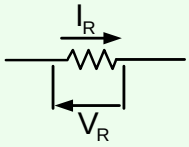
Current Sensing

- 9.1 Resistor
- 9.2 Current transformer

Current Sensing

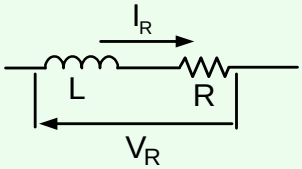
* Control PCM, ACM
* Protection

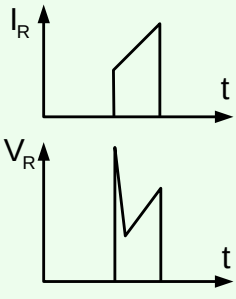
Sense Resistor



Problems

* Inductive component





Losses

$P_d = R I_{Rrms}^2 = V_{Rrms} I_{Rrms}$

For a reasonable S/N $V_R \approx 100\,mV$ at least

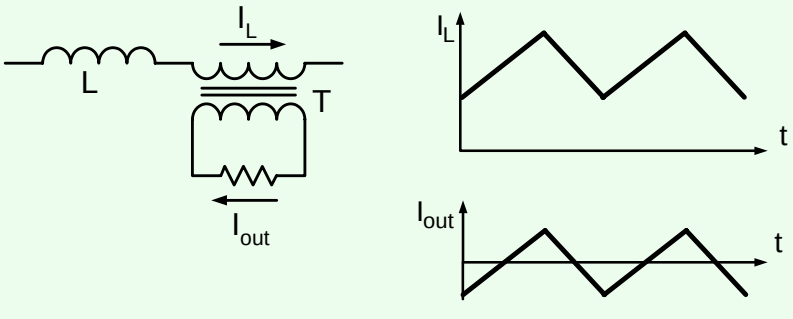
Assuming V_R, V_{Rrms} same order of magnitude

$P_d \approx 0.1\, I_{Rrms}$

$I_{rms} = 10\ A \quad P_d \cong 1\ W$

Not practical for I>10A

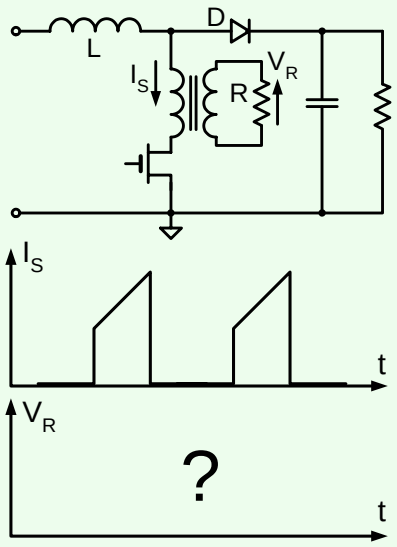
Current transformer



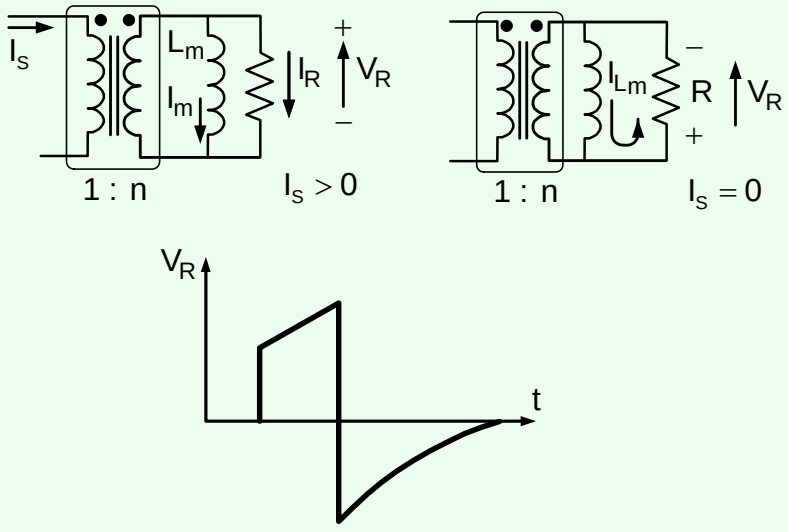
DC component via primary lost !

