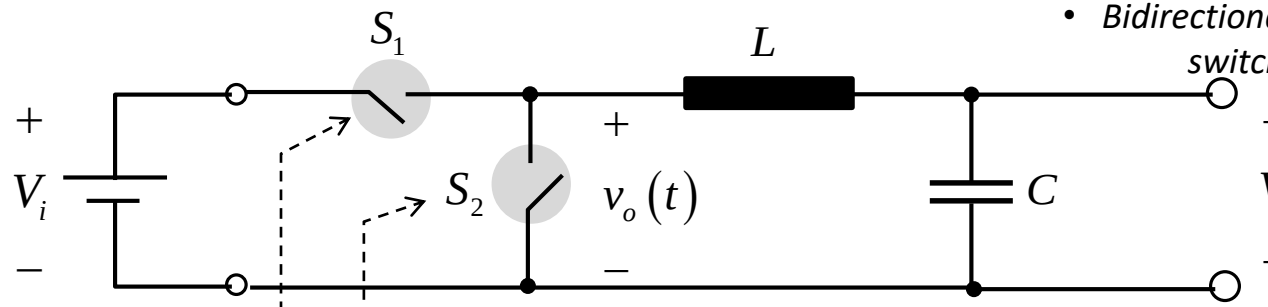
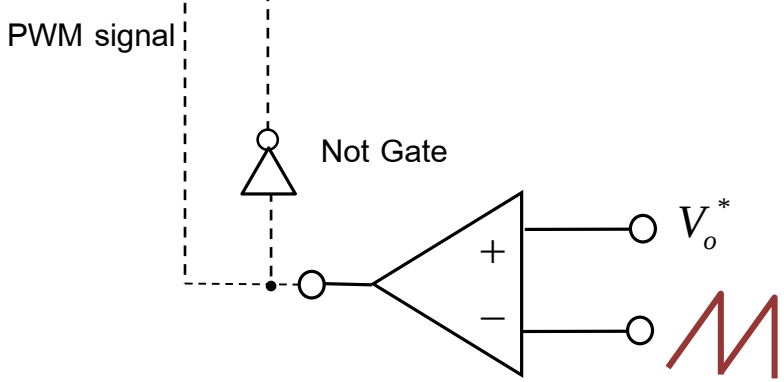
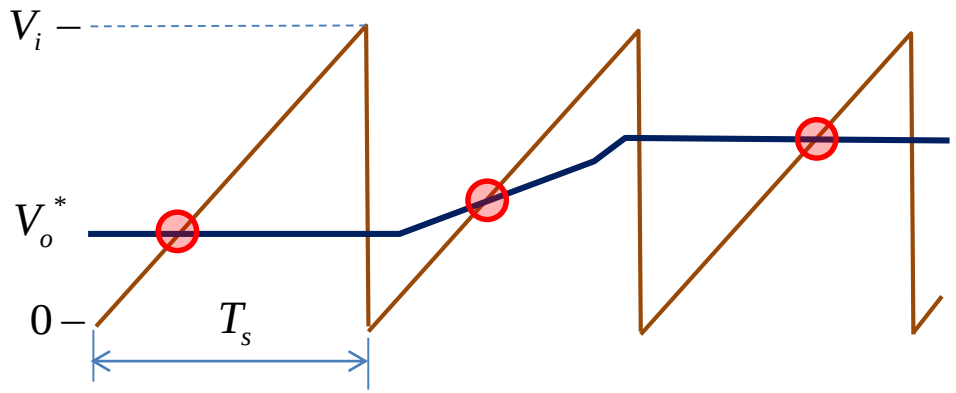
Chapter 3
DC-AC Converter (Inverter)

PWM Buck Converter (Revisited)

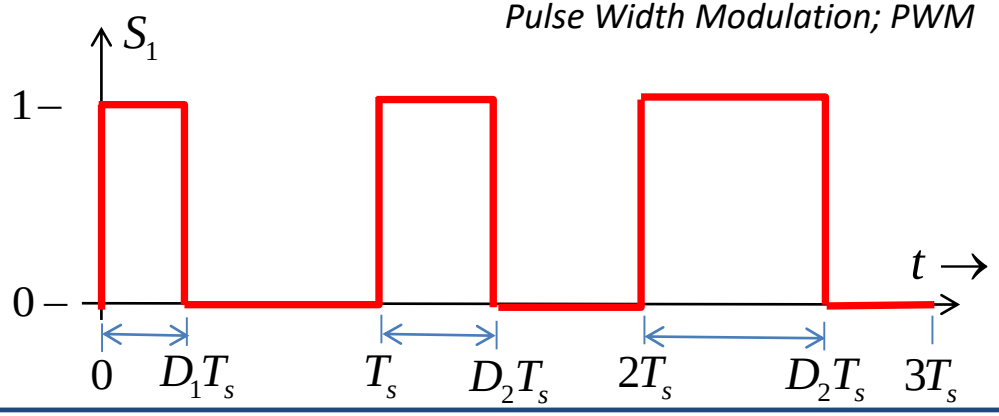
- *Bidirectional power flow is achieved using controlled switches with anti-parallel diode for S1 and S2.*







