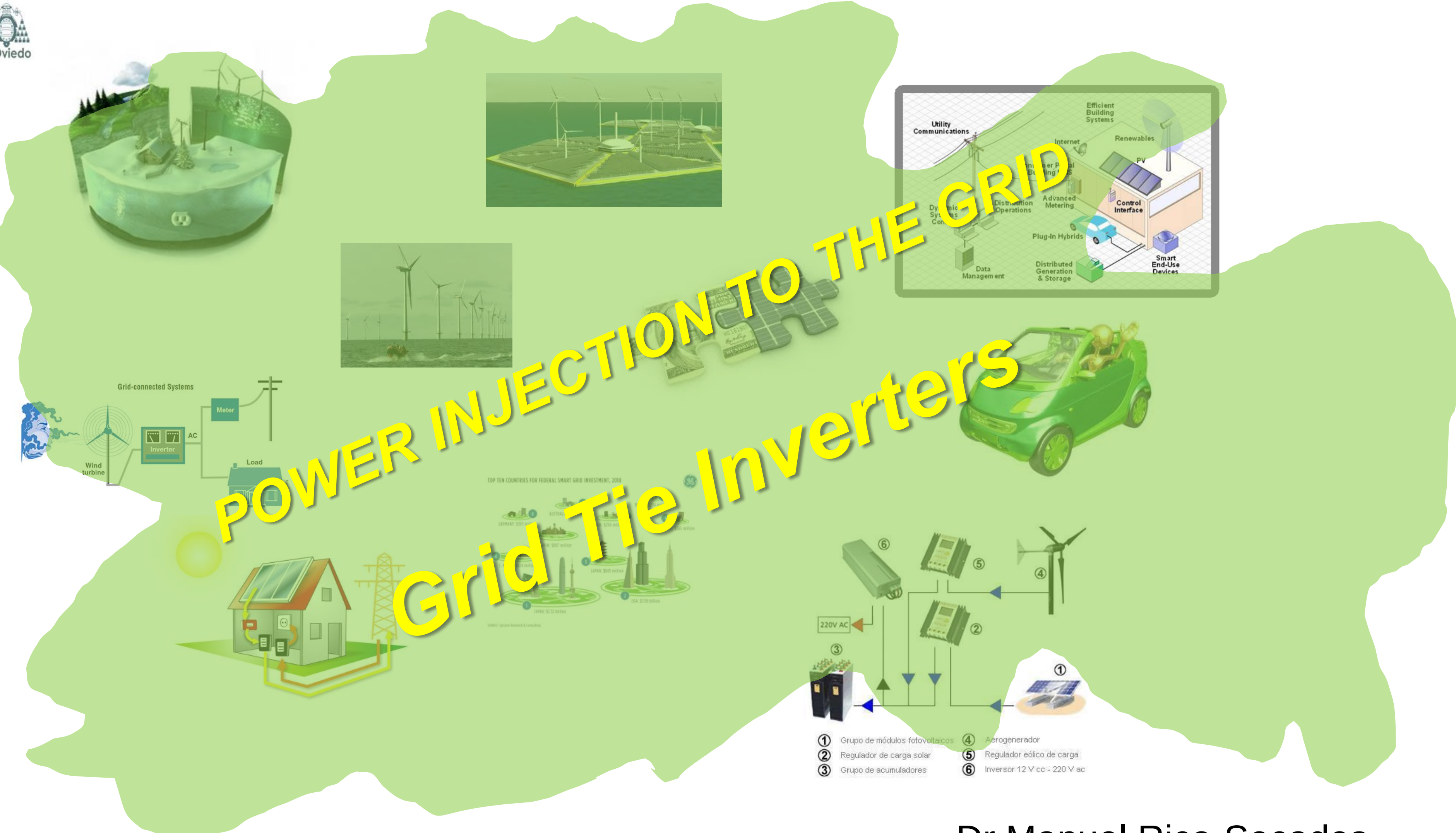
POWER INJECTION TO THE GRID

Grid Tie Inverters



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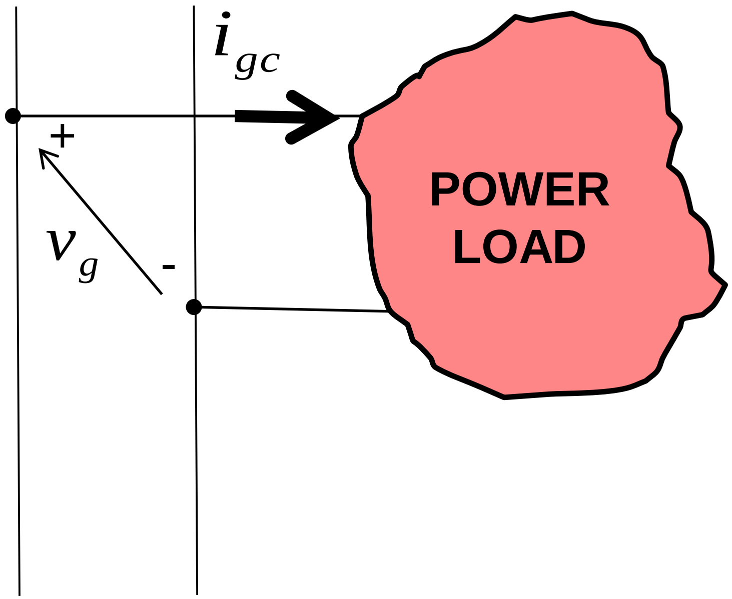
SEP
SECRETARÍA DE EDUCACIÓN PÚBLICA

TECNOLÓGICO NACIONAL DE MÉXICO
Centro Nacional de Investigación y Desarrollo Tecnológico

"2015, Año del Generalísimo José María Morelos y Pavón"

Cenidet – Mexico
June 24, 2015

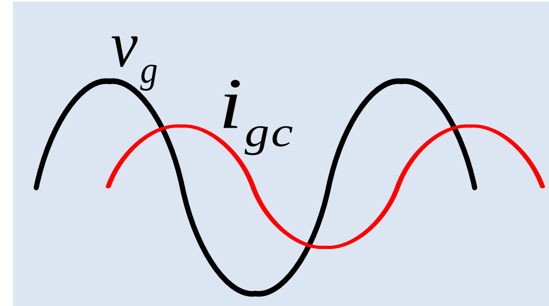
BASIC CONCEPTS

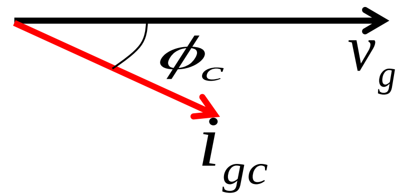


POWER LINE

Active and reactive

Valores eficaces





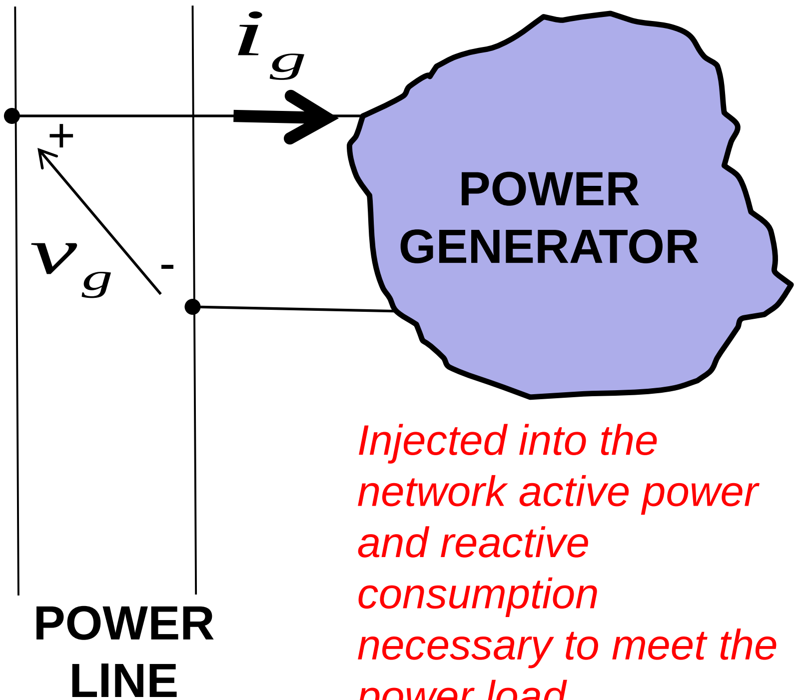
Inductive load

Assuming sinusoidal waveforms

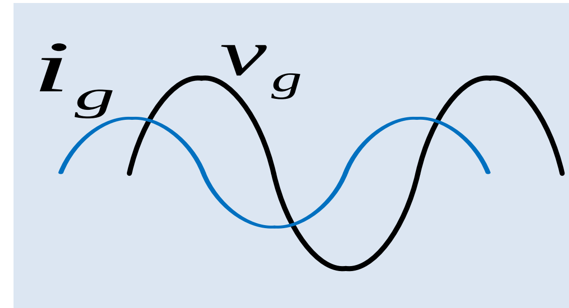
$$P = v_g \cdot i_{gc} \cdot \cos\phi_c$$ **Active Power**

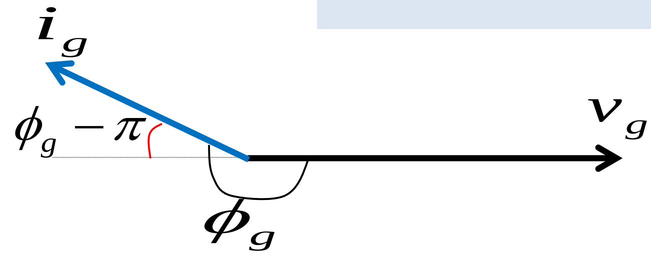
$$Q = v_g \cdot i_{gc} \cdot sen\phi_c$$ **Reactive Power**

BASIC CONCEPTS



Injected into the network active power and reactive consumption necessary to meet the power load





Active power generated

$$P = v_g \cdot i_g \cdot \cos(\phi_g - \pi)$$

Reactive power generated

$$Q = v_g \cdot i_g \cdot sen(\phi_g - \pi)$$

(Reactive power injected is capacitive)

