

Description of the L&R DC/DC Converter for Cathodic Protection Rafael Oliva - Sebastian Hermann

1. Main Features

The L&R converter model C3b can produce an adjustable constant direct current for cathodic protection from a battery system (48Vdc), which has a voltage range from 32V to 68V.

The input terminals of the converter are connected to the DC bus, a pair of conductors carrying the high levels of current exchanged between wind turbine and battery system. The positive output terminal is connected to the disperser and the negative output to the casing. The nominal efficiency of the conversion is 85%.



To reach these high levels of efficiency a chopper-type circuit is used, which is based on high frequency switching of the incoming voltage. The output level is controlled by a system based on a PWM-chip (Pulse Width Modulation). The specific architecture used is "buck" converter.

The user can adjust voltage and current with potentiometers on the panel. The converter will switch off automatically in case of too high or too low voltage from the battery system, or if the temperature in the converter rises too high. There is also a switch for manual "shutdown" installed as well as a proprietary interface (DB-25 connector) for data acquisition (using L&R – T1/SBC) with the possibility of automatic control.

2. Output Characteristics

The converter C3b has the capacity to maintain a constant direct current of 15A across a resistance of 0 to 2 Ohms and up to a maximum voltage of 30V. It is designed to work with loads presented by a disperser with the typical values of 0.5 to 1.0 Ohm. The case of maximum power output occurs when the disperser has a resistance of exactly 2 Ohm, in this case the converter has an output of 450W (15A x 30V). Under these circumstances the converter consumes 530W (11A x 48V, normal voltage of the battery system) from the BUS/DC to which the wind turbine (or photovoltaic cell) and the battery bank is connected. In case of sufficient wind the wind-turbine provides the necessary current, if there is not sufficient wind the battery system will take over automatically.

In the following figure the variation of the consumed power from the BUS/DC with respect to the resistance of the disperser can be observed, with the maximum output voltage as a parameter.

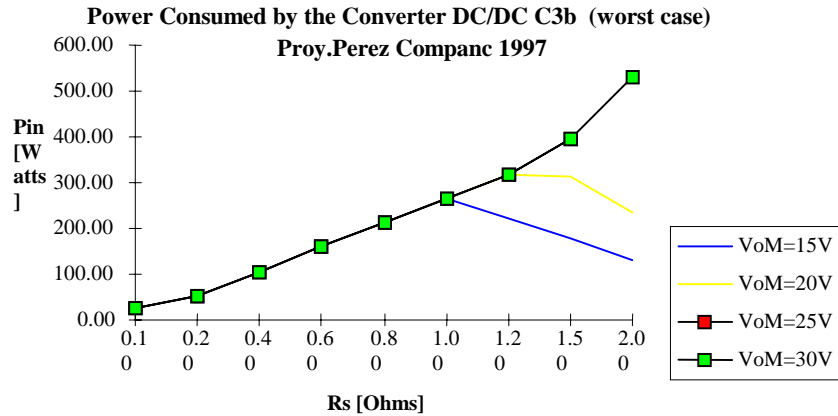


figure 1 - Power Characteristic

The voltage VoM is adjustable from the inner panel. The output current from the converter to the disperser under the same conditions can be seen in the following figure.

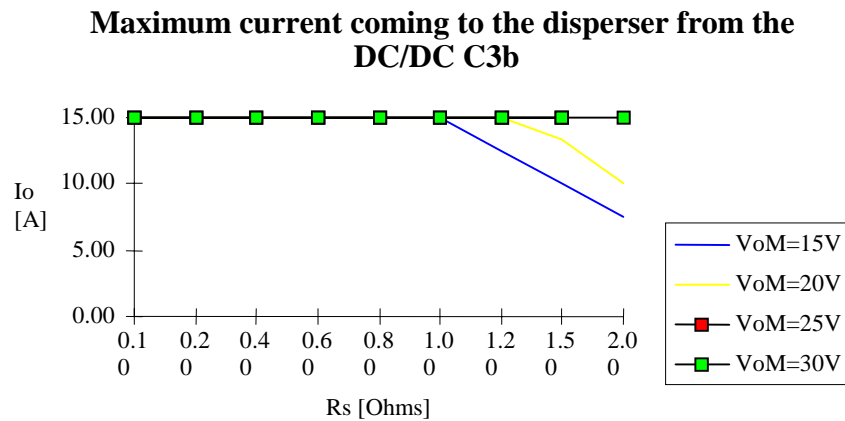


figure 2 - Current Characteristic

As can be observed, different levels of resistance in the disperser (up to a maximum of 2 Ohm) produce different levels of dissipation of power. If the resistance R_s in the disperser exceeds this limit of 2 Ohm it is not possible anymore to reach a current output of 15A because the design of the converter allows only a maximum voltage output of 30V. The output current is adjustable with a potentiometer and LCD display on the inner panel of the equipment. This

inner panel is protected by a metal cover, on which two LEDs can be seen. A green LED indicates normal operation and a red flashing LED indicates an error condition.

