A closer look at the...

Volt/Ampera

Written by Jim Gilmour Blue Print's Technical Consultant.

Toyota, Lexus and Honda have dominated the hybrid market for the last 12 years but recently we have seen a flurry of hybrids emerging from manufacturers including Porsche, Mercedes, Volkswagen, Peugeot, Citroën and Hyundai.

By adding a motor/generator to the transmission and a battery to store electricity, substantial improvements in fuel consumption can be achieved. However the plug-in hybrid from GM, the Volt/Ampera, is a new approach to hybrid cars.

Concept

Electric vehicles have the advantage of using relatively cheap electricity to propel the vehicle for finite distances. How far you get is dependent on the battery capacity, the time of day, weather and driving style. Charging the battery takes time and consequently living with an electric car requires a lot of forethought.

The GM approach is to supplement the electric vehicle with an engine that can generate electricity to take over where the battery left off. It sounds simple but GM have had to overcome some major technological hurdles to provide something that can replace a conventional vehicle and still offer near electric car economy.

What's in it?

The Volt/Ampera is described as a Series Hybrid – the engine drives a generator which provides energy to an electric motor, which in turn drives the wheels. In a true Series Hybrid there is no mechanical connection between the engine and the wheels. As we will see later, at times the Volt/Ampera is not a true Series Hybrid.

Note: GM have been very quiet about the details of the Volt/Ampera and the following description is derived from research, test driving and inspection.

Battery

The Volt/Ampera uses a battery weighing close to 200kg and provides a maximum discharge power of 111kW or 149bhp – that's 12 times bigger than a Prius battery. It has a nominal voltage of 360V DC and can be charged from a 230V AC domestic supply in around 4 hours. Lithium-ion (Li-Ion) technology is used as opposed to Nickel Metal Hydride (Ni-MH), which is commonly used in most other hybrids. Li-Ion has the advantage of having a higher power density i.e. smaller and lighter for a given capacity. The battery is guaranteed for 100,000 miles, or 8 years and is expected to last much longer.

The battery is made up of 288 cells which have to be monitored carefully. Li-Ion batteries are heat sensitive; their charge rate changes with temperature so it is very important that the cells are all at the same temperature. The battery temperature is controlled by a liquid cooling/heating system which uses Ethylene Glycol anti-freeze. A separate radiator is positioned at the front of the vehicle for this.

The Inverter

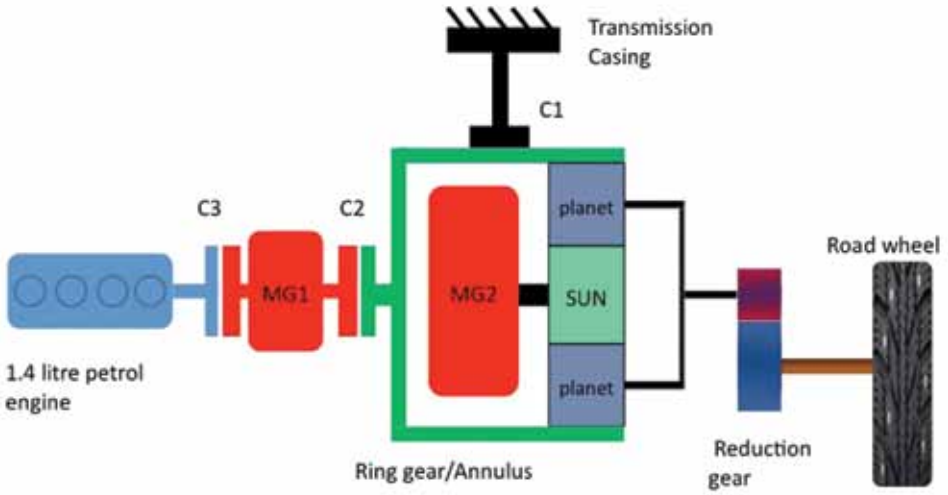
The inverter controls the current flow to and from the motor/generators. The battery provides around 360V DC and the motor/generators use a variable frequency AC current. It is the job of the inverter to control the motor/generators, changing DC to AC, to power the motors and AC to DC to regenerate electricity to charge the battery. Motor torque control is achieved by Pulse Width Modulation within the AC phase. The inverter uses large insulated gate bi-polar transistors which can handle high current and switch at high speed – the inverter also has its own separate cooling system.

