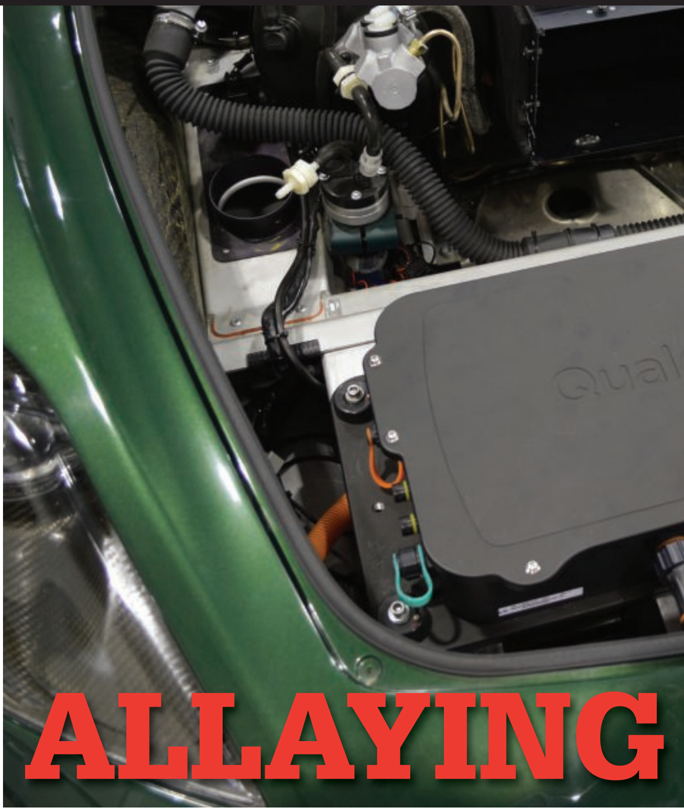

ALLAYING

Engineering solutions to EV range anxiety. By **Peter Dallimore**.

Electric vehicles on general sale today offer adequate ranges for tasks such as commuting, shopping and urban journeys. Nissan, for example, claims up to 124 miles per full charge for its all electric Leaf, while Tesla suggests up to 310 miles for its Model S when specified with the optional 85kWh battery. Even so, range anxiety – the fear of running out of charge before journey's end – is recognised as a potential barrier to widespread acceptance of electric vehicles.

One response to range anxiety can be seen in the new BMW i3, a full electric vehicle (EV) that offers the option of an additional small petrol engine as a range extender. Unlike in a hybrid drive system, this range extender is used only to charge the i3's battery, increasing its maximum range from 190km to a more impressive 340km.

Of course, the goal for EV advocates is the elimination of the conventional combustion engine. Improvements in the technologies used throughout electric drives – which comprise the battery and battery management system (BMS), motor controller, inverter and the motor itself – are expected to yield a fivefold increase in maximum range by the end of the coming decade, according to a recent report by IDTechEx.

Whilst car makers like Tesla have shown that increasing the battery capacity can offer a solution to range limitations, better BMS performance can improve energy use.

Basic BMS functionality

A basic BMS will monitor critical parameters such as voltage and temperature. Individual cells in the battery pack will naturally display variations in voltage and the battery monitor can prevent cells with the lowest voltage becoming damaged due to over discharge by signalling to the vehicle controller when the system should be shut down.

Similarly, the BMS can control charge termination when cells with the highest voltage reach full charge. In this way, a BMS helps to prolong the life and optimum performance of the battery.

Justin van't Hoff, senior electrical systems engineer at Delta Motorsport, says a BMS that provides charge balancing can have a more significant effect on the use of battery energy and may improve the range of the vehicle by several percent. The BMSs currently used in EVs implement passive balancing, using banks of resistors to ensure that all cells are kept at the same state of charge.

The BMS communicates with other vehicle ECUs via the CAN bus to share information about the battery, which is vital for the performance and safety of the vehicle. It is responsible for providing State Of Charge information – the EV's 'fuel gauge' – which the driver needs in order to assess the available range.

The BMS can communicate via CAN with the vehicle's user interface software to display status information via the vehicle's instrumentation. Other data collected by the BMS can include input and output current, overall voltage, individual cell voltages, internal resistances and environmental data such as temperature. These enable the vehicle controller to determine its optimum response to the driver's demands.

For example, if the accelerator position demands a certain power, the motor controller uses data from the BMS to determine whether the battery can provide the requested power or, if not, to determine the closest possible response. The BMS may also record historical data, such as cumulative operating hours, which can be used to advise when maintenance or replacement is needed.

Today's EVs are typically sold with a home charging kit, which may operate

Current Wireless Electric Vehicle Charging trials are based on Qualcomm Halo technology

