System Power Determination Validation Program

Status of EPA testing

28th EVE, Ottawa, October 2018

Numbers don’t lie!

EPA test vehicles

- 2013 Malibu Eco
  - Mild HEV (BAS)
  - Engine: 136 kW @ 6200 rpm (est.)
  - Motor: 11 kW
  - Battery: 0.5 kWh
  - Odometer: 5400 miles (8700 km)

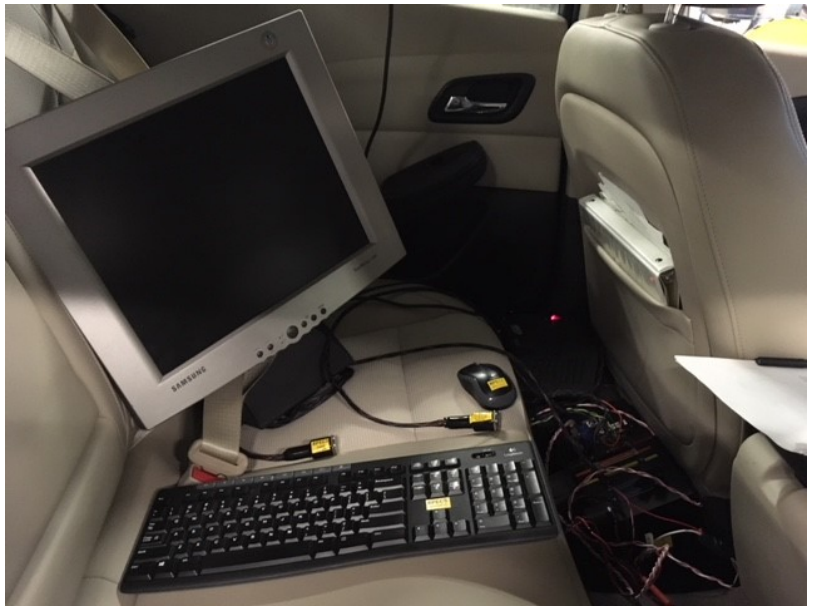
- 2013 Chevrolet Volt
  - OVC-HEV (series with power split)
  - Engine: 63 kW @ 4800 rpm
  - Drive motor: 111 kW; generator: 55 kW
  - Battery: 16.5 kWh
  - Odometer: 11100 miles (17,870 km)

Test protocol - General

- Identify speed of maximum power by conducting speed sweep
  - Day 1: Run constant speeds from 50 to 130 kph in 10 kph increments
    - Perform two 15-second accel pulses at each speed
    - Examine dyno logs to see power delivered to dynamometer rolls at each speed
  - Day 2: Conduct second, finer speed sweep
    - As indicated by Day 1 results
    - The speed of maximum power is likely to be one of the speeds swept
    - The data collected at that speed can then be used to perform TP1 and TP2
- Rate of accel was varied slightly for some pulses (no effect seen)
- Temperatures were monitored to stay within design range
- SOC restored after each pulse by light braking or coasting
  - Attempted to limit charging to 1C but this was difficult to control
  - Often, coasting at constant speed was sufficient to restore SOC

Instrumentation

- EPA utilizes Southwest Research Institute (SwRI) for instrumentation services
- Data collected by Rapid Prototyping Electronic Control System (RPECS)
- SwRI was limited in ability to instrument high voltage battery
  - Lack of standard procedure (SOP) would have added to development time
  - We decided to see if CAN signals for voltage and current would be adequate (10-sec acceleration is relatively steady state)
- For expediency, most signals were collected from CAN except manifold air pressure



Example of signals collected (Malibu Eco)

2013 Malibu Eco – test configuration

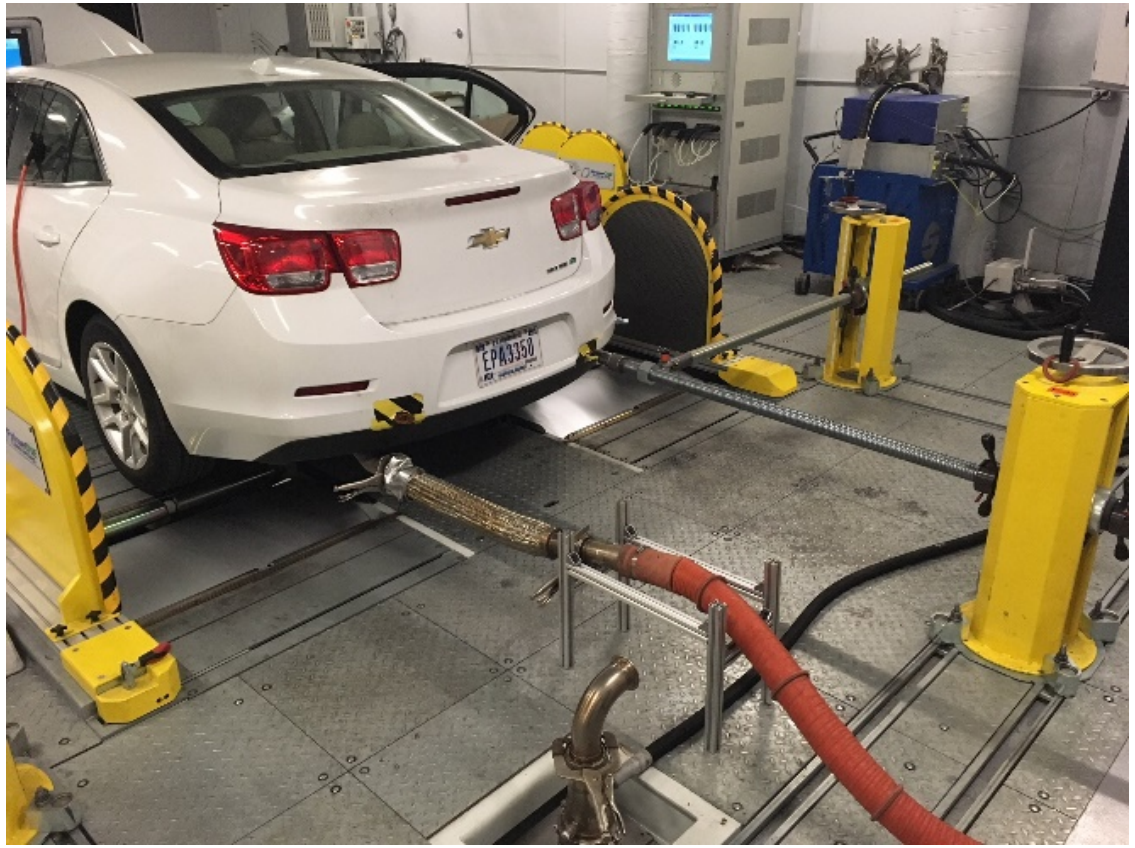
Vehicle ID	GHGMAL		**Front: 2250 lb. Rear: 1744 lb. (with 2 occupants as tested)**					
Configuration	2WD		**ETW**	**3875 lbs (3994 actual)**				
Model Year	MY2013 Manufactured 3/2012		**Coefficients**	**Target**		**Dyno Set**		
Manufacturer	GM		**A**	26.48	**lb**		**lb**	
Model	Malibu Eco		**B**	0.2366	**lb/mph**		**lb/mph**	
VIN	1G11D5RR3DF109037		**C**	0.01659	**lb/mph²**		**lb/mph²**	
Drive axle	FWD							
Dyno conf.	FWD							
Tire pressure	**Front**	35 psi	**Rear**	35 psi				
Tire size:	P225/55R17 (nominal diameter 26.74 inches, radius 0.3396 m)							

