Study on One-Chip Wave-Particle Correlator for Space Plasma Observations

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Wave-particle correlator (WPC) conducts direct quantitative observations of wave-particle interaction in space plasma by direct 'E-v' calculation on-board. As we need to measure the precise phase and to observe the data with high time resolution, data calibration and real-time processing is much important for correlation computation in WPC system.

The objective of our study is to realize one-chip type of WPC system with real-time processing and optimize its performance for future observations. We use Field Programmable Gate Array (FPGA) as a device to integrate WPC system into one-chip. In WPC system, we need to observe plasma wave (electric, magnetic), particles (electron, ion), and ambient DC magnetic field. Each sensor line is connected to WPC system as digital data. We design every function to transform digital raw data to real physical parameters and to realize practical calculations of wave particle interaction on-board. The detail calculation modules in functions are waveform calibration, coordinate transformation, data synchronization, and correlation calculations. As the total supplied power of several numbers of instruments in a spacecraft is limited about 4W, we set the realistic power consumption of WPC less than 500mW. Additionally the available FPGA logic gates are limited and the system clock frequency set 4MHz from low power saving. We need to optimize the WPC functions to realize the real-time processing.

We achieved one-chip WPC system which has installed all required functions. Besides we found if signal-to-noise ratio was greater than 20dB, the phase errors in calibration fell below 5 degrees. Moreover we realized 494mW as the total power of WPC system. The one-chip WPC system we designed will have a good performance required for future space plasma observations.