

Operating manual



Motor driven AC source

| | |
|----------------------|---------------|
| variatic-NX 1-260-16 | 0 - 260V 16 A |
| variatic-NX 1-260-32 | 0 - 260V 32 A |
| variatic-NX 1-280-16 | 0 - 280V 16 A |

The motorized AC variacs of the series NX are suitable for voltage dips and voltage variation test.

The the internal voltage control compensates automatically voltage variations on the mains supply for the tapped output voltage.

EN/IEC 61000-4-11
EN 61000-6-1
EN 61000-6-2



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Specifications subject to change

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1. Standards for testing with variac-NX series

The AC motorized transformers of the series variac-NX are used for the following standard tests:

| | |
|-------------------------|--|
| - IEC 61000-4-11 | Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests |
| - IEC 61000-4-8 | Testing and measurement techniques – Testing and measurement techniques – Power magnetic field immunity test |

1.1. Models and options

All models are designed for 50 / 60 Hz application. This manual is written for the following devices and options:

1 phase equipments:

| | | |
|--------------------|---------------------------|---------------------|
| variac-NX 1-260-16 | 1- phase Motorized Variac | 0 – 260 V / 16 A ac |
| variac-NX 1-260-32 | 1- phase Motorized Variac | 0 – 260 V / 32 A ac |
| variac-NX 1-280-16 | 1- phase Motorized Variac | 0 – 280 V / 16 A ac |

Special models



The manual takes as reference the variac NX 1-260-16 model.

In general, the statements are also valid for the other models with 280 V output voltage and 32 A. The manual does not list all model versions in the text and the user has to respect the different parameters.

2. Operating Functions

2.1. Operating elements on front and rear side variac-NX 1-260-16



Figure 2.1: Rear side variac NX 1-260-16

| | | | | | |
|---|-------------------------|---|---------------------------|----|--------------------|
| 1 | output PF1 | 5 | fuse for F1 for PF1 | 9 | main fuse F3 |
| 2 | output PF2 | 6 | fuse for F2 for PF2 | 10 | main fuse F4 |
| 3 | output neutral | 7 | control voltage 0-10 V dc | 11 | power supply input |
| 4 | output protective earth | 8 | power supply switch | | |

1 Output PF1

Output voltage for channel PF1 at the generator side (e.g. UCS 500M). The voltage is 100% of the input voltage for the variac (at port 11). This voltage is normally the rated voltage of the EUT.

2 Output PF2

Output voltage for channel PF2 at the generator side. The voltage is adjustable in the range of 0-260V in case of a 230V input voltage and 0 - 130V in case of a 115V input voltage (at port 11). This output is normally used for voltage variations and to generate the 40% and 70% test levels for voltage dips testing.

3 Output neutral

This is the common neutral output for both channels PF1 and PF2.

4 Output protective earth

This is the common protective earth output for both channels PF1 and PF2.
Fix connected power supply cable.

5 Fuse for PF1

The output PF1 is fused by 20AT.

6 Fuse for PF2

The output PF2 is fused by 16AT.

7 Control voltage 0-10V

To control the output voltage of the motor variac this input shall be connected to the 0 - 10V control output of the generators. The voltage settings than can be selected via the frontpanel keyboard of the simulator.

8 Power supply switch

Main power switch ON/OFF.

9 Main fuse F3

Mains input fuse 20A Line..

10 Main fuse F4

Mains input fuse 20AT Neutral.

11 Input connector

CEE Input connector for 1-phase.

3. Putting into Operation

Prior to unpack completely the equipment check if the packing materials do show visible damages. In this case do not remove the equipment from packing.

3.1. Inspection

Check if the equipment shows visible transportation damages.

3.2. Supply voltage

Prior to turning on the equipment check if the selected supply voltage corresponds with the actual power supply mains in your laboratory. Damages which may arise from wrong supply voltage are not covered by warrantee.

3.3. Main socket and plug

Main socket, power-on switch and fuses are located at the rear part of the equipment.

3.4. Safety aspects

This description contains the necessary information for the correct application of the product described below. It is intended for use by technically qualified personal only. Please read carefully the the Safety manual

Qualified personnel are persons who, because of their training, experience and position as well as their knowledge of appropriate standards, regulations, health and safety requirements and working conditions, are authorised to be responsible for the safety of the equipment, at all times, while carrying out their normal duties and are therefore aware of, and can report, possible hazards (Definition of qualified employees according to IEC 364).

Safety instructions

The following instructions are provided for the personal safety of operators and also for the protection of the described product and connected equipment.



Warning !

Hazardous Voltage. Missing attention can lead to death, cause serious injury or damage.

- **Disconnect from power mains supply before installation or dismantling work, as well as for fuse changes or post installation modifications.**
- **Observe the prescribed accident prevention and safety rules for the specific application.**
- **Before putting into operation check if the rated voltage for the unit conforms with the local supply voltage.**
- **Emergency stop devices must be provided for all applications. Operation of the emergency stop must inhibit any further uncontrolled operation.**
- **The electric connections must be covered!**
- **Earth connection must be checked for safe function after assembly!**

Use According to Designation

The units described herein are electrical equipment for the use in industrial plants. They are **not** determined for private households.

Units with open electric connections are determined for installation only.

3.5. Switch on condition

After switching ON the equipment is set into the following condition:

- Output voltage is returning to zero position if no BNC signal is available
- Remote voltage depends to the voltage at the control input 0-10V DC.

3.6. Remote control voltage

The output voltage level is controlled by an external DC-voltage signal (0-10V DC). The output voltage is directly proportional to the input signal. The input voltage signal is connected at the BNC-plug available at the rear panel of the equipment.

| DC voltage | Position | Output voltage AC |
|------------|----------|--|
| 0V dc | minimum | 0V |
| 10V dc | maximum | Maximum output voltage approx. 254V for variac NX 1-260-x models |

3.7. Variatic-NX 1-260-xx configuration in the generator setup menu

The setup procedure is described in the generator setup menu and the setup procedure for set voltage. The generator menu offers two separate voltage settings for low and high mains voltage, e.g for labs with equipment for 115 V and 230 V.