DC component may saturate transformer !

Current Transformer



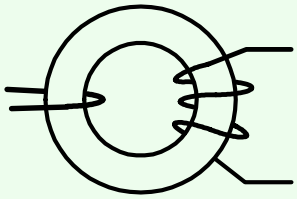
Current Transformer



Conclusions

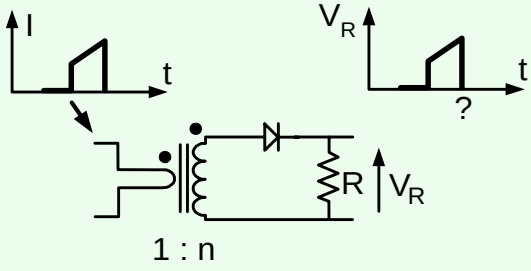
- Linear Current transformers are useful only if current to be measured is AC
- In Power Electronics, Pulse Current transformer is useful for measuring pulsed current

Pulse Current transformer Design



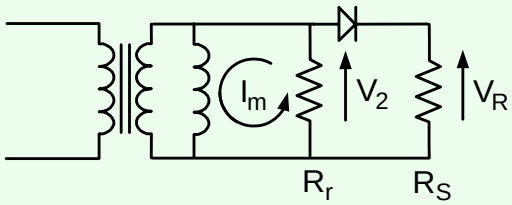
1 : n

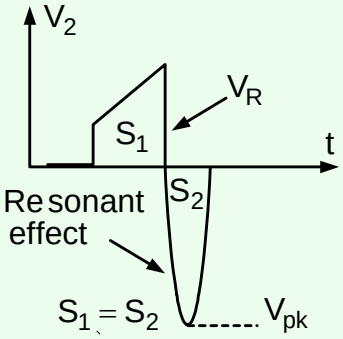
1. DC pulses



During pulse $V_R = \frac{I}{n} \cdot R$

Resistor reset

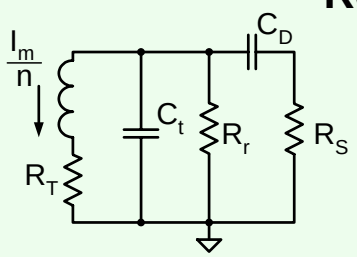




$R_r > R_s$

V_{pk} might be too high for diode

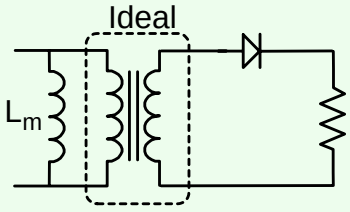
Reset



C_t - Transformer capacitance

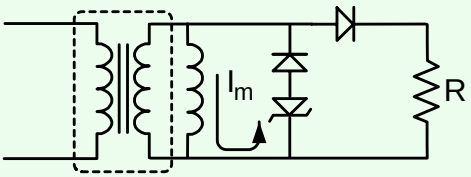
C_D - Diode capacitance

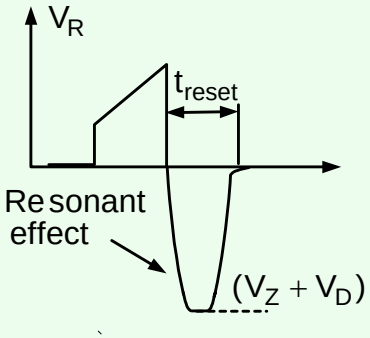
R_T - Transformer Resistance



Sometime no resistor is used.

Reset - Clamp

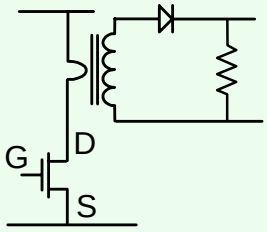




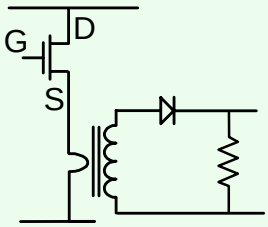
$t_{reset} < t_{off}$

Place to put current transformer

O.K.



