



Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, DC

TSO-C174

Date: 07/25/05

Technical Standard Order

Subject: **BATTERY BASED EMERGENCY POWER UNIT (BEPU)**

1. PURPOSE. This technical standard order (TSO) is for manufacturers of battery based emergency power units (BEPU). In it, we (the Federal Aviation Administration, or FAA) tell you what minimum performance standards (MPS) your BEPU must meet if you apply for a TSO authorization or letter of design approval.

2. APPLICABILITY. This TSO affects new applications submitted after its effective date.

3. REQUIREMENTS. New models of BEPUs identified and manufactured on or after the effective date of this TSO must meet the requirements in this TSO, including appendixes **1, 2** and **3**. The battery used in the BEPU must meet the requirements of TSO-C173, *Nickel-Cadmium and Lead Acid Batteries*, dated May 2, 2005, or any other battery standards approved by the Administrator.

a. Functionality. This TSO MPS applies to BEPUs used to provide emergency back up electrical power for, but not limited to, instrument systems, navigation systems, egress lighting, and other emergency or standby electrical power applications on an aircraft.

b. Failure Condition Classification. Failure of the function defined in paragraph **3.a** of this TSO is a *hazardous/severe-major* failure. Develop the BEPU system to, at least, the design assurance level equal to this failure condition classification.

c. Environmental Qualification. Test the BEPU according to appendix **2** of this TSO.

d. Software Qualification. If the article includes a digital computer, develop the software according to RTCA, Inc. document RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 1, 1992. The RTCA/DO-178B software level should be consistent with the failure condition classification in paragraph **3.b** above. In accordance with RTCA/DO-178B, paragraph 9.3, submit the following documents to the FAA aircraft certification office (ACO) manager responsible for your facilities, for review and approval:

(1) Plan for software aspects of certification (PSAC).

(2) Software configuration index.

(3) Software accomplishment summary.

e. All data supporting the applicable objectives found in RTCA/DO-178B, Annex A, *Process Objectives and Outputs by Software Level*, must be available for review. For software developed before December 1, 1992, see RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 1, 1992. Section 12.1.4 of RTCA/DO-178B provides a way to upgrade a baseline for software development so that changes can be made according to RTCA/DO-178B criteria.

NOTE 1: We recommend that you submit the PSAC early in the software development process. Early submittal allows us to resolve issues with the software aspects of the certification plan, such as partitioning and determining the software levels.

NOTE 2: Substantiate the software levels in the safety assessment process outlined in RTCA/DO-178B. If the equipment incorporates more than one software level, appropriate partitioning of different software levels is required.

f. Hardware Qualification. If the hardware element contains electronic devices whose functions cannot be feasibly evaluated by test and/or analysis, those electronic devices must comply with RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware*, dated April 19, 2000. The design assurance level you rely on in RTCA/DO-254 must be consistent with the failure condition classification in paragraph **3.b** of this TSO.

g. Deviations. We have provisions for using alternate or equivalent means of compliance to the criteria in the MPS of this TSO. If you invoke these provisions, show that your BEPU maintains an equivalent level of safety. Apply for a deviation under Title 14 of the Code of Federal Regulations (14 CFR) § 21.609.

4. MARKING.

a. Mark at least one major component permanently and legibly with all the information in 14 CFR § 21.607(d).

b. Indicate on the product label:

- The rated capacity (e.g. 20 hours),
- Nominal voltage, and
- Battery chemistry.

5. APPLICATION DATA REQUIREMENTS. As a manufacturer-applicant, you must comply with 14 CFR § 21.605(a)(2) by giving the FAA aircraft certification office (ACO)

manager responsible for your facilities one copy each of the following technical data to support our design and production approval:

- a. Operating instructions and BEPU limitations, sufficient to describe the operational capability.
- b. Installation procedures and limitations, sufficient to ensure the BEPU, when installed per the installation procedures, continue to meet this TSO's requirements. The limitations must identify any unique aspects of the installation. The limitations must include a note with the following statement:

The conditions and tests required for TSO approval of this BEPU are minimum performance standards. Those installing this BEPU on or in a specific type or class of aircraft must determine that the aircraft installation conditions are within the TSO standards. TSO articles must have separate approval for installation in an aircraft. The article may be installed only if performed under 14 CFR part 43 or the applicable airworthiness requirements.