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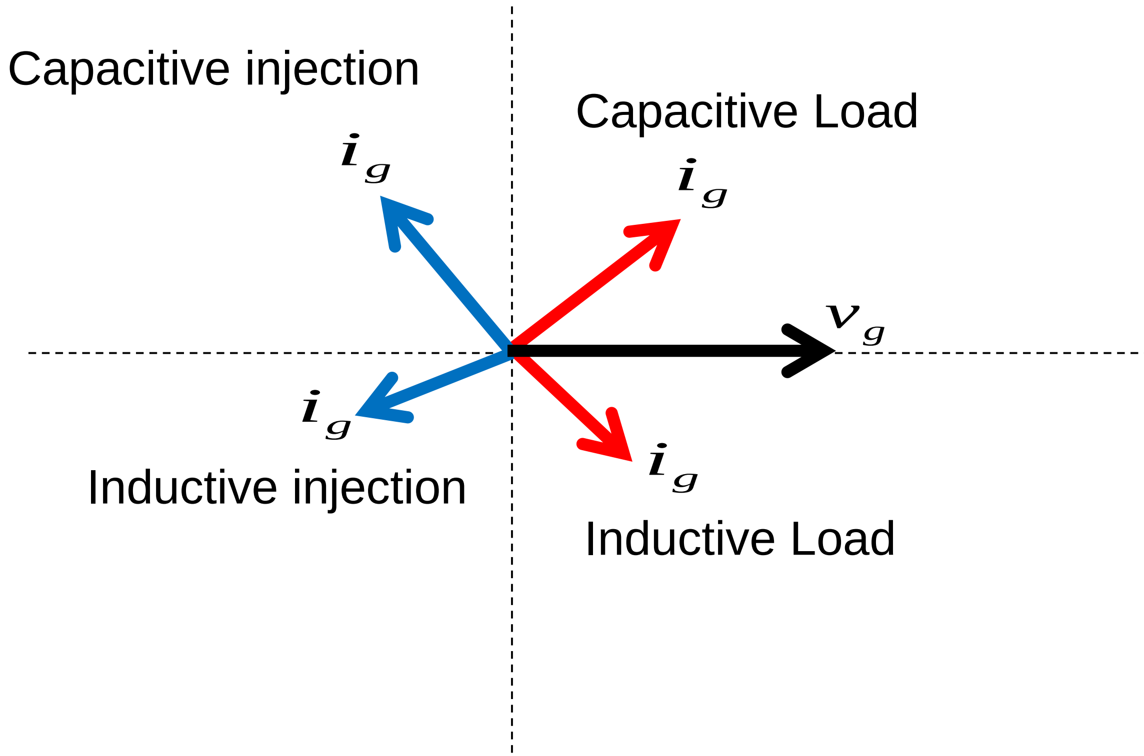
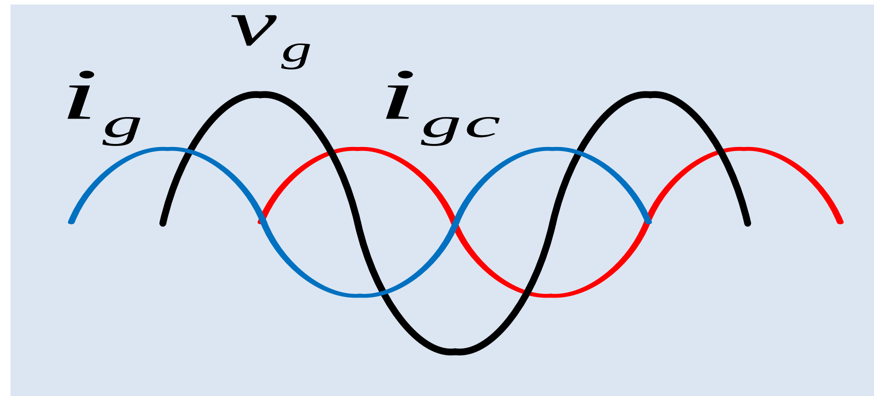
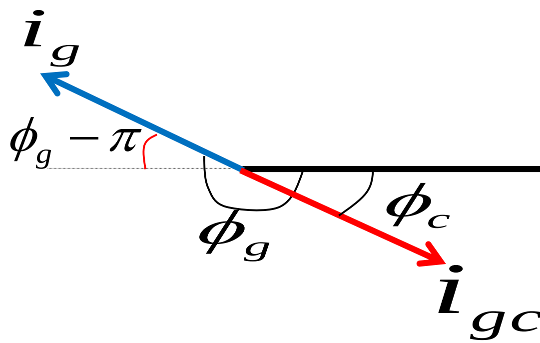
BASIC CONCEPTS



Our objective is to generate active and reactive power needed by a given load





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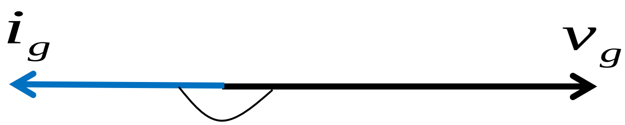
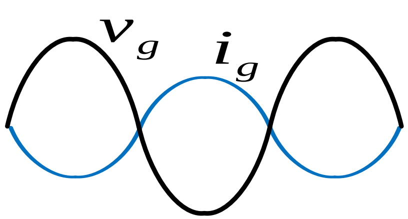
SPECIAL SITUATIONS

Injecting only active power (Q=0)

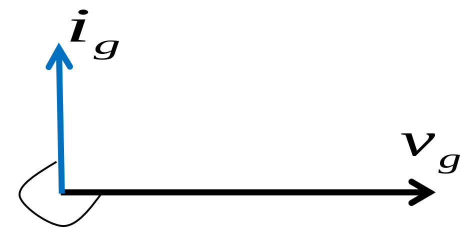


$$\phi_g = 180^o$$

Generation system behaves like a resistance

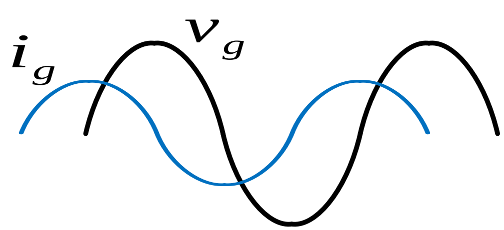


Injecting only reactive power (P=0)

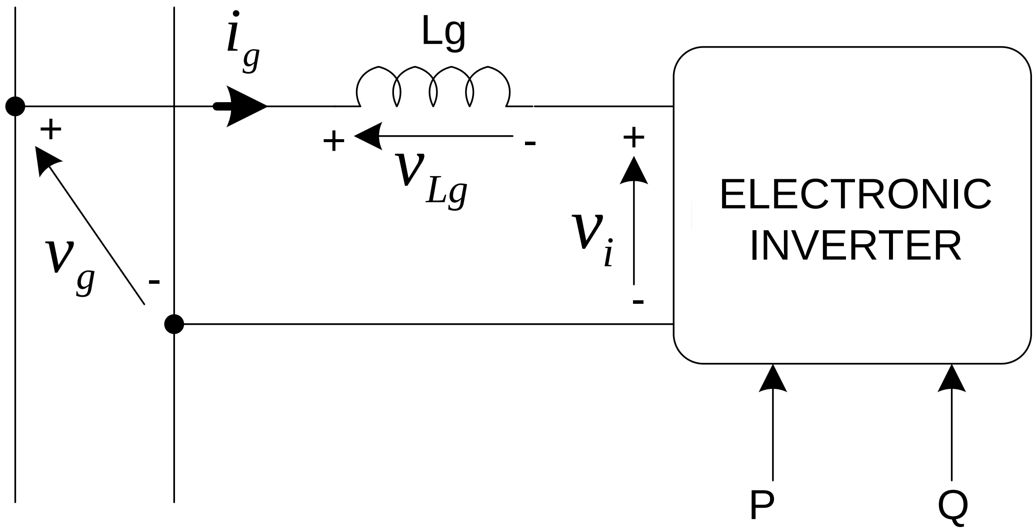


$$\phi_g = 270^o$$

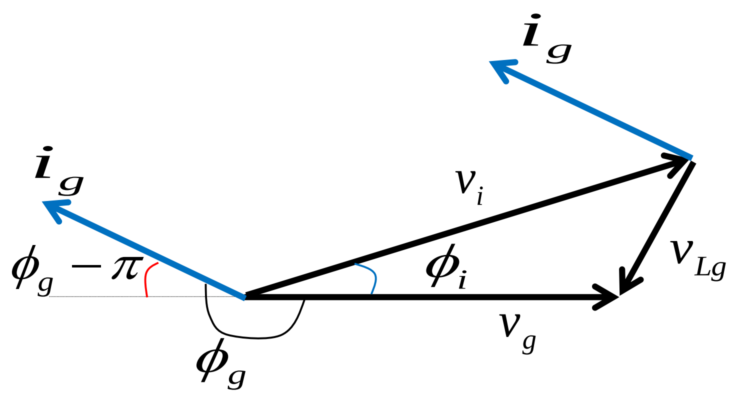
Generation system behaves like a capacitor



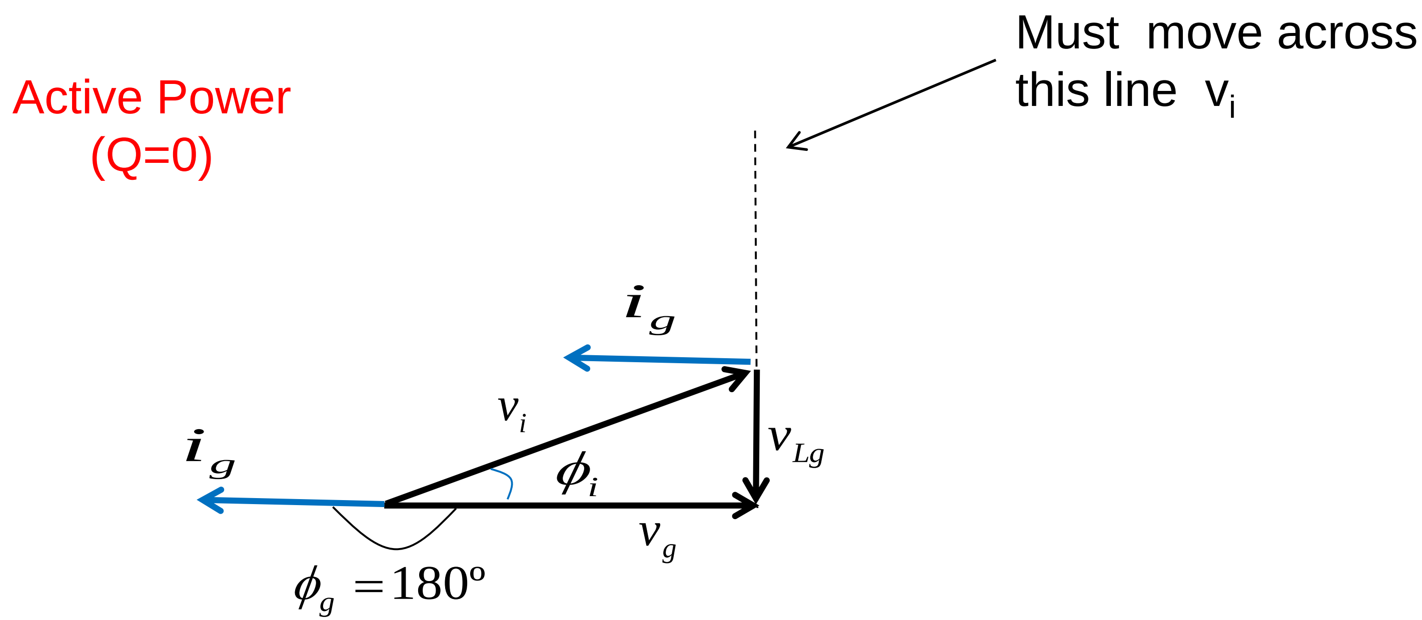
BASIC CONCEPTS



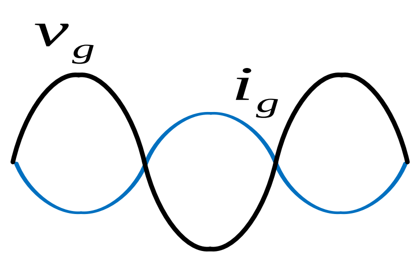
Current i_g in delay 90º with voltage v_{Lg}



