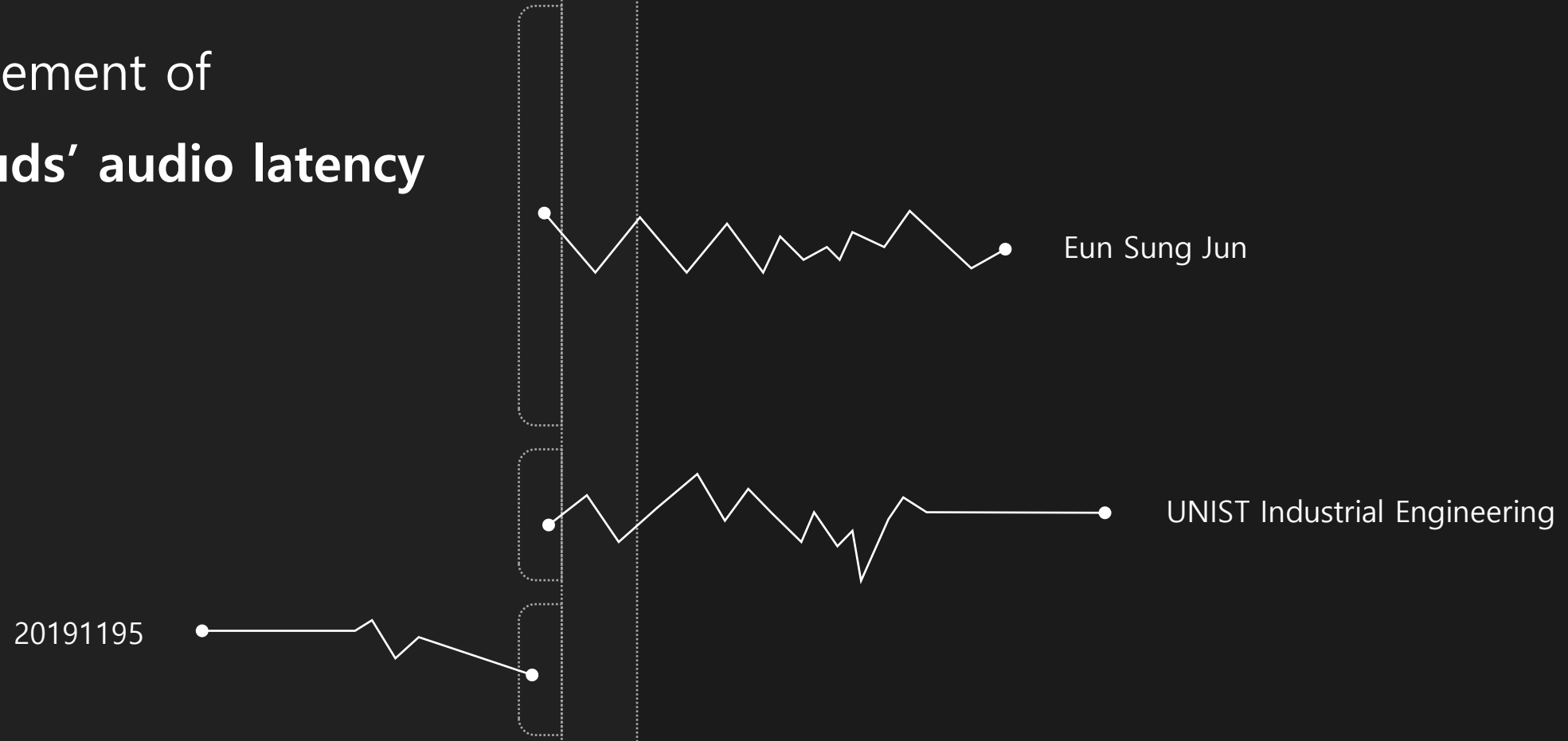
Quality management of **wireless earbuds' audio latency**



Problem of wireless earbuds

Low Audio Quality

Compare to wired earphone, it's hard to include big drivers or high quality DACs.

