

Chapter 18

Utility Interface

Chapter 18 Optimizing the Utility Interface with Power Electronic Systems

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- Power quality has become an important issue

Various Loads Supplied by the Utility Source

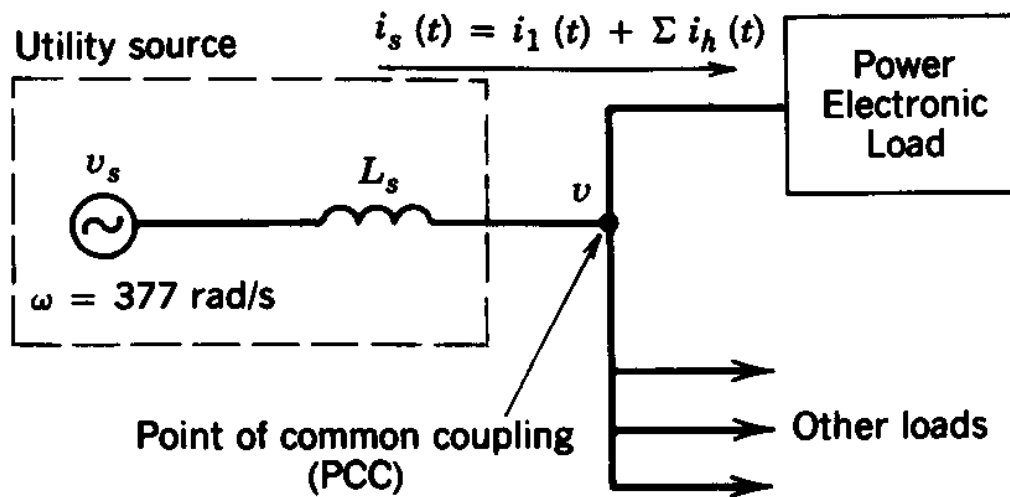


Figure 18-1 Utility interface.

- PCC is the point of common coupling

Diode-Rectifier Bridge

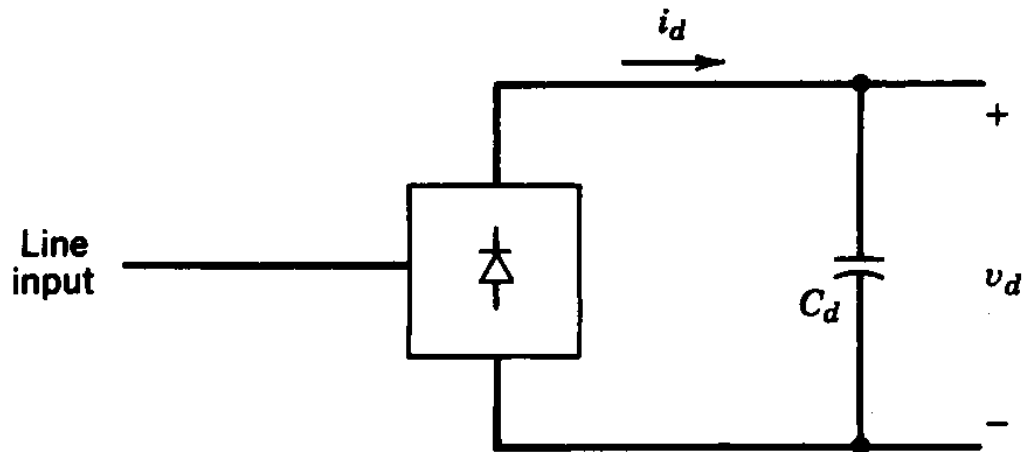


Figure 18-2 Diode rectifier bridge.

- Bock diagram

Typical Harmonics in the Input Current

Table 18-1 Typical Harmonics in a Single-Phase Input Current Waveform with No Line Filtering

<i>h</i>	3	5	7	9	11	13	15	17
$\left(\frac{I_h}{I_1}\right)\%$	73.2	36.6	8.1	5.7	4.1	2.9	0.8	0.4

- Single-phase diode-rectifier bridge

Harmonic Guidelines: IEEE 519

Table 18-2 Harmonic Current Distortion (I_h/I_1)

I_{sc}/I_1	Odd Harmonic Order h (%)					Total Harmonic Distortion (%)
	$h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h$	
<20	4.0	2.0	1.5	0.6	0.3	5.0
20–50	7.0	3.5	2.5	1.0	0.5	8.0
50–100	10.0	4.5	4.0	1.5	0.7	12.0
100–1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

Note: Harmonic current limits for nonlinear load connected to a public utility at the point of common coupling (PCC) with other loads at voltages of 2.4–69 kV. I_{sc} is the maximum short-circuit current at PCC. I_1 is the maximum fundamental-frequency load current at PCC. Even harmonics are limited to 25% of the odd harmonic limits above.

