PRODUCT REVIEW

More Switching Power Supplies

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While we were unpacking these switching power supplies at the studio for the photos that accompany this review, I was struck once again by their compact size and light weight. The *combined* weight of these four supplies is less than the old but reliable 13.8 V, 25 A power supply in my station with its bulky transformer, linear regulator, pass transistors and heat sink. The largest of these switching supplies occupies perhaps half the space of my station supply.

This month we look at the Daiwa SS-330W, Kenwood KPS-15, MFJ-4125 and Ten-Tec 963. All of them deliver at least 22 A continuously and will power a 100 W HF transceiver, one or more VHF radios, or a 100 to 150 W "brick" amplifier. They're especially attractive for portable operation with today's tiny transceivers, for stations in limited space, or for anyone with a bad back.

This is the fourth *QST* review of switching power supplies, and many of the models reviewed previously are still available for your consideration. Our initial review in January 2000 detailed the Astron SS-30M, ICOM PS-85, Kenwood PS-40, MFJ-4225MV, Samlex SEC 1223 and Yaesu FP-1023.[1] We followed that up in September 2000 with the Alinco DM-330MV and Diamond GZV4000.[2] The ICOM PS-125 appeared in September 2002.[3]

Switch Mode Regulators

In a conventional linear power supply, the ac line voltage is transformed to something close to the desired output voltage, then rectified, filtered and regulated. In a typical switching power supply, the ac line voltage is rectified (usually with a voltage doubler for 120 V ac lines) and filtered and then sent to a power oscillator to generate ac at a much higher frequency than the 50/60 Hz ac line. This relatively high frequency — typically 25 kHz to several hundred kHz — allows the use of a small, lightweight transformer to step the voltage back down to the desired output range. The output is then rectified and filtered. Control circuitry monitors the dc output and adjusts the power oscillator to maintain tight voltage regulation. For Amateur Radio applications, the main concern is RF noise generated by the frequency conversion circuitry. All of the power supplies reviewed here are designed and built with shielding and other EMI reduction techniques to suppress noise that could be heard in a station receiver.

Lab Testing

The ARRL Lab ran each of the supplies through the same battery of tests used for the previous reviews. The test parameters and presentation of results remain the same, so the performance of these supplies can be directly compared to that of the samples in the previous reviews.

The test began with measurements of the dc output voltage with 1.1 A and 21 A loads. Next, the test engineer inserted a Variac in the ac line and measured the minimum ac voltage input required to retain proper regulation of the dc output. In the tables this is shown as *Low line drop out voltage*. It's an important parameter to know if you're using the supply under less than ideal conditions.

Next, an oscilloscope was used to observe any ripple on the dc output, as well as the presence of high frequency switching spikes while under load. The resulting oscilloscope plots are included for each supply lined up for easy comparison.

The next test presents a dynamic load to the supply, similar to what you would expect during SSB or CW operation or as you switch between receive and transmit. In this case, a test fixture rapidly alternates the load between 1.1 A and 21 A. The test result appears as *Dc variation during dynamic testing* in the tables.

In the final lab test, the supply is connected to a 20 A load. The supply output is ac-coupled to a spectrum analyzer and the analyzer set up to sweep the frequencies from 1.5 to 100 MHz. The resulting spectral plot shows the level of noise generated by the power supply at these frequencies.

After Lab testing, each supply was field tested and compared to a transformer-based 25 A supply in an existing station.

DAIWA SS-330W

The Daiwa SS-330W has a different form factor than the other power supplies in this group. It's narrower and taller, shaped like a loaf of bread and about the same size. The cabinet has a carrying handle on top, and there are removable soft rubber bumpers around the front and back edges. At nearly 5 pounds it's the heaviest supply in this group, but still just a fraction of the weight of a conventional 25 A supply.

The SS-330W offers a few more features than the other power supplies in this group. The front panel includes meters for output voltage (0-20 V) and current (0-50 A). The meters are not illuminated. It's the only supply in this group to offer an external control for voltage (V.ADJ) from 5 to 15 V. In addition to powering your transceiver it would make a nice variable bench supply.

Conveniently spaced binding posts handle the dc output connections. They turn by hand, no tools required. A red POWER switch and

[1]J. Bottiglieri, "*QST* Compares: Switching Power Supplies," Product Review, *QST*, Jan 2000, pp 70-73.
[2]J. Bottiglieri, "Switching Power Supplies Revisited," Product Review, *QST*, Sep 2000, pp 76-79.
[3]S. Ford, "ICOM PS-125 Power Supply," Product Review, *QST*, Sep 2002, p 62.

