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Technical Practice

Issue 3, March, 1999

MODEL 733 DC UPS POWER SUPPLY

Contents

1. General Description

1.1 PRACTICE Issue 3 of the Model 733 Technical Practice is released to document a change to the specification for the output voltage tolerance. Issue 2 was released to support units with serial number 00293 and later. Improvements made to the metal enclosure eliminated the requirement for mounting the unit over concrete or other noncombustible surfaces.

1.2 PRODUCT OVERVIEW The Model 733 DC UPS Power Supply provides a filtered and regulated 48Vdc (nominal) output with a maximum current of 2A. The nominal input voltage is 120V, 47-63Hz, with an allowable input voltage range of 95 to 135V. Rechargeable batteries contained within the Model 733 provide backup capability in the event of an AC input voltage failure. Under battery operation, the Model 733 will continue to supply a full 48V, 2A output for 2 hours. For output loads of less than 2A the battery operating time will substantially increase. The Model 733 is Underwriters Laboratories, Inc. Listed.

1.3 FEATURES Model 733 features include LED status indicators, talk-battery-quality DC output, wide input-voltage operating range, full on-line UPS operation with internal backup batteries, output short-circuit protection, auxiliary relay contact, and simple installation. Three status LEDs are provided as installation, operation, and maintenance aids. The DC output is expressly designed for a wide range of telecommunications applications, including acting as a source of talk battery. The output noise, especially over the voice band, was carefully minimized. The wide input-voltage range, 95-135V, allows AC operation even when the power source deviates significantly from nominal 120V.

The Model 733's circuitry implements a full on-line UPS (uninterruptible power source) system for telecommunications applications. Events ranging from a momentary power "glitch," up to an extensive AC power outage will have no impact on the 48V output. A 48V, 2A output can be supported for 2 hours, with a nominally inverse-linear increase in support time as the load current decreases. The internal batteries are carefully charged to ensure maximum output performance and long life.

The Model 733's circuitry is designed for robust performance. The output is short-circuit and over-current protected, automatically returning to normal operation when a fault condition is removed. An electrically-isolated, auxiliary relay contact is provided for installer selected applications. The contact indicates three Model 733 operating states: normally open (not shorted) for normal operation under incoming AC power, a one-second open (not shorted)/one-second closed (shorted) cadence when the unit is operating under battery power, and closed (shorted) when the 48V output has ceased

due to a lack of incoming AC power and the internal batteries have reached their maximum allowed discharged state.

The unit is completely self-contained in a compact wall-mounted cabinet. DC-output and auxiliary relay contact interconnections are made using a 5-conductor removable screw terminal strip. Nominal 120V power is connected using a standard 3-conductor cord and plug.

1.4 PHYSICAL DESCRIPTION The Model 733 consists of a painted steel enclosure that houses a precision-fabricated circuit board, a groovy-looking aluminum heat-sink assembly, and four 12V sealed lead-acid batteries. The Model 733's overall dimensions are 6.3 inches (24.8cm) high, 12.4 inches (31.5cm) wide, 8.1 inches (20.6cm) deep, and weighs a hefty 29.8 pounds (13.6kg). It wall mounts using four screws.

2. Applications

2.1 PRIMARY APPLICATION The Model 733 DC UPS Power Supply is intended to provide telecommunications applications with an uninterruptible source of filtered and regulated 48Vdc. The true on-line UPS implementation ensures a reliable 48V output even in the face of an uncertain AC power input.

2.2 FLOATING OUTPUT The Model 733 has a floating output, making it suitable to provide positive or negative ground-referenced DC voltage. The DC output can float up to ±150V away from ground, allowing it to be connected in series with a telecommunications ring voltage generator.

2.3 UL LISTING The Model 733 has been tested and approved by Underwriters Laboratories, Inc. as a Listed power supply in their UL1459 category. A Listed product is one that has passed the requirements of a complete, independent unit. This helps to ensure that the Model 733 will perform in a safe manner, and will comply with most electrical codes.

3. Installation

3.1 WORDS OF CAUTION As with any product, installing the Model 733 requires a safety-first approach. Read the entire installation section of this practice before starting the installation process.

WARNING: Handle the Model 733 with great caution! It is very heavy relative to its physical dimensions. If dropped, it can be quite dangerous to property or human beings.

3.2 CHECKING FOR DAMAGE The Model 733 should be inspected for damage immediately upon receipt. A claim should be filed with the shipper if damage is found. A replacement should be ordered if necessary.

