ePROPELLED™

APPLICATION NOTE

Using Power Systems to Enable Hybrid Modes

HYBRID™ READY

UAV designers face a complex range of tradeoffs within systems and parameters that affect one another. Payload and power needs affect each other directly, while propulsion method and electrical power requirements are also intertwined. That's why no decisions should be made in isolation. A hybrid design is one that creates synergies between the propulsion system and the power system to produce a lighter, more efficient aircraft. What's exciting about this approach is the fact that it does not require continuous hybrid operation to be effective.

Engine Size and Power Requirements

Internal combustion engines still provide the most efficient propulsion system for many UAV applications. The power density of fuel remains the most important consideration for many propulsion applications, and gasoline has nearly 100 times the energy density of a lithium-ion battery. Therefore, many defense, security, and commercial mission profiles use only internal combustion engines, which can profit from a hybrid mode of operation.

The weight of a UAV is a function of many factors, including payload, which ultimately determines the requirements for the airframe and other systems. Payload also has a major impact on the electrical power requirements of an aircraft. Additionally, the weight of the electrical system, including the battery, is a function of the mission parameters, payload, and other requirements. It's all interconnected.

The mission parameters will determine systems like avionics, which will have specific power requirements. However, all the systems on board will have a range of power requirements that must be met in the UAV design. And because the power requirements for takeoff and steady flight are fundamentally different, UAV designers face an interesting dilemma when determining engine size, which can result in an engine that is not as fuel efficient as possible for steady flight. The engine size can also add weight, reduce flight time, and add cost to the aircraft design.

An intelligent hybrid power assist system (iHPAS) solves this problem. An iHPAS marries an existing internal combustion engine, a combined starter generator and propulsion motor, and an intelligent electronic control unit that merges an electronic engine starter (EES) and an intelligent air motor controller (iAMC). This allows the starter generator to change from power generation mode to power assist mode, enabling it to draw power from the battery and utilize this energy for propulsion, thereby supplementing the engine in propulsion mode.

As UAV designers seek to create products that meet specific mission profiles, it is critical that they size internal combustion engines for steady flight rather than exclusively for peak power requirements at takeoff. We refer to this design feature as "power assist" and it is available with ePropelled's Hybrid Ready™ products.

The Need for Power Systems

An internal combustion engine cannot supply electrical power directly, so an alternator or starter generator is required. Technically, these are different electrical machines that perform a similar function in supplying electrical power. A starter generator differs from an alternator in that it has sufficient torque and power to start the engine from the onboard battery power. Incorporating an electronic engine starter as a component of the power electronics eliminates the need for separate external starters.

However, the starter generator must be sized to generate the appropriate electrical power budget for the payload avionics and mission parameters and be able to capture mechanical energy from the engine to provide a 3-phase AC power output.

Power capacities for input and output need to be compatible and the electronic power systems must match the starter generator conversion requirements from AC to DC for onboard avionics and to charge the battery. Power electronics such as an intelligent power system (iPS) take the DC power and break it down to the net appropriate voltages for the various systems within the UAV.

Considerations for Power Assist

There are several factors that an aircraft designer must consider when building their product. First, the battery must be appropriately sized (and fully charged). Second, the starter generator needs to provide sufficient additional power to assist in takeoff, and the designer must consider the relative power requirements of takeoff and steady flight. Third, and as noted previously, the appropriate electronic engine starter must also be in place. It is important to remember that the starter generator must be sized to have enough torque to turn over the engine when starting it, and to reach cranking speed at the required engine torque, in seconds.

Using an example scenario, a starter generator when mounted to an internal combustion engine (ICE) must be able to provide the following:

1. Initial torque to overcome compression when at zero speed to start spinning.
2. Required cranking torque at the required cranking speed. For example, if the torque required is 15 Nm at 2000 RPM for five seconds, approximately 3.14 kW of power would be required for this specific engine to crank.
3. To achieve the required cranking torque and speed, a certain minimum current, around 112 A from the batteries at 28 V, is required.
4. The initial torque to overcome the compression may be much higher depending on the temperature of the engine. A cold start will always require much higher torque to overcome compression. In some cases, this torque can be twice as much as the nominal cranking torque.

A torque speed graph should show if the above requirement is achievable for a specific-size starter generator. The example graph shows that a 10 Nm torque was achievable at 1000 RPM using 24 VDC and approximately 70 A.

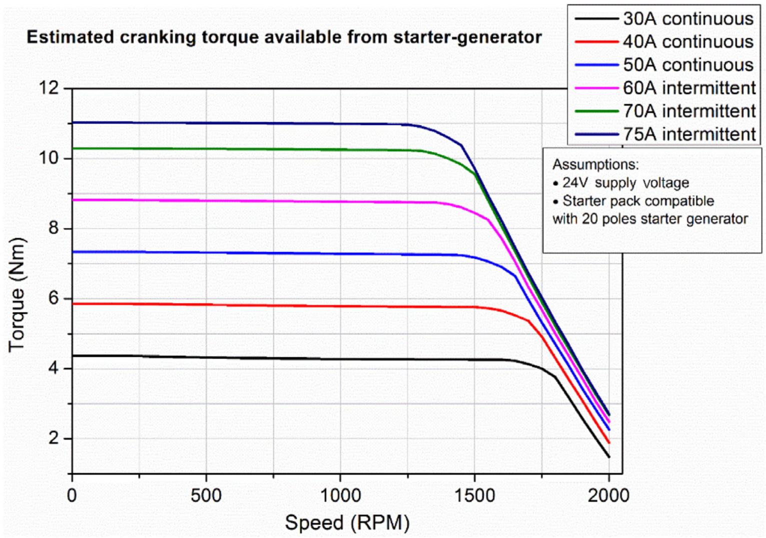

FIGURE 1: Estimated cranking torque available from starter generator

It is important to note that the starter generator will not charge the battery if the ICE is running below a certain RPM. For example, when a given ICE is running at 3000 RPM, the starter generator will produce 30 VDC output after its 3-phase has been rectified. The 30 VDC will be able to charge a 7-cell LiPo pack, each cell being 4.2 volts. If the RPM drops to 2500 RPM, the rectified voltage may drop to 25 VDC and the 7-cell pack will not be able to charge.

This illustrates the importance of properly matched power system components, including the starter generator, power management unit, and electronic engine starter. ePropelled's patented technology provides significant advantages to UAV designs and we can work with your team to determine the correct components for your specific application.

Best Uses

As UAV designers seek to create products that meet specific mission profiles, it is critical that they size internal combustion engines for steady flight rather than exclusively for peak power requirements at takeoff. We refer to this design feature as "power assist" and it is available with ePropelled's Hybrid Ready™ products.

Power assist can:

- use a starter generator as a propulsion motor to provide sufficient power to assist the internal combustion engine during takeoff,
- use battery power to extend flight time providing a mechanism to land the aircraft in the event of a fuel emergency, and
- temporarily use only electrical power for reduced noise.

In their work, aircraft designers must consider the various requirements and options available for production, including the selection of an appropriate starter generator and power electronics. Additionally, the battery and control systems must be sized to support their unique applications. Since an electrical system is a required component in aircraft design, its weight can be offset by utilizing it as power assist or range extender. These features will enable UAVs to fly higher, longer, and smarter, and should be an integral part of the aircraft systems design.

For more information about ePropelled, please visit our website.