Fuel tank volume	15.8 gallons	
Fill amount	100%	

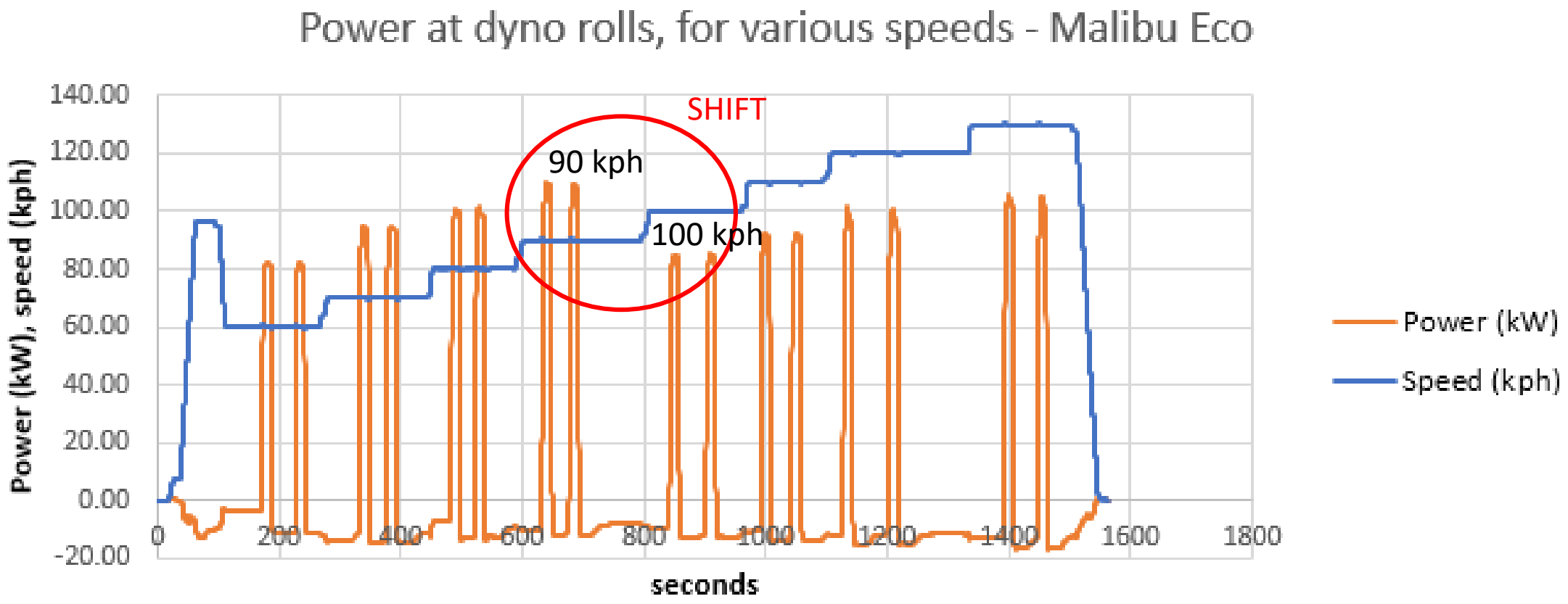
Fuel Type	Tier 2 test fuel
FTAG	26864

Fan Type and position: a) US06 fan on engine (40 mph).
Hood: Hood open