Pulse Width Modulation; PWM



$$\frac{V_o}{V_i} = \frac{DT_s}{T_s}$$

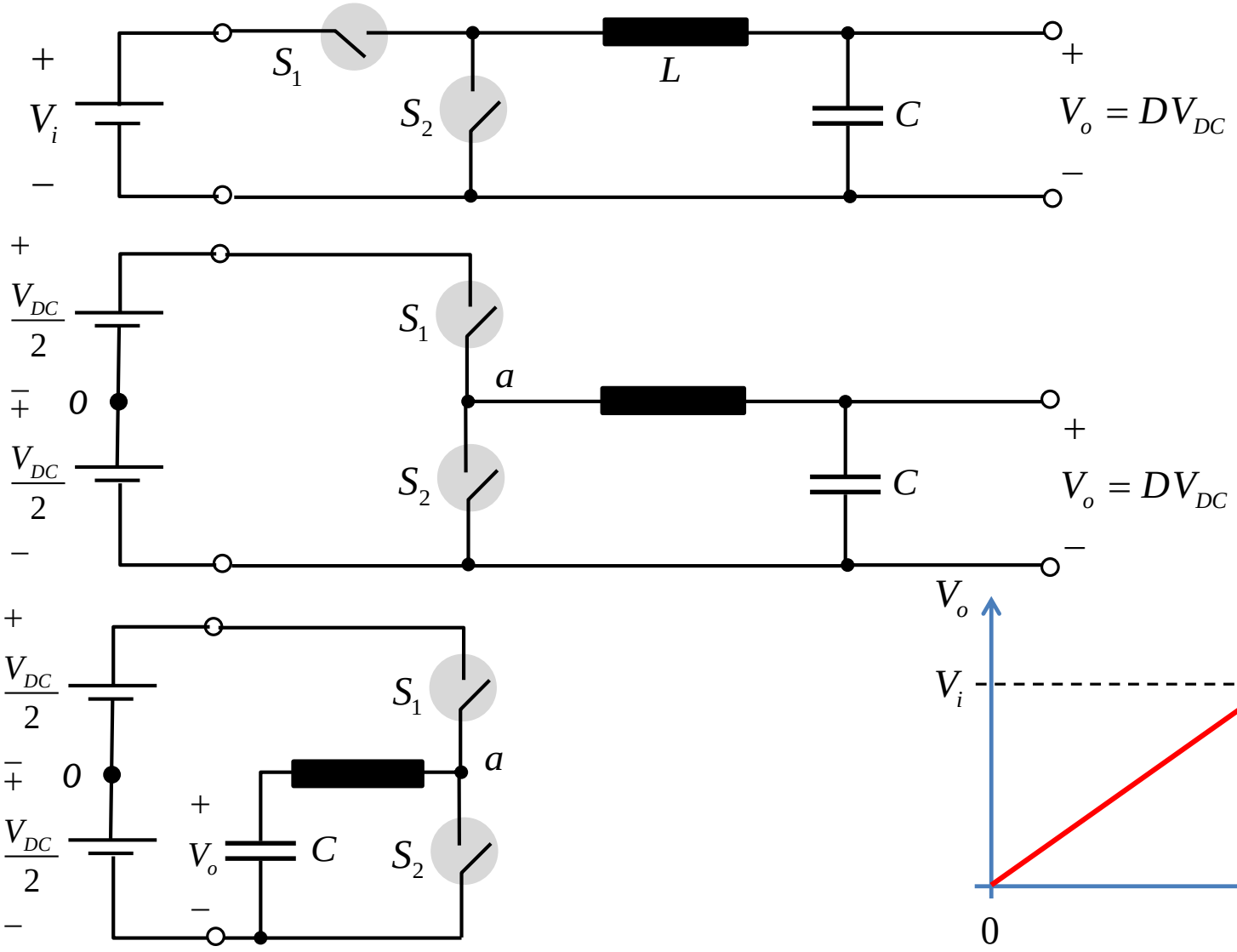
Carrier

(fs kHz range)

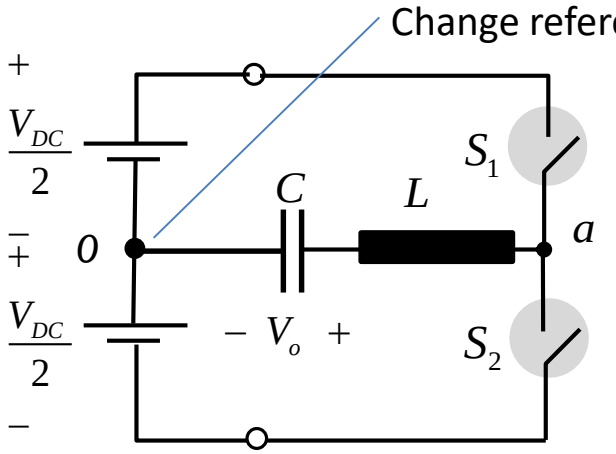
$$T_s = \frac{1}{f_s}$$

$$0 \le D \le 1; \quad 0 \le V_o \le V_i$$

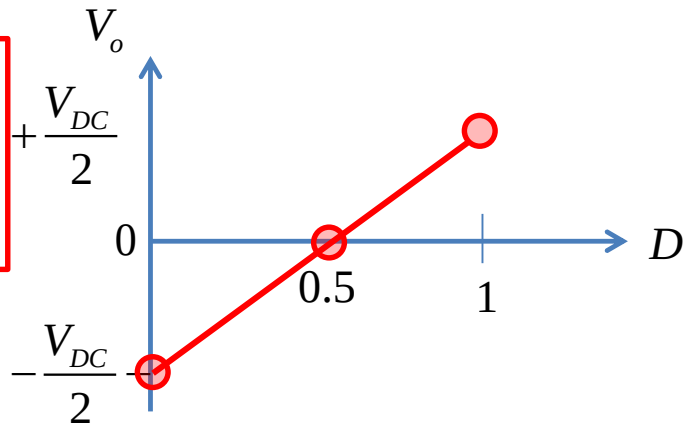
DC-AC Converter : Inverter (*Derivation from buck converter)*