Audio Latency

Sync slightly doesn't matches when we play game or watch video

Low Battery duration time

For average wireless earbuds, it lasts for 3~6hours if its full charged. Also, battery lifespan affects the earphone's lifespan.

Audio Latency

- Personal Experience

Most annoying part of the wireless earbud is the audio latency.

I enjoy watching Netflix and sometimes I feel that sync doesn't matches.

The sound that I hear and person talking in the movie has slight delay and once I notice that it becomes very annoying.

- Many people suffer from it

블루투스 이어폰을 쓰면서 가장 거슬리는 것 - 커뮤니티 게시판

2018. 11. 8. - 네 저는 음질도 아니고 가끔씩 끊기는 것도 아니고 **블**

을때는 아무런 상관이 없지만

블루투스 이어폰 싱크

블루투스 이어폰 딜레이는 어

2018. 6. 25. - 답글 10개

2018. 6. 27. - 블투 **이어폰** 꼴려서 몇가지 청

폰에 블투 **이어폰**을 쓰는데영상과 소리 **딜레이**가 느껴지네요.영상보다 소리가 약간 늦는 느낌이

경안쓰고 있었는데 영상볼때 **딜레이** 좀 있는

갤럭시버즈 딜레이 있는거 다들 공통적으로 느끼는 부분인거죠 ...

배틀그라운드 하는데 **딜레이**가 굉장히 크게 느껴지더라고요.. 발사버튼 누르면 ... **블루투스**로 연결되는 무선 **이어폰**들은 모두 **딜레이**가 발생할 수 밖에 없습니다ㅎㅎ.

NETFLIX

Disney+

Process of Bluetooth earbuds

1. Inquiry

If it's first time to connect the Bluetooth earbuds and audio device, running inquiry is necessary. One of device will send the inquiry to other device and other one will respond with its unique address or name..

2. Connect

By selecting the corresponding address, we can accept the pairing which makes the earbuds and audio device connected.

3. Signal

Audio device will send the digital signal of music to earbuds through Bluetooth

4. Convert

As Bluetooth earbuds only deals with analog signals, DAC (digital-to-converter) in the earbuds will convert digital signal to analog signal

5. Output

Analog signal is sent the amplifier and then sent to the speaker of the earbuds.

Collect the Data

- Materials

QCY T1(my earbuds)

Galaxy A90(my phone)

Audio latency test video

- Process

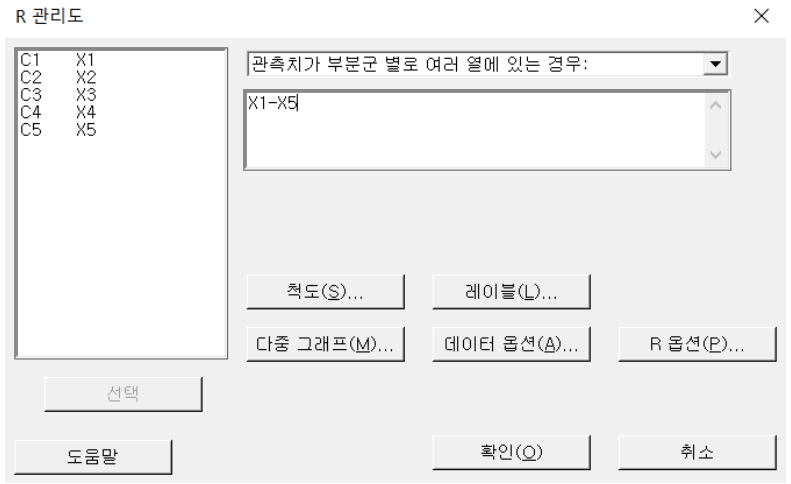
1) **Connect earbud to my phone**
2) **Conduct audio latency test video with my phone for 5 times**
3) **Measure the delay**
4) **Repeat 20 times**

