Forecast:
Possible waves and lightning

The Relaxation Times

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Return of the TeachScope!

Old-timers among you might remember when TeachSpin offered the 'TeachScope', a teaching tool helping students learn *how to use an oscilloscope*. Loss of access to a crucial chip forced us to discontinue that device long ago, but a new collaboration with HuckansLabs has brought back the idea, renewed and better, in the 'TeachScope II'.

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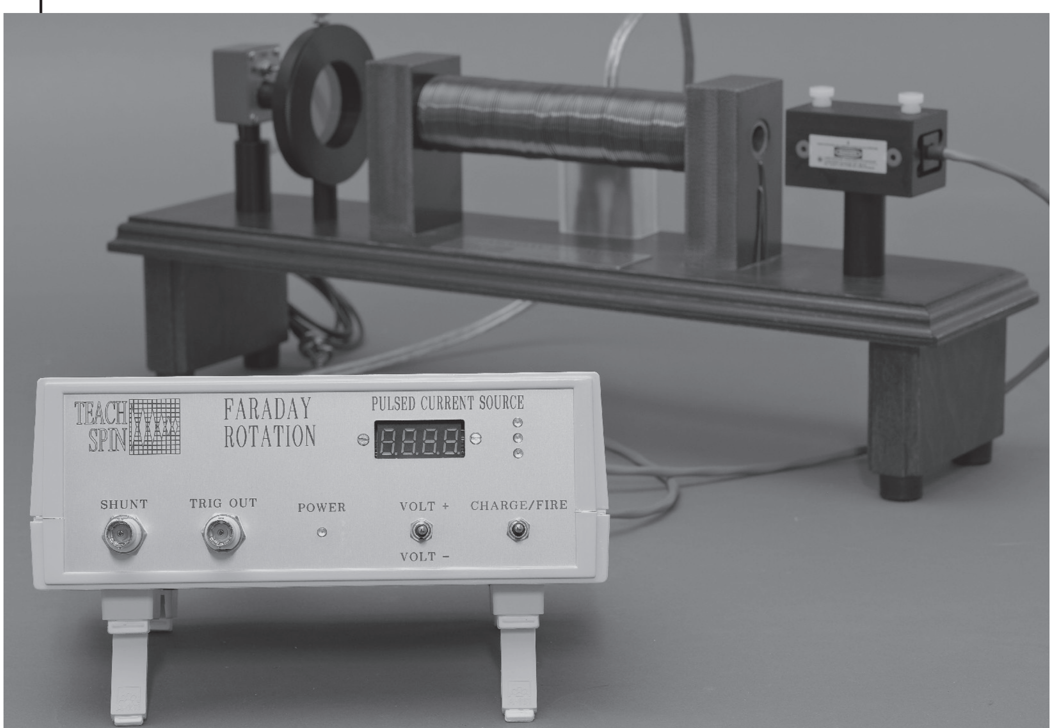

A Pulsed high-Current Source for Faraday Rotation

Over the years we've steadily made improvements to TeachSpin's 'Faraday Rotation' apparatus, most recently offering a green-laser light source and a newer 6-A power supply for its solenoid. Even so, some students might still be disappointed that the apparatus shows definite but rather small rotations of the plane of polarization of light passing through its optical sample. But using our new pulsed-current source, students are *no longer limited* to small Faraday rotations.

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** Just read it: Two new (instruments) for you!*

With TeachScope II once again we offer a box, a source of unknown waveforms, to provide students with a ‘treasure hunt’ experience. They get to search among 16 waveform options, learning in the process what it takes to get a ‘scope to reveal what’s in those waveforms. They will have to learn about setting the scale of horizontal and vertical axes, and something about triggering that ‘scope as well. We at TeachSpin and HuckansLabs are convinced that real *facility with using a ‘scope* is a vital part of the education of all experimental physicists, and we believe that the TeachScope will assist students in that hands-on learning process.

The waveforms include signals from mV to Volts in size, and with frequency content from Hz to MHz. The shapes of the waveforms have some real variety, too. And we didn’t just replicate what was in the old TeachScope! Taking advantage of the capabilities of modern ‘scopes in displaying frequency-domain as well as time-domain information, we have included, among the waveforms available, some whose true natures are much better revealed in frequency space than in the familiar $V(t)$ time-domain view.

TeachScope II is a compact little box, with power supplied via a USB-C input (cable supplied). It is conveniently powered either from the USB-A port found on most modern ‘scopes, or from an optional USB-style charger (the ones we supply provide *clean* +5-V power). TeachScope II has a simple push-button for choosing among 16 possible waveforms, and a (4-bit binary!) display to indicate which of these is emerging. TeachScope II has a BNC output, and it also provides an output at test points, suited to teaching the usefulness of a ‘scope probe.