Source: Reference 1.

- commonly used for specifying limits on the input current distortion

Harmonic Guidelines: IEEE 519

Table 18-3 Harmonic Voltage Limits (V_h/V_1) (%) for Power Producers (Public Utilities or Cogenerators)

	<i>2.3–69 kV</i>	<i>69–138 kV</i>	<i>> 138 KV</i>
Maximum for individual harmonic	3.0	1.5	1.0
Total harmonic distortion	5.0	2.5	1.5

Note: This table lists the quality of the voltage that the power producer is required to furnish a user. It is based on the voltage level at which the user is supplied.

Source: Reference 1.

- Limits on distortion in the input voltage supplied by the utility

Reducing the Input Current Distortion

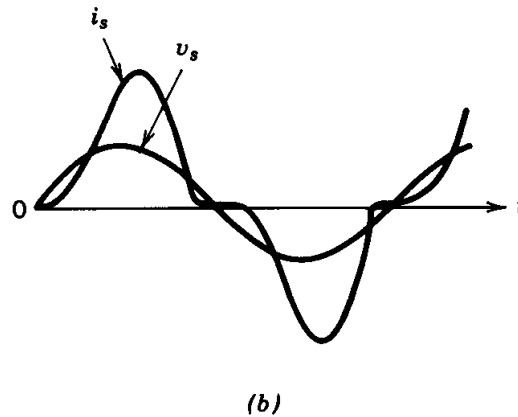
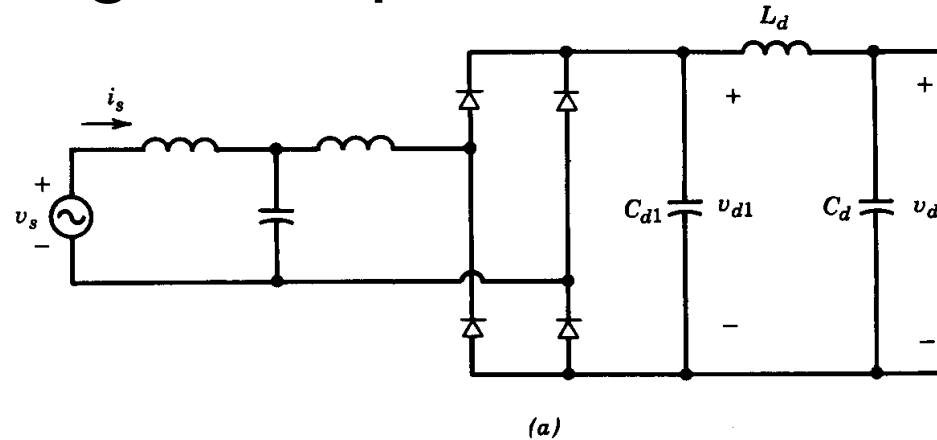


Figure 18-3 Passive filters to improve i_s waveform: (a) passive filter arrangement; (b) current waveform.

- use of passive filters

Power-Factor-Correction (PFC) Circuit

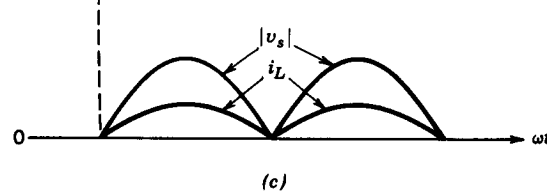
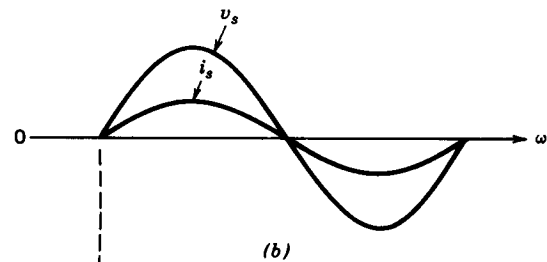
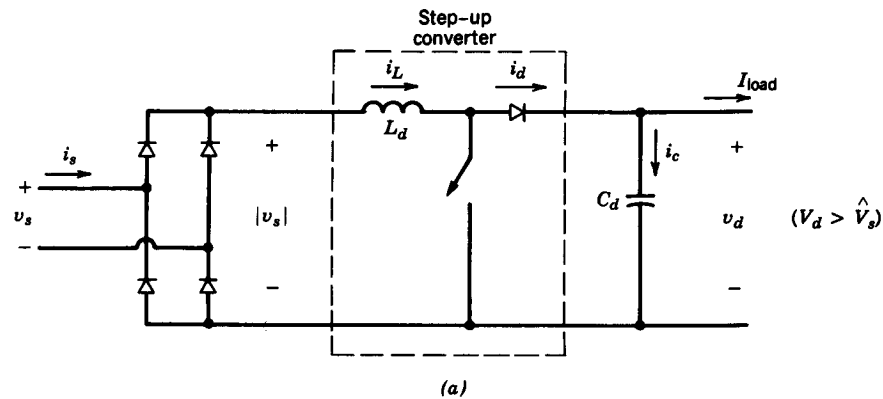