BASIC CONCEPTS

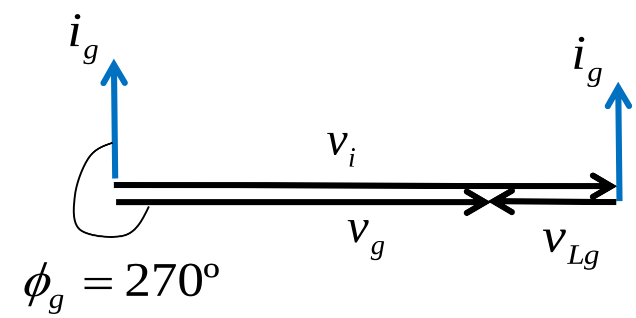


System behaves like a negative resistance

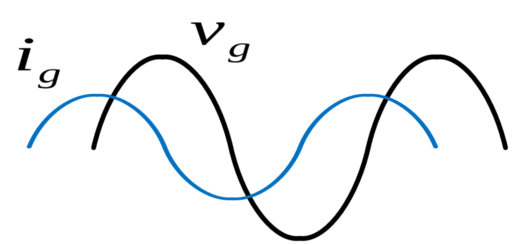


BASIC CONCEPTS

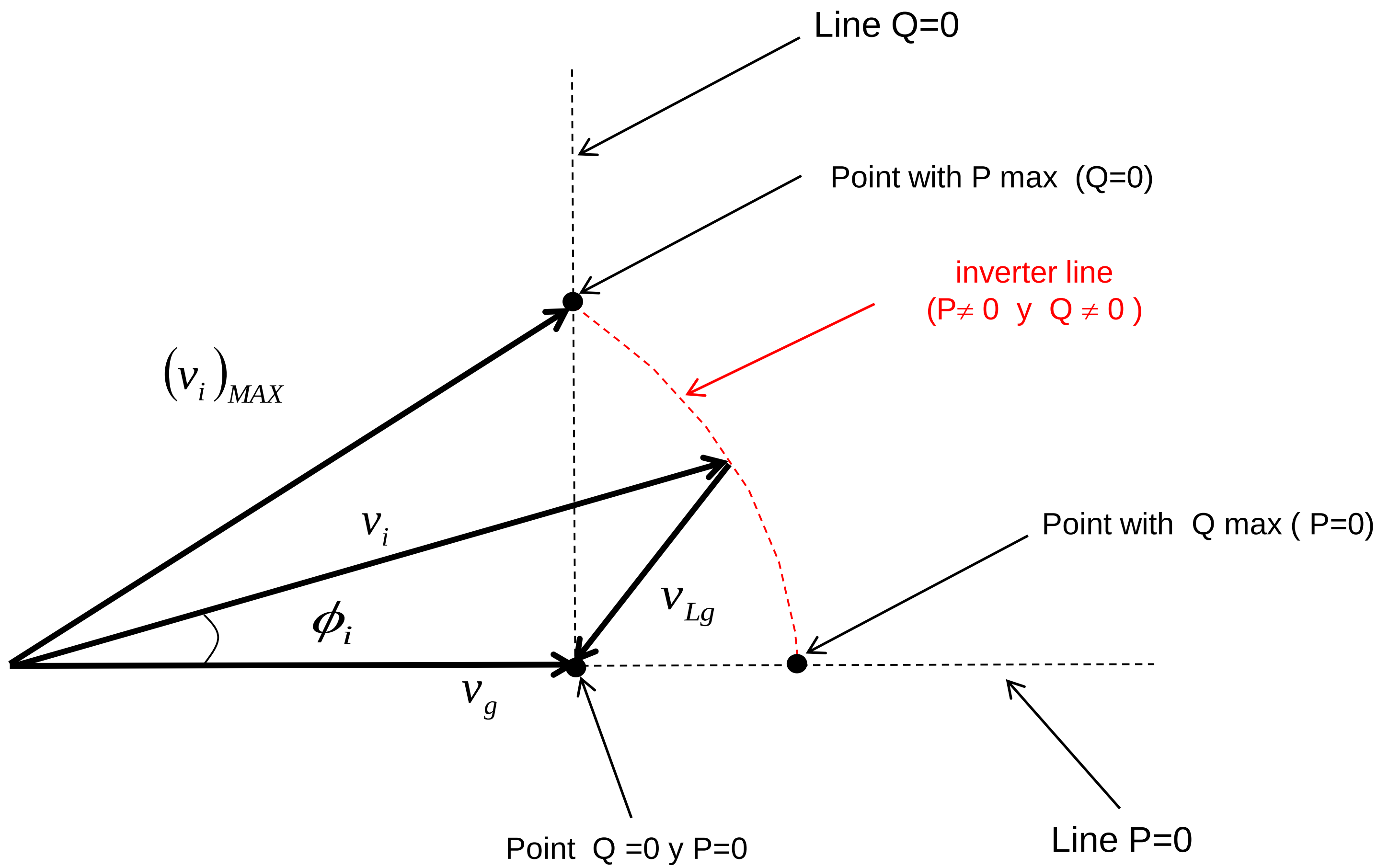
Injecting only reactive power (P=0)



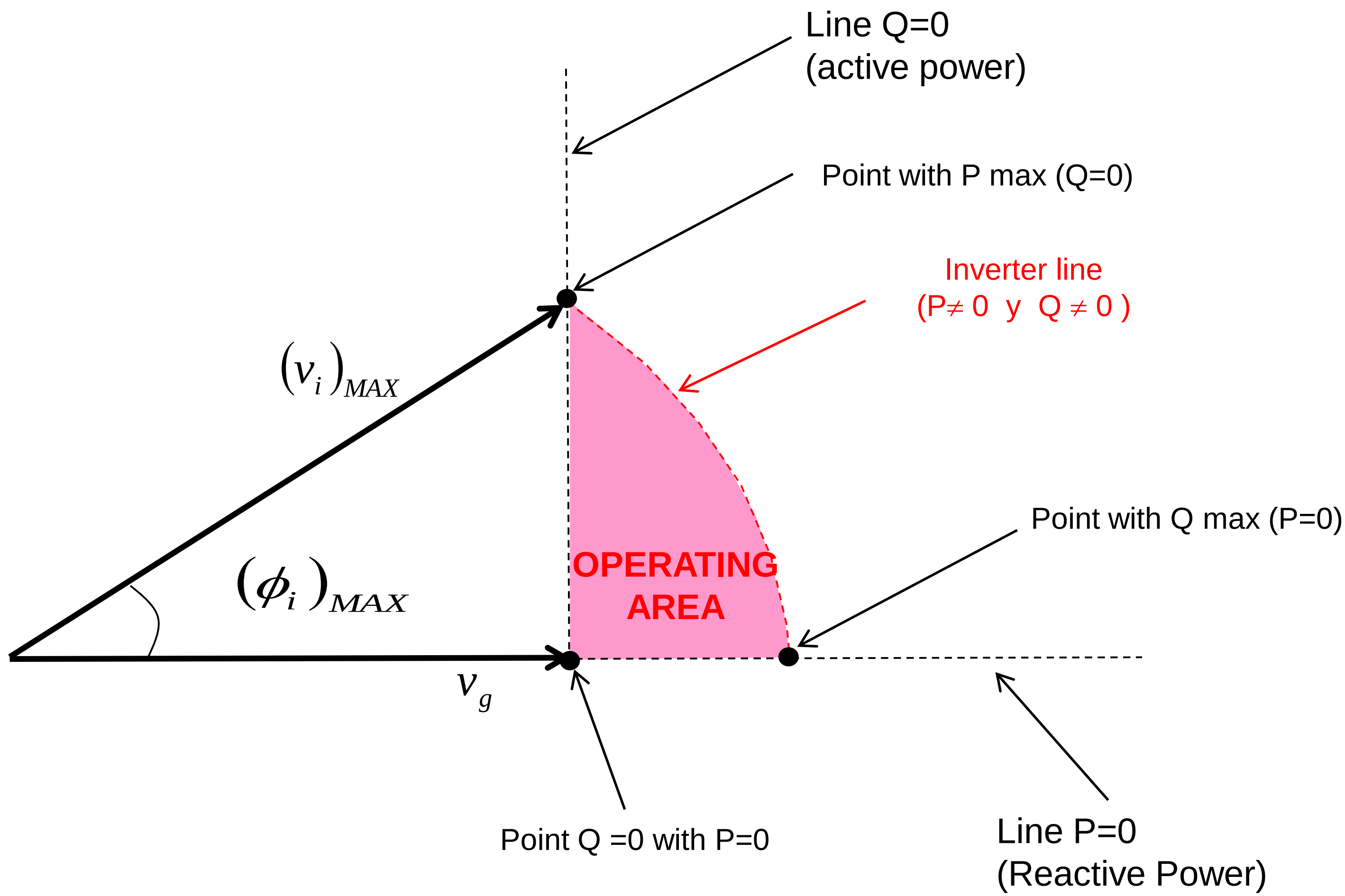
Generation system behaves like a capacitor



