Tonochi's Audio Room – Supplemental Info

Things I Learned from Gaudi

2021/05/16

Things I learned from Gaudi – What I've learned from my experiences in Gaudi Project for the past 39 years.

The contents of this document were reprinted from my previous homepage 'Tonochi's Audio Room'. The original was written in 2013. Now I see some misunderstandings, groundless beliefs and lack of experiments and measurements in this document, but lessons learned from experience are important, and they are the base of Tonochi Theory. So, I decided to reprint the article. Some parts were edited.

Contents

Preface

I have learned a lot of things from Gaudi, which I have been developing for 39 years (as of 2013). These are somewhat different from things written in audio magazines, or can't be found in the magazines. The lessons learned from Gaudi are precious properties for me.

Especially, I would like to feature the following five lessons:

- Importance of system design
- Charms of vinyl records
- Merits of tube amplifiers

- Superiority of multi-amplifier system
- Significance of home-built audio systems

Importance of System Design

I was an only high school boy and not proficient in technologies, when I designed Gaudi. The fact, however, was not disadvantage but rather advantage for me. I was not particular about each elemental technology. I pursued performance of the system as a whole. If I had been an experienced engineer those days, I might have been particular about circuit design or some mechanisms; I might have failed to pursue system performance, as the old sayings go, "cannot see the forest for the tree," "too clever by half."
I had extended knowledge of audio products, though I was inexperienced in technology. I memorized specifications of all products of 120 foreign and domestic audio makers (including audio parts such as speaker drivers). I would show my knowledge and silence salesmen of audio shops in Akihabara those days (I was such an impertinent fellow). My knowledge was so useful when I considered and decided Gaudi's system configuration and performance goals.

I think I could avoid wasting time and money by setting clear performance target in the early stage. Do you wonder why it took so many years to develop Gaudi? That's not because I wasted time, but because my budget was limited to 70,000 to 80,000 yen a year, and I stopped building Gaudi when I was busy for my main occupation. [2013/08/01 added] {There is one more reason to delay. I spend so much time to improve the existing devices that I can hardly start the next project. But the effort to know shortcomings of the existing devices and consider the measure to improve them leads to making the design of the new device a lot better}

It is essential to consider the specification of each equipment based on system design. Redundant features and unnecessarily high performance are things to be omitted. They probably lower the sound quality.
For example, ~~an attenuator isn't necessary on a network if a power amplifier has one~~. [2015/01/21 corrected] {Generally, the attenuator precedes the first stage of the power amplifier. When the signal is attenuated, high-value resistance is inserted into the signal line in series, and that distorts the signal before it is input to the first stage. So the attenuator shouldn't be used. In order to eliminate the attenuators of the network, the gain of each power amplifiers has to be determined based on the sensitivities of the corresponding LS unit. It is feasible for DIY systems, and it is the essence of system design}
You should pay attention to unnecessarily high performance, too. The higher the performance, the better the sound quality? I don't believe so. In many cases, circuits are more complex and the number of parts is larger for higher performance. They negatively affect the sound quality. The best example is the maximum output power of power amplifiers. If it's 100W, though the system requires only 10W, more complex circuit, more parts, larger parts and longer signal paths are needed comparing with a 10W amp. In that case, the sound quality is more likely to get worse.
I don't believe too high stability is good for sound quality, either. I feel excessively stabilized amplifiers lack dynamism and vividness in their sound. Manufactured amplifiers and circuits introduced in articles of specialized magazines are designed thoroughly to achieve the maximum stability, because they have to be able to drive any type of speakers. In a particular system, the load of the amplifier is within the specified range, and excessive margin is not necessary.
There are many kinds of margins in audio equipment design. Too much margin doesn't lead to higher sound quality; on the contrary, it negatively affects sound quality, just as the saying goes, "Too much is as bad as too little." It is important to know appropriate levels of the margins based on a good system design.

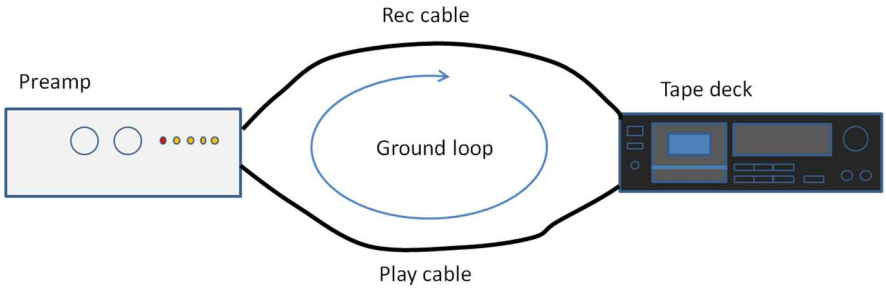
Though I'll never buy high-end audio products as I am not a rich man, I sometimes try them out at an audio shop I visit regularly. I usually occupy the listening room of the audio shop for one hour. I also listen to high-end audio systems at audio events such as Tokyo International Audio Show. In many cases, I think "This one may be better than Gaudi, but not so much for its price." In some cases, I think "Gaudi is better than this." [2013/08/01 added] {Only once, I tried to replace Gaudi by a system composed of high-end audio products of which total price was about five million yen. So a possibility I buy a high-end audio product is not zero}
You can realize excellent sound quality without high-end parts and components, if there's no major weak point in the system. On the other hand, the sound quality of a high-end system is worsened drastically by a single weak point.
From my past experience, I would like to mention the following six points to which you should give extra care:

- Ground loop

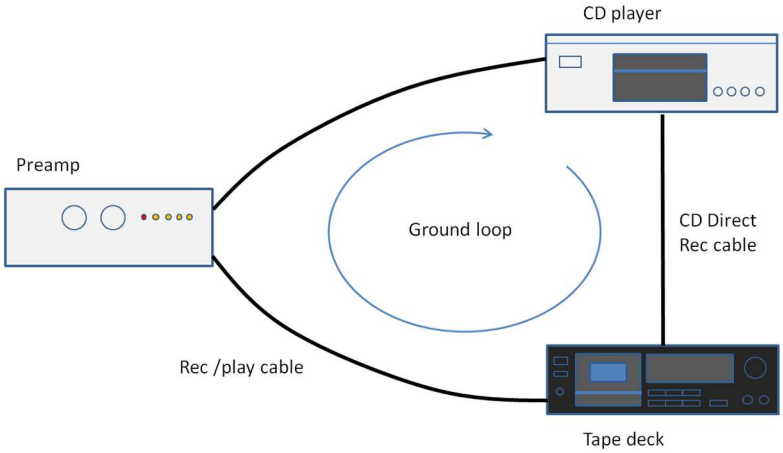
- Common impedance
- Contact
- Vibration
- RF noise
- Potential difference

Ground Loop

A ground loop in an audio system makes the sound brassy and unpleasant on the ear. In some cases, hum noise occurs. The ground loop is such harmful, though, you may make it without knowing, unless you always keep it in mind.
The figure below is an example of the ground loop; the cables for recording and playing, which connect the preamp and tape deck, are separated. No matter how expensive the cables are, the ground loop deteriorates sound quality. Cheaper cables that parallel rec and play cables together and are sold in a blister package at electric appliance stores are much better.



Harmfulness of the ground loop had not been known until relatively recent years. The cassette tape deck, Excelia XK-007, which is used in Gaudi, is a good example. It was manufactured in 1989, and designed to form a ground loop in its use. At least until the end of 1980s, even professional audio engineers didn't know harmfulness of the ground loop.
XK-007 has a jack called 'CD DIRECT', which is supposed to be connected to the output of a CD player. Many of CD players those days had two output jacks; one is supposed to be connected to a preamp (or an integrated amp), the other to the 'CD DIRECT' of the cassette deck. The 'CD DIRECT' switch on the front panel of the deck selects the input source between REC and CD DIRECT. When CD DIRECT is selected, the input signal comes directly from the CD player. That is, it doesn't come through the amplifier, and the loss of the signal is minimal. It was firmly believed that CD DIRECT makes the sound quality better when you record a CD.
Naturally, I tried the CD DIRECT feature. But it didn't make the sound quality better. On the contrary, it drastically worsened sound quality. Not only for cassette tape but also for any other sources, the sound was brassy and unpleasant. It was still the same when XK-007 was off. It took me some time to find the cause. Finally I found it while I was checking the connection, guessing it was related to KX-007. I removed the CD DIRECT Rec cable. The sound quality became good as it used to be.

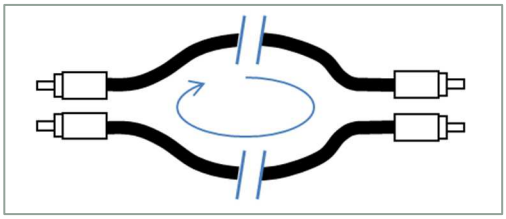


XK-007 has another weak point that leads to ground loop. Its REC and Play jacks are apart. That makes a small ground loop. As of the year 2013, XK-007 is used as a cassette tape player, and this problem is avoided because the REC cable is not connected.

