SNS lab 08

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Pre lab task:

Sns LaB 08

Date : ....

$$x(t) = \begin{cases} a\cos\left(\frac{\pi t}{2T'}\right) & -T' < t \le T' \\ 0 & T' < t \le (T - T') \end{cases}$$

$$a_0 = \frac{1}{T}\int_{-T'}^{T'} a\cos\left(\frac{\pi t}{2T'}\right)\cos(0)\,dt$$

$$a_0 = \frac{1}{T}\int_{-T'}^{T'} a\cos\left(\frac{\pi t}{2T'}\right)dt$$

$$a_0 = \frac{a}{T}\int_{-T'}^{T'} \cos\left(\frac{\pi t}{2T'}\right)dt$$

$$a_0 = \frac{a}{T}\left[\frac{\sin(\pi t/2T')}{\pi/2T'}\right]_{-T'}^{T'}$$

$$a_0 = \frac{a}{T} \times \frac{2T'}{\pi}\left[\sin(\pi T'/2T') - \sin(\pi(-T')/2T')\right]$$

$$a_0 = \frac{4aT'}{\pi T}$$

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$$a_k = \frac{2}{T}\int_{-T'}^{T'} a\cos\left(\frac{\pi t}{2T'}\right)\cos\left(\frac{k\pi t}{T}\right)dt$$

$$= \frac{2a}{T}\int_{-T'}^{T'} \cos\left(\frac{\pi t}{2T'}\right)\cos\left(\frac{k\pi t}{T}\right)dt$$

$$= \frac{2a}{2T}\int_{-T'}^{T'} \cos\left(\frac{\pi t}{2T'} - \frac{k\pi t}{T}\right) + \cos\left(\frac{\pi t}{2T'} + \frac{k\pi t}{T}\right)dt$$

$$= \frac{a}{T}\int_{-T'}^{T'} \cos\left(\frac{T\pi t - 2T'k\pi t}{2TT'}\right) + \cos\left(\frac{T\pi t + 2T'k\pi t}{2TT'}\right)dt$$

$$= \frac{a}{T}\int_{-T'}^{T'} \cos\left(t\left(\frac{T\pi - 2T'k}{2TT'}\right)\right) + \cos\left(t\left(\frac{T\pi + 2T'k\pi}{2TT'}\right)\right)dt$$

$$= \frac{a}{T}\left\{\left.\frac{\sin t\left(\frac{T\pi - 2T'k\pi}{2TT'}\right)}{\frac{T\pi - 2T'k\pi}{2TT'}}\right|_{-T'}^{T} + \left.\frac{\sin t\left(\frac{T\pi - 2T'k\pi}{2TT'}\right)}{\frac{T\pi + 2T'k\pi}{2TT'}}\right|_{-T'}^{T'}\right.$$

$$= \frac{a}{T}\,2TT'\left(\frac{2}{T\pi - 2T'k\pi}\sin\left(\frac{T\pi - 2T'k\pi}{2T}\right) + \frac{2}{2\pi + 2T'k\pi}\sin\left(\frac{T\pi + 2T'k\pi}{2T}\right)\right)$$

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$$a_k = 4aT' \left[\frac{\sin\left(\frac{T\pi - 2T'k\pi}{2T}\right)}{T\pi - 2T'k\pi} + \frac{\sin\left(\frac{T\pi + 2T'k\pi}{2T}\right)}{T\pi + 2T'k\pi} \right]$$

$$b_k = \frac{2}{T} \int_{-T'}^{T'} a \cos\left(\frac{\pi t}{2T'}\right) \sin\left(\frac{k\pi t}{T}\right) dt$$

$$= \frac{2a}{2T} \int_{-T'}^{T'} \sin t \left(\frac{T\pi + 2T'k\pi}{2TT'}\right) - \sin t \left(\frac{T\pi - 2T'k\pi}{2TT'}\right) dt$$

$$= \frac{2aTT'}{T} \left[\frac{1}{T\pi + 2T'k\pi} - \cos t \left(\frac{T\pi + 2T'k\pi}{2TT'}\right) + \frac{\cos t}{T\pi - 2Tk\pi} \left(\frac{T\pi - 2T'k\pi}{2TT'}\right) \right]_{-T'}^{T'}$$

