ALTERNATIVE CALIBRATION PROCEDURE FOR POWER AMPLIFIER MODULE A17 IN FLUKE 5100B/ 5101B CALIBRATOR

Fluke is recommending a special procedure for the alignment of the power amplifier module A17. Unfortunately, for my 5101B as well as my 5100B this procedure can only party be done as described. There are too many deviations between the official Fluke 51001B schematics manual and the "real" PCB that I have in my 5101B. It was probably made in 1987 (I derive that out of a date code printed on one of the precision resistors, that matches fairly good to the date "1985" etched in the PCB's copper). I believe, that the schematics provided by Fluke show the newest/latest revision of the 5101B and that I have an older model that provides some differences compared to the schematics.

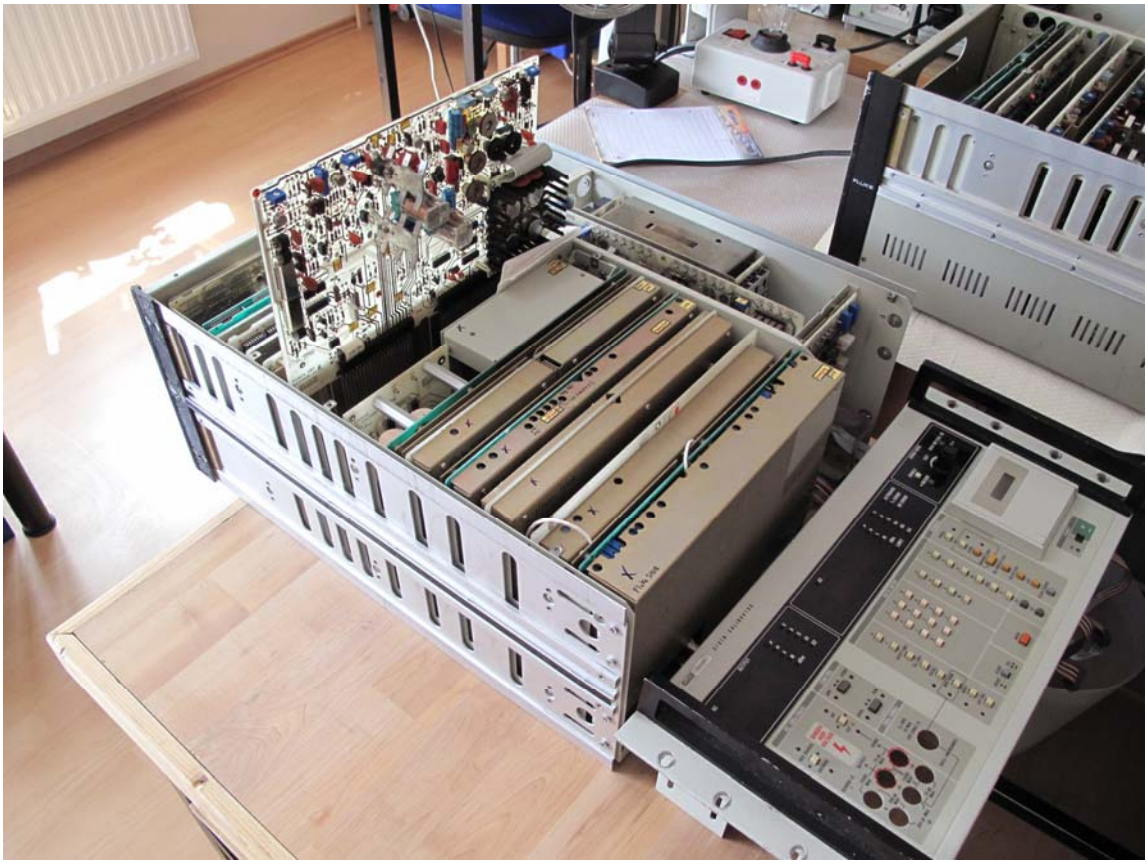

Figure 1: Module A17, slot into an extender card in an Fluke 5101B

In the original Fluke manual you can find the alignment tolerances for offset adjustments. Although this is will surely be correct from technical point of view, it is often not applicable in praxis very well. You can feel happy if you find a suitable DC voltmeter that has a DC resolution of the 10mV digit when applying a 30V RMS AC voltage. In my opinion it does not reflect the reality to request alignment requirements with tolerances of 500µV when you hardly cannot measure the 10mV stage. My recommendation: in this case just try to meet the "0mV" as good as possible and be happy about the result. ;-)

In order to align this old 1985 PCB, I suggest a deviating procedure which is like this.

DMM = Digital Multimeter; OPR = "operate"; STDBY = "Standby mode"

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1. Power Amplifier module (A17) block diagram

To get a first overview which points and logical units you will have to align, have a short look at this block diagram. Usually each amplifier stage has a device for the alignment of DC-Offset and bias current. Take note to follow the correct alignment order: it makes no sense to align the output stage unless you have not taken care for an undesired offset in the input stage.

So first check the VCA control voltage to be sure, that the voltage control loop mechanism has successfully locked. Then proceed with the loop gain factor adjustment.

After that, the HF-Amplifier -which is ALWAYS in use for any AC & DC operation mode- has to be checked for offset and bias current. Finally, the LF-Amplifier as well as the Hi-Current-Amplifier will be adjusted.

