

Design Kit

PV Li-Ion Battery System

Contents



	Slide #
1. Lithium-Ion Batteries Pack	
1.1 Lithium-Ion Batteries Pack Specification.....	3
1.2 Discharge Time Characteristics.....	4
1.3 Single Cell Discharge Characteristics.....	5
1.4 Charge Time Characteristics.....	6
2. Solar Cells	
2.1 Solar Cells Specification.....	7
2.2 Output Characteristics vs. Incident Solar Radiation.....	8
3. Solar Cell Battery Charger.....	9
3.1 Concept of Simulation PV Li-Ion Battery Charger Circuit.....	10
3.2 PV Li-Ion Battery Charger Circuit.....	11
3.3 Charging Time Characteristics vs. Weather Condition.....	12
3.4 Concept of Simulation PV Li-Ion Battery Charger Circuit + Constant Current.....	13
3.5 Constant Current PV Li-Ion Battery Charger Circuit.....	14
3.6 Charging Time Characteristics vs. Weather Condition + Constant Current.....	15
4. Simulation PV Li-Ion Battery System in 24hr.	
4.1 Concept of Simulation PV Li-Ion Battery System in 24hr.....	16
4.2 Short-Circuit Current vs. Time (24hr.).....	17
4.3 PV-Battery System Simulation Circuit.....	18
4.3 PV-Battery System Simulation Result.....	19-23
Simulations index.....	24

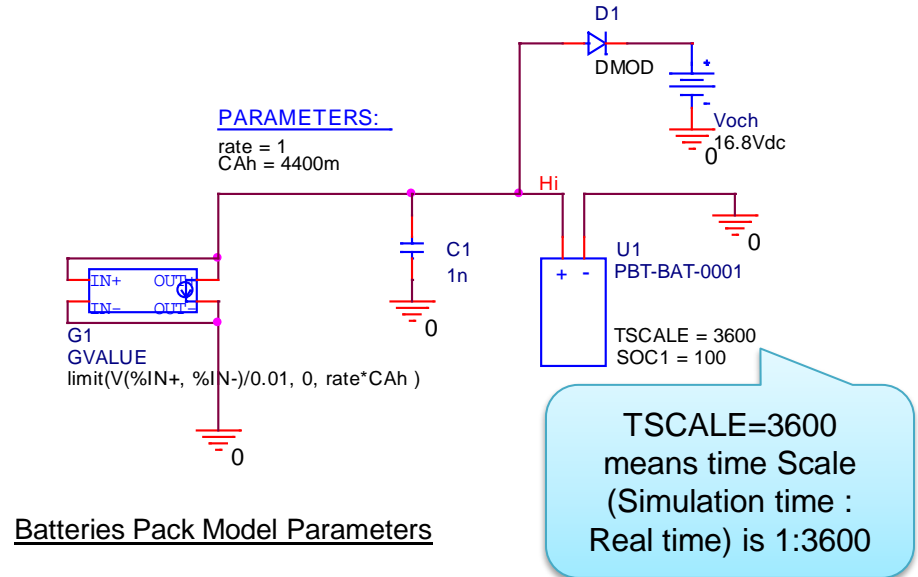
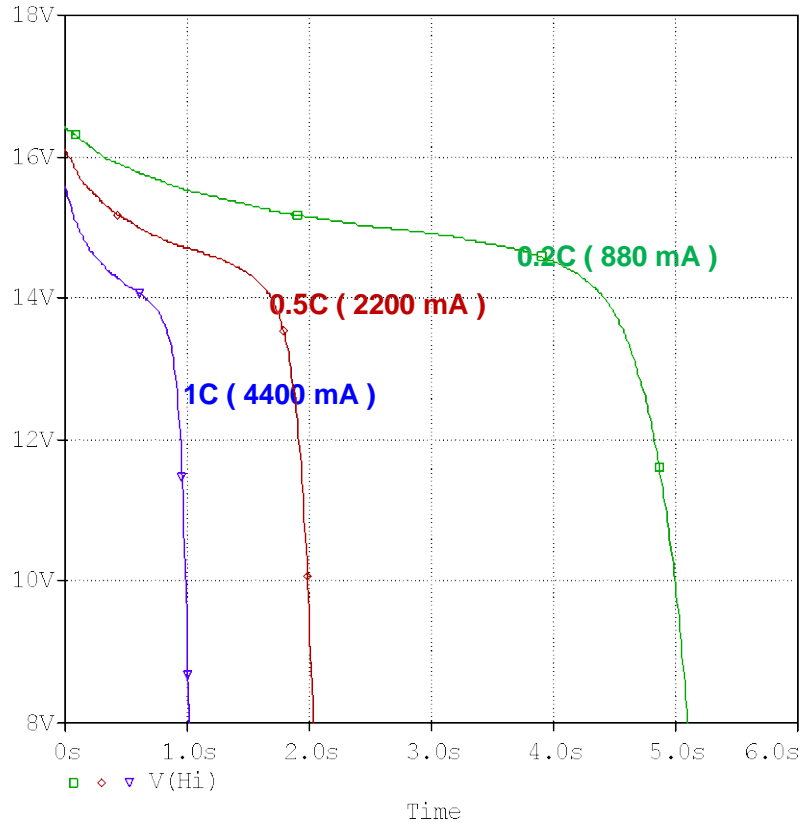
1.1 Lithium-Ion Batteries Pack Specification

BAYSUN's Lithium-Ion Batteries Pack : Power Battery Plus (PBT-BAT-0001)

- Capacity.....65[Wh], 4400[mAh] (Approximately)
- Rated Current.....3[A]
- Input Voltage.....20.5 [Vdc]
- Output Voltage.....12.8 ~ 16.4 [Vdc] (4 cells)
- Charging time.....5[hours] (Approximately)



1.2 Discharge Time Characteristics

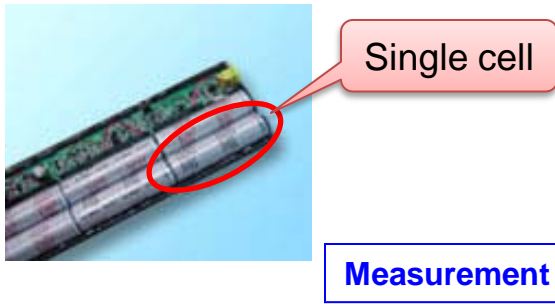


Batteries Pack Model Parameters

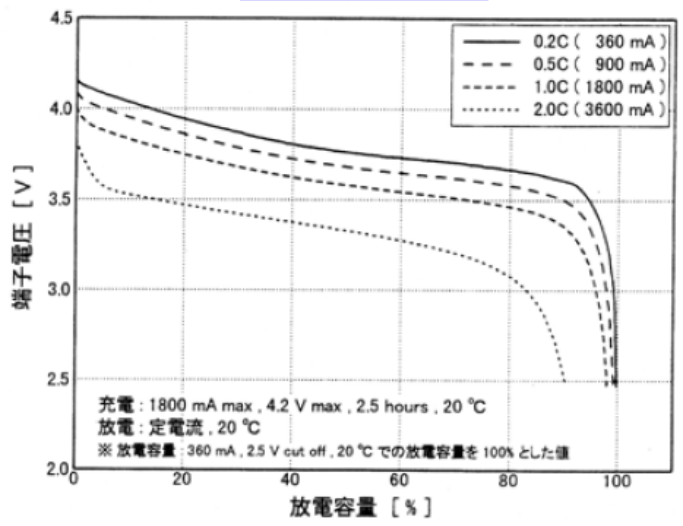
- NS (number of batteries in series) = 4 cells
- C (capacity) = 4400 mA
- SOC1 (initial state of charge) = 100%
- TSCALE (time scale) , simulation : real time
1 : 3600s or
1s : 1h

Discharge Rate : 0.2C(880mA), 0.5C(2200mA), and 1C(4400mA)

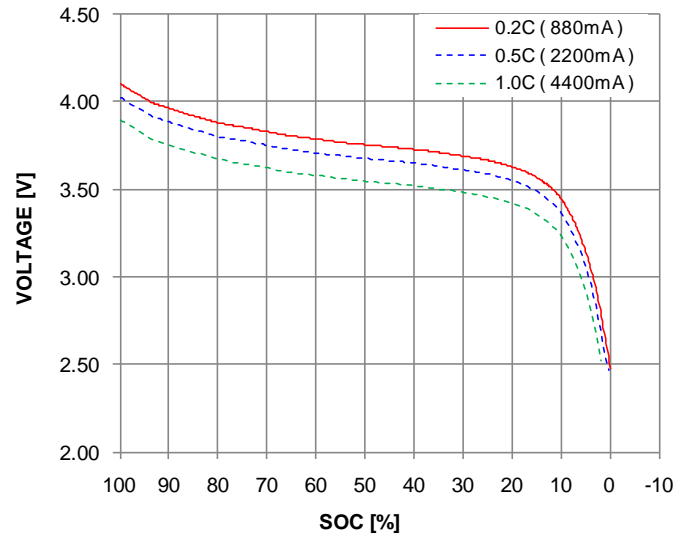
1.3 Single Cell Discharge Characteristics



