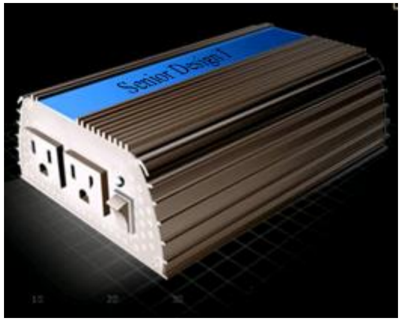
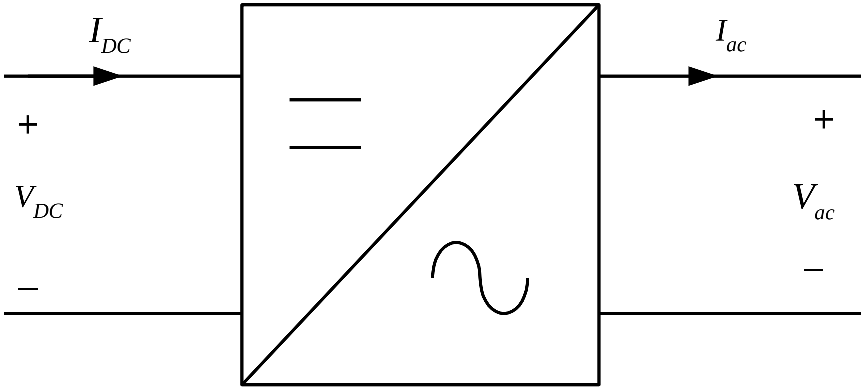
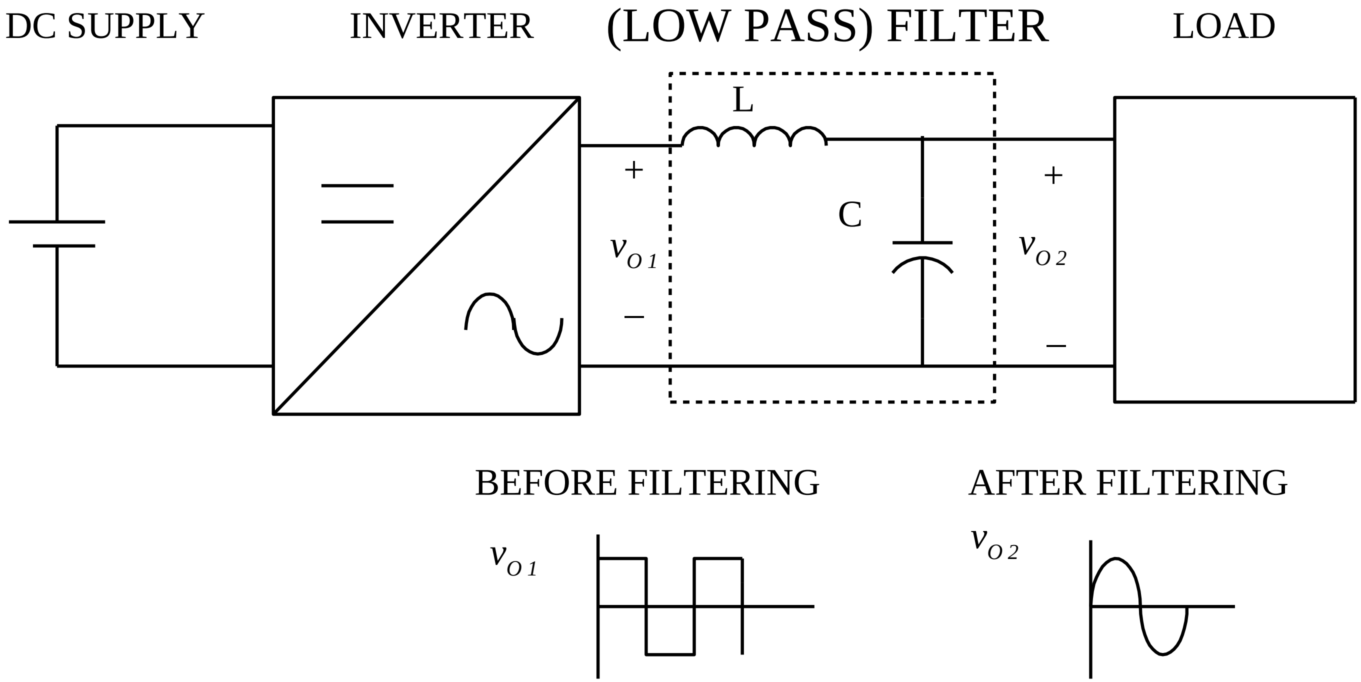
ELG4139: DC to AC Converters

Converts DC to AC power by switching the DC input voltage (or current) in a pre-determined sequence so as to generate AC voltage (or current) output.



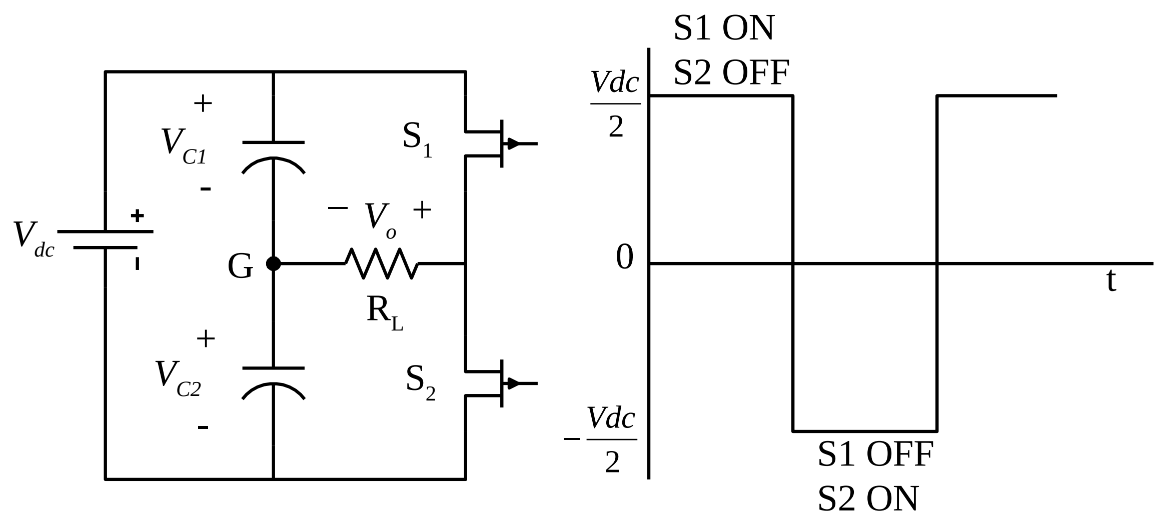


Harmonics Filtering



Output of the inverter is "chopped AC voltage with zero DC component". It contain **harmonics.** An **LC section low-pass filter** is normally fitted at the inverter output to reduce the high frequency harmonics. In some applications such as UPS, "*high purity*" sine wave output is required. Good filtering is a must. In some applications such as AC motor drive, filtering may not required.

