



Technical Specification for Power Supply Test for Liquid Cooling Unit



Bharat Heavy Electricals Limited
Corporate Research & Development Division
Vikasnagar, Hyderabad- 500093, India

Prepared by: D Pavitran	Checked by: A Sandeep	Approved by: G R Rao	Date: 03-12-2021
COPY RIGHT AND CONFIDENTIAL The information on this document is the property of BHEL. It must not be used directly or indirectly in any way detrimental to the company			



1. Power Supply Tests:

Power supply test to be carried out only for LCU, ECU and ACM Module. Power supply test of LCU will be carried out along with ECU. Tests to be carried out are described below.

Sl. No.	TEST & PROCEDURE	SEVERITY	DURATION	REMARKS
1	LDC 102: Steady State Limits for Voltage	As per MIL-HDBK-704 F	As per MIL-HDBK-704 F	The test will be carried out with unit in ON condition
2	LDC 103: Voltage Distortion Test	As per MIL-HDBK-704 F	As per MIL-HDBK-704 F	The test will be carried out with unit in ON condition
3	LDC 104 : Total Ripple Test	As per MIL-HDBK-704 F	As per MIL-HDBK-704 F	The test will be carried out with unit in ON condition
4	LDC 105 Normal Voltage Transients	As per MIL-HDBK-704 F	As per MIL-HDBK-704 F	The test will be carried out with unit in ON condition
5	LDC 301 : Abnormal Steady State Limits for Voltage	As per MIL-HDBK-704 F	As per MIL-HDBK-704 F	The test will be carried out with unit in ON condition
6	LDC 302 : Abnormal Voltage Transients	As per MIL-HDBK-704 F	As per MIL-HDBK-704 F	The test will be carried out with unit in ON condition
7	LDC 401: Emergency Limits for Voltage	As per MIL-HDBK-704 F	As per MIL-HDBK-704 F	The test will be carried out with unit in ON condition

Low Direct Current Tests as per MIL STD 704F :

1 LDC 102 – Steady State Voltage Test:

Severity:

Voltage NLSS : 22VDC

Voltage NHSS : 29VDC

Purpose: This test is used to verify that EUT operates and maintains specified performance when provided with input power with steady state voltage levels.

Test Setup: Make the test setup as given in figure below-

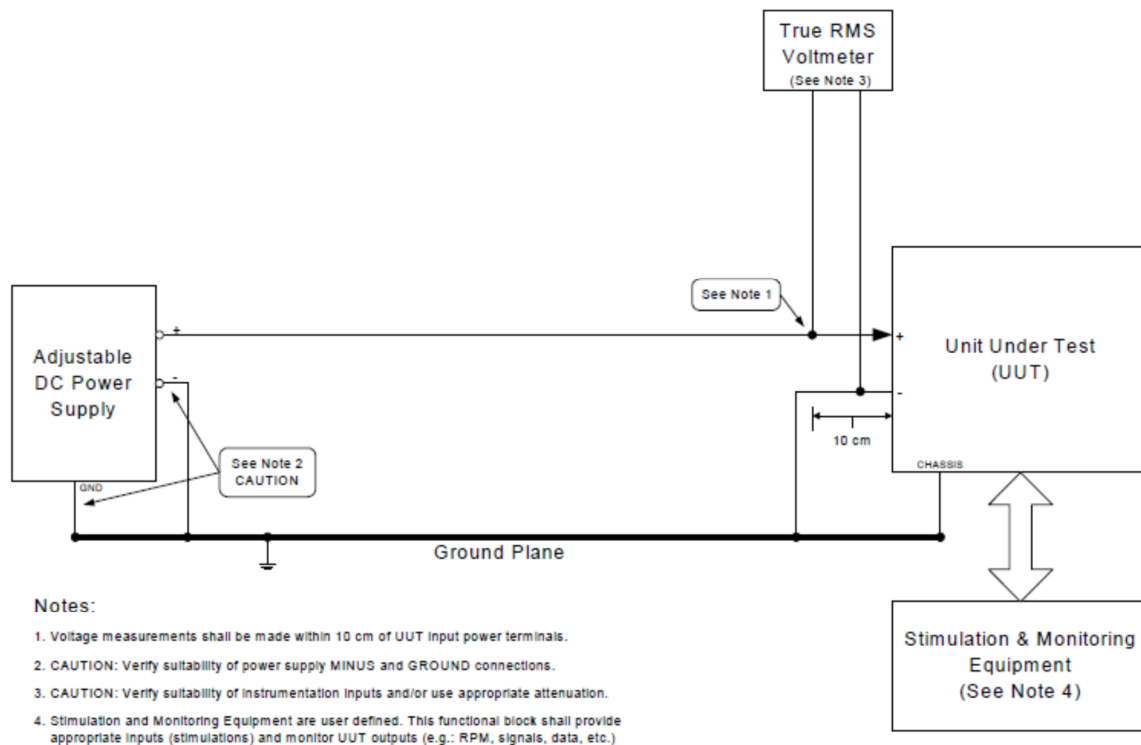


FIGURE LDC102-1. Normal operation - steady state limits for voltage.

Figure 1 LDC- 102 test set up

Test Procedure:

- a) Make the test setup and power 'ON' the EUT with steady state voltage of + 28V (Nominal).
- b) Conduct functional test on EUT as given in ATP document and record the test results
- c) Set the input power supply voltage to the EUT to +22V (Normal Low Steady State).
- d) After stabilizing the input power, conduct functional test on EUT and record the test results.
- e) Keep the unit in power ON condition for minimum of 30 minutes. Monitor the EUT performance during entire duration.
- f) Restart the EUT at +22V (NLSS) to verify that EUT can be restarted. After restart, conduct the functional test on EUT and record the test results.
- g) Repeat c) through f) for input power supply voltage of +29V (Normal High Steady State)

- h) After completion of above test, set the input voltage to +28V (nominal) and carry the functional test and record the test results.

Pass / Fail Criteria: The EUT is considered to be passed if EUT operates and maintains specified functional performance for input power of steady state voltage.

2 LDC 103 – Voltage Distortion Test:

Purpose: This test is used to verify that EUT operates and maintains specified performance when subjected to voltage distortion of frequencies and amplitudes as specified in figure below-

TABLE LDC103-II. Test conditions for voltage distortion spectrum.