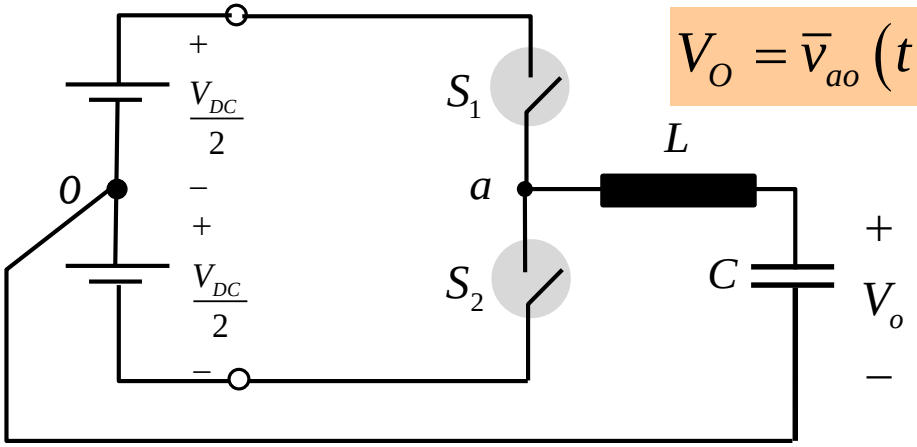
Inverter : *Derivation from buck converter*



- *Vo* can be varied between $+\frac{V_{DC}}{2}$ and $-\frac{V_{DC}}{2}$



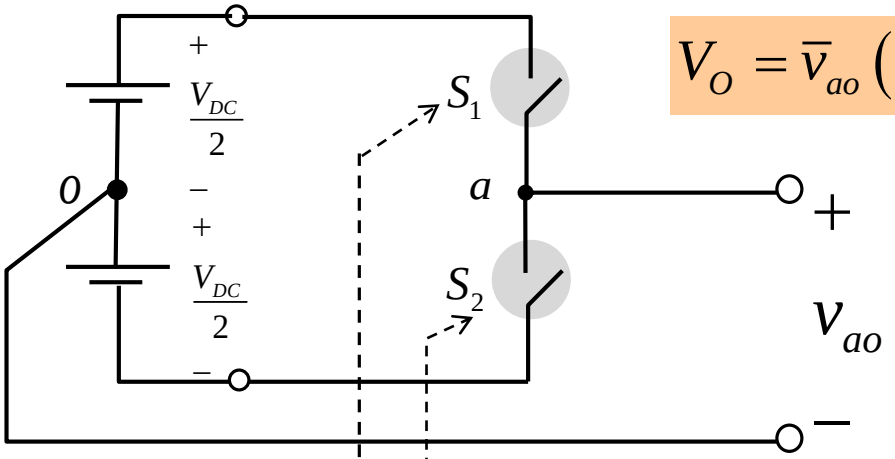
$$V_O = \left(D - \frac{1}{2}\right) V_{DC}$$



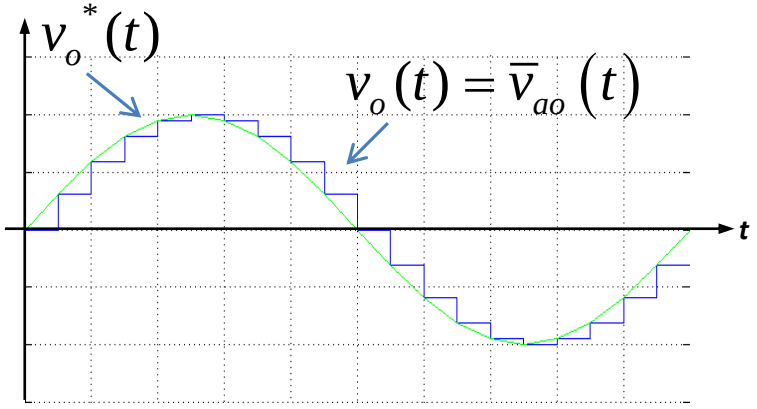
$$V_O = \bar{v}_{ao}(t)$$

S1	S2	v_{ao}
ON	OFF	$+V_{DC}/2$
OFF	ON	$-V_{DC}/2$
ON	ON	Not allow
OFF	OFF	Uncontrolled Voltage

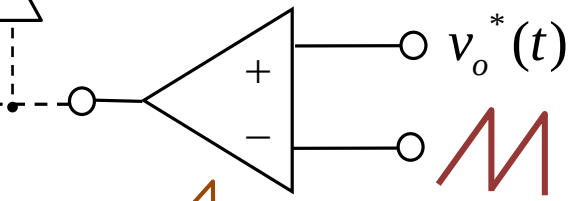
Half-Bridge Inverter : Pulse-Width Modulation