Measurement

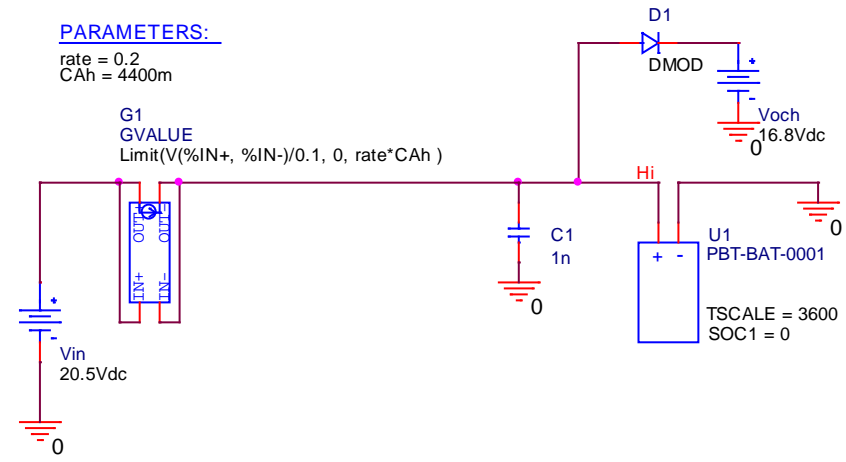
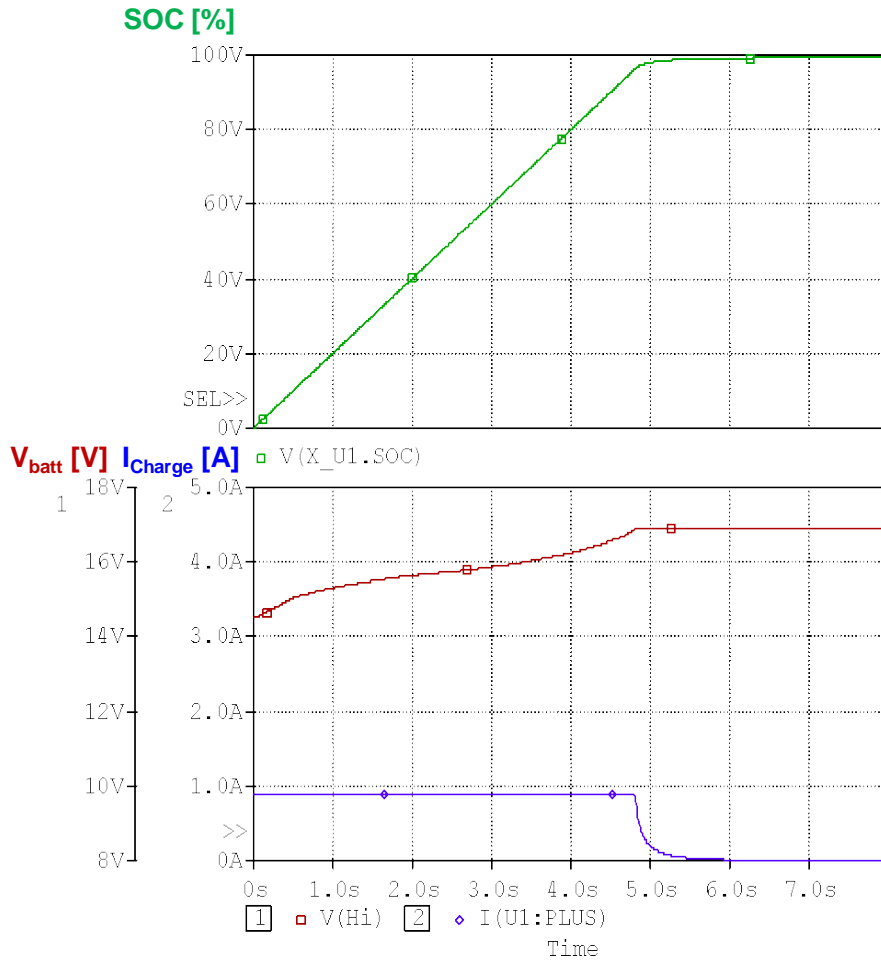


Simulation



- Single cell discharge characteristics are compared between measurement data and simulation data.

1.4 Charge Time Characteristics



Batteries Pack Model Parameters

NS (number of batteries in series) = 4 cells
C (capacity) = 4400 mA
SOC1 (initial state of charge) = 100%
TSCALE (time scale) , simulation : real time
1 : 3600s or
1s : 1h

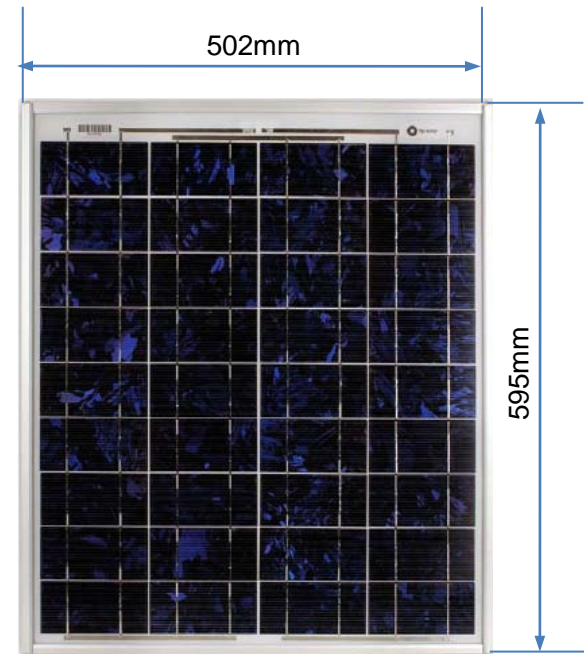
Charger Adaptor

Input Voltage = 20.5 Vdc
Input Current = 880 mA(max.)

2.1 Solar Cells Specification

BP Solar's photovoltaic module : SX330

- Maximum power (P_{max}).....30[W]
- Voltage at Pmax (V_{mp}).....16.8[V]
- Current at Pmax (I_{mp}).....1.78[A]
- Short-circuit current (I_{sc}).....1.94[A]
- Open-circuit voltage(V_{oc}).....21.0[V]



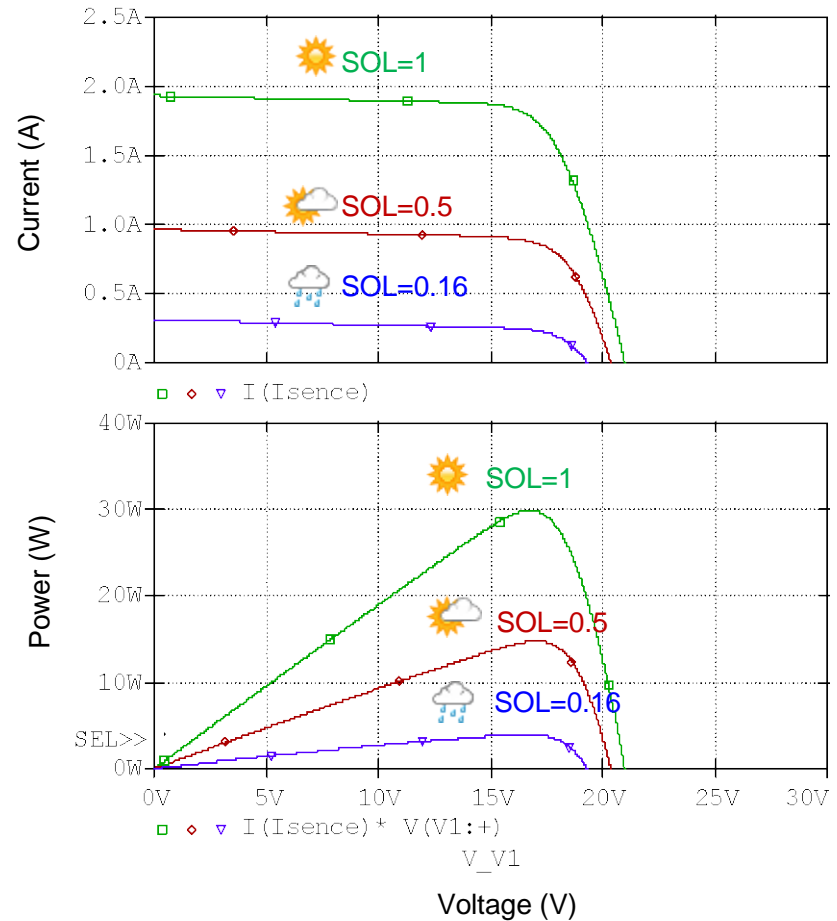
2.2 Output Characteristics vs. Incident Solar Radiation



U1
SX330
SOL = 1

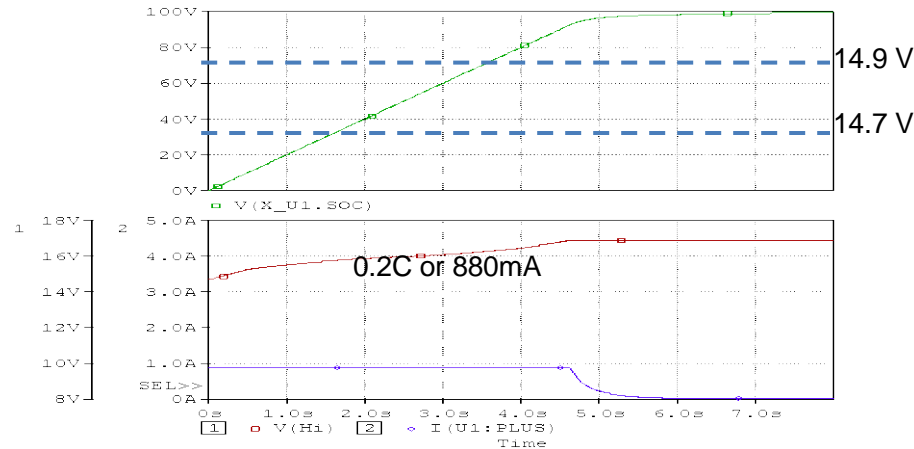
Parameter, SOL is added as normalized incident radiation, where SOL=1 for AM1.5 conditions

