

# Design Kit

## PV Lead-Acid Battery System (AC Out)

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## 1.1 Lead-Acid battery Specification

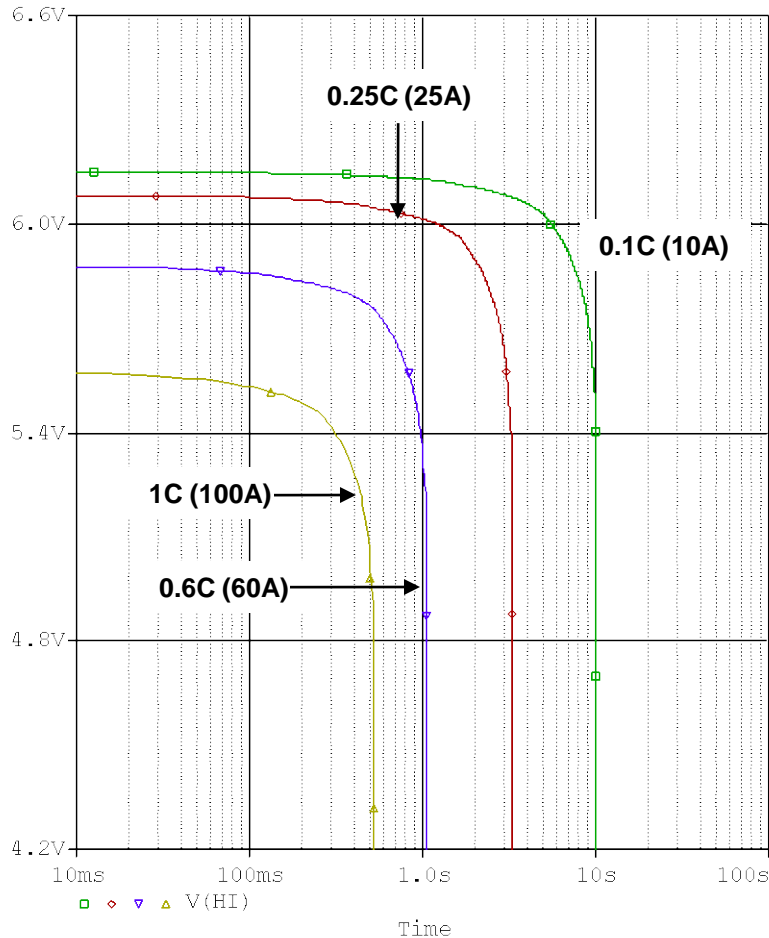
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### GS YUASA's Lead-Acid : MSE-100-6

- Nominal Voltage..... 6.0 [Vdc]
- Capacity..... 100[Ah]@C<sub>10</sub>, 65[Ah]@C<sub>1</sub>
- Rated Charge..... 0.1C<sub>10</sub>A
- Input Voltage..... 6.69 [Vdc]
- Charging time..... 24 [hours] @0.1C<sub>10</sub>A

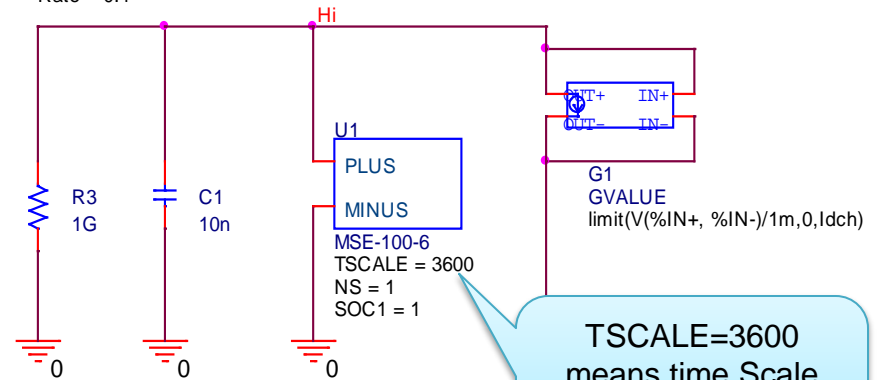


# 1.2 Discharge Time Characteristics



**PARAMETERS:**

$I_{dch} = (\text{Rate} \times C \times Ah)$   
 $C \times Ah = 100$   
 Rate = 0.1



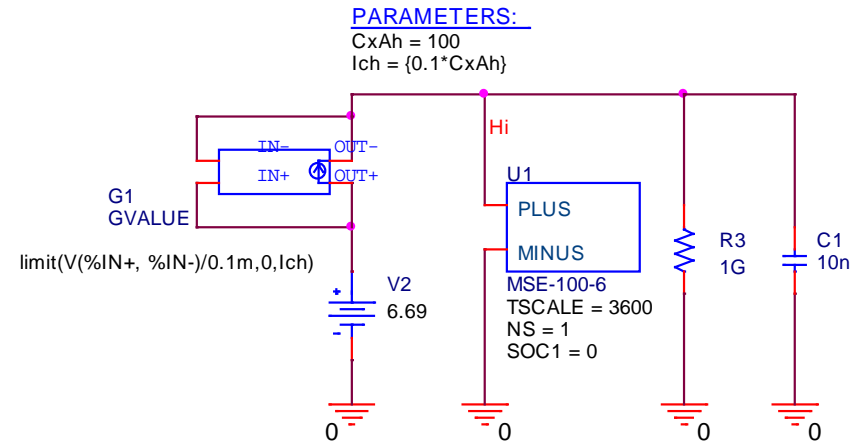
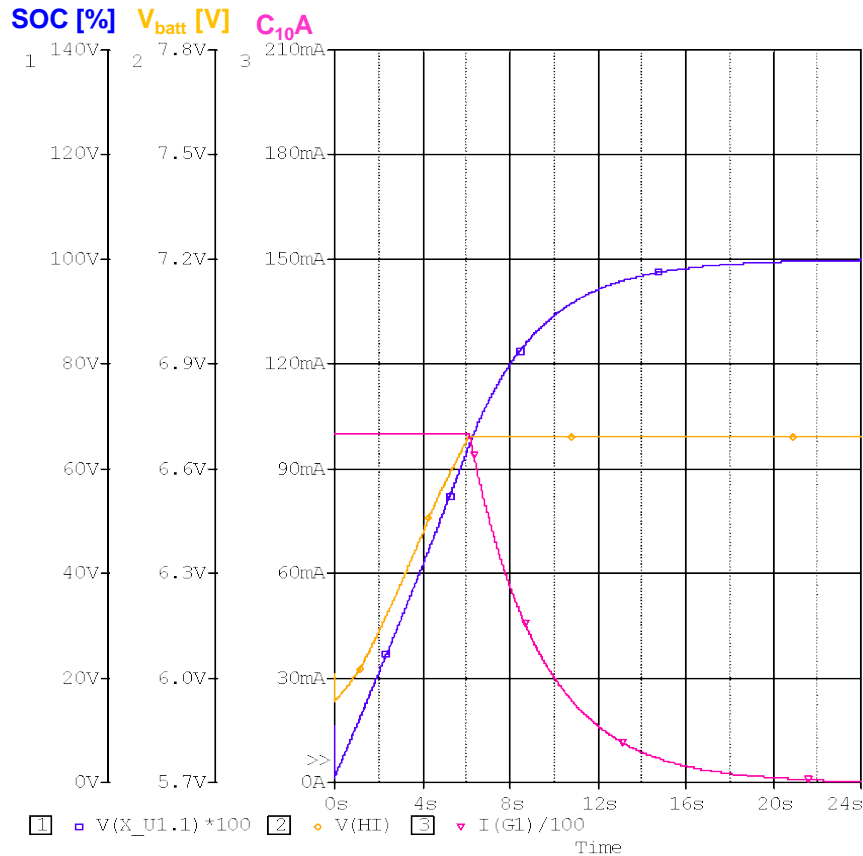
**TSCALE=3600**  
 means time Scale  
 (Simulation time :  
 Real time) is 1:3600

**Battery Model Parameters**

NS (number of batteries in unit) = 1 cell  
 C (capacity) = 100[Ah]@C<sub>10</sub>  
 SOC1 (initial state of charge) = "1" (100%)  
 TSCALE (time scale) , simulation : real time  
 1 : 3600s or  
 1s : 1h

**Discharge Rate** : 0.1C(10A), 0.25C(25A) , 0.6C(60A), and 1C(100A)

# 1.3 Charge Time Characteristics



## Battery Model Parameters

NS (number of batteries in series) = 1 cell  
 C (capacity) = 100[Ah] @  $C_{10}$   
 SOC1 (initial state of charge) = "1" (100%)  
 TSCALE (time scale) , simulation : real time  
 1 : 3600s or  
 1s : 1h

