# §42-15 Development of a Detector System for High-energy and Heavy Ions

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The heavy ion beam probe (HIBP) at the LHD experiment works, and the electrostatic potential can be measured in the core region of LHD plasmas. However, since attenuation of the probe beam inside of the plasma is severe, under the present circumstances, the accurate measurement of the potential profiles in plasmas with the electron density of 1.5 x $10^{19}$ $m^{-3}$ or more is difficult. Moreover, turbulence measurement, which requires high signal-to-noise ratio and temporal resolution, is performed only in quite low density plasma ~ 0.1 x $10^{19}$ $m^{-3}$. In order to study the plasma confinement of LHD, further high precision measurement is required. In this study, a new detector equipped with high detection efficiency and a high multiplication factor for heavy ion beams is developed, and it aims at the high performance HIBP.

To estimate the performance of the plastic scintillator which is one of detection device candidates by detector development aiming at turbulent measurement, we decided to check the scintillator through photoelectric multiplier (PMT), with linearity to the luminosity and incident beam current. The test of the plastic scintillator element (made by Ohyo Koken Kogyo) for the detector was installed in downstream edge on the charge separator of HIBP. Emission of the light intensity to the injection beam current (from 15 to 55 x $10^{-9}$ A) was checked by CCD camera. As a result, the linearity was confirmed. Next, the multi-channel plastic scintillator with light guide for secondary beam detection was made as shown in Fig. 1. It was installed in the energy analyzer edge of HIBP. It was tested using PMT of H10722 (made by Hamamatsu Photonics). As a result, the performance of the necessary minimum value was confirmed in the signal strength and the frequency response. However, it can't be used because of the large cross talk between the scintillators. As a reform measure, the improvement for changing the shelter material to aluminum evaporation Mylar is needed. Additionally, damage of the plastic scintillators by the ion beam is also possible. These problems will be settled in the next year.

In the signal processing, systems are required for high position resolution the low noise high gain amplifier and the low cross talk of multi-channel readout. For the front-end circuits of the high gain amplification which convert fine current of the order -$10^7$ A to voltage, it is necessary to arrange the amplifiers at nearest and very small space on the detection device. Therefore, we decided to develop the readout electronics of the front-end circuit as an application specific integrated circuit (ASIC). For developing the CMOS analog ASIC, the device parameters for the circuit simulator (SPICE) were changed to the specification of the ASIC manufacturing firm, and the circuits were redesigned. It was possible to get a good result in SPICE, so the design was advanced to the mask layout for the ASIC. The example of the operational amplifier circuit is shown in Fig. 2(circuit diagram) and the mask layout is shown in Fig.3.

In next year, the experimental production of the ASIC and its installation with the detector is being considered.

Further, this case of the ASIC design was carried out by cooperation of High Energy Accelerator Research Organization (KEK) Open-It [1] and University of Tokyo VDEC[2].

1) http://openit.kek.jp/
2) http:// www.vdec.u-tokyo.ac.jp/

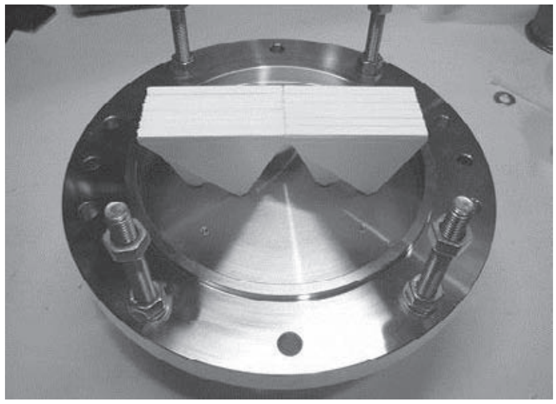

Fig. 1. Multi-channel scintillator with light guide

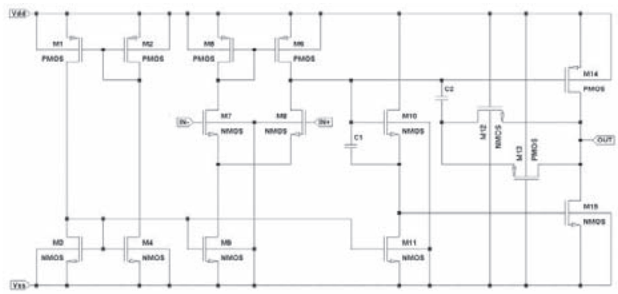

Fig. 2. Example of op-amp circuit diagram

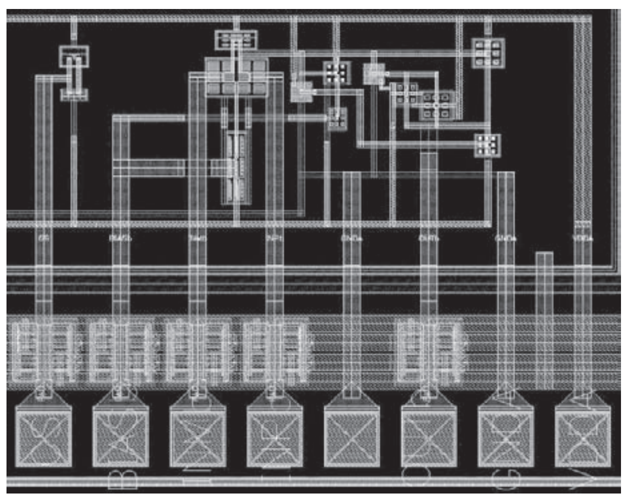

Fig. 3. Example of op-amp mask layout