Test Condition	Frequency of Voltage Distortion	MIL-STD-704A Amplitude of Voltage Distortion Voltage rms	MIL-STD-704B, C, & D Amplitude of Voltage Distortion Voltage rms	MIL-STD-704E & F Amplitude of Voltage Distortion Voltage rms
A	10 Hz	0.900 Vrms	0.100 Vrms	0.100 Vrms
B	25 Hz	0.900 Vrms	0.158 Vrms	0.158 Vrms
C	50 Hz	0.400 Vrms	0.200 Vrms	0.223 Vrms
D	60 Hz	0.320 Vrms	0.224 Vrms	0.245 Vrms
E	250 Hz	0.320 Vrms	0.398 Vrms	0.500 Vrms
F	1 kHz	0.790 Vrms	0.707 Vrms	1.000 Vrms
G	1.7 kHz	1.000 Vrms	0.891 Vrms	1.000 Vrms
H	2 kHz	1.000 Vrms	1.000 Vrms	1.000 Vrms
I	5 kHz	1.000 Vrms	0.316 Vrms	1.000 Vrms
J	6.5 kHz	1.000 Vrms	0.707 Vrms	0.707 Vrms
K	10 kHz	0.400 Vrms	0.125 Vrms	0.500 Vrms

Test Setup: Make the test setup as given below-

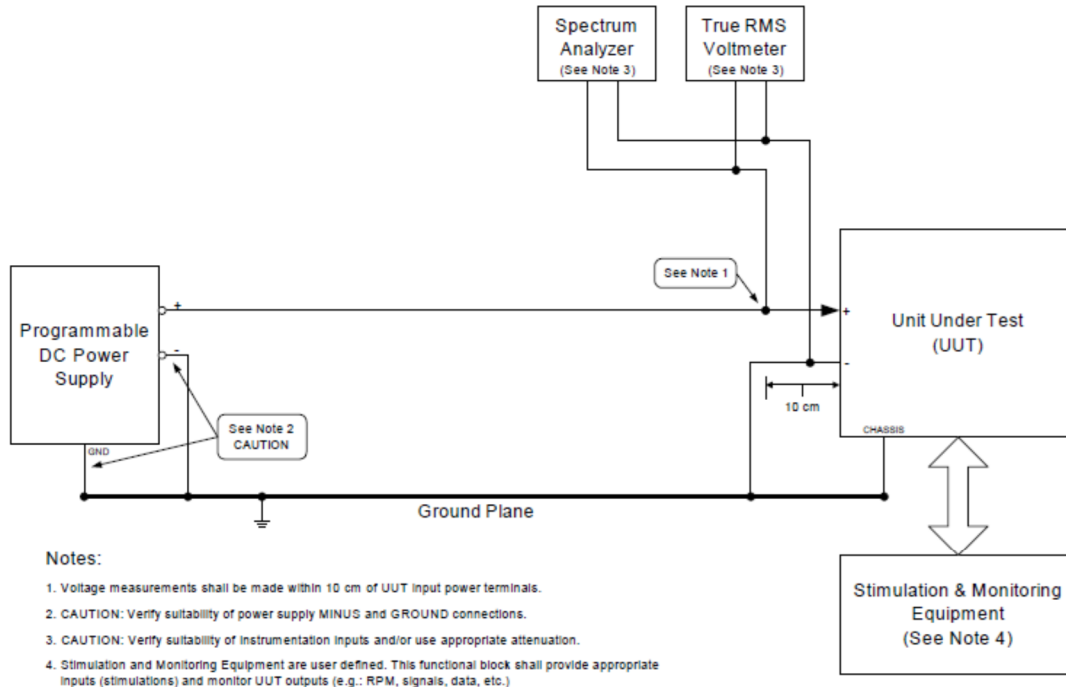


FIGURE LDC103-1. Normal operation - voltage distortion spectrum (10 Hz and 25 Hz).

Figure 2 LDC- 103 test set up

Test Procedure:

- a) Make the test setup and power 'ON' the EUT with steady state voltage of +28V (Nominal).
- b) Conduct the functional test on EUT as given in ATP document and record the test results.
- c) Set the amplitude of input voltage distortion to 0.1Vrms with 10 Hz rate over steady state DC voltage of +28V.
- d) Keep this input distortion for 5 minutes and monitor the EUT performance.
- e) Repeat c) through d) for the various setting as given in the table above.
- f) After completion of above test, set the input voltage to +28V DC without voltage distortion and carry the functional test and record the test results.

Pass / Fail criteria: The EUT is considered to be passed if EUT operates and maintains specified functional performance as per ATP document when subjected to voltage distortion as specified in the mil standard.