3. Elements of the DC/DC Converter.

On the board of the C3b converter the following elements can be found:

1. In the lower left corner, there is the switch for the disconnection of the 48 Volt (DC) "input" (current from the battery system). Next a 20A fuse (DIN) can be observed.
2. The middle and upper part is occupied by the main circuit board, which has no user-adjustable parts and should not be altered or manipulated under any circumstances. This section also includes a cooling system with ventilator. This ventilator is started automatically when the temperature exceeds a preset value. On the main circuit board a green LED which indicates operation can be observed. See **figure 3**.

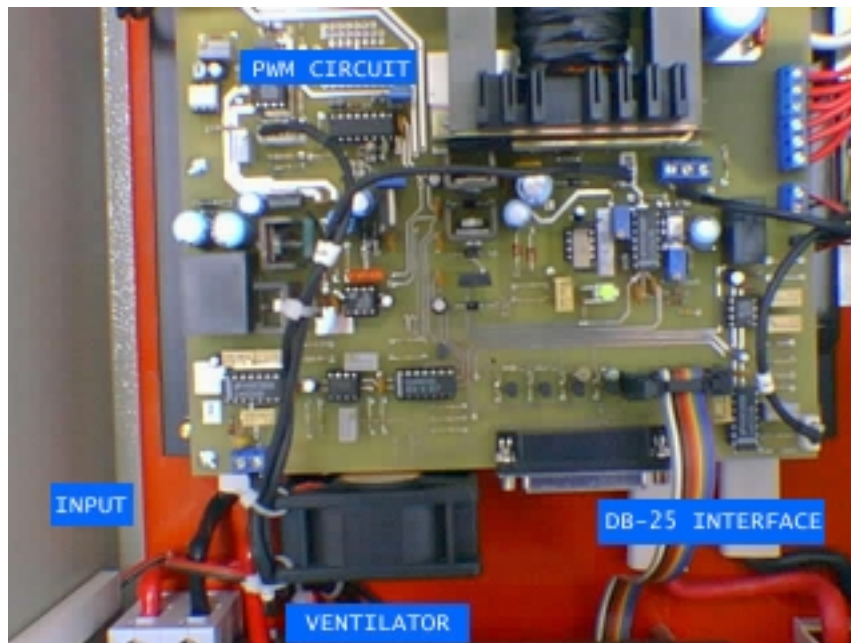


figure 3 - Main Board and Circuits

3. The connection with the casing-output can be seen on the lower right side.
4. In the lower part a sub-panel with controls can be seen, which allows the adjustment of the level of current and voltage and also checking the state of the system. The sub-panel with all switches and indicators is shown in **figure 4**.

From left to right the controls are:

1. LCD Display: Shows the final current en Amperes.
2. Red LED V_HI: Indicates a circuit shutdown due to too high battery voltage. It will light up together with the flashing green LED for shutdowns.

3. Red LED V_LO: Indicates a circuit shutdown due to too low battery voltage. It will light up together with the flashing green LED for shutdowns.
4. Red LED TEMP: Indicates a circuit shutdown due to excessive temperature in C3b. It will light up together with the flashing green LED for shutdowns.
5. LED flashing green CORT: Indicates malfunction or manual shutdown.
6. Potentiometer for regulating the Output Voltage.
7. Potentiometer for regulating the Maximum Output Current.
8. Switch (CORT) for producing a manual short circuit.

