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The Relaxation Times

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TeachSpin Customer Stocks Up on Stocking Stuffers

It is beyond our wildest imagination! Who would have ever imagined that a TeachSpin product would become so popular that you'd see signs of it everywhere? Just a few blocks from our factory they are selling like crazy, just look at that guy in the photograph coming out of the store with a stash of Crickets in his hands. It's amazing!

Truth-be-told, we can't keep up with production. We have opened up a new assembly line, hired more assemblers, gotten a special shipping service from UPS – you name it – but still, demand exceeds production. Those Crickets just keep flying off the shelf.

Why bother putting this in our newsletter if sales are going so well? We just want to tell our faithful customers to be patient if the store nearest you is out of Crickets for your Two-Slit apparatus, even though they still have the sign in the window. Don't get discouraged. We will soon be catching up with demand. Maybe a nearby store has one. Just keep a look out for the sign "Cricket Is Here", or just "go CricKet."

Now if the clerk at the store doesn't know how this new gadget works, because we have not yet had time to train him or her, check out the next page for an explanation.

With a little bit of luck, a TeachSpin Cricket will soon be chirping in your lab.

Cricket Clarified

When TeachSpin's Two-Slit Interference apparatus is in the single-photon mode, photons emitted by the light bulb source are incident on the photomultiplier's photocathode, where they create photoelectron ejection events. These single photoelectrons are multiplied inside the photomultiplier to form a charge pulse. This charge pulse is then amplified and used to fire an electronic discriminator. Each firing of the discriminator produces one TTL output pulse of about 400 μs duration.

Ordinarily the TTL pulses are directed to an electronic counter. But those pulses will also trigger the ***Cricket***. Cricket's electronics stretch each 400 μs TTL pulse into a 5 ms long internal pulse and, for a 5 ms duration, Cricket emits a tone of fixed amplitude and frequency from its piezoelectric buzzer. Thus, for every photon detection event, Cricket emits a short tone-burst, which sounds very similar to an old-fashioned Geiger counter. The sound is clearly audible for a whole classroom of listeners.

Cricket is intended for use with a "Two-Slit" which has been adjusted to deliver photon events at a low rate, for example 100/second, so that the mean time between events is 10 ms or longer. This makes the probability of two events overlapping very small. Then, in the TeachSpin tradition of direct connection to the senses, students get auditory access to individual photon events (events which a counter would only totalize). The clicks are manifestly non-uniform in time since they correspond to individual, uncorrelated, random photon events. When the settings on the Two-Slit apparatus are changed, for instance, from one slit open to two slits open, the sound of the click stream changes dramatically.

Now you can directly demonstrate the qualitative character of a series of individual quantum events, and can directly demonstrate the qualitative changes that ensue when you change settings in your Two-Slit apparatus.

Here's our favorite demonstration. First, open both slits and find the central maximum of the two-slit interference pattern; then, move the detector slit to an adjacent minimum. Now, use the slit blocker to cover one of the two slits.

Obviously, this cuts the total light coming down the channel in half. The event rate at this location, however, audibly increases. Evidently, we have eliminated the destructive interference – but of what? We have already established that these photons are coming down the channel ***one photon at a time!***

A "Nobel" Adventure

At last month's OSA conference a man without an identification tag was examining the Two-Slit Apparatus. This, he informed me, was the piece-de-resistance of the final lecture of a course he was teaching. He, however, had managed to borrow a camera which allowed his class to watch the random single photon arrivals across the interference pattern. He was certainly fortunate to have access to such a camera, I observed, but such apparatus was far beyond the budget of a TeachSpin instrument. Of course, I added, the lecture hall demonstration was passive and TeachSpin is committed to hands-on, student controlled experiments. With Cricket clicking merrily, I showed him how we could switch from two slit to one slit observation and pointed out that, with this apparatus, students could even investigate the way the photomultiplier worked.

Suitably impressed, my visitor asked for a brochure. Given a name and school, I said, I would send one. Slipping his hand into his pocket, he placed his missing name tag on the table. "Oh dear," I gasped, "Roy Glauber!" "Yes," he replied gently, "my name HAS been in the news a bit lately."

