In The Name of God

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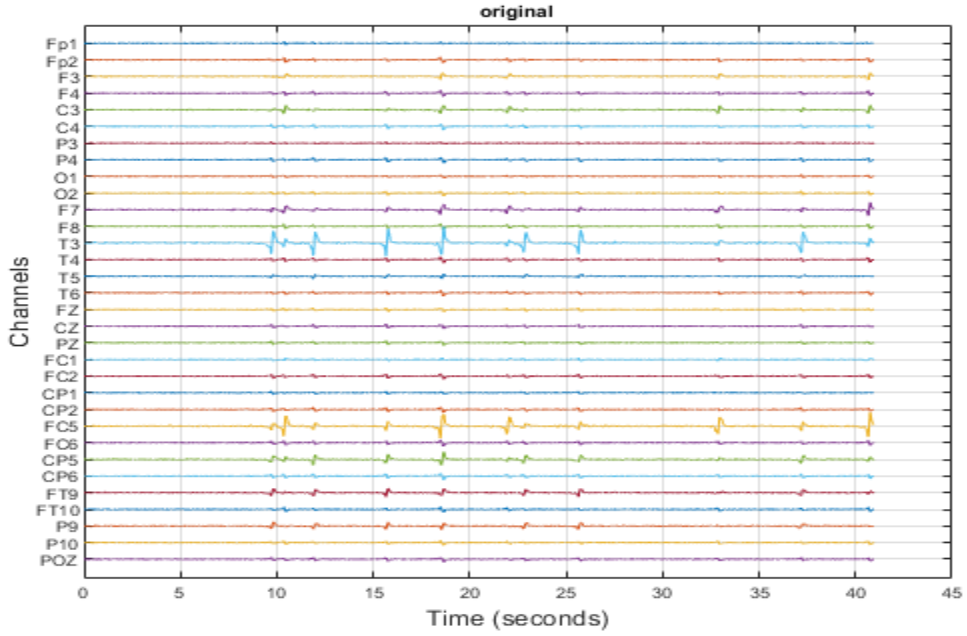
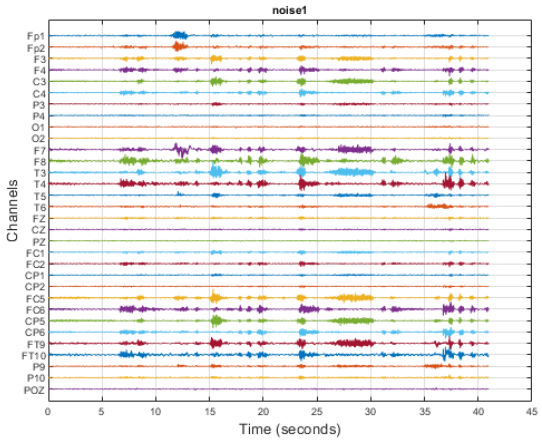
Question2:

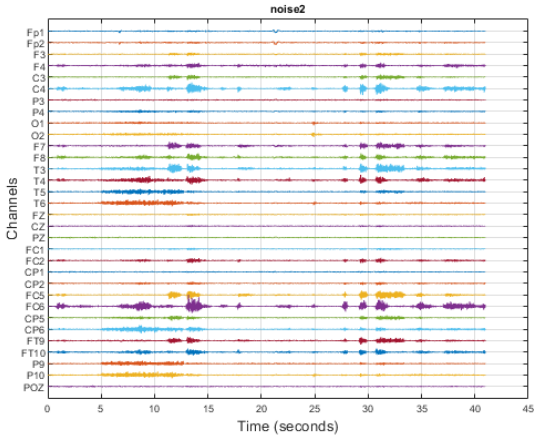
Original signal in the time domain:



Noise_1:



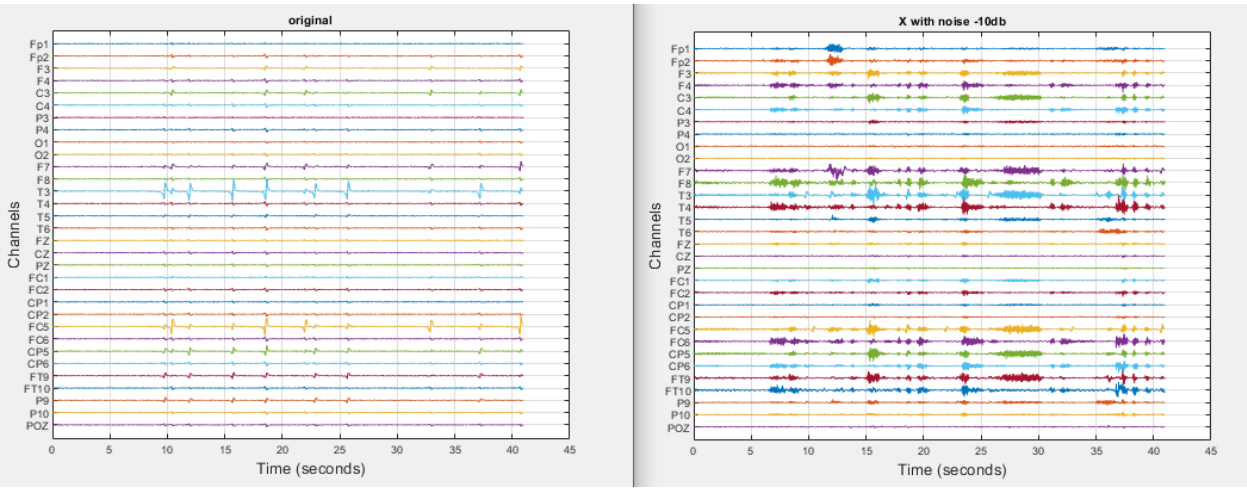
Noise_2:



a) Based on the below formulation, we can add a noise with the given SNR to signal:

$$SNR_{dB} = 10\log_{10}\frac{\sum_{n=1}^{N}\sum_{m=1}^{M}s[m]^2}{\sum_{n=1}^{N}\sum_{m=1}^{M}N[m]^2} = 10\log_{10}\frac{P_s}{\sigma^2 P_n}$$

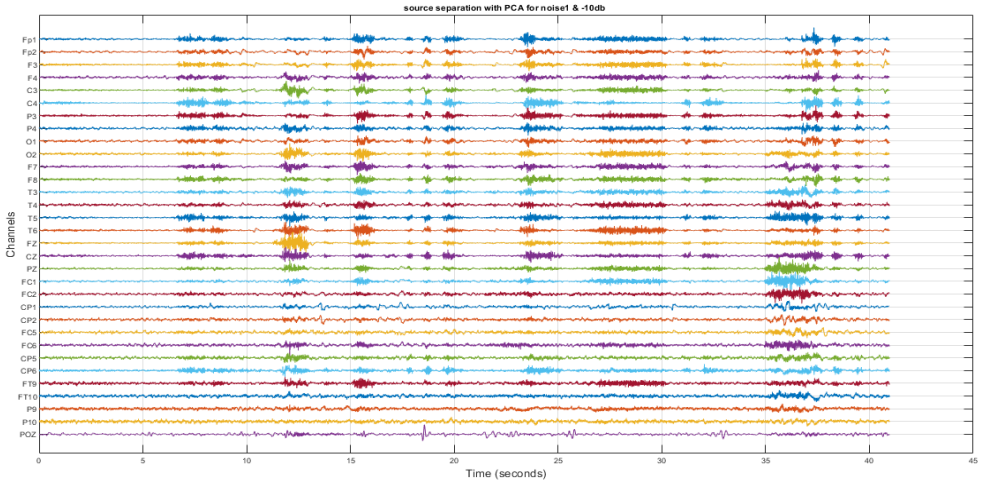
$$\sigma^2 = \frac{P_s}{P_N} * 10^{-\frac{SNR_{dB}}{10}}$$



