

Review: The MFJ-4403 Transceiver Voltage Conditioner  
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Introduction

We can't always count on our transceiver's DC voltage source to be clean. In particular, noisy power sources are probably more prevalent during portable operations (like Field Day and DXpeditions), and in automotive (mobile) environments. The MFJ-4403 Transceiver Voltage Conditioner was designed to provide DC voltage protection for transceivers subjected to virtually any DC power situation.



Figure 1: MFJ-4403 Front Panel



Figure 2: MFJ-4403 Input/Output Connections

The MFJ-4403 Features

The MFJ-4403 draws its own power from the DC voltage source. Normal DC operating current is 250ma. The MFJ-4403 features are listed in Table 1.

Table 1: MFJ-4403 Protection Features

- Reverse Polarity Protection – A reverse voltage input is blocked from the MFJ-4403 output. No damage occurs to any equipment, including the MFJ-4403.
- Transient Suppression – Voltage transients are clamped at 15VDC maximum with a 75-amp transient suppressor. Long duration high voltage transients will cause the MFJ-4403 input fuse to blow before any damage occurs to the MFJ-4403 or any connected equipment.
- Short Circuit Protection – The MFJ-4403 includes internal automotive fuses that protect both the source and connected equipment.
- Noise and Ripple Filtering – A 4-farad super-capacitor bank in conjunction with traditional high frequency filter capacitors ensures that the cleanest possible DC voltage is applied to your equipment.
- Input and output DC connections are “standard” Anderson Powerpole™ connectors.

An internal view of the MFJ-4403 is shown in Figure 3. The six 25-farad series-connected capacitors are on the upper part of the assembly. On the right are automotive 15-amp input and 25-amp output fuses. The 15-amp input fuse provides protection for less-than-adequate power sources and wiring when operating low current, or high peak current low duty-cycle, modes. For high duty-cycle modes and a properly sized power supply, the 15-amp input fuse should be replaced with a 25-amp fuse. And as the MFJ-4403 includes a 4-farad capacitor bank, you could conceivably see currents in the

hundreds of amps for a few milliseconds if you accidentally short circuit the output. The output fuse protects a short from causing serious damage.

The power resistor is used both for current limiting during the charging of the capacitor bank, and for discharging the capacitor bank when the MFJ-4403 is turned off. The discharge function is provided because the charged 4-farad capacitor bank can provide a HUGE amount of energy should it be inadvertently shorted when you think everything is off. Finally, you'll notice a strap option between the relay and the 15-amp fuse. This strap is a pre-charge timing strap but it isn't mentioned in the manual. You should strap across these pins if you have an input voltage less than about 13.25VDC. But normally the pins should not be strapped as you want the capacitor bank charged as close to the input voltage as possible before operating.

