[illegible]
باستخدام الحاسبة الشخصية

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الخلاصة

[illegible] (0.5) [illegible] (100) [illegible] ECG [illegible] ECG [illegible] (IA) [illegible] (BPF) [illegible] (NF) [illegible] (RLDC).

[illegible] (PC) [illegible] (ALS 4000) [illegible] Matlab [illegible] (6.5) [illegible] (ECG) [illegible]

DESIGN AND IMPLEMENTATION OF A SINGLE-CHANNEL ECG MONITOR USING PC

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ABSTRACT

An Electro-Cardio-Graph (ECG) is a device that records the electrical activity of the heart. Skin electrodes placed at designated locations on the body collect ECG measurement information, and from these waveforms different information on heart condition can be derived.

This paper discusses the design and implementation of a single-channel ECG (three-electrode) circuit with a bandwidth of (0.5-100) Hz for patient monitoring purposes. The front end of an ECG must be able to deal with weak signals ranging from few microvolts to few millivolts. An analogue ECG amplifier is designed and implemented using instrumentation amplifier (IA) followed by band pass filter (BPF), then by notch filter (NF) to minimize noise affecting the signal, and a right leg drive circuit (RLDC). .

The ECG data is recorded and analyzed with greater flexibility using personal computer. The (ALS 4000) PC-sound card is used as a data acquisition device. The Matlab program (version 6.5) is employed to acquire data from sound card then digitally processing the signal in order to display the ECG signal on a PC monitor.

[illegible] [illegible]

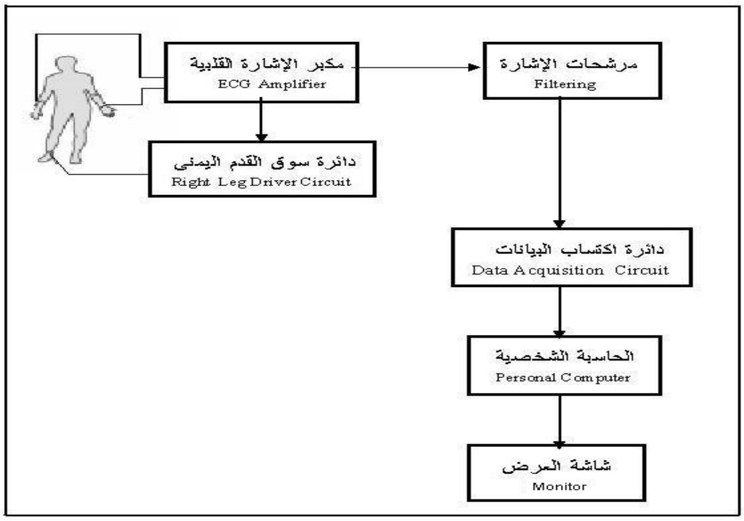
المقدمة

(Electrocardiograph) **(ECG)** **(Surface Electrodes)** **ECG** **National** **Ben Ellis** **(1998)** **(Instruments** **(AT-MIO-16-XT-10))** **(DAC)** **BioBench software)** **ECG** **National** **(Instruments** **.[1]**

D.T. Gleeson **J. Burke Martin** **(2000)** **ECG** **(30)** **(Op Amp)** **(IA)** **(3.3)** **. [2](MAX400)**

Christopher M.Tenedero **(2002)** **(40)** **(0.05)** **ECG** **(Quanser Multi-Q)** **.[3] (5.3** **Matlab**

Enrique **(Hartmann** **Boscg)** **(2003)** **(Company** **(Micro converter)** **.[4] ECG** **(ADuC842)** **ECG** **(IA)** **(Data Acquisition Circuit)** **(6.5** **Matlab** **(ECG** **.(1)**



:(1) ...

.(Analog Device-AD524-) ... (IA) ...

Medical) ... (high precision amplifier) ... (Instrumentations

) ... (Common Mode Rejection Ratio-CMRR

... G_{IA} ... R_G ...

:[5]

$$G_{IA} = \frac{40K}{R_G} + 1 \qquad \text{……………….(1)}$$

... R_G ...

.($R_G = 375\Omega$) ... (107.6) ...

