

**APPLICATION NOTE:
SERIES CONNECTION OF ELECTRONIC LOADS**



Elektro-Automatik



Note: This document is only valid for following series

- ELR 10000
- PSB 10000 (running in sink mode)

Preamble

Series connection of electronic loads requires all involved units to always have equal internal resistance to equally distribute the DC input voltage. That also includes the potential of the DC input poles against ground (PE) which is limited by the internal insulation. Electronic loads usually have no protection against overvoltage. In order to safely run series connection it would require an internal hardware solution than can balance the voltage out, but which doesn't exist. The end user could still go and connect electronic loads in series and carefully and separately control them when one important thing would still matter: **protection from overvoltage**.

For that the so-called **SCB** (Serial Connection Box) has been developed, which comes in form of an externally installed hardware box that is connected to the Share bus and the DC input in order to monitor the DC voltage and to shut down the DC input in case of an overvoltage between DC+ and DC- . It accomplishes that by short-circuiting the Share bus which leads to a Share bus fail (short: SF) alarm, causing all units with an SCB to switch off their DC input.

Restrictions

- The SCB is only available for models with a voltage rating of 360 V or higher, so that models with 60 V, 80 V and 200 V are not qualified for protected series connection
- Mixed models series connection isn't permissible
- No master-slave support for the series connection - all units must be configured and controlled separately, ideally via remote control because it advantages over manual control
- The maximum allowed series connection voltage is 3500 V
- Certain configurations require to ground DC at one point in the line

General information

- The number of devices allowed in series connection solely depends on the resulting potential on their DC minus and DC plus terminals. The float voltage specification is the overall limit
- Every unit in the series connection requires to have an SCB installed, so if there are three units then it would need three SCBs
- The SCB can be retrofitted and thus a series connection system can be configured whenever needed

Example configurations

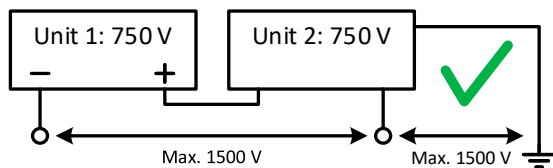


Figure 1

- Example 1: two units of 750 V in series
- Permissible: Yes
- Grounding required: No
- Restrictions: None

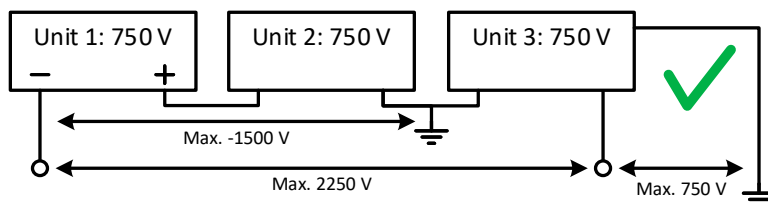


Figure 2

- Example 2: three units of 750 V in series
- Permissible: Yes
- Grounding required: Yes, either between unit 2 and 3 or between 1 and 2
- Restrictions: None

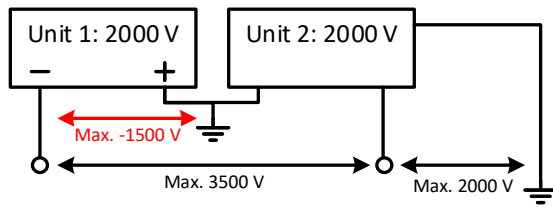


Figure 3

- Example 3: two units of 2000 V in series
- Permissible: With restrictions
- Grounding required: Yes
- Restrictions: total voltage can only be up to 3500 V, so Unit 1 must be limited to 1500 V

