

Power electronics in electric cars

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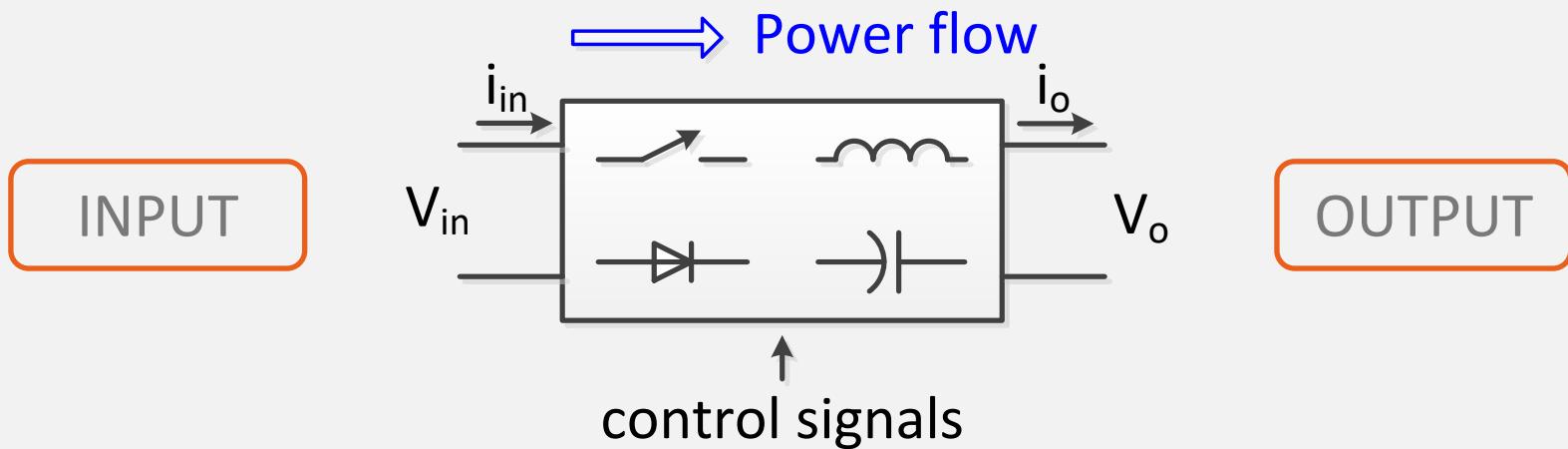


Learning objectives

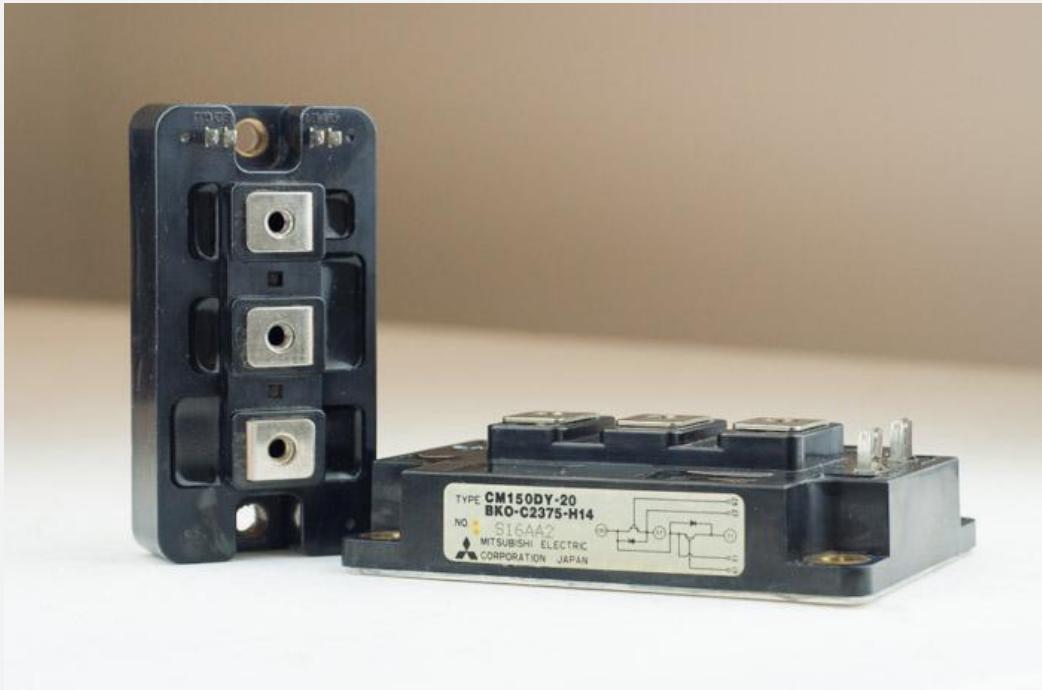
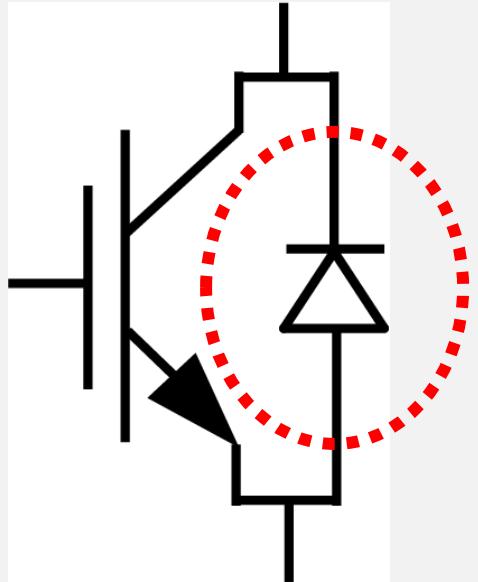
- What is a power electronic converter?
- Power converter types:
 - AC or DC
 - Power flow direction
 - Isolation
- Power converters in an electric car
- Four quadrant power converter operation

