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Measurement of the influence of changes in the HV converter SW on the input impedance

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Abstract This paper, we focus on the measurement of the effect of the SW filter division frequency shift of the measured input voltage on the value of the input impedance at an input signal frequency of 50 Hz. The aim of the measurement is to find out what effect this shift has on the input impedance and thus on the performance and efficiency of the whole system.

Keywords impedance matching, measurement, high voltage

JEL L63

1. Introduction

A SW HV inverter (Switched Voltage Network Inverter) is an electronic device that is used to change one voltage system to another. It is a device that can change the voltage and current in different circuits. Nowadays, it is increasingly used as a means of regulating voltage and current in the event that, for example, it is necessary to adjust the voltage and current from the production of solar panels for homes or businesses.

The SW HV converter allows the conversion of one voltage system to another by means of different switches. These switches open and close the circuits so that the voltage and current can be regulated. Thus, a SW HV converter is a device that can change the voltage and current in different circuits. Nowadays, SW HV inverter is used in various applications such as voltage and current regulation in the case of solar panels for homes or businesses. It is also used in voltage and current regulation in electric vehicles or voltage and current regulation in various industrial applications. SW HV converter consists of various components such as transistors, diodes, capacitors and transformers.

These components are used to form various circuits and to regulate voltage and current. For example, capacitors are used to maintain a constant voltage, diodes are used to protect the circuit from return current, and transistors are used to open and close the circuit.

2. The effect of the converter on the input impedance

The goal of the described experimental measurements was to verify the influence of changes in the control SW of the HV inverter CZE on the input impedance. The measurements were carried out on the ST-JN-3-1 bench at input voltage U_{in}=1500 V DC and load power P=26 kW.

2.1. Effect of changing the SW filter frequency of the measured input voltage

The measured value of the input voltage U_{in} passes through a low-pass filter in the control software and then enters the D_{shift} calculation block, whose output directly affects the reference value entering the PWM modulator. The input impedance was measured for filter frequencies of 80 Hz, 250 Hz, 500 Hz and 1000 Hz. The measured values are shown graphically in Figure 1.

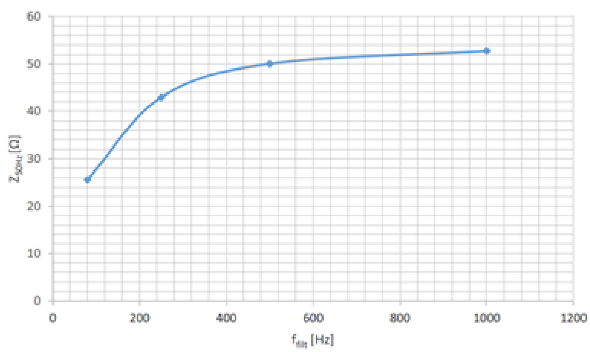

Figure 1. Measured waveform of input impedance vs. SW filter frequency for 50 Hz input signal.

In the measurement, it was found that the shift of the division frequency has a significant effect on the value of the input impedance. Specifically, as the filter frequency increased, the input impedance decreased. This can have a negative effect on the reliability and efficiency of the overall system.

The effect of the division frequency shift on the input impedance is important in terms of control and regulation of power converters. In the case of using a static power converter as an auxiliary drive of a rolling stock, it is critical that the input impedance meets the specified criteria according to UIC 550-3. This standard specifies that the input impedance of a static power converter must meet certain criteria to ensure reliable operation and minimise power losses.

Currently, active input impedance control attempts to raise the input impedance above the required limit. Experiments are aimed at changing the coefficients for different frequencies, with the calculated values used for linear compensation. The control program of the power converter is then modified according to the experimental results.

Overall, the effect of the SW filter cut-off frequency shift on the input impedance is an important topic in terms of power converter control and regulation. Finding out the optimal filter frequency can improve the reliability and efficiency of the whole system, which has a positive impact on the operation.

Next, the dependence of the input impedance of the converter on the frequency of the injected signal was measured using control software with the input voltage filter frequency adjusted to 1000Hz. The measured values are for comparison to the graph from the previous measurements with the unadjusted filter (Fig. 2).

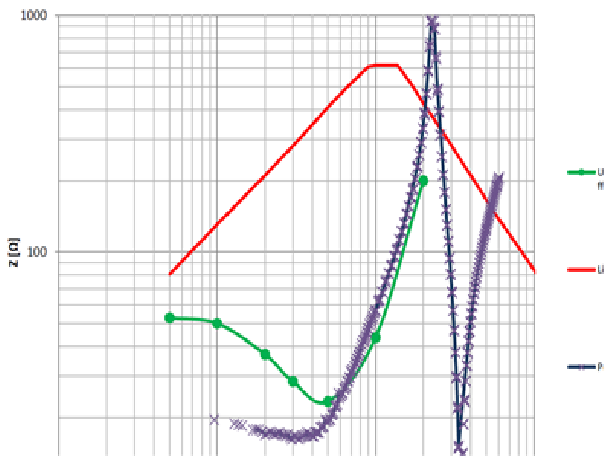

Figure 2. Measured input impedance waveforms with the modified SW filter value and with the original SW

2.2 Input impedance measurement with added ripple compensator of current to SW HV converter

In this measurement, the effect of adding a ripple current compensator to the control SW of the HV converter on the value of the input impedance was investigated. The AC component is separated from the measured input voltage, which is multiplied by a factor (gain) A and directly affects the reference value entering the PWM modulator of the HV converter.

