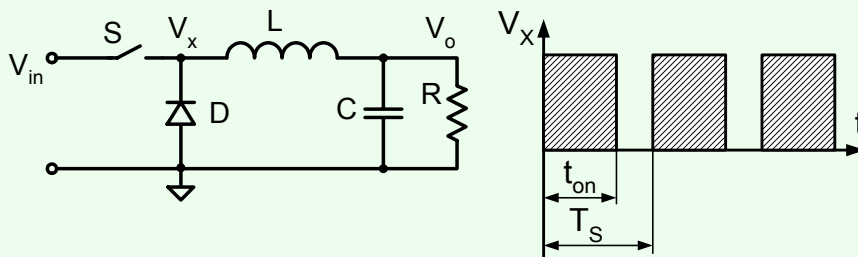


Half Bridge, Full Bridge, Push-Pull, Cuk, SEPIC

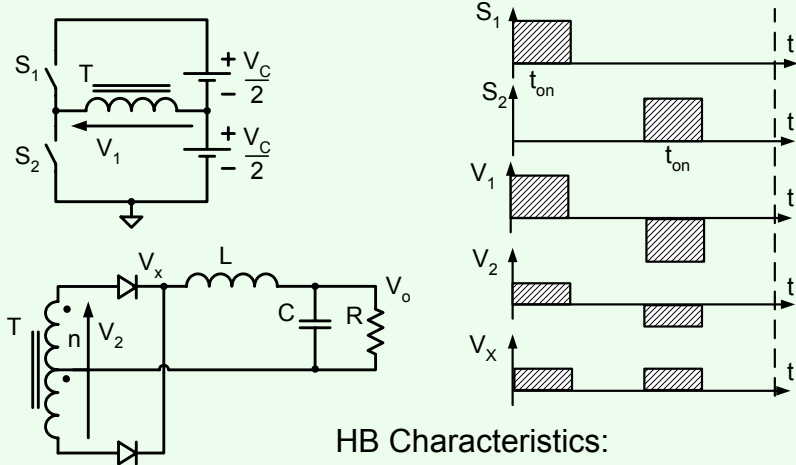
Buck topology



Buck derived topologies

- Forward - one switch
- Half Bridge HB - two switches
- Full Bridge FB - four switches

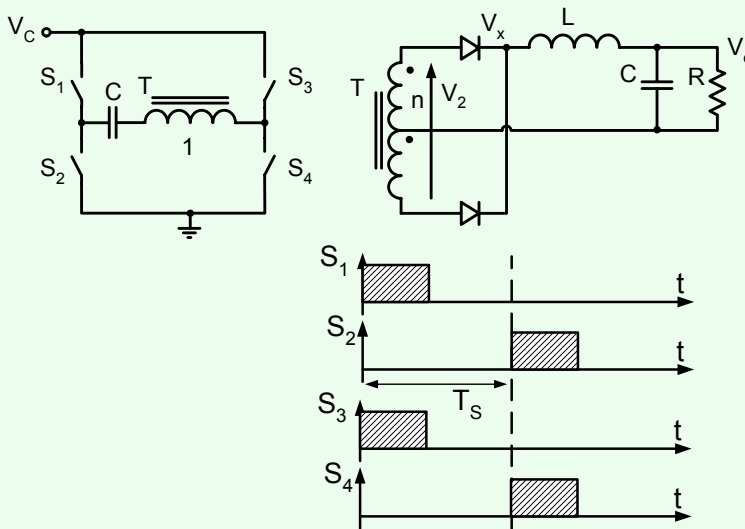
Half Bridge HB



HB Characteristics:

