Hubbell Industrial Controls

Steel Industry – Crane case study

Steel industry training – Scrap yard crane case study

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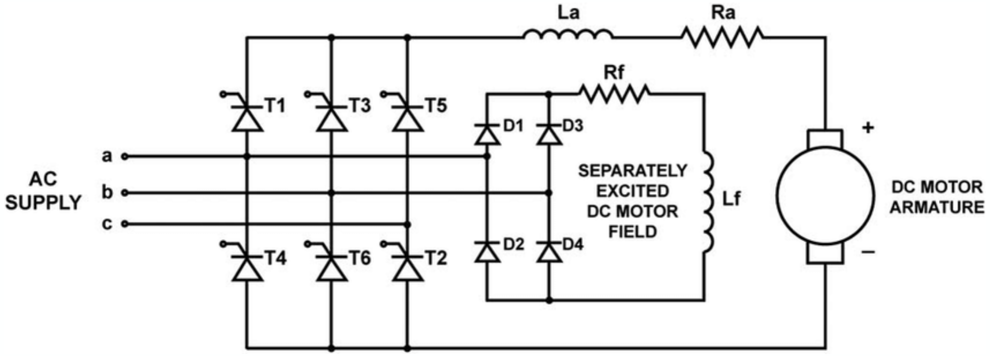
It's all about voltage.

DC driven hoist in a scrap yard crane

- A scrap yard crane (or any crane) is driven with a DC motor, especially in older installations
- The DC drive performance is dependent on **stable input voltage**, which is usually simply assumed by any electric system user when connecting
- However, the DC drive's interaction with the feeding electrical grid might cause the voltage to drop
- In this case we analyze how PQS APEX active harmonic filters help stabilize the voltage.

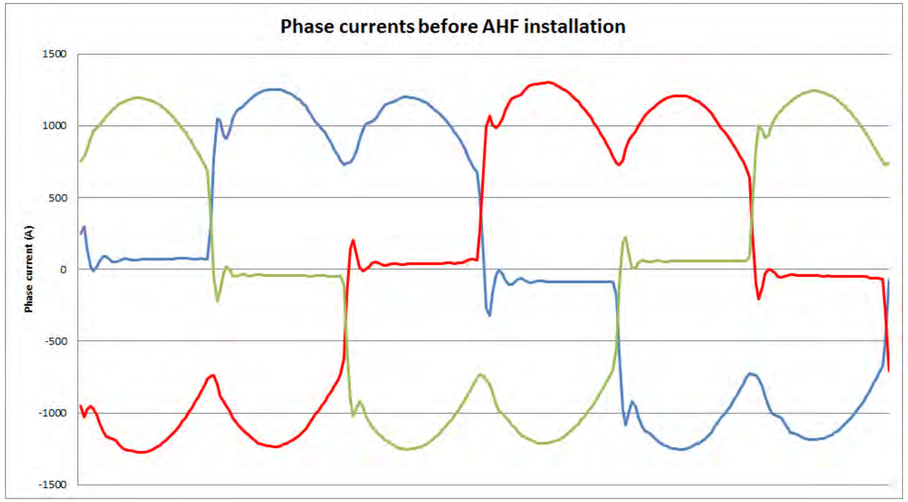
Thyristor-switched DC drive operation

- **The thyristors form a network-commutated switching bridge that converts the AC voltage to DC voltage that a DC motor can use**
- **The armature voltage at the DC motor is thus dependent on the available AC voltage:**
  - The DC voltage can be up to peak AC phase voltage
  - It may not be more
- **A thyristor-switched DC drive always consumes reactive power and has a significant harmonic current content**



Example of one DC drive topology

Source: Hoevenaars, A.H. & McGraw, Mike & Rittammer, Kerwin. (2015). Preventing Centrifuge Failure Due to Voltage Distortion on a Drilling Rig. IEEE Transactions on Industry Applications. 2015. 1-1.



Measured DC Drive currents

Thyristor-switched DC drive operation

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In any DC motor, the produced torque is directly dependent on the armature current:

$$T = K_a \phi I_a,$$

where K_a is the armature constant of the motor, ϕ magnetic flux per pole and I_a the armature current.

