Bird 4311
Thruline Wattmeter

Welcome onboard this restauration report of a Bird 43 RF wattmeter!

1 Introduction

My german readers may be a little astonished to read this in english, but as this wattmeter was manufactured by an American company and I am used to give my reports to the suppliers for approval first, I cannot expect them to read german texts for review. So sorry to all my german fans for any inconveniences caused- and welcome to all the others :-)

figure 1: my Bird4311 Thruline wattmeter

The Bird43 wattmeter is something like a "standard" in RF technology. Everybody who has something to do with RF power amplifiers or transmitting technology, usually knows them. If you tell anybody "I've measured this with a Bird43", then I promise nobody will criticize your measurement. The reason is as simple as its technology: Bird43 Thruline wattmeters are so well and rugged designed, that there is almost nothing that really can get defective. The Bird designers omitted any sophisticated feature or unnecessary things, concentrating to the main key feature: measuring the RF power- and this in *any* environment, *any* situation and by almost *any*body ;-) Because of this "purism thinking" it is extremely reliable and robust design and if you don't mistreat it very heavily, it will probably satisfy you for a complete human's life.

Apropos- this is exactly the point:

I got this Bird 43 (precisely: Bird 4311-200) as part of a bequest from a good friend of mine. He was radio amateur and one of the founder of our german INTERRADIO amateur radio exhibition in Hannover (germany). Before he passed away a while ago, he gave me this unit for our INTERRADIO RF test station and we used it for many years without any problems.

But somewhen there were rumours from the testers, that the readings of the Bird do slightly mismatch a bit with other power meters. So this calls for a detailed service of this Bird 4311 unit and somehow I feel responsible myself to do this- as kind of "last hommage" to my dead friend.

2 General thoughts

Ok, so if this Bird4311 is supposed to have a decreased accuracy, I am wondering why and am going to check it in comparison to a modern Rohde&Schwarz URV35 RF voltmeter in combination a suitable RF power measuring head. I always take this URV35 power meter as my RF reference as it provides special measuring heads with a guaranteed error of absolutely max. +/- 0,2dB over the entire frequency range from DC to 18GHz (power head NRV-Z51). I check it regularly using a Fluke 5100B calibrator's wideband-option (10MHz) and so I am quite sure, that my URV35 still meets its specification.

figure 2: Rohde & Schwarz URV35

(source www.rohde-schwarz.com)

One sentence about old/ new measurement stuff: Don't be mislead by the expectation, that modern power heads are *in general* better than the old powermeters just because the fact that they are new! As you can see in the Bird43 datasheet, the absolute accuracy is rated as 5% of the max. scale value. Means: If you are using a 100watts RF slug, and reading 100watts in the meter, then the actual value may be between 95..105watts in truth. So if you describe that in dB, it also +/- 0,21 dB! Means: roughly the same inaccuracy like the modern URV35 with the NRV-Z51 power head! => 0,2dB represents ~5% error!

3 Preconditions

So if any professional metrology expert is going to read this report, he surely will claim this; normally the reference needs to be at least 10times better than the meter you are checking. In my case I cannot provide that. The calibrator-checked URV35 is the best I have and thus I will take it and declare it to *my* personal reference, ignoring any metrology and statistical rules. So don't wonder that it is not officially NIST traceable, but for sure decades better than any low cost hobbyist power meter.

4 Comparison

As I performed the RF comparion test, the situation was quite clear, anyway: I can see a deviation of up to 20% between the old Bird4311 and my URV35. This is definitely more than just an "uncertainty" problem! Something is supposed to be actually wrong with the beloved Bird!

4.1 S11 and S21

Let's check the correct 50ohms matching as precondition for a valid power measurement. For that I used a Rohde&Schwarz FSEB30 Spectrum analyzer, hooked up to a Rohde&Schwarz ZRB VSWR reflection bridge. This was fed by a Rohde&Schwarz SME03 signal generator.

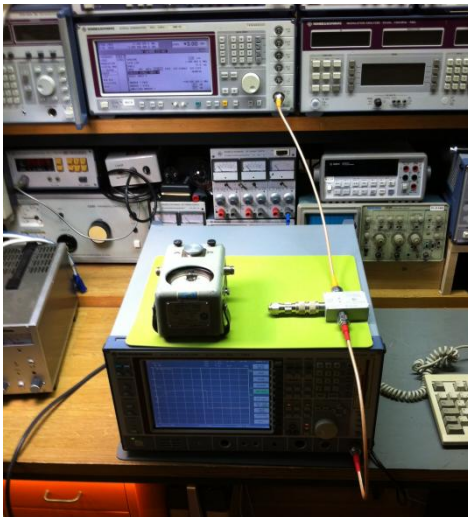

figure 3: S11 measurement setup with Signal generator, Spectrum analyzer and VSWR bridge

Very luckily, a friend of mine owns a quite new Bird4304-400 Bird Wattmeter for comparison. This made it very easy for me to judge, if the measured VSWR plot is correct or "miles away" from the reference.

I checked the frequency range up to 3GHz, using different slugs in the Bird. The overall result was, that my old Bird4311 provided absolutely comparable performance regarding the VSWR. So the thruline element itself is still supposed to work according to spec!

In figure 4 you can see the matching parameter (S11) of my Bird4311 and the one from my friend. During this test, the 500watts power slug (500H) was used; forward position.

