Lecture #11, 10/25/2021

- Last Time
  - Overview of lab PWM Chip & gate driver
  - Tiny bit of C/L, devices

- Lab discussion
  - Loose ends on bootstrap design

UC27712 datasheet gives good design tips

Need to pick C_{boot}, R_{boot}

Look at Eq (1) - (2) for C_{boot}

$$Q_{total} = Q_g + \frac{I_{qbs}}{f_{sw}}$$

$I_{qbs} \approx 0$ can ignore this

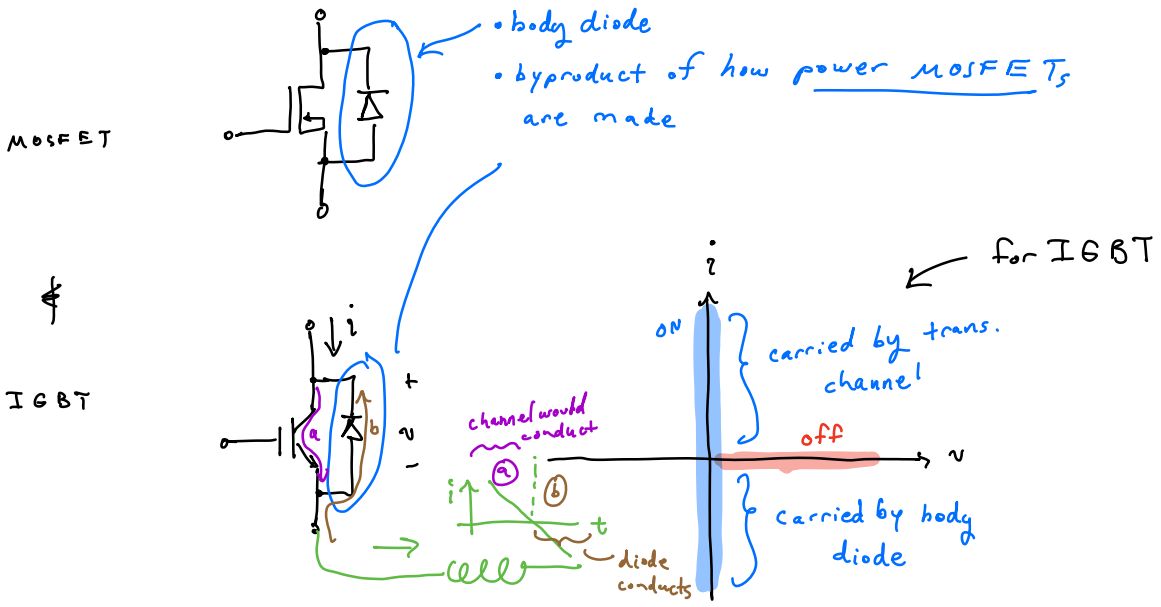
- Q_g: gate charge on MOSFET
- This value is in MOSFET datasheet

Look @ eq (5) For R_{boot} — helps limit current flow into C_{boot}

$$\text{pick } R_{boot} \geq \frac{V_{DD} - V_{diode}}{I_{BOOT,pk}} \approx \text{a few ohms}$$

- V_{DD}: 12V supply voltage
- V_{diode}: diode drop
- $I_{BOOT,pk}$: ≈5A diode datasheet

– Switches w/ Intrinsic "anti-parallel" body diodes



Recap of devices & where they are used

controlled

- MOSFET (Si) → Usually voltage below 600 V, "low power" → Watts to kW, f_s up to MHz
- IGBT → up to several kV, "moderate to high power" → up to 100's of kW, f_s up to 10's of kHz

