Part #: ZCU104 Evaluation Kit
XILINX
AUTHORIZED DISTRIBUTOR Digi-Key ELECTRONICS
Description: Enables designers to jumpstart designs for embedded vision applications, such as surveillance, ADAS, machine vision, augmented reality, and medical imaging.
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Author Topic: Repair Datron/Wavetek 4910 Voltage Standard (Read 9875 times)

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zlymex
Frequent Contributor

Posts: 556
Country:

Repair Datron/Wavetek 4910 Voltage Standard
« **on:** March 03, 2016, 04:17:51 am »

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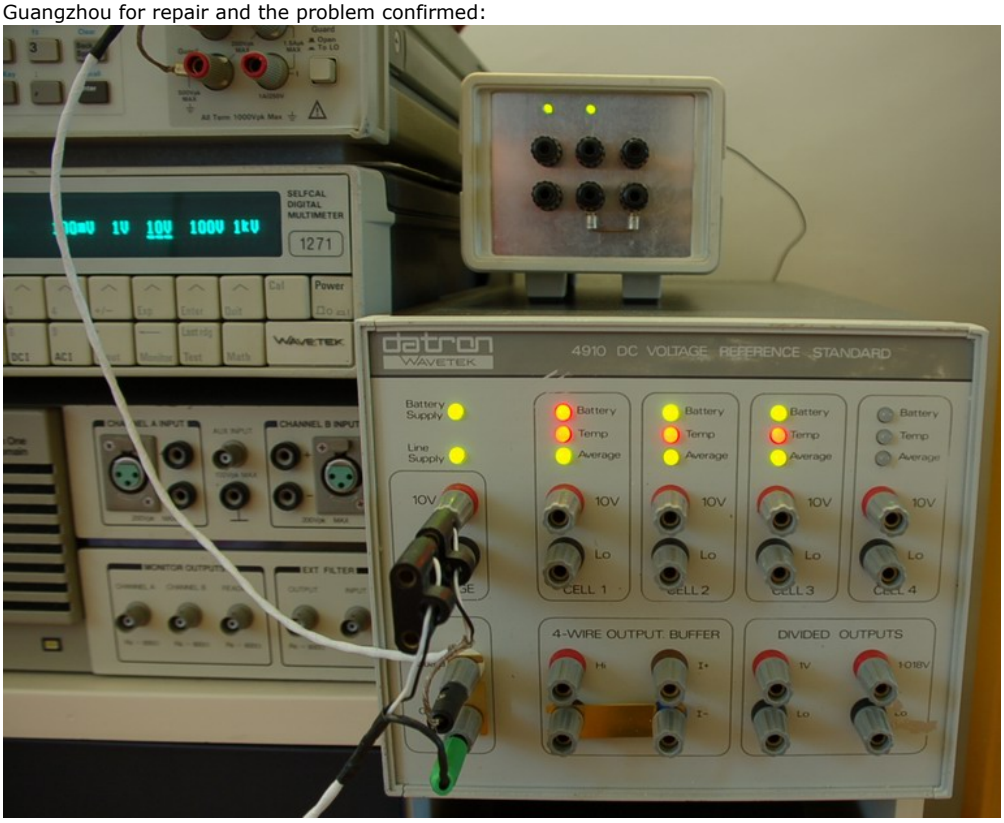
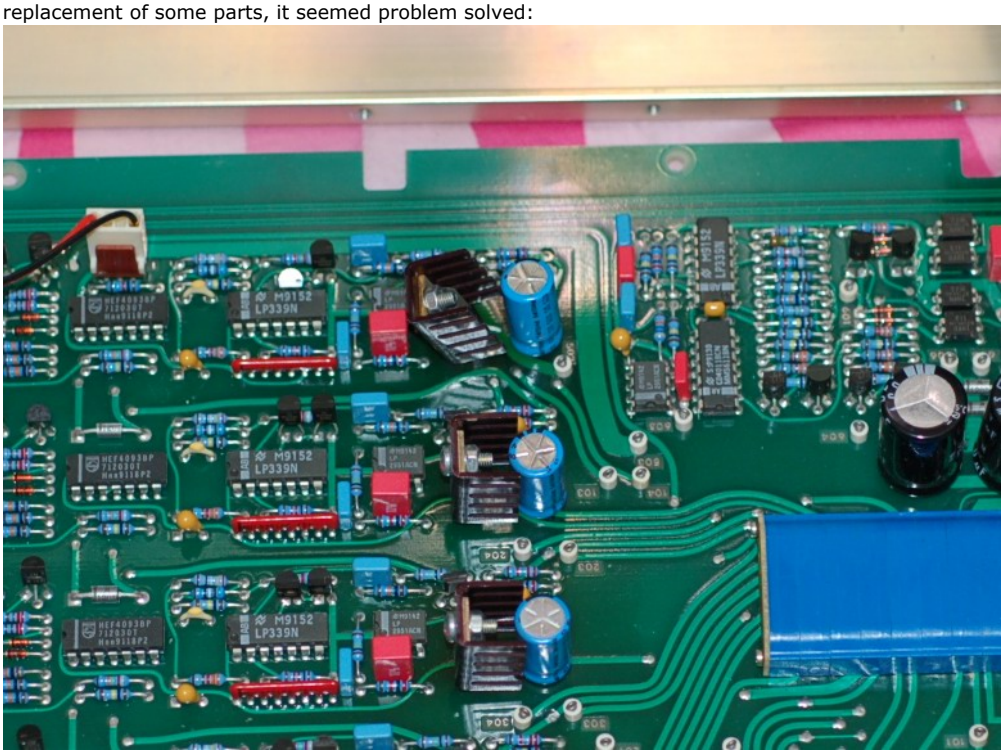
Hello fellow voltnuts, I had a very rare and interesting repair example that I'd like to share.
We(Chinese volt-nuts) once became very interested in Datron/Wavetek 4910 and one of us(who's nick name is grn for short) in Beijing bought a partially bad 4910 as shown by this seller's photo.

