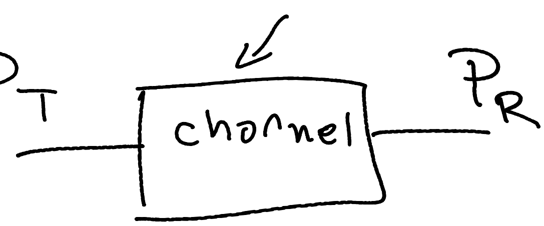
Diversity

Exercise 1: Which of these might lead to a reduction in system efficiency by requiring more time or bandwidth? Which of these would require additional or more complex antennas?

	time or bandwith	antenna cost (more or more complex)
space	NO	YES
frequency	YES	NO
polarization	NO	YES
time	YES	NO

$$gain = \frac{out}{input} = \frac{P_R}{P_T} < 1 \text{ in dB -ve}$$

gain < 1



$$loss = \frac{1}{gain}$$

in dB:

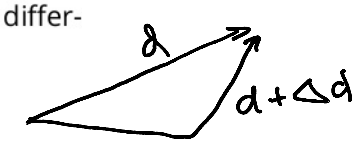
$$loss = -gain$$

Exercise 2: What spacing is required for 10λ separation at 900 MHz?

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{9\times10^8} = \frac{1}{3}\,m$$

$$10\lambda = \approx 3.3\ m$$

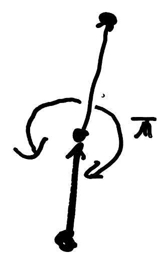
Exercise 3: What frequencies would see complete cancellation due to multipath if there are two equal-gain paths with a delay difference of τ? If the path length differences are 300 m? 3 m?



$$\Delta\Theta = \tau \cdot \Delta f \cdot 2\pi = \pi$$

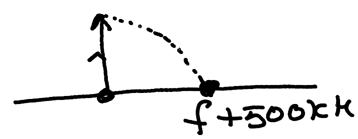
$$\tau = \frac{\Delta d}{c}$$

$$\Delta f = \frac{\pi}{2\pi\tau} = \frac{1}{2\tau}$$



$$\Delta d = 300\,m \qquad \tau = \frac{3\times10^2}{3\times10^8} = 1\,\mu s.$$

$$\Delta f = 500\,kHz$$



$$\Delta d \quad 3\,m \qquad \tau = 10ns.$$

$$\Delta f = 50MHz$$

as delay smaller need larger frequency differences for effective freq. diversity.

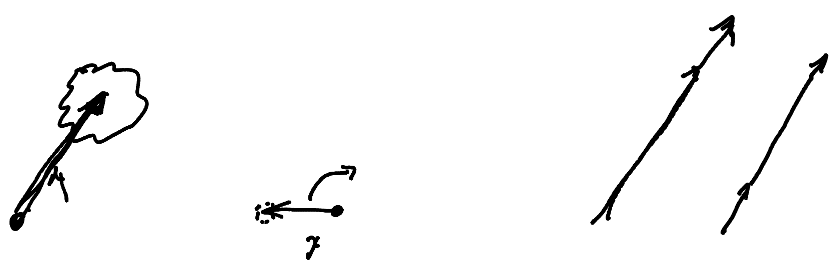
Exercise 4: Would time diversity be more or less effective as the receiver's speed increased? What would happen if the receiver was stopped (such as a traffic light)?

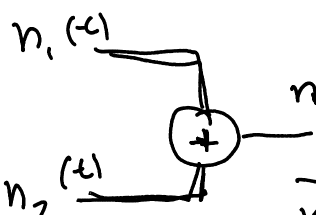
- more effective as speed increases
- possiby channel does not change but depends on if scattering environment is changing or not.

Exercise 5: Assuming maximal-ratio combining, what would be the resulting SNR if the branch SNRs were +10 dB and +20 dB? If they were both +10 dB?

$10\,dB = 10$
$+\ 20\,dB = 100$
$110 \approx$

$10^{dB/10} = 10$
$+10 = 10$
20
$= 13\,dB$





$n(t) = n_1(t) + n_2(t)$

$\overline{n^2(t)} = \overline{n_1^2(t)} + \overline{2 n_1(t) n_2(t)} + \overline{n_1(t)}$

$= \overline{n_1^2(t)} + \overline{n_2^2(t)}$

= sum of powers.

Exercise 6: Assuming independent Rayleigh fading, the same SNRs as in the previous exercise and that the signal is considered "faded" if the SNR is below 0 dB, what fraction of time would be signal be faded with and without two-branch selection diversity?

SNR = 20 P = 0.01 10 = 0.1 M = 2

= 10 P = 0.1 10 = 0.1

10^{-2}

P (both faded) = 0.01 × 0.1

= 10^{-3} 0.99

P (not faded) = 0.999

Exercise 7: What type of diversity would you expect to be implemented in an (inexpensive) WLAN card? In a cellular base station?

cheap → switching diversity

good → maximal ratio