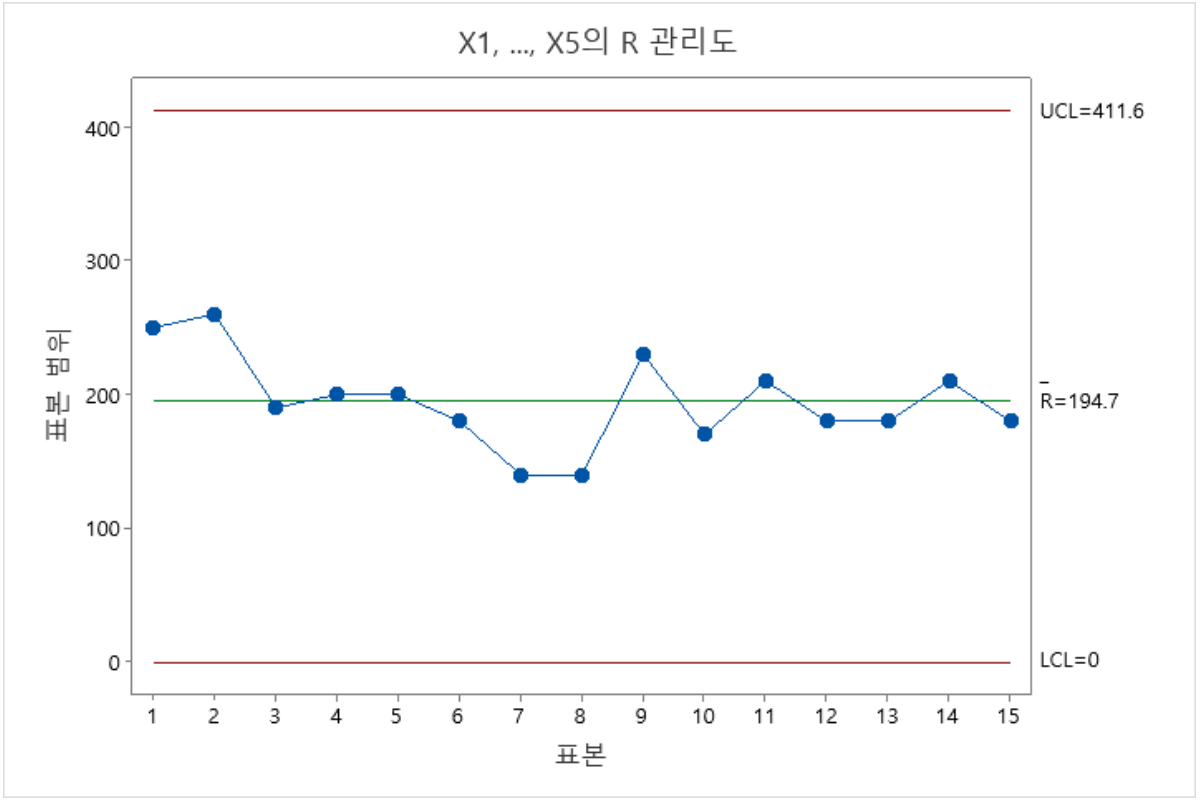
Data Analysis

- Data Set

	C1	C2	C3	C4	C5
	X1	X2	X3	X4	X5
1	180	-70	180	-40	140
2	180	-40	80	-80	140
3	-80	100	-80	110	40
4	120	-80	-80	-80	50
5	130	130	-60	140	-30
6	170	0	90	20	180
7	-40	19	-100	40	30
8	140	0	40	30	40
9	100	-90	140	80	-40
10	70	80	-30	140	10
11	80	40	20	30	-130
12	-30	80	-80	20	100
13	0	80	10	70	180
14	40	70	10	-140	60
15	19	-110	30	70	30