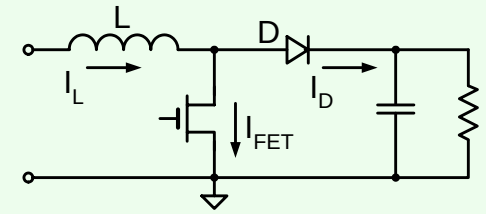
avoid

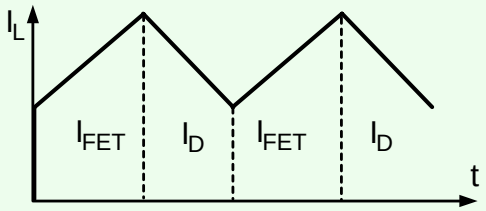


Why ?

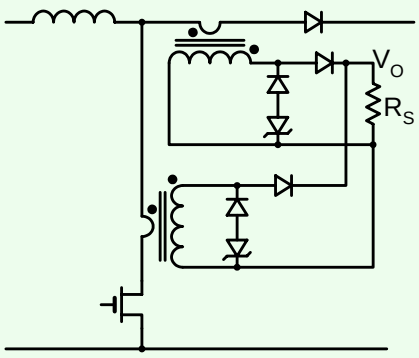
Measuring “DC” current with pulse current transformer

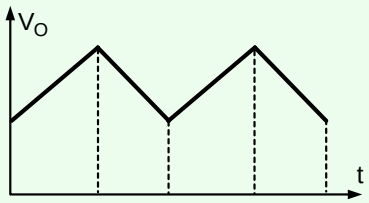
Need to measure I_L $I_L = I_D + I_{FET}$





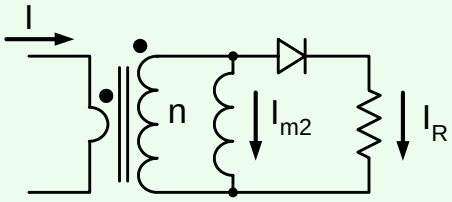
Inductor DC Current





Long wire for illustration only

Problem

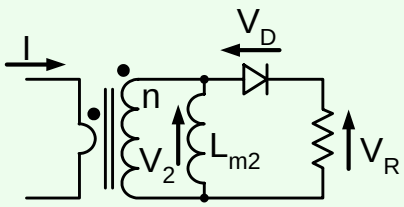


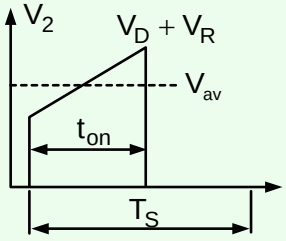
$$\frac{I}{n} = I_{m2} + I_R$$

I_{m2} must be smaller than I_R or $2\pi f_s L_m > R$

This becomes a problem at low frequencies

Design of current transformer





Transformer operation is limited by voltage NOT CURRENT

$$B_{max} = \frac{\int V dt}{nA_e} \qquad V_R \cong \frac{I}{n}R$$

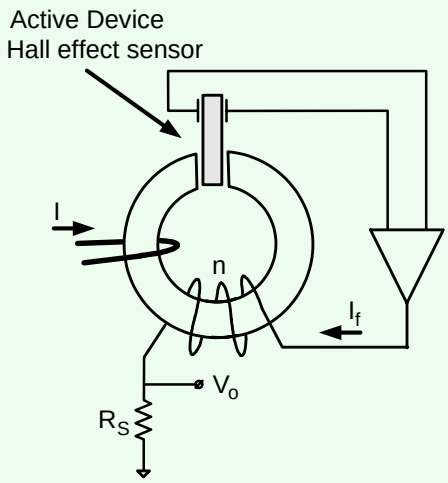
$$\int V dt = V_{av} t_{on} = \frac{V_{av} D_{on}}{f_s}$$

$$B_{max} = \frac{I_{av} R D_{max}}{nA_e f_s}$$

If I_{av} large need R small.

Problem at low frequencies

DC Current transformer



Null operation $\Phi=0$ by feedback

$$I_f \cdot n = I \qquad V_o = \frac{I}{n} R_S$$