

Battery on Board

When I was young, I never thought much about how batteries worked. I knew that if D cells were left in a flashlight or radio for too long, they would eventually stop working and, even worse, leak and cause damage. As the years went by, batteries got much better—they lasted longer and leaked less. Then rechargeable batteries appeared, and they got

better and better as well. But how batteries worked was mysterious; I wasn't about to take one apart to find out.

Once I came across a large tome on battery physics, and I quickly found out that the analysis of batteries depends on my two "worst" subjects, namely, chemistry and electromagnetism. So the cover article of this issue presented me with a unique opportunity to face my shortcomings and learn something new.

The cover article of this issue is, in fact, the second article on batteries since at least 2004; the first was in the April issue of this year. These back-to-back battery articles suggest that the controls field might have a role to play in this next-generation technology.

It's cool to imagine the gas tank of a car replaced by batteries that you plug in and recharge from time to time, much like you recharge your cell

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Contributors



Eugene Lavretsky.



Karla Kvaternik on Five-Lakes trail in Jasper National Park.



Nalin Chaturvedi on the Eiffel Tower with Palais de Chaillot in background.



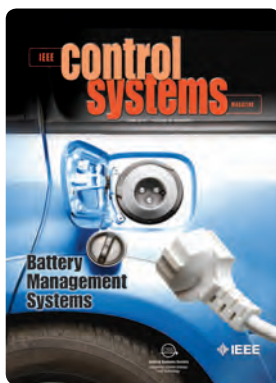
Mohinder S. Grewal and Angus P. Andrews.



Zachary Dydek (left) and snowman (right) outside his apartment in Cambridge.

phone. But the energy density in gasoline is amazingly high, and building safe, practical, and affordable batteries that can match that density is a daunting task. Who you gonna call?

The battery articles in the April and present issues of *IEEE Control Systems Magazine* focus on battery management, where the goal is to provide a real-time assessment of the state of the battery in order to use it effectively. Ultimately, this is a problem in state estimation, a specialty of our field for at least 50 years. But state estimation—despite decades of theoretical research and innumerable applications—is far from a completely solved problem. Think nonlinear,



non-Gaussian, and high order, for starters. What are the chances that battery applications would involve those kinds of challenges? Pretty good, it turns out. Rumors of the death of systems and control theory are, as usual, greatly exaggerated.

The article by Nalin Chaturvedi, Reinhardt Klein, Jake Christensen, Jasim Ahmed, and Alesandar Kojic provides a detailed description of lithium-ion batteries in a form that bridges the gap between the physics and chemistry on the one hand and the kinds of models needed for estimation and control on the other. The partial differential equations that model these systems are presented, reformulated, and sim-

plified to facilitate the kinds of tasks that our community specializes in.

The other feature article in this issue revisits the tragic flight of the X-15-3, which occurred in 1967. This accident was part of the otherwise successful development of an aircraft that could venture to the edge of space. The X-15 used a form of adaptive control technology, in an analog implementation, of course. Zachary Dydek, Anuradha Annaswamy, and Eugene Lavretsky reconstruct the accident to determine the effectiveness of modern adaptive control methods under similar circumstances. Their article provides a fascinating account of control system history along with an introduction to recent progress in the adaptive control field.

In addition to these unique and interesting articles, Mark Denny explains the operation of watches equipped with a tourbillon. Although



Jasim Ahmed hiking in South Bay.



Mark and Jane Denny at their home on Vancouver Island, Canada.



Reinhardt Klein hiking in Yosemite.



Anu Annaswamy with her husband, Mandayam Srinivasan, at the Institute of Automatic Control Engineering, Technische Universität München, Munich, Germany.



Aleksandar Kojic at Johnson Space Center in Houston.

it's unlikely that you own a watch with this feature, you might have seen "tourbillon" mentioned in ads for wristwatches that cost as much as the car you drive if not the house you live in. Mark has written several popular science and engineering books, some of which touch on control engineering topics.

For "Ask the Experts," we continue to celebrate the Kalman filter golden anniversary by asking Bruno Teixeira to provide a quick derivation of this result. Along the same lines, Mohinder Grewal and Gus Andrews provide a fascinating history of Kalman filter applications in the aerospace field. In the "Ask the Experts" column of the February 2010 issue, Gus and Mohinder discussed gyro specifications.

For "Perspectives," Steven Kahne relates his odyssey in control and related fields through various positions in industry, academia, and

government laboratories, including activities outside our field, for example, in health care.

For "People in Control," we speak with Yasamin Mostofi and Dale Ulrich. Yasamin specializes in communication and sensing within networks of vehicles, while Dale's expertise is in kinesiology. The link between Dale's work and our field can be better appreciated by first reviewing the article "Bicycle Dynamics and Control," which appeared in the August 2005 issue of *IEEE Control Systems Magazine*. We also recognize the 2010 IEEE Fellows nominated through IEEE Control Systems Society.

This issue also includes one book review, numerous new book announcements, two conference reports, and previews of the 2010 CDC and MSC. We also sadly publish an obituary of Daniel Repperger, who made extensive contributions to the interface

between humans and machines. Dan was the author of the cover article in the December 2003 issue of this magazine on the 100th anniversary of the first controlled and powered flight. In addition, we report the death of Tsien Hsue-shen, the author of a remarkable control text published in 1954, written while he was prevented from practicing his main field of expertise, namely, propulsion and combustion. This brief announcement scarcely does justice to his accomplishments.

We end this issue with a contribution from Karla Kvaternik, who presents control ideas in a nonstandard format.

It's hard to believe it's almost time for another ACC. If you have ideas for contributing to your magazine, please let me know—by e-mail or in person. See you soon.

Dennis S. Bernstein



MOVING?

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Educational Incentives

Dear Sir Obama,

These are the first 10 things you should do as president:

- 1) Make everyone read books.
- 2) Don't let teachers give kids hard homework.
- 3) Make a law where kids only get one page of homework per week.
- 4) Kids can go visit you whenever they want.
- 5) Make volunteer tutors get paid.
- 6) Let the tutors do all the thinking.
- 7) Make universities free.
- 8) Make students get extra credit for everything.
- 9) Give teachers raises.
- 10) If No. 4 is approved, let kids visit the Oval Office, but don't make it boring.

—Mireya Perez, age 8, San Francisco

—"Dear Sir Obama: Presidential Advice," by Jory John,
New York Times OP-ED, Friday, January 16, 2009.