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News Release

June 28, 2021

Collaborative Research with the Swiss Federal Institute of Technology

Development of Integrated Motor Drive Systems Using Wide-bandgap Semiconductors

Through collaborative research with the Power Electronic Systems Laboratory (Location: Zurich, Switzerland; Head: Prof. Johann W. Kolar) of the Swiss Federal Institute of Technology in Zurich (Eidgenössische Technische Hochschule Zürich, hereinafter referred to as "ETHZ"), Nabtesco Corporation (Headquarters: Chiyoda-ku, Tokyo; President: Katsuhiro Teramoto) has developed a motor-integrated power factor corrected (PFC) rectifier and inverter output stage (hereinafter referred to as "IMDS" (Integrated Motor Drive System)), which can operate from a single-phase power supply without electrolytic capacitors, and alternatively can be powered from a DC source. Moreover, a motor-integrated modular inverter concept (hereinafter referred to as "IMMD," Integrated Modular Motor Drive) that employs stacked inverter cells for supplying associated three-phase motor winding sets and features build-in redundancy has been conceptualized and demonstrated in hardware. In both cases, high power density and highly efficient realization were able to be achieved by taking advantage of the high switching speed and low conduction losses of latest wide-bandgap (WBG*) power semiconductor technology.

*WBG, i.e. SiC (silicon carbide) and GaN (gallium nitride) power semiconductors are excellent candidates for the implementation of next-generation power elelctronic switches due to their high voltage-blocking capability and high admissible operating temperatures, in addition to high switching speeds and low conduction losses.

Nabtesco Corporation started collaborative research with ETHZ in 2014 for the purpose of developing novel power electronics concepts as well as motion control systems in order to prepare future disruptive innovations in motor drive technologies.

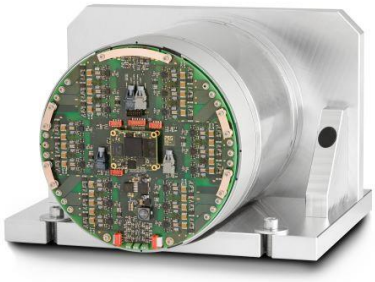
The newly developed IMDS is designed based on the specifications of a 7.5-kW electric air compressor for railway brakes, and employes a novel control concept which allows buffering of the inherently large power pulsation of a single-phase power supply using only the moment of inertia of the electric motor. In combination with a PFC rectifier front-end, built using SiC semiconductors, with regard to the inverter output stage, a purely sinusoidal current consumption (power factor of 1, THD / total current harmonic distortion of typ. less than 2%) and full EMI compliance is guaranteed. Overall, high reliability and miniaturization

are achieved without using electrolytic capacitors that may limit lifetime due to aging resulting from high current stress and/or elelvated operating temperature. In addition to 60Hz AC supply voltages of 360V to 480V, the system can also handle a wide DC input voltage of 60V to 110V and features a power conversion efficiency of 98% and a volumetric power density of 5 kW/L (excluding the motor body). By applying the novel IMDS, it will be possible to, for example, initially operate an attached compressor from a battery, which is necessary to raise the pantograph when starting a railroad vehicle, and to subsequently continue compressor operation at normal voltage with very low electrical noise in the overhead line or vehicle thanks to the properties of low current distortion or high power factor, respectively. Advantageously, the IMDS technology can not only be applied for single-phase mains supply but also for unbalanced three-phase and DC input, and accordingly covers the needs for electrification in a wide range of application areas.

The IMMD system employs 6 low-voltage GaN (gallium nitride) converter cells which are connected in series at the DC input side. By using GaN power semiconductors with high switching speed and low on-state losses, a high power conversion efficiency is guaranteed, and considering future wide-ranging adoption of GaN devices, low cost can be expected. The built-in redundancy ensures high reliability. Even if an inverter cell fails, the remaining cells keep the motor rotating. Further development can be expected, aiming for variable speed motor drive applications which require high reliability, such as aircraft, commercial vehicles, and ships.

We will continue to contribute toward the realization of a carbon-free society in the industrial world through technological developments and innovations that meet the needs for electrification of various motion control systems.

Electrolytic capacitor-less single-phase to three-phase SiC AC/ AC Integrated Motor Drive System (IMDS).



Stacked GaN multi-cell inverter Integrated Modular Motor Drive (IMMD) featuring built-in redundancy.