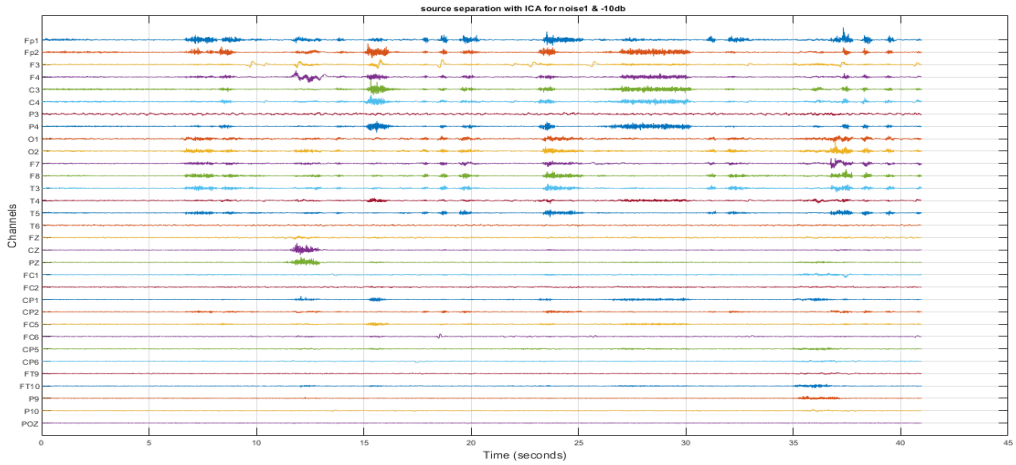
Now do each part for different noise & SNR separately.

1.For noise_1 & SNR=-10db:

b) After calculating PCA and applying D to our data, we have this result:

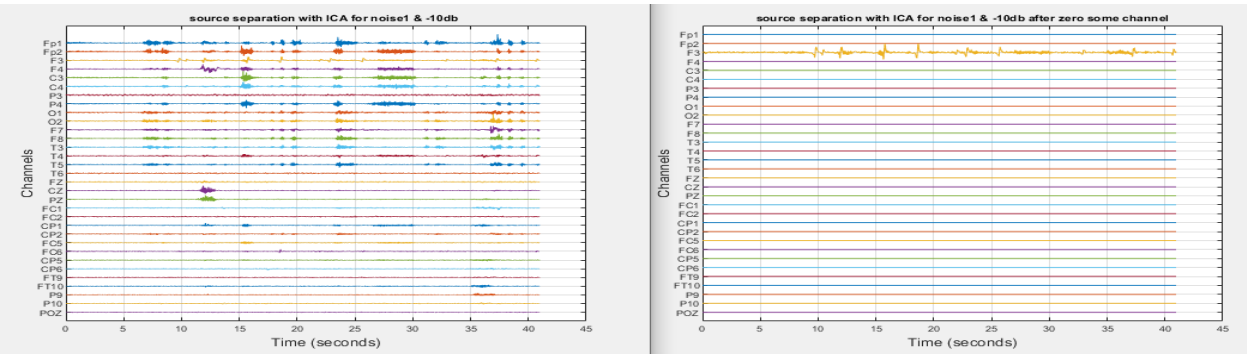


After applying ICA to our data, we have this result:



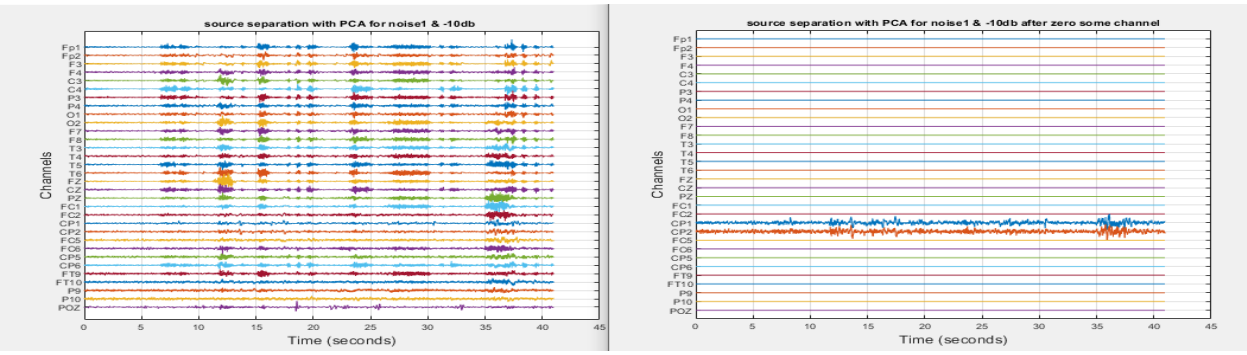
As we can see, many of the channels are noisy.

c) keep the spiky channel and remove others: In ICA, we have:



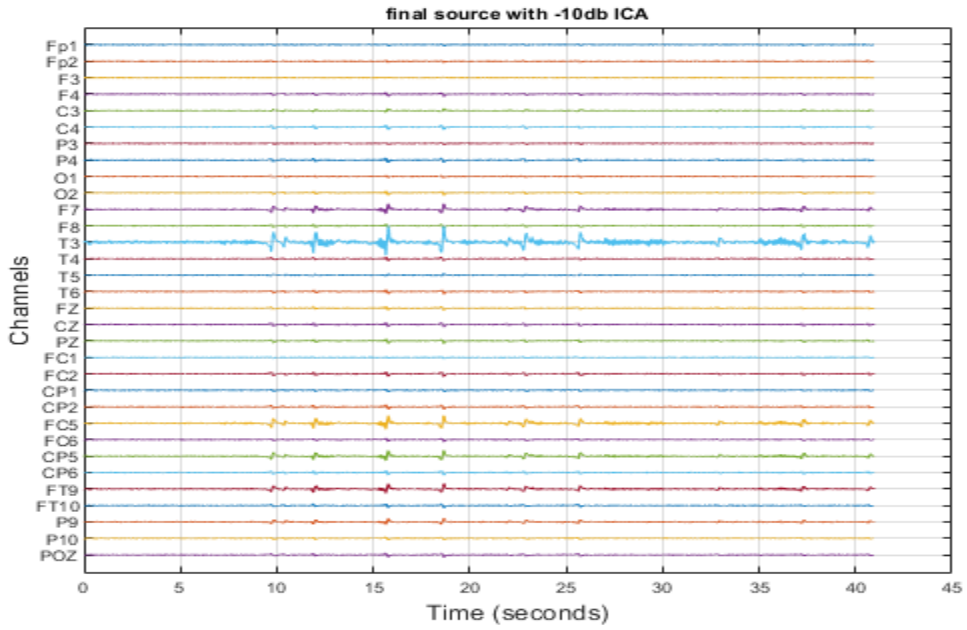
In this case, we keep only one channel!!

