Designing the front end for Respiration Signal

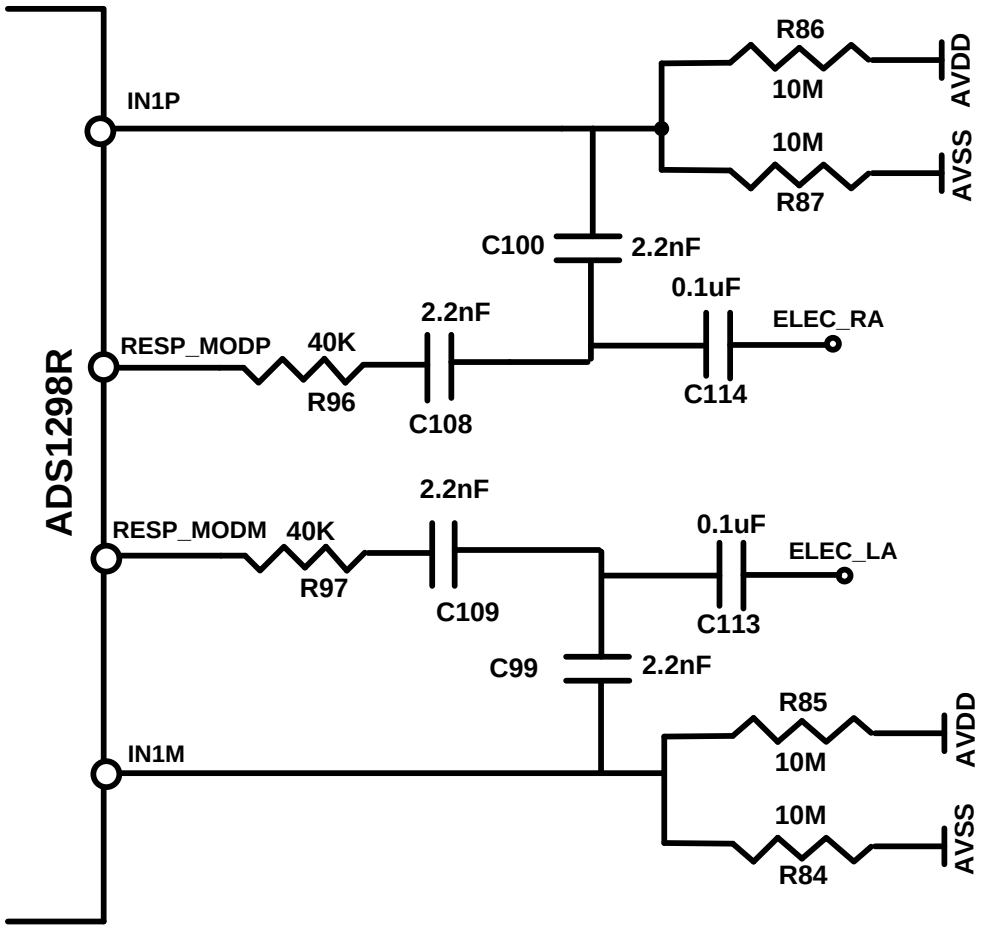
Measuring Respiration using ADS1298R

- Need to Isolate ECG from Respiration
- Isolation done prior to ADS1298R input using High Pass Filter
- Problem - the High Pass Filter will also attenuate the respiration carrier, so an optimal value needs to be used
- Problem manifests at high levels of baseline impedance

Experimentation

Effect of input RC filter on Respiration Magnitude

Test Schematic



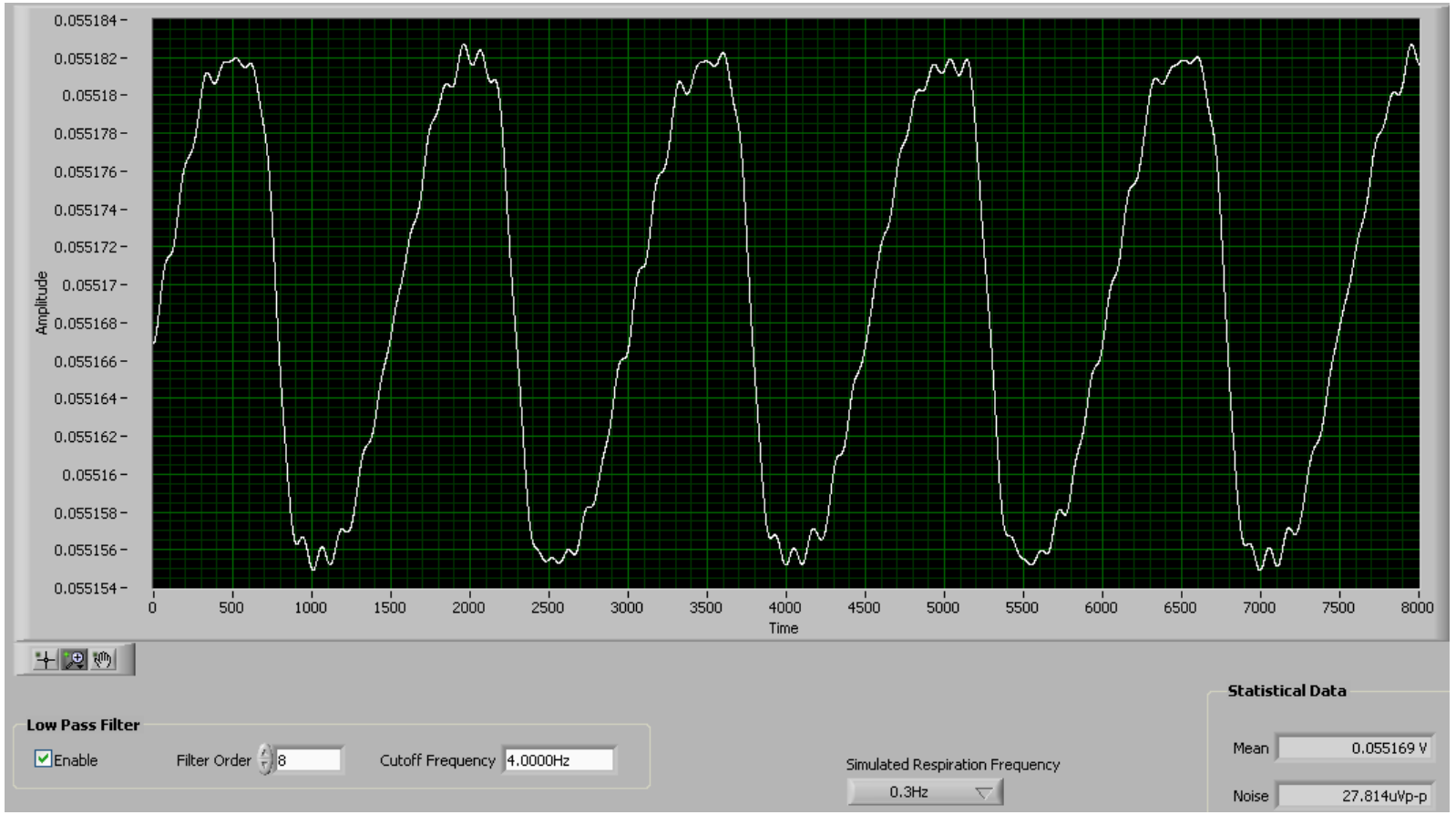
Increasing the input high pass frequency will filter the ECG signal
This can be accomplished by reducing C99 and C100

