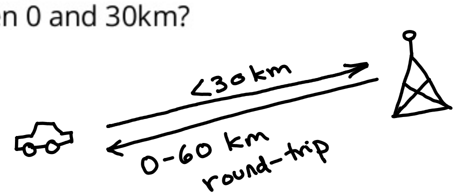
Multiple Access and Duplexing

Exercise 1: The GSM TDMA frame duration is approximately 5ms. What frequency would you expect to hear if the GSM RF signal was rectified and output to a speaker?

$$f = \frac{1}{5ms} = 200\text{ Hz} \quad \text{(audible)}$$

Exercise 2: How much uncertainty is there in the round-trip propagation delay if the distance from a subscriber to a base station can be between 0 and 30km?



$$\min = 0 \qquad \max = \frac{60 \times 10^3}{3 \times 10^8} = 200\mu s$$

Exercise 3: In 802.11g/n the delay before transmitting is in multiples of 9μs. Assuming the average frame is 140 bytes long and is transmitted at 12 Mb/s, what fraction of the channel time is consumed by a contention delay of 4 slots between frames?

$$\text{contention delay} = 4 \times 9\mu s = 36\mu s$$

$$\text{transmission time} = \frac{140 \times 8}{12 \times 10^6} \approx 93\mu s$$

$$\text{fraction of total} = \frac{36}{36+93} \approx 28\%$$

140×8÷12E6=
93.3333E-06

$\frac{36}{36+93}$=
279.0698E-03

Exercise 4: Two spreading codes, $s_1 = \{+\sqrt{2}, +\sqrt{2}\}$ and $s_2 = \{+\sqrt{2}, -\sqrt{2}\}$ are used to separate the signals from two users. Are these codes orthogonal over a period of two chips? Orthonormal? The first user transmits the value +5 and the second user transmit the value -2. Calculate the output of the individual spread signals, the composite CDMA signal and the outputs of the two correlators.

orthogonal means: $\int_0^T s_i \, s_j = k \, \delta_{ij}$ orthonormal: $k = 1$

check: $s_1 \cdot s_2 = s_2 \cdot s_1 = \frac{1}{\sqrt{2}} \cdot \frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}} \cdot \frac{1}{-\sqrt{2}} = \; = 0$ ∴ orthogonal

$s_1 \cdot s_1$: $\sqrt{2} \cdot \sqrt{2} + \sqrt{2} \cdot \sqrt{2} = 2 + 2 = 4$ not orthonormal

$s_2 \cdot s_2$: $+\sqrt{2} \cdot +\sqrt{2} + -\sqrt{2} \cdot -\sqrt{2} = +2 + 2 = 4$

$$5 \cdot \overset{s_1}{(\sqrt{2}, \sqrt{2})} \rightarrow 5\sqrt{2}, \; 5\sqrt{2}$$

$$-2 \; \overset{s_2}{(\sqrt{2}, -\sqrt{2})} \rightarrow -2\sqrt{2}, \; 2\sqrt{2}$$

receive the sum: $3\sqrt{2}, \; 7\sqrt{2}$

r $\quad$ s_1 $\quad$ r

receiver 1 correlates with s_1: $3\sqrt{2} \cdot \sqrt{2} + 7\sqrt{2} \cdot \sqrt{2}$

to get: $3 \cdot 2 + 7 \cdot 2 = 6 + 14 = 20$

receiver 2 correlates with s_2: $3\sqrt{2} \cdot \sqrt{2} + 7\sqrt{2} \cdot -\sqrt{2}$

to get: $= 6 - 14 = -8$

normalize by $|s_i| = 4$ to recover: $\frac{20}{4} = 5, \; \frac{-8}{4} = -2$

Exercise 5: Is a cellular phone call half-duplex, full-duplex or simplex? How about a radio broadcast? A typical taxi dispatch radio?

phone calls → full duplex

radio broadcast → simplex

dispatch → half duplex