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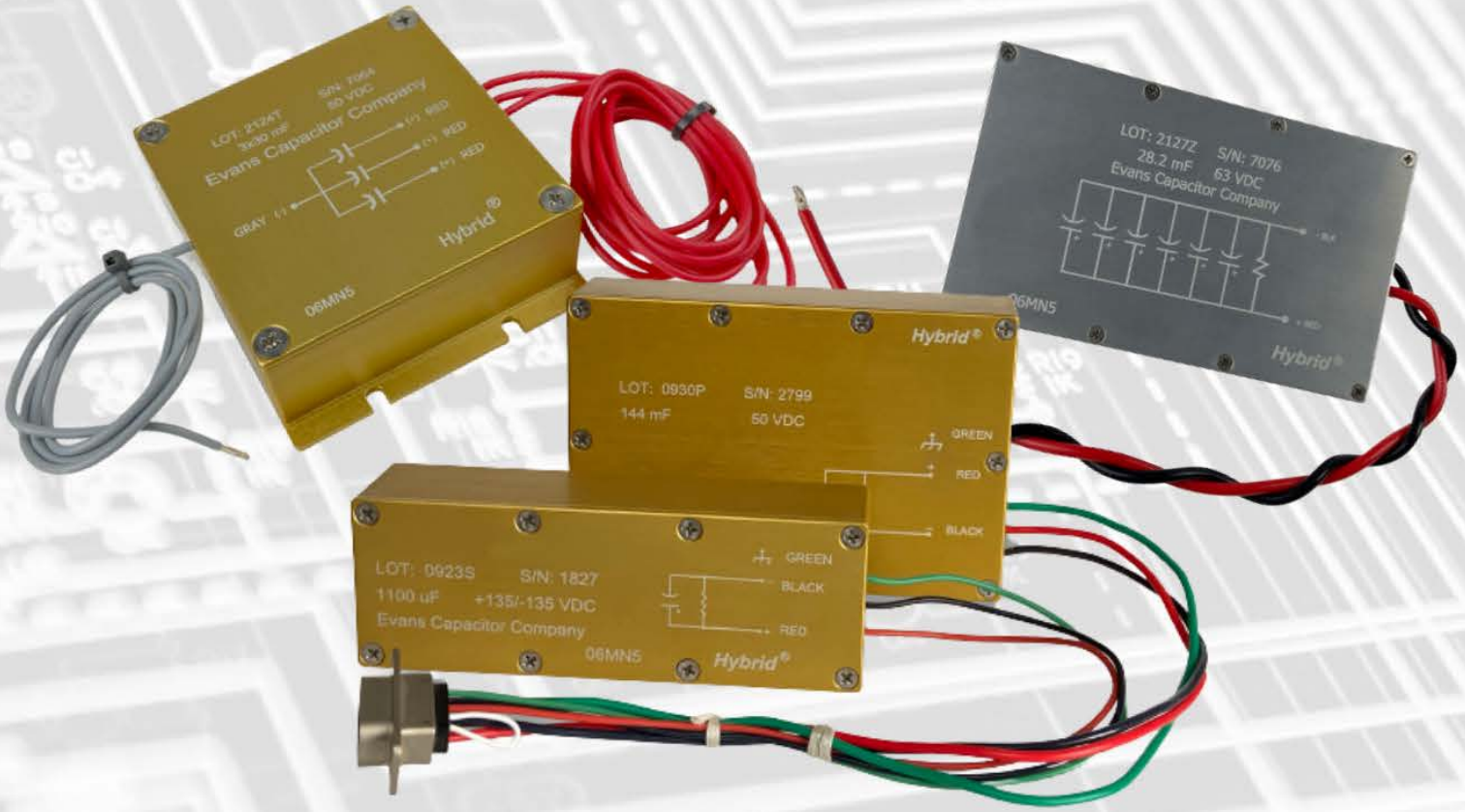
Specifying a Capacitor to Meet MIL-STD-704 / DO-160 Power Hold-Up Requirements

White Paper



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Introduction

Today's aircrafts and airborne vehicles have evolved significantly from their origins. They contain a suite of advanced navigation, communication, and display systems. This is particularly true on military aircrafts which use cutting edge technologies that add capabilities and improve effectiveness, performance, and safety. As these advanced systems are increasingly incorporated into modern avionics systems, airborne electric power systems have evolved to support them.

In avionics, these technologies are referred to as utilization equipment. Utilization equipment is defined as any equipment which receives power from the aircraft's electric power system.[1] Some types of utilization equipment will not properly function if their supply of electric power is interrupted. In these cases, power hold-up functionality is required to ensure that certain critical systems remain in operation during certain power interruption events.

