



# Keith Moffat

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## RESEARCH OVERVIEW

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I am a researcher working at the interface of power systems engineering and data-driven control. We are at an inflection point of the energy transition to electrification and 100% renewable energy sources. My research advances the theory and application of data-driven control to facilitate this transition.

## POSTDOCTORAL WORK

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*Postdoctoral Researcher*

**Automatic Control Laboratory, ETH Zurich**

2022-present

Conducting research, mentoring Masters and Ph.D. students, and teaching

Primary research direction: Data-driven control of grid-connected inverters

Supervisor: Prof. Florian Dörfler

## EDUCATION

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**Ph.D. Electrical Engineering and Computer Science**

2016-2022

*University of California, Berkeley*

Advisors: A. von Meier, C. Tomlin

Dissertation: *Learning, Control and Optimization for Electricity Distribution Networks*

Doctoral Committee: C. Tomlin, A. von Meier, D. Callaway, and J. Lavaei

**Bachelors of Engineering**

2009-2016

*Dartmouth College*

Research advisors: J. Stauth and C. Sullivan

## INDUSTRY COLLABORATIONS

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**eRoots Analytics**

2023-present

*Barcelona, Spain*

Developing novel system identification techniques for power systems to be incorporated in eRoots products that identify and resolve the challenges of high-renewable, low-inertia grids.

## GOVERNMENT RULEMAKING

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### California Public Utility Commission (CPUC)

2022

*California, United States*

Participated in the CPUC Energy Division's workshop on advanced demand flexibility management and distributed energy resource compensation on 7.21.22.

Provided a public comment on the CPUC's R2207005 ratesetting proceeding "Order Instituting Rule-making to Advance Demand Flexibility Through Electric Rates" on 8.15.22.

## TEACHING

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### Computational Control

Spring 2023

*ETH Zurich, Department of Information Technology and Electrical Engineering*

Worked with a team in the Automatic Control Lab to develop and teach the material for ETH Zurich's new Computational Control course which covers Model Predictive Control, basic system ID + control, Data-enabled Predictive Control, and Reinforcement Learning. I was in charge of the system ID + control and Data-enabled Predictive Control material and the course project.

### Control Systems

Fall 2022, Fall 2023

*ETH Zurich, Department of Information Technology and Electrical Engineering*

Ran exercise sessions for ETH Zurich's Control Systems course, the Bachelor/Masters introductory course on control theory. My exercise sessions covered the prerequisite linear systems theory, stability, the concept of feedback, and feedback control design (e.g. root locus, pole placement, Bode, Nyquist).

### The Flow of Power Information and Money in Tomorrow's Electric Grid: Storage, Renewables, and Demand Response

Summer 2022

*UC Berkeley College of Engineering's Master of Future Energy Systems and Technology program*

I taught fifteen remote lectures on energy markets and power system operations to employees of the Dubai Electric and Water Authority (DEWA, the utility company that provides power to the United Arab Emirates). The course material and project improved the DEWA employees' understanding of power systems concepts such uniform-clearing-price electricity markets, locational marginal prices, and reactive power that affect DEWA's bottom line.

### EE 137A Introduction to Electric Power Systems

Fall 2019, Fall 2021

*UC Berkeley, Electrical Engineering Department*

Twice served as the graduate student instructor (GSI) for EE 137A, a semester-long course with an enrollment of around 50, representing a mixture of undergraduate, Masters, and Ph.D. students in power systems, power electronics, and other related fields. My responsibilities/contributions included:

- Writing discussion/lecture notes.
- Conducting sections.
- Helping students during weekly office hours.
- Occasionally giving the main lecture.
- Setting up and running a Piazza online question-and-discussion forum.
- Grading exams.

