POWER SOLUTION BRIEF

DCM for Tethered UAV Applications

Written by: Arthur Russell, Alexander Mezin

DCMs Help Tethered UAVs to Fly

Many applications require power to be supplied using long cables. To minimize cost and weight, power-systems designers must find an optimal supply voltage that balances the size of the conductors and losses in the cabling, with the size and weight of the insulation required, as well as minimizing the size and weight of the converters in the equipment. Tethered drones are particularly demanding as weight reduction is a critical requirement: this post describes how Vicor DCMs can be used to create an optimum solution for this demanding application.

The Drone Revolution

Recently the use of unmanned aerial vehicles (UAV) has become more popular not only in military settings but also in commercial applications. The use of drones opens up a wide range of opportunities for more effective support from the air. One example might be a remote transmission of human senses – remote "eyes and ears" can be transmitted back to a personal computer or smartphone in the form of a real-time video stream.

As the performance of UAVs improves, they are entering the consumer package delivery segment, formerly reserved for manned vehicles and foot delivery. Such airborne delivery methods improve delivery reach in cases where rough terrain, or flooding might otherwise block access. Alternately, rather than a delivery payload, drones can be outfitted with sensors for analyzing environmental gases, pressure, humidity, and other physical parameters. In military or secure industrial settings, tracking movement or inspection and examination of unidentified objects has already been a well-established core capability of UAVs.

Tethered Drones

In most cases, when we talk of UAV, we mean a flying machine with remote control powered by a rechargeable battery. A UAV with a battery has limited energy stored on board, and therefore has finite flight time. UAVs whose missions involve a finite airspace, however, can use power provided by a cable to enable unlimited flight time.

A cabled, or tethered UAV is referred to as an Unmanned Aerial System (UAS), and receives its primary power via a cable bundle back to the ground. Control and telemetry may also be transmitted via the cable, or may continue to be wireless like their battery powered counterparts. In a battery-powered UAV, the local battery discharge must be closely monitored by the drone. In contrast, the situation is quite different in a UAS, since the tether supplied DC power is typically very predictable and reliable.

UAS Power Systems

The base station of the UAS is the power provider for the UAV. A global manufacturer will want to build a system with capability to be able to work with different AC or DC power networks, supplying the tethered vehicle with a stable DC bus voltage. The designer must consider regulating against disturbances and changes on the power line as these changes could otherwise impact the UAV position in the air (modulated prop speed or other flight surfaces).

Events such as load dumps and power transients are common while supporting the base station off-grid, for example when a ground vehicle or sea vessel supplies power. These events can also create disturbances or even interruptions on the power source for the UAV, and so UAVs often include an emergency battery to guarantee controlled, powered descent from the greatest altitude. Therefore the UAV itself needs a power supply to regulate the tethered input power and handle management of the on-board battery.

One of the challenges when designing a power supply for UAV is choosing the most suitable voltage range. The designer has to decide between Low Voltage (LV, up to $1500V_{DC}$) or Safety Extra Low Voltage (SELV, less than $60V_{DC}$) to power the UAV. Supplying SELV from the base station means no hazardous voltages exist, and therefore the cable insulation can be thin, and relatively light-weight. On the other hand, transmission of high power within the limited SELV voltage range leads to high current flow. To offset otherwise unacceptable losses and heating in that case, larger conductors are needed, which adds copper weight and cost across the length of the tether. Moreover the maximum permitted AC line impedance presented to the UAVs on-board power supply are more aggressive at lower voltages, at a given power level. The copper is lighter and the impedance stabilization more straightforward for a UAS that uses a LV source. The higher voltage, however, brings with it higher safety requirements to control shock hazards, which tends to drive with thicker insulation on the tether power line.

The longer the cable is, the more voltage drop is expected. This disadvantage can be solved by using a power cable with higher cross section, but the weight of the cable directly offsets payload weight capacity. For example, a 10m copper cable pair with 1mm diameter weights 140g without insulation. A diameter of 2mm will be already 560g for every 10 meters! Heavier cable bears higher material costs and is less agile. In military applications using a thick power line in a system that should remain undetected may be a disadvantage as a UAV capable of lofting this heavier cable may generate more acoustic noise, or be more easily spotted.

UAS Power Systems Using Vicor DCMs

The Vicor DCM family is an ideal solution for UAS applications, offering both ELV and LV input voltage options, with most UAS designers using higher voltages. The DCM is an isolated, regulated DC-DC converter utilizing a high-frequency, zero-voltage switching (ZVS) topology, with very high power density. It operates from an unregulated, wide-range input to generate an isolated, regulated output.

Let’s consider a typical application. DCMs allow the design of an extremely flexible system with wide input voltage range. The DCM300P240x600A40, for example, has an input voltage range of 200 – $420V_{DC}$ with a regulated 24V output at up to 600W, minimizing on-board energy storage.

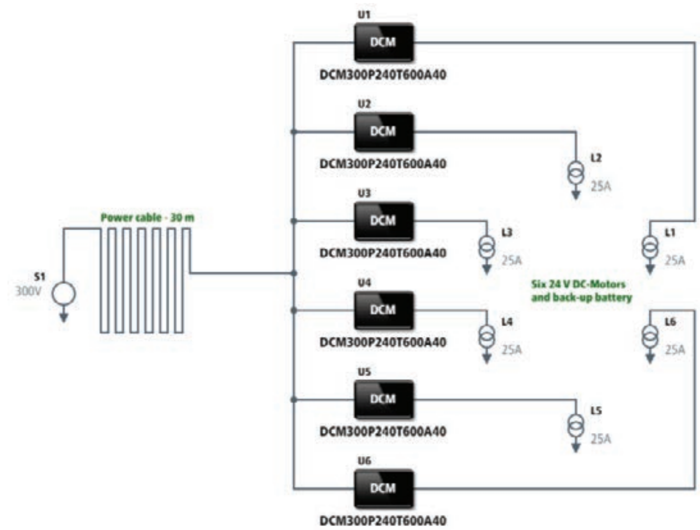
The DCM offers the capability to adapt to changing requirements. In the initial system requirement of the UAS application, a standard cable length will be chosen. If subsequent extensions to the cable length are needed, the wide input range of the DCM can accommodate added voltage drop per unit tether length.

The DCM family offers outstanding output power to weight ratio. DCMs suitable for LV applications are offered in the 4623 package, with up to 600W output from a typical package mass of 29g! Saving several grams on each DC motor enables more lifting capacity (payload).

The DCM offers high efficiency. Its high density is partially enabled by the stacked input cell structure possible with the double-clamped ZVS architecture. Stacking input cells safely permits the use of lower voltage FETs, with correspondingly higher figures of merit compared to higher-voltage switches.

A typical UAS application is given in the PowerBench Whiteboard design here. It uses multiple DCMs to take a high voltage input through a long (30m) cable and provide regulated power to the motors and the batteries.

A typical UAS application



Contact Us: http://www.vicorpower.com/contact-us

Vicor Corporation
25 Frontage Road
Andover, MA, USA 01810
Tel: 800-735-6200
Fax: 978-475-6715
www.vicorpower.com

email
Customer Service: custserv@vicorpower.com
Technical Support: apps@vicorpower.com