Standalone Hybrid Wind & Solar Generation

May1727

Team

<u>Members:</u>

Matt Lee

Nathaniel Byrne

Michael Trischan

Brian Gronseth

Eric Cole

Jeffrey Szostak

<u>Faculty:</u>

Dr. Ajjarapu

<u>PhD Graduate Students:</u>

Ankit Singhal (PhD Candidate)

Pranav Sharma (PhD Candidate)

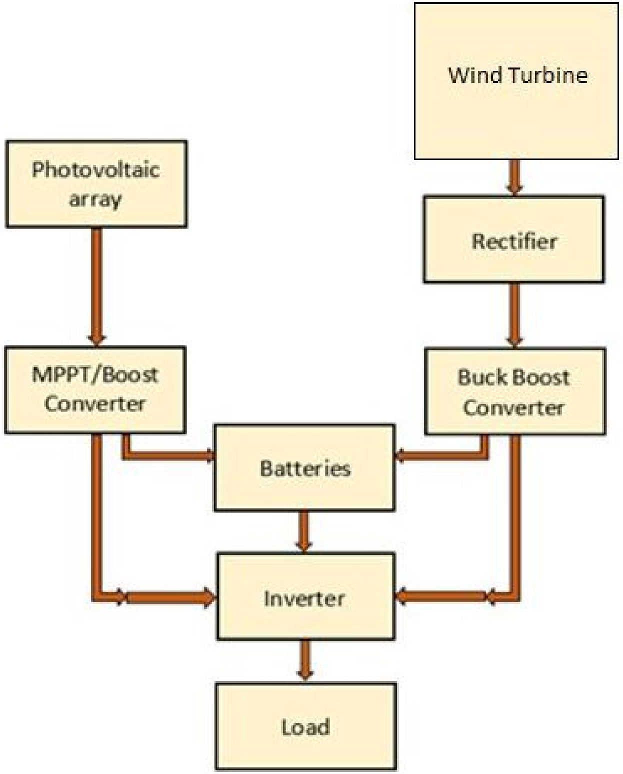
Project Plan- Project Statement

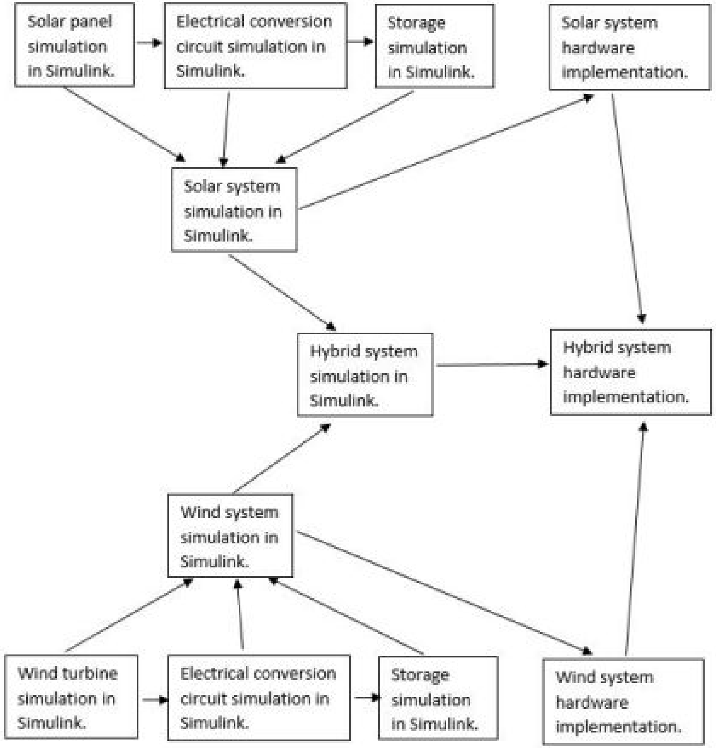
- Formal Project Statement:

  "To Create a combined Solar and Wind Electrical generation system that hybridizes the most supporting hardware as possible."

- Deliverables
  - Design a hybrid wind and solar system
  - Add components to existing PV array
    - Wind Turbine, Inverter, Solar Panels
  - Create labs for EE 452 centered around the hybrid system so future ISU students can use the hybrid system as a learning tool.

Project Plan- Conceptual Sketch





Project Plan- Requirements

- Functional Requirements
  - Working Simulink diagrams for both the wind turbine and PV array.
  - Solar panels will utilize maximum power point tracking control, as well as a boost converter.
  - The wind turbine will produce AC power that is rectified and then sent to a Buck/Boost converter.
  - Both systems meet to charge the battery and from the battery go through the inverter to power the load.

- Nonfunctional Requirements
  - Analysis of solar and wind generation system components
  - Analysis of solar and wind emplacement for max power generation
    - Measure of wind speed and irradiance
  - Create labs for EE 452 centered around the hybrid system so future ISU students can use it as a learning tool.

Project Plan- Constraints/Risks/Considerations

- Lack of experience
  - Power Systems
  - Simulink
- Non-engineering aspects
  - Wind turbine placement regulation
  - Budget

- Risks
  - Lab safety
  - Wind Turbine setup

Project Plan- Market and Costs

- Market Survey
  - The customers for this project are future EE 452 students, as well as the EE power department.
  - An important component of this project is the relationship with WESO, who is willing to allow academic use of their wind turbine for certain periods of the semester.
    - Saves money
    - Non-black box model
- Resource/Cost Estimate
  - Solar Panels

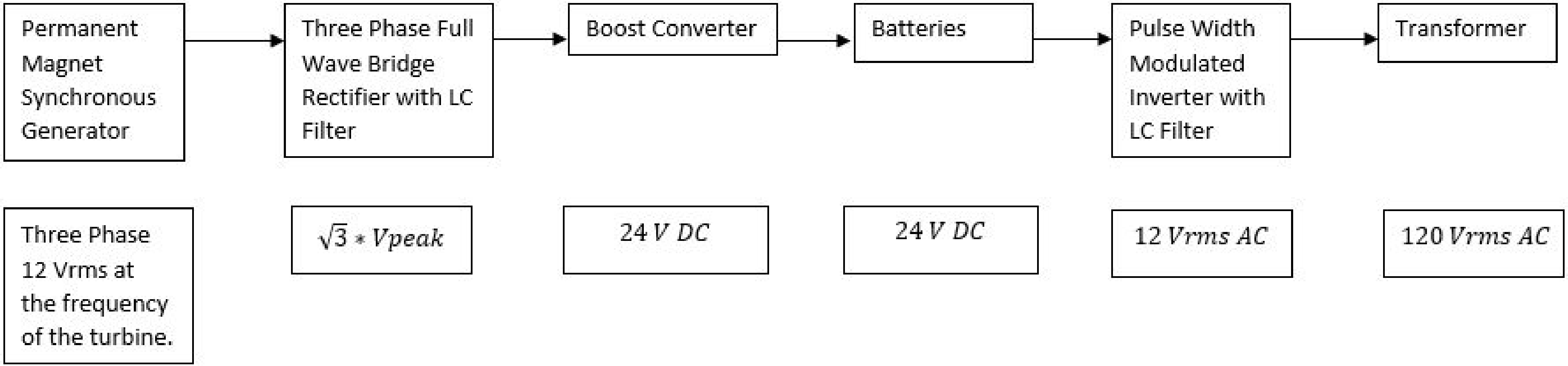
1000W/m^2 & 25C	Pmp[W]	Vmp[V]	Imp[A]	Voc[V]	Isc[A]	Cells/Module	Dimensions[mm]	Weight[kg]	Price
KD135GX-LPU	135	17.7	7.63	22.1	8.37	36(4x8)	1500/668	12.9	Current Model
KD140GX-LFBS	140	17.7	7.91	22.1	8.68	36(4x8)	1500/668	12.9	$240
KU320-72PA	320	36.8	8.7	45.5	9.22	72(6x12)	1956/992	27.5	$260 (min purchase of 4)

Project Plan- Milestones and Schedule

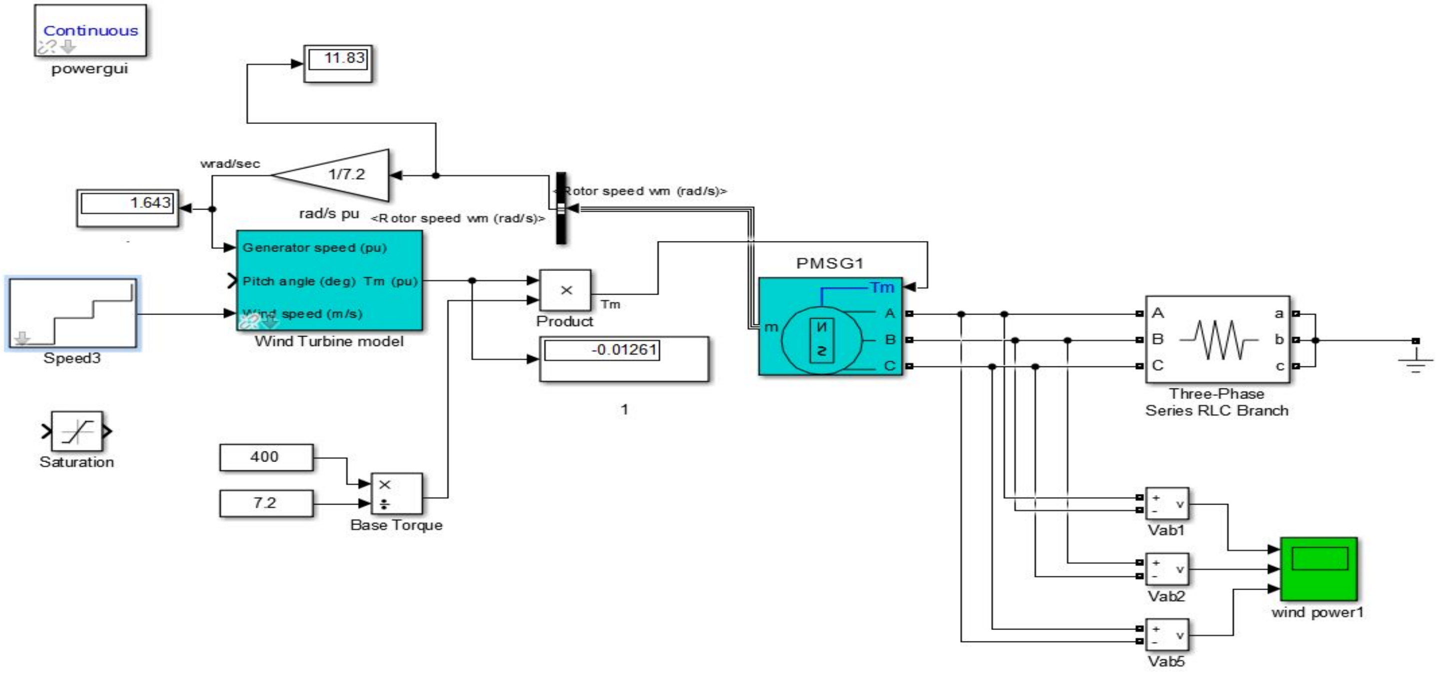
- Researched wind and solar systems
  - Boost converters, MPPT, inverters, turbine prices
- Obtained wind turbine from WESO
  - Planned with Coover administration about
  - turbine placement
- Wind and solar teams design respective systems in Simulink
  - Parameters are modeled after the existing PV hardware and potential wind hardware.
  - Simulink models functioning individually.

