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MJ Technical report

**High power amplifier that eliminated emitter resistors and output relays.**

**Technical Brain's TBP-Zero power amplifier and its circuit technology**

By Isao Shibasaki

Technical Brain Company announced a power amplifier that has eliminated the emitter resistors of four parallel output stages. The amplifier also eliminated all input and output electric contacts. The output power is specified 200W/8ohms. This is the report of this technology that is unveiled for our magazine..

### **Technical Brain Company**

The company was found in 1979 by Mr. Naoto Kurosawa, the president, in Tokyo. It has been established as audio laboratory. The company provided service for repair and remodeling of imported audio equipments, research and development of special purpose equipments, sales and engineering consultant.

In 1995, the company moved to Kawagoe City, Saitama Prefecture where they have spacey log house listening room (Picture 1), tea room and laboratory. There, many audiophiles started to gather, and in the laboratory, amplifier development had started little by little.

### **TBP-Zero, the concept**

TBP-Zero monaural amplifiers has the figure shown in Picture 2. Thick aluminum enclosure reflects the simple, but beautiful posture. Front panel provides only “Stand by” switch and a power indicator while rear panel has input and output terminals. All terminals are adaptable for both full balanced and unbalanced lines. The power cable is delivered from the bottom at the nearest position of the power transformer terminals. The balanced and unbalanced input terminals are parallel connected, not “switching”, avoiding the mechanical switch. The signal lines to the PCB are all solder connected, not connected by “plugs”. Protection relays for output stage transistors and chalk coils are eliminated by an ingenious circuit. The most significant point of this amplifier is that, in the four parallel push-pulls with 200watts/8  $\Omega$ , there are no emitter and base resistors. The specification is shown in Table 1.

Table 1. TBP-Zero Specification

Terms	Specification
Rated output power	200W/8ohms, 400W/4ohms
Frequency Characteristics	1Hz to 100kHz (+/-0.2dB, 1W)
Circuitry	Full balanced BTL (AB class biased)
Cooling system	Natural air radiation
Input sensitivity	1.29V
Gain	29.8dB
Input impedance	Balanced line: 3.6k $\Omega$ Unbalanced line: 1.8k $\Omega$
Dumping factor	550 approx.
Distortion	0.02% max./8 $\Omega$ (20kHz to 20kHz, Rated power)
Size	346W x 250H x 600D mm
Weight	65 kg approx.

Conventional temperature compensation circuit and its problem

Typical temperature compensation circuit of SEPP amplifier is described in Fig 1. Q5 works for temperature compensation as well as for bias circuit. When the base current to Q1/Q2 become too much, Vce of Q5 get the feed back decided by the base resistance (the trimmer in Fig 1) and current to reduce the excess current. The feedback level is controlled by the trimmer value. By thermal coupling Q5 with power stage transistors, Q5 control the bias voltage of Q1 and Q2, eventually the bias of power stage Q3 and Q4. This circuit is very popular and applied frequently, but the circuit also has two problems that cause to the sound quality. One: Q5 usually is provided in high impedance circuit, and Q5 is a negative feedback amplifier at the same time, therefore, when Q5 is set in the proximity of Q3 and Q4, which is necessary to obtain good thermal connection, it easily get affected by electro magnet and/or electro static induction that invites oscillation and distortion. In order to avoid this problem, locating Q5 away from Q3 and Q4 sacrificing the effect of the heat connection feed back, or excessive phase adjustment becomes necessary.

Two: To compensate the temperature traceability, the emitter resistors are inevitable for output stages. However, these resistors deteriorate the sound because it creates signal delay and switching distortion which always happen to the output stages. There are few studies to avoid these particular problems eliminating emitter resistors applied for medium power amplifiers. (See “15W A class DC monaural amplifier. By Shinichi Kamijou. August 1983. MJ. etc.) However, for High power amplifier, not so many studies have been done because of the difficulty. High power source must be provided, also parallel connection of the final stage is necessary. Therefore, thermal runaway is very likely to happen. Moreover, when the product is supplied in the commercial market, it is expected to operate safely without breakage in various extreme environments. Absolutely for this reason, I have not seen an amplifier product that does not have “emitter resistor”.

### Duplex temperature compensation circuit

Technical Brain invented a duplex temperature compensation circuit that operates stable even there is no emitter resistors in the final stages. Q5 is allocated in the middle of power transistors, but just for idle current compensation by the environment temperature change that is rather moderate. The bias compensation for the final stage is performed Q6 and Q7 in Fig 2. Those are added to the low impedance driver stages. They are very less influenced by the final stages despite of the proximity because of its low impedance. When Q6 and Q7 are the same type of transistors as final stages, and R1 and R2 (emitter resistors of the drivers) are well adjusted, thermal coefficient of Q6 and Q7 is well trimmed to eliminate the emitter resistances of the final stages. Also, four stage parallel connection of the final stage became stable by sorting the transistors. Among the four transistors,  $V_{BE}$  must be “same” in three points, cut off, idle current and large current vicinity. Also,  $h_{fe}$  of them must be the “same”. This artifice successfully realized the “no emitter and base resistors amplifier” for a commercial supply.