- c. Schematic drawings of the installation procedures.
- d. Wiring diagrams of the installation procedures.
- e. Minimum performance standards.
- f. Instructions for periodic maintenance and calibration for continued airworthiness once the equipment is installed.
- g. An environmental qualification form describing the environmental tests conducted in accordance with appendix 2 of this TSO, and RTCA/DO-160E, *Environmental Conditions and Test Procedures for Airborne Equipment*, dated December 9, 2004.
- h. List of components by part number.
- i. Manufacturer's TSO qualification test report.
- j. Nameplate drawing with the information required in paragraph 4 of this TSO.
- k. A list of all drawings and processes (including revision level) to define the BEPU's design.

6. MANUFACTURER DATA REQUIREMENTS. Besides the data given directly to the FAA, a manufacturer must have the following technical data available for review by the responsible ACO:

a. The functional qualification specifications to be used to qualify each production article to ensure compliance with this TSO.

b. Equipment calibration procedures.

c. Corrective maintenance procedures (within 12 months after TSO authorization).

d. Schematic drawings.

e. Wiring diagrams.

f. The results of qualification tests conducted in accordance with appendixes 1 and 2 of this TSO, and RTCA/DO-160E.

7. FURNISHED DATA REQUIREMENTS. Send one copy of the data and information specified in paragraphs 5.a through 5.g to each person receiving one or more battery based emergency power units manufactured under this TSO.

8. HOW TO GET REFERENCED DOCUMENTS.

a. Order RTCA documents from RTCA Inc., 1828 L Street NW, Suite 805, Washington DC 20036. Telephone (202) 83309339, fax (202) 833-9439. You can also order online at: www.rtca.org.

b. Order copies of MIL-STD-704F from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia PA 19111-5094.

c. Order copies of 14 CFR, part 21, Subpart O, from the Superintendent of Documents, Government Printing Office, P.O. Box 37154, Pittsburgh PA 15250-7954. Telephone (202) 512-1800, fax (202) 512-2250. You can also order copies online at www.access.gpo.gov. Select "Access," then "Online Bookstore." Select "Aviation," then "Code of Federal Regulations."

d. You can find a current list of technical standard orders on the FAA Internet website Regulatory and Guidance Library at www.airweb.faa.gov/rgl. You will also find the TSO Index of Articles at the same site.

/S/ Susan J. M. Cabler

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APPENDIX 1. MINIMUM PERFORMANCE STANDARD FOR BATTERY BASED EMERGENCY POWER UNITS UNDER STANDARD CONDITIONS

1. PURPOSE. These are the requirements under standard conditions for a BEPU to meet the MPS for this TSO. You may enhance the performance of specific equipment, depending on your intended application and configuration.

2. GENERAL REQUIREMENTS. The BEPU must meet the power quality requirements of MIL-STD-704F, *Aircraft Electrical Power Characteristics*, dated March 12, 2004, and maintain the rated values and functionality according to its specification data sheet, unless otherwise specified in this TSO.

a. Design the BEPU to minimize the risk of causing or spreading a fire.

b. Storage batteries must be designed and installed as follows: Safe cell temperatures and pressures must be maintained during any probable charging or discharging condition. No uncontrolled increase in cell temperature may result when the battery is recharged (after previous complete discharge):

- At maximum regulated voltage or power,
- During a flight of maximum duration, and
- Under the most adverse cooling condition likely to occur in service.

c. Demonstrate the above conditions by test, unless your experience with similar batteries and installations has shown that maintaining safe cell temperatures and pressures do not present a problem.

d. Systems like electronic circuits installed in the BEPU must be compatible with the battery chemistry.

e. During a failure of the normal power source to the emergency electrical bus, the BEPU supplies emergency electrical bus loads without intervention by the flight crew. After re-establishment of the normal power source, the emergency bus loads revert automatically from the BEPU to the normal power source, and the BEPU automatically returns to charging mode. To prevent inadvertent recharging of the BEPU from the aircraft battery when a normal power source is not available, the BEPU shall not enter the recharge mode when the BEPU's input (source) voltage is below 24vDC.

f. Specify the value of voltage spikes occurring when the BEPU is switched on and off and between modes (if applicable).

g. Any single component failure within the BEPU (either open or short) cannot result in an over voltage condition on the battery.