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Table 1

Daiwa SS-330W, Serial number 1608

Manufacturer's specifications	*Lab Measurements*
Power requirement: 90-130 V ac or 180-260 V ac.	Output voltage, no load: 4.67-14.46 V dc. (tested at 13.7 V dc).
Output voltage: 5-15 V dc.	Output voltage, 21 A load: 13.5 V dc.
Output current (continuous): 30 A.	Low line drop out voltage: 45 V ac.
Size (HWD): 3.9 × 5.1 × 9.0 inches; weight, 4.85 pounds.	Dc variation during dynamic testing: ≈200 mV.

LEDs for AC LINE and PROTECTOR complete the front panel. The instructions don't say what conditions trigger the PROTECTOR circuitry, but the LED did come on once when I accidentally shorted the output. The rear panel has a detachable power cord, fuse holder and ground lug.

The cooling fan is mounted inside the cabinet and attached to the rear panel. The panel opening is about 3 inches in diameter, and there are cooling vents on both side panels. The fan runs all the time and is very, very quiet. The case remains cool to the touch, even after extended transmitting periods with a 100 W transceiver drawing about 20 A and 30 minutes of continuous operation with a 17 A load.

Documentation is a photocopied A4 size two-sided sheet that covers three other Daiwa supplies in addition to the SS-330W. There's a drawing of the front and rear panel features and controls, a table of specifications, three graphs showing performance characteristics and a few words about features. There's also a section with some cautions (for example, operation with a generator and lightning protection). There are a few misspelled words and the translation to English leaves something to be desired, but it's certainly understandable. No warranty information or schematic is included, but information about a 1 year warranty and return/repair details are included on the US distributor's Web site.

Manufacturer: NCG Companies, Inc (US distributor), 1275 North Grove St, Anaheim, CA 92806; tel 800-962-2611, fax 714-630-7024; **www.cometantenna.com**. *Price*: $170.

KENWOOD KPS-15

At 2 inches high not including the rubber feet, Kenwood's KPS-15 has the lowest profile of the power supplies in this group. At just over 3 pounds, it's a few ounces heavier than the MFJ but still at the light end of the scale. A lighted rocker switch is the only control on the front panel.

The power cord is removable. To convert it to 240 V operation, simply remove one internal jumper. The ac line fuse is located on the PC board inside the cabinet and is a little hard to get to.

Rear-panel dc output connections are via two screw-down terminals. The screws are accessible from the top, helpful for making connections in a tight space. They'll handle a variety of wire sizes, but remember to bring a small screwdriver if you're operating from a portable location. According to the instructions, the KPS-15 protection circuits will shut the supply off in the event of excessive heat buildup or excessive output voltage or current.

A temperature controlled cooling fan is mounted to the bottom of the cabinet inside the box. It draws air through an opening about 2.25 inches in diameter and vents through slots in the side of the cabinet. The instructions call for 6 inches of open space around the supply for proper ventilation and cooling. The fan rarely runs during normal operation and is fairly quiet. The case gets slightly warm to the touch after extended transmitting periods with a 100 W transceiver drawing about 20 A and after a half hour of continuous operation with a 17 A load.

Documentation is two A4 size sheets and is easily the most comprehensive in this group. It covers installation and use, conversion for 240 V operation and specifications. There's a section on the KMB-20 sheet metal cabinet option for integrating the KPS-15 and one of Kenwood's land mobile VHF/UHF radios to make a desktop base station. No schematic is included, but there's a section on troubleshooting. The warranty is 1 year, and service is handled by Samlex America, a well known supplier of switching power supplies.

Manufacturer: Kenwood USA Corp, 3975 Johns Creek Ct, Suite 300, Suwanee, GA 30024; tel 310-639-4200, fax 310-537-8235; **www.kenwood.net**. *Price*: $139.

MFJ-4125

Also called the *MightyLite*, the MFJ-4125 is the smallest and lightest supply in this group. There's a rocker switch for power ON/OFF on the front panel, and a separate small green LED to indicate that power is on.

The ac power cord is permanently attached to the rear panel. A switch on the back panel provides for the selection of either 120 or 240 V operation. The ac line fuse is located on the PC board inside the cabinet and is easily accessible once the cover is removed.

The '4125 has two sets of dc output jacks. The front panel has a pair of five-way binding posts for high current (25 A maximum). A set of spring loaded "quick connectors" on the rear panel is rated for up to 5 A. Separate low current connectors are convenient for powering radio interfaces, keyers, TNCs or other accessories found in most shacks. No tools are required for either set of terminals. Protection circuits for overvoltage and overcurrent are included.