Thyristor-switched DC drive operation

The armature current itself is proportional the voltage applied to motor terminals:

$$I_a = \frac{V_a - E_b}{r_a},$$

Where V_a is the applied voltage, E_b is the back emf produced by the rotating rotor and r_a is the constant armature resistance.

The back emf is created in the rotor windings to balance the voltage applied to the armature, which then directs a specific rotational speed.

Thyristor-switched DC drive operation

For any electrical rotating machine

$$P_m = T\omega,$$

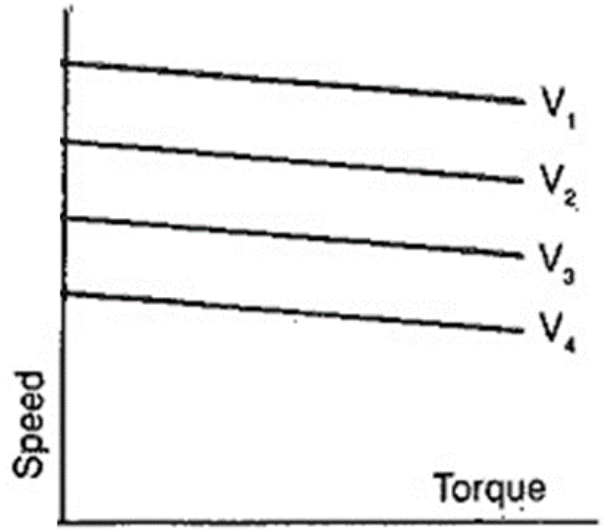
where P_m is the mechanical power of the machine, T is the generated torque and ω is the rotating speed.

Therefore with the same power **you can either get rotational speed or torque.**

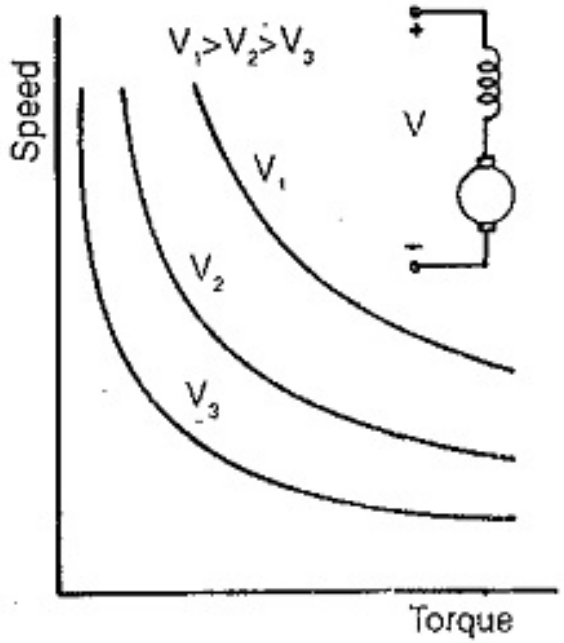
In a crane application the speed is controlled by the drive controller according to the application and the torque is dependent on the crane payload.

Thyristor-switched DC drive operation

To summarize, in a crane the target speed is usually constant, and the armature voltage is in relation to armature current and thus torque. This relationship can be illustrated with the following curves speed-torque curves with different voltages:



For separately excited motors, where the flux
Is controlled



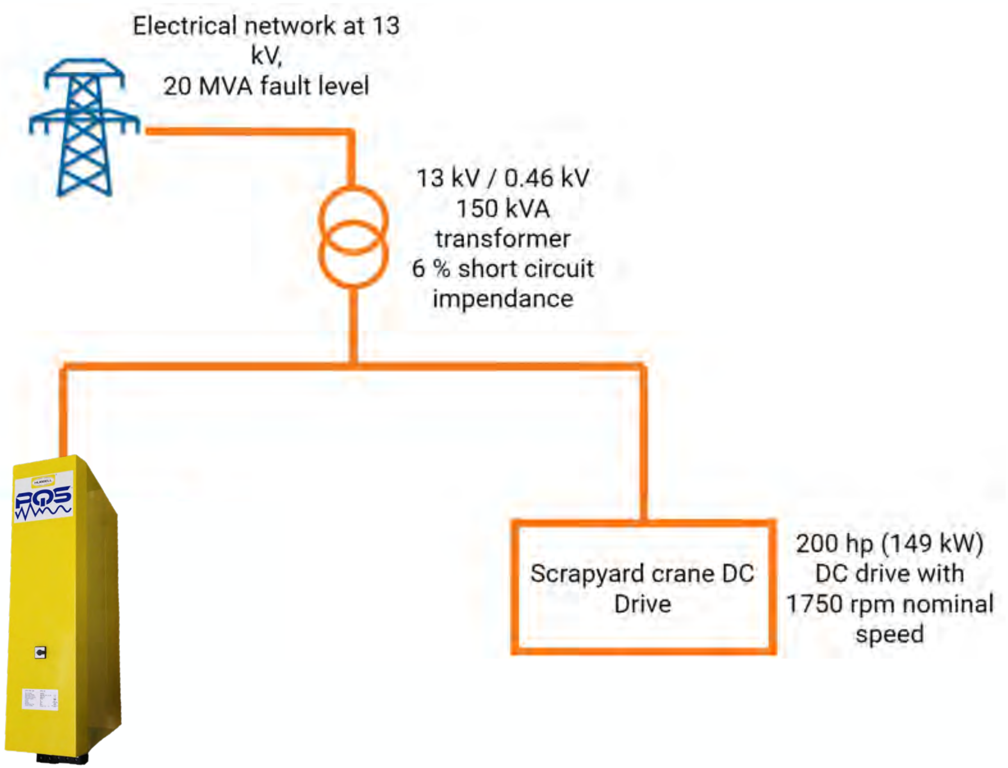
For series excited motors, where the flux
is also dependent on voltage

200hp crane DC drive example

5 seconds machine acceleration, start at 0.5 seconds

The crane duty drive is accelerated to nominal speed with the maximum load

So in practice we are trying to lift the theoretical capacity that the drive should be able to lift



