Study on the integration of analog circuits for plasma wave instruments onboard scientific satellites

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Recently, on environment measurement missions, it is the main stream to measure many points at the same time by formation flight satellites. In addition, the investigation of outer space environment has also been needed, and demands for Plasma Wave Instruments (PWI) are increasing because in the collisionless plasmas, the energy/momentum is transferred through wave-particle interactions. Especially, the restriction for the size and the weight comes to be severer and severer, the downsizing and light-weighting of the analog parts that occupies quite large area on PWI. Therefore, we tried to realize the analog parts of PWI on integrated circuit called ASIC (Application Specified Integrated Circuits). In this system, the detected signals by sensors pass through the ASIC, which contains a differential amplifier, band restricting low pass filter, band pass filters for decomposition of electromagnetic waves depending their spectrum energy revels, circuits for smoothing, multiplexer, and AD converter.

As the beginning, we tried the integration of Gm-C filter for frequency band restricting low pass filter, folded cascade op-amps for main amplifier and switched capacitor filter for anti-aliasing filter. After the designs and the layouts of those circuits, we ordered Taiwan Semiconductor Company (TSMC) to make the integration chips from those layouts. Finally, we evaluated the performance of the integrated chips by measurement experiments. As a result, Gm-C filters on the chips showed lower cut-off frequency and higher noise level characteristics than we need. These filters also displayed low Common Mode Rejection Ratio (CMRR) as 40dB. Those points, however, will be solved by the re-design based on thoughtful consideration of elements' fluctuation. Folded cascade op-amps came out to have gain characteristic we designed, but to have higher noise level than we demands. Therefore, we need arrangements in the redesign, especially for MOSFET gate size to control the noise. We also tried to apply the op-amps for switched capacitor. We designed the switched capacitor filter and checked the performance by the transient analysis. We found that the output reflected the input as disintegration signals.

We tried the integration of single-end Gm-C band pass filter because the fully-differential band pass filter circuits have not indicated desirable characteristics at low frequency region. Since single-end circuits require other type of OTA (Operational Transconductance Amplifier) as effective resistances in Gm-C filters, we are designing new OTA.

Finally, we examined the size and the weight of the integration chip as PWI analog parts. Compared with A4 size and 400g of conventional one, the size and the weight were only several square meters and several g. About those prospects, it is inevitably possible to answer the demands of missions the in the future.