

White paper Latency in the Kyub

Summary: The Kyub achieves a latency of less than 4 ms between touch and MIDI transmission. Achievable synthesis speeds of 7 ms provide a total latency of less than 13 ms.

Background: Latency is the time between pressing a pad on the Kyub and hearing sound. It is generally a sum of the time between pressing a pad on Kyub and the Kyub outputting a MIDI command on USB and the time between a computer software synthesizer (such as in digital audio workstation) receiving the MIDI command and generating sound.

Trained musicians can detect low levels of latency but also have the ability to compensate for relatively high levels of latency. For example, a trained musician may be able to hear 8 ms latency by then acoustic piano has a latency of nearly 30 ms (http://www.speech.kth.se/music/5_lectures/askenflt/measure.html). Most musicians appear to have the ability to accommodate latencies as high as 15 ms long as they are reasonably consistent. (<http://www.soundonsound.com/sos/sep02/articles/pcmusician0902.asp>) It takes sound about 1 ms to travel 1 foot.

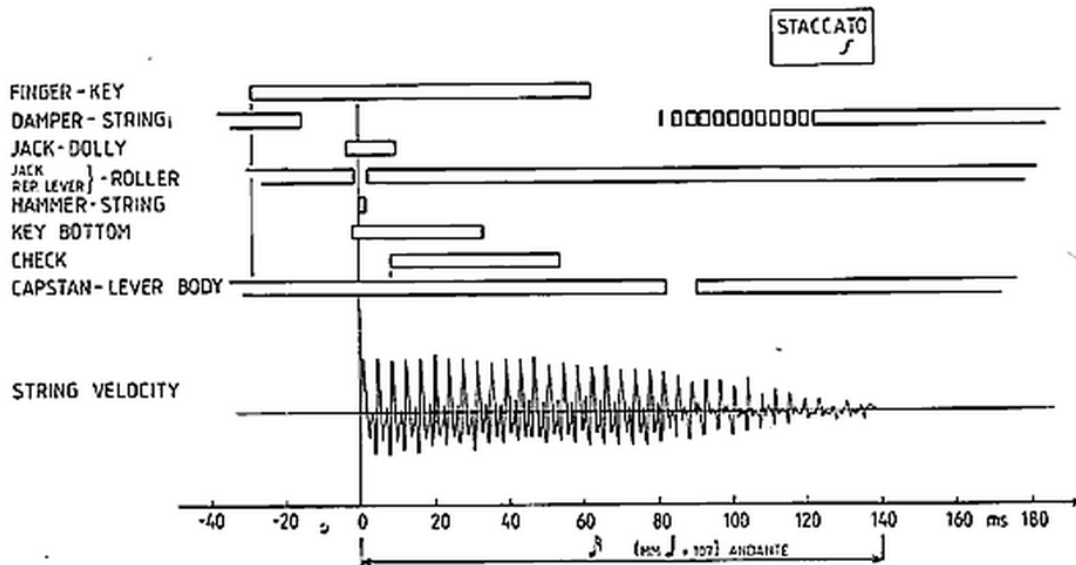


Fig. 1: timing diagram for an acoustic piano
http://www.speech.kth.se/music/5_lectures/askenflt/measure.html

Kyub Latency: The Kyub introduces some delay caused by the time required for the pads to cycle in charge for capacitive sensing (about 400 μ s) and the process of scanning through 11 pads. This cycling time takes about 4.5 μ s introducing a jitter of as much as plus or minus 2.25 μ s depending on when the finger touch occurs in this cycle. Measurement of velocity from the internal accelerometer is pre-buffered to minimize any velocity associated delay.