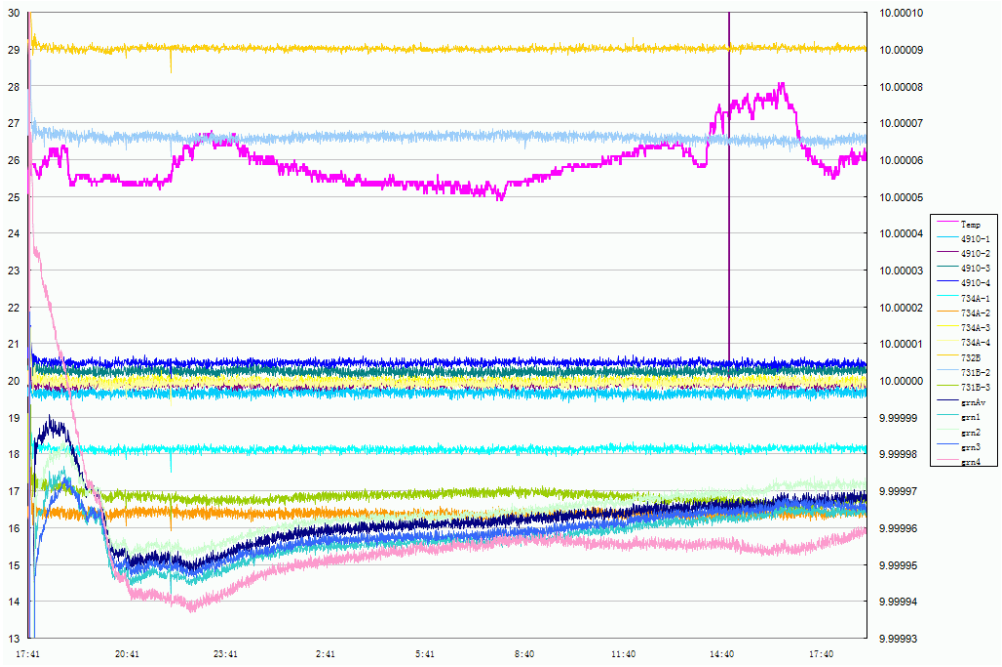
The thoughts was that the channel 4 may be a simple failure such as power supply. Even the 4th channel cannot be repaired, it can be used as a perfect tool to reverse engineering the PWM part and the rest of three channels are still make it a very good reference. He sent it to another one of us in Guangzhou for repair and the problem confirmed:



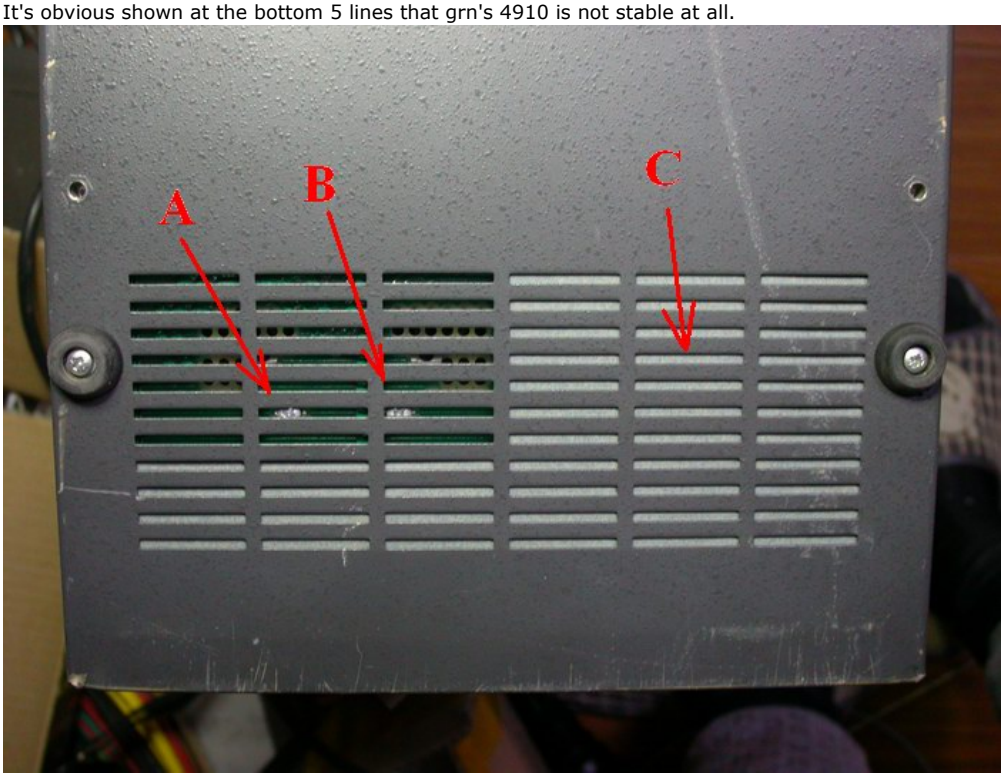
It was quickly find out that the 12V power supply of channel 4 was damaged(no output). After replacement of some parts, it seemed problem solved:



However, when he measured the output by 3458A/1271 and also against his own 10V standard, the drift/noise was much larger than expected. He cannot figured it out and sent to me for examination. I hooked it up to my own system(2-pole-by-17-throw DIY scanner https://www.eevblog.com/forum/projects/diy-low-thermal-emf-switchscanner-for-comparisons-of-voltage-and-resistor-stand/msg610769/ plus 3458A and my other 10Vs) and here is the result of 24 hrs test:

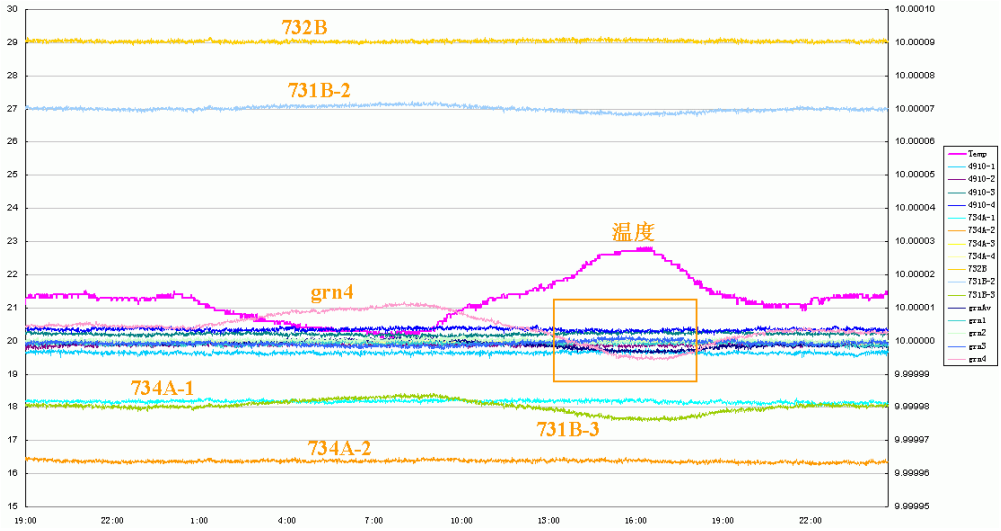


Measured by my 3458A in 2 second interval(NPLC=50), one cycle to read all these 17 references takes 17*2=34 seconds. There are more than 2500 data points for every reference.
Left vertical axis represents the temperature in degree C and the right vertical axis is the voltage in V. The purple line is the room temperature(sometimes I deliberately alter it by air conditioning or open up windows)
For each set of 17 voltage data, every data is first divided by the measured averaged output of my 4910(therefore it not shown on the chart) and multiply by 10. In this way, the drift and error of the 3458A is largely eliminated.
The figure of 10 may be slightly adjusted for different references to show them on the same condensed chart, but is a constant for that reference. I don't care about absolute values at this time. Also, when the measured reference is an 7V standard, I'll multiply by its nominal value(say 7.09876). In this way, it will show the relative performance all at 1ppm-per-horizontal-line level.
It's obvious shown at the bottom 5 lines that grn's 4910 is not stable at all.