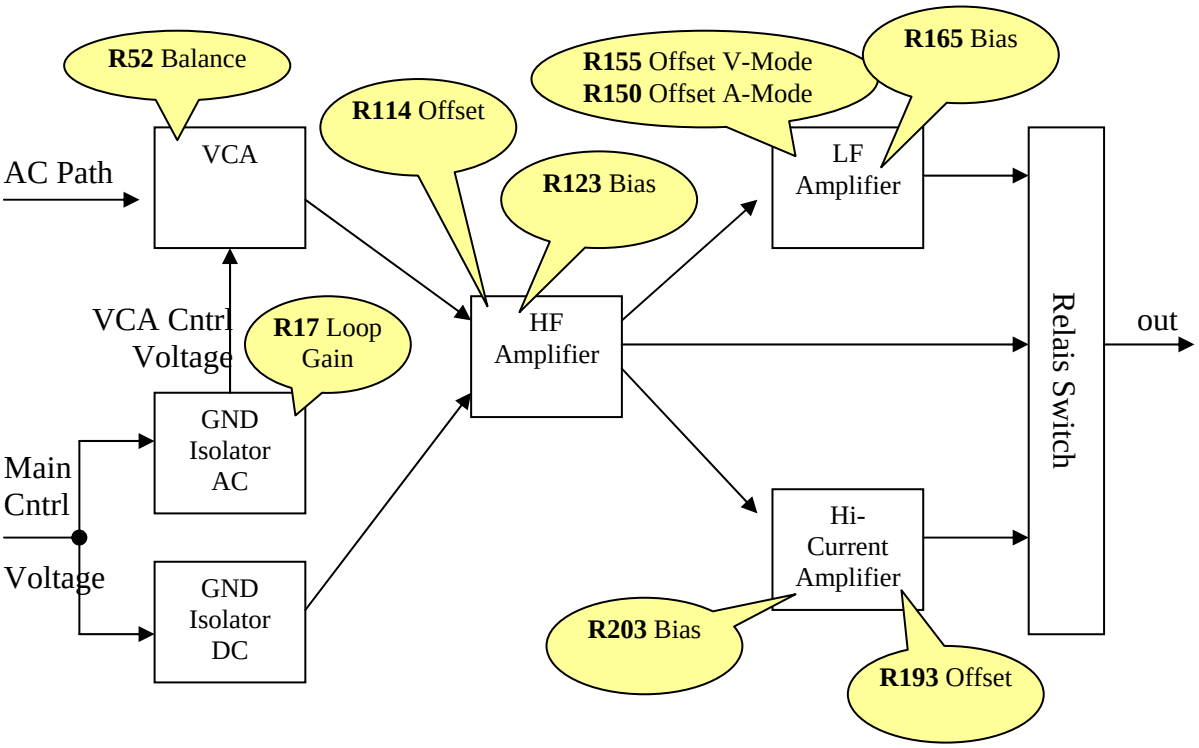

Figure 2: block diagram of module A17

In case of an error, this list may help to determine the root cause:

HF-Amp: DC V < 20V
AC & DC A < 20mA
AC V < 110V, max. 20kHz
AC V < 20V, max. 50kHz

LF-Amp: AC V >= 20V < 1kHz
DC V >= 20V

Hi-Current-Amp: AC & DC A >= 200mA

2. VCA Calibration: BALANCE

The chapter "R52 Adjustment" that you can see in the original Fluke manual has to be skipped as in the 1985 PCB there is no R52 at all.

Note: R52 is part of the VCA (VoltageControlledAmplifier) that is used for any AC Voltage operation mode.

3. VCA-CONTROL-VOLTAGE (TP24)

In this chapter we will check the amplitude control voltage with which the VCA is controlled.