$$V_O = \bar{v}_{ao}(t)$$

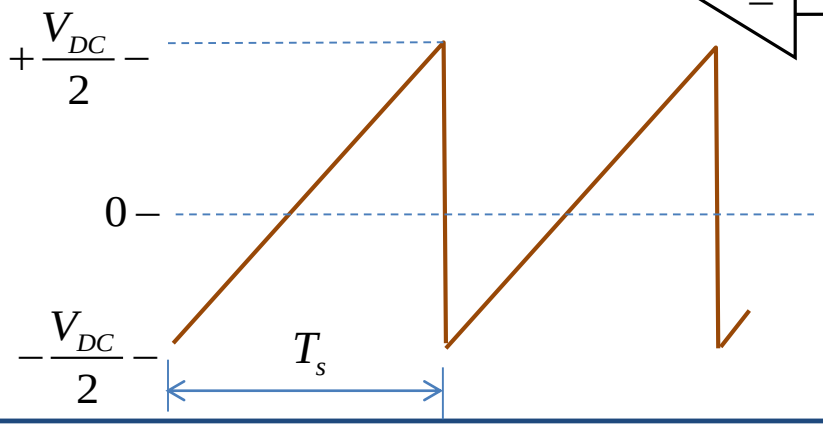


PWM signal



$$v_o^*(t) = V_m^* \sin\left(2\pi f^* t + \phi^*\right)$$

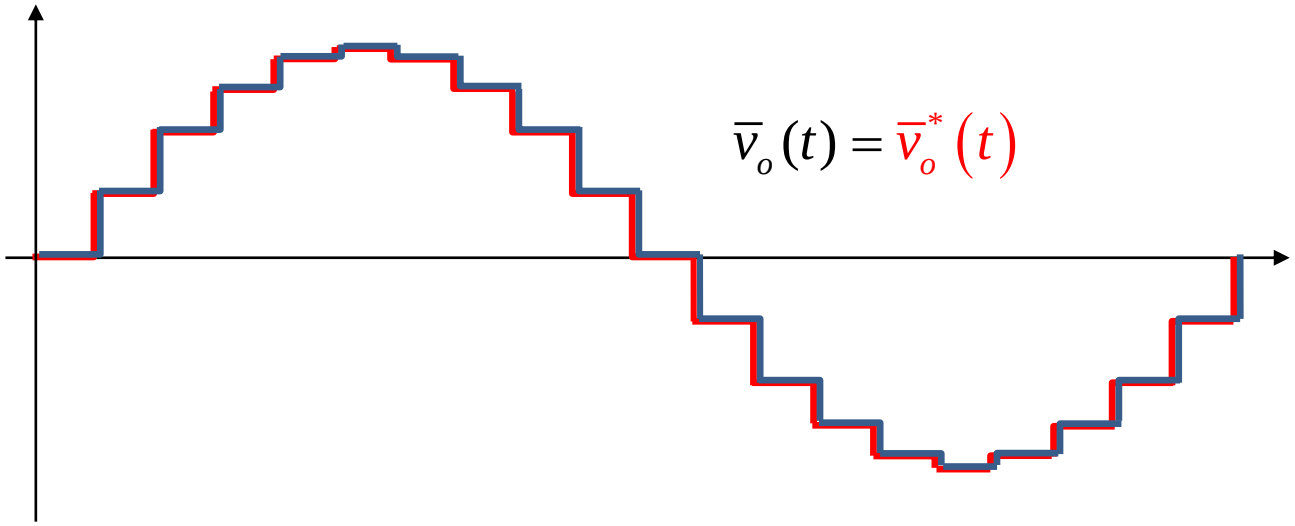
Carrier

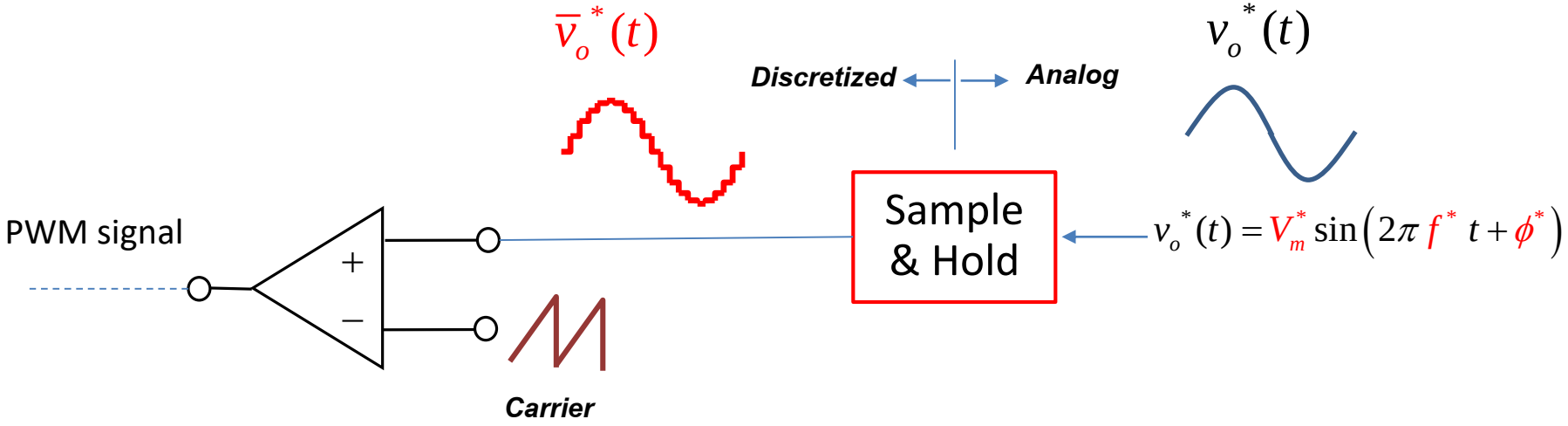


- *Inverter can generate AC voltage which corresponds to the commanded voltage amplitude, frequency and phase shift.*