The Transmission

The transmission consists of two brushless motor/generators, and an epicyclical power 'combiner' (much like the power split device in a Prius). Electric motors deliver the greatest torque at low speed, consequently the torque output of the motor drops off at higher speeds, just when the torque demand increases. To overcome this, the main drive motor / generator (MG2), is supplemented by a smaller motor generator at speeds above 70mph. The main components are: C1, C2 and C3 which are clutches; MG2 is an 111kW motor/generator and MG1 is a 54kW motor/generator – the 1.4 litre petrol engine develops 62kW.

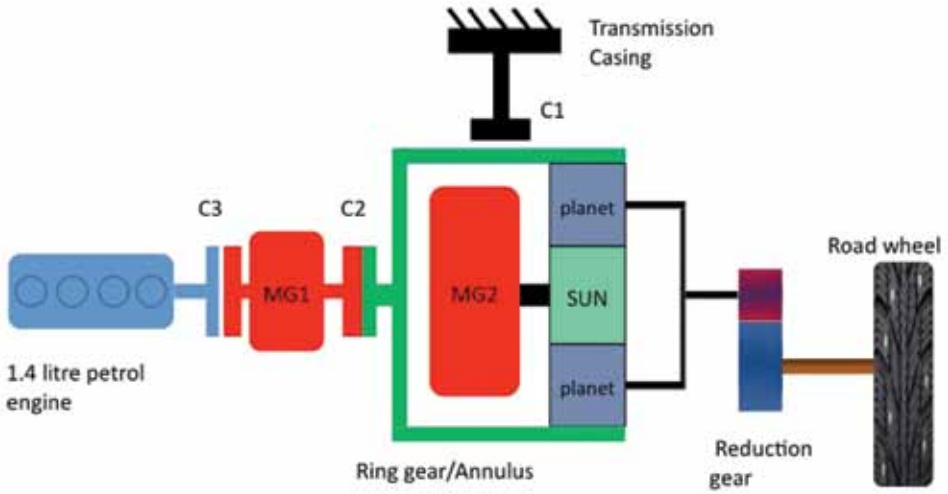
Operation

Figure 1



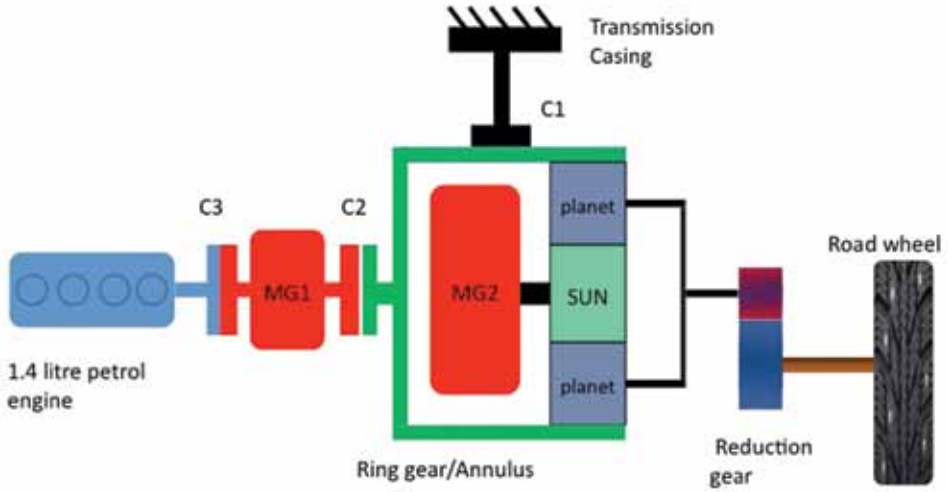
In normal 'Drive' mode up to 70mph, MG2 drives the sun of the epicyclical gear. The ring gear is fixed to the transmission casing by C1. Drive is taken out of the planet carrier, through the reduction gear to the drive wheels. At 70mph MG2 is turning at over 6,000rpm and has lost efficiency.

