ECE 404-TD / 504-TD

ST: T&D APPLICATIONS OF VOLTAGE SOURCE CONVERTERS

SESSION no. 24

So far in the course

- Voltage source converter basics
- Topologies for 1ϕ and 3ϕ
  - → 1/2 Bridge
  - full single phase bridge
  - 3 phase bridge
  - multilevel converters
    - NPC

- modular multi-level converter (mmc)
  - → Chain link converter
  - → Bridge of bridges converter

- switching schemes
  - sine - triangle PWM
  - space vector PWM
  - phase control (unmodulated)

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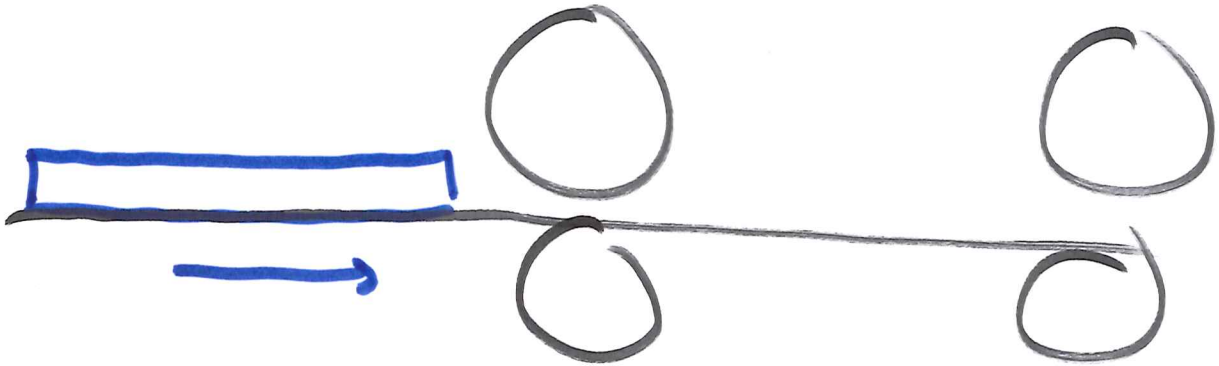

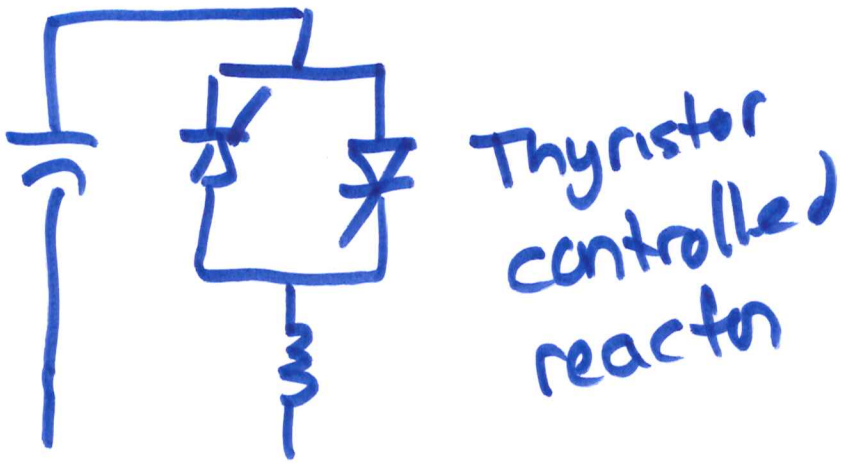

Thyristor controlled reacton

GRADING:

Item	Percent of Grade	A: 90-100
Homework	30%	B: 80-89
Exam 1	30%	C: 70-79
Final Exam	40%	D: 60-69
		F: < 60

COURSE OUTLINE

Lecture Topic	Chapter/Book
Introduction/overview	1/M and 1/Y&I
Basic Concepts/review of transient circuit analysis	2/M and 1/Y&I
General overview of voltage sourced converters	12/M and 2,5/Y&I
Generic models for simulation—introduction	Notes
Converter Topologies	
1. Single phase bridge	12/M and 2/Y&I
2. Single phase half bridge	12/M and 2/Y&I
3. Three phase bridge	12/M and 5/Y&I
4. Multilevel converter	12/M and 6/Y&I
5. Bridge of bridges/chain link converter	Notes
Switching Schemes	3,12/M and 2/Y&I
Inner Control Schemes	Notes, 3,9,10/Y&I
Basic concepts for outer control schemes	Notes, 7,8/Y&I
Applications (includes case studies with normal and abnormal operation, simulation models and results)	
1. Challenges with getting model data	Notes
2. Modeling the rest of the system	Notes
3. Wind turbines	14.4/M and 13/Y&I
a. Type 3	
b. Type 4	
4. Photovoltaic generation	14.4/M and Notes
5. VSC HVDC	14.7/M and 12/Y&I
6. FACTS/Custom Power	14.6/M and 11/Y&I
7. Energy Storage	
a. Flywheels	Notes
b. Battery and ultracapacitor	
6. DG sources	14.4/M and Notes

1. Exams may given as "take homes"
2. Note: homework assignments and projects will require software tools, especially MathCAD and Powerworld.