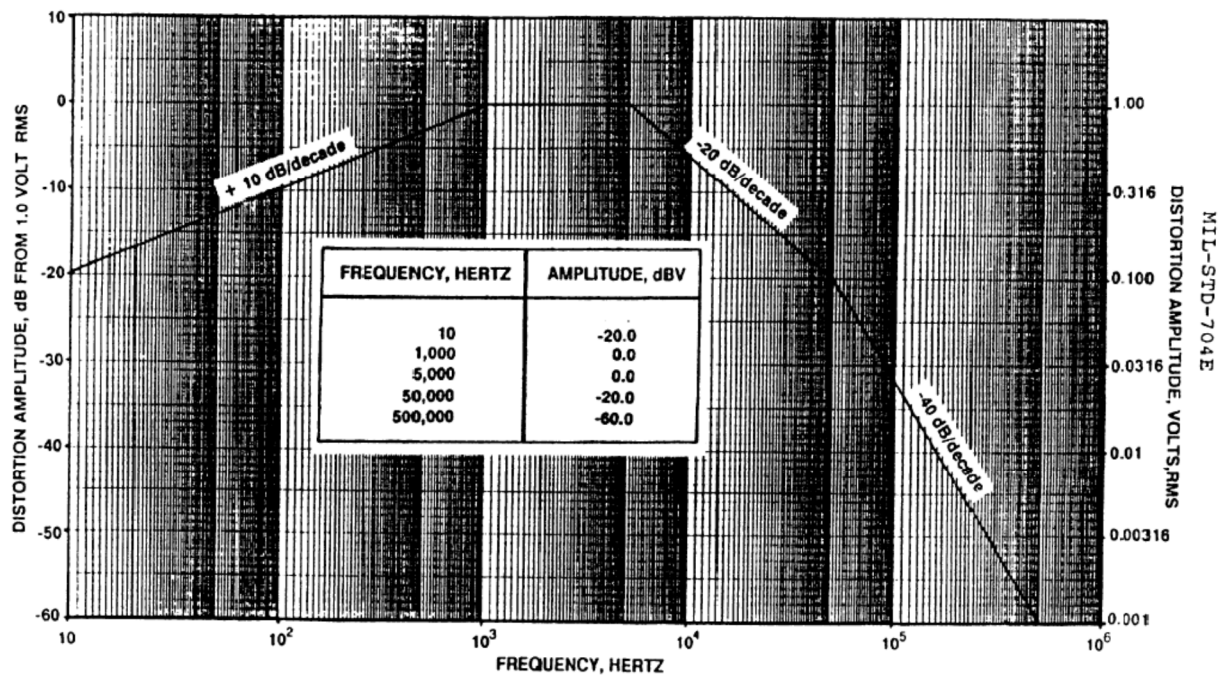


FIGURE 8. Maximum distortion spectrum for 28 volts DC system.

Figure 3 Maximum Distortion spectrum

3 LDC 104 - Total Ripple Test:

Purpose: This test is used to verify that the EUT operates and maintains specified performance when subjected to voltage having a ripple of 1.5V peak to average as specified in table below

Test Setup: Make the test setup as given in figure below-

Test Procedure:

- Make the test setup and power 'ON' the EUT with steady state voltage of +28V (nominal).
- Conduct the functional test on EUT as given in ATP document and record the test results.
- Calibrate the test system to produce waveforms for test conditions as in table below with the help of equivalent resistive load.

- d) Set the programmable power supply to the setting recorded during the calibration procedure of Setting –A.

TABLE LDC104-II. Ripple frequency and amplitude.

Test Condition	Ripple Frequency Components	MIL-STD-704A Amplitude of Ripple Component Vrms	MIL-STD-704B, C, D, E, & F Vrms
A	1200 Hz	1.00 Vrms	0.80 Vrms
	2400 Hz	0.20 Vrms	0.16 Vrms
	3600 Hz	0.33 Vrms	0.26 Vrms
	4800 Hz	0.10 Vrms	0.08 Vrms
	6000 Hz	0.16 Vrms	0.13 Vrms
	7200 Hz	0.05 Vrms	0.04 Vrms
	8400 Hz	0.08 Vrms	0.06 Vrms
B	2400 Hz	0.80 Vrms	0.80 Vrms
	4800 Hz	0.16 Vrms	0.16 Vrms
	7200 Hz	0.26 Vrms	0.26 Vrms
	9600 Hz	0.08 Vrms	0.08 Vrms
	12000 Hz	0.13 Vrms	0.13 Vrms
	14400 Hz	0.04 Vrms	0.04 Vrms
	16800 Hz	0.06 Vrms	0.06 Vrms

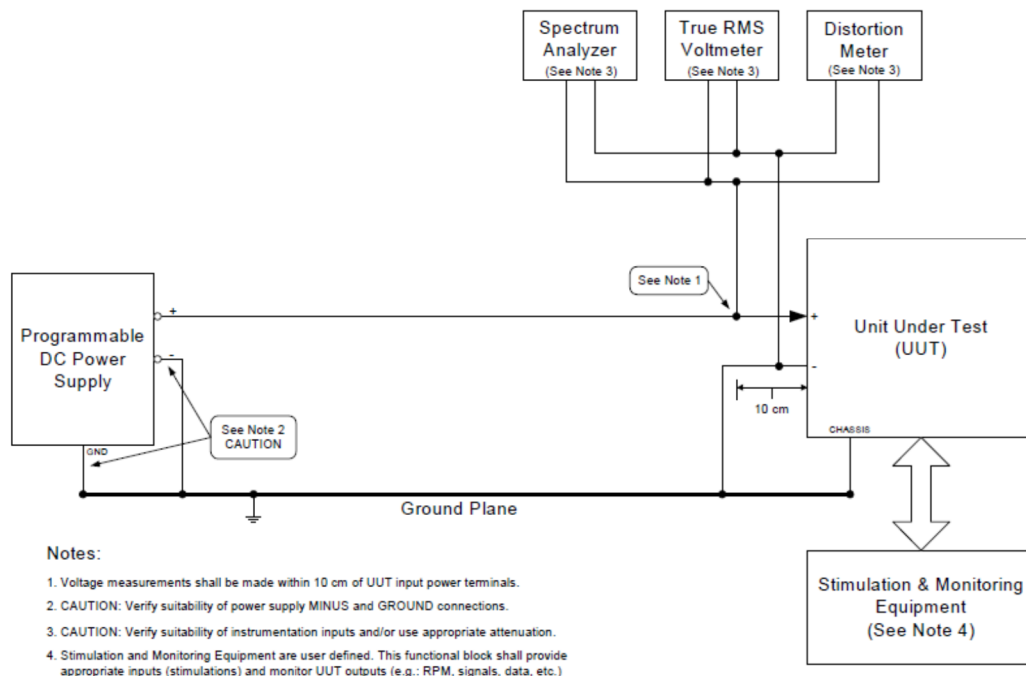


FIGURE LDC104-1. Normal operation - total ripple.

Figure 4 LDC- 104 test set up

- e) Power 'ON' the EUT. Conduct the functional test of the EUT and record the test results. Keep the unit in power 'ON' condition continuously for minimum 30 minutes.
- f) Measure and record the DC ripple frequency and amplitude during the test.
- g) Repeat d) through f) for other test settings as in table above.
- h) For each test condition, record the frequency and amplitude of ripple voltage, time duration at test condition, and the performance of the EUT in the table above.
- i) After completion of above test, set the input voltage to +28V DC without ripple voltage and carry the functional test and record the test results.

Pass/Fail Criteria: The EUT is considered to be passed if EUT operates and maintains specified functional performance as per ATP document when subjected to voltage having a ripple of 1.5V peak to average.

