

HP 738BR voltage calibrator

Ser. 503-03414 and 6003

Clean complete condition. AC plug ok but no strain relief. AC internals have AC internal wiring after fuse/switch, but still loomed with other wiring. Hardwired for 230Vac input. PE ok. Megger 1kV primary to PE at 180Meg. Mains 1.1A nominal, 2A fuse needs to be delay, so 3A fitted.

[HP 738BR Manual](#) schematic needs manual changes for B+ rectifier to 5U4. R52 is 90k.

V5 is 6189. V9 is 12AT7WA.

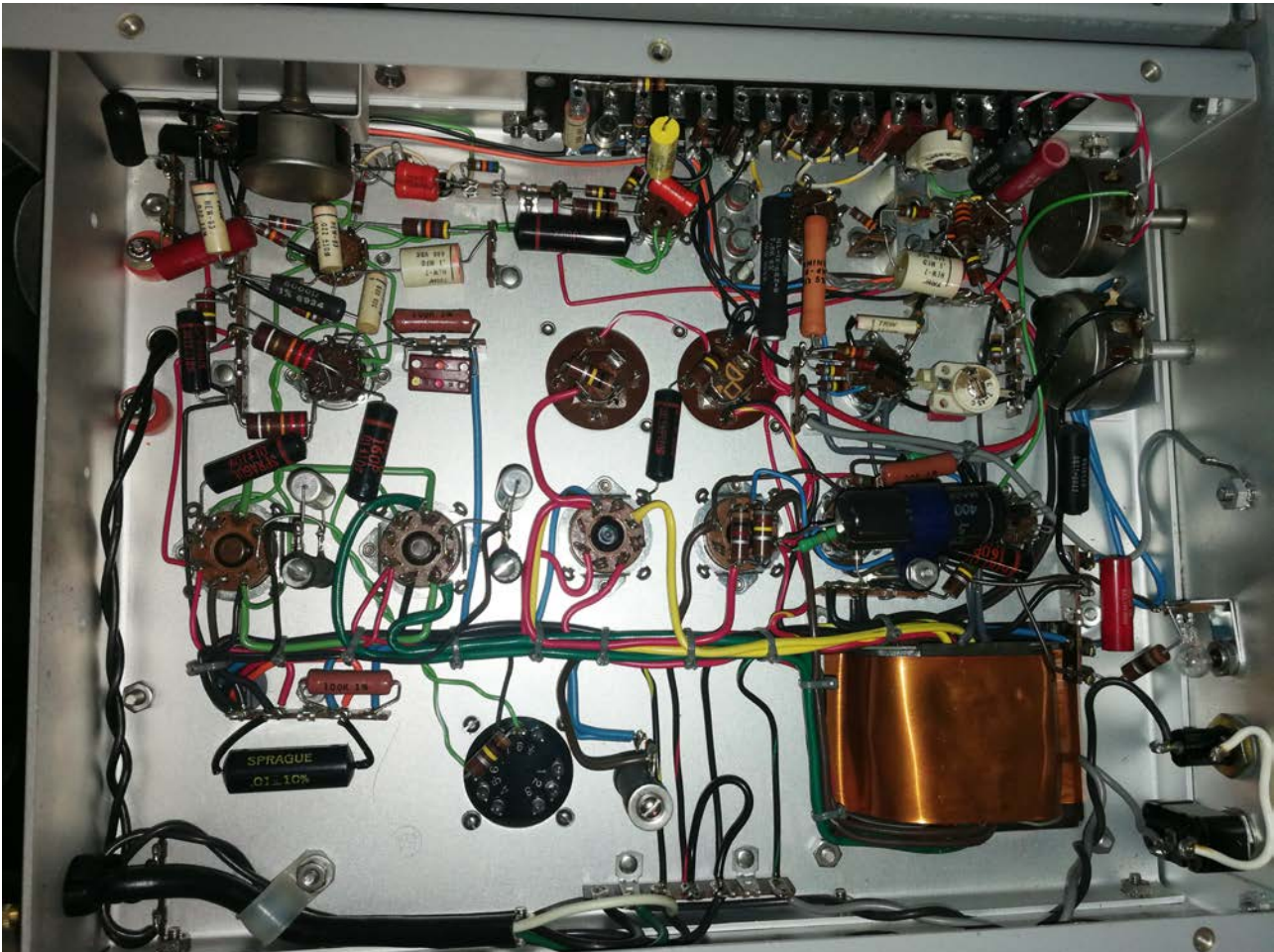
Better manual for adjustment and calibration information is [HP738AR](#).

