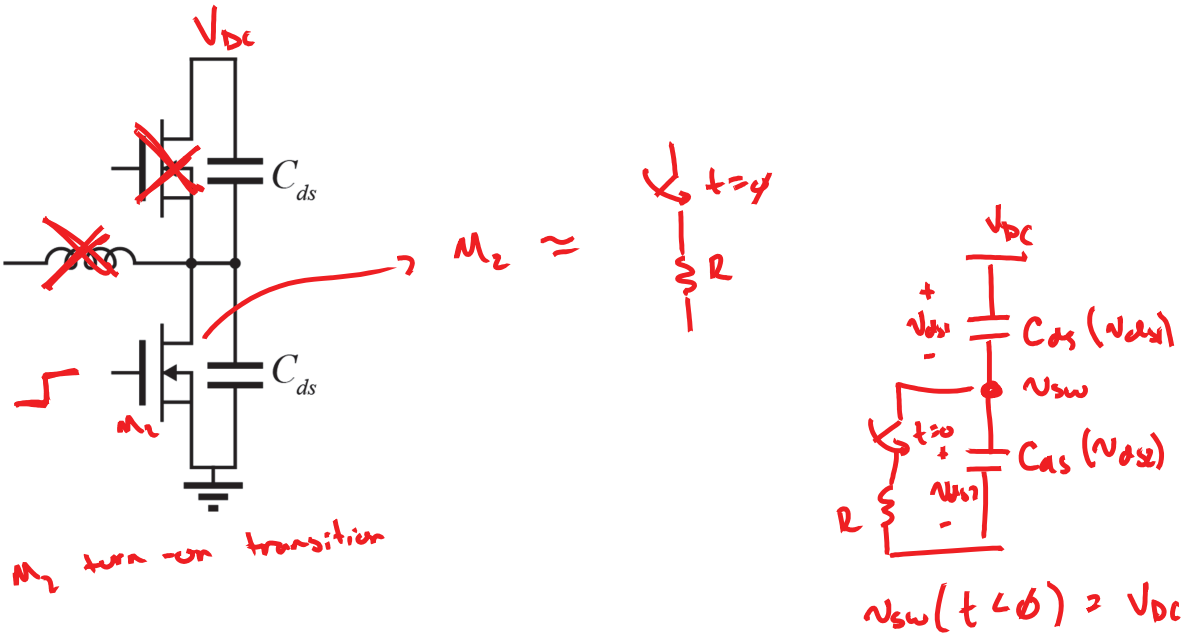
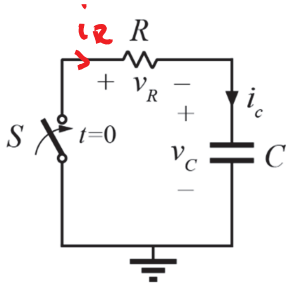
C_{oss} Losses in a Half Bridge



M_2 Energy Loss



$v_c(t<0) = V_{DC}$

$$E_R = \int_0^\infty v_R \cdot i_R \, dt$$

$$i_R = i_c = C(v_c)\frac{dv_c}{dt}$$

$$v_R = -v_c$$

$$E_R = \int_0^\infty -v_c \, C(v_c) \frac{dv_c}{dt} \, dt$$

$$E_R = \int_{V_{DC}}^{0} -v_c \, C(v_c) \, dv_c$$

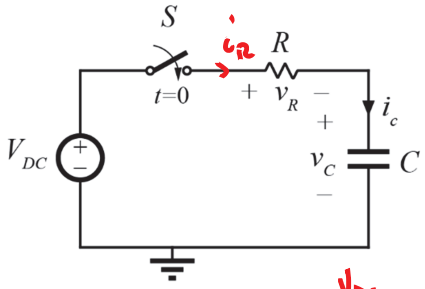
$$E_R = \int_0^{V_{DC}} v_c \, C(v_c) \, dv_c = E_c = \boxed{\frac{1}{2} C_{eq,E} V_{DC}^2}$$

M_1 Energy Loss

$v_C(t<0) = 0$

$$E_R = \int_0^\infty v_R i_R \, dt$$

$$\begin{cases} i_R = i_C = C(v_c)\dfrac{dv_c}{dt} \\ v_R = V_{DC} - v_c \end{cases}$$



$$E_R = \int_0^\infty (V_{DC} - v_c)\, C(v_c)\, \frac{dv_c}{dt}\, dt$$

$$E_R \int_0^{V_{DC}} (V_{DC} - v_c)\, C(v_c)\, dv_c$$

$$E_R = V_{DC} \underbrace{\int_0^{V_{DC}} C(v_c)\, dv_c}_{Q_C} - \underbrace{\int_0^{V_{DC}} C(v_c)\, v_c\, dv_c}_{E_C}$$

