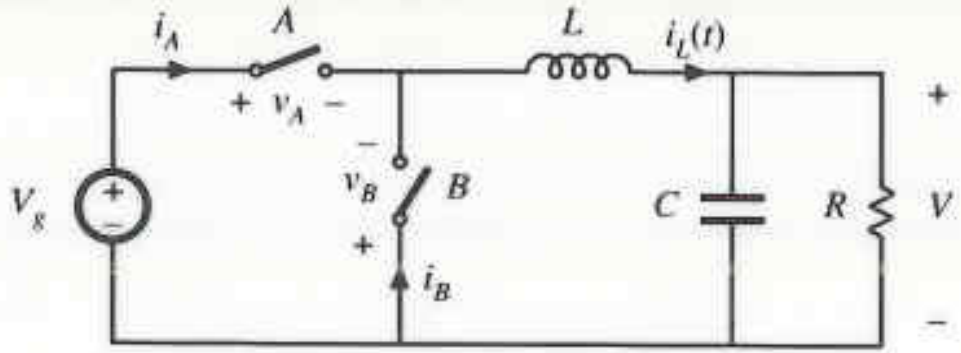
Realization of switch using transistors and diodes

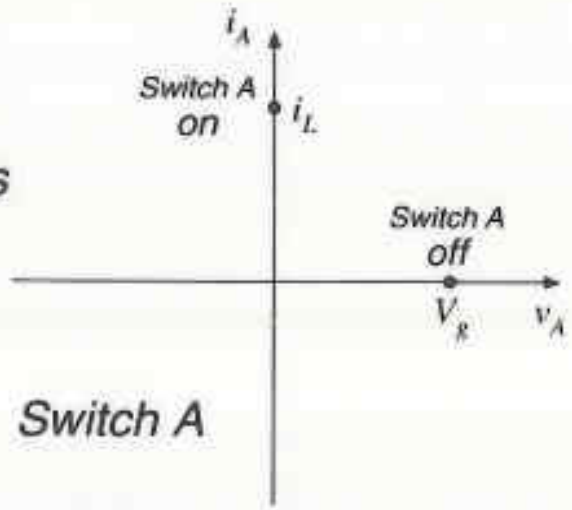
Buck converter example

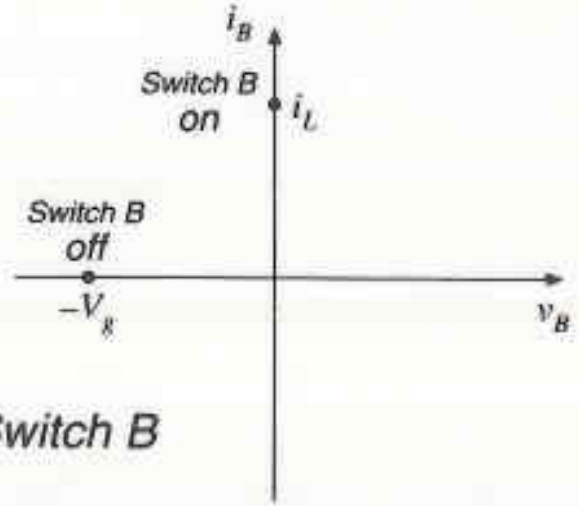


Switch A: transistor

Switch B: diode

SPST switch operating points



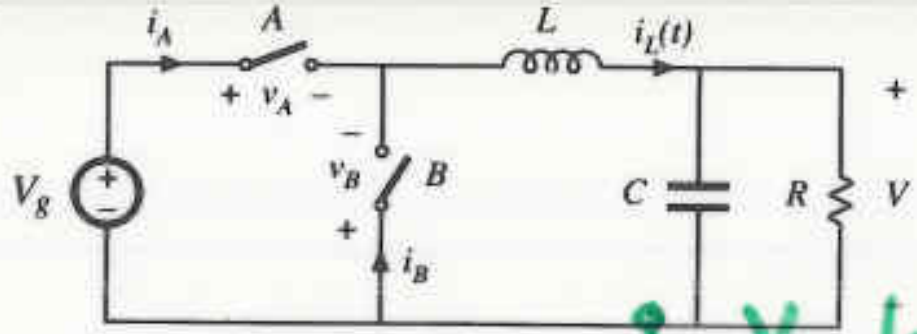


Realization of switch using transistors and diodes

circuit driven

"gated" ↑ BJT, IGBT, MOSFET, more!

Buck converter example



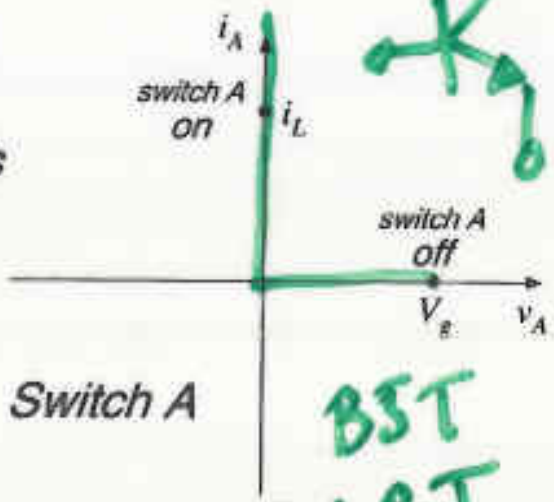
Switch A: transistor

Switch B: diode

V_{off} (max)

I_{ON} (max)

