



Computer Networks: Physical layer

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Maximum data rate of a channel

- Depends on
 - The bandwidth available
 - The level of the signals we use
 - The quality of the channel (the level of noise)
- Noiseless channel
 - Nyquist formula
 - $\text{bitrate} = 2.B.\log_2 L$
- Noisy channel
 - Shannon formula
 - $\text{capacity} = B.\log_2(1+\text{SNR})$

Example

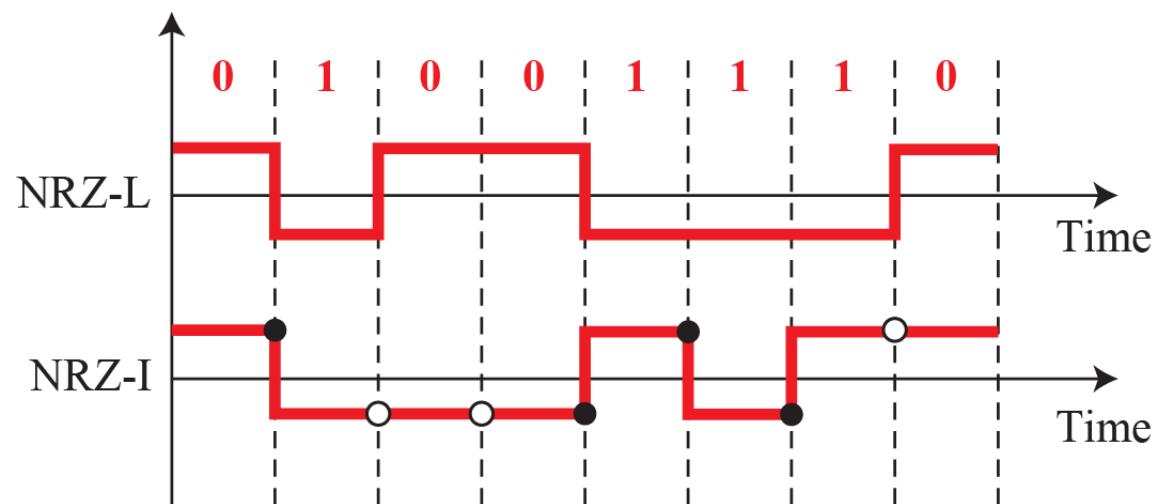
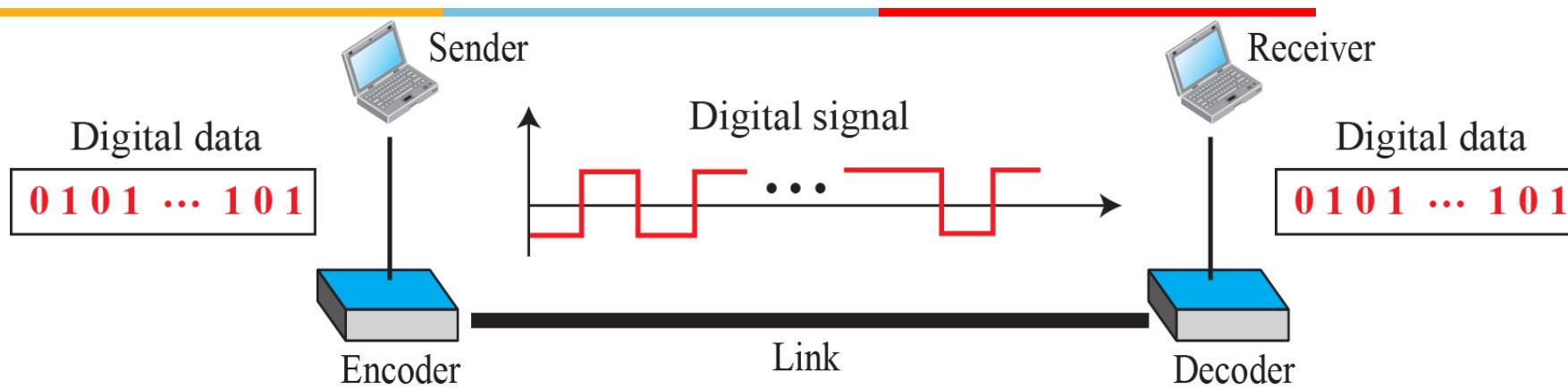
We need to send 265 kbps over a noiseless (ideal) channel with a bandwidth of 20 kHz. How many signal levels do we need?

