POWER SUPPLY – Regulated 350V & -140V – Melb Uni

Mains powered, valve regulated 350VD.C. and -140Vdc Power Supply
Hrsa Sept 2022

PT #1 Ironcore Pri 0,230,240 DCR=15 ; 840Meg 1kV;
385V-0-385V; 173+184Ω ; 850Meg 1kV
PT #2 DS654: 240V Pri DCR=64 ; 1250Meg 1kV;
325-0-325V 515Ω - O/C; Megger ok after dismantling and checking
Phillips 8045 D 6.3V bulb 320mA
15H choke 100mA 150Ω DCR, D.4066; megger ok
4uF 600V (1) measures 4uF, 500V megger ok; 1kV megger to can ok.
4uF 600V (2) measures 4uF, 500V megger ok; 1kV megger to can ok.
Bramco 12/50 choke; 633 DCR; megger ok; 1400M 1kV
5k 20W IRC ok
20k WW pot (not 10k)
15uF 450V added to 4uF (measures 19uF)
Voltmeter 0-400V 5mA FSD Paton K35, S.N. B7-4569 (79kΩ)
Current meter 0-150mA Paton K35, S.N. RH7-127 (Series R ~0.4 Ω)

Issues:
Mains switch faulty.
D5654 PT has half HT secondary open-circuit – but should be ok for 25-30mA loading
560k 1W, 330k 1W, 11Ω 0.5W (6AS7), 470R too high.
Star ground node taken to mains PE tag.
Some star ground points are suspect.
PT#1 secondary voltages were higher than expected – changed primary tap.
B+ bleed and load resistors are subject to over 500Vdc.
A 450V e-cap is used on filtered B+.
Chassis marked with 12AX7. 85A2 not marked.
HT ON switch has poor contacts.
85A2 regulation voltage out of spec.
6AS7 triode out of balance.

Modifications:

- Added IEC front panel socket with fuse, switch and indicator, and separate chassis PE connection.
- MOV on PT pri.
- PT#1 primary tap changed to unused 240V (it apparently was on 230V).
- Fused PT #1 HT secondary – replaced existing front panel mains switch location, and internal bulb
    - 0.2A IEC Fast
- Anode 1N4007 ss diodes for 6X5, and 2x series for 5Y3.
- Diode protection on neg rail to avoid reverse biasing e-caps
- New caps for neg rail – 2u2 poly for first, 22uF 450V for second.
- Swapped positive rail e-cap for 10uF 350Vac poly.
- Rearranged grounds a bit.
- Replaced 0.1uF 400V waxy (leaky).
- 560K 1W bleed and 150k 1W screen supply changed to 2x MF50 in series.
- HT ON switch replaced.
- Separate 6AS7 triode grid bias adjustment added using 25k trimpot. Separate cathode 10Ω current sense resistors added.
- VE13 0421K MOV across regulated rail.

To do:

- earthed box lead.
- Modified EF86 screen circuit for better supply voltage regulation.

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- Tuned C for chokes
- Variable neg supply option and voltmeter
- Use 3PDT switch for 'Cut HT' to provide a load pre-charge step.
- Could use EF86 heater for accessory powering as one end is grounded.
- Could check performance of -85V ref with Alex Pogossov's mod.
- Could check performance with EF86 screen bypass.
- Revise HT fuse given ~125mA max capability.

Dr. D.J. Dewhurst – biomedical engineer; Melb Uni Dept of Physiology.

Measurements

Mains megger ok. Magnetising current 140mA.

PT1: 410-0-410V and 6.9V unloaded	B+ 500Vdc at 215Vac mains (ss diode rect)
	B+ 550Vdc at 245Vac mains (5Y3GT)
PT2: 6.6V unloaded	B+ -450Vdc at 245Vac mains (6X5) no VR150

Both the 5Y3 and 6X5 show a few hundred MΩ at 1kVdc IR cold.

Negative regulated rails are generated when mains at least 150Vac.

350V 10mA load = 35k 3.5W. 30k external load. 262V total current 13.9mA (18.8k) comprising 8.7mA external, 3.3mA meters, 0.8mA adjust. But each 6AS7 triode cathode conducts 12.3 and 1.6mA respectively, so 6AS7 is quite unbalanced. Inserted a 25k trimpot set to about 12k to give nominal balance, but balance shifts with regulated voltage.

