We declutter our

Switching power supply

Lecture/Workshop

Version 20.3.25

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1 Introduction

Shortwave has changed. Quiet bands without interference are often just a pipe dream in urban areas.

Interference emissions from shadow power supplies, energy-saving lamps, photovoltaic systems, and PLCs are increasingly spoiling the fun of shortwave radio for amateur radio operators and shortwave radio operators.

The EU Ecodesign Directive requires energy-efficient devices and lighting, which can only be technically implemented using switched-mode power supplies.

Switching power supplies have replaced linear power supplies.

More and more devices in the home generate unwanted high-frequency interference. Basic knowledge of EMC is beneficial for radio amateurs.

In this way, electromagnetic interference can be detected and eliminated, or at least reduced, at least in one's own environment.

And this brings us to the topic to which this lecture refers.

In addition, "DIY" is disappearing more and more in amateur radio, as equipment and accessories have become cheaper than ever. Thus, we can, or even must, take matters into our own hands to eliminate these sources of interference (switching power supplies).

2 Contents - Overview

- Check the interference behavior with the receiver
- Testing the interference behavior with the spectrum analyzer. Theory: Why
- does the newly purchased power supply (unfortunately) cause
- interference? Now we'll examine the interference of the Chinese 5A
- switching power supply itself. Summary and additions

3 theory

3.1 EMC interference from switching power supplies

Switching power supplies emit conducted interference that can disrupt other devices. The resulting radio interference voltages can be suppressed with line filters. These consist of passive components such as current-compensated line chokes and X and Y capacitors. Interference currents generate radio interference voltages via impedances.

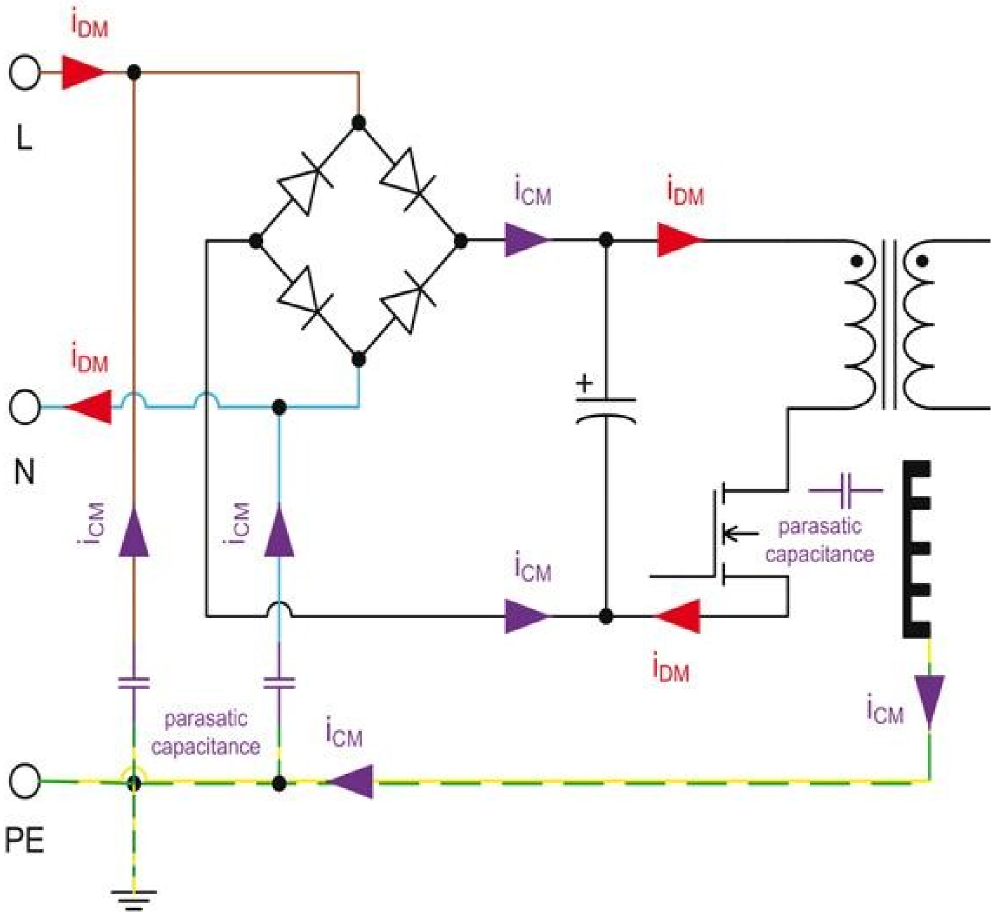

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Figure 1: Interference currents at the switching power supply input (iDM: differential mode currents; iCM: common mode currents)

Image 1shows where and how interference currents flow in a switching power supply. On the mains side, initially, the current flows at the clock frequency of the switching regulator f_{sw}a high-frequency useful current i_{DM}, which leads to differential mode interference. Due to the rapid switching processes of semiconductor components – usually MOSFETs – and parasitic effects, high-frequency oscillations occur. In principle, the differential mode current flows from the mains line L through a rectifier bridge, then through the primary winding of the transformer, through the MOSFET, and back to the mains via the neutral conductor N.

For cooling, the MOSFET is mounted on a heat sink, which in turn is connected to the protective conductor (PE). At this point, capacitive coupling occurs between the heat sink and the MOSFET drain, generating common-mode noise. A common-mode current then flows through the capacitive coupling.i_{CM}via the earth line PE back to the switching power supply input, where it is again coupled via parasitic capacitances to both the mains line L and the neutral line N. The common-mode current i_{CM}now flows like in**Image 1** shown via both power lines, via the rectifier bridge to the MOSFET, where it is again parasitically coupled via the heat sink to the earth line PE.

The rectified mains voltage is applied to the drain-source path of the MOSFET. The peak value of the rectified mains voltage û corresponds to 325 V.

4 Suppression theory

The measurements and tests presented in this article were performed using the most amateur methods possible. To make direct comparisons with commercial measurement results, additional effort is required: a so-called "network simulation." In technical terms, this is referred to as an "artificial mains network."

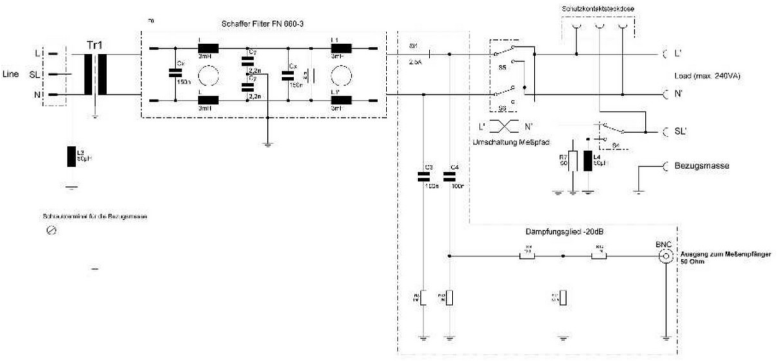


Figure 2, Schematic of a network simulation, Source: DL2KHP

So, anyone who wants to determine absolute values can't avoid using such a tool. I'll cover this in a separate article to compare it with the current IEC 61000 standard, also known as EN55032.

4.1 EMC limits according to IEC 61000 standard

These limits were set with the goal of ensuring interference-free operation. However, for us radio amateurs, these limits are still far too high, see Table 1 below.

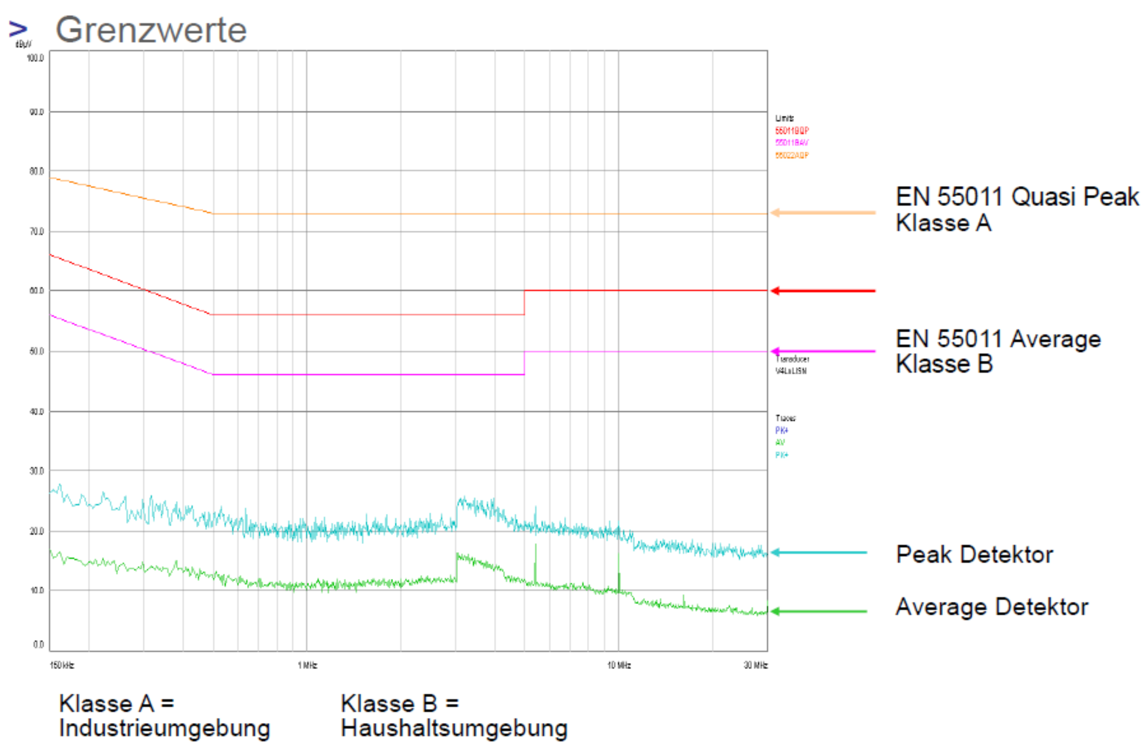


Figure 3, EMC limit values according to IEC 61000 standard also EN55032, source Schurter

The image above shows the current values   for interference emissions. However, these limits are in dB(μV) Quasi-peak value indicated.