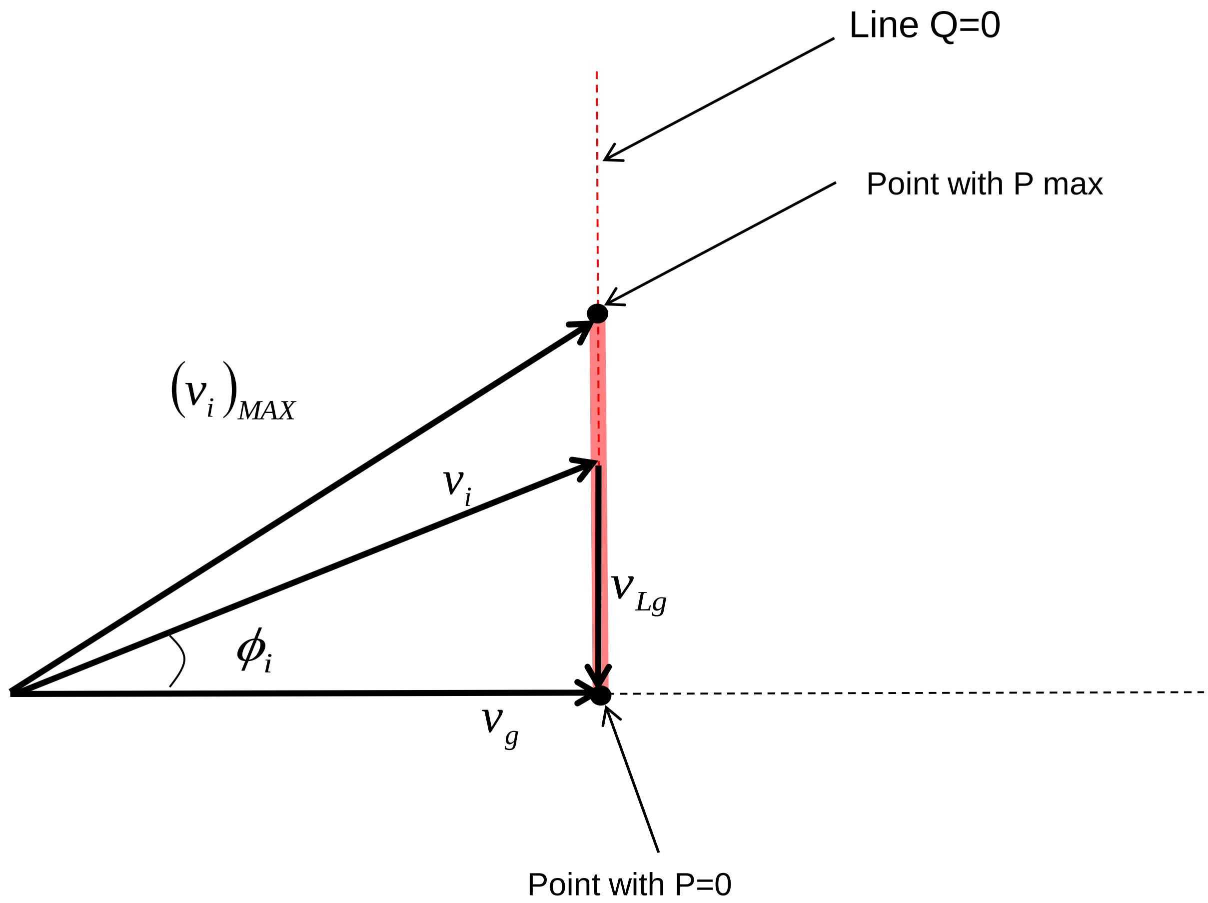
BASIC CONCEPTS



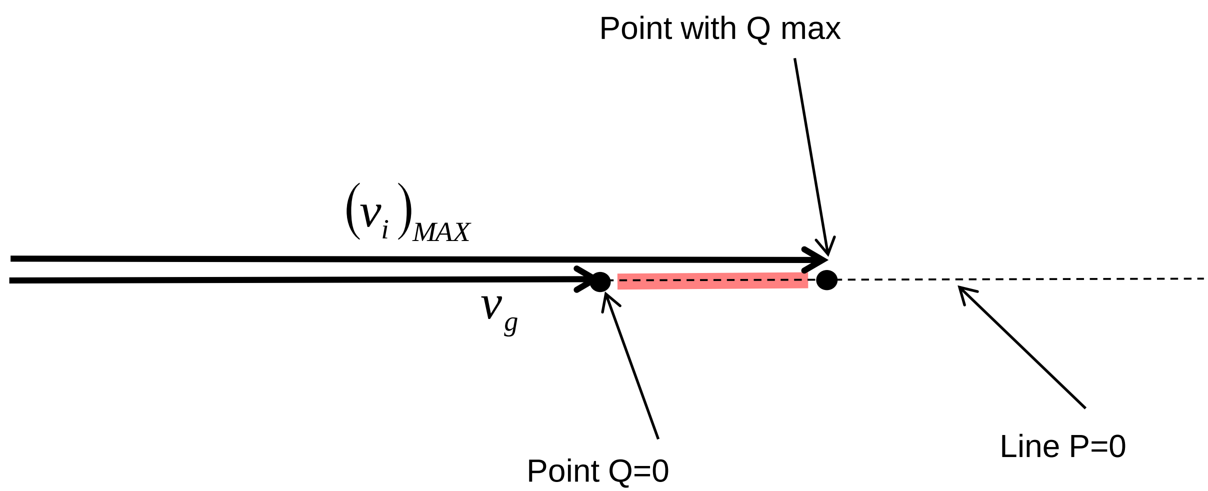
BASIC CONCEPTS



BASIC CONCEPTS



ONLY ACTIVE POWER



ONLY REACTIVE POWER

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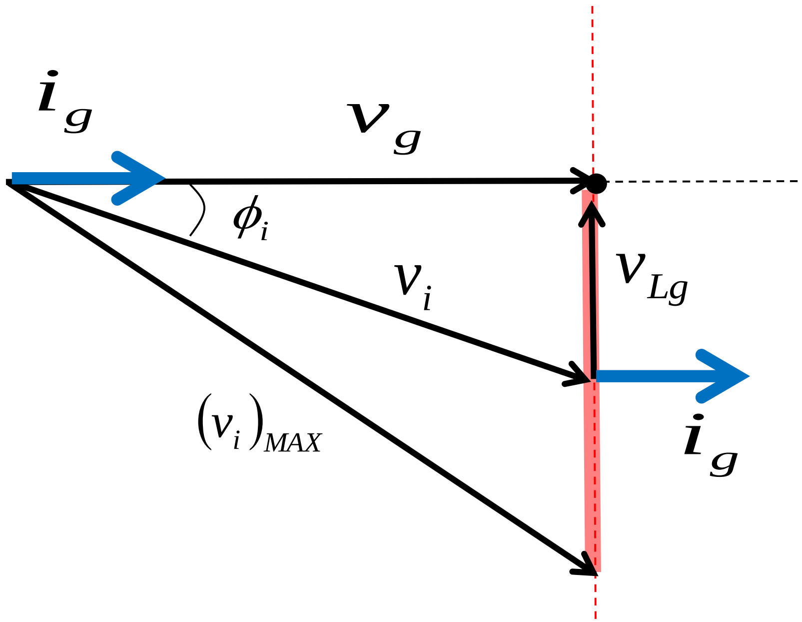
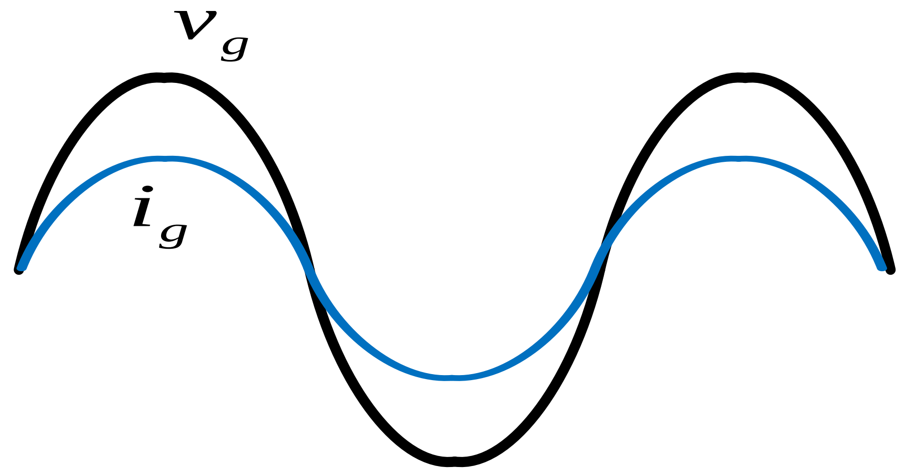
RESISTIVE BEHAVIOUR (PF = 1)





