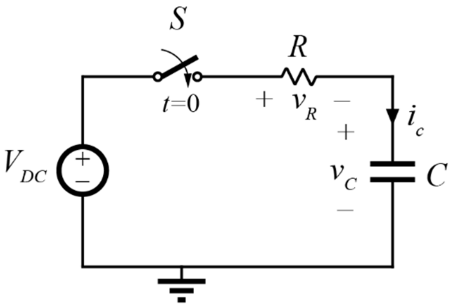
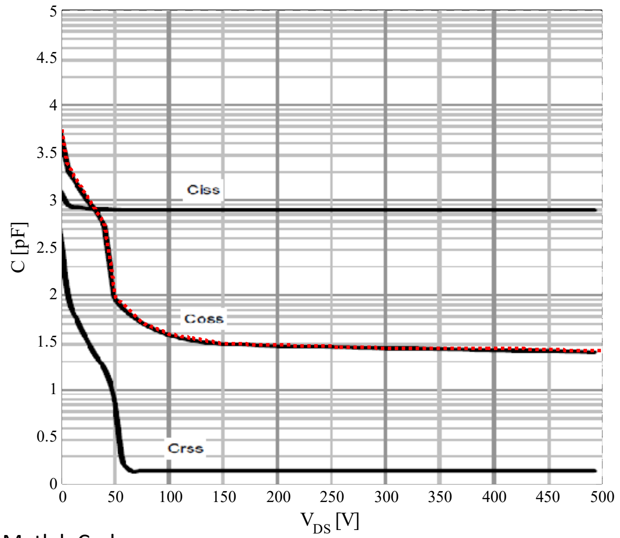
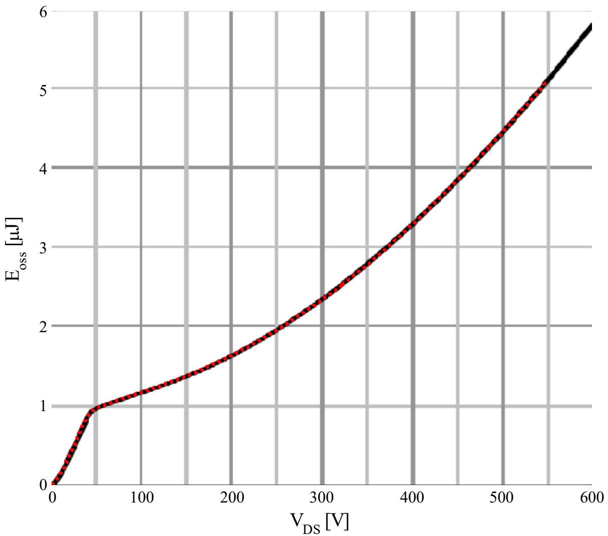
M_1 Energy Loss



Total Half Bridge C_{oss} Loss

Energy Equivalent





<u>Matlab Code:</u>

```
Vdc = 550;

Vds = [0    5    10   40  50 75 100 150 200 300 400 500 600];
Coss = [5500 2500 1900 550 95 50 38  30  29  27  27  25  24]*1e-12;

vx = 0.01:.01:Vdc;
Cx = 10.^interp1(Vdc,log10(Coss),vx,'linear');

E = cumtrapz(vx, Cx.*vx);
Ceq_e = 2*(E)./vx.^2;
```

Nonlinear Capacitance Extraction

- http://web.eecs.utk.edu/~dcostine/personal/PowerDeviceLib/DigiTest/index.html

Datasheet Reported Capacitance

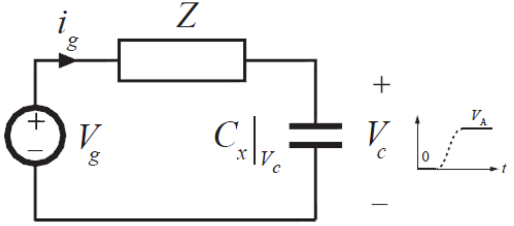
Dynamic characteristics

Input capacitance	C_{iss}	V_{GS}=0 V, V_{DS}=100 V, f=1 MHz	-	790	-	pF
Output capacitance	C_{oss}		-	38	-	
Effective output capacitance, energy related[6)]	$C_{o(er)}$	V_{GS}=0 V, V_{DS}=0 V to 480 V	-	36	-	
Effective output capacitance, time related[7)]	$C_{o(tr)}$		-	96	-	
Turn-on delay time	$t_{d(on)}$	V_{DD}=400 V, V_{GS}=10 V, I_D=5.2 A, R_G=3.3 Ω	-	10	-	ns
Rise time	t_r		-	5	-	
Turn-off delay time	$t_{d(off)}$		-	40	-	
Fall time	t_f		-	5	-	

[6)] $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS}.

[7)] $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS}.

