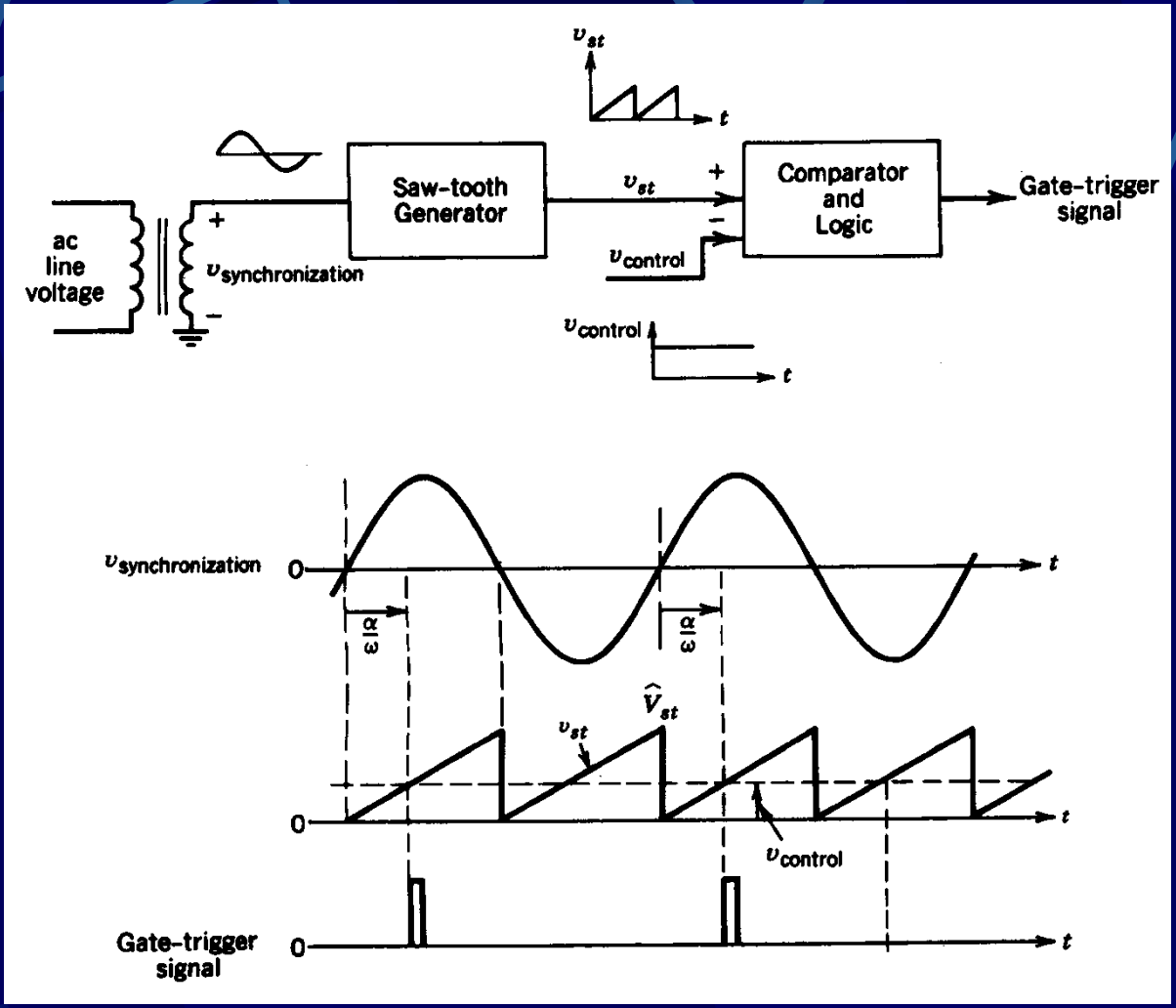
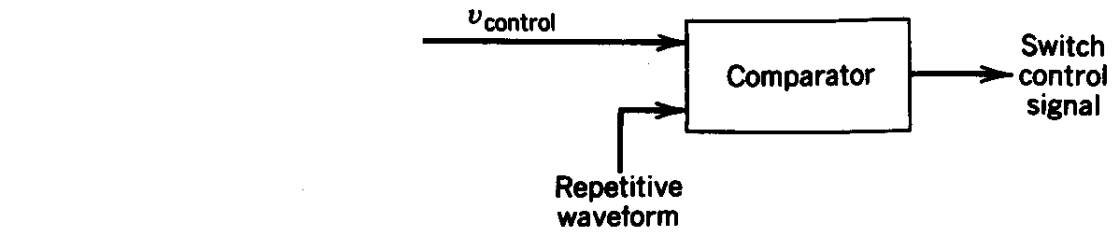
Thyristor Triggering

