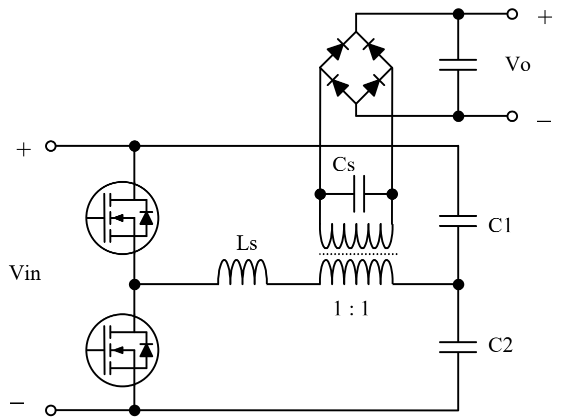
Resonance half bridge LCC converter analysis

Main iteration routine



Basic half bridge resonance LCC converter.

Logarithmic frequency sweep:

Min. frequency: $fmin \equiv 50 \cdot 10^3$

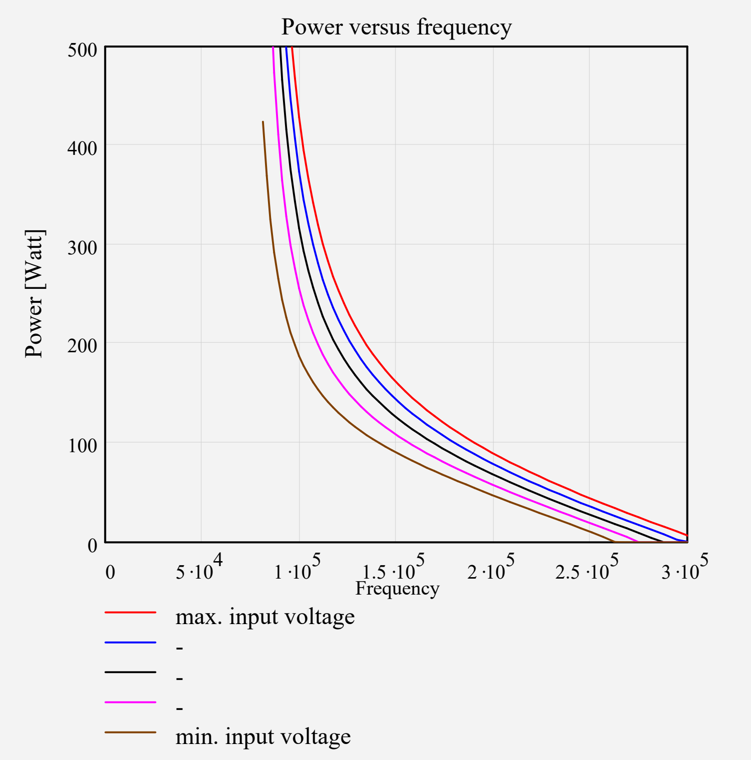
Max. frequency: $fmax \equiv 400 \cdot 10^3$

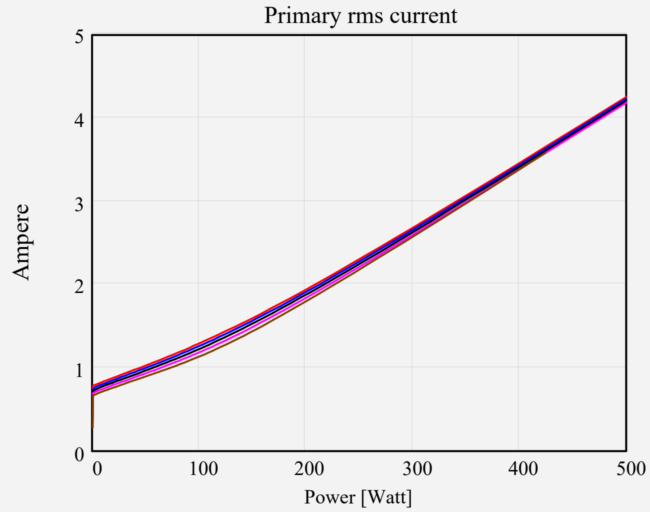
Number of steps pr. decade: $S \equiv 100$