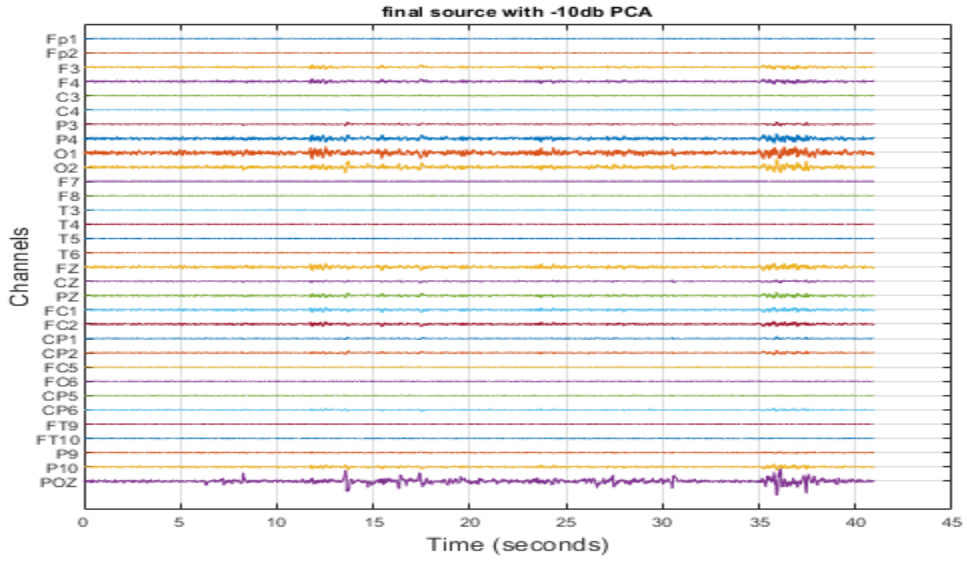
In PCA, we have:



All channels are noisy, and it is difficult to pick one of them. In comparison to other channels, CP1 & CP2 are better.

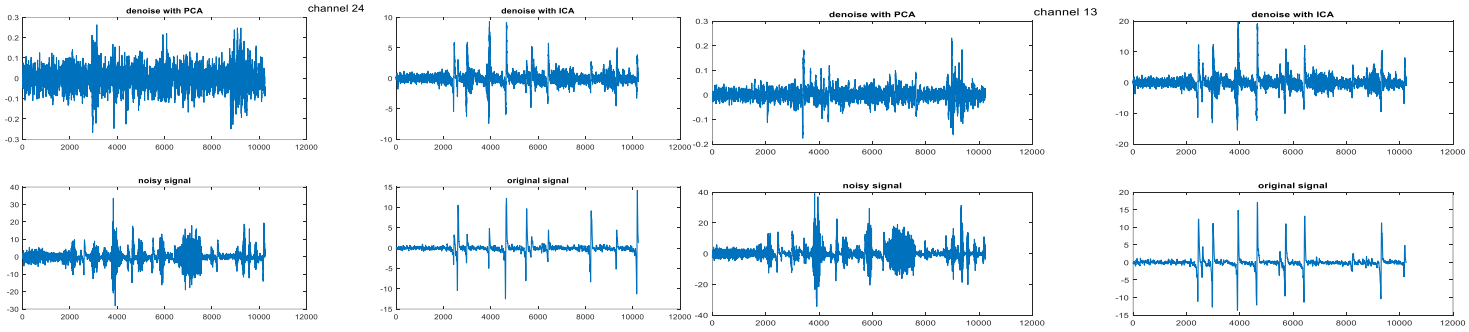
d) we can see the result of denoising on the below figures:





As we see, the result of ICA is better than PCA and is similar to the original signal.

e) in this section, we can see channels 13 & 24 before and after denoising with PCA & ICA.



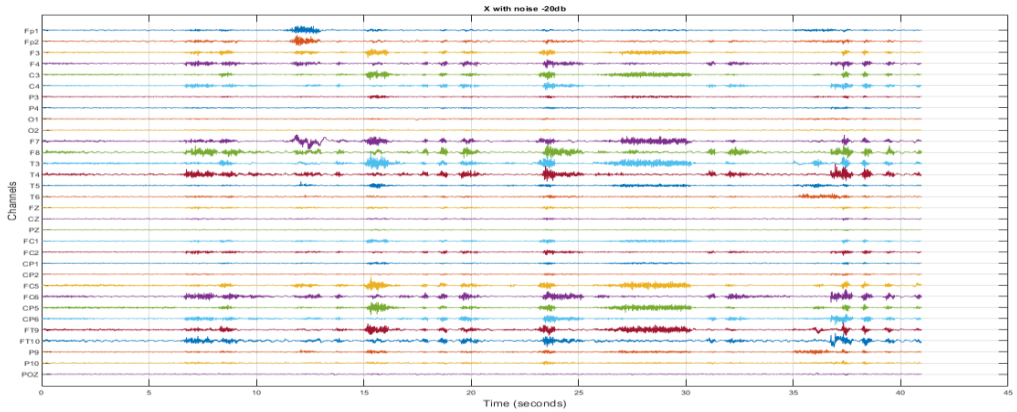
As shown, the result of the ICA method is close to the original signal.

f) and finally, the RRMSE is equal to:

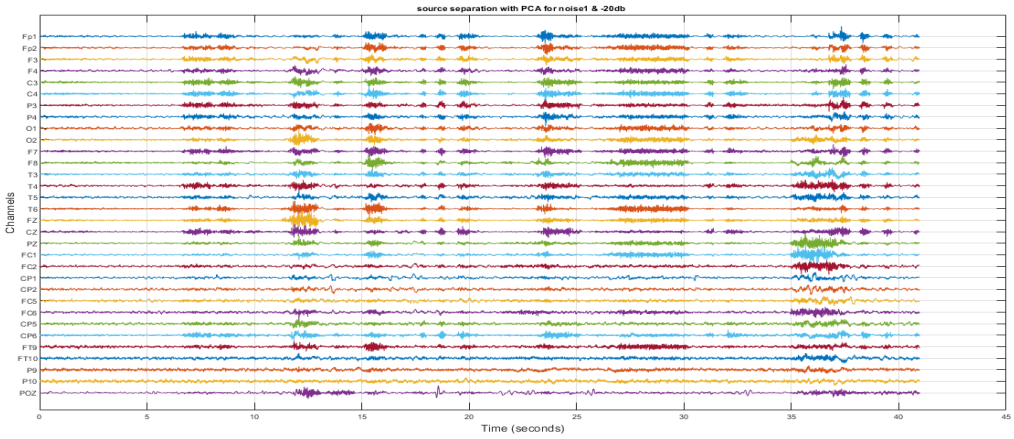
```
RRMSE_noise1_10db_PCA =
    1.3906

RRMSE_noise1_10db_ICA =
    0.6580
```

	RRMSE for ICA	RRMSE for PCA
Noise1 & SNR=-10db	0.6580	1.3906

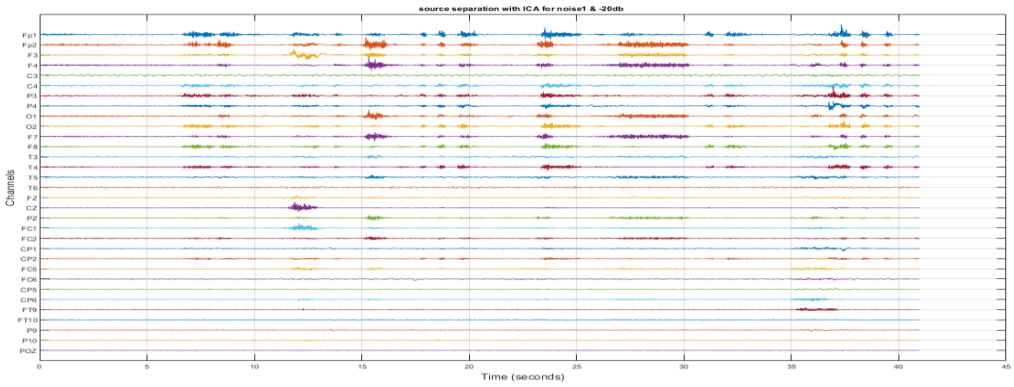
2.For noise_1 & SNR=-20db:



a) After calculating PCA and applying D to our data, we have this result:

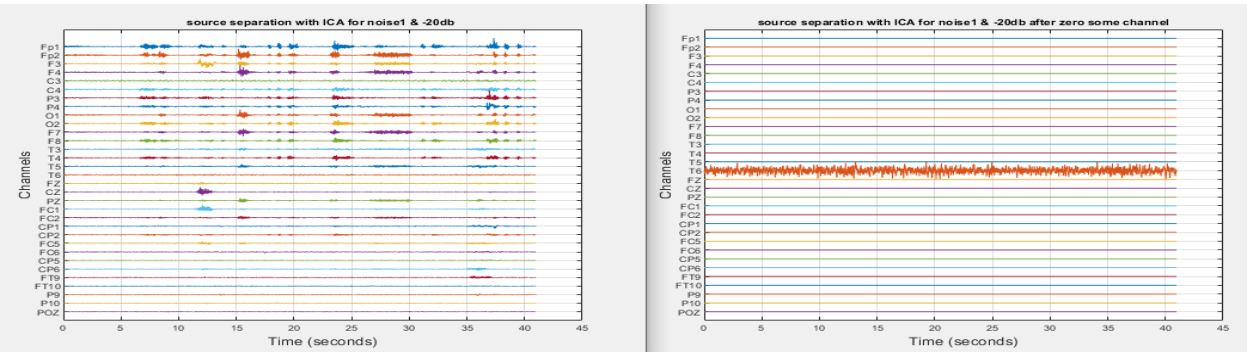


After applying ICA to our data, we have this result:



As we can see, many of the channels are noisy, and in both cases, we don,t have any spiky channels.

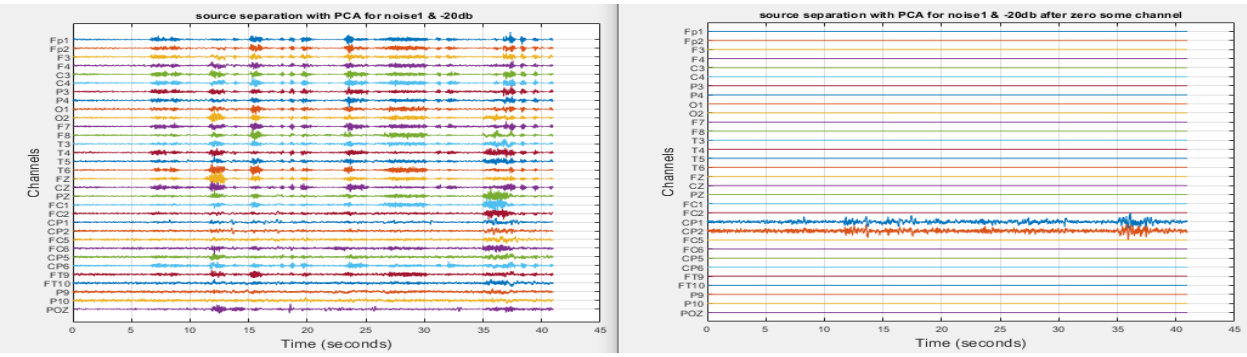
c) keep the spiky channel and remove others: In ICA, we have:



In this case, we keep only one channel.

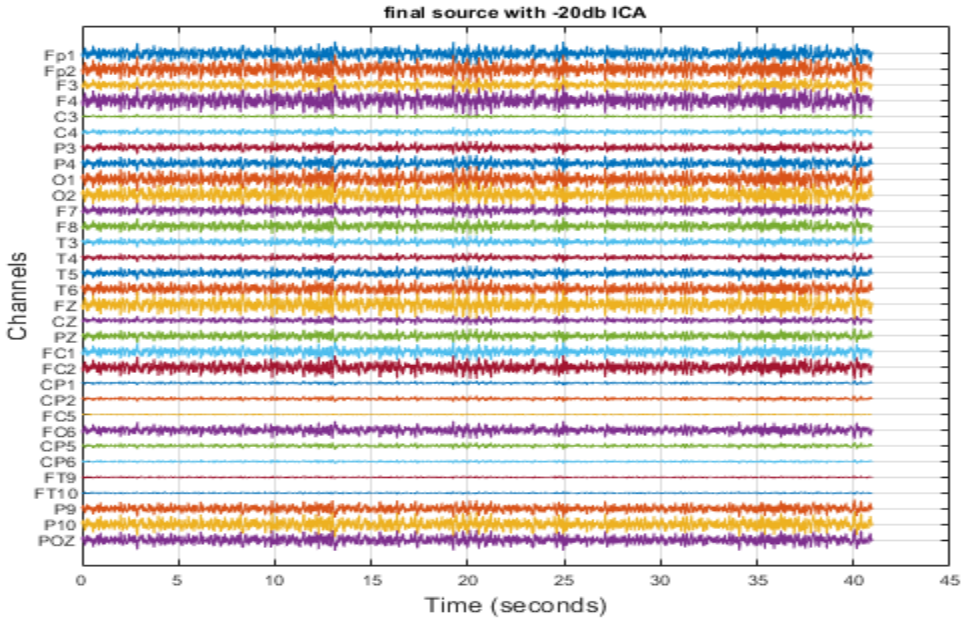
Because we don’t have any spiky channels, the best result in RRMSE performance happens when we keep T6 and remove other channels.

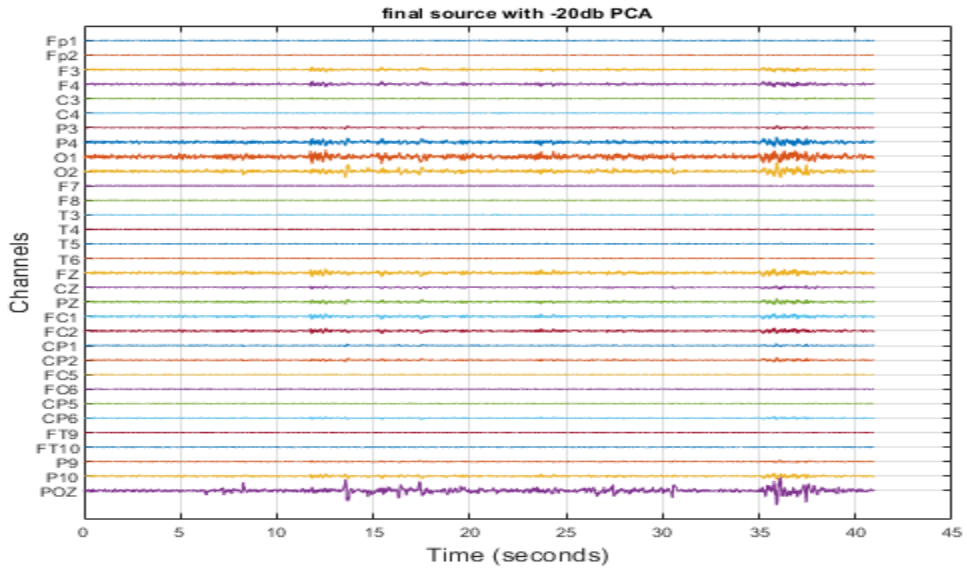
In PCA, we have:



All channels are noisy, and it is difficult to pick one of them. In comparison to other channels, CP1 & CP2 are better.

