###### Solution to Exercise 6.5.2

As frequency decreases, wavelength increases and can approach the distance between the earth's surface and the ionosphere. Assuming a distance between the two of 80 km, the relation *λf* = c gives a corresponding frequency of 3.75 kHz. Such low carrier frequencies would be limited to low bandwidth analog communication and to low datarate digital communications. The US Navy did use such a communication

scheme to reach all of its submarines at once.

###### Solution to Exercise 6.7.1

Transmission to the satellite, known as the uplink, encounters inverse-square law power losses. Refecting of the ionosphere not only encounters the same loss, but twice. Refection is the same as transmitting exactly what arrives, which means that the total loss is the **product** of the uplink and downlink losses. The geosynchronous orbit lies at an altitude of 35700km. The ionosphere begins at an altitude of about 50 km.

The amplitude loss in the satellite case is proportional to 2.8 × 10−8; for Marconi, it was proportional to 4.4 × 10−10. Marconi was very lucky.

###### Solution to Exercise 6.8.1

If the interferer's spectrum does not overlap that of our communications channel - the interferer is out-of-band we need only use a bandpass flter that selects our transmission band and removes other portions of the spectrum.

###### Solution to Exercise 6.9.1

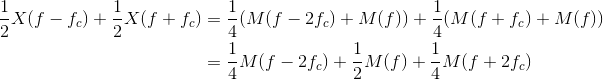
The additive-noise channel is **not** linear because it does not have the zero-input-zero- output property (even though we might transmit nothing, the receiver's input consists of noise).

###### Solution to Exercise 6.11.1

The signal-related portion of the transmitted spectrum is given by



Multiplying at the receiver by the carrier shifts this spectrum to *fc* and to −*fc*, and scales the result by half.



(6.67)

The signal components centered at twice the carrier frequency are removed by the lowpass flter, while the baseband signal *M(f)* emerges.

###### Solution to Exercise 6.12.1

The key here is that the two spectra *M* (*f − fc*), *M* (*f + fc*) do not overlap because we have assumed that the carrier frequency fc is much greater than the signal's highest