3.3 INSTALLATION KIT Included in each Model 733 shipping carton is a mounting kit. Each kit contains four pan-head screws (Type A, ¾-inch).

3.4 SELECTING A MOUNTING LOCATION Two factors come into play as you select the "perfect" mounting location: air flow and proximity to an AC outlet. The extruded aluminum heat sink, located on the front "face" of the Model 733's enclosure, must remain clear to allow adequate air flow across its surface. The Model 733 contains a 6-foot (2-meter) 3-conductor power cord. Select a mounting location that allows convenient access to a grounded AC outlet.

3.5 MOUNTING THE UNIT Mount the Model 733 using the four screws supplied in the installation kit. These screws are intended for use with a wooden-backboard surface (minimum thickness ¾-inch.) The Model 733's cabinet is outfitted with four keyhole screw slots. Use one screw per slot and securely fasten the unit to the backboard. Do not plug in the power cord at this time. You will be instructed do so later in this section.

3.6 ENSURE NO DC OUTPUT Before connecting to the DC output ensure that the power cord is not plugged into an AC outlet. Be certain that the DC output LED is not lit. If the AC cord is not plugged in, but the unit is operating under battery power and the DC output LED is lit, refer to Section 8.3 for details on "shutting down" the unit.

3.7 GROUND, DC OUTPUT, AND AUXILIARY RELAY CONNECTIONS Ground, DC output, and auxiliary relay connections are made via terminals on a 5-position plug-in screw terminal strip. The terminal strip is located on the left side of the Model 733's cabinet and is illustrated in Figure 1.

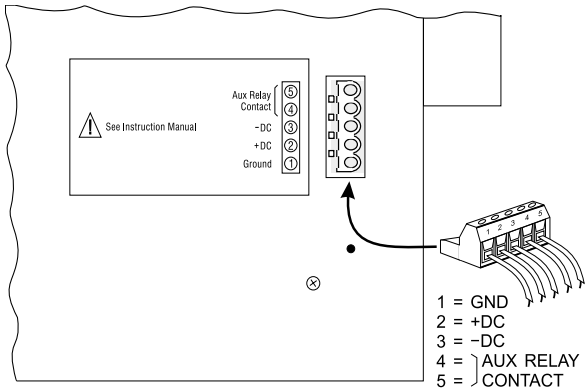

Figure 1 Model 733 cabinet showing 5-position plug-in terminal strip.

Remove the terminal strip by firmly grasping it with your fingers and pulling is straight away from the cabinet. Do not wire the terminal strip while it is attached to the unit. Once it is removed, a small straight-blade screwdriver is required to loosen the clamp screws. The interconnecting wires are slipped into the openings of the terminal strip, and then the screws are tightened to secure the wires into place. For connecting the DC output, a minimum wire gauge of #20 AWG or larger is recommended. (Remember that the smaller the AWG number, the larger its current rating.) Although not required, using a wire that is "heavier" than is technically necessary will help to minimize the resistance, and the resultant voltage drop, between the Model 733 and the equipment being powered.

3.8 EARTH GROUND CONNECTION For safety, the third pin of the AC power cord brings earth ground to the Model 733's cabinet. Inside the cabinet earth ground is also connected to pin 1 of the terminal strip. There are testing or maintenance situations where you may wish to disconnect the AC power cord from the associated AC outlet. Unfortunately, while this does disconnect 120V power from the Model 733, it also disconnects the safety ground. To eliminate this potential problem it is recommended that a separate earth ground connection be made to pin 1 of the terminal strip. The wire should be #12 or #14 AWG.

3.9 SELECTING THE DESIRED DC OUTPUT SCHEME As mentioned previously, the DC output is floating (isolated) in respect to ground. The DC output can be connected to the equipment to be powered in this manner, or it can be

referenced to ground. In telecommunications applications it is typical to utilize a positive ground, with the output configured to be –48Vdc with respect to earth ground. This is easily accomplished by strapping terminal strip pin 1 (ground) to pin 2 (+DC) and using this combination as the ground connection to the load. The –48Vdc is then connected from pin 3 (–DC) to the load. Refer to Figure 2.