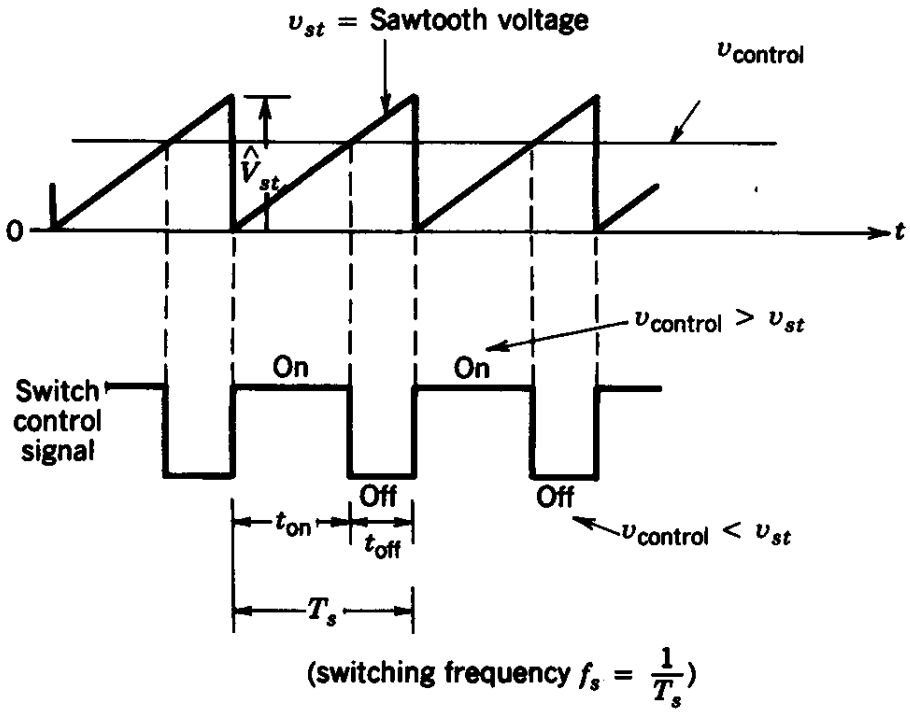


- ICs available

Control of DC-DC converters by PWM



(a)



(b)

Three-Phase PWM Waveforms

Leg A:

$v_{control,A} > v_{tri}$ T_{A+} on $v_{AN} = V_d$;

$v_{control,A} < v_{tri}$ T_{A-} on $v_{AN} = 0$;

Leg B:

$v_{control,B} > v_{tri}$ T_{B+} on $v_{BN} = V_d$;

$v_{control,B} < v_{tri}$ T_{B-} on $v_{BN} = 0$;

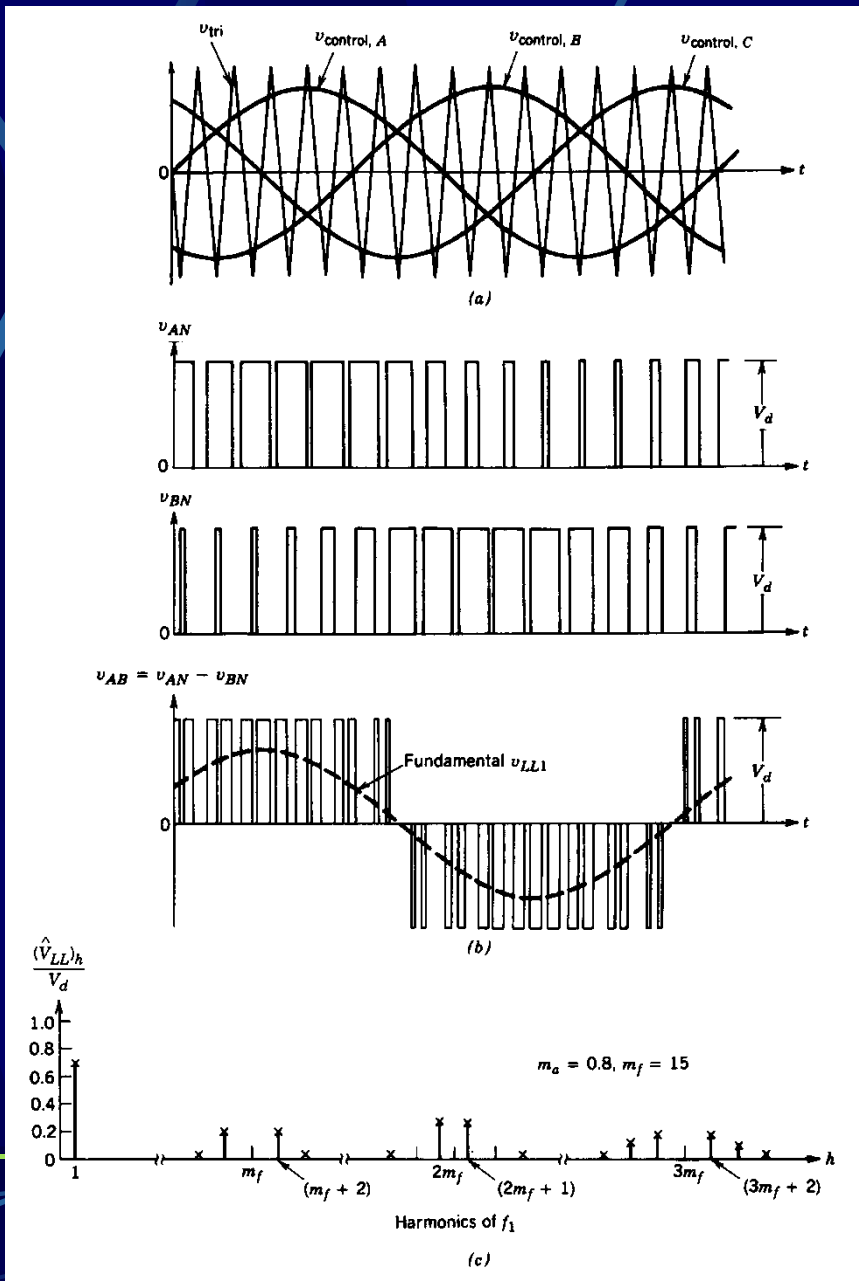
Leg C:

$v_{control,C} > v_{tri}$ T_{C+} on $v_{CN} = V_d$;

$v_{control,C} < v_{tri}$ T_{C-} on $v_{CN} = 0$;

$$v_{AB} = v_{AN} - v_{BN}$$

m_f should be odd and a multiple of 3 to cancel out even harmonics and the harmonics at the odd multiples of m_f in the line-to-line voltage.



Thyristor Gate Drive Requirements

Gate drive by *pulsed current*

fast rise pulse of sufficient length

to allow the anode current to reach its latching value

(several microseconds)

MOSFET and IGBT Gate Drive Requirements

- Gate voltage must be higher than the threshold voltage when turn-on but lower than the breakdown;
- The gate current is needed at turn-on or -off to charge or discharge the parasitic input capacitor though the steady on- and off-state gate currents are essentially zero;
- Negative gate voltage can be used to discharge the parasitic capacitor fast when turn-off;
- Isolation is needed.

Power Electronics

Chapter 7

Gate and Base Drives

Gate and Base Drive Circuits

produce control terminal currents or voltages to cause the devices to switch.

Signal processing circuits
which generate the logic control signals
not considered part of the drive circuit

- **Drive circuit**

amplifies logic control signals to levels required to drive power switch,

has significant power capabilities compared to logic level signal processing circuits.

