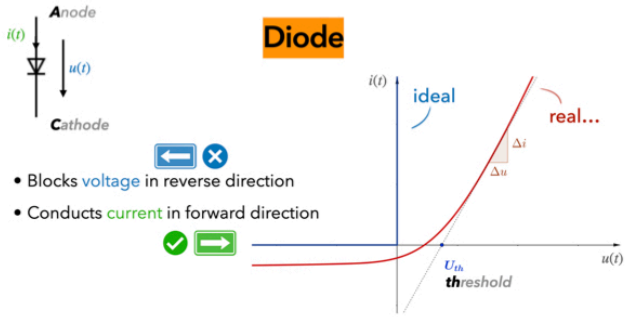
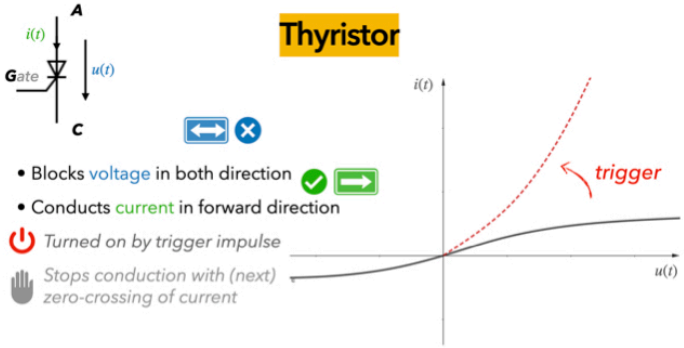
Diode



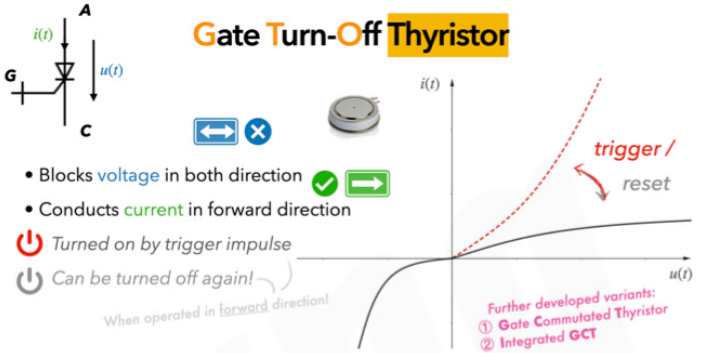
- Blocks voltage in reverse direction
- Conducts current in forward direction

Thyristor



- Blocks voltage in both direction
- Conducts current in forward direction
- *Turned on by trigger impulse*
- *Stops conduction with (next) zero-crossing of current*

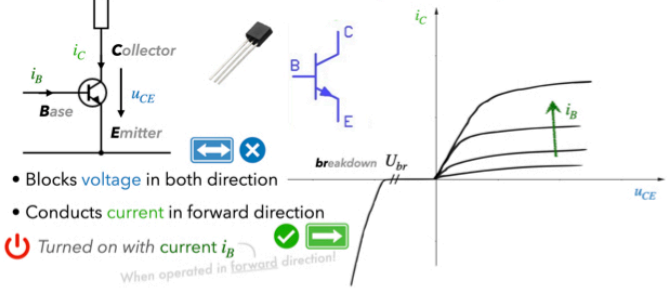
Gate Turn-Off Thyristor



- Blocks voltage in both direction
- Conducts current in forward direction
- *Turned on by trigger impulse*
- *Can be turned off again!*

When operated in forward direction!

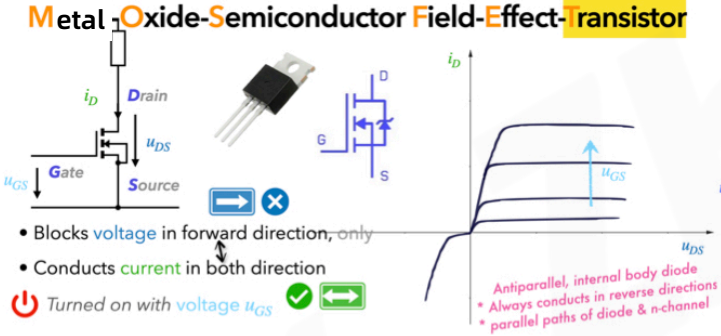
Bipolar Junction Transistor



- Blocks voltage in both direction
- Conducts current in forward direction
- *Turned on with current i_B*

When operated in forward direction!

