



## Phono-Equalizer Circuit

### Technical Information

ver1 2021.11.22

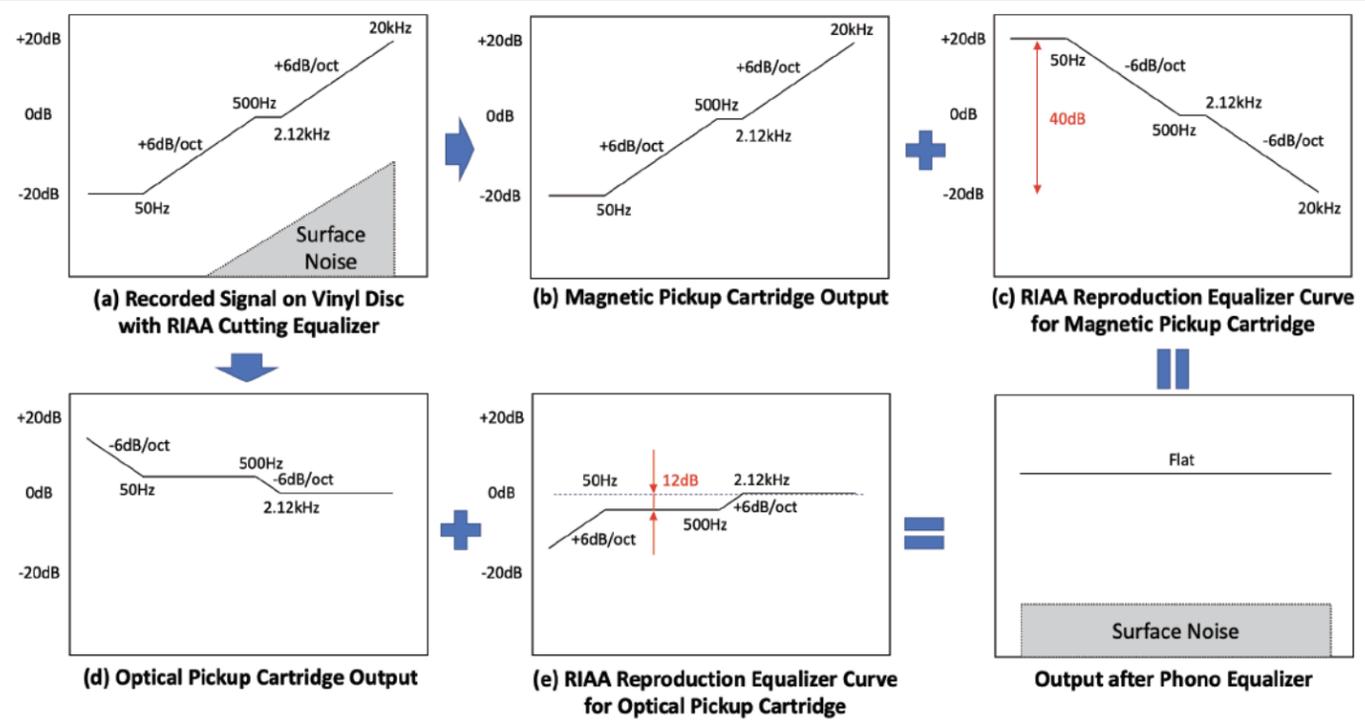


fig. 1

**Q Why is the phono equalizer circuit of the optical cartridge different from that of MM / MC?**

**A** The transducers such as loudspeaker, microphones and pickup cartridges are classified into two types as “velocity proportional type” and “amplitude proportional type”.

Transducers based on electromagnetic induction such as MM / MC pickup cartridges and the cutting head are “velocity proportional type”. If the driving voltage is constant over the entire frequencies, moving width of the cutting head is decreased while input frequency goes up. This is in the same manner as the motion of magnetic loudspeaker’s diaphragm.

When reproduce this groove with MM / MC pickup cartridges, output voltage increases while groove frequency goes up, but groove width decreases while groove frequency goes up. As a result, output voltage becomes constant over the entire frequencies. This is the basis of vinyl record cutting and reproduction.

On the other hand, transducers such as Optical and Condenser pickup cartridges are “amplitude proportional type”.

When reproduce the groove cut by “velocity proportional” cutting head with Optical pickup cartridges, output voltage decreases while groove frequency goes up because groove width decreases while groove frequency goes up.