A cooling fan is mounted inside the cabinet on the rear panel. It draws air through holes in the cabinet sides and vents through an opening about 2 inches in

Table 2

Kenwood KPS-15, Serial number KPS15-5D12-00044

Manufacturer's specifications	*Lab Measurements*
Power requirement: 120/230 V ac ±10% at 50/60 Hz (internal switch selectable).	Output voltage, no load: 13.87 V dc.
Output voltage: 13.8 V dc.	Output voltage, 21 A load: 13.77 V dc.
Output current (continuous): 23 A.	Low line drop out voltage: 59 V ac.
Size (HWD): 2.2 × 7.2 × 8.7 inches; weight, 3.3 pounds.	Dc variation during dynamic testing: ≈100 mV.

Table 3

MFJ-4125, Serial number 300003471

Manufacturer's specifications	*Lab Measurements*
Power requirement: 85-135 V ac or 170-260 V ac at 47-62 Hz (switch selectable).	Output voltage, no load: 13.63 V dc.
Output voltage: 13.8 V dc.	Output voltage, 21 A load: 13.12 V dc.
Output current (continuous): 22 A.	Low line drop out voltage: 62 V ac
Size (HWD): 2.5 × 5.5 × 6.5 inches; weight, 2.8 pounds.	Dc variation during dynamic testing: ≈500 mV.

diameter. The fan runs all the time and, though not exactly "loud," the sound is quite noticeable. The case gets warm to the touch in a few places, though not much above room temperature, after extended transmitting periods with a 100 W transceiver drawing about 20 A and after 30 minutes of continuous operation with a 17 A load.

Documentation is an 8.5 × 11 inch sheet folded in half. It covers installation, operation and specifications and includes a schematic diagram. MFJ offers a 1 year warranty.

Manufacturer: MFJ Enterprises, 300 Industrial Park Rd, Starkville, MS 39759; tel 662-323-5869, fax 662-323-6551; **www.mfjenterprises.com**. *Price*: $110.

TEN-TEC 963

Ten-Tec's model 963 is intended for use with the Ten-Tec Jupiter transceiver, but it's of interest to anyone looking for a 25 A supply for a transceiver or amplifier. It's a bit larger and about a pound heavier than the MFJ and Kenwood supplies, with plenty of elbow room inside the sturdy cabinet. Still, it's considerably smaller and lighter than a conventional supply. There's a lighted rocker switch for power ON/OFF on the front panel.

The ac power cord on the rear panel is detachable. A slide switch makes changes between 120 and 240 V operation a snap. The ac line fuse, located on the PC board inside the cabinet, is very easy to get to with the cover removed.

Two screw-down terminals on the rear panel provide dc output connections. The screws require a small flat blade screwdriver and are accessible from the side of the cabinet. The terminals handle a wide range of wire sizes.

A thermostatically controlled cooling fan is mounted to the outside of the cabinet's rear panel. It blows air into the cabinet through an opening about 3 inches in diameter; air exits through slots in the bottom and side panels. The fan came on only occasionally during our testing. The sound is noticeable when it runs. The case remains cool to the touch, even after extended transmitting periods with a 100 W transceiver drawing about 20 A and after 30 minutes of continuous operation with a 17 A load.

Documentation is on two 8.5 × 11 inch sheets. It briefly covers installation and specifications and includes a schematic diagram. The warranty is 1 year.

Table 4

Ten-Tec 963, Serial number 206010033

Manufacturer's specifications	*Lab Measurements*
Power requirement: 115 or 230 V ac at 50/60 Hz (switch selectable).	Output voltage, no load: 14.11 V dc.
Output voltage: 13.8 V dc.	Output voltage, 21 A load: 14.03 V dc.
Output current (continuous): 25 A.	Low line drop out voltage: 69 V ac.
Size (HWD): 3.5 × 7.0 × 9.0 inches (incl. fan; weight, 4.4 pounds.	Dc variation during dynamic testing: ≈100 mV.

Manufacturer: Ten-Tec, Inc, 1185 Dolly Parton Parkway, Sevierville, TN 37862; tel 800-833-7373; **radio.tentec.com**. *Price*: $169.

Some Impressions

In the Lab, all of the supplies measured around 13.8 V with no load, varying from about 13.6 V for the MFJ-4125 to 14.1 V for the Ten-Tec 963. The Daiwa is, of course, a variable supply easily set to about 13.8 V with its front panel meter. Based on the previous reviews, we expected this group to exhibit fairly tight regulation during the dynamic load test. We weren't disappointed. Past dynamic testing results have shown dc variation of 40 to 300 mV, with most supplies right around 200 mV. In this test, the Kenwood and Ten-Tec supplies checked in at about 100 mV and the Daiwa measured about 200 mV. The MFJ was a bit higher at 500 mV, but this wasn't an issue during on-air operation.