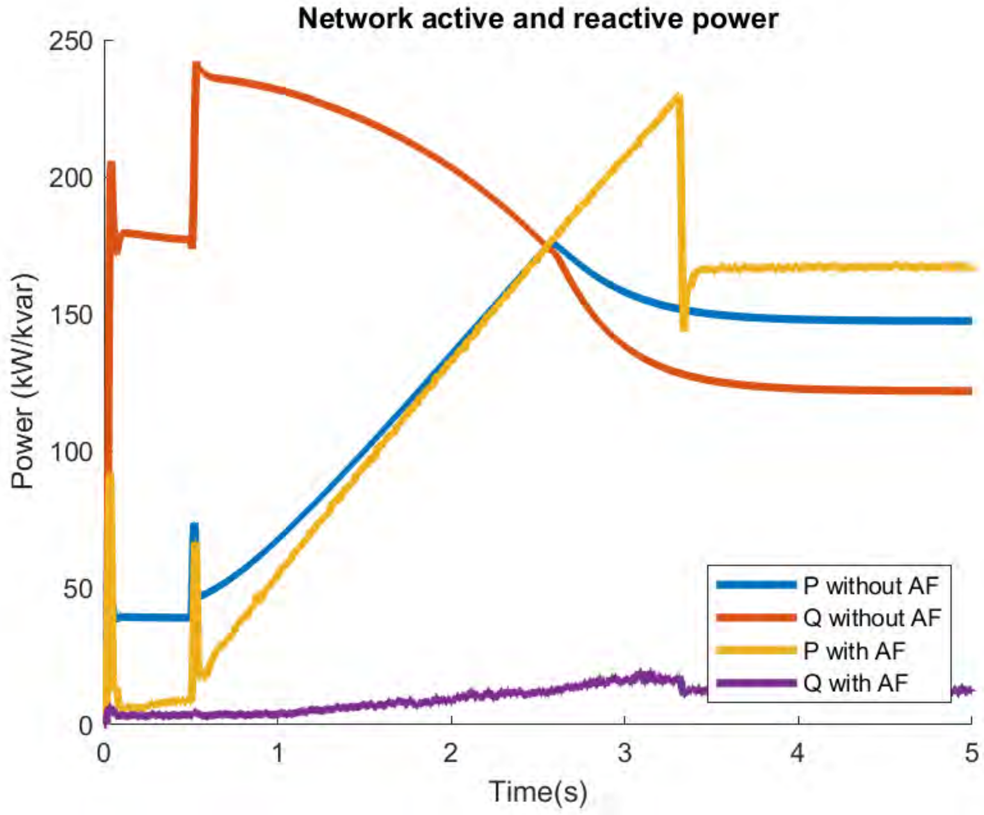
Hubbell Solution

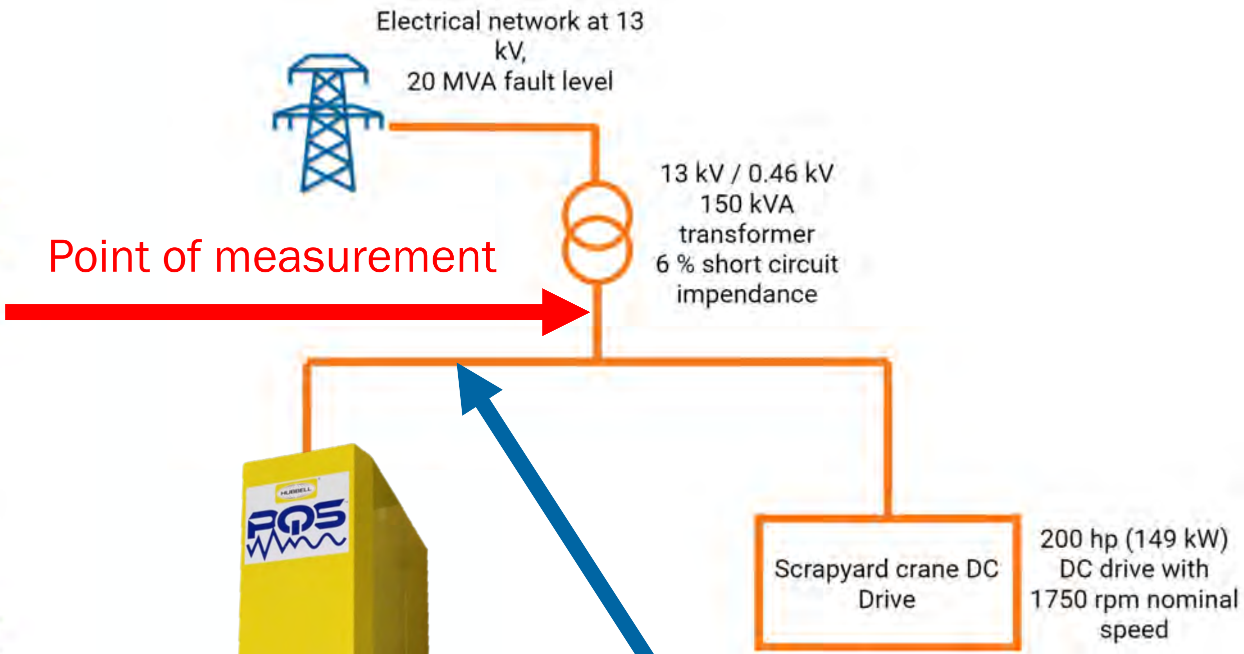
Dynamic reactive power compensation with APEX active harmonic filter sized to the specific case

Hubbell– Settings:
All harmonics –mode

Completely automatic carefree operation!