Test Setup

- Three different values of C99/C100 are used.
  1) 2.2nF
  2) 470pF
  3) 100pF
- A baseline impedance of 2Kohm is used with expected dc value of 58.5mV
- Delta impedance of 0.1ohms is used to with expected peak-to-peak value of 2.9uV
- ECG is set to highest amplitude on simulator 5.5mV
- The output is filtered to 40Hz using a LPF
- The simulator used in Fluke Medsim 300B

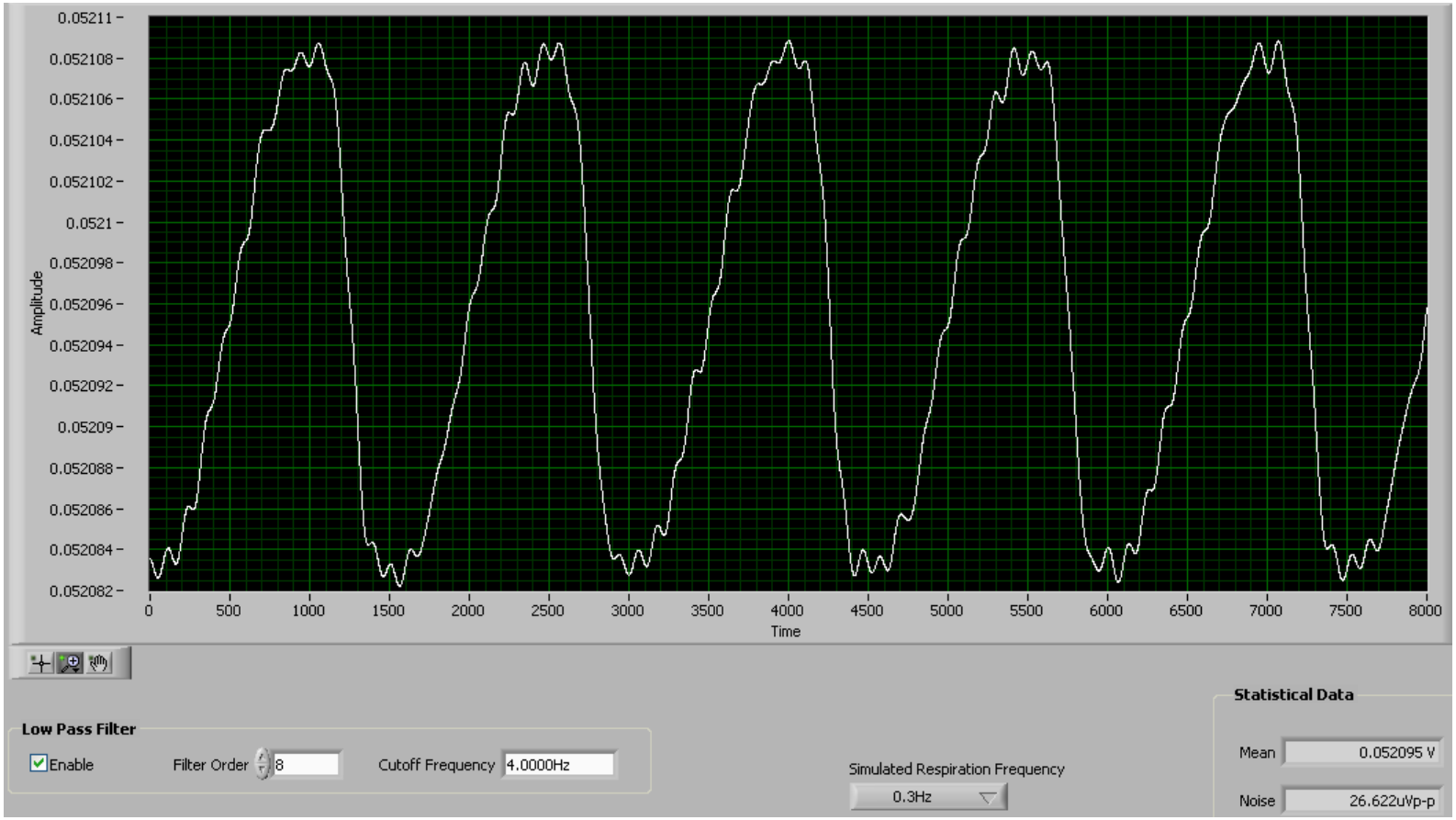
Respiration Frequency = 64KHz