Example Simulation

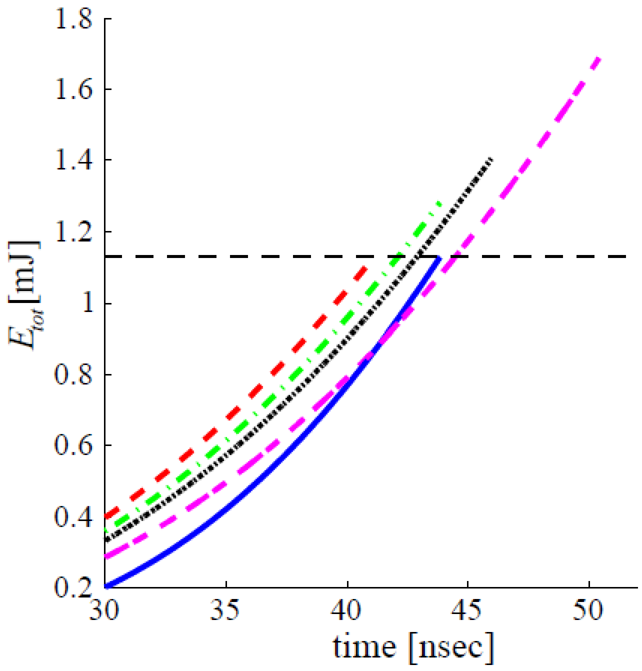


$C_{eq,Q} = 70.5$ pF,

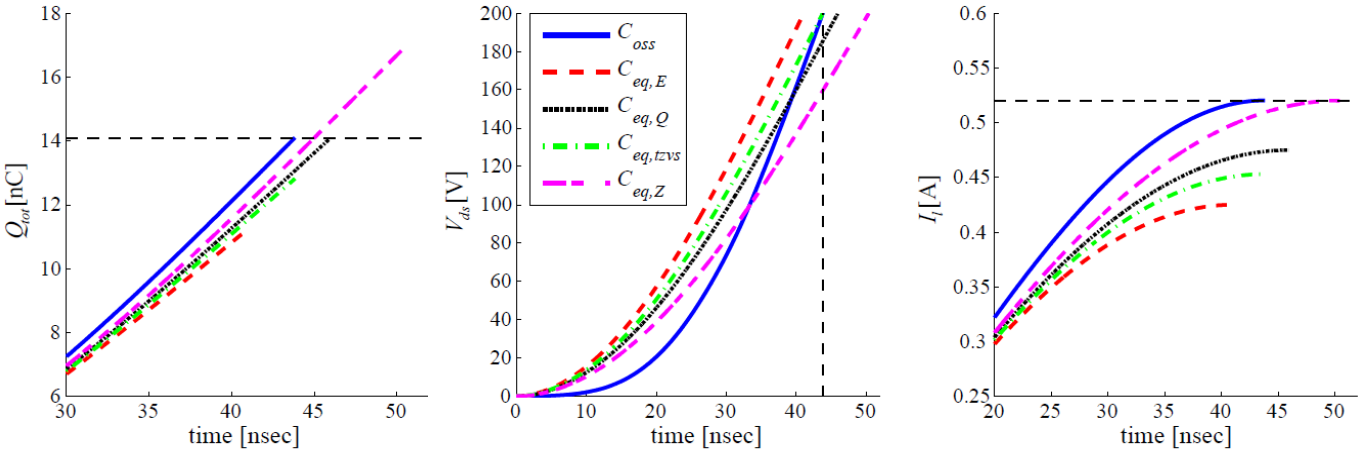
$C_{eq,E} = 56.4$ pF,

$C_{eq,tzvs} = 64.1$ pF

$C_{eq,Z} = 84.5$ pF.



