DHT heaters

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

![Graph showing intermod 300b, AC versus DC heater]
• Intermod caused by RF may be outside audible range
• The cathode can be modelled by many in parallel
• Consider 2 halves (keep it simple)

\[ V_a = 400V \]
\[ V_g = -80V \]

\[ V_{gk} = 80V \]
\[ gm = 12,0mA/V \]
\[ R \sim 4\Omega \]
\[ V_{gk} = 75V \]
\[ gm = 13,4mA/V \]
• DC gives no anode current modulation (only shift)
• DC yields unbalanced DC current distribution
• Unbalance gives different (>10%) gm for both halves
• Different gm results in different audio currents through both left and right part of the cathode

\[ I_{\text{left}} = V_g \times 12.0\, \text{mA} \quad I_{\text{right}} = V_g \times 13.4\, \text{mA} \]

\[ R \sim 4\, \Omega \]

• 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 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 $>> 4 \ \Omega$
• 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
• 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
• 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