$$b_k = a \times 2T'(0) = 0$$

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Task2:

```
N = 50;

a = 0.35;

T = 0.88;

Td = 0.16;

t = -0.2:1/N/10:1.2;
```

```
k = 1:N;

a0 = (4*a*Td)/(pi*T);

ak =
4*a*Td*((sin((pi*T-2*k*pi*Td)./2*T)./(pi*T-2*k*pi*Td))+(sin((pi*T+2*k*pi
*Td)./2*T)./(pi*T+2*k*pi*Td)));

bk = 0;
```

```
xtNp = a0;

for kk=1:N

xtNp = xtNp+ak(kk)*cos((2*kk*pi*t)/T);

end
```

```
figure;

subplot(5,1,1)

plot(t, xtNp, 'linewidth',1);

grid on; xlabel('time(s)');

ylabel('Amplitude(mV)')

title('P-wave component of ECG signal');
```

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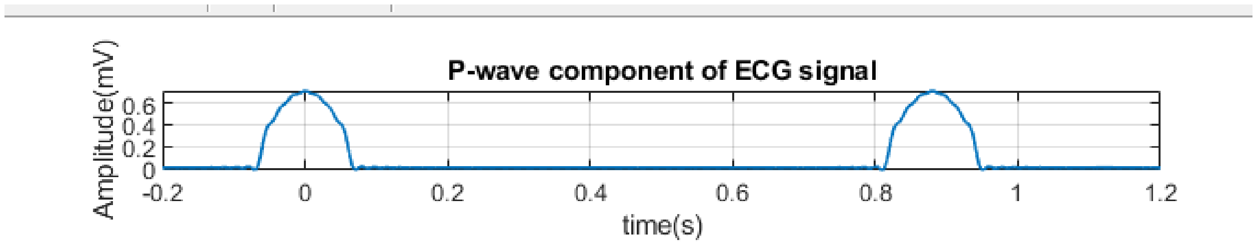

In this we initialize parameters such as N (number of harmonics), a, T, and Td to define the characteristics of a ECG signal. Then we calculate Fourier coefficients (ak) to represent the amplitudes of different frequency components in the Fourier series expansion of the P-wave signal. After finding this we make the P-wave signal (xtNp) using a Fourier series approximation method. Starting with the DC term (a0) we then by iterations make contributions from each harmonic using cosine functions. Then we generate a P-wave signal (xtNp) against time (t) through plotting. The shape of the P-wave signal tells us how long it lasts, how tall it is, and what it looks like. Its duration shows how much time it takes for the heart to contract. The amplitude indicates how strong the electrical signal is during this process.

Task 3:

```
N = 50;

a = 1.2;

T = 0.88;

Td = 0.08;

t0 = 0.2;

t = -0.2:1/N/10:1.2;
```

```
k = 1:N;

a0 = (4*a*Td)/(pi*T);

ak =
4*a*Td*((sin((pi*T-2*k*pi*Td)./2*T)./(pi*T-2*k*pi*Td))+(sin((pi*T+2*k*pi
*Td)./2*T)./(pi*T+2*k*pi*Td)));

bk = 0;
```

```
xtNq = a0;
```

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```
for kk=1:N

xtNq = xtNq+ak(kk)*cos((2*kk*pi*(t-t0)/T));

end
```

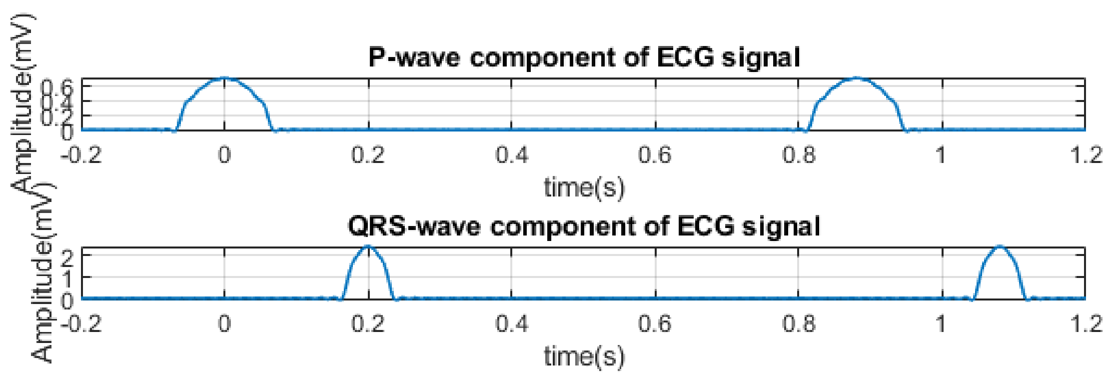
```
subplot(5,1,2)