ACTIVE LOAD

Power Factor Correction

Animation

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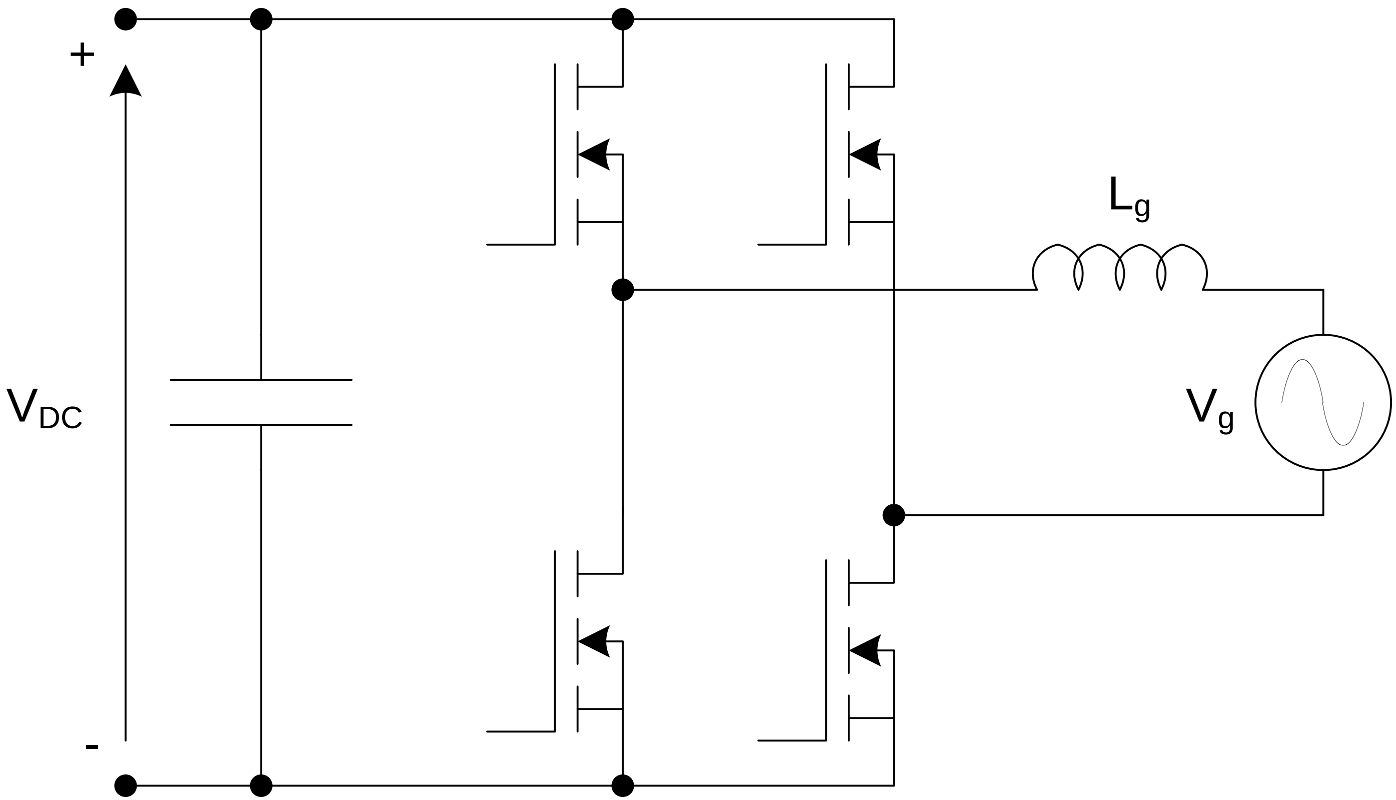
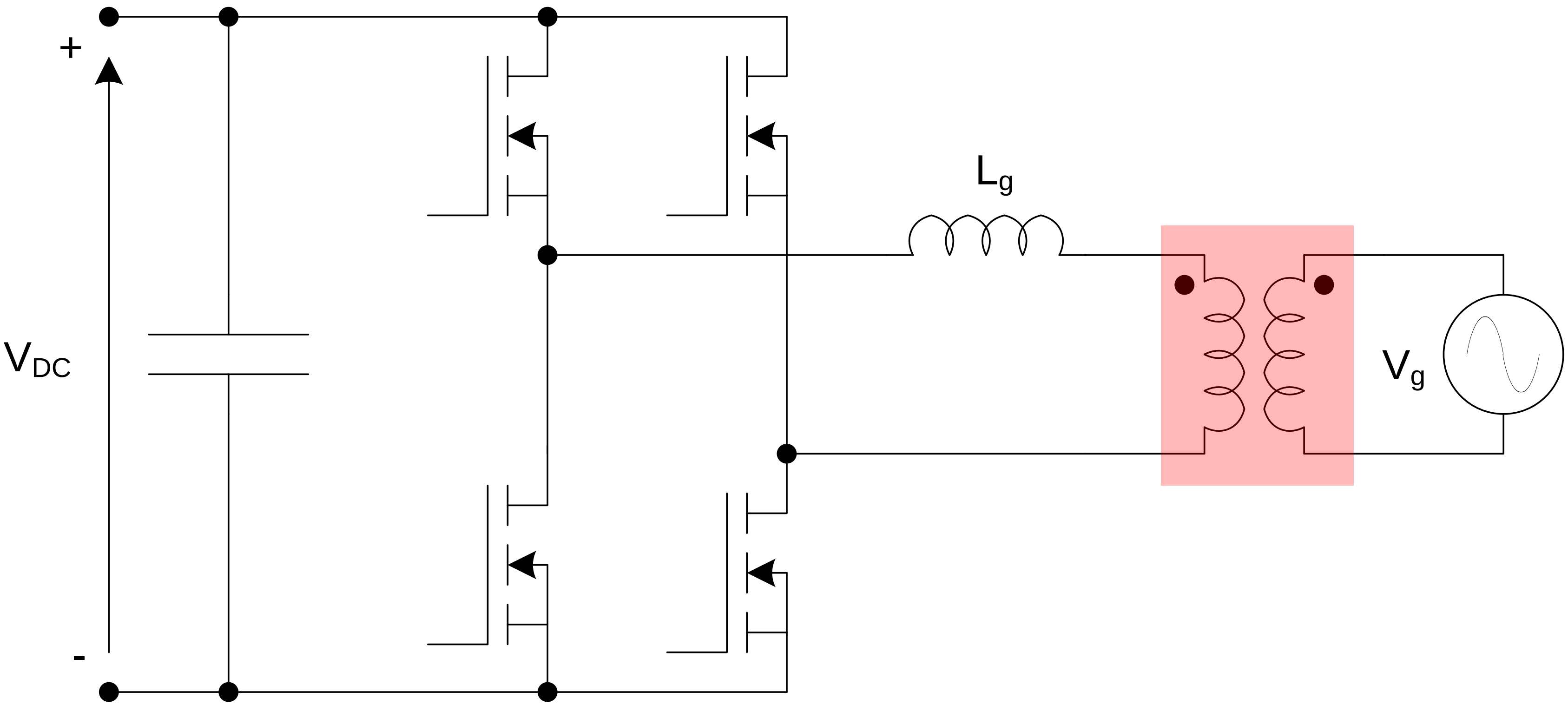
SINGLE-PHASE INVERTERS



FULL BRIDGE

SINGLE-PHASE INVERTERS



ISOLATED FULL-BRIDGE

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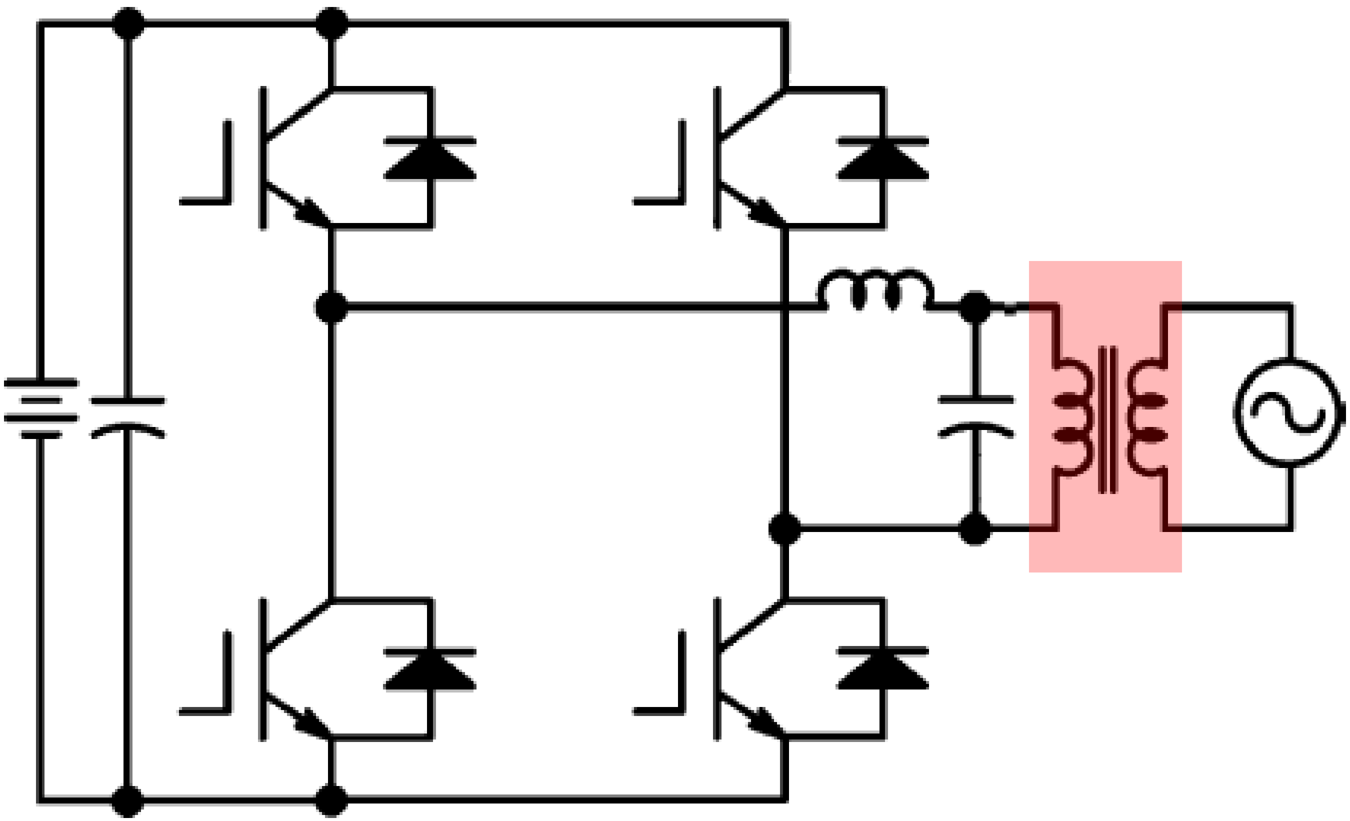
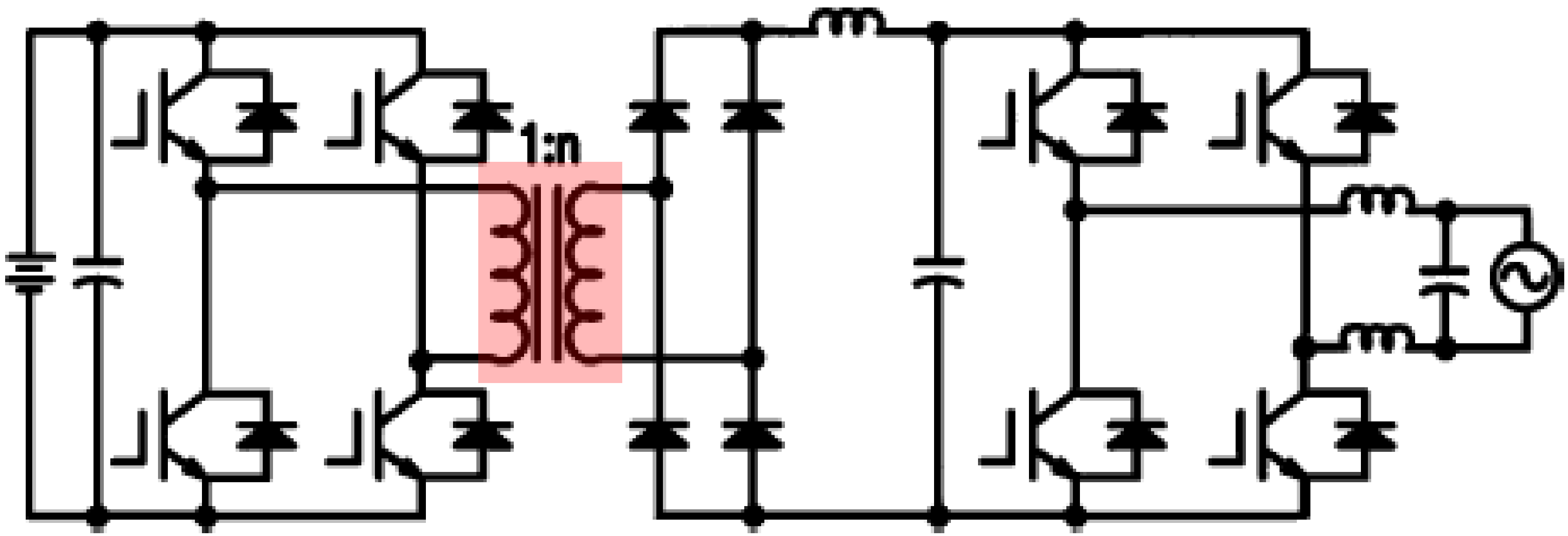
SINGLE-PHASE INVERTERS



Traditional buck inverter and line-frequency transformer.