SX330 Output Characteristics vs. Incident Solar Radiation

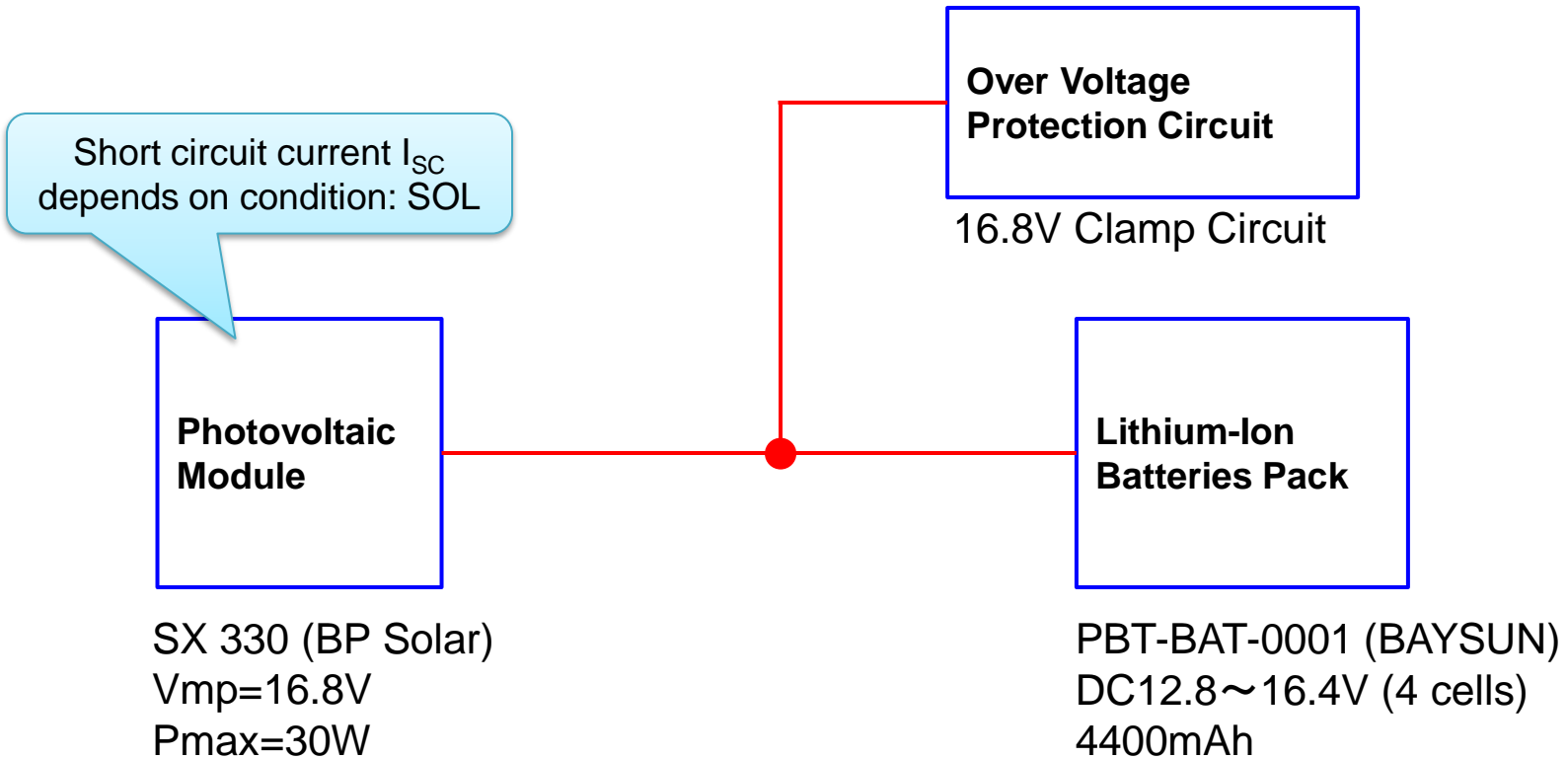


3. Solar Cell Battery Charger

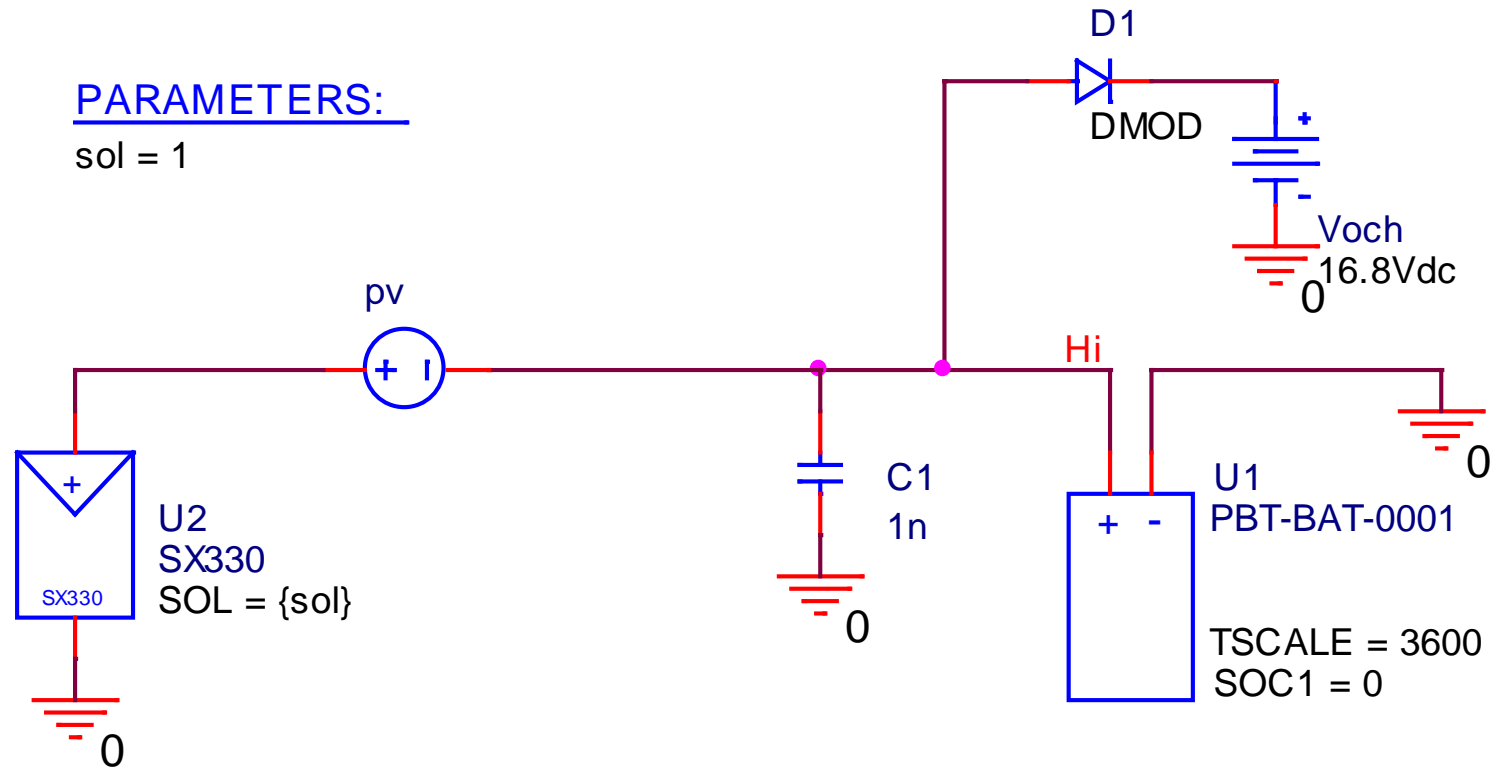
- Solar Cell charges the Li-ion batteries pack (PBT-BAT-001) with direct connect technique. Choose the solar cell that is able to provide current at charging rate or more with the maximum power voltage (V_{mp}) nears the batteries pack charging voltage.
- PBT-BAT-0001 (Li-ion batteries pack)
 - Charging time is approximately 5 hours with charging rate 0.2C or 880mA
 - Voltage during charging with 0.2C is between 14.7 to 16.9 V



