F26/F300 Project 1

Hello doktor Pyta. Herewith some stuff I have cut/pasted from a series of monographs. Most of it is relevant to the F26/F300 but I may have overlooked a few bits.

Also, it is over 30 years and my memory is far from perfect.

To get you going I suggest some basic checks which will help you track down any problems.

Suggested equipment: -
4 BNC to croc clips (better still BNC/BNC with female connectors and short twisted pairs for soldering) for connection to RS and RT.
Another BNC/BNC for analog output to moving coil voltmeter or ‘scope (preferably the latter).
Basic dual beam scope and DMM.

First: basic operation and controls: -

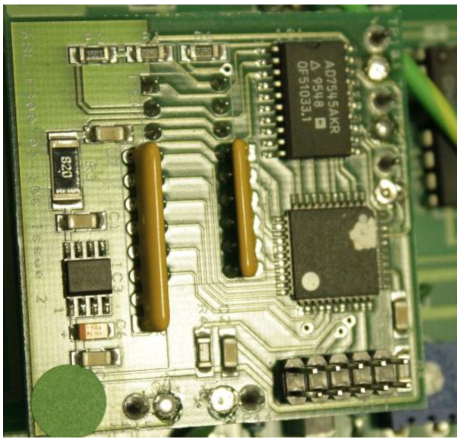
Test 1.
Two 100Ohm resistors connected as RS and RT as fig.1.1.1 Set current to 1mA; ext RS; sensitivity (detector gain) high; ratio mode; cal off.
Does the bridge balance in auto? Try again in low and med gain – auto balance should slow down.
You should also see 100mV RMS on RS and inverted on RT (input and output of active guard circuit (see fig. 1.2.1, basically an inverter). Do not connect scope 0V to virtual earth – use the earth terminal on rear panel.

Test 2
In manual mode set the ratio to 1.00000; low gain and observe detector output (BNC rear panel). Vary the manual ratio setting up and down (top 3 decades from 0.00 to 3.99). The detector DC output should be proportional with no obvious gaps.

Note: On max gain you should get approx ±1V for ±1 digit in the 5^{th} decimal place (±0.00001) and pro-rata for med and low gain settings. Similarly for different current settings: more current = more DC change per digit.

If there are jumps suspect a dry joint or one of the relays (transformer tap selection) not working.

Test 3
The last three digits is implemented with a multiplying DAC and added in series with the main xformer output.
Connect both RT volt sensing leads to same point on RT (virtual earth side) equivalent to a RT=0.
Manually set ratio to zero and check for balance. Increase one digit at a time on max gain. The DC output should change accordingly, with no gaps.



I suspect this is the MDAC (AD 7545)

Let me know how you get on. If all OK next is a thorough accuracy check/any intermittent faults.

From part 3 monograph 6: -

Link to the collection of monographs: -
https://drive.google.com/folderview?id=1TbomXeoBble-IVADaOOmyyLH9le-3wAt

1.1 The basic principle of operation

The followers drive both energising windings and ratio windings in parallel. Note the order of connections – the current flowing through the first energising winding does not flow in any part of the connection to the second energising winding or the ratio winding. Similarly, the (smaller) current flowing through the second energising winding does not flow in any part of the connection to the ratio winding. The connections to the ratio winding are thus closest to the inverting input which, by the action of negative feedback, is at the same voltage as the non-inverting input to a very high degree of accuracy. This order of connections is essential for accurate operation – and not a little disconcerting for the production department.