SPST switch operating points



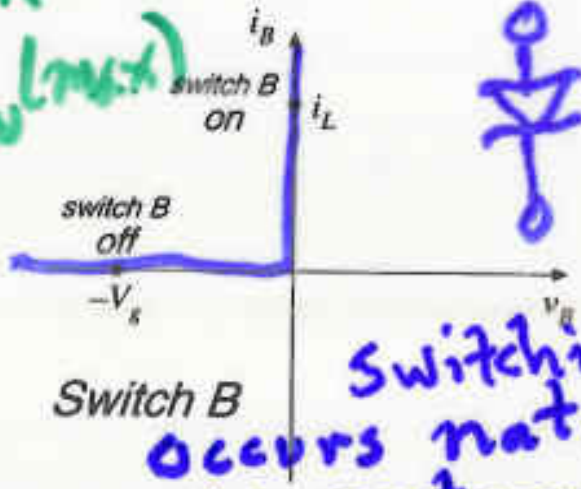
Switch A

BJT

IGBT

Requires control drive

each device: different driver



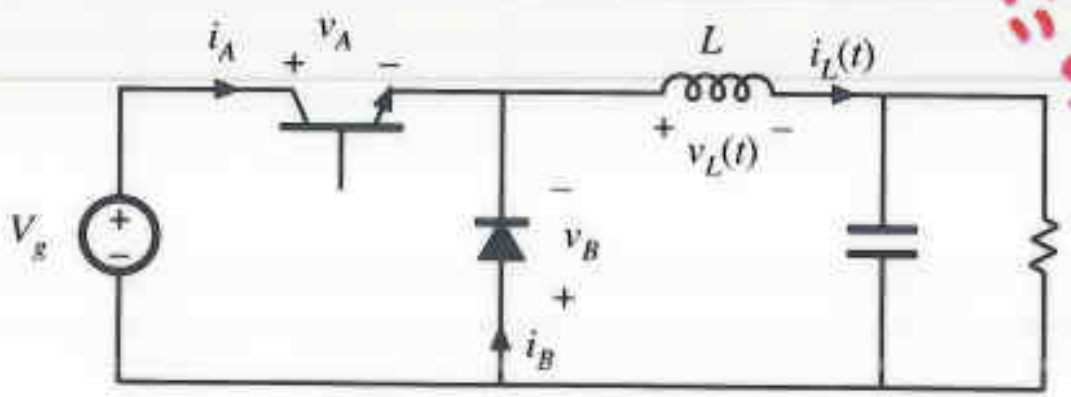
Switch B

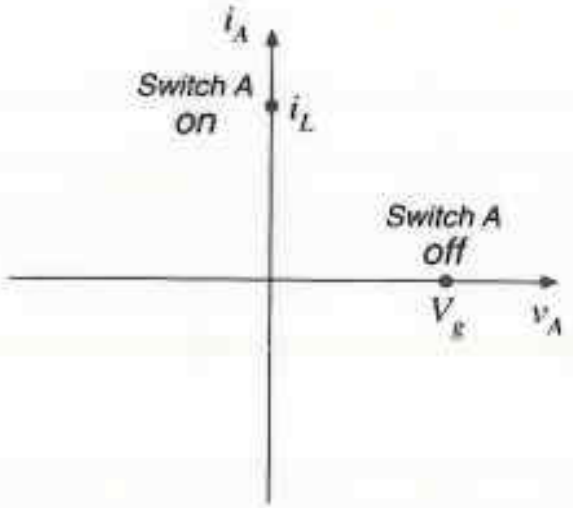
Switching occurs naturally

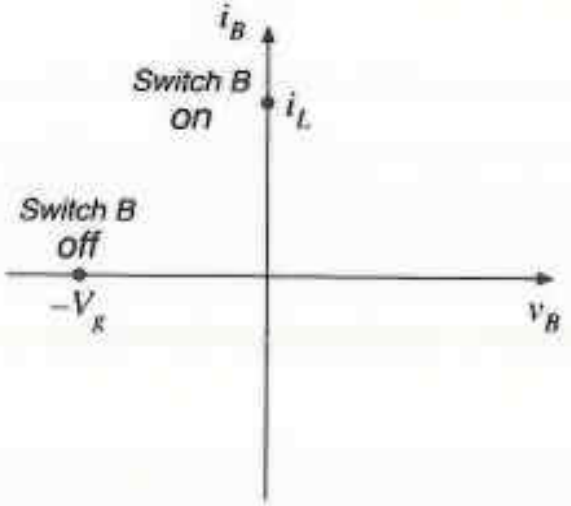
No external control

Realization of buck converter using single-quadrant switches

When / How "shoot-through"