Power electronic converter

A power electronic converter is an electronic device made of high power semiconductor switches that uses different switching states to change the magnitude and waveform of the voltage and current between the input and output.

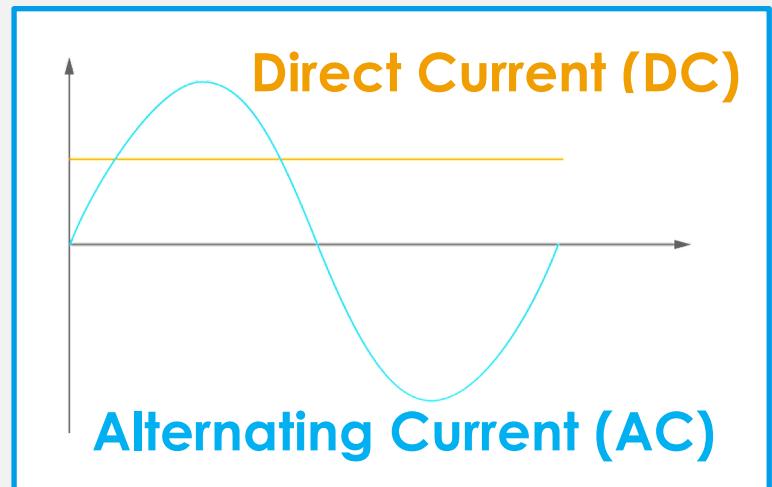


Power electronic switch