1. Connect DMM to **TP24** (MainCntrlVoltage) and **TP29** (GND F)

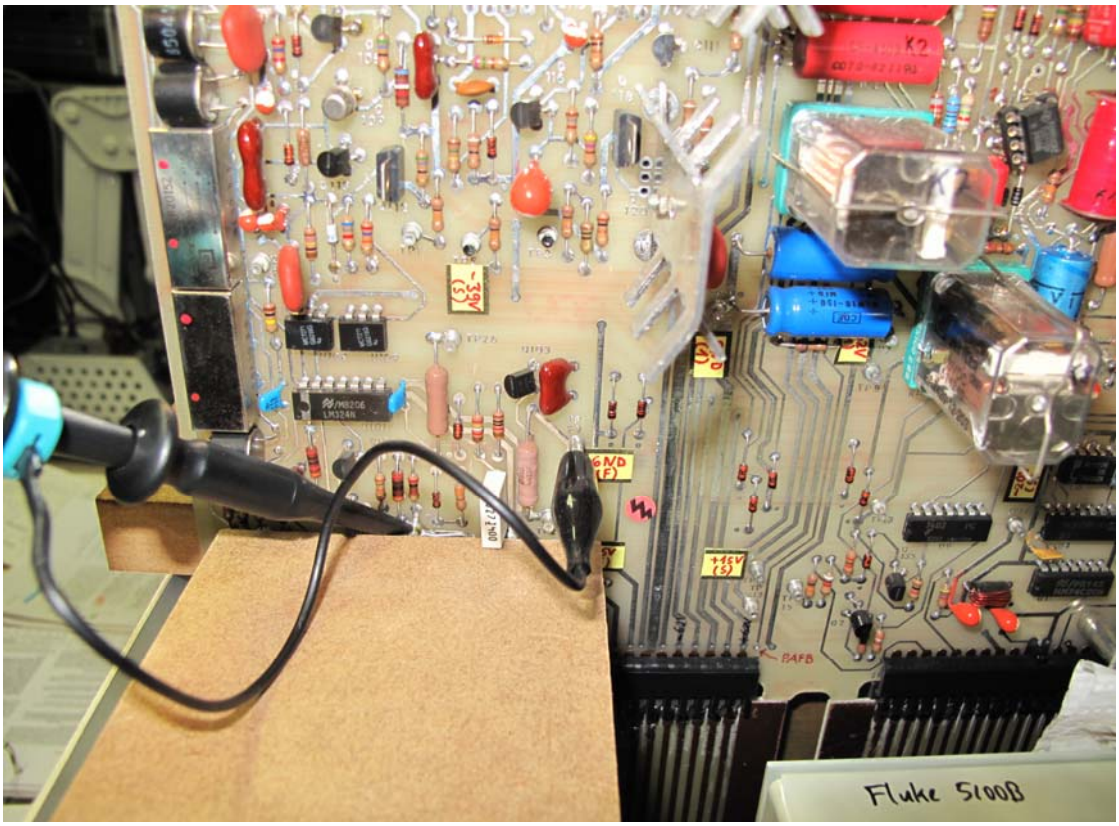

Figure 3: Setting test probes for VCA-Controle-Voltage check

2. Program Calibrator for an output of +20V DC.*

3. Fluke manual says: "Adjust **R17** for a DMM reading of +1V +/- 0.02V DC"

According to my experience, you won't meet this requirement at any time. The default setting of my (properly working) calibrators is like this.

My Fluke 5100B as reference	My Fluke 5101B as reference	Your device is:	Judgement ok/nok

* Even though you will get a DC output, this DC is generated internally via the AC stage, transformer and rectifier! So in truth this is -indeed- an AC issue!

4. Program Calibrator for an output of 2V AC @1kHz

5. Check: DMM should read 1,25V +/- 0,5V DC (=> 750mV..1,5V)
This is just a double-check item. Don't worry too much if you won't meet exactly.

My Fluke 5100B as reference	My Fluke 5101B as reference	Your device is:	Judgement ok/nok

6. Program Calibrator for an output of 19,999V AC @50kHz

7. Check: DMM should read between 7,5V and 11,5V DC.
This is also a double-check item.

My Fluke 5100B as reference	My Fluke 5101B as reference	Your device is:	Judgement ok/nok

Note:
When I compare the schematics with the 1985 PCB, then you can see a difference in the AC control path. A "GND-Isolation-Transfer" Circuit, that is transferring the control voltage from GND(F) to GND(S), is totally different. This is probably the reason why the control voltages can differ slightly from those who are considered in the original Fluke manual. In case of alignment of R17, I would also obey my Fluke 5100B measured "default values" as alignment parameters. Would make more sense to adjust to these values than forcing the 1985 PCB to fulfil adjustment requirements that are written for a newer PCB with newer circuits on it!

4. HF-Amplifier Adjustment: Offset

For performing this alignment, you need a really high-performance DC meter! It needs to be able to measure the presence of only a few mV DC-Offset overlayed by a ~30Vrms AC signal!! An extremely high normal mode rejection is required. I am using a Rohde&Schwarz URE3 -switched to "Float"-Mode- for that, but even with this excellent and very expensive device I wish the resolution could be even slightly better.

1. Connect DMM to **TP4** (output of HF-Amp) **and TP23** (GND S)

2. Connect a jumper from **TP27 (**Input of HF-Amp) to **TP23** (GND S)
This will cause a short circuit on the input of the HF-Amp stage.

