

# Round Robin for Variable Speed Drives

**EMSA6**  
UPDATED

The 4E Electric Motor Systems Annex (EMSA) promotes the opportunities for energy efficiency in motor systems by disseminating best practice information worldwide. It supports the development of internationally aligned test standards and policies to improve the energy performance of new and existing motor systems with the aim of achieving 20% to 30% energy savings.

Variable speed drives (VSD) attached to motors adjust the power output to meet the requirements of the end-use application and this can lead to large energy savings. However, there are energy losses associated with VSDs which affect their overall energy efficiency.

EMSA in cooperation with the International Electrotechnical Commission (IEC) launched the project to determine whether the current energy efficiency test methods provide accurate and repeatable results and if the level of reference losses described in these provide a sufficient incentive to encourage greater levels of efficiency. The test method to determine the losses in variable speed drives (and hence their efficiency) is described in two IEC standards<sup>1</sup>.

In this EMSA organised international Round Robin, independent testing laboratories in Australia, Denmark, Switzerland and the USA were funded by EMSA members.

This Policy Brief summarises the key findings of the Round Robin for converter losses.



## Observations for Policy Makers

- This Round Robin ran from 2017 to 2022 and is the first publicly available independent study that has systematically examined the efficiency of VSDs.
- During the Round Robin, 8 laboratories performed a total of 172 tests on 52 different converters in the range of 0.12 kW to 55 kW according to the uniform testing protocol devised for this project.
- This protocol has proven itself by returning highly repeatable and accurate results from a broad range of VSDs on the market and helped the IEC to eliminate ambiguities in the second revision of IEC 61800-9-2.
- The participation of independent test laboratories and the cooperation with IEC were crucial to the success of this project.
- The European Union, Switzerland and the UK were the first economies to adopt Minimum Energy Performance Standards (MEPS) for VSDs in July 2021.
- MEPS in these economies are set at the IE2 level, which is currently the highest (most efficient) class for VSDs specified in the relevant standards.
- The Round Robin has shown that the introduction of additional IE classes could enable further differentiation of VSDs, however, may not bring substantial added value in terms of energy savings. For many applications, energy can be saved effectively through variable speed control, reducing the losses in part load operation.

<sup>1</sup> IEC 61800-9-2:2017. Adjustable speed electrical power drive systems – Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications – Energy efficiency indicators for power drive systems and motor starters. IEC TS 60034-2-3:2013. Rotating electrical machines – Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors. Replaced by IEC 60034-2-3:2020 during the Round Robin Converters (RR'C).

### MORE INFORMATION

Published May 2023

Further information is available [here](http://www.iea-4e.org/emsa) on the EMSA website: [www.iea-4e.org/emsa](http://www.iea-4e.org/emsa) and by contacting [andrea.vezzini@bfh.ch](mailto:andrea.vezzini@bfh.ch) and [sbn@teknologisk.dk](mailto:sbn@teknologisk.dk).

## Key Findings

### Almost all VSDs on the market reach IE2

The standard defines two efficiency classes for converters: IE1 and IE2. All the measured VSDs met the IE2 class. The absolute losses of VSDs compared to the losses of electric motors are considerably smaller, with an average efficiency of VSDs of 97.5%. All VSDs tested showed an efficiency between 96% and 98% at nominal load.

The losses of all VSDs are clustered within the same IE-index area (IE-index of 0.2–0.6) and are much below the threshold for IE2 (IE-index 0.75), see Figure 1. Introducing additional IE classes could enable further differentiation, however, may not bring significant added value in terms of energy savings.

The most beneficial policy options are introducing MEPS for VSDs, as they exclude the lower performing VSDs from the market and by introducing information requirements for part load duty points (similar to the current European MEPS) as this would enable calculation of efficiency at part load. These could be combined with other policies that stimulate improving efficiency at a system level.