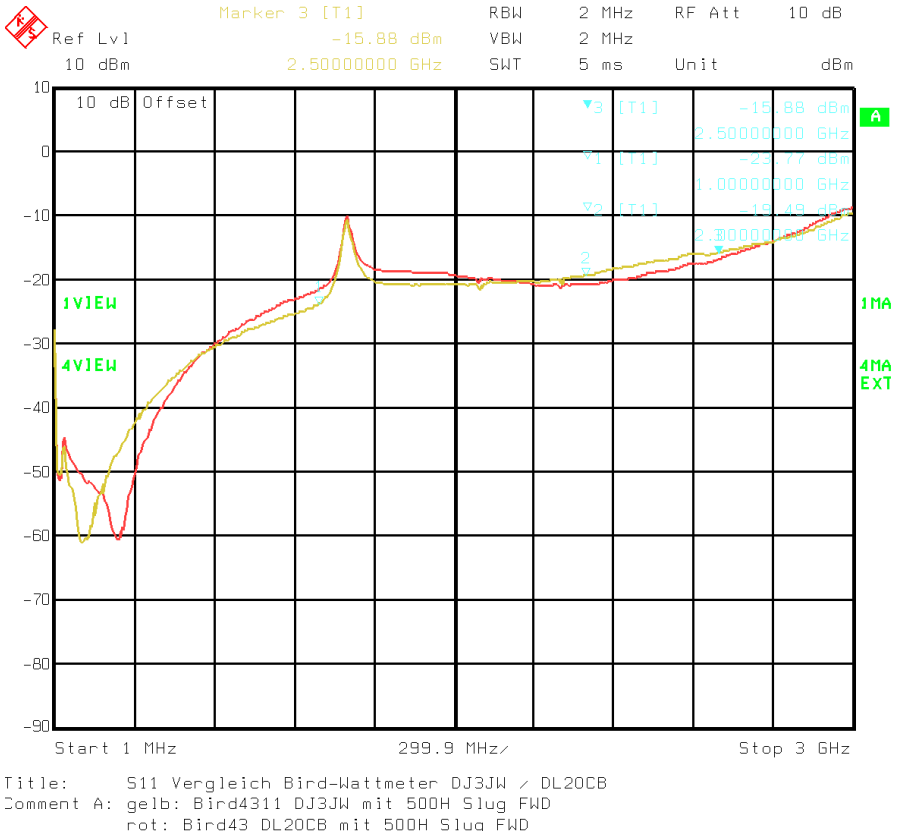

figure 4: S11 comparison with 500W slug

I guess anybody can easily see, that both curves in the diagram are absolutely comparable. So no problems here. Also with a smaller 5watts slug (5E), see figure 5.

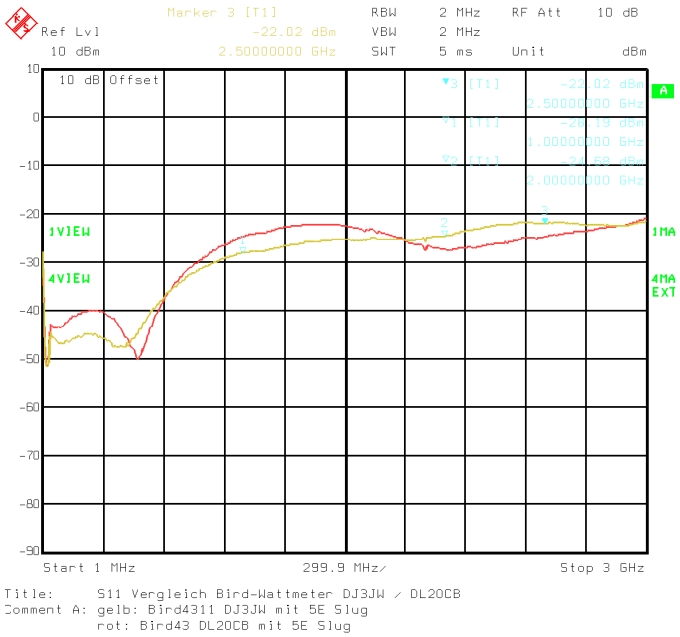

figure 5: dito, with 5E slug

4.2 Meter

In order to search the reason for the displayed error, I observed that tipping the meter with the finger changes the measured value quite a lot! Also the reproduceability of the readings was not as good as with the newer 4304-400 one from my friend. After some tests, I am quite sure, that the needle mechanically touches the scale (or magnet) somewhere that caused it getting stuck somewhere on the way to the "correct" needle position.

Furthermore the finger-tipping showed another effect that especially the electronic new-comers may not know: electrostatics!

figure 6: distracting the needle just by finger moevement!

4.3 Electrostatic

Electrostatic effects usually get worse the more sensitive the meter is. The effect is, that just the electrostatic charge of the display glass (or the finger of somebody, tipping onto the glass) is sufficent to generate an electrostatic field with enough strength to distract the meter's needle. Especially if the glass is made of plastic (as it is in my old Bird4311), it collects thankful any kind of electrostatic charge it can get.

figure 7: using an ESD gun for electrostatic measurement

To convince myself that electrostatics is really an issue with this Bird, I am the glad owner of an electrostatic measurement gun (see figure 7). It was designed to measure electrostatic field strength in ESD environment, so ideally useable for my problem. Laying the old and new Bird next to each other, rubbing a little bit with my finger on their displays, showed immediately measure-able effects with the ESD gun!

figure 8: 0kV on the left Bird; more than 20kV on the right one!

My old Bird caused readings of up to 20kV/m whereas the new Bird of my fried behaved completely different: no significant fields can be measured here!

For me, this is the evidence for having definately a problem with electrostatic effects!

Sure, this can easily cause misreadings that could explain the observed measurement error.

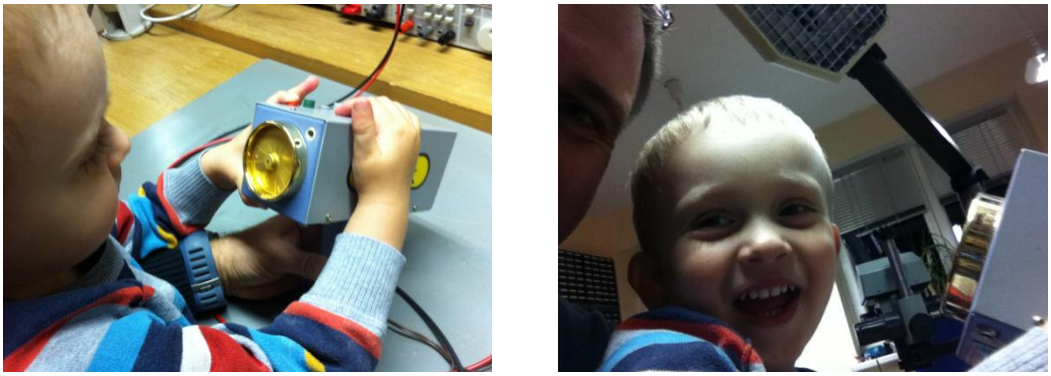

figure 9: my little boy is happy about the funny shutter disc turning around in the HighVoltage sensor

5 Disassembly

Well, this is THAT opportunity for me to crack the Bird4311 open! As I removed the few screws, took the back cover apart, I got a first look inside. Oh dear! This Bird meter is THAT dirty and "worn out" inside, that I am really astonished, that the meter needle is -at least- still moving!

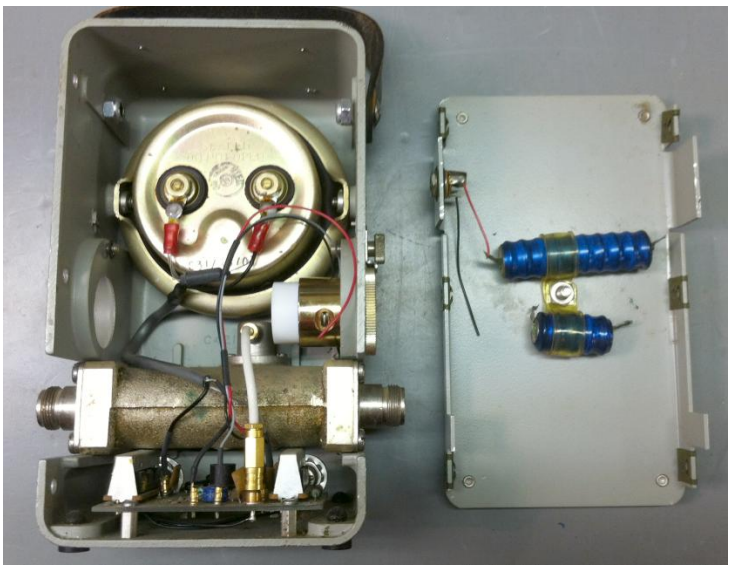

figure 10: crack this thing open!