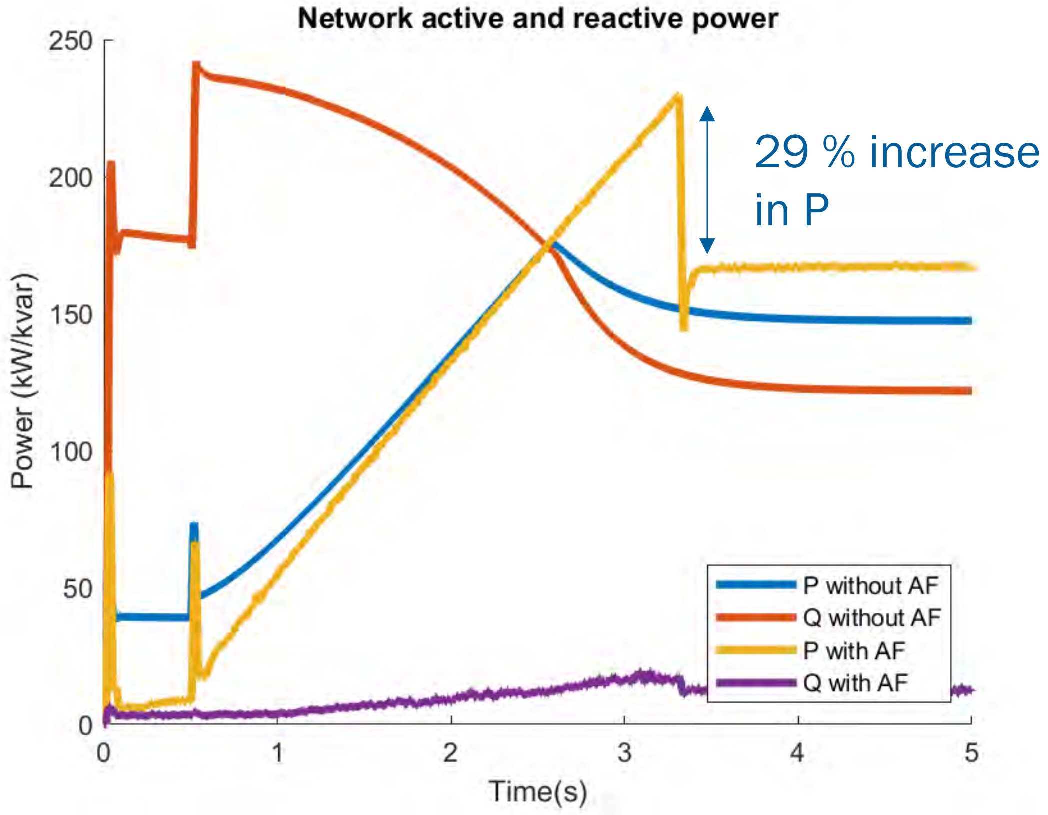
DC drive lifting operation – first 5 secs