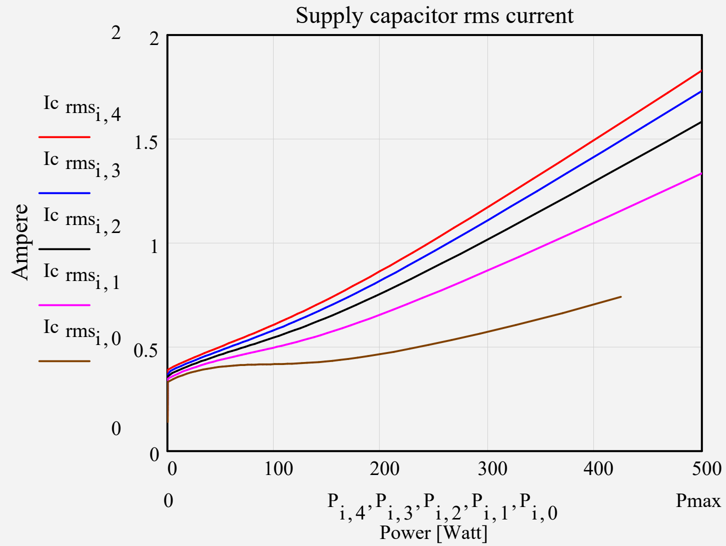
Plot to max. power: $Pmax \equiv 500$

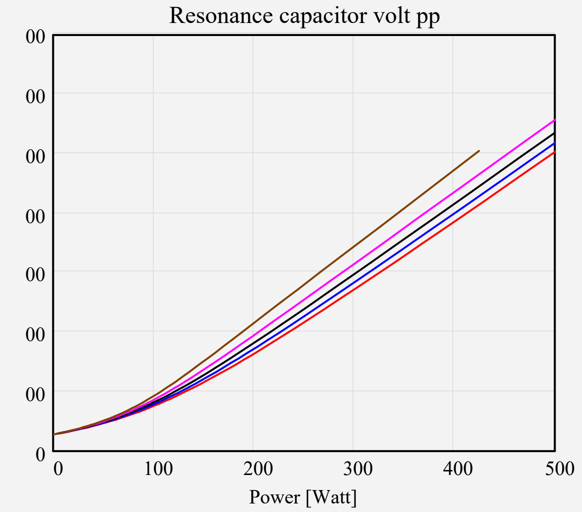
$$i \equiv 0, 1 .. S \cdot \log\left(\frac{fmax}{fmin}\right) \qquad f_i \equiv fmin \cdot 10^{\frac{i}{S}}$$

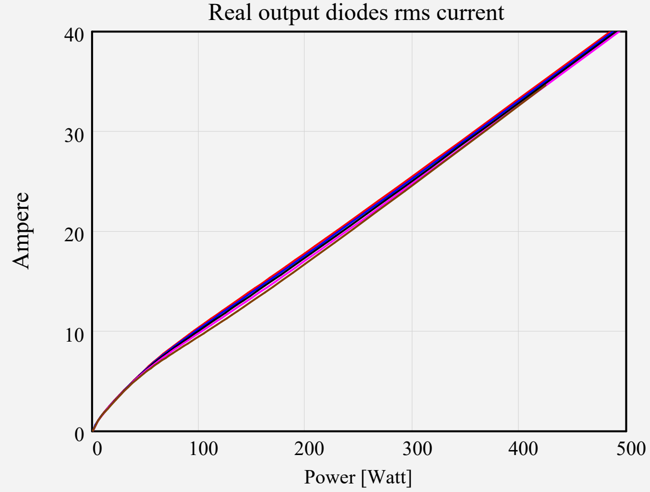
Input voltages: $\begin{pmatrix} VI_4 \\ VI_3 \\ VI_2 \\ VI_1 \\ VI_0 \end{pmatrix} = \begin{pmatrix} 460 \\ 410 \\ 360 \\ 310 \\ 260 \end{pmatrix}$

