# Inverter improvement clears way for smaller, more efficient motor drive systems for electric vehicles

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A Purdue University professor of electrical and computer engineering and a recent Ph.D. graduate have found a way to make smaller, more efficient motor drive systems for hybrid and electric cars, trucks, trains, ships and aircraft.

Oleg Wasynczuk, a professor in Purdue's School of Electrical and Computer Engineering, and Minyu Cai have designed an improved power inverter that can be used to convert direct current electricity from a battery, fuel cell or other source into alternating current to power a motor.

Conventional power inverter technologies require passive filters to protect motors from side effects due to high voltage edge rates (dv/dt). However, the filters increased power loss, weight and overall volume. The Purdue researchers developed a circuit, entitled auxiliary resonant soft-edge pole (ARSEP), to control the dv/dt using a mechanism called soft-switching, which eliminates the need for a filter and further reduces power loss.

"High dv/dt can cause over voltages at motor or inverter terminals, electromagnetic interference and failure of motor bearings because of micro-arcs. These effects lead to shorter motor life times," said Cai, who received his Ph.D. from Purdue in electrical and computer engineering this year. "Our technology can reduce the dv/dt at a much lower cost

than passive filters."

Instead of adding passive filters, which are conducting all the time, the researchers' ARSEP circuit augments an inverter with auxiliary circuits that are active only during voltage transitions.

"The auxiliary circuits are only active for short time periods," Cai said, "Therefore, the average current going through the circuits are small, which results in lower power loss and smaller components."

The ARSEP circuit not only generates less loss than passive filters, it also can reduce the loss in the inverter main circuit through soft-switching.

"Soft-switching eliminates switching losses to almost negligible levels," Wasynczuk said. "So you are able to achieve a better efficiency compared to the current state of the art."

Cai and Wasynczuk have built a prototype of the ARSEP inverter with funding from the Department of Energy. In an 800-watt case study, the ARSEP circuit was 45 percent lighter, and occupied 61 percent less volume than a passive filter. The overall system loss was reduced by 20 percent.

"That is a significant improvement," Wasynczuk said. "Now we want to show it's commercially viable."

Virtually all variable-speed motor drive systems, such as those used in hybrid or electric vehicles, and grid-connected renewable generators, such as solar and wind, use inverters. This new technology has wide applications and it can be integrated into existing inverters. The researchers are hoping automakers, truck manufacturers, makers of trains, ships and aircraft, and other industries, such as heating,

ventilation and air conditioning, and solar power companies will be interested in working with them to further develop the inverter.

They say even with current considerations to ease fuel economy standards for automobiles and trucks, an improved inverter will still be sought by U.S. and global automakers.

"There are still incentives to electrify," Wasynczuk said.

Wasynczuk said other nations are seeking to phase out production and sale of gasoline and diesel vehicles. Among those nations and the years they plan to stop sales of fossil-fueled-powered vehicles are Norway (2025), India (2030), France (2040), Britain (2040) and the Netherlands (2040). China also has announced plans to limit carbon emissions by 2030, putting fossil-fueled vehicles in the target.

Provided by Purdue University