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h. The BEPU will not have any protection/provision that results in automatic removal of power from the emergency load.

i. The BEPU will not discharge through the input side of the BEPU.

j. If the BEPU provides backup power to multiple loads, equip the BEPU with protection provisions that allow for the isolation and removal of excess load on any of its output feeders that draw more than its pre-determined maximum current. This will protect remaining loads in case of a load short circuit.

k. The BEPU should not drain its battery power when the aircraft power is off.

l. Fully charge the battery before installation. Charge the battery every time the aircraft is powered up, independent of cockpit switch position.

m. The charging time from 20 % to 80 % capacity will be less than 3 hours.

n. Specify the nominal current and the short time maximum current.

o. Design the BEPU so separation devices placed between input, output, and battery will enable the current flow from input to output, even when there is a malfunction with other BEPU components. The separation devices will prevent current flow in the direction from output (respectively the battery) to input, and from output to battery. See Figure A-2 in appendix 4 of this TSO. The minimum current rating of the separation devices must be greater than three times the continuous rated output current of the BEPU. Unless provided in the aircraft, design the BEPU to prevent output current greater than 30 miliAmpere (mA) from flowing back to battery. The loss (breakdown) of voltage of such separation devices will exceed three times the BEPU rated voltage.

p. The maximum output voltage ripple cannot exceed the limits stated in MIL-STD-704F. Note this limit does not include the ripple already on the input line into the BEPU. (See appendix 4, Figure A-3 of this TSO.)

q. To preclude catastrophic effects of excess temperature, the BEPU will monitor battery temperature during battery-charging cycles, and remove power when over temperature limits are reached. Applications where excessive battery temperature cannot cause catastrophic events do not require monitoring.

r. If the BEPU contains a battery heater device, a single-fault failure redundancy protection is required to prevent heater runaway.

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3. CAPACITY AND RELATED PARAMETERS. As a manufacturer-applicant, you must provide the parameters listed in this section under environmentally benign and ground benign conditions at 25°C. Following are considered nominal conditions.

a. BEPU capacity. Specify the value for the nominal capacity in Amp-Hours (Ah) based on a constant discharge current for 1.0 hour. During capacity testing, the output voltage cannot degrade below 20vDC.

b. BEPU output voltage excursions. Provide graphs of output voltage versus time for the following conditions:

- Complete discharge to low voltage dropout point after being fully charged.
- Complete discharge to low voltage dropout point after being charged to 72% capacity. This (72% capacity) represents a BEPU at end of its life and 90% state of charge.

c. BEPU life. Declare the expected battery life based on the number of 100% discharge cycles on the battery nameplate. Battery life is expired when 80% of nameplate stated capacity is reached.

d. BEPU maximum current consumption. Specify the maximum current consumption (excluding external loads) of the BEPU. Maximum current includes charging, heating, and other functionalities performed by electronic circuits.

e. BEPU output current. Specify the nominal current that can be delivered by the BEPU related to the nominal Ah rating specified in paragraph **3.a** of this appendix, and the short time maximum current, versus time, if necessary.

4. MONITOR AND CONTROL.

a. Instrumentation, data read-outs, and controls can be provided by support equipment instead of the BEPU.

b. Design all instrumentation and data read-outs for easy interpretation to avoid misunderstandings.

c. The BEPU can have (but is not limited to) the following optional controls:

- BEPU Off: Battery power is disconnected from all loads.
- BEPU Arm: Ready to engage power to the loads if aircraft power is lost. The BEPU should be in “Charging Mode” unless there is a failure of the emergency bus.

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- **BEPU On/Engage:** Causes the battery to be applied to the loads. The BEPU should be in “Charging Mode” unless during failure of the emergency bus.

d. Provide a test function for pre-flight check, showing the system function and battery status. The battery is considered good with 80% state of charge. We recommend an in-flight low battery warning indication. Perform a lamp test where the checked segments are lighted.

