



# DHT heaters



- Introduction
- AC or DC, LF or RF
- Voltage or Current
- External cathode circuitry
- Conclusions



# Introduction

- **Statement**

All heaters heated differently sound different

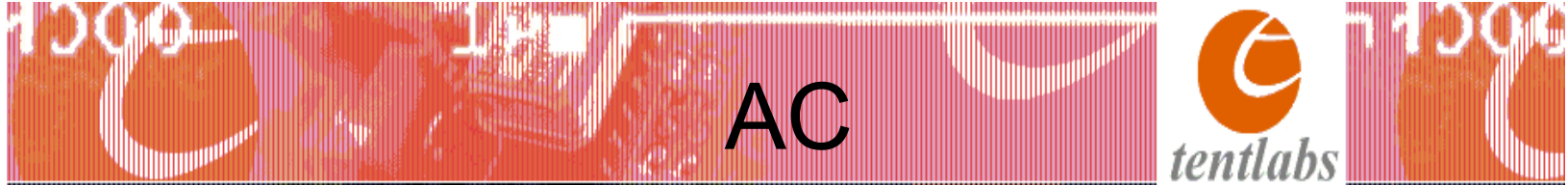
- **Notes**

All examples and measurements refer to 300b

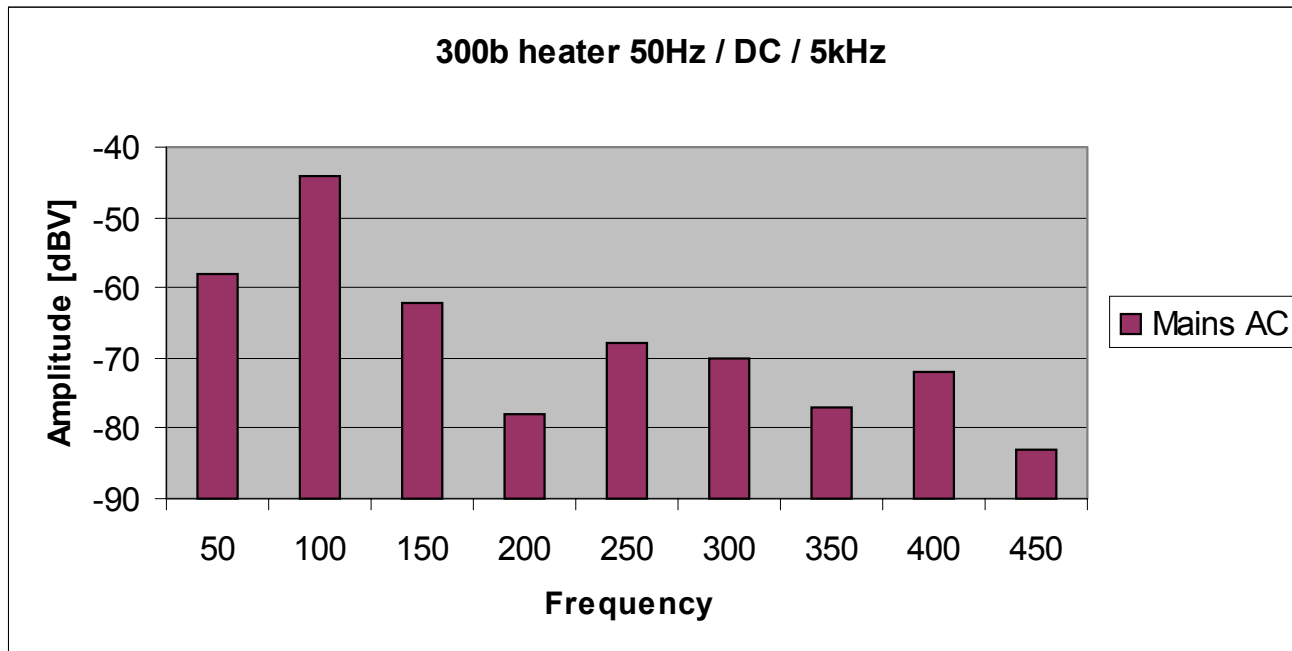
This work is result of mutual efforts and fruitful discussions with

- **Marc Heijligers**
- **Jos van Eijndhoven**
- **Henk ten Pierick**

The author can be contacted at: [Guido@TENTlabs.com](mailto:Guido@TENTlabs.com)