Realization of buck converter using single-quadrant switches

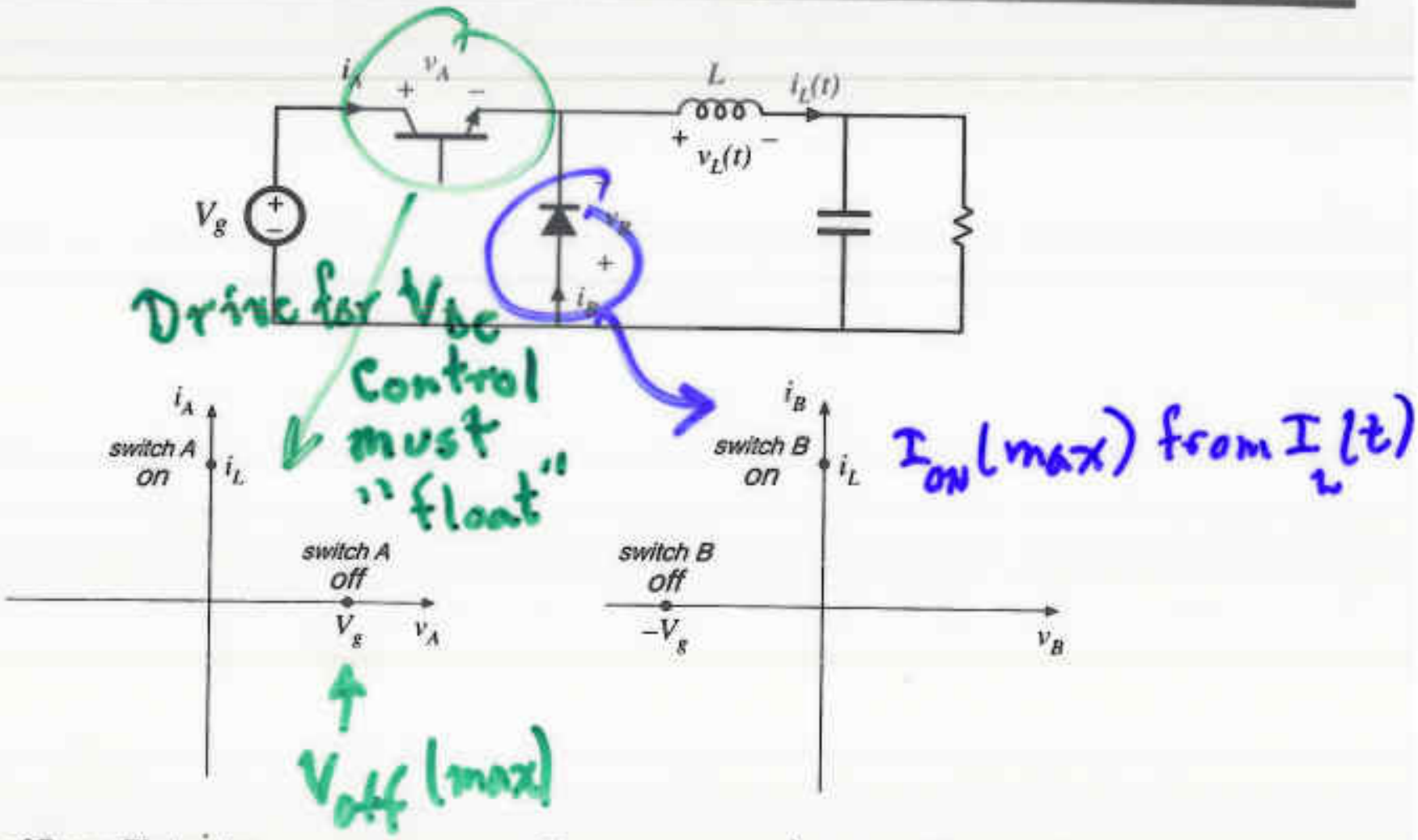


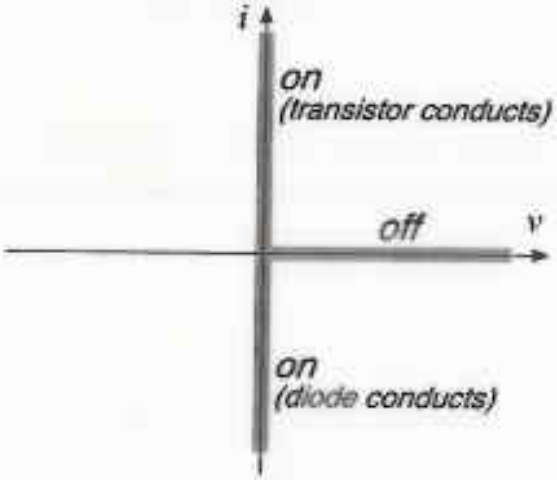
Fig 4.10 p 68

MOSFET body diode

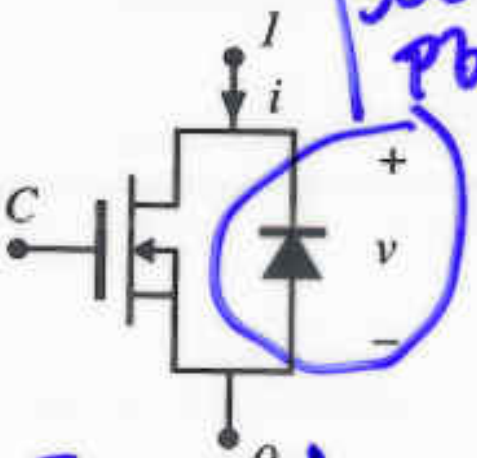
For i_D flow parasitic diode

Very slow turn-off 300ns 800ns?

