ENGINEERING TOMORROW

Opportunities for increasing the efficiency of **variable speed drive systems**

Norbert Hanigovszki, Danfoss Drives
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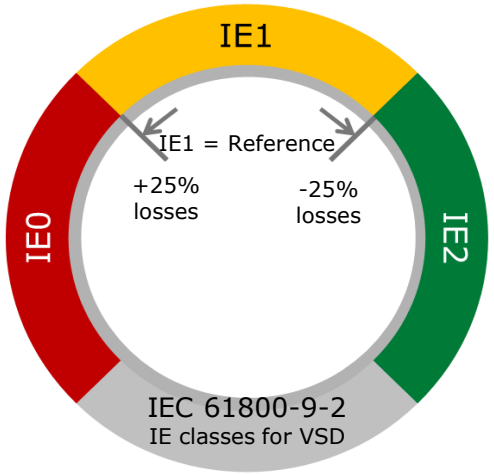
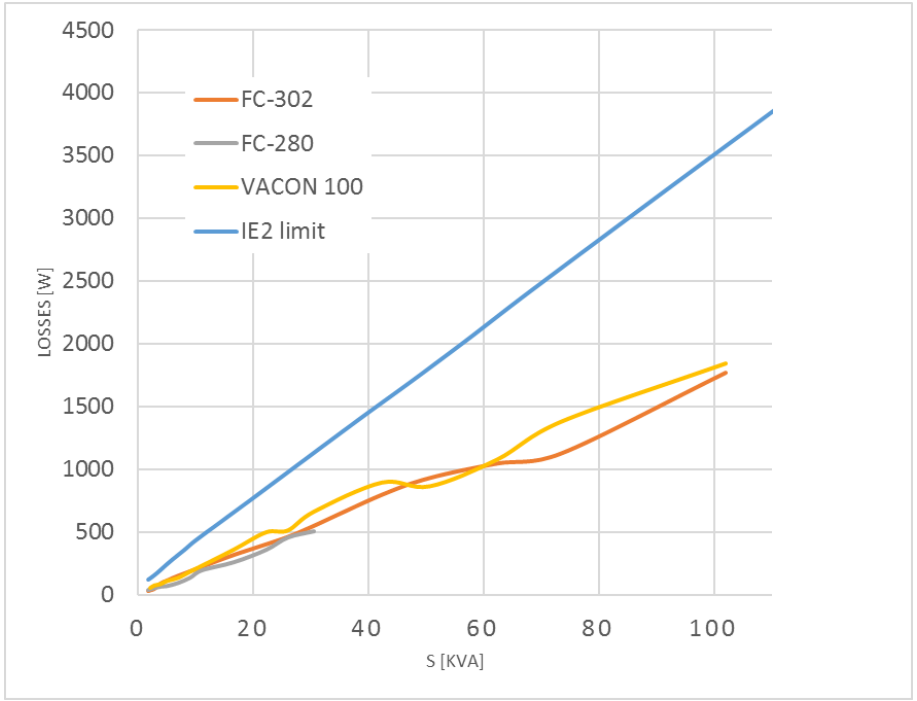
Background

- IE classes for variable speed drives (VSD) have been introduced by EN 50598 and IEC 61800-9
- Preliminary investigations show that all drives are well within the IE2 class
- Further investigations are necessary, for example to clarify the influence of filters
- The question about additional IE classes is still open …
- … however, will additional IE classes lead to efficiency improvements?





Efficiency vs. cost in drives

- Lower efficiency yields to more losses, which leads to more cooling requirement. This results in a larger size and higher cost.
- Higher converter efficiency results in smaller size and weight and lower cost (higher profitability) – assuming similar electronic component cost
- The physics of the losses is an incentive for the drive producers to make more efficient drives
- The example shows the latest development for a 400 kW drive

Old E-frame

8677 W losses

585 x 1547 x 498

(mm: w x h x d)

