

# Accurate Measurement of EV Range

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## Abstract

Vehicle level control will greatly affect the range of electric vehicles (EV). By measuring the power consumption of all components in an EV during a drive cycle engineers can better understand the power consumption of a vehicle. A challenge to this type of testing is measurement uncertainty of electrical power, specifically during dynamics. This paper will propose methods for accurate acquisition of dynamic power signals to give trustworthy power measurements during drive cycles.

## 1. Vehicle Range Testing Background

Understanding how vehicles use and distribute energy is crucial for electric vehicle development and certification. Electrical powertrain, including motors and inverters, heating, air conditioning, infotainment, and other sub systems all consume energy that is being supplied by the battery pack. Any energy usage or inefficiency can result in a shorter range of the vehicle. By mapping out the energy usage of all the subcomponents, automotive engineers can start to make decisions about vehicle control, and component selection to maximize the range of the vehicle.

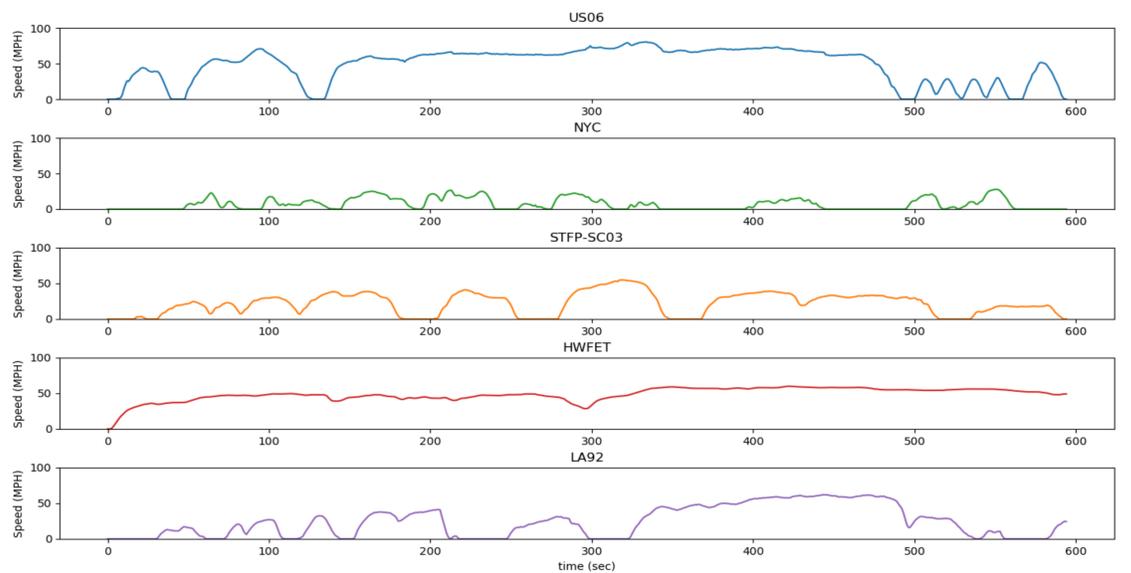


Fig. 1. Excerpts of various drive cycles showing speed vs time

This testing can be broken into three categories, certification testing, engineering range test, and component testing. All of these tests rely on drive cycles which can be seen in figure 1.

