BENNING

World Class Power Solutions

Rectifiers

For Stationary Battery Systems in Nuclear Power Plants

1.1 Application

Electronically controlled rectifier assemblies are used in conjunction with suitable lead-acid or nickel-cadmium batteries, to provide a protected DC power supply system. These systems are then used to supply power to critical loads in nuclear power plants, both when the mains supply is present, and during power failures.
Typical loads are:

- **Power station equipment**
- **Signalling, control and protective electronics**
- **Telemetering and telecontrol engineering**
- **Telecommunications equipment**
- **Static inverters**
- **AC and DC motors**
- **Solenoid valves**

The rectifier assemblies used normally give output voltages of 110 V or 220 V. When the mains supply is on, they are responsible for providing power to the load and also for supplying the charging and float charging current for the battery. This ensures that, if a mains failure should occur, the battery is ready to supply the full power. The engineering supply is provided by 26 V rectifiers or DC-DC-Converters.

The rectifiers are planned and produced in line with the appropriate KTA guidelines, and can be used in any type of power station.

Optional test equipment can be supplied with the rectifiers, to undertake the repeat measurements necessary in power station applications.

Fig. 1: Test item

1.2 Output characteristics

The units operate with an IU charging characteristic to DIN 41 773 and the variations which can be corrected for are as follows:

- Mains voltage variations of ± 10 %
- Frequency variations of ± 5 %
- Load variations from 0 to 100 %

Float charge voltage 2,23 V per cell
The float charge voltage is the voltage at which the on line loads are supplied and the battery`s nominal charge level is maintained.

Boost charging voltage 2,4 V per cell
With this higher level of constant voltage it is possible to re charge the battery more quickly after mains failure.
Access can be gained to the selector switch required to change from 2.23 V per cell and to the setting potentiometers by opening the front doors.

Commissioning
In order to charge the battery for the first time and for any equalising charges, which may be necessary, the power supply unit is also equipped to operate to a supplementary W characteristic.
With a smooth variable charging current, the battery voltage goes up to 2,7 V per cell.
The change-over of the charging characteristic from charging to commissioning is locked with an auxiliary contact of the distribution feed-in switch.
For NiCd batteries the same characteristic is produced with constant voltage values of 1,4 V per cell or 1,55 V per cell.
The max. commissioning voltage is 1,8 V per cell.

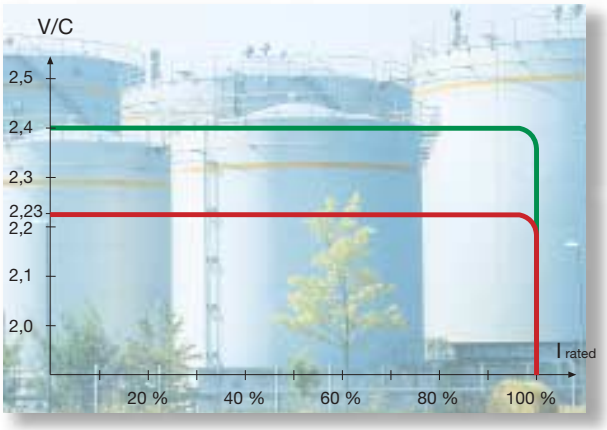


Fig. 2: IU characteristic to DIN 41773 for lead-acid batteries

1.3 Regulation

The units are regulated by a controller with thyristors acting as control devices in the rectifier assembly. The rectifier assembly is in the form of a fully controlled (6-pulse) three-phase bridge circuit.
The semi-conductors are sized to ensure that they are able to operate continuously at full load with natural ventilation. The silicon semi-conductors are protected against short circuits by ultra high-speed fuses which are designed to act as cell fuses at rated currents of more than 100 A.

1.4 Smoothing

As ripple sensitive loads could be connected a reinforced smoothing device is fitted in the units, which limits the ripple of the output voltage when operated without batteries to a value of 5 % peak-to-peak.