Blocks internal diode use

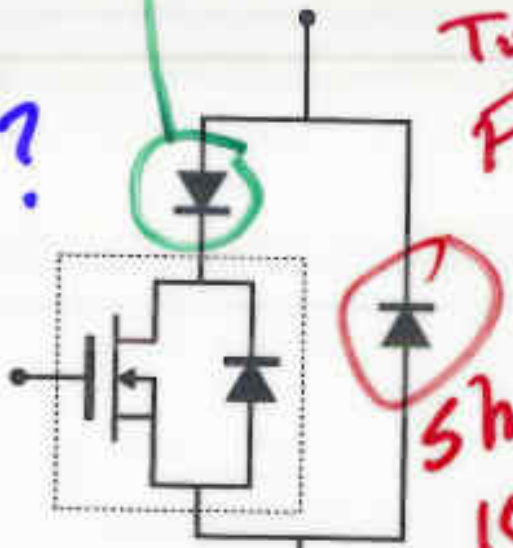


Power MOSFET characteristics



Forces i_D into FET drain

Power MOSFET, and its integral body diode



Turn-off Fast D ext. Schottky 10ns

i_D flow very brief ⇒ Loss↓

Use of external diodes to prevent conduction of body diode

before $v_{DS} \to 0$

⇒ LOSS = $V_{DS} i_D \Delta t_{off}$

Figure 4.9 p 68

4.1.2. Current-bidirectional two-quadrant switches

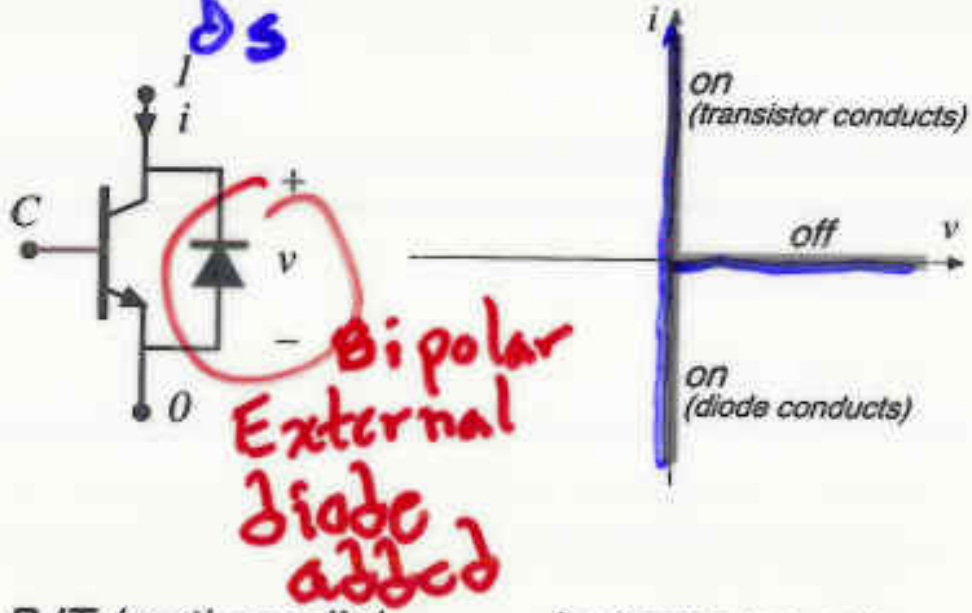
MOS

body diode (internal) — MOS ± i DX

G

Control is V_{GS}

S

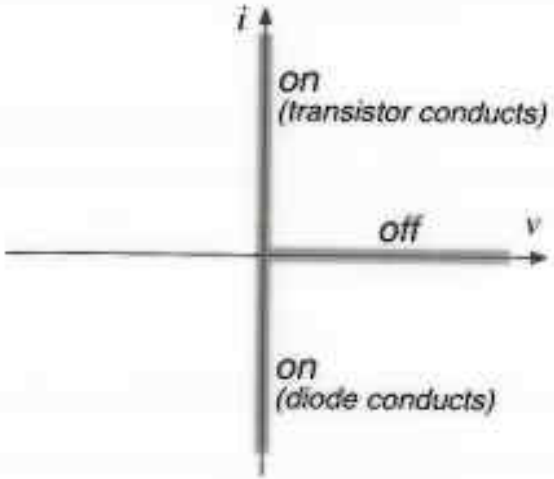


BJT / anti-parallel diode realization

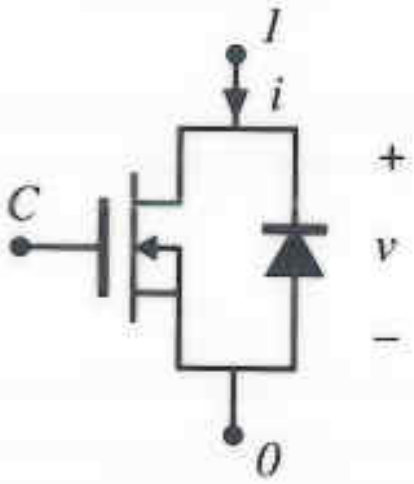
instantaneous i-v characteristic

- *Usually an active switch, controlled by terminal C*
- *Normally operated as two-quadrant switch:*
- *can conduct positive or negative on-state current*
- *can block positive off-state voltage*
- *provided that the intended on-state and off-state operating points lie on the composite i-v characteristic, then switch can be realized as shown*