3.1 Concept of Simulation PV Li-Ion Battery Charger Circuit

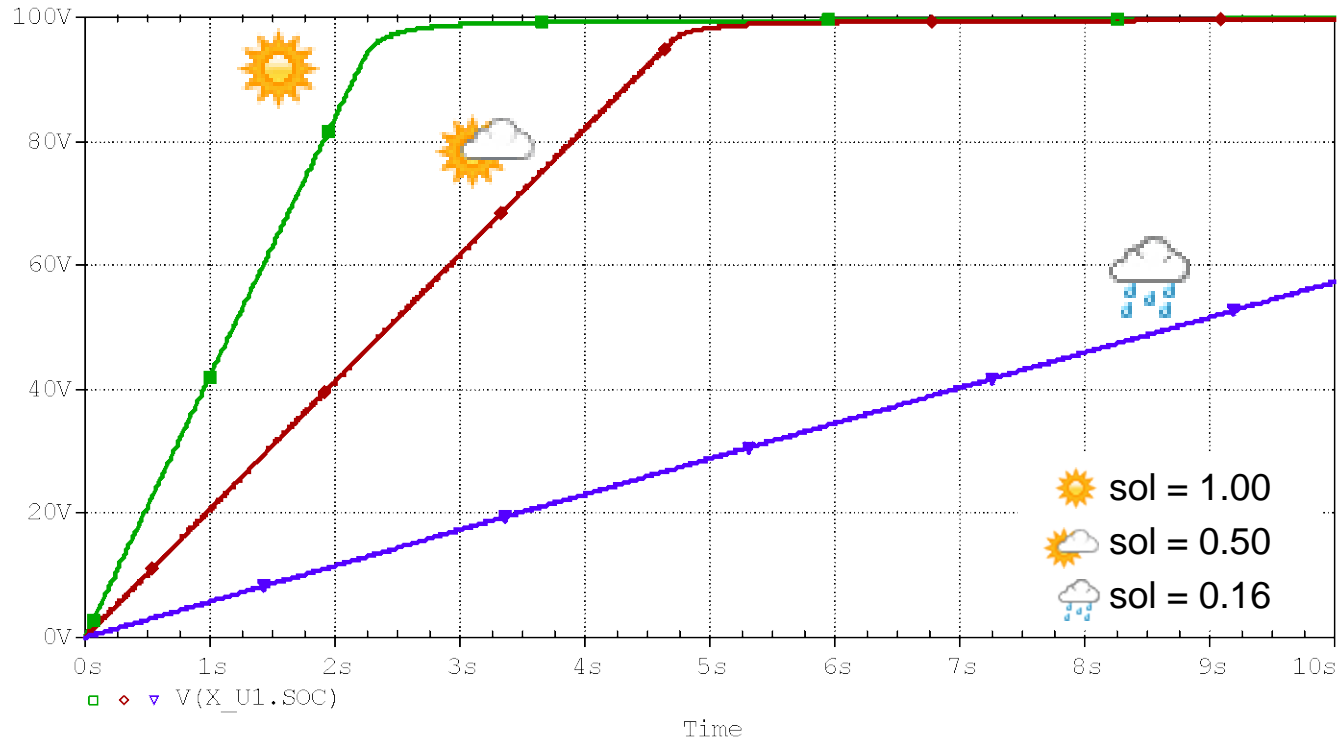


3.2 PV Li-Ion Battery Charger Circuit



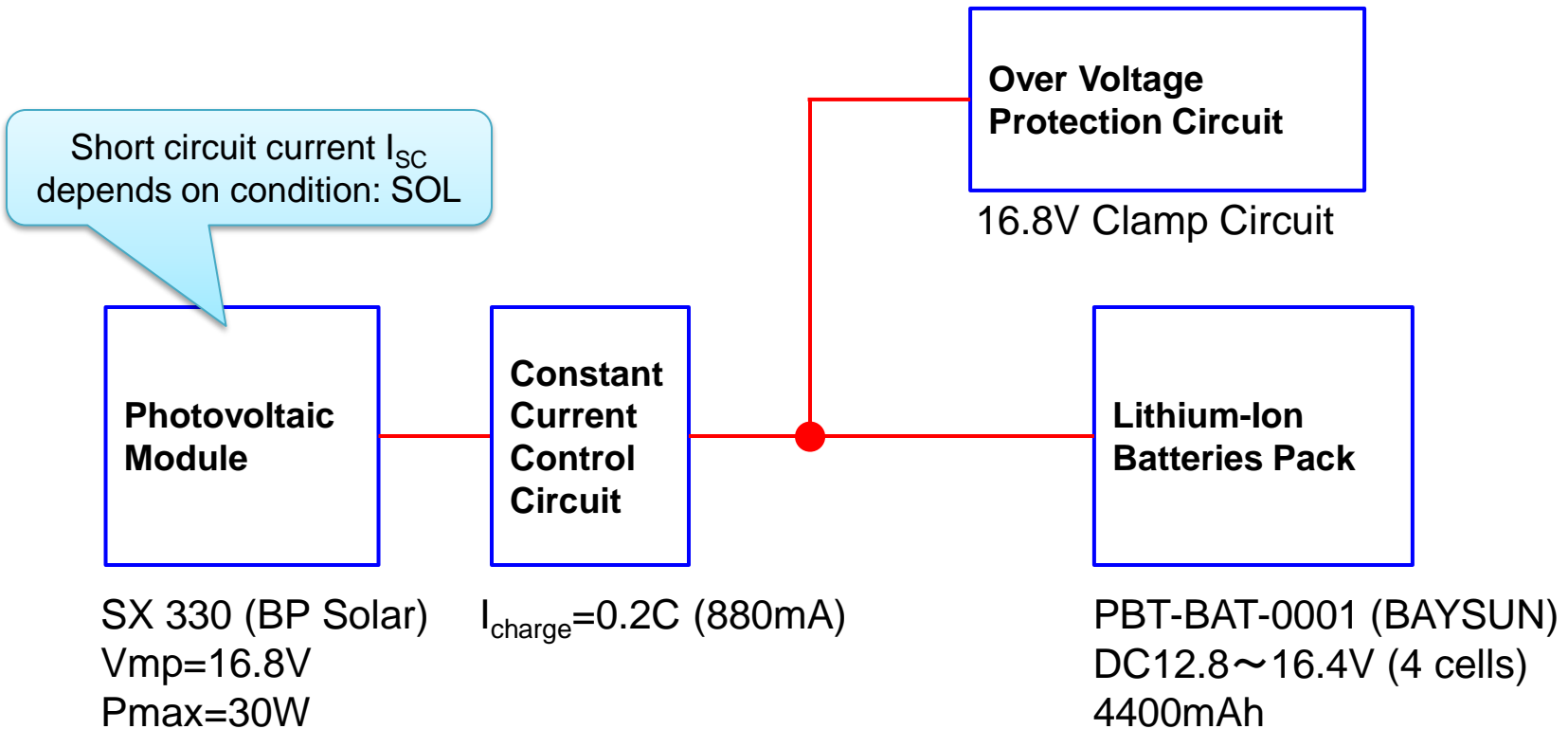
- Input value between 0-1 in the “PARAMETERS: sol = ” to set the normalized incident radiation, where SOL=1 for AM1.5 conditions.

3.3 Charging Time Characteristics vs. Weather Condition

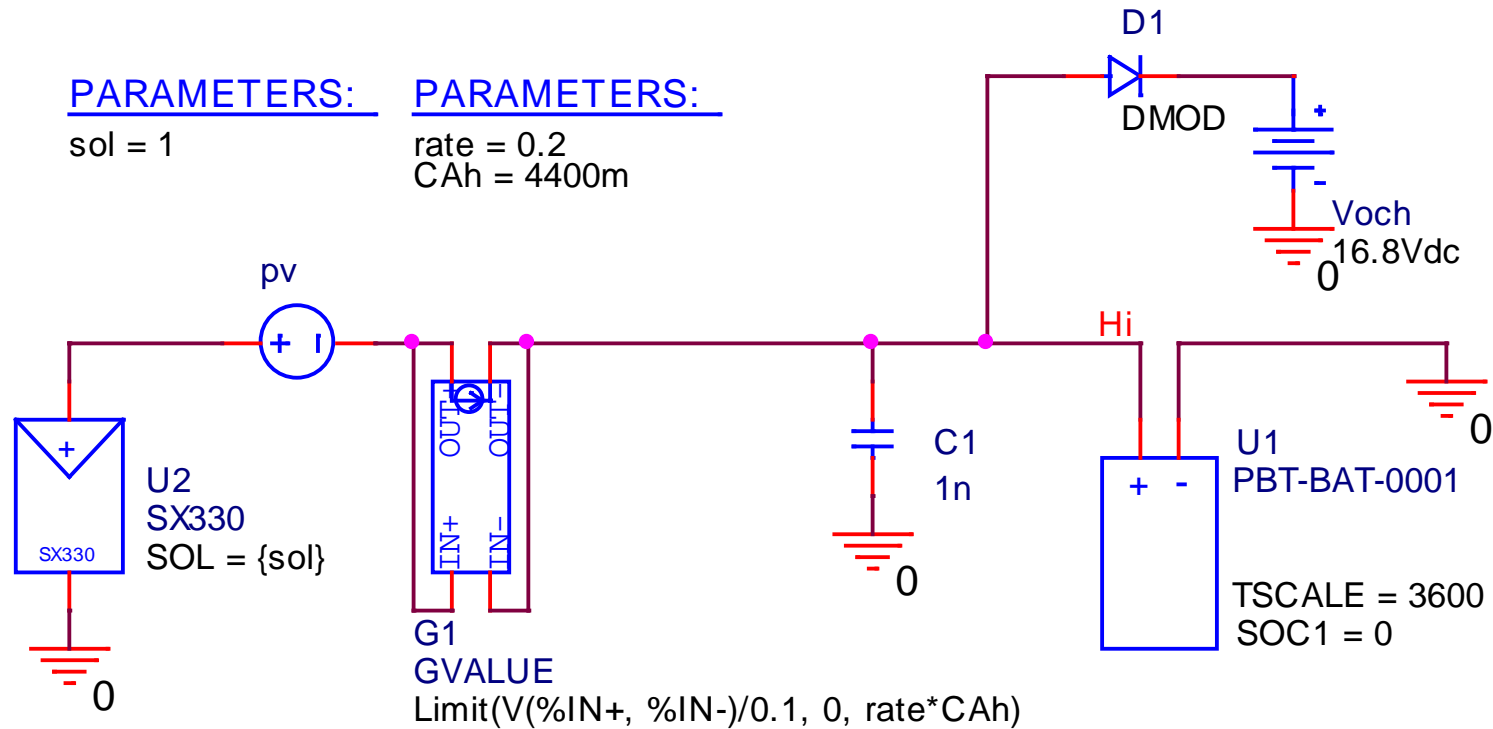


- Simulation result shows the charging time for sol = 1, 0.5, and 0.16.

