Problem 1: Radio transmission range. We will learn later that the minimum receiver power is \( P_{\text{min}} = kTFBQ^2 \) where \( k \) is Boltzmann's constant, \( T \) is the absolute temperature, \( F \) is the receiver noise figure, \( B \) is the bit rate and \( Q^2 \) is the required signal/noise ratio. Simple QPSK without error-correcting codes requires \( Q = 6 \) for 1E-9 bit error rate. If we assume a 5 dB noise figure and a 1 Mb/s data transmission rate, and dipole antennas, what radiated power is required for 10 km transmission using a 1 GHz carrier frequency assuming fair weather? If it is raining at a rate of 50 mm/hr (heavy?) how much power would be required? How large is the Fresnel zone for a blocking object 200 meters away from the receiving antenna? How long phycially are the antennas?

Problem 2: Please repeat problem 1 for a 100 MHz carrier. Extrapolate the rain attenuation curves from the Notes using the Rayleigh scattering \( (\lambda^+\lambda) \) approximation.

Problem 3: Working with a 10 GHz carrier, with transmit antennas having directivities of 1000:1 (#0 dB), what transmit and what received power is necessary in fair weather and given 50 mm/hr rain?

Problem 4: Assuming the parameters of problem 1 and the block diagram below, if we assume a 900 MHz Local oscillator, a 100 MHz IF frequency, and root-raised-cosine filters with \( \beta = 0 \), make clean plots of the Fourier signal spectrum (a) at the antenna (b) at the output of the first mixer and (c) at the outputs of the I/Q demodulator. What bandwidths must the (root) raised cosine filters have?

![Block diagram](image)