

MIL-STD-1281(EL)
10 October 1968

MILITARY STANDARD

INTERNAL TRANSIENT CONTROL
FOR
SOLID STATE POWER SUPPLIES

FSC-MISC

MIL-STD-1281(EL)
10 October 1968

UNITED STATES ARMY ELECTRONICS COMMAND
FORT MONMOUTH, NEW JERSEY 07703

Internal Transient Control For Solid State Power Supplies

MIL-STD-1281(EL)

1. This Military Standard is mandatory for use by all organizations of the U. S. Army Electronics Command.
2. Recommended corrections, additions or deletions should be addressed to the Commanding General, U. S. Army Electronics Command, Fort Monmouth, New Jersey, 07703, ATTN: AMSEL-PP-ET.

MIL-STD-1281(EL)
10 October 1968

FOREWORD

The intent of this document is to establish internal transient control for static solid state power supplies and static solid state power supply systems of military electronic equipment.

Conformance to the requirements and tests of this standard insures adequate design and engineering of static solid state power supplies relative to safe operation of semiconductor components under the stress of internal transients. It shall be the responsibility of the power supply designer or manufacturer, or both, or the equipment designer or fabricator, or both, to provide for conformance to this standard.

.. MIL-STD-1281(EL)
10 October 1968

CONTENTS

Paragraph		Page
1.	GENERAL	1
1.1	Scope	1
1.2	Purpose	1
2.	REFERENCED DOCUMENTS	1
3.	TERMS AND DEFINITIONS	2
3.1	Transients	2
3.1.1	Surges	2
3.1.2	Spikes	2
3.2	Frequency Modulation	2
3.3	Voltage Modulation	2
3.4	Unsafe Condition	2
3.5	Utilization Equipment	2
4.	GENERAL REQUIREMENTS	3
4.1	Application of Standard	3
4.1.1	Equipment	3
4.1.2	Power Supplier	3
4.2	Internal Transient Recognition	3
4.3	Transient Magnitude	3
4.4	Internal Transient Control	4
4.5	Qualification	4
4.6	Design	4
4.6.1	Change in Design	4
5.	DETAIL REQUIREMENTS	5
5.1	Measurement Points	5
5.2	Measured Variables	5
5.2.1	Diodes	5
5.2.2	Transistors	5
5.2.3	Thyristors	5
5.2.4	Control or Logic Circuit Electrical Bus ..	5
5.3	Test Conditions	5
5.3.1	Ambient Conditions	5
5.3.1.1	Measurements of Test Conditions	5
5.3.1.2	Accuracy of Test Apparatus	5
5.3.2	Input Voltage	6
5.3.2.1	D.C. Power Supplies	6
5.3.2.2	A.C. Power Supplies	6
5.3.3	Loads	6
5.4	Test Data	7
5.5	Data Analysis	7
5.6	Test Measurements	8

MIL-STD-1281(EL)
10 October 1968

CONTENTS

		Page
Paragraph	5.6.1 Tests, General	8
	5.6.2 Test Plan	8
	5.6.3 Input Voltage Variation Tests - Full Load ..	8
	5.6.4 Input Voltage Variation Tests - Short Circuit	8
	5.6.5 Output Load Variation Tests - High Line ...	8
	5.6.6 Power Dissipation	8
	5.6.7 Pulsed Energy Test	9
	5.6.8 Acceleration Stress Test	9

MIL-STD-1281(EL)
10 October 1968

1.1 Scope. This standard covers the requirements and test limits for the determination, measurement and control of internal transients of solid state power supplies. The requirements shall be applied to equipments embracing any or all of the power conversion functions, A.C. to D.C., D.C. to D.C., A.C. to A.C. and D.C. to A.C.

1.2 Purpose. The purpose of this standard is to insure that the design of solid state power supplies is such as to avoid internal transients that could result in degradation or catastrophic failure of power supply components.