... ECG ...

(100 ... 0.5) ...

. (Monitoring applications) ... ECG ...

(2) ...

(LPF) ... (HPF) ...

(0.5) ... (HPF) ...

:...

$$f_{hc} = \frac{1}{2\pi R_i C_i} \qquad \text{…………….(2)}$$

[illegible] $68\mu F$ [illegible] C_i [illegible] $4.7k\Omega$ [illegible] R_i [illegible] (**LPF**) [illegible] . $f_{hc}=0.498Hz$ [illegible] (**100**) [illegible] (**low cutoff frequncy**) f_{lc} [illegible]:

$$f_{lc}=\frac{1}{2\pi R_f C_f} \qquad \text{.....................}(3)$$

$16nF$ [illegible] C_f [illegible] $100k\Omega$ [illegible] R_f [illegible] . $f_{lc}=99.742Hz$ [illegible]

$$0.498\ Hz \le f \le 99.742\ Hz$$

[illegible] (**Active Filter**) [illegible] G_{BPF} [illegible]:

$$G_{BPF}=\frac{R_f}{R_i}=\frac{100*10^3}{4.7*10^3}=21.276 \qquad \text{....................}(4)$$

[illegible] (**50 Hz power line interference**) [illegible] (**ECG**) [illegible] (**notch filter**) [illegible] (**Twin-T**) [illegible] [**6**] [illegible] (**2**) [illegible] $R1=R2=R3/2$ [illegible] $C1=C2=2C3$ [illegible] f_{notch} (**Notch Frequency**) [illegible]:

$$f_{notch}=\frac{1}{2\pi R_2 C_2} \qquad \text{.............}(5)$$

[illegible] $R_2=32K\Omega$ [illegible] $C_2=100nF$ [illegible]:

$$f_{notch}=\frac{1}{2*\pi*32*10^3*100*10^{-9}}=49.76Hz$$

[illegible] (**Common Mode Noise Signal**) [illegible] (**right leg driver circuit -RLDC**) [illegible] (**2**) [illegible] [**4**] [illegible] (**IA**) [illegible] R_G [illegible] :[**4**]

$$R_G=Rb//(2*Ra) \qquad \text{..............}(6)$$

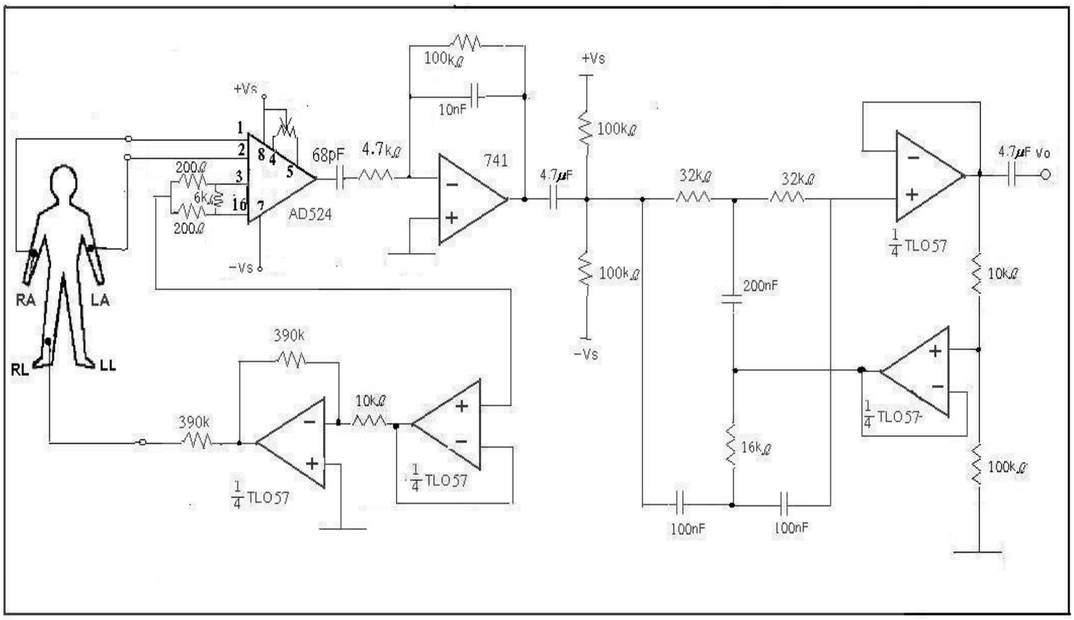
[illegible] $6k\Omega$ [illegible] **Rb** [illegible] 200Ω [illegible] **Ra** [illegible]
: [illegible] **(IA)** [illegible]