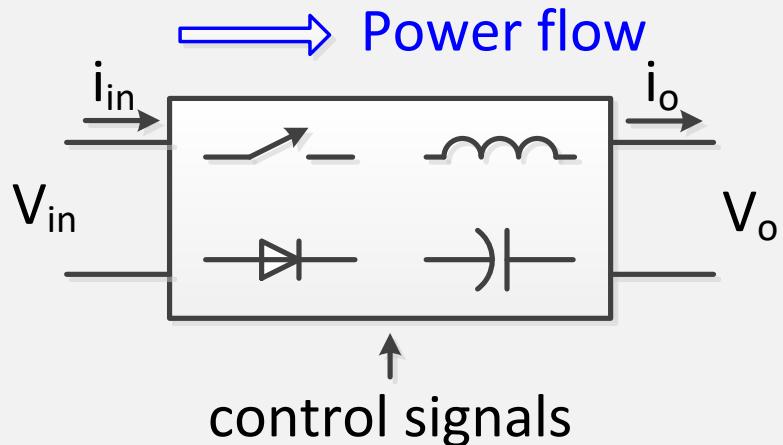
Power converter: AC and DC

1. DC-DC converter
2. DC-AC converter (or) inverter
3. AC-DC converter (or) rectifier
4. AC-AC converters

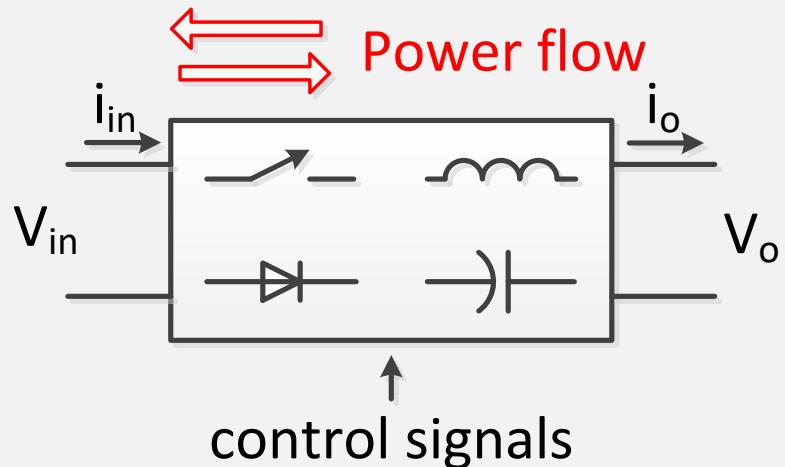


Power electronic converter

1. Unidirectional



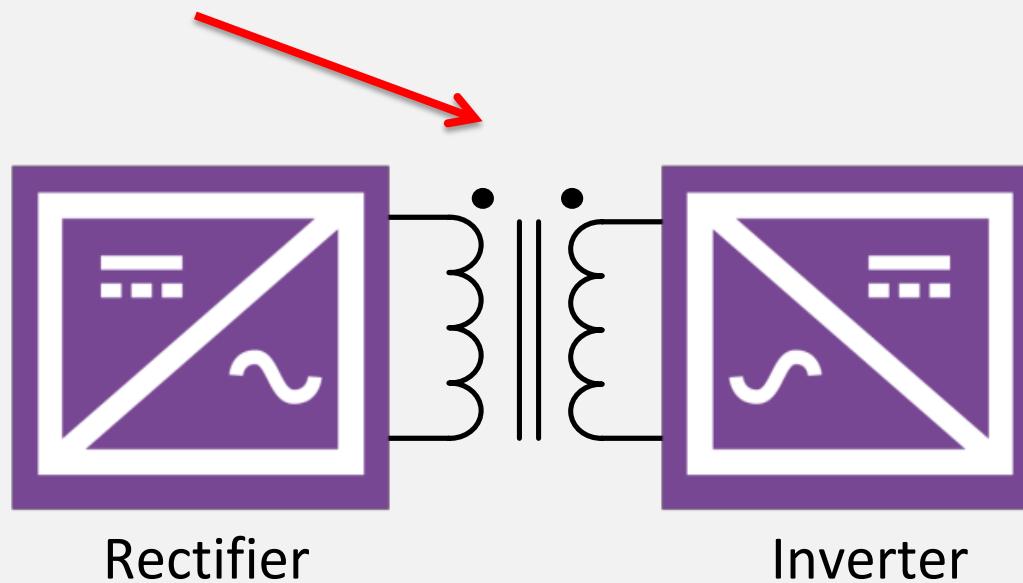
2. Bidirectional