Figure 18-4 Active harmonic filtering: (a) step-up converter for current shaping; (b) line waveforms; (c) v_s and i_L .

- For meeting the harmonic guidelines

Power-Factor-Correction (PFC) Circuit Control

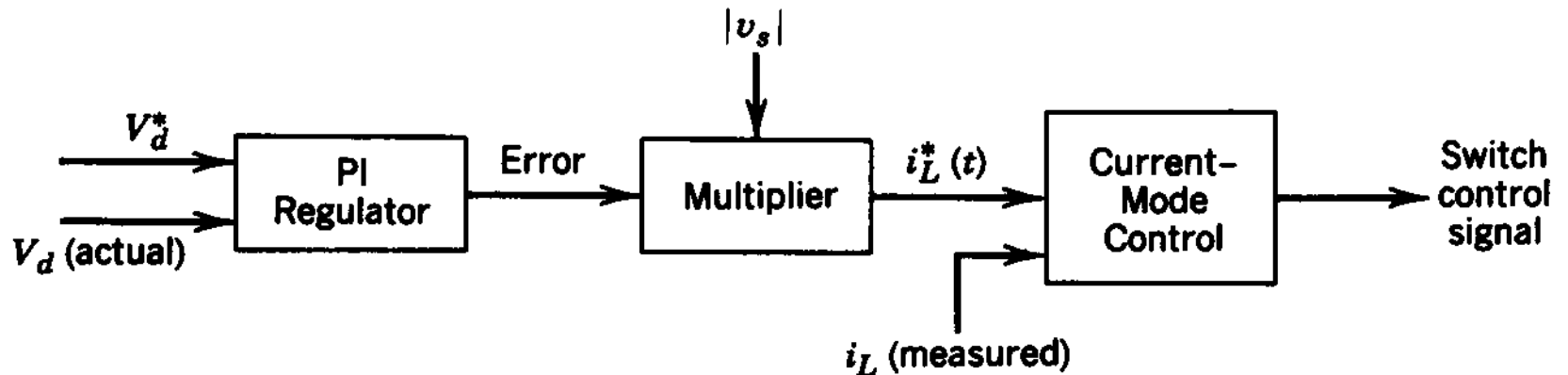


Figure 18-5 Control block diagram.