$$R_G = 6k\Omega \,//(2 * 200) = 375\Omega$$

[illegible] (G_{total}) [illegible]
:(G_{BPF}) [illegible] (G_{IA})

$$G_{total} = G_{IA} * G_{BPF}$$

$$\therefore G_{total} = 107.3 * 21.276 = 2282.9148$$



.[illegible] :**(2)** [illegible]

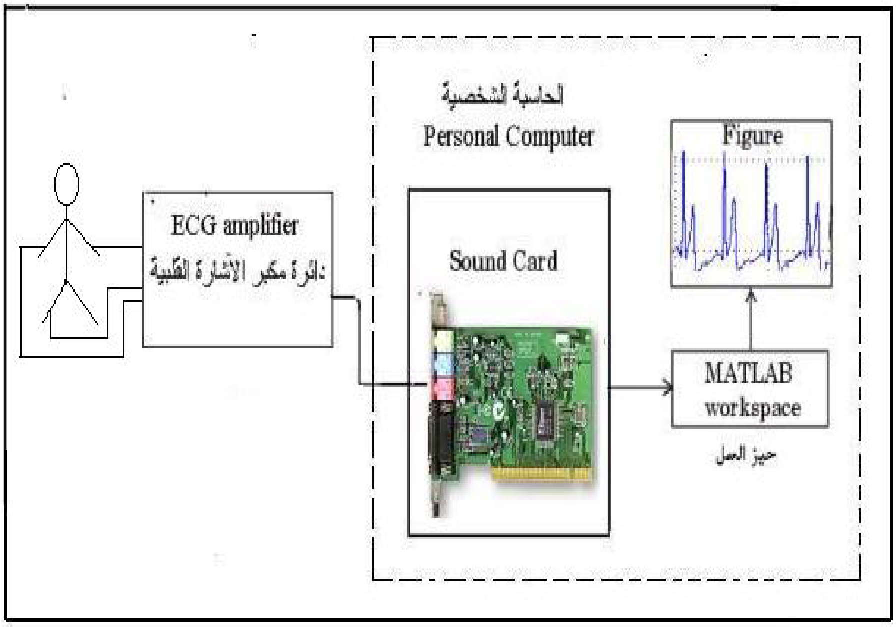
[illegible]

[illegible] **digital signal**) [illegible] (**analog signal**) [illegible] **–ADC)** [illegible] (**Data -DAC)** [illegible] **(Analog to Digital Converter** [illegible] (**Acquisition Circuit** [illegible] **(easy acceptable**) [illegible] (**sound card**) [illegible] .(**low cost**) [illegible]

[illegible] **(cost)** [illegible] **.(efficiency)** [illegible]

[illegible] **(ALS 4000)** [illegible] **(sound card)** [illegible] **(ADC)** [illegible] **(16)** [illegible] **(-5)** [illegible] **(5)** [illegible] **PCI** [illegible] **Peripheral)** **Component Interconnect)[7].** [illegible] **(new hardware)** [illegible]

[illegible] **(output)** [illegible] **(ECG amplifier)** [illegible] **(Line-In)** [illegible] **Data Acquisition)** [illegible] **(Toolbox** [illegible] **Matlab** [illegible] **(6.5-** [illegible] **[8]** [illegible] **(ECG** [illegible] **(sampled data)** [illegible] **(work space)** [illegible] **(3)** .