4 LDC 105 – Normal Voltage Transients

Purpose: This test is used to verify that EUT operates and maintains specified performance when subjected to normal voltage transients (under voltage, over voltage and combined transients) as per profile given in figure and table below:

Test Setup: Make the test setup as given figure below:

Test Procedure:

- a) Make the test setup and power 'ON' the EUT with steady state voltage of +28V (nominal)
- b) Conduct the functional test on EUT as given in ATP document and record the test results
- c) Subject the EUT to voltage transients for each of test condition AA through RR as listed in table
- d) For test condition EE and JJ, perform three over-voltage transients of 50V for 10 milliseconds separated by 0.5 seconds each
- e) For test condition MM and PP, perform three under-voltage transients of 18V for 10 milliseconds separated by 0.5 seconds each
- f) Repeat each of the test condition 5 times
- g) Monitor the performance of unit during the transients



- h) After the power is returned to ambient, carry out the functional test at the end of each transient test
- i) After the completion of all transient tests as listed in table, inject the repetitive voltage transient to EUT.
- j) Program the power supply to provide a continually repeating voltage transient that decreases from 28.5V to 18 V in 2.5 millisecond, then increases to 45V over 30 milliseconds, then decreases to 28.5V over 2.5 milliseconds. The voltage transient is repeated every 0.5 seconds.
- k) Conduct the repetitive voltage transient on the EUT for 30 minutes and carry the functional test of EUT during the test
- l) For each test condition, record the steady state voltage and voltage transient, time duration at voltage transient and the performance of the EUT
- m) After completion of above test, set the input voltage to +28V DC without any transient and carry out the functional test and record the test results

Pass/Fail criteria: The EUT is considered to be passed if EUT operates and maintains specified functional performance as per ATP document when subjected to normal voltage transients.



TABLE LDC105-III. Test conditions for MIL-STD-704B, C, D, E and F normal voltage transients.

Test Condition	Steady State Voltage Vdc	Time From Steady State Voltage to Voltage Transient Level milliseconds	Voltage Transient Level Vdc	Duration at Voltage Transient Level milliseconds	Time From Voltage Transient Level to Steady State Voltage milliseconds
Overvoltage Transients					
AA	29 Vdc	< 1 msec	50 Vdc	12.5 msec	< 1 msec
BB	29 Vdc	< 1 msec	50 Vdc	12.5 msec	70 msec
CC	29 Vdc	< 1 msec	40 Vdc	45 msec	< 1 msec
DD	29 Vdc	< 1 msec	40 Vdc	45 msec	37.5 msec
EE	29 Vdc	< 1 msec	50 Vdc (3 times)	10 msec Every 0.5 msec	< 1 msec
FF	22 Vdc	< 1 msec	50 Vdc	12.5 msec	< 1 msec
GG	22 Vdc	< 1 msec	50 Vdc	12.5 msec	95 msec
HH	22 Vdc	< 1 msec	40 Vdc	45 msec	< 1 msec
II	22 Vdc	< 1 msec	40 Vdc	45 msec	62.5 msec
JJ	22 Vdc	< 1 msec	50 Vdc (3 times)	10 msec Every 0.5 msec	< 1 msec
Undervoltage Transients					
KK	29 Vdc	< 1 msec	18 Vdc	15 msec	< 1 msec
LL	29 Vdc	< 1 msec	18 Vdc	15 msec	234 msec
MM	29 Vdc	< 1 msec	18 Vdc (3 times)	10 msec Every 0.5 sec	< 1 msec
NN	22 Vdc	< 1 msec	18 Vdc	15 msec	< 1 msec
OO	22 Vdc	< 1 msec	18 Vdc	15 msec	85 msec
PP	22 Vdc	< 1 msec	18 Vdc (3 times)	10 msec Every 0.5 sec	< 1 msec
Combined Transient					
QQ	29 Vdc then	< 1 msec < 1 msec	18 Vdc 50Vdc	10 msec 12.5 msec	< 1 msec 70 msec
RR	22 Vdc then	< 1 msec < 1 msec	18 Vdc 50Vdc	10 msec 12.5 msec	< 1 msec 62.5 msec