This compensates for the effect of the input voltage ripple on the input current ripple of the converter, which should lead to an increase in input impedance. The dependence of the input impedance on the gain value A of the compensation term was measured for the values of input signal frequencies of 50 Hz, 100 Hz, 200 Hz and the SW filter input voltage frequency of 1 kHz and 1,5 kHz.

The measured input impedance waveforms are shown graphically in Fig. 3.

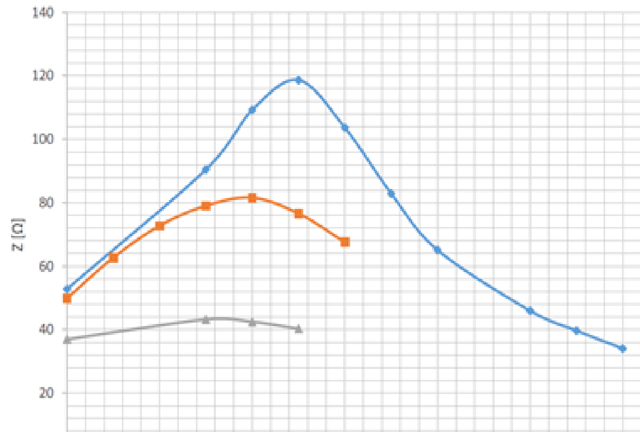

Figure 3. Input impedance waveforms as a function of compensator gain

Furthermore, the dependence of the input impedance on the frequency of the injected signal was measured with the addition of A=0.5 compensation element with constant gain A=0.5 to the control SW of the HV converter. The measured waveform of the impedance is shown in the graph in Fig. 4.

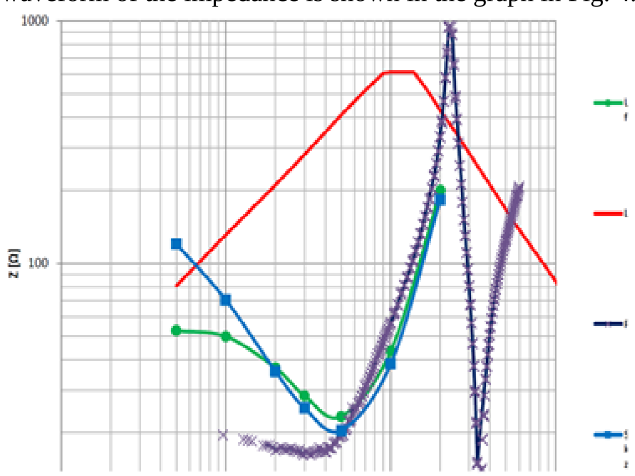

Figure 4. Measured input impedance waveforms with adjusted SW filter value, with added current ripple compensator and with the original SW

3. Conclusions

In this paper, we address the issue of the input impedance of a static HV converter, which is a critical parameter for the control and regulation of converters in a powertrain. According to the UIC 550-3 standard, the input impedance of a static HV inverter used as an auxiliary drive in powertrain vehicles must meet certain criteria to ensure reliable operation and minimize power loss. In this work, we try to find out how and what modifications to the dilution software can help to increase the input impedance. The first step was to investigate the effect of the SW filter divider frequency shift of the measured input voltage on the value of the input impedance at an injected signal frequency of 50 Hz. The measured value of the input voltage U_{in} is low-pass filtered in the controlling SW and then enters the D_{shift} calculation block, whose output directly affects the reference value entering the PWM modulator. The input impedance was measured for different filter frequencies, namely 80 Hz, 250 Hz, 500 Hz and 1000 Hz.

From the measurements, it was found that shifting the filter cut-off frequency to higher values results in an increase in the input impedance, especially at lower frequencies of the injected signal.

At frequencies above 500 Hz this effect is negligible. In the next step, we added a current ripple compensation block to the dilution SW of the HV converter and investigated the effect of this compensator on the input impedance increase.

From the waveforms, we saw that the maximum impedance was obtained for a certain optimum gain value of the A_{opt} compensation element, while this value varies for different frequencies. As the frequency increases, the value of optimum gain decreases. From the input impedance waveform, we saw that further increase in input impedance was achieved at lower values of the frequency of the injected signal. For a frequency of 50 Hz, the input impedance value was achieved.

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