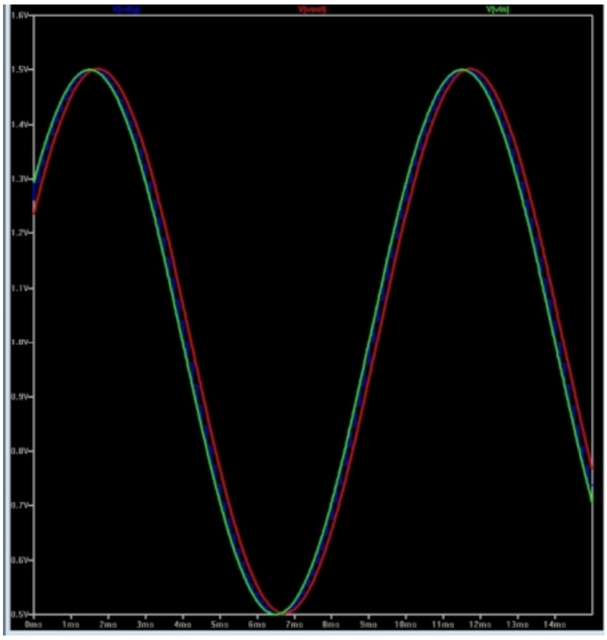
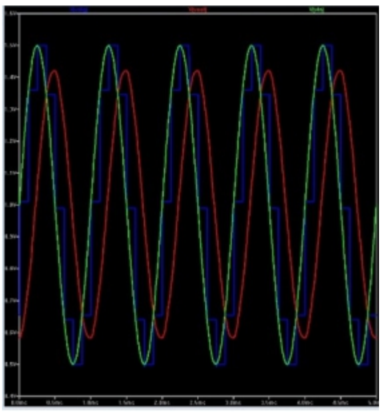
Exercise 1 (Generating sine waves). This exercise covers generating a sinusoidal voltage signal, sampling it using the sample and hold device, then passing the output signal through a reconstruction filter. Display the resulting signals in LT-Spice see if the digitised (Vdig in Slide 9) and reconstructed signals (Vout) represent well the original signal (Vin). Answer the following questions:

a. Using a voltage signal generator, generate a sine wave of frequency 100 Hz, whose amplitude is 0.5V. It is best to add a DC offset of 1V as the op-amps in your circuit will only be powered between 0-3.3V and they will clip any signal outside this range. Explain the results that you see?

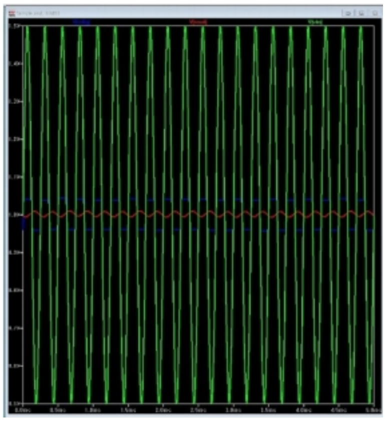


b. Now change the sine wave frequency to 1 kHz. Explain what you see now.

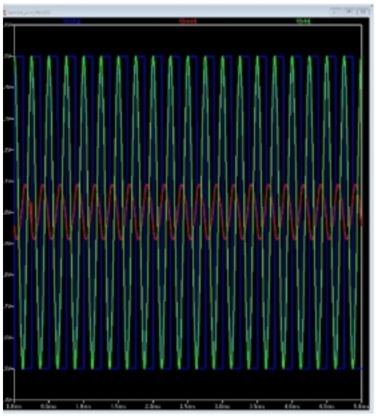


c. Finally change the sine wave frequency to 4 kHz and vary the sine wave phase over the range from 0-180 degrees in small steps, e.g. 15-30 degrees. What do you observe?

4kHz with 0 degree:



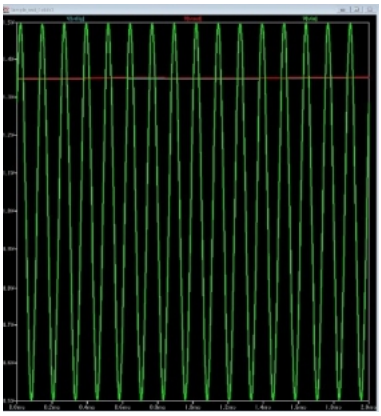
4k Hz with 90 degree:



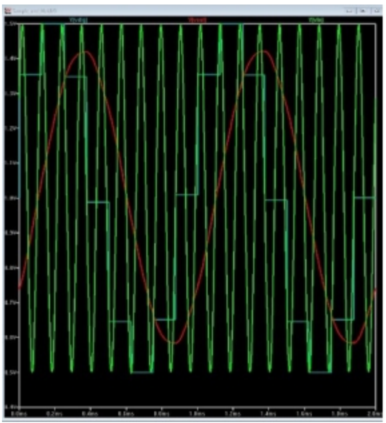
Exercise 2 (Above Nyquist Frequency). Now we will explore what happens when the input signal goes above the Nyquist frequency. You should consider particularly whether the reconstructed signal matches well with the original signal. Answer the following questions:

a. Increase the input frequency from 6 kHz to 9 kHz in 1 kHz intervals. For the specific case of 8 kHz try varying the phase from 0-180 degrees. See if you can work out the frequencies of the signals by estimating the period from the time-axis of the plot. What do you notice?

8 KHz example aliased to an almost DC signal:



9 kHz example aliased to a 1 KHz sine wave:



b. Next set the input frequency to 12 kHz and vary the phase of the sine wave in the range 0-180 deg. What do you observe?

A 12 kHz sine wave will again alias down to a 4 kHz reconstructed signal.

c. Finally increase the frequency again from frequency to 14 kHz to 17 kHz. What do you observe?

The results for 14 kHz – 17 kHz should be essentially similar to those obtained for 6 kHz – 9 kHz.

d. Deduce which frequencies produce the same sampled output, and determine a relationship between the frequencies measured.

The aliased frequency will linearly increase from 0-4 kHz and then back to 0 kHz again as the input frequency changes from 0-8 kHz.