Chapter 11

Power Conditioners and Uninterruptible Power Supplies

- Becoming more of a concern as utility de-regulation proceeds

Distortion in the Input Voltage

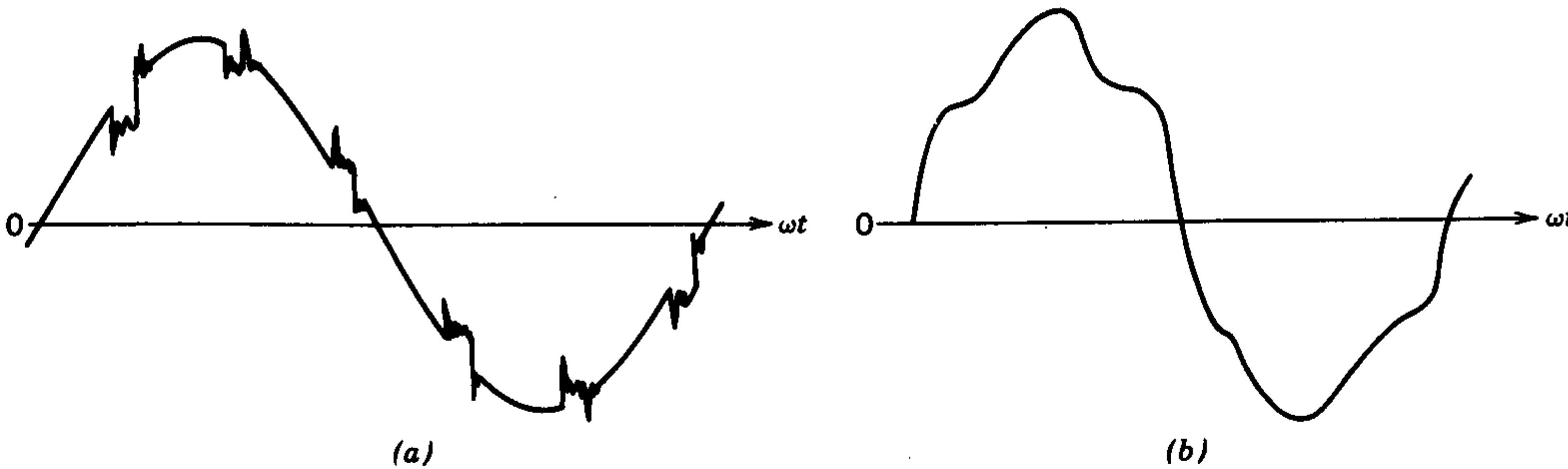

Figure 11-1 Possible distortions in input voltage: *(a)* chopped voltage waveform; *(b)* distorted voltage waveform due to harmonics.

- The voltage supplied by the utility may not be sinusoidal

Typical Voltage Tolerance Envelope for Computer Systems

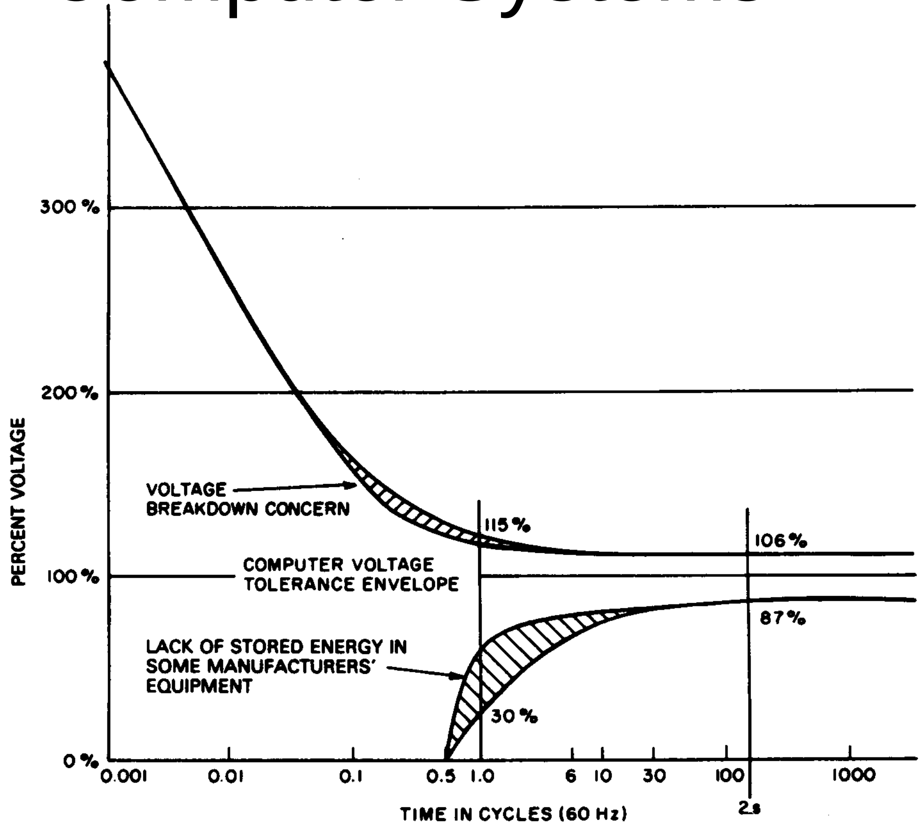

Figure 11-2 Typical computer system voltage tolerance envelope. (*Source:* IEEE Std. 446, "Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications.")

