Questions and Answers for Lecture 3

1. Since passband signals are real, why do we use complex valued baseband signal for a physical passband communication channel, and not the passband signals themselves?

   Each passband signal can be uniquely determined by its in-phase and quadrature components, $u_I(t)$ and $u_Q(t)$, which can be expressed by a complex signal $\tilde{u}(t) = u_I(t) + ju_Q(t)$ for easy manipulation

2. How is there a 1-1 correspondence between baseband and passband signals?

   For a given carrier frequency, a baseband signal can be converted into a unique passband signal using up-conversion; the passband signal can be also converted back into the baseband signal using down-conversion, which is why the 1-1 correspondence holds

3. Slide 7 in passband signal imaginary part plot, shouldn't the two segments be centred in f_c and $-f_c$ respectively? How come the corner frequency is at the edges?

   It is not necessary. It depends on the shape of the spectrum of the baseband signal. If the spectrum of the baseband signal is not centred at 0, then the spectrum of the corresponding pass-band signal is not centred at f_c, either.

4. Why do we need to subtract the quadrature component from the in-phase component instead of adding it for example? Is it because the sine and cosine have a π/2 phase difference?

   You can use addition "+" or subtraction "-" in real systems. They are equivalent. But, when you use "-", you can easily express the relationship between baseband and passband signals in the identify on slide 14. Therefore, we usually use "-".

5. Why would we want to go back to the original complex baseband signal if we want to only consider real signals in an actual system?

   In real communication systems, especially in digital communication systems, almost all processing is performed in baseband, such as converting binary data streams into baseband signals at the transmitter, signal detection at the receiver, etc. The passband processing (at high frequency) is either too expensive or technically impossible. Therefore, we need to consider the baseband signal.

6. Would we ever modulate a real valued baseband signal, or is it only for complex valued baseband signals?

   In analogue communications, we usually modulate real valued baseband signals, such as speech signals, as you can see from the next week's class. In digital communication systems, some modulates real baseband signals and some modulates complex baseband signals.

7. A passband signal's info is contained in the baseband, so I was wondering whether the opposite is true, so is the baseband's info also contained in the passband? I would say no, because we also need to complex part, yet couldn't we go back from the modulated passband signal to the baseband signal?

   This is related to the 2nd question. In brief, baseband signal can be expressed as $\tilde{u}(t) = u_I(t) + ju_Q(t)$ and passband signal can be expressed as $u_I(t)\cos(2\,\pi f_c t)\ \ u_Q(t)\sin(2\,\pi f_c t) = Re\{\tilde{u}(t)e^{j2\,\pi f_c t}\}$. They both contains and determined by $u_I(t)$ and $u_Q(t)$. We can use up-conversion and down-conversion to change forth and back.

8. Does pre-envelope for negative frequencies removes positive frequencies I presume? But why do we need the pre-envelope when we have said that we only have +ve frequencies at a real signal, and passband is a real signal?

   We will use this concept when addressing single-side band (SSB) modulation in the next week and presenting digital modulation in the future.

9. In example in slide 19, the signal is from -fc - w to -fc + w, so concentrated only around -fc, how can it be around +- fc then?

   The second term, $U_+^*(-f)$ is around -fc since the first term, $U_+(f)$, is around fc

10. Slide 20: how do you infer that the envelope is obtained by shifting the spectrum of u+(t) to the left by fc?

    In the frequency domain, you shift the spectrum of the baseband signal to the right by fc Hz and the mirror version of the spectrum to the left by fc Hz to get complex conjugate spectrum of the passband signal. Therefore, to get the baseband signal, you only need to shift $U_+(f)$ to the left by fc since $U_+^*(-f)$ and $U_+(f)$ essentially contain the same information.