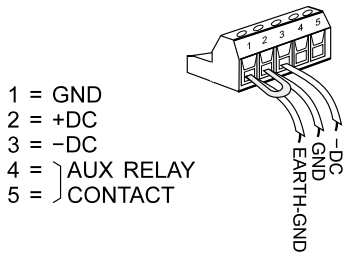

Figure 2 5-position terminal strip showing DC output connected for a positive ground scheme.

3.10 AUXILIARY RELAY CONTACT The auxiliary relay contact provides an indication of the Model 733's operating status, and is accessible via pins 4 and 5 of the terminal strip. The relay contact is intended for use in a wide variety of site-specific applications. It is isolated from ground, making it compatible with a wide variety of monitoring and alarm equipment. When the Model 733 is producing 48V from the incoming 120V, the relay contact is open (not shorted). When the Model 733 is producing 48V from the internal batteries, the relay contact operates in a continuous one-second open (not shorted)/one-second closed (shorted) cadence. This would occur when the incoming 120V has failed, or has dropped so low in voltage that the Model 733's internal batteries are required to supply power. When the 48V output has failed, the relay contact goes into the closed (shorted) state. This would occur when incoming 120V power has failed and the Model 733's internal batteries have been discharged to their maximum allowed state. Note that the relay contact is intended only for use in low voltage (less than 60V DC or AC), low current (less than 0.5A) applications.

3.11 CONNECTING AC POWER Before the Model 733's power cord is plugged into a nominal 120V outlet, ensure that ground, DC, and if desired, auxiliary relay connections have been made. Once complete, plug the 5-position terminal strip back into the Model 733. Now plug the power cord into the designated AC outlet. The DC output LED should light and the unit should be producing 48Vdc. Do not secure the power cord to the wall. It must hang free to allow rapid disconnection if circumstances require. Attaching the power cord to the wall surface creates a safety hazard and may be an electrical-code violation.

4. Testing and Operation

4.1 INSTALLATION REVIEW By this point, the connections should have been made between the related equipment and the Model 733's DC output and auxiliary relay contact. An earth (safety) ground connection should have been made to pin 1 of the terminal strip. The power cord should have been plugged into the selected AC outlet. Confirm that the power cord is hanging free and is not attached to the wall surface. At this time only the DC output LED should be lit steadily. If the LED does not light, or appears to flash rapidly, a wiring error exists; most likely a short or over-current condition. Check the installation and refer to section 7 of this practice for trouble-shooting assistance.

4.2 STATUS LEDS The Model 733 contains three status LEDs which are visible on the unit's front panel. The DC OUTPUT LED lights steadily whenever 48V is being produced by the unit, regardless of whether the unit is operating from incoming AC power or the internal backup batteries.

The BATTERY OPERATION LED lights in a one-second on/one-second off cadence whenever the Model 733 is using energy from the internal batteries. This can occur when the incoming AC power fails, or the AC voltage drops below the minimum required for proper operation.

The LOW BATTERY LED lights whenever the Model 733 is operating from battery power, and the batteries have less than approximately 20% of their maximum energy available. The LED provides an indication of when the 48V output is on the verge of shutting down. (For protection, a circuit automatically disconnects the batteries when their voltage has reached a specific threshold.)

4.3 TESTING THE ASSOCIATED EQUIPMENT Now that 48V is being produced, check each piece of equipment that is being powered. If possible, use a digital volt meter to check the DC output for nominal 48Vdc; a reading of 46 to 50V would be considered normal. If the auxiliary relay contact is connected, check the related equipment to ensure that it recognizes the Model 733's normal operating state.

4.4 TESTING BATTERY OPERATION

WARNING: The testing method described in this section makes the assumption that an earth ground connection has been made to pin 1 of the Model 733's terminal strip. This ensures that a safety ground connection is maintained even if the AC power cord is disconnected from an outlet. If you are uncertain whether this earth ground connection has been made, review section 3.8 of this practice.

The Model 733 does not include a direct means of placing the unit under battery operation. This design decision was made to enhance system reliability and prevent "button pushers" from accidently placing the unit in a test mode. To test the Model 733's UPS capability simply unplug the unit from AC power. The DC OUTPUT LED should remain lit and the BATTERY OPERATION LED should start a one-second on/one-second off cadence. (The associated "clicking" sound you may hear is the auxiliary relay changing state.) The LOW BATTERY LED will light only if the batteries have reached approximately their final 20% of capacity. If the auxiliary relay contact has been connected to other equipment, ensure that this battery operation state is being recognized. After observing the Model 733 under battery operation, again plug the power cord into the AC outlet. The BATTERY OPERATION LED should stop lighting as should the LOW BATTERY LED, if it was previously lit.