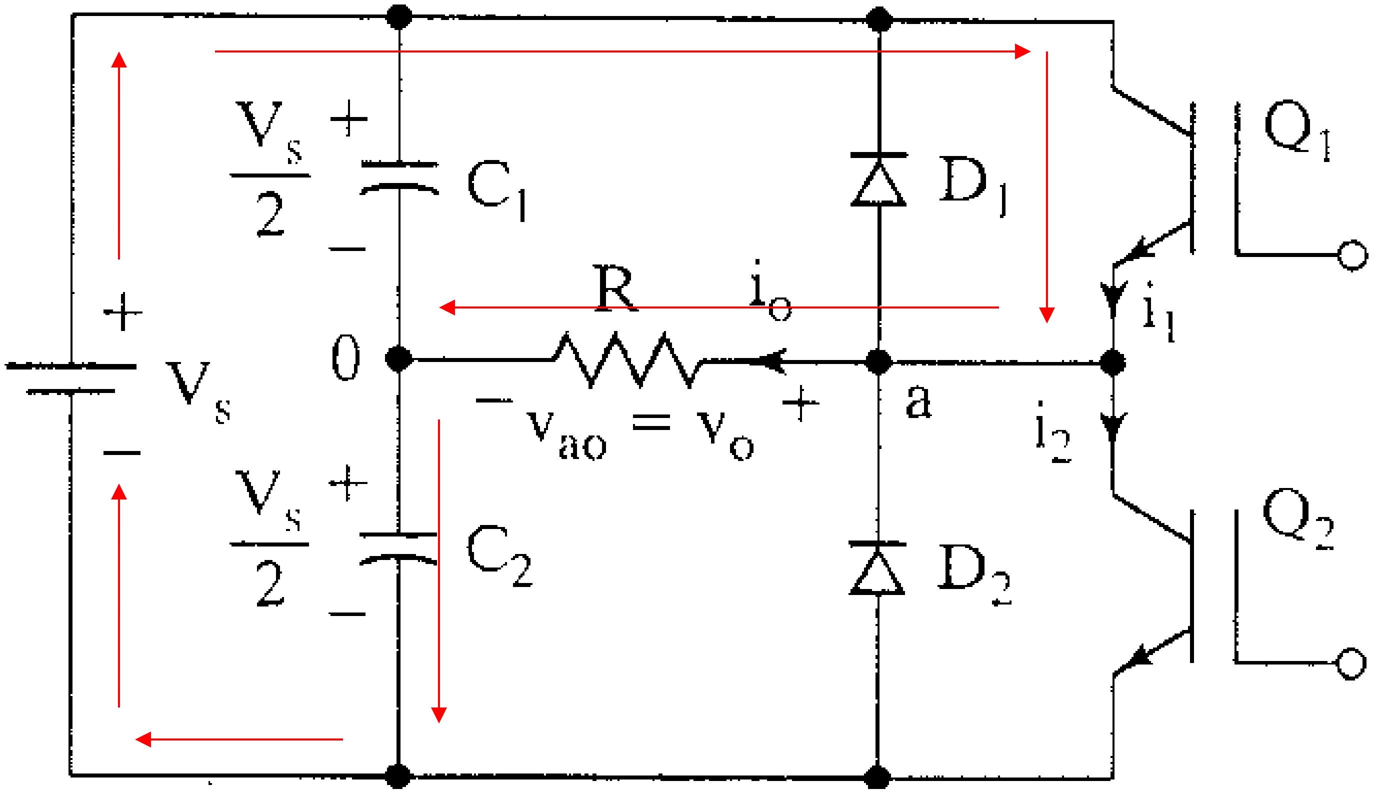
Single Phase Half-Bridge Inverter



Also known as the Inverter Leg!

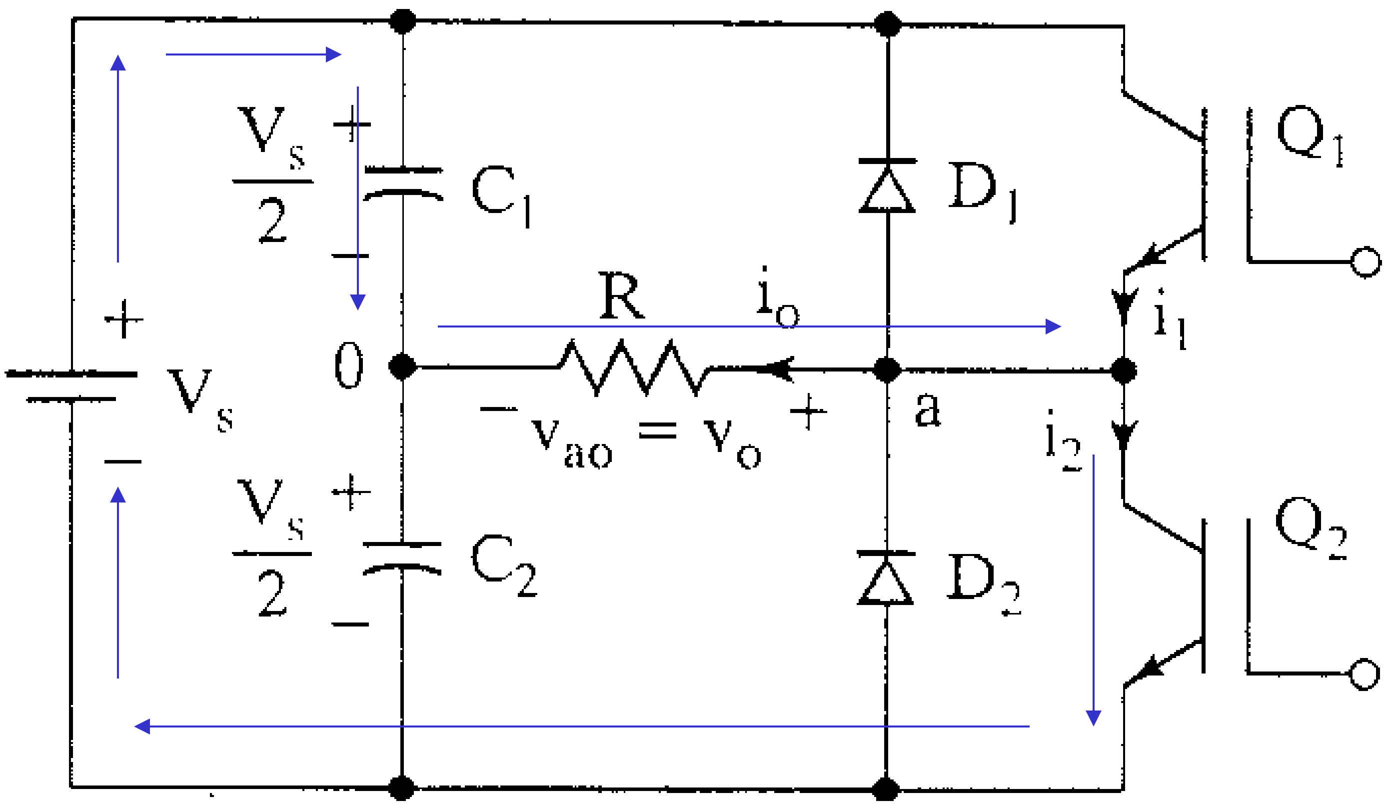
Both capacitors have the same value. Thus the DC link is equally spilt into two. The top and bottom switch has to be complementary. Meaning, If the top switch is closed (ON), the bottom must be OFF, and vice-versa.

