

Technical Practice

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Model 728 DC Power Supply



1. General Description

1.1 Product Overview

The Model 728 Power Supply provides a filtered and regulated 48 Vdc output with a maximum current of 3 amperes. The nominal input voltage is 110-240 V, 47 to 63 Hz. The Model 728 is Underwriters Laboratories, Inc. LISTED under their CUL-60950 ITE category.

1.2 Features

Model 728 features include an LED indicator, talk-battery-quality DC output, wide-input voltage operating range, output short-circuit protection, and simple installation. An LED is provided as an installation, operation, and maintenance aid. This LED is referred to as the DC output LED. The DC output is expressly designed for a wide range of general purpose and 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, 110 to 240 V, allows operation even when the power source deviates significantly from nominal 120 V. The Model 728's circuitry is designed for robust performance. The output is short-circuit and over-current protected, automatically returning to normal operation when the fault condition is removed. The unit is completely self-contained in a compact wall-mounted cabinet. DC-output interconnections are made using a 3-conductor removable screw terminal strip. Input power is connected using a standard 3-conductor cord and plug.

1.3 Physical Description

The Model 728 consists of a precision-fabricated printed circuit board, enclosed in a painted steel enclosure. The Model 728's overall dimensions are 4.7 inches (11.9 cm) high, 7.4 inches (18.7 cm) wide, 2.3 inches (5.8 cm) deep, and weighs 2.8 pounds (1.3 kg). It wall mounts with two screws.

2. Applications

2.1 Primary Application

The Model 728 Power Supply is intended to serve a wide range of telecommunications and general-purpose commercial and industrial applications. As previously mentioned, the quality of the DC output makes it compatible with talk battery applications.

2.2 Floating Output

The Model 728 has a floating output, making it suitable to provide positive or negative ground-referenced DC voltage. The DC output can float up to ± 150 V away from ground, allowing it to be connected with telecommunications ringing voltage generators.

2.3 UL Listed Versus UL Recognized

The Model 728 has been tested and approved by Underwriters Laboratories, Inc. as a Listed power supply. UL is a not-for-profit organization which serves as an independent testing agency, assisting manufacturers in the process of designing and building safer products. They are not affiliated with any governmental body. UL works with industry to establish standards and testing procedures for products in hundreds of categories. Gordon Kapes, Inc. works with UL under CUL (Canada-United States), UL 60950 equipment standard.

UL has two main standards categories for which a product can be tested: Recognition and Listing. A Recognized product has been tested for use as part of another product or system, and is not intended as a stand-alone item. A Recognized product is allowed to display the RU mark, where the “R” is displayed backwards. Recognized products are frequently used as part of a finished product.

A Listed product is one that has passed the requirements of a complete, independent unit. Listed products are granted the right to display the UL mark, a circle with the letters “U” and “L” in it. Often a manufacturer will imply that a product is UL Listed, when actually it is only Recognized. Many telephone system components, including power supplies, are Recognized rather than Listed but are actually installed in end-use applications. Gordon Kapes, Inc. felt that it was important for the Model 728 to be tested and approved as a Listed item. This helps to ensure the unit will perform in a safe manner, and that compliance with most electrical codes are met.

3. Installation

3.1 Words of Caution

As with any product, installing the Model 728 requires a safety-first approach. The Model 728 is intended for wall mounting only in a dry location.

3.2 Checking for Damage

The Model 728 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 728 shipping carton is a mounting kit. Each kit contains two #8 pan-head screws (type A, $\frac{3}{4}$ -inch long).

3.4 Selecting a Mounting Location

Because the Model 728 is intended for wall mounting only, you must select a suitable position on the equipment room wall, preferably on a wooden backboard. Two factors come into play as you select the “perfect” mounting: air flow and proximity to an AC outlet. The openings in the cabinet must remain clear to allow adequate ventilation. Also, ensure that the cabinet is not located underneath terminal blocks where small pieces of wire could fall into the unit. Do not install the Model 728 on the bottom of a wiring frame, i.e., the MDF! The Model 728 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 728 using the two screws supplied in the installation kit. These screws are intended for use with a wooden-backboard surface (minimum thickness $\frac{3}{4}$ inch). The Model 728's cabinet is outfitted with two 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 to do so later in this section.