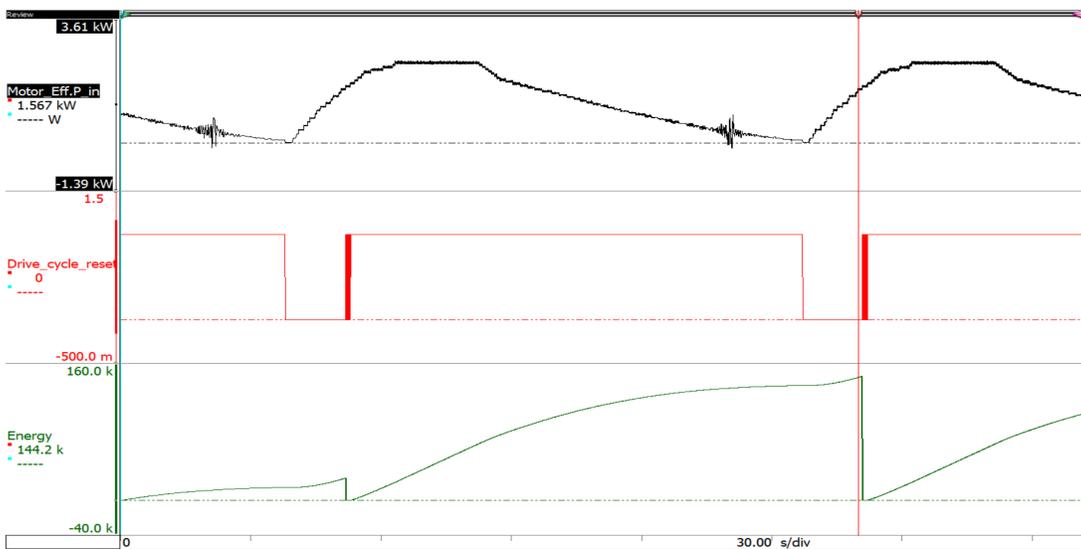


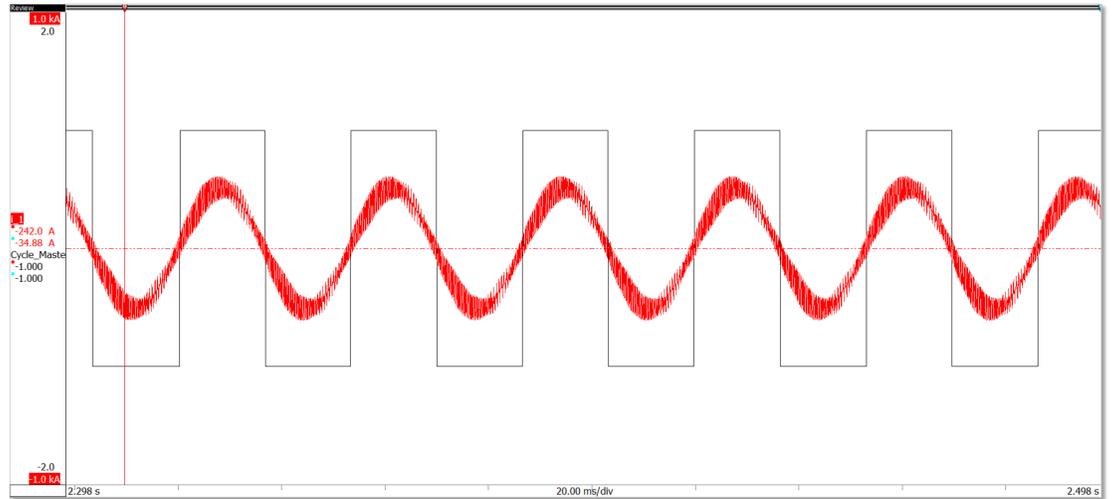
Fig. 2. Drive cycle power, energy, and segment reset signals

## 1. Certification Testing

When a manufacturer brings a vehicle to market, it needs to have a range and fuel efficiency certified by the governing bodies of that country. These groups run the drive cycles from full charge until the vehicle runs out of battery charge and record the energy used and distance the vehicle traveled. Measuring the energy usage is accomplished by putting a current clamp around the main DC cable and measuring the DC voltage and current into a power analyzer. The power analyzer will then calculate the electrical power and energy being passed through the cable. In the event a vehicle has multiple DC batteries the energy would be measured from those as well and add them up. The drive cycles will typically be segmented into city and highway for the different ratings. An example of this can be seen in figure 2 as the power, energy, and reset between segments of a drive cycle is shown.

## 1.Engineering Range Test

An engineering range test is similar to a certification test but with more measurements and potential configurations. Engineers run the tests to optimize their vehicle energy usage so that they can maximize their range for the certification. The test is still a full vehicle running through drive cycles on a chassis dyno, there is still limited access to voltages and currents, and the collection of data is even more important because now engineers will want to understand the details to make changes. The tests require more measurements because in addition to the DC bus measurements, they will also include all the subcomponents and sub systems. This can include as many as 15 power/energy measurements, which can create measurement challenges since many power analyzers only offer 3,6, or 7 channels



## 1.Component Range Test

Component range testing can be done on a chassis dyno, like the other two tests, but is often done on a direct drive dynamometer for the best quality measurements on components. The test involves mounting a motor and inverter to a precision dynamometer (figure 4) and then running the torque and speed profile of the drive cycle. The DC bus, AC phase measurements, torque, and speed will typically be measured for these profiles with high precision instrumentation. By taking high accuracy measurements, engineers can start to understand the power losses of the components in detail. If the engineers choose to incorporate temperatures of both the rotor and the stator, they can start to look at iron, copper, and other losses to understand how energy losses are distributed throughout a drive cycle. Once the losses of the component are understood, they can start to be controlled and minimized<sup>3</sup>.

## 1.Conclusions

Vehicle energy management is a detailed process that includes many steps and considerations. It presents challenges because of potentially high channel counts and the dynamic nature of the signals. Vehicle energy management is potentially handled by a variety of groups all with the goal of minimizing their losses and maximizing their range for real world driving scenarios. The need to accurately understand the energy distribution throughout the vehicle has made measurement an important topic when discussing these types of tests.