	August	September	October	November	December
Whole Team					
	Pick teammates				
	Assign Project				
				Combine Simulink models	
Wind Team					
		Research Wind Energy			
		Create Simulink model			
		Research Wind Turbines			
				Install Hardware	
Solar Team					
		Research Solar Energy			
		Create Simulink model			

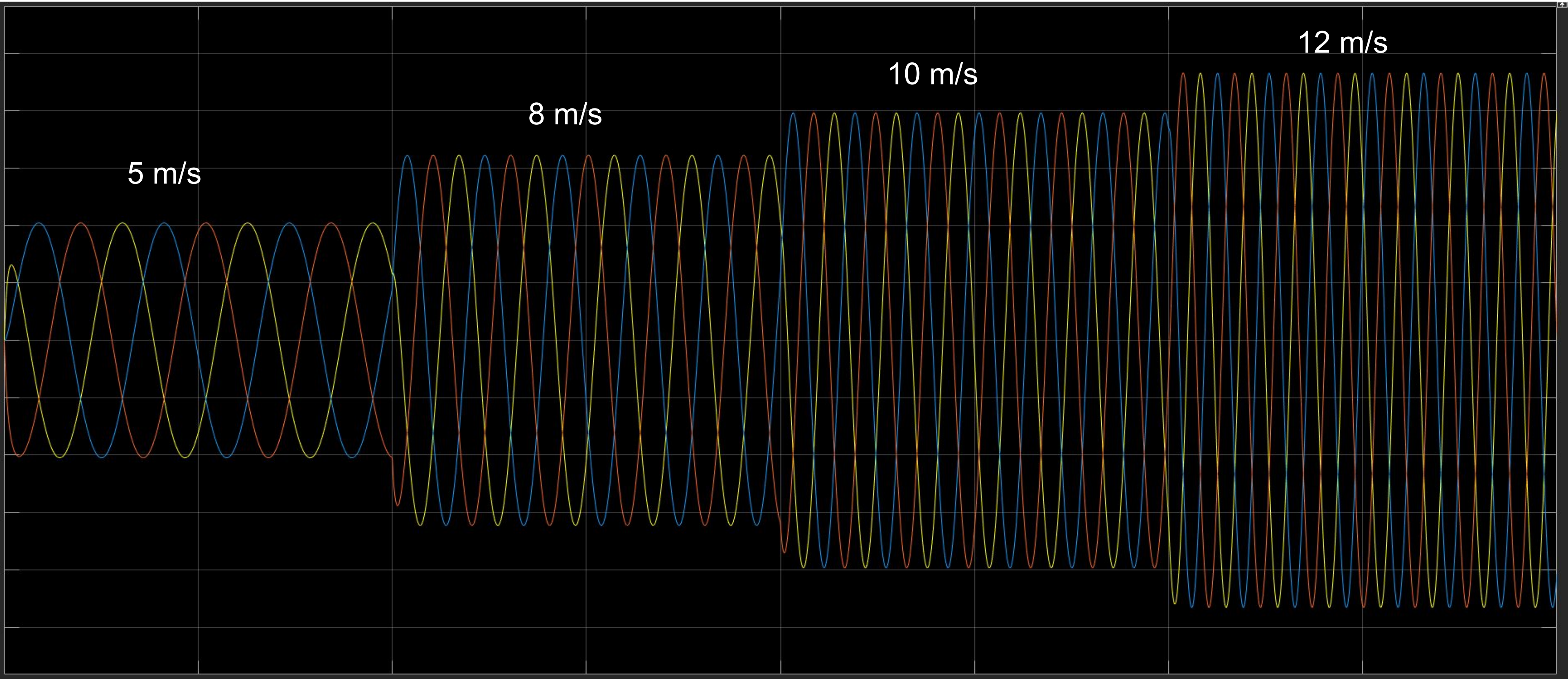
Wind System Flowchart



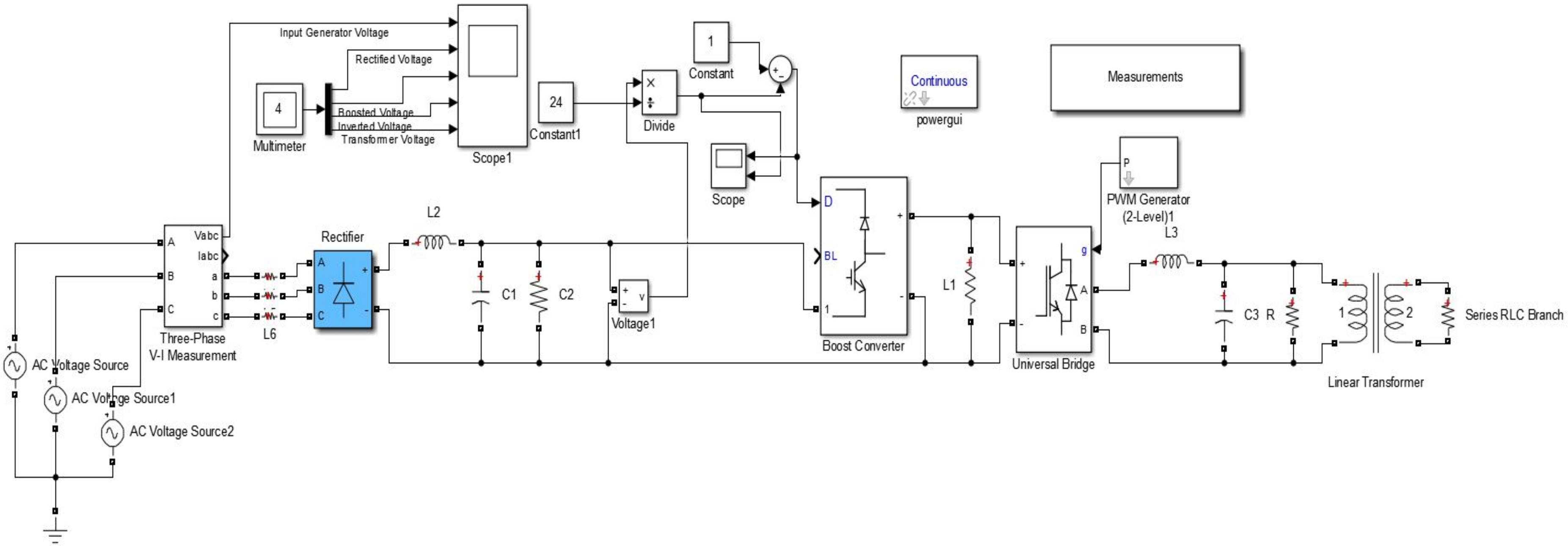
Wind Generator



Generator Output

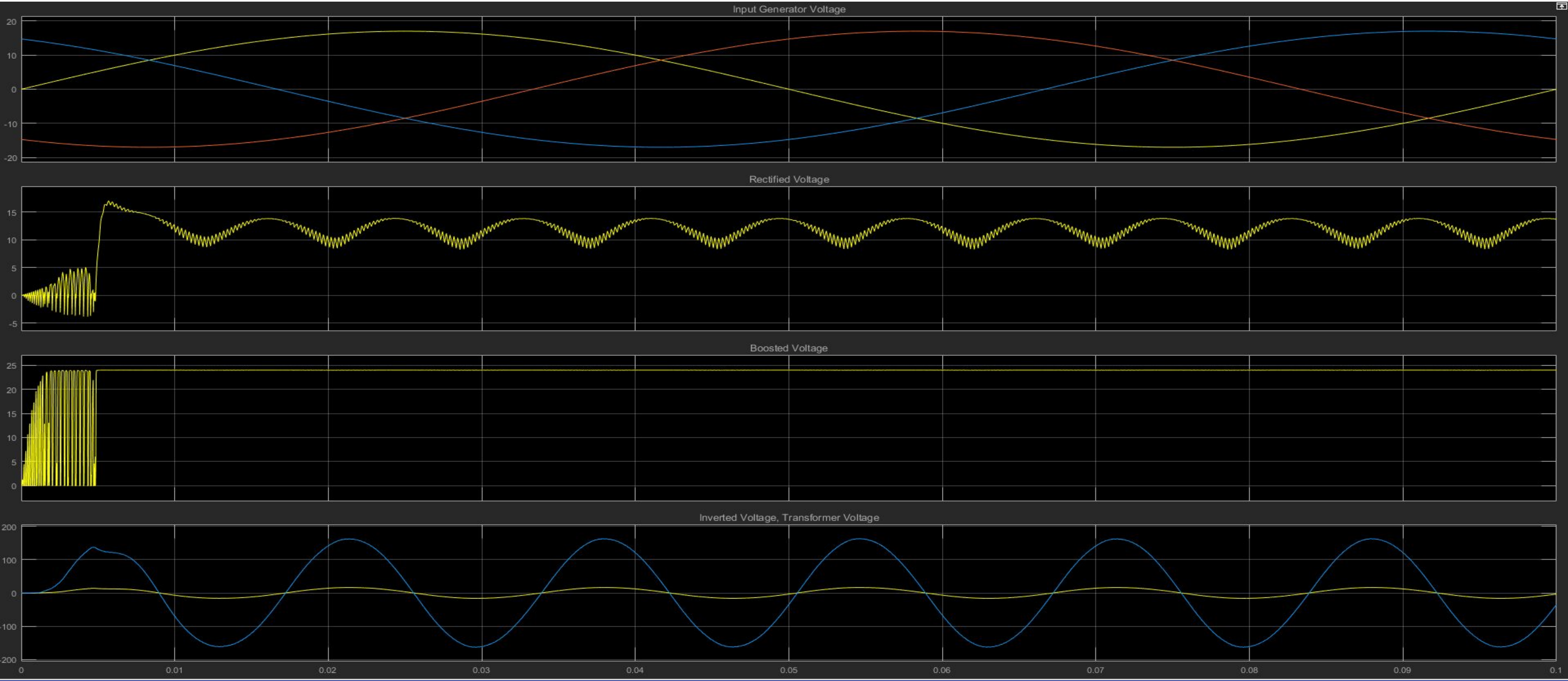


AC-DC-AC

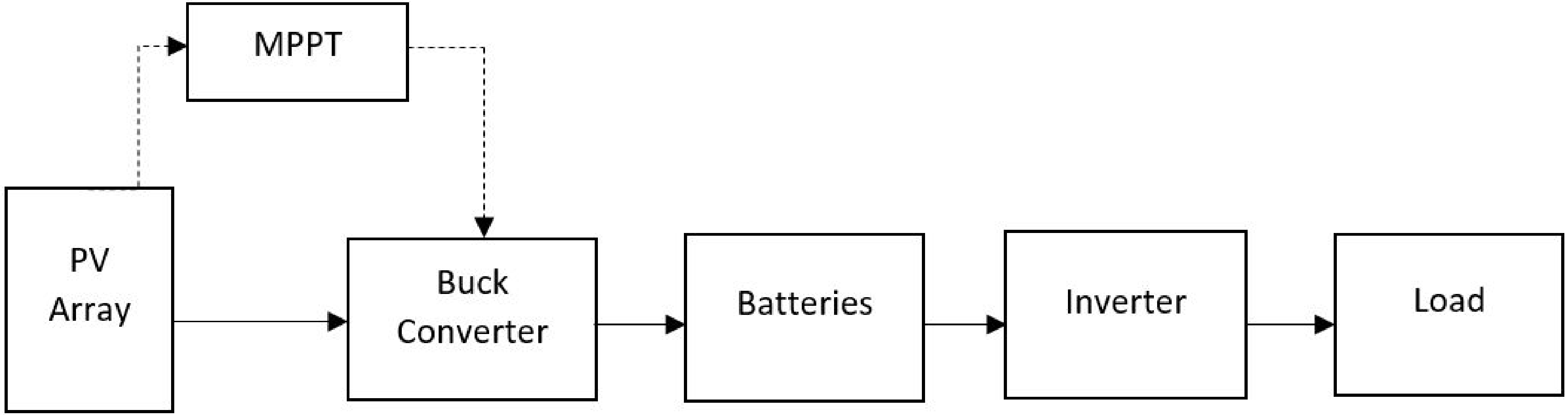


Input Generator Voltage
Rectified Voltage
Boosted Voltage
Inverted Voltage
Transformer Voltage
Multimeter
Scope1
24
Constant1
1
Constant
Divide
Scope
Continuous
powergui
Measurements
PWM Generator (2-Level)1
Three-Phase V-I Measurement
L6
Rectifier
L2
C1
C2
Voltage1
Boost Converter
L1
Universal Bridge
L3
C3
R
Linear Transformer
Series RLC Branch
AC Voltage Source
AC Voltage Source1
AC Voltage Source2