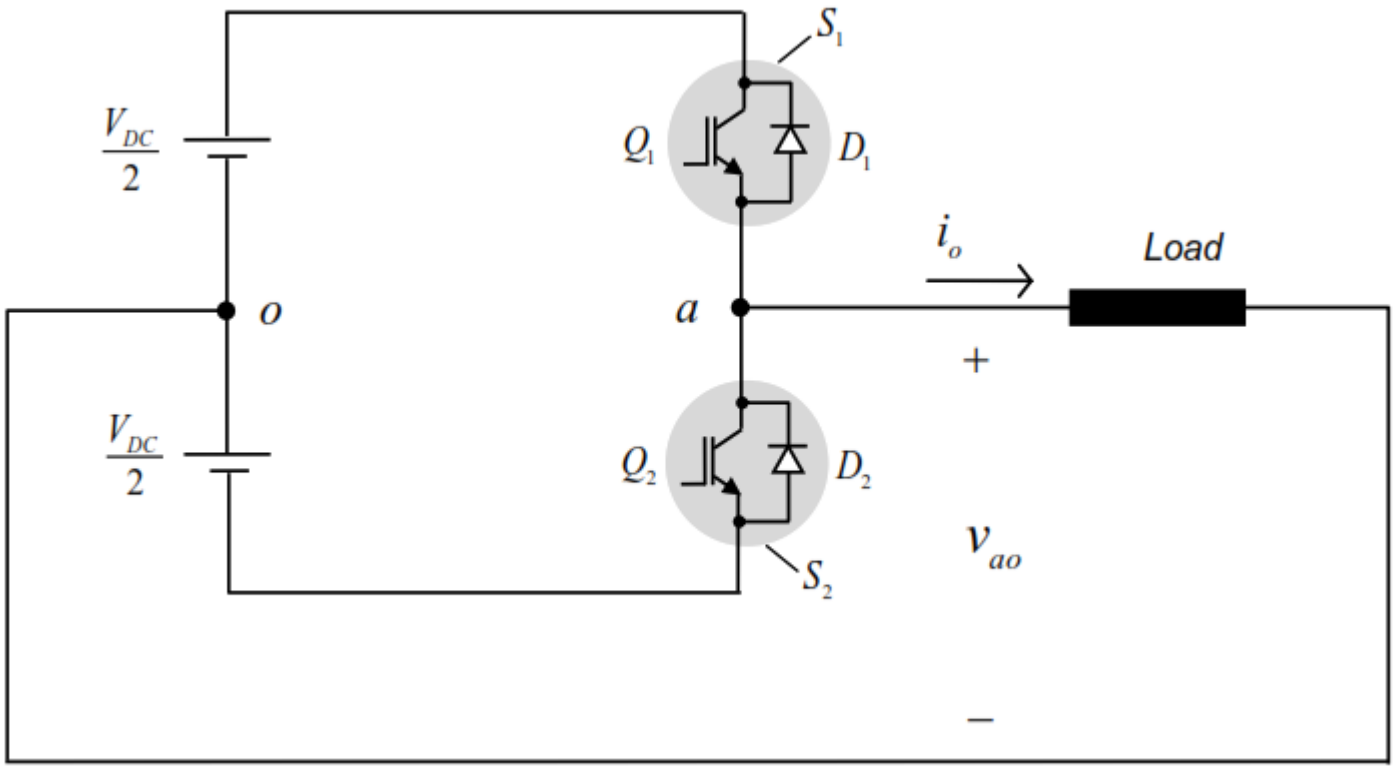
$$V_m^* \leq \frac{V_{DC}}{2}$$

Real-World Pulse-Width Modulation with Embedded System

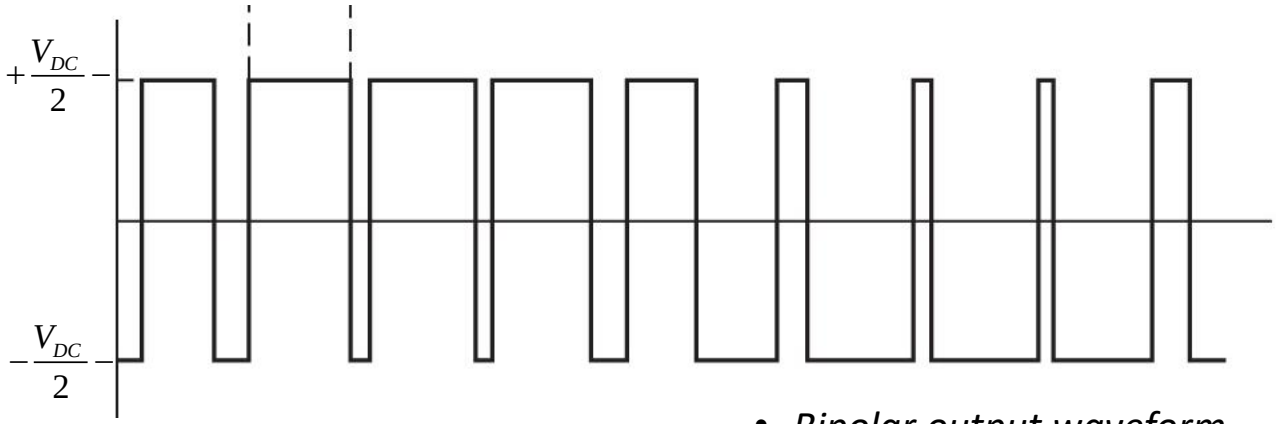




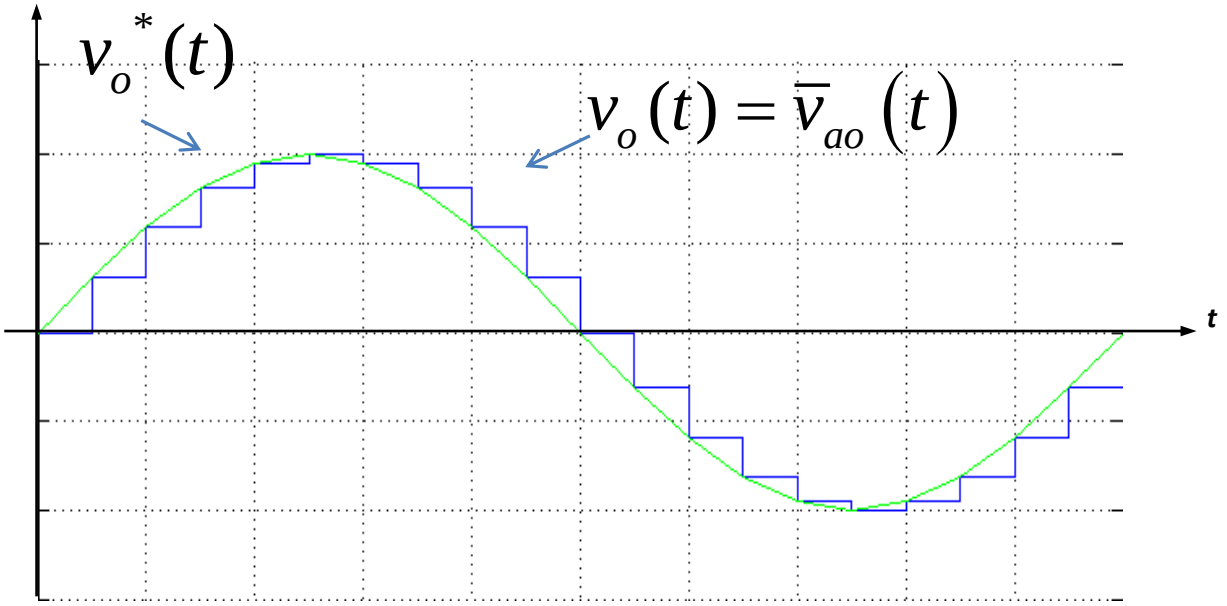
Switch Realization



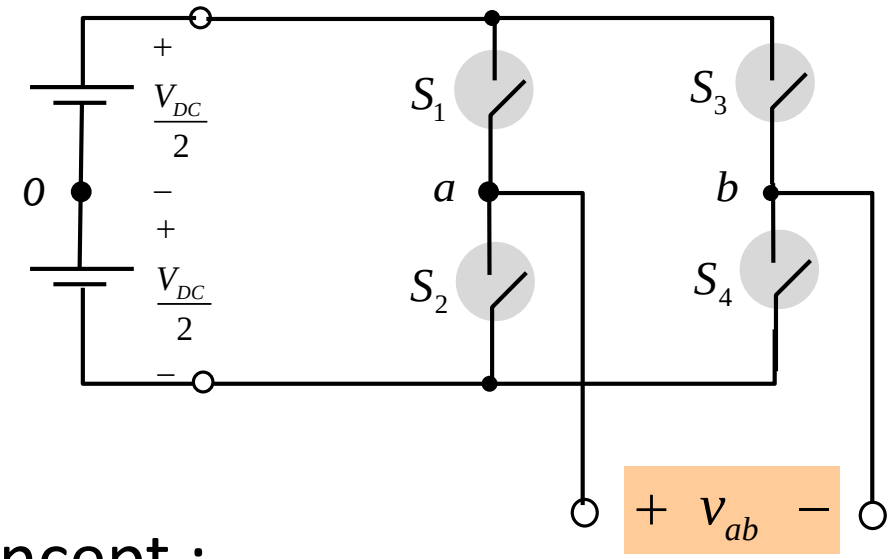
Half-Bridge Inverter : Output waveform



- *Bipolar output waveform*



Full-Bridge Inverter



