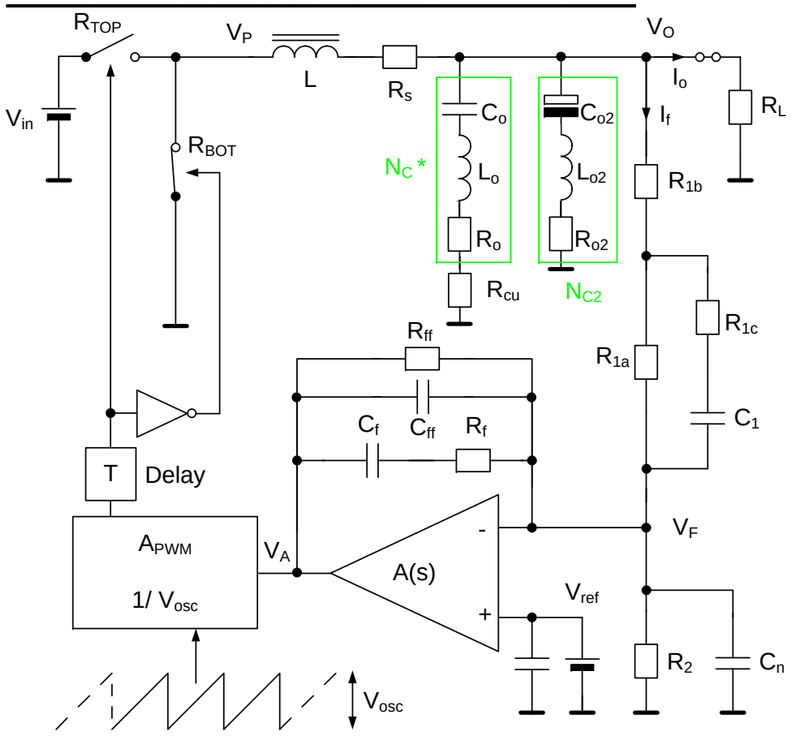
Globals - to dec 16 20:30:06 2010

Buck Converter AC model Version 1.13



Jens N. Rasmussen 11-05-2010 V_{ref} is considered as AC ground, I_f = 0A

Chosen manual values:

$C_f := 2.7nF$ $C_{ff} := 27pF$ $C_1 := 1200pF$ $R_f := 12k\Omega$ $R_{1c} := 560\ \Omega$

Compensation components:

$R_{1a} := 10k\Omega$

$R_{1b} := 0\Omega$

$R_2 := 8.2k\Omega$

$R_{ff} := 99999k\Omega$

$C_n := 0pF$

Error amplifier selector:

(•) Minimum gain and bandwidth
( ) Typical gain and bandwidth
( ) Maximum gain and bandwidth

Compensation:

$FCO := 50 \cdot kHz$

$\Theta_{PM} := 60$

Power stage components:

Ceramic cap*:

$C_o := 65\mu F$

$L_o := 0.5pH$

$R_o := 1m\Omega$

$N_C := 4$ Number of Caps

$R_{cu} := 1m\Omega$

Electrolytic:

$C_{o2} := 390\mu F$

$L_{o2} := 0.5pH$

$R_{o2} := 9m\Omega$

$N_{C2} := 0$ Number of Caps

Main inductor:

$L := 1.1\mu H$

$R_s := 3m\Omega$

Error amp spec.:

$Gain_{typ} := 70$ [dB] $G_{BW\_typ} := 16MHz$

$Gain_{min} := 55$ [dB] $G_{BW\_min} := 5MHz$

$Gain_{max} := 200$[dB] $G_{BW\_max} := 200MHz$

PWM modulator:

$V_{osc} := 0.93Vpp$ Ramp peak/peak voltage

$T_{delay} := 0ns$ Delay through PWM

Converter data:

$V_{in} := 5V$

$V_{out} := 1.5V$ Update R_2 value to match!