Flexible AC Transmission Systems

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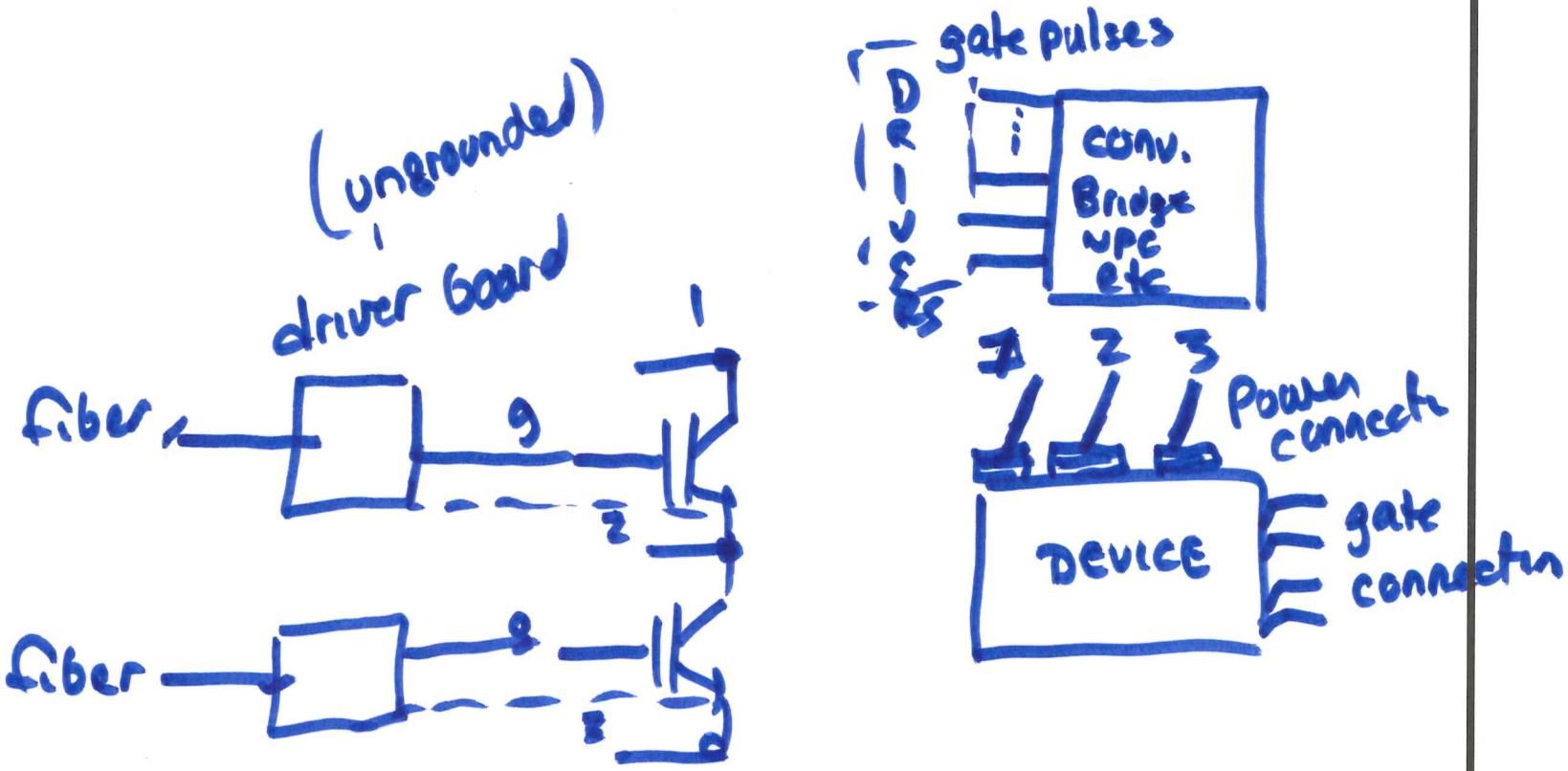
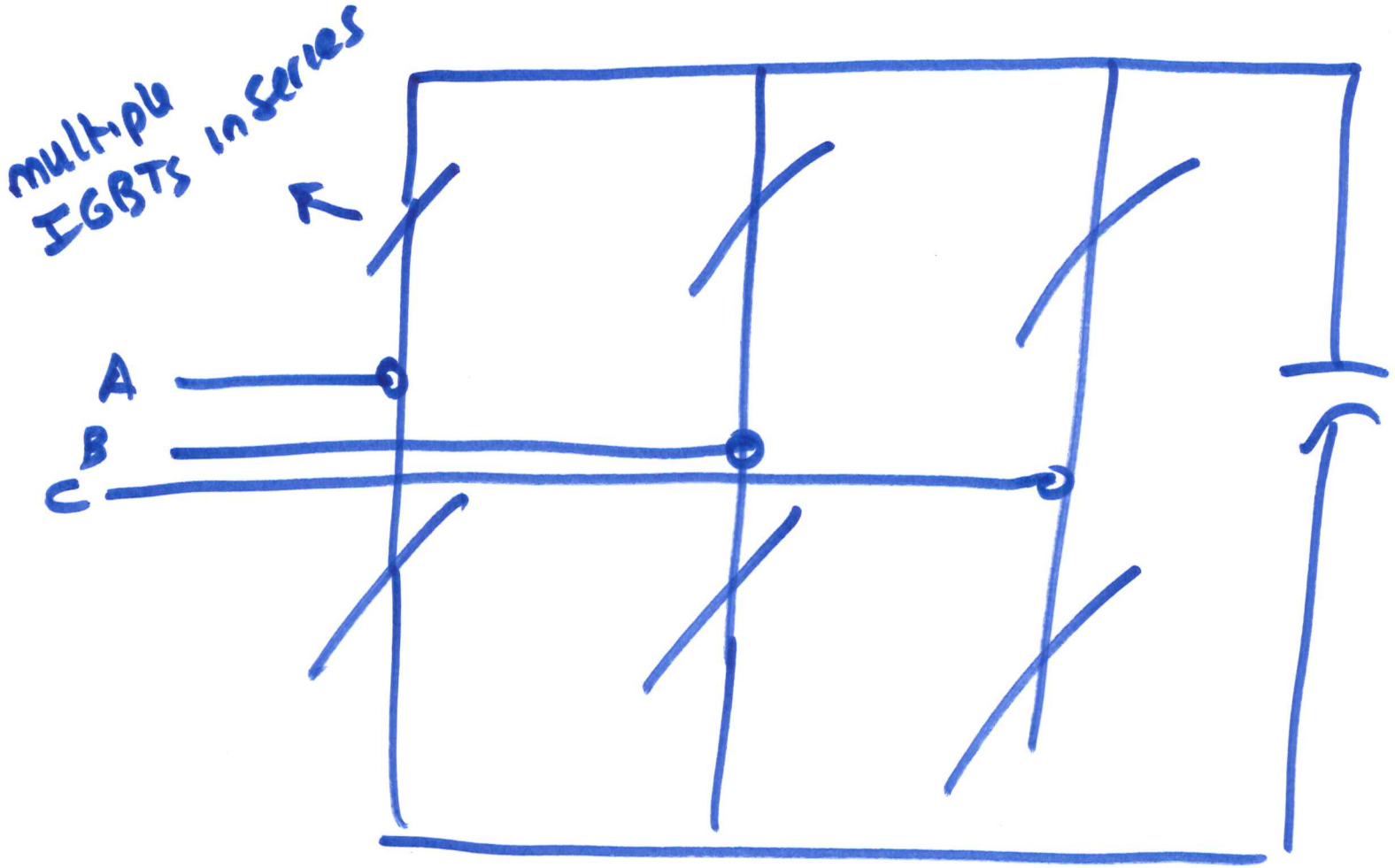
Controls for voltage source converters