Capacitor =2.2nF/ Resp Frequency = 64Khz



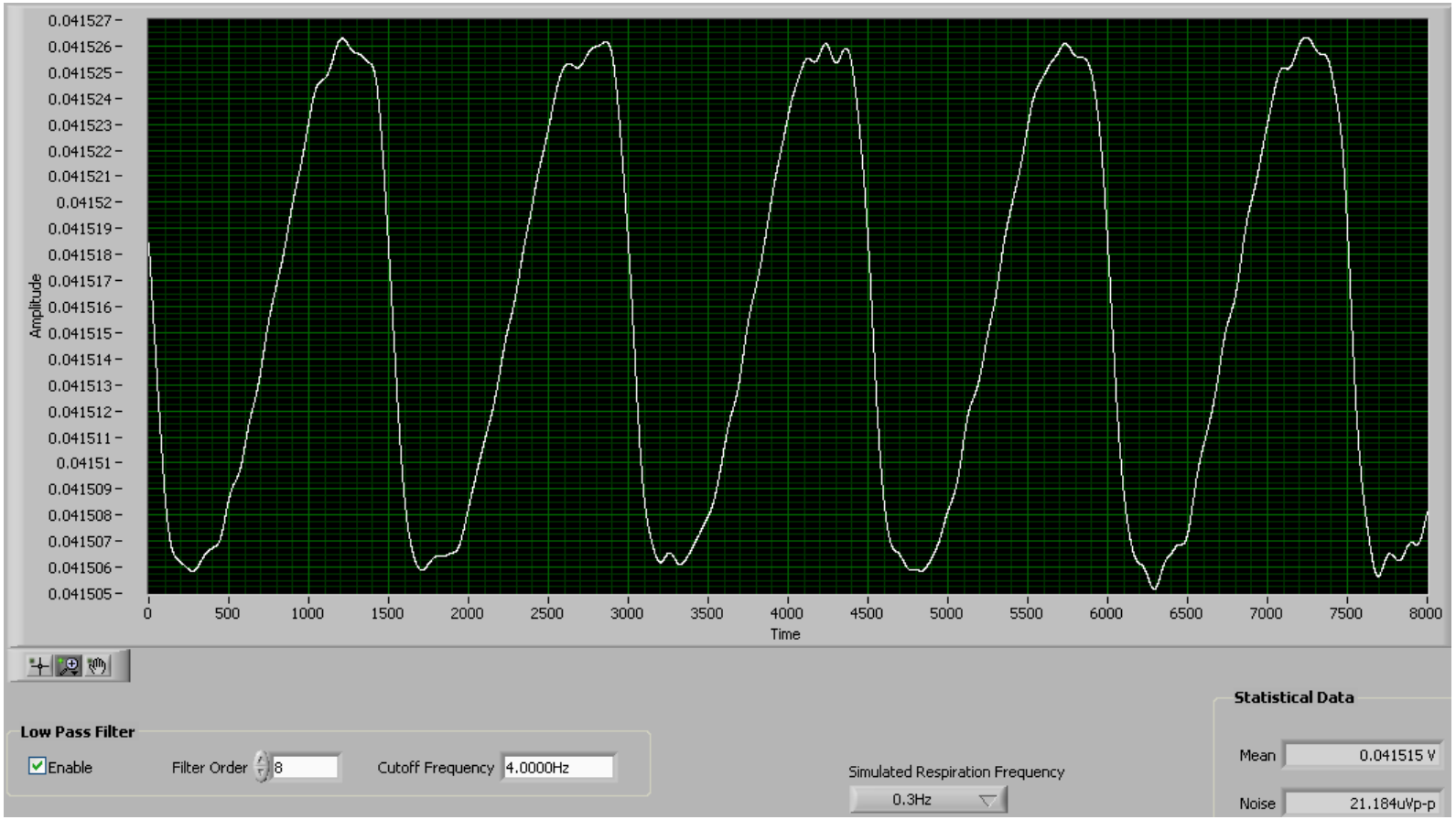
- Resp frequency =64Khz,G=3;Φ =135
- Similar results are obtained for G =2/3; Φ =90 to 157.5

Capacitor =470pF/ Resp Frequency = 64Khz



- Resp frequency =64Khz,G=3;Φ =135
- Similar results are obtained for G =2/3; Φ =90 to 157.5

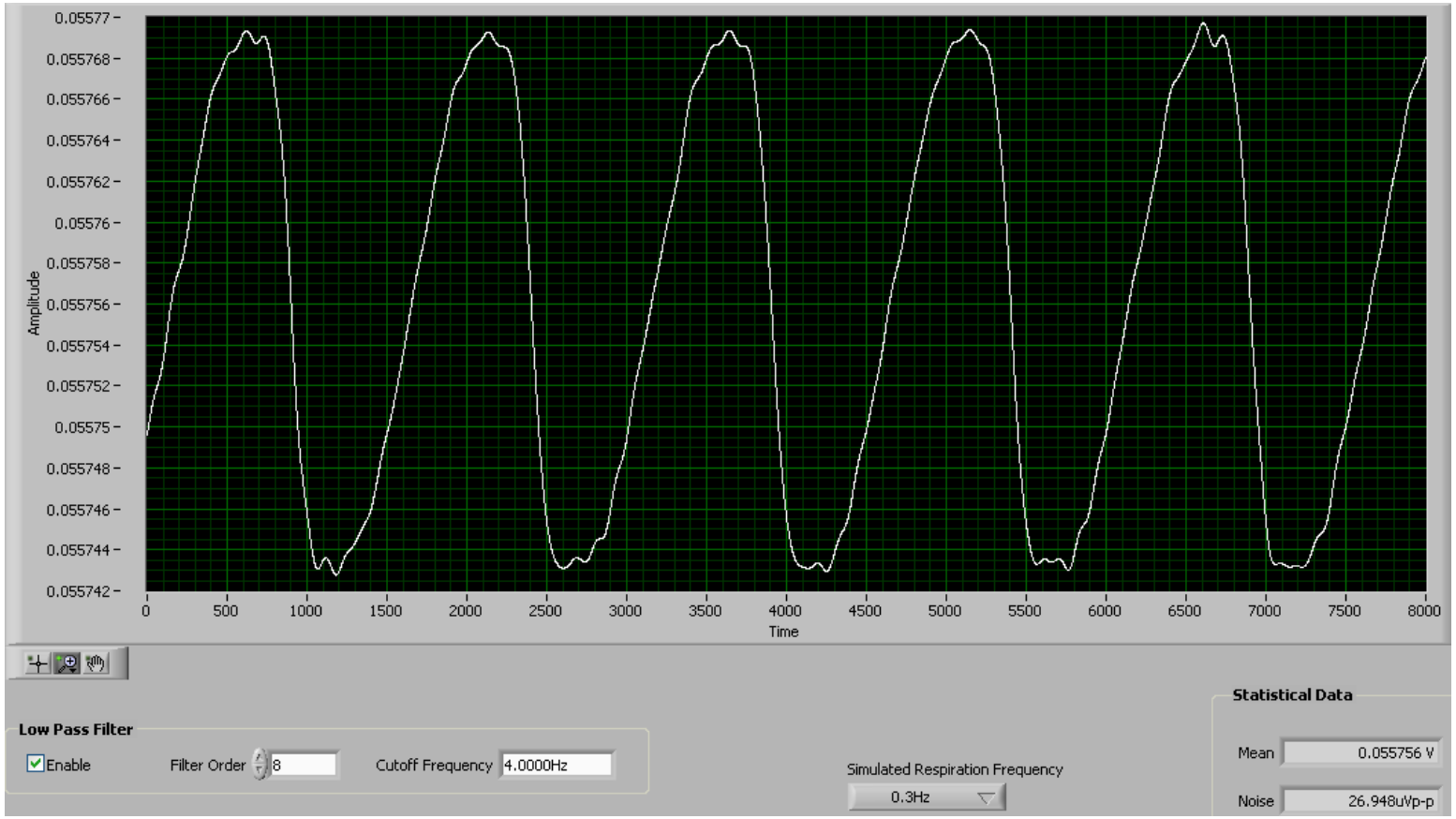
Capacitor =100pF/ Resp Frequency = 64Khz



- Resp frequency =64Khz,G=3;Φ =135
- Similar results are obtained for G =2/3; Φ =90 to 157.5