If you design your own phono equalizer circuit for Optical pickup cartridges, please be aware of this difference.

At the actual vinyl record cutting, input signal is shelving down in lower frequency range not to make groove too aggressive, and is boosted in higher frequency range not to make groove too quiet.

With this pre-processing, groove widths are kept in almost constant over the entire frequency range.

As a result, physical noises due to the surface coarseness of the material becomes almost constant, and longer playback time becomes possible.

In reproduction process, lower frequency is shelving up, and higher frequency is rolling off in order to compensate cutting characteristics.

With this post-processing, flat frequency response and good signal to noise ratio are achieved.

This is the basis of the phono equalizer, and “RIAA” standardized the equalizer curve for vinyl record in 1954.

Now, it is temporarily decided to call the cutting equalizer curve as “Inverted RIAA equalizer” here, because the reproduction equalizer curve is generally called “RIAA equalizer” in consumer audio market.

For vinyl record cutting, “velocity proportional” cutting head is used with “Inverted RIAA equalizer” to boost high frequency range. [fig. 1 (a)]

When reproduce this record with “velocity proportional” MM / MC pickup cartridges, output frequency response of the cartridge is identical with “Inverted RIAA equalizer” [fig. 1 (b)], and “RIAA equalizer” is required in order to get flat frequency response in phono equalizer. [fig. 1 (c)]

When reproduce this record with an “amplitude proportional” Optical pickup cartridge, output frequency response of the cartridge becomes nearly flat. [fig. 1 (d)]

In order to achieve flat frequency response for Optical pickup cartridge, only gentle compensation is needed for RIAA equalizer compatible. [fig. 1 (e)]

Therefore, it is not necessary to have more than 40dB gain which is demanded for MM/MC cartridges, and even more simpler circuit design would be possible.

When you design your own phono equalizer for Optical pickup cartridge, please be aware of phase issue of output signal as follows.

In order to keep backward compatibility with monaural record, left and right signals are intentionally out of phase on 45/45 stereo record to make horizontal groove motion for monaural signal.

As the output signal from photo detectors in Optical pickup cartridge follows the groove motion as it is, stereo output signal from Optical pickup cartridge is out of phase as well.

Therefore, you should invert left or right signal in phono equalizer to make stereo output signals in phase.

For your information, a simplest circuit design example optimized for DS Audio’s 3rd generation optical pickup cartridges “Grand Master” and “003” is shown in fig. 2.

If you would like to match the absolute phase with MM/MC pickup cartridges, please invert left channel in this example.