- Frequency at output twice f_s
- Output section: Buck

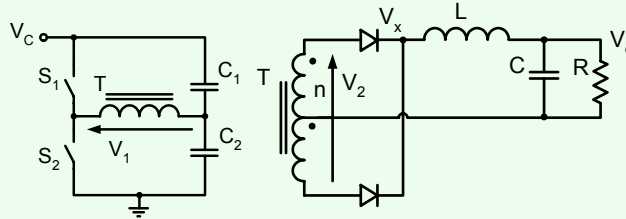
Full Bridge FB



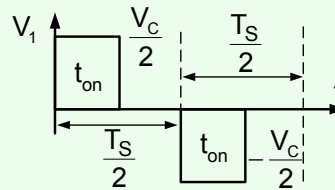
Reset of Forward, HB, FB

- Forward - auxiliary winding
- HB,FB - Natural

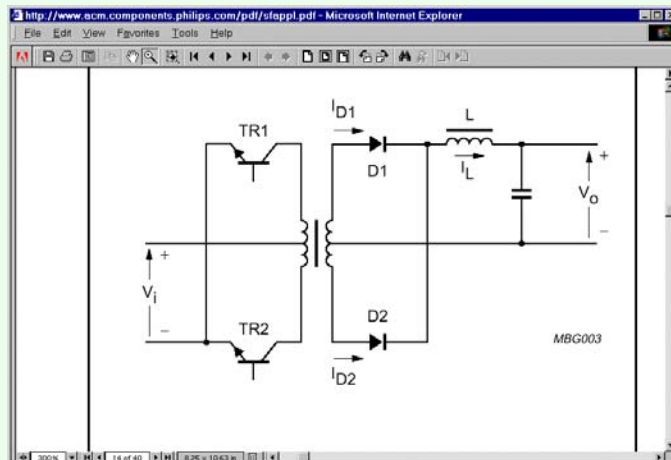
Example HB



- C_1, C_2 capacitor divider



Push-Pull



Forward, HB, FB, PP

I_L ripple for same L

- Forward: ΔI
- HB, FB, PP: $\frac{\Delta I}{2}$

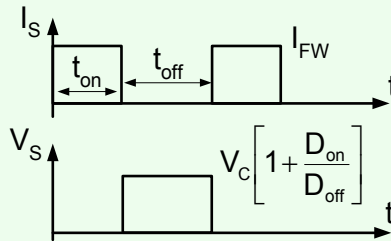
Switch Utilization

Important consideration: $V_s(\text{off}), I_s(\text{on})$

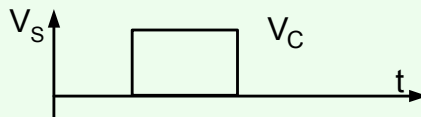
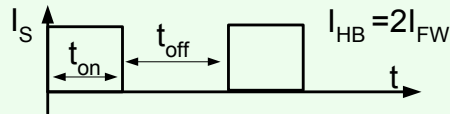
Assumption:

- Same input and output power
- Same input voltage

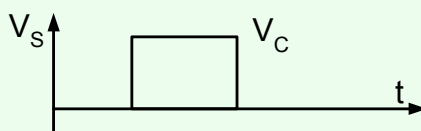
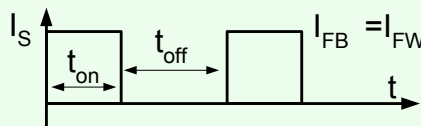
FORWARD



