HP 5065A Rubidium Vapor Frequency Standard
Ser. 0960A 00259

1.1 General condition and comments

No power on switch - always on when mains connected. Use Pozidrive screwdriver bits - PZ1, PZ2, PZ3. This instrument turned out to have many faults to identify and repair.

Appears to be an early version of 5065A, so care is needed to identify specific module versions and locate the correct service manual section. The A7 module is the 6010 version (series 916) [hp5065a_part2.pdf instead of HP_5065A_ops_svc_OCR_05065_9041_Nov_1979.pdf], which was quickly upgraded by HP as it has some performance limitations.

Forum thread: www.eevblog.com/forum/metrology/hp-5065a-rubidium-standard-repair-log/25/

Measurement points:
+24 to 32V - L1 LHS or C2-C3
+22 to 30V - A15/4 also collector bolt on Q1 - goes to +24V on 00105-6013 oven oscillator
+20V - A15/6 - TCW busbar between rear connectors - goes to +20V on 00105-6013 oven oscillator
-20V - A15/11 - XA9/1

1.2 00105-6013 oven oscillator A10 module

The two internal heater windings both had degraded insulation to internal aluminium can (and hence to chassis). The internal insulation had baked hard, and ribbon cable wiring was charred and causing faults, and some electronic parts were failing, and the coarse frequency adjust shaft had broken off.

117Vac leakage to chassis from white wire side - goes in to foamed side, and then returns as white wire to internal pcb - (accessed through end cap and then foam cover). Fast heat up using 117Vac is not a requirement so was completely disconnected/isolated in rear wiring harness, as it can also cause external mains earth leakage protection to trip.

The internal can was removed and the dc heater recovered to show negligible leakage to core, and so was re-instated, but is a risk going forward. The core was held in correct location (relative to end caps and end pcbs) with added neoprene strips (to allow future removal if needed). The ribbon cable was replaced with silicon insulated wires. See separate repair doc [HP 00105-6013 internal wiring info.pdf].

4R7 R8 had overheated. The heater end pcb two diodes CR1 and Cr2 were both shorted and replaced with 1N4148. Q2 HP 1854-0023 was faulty (silicon npn TO-18 360mW selected from 2N2484) - replaced with high hfe selected BC550C. 200 ohm trimpot on heater end pcb was intermittent and replaced.

M terminal via blue to pcb C4/Q3/Q4 node (schematic shows this should be through L3 - possibly the two adjacent blue wires were originally transposed)

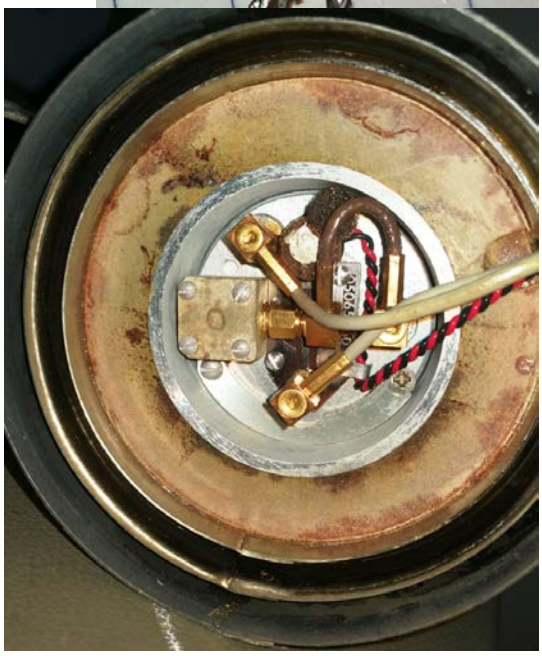
The coarse freq trimpot shaft was snapped inside can. Fine freq adjust can span about 0.1Hz. So heater temp trimpot was only mechanism for coarse freq adjust: fully CCW = 4,999,999.24Hz ; fully CW = 5,000,001.4Hz for fine trim fully CW. So Temp trimpot adjusted for 5,000,000.0Hz with fine adjust trim midway (5 full-turn vernier).