$F_{sw} := 300kHz$

Mosfets:

$R_{TOP} := 2m\Omega$

$R_{BOT} := 2m\Omega$

***Remember to derate ceramic filter capacitor value for DC bias! and temprature**

Note:
To make this worksheet work, please go to: Tools-> preferences-> script security and choose low securety

Load:

$R_L := 1\Omega$

$Fstep := 4 \cdot kHz$

$Istep := 5A$

$\delta := 800 \cdot \frac{mA}{\mu s}$ ☐ Infinite step slope

$Vstep := 55$ [mV] ☑ Include swtich ripple

Help line to evaluate dynamic performance

Sliders that change compensation poles and zeros:

$F_{CZ1} = 11.22 \times 10^3$ [Hz] $F_{CP1} = 125.893 \times 10^3$ [Hz]

$F_{CZ2} = 6.31 \times 10^3$ [Hz] $F_{CP2} = 199.526 \times 10^3$ [Hz]

Select your operation:

(•) Use manual compensation (Values shown uder model)
( ) Use calculated compensation (Ceramic output caps only)
( ) Use sliders to place individual poles and zeros
( ) Use sliders to place double poles and zeros (CZ1 & CP1)
( ) Auto placement of poles and xeros (Use FCO and PM)
( ) Auto placement of poles and xeros (Use FCO, PM and KC)

"Distance" from F_o to first pole and zero pair: $KC := 10$
This value will determine Lift1 and Lift2 Bandwidth requirements for erroramp will depend on this ratio!!!

For full functionality: Place file License.txt in the same folder as Syncron buck AC model.xmcd (This file)

Calculations - to dec 16 20:29:58 2010

Values used in calculation of graphs:

$C_f = 2.7 \times 10^{-9}$ $C_{ff} = 27 \times 10^{-12}$ $C_1 = 1.2 \times 10^{-9}$ $R_f = 12 \times 10^3$ $R_{1c} = 560 \times 10^0$

$F_{PM} = 48.6 \cdot kHz$ $F_{GM} = 239 \cdot kHz$ $F_{LC} = 9.4 \cdot kHz$

PhaseMargin = 56.7 GainMargin = 18.9

For auto placement using KC:

Phase boost from first pair:

Lift1 = 78.579

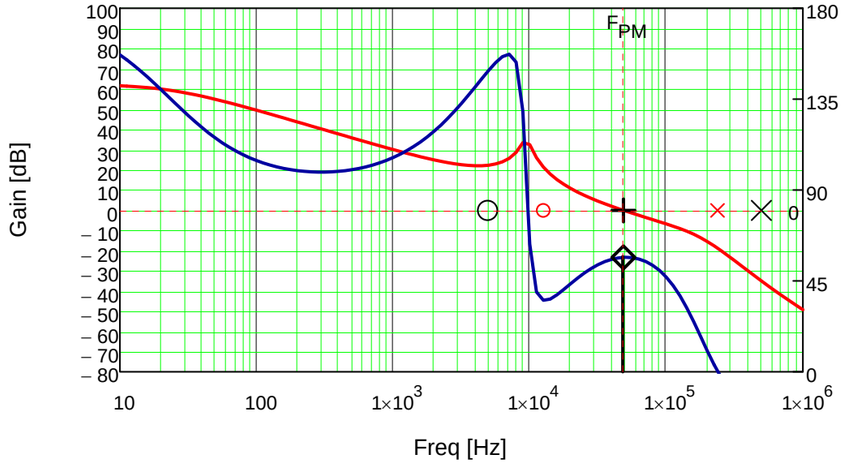
Phase boost from second pair:

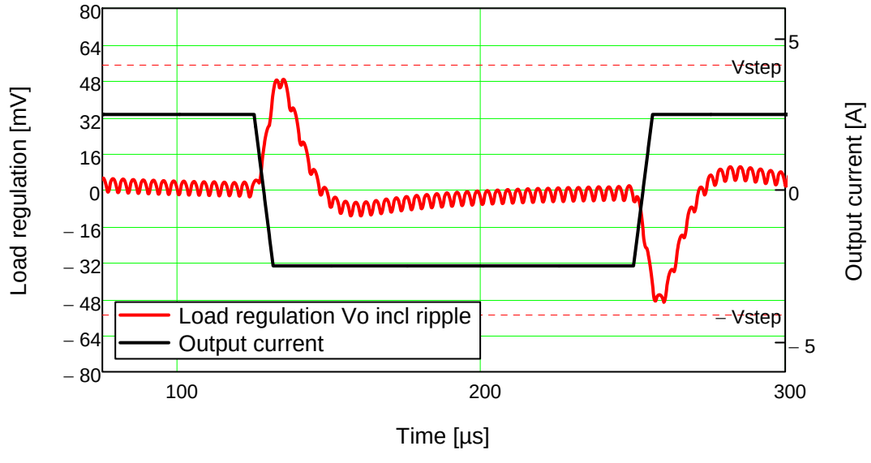
Lift2 = 64.135

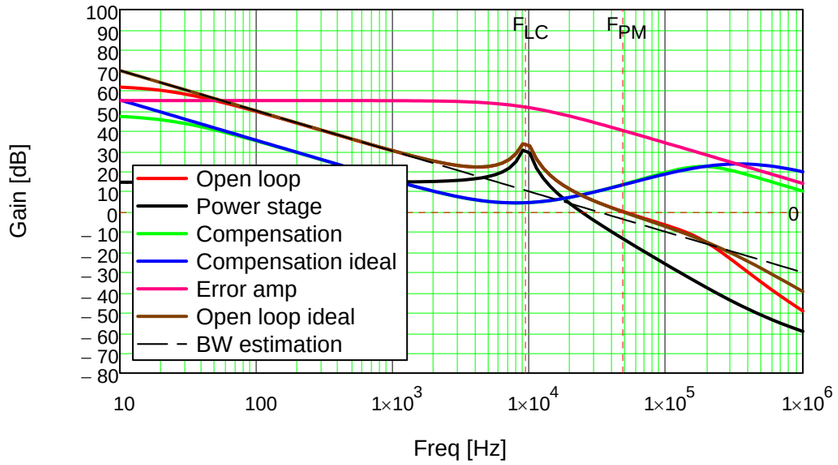
K method values:

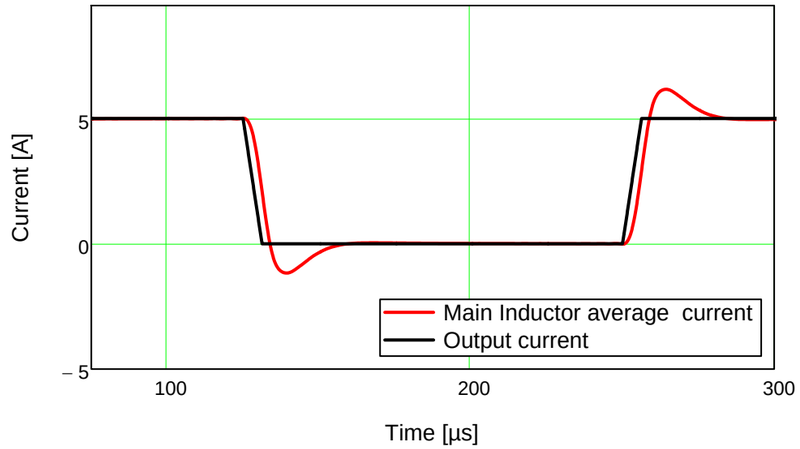
$K_{double} = 6.092$

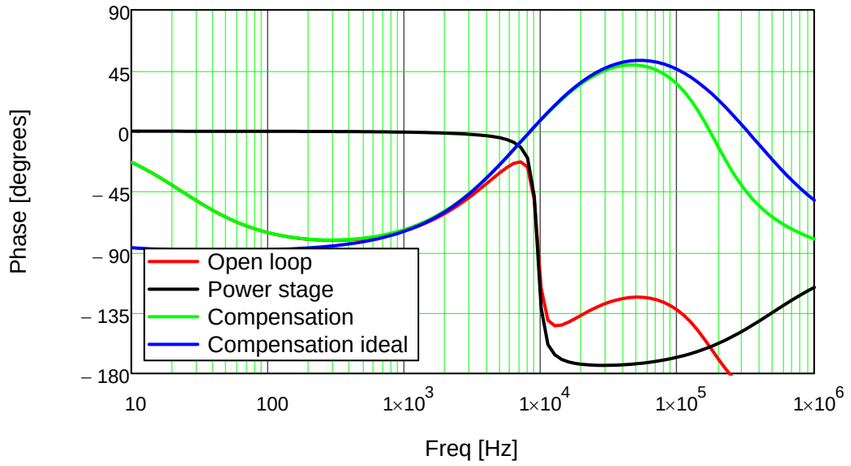
$K_{other} = 4.355$

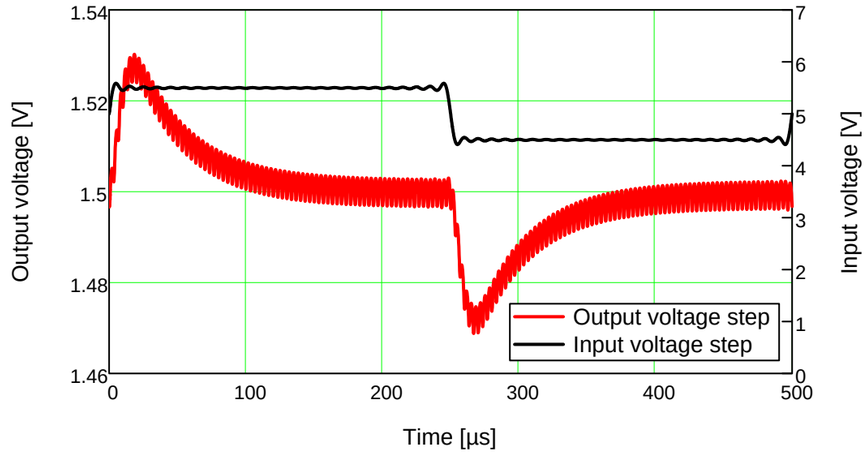


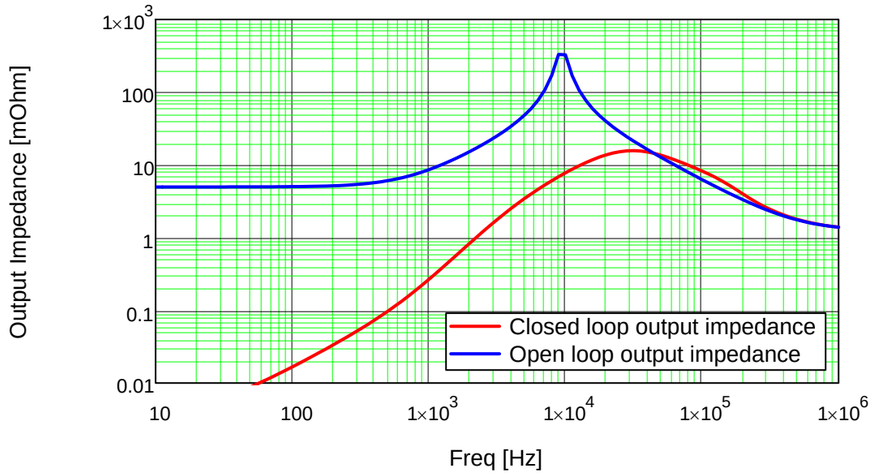


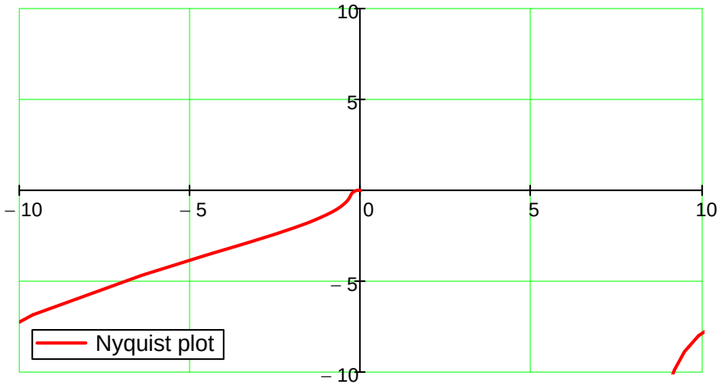

Gain [dB]
Freq [Hz]
F_LC
F_PM
Open loop
Power stage
Compensation
Compensation ideal
Error amp
Open loop ideal
BW estimation

