Study of a grid-connected photovoltaic power conversion system with single-phase multilevel inverter

Dan Fisher
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Beser, E., Arifoglu, B., Camur, S., Kandemir Beser, E., 2010. A grid-connected photovoltaic power conversion system with single-phase multilevel inverter. Solar Energy 84 (12), 2056-2067.

Photovoltaic systems

- Typical: DC bus voltage input into an inverter
- Maximum power point tracker (MPPT) controls power from the PV array

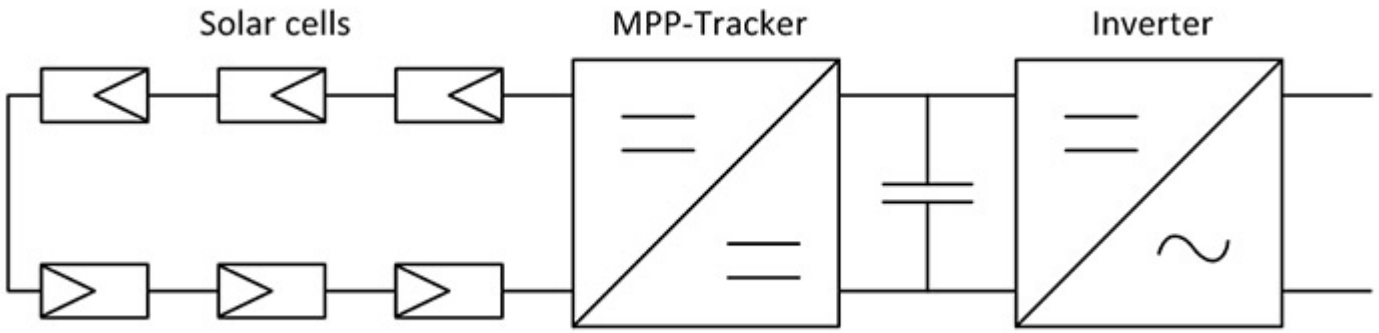
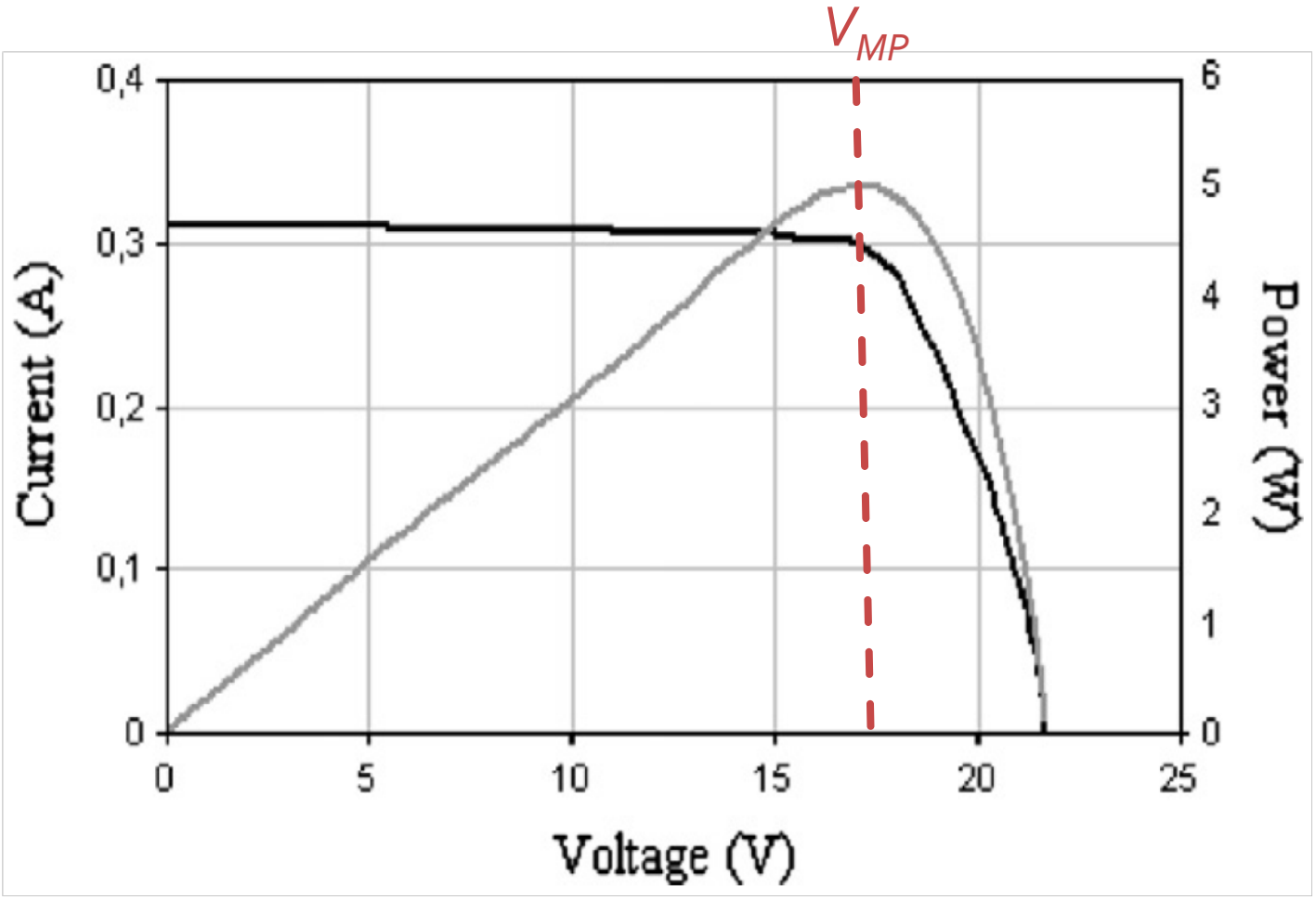