- R Chart

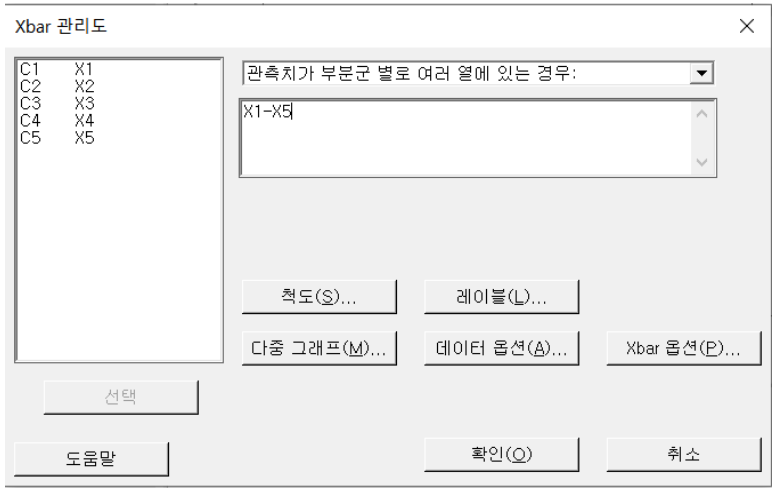


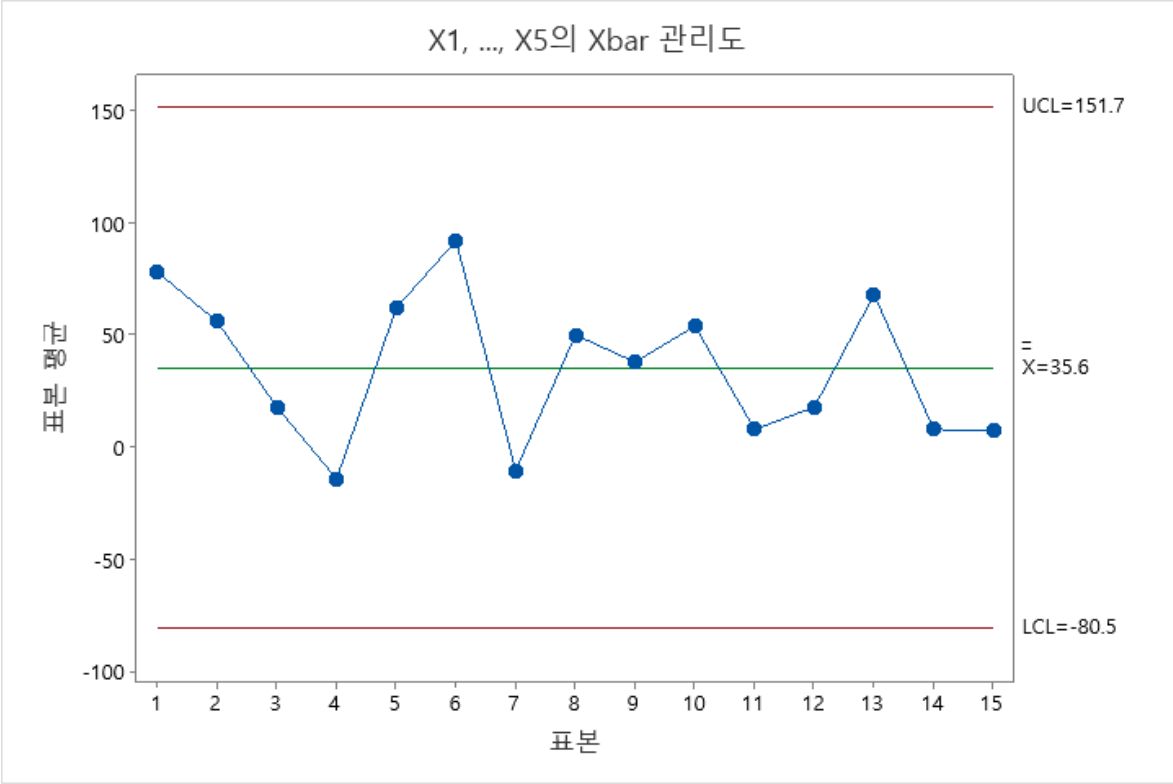


The unit of data is ‘ms’. As there is no point which are out of range between UCL and LCL, the process is in control