Setup Menu: Set voltage low/high UCS 500 Firmware V 6.01ax (UCS 500N5) V9.04ax (N7x) or higher
 This menu offers **two separate voltage settings** for user that needs to test equipment for 115 V and 230V mains supply. Thanks to the two settings, the user can keep the Motorvariatic in the 230V position

Using a VARIAC-NX 1-260-16 with voltage selector switch:

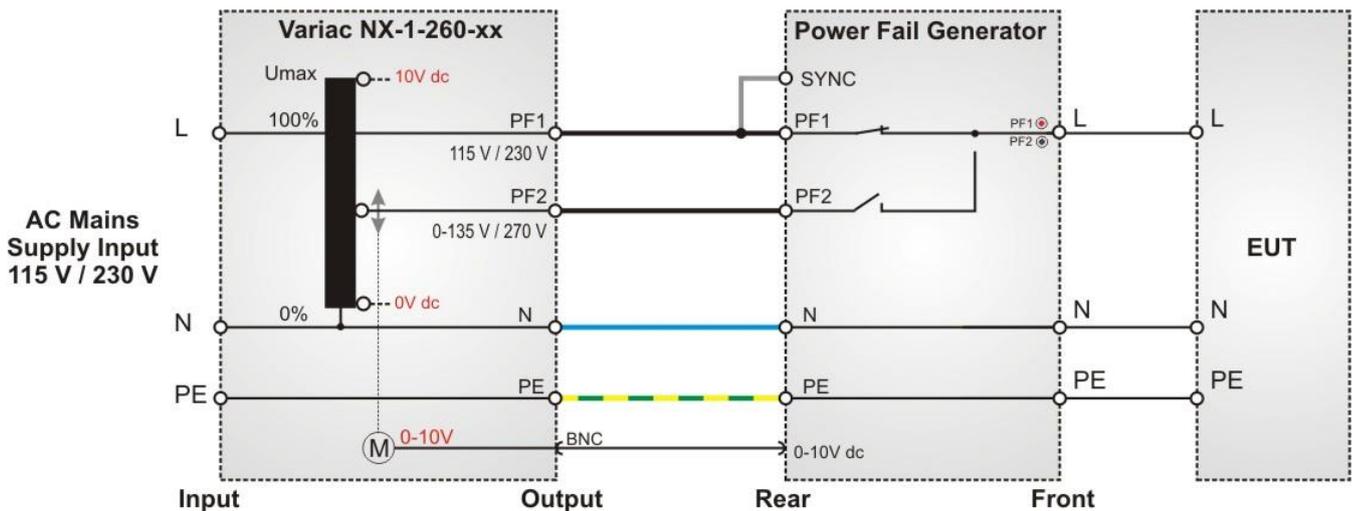
- Set the voltage selector to the 230V position for low and high mains voltage supply.
- Use the Firmware with low and high settings and use the VARIAC-NX 1-260-16 for any supply in the 230 V position.

3.8. Output plugs

The AC source has two different power supply outputs at the rear panel of the equipment.

- PF1:** 100% output = nominal AC input voltage
- PF2:** Variable output voltage depends to the variatic position

The output is realised with the three safety laboratory leads (black, yellow-green, black). The PF1 output is connected to the PF1 input of the generator and the PF2 output is connected to the PF2 input of the generator, e.g. the compact NX5.



4. Variac

4.1. General

The equipment consists of a single-phase variable transformer with motor drive.

A main switch is provided at the input; glass tube fuses are mounted in the output for protection of the unit.

The regulation is realised by using a pulse duty regulator (TVR 6500). The regulator is fed over the control transformer (BV 16-149 with tapping at 115V).

All connections of the AC-DC-Supply unit are led on connectors or sockets.

The mains power supply is effected through an approx. 2 m long flexible lead with a shock-proof plug. The outputs are wired on safety laboratory sockets.

The equipment is protected against short-circuit by fuses.

4.2. Function description

After installation of the connections the single-phase variable toroidal transformer can be put into operation.

The supply voltage for the regulator is adapted to the mains voltage fed by using the change-over switch S2. Before switching on the main switch S1 it must be assured that the supply voltage at the regulator corresponds to the prescribed value of 32 V-36 V.

If the supply voltage for the regulator is too low or too high, either the function of the regulator is not assured, or the regulator may be destroyed by over voltage.

The output voltage of 0...260V is adjusted with a set point of 0...10V, DC over a BNC-socket.

4.3. Overload



NOTE The variac NX is designed for high overload during short time as per the overload curve below. For magnetic field test up to 1000 A/m the current transformer requires a primary current up to 39 A during 3 seconds. Therefore, it is required to use fuses with slow blow characteristics, that are capable to support the required current.