3.4 Concept of Simulation PV Li-Ion Battery Charger Circuit + Constant Current

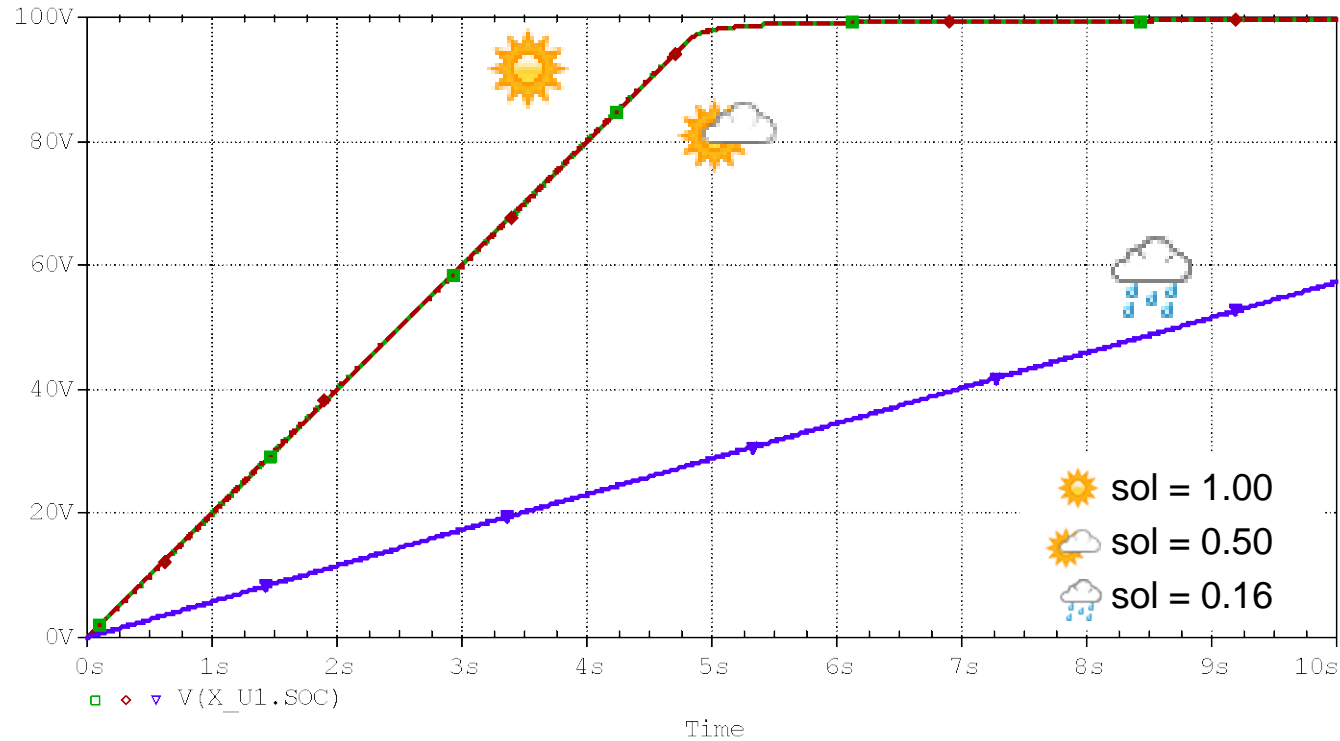


3.5 Constant Current PV Li-Ion Battery Charger Circuit



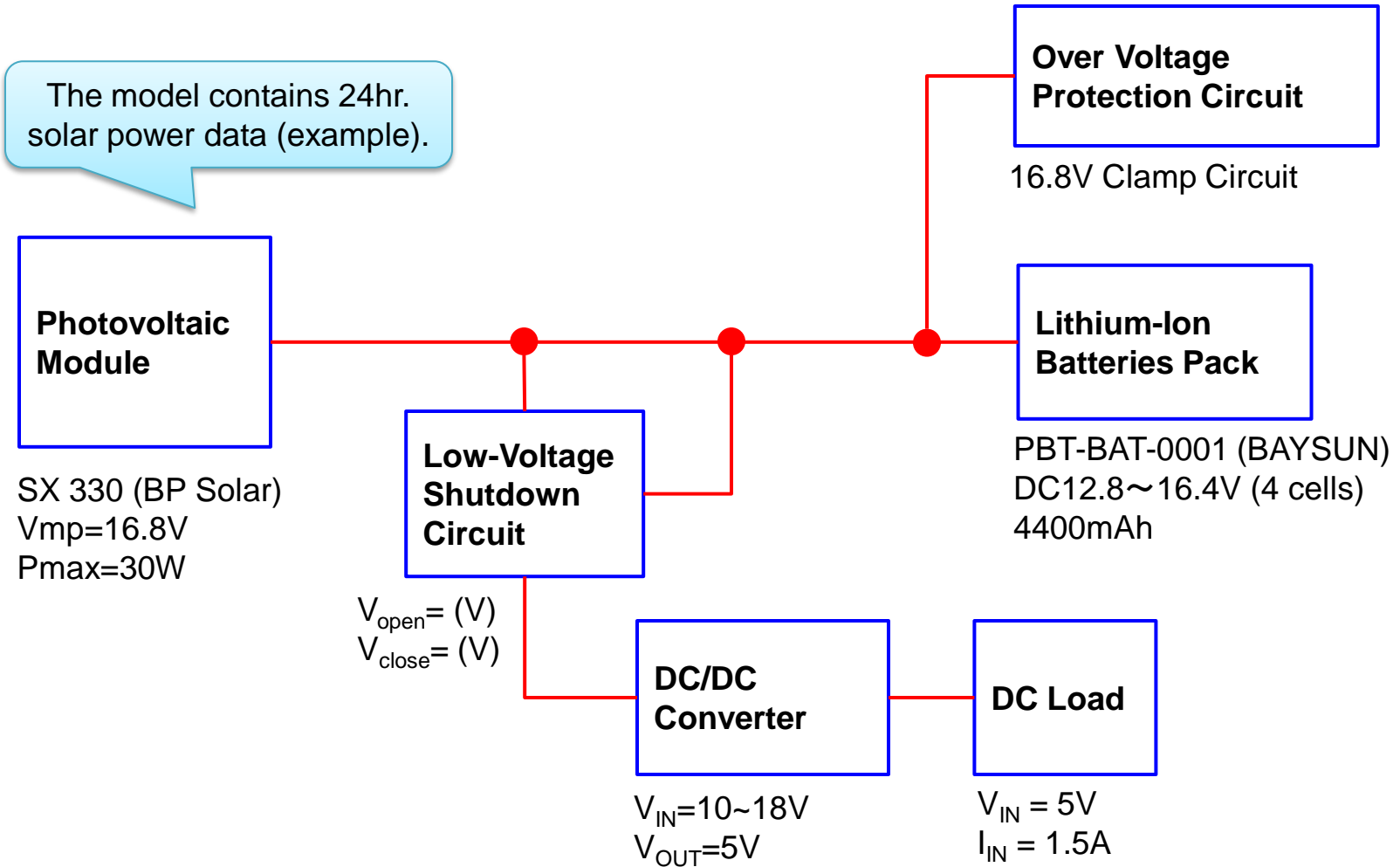
- Input the battery capacity (Ah) and charging current rate (e.g. $0.2*CAh$) in the
- “PARAMETERS: CAh = 4400m and rate = 0.2 ” to set the charging current.