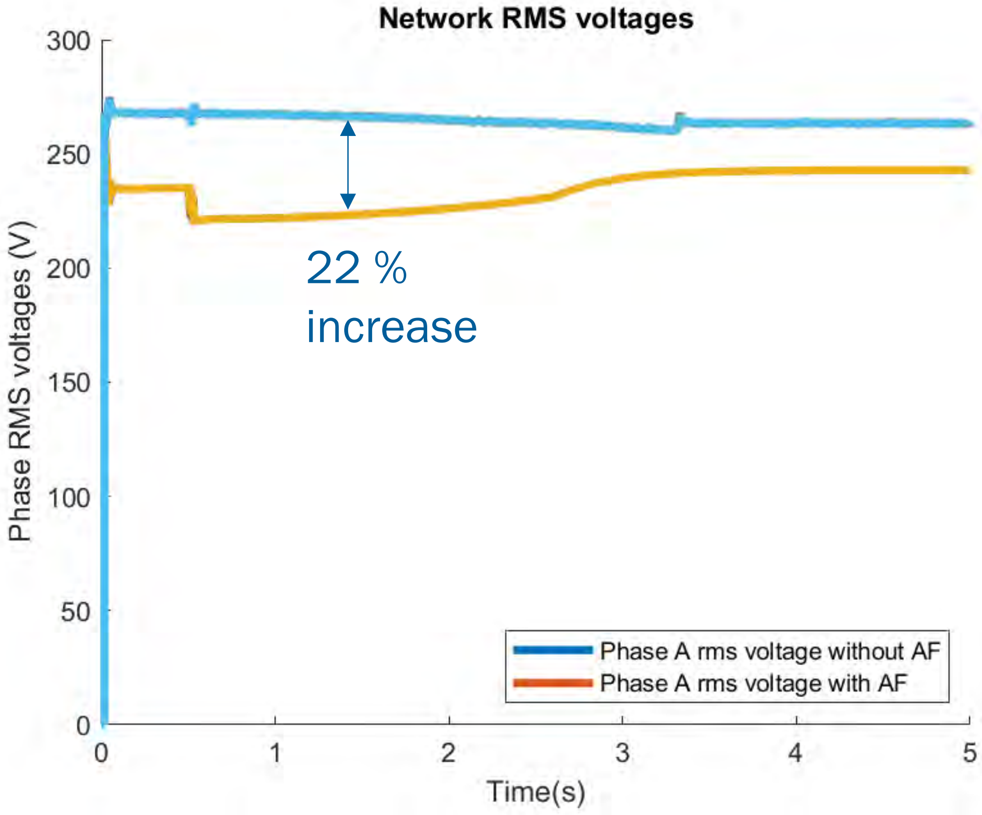




Hubbell is filtering current harmonics and compensating reactive power locally

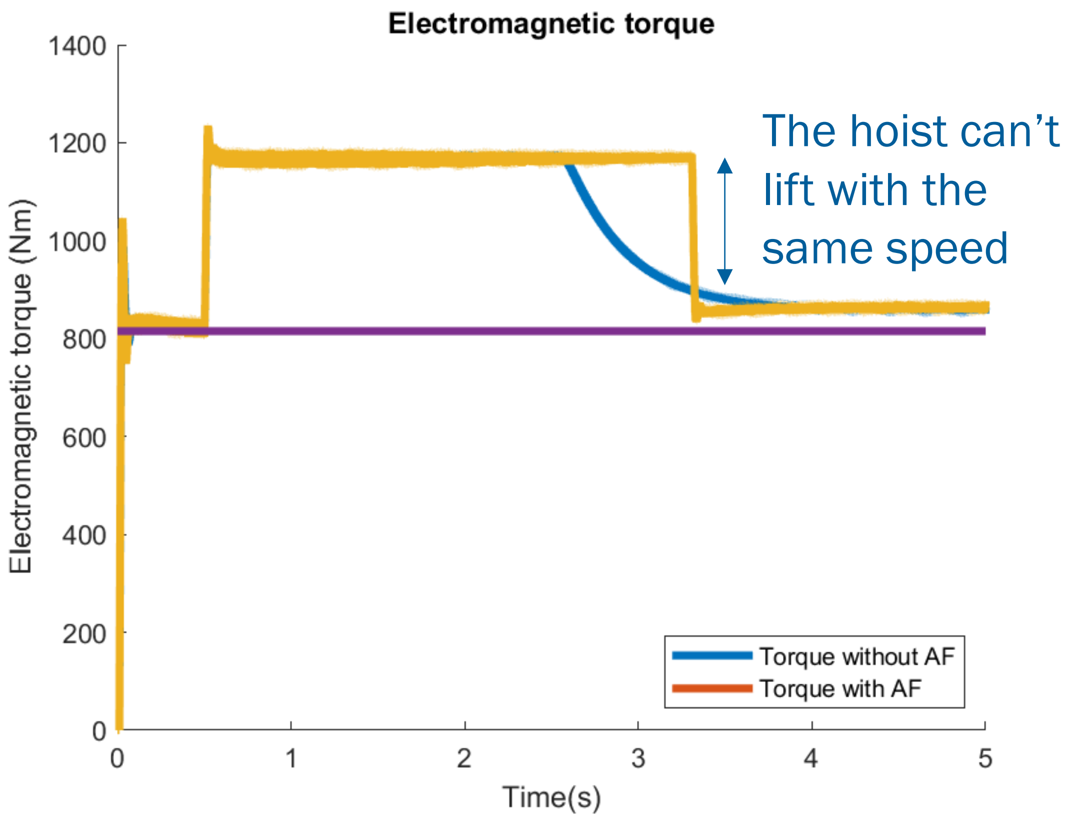
DC drive lifting operation – first 5 secs