New E-frame

8036 W losses

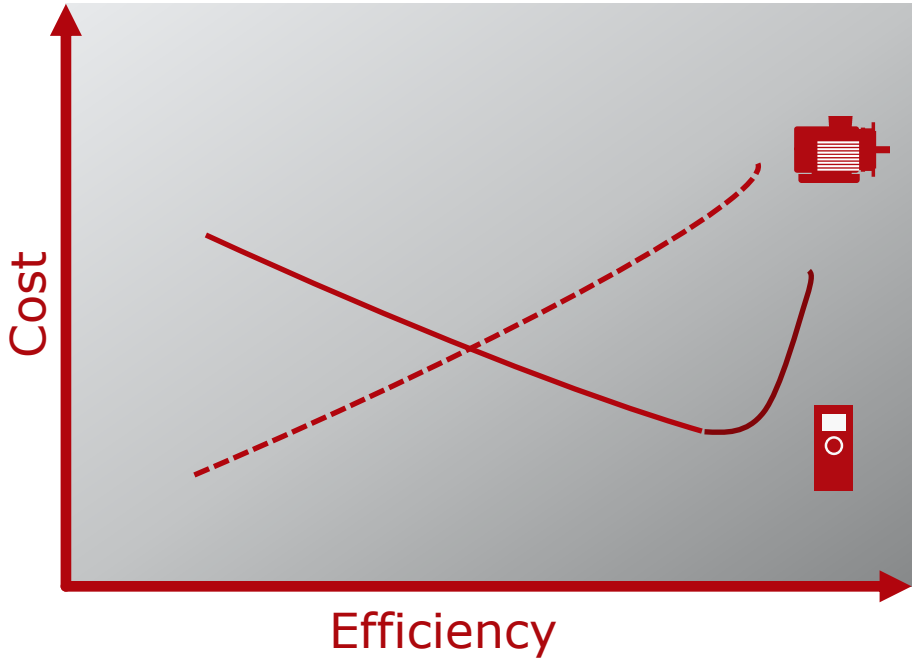
507 x 1578 x 482

(mm: w x h x d)

approx. 5 – 10% cost reduction

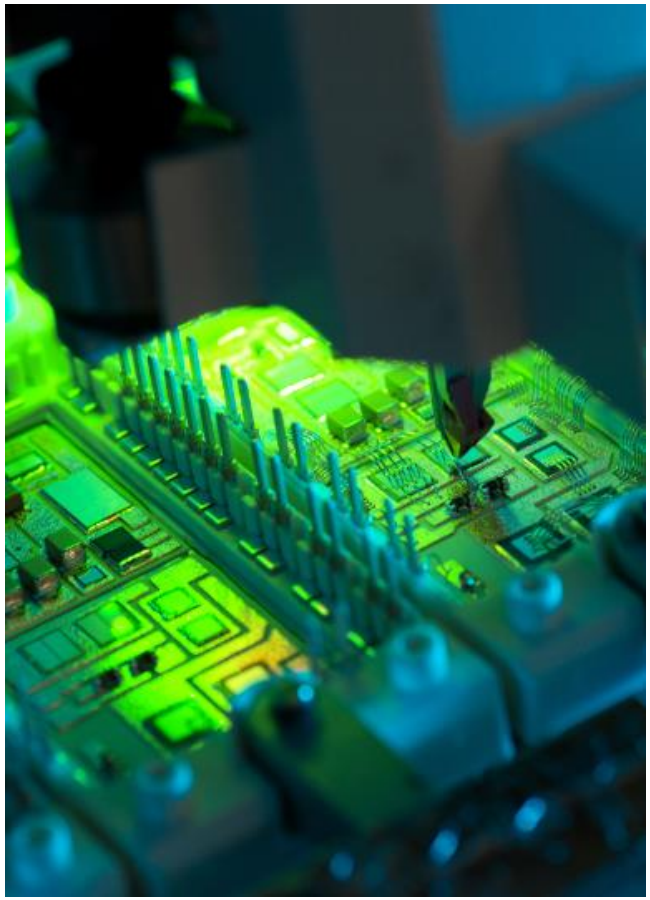
Drive efficiency compared to motor efficiency

- For drives: higher efficiency leads to lower cost for cooling and size reduction – up to a limit mainly caused by dU/dt
- For motors: higher efficiency leads to higher costs because more material is needed or more expensive materials are used (special low loss steels, permanent magnets)
- The incentives are different between drives and motors