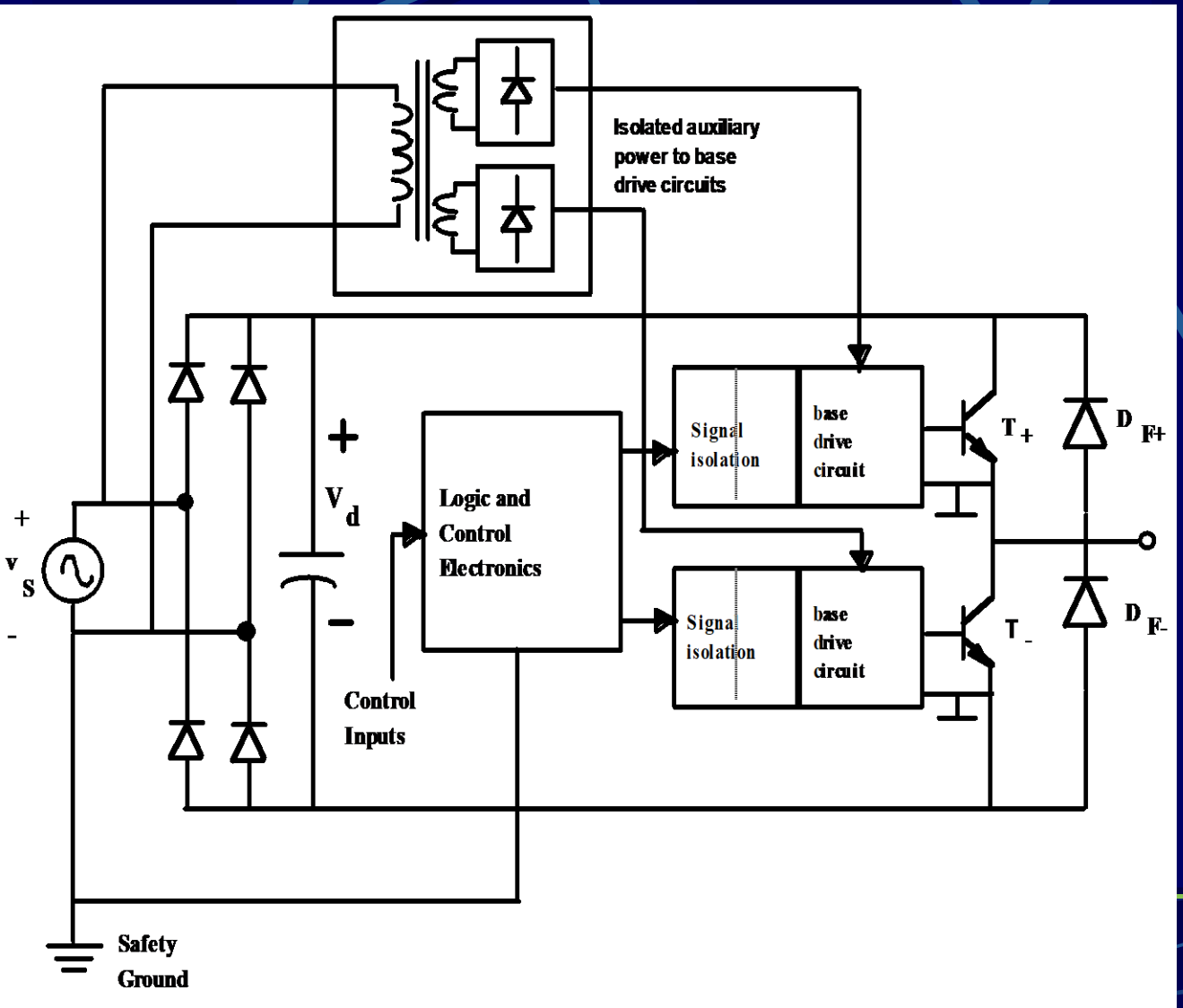
Functionality of Gate/Base Drive Circuits

- **Turn power switch from off-state to on-state**
  - Minimize turn-on time
  - Provide adequate drive power to keep switch in on-state
- **Turn power switch from on-state to off-state**
  - Minimize turn-off time
  - Provide bias to insure that switch remains off
- **Control power switch to protect it**
  when overvoltages or overcurrents are sensed
- **Provide electrical isolation when needed**
  between power switch and signal processing circuits

Drive Circuit Design Considerations

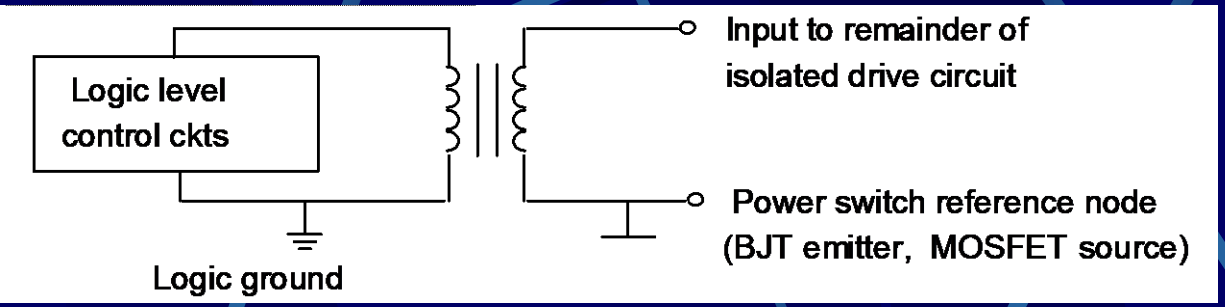
- Output current/voltage magnitude
- Waveshaping to improve switch performance
- Provisions for electrical isolation and power switch protection
- Drive circuit topologies
- Component layout to minimize stray inductance and shielding from switching noise