4.5 PLACING THE MODEL 733 INTO SERVICE The unit should now be ready for a long, uneventful life. Normal operation should find only the DC OUTPUT LED lit.

5. Circuit Description

5.1 GENERAL This circuit description is intended to familiarize you with the Model 733 for engineering and applications use. Repairs to the unit should not be attempted as they will expose you to dangerous voltage levels. Please refer to the block diagram, Figure 3, when reading this technical description.

5.2 INPUT FUSE A fuse, in series with the nominal 120V input, limits the amount of AC-line current that can enter the unit. Should the unit experience a catastrophic failure the fuse will open. A fuse that opens (blows) indicates a serious problem with the Model 733 with factory service required.

5.3 INPUT FILTER From the power cord and fuse, nominal 120V passes through an electromagnetic interference (EMI) filter. This filter limits the amount of high-frequency energy exiting the unit by way of the power cord. Across the filter's input is a transient suppressor which protects the unit from short-duration, high-voltage power line surges.

5.4 RECTIFIER AND FILTER From the EMI filter the AC input voltage is full-wave rectified, then filtered to provide high-voltage DC.

5.5 PWM SWITCHING REGULATOR An integrated-circuit, along with supporting components, forms a pulse-width-modulator (PWM) switching regulator. Technically, the Model 733 implements a discontinuous mode flyback regulator. Integral to the PWM circuit is a multiple input and output transformer. One input winding is driven by a field-effect transistor (FET) which is controlled by the PWM output. A second winding on the input side of the transformer provides a feedback signal, providing power for the PWM circuit, as well as suppling a "macro" output voltage control signal.

5.6 OUTPUT RECTIFIER AND FILTER The secondary of the transformer provides a step-down function, as well as isolation from the AC line. A high-speed, high-efficiency rectifier is used to half-wave rectify the transformer's secondary. A capacitor is used to filter the rectified signal.

5.7 VOLTAGE FEEDBACK AND CONTROL An optical coupler is used to send a scaled version of the rectified and filtered signal back to the PWM circuit. This signal is used for precision control of the voltage. A trim potentiometer is used at the factory to set the voltage to 56.4V.

5.8 INTERSTAGE DC VOLTAGE The 56.4V can be considered the interstage DC and is used to supply energy for battery charging and to operate a second PWM switching regulator. The second PWM switching regulator produces the output 48V. The interstage DC is energy limited and gets shared by the batteries and the output PWM circuit. The greater the 48V output load, the less energy is available for battery charging.

5.9 BATTERY CHARGING/DISCHARGING When incoming AC is present and the interstage 56.4V is being produced, the batteries charge in a constant voltage/current limited manner. When the incoming AC fails, or falls low enough to prevent the 56.4V from being produced, the batteries supply currently to the output PWM circuit.

5.10 LOW BATTERY DETECTION The batteries are connected to the interstage 56.4V via a low-voltage detection/switching circuit. A related circuit also monitors the battery voltage, lighting the LOW BATTERY LED whenever the battery voltage reaches 44V. This represents a condition when the batteries have available less than approximately 20% of their maximum energy. Should the battery voltage fall below 41V, the batteries automatically disconnect. This allows the batteries to supply

