Educational Set-up for Brushless Motor Drives

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Table of contents

Brush or Brushless

What is easier to explain, Brushed or Brushless motor?

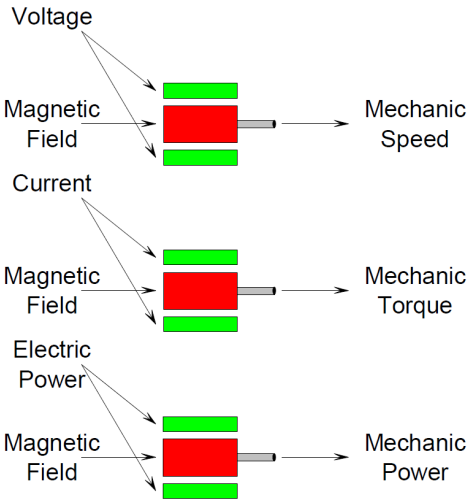
- Brushed DCM: Mechanical commutator
- Brushed DCM: Interpole/Commutator winding
- Brushed DCM: Commutator segments and winding
- Brushed DCM: Brush fire

Electric drive basics

$$U = K \cdot \omega = pp \cdot \Phi \cdot \omega$$
$$T = K \cdot I = pp \cdot \Phi \cdot I$$
$$P = \omega \cdot T$$
$$P = U \cdot I$$

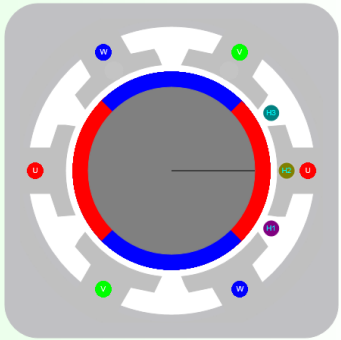
Magnetic Field is the key parameter

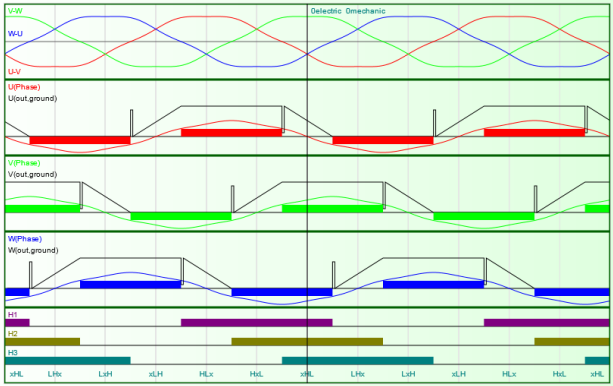
$$U = pp \cdot \Phi \cdot \omega$$
$$T = pp \cdot \Phi \cdot I$$
$$U \cdot I = T \cdot \omega$$