Need for Electrical Isolation of Drive Circuits

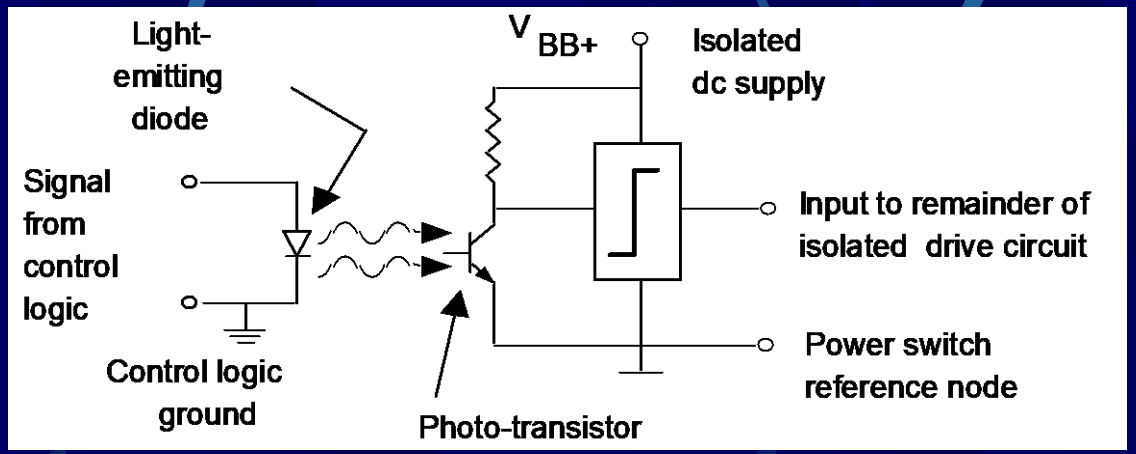


Variation in emitter potentials with respect to safety and logic ground means that electrical isolation of emitters from logic ground is needed.