APPENDIX 2. MINIMUM PERFORMANCE STANDARD UNDER ENVIRONMENTAL TEST CONDITIONS

1. GENERAL. Unless otherwise specified, applicable test procedures are in RTCA/DO-160E.

2. PERFORMANCE TESTS. The following environmental tests verify BEPU operations based on manufacturer specifications and requirements under extreme environmental conditions. If the manufacturer's specifications during these tests are different than those recorded under benign environmental conditions as specified in paragraph 3, appendix 1 of this TSO, the manufacturer will specify the modified rating and under what condition such ratings would occur. For the following tests, determine compliance of the BEPU to the manufacturer's nominal ratings (unless otherwise specified) as referenced in paragraph 3, appendix 1 of this TSO. Except when otherwise noted, charge the batteries to at least 80 % of manufacturers rated capacity before conducting these tests:

- BEPU capacity using nominal current discharge
- BEPU output voltage excursion
- BEPU current consumption

The applicable test requirements contained in RTCA/DO-160E are:

a. RTCA/DO-160E Section 4, Temperature and Altitude.

• Operating Low Temperature Test. You may use an internal battery heater for this test.

- Operating High Temperature Test
- Altitude Test
- Decompression Test
- Overpressure Test

b. RTCA/DO-160E Section 5, Temperature Variation. Combine this test with RTCA/DO-160E, Section 4 testing requirements.

c. RTCA/DO-160E Section 6, Humidity.

d. RTCA/DO-160E Section 7, Operational Shocks and Crash Safety. After this test, the equipment must remain in its mounting with no part of the equipment or its mounting becoming detached and free on the shock test table. Measure and record the BEPU capacity after completion.

NOTE: These tests may damage the equipment. Therefore, you may want to conduct this test last.

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e. RTCA/DO-160E Section 8, Vibration. While the equipment is subjected to this test, ensure that all mechanical devices operate satisfactorily and that the mechanical construction remains undamaged.

f. RTCA/DO-160E Section 9, Explosion Proofness. Required only if the BEPU contains components that are known to cause inductive arcing.

g. RTCA/DO-160E Section 10, Water Proofness (if required).

h. RTCA/DO-160E Section 11 Fluids Susceptibility (if required). Not mandatory for TSO approval.

i. RTCA/DO-160E Section 12, Sand and Dust (if required).

j. RTCA/DO-160E Section 13, Fungus Resistance (if required). Compliance by analysis is acceptable.

k. RTCA/DO-160E Section 15, Magnetic Effect.

l. RTCA/DO-160E Section 16, Power Input.

m. RTCA/DO-160E Section 17, Voltage Spike. During and after this test, no failed parts must exist, including any degradation on component voltage and current ratings. No parasitic or transient mode switching can result from this test.

n. RTCA/DO-160E Section 18, Audio Frequency Conducted Susceptibility – Power Inputs. Conduct by charging the BEPU when its capacity is between 0% and 75%. No parasitic or transient mode switching can result from this test.

o. RTCA/DO-160E Section 19, Induced Signal Susceptibility. No parasitic or transient mode switching can result from this test.

p. RTCA/DO-160E Section 20, RF Susceptibility. No parasitic or transient mode switching can result from this test.

q. RTCA/DO-160E Section 21, Emission of RF Energy. Conduct while BEPU is being charged. Charge must be between 0% and 75% of capacity during this test.

r. RTCA/DO-160E Section 22, Lightning Induced Transient Susceptibility. No parasitic or transient mode switching can result from this test.

s. RTCA/DO-160E Section 23, Lightning Direct Effects. Not mandatory for this TSO approval. If you conduct this test, no failed parts may exist during and after the test. Failed parts

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include any degradation on component voltage and current ratings. No parasitic or transient mode switching should result during this test.

t. RTCA/DO-160E Section 24, Icing (DO-160E). Not mandatory for this TSO approval. If you conduct this test, no failed parts may exist during and after the test. Failed parts include any degradation on component voltage and current ratings.

u. RTCA/DO-160E Section 25, Electrical Discharge.

APPENDIX 3. ELECTRICAL TEST PROCEDURES

1. GENERAL. Electrical test procedures covered under environmental test conditions in appendix 2 of this TSO are conducted according to RTCA/DO-160E. Under paragraph 3 below, we outline test procedures that meet specific requirements for the BEPU.