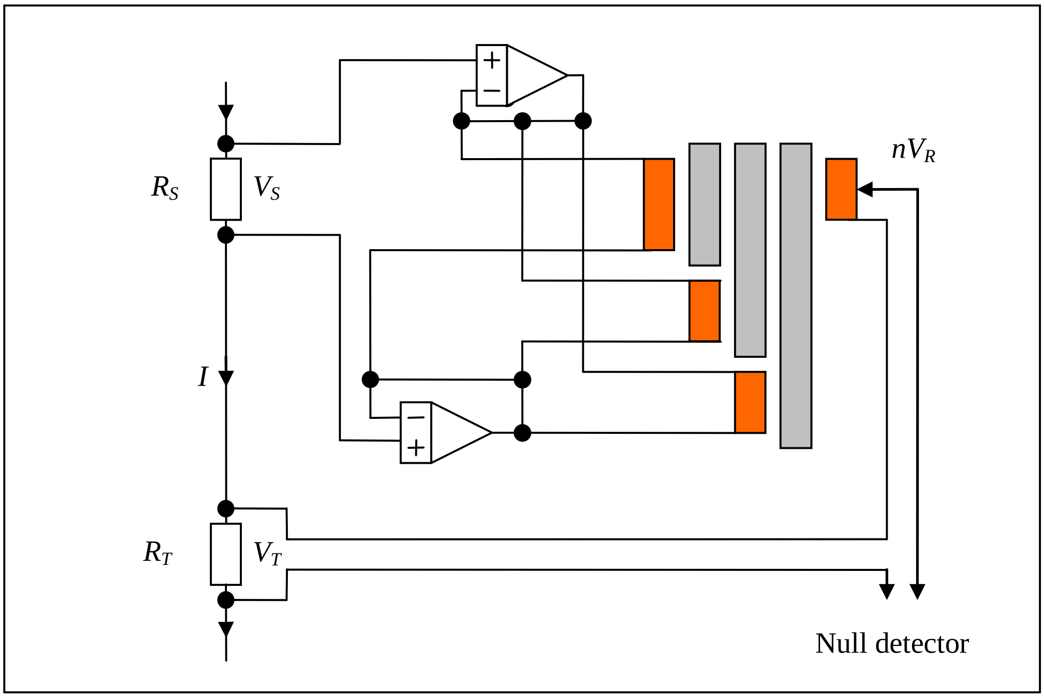
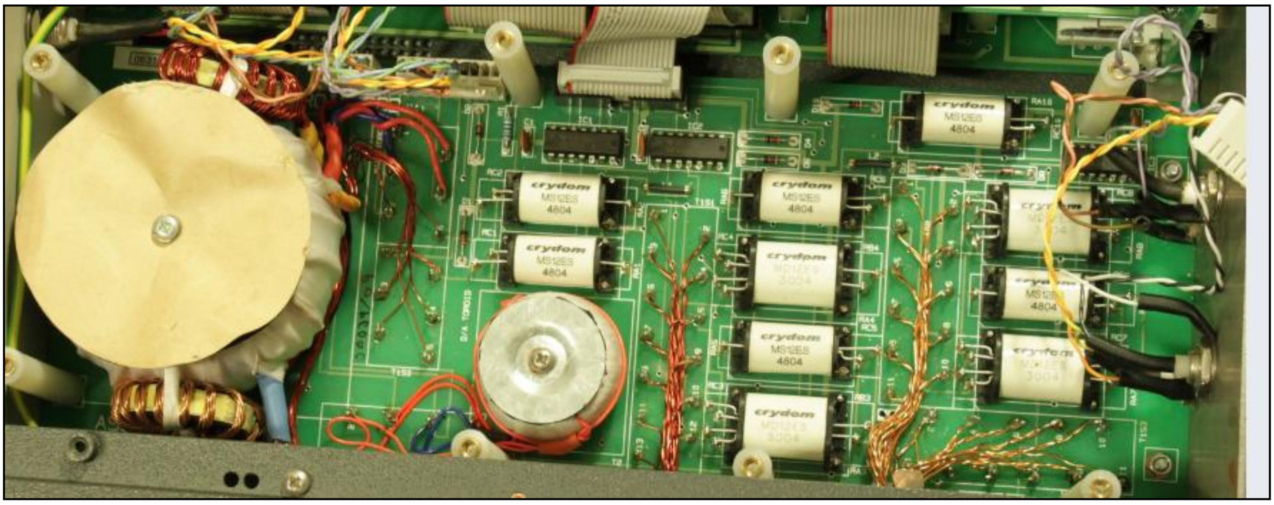


Fig. 1.1.1 The basic bridge configuration (simplified)

The ratio transformer is very easy to construct. The followers had sufficient accuracy (sub-ppm) and low noise to achieve the target specification – accuracy to better than 1mK with a 25Ω SPRT.



The three-stage ratio xformer (ratio 0.00 to 3.99) and tap selecting relays

1.2 Active guard circuit

Another innovative design feature of the F26 is the use of a high gain block (HGB, two-stage, type 1 [1]) to create a "virtual earth" point for the bridge. The HGB, standard resistor and thermometer are configured as an inverting amplifier. The action of feedback ensures that the inverting input of the HGB is maintained at 0V very accurately, setting the bridge potentials relative to local earth. This is an improvement over a simple direct connection to earth by making the bridge immune to "leaky" cables and connectors, which can happen in some applications. In the following diagram, for example, C_1 to C_3 represent leaky capacitances. If a direct earth connection is made to the same point then any in-phase component of the impedance of C_1 to ground would look like a large resistor in parallel with R_S, affecting the measurement. Similarly C_3 acts in parallel with R_T. No current flows in C_2 as there is no potential difference. With a virtual earth at the same point the leakage current through C_3 is provided by the HGB and C_1 simply appears in parallel with the current source – problem solved.

