

Motor technology from Model 3 helps Tesla boost Model S range 10%

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Tesla's Model S is known for its long range, with the 100kWh version rated to travel 335 miles between charges. On Tuesday, Tesla announced changes to the Model S drivetrain that boosted the range by more than 10 percent to 370 miles.

Similar improvements have pushed the range of the high-end Model X up to 325 miles. And that's all without increasing the vehicle's battery capacity. The cars are simply able to go 10 percent further for every kWh of charge—which translates to electricity savings for Tesla customers.

Several factors combined to produce these impressive efficiency gains. Tesla switched one of the motors in the Model S and Model X to a new technology pioneered in the Model 3. The company also announced an improved suspension system and other efficiency tweaks throughout the vehicle. The impressive result: greater than 93 percent energy efficiency.

Permanent magnet synchronous

reluctance motors, explained

Until now, the Model S and X used conventional induction motors. In an induction motor, alternating current is run through windings in the stator (the stationary portion of the motor) to produce a rotating magnetic field. This magnetic field induces electric currents in the windings of the rotor (the spinning part of the motor) that generates an opposing magnetic field, causing the rotor to turn in the same direction as the magnetic field.

The Model 3 debuted with an alternative motor technology that Tesla calls a permanent magnet synchronous reluctance motor. A synchronous reluctance motor—also known as a switched reluctance motor—has a series of electromagnets around the stator, but the rotor doesn't have any windings or permanent magnets. Instead, the rotor is fashioned from a solid piece of metal (usually steel) that has several poles reaching outward toward the stator.

To turn the rotor, the motor turns on an electromagnet near each pole that pulls it in the desired direction. The poles are attracted to the electromagnet, and the rotor begins to spin. As each pole passes a particular electromagnet, that electromagnet is switched off and the next one is switched on, pulling the rotor along. This design is known as a synchronized motor because the switching of the electromagnets is synchronized to the rotation speed of the rotor—something that isn't true for an induction motor.

Switched reluctance motors are an old technology, with some experiments dating back to the 1830s. But after those early experiments, the technology largely lay dormant for more than a century. This 2013 passage from *Charged* describes one big reason why:

The inductance of each phase is proportional to the degree of alignment with the salient poles of the rotor. As one or more

rotor poles line up with a given stator winding, the inductance of that winding shoots up, making it harder to push the correct amount of current through it at the correct time. Conversely, as the rotor pole moves away from the winding, its inductance once again drops. The worst thing about this is that rotor torque will only be positive as current is supplied to the winding when inductance is increasing; the torque turns negative—i.e., regeneration occurs—when the inductance is falling. Thus, small timing errors in the delivery of current to each winding can result in less torque than expected, vibrations from the torque being inconsistent from phase winding to phase winding, or even from it going negative every so often.

This can produce high “torque ripple”—uneven power output that leads to jerky performance. The torque ripple can be a particularly serious problem when the motor first starts to accelerate, since at this point the rotor spends more time near each stator winding.

But as Clean Technica pointed out last year, recent research has suggested that carefully placed permanent magnets can “smooth out” the magnetic fields inside of switched reluctance motors, leading to lower torque ripple and higher energy efficiency.

The dual-motor versions of the Model 3 have an induction motor in the front and a permanent magnet synchronous reluctance motor in the back. The Model S and Model X switch this around, putting an induction motor in the back and a PMSRM in the front.

Combining an induction motor with a PMSRM makes sense because the two motor types have different performance characteristics. As Elon Musk put it last year, “one is optimized for power & one for range.” Induction motors offer high torque at low speeds, but they’re less energy-efficient

overall. So dual-motor vehicles can send power to the induction motor when immediate, rapid acceleration is called for, then shift power to the PMSRM as the vehicle gets up to speed.

Tesla says that the Model S and X efficiency gains haven't come at the expense of reduced torque. To the contrary, the company says the latest versions have improved 0-60 times compared to earlier iterations.

Other improvements

Along with the new motor design, Tesla says the latest Model S and X designs have "silicon carbide power electronics, and improved lubrication, cooling, bearings, and gear designs." Tesla says that the new vehicles are also better at regenerative braking, allowing a car to recapture more of its kinetic energy as it decelerates.

Tesla also overhauled the air suspension on the Model S and Model X. The new technology uses a "predictive model to anticipate how the damping will need to be adjusted based on the road, speed, and other vehicle and driver inputs." Tesla says that it has "improved the leveling of the system while cruising, keeping the car low to optimize aerodynamic drag."

Tesla also says that it has dramatically improved supercharging times, with peak charging of 200kW on new V3 Superchargers. Tesla says customers will be able to recharge 50 percent faster.

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