- generating the switch on/off signals

Power-Factor-Correction (PFC) Circuit

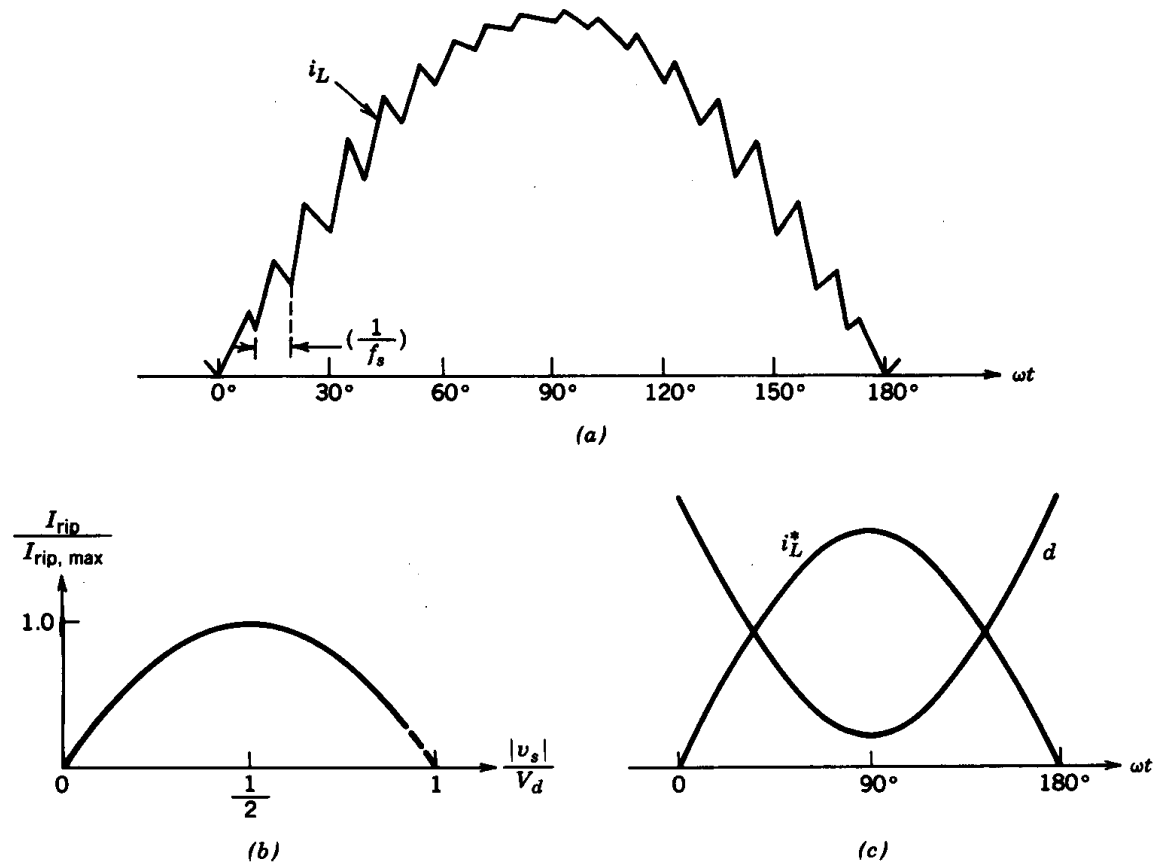


Figure 18-6 Constant-frequency control.

- Operation during each half-cycle

Thyristor Converters for 4-Quadrant Operation

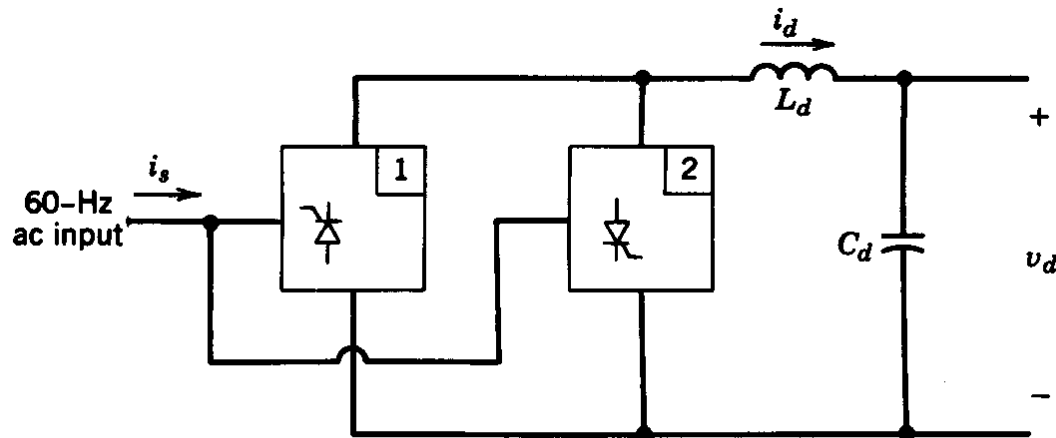


Figure 18-7 Back-to-back connected converters for bidirectional power flow.