Class B limits according to EN55032			
Frequency range	Class B limit value in dB (μ V) Quasi-peak value	In dBm	This would correspond in S-levels
0.15 - 0.5 MHz	66-56	- 41	$S9_{+32dB}$
0.5 - 5 MHz	56	- 47	$S9_{+26dB}$
5 - 30 MHz	60	- 51	$S9_{+22dB}$

Table 1, Comparison db (μV) Quasi-peak values   to S-levels

This table shows us what kind of interference levels can be expected in the usual amateur specifications, the S-levels.
However, this current standard only applies to the 230V AC primary side!
There is no valid standard for limit values   on the secondary side yet.
However, due to disruptive optimizers in solar systems, one is in the works.
Conclusion: Many power supplies comply with the standard and have the CE marking, but for us radio amateurs they still cause too much interference.
In my opinion, either way, action is needed if we want trouble-free reception in the future.
This action needs to start in our apartment.

4.2 Interference on lines spreads mainly in two ways

We know the basic knowledge from the lecture "The Secret of the Balun" and can derive the theories for interference suppression from it.Here is the link

4.2.1 a.) As differential mode interference

This term can also be found under "Differential Mode" and "Symmetrical Disturbance"

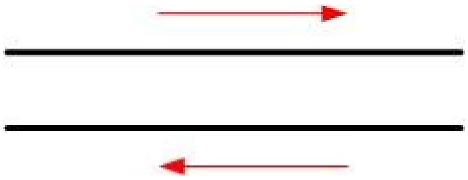


Figure 4, the currents run in opposite directions, the line hardly radiates

With differential mode interference, the currents flow in opposite directions, but with the same magnitude. Such a line hardly radiates, but radiates strongly at points of asymmetry, because components there are converted into differential mode interference. This also applies to PLCs! (Source: DG0SA)

4.2.2 b.) As common mode interference

This term can also be found under "Common Mode" and "Asymmetrical Disturbance"

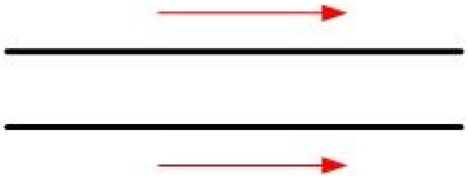


Figure 5, the currents run in the same direction, the line radiates strongly

In common mode interference, the currents run in the same direction, the line radiates strongly

The manufacturer of interference suppression material (toroidal cores) claims that 90% of all conducted interference is in common mode, or common-mode interference. Perhaps because it's easier to detect due to its radiation. But according to DG0SA, this is incorrect. This is why some simple interference suppression methods that only target common-mode interference don't work.

5 Our test object

We are testing the following purchased switching power supplies:

Picture 6, Chinese 12V power supply 5A, purchased from Ebay

6 How can I reliably check my power supply for faults?

a.) With a spectrum analyzer, or
b.) With a shortwave receiver

Most of us do not own a spectrum analyzer, so we start with a receiver and then use a spectrum analyzer for further confirmation.

6.1 Testing with a receiver:

For this we need an existing transceiver / shortwave receiver.
I like to use a portable transceiver, usually the KX3 or FT817. These are handy, fit on my desk, and are absolutely sensitive enough.
The most important thing when testing power supplies is that the power supply must always be under load; otherwise, we won't be able to detect the interference, or we'll barely notice it. The load should be at least 1A to 2A, because interference increases with the load.
Furthermore, we should operate the test Rx with a battery, so that we can be sure that we are not introducing any interference in this way.

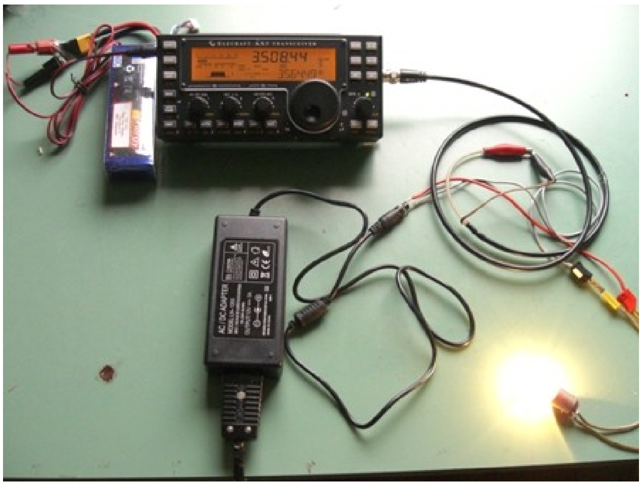


Figure 7, Test setup with KX3

As shown in the image above, we're using a light bulb from a car accessory as the load. It goes without saying that it can't be a modern bulb, because, firstly, they unfortunately cause interference, and secondly, the power consumption is too low.

As an indicator, sensor, or antenna, we use a lab cable with the ends clamped together. This creates a small loop antenna with a circumference of approximately 10 cm to 20 cm. The effective antenna should not be any larger than this, otherwise the sensitive receiver will pick up interference from the surroundings. This can be easily tested by turning on the receiver without the power supply connected.

For now, we simply place the end of this loop antenna on the supply lines to the load (light bulb)

Now, with the VFO, sweep the 80m band, from 3,500 MHz to approximately 3,600 MHz. We should only detect some noise; the S-meter shows zero.

Now it's time for the first test. We turn on the power supply to be tested and once again scan the 80m band with the VFO, as mentioned above.

Typically, we now hear a distinct growl, with the S-meter indicating interference of S5 and above. As we now sweep the 80m range with the VFO, the S-meter reading increases or decreases depending on the converter's fundamental harmonic clock.

We do one more test by placing our loop antenna directly on the power supply, as shown in the picture below.

Figure 8, test antenna placed directly on the power supply

As a rule, the disturbance increases.

What next?

So, if we encounter such a case where our power supply is exhibiting such interference, we need to look for a different power supply and test it. If it's an old classic power supply with a linear regulator, we won't find any interference, "thank goodness." However, if we don't have a replacement solution at hand, we have no choice but to take matters into our own hands and eliminate the interference.

Is that even possible?

Yes, in the picture below we see our test object (picture above), but with noise suppression.

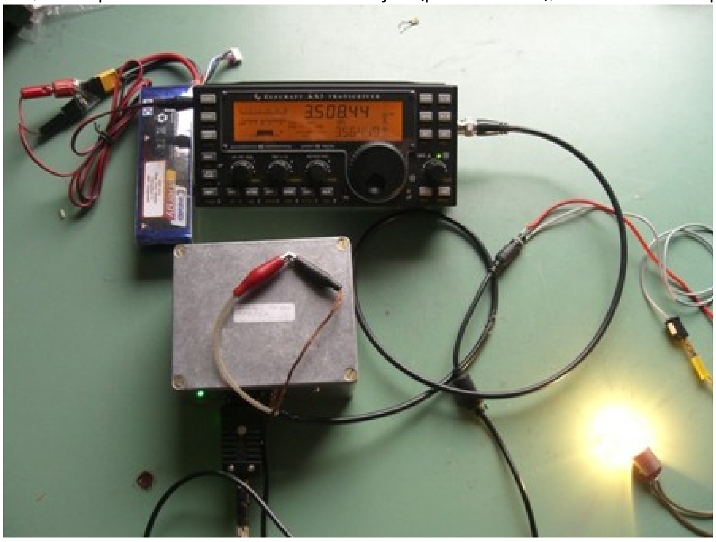


Figure 9, Suppressed Chinese 12V power supply 5A (as in Figure 6 above)

This is the result: absolutely no interference can be detected, even when we place our test loop antenna on the power supply. At this point, I'd like to explain the following observation: If we now begin to loosen the four countersunk screws in this situation, the interference gradually increases. This clearly shows us that for complete interference suppression, we need a new housing, and one that cannot be made of plastic. I always use die-cast aluminum housings, which are inexpensive to purchase and also very easy to machine.

Further tests / confirmations

Image 10, red core, T225-2

Figure 11, gray ferrite core, FT140A-43

This is an old trick: take a toroidal core and lead the connecting cable through the ring several times, thus forming a choke.

The result, however, is very often disappointing; the disturbances remain, albeit somewhat less frequent.

As shown in the two images above, the interference cannot be eliminated. Certainly not with the red core, T225-2. The gray ferrite core, FT140A-43, is slightly better.

The industry is fully aware of this problem and is installing apparent throttles, as shown in the image below.

Figure 12, The end of the supply cable is equipped with a suppression choke

This attractive, encapsulated interference suppression choke is intended to deceive the consumer into believing that the power supply is interference-suppressed. Some of us may rightly laugh our heads off at this point, wondering if the two thick toroidal cores shown above are useless, how could this small, encapsulated ferrite sleeve be an effective measure?

Now we are getting closer to the actual content of this document, namely successfully suppressing interference in a power supply.

7 Testing with a spectrum analyzer:

If you have a spectrum analyzer at your disposal, the measurements will be easier, as the entire spectrum of interest is displayed at once. One disadvantage is certainly the sensitivity, as hardly any spectrum analyzer has as much sensitivity as a classic shortwave transceiver. I myself am fortunate enough to own one, a "Red Pitaya," and now use both options. So, for the initial interference suppression measures, I use the "Red Pitaya," and to extract the last few dB, I use my KX3.