Q_1 on, Q_2 off, $v_o = V_s/2$

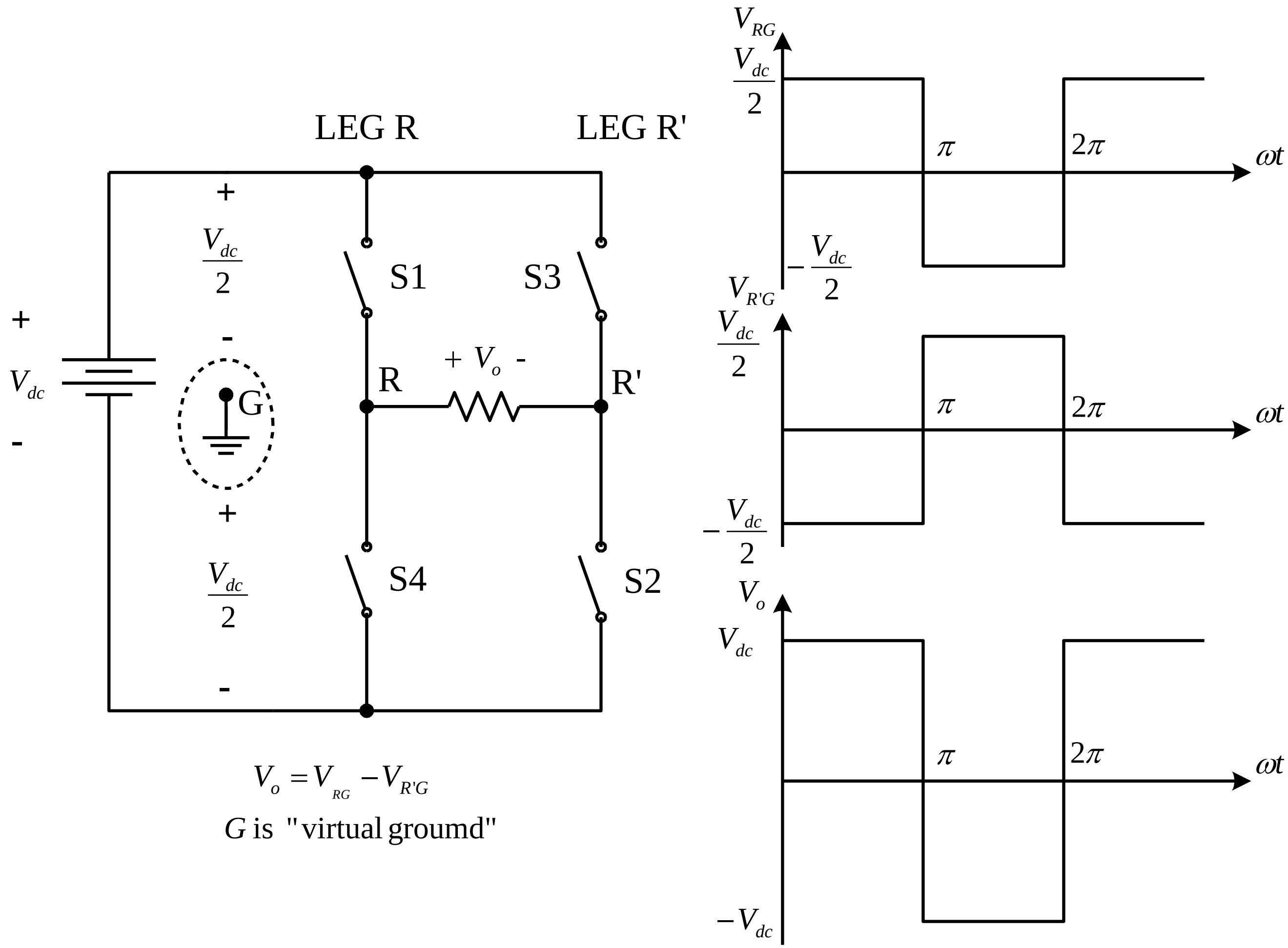


Peak Reverse Voltage of $Q_2 = V_s$

Q_1 off, Q_2 on, v_o = $-V_s/2$

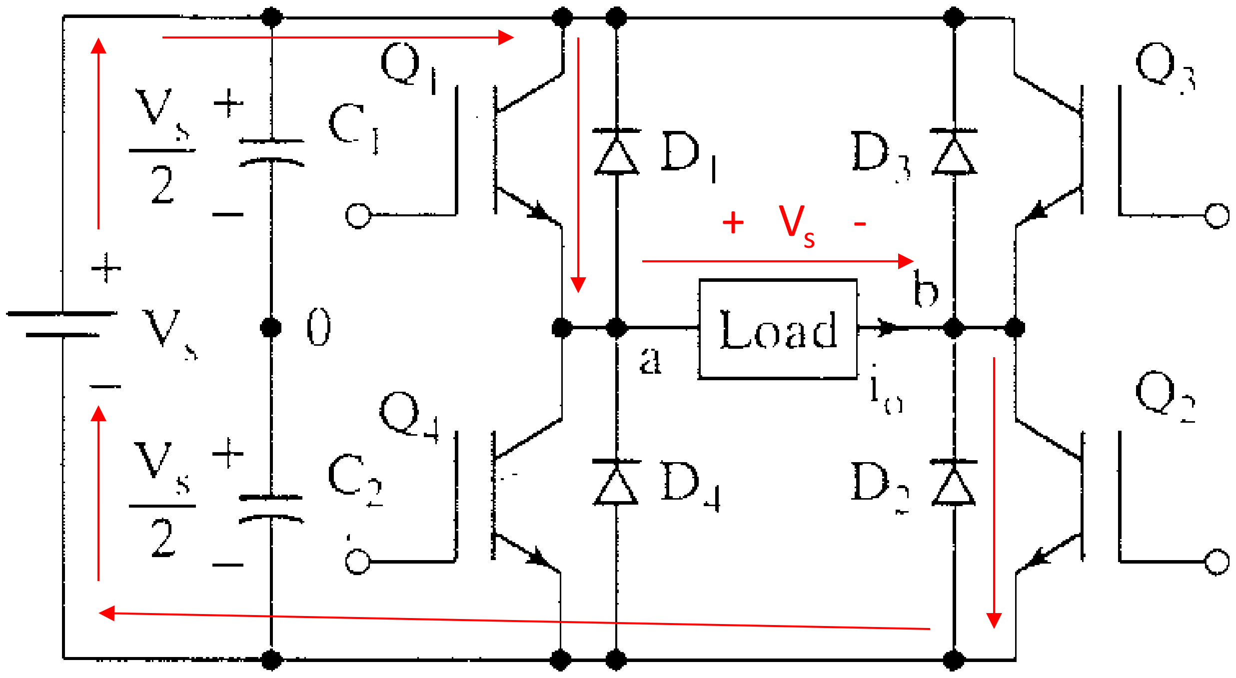


Single Phase Full Bridge

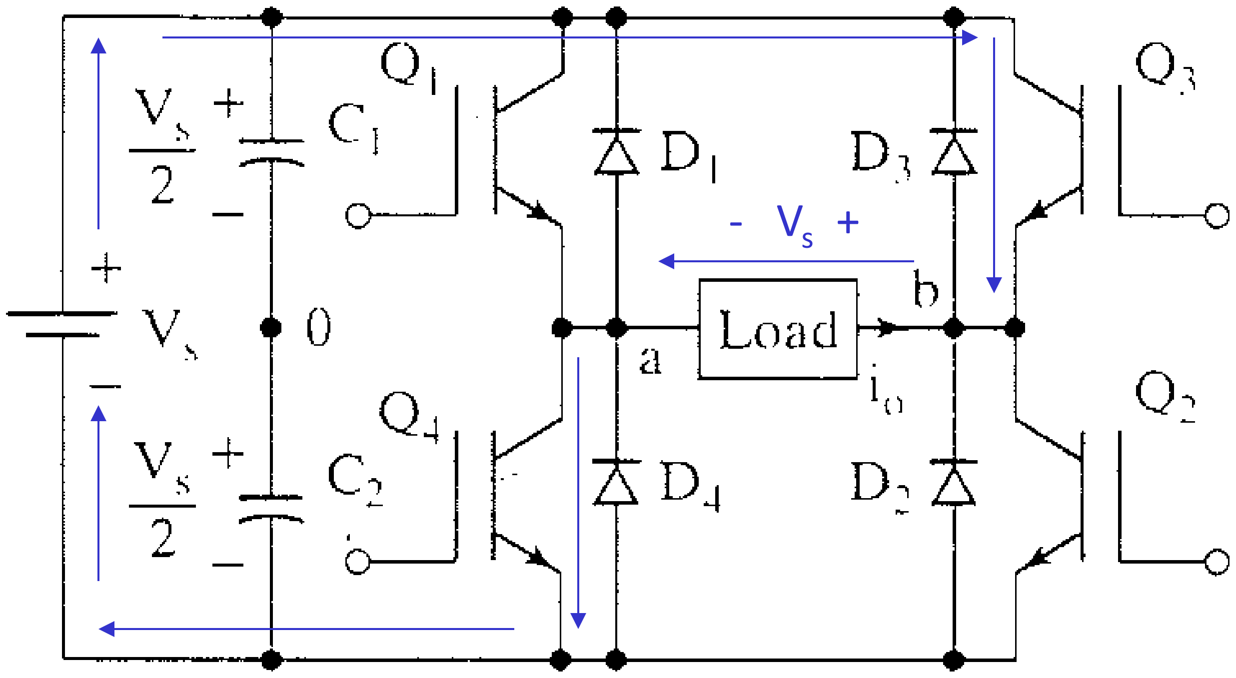


Single phase full bridge is built from two half-bridge leg. The switching in the second leg is delayed by 180 degrees from the first leg.