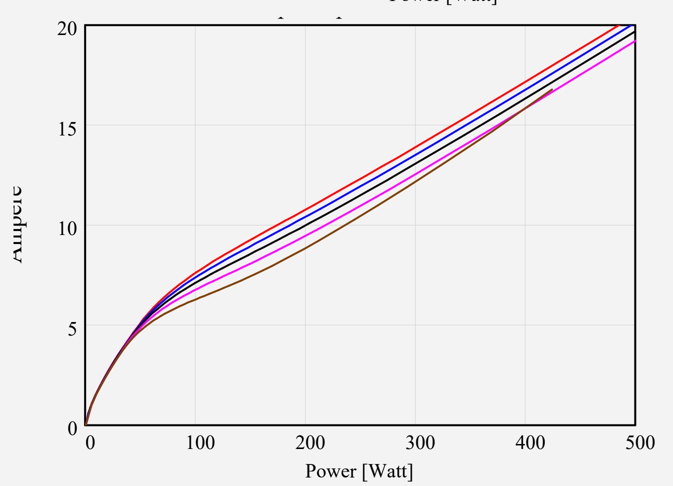


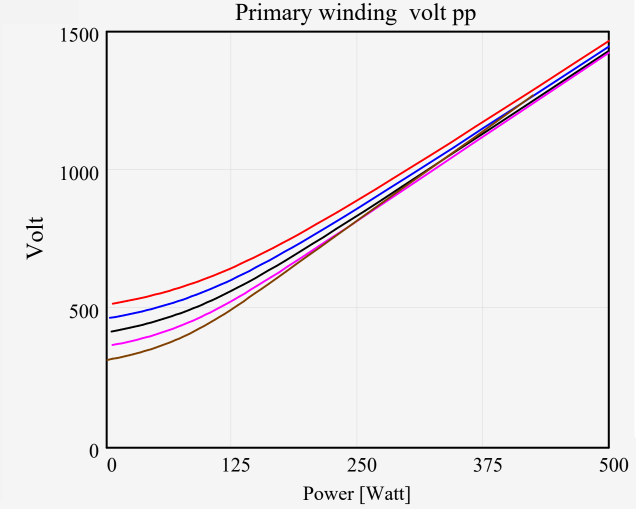


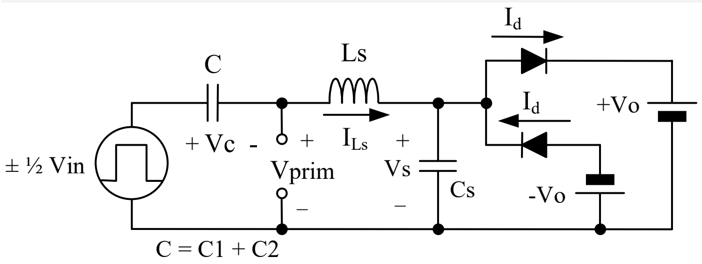












LCC converter model

Data input:

Selected component values:	$C \equiv 2 \cdot 10 \cdot 10^{-9}$	$Ls \equiv 216 \cdot 10^{-6}$	$Cs \equiv 4.073 \cdot 10^{-9}$
Input voltage Vin:	$Vmin \equiv 260$	$Vmax \equiv 460$	
Fictitious output voltage (1:1 trafo):	$Vo \equiv 137$		
Real output voltage:	$Vout \equiv 14$		

Real secondary side capacitor:

$C_s = 390 \times 10^{-9}$

Time plots.

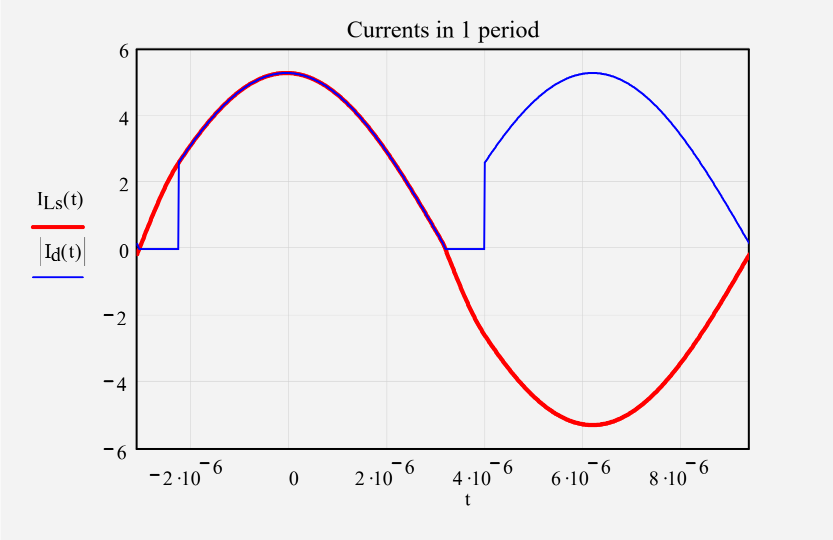
For check of the above results and for comparison with scope pictures or simulation currents and voltages are plotted within one switching period, in which the input voltage starts positive. Input voltage is switched between -½ Vin og ½ Vin.