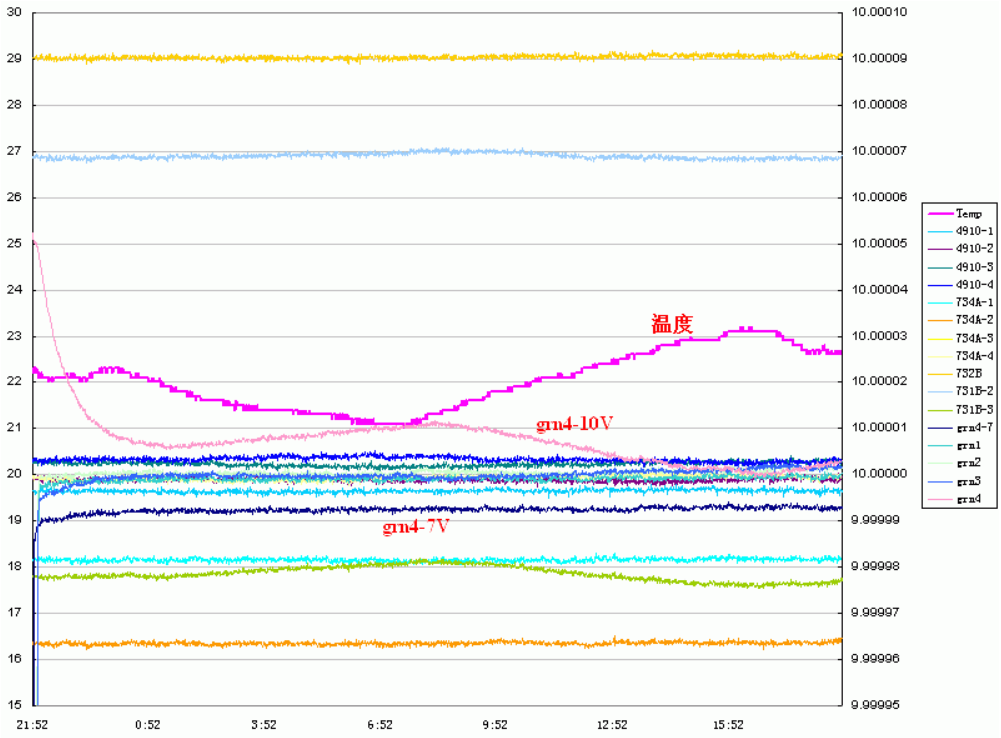


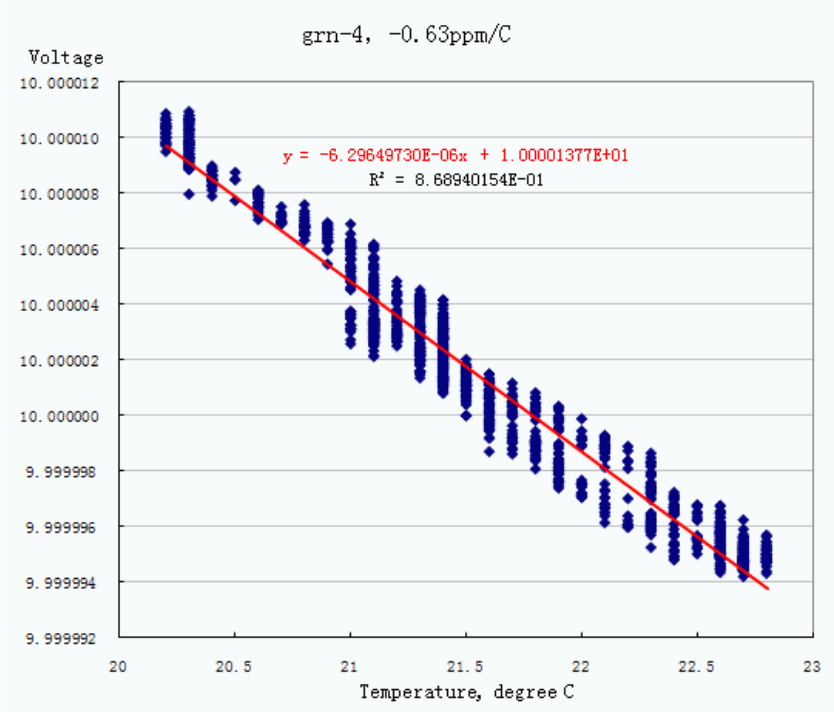
To my surprise when I looked it over, the case bottom unexpectedly deformed and shorted to two screws A and B which is internally connected to the common Low of all the output terminals. This was probably caused by ill handling during packaging/transportation. I regarded this as a design flaw because it has no insulation inside that portion of the case for ventilation, the two screws should be connected internally to case/ground rather than Lo. Guys if you have an 4910, check it out.