plot(t, xtNq, 'linewidth',1);

grid on; xlabel('time(s)');

ylabel('Amplitude(mV)')

title('QRS-wave component of ECG signal');
```



In this we generate a synthetic ECG QRS-wave signal by approximating it using a Fourier series. we initialize parameters such as N (number of harmonics), a, T, and Td to define the characteristics of the signal. Then we calculate Fourier coefficients ak based on these parameters to represent the amplitudes of different frequency components in the Fourier series expansion of the QRS-wave signal. By Using these coefficients we make the QRS-wave signal xtNq by a Fourier series approximation, starting with the DC term a0 and iterating through each harmonic to add its contribution using cosine functions. This graph shows the synthetic QRS-wave component of an ECG signal plotted against time. It provides insights into the amplitude and duration of the QRS complex, which are essential features in analyzing ECG signals for various cardiac conditions.

Task 4:

```
a = -0.2;

Td = 0.08;
```

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```
t0 = 0.28;
```

```
a0 = (4*a*Td)/(pi*T);

ak =
4*a*Td*((sin((pi*T-2*k*pi*Td)./2*T)./(pi*T-2*k*pi*Td))+(sin((pi*T+2*k*pi
*Td)./2*T)./(pi*T+2*k*pi*Td)));
```

```
xtNs = a0;

for kk=1:N

xtNs = xtNs + ak(kk)*cos((2*kk*pi*(t-t0)/T));

end
```

```
subplot(5,1,3)

plot(t, xtNs, 'linewidth',1);

grid on; xlabel('time(s)');

ylabel('Amplitude(mV)')

title('S-wave component of ECG signal');
```

T Wave:

```
a = 0.3;

Td = 0.08;

t0 = 0.48;
```

```
a0 = (4*a*Td)/(pi*T);

ak =
4*a*Td*((sin((pi*T-2*k*pi*Td)./2*T)./(pi*T-2*k*pi*Td))+(sin((pi*T+2*k*pi
*Td)./2*T)./(pi*T+2*k*pi*Td)));
```

```
xtNt = a0;

for kk=1:N
```

```
xtNt = xtNt + ak(kk)*cos((2*kk*pi*(t-t0)/T));
end
```

```
subplot(5,1,4)
plot(t, xtNt, 'linewidth',1);
grid on; xlabel('time(s)');
ylabel('Amplitude(mV)')
title('T-wave component of ECG signal');
```

U Wave:

```
a = 0.055;
Td = 0.06;
t0 = 0.68;
```

```
a0 = (4*a*Td)/(pi*T);
ak =
4*a*Td*((sin((pi*T-2*k*pi*Td)./2*T)./(pi*T-2*k*pi*Td))+(sin((pi*T+2*k*pi
*Td)./2*T)./(pi*T+2*k*pi*Td)));
```

```
xtNu = a0;
for kk=1:N
xtNu = xtNu + ak(kk)*cos((2*kk*pi*(t-t0)/T));
end
```

```
subplot(5,1,5)
plot(t, xtNu, 'linewidth',1);
grid on; xlabel('time(s)');
ylabel('Amplitude(mV)')
title('S-wave component of ECG signal');
```