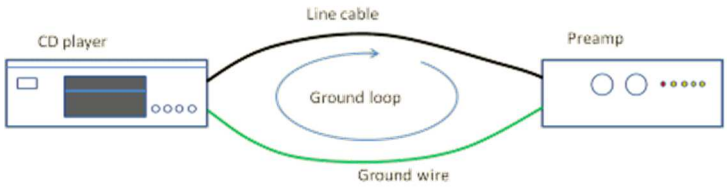
From the experience, now I regard ground loop as the most fatal trouble in an audio system. From then on, I took the greatest care not to form any ground loop both in the whole system and within each amplifier.

I'll give some more examples of ground loop.

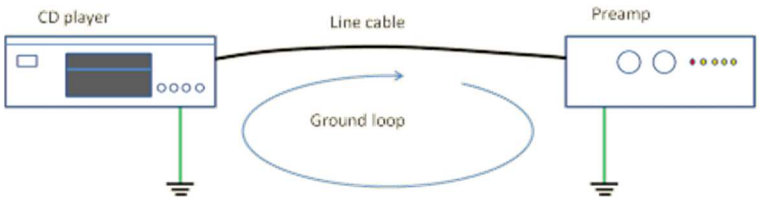
When you make a stereo cable, don't let the wires of the left and right channels separated so that a ground loop won't be formed. The best way is twisting the wires loosely.



Don't add a ground wire to connection between audio equipment.



Don't connect each audio equipment to the earth. If you do, it makes a ground loop. In addition, it induces various kinds of noise current flowing under the earth. The noise level would increase drastically.

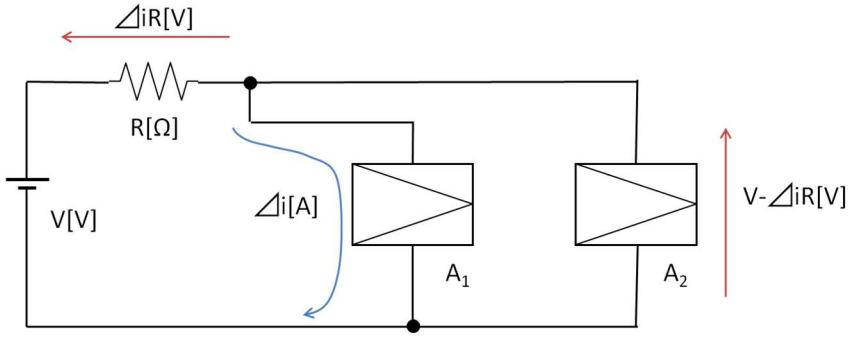


Common Impedance

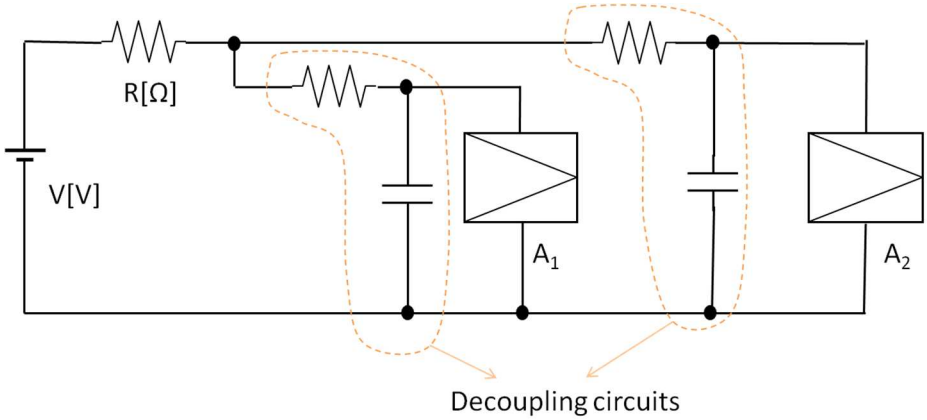
The next most harmful thing to ground loop is common impedance.

If a path through which more than one electric current flow has impedance, the voltage drops in proportion to the intensity of each current. As the current increases or decreases, the voltage drop will increase or decrease. Therefore, circuits interfere each other.

For example, assume that two amplifier stages, A1 and A2, share a power supply voltage V[V] and there is a common impedance R[ohm] between the power supply and the amplifier stages. When the current through A1 varies by delta-i[A], the supply voltage will vary by delta-i x R [V]. Any amplifier is affected by the fluctuation of the supply voltage more or less. That is, the operation of A1 affects A2. This phenomenon is called **coupling**.



A circuit that is designed to prevent coupling is called **decoupling** circuit. Many audio amplifier have a decoupling circuit for each stage.



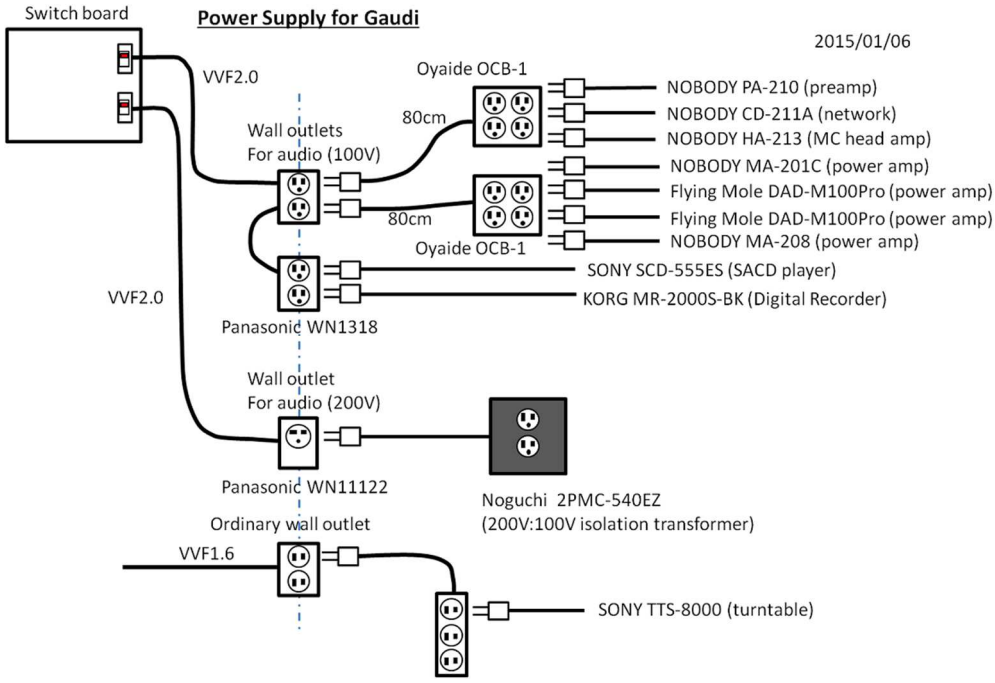
Common impedance is a big problem in system level, too. A power strip is a good example. If there were a cable and connector that have no impedance at all, an ideal power strip could be made. Unfortunately, there aren't such materials. Audio devices slightly interfere each other because the impedance of the power strip is common to them, although every audio device is designed to minimize the influence caused by fluctuation of the power supply voltage.
Some manufactured amplifiers have AC outlets for other audio devices. They should not be used, if sound quality is considered important. It is surely handy to turn on/off all the devices in the system with the amplifier's power switch, though, sound quality deteriorates instead of the convenience.

The preamp PA-203, which once was used in Gaudi, had six AC outlets. I noticed they worsen sound quality, while I used them. The power amplifiers and CD player, whose current swing largely and rapidly, affect the sound quality of the preamp, which handles very small signals, if their power cords are connected to the preamp's AC outlets. Especially, the CD player's power current fluctuates very sharply, because it has some servo motors in it. The CD player's power cord shouldn't be connected to the amplifier's AC outlet. Moreover, it shouldn't be connected to even a power strip; it should be connected directly to a wall outlet.

You should care about wiring that can't be seen usually; that is, a cable in the wall. The cable connecting the switch board and the wall outlets for audio must be as short as it can be, and must not be connected to outlets for other purposes.

The figure below shows Gaudi's power connection as of 2015. As it is a tri-amplified system, many outlets are needed, and inevitably, power strips are necessary. I use two Oyaide OCB-1 power strips. Its original cable length was as long as 3m, I cut it to 80cm.

A breaker for audio is built in the switch board; A cable VVF2.0, which is the thickest one for ordinary houses, is used connect the breaker and the outlets for audio. For the wall outlets, two Panasonic WN1318 hospital-grade outlets are used. Its contact resistance is one-thirds of ordinary outlets. So it surely reduces the common impedance.
WN1318 is also used on OCB-1.



So-called audio grade outlets are available, which are supposed to be more excellent than the hospital grade. But I don't believe in their performance. I think it is a superstition that some costly material--something very rare--makes sound quality better. Especially, I'd like to say that it is not a good if the contact is made of a material rather than nickel. Contacting different metals accelerates corrosion of the one of them that has stronger ionization tendency (easy to corrode). This phenomenon is called bimetallic corrosion. Plugs are made of nickel. A hospital grade outlet's contact is nickel-plated. Most of audio grade outlets are not good match for the plugs, while hospital grade outlets are good.
A common outlet contact is made of phosphor bronze. It is easy to corrode (ionization tendency is strong), and it corrodes rapidly by being contacted to a nickel-plated plug. I don't think the ordinary outlets are good for audio, either.