[illegible] **ECG** [illegible] **(3)** [illegible]

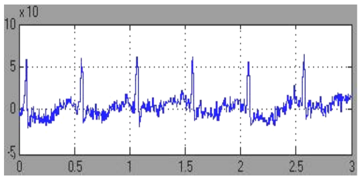
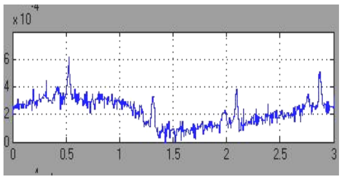
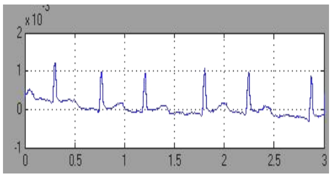
[illegible]

[S fs]=daqrecord (‘time’, ‘sampling frequency’)

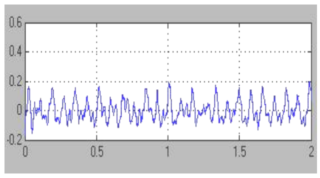
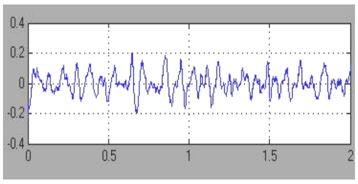
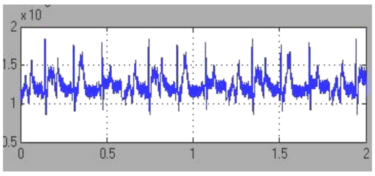
[illegible] **(array)** [illegible] **[S.mat]** [illegible] **(work space)** [illegible] **(Matlab)** [illegible] **"time"** [illegible] **ECG** [illegible] **"fs"** [illegible] **(sampling frequency)** [illegible] **(time)** [illegible] **(5)** [illegible] **fs** [illegible] **8** [illegible]

[illegible]

[illegible] **ECG** [illegible] **(analog signals)** [illegible] **(digital signal)** [illegible] **(arrays)** [illegible] **(work space)** [illegible] **Matlab** [illegible] **(6.5** [illegible]**)** [illegible] **(4)** [illegible].

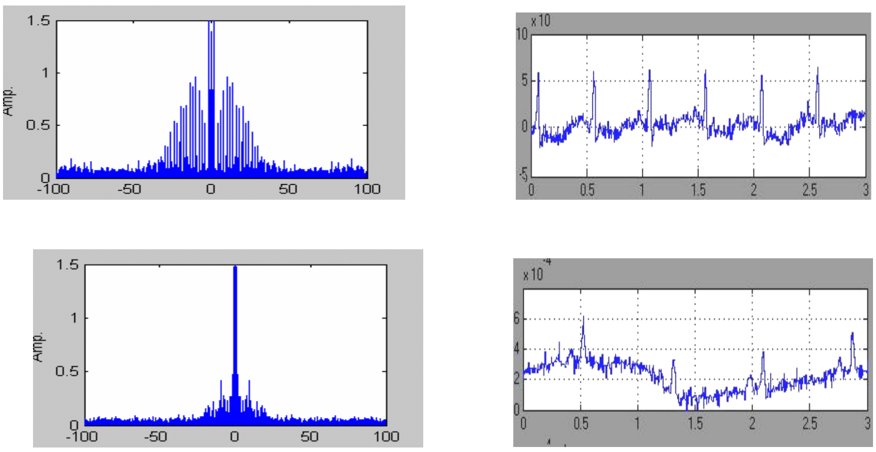
-1- -2- -3-

-4- -5- -6-

[illegible] **(4)**: [illegible].

[illegible] **(spectral analysis)** [illegible] **ECG** [illegible] **(4)** [illegible] **(2)** [illegible] **(simulation)** [illegible] **Matlab** [illegible] **(5)**.



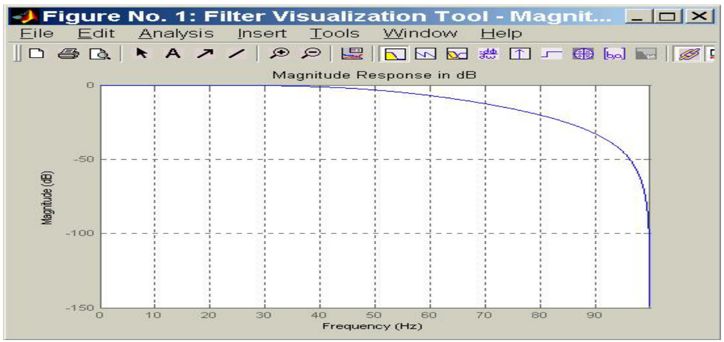
[illegible] **(5)**: [illegible].

