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Powering counter-UAS systems



with uncompromising speed and reliability

VICOR

Power averaging for counter-UAS systems delivers speed and reliability

DC-DC converters provide high-power pulses for size- and weight-constrained platforms explains Dave Berry, sr. principal applications engineer, Vicor

Whether detecting or disabling enemy drones or drone swarms, counter-UAS (unmanned aircraft system) platforms rely on power delivery networks (PDNs) that can deliver short, high-power pulses to their load. The challenge, however, is optimizing the source of power to ensure speed and reliability.

In most cases, supporting sustained peak loads requires PDNs with extremely bulky supplies adding size and weight. Unfortunately, Counter-Unmanned Aircraft Systems (C-UAS) are often mobile and battery- or generator-powered, inherently limiting their PDN's peak power capabilities. While a platform's pulsed emitter may demand tens of kilowatts for a few hundred microseconds, most C-UAS systems can only provide a small fraction of that.

Power averaging offers an efficient solution. With power averaging, rather than sizing the entire supply for the peak power condition that occurs only for brief periods, a power-averaging circuit pairs a current-limiting converter with a bulk capacitor to deliver far more power than the converter alone could supply. With high power density, fast capacitor recharge and safe operation into large bulk capacitance, high-density modular DC-DC converters can make power averaging a reality for C-UAS systems.

Using power averaging to deliver C-UAS speed and performance

One solution for applications where the load is only on for a short duration and is repetitive, is to use a current-limiting converter and a capacitor to supply peak power needs. When configuring such a power system, the designer must take into account the current limit, power limit and stability of the power supply as well as sizing the capacitor properly to keep the voltage drop at the load within its tolerances. Pulsed emitters, radar and LIDAR arrays, and similar pulsed C-UAS loads can take advantage of power averaging to reduce cost, space and weight within the system.

Power averaging configurations are very effective when the load can tolerate a wide input voltage range. This is typically the case where the load is another regulating

$$C = 2 \cdot \left(\frac{P \cdot (T_1 - T_2)}{V_1^2 - V_2^2} \right)$$

Figure 1: C is the hold-up capacitor value, P is the power needed during each pulse. T1 - T2 is the pulse duration. V1 is the starting voltage before the pulse and V2 is the final voltage at the end of the load pulse.

device — typically a point-of-load converter — or several of these regulating devices.

When the point-of-load (PoL) or load demands power, the capacitor will deliver a greater portion of the load current because the DC converter will go into current limit feeding the capacitor and the load. As the capacitor delivers the PoL or load current, its voltage will begin to fall. The capacitor must be sized so that the voltage across the capacitor stays within the input voltage range of the PoL converter (Figure 1).

To minimize the capacitance needed the designer can charge the capacitor to the PoL's maximum input voltage and allow the power draw over the power duration to operate the capacitor down to the PoL's minimum input voltage.

Safeguard against power system failure by setting current limiters

DC-DC converters are typically designed to regulate voltage up to a maximum power level and therefore have a maximum current and power rating. If the load, such as the radar load in a C-UAS emitter, tries to draw more than the rated current from the supply, the supply typically goes into a current-limiting mode that either folds back the output voltage or shuts down and restarts.

The current limit is typically set just above the maximum rated current so that full power delivery is possible at the voltage set point of the converter. A converter rated for 500W at 48V_{DC} will have a maximum continuous current rating of 500W/48V_{DC} or 10.4A. The current-limiting feature however, may not start until the output current is at 13A.

Current limiting is typically designed for load faults where the converter will see current limit only a few times in its life. If the converter isn't designed to go into current limit as a normal mode of operation, doing so too frequently can stress components within the converter and shorten the life of the power system.

If the load draws more than the maximum current but below the current limit at the voltage set point, then eventual power system failure can result from chronic overpowering of the supply. Thus, a 500W converter at 48VDC with a current limit set at 13A will be overpowered up to 624W before current limiting starts.

Dealing with complications of large bulk capacitance

The large bulk capacitance used in power-averaging applications can cause many complications for the DC power system. Upon power-up the larger capacitor, which in many cases can be in the thousands of microfarads, can draw the DC supply into current limit. With the potential problems associated with built-in current limiter, frequently an external current-limiting circuit is required to limit the supply within its maximum current and maximum power ratings.