- This has been superceded by a more recent standard

Typical Range of Input Power Quality

Table 11-1 Typical Range of Input Power Quality and Load Parameters of Major Computer Manufacturers

Parameters[a]	*Range or Maximum*
1. Voltage regulation, steady state	+5, −10 to +10%, −15% (ANSI C84.1—1970 is +6, −13%)
2. Voltage disturbances	
a. Momentary undervoltage	−25 to −30% for less than 0.5 s, with −100% acceptable for 4–20 ms
b. Transient overvoltage	+150 to 200% for less than 0.2 ms
3. Voltage harmonic distortion[b]	3–5% (with linear load)
4. Noise	No standard
5. Frequency variation	60 Hz ± 0.5 Hz to ±1 Hz
6. Frequency rate of change	1 Hz/s (slew rate)
7. 3ϕ, Phase voltage unbalance[c]	2.5–5%
8. 3ϕ, Load unbalance[d]	5–20% maximum for any one phase
9. Power factor	0.8–0.9
10. Load demand	0.75–0.85 (of connected load)

[a]Parameters 1, 2, 5, and 6 depend on the power source, while parameters 3, 4, and 7 are the product of an interaction of source and load, and parameters 8, 9, and 10 depend on the computer load alone.

[b]Computed as the sum of all harmonic voltages added vectorially.

[c]Computed as follows:

$$\textit{Percent}\text{ phase voltage unbalance} = \frac{3(V_{max} - V_{min})}{V_a + V_b + V_c} \times 100$$

[d]Computed as difference from average single-phase load.

Source: IEEE Std. 446, "Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications."

Electronic Tap Changers

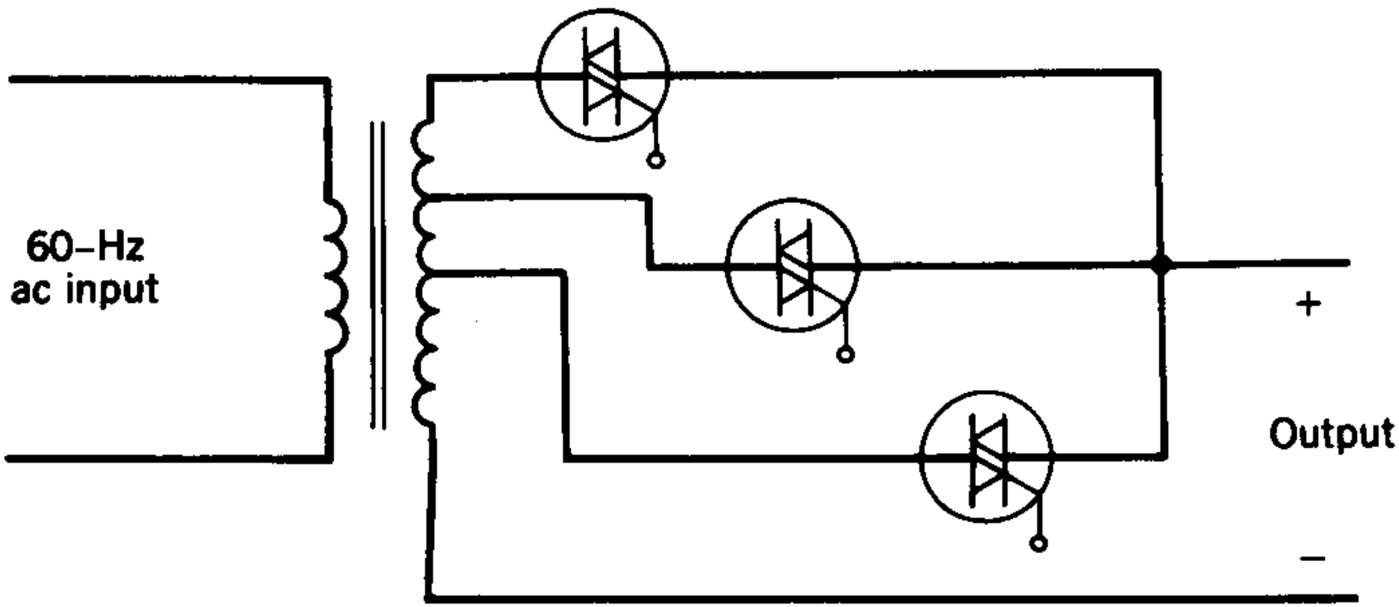

Figure 11-3 Electronic tap changer.

