

Article: SiC Inverter for tram propulsion systems – introduction into service

Introduction

All new propulsion system components must undergo detailed tests to ensure their safety and reliability before they can be used while carrying passengers. When a new traction inverter is to be used, the factors that must be examined include the tram's dynamic parameters and EMC interference, as well as the voltage levels in the contact line during recuperation.

Installation on a tram

The small mass and compact dimensions of the ENI-ST600/SiC.2 inverter, described in a [Previous Article](#), made it possible to install without making any structural changes to the Cityrunner tram. The only thing required were special adapters to reduce the spacing between the mounting points, due to the much smaller dimensions of the SiC inverter compared to a traditional one. The integration of the new inverter with the tram went very smoothly, since the high versatility of the SiC inverter's software made it possible to adapt its communication protocol to the other components already installed on the tram. The first static and dynamic tests took place at the Łódź tram depot, where the functionality and traction performance of the SiC inverter was verified.

Tests

One of the first tests that the tram had to undergo after the installation of the new inverter was electromagnetic compatibility testing, concerning both magnetic and electric field emissions; the tram would not be permitted to travel otherwise. These tests were carried out by the ENIKA company.



Figure 1 CityRunner tram EMC tests

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Figure 2 Electric field emission test in the 30 Mhz – 1 GHz range

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Thanks to the use of optimised software and the appropriate filters on the inverter itself, the ENI-FT600/SiC.2 passed the EMC tests on the very first attempt.

An example is presented below, of an electric field emitted by a tram equipped with a SiC inverter while in motion.



Figure 3 Radiated interference (electric field), horizontal antenna polarisation, tram in motion

The other procedures conducted before the tram was permitted to travel were the tests of all braking modes, including standard service braking, rapid braking and emergency braking. These tests were carried out by the Institute of Urban and Regional Development in Warsaw. As part of these tests, a tram equipped with the ENI-FT600/SiC.2 inverter had to achieve a sufficiently short braking distance as well as proper acceleration while braking. All of the latter tests were successful as well.

The final procedure was a series of test drives around the city in a tram equipped with the ENI-FT600/SiC.2 inverter. Its purpose was to analyse the behaviour of the tram drive during normal operation, as well as to check for any possible interference generated by the tram on the current collector, including the observation of voltage increases on the contact line and energy recuperation to the contact line. The all-night-long test confirmed that both the software and the ENI-FT600/SiC.2 inverter work properly.

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Summary

The results of all the tests described above were positive. This was not only due to the successful mechanical and electrical design of the ENI-FT600/SIC2 inverter, but also its excellent control algorithm. By increasing the inverter's switching frequency, it was possible to reduce the motor current pulsations and render the entire propulsion system inaudible during operation.

Lower motor current pulsations and a higher switching frequency have resulted in extremely precise operation of the inverter current regulators, and thus more accurate motor torque control. Thanks to this, the drive system equipped with the ENI-FT600/SIC.2 inverter allows the tram to operate very smoothly while maintaining excellent dynamics and comfort indicators.

After passing all tests required, the tram with the new SiC technology-based inverter has begun supervised trials, which will last several months. These will verify the reliability of the new technology and collect data regarding the possible energy savings that a widespread introduction of this technology can bring.

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