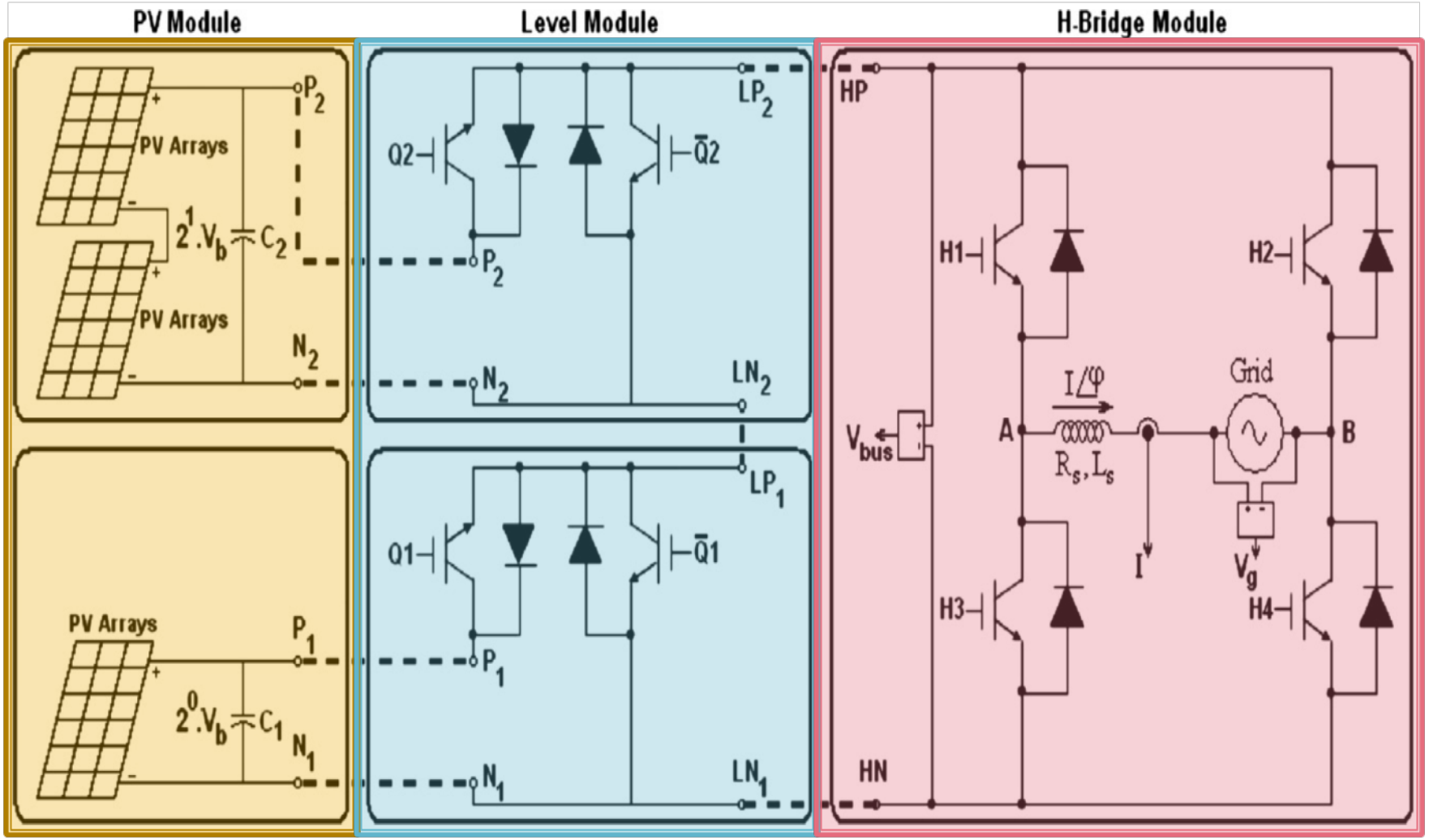
Image – http://www.semikron.com/applications/solar-energy/application-examples.html