Power electronic converter

1. Magnetically Isolated

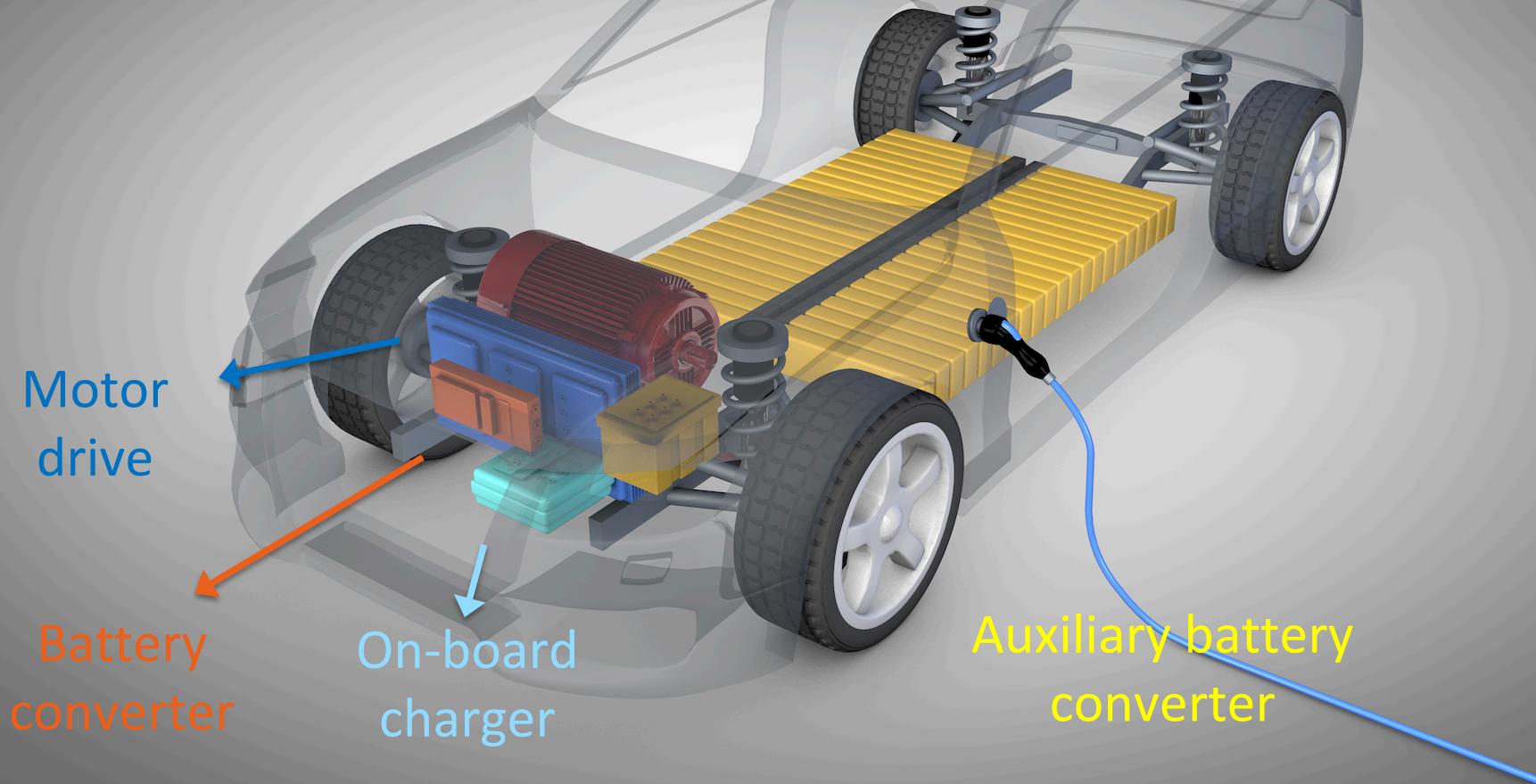
2. Non-isolated



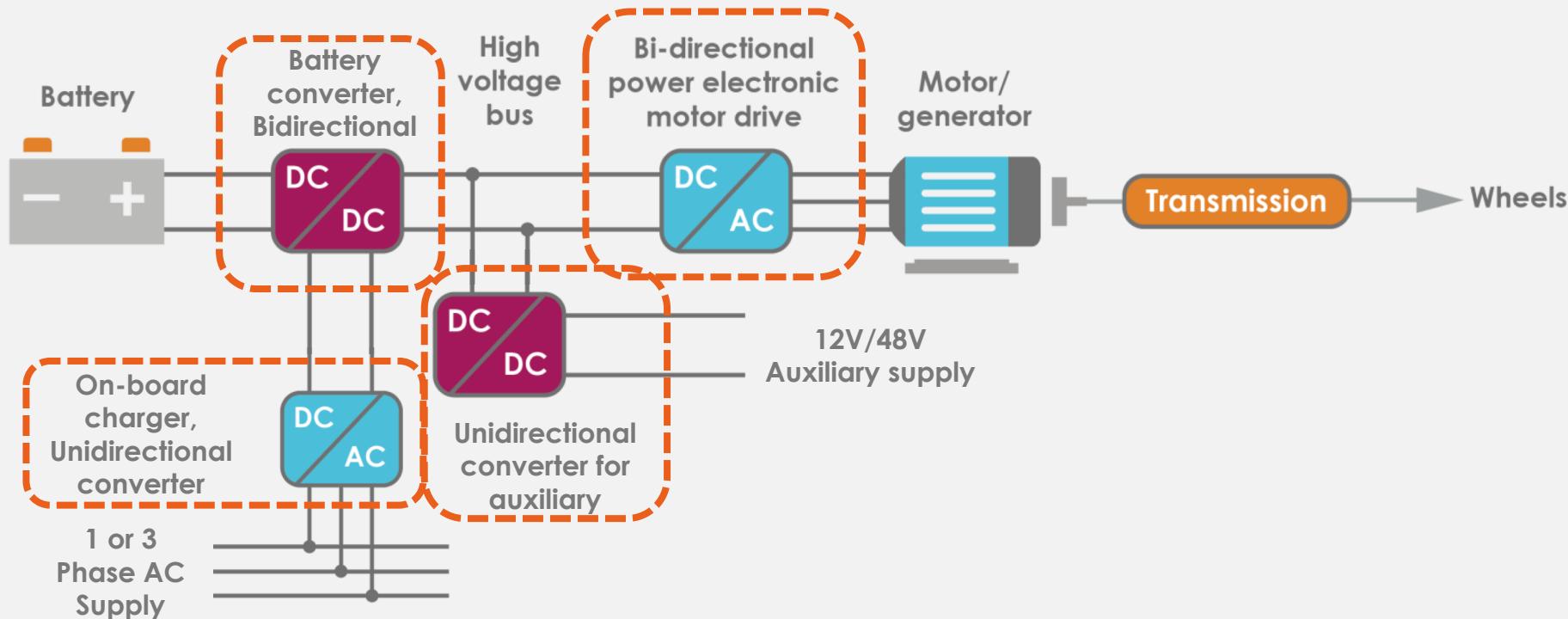
Power converter

Type				
AC or DC	AC-DC	DC-AC	DC-DC	AC-AC
Magnetic Isolation	Isolated		Non-isolated	
Bidirectional power flow	Bidirectional		Unidirectional	