[illegible] **(5)** [illegible] **ECG** [illegible] **50** [illegible] **Matlab** [illegible] **Simulink** [illegible] **ECG** [illegible] **(Digital Filter Design)** [illegible] **(Digital Filters)** [illegible] **(Digital Filter Design Unit)** [illegible] **(DSP block set)** [illegible] **(simulink)** [illegible] **Matlab** [illegible] **(6.5)** [9].

[illegible] **(IIR)** [illegible] ($f_s = 200 sample / second$ [illegible] **r=0.7**) [illegible] ($f_c = 49 Hz$) [illegible] **H(z)** [illegible] :

$$H(Z)=\frac{1+2Z^{-1}+Z^{-2}}{1-0.043975Z^{-1}+0.49Z^{-2}}$$

[illegible] **(6)**.

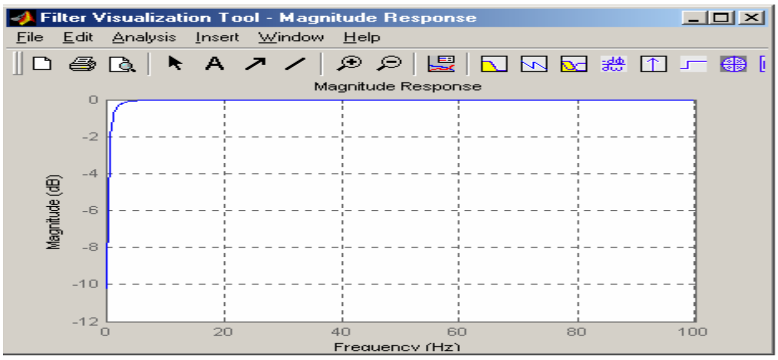


[illegible] **(6)**: [illegible] **(LPF)** [illegible] **IIR**.

(slow baseline wander) [illegible] **ECG** [illegible] **(DC)** [illegible] **(0.5)** [illegible] [4] [5] [illegible] **(HPF)** [illegible] **(IIR)** [illegible] **(0.5)** [illegible] **H(z)** [illegible]:

$$H(Z)=\frac{1-2Z^{-1}+Z^{-2}}{1-1.3998272\,Z^{-1}+0.49Z^{-2}}$$

[illegible] **(7)** [illegible].



.IIR ƠNjǖ ĎžĎž (HPF) ƕĭǁFyǁǫ l ǫǭǭβǂǁǫ η⌈βĎžǁ ǭǭβǂǁǫ ƕǤǛǀǂ ƨ ǫ:(7)üǀ⌈ǁǫ

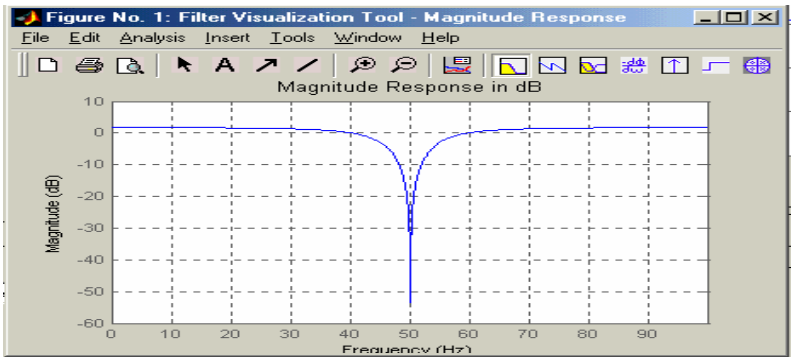
ƕøĭǂĎžY üøǤǃ ƧƑø ƨŮǫ ƯǭǁǫƑ Ĭƺ ƺ ǫβƟǖǫ ĂǂY ăNjǂƟǂ Ĭǂǁǫ Nj **ECG** γβƑ⌈ǡ **(8)** üǀ⌈ǁǫ ĎžĭǤĭ Nj
.ƑljǭyǤNj ηĭ⌈βǂǁǫ