- Controls voltage magnitude by connecting the output to the appropriate transformer tap

Uninterruptible Power Supplies (UPS)

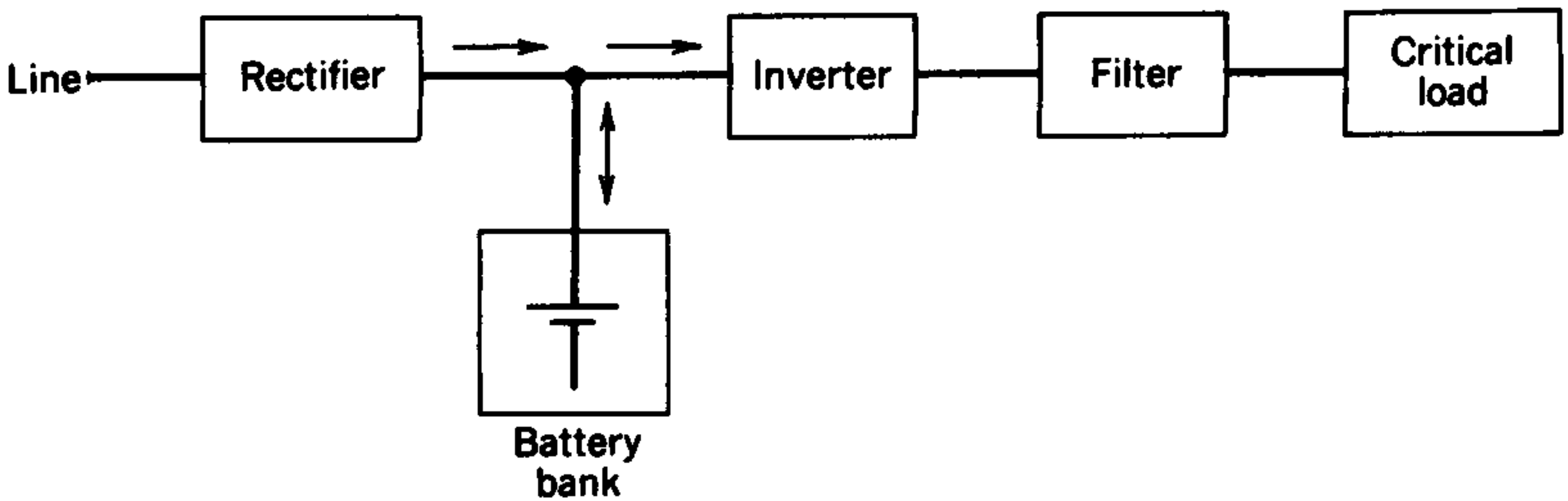

Figure 11-4 A UPS block diagram.

- Block diagram; energy storage is shown to be in batteries but other means are being investigated

UPS: Possible Rectifier Arrangements

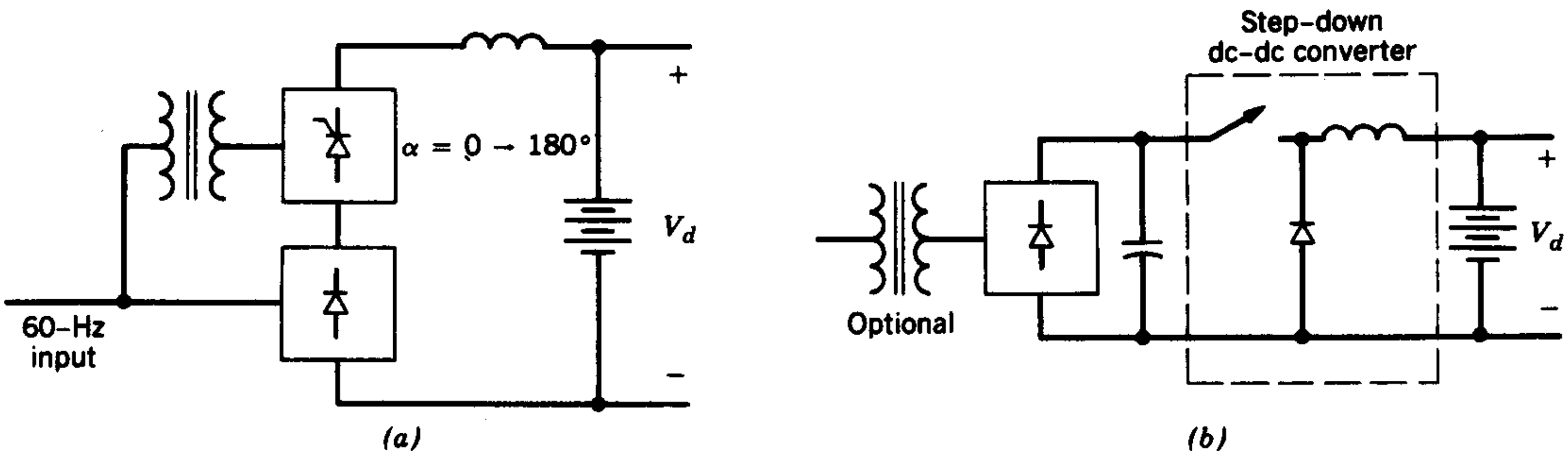

Figure 11-5 Possible rectifier arrangements.