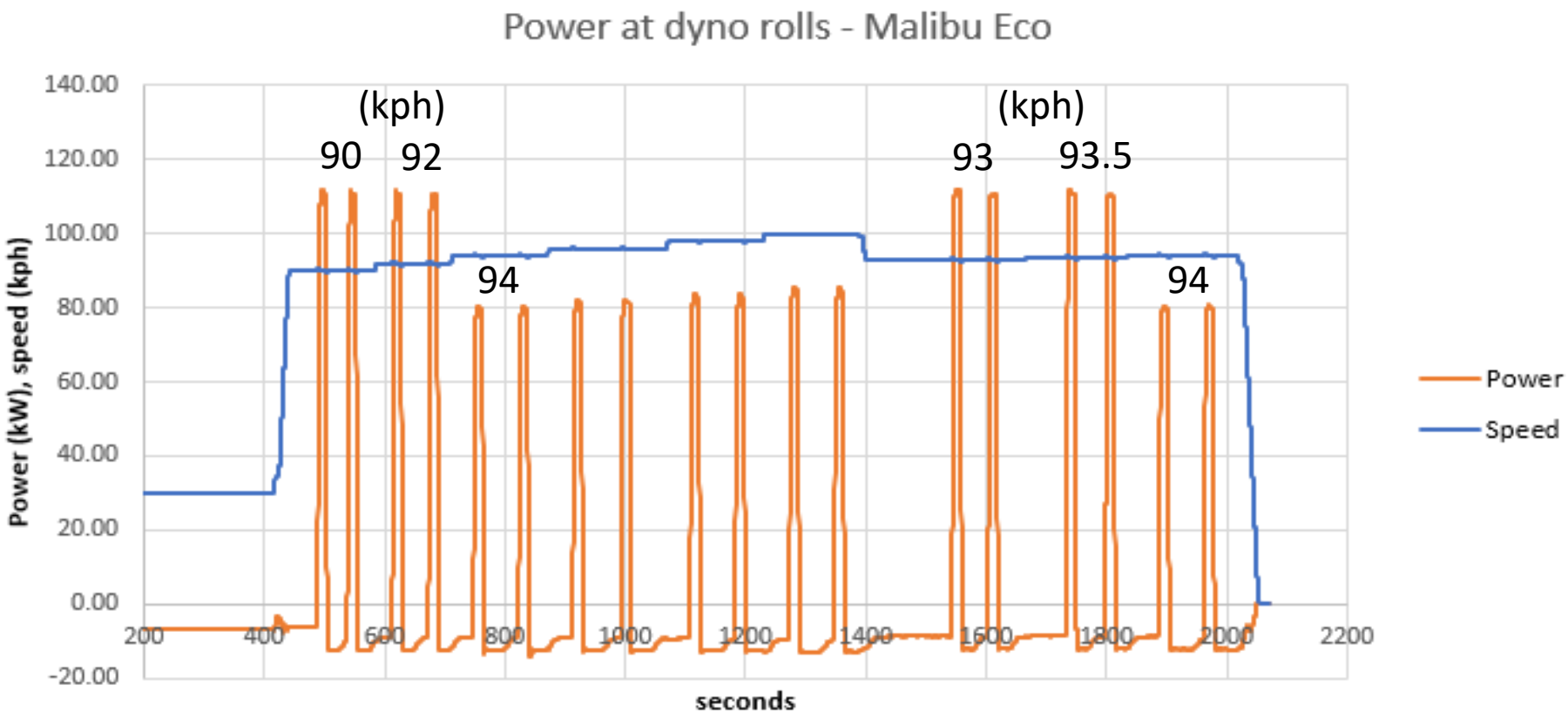
2013 Malibu Eco – Test cell setup



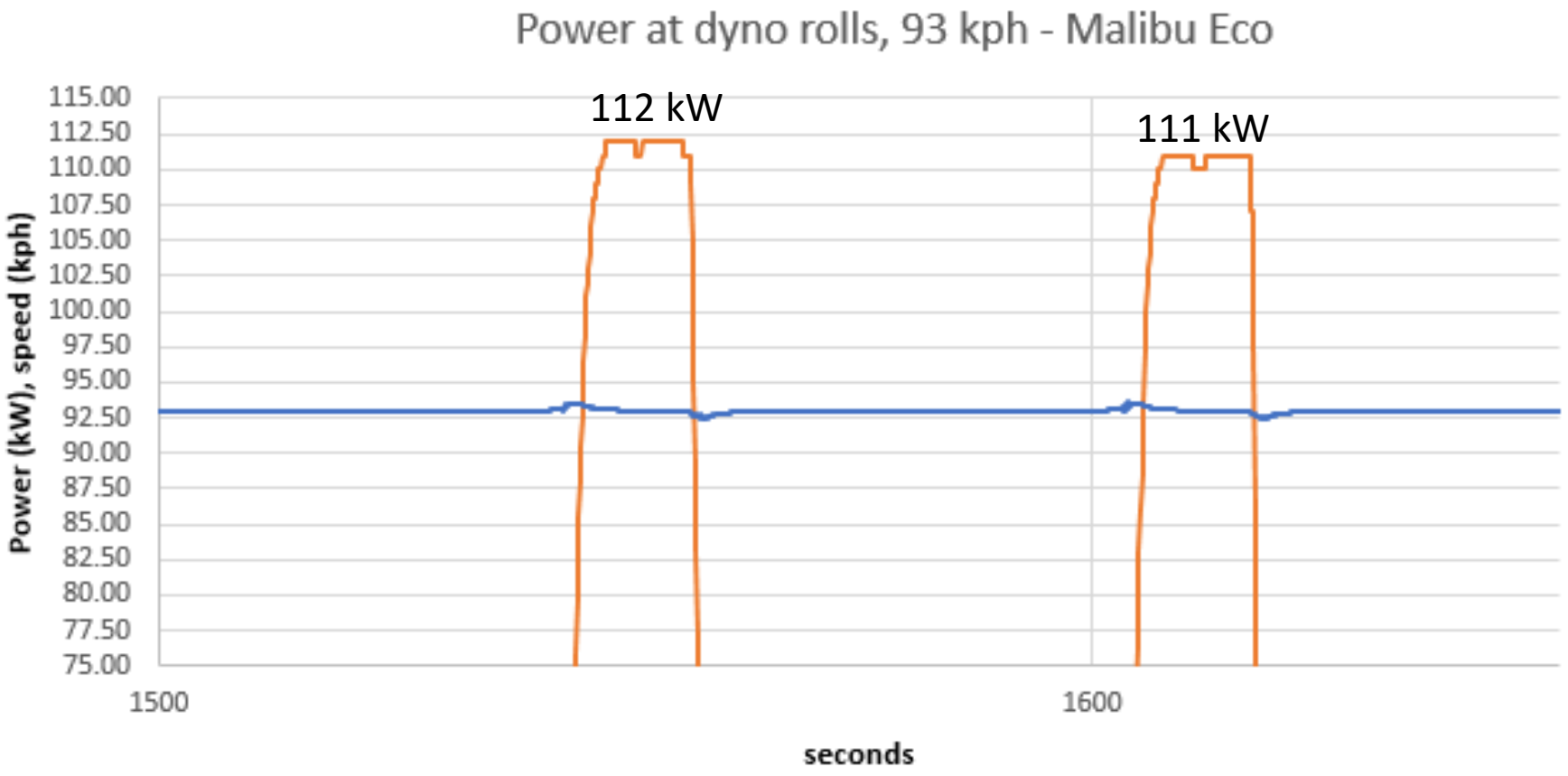
Identifying speed of maximum power
Day 1: Initial speed sweep – 60 to 130 kph