I will learn later by the Bird engineers, that the 4311 model is minimum ++25 years old and the crusty appearance inside definately matches to this statement. For me it is clear now: if I somehow manage to repair/fix/change the old meter and get it working again, I need to restaurate the complete unit afterwards. The PEP-measurement extension PCB is currently not working- at least because of a cut power supply cable and defective NiCd accumulators. But one step first; we wanted to check the meter assembly.

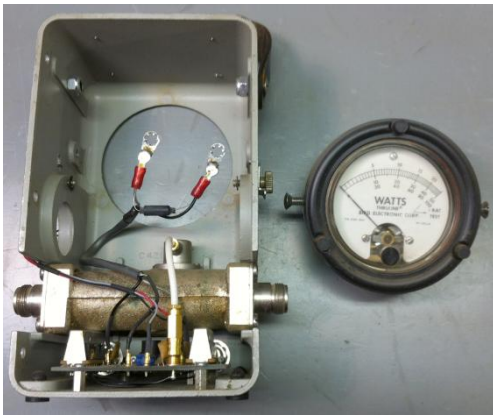

figure 11: meter separated from the unit

The meter itself is also easily removed after turning a few screws. Take care when removing the rubber ring beneath the display (plastic) glass and the frame, after this long time it got a little bit hard and can break easily.

As I had removed all the necessary parts, I took a non-magnetic gripper and bended the balancing part of the needle a little bit to provide a little more distance between the needle and the housing. So I most-probably successfully removed the "sticky" effect of the meter.*

* At this timepoint I thought that this was the potential problem of the sticky needle. I was probably wrong, but read further in this report.

figure 12: adjusting the needle mechanics

Then the electrostatic problem: the electrostatic effect. This was still reproducible and the plastic glass of the display turned out to be the main "charge collector".

plastic cover of the meter under test

ESD gun shows >2kV

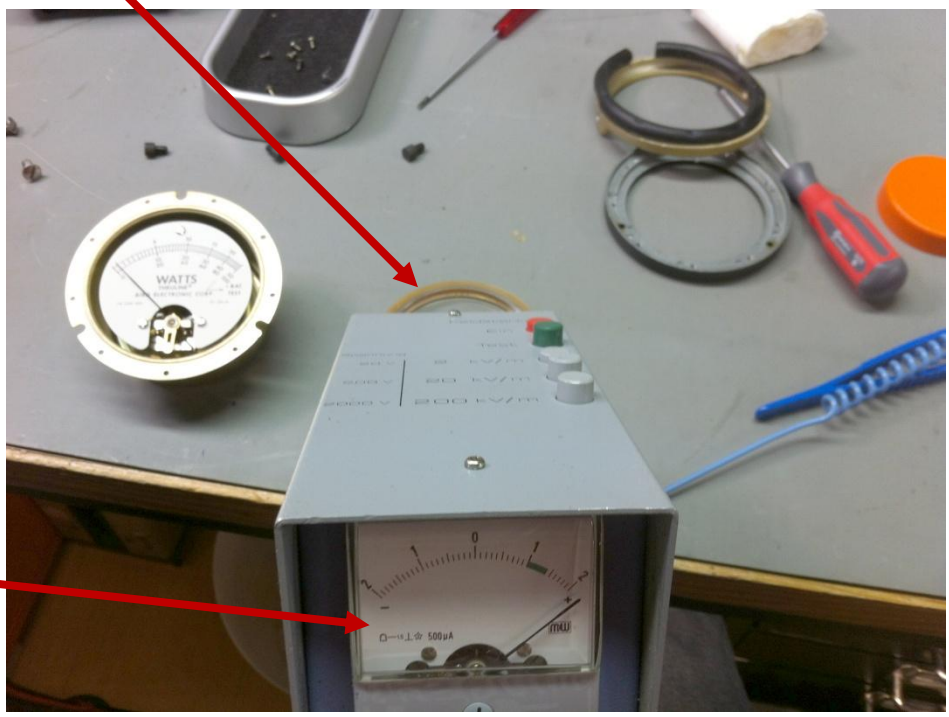

figure 13: examinating the meters's front cover

6 BIRD spare part

Frankly speaking, before I started any service on the meter, I tried to just replace it by a new one. So I checked in the internet and actually found a complete meter replacement unit for Bird43 meters. Don't ask me why, but I found it a little bit suspicious, that my model number (4311) was not mentioned on this replacement kit. First I hesitated to ask, but finally was encouraged by the statement "in case of questions just ask Bird sales directly", to write the Bird company an email, describing my problem: is the replacement kit applicable for my old Bird4311?

Honestly, I did not expect an answer to my question. Me as private user of equipment in the age of about 30years will not smell like "profitable business", so I had no expectations. But the opposite was the case: only a few hours later not less than 3 Bird engineers(!) replied to my approach- also involving their european colleagues.

Wow!

What a customer service! For a unit of ~30years you still get support from Bird, folks! That is great!!!

It turned out, that unfortunately the replacement kit is actually *not* suitable for my old 4311, so it was 100% a good idea from me to ask the experts first. But it was a very impressive thing to see, how intensively the Bird colleagues tried to help me. That is worth an honest "Thank you" for that.

7 Meter repair

So at the end of the day, it looked like
a) I need to get rid of the nasty electrostatic effect somehow or
b) I need to throw the complete meter away.

Solution b) would break my heart, because this unit so well designed and rugged, that it is almost my duty to try the repair as good as I can!

Another friend of mine, who is very experienced with electronics gear (because he works in a professional calibration lab) gave me this important hint: ansti-static spray!

Well, I have heard about this kind of spray already before, but personally thought that this is voodoo stuff that does not really help, but only makes the manufacturer rich. ;-) But as I saw that there is also a detailed specification for this spray available where you can see values for typical resistance values over time, this sounds definately more than "magic"!

I ordered one of these bottles "Antistatik 100" (supplier: Kontakt-Chemie; is a german manufacturer). A few days later I made the ultimate try: I sprayed this product on both sides of the plastic glass of the Bird meter, as well as on the rubber grommet and the three rubber distance pieces (sorry for not knowing the correct english term for that).

First I was quite disappopinted as I could not measure any change of the resistance of the rubber grommet- even with an 1kV isolation tester. So I first expected "this was a fail", but nevertheless assembled the meter after the spray film in the display glass dryed out safely.