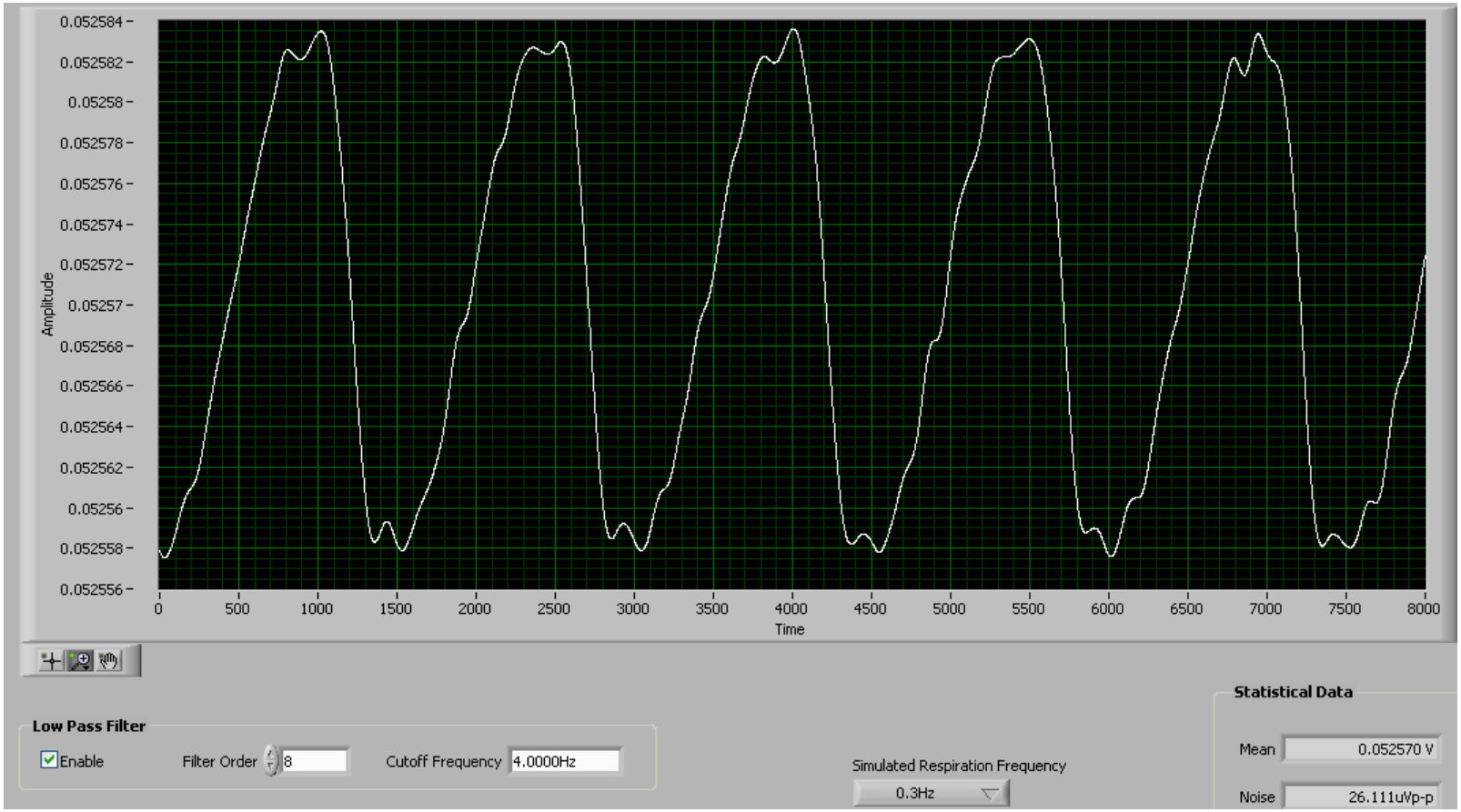
Respiration Frequency = 32KHz

Capacitor =2.2nF/ Resp Frequency = 32Khz



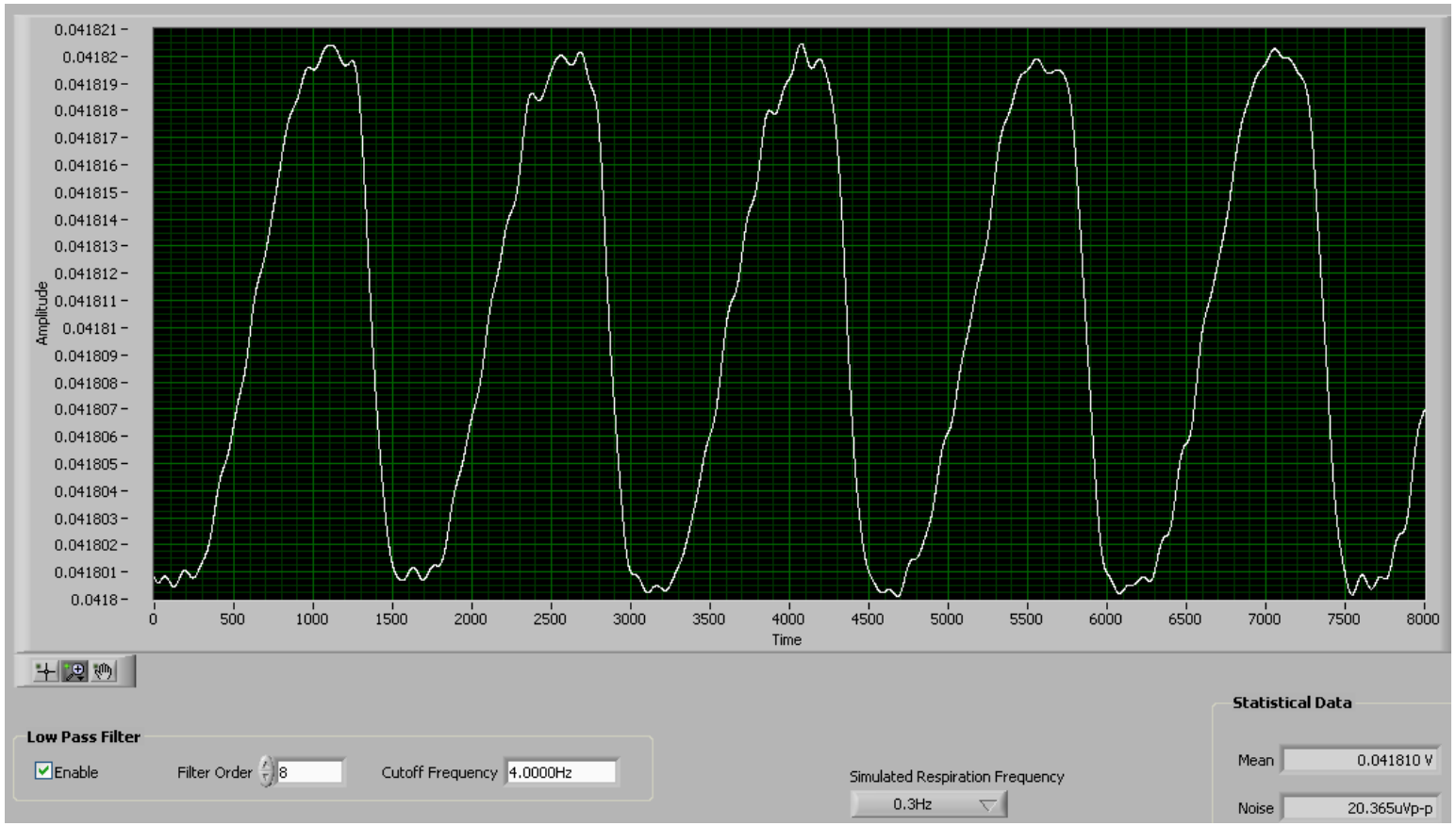
- Resp frequency =32Khz,G=3;Φ =135
- Similar results are obtained for G =3/4; Φ =90 to 157.5