Identifying speed of maximum power
Day 2: Second speed sweep – 90 to 100 kph



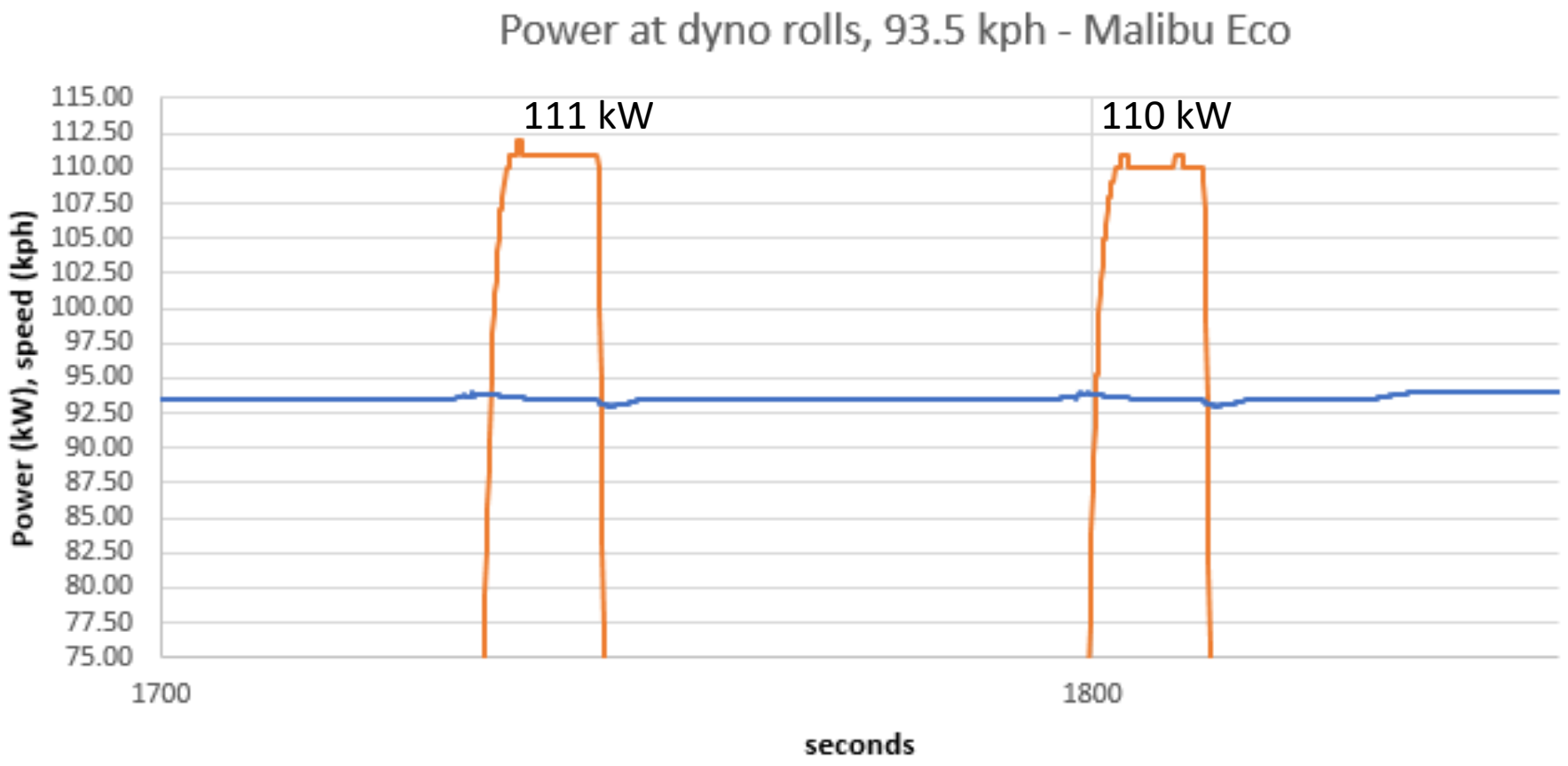
Wheel power at 93.0 kph - Malibu



(Engine speed is about 6000 rev/min)

6200 rpm = 136 kW

Wheel power at 93.5 kph - Malibu

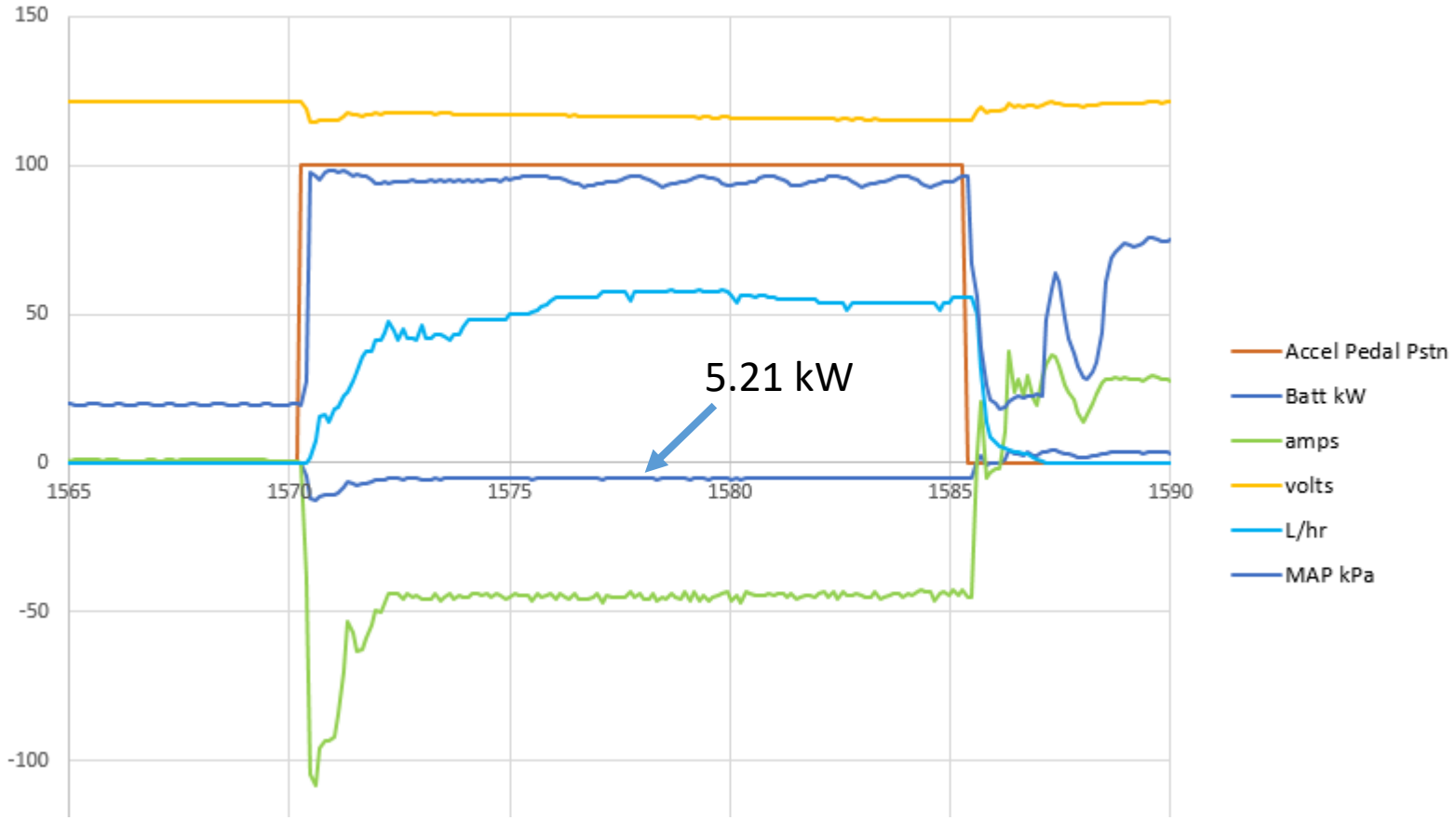


(Engine speed is about 6000 rev/min)