2. REFERENCED DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein:

SPECIFICATIONS

Military

MIL-C-45662

Calibration System Requirements

(Copies of documents required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

MIL-STD-1281(EL)
10 October 1968

3. TERMS AND DEFINITIONS

3.1 Transients. A transient is the changing condition of a characteristic. These usually go beyond the steady-state limits and return to the steady-state limits within the specified time period.

3.1.1 Surges. A surge is a variation from the controlled steady state level of a characteristic, resulting from the inherent regulation of an electric power supply system and remedial action by the regulator.

3.1.2 Spikes. A spike is a variation from the surge level or from the controlled steady-state level of a characteristic which reaches its greatest amplitude in an extremely short time. It results from very high frequency currents of complex wave form when loads are switched. A spike generally lasts for less than 50 microseconds and tapers off to the surge level or to the steady-state limits.

3.2 Frequency modulation. Frequency modulation is the cyclic or random variation, or both, of instantaneous frequency about a mean frequency during steady-state electric system operation. The frequency modulation is normally within narrow frequency limits and occurs as a result of speed variations in a generator rotor owing to the dynamic operation of the rotor coupling and drive speed regulation.

3.3 Voltage modulation. Voltage modulation is the cyclic variation or random variations, or both, about the mean level of the a.c. peak voltage during steady-state electric-system operation such as caused by voltage regulation and speed variations. The modulation envelope is formed by a continuous curve connecting the successive peaks of the basic voltage wave.

3.4 Unsafe condition. An unsafe condition is any condition within the power supply that jeopardizes the safety of the components or utilization equipment or system.

3.5 Utilization equipment. Utilization equipment will be considered as comprising either an individual unit, set, or a complete system to which the power supply output is applied.

MIL-STD-1281(EL)
10 October 1968

4. GENERAL REQUIREMENTS

4.1 Application of standard. The requirements of this standard shall be applied to static, solid state power supplies as indicated herein-after:

4.1.1 Equip mt. The requirements of this standard shall be applied to static, solid state power supply units, or static solid state power supply systems that are intended to operate as individual items or to operate as part of a military electronic system.

4.1.2 Power Supplies. The requirements of this standard shall be applied to static, solid state power supplies or power supply systems which incorporate any or all of the following electrical to electrical transformations:

- a. A.C. to A.C.
- b. A.C. to D.C.
- c. D.C. to A.C.
- d. D.C. to D.C.

4.2 Internal transient recognition. The interaction of switches with energy storage elements initiates voltage and current transients within a power supply. In addition, voltage and current transients may appear within a power supply caused by line and load transients at its terminals. The internal transients resulting from combinations of these effects may cause failure by exceeding component specifications. Power supplies shall be examined to determine the existence of transient current, voltage or energy pulses generated by surges, spikes or level changes resulting from combinations of:

- a. Equipment turn-on
- b. Equipment turn-off
- c. Step changes in line
- d. Step changes in load
- e. Operation of internal switches

The examination shall be made using instrumentation which can detect transients over the frequency range from D.C. to 10 MHz.

4.3 Transient magnitude. The amplitude and energy content of existing transients shall be measured to insure that maximum ratings of all exposed solid state components are never exceeded under worst case operation including steady state and dynamic conditions.

MIL-STD-1281(EL)

10 October 1968

4.4 Internal transient control. Power supplies shall not produce voltage, current or power transients, during the course of operation, which affect the life of the semiconductor complement or create an unsafe condition.

4.5 Qualification. All solid state power supplies furnished under this document shall be tested for compliance with the requirements specified herein, in addition to those of the equipment specification.

4.6 Design. All power supplies, during the design engineering phase, when final components have been selected and specified, shall insure that internally generated transients and those produced by operation of the power supply, shall not exceed the maximum specified ratings of the semiconductor complements.