Power converters in electric car



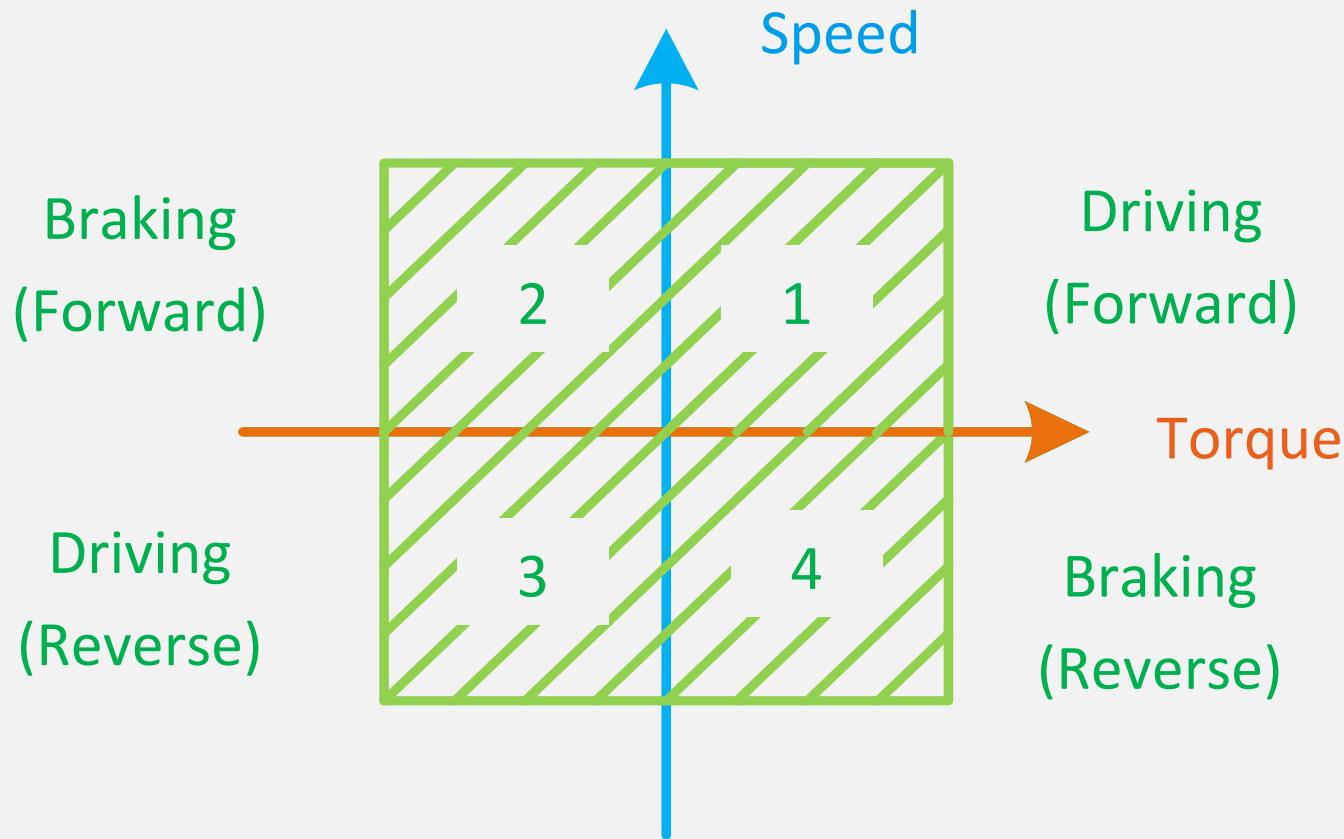
Power converters in electric car



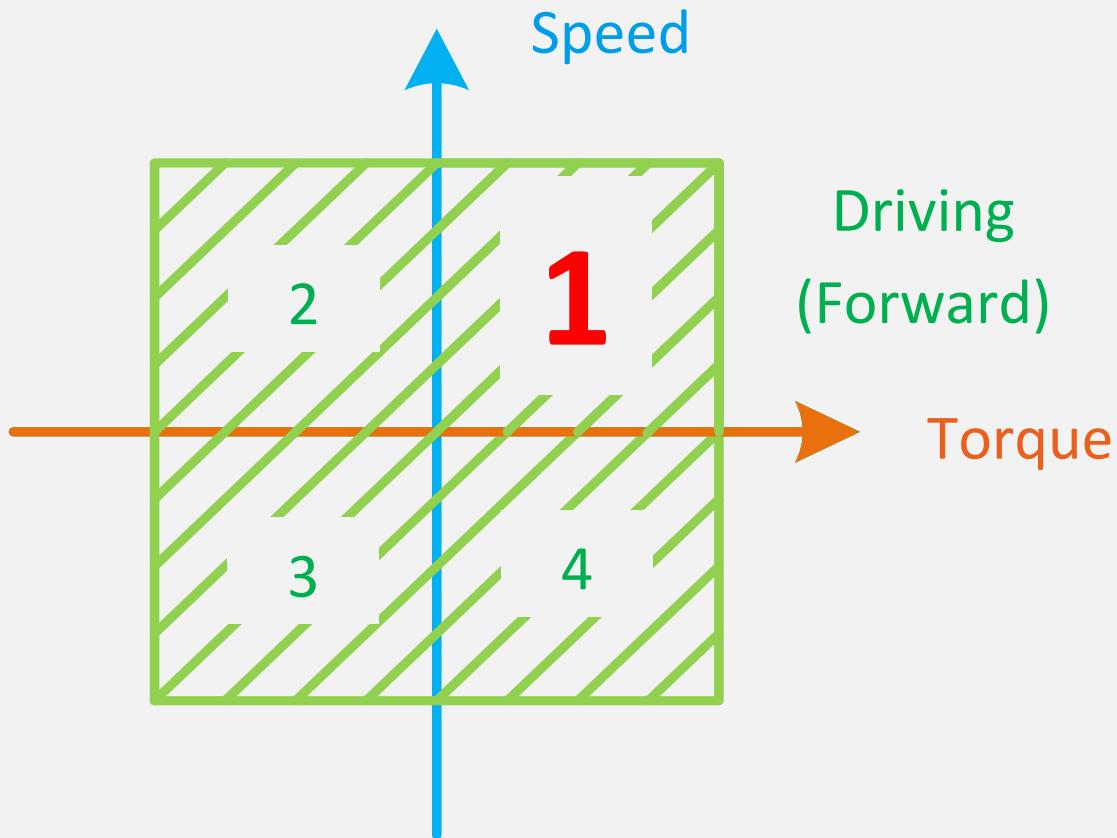
Power converter

Converter	AC or DC	Isolation	Direction
On-board charger	AC-DC	Isolated	Unidirectional
Battery converter	DC-DC	Isolated	Bidirectional
Motor drive	DC-AC	Isolated / Non-Isolated	Bidirectional
Auxillary battery converter	DC-DC	Isolated / Non-Isolated	Unidirectional