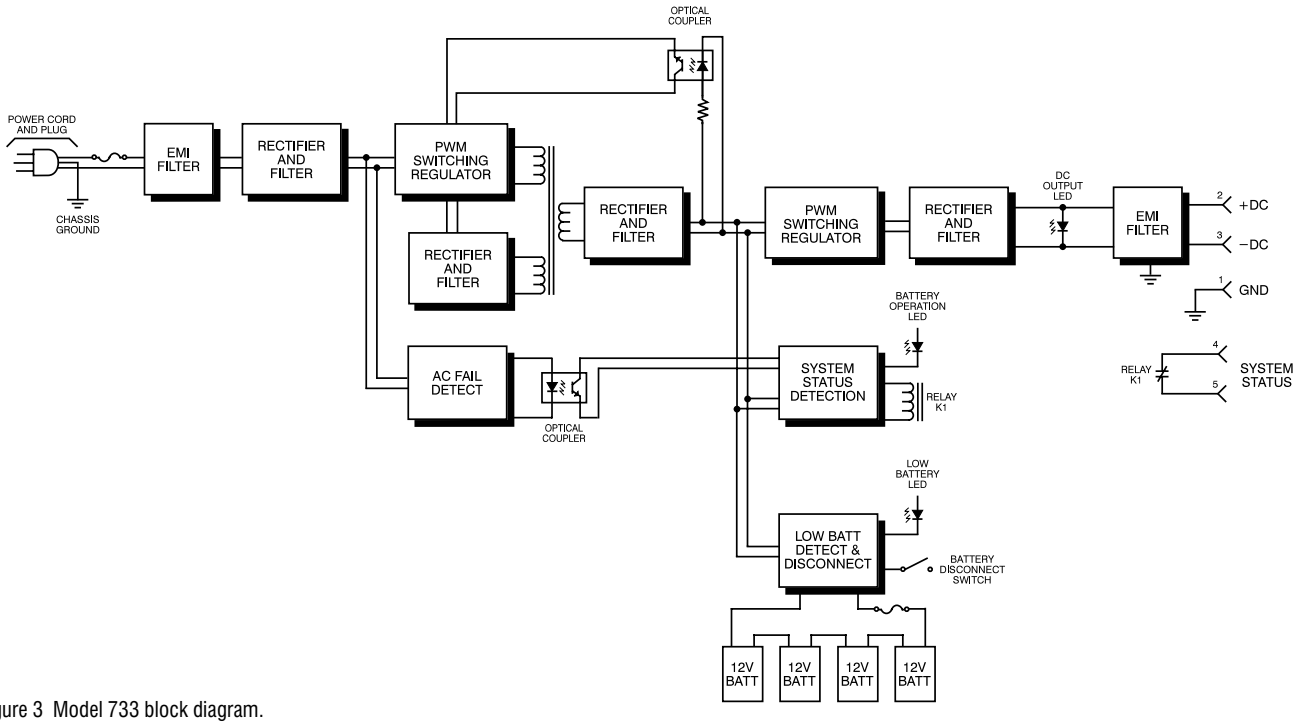

Figure 3 Model 733 block diagram.

the bulk of their available energy, while protecting them from damage due to deep discharge. A manual shutdown switch is connected to the voltage detection circuit. When pressed, the circuit gets "fooled" into detecting the batteries as being in an under-voltage state.

5.11 OUTPUT PWM A second PWM circuit produces 48V from the interstage 56.4V. This PWM circuit is considerably simpler than the first one due to the fact that isolation from the incoming AC power line is not required. An inductor, rather than a transformer, provides energy storage. Again a high-speed, high-efficiency rectifier is used to half-wave rectify the PWM's output signal. Capacitors are used to filter the rectified signal. An EMI filter is implemented to limit the amount of high-frequency energy that leaves the unit by way of the DC-output terminals. The output circuitry was carefully optimized to have extremely low noise over the audible frequency band. This is critical when the Model 733 is to be used in talk-battery applications. The DC OUTPUT LED, along with a series dropping resistor, is connected directly across the 48V output.

5.12 SYSTEM STATUS A scaled signal from the rectified and filtered incoming AC is connected, by way of an optocoupler, to the status circuit. The circuit compares the incoming AC signal with the interstage nominal 56.4V signal. When the incoming AC is insufficient to provide the required energy for the output PWM, the batteries stop charging and begin to supply energy. The system status circuit detects this condition, and enables the auxiliary relay and BATTERY OPERATION LED in a one-second on/one-second off cadence.

5.13 OPERATING CHARACTERISTICS Many hours were spent optimizing the performance of the Model 733. Unlike some power supplies, the Model 733 does not require that a 48V output overload or short-circuit condition be removed completely before the output will return to normal. The 48V output can be shorted indefinitely without damage to the circuitry. Several times each second the DC OUTPUT LED will "flash" as the circuit tries to restart. Remove the short and the output will automatically return to 48V.