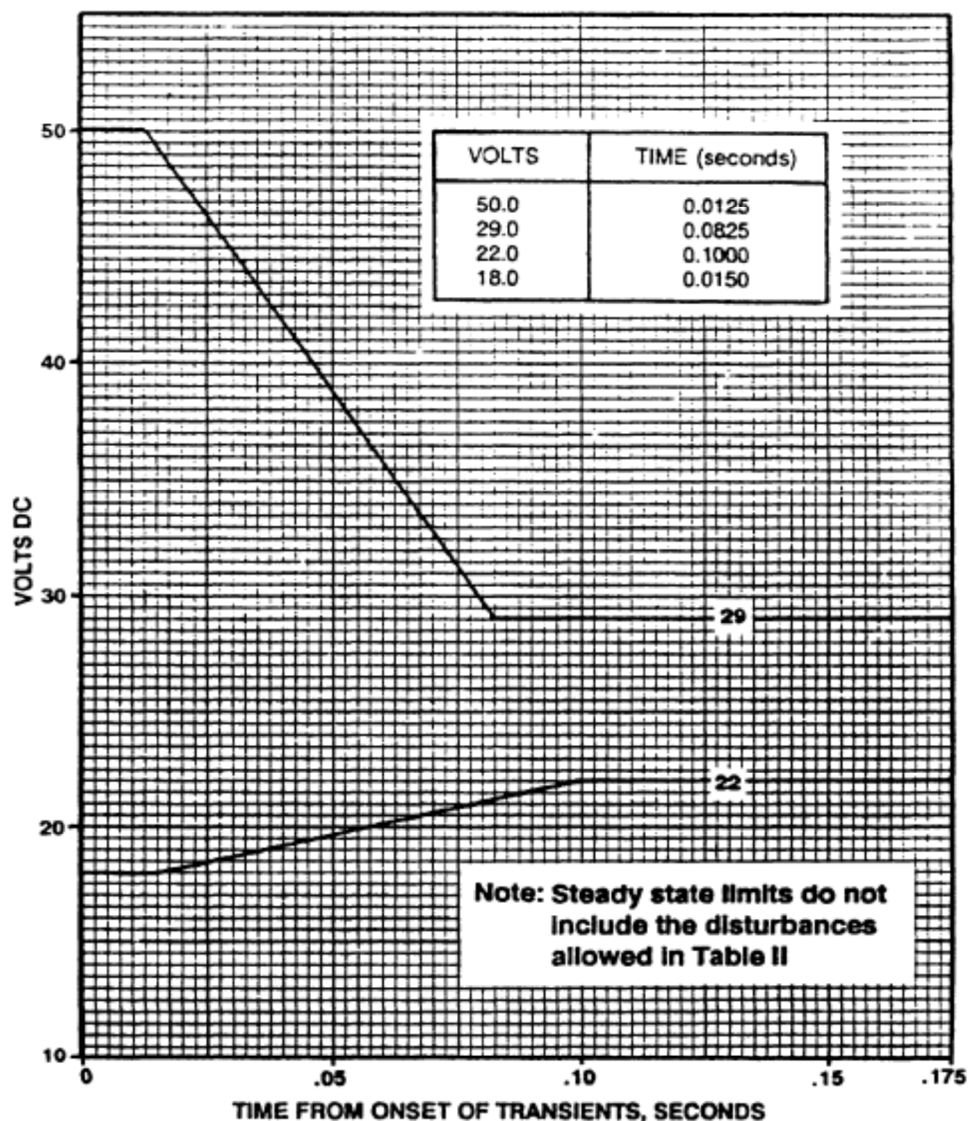


FIGURE 9. Envelope of normal voltage transient for 28 volts DC system.

Figure 5 Normal voltage transient spectrum

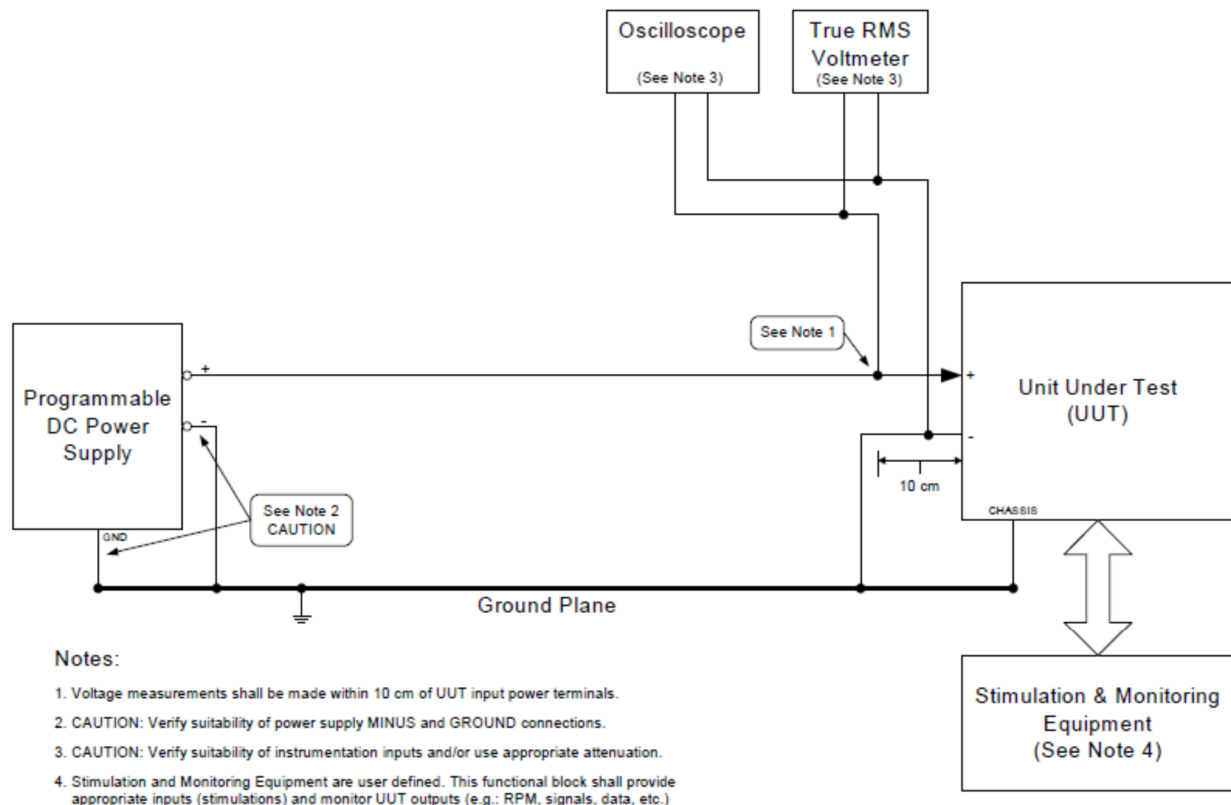


FIGURE LDC105-1. Normal operation - normal voltage transients.

Figure 6 LDC- 105 Normal operation – normal voltage transients

5 LDC 301 – Abnormal Steady State Voltage Test

Severity:

Abnormal limits for steady state voltage as per MIL-STD-704F is

Voltage ALSS: 20.0 VDC

Voltage AHSS: 31.5 VDC

Purpose: This test is used to verify that EUT operates and maintains specified performance when provide with input power with abnormal steady state levels.

Test Setup: Make the test setup as given below-

Test Procedure:

- Make the test setup and power 'ON' the EUT with steady state voltage of +28V
- Conduct functional test on EUT as given in ATP document and record the test results
- Set the input power supply voltage to the EUT to +20V
- After stabilizing the input power, conduct functional test on EUT and record the test results
- Keep the unit in power 'ON' condition for minimum of 30 minutes. Monitor the EUT performance during entire duration
- Restart the EUT at +20V to verify that EUT can be restarted. After restart, conduct the functional test on EUT and record the test results
- Repeat c) through f) for input power supply voltage of +32 V
- After completion of above test, set the input voltage to +28V and carry the functional test and record the test results.

