Standalone Hybrid Wind & Solar Generation System

May1727
26 April 2017

Team

Members:

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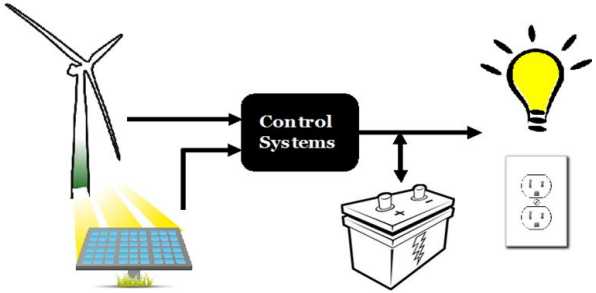
Agenda

- Design
- Problem Solving
- Project Successes, Prototyping, Technical Skills
- Testing

Design

Project Plan - Project Statement

- Project Statement:
  - Development of lab manuals and curriculum pertaining to a hybrid wind and solar system, modelled in software and hardware, to emulate microgrid environments and to provide a beneficial learning tool for students
- Project Need:
  - Green energy is a growing industry, obstacles are arising from the fluid architecture of the power grid. Building this hybrid power generation device will allow us to test the role renewable energy will have on peak loads and in specific environments.



Project Plan - Requirements

Functional Requirements

- Lab Manuals
  - Study of Conservation of Energy and PV Power Generation
  - AC-DC-AC Power Conversions
  - Effects of Irradiance and Temperature on PV Generation
  - Calculating Power Coefficient

Nonfunctional Requirements

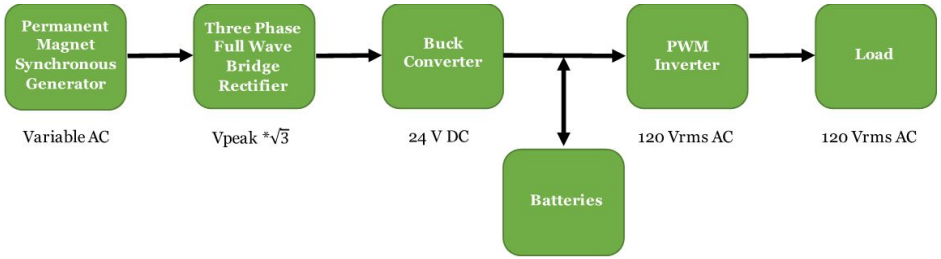
- Solar Software System
- Wind Software System
- Solar Hardware System

Project Plan - Market /Literature Survey

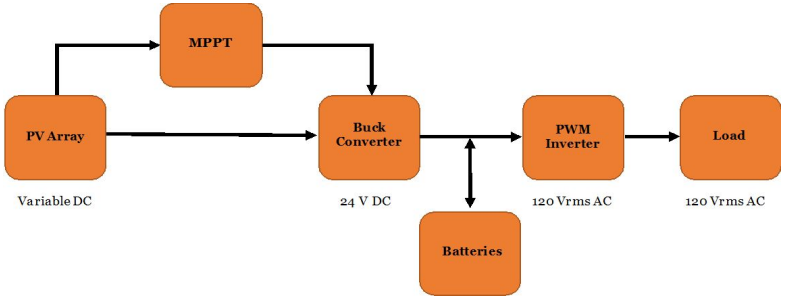
- Market Survey
  - This project is intended to supplement student learning for those who are taking EE 452. Therefore, at the professor's discretion, students will be the primary users of the project deliverables in a lab setting. Lab experiments will be done under the guidance of a TA who is knowledgeable on the PV hardware system, as well as the software simulation portion of the experiments.
  - An important component of this project was the relationship we built with WESO, who was willing to allow academic use of their wind turbine for testing and research purposes throughout Fall and Spring semester.

Project Plan - System Analysis & Decomposition

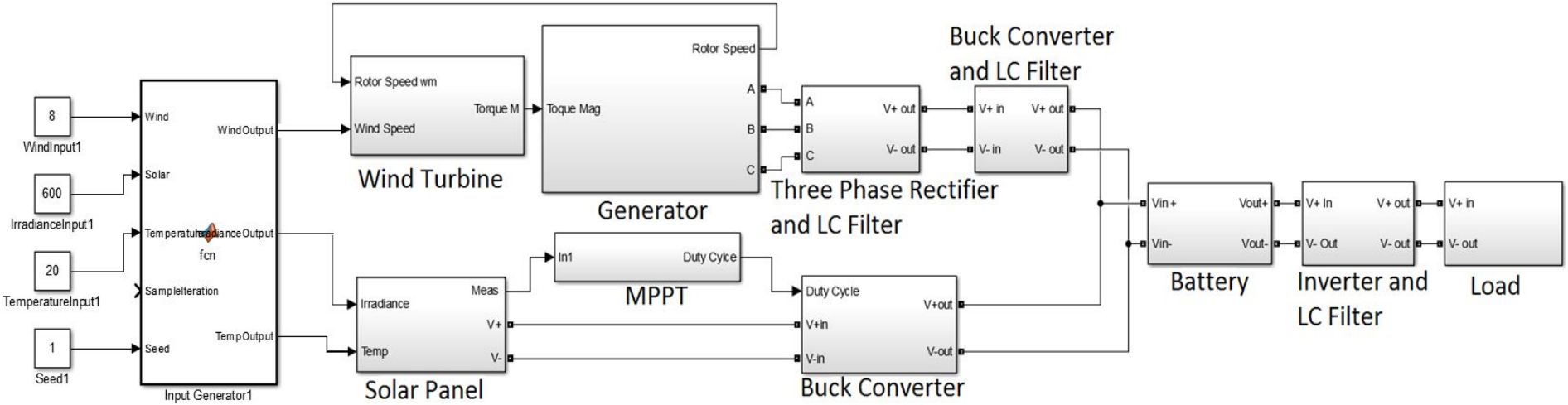
Wind System