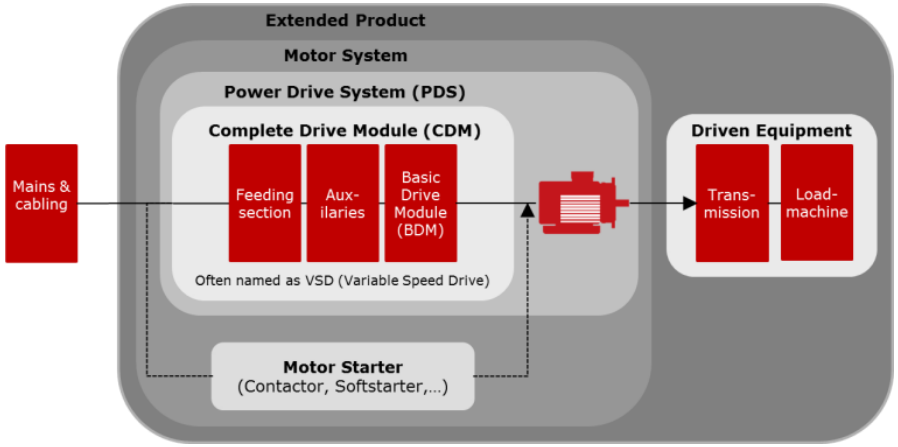
Efficiency increase in drives – opportunities and limitations

- Higher efficiencies can be achieved by lowering commutation losses
- There are possible solutions like wide bandgap devices with low switching losses (Silicium SiC, Gallium GaN, etc.) or multilevel topologies
- Faster switching has adverse effects on the motor isolation and requires an output filter. The filter adds extra losses and the total saving is small – if any
- Electromagnetic interference emissions increase because of the higher dU/dt



System level optimization potential

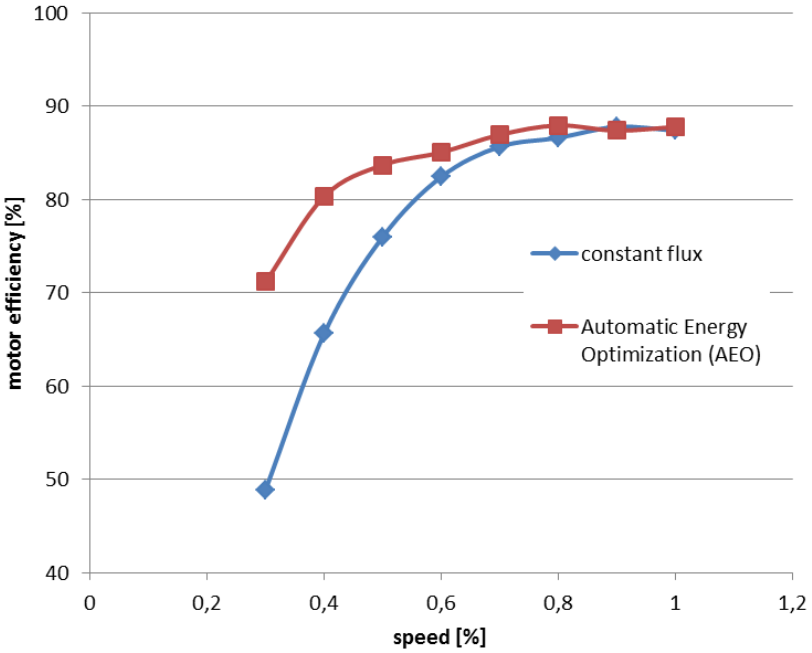
- ”Extended product approach (EPA)” is a fundamental concept in IEC 61800-9
- System level optimization yields larger efficiency improvement opportunities than component level approach
- An important enabler for EPA is the availability of partial load efficiency data for drives and motors
- Most drive manufacturers publish data
- Availability of motor part load loss data is still very limited
- Motor part load loss data can be expressed in two formats:
  IEC 60034-2-3 style or EN 50598 style – can be mutually calculated

