Short-course on HVDC Fundamentals and Applications

HVDC Short Course Agenda, Thursday May 22, 2025

	Time	Duration	Speaker	Module	Topic
Intro/P2P, Offshore	8:00-8:15	15 mins	J. McCalley		Course introduction
	8:15-9:05	50 mins	P. Lof (National Grid)	1a	Industry speaker: Intro to HVDC technology
	9:05-9:55	50 mins	J. McCalley	7a	Point-to-point HVDC
	9:55-10:10	15 mins			Break
	10:10-11:00	50 mins	X. Fang	1c	Offshore wind power integration
Industry	11:00-11:50	50 mins	M. Tackett (MISO)		Industry speaker: Legacy EHV vs. 765 kV vs. HVDC
	12:00-1:00	1 hour	Raj Rajan (SOO Green)		Lunch, with Industry speaker: SOO Green HVDC Project
Power electronics	1:00-1:50	50 mins	Ali Mezhri-Sani	1c	PowerElectronics 101:Fundamentals of switching pwr converters+EMT
	1:50-2:40	50 mins	H. Cui	2b	VSC-HVDC converter station technologies
	2:40-3:30	50 mins	L. Tolbert	3d	Modular multilevel converter design

HVDC-Learn

HVDC-Learn Project

- Funded by DOE, EERE
- 3 years, 7 universities, 12 authors
- Elevate community's understanding of HVDC domain & increase HVDC presence as a transmission solution
- 35 modules (see table to right)
- What is a module?

➔A "mini-textbook"

  - Self-contained, 30-60 pages
  - Targets
    - university engineering courses
    - industry-focused short courses
    - community colleges
    - Regulatory & policy groups
    - individual learning.

(yellow to be completed year 1; blue in year 2; white in year 3)

Mod #	Lead-auth /Lead-rvwr	Module title	# of 1-h lectures	Comp date
1. INTRODUCTORY/OVERVIEW COVERAGE, Li				
1a	T2/UT1	Intro to HVDC technology	3	Q4
1b	UT1/T2	Application Guide for HVDC Transmission	3	Q2
1c	M1/T1	Intro to HVDC for offshore wind	3	Q2
1d	T1/C1	HVDC for executives	2	Q9
2. STATION COMPONENTS, Cui				
2a	V1/O1	HVDC reactive power, EMI, and filter design	4	Q5
2b	O1/C1	VSC-HVDC converter station technologies	3	Q4
3. CONVERTERS, Enslin				
3a	C2/C1	Interoperability between different HVDC converter technologies/vendors	3	Q12
3b	V1/M1	Power electronics 101: Fundamentals of switching pwr conv+EMT	3	Q3
3c	M1/UT2	Operation of thyristors & IGBTs in converters	4	Q7
3d	UT2/M1	Modular multilevel converter as HVDC cnvrtr interface and its control	3	Q3
4. CONTROL, Mehrizi-Sani				
4a	UT2/O1	Cnvtr cntrl fundamentals	4	Q6
4b	V1/C2	Dynamic modeling/cntrl of HVDC converters and grid-forming functions	4	Q8
4c	O1/V1	Control of multiterminal HVDC networks	4	Q8
4d	C2/C1	Offshore HVDC cnvrtr grid forming controller design for black start capability	3	Q4
5. HVDC PROTECTION, Nazir				
5a	M2/UT2	HVDC fault management & protection systems	6	Q4
5b	V1/UT1	HVDC measurements, faults, and misoperation	3	Q9
5c	C1/C2	Protection for multi-terminal HVDC networks	3	Q7