A 200V AC outlet for audio is also installed in my room. The connector is also hospital grade, Panasonic WN11122. Now this outlet is not used, though, I am planning to use it as mains for the power amplifiers with a 200V:100V step-down transformer.
If the voltage is doubled, the current is halved at the same power dissipation. The fluctuation of the amplifier's current is halved on the 200V line. Besides, the voltage fluctuation on the 200V line is halved at the secondary winding of the step-down transformer (100V line). In total, it is the same effect that the in-wall cable impedance is reduced to 1/4.
The step-down transformer also works as a noise filter. It filters RF noises. And, because it isolates the amplifiers from the earth, noise currents don't flow through the power cords. It's a great advantage.

I want to buy the step-down transformer as soon as I get a budget, since it is so advantageous to use the 200V mains.
[2013/08/01 added] {I have been using a step-down transformer, Noguchi Trans 2PMC-540EZ, for the power amplifiers for the midrange since June 2013. The transformer's power capacity is 540W and it has two outlets. I don't know it has improved sound quality yet. I am planning to buy one more transformer and make all the power amplifiers powered from the 200V outlet}

[2015/01/21 corrected] {I found out the sound quality of the power amps for midrange, Flying Mole DAD-M100Pro, was degraded probably because the step-down transformer disconnected them from the earth though their power supply circuitry, which doesn't use a transformer, may need earthing. Now they are connected to the OCB-1. I'm planning that 2PMC-540EZ will be used for NOBODY amp in the future. I don't intend to buy any more step-down transformer, because it's hard to find a place for it due to its magnetic flux leak and groaning, and there is only one 200V outlet on the wall behind Gaudi}

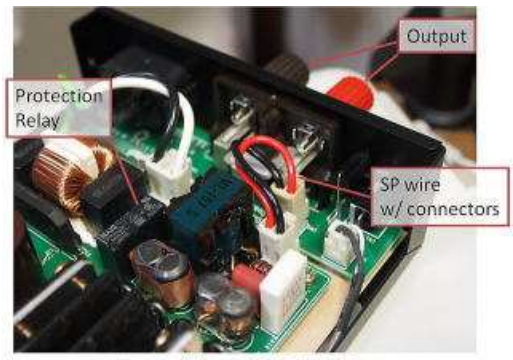
Contact

Contacts, such as switches, relays and connectors (plugs, jacks, terminals), often cause troubles like a bad connection. In less serious cases, the contact has considerable impedance. As the electrical current increases, the impedance affects more seriously the operation of a circuit.
In an audio system, the biggest current flows from the output of a power amplifier to a loudspeaker. For example, assume that the output of the amp is 100W and the impedance of the speaker is 8 ohms; As big as 3.5A of current flows through the amplifying element (transistor or valve) to the speaker cable and finally to the voice coil of the speaker. Contacts on this route must has fine quality in particular. If the cable can be soldered to the terminals, that is, the number of contacts can be reduced, it leads to finer sound quality.

What if the quality of a contact is not fine, in other words, it has some impedance? To my ears, the outline of the sound image is blur, and sound is not clear though it is not unpleasant. It is hard to catch speech and conversation. But from another point of view, it can also be said that the sound is so soft and rich like sounds of tube amplifiers.

I have experienced this kind of cases twice.
The first experience is about the speaker switch of an integrated amplifier LUXMAN L-505V. One day, a friend of mine came to me and said, "I have used this amp for many years and it's now broken. I don't need it any more," and gave me the amp. I checked it and found the trouble was only the maladjusted bias current of the output transistors. I adjusted the bias and began using it in my subsystem. The loudspeaker was Victor (JVC) SX-3 III. L-505V sound was soft and warm. I was impressed that LUXMAN's semiconductor amplifiers sound like tube amplifiers because LUXMAN had been a prestigious manufacturer since the vacuum tube era.
At that time, I used the subsystem to play Laser Disc's sound tracks. I realized it was hard to catch what an actor or actress said in either English or Japanese. I didn't catch the meaning of the script from time to time.
A few years later, one channel became silent. I investigated and found it was the speaker switch of the amp was broken. This switch was the same type as switches for small signals like the tape monitor switch.
For each switch, the optimum current range is specified. For a small current, contact structure and materials suitable for it must be employed; and for a large current, the same thing goes. It is not good, if the current through the contact is equal to or the greater than the switch's maximum ratings. It's obvious there are different basis of selection for small current switching and large current switching like the speaker switch. LUXMAN, however, selected the same part for both the small signal switches and the speaker switch, probably because that made the front panel look better.
I said to myself, "Even a prestigious maker like LUXMAN could make such a basic mistake." And, I changed the wiring so that the output of the amp went straight to the output terminal passing the speaker switch, because I seldom used the switch anyway. To my surprise, the sound had been dramatically changed. The amp seemed to be quite another one. Its sound was clear and more dynamic like other semiconductor amplifiers. Its valve-amp-like soft sound had been caused by the small switch.

The second experience is the power amplifier currently used in Gaudi, Flying Mole DAD-M100Pro. It is a class-D amp, yet its sound is soft as a tube amplifier. I remembered the previous experience with L-504. I wondered if the same technique (?) might be applied to this amp too. I removed the cover and took a look into the amp. At a glance, there seemed to be no speaker protection relay. But I found a micro relay for protection by a close look. It was Panasonic ALD112, and its maximum rating is only 3A. The maximum rating means the maximum acceptable value with which the part can work without any damage. It does not mean the value of the current is suitable for the

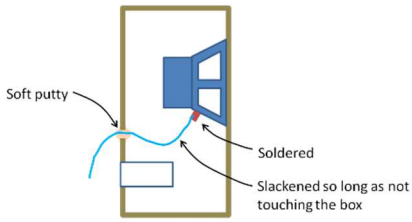


Internal View of DAD-M100Pro

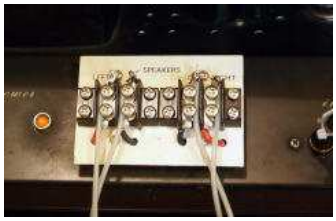
part. The suitable range of current, which flows through the contact with the minimum distortion, is far smaller than the maximum rating. 3A is obviously too small for the speaker protection relay. At least 10A, or 20A if possible, is required as the maximum rating of the relay. I firmly believe that this small protection relay makes the sound of this amp so mild. Unlike L-504, however, DAD-M100's sound is not so blur. It's properly mild.
The output current flows through the relay, the connector on the main board, the interconnection cable, the connector on the sub-board and the output terminal, and finally it reaches the speaker cable. That is, the current passes through the four contacts: the relay, the connector on the main board, the connector of the sub-board and the output terminal, between the power transistors to the speaker cable. The contacts other than the relay may not affect the sound quality so much, because their maximum ratings are greater than the relay. But still I guess they also make the sound less clear.

W. Marshall Leach Jr. said, in his book "Introduction to Electroacoustics And Audio Amplifier Design,"the easiest way to accomplish tube-amp-like sound is adding a 2 ohms of resistor in series to the output of a semiconductor amplifier. It is surely a good way to get soft and comfortable sound like a tube amplifier.

In audio system Gaudi, the number of contacts is reduced by using soldering the speaker cable to the terminals of the amplifiers and those of the speaker drivers. This measure makes the sound so clear, and makes it easier to catch the speech and conversation. Besides, the sound becomes more powerful so that super bass sound can be felt by skin rather than heard, and you can realize the sound of cymbal is generated by hitting a heavy metal disc.



Connection of the speaker cable
(the speaker side)



Connection of the speaker cable
(the woofer amp side)

Connection of the speaker cable
(the tweeter amp side)

This method takes a lot of effort to change the cables. When changing the speaker cable, you have to remove the speaker driver and need a soldering iron. But you shouldn't avoid this labor to improve sound quality. This method is more effective than using any costly terminals. The cables are changed not so often, and for a man who is energetic to build his/her original amplifier this labor must be nothing.

In addition, all the cable to the channel divider CD-211 are soldered directly its internal circuits. Though this is somewhat effective, it is not as effective as reduction of the contacts of the speaker cables.

Vibration

Some say, "A man who can control vibration can control audio." It's true. Vibration control really influences sound quality. But you can say, this is the most difficult problem to solve. Easy ways such as attaching an antivibration goods to audio equipment and reinforcing racks and cases won't work in most cases.

I used to have two big misunderstandings about propagation of vibration (sound).

- A hard and heavy object hardly propagates vibration (sound)
- Solid cases and racks are vibration free

A hard and heavy object like a rock tends to keep its position by inertia when it gets an external force. It can be used as the mechanical earth. I, like other audiophiles do, placed granite boards under the loudspeakers, in order to give the speakers the mechanical earth. My misunderstanding was that I believed the granite boards also worked as insulators. They didn't live up to my expectation. Bricks, which I used to use as speaker stands, were rather better than the granite boards in insulation of vibration. But as the mechanical earth, the granite boards are far better, and they improved sound quality. So I still use them.