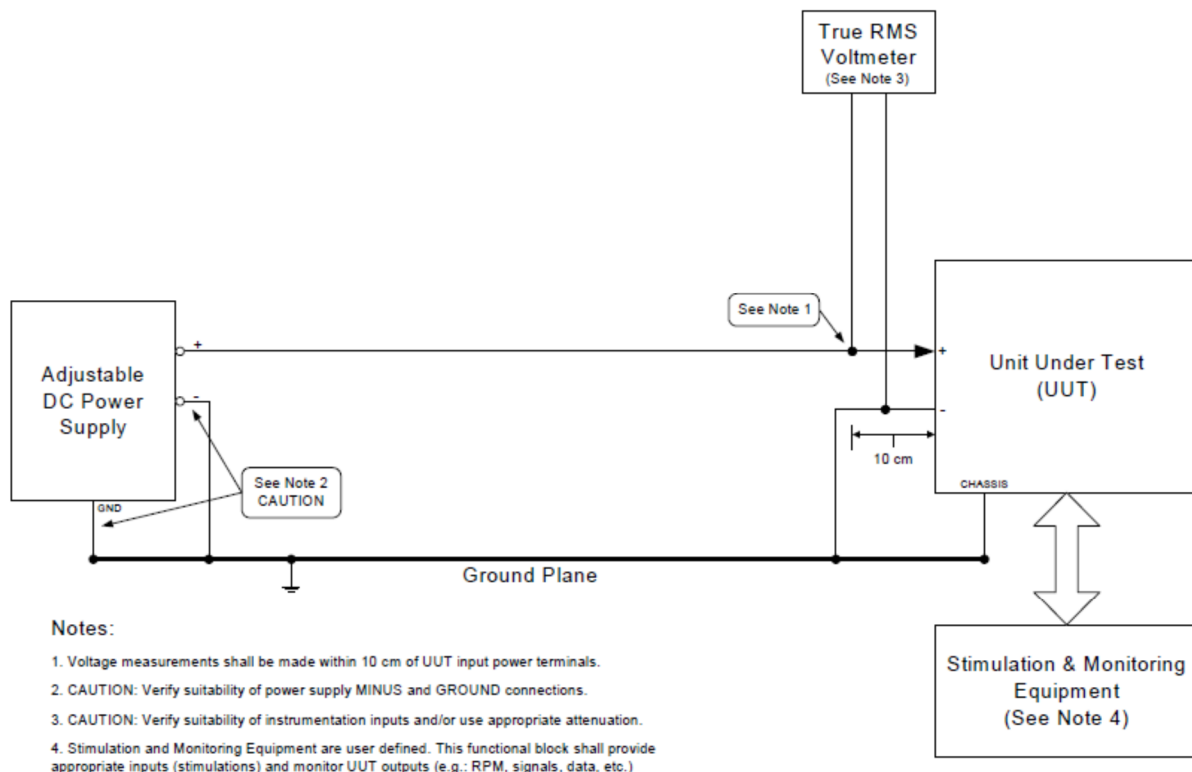


FIGURE LDC301-1. Abnormal operation - steady state limits for voltage.

Figure 7 LDC- 301 Abnormal operation – Steady state limits

	Product Standard Heat Transfer & Fluid Flow	No: PST/LDC/DARE 001 Rev 01	Page 14 of 20
--	--	-----------------------------------	---------------

Pass/fail criteria: The EUT is considered to be passed if EUT operates and maintains specified functional performance as per ATP document for input power of abnormal steady state voltage.

5 LDC 302 – Abnormal voltage transients

Purpose: This test is used to verify that EUT operates and maintains specified performance when subjected to abnormal voltage transients (under voltage, overvoltage and combined transients) as per profile given in figure and table below: -

Test Setup: Make the test setup as given in figure below

Test Procedure:

- Make the test setup and power 'ON' the EUT with steady state voltage of +28V
- Conduct the functional test on EUT as given in ATP document and record the test results
- Subject the EUT to voltage transient for each of test condition AA through NN as listed in table
- For test condition CC and FF, perform three over-voltage transients of 50V for 45 milliseconds every 0.5 seconds each
- For test condition II and LL, perform three under-voltage transients of 7V DC for 45 milliseconds every 0.5 second each
- Repeat each of the test condition 5 times. Monitor the performance of unit during the transient
- After the power is returned to ambient, carry out the functional test at the end of each transient test.
- For each test condition, record the steady state voltage and voltage transient, time duration at voltage transient level and performance of the EUT.
- After completion of above test, set the input voltage to +28V DC without any transient and carry out the functional test and record the test results.

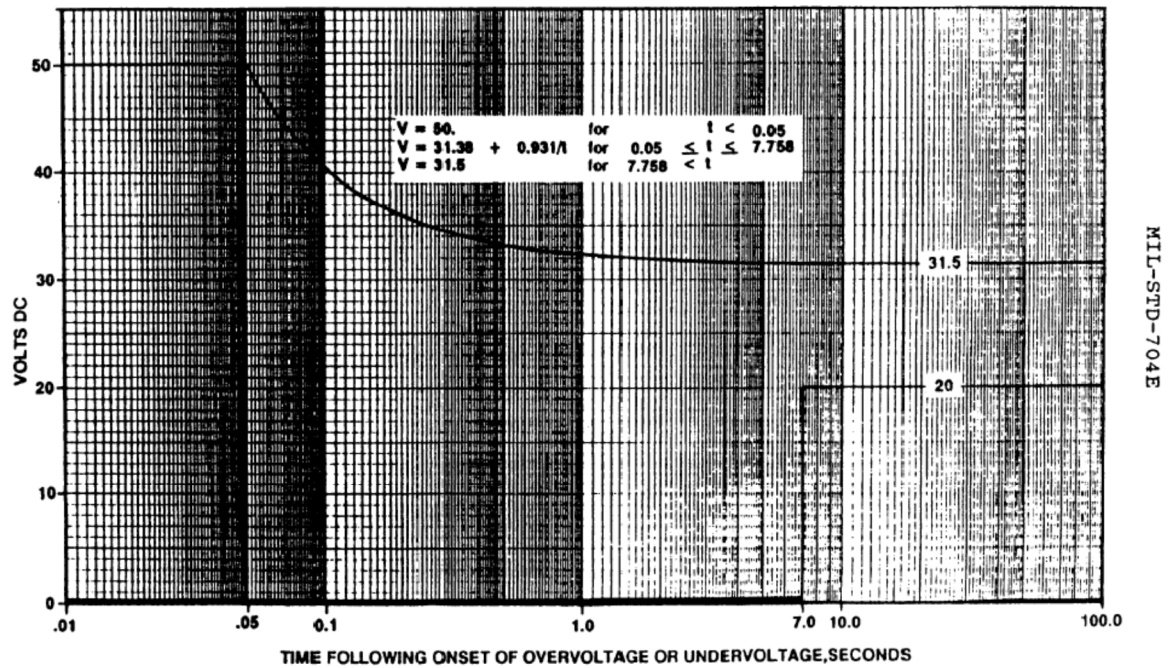


FIGURE 11. Limits for DC overvoltage or undervoltage for 28 volts DC system.