Capacitor =470pF/ Resp Frequency = 32Khz



- Resp frequency =32Khz,G=3;Φ =135
- Similar results are obtained for G =3/4; Φ =90 to 157.5

Capacitor =100pF/ Resp Frequency = 32Khz



- Resp frequency =32Khz,G=3;Φ =135
- Similar results are obtained for G =3/4; Φ =90 to 157.5

Conclusions

Summary

	DC value	Pk-pk
Ideal Value	58.5mV	29.2uV
2.2nF	55mV	27.4uV
0.47nF	52mV	26.2uV
0.1nF	41.6mV	21uV

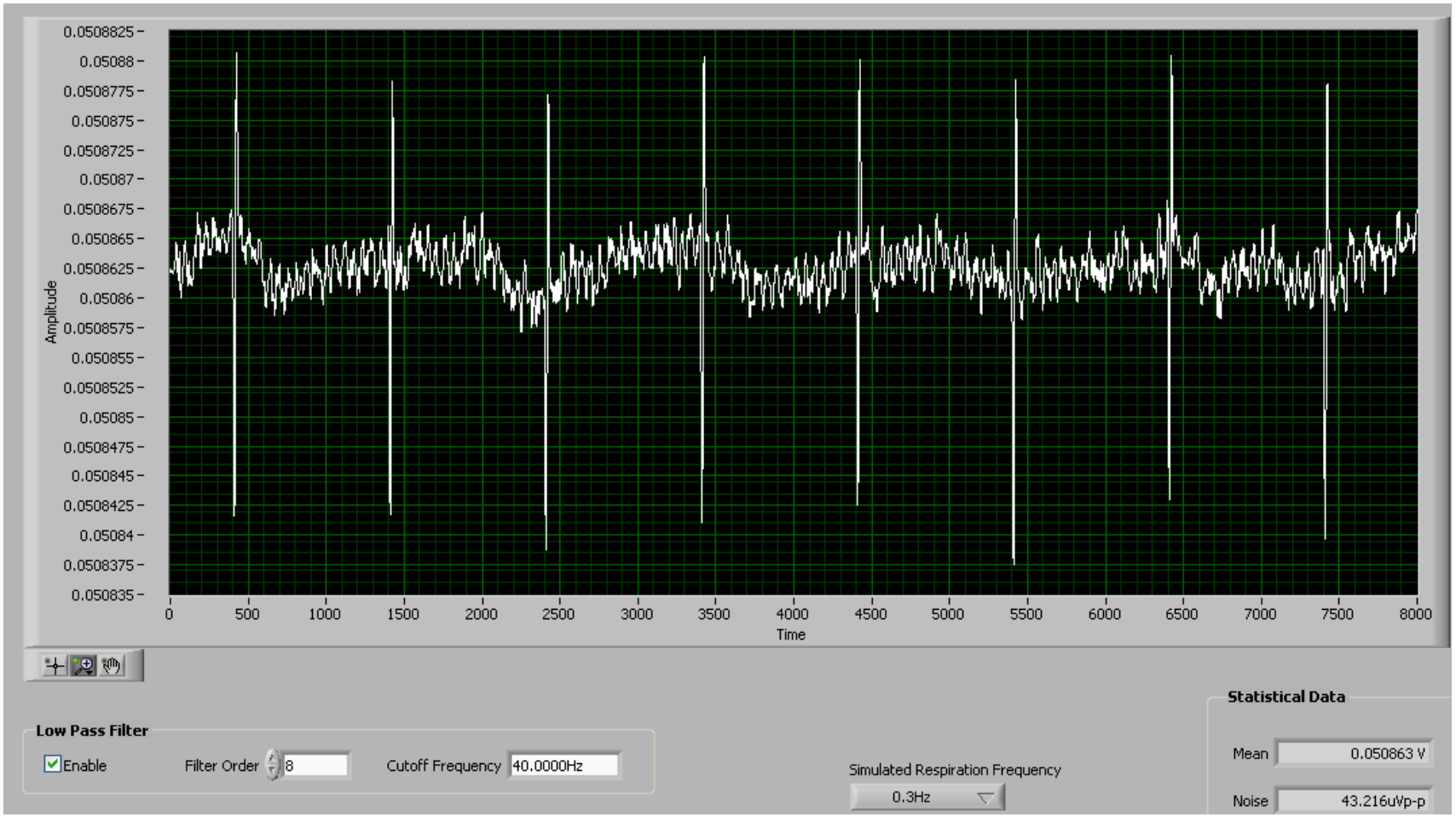
- The attenuation of both the dc value and the peak-peak is independent of respiration frequency
- The attenuation in both dc value and pk-pk value is same
- At 470pF the signal lost is 10%.
- It is advisable to keep the capacitor as 470pF or higher