3.6 Charging Time Characteristics vs. Weather Condition (Constant Current)

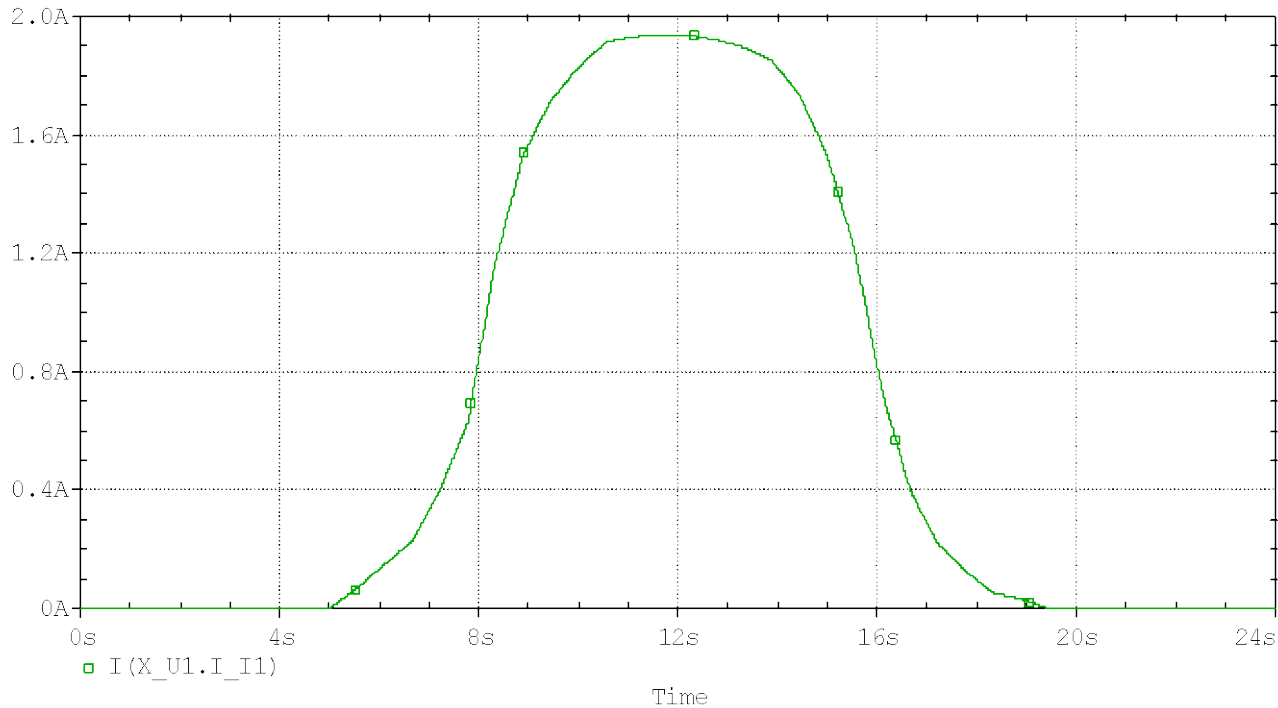


- Simulation result shows the charging time for sol = 1, 0.5, and 0.16. If PV can generate current more than the constant charge rate (0.2A), battery can be fully charged in about 5 hour.

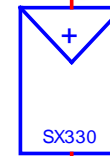
4.1 Concept of Simulation PV Li-Ion Battery System in 24hr.



4.2 Short-Circuit Current vs. Time (24hr.)



The model contains 24hr. solar power data (example).



U2
SX330_24H_TS3600

- Short-circuit current vs. time characteristics of photovoltaic module SX330 for 24hours as the solar power profile (example) is included to the model.

4.3 PV-Battery System Simulation Circuit

Solar cell model with 24hr. solar power data.

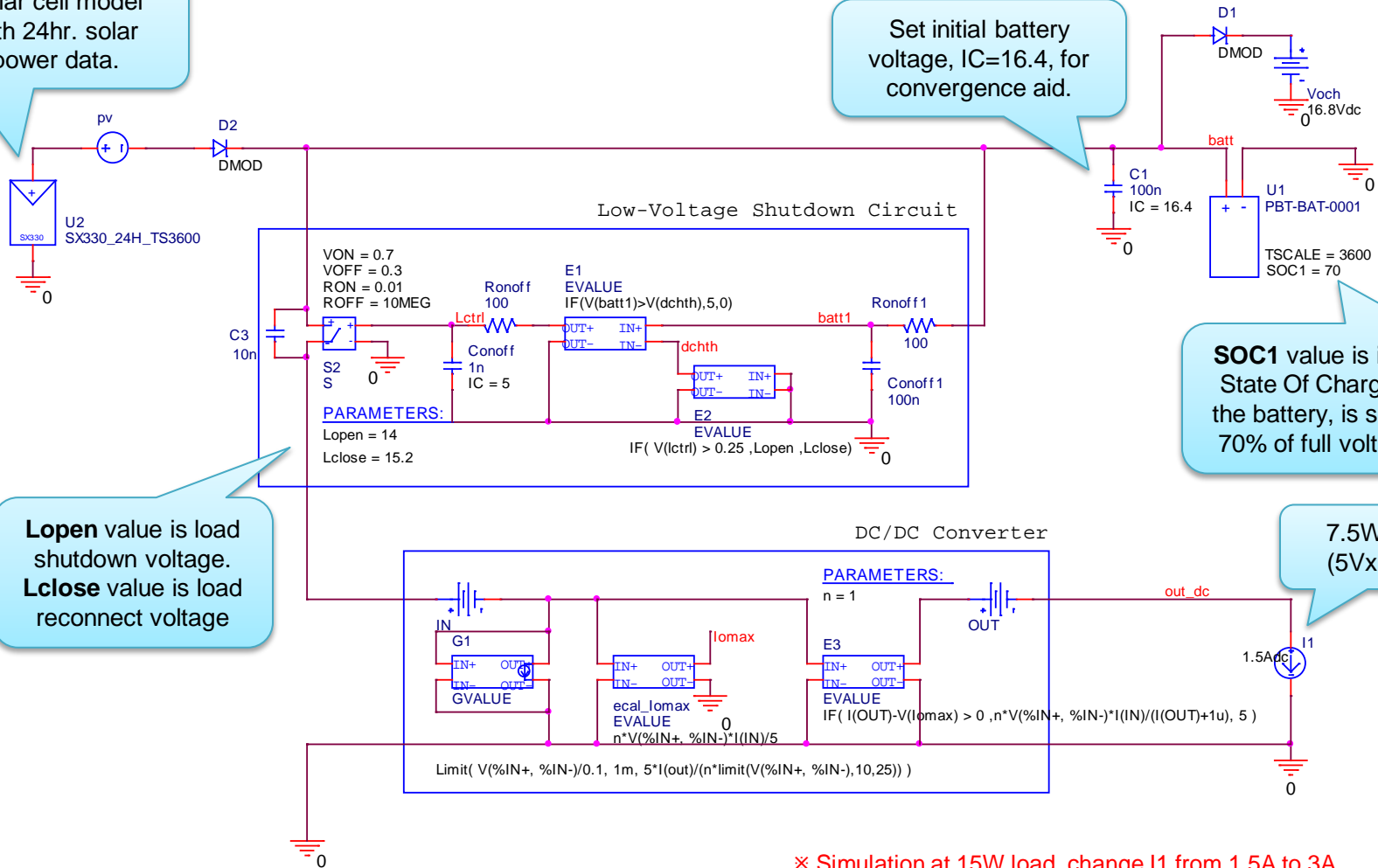
Set initial battery voltage, IC=16.4, for convergence aid.

SOC1 value is initial State Of Charge of the battery, is set as 70% of full voltage.

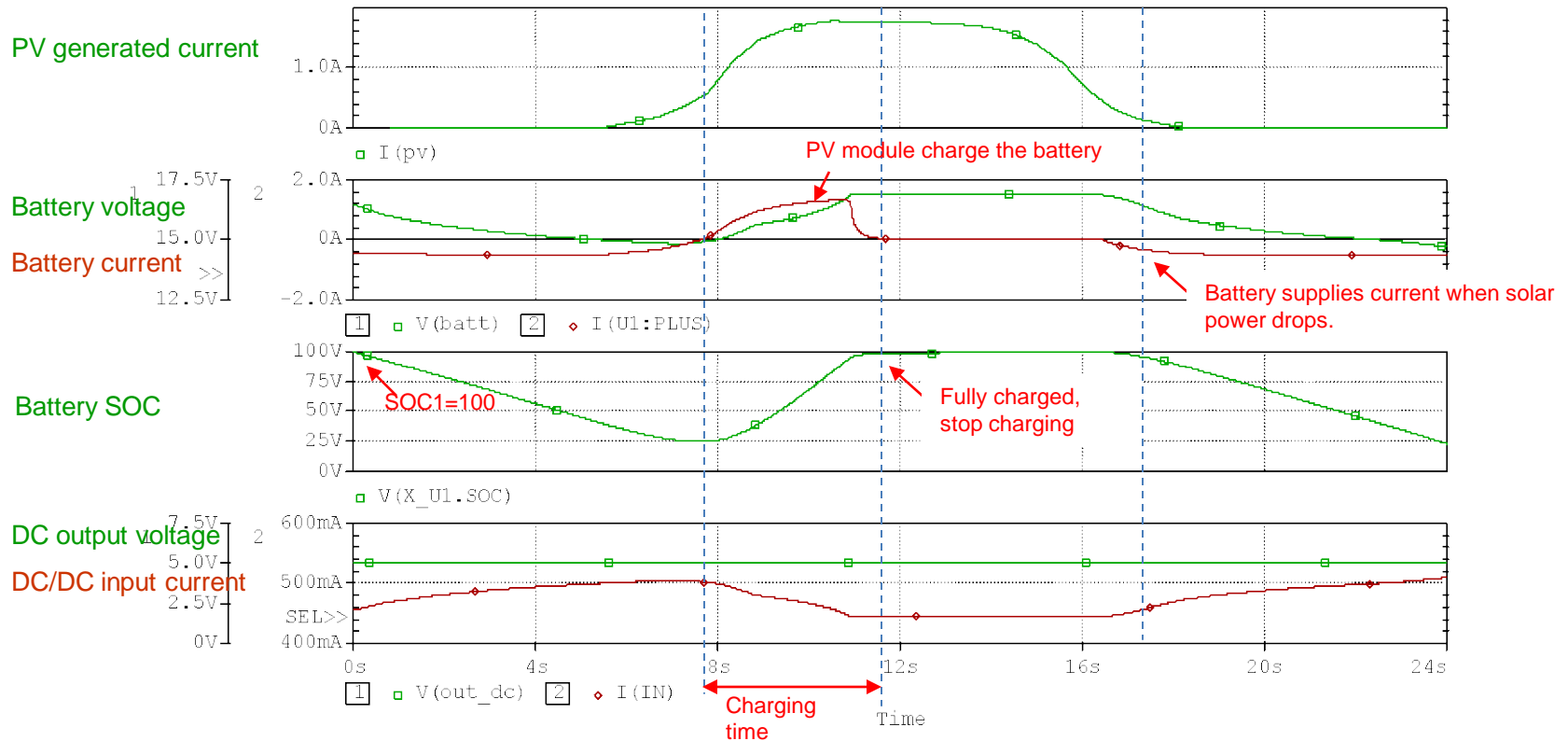
Lopen value is load shutdown voltage. Lclose value is load reconnect voltage

7.5W Load (5Vx1.5A).

