From the waveform plots shown in [Figure 4.15](#_bookmark296), determine the pitch period and the pitch frequency. Since speech signals are periodic, speech has a Fourier series representation given by a linear circuit's response to a periodic signal (4.27). Because the acoustics of the vocal tract are linear, we know that the spectrum of the output equals the product of the pitch signal's spectrum and the vocal tract's frequency response. We thus obtain the **fundamental model of speech production**.

**Exercise 4.10.2**



Here, ***HV*** (***f***) is the transfer function of the vocal tract system. The Fourier series for the vocal cords' output, derived in this equation (p. 122), is



and is plotted on the top in [Figure 4.16](#_bookmark298). If we had, for example, a male speaker with about a 110 Hz pitch (



) saying the vowel "oh", the spectrum of his speech **predicted by our model** is shown in [Figure 4.16](#_bookmark298).