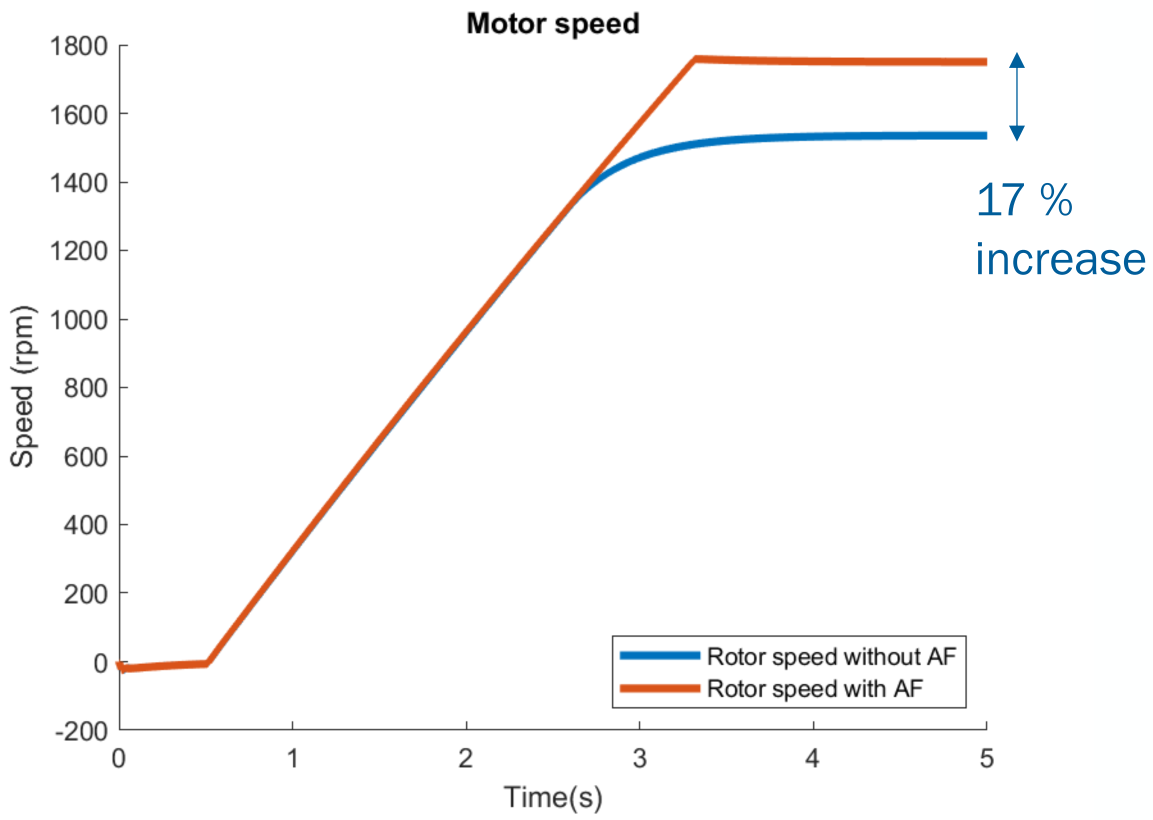




The reactive power and current harmonics are compensated locally by Hubbell and do not flow through the network impedances!

DC drive lifting operation – first 5 secs





Either the torque (weighing capacity) or the speed is lost because of the voltage drop – either one will slow down the process

Key takeaways

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- Reactive power flow and harmonic currents cause a voltage drop in the line impedances, that cause a loss of torque or speed in the crane duty drive
- The network strength is the key – in this case we were operating in a normal network
- The process improvement is significant, but does not even take into account the benefits of a stable voltage and filtered harmonics to other equipment in the same network!

Payback

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- **Process improvement:** increasing the lifting capacity of the crane
  - More torque = more lifting capacity
  - More motor speed = faster lifting
- Smaller power losses: less power losses in transformer and in other network impedances because of smaller currents
- Improved power quality: voltage THD is improved and other equipment is protected

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