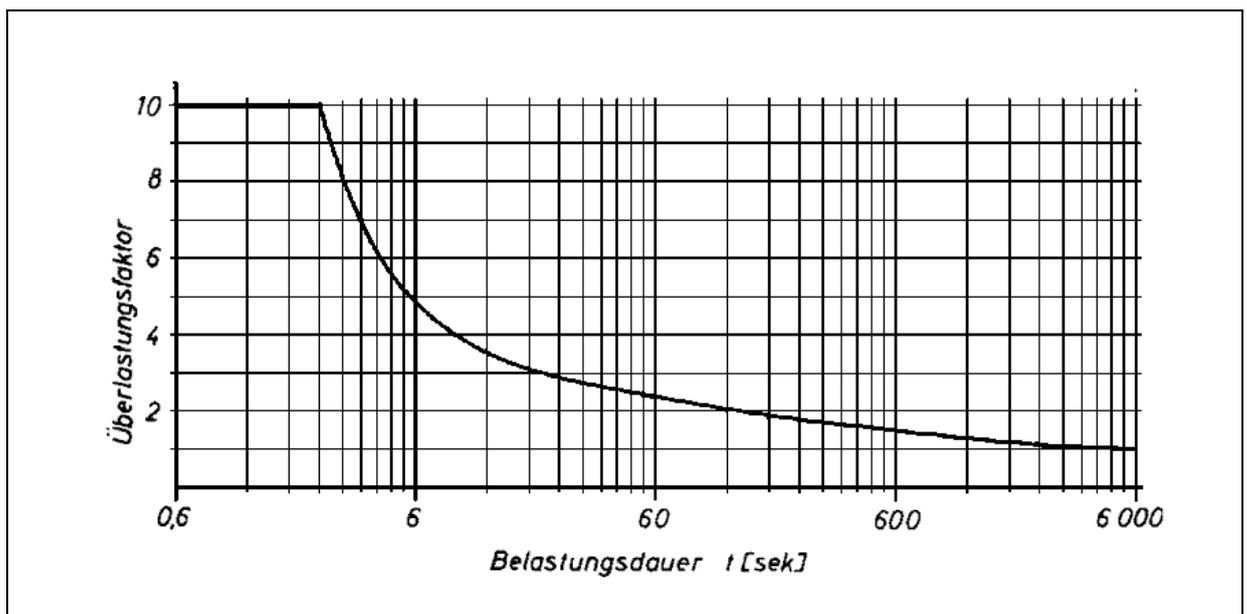


Figure 4.1: Overload curve of Variac NX 1-xx series

5. Controller type TVR 6500

5.1. General

Control Unit for Motorised Variable Transformers

Variable power supplies within the mains voltage and high power range, in the most of the cases, are realised with variable transformers. In general, it is not sufficient to just adjust the voltage or resp. the power, but it is often necessary to keep the adjusted value constant. For this purpose, the variable transformer is driven by a motor which is controlled by a suitable electronic regulator. The unit described below, is such an electronic regulator for controlling a DC motor with a permanently excited field.

The regulator essentially comprises the following main components:

A power supply, within a voltage range of 80 to 265 VAC, provides the internally required operating voltages and the operating voltage for the servo motor.

The regulator circuit compares the selected set point voltage with the fed back actual voltage, and in case of deviation, produces an error signal, corresponding in amplitude and polarity, which is transmitted to the motor drive circuit.

The actual value input is followed by a precision rectifier which generates the required signal voltage for the regulation circuit from the connected actual value voltage (DC/AC).

The motor drive circuit, in case of deviation between set point and actual value, receives an error signal from the regulator circuit. This signal is converted into a variable pulse-duty factor. The pulse-duty factor determines the adjusting speed of the motor and the direction of rotation of the motor. The input signals of the end limit switches are logically connected to the direction of rotation signals and thus limit the adjustment range of the drive gear.

5.2. Function description TVR 6500

Set point inputs:

The set point can be derived in various ways. Basically the set point is a 0...10 V, DC voltage signal. It can either use a 0...10 V control direct or a control potentiometer fed from the internal 10 V reference voltage source. An input for a 0...20 mA, DC control current is likewise available.



By using the additional switching function (set point 1 and set point 2), two different set points can be operated eg. hand adjusted potentiometer for set point 1 and an external control voltage from a supervisory control system for set point 2. By switching the input, set points 1 and 2 can be changed from one to the other.

If the set point is to remain fixed (voltage stabiliser system), then the internal trimmer can be used by inserting a jumper link.

Feedback Input:

Depending upon the output rating of the complete system which is to be controlled, the feedback signal can be derived in various ways. The standard unit has three possible feedback ranges:

- 0...10 V, DC - corresponding to 0...100%
- 0...7 V (Effective) AC - 0...100%
- 0...500 V (Effective) using an internal voltage conversion transformers

Should there be other feedback voltage values, there is a bank of switches available for feedback selection. An externally adjusted trimmer "ISTWERT" provides fine control of the system.

5.3. General functions of TVR 6500

Switching AUTO/HAND:

The normal operation of the unit is for the automatic regulation against a selected set point. However, by using the switch AUTO/HAND the adjustment drive control method can be changed so that the drive system (e.g. transformer) can be controlled by push buttons for testing. The selected set point becomes ineffective. Also the regulation operation is now no longer present.

Control Adjustment:

By the comparison of the set point voltage and the feedback voltage, the required correction signal is derived in the PI-terms. The P-portion of the regulator is adjustable externally to alter the regulator characteristics of the system (amplitude of the drive).