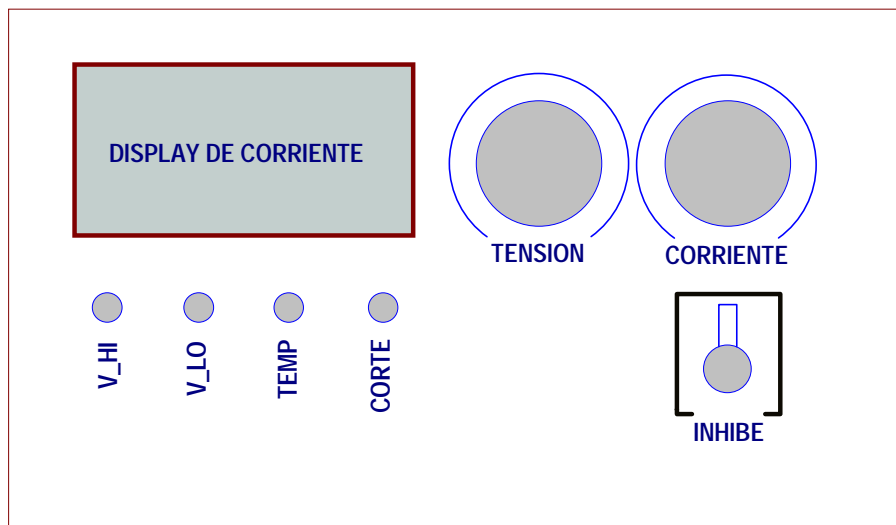


figure 4 – Diagram of the Front Panel C3b

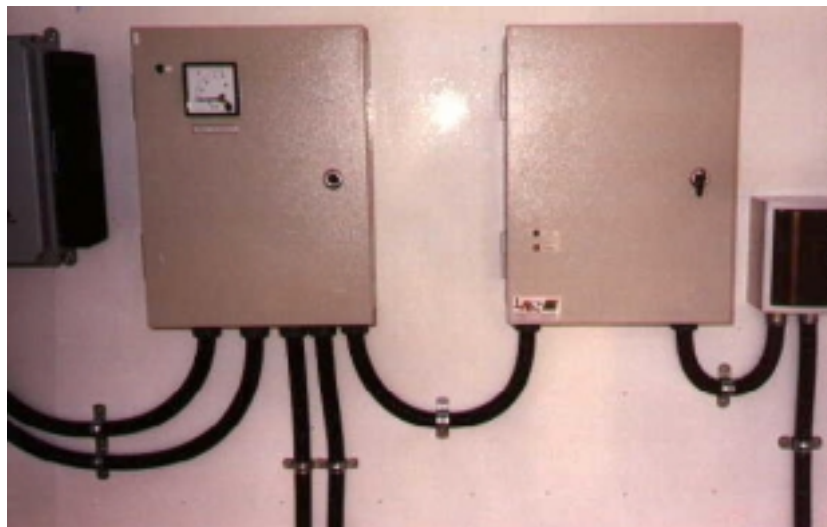
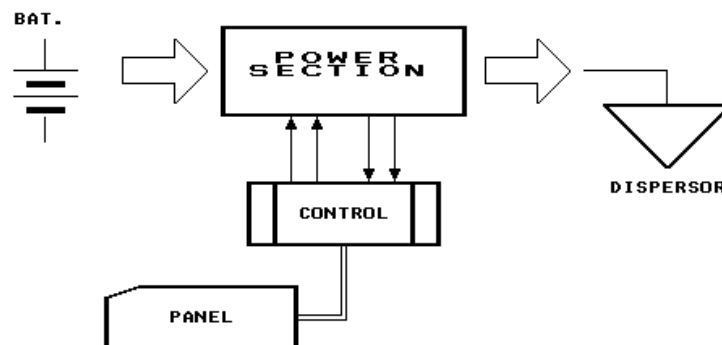


figure 5 – Instalation of the C3b (right) here connected to a Wind Energy System (constr. INGEZA./ Pérez Compans SA)

4. BLOCK DIAGRAM

CONVERTIDOR CC/CC C3b L&R INGENIERIA 1996



5. SUMMARY OF THE TECHNICAL CHARACTERISTICS OF THE C3b

Type: Switching DC/DC Converter

Architecture: Buck with MOSFET switches

Switching Frequency: 35kHz

Efficiency: Nominal 85%

Output Current: Adjustable from 3 to 15A

Output Voltage: Adjustable from 2.5 to 30V

Range of Input Voltage: Between 37 and 68V (DC)

Detection of discharged Batteries: Switch to Stand-By if $V_{bat} < 42V$ (1.72Vpc) for Pb-Acid / Gel Batteries with Hysteresis.

Detection of Over voltage: Switch to Stand-By if $V_{bat} > 68V$

Ventilation: Electric Ventilator plus Automatic Shutdown controlled by Temperature Sensor

External Indicators (Cover): Green LED = Normal Operation, Red flashing LED = Shutdown (causes: manual shutdown, too high or too low battery voltage or too high temperature shutdowns)

Indicator (Internal Panel):

- LCD Display for Actual Output Current
- Green LED = Normal Operation
- Green Flashing LED = Short Circuit
- Red LEDs indicate too low Voltage, too high Voltage or too high Temperature

Controls (Internal Panel):

- Potentiometer for adjusting output Voltage
- Potentiometer for adjusting output Current
- Switch for Manual Shutdown.

Data Acquisition: Interface for data acquisition and for checking the state of the system (Data Acquisition System T1/SBC – L&R Ingeniería) with a DB-25 connector.