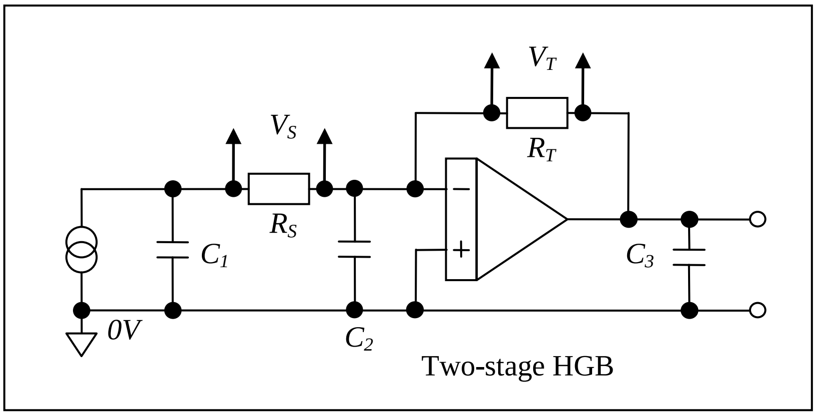
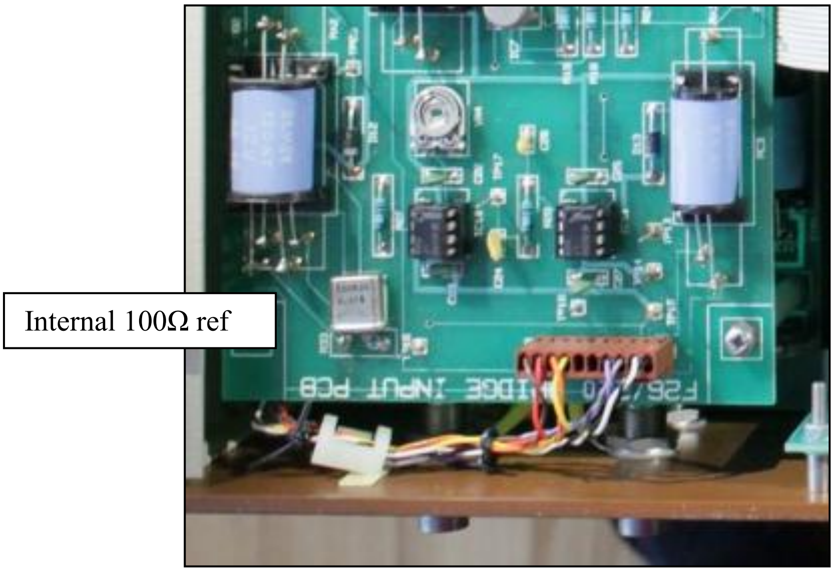
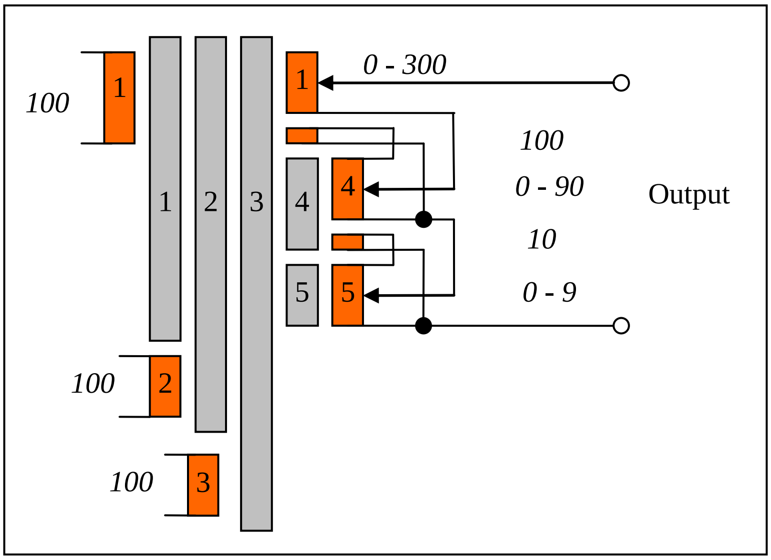


Fig. 1.2.1 The F series active guard



The two op-amps are the two-stage HGB of the active guard

(Two op-amps for much more open loop gain)



The three-stage ratio xformer in a bit more detail

Note: From the pics it seems not to be a simple case of one reed relay per tap (1 of 10). Some of the coils have two reeds – DPDT? Please chase through and check.

