Electrodes

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This code was developed by Miodrag Bolic for the book PERVASIVE CARDIAC AND RESPIRATORY MONITORING DEVICES: https://github.com/Health-Devices/CARDIAC-RESPIRATORY-MONITORING

```
main_path=fileparts(which('Main_Content.mlx'));
if ~isempty(main_path)
    %addpath(append(main_path,'/Chapter2'))
    cd (append(main_path,'/Chapter2/Electrodes'))
    addpath(append(main_path,'/Service'))
end
SAVE_FLAG=0; % saving the figures in a file
```

Introduction

In this notebook we will show different models of the electrodes as well as the interface between the skin and the electrodes.

Connecting two wet electrodes

```
load('ecg.mat')
model_name = 'ConnectingWetElectrodes';
open_system(model_name);


%blockHandle = get_param('ConnectingWetElectrodes/ElectrodeSkinModel2/Rep', 'Handle')
%block = get(blockHandle);
```

Potential difference for the same electrodes and skin parameters

```
set_param('ConnectingWetElectrodes/ElectrodeSkinModel2/Rep','R','500')
set_param('ConnectingWetElectrodes/ElectrodeSkinModel1/Rep','R','500')
set_param('ConnectingWetElectrodes/Zero','Value','0')
```
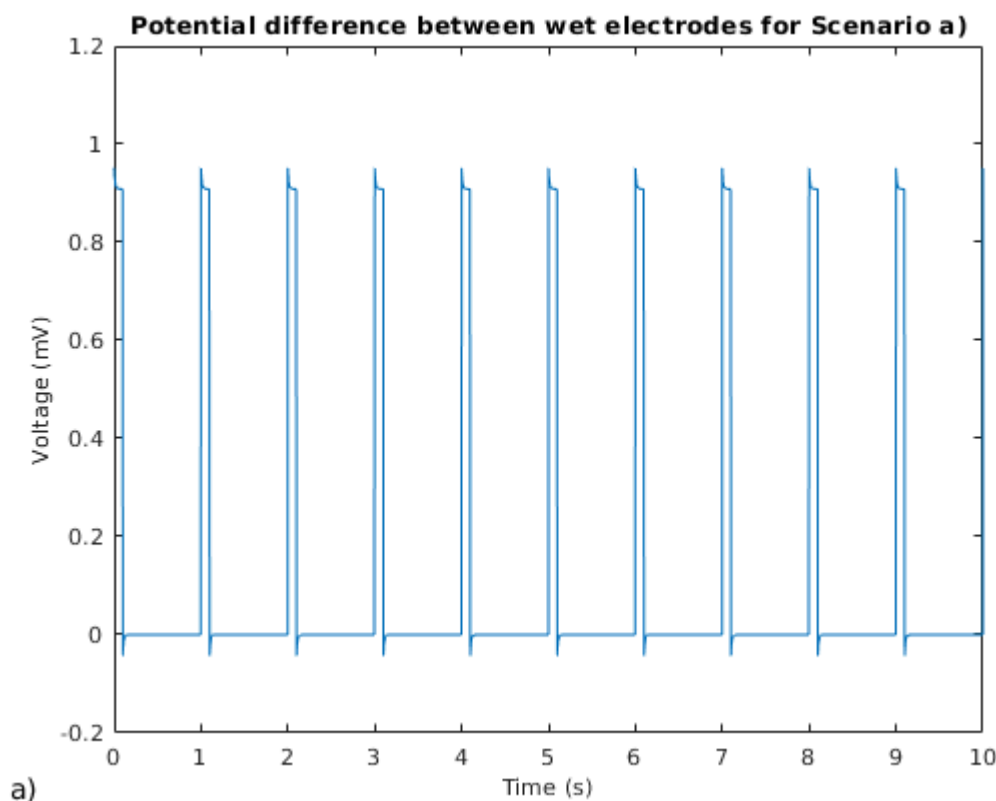
```
s=sim(model_name)
```

```
s =
  Simulink.SimulationOutput:

             simout: [1x1 timeseries]
               tout: [100001x1 double]

     SimulationMetadata: [1x1 Simulink.SimulationMetadata]
          ErrorMessage: [0x0 char]
```

```
figure
plot(s.simout.Time, s.simout.Data*1000)
xlabel('Time (s)', 'FontSize', 10)
ylabel('Voltage (mV)', 'FontSize', 10)
ylim([-0.2, 1.2])
title("Potential difference between wet electrodes for Scenario a)")
annonation_save('a)',"Fig2.12a.jpg", SAVE_FLAG);
```


a)

