• MC Head Amp and Phono Equalization Circuit (Refer to Fig. 2-1)

The circuit configuration from MC head Amp to output of power amp stage used in AU-919 is a fully Push-pull DC amp with direct coupled input-capacitor-less DC amplifier. In order to ignore time constant with lagging or leading phase caused by input capacitor, FET input circuits are employed. By this, higher slew-rate and low-noise factor can be obtained.

1) MC (Moving Coil) type cartridge generally requires head amp to boost up weak signal from the stylus. The pre-amp section of AU-919 includes this head amp and conventional phono equalizer circuit for MM (Moving Magnet) type cartridge. MC type cartridge provides high frequency performance and excellent tonal quality, but as its output voltage from stylus is as low as approx. 0.1mV, the MC head amp or step-up transformer is needed as mentioned above. To ensure the outstanding performance in tone quality and signal-to-noise ratio(S/N), AU-919 employs the head amp which meets with these reqirements.
The circuit configuration of MC head amp in AU-919 is input-capacitor-less (ICL) direct coupled complementary circuit using low-noise and high gm FETs of P-ch and N-ch in parallel connection on both channels. The requirements of MC head amp are to provide a enough S/N ratio and gain to connect the MC head amp to conventional phono equalizer. (approximately 28dB for MC cartridge with output impedance, 10 ohms). As high gm can be obtained equivalently by connecting low-noise & high gm FET in parallel, remarkable S/N ratio and gain(gm) can be obtained.

* The relation between noise and gm of FET is indicated as shown below.

$em = \sqrt{4 K. T. B. R}$

em = Noise voltage
K = Bolzman constant
T = Absolute temperature
B = Band width
R = Channel resistance of FET (= 1/gm)

Channel resistance R of FET is equal to 1/gm. By this, when FETs are connected in parallel, the total gm becomes higher and S/N ratio is excessively improved.
On AU-919, −154dB of total noise level under equivalent input is obtained. The circuit as shown in Fig. 2-1 uses ICL construction with total six low-noise Dual-FETs per channel (in case of using rank K2 of the FET) in parallel push-pull connection, and Diamond differential DC(DD/DC) circuit with fully push-pull trasistor in output stage of the pre-amp section.

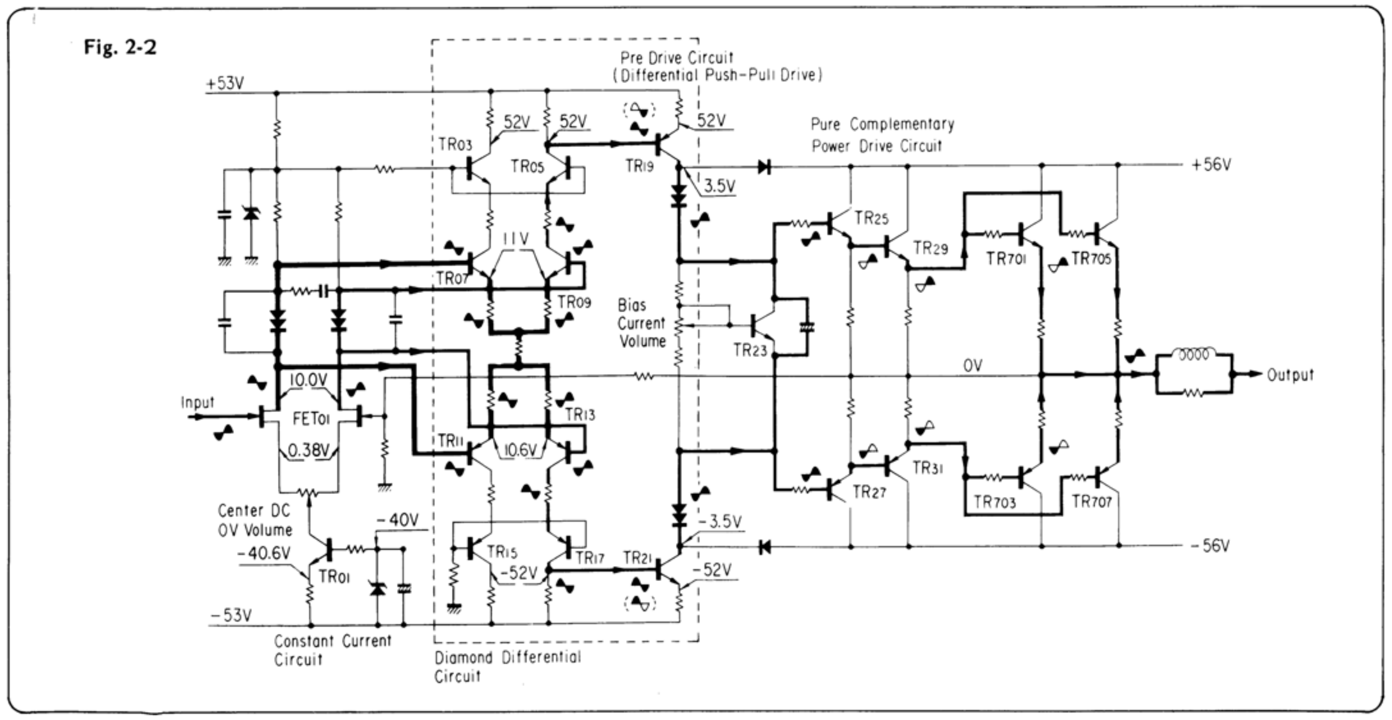
2) Phono equalizer circuit is input-capacitor-less (ICL) direct coupled DC equalizer amp employing DD/DC circuit. The output impedance on this circuit is as low as 200 ohms, S/N ratio better than 90dB and the deviation of RIAA equalization curve within ±0.2%. In addition, the slew rate of the equalization circuit itself is excessively high, 200V/μsec.
The circuit configuration of pre-amp section as shown in Fig. 2-1 is that the first stage is differential input circuit of Dual-FET with cascode-connected bootstrap, and high performance constant current circuit to avoid tonal coloration, phase shift and external noise, and second and third stage include DD/DC circuit with high driving capability. The output stage is composed of Darlington-connected SEPP circuit.
The features of the constant current circuit and the bootstrap cricuit are simply explained below, description of DD/DC circuit is on the next page.

