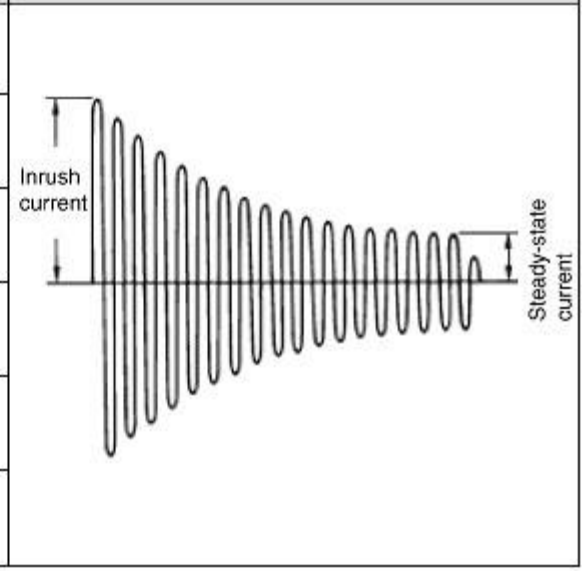


# Start-up Current

Depending on your application, you may also have to deal with a start-up current.

Here are some examples of applications with a high inrush current.

Depending on the technology used in the AC power supply.

| Load type | Inrush current/steady-state current | Waveform |
|---|---|---|
| Solenoid | Approx. 10 times |  |
| Incandescent bulb | Approx. 10 to 15 times | |
| Motor | Approx. 5 to 10 times | |
| Relay | Approx. 2 to 3 times | |
| Capacitor | Approx. 20 to 50 times | |
| Resistive load | 1 | |

# Start-up Current

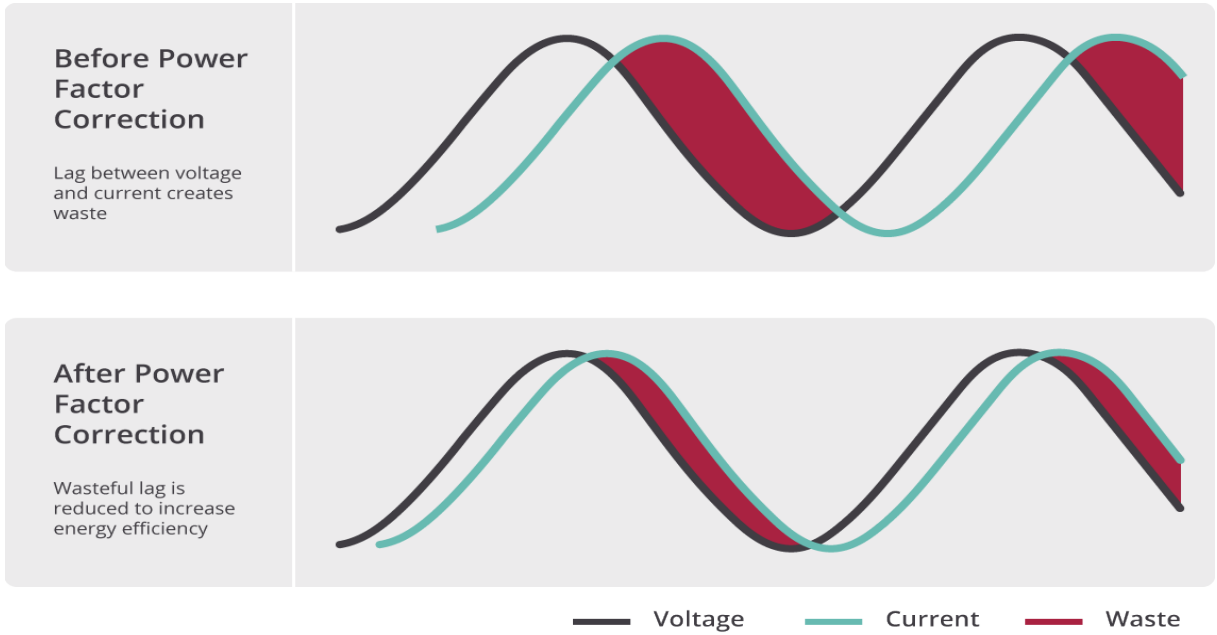
**Highlights**

- Output frequency 10Hz to 80Hz (DC option
- Output voltage from 0 VAC to 300 VAC
- Continuous power 1500 VA
- Power inrush 3000 VA (3 sec.)
- Accuracy <0,5%
- Stability <0,1%
- Distortion <0,3%
- Remote control
- Short circuit protection, overload, Undervoltage, overvoltage, overtemperature

# The power factor

In the case of a capacitive or inductive load, we are faced with a phase shift between voltage and current.