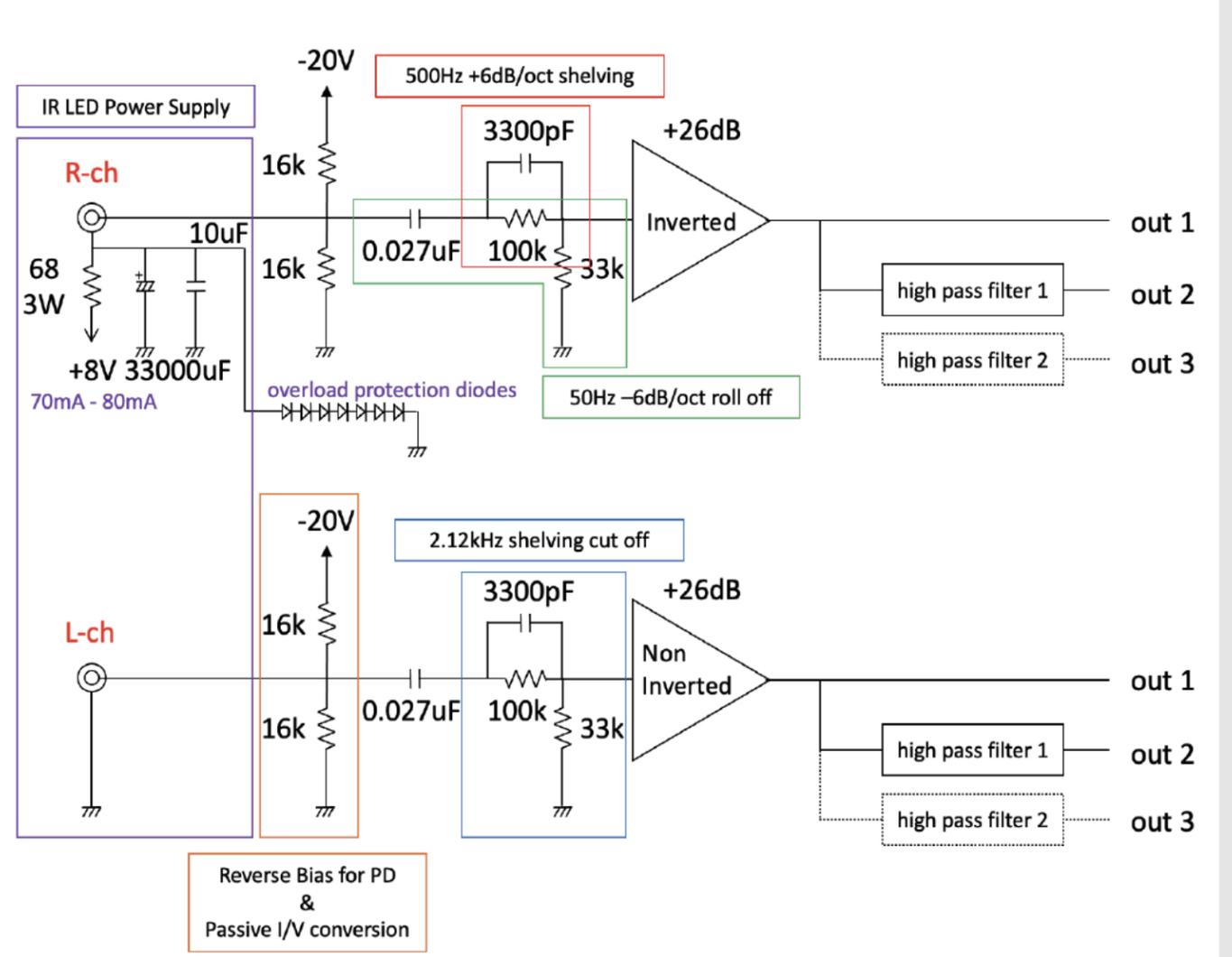


fig. 2

**Q How to supply the power to DS Audio’ s optical pickup cartridge.**

**A** The power to DS Audio’ s optical pickup cartridge is supplied with using ground lines (blue line and green line) of the head-shell leads.

In case of the optical pickup cartridge, green lead connected to right channel ground of the tone arm cable is +DC power line, and blue lead connected to left channel ground of the tone arm cable is common ground line.

If ground lines are shorted occasionally, the optical pickup cartridge becomes out of operation.

Red and white leads are signal lines, but please note that -DC bias voltage is supplied from phono equalizer as shown in fig. 2. As the optical pickup cartridge consume relatively large current (70 – 80 mA), please keep the tone arm connectors clean to maintain lower contact resistance.

If you use the alcohol or other liquids for cleaning, please dry up the connectors before use.

**Q Do we need high pass filters in sub-sonic frequency range?**

**A** Warp of the records and a low frequency resonance of the tone arm will generatesub-sonic frequency signals which may cause intermodulation distortion in amplifier or crush woofer in loudspeaker.

As Optical pickup cartridge is an “amplitude proportional type” transducer, it is possible to reproduce down to DC (0Hz) signal in low frequency range theoretically.

Therefore, Optical pickup cartridge is a bit critical to this problem because of its sub-sonic frequency response.

MM/MC pickup cartridges are less critical because the generating efficiency in sub-sonic frequency range is turned down.

To avoid these problems, sub-sonic filter would be a helpful.