ƧƑƨŮǫ ƯǭǁƑǤ ƺ ǫβƟǖǫ ĂǂY ăNjǂƟǂ ηĭ⌈βǂǁǫ üǤǃ **ECG** γβƑ⌈ǡ - ǥ:**(8)**üǀ⌈ǁǫ
(HPF) ƕĭǁFyǁǫ l ǫǭǭβǂǁǫ η⌈βĎž !ǫǭǁǂ ƨ ǫ ǭyǤ **ECG** γβƑ⌈ǡ - ƒ

(50) ǀǀβǫǭsĎž ƕĎžǂǩ ǭǭβǂ ăƤ **(Digital Notch Filter)** ĬĎžƺβ ĬĎžǂǩ η⌈βĎž Ƥĭƺǖǂ Nj !ĭĎžTǂ !ǂ ƑĎžǀ
:ƕǃűyǁǫ ƒ ƨ Θ **H(z)** üĭNjΘǂǁǫ ƕǁǫǭ ĂƯyǂ ƘĭΘ γβƑ⌈Ǖǫ ĎžǀǫǀǂĎž ǂ ĬsǤĎžĎžǁǫ βǭTĎžǁǫ ǭǭβǂ βĭǩΘǂ ƕǁǫ RŨ Rǂβĭǀj

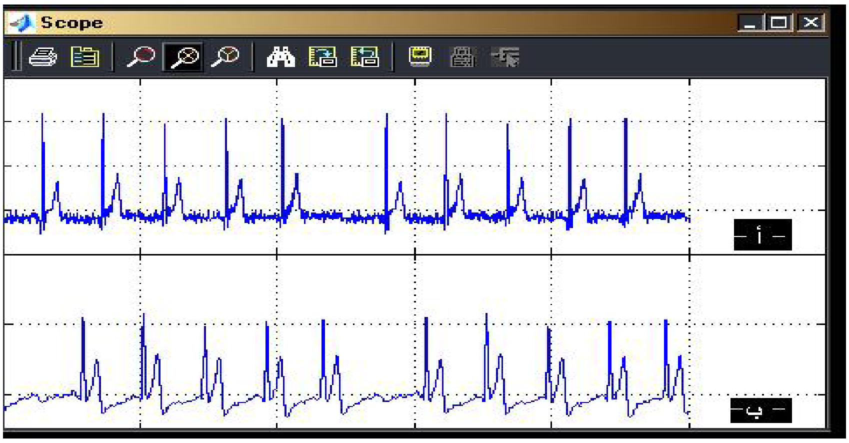
$$H(z)=\frac{1+Z^{-2}}{1+0.49Z^{-2}}$$

.(9) üǀ⌈ǁǫ Ĭƺ ĎžĭǤĎž ƑĎžǀ η⌈βĎžǁǫ ǫPNǁǁ ǭǭβǂǁǫ ƕǤǛǀǂ ƨ ǫ lǖƑǀ Nj



.(Notch Filter) ĬDŽǂǁǁ ŋ ĺ þDŽǂǁ ǫǫþǂǁǁ ƕǤƑƜǂ ƨƐ:(9)üǀ ĺ ǁǁ

.ƑǉǫƴǤŅǰ ƔþǫşǁǁƐ þǫ T DŽ üǪƐǫǂ DŽDŽ ŋǐ ĺ þǂǁǁ ƕǐǂDŽƳ üǤƷ **ECG** ƔþƑ ĺ ƌ **(10)** üǀ ĺ ǁǁ DŽǐǤǏǰ