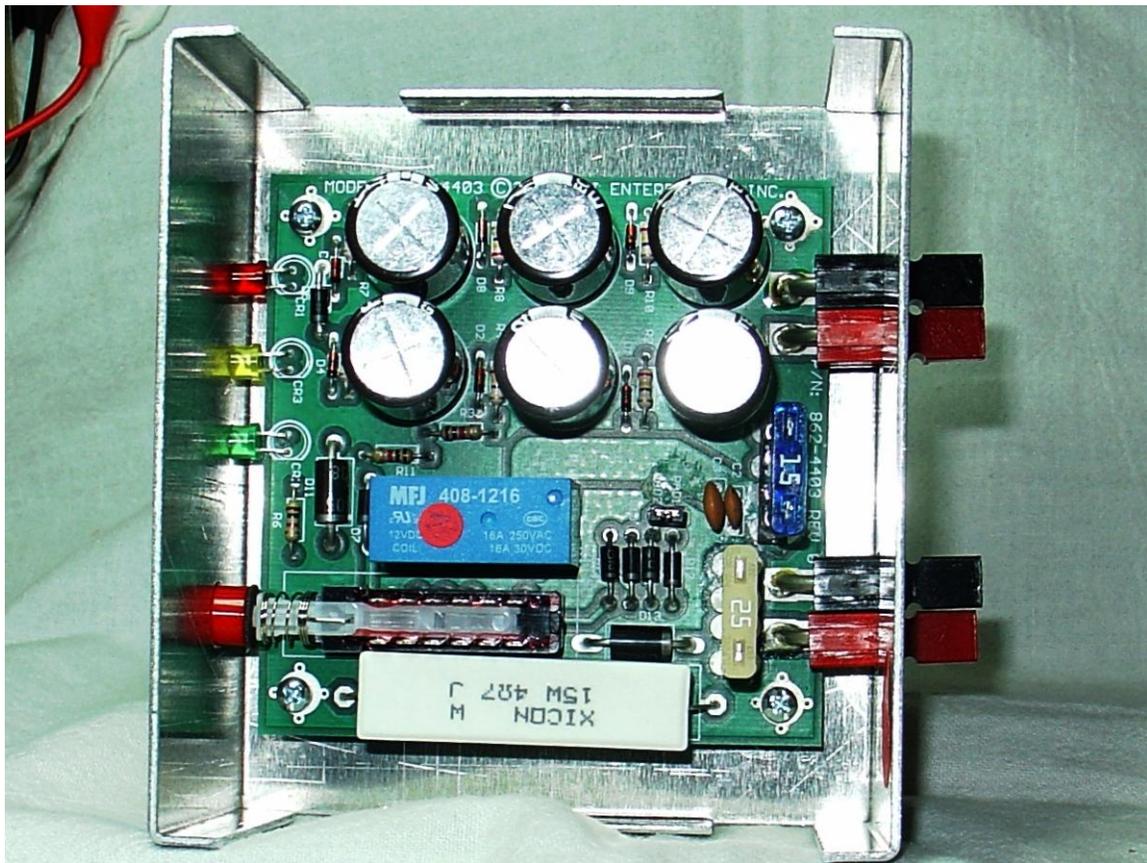


Figure 3: Internal View of the MFJ-4403 Transceiver Voltage Conditioner

Reverse-voltage protection is provided by a combination of the relay and a reverse protection diode. If a negative voltage is applied to the input, the relay cannot operate, and so no reverse voltage can appear across the capacitor bank or the output of the MFJ-4403. Additionally, a high-current diode in series with the pre-charging resistor keeps reverse voltage from finding its way to the output via the pre-charging circuit. Finally, the REVERSE POLARITY LED indicates a negative input voltage condition.

Damaging voltage spikes can occur in automotive environments, and with dirty or failing power supplies. Therefore a high-current 15-volt clamping diode clamps any spike to 15VDC (nominal), and blows the input fuse if the clamped overvoltage persists for a few seconds. The 15-volt clamping diode can handle 70 amps without damage. Of course, the 4-farad capacitor bank also serves to momentarily clamp any over-voltage condition. Since  $I = C \, dV/dt$ , a sudden voltage change over a short period of time results in a high current pulse that can also blow the input fuse.

And finally, the MFJ-4403 4-farad super-capacitor bank provides outstanding filtering of any noise or ripple on the DC input. Smaller value capacitors take care of any high frequency noise that might make it by the super-capacitors. An interesting side effect of this capacitor bank is that you can power a SSB 100-watt transceiver from an automotive accessory socket. We will look at this in more detail a little later.

### MFJ-4403 Operation

After connecting your DC source to the DC input connector and any connected equipment off, push the ON button. The CHARGING and POWER LEDs light and a current-limited charge of the capacitor bank begins. The high value of the MFJ-4403 capacitor bank requires that the capacitors must be pre-charged before you can operate any equipment – i.e. connecting a DC source directly to a discharged capacitor bank of this value will short the power supply output! After about 1-minute the current limiting resistor is shorted by the relay, the CHARGING LED extinguishes, and your connected equipment can be turned on. Incidentally, if any connected equipment is turned on, the pre-charge cycle will not complete and little voltage will be available for the equipment.