- Two back-to-back connected 2-quadrant converters

Switch-Mode Converter Interface

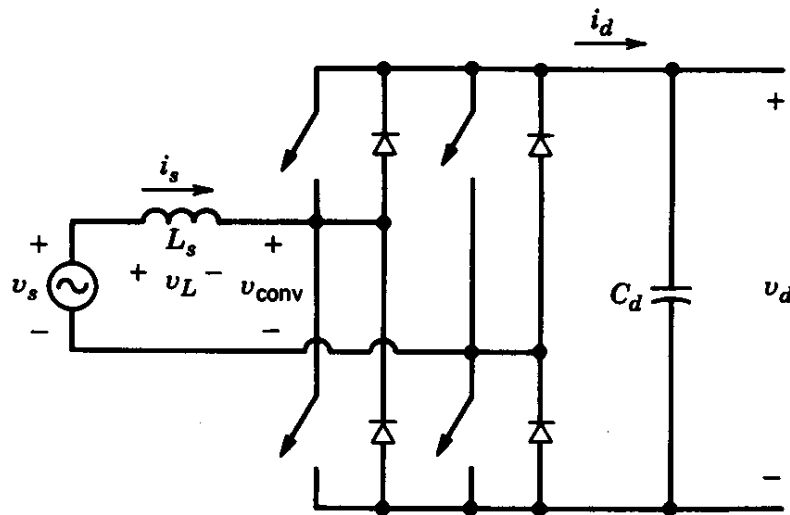


Figure 18-8 Switch-mode converter for the utility interface.

- Bi-directional power flow; unity PF is possible

Switch-Mode Converter Interface

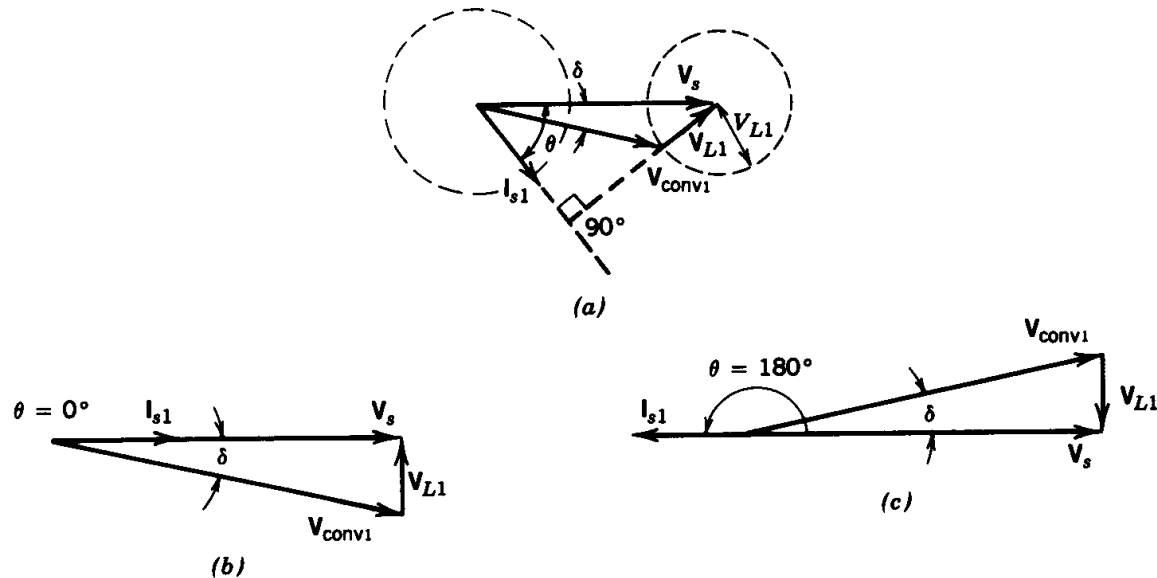


Figure 18-9 Rectification and inversion: (a) general phasor diagram; (b) rectification at unity power factor; (c) inversion at unity power factor.

- Rectifier and Inverter modes based on the direction of power flow

Switch-Mode Converter Control

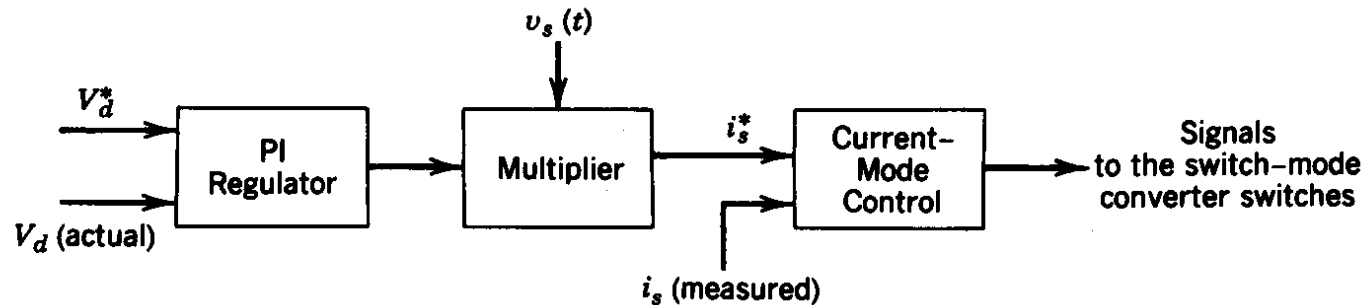


Figure 18-10 Control of the switch-mode interface.