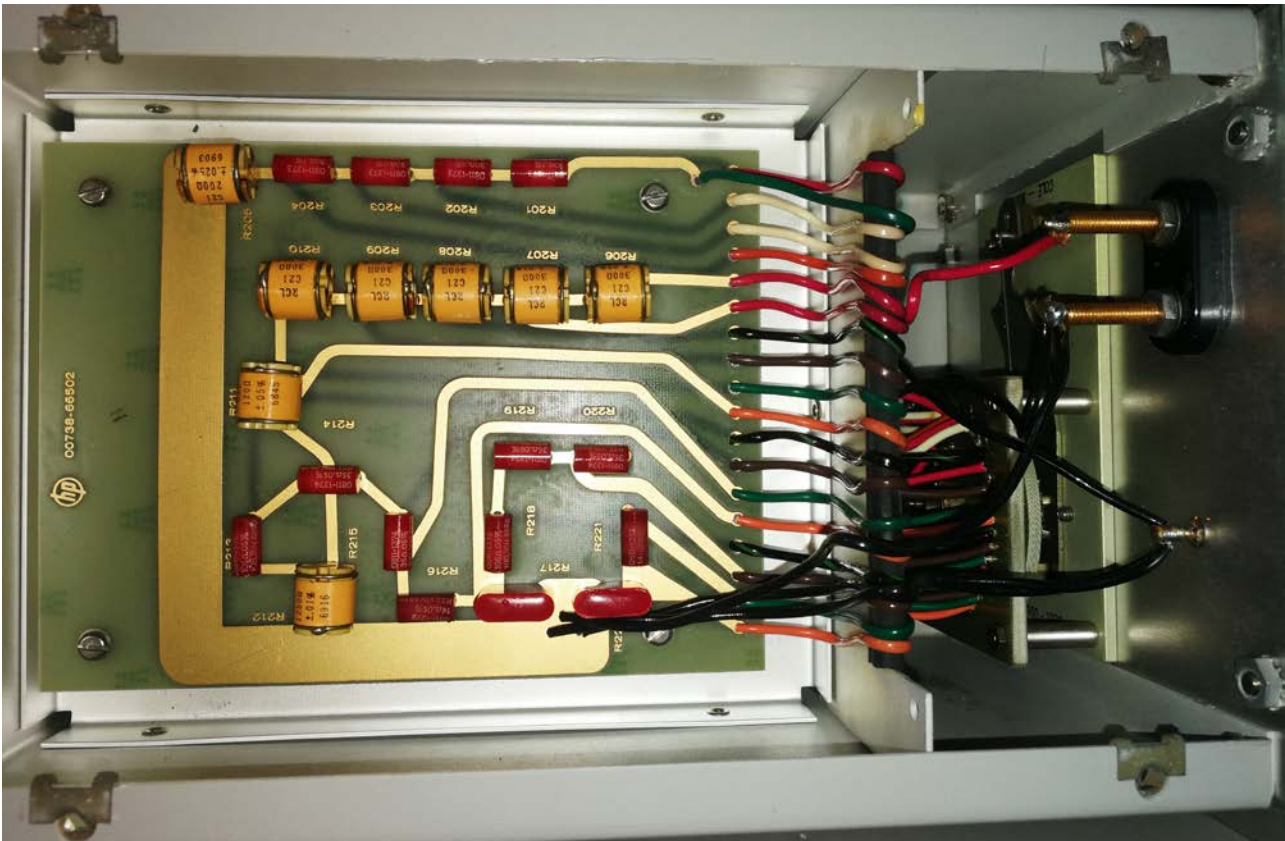
Attenuator resistance and switch contacts were better than 0.001% to K179 4W measurement readings relative to marked resistor values (ie. 3k, 6k, 9k, 12k, 15k, 18k), such as 18.0000 kohm, although 1-2 LSD variation for lower values and grounding divider values. Resistors typically marked +/-0.05%, but some as 0.01%.

Initial start-up with variac and checked 5U4 operation and balanced B+ e-cap voltages.

6550A's nicely balanced (23.9 and 23.7V idle)

5651A bad - substitute good 85A2 allowed 300.0V trim – so fitted new 5651A – now 86.0V.





DC output after warm-up and cal pot adjustment at 300Vdc

Picotest M3510A (uncal) with 10.0 M $\Omega$  input resistance.

300V	+300.179	-300.212
100V	+100.009/+100.0158	-100.042/-100.0181
30V	+30.0158	-30.0188
10V	+10.0053/10.00747	-10.0083/-10.00788
3V	+3.00242	-3.00285
1V	+1.00054/1.000677	-1.00099/-1.000676
0.9V	+0.900619	-0.900622
0.8V	+0.800577	-0.800579
0.7V	+0.700531	-0.700537
0.6V	+0.600442	-0.600453
0.5V	+0.500405	-0.500418
0.4V	+0.400336	-0.400349
0.3V	+0.300252	-0.300267
0.2V	+0.200161	-0.200176
0.1V	+0.100073/0.1000989	-0.100081/-0.1001095
0.03V	+0.0300258	-0.0300352
0.01V	+0.0100066	-0.0100166
0.003V	+0.0029992	-0.0030085
0.001V	+0.0009966	-0.0010062

DCV cal pot R53 wiper adds some minor setting variation when pot or shaft or chassis is tapped, but wiper can't be accessed as pot is sealed. Given the pot span of output is about +/-10 to 12V, the influence of the pot was alleviated by adding fixed resistors to the wiper, which may need to be reset for age or a change in 5651A regulator. Given the wiper was 4.25/5.7 position for 300V, a 3k9 and 5k6 were added across the arms, and tapping had less than 0.1V jitter on 300Vdc (ie. <0.003% change).