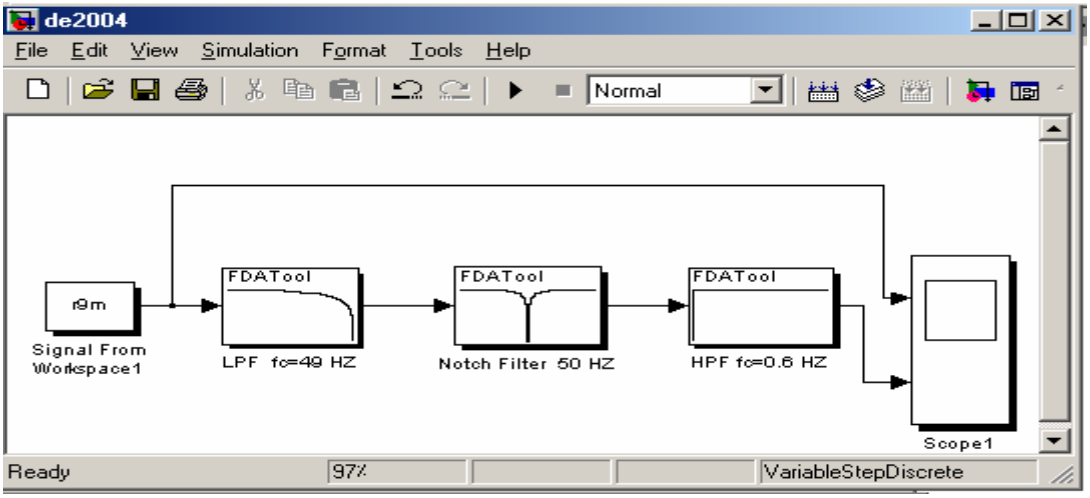


ŖǂþǐǀǰǓ **50** þǫ T DŽǁǁ ǫǫþǂ ŋǐ ĺ þǂ üǤƷ **ECG** ƔþƑ ĺ ƌ - ƈ:**(10)** üǀ ĺ ǁǁ

þǫ T DŽǁǁ ǫǫþǂ ŋǐ ĺ þǂ ǫƴǤ **ECG** ƔþƑ ĺ ƌ - ƒ

üøǂǀ ƕƯø ƨƐǋǰǤ ƑǉDƑǖǤ !ǂ Ĭǂǁǁ **(digital filters)** ƕǐDŽƽþǁǁ ǀ ƑƟ ĺ þDŽǁǁ **(11)**üǀ ĺ ǁǁ DŽǐǤǏ ǋǰ

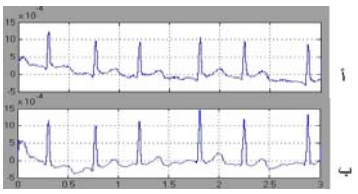
.**Matlab** ƛDŽƑǖþǤǁ **(Simulink)** ǀ ƑǏǯDŽþǤǁǁ



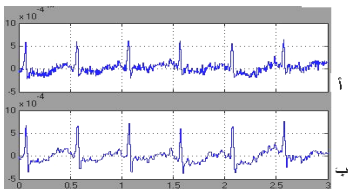
) lƒøĭŰŰŽƥĞŰŁ üøł hUƠøƨ€NjĞ hŰŽŰŽTøŰŽŰŁ€Nj hŰŽqŰHƨøŰŽŁ høĭŰŽsƥŁ lƒΘølƥŰŽŁ :**(11)**ül løŁ
.Matlab ĂŰŽFŭƥĞŰ**(Simulink**

lƑŰŰFŦŭŦƨÛ€Nj ĂəFŦŭŁ

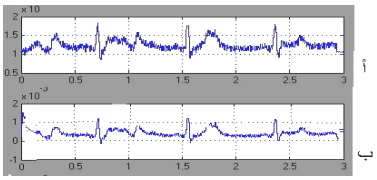
njqŰŽ DŽƑĬĞŰ **(4)** ül łŁ Ĭȝ hŰŭĬĞŰŽŁ ĬĞ↓sŁ UĭŰƠŰHŁ l€ƥƒlą DŽŰŽ hUYNjŰŽŰŰŽ Ă↓Y !ƒưŭŽŁ €Plj ƁĭĞŰ↓ !Ł üł løŁ Ĭøȝ DŽĭøĞŰŽ ƑŰŽł ĂəFŦŭŁ l ŭƒ!Nj l€ƥƒlŰ€ LJPlj Ă↓Y ƳƥkDŰŽŁ bƑTNjTŁ hŰŽĭs DŽŰŽ üĭ↓sŦŁ Ĭȝ LjŦbƒƨł **.(12)**