* Constant Current Circuit
Common mode rejection ratio and power supply rejection ratio, as an advantage of differential amplifier, can be more improved by adding the constant current circuit.

* Cascode bootstrap circuit
This circuit allows the following features as differential amplifier using low-noise Dual-FET.
1. Gate leak current is almost ignored by making voltage between Drain and Source of FET low.
2. As mirror effect is decreased, the frequency response of high range is more extended.
3. The distortion caused by voltage dependance of negative feedback capacitance is decreased.
4. Linear response can be highly improved.

2-2. Operation and Features of Diamond Differential DC(DD/DC) Circuit

Fig. 2-2



• Operation and Features of Diamond Differetial DC(DD/DC) Circuit (Refer to Fig. 2-2)

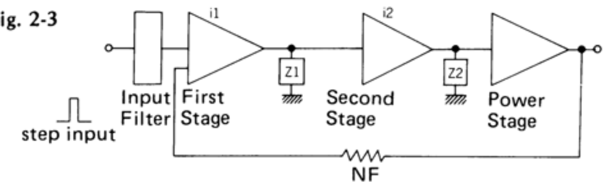
1. Features

1) The DD/DC circuit has been developed based on Sansui's latest electronic technology and our sound policy which have been living in our tradition since a series of Sansui AU-517 & AU-717. That is, the performance of this AU-D919 is positively pursued and improved in dynamic characteristics as well as in static characteristics.
2) By improving open-loop characteristics to perform NFB properly and providing sufficient current margin for this circuit, TIM (Transient Intermoduration) distortion has been able to be reduced.

2. NFB and TIM distortion

As shown in Fig. 2-3, in a conventional power amplifier, an NF signal delays due to time constant of impedance element, and is operated with an input signal. As by this lagging, the phase of NF signal does not coincide with that of input signal, it is not possible to feed back the signal instantaneously containing transient components such as music with various harmonics. As a result, it brings TIM distortion which the waveform of output signal clips instantaneously. For this reason, the input signal can not be purely amplified and distortion is incurred.

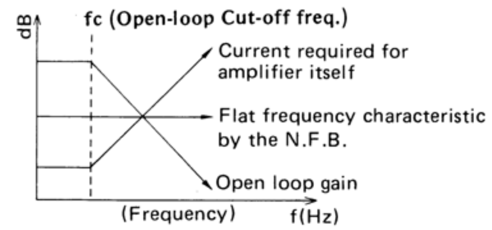
Fig. 2-3



Taking into consideration on TIM distortion and NFB, they are essential for enhancement of better sound quality in dynamic characteristics, also NFB is very effective for following points.
1) Improvement of non-linear distortion.
2) Stabilization of gain against temperature drift, caused by current-flows, and fluctuation of power source voltage.
3) Reduction of amplifier noise.
4) Improvement of input and output impedance.