3.6 DC Output Connections

Before connecting to the DC output ensure that the power cord is not plugged into an outlet. Be certain that the DC output LED is not lit. The DC-output connections are made via a 3-position plug-in terminal strip. The terminal strip is located on the bottom face of the unit, adjacent to the where the power cord exits the chassis. Remove the terminal strip by firmly grasping it with your fingers and pulling it straight away from the cabinet. Do not wire the terminal strip while it is attached to the power supply. 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. A minimum wire gauge of #18 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 a power source and the equipment being powered. After the wires are secured into the terminal strip, plug it back into the socket on the Model 728. Ensure that the terminal strip is firmly mated with the socket.

3.7 Selecting the Desired DC Output Scheme

As mentioned previously, the DC output is floating (isolated) in respect to earth ground. The DC output can be connected to the equipment to be powered in this manner, or it can be referenced to earth ground. In telecommunications applications it is typical to utilize a positive ground, with the output configured to be -48 Vdc in 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 -48 Vdc is then connected from pin 3 (-DC) to the load. Note that pin 1 is internally connected to the Model 728 chassis and the safety ground wire of the power cord. Alternately, a negative ground scheme is created by strapping pin 1 (ground) to pin 3 (-DC) and using this combination as the ground connection to the load. $+48$ Vdc is then connected from pin 2 (+DC) to the load.

3.8 Connecting Power

Before the Model 728's power cord is plugged into a 110-240 V outlet, ensure that all DC-output connections have been made between the unit and the equipment to be powered. Now plug the power cord into the designated AC outlet. The DC output LED should light and the unit should be producing 48 Vdc. 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, connections should have been made between the Model 728 and the equipment to be powered. 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. The vents must be clear to allow air flow. The power cord exits the unit from the bottom, i.e., a correctly mounted Model 728 will have the power cord exiting directly toward the floor.

4.2 DC Output LED

The DC output LED will light steadily any time power is supplied to the unit and 48 Vdc is present on the output. If the LED does not light, or appears to flash rapidly, a wiring error exists. Check the installation and refer to Section 6 of this practice for troubleshooting assistance.

4.3 Testing the Associated Equipment

Now that 48 Vdc is being produced, check each piece of equipment that is being powered. If possible, use a digital volt meter to check the output for nominal 48 Vdc; a reading of 47 to 49 Vdc would be considered normal.

4.4 Placing the Model 728 into Service

The Model 728 should now be ready for a long, uneventful life. Normal operation should find the DC output LED lit steadily.

4.5 Maintenance

The Model 728 requires no normal maintenance. It is recommended that the Model 728 be examined not less than once a year to ensure that the openings in the cabinet remain unobstructed. Long, reliable Model 728 life depends on its ability to stay cool. (This is not bad advice for all of us to live by!)

5. Circuit Description

5.1 General

The circuit description is intended to familiarize you with the Model 728 for engineering and applications use. Repairs to the unit should not be attempted as they will expose you to dangerous voltage levels.

5.2 Fuse

In series with the AC-power input is a fuse that 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 unit, and factory service is required.

5.3 Input Filtering

From the power cord and fuse, nominal 120 V 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 AC-power input is a transient suppressor which protects the units from short-duration, high-voltage power line surges.

5.4 Rectifier and Filter

From the EMI filter the 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 728 implements a discontinuous mode flyback regulator. The operating frequency of the circuit is approximately 35 kHz. 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 which provides power for the PWM circuit, and supplies 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. It is at this point that the output DC is created. The DC output LED is connected to the circuit at this point.

5.7 Output Voltage Feedback and Control

An optical coupler is used to send a scaled version of the output voltage back to the PWM circuit. This signal is used for precise control of the output voltage.

5.8 EMI Filter

A second EMI filter is implemented to limit the amount of high-frequency energy that leaves the unit by way of the DC-output terminals.

5.9 Operating Characteristics

Untold hours of hair pulling were spent optimizing the performance of the Model 728. An area of critical interest was the operating characteristics as the output load current approaches, meets, and exceeds the rated maximum. The unit will supply DC power that meets all specifications for regulation and noise up to the rated 3 A output. At approximately 3.3 A the over-current threshold is reached, and the PWM circuit shuts down. The PWM performs a restart approximately every 120 milliseconds. The circuitry restarts but will continue operation only if the output load is in the normal range. Note that unlike some power supplies, the Model 728 does not have to have the load removed completely, or the power cord unplugged, before the unit will restart. The Model 728 can have its output shorted indefinitely without damaging its circuitry. Every 120 milliseconds the DC output LED will “flash” as the circuit tries to restart. Remove the short and the output will return to 48 Vdc.