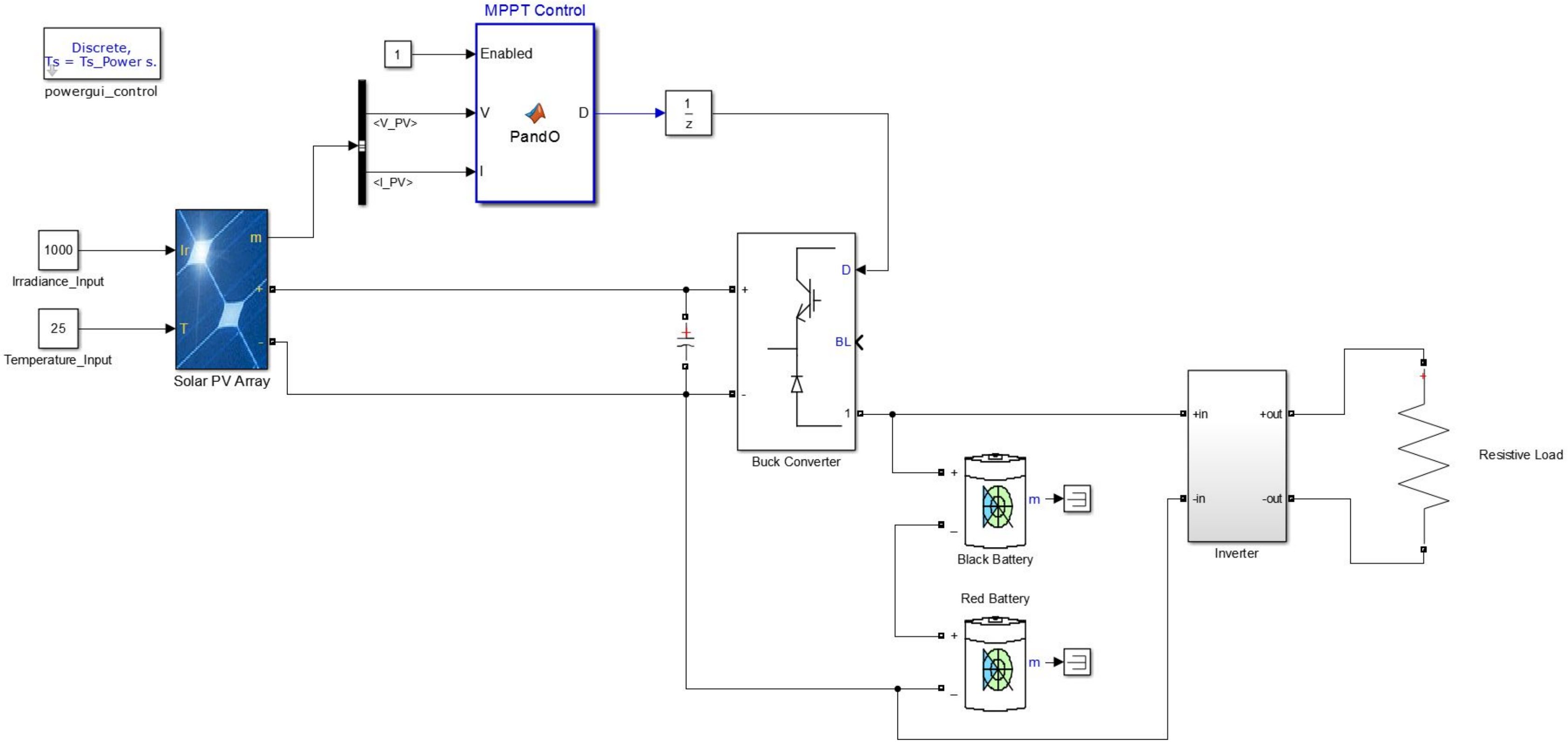
AC-DC-AC Output



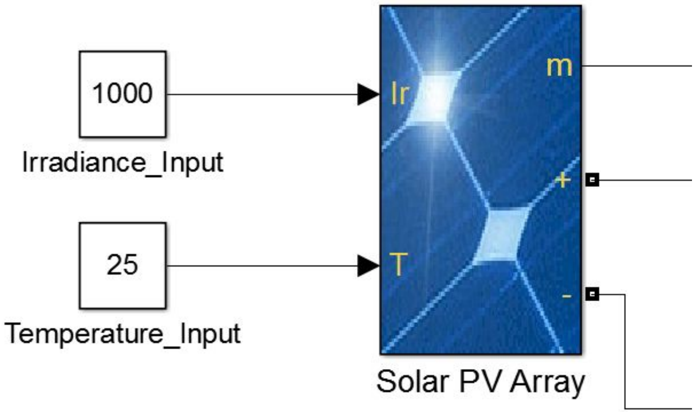
Solar System Flowchart



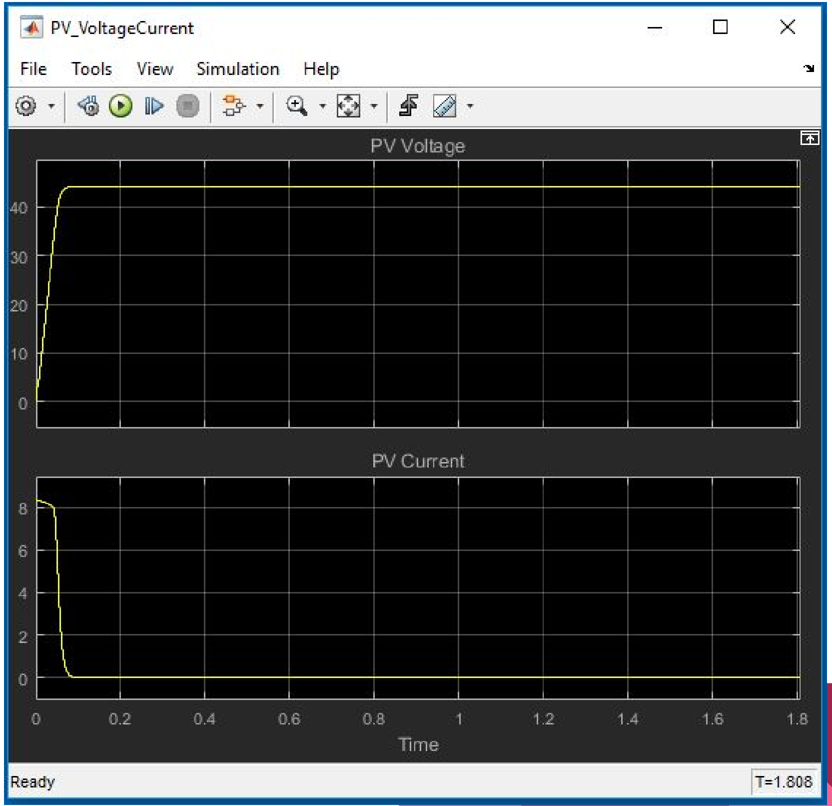
Solar System



Solar PV

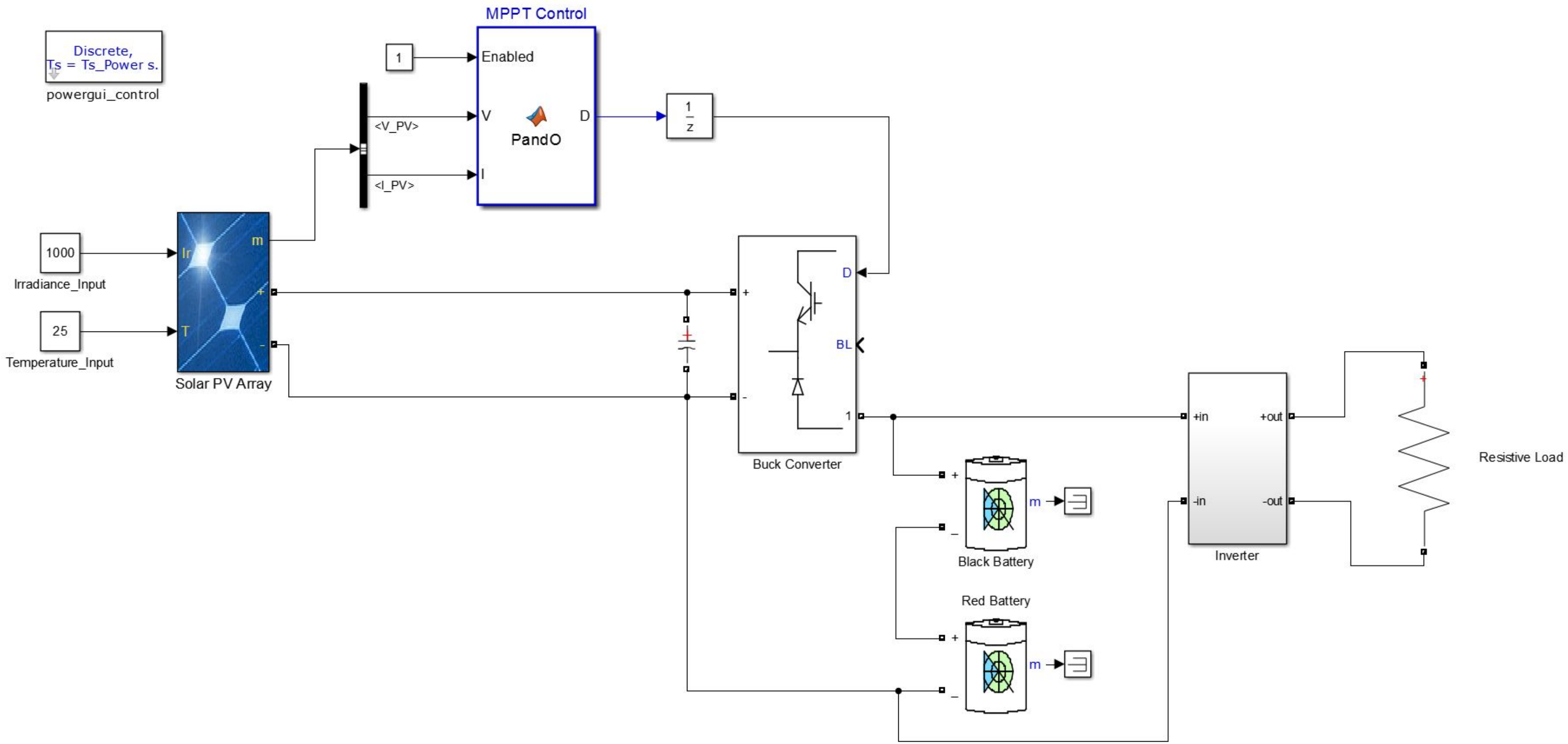


1000
Irradiance_Input
25
Temperature_Input
Ir
T
m
+
-
Solar PV Array

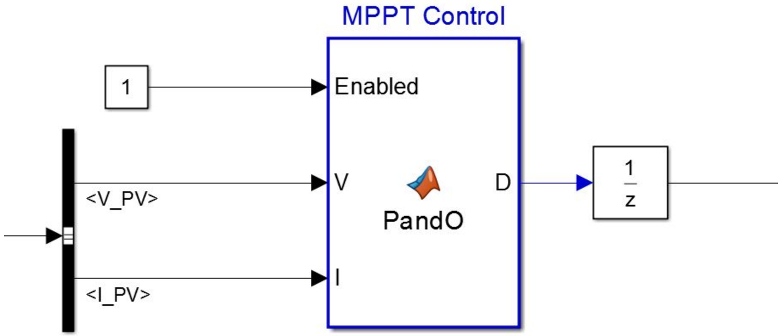


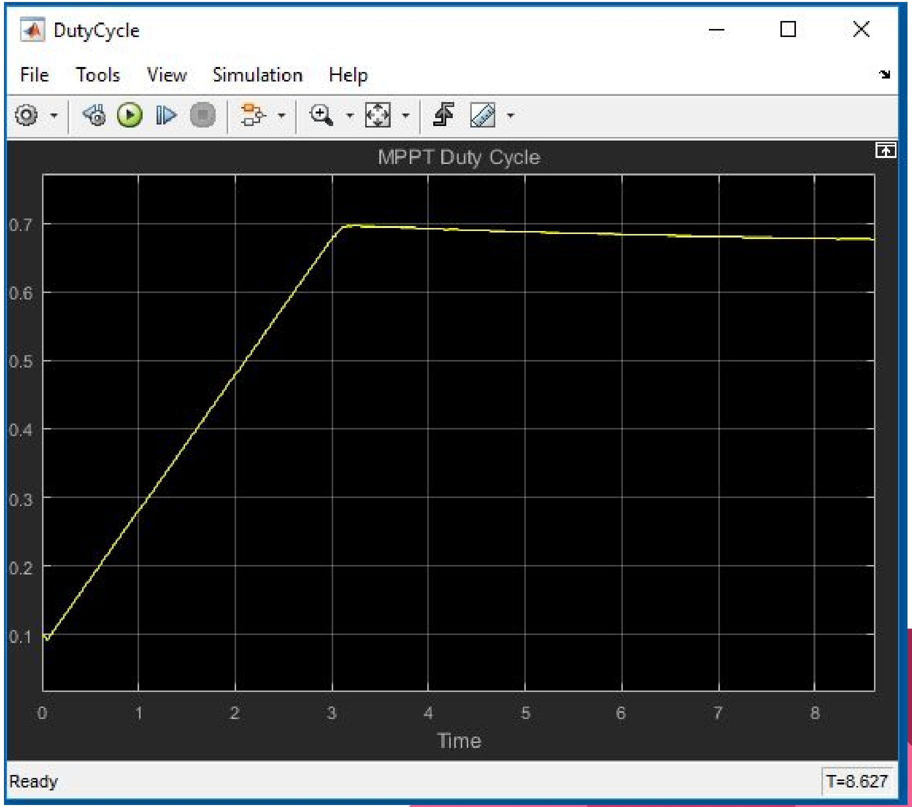
PV_VoltageCurrent
File Tools View Simulation Help
PV Voltage
40
30
20
10
0
PV Current
8
6
4
2
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8
Time
Ready
T=1.808