Compared to a resistive load, this also results in a blind power and current increase.

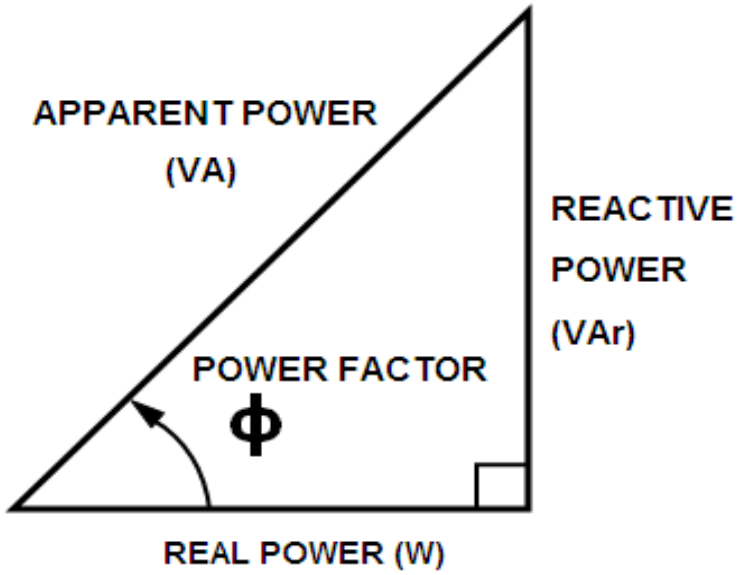


# The power factor

This is also the reason why the power of AC power supplies is indicated in VA and not in W.

Examples of devices with a low power factor are DC power supplies and LED drivers.

Depending on your DUT, you will need an AC power supply with a higher VA specification than your DUT.

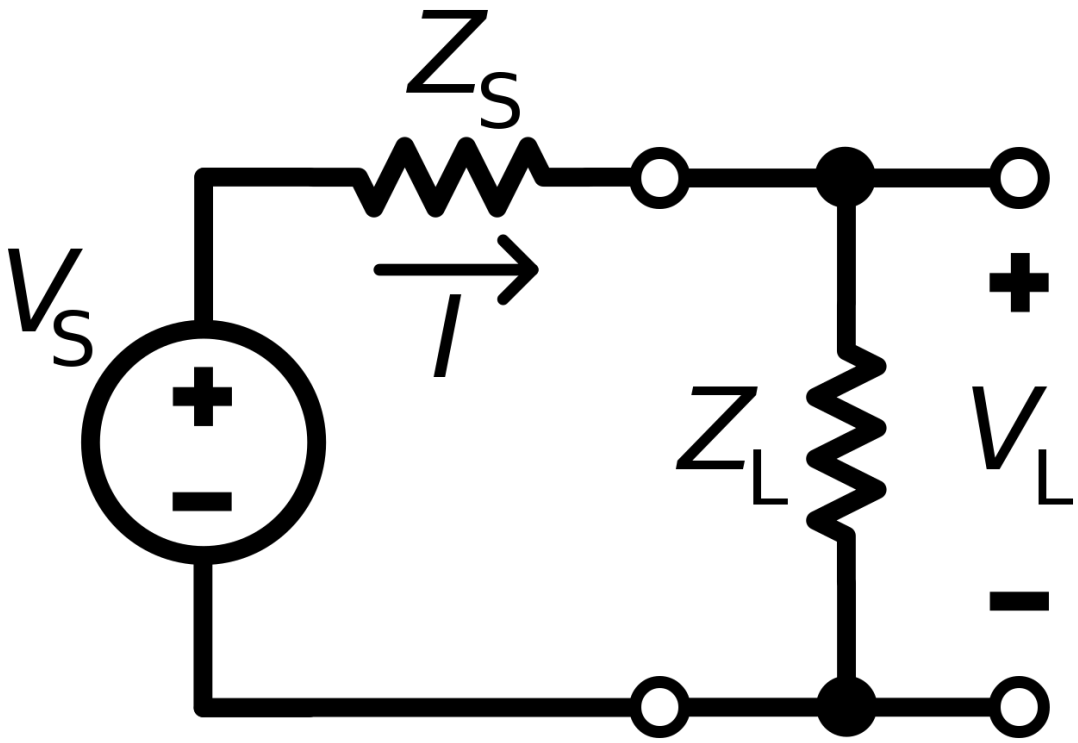


# Output impedance

For some applications, it is important that the AC power supply responds quickly and accurately to a change in load. You don't want a voltage drop on the output if the load suddenly increases.