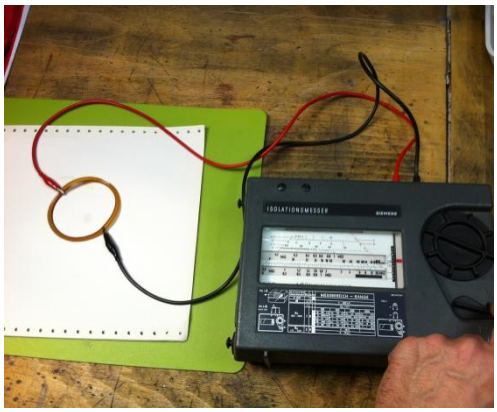

figure 14: checking the "Antistatik 100" spray with HV isolation tester

Then the surprise: like with the new Bird4304 of my friend, the ESD gun could not detect any ESD charge any more on my sprayed Bird4311 meter! Electrostatic effects were completely gone! Great!!!!


figure 15: ESD problems are gone after spraying the meter's glass with Antistatik 100!

8 Calibration

Encouraged by this great success, I made a final check using my DC current calibrator. The meter is supposed to be a 30µA full-scale meter and -indeed- the needle reached its full-scale at a current of exactly 29,6µA- this is about 2% error only! Again: great!

figure 16: meter check with DC calibrator

A bit pity is, that the watt scale on the meter is not linear so I cannot make more accuracy tests without knowing the transfer table of DC current and displayed meter deflection. Maybe it's something with the power of 2 (because of P= I^2*R) but I did not follow this up entirely.

I made spot-checks at 0µA (= zero position), 30µA (=fullscale) and 15µA whereas the needle optically met the middle of the scale quite good. So this 3-spot-calibration is supposed to be enough to confirm, that the meter itself might be still usable.

9 Meter disassembly

So I decided that this Bird 4311 unit is worth being restaurated entirely and took everything apart that I could find. Related to the straight-forward-design of the Bird43, this is very simple. Loose only a few screws and you can disassemble the whole thing within minutes! Great!

10 Housing

I started with the housing. This was really worn-out and many scratches and dells show a small glance at its 30years history. I need to lacquer is completely new, so I started with a piece of sanding paper, removing all the old painting. Before I started re-painting, I covered the rubber feet with an adhesive tape to prevent them from over-painting. You may ask why I make this effort and not simple remove the rubber stands for painting. The reason is simple: during the 30 years, the rubber became quite hard and rippy. If I would pull them out with

force of their fixing holes, I bet they would break. So I let them in the position they just are and protect them (only for cosmetical issues) with these strips.

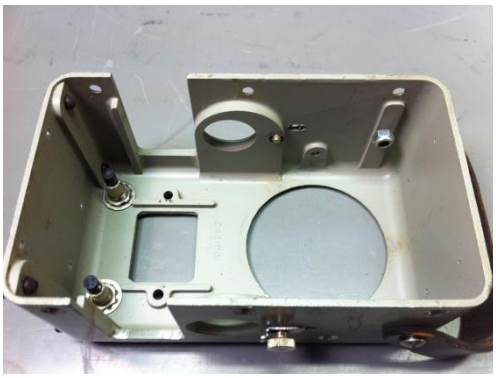

figure 17: housing, completely empty for re-painting

I take a spray bottle with undercoat lacquer for the first layer. As it turns out that the colour of this undercoat is already so close to the original painting, I decide not to use a finish lacquering, but just use the same undercoating as "lacquer". Grinding paper with a very small roughness in combination with water behaves like a "polish" and helps to get a really smooth surface. At least, I use a transperent protective lacquering for the finish. In total I put about half a dozen paint layers on the housing- each with individual water polish procedure.

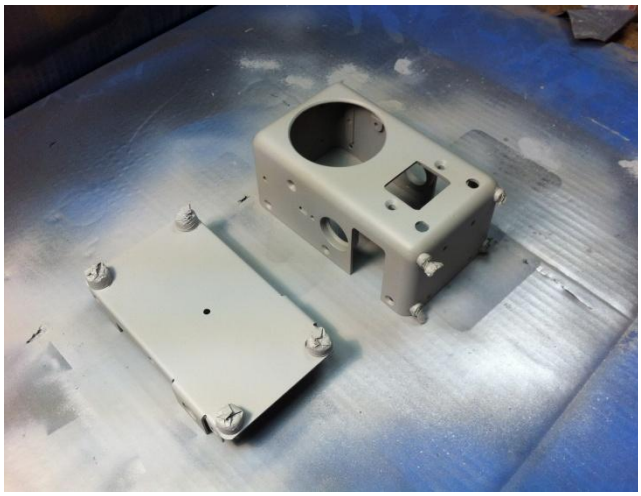

figure 18: painting is finished

The result is not too bad for a homemade job in the basement although honestly it does not meet factory quality. Ok, I can live with that. :-)

11 Assembly1

The finalized housing is a prerequisite for all of the next upcoming steps. First the reassembly of the refurbished meter is on the to-do-list. I have to take care, that the meter is safely attached to chassis ground, otherwise we could run again into the electrostatic trouble. To prevent us from that, I intensively sprayed the three rubber distance bolts with this Antistatik 100 product to guarantee good enough leakage between the meter and the Bird4311 housing.

12 RF Thruline

The RF block of the Bird is so rugged and solid, that it is made forever. Nevertheless after about 30years I think, that it may need some cleaning service. So I removed the two N connectors by loosing 8 screws. Doing so, you can see the silver transmission line, placed in two plastic (teflon?) discs.

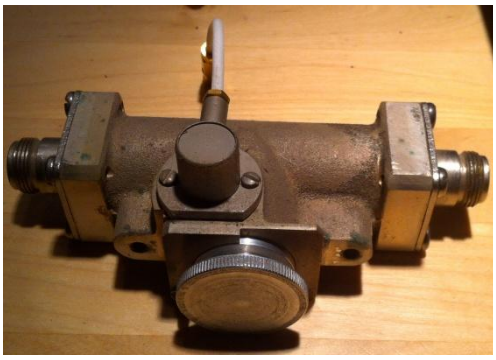

figure 19: the naked RF thruline element

You also can disassemble that! By pressing that thing with the push of a strong men's thumb, the parts will slide out of the housing. At the end, you will have two plastic discs, one transmission line and the housing. All RF conducting parts have a surface that reminds me of silver (that would make sense- silver is a very good RF conductor). Over the years, some crusty dirt came along. This does not match to the brandnew lacquered housing, so I will clean it.

figure 20: RF thruline element opened

I use a cleaner that was originally made for silver jewels (you can also consider the Bird43 to be a "jewel" somehow ;-)
My wife (who studied chemistry) told me that I have to take preventive safety actions, because this cleaner is supposed to cause cancer and also can damage your genetic code, so we have to take this serious. I wear plastic gloves and switch on the fume extractor that I have installed in my workshop.

figure 21: using chemical silver cleaner for the RF path

Simple toilet paper is nicely suitable to deploy the silver cleaner to the thruline element parts. Wipe it softly and observe how the surface gets smooth and shiny again. Don't forget to remove all of the residual cleaner afterwards, because normally the guy who just wants to measure RF power, will *not* wear protective gloves ;-)

figure 22: cleaning the rest; then re-assembly

I also disassemble the metal tongue that provides the electrical contact between the Bird43 and the inserted slug. Also here: no problems. Contacts get clean and nice. I clean everything as good as I can and then I put everything together again.