Waveforms



HB



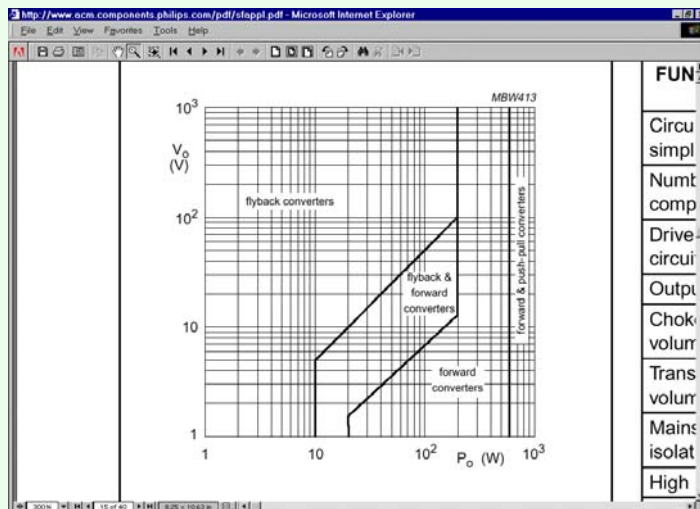
FB

Stresses

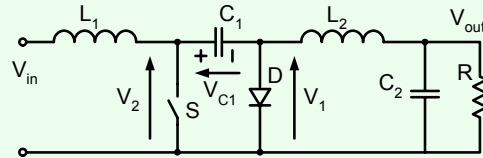
	I_s	V
FW	1	$1 + \frac{D_{on}}{D_{off}}$
HB	2	1
PP	1	2
FB	1	1

- Power conversion capability: FW<HB<FB

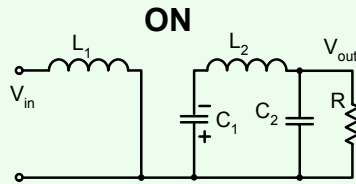
Topology selection



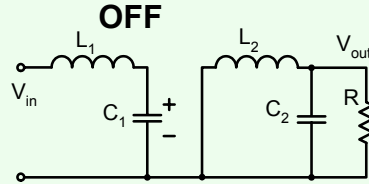
Cuk Converter



- Voltage of $C_1 \approx$ constant



ON



OFF

$$\bar{V}_1 = V_o$$

$$\bar{V}_2 = V_{in}$$

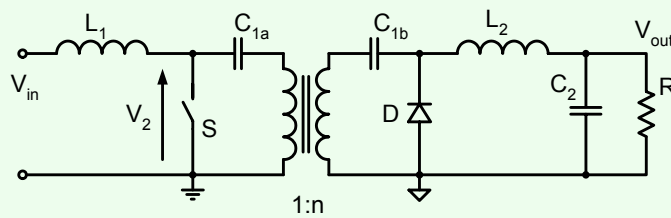
$$\bar{V}_{c1} = V_{in} - V_o$$

$$V_o = -V_{c1} \cdot D_{on} \text{ (buck)}$$

$$V_o = -(V_{in} - V_o) \cdot D_{on}$$

$$\frac{V_o}{V_{in}} = -\frac{D_{on}}{D_{off}}$$

Cuk with isolation



- Any polarity
- Any voltage ratio

$$\frac{V_o}{V_{in}} = \pm \frac{D_{on}}{D_{off}} n$$

Cuk advnatages and disadvantages

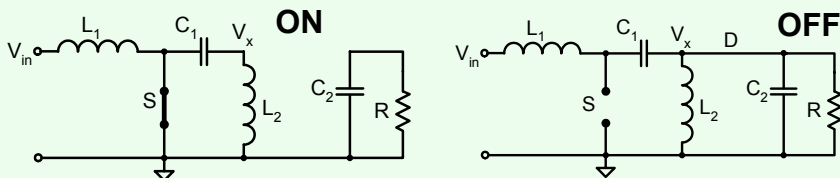
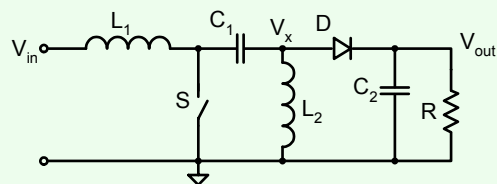
Advantages

- Continuous input and output currents
- Single switch
- Step-up and step-down

Disadvantages

- Two inductors
- Extra capacitor (of high rms current)
- Difficult to stabilize
- High voltage on switch $|V_{in}| + |V_{out}|$