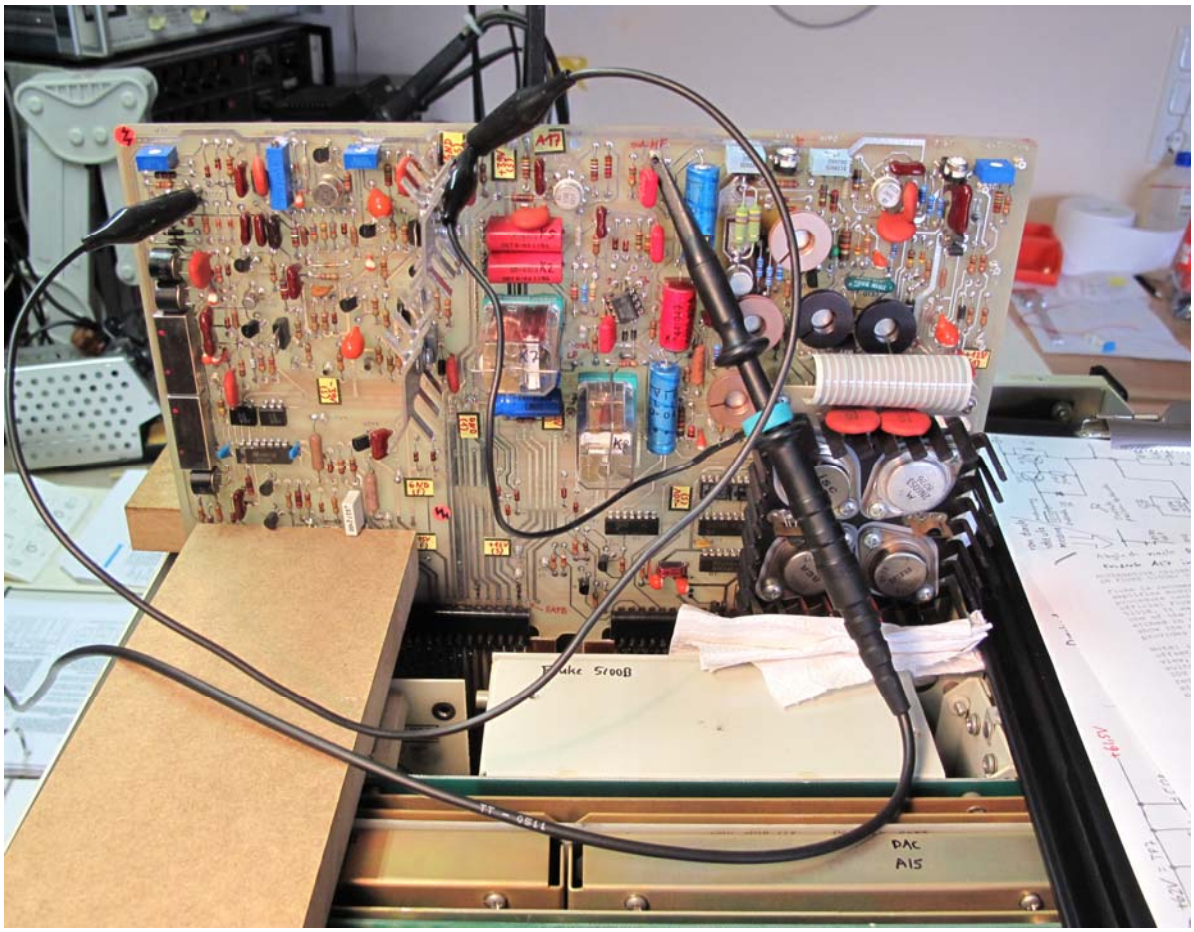

Figure 4: Setting test probes for HF-Amp, offset

3. Adjust **R114** for a reading of close to 0mV DC. Try to meet as good as possible.

My Fluke 5100B as reference	My Fluke 5101B as reference	Your device is:	Judgement ok/nok

4. Remove the jumper.

5. HF-Amplifier Adjustment: Bias

With this procedure we adjust the bias current in the HF-Amp. As already announced, during the bias calibration some Fluke-manual-values will probably not be reached with the 1985 PCB version. In this case, I took the readings from a correct working 5100B calibrator and use them as calibration reference values.

The bias current will be measured as a voltage drop across the emitter resistors (R143 = 10Ohms) in the output stage. Too much bias current will cause unnecessary (over)heating of the output power transistors.

1. Connect DMM to **TP3** (one end of R143) **and TP5** (other end of R143)

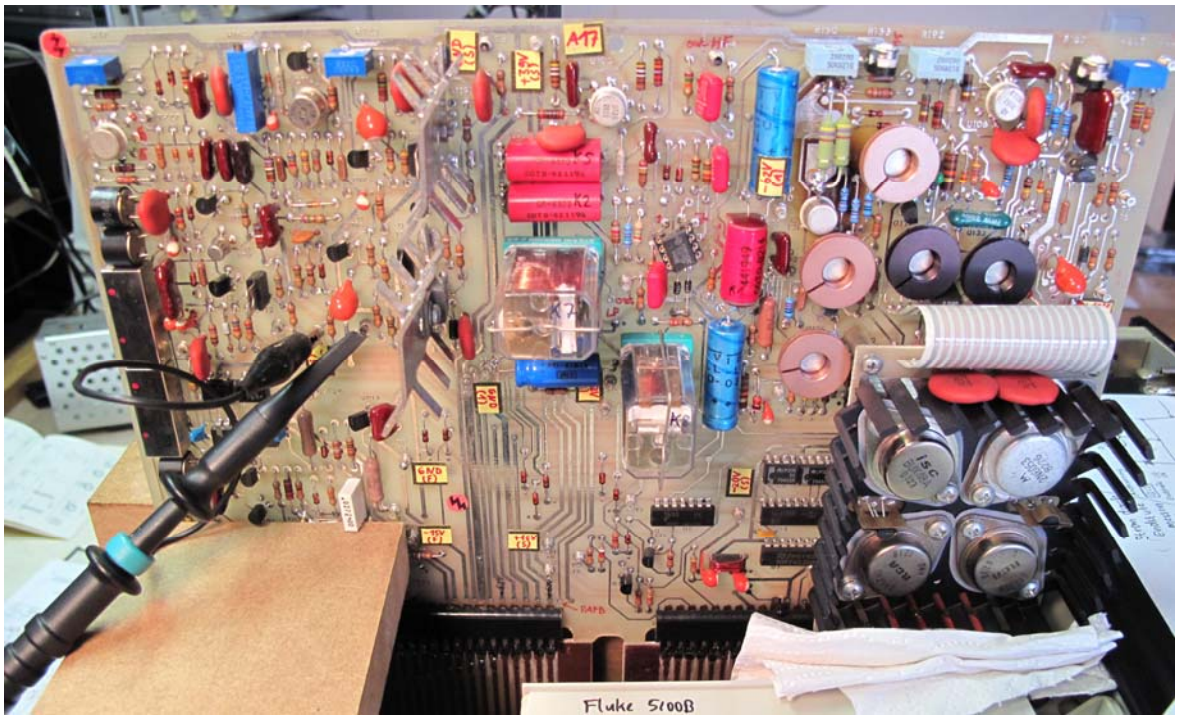

Figure 5: Setting test probes for HF-Amp, bias

2. Program calibrator to 190V AC @400Hz and set to OPR

3. Adjust **R123** for a reading of ~100mV.

My Fluke 5100B as reference	My Fluke 5101B as reference	Your device is:	Judgement ok/nok

Note: Manual says "149..151mV". According to my experiences that is not achievable, even when turning R123 to 100%. Instead of that, I would follow the measured 5100B default setting which was ~100mV.