Barbara Wolff-Reichert

Signal Processor/Lock-In Amplifier

"OUR UTILITY INFIELDER"

It's true that in its brochure we nicknamed our Power/Audio Amplifier the "utility infielder." But we should have reserved that designation for our Signal Processor/Lock-In Amplifier (SPLIA1-A). When TeachSpin originally conceived of a "teaching lock-in", we concentrated on building an instrument that would aid students' understanding of the ***process*** of extracting weak signals that are imbedded in a noisy environment using lock-in detection. Current research lock-in instruments intentionally "hide" the fundamentals of signal extraction techniques to simplify their use. Whereas, TeachSpin's SPLIA1-A intentionally "forces" the student to learn these principles (or it won't work).

However, since developing these units for the student laboratory, we have discovered many other uses for this instrument in TeachSpin's own testing and product development laboratory. This has become our "utility infielder," and we believe it would serve that useful function in your advanced lab, even in your research laboratory. I can give a few examples, but I am sure you will find many more uses when you have the unit in hand.

Measurement of Small Resistance

Determining the resistance of a four inch long one eighth inch diameter OFHC copper rod cannot be carried out using even an expensive multimeter. An accurate measurement can be made rather easily, however, using SPLIA1-A and our Power/Audio Amplifier (PAA1-A). Figure 2 shows the block diagram for this measurement.

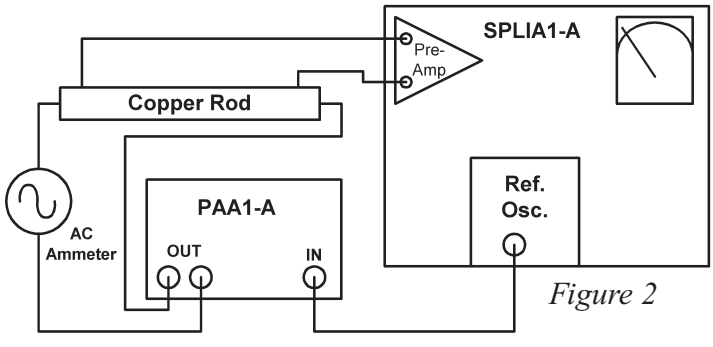


Figure 2

This is a basic four-terminal measurement with the ac current supplied through the ends of the rod and measured by an accurate ac ammeter. The voltage across the rod is measured by the lock-in. Here it is essential to use the differential input to the pre-amplifier with maximum common-mode rejection. For currents of the order of amperes, the ac voltage developed across the rod is of the order of microvolts. In this case, phase-sensitive detection is the ideal method to extract the signal in the presence of noise interference.

The same basic system can be used to measure small Hall voltages that are generated by metallic samples.

Additional Signal Averaging

It is often necessary to average an analog voltage signal to obtain additional resolution. For example, the Hall effect voltage for TeachSpin's HE1-A has a ± 2 mV fluctuation due to noise presence on the output signal. This noise fluctuation sets a limit on the resolution of a magnetic field measurement by this instrument.