2. GENERAL TEST CONDITIONS. Unless otherwise specified, the following test conditions apply:

a. Conduct all tests under conditions of ambient room temperature (except RTCA/DO-160E, sections 4, 5 and 6) and ambient pressure and humidity as outlined in RTCA/DO-160E, Section 1, Paragraph 3.

b. Unless otherwise specified, the input supply voltage will be within 10 % of the nominal value the BEPU is designed to operate.

c. A reasonable warm-up period for stabilization is permissible. Battery nominal capacity is defined at 25 °C.

3. SPECIFIC TEST CONDITIONS. (Per appendix 1, paragraph 4, this document)

a. Lamp test: All segments lighted.

b. Check load segment on when load is applied.

4. ALIGNMENT, ADJUSTMENT AND CALIBRATION PRIOR TO TEST. If necessary, perform alignment, adjustment and calibration before testing.

5. TEST EQUIPMENT. Calibrate the test equipment you use to verify final test results traceable to the National Bureau of Standards. Test equipment accuracy will be at least 2 %.

APPENDIX 4. DESCRIPTION OF A BEPU

1. GENERAL. A BEPU supplies power for a specified time period to an emergency power bus (output) in case of main or emergency bus failure.

2. PARTS OF A BEPU. The BEPU consists of a remote unit or panel-mounted device containing a rechargeable battery pack (accumulator) and means for providing charging, monitoring of battery temperature, battery state, current, as well as system testing and related functions. The batteries are kept fully charged during normal operation independent from surrounding temperature.

a. An indicator/test switch gives information on the battery status of the BEPU before commencing flight.

b. Figure A-1 block diagram illustrates the description of the BEPU functionality. It does not define a requirement.

c. Figure A-2 depicts an example BEPU current flow.

d. Figure A-3 depicts a recommended measurement of BEPU output voltage ripple.

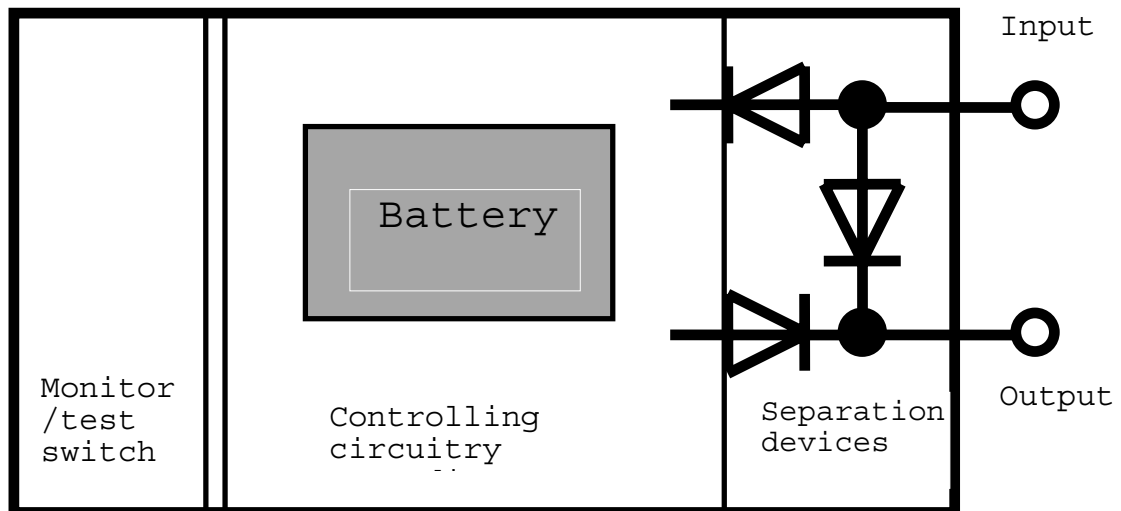


Figure A-1: BEPU Block Diagram.