300V regulated output; 300V front panel meter; 30k 15W load (10mA 3W); 14mA front panel current; 15.4mA common sense resistor; 240Vac mains 0.35A; 492Vdc filtered B+ with 250mVrms ripple. 29.6k reduces to measured 21.5k with HT off, and 20k with HT on, as meter resistance is 79k.

300V regulated output 3.0mVrms ripple/noise; 300V front panel meter; 3.65k 200W load (82mA 25W); 84mA front panel current; 87.6mA common sense resistor; 240Vac mains 0.51A; 385Vdc filtered B+ with 860mVrms ripple.

- 6AS7 triode balance 41.5mA and 46.1mA.

Unloaded (HT OFF) causes 300V regulated output to increase 1.3V, and ripple to drop to 2.1mVrms, and B+ to increase to 527Vdc.

- Effective output resistance isn't then 1.3V/0.087A = 15Ω, due to large +140Vdc step of input filtered voltage.
    - Could be alleviated by bridging 5Y3 anode option.
    - Could be alleviated by adjusting EF86 screen voltage.
        - With 390V feed and 300V reg, the screen is ~83V.
        - With 527V feed and 300V reg, the screen is ~106V.
        - Need 6AS7 grid voltage to go significantly more negative, so EF86 Va has to go lower but for a constant Vg and an increased Vsupply , so screen voltage needs to increase more than just the 150k-33k-470k circuit allows.
    - Front panel current meter shunt resistance is <1Ω. HT switch has <1Ω.
- Possibly some over-voltage transient spike when HT switch toggled.
    - PSUD2 doesn't show any ringing of the filtered B+ at turn-off of load. Extra 10uF on output of B+ suppresses any ringing.
    - A MOV across the regulated rail should have a Vdc-min 1mA rating of at least 600V, such as VE13 0421K which should start loading any transient above about 750Vdc.

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Design notes:
Schematic indicates 250 to 350Vdc range at 100mA with 0.5% regulation.

Rated output power 350V 0.1A = 35W, although 6AS7 allows up towards 200mA if difference voltage below 120VB+ (assuming shared current), but 5Y3GT is limited to circa 120mA. A 5V4 has benefit of indirect heater, and low voltage drop, and 175mA output capability, but PT #1 HT may only be rated for 100mA (ambiguous as winding current is 116mArms for 100mA DC) as no Ironcore data is available. There are no other indirectly heated rectifiers with 5V 2A, or better directly heated rectifiers, so a 5V4 appears to be only valve-based option (especially if higher voltage output is required). Given that series ss diodes are now used, then a bridged valve anode option is available, such that valve current always passes through both 5Y3 anodes in parallel, which should increase B+ under heavier load.

Design is similar to HP 710B P/S with 100-360V 75mA rating and <5mV ripple and noise.

At 100mA loading the raw B+ likely sags to 360Vdc + 6Vpp ripple (this can be suppressed by choke resonant cap). At 50mA/plate, the 6AS7 Vak drop may be circa 25V, and 100Ω cathode stopper drops 5V, so the max regulated output could be circa 330Vdc.

Each 6AS7 triode capable of only 50mA up to 260V drop (ie. output can only regulate down to circa 220Vdc (assuming filtered input sags to 480Vdc.

Continuous operation – max load 180mA

Simulate period in PSUD2	**10ms**	**20ms**	**50ms**	**150ms**	**600ms**	**continuous**
Simulated RMS current	0.26A		0.22A			0.18A
Multiplier (for 0.2A fuse rating)	1.3		1.1			0.9
IEC 60127-2 **F** min limit multiplier	4		2.75			1

Short circuit downstream of 15H choke causes prospective current of 0.74Arms, so 3.7x multiplier. Short circuit downstream of 6AS7 passes through cathode stopper (identified as 100R, but appears to be 11R and measures 25R) – a 10R 0.4W provides current sense and may provide over-current protection.

EF86 screen is pulled down with regulated output voltage. Anode should be able to pull down to 50V. Voltage adjust pot is 20k ww. At 350V output, grid is adjustable from (350+85)x 82/432 -85= -2.5V, to (350+85)x 102/432 -85= +17.5V. At 200V output, grid is adjustable from (200+85)x 82/432 -85= -31V, to (200+85)x 102/432 -85= -17.5V.