Connection principle with the SCB

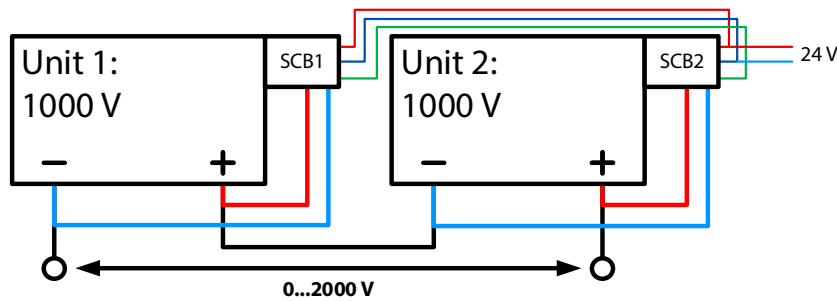


Figure 4

Each SCB monitors the input voltage of the device it's attached to. Any SCB which detects an overvoltage short-circuits the Share bus of the device it's attached to and also forwards the signal (green line) to other units to trigger them to do the same. The short-circuited Share bus triggers an alarm which shuts down the DC terminals immediately.

Ordering information

Name	Voltage rating	Compatible to model	Ordering number
SCB 10360	360 V	ELR/PSB 10360-240	33000950
SCB 10500	500 V	ELR/PSB 10500-180	33000951
SCB 10750	750 V	ELR/PSB 10750-120	33000952
SCB 11000	1000 V	ELR/PSB 11000-80	33000953
SCB 11500	1500 V	ELR/PSB 11500-60	33000954
SCB 12000	2000 V	ELR/PSB 12000-40	33000955

Technical data

Required supply: 24 V_{DC} (22...26 V) @ 20 mA per SCB

Dimensions (W x H x D): approx. 40 mm (1.6 in) x 72 mm (2.8 in) x 73 mm (2.9 in)

Weight: approx. 150 g (5.3 oz)

Connection: Standard BNC (50 Ω), 3-pole Phoenix, M6 ring lugs

Features: supports series connection and parallel connection

Transient time (overvoltage detection to shutdown): approx. 25 μs

Views & Dimensions

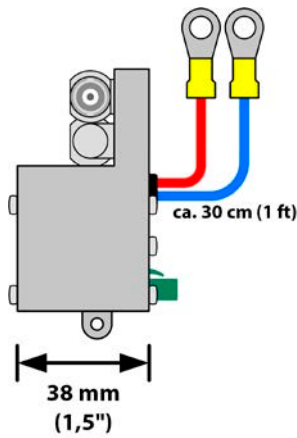


Figure 5 - Rear view

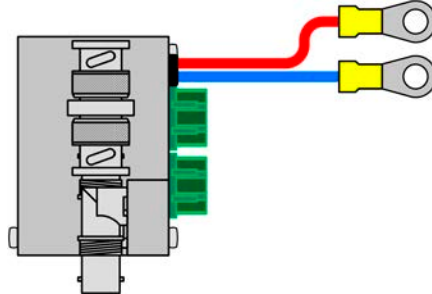


Figure 6 - Top view

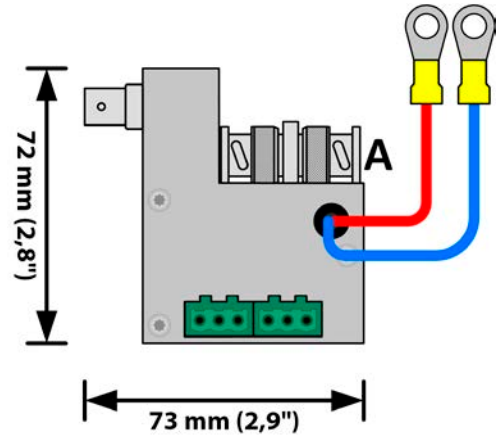


Figure 7 - Side view

Scope of delivery

- 1x SCB module
- 1x Cable for SCB to SCB connection (2x plug 3-pole), ca. 70 cm (2.3 ft)
- 1x Cable for DC supply (1x plug 3-pole)

Installation & connection

1. Remove this screw on each unit.

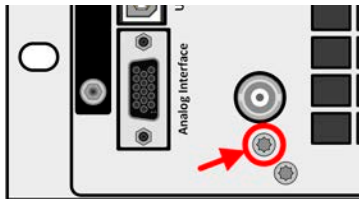


Figure 8

2. Plug the BNC connectors A (see images above) of the SCB modules to the upper Share bus sockets labeled "Share BUS Input". See Figure 9 for correct placement.

3. Mount the screws from step 1 again, firmly tighten them and make sure the included contact disk is put under each screw to ensure good connection to PE.