2. Signalling and Monitoring Devices

The power supply units are fitted as standard with electronic monitoring modules. These are integrated into a subrack (Fig.3).

2.1 DÜW III Three-Phase Current Monitoring

The DÜW III three-phase current monitoring device has three monitoring functions:

- Mains undervoltage (V_N - 15 %)
- Mains overvoltage (V_N + 15 %)
- Mains balancing

Any disturbance which arises is signalled on the front panel on a yellow LED display.
The signal output terminals are fitted with an operate delay (0.1 - 15 sec.). When the delay period expires, the signal is given on the SME I centralized fault indication module (see section 2.6), which switches off the unit. When the fault is cleared, the unit auomatically switches itself on again. The signal memory is reset using a reset button on the SME I.
If there is an overvoltage in the mains supply, a pot.-free contact is also operated which inhibits the controller for the duration of the overvoltage or for a period of no less than 200 msec, whichever is the longer.

2.2 GKÜ I Unit and Short Circuit Monitoring Device

The GKÜ I has two monitoring functions:

- current dependent undervoltage (characteristic monitoring)
- system short circuit

The unit monitoring device consists of a voltage and a current relay. If the unit output voltage falls to a value less than 2.1 V per cell and the current is less than 80 % of the nominal current, a fault signal is sent, which is indicated on a yellow LED. The short circuit monitoring device also consists of a voltage and a current relay.

If the voltage falls below 1.6 V per cell and the current is 100% of the nominal current, a fault signal is given. The signal is processed on the SME I and in the unit as described in 2.1. However the unit only switches itself back on once acknowledgement has been given on the SME I.

Fig. 3: Signal and Monitoring Device Sub-Rack.

2.3 GSR VII Direct Voltage Relay

The GSR VII is an overvoltage monitoring relay with two functions:

- Dynamic overvoltage monitoring
- Static overvoltage monitoring

The dynamic overvoltage monitoring device is an instantaneous DC voltage monitor with a controller inhibit.
If a voltage peak occurs, the controller is instantaneously ($t < 10$ msec.) inhibited for a period of about 200 msec. (Yellow LED lights up).
If such a voltage peak occurs four times in succession within 30 seconds, the unit trips out via a signal to the SME I.
The static overvoltage monitoring device measures the effective value of the DC voltage.
If the specified value is exceeded, a fault signal is sent and is shown on a yellow LED. The signal is processed as already described under 2.2.

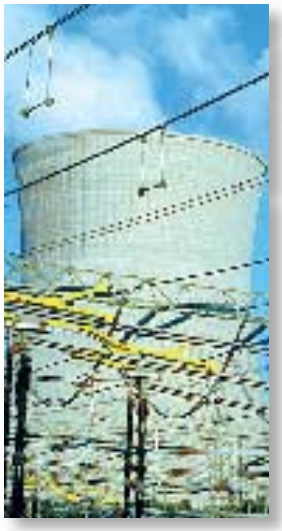


Fig. 4: SME I

2.4 GUG III Ripple Monitor

The GUG III ripple monitor measures the alternating component of the rectifier units superimposed on the DC voltage.
If the residual ripple content exceeds a set value, a signal is given via a yellow LED.
The signal is processed by the SME I as already described in 2.2.
In rectifier units without reinforcing smoothing, the GUG III can also be used as a battery circuit monitor. In this case the unit tripping and locking function does not apply.

2.5 Fuse Monitoring

The fuses connected ahead of the power semiconductors and the auxiliary circuit and control circuit fuses are monitored for failure. If a fault occurs, a signal is given via the SME I. At the same time the unit is disconnected on the supply side. The disconnection remains locked in and acknowledgement is required.

2.6 SME I Centralized Fault Indicator with First Up Value Recording

In the SME I "Centralized Fault Indicator with First Up Value Recording", all signals are shown as a centralized fault signal.

The SME I has two separate output signals:

- Fault
- Fault Stored

The signal "Fault" is automatically reset when the fault is removed. The signal "Fault Stored" continues to be applied and has to be acknowledged.