Potential difference for the same electrodes and skin parameters

```
Rep=get_param('ConnectingWetElectrodes/ElectrodeSkinModel2/Rep','R')
```

```
Rep =
'500'
```

```
set_param('ConnectingWetElectrodes/ElectrodeSkinModel2/Rep','R','251')
s=sim(model_name)
```

```
s =
```

```
   Simulink.SimulationOutput:

             simout: [1x1 timeseries]
               tout: [100001x1 double]

   SimulationMetadata: [1x1 Simulink.SimulationMetadata]
         ErrorMessage: [0x0 char]
```
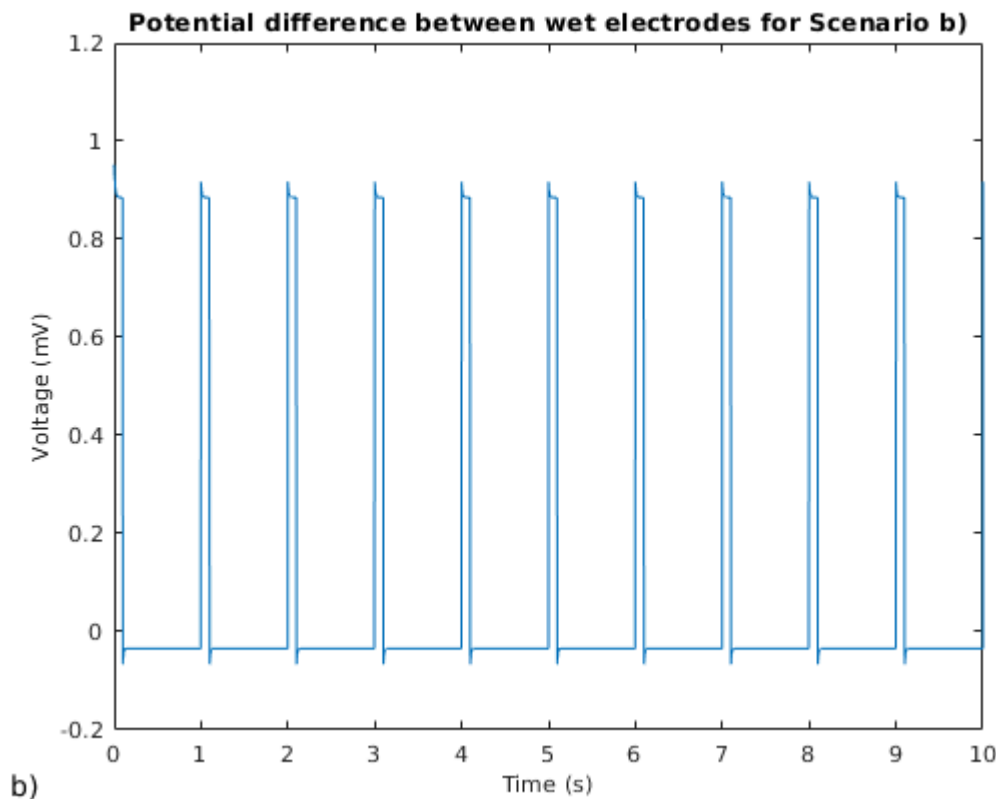
```
figure
plot(s.simout.Time, s.simout.Data*1000)
xlabel('Time (s)', 'FontSize', 10)
ylabel('Voltage (mV)', 'FontSize', 10)
ylim([-0.2, 1.2])
title("Potential difference between wet electrodes for Scenario b)")
annonation_save('b)',"Fig2.12b.jpg", SAVE_FLAG);
```


b)