Solar System

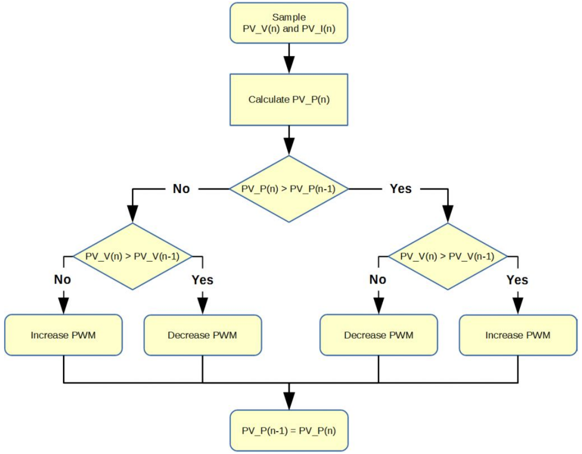


MPPT


MPPT Control
1
Enabled
V
I
D
<V_PV>
<I_PV>
PandO
1
z

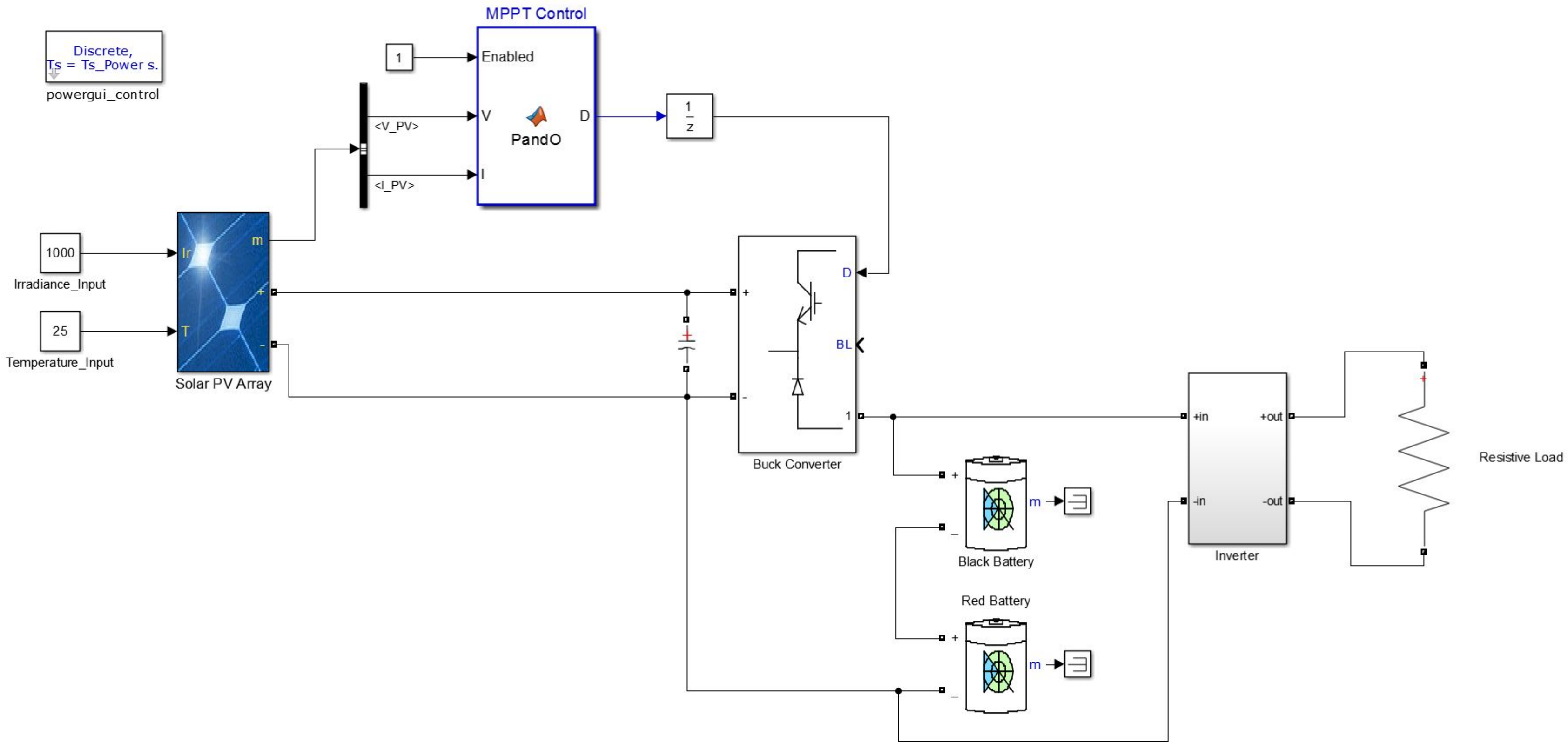

DutyCycle
File Tools View Simulation Help
MPPT Duty Cycle
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0 1 2 3 4 5 6 7 8
Time
Ready
T=8.627

P&O Algorithm

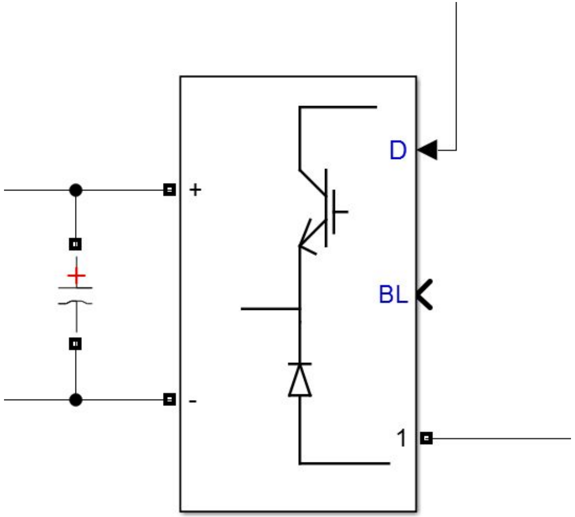


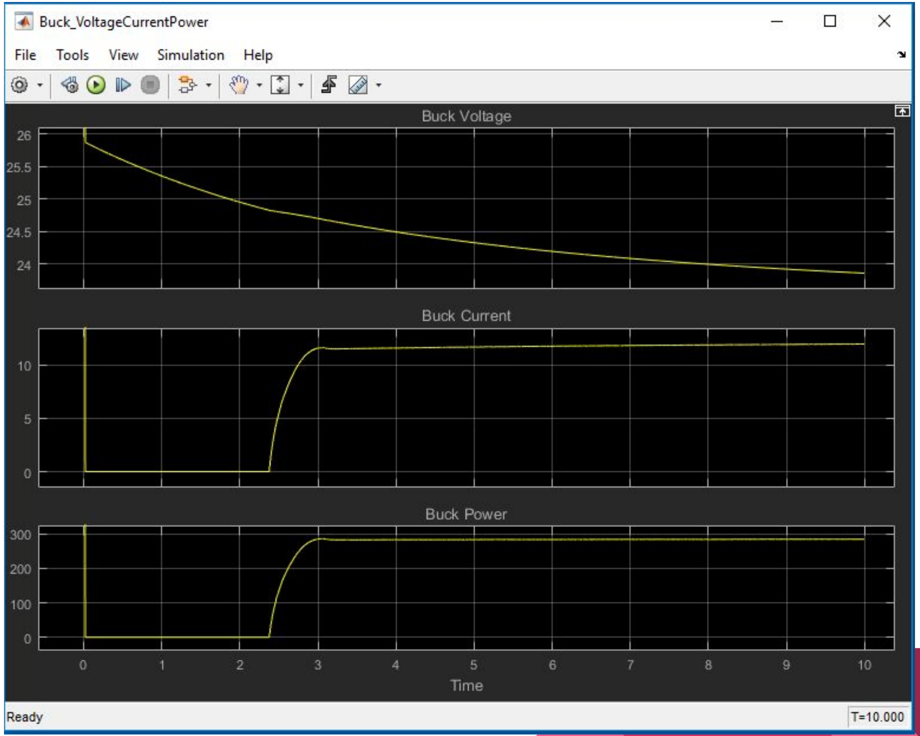

```
% Param input:
Dinit = Param(1);  %Initial value for D output
Dmax = Param(2);   %Maximum value for D
Dmin = Param(3);   %Minimum value for D
deltaD = Param(4); %Increment value used to increase/decrease the duty cycle D
% ( increasing D = decreasing Vref )
%

persistent Vold Pold Dold;

dataType = 'double';

if isempty(Vold)
    Vold=0;
    Pold=0;
    Dold=Dinit;
end
P= V*I;
dV= V - Vold;
dP= P - Pold;

if dP ~= 0 & Enabled ~=0
    if dP < 0
        if dV < 0
            D = Dold - deltaD;
        else
            D = Dold + deltaD;
        end
    else
        if dV < 0
            D = Dold + deltaD;
        else
            D = Dold - deltaD;
        end
    end
else D=Dold;
end

if D >= Dmax | D<= Dmin
    D=Dold;
end

Dold=D;
Vold=V;
Pold=P;
```

Solar System

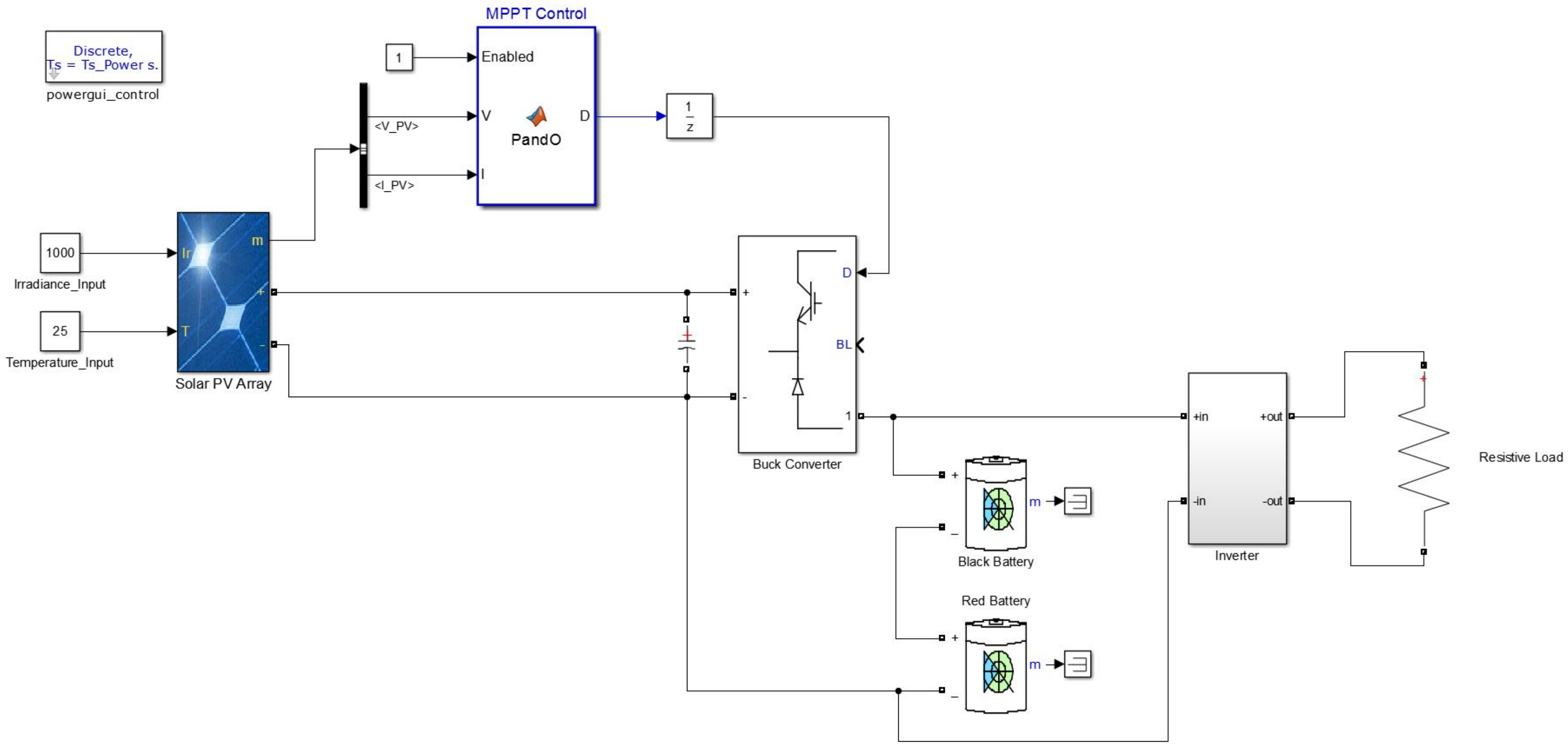


Buck

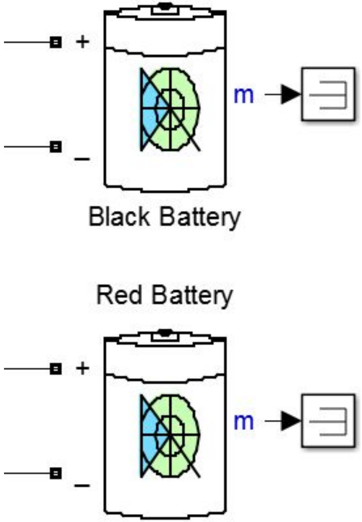

D
BL
+
-
1
Buck Converter


Buck_VoltageCurrentPower
File Tools View Simulation Help
Buck Voltage
26
25.5
25
24.5
24
Buck Current
10
5
0
Buck Power
300
200
100
0
0 1 2 3 4 5 6 7 8 9 10
Time
Ready
T=10.000

