Using PSoC's for Instrumentation in the Advanced Laboratory

Indiana University Purdue University-Fort Wayne
July 27–29, 2017.

(10 set-ups)

Host and Mentors

Mark Masters (B.S. Moravian College and Ph.D. Lehigh University) is professor (and chair) of physics at Indiana University Purdue University Fort Wayne (IPFW). He has been at IPFW since 1993. Prior to coming to IPFW, he was at Rider University, and the Naval Research laboratory (Laser Physics). One of his biggest pleasures is building things such as furniture, keeping his 200 year old farm house from collapsing and creating odd buildings about the yard. This pleasure extends to research and developing instrumentation, often based on a PSoC to aid in the variety of experimental investigations. These investigations often involve lasers and vary from developing laser systems to using Rayleigh scattering to measure atomic cluster sizes to the newest pursuit—single photon investigations.

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Jacob Millspaw is a continuing lecturer at Indiana Purdue University at Fort Wayne (IPFW). He did his undergraduate work at Towson University in Baltimore MD and received his M.S. and Ph.D. in condensed matter physics at Purdue University in 2009. He accepted a short term visiting assistant professor position at IPFW and remained at IPFW as a continuing lecturer. While at IPFW he has worked to improve online and distance learning through the use of interactive desktop exploration lab kits for investigations related to light and color, geometric optics, and first semester mechanics experiments. He is also currently pursuing research in surface physics as a mentor to undergraduates in the IPFW Physics Department and development of inexpensive high quality instrumentation for educational purposes.

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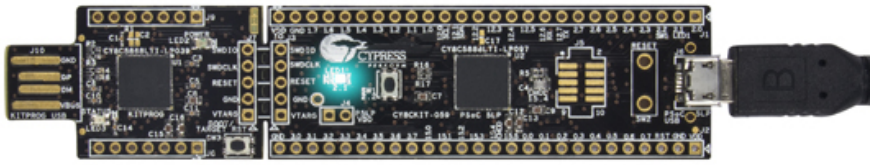
Almost all investigations ultimately rely on electronic instrumentation in order to collect, massage and transmit the data to a computer. However, we prefer that these not be black boxes, but that students know how to build instruments to collect data in a variety of ways. In this workshop, we will use a Programmable System on a Chip (PSoC) development kit from Cypress Semiconductor Corporation to build a variety of electronic instruments. This device is the focus of our electronic instrumentation class and is also used throughout our curriculum in our advanced laboratory class, and as part of student research.

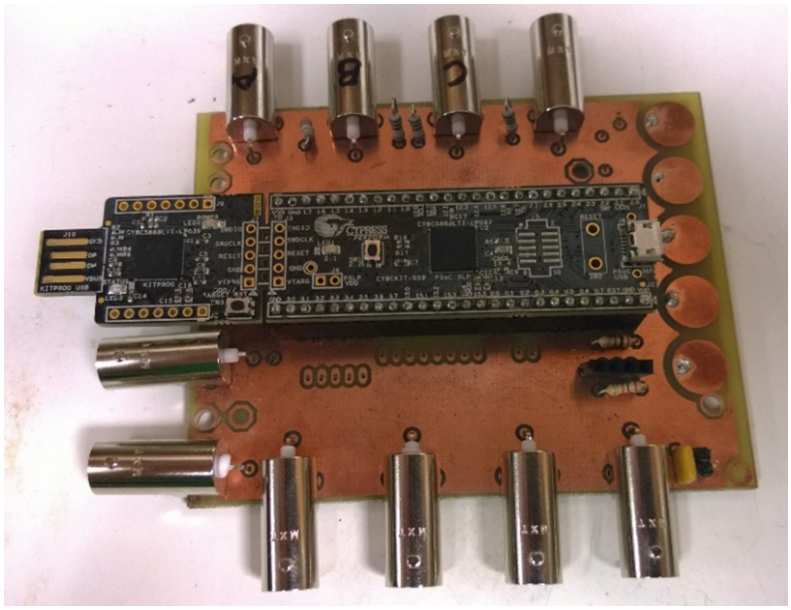
The PSoC is a mixed signal processor. It has a 32bit ARM processor (like most smart phones). What makes this device truly unique and useful for the physics laboratory is the inclusion of programmable analog capabilities (two op-amps, programmable gain amplifiers, three analog to digital converters [1-20 bit, 2-12 bit], analog multiplexers, digital to analog converters, frequency mixer, comparators, and sample and hold elements) and 24 Universal Digital Blocks (UDB's). The UDB's are "FPGA-like" in that they can be programmed for a variety of digital devices from discrete logic gates up to counters, timers, pulse width modulators, etc. Finally, there are two digital filter blocks which are helpful for signal processing.

We will explore interfacing to analog and digital sensors to perform a variety of measurements. These sensors will include thermal sensors, photodiodes, accelerometers, 1-D image arrays, radiation sensors, and thermocouple vacuum gauges. We will go over I2C, SPI, and USB communication for sensor to PC data transmission.



In the workshop, attendees will develop a variety of electronic instruments. Then the instruments will be used to perform an investigation. Sample instruments will include:

1. A coincidence counter and pulse interval measurement which will be used with a simple LED based Single Photon Avalanche Photodiode, and for radiation counting.
2. A multichannel voltmeter with ramp generator which will be used to determine Planck's constant using an LED.
3. Construction of a spectrograph using the PSoC to read a linear photodiode array and analyze the spectrum.
4. Lock-in Amplifier



Tentative Schedule
Day 1: Introduction to PSoC hardware capabilities and software. Overview of our current use of PSoC and successes with students. Diving in with simple programming tasks to familiarize with the software and programmer. Create functional volt-ammeter for introduction to external interfacing.

Day 2: Linear detector array and spectroscopy. Build a lock-in amplifier.

Day 3: Digital logic—Pulse Width modulators, Counters, Building a counter for the SPADs. LED as a SPAD experiments.

Attendees should bring their own laptop. A notebook will also be helpful.

Costs: Cy8cKit-059—PSoC 5 prototyping kit, $10; LCD screen, $10; Breadboard, $30; and assorted sensors, $20-$70.

Financial support to help purchase apparatus used in Laboratory Immersions is provided on a competitive basis by a program of the Jonathan F. Reichert Foundation. Limitations and exclusions apply, but generally speaking the foundation may support up to 40% of the cost of the required equipment.