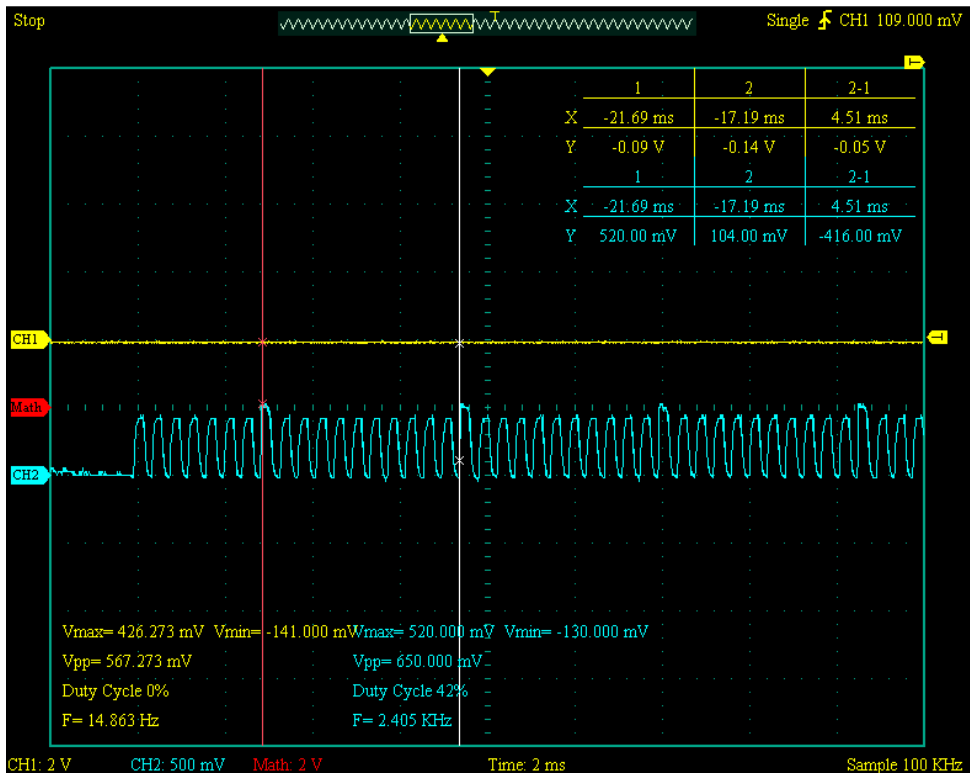


Fig. 2: scan cycle through pads on Kyub

Kyub latency was measured using aluminum foil wrapped about my finger and attached to one oscilloscope probe. Touching a pad connects the probe to the capacitive charging currents visible in the blue trace below. One pin of the Teensy was strobed on right before the USB MID transmission instruction and then off after the transmission instruction. USB transmission appears to be practically instantaneous. The Kyub typically provides provides MIDI output in about 2 ms with 2 ms jitter.

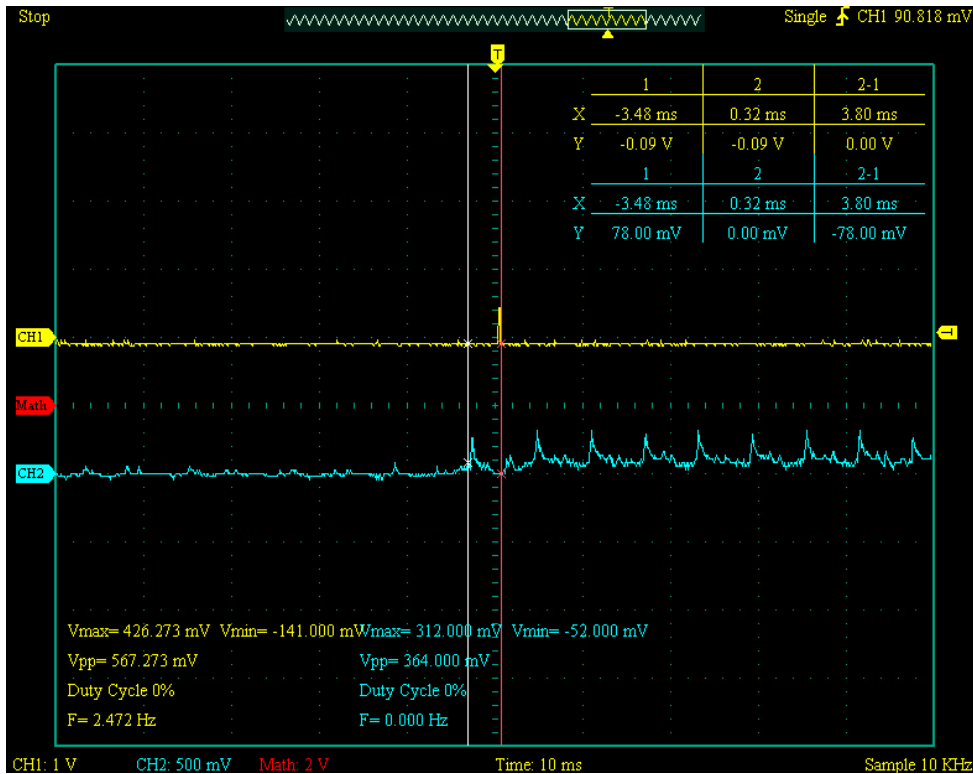


Fig. 2: Time between pad touch (blue) and output of MIDI data.

Synthesizer Latency: The dominant source of latency is typically the synthesizer and the associated sound card. A good discussion of latency is found here: <http://www.soundonsound.com/sos/sep02/articles/pcmusician0902.asp>. In a Windows machine, a low latency soundcard and ASIO drivers are important. Free ASIO drivers are available from ASIO4all.com. Using ASIO4all drivers, a Sound Blaster Audigy on a 5 year old Windows 7 machine, and PropellerHead Reason, 7 ms latency is easily achieved.

Further reductions in delay

PJRC website:

MIDI messages are grouped together into USB packets. Up to 16 messages can transmit at once! They are held for a brief time, not more than 1 ms, to facilitate grouping. You can use the `send_now()` function to immediately allow any buffered message to transmit