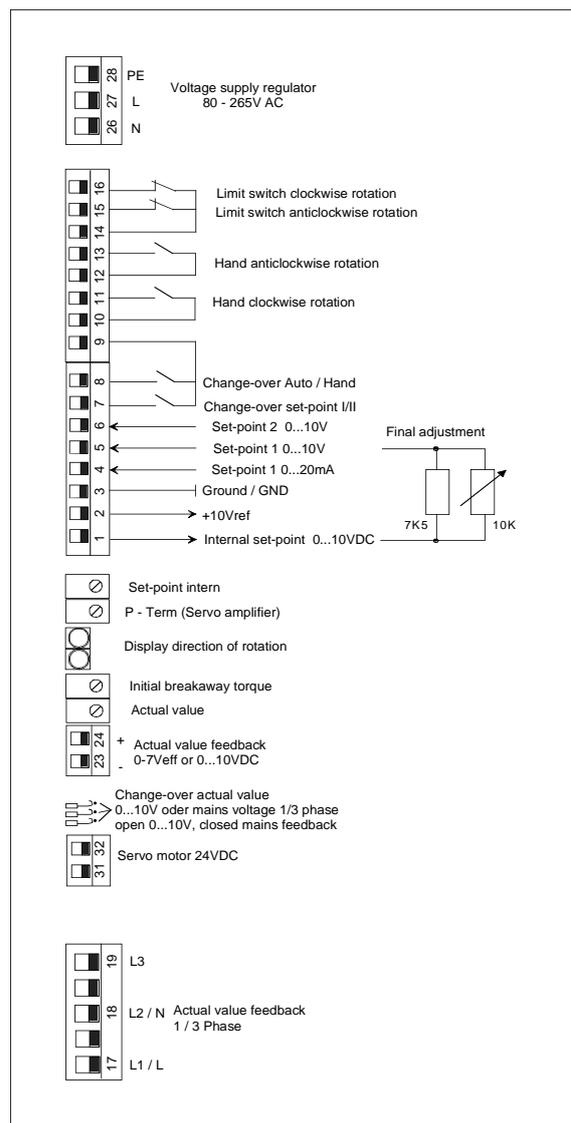
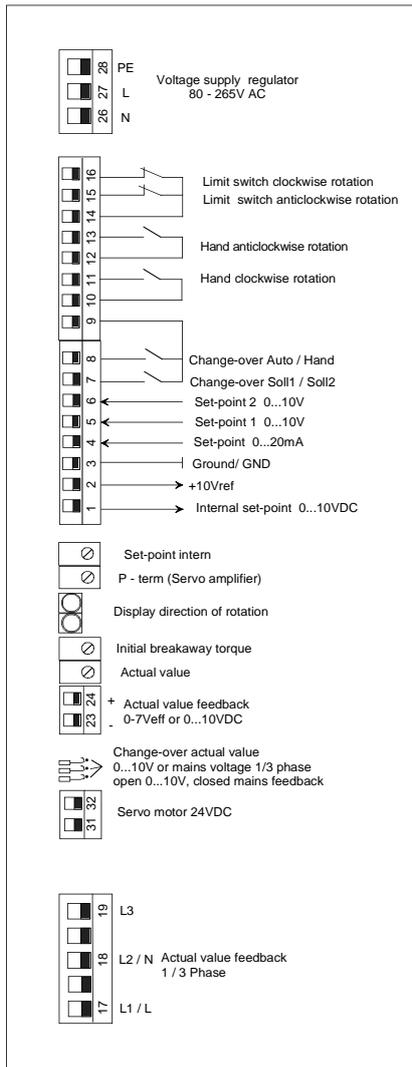
Control Signal for the Motor:

The correction signal of the regulator is connected to a saw tooth generator, which produces a pulse width modulated correction signal. This means that a small variation will generate short pulses, where as a greater variation will produce longer pulses. The correction signal is logically connected to the limit switches and also to a motor bridge drive. The motor is connected to the output of the bridge drive.

Features:

| | |
|---|---|
| Set point | 0...10 V/0...20 mA |
| Switching for two set points | (closed = 2. set point) |
| Switching for testing (without regulation) | (closed = manual operation) |
| Internal 10 V - reference voltage | |
| Internal set point setting option | |
| Measured voltage input | 0...10 V, DC |
| Measured voltage input | 0...10 V SS AC / 0...7V _{eff} AC |
| Internal voltage measurement transformers | (up to 500V) |
| Inputs for limit switches (inhibit) | (Inhibit) |
| Proportional speed control correction | |
| Adjustable motor response | |
| Adjustable regulation characteristic (P-term) | |
| Dead time | ca. 200ms |
| Built into a | snap-on module for DIN rail mounting |
| Motor voltage | 24 V, DC - 1 A max. |
| Supply voltage | 80V-265 V AC |

5.4. Wiring diagram TVR 6500



6. Maintenance of Air cooled variable Transformers

To ensure a trouble free operation of the variable transformer, after running time of approximately 4000 hours, or 1 year after installation, and at the latest after further approximately 8000 operating hours (2 years), the following maintenance procedure is recommended

1. The carbon rollers/brushes must be checked for free movement and spring tension. Contact pressures between the roller brush and contact track is most important
2. Sized worn or flat sided carbon rollers and brushes must be replaced immediately, otherwise the winding, brush-holder or contact surface are likely to be damaged.
3. The contact surface should then be cleaned with a stiff brush, to remove adhered dirt. Alternatively the contact surface can be cleaned with a contact cleaner lubricant, which must be completely removed following cleaning.
4. Brush guides and contacts must be examined for abrasion. Badly worn parts should be replaced
5. Transformers with spindle drives should be greased on bearings and shafts. The bearing block should be lubricated. Also the contact should be treated with a contact spray.

For more demanding duty, as per 0552 G Standard, the operating time should be reduced to approximately 1500 – 2000 hours and the further routine maintenance is recommended at approximately 4000 operating hours.

7. Application and setup

7.1. Application for IEC 61000-4-11

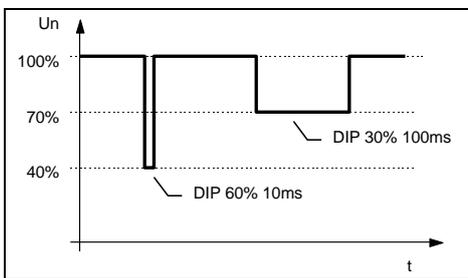
The motorized transformer variac-NX 1-260-16 can be used with the equipment listed below:

- compact NX5 series
- PFS 500N series
- PFS 503N series for 1-phase application
- UCS 500N series

The motor variac can be used to simulate power supply failures as undervoltages, voltage interruptions and voltage variations. The Basic Standard IEC 61000-4-11 and the Generic Standard EN 61000-6-1 / 2 are specifying these phenomenas.

Voltage interruptions (DIPS)

Voltage interruptions will cause a reduction of the power supply voltage for a certain period of time. see figure. 10.1. Three different test levels are required:



Reduction by:

- 100% = reduction to 0% of the nominal voltage
- 60% = reduction to 40% of the nominal voltage
- 30% = reduction to 70% of the nominal voltage
- 20% = reduction to 80% of the nominal voltage

Figure 7.1: Voltage dips

Voltage variation

Additionally, it is possible to drive certain functions of variation, which also are required in older versions of the standard IEC 61000-4-11. These functions can easily be programmed within the simulators itself or within the related windows software.