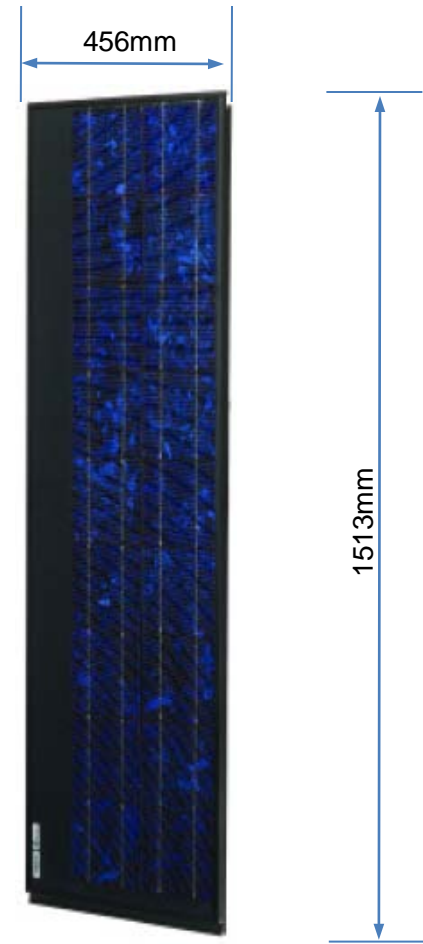
## Charging Time

Input Voltage = 6.69 Vdc  
 Input Current = 10 A @  $0.1C_{10}$

## 2.1 Solar Cells Specification

### BP Solar's photovoltaic module : BP365TS

- Maximum power ( $P_{max}$ ).....65[W]
- Voltage at Pmax ( $V_{mp}$ ).....8.7[V]
- Current at Pmax ( $I_{mp}$ ).....7.5[A]
- Short-circuit current ( $I_{sc}$ ).....8.1[A]
- Open-circuit voltage( $V_{oc}$ ).....11.0[V]



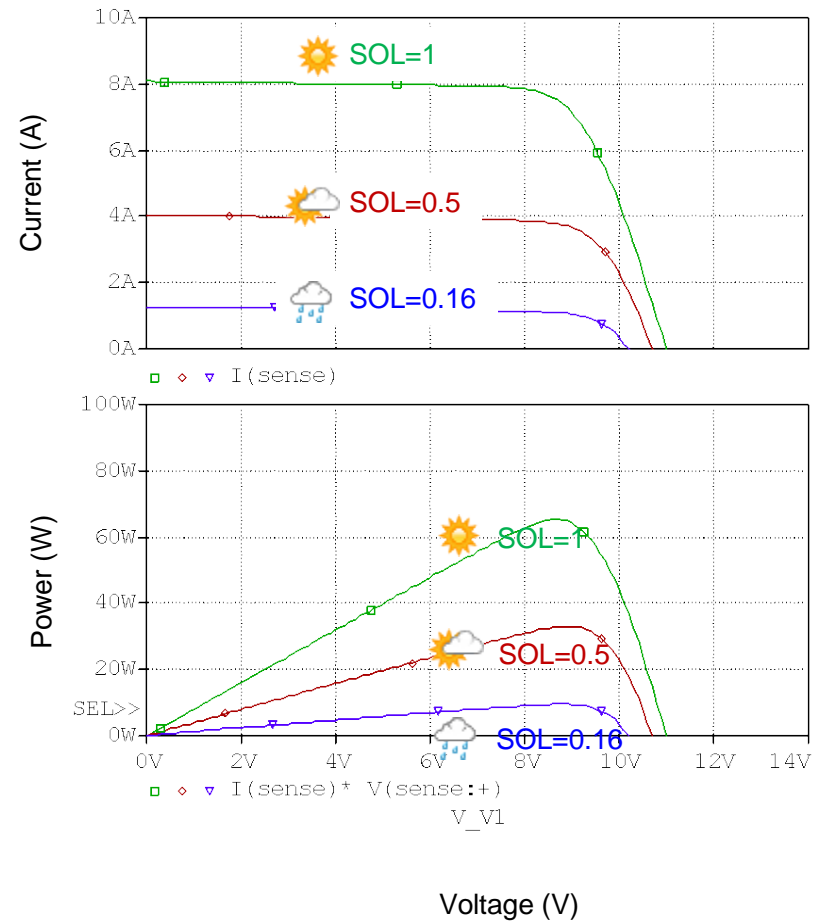
## 2.2 Output Characteristics vs. Incident Solar Radiation



U2  
BP365TS  
SOL = 1

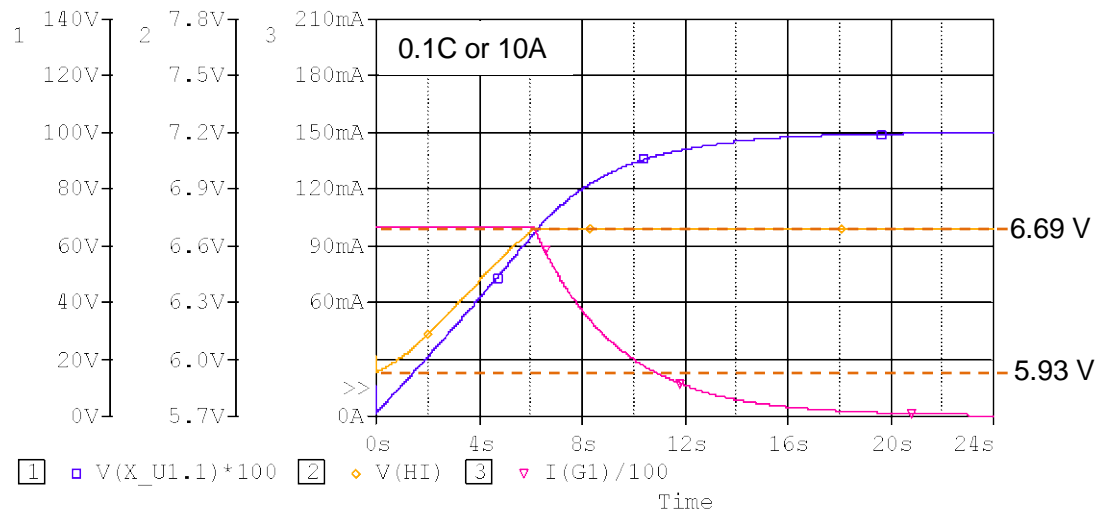
Parameter, SOL is added as normalized incident radiation, where SOL=1 for AM1.5 conditions