6. Specifications

INPUT VOLTAGE
95-135V, 47-63Hz

INPUT CURRENT
2.1A rms steady state, maximum

POWER CORD
3-conductor with plug, length 6 feet (2 meters), nominal, not detachable

OUTPUT VOLTAGE
48.5 ±2Vdc (with 50mA minimum load)

OUTPUT CURRENT
2A maximum, continuous

OUTPUT TECHNOLOGY
on-line uninterruptible power supply (UPS)

BATTERY OPERATING TIME (NOMINAL)
10 hours, with 0.5A output current
4.5 hours, with 1A output current
2 hours, with 2A output current

BATTERY CHARGE TIME (NOMINAL)
batteries fully discharged
4.5 hours, with 0.5A output current
4.75 hours, with 1A output current
5 hours, with 2A output current

BATTERIES
Qty: 4
Type: 12V, 6.5Ah, sealed lead-acid (Panasonic LCR12V6.5P or equivalent)

OUTPUT CURRENT FOR AUTOMATIC SHUTDOWN
2.6A, nominal

MINIMAL LOAD CURRENT FOR OPTIMAL REGULATION
50mA

LOAD REGULATION
Less than 1%, load current 50mA to 2A, input voltage 95 to 135V

OUTPUT RIPPLE VOLTAGE
Less than 10mV rms, maximum

OUTPUT COMPLIANCE
Complies with FCC Part 68 for talk battery quality

INPUT TO OUTPUT EFFICIENCY
87% at full load, nominal

OUTPUT CONNECTIONS
5-position detachable screw terminal strip

TRANSIENT PROTECTION
Input and output protected against transients

LED INDICATORS
Qty 3

AUXILIARY RELAY CONTACT
Type: normally open (not shorted)
Rating: 0.5A maximum at 60Vdc or 60Vac (resistive)

OPERATING ENVIRONMENT
–10 TO 50 degrees C, humidity to 95% (no condensation)

RADIATED NOISE COMPLIANCE
Complies with FCC Part 15, subpart J, class A for radiated and conducted emission

SAFETY COMPLIANCE
Underwriters Laboratories, Inc. Listed Power Supply

DIMENSIONS (OVERALL)
6.3 inches (24.8cm) high
12.4 inches (31.5cm) wide
8.1 inches (20.6cm) deep

WEIGHT
29.8 pounds (13.6kg)

MOUNTING
Intended for wall mounting only

7. Incorrect Operation

7.1 REVIEW PRACTICE Should problems arise in the operation of the Model 733, please review Section 3—Installation and Section 4—Testing and Operation in this practice.

7.2 AC OUTLET If the DC OUTPUT LED does not light, reconfirm that the AC outlet is functioning by plugging another piece of equipment in the AC outlet. If the AC outlet is okay, but the DC OUTPUT LED doesn't light, the Model 733 needs to be returned to the factory for repair.

7.3 OUTPUT OVERLOAD OR SHORT CONDITION If the DC OUTPUT LED flashes rapidly, an overload condition is being placed on the Model 733's DC output. This will occur whether the output is being shorted, or has a load that is attempting to draw more than 2A. Carefully recheck the wiring and equipment being powered. "Shed" some of the load to ensure that an overload is not present. Once an acceptable load is connected, the Model 733 will restart and the DC OUTPUT LED will light steadily.

7.4 INTERNAL FUSE The Model 733 contains two internal fuses. One is in series with the incoming AC power. This fuse will blow if the unit experiences serious trauma. The other fuse is in series with the batteries. It will blow if the batteries are connected incorrectly, or if excessive current is being drawn by or from the batteries. A blown fuse always indicates that the unit must be returned to the factory; neither fuse is intended for user replacement. Removing the unit's cover will expose you to hazardous voltages.

7.5 APPLICATION LIMITATIONS The Model 733 was designed to operate correctly in most applications. However, Gordon Kapes, Inc. does not guarantee the Model 733 to be compatible with every specific application. All functions of the installed Model 733 should be thoroughly tested before the unit is placed into service.

7.6 SAVE TIME You are encouraged to call or E-mail Gordon Kapes, Inc. for technical support. Please check our website, www.gkinc.com, for the current area code and telephone number. We do not mind "walking" you through an installation, or performing a verbal review prior to your actually getting started. Please have these items with you: a copy of this technical practice, system configuration documentation, and adequate tools, including a digital volt-ohm meter (VOM). Our favorite meters come from the excellent Fluke 70 or 80 series.

8. Maintenance

8.1 MAINTENANCE The Model 733 requires no normal maintenance. It is recommended that the unit be examined not less than once a year to ensure that the vents on the front-panel heat sink are unobstructed and free of dirt.

