The Inverter The Unsung Hero of an EV Drivetrain

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As you know, electric vehicles have one or more batteries, and one or more propulsion motors. Our designs use a single propulsion motor which connects via a simple transmission unit to the vehicle"s drive shaft. But have you ever wondered what goes in-between the batteries and the motor?

Just like the AA batteries in your flashlight, the batteries in an EV are DC (direct current) devices, which means that there"s a positive terminal and a negative terminal, and the voltages on these terminals are steady. OK, unlike your AA batteries, our batteries generate hundreds of volts and lots of current; but they still have "+" and "-" connections.

So - somehow - we need to take the high-voltage, high-current DC electricity that comes from the batteries and convert it to AC electricity for the motor. That"s where the inverter comes in.

An inverter is an electronic device which uses power transistors as switches to slice and dice the DC electricity to create an AC output. AC has positive and negative voltages in its cycle, and the transistors open and close connections which alternately allow the voltage through unchanged or make it negative (hence the name "inverter"). In its simplest form, the output would be a "square wave":

A sine wave has a much smoother variation between positive and negative, and it"s a lot more suitable for AC motors, which have magnetic fields inside them which need time to rise and fall in strength.

By switching the transistors on and off very rapidly, the output voltages can be "constructed" by mixing short bursts of positive and negative volts in varying amounts to give an average voltage that follows the sine wave ("sinusoidal") shape. This technique is called "pulse width modulation". Adding some "filtering", which consists of electronic components that smooth the signal out, can produce a pure sinusoidal AC output.

Regen - short for "regeneration" - is the behavior of EVs where when you take your foot off the accelerator pedal, the motor becomes a generator which sends charge to the batteries. This helps to improve the range on the road - and to extend the lifetime of your brake components. So, when the motor is acting as a generator, it produces three phases of sinusoidal AC power. The inverter has to take these and convert them to a single DC output which has a higher voltage than the batteries, in order to charge them.

The photos in this article show an inverter from our partner UQM (now Danfoss Editron), which we employ in our new 2nd generation Ford Transit powertrain. UQM doesn"t just supply the inverter, but also the permanent-magnet motor and the clever control software embedded in the inverter. Supplying the whole system like this lets them optimize it for best torque and efficiency with low weight, which makes it a great fit for the Transit platform.

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