Q_1-Q_2 on, Q_3-Q_4 off, $v_o = V_s$



Q_3-Q_4 on, Q_1-Q_2 off, $v_o = -V_s$



Performance Parameters

- Harmonic factor of the nth harmonic (HF_n)

$$HF_n = \frac{V_{on}}{V_{o1}} \quad \text{for } n>1$$

V_{on} = rms value of the nth harmonic component

V_{01} = rms value of the fundamental component

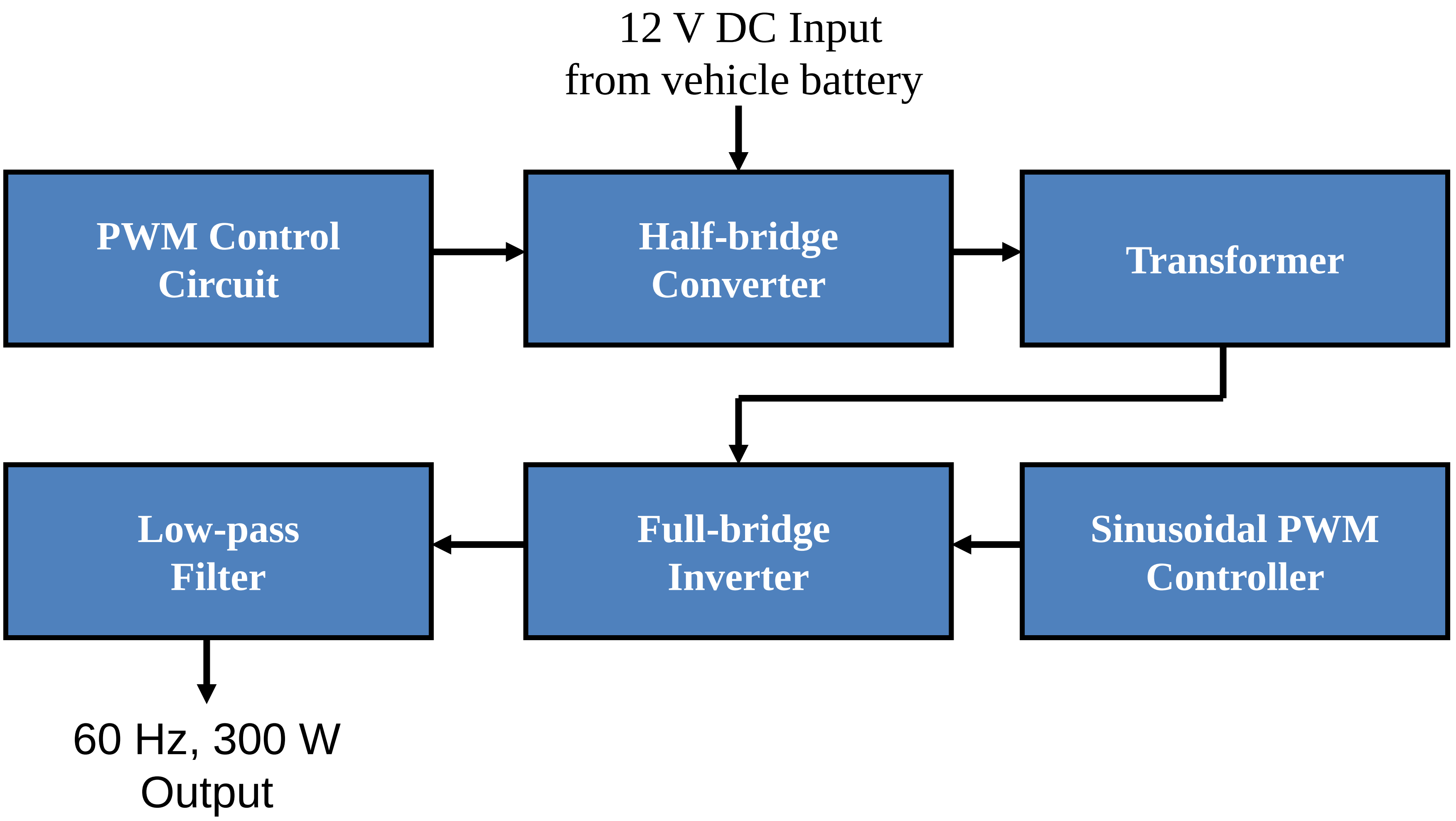
- Total Harmonic Distortion (THD): Measures the “closeness” in shape between a waveform and its fundamental component

$$THD = \frac{1}{V_{o1}} \left(\sum_{n=2,3,...}^{\infty} V_{on}^2 \right)^{\frac{1}{2}}$$

Design Constraints of a Pure Sine wave Inverter

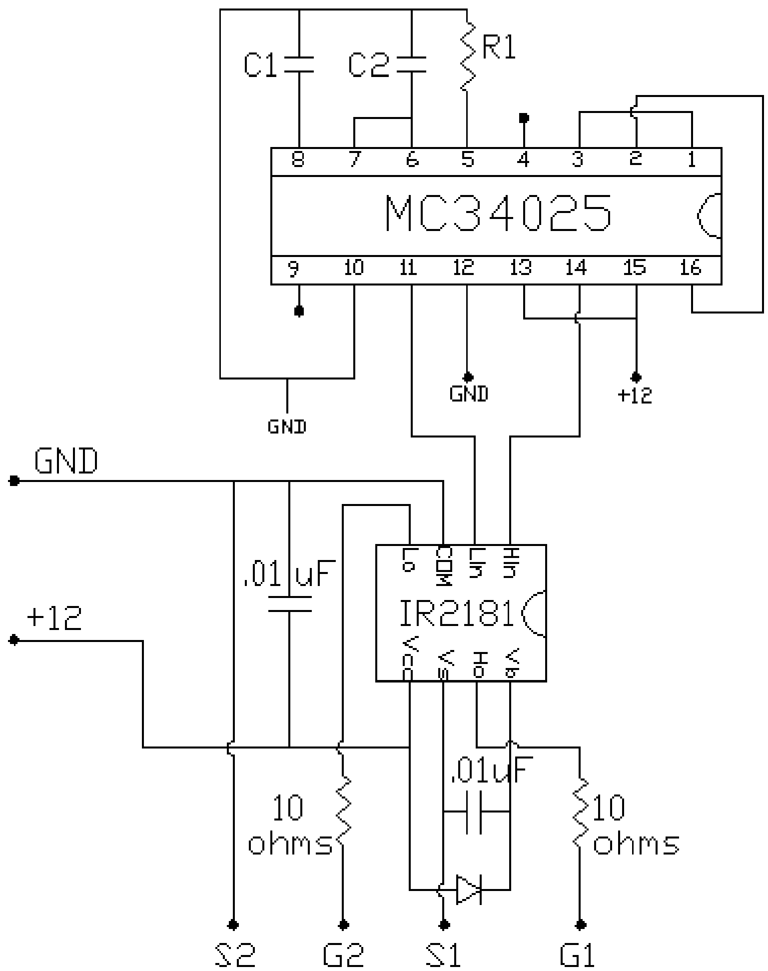
Quantity	Details
Voltage	Convert 12VDC to 120 VAC
Power	Provide 300 W continuous
Efficiency	> 90% efficiency
Waveform	Pure 60 Hz sinusoidal
Total Harmonic Distortion	< 5% THD
Physical Dimensions	8” x 4.75” x 2.5”
Cost	$175.00