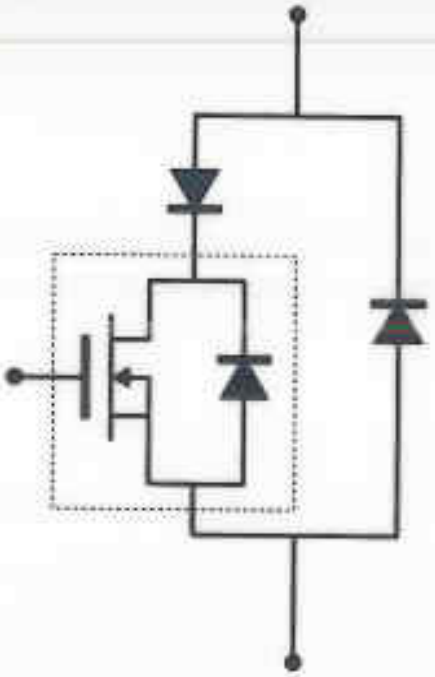
MOSFET body diode



Power MOSFET characteristics



Power MOSFET, and its integral body diode



Use of external diodes to prevent conduction of body diode

Two quadrant switches

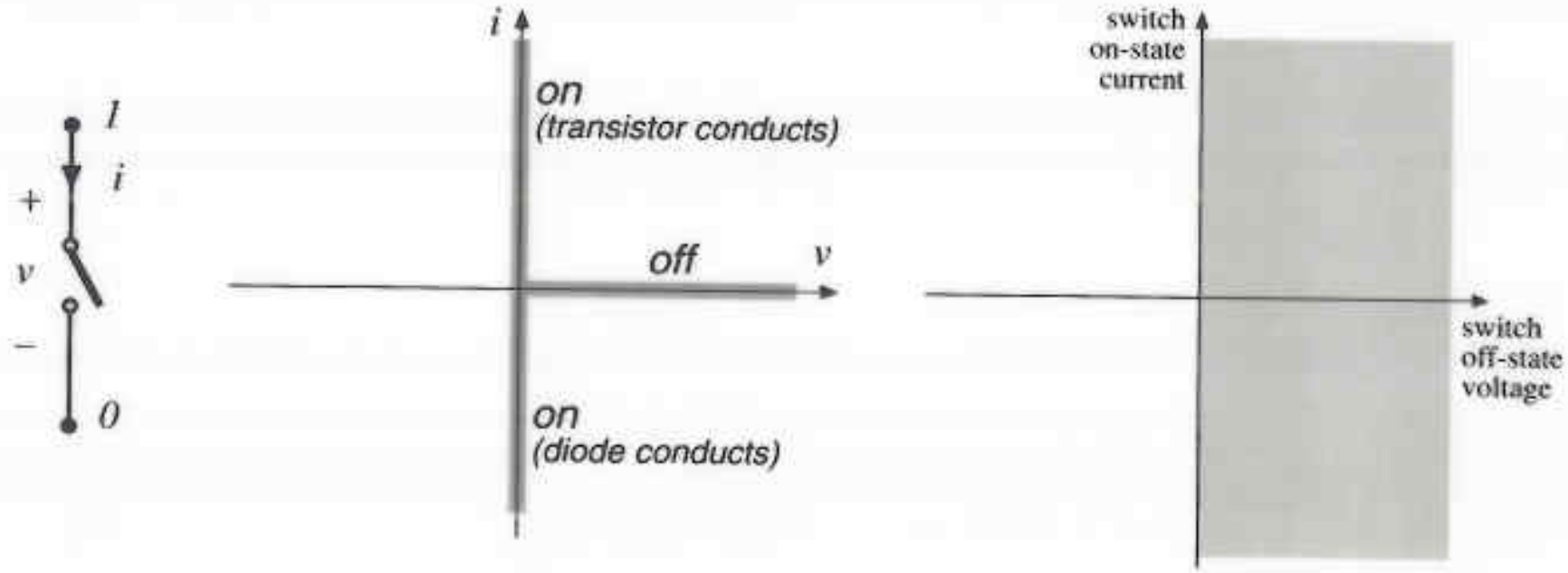
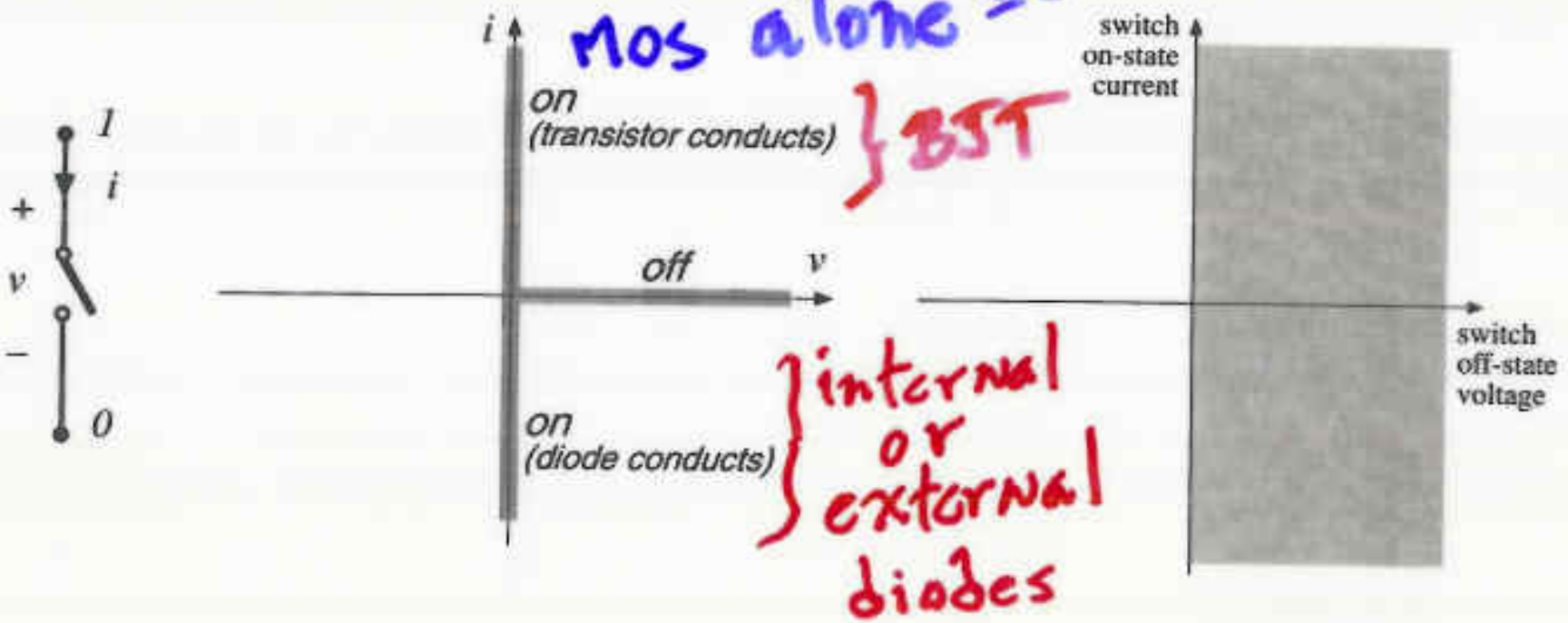
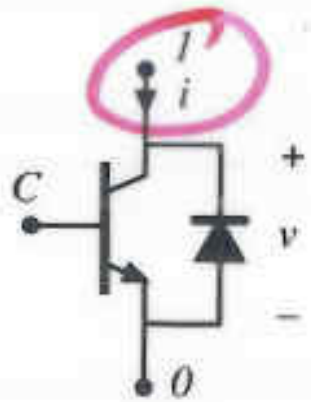