5.10 Output Noise

The Model 728’s circuitry was carefully optimized to have extremely low noise over the audible frequency band. This is critical when a power supply is to be used in talk battery applications. The human ear is incredibly sensitive to hum and noise and doesn’t tolerate “poor” DC. While a power supply can be tested using thousands of dollars worth of sophisticated equipment, one the best tests is to simply “listen” to its output. We use a lineperson’s handset, with an 800 ohm 5-watt resistor in series with its tip lead, connected directly across the DC output. By listening to the receiver, we can quickly “hear” the quality of the DC; the results can be enlightening. Good power supplies, like the Model 728, have noise that is almost imperceptible, even when the output is operating at its maximum rated load. Poor power supplies will put out a variety of sounds, including hums, hisses, and “popcorn.” This is especially true as the output load is varied over its rated range. We tested a beautifully built, very expensive power supply (fancy molded wall rack with plug-in modules) from a major manufacturer that made noises in the audible band that any “B” horror film would be proud to include! (Note that noise wasn’t its only problem. As the rated load was approached the DC output really fell apart. Regulation was shot and an orderly over current shut down wasn’t provided.)

5.11 Nominal Output Voltage

When reviewing the specifications you may note that the stated output voltage is 49.5 Vdc, rather than 48.0 Vdc. The output voltage was set a little higher than 48 Vdc for a simple reason. When an installer measures the output voltage, receiving a reading of 48 Vdc or greater (absolute value) is desirable. Normal manufacturing tolerances, voltage drop in connecting cables, etc. can lead to minor voltage drops. An installer seeing 47.8 Vdc might be under the assumption that the “48 Vdc” was low, even though in actuality a reading of even a few volts lower than 48 Vdc would be acceptable. We felt that making it “look” better could prevent undue concern. This voltage setting, along with the excellent output regulation should keep the Model 728’s output very close to 48 Vdc under all normal operating conditions. We hope our attempt at amateur psychology will make life in the field a little less stressful!

5.12 Design Philosophy

With literally dozens of power supplies already on the market, you might be interested in why Gordon Kapes, Inc. went ahead and developed the Model 728 as part of a line of general-purpose power supplies. For years we have manufactured equipment that requires external sources of power. We assumed that getting standard telecommunications power sources was inexpensive and simple. However, after we built some special systems we found that obtaining power supplies that we liked was not at all easy. Many were old designs that used linear technology, weighed a ton and generated considerable heat. Others were intended for KSU mounting, which is not very common these days. Still others were setup for “Type 10” card edge mounting which isn’t always convenient. One supply purported to be filtered and regulated, but how they made that claim we couldn’t figure out! Others were quite good, excellent in fact, but were very pricey, didn’t have the right output current, or were hard to install. So in the end we felt that if we were having problems, maybe you were too!

The following paragraphs detail some of the Model 728's design highlights:

Clean, "Honest" 48 Vdc Output: The Model 728's output is a talk-battery-quality DC signal suitable for virtually any telecommunications application (within the rated load). The nominal 48 Vdc output varies little with changes in input voltage and output load. In fact, over the rated 110 to 240 V input range you should measure no change in output voltage. Tight output load regulation keeps the output voltage close to 48 Vdc. From no load to full load you'll find less than 0.5 volt difference.

Non-Detachable Power Cord: A non-detachable power cord was selected so that the Model 728's input power could not accidentally become unplugged. Using a detachable 3-conductor power cord would be less costly from a manufacturing standpoint, look more "high-tech," but wouldn't best serve the Model 728.

Single Output Voltage: Some power supplies allow you to select the output voltage, such as 24 or 48 Vdc. While this is convenient for the manufacturer, purchasing agents, and warehouses, we felt that having a selectable output voltage is not worth the potential downside. We have seen too many pieces of equipment get ruined because a switch was set to the wrong position. With the Model 728 you get a clearly labeled 48 Vdc, 3 A power supply. If your installation requires a different voltage, simply select a different Gordon Kapes, Inc. power supply unit, such as the Model 727 which provides 24 Vdc, 5 A.

Easy Installation: Some power supplies are difficult to mount, requiring adapter brackets or special enclosures. Other units make you remove the cover to allow connection to the DC output. Not so with the Model 728. The unit wall mounts using just two screws; we even provide the screws! A detachable screw terminal strip gives easy access to the DC output. Once installed, the DC output LED tells you that output voltage is present, or if the unit is in the over-current mode.