PV array I-V and P-V curves



(Beser et al., 2010)

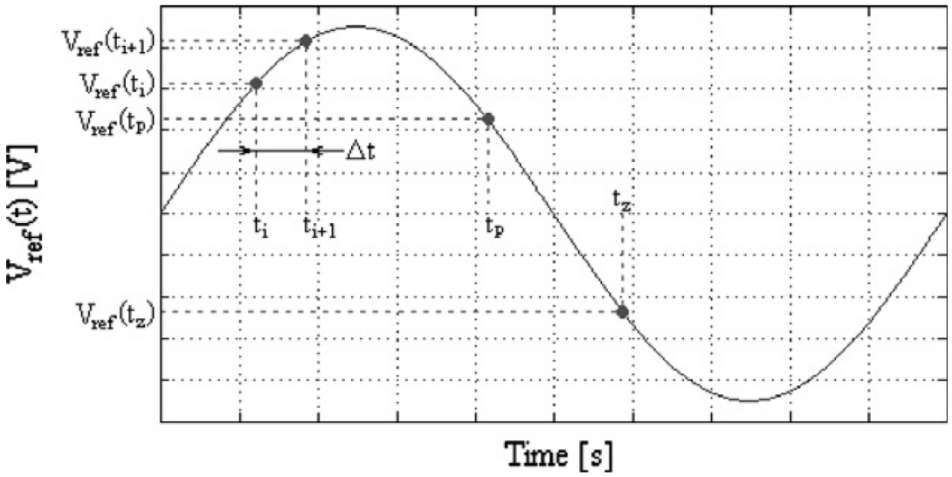
Proposed inverter topology



(Beser et al., 2010)

Switching scheme

- Reference voltage $V_{ref} = V_{max} \sin(\omega t + \delta_{ref})$



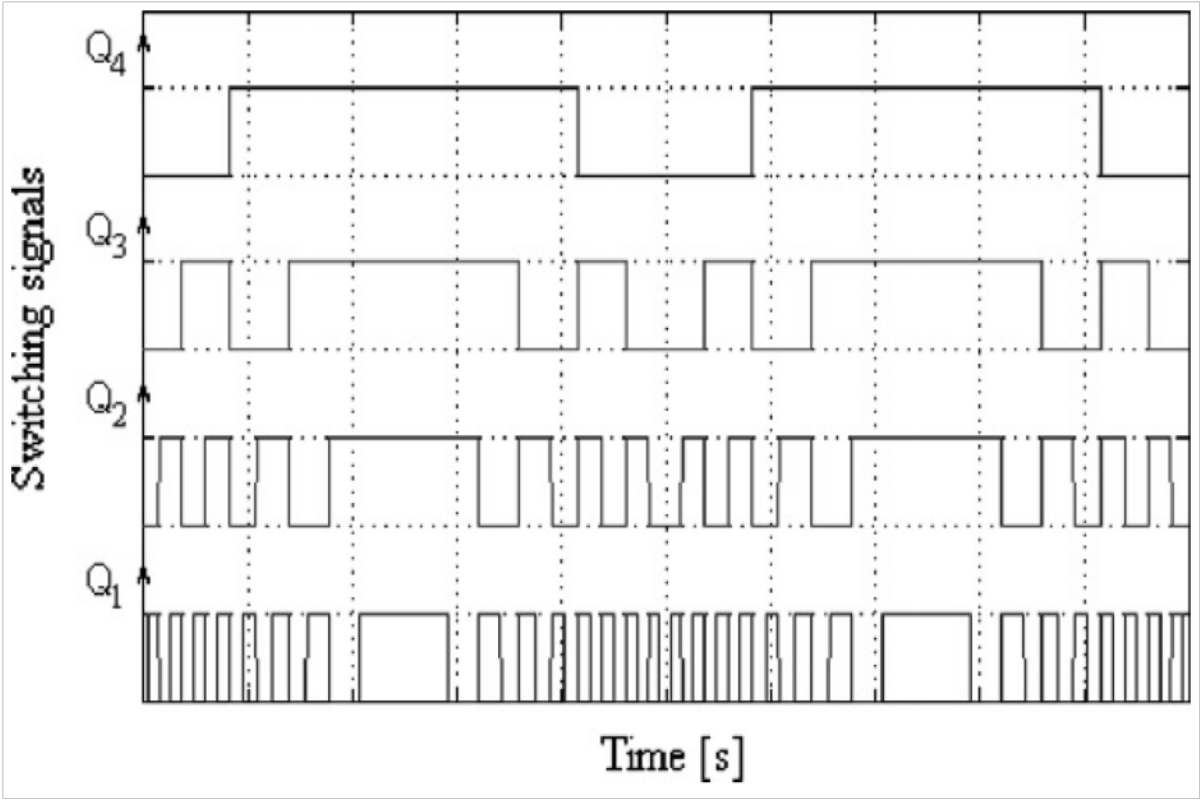
- Switching equations: $Q_1(t) = V_{ref}(t) \bmod 2$

  and $Q_k(t) = \left(\frac{V_{ref}(t) - V_{ref}(t) \bmod 2^{(k-1)}}{2^{(k-1)}} \right) \bmod 2$