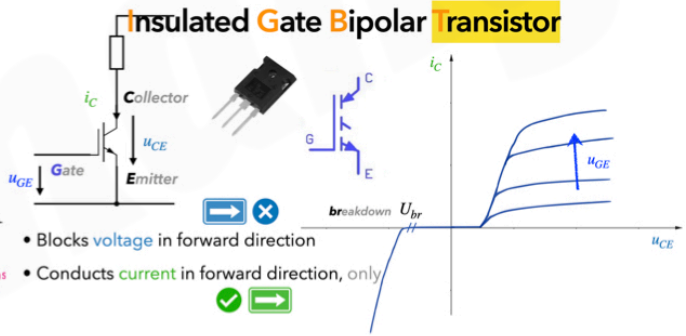
Metal-Oxide-Semiconductor Field-Effect-Transistor



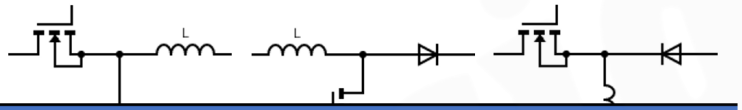
- Blocks voltage in forward direction, only
- Conducts current in both direction
- *Turned on with voltage u_{GS}*

Antiparallel, internal body diode
* Always conducts in reverse directions
* parallel paths of diode & n-channel

Insulated Gate Bipolar Transistor

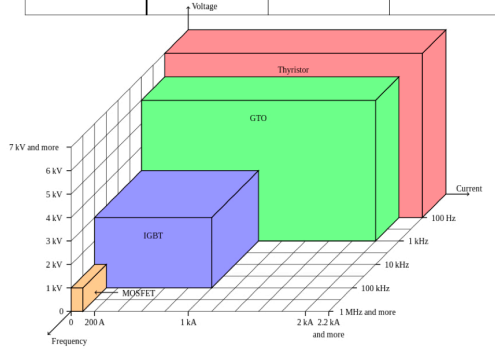


- Blocks voltage in forward direction
- Conducts current in forward direction, only



	Buck	Boost	Buck-Boost
$\frac{< v_o >}{V_i}$	D	$\frac{1}{1-D}$	$\frac{D}{1-D}$
L_{crit}	$\frac{V_i - < v_o >}{2 < v_o >} RDT$	$\frac{V_i^2}{2 < v_o >^2} RDT$	$\frac{V_i^2/(V_i + < v_o >)}{2 < v_o >} RDT$
C	$\frac{T\Delta i_L}{8\Delta V_o}$	$< v_o > \frac{DT}{R\Delta V_o}$	$< v_o > \frac{DT}{R\Delta V_o}$
DCM: $\frac{<v_o>}{V_i}$	$-\frac{RD^2T}{4L} + D\sqrt{\frac{RT}{2L} + \frac{R^2D^2T^2}{16L^2}}$	$\frac{1}{2} + \sqrt{\frac{1}{4} + \frac{RD^2T}{2L}}$	$D\sqrt{\frac{RT}{2L}}$

	Thyristor	GTO	BJT	MOSFET	IGBT
Availability	Early 60s	Mid 80s	Late 70s	Early 80s	Late 80s
Drive Circuit	Simple	Very difficult	Difficult	Very simple	Very simple
Trait	*Can't turn off* using gate signals	*King* in very high power	*Phasing out* in new products	Good performance in *high frequency*	Best of all performance

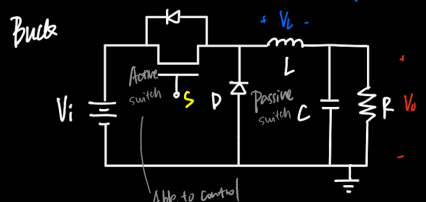


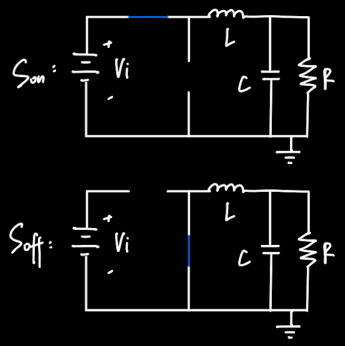
Comparison

Review!

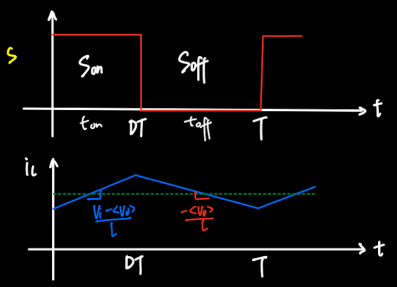
6. Buck Converters

Buck Converter Operation and Voltage Equation





Assume: CCM, S.S. [Average]



$$\frac{V_i - \langle V_o \rangle}{L} DT = \frac{\langle V_o \rangle}{L}(1-D)T$$

$$(V_i - \langle V_o \rangle)D = \langle V_o \rangle (1-D)$$

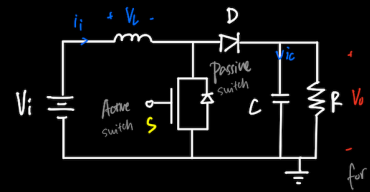
$$DV_i - D\langle V_o \rangle = \langle V_o \rangle - D\langle V_o \rangle$$

$$DV_i = \langle V_o \rangle$$

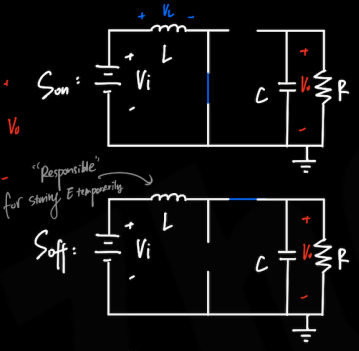
$$\boxed{D = \frac{\langle V_o \rangle}{V_i}}$$

