Procedures and Guidelines (PG)

DIRECTIVE NO.	563-PG-8700.2.4C	**APPROVED BY Signature:**	
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COMPLIANCE IS MANDATORY

Responsible Office: 563 / Power Systems Branch

Title: Low Voltage Power Supply Design

PREFACE

P.1 PURPOSE

The purpose of the Procedure/Guideline is to define the process of designing, building and testing low voltage power supplies for spacecraft instruments and payloads.

P.2 APPLICABILITY

This PG applies to personnel in Code 563/Power Systems Branch who are designing, building and testing low voltage power supplies.

P.3 AUTHORITY

a. GPG 1410.1D, Directives Management

P.4 REFERENCES

EEE-INST-002	Instructions for EEE Parts Selection, Screening, Qualification, and Derating
MIL-STD-975	NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List
06-063-1	NASA Guidelines for Selection and Application of DC/DC Converters

P.5 CANCELLATION

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P.6 SAFETY

None

P.7 TRAINING

A degree is required per the Position Description. It is recommended personnel using this procedure also have some background in designing low voltage power supplies.

P.8 RECORDS

None

Record Title	Record Custodian	Retention
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** NRRS – NASA Records Retention Schedule (NPR 1441.1)*

P.9 MEASUREMENT/VERIFICATION

None

PROCEDURES

In this document, a requirement is identified by "shall," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive material by "is."

These procedures/guidelines are formulated to provide efficient definition, design, and implementation of low voltage power supplies for spacecraft instruments, whether designed in-house or purchased.

These procedures/guidelines are based on the experience gained in other flight programs.

The design engineer has the responsibility for gathering the design requirements and implementing the design. Storage of the design documentation and design validation testing procedures and data are the responsibility of the design engineer.

1 IMPLEMENTATION

1.1 Define performance requirements

Coordinate with systems engineers and project scientists, spacecraft power systems engineer, and instrument design engineers to determine specific detailed power and performance requirements. Determine environmental constraints including input power characteristics and radiation. Determine grounding configuration and constraints. Determine whether large central power supplies are adequate or multiple smaller distributed power supplies are required. Determine whether requirements will allow the use of off-the-shelf purchased power supply modules or if a custom design will be required. Determine whether instrument subsystems are single string or redundant.

1.1.1 Draw block diagram

1.1.2 Define interfaces

Define power-input interfaces: voltage and variations and transients, current limitations and fusing requirements, turn-on inrush current restrictions, ripple, etc. Determine whether input power is single-string or redundant power feeds from spacecraft and grounding restrictions. Document requirements in an Interface Control Document or incorporate into Instrument Power Subsystem Requirements or similar document.

Determine how power will be distributed to the various instrument loads: whether through a backplane to instrument boards or through wiring harness to instrument boxes. Determine whether instrument subsystems are single-string or require redundant power supplies. Determine instrument power and signal grounding requirements and constraints.

Determine control and telemetry requirements for both input and output power and temperature monitoring.

1.1.3 Define package constraints (size, mass, and shape)

Determine whether power supply will be packaged in a stand-alone box or whether it will be packaged on a board assembly to be incorporated into another instrument box.

1.2 Preliminary design
1.2.1 Select and order breadboard parts
1.2.2 Simulate circuit and/or build breadboard and test

Simulate complete circuit or subsections of circuit using existing models in Pspice or similar program. On breadboard circuit, measure stability of regulation by manually measuring and plotting the phase and gain margin.

1.3 Engineering Unit design and fabrication

Some projects chose to skip the Engineering Unit phase, for budget and schedule limitations, for any subassembly that is deemed to have low enough risk.

1.3.1 Select and order engineering unit parts

Parts selected must be capable of being flight-qualified. For the engineering unit, the nearest electrical equivalent parts may be substituted as long as they will adequately prove the performance requirements including temperature variations.
Calculate the stress on each electrical part and compare to ratings and derated values.

1.3.2 Mechanical design
1.3.3 Board layout and fabrication

Verify that vibration and thermal analysis have been accomplished – either by contractor doing board layout or by Mechanical and Thermal Branches.

1.3.4 Assemble Engineering Unit
1.3.5 Test Engineering Unit

On Engineering Unit, verify the stability of regulation by manually measuring and plotting the phase and gain margin.

Testing will include performance over the expected operating temperature range and usually 10°C above and below to verify robustness of the design.

1.4 Flight Unit design and parts definition

Perform design iteration and validation based on Engineering Unit or breadboard test results.
Recalculate the stress on each electrical part and compare to ratings and derated values for any changes from Engineering Unit.

1.4.1 Order flight parts
1.4.2 Design mechanical packaging
1.4.3 Board layout

Verify that vibration and thermal analysis have been accomplished – either by contractor doing board layout or by Mechanical and Thermal Branches.

1.4.4 Fabricate boards and housing
1.4.5 Assemble boards and complete unit
1.4.6 Test subassemblies

If a stand-alone unit, then Flight Unit testing includes all qualification verification tests such as vibration, electromagnetic compatibility, and thermal/vacuum. Test procedures shall be documented and kept up-to-date prior to performing the tests.

1.5 Deliver completed unit for integration into instrument.

Appendix A – Definitions

Breadboard	A circuit built using commercial parts to verify design concept by testing.
Engineering Unit	An assembly built to the flight design form, fit, and function to prove final design but without final finish or certification documentation.
Flight Unit	The final product that will be installed and flown on the actual spacecraft.

Appendix B – Acronyms

None

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	10/09/1998	Initial Release
A	10/29/2004	1. Revised Document to incorporate template defined in GPG 1410.1D 2. Added information on grounding configuration and redundancy to Procedure section 1.1 3. Added information on fusing, redundancy, grounding and Telemetry to Procedure section 1.1.2
B	12/18/2009	**GDMS posting mistake**
C	12/18/2009	1. Formatted to new PG Template, GSFC 3-18 (11/09) 2. Revised section P.4: replaced PPL-21 with EEE-INST-002; added 06-063-1. 3. Added “and project scientists” in section 1.1.