4. Connect the voltage monitoring cable (red/blue), which comes out of the SCB, to the DC terminal with correct polarity (red = DC+, blue = DC-), as depicted in Figure 9.

5. Connect the SCB link cable (2x green connector) between the SCBs of all units by using any of the two green Phoenix connectors.

6. At one end of the SCB line, no matter which, connect the other cable for 24 V DC supply. Connect a DC power supply to this cable.

Attention!

- Never connect the Gnd/neg. DC of the 24 V supply to the neg. DC pole of the device!
- The DC side of power supply must be galvanically isolated from all other parts and must have an insulation against PE that is at least as high the DC voltage of the series connection.

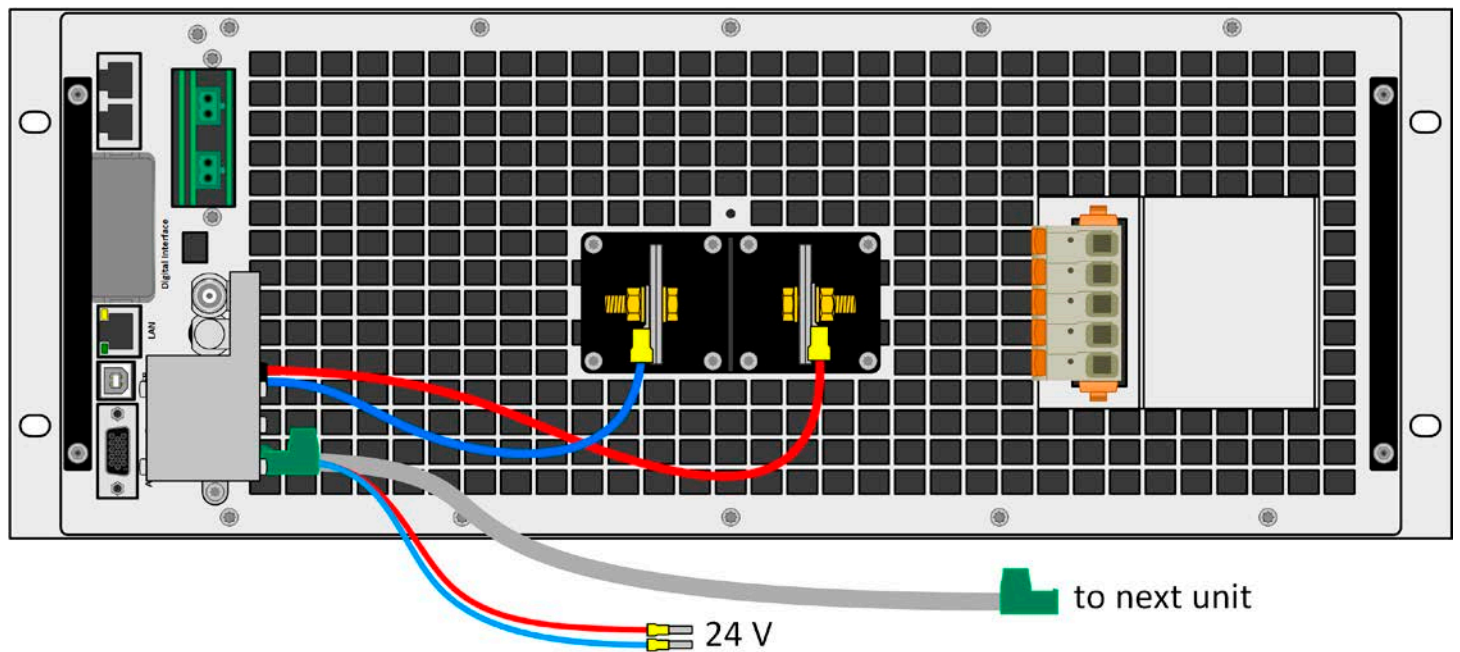


Figure 9 - Installation position and cabling

General rules for operation

- In series connection, the DC inputs of all units must be switched on to have a current flow, even if less power is required
- Always make sure that the power supply of the SCB modules is running before powering the PSB/ELR devices or at least before putting an external voltage to the DC terminals.