When you want to cease operation, turn off any connected equipment and push the ON/OFF pushbutton on the MFJ-4403. The internal power resistor is connected across the capacitor bank and discharges the capacitors in about 1-minute.

### Performance

I first looked at pre-charge times. With the timing pins unstrapped, the pre-charge time was 55 seconds at 14.2VDC, 65 seconds at 13.8VDC, approximately 2-minutes at 13.5VDC, and 3.5 minutes at 13.25VDC. The pre-charge would not reliably complete below 13.25VDC. With the timing pins strapped the pre-charge worked well down to 12.25VDC.

I next connected reverse voltage to the DC input. The REVERSE VOLTAGE LED lit immediately, and no negative voltage appeared at the output regardless of the position of the ON/OFF switch. When the reverse-voltage condition was corrected, the MFJ-4403 automatically reverted to normal operation.

Next I tested the input voltage clamping level. A variable voltage power supply was connected across the input and the voltage was increased. I had to increase the input voltage very slowly as the 4-farad capacitor bank does an outstanding job of trying to hold the voltage constant, resulting in power supply current limiting if the voltage is

adjusted too rapidly. This is a desired characteristic which provides both filtering and impulse protection. With a little care, I found that clamping occurred at 15.5VDC.

Finally I looked at power supply filtering. I previously reviewed the WF5Y Battery Booster (QST August 2013) which had ripple and noise so bad that I was afraid to connect it to my transceiver. I couldn't think of a better "dirty" voltage source for testing the MFJ-4403. First I connected the WF5Y regulator directly to a 10-amp resistive load. The WF5Y input voltage was set to 11VDC, and the output set at +13.8VDC. Figure 4 is a time-domain oscilloscope trace of the AC-coupled 13.8VDC output across the load. As you can see, it is a pretty nasty signal. The amplitude of the ripple and noise is about 6Vp-p! A spectrum photo of the noise can be found in the August 2013 review article.

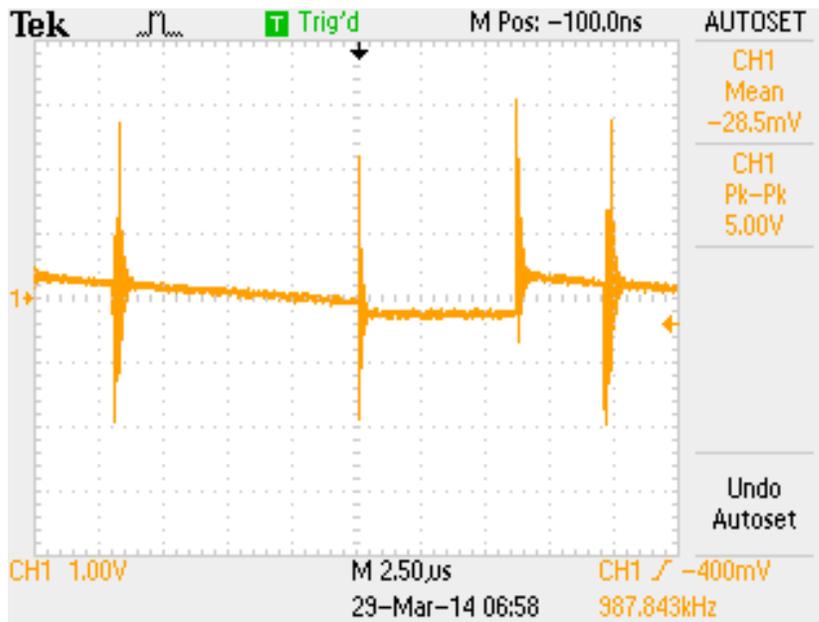


Figure 4: WF5Y Battery Booster feeding a 10-amp load

After connecting the MFJ-4403 between the WF5Y booster and the 10-amp load, absolutely no ripple or noise could be seen. The MFJ-4403 definitely does its job!