6200 rpm = 136 kW

Measured battery power – 93 kph

Measured battery, fuel, MAP – 93 kph



111 kW at road / (135 kW + 5 kW) at engine/battery = ~ 80% downstream efficiency

Conclusions – Malibu Eco

- Speed of maximum power: ~93 kph (expect 111-112 kW at wheels)
- Shape and magnitude of each power pulse are similar
- CAN data for current and voltage is stable and repeatable during steady state portion of pulse
- Fuel flow and MAP signals appear reasonable
- Power calculations should be achievable with this data
  - TP1 depends on availability of engine test data (equivalent to ISO 1585)
  - TP2 depends on availability of tire data (equivalent to RRC class in WLTP)

2013 Chevy Volt – test configuration

Vehicle ID	EPA3047		**Front: 2465 lb. Rear: 1704 lb. (with 2 occupants as tested)**				
Configuration	2WD		**ETW**	**3750 lbs (4169 actual)**			
Model Year	MY2013		**Coefficients**	**Target**		**Dyno Set (4WD dyno)**	
Manufacturer	GM		**A**	26.05	**lb**	2.88	**lb**
Model	Chevy Volt		**B**	-0.0120	**lb/mph**	-0.072	**lb/mph**
VIN	1G1RA6E41DU102286		**C**	0.01820	**lb/mph²**	0.01712	**lb/mph²**
Drive axle	FWD						
Dyno conf.	4WD						
Tire pressure	**Front**	38 psi	**Rear**	38 psi			
Tire size:	P215/55R17 (nominal diameter 26.31 inches, radius 0.33414 m)						

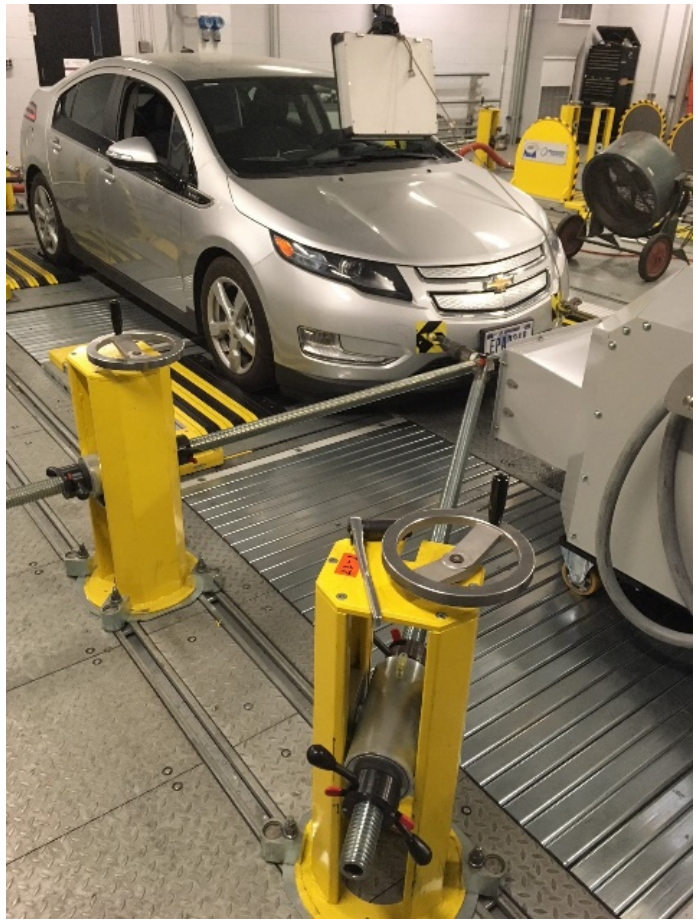
Fuel tank volume	11 gallons	
Fill amount	100%	

Fuel Type	Tier 2 test fuel
FTAG	26967

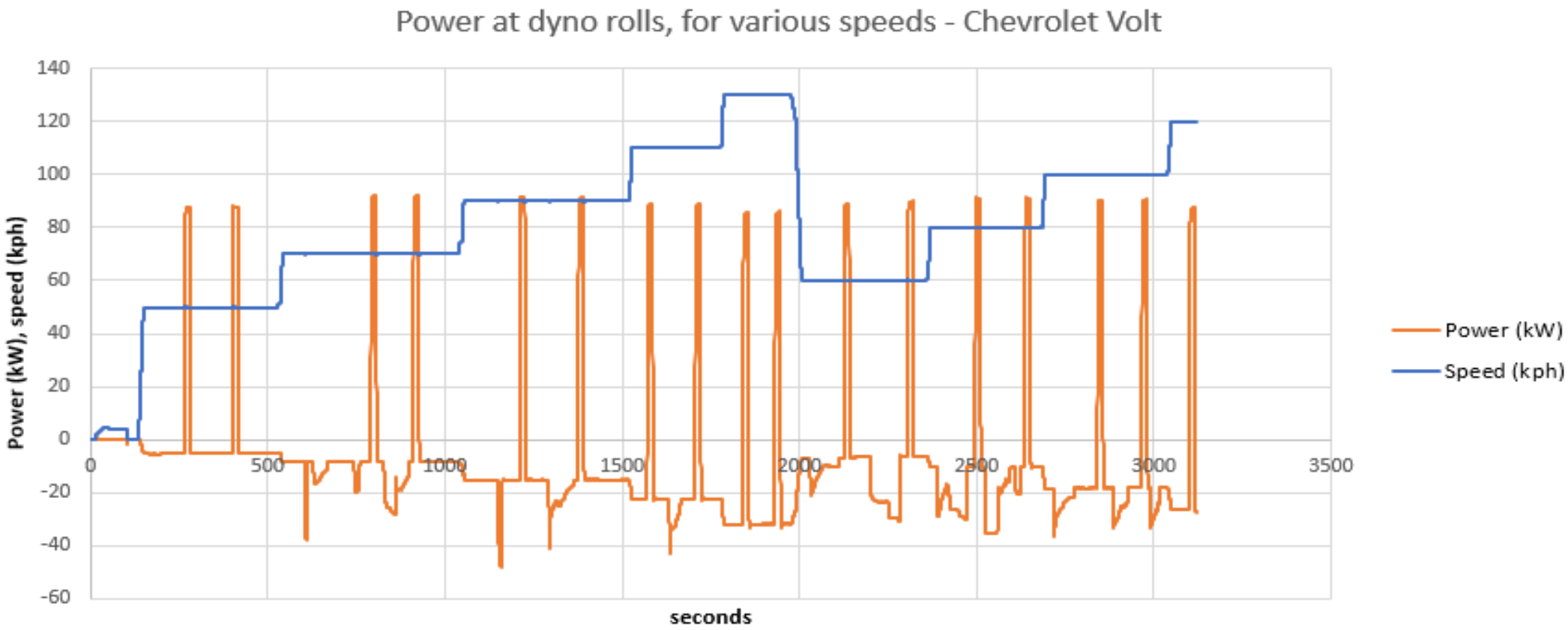
Fan Type and position: a) Road speed fan on engine.
Hood: Hood closed