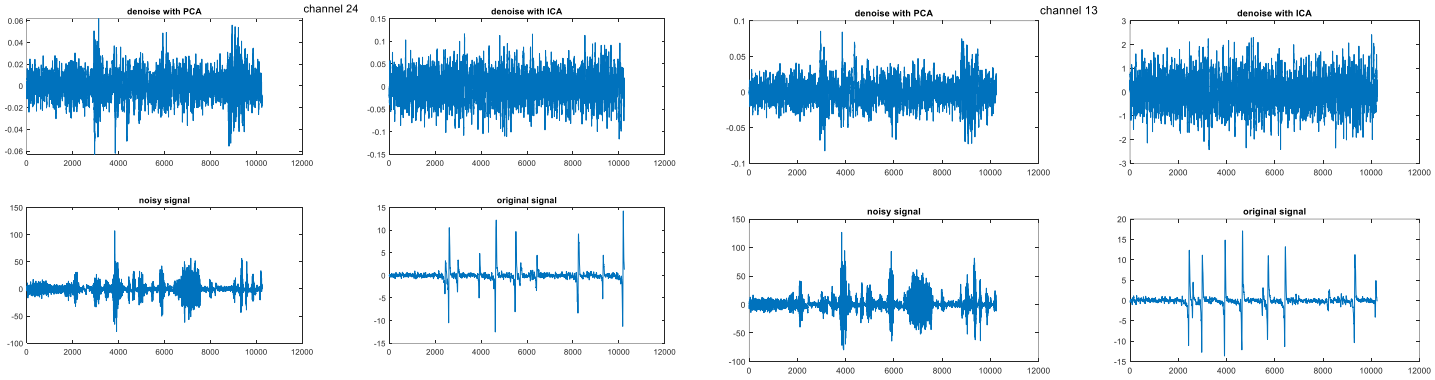
d) we can see the result of denoising on the below figures:





As we see, both ICA & PCA results are too bad and far from is the original signal.

e) in this section, we can see channels 13 & 24 before and after denoising with PCA & ICA.

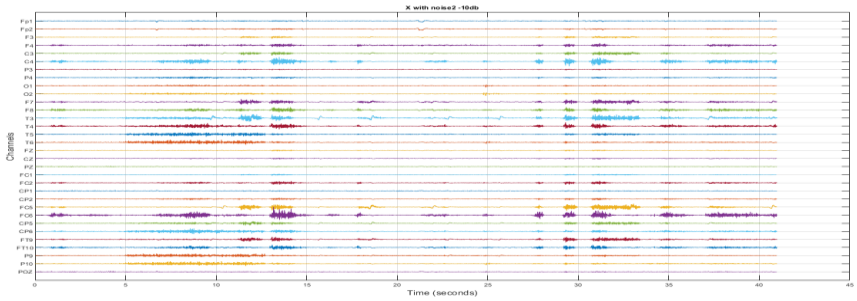


As shown, the result in both cases is too bad. The reason for that in this case, we have noise with stronger SNR than the previous case.

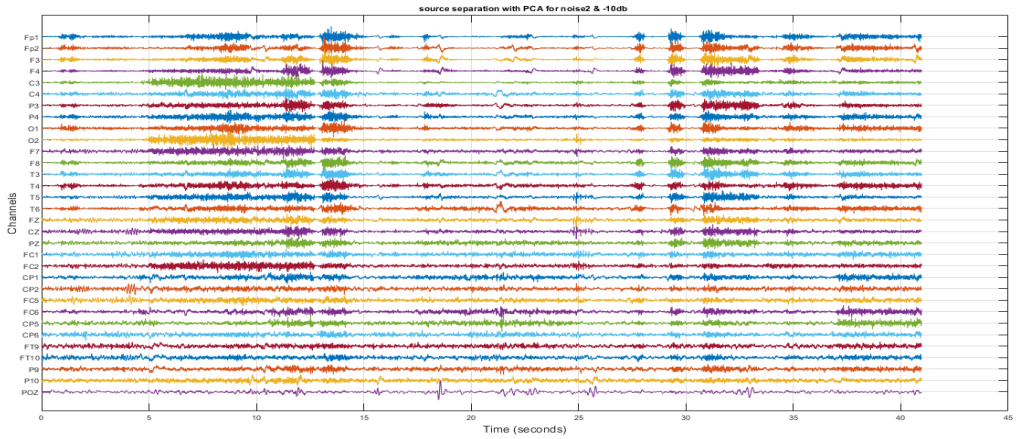
f) and finally, the RRMSE is equal to:

	RRMSE for ICA	RRMSE for PCA
Noise1 & SNR=-20db	1.7938	1.0457

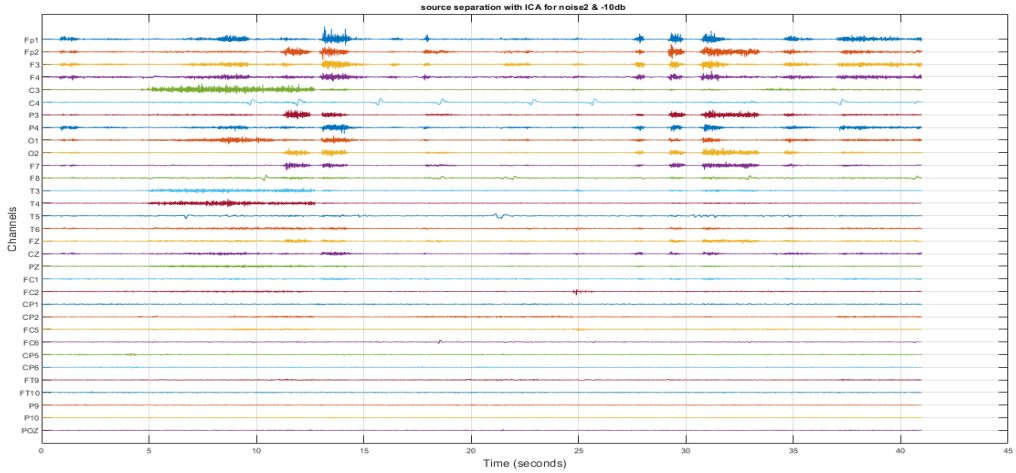
3.For noise_2 & SNR=-10db:



a) After calculating PCA and applying D to our data, we have this result:



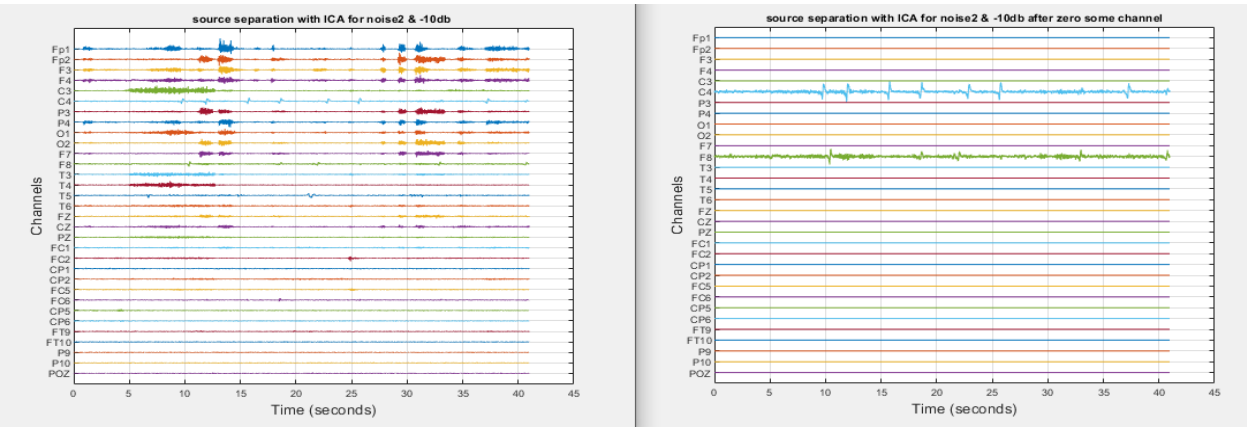
After applying ICA to our data, we have this result;



As we can see, all of the channels in PCA are noisy, and we don,t have any spiky channels, but in ICA, we have two spiky channels to keep that.