4. Re-Check of Offset-Adjustment of HF-Amp
To be sure that the bias calibration did not have influence of the offset calibration, please re-check the last chapter again!

6. LF-Amplifier Adjustment: Offset

The LF Amplifier provides two operation modes: the "voltage mode" and the "current mode". For both modes we have a sepearte adjustment point.

- **VOLTAGE MODE**

1. Program calibrator for an output of +1100V DC and switch to OPR (operate)
2. Connect DMM to **TP21** (PA out) and **TP23** (GND S)

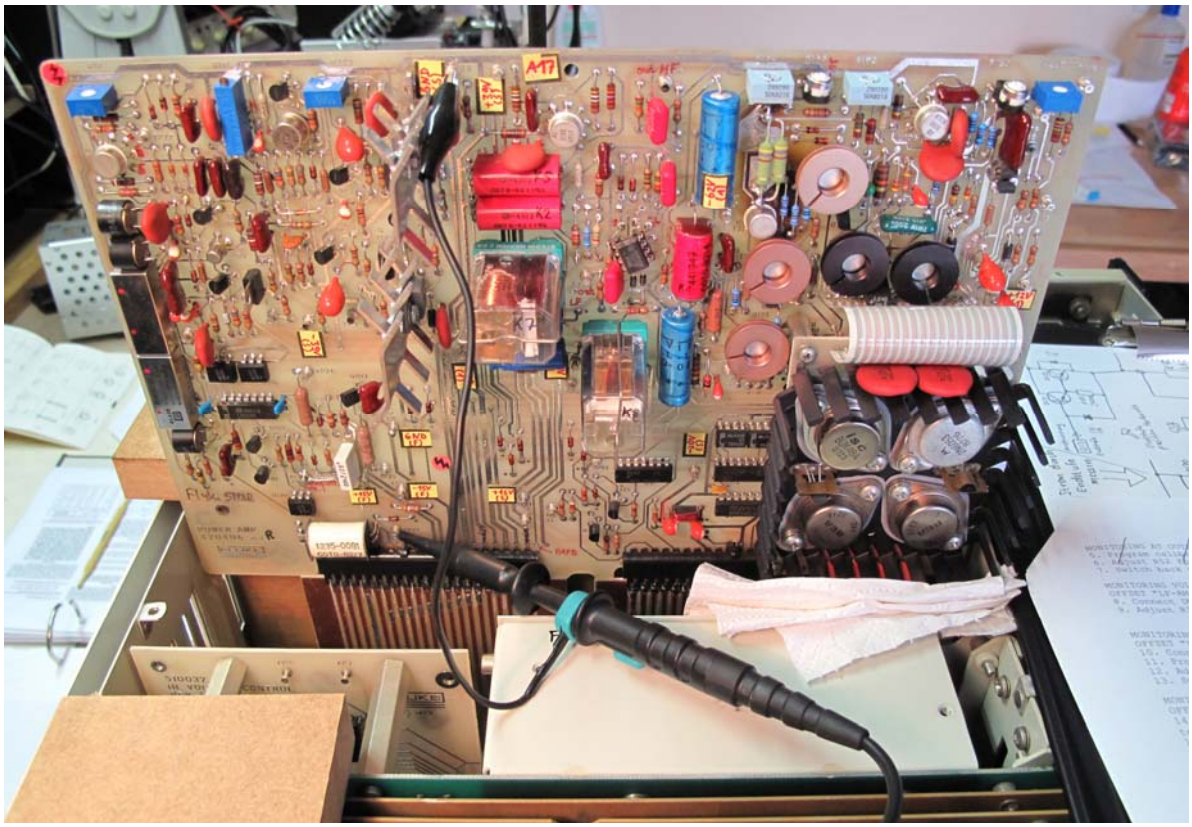

Figure 6: Setting test probes for LF-Amp, offset

3. Adjust **R155** for a reading of 0mV DC.

My Fluke 5100B as reference	My Fluke 5101B as reference	Your device is:	Judgement ok/nok

Alternatively:

Switch calibrator to Standby mode. Measure with ordinary DMM (e.g. Fluke 87) the voltage between TP21 (PA out) and TP23 (GND S). Then adjust **R155** for a reading of 0mV DC.