From part 4 monograph 2: -
High accuracy voltage followers (HAVFs) have numerous applications. The F series range of resistance bridges, for example, employs a pair of HAVFs to drive the primary windings of a ratio transformer.

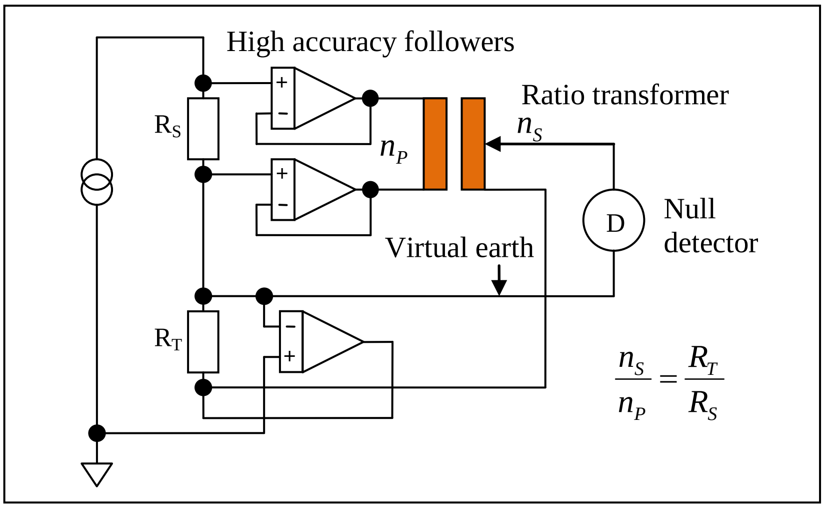


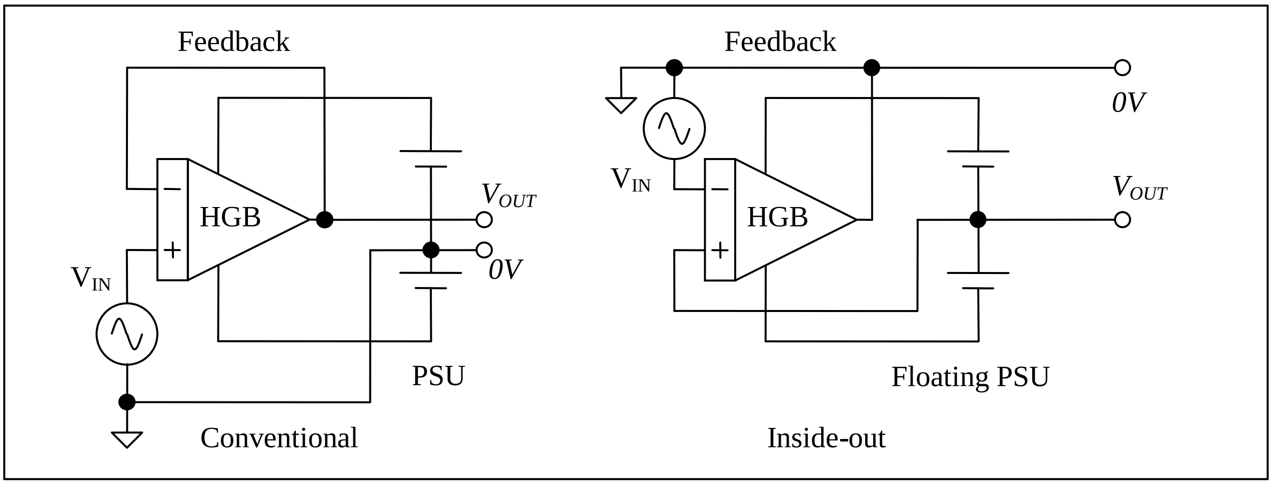
Fig. 1.1 Outline schematic of the F16/17/18 series resistance bridges

The high accuracy voltage followers (see fig. 1.1.1) consist of low noise pair (LM394) and two op-amps each.