- DC bus voltage is maintained at the reference value

Switch-Mode Converter Interface

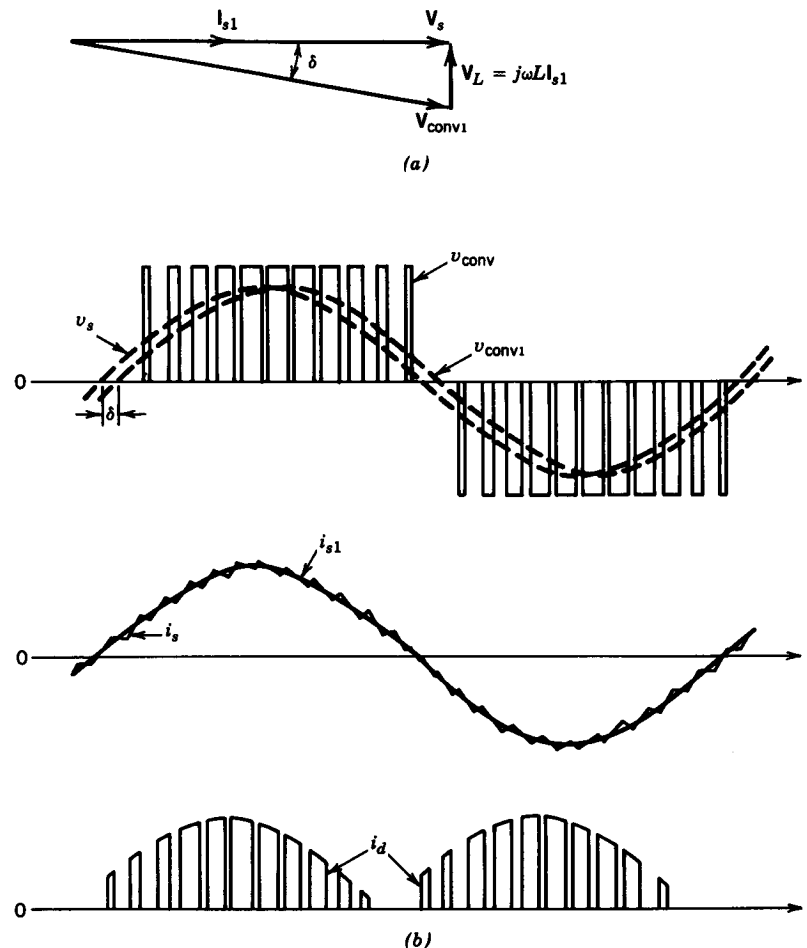


Figure 18-11 Waveforms in the circuit of Fig. 18-8 at unity power factor of operation: (a) phasor diagram; (b) circuit waveforms.

- Waveforms in the rectifier mode

3-Phase Switch-Mode Converter Interface

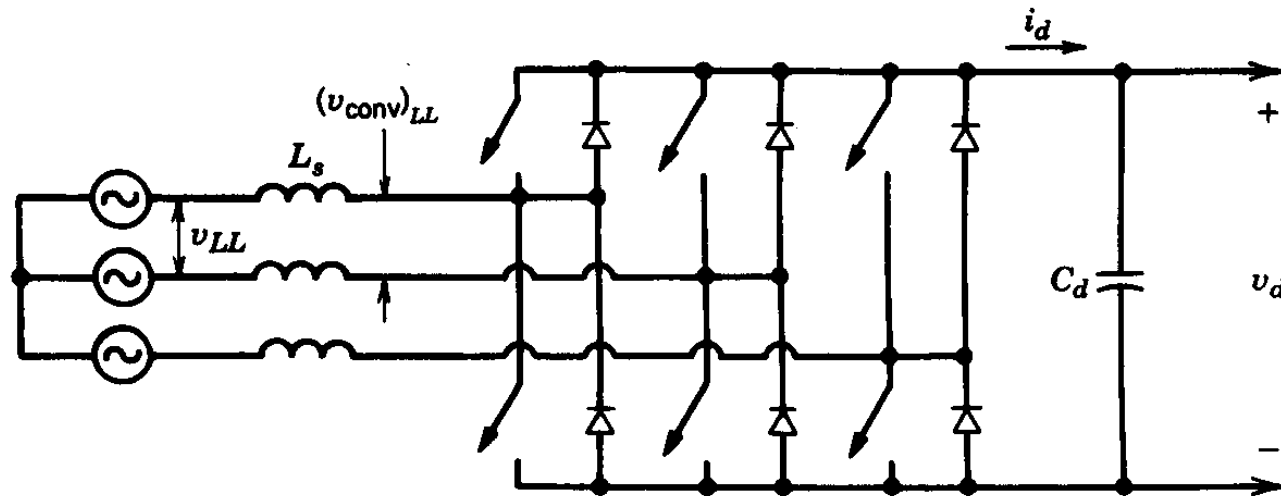


Figure 18-12 Three-phase, switch-mode converter.