Fig 4.22 pg 73

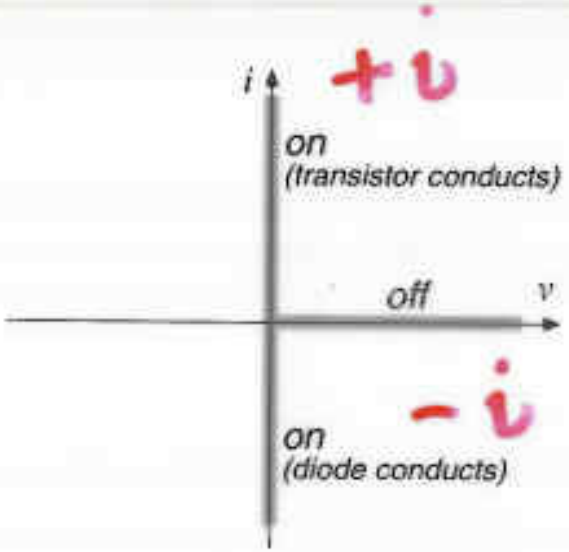
Two quadrant switches



4.1.2. Current-bidirectional two-quadrant switches



BJT / anti-parallel diode realization

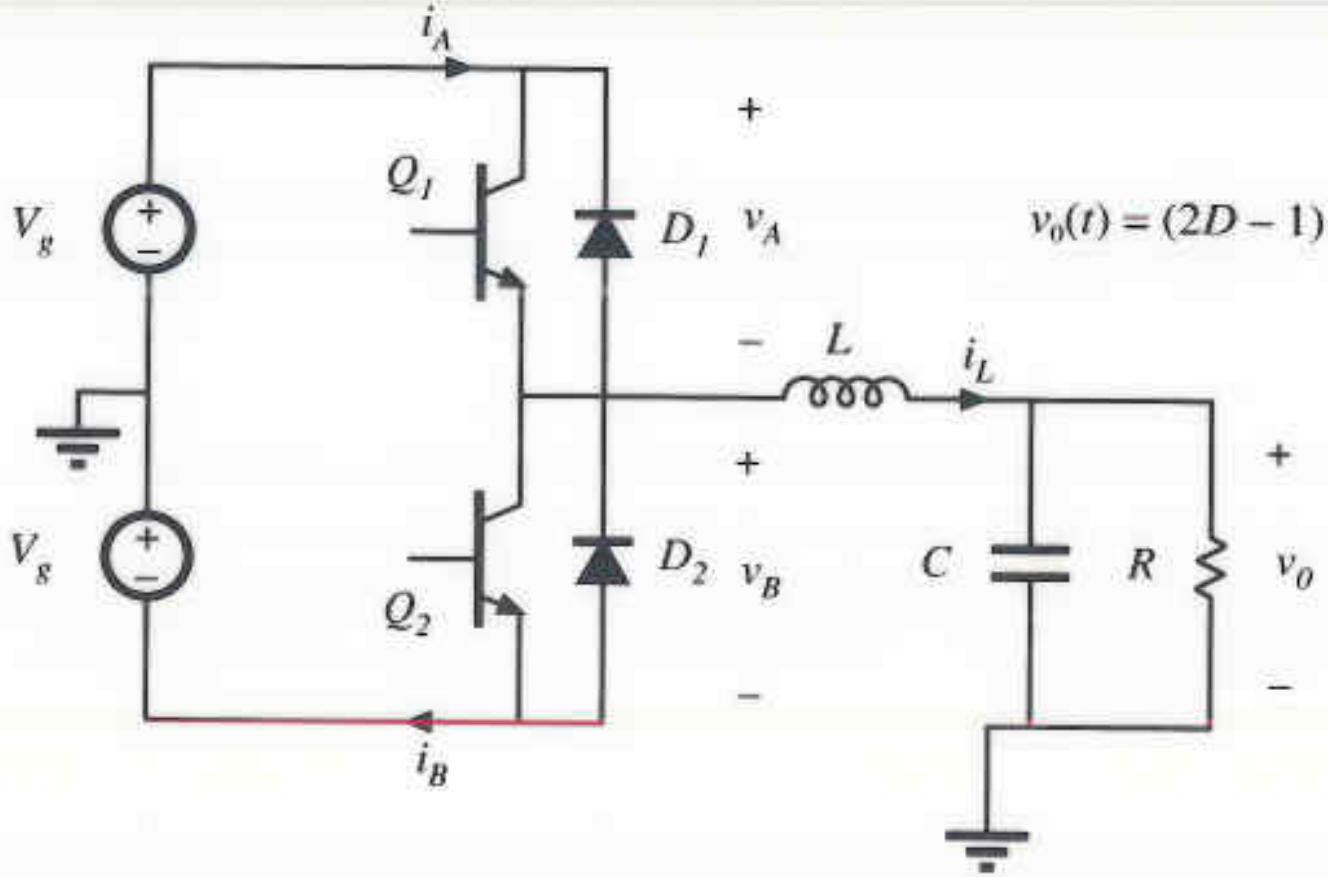


instantaneous i-v characteristic

- Usually an active switch, controlled by terminal C
- Normally operated as two-quadrant switch:
- can conduct positive or negative on-state current
- can block positive off-state voltage
- provided that the intended on-state and off-state operating points lie on the composite i-v characteristic, then switch can be realized as shown

A simple inverter

DC → ?



$$v_0(t) = (2D - 1)\, V_g$$

DC
V_{out}

461 Solar → AC etc

DC → AC (any frequency)