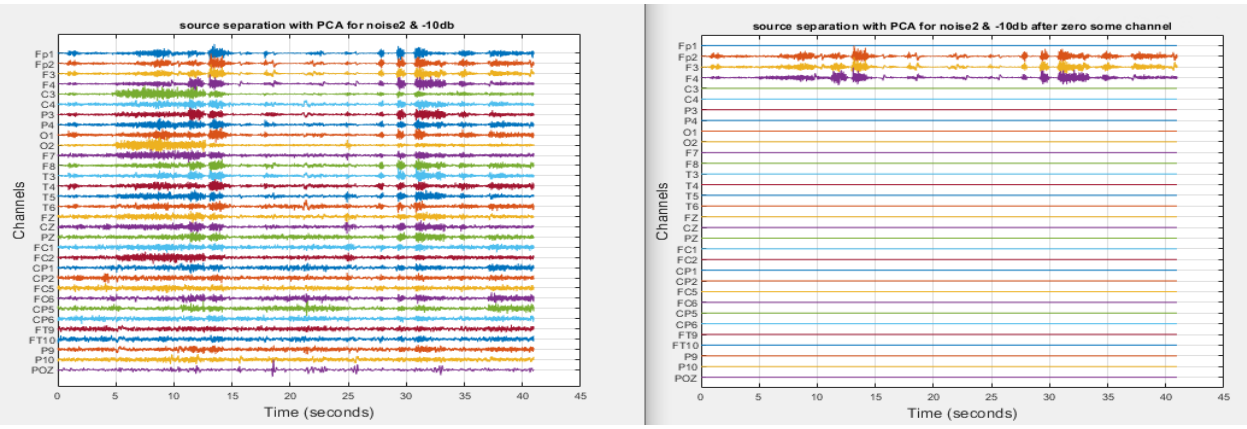
c) keep the spiky channel and remove others:

In ICA, we have:



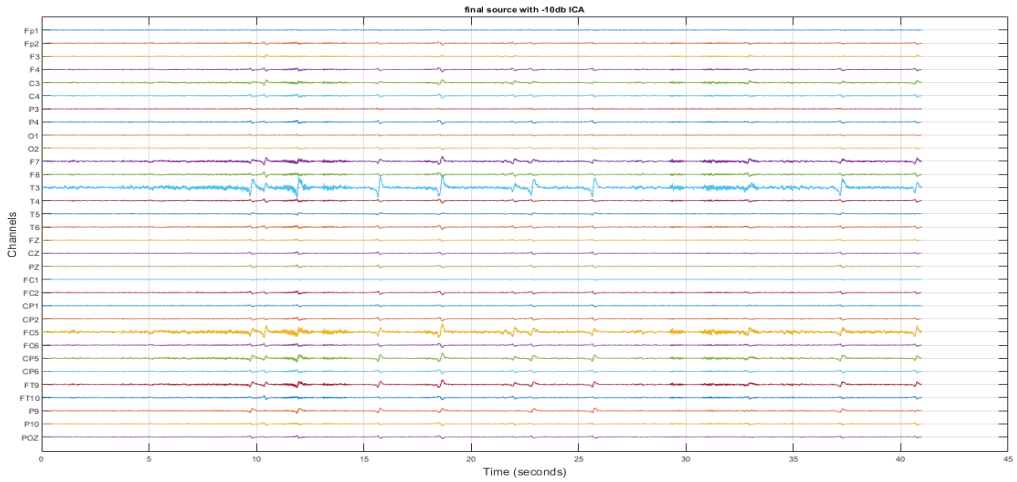
In this case, we keep two channels. The best result in RRMSE performance happens when we keep C4 & F8 and remove other channels.

In PCA, we have:

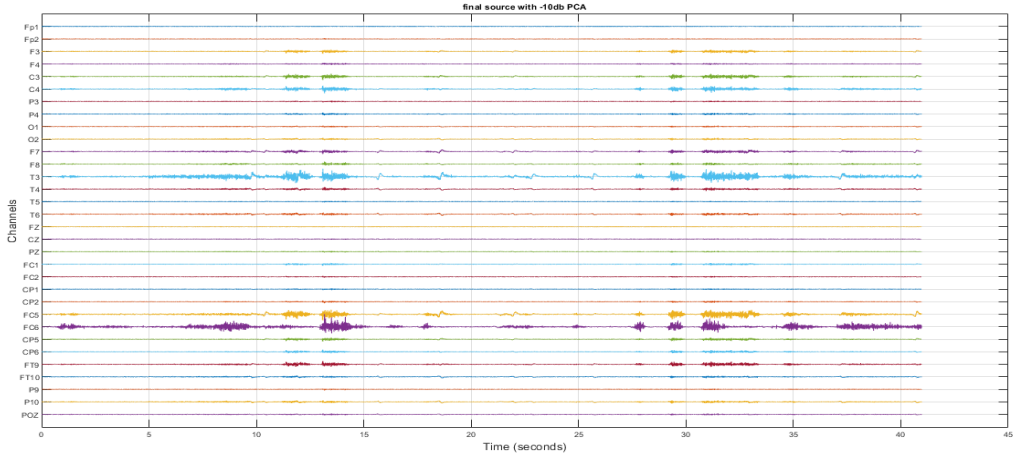


In this case, we keep three channels. All channels are noisy, and it is difficult to pick one of them. In comparison to other channels, FP1, F3 & F4 are better.

d) we can see the result of denoising on the below figures:

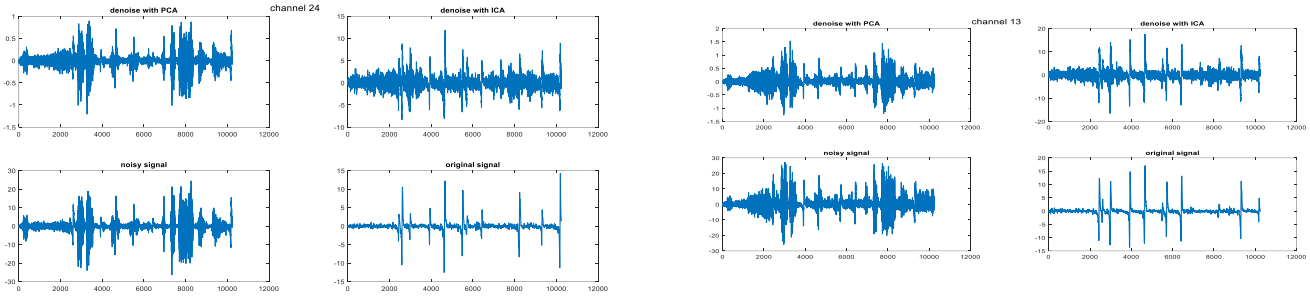


As we see, the ICA result is close to the original signal.



As we see, the PCA result is too bad and far from is the original signal.

e) in this section, we can see channels 13 & 24 before and after denoising with PCA & ICA.



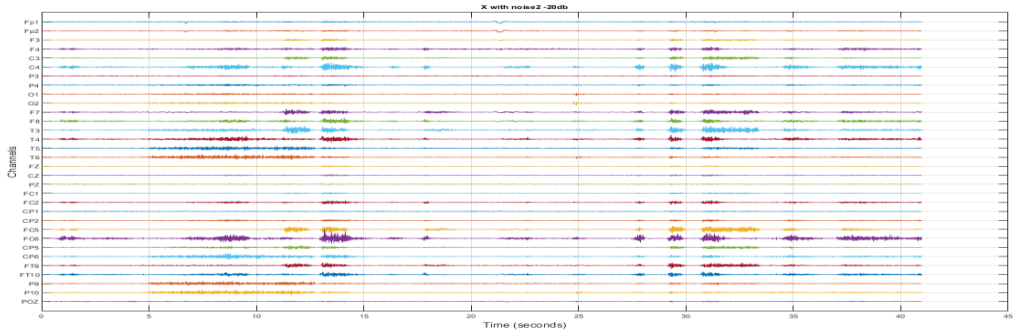
As shown, the result in ICA is excellent and close to the original signal but, the PCA result, similar to previous sections, is terrible.

f) and finally, the RRMSE is equal to:

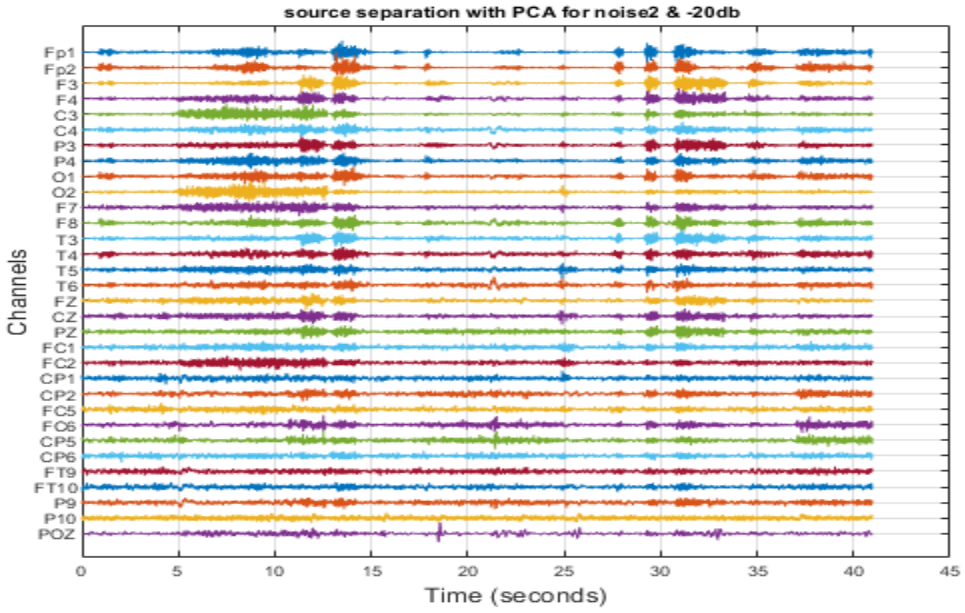
```
RRMSE_noise2_10db_PCA =

    0.9678

RRMSE_noise2_10db_ICA =

    0.6567
```

	RRMSE for ICA	RRMSE for PCA
Noise2 & SNR=-10db	0.6567	0.9678

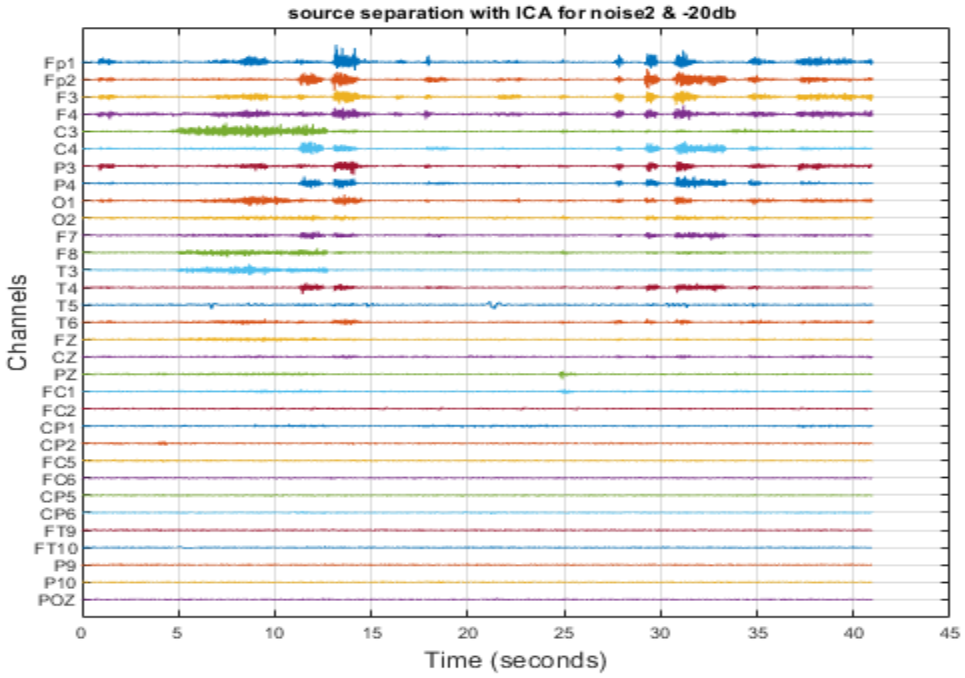
4.For noise_2 & SNR=-20db:



a) After calculating PCA and applying D to our data, we have this result:



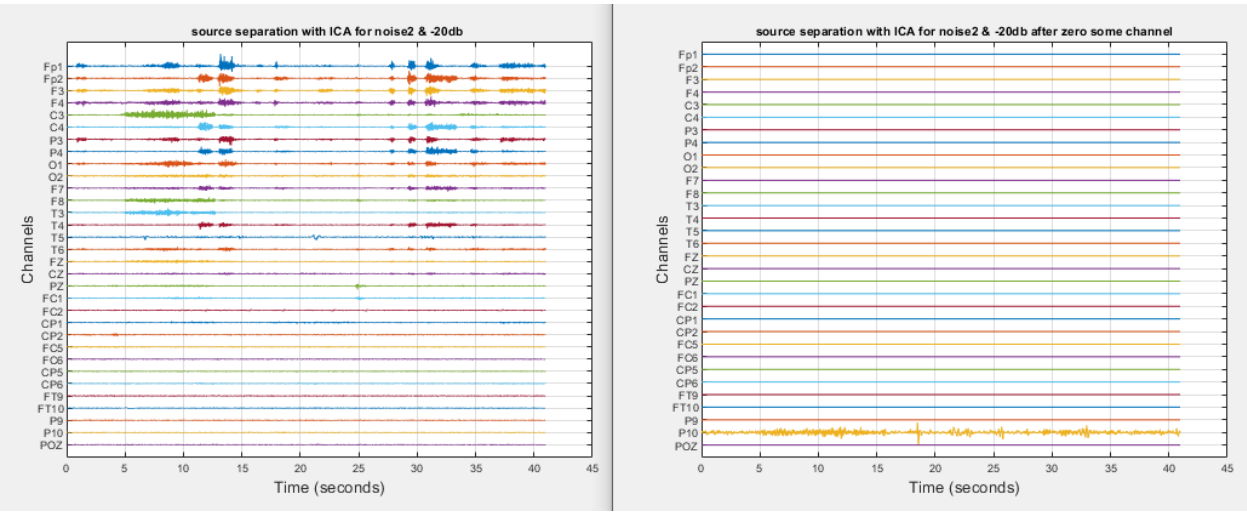
After applying ICA to our data, we have this result;



As we can see, all of the channels in PCA & ICA are noisy, and we don,t have any spiky channels.

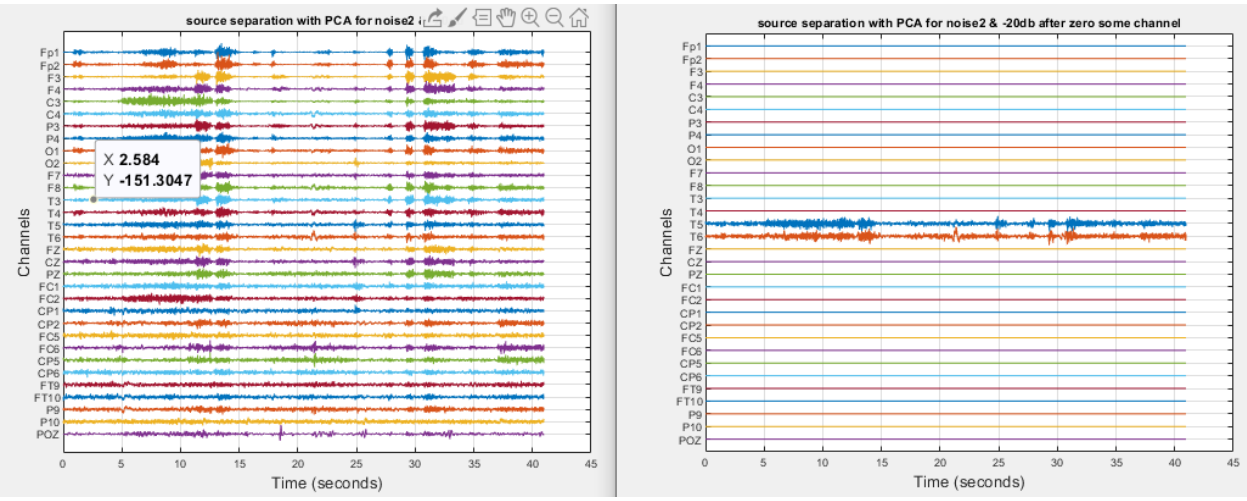
c) keep the spiky channel and remove others:

