How to define a Hybrid or Generator System

In a Hybrid or generator system, the engine runs at a fairly constant speed. The alternator is normally wound for the desired DC output after rectification at the engine's nominal RPM at full load. Then, the engine throttle is modulated to maintain output voltage as the load varies.

This lets the engine run at an efficient RPM.

The faster an alternator spins the more power it can make. So the higher the engine's nominal RPM, the smaller the alternator can be for a given wattage.

The primary DC output is rectified three phase AC. There will be some three phase ripple, depending on the level of filtering. Subsidiary DC voltages, if needed, are created by switching regulation.

If tighter primary DC output regulation is required, or if the engine speed will vary, switching regulation can provide the primary DC voltage. Switching regulation is larger and more expensive than simple rectification.

System design starts with the required power. For a generator or APU, this is a matter of the maximum power needed. In a hybrid system, the required power depends on the desired duration, the weight of the vehicle and propulsion motors, and other factors.

For example, if the hybrid system is for a multirotor aircraft, it may be possible to estimate required power by measuring the energy used by a battery (KWH) for a given flight time with a maximum payload.

Once you have an estimate of the wattage you need, the rule of thumb is to choose an engine with a maximum rating about twice the output power you need. This covers the power system efficiency (typically 75% to 85%) and provides margin for engine wear, adverse operating conditions, transient loads and engine lifespan.

Once you have calculated a power level, you can choose an engine based on the type you want to use. Options include 2 stroke or 4 stroke, piston or rotary and gasoline or heavy fuel. Each engine type has advantages and disadvantages.

In a multirotor aircraft, the next step is to calculate the generator system weight. This includes the engine and accessories and mounting hardware. It also includes the alternator, regulation electronics, and fuel system.

The alternator weight will depend on the wattage and the nominal RPM. The PMU weight depends on the wattage and any secondary features, such as subsidiary voltages or onboard starting. The fuel weight will be a matter of the desired duration divided by the engine's fuel consumption at full load, or the limit of the vehicle's available payload.

The overall vehicle weight will include the above, plus of course the vehicle frame, propulsion motors, and controls. Since the vehicle weight and size of the motors will depend on the payload you are trying to carry, it is likely that you will need to iterate a few times to find a suitable size vs. flight time balance.