× Simulation at 15W load, change I1 from 1.5A to 3A

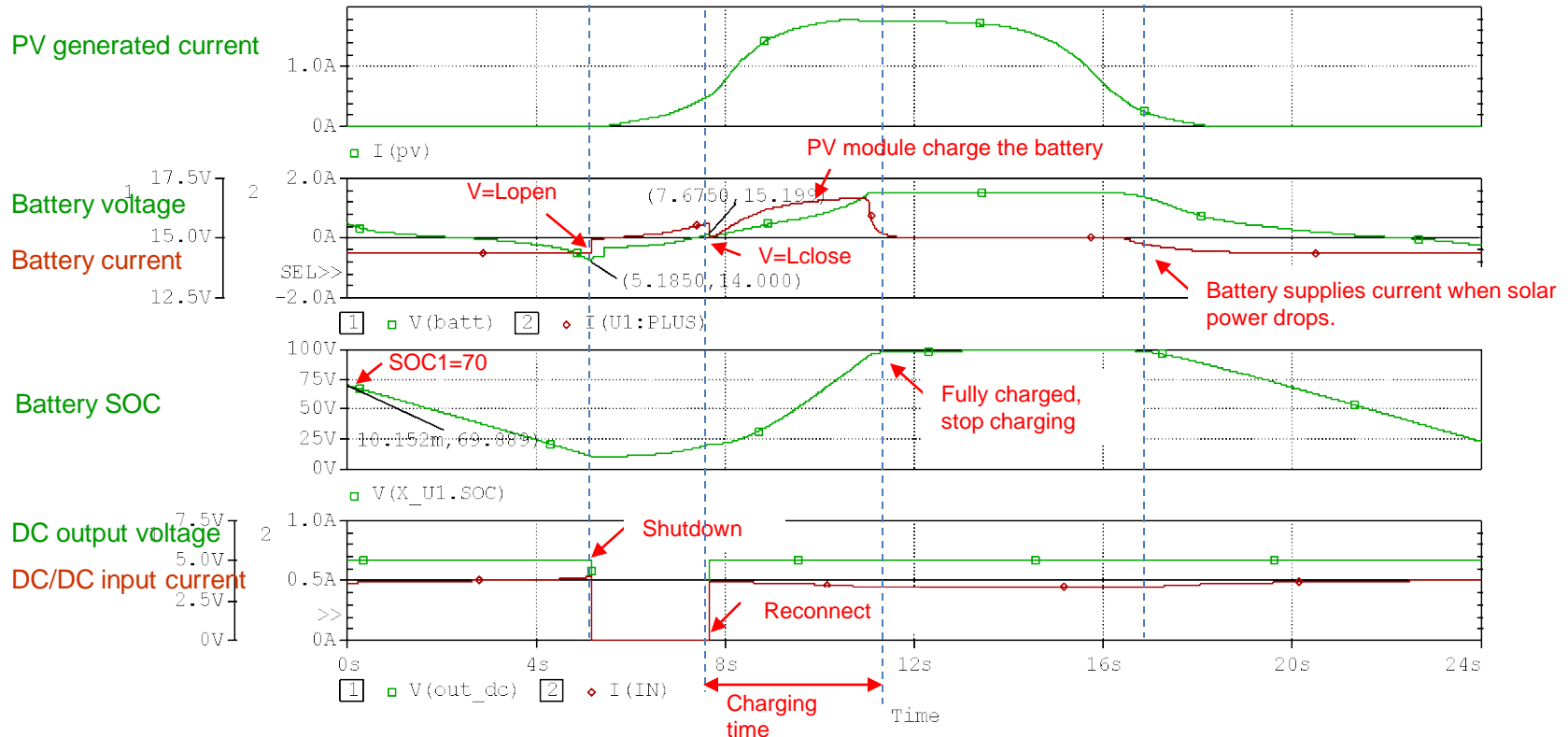


4.3.1 Simulation Result (SOC1=100)



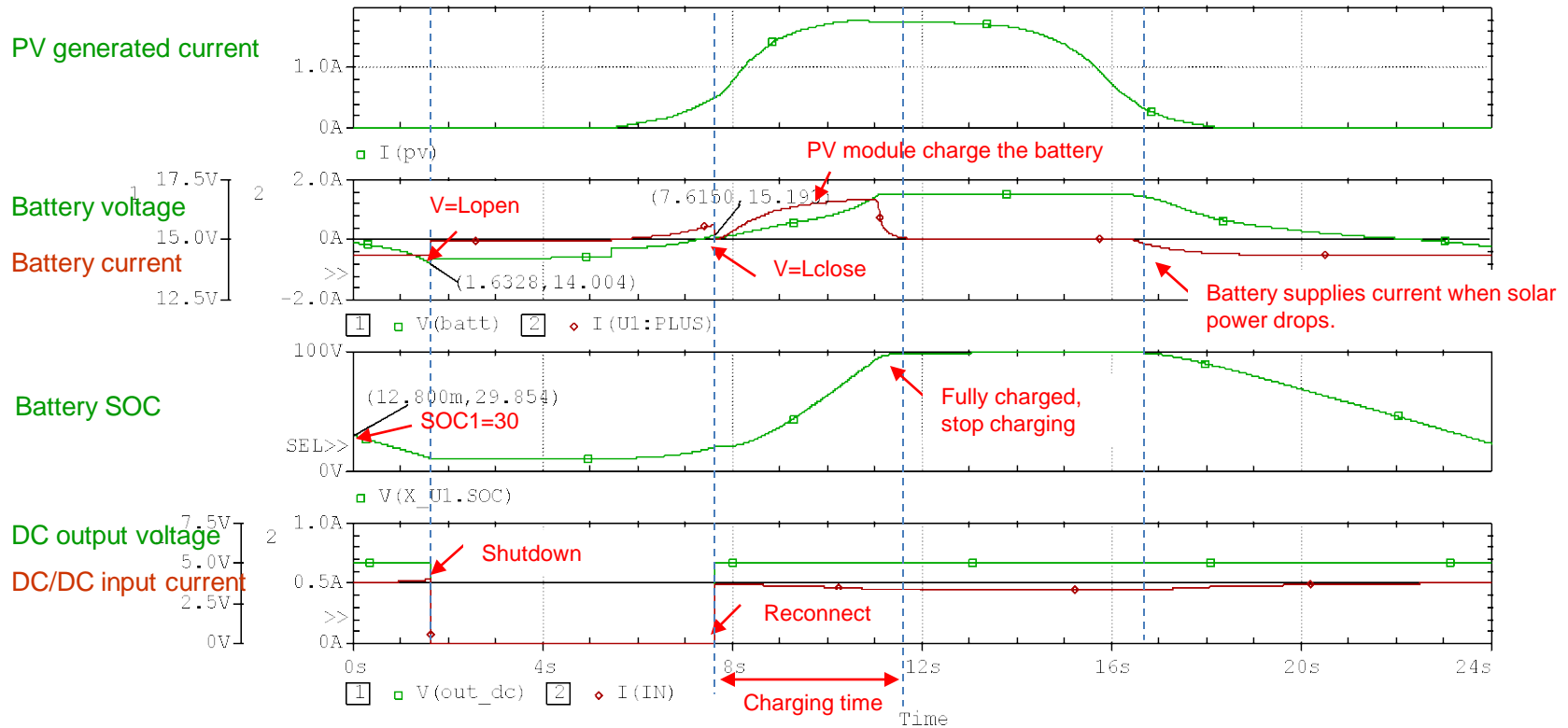
- C1: IC=16.4
- Run to time: 24s (24hours in real world)
- Step size: 0.01s
- .Options ITL4=1000