400Hz frequency adjusted according to HP738AR procedure for zero phase shift. Filter values were measured as 49nF, 51nF, 1068nF, 144.5mH. One of two padded caps was removed to give zero phase shift at 396.4Hz – with both padder caps removed the zero phase shift frequency was 404Hz – so both padder caps connected in series to give 400.4Hz. Frequency drifts during warm up.

Distortion of 400Hz measured with EMU0404/REW and 2HD was 0.048% at PTP and 3V output setting, and higher HDs were > 20dB lower, so THD was 0.048%. 50Hz was 12dB higher than 2HD, but that could be via USB path. Padder cap C32 in AGC feedback has negligible influence on noise and HD's. Increasing PTP output to 30V raised 2HD to 0.063% and 3HD increased to 2dB below. Switching to RMS and 3V, 2HD was 0.15%, and 0.16% for 10V setting.

#### AC output - rms

300.0V with up to 1V jitter. Signal is clean when AGC loop opened (C29 on V9/6). Noise surges on V9 signal about every 100ms – not always exactly 100ms, and not to same severity. Coupling cap 1n5 C6 was replaced and the level of jitter dropped below 0.01Vpp on Pico 100V range on 300V PTP.

Picotest M3510A (uncal) with 10.0 MΩ input resistance: Vrms with some final digit jitter

300V	300.0	149.3
100V	99.6 / 99.57	
30V	29.96	
10V	10.00 / 9.991	
3V	3.000	
1V	0.9999 / 0.9998	
0.9V	0.8999	
0.8V	0.7999	
0.7V	0.7000	
0.6V	0.5999	
0.5V	0.5001	
0.4V	0.4001	
0.3V	0.3001	
0.2V	0.1999	
0.1V	0.1000 / 0.10005	
0.03V	0.03004	
0.01V	0.01001	
0.003V	0.002998	
0.001V	0.000969	

ACV cal pot had same issue with chassis and pot vibration. Adjustment span was -10 to +4Vrms, with 7k8 and 17k from wiper to ends, so 3k9 and 56k were paralleled to pot arms.

AC output PTP – calibrate to  $300V_{pp} / (2\sqrt{2}) = 106.06V_{rms}$  on 300V setting.

CR3 rectified waveform is as expected – half-wave half-sine train. CR2 rectified and biased waveform shows just a titch of 400Hz transient when half-sine waveform transient reversal occurs. That transient point then gets amplified to form about a 50us glitch that is clamped by CR1 at just above 0V, with the main duration of the 2.5ms signal providing about a -6V bias level across R48. The bias signal recovers from each clamped glitch by overshooting beyond -6V by up to about 2V with a 20ms mains frequency modulation. That signal then gets RC filtered ( $100k/220n = 7Hz$  corner) to a nominal -6Vdc with a small level of 20ms signal. The DC bias level, and likely the

20ms signal level is adjustable to a minor level by C32 (AGC sine neut), but how C32 is used is unclear. That signal also appears to have a low level of periodic variation over about 2 seconds which appears to coincide with the Pico display jitter (unsure if that is related to LF closed loop feedback response).

The spec for the instrument only relates to a nominal accuracy of Vac of 0.2% (ie. +/-0.2V), with a cal setting of 0.01V deviation, so the observed fluctuation of <0.01Vrms is well within spec.

After some time, gross disturbance on the AGC negative bias was sometimes observed. Freeze spray didn't show up any under-chassis suspect parts so possibly one of the 400Hz signal related valves.

Sprague 'black beauty' STM 600V C30 had 2x measured capacitance but no leakage at 500V, but was replaced with 22nF 1500V.

Remedial changes:

1N4007 in series with each 5U4 anode

CT fuse in red/yel lead – UL 350mA radial.

Assuming 400-0-400V secondary with 31ohm ESR and 440Vdc 220mA dc load (80+80mA + 54mA to 6AV5 anode current) with 265mArms CT measured current. An IEC 315mA T fuse in CT should be ok for a hot turn-on. PSUD2 sim results:

Simulate period in PSUD2	10ms	20ms	50ms	150ms	600ms	continuous
Simulated RMS current		1.2A		0.6	0.44A	0.27A
Multiplier (for 315mA fuse rating)		3.8		1.9	1.4	0.86
IEC 60127-2 T min limit multiplier		10		4.0	2.75	1

An F fuse is marginal.

Simulate period in PSUD2	10ms	20ms	50ms	150ms	600ms	continuous
Simulated RMS current	1.6		0.86			0.27A
Multiplier (for 315mA fuse rating)	5.1		2.73			0.86
IEC 60127-2 F min limit multiplier	4		2.75			1

A 350mA BEL MJS fuse is ok, as just under 80% continuous.