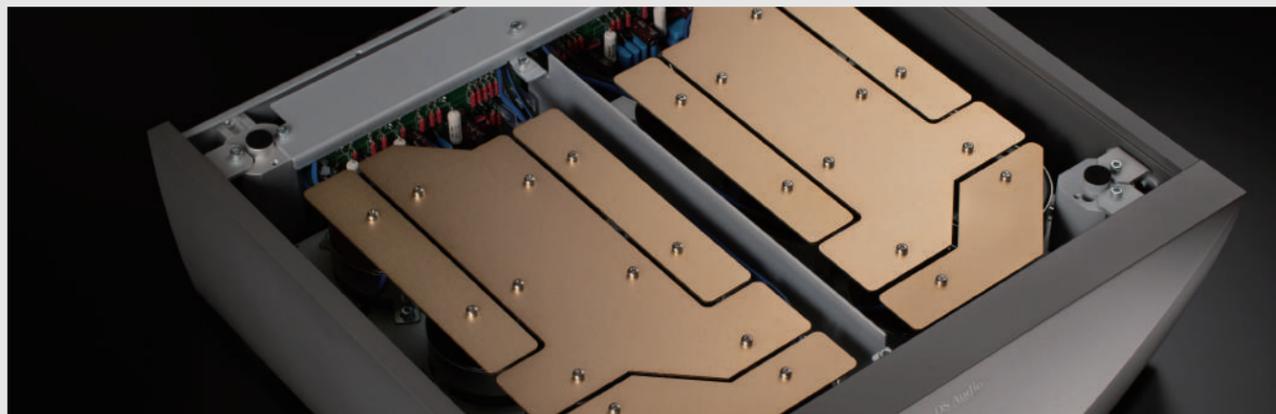
As the time-constant and the order of the filter would be up to warp of the records and the tone arms, please determine the optimum values for your system.

**Q Pickup cartridge protection (Mandatory)**

**A** In DS Audio’ s optical pickup cartridges, infrared LED for light source and photo detector (PD) are connected as shown in fig.3. In order to protect PD from overload damage, supply voltage to the infrared LED must be kept lower than +5V in any situation.

For this purpose, 7 cascaded diodes are connected in parallel to the infrared LED not to exceed +5V.

Without these protection diodes, inrush current should cause overload damage to PD when the optical pickup cartridge is hot-connected to the tone arm. If you design your own protection circuit for DS Audio’ s optical pickup cartridges, please be aware of this issue.



**Q About the internal connection of DS Audio’ s optical pickup cartridge**

**A** The internal connection of DS Audio’ s optical pickup cartridges are shown as follows.

In the 2nd generation pickup cartridges such as “DS Master1”, “DS-W2”, “DS002” and “DS-E1”, single infrared LED is used as a light source for both channel PD.

In the 3rd generation pickup cartridges such as “Grand Master” and “DS003”, separated infrared LEDs are used as light source for each channel PD individually.

As a result, output signal from the 3rd generation pickup cartridges is boosted against that of the 2nd generation.

If you would like to optimize your phono equalizer for the 2nd generation pickup cartridges, additional gain would be desirable.

(For example, replace 16k ohm bias resistors to 20k ohm in fig. 2.)

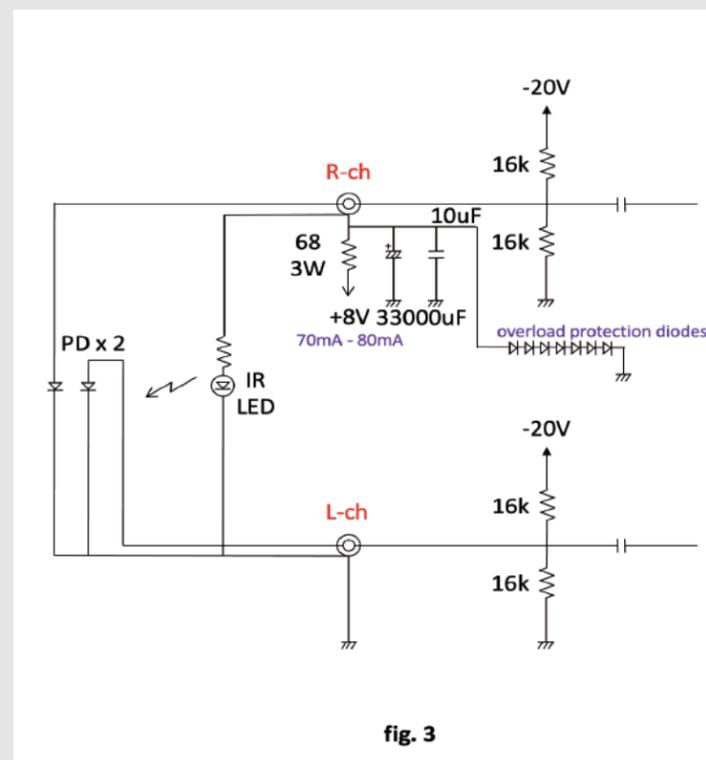


fig. 3