$$265,000 = 2 \times 20,000 \times \log_2 L \quad \rightarrow \quad \log_2 L = 6.625 \quad L = 2^{6.625} = 98.7 \text{ levels}$$

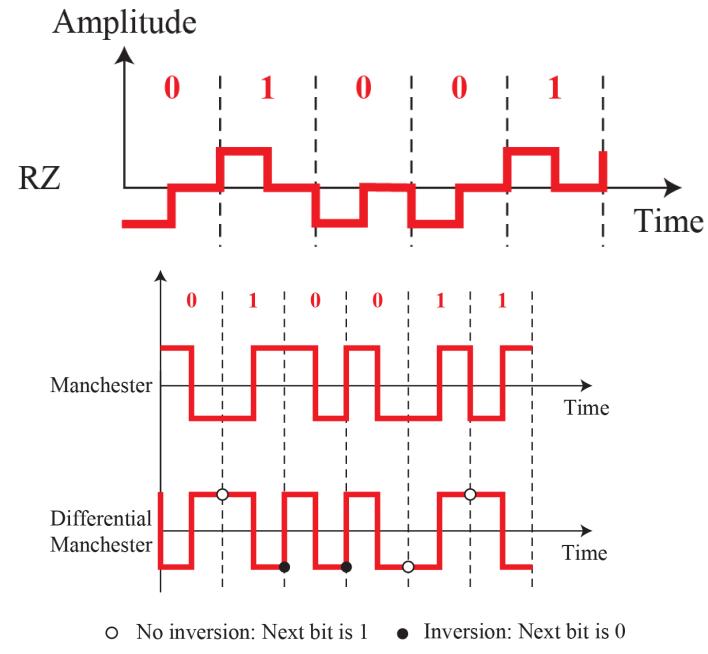
A telephone line normally has a bandwidth of 3000 Hz assigned for data communications. The signal-to-noise ratio is usually 3162. Find out the capacity.