Figure 8 LDC- 302 Voltage limits

TABLE LDC302-IV. Test condition for MIL-STD-704E and F abnormal voltage transients.

Test Condition	Steady State Voltage Vdc	Time From Steady State Voltage to Voltage Transient Level milliseconds	Voltage Transient Level Vdc	Duration at Voltage Transient Level	Time From Voltage Transient Level to Steady State Voltage or Next Voltage Level
Overvoltage Transients					
AAA	29 Vdc	< 1 msec	50 Vdc	50 msec	< 1 msec
BBB	29 Vdc	< 1 msec	50 Vdc	50 msec	15 msec
		then	45 Vdc	decreasing	30 msec
		then	40 Vdc	decreasing	60 msec
		then	35 Vdc	decreasing	4.85 sec
		then	30 Vdc	decreasing	1 sec
		then	29 Vdc		
CCC	29 Vdc	< 1 msec	50 Vdc (3 times)	50 msec Every 0.5 sec	< 1 msec
DDD	22 Vdc	< 1 msec	50 Vdc	50 msec	< 1 msec
EEE	22 Vdc	< 1 msec	50 Vdc	50 msec	15 msec
		then	45 Vdc	decreasing	30 msec
		then	40 Vdc	decreasing	60 msec
		then	35 Vdc	decreasing	4.85 sec
		then	30 Vdc	decreasing	8 sec
		then	22 Vdc		
FFF	22 Vdc	< 1 msec	50 Vdc (3 times)	50 msec Every 0.5 sec	< 1 msec
Undervoltage Transients					
GGG	29 Vdc	< 1 msec	7 Vdc	50 msec	< 1 msec
HHH	29 Vdc	< 1 msec	7 Vdc	50 msec	15 msec
		then	12 Vdc	increasing	30 msec
		then	17 Vdc	increasing	60 msec
		then	22 Vdc	increasing	4.85 sec
		then	28 Vdc	increasing	1 sec
		then	29 Vdc		
III	29 Vdc	< 1 msec	7 Vdc (3 times)	50 msec Every 0.5 sec	< 1 msec
JJJ	22 Vdc	< 1 msec	7 Vdc	50 msec	< 1 msec
KKK	22 Vdc	< 1 msec	7 Vdc	50 msec	15 msec
		then	12 Vdc	increasing	30 msec
		then	17 Vdc	increasing	60 msec
		then	22 Vdc		
LLL	22 Vdc	< 1 msec	7 Vdc (3 times)	50 msec Every 0.5 sec	< 1 msec



Test Condition	Steady State Voltage Vdc	Time From Steady State Voltage to Voltage Transient Level milliseconds	Voltage Transient Level Vdc	Duration at Voltage Transient Level	Time From Voltage Transient Level to Steady State Voltage or Next Voltage Level
Combined Transient					
MMM	29 Vdc	< 1 msec	7 Vdc then	10 msec	< 1 msec
		< 1 msec	50Vdc	50 msec	15 msec
		then	45 Vdc	decreasing	30 msec
		then	40 Vdc	decreasing	60 msec
		then	35 Vdc	decreasing	4.85 sec
		then	30 Vdc	decreasing	1 sec
NNN	22 Vdc	< 1 msec	7 Vdc then	10 msec	< 1 msec
		< 1 msec	50Vdc	50 msec	15 msec
		then	45 Vdc	decreasing	30 msec
		then	40 Vdc	decreasing	60 msec
		then	35 Vdc	decreasing	4.85 sec
		then	30 Vdc	decreasing	8 sec
		then	22 Vdc		

Pass/fail criteria: The EUT is considered to be passed if EUT operates and maintains specified functional performance as per ATP document when subjected to abnormal voltage transients.