Data Analysis

- X bar Chart

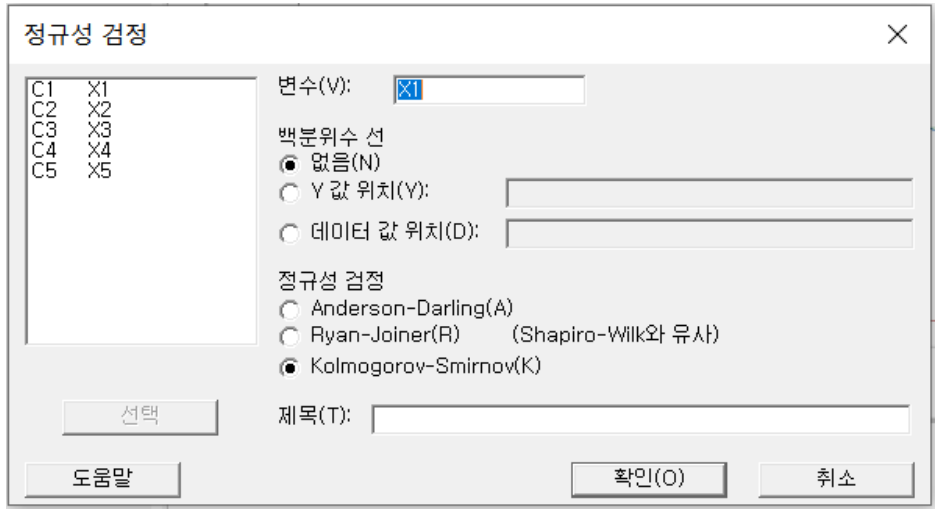


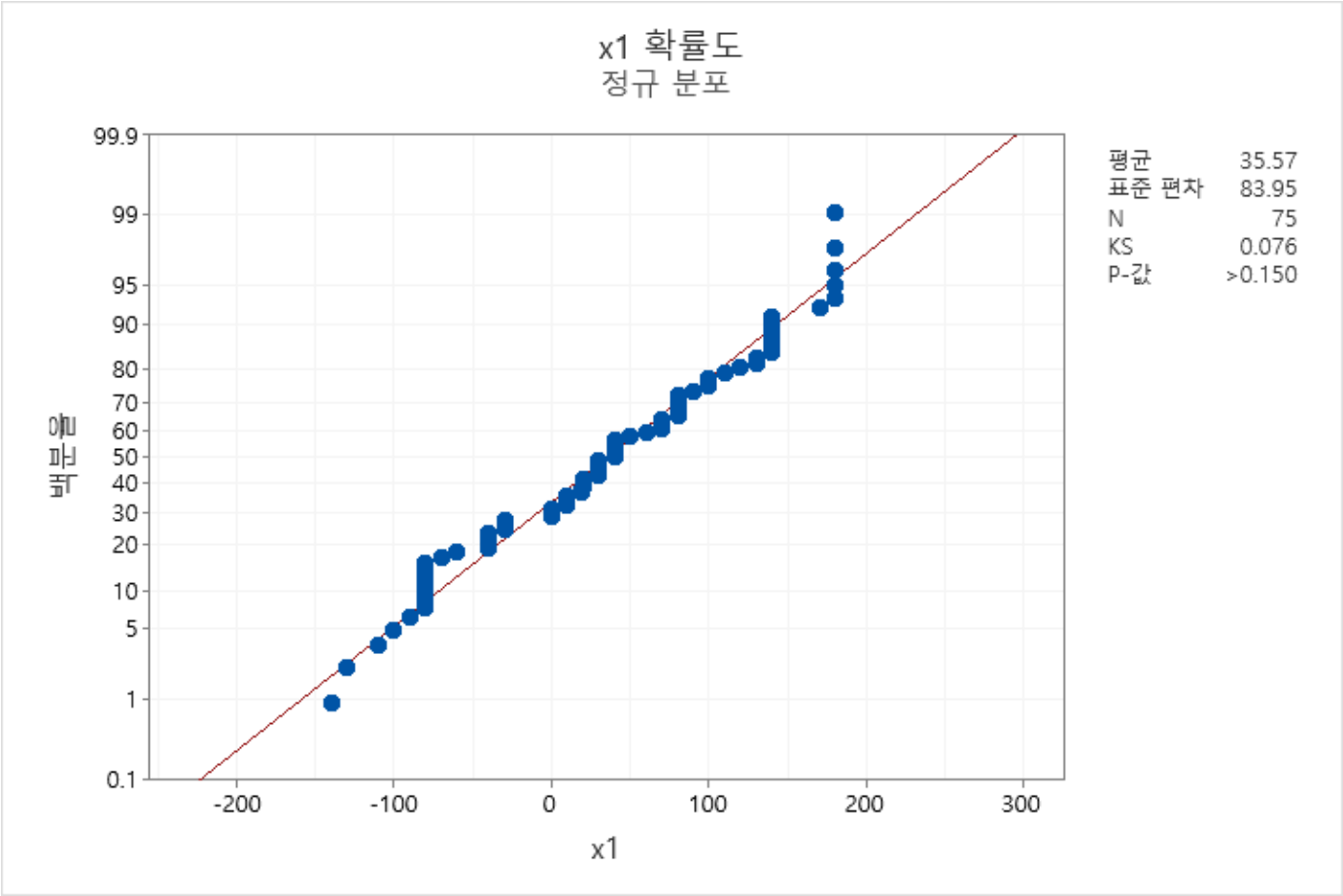


As there is no point which are out of range between UCL and LCL, the process is in control