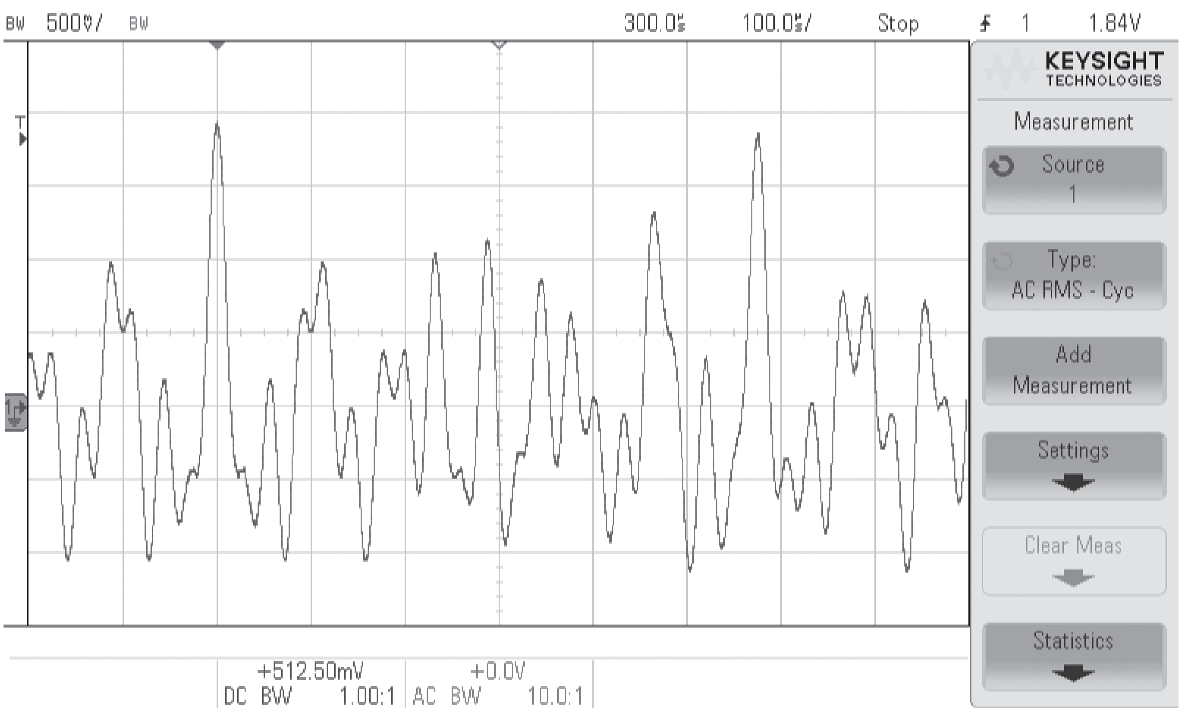

Figure 3: One of the waveforms emerging from a TeachScope II; we’re displaying a waveform whose content in *frequency space* (as revealed with an FFT function) is particularly interesting.

TeachScope II is built and maintained by HuckansLabs, and distributed by TeachSpin. The introductory price is $199 for single units of TeachScope II ($215 with USB power unit), and a discount schedule for quantity purchases is visible at the TeachSpin website https://www.teachspin.com/pricing or scan the QR code.

With guidance from Jean Leotin of LNCMI (the French national lab for high magnetic fields), we are now able to offer a new current source, designed to drive large (> 50 A!) currents through the Faraday-rotation solenoid in the form of short (≈ 10 ms) pulses. With pulses this brief, we escape the thermal problems (aka 'meltdown') that would arise using such large currents continuously. But during such a pulse, we really do get large fields (> 0.5 T!) inside the solenoid. And since our Faraday Rotation apparatus already includes a photodetector with high-speed response, students are able to get Faraday rotation data in real time even during a brief pulse of the magnetic field. In the process, they will gain a new respect for the capabilities of an oscilloscope for real-time data capture.

Our new PCS = Pulsed Current Source uses a rather slow charging of a suitable capacitor, plus a solid-state switch, to discharge that capacitor suddenly through the inductive/resistive load of existing Faraday-Rotation solenoids. The result is a single-sided current pulse, having a peak current that scales with the user-chosen initial charging voltage.

Of course, students need a way to find the history of that rapidly-changing current, and our PCS offers *two* such methods. One is a 'current shunt' built into the PCS, which gives a voltage waveform proportional to the instantaneous current $i(t)$. Together with the fixed 'coil constant' of the solenoid, this allows a prediction of the $B(t)$ field waveform.