After skin abrasion, epidermal resistances are 5kOhm and 10kOhm

```
%Rep=get_param('ConnectingWetElectrodes/ElectrodeSkinModel2/Rep','R')
set_param('ConnectingWetElectrodes/ElectrodeSkinModel2/Rep','R','5')
set_param('ConnectingWetElectrodes/ElectrodeSkinModel1/Rep','R','10')
s=sim(model_name)
```
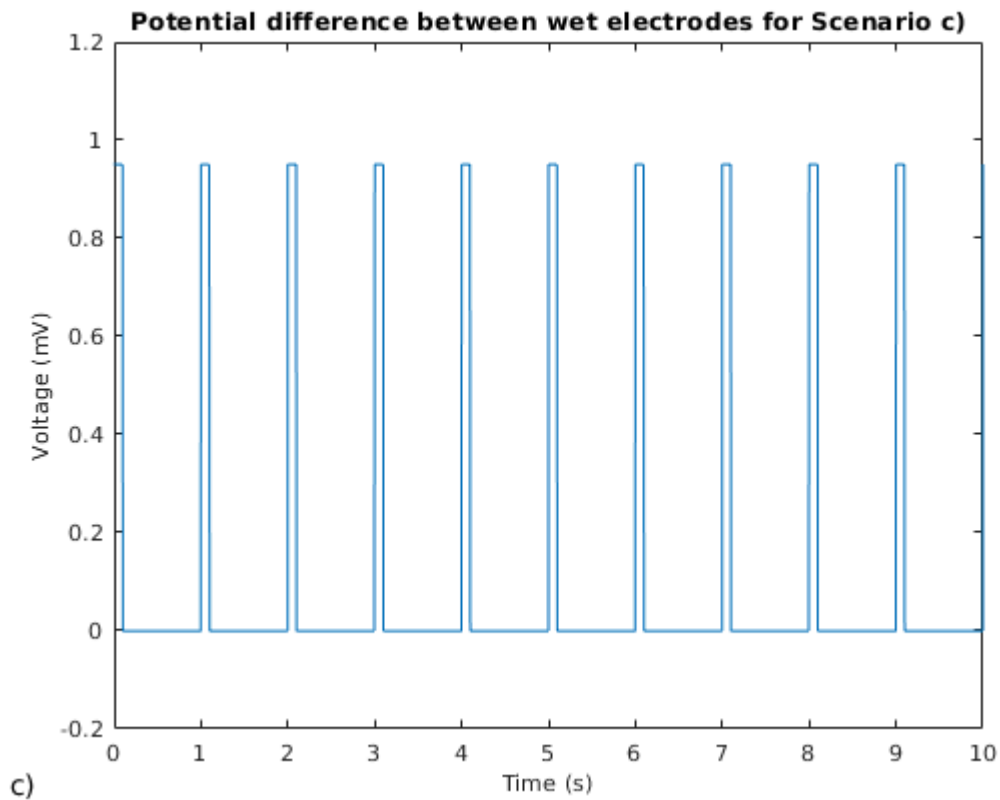
```
s =
  Simulink.SimulationOutput:

             simout: [1x1 timeseries]
               tout: [100001x1 double]
```

```
    SimulationMetadata: [1x1 Simulink.SimulationMetadata]
           ErrorMessage: [0x0 char]
```

```matlab
figure
plot(s.simout.Time, s.simout.Data*1000)
xlabel('Time (s)', 'FontSize', 10)
ylabel('Voltage (mV)', 'FontSize', 10)
ylim([-0.2, 1.2])
title("Potential difference between wet electrodes for Scenario c)")
annonation_save('c)',"Fig2.12c.jpg", SAVE_FLAG);
```


c)

After turning on sweat:

```matlab
%Rep=get_param('ConnectingWetElectrodes/ElectrodeSkinModel2/Rep','R')
set_param('ConnectingWetElectrodes/ElectrodeSkinModel2/Rep','R','500')
set_param('ConnectingWetElectrodes/ElectrodeSkinModel1/Rep','R','500')
set_param('ConnectingWetElectrodes/Zero','Value','1')
s=sim(model_name)
```

```
s =
  Simulink.SimulationOutput:

            simout: [1x1 timeseries]
              tout: [100001x1 double]
```