AC sources with a fast response time generally have a low impedance.

AC sources with these characteristics are often called constant voltage sources because the output remains constant even when switching from zero load to full load. This is then comparable to what we call "a strong grid".

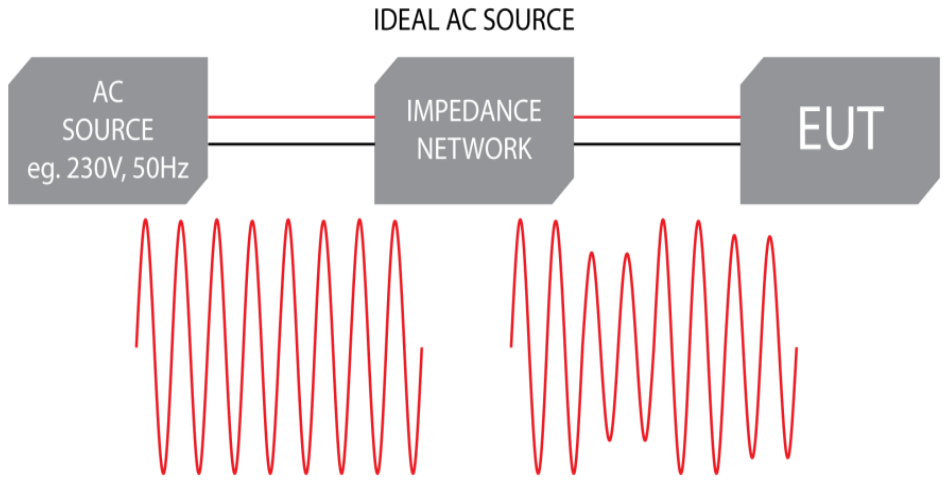


# Output impedance

The response time is also important if we are going to do tests according to certain standards.

For the IEC-61000-3-3 (flicker) standard test, it is important that the output impedance is adjustable.

For more detailed information about flicker measurements, I refer you to a white paper of Newtons 4th.



# Harmonic distortions

Our low-voltage grid must also comply with certain standards as regards harmonic distortions in accordance with NEN-EN 50160:2010.

In recent years there have been some changes to this regarding the percentages in relation to the ground wave.

According to the standard, we measure up to the 25$^{th}$ harmonic, but new standards are being developed.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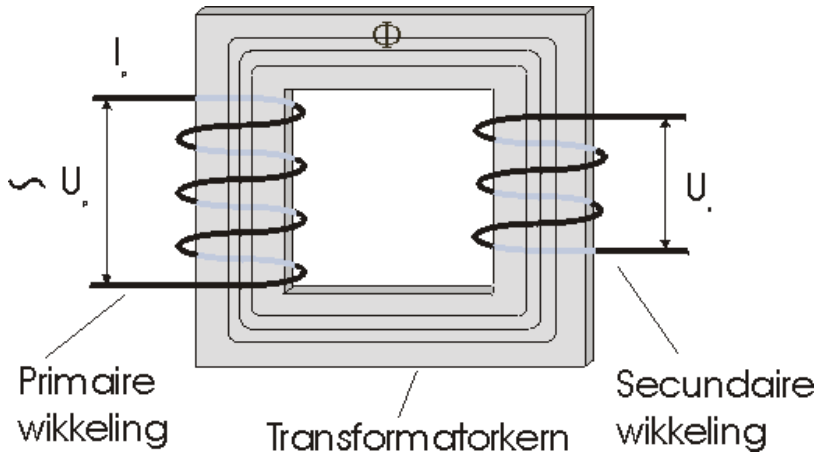
# Harmonic distortions

Does your DUT still work correctly when the AC-network has such harmonics?

Harmonic distortion often results in extra heat being generated in your DUT, which in turn affects its lifespan and efficiency.

Can your AC power supply generate the correct harmonics and inter-harmonics.

For more information on the consequences of harmonic distortion and mains pollution, I would like to refer to a presentation by René Bos.