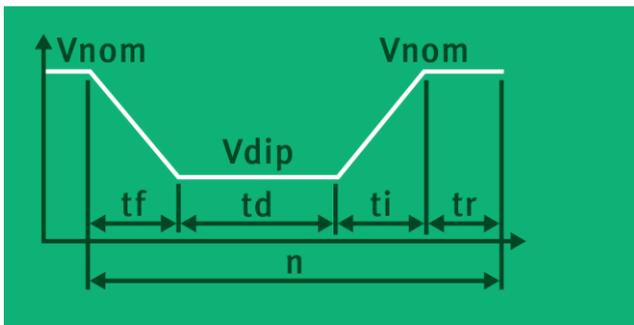
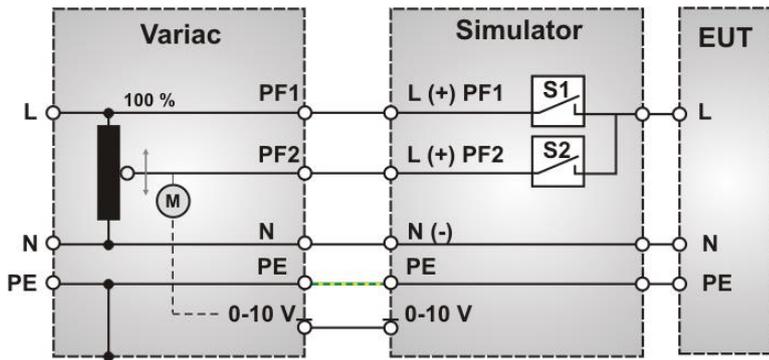


Figure 7. 2: Voltage variations

7.1.1. Test setup for dips and interruption

The transformer will be connected as in figure 7.3:



The motor variac must be connected to the rear panel of the UCS 500. For connection safety laboratory leads, shall be used. The control a BNC cable shall be used.

Figure 17.3: Connection diagram variac NX 1-260-16 and compact NX generator.

7.1.2. Test setup for dips and interruption

For detailed infos refer to the manual for magnetic field testing

Test setup for 1 A/m to 30 A/m

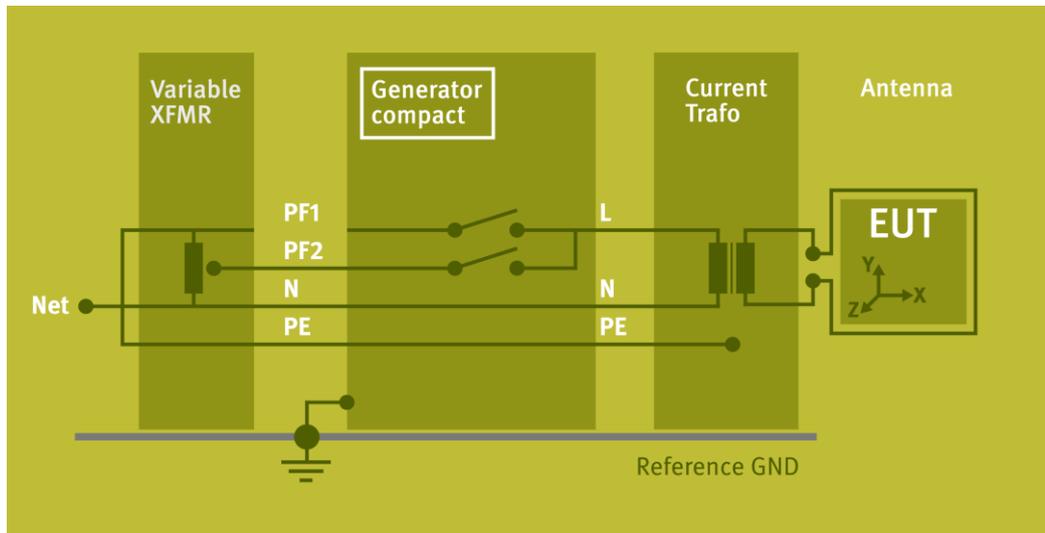


Figure 7.3

Test setup for 100 A/m to 1000 A/m

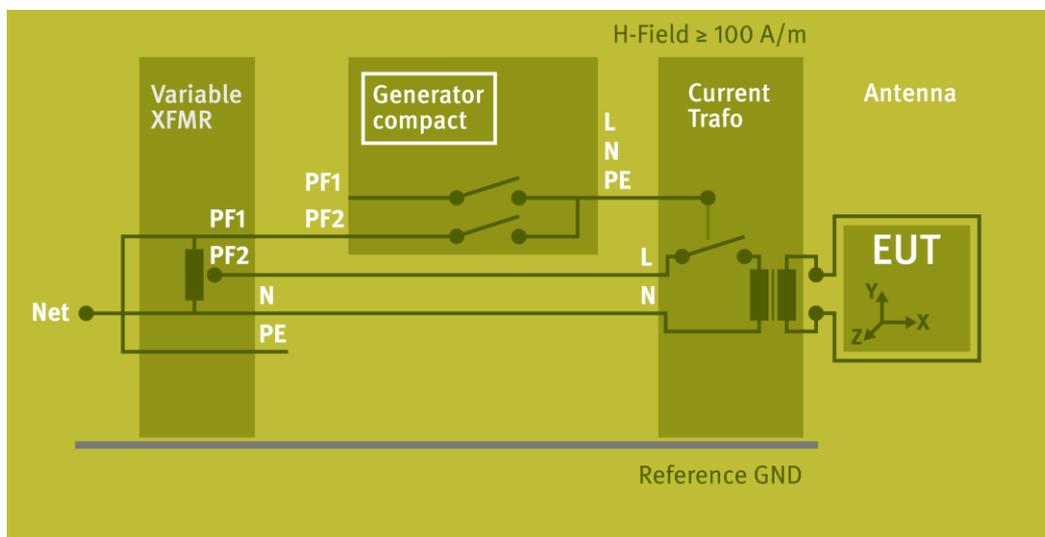


Figure 7.4

8. Technical data

8.1. Technical data variac-NX 1-2xx-yy family

Input:

Voltage U_{in}: nominal 230 V, max. 250V
 Frequency : 50/60Hz

| | variac-NX 1-260-16 | variac-NX 1-260-32 | variac-NX 1-280-16 |
|-------------------------------|--------------------|--------------------|--------------------|
| Output: | | | |
| Output voltage output PF1 | 230 V | 230 V | 230 V |
| Output voltage output PF2 | 0 – 260 V approx.. | 0 – 260 V approx.. | 0 – 280 V |
| Current I max : | 16 A | 32 A | 16 A |
| Power | 0 - 4.1 kVA | 0 - 8.2 kVA | 0 - 4.48 kVA |
| Dimensions and weight: | | | |
| Dimensions | 19" 6 units | Special cabinet | 19" 6 units |
| (HxWxD) | 266x485x400 [mm] | 680x600x410 [mm] | 266x485x400 [mm] |
| Weight | app. 34.6 kg | app. 65 kg | app. 34.6 kg |
| Power supply | 85 V – 256 VAC | 85 V – 256 VAC | 85 V – 256 VAC |
| Environment Tmax | 40°C | 40°C | 40°C |

Control:

Main switch On/Off for the output voltages
 Control voltage 0 – 10 V DC for 0-260 V, 0-280 V
 Time 0...100% < 2 s
 Protection IP 20

8.2. Environmental conditions

Temperature 10 °C to 35 °C
 Humidity 30 % to 70 %; non condensing
 Atmospheric pressure 86 kPa (860 mbar) to 106 kPa (1 060 mbar)

=> All parameters that are not relevant for the standard can be changed by manufacturer <=

Overload

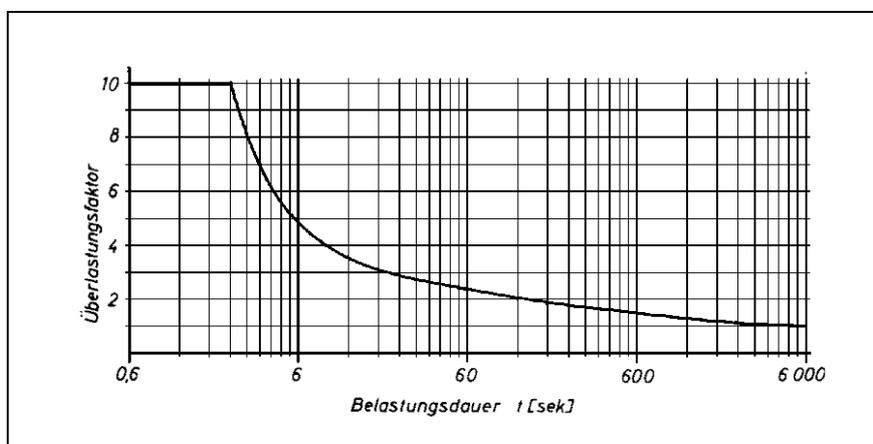


Figure 8.1.4 Load diagram variac NX transformer

9. Model design

9.1. variac-NX 1-260-16 and variac NX 1-280-16

The equipment consists of a single toroid transformer with motor drive. The regulation is realized by using a duty regulator (TVR 6500 model)

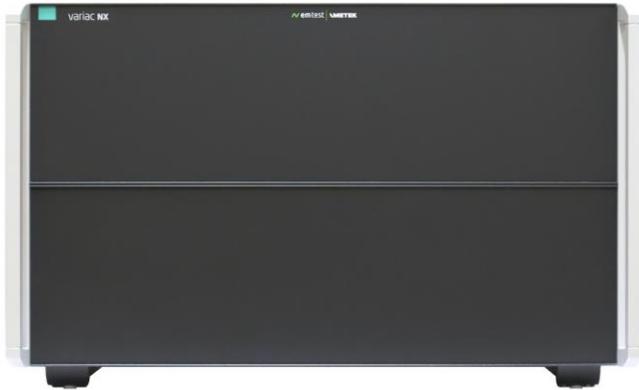


Figure 9.1: Front variac-NX 1-260-16.x



Figure 9.2: Rearside variac-NX 1-260-16.x

Fuses

The equipment is protected against short-circuit by fuses.

Fuses: SIBA Type 189140.20

Size: 6.3 x 32mm



Figure 9.3

| Fuse | destination | current | character | Voltage |
|------|--------------------|---------|------------|---------|
| F1 | to PF1 | 20 A | T time lag | 440 V |
| F2 | to PF2 | 20 A | T time lag | 440 V |
| F3 | mains input line | 20 A | T time lag | 440 V |
| F4 | mains inputneutral | 20 A | T time lag | 440 V |

Time-Current Characteristics

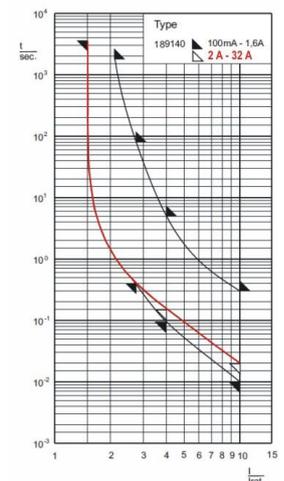


Figure 9.4

Internal Fuse

Fuses: SIBA Type 172530.1

Size: 5 x 30mm

| | | | | |
|----|----------------------|-----|--------------|-------|
| F3 | Power TVR 6500 | 1 A | Med time lag | 500 V |
| F4 | Feedback transformer | 1 A | Med time lag | 500 V |