$$V_m^* \leq V_{DC}$$

- *Utilize the whole DC Bus Voltage: the amplitude of AC voltage can be up to DC bus voltage VDC !!*

Concept :

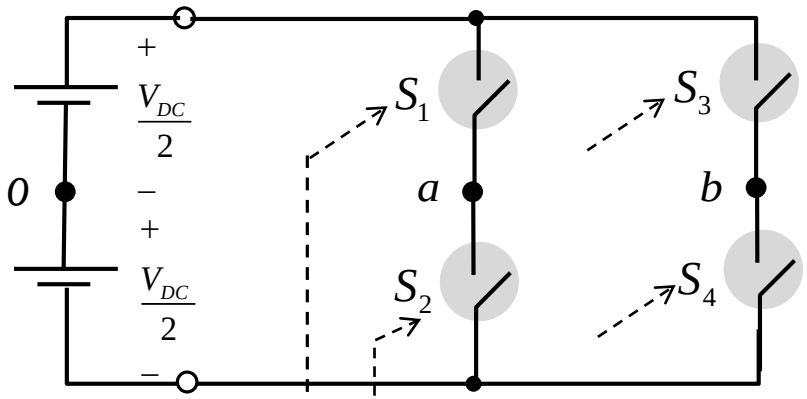
$$v_o^*(t) = v_{ab}^*(t) = V_m^* \sin\left(2\pi f^* t + \phi^*\right)$$

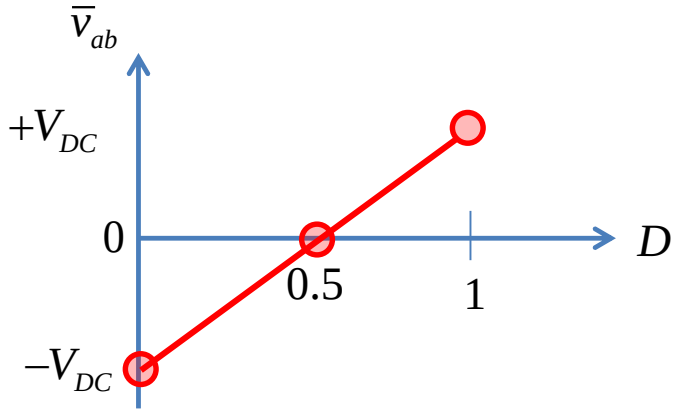
$$v_{ao}^*(t) = \frac{V_m^*}{2} \sin\left(2\pi f^* t + \phi^*\right)$$