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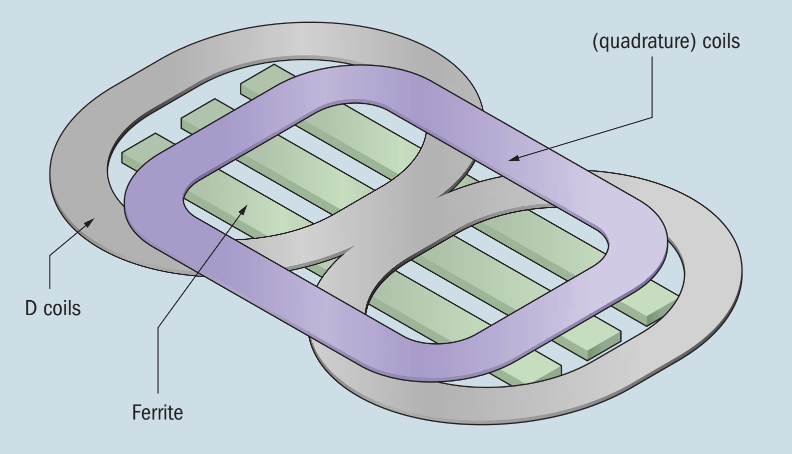
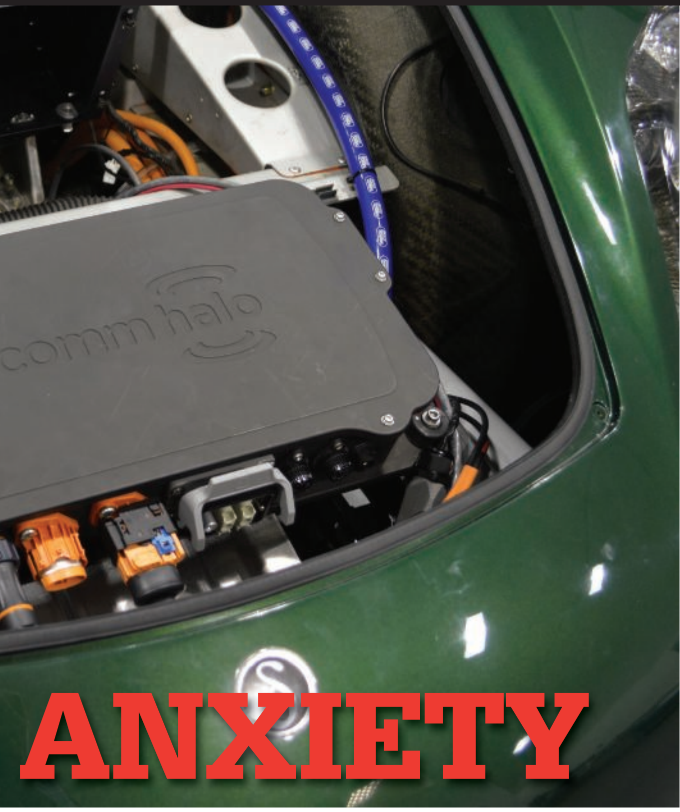
Fig 1: The Qualcomm Halo charging pad





ANXIETY

at the normal AC line voltage or at a higher voltage for faster charging. Ideally, the owner will charge the vehicle while at home and use the car routinely to reach destinations within the vehicle's return travel range. However, an accessible and easy to use public charging infrastructure has a role to play in eliminating range anxiety.

Wireless Electric Vehicle Charging (WEVC) – currently being trialled in central London – offers a secure and easy to use approach, while achieving charging efficiency comparable to that of a plug in charging station. After the car is driven into the charging bay, a set of automatic interlocks handles the procedures needed to verify user account details for payment and the commencement and termination of charging. Safety features – such as foreign and living object detection – are built in and known to operate satisfactorily.

The current WEVC trial is based on technology developed by Qualcomm Halo. Qualcomm Europe's senior director Joe Barrett said the system, which uses the latest J2954 wireless charging standards, has a three coil inductive loop to minimise the influence of vehicle position on charging efficiency. The Qualcomm Halo charging pad (see fig 1) comprises two D-shaped coils, with a third coil to ensure optimal field characteristics for high charging efficiency and greater tolerance for any positional misalignment between the radiating pad installed in the charging bay and the receiving pad on the vehicle being charged.

The SAE International Hybrid-EV Committee, responsible for issuing J2954, recently standardised an operating frequency of 85kHz; earlier proposals and systems operated at 20kHz/3.3kW or 40kHz/6.6kW, with 6.6kW being the maximum power for charging over a wired connection from a standard domestic 16A socket. The higher operating frequency allows a smaller charging pad for a given output power.

The committee chose 85kHz after taking into account factors such as interference issues at higher frequencies and the relative cost of high power/high frequency switching components. Further standardisation work will focus on the communication protocols for connecting the Vehicle Charging Unit (VCU) and the Base Charging Unit.

Currently, Qualcomm Halo is working with partners to develop solutions based on the HomePlug Green PHY specification, using Wi-Fi for the air link between the vehicle and the charging pad. Standardising the communication protocol will promote interoperability between charging pads and vehicle-mounted charging systems from various manufacturers.

In the London WEVC trials, J2954-compliant bays will charge at up to 20kW, depending on the type of vehicle. A number of EV types are involved in the trial; Delta Motorsport has converted several Citroen C1s to electric power to take part in the trial and is supplying several examples of its Delta e4 all electric EV to the project. The cars are fitted with VCUs supplied by Qualcomm Halo.

The current trial is for static WEVC, although wireless charging of moving vehicles is also possible. The prospect of recharging while on the move could further enhance the usability of EVs, but Barrett expects dynamic WEVC to be better suited to public service vehicles, rather than general consumer use.

Conclusion

Now that electric vehicles are reaching consumers, the pace of development should continue to increase. There is room for improvement in many areas, including: battery technology, to improve energy storage and discharge; regenerative braking, to reclaim and store recoverable energy; and electric motors, aimed at reducing weight and increasing the torque produced in relation to input power.

The combined effects of improvement in all of these areas, and probably more as EV design continues to advance, could finally deliver on the promise of anxiety free, low carbon mobility.

Peter Dallimore is a freelance technology writer.

The battery management system can use the vehicle's instrumentation to display status information