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Practical implementation of low-latency DSP for feedback control of sound in research contexts

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Feedback control of sound requires low-latency signal processing. In addition, because the human range of hearing extends roughly from 20Hz to 20kHz, controller hardware must process signals with relatively large bandwidths in comparison with common control applications. Over the past decade, the appropriate embedded hardware has become a niche product, so its cost has actually increased. The open source community has developed an excellent alternative: a general-purpose computer runs Linux with the Real-Time Application Interface (RTAI). Open source drivers (see www.comedi.org) enable software to communicate efficiently with data acquisition cards. For the first time, we describe in detail from start to finish how to configure such a system. In particular, we explain how to run control code from user space while still disabling interrupts. We further explain how to reserve a processor for running only feedback control code. This configuration achieves less than one sample of total system delay at sampling rates as high as 50kHz. Other processors remain free to run standard Linux programs, allowing researchers to control sound with calls to many generic software libraries. We present detailed measurements of system jitter for various configurations and provide an example open-source toolbox demonstrating all these aspects at <http://ccrma.stanford.edu/~eberdahl/Projects/TFCMI>.