The SME I has three functions:

- recording of the first up value, which stores the first fault arising and is signalled by a red LED.
- a "Card Withdrawn" signal, which responds when a monitoring card is taken out from the magazine. The units simultaneously trip out when the signal is given. The tripping out can be blocked for testing purposes.
- a "Function Test" key.
  This key can be used to test all the monitoring cards. All monitoring functions together with the maintenance signal are activated and tested.
  This test lasts about 20 seconds. After this a resetting signal is automatically sent to the monitoring cards.

The monitoring and signalling devices described in 2.2 to 2.6 (with the exception of 2.5) are in the form of plug-in cards (European standard format 3 units high - 7 units deep).
The power is supplied from the alternating current mains at 220 V 50 Hz and diode decoupled from the DC system at 24 V (for 220 V system via a DC - DC converter).

Accessories for 26 V,110 V and 220 V Units
(not provided as standard)

In addition to the standard monitoring relays, the following modules can also be fitted if required.

2.7 Battery monitoring

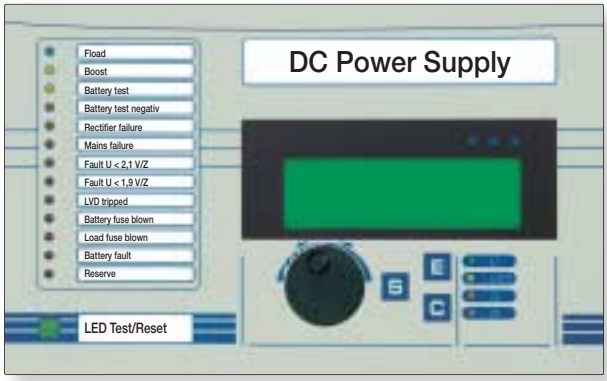
With continuous battery power supply, there is the danger that a failure of the battery or that an interruption in the battery circuit will go unnoticed. This can result in serious disruption to the system, if there is a mains power supply failure. Therefore battery monitoring is strongly recommend.

Two different systems are available:

- Battery circuit monitoring (current control)
- Battery symmetrie monitoring
  (battery center point required)

2.8 Measuring and alarm unit MCU 2000

With the MCU 2000 unit, all measurements and alarms are available on an interface like RS 232.
An event memory for max. 500 events and a graphic display with several LED's for all measurements, alarms and events is integrated.



3.1 External Construction

The units are built into a welded steel section framed housing to IP 20 protection standards and are designed with vents at the joints. The side and rear panels can be prepared.
For transportation (loading and unloading) the housing is fitted with crane lifting eyes. If desired, casement-type or espagnolette fasteners can be used.
At seismic requirements, additional mechanical reinforcements are implemented (see figure 6).

The following display and control elements are positioned on the front door of the housing (see Fig. 5).

- Unit ON/OFF switch
- Moving coil ammeter, class 1,5, format 96 x 96
- Moving coil voltmeter, class 1,5, format 96 x 96
- "Fault" warning light
- "Fault Stored" warning light
- Lamp Testing key
- Manual charging potentiometer

Fig. 5: External view

Fig. 6: Internal view

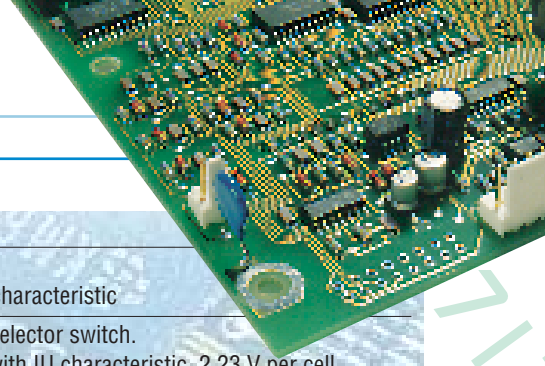
3.2 Internal Construction

The mains transformer and the smoothing reactor are positioned at the base of the housing on the base frame and bolted on. The thyristor assembly is placed in the upper part of the housing so that the heat given off can be easily dissipated and does not build up.

