HIGH-PRECISION RAMPED HIGH-VOLTAGE SOURCE WITH UP TO 50 kV OUTPUT VOLTAGE

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Abstract

This report describes the precision high-voltage ramped high-voltage power system. The output voltage up to 50 kV with 10 ppm precision. The power system consists of the 3 kW high-voltage source based on multiplier, precision high-voltage divider with digital interface and high-voltage discharge switch to provide low ramp-down time for output voltage. The power system is planned to use in the NIKA booster electron cooler project. The description and test results are presented.

DESCRIPTION

The presented source was designed as part of electron cooler for booster ring of NIKA project (JINR, Dubna). The booster operating circle scenario is shown on Fig. 1. The electron cooling is planned to use at the injection plato and at the extraction plato. That was reason for some specific terms like: low transient process time after voltage increase, high voltage stability (10 ppm) in the full range of output voltage. The high-voltage terminal (see cooler electrical diagram Fig. 2) is the sourse of 2-3 mA current ripples at 150 and 300 Hz. So the high-voltage source have to suppress load voltage variation generated by this ripples to the 10ppm level. The basic characteristics of high-voltage source are shown in Table1.

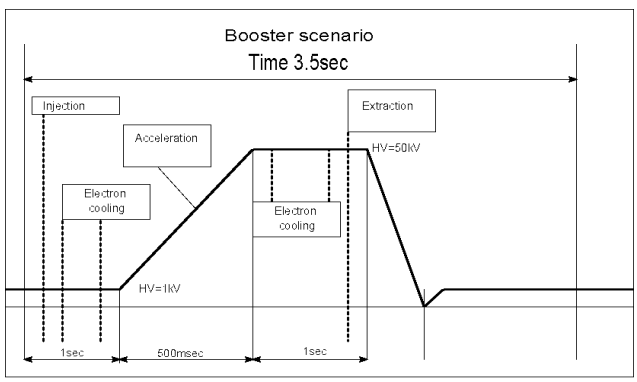

Figure 1: Booster operating cycle scenario.

Overview

The high-voltage source consists of the 20 kHz power converter, high-voltage transformer with the two-stage multiplier (part B) the separate precision high-voltage divider with digital output (Part C) and the ripple suppressor (Part D). The power converter with high-voltage multiplier generates 0-50 kV output voltage. The precision high-voltage divider is used for feedback loop. The analogue ripple suppressor is used to decrease output voltage variations at 150 and 300 Hz caused by the external (from load) current ripples. The suppressor increase effective gain of feedback system at these frequencies.

Table 1. Basic Characteristics of High-Voltage Source

Parameter	Unit			
		Min	Nom	Max
Output voltage	kV	0.5	50	55
Output current	mA		0.2	10
Output power	kW			3
Voltage ripples(nom load)	ppm			10
Long term stability	ppm			10
Transient time	ms		100	
Converter frequency	kHz		20	

Power Converter

The power converter uses two DC-link stage to decrease voltage ripples. First AC-DC converter supply its output with stabilized 50 VDC voltage. The boost stage can increase this voltage to level 50-250 V in depends on specified power source output voltage. This boost stare feeds the 20 kHz full-bridge inverter operates with PWM modulation to precision regulate the output voltage.

High-Voltage Transformer and Multiplier

Sectioned high-voltage transformer consists of two high voltage sections, joined in series. The nominal output voltage of transformer is 30 kV. The multiplier has two parallel connected brunches. Each brunch is the same.

The multiplier brunch is complete design and it includes multiplier, output filter capacitors, output current sensor and protection system voltage divider resistors. Output filter capacity is chosen to decrease output voltage 40 kHz ripples less than ±0.01% for full load operation, and 10ppm ripples at nominal output current. The silicon oil [1] is used as insulator the high voltage volume.

High-Voltage Divider

The separate precision high voltage divider is used for feedback system. This divider is located is separate oil tank heated to 40 °C. Its consists of two independent divider with and precision ADC board. The fiber link is used for output voltage data transmit to power source feedback system. In addition, the voltage information