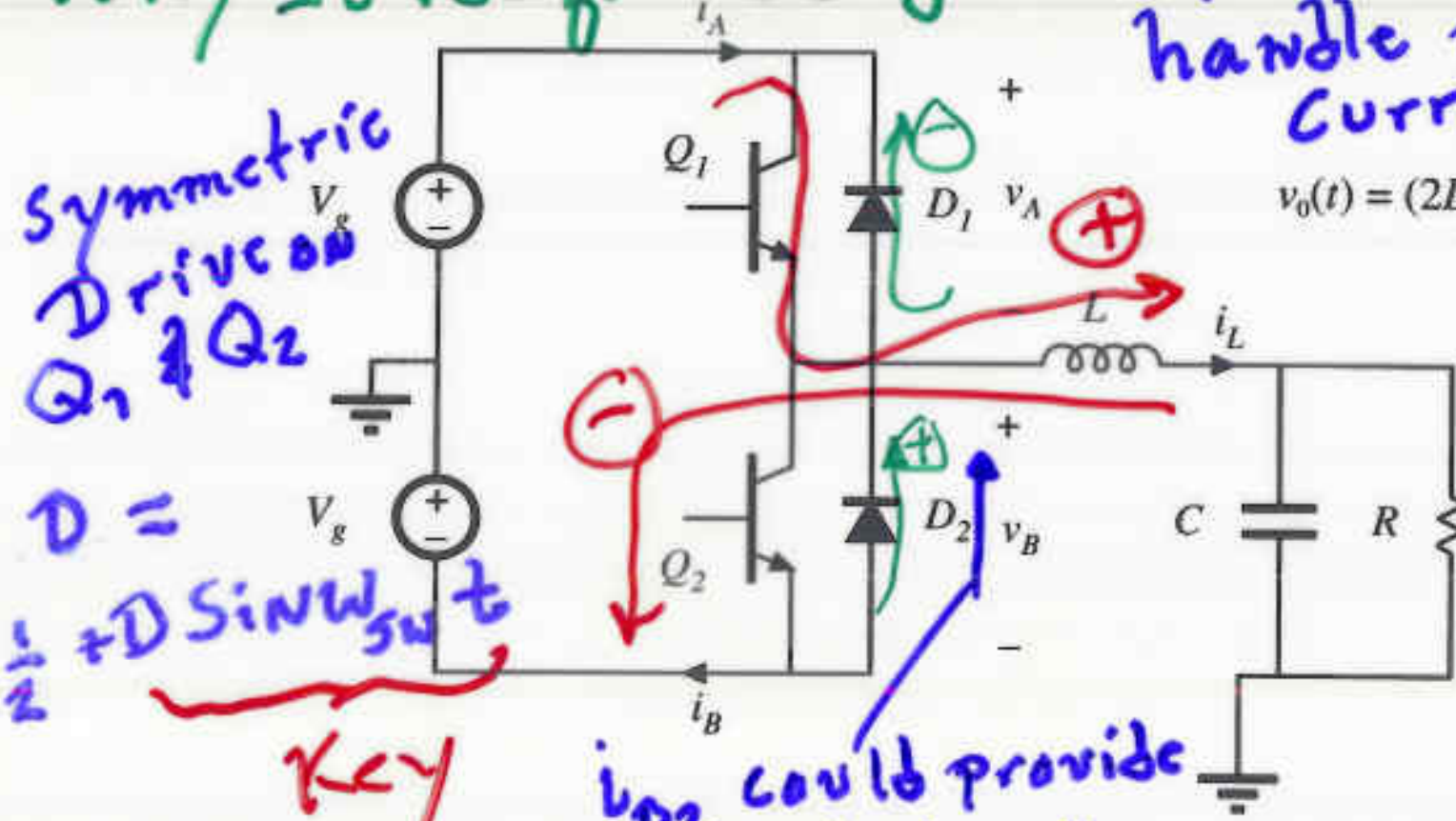
A simple inverter

Fig 4.11 pg 69

Why ± i required!

External diodes

D_1 and D_2 CAN handle reverse currents "before" Q ON



$v_0(t) = (2D - 1)\, V_g$

Symmetric Drive on Q_1 & Q_2

$D = \frac{1}{2} + D \sin \omega_{sw} t$

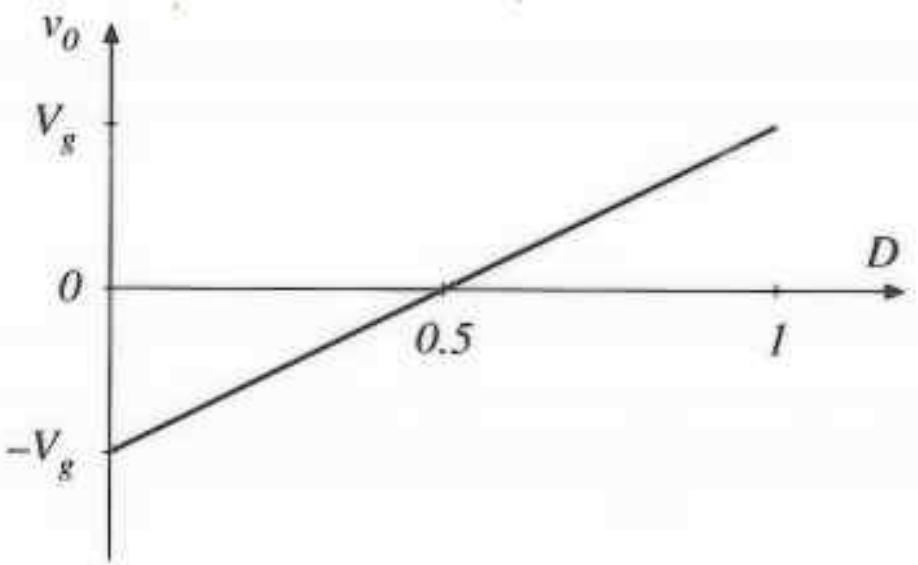
key

DC level $(2D-1)V_g$

i_{D2} could provide (+) before Q_1 is ON

Inverter: sinusoidal modulation of D

$$v_0(t) = (2D - 1)\, V_g$$



Sinusoidal modulation to produce ac output:

$$D(t) = 0.5 + D_m \sin(\omega t)$$

The resulting inductor current variation is also sinusoidal:

$$i_L(t) = \frac{v_0(t)}{R} = (2D - 1)\,\frac{V_g}{R}$$

Hence, current-bidirectional two-quadrant switches are required.

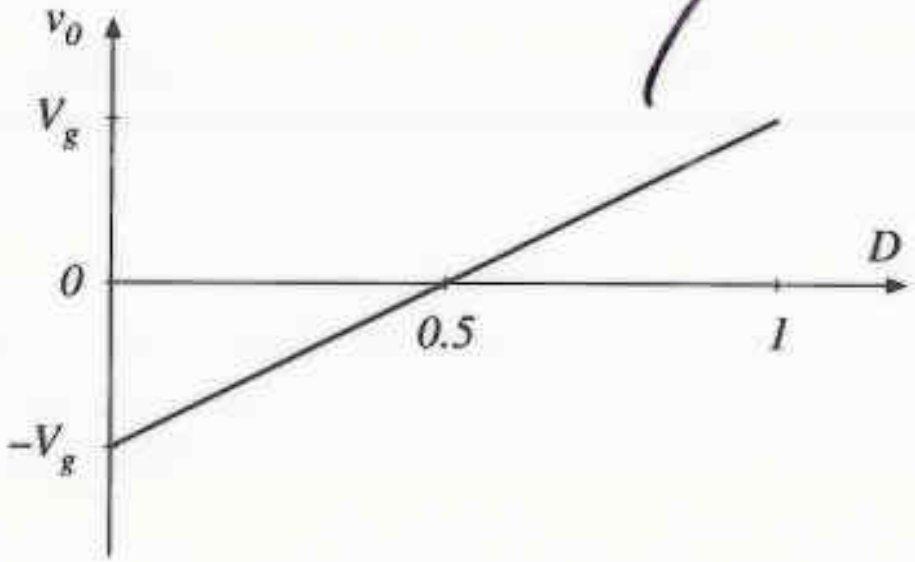
2.4 2.6

Fig 4.12 Pg 69

Inverter: sinusoidal modulation of D

Recognize Pbm Ch2 ?