- The input normally supplies power to the load as well as charges the battery bank

UPS: Another Possible Rectifier Arrangement

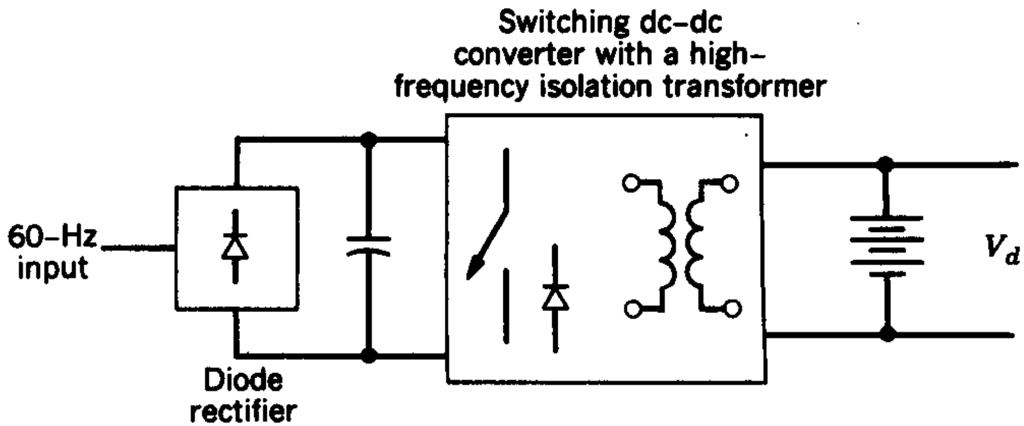

Figure 11-6 Rectifier consisting of a high-frequency isolation transformer.