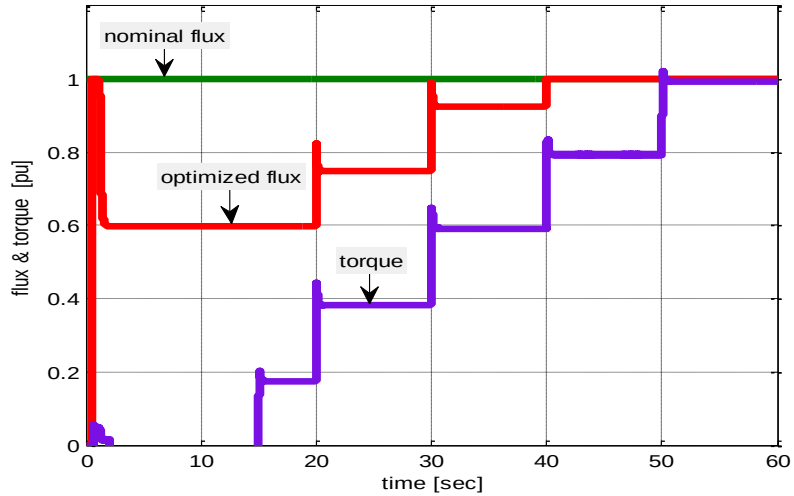


Speed, Torque	EN50598	IEC60034-2-3
100,100	☐	
100,50	☐	
90,100		☐
90,50		☐
50,100	☐	☐
50,50	☐	☐
50,25	☐	☐
25,100		☐
25,25		☐
0,100	☐	
0,50	☐	
0,25	☐	

Motor control influence

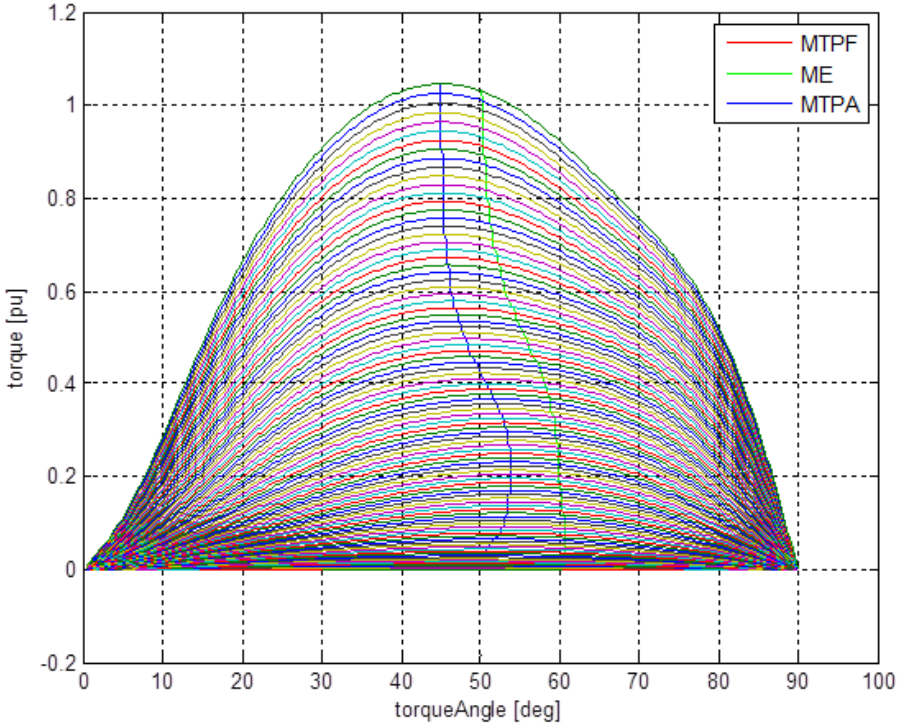
- The motor control algorithm of the drive influences system efficiency
- The effects of the control exceed by far the impact of the drive itself
- For induction motors, Automatic Energy Optimization (AEO) reduces magnetization flux in the motor, according to the working point
- The AEO function is commonly used in applications where the motor runs a long time under part load conditions – even in fixed speed applications such as escalators
- Similar function can be found in the products of many manufacturers, under different names





Synchronous motors (PM and SynRM)

- For synchronous motors (both PM and SynRM) a “Maximum Torque Per Ampere – MTPA” algorithm is used
- Iron losses in synchronous motors are significantly lower than in induction motors - there are nearly no losses in the rotor
- Therefore the aim is to reduce copper losses
- MTPA minimizes copper losses
- MTPA is slightly different from Maximum Motor Efficiency (ME), but closer to maximum system efficiency



Future trends

- More customers focus on **total cost of ownership** (TCO) and other similar indicators (lifecycle cost) – also in the purchasing phase
- Focus on TCO highlights the importance of system level approach and ability of predicting system efficiency in a standardized manner

- **Digitalization** leads to major opportunities
- For example, pumps loose efficiency during their lifetime because of factors such as wear-out, fouling, sanding, etc.
- **Condition monitoring** enables continuously monitoring the efficiency of the pump and triggering maintenance when the efficiency falls below prescribed parameters

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Norbert Hanigovszki
norbert@danfoss.com