To minimize the microphonic noise, the preamplifier had to be molded in a metal can.

Fabricated hybrid IC was first coated with a silicone resin, (X-25-180 Shinetsu chemical company Co., Ltd.) for high insulation resistance, since a leakage current through epoxy resin was significant. Then it is packed in a copper metal box with an epoxy resin (as shown in Fig. 2).

(b) Shaper amplifier

The pulse shaping stage was built on a mini-card for easy maintenance. A photograph is shown in Fig. 3. The mini-card occupied the mother PCB board with the pins on both sides of the mini PCB board. The shaper amplifier consists of a differential receiver, a pole/zero cancellation amplifier, a fourth-order Gaussian integrator and a base-line restorer. The constant of the integration stage was chosen to be 1μS. A triangular shaping or a truncated step shaping was not used because the size of delay lines and prefilters could not match with high density requirement. High speed and low noise operational amplifiers were used for each stage to minimize the size. The circuit diagram is presented in Fig. 4. A new design of a base-line restorer circuit using a pair of transconductance amplifiers was added.

Fig. 1. Circuit diagram of the preamplifier.

They have similar $\delta_m$ values (30-40mS for ID = 10mA) and have little difference within their specifications. Hitachi 2SK322 was chosen since a measurement on $\delta_m$ over a hundred samples were completed and the variation was found to be small.[3]. The drain current of the first stage FET was set to 10mA for high $\delta_m$. Secondly, 1GΩ thin film metal resistor (+2% accuracy) was used for feedback resistor to reduce parallel noise. Thirdly, the charge gain of the first stage was chosen to be very high but the effect of a floating capacitance to the gain stage was still reasonably small. Thus, the feedback capacitor of about 0.2 pF was built as a printed circuit pattern to keep the channel-to-channel variation of the capacitance minimum. Fourthly, the insulator of the PCB board is made of glass-reinforced Bismaleimide Triazine resin (called as BT resin: a trade mark of Mitsubishi gas chemical company Co., Ltd.) which has an order of magnitude higher insulation resistance than that of an Epoxy resin (G-10 board) and has a very low dielectric loss at high frequencies. Since the thickness variation is reflected to the capacitance variation and hence the gain of the first stage, the thickness variation was kept within ±5%. Fifthly, the second stage is an inverting amplifier with a closed loop gain of 20. The overall gain of the preamplifier was expected to be about 50mV/VC when the output was terminated to 50Ω. The gain variation of the preamplifier was designed to be less than ±7% including the gain variation of the second stage.

Since the gain of the preamplifier is very high, any mechanical vibration causes microphonic noise.

Fig. 2. Photograph of the preamplifier.