Experimentation

Cardiovascular interference on Respiration Signal

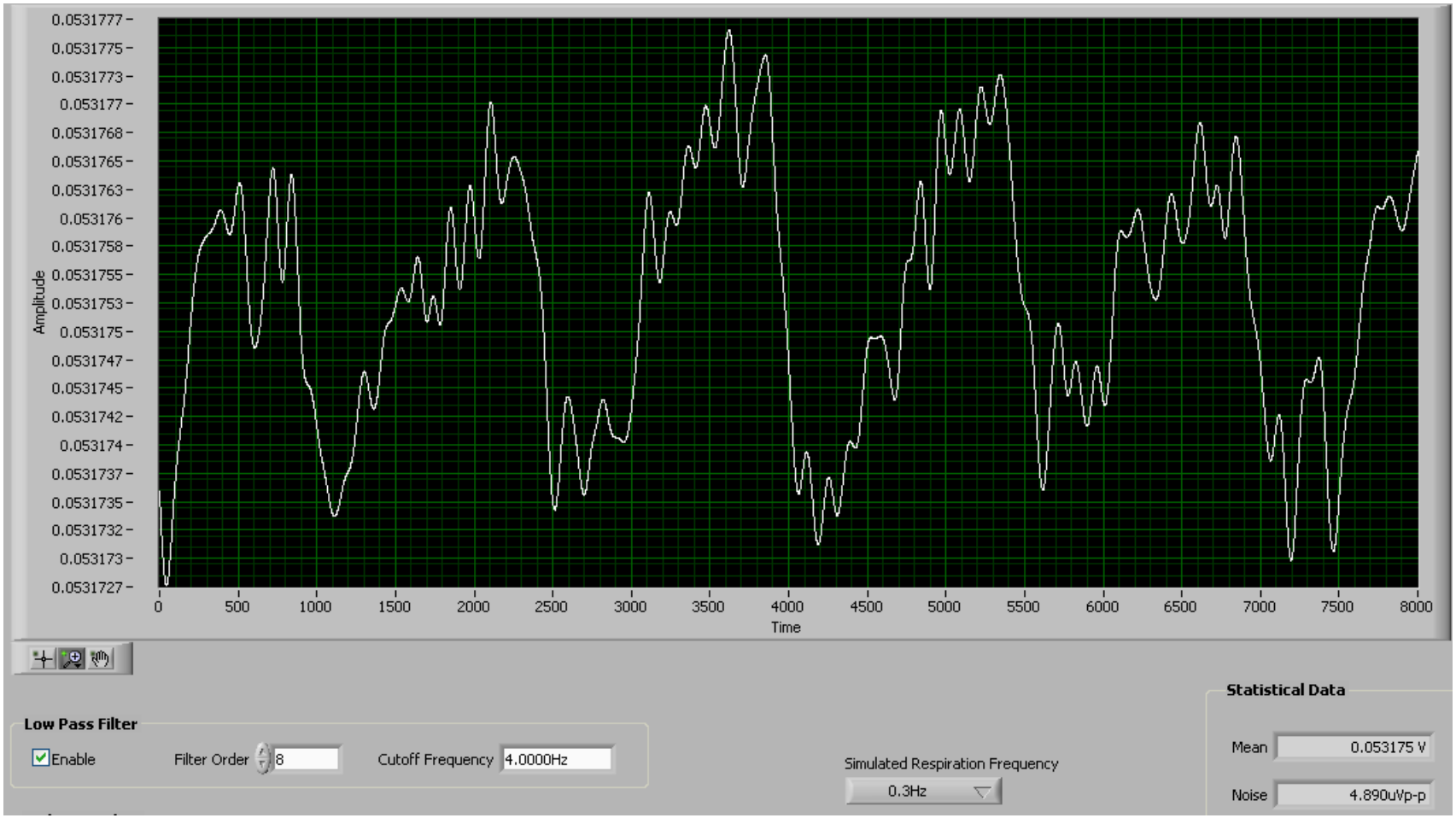
Respiration Frequency = 64KHz

C=2.2nF;resp frequency =64Khz



•The respiration signal can still be detected for this case once it is low pass filtered.

Filtered respiration signal



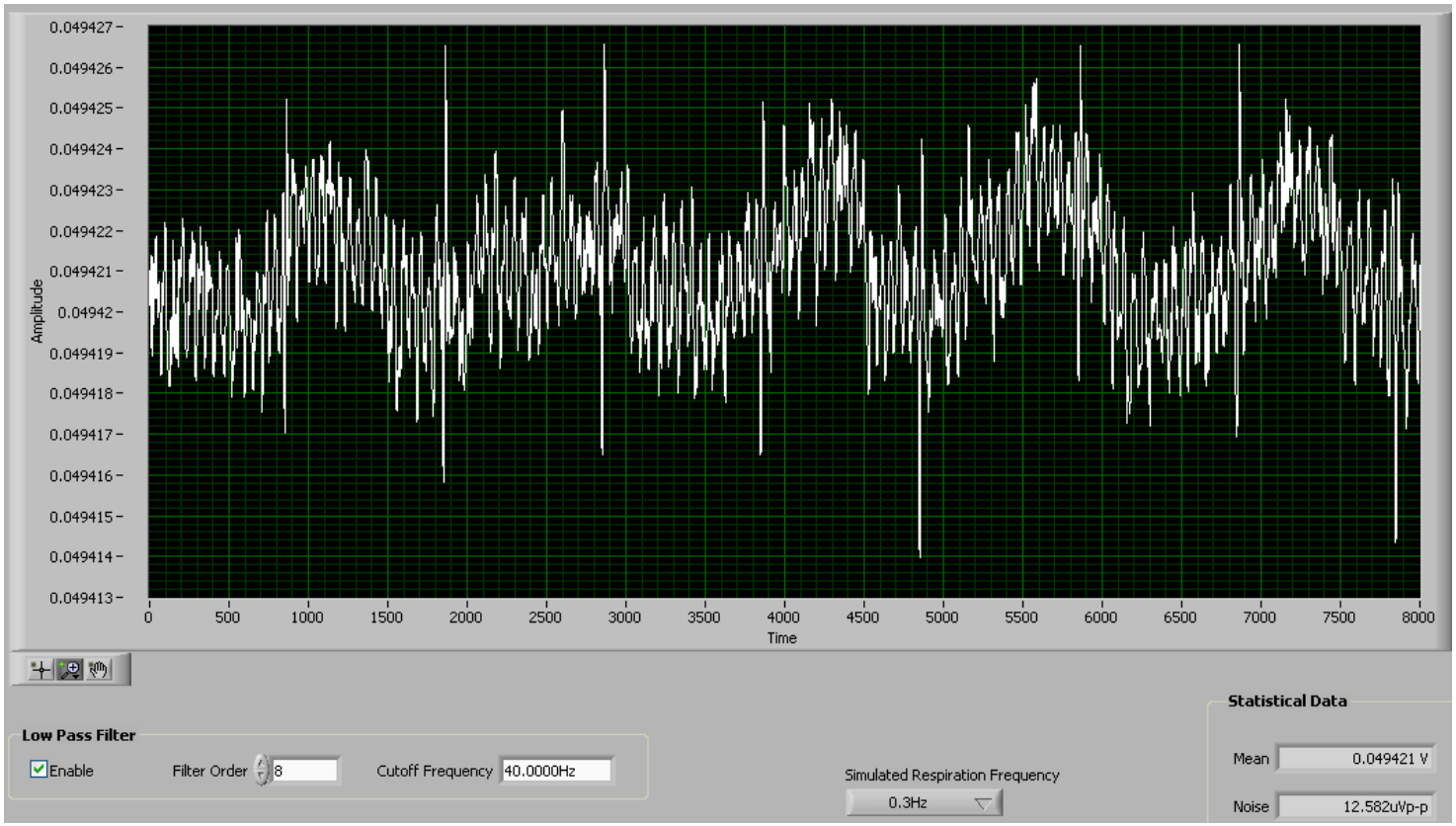
- Interference depends strongly on gain and phase. The pk-pk value is a good indication of amount of interference.
- A summary is provided on next slide