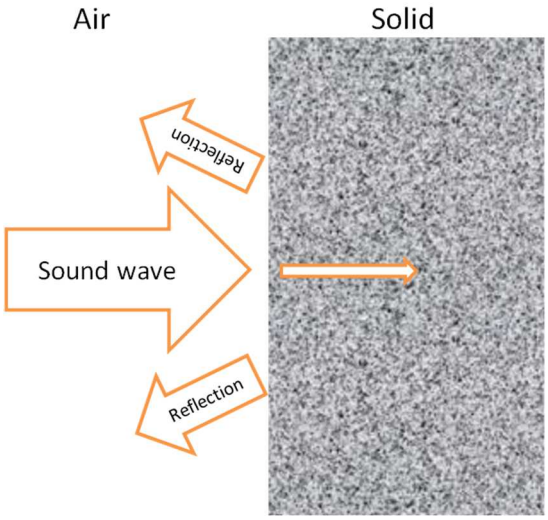
I experienced one more thing like that, though it was not concerned with Gaudi.

I have conducted an experiment about ultrasonic wave at work. I had to shut out vibration somehow from the outside of the apparatus in order to prevent the measured data from being mixed with noise (vibration from outside). At that time, I misunderstood that a hard and heavy object shuts out vibration, and placed a 20cm thick and 50kg aluminum board on a stand and placed the apparatus on it. Soon after beginning the experiment, I realized this counter measure was useless at all. Footsteps of a person walking around in the lab was sensed by the apparatus. Moreover, even vibration caused by a large vehicle that ran on a road outside of the venue was sensed.

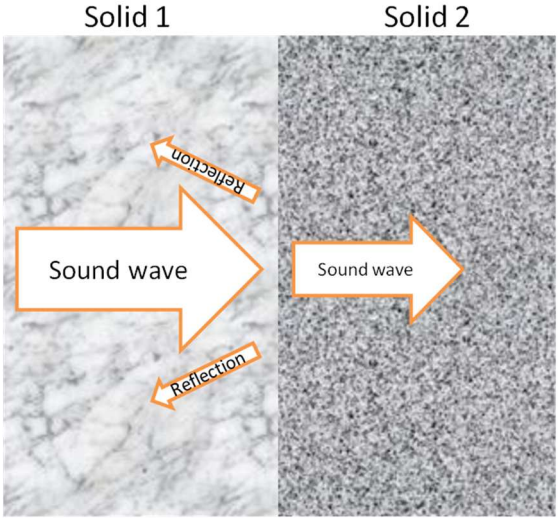
I have one more bitter experience.
When I designed the preamplifier PA-210, I still misunderstood that a solid and heavy case was vibration proof. I designed a very solid case for PA-210; A solid frame was formed with aluminum square bars and 2 or 3 aluminum boards were fixed with screws to each side.
When I used PA-210 in Gaudi for the first time, I was appalled by the click noise caused by the operation of the selector switch. It was not an electrical noise, but a microphonic noise, which the vacuum tube in the flat stage picked up the vibration caused by the rotary switch.
I didn't have this kind of trouble at all with PA-203, which was not designed to be vibration proof.

From those experiences, I understand that a hard and heavy object does not have any function that prevents vibration in spite of its reliable appearance, and a solid case is rather sensitive to vibration.

It's true that a rock or a concrete wall blocks sound. But it's not because they don't convey sound, but because they reflect most of the sound due to the big difference in acoustic impedance between them and air. The bigger the difference, the more sound is reflected. Only little part of sound goes into them.
A gaseous body, a liquid and a solid body are all a medium that carry sound. In this order, acoustic impedance lowers. In a solid body, the velocity of sound is very fast and sound is carried for long distance without much decrescence. That is, a rock or a concrete itself conveys sound very well. In case that two solid bodies are stuck, sound propagates from one to the other so well. The magnitude of reflection is so little. It is so difficult to prevent sound from propagating between two solid bodies.
No insulator can stop vibration transmitting from the loudspeaker to the floor, and the vibration reaches the amplifiers and the players. This tells difficulty of vibration control.



Sound propagation from a gaseous body to a solid body
Most sound is reflected.

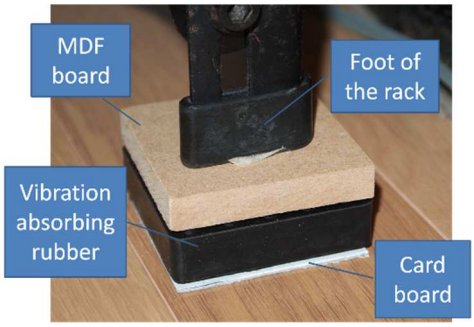


Sound propagation from a solid body to a solid body
Reflection is small, most sound goes into the other body.

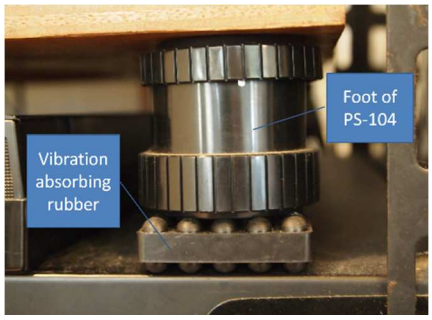
To prevent propagation of vibration, I believe the best method is use of elastic material in the path of vibration. In Gaudi, the insulator made of vibration absorbing rubber shown below is used. I found and bought it at a home center near my house. Antivibration goods sold at audio shops are expensive, though their performance is poor. I don't buy them.

Insulators used in Gaudi

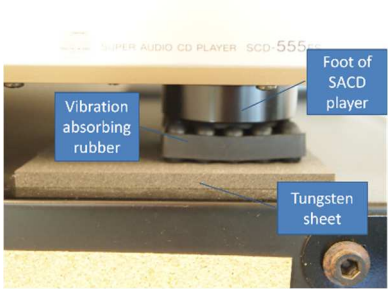
A pack of insulators for office equipment
It's good for audio too, and used in many parts of Gaudi.



Insulator of the main rack
The combination of the MDF and the rubber works so well.

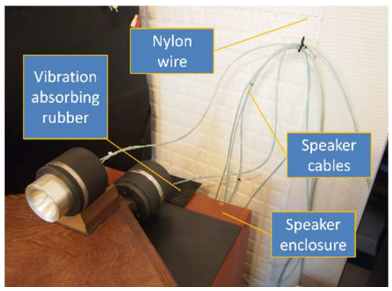


Insulator of the analog player PS-104
The foot of PS-104 (DENON AF-10) itself is a good insulator. The rubber cushion is made of Hanenite rubber. It's an excellent insulator.

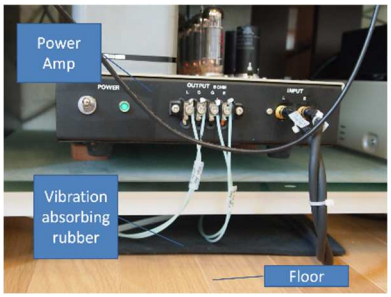


Insulator of the SACD player
The rubber is Hanenite. It's excellent. The tungsten sheet is a Fostex. It is not effective despite of its high price.

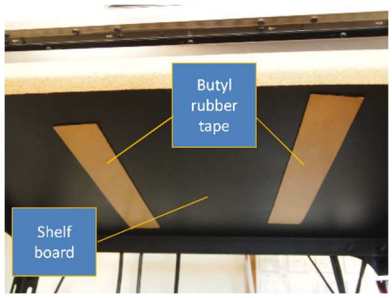
Insulator of the preamplifier PA-210
It's made of butyl-rubber, Hanenite rubber and 5mm-thick felt.



Antivibaration measure for speaker cable
The speaker cables are hung by the nylon wire fixed on the wall so that they don't touch the floor, the rack or the speaker enclosure.



Insulator of cables
If it is unavoidable for cables to touch the floor, the vibration absorbing rubber sheet is placed on the floor.



Antivibration measure of shelf board
The butyl-rubber tape is attached to the wrong side of the shelf board. It does not work at all.

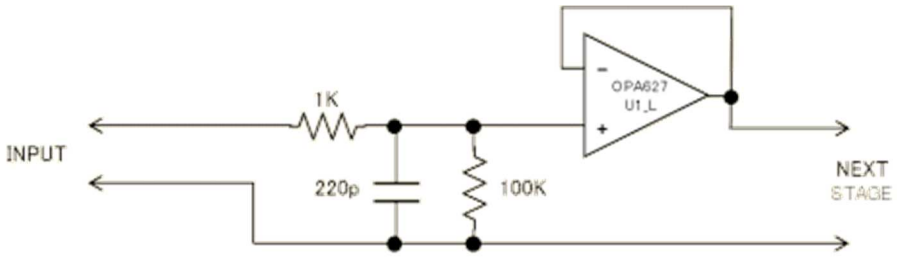
Turntable sheet
It is filled with gel to damp vibration.