- Rectifier and Inverter modes based on the direction of power flow

EMI: Conducted Interference

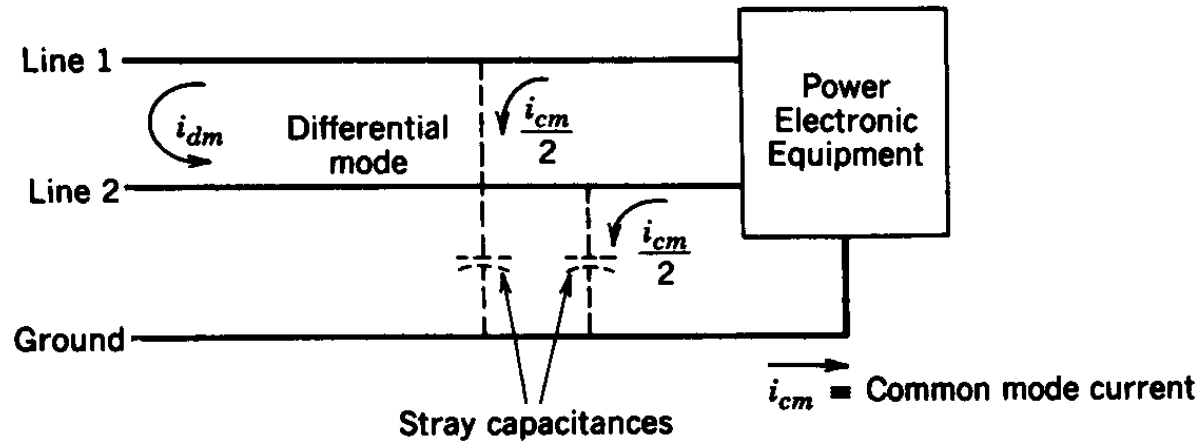


Figure 18-13 Conducted interference.

- Common and differential modes

Switching Waveforms

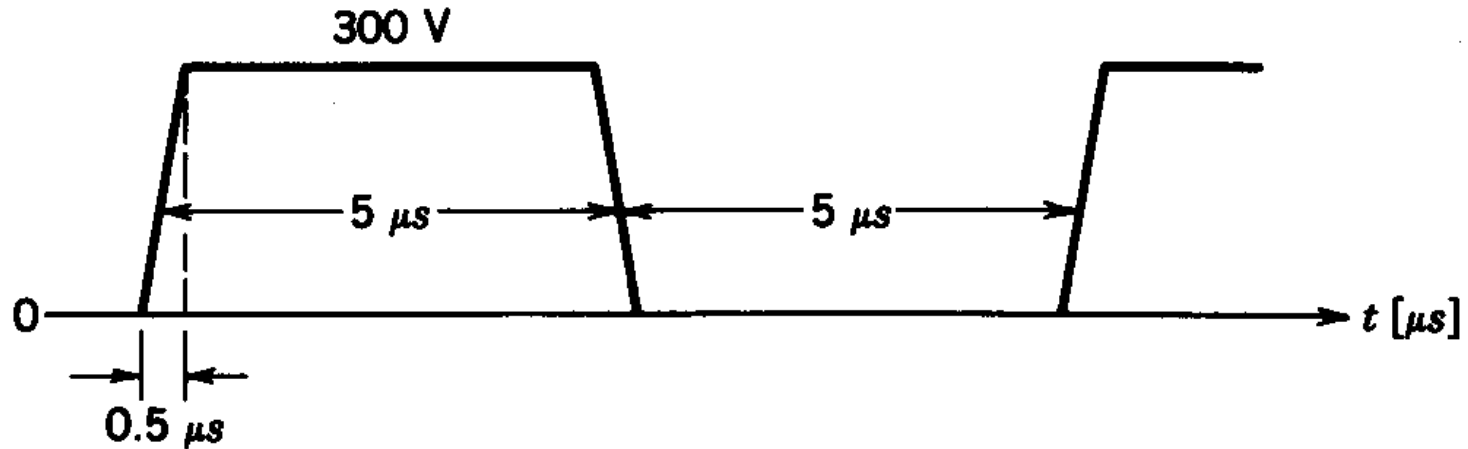


Figure 18-14 Switching waveform.