In ICA, we have:



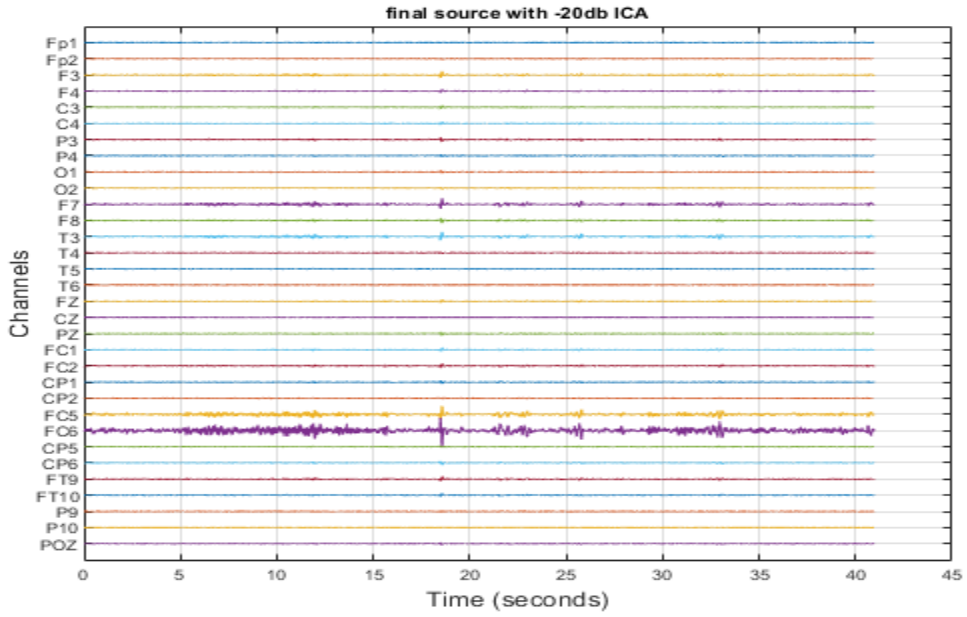
In this case, we keep only one channels. The best result in RRMSE performance happens when we keep P10 and remove other channels.

In PCA, we have:

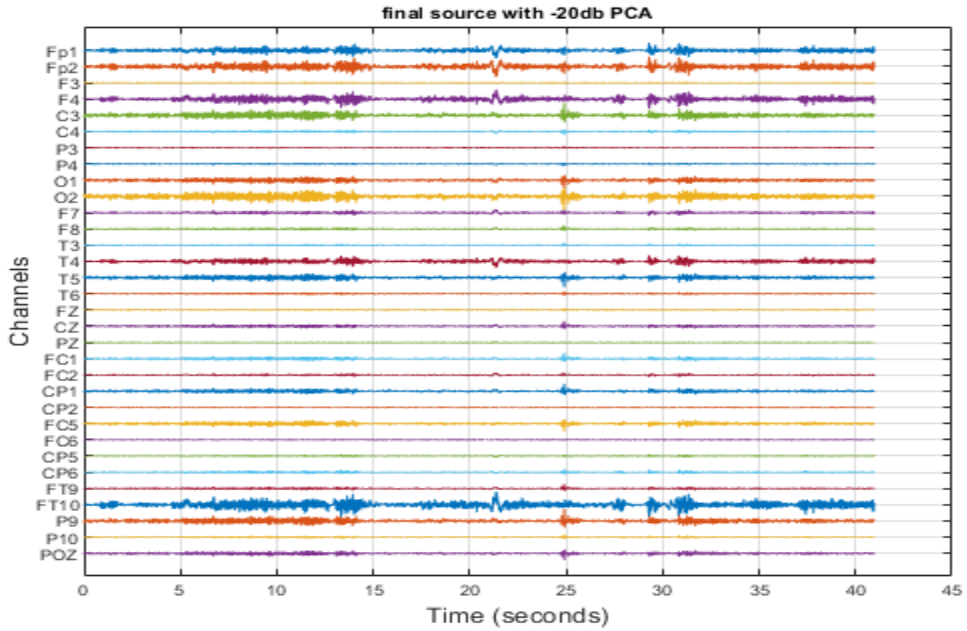


In this case, we keep two channels. All channels are noisy, and it is difficult to pick one of them. In comparison to other channels, T3 & T4 are better.

d) we can see the result of denoising on the below figures:

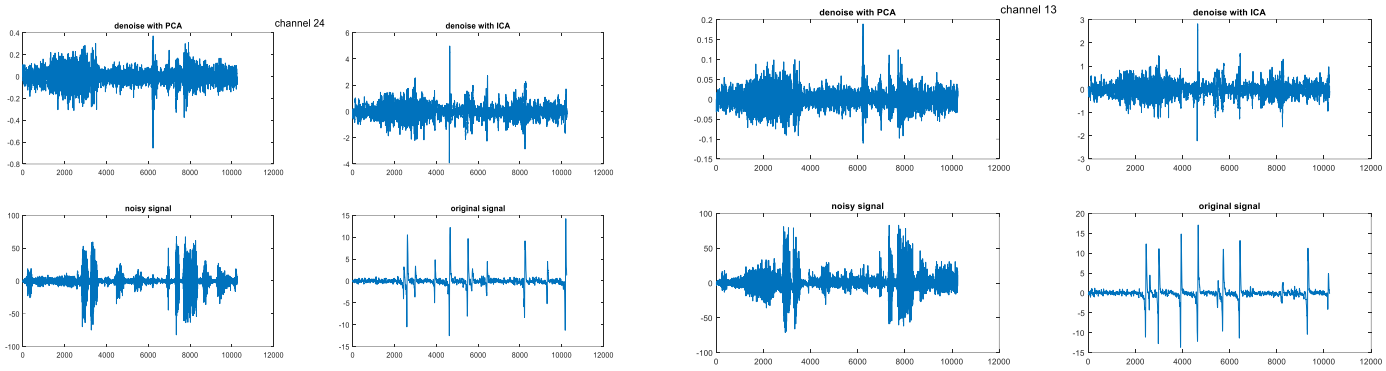


As we see, the ICA result, in this case, is close to the original signal, but in comparison to the result of the previous section, it is worse.



As we see, the PCA result is too bad and far from is the original signal.

e) in this section, we can see channels 13 & 24 before and after denoising with PCA & ICA.



As shown, the result in ICA is close to the original signal but, the PCA result, similar to previous sections, is terrible.

f) and finally, the RRMSE is equal to:

```
RRMSE_noise2_20db_PCA =
    1.0044

RRMSE_noise2_20db_ICA =
    1.0448

>>
```

	RRMSE for ICA	RRMSE for PCA
Noise2 & SNR=-20db	1.0448	1.0044

Conclusion:

	RRMSE for ICA	RRMSE for PCA
Noise1 & SNR=-10db	0.6580	1.3906
Noise1 & SNR=-20db	1.7938	1.0457
Noise2 & SNR=-10db	0.6567	0.9678
Noise2 & SNR=-20db	1.0448	1.0044