

Hints

1. No comments.
2. No comments.
3. No comments.
4. No comments.
5. No comments.
6. To help you understand what is going when you multiply a discrete-time signal by $(-1)^n$ consider

$$s[n] = (-1)^n = \cos(\pi n) = e^{j\pi n}$$

If $x[n]$ is a discrete-time sinusoid signal

$$x[n] = \cos(\omega_0 n) = \cos(2\pi(f_0/f_s))$$

where f_s is the sampling rate in Hz, then it follows that

$$\begin{aligned} y[n] &= s[n]x[n] = \cos(\pi n)\cos(\omega_0 n) \\ &= \frac{1}{2}\{\cos[(\pi + \omega_0)n] + \cos[(\pi - \omega_0)n]\} \end{aligned}$$

There is more, since the frequency of a sinusoidal signal is unique only on a 2π interval (cosine is a mod 2π function) and cosine is also an even function, you can write

$$\begin{aligned} \cos[(\pi + \omega_0)n] &= \cos[(\pi + \omega_0)n - 2\pi n] \\ &= \cos[(\omega_0 - \pi)n] = \cos[(\pi - \omega_0)n] \end{aligned}$$

Hence, it follows that

$$y[n] = \cos[(\pi - \omega_0)n].$$

Using Fourier transform theorems this result along with the general result can be obtained much faster. The frequency translation theorem says that

$$\text{FT}\{x[n]e^{j\omega_c n}\} = X(e^{j(\omega - \omega_c)})$$

where $X(e^{j\omega}) = \text{FT}\{x[n]\}$ and here $\omega_c = \pi$. This points to the notion of flipping the spectrum about $\omega = \pi$ since you already know, or can recall, that the spectrum in the discrete-time domain is periodic with period 2π , that is $X(e^{j(\omega \pm k2\pi)}) = X(e^{j\omega})$ for any integer k . To relate these results back to continuous-time signals on the frequency interval $[0, f_s/2]$, just remember that $f = \omega/(2\pi) \times f_s$ and $\omega = 2\pi \times f/f_s$.

7. My intent with this problem is for you to try and help me out with getting true ISRs set up for this codec. At minimum use the existing code and verify loop-through performance at 48 ksp/s. Obtain a network analyzer sweep of the ADC–DAC path and/or a noise test spectrum plot of the DAC path.