For the assembly of the thruline element parts you need a little bit patience, because everything fits so exactly and precisely together (no play!), that you must care not to twist it, because then you will not be successful.

At the end of the day I have a thruline element that looks like brandnew again, despite of its enormous age. That's quality, folks!

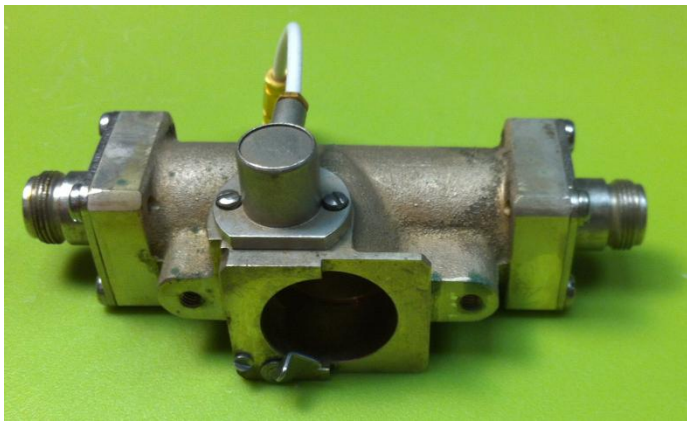

figure 23: RF thruline element- nice and clean now!

13 Assembly2

I continue with the assembly. The two switches (Battery check, PEP measurement) I can fix-ate using a long 13mm hexagon nut. The thruline element itself is locked by two big fat screws that are as solid as the rest of the Bird43. Now, the Bird looks quite complete already. But there is still something to come!

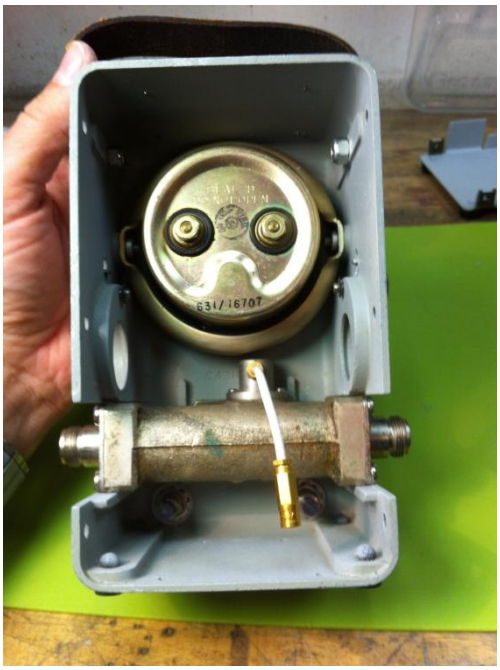

figure 24: Assembly

14 Electronics

Now comes a little bit of challenge: the electronics module! It is for PEP measurements; means PeakEnvelopePower. That feature is important for measuring the peak RF level value for double tone SSB or AM signals. Electrically it is probably something like a peak-envelope rectifier with a short attack, but a long release time. For this feature, the Bird43 needs an external power supply. And this is obviously defective in mine- first, one of the connecting cables is already broken and second, the battery back (NiCd accumulators?) is also defective. I count 15 cells in series- with assumed 1,2V/cell we have 18Volts in total. That does perfectly match to the picture of newer Bird PEP measurement kits which are using two 9V-Blocks as power supply (2X9V = 18V).

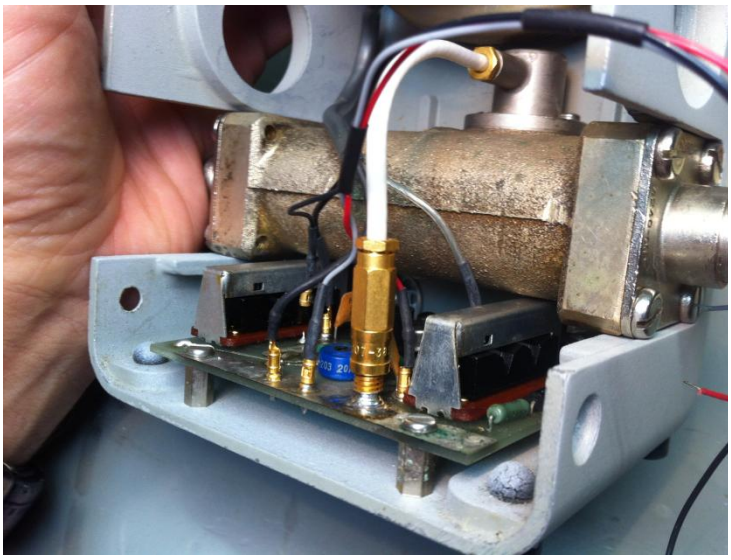

figure 25: the electronics for PEP measurement

Because of the unusual shape factor of the internal NiCd accus, I decide to replace them by two ordinary 9V-Blocks- the same way like Bird did with their newer wattmeters.

But first I have to take care for the PCB itself. It is very dirty, so the first thing to do is to clean it with a brush and compressed air. Then I have to do something with the SMB jack, which is directly soldered onto the PCB. Don't ask me why, but the metal surface of this jack looks very "worn out". Normally this connector is plugged only *once* in the factory to connect the Slug's detector output to the PCB. But this one looks like somebody would have plugged it in and out a couple of hundreds of times. Cannot understand that.

Anyway, this connection has properly to by repaired, because any contact problem at this point results in an additional measurement error of the complete meter! So I simply replace the SMB jack by a new one and solder it briefly to the PCB.

The same for the switches, although they seem to be gold plated and in much better condition.

Unfortunately I couldn't find any schematics in the internet, so it would be not so easy to repair in case of errors in the circuit.

15 Barcelona

Nobody would expect a holiday picture in a technical report about RF measurement, so at least that is the reason for me to do exactly that :-)

figure 26: Barcelona view

Especially for my foreign readers it may be interesting to see something nice from good old Europe. One of the most impressive things I've been to is Barcelona (Spain). The artist "Gaudi" with its "organical" looking art pressed his individual pistil into the face of Barcelona. I have to confess that during this single week in this city I spent almost all of my money for entrance fees of Gaudi architecture stuff and Jazz music CDs made by Barcelona street musicians.

figure 27: left: one of Barcelona's street musicians in a park; right: me watching at this amazing city

In case you are interested in culture, art and music, Barcelona is definately worth a visit.
In case you are interested in RF measuring stuff, I propose to proceed with reading this report :-)

16 Test

Now let's do the test. figure 28 shows the complete setup. Using a 2m as well as a 10m amateur radio transmitter as RF power source, I connect the Bird4311 and the Bird4304 of my friend in front of a 50ohm power attenuator. In front of it, a have my R&S URV35 powermeter with its sensor head which I use as my reference. The output of the power attenuator goes to the RF spectrum analyzer for analysis of harmonics and sidebands. The R&S UPL I use as AF signal source to drive the SSB transmitters with modulation.