BP365TS Output Characteristics vs. Incident Solar Radiation



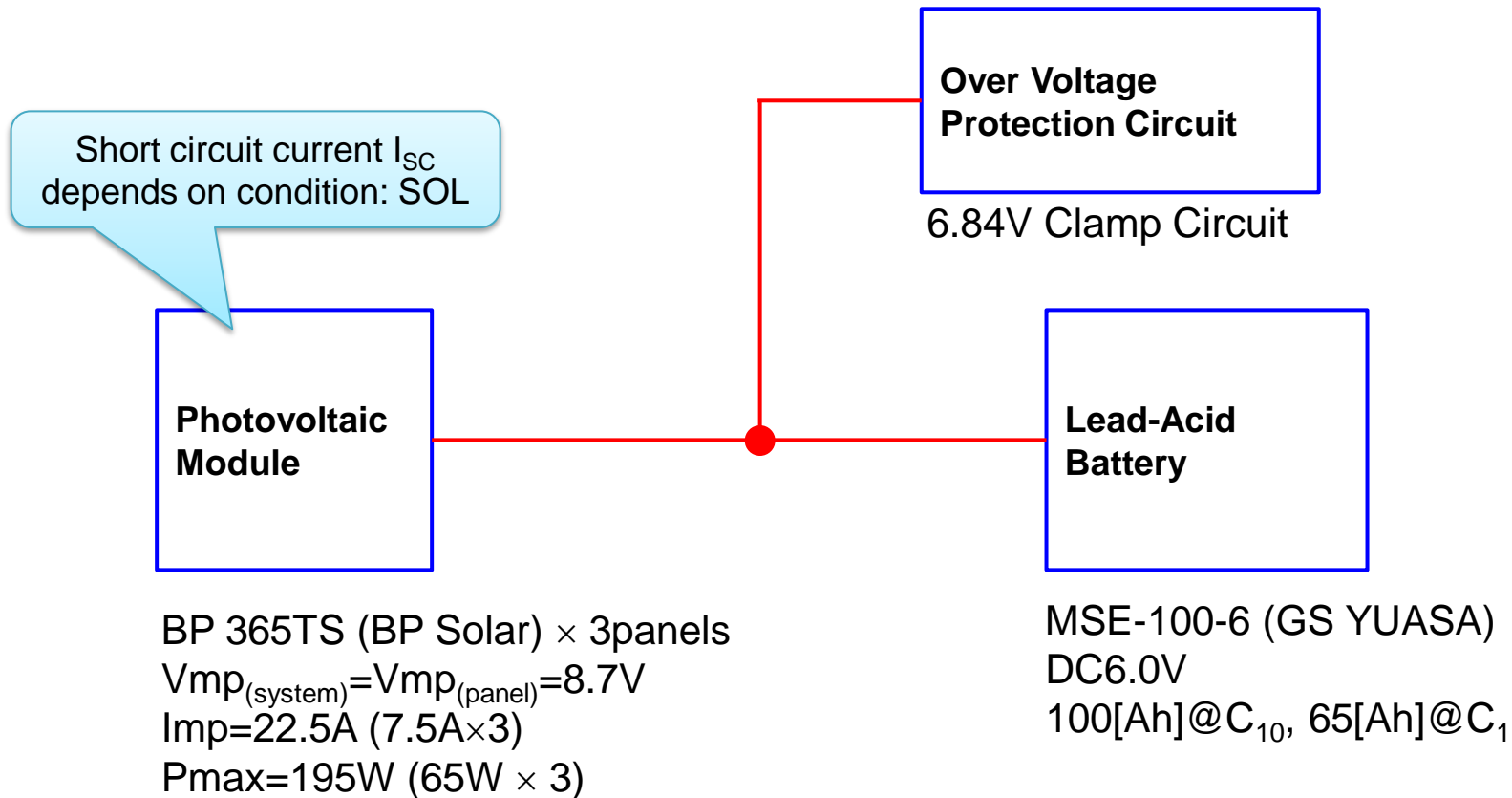
### 3. Solar Cell Battery Charger

- Solar Cell charges the Lead-Acid Battery (MSE-100-6) 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 battery charging voltage.
- MSE-100-6
  - Charging time is approximately 24 hours with charging rate 0.1C or 10A
  - Voltage during charging with 0.1C is between 5.93 to 6.69 V