SINGLE-PHASE INVERTERS



Multiple-stage inverter with a high frequency transformer.

SINGLE-PHASE INVERTERS

GRID CONVERTERS FOR PHOTOVOLTAIC AND WIND POWER SYSTEMS

Remus Teodorescu
Aalborg University, Denmark

Marco Liserre
Politecnico di Bari, Italy

Pedro Rodríguez
Technical University of Catalonia, Spain

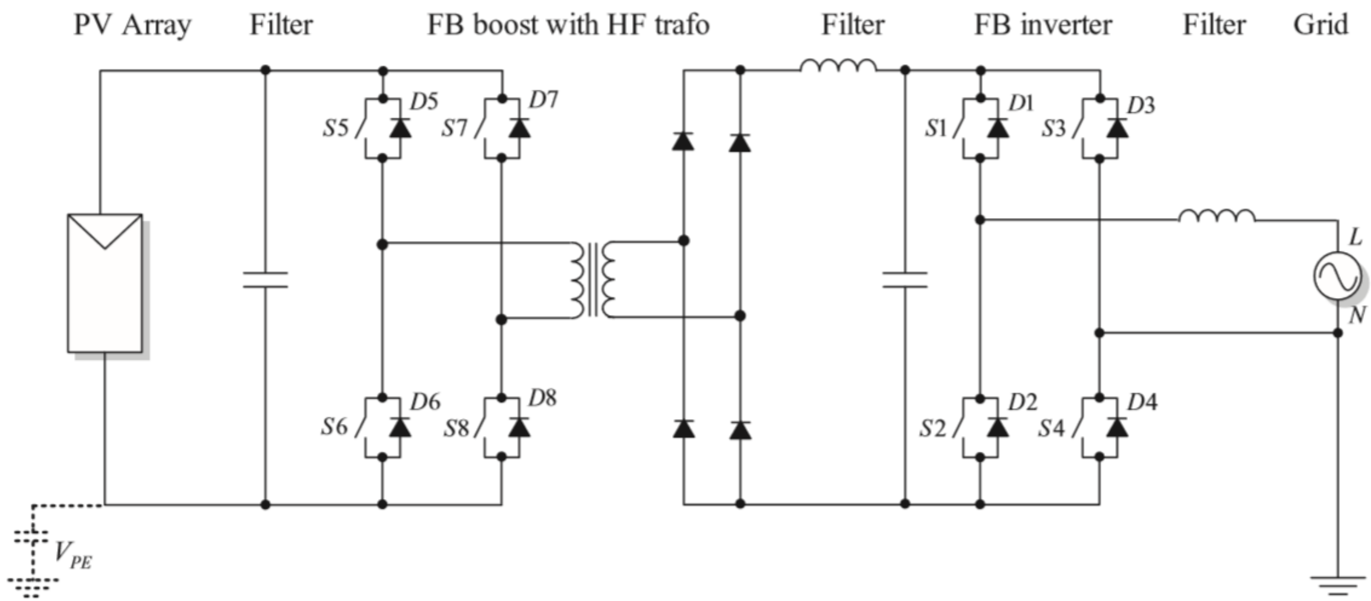
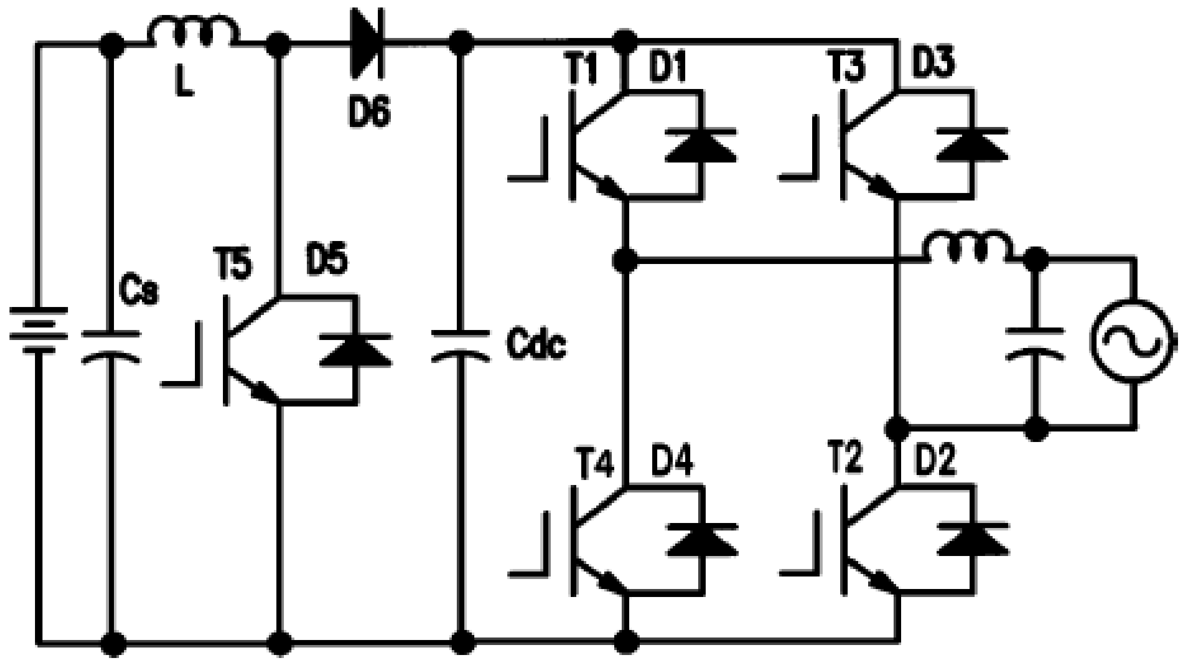


Figure 2.19 Boosting inverter with a HF transformer based on the H-bridge

SINGLE-PHASE INVERTERS



Two-stage boost inverter

SINGLE-PHASE INVERTERS

GRID CONVERTERS FOR PHOTOVOLTAIC AND WIND POWER SYSTEMS

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Aalborg University, Denmark

Marco Liserre
Politecnico di Bari, Italy

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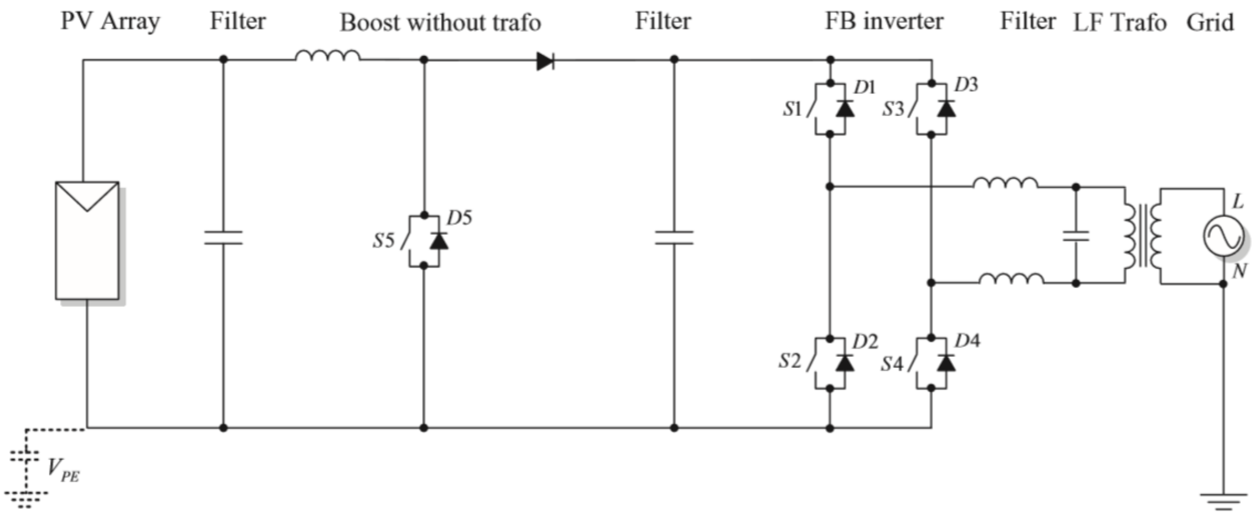
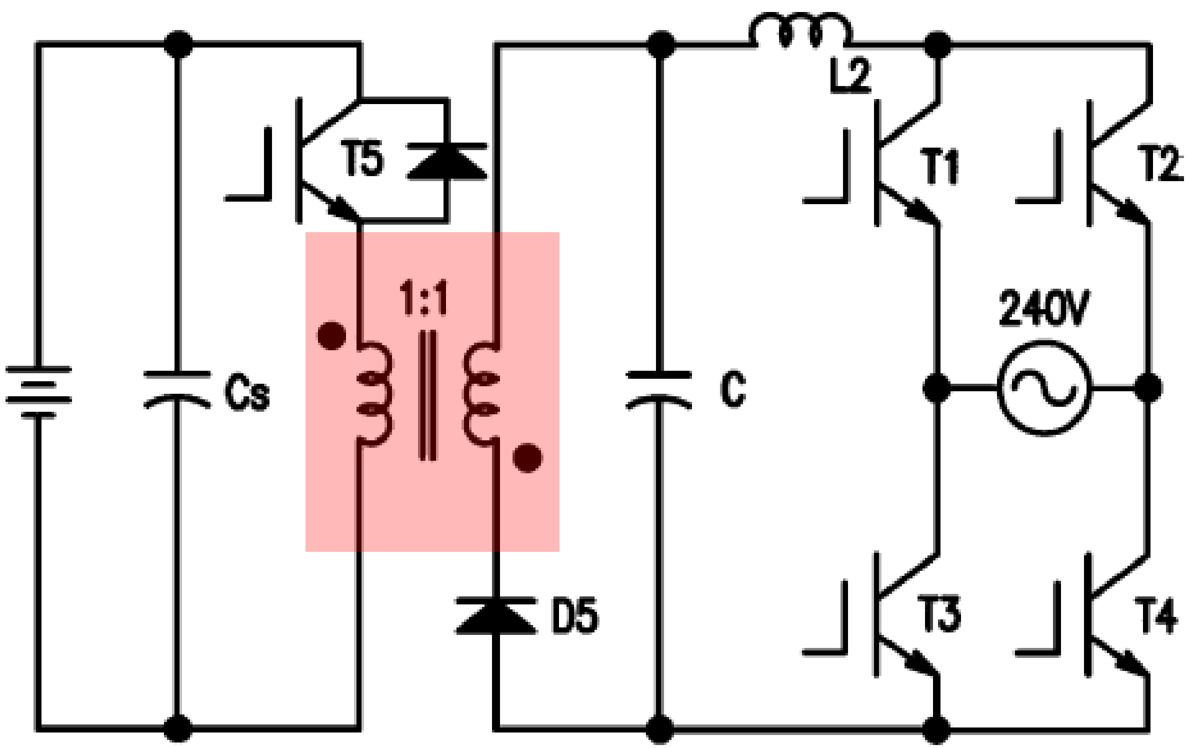