Data Analysis

- Normality test

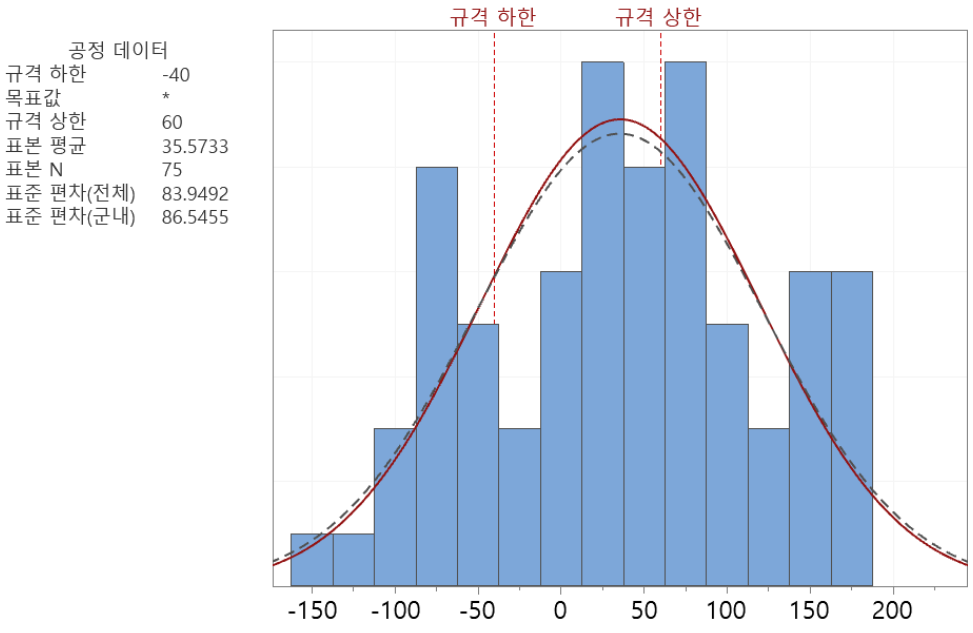




Because p value is bigger than alpha, we can accept that data follows the normal distribution.