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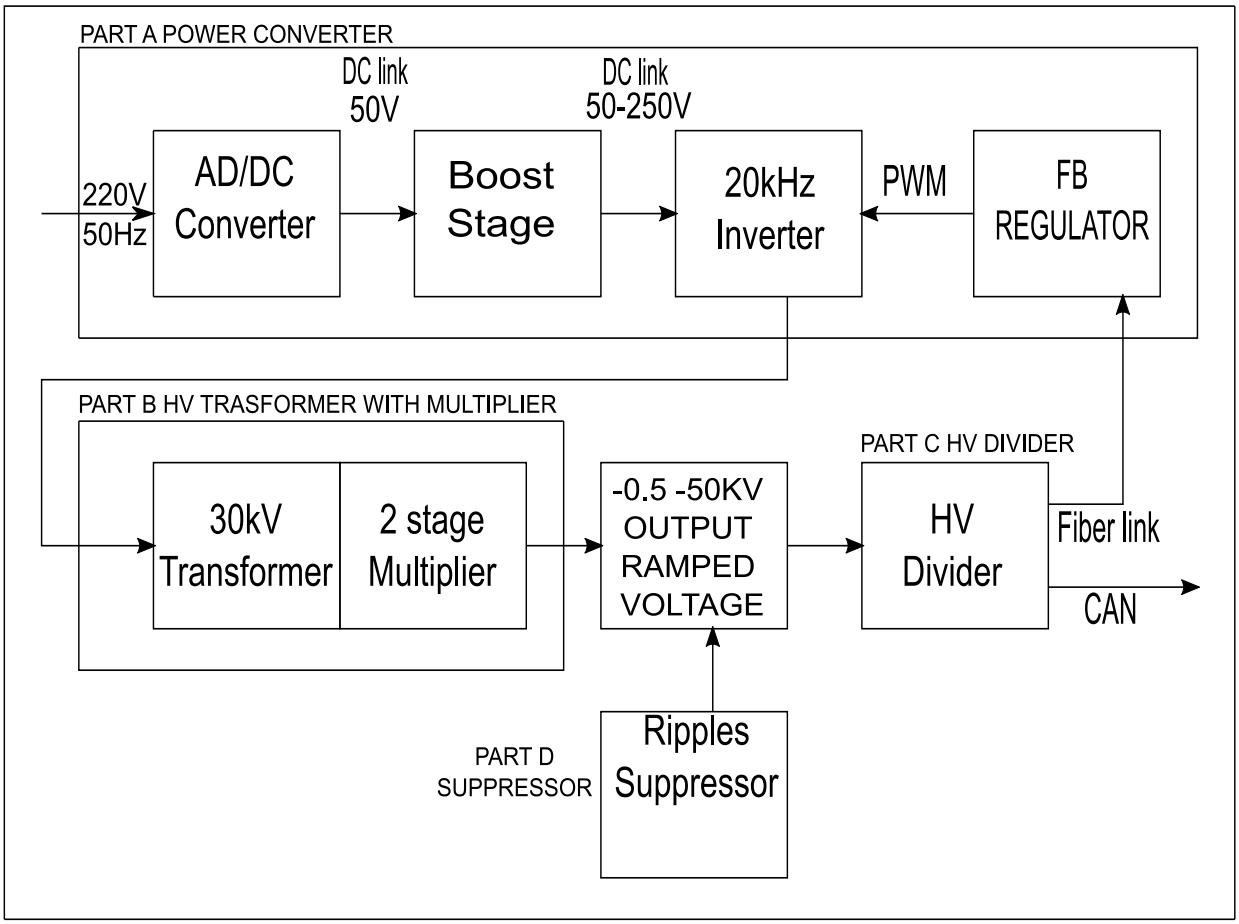

Figure 2: The high-voltage source block-diagram.

controller send with CAN-bus interface the cooler control system. The used data rates are 125, 250, 500 and 1000 Kbits in second. The protocol of CAN-bus interface is compatible with devises produced in the BINP [2].

Ripples Suppressor

During the tests was discovered that the cooler high-voltage terminal produce the 2-3 mA current ripples with 50, 150 and 300 Hz frequencies (Fig.3). The power converters feedback system dynamic diapason cants decrease the high-voltage terminal voltage variations, produced by this ripples the 10 ppm level. So the additional suppressor was designed and tested. This suppressor operates at injection and extraction plato and increase effective gain twenty thirty times depends on frequency.

Design

The high voltage source is made in one 4U crate in the rack of 19" Euromechanics standard, two high-voltage volumes with oil isolation, one for multiplier and one for high-voltage divider and separate suppressor located near the load. The high-voltage divider operates with heated to 40°C oil to the compensate ambient temperature variation.

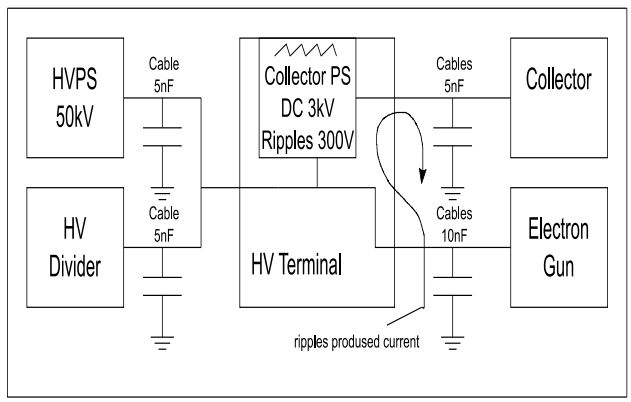

Figure 3. The Cooler high-voltage terminal.

RESULTS

The high-voltage source was designed tested and now it ready to use at JINR. The tests are shown high reliability, long term stability better than 5 ppm and voltage ripples level less than 10ppm during the operating cycle (see fig. 4).

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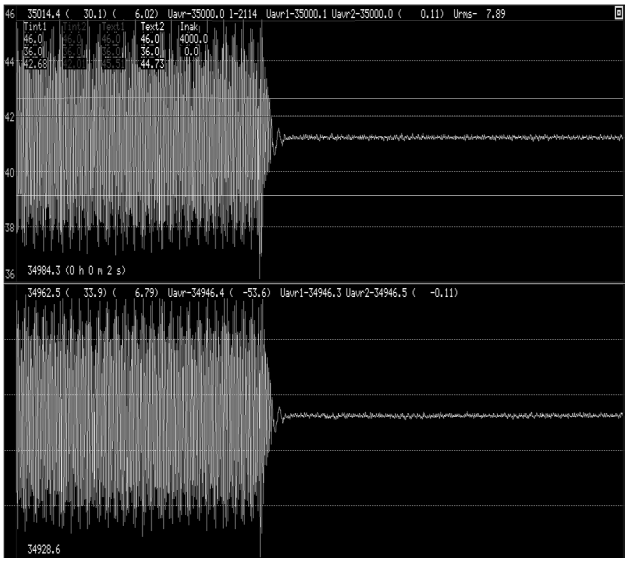

Figure 4: Suppressor operates. Decrease Cooler HV terminal voltage ripples from 100 ppm to 10 ppm.

REFERENCES

[1] http://www.sofex.ru/pdf/SOFEXIL-TCJ.pdf. Transformer fluid technical manual.

[2] V. R. Kozak, M. M. Romakch “The devices vith CANBUS interface for automatic control systems of physical complexes” pre-print BINP 2004-68, 2004.

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