Conditioning cycle: “Hold Mode”
Power cycle: “Normal Mode”

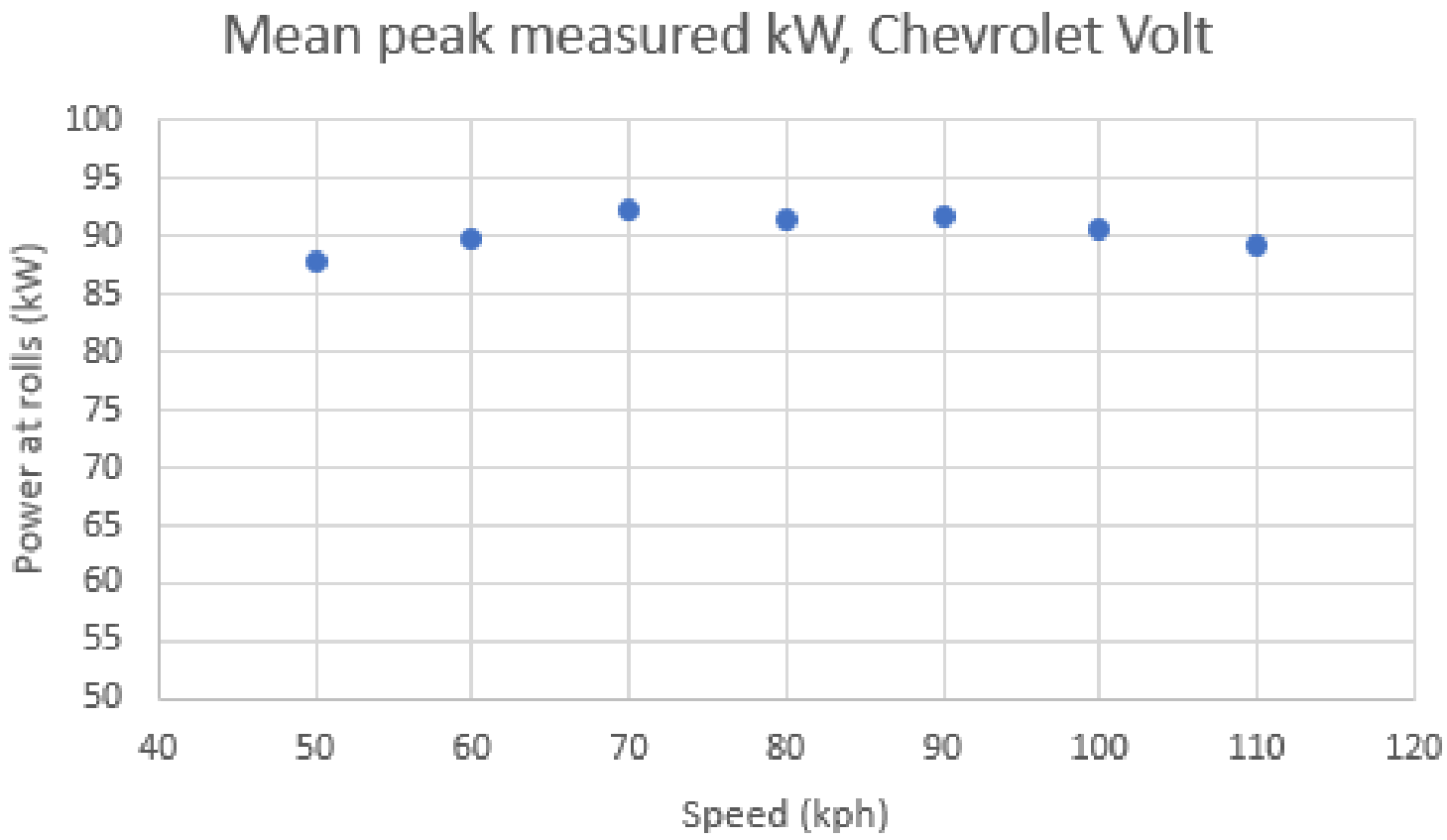
2013 Chevy Volt – Test cell setup



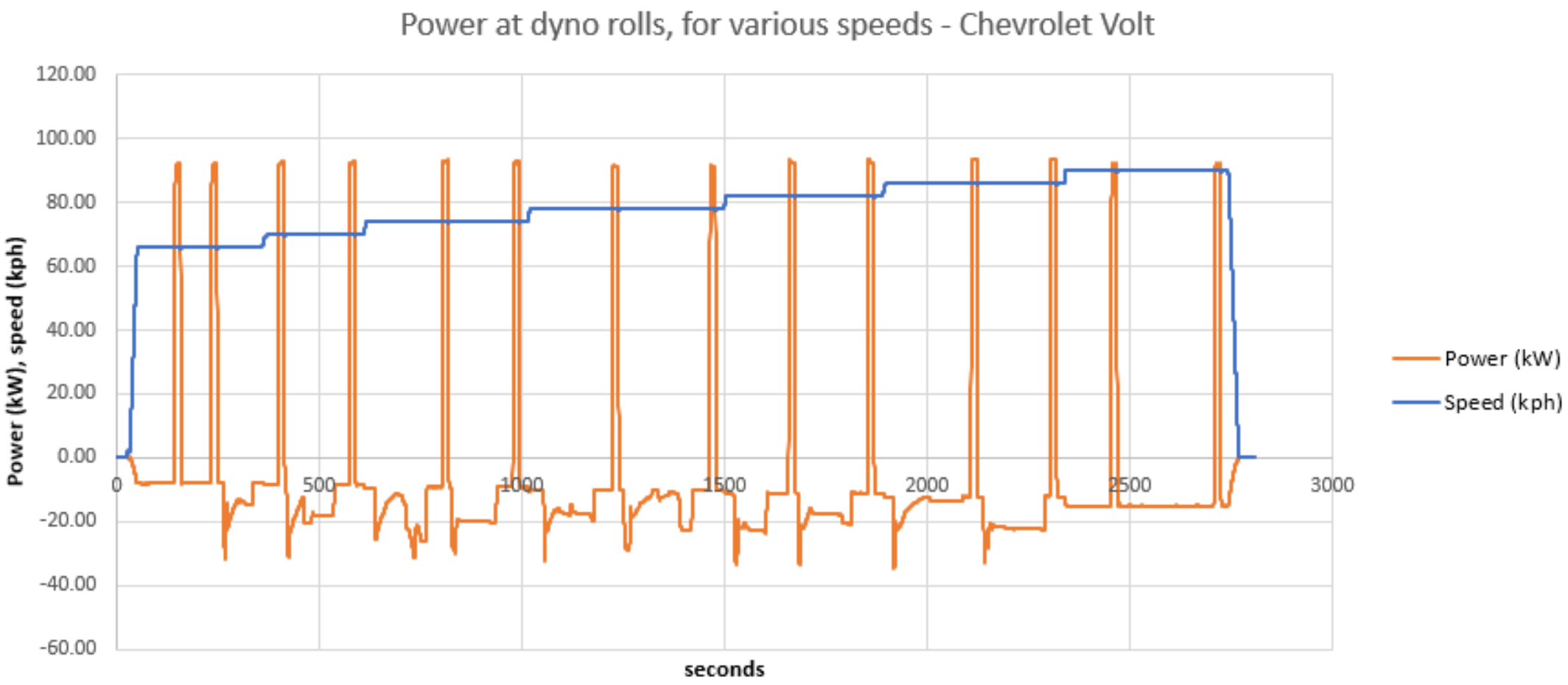