The thyristors are fitted with special semiconductor fuses with fuse monitors. Auxiliary and control circuits are protected by automatic circuit breakers or motor protection switches.

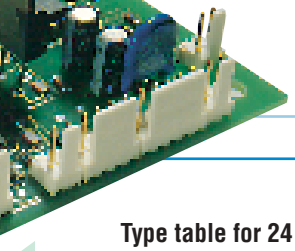
Controller and monitoring modules are designed in the form of standard European format plug-in cards and built into a sub-rack.

Where the nominal current of the units is greater than approx 400 A, the wiring in the power circuit uses copper bus bar.
At the rectifier output terminal there are fuse switch disconnectors to disconnect the unit from the supply. The connection terminals for the direct and alternating voltage are placed at the base of the unit and are easily accessible when the doors are open.



Type:	see Type table
Charging characteristic:	IU to DIN 41 773, can be switched to manually controlled W characteristic
Operating modes:	The mode required can be selected with a selector switch. Float charging: Parallel standby operation with IU characteristic, 2.23 V per cell Boost charging: Parallel standby operation with IU characteristic, 2.4 V per cell Commissioning charging: W characteristic at up to 2.7 V per cell. The charging current is smoothly adjustable.
Stability of output values:	Voltage ± 1 %, Current ± 2 %
Permitted variations under DIN 41 773:	Mains voltage ± 10 % at 2.4 V/Z, + 10 - 15 % at 2.23 V/c Mains frequency variations ± 5 %, Load variations 0 - 100 %
Rectifier circuitry:	Fully controlled three-phase bridge circuit
Control and regulation:	Transistorised controller with thyristors as regulating devices
Derating-factor:	≥ 2,5 acc. to VDE 0160
Protection:	The semiconductors are protected by ultra high-speed fuses. Depending upon the power rating of the unit it is protected either by cell fuses or by a fuse in the output.
Dynamic characteristics: (battery disconnected)	If the load increases from 50 % to 100 %, the output voltage does not drop below 20 V / 90 V / 180 V*1 (t=200ms). If the mains voltage drops by 30 %, the output voltage does not drop below 20 V / 90 V / 180 V (t=200ms). If the load drops from 100 % to 50 % the output voltage does not rise above 33 V / 135 V / 270 V. If the mains voltage rises again from 70 % to 100 %, the output voltage does not exceed 33 V / 135 V / 270 V *1.
Ripple:	Smoothing facility, which reduces the ripple of the stated DC-voltage to approx. 5 % peak to peak over the entire load range from 0 to 100 % (battery disconnected).
Start-Up Module:	Pulse enable after 300 ms. Avoidance of missing pulses when connecting the rectifier (e.g. bouncing the earthing contacts).
Ramp-Up Module:	Delayed voltage increase when connecting the rectifier unit. The voltage increases following an exponential function.
Meters:	Moving coil ammeter, class 1,5, size 96 x 96 mm Moving coil voltmeter, class 1,5, size 96 x 96 mm
Monitoring facilities:	Undervoltage monitoring facility for mains supply, monitoring facility for semi-conductor fuses, facility for monitoring auxiliary and control circuit fuses, overvoltage monitoring facility on DC side, monitoring facility for current-related undervoltage, short-circuit monitoring facility.
Indications: visual inside the unit	"Mains asymmetry" "High mains voltage" "Low mains voltage" "Unit fault" "Short-circuit" "High battery voltage (stat.)" "High battery voltage (dyn.)" "Fuse fault" „Card withdrawn"
visual on unit and pot.-free on terminals:	General "fault" signal "Fault stored"
Construction:	Free-standing sheet-steel cabinet with doors at front. The side and rear panels can be removed. For dimensions see type table. Standard of enclosure provided by cabinet: IP 20 Painting: RAL 7035
Ambient temperature:	-5 °C to + 40 °C
EMV:	EN 50081-2 and EN 50082-2
Humidity classification:	humidity classification F under DIN 40040
Type of cooling:	Natural air cooling, air enters from below.
Mains supply: For other technical data see type table	3 x 400 V, 50 Hz, with neutral, other mains voltages if desired.