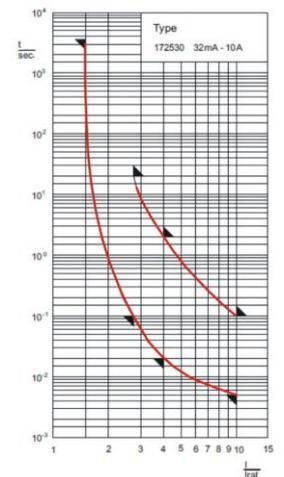
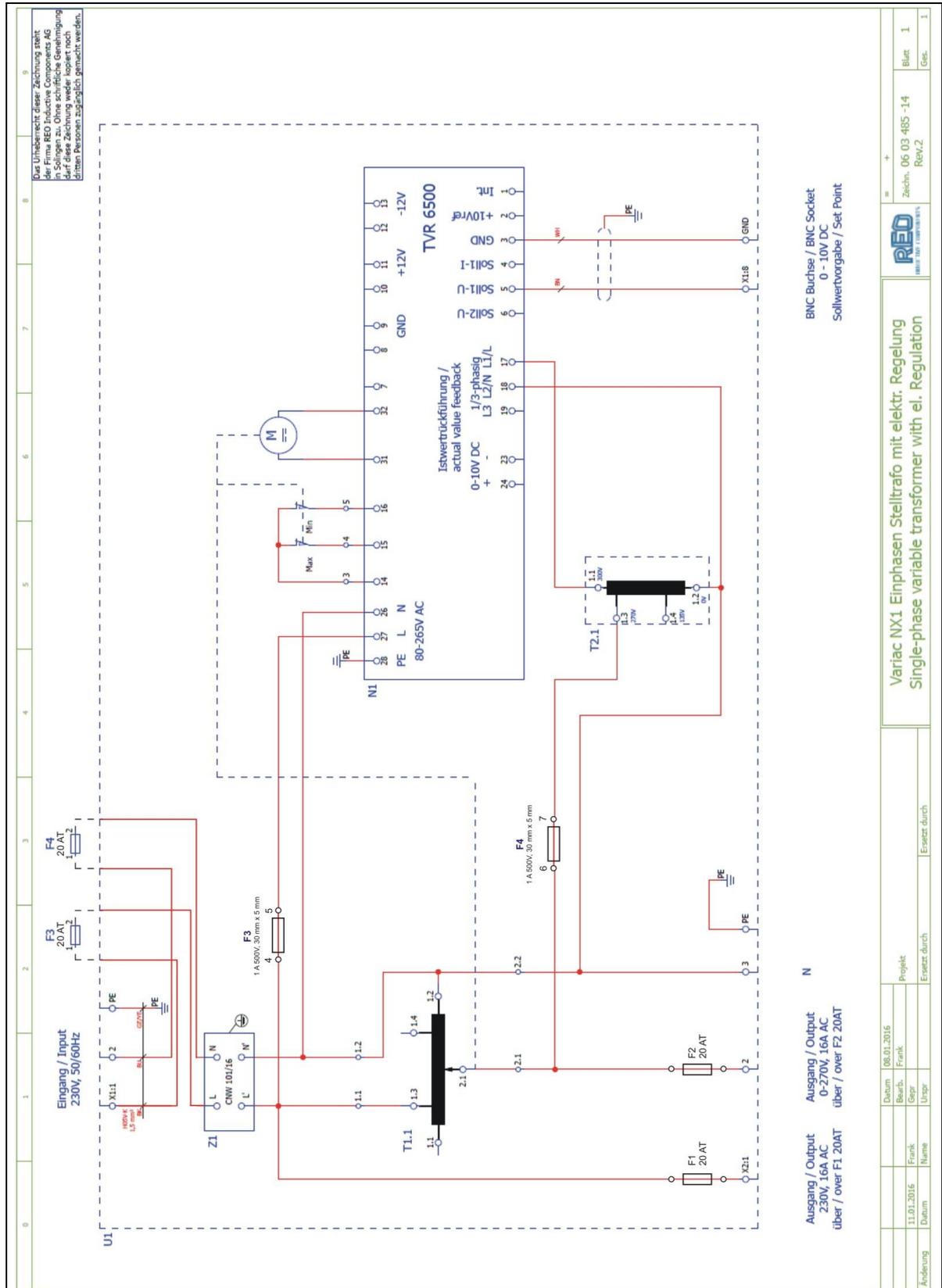


Fig 9.5

9.1.1. Diagram variac NX 1-2x0-16

Motorvariac variac-NX 1-260-16
 Motorvariac variac-NX 1-280-16



| | | | |
|-------------------|--|-----------------------|--|
| Datum: 08.01.2016 | | Projekt: Frank | |
| Bearb.: Frank | | Erstellt durch: Frank | |
| Gepr.: Gspg | | Ersetzt durch: | |
| Umriss: Frank | | Ersetzt durch: | |
| Name: Frank | | Ersetzt durch: | |
| Änderung: Datum | | Ersetzt durch: | |
| Blatt: 1 | | Zeichn.: 06 03 485-14 | |
| Ges.: 1 | | Rev.2 | |

Variac NX1 Einphasen Stelltrafo mit elektr. Regelung
 Single-phase variable transformer with el. Regulation

9.2. variac-NX 1-260-32

The equipment consists of a single toroid transformer with motor drive. The regulation is realized by using a duty regulator (TVR 6500 model)

Switch S2

The switch S2 is used vor the match the voltage PF2 to the internal regulator. There are two position.

| Position S2 | Voltage range |
|-------------|---------------|
| 115 : | 0-130V |
| 230 : | 0-260V |

Fuses

The equipment is protected against short-circuit by fuses.