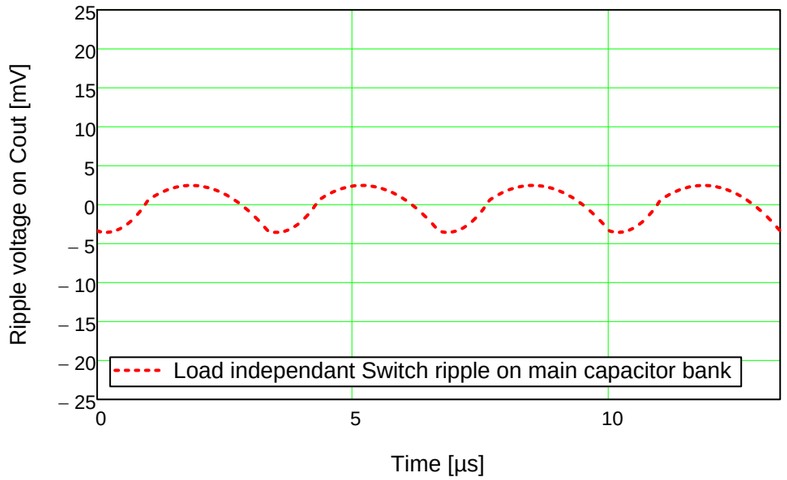

Current [A]
Time [µs]
Main Inductor average current
Output current

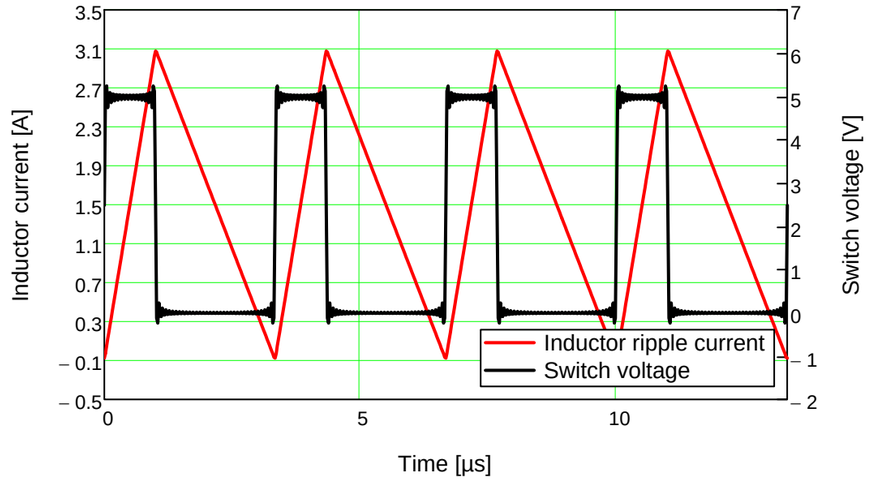

Phase [degrees]
Freq [Hz]
Open loop
Power stage
Compensation
Compensation ideal

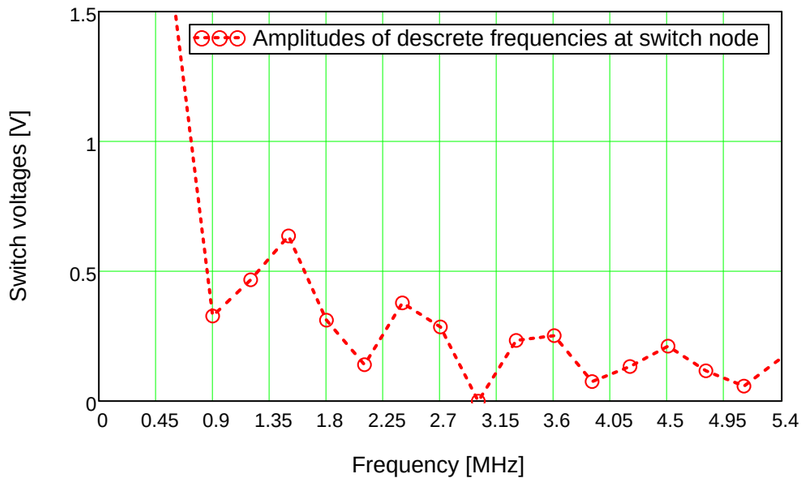

Output voltage [V]
Input voltage [V]
Time [µs]
Output voltage step
Input voltage step

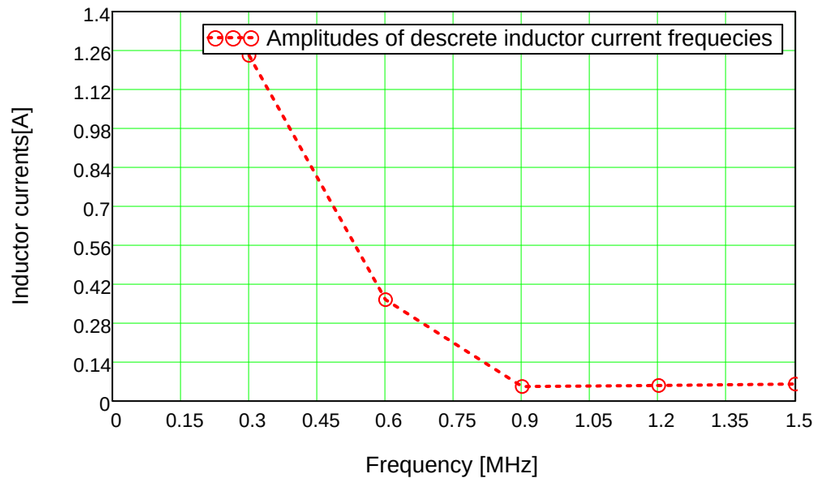

Output Impedance [mOhm]
1×10^3
100
10
1
0.1
0.01
10
100
1×10^3
1×10^4
1×10^5
1×10^6
Freq [Hz]
Closed loop output impedance
Open loop output impedance


10
5
– 10
– 5
0
5
10
– 5
– 10
Nyquist plot


Ripple voltage on Cout [mV]
25
20
15
10
5
0
– 5
– 10
– 15
– 20
– 25
0
5
10
Time [µs]
Load independant Switch ripple on main capacitor bank


Inductor current [A]
3.5
3.1
2.7
2.3
1.9
1.5
1.1
0.7
0.3
– 0.1
– 0.5
7
6
5
4
3
2
1
0
– 1
– 2
Switch voltage [V]
0
5
10
Time [µs]
Inductor ripple current
Switch voltage


Amplitudes of descrete frequencies at switch node
Switch voltages [V]
1.5
1
0.5
0
0
0.45
0.9
1.35
1.8
2.25
2.7
3.15
3.6
4.05
4.5
4.95
5.4
Frequency [MHz]


Amplitudes of descrete inductor current frequecies
Inductor currents[A]
1.4
1.26
1.12
0.98
0.84
0.7
0.56
0.42
0.28
0.14
0
0
0.15
0.3
0.45
0.6
0.75
0.9
1.05
1.2
1.35
1.5
Frequency [MHz]