Procedures and Guidelines (PG)

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EFFECTIVE DATE:	12/15/2009	**NAME:**	Thomas Yi
EXPIRATION DATE:	12/15/2014	**TITLE:**	Branch Head

COMPLIANCE IS MANDATORY

Responsible Office: 563 / Power Systems Branch

Title: High Voltage Power Supply Design

PREFACE

P.1 PURPOSE

Spacecraft high voltage power supplies require careful electrical design, layout, material processes, and testing to achieve successful long term operation. Failure can occur within the insulation system of the supply due to time-dependent degradation produced by corona and discharging. The areas requiring particular attention to prevent this phenomenon are covered within this document.

P.2 APPLICABILITY

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

P.3 AUTHORITY

a. GPG 1410.1D, Directives Management

P.4 REFERENCES

1. R.S. Bever, A.P. Ruitberg, C.W. Kellenbenz, S.M. Irish, “High Voltage Power Supply Design Guide for Space,” NASA/TP-2006-214133, GSFC, Greenbelt, MD, 2006.
2. J.F. Sutton and J.E. Stern, “Spacecraft High Voltage Power Supply Construction,” NASA Tech. Note TN D79948, GSFC, Greenbelt, Md., 1975.
3. W. Khachen, et al., “Aerospace-specific Design Guidelines for Electrical Insulation,” IEEE Transaction on Electrical Insulation, Vol. 28, No. 5, pp. 876-886, October 1993.
4. M. Gollor and K. Rogalla, “HV Design of Vacuum-insulated Power Supplies for Space Applications,” IEEE Transactions on Electrical Insulation, Vol. 28, No. 4, pp. 667-680, August 1993.

P.5 CANCELLATION

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P.6 SAFETY

Oxygen Deficiency Hazard (ODH), Basic Cryogenic Hazard, High Voltage Hazard

P.7 TRAINING

A degree is required per the Position Description. In addition to some background in designing High Voltage Power Supplies, the following training (or equivalent) is required:

1. Electrical Safety –SMA-SAFE-NSTC-0309
2. Oxygen Deficiency Hazard - GSFC-002-08
3. GSFC Basic Cryogenic Hazards - GSFC-001-09

P.8 RECORDS

None

P.9 MEASUREMENT/VERIFICATION

None

PROCEDURES

Guidelines apply to high voltage power supplies used primarily for long term earth orbiting and interplanetary spaceflight scientific instruments. Aspects pertaining to Shuttle payload, sounding rocket, and balloon applications are also covered. High power, high voltage electrical designs are not specifically addressed, but insulation considerations for these designs follow similar criteria as listed in this guideline. Please refer to sited references for further details.

IMPLEMENTATION

I. Power Supply Specifications Generated by Code 500/600 Personnel.

- A. Electrical
  - 1. Output voltage dc, ripple, and dynamic characteristics.
  - 2. Input voltage and power range.
  - 3. Fault protection.
    - a) Overvoltage.
    - b) Short circuit and discharge.
- B. Mechanical
  - 1. Size and weight.
  - 2. High voltage termination/interface.
- C. Mission Requirements.

1. Lifetime.
2. Temperature limits and cycling.
3. Ambient Pressure.
4. Radiation.
5. Schedule.

II. Electrical Circuit Design. Codes 563/600.

A. Converter Topology

1. Resonant sinewave, voltage multiplier.
2. Flyback.

B. Regulation Method

1. Input DC control.
2. Oscillator switch conduction control.
3. Secondary pass regulation.
4. PWM for higher power applications.

III. High Voltage Components. Codes 563/600/562.

A. Void free solid construction.
B. Component coatings compatible with encapsulating/board coating materials.
C. Capacitors types- Solid ceramic, single layer and multi-layer disc construction.
D. HV semiconductor selections.
E. HV transformer construction.
F. Resistor and voltage dividers.
G. Connector and feedthrough design.
H. HV wire.
I. Derating factors.

IV. Layout and Assembly Methods. Codes 563 and 600.

A. Bare, coated or solid encapsulated HV assembly.

1. Control of E-field distribution within assembly dielectrics and maximum E-field limits.
2. Reliability factors.
3. Testing requirements.
4. Mission environment and lifetime considerations.
5. E-field analysis to determine regions of highest dielectric stress.

B. Circuit assembly.

1. PC card construction with circuit traces vs. “free standing” assembly with solid wire interconnects.
2. Surface mount construction.
3. Modular vs. single board construction.
4. Internal shielding considerations.
5. Low voltage electronics protection of discharge events.
6. Insulator design and material selection.

C. Use of semiconductive materials to control E-field distribution.

V. Power Supply Fabrication. Codes 563/600/562.
- A. Component installation.
  1. Solder ball techniques.
  2. Insulating standoffs and lead attachment.
  3. Connector assembly.
  4. Cleanliness requirements.
- B. Materials Processing
  1. High voltage transformers.
  2. Solid encapsulation methods.
  3. Conformal coatings.
  4. Semiconductive materials.

VI. High Voltage Power Supply Testing. Codes 562/563/600.
- A. Component.
  1. GSFC manufacturing specifications for HV components.
  2. AC/DC Corona test methods.
  3. HV transformers.
  4. Life testing.
  5. Vacuum testing.
- B. Power Supply
  1. Electrical functional testing.
     a) Pre & post coating/encapsulation.
     b) Temperature.
  2. Environmental
     a) Vibration.
     b) Long term thermal vacuum.
  3. Accelerated Life Testing.
  4. Corona Testing.
     a) RF techniques.
     b) Partial discharge systems.
- C. Integrated System Test

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

N/A

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	10/06/1998	Initial Release
A	10/29/2004	1. Revised Document to incorporate template defined in GPG 1410.1D 2. Added Definitions in section P.10
B	12/15/2009	1. Revised Document to incorporate template GSFC 3-18 Nov 09 PG.docx 2. Added additional resource to *References* section 3. Added Hazards to *Safety* section 4. Added required training to *Training* section