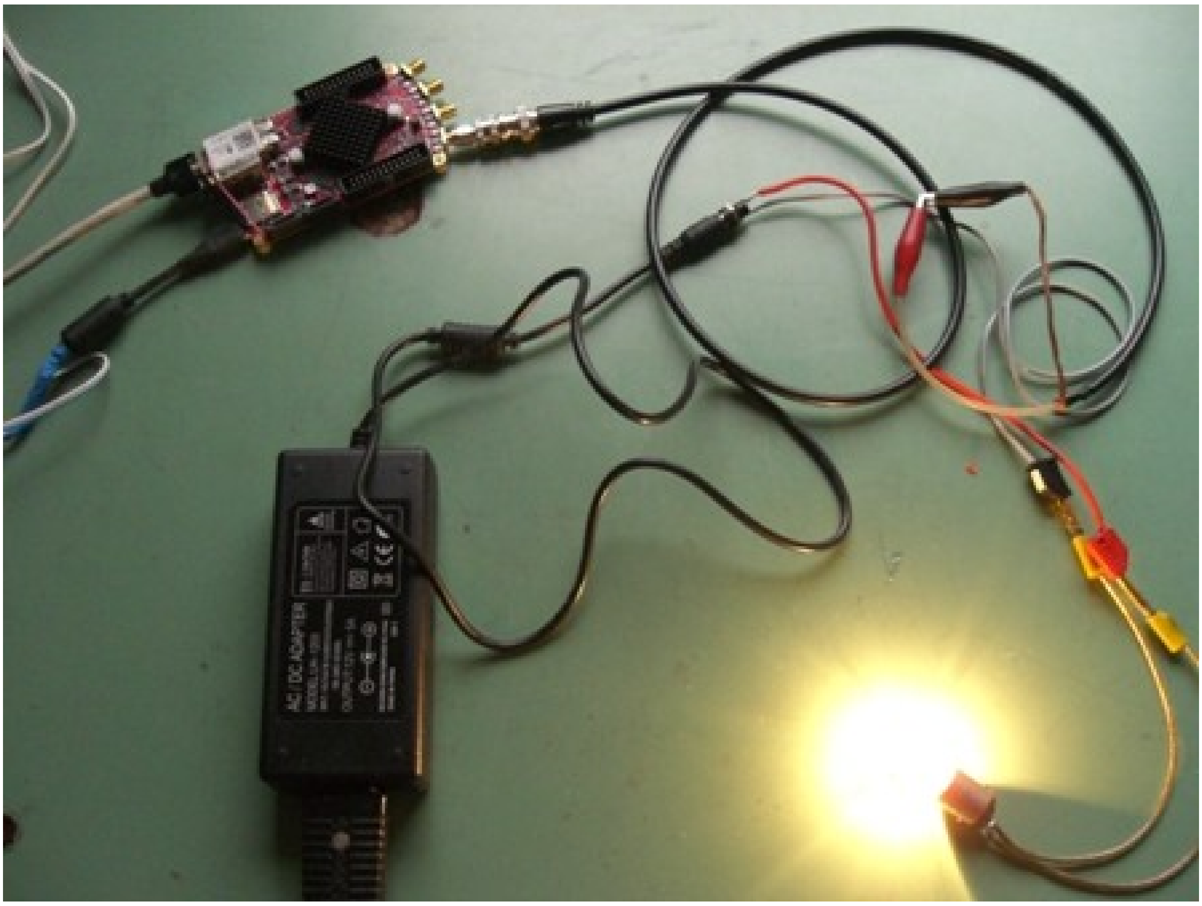


Figure 13, top left of the "Red Pitaya" in use as a spectrum analyzer

In the picture above we see the measuring setup with the "RedPitaya"

7.1 Procedure with the spectrum analyzer

The first step is to perform a quasi-calibration. This isn't an absolute calibration, but rather a reference measurement that can be referenced repeatedly. This also allows other OMs who are dealing with this subject to follow suit.

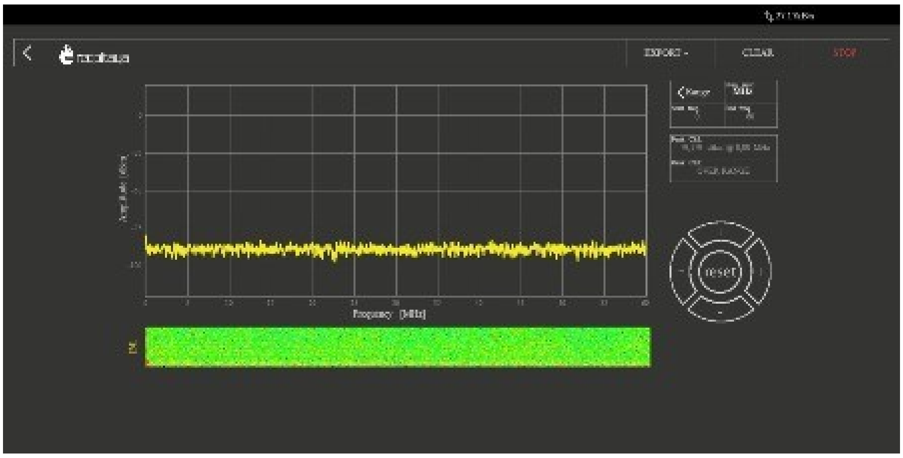


Figure 14, Calibration or reference of the Red Pitaya, span 0-60MHz

I have the Red Pitaya with a 50Ω load. The supply of theRed Pitaya It is best to pay attention to theRed Pitaya is initially powered by a battery or an old classic longitudinal power supply. This ensures that we won't introduce any interference with the power supply. Here we can clearly see the sensitivity we can expect from the Red Pitaya. The Red Pitaya as a spectrum analyzer is not as sensitive as a classic shortwave receiver. This is probably due to the fact that I operate it openly on the table, i.e., without a case or shielding.

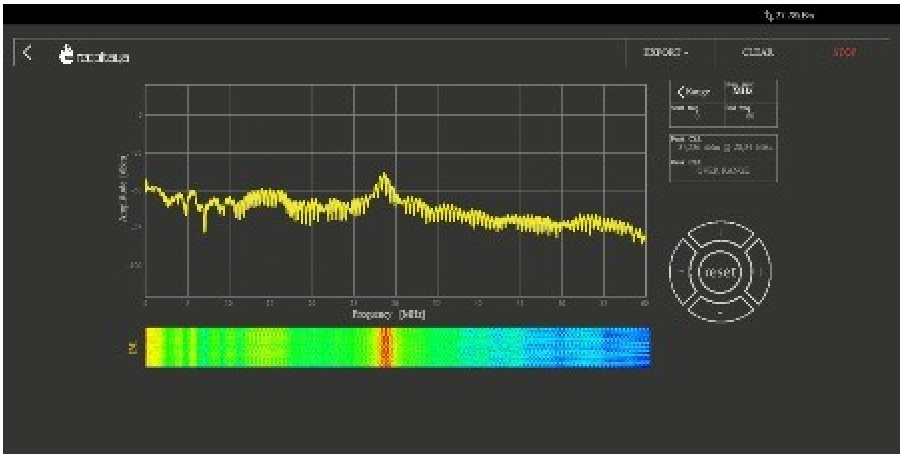


Figure 15, antenna loop connected to the China power supply, span 0-60MHz

Now we set up our antenna loop, just as shown in Figure 3 above with the KX3. We can clearly see the interference peak at 28.34 MHz, with a level of -37 dBm. The figure also shows us that with this simple measurement, our newly purchased 5A power supply is "ruining" the entire HF band and requires action.

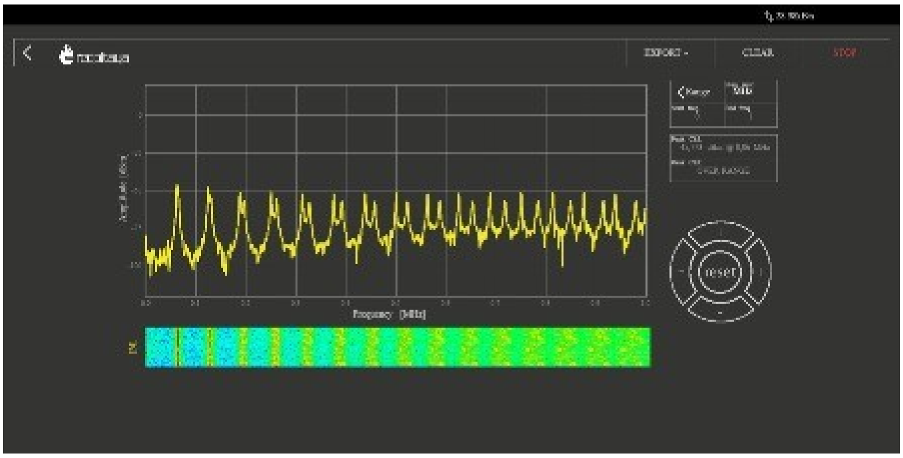


Figure 16, antenna loop connected to the China power supply, span 0-1MHz

If we now reduce the span to 0-1MHz, we can clearly see at which frequency the power supply under investigation is clocked, i.e. at 60kHz, with a level of -45 dBm!!

7.2 Is it common-mode or differential-mode interference?

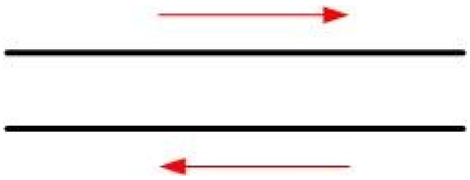


Figure 17, Differential Mode Interference

In differential mode interference, the forward and return currents cancel each other out. Therefore, the transmission line (cable) does not radiate.