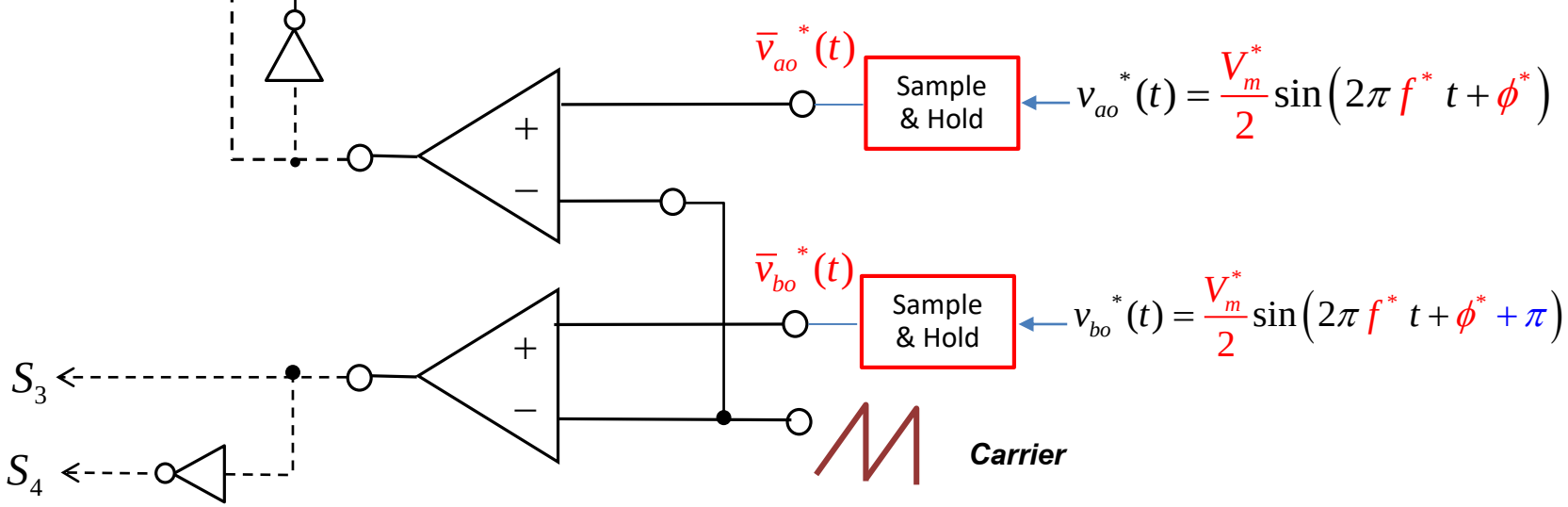
$$v_{bo}^*(t) = \frac{V_m^*}{2} \sin\left(2\pi f^* t + \phi^* + \pi\right)$$

- *There are 2 ref. voltages which are out of phase.*

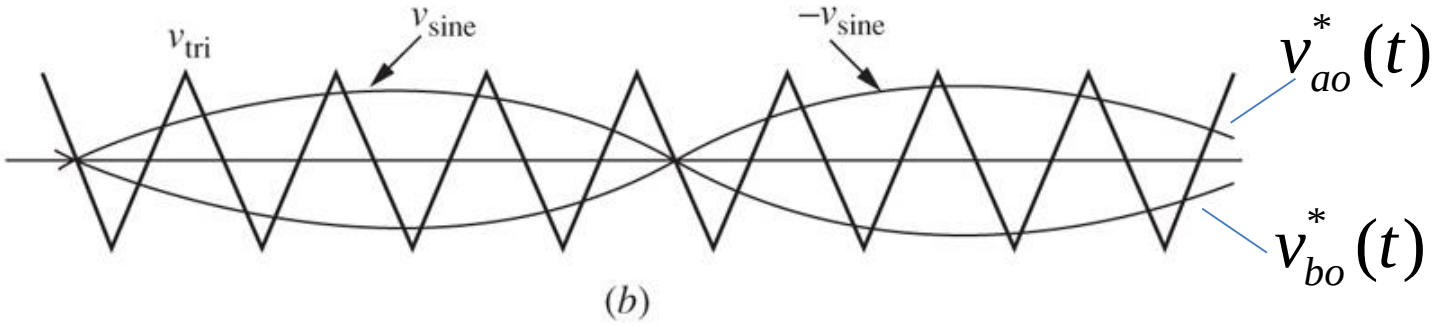
Full-Bridge Inverter : Pulse-Width Modulation



