**3.2- Ventricular Arrhythmia detector**

**1-** We use the function plot(pspectrum(“some frame”)) to plot the spectrum of some frames of the signal in ecg-422a. It must also be mentioned that we filtered these signals to remove some of the DC bias using an IIR Chebychev type 1 filter with order 10, which will not cause much delay, nor will it affect the phase of the frequency domain too much, only remove the DC component. After plotting the spectra for some 10s intervals without VF (blue) and with VF (red), we see some obvious differences.

Graphical user interface

Description automatically generated

As we can see, without ventricular fibrillation, we have many frequencies that are being stretched out across the spectrum. With VF, we only have one main frequency in the entire signal. Notice that the frequencies have been divided by the sum of all the magnitudes in the plot. This is in order to take them as a percentage, i.e. in the bottom left signal, one single frequency is 6% of the signal.

**2-** After seeing this, we can propose one metric relating the number of peaks and their dominance in the signal. If we have less than 18 points of 4096 in the signal with 0.5% of the power that do not fall away from the main VF frequency, then we have ventricular fibrillation. That is, if less than 18 points, **which are not in the repeated lobe of VF**, have at least 0.5% of the power, then VF is existent.

**3-** The process we have done is to take 10 second intervals, filter them, and join them with the two second intervals(filtered) from before, and find the pspectrum of that, and then compute the metric on every frame, and sound an alarm if VF might be present. In order to make it smaller than 10 seconds, we can simply filter every 2 seconds for example, and concatenate it to some amount of the old signal. Then we repeat the same steps of computing the spectrum and applying the metric.

**4-**

Chart

Description automatically generated with medium confidence

The detection on the extreme levels (far right and far left) is accurate. However, at around 90 and 100-110s, there are some missed detections. We zoom into the 90s to 110s interval. Since the detector signals an alarm *at the end* of each 10s interval, then the false alarm is triggered after finishing 90s. Visually, we notice that even though there is in fact VF at 90s, the magnitude of the oscillations is small, and might cause other frequencies to show up, and have a relatively larger effect on the spectrum, hence leading to a false result.

Chart, histogram

Description automatically generated

For ECG 422:

Timeline

Description automatically generated

We see that we have VF everywhere in this signal, hence why it shows positive everywhere on the detector.

For ECG 421-n: We expect not to have any alarm, since this is a normal heart rhythm. A picture containing chart

Description automatically generated

This is true as shown by the figure.

Finally, for ECG 424: Timeline

Description automatically generated with low confidence

For this signal, it is not very clear initially whether the patient does have VF, since the amplitude of the oscillations is too small to really see clearly what is happening. The main frequency in the first half can actually be considered the large oscillations around 0, which is why VF is considered true. However, at the end of 60s, we notice that a change in frequencies has occurred, which is why there may be more than one frequency playing a role in the spectrum, and hence the metric calculated at that point to not have VF.

Close up of Signal 424 at around 60sA picture containing timeline

Description automatically generated

**5-** Noise occurs in electrical lines when it is being transferred from the sensor into the computer. Since our design employs a filter which filters noise from 0 to 0.1 Hz, and has an upper cutoff of 45Hz, then it should not affect the design very much. However, the noise might be at a lower frequency, or the signal itself might have a low amplitude so it will be indistinguishable from the noise, which is where the design becomes faulty, as seen in signal 424. We could attempt to improve it by amplifying the frequencies which we want to see, or by making the metric more well defined (by checking number of peaks using derivatives for example), or by seeing the location of the peaks with respect to each other along with their number.