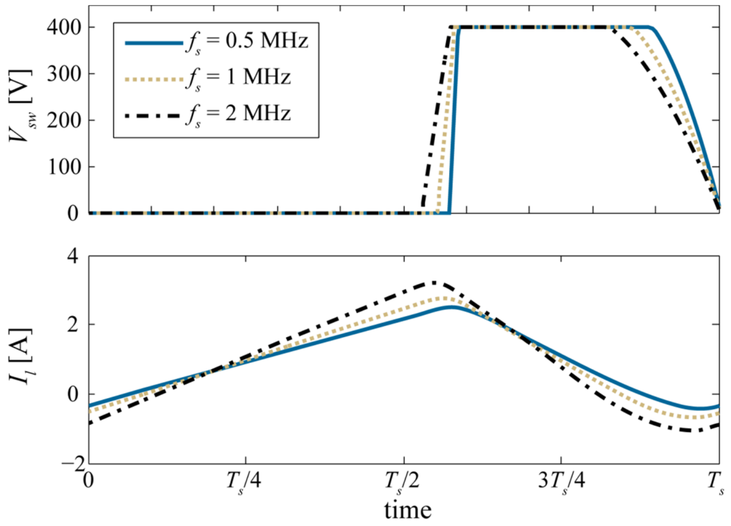
Further Simulation



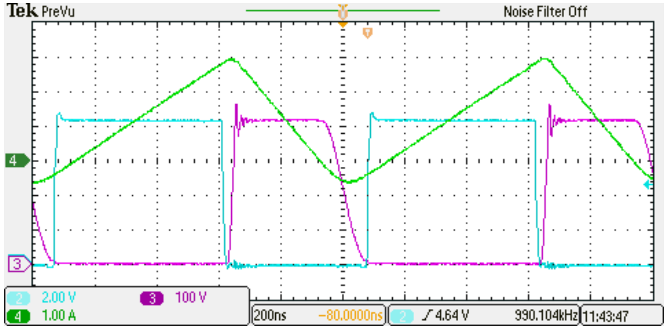
Solving resonance in power electronics

STATE PLANE ANALYSIS

Motivation

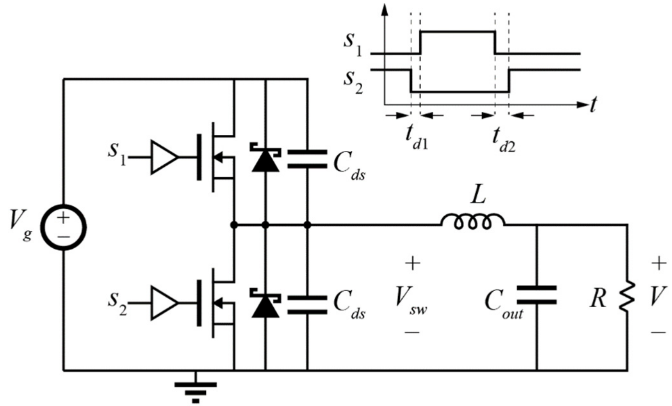


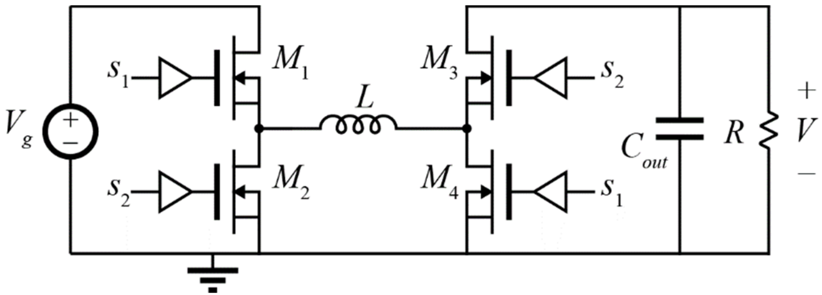
400
300
200
100
0
V_{sw} [V]
f_s = 0.5 MHz
f_s = 1 MHz
f_s = 2 MHz
4
2
0
−2
I_l [A]
0
$T_s/4$
$T_s/2$
$3T_s/4$
T_s
time



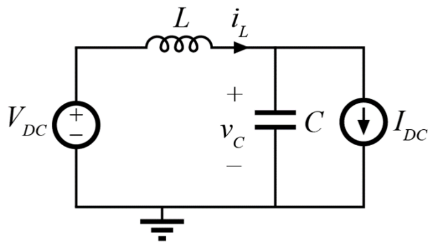
Tek PreVu
Noise Filter Off
4
3
2 2.00 V
3 100 V
4 1.00 A
200ns
−80.0000ns
2 ∫ 4.64 V
990.104kHz
11:43:47

Time-Domain Analysis of Switching Transitions





Resonant Circuit Solution



$$v_c(t) = V_{DC} + \left(V_0 - V_{DC}\right)\cos\left(\frac{t}{\sqrt{LC}}\right) + \left(I_0 - I_{DC}\right)\sqrt{\frac{L}{C}}\sin\left(\frac{t}{\sqrt{LC}}\right)$$

$$i_L(t) = I_{DC} + \left(I_0 - I_{DC}\right)\cos\left(\frac{t}{\sqrt{LC}}\right) + \left(V_{DC} - V_0\right)\sqrt{\frac{C}{L}}\sin\left(\frac{t}{\sqrt{LC}}\right)$$

Normalization and Notation

$$v_c(t) = V_{DC} + (V_0 - V_{DC})\cos(\omega_0 t) + R_0(I_0 - I_{DC})\sin(\omega_0 t)$$

$$i_L(t) = I_{DC} + (I_0 - I_{DC})\cos(\omega_0 t) + \frac{1}{R_0}(V_{DC} - V_0)\sin(\omega_0 t)$$

$$v_c(t) = V_{DC} + (V_0 - V_{DC})\cos(\omega_0 t) + R_0(I_0 - I_{DC})\sin(\omega_0 t)$$

$$i_L(t) = I_{DC} + (I_0 - I_{DC})\cos(\omega_0 t) + \frac{1}{R_0}(V_{DC} - V_0)\sin(\omega_0 t)$$