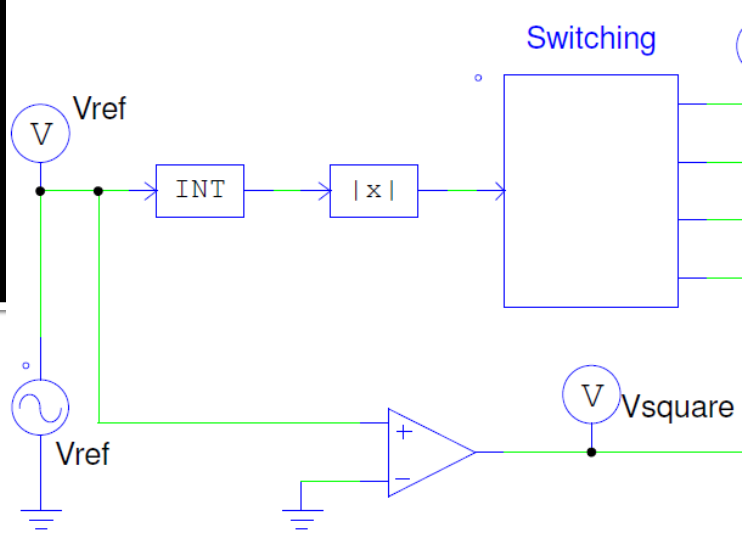
(Beser et al., 2010)

Switching scheme

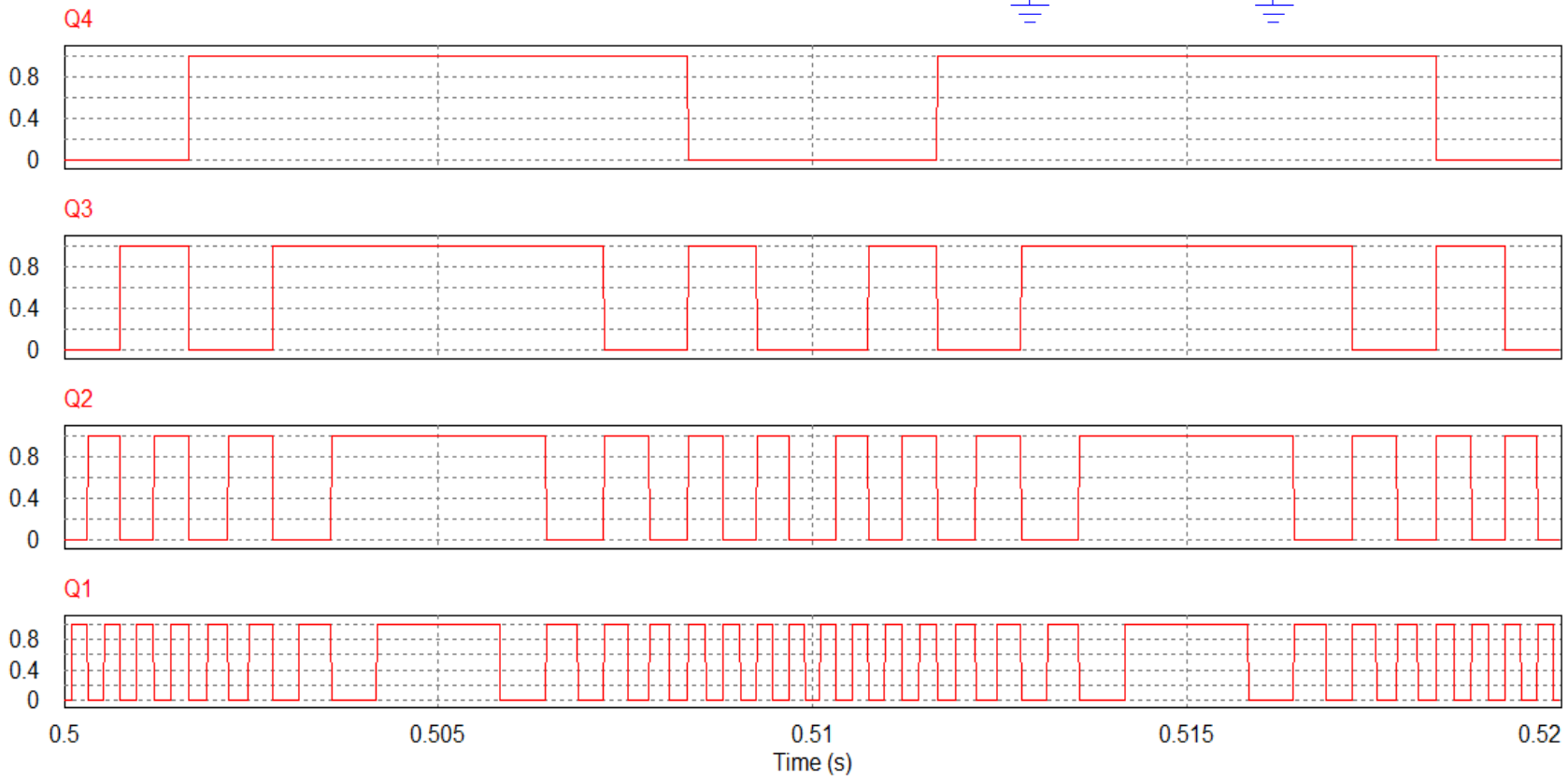
- Besser et al.:



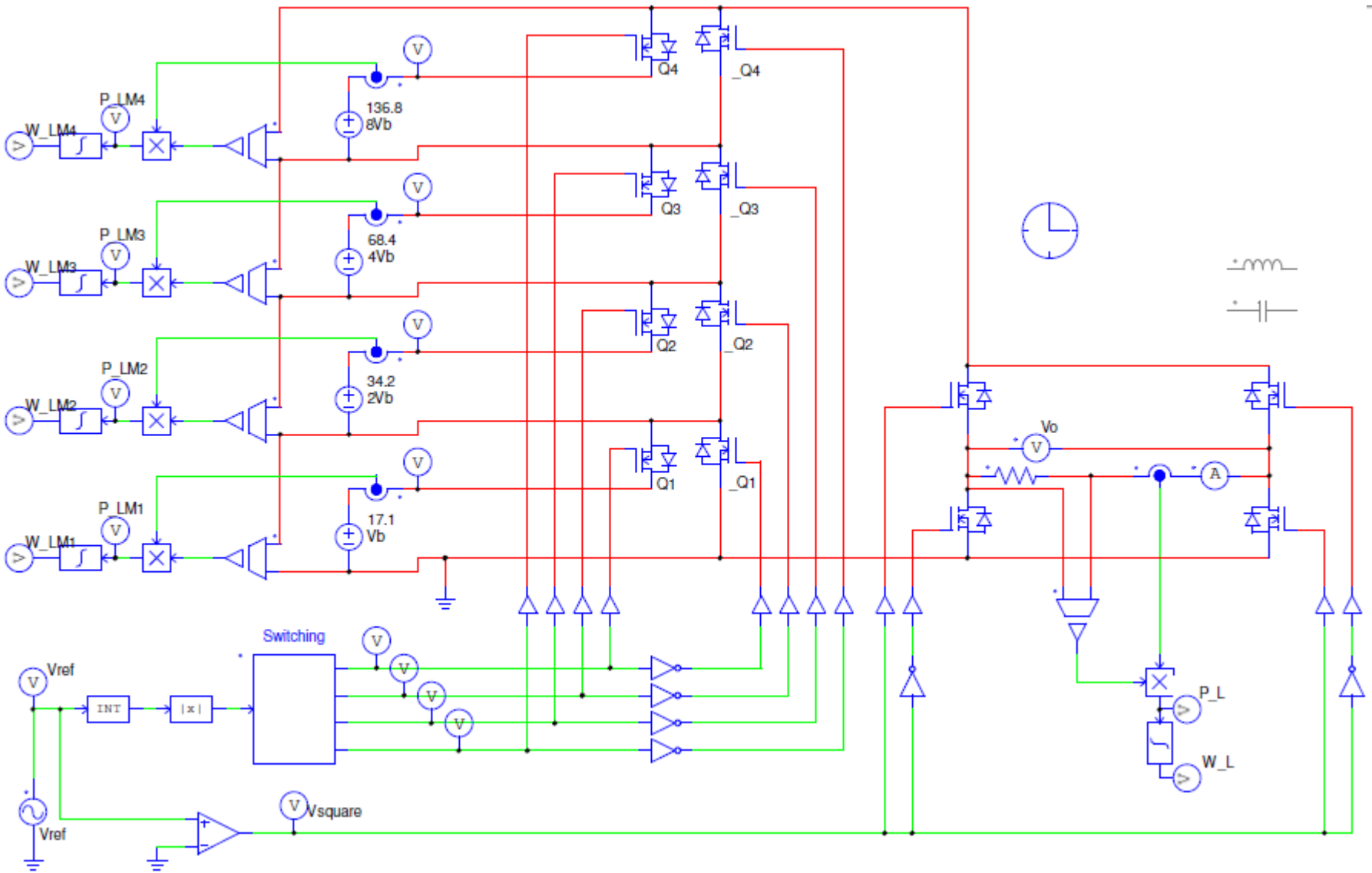
Switching scheme



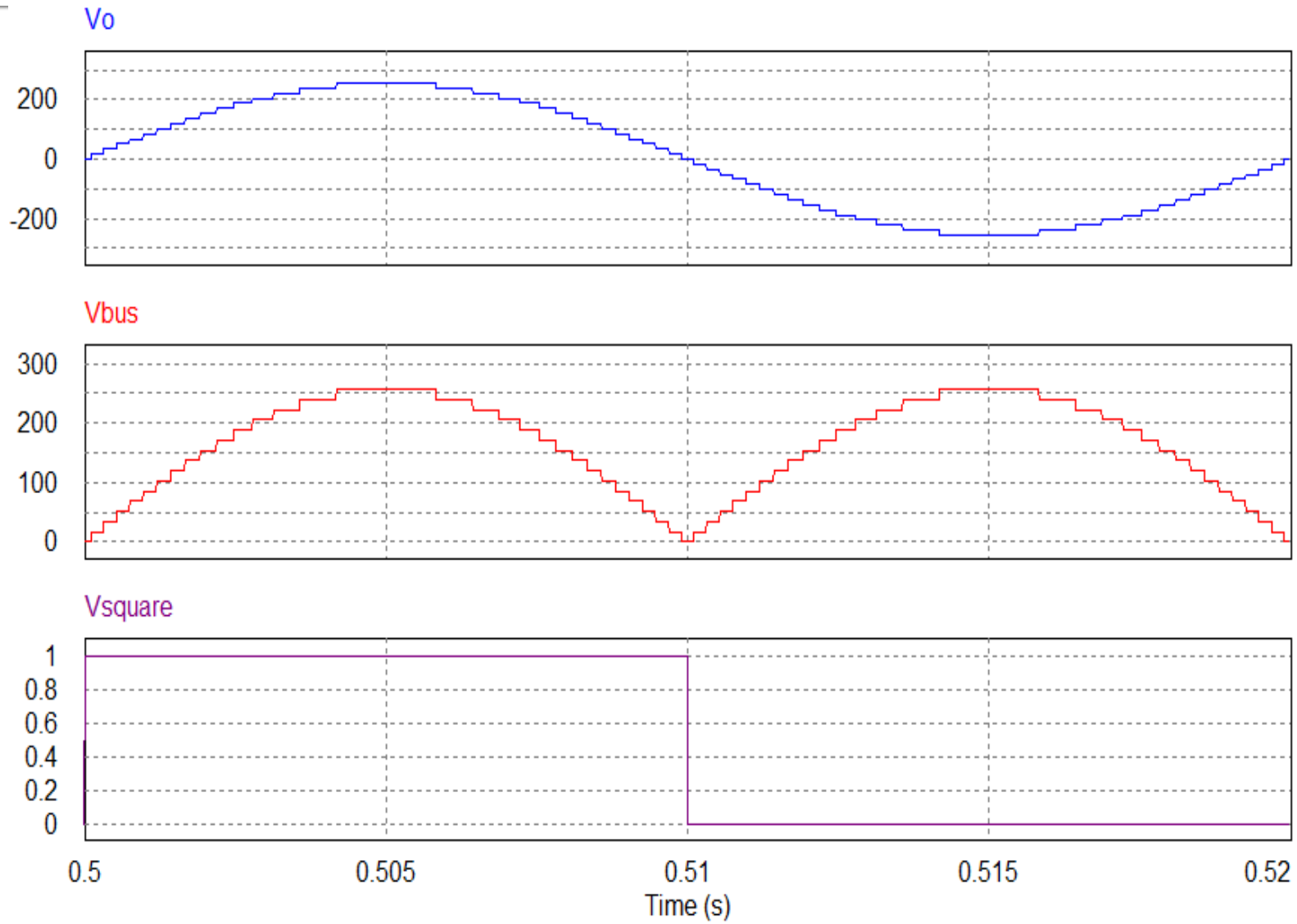
- Fisher:



Simulation (DC sources)



Simulation (DC sources)