#### Powering a 100-watt transceiver from an auto accessory connector?

This is where I really had fun with this review/evaluation. We've all been told to never power high-power ham equipment from an auto's accessory socket. Yet MFJ states that a 100-watt output SSB transceiver (75-watts output for CW) may be powered via the accessory socket for temporary operations when the MFJ-4403 is used. The reason is that the accessory socket should be able to supply the average current required by the equipment, and the MFJ-4403 super-capacitor bank will provide the peak current necessary for low duty-cycle transceiver operation. Low duty-cycle SSB and CW modes permit the capacitor bank to be re-charged by the auto accessory socket during speech pauses or CW gaps. MFJ does recommend making a direct connection to the car's battery for normal operation, along with the MFJ-4403 for voltage transient and filtering. So - let's look at the accessory socket possibility for powering the typical SSB/CW transceiver.

UL2089 Vehicle Battery Adapters is the standard for low-voltage power-ports. This standard limits accessory outlets to 20 amps, and also states that a minimum of 12-gauge copper wire is required for 20-amps. But that is the maximum current permissible, and is not necessarily what is available in most cars. I've spent quite a bit of time looking into this and have found accessory socket ratings varying from 10-15 amps, and/or 150-180 watts, continuous, in manuals or printed on the covers of some accessory sockets. You can also get an idea of the accessory socket current rating by looking at inverters and tire inflators that are available for use with these accessory sockets. Based on my research, I think that a 10-amp continuous rating is probably reasonable, but you should determine this for your own vehicle. However 10 amps is much less than the peak current required by most 100-watt mobile transceivers. Further, the mating accessory plug is a spring-loaded pressure contact that doesn't provide the best electrical contact for the high peak current requirement.

I tested three external accessory sockets connected to the high current output of my MFJ-4245 power supply, as well as the 7-amp rated MFJ-4245 internal accessory socket. I also tested two different cigarette lighter plugs with each of these sockets (see Figure 5). Both plugs are 10-amp rated Radio Shack plugs. The upper plug is not fused, while the lower plug includes an internal 10-amp fuse. With a 10-amp load (QST Oct. 2006, P.61) connected to the plugs, I found a very consistent 0.08 ohm resistive loss (measured as 0.8 volt drop) with the un-fused plug/sockets, and 0.10 ohm resistive loss (measured as 1.0 volt drop) with the fused plug/sockets. The fused-plug additional 0.02 ohms is probably due to the extra pressure contact and the fuse resistance. Then I subjected the connector pairs to a continuous 10-amp current for five minutes. All socket and plug combinations felt cool. And all socket pins were cool to the touch. However, I found that the center pin of the fused (lower) plug was quite warm after 5-minutes. Based on my resistive loss measurements, this plug is dissipating 2-watts more than the un-fused plug, probably all in the extra center pin pressure contact and the fuse.



Figure 5: Reviewer's tested accessory connectors

Next I evaluated my IC-706MKIIG current requirements. This radio draws the most current on 20 meters (18.6 amps at 100 watts output), so I used this band for testing. I used CW for my tests since CW has a higher duty cycle than SSB (44% PARIS standard CW duty cycle vs 20-30% SSB duty cycle). Table 2 shows my measurements for key-down and a string of dits (50% duty cycle), and the estimated average current based on the PARIS standard 44% duty cycle.