        SimulationMetadata: [1x1 Simulink.SimulationMetadata]
            ErrorMessage: [0x0 char]

```
figure
plot(s.simout.Time, s.simout.Data*1000)
xlabel('Time (s)', 'FontSize', 10)
ylabel('Voltage (mV)', 'FontSize', 10)
ylim([-0.2, 1.2])
title("Potential difference between wet electrodes for Scenario d)")
annonation_save('d)',"Fig2.12d.jpg", SAVE_FLAG);
```

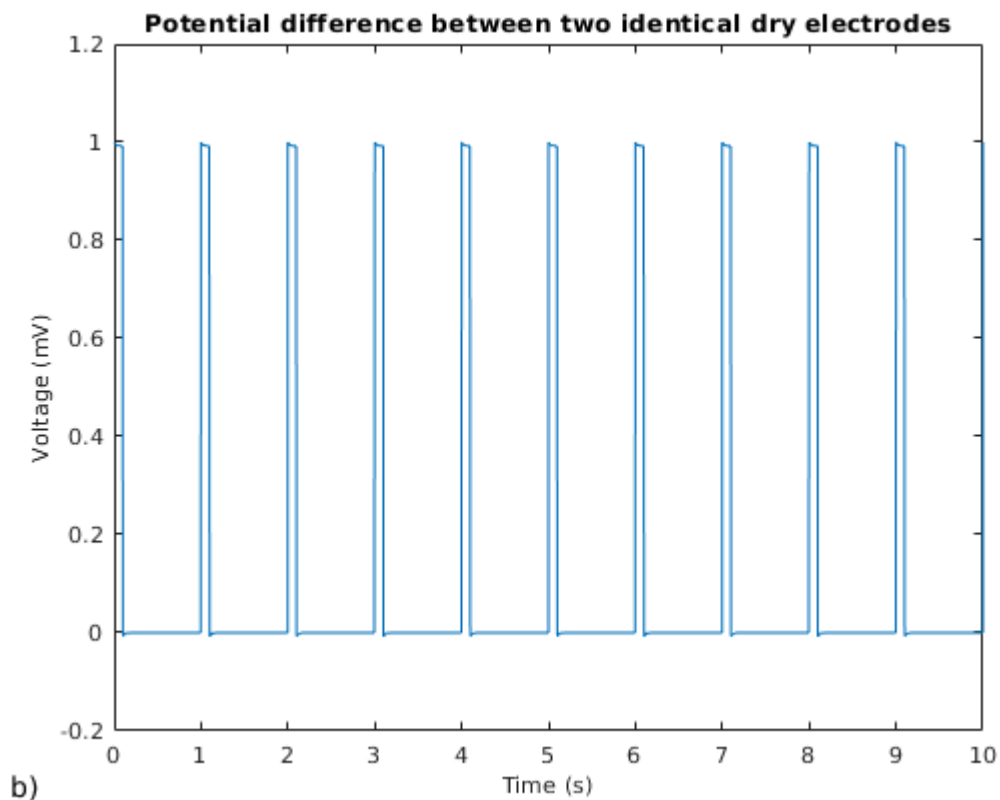Potential difference between wet electrodes for Scenario d)