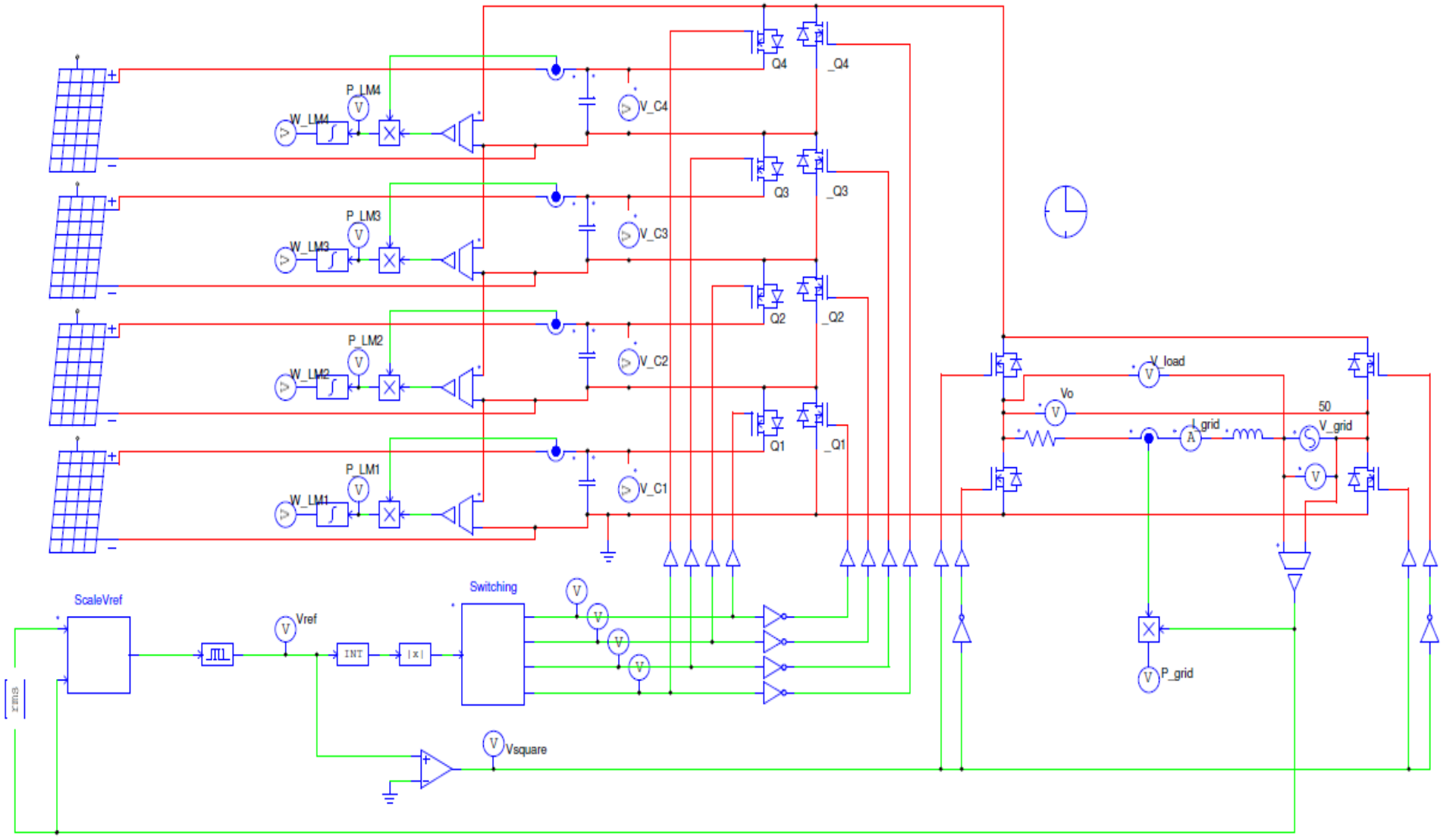


PV array power considerations

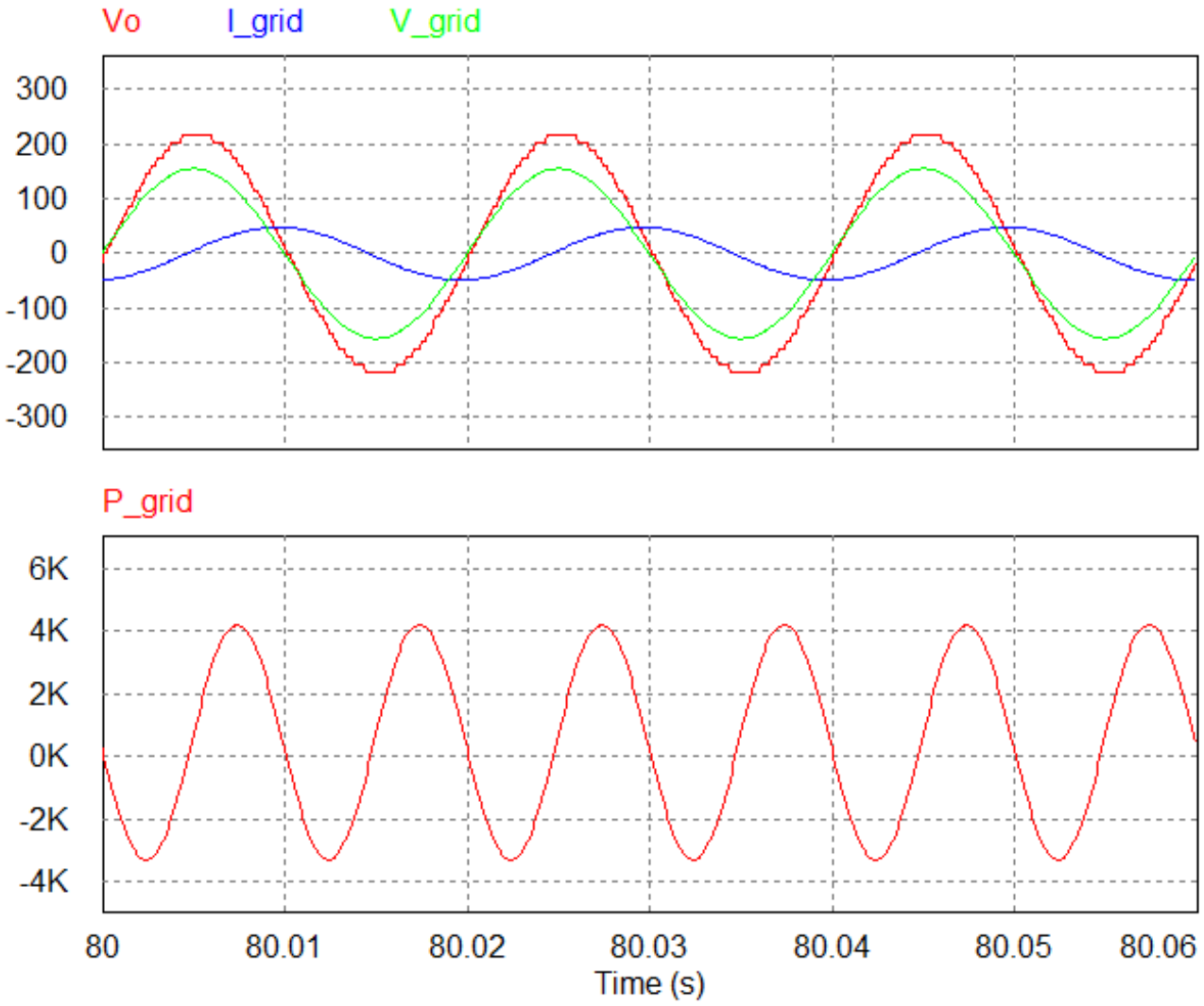
Load side			Series load			
W_L (J)	P_L (W)		Q_L (VAr)	R (Ω)	X_L (Ω)	X_C (Ω)
10.052	497	502	0	65.76	-	-
20.103	1026	1004	0	32.88	-	-
40.207	2034	2008	0	16.44	-	-
6.181	309	309	463	32.88	49.32	-
17.463	869	873	-337	32.88	-	12.73