Position of the Hall sensors 60° or 120°

Magnetic Field is the key parameter



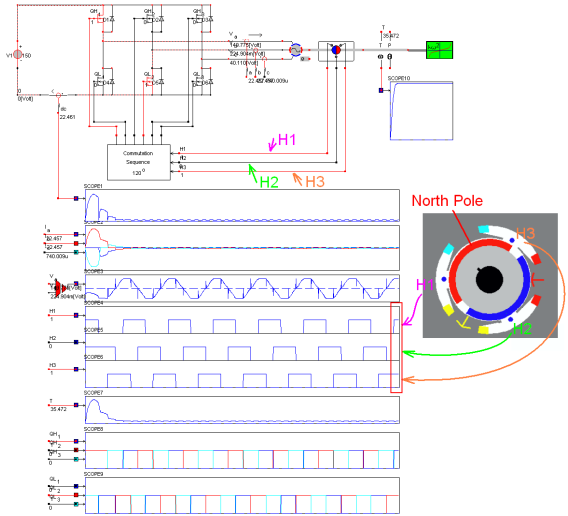


Rotor angular position θ_m=0^0

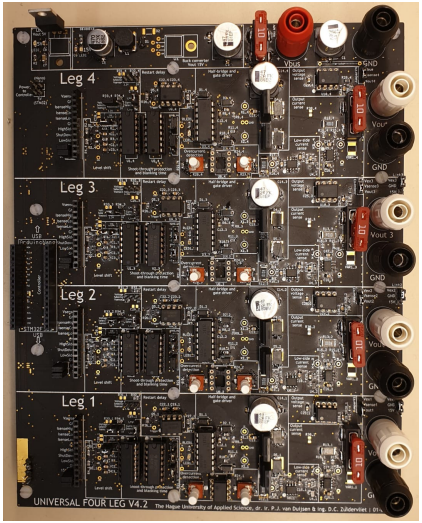
Rotor angular electrical position θ_e=0^0