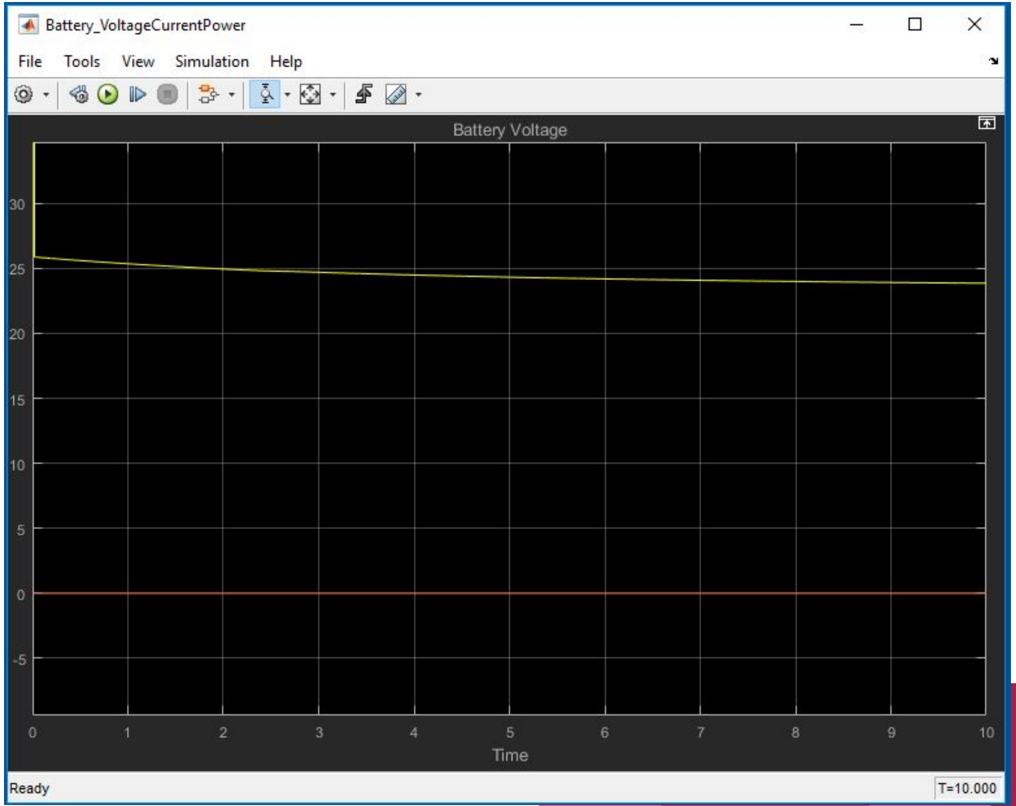
Solar System



Battery

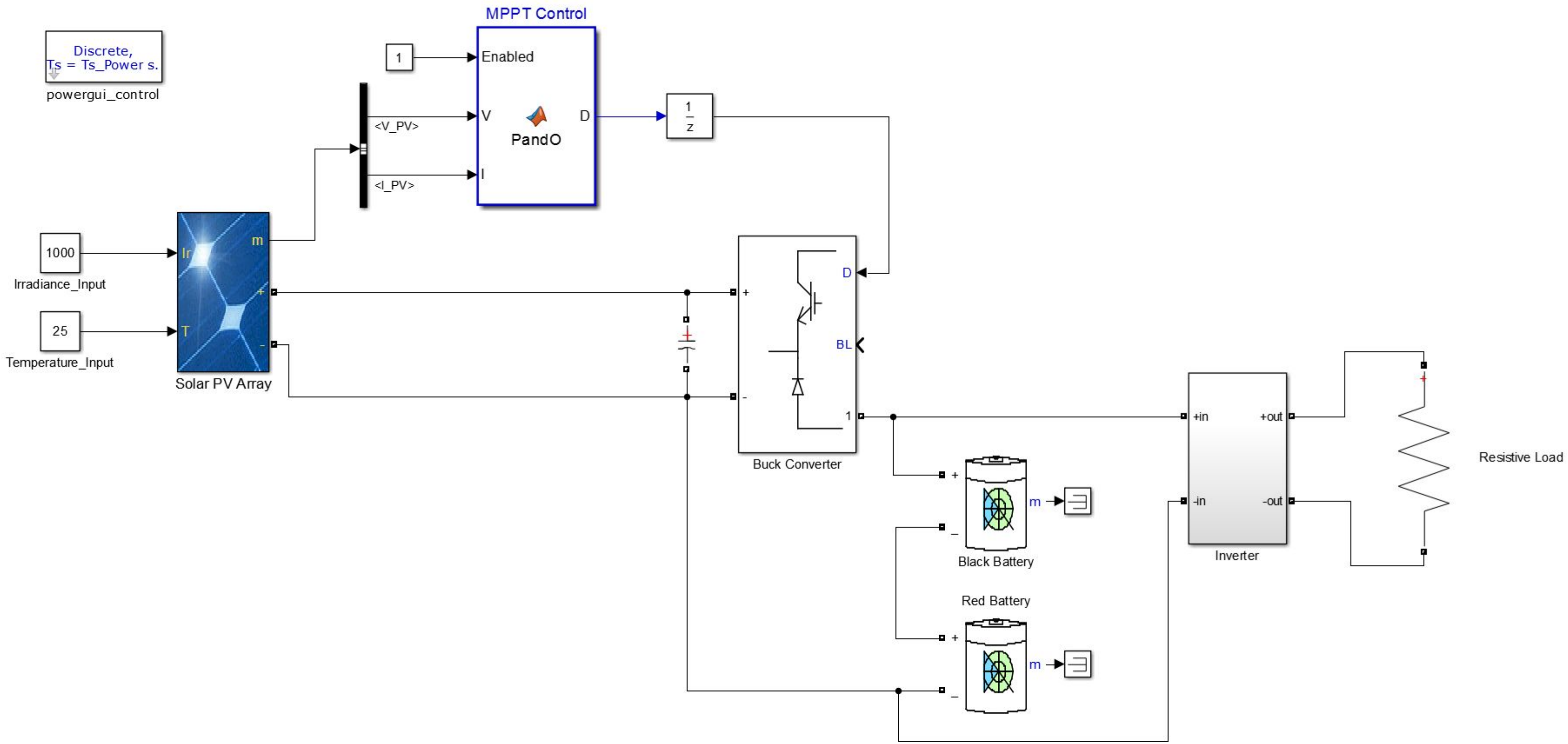


+
m
_
Black Battery
Red Battery
+
m
_

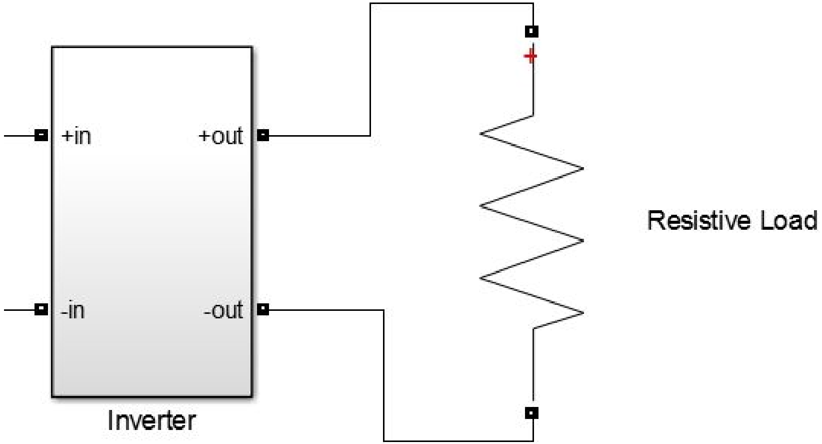


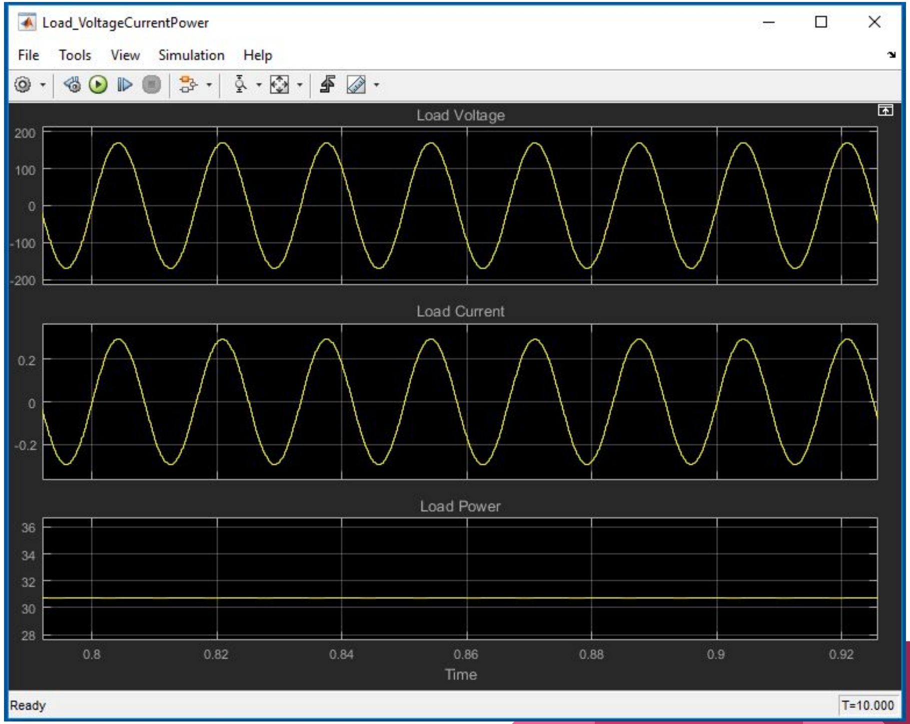
Battery_VoltageCurrentPower
File Tools View Simulation Help
Battery Voltage
30
25
20
15
10
5
0
-5
0 1 2 3 4 5 6 7 8 9 10
Time
Ready
T=10.000

Solar System



Inverter/Load

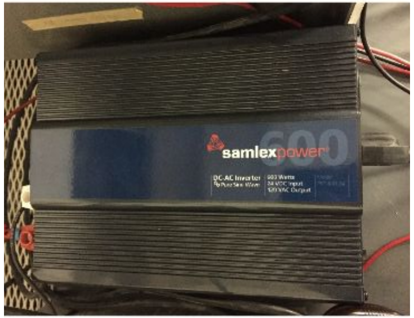




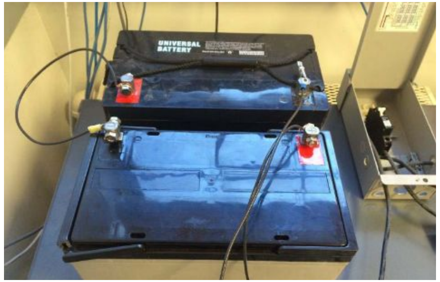
Hardware Technology Platform

Solar Panels

MPPT



Inverter



Batteries

Load

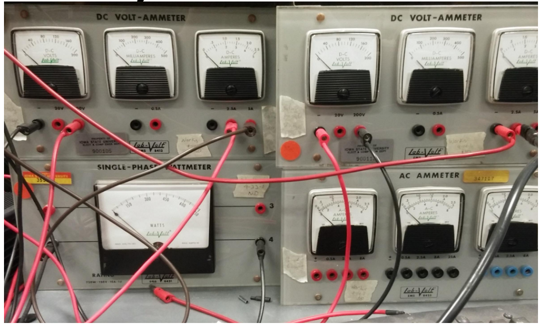
Instruments

User Adjustable Load

Safety Switch

Data Recorder

Monitor



Voltage, Current, and Power Meters

Functional Prototype planned to be implemented next semester.