The electronics PCB of my Bird4311 is supplied by 18V DC coming from a regulated power supply. After pushing the PTT button on my transmitter, I compare the Bird4311 RF power readings between CW and PEP mode.

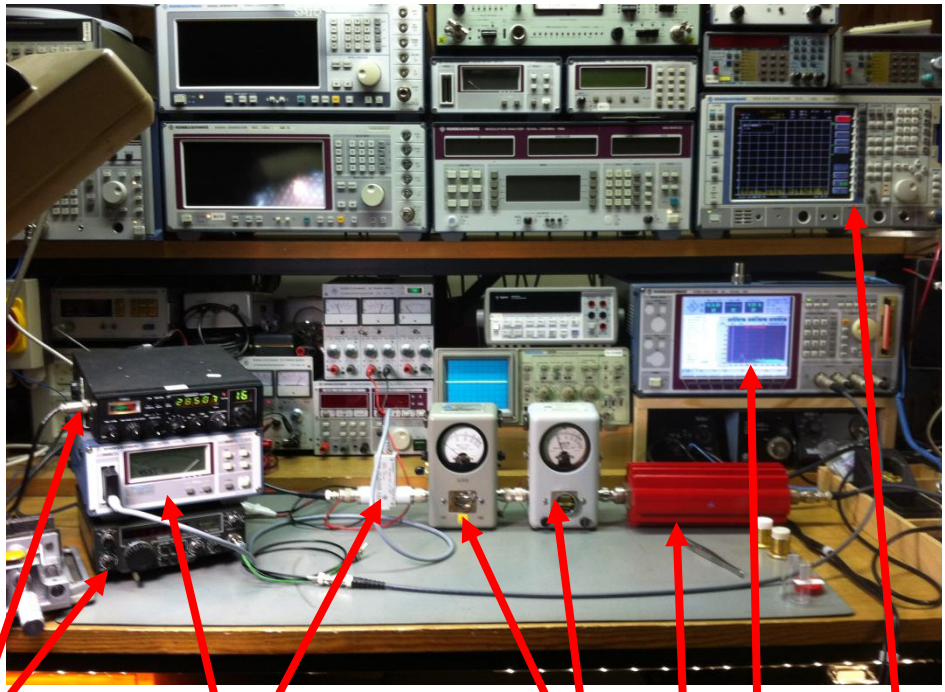

figure 28: calibration setup

During normal FM modulation, both should be exactly the same, because the RF envelope in FM is almost constant (as far as I know in physical theory it actually isn't, but this is neglectible here). And after a small adjustment of a trimpot in the Bird PCB I can achieve that! Great!

Then the second test; switching the transmitter to SSB modulation, feeding it with a 1kHz sinewave tone. Also here both readings are supposed to be the same. And they are!

In the third test I modulate the transmitter with a doubletone modulation generated by an old HP8904 arbitrary generator. And that is what the Bird4311 PEP-Detector is made for: he still

shows me the correct peak RF value whereas the normal Detector reads wrong values in this case. So obviously the electronics PCB still works fine! That's really good news.

17 Precision

Normally I could finish this project now just by adding two 9V battery holders in it and close the housing. For hobby issues that would be ok, but as I said, that we are going to use this unit for our official amateur radio exhibition's test station, I need to check the measurement precision- as good as I can.

So - as already shown in the setup photo in figure 28- I make another test, using the Bird4304 from my friend as well as my Rohde&Schwarz URV35 with 100V sensor head to compare all the readings. As said before, I use my amateur radio transmitter as RF power source for this test. I use SSB modulation because with adjusting the 1kHz AF level of the modulation, I can vary its RF output power. That is needed as I not only want to check one single spot on the meter's scale, but also several values between min and max values of the scale. Because of its linear nature between AF modulation and RF power, SSB Modulation is quite good useable for that.

17.1 A few things to think about

In real world, using SSB modulation for power calibration unfortunately has also some ugly effects that you need to be aware of: a) supression of the carrier and b) linearity performance causing AF distortion! What do I mean with this?

The problem is simple. Single sideband modulation with a single 1kHz AF tone has in theory only one single peak in the RF spectrum visible. Unfortunately my ICOM IC260 amateur transmitter does not produce SSB modulation with ideal performance (as all other transceivers on the world will also not do ;-) . On the spectrum analyzer you easily can see several peaks:

- the 1kHz USB tone itself (=USB peak)
- the "surpressed" carrier
- harmonics of the 1kHz AF tone (= USB harmoncis)
- the "surpressed" LSB peak

As the Bird4311 is a wideband powermeter, it detects ALL of the transmitted peaks - not only the desired one (=USB peak). As long as the headroom between the main USB peak and its neighbours is big enough, this is no problem and the influence of the "dirt" peaks is negectible. But I discovered, that with RF power >8Watts, my IC260 produces more and more "RF dirt", resulting in a misreading of the RF power.

You can discover this not only on the spectrum analyzer, but also on the Bird43 itself: if the "normal" and "PEP" measuring mode causes two different readings which differ from each other, this may be a hint for a "dirty" RF spectrum. (Note: only when modulating with a single 1kHz tone!)

To confirm my observation, I made a small math check. At RF power >8 watts I observe that some of the "RF dirt" grows to values to almost -20dBc only. You need to know, that multitone peaks in a RF spectrum add geometrically with the power of 2 of their voltages. Means: two RF signals with 0dBm each will cause a RF power meter to display +3dBm (=double power). If we calculate this in reverse, you will discover, that a single RF peak with a power of 20dB below the main carrier already causes an increase of the total power of ~1%! One percent is a value that you must not neglect when you are checking a power meter with an uncertainty of 5% only!