But wholly independent information comes from a pick-up coil, placed inside the solenoid, wound onto a sleeve which holds the optical sample in place. Faraday's Law of Induction gives a readily-detected emf proportional to dB/dt – sizeable, given a huge ΔB occurring in a small Δt. And given this derivative information, either real-time analog integration, or after-the-fact digital integration, can give users another measure of the waveform of $B(t)$.

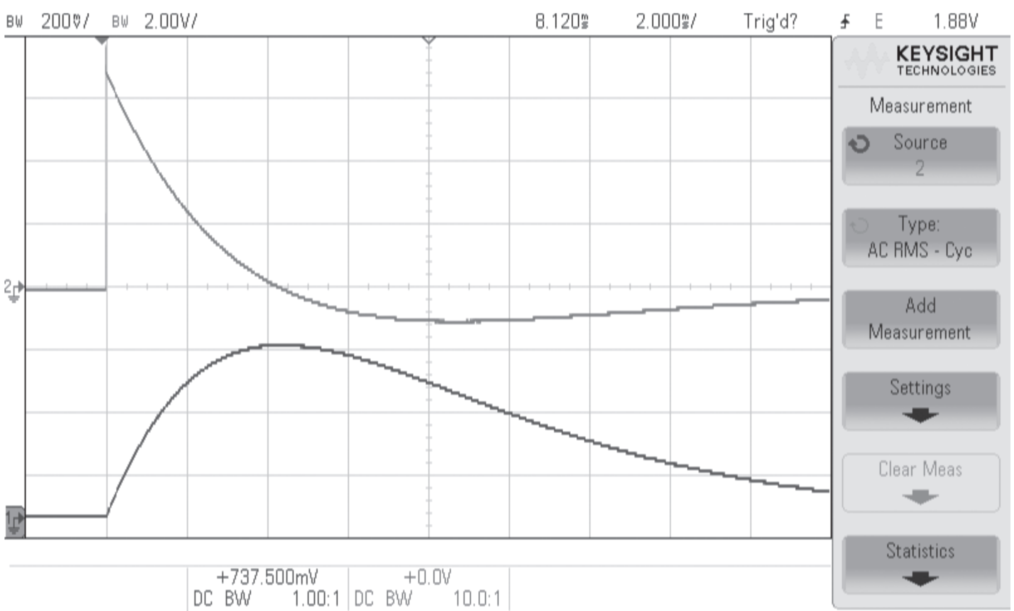

Figure 4: Two waveforms emerging from a PCS-driven solenoid. Lower trace: the shunt-derived voltage giving the history of the current $i(t)$ in the solenoid. Peak occurs at about 4.5 ms after start of pulse, and its height represents a current near 53 A. Upper trace: the emf generated by the pick-up coil, giving information proportional to *dB/dt* in the solenoid. Note its zero-crossing occurs at the time at which the current reaches a maximum. (Why?)

With magnetic fields now about *ten-fold larger* than can be used continuously, students are no longer limited to small Faraday rotation angles. Even using the red-laser light source, Faraday rotations *in excess of 45 degrees* are easily (though briefly) attained. This in turn can motivate students' thinking about 'optical isolators' that depend on the combination of optical rotation and Faraday rotation. Some students will enjoy relating these experimental facts to theoretical statements about the time-reversal properties of electric and magnetic fields.

Our new PCS, complete with its related pick-up coil, is now available at the introductory price of $945. Future newsletters will show you some of the signals emerging from real-time optical detection of Faraday-rotation effects. We also plan a 'package' including the PCS and a suitable oscilloscope, in case you'd like to upgrade a present 'static' Faraday Rotation experiment to the new and nimble high-current form.

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Inside:

Announcing two new instruments:

**Pulsed-Current Source for Faraday Rotation
and the Return of the TeachScope (II)**

Quantum Control

units available for
delivery from stock

Visit the TeachSpin exhibition trailer, **"Food Truck for the Physics Mind"** at the APS March meeting, Anaheim, CA
2025 March 17-20

Job Posting for Experimental Physicist

TeachSpin Inc., an established designer, developer, manufacturer, and marketer of Advanced Laboratory Physics Instructional apparatus, is looking to hire an experimental physicist with experience in building physics apparatus. We're replacing the retiring founding CEO of 32 years, and seeking a candidate with long-term career aspirations. An MS in physics is required, but preference will be given to those with a PhD and having experience in teaching the Advanced Laboratory. Send resume and a cover letter to jfreichert@teachspin.com.