Required Components for Design

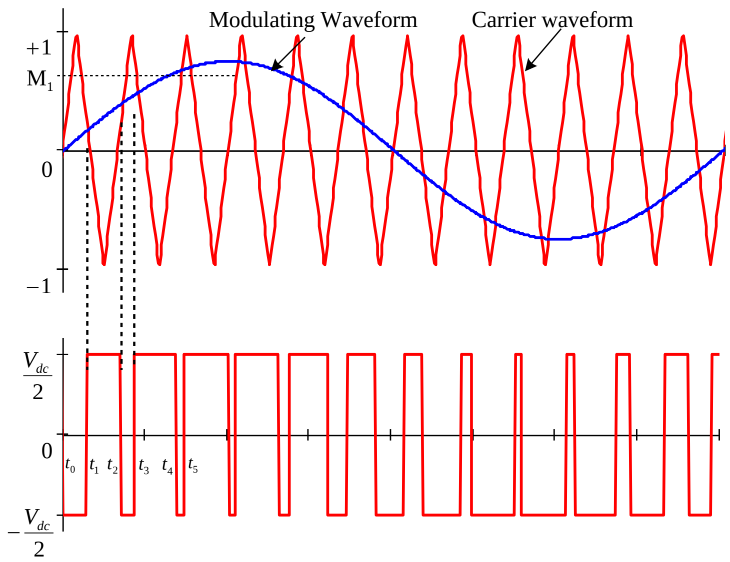


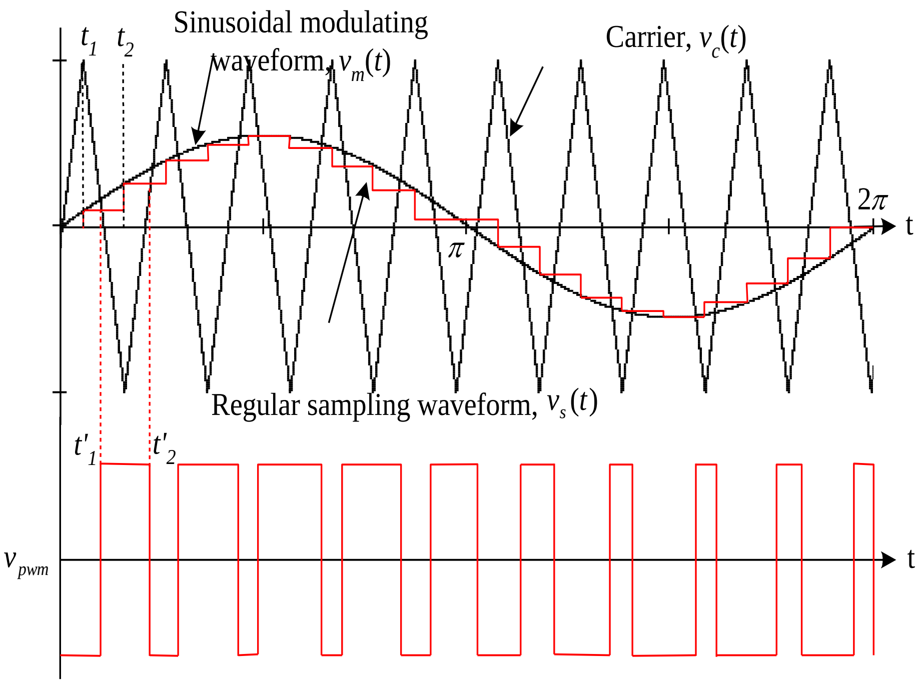
PWM Controller

- Produces two complementary pulses to control half-bridge transistors.
- **Problem:**
  - Voltage may drop when the input voltage is decreased.
- **Solution:**
  - A feedback network may be added for voltage regulation.



Pulse Width Modulation



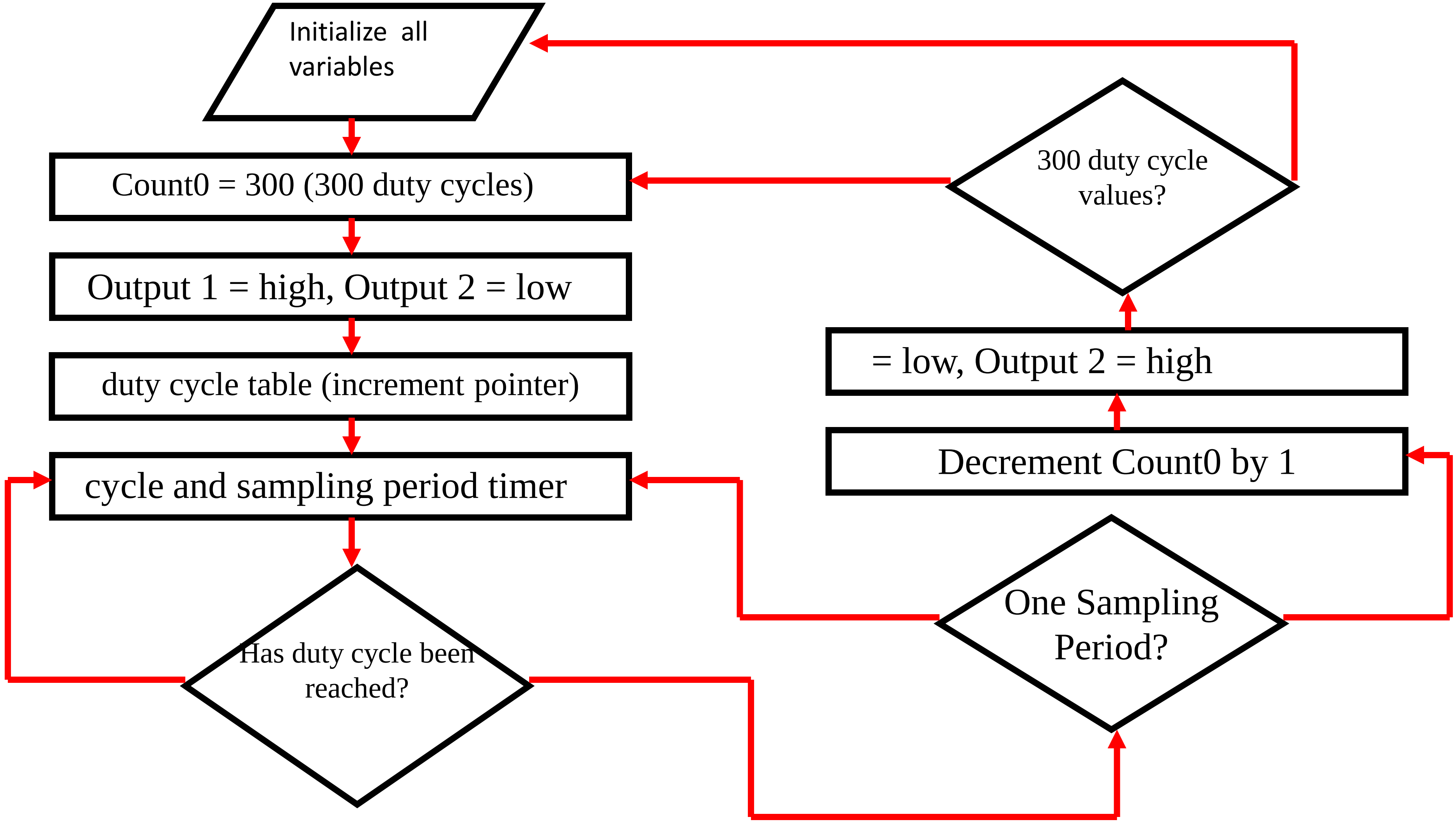


Regular sampling PWM

Triangulation method (Natural sampling). Amplitudes of the triangular wave (carrier) and sine wave (modulating) are compared to obtain PWM waveform. Analogue comparator may be used. Basically an analogue method. Its digital version, known as REGULAR sampling is widely used in industry.