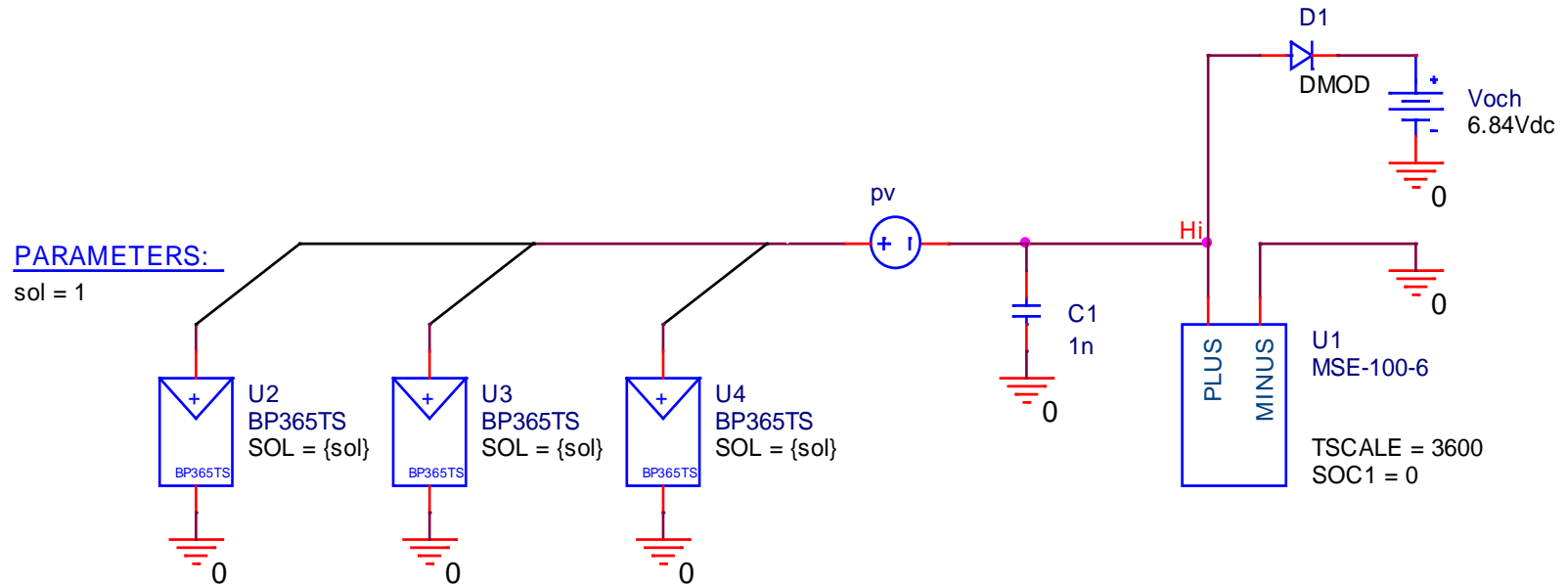




# 3.1 Concept of Simulation PV Lead-Acid Battery Charger Circuit

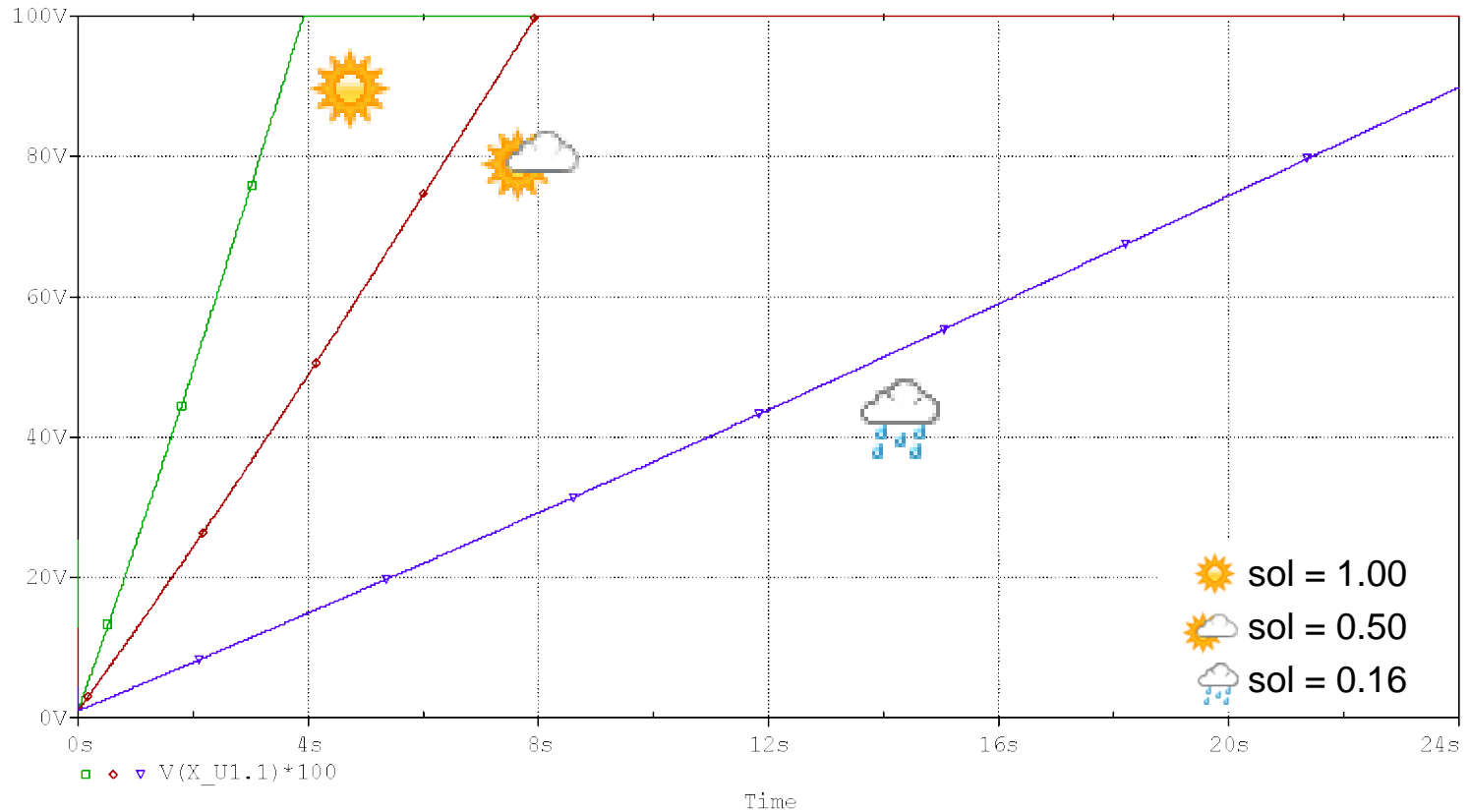


## 3.2 PV Lead-Acid Battery Charger Circuit



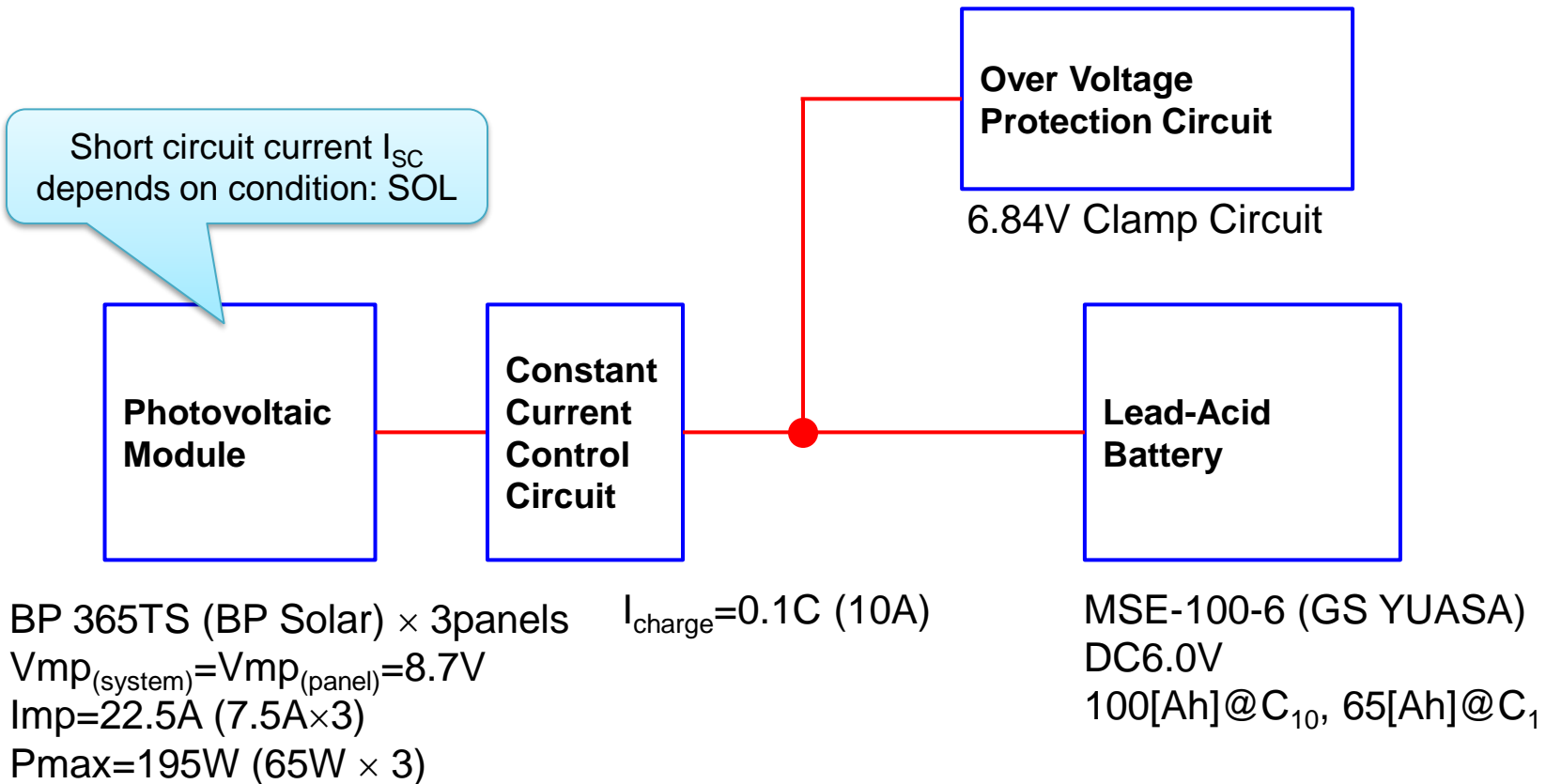
- Input value between 0-1 in the “PARAMETERS: sol = ” to set the normalized incident radiation, where SOL=1 for AM1.5 conditions.

### 3.3 Charging Time Characteristics vs. Weather Condition

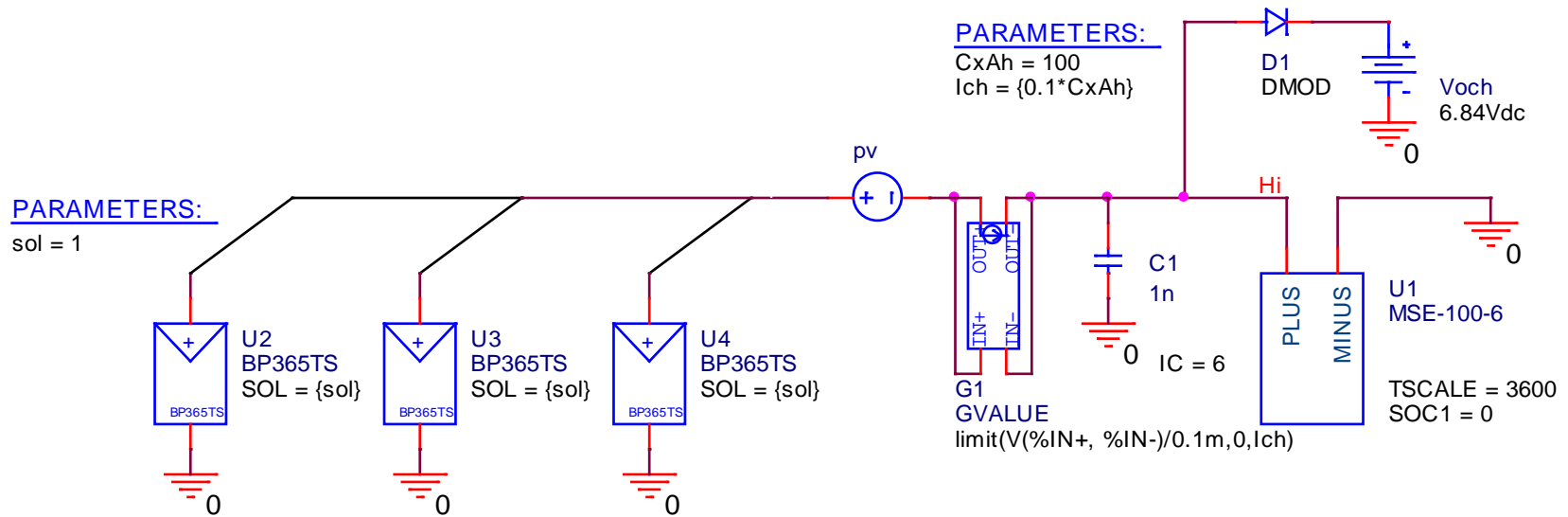


- Simulation result shows the charging time for sol = 1, 0.5, and 0.16.

## 3.4 Concept of Simulation PV Lead-Acid Battery Charger Circuit + Constant Current



## 3.5 Constant Current PV Lead-Acid Battery Charger Circuit



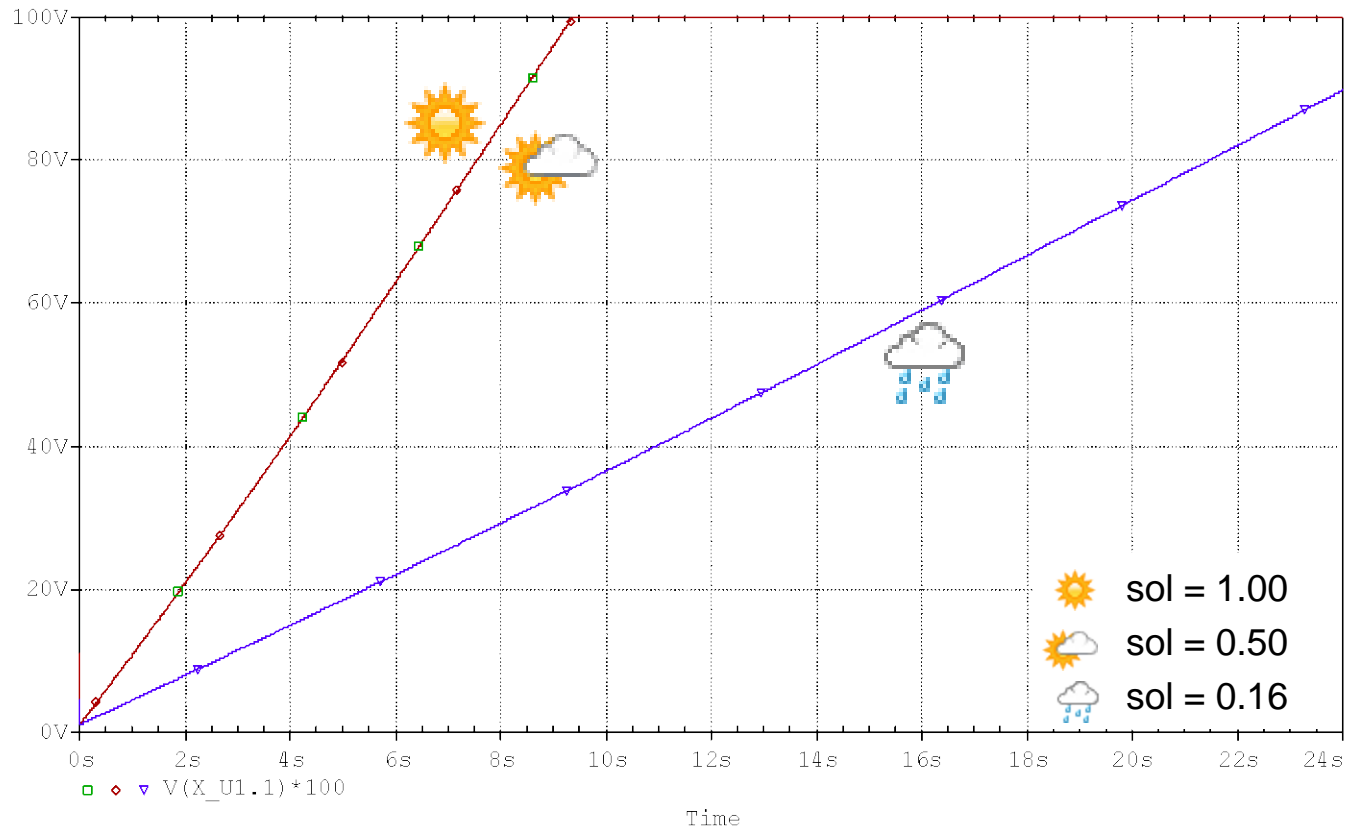
$$V_{mp(\text{system})} = V_{mp(\text{panel})} = 8.7V$$