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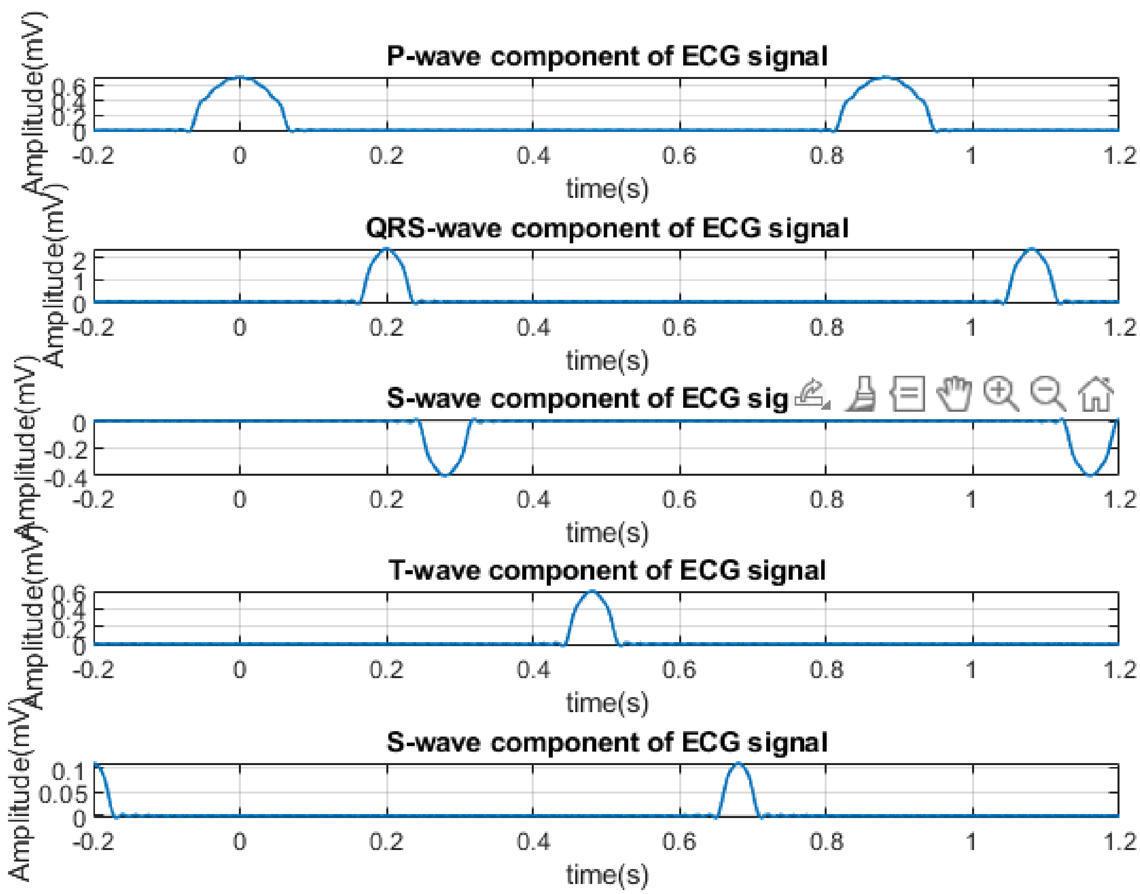

The graphs generated display the individual components of an ECG signal, the P-wave, QRS complex (which includes the Q-wave, R-wave, and S-wave), T-wave, and U-wave. Each plot shows one of these components, showing their respective shapes and characteristics. These components show their different phases of the cardiac electrical activity. The P-wave represents atrial depolarization, the QRS complex reflects ventricular depolarization, the T-wave represents ventricular repolarization, and the U-wave, if visible, may indicate repolarization abnormalities. By visualizing these components separately, the graphs help in analyzing the ECG signal and identifying any abnormalities.

Task 5

```
ECG = xtNp + xtNq + xtNs + xtNt + xtNu;

figure; plot(t,ECG, 'linewidth',1)

title ("ECG Wave");

grid on;
```

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In this task5, we combined all components of ECG and got the final ECG wave

Postlab:

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$$a_k' = \frac{2}{T_0}\int_{-T'}^{0} a\left(\frac{t}{T'}+1\right)\cos(k\omega_0 t)\,dt$$

$$u = \frac{t}{T'}+1 \qquad u' = \frac{1}{T'}$$

$$v = \cos(k\omega_0 t) \qquad \int v = \frac{\sin k\omega_0 t}{k\omega_0}$$

$$\left(\frac{t}{T'}+1\right)\frac{\sin(k\omega_0 t)}{k\omega_0} - \int_{-T'}^{0}\frac{\sin(k\omega_0 t)}{T'(k\omega_0)}\,dt$$

$$= \left(\frac{t}{T'}+1\right)\frac{\sin(k\omega_0 t)}{k\omega_0} - \left(\frac{-\cos(k\omega_0 t)}{T'(k\omega_0)^2}\right)$$

$$= \left(\frac{t}{T'}+1\right)\frac{\sin(k\omega_0 t)}{k\omega_0} + \frac{\cos(k\omega_0 t)}{T'(k\omega_0)^2}$$