4.3.2 Simulation Result (SOC1=70)



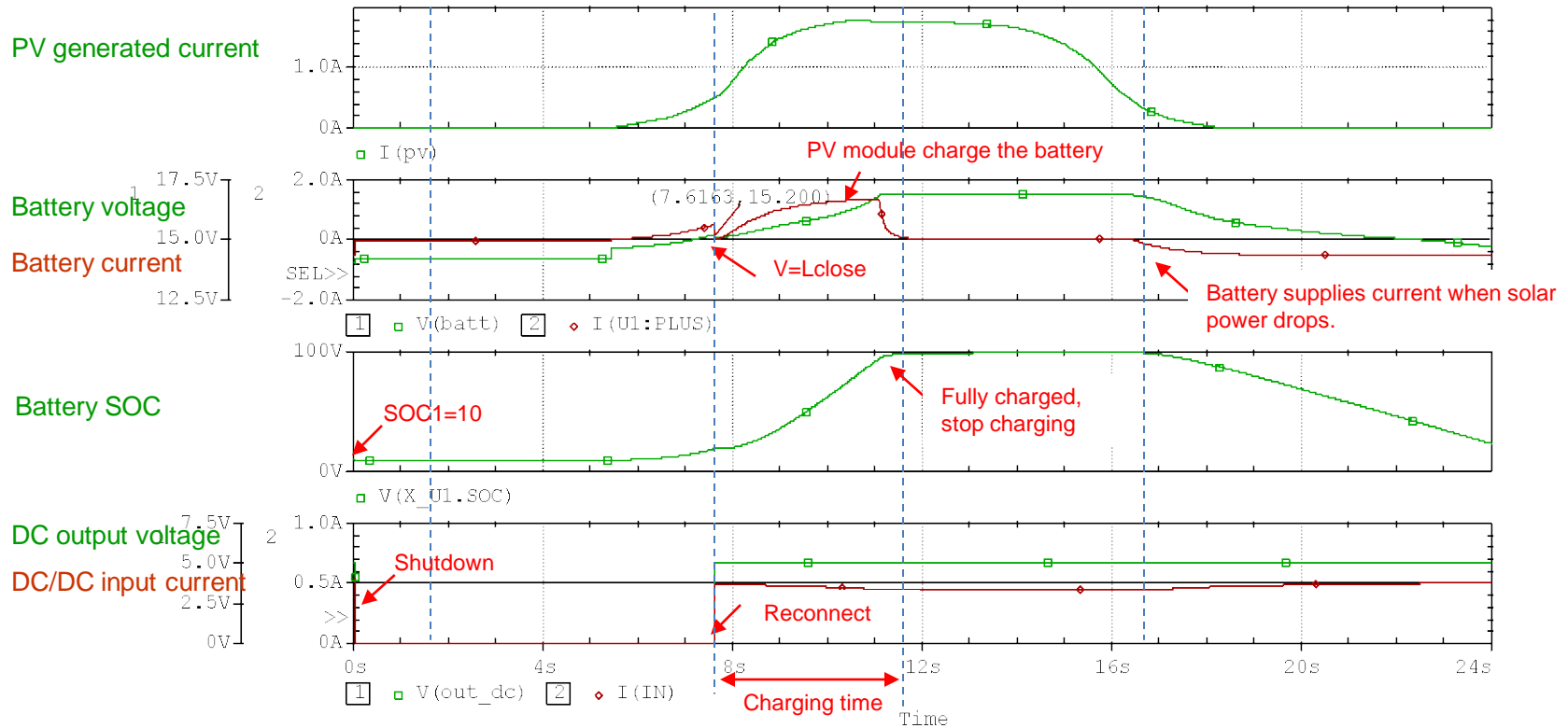
- C1: IC=16.4
- Run to time: 24s (24hours in real world)
- Step size: 0.01s
- SKIPBP
- .Options ITL4=1000

4.3.3 Simulation Result (SOC1=30)



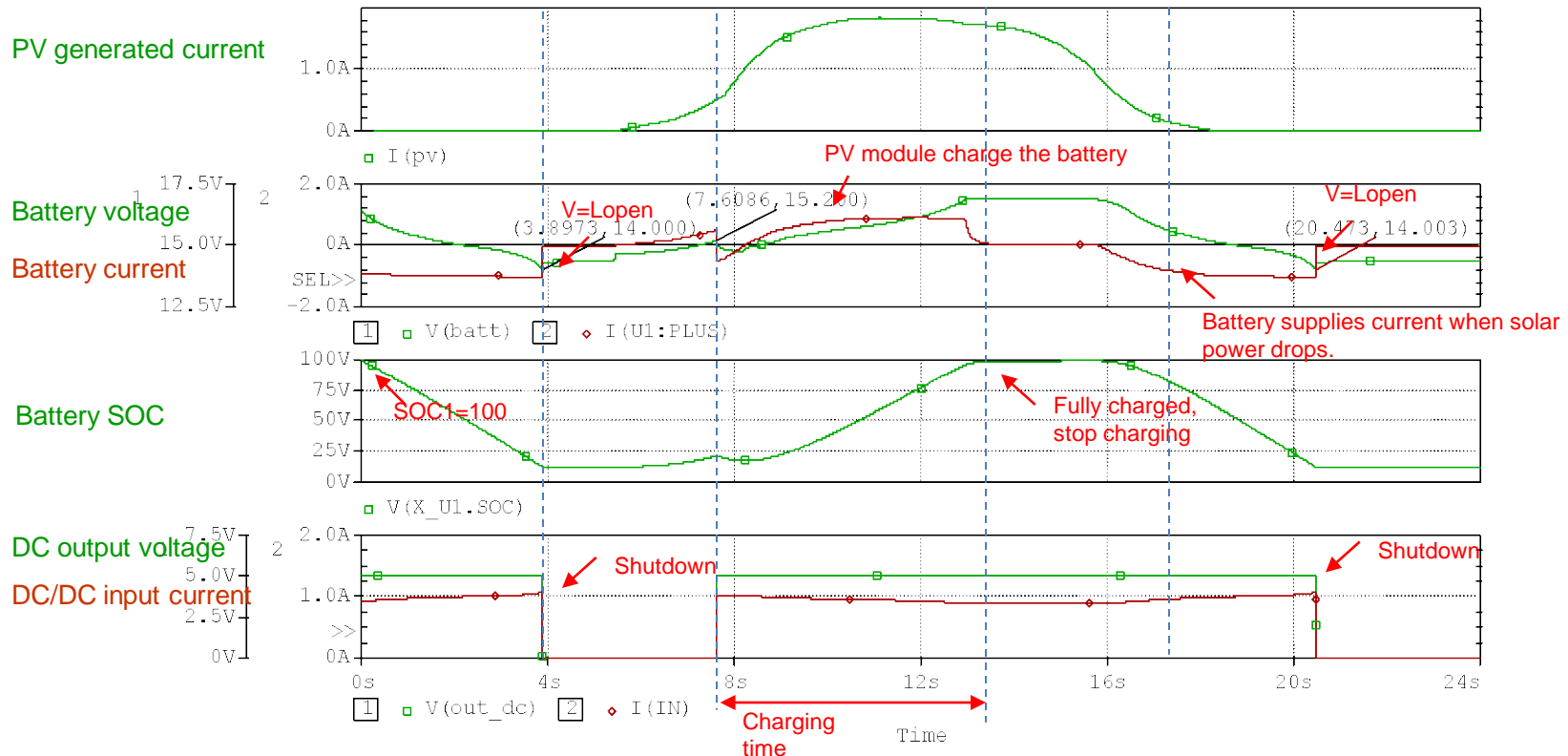
- C1: IC=15
- Run to time: 24s (24hours in real world)
- Step size: 0.01s
- Total job time = 2s
- .Options ITL4=1000

4.3.4 Simulation Result (SOC1=10)



- C1: IC=14.4
- Run to time: 24s (24hours in real world)
- Step size: 0.01s
- SKIPBP
- .Options RELTOL=0.01
- .Options ITL4=1000

4.3.5 Simulation Result (SOC1=100, IL=3A or 15W load)



- C1: IC=16.4
- Run to time: 24s (24hours in real world)
- Step size: 0.001s
- .Options ITL4=1000

4.3.4 Simulation Result (Example of Conclusion)

The simulation start from midnight(time=0). The system supplies DC load **7.5W**.

- If initial SOC is **100%**,
 - this system will never shutdown.
- If initial SOC is **70%**,
 - this system will shutdown after 5.185 hours (about 5:11AM.).
 - system load will reconnect again at 7:40AM (Morning).
- If initial SOC is **30%**,
 - this system will shutdown after 1.633 hours (about 1:38AM.).
 - system load will reconnect again at 7:37AM (Morning).
- If initial SOC is **10%**,
 - this system will start shutdown.
 - this system will reconnect again at 7:37AM (Morning).
- With the PV generated current profile, battery will fully charged in about 4.25 hours.

The simulation start from midnight(time=0). The system supplies DC load **15W**.

- If initial SOC is **100%**,
 - this system will shutdown after 3.897 hours (about 3:54AM.).
 - system load will reconnect again at 7:37AM (Morning).
 - this system will shutdown again at 8:28 PM (Night).
- With the PV generated current profile, battery will fully charged in about 5.5 hours.

Simulations	Folder name
1. PV Li-Ion Battery Charger Circuit.....	charge-sol
2. Constant Current PV Li-Ion Battery Charger Circuit.....	charge-sol-const
3. PV-Battery System Simulation Circuit (SOC1=100).....	sol_24h_soc100
4. PV-Battery System Simulation Circuit (SOC1=70).....	sol_24h_soc70
5. PV-Battery System Simulation Circuit (SOC1=30).....	sol_24h_soc30
6. PV-Battery System Simulation Circuit (SOC1=10).....	sol_24h_soc10
7. PV-Battery System Simulation Circuit (SOC1=100, 15W).....	sol_24h_soc100_15W