$$I_{mp} = 22.5A$$

$$P_{max} = 195W$$

- Input the battery capacity (Ah) and charging current rate (e.g.  $0.1 \cdot C_{xAh}$ ) in the PARAMETERS: CxAh = 100 and rate = 0.1 ” to set the charging current.

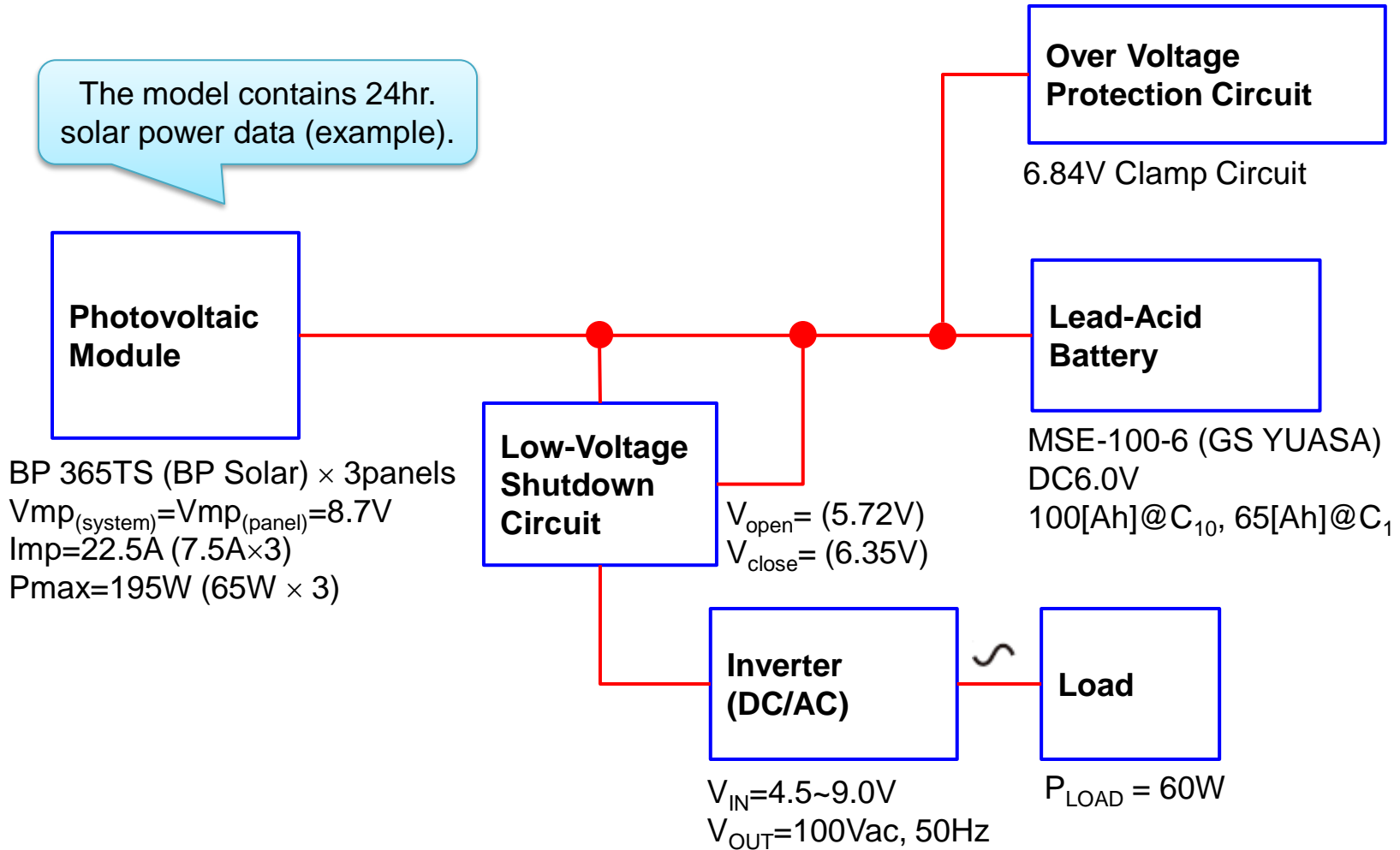
## 3.6 Charging Time Characteristics vs. Weather Condition (Constant Current)



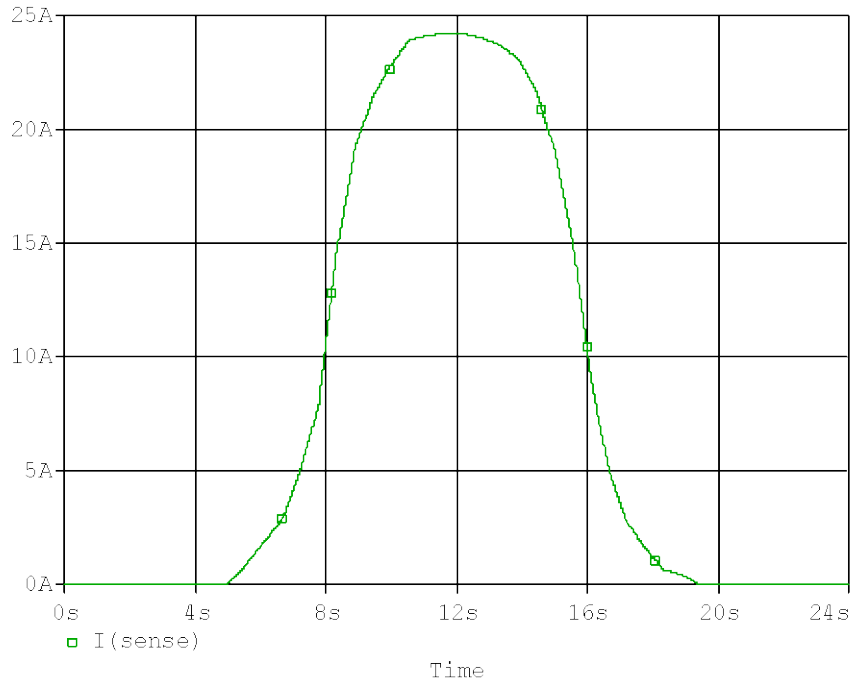
- Simulation result shows the charging time for sol = 1, 0.5, and 0.16. If PV can generate current more than the constant charge rate (0.1), battery can be fully charged in about 9.364 hour.

# 4.1 Concept of Simulation PV Lead-Acid Battery System in 24hr.

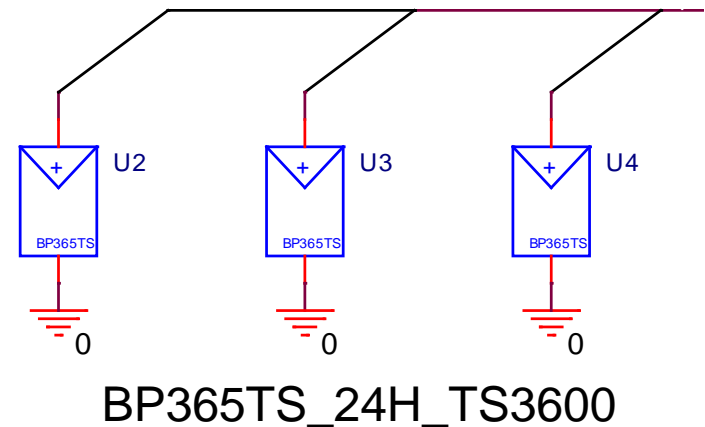
The model contains 24hr. solar power data (example).