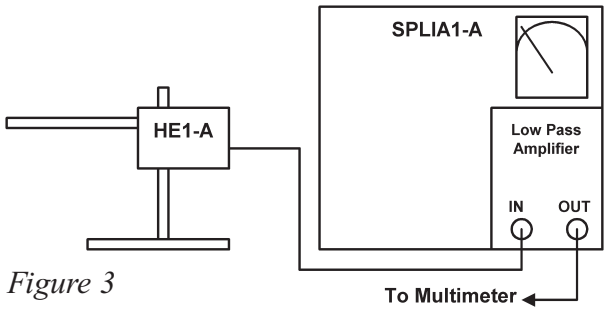


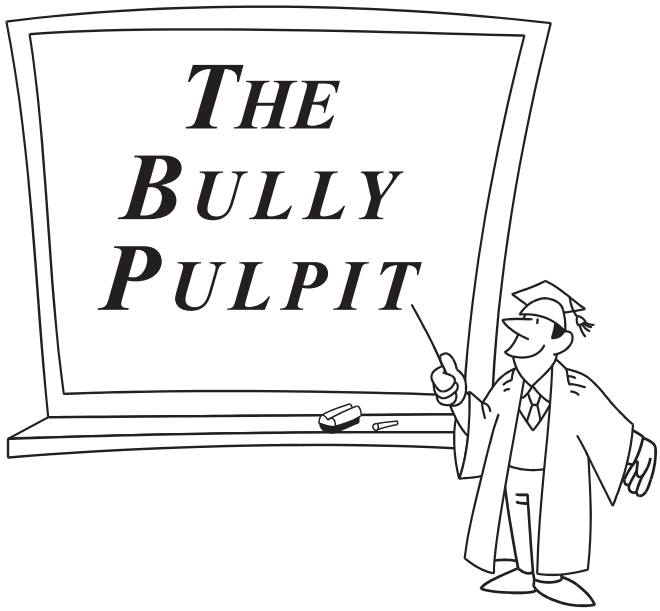
Figure 3

However, significant enhancement in the resolution can easily be achieved if the output is amplified ***and*** filtered by the low-pass section of the SPLIA1-A. The amount of improvement depends on the time constant and the roll-off chosen. The trade-off is between signal-to-noise improvement and response time, with the signal-to-noise increasing approximately as the square root of the signal averaging time.

This low-pass section can be used with any analog signal up to approximately 10 volts.

Handy AC/DC Low-Noise Preamp

"It's always nice to have a preamp around the house." Here, in our SPLIA1-A, you have a ***low-noise, variable gain, differential input, 0 – 500 kHz, ac/dc, 1 MW input impedance, low output impedance, BNC connected*** ready-to-go preamp. You will find plenty of uses for it; I guarantee it!



My heart rate significantly increased as I read the President's Report in the last AAPT Announcer (Vol 35, Fall 2005). In case you missed it, Dick Peterson, the AAPT's current president is calling on the physics community to pay more attention to advanced laboratory instruction. I want to add my voice to this wake-up call.

As an undergraduate student at Case Institute of Technology, I must confess that I struggled with my theoretical course work. But when I went into the Advanced Lab on the second floor of Old Rockefeller, things looked much brighter. I loved that lab, and I believe I began to learn that physics. It certainly helped that I had a great instructor in Chuck Smith. His love of experimental physics was inspirational and infectious. I have to believe that all over this country, no, all over the world, there are students like me who will learn much of their physics in the laboratory environment. I also believe they are a critical component of our scientific population. God forbid we should all be theorists!

Dick Peterson is calling for a "national task force that will make recommendations for encouraging and assisting faculty and staff working on "advanced laboratories," . . . We envisage conferences and listservs for better communication, databases for experimental approaches and apparatus, professional forums for documenting experiments, and awards for exemplary work." To this I'll add, "Let's GO!!"

The advanced laboratory has always been a special part of the instructional mix we offer our students. This component of the student's education also requires special faculty with special skills and dedication. I remember many APS and AAPT meetings years ago where there were active discussions and exchanges about new and exciting experiments. These sessions seem to be much less frequent and the faculty teaching them seem to be becoming increasingly isolated. If we are to enhance or even to maintain, the quality of experimental instruction, this culture must change.

The political reality of cultural change in the physics community requires, at minimum, the coordinated and dedicated efforts of three entities: AAPT, APS and the NSF. All three need to be on the same page, each committed philosophically and financially to the project. Without all three, I fear the effort may only turn out to be a waste of many talented people's time. TeachSpin stands ready, even eager, to do its part. We have informed these groups that TeachSpin will commit financial and intellectual resources to the effort. We believe it is both in our interest and in the interest of the entire physics community to make this a serious and sustained effort.

And you, a member of the TeachSpin community, what can you do? Plenty! Get on board. Write to the officers of AAPT and APS supporting this idea. Add your own ideas on enhancing laboratory instruction. Talk to those you know at the NSF. Talk to folks you know at educational foundations. Send me feedback. I will pass it on. Let's get some tangible results while I'm still vertical.

Jonathan

TeachSpin's Exhibits in 2006

March 13-15	APS, Baltimore, MD
March 27-28	DPG, Dresden Germany
May 16-18	DAMPO, Knoxville, TN
August 24-25	AAPT, Syracuse, NY

Our "shopper" is actually Markenzy Cesar, one of the TeachSpin family that actually builds our instruments. Those are Crickets he is holding in his right hand, but he didn't buy them in the store behind him. He helped build them.