**Questions**

1. **What are the two functions of a PLL in a communications system?**

The 2 important functions are used for synchronization tasks:

-carrier recovery, which involves synchronizing the local oscillator (LO) to the incoming signal

-symbol timing recovery, or properly aligning the sample times at the matched filter output.

1. **What are the key components (operations) used to implement a PLL?**

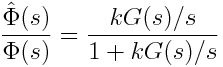
**Multiplier**: takes product of local reference from VCO and input reference

**LPF**: removes doubled frequency component from output of multiplier

**VCO:** low frequency component from multiplier passes through the filter and produces a slow varying voltage which is fed to the VCO. The VCO then controls the speed of the oscillator depending on whether y(t) lags/leads x(t). Feeding this phase difference to the voltage controlled oscillator (VCO) causes the oscillator to speed up when *y*(*t*) is lagging *x*(*t*) or to slow down when *y*(*t*) is leading *x*(*t*).

1. **When we write the second-order frequency response of the PLL, this expression relates the input and output \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the references.**

phase



1. **What does the corner frequency of the PLL loop filter control?**

The corner frequency of the PLL loop filter controls how fast the loop adapts to phase changes.

1. **How should the loop filter corner frequency compare to the input reference frequency?**

The corner frequency ω0 should be much lower ( <0.1) than the input reference frequency or clock being tracked.

1. **What does it mean for a PLL to track?**

The PLL is said to track when the phase of input reference signal and the output reference signal is said to reach proper alignment, which brings the control voltage to the VCO to be close to 0.

1. **What does it mean for the PLL to be overdamped or underdamped?**

A PLL is said to be **overdamped** if it requires a long time to adapt to phase changes while it is **under-damped** when it has the characteristics of fast response but a tendency to overshoot a target leading to oscillation.

1. **Why is an accumulator useful for a PLL implementation?**

The accumulator is used because of instead of having an incrementing time variable t and a separate phase phi, we have a single real number, known as the accumulator, that keeps track of the current phase. At each time step, the contents of the accumulator tell us the current position in the sin () lookup table, where the lookup table holds just one sinusoidal cycle.

1. **Why do we need to sample sin() in our lookup table more finely than at the normal sample rate of the system?**

sin() has to be sampled more finely as the PLL often needs samples which lie in between the samples spaced by the sample period and the phase can change continuously to track the input.

1. **How do we keep our accumulator in the range [0,1]?**

The accumulator is kept in range by wrapping around once the value of the accumulator exceeds 1. This is done using accum = accum – floor(accum).

1. **What is the point of storing and restoring the state of the PLL for each block?**

The state of the PLL is stored and restored after every block in order to store the current estimate of the phase and amplitude. This allows better estimates for the following samples.

1. **How do we handle signals with arbitrary amplitude?**

The block of samples has to be scaled so that it has approximately unit amplitude. This is done by averaging the magnitude of the samples. After each block the amplitude estimate is stored and used to scale the next block of samples so that the amplitude of the scaled signal is approximately 1.