Energy Detection in Time Domain

This example shows you how to detect the energy of a discrete-time signal over a finite interval using the RMS (Root Mean Square) value of the signal. By defintion, the RMS value over a finite interval $-N \le n \le N$ is given by :

$$RMS = \sqrt{\frac{1}{2N+1}\sum_{-N}^{N}|x(n)|^2}$$

The enrgy of a discrete-time signal over a finite interval $-N \le n \le N$ is given by :

$$\mathrm{E}_N = \sum_{-N}^{N}|x(n)|^2$$

To determine the signal energy from RMS value, square the RMS value and multiply the result by the number of samples that are used to compute the RMS value.

$$E_N = RMS^2 \times (2N+1)$$

To compute the RMS value in MATLAB and Simulink , use the moving system object and block, respectively.

For the moment we will not use this method, instead we recommand to use Mathematic formula of Energy and try to implement it in MATLAB.

I- Detect Signal Energy

This example shows how to compute the energy of a signal by applying the Energy formula. So, we will start coding it in MATLAB as shown below :

$\mathrm{E}_N = \sum_{-N}^{N}|x(n)|^2$ Energy Formula : $(2N+1)$: Number of samples

: $|x(n)|$: Module of samples

For an algorithm very efficient we start to calculate the square of all the samples and add them each element with the previous elements.

```
clear
load ToneParameters.mat
```

```
squareSinusPulse = abs(sinusPulse).^2;  % |x(i)|

Energy(length(sinusPulse)) = 0;         % Initialize the Energy buffer
```

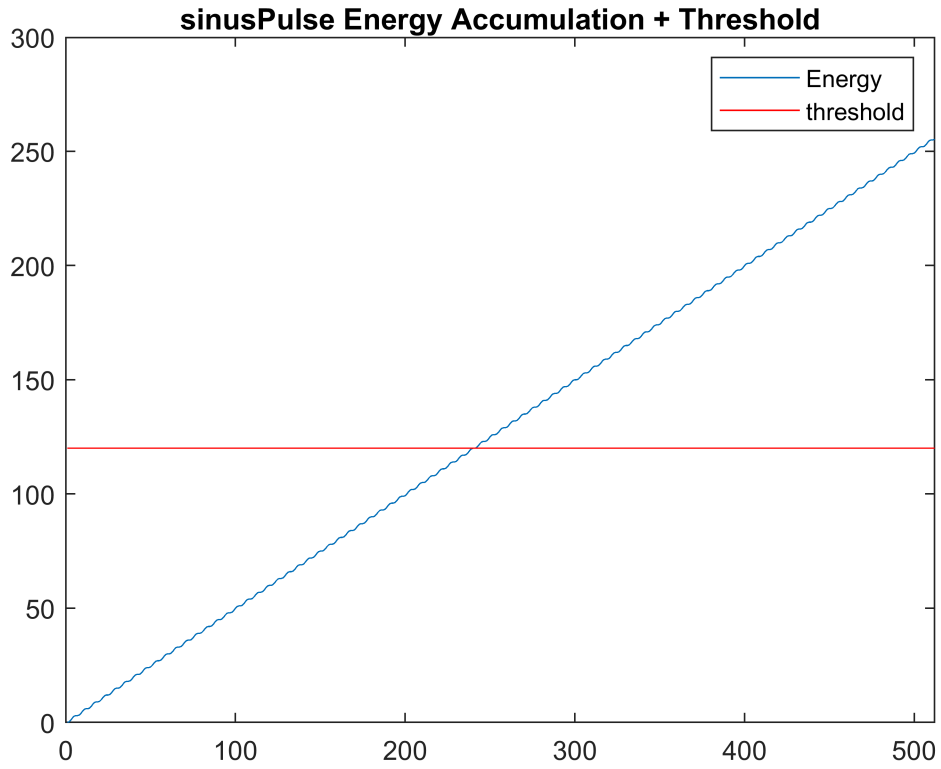
```
Energy(1) = squareSinusPulse(1);

for i = 1:length(sinusPulse)-1
    Energy(i+1) = Energy(i) + squareSinusPulse(i+1);    % Sweep each element of the array
end
```

Choose a random threshold to compare it with Energy values then plot the boolean signal.

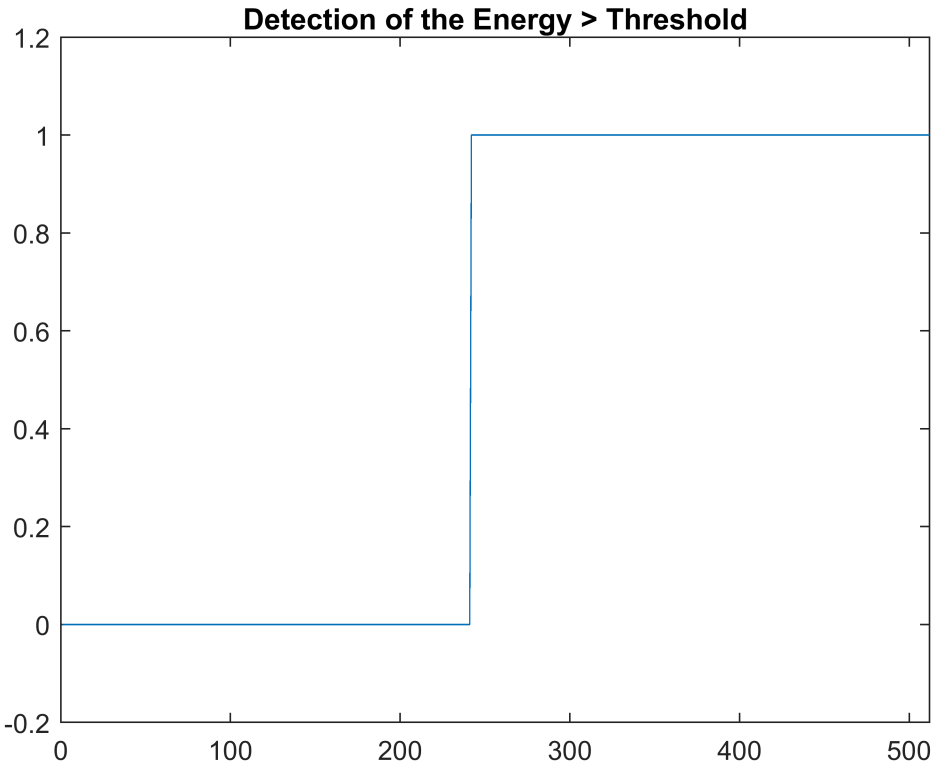
```
threshold(length(sinusPulse)) = 0;  % Initialize the array of threshold
for i = 1:length(sinusPulse)
    threshold(i) = 120;         % random threshold
end
```

```
plot(Energy)
hold on
plot(threshold,'r')
xlim([0 length(sinusPulse)])
title('sinusPulse Energy Accumulation + Threshold')
legend('Energy','threshold')
hold off
```




```
event = Energy >= threshold;        % event = 1 if Energy value >= threashold
```

```
                                    % event = 0 if Energy value < threashold
plot(event)
title('Detection of the Energy > Threshold')
xlim([0 length(sinusPulse)])
ylim([-.2 1.2])
```



References :

- https://www.idc-online.com/technical_references/pdfs/data_communications/ENERGY%20DETECTION.pdf
- https://www.mathworks.com/help/dsp/ug/energy-detection-in-time-domain.html