multiple IGBTs in series
A
B
C

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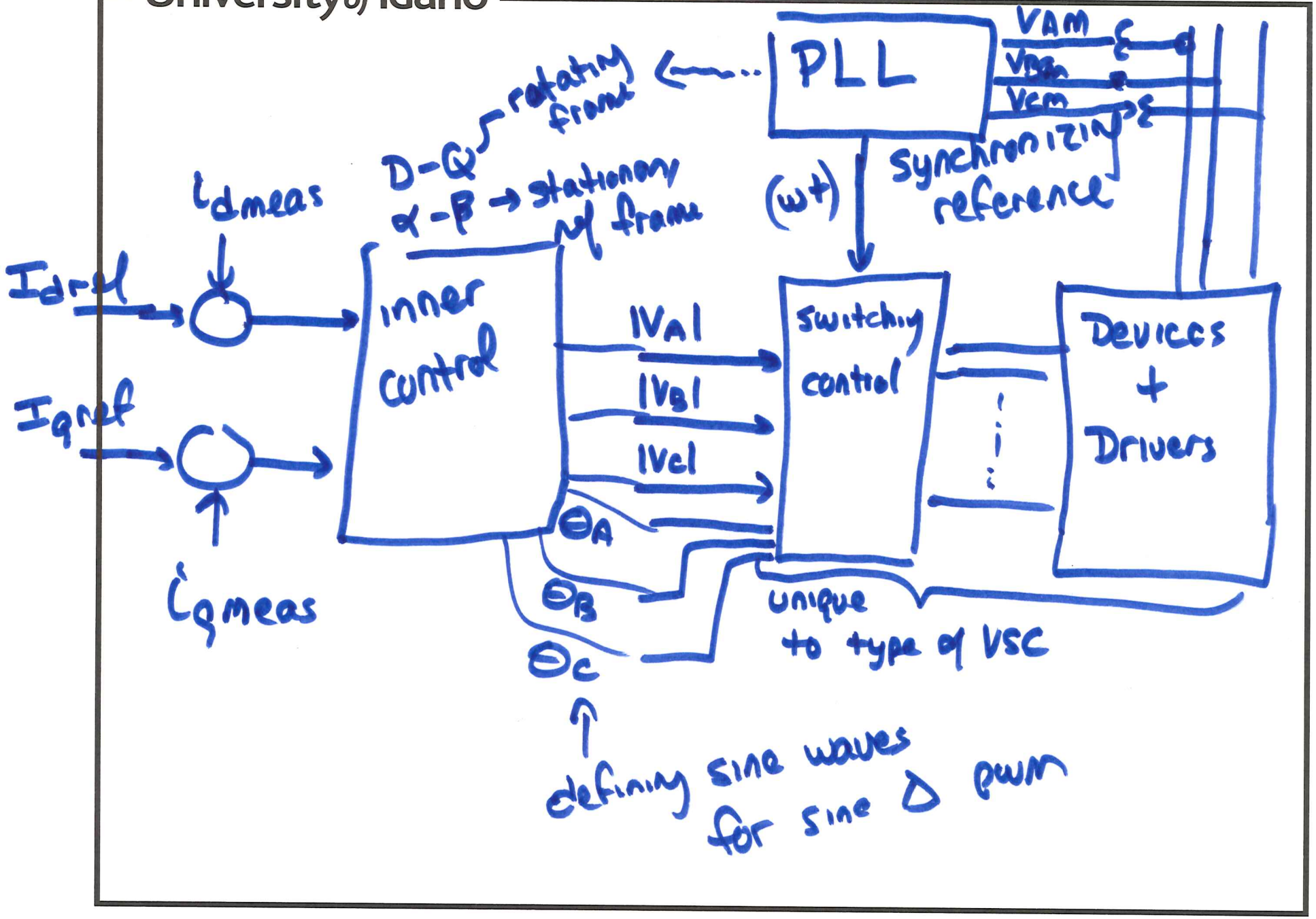
PLL
VAM
VBM
VCM
synchronizing reference
(ωt)
D-Q rotating frame
α-β → stationary frame
i_{dmeas}
I_{dref}
I_{qref}
i_{qmeas}
inner control
|VA|
|VB|
|VC|
Θ_A
Θ_B
Θ_C
switching control
Devices + Drivers
unique to type of VSC
defining sine waves for sine Δ pwm

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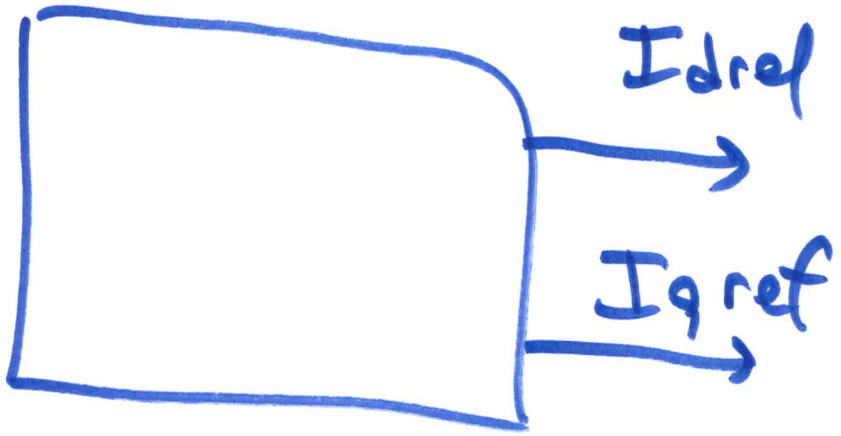
Outer control

MANY POSSIBLE INPUTS

- $|V|_{AC}$ vs $V_{AC,ref}$
- $|V_{dc}|$ vs $V_{dc,ref}$
- P vs Pref
- Q vs Qref



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→ The VSC schemes we have discussed control 2 quantities per phase

↳ $|V|, \Theta$

$|V|$ — magnitude

Θ — angle