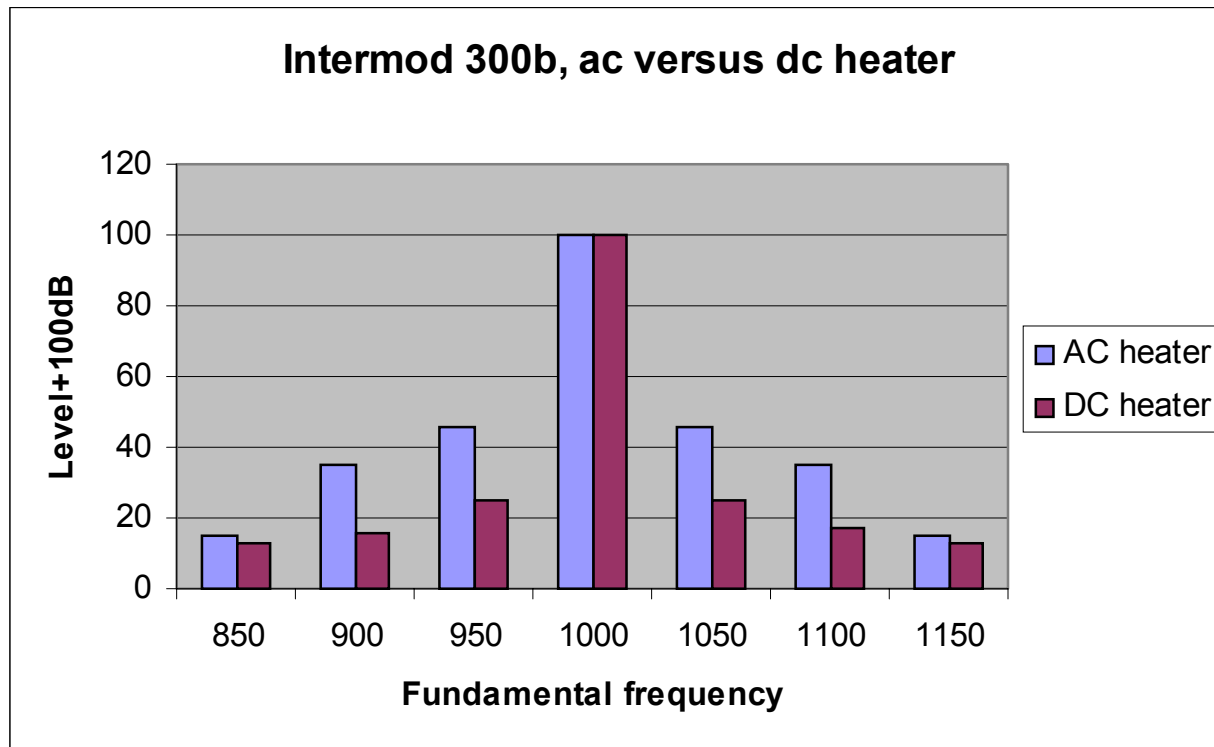
- AC gives hum, fundamental can be reduced (humpot)
- Harmonic distortion (cathode to anode) **remains**
- Typically 5mV seen at speaker output, spectrum below