Figure 2



At 70mph C1 is disengaged and C2 engaged. MG1 now starts to turn driving the ring gear in the same direction as MG2. The result is to reduce the speed of MG2, allowing it to develop more torque. The torque produced by MG1 is combined with that of MG2 to allow the car to overcome the air resistance up to a maximum speed of 100mph.

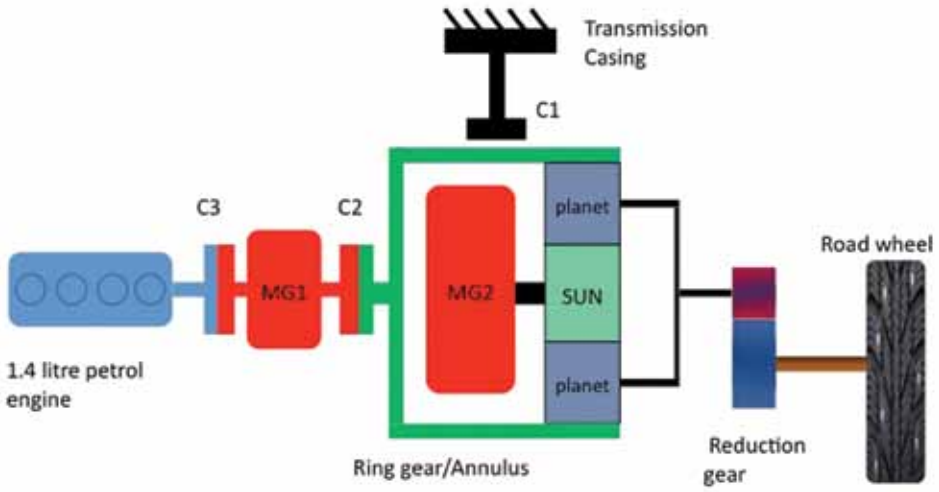
Figure 3



When the battery SOC (State of charge) drops to a minimum level or if 'Hold' mode is selected, the transmission drives in extended range mode. C3 is engaged and the engine drives MG1. This generates the electricity to drive MG2. C1 is engaged and drive is taken out of the planet carrier.

To continue reading...

Figure 4



In extended range mode at 70mph C1 is released and C2 engaged. The engine now drives the ring gear and MG1. This brings down the speed of MG2 allowing it to develop more torque. At this point there is a direct link between the engine and the wheels, and the hybrid is no longer in 'Series Mode'. Engine speed can be varied independently of the vehicle speed, giving a continuously variable transmission.

Lithium-ion Battery

Regeneration

Regeneration of the battery takes place as soon as the vehicle decelerates, brakes, or descends an incline. This can be done by MG2 up to 70mph or by both MG1 and MG2 above 70mph.

There will be a time when the battery is fully charged, meaning there is no capacity in the battery for regeneration to take place. If no electricity is generated there will be no braking effect from the transmission. It has not been disclosed what happens under these circumstances or when the 'L Mode' is selected. It is likely that either the energy generated by MG2 is directed to MG1 to turn the engine (with C1 engaged and the fuel and ignition off), which wastes the energy generated by MG2, or at higher speeds the clutches are engaged (as in Figure 4), where the road wheels are connected to the engine and the engine provides the braking.

Fuel consumption

Fuel consumption figures can vary wildly. In extended range mode it can achieve around 38 – 42mpg, but if used as an electric vehicle GM claim 313.9mpg. It's true to say that the type of journey and how frequently it is plugged in dictates fuel consumption.

Conclusion

The GM Volt/Ampera is a new concept and fits nicely between electric and hybrid offerings.

Blue Print are already listing parts for the GM Volt/Ampera.

Description	Part Number
Oil Filter	ADZ92126
Air Filter	ADG022130
Cabin Filter	ADG02562
Rear Brake Pads	ADG042123
Stabiliser Link	ADG085139