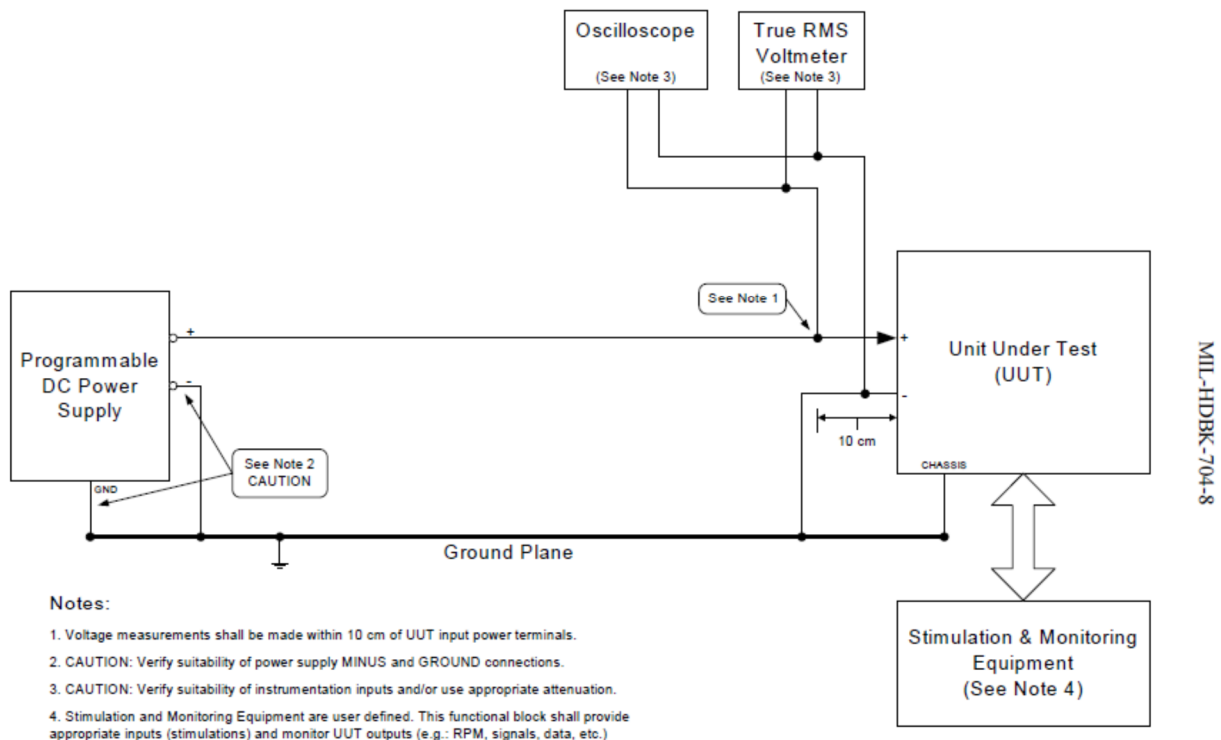


FIGURE LDC302-1. Abnormal operation - abnormal voltage transients.

Figure 9 LDC- 302 test set up

7 LDC 401 – Emergency Steady State Voltage Test:

Severity: Emergency limits for steady state voltage as per MIL-STD-704F is

Voltage ELSS: 18.0 VDC

Voltage EHSS: 29.0 VDC

Purpose: The test is used to verify that EUT operates and maintains specified performance when provided with input power with emergency steady state levels.

Test Setup: Make the test setup as given in figure below

Test Procedure:

- a) Make the test setup and power 'ON' the EUT with steady state voltage of +28V

- b) Conduct functional test on EUT as in given ATP document and record the test results
- c) Set the input power supply voltage to the EUT to +18V
- d) After stabilizing the input power, conduct functional test on EUT and record the test results
- e) Keep the unit in power ON condition for minimum of 30 minutes. Monitor the EUT performance during entire duration
- f) Restart the EUT at +20V to verify that EUT can be restarted. After restart, conduct the functional test on EUT and record the test results
- g) Repeat c) through f) for input power supply voltage of +29V
- h) After completion of above test, set the input voltage to +28V and carry the functional test and record the test results.

Pass / fail criteria: The EUT is considered to be passed if EUT operates and maintains specified functional performance for input power of emergency steady state voltage level.

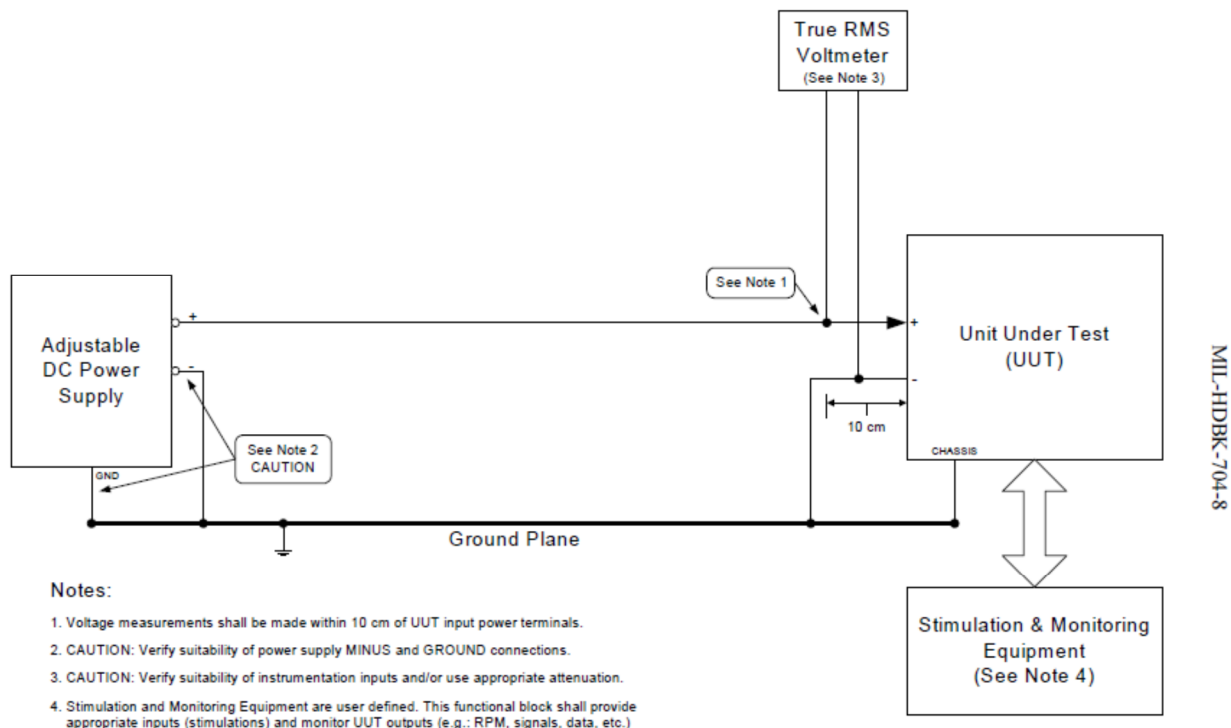


FIGURE LDC401-1. Emergency operation - steady state limits for voltage.

Figure 10 LDC- 401 test set up



2. RECORD OF REVISIONS

REV.NO.	DATE	REVISION DETAILS	REVISED	APPROVED
00	03-12-2021	New Specification	D Pavitran	G R Rao
01	31-03-2022	Details of tests included	A Sandeep	G R Rao

Reference Documents:

- MIL-STD-HDBK 704 F – AIRCRAFT ELECTRIC POWER CHARACTERISTICS
- MIL Handbook 704 - GUIDANCE FOR TEST PROCEDURES FOR DEMONSTRATION OF UTILIZATION EQUIPMENT COMPLIANCE TO AIRCRAFT ELECTRICAL POWER CHARACTERISTICS