On the other hand, Fig. 2-4 below shows the change of the required current to provide NFB. This Fig. shows that it is necessary to increase the required current in order to increase the NFB and that the more open-loop characteristics becomes narrow, the more the required current becomes large. This means that if ample cuurent margin is not available, TIM distortion will be arised.

Fig. 2-4



3. Prevention of TIM distortion

The prevention methods of TIM distortion are as follows:
1) To minimize NFB amount
2) To apply local feedback to the voltage amplification stage in order to improve main feedback.
3) To apply current as much as possible into the voltage amplification stage.
4) To connect a filter so that a tansient input signal does not enter into the input stage beyond response of the amplifier.
5) To adopt an input capacitor providing lagging-phase in addition to the conventional mirror type circuit, in order to achieve 2-pole phase compensation, and at the same time, to enhance the stability by carrying out leading-phase compensation.

This AU-919 adopts the abovementioned methods 1) to 5), also the DD/DC circuit is designed to achieve the subject above item 3). As shown in Fig.2-3, when figuring out current values required for each voltage amplification stage of the amplifier, assumig that the most severe input (an input which is large enough to operate the amplifier and contains infinite frequency comopnents) is applied to the amplifier, it is found that large current is required for second and its following stages of this section. Therefore, AU-919 includes the DD/DC circuit to prevent annoying TIM distortion.

4. Operation of Diamond Differential DC Circuit for Large Current Drive

* DD/DC circuit which is one of methods to prevent TIM distortion can supply an amplifier itself with large current required.

1) Fig. 2-7 shows the fundamental circuit of DD/DC section. The voltage differential circuit consists of TR07 and TR09 as well as TR11 and TR13, On the other hand, the current differential circuit consists of TR07 and TR13 as well as TR09 and TR11.

Fig. 2-5 Current Differential Circuit

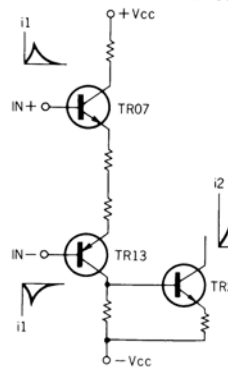


Fig. 2-6 Voltage Differential Circuit

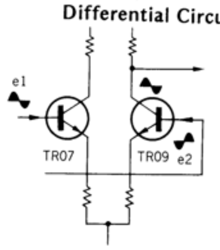
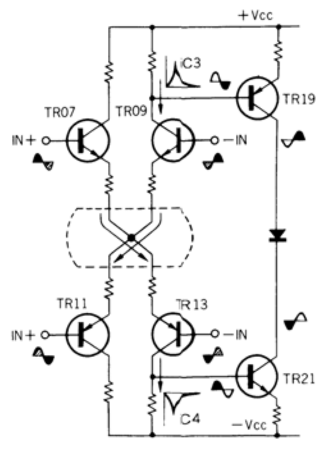


Fig.2-7 Fundamental Circuit of DD/DC section



※ In the above Fig.2-7, the cascode-connected Circuit consisting of TR03, TR05, TR15 and TR17 is omitted.

Fig. 2-5 shows the current differential circuit.
Fig. 2-6 shows the voltage differential circuit.
In Fig. 2-7, TR07 and TR09 as well as TR11 and TR13 perform voltage differential amplification under an audible signal frequency band. When signals including transient or high frequency components is applied to input in Fig. 2-5, the operation of this stage shifts from voltage differential amplification to current differential amplification consisting of TR07 and TR13 as well as of TR09 and TR11, which let the large current flow into this stage. Above function results the improvements of rise-time and slew rate, in other word, it brings the reduction of TIM distortion.

2) The detailed operation of the current differential circuit is as follows:
The complementary circuit in Fig.2-5 consists of TR07 and TR13 and two input signals into these TR07 and TR13 are anti-phase each other, therefore, only when a transient signal including positive (+) side component into TR07 and negative (−) side into TR13 is applied to the inputs, the circuit functions and outputs only half wave with large amount of current each other from two outputs. TR09 and TR11 perform the similar function in Fig.2-7, and the output signals are out-of-phase each other with half wave, so that TR19 and TR21 in next stage operate as a push-pull function and large current is able to be flowed.