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DC Power Sources for the High Power RF Amplifiers

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Review ESS Spoke RF Source

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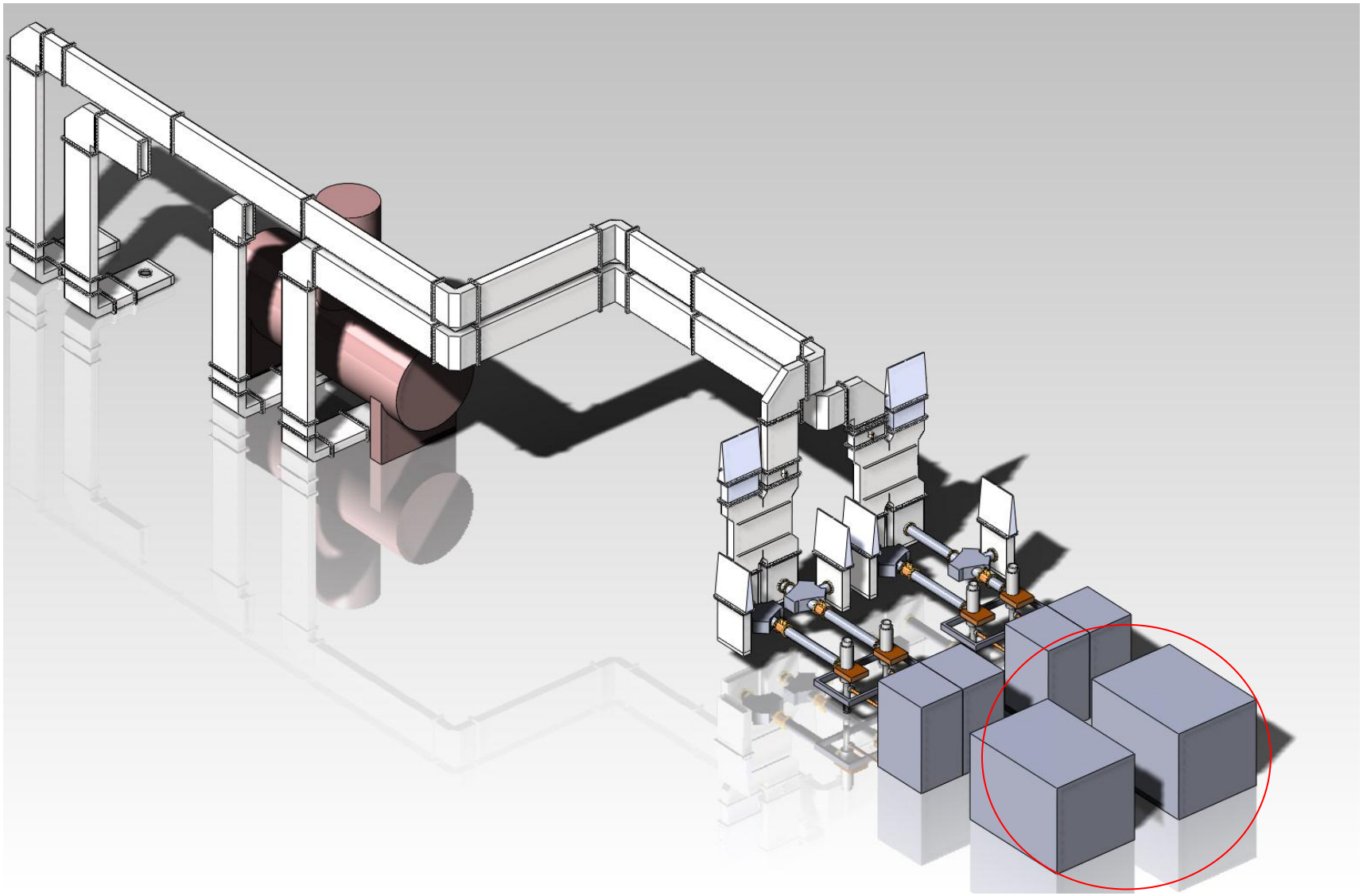
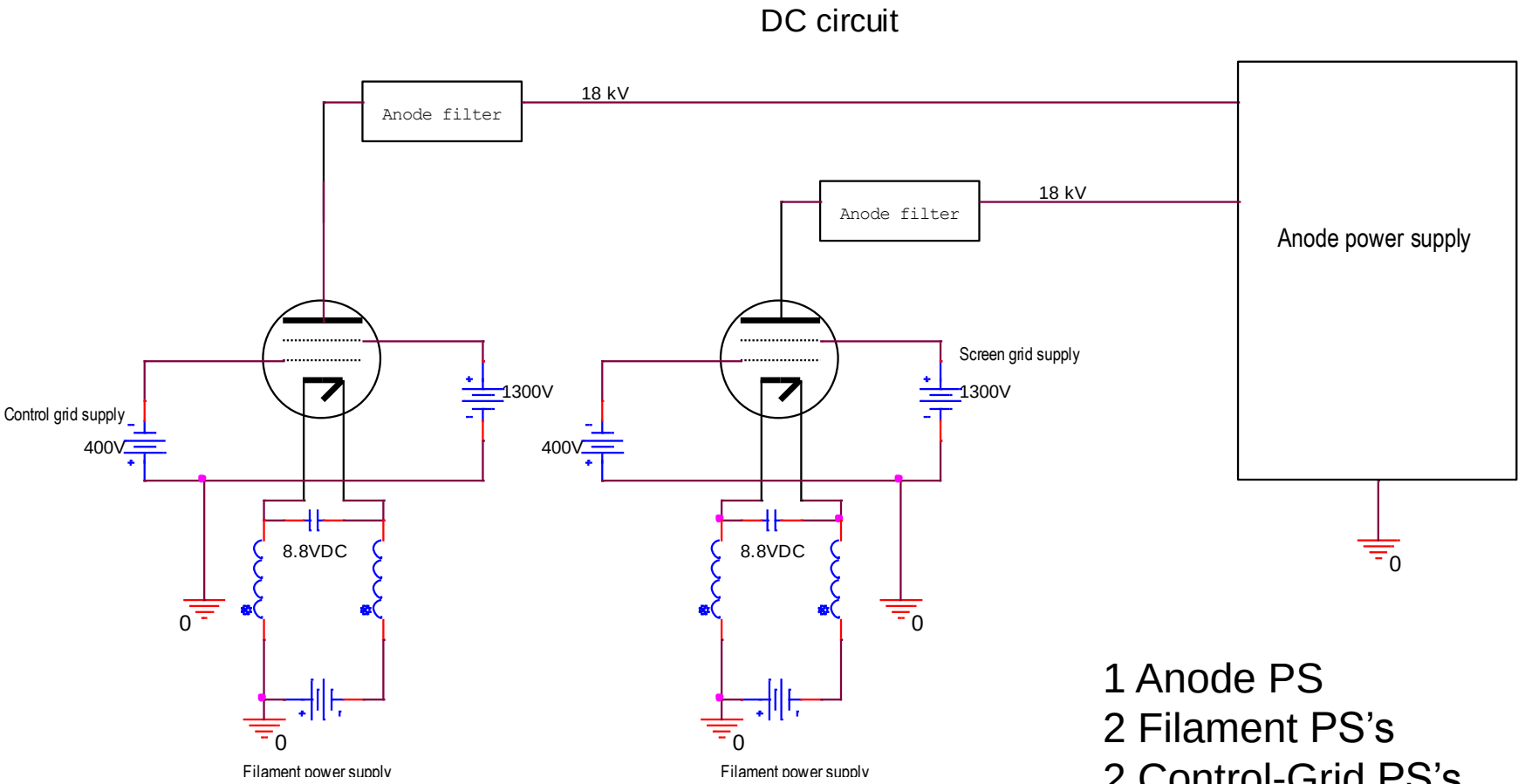
Agenda