RF Noise

Some misunderstand that RF noise is not needed to eliminate, because it can be heard by human. RF that comes into an amplifier modulates signals in the audio band, and distorts sound. In the most serious case, RF is amplified to the extent that the amplifying element (i.e. transistor or valve) is saturated.

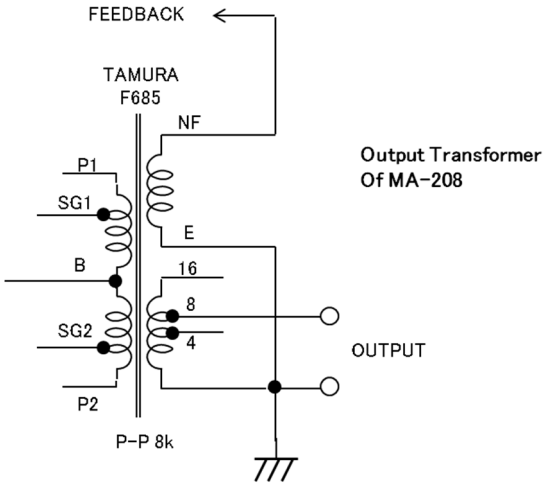
RF comes into the amplifier through the following three paths: (1) the input, (2) the output, and (3) the mains. For each, the counter measures mentioned below should be applied.

(1) A low-pass filter that passes only the audible band is added just after the input. This filter must be a passive type.

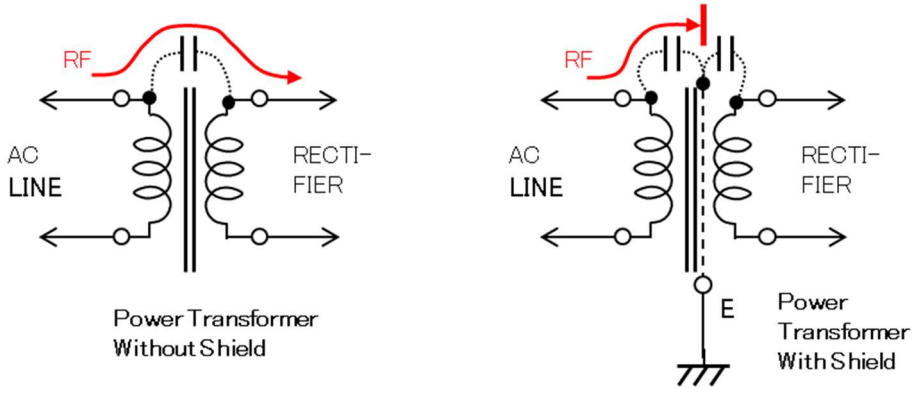


Input Low Pass Filter of CD-211

(2) RF noise comes in through the output terminal, conducts through the NFB loop, reaches the previous stage and is amplified. It is hard to imagine the output terminal acts as the input, but it really happens. In the power amplifier, the NFB loops from the output stage to the first stage, so this problem is more serious. As for tube amplifiers, because the gain in the RF band is relatively low, this problem may not be so serious. Besides, for an amp like MA-208, in which the feedback loops from the NF windings of the output transformer, less RF sneaks in the first stage than a typical power amp, in which the feedback loop is connected to the output terminal.



(3) Many people may think that the impedance of a power supply circuit is so low that RF noise can hardly pass. But it's not true. In RF band, the impedance is not so low. For example, large E-caps used in a smoothing circuit become inductive in RF band. That is, they don't work as a capacitor, but an inductor. A small capacitor should be added in parallel with a large capacitor, in order to lower the impedance in RF band.
Transformers tend to be taken as a part that scarcely conducts RF, but a stray capacity between the primary and secondary windings conducts RF. When you choose a transformer, be sure it has a shield between the primary and secondary windings. The grounded shield prevents capacitive coupling between the primary and secondary.

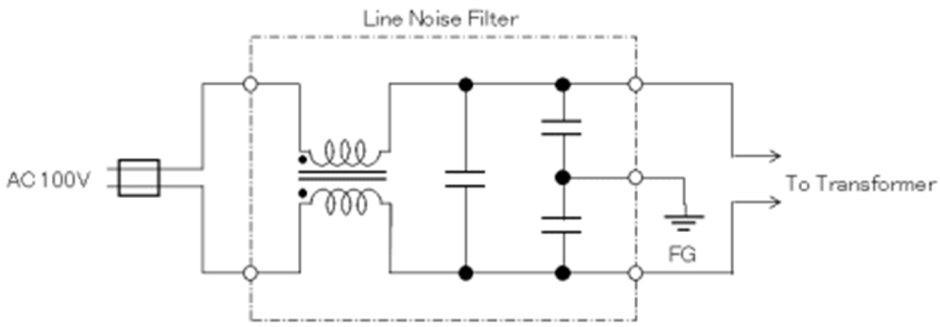


The mains is full of noises. For example, it is a good antenna for a germanium diode radio. Insert its antenna terminal into an AC outlet, then you can hear AM radio. It can drive a crystal ear phone only with the electric power of AM waves received from the mains line.
I use an AC line noise filter on every NOBODY-branded amplifier in an attempt to reduce noises from the mains as much as possible. Because AC line noise filters' rejection band tends to be so high, I am not so sure the filters are so useful in audio amplifiers. Anyway, I feel uneasy if an amp is directly connected to the mains without any filter. I choose filters whose rejection band is as wide as possible, and use them.

As for RF noise reduction, not only the filter in the amp but also reduction of noises at their origin is important. I recommend you turn off an air conditioner, PC, mobile phone, fluorescent lamps, etc before listening to music.

Potential Difference

If ground potential is different among devices, a large current flows through the cable that connects the devices according to the magnitude of the potential difference. For example, if ground potentials of a preamp and a network are not the same, a current proportional to the difference flows through the cold line of the cable (usually shield meshed wire). If the impedance of the cold line is zero, the potential difference between the device will be zero, but every actual wire has a small impedance and a noise voltage appears in proportion to the current.
In order to avoid this problem, in Gaudi, the potential of ground is specified to be the midpoint of the hot and cold lines of the mains. However, manufactured devices like a CD player may have different potential. So it isn't a perfect counter measure.



I hit upon the idea lately that more fundamental counter measure is floating every device from the earth. If a device is connected to a wall outlet, the potential is fixed to the earth, because the cold side of AC line is connected to the earth. By using an isolation transformer, devices can be isolated from the earth. I am planning to do so in the near future.

Charms of Vinyl Records

On early days of Gaudi, my music source was mainly vinyl records. What's it today? Any digital media? No. It's still vinyl records. Of course, I have collections of CDs and SACDs, but they are no match for vinyl records, which contain 'full-of-life sound.'
Many people love vinyl records like me. Among them, some say they don't care if big noises are mixed with music, and some believe sound quality of the vinyl is superior for no rational reason. But I believe the excellent sound quality of the vinyl has scientific basis.
Let's discuss drawback and advantage of the vinyl records in comparison with CD.

Advantages of Vinyl Records

The vinyl record has many advantages. I highlight the following five points.

- Wide dynamic range (D-range)
- Wide frequency range (f-range)
- Semipermanent life
- Artistic jacket
- Rich variety of software

D-range of the vinyl record

Generally, the D-range of the vinyl is believed to be narrow (60-70dB), though, I have a different idea.
~~The definition of the D-range is the ratio of the smallest and biggest sound in dB. The smallest sound depends on the smallest amplitude of the stylus that the cartridge can generate a signal. Therefore, as the performance of the cartridge is improved, the smaller sound can be picked up.~~[2015/01/22 corrected] {This definition was quoted from Japanese version of Wikipedia and it was wrong. The right definition is the voltage ratio in dB between the maximum output signal and the residual noise. I searched for the information about the measurement method of the D-range of the analog disc and analog disc player, but couldn't find good one so far. If anyone knows the method and let me know it, I'd appreciate it}
The biggest sound depends on the pitch of the groove. Though the standard groove pitch of LP records is 0.05mm, actually, there are records that have the bigger pitch, such as 45rpm LPs and 12 in. single records. The record that has the biggest pitch in my collection is 12 in. single, Eigo Kawashima, *Sake to Namida to Otoko to Onna*, WARNER-PIONEER L-3503E, and its pitch is as big as 0.35mm. Among 45rpm LPs, there are ones that have about 0.15mm pitch. For example, Sonny Clark, *Cool Struttin'*, Blue Note/Music Matters BST81588. The magnitude of the biggest sound of recent high quality record (HQ disc) is evidently bigger than that of traditional LPs.
Consequently, I believe HQ discs' D-range is 80-90dB.
[2015/01/22 added] {My opinion above is not based on theoretical or quantitative grounds, though, I still believe analog discs' well-detailed, deep sound is brought about by its virtually wide D-range. In particular, I believe a hypothesis that signals smaller than the scratch noise could be sensed as musical information by human}