MIL-STD-704 and DO-160 are standards that designers use to determine the required power hold-up capability of a system. Power hold-up is achieved by using capacitors. This whitepaper will help designers of power supplies and/or airborne systems determine how much capacitance is needed to support an application's unique power hold-up needs and how to choose the right aerospace grade SWaP (Space, Weight, and Power) optimized capacitor to ensure compliance with MIL-STD-704 and/or DO-160.

Understanding Airborne Power Needs

Aircrafts and airborne vehicles have multiple electric power sources. Engines drive onboard generators to provide the main power. Other onboard power sources include batteries, independent auxiliary power units, and air or hydraulically driven generators.[2] While on the ground, an external power source such as a Ground Power Unit (GPU) can be used.

A transfer operation occurs when there is a switch from one electric power source to another.[3] During a transfer operation, there is a brief lapse in electric power that is supplied to the utilization equipment. This is known as a power interruption. Even a 20ms power interruption event can disrupt some types of utilization equipment to the point that they may not function for a period of time, which can create performance and safety issues.

There are military and FAA standards (MIL STD-704 and DO-160) that specify that some types of utilization equipment must have the ability to continue to operate during a power interruption. This ability is referred to as "power hold-up".

Designers must determine if their utilization equipment requires power hold-up and how long the power hold-up duration must be (known as the hold-up time). While there are COTS power supplies that have their own built in power hold-up capability, designers can work with power supply manufacturers to create custom options that meet their specific requirements based on their unique needs. In some cases, a separate stand-alone power hold-up capacitor module can be integrated into an airborne electric system.

Calculating Capacitance Needs and Choosing the Right Capacitor

Achieving power hold-up is done by using a capacitor or bank of capacitors. During operation, the capacitor is in a charged state. If a transfer operation occurs that results in a power interruption, the capacitor functions as the power source during the power interruption period. The capacitor will continue to function as the power source until it reaches the minimum allowable voltage as determined by the regulator, or until normal power is restored.

A designer must specify a capacitance value such that the hold-up time is long enough to provide power through a specified power interruption period. The equation used to determine the capacitance value is as follows:

$$C = \frac{2 \text{ x } (P \text{ x } T)}{V_{(bus)}^2 - V_{(min)}^2}$$

Where:

C = capacitance in F
P = power in watts
T = time in seconds
V_{bus} = bus voltage
V_{min} = minimum allowable regulator input voltage[4]

Assuming a designer is calculating how much capacitance is required to hold-up 400 watts for 60ms on a system with a 50V bus voltage and a 10V minimum allowable regulator input voltage, the calculation would be as follows:

$$C = \frac{2 \text{ x } (400 \text{ x } .06)}{50^2 - 10^2} = \frac{48}{2500 - 100} = 20\text{mF}$$

After the needed capacitance is known, the designer is ready to begin their search for a suitable capacitor. Assuming a 50% voltage derate, the designer can specify a 100V capacitor. Being an avionics application, the size, weight, and reliability of the capacitor choice must be carefully considered. These calculations assume and ideal capacitor and do not take losses into consideration. A capacitor with high ESR will contribute to voltage droop and reduce the hold-up time thus requiring more capacitance. It's important to keep an eye on the capacitor's electrical characteristics such as ESR and DCL.

Part number TDE4100103 from Quantic Evans is one such option. This is a 100V, 10.4mF, hermetically sealed hybrid wet tantalum capacitor. This capacitor has a 1.4" x 1.4" square footprint and a height of 0.755". Two of these capacitors connected in parallel will satisfy the 20mF / 100V requirement. Quantic Evans also offers capacitors configured in capacitor modules that can contain 2 - 8 (or more) capacitors. Quantic Evans' capacitors and capacitor module assemblies are widely used in aerospace power hold-up applications and have a long track record of success.

Regardless of capacitor choice, finding a reliable solution that minimizes space and weight, has low ESR, and can withstand the environmental and mechanical conditions seen in common avionics systems will contribute significantly to overall system reliability and performance.

About Quantic Evans:

Quantic Evans manufactures high power density capacitors for demanding defense and aerospace applications. Quantic Evans capacitors are hybrid wet tantalum capacitors that offer significant savings on space, weight, and power (SWaP) when compared to other capacitor technologies. For over a decade, Quantic Evans has been a preferred supplier for several Tier 1 Aerospace and Defense contractors and is ISO9001/AS9100 certified.

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1,2,3. (Department Of Defense Interface Standard, "Aircraft Electric Power Characteristics", 1991)
4. (Atrenne Computing Solutions, A Celestica Company, "Aircraft Electrical Power System Hold-up Requirements White Paper", 2016)