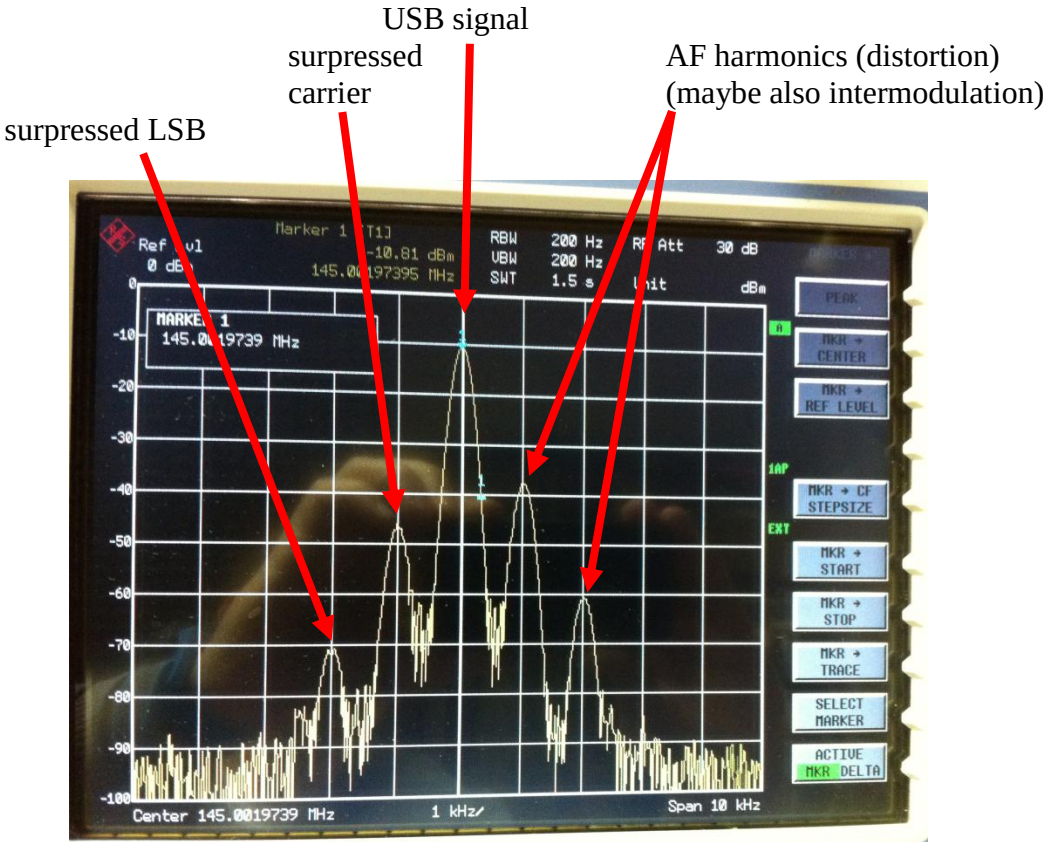

figure 29: RF spectrum of a real SSB signal

The more RF "dirt" peaks you have, the more ugly it gets. As an example: if you have two "dirty peaks" next to your main signal and want to be sure that their influence oo the total %error is less than 1/100; each dirt peak is only allowed to be not greater than 36dB below the main signal!

P1= 0dBm (= desired main signal)
P2= -36dBm (= 1st dirt signal)
P3= -36dBm (= 2nd dirt signal)

Psum =P1+P2+P3 = +0,00218dBm
= 0,05% of the main signal P1

which is about factor 100 lower than the specified uncertainty of the Bird4311 (5%).

So if you want to be sure to keep dirt small, you need to provide a very clean RF power signal. Unfortunately this requirement will by violated during my test with RF power output greater than a few watts already, limiting my precision in test capability.

18 Test (proceed)

Ok, at least we have now a clear view on the things that we have to take care about during calibration. As AF generator I use my Rohde&Schwarz UPL audio analyzer. To prevent the transceiver from excessive overdrive (see text above), I check the (attenuated) RF waveform permanently with my Rohde&Schwarz FSEB30 spectrum analyzer. Let's go!

Frankly speaking, I expected this to be much easier. Not only the RF transmitter changing its RF output power as it warms up very quickly, I detect another problem of my Bird4311 meter: the repeatability of the measurements is awful! Switching the transmitter on and off for a few times, I get readings varying of more than 10%. Interesting: when I tip gently with my finger on the Bird4311 during measurement, this small mechanical vibration is already sufficent to move the meter's needle forward a few steps on the RF scale. Damn! We probably still have a "sticky" meter- or at least a meter with too much inner friction.

In order to evaluate if my assumption is correct, I make several checks. First I compare the readings with the new Bird4304 of my friend. Here, the repeatability is much, much better. The needle stops every time at the same position- as I would expect it. Also my URV35 meter shows roughly the same values.

figure 30: ~ 5,4Watts shown on Bird 4304 (left) and my Bird 4311 (right)

I swap the two Bird's in the RF signal flow order to exclude possible contact problems that could cause a non-stable RF reading. Result: no change. And this is additionally confirmed by the spectrum shown on the RF analyzer: the bad repeatability definately has something to do with the old Bird4311 itself.

In the last step I finally measure the DC voltage across the meter's connecting pins (to exclude a bad RF slug to deliver bad values). Result: the voltage across its pins is also almost the same, so there is only one thing left as root cause: the meter of the Bird4311 has too much friction for its easy needle movement! Oooouuuh... :-(((

19 Disassembly of the meter

I conclude that the test obviously was worth every minute. It turned out a (partly) sticky meter, but also something positive: if you allow the user to tip the meter with the finger gently a few times, the readings itself is within its 5% tolerance and also in line with the Bird4304 of my friend. The Slug itself tends to read a little bit low, but still within tolerance and as this is on both Bird meters the same, it is no effect of the Bird's, but one of the Slug only.

The PEP functionality obviously works, and it is very interesting to see how SSB distortion effects of even -20dB peak below carrier already lead to a small, but noticable difference between CW and PEP measurement mode. PEP function is definately a senseful feature of a RF wattmeter.

Note: Distortion of an 1kHz AF signal in SSB modulation can be seen in RF spectrum as additional peaks to the (surpressed) carrier that are 2, 3, 4 etc. kHz away from it. Compare to figure 29!

20 Meter service no.2

As a replacement meter for my 4311 is not available (remember the info from Bird USA), I need to have a look to it by myself again. I am not really sure if I even have a small chance to fix it, as an increased friction in such meters can have many reasons. Some dirt may have intruded into the bearings or the magnet's moving area, the needle may touch the scale somewhere, the axis of the complete coil package may be dis-aligned, and so on. But as I have nothing to loose, I'll give it a try.

I unscrew the display out of the housing again, remove the holder ring and finally unscrew the display "glass" with its metal holder. Then I recognized, that the complete meter assembly can be pushed out of its shielding, if you just press the two tapped bolts (=the connecting pins) with a little bit of force from behind. The complete inner meter assembly comes out and so you can see the details much better than before.

figure 31: service-ing the meter (again!)

Sorry for not having made any photos of that- my little 2,5years old boy was so interested to see my repair that I was 100% busy to prevent him from getting Daddy's servicing tools stucked into the meter assembly somehow ;-) I needed both of my hands to control this situation- no capacities left for operating a photo camera in addition :-)

With the help of my Fluke 5100B calibrator as precision 15/ 30µA source, I observe the needle's movement. Obviously full scale deflection is not the problem, but -as expected- it still needs a few fingertips to reach it. Before I start to de-solder the VERY sensitive moving coil assembly, I try it with the easiest thing first: a new mechanical adjustment of the moving coil. This can be done with the help of two small screws- one on each side of the needle's axis.

The correct adjustment is comparable with the adjustment of the bearings of a bicycle's wheel: if it's too tight, friction is too high and the wheel will not run easily. But if it's too loose, it gets too much play and the wheel will start shaking. The ideal adjustment is exactly between these two settings and quite difficult to meet: adjust the bearings in a manner, that the wheel will not shake, but still turns around very easily.