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



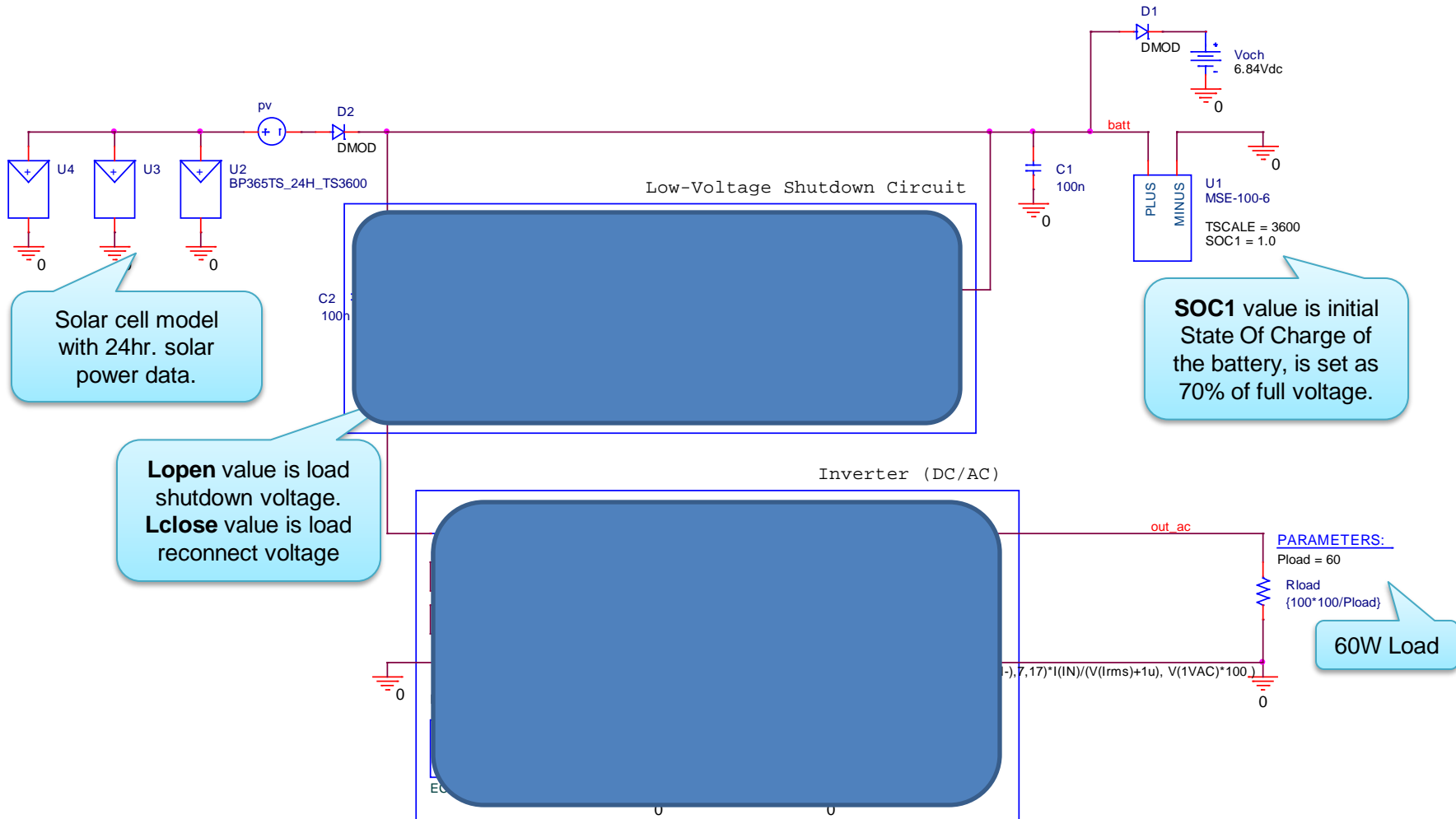
The model contains 24hr. solar power data (example).



- Short-circuit current vs. time characteristics of photovoltaic module BP365TS for 24hours as the solar power profile (example) is included to the model.

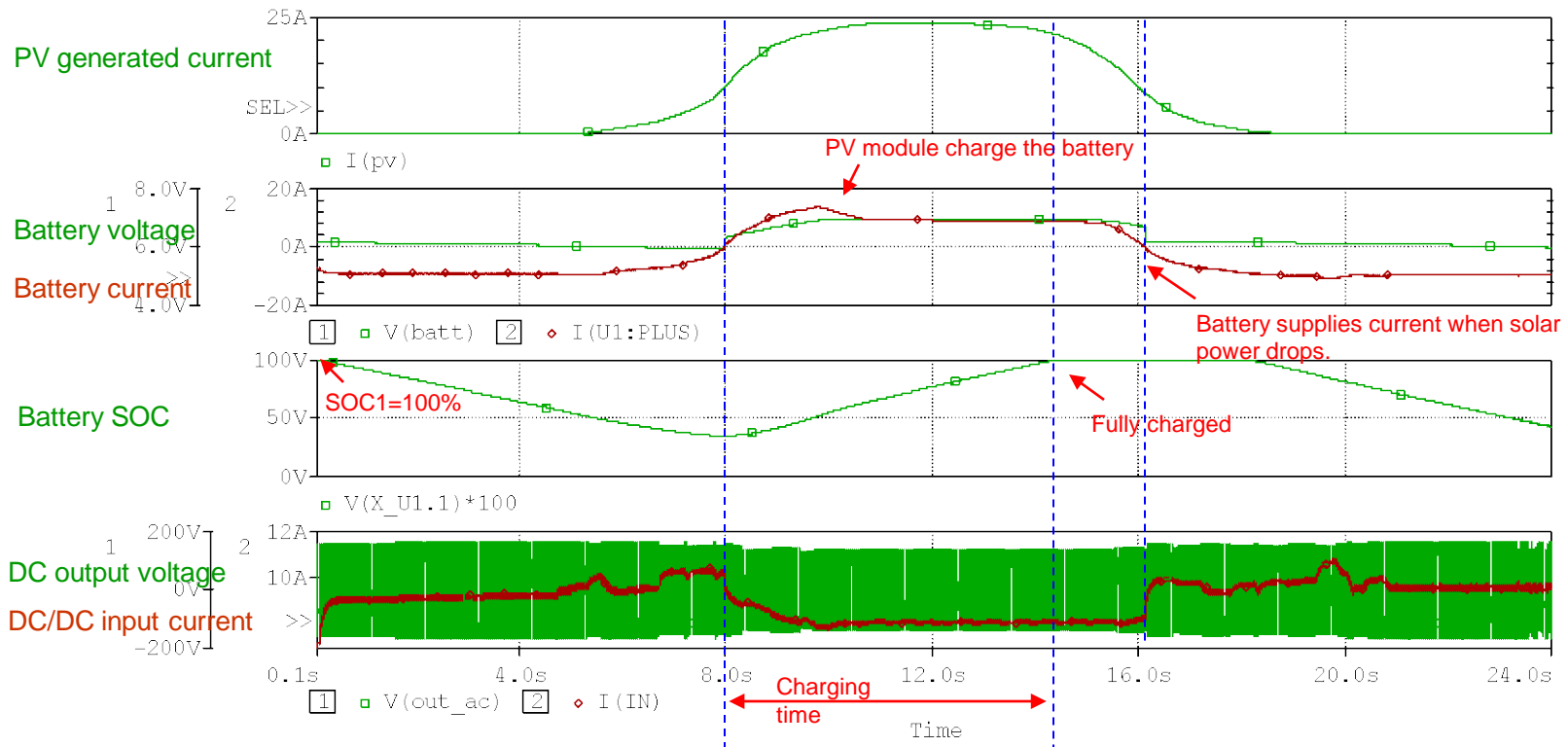


# 4.3 PV-Battery System Simulation Circuit



※ Simulation at 100W load, change Pload from 60(W) to 100(W)