$$C = B \log_2 (1 + SNR) = 3000 \log_2 (1 + 3162) = 34,881 \text{ bps}$$

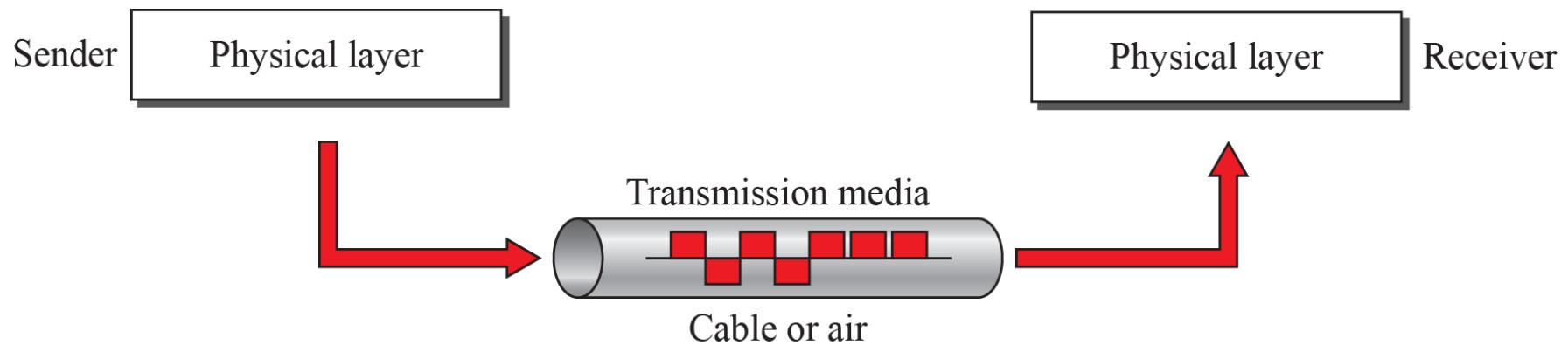
Digital data to Digital signal



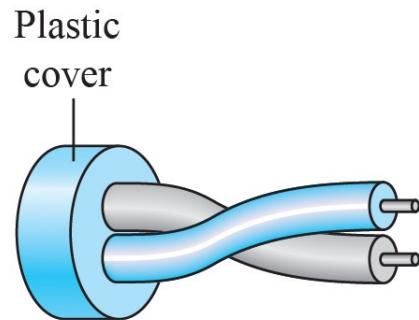
- No inversion: Next bit is 0
- Inversion: Next bit is 1