- Consists of a high-frequency isolation transformer

UPS: Another Possible Input Arrangement

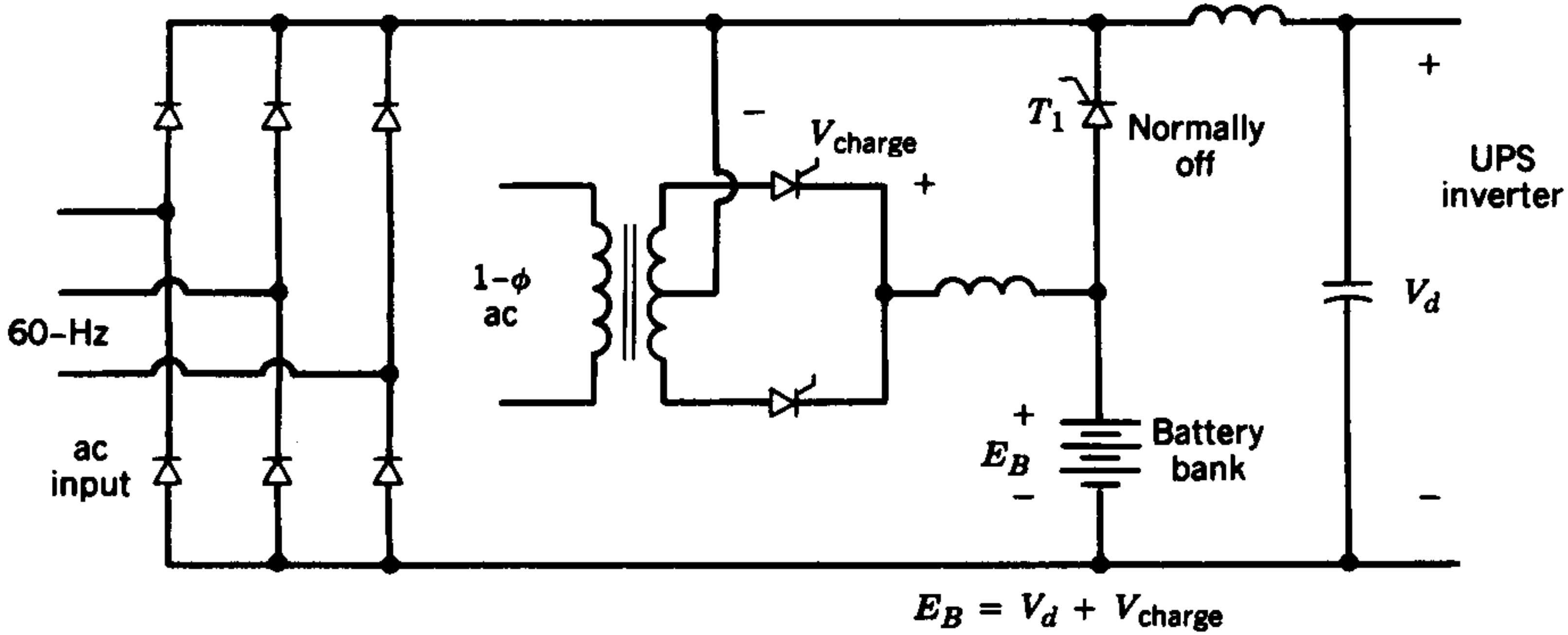

Figure 11-7 A rectifier with a separate battery charger circuit.

- A separate small battery charger circuit

Battery Charging Waveforms as Function of Time

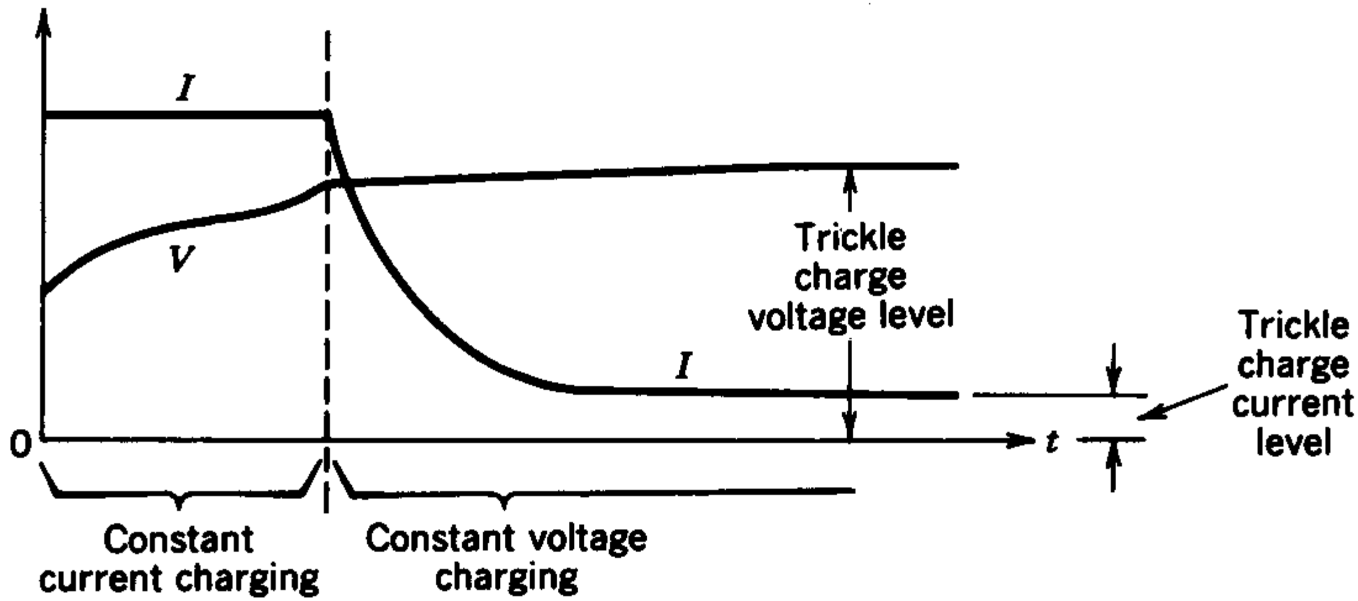

Figure 11-8 Charging of a battery after a line outage causes battery discharge.