On the other hand, how wide is the D-range of the CD? Generally speaking, it is 96dB. This value is calculated by multiplying 6dB by the number of bits; 6dBx16=96dB. In this definition, however, the quantifying bit number of the smallest sound is zero. That is, it is complete silence. This does not fit the definition of D-range.
How about specifying the resolution of the smallest sound is 1 bit? In this case, D-range is 6dBx(16-1)=90dB. Still I am not convinced.
In my opinion, at least 4 bits are necessary to form a signal a man senses as 'sound'. Then, D-range is 6dBx(16-4)=72dB. This implies D-range of the CD is equal to or less than that of the vinyl record. I think this value corresponds to the D-range I guess based on my sense.
[2015/01/22 added] {The measurement method of the D-range of digital audio equipment is stipulated by JEITA (Japan Electronics and Information Technology Industries Association) CP-2150. CD players' D-range measured with this method is said to be 90dB or more. And, I heard that the D-range can be widened up to 120dB with a technique called 'dither' (a sort of noise shaping). For example, the D-ranges of my SACD player, SONY SCD-555ES, are 100dB for CD and 105dB for SACD. There is no big difference between CD and SACD. I feel something questionable about these values. I can't believe that technique enriches musical information. I can't help suspecting it merely lowers the seeming noise floor}

When I record a vinyl record with a digital recorder, I actually feel the wide D-range of the vinyl. If the resolution is set to 16 bits and the input volume is set to a typical level, the input signal saturates sometimes. The album mentioned above, Sonny Clark: *Cool Struttin'*, is a good example. The peak level of the album is so high that the input level must be set so low in order to prevent saturation. That impairs the details of the sound.
I hear the recording engineer of this album, Rudy Van Gelder, hated to use a limiter. I understand it well every time I listen to this album. 24-bit resolution is required to record this album perfectly.

I believe that D-range of the HQ disc is wider than that of the CD, and it is the reason why HQ discs' sound is so fine and smooth. I think some ordinary LPs have the wider D-range than CD, too.

F-range of vinyl records

No audiophile would deny the f-range of the vinyl is so wide. Although some say high frequencies above 20kHz cannot be heard and they are only useless noise, it's not true.
Actually, frequencies above 20kHz cannot be heard as a fundamental pitch, but they influence tone as higher harmonics. It is a sort of subliminal perception. The wider f-range makes the grade of sound higher, and adds heavenly sonority to the sound.

Many of sounds that make men comfortable include ultrasound. Not only sounds of musical instruments, but also many comfortable sounds such as murmuring of a stream and rustling of leaves in woods include ultrasound.

Humans can vocalize ultrasound too by voice training. Mongolian traditional vocalism, khoomii, and East-European transitional female chorus, Bulgarian polyphony, are good examples. Among Japanese singers, Yumi Matsutoya has voice including ultrasound. I haven't listened to her directly, though, according to a man who knows her real voice, her voice is so comfortable.

The fact that the ultrasound influences impression of a sound has been proved scientifically. According to some researchers' experiment, the subject's alpha wave from his/her brain increases when he/her listens to a comfortable sound including ultrasound. On the other hand, the alpha wave decreases when the ultrasound (frequencies more than 20kHz) are filtered out. Consequently, the sound including ultrasound makes a listener more comfortable.

In my opinion, the required f-range for audio source is 20Hz-40kHz. Frequencies more than 40kHz should not be included, because most of them are noises due to limited performance of microphones.
The vinyl records meet the requirement without doubt. It is the one reason to prove the superiority of the vinyl records.
I don't regard CDs as Hi-Fi source because of the limited f-range (only 20kHz). I seldom buy a CD, though I rent it sometimes.

Life span of the vinyl record

I think the most charming point of the vinyl record is its long life. It may be semipermanent. There's no possibility that the groove disappears while the record is properly kept in a cabinet. The record could be played without any major problem in 100 or 200 years.
It is said that the groove is worn every time the record is played and the sound quality worsens. But it won't be worn so much, if a line-contact stylus is used.
Expensive records are worth buying, because they can be your lifetime treasures.
The oldest record in my collection was made in 1967 (Ted Sommer, *Percussive Mariachi*, Solid State SS18012), whose sound is still clear and vivid. My first jazz record (Oscar Peterson Trio/Sonny Stitt, *Sonny Stitt Sits in with The Oscar Peterson Trio*, Verve MV2022）I bought in 1970, when I was a junior high school student, is my favorite record all the time. It still keeps sound quality good enough for appreciation, though I have played it countless times since then.

On the other hand, because the life of optical discs like CD is 20-30 years, they cannot be lifetime treasures. In my CD collection, some CDs made in 1980s are bad in sound quality, and a few of them are unplayable. I rip my CDs before they go bad.

Extra charm of the vinyl record

An extra charm of the vinyl record is its visual aspect. The jacket is so artistic that it may be a good decoration if it's hung on a wall. However, it shouldn't be kept there for a long time, because it will be discolored by light.
The font sizes of the liner note and lyrics are so big that they are easy to read and get me in the mood to read them carefully.

The number of album titles of the vinyl records

How many album titles of the vinyl records do you think there exist? Maybe, it's countless.
Even today, new albums are released. There is a market of used records. Used vinyl records are available not only at record shops but also at secondhand shops like 'Hard Off' (a famous secondhand shop chain in Japan). So many precious albums haven't been reissued on CD and only available on vinyl.
This great variety of album titles is one of the charm points of the vinyl records.

Drawbacks of the Vinyl Record

The vinyl record has many drawbacks. Why do they spoil the charms of the vinyl? Let's discuss it. At first, I listed up major drawbacks as below:

- Much noise is mixed
- Sensitive to vibration
- Not good channel separation
- Affected by wow and flutter
- Troublesome maintenance is necessary
- Relatively short recording capacity

Noises of the vinyl record

The vinyl record generates any kinds of noises. The most typical one is scratch noise. It is always generated when the stylus scratches the groove, and it's impossible to make it zero. This noise is a random wave, so it is heard so-called white noise. It is relatively not uncomfortable one. The better the performance of the pick-up, the quieter this noise.
I am not bothered by the scratch noise so much. I feel it a little noisy in the interval, but I feel it recedes behind the sounds of music as soon as a performance begins, and I am no longer conscious of the noise during the performance. And, the better the condition of the record, the more it has this characteristic.

The most uncomfortable one is crackle noise. Even for a vinyl-lover like me it's not acceptable. The cause may be a damage, but in most cases, it is caused by mold.
You should not speak while you are handling a record, because saliva is sprayed to the surface of the disc and it becomes nutriment of mold. Touching the surface of the disc by hand must also be avoided. Fingerprints is nutriment of mold too.

Some new records generate crackle and rustling noises. That's probably because the remover still remains on the disc. It could be eliminated by cleaning the disc. I will write the method in 'Misc Info' someday.

Though noises are unavoidable drawbacks of the vinyl record, they won't spoil music as long as the record is well-maintained and the pick-up is well-adjusted. I think they are acceptable.

The vinyl record and vibration

The weakest point of the vinyl is its high sensitivity to vibration. Vibration conducts from the loudspeaker to the analog player, and the player picks up the vibration. It is called acoustic feedback. In the worst case, the system oscillates by the acoustic feedback.
The player and the rack must be vibration proof. But as mentioned above, antivibration measures is difficult to carry out. Cut and try is necessary to improve little by little.

As a matter of fact, the CD is as sensitive as the vinyl to vibration. The CD player emits a laser beam to pits on the disc, and senses reflection. It's like shooting a small moving target. The powerful servo control of the pick-up enables such a difficult operation. Without vibration, the laser beam hits the target. But as vibration increases, the beam miss the target more often. It is natural that even the best sniper misses the target if he is shaken.
If errors occur often, the sound reproduced from the CD is not clear and lacks perspective. Though the acoustic feedback like the vinyl doesn't occur, a concrete antivibration measure is necessary to the CD player, too.

After all, which is more sensitive to vibration, the vinyl or the CD? I think it's the CD. With elaborate antivibration measure, the vinyl is less affected by vibration rather than the CD.

Channel separation of the vinyl record

The channel separation of the cartridge is 30dB at a maximum. The vinyl is inferior to the CD in this respect. However, stereophonic effect and localization of sound is good enough. This weak point is not so serious to spoil the charm of the vinyl.

The vinyl record and wow and flutter

Wow and flutter can be made small enough not to be sensed by a human, provided that the turntable is heavy enough and it is not servo-controlled. It is not a big problem.
Although the disc itself has problems like eccentricity and warping, they are kept within acceptable levels for most discs.

The vinyl record and maintenance

It is so troublesome to maintain damaged or dirty discs. But they are not easily damaged or smeared under normal handling.
Usually, only simple maintenance is necessary.
My usual maintenance is just clean the disc with an electric motor-driven cleaner just before and after play. I never use any chemical product like a record spray.
When I was young, I tried out various kinds of chemical products for vinyl records and damaged my record each time I did so.
You should rather do nothing than do an improper maintenance in order to keep your records in good condition for long time.

In case dust has been accumulated in the groove or the record got moldy, or I bought a used record, I clean the record by my own method. Since it is rather complicated, I will describe it in the page of 'Misc Info' in the future. Anyway, I never use any chemical products for record. I clean the record with purified water and alcohol. My method needs a lot of time and labor, though, the record will be kept clean for 10-15 years.

I don't care the labor needed for record maintenance. I feel it worthwhile to keep the record clean, since even a junk record could revive to be a good one you can appreciate music in it by cleaning.