Conclusion- Status

Current Project Status

Software:

- Section-by-section functionality Simulink models for the Wind and Solar systems.

Hardware

- Obtained permission from WESO to use their Wind Turbine.
- The turbine is fully functioning and generates either 3-phase AC voltage or DC voltage. It's equipped with several sensors which can be used in lab.

Conclusion- Contributions

Individual Contributions:

Eric Cole - Webmaster - Developed Team Website and Wind Simulink Model

Jeffrey Szostak - Wind Tech Lead - Procured WESO Wind Turbine Usage

Michael Trischan - Key Concept Holder - Researched Potential Wind Turbines

Nathaniel Byrne - Group Leader - Solar Fundamentals and Solar Panel Research

Matt Lee - Communications Leader - Communications, Weekly Reports, Solar Simulink Model

Brian Gronseth - Solar Tech Lead - Solar System design, hardware setup

Conclusion- Plan

Next Semester Plan:

- Combine solar and wind simulink diagrams with batteries
- Combine hardware systems
  - Purchase additional Solar Panels
  - Make necessary edits to WESO wind turbine
- Create lab documents for EE 452

Conclusion- Questions

Questions?

Contact info:

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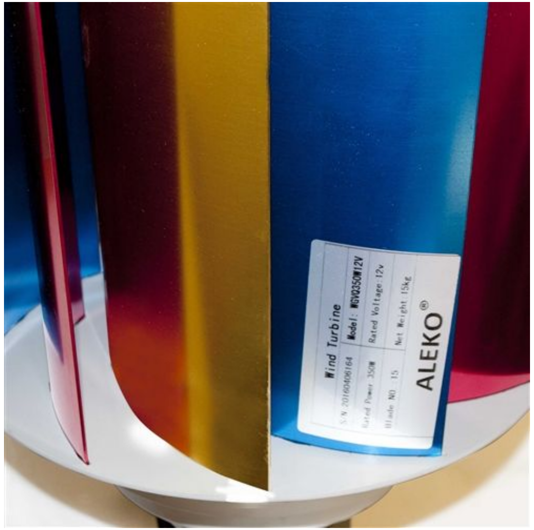
Website: http://may1727.sd.ece.iastate.edu

Appendix

ALEKO 350 W VAWT



Rated Power	350 W
Start up speed	**1.5 m/s**
Rated speed	11 m/s
Max speed	45 m/s
Diameter	1.12 m
Cost	$495.00
Shipping	Free; 1-3 weeks

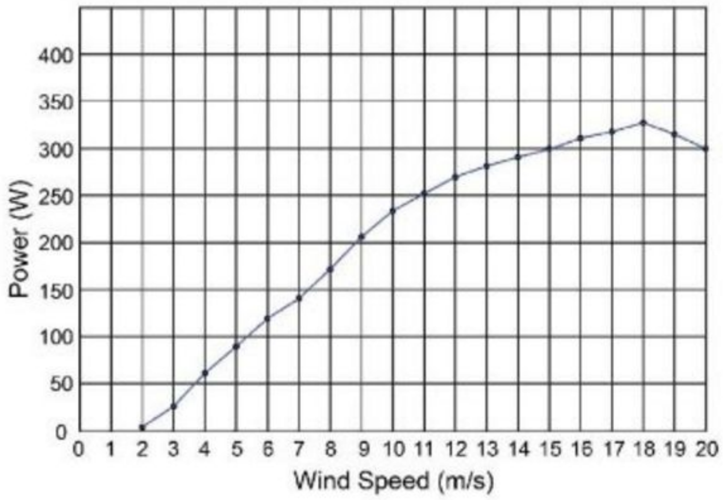
http://www.alekoproducts.com/ALEKO-350W-24V-Vertical-Wind-Power-Generator-p/wgvq350w24v-ap.htm

Shineman 600 W VAWT

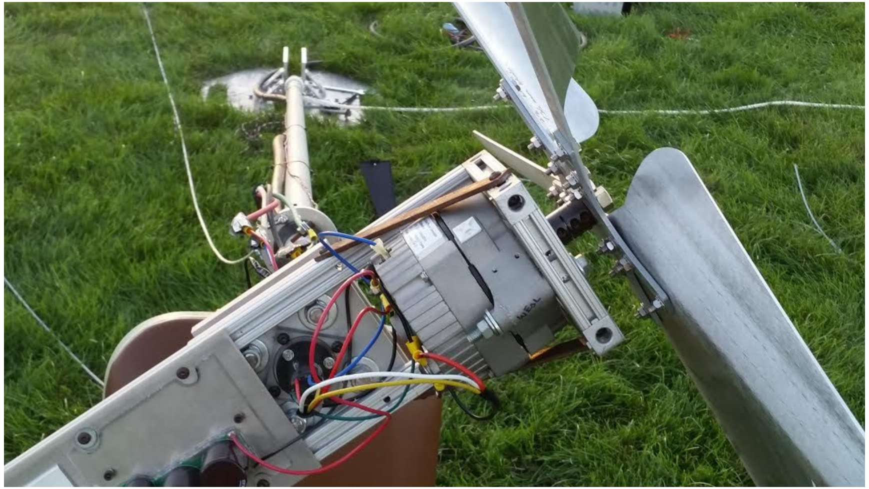
Max Power	650 W
Rated Power	600 W
Start up speed	3 m/s
Max speed	40 m/s
Diameter	1.2 m
Height of tower	6 m
Cost	$480.00
Shipping	Free; 5-7 weeks

http://www.ebay.com/itm/1m-length-600W-Wind-turbine-Vertical-axis-blade-high-quality-for-sale-5pcs-lot/262679596613?_trksid=p2047675.c100005.m1851&_trkparms=aid%3D222007%26algo%3DSIC.MBE%26ao%3D1%26asc%3D39497%26meid%3De8946d39f4aa4d07808671ea391cf64c%26pid%3D100005%26rk%3D2%26rkt%3D6%26sd%3D252581684544

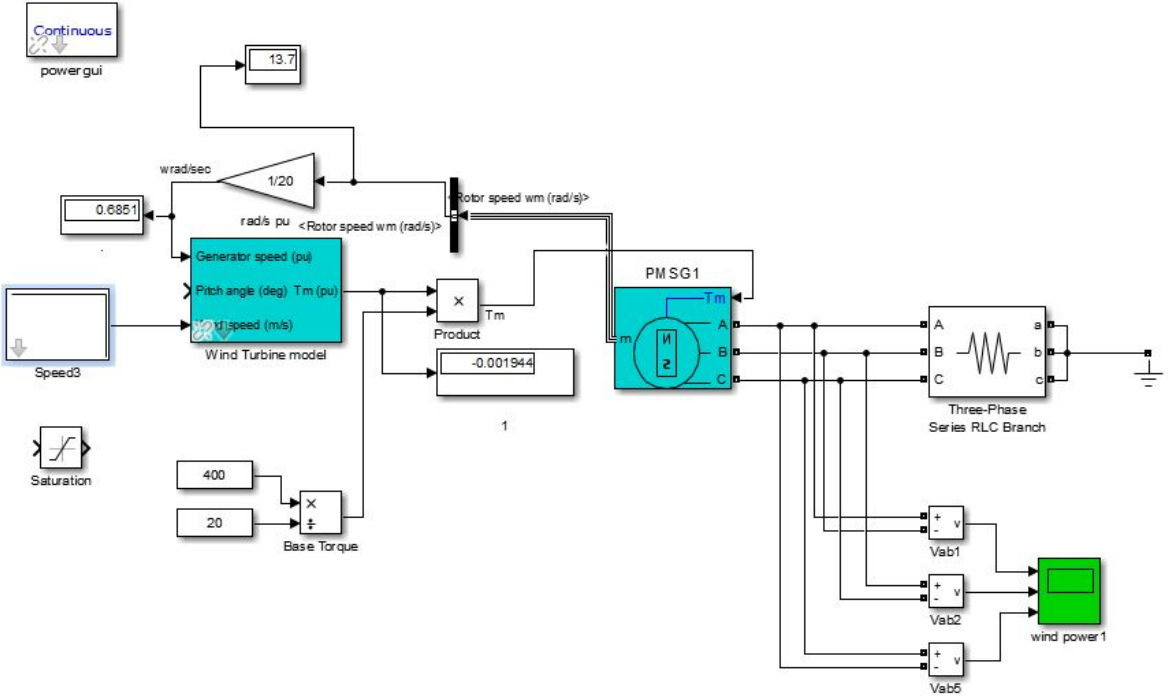
Typical power curve for turbines we researched