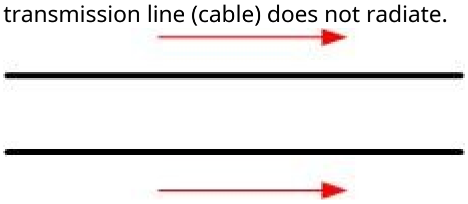


Figure 18, Common Mode Noise

In common-mode interference, the forward and return currents cancel each other out. Therefore, the transmission line (cable) does not radiate.

This is very important to know so that we can take the correct interference suppression measures. To determine this, we use a homemade measuring head, see Figure 17 below.

Picture 19, a self-built 50Ω-measuring head

This measuring head consists of a toroidal core FT140-43 or similar, about 10 turns also Cul, and terminated with a 50ΩResistor. I mounted the whole thing to a BNC socket.

7.2.1 Testing for differential mode interference

It's always important for all measurements that the power supply under test is under load. An unloaded power supply is hardly a problem, but as soon as it is under load, the "truth" becomes apparent.

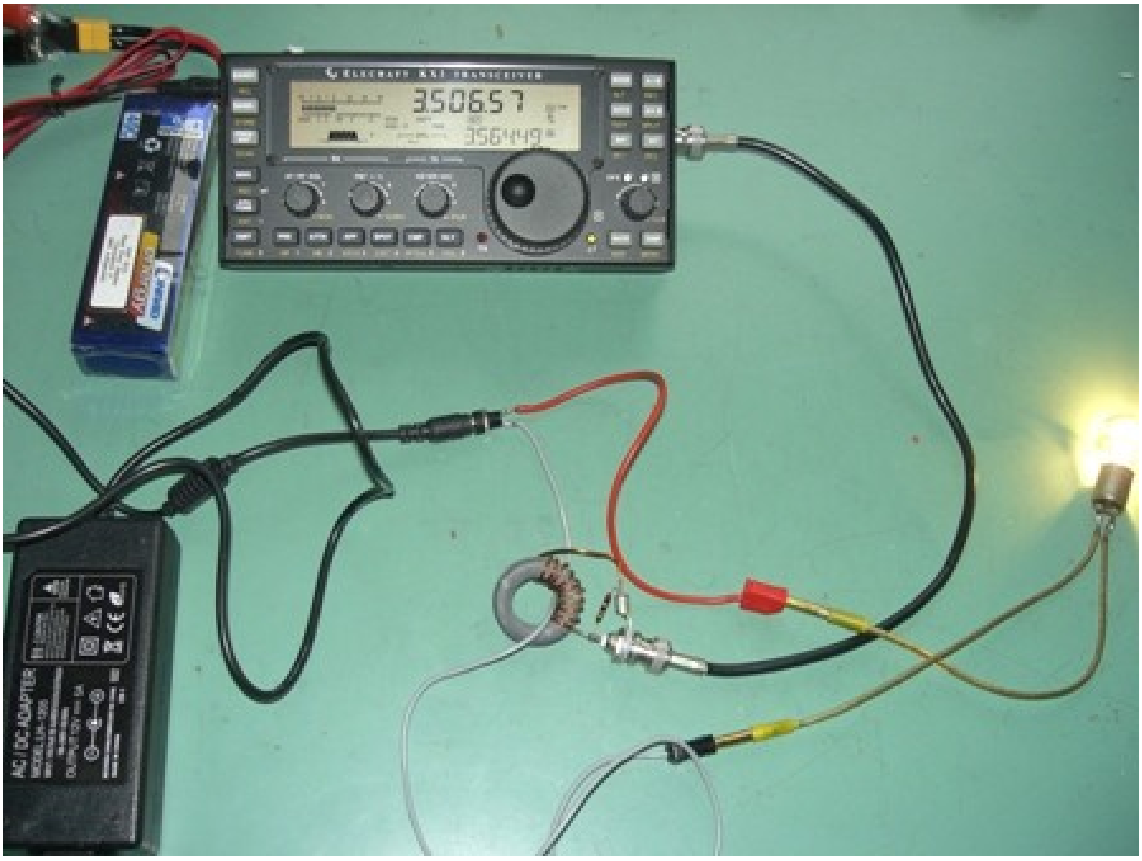


Figure 20, testing for differential mode interference.

To do this, we only feed one wire through our measuring head, as shown in the image above. Whether it is the positive or the negative wire is irrelevant. On the KX3, we read a noise level of S9 and more. The occurrence of differential mode noise with such a high signal level means that the 12V line

DC voltage is superimposed with a strong high-frequency interference signal, as can be seen in the spectral image xxx. The interference signal uses the line (like RF on a chicken ladder) to penetrate the connected devices. This can lead to significant interference and interference in the Rx, which we would like to counteract with interference suppression.

Furthermore, we can see in Figures 10, 11, and 18 that I'm powering the KX3 with batteries to ensure I don't introduce any unwanted interference. In all of these tests involving the 5A Chinese power supply, I loaded it with 1/4 of its rated current, i.e., 1.3A, a light bulb from an automotive light bulb. The interference always increases with increasing load, but the value of 1.3A has proven to be reliable. With higher loads, the interference doesn't increase significantly, which eliminates the need for a larger load.

7.2.2 Testing for common-mode interference

It's always important for all measurements that the power supply under test is under load. An unloaded power supply is hardly a problem, but as soon as it is under load, the "truth" becomes apparent.

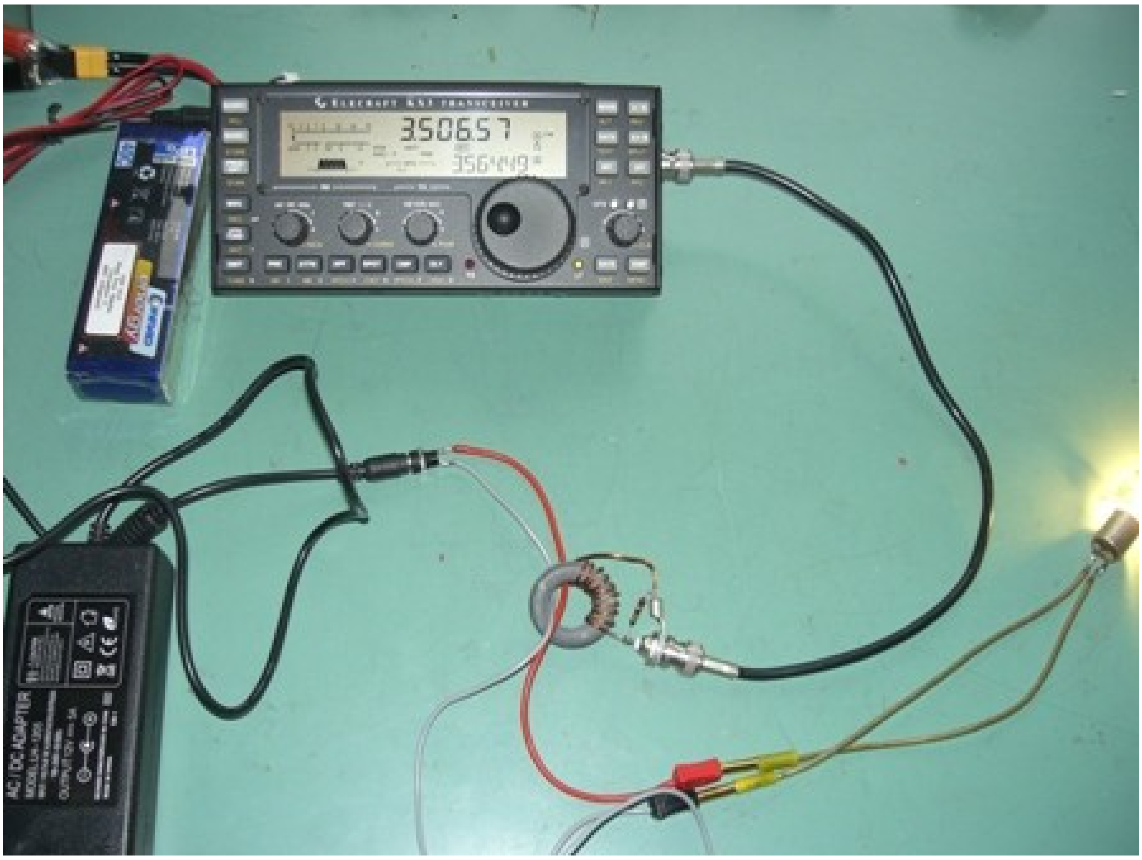


Figure 21, testing for common mode interference.

To do this, we now lead both cables through our measuring head, as shown in the picture above
The interference has decreased significantly, by about S1. This proves that we are dealing with common-mode interference, and that the usual interference suppression method, such as wrapping the supply line with a toroidal core, offers little or no improvement.

8.1 Security

The examination catalog for obtaining an amateur radio license contains a number of topics related to electrical safety. The work described in this article requires opening the power supply unit, and there is a risk of electric shock.
Socket amateurs therefore prefer to leave it alone and ask for help from experienced professionals.

8.2 First we open the case.

Figure 22, sawing open the welded housing

Picture 23, opening with a screwdriver

This works best if you can clamp it in a vice.