Identifying speed of maximum power
Day 1: Initial speed sweep – 50 to 130 kph



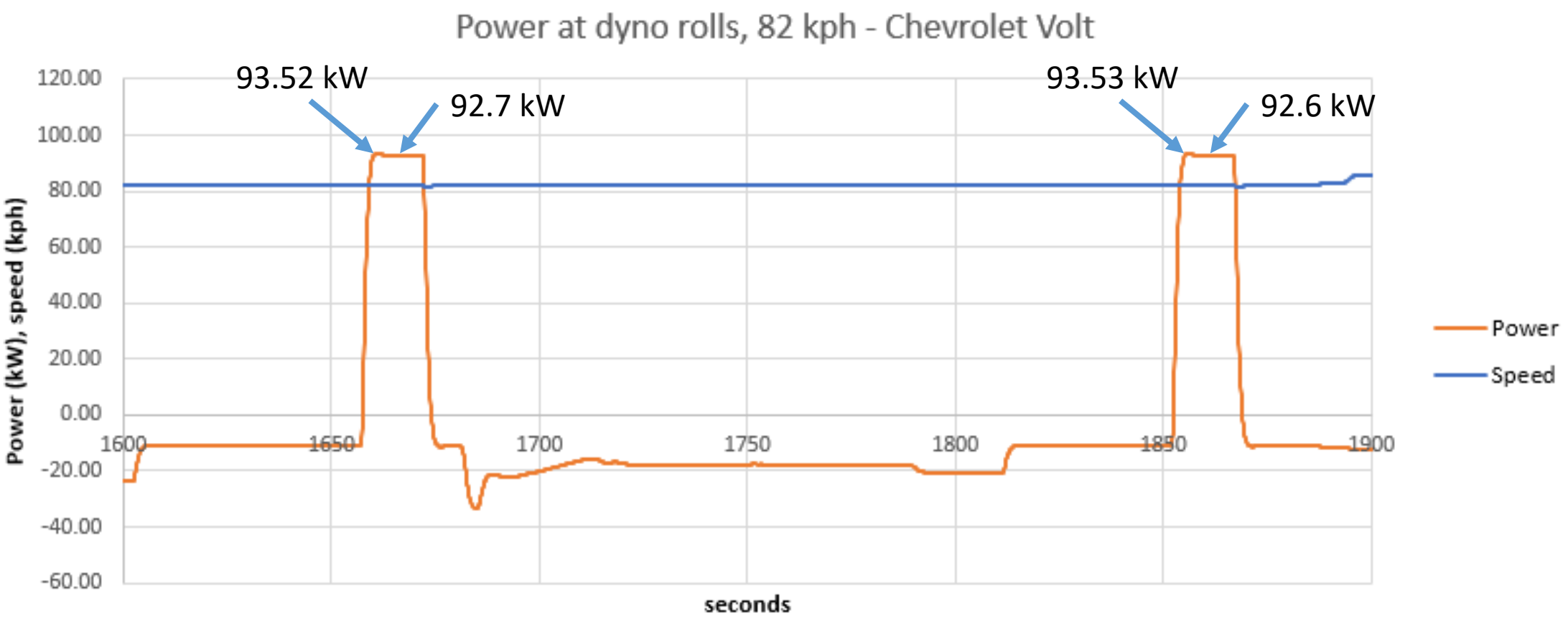
Power at wheels varies little with speed