Interference (uV pk-pk) C=2.2nF;resp frequency =64Khz

Phase/Gain	3	4	6
45	**26.5**	**53**	**98**
90	9.3	**18.5**	**43**
112.5	7.9	**11.8**	**31**
135	9.4	**11.3**	**21.4**
157.5	12.5	9.5	**24.8**

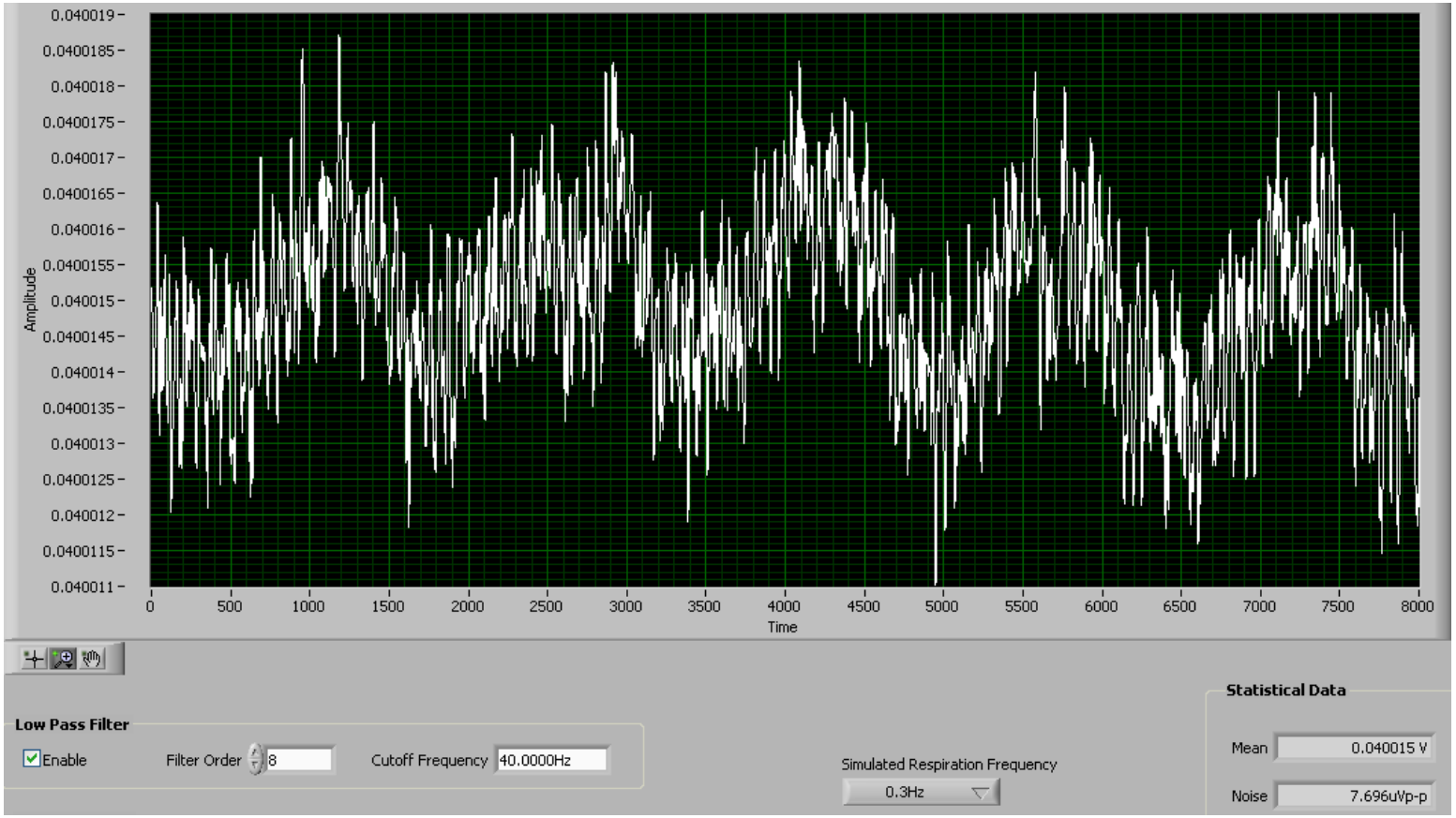
Highlighted entries have visible interference with 40Hz LPF

C=0.47nF;resp frequency =64Khz
G =6; phase =112.5



- No interference is observed for G =3/4
- G =6 still shows some interference; it clears up at phase =157.5