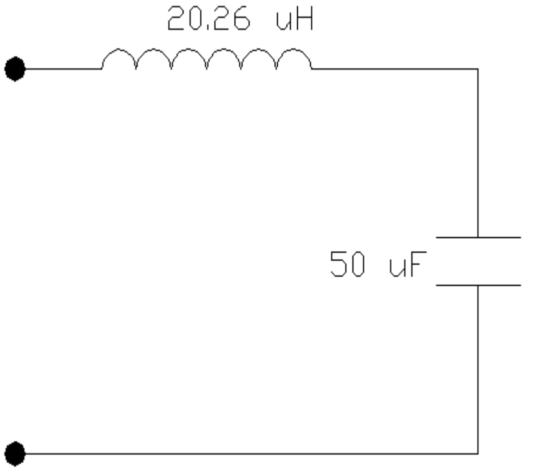
Software Flow Diagram

(Dr. Yaroslav Koshka)

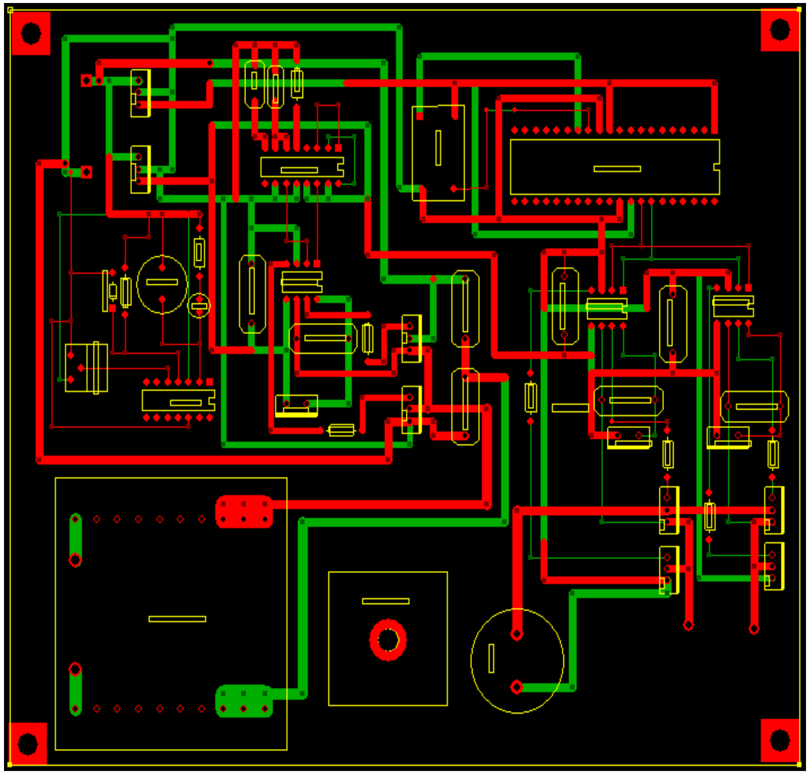


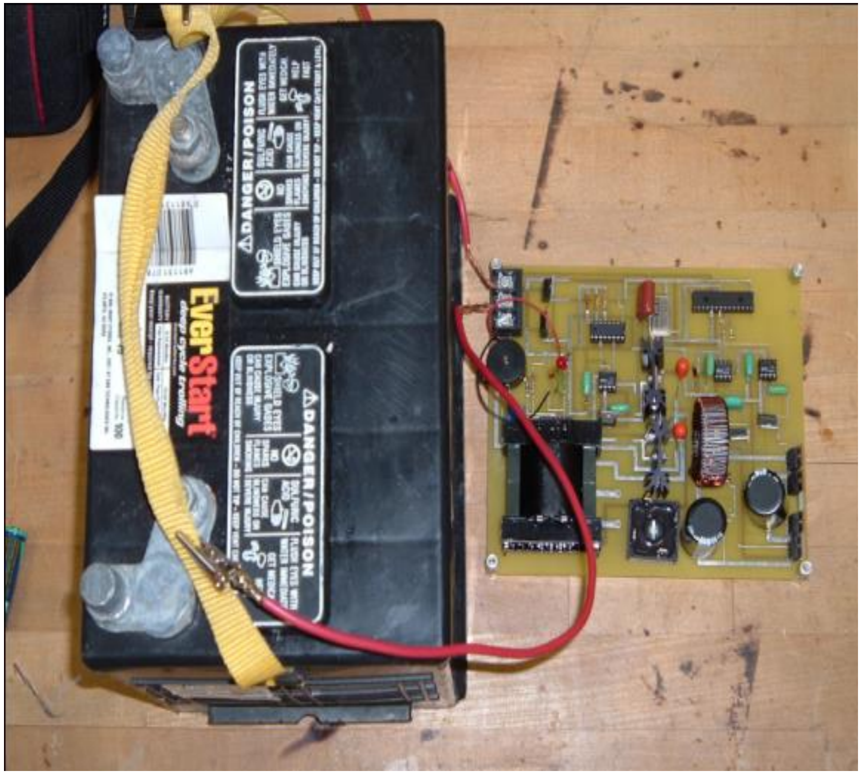
Low-pass Filter

- 2nd order *L-C* filter
  - Filters to retain a 60 Hz fundamental frequency
  - Few components
  - Handle current
  - Wind inductor (fine tune)