Calculated from simulations:		
P_{LM1}	-49.06	W
P_{LM2}	-111.56	W
P_{LM3}	-254.63	W
P_{LM4}	-589.78	W

Simulation (PV arrays & grid ref)



Simulation (PV arrays & grid ref)



Control – Where's the knob?!

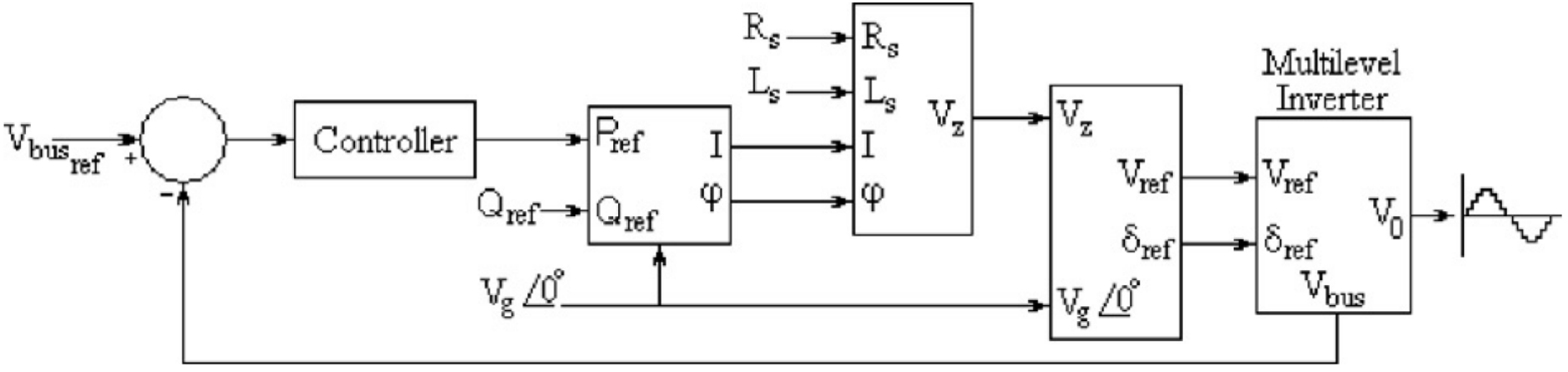


Fig. 12. Control block diagram of the proposed PV assisted inverter system.

δ_{ref} (deg)	time delay (s)	P_{grid} (W)	V_o (V-rms)	I_{grid} (A-rms)	Q (VAr)
0.0	0	469.14	154.97	34.63	1507.21
-1.0	0.0000556	580.18	146.55	27.94	980.70
-1.8	0.0001000	470.22	154.96	34.62	1506.08
-3.6	0.0002000	267.89	165.42	43.05	2328.88
-10.8	0.0006000	-1180.87	198.01	70.93	6322.97