The CD is supposed to be maintenance-free. But careless handling could give a damage to it. For example, a CD may get scratched if it is left naked on a table. Even if scratches are too small to apparent, they could affect sound quality. CD needs more careful handling than you think.

Recording capacity of the vinyl record

As the recording capacity of LP record is 20-30 min. per side, it is impossible to contain all movements of a big piece like a symphony within on side. It's necessary to turn the disc or change discs at the end of a movement. Though it is a drawback in a way, for me, this break at 20 min. interval is a good refreshment, and I can deeply concentrate on music.

Comprehensive Evaluation

From all the discussions above, I conclude that the vinyl record is the most excellent music media.
The CD's sound quality is not satisfactory. The SACD, like the CD, has the drawbacks endemic to optical discs: short life, vibration sensible, etc. One more big problem for SACD is that the number of titles is very small.

The only possible replacement of the vinyl record may be Hi-Res music file download. However, Japan's music industry sticks to the CD, and is negative to Hi-Res files. Domestic download sites are selling only nameless artists' albums at high prices. The major oversea download sites like HDtracks reject orders from Japan. [2015/01/22 added] {HDtracks has begun selling music files to Japanese customers, though some titles are still blocked to Japanese}
There's another catch. As long as I know, there are only few good audio devices for playing Hi-Res music files. Still the most of audio makers are not so eager to develop a new type of music player. [2015/01/22 added] {SONY has been releasing hi-res digital players and related products one after another lately. I favorably receive this movement. I hope other audio makers follow it and more titles become available}

Still, the vinyl record is the best.
[2015/01/22 added] {Hi-res music files might be the main source for my next audio system Gaudi II}

Merits of Tube Amplifiers

I exclude preamplifiers here and discuss merits of tube power amplifiers only.
[2015/01/22 added] {In this section, I describe how tube power amplifiers excel solid state ones. However, I have found many problems concerning tubes for the past few years. Now I believe solid state amplifiers are better in various aspects. In particular, solid state amplifiers using ICs are more easy-to-build and inexpensive than tube amps. I am investigating whether or not the highest sound quality can be achieved by using such amplifiers}

In my opinion, the biggest advantage of the tube amp is its **high cost/performance ratio**. Even low-priced products and handmade amps built with cheap parts have as high sound quality as high-end manufactured amps.
A vacuum tube I recommend is 6BQ5, which is used on MA-208. It is a miniature pentode, and looks a bit powerless, but it can be the output tube of a more than a dozen watt power amp whose output stage is push-pull. Though the sound quality also depends on the circuit design and other parts generally, its sound is of high-resolution, dynamic and vivid. When I can hardly select a part, I usually choose the smaller one if function and performance are the same as the bigger one. I believe this way is applicable to choice of vacuum tubes.

On the contrary, I don't recommend expensive tube amplifiers, because most of them are aimed to enjoy healing music or good-old-day sound. Figuratively speaking, they are like a diminish filament lamp that does not light up the details of things and makes a calm atmosphere. A typical one of this kind is an amplifier whose output valve is a filamentary type triode like 300B.

I have had many chances to see and listen to 300B amplifiers at audio shops and events like Vacuum Tube Audio Fair, since they are one of the most popular amplifiers. But I have impressed by them only few times. I don't understand why they are so popular. After all, I can't understand at all the idea to make healing sound with a power amplifier. I believe the power amplifier must be Hi-Fi.

Without doubt, there were so many audiophiles who love soft, comfortable sound, but most of them are older than me (in their 60s and 70s). The aged people tend to like less stimulating sounds.
My father was no exception. He prefers AM radio to FM. When I let him listen to FM with Gaudi, at first, he complimented the sound on its clearness. A while later, he began complaining saying, "It's too harsh," "Bass sound is too loud," "I feel uneasy because sounds come from the both left-hand and right-hand sides." When I let him listen to AM, he was satisfied.
I hear, many years ago, when Elvis Presley was a top star, the aged people then harshly criticized his music saying, "It's so loud that I can't stand it." Even the slow tune 'Love Me Tender' was criticized in the same way. In any era, the aged may want less stimulating sounds.

I think the healing sound won't appeal to young people. It's too unstimulating. I guess young people may feel it somewhat strange sound, when they listened to tube amplifiers designed and tuned for the aged (and most manufactured tube amplifiers now are so designed).
I strongly recommend young people that they try to listen to a Hi-Fi amplifier utilizing MT tubes. I would like them to know not all the tube amplifiers are designed for healing music.

I'll show some of my own experiences concerning tube amplifiers below.

I was invited to an event held at the music studio of Tamura Corp. in September 2011. The main theme is listening to three 300B amplifiers designed and built by a renowned DIYer (I don't remember his name). Those amplifiers used transformers manufactured by Tamura. We, guests, listened to the three amplifiers carefully all through the afternoon. I had my CDs and SACDs played.

I felt the sounds of them were not sharp. The treble was so damped that I doubted the tweeters were out of order. Hit sounds of a cymbal were faint. Although surely they never output harsh sounds, they filter out details of sounds. It is not sound quality in which I can concentrate on music, especially jazz. Again, I thought 300B amplifiers are unattractive to me.

In those days when there was Sato Musen on the 4th floor of the former Radio Kaikan (a famous audio shop), I swung by it each time I went to Akihabara. One day at the shop, I witnessed a gentleman was asking tryout of tube amplifiers to a sales clerk. He said he wanted the best tube amplifier no matter how expensive it was. I was so interested that I decided to listen beside him.
He began with the most expensive one. He rejected it at once. Next, he tried the next most expensive one. He looked dissatisfied. He tried one after another, and the most inexpensive amplifier was left at the end. It was 6GW8 PP. The price was about 70,000 yen, if I remember correctly. The gentleman was satisfied with it, and bought it. I thought it was a wise selection, because the amplifier was the best in sound quality even to my ear.

I would drop by San-ei Musen along with Sato Musen, which was a shop for audio amplifier builders and located on the fourth floor of the former Radio Kaikan too. It was well-known for tube amp kits. I tried their products many times. My favorite one was the least expensive 6BQ5 amplifier.

Based on these experiences, I concluded that as for tube amplifiers, the cheaper, the better. I recommend cheap, yet high quality tube amps to young people.

Tube amplifiers have many merits other than price/performance as follows:

Easy to build

Even a simple circuit has high quality. And, the circuit constant does not have to be so precise. So even a beginner can build a good amp.

Tolerant to power voltage fluctuation

Especially, the push-pull layout is little affected by the mains fluctuation.

Immune to RF noise

Because vacuum tubes, especially triodes, have low gain in RF band, a tube amp is not affected so much by RF.

Quick warm up

Warm up time of tube amps is about one minute. On the other hand, semiconductor amps need 15 to 30 minutes for the heat sink to reach its normal temperature. Until then, the sonic is impaired.

Big music power

A tube amp using output transformers can output as 3 or 4 times bigger power as the rated power for a moment. Though it depends on the sensitivity of the loudspeaker and the size of the room, if the rated output power is 10-15W, it's enough for tube amps.

Easiness of design is the next most important merit to price/performance. When you design a circuit, if you miscalculate the values of capacitors or resistors and they are doubled or halved of the proper values, the tube amp operates without any major problem. I like this tolerance.
For accurate calculation of the circuit constants, the standard data published in the vacuum tube's data sheet are used. But those data are mere typical data and the real data vary considerably from tube to tube. For example, if the standard mu is 20, the real one may be 17 or 24. It is not unusual, the units in a double triode have different characteristics. So you don't have to be so sensitive to the calculation.

I've mentioned my personal opinion about merits of tube power amplifiers.

Tube power amplifiers are often talked about, and a lot of articles appear in specialized magazines like MJ (Japanese audio magazine). On the contrary, tube preamplifiers are not so often taken up as a topic. I think it is because design and building a tube preamp is so difficult for an amateur.
So much so, it is worth doing. It took me four years and a lot of efforts to complete PA-210, and it turned to be the first preamp I am satisfied with. My efforts and success gave me much delight and confidence about my skill. Now PA-210 is the flagship in Gaudi (The photo at the upper left corner of the top page is the rear view of PA-210). I hope tube preamps would be a topic more often.

Superiority of Multi-amplifier System

To describe the superiority of multi-amplifier system in one sentence, it is a pure sound quality oriented system with the least number of weak points.
The smallest number of parts are used between the output of the amplifier and the voice coil of the loudspeaker, so almost 100% of the power is conducted to the voice coil. In other words, power loss is minimum.
As a result, the sound quality of the system so excellent that it can reproduce any kind of sounds from Japanese taiko drum's powerful sound (it is almost like wind pressure) to a delicate sound like rustling of leaves in woods.

It is often said, audiophiles choose audio equipment according to their preference for sound character. For example, some like flashy treble and choose a loudspeaker using a hard dome tweeter, and some like soft tone and choose a tube amp. I believe, however, the multi-amplifier system's absolutely pure sound exceeds individual's preferences like those.
Assume that, if seeing a real Miss International, almost every man would be overwhelmed by her beauty and excited. Not only men, but women could be impressed her beauty, too. The true beauty is beautiful to everyone. The same thing goes to audio systems. A really good system impresses everyone with its superior sound quality. I'd like to stress it is the multi-amplifier system that impresses every audiophile.