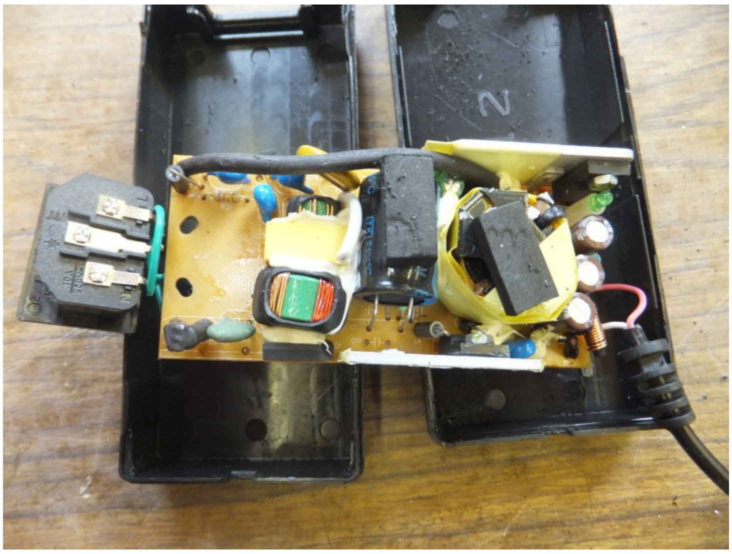


Figure 24, the electronics removed

Here we can clearly see that the earthing pin is not used at all, although the Euro plug appears to be.

8.3 Now we build the electronics into a metal housing

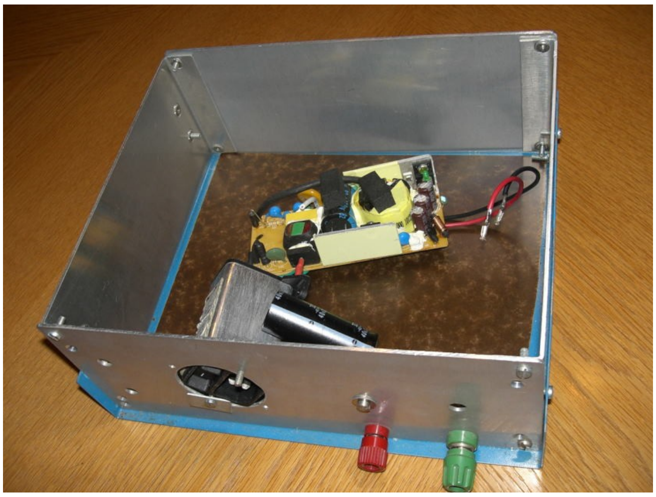


Figure 25, the temporary metal housing for testing

For further testing, we'll install the removed power supply in a temporary metal case with a lid large enough to accommodate the various interference suppression measures. Once we've found the exact components, we'll install the entire thing in a smaller metal case. Figure 22 shows that I've installed a Schurter plug-in filter for the primary side, i.e., the 230V AC side. This way, we're already on the safe side that nothing penetrates from this side. For total interference suppression, which is what we're aiming for here, it's essential that the primary side is also suppressed. This prevents additional interference from entering the power grid.

By the way, we can see in Figure 22 that our power supply has hardly any noise suppression measures on the primary side. Therefore, such a filter will also be included in the final housing. Of course, you could also build a filter for the primary side yourself, but I advise against it, and besides, using a commercial filter is a cleaner option. This filter example even has a built-in switch, which adds a certain level of convenience.

8.4 Measuring with the RP spectrum analyzer

We perform the measurements with an RP spectrum analyzer, which makes it easier to record the measured values. We select a sweep range of 0.020 MHz to 2.000 MHz to ensure we can accurately determine the clock frequency. For future comparisons, the sweep range must always be specified; this is the only way to ensure the measured values are comparable.

First, make a reference measurement

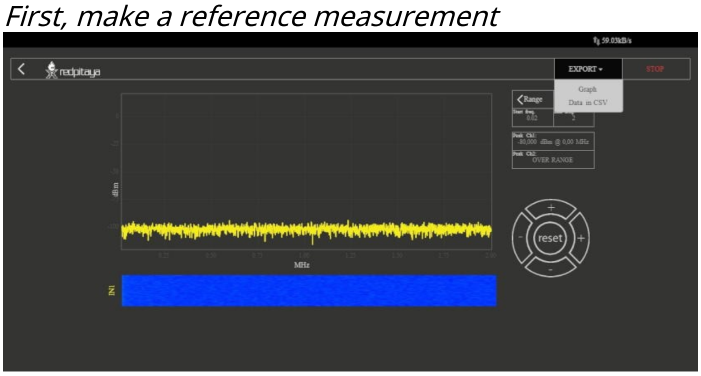


Figure 26, Reference measurement

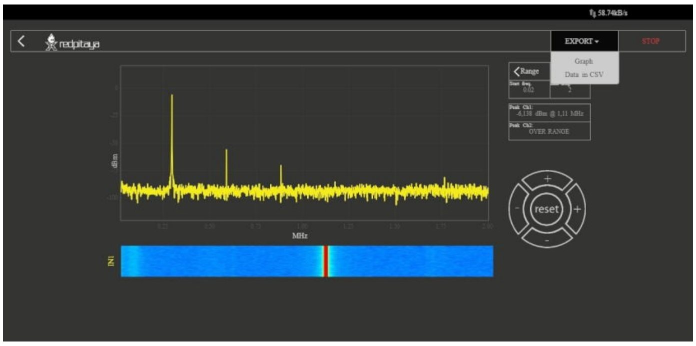


Figure 27, the reference measurement with an absolute 1 MHz level of -10 dBm

In the image, we can see that the 1 MHz amplitude is displayed at exactly -6.138 dBm. This is because I didn't calibrate the RedPitaya. But that's irrelevant here, since we're not making absolute measurements, just comparisons. At least it provides some traceability for people who also want to take measurements.

The following chokes are used

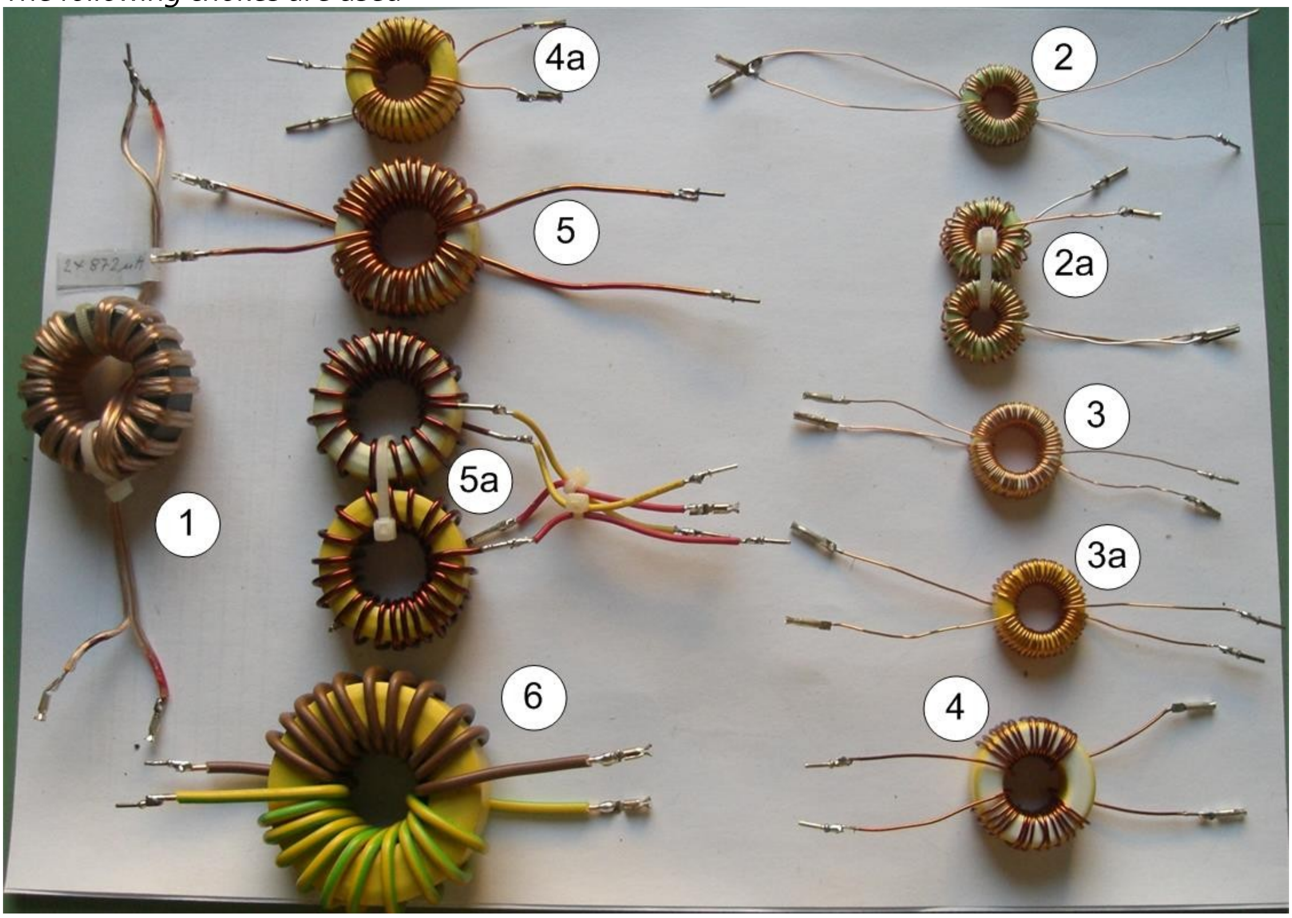


Figure 28, various proven elements are used and tested

No.	Electricity	type	Al	Dimensions D/d/H, mm	Max Cul mm	Source	Price/piece	Wdg	uH	Wire length
1	Standing wave trap 2x872 uH									
2	1.5 A	T68-40	47	17.5x9.4x4.83	0.5	BFI Optilas, Germany	CHF 1.00	2x21	26	2x50cm
2a	3 A	2x T68-40	47a	17.5x9.4x4.83	0.7	BFI Optilas, Germany	CHF 1.00	2x28	42	2x55cm
3	1.5 A	T80-26	45	20.2x12.6x6.35	0.4	Distrelec, 158-72-841	CHF 1.65	2x36	2x70	2x75cm
3a	3 A	2xT80-26	45	20.2x12.6x6.35	0.6	Distrelec, 158-72-841	CHF 1.65	2x22	2x25	2x60cm
4	3 A	T106-26	90	26x14.5x11.1	0.6	Distrelec, 158-72-890	CHF 1.80	2x15	2x25	2x65cm
	10 A	T130-26	78	33x19.8x11.1	1.5	Distrelec, 158-74-094	CHF 5.90	2x16	2x24	2x75cm
	20 A	T184-26	47	46.7x24.1x18	2.5	Distrelec, 158-72-601	CHF 11.20	2x11	2x23	2x85cm
	20 A	RK1	750	61x35x13	-	DARC	4.00 euros	-	-	-
	less suitable									
		FT82-43	470	21x13.2x6.35	-	Distrelec, 158-74-169	CHF 1.70	-	-	-
		FT82-77	1170	21x13.2x6.35	-	Distrelec, 158-74-177	CHF 3.05	-	-	-