$$v_0(t) = (2D - 1)\, V_g$$



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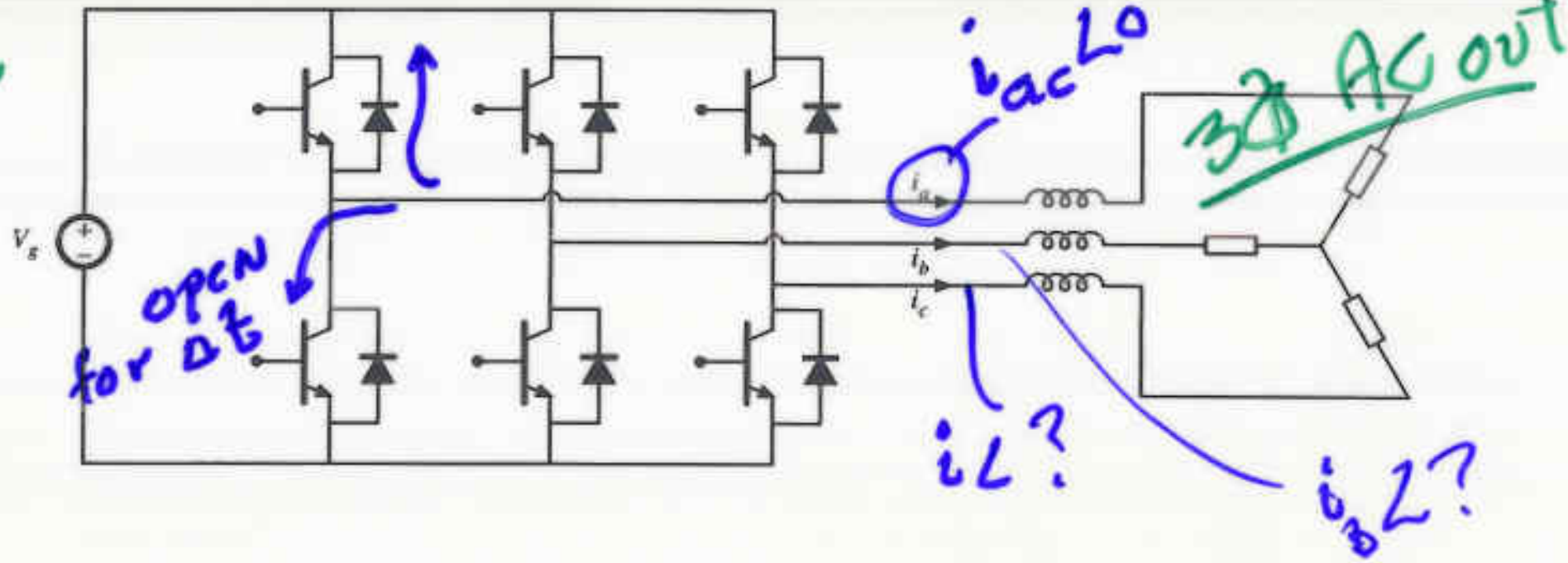
Hence, current-bidirectional two-quadrant switches are required.

Fig 4.14 pg 70 In mains Power System

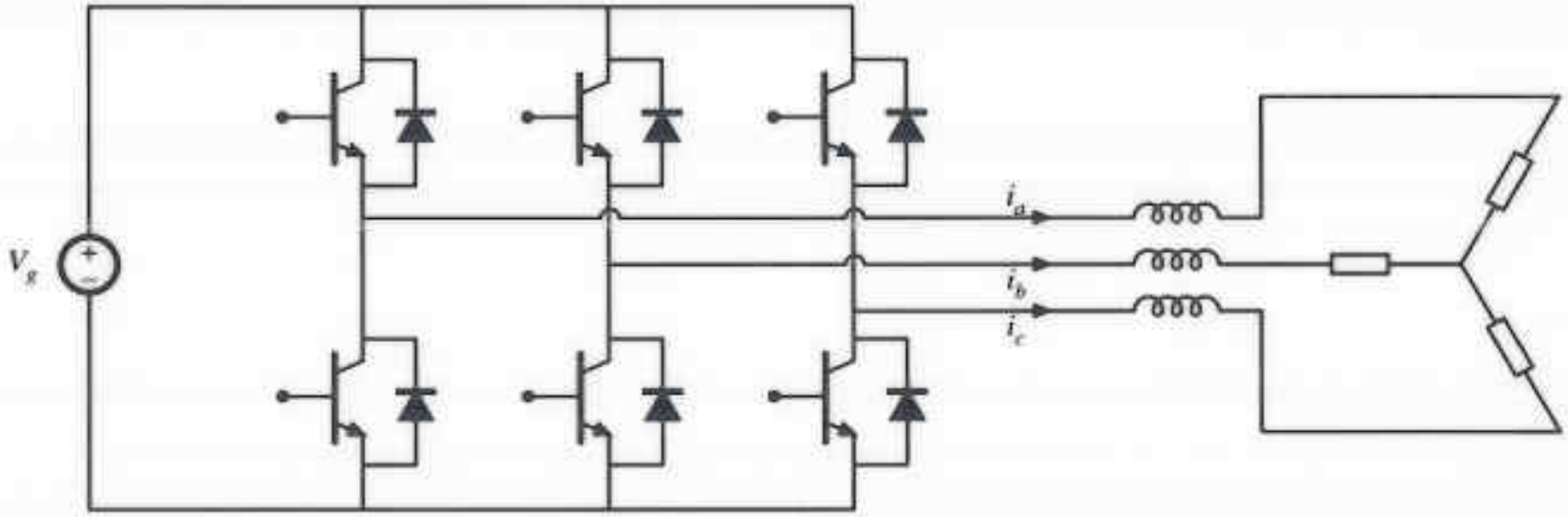
The dc-3øac voltage source inverter (VSI)

Diodes allow -i flow even when switches are not yet closed



Switches must block dc input voltage, and conduct ac load current.

The dc-3øac voltage source inverter (VSI)



Switches must block dc input voltage, and conduct ac load current.