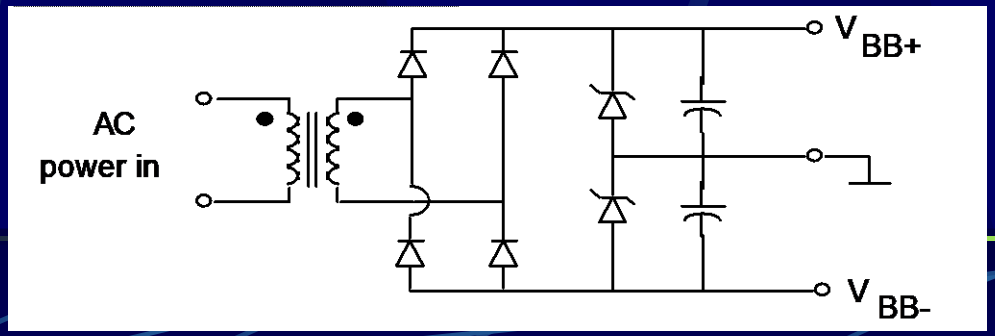
Methods of Control Signal Isolation



Transformer isolation

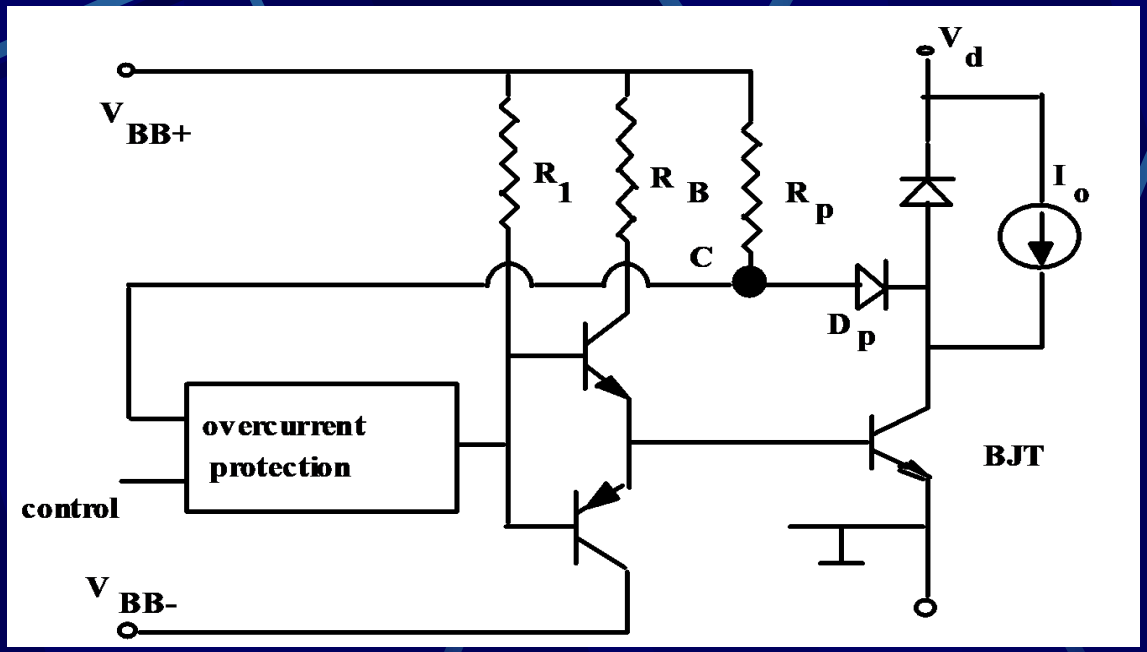


Opto-coupler isolation



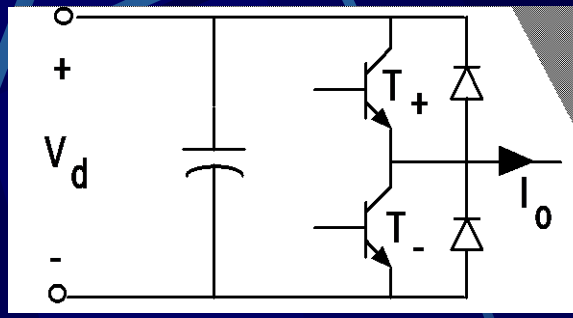
Isolated dc power supplies
for drive circuits

Overcurrent Protection with Drive Circuits

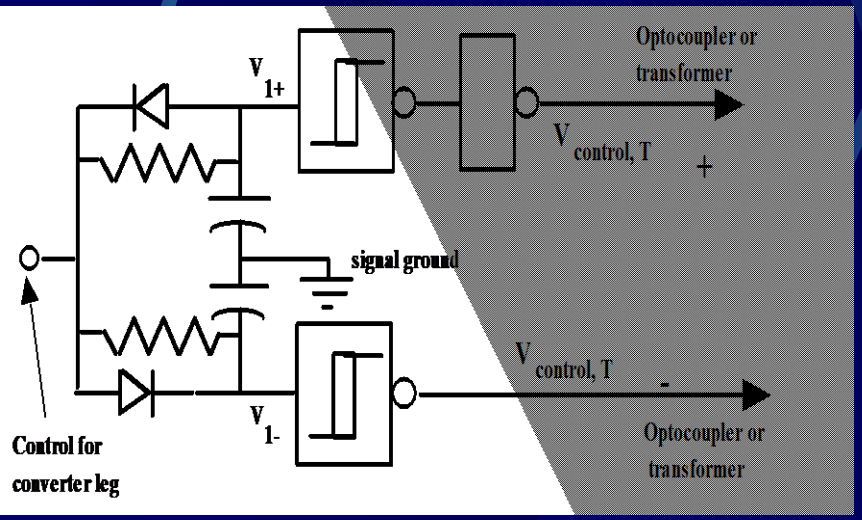


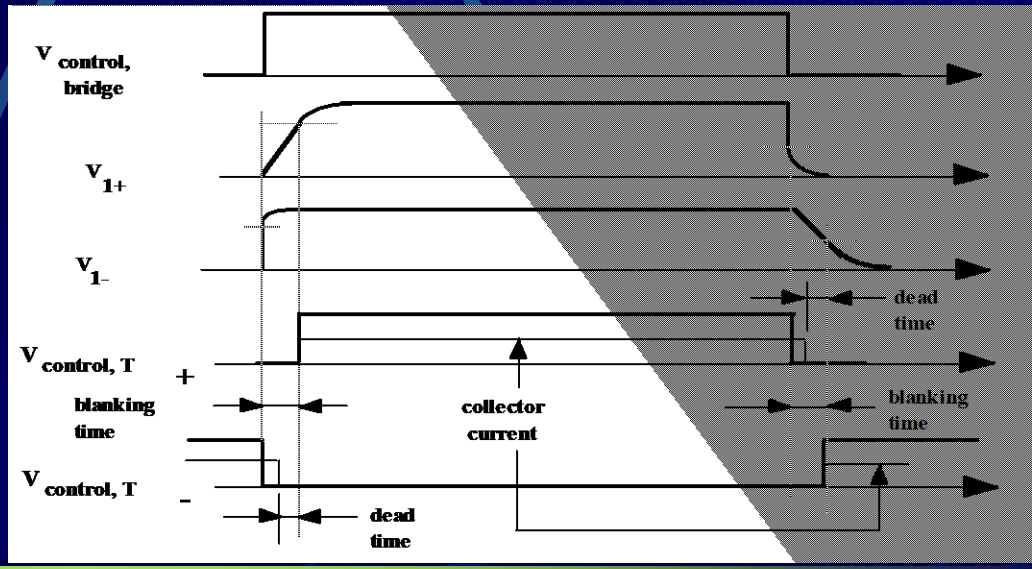
- Point C one diode drop above $V_{CE(sat)}$ when BJT is on. Overcurrent will increase V_{CE} and thus potential at C.
- If C rises above a threshold value and control signal is biasing BJT on, overcurrent protection block will turn off BJT.