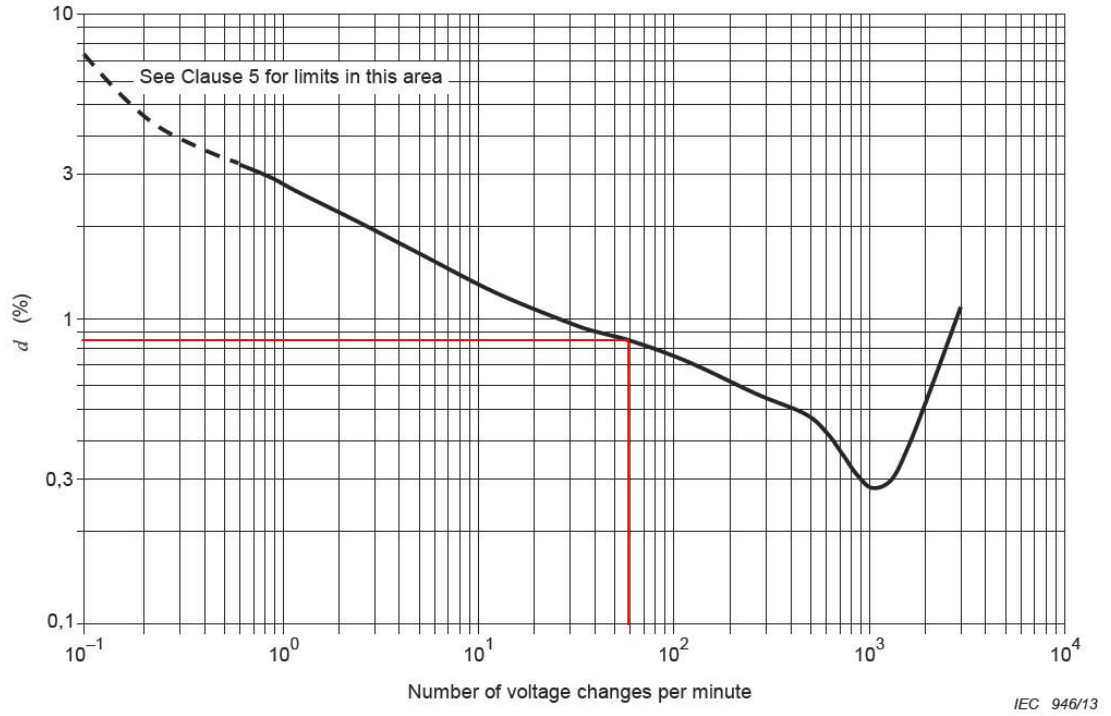


# Standards testing

We see a multitude of standards tests that require AC power supplies:

- IEC 61000-3-3
- IEC 61000-4-11, 13,14,28,29
- SemiF 47 tests
- IEC 1668
- ABD0100.x.x
- Mil-Std xxx
- DO-160D
- ????

If your standard test has already been implemented by the power supply manufacturer, it will save you a lot of time.

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# Automation requirements

AC power supplies have or can optionally be equipped with a wide range of communication ports. The most common are RS-232, USB, GPIB, CAN and LAN for integrating the power supply into a test system.

For some applications an analogue interface is also important.

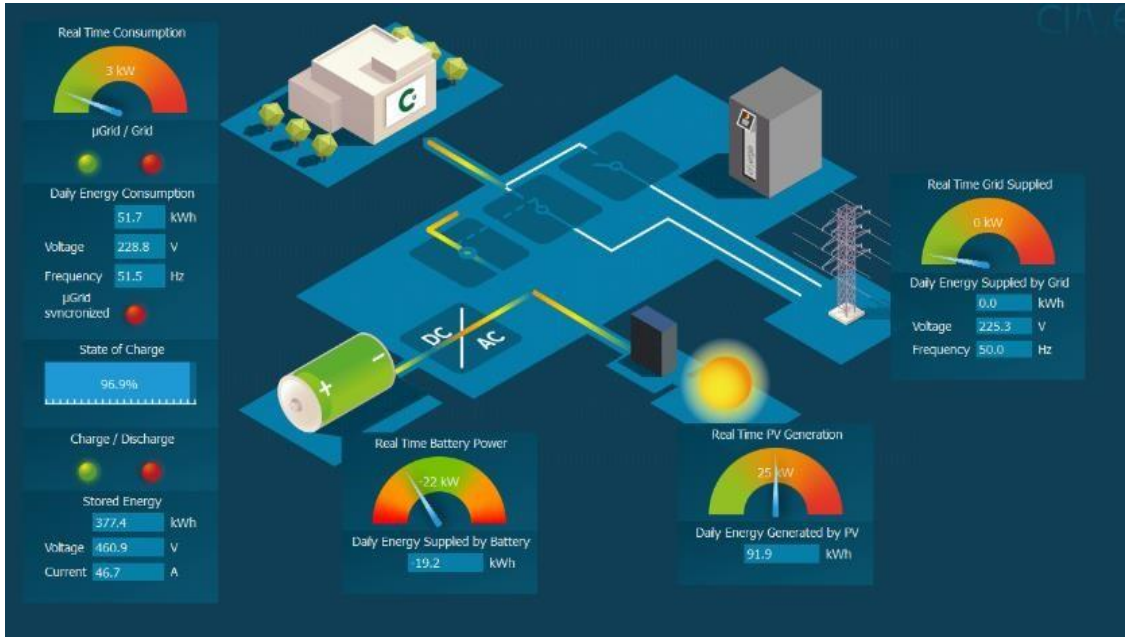
And are the right software drivers available to integrate your AC power supply into your specific software?