Boost Converters

Boost Converter Operation and Voltage Equation

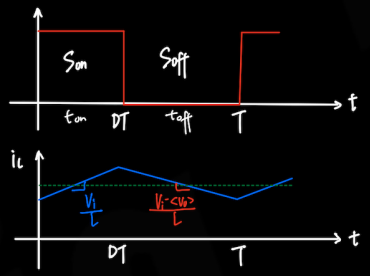


"Figure out which switch is on"



"Responsible for storing E temporarily"

Assume: CCM, S.S. [Average]



$$\Delta i_L = \frac{V_i}{L} DT + \frac{V_i - \langle V_o \rangle}{L}(1-D)T = 0$$

$$\Rightarrow V_i D = (-V_i + \langle V_o \rangle)(1-D)$$

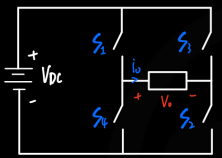
$$V_i D = V_i D - V_i + \langle V_o \rangle - \langle V_o \rangle D$$

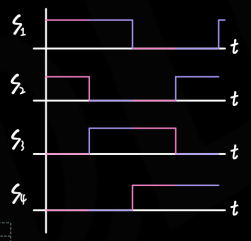
$$V_i = \langle V_o \rangle (1-D)$$

$$\boxed{\langle V_o \rangle = V_i \frac{1}{D}}$$

11. Full-Bridge Inverters

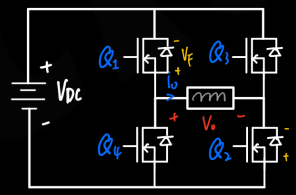
Half-Bridge Inverter Switch States

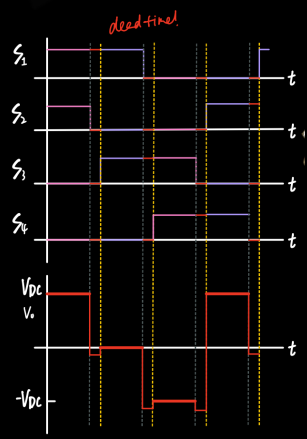




S_1	S_2	S_3	S_4	V_o
1	1	0	0	V_{dc}
1	0	1	0	0
0	0	1	1	$-V_{dc}$
0	1	0	1	0

Half-Bridge Inverter with MOSFET Switches

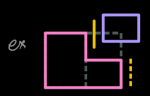




Q_1	Q_2	Q_3	Q_4	V_o
1	1	0	0	V_{dc}
1	0	0	0	$-V_F$ or $V_{dc}+V_F$
1	0	1	0	0
0	0	1	0	$-V_{dc}-V_F$ or V_F
0	0	1	1	$-V_{dc}$
0	0	0	1	$-V_{dc}-V_F$ or V_F
0	1	0	1	0
0	1	0	0	$-V_F$ or $V_{dc}+V_F$

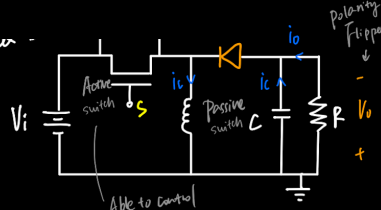
V_F / $V_{dc}+V_F$ / $-V_F$ / $-V_{dc}-V_F$ / or

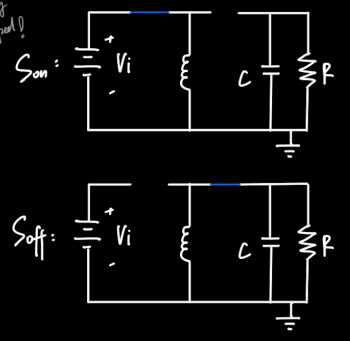
ex



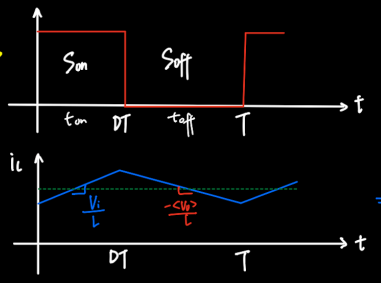
Converters

er Operation and Voltage Equation





Assume: CCM, S.S. [Average]



$$\Delta i_L = \frac{V_i}{L} DT + \frac{-\langle V_o \rangle}{L}(1-D)T = 0$$

$$\Rightarrow V_i D = \langle V_o \rangle (1-D)$$

$$V_i = \langle V_o \rangle \frac{1-D}{D}$$

$$\boxed{\langle V_o \rangle = V_i \frac{D}{1-D}}$$