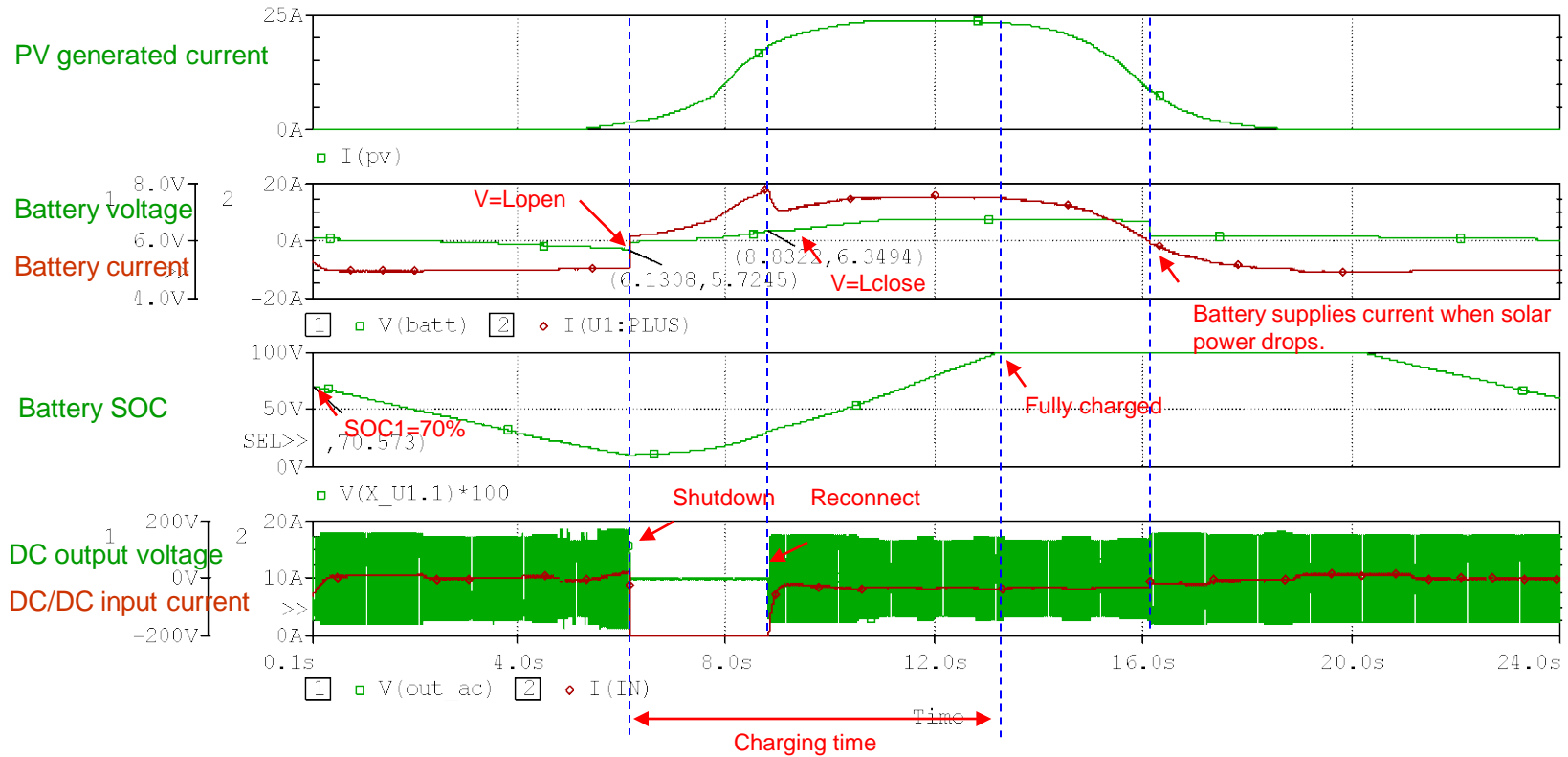
### 4.3.1 Simulation Result (SOC1=100, 60W load)



- Run to time: 24s (24hours in real world)
- Step size: 0.0025s

- .Options
  - RELTOL=0.01
  - ABSTOL=1.0u
  - ITL4=100

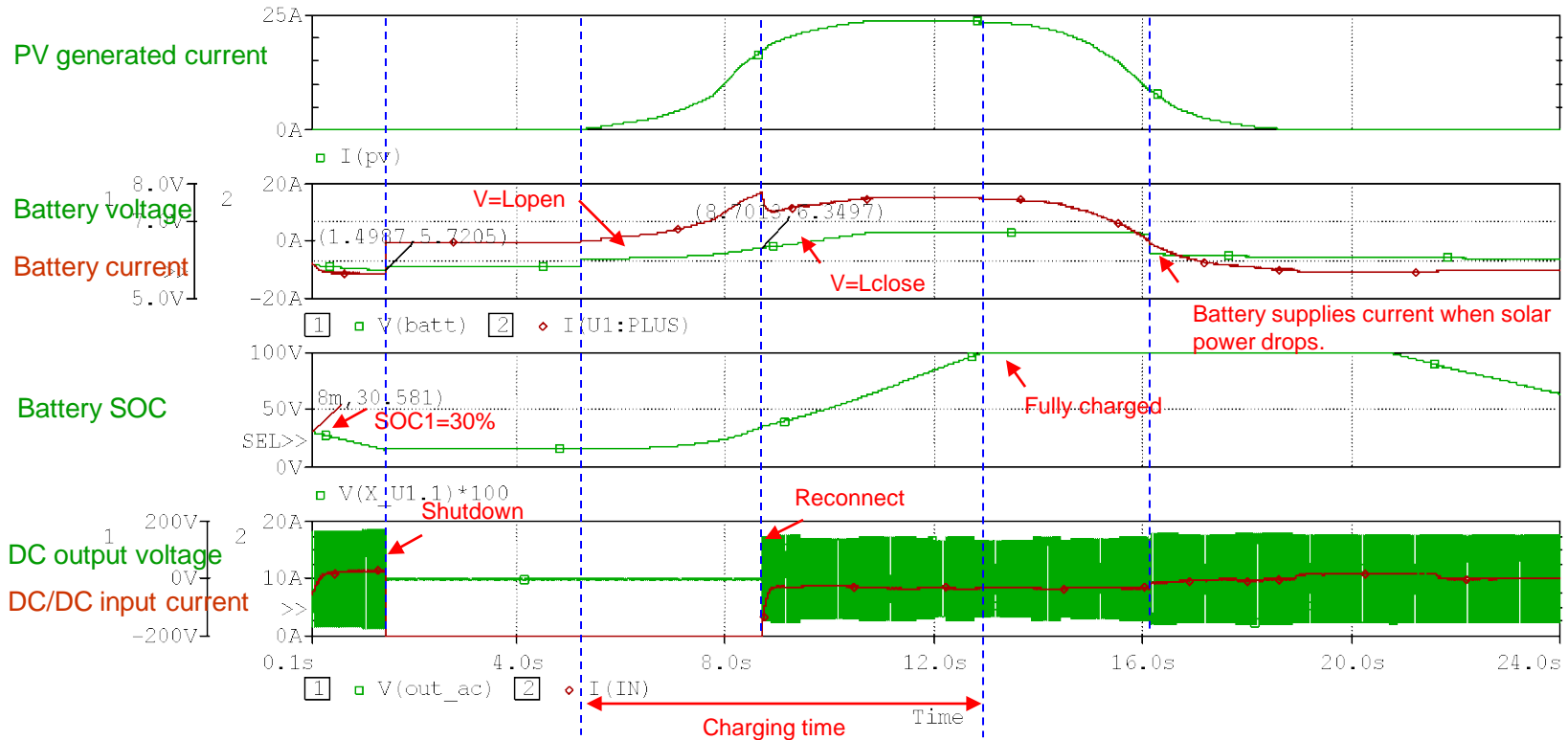
## 4.3.2 Simulation Result (SOC1=70, 60W load)