- DC Power supplies overview
- Anode power supply
  - Main components
  - Suppliers
  - Expected performance (simulation)
  - Simple simulation for ringing and envelope vs time
- Filament power supply
- Grids power supplies
  - Control grid
  - Screen grid (modulation)
- Summary

DC Power Supplies

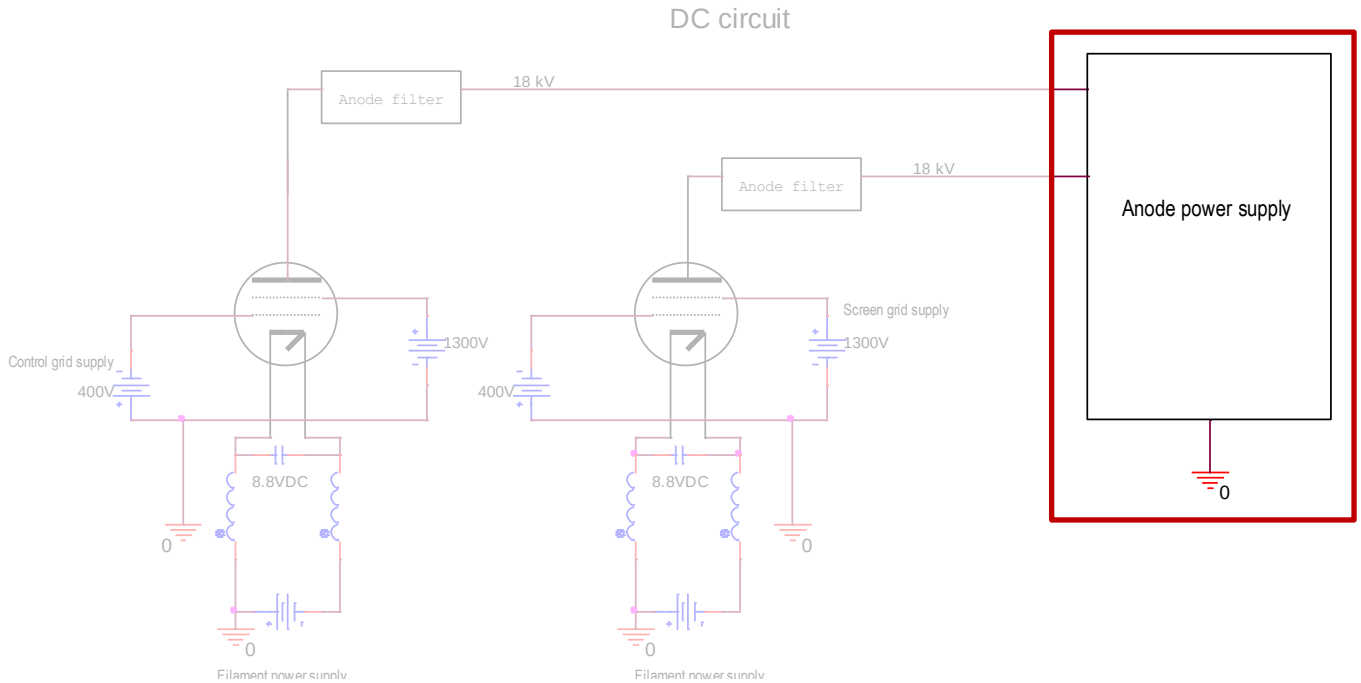


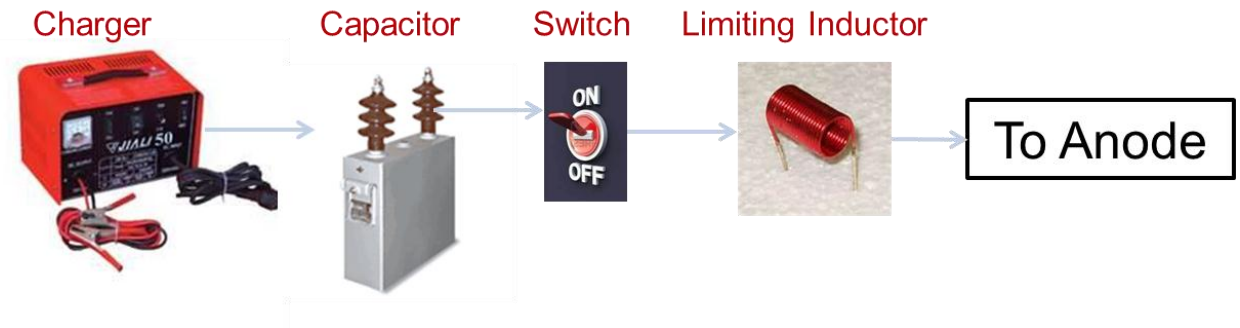
DC Power Supplies: Overview



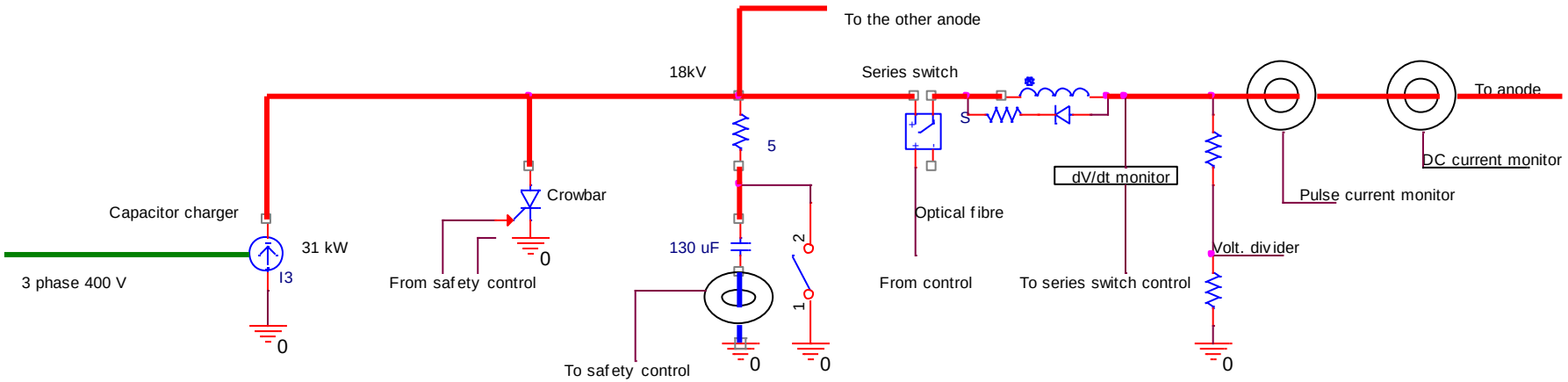
1 Anode PS
2 Filament PS's
2 Control-Grid PS's
2 Screen-Grid PS's

Anode Power Supply





Anode Power Supply: Main Components



Anode supply

Two Outputs

In each output

V_{max} = 18 kV
I_{max} = 18 A
Series-switches
dI/dt limiting with inductors

For both outputs

pulse width 3.5 ms
pulse rate 14 Hz
Maximum voltage droop 1 kV
Capacitor charger with voltage and power regulation

Anode Power Supply: Suppliers

- These components are **not** state-of-the-art
- Readily available
- Some examples:
  - Capacitor Charger: FuG , TECHNIX
  - Capacitor: Nokian, Hivolt capacitors, ABB and others
  - Switches: Behlke, DTI and Gihomeq AB
  - Coils: Unitrafo, Transform and others
  - Assembly: High Voltage AB, JACO industries and others