SEPIC Converter



$$\bar{V}_{L1} = 0$$

$$\bar{V}_x = V_o \cdot D_{off} - V_{in} \cdot D_{on} = 0$$

$$\bar{V}_{L2} = 0$$

$$\frac{V_o}{V_{in}} = \frac{D_{on}}{D_{off}}$$

$$\bar{V}_{C1} = V_{in}$$

$$\frac{V_o}{V_{in}} = \frac{D_{on}}{D_{off}}$$

Auxiliary output

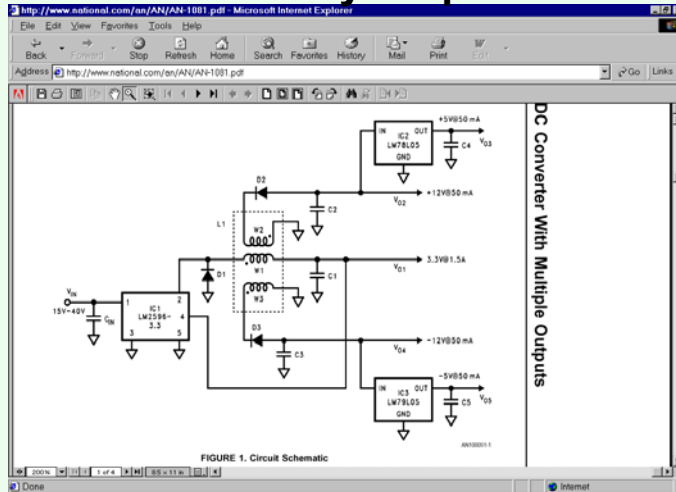


TABLE 1.3 Transistor and Diode Requirements for Switching Converters

CIRCUIT CONFIGURATION	BUCK STEP-DOWN	BUCK-BOOST	BUCK-BUCK*
TYPE OF CONVERTER	BUCK STEP-DOWN	BUCK-BOOST	BUCK-BUCK*
TRANSFORMER FUNCTION	$\frac{V_2}{V_1} = \frac{N_2}{N_1}$	$\frac{V_2}{V_1} = -\frac{N_2}{N_1}$	$\frac{V_2}{V_1} = \frac{N_2}{N_1} \cdot \frac{N_3}{N_2}$
COLLECTOR CURRENT (A)	$I_{Tmax} = I_{Lmax} + \Delta I_{Lmax}/2$	$I_{Tmax} = I_{Lmax} + \Delta I_{Lmax}/2$	$I_{Tmax} = I_{Lmax} + \Delta I_{Lmax}/2$
COLLECTOR VOLTAGE (V)	$V_{Tmax} = V_{in}$	$V_{Tmax} = V_{in} + V_{out}$	$V_{Tmax} = V_{in} + V_{out}$
DIODE CURRENTS (A)	$I_{Dmax} = I_{Lmax} (\frac{1}{\sqrt{2}})$	$I_{Dmax} = I_{Lmax}$	$I_{Dmax} = I_{Lmax}$
DIODE VOLTAGES (V)	$V_{Dmax} = V_{in}$	$V_{Dmax} = V_{in}$	$V_{Dmax} = V_{in} + V_{out}$
VOLTAGE AND CURRENT WAVEFORMS			
ADVANTAGES	NO INDUCTOR ENERGY IS STORED IN THE INDUCTOR. TRANSFORMER IS NECESSARY TO PROVIDE ISOLATION AND STEP-UP TO PROVIDE THE DESIRED GAIN.	INDUCTOR ENERGY IS STORED IN THE INDUCTOR. TRANSFORMER IS NECESSARY TO PROVIDE ISOLATION AND STEP-UP TO PROVIDE THE DESIRED GAIN.	INDUCTOR ENERGY IS STORED IN THE INDUCTOR. TRANSFORMER IS NECESSARY TO PROVIDE ISOLATION AND STEP-UP TO PROVIDE THE DESIRED GAIN.
DISADVANTAGES	NO ISOLATION BETWEEN INPUT AND OUTPUT. INDUCTOR ENERGY IS STORED IN THE INDUCTOR. TRANSFORMER IS NECESSARY TO PROVIDE ISOLATION AND STEP-UP TO PROVIDE THE DESIRED GAIN.	NO ISOLATION BETWEEN INPUT AND OUTPUT. INDUCTOR ENERGY IS STORED IN THE INDUCTOR. TRANSFORMER IS NECESSARY TO PROVIDE ISOLATION AND STEP-UP TO PROVIDE THE DESIRED GAIN.	NO ISOLATION BETWEEN INPUT AND OUTPUT. INDUCTOR ENERGY IS STORED IN THE INDUCTOR. TRANSFORMER IS NECESSARY TO PROVIDE ISOLATION AND STEP-UP TO PROVIDE THE DESIRED GAIN.