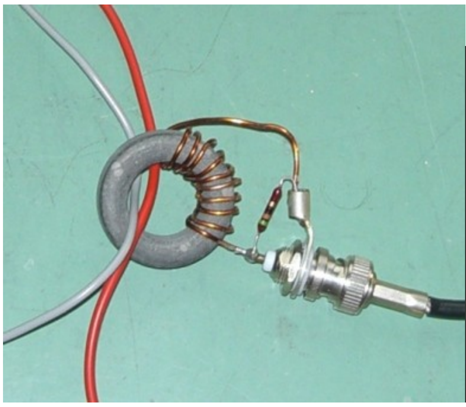
Table 1 on suitable toroidal cores and their procurement

8.5 Step 1

Installation of China 5A power supply in test case, see picture below

Figure 29, 5A power supply installed in the housing, preceded by a Schurter plug filter

We check again what type of fault is present. a.)
Differential mode fault or
b.) Common mode interference, and the respective amount as a basis



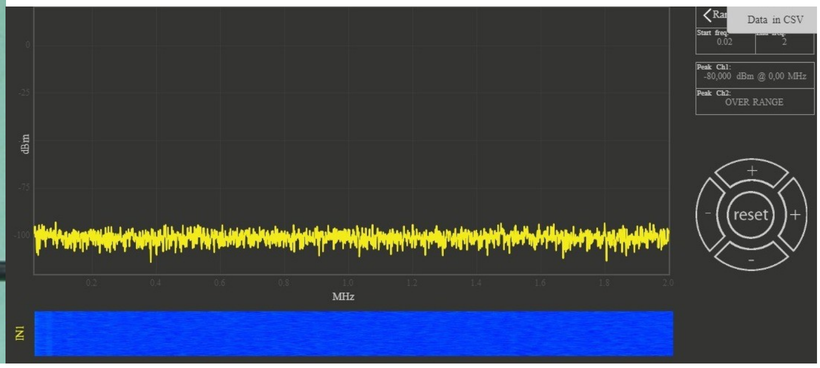
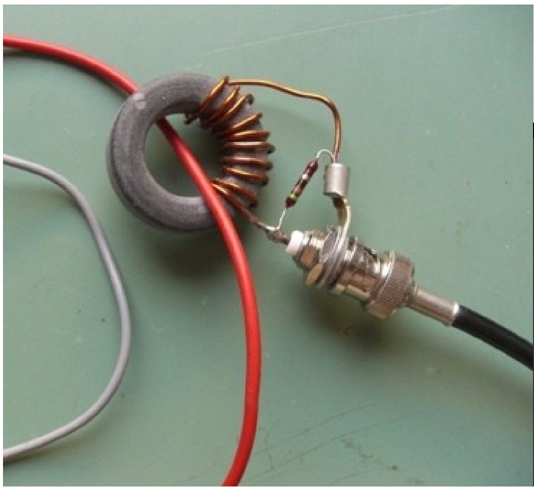


Figure 30, Checking for common mode interference

Figure 30a shows no common mode interference

Figure 30a shows no common-mode noise at all, so from that perspective everything is OK.
But what about the differential-mode noise?



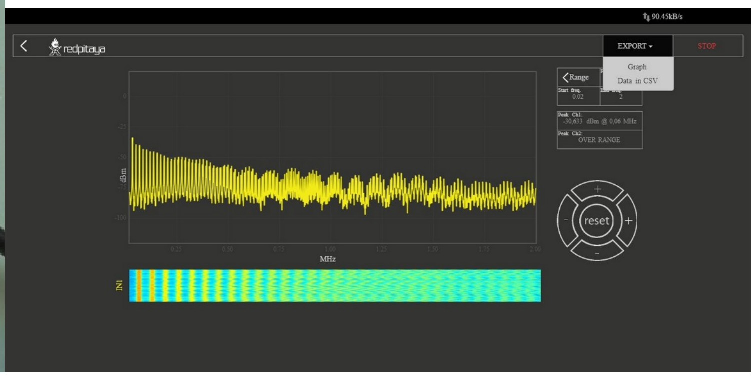


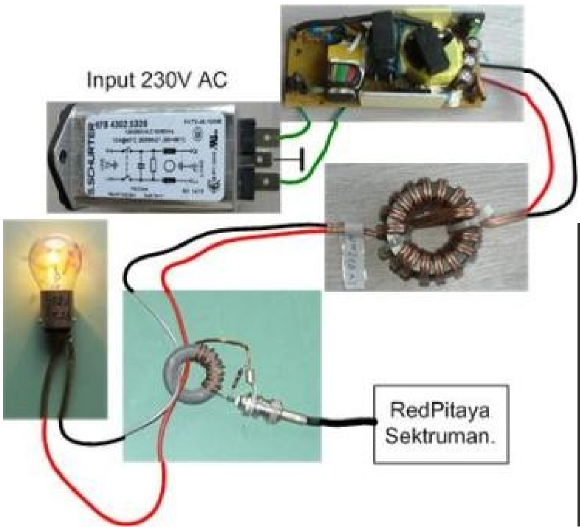
Figure 31 Checking for differential mode interference

Figure 31a, shows significant differential mode interference!!

Here we see the great evil of differential mode interference. The peak is at a level of - 29dBm at 60kHz.

8.6 Step 2, Troubleshooting measures

We begin with interference suppression measures. First, we try a conventional choke, specifically a standing wave suppressor.
The overall scheme looks like this:



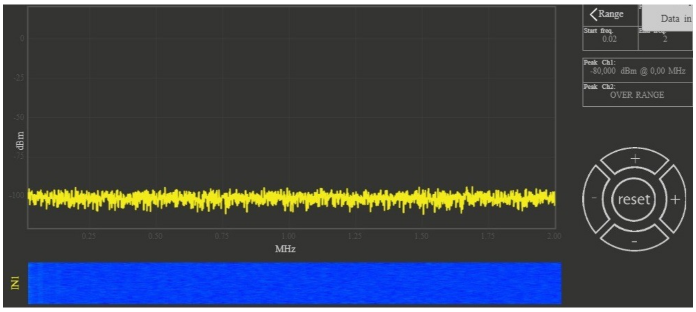


Figure 32, Schematic with MW blocker & Gl-TFigure 32a, Spectrum with built-in MW blocker
Figure 29a shows the spectrum with the built-in sheath wave trap according to the diagram in Figure 29. As expected, there are no common-mode interferences, as we didn't detect any in the measurement in Figure 27a. We continue with testing for differential-mode interference.

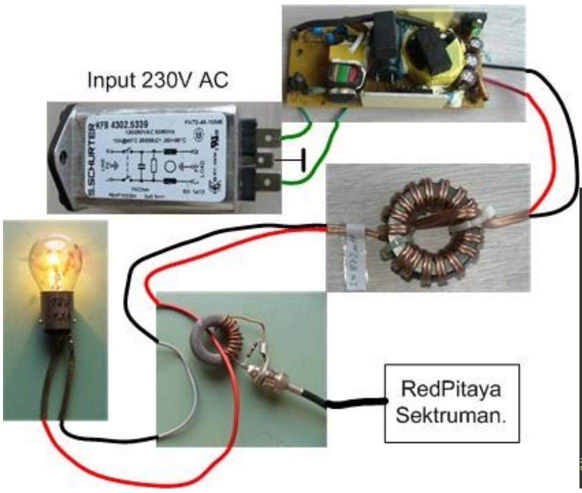


Figure 33, Scheme with MW lock & GT

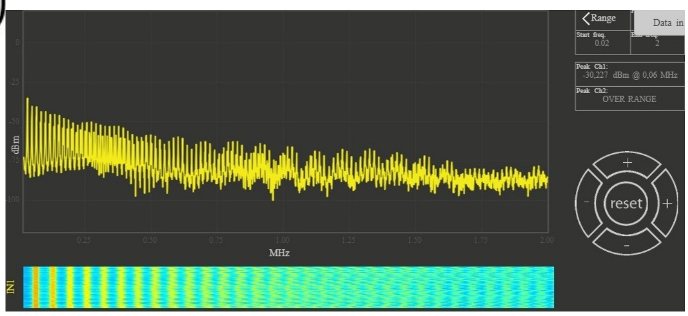
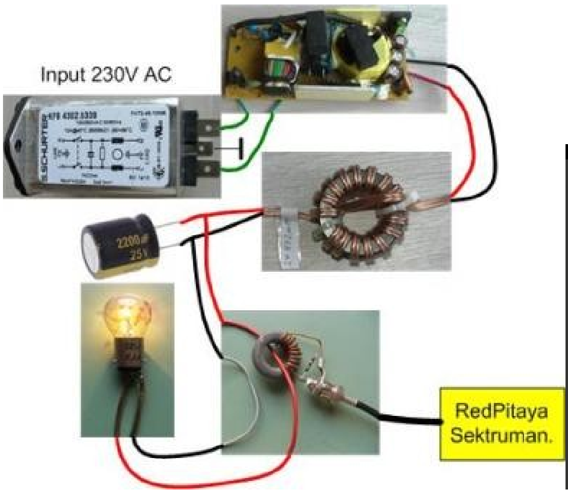


Figure 33a, spectrum with built-in MW blocker

The result: no improvement. Installing the MW blocker doesn't help in the push-pull situation. Upon closer inspection, you can see an improvement of 1 dB.
Let's try using an additional electrolytic capacitor with =>2200uF, as suggested in various EMC articles.