uncontrolled

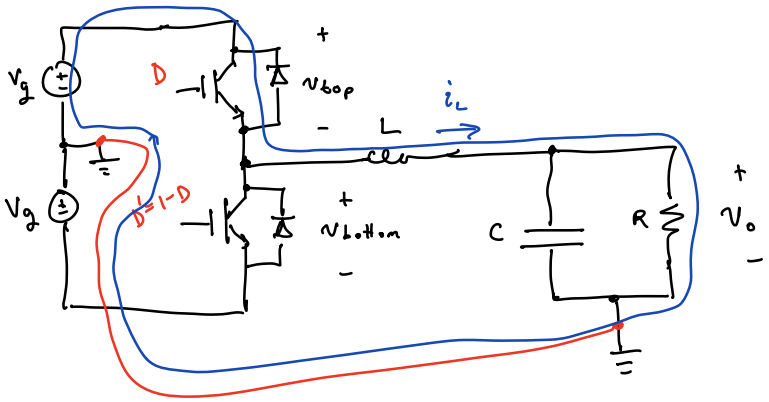
- Diodes → ubiquitous across all applications

only turn on is controlled

- Gate turn off (SCR, thyristor) devices
  - High power, up to MW
  - $f_s \approx$ 100's of HZ, down to 10's of HZ

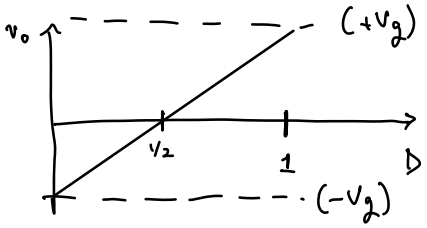
— Converter Examples

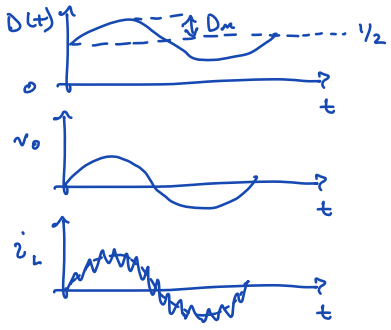
- Basic "voltage source inverter" ... single phase



In SS, can show that

$$V_o = (2D - 1) V_g$$





Can get a sinusoidal output!

pick $D(t) = \frac{1}{2} + D_M \sin(\omega t)$

↳ $-\frac{1}{2} < D_M < \frac{1}{2}$

$$i_L \approx \frac{v_o}{R} = (20-1)\frac{V_g}{R}$$

as D varies between 0 & 1

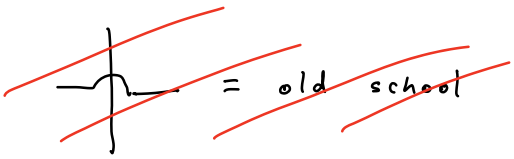
can get both ⊕ & ⊖ i_L values

↳ need bidirectional conducting devices

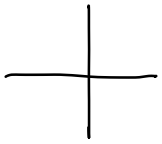
- Look @ voltage across each sw.
  ↳ only need to block ⊕ voltage

→ imply either IGBT (w/ body diode) or MOSFET will work.

- Ideal 4 quadrant sw can be made with heroic efforts. Very specialized. See book for more info.



= old school



= no connection

= connection

Lecture #12 10/27/21

Last time

- Switches w/ body diodes
- Inverter example (half bridge)
- Started sw. loss example