Anonymous student review from the Fall 2019 offering:

*"Keith was a great GSI. He was always very well prepared for discussion sections, and each week kept on pace with lecture and highlighted topics he thought were important. The discussion notes were helpful*

*(although sometimes a little long). While helping with homework questions, he really tried to make sure we understood the question and content instead of just giving out the answers, which forced me to have a deeper conceptual understanding. I really appreciated Keith's effort and engagement in the course; it made a huge difference in my understanding of the material and enjoyment of the course."*

Anonymous student reviews from the Fall 2021 offering:

*"Keith was an exceptionally instructor, whose knowledge about the subject was evident and ability to teach resonated."*

*"Great GSI — clearly knows his stuff, and is very approachable & friendly. I also love how the discussion worksheets doubled as a study resource."*

*"Absolutely amazing GSI! I would be very happy with Keith leading a class of mine in the future. He is incredibly knowledgeable on the material, explains content very clearly, and (even when we're in person and have masks on) can clearly tell whether people are following along."*

## **GRAD SCHOOL POSITIONS**

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### *Visiting Researcher*

#### **Institute for Automatic Control, ETH Zurich**

Summer 2021

Working with Prof. Florian Dörfler and Dr. Saverio Bolognani, I incorporated online sensitivity estimation into the Feedback Optimization loop and collaborated on implementing a state-of-the-art recursive, Bayesian, Error-In-Variables network estimation method on three-phase distribution networks.

### *Graduate Student Researcher*

#### **DOE's VTO's GEMINI-XFC Program**

2020-2022

Collaborating with researchers at the National Renewable Energy Lab (NREL) and Lawrence Berkeley Lab (LBL) to build a grid + transportation co-simulation. Designed and implemented the vehicle charging optimization.

#### **DOE's SETO's Phasor Based Control for Scalable PV Integration**

2017-2020

Head research engineer. Designed the adaptive phasor feedback controller and implemented the controller on real hardware using an extensible grid control software platform developed at Berkeley.

#### **ARPA-E Micro-Synchrophasors for Distribution Systems Project**

2016-2017

Discovered new applications for micro-PMU data including switch-actuation event detection.

### *Graduate Student Instructor*

#### **EE 137A Introduction to Electric Power Systems**

Fall 2019, 2021

## **PRE-GRAD SCHOOL WORK EXPERIENCE**

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### *SBIR Grant Author*

#### **HIVE Battery Labs**

2015-2016

Wrote the NSF SBIR Phase I grant with the other founding members that got HIVE Battery Labs off the ground. HIVE was acquired by Tesla in 2020.

### *Power Electronics Intern*

#### **Motiv Power Systems**

2015

Designed power converters and filters for the electric school bus's battery-inverter-charger connections.

*Downhill Ski Racer*

**US Ski Team**

2009-2015

Trained and competed internationally in downhill ski racing. During this time I intermittently attended Dartmouth College. Over the course of seven years I completed the B.E. in eleven quarters, three fewer than the fourteen usually required.

## **PROFESSIONAL ACTIVITIES**

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*Professional Organization*

**Program Director, IEEE Power and Energy Chapter, UC Berkeley**

2021-2022

After being elected in the winter of 2021, I organized the Spring Seminar Series and Fall Seminar Series with leaders in the fields of Power Systems and Power Electronics. Made announcements and advertised to the department and campus. Hosted the majority of the talks.

*Community Organization*

**EECS liaison for the Berkeley Energy Resources Collective (BERC)**

2017-2019

Connected the EECS department with the other departments and events at UC Berkeley related to energy research.

**EE Graduate Student Association (GSA) Social Committee**

2016-2020

Organized social hours and Bar Night for the Berkeley EECS program.

*Peer Review Activities*

**Journals**

IEEE Transactions on Smart Grid (TSG), Elsevier's Electric Power System Research (ESPR), IEEE Transactions on Energy Conversion

**Conferences**

Power Systems Computation Conference (PSCC), IEEE International Conference on Control & Automation (ICCA), IEEE Workshop for Control and Modeling for Power Electronics (COMPEL)

## **GRANTS**

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*Author*

**Distribution Network Feedback Optimization**

2021

ThinkSwiss research grant from the Swiss Secretariat for Education, Research and Innovation (SERI)

**Event Detection and State Estimation via Real Time**

**Effective Impedance Estimation**

2018

DOE Office of Electricity's Big Data Analysis of Synchrophasor Data Program, DE-FOA0001861  
Unsuccessful—to be resubmitted with modifications.