*1 Values for 24 V, 110 V and 220 V units



Type table for 24 V units

Type	Mains current at 3 x 400 V	Power factor at 29 V and rated current	Efficiency at 29 V and rated current	Dissipated power in kW	Dimensions H x W x D (mm)	Weights in kp
D 400 G 26/ 400 BWLrug-Dt	29	0,7	83 %	2,4	2200 x 800 x 800	680
D 400 G 26/ 600 BWLrug-Dt	43	0,7	84 %	3,3	2200 x 800 x 800	800
D 400 G 26/ 800 BWLrug-Dt	57	0,7	84 %	4,4	2200 x 1200 x 800	950
D 400 G 26/1000 BWLrug-Dt	71	0,7	85 %	5,2	2200 x 1200 x 800	1100
D 400 G 26/1200 BWLrug-Dt	85	0,7	85 %	6,2	2200 x 1200 x 800	1200
D 400 G 26/1600 BWLrug-Dt	112	0,7	86 %	7,6	2200 x 1600 x 800	1500
D 400 G 26/2000 BWLrug-Dt	138	0,7	87 %	8,7	2200 x 1600 x 800	1900
D 400 G 26/2500 BWLrug-Dt	173	0,7	87 %	10,8	2200 x 2000 x 800	2300
D 400 G 26/3000 BWLrug-Dt	207	0,7	88 %	12,9	2200 x 2000 x 800	2650