Status meter needed series resistor changed for OSC Oven to give FS '50' reading for about 29V - 8.5V; presently this shows >50. Added 120k in series with 316k, and now 29.2-9.1=47.5 on meter.

1.3 05065-6001 RVFR includes Rb lamp and photocell - A12 module

A12 has DB9 HR2 pin 5 (lamp heater) shorting to ground. All other 9-pin connector pins showed correct resistances and no grounds, but the cell heater was shorting to the ground shield of the CR1 harmonic diode and was then shorting to ground when that coax feed connects to J4 on A3. So both internal heaters need to be replaced, and preferably without altering the thermistors. Rather than fully extract the two internal aluminium tubes with their heaters, a somewhat simpler fix was to insert two new heater assemblies and retain the existing DB9 for thermistor and magnetic coil connection, but bring the heater wiring out separately and reconnect. Lamp heater wiring taken to DB9 plug and existing heater wires disconnected. See separate repair doc [HP 05065-6001 lamp heater repair.pdf]

The main 2N3553 Q2 had been previously replaced/repaired. On inspection the 2N3553 emitter tab removed and smoothed, and insulator pad added between 1101A and top cover, and heatshrink added to stud, to ensure no electrical contact. 1k33 resistor replaced on Corby's advice.



Cell heater wires exiting separately and taken to rear of 6024 pcb connector.

Lamp oven starts regulating after 35 mins, but has damped 8 sec period swings. Cell oven after 40 mins with 50 sec damped period. OCXO starts to regulate after about 50 mins. The hunting behaviour of the lamp and cell temp controllers was a result of the heater element repair short-cut used, where the heater coil was not directly over the thermistor.

Lamp oven meter swings sometimes extended to 50 on meter and tripped the logic to stop continuous operation. The top and bottom covers were not fitted, so unsure how much they may affect this meter swing. To alleviate logic tripping the A14 pcb was modified by adding 66uF BP e-cap between Q10 base and emitter to add .024x2x38= 1.8 sec TC to hi swing fault signal of Lamp oven (which turns off Q10 when it gets to within 1V of 22-30Vdc rail).

1.4 05065-6024 RVFR temp controller A11 module

Q7 showed as ok diodes but zero hfe. Q8 now with 2N2219 replacement and ok. Capacitor 20uF 50V C23 was faulty. C23 and C24 had both gone bad (low uF and high R), likely due to reverse bias from bad heater pulling 6024 pcb pin 2 and 14 low - each replaced with 2x // 10uF 50V 105C e-caps.

Accidently blew Q5 1854-0023; alternate Q6 temporarily removed and measured with uP tester as hfe=601 Vbe=800mV; replaced with high hfe selected BC550C measured as hfe=513 Vbe= 805mV.

Due to shorting heaters the chassis mount Q2 was faulty = Motorola 1854-0300 NPN 25W ft=4MHz (alt = 21W 10MHz) (2nd alt VCE-40V IC-3A PD-30W FT-3MHz). Q3 measures hfe=14, Veff=662mV. TO-126 package. Similar to BD137/9 with hfe=40 (MJE180/1/2 has higher measured hfe) - same pinout - so used BD137.

1.5 05065A-6010 Signal amp A7 module

A7 rear connections had WBO lead terminating to TP2 - swapped over. TP1 is not identified on schematic or in A7 text as pcb is 6010, but Figure 8-2 block diagram shows TP1 and reference to scope plot 12. The 6010 version of A7 presents a 2nd H meter level even for 137Hz signal. The 2nd H meter level varies with 234 and/or 137Hz magnitude.

A battery powered low level audio sinewave source via 10Meg was connected to input J1, and REW/soundcard frequency spectrum analyser to check the output of the first stage amplifier at TP2, and then the frequency filtered outputs at Y and WBO outputs.

