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Research on Monitoring Circuit for Beam Spot Position Based on Diamond Detectors

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Based on the fourth generation synchrotron radiation light source, the stability of X-ray beam is an urgent problem to be solved in current cutting-edge experiments. This project is based on fast response time of diamond detectors. A fast response four channel weak current measurement and data acquisition circuit based on diamond detectors was developed using ADA4530. Experimental tests show that when the weak current is greater than 10pA, the circuit has an error of 1.3%. Moreover, for weak currents of the pA level, it can measure and refresh the beam position above 10kHz, and achieve 24 bit high-precision signal acquisition.

Summary (500 words)

This project aims to collect high-frequency and high-precision data on the weak current signal of the four quadrant diamond position sensitive detector in the fourth generation synchrotron radiation X-ray beam stabilization system. Mainly by studying the theory of high resistance I-V weak current detection, designing a pA level weak current conversion amplification circuit, achieving fast conversion and synchronous collection of four channel pA level currents, and then forwarding the signal to the core control board of the beam stabilization system to achieve beam position calculation and feedback control. The front-end circuit is built using the ADI company's extremely low input bias current budget amplifier ADA4530-1. For the overall circuit measurement system, bandwidth simulation analysis was conducted, and the parasitic capacitance of the 10G feedback resistor was approximately 100fF. The simulation measured that the bandwidth was limited to 159Hz. The design adopts a protective ring design, with a three coaxial BNC connection for weak current input. The front-end amplification circuit is shielded by a shielding box to enhance the shielding performance of the measurement system. The output signal is transmitted to ADI company's AD7172-2 through the SMA interface for 24 bit high-precision analog-to-digital conversion. Through the FMC output interface, it is connected to a digital control board to achieve signal closed-loop control and achieve overall isolation of analog and digital circuits. The final experimental test shows that the detection sensitivity of the circuit can reach 9.7936mV/pA for weak currents of the pA level. When the weak current is greater than 10pA, the error of the circuit is 1.3%, which meets the requirements for weak current measurement of the fourth generation light source and can meet the position measurement requirements of the beam stability system.

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