After the re-formation and insulation, I made another test of more than 24 hrs:

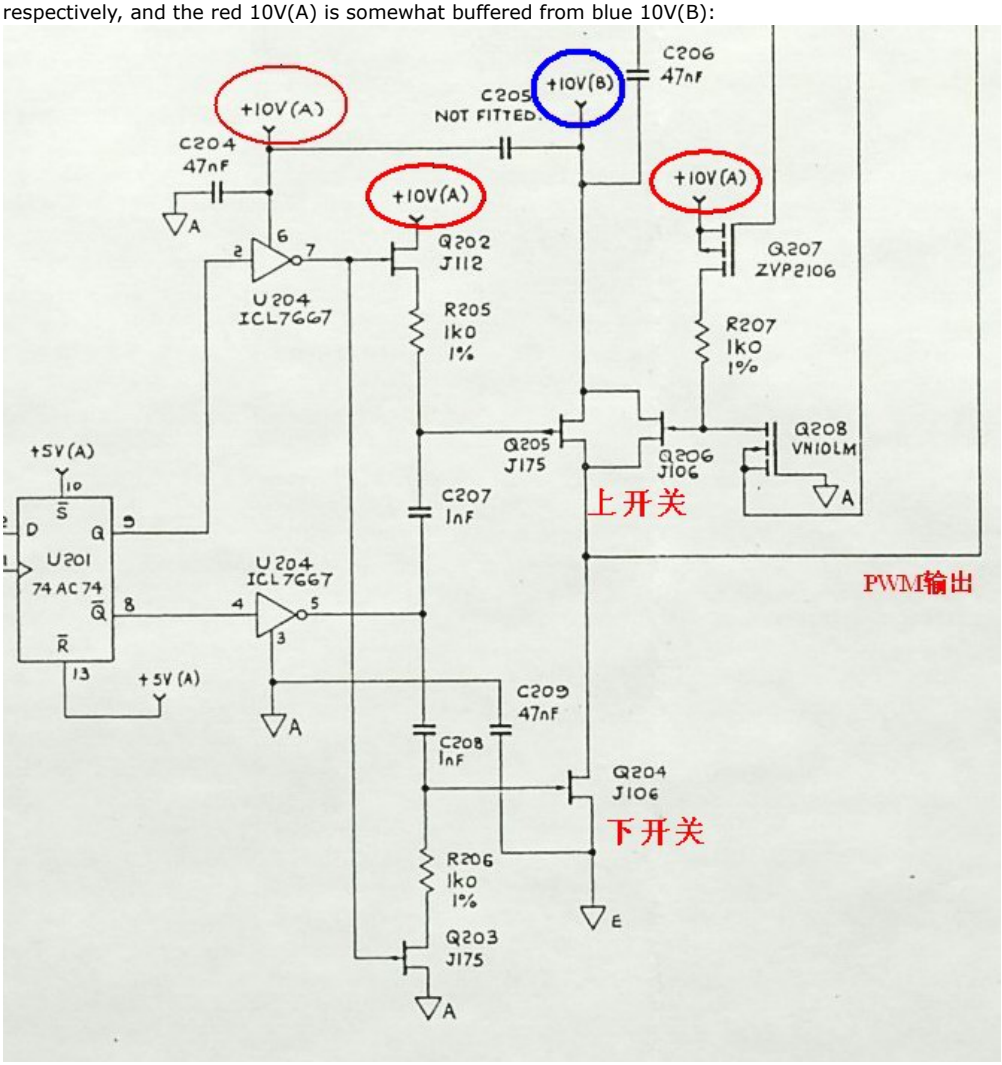


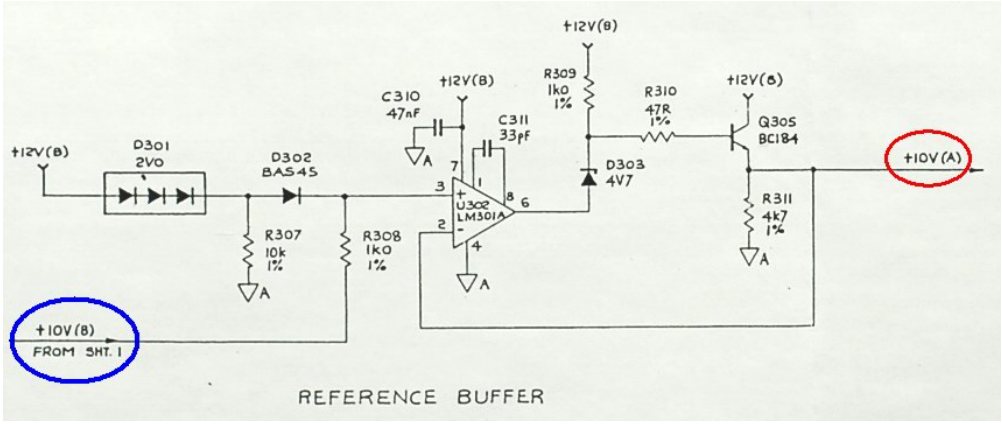
It seemed promising that almost every lines back to its track except channel 4 that apparently temperature related. Further calculation shows that it had a -0.63 ppm/C temp-co which was much larger than specified. I then located the internal 7V point and soldered a wire outside for measurement, here is the test result:





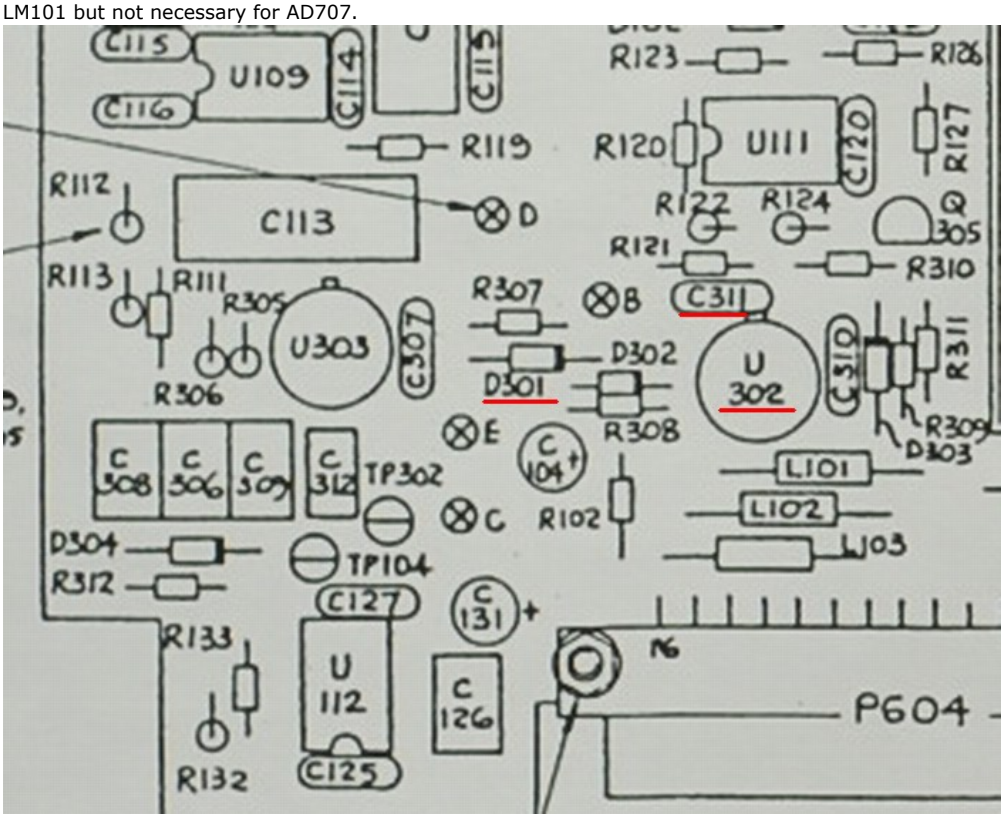
The 7V(marked by grn-7V) is perfect while the corresponding 10V is drifting with temperature, the problem must lies in the PWM section.
Looking at the servicing manual, there are two power supplies for the PWM circled with red and blue respectively, and the red 10V(A) is somewhat buffered from blue 10V(B):