A7 AC Amp module J1 input stage to TP2 shows low harmonics for 0.5Vpp in, with +5.4dB gain. TP1 shows 0.14% H2 with +0.7dB gain from input. Y output clips for signal levels above ~0.19Vpp, with lower signal level output with low HDs.

A7 assembly C18 had been replaced. R48 (51R) was very heat stressed and measures +10% (YEL output to A8) and C24 (60uF tant) appears to be leaky when grounding Y, so replaced R48 and C24. Also adjusted R3 for <1mV input offset - offset very sensitive to local temps.

1.6 05065-6023 Power supply A15 assembly

Due to shorting lamp circuit, XA15 had many hot parts and L2 22uH 9140-0179 was burnt and cracked - replaced.

Board A18 Jumper Board [8-7] shows heat stress on CR2 (with heatsink)

Magnetic field control had a fault. A15 Q6 1854-0221 had one npn bad - dual npn - tested good half = hfe 200, 0.95V. Replaced with BC547B matched, and physically coupled. Pin1 voltages may not match but varied from 2.61V at 2 setting to 4.76V at 10 setting.

1.7 Other and final setup

A1 Synth 6076 assembly removed and inspected - see manual part 2 - pcb browning under Q1 2N3054 and R3 75R 3W and CR1 and CR2 and R1 - and smoke indication below Q1 on housing - caution there are differences between photo and actual pcb layout. Inserted a current sense to J1 +20V input to try and identify any intermittent high current. No issue found.

With 137Hz signal, the following A8 Phase detector module generates an Error meter reading that cycles between -50 and +50, and the Integrator Limit indicator lights at <-50, and >+50, and the A9 Integrator output to OCXO EFC- cycles from -14.4V to +7.8Vdc. The reference 137Hz oscillator in A8 module shows sync with external REW signal at 137.035Hz so is ok.

Rubidium cell de-flooding process took many days. Applied TED external power (5Vdc supply through 5 ohm) and monitor 2nd harmonic level using scope on A7 TP2. Able to get the A7 TP2 level of 2nd H up to 150mVrms (ie. circa 420mVpp).

Random glitching high on 2nd H meter – didn't identify any failing part, and not occurring after alignment procedure.

With the 5065A in open loop, and the OCXO fine tune set for zero error and a null of the 137Hz signal in the spectrum on A7 TP2 (137Hz <-45dB below 273Hz), a comparison of the 5065A 5MHz output to GPSDO shows negligible roll down below 240 secs per 200ns full-cycle sine, so circa 200n/240 = 0.8 ppb, and below the 1ppb that the GPSDO is indicating it is within.

Used Corby's V22 alignment procedure (see eevblog thread). The OCXO fine tune is offset to get a certain error before closing the loop:

With the loop gain setting procedure, I can only reach about -14 on meter error reading when fine tune is 50 units CW of centre frequency. The repaired 6013 OCXO doesn't have coarse adjust capability, so the fine tune setting can't be easily made '250'. With the loop closed, the control voltage at the rear bnc is 0V at centre frequency, and goes to +0.8V at 50 units CW fine tune, and to -0.7V at 50 units CCW, so not quite +1 to -1V. The error meter reading swings from -14 to +14 respectively. With the fine tune back at 50 units CW, and loop operate switched on, the error falls to 0.

Magnetic field control had a fault and no coil current. A15 Q6 1854-0221 had one bad npn – the good half npn was tested as hfe 200, 0.95V. So Q6 was replaced with a matched pair of BC547B that were thermally coupled. This repair allowed the 2nd H level to jump up as an incorrect Ru transition line was being used with no magnetic field current – this fault is not monitored by the logic so is not noticed by the Continuous Operation indicator. Noticing this fault and repairing it earlier would have likely made de-flooding and final setup a whole lot easier.

Control is now at +10 meter and +0.8Vdc rear bnc, and the 5065A 5Mhz output is now within the nominal 1ppb jitter available from the GPSDO using the Magnetic field adjustment.

Continuous Operation light needs a buzzer or monitored alarm to identify when faults have occurred (eg. to save internal cooking).