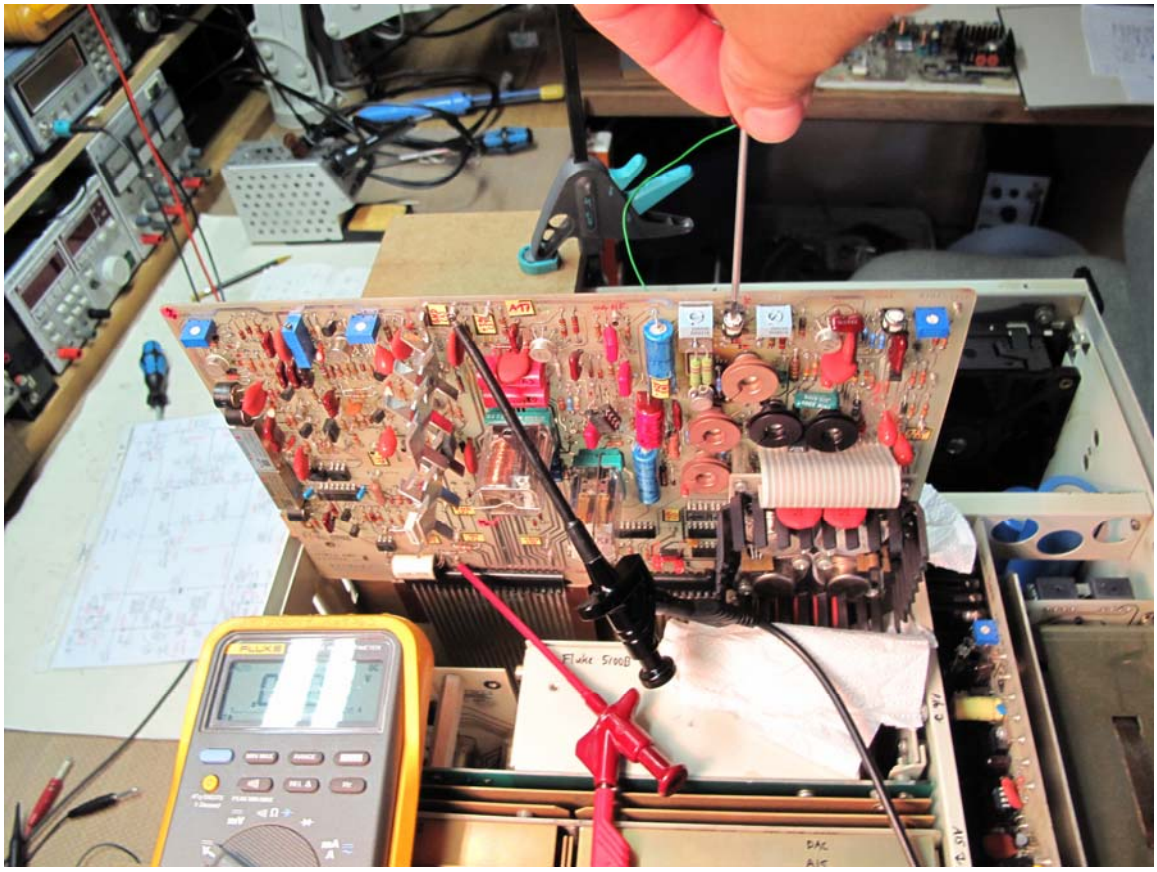

Figure 7: Setting test probes for alternatively alignment

After having adjusted to zero (0V DC +/- 1mV) with **R155**, verify, that the zero point will be roughly maintained during programming 25V@400Hz at the calibrator. Toggle between OPR and STDBY. The difference shall be <10mV.

My Fluke 5100B as reference	My Fluke 5101B as reference	Your device is:	Judgement ok/nok

- **CURRENT MODE**

Keep all connections as described the chapter before.

4. Connect a 33Ohms/2W resistor to the calibrator's output terminals

5. Program calibrator for an output of 199mA @400Hz and switch to OPR

6. Adjust **R150** for a reading of 0mV DC.

My Fluke 5100B as reference	My Fluke 5101B as reference	Your device is:	Judgement ok/nok

7. Switch back calibrator to STDBY

7. LF-Amplifier Adjustment: Bias

Analogue to the bias current adjustment of the HF Amplifier, the LF-Amp's bias will be measured as an voltage drop across the shunt resistor R182 (1,6Ohms).