4.6.1 Change in design. The procedures specified herein shall be repeated whenever the design is changed, and whenever any transformer, diode, rectifier, transistor, or thyristor is substituted for those specified and specifically covered by the contract, military specification, Government approved drawing, or subsidiary document applicable to the power supply being procured, unless the item substituted is an identical item meeting the same specified requirements. Whenever First Article Tests and Evaluation is part of the contract, the procedures of this Standard shall be part of such tests.

MIL-STD-1281(EL)
10 October 1968

5. DETAIL REQUIREMENTS

5.1 Measurement points. Transient measurements shall be made at critical points in the power supply. Critical points shall be considered to be at solid state devices within the main power flow circuitry, the electrical bus supplying auxiliary control and logic circuitry, protective and sensing devices external to power flow and control circuits. If the measurements of 5.2.4 indicate the presence of transients, the measurements of 5.2.1, 5.2.2 and 5.2.3 shall be conducted on components of the control and logic sections.

5.2 Measured variables. For each of the measurement points, the following measurements, as appropriate, shall be made. The measurements shall be made while performing the tests described in 5.6.

5.2.1 Diodes.

- a. Peak inverse voltage
- b. Peak forward current

5.2.2 Transistors. Collector current versus collector to emitter voltage.

5.2.3 Thyristors.

- a. Peak inverse voltage
- b. Peak forward blocking voltage
- c. Anode current versus time

5.2.4 Control or logic circuit electrical bus. Peak voltage.

5.3 Test conditions.

5.3.1 Ambient conditions. Unless otherwise specified herein, or in the individual equipment specification, all measurements and tests shall be made at standard ambient conditions. Standard ambient conditions are defined as:

Temperature	$23^{\circ} \pm 10^{\circ}\text{C}$ ($73^{\circ} \pm 18^{\circ}\text{F}$)
Relative Humidity	50 percent \pm 30 percent
Atmospheric pressure	725 \pm 50 - 115mm of mercury (28.5 \pm 2.0 in. of mercury) -4.5

MIL-STD-1281(EL)

10 October 1968

When these conditions must be closely controlled, the following shall be maintained.

Temperature	$23^{\circ} \pm 1.4^{\circ}\text{C}$ ($73^{\circ} \pm 2.5^{\circ}\text{F}$)
Relative humidity	50 percent \pm 5 percent
Atmospheric pressure	725 \pm 50 of mercury - 115mm (28.5 \pm 2.0 in. of mercury) - 3.0

5.3.1.1 Measurements of test conditions. All measurements of test conditions shall be made with instruments of an accuracy specified in 5.4.1.

5.3.1.2 Accuracy of test apparatus. The accuracy of instruments and test equipment used to control or monitor the test parameters, whether located at a government testing laboratory or at the contractor's plant or approved commercial testing laboratory, shall be verified periodically (at least every 12 months; preferably once every 6 months, unless the contractor procedures prepared to satisfy the requirements of MIL-C-45662 for calibration cycle of specific instruments, specify otherwise) to the satisfaction of the procuring activity. All instruments and test equipment used in conducting the tests specified herein shall:

a. Conform to laboratory standards whose calibration is traceable to the prime standards at the U. S. Bureau of Standards.

b. Have an accuracy of at least one-third the tolerance of the variable to be measured. In the event of conflict between this accuracy and a requirement for accuracy in any one of the tests of this standard, the latter shall govern.

c. Be appropriate for measuring test parameters.

5.3.2 Input voltage.

5.3.2.1 D.C. power supplies. The upper and lower limits of the normal operating voltage band specified in the detailed equipment or system specification.

5.3.2.2 A.C. power supplies. The upper and lower limits of the normal operating voltage band, at the nominal operating frequency and phase displacement, with negligible voltage and frequency modulation, as specified in the detailed equipment or system specification.

MIL-STD-1281(EL)
10 October 1968

5.3.3 Loads.

- a. Normal load termination equivalent to the load specified in the individual equipment specification including reactive components.
- b. Open circuit output terminals.
- c. Short Circuit output, if short circuit operation is required by the individual equipment specification.