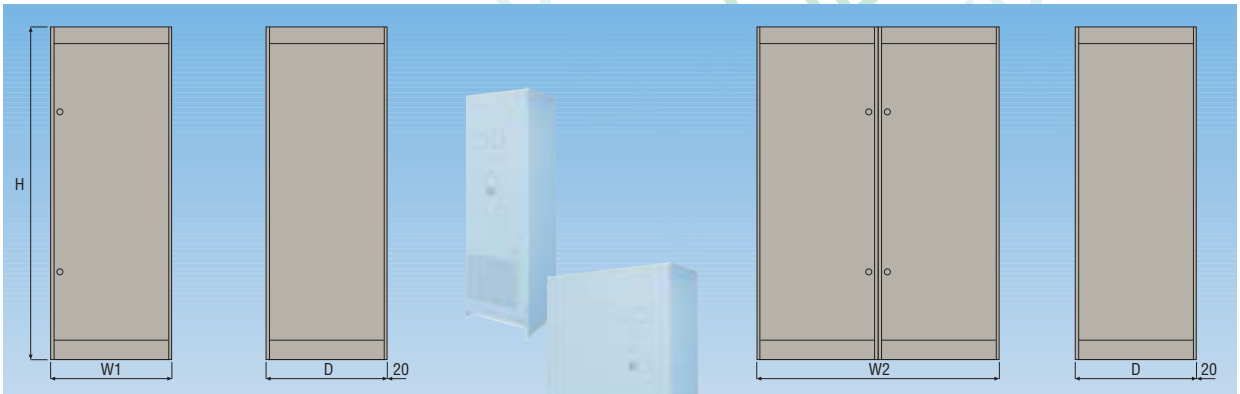
Type table for 110 V units

Type	Mains current at 3 x 400 V	Power factor at 121 V and rated current	Efficiency at 121 V and rated current	Dissipated power in kW	Dimensions H x W x D (mm)	Weights in kp
D 400 G 108/ 200 BWLrug-Dt	54	0,7	90 %	2,5	2200 x 1000 x 800	620
D 400 G 108/ 300 BWLrug-Dt	80	0,7	90 %	3,6	2200 x 1200 x 800	850
D 400 G 108/ 400 BWLrug-Dt	105	0,7	91 %	4,4	2200 x 1200 x 800	1120
D 400 G 108/ 600 BWLrug-Dt	160	0,7	92 %	5,8	2200 x 1600 x 800	1500
D 400 G 108/ 800 BWLrug-Dt	210	0,7	92 %	7,7	2200 x 1600 x 800	1750
D 400 G 108/1000 BWLrug-Dt	265	0,7	93 %	8,4	2200 x 2000 x 800	1900
D 400 G 108/1200 BWLrug-Dt	315	0,7	93 %	10,1	2200 x 2400 x 800	2080
D 400 G 108/1600 BWLrug-Dt	420	0,7	94 %	11,6	2200 x 3200 x 800	2400

Type table for 220 V units

Type	Mains current at 3 x 400 V	Power factor at 245 V and rated current	Efficiency at 245 V and rated current	Dissipated power in kW	Dimensions H x W x D (mm)	Weights in kp
D 400 G 212/ 100 BWLrug-Dt	54	0,7	93 %	1,9	2200 x 800 x 800	530
D 400 G 212/ 200 BWLrug-Dt	107	0,7	95 %	2,7	2200 x 1200 x 800	1030
D 400 G 212/ 300 BWLrug-Dt	160	0,7	95 %	3,9	2200 x 1600 x 800	1480
D 400 G 212/ 400 BWLrug-Dt	210	0,7	96 %	4,2	2200 x 1600 x 800	1700
D 400 G 212/ 600 BWLrug-Dt	316	0,7	96 %	5,8	2200 x 1600 x 800	1900
D 400 G 212/ 800 BWLrug-Dt	418	0,7	97 %	6,1	2200 x 2400 x 800	2300
D 400 G 212/1000 BWLrug-Dt	521	0,7	97 %	7,6	2200 x 3200 x 800	2800
D 400 G 212/1200 BWLrug-Dt	625	0,7	97 %	9,1	2200 x 3200 x 800	3200

Dimensions Diagrams



Type of cabinet	H	W1	D
PS 220808	2200	800	800
PS 221008	2200	1000	800

Type of cabinet	H	W2	D
PS 221208	2200	1200	800
PS 221608	2200	1600	800
PS 222008	2200	2000	800

General

The battery supply unit connects the power supply to the battery, and is designed as a floor standing sheet steel cabinet, with hinged front door and corresponding KKS marking.

The unit should stand adjacent to the power supply, and is connected via copper bus bar.

The connection to the battery can be via parallel single core cable or copper bus bar. The unit can be provided with top or bottom cable entry.

The requirements of the UVV BGV A2 are met, especially with regard to protection against accidental contact.

Equipment

The standard battery supply units are equipped as follows:

- NH-fused load disconnection switch equipped with the corresponding battery fuses with fuse monitoring.
- battery circuit monitoring (BKÜ), either as BKÜ with charging current measuring or as BSÜ (battery symmetry monitoring) with centre tap of the battery
- 2-pole push-button and the corresponding fuses and resistors for charging the smoothing capacitors in the power supply units before putting in the battery fuses
- ammeter with middle zero point for the measurement of the battery current
- voltmeter for the battery voltage with the corresponding fusing
- lamp “fault“
- copper bars and connection plates for the battery and load cables as well as the cross bar to the rectifier
- KKS-marking as engraved plastic label

Rating

The battery supply units can optionally be delivered for 24 V, 110 V and for 220 V in different current sizes. The standard current allocations can be taken from the type table.

Type Table

Type	Fuse size	Batt. fuse	Dimensions in mm			Weight
		A	H	W	D	kg
BES 250	NH 2	250	2200	800	800	150
BES 400	NH 3	400	2200	800	800	150
BES 630	NH 3	630	2200	800	800	150
BES 1250	NH 4	1250	2200	800	800	170
BES 1600	NH 4	1600	2200	800	800	170
BES 2500	2 x NH 4	2 x 1250	2200	1000	800	200
BES 3200	2 x NH 4	2 x 1600	2200	1000	800	200

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