d)
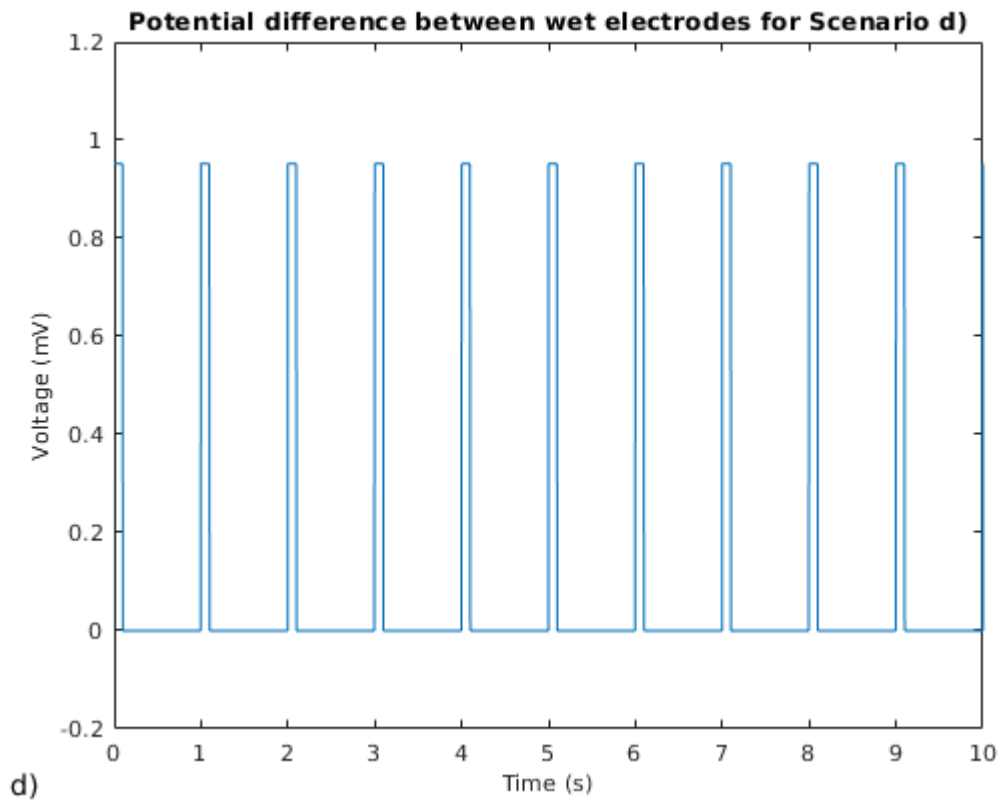
Dry electrode

```
model_name = 'ConnectingDryElectrodes';
open_system(model_name);
```

```
s=sim(model_name);
figure
plot(s.simout.Time, s.simout.Data*1000)
xlabel('Time (s)', 'FontSize', 10)
ylabel('Voltage (mV)', 'FontSize', 10)
ylim([-0.2, 1.2])
title("Potential difference between two identical dry electrodes")
```

```
annonation_save('b)',"Fig2.13b.jpg", SAVE_FLAG);
```
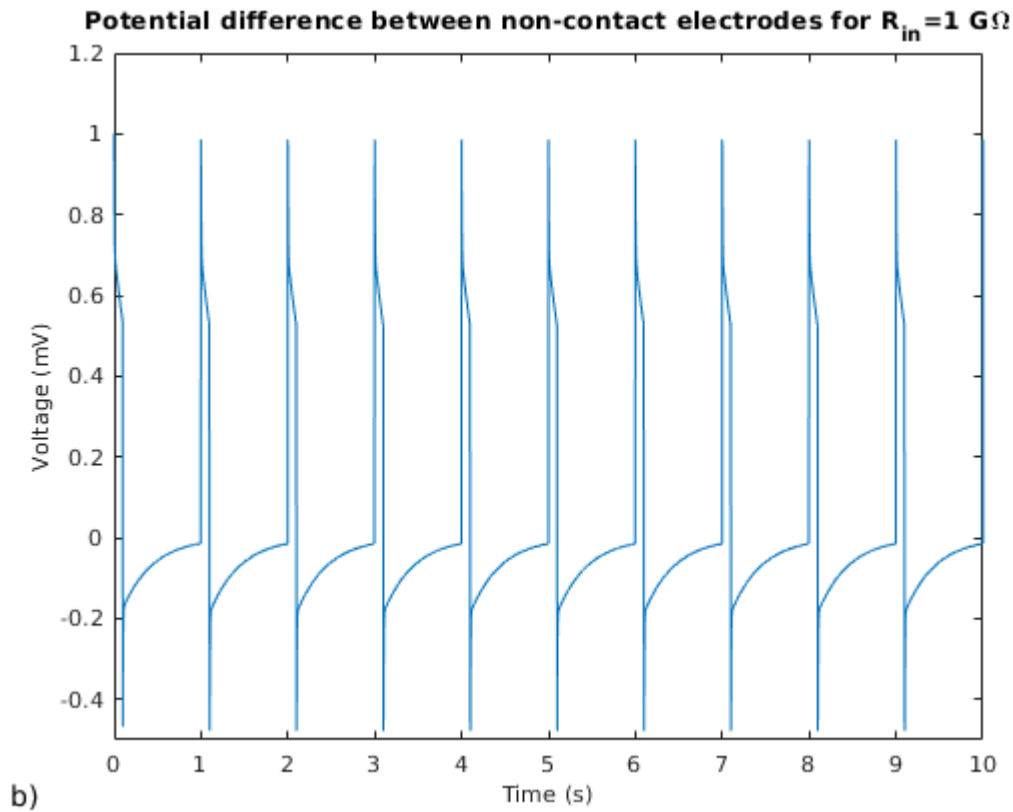

b)