It's the same with the moving coil of the meter. But in addition you need to keep an eye on the vertical position of the coil and its needle! If you don't get it centered 100% correctly in Y-axis also, the needle will hit the scale somewhere, or the balancing weights (=the opposite side of the needle) will touch the housing, or even the moving coil itself will leave the magnet's gap position and hit the magnet somewhere. This vertical position along the axis has to be found- and additionally adjusted to correct play and friction. That is not easy, folks!

A little top tip from me: start with the vertical alignment first and verify with a good magnifier glass, that the moving coil is roughly in the center of the magnet. Means: equal distances of the moving coil to the magnet limit positions on both sides.

Top tip no.2: To check the play, touch the coil very softly(!) with a non-magnetic tool (plastic tweezers or a simple wooden stick, e.g. a match) and observe the possible play along the axis. Correctly adjusted you can see almost no possible play with your eyes, because it is usually about 0,1mm only.

You can check this also with blowing the needle "gently" with your mouth: if you can blow it across the whole scale from min to max deflection and it gets not stuck somewhere, you are supposed to be not too bad. If it gets stuck, search for the reason. Is it a problem in the vertical center position or just too strongly adjusted bearings? To correct that, tweak the little bearing screws on both sides of the meters' unit.

I needed a few tries, always checking with 30µA source, fingertipping and mouth blowing. At least I actually found a setting where exactly 29,6µA were sufficent for full-scale deflection and additional fingertipping did not change the value anymore. Wow- if this performance could be maintained after re-assembly, that would be great!

21 Re-assembly

And yes, it did.

The same test environment like described above, caused the meter's needle to show the correct value- AND (!) fingertipping does not influence the reading any more. Re-adjustment successful! :-)))

Okay, perhaps this performance cannot be maintained for all the time and under any condition (humidity, change of temperature, vibration during transport, etc.). But this is all what an amateur like me can do. De-soldering the springs, removing the moving coil and re-sharpen the bearing (probably a saphire tip going into a small trough; like the bearings of a christmas pyramide (hey, do you know this candle-driven, rotating pyramides in the USA?)) would be far beyond the possibilities of a private electronics tinker. And the achieved result of this 30years old meter is not too bad, I think. Maybe not perfect, but -in any case- much better than before.

22 Give it an end- please! ☺

The final calibration is one of the last steps that I do with the "Birdie". Although I have to admit that for precision lab measurements I will still use my URV35 and its frequency- and temperature compensated precision sensor heads, the Bird4311 with its PEP capability is THE ideal and robust power meter for outdoor usage and "go / nogo"-Tests that we are doing at the INTERRADIO exhibition. With its simple looking, moving needle on a black and white paper scale even "worst-case"-customers ;-) do normally trust the reading, because they are familiar with moving coil meters. I sometimes see that -especially- older amateurs sometimes the modern instruments are suspicious to them. They usually prefer the old, analog style equipment where they can see the needle moving around :-)

23 Batteries

I order two 9V block battery holders from my local electronics store and place them in the back plate of the Bird. To comply with the rest of the good quality (and to avoid falling apart during vibration), I mount them safely by using 6pcs 2mm panhead screws. I renew the complete cabeling for the power supply. Then I assemble the complete unit.

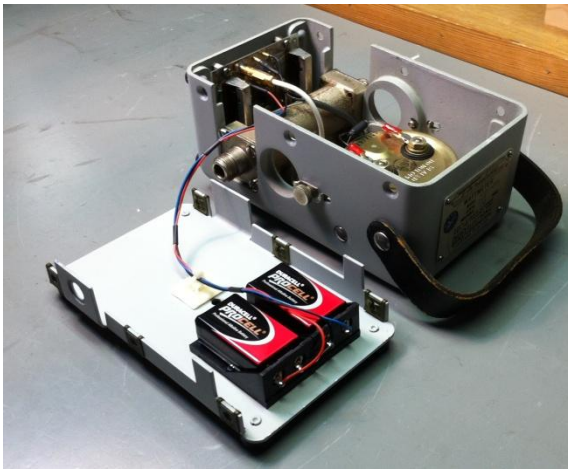

figure 32: fitting the Bird with two 9V standard batteries

24 Final finish

I thought already "that's it", then I discovered that I had accidently over-painted the printing for the two operating knobs for the peak meter. I made very good experiences with self-adhesive laser printer films. They are cheap, and you can get them in almost any paper store. If used MS Word and the style "Calibri 11" to reproduce the letters for the printing ("+BAT.", "TEST", "PEAK" and "READ"). This text style looks very, very close to the original. I print it to such a self-adhesive foil, cut it with a simple cisors and place the four words to their original places. Great! Looks good!

In the "winner photo" of the finished Bird4311-200, you may also see an additional text that I placed to its front. It shall remind the user not to forget to place batteries inside first before using the peak meter circuit! Normally the Bird has a set of internal NiCd-accus, charged by a 3,5mm jack in the side. As you can read above, I decided to replace them by two normal 9V batteries- like Bird also did in their newer instruments. So the "charge"-jack is now without function, as there is nothing to charge inside any more. I thought that this was worth a small notice on the front.

figure 33: it's done! :-)

A selfmade, wooden slug holder completes my Bird powermeter project.

FINISH! Ready! Yes! :-)

For me, this was a really nice project to do. I learned a lot again, and am very impressed by the good quality design of this Bird wattmeter. Sorry to you guys from sales, as I was able to restore this unit, I probably will not need a new one for the next years. But I promise: if it may fail somewhen in the future (and only if it fails earlier than "me", what I am not 100% convinced of;-) then I will buy a Bird wattmeter again! My promise! :-)

Thanks for reading and best regards to all who share my nerdish interest for electronic test gear.

figure 34: Barcelona's streets during sunset

Disclaimer

1. If you follow the descriptions or techniques given in this report, please keep in mind: Any work that you do, is on your own risk!
2. This is a private report written by an hobbyist. There is no guarantee of the correctness of the report's content.
3. There will be no payments from my side, if the content of this report leads to any problems on your side (e.g. technical damage or injuries of persons).
4. Servicing electronic test gear can -at least- be very risky for persons without special knowledge and/or education, because it can cause serious risks for your safety! So if you don't feel 100% safe with what you are doing and are also not 100% up-to-date with electrical protective measures, I strongly recommend to keep your fingers away from it and ask a qualified technician to do the repair work instead of yourself.
5. This report is written for personal/private use only. It is not planned for companies to use this knowhow in a professional/business way.
6. If you read any comments or opinions (especially if they go about companies or manufacturers), then please take note, that these opinions are my subjective, personal one's which are basing on my own experiences or favorites. They must not be misunderstood neither as "commercials" nor as "blaming" someone. They are supposed to be understood as using my rights for writing my "free opinion".
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