ECG harmonic noise removal with IIR Notch Filters

2018140088\_이도성

텍스트, 라인, 도표, 스크린샷이(가) 표시된 사진

자동 생성된 설명폰트, 텍스트, 라인, 친필이(가) 표시된 사진

자동 생성된 설명

Figure 1. Notch filter example & System function of the Notch filter (BMED311 hands-on).

A common heart test is an electrocardiogram (ECG or EKG) which records electrical activity that changes during the cardiac cycle. Metal electrodes placed at several locations on the body “pick up” these cardiac electrical signals. Unfortunately, the electrodes also pick up signals from other electrical sources, most notably harmonics of the 60-Hz power signal (or 50-Hz in some other countries). The objective of this short lab is to show that you can remove a sinusoidal interference from a corrupted ECG signal and produce a cleaned-up signal (BMED311 hands-on).

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Figure 2. Plot in time & frequency domain to show that the noise at 60Hz removed.

An IIR notch filter will null out one frequency, while having a frequency response that is relatively flat across the rest of the frequency band. It has one complex-conjugate zeros and poles: Zeros at exp(±𝑗𝜃), Poles at r\*exp(±𝑗𝜃) where r is a number slightly less than one (BMED311 hands-on). The system function in figure 2 helps us get the coefficient of the filter directly. The sampling frequency 500Hz, noise at 60Hz was used to get the w = 2\*pi\*60/500, and the r coefficient of the denominator pole was set as 0.95 which is close to 1 to make a sharp notch filter. The numerator coefficient bb = [1 -(exp(j\*w) + exp(-j\*w)) 1] and the denominator coefficient aa = [1 -r\*(exp(j\*w) + exp(-j\*w)) r\*r] was used for the notch filter to target the 60Hz noise. The figure 3 Frequency domain plot shows that the notch filter removed the noise at 60Hz. The filtered result in time domain also shows that the high frequency component.