- Initially, a discharged battery is charged with a constant current

UPS: Various Inverter Arrangements

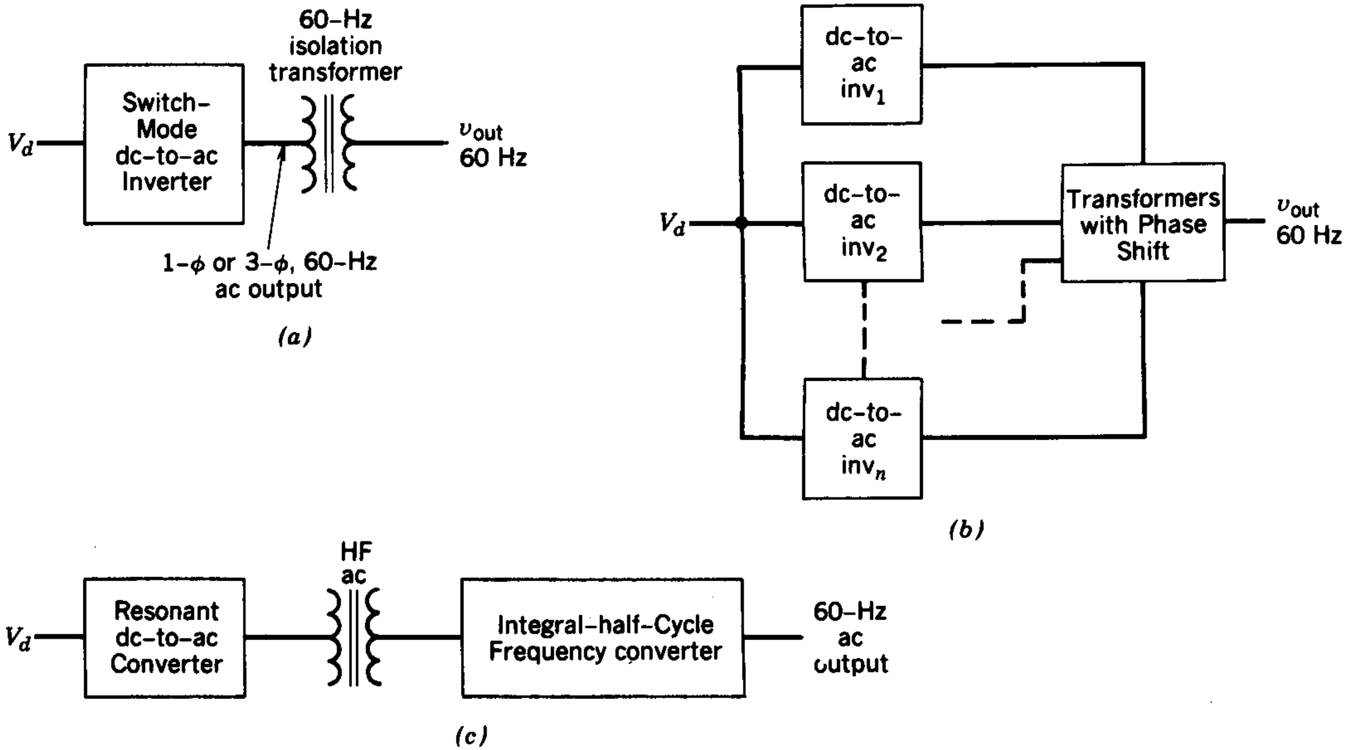

Figure 11-9 Various inverter arrangements.