TABLE 1.3 (Continued)

CIRCUIT CONFIGURATION	BUCK-BOOST	BUCK-BUCK*
TYPE OF CONVERTER	BUCK-BOOST	BUCK-BUCK*
TRANSFORMER FUNCTION	$\frac{V_2}{V_1} = -\frac{N_2}{N_1}$	$\frac{V_2}{V_1} = \frac{N_2}{N_1} \cdot \frac{N_3}{N_2}$
COLLECTOR CURRENT (A)	$I_{Tmax} = I_{Lmax} + \Delta I_{Lmax}/2$	$I_{Tmax} = I_{Lmax} + \Delta I_{Lmax}/2$
COLLECTOR VOLTAGE (V)	$V_{Tmax} = V_{in} + V_{out}$	$V_{Tmax} = V_{in} + V_{out}$
DIODE CURRENTS (A)	$I_{Dmax} = I_{Lmax}$	$I_{Dmax} = I_{Lmax}$
DIODE VOLTAGES (V)	$V_{Dmax} = V_{in}$	$V_{Dmax} = V_{in} + V_{out}$
VOLTAGE AND CURRENT WAVEFORMS		
ADVANTAGES	INDUCTOR ENERGY IS STORED IN THE INDUCTOR. TRANSFORMER IS NECESSARY TO PROVIDE ISOLATION AND STEP-UP TO PROVIDE THE DESIRED GAIN.	INDUCTOR ENERGY IS STORED IN THE INDUCTOR. TRANSFORMER IS NECESSARY TO PROVIDE ISOLATION AND STEP-UP TO PROVIDE THE DESIRED GAIN.
DISADVANTAGES	NO ISOLATION BETWEEN INPUT AND OUTPUT. INDUCTOR ENERGY IS STORED IN THE INDUCTOR. TRANSFORMER IS NECESSARY TO PROVIDE ISOLATION AND STEP-UP TO PROVIDE THE DESIRED GAIN.	NO ISOLATION BETWEEN INPUT AND OUTPUT. INDUCTOR ENERGY IS STORED IN THE INDUCTOR. TRANSFORMER IS NECESSARY TO PROVIDE ISOLATION AND STEP-UP TO PROVIDE THE DESIRED GAIN.

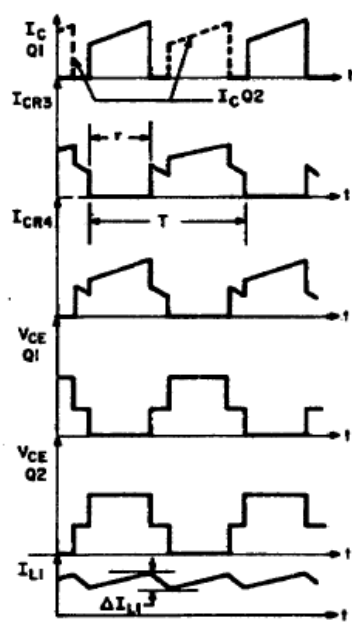
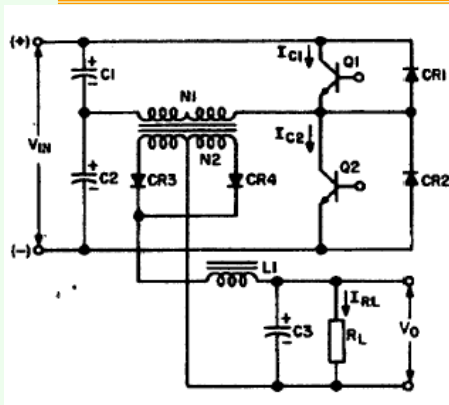
TABLE 1.3 (Continued)