Analysis result

- Process Capability Analysis



I set LSL and USL based on EBU(Europe Broadcasting Union) Recommendation R37-2007, which that claimed that sound earlier than 40ms and later than 60ms make people felt weird.
https://tech.ebu.ch/docs/r/r037.pdf

Presumed Cause of Audio latency

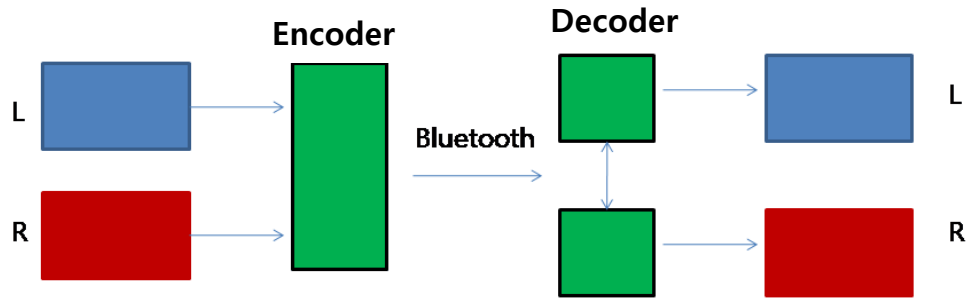
- **Signal**

As digital signal is delivered from audio device to earbuds without wire, it may take some time which affect the audio delay.

- **Convert**

When wireless earbuds convert digital signal to analog signal they mostly use method of dividing into two sperate packets which manage the signal and send it to L and R after conversion.

In this method, the signal interference is relatively less, but delay occurs because the processing speed and the sending speed must be matched between packets.



Conclusion

- Quality evaluation result

Cp value is 0.19 and Cpk value is 0.09. I think this value is relatively low, which means that process is not in high quality.

- Quality improvement idea

To solve the cause of audio latency, using high quality codec or redesigning the hardware structure could decrease the audio latency.
The left table is several wireless earbuds and headphone's audio delay which are measured by the users of community site "0db". We can know that all of those products doesn't fit in the guideline of EBU's recommendation. So I think fundamental technology should be shifted to solve this problem.

제품명	딜레이(ms)	코덱
Plantronics Backbeat Go 3	60	SBC(HQ 커스텀 코덱)
Marshall Major2	100	apt-X
Sennheiser Momentum 2 overear	105	apt-X
Bose soundlink OE	110	SBC
Awei A920BL	110	SBC
Apple airpot	130	SBC
B&O play H5	130	apt-X
Sony Mdr 1000x	150	apt-X
Bose QC35	150	SBC
B&W p5	150	apt-X
Jabra sport coach	155	SBC
Jaybird Freedom	160	SBC
Sennheiser pxc550	160	apt-X
Bose SoundSport wireless	175	SBC
Beats powerbeats2	275	SBC
Earin	400	apt-X
Samsung Gear icon X	440	SBC

Discussion

- Process to collect data is not accurate

Once I set my goal to measure the audio latency, the most accurate way that I could find in internet is using the Arduino and using the audio sensor. However, because this assignment has a week of duration and individual assignment, it was hard for me to do it. So alternative way was using the audio latency test video. Using Arduino would make more reliable data to evaluate the quality of the process.

- Theory and application is different

When I hear about the quality management in the lecture, I thought I understand most of it. However, as I tried to use Minitab and do procedure for quality management myself, it was very confusing. Although there is explanation in the lecture slides, applicating what I learned in lecture to real world problem was challenging work.