8.7 Step 3 with electrolytic capacitor



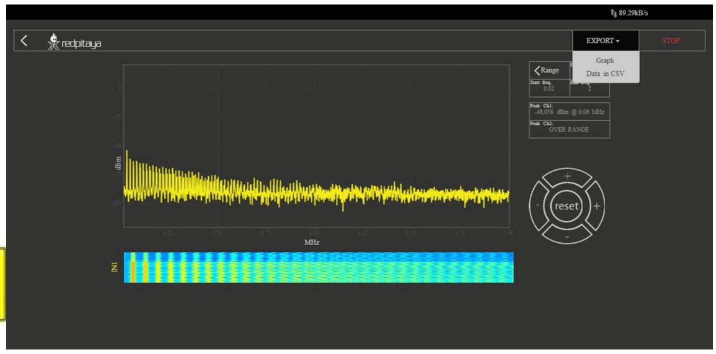


Figure 34, sheath wave trap and electrolytic capacitor, Figure 34a, spectrum according to the left picture in the push-pull test

Such an electrolytic capacitor makes quite a difference; we can see a peak of -48 dBm at 60 kHz. The waterfall diagram in Figure 31a clearly shows the transition when I added the electrolytic capacitor. The time course shows the recording with the electrolytic capacitor in the upper quarter, and without the electrolytic capacitor in the lower three-quarters. For all further tests, we'll leave this 2200 uF electrolytic capacitor in all the different circuits. A further common-mode test is unnecessary, since we haven't detected any common-mode interference here.

9 The push-pull choke (Gt-Dr)

So, we can't suppress interference from this power supply with a sheath wave trap!
The interference is a conducted wave, and the currents are in push-pull mode.
Therefore, there is no flux in the ferrite, the inductance is zero, and the interference on the line is not affected.
In case of differential mode interference, a differential mode choke (GT-Dr) is required. See next picture.

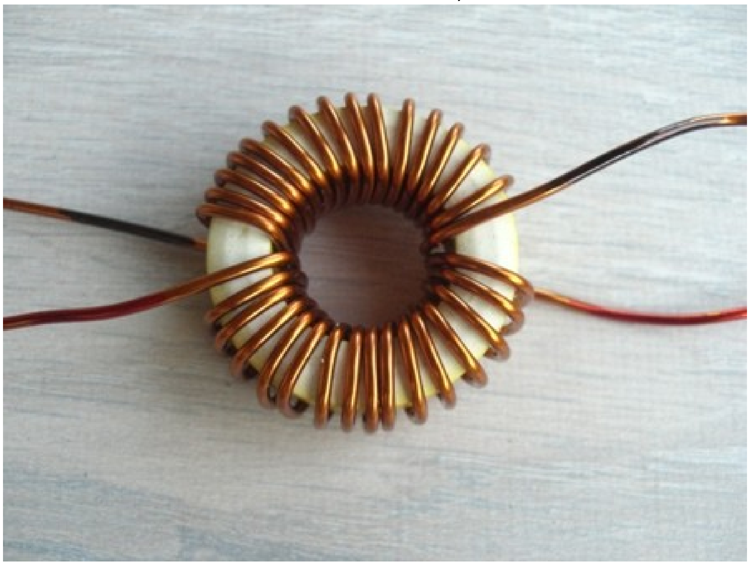


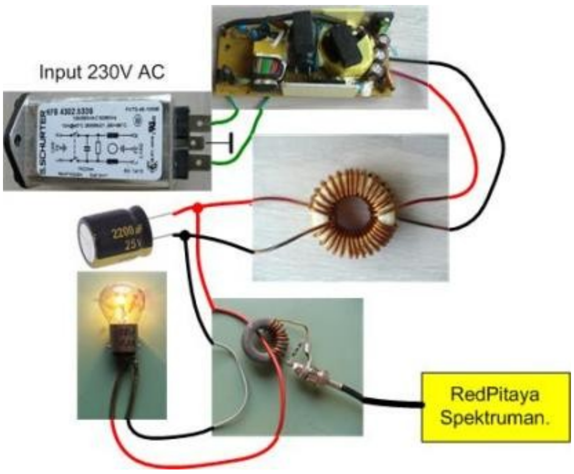
Figure 35, Push-pull choke (Gt-Dr) on a core

However, the wrapping technique is very important, otherwise the desired effect will not be achieved.

Figure 36, push-pull choke (Gt-Dr) distributed over two cores.

If you want to suppress interference from a high-current power supply, you need a correspondingly thick winding wire to keep the voltage drop low. However, in this case, you can only place a few turns on the core, which may result in an inductance that is too small. Two individual windings can be used, see Figure 33. Here, too, you have to pay attention to the winding technique, as mentioned above.

9.1 Step 4, Installing the push-pull choke



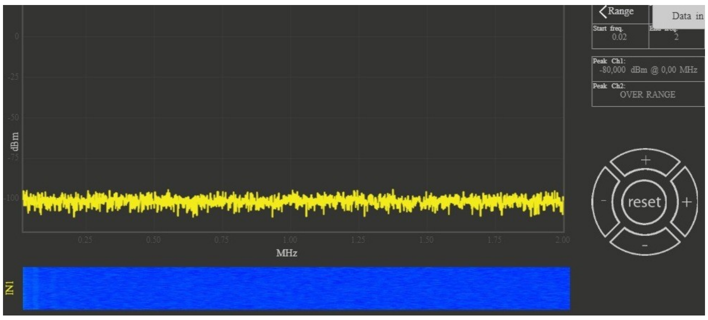
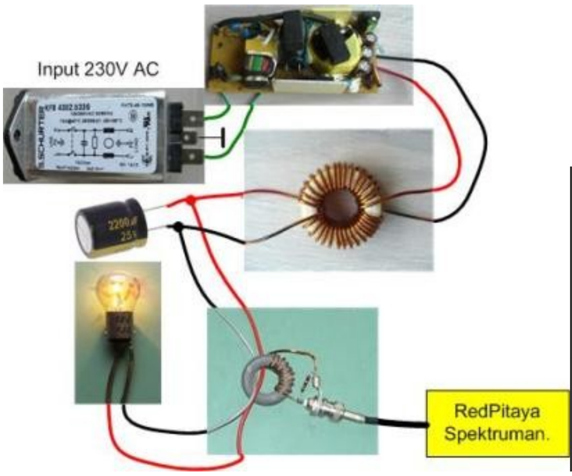


Figure 37, push-pull choke (Gt-Dr) and electrolytic capacitor, Figure 37a, spectrum according to Figure 34 left in the push-pull test

As we can see in Figure 34a, the differential-mode interference disappeared with the installation of a differential-mode choke (DCT) and electrolytic capacitor. We achieved our goal.
Finally, a test to see if there is any common-mode interference.



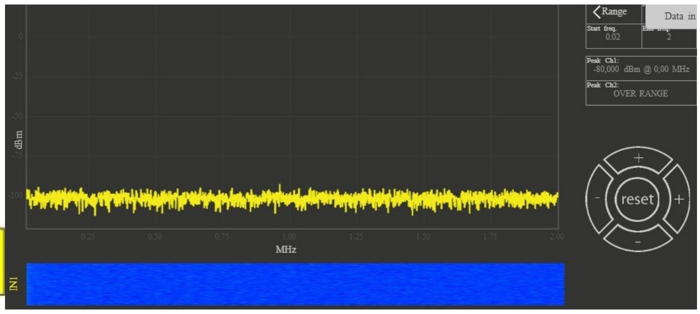


Figure 38, common mode choke (Gt-Dr) and electrolytic capacitor, Figure 38a, spectrum according to Figure 35 left in the common mode test

As expected, there is no common mode interference.
Thus, we have achieved our goal and can install all these components in a suitable metal housing.

9.2 Push-pull choke (Gt-Dr) and winding direction

As mentioned above, the winding direction of the push-pull choke is very important. Instead of the push-pull choke (Gt-Dr) in Figure 35, we install the following choke:

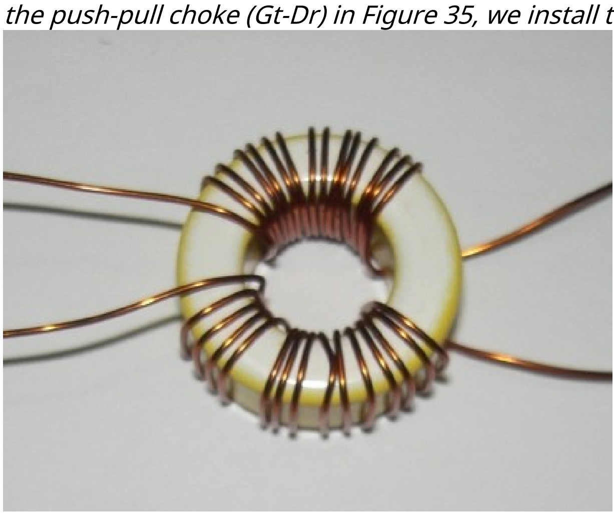
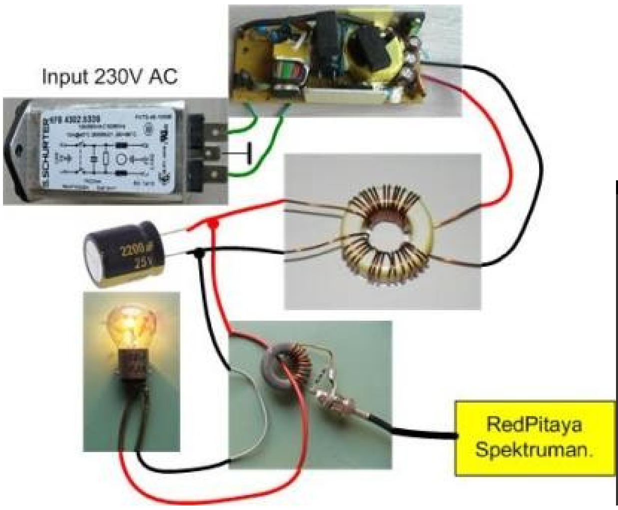


Figure 39, incorrectly wound push-pull choke.