- F1.1 to PF1 35A
- F1.2 to PF2 35A
- F2.1 to feedback transformer 1A
- F3.1 to regulator 3.15A

Fuses: Type:



NEOZED 35A ;400V AC
series : 5SE2
size : D02



size : 5 x 30mm
type 1A; 3.15A 500V
time lag

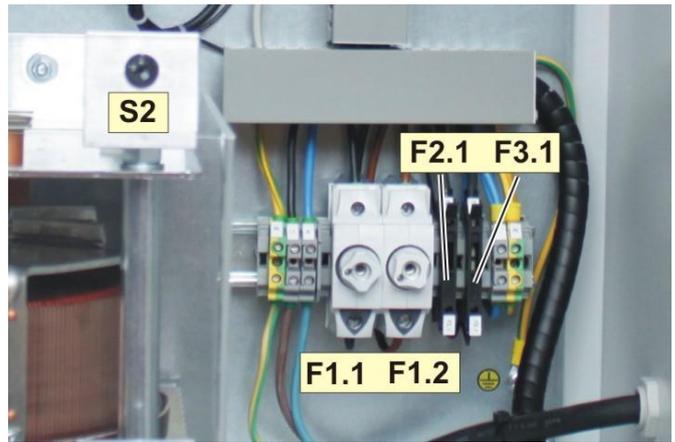


Figure 9.5: Fuses variac NX 1-260-32



Figure 12.6: variac NX 1-260-32 frame



Figure 12.7: variac NX 1-260-32 internal wiring

10. Appendix

10.1. Declaration of conformity

The variac NX 1-260-xx models are exclusive manufactured for AMETEK CTS by REO. Please refer to the declaration of conformity of the manufacturer:

Operating instructions**Single-Phase Variable Transformers**

Technical Safety Information for the User

This description contains the necessary information for the correct application of the product described below. It is intended for use by technically qualified personal.

Qualified personnel are persons who, because of their training, experience and position as well as their knowledge of appropriate standards, regulations, health and safety requirements and working conditions, are authorised to be responsible for the safety of the equipment, at all times, whilst carrying out their normal duties and are therefore aware of, and can report, possible hazards (Definition of qualified employees according to IEC 364).

Safety Instructions

The following instructions are provided for the personal safety of operators and also for the protection of the described product and connected equipment.



Warning!
Hazardous Voltage.
Failure to observe can kill, cause serious injury or damage.

- Isolate from mains before installation or dismantling work, as well as for fuse changes or post installation modifications.
- Observe the prescribed accident prevention and safety rules for the specific application.
- Before putting into operation check if the rated voltage for the unit conforms with the local supply voltage.
- Emergency stop devices must be provided for all applications. Operation of the emergency stop must inhibit any further uncontrolled operation.
- **The electric connections must be covered!**
- **Earth connection must be checked for safe function after assembly!**

Use According to Destination

The units described herein are electrical equipment for the use in industrial plants. They are not determined for private households. Units with open electric connections are determined for installation only.

This unit conforms to the Low Voltage Directive 93/68/EWG**CE**

REO-INDUCTIVE COMPONENTS AG2

10.1.1. Diagram variac NX 1-260-16

Manufacturer: **AMETEK CTS GmbH**
Address: Sternenhofstr. 15
CH 4153 Reinach BL1
Switzerland

declares, that under is sole responsibility, the product's listed below, including all their options, are conformity with the applicable CE directives listed below using the relevant section of the following EC standards and other normative documents.

Product's name: Motor driven AC source
Model Number(s) variac-NX 1-260-16

Low Voltage Directive 2014/35/EU

Standard to which conformity is declared:

EN 61010-1: 2011 Safety requirements for electrical equipment for measurement, control, and laboratory use.

EMC Directive 2014/30/EU

Standard(s) to which conformity is declared:

EN 61326-1: 2013 Electrical equipment for measurement, control and laboratory use Class A
EN 61000-3-2: 2014 Limits for harmonic current emissions
EN 61000-3-3: 2013 Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems.

Manufacturer
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Fax: +41 61 204 41 00



By A. Burger
Business Manager Conducted EMC
Place Reinach BL, Switzerland
Date 1.July 2017

10.1.2. Diagram variac NX 1-260-32

Manufacturer: **AMETEK CTS GmbH**
Address: Sternenhofstr. 15
CH 4153 Reinach BL1
Switzerland

declares, that under its sole responsibility, the product's listed below, including all their options, are in conformity with the applicable CE directives listed below using the relevant section of the following EC standards and other normative documents.

Product's name: Motor driven AC source
Model Number(s) variac-NX 1-260-32

Low Voltage Directive 2014/35/EU

Standard to which conformity is declared:

EN 61010-1: 2011 Safety requirements for electrical equipment for measurement, control, and laboratory use.

EMC Directive 2014/30/EU

Standard(s) to which conformity is declared:

EN 61326-1: 2013 Electrical equipment for measurement, control and laboratory use Class A
EN 61000-3-2: 2014 Limits for harmonic current emissions
EN 61000-3-3: 2013 Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems.

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By A. Burger
Business Manager Conducted EMC
Place Reinach BL, Switzerland
Date 1. July 2017

10.1.3. Diagram variac NX 1-280-16

Manufacturer: **AMETEK CTS GmbH**
Address: Sternenhofstr. 15
CH 4153 Reinach BL1
Switzerland

declares, that under its sole responsibility, the product's listed below, including all their options, are conformity with the applicable CE directives listed below using the relevant section of the following EC standards and other normative documents.

Product's name: Motor driven AC source
Model Number(s) variac-NX 1-280-16

Low Voltage Directive 2014/35/EU

Standard to which conformity is declared:

EN 61010-1: 2011 Safety requirements for electrical equipment for measurement, control, and laboratory use.

EMC Directive 2014/30/EU

Standard(s) to which conformity is declared:

EN 61326-1: 2013 Electrical equipment for measurement, control and laboratory use Class A
EN 61000-3-2: 2014 Limits for harmonic current emissions
EN 61000-3-3: 2013 Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems.

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