- Typical rise and fall times

Conducted EMI

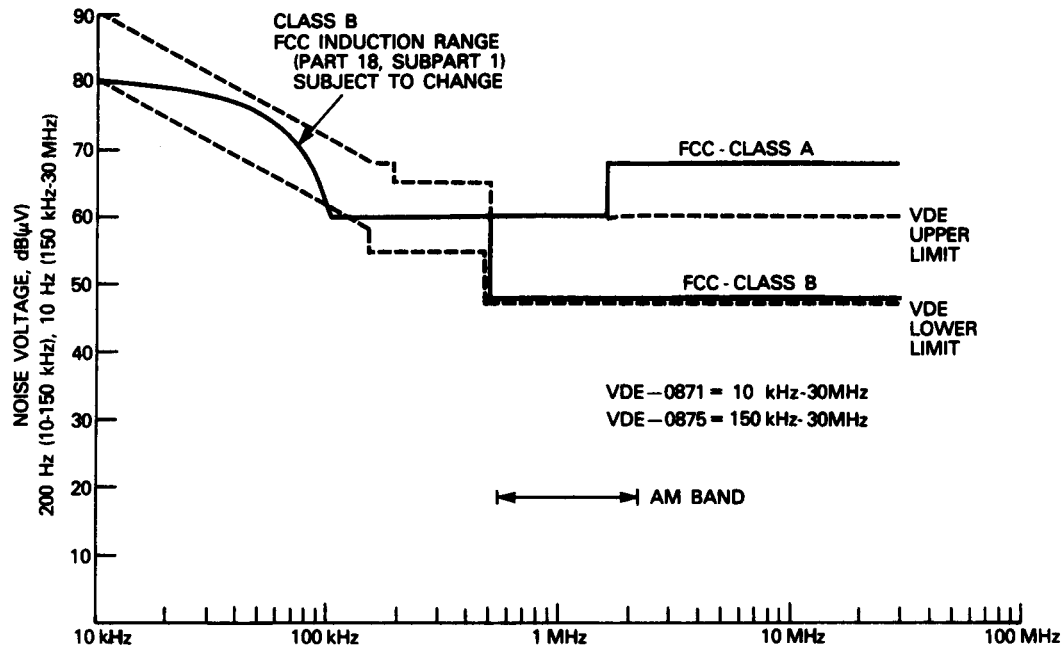


Figure 18-15 The FCC and VDE standards for conducted EMI.

- Various Standards

Conducted EMI

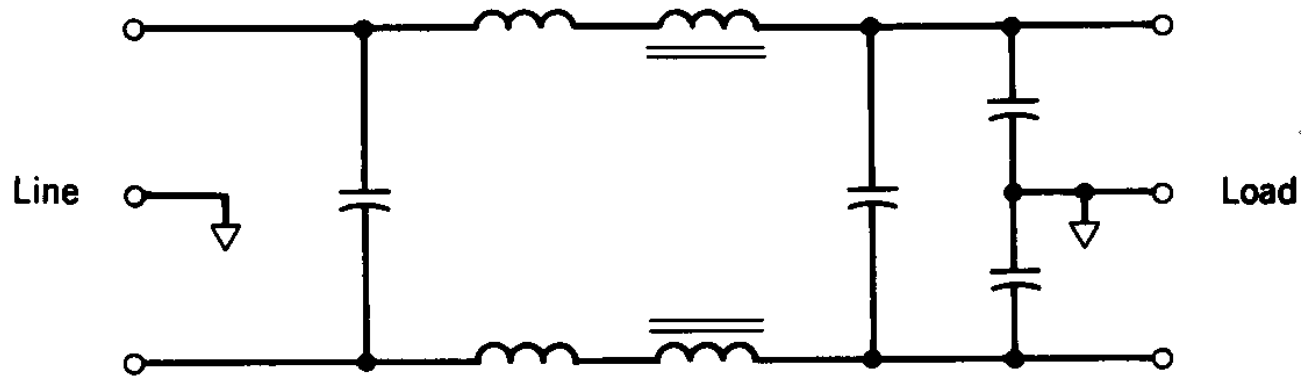


Figure 18-16 Filter for conducted EMI.

- Filter arrangement