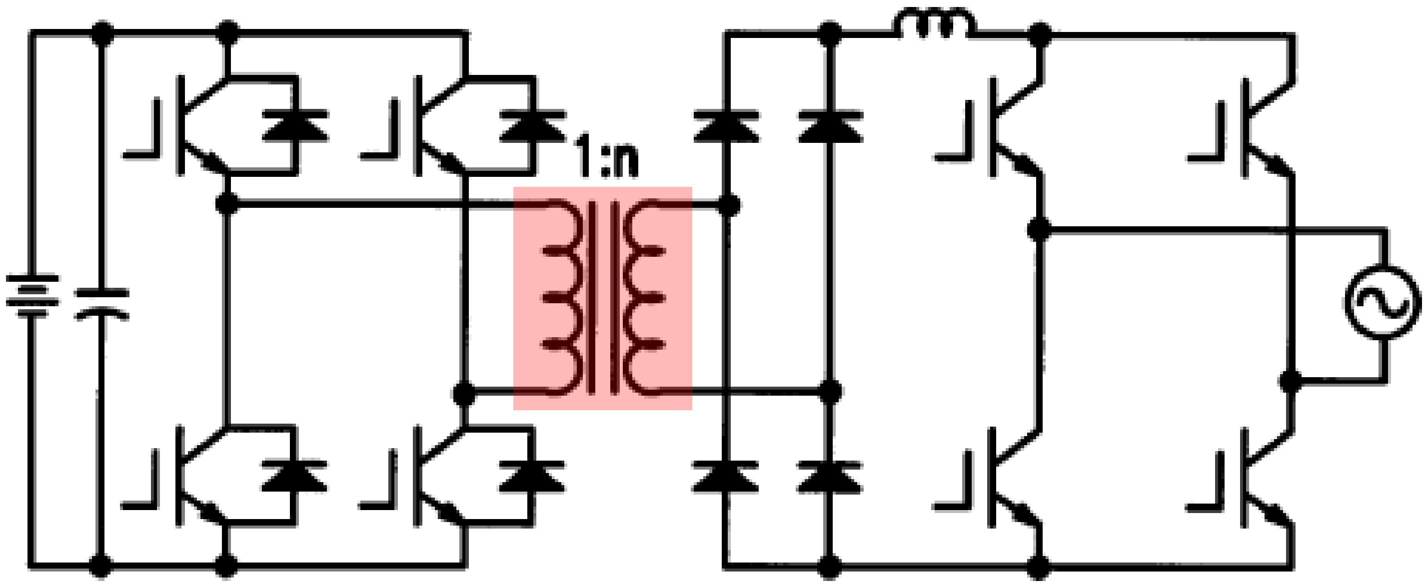
Figure 2.20 Boosting inverter with a LF transformer based on the boost converter

SINGLE-PHASE INVERTERS



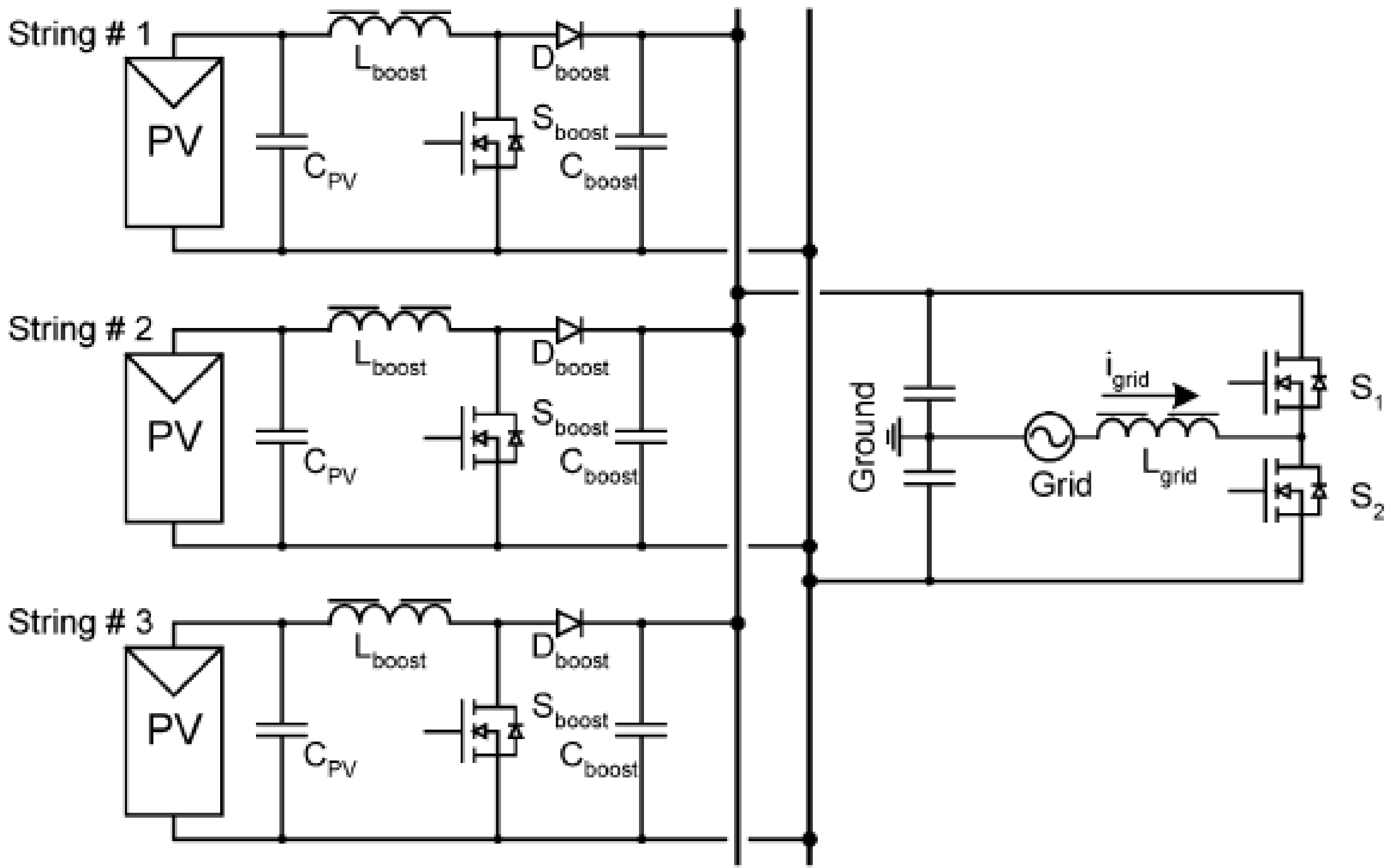
Two-stage isolated buck-boost inverter

SINGLE-PHASE INVERTERS

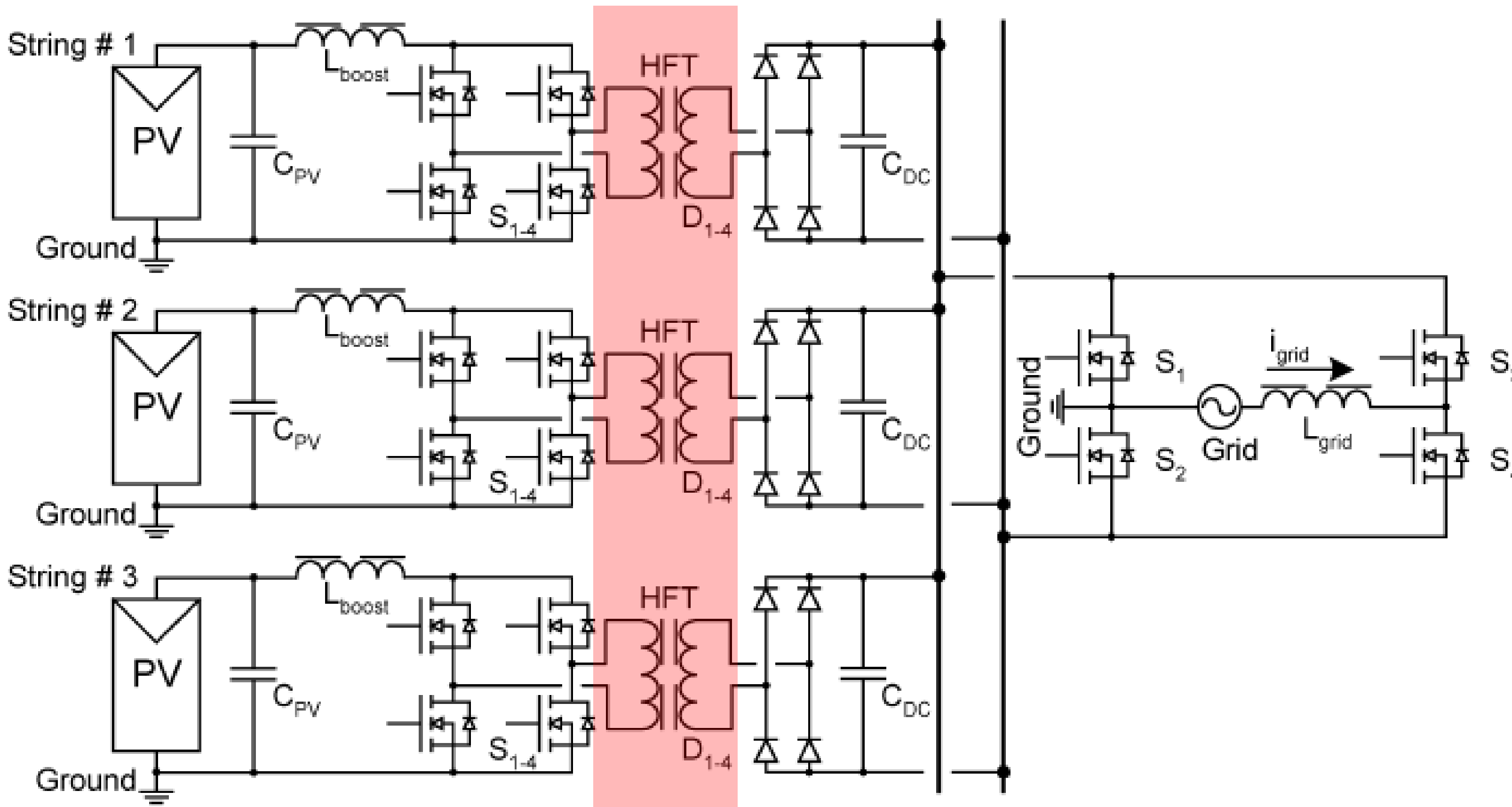


Multiple-stage boost inverter

SINGLE-PHASE INVERTERS



SINGLE-PHASE INVERTERS



SINGLE-PHASE INVERTERS

GRID CONVERTERS FOR PHOTOVOLTAIC AND WIND POWER SYSTEMS

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Pedro Rodríguez
Technical University of Catalonia, Spain