The Round Robin has shown that the correction factors introduced for VSDs with modified functionality tend to slightly overcompensate the additional losses, which in extremis, could mean that an IE1 VSD could be 'upgraded' to an IE2 by adding a filter. This could be addressed by reviewing the correction factors in the standard.

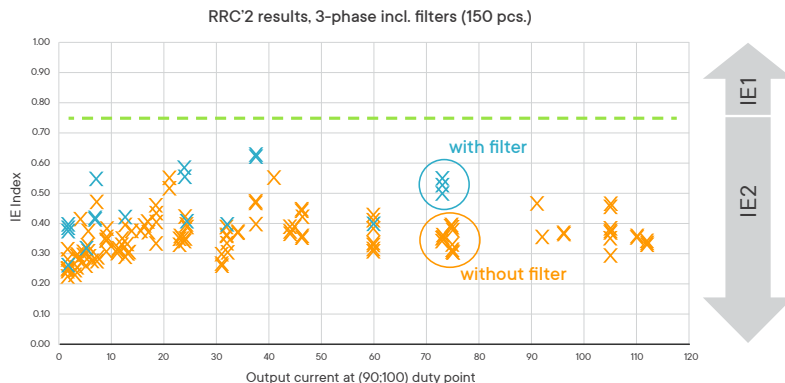


Figure 1: IE-index for 3-phase Basic Drive Modules over nominal output current at (90:100) duty point. Dotted line is the threshold between IE2 (below the line) and IE1 (above the line). Orange crosses: without filter, blue crosses: with filter. Note: the efficiency classes refer to the losses of the tested VSD and the losses of a reference VSD; the IE-index value is calculated by dividing the losses of the tested VSD with a reference VSD.

### Test results are good match with manufacturers' data

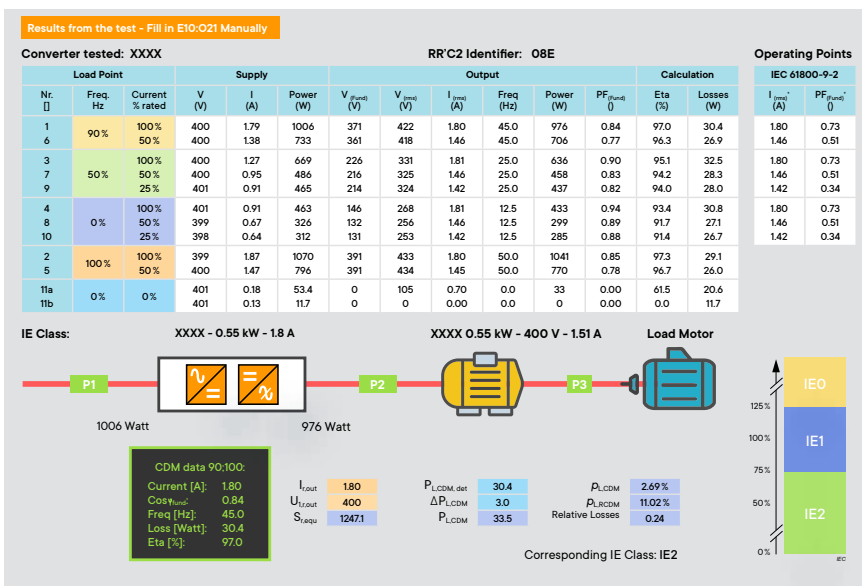
IEC 61800-9-2 gives only a prototype calculation model with some standard parameters, therefore, since most manufacturers do not disclose all the assumptions for their calculations, an independent third-party recalculation is not possible.

Hence, it was reassuring that the Round Robin test results were consistent with manufacturer catalogue data, presumed to be calculated.



### Uniform Testing Protocol taken into IEC 61800-9-2

The Uniform Testing Protocol of the Round Robin has proven to be a valuable test method that returns highly repeatable and accurate results from converter tests in different laboratories. Thus, the IEC has included the proposed modifications to eliminate the ambiguities regarding the repeatability of the testing method in the second revision of IEC 61800-9-2.



Output of the Round Robin reporting file.