J. Donovan, G. Stetten, "Micro-BLIP: A Customized Arduino System for an Instrumentation Course in Bioengineering," BMES 2018, Atlanta, Georgia, October 17-20.

Introduction: For the past ten years, every student in the required undergraduate Bioengineering course in instrumentation at the University of Pittsburgh has constructed a custom microprocessor system we call the Breadboard Laboratory Interface Processor (BLIP) [1,2]. The BLIP is programmed to function as a recording voltmeter, signal generator, frequency counter, duration timer, and digital event logger, and supplies 5V power for operational amplifier circuits. The BLIP has provided over 500 students with the experience of constructing their own instrumentation system, which they take with them after the course. Recent advances in microcontrollers and the growth of the Arduino community have inspired us to update our system to take advantage of these ubiquitous and user-friendly systems. Last year we designed a new BLIP to incorporate an Arduino Micro microcontroller, while maintaining the instrumentation functions of the original BLIP [3], which we call the "Micro-BLIP." We present here the results of incorporating this device into the Spring 2018 instrumentation course, as well as our efforts, based on these results, to improve the system further for the upcoming Spring 2019 semester.

Materials and Methods: An Arduino Micro microcontroller, an MCP4801 D/A converter, and a TC77662A ±5V charge pump are combined in the Micro-BLIP with male and female headers on a custom printed circuit board (PCB), to plug directly into the student's solderless breadboard. Functions are selected with a pair of user buttons (Fig. 1 left). As with the original BLIP, our new device appears to the host computer via USB as a human typing on a standard computer keyboard. Data may thus be entered directly into any standard word processor or spreadsheet, with no specific software or operating system required on the host computer.

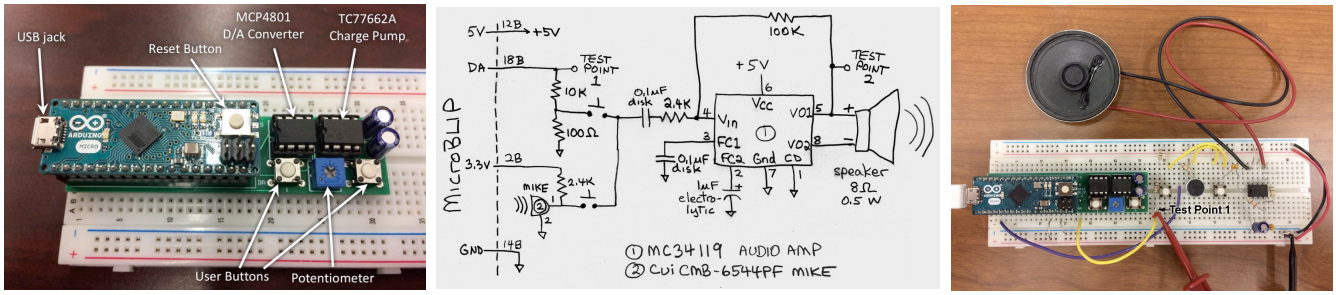

Fig. 1. Assembled Micro-BLIP in breadboard, schematic for audio lab, completed audio lab circuit with Micro-Blip.

Results and Discussion: As opposed to the original BLIP, in which the custom program was permanently programmed into the microcontroller, the Micro-BLIP is now easily reprogrammable by students using the Arduino software libraries and thus we expect it to be more useful for future projects after the course. All of the interface pins are passed through to the breadboard, where they are available for further development and experimentation. In Spring 2018, we introduced the Micro-BLIP into the instrumentation course, where ninety students were given the components and step by-step instructions detailing how to solder them into the PCB. This construction was completed with essentially a perfect success rate, after a few soldering mistakes were identified by teaching assistants. Students then used the Micro-BLIP in weekly experiments involving analog and digital circuits in the laboratory portion of the course. Shown in Figure 1 (center and right) is a particular lab in which the Micro-BLIP's signal generator output and a small microphone were connected to an audio amplifier. Complete descriptions of the labs, as well as the rest of the course material are available through www.pittkit.org.

Since the Spring 2018 course, we have introduced interrupt-driven routines into the Arduino program, resulting in ~2x speed increase and greater accuracy in many of the operation modes. We are currently adding custom assembly code beneath the standard Arduino libraries to push the speed and accuracy even further.

Conclusions: We believe that students enjoy the hands-on nature of building and using the Micro-BLIP, and that it contributes a valuable experience to their education. By teaching students about microcontrollers and providing them with equipment that they own, we hope will help to increase their potential for life-long-learning.

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References:

[1] D. Weiser, et al., BMES, 2005. [2] G. Stetten, et al., ASEE, 2008. [3] J. Donovan, et al., BMES, 2017.