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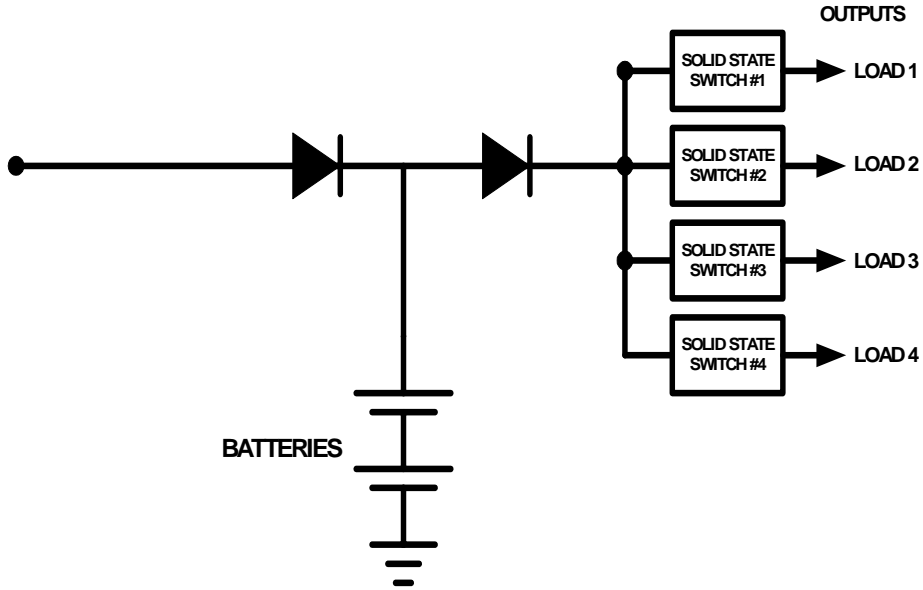


Figure A-2: An example BEPU Current Flow.

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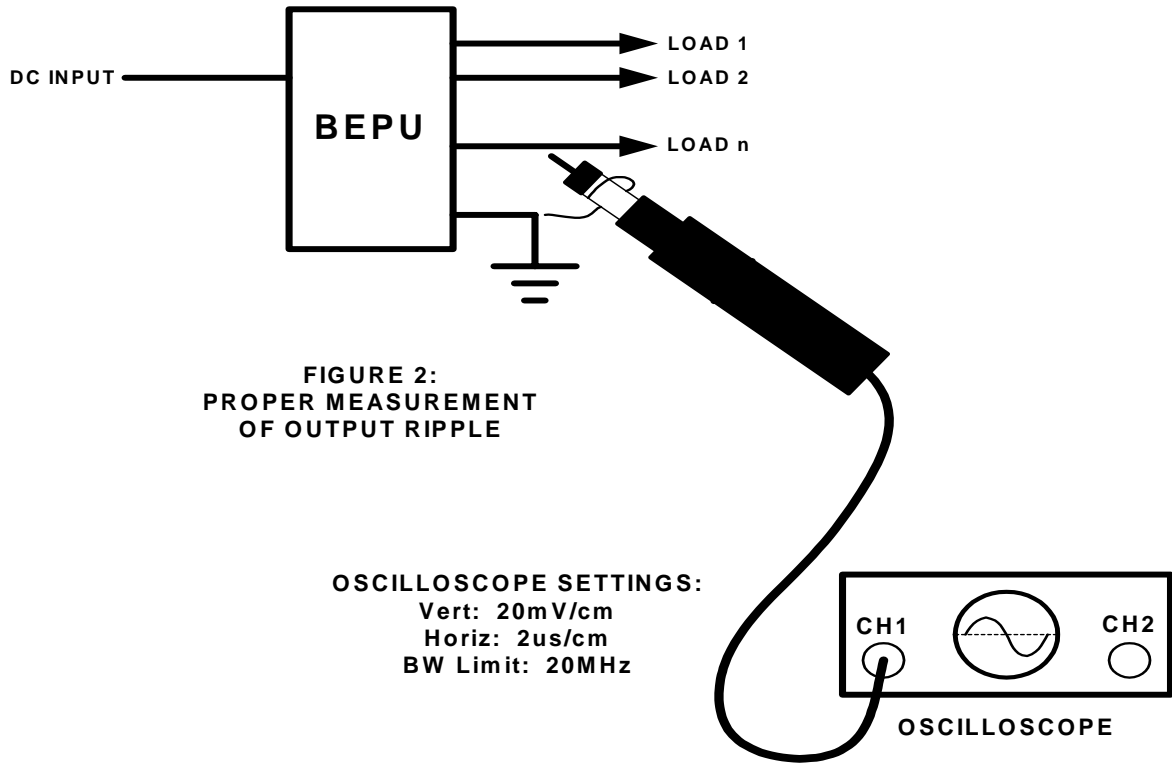


Figure A-3: Recommended Measurement of BEPU Output Voltage Ripple.