TYPE OF CONVERTER ① Half-bridge ② Full-bridge	
DC LINK FUNCTION	① $\frac{1}{2} V_m$ (1) ② V_m (2)
COLLECTOR CURRENT (%)	① $I_{cmax} = \frac{1}{2} (I_m + I_{Lmax}) + I_{Lmax}$ ② $I_{cmax} = \frac{1}{2} (I_m + I_{Lmax}) + I_{Lmax}$
DIODE CURRENT (%)	① $I_{Dmax} = I_{Lmax}$ ② $I_{Dmax} = I_{Lmax}$
DIODE VOLTAGES (%)	① $V_{Dmax} = \frac{1}{2} V_m$ ② $V_{Dmax} = \frac{1}{2} V_m$
VOLTAGE AND CURRENT WAVEFORMS	
REMARKS	① HALF-BRIDGE INVERTERS REQUIRE FREQUENCY-SENSITIVE CURRENT LIMITING DEVICES IN THE FORM OF A DIODE OR A DIODE WITH AN INDUCTIVE LOAD. ② FULL-BRIDGE INVERTERS REQUIRE FREQUENCY-SENSITIVE CURRENT LIMITING DEVICES IN THE FORM OF A DIODE OR A DIODE WITH AN INDUCTIVE LOAD.
DESIGNATION	① HALF-BRIDGE INVERTER ② FULL-BRIDGE INVERTER

TABLE 1.3 (Continued)

TYPE OF CONVERTER ① Half-bridge ② Full-bridge			
DC LINK FUNCTION	① $\frac{1}{2} V_m$ (1) ② V_m (2)	③ V_m (3)	
COLLECTOR CURRENT (%)	$I_{cmax} = \frac{1}{2} (I_m + I_{Lmax}) + I_{Lmax}$	$I_{cmax} = \frac{1}{2} (I_m + I_{Lmax}) + I_{Lmax}$	③ $I_{cmax} = \frac{1}{2} (I_m + I_{Lmax}) + I_{Lmax}$
DIODE CURRENT (%)	$I_{Dmax} = I_{Lmax}$	$I_{Dmax} = I_{Lmax}$	③ $I_{Dmax} = I_{Lmax}$
DIODE VOLTAGES (%)	$V_{Dmax} = \frac{1}{2} V_m$	$V_{Dmax} = \frac{1}{2} V_m$	③ $V_{Dmax} = \frac{1}{2} V_m$
VOLTAGE AND CURRENT WAVEFORMS			
REMARKS	① HALF-BRIDGE INVERTERS REQUIRE FREQUENCY-SENSITIVE CURRENT LIMITING DEVICES IN THE FORM OF A DIODE OR A DIODE WITH AN INDUCTIVE LOAD. ② FULL-BRIDGE INVERTERS REQUIRE FREQUENCY-SENSITIVE CURRENT LIMITING DEVICES IN THE FORM OF A DIODE OR A DIODE WITH AN INDUCTIVE LOAD.	③ HALF-BRIDGE INVERTERS REQUIRE FREQUENCY-SENSITIVE CURRENT LIMITING DEVICES IN THE FORM OF A DIODE OR A DIODE WITH AN INDUCTIVE LOAD. ④ FULL-BRIDGE INVERTERS REQUIRE FREQUENCY-SENSITIVE CURRENT LIMITING DEVICES IN THE FORM OF A DIODE OR A DIODE WITH AN INDUCTIVE LOAD.	
DESIGNATION	① HALF-BRIDGE INVERTER ② FULL-BRIDGE INVERTER	③ HALF-BRIDGE INVERTER ④ FULL-BRIDGE INVERTER	

*For reliable operation, it is suggested and recommended that all voltage and current ratings be increased to 125% of the required maximum.



VOLTAGE REGULATION MODULE (VRM)

- Synchronous rectifier