All of the supplies reviewed here will maintain regulation over a wide range of inputs and will work down to 70 V ac input or even lower. The Daiwa surprised us by hanging in there down to 45 V. Any of these supplies would be a great choice for Field Day operation with a cranky generator or for emergency communications in an area with marginal power line service.

We observed switching spikes of 200 to 600 mV in several of the supplies featured in our January 2000 review. In the oscilloscope plots (Figures 1, 3, 5 and 7), none of the supplies in this group exhibited significant spikes and all had low ripple.

As shown in the spectrum analyzer plots, the output spectrum under load varies noticeably from supply to supply. As noted in the previous reviews, the level of broadband noise generated by the switching power supplies is proportional to the load — more current demand creates more noise. The plots show the noise levels under a typical 100 W transmitter load, and the noise levels are lower with the 1 A load typical during receive.

Daiwa's SS-330W shows two noise peaks in the –60 to –70 dB range below 6 MHz and around 14 to 18 MHz (Figure 2). Although these peaks are of potential concern, I could not hear any signals from the power supply in the ham bands, even with careful listening on 160, 80, 20 and 17 meters. The SS-330W's quiet fan, higher current rating (30 A), meters and adjustable output voltage make it stand out in this group.

Below 5 MHz, the Kenwood KPS-15 has noise levels in the –48 to –60 dB range, with another peak of about –65 dB around 14 MHz (Figure 4). Compared to the Kenwood PS-40 reviewed in January 2000, the KPS-15 has a higher noise level from about 1.5 through 25 MHz but is generally quieter above 40 MHz.

Signals from the KPS-15 were clearly

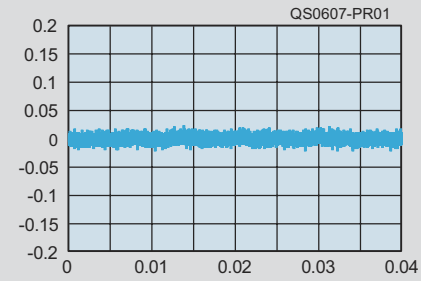

Figure 1 (l) — An oscilloscope trace of the dc output of the Daiwa SS-330W under load. The vertical scale is 50 mV/div and the horizontal scale is 5 ms/div. The level of the dc ripple is low, approximately 35 mV p-p. There are no discernible spikes due to switching.

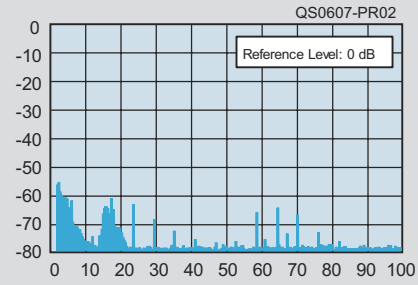

Figure 2 (r) — A spectral plot of the output of the Daiwa SS-330W under load. Overall, the noise generated by this supply is very low. Broadband noise is moderate, however, below 6 MHz and at approximately 14 to 18 MHz.

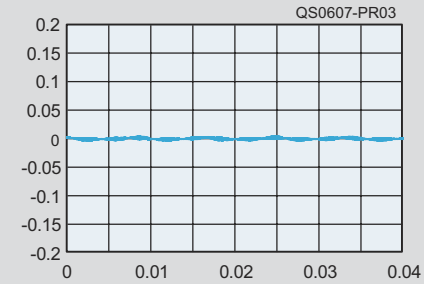

Figure 3 (l) — An oscilloscope trace of the dc output of the Kenwood KPS-15 under load. The vertical scale is 50 mV/div and the horizontal scale is 5 ms/div. The level of the dc ripple is very low, <10 mV p-p. There are no discernible spikes due to switching.

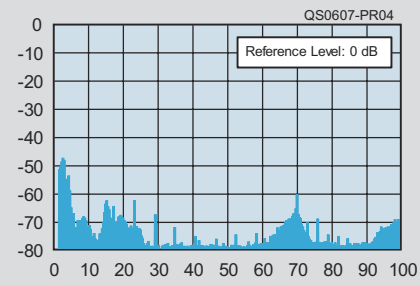

Figure 4 (r) — A spectral plot of the output of the Kenwood KPS-15 under load. Overall, the noise generated by this supply is low. There are some ranges where broadband noise is moderate, primarily below 5 MHz and at approximately 14 to 20 MHz.