### **Circuit of the amplifier**

From input to the output, TBP-Zero is constructed of completed full balanced BTL amplifier. Fig 3 shows the scheme diagram. Input is lead to the voltage amplifier that has the balanced output. The output is followed by three stage Darlington power amplifier. The cross feedback loops are provided from the hot output line to the cold input, and vice versa. Fig 4 shows the circuitry of the amplifier. In the “Stand by” mode, the input signal line is grounded through the muting relay. Also, the input transistors’ gates are terminated via the photo MOS relays having all power stages cut off condition. This photo MOS relay is a photo coupler that is constructed of a LED and MOS-FET switch. (Fig 5.) The voltage amplifier is a cascode push-pull amplifier. (Fig 6) The FET amplifier’s drain voltage is controlled by the transistor which collector is controlled by a constant current circuit. The input signal to the FET is converted to a current signal that is converted to the voltage at 120k ohm load in the next stage. The sources of hot and cold FETs are mutually connected so that they compensate the nonlinearity of two FETs. This circuit increases accuracy of the amplitude.

DC servo feedback line is provided to the drains of FET. If feedback is provided to the signal line directly, the signal should be distorted, then, here, a new circuitry is applied to control the current balance between P channel and N channel. (Fig 7) For the servo amplifier, using dual operational amplifiers with FET input, long time constant (ten seconds) integral circuit is constructed.

For the four parallel power transistors, (Q29 to Q32, Q23 to 27) each transistor was sorted by  $V_{be}$  and  $h_{fe}$ . The  $P_c$  is 150W each and  $f_r$  is 30 MHz. As shown on Fig 8, each transistor has 150mA idle current, 600mA in total. This works as A class amplifier up to 5.8W/8  $\Omega$  and in AB class 200W/8  $\Omega$ .

For the temperature compensation transistors, the same transistors as power transistors are applied with the same idling current, 150mA.

The transistors are arranged as shown Fig 8(b). The temperature compensation transistor (Q23 and Q28) are set in the middle of output four transistors. They are connected by gold plated copper bus bars.

### **Power source circuit**

The transformer has applied large size EI core. Flat and thick copper wires are wound to allow free quick rush current and avoid vibration of the transformer at the same time. It has 1.2kVA and weighs 20kg.

DC for the final stage is regulated utilizing Shotkey barrier diodes (KCH30A15 and KRH30A15 from Nihon Inter) and two 68,000  $\mu$  F smoothing condensers.

Regulated DC circuit for voltage amplifier is shown in Fig 9. After a diode bridge by 30DF2, two 15,000  $\mu$  F rectifier capacitor are provided. The DC voltage is obtained by a no feedback type stabilize circuit.

### **Protection circuit**

The TBP-Zero amplifier eliminated protection relay of the output circuit as well as emitter resistors. This is realized by the special protection circuit shown in Fig 10. Differential detector circuit works to detect the level difference between input and one tenth level of the output. In the cases when output line is shortened, or output signal is clipped by too much input, or amplifier oscillates, or output line finds DC voltage more than expected, the output signal figure does not conform to the input signal, then, the detector give an alarm signal to the control circuit. Another signal would be fed to the control circuit from the hole element current sensor that is lined in the DC line. The hole element sensor sends the warning signal when DC line is shortened or transistor is shortened. As soon as the control circuit receive the alarm signal from either the differential detector circuit or current sensor, this order the circuit breaker shut down and let the power MOS FET switch shorten after the time lag of circuit breaker's shut down. This MOS FET switch works to discharge the electrolytic capacitors instantly. The circuit breaker contains a dual coil circuit protector that consists of serial trip coils and relay trip coil.

### **Layout particularity**

Pictures 3 to 16 show the detail layout of each function inside of the amplifier. Impressive care have been paid for the power lines wiring that apt to give some deteriorating affects to the amplifier due to its inducing and reflecting noise. The power transformer is placed to the far front. The AC line is introduced through the bottom chassis to be connected to the transformer taps with the minimum length. The outputs from transformer flows from front to the rear panel connecting to power PCB and output stages power block and loudspeaker terminals, all with minimum length. The PCB for voltage amplifier is vertically set in the very vicinity of input terminals. The input signal is connected to the input terminal. And then from the upper side of the PCB, give the signal to the transistors of output stage. Power block, output transistor block, voltage amplifier block are separated and shielded with the thick plates respectively.

### **Summary**

Technical Brain has been involved in repair business for years. Mr. Kurosawa, after the studies during repair works, had frequently proposed the improvement of the equipments to many manufacturers, which had been appreciated. With all these knowledge and experiences and his own originality, TBP-Zero is designed. The circuitry and layout of TBP-Zero is ideal in every aspect. And the sound is very transparent ever that I could not find in the past amplifiers.

Interview and information: cooperated by Mr. Naoto Kurosawa, CEO of Technical Brain Company.