- Run to time: 24s (24hours in real world)
- Step size: 0.0025s

- .Options
  - RELTOL=0.01
  - ABSTOL=1.0u
  - ITL4=100

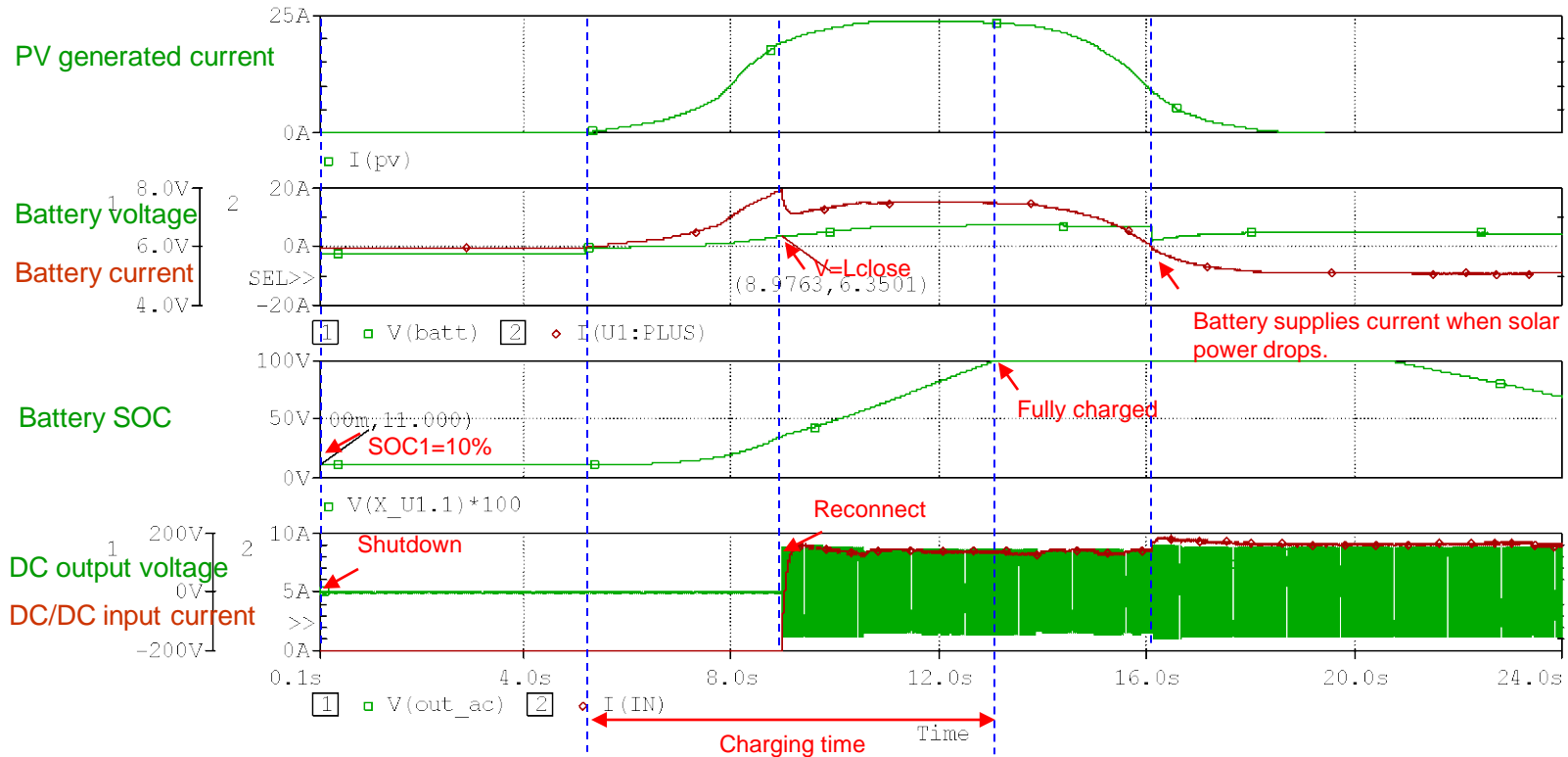
### 4.3.3 Simulation Result (SOC1=30, 60W load)



- Run to time: 24s (24hours in real world)
- Step size: 0.0025s

- .Options
  - RELTOL=0.01
  - ABSTOL=1.0u
  - ITL4=100

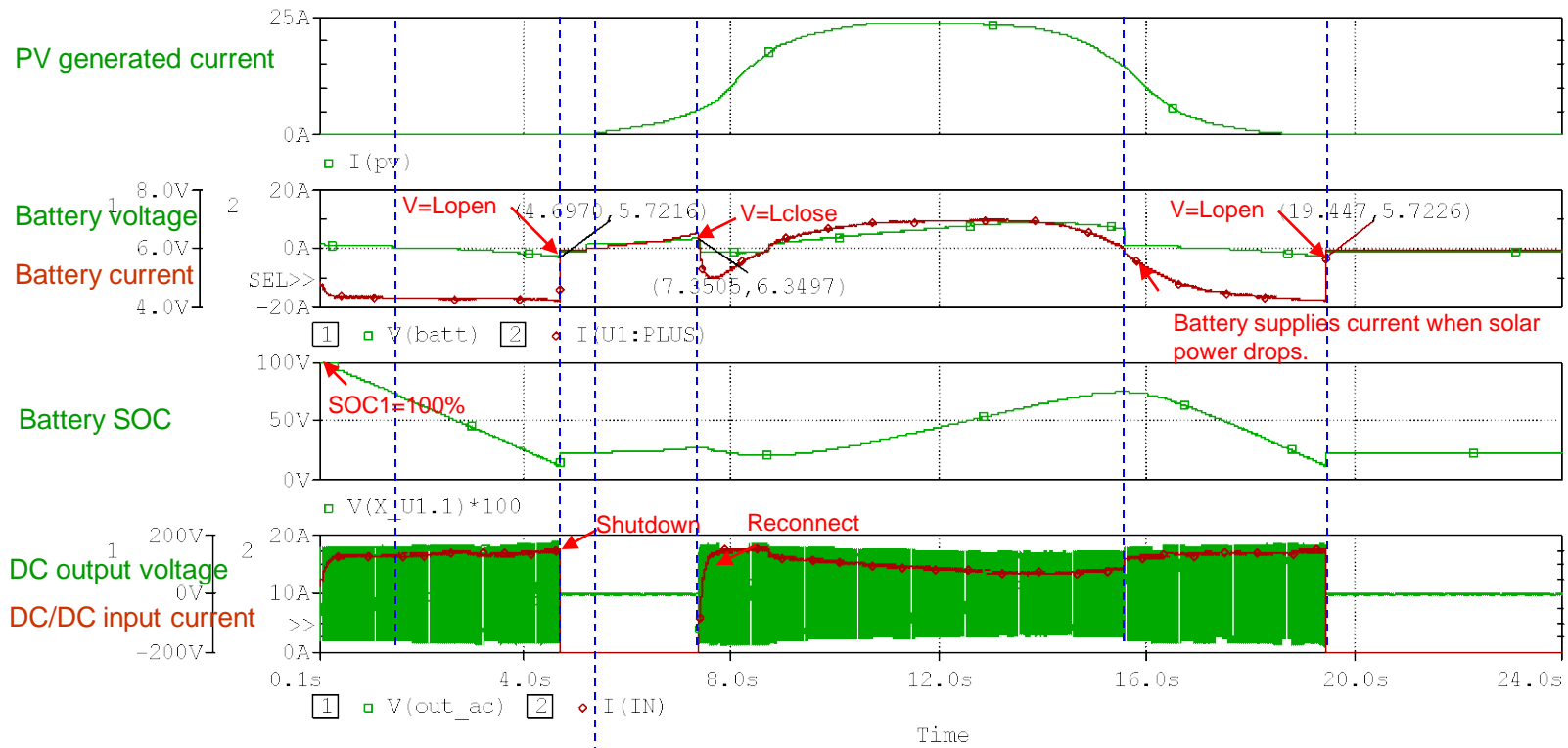
## 4.3.4 Simulation Result (SOC1=10, 60W load)



- C1: IC=5
- Run to time: 24s (24hours in real world)
- Step size: 0.0025s

- .Options
  - RELTOL=0.01
  - ABSTOL=1.0u
  - ITL4=100

## 4.3.5 Simulation Result (SOC1=100, 100W load)



- Run to time: 24s (24hours in real world)
- Step size: 0.001s

- .Options
  - RELTOL=0.01
  - ABSTOL=1.0u
  - ITL4=100

## 4.4 Simulation Result (Example of Conclusion)

The simulation start from midnight(time=0). The system supplies DC load **60W**.

- If initial SOC is **100%**,
  - this system will never shutdown.
- If initial SOC is **70%**,
  - this system will shutdown after 6.1308 hours (about 6:08AM.).
  - system load will reconnect again at 8:50AM (Morning).
- If initial SOC is **30%**,
  - this system will shutdown after 1.4987 hours (about 1:30AM.).
  - system load will reconnect again at 8:42AM (Morning).
- If initial SOC is **10%**,
  - this system will start shutdown.
  - this system will reconnect again at 8:59AM (Morning).
- With the PV Panel generated current profile, battery will fully charged in about 8.00 hours.

The simulation start from midnight(time=0). The system supplies DC load **100W**.

- If initial SOC is **100%**,
  - this system will shutdown after 4.697 hours (about 4:42AM.).
  - system load will reconnect again at 7:21AM (Morning).
  - this system will shutdown again at 7:27PM (Night).
- With the PV Panel generated current profile, battery will not fully charged.

<b>Simulations</b>	<b>Folder name</b>
1. PV Lead-Acid Battery Charger Circuit.....	charge-sol
2. Constant Current PV Lead-Acid Battery Charger Circuit.....	charge-sol-const
3. PV-Battery System Simulation Circuit (SOC1=100, 60W).....	sol_24h_60W_soc100
4. PV-Battery System Simulation Circuit (SOC1=70, 60W).....	sol_24h_60W_soc70
5. PV-Battery System Simulation Circuit (SOC1=30, 60W).....	sol_24h_60W_soc30
6. PV-Battery System Simulation Circuit (SOC1=10, 60W).....	sol_24h_60W_soc10
7. PV-Battery System Simulation Circuit (SOC1=100, 100W).....	sol_24h_100W_soc100