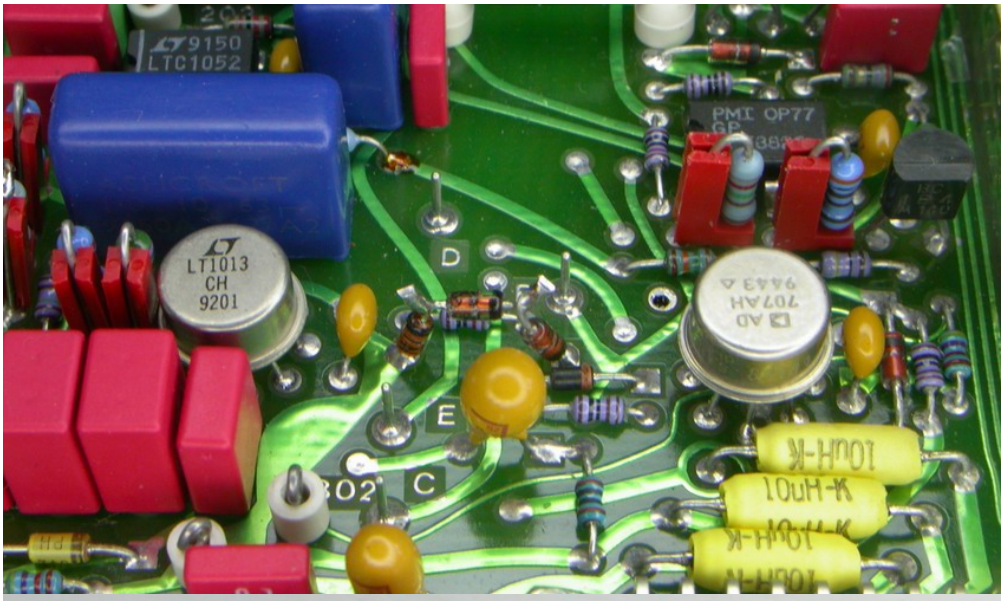




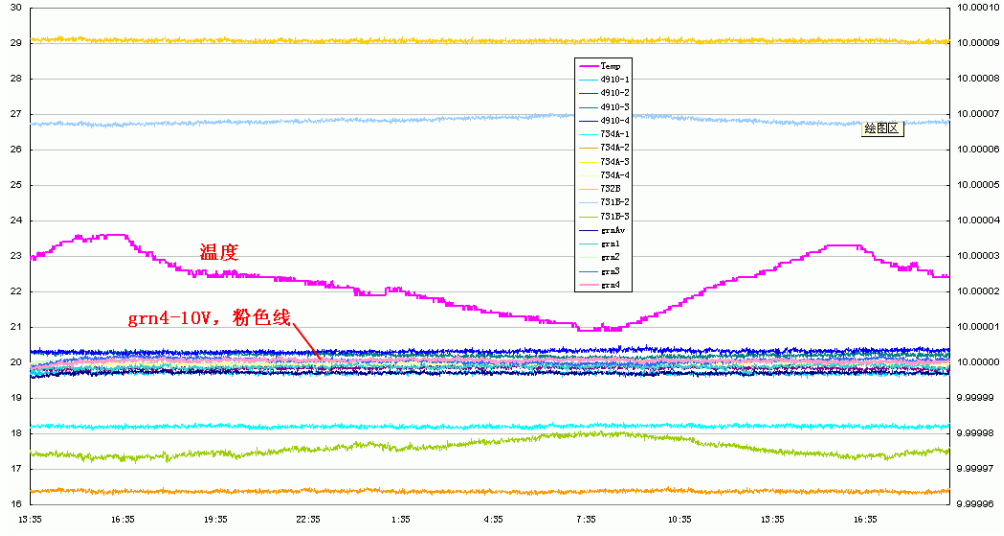
Again to my surprise, 10V(A) measured at 11.24V and changing all the time. I found out that D301 was shorted. Replaced it with three 1N4148 in series and the 10V(A) remained the same at 11.24V! I soldered another two wires to pin3 and pin6 of U302, the voltage of pin3 was 10.0V but pin6 was 11.9V. By this time I de-soldered the U302 and that gave me an even bigger surprise: pin3 and pin4 were crossed!

No wonder, the problem is inherent and no one even noticed after all these years. As Dave pointed out in his blog #727, this is the correct way to kill an opamp. Replacing this U302/LM101AH(yes, military grade) and C311 with an AD707AH(industrial grade) is straight forward. C311 is the compensation for LM101 but not necessary for AD707.



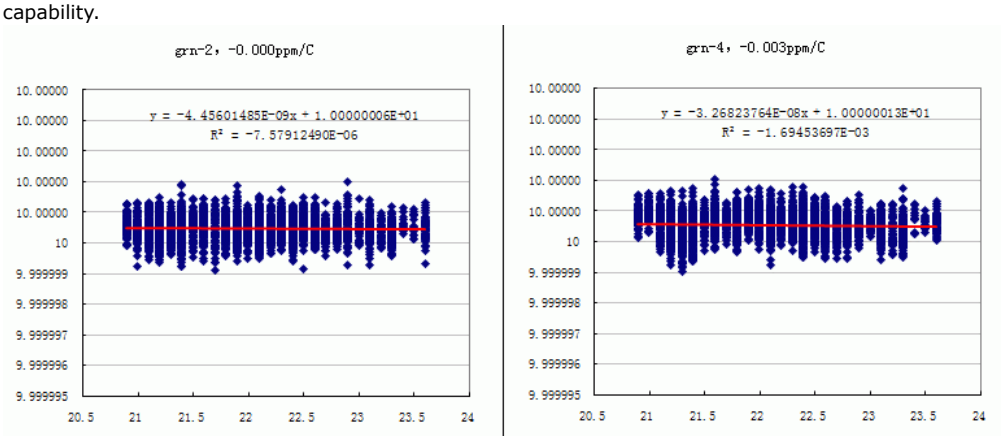


Although looked stable, now the output of channel 4 becames 10.00071V, 71ppm higher than nominal. After re-adjust ch4 to the average of the other 3, one more test of 29 hours:



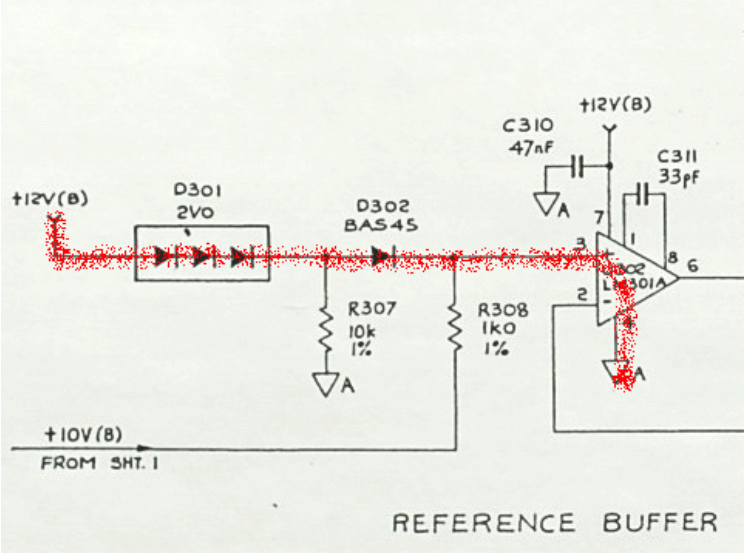
The light purple line is back to its track and so much for the repair. Temp-co is very small beyond my

capability.



Standard deviation of channel 4: 0.030ppm, that's great! This is calculated by taking 100 reading, each reading takes 2 seconds sample time and 32 seconds interval. This may regarded as the hint for low frequency rms noise(of the reference and 3458A combined). As a comparison, standard deviation of the averaged output is measured 0.025ppm, one of my 732B is also measured 0.025ppm, noise of one channel of 4910 is specified as 0.04ppm, 3458A is specified as 0.014ppm(NPLC=50).
Here is the photo of that 4910 being calibrated at NIM(looks lousy but is the top in China), It lives happily ever after.

Hypothesis:
1. When this 4910 was assembled in the factory, pin3 and pin4 of U302 was ill positioned and soldered on to the board
2. When powered on and adjusted to 10V at the factory, this channel 4 performed good regardless 10V(A)=11.24V either because Datron/Wavetek did not make extended test or the room temperature remains constant so they did not find out the problem.
3. When this unit shipped to the customer and powered up for a long time, there exist a quick path for current to go through: from 12V(B), through D301 and D302, pin3 to pin4(actually is pin4 to pin3, input protection diode) to the ground. Soon the D302 was overheated and shorted, This make the power supply overload and damaged some components resulting no output at all for ch4.
4. When my friend repaired the power supply, it burn that U302 down(pin4 through pin3 were opened).



btw, D301, D302 and R307 are used for starting up of the buffer and hence starting up the whole PWM section.

5. When I replaced D302, there are four diodes connected in series with -100ppm/C tempco for 10V(A) and resulting its PWM output with -0.63ppm/C temp-co.

Sorry about my poor English, not my mother tongue. Here is the specification of 4910:

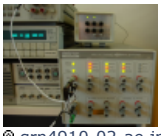
OUTPUT SPECIFICATIONS

	10V AVERAGE	10V CELL	10V 4-WIRE BUFFER*
STABILITY (±1°C), ppm			
30 days	0.3	0.3	0.3
90 days	0.8	1.0	1.0
1 year	1.0	1.5	1.5
TC (0°C - 50°C), ppm/°C	0.05	0.05	0.06
NOISE, 0.01Hz- 2Hz, ppm RMS	0.02	0.04	0.03
OUTPUT RESISTANCE	100Ω	100Ω	<100μΩ
CURRENT DRIVE	-	-	15mA
SETTING RESOLUTION, ±ppm	-	<0.1	-

LINE REGULATION: <0.01ppm for all power supply conditions

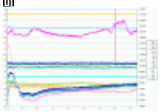
OUTPUT SHORT-CIRCUIT DURATION: Indefinite

grn4910-01-ebay.jpg (16.66 kB, 500x375 - viewed 4157 times.)



grn4910-02-ae.jpg (131.83 kB, 767x609 - viewed 4190 times.)

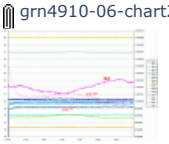
grn4910-03-pwr.jpg (180.25 kB, 777x564 - viewed 3906 times.)



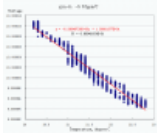
grn4910-04-chart1.gif (60.53 kB, 1024x680 - viewed 3795 times.)

grn4910-05-shorted.jpg (86.95 kB, 700x525 - viewed 3770 times.)

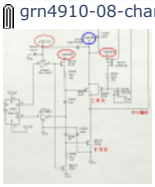
grn4910-06-chart2.gif (24.56 kB, 1112x586 - viewed 7081 times.)



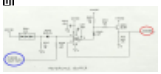
grn4910-07-chart3.gif (19.8 kB, 799x590 - viewed 3746 times.)



grn4910-08-chart4.gif (12.69 kB, 540x462 - viewed 3743 times.)



grn4910-09-PWM1.jpg (111.27 kB, 669x694 - viewed 3806 times.)

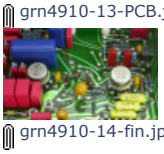


grn4910-10-PWMp.jpg (79.38 kB, 856x360 - viewed 3832 times.)

grn4910-11-X1.jpg (44.25 kB, 504x569 - viewed 3744 times.)

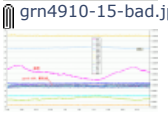
grn4910-12-X2.jpg (30.95 kB, 528x432 - viewed 3731 times.)

grn4910-13-PCB.jpg (140.05 kB, 702x554 - viewed 3720 times.)

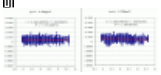


grn4910-14-fin.jpg (135.98 kB, 845x500 - viewed 3744 times.)

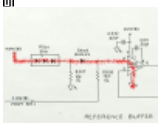
grn4910-15-bad.jpg (37.12 kB, 714x492 - viewed 3697 times.)