I've listed up the concrete advantages of multi-amplifier system as follows:

Various kinds of filters can be employed

In a multi-amplifier system, the filters are embedded in the channel divider (network) positioned between the preamplifiers and the power amplifiers. Because active filters can be used in the network, it's easy to make the filters' slopes as sharp as -18dB/oct or -24dB/oct. Of course, a -6dB/oct passive filter is one of the options. If a digital filter is employed, it gives a lot more options for the filter design. It's possible to make a filter with very sharp cut-off like -96dB/oct and no phase shift. Including fc, every filter parameter can be switchable. It is possible to draw out 100% of the loudspeaker's performance, because the filter characteristics are easy to change.

Free choice of loudspeaker drivers

In a mono-amplifier system, the sensitivity of the tweeter must be higher than that of the woofer. In a multi-amplifier system, there's no such limitation, and it is possible to match a highly efficient woofer and a low efficient tweeter. In

general, the larger the driver, the higher its sensitivity. If a large size (highly efficient) woofer is chosen, the range of options about midranges and tweeters is wider by far in a multi-amplifier system than in a mono-amplifier system. As a matter of fact, I used small size full-range drivers as a midrange for 30 years (1982-2012), and it worked without any problem even though their sensitivities were lower than the woofer's.

Direct connection of power amplifier and speaker driver

In a multi-amplifier system, the loudspeaker does not have attenuators or a passive network in it. So the output of the amplifier is directly connected to the speaker driver. The amplified signal flows through the voice coil of the driver with no loss. I believe this is the reason why the multi-amplifier system can reproduce a sound like a wind pressure, that is felt by skin rather than heard.

Less cross-modulation distortion of the power amp

Cross-modulation distortion is low, because only narrow band is input to each power amplifier.

Large margin of the maximum output power

The peak level of a signal that mixes bass and treble reached so high in a moment. For example, assume that the peak of bass is v_{pl}, the peak of treble is v_{ph}, then, the total peak level v_{pt} reached $v_{pt}=v_{pl}+v_{ph}$ when the two peaks come at the same time. If the maximum output power of the amp is lower than v_{pt}, the signal will be distorted. In case that bass and treble are divided, each peak level is lower than the total peak level. That is, they become the original v_{pl}、v_{ph}, respectively. Compared to mono-amplifier system, the power amps in the multi-amplifier system don't need so much output power.

Gaudi is composed of my original audio devices with many drawbacks and weak points. Nevertheless, the sound quality is very good. I think that's because it is a multi-amplifier system.

Significance of Home-build Audio Systems

The top advantage of building an audio system oneself is that there is no limitation for system design. Either a mono-amp or multi-amp system can be chosen.
As a matter of fact, the multi-amp system is so difficult to build, unless it is handmade. Manufactured loudspeakers and amplifiers are not designed for multi-amp systems, and if you dare build a multi-amp system using the products, many problems will occur such as high cost, lack of space to install and necessity to customize the loudspeakers. If you yourself design and build each component, you can build a multi-amp system with a limited budget and install it to a limited space.
Hereafter, I will talk about tips for building a multi-amp system.

The specification of each equipment is not restricted in a home-built system. Not only the electronic specification but also the mechanical specification such as the size and the shape of the cases can be freely decided. You shouldn't stick to standards. For example, input/output terminals on the side panel of the amplifier, an amplifier case that just fits the room of your audio rack, a slim loudspeaker that has the largest woofer for the slim enclosure, etc; all of them are possible. You can make the specifications just as they fit your requirements. This is a key point to create a multi-amplifier system, which is generally larger than a mono-amplifier system.

In the system, the **loudspeaker** is the component that most needs to be designed and built by yourself. Almost all manufactured loudspeakers have built-in network and attenuator, which are not necessary in the multi-amp system. Though many of them have bi-amplified connection feature, it is not enough. Unnecessary parts (the network and attenuator) should be removed, and it is desirable to connect the speaker cable directly to each driver. In order that, it is necessary to disassemble and customize the speaker. By doing so, the warranty becomes void, and its price will be very low when you sell the speaker. The more expensive the speaker, the more you may hesitate to customize it.
If you yourself design the speaker, it is so easy to make the one specialized for multi-amp system. All you have to do is omit the network and attenuator. Besides, selection of the speaker drivers is much easier than ordinary speakers. You don't have to consider the sensitivity as a criterion. It is possible to combine a large woofer (high sensitivity) and a dome tweeter (low sensitivity).
The multi-enclosure construction, which is employed for SS-307 and SS-309, makes it possible to upgrade each driver independently. For example, it is possible to upgrade the midrange driver only.

Many amateur audiophiles may wonder if handmade loudspeakers are not competitive with products of top ranked loudspeaker manufacturers. In fact, handmade ones are competitive against all expectations.
The sound quality of a loudspeaker mainly depends on drivers used on it. Most drivers available at audio shops are so excellent in both quality and performance that the sound quality of the speaker system using them can be excellent. It is natural that the sonic is greatly impaired if the enclosure has obvious defect, but it is unlikely if the enclosure is designed based on fundamentals.
Commercials of prestigious manufactures and articles of specialized magazines often make us feel it so difficult to make a good speaker enclosure, though, in fact, a simple enclosure is satisfactory for a high-quality speaker system. The following old sayings are applicable to designing speaker enclosure, "Everything is difficult before it is easy," and "If you try, you can make it."
When I was a university student, I once visited my friend room and was so surprised at a fine sound quality of his handmade loudspeaker. Although he did not have expert knowledge, he made his own speaker equipped with an 8 in. full-range driver he bought at a junk shop at Akihabara, since he was poor but wanted a good speaker. To my surprise, the material of the enclosure was corrugated cardboard! Despite its appearance, the frequency response seemed flat, and sound quality was so good. I am sure experts deny the performance of the cardboard box before they try it, but in reality, it is rather good. It is the typical case of "If you try, you can make it."

As for **power amplifiers**, it is possible to reduce the cost and the size of the case by making the specification specialized for the multi-amplifier system.
The design of the power amp is greatly influenced by how high the maximum output power is. In general, the higher the power, the more complicated circuit and the larger number of parts are needed. Accordingly, the cost get higher and the part layout gets more difficult.
In a multi-amplifier system, as mentioned above (Superiority of multi-amplifier system), the required maximum output power is relatively lower than in a mono-amplifier system. If horn speakers employed, which can hardly deliver superior performance in a mono-amplifier system, the required power is much lower because the horn speakers have very high sensitivity.
Apart from multi-amp systems, I believe the gain of a handmade amplifier can be lower than that of manufactured amplifiers.
The circuit of the low gain, low power amplifier can be simplified significantly. That makes the number of the parts so small and the signal path so short. And, that leads to not only the cost reduction but excellent sound quality. It is not a dream that your original amplifier will be competitive to products of prestigious manufactures.

How about **preamps** and **channel dividers** (**networks**)? Is it meaningful to make your original one? My answer is yes. You have to learn a lot of techniques to design and build power amplifiers, and need measurement instruments to check them. It is natural to apply those techniques and instruments to making your original preamps and networks.
It requires a higher degree of technical skill to design a preamp. Since the level of signals to handle is so small, noise and distortion are likely to occur. Designing and building preamps lead to brush-up of technical skill, and it is helpful for power amp design.
I believe the key to make preamps successfully is simplification. You should omit features you won't need or seldom use, as possible as you can. However, if you are too radical, you might regret later. Now I myself regret it a little bit not to equip a tone control to PA-210.
The network is most suitable for designing it yourself, because only few networks are available in a market, and its specifications largely depend on the other components in the system like the loudspeaker, power amplifier and preamplifier.

I believe that the most important thing to succeed at a home-built audio system is well-trained ears like a precision measurement instrument. It is hard for an amateur, especially an ordinary person like me, to obtain expensive precision measurement instruments. It is necessary to evaluate sound quality and find problems by listening.
However, there are surprisingly many people who can't evaluate audio equipment for themselves. I know a few people of such kind among my audiophile friends. They tend to be greatly influenced by someone else's opinion, and often merely repeat what is written in a magazine article. Such a kind of person cannot evaluate a home-built audio system, and wastes money and labor for his system, of which quality turns to be no good for the cost. An audio system builder have to be able to evaluate the system as a whole and each part for himself.

How can you learn the skill? The answer is, "practice makes perfect." Do it yourself, even if you are not confident. By repeating development cycle that consists of design, building, evaluation and improvement, you may gradually understand what makes sound quality better and what makes it worse and how to treat them. You are deserved to be called an expert, if you can pinpoint a problematic part only by listening.

Your original audio system is just like a mirror; it reflects your idea, skill and even way of thinking. As your skill improves, your system improves. I think building an audio system is really a deep hobby that needs intelligence and creativity.

[END OF DOCUMENT]

NOBODY Audio
Tonochi’s Audio Room - Supplemental Info