- Depends on applications, power ratings

UPS: Control

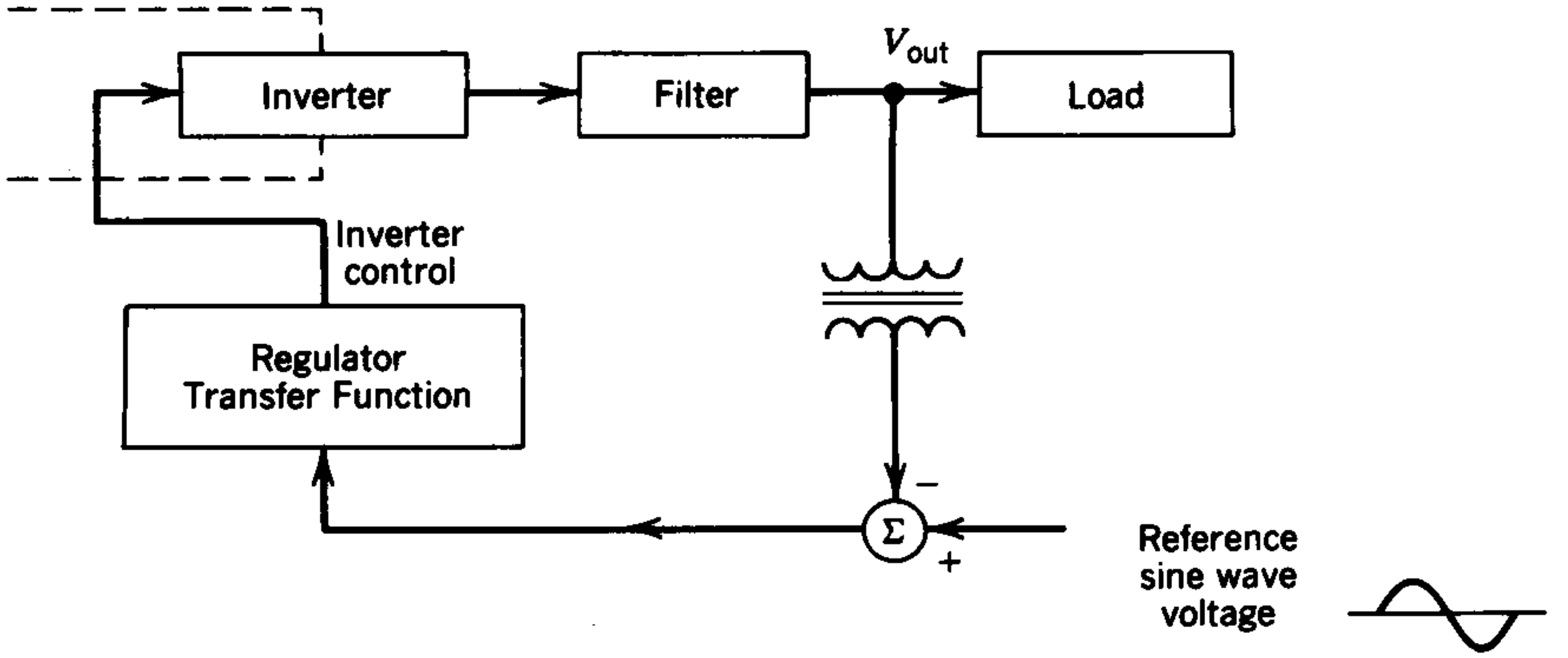

Figure 11-10 Uninterruptible power supply control.

- Typically the load is highly nonlinear and the voltage output of the UPS must be as close to the desired sinusoidal reference as possible

UPS Supplying Several Loads

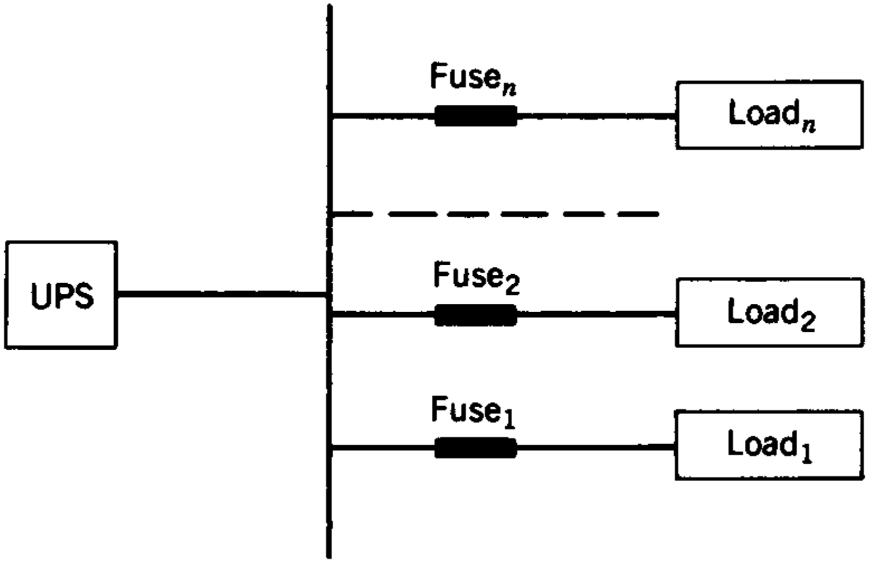

Figure 11-11 A UPS supplying several loads.

- With higher power UPS supplying several loads, malfunction within one load should not disturb the other loads