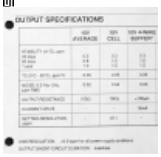
grn4910-16-chart5.gif (22.85 kB, 1043x559 - viewed 3645 times.)



grn4910-17-tempco.gif (17.36 kB, 769x316 - viewed 3618 times.)



grn4910-18-path.gif (77.62 kB, 481x359 - viewed 3696 times.)



grn4910-19-spec.gif (77.15 kB, 659x629 - viewed 3664 times.)

grn4910-at-NIM.gif (164.9 kB, 450x600 - viewed 3723 times.)

« *Last Edit: March 03, 2016, 05:22:25 am by zlymex* »

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TiN

Super Contributor

Posts: 4206
Country:

xDevs.com/live - 24/7 lab feed

Re: Repair Datron/Wavetek 4910 Voltage Standard

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« **Reply #1 on:** March 03, 2016, 04:35:46 am »

Highly appreciate you posting in here, as us, unfortunate people who cannot read chinese miss lot of great discussion for volt-nut topics over bbs.38hot.net, especially your countless threads. Me myself learnt lot of things just from looking at photos in those threads. Wish only to see more.

P.S. you can insert images in post directly by using [img]URL[/ img] with square brackets tag

P.P.S. perhaps we can see thread about 600A current source build one day?

« *Last Edit: March 03, 2016, 04:37:32 am by TiN* »

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zlymex

Frequent Contributor

Posts: 556
Country:

Re: Repair Datron/Wavetek 4910 Voltage Standard

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« **Reply #2 on:** March 03, 2016, 05:13:30 am »

Quote from: TiN on March 03, 2016, 04:35:46 am

> Highly appreciate you posting in here, as us, unfortunate people who cannot read chinese miss lot of great discussion for volt-nut topics over bbs.38hot.net, especially your countless threads. Me myself learnt lot of things just from looking at photos in those threads. Wish only to see more.
>
> P.S. you can insert images in post directly by using [img]URL[/ img] with square brackets tag
>
> P.P.S. perhaps we can see thread about 600A current source build one day?

Thanks very much for the compliment and encouragement, I have edited the images and now they are okay.

I'll for sure post more here. As for that 600A, progress is very slow, actually stopped for sometime. However, I'll start posting by small current sources such as 1mA, 100mA and gradually build up.

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Vgkid
Super Contributor

Posts: 2600
Country:

Re: Repair Datron/Wavetek 4910 Voltage Standard
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« **Reply #3 on:** March 03, 2016, 05:48:42 am »

Thanks for the post, very informative.
The smaller curent source will be very interesting.

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If you own any North Hills Electronics gear, message me. L&N Fan

quarks
Frequent Contributor

Posts: 834
Country:

Re: Repair Datron/Wavetek 4910 Voltage Standard
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« **Reply #4 on:** March 03, 2016, 06:05:49 am »

Great post and very surprising failure.
Thanks a lot for sharing.

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acbern
Frequent Contributor

Posts: 316
Country:

Re: Repair Datron/Wavetek 4910 Voltage Standard
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« **Reply #5 on:** March 03, 2016, 08:49:03 am »

That was very interesting information. I did notice on my 4910, after it was up for about one year, a drift of about 5ppm on channel 4 (compared to my other calibrated 732A ref.), the other outputs were good. I decided to leave it allone, to see if it will stabilize, and will do a formal verification when my 732A is re-calibrated soon, but now, I have the suspicion that I have the same problem. I do not want to take it appart at this time, as it is continuously running, so I would loose history, but I will do a temp check.

So a few questions:
Have you checked the other channels? Are they different (PCB version/number, wire switch on U302)? Such a switch in wires is not done by mistake, someone must have made this intentionally. Why? Any guess?

On another note, back then when I started to run my 4910, after a short while, a few voltages dropped out, PSU failure. I determined that it was shorted tantalums, which are all over the place in this unit. So I exchanged all of them against Oscons as i did not want to wait for the next to fail. This unit had been off for a while, and tantalums dont like that.

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zlymex
Frequent Contributor

Posts: 556
Country:

Re: Repair Datron/Wavetek 4910 Voltage Standard
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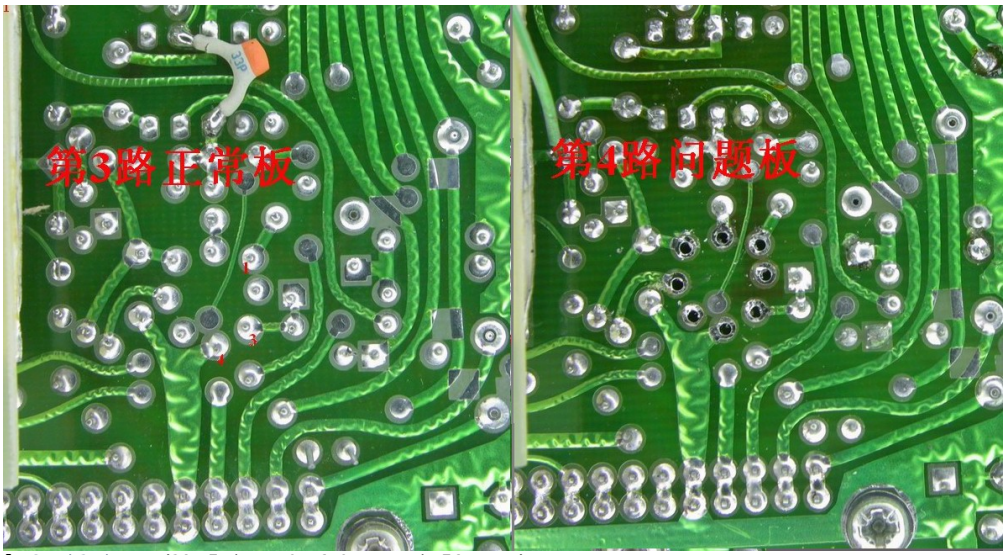
« **Reply #6 on:** March 03, 2016, 09:33:45 am »

Quote from: acbern on March 03, 2016, 08:49:03 am

> So a few questions:
> Have you checked the other channels? Are they different (PCB version/number, wire switch on U302)?
> Such a switch in wires is not done by mistake, someone must have made this intentionally. Why? Any guess?

Yes, I checked other three and they seemed all the same. I also examined other LM101AH to see if their pin3 and pin4 are switched, which are not. My best guess is that during the making of the board, many components(if not all) were hand inserted especially those with long pins. Its not unusual that human make mistakes to insert something in the wrong hole. Here is the comparison of the partial PCB for channel 3 and 4:



PCB-ch3-ch4.jpg (287.54 kB, 1191x649 - viewed 456 times.)

