Aircraft Electrical Power System Holdup Requirements

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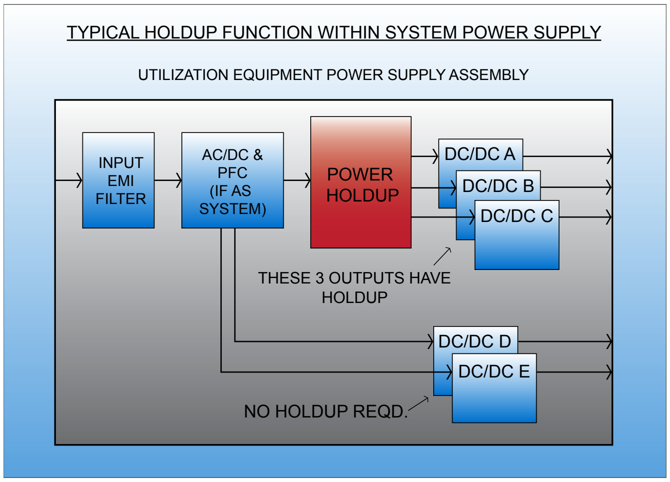
Part 1 – Understanding the Standards

This white paper is the first in a series exploring the standards and design considerations related to MIL-STD-704 and DO-160 power supply hold-up.

Overview:

When designing airborne systems, compliance to certain parameters of the MIL-STD-704 (A-F) or DO-160 (A-G) standards will be required. Systems that are connected to and derive their power from the aircraft electrical power bus are called Utilization Equipment. There are many electric power parameters that must be considered for proper operation of the utilization equipment that is connected to the power bus. This white paper will help system designers to better understand the terminology and requirements specific to the parameter commonly referred to as "holdup".

A Transfer operation as defined in MIL-STD-704 is a switching operation that transfers the aircrafts electrical power feed from one source to another. In the process of executing the power transfer, there will be a momentary



interruption in electrical power supplied to utilization equipment. It is sometimes a requirement that utilization equipment continue to operate during the resultant power interruption. This capability is defined as a holdup function. Simply stated, the utilization equipment must ride-through a power interrupt without any interruption of its intended function. In such systems, the power supply within the equipment must have sufficient energy stored in reserve to draw upon during these dropout events. A holdup requirement can be applicable to systems of various power levels, and holdup time durations can range from 50 mS up to 1 second in some systems.

The Power System:

The electrical power holdup function is usually embedded into the power supply subassembly that is utilized within, and powers the utilization equipment in question. The energy storage holdup module itself will typically reside between the input filtering (and AC/DC conversion and Power Factor Correction (PFC) block if applicable) and the downstream DC/DC converter blocks that provide the final output voltages used to power the equipment.

Utilization equipment that must include holdup capability will most often utilize a custom designed power supply.

Separate stand-alone holdup modules are available for certain requirements.

System designers will generally turn to power system design experts to provide the power supply and holdup functions within a single assembly. Commercial Off-The-Shelf (COTS) units are available, as well as custom designed power supplies with internal holdup capability can be utilized. Part 1 of this series will provide the system designer with the knowledge and the tools to interpret and understand the applicable requirements such that adequate specifications can be defined and flowed down to the power system designers.

Which Standard Applies?

Airborne equipment will have to comply with many environmental and operational standards. In this article we are dealing exclusively with the potential power holdup requirements of utilization equipment. Within this framework, our discussion will be limited to understanding the requirements of MIL-STD-704 and RTCA DO-160 as they pertain to the holdup function. In the end, the system designer will need to make the determination as to which standard (or both) they will need to follow. In many cases, system requirements will flow down to the power supply design. This paper does not provide details or procedures for certification of equipment, only guidelines for determining which standards may apply.

In general, equipment being developed for use in military airborne applications will need to meet some or all of the requirements defined in MIL-STD-704. Note that the standard does not state that any given equipment must have a holdup capability. It only states that if it is required, it must meet certain detailed parameters. These parameters are defined in the standard and will be detailed later in this paper. Application requirements and related system functions determine if a holdup is required.

The Radio Technical Commission for Aeronautics (RTCA) is a private, not-for-profit association. Through the release of their Minimum Aviation System Performance Standards (MASPS), & Minimum Operational Performance Standards (MOPS), their documents define minimum certification standards of utilization equipment, but these are recommendations only. The RTCA DO-160 document provides specific Environmental Conditions and Test Procedures for Airborne Equipment. Section 16 of that document provides recommended guidelines for holdup during power interrupt conditions. MASPS and MOPS are frequently referred to by the FAA in Technical Standard Orders (TSO) which provide a partial basis for the certification of equipment. A TSO is a minimum performance standard for specified materials, parts, and appliances used on civil aircraft.

In the end, it is the responsibility of the system designer to understand the intended functions of the system, and to determine how to design his or her equipment to meet the requirements.

Typical Utilization Equipment Power Supply With Holdup

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Military Standard 704:

MIL-STD-704 is a Department of Defense (DOD) interface standard. MIL-STD-704 establishes the DOD requirements and characteristics of aircraft electric power provided at the input terminals of electric utilization equipment. System designers need to ensure that their equipment is compliant to the standard, and is tolerant of the electrical parameters as called out in the standard.