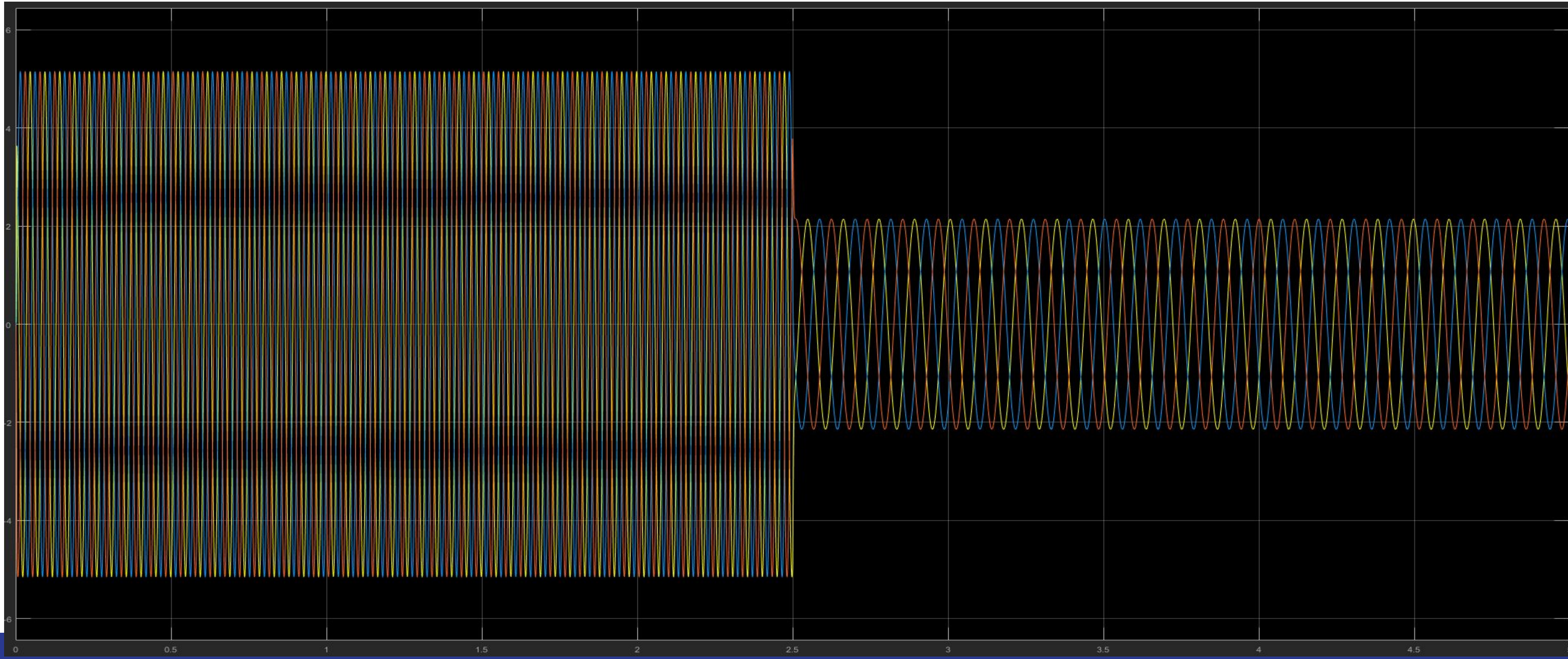
Wind Turbine



Wind Turbine and Generator

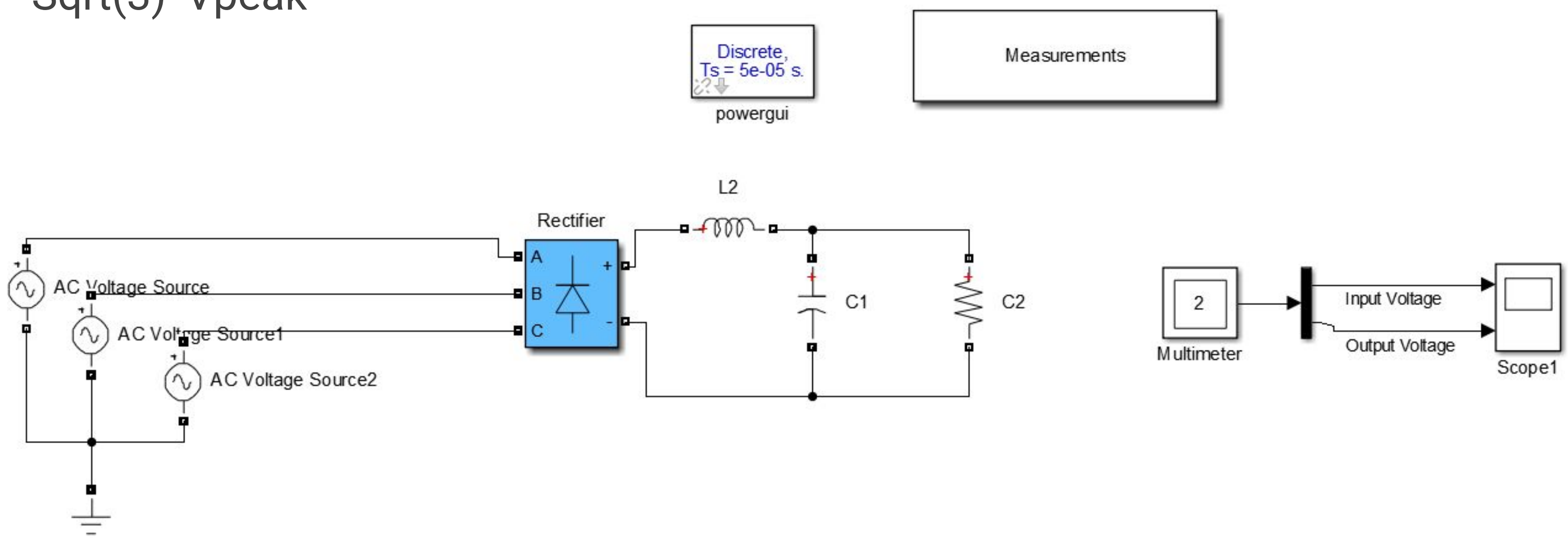


Generator Output

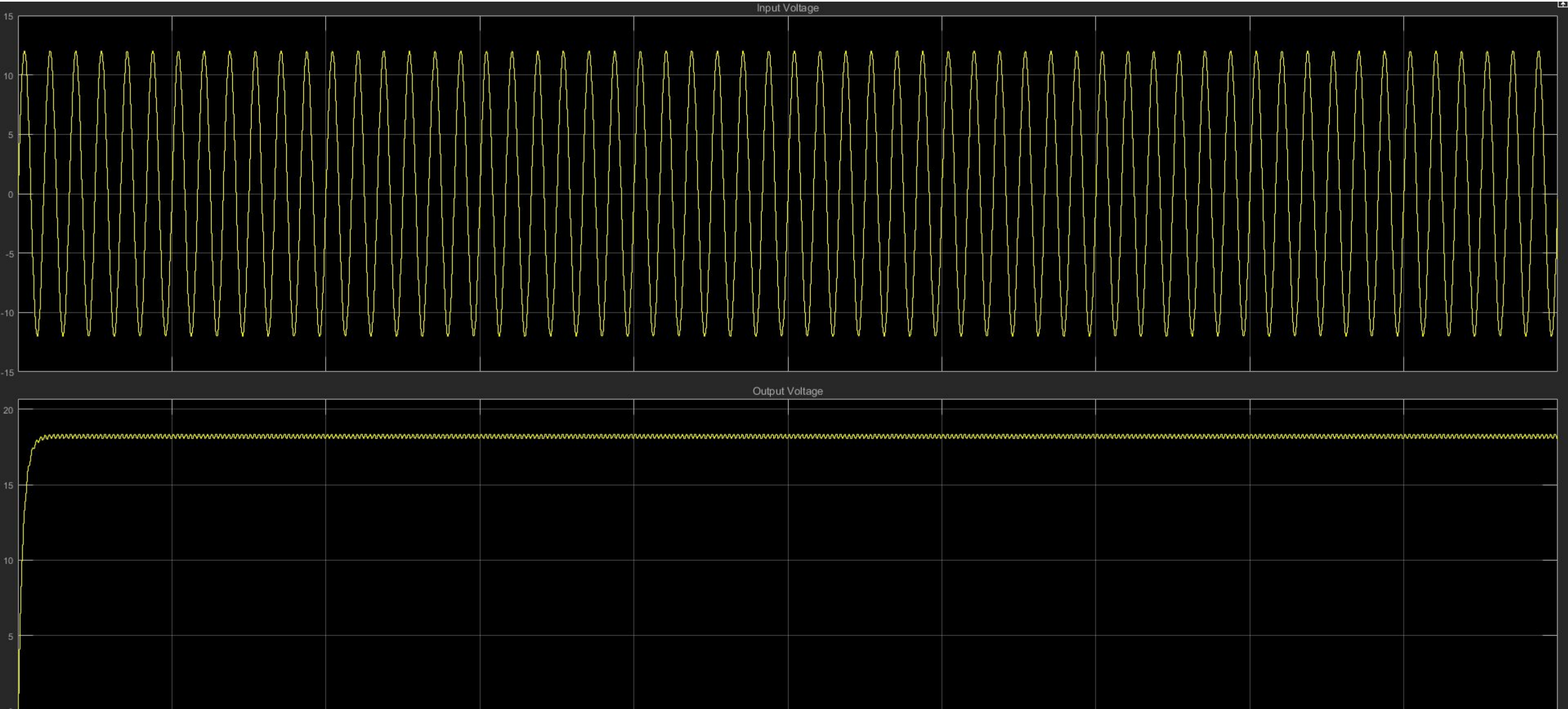


Three phase Rectifier

Sqrt(3)*Vpeak

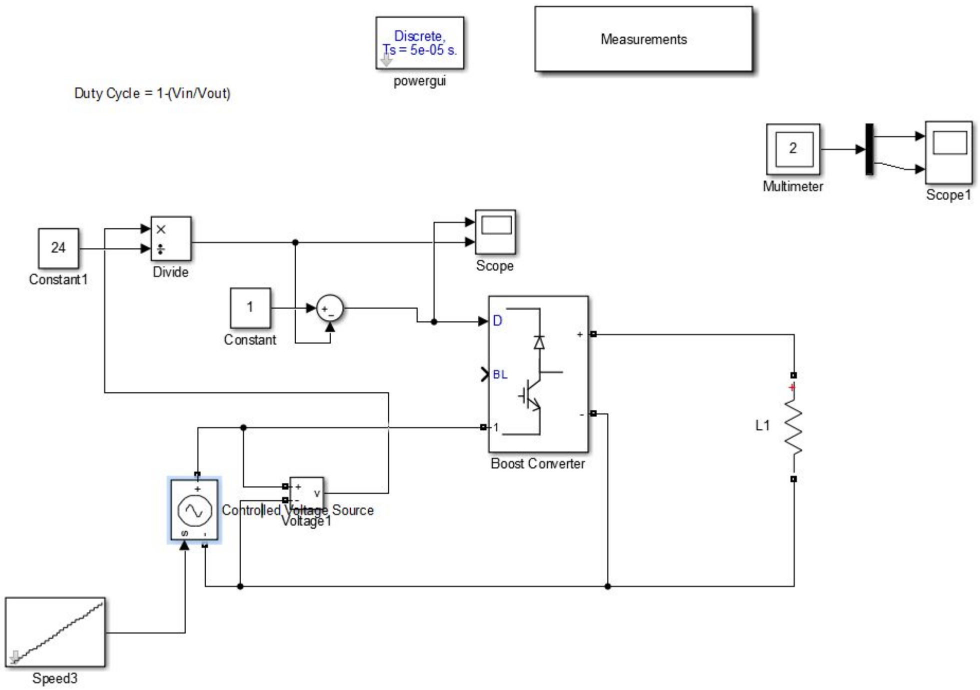


Rectifier Output

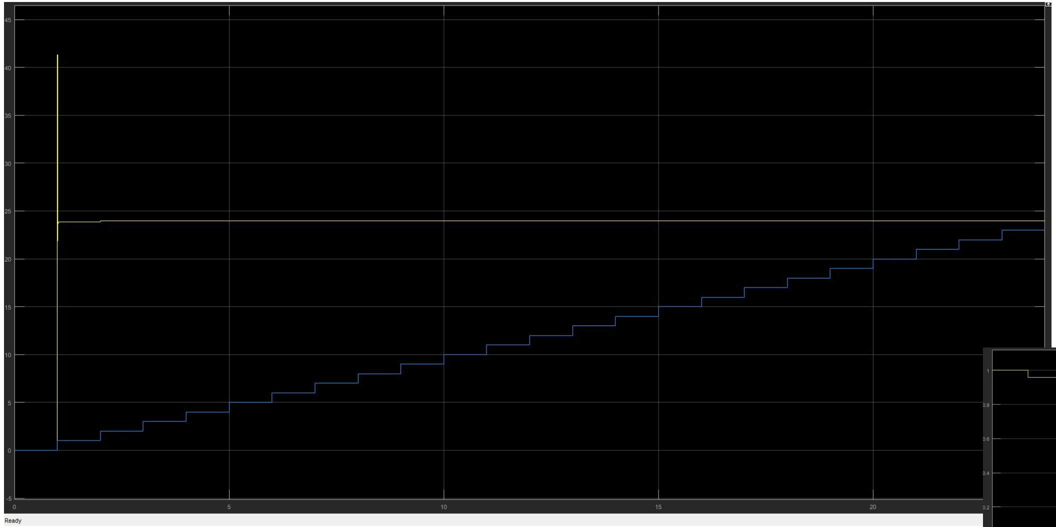


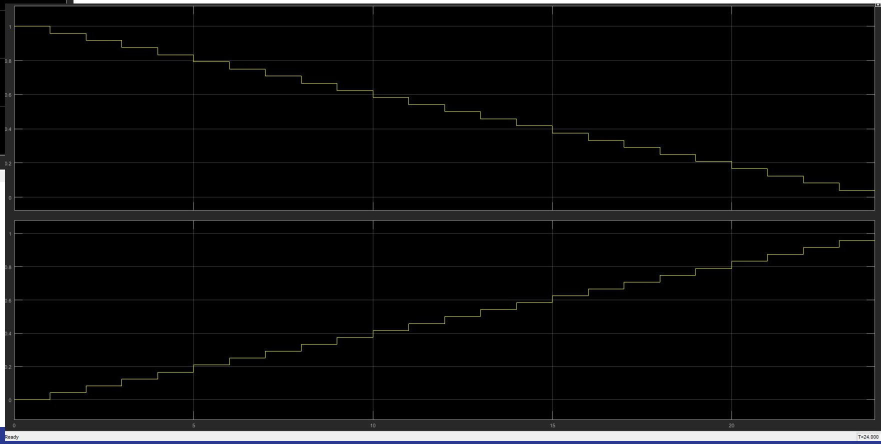
Boost Converter

Duty Cycle = 1-(Vin/Vout)