Counter-UAS power designers can pre-charge the capacitor or add series resistance that limits the current

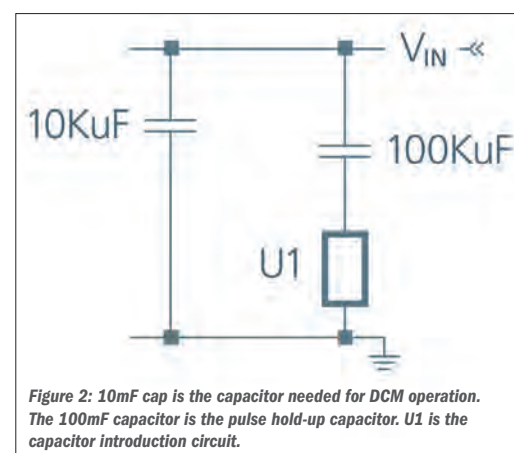


Figure 2: 10mF cap is the capacitor needed for DCM operation. The 100mF capacitor is the pulse hold-up capacitor. U1 is the capacitor introduction circuit.



Figure 3: Vicor DCM4623 is power dense and has a safe current-limiting feature for counter-UAS platforms. Vicor DCM™ DC-DC converters are designed to handle large amounts of capacitance at their outputs and can operate within their maximum current rating and power rating even when driving capacitance values as large as 10 millifarads.

at start up, which can be shorted out once the external current limiting circuit is active (Figure 2). Pre-charging and current-limiting circuits can be complex and they take

up valuable board real estate. The external current-limiting circuits must also be fast enough to catch an overcurrent event.

This can be challenging because even a few switching cycles can cause an overcurrent event. Once the DC supply successfully powers up, the power system must be stable. With some DC-DC converters, the large capacitor can destabilize the voltage control loop, which can cause supply or system failure. This potential stability issue can be overcome with access to the control loop of the power system, but this requires complex and time-consuming engineering work.

DC-DC converter designed for highly capacitive counter-UAS loads is essential

The peripheral circuitry can become very complex if the power converter isn't designed to handle a large capacitor at its output. Vicor DCM™ DC-DC converters, however, are

designed to handle large amounts of capacitance at their outputs and can operate within their maximum current rating and power rating even when driving capacitance values as large as 10 millifarads. Even larger capacitance can be handled if it is switched in during start up. The DCM has a safe current-limiting feature which means it can safely operate at the voltage set point of the module because the DCM can deliver more than its rated power for short durations (Figure 3).

At start up, the DCM will drive the capacitor up to voltage while staying within its specified operating area. Once the capacitor is charged, the control loop of the converter is designed to be stable during normal operation.

If the application is designed for power averaging, the initial power burst into the downstream PoLs will be greater than the converter's capability. The PoL input current will be delivered from the voltage source that has the largest potential. Due to the ESR of the capacitor, the converter's output can have the larger potential and will deliver the initial surge of current until its output drops because of current limit. DCMs are designed to handle this surge current until its internal current limit takes over. Once the DCM's voltage drops, the current demand will then be satisfied by the capacitor. The capacitor can be sized to deliver much more current than the DC converter module. Once the PoL or load current demand is over, the DC converter has to recharge the capacitor to its initial voltage so it can be ready for the next current demand (Figure 4).

Agility and reliability are cornerstones of top C-UAS platforms

The challenges of protecting borders from threats are perpetually evolving. However, the importance of speed and reliability in responding to threats will never change. Configuring a power delivery network that can respond under the most daunting conditions is essential and saves lives.

Power supplies configured for power averaging enable fast response and reduce the size, weight and the cost of power systems. Reduced size and weight, of course, increase mobility and flexibility in the field which is always an added benefit. Deploying a power averaging approach, where the load is on for a short, periodic duration, is the optimal profile of reliable counter-UAS detection and response system.

The support circuitry can be minimized if the DC converter module is designed to operate safely within its current-limit and power limit maximums. Sizing the power system for the average power also helps eliminate the support circuitry and hardware needed for power systems sized for continuous peak-power delivery. This also helps the designer maintain the system space and weight constraints.

In the field, every detail matters – speed, agility, reliability, size and weight. When designing C-UAS platform, fighting for every kilogram and watt is the difference between a power system that fits within the application and one that does not.

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