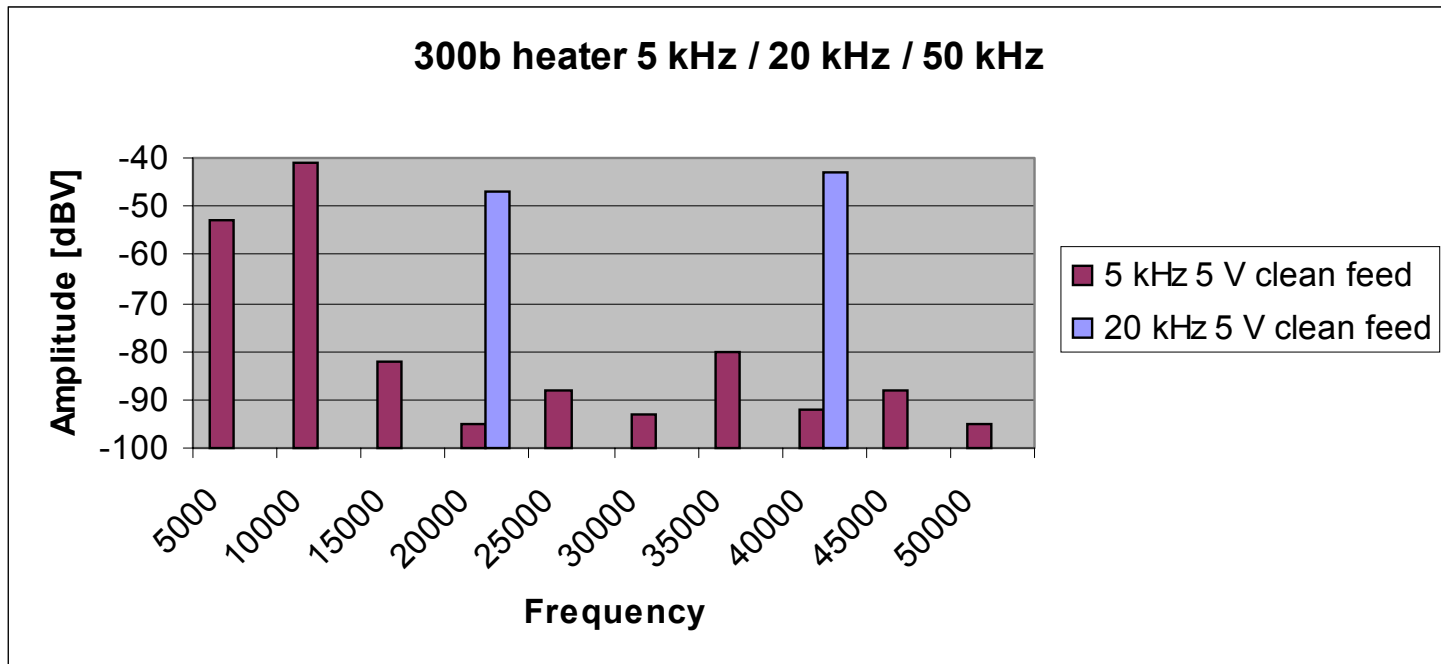
# AC and intermod



- AC heating increases intermodulation distortion



- Intermod caused by RF may be outside audible range



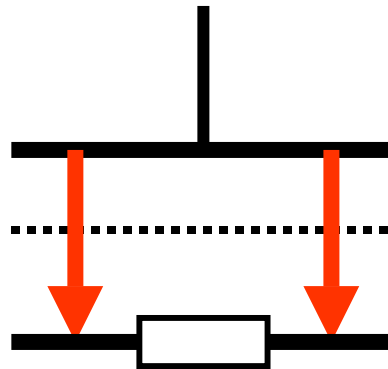
- The cathode can be modelled by many in parallel
- Consider 2 halves (keep it simple)