# Software

Such software is also indispensable for the demanding user.

User-friendly software to operate the power supply, create waveforms, take measurements and store them.

The better manufacturers also develop software for specific applications, such as standardisation tests or real-time monitoring of complex test set-ups.

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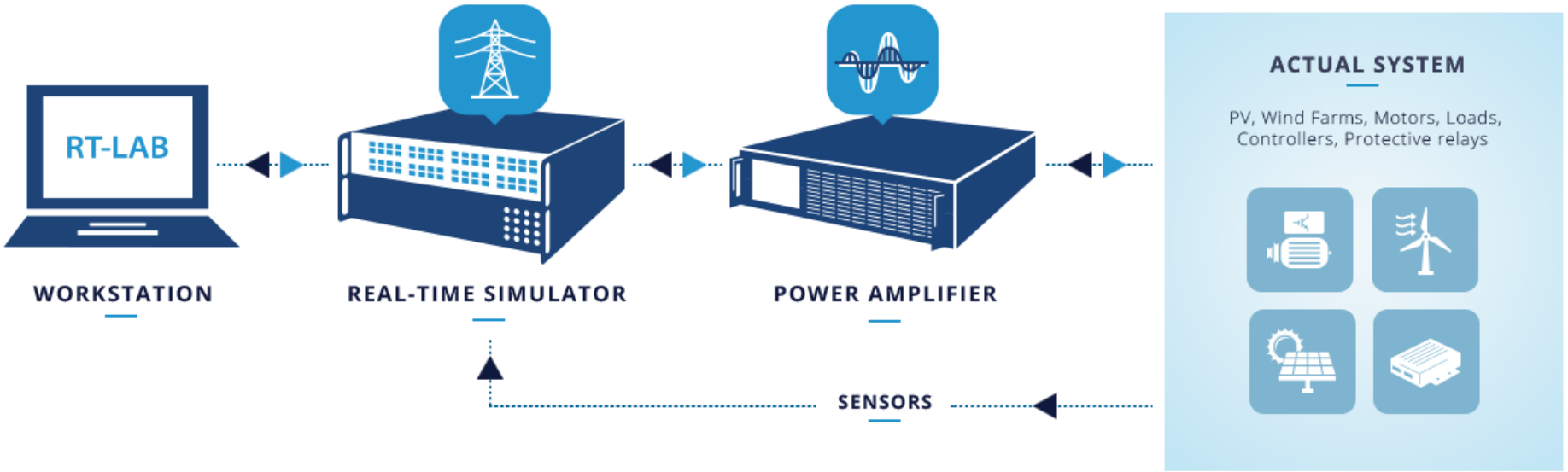
# Other requirements

Would you like to use the AC power supply as an AC amplifier, for example?



# Other requirements

In some applications it is a requirement that a DC offset can be given to the AC signal.

If you have to comply with this requirement, it becomes a lot harder to find a suitable AC power supply.

# Other requirements

Are there also requirements in your application regarding the accuracy of the measurements in the AC power supply?

Some AC power supplies have a comprehensive power analyzer integrated into the unit. Including inrush current measurement, W, VA, VAR, PF, THD etc.

But are the specifications of these measurements sufficient for your application?

# Conclusion

The selection of the right AC power supply for your application involves a large number of specifications.

The behavior of the load to be connected also plays a major role.

Prepare yourself well when making such a purchase.

Get advice from the specialists in this field.

For an extensive overview of our AC power supplies, please visit our website.

# Conclusion

Get advice from the specialists in this field.
We will gladly help you select an AC power supply for your application.

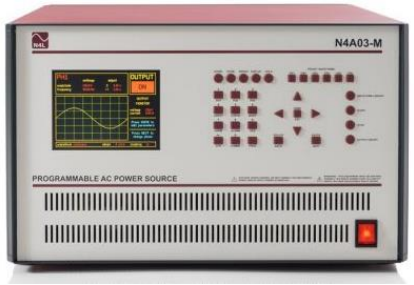












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# Do you have any questions?

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