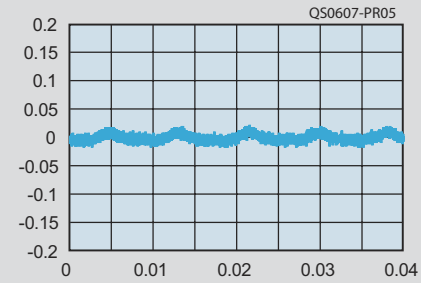

Figure 5 (l) — An oscilloscope trace of the dc output of the MFJ-4125 under load. The vertical scale is 50 mV/div and the horizontal scale is 5 ms/div. The level of the dc ripple is low, approximately 35 mV p-p. There are no discernible spikes due to switching.

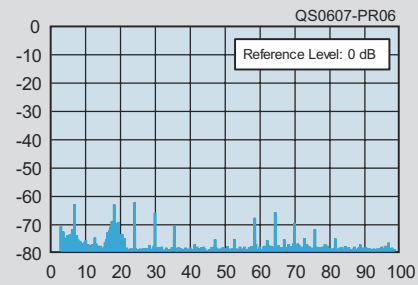

Figure 6 (r) — A spectral plot of the output of the MFJ-4125 under load. This supply exhibited very low levels of broadband noise, with small peaks at approximately 2 MHz, 5 MHz and 15 to 18 MHz.

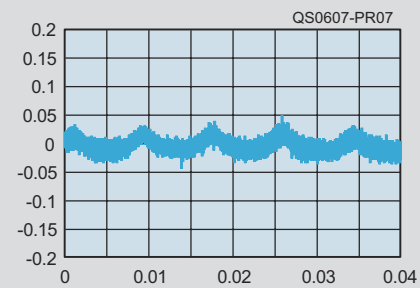

Figure 7 (l)— An oscilloscope trace of the dc output of the Ten-Tec 963 under load. The vertical scale is 50 mV/div and the horizontal scale is 5 ms/div. The level of the dc ripple is low, approximately 50 mV p-p. Spikes due to switching measure about 100 mV p-p.

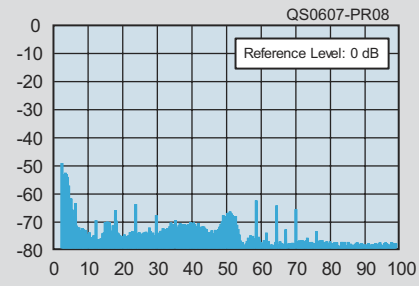

Figure 8 (r) — A spectral plot of the output of the Ten-Tec 963 under load. This supply exhibited a broader range of low-level noise than the other supplies in this test, with moderate levels of broadband noise below 5 MHz.

audible in the receiver at a dozen or so spots in the 160 and 80 meter bands, well above the noise level in several cases and strong enough to be annoying. A few were strong enough to interfere with reception of weak signals. Listening with a second receiver confirmed that the noise was present only with the KPS-15 turned on and delivering current, and the noise wasn't evident when powering the transceiver from the usual linear station supply.

The KPS-15 has a low profile and weighs little, making it attractive for portable operation. I'd definitely consider it for a VHF/UHF station, but there are better choices (including Kenwood's linear power supplies) for powering an HF transceiver because of the broadband noise levels.

In the January 2000 review, the MFJ-4225MV exhibited an exceptionally low level of broadband noise. As shown in Figure 6, the MFJ-4125 reviewed here is almost as good, although it has more noise output around 15 to 18 MHz. With the exception of a few discrete spikes, though, the MFJ's noise output is down in the –70 dB range. I could not hear noise from the MFJ-4125 in any of the ham bands. This supply's compact size, rock bottom price and separate low current output make it attractive. It would be better if the fan didn't run all the time or was quieter, though.

The Ten-Tec 963 exhibited some broadband noise throughout the HF and low VHF spectrum, but for the most part this noise is 70 or more dB down and not an issue (Figure 8). The exception is below 5 MHz, with levels of about –53 dB in the 160 and 80 meter amateur bands. After careful listening, I could identify one signal from the 963 on 160 meters and two signals on 80 meters, all close to the background noise. I liked the 963's solid feel, cool operation and excellent dynamic regulation. Although the fan noise is noticeable (the loudest in this group), it doesn't come on very often during normal operation.

If you're in the market for a power supply, a switching supply can provide good performance in a compact package at an attractive price. It's worth taking a few moments to compare the supplies reviewed here and in past *QST*s, as there is quite a range of features and performance.