$$V_a = 400V$$

$$V_g = -80V$$

$$V_{gk} = 80V$$

$$g_m = 12,0 \text{ mA/V}$$



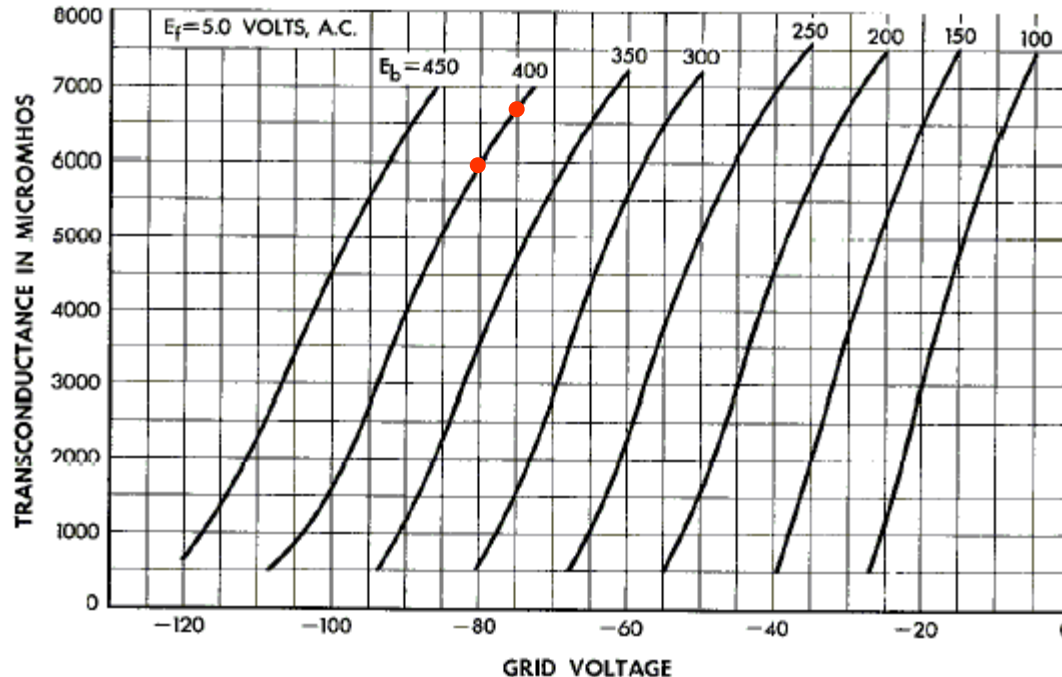
$$R \sim 4\Omega$$

$$V_{gk} = 75V$$

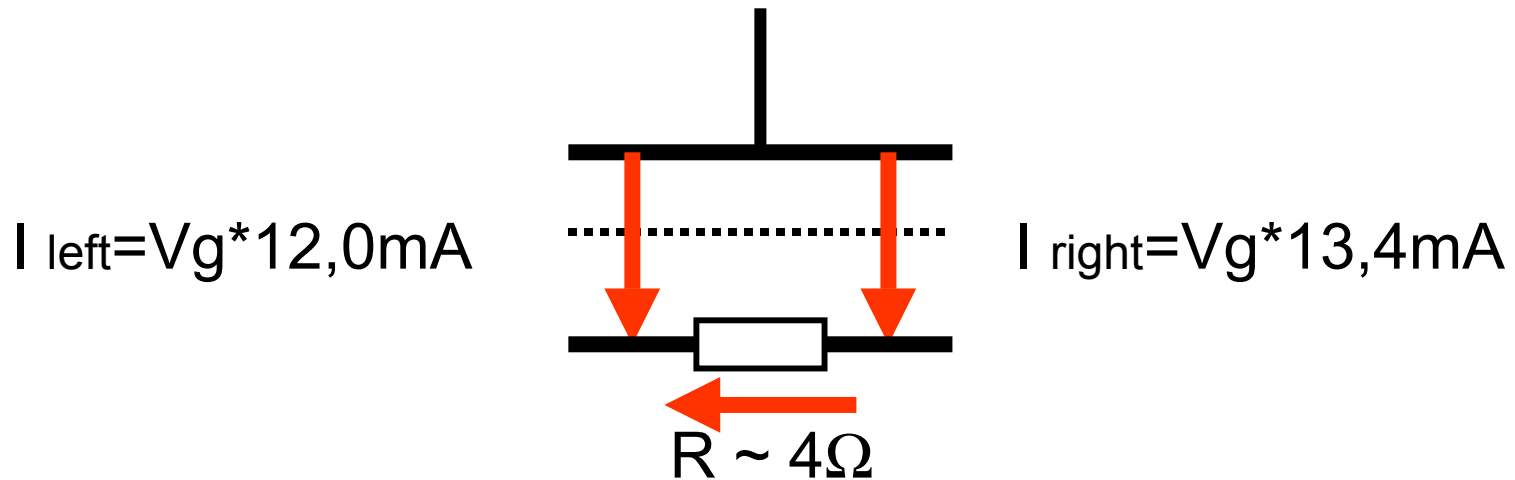
$$g_m = 13,4 \text{ mA/V}$$

# DC

- DC gives no anode current modulation (only shift)
- DC yields unbalanced DC current distribution
- Unbalance gives different (>10%) gm for both halves



- Different  $g_m$  results in different audio currents through both left and right part of the cathode



- A resulting current **through\*** the cathode is generated
- \* **Different from the heater current - we are talking audio here !**





# Voltage or Current



- Voltage sources heating a DHT **short** the cathode
- Cathode source impedance  $Z=4\Omega$  (5V/1,2A)
- Audio current will (partly) run through the external impedance (voltage regulator, electrolytic capacitor)



# Current



- Current sources do **not short** the cathode.....
- The differential current still generates a voltage across the heater, depending on external circuit
- Current source output impedance should be  $\gg 4 \Omega$
- When adjusting a current source, the resulting voltage should match the specification (e.g. 5V)
- TentLabs will come up with a novel design to overcome the need for adjustment

# External cathode circuit



- The differential cathode current also depends on the external cathode connection
- AC
  - Potentiometer
  - CT heater transformer (no nulling possible)
- DC
  - Potentiometer - what is optimum position
  - 1 side to ground - better than a pot ?

# Conclusions AC



- 50 / 60Hz AC heating
  - easy to implement
  - heater voltage depends on mains voltage
  - resulting LF hum cannot be nulled
  - 20dB or more intermodulation distortion compared to DC
- RF AC heating
  - may be used: modulation outside spectrum audible ?
  - Complex circuitry

# Conclusions DC



- Voltage sources
  - rather simple set-up
  - heater supply and or decoupling in audio signal
- Current sources
  - somewhat more complex to apply
  - heater supply virtually outside signal