Mod #	Lead-auth /Lead-rvwr	Module title	# of 1-h lectures	Comp date
5d	UT2/M2	Protection: ability to ride through faults in HVDC	3	Q9
5e	V1/UT1	Cybersecurity in HVDC systems	3	Q11
6. HVDC LINE & CABLE TECHNOLOGIES, Wallace				
6a	M2/C1	Insulation - HVDC cables	5	Q10
7. POINT-TO-POINT HVDC CONFIGURATIONS, McCalley				
7a	I1/UT1	Onshore & offshore apps	2	Q3
8. MULTI-TERMINAL HVDC NETWORKS, Tolbert				
8a	UT2/O1	Design/operation of multiterminal HVDC grids	3	Q12
9. PLANNING AND DESIGN, McCalley				
9a	T2/O1	HVDC in pwr sys.; meshed HVDC systems	3	Q8
9b	I1/T1	Processes for planning & building offshore HVDC	3	Q2
9c	I1/T1	Expansion planning for offshore HVDC, topology/ capacity design for HVDC interregional transmission	5	Q6
9d	I1/M1	Macrogrid & HVDC offshore networks	4	Q8
9f	UT1/T2	A long-term planning study of offshore HVDC	4	Q8
10. HVDC SYSTEM SIMULATION & ANALYSIS, Fang				
10a	O1/C2	Hardware-in-the-loop electromag transient sim	3	Q12
10b	I1/T3	Large-sys analysis of multiterminal HVDC grids	4	Q10
10c	V1/M1	Frequency-dependent representation of AC syst	4	Q12
10d	M1/O1	Modeling of HVDC grids	6	Q11
10e	T3/I1	Reactive power & harmonics	6	Q8
11. REGULATORY/PERMITTING PROCESSES & PROC, McCalley				
11a	T1/T2	Offshore transmission development processes	3	Q5
11b	I1/UT1	HVDC right-of-way	3	Q12
12. ENERGY EQUITY & ENVIRONMENTAL JUSTICE, Hines				
12a	T1/V1	Effects of HVDC on enrgy equity & env. justice.	3	Q11

Faculty participants

Power Systems

Hantao Cui, Assist. Prof., Oklahoma State
Xin Fang, Asst. Prof., Mississippi State
Eric Hines, Prof. of Practice, Tufts
Fran Li, Chaired Prof., U. Tenn.-Knox.
Per-Anders Lof, Lecturer, Tufts;
Principal Engr, National Grid
James McCalley, Chaired Prof., Iowa State

Power Electronics

Leon Tolbert, Chaired Prof., U. Tenn-Knox.
Alex Stankovic, Chaired Prof., Tufts
Ali Mehrizi-Sani, Assoc. Prof., Virginia Tech
Johan Enslin, Chaired Prof., Clemson
Moazzam Nazir, Rsrch Scientist, Clemson

High Voltage Engineering

David Wallace, Asst. Clin. Prof. Miss. State

Year 1 modules only (completed, under review)

Mod ID	Module title	Person/ school	# of pages	Comple-tion target
7a	Pt 2 pt onshore & offshore apps (Early completion is goal)	McCalley/ISU	42	Q1
1c	Intro to HVDC for offshore wind	Fang/MS	42	Q2
1b	Application guide for HVDC transmission	Li/UTK	35	Q2
1a	Intro to HVDC technology	Lof/Tufts	60	Q4
3d	Modular multilevel converter as HVDC cnvrtr interface and its control	Tolbert/UTK	46	Q3
3b	Power electronics 101: Fundamentals of switching pwr conv+EMT	Mehrizi-Sani/VT	31	Q3
5a	HVDC fault management & protection systems	Wallace/MS	35	Q4
2b	VSC-HVDC converter station technologies	Cui/NCSU	39	Q4
4d	Offshore HVDC cnvrtr grid forming controller design for black start capability	Nazir/ Clemson	30	Q4
9b	Process for planning & building offshore HVDC	McCalley/ISU	58	Q4

Short-course on HVDC

Course outcomes:

This course equips professionals with essential knowledge to navigate the complexities of deploying HVDC technology. It addresses both the theoretical and practical aspects, preparing participants to tackle current challenges and to leverage future opportunities in the evolving landscape of power transmission and renewable energy integration. By completing this course, participants will:

- **Gain a foundational understanding of HVDC technology and its historical context.**
- **Understand technical and economic advantages of HVDC transmission, including offshore wind applications.**
- **Learn the design and operation of P2P HVDC systems and their components.**
- **Familiarize with VSC-HVDC converter station technologies and their integration with AC grids.**
- **Understand design principles of MMCs and their role in HVDC systems.**

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Virtual participants

- please enter questions on chat
- for PDHs, questions were sent to you; send answers to jdm@iastate.edu by 5/30

Modules are available for download at:
home.engineering.iastate.edu/~jdm/hvdclearn/index.htm
(or google hvdc-learn project and it will turn up).

When you go to HVDC learn website, you will also find the following link to an evaluation form. Please fill it!
https://forms.gle/XAUApgKPXtDGiq8A7