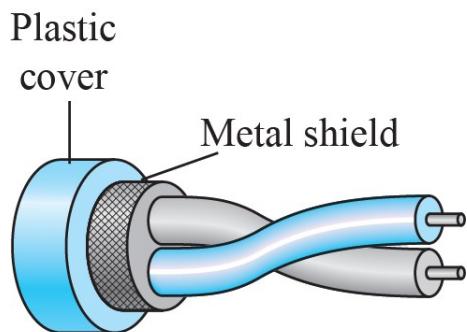
Transmission media



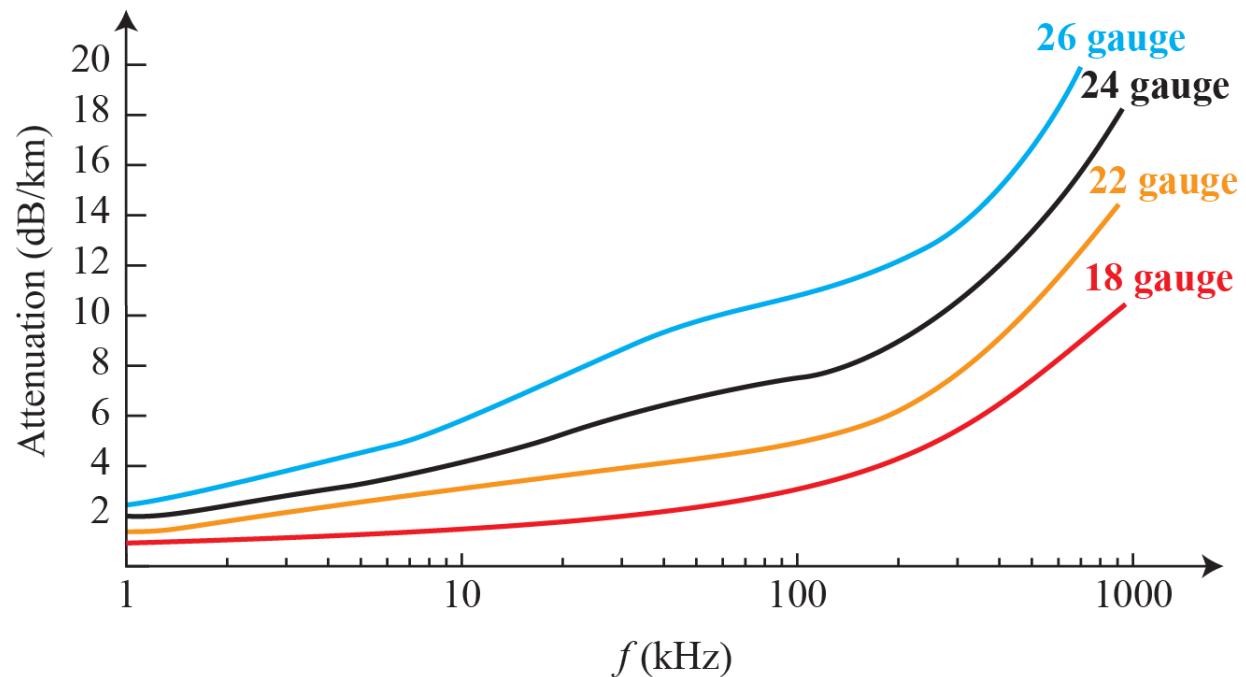
Guided media



a. UTP



