Lecture # 11, 10/25/2021

- Last Time
  - Overview of lab PWM Chip & gate driver
  - Tiny bit of Ch 4, 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}

$$Q_{total} = Q_g + \cancel{\frac{I_{QBS}}{f_{sw}}}^{\approx 0}$$

can ignore this

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

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

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

12V supply voltage

diode drop

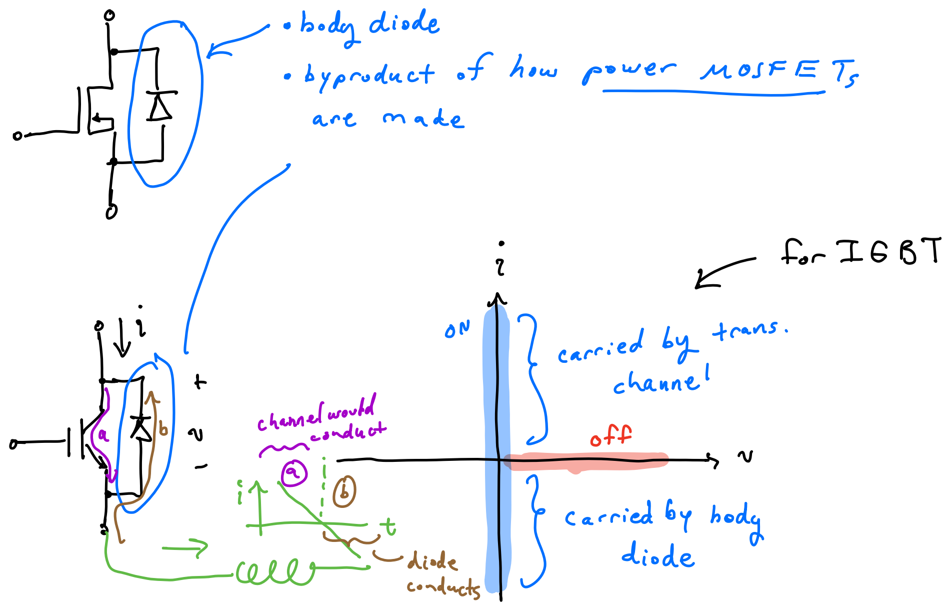
≈5A diode datasheet

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

MOSFET

&

IGBT



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

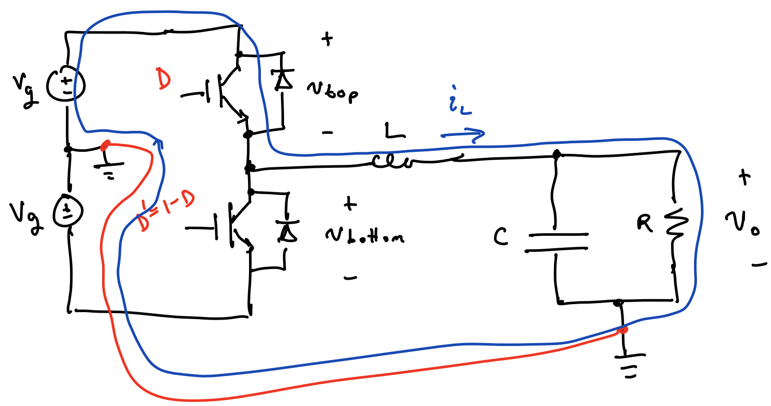
uncontrolled { • Diodes → Ubiquitous across all applications only turn on is controlled { • Gate turn off (SCR, thyristor) devices

↳ High power, up to MW

↳ $f_s \approx$ 100's of HZ, down to 10's of HZ

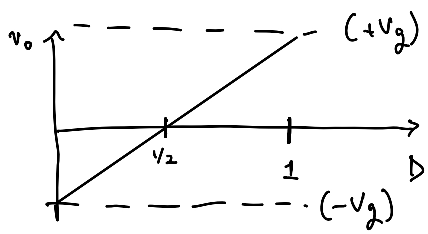
— Converter Examples

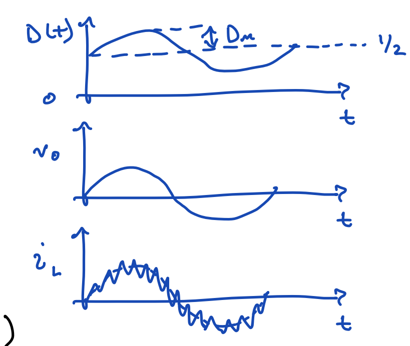
• Basic "voltage source inverter" ... single phase



In SS, can show that

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





Can get a sinusoidal output!

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

↳ $-\frac{1}{2} < D_m < \frac{1}{2}$

$$i_L \approx \frac{v_o}{R} = \underbrace{(2D-1)}\frac{V_g}{R}$$

as D varies between 0 & 1

can get both ⊕ & ⊖ i_L values

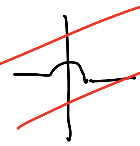
↳ • need bidirectional conducting devices

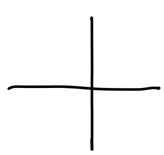
• Look @ voltage across each sw.