Another Possible UPS Arrangement

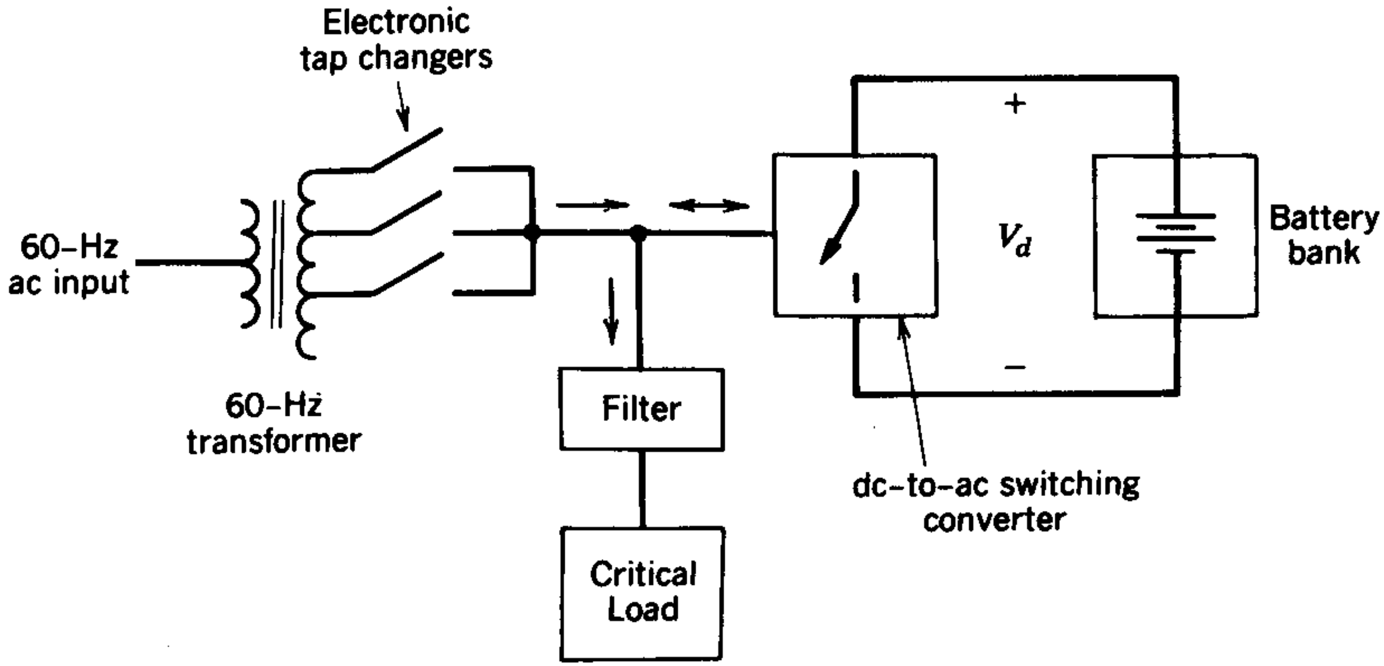

Figure 11-12 A UPS arrangement where the functions of battery charging and inverter are combined.

- Functions of battery charging and the inverter are combined

UPS: Using the Line Voltage as Backup

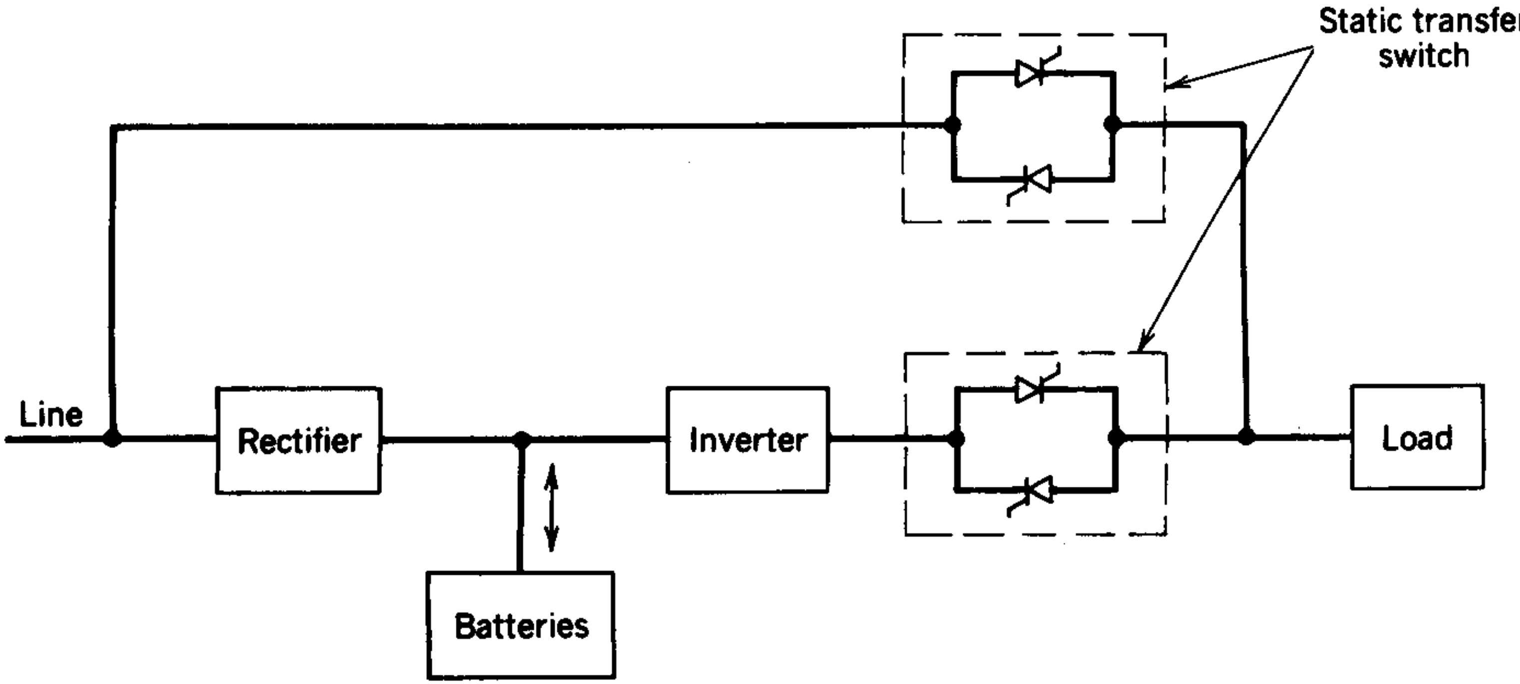

Figure 11-13 Line as backup.

- Needs static transfer switches