$$= \frac{2a}{T_0}\left[\left(\frac{0}{T'}+1\right)\frac{\sin k\omega_0(0)}{k\omega_0} + \frac{\cos(k\omega_0(0))}{T'(k\omega_0)^2} - \left(\frac{-T'}{T'}+1\right)\frac{\sin(k\omega_0(-T'))}{k\omega_0} - \frac{\cos(k\omega_0(-T'))}{T'(k\omega_0)^2}\right]$$

$$= \frac{2a}{T_0}\left[1(0) + \frac{1}{T'(k\omega_0)^2} - 0 - \frac{\cos(k\omega_0 T')}{T'(k\omega_0)^2}\right]$$

$$a_k' = \frac{2a}{T_0}\left[\frac{1}{T'(k\omega_0)^2} - \frac{\cos(k\omega_0 T')}{T'(k\omega_0)^2}\right]$$

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$$a_k''' = \frac{2}{T_0}\int_0^{T'} a\left(\frac{-t}{T'}+1\right)\cos(k\omega_0 t)\,dt$$

$$u = \frac{-t}{T'}+1 \qquad u' = \frac{-1}{T'}$$

$$v = \cos(k\omega_0 t) \qquad \int v = \frac{\sin(k\omega_0 t)}{k\omega_0}$$

$$= \left(\frac{-t}{T'}+1\right)\frac{\sin(k\omega_0 t)}{(k\omega_0)} - \int_0^{T'} \frac{-\sin(k\omega_0 t)}{T'(k\omega_0)^2}\,dt$$

$$= \left(\frac{-t}{T'}+1\right)\frac{\sin(k\omega_0 t)}{(k\omega_0)} - \frac{\cos(k\omega_0 t)}{T'(k\omega_0)^2}$$

$$= \frac{2a}{T_0}\left[\left(\frac{-T'}{T'}+1\right)\frac{\sin(k\omega_0 T')}{k\omega_0} - \frac{\cos(k\omega_0(T'))}{T'(k\omega_0)^2} - \left(\frac{-0}{T'}+1\right)\frac{\sin(0)}{k\omega_0} + \frac{\cos(0)}{T'(k\omega_0)^2}\right]$$

$$= \frac{2a}{T_0}\left[0 - \frac{\cos(k\omega_0 T')}{T'(k\omega_0)^2} - 0 + \frac{1}{T'(k\omega_0)^2}\right]$$

$$a_k'' = \frac{2a}{T_0}\left[-\frac{\cos(k\omega_0 T')}{T'(k\omega_0)^2} + \frac{1}{T'(k\omega_0)^2}\right]$$

$$a_k = a_k''' + a_k''$$

$$a_k = \frac{2a}{T_0}\left[\frac{2}{T'(k\omega_0)^2} - \frac{2\cos(k\omega_0 T')}{T'(k\omega_0)^2}\right]$$

$$a_k = \frac{4a}{T}\left[\frac{1-\cos(k\omega_0 T')}{T'(k\omega_0)^2}\right]$$

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$$b_n = \frac{2}{T_0}\int_{-T'}^{0} a\left(\frac{t}{T'}+1\right)\sin(k\omega_0 t)\,dt$$

$$+\frac{2}{T_0}\int_{0}^{T'} a\left(\frac{-t}{T'}+1\right)\sin(k\omega_0 t)\,dt$$

$$u = \frac{t}{T'}+1 \qquad u' = \frac{1}{T'}$$

$$v = \sin(k\omega_0 t) \qquad \int v = \frac{-\cos(k\omega_0 t)}{k\omega_0}$$

$$= \left(\frac{t}{T'}+1\right) - \frac{\cos(k\omega_0 t)}{k\omega_0} - \int \frac{-\cos(k\omega_0 t)}{T'(k\omega_0)}\,dt$$

$$= -\left(\frac{t}{T'}+1\right)\frac{\cos(k\omega_0 t)}{k\omega_0} + \frac{\sin(k\omega_0 t)}{T'(k\omega_0)^2}$$