Smart Handling of Overloads and Short Circuits: Making the Model 728 "bullet proof" was probably the most important requirement. Overloads and shorts are a fact of life in the real world. (A fact that some power supply manufacturers seem to forget!) Some power supplies have the bad manners to blow a fuse if their output is shorted. (Not too good if you don't have a replacement fuse.) Others shut down and require their power cord to be unplugged, then again plugged in before they'll restart. Still others require the output load to be disconnected before they'll restart. As you might expect, the Model 728 behaves very nicely under duress. A continuous load of 3 A is perfectly acceptable, however if the output current exceeds 3.3 A (nominal) the unit will shut down, with the output voltage dropping to 0. Several times each second the Model 728 will try to restart. The unit can continue in this mode indefinitely without damage. Once the load is brought to within the rated 3 A range the output will again return to nominal 48 Vdc. The power cord does not have to be disconnected, nor the output load removed, for restart to occur.

Part of a Power Supply Family: In addition to the Model 728, Gordon Kapes, Inc. offers a number of power supply units with output voltages and currents to meet a wide range of requirements. Units are available which provide 18, 24, and 48 Vdc. In addition, units are also available that provide battery back up. Contact Gordon Kapes, Inc. for details.

6. Incorrect Operation

6.1 Review Practice

Should problems arise in the operation of the Model 728, please review Section 3—Installation and Section 4—Testing and Operation in this practice.

6.2 AC Outlet

If the DC output LED does not light at all, reconfirm that the AC outlet is functioning by plugging another piece of equipment into the AC outlet. If the AC outlet is okay, but the DC output LED doesn't light, the Model 728 needs to be returned to the factory for repair.

6.3 Output Overload or Short Condition

If the DC output LED flashes rapidly an overload condition is being placed on the Model 728. This will occur whether the output is being shorted, or has a load that is attempting to draw more than 3 A. Carefully recheck the wiring and equipment being powered. "Shed" some of the load to ensure an overload is not present. Once an acceptable load is connected the Model 728 will restart and the DC output LED will light steadily.

6.4 Wiring Errors

If the Model 728's DC output LED is lighting steadily but the equipment being powered does not function correctly: check the interconnecting wiring for errors, including voids in a conductor hidden by the insulation—no kidding, we've actually seen this! Carefully review the polarity of the installation, floating output versus positive-ground output, etc.

6.5 Internal Fuse

The Model 728 contains an internal fuse which is electrically in series with the incoming AC power. This fuse will blow only if the unit experiences serious trauma. A blown fuse always indicates that the unit must be returned to the factory. The fuse is soldered into the circuit board and is not intended for user replacement. Removing the cover will expose you to hazardous voltages.

6.6 Application Limitations

The Model 728 was designed to operate correctly in most applications. However, Gordon Kapes, Inc. does not guarantee the Model 728 to be compatible with every specific application. All functions of the installed Model 728 should be thoroughly tested before the unit is placed into service.

6.7 Save Time

You are encouraged to call Gordon Kapes, Inc. for technical support. 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 meter is the excellent Fluke 70 or 80 series.

7. Repair and Replacement

7.1 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.

7.2 Send it Back

If you determine that the Model 728 is defective, return 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.

7.3 Only We Fix It

In the event repairs are ever needed on your Model 728, 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.

8. Specifications

Input Voltage: 110-240 V, 47-63 Hz, single phase

Input Current: 2.6 A rms steady state, maximum

Power Cord: 3-conductor with plug, length 6 feet (2 meters), nominal, not detachable

Output Voltage: 48.5 \pm 1 Vdc (with 100 mA minimum load)

Output Current: 3 A maximum, continuous

Output Current for Automatic Shutdown: 3.3 A, nominal

Minimum Load Current for Optimal Regulation: 100 mA

Load Regulation: less than 1%, load current 100 mA to 3 A, input voltage 110 to 240 V

Output Ripple Voltage: less than 10 mV rms, maximum

Output Compliance: complies with FCC Part 68 for talk battery quality

Input-to-Output Efficiency: greater than 85% at full load

Output Connections: 3-position detachable screw terminal strip

Transient Protection: input and output protected against transients

LED Indicator: 1, indicates DC output

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 emissions

Safety Compliance: Underwriters Laboratories, Inc. CUL-60950 ITE Listed

Dimensions:

4.7 inches high (11.9 cm)

7.4 inches wide (18.7 cm)

2.3 inches deep (5.8 cm)

Mounting: wall mounted only using two #8 pan head screws

Weight: 2.8 pounds (1.3 kg)

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