PCB Layout

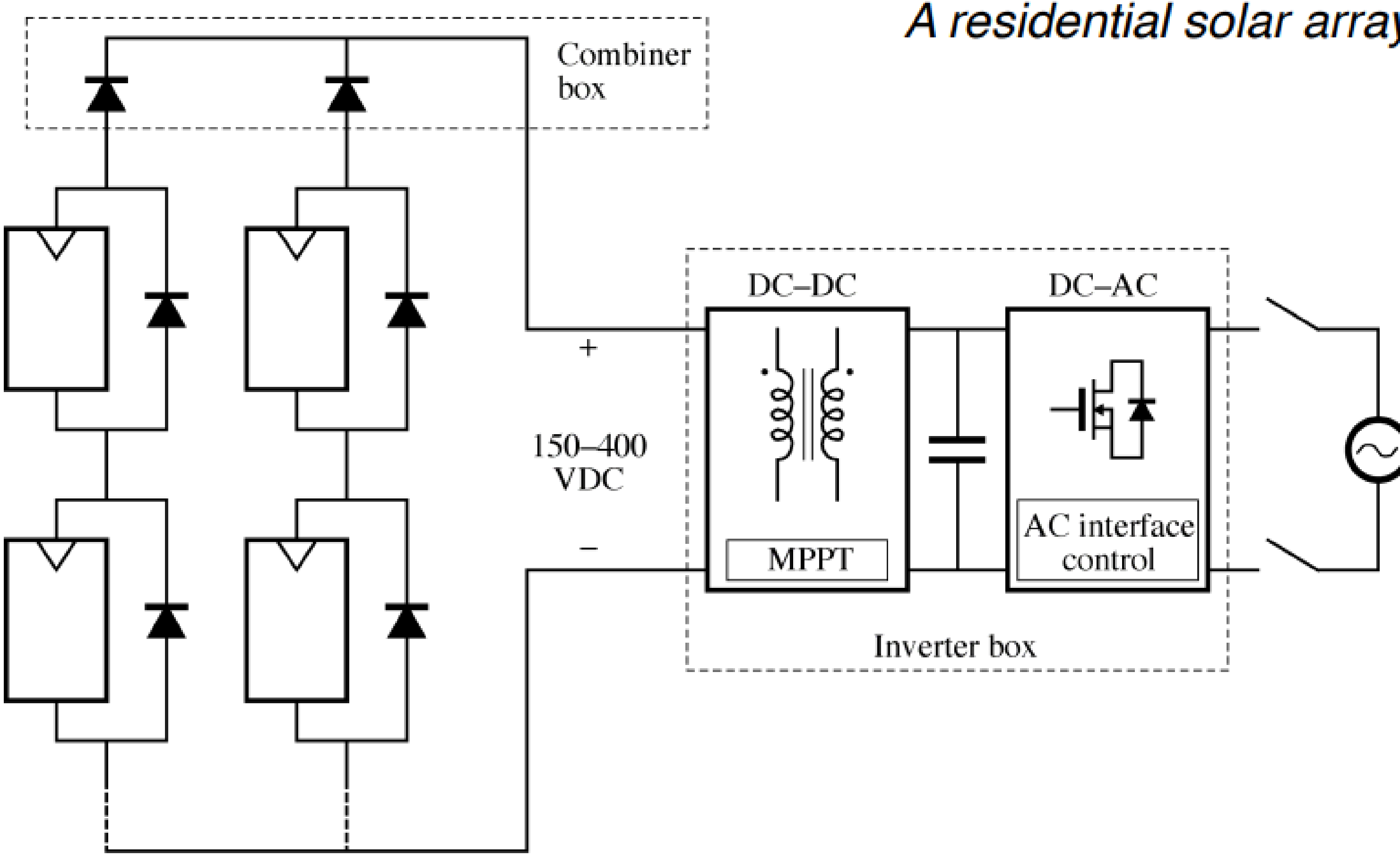


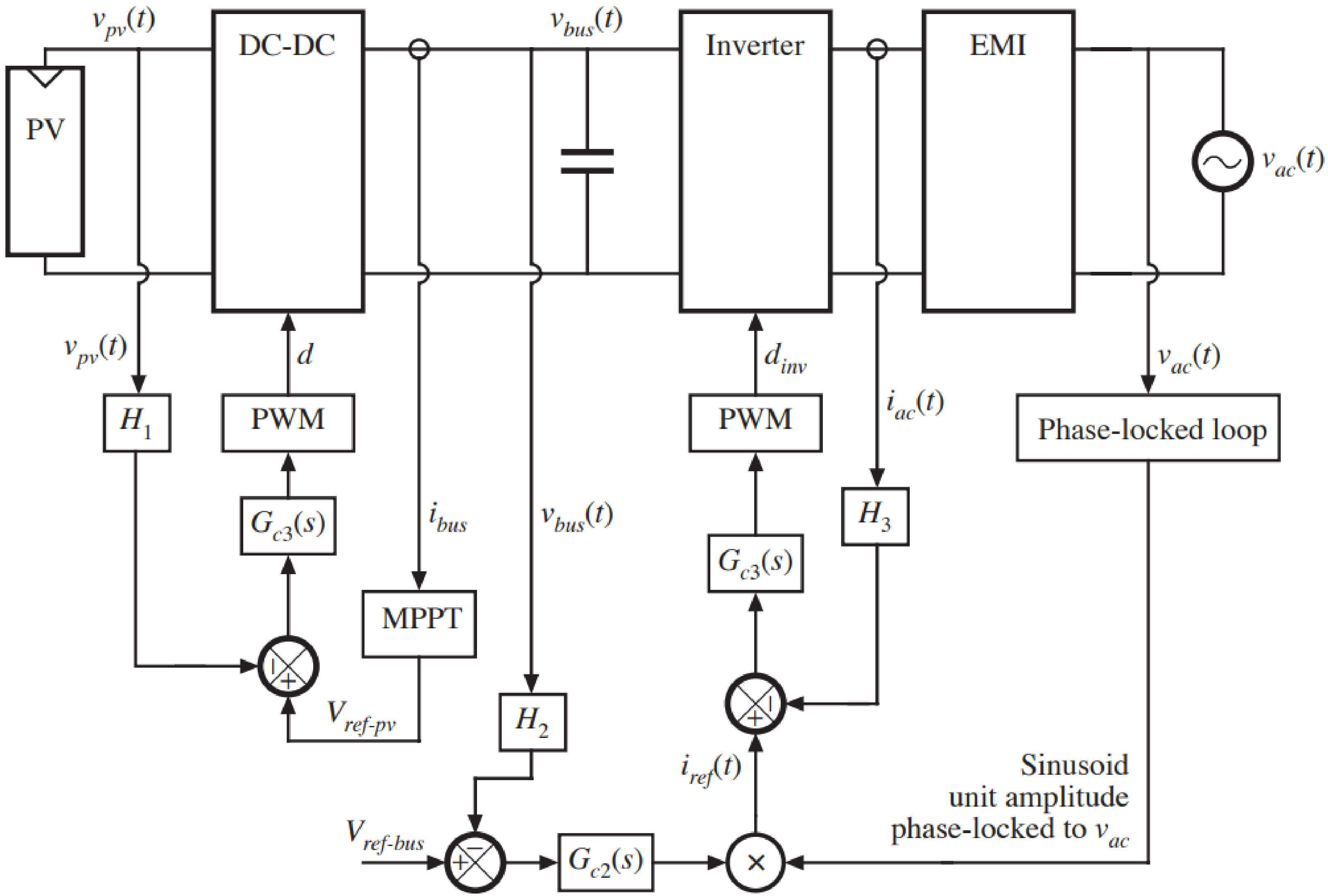


Case Study: Solar System Using Inverters
Stand Alone; Simple Grid Tied; Grid Tie with Battery

