USING EMRAX MOTORS FOR EV

How to calculate power and torque for EV?

1. First you have to calculate the torque that will be needed for the vehicle (torque on the wheels):

Example:

EV weight:	G = 1700 kg
Acceleration time from 0 km to 100 km/h (= 27,78 m/s):	t = 5 sec

Acceleration:

$$a = v \div t = 27{,}778\ m/s \div 5\ s = 5{,}55\ m/s^2$$

Force for acceleration:

$$F = 1700\ kg\ * 5{,}55\ m/s^2\ = 9444{,}5\ N$$

Torque on the wheels (wheel diameter 0,64 m):

$$Mt = 9444{,}5\ N\ * 0{,}32\ m\ = 3022{,}2\ Nm$$

3000 Nm is a torque on the wheels, which is needed to accelerate the vehicle (EV weight is 1700 kg) from 0 km/h to 100km/h.

2. Now you need to consider the transmission gear (TG) ratio and calculate the torque:

Example:

Differential ratio is approximately 3:1, TG ratio is approximately 4:1. Therefore total ratio in the first gear is:

$$total\ ratio = 3\ * 4\ = 12$$

For example, one EMRAX 228 motor can deliver 240 Nm peak torque and 120 Nm continuous torque. Therefore peak torque on the wheels in first gear is:

$$total\ peak\ torque\ on\ the\ wheels\ in\ first\ gear = 12\ * 240\ Nm\ = 2880\ Nm$$

In this case close to 3000 Nm of peak torque in first gear can be expected. In the second gear the torque is lower. Only higher gear can deliver higher and finally end speed of EV.

End speed also depends on the maximal battery voltage (Vdc) and magnetic field weakening (MFW) – more information in Item 9. Final EV speed can be even higher if magnetic field of the motor is weakened. This can be done in the controller settings. Power stays the same at higher speed. Power of EV is rising at higher speed because of the air drag.

EV needs enough high torque for starting EV and driving up the hill. 15% slope is minimal for torque calculation.

3. Torque, power calculation:

$$\boldsymbol{P}\ [\boldsymbol{kW}]\ =\ \boldsymbol{n}\ [\boldsymbol{RPM}] * \boldsymbol{Mt}\ [\boldsymbol{Nm}]\ /\ \mathbf{9550}$$

At lower RPM (motor rotation), you can expect lower motor power at the same torque. At higher motor speed you can expect higher motor power at the same torque.

Mt……torque [Nm]

P………power [kW]

n………motor rotation [RPM]

Very important considerations when calculation power and torque for EV:

- acceleration

- air drag at higher speed

- driving up the hill

Usually there is no need to add higher torque for climbing up the hill, because there is enough high torque in the first gear in the case of using TG. Only EV speed is lower. Normally we do not need to drive up the hill at full speed.

EV must start with good acceleration even at very low RPM or at zero speed. Therefore the most important are motor torque and reduction drive ratio (belt drive, chain drive, differential or transmission gear etc.).

Mounting options of EMRAX motor for electric car:

- In-wheel (in Item 6)

- On the differential

- In the transmission gear (TG).

Firstly, you should know how much torque you need on the driven wheels.

1.) If you use the transmission gear then one EMRAX 208 gives enough power:
1900 Nm peak / 900 Nm continuous in the first gear.

2.) EMRAX 228 mounted in the TG is better option. You can expect much better EV acceleration, also you will be able to drive up the hill at higher gear:
3800 Nm peak / 1900 Nm continuous in the first gear .

3.) EMRAX 228 is useable for lighter EV if mounted directly on the differential:
nearly 1000 Nm peak / 500 Nm continuous on the wheels at full range of motor RPM.

4.) EMRAX 268 is useable for heavier vehicles if mounted directly on the differential: approximately 1600 Nm peak / 800 Nm continuous on the wheels at full range of motor RPM.

5.) If EMRAX 268 is mounted in the TG, than you can expect very high torque: 6000 Nm peak / 3000 Nm continuous on the wheels at full range of motor RPM. You can also use EMRAX TWIN (torque/power is doubled). Peak torque means that the power lasts 1-2 minutes.

Example of calculation for electric Audi ETT:

Engine:	1x EMRAX 268 MV CC(IP21)
Differential gear ratio:	i = 2,65 (BMW differential)
EV weight:	G = 1500 kg
Peak / continuous motor torque:	500 Nm / 250 Nm
Wheel diameter:	D = 0,64 m
Battery capacity:	Qbat = 30 kWh

Acceleration:

Maximal torque on the front wheels:

$$Mw = 500\ Nm * 2{,}65 = 1325\ Nm$$

Force that is needed for this torque:

$$F = M\ \div r = 1325\ Nm\ \div 0{,}32\ m = 4140{,}6\ N$$

Acceleration is:

$$a = F\ \div m = 4140{,}6\ N\ \div 1500\ kg = 2{,}76\ m/s^2$$

Acceleration time from 0 to 100 km/h (=27, 77 m/s):

$$t = v\ \div a = 27{,}77\ m/s \div 2{,}76\ m/s^2 = 10\ s$$

Final EV speed:

Nominal DC battery voltage:	384 Vdc
Specific load motor speed:	7,5 RPM/1Vdc at full load

Maximal motor RPM according to specific load motor speed:

$$N_{mot} = 348\ Vdc * 7{,}5\ RPM/1Vdc = 2880 RPM$$

Maximal wheel rotating at full load:

$$Nw = 2880\ RPM\ \div 2{,}65 = 1087\ RPM$$

Circumference of the wheel:

$$Cr = 2 * 3{,}14 * 0{,}32\ m = 2{,}01\ m$$

Maximal EV speed without magnetic field weakening:

$$V_{max} = 1087\ RPM * 60 * 2{,}01\ m\ \div 1000 = 131{,}1\ km/h$$

!Note: Maximal EV speed can be much higher at the same power with magnetic field weakening (MFW). This setting can be made in the controller software.

Travel range with 30 kWh of battery capacity:

Average power, which is needed to drive EV approximately 100 km/h, is approximately 12 kW motor power. Therefore theoretically expected travel range is close to 250 km with one charging of the batteries. In practice the producer of the batteries does not recommend 100% discharging of the batteries, therefore 200 km is what can be expected in reality.