b. STP

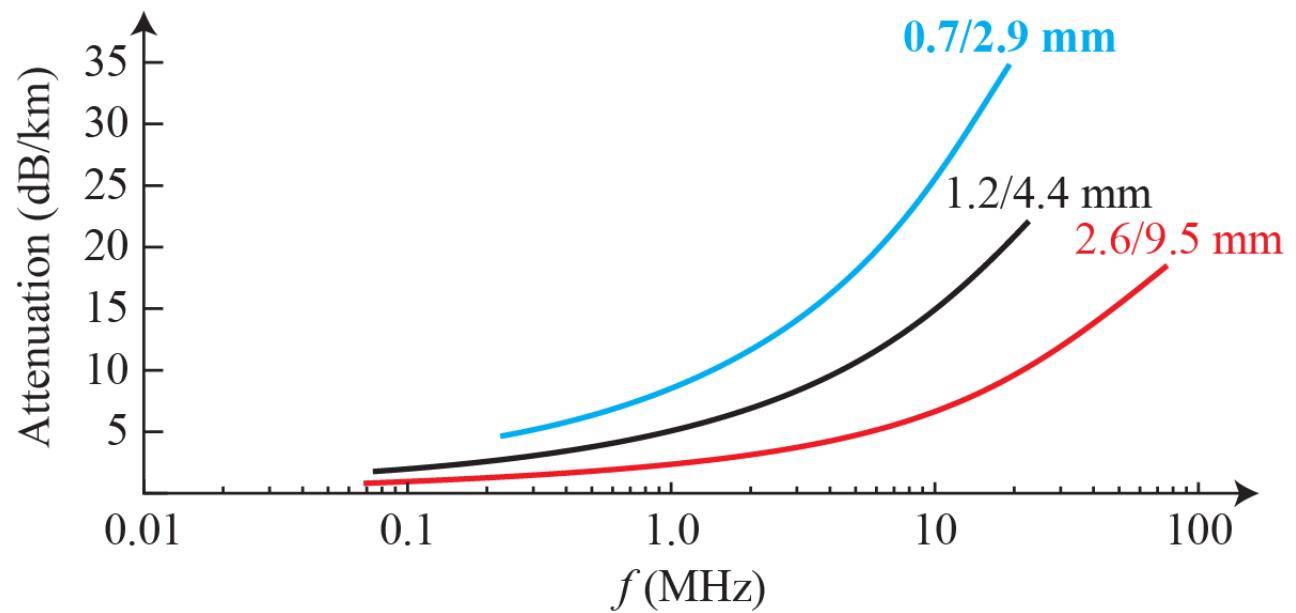
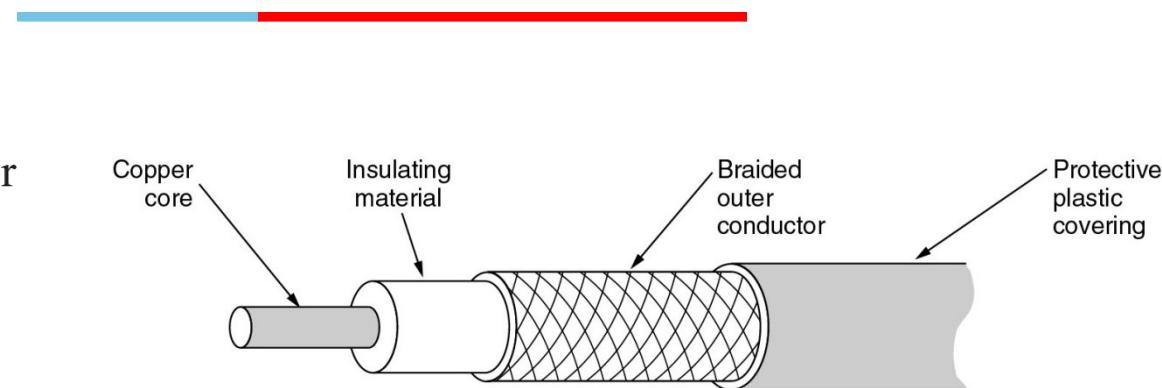
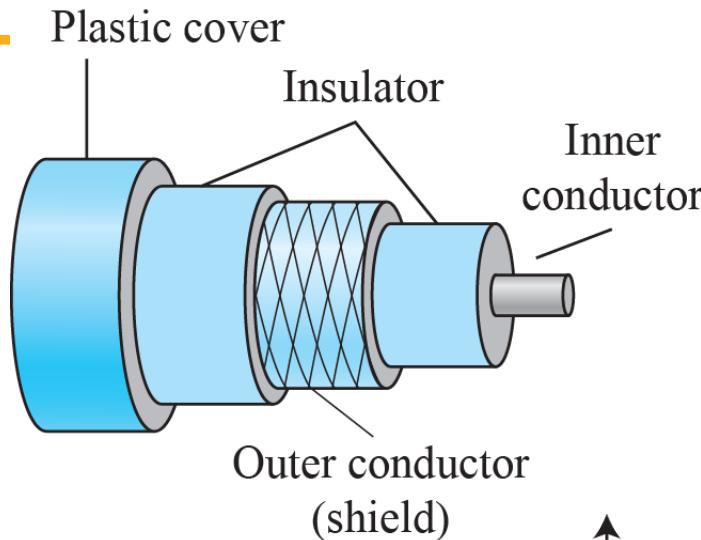