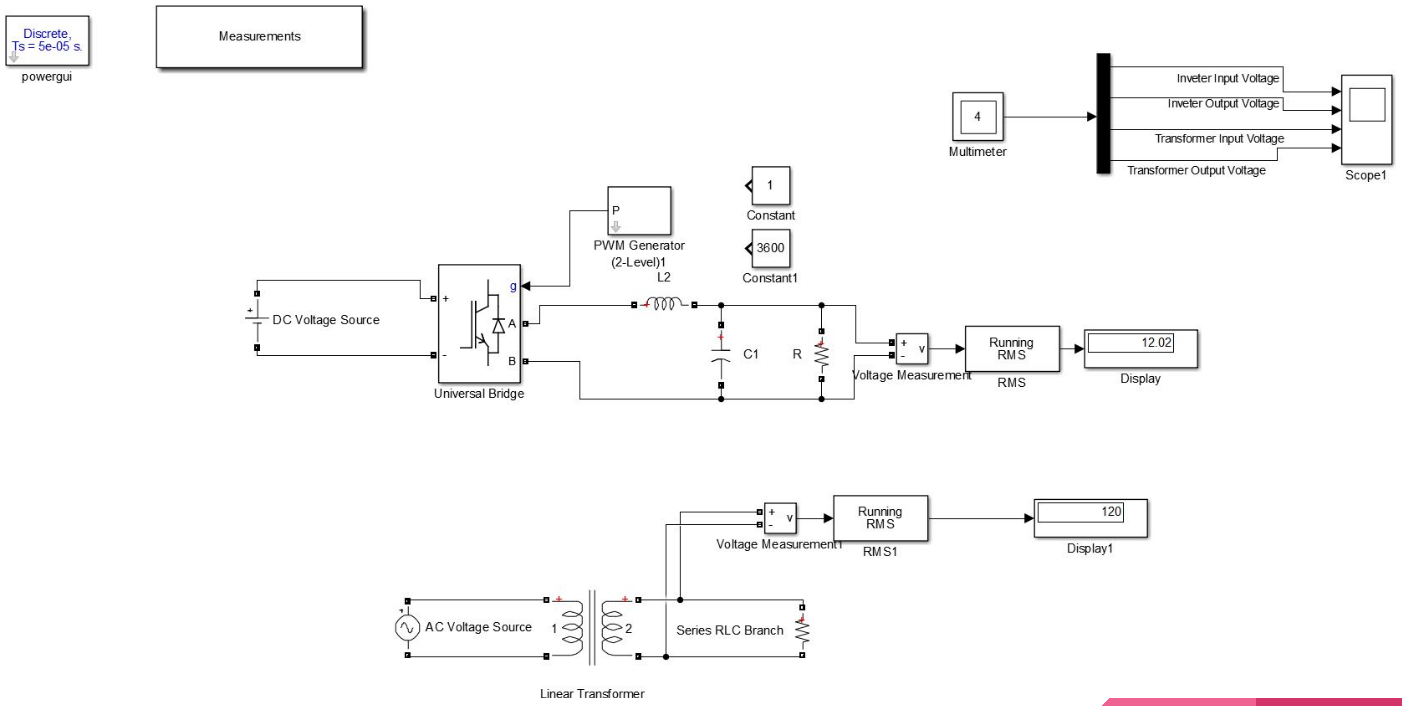


Boost Converter Output

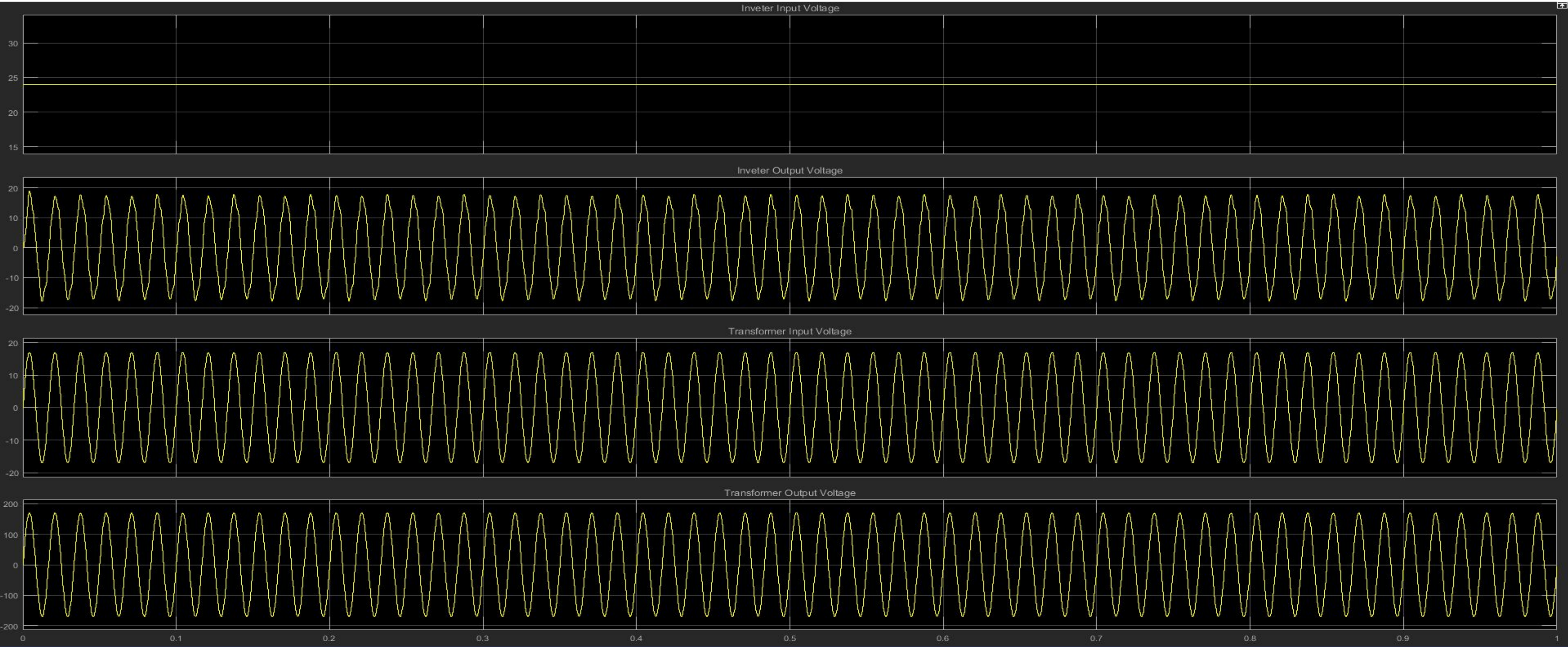




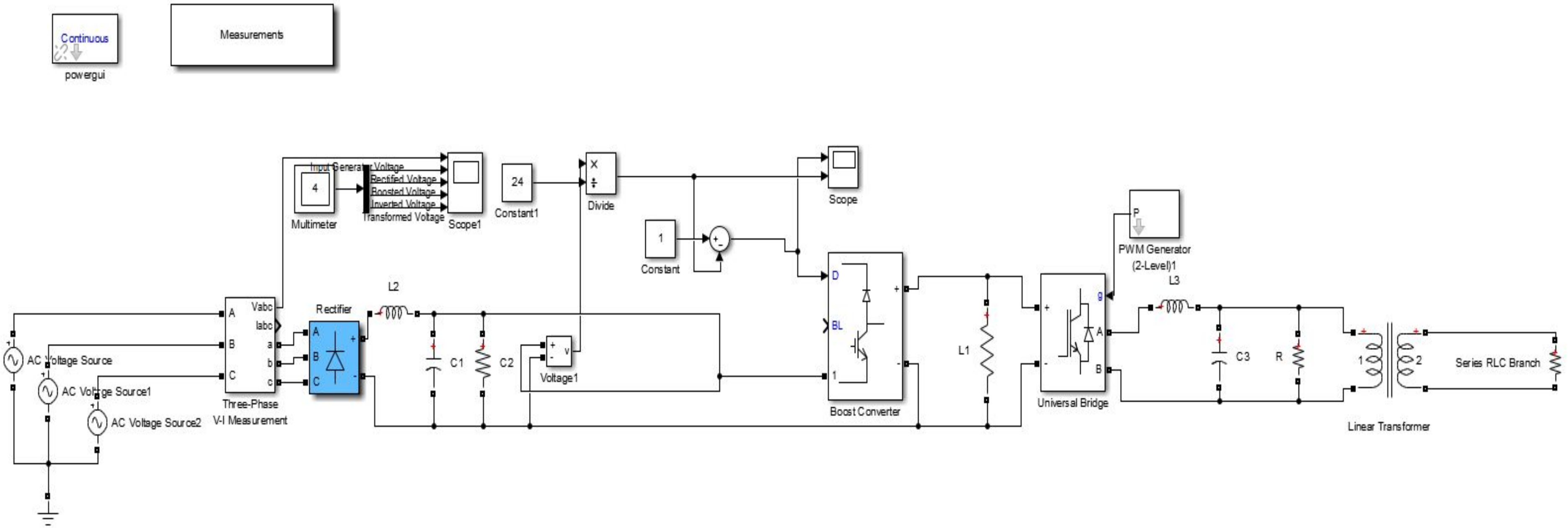
Inverter


Discrete,
Ts = 5e-05 s.
powergui
Measurements
4
Multimeter
Inveter Input Voltage
Inveter Output Voltage
Transformer Input Voltage
Transformer Output Voltage
Scope1
P
PWM Generator
(2-Level)1
1
Constant
3600
Constant1
L2
g
+
A
B
DC Voltage Source
Universal Bridge
C1
R
Voltage Measurement
Running
RMS
RMS
12.02
Display
Running
RMS
RMS1
120
Display1
Voltage Measurement1
AC Voltage Source
1
2
Series RLC Branch
Linear Transformer

Inverter and Transformer Output

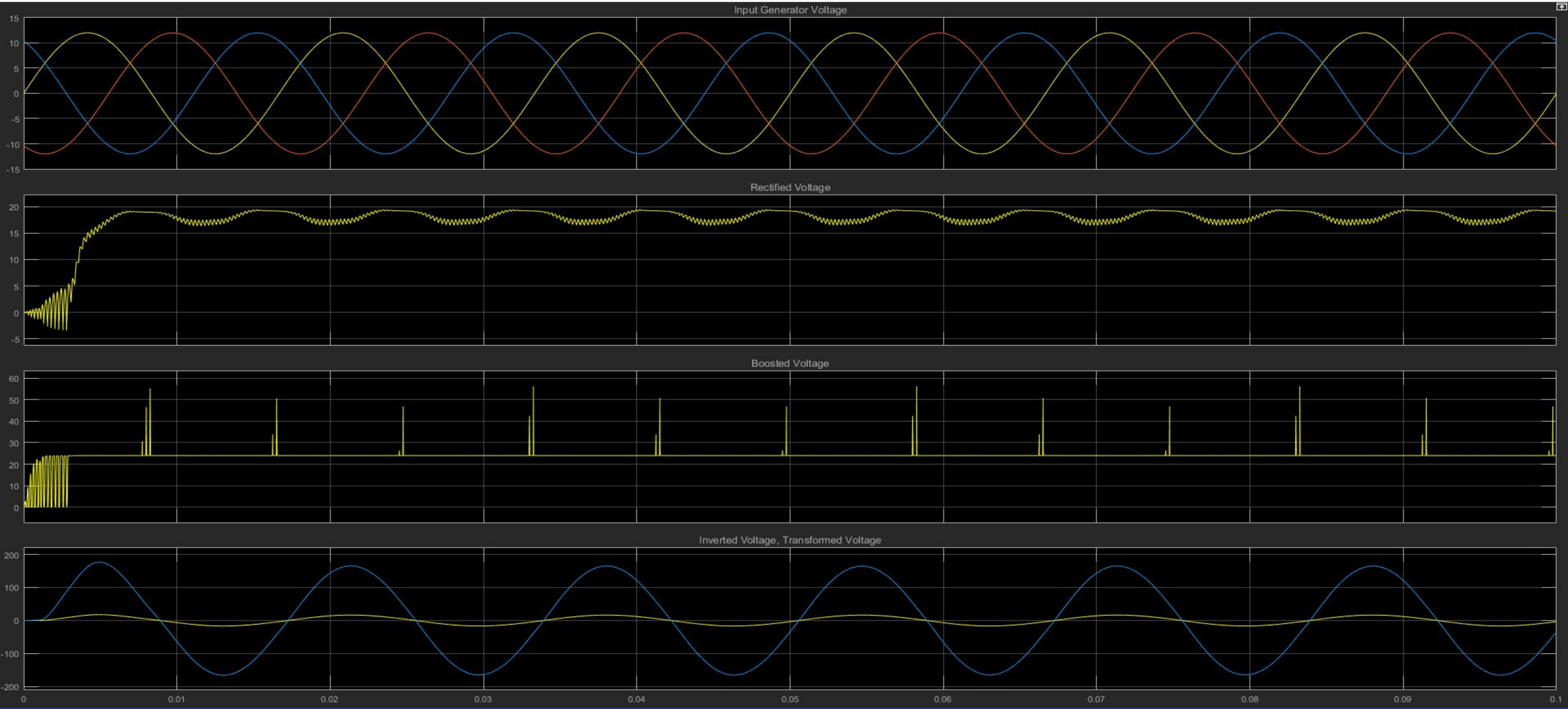


AC-DC-AC



Continuous
powergui
Measurements
Input Generator Voltage
Rectified Voltage
Boosted Voltage
Inverted Voltage
Transformed Voltage
4
Multimeter
Scope1
24
Constant1
Divide
Scope
1
Constant
PWM Generator (2-Level)1
L3
L2
Rectifier
Vabc
Iabc
Three-Phase V-I Measurement
AC Voltage Source
AC Voltage Source1
AC Voltage Source2
C1
C2
Voltage1
Boost Converter
L1
Universal Bridge
C3
R
Linear Transformer
Series RLC Branch

AC-DC-AC Output



Forecasted Prototype

Functional Prototype planned to be implemented next semester.

Along with aforementioned Design, Prototype will have:

- Meters for measuring current and voltage values, similar to simulations.
- Monitor and Controller for analysing data during operation.
- User Interface limited to adjusting load via light bulb switches, as seen on previous slide.