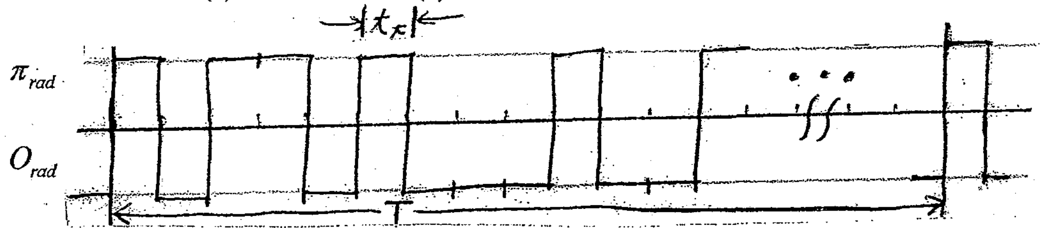
I will describe waveform $\phi(t)$ and signal $s(t)$ then I will ask a few questions.

Given $\phi(t)$



A. Periodic signal $\phi(t)$ with minimum change period t_t and period T

a, b, k are integers
a = number of t_t intervals that are $+\pi$
b = number of t_t intervals that are O
k = a + b   and $kt_t = T$

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Jan. 2006

B. Sinusoidal signal s(t) with frequency f_c

$f_c \gg 1/t_t$ and $\phi(t)$ represents phase of s(t)

1. Write a mathematical representation of s(t) either complex exponential or trigonometric representation.

2. Rough sketch s(t) showing important features

3. Is it possible to choose a and b such that there is no spectral component of s(t) at f_c in the frequency domain?

4. What is relationship between a and b for no spectral component of s(t) at f_c?

5. If $a \neq b$, what is the minimum possible spacing between spectral components of s(t)?

6. For $a \neq b$ in terms of a and b, what is the power of the spectral component at f_c compared to the total power in s(t)?

7. With a = b, i.e., no spectral component at f_c, how could you recover (estimate) f_c from s(t)?

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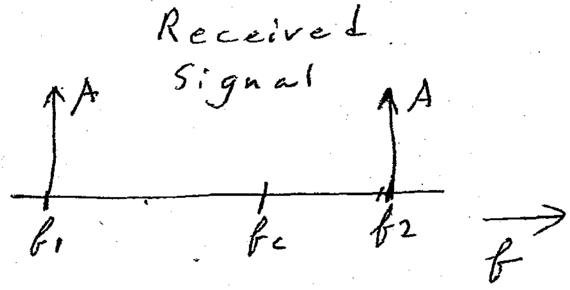
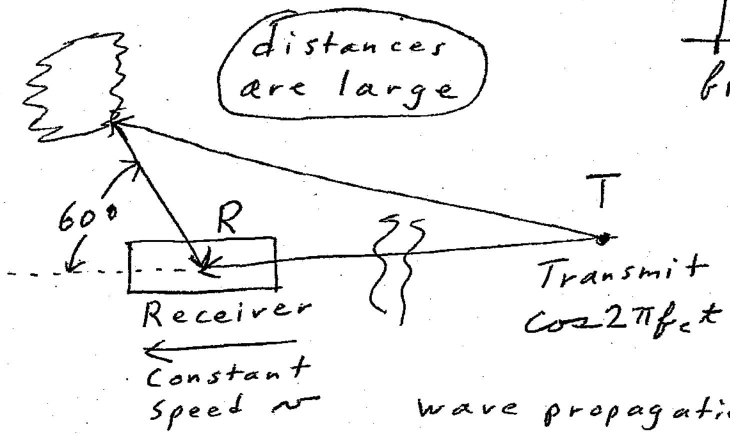




$f_1 = 10^{10} - 10^{3}\,Hz$

$f_2 = 10^{10} + 0.5\times 10^{3}\,Hz$

wave propagation is in air $\simeq$ free space

Figures above were on the white board. The situation was explained: one attenuated direct path and one reflected path. The received signal spectrum is shown with two spectral lines at f_1 and f_2. There is no signal at f_c.

Questions for discussion:

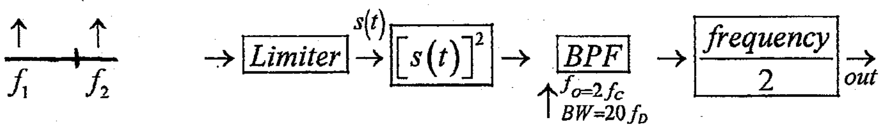
a) What is f_c?
(If student did not recognize or know Doppler relationship, he/she was coached to attempt to derive it from EM wave propagating as $\cos(2\pi f_c - kz)$.

b) What is Doppler shift frequency?
(resulted from work for a)

c) What is v?

d) Is v reasonable speed for a car?

If student progressed this far, a block diagram on the white board was uncovered (it was covered by opaque paper at start of exam).



The block diagram was described and the question asked was what is the frequency or frequencies at the output?