Choose a switching frequency F and an input voltage Vin. Note the "Status" sign at too low frequency.

Status = "OK"

Switching frequency: $F \equiv 80 \cdot 10^3$

Input voltage: $Vin \equiv 260$



$I_{Ls}(t)$: current in inductor and primary switches.

$|I_d(t)|$: current in output diodes all together (trafo = 1:1)

Power: Power = 450.9

Input rms current: $I_{i.rms} = 3.81$

Output diodes rms current: $I_{o.rms} = 36.88$

Output capacitor rms current: $I_{lyt} = 17.96$

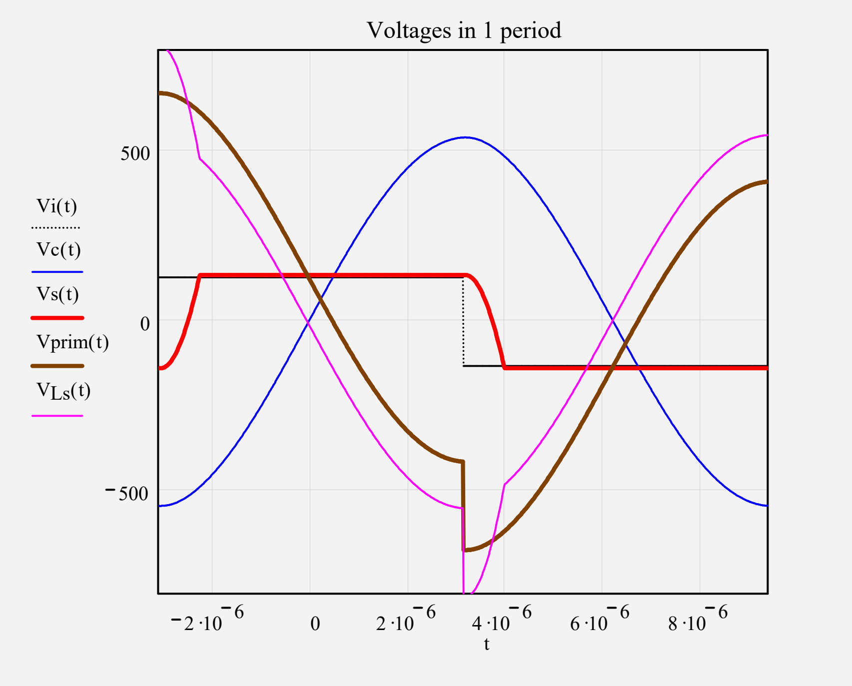
$Vo = 137$

$Vout = 14$

$Ls = 216 \times 10^{-6}$

$Cs = 4.07 \times 10^{-9}$

$C = 20 \times 10^{-9}$



Vi(t): input voltage.

Vs(t): voltage over secondary capacitor Cs. Will be clamped til ± Vo.

Vc(t): voltage over primary series capacitor C. Will be very high near resonance !

Vprim(t): voltage over primary winding if Ls is the leakage inductance of the transformer.

$V_{Ls}(t)$: Voltage over external inductor Ls.

Mode = 2

Transformer core and winding data input:

Core cross section: $A_{fe} \equiv 173 \cdot 10^{-6}$ [m²] **ETD44**

Core volume: $vol_{fe} \equiv 17.8$ [cm³]