Blanking Times in Bridge Circuit Drives

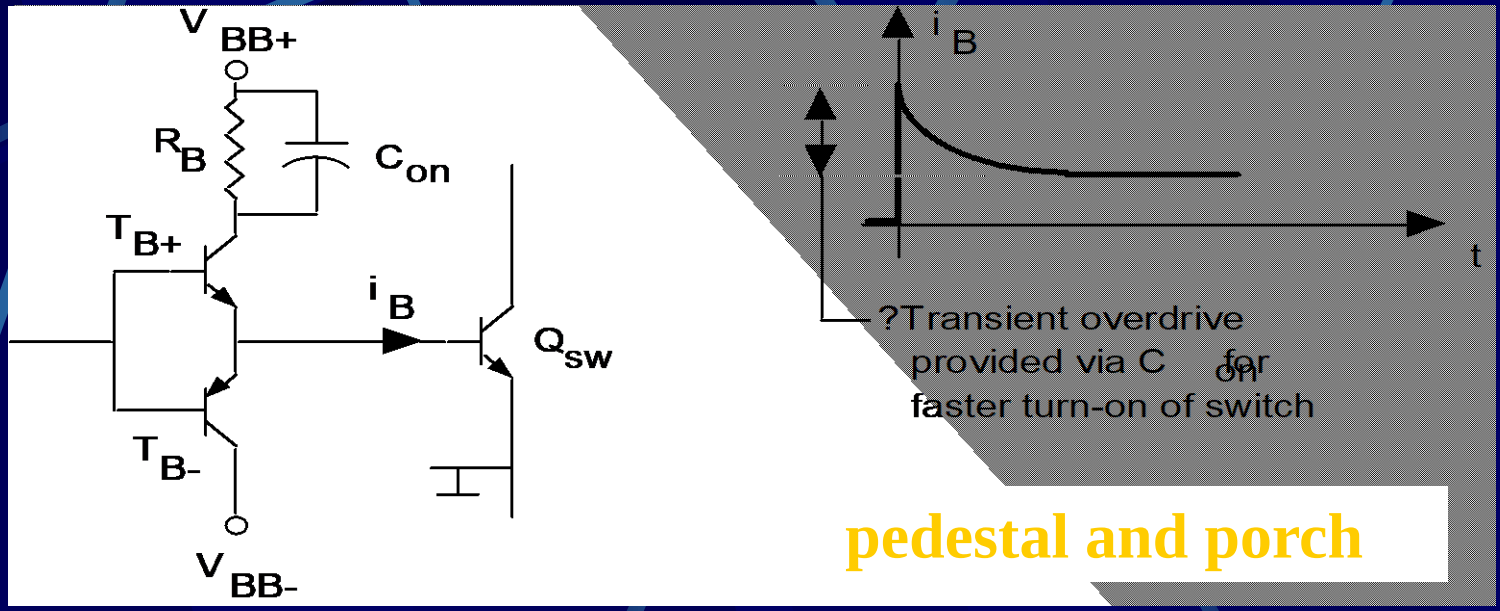


?Turn off T+ before turning on
T- in order to avoid cross
-conduction (shorting out of Vd)