Non-contact electrode

```
model_name = 'ConnectingNoContactElectrodes';
open_system(model_name);
```
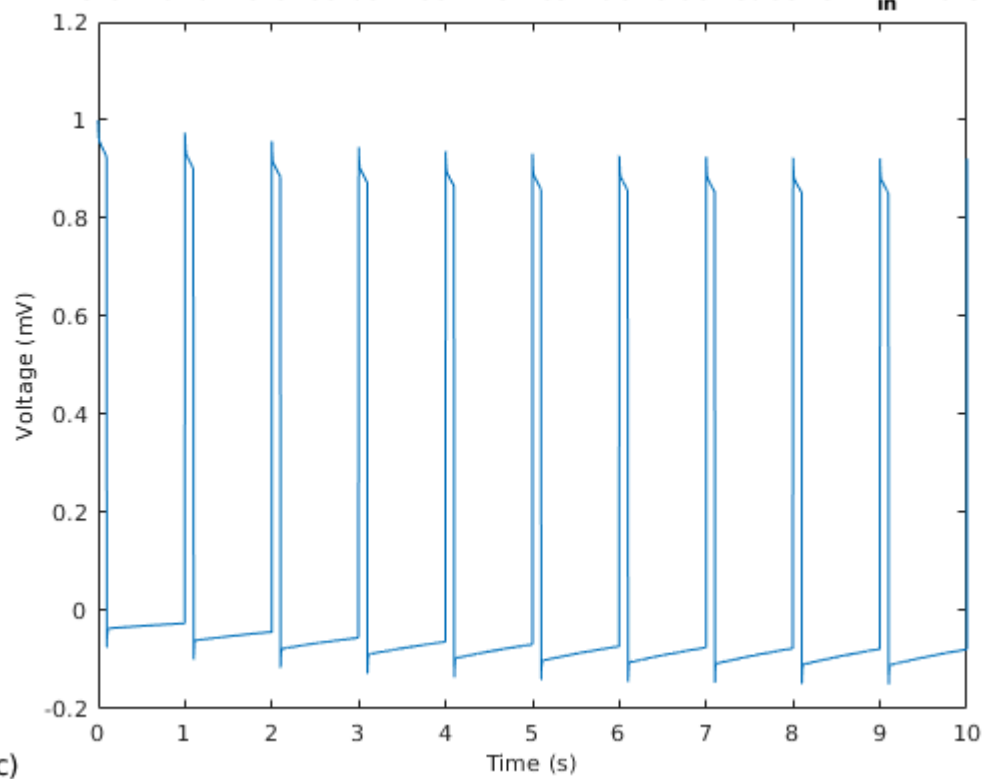
Simulation with Rin=1GOhm

```
set_param('ConnectingNoContactElectrodes/Rin','R','1')
s=sim(model_name);
figure
plot(s.simout.Time, s.simout.Data*1000)
xlabel('Time (s)', 'FontSize', 10)
ylabel('Voltage (mV)', 'FontSize', 10)
ylim([-0.5, 1.2])
title("Potential difference between non-contact electrodes for R_{in}=1 G\Omega")
annonation_save('b)',"Fig2.14b.jpg", SAVE_FLAG);
```

Potential difference between non-contact electrodes for R$_{in}$=1 GΩ

b)

Simulation with Rin=1GOhm

```
set_param('ConnectingNoContactElectrodes/Rin','R','10')
s=sim(model_name);
figure
plot(s.simout.Time, s.simout.Data*1000)
xlabel('Time (s)', 'FontSize', 10)
ylabel('Voltage (mV)', 'FontSize', 10)
ylim([-0.2, 1.2])
title("Potential difference between non-contact electrodes for R_{in}=10 G\Omega")
annonation_save('c)',"Fig2.14c.jpg", SAVE_FLAG);
```

Potential difference between non-contact electrodes for R_{in}=10 GΩ

c)