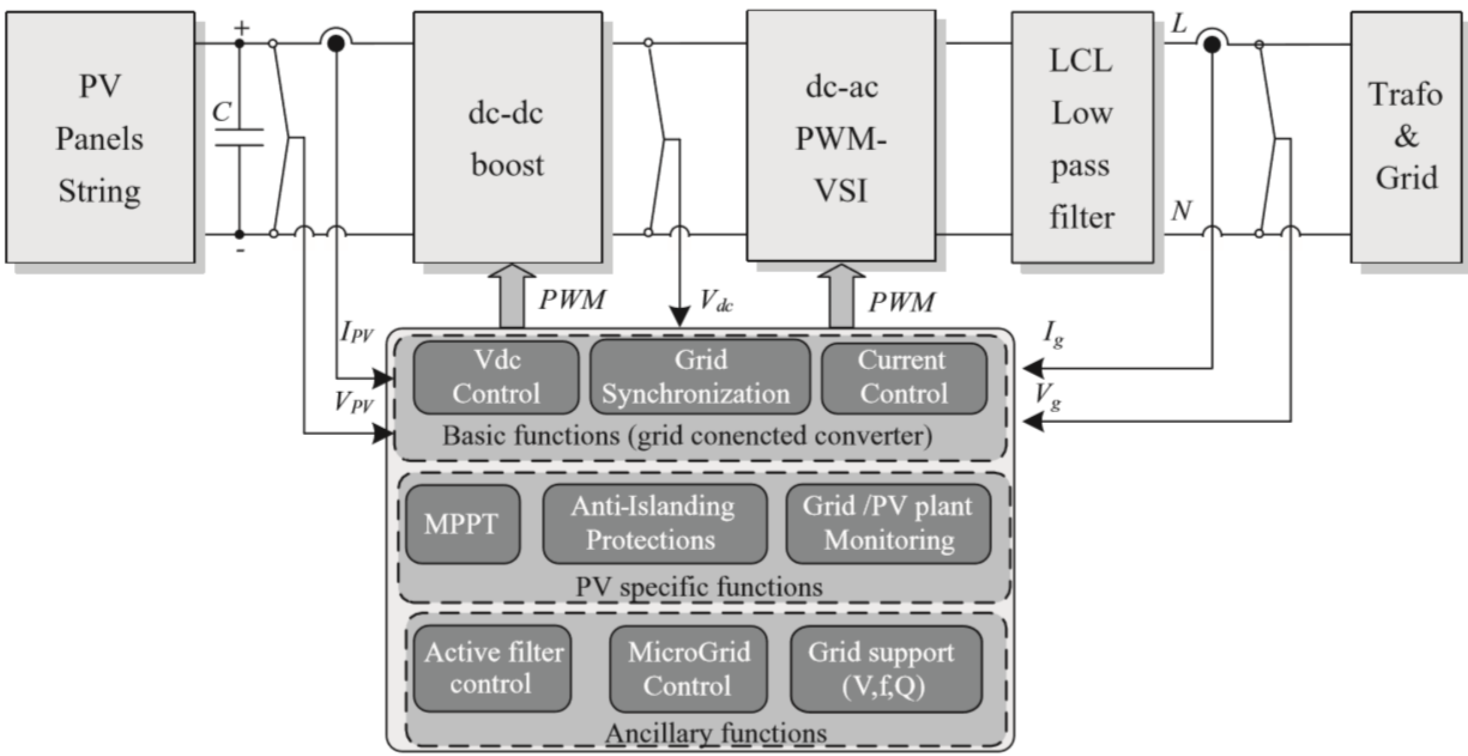


Figure 2.21 Generic control structure for a PV inverter with boost stage

NORMATIVE

TABLE I
SUMMARY OF THE MOST INTERESTING STANDARDS DEALING WITH INTERCONNECTIONS OF PV SYSTEMS TO THE GRID

ISSUE	IEC61727 [3]	IEEE1547 [5]	EN61000-3-2 [4]
Nominal power	10 kW	30 kW	16 A × 230 V = 3.7 kW
Harmonic currents (Order – h) Limits	(3-9) 4.0% (11-15) 2.0% (17-21) 1.5% (23-33) 0.6%	(2-10) 4.0% (11-16) 2.0% (17-22) 1.5% (23-34) 0.6% (> 35) 0.3%	(3) 2.30 A (5) 1.14 A (7) 0.77 A (9) 0.40 A (11) 0.33 A (13) 0.21 A (15-39) 2.25/h
	Even harmonics in these ranges shall be less than 25% of the odd harmonic limits listed.		Approximately 30% of the odd harmonics -see standard.
Maximum current THD	5.0%		-
Power factor at 50% of rated power	0.90	-	
DC current injection	Less than 1.0% of rated output current.	Less than 0.5% of rated output current.	< 0.22 A -corresponds to a 50 W half-wave rectifier.
Voltage range for normal operation	85% - 110% (196 V – 253 V)	88% - 110% (97 V – 121 V)	-
Frequency range for normal operation	50 ± 1 Hz	59.3 Hz to 60.5 Hz	-

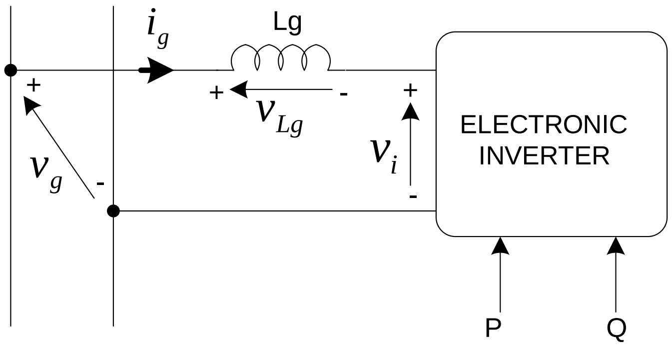
EXAMPLE

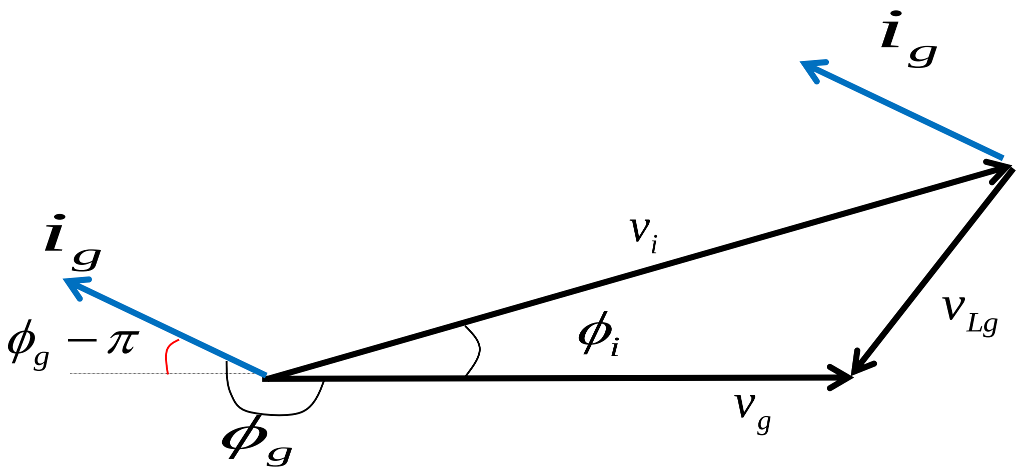
Design example:
Using a PWM inverter, DC bus voltage 400 V, inject to the grid (230 Vrms and 50 Hz) a power of 50 W and 20 VA.

questions:

1.- Inductance value (Lg)?

2.- Maximum active power (P) and reactive power (Q)?

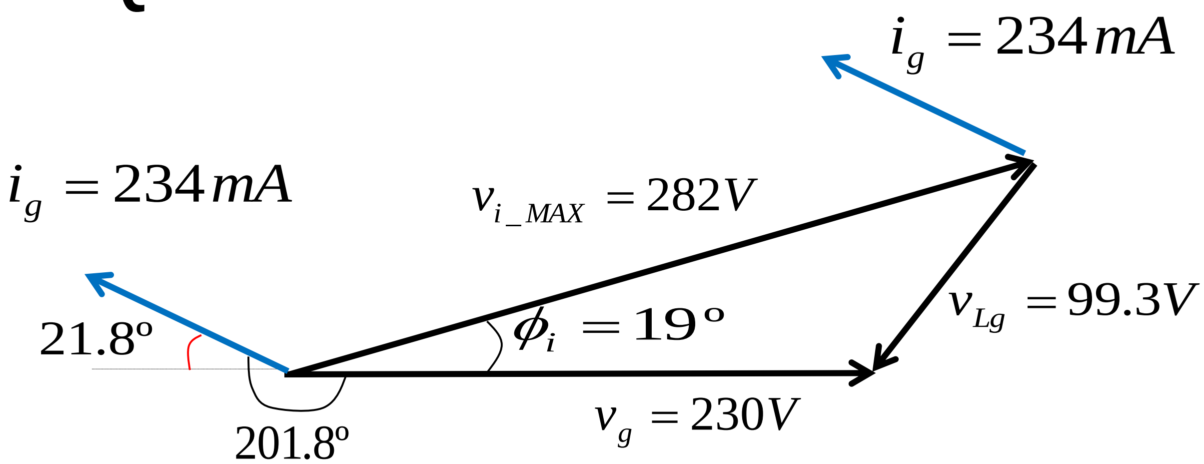




EXAMPLE

P = 50 W

Q = 20 VA



$$L_g = 1.35\ H$$