*Co-Author*

**Phasor Based Control for Scalable PV Integration**

2016

DOE OE's Solar Energy Technologies Office's ENERGISE Program, DE-EE0008008

## INVITED SEMINARS/TALKS

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### *Invited Seminars*

**Learning, Control, and Optimization for Electricity Distribution Networks** 10/06/22

Audience: Smart Grid Research Group at Australian National University

**Learning, Control, and Optimization for Electricity Distribution Networks** 09/06/22

Audience: Electrical Engineering and Computer Science Department, UC Berkeley

**Voltage Phasor Control for Electricity Distribution Networks** 7/14/21

Audience: ETH's Automatic Controls Laboratory

**Translating Sensor Data into Power Commands and Prices** 6/20/21

Audience: ETH's Feedback Optimization Group

### *Talks*

**The Multiple Model Adaptive Power System State Estimator** 12/15/21

Audience: 2021 Conference on Decision and Control (CDC)

**Linear Quadratic Phasor Control of Unbalanced Distribution Networks** 6/29/21

Audience: 2021 IEEE PowerTech Madrid

**Local Power-Voltage Sensitivity and Thevenin Impedance Estimation from Phasor Measurements** 6/28/21

Audience: 2021 IEEE PowerTech Madrid

**Translating Sensor Data into Power Commands and Prices** 5/22/21

Audience: NREL and LBL GEMINI-XFC Team

**Distribution PMU Applications, Academia to Industry** 4/9/21

Audience: ComEd PMU Application Division

**Phasor Based Control with the Distributed, Extensible Grid Control Platform** 2/16/21

Audience: 2021 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT)

**An Extensible Software and Communication Platform for Distributed Energy Resource Management** 11/11/20

Audience: 2020 IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids (SmartGridComm)

## STUDENTS MENTORED

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### *UC Berkeley*

**Gabriel Colon-Reyes, Ph.D. candidate** 2018-present

Grid-forming control of low-inertia grids

**Jasper Pakshong, M.S.** 2018-2020

Voltage Phasor Control optimization for transmission networks	
<b>Leo Chu, undergraduate</b>	2018-2020
Voltage Phasor Control hardware implementation	
<b>Daniel Tutt, M.S.</b>	2019
Voltage Phasor Control feedback controller LQR/PI comparison	
<b>Brittany Wais, undergraduate</b>	2019
Voltage Phasor Control power flow simulations	
<b>Joseph Palakapilly, undergraduate</b>	2019
Three-phase distribution network optimal power flow	
<i>ETH Zurich</i>	
<b>Jean-Sebastien Brouillon, Ph.D. candidate</b>	2021-present
Distribution Grid Identification and Control	
<b>Gianni Hotz, M.S.</b>	2021
Online feedback optimization for emergency power system operation	
<b>Michael Cummins, M.S., Trinity College Dublin</b>	2023
Data-enabled Predictive Control Hyperparameter Tuning with via Differentiable Optimization Layers	
<b>Luca Hartmann, M.S.</b>	2023
Data-enabled Predictive Control for Converter Power Control	
<b>Maxamilian Degner, M.S.</b>	2023
Real-Time Model Predictive Control for Microgrid Generation Optimization	
<b>Nando Waser, M.S.</b>	2023
Radial Electric Grid Reconstruction Using Voltage Magnitude Measurements	
<b>Marlais Lüthi, B.A.</b>	2023
Walenstadt topology Identification	
<b>Sebastien Graf, M.S.</b>	2023-2024
Data-enabled Predictive Control for Feasible Virtual Inertia	

## Dissertation

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- [1] **K. Moffat**. “Learning, Control and Optimization for Electricity Distribution Networks”. In: University of California, Berkeley Library, 2022-225 (Sept. 2022).

## Journal Publications

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- [2] N. Panossian, H. Laarabi, **K. Moffat**, H. Chang, B. Palmintier, A. Meintz, T. Lipman, and R. Waraich. “Architecture for Co-Simulation of Transportation and Distribution Systems with Electric Vehicle Charging at Scale in the San Francisco Bay Area”. In: *Energies* 16.5 (2023), p. 2189.
- [3] J.-S. Brouillon, E. Fabbiani, P. Nahata, **K. Moffat**, F. Dorfler, and G. Ferrari-Trecate. “Bayesian Error-in-Variables Models for the Identification of Distribution Grids”. In: *IEEE Transactions on Smart Grid* (2022).
- [4] A. von Meier, E. L. Ratnam, K. Brady, **K. Moffat**, and J. Swartz. “Phasor-based control for scalable integration of variable energy resources”. In: *Energies* 13.1 (2020), p. 190.