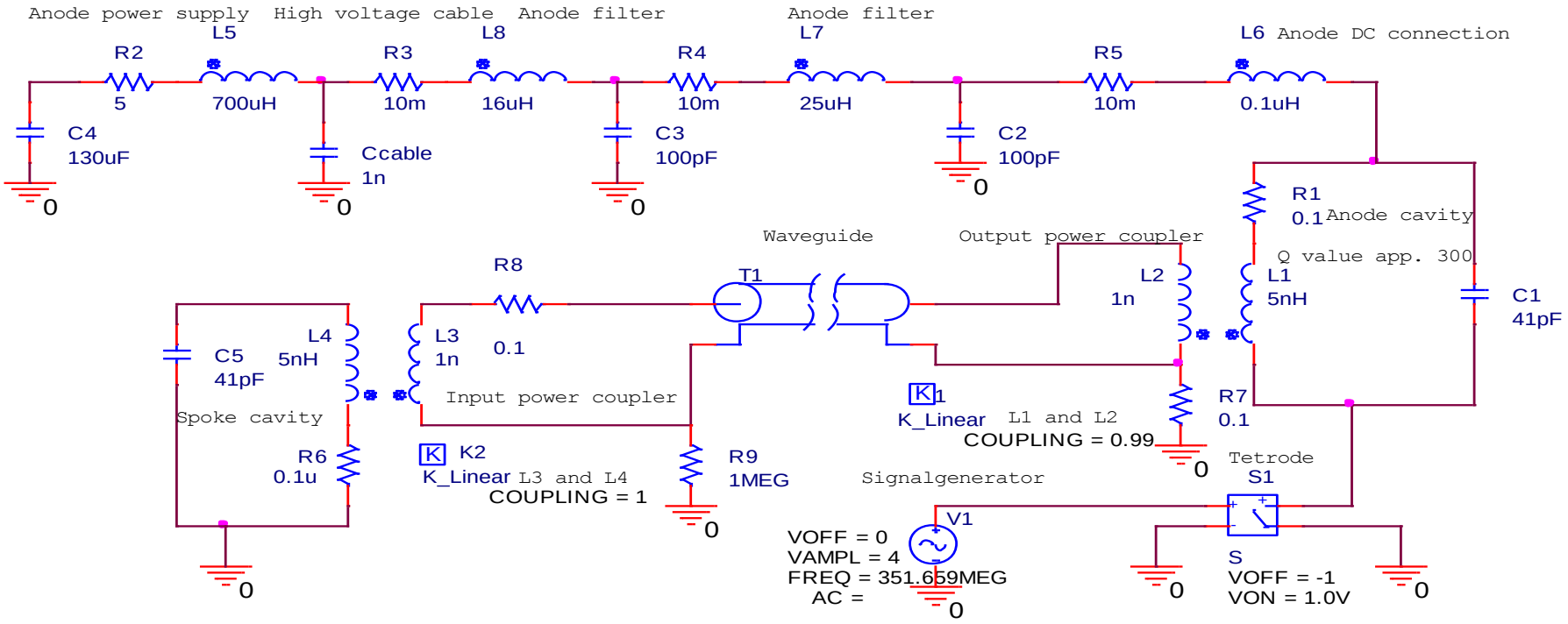
Anode Power Supply: Performance

- Main problems:
  - Series switches current capability
  - Output voltage ringing due to the inductive outputs

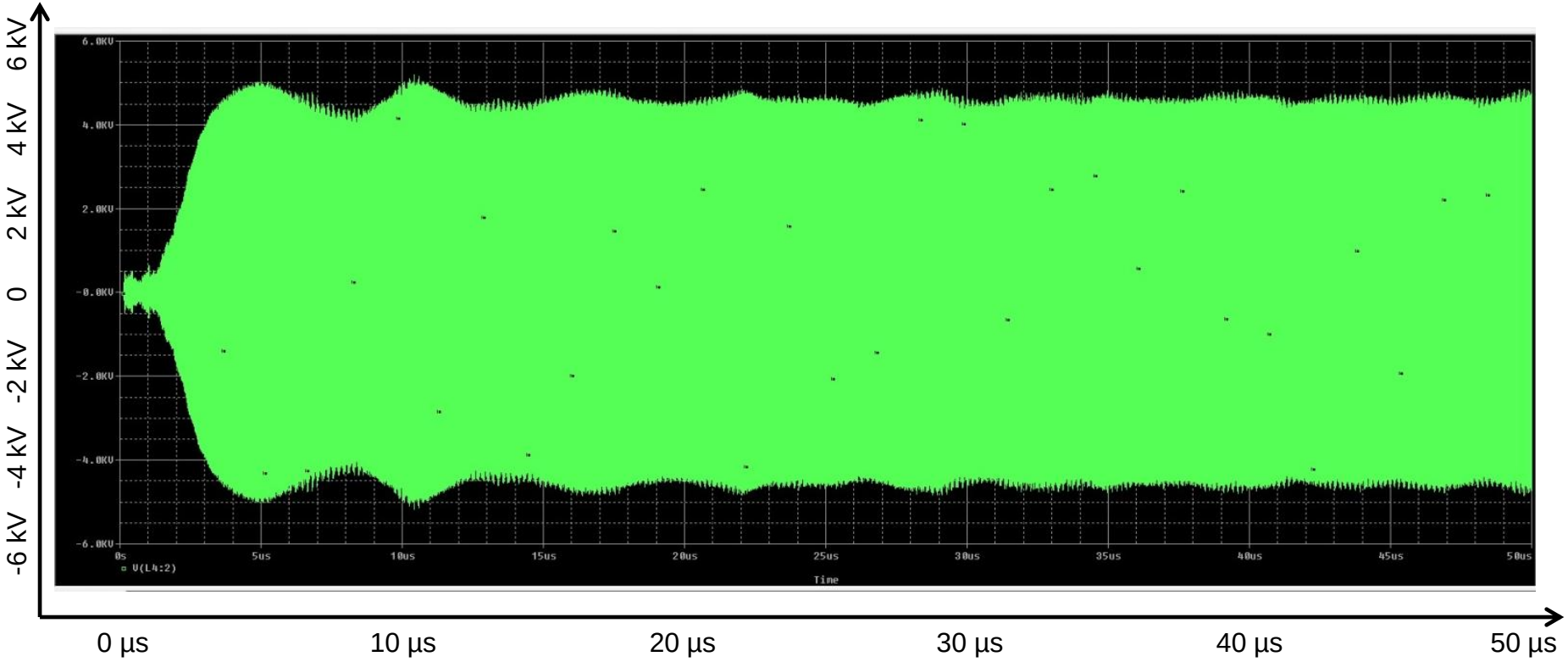
- To check performance ⟹ **Anode Power Supply Simulation**
  - A simple simulation has been run to observe behaviour and ringing of the output voltage of the anode power supply
  - Cable length, filters, cavity etc. have been included
  - Assumptions:
    - Tetrode considered as a switch