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krivx
Frequent Contributor
Posts: 763
Country:

Re: Repair Datron/Wavetek 4910 Voltage Standard
« **Reply #7 on:** March 03, 2016, 10:12:50 am »
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Very nice repair, thanks for sharing

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ManateeMafia
Frequent Contributor
Posts: 720
Country:

Re: Repair Datron/Wavetek 4910 Voltage Standard
« **Reply #8 on:** March 03, 2016, 02:02:45 pm »
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Thanks for the information. I too have a 4912 that has been on the back burner for repair.

Your pictures of your gear is always fascinating. Is that dewar in the photo used for any volt-nuts activities?

Your voltage references are begging to be placed on display similar to how Fluke has their 732A/B collection. http://m.eet.com/media/1158200/296800-fluke_metrology_figure3.jpg

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ManateeMafia
Frequent Contributor
Posts: 720
Country:

Re: Repair Datron/Wavetek 4910 Voltage Standard
« **Reply #9 on:** March 03, 2016, 06:40:27 pm »
Say Thanks Reply Quote

Thanks for pointing that out....

Report to moderator Logged

nidlaX
Frequent Contributor
Posts: 647
Country:

Re: Repair Datron/Wavetek 4910 Voltage Standard
« **Reply #10 on:** March 03, 2016, 10:38:08 pm »
Say Thanks Reply Quote

Great post, your English is fine! Keep showing us the goods, volt-nuts here can't get enough!

Report to moderator Logged

acbern
Frequent Contributor
Posts: 316
Country:

Re: Repair Datron/Wavetek 4910 Voltage Standard
« **Reply #11 on:** March 04, 2016, 08:29:21 am »
Say Thanks Reply Quote

So as far as my 4910 is concerned I did some temperature tests, and everything looks fine. I find it hard to belive that this reported swap of pins happened by coincidence. Normally, if that happened, the pins would not have been bent in such a special way as shown on the pictures so that they do not touch, it rather looks as if someone bent it intentionally, so I was concerned about a systematic issue, combined with the drifts I had in mind with my ch4. It turned out that my memory was wrong, it was

about 2-3 ppm back then, I had done a quick check with a Keithley 155. The drift of this channel measured now (with a 3458A) to my 732A is 1ppm in 1.5 years (so within spec), and about 0.2ppm on all other channels, which sounds pretty good. I will continue to watch it.

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manganin
Regular Contributor
Posts: 109
Country:

Re: Repair Datron/Wavetek 4910 Voltage Standard
« **Reply #12 on:** March 04, 2016, 12:33:39 pm »
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> **Quote from: acbern on March 04, 2016, 08:29:21 am**
>
> I find it hard to belive that this reported swap of pins happened by coincidence. Normally, if that happened, the pins would not have been bent in such a special way as shown on the pictures so that they do not touch, it rather looks as if someone bent it intentionally

Maybe there was a layout mistake in the first PCB version that was corrected by swapping the pins. And after the second PCB run they simply forgot to change the assembly instructions.

The Datron PCB designs were hand drawn (taped) until early 90's while their competitor Solartron used a CAD system in the 70's.

Report to moderator Logged

Theboel
Frequent Contributor

Posts: 269
Country:

Re: Repair Datron/Wavetek 4910 Voltage Standard
« **Reply #13 on:** March 04, 2016, 03:03:02 pm »
Say Thanks Reply Quote

Sorry Zlymex and everybody if I asking something not related to the subject but maybe its useful.
Is there any one can identify and give information what kind of cable in this picture use to connected the equipment.

grn4910-at-NIM.gif.jpg (164.9 kB, 450x600 - viewed 466 times.)

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manganin
Regular Contributor

Re: Repair Datron/Wavetek 4910 Voltage Standard
« **Reply #14 on:** March 04, 2016, 03:36:35 pm »
Say Thanks Reply Quote

Posts: 109
Country:

Quote from: Theboel on March 04, 2016, 03:03:02 pm

> Is there any one can identify and give information what kind of cable in this picture use to connected the equipment.

Looks like telephone cross connect wire...

Report to moderator Logged

zlymex
Frequent Contributor

Posts: 556
Country:

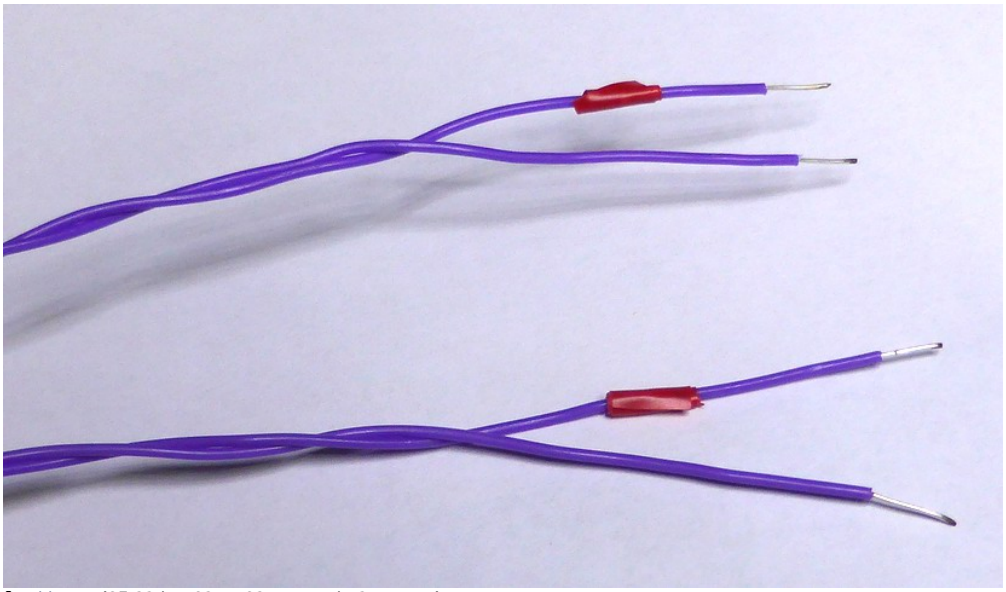
Re: Repair Datron/Wavetek 4910 Voltage Standard
« **Reply #15 on:** March 04, 2016, 03:50:44 pm »

Say Thanks Reply Quote

Quote from: Theboel on March 04, 2016, 03:03:02 pm

> Sorry Zlymex and everybody if I asking something not related to the subject but maybe its useful.
> Is there any one can identify and give information what kind of cable in this picture use to connected the equipment.

I'm guessing, the cable is silver/tin coated single copper wire of about 0.6mm in diameter, teflon insulated, two-wire-twisted(DIY), none-shield.



cable.jpg (85.32 kB, 827x483 - viewed 421 times.)

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