Primary turns number: $Np \equiv 39$

Ferrite type: $ferrite \equiv 3$

ferrite = 1 ~ 3C90
ferrite = 2 ~ 3C94
ferrite = 3 ~ 3C95
ferrite = 4 ~ 3F3

copper resistivity @ 25ºC [Ω∗mm] $\rho cu \equiv 17 \cdot 10^{-6}$

wire temperature [ºC] $temp \equiv 100$

diameter primary [mm] $Øprim \equiv 20$

diameter secondary [mm] $Øsek \equiv 20$

diameter primary wire [mm] $Øprimwire \equiv 0.05$

diameter secondary wire [mm] $Øsekwire \equiv 0.05$

parallel primary wires $parprim \equiv 180$

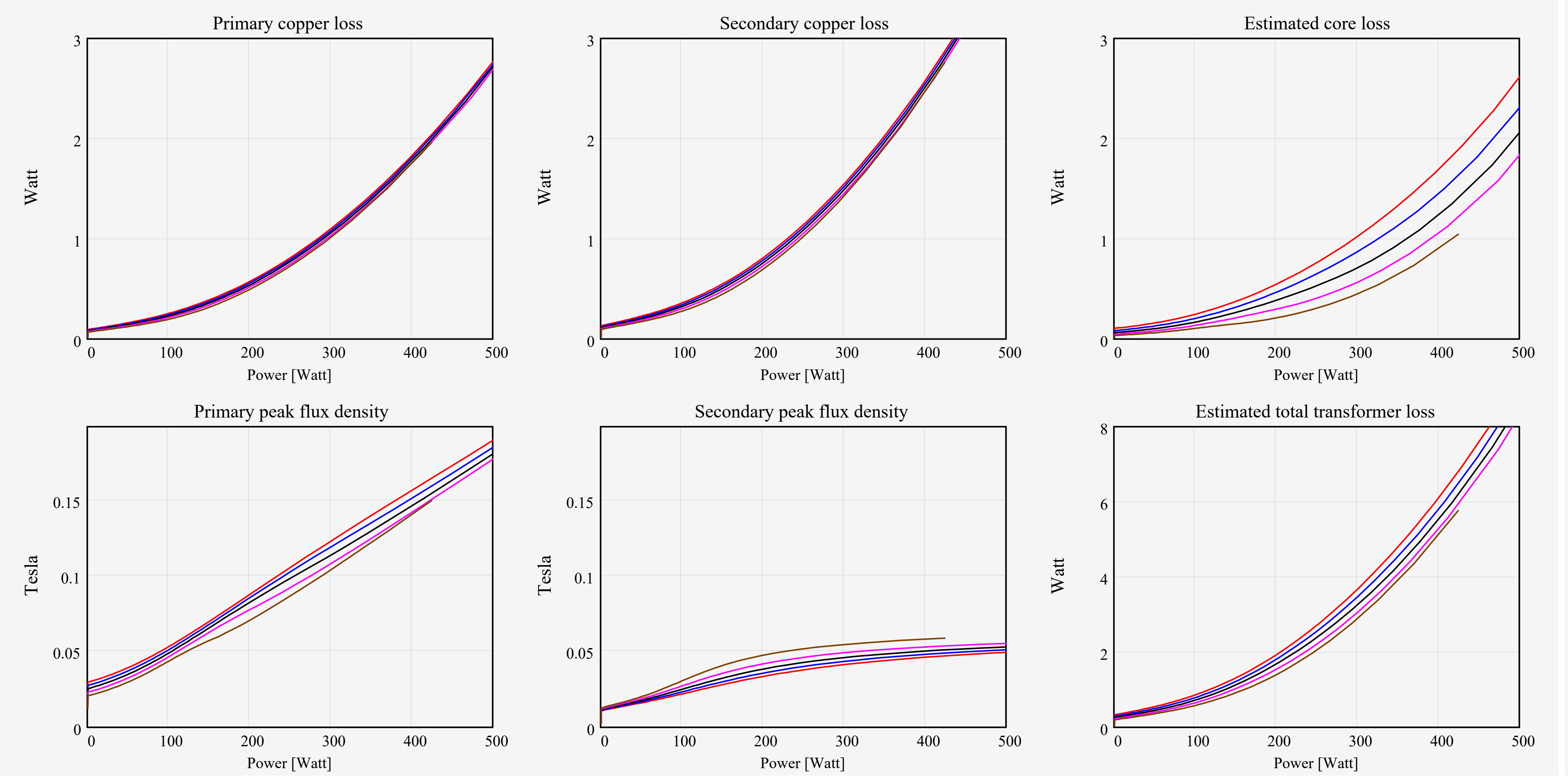
parallel secondary wires $parsek \equiv 1250$

If you use external inductor on input side, write **inductor = "external".** Otherwise Ls is integrated in the transformer:

inductor ≡ "internal"