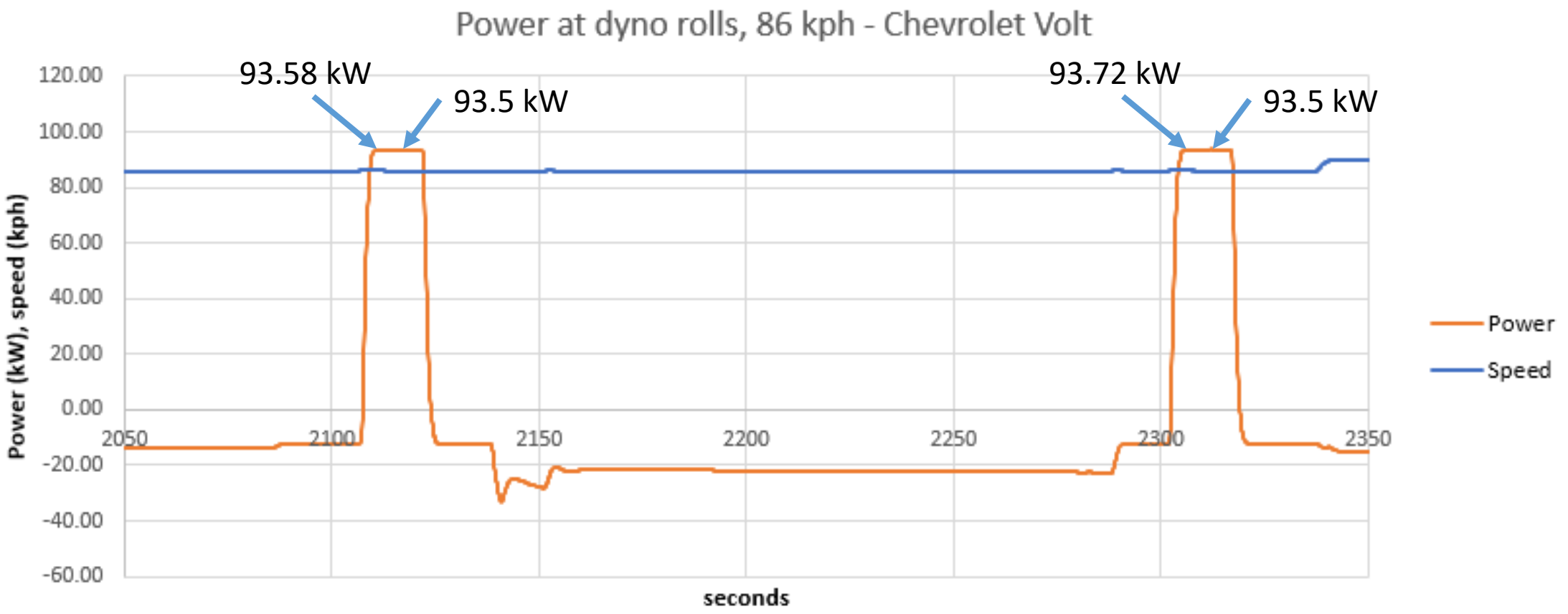
Identifying speed of maximum power
Day 2: Speed sweep from 66 to 90 kph @ 4 kph



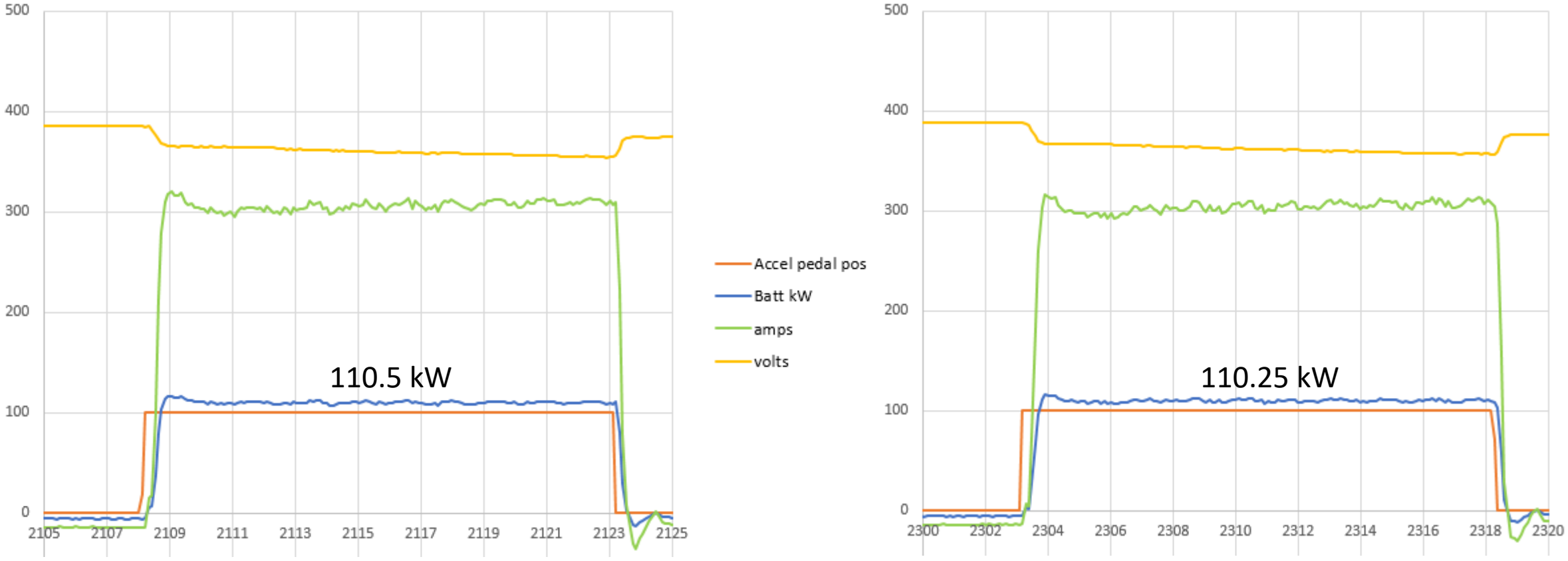
Wheel power at 82 kph – Chevy Volt



Wheel power at 86 kph – Chevy Volt



Measured battery power - 86 kph



93.5 kW at road / 110.25 kW at battery = 84.8% battery-to-road efficiency

Conclusions – Chevy Volt

- Speed of maximum power: ~ 86 kph (expect 93.5 kW at wheels)
- Shape and magnitude of each power pulse are similar
- CAN data for current and voltage is stable and repeatable
- Fuel flow and MAP signals not needed (CD = no engine operation)
- Power calculations should be achievable with this data
  - TP2 depends on availability of tire data (equivalent to RRC class in WLTP)

Other observations

- Canada, JRC, and EPA found that constant speed mode is rarely used
  - Dynamometer staff needed to review how to operate in constant speed mode
  - Controlling speed in response to sudden loading requires some attention
  - EPA found that speed control under loading was not a difficulty (+/- 0.5 kph)
- 20 min conditioning cycle was not sufficient for transmission oil temperature to fully stabilize
  - Temperature continues to creep up during testing
  - Temperature is still within design range, just higher than at end of conditioning
  - Strict interpretation of test procedure would require a return to conditioning cycle, but this is not effective at reducing oil temperature