60 120

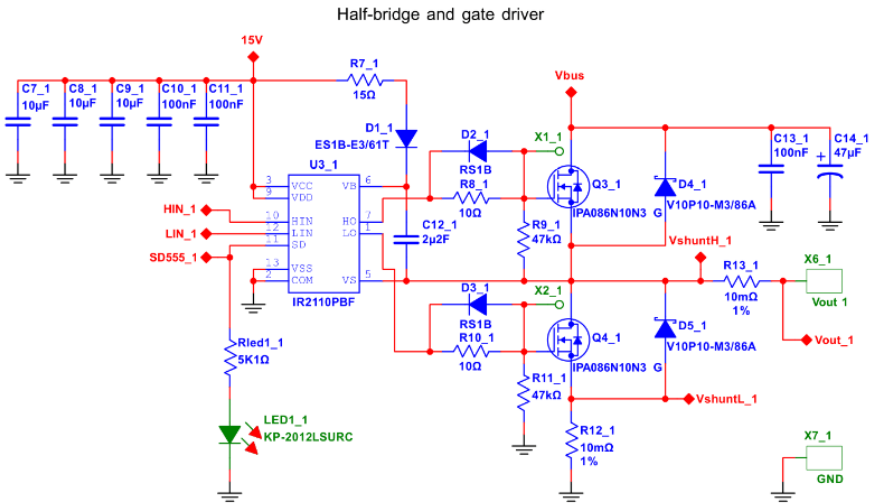
Brushless drive animation



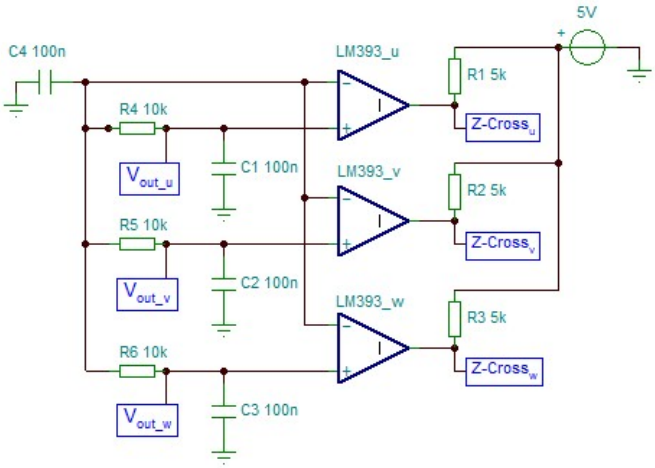
Power electronics inverter U4L



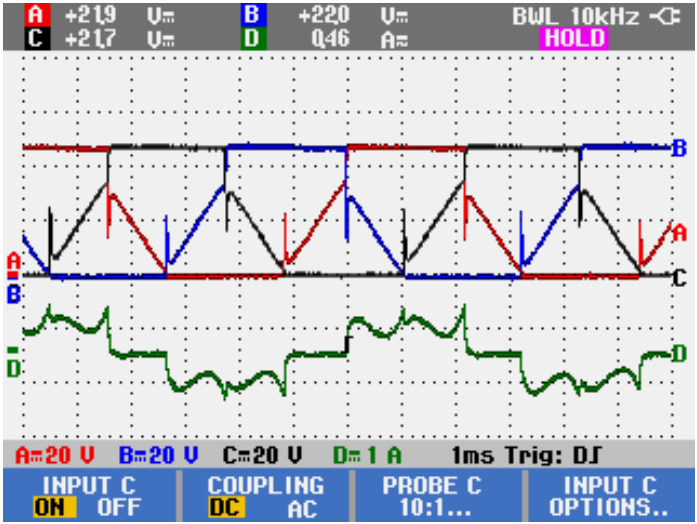
Halve bridge gate driver



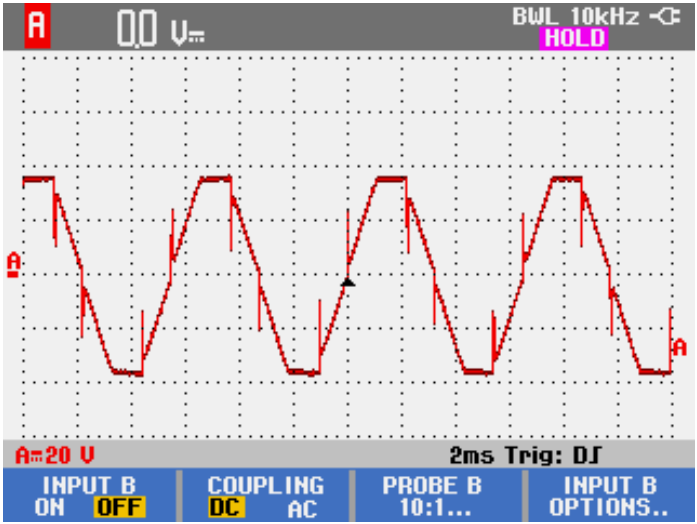
Sensorless


5V
C4 100n
LM393_u
R1 5k
R4 10k
Z-Cross_u
V_out_u
C1 100n
LM393_v
R2 5k
R5 10k
Z-Cross_v
V_out_v
C2 100n
LM393_w
R3 5k
R6 10k
Z-Cross_w
V_out_w
C3 100n

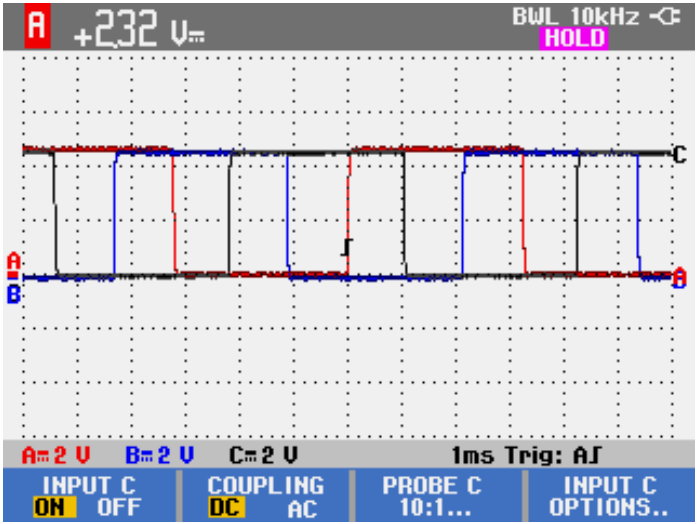
Measurement: Inverter output voltage and current



Measurement: Brushless Lin-Line voltage



Measurement: Hall signals



Set up with two motors, sensorless

Conclusion

- Brushless machine is straightforward to understand
- Basic drive principles can be explained
- Animation with slider explains the control
- Visualize the control using simulation with Animation!
- Hall-Sensor and sensorless operation

Thank you!

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