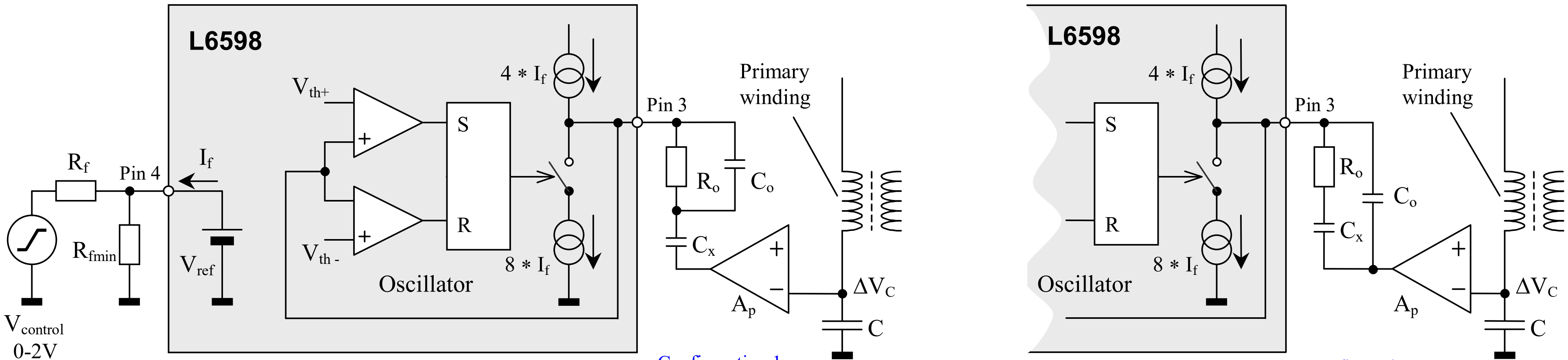
Transformer turns numbers: $Np = 39$, $Ns = 4.0$

Transformer wire resistance: $R_{prim} = 0.15$, $R_{sek} = 2.25 \times 10^{-3}$



Charge mode application with L6598.

Design of control graphs for regulation loop linearity.



Charge mode model

Configuration 1

Configuration 2

Charge mode equations

Control data input:

Oscillator peak-peak voltage pin 3: $\Delta V_{th} \equiv 2.9$

Pin 4 reference voltage: $V_{ref} \equiv 2$

RC configuration - see above: $configuration \equiv 2$

Oscillator capacitor: $C_o \equiv 100 \cdot 10^{-12}$

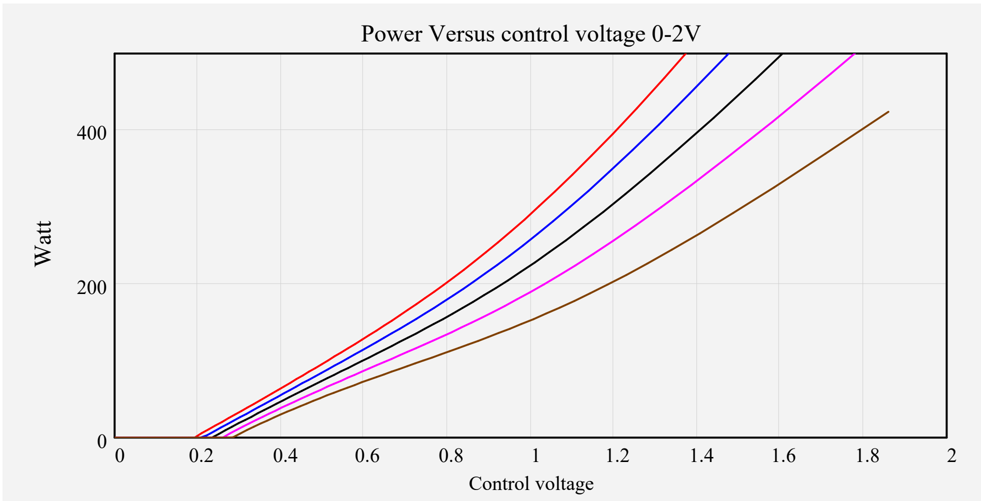
Resistor in RC network: $R_o \equiv 4.7 \cdot 10^3$

DC blocking capacitor: $C_x \equiv 1 \cdot 10^{-9}$

Start-up resistor: $R_{fmin} \equiv 220 \cdot 10^3$

Frequency programming resistor: $R_f \equiv 25 \cdot 10^3$

Charge signal inverter gain: $A_p \equiv 2.1 \cdot 10^{-3}$



Input voltages:

$$\begin{pmatrix} VI_4 \\ VI_3 \\ VI_2 \\ VI_1 \\ VI_0 \end{pmatrix} = \begin{pmatrix} 460 \\ 410 \\ 360 \\ 310 \\ 260 \end{pmatrix}$$

CAUTION: with charge mode control the control voltage for no-load is quite sensitive to R_f and other parameters! Leave a good margin to $V_{control} = 0$