VR150/30 has a prospective peak strike current with no external load of (450-150)/5k = 60mA. After striking the B+ sags to -285V, so (285-150)/5k = 27mA nominal with no 85A2 loading.

85A2 has a nominal load current of (150-85)/15k = 4.3mA. 83.6V is within spec. Original 85A2 was 100V, and other spare was 90.1V.

Meters are on external side of HT ON switch, and load Reg rail by 79kΩ (4.4mA at 350Vdc).

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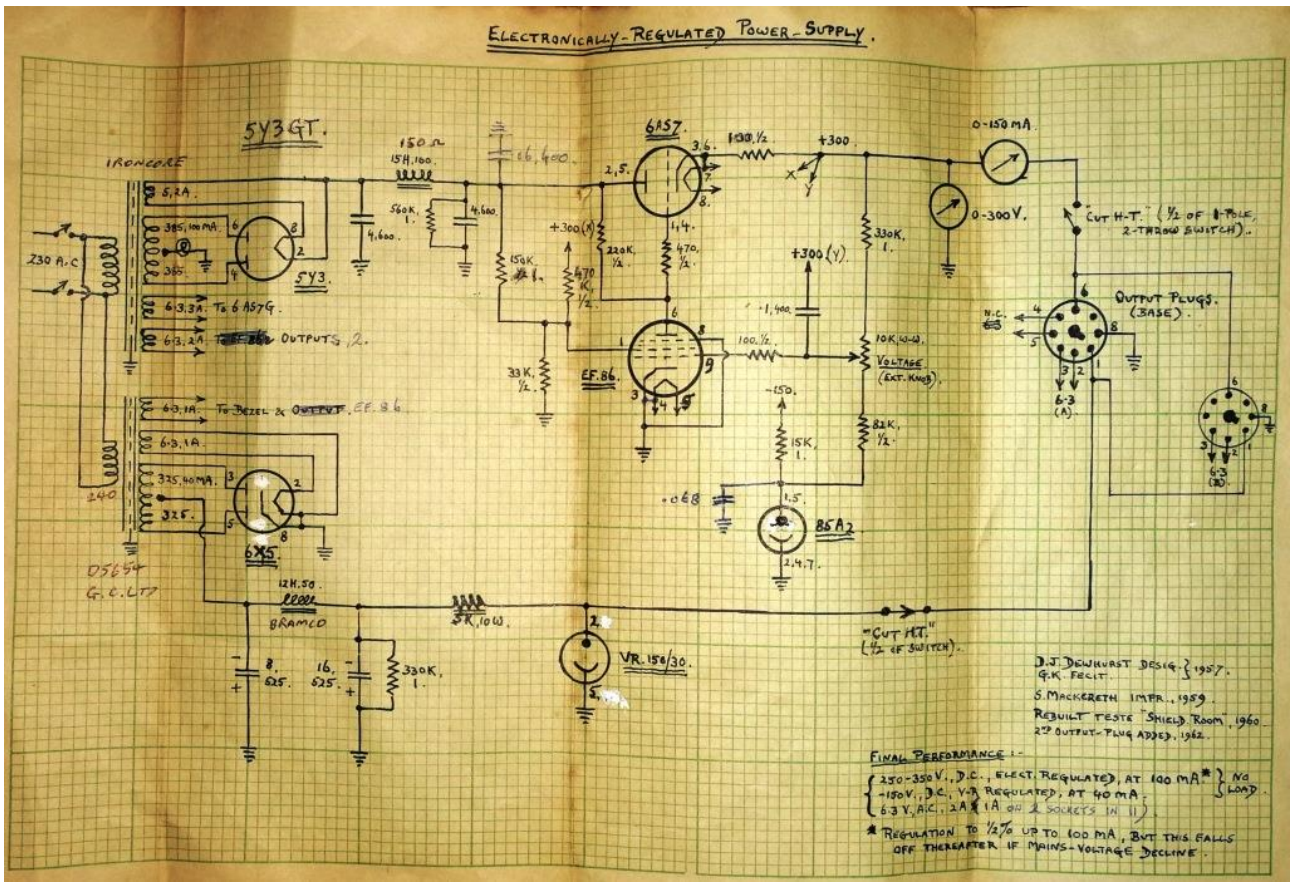

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