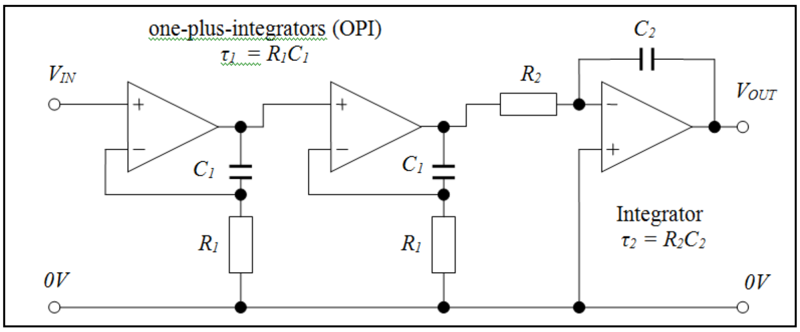
The trim pots are for DC offset adjust – quite critical as any DC to the transformer is trouble): -

Two high accuracy voltage followers

Caution: I'm not sure but I think each follower has a "floating" power supply. The output of the final op-amp is connected to 0V and the centre of the PSU is the output! This is called an "inside-out" follower. See part 4 monograph 2. Can you check this please – not clear from the pics. There should be extra PSU components and possibly extra windings on the mains xformer**: -**



It a bit of a brain teaser but it works: no common mode error!



A three-stage high gain block (HGB)

From Part 4 monograph 2: -

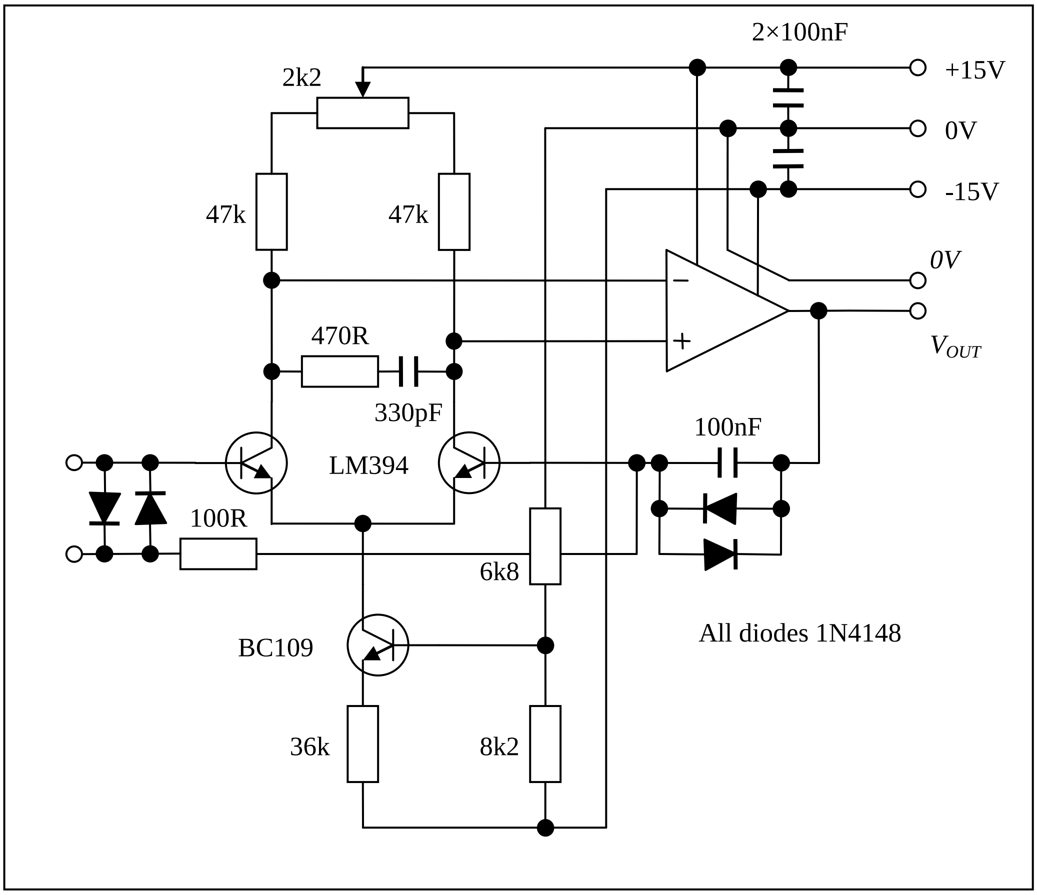


Fig. 4.1.3 A low noise one-plus-integrator front-end

The BJTs are operating at 0.1mA each and generate less than $2\,nV/\sqrt{Hz}$ (RMS).

The feedback capacitor is quite large as the resistor needs to have a low value (to keep Johnson noise low).

For more details see the monograph “Low noise BJT pre-amplifiers” by the same author [1].

Note: The F26/300 may be running at higher current/lower noise/better noise match. Please check the component values.

1. Monograph: “Low noise BJT pre-amps”.