Anode Power Supply: Simplified circuit

The equivalent electric circuit used for the simulations:



Anode Power Supply: Transient regime



Order-of-magnitude estimate shows that the tetrode cavity voltage is stabilized after 20 us

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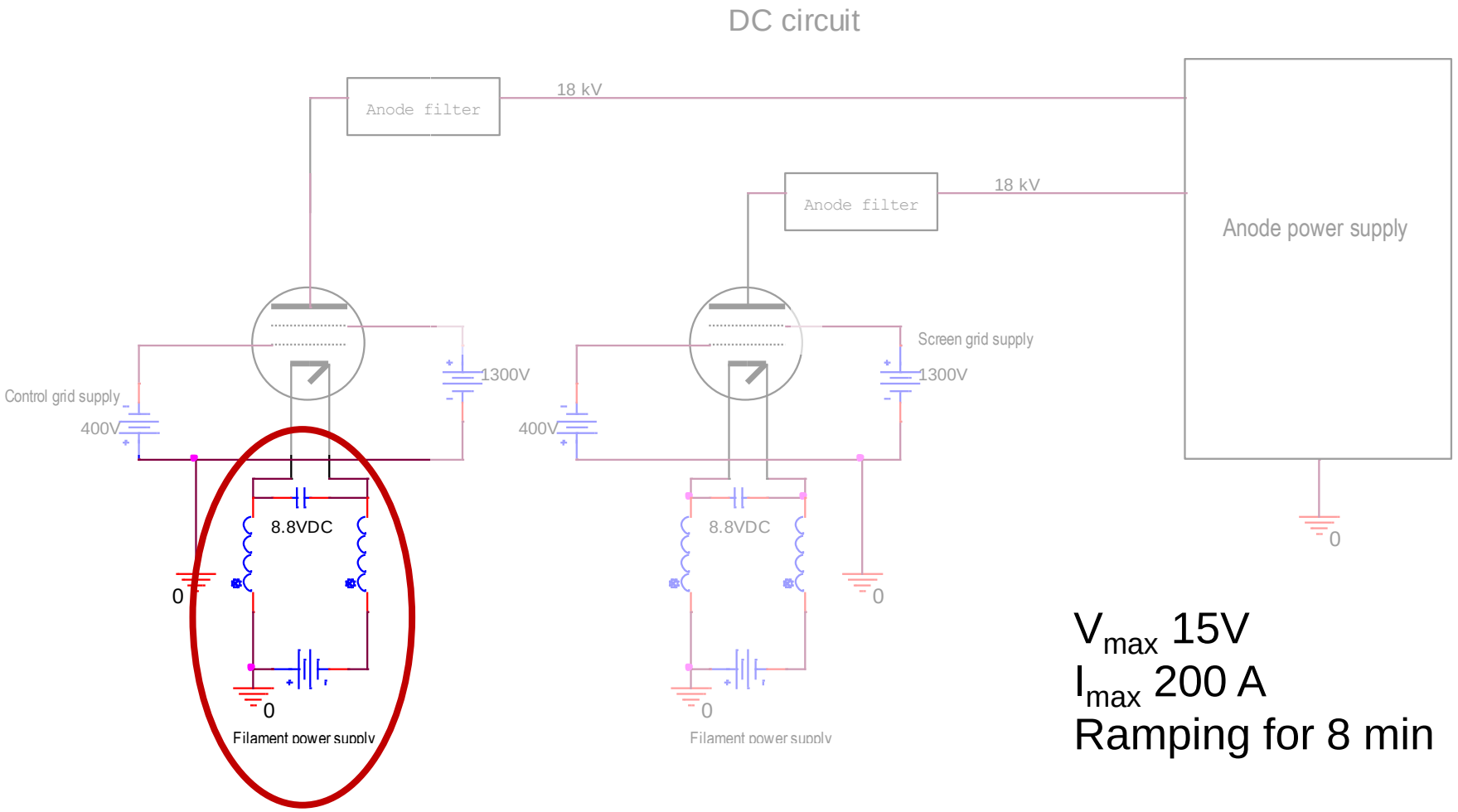
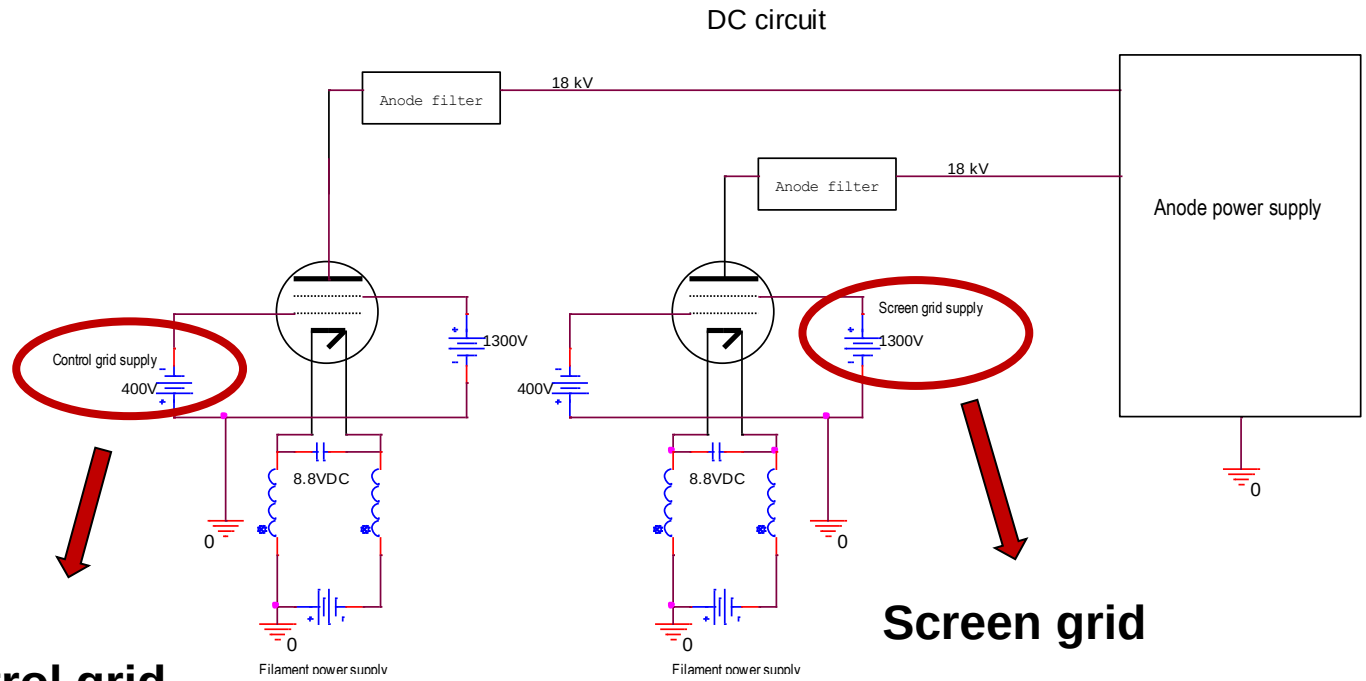
Enough time for the amplifier to be stable on every pulse