Application

In order to distinguish the units in series connection, the one with the positive DC pole and highest potential against ground is called the “high unit” and the other unit(s) are called the “low unit(s)”.

When supplying voltage to the series connection there are basically two methods: either the external voltage is already present and the loads could instantly have an excess voltage on their DC inputs or the external voltage is 0 V in the moment when the DC inputs are switched on and after that the external voltage will be increased to the targeted level, more or less slowly. Both situations have their advantages and disadvantages. It's up to the user to decide which one is the best for the application.

Note: the SCB doesn't balance the voltage between the units. For series operation it's thus recommended to run the units in **CV** mode, if possible, even electronic loads.

Example: there are three loads in series connection, each rated 500 V. Max. total voltage is 1500 V, no grounding required here. When applying 1500 V to the DC input it must be prevented that any of the units can have more than 500 V on its DC input. One way of achieving that could be to adjust the low unit and the mid unit to max. voltage, i. e. 500 V, and the high unit to 0 V. The series connection would then only start to draw current when the supplied voltage exceeds 1000 V, which is probably not wanted as it narrows down the available voltage range for dynamic tests.

The high unit would be considered as the “boss” of this connection and define the total serial current by setting a specific current set value while the current set values of the other two units, low and mid, must be set slightly higher than the one of the high unit. In case wider voltage range is required for an application, for example 800 V - 1500 V, only the low unit would be set to 500 V and the mid unit to 300 V etc. As soon as the units start to clip the voltage in CV mode their DC input voltage should balance or at least not exceed the rating.

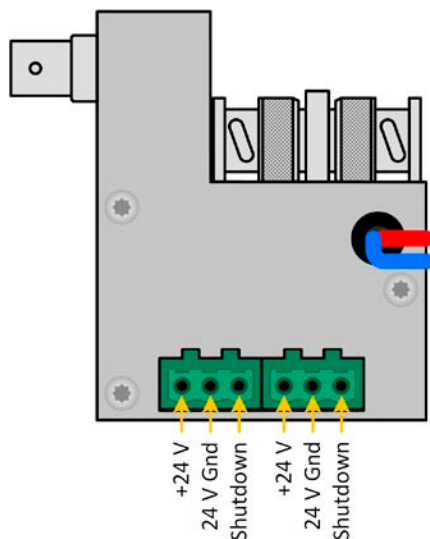
A critical situation is when the DC inputs of the units are switched on, especially during manual handling. Rule: in manual control and when switching the DC inputs on one by one the low unit(s) must be first.

Further important notes:

- Before initial operation of the series connection and also in regular intervals the correct connection and operation of the SCB has to be checked. Correct operation can be checked by intentionally applying an overvoltage to one unit which is 10% higher than the rating, increasing it slowly until the SF alarm occurs.
- Before using the series connection in an actual application we recommend to “play around” with the devices and the external source to get a feeling about the flow of actions and the required settings for a smooth operation. This is possible without any problem, when for example testing 600 V on a series connection of two 500 V models, because the SCB would perfectly protect the devices.
- When using PSB devices and due to the voltage on the lower units probably being set to maximum, those lower PSB units could switch into source mode suddenly. In source mode the series connection could generate and supply back a voltage to the external source which is higher than the external source’s rating and thus damage it. Accidental source mode can be avoided by setting the set values of power and current for source mode to zero.
- Alternatively to CV mode, the units could also run in **CR** mode, but then it would be required to adjust them to the same resistance values at the same time which can only be achieved in remote control.
- The SCB is designed to trigger the protection at around 110% of the rated voltage of a device. Different models can withstand different overvoltage levels for a few seconds, but the average is approx. 120% of the rated voltage. For example, a 500 V model can take up to approx. 700 V for a few seconds without damage, which is even 40% overvoltage. Other models, especially the 2000 V model, can’t sustain so much overvoltage. Since the SCB reacts within microseconds, the duration of overvoltage isn’t decisive, but the level is.

Other

The included cables are sufficient for a series connection where the devices are either stacked or closely placed next to each other. In case the length of the cables doesn’t suffice, they can be extended. Following signal layout:



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