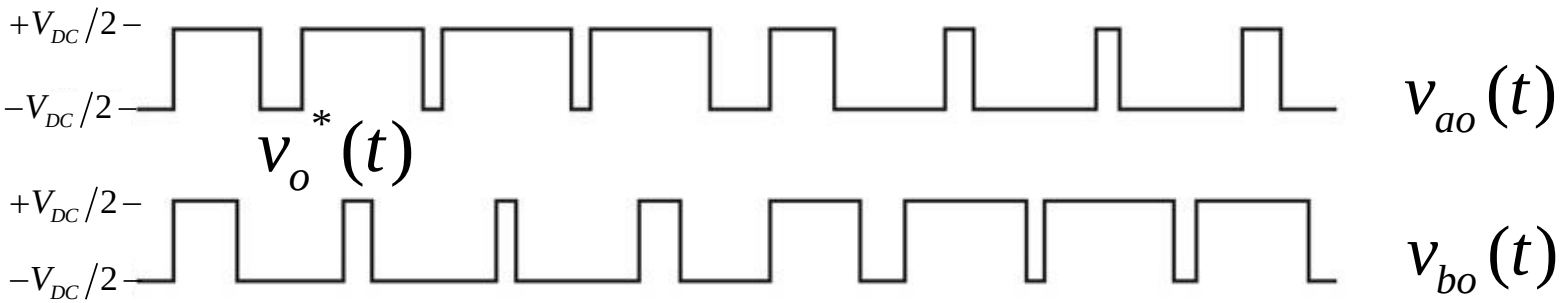




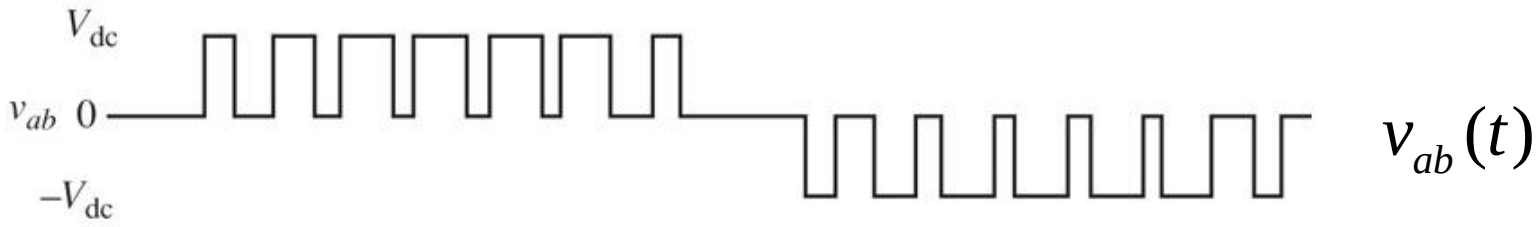
Full-Bridge Inverter : Output waveform



(b)



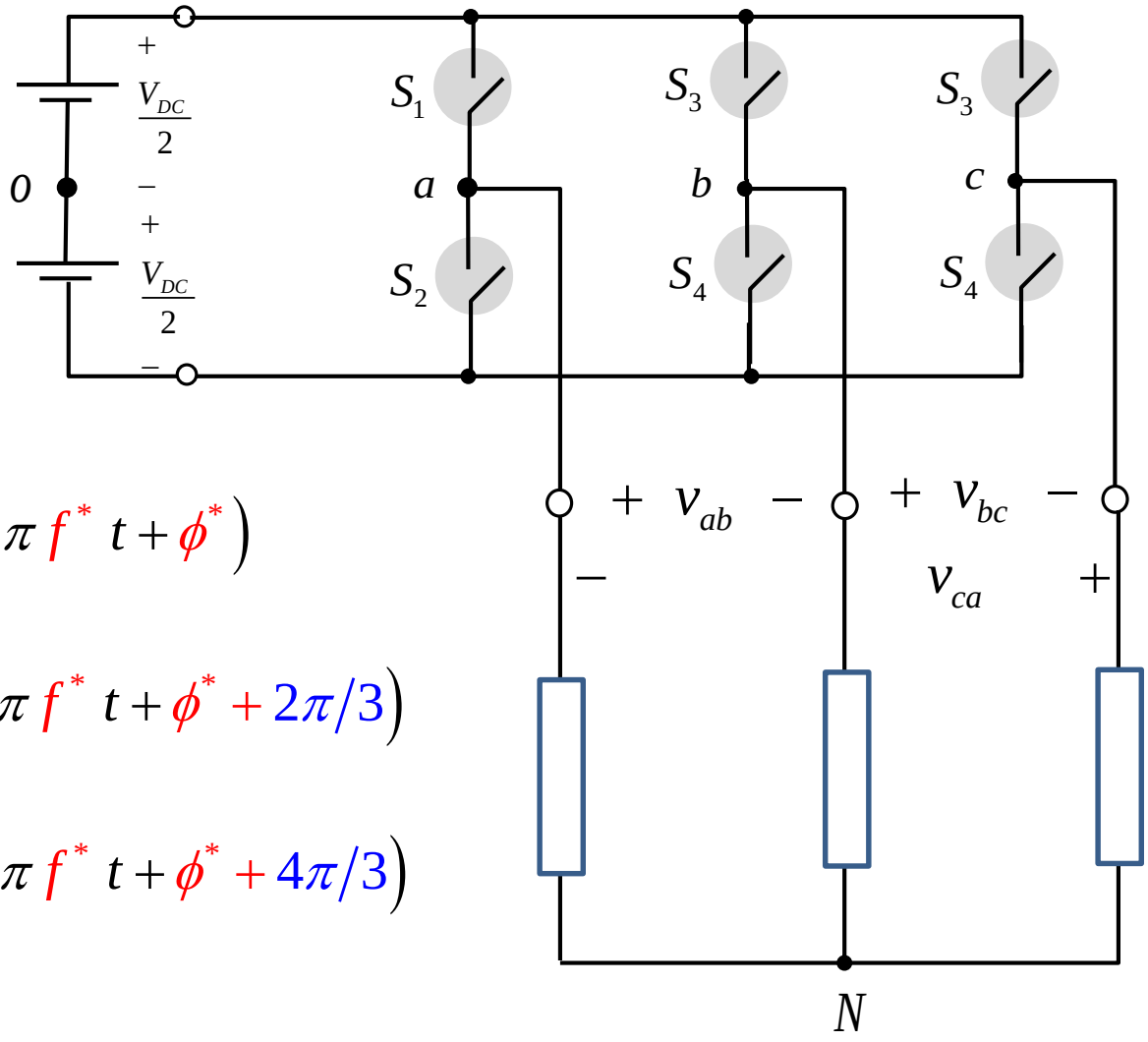
(c)



(d)

- *Unipolar output waveform*

3-Phase Inverter



Assume $v_{No} = 0$

$$v_{ao}^{*}(t) = V_{mp}^{*} \sin\left(2\pi f^{*} t + \phi^{*}\right)$$

$$v_{bo}^{*}(t) = V_{mp}^{*} \sin\left(2\pi f^{*} t + \phi^{*} + 2\pi/3\right)$$

$$v_{co}^{*}(t) = V_{mp}^{*} \sin\left(2\pi f^{*} t + \phi^{*} + 4\pi/3\right)$$

$$V_{mp}^{*} = V_{mL-L}^{*} / \sqrt{3}$$

3-Phase Inverter : Output waveform