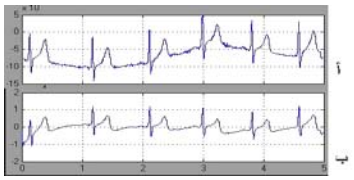
-2-



-1-



-4-



-3-

ƳƥəƐqŁ DŽŰŽ ƑNŭĭ↓Y üNjTΘŁ !Ł ĬŦŁ **ECGs** *ƒ↓s*Ł UĭŰƠŰH l€ƥƒlą DŽŰŽ hUYNjŰŽŰŰŽ:**(12)**ül łŁ
.nĭlƥŦŁ hŭĭŦŰŽY qƴĞ - *ƒ* Ûnĭlƥŭ€ hŭĭŦŰŽY üĞs-ć :hUĭĞ↓sŁ Ƴƥƒlŭ€ pĞ!ŰŽŭ hŭĭŦŰŽyŁ

DŽøŰŽ ƒøNŭŦĭs↓ŦŭNj **ECG** l€ƥƒølą DŽŰŽ qqY nĭlƥŦ DŽć LJúYć Ĭȝ **(12)** ül łŁ DŽŰŽ ưΘŦŭ
DŽŰŽ hUƨƨ Ă↓Y ăNjŦΘŦ üƐRŦ ƑŰŽ **(4)**Ƴƥƒlŭ€ DŽć DŽĭΘ Ĭȝ Û bƐ! ụ!lƴĞ !Ł qs **(3**Nj**2**Nj**1** l€ƥƒlŭ€**)** bƑTNjTŁ €PljNj bƑTNjTŁ DŽŰŽ hŭŁƒY hɵĭĞ Ĭȝ l↓ŁŁ qs **ECG** Ƴƥƒlą DŽć pŁP Ĭȝ *ƒ*Ğƨ DŽNj!ĭ DŽć DŽ!DŽĭNj ÛbƑTNjTŁ Ăø↓Y *ƒ*ø↓ƷŦŁ !ø↓ Nj↓ȝ .**ECG** Ƴƥƒlą Ă↓Y ƥkDŦ ĬŦŁ bƑTNjTŁ ƱƐNjŭć UĭŰŽŁ Ă↓Y ƳƥUĭƨŁ hUĞNjyT ƥƨ2ĭ ƥƒTøŰŽ Ăø↓Y ƳƥUĭƨøŁ høƐŁƑĞŁ hUĞNjyTøŁ DŽŰŽ Dŭȝ Û(DŽƒƨŭƑĞ hUĭΘŰŽŁ) hɵŁƥƑQŁ bƑTNjTŁ ƥƒTŰŽ

ƖƑƟøƪƥƊǇƐ ƔƀƑø2Ɩ Ɩ øƺƚƠ ƑøƊǇƝƊǇƺ ƐƤøƖ Ʊ(ƊǇƑƨƸǕƖ ƮƜƝǀƝƘƦ2Ɛ ƒƮƖƥƗƐ ƊǇƊǇ ƕƜƗƑƸƐ) ƕƮƗƑƮƟƐ ƋƑƮƝƮƐ
ƊǇøƖƝ **ECG** ƔƥƑøƪƌ ǍƗƔ ƔƥƙƊǇƐ ƋƑƮƝƮƐ ƕƊǇƽ ƊǇƊǇ ƥƮƠƖ ƣƟ ǍƖƌ ǕƮƚƗƐ ǍƗƔ ǕƊǇƴƗ ƑƝǇƺ ƕƊǇƣƗƨƊǇƐ
ƕƾƮƾƟ ǍƾƠƗ ƊǇƖƝ . ƔƥƊǇ ƊǇƊǇ ƥƙƖƠ ƯƮƯƣƗƐ ƔƣƑƔƌ ǍƖƌ ƵƑƮƗ ƣƽ ƒƠƨƐ ƐƤƝƖƝ ƮƏƑƝǇ ƝƟǇ ǍƗƔ ƑǉƀƑƺƌ ƧƮƖ
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