$$\boxed{E_R = V_{DC}(V_{DC} C_{eq,Q}) - \frac{1}{2} C_{eq,E} V_{DC}^2}$$

Total Half Bridge C_{oss} Loss

$$E_{C,tot} = E_{R1} + E_{R2}$$

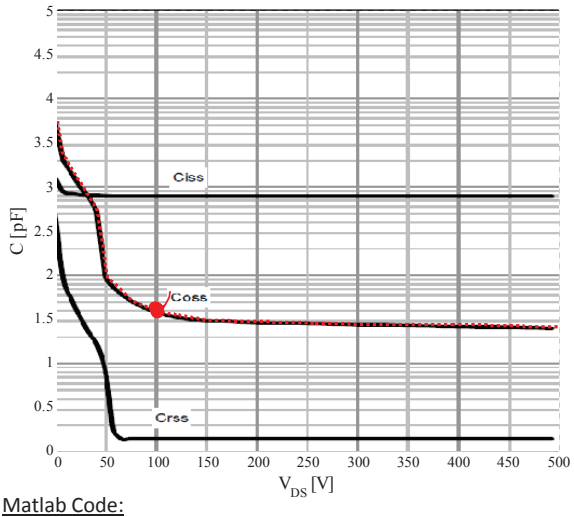
$$= \frac{1}{2} C_{eq,E} V_{DC}^2 + \left(V_{DC}^2 C_{eq,Q} - \frac{1}{2} C_{eq,E} V_{DC}^2 \right)$$

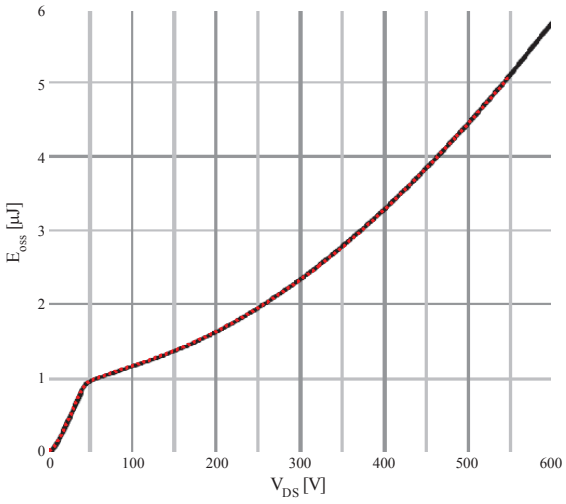
(from M_2; from M_1)

$$\boxed{E_{C,tot} = V_{DC}^2 C_{eq,Q}} \quad !$$

only applies if $C_{ds1} = C_{ds2}$

Energy Equivalent





Matlab Code:

```
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;
```

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Nonlinear Capacitance Extraction

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

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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}.

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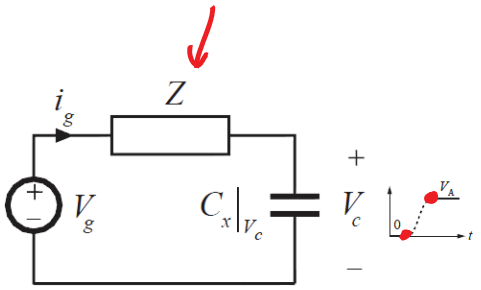
Example Simulation

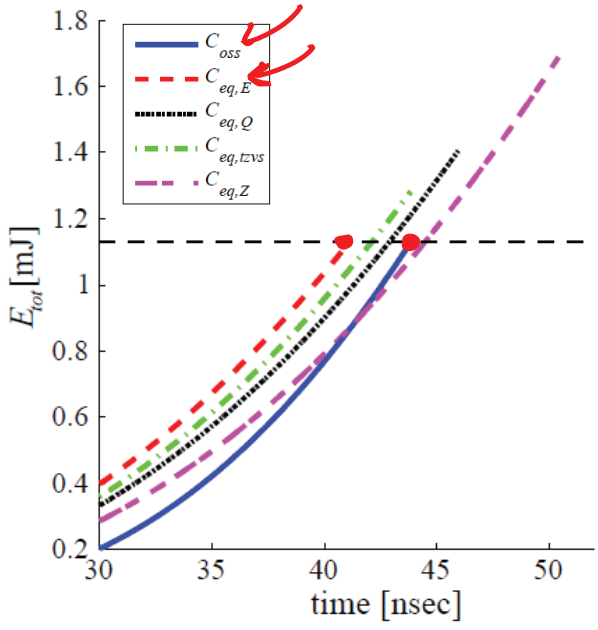


$C_{eq,Q} = 70.5$ pF,

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

$C_{eq,tzvs} = 64.1$ pF

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



Further Simulation