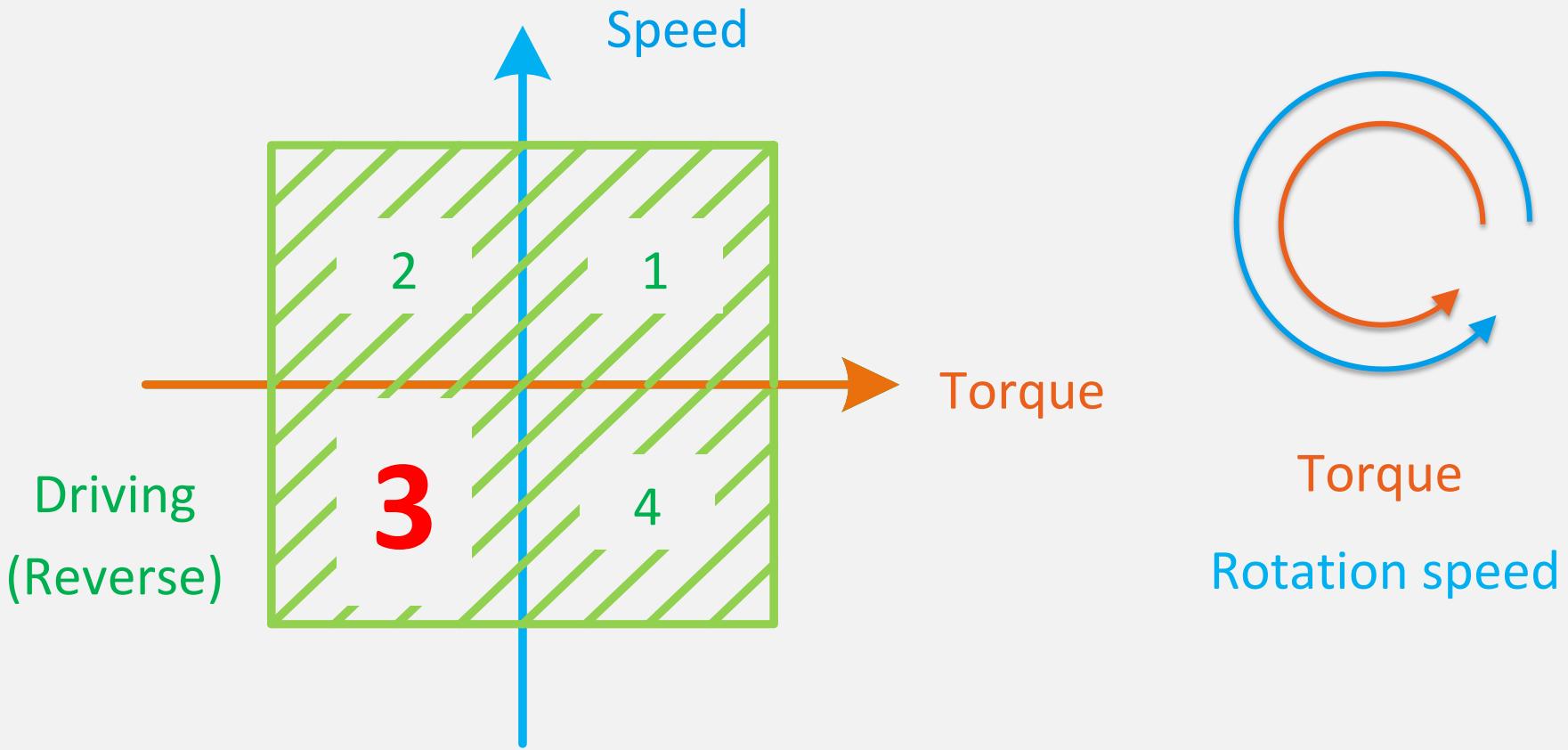
Four quadrant operation



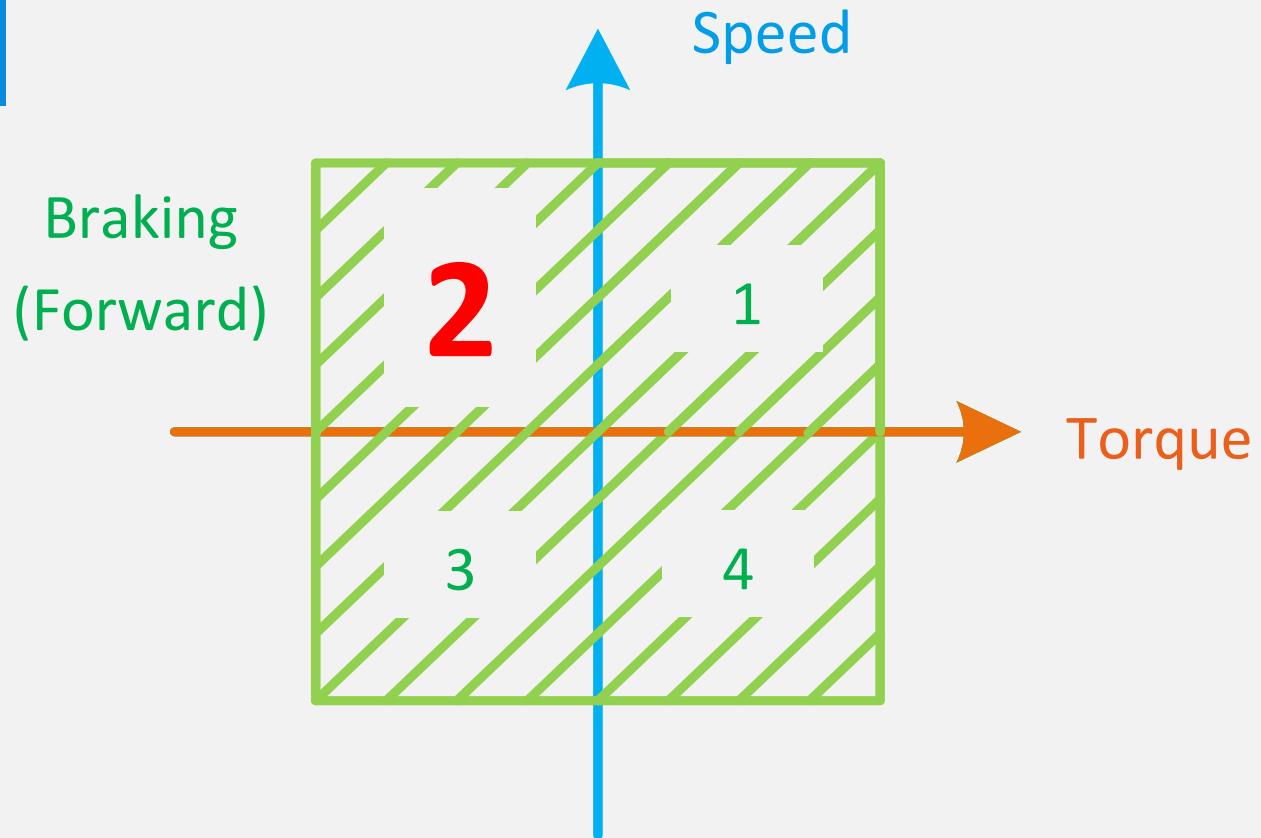
First quadrant operation



Third quadrant operation

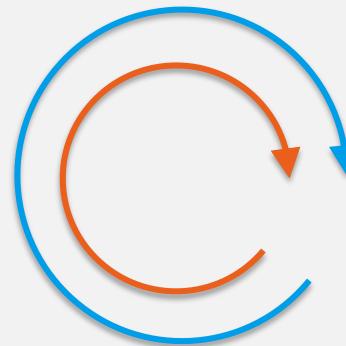


Third quadrant operation



DC Motor and motor drive operation

- Current magnitude → Torque magnitude
- Current direction → Torque direction
- Voltage magnitude → Rotation speed magnitude
- Voltage polarity → Rotation speed direction

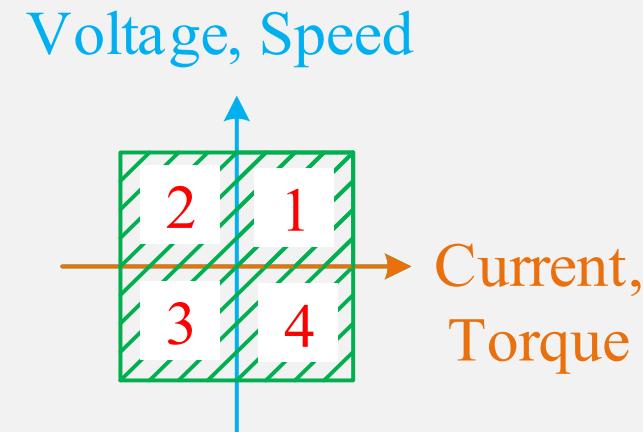


Torque
Rotation speed

Four quadrant operation

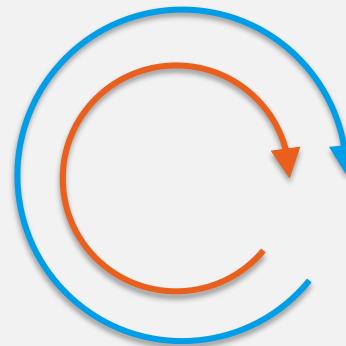
Bidirectional power flow can be achieved by controlling the polarity of voltage and/or current:

Voltage	Speed	Current	Torque	Quadrant
+	+	+	+	1
+	+	-	-	2
-	-	-	-	3
-	-	+	+	4



AC and motor drive operation

- AC motors more complicated than DC motors
- Reverse rotation by changing the connection of the phases
- Torque and speed control through control of AC voltage magnitude and frequency



Torque

Rotation speed

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