Table 2: IC-706MKIIG CW transmitting current measurements

<u>Output</u>	<u>I-pk</u>	<u>I key-up</u>	<u>I avg (50% duty cycle)</u>	<u>I avg. est (44% duty cycle)</u>
100 W	18.6A	4.5A Semi Break-In	11.55	10.66A
100 W	18.6A	1.4A QSK	10.0	8.97A
75 W	16.5A	4.5A Semi Break-In	10.5	9.78A
75 W	16.5A	1.4A QSK	8.95	8.04A

As you can see, about 10-amps is a good average current drain that you might see when transmitting. However, we don't want to subject the accessory socket to the 18-19 amp peak current that is drawn on every "dit". And this high peak current will also result in a peak voltage drop of 1-2VDC.

I connected the MFJ-4403 between my MFJ-4245 power supply high-current output and the transceiver and measured the input and output DC current peaks while transmitting (receive current drain is well within any accessory socket current rating and so the MFJ-4403 just provides filtering and transient protection). An AEMC 514 digital Hall-effect clamp on meter was used for measuring current. This meter provides both peak- and average DC current readings.

Initially I was surprised to see a high MFJ-4403 input spike of almost 16 amps (corresponding to the 18.6-amp peak current output). Then I used an accessory plug/cable between the MFJ-4245 power supply and the MFJ-4403 DC input and saw the MFJ-4403 input current spike drop to 11.2 amps. After thinking about this I realized that in a perfectly lossless system, any discharge of the capacitors will be instantly recharged by the sourcing power supply resulting in the same input and output current. However, if there is any loss from the input DC source the re-charge current is spread-out over the R-C time constant due to the DC-line loss and the total capacitance. With a 4-farad capacitor, even a 0.08 ohm loss results in a time constant of about 1/3rd second. My bench tests are probably as close to ideal as possible, but accessory sockets and wiring in most cars probably have more loss. Therefore I ran some additional tests showing the effect of adding in very low resistive losses. The results are shown in Table 3.

Table 3: IC-706MKIIG peak current measurements with MFJ-4403

<u>Output</u>	<u>I-pk inp (Pwr Sply)</u>	<u>I-pk inp (Acc Skt)</u>	<u>I-pk inp (0.1Ω)</u>	<u>I-pk inp (0.2Ω)</u>	<u>I-pk Output</u>
100 W	15.9A	11.2A	10.2A	7.3A	18.6A
75 W	14.3A	10.2A	9.5A	6.8A	16.5A

From Table 3 you can see that the accessory socket output current measurements are very similar to the IC-706MKIIG average current requirements when there is just a little loss

in the system. In other words, you limit peak current when using an accessory socket to power a 100-watt SSB/CW transceiver because the accessory socket and associated wiring is not lossless!

So – is it safe to use an auto accessory socket to power a MFJ-4403 connected to a 100-watt SSB transceiver? I will leave this decision up to you. My measurements indicate that this is viable. And I did connect my IC-706MKIIG this way to my wife’s 1997 Mustang. I used a high power dummy load and a peak-reading Bird wattmeter and verified that the transceiver put out full power on SSB. However, I have a few recommendations. First, if you build your own cable make sure you use a quality accessory plug that is rated for at least 10-amps. The plug should have two ground “ears”, and it should fit firmly into the accessory socket. You should also use 14-gauge wire minimum, preferably 12-gauge. MFJ does sell an accessory-plug-to-Powerpole™ cable (MFJ-5515M) that has a 3-foot super-flexible 12-gauge cable. Finally, you should consider this as a temporary mobile solution. For permanent solutions, the input to the MFJ-4403 should be connected directly to the battery.

### Conclusion

The MFJ-4403 is a very robust DC filtering and transient protection device. It is certainly something to think about adding to your mobile power supply line, and any place where there is concern about power supply “cleanliness”. And it is even at home in your main station should you have any concerns about your main power supply failure causing a problem. My only complaint is that I like all my ham equipment to include a ground stud. Of course, a ground stud is easy to add. Maybe MFJ will add one in the future.

Manufacturer: MFJ Enterprises, Inc. 300 Industrial Park Rf., Starkville, MS 39759.  
[www.mfjenterprises.com](http://www.mfjenterprises.com).