C=0.1nF;resp frequency =64Khz
G =6; phase =135

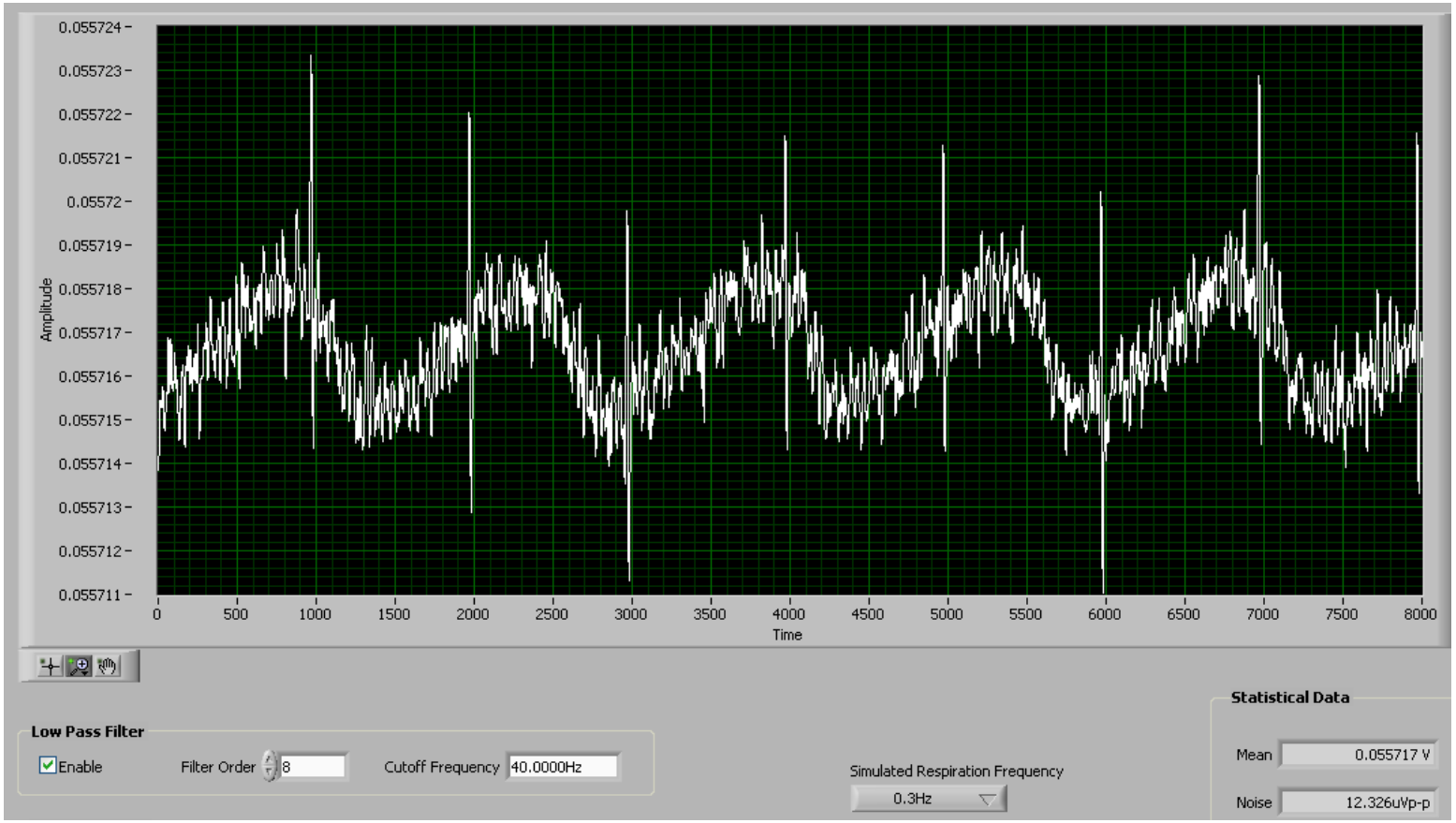


No interference is observed for G =3/4/6

Respiration Frequency = 32KHz

High Resolution Mode

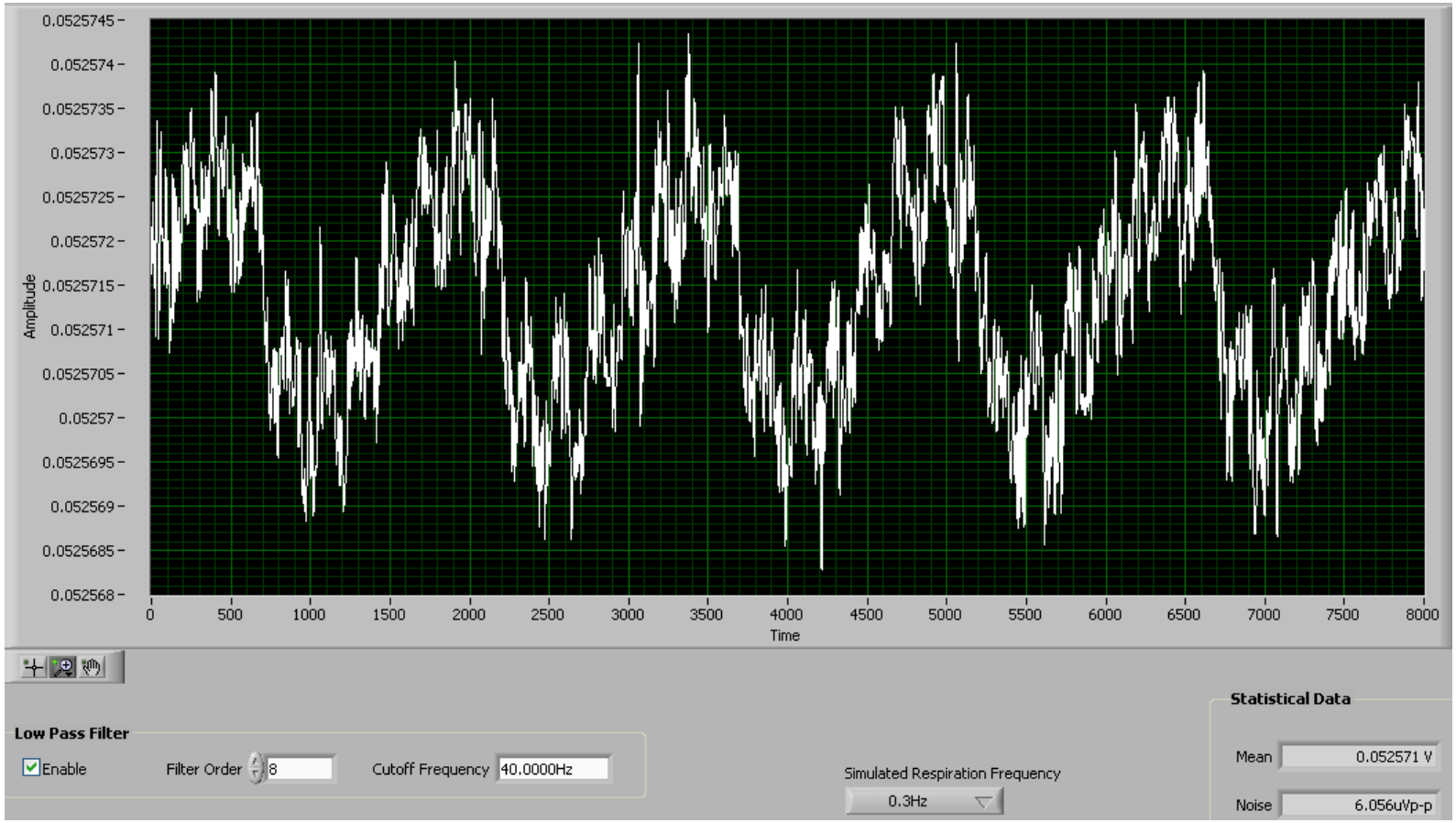
Cap =2.2nF; Freq =32KHz
G = 6 ; phase =112.5



No interference is observed for G =3/4

For G =6 interference is observed only for phase lower than 135

Cap =0.47nF / 0.1nF
G=6; phase =135



- No interference is observed for G =3/4/6

Respiration Frequency = 32KHz

Low Power Mode

LP mode

- Low Power mode may be more sensitive to interference than HR mode.
- There is no interference for C =0.1nF
- For C =0.47nF only G =6 phase <=90 have interference
- C =2.2nF shows significant interference

The summary of interference is in next slide

Interference uVpk-pk
C =2.2nF; resp freq = 32KHz

Phase /Gain	3	4	6
90	11.5	25.9	50
112.5	9.2	17.5	30
135	9	9.7	9

Conclusions

Conclusion

- Respiration frequency of 64Khz is more prone to ECG interference compared to 32Khz
- Lower gain settings have less interference
- Increased blocking (higher phase) gives less interference
- LP mode exhibits more interference than HR mode
- May want to **change C99/C100 to 470pF**.