

Mor M. Peretz, Switch-Mode Power Supplies [6-1]

### Advanced topologies

Half-bridge, Full-bridge, Push-Pull, C'uk, SEPIC

- C'uk
- Sepic
- Half-bridge
  - Symmetrical operation
    - Double power supply
    - Principle of operation , definition of D
    - Using bus capacitors – capacitive voltage division?
    - The concept of split bus capacitor
    - Component stress
  - Asymmetrical operation
- Full-bridge
  - Operation
  - Stress
- Reset
- Push-pull

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-2]

### Types of PWM converters

C'uk and SEPIC

**C'uk**

$$\frac{V_o}{V_{in}} = -\frac{D}{1-D}$$

**SEPIC**

$$\frac{V_o}{V_{in}} = \frac{D}{1-D}$$

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-3]

### C'uk Converter

Voltage of  $C_1 \approx$  constant

**ON**

**OFF**

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

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

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

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

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

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

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-4]

### C'uk with isolation

- Any polarity
- Any voltage ratio

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


---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-5]

### C'uk Converter Inductors on the same core

Can be done only if the voltage on the windings are equal

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-6]

### C'uk advnatages and disadvantages

#### Advantages

- Continues 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  $|V_{in}| + |V_{out}|$

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-7]

### SEPIC Converter

**ON** **OFF**

$$\bar{V}_{L1} = 0 \quad \bar{V}_x = V_o \cdot D_{off} - V_{in} \cdot D_{on} = 0$$

$$\bar{V}_{L2} = 0 \quad \frac{V_o}{V_{in}} = \frac{D_{on}}{D_{off}}$$

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


---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-8]

### Half-bridge

HB, symmetrical operation

$$\frac{V_o}{V_{in}} = \frac{n1}{n2} D$$

$$D = \frac{t_{on}}{T_s/2}$$


---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-9]

### Half-bridge

What is the transformer voltage at off time

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-10]

### Types of PWM converters

#### HB –Capacitors to replace supplies

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-11]

### Types of PWM converters

#### HB -Concept of split bus capacitors

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-12]

### Types of PWM converters

#### Asymmetrical operation – synchronous rectifier

Motivation to asymmetrical operation: Spikes and oscillations at the mid point an off time

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-13]

### Full-bridge

$$\frac{V_o}{V_{in}} = 2 \frac{n1}{n2} D$$


---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-14]

### Push-pull

$$\frac{V_o}{V_{in}} = 2 \frac{n1}{n2} D$$


---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-15]

### Reset of Forward, HB, FB

- Forward - auxiliary winding
- HB,FB - Natural

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-16]

### Forward, HB, FB, PP

$I_L$  ripple for same L

- Forward:  $\Delta I$
- 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**

---

---

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-17]

### Waveforms

**HB**

**FB**

---

---

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-18]

### Types of PWM converters Comparison chart

Converter	Sw current	Sw voltage
Buck	$I_o$	$V_{in}$
Boost	$I_o(D_{on}/D_{off})$	$V_o$
Buck-Boost	$I_o(D_{on}/D_{off})$	$V_{in}+V_o$
C'uk	$I_{in}+I_o$	$V_{in}+V_o$
SEPIC	$I_{in}+I_o$	$V_{in}+V_o$
Forward	$I_o \cdot (n_2/n_1)$	$V_{in}+V_{rst}$
Flyback	$I_o \cdot (n_2/n_1)(D_{on}/D_{off})$	$V_{in}+V_o \cdot (n_1/n_2)$
HB	$2I_o \cdot (n_2/n_1)$	$V_{in}$
FB	$I_o \cdot (n_2/n_1)$	$V_{in}/2$
PP	$I_o \cdot (n_2/n_1)$	$2V_{in}$

---

---

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-19]

Chapter 1

TABLE 1.3 Transistor and Diode Requirements for Switching Converters

Converter	Transistor	Diode
Buck	$V_{CE} = V_{in}$ $I_C = I_{out}$	$V_{D} = V_{in}$ $I_D = I_{out}$
Buck-Boost	$V_{CE} = V_{in} + V_{out}$ $I_C = I_{out}$	$V_{D} = V_{in}$ $I_D = I_{out}$
Boost	$V_{CE} = V_{in} + V_{out}$ $I_C = I_{in}$	$V_{D} = V_{in}$ $I_D = I_{out}$
Full-Bridge	$V_{CE} = V_{in}$ $I_C = I_{out}$	$V_{D} = V_{in}$ $I_D = I_{out}$

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-20]

TABLE 1.3 (Continued)

Converter	Transistor	Diode
Push-Pull	$V_{CE} = V_{in}$ $I_C = I_{out}$	$V_{D} = V_{in}$ $I_D = I_{out}$
Half-Bridge	$V_{CE} = V_{in}$ $I_C = I_{out}$	$V_{D} = V_{in}$ $I_D = I_{out}$

\*For reliable operation, it is suggested and recommended that all voltage and current ratings be increased to 150% of the required maximum.

---

---

---

---

---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-21]

---

---

---

---

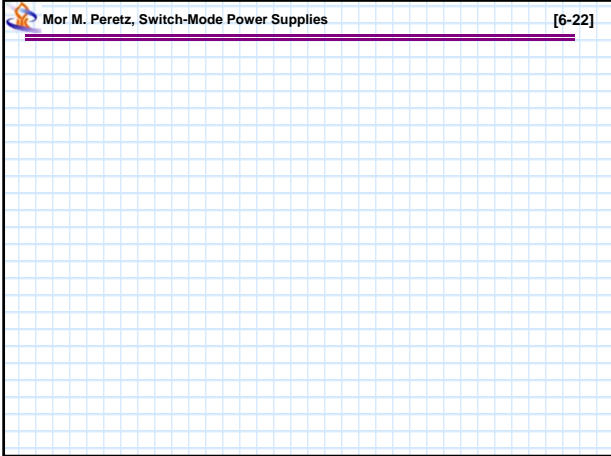
---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [6-22]



---

---

---

---

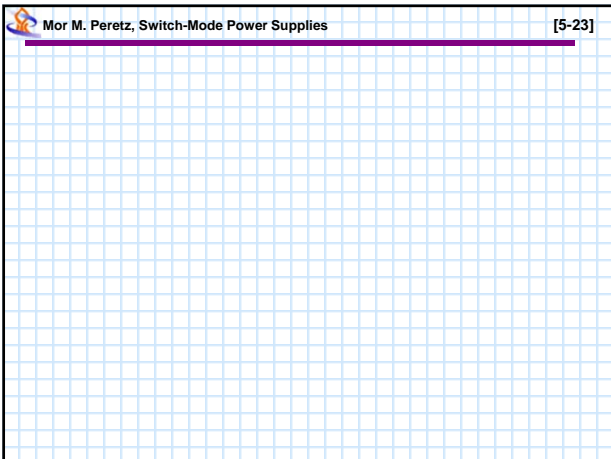
---

---

---

---

Mor M. Peretz, Switch-Mode Power Supplies [5-23]



---

---

---

---

---

---

---

---