(a)



(b)

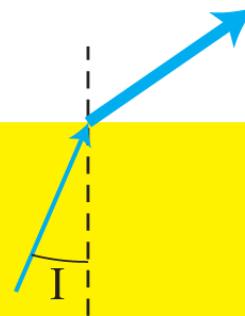
Coaxial cable



Optical fiber

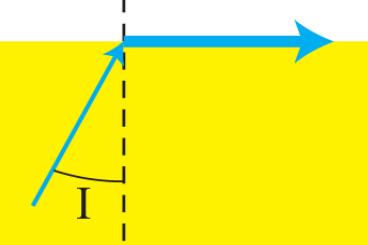
Less dense

More dense



$I <$ critical angle,
refraction

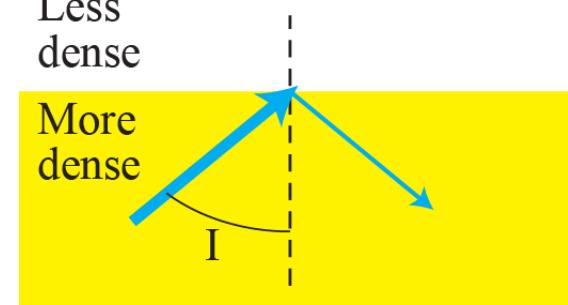
Less dense
More dense



$I =$ critical angle,
refraction

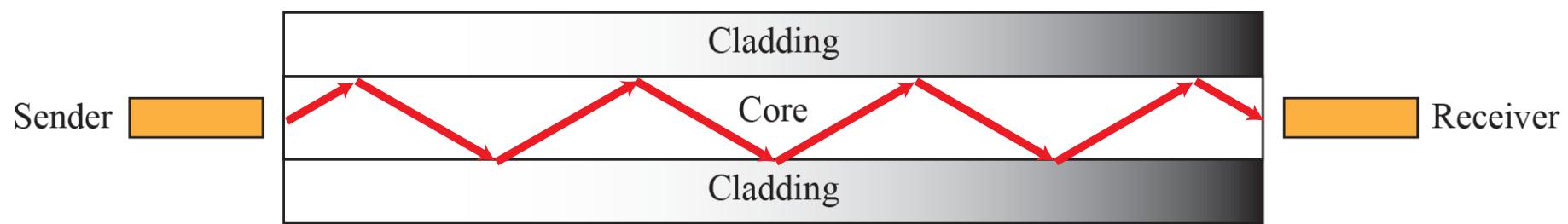
Less dense

More dense

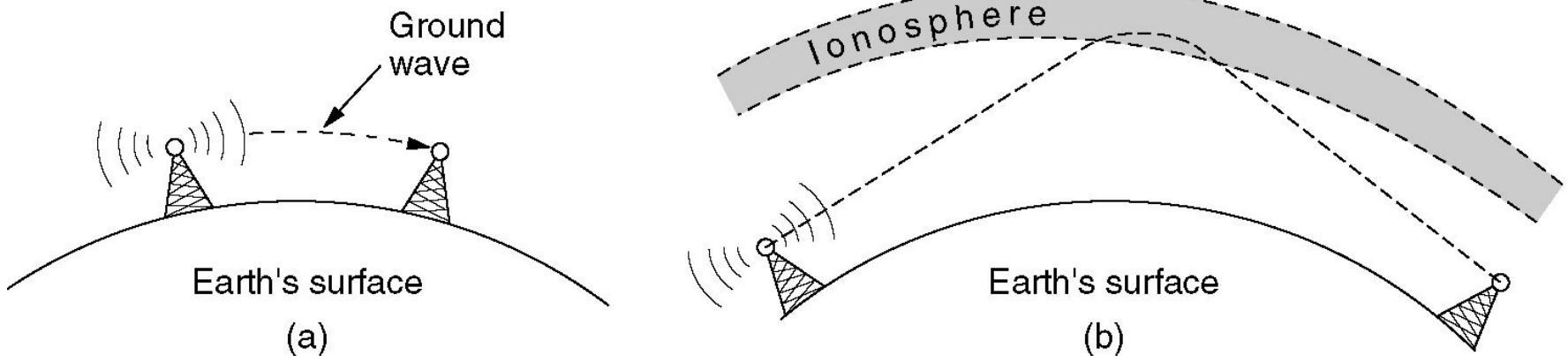
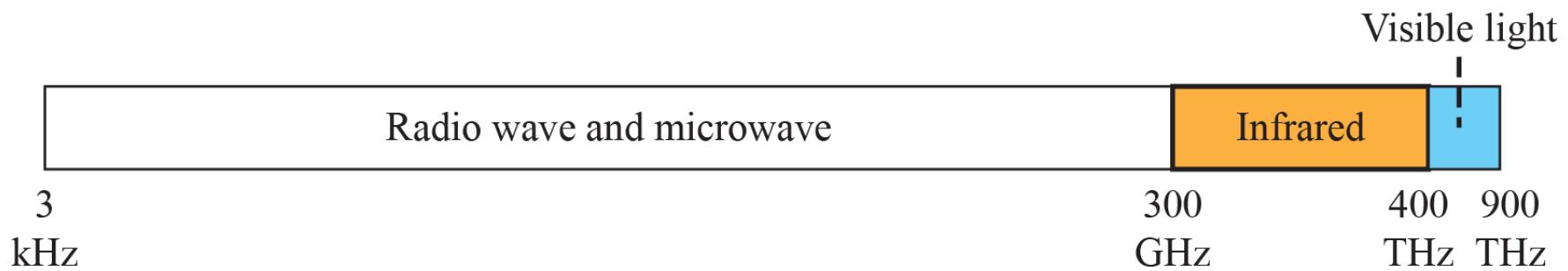


$I >$ critical angle,
reflection

Continued...



Unguided media



Bands

<i>Band</i>	<i>Range</i>	<i>Propagation</i>	<i>Application</i>
VLF (very low frequency)	3–30 kHz	Ground	Long-range radio
LF (low frequency)	30–300 kHz	Ground	Radio beacons
MF (middle frequency)	300 kHz–3 MHz	Sky	AM radio
HF (high frequency)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF (very high frequency)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (ultrahigh frequency)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF (superhigh frequency)	3–30 GHz	Line-of-sight	Satellite communication
EHF (extremely high frequency)	30–300 GHz	Line-of-sight	Radar, satellite