1. Connect DMM to **TP8** (one end of R182) **and TP9** (the other end of R182)

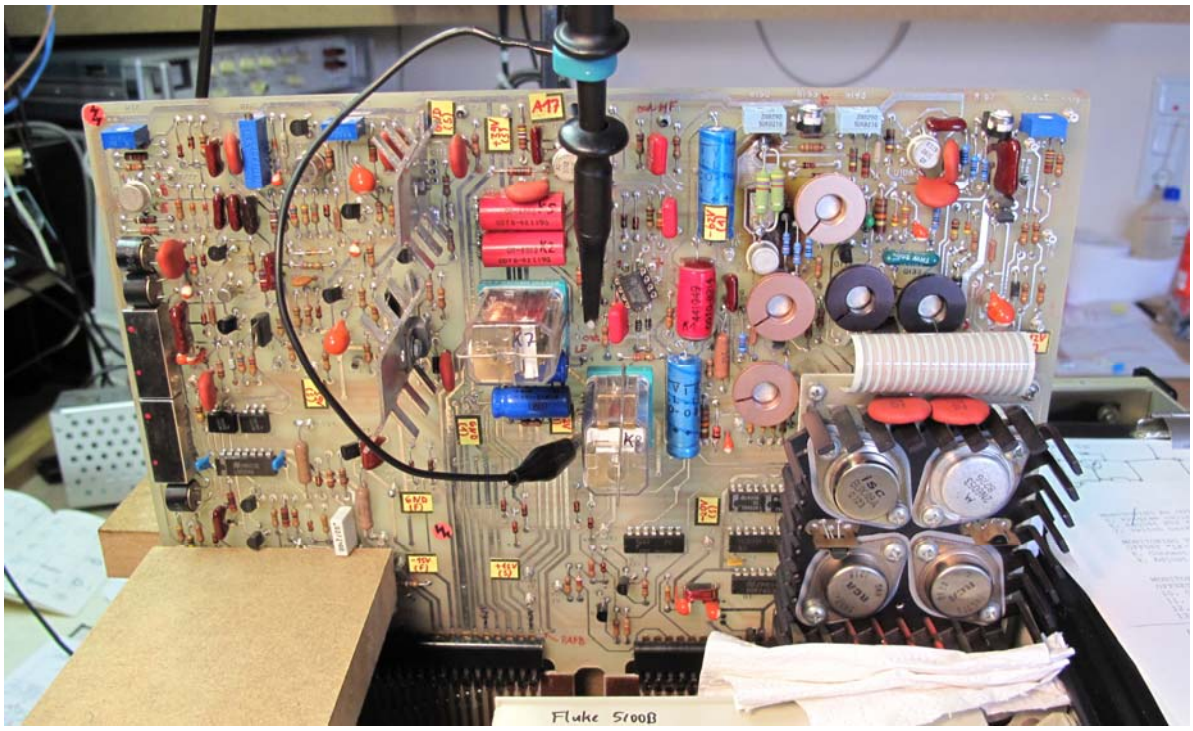

Figure 8: Setting test probes for LF-Amp, bias

2. Program calibrator for 25V AC @400Hz and set to OPR

3. Adjust **R165** fo a reading between 44,9mV...45,1mV DC

4. Set calibrator to STDBY

My Fluke 5100B as reference	My Fluke 5101B as reference	Your device is:	Judgement ok/nok

Note1:
Although the manual requires you to switch to OPR, I suggest to leave it in standby mode! You can much more easily adjust the 45mV DC with R165. At the end, just verify, that these 45mV will not change too much when switching in OPR mode (~ 3mV change seems to be normal).

Note2:
The recommended limit of +/- 0,1mV is in my opinion not applicable. You did a good job, if you meet within +/- 1 or 2 mV. The bias point is running a little bit- completely impossible to meet an adjustment precision of +/- 0,1mV.

Note3:
If it may occur, that the measured voltage (45mV) differs very much (that means >3mV) between OPR and STDBY mode. This can be caused by a poor DC Offset alignment. So in case of any trouble, verify the correct offset alignment before you start any avoidable repair session!

8. Hi-Current Amplifier Adjustment: Bias

Like all the other amplifier stages, the bias current will be measured as a voltage drop across the shunt resistor (R123= 0,15Ohms). It makes sense first to align the bias value. After that the offset compensation shall be done as shown in the next chapter.

1. Connect a 0,5Ohm/4W resistor (e.g. 0,47Ohms) to the calibrator's output terminals

2. Connect DMM to **TP18** (one end of R123) and **TP19** (the other end of R123)

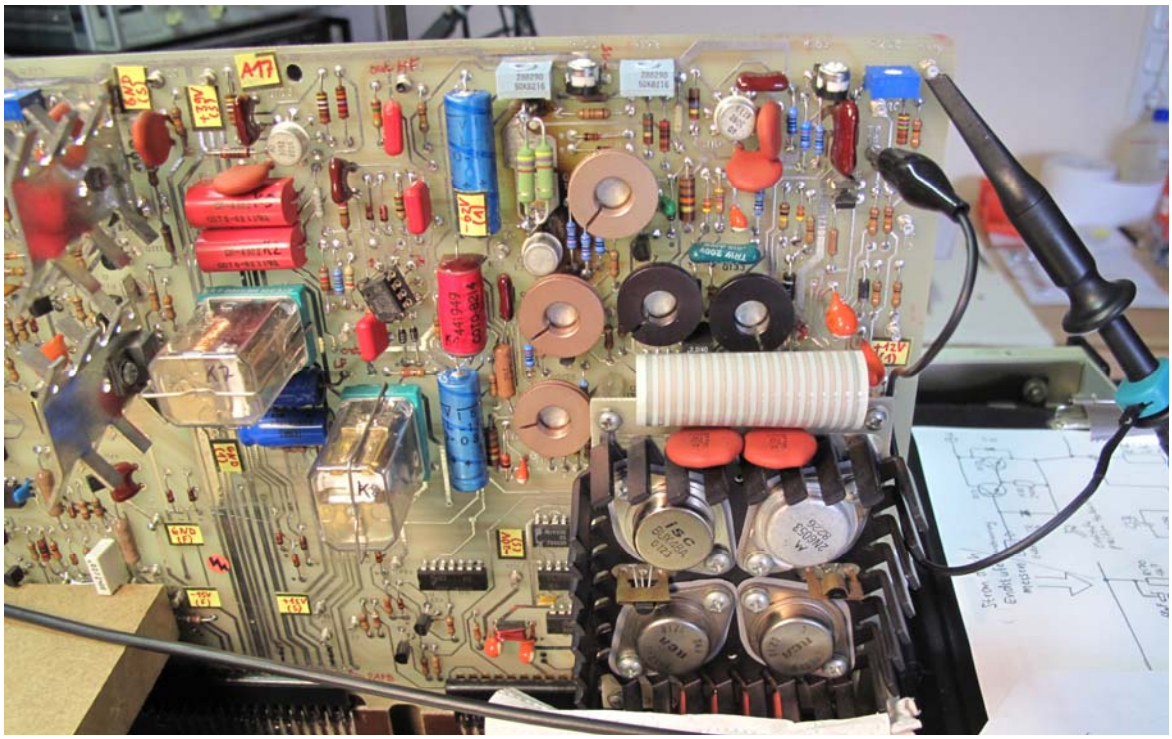

Figure 9: Setting test probes for Hi-Current Amp, bias

3. Program calibrator for an output of 200mA AC @400Hz

4. Adjust **R203** for a reading between 17,9mV..18,1mV DC

5. Switch back to STDBY and remove the resistor.

My Fluke 5100B as reference	My Fluke 5101B as reference	Your device is:	Judgement ok/nok