- [5] **K. Moffat**, M. Bariya, and A. von Meier. “Unsupervised impedance and topology estimation of distribution networks—limitations and tools”. In: *IEEE Transactions on Smart Grid* 11.1 (2019), pp. 846–856.
- [6] E. Din, C. Schaef, **K. Moffat**, and J. T. Stauth. “A scalable active battery management system with embedded real-time electrochemical impedance spectroscopy”. In: *IEEE Transactions on Power Electronics* 32.7 (2016), pp. 5688–5698.

## Conference Publications

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- [7] J-S Brouillon, **K. Moffat**, F. Dörfler, and G. Ferrari-Trecate. “Robust Online Joint State/Input/Parameter Estimation of Linear Systems”. In: *2022 IEEE Conference on Decision and Control (CDC)*. IEEE. 2022, pp. 1–6.
- [8] **K. Moffat**. “Local power-voltage sensitivity and thevenin impedance estimation from phasor measurements”. In: *2021 IEEE Madrid PowerTech*. IEEE. 2021, pp. 1–6.
- [9] **K. Moffat** and A. von Meier. “Linear Quadratic Phasor Control of Unbalanced Distribution Networks”. In: *2021 IEEE Madrid PowerTech*. IEEE. 2021, pp. 1–6.
- [10] **K. Moffat**, J. Pakshong, L. Chu, G. Fierro, J. Swartz, M. Baudette, C. Gehbauer, and A. von Meier. “Phasor Based Control with the Distributed, Extensible Grid Control Platform”. In: *2021 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT)*. IEEE. 2021, pp. 1–5.
- [11] **K. Moffat** and C. Tomlin. “The Multiple Model Adaptive Power System State Estimator”. In: *2021 IEEE Conference on Decision and Control (CDC)*. IEEE. 2021, pp. 1–6.
- [12] M. Baudette, J. Swartz, **K. Moffat**, J. Pakshong, C. Gehbauer, A. von Meier, et al. “Hardware-In-the-Loop Benchmarking Setup for Phasor Based Control Validation”. In: 2021.
- [13] **K. Moffat**, M. Bariya, and A. von Meier. “Real Time Effective Impedance Estimation for Power System State Estimation”. In: *2020 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT)*. IEEE. 2020, pp. 1–5.
- [14] M. Bariya, **K. Moffat**, and A. von Meier. “Physically Meaningful Grid Analytics on Voltage Measurements using Graph Spectra”. In: *2020 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT)*. IEEE. 2020, pp. 1–5.
- [15] G. Fierro, **K. Moffat**, J. Pakshong, and A. von Meier. “An extensible software and communication platform for distributed energy resource management”. In: *2020 IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids (Smart-GridComm)*. IEEE. 2020, pp. 1–6.
- [16] M. Bariya, **K. Moffat**, and A. von Meier. “Empirical noise estimation in distribution synchrophasor measurements”. In: *2019 International Conference on Smart Grid Synchronized Measurements and Analytics (SGSMA)*. IEEE. 2019, pp. 1–7.
- [17] **K. Moffat**, M. Bariya, and A. von Meier. “Network impedance estimation for microgrid control using noisy synchrophasor measurements”. In: *2018 IEEE 19th Workshop on Control and Modeling for Power Electronics (COMPEL)*. IEEE. 2018, pp. 1–6.
- [18] E. Din, C. Schaef, **K. Moffat**, and J. T. Stauth. “Online spectroscopic diagnostics implemented in an efficient battery management system”. In: *2015 IEEE 16th Workshop on Control and Modeling for Power Electronics (COMPEL)*. IEEE. 2015, pp. 1–7.

## Patents

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- [19] E. Din, C. Schaef, **K. Moffat**, and J. T. Stauth. *Systems and methods for characterizing impedance of an energy storage device*. US Patent 10,393,818. Aug. 2019.
- [20] E. Din, C. Schaef, **K. Moffat**, and J. T. Stauth. *Modular battery arrays and associated methods*. US Patent App. 15/368,442. June 2017.



## REFERENCES

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