The choke shown in Figure 36 is a current-compensating choke and does not achieve the desired result; see the next experiment below. Such a current-compensating choke is often found in commercial line filters. Such a choke can, of course, simply be rewound or rewired to form a push-pull choke. See Figure xx below.



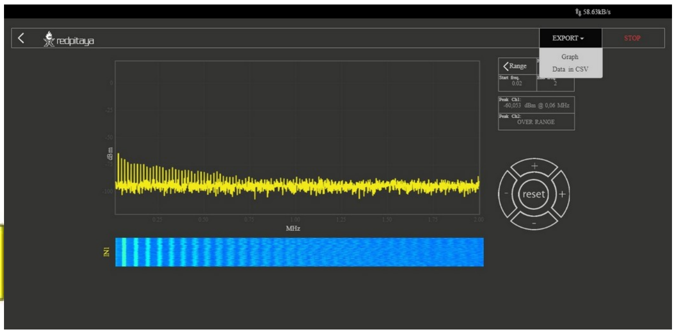


Figure 40, Incorrectly selected push-pull choke (Gt-Dr) in push-pull test

Figure 40a, spectrum according to circuit left

In Figure 40a, we see that the winding direction is very important for the push-pull choke. The peak is -60 dBm at 60 kHz.
In this case we have to rewind the choke in Figure 40 (current compensating choke) to a push-pull choke, or re-wire it,

Technical information for a replica

Security

The examination catalog for obtaining an amateur radio license contains a number of topics related to electrical safety. The work described in this article requires opening the power supply unit, and there is a risk of electric shock.
Socket amateurs therefore prefer to leave it alone and ask for help from experienced professionals.

Toroidal core material

Switching power supplies operate in the kHz range, so the toroidal core material must be selected for this range. To achieve acceptable suppression, the inductance should be greater than or equal to 100 uH.

The following materials / types are very suitable:
Amidon -Material 26 (colour yellow-white)
A T-106-26 is therefore well suited for a current of up to approximately 3A, if you use two of them (see winding technology) then 6A

9.3 The current-compensated choke

Many devices incorporate so-called current-compensated chokes into their mains filters. These chokes pose little problem for differential-mode interference.
To suppress differential mode interference, you can either reverse the winding direction of one of the two windings of the current-compensated choke, see picture below.

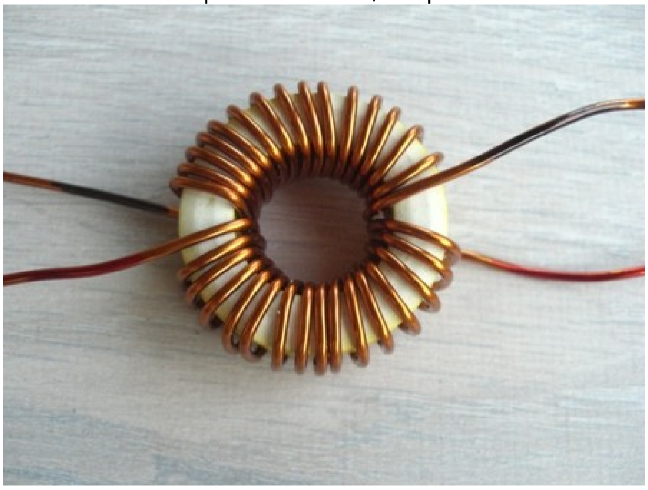


Figure 41, converted current-compensated choke
Here I have removed one coil of the choke and reapplied it in the opposite direction

You can also change the direction of the current by swapping the connections, see the following picture

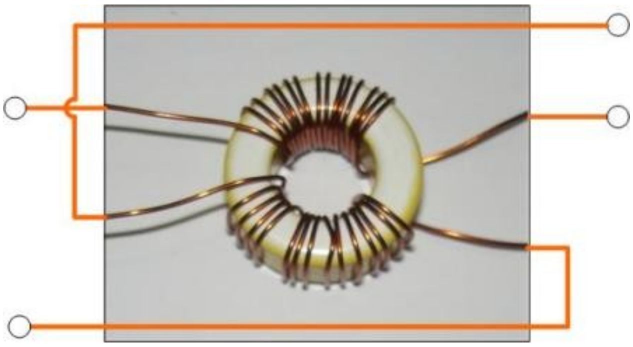


Figure 42, Current compensated choke connections changed to a push-pull choke.

When winding the push-pull choke, it is important that the two applied windings are identical.

9.4 But what does it look like on the primary side, 230V AC?

This is where the additional facility, a network replica (Artificial Mains Network), helps us.

Figure 43 Artificial Mains Network

The network simulation provides the device under test (Device under Test,**DUT**) provides the supply voltage. An internal filter keeps out interference from the mains, and the conducted interference caused by the DUT is extracted and provided for evaluation at a BNC socket.

But you can also make reliable measurements using our already well-known method, our self-built measuring head.

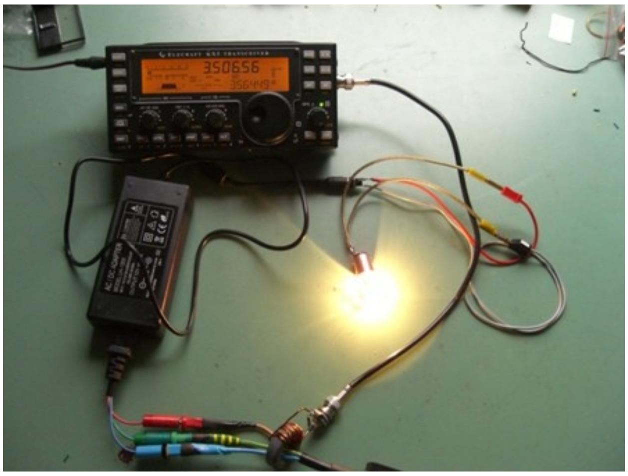


Figure 44, Checking for common mode interference on the primary side of the power supply. Here too, we find significant interference.

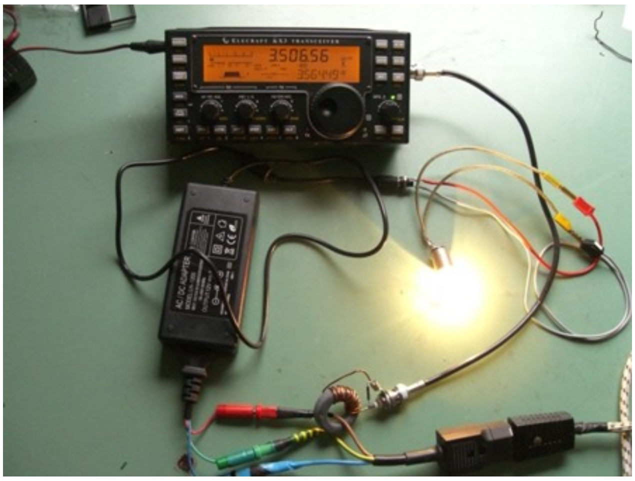


Figure 44, Checking for differential mode interference on the primary side of the power supply. Here, too, we find significant interference.

9.4.1 The solution: installing a Schurter/Schaffner filter

Figure 45: Built-in power supply in a metal housing and Schurter filter.
The result: absolutely no interference can be detected with the KX3.

10 Summary

Many of the commercially available power supplies comply with the current IEC 61000 standard, but the upper level limits are still far too high for our desired interference-free shortwave reception.
Of course, from a pessimistic perspective, one might conclude that amateur radio and shortwave reception are a thing of the past. I personally see things somewhat differently and have learned to deal with it by seeking ways to eliminate the biggest sources of interference. The biggest sources of interference are often located in**«yours»**immediate vicinity, i.e., in your own home. If you can eliminate these, then shortwave reception will be possible again.
Classic linearly regulated power supplies are still the best choice for radio amateurs. These types of power supplies never cause interference, and you shouldn't throw them away; they can often be put to good use later, even if only temporarily, to ensure that you don't cause interference yourself. The common disadvantage, efficiency, can be easily optimized yourself. More information at xxx

10.1.1 Links to my source information:

-Schurter EMC Conference Technopark2008
https://ch.schurter.com/content/download/677217/13559265/file/Fachvortrag_Schurter.pdf

-Elimination of EMC interference Hans Breitenmoser
http://archiv.swisstmeeting.ch/tl_files/images/EMV%202014/2_4_Beaufnahme%20von%20Stoerungs_Hans%20Breitenmoser.pdf

-TDK Germany
https://de.tdk.eu/download/433954/a7c1529e38398c3082191bbea33b658f/pdf-general.pdf

-EMC in the jungle of directives and standards, Electrosuisse
http://archiv.swisstmeeting.ch/tl_files/images/emv2013/2_1_HAUSER_Electrosuisse_Guidelines_Standards.pdf