9. Hi-Current Amplifier Adjustment: Offset

With this adjustment, the offset compensation is done.

1. Connect DMM to **TP21** (PA out) and **TP23** (GND S)

2. Verify, that the **0,5Ohm/4W resistor** (e.g. 0,47Ohms) is still connected to the calibrator's output terminals

3. Key in 1,999A @400Hz and switch to OPR

4. Adjust **R193** for a reading of 0mV DC

My Fluke 5100B as reference	My Fluke 5101B as reference	Your device is:	Judgement ok/nok

5. Switch back to STDBY.

Alternatively:
According to my experience, you can run the alignment of bias + offset simultaneously. For bias current, you still need TP18 and TP19 for checking. But for offset compensation, just connect a DMM in DC mode to the calibrator output terminals.

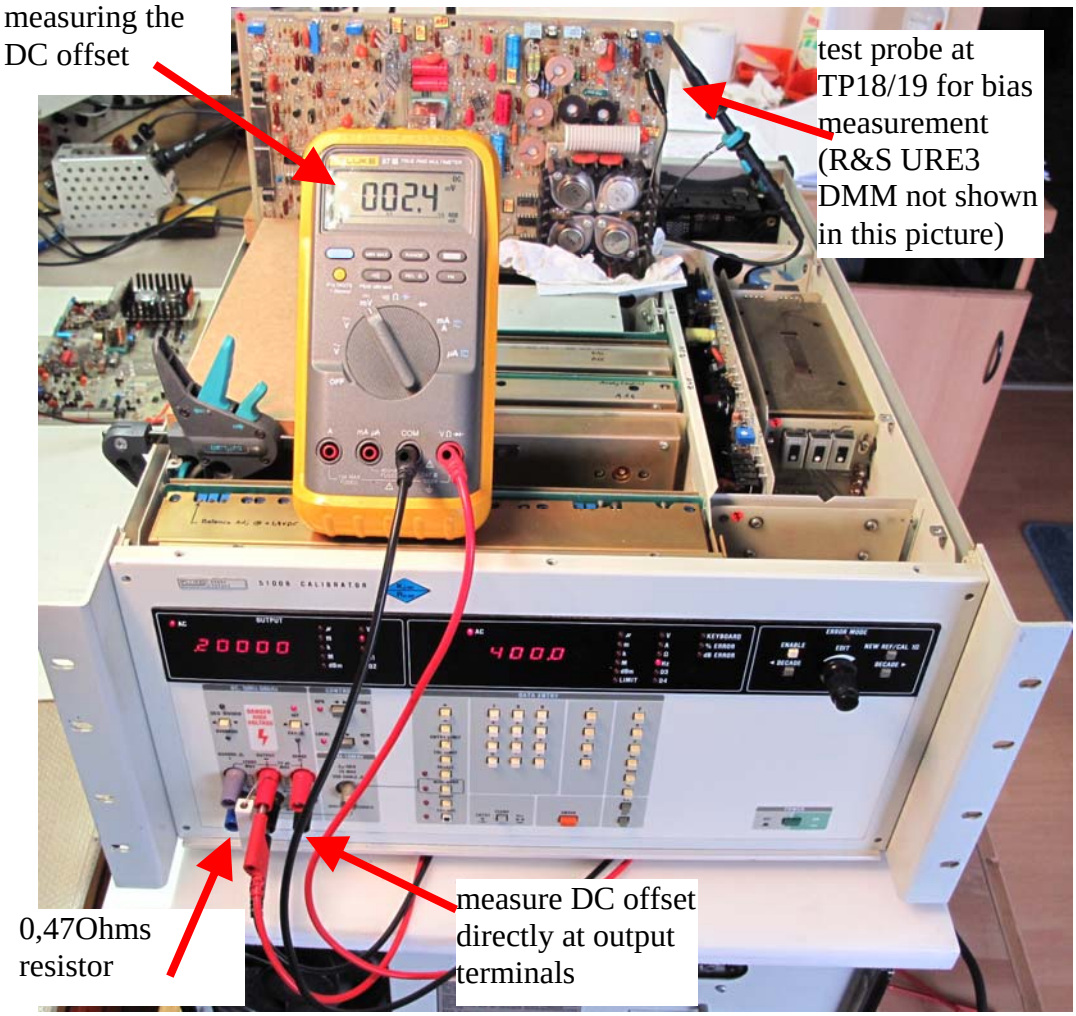

Figure 10: alternatively setting of testing probes (Bias+Offset)

Use the same alignment and checking conditions as described in chapter 8 and 9!

That's it :-)

Marc Michalzik, AUG 2010

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