Specifically in regard to holdup, the basics of meeting the above statement are as follows: A holdup function is not a requirement for every type of utilization equipment that derives its power from the aircraft power bus. It is up to the system designer to make this determination. The MIL-STD-704 specification itself only establishes the characteristics of the Transfer Operation described earlier. Per MIL-STD-704, under conditions of bus or power source transfers, voltage and frequency shall not vary between zero and normal operating limits for longer than 50 milliseconds. A normal transient may occur upon completion of a transfer. That statement tells the system designer that he or she will need to provide enough energy storage such that the power supply assembly can continue to power the system during a 50mS power interrupt.

The system designer should be aware that the utilization equipment may not be required to operate under the transfer condition unless a level of performance is specified by its detailed specification. Keep in mind that not all of system functions may be required to stay powered for the duration. The designer may save cost, space, and weight if he or she gives some thought to only keeping critical functions alive throughout the interrupt period. This will be further discussed in Part 2 of this series. MIL_STD-704 does however require that all utilization equipment shall automatically resume specified performance when normal operating characteristics are resumed. Thus even if it is determined that a system does not have to ride-through the power interruption, all systems connected to the aircraft power bus must recover cleanly and resume normal operation without user intervention.

To reiterate, the military standard itself only defines that holdup may be a requirement, and it defines the transfer operation parameters. If it is determined that a design is required to comply with MIL-STD-704, the designer will need to understand how to test and verify system performance against that standard. Referring to the applicable MIL-HDBK-704 for the specific Aircraft Power Group will provide detailed descriptions and test methods that will enable verification that a system design meets the requirement.

There are seven utilization input power types defined by the different sections within MIL-STD-704. The testing of each type for compliance to power transfer operation (and all other parameters) is established in the appropriate MIL-HDBK-704 as defined in the table provided here:

Aircraft Power Group	MIL-HDBK-704
Single Phase, 400 Hz, 115 Volt (AC)	MIL-HDBK-704-2
Three Phase, 400 Hz, 115 Volt (AC)	MIL-HDBK-704-3
Single Phase, Variable Frequency, 115 Volt (AC)	MIL-HDBK-704-4
Three Phase, Variable Frequency, 115 Volt (AC)	MIL-HDBK-704-5
Single Phase, 60 Hz, 115 Volt (AC)	MIL-HDBK-704-6
Direct Current, 270 Volt (DC)	MIL-HDBK-704-7
Direct Current, 28 Volt (DC)	MIL-HDBK-704-8

RTCA DO-160:

The not-for-profit RTCA, Inc. functions as a Federal Advisory Committee and develops consensus based recommendations on contemporary aviation issues. The organization's recommendations are often used as the basis for government and private sector decisions as well as the foundation for many Federal Aviation administration technical Standard Orders.

Section 16 of the RTCA DO-160 document defines power input requirements for utilization equipment flown on commercial and private aircraft. Within this section there is a separate delineation of the power interruption and holdup requirements for AC and DC systems respectively.

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For AC systems, a transfer operation can result in power interruptions for periods of up to 200mS.

For DC systems, a transfer operation can result in power interruptions for any period up to 200mS for equipment Category A and 50 mS for Category B equipment, and 1.0 second for Category D and Z equipment. The category definitions are defined in the box to the right.

Unlike the military standard, DO-160 includes the compliance Test Procedures within the main document. These test procedures should be reviewed as part of the designer's research. As with the military standard, the test procedure sections of the document will provide detailed descriptions and test methods that the designer will need to know to verify that a system design meets the requirement.

Specifying Design Requirements:

Determining whether system functions are critical and require holdup is a first step in the design process. Determining the required holdup duration (if any) is step two. The next step will be to understand power consumption requirements. With this information a reasonable estimate of cost, space, and weight can be determined. Part two of this series will provide guidance for that effort. Keep in mind that not all systems may be required to ride through the interrupt.

Partner with Atrenne Computing Solutions

If your system requires MIL-STD-704 and/or DO-160 compliance, let Atrenne Computing Solutions be your backplane and chassis integration partner. To consult with one of our representatives, please reach out to us at:

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DO-160 Section 16 Equipment Categories

Category A (for DC Systems)
Designates 28 V DC equipment intended for use on aircraft electrical systems where the DC is generated from primary power supplied from either a constant or variable frequency AC system. Category A DC equipment may have a battery floating on the DC bus.

Category B
14 V or 28 V DC equipment intended for use on aircraft electrical systems supplied by engine driven alternator/ rectifiers, or DC generators where a battery of significant capacity is floating on the DC bus at all times, is identified as Category B

Category D
270 V DC equipment intended for use on aircraft electrical systems where the DC is generated from primary power supplied from either a constant or variable frequency AC system.

Category Z
28 V DC equipment that may be used on all types of aircraft electrical systems applicable to these standards is identified as Category Z. Category Z shall be acceptable for use in lieu of Category A or Category B. Examples of this category are DC systems supplied from variable speed generators where:

1. The DC supply does not have a battery floating on the DC bus, or
2. The control or protective equipment may disconnect the battery from the DC bus, or
3. The battery capacity is small compared with the capacity of the DC generators.

About the Author

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