5.4 Test Data. Test data shall include complete identification of all tests and accessories. The data shall include the actual test sequence used and ambient test conditions recorded periodically during the test period. The test record shall contain a signature and date block for certification of the test data by the test engineer.

5.5 Data analysis. The data gathered during the tests of 5.6 shall be compared to the solid state device maximum ratings to insure that the measured transients are maintained within specified limits of components. Device parameters to be checked include the following:

- a. Diodes.
 1. Peak inverse voltage
 2. Peak forward current
- b. Transistors.
 1. Peak voltage
 2. Peak current
 3. Safe operating area versus time
- c. Thyristors.
 1. Peak inverse voltage
 2. Peak forward blocking voltage
 3. Maximum pulse I^2t
 4. Rate of rise of forward current
 5. Peak forward current

MIL-STD-1281(EL)

10 October 1968

5.6 Test Measurements.

5.6.1 Tests, general. The following tests shall be performed in the order approved in accordance with 5.6.2 in addition to those required by the detailed equipment or system specification.

5.6.2 Test Plan. The contractor shall submit three (3) copies of a test plan to the contracting officer's technical representative (COTR) or designated representative (CODR). The test plan shall be submitted prior to the date the contractor or Government has scheduled presubmission or preproduction tests. The procuring activity shall, after the test plan is received, furnish to the contractor a statement of approval accompanied by one copy of the test plan bearing an appropriate stamp "APPROVED"; or a statement of disapproval accompanied by an explicit review of the deficiencies of the test plan requiring correction. When a test plan is disapproved, the contractor shall prepare a new test plan and submit three (3) copies to the COTR or CODR for approval. The test plan shall include, but not be limited to, the following:

- a. Time schedule sequence of tests
- b. Procedures for all tests necessary to demonstrate compliance with this standard, acceptance testing of the individual equipment or system specification and their subsidiary documents.
- c. Block diagrams for test setups.
- d. Identification of test instruments and certification of a calibration system in accordance with Specification MIL-C-45662.

5.6.3 Input voltage variation tests - full load. With the normal full load termination applied to the power supply, the internal transient measurements shall be made during each of the following input voltage variations:

- a. 0 to high line (turn-on).
- b. High line to low line (step change).
- c. Low line to high line (step change).
- d. High line to 0 (turn-off).

5.6.4 Input voltage variation tests - short circuit. With the power supply output terminals shorted, the internal transient measurements shall be taken when the input voltage is varied from 0 to high line (turn-on).

5.6.5 Output load variation tests - high line. With the input voltage at high line, the internal transient measurements shall be made during each of the following load variations.

- a. No load to full load.
- b. Full load to no load.
- c. No load to short circuit.

MIL-STD-1281(EL)

10 October 1968

5.6.6 Power dissipation. With high line voltage applied, and the ambient temperature at $65 \pm 10^{\circ}\text{C}$ ($149^{\circ} \pm 18^{\circ}\text{F}$) with full load termination, the semiconductor device power dissipation shall not exceed the maximum specified for the device under temperature equilibrium conditions.

5.6.7 Pulsed energy test. A step voltage shall be applied at a level of 20 percent greater than the specified high line voltage with the normal load. The peak powers applied to the semiconductors during the interval until equilibrium conditions of voltage and current are reached shall be measured to insure that these peak powers are within the maximum ratings of the semiconductors.

5.6.8 Acceleration stress test. With an input voltage 20 percent greater than the specified high line voltage and normal full load termination, the power supply shall be operated for a five minute interval with no component degradation or failure.

MIL-STD-1281(EL)
10 October 1968

Custodian:

Army - EL

Preparing Activity:

Army - EL

(Project Nr. MISC-A552)

Review Activities:

Army -

User Activities:

Army -