Solar Schoolhouse and San Mateo College

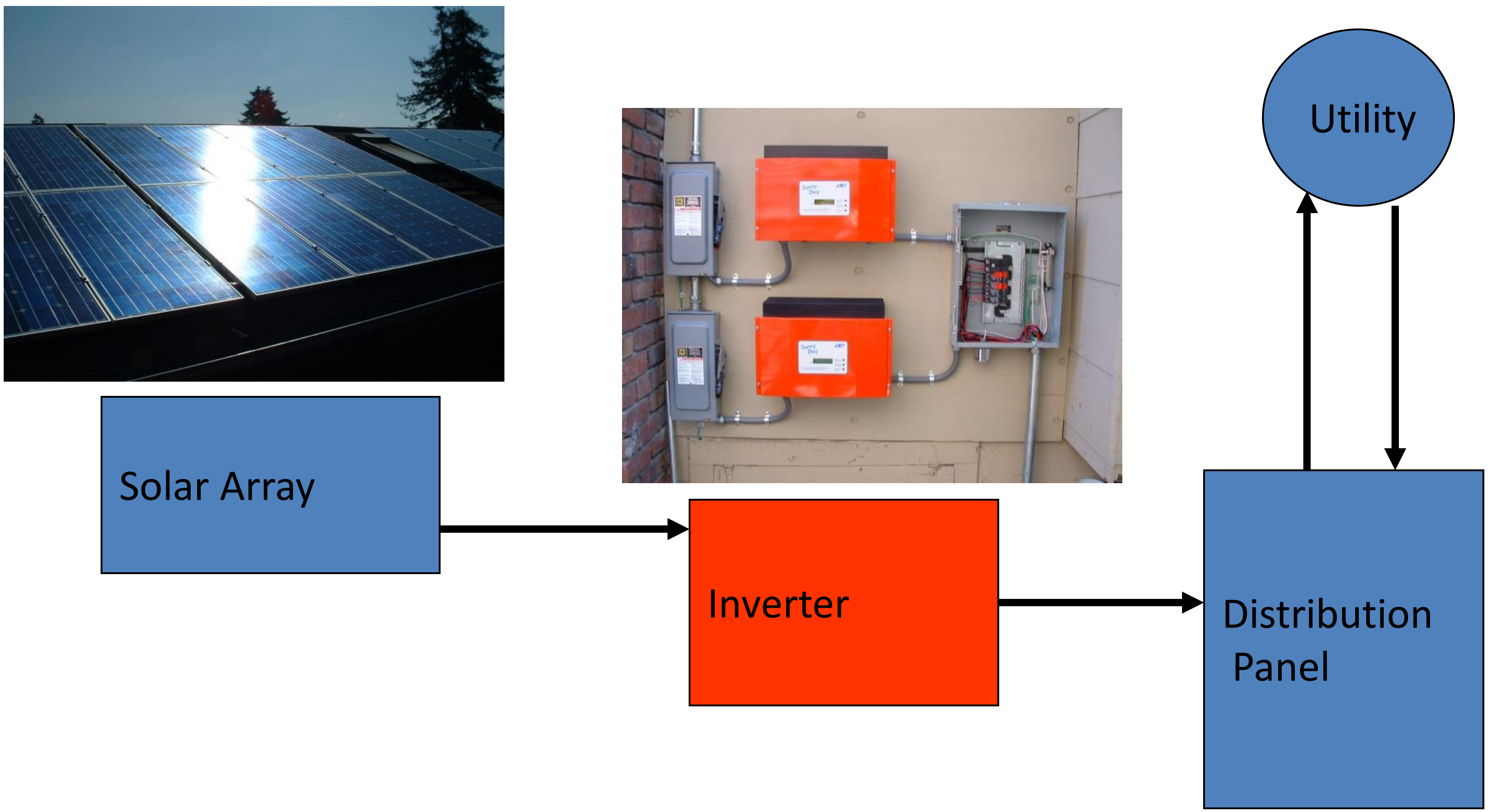
A residential solar array system



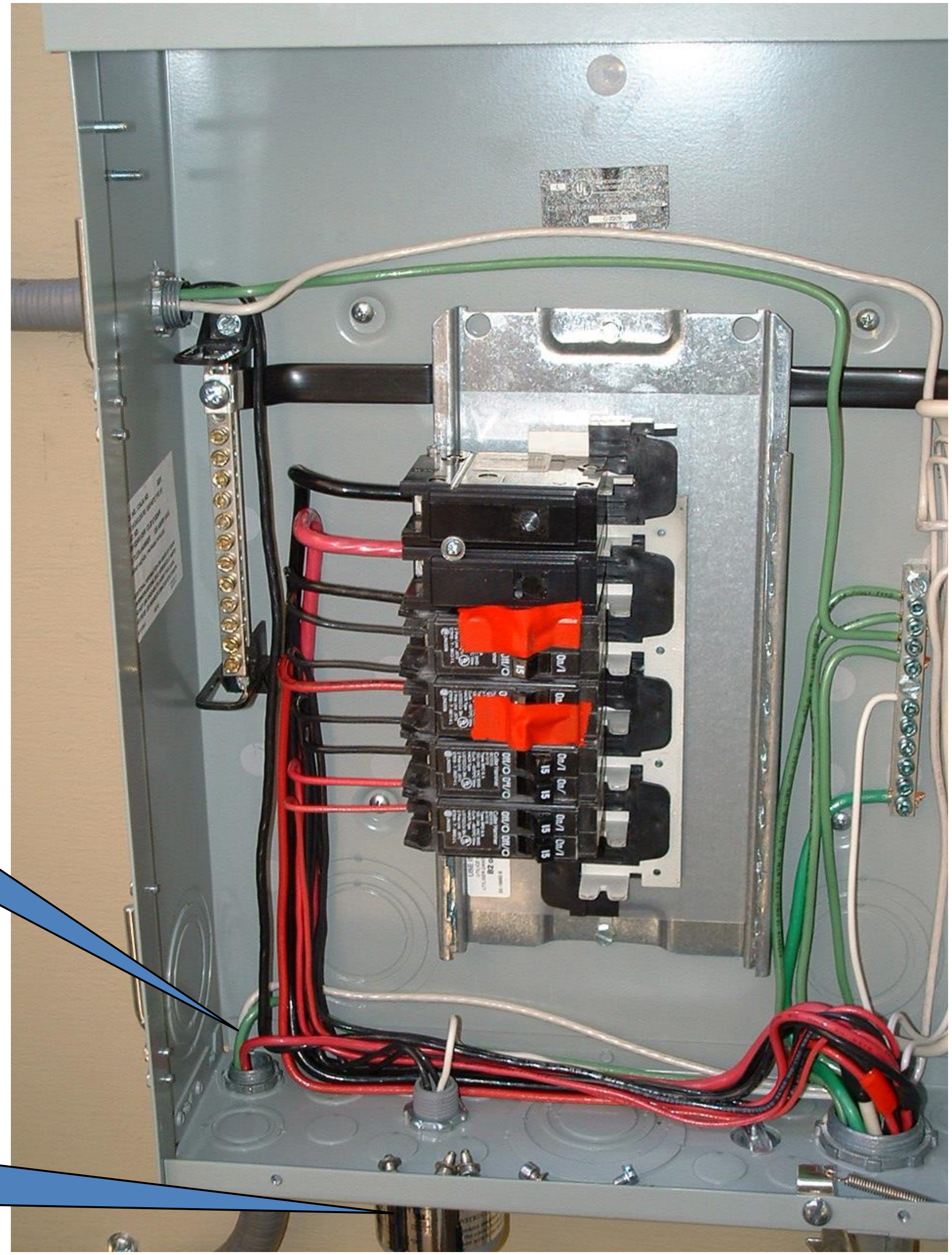


vpv(t)
DC-DC
vbus(t)
Inverter
EMI
PV
vac(t)
vpv(t)
d
dinv
vac(t)
H1
PWM
PWM
iac(t)
Phase-locked loop
Gc3(s)
ibus
vbus(t)
Gc3(s)
H3
MPPT
Vref-pv
H2
iref(t)
Sinusoid
unit amplitude
phase-locked to vac
Vref-bus
Gc2(s)

Simple Grid-Connected System



Subpanel

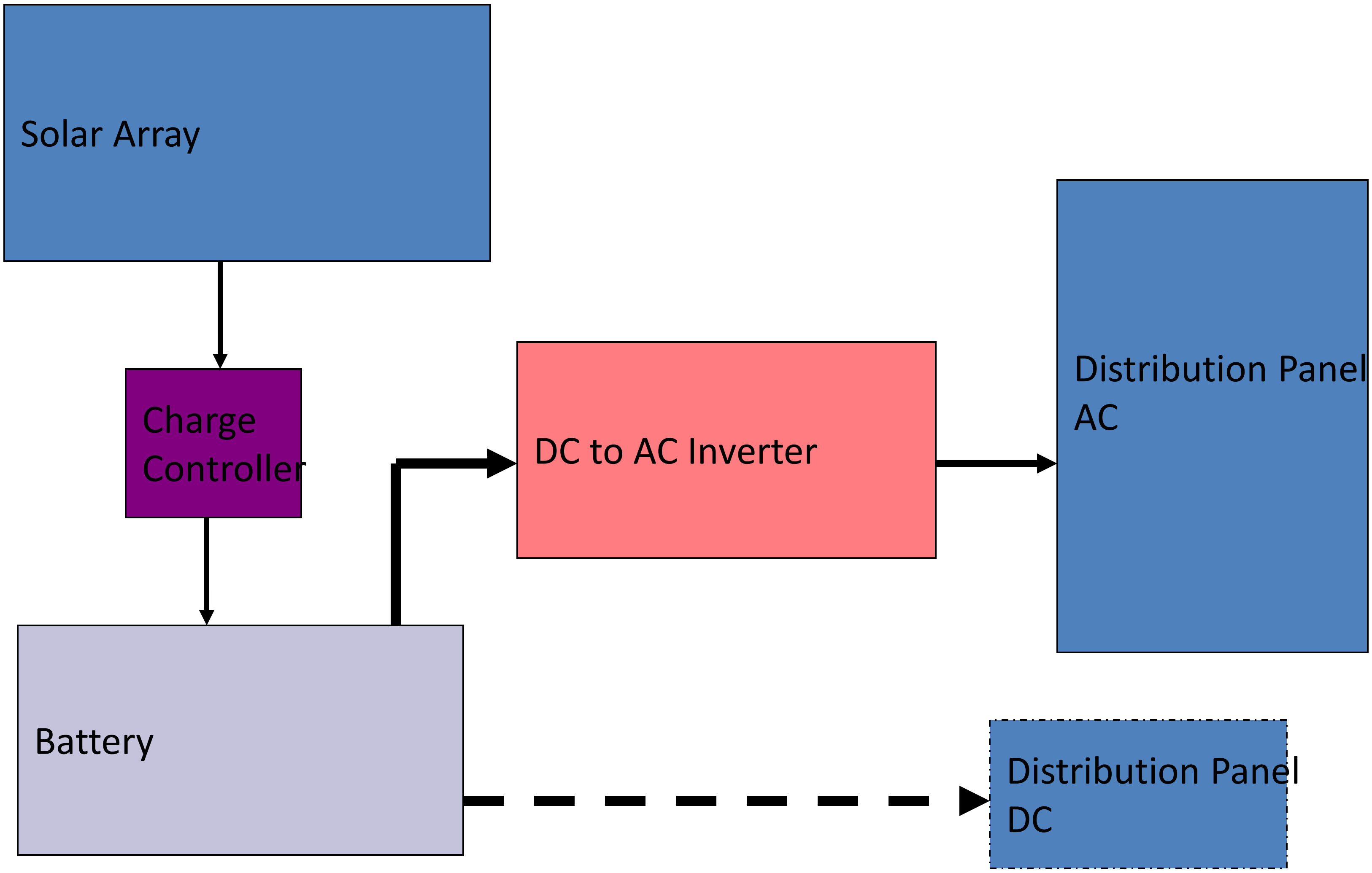


Solar AC in from Inverter

Lightning surge arrestor


GENERAL ELECTRIC
KILOWATTHOURS
CL 200
240V 3W
720X1G1
650T73
44 289 079
WARNING
DUAL POWER SUPPLY
SOLAR ELECTRIC SOURCE

Stand Alone Residential System



Small Stand Alone System

(to power an office)

Solar Array

Charge Control

Storage: Battery

“Fuel Gauge”

Inverter DC to AC