Filament Power Supply



V_{max} 15V
I_{max} 200 A
Ramping for 8 min

Grids Power Supplies



Control grid

- Max. output:
- Voltage 400 VDC
- Current 4 A
- Positive terminal grounded
- *i.e* Delta, FuG or Technix

Screen grid

- Max. output:
- Voltage 1300 VDC
- Current 0.7 A
- Negative terminal grounded
- *i.e* FuG or Technix

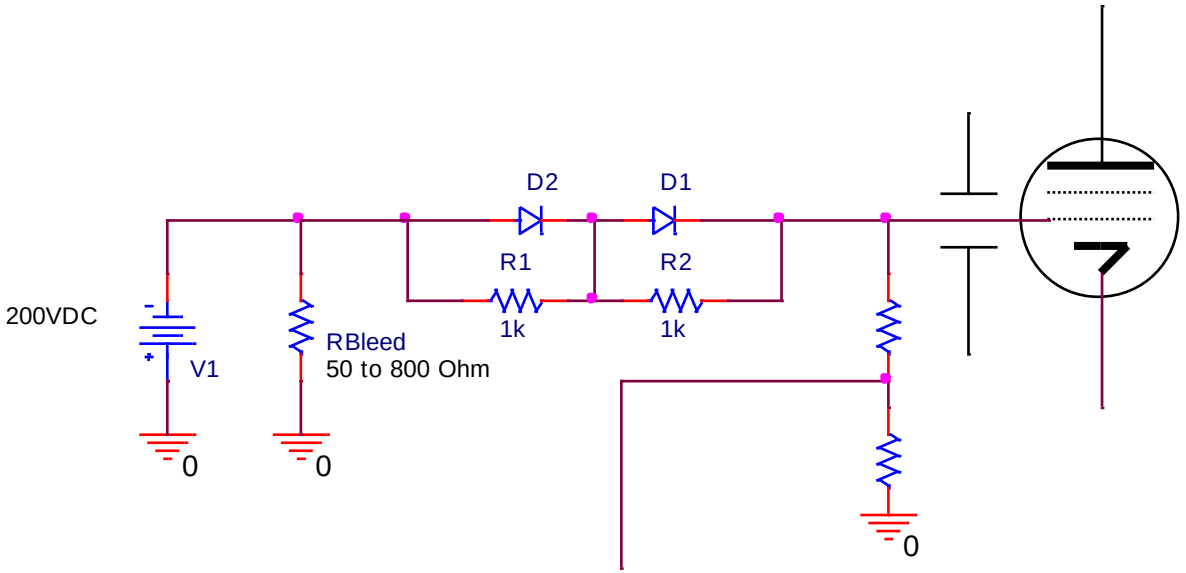
Summary

- The Anode Power supply:
  - can be made of an assembly of commercial components
  - is special to use the power grid in an efficient way and designed for the pulsed load
- Grid and filament power supplies are ”off the shelf” commercial power supplies

Thank you Rocio and Vitaliy for help with Power Point

Control Grid Connection

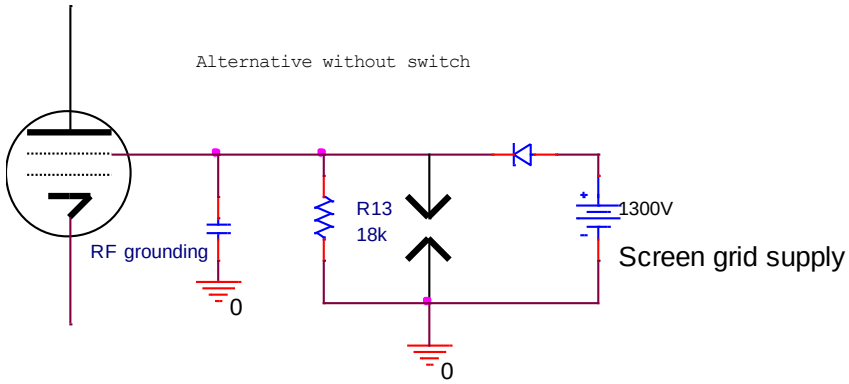
Thales recommended control grid connection.

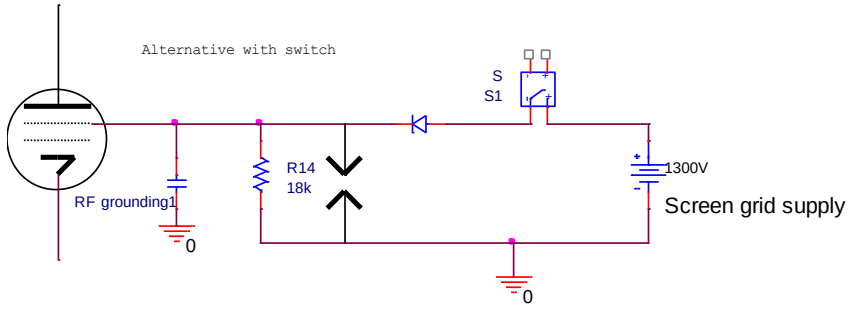


If positive switch off RF within 100 us and control grid power supply in 20 ms.

The control grid voltage will become more negative during RF-pulse. Bootstrapping?
The power supply is working with high output current into the bleeder resistor so that it may sink current during the RF-pulse.

Screen-grid Connection: Modulation





The Power Supply needs protection when there is an arc from the anode. The Screen grid may be used to modulate, turn off anode current between RF pulses.