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$$b_k = \frac{2a}{T_0}\left[-\left(\frac{t}{T'}+1\right)\frac{\cos(k\omega_0 t)}{k\omega_0} + \frac{\sin(k\omega_0 t)}{T'(k\omega_0)^2}\right]_{-T'}^{0}$$

$$+\frac{2a}{T_0}\left[-\left(\frac{-t}{T'}+1\right)\frac{\cos(k\omega_0 t)}{k\omega_0} - \frac{\sin(k\omega_0 t)}{T'(k\omega_0)^2}\right]_{0}^{T'}$$

$$= \frac{2a}{T_0}\left[-\left(\frac{0}{T'}+1\right)\frac{\cos(0)}{k\omega_0} + \frac{\sin(0)}{T'(k\omega_0)^2} + \left(\frac{-T'}{T'}+1\right)\frac{\cos(k\omega_0(-T'))}{k\omega_0} - \frac{\sin(k\omega_0(-T'))}{T'(k\omega_0)^2}\right]$$

$$+\frac{2a}{T_0}\left[-\left(-\frac{T'}{T'}+1\right)\frac{\cos(k\omega_0 T')}{k\omega_0} - \frac{\sin(k\omega_0 T')}{T'(k\omega_0)^2} + \left(\frac{0}{T'}+1\right)\frac{\cos(0)}{k\omega_0} + \frac{\sin(0)}{T'(k\omega_0)^2}\right]$$

$$= \frac{2a}{T_0}\left[\frac{-1}{k\omega_0} + 0 + 0 - \frac{\sin(k\omega_0(-T'))}{T'(k\omega_0)^2}\right]$$

$$+\frac{2a}{T_0}\left[-(0) - \frac{\sin(k\omega_0 T')}{T'(k\omega_0)^2} + \frac{1}{k\omega_0} + 0\right]$$

$$= \frac{2a}{T_0}\left[-\frac{1}{k\omega_0} - \frac{\sin(k\omega_0(-T'))}{T'(k\omega_0)^2} - \frac{\sin(k\omega_0 T')}{T'(k\omega_0)^2} + \frac{1}{k\omega_0}\right]$$

$\sin(-\theta) = -\sin\theta$

$$\therefore \frac{2a}{T_0}(0)$$

$$b_k = 0$$

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$$a_0 = \frac{1}{T_0}\int_{-T'}^{0} a\left(\frac{t}{T'}+1\right)dt + \frac{1}{T_0}\int_{0}^{T'} a\left(\frac{-t}{T'}+1\right)dt$$

$$= \frac{a}{T_0}\left[\frac{t^2}{2T'}+t\Big|_{-T'}^{0} + \left(\frac{-t^2}{2T'}+t\right)\Big|_{0}^{T'}\right]$$

$$= \frac{a}{T_0}\left[0+0-\left(\frac{(-T')^2}{2T'}-T'\right) + \left(\frac{-(T')^2}{2T'}+T'-0-0\right)\right]$$

$$= \frac{a}{T_0}\left[-\left(\frac{T'^2}{2T'}+T'\right) - \frac{T'^2}{2T'}+T'\right]$$

$$= \frac{a}{T_0}\left[-\frac{T'}{2}+T' - \frac{T'}{2}+T'\right]$$

$$= \frac{a}{T_0}\left[-T'+2T'\right]$$

$$= \frac{a}{T_0}\left[T'\right]$$

$$a_0 = \frac{aT'}{T}$$

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Task 7:

QRS Wave:

```
N = 50;
a = 1.2;
T = 0.88;
Td = 0.08;
t0 = 0.2;
t = -0.2:1/N/10:1.2;
```

```
k = 1:N;
w0 = 2*pi/T;
a0 = (a*Td)/T;
ak = (4*a/T)*((1-cos(Td*w0.*k))./(Td*k.^2*w0.^2));
% a0 = a/2;
% ak = ((2*a)/Td)*((1/cos(k*Td*(pi/2*Td)))/(Td*(k*(pi/2*Td)).^2));
```

```
xtNq = a0;
for kk=1:N
xtNq = xtNq+ak(kk)*cos((2*kk*pi*(t-t0)/T));
end
figure;
subplot(2,1,1)
plot(t, xtNq, 'linewidth',1);
grid on; xlabel('time(s)');
ylabel('Amplitude(mV)')
title('QRS-wave component of ECG signal');
```

S Wave:

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```
a = -0.2;
Td = 0.08;
t0 = 0.28;
```