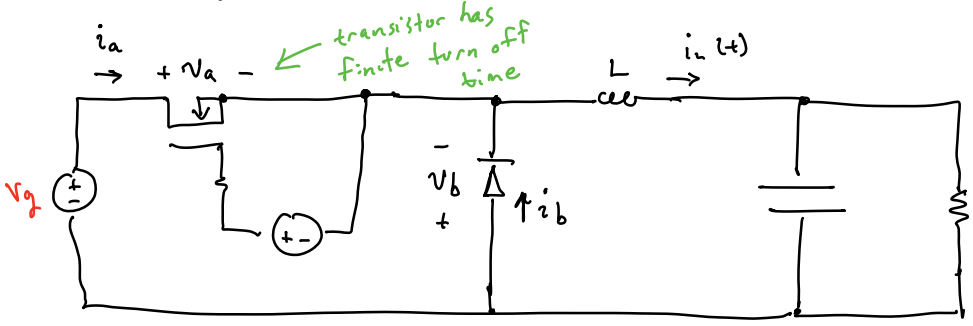
Today

- Switching loss
- Device Modeling

Logistics

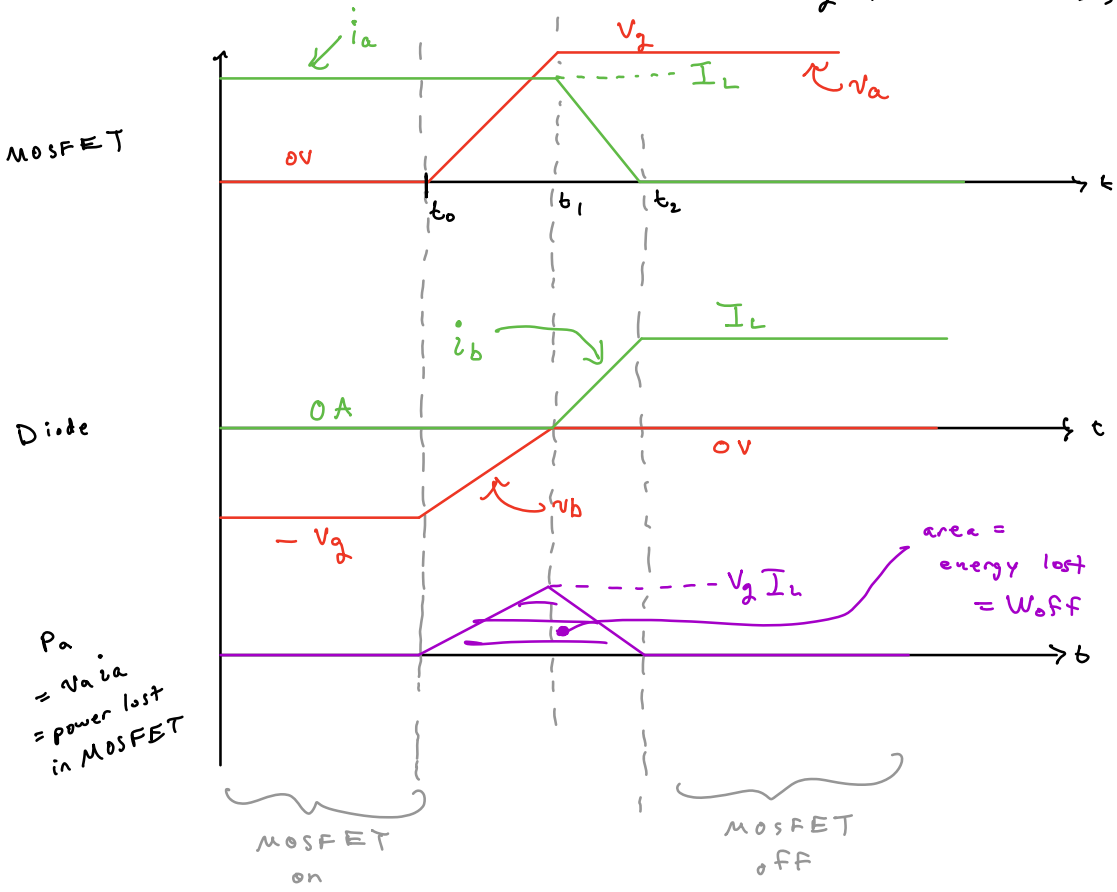
- No lecture Friday -> Will post a make-up video.

— Switching losses & Buck example



* All devices take finite time to turn on/off.
  Causes "switching loss" during transitions.

- In example assume, ideal diode. Study MOSFET losses.



$$W_{off} = \frac{1}{2} V_g I_L (t_2 - t_0)$$

- This tiny amt lost in one transition.

  ... but we have switching.

$$P_{sw} = \frac{1}{T_s} \int_0^{T_s} P_a(t)\,dt = (W_{on} + W_{off}) \frac{1}{T_s}$$

$$= (W_{on} + W_{off}) f_s$$