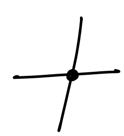
↳ only need to block ⊕ voltage

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

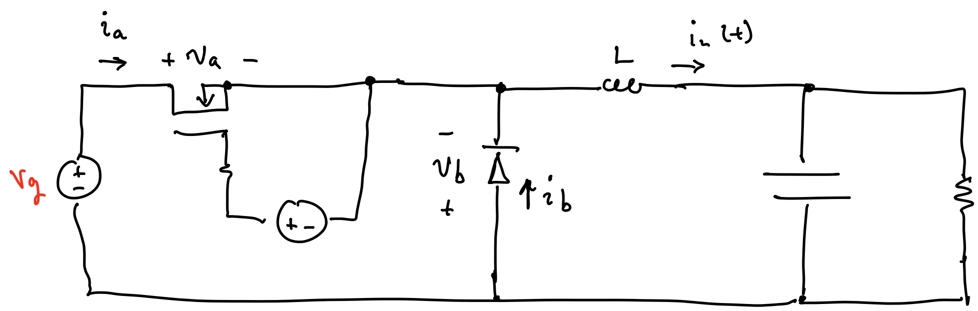
• Ideal 4 quadrant sw can be made with heroic efforts. Very specialized. See book for more info.

 = ~~old school~~

 = no connection ,

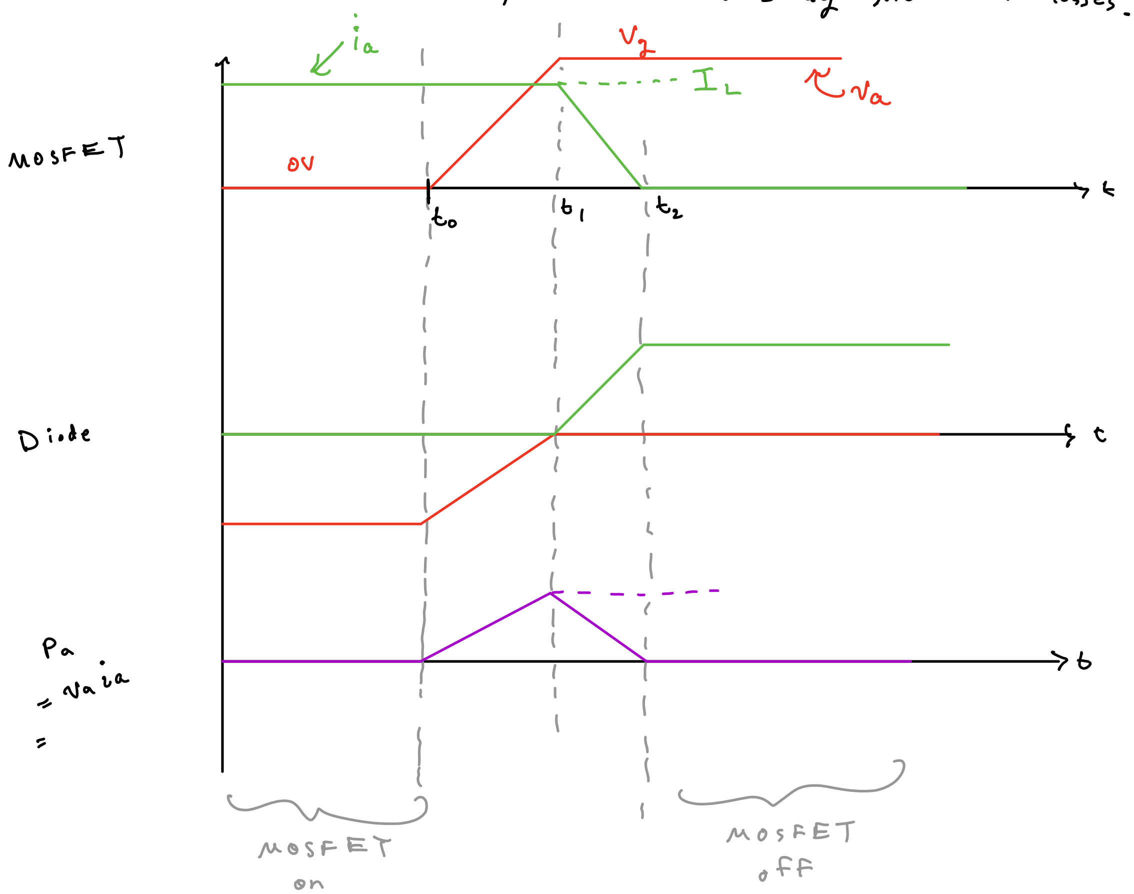
 = connection

– 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.



- This tiny amt lost in one transition.

... but we have switching.

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

$$=$$