```
w0 = 2*pi/T;
a0 = (a*Td)/T;
ak = (4*a/T)*((1-cos(Td*w0.*k))./(Td*k.^2*w0.^2));
```

```
xtNs = a0;
for kk=1:N
xtNs = xtNs + ak(kk)*cos((2*kk*pi*(t-t0)/T));
end
```

```
subplot(2,1,2)
plot(t, xtNs, 'linewidth',1);
grid on; xlabel('time(s)');
ylabel('Amplitude(mV)')
title('S-wave component of ECG signal');
```

ECG Wave:

```
ECG = xtNp + xtNq + xtNs + xtNt + xtNu;
figure; plot(t,ECG, 'linewidth',1)
title ("ECG Wave");
grid on;
```

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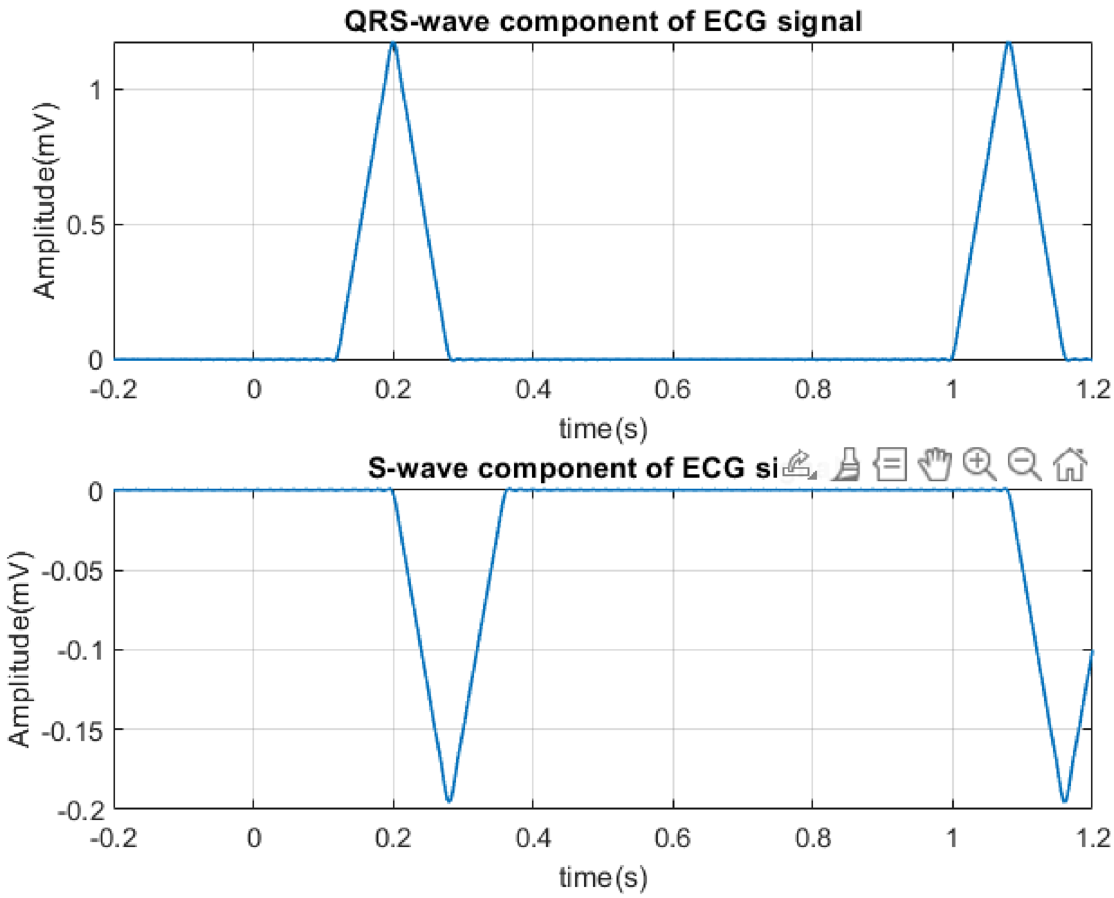

In this we generate and plot two components of an ECG signal: the QRS-wave and the S-wave as well as the combined ECG waveform. The QRS-wave is made using Fourier series approximation with parameters which are its amplitude, duration, and starting time, while the S-wave is similarly maked. Then we combine these components with other ECG components to form the complete ECG waveform