8.2 BATTERY REPLACEMENT The Model 733's internal batteries should provide reliable service for a minimum of 5 years, with 8 to 10 years possible. Variables that can effect battery life include the number of charge/discharge cycles and ambient temperature. A label, attached to the right side of the cabinet, indicates when the batteries were installed at the factory. This can be used to "guess" when the batteries will require replacement. However, the only true test of battery quality is to place a known load across the Model 733's DC output, disconnect AC power to place the unit under battery operation, and then measure the time until the unit automatically "shuts down." Now compare the measured time with curve shown in Figure 4. If the measured time deviates significantly from the published specification, the batteries need replacement.

WARNING: The batteries are not user replaceable, and require the Model 733 to be returned to the factory or authorized service center. Removing the Model 733's cover can expose you to potentially lethal voltages—don't do it!

8.3 MANUAL BATTERY SHUTDOWN By virtue of its UPS design, the Model 733 doesn't contain an on/off switch. The 48V output is supposed to be there whether incoming AC power is present or not! Only when the batteries have discharged to their minimum acceptable voltage level will they

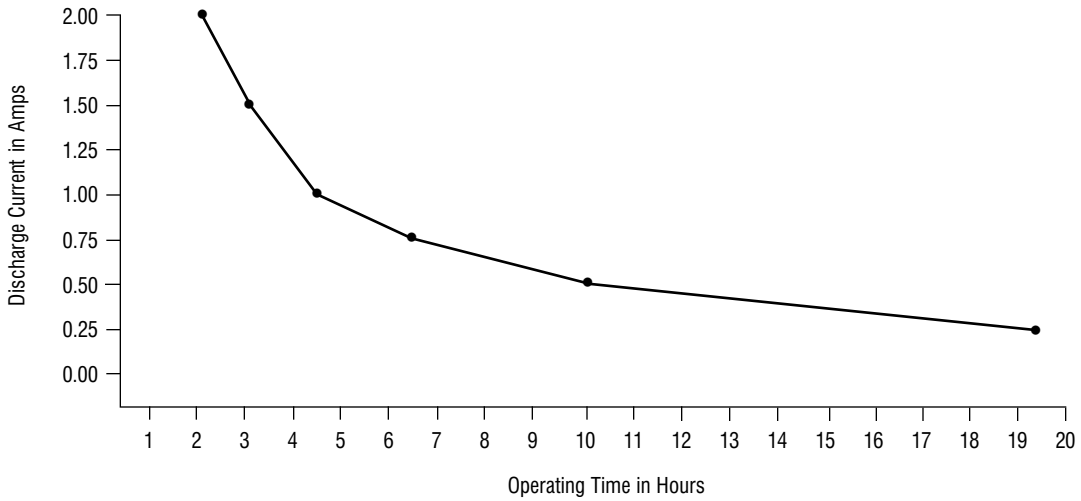

Figure 4 Model 733 discharge data.

automatically disconnect, protecting them from damage due to deep discharge. There may be cases, e.g. testing or storage purposes, where a Model 733 with fully charged batteries will need to be manually "shut down." The Model 733 provides a "secret" button to allow this to happen ("if I tell you, I'll have to..."). Personnel at Gordon Kapes, Inc. use the button to manually shut down new units, allowing them to be shipped with fully-charged batteries. The button is located on the left side of the unit, approximately 1 inch below the terminal strip. The button is accessible through a small hole in the panel, preventing accidental activation.

Starting with the Model 733 operating under battery power (incoming AC power disconnected), press the button with a small nonconducting tool. You'll hear a small "click" and the DC OUTPUT LED will stop lighting. At this point, the batteries are completely disconnected from any load. The Model 733 can now be stored for up to six months without significant adverse effect on the batteries. To return the Model 733 to normal operation, simply reconnect incoming AC power.

9. Repair and Replacement

9.1 NOT SO FAST Statistically, most equipment returned to Gordon Kapes, Inc. for repair actually has nothing wrong with it. A telephone call to Gordon Kapes, Inc. technical support can often help to get the equipment operating correctly. We don't mind spending time with our customers getting a site up and running.

9.2 SEND IT BACK If you determine that the Model 733 is defective, return it for repair or replacement according to the Gordon Kapes, Inc. Warranty/Repair and Return policy. Like the big guys, we require that you obtain a return authorization number prior to returning any equipment.

9.3 ONLY WE FIX IT In the event repairs are ever needed on your Model 733, they should only be performed by Gordon Kapes, Inc. or an authorized representative. Do not remove the cover as it will expose you to hazardous voltages.

Specifications and information contained in this technical practice subject to change without notice.

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