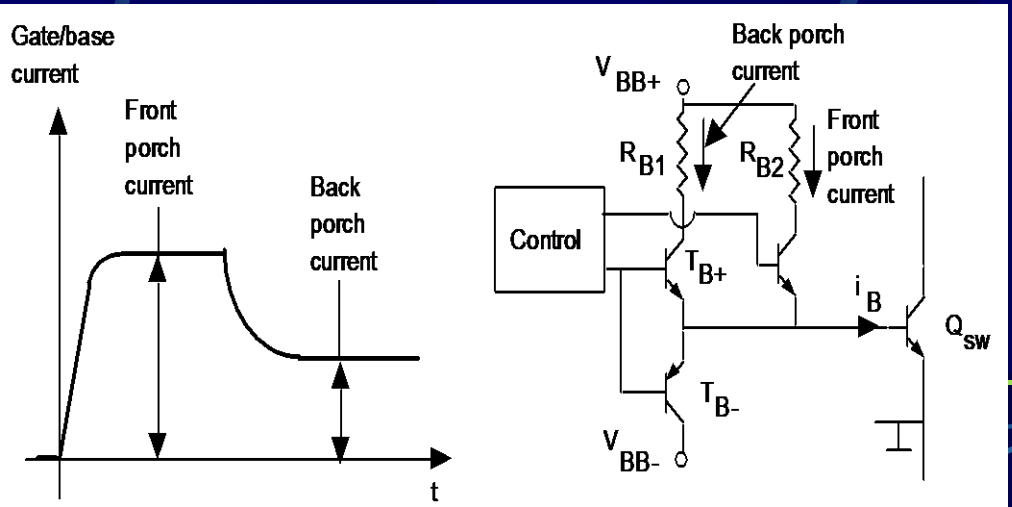




Drive Circuit Waveshaping for Improved Operation



pedestal and porch



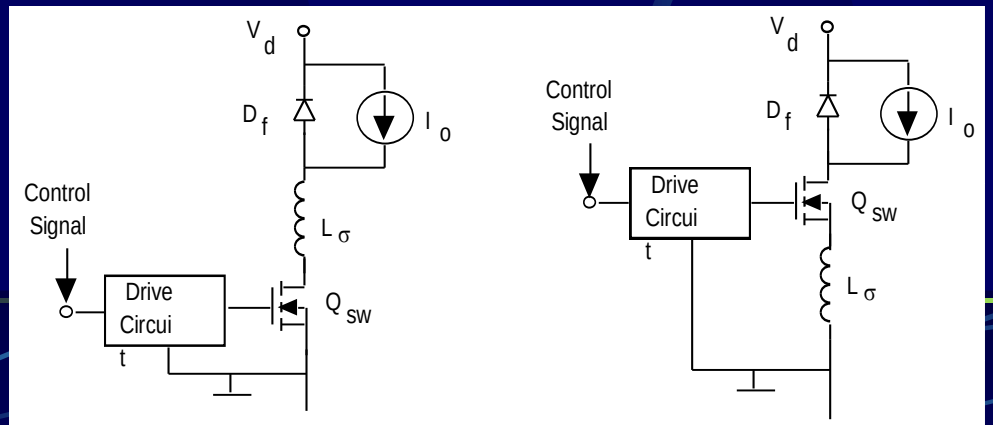
Front porch, back porch gate/base currents at turn-on

- Faster turn-on without putting device deeply into on-state where turn-off delay time will be substantially increased.

Circuit/Component Layout Considerations

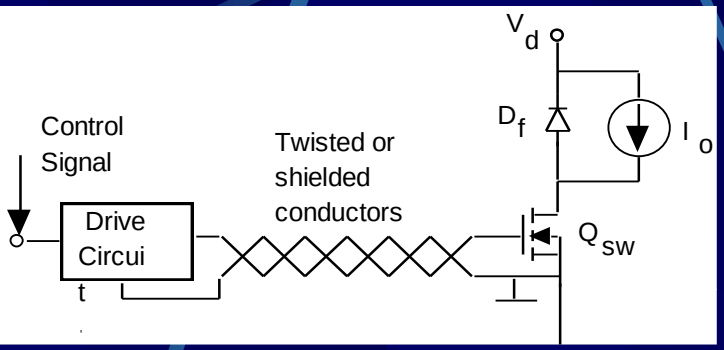
Prime consideration is minimizing stray inductance

- Stray inductance in series with high-voltage side of power device Q_{sw} causes overvoltage at turn-off.
- Stray inductance in series with low-voltage side power device Q_{sw} can cause oscillations at turn-on and turn-off.
- 1 cm of unshielded lead has about 5 nH of series inductance.
- Keep unshielded lead lengths to an absolute minimum.

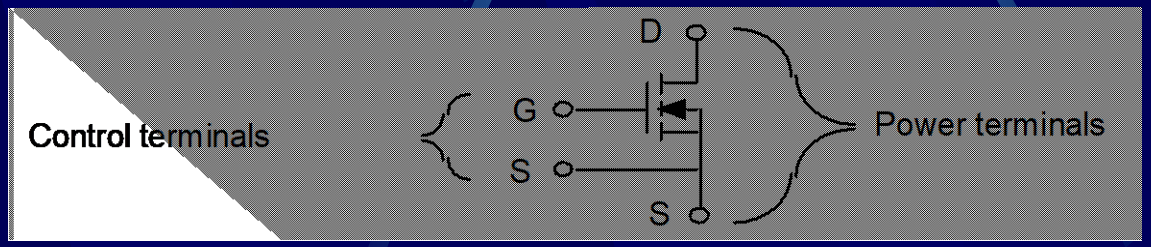


L_σ -- Stray inductance with high-voltage side

Circuit/Component Layout Considerations (cont.)



Use shielded conductors to connect drive circuit to power switch if there must be any appreciable separation (few cm or more) between them.



Some power devices provided with four leads, two input leads and two power leads, to minimize stray inductance in input circuit.


The End