Charging Energy Storage Capacitors in Electronic Devices

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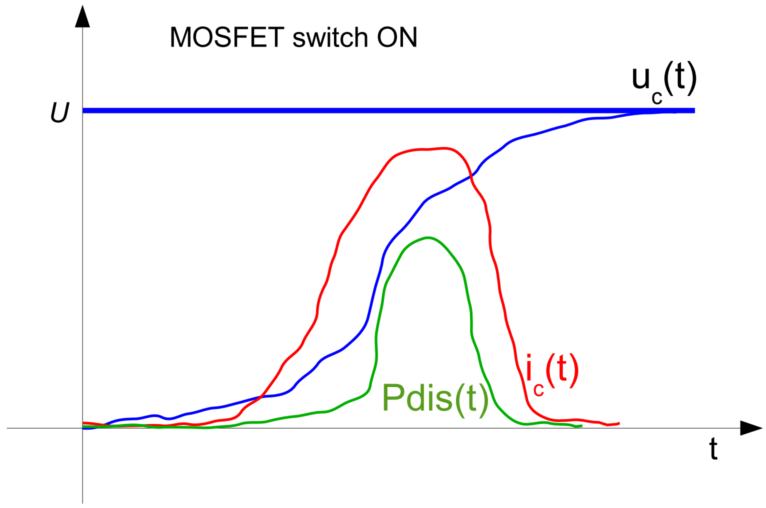
Abstract

Charging high-capacitance capacitors or supercapacitors in electronic devices during power-on transition requires correct selection of MOSFET or bipolar switch. Energy dissipated within few miliseconds in silicon chip using dissipative charging must be kept lower than destructive energy of the chip.

Model and calculation



Where $i_c(t)$ is immediate charging capacitor current $u_c(t)$ is immediate capacitor voltage. *U* is supply voltage reached after switch-on transistion.

Total energy dissipated in switch (MOSFET):

$$E_{dis}=\int_0^T i_c(t)(U-u_c(t))dt=U\int_0^T i_c(t)-\int_0^T i_c(t)u_c(t)dt$$

Note that $U=\frac{1}{C}\int_0^T i_c(t)dt$ for *T* <u>fully charged C</u> when $u_c=U$ or $Q=CU=\int_0^T i_c(t)dt$ is total charge and therefore $E_{dis}=CU^2-\int_0^T i_c(t)u_c(t)dt$

Immediate power $i_c(t)u_c(t)=p_C(t)$ is transfered into the capacitor C.

And $\int_0^T i_c(t)u_c(t)dt=\frac{1}{2}CU^2$ is exactly the energy transfered into fully charged capacitor C.

Dissipated energy in MOSFET (no matter how switched):

$$E_{dis}=CU^2-\frac{1}{2}CU^2=\frac{1}{2}CU^2$$

Please consider heat spreading in silicon chip. Rule: slower switching (1-10-100ms) enables better spreading into volume and also in copper drain electrode which results in higher heat dissipation.