

## 2020 Alternative Powertrain Technology exam.

module code: M6X02209

name: Michael Cuniffe (P148021)

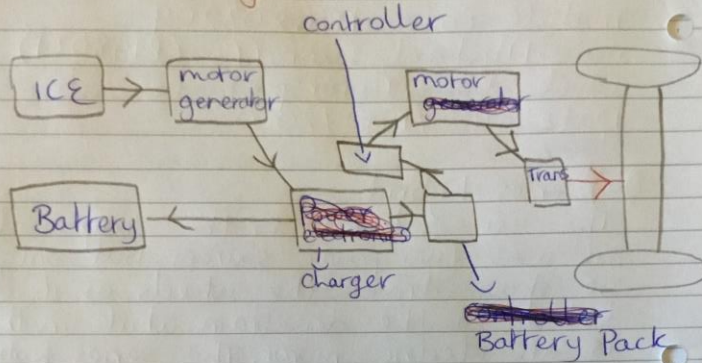
level: BSc Motorsport Level 6

Date: 11<sup>th</sup> / May / 2020

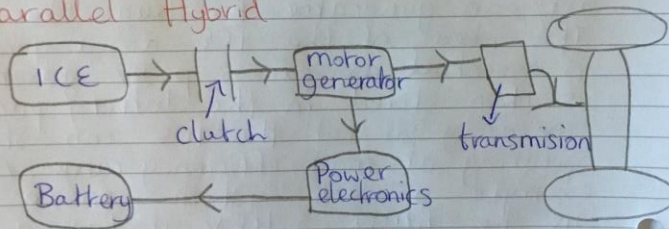
### 3) a) Series Hybrid

The series hybrid is the simplest topology, it uses two power sources but only one of those drives the wheels as it is directly linked to the drivetrain which in this case is an electric motor. The series hybrid has an ICE but only the electric motors drive the wheels so essentially the ICE acts <sup>as</sup> a generator to charge the battery. The idea of the ICE as a generator is essential as excess power generated is then stored in the battery pack separately so that the ICE can stay operating at max efficiency range. An example of such system can be seen in the BMW i3 HEV. It has a small 25kw engine used to supply charge throughout the system, so the ICE has different requirements than the normal ~~and~~ road cars. For example the electrical storage system has different cycles where they are derived as "shallow" cycle, high-dynamic charge acceptance particularly for regenerative braking and robust service life in sustained partial state of charge.

## Series Hybrid



## Parallel Hybrid



with a parallel, electric motor assist with the engine assist is possible. These designs are more cost effective because energy is converted twice between the ICE and the driven wheels in a series. The Series design shows efficiency loss due to the generator, charger, controllers and motors all have a certain efficiency therefore everytime energy is transferred from one component to the next, voltage transferred is less as it reaches the wheels. In actual fact a parallel hybrid is better in efficiency as the engine can directly put power down

But a series hybrid can operate in a more efficient manner because the engine is not coupled to the wheels. So if you don't have your engine coupled to the drivetrain, ~~it~~ do like as in a ~~parallel~~ <sup>series</sup> hybrid it doesn't have to operate through the large rev range and the ICE can be kept running at the most efficient point and charge the battery pack.

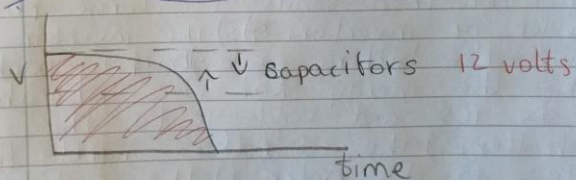
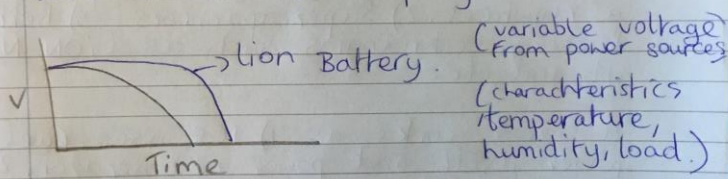
#### b) Energy storage

There are different ways hybrid systems can store energy. 1) is the way of using a flywheel. 2) Supercapacitors 3) Better battery technologies such as LiON, NiMH, Pb acid etc.

A series works as 1) ICE uses fuel to power itself and power a generator. 2) Generator then sends a charge to a charger or inverter. 3) The inverter charges the battery pack. 4) Battery pack takes the energy that was generated by the ICE and sends it to the controller. 5) the controller controls the voltage to the motor. 6) The motor will then rotate the wheels. Then with regenerative braking, the regenerative frictional and heat energy gathered is reversed back up the system, i.e. from the motors to the controllers and then to the battery pack to charge it.

Flywheel technology is used in F1 to store massive amounts of energy behind the driver to be released. The flybrid system has a very light and composite flywheel to ~~not~~ reduce rotational mass and can be spun 20,000+ rpm.

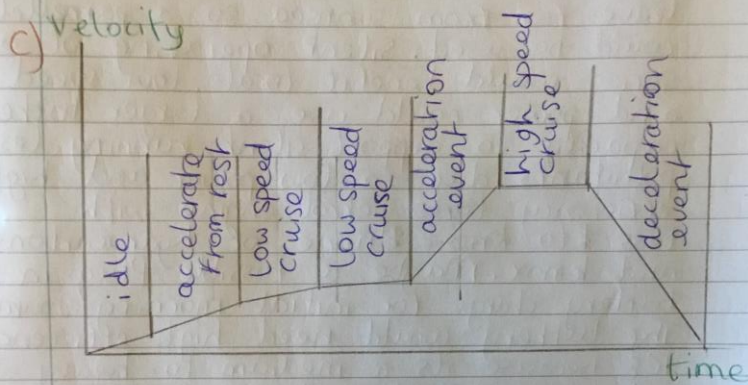
Super capacitors <sup>storage</sup> can be filled to a larger amount but their discharge is so inefficient as ~~slow~~ when storage drops below a certain volume they lose effectiveness rapidly.



|             |             | max volts | max current | Switch time |
|-------------|-------------|-----------|-------------|-------------|
| Big Stuff   | ⇒ Thyristor | 4500      | 4000        | 10-25       |
| lower Power | ⇒ MOSFET    | 1000      | 50          | 0.3-0.5     |
| most common | ⇒ IGBT      | 1700      | 600         | 1-4         |

resistance ↗

as you can see on previous graph the difference in energy density, power density.



- Since it's a flat bed not leaving Swansea really.
- Fairly constant start running at low speeds.
- Lots of regular stops / starts for carrying and delivering council load.
- Higher speed runs on the dual carriage ways of Swansea.
- Lower average power demand
- Tow limit is 900kg so low and constant consistent vehicle mass.

D) the flat beds have very low average speeds = low average power so a series hybrid is possible but not the only solution, because the flat bed won't leave far from Swansea so a parallel could be used. Silent operating of a series would benefit locals, low speed and power could use a larger battery capacity to support silent running, less pollutants due to low power and high efficiency ~~also~~ petrol engine with less ~~to~~ ~~none~~ of hydrocarbons and ~~knock~~. Maybe a Possible Plug in battery charge for initial morning Journey. The battery would need high efficiency ICE because it's a medium to heavy vehicle to support recharge.

9) a) Power = Force x velocity

$$\Rightarrow \frac{70 \times 1000}{60 \times 60} \Rightarrow 19.4 \text{ m/s}$$

Rolling resistance = (load x gravity x coefficient of rr)

$$= 1500 \times 9.81 \times 0.013 = 191.3 \text{ N}$$

Aero resistance =  $0.5 \times \text{density of air} \times C_d \times \text{frontal area} \times \text{velocity squared}$ .

$$\Rightarrow 0.5 \times 1.2 \times 0.5 \times 3 \times (19.4)^2 \text{ or } 338.8$$

$$\Rightarrow 338.8 \text{ N}$$

$$\text{Total resistance forces} = 191.3 \text{ N} + 338.8 \text{ N} \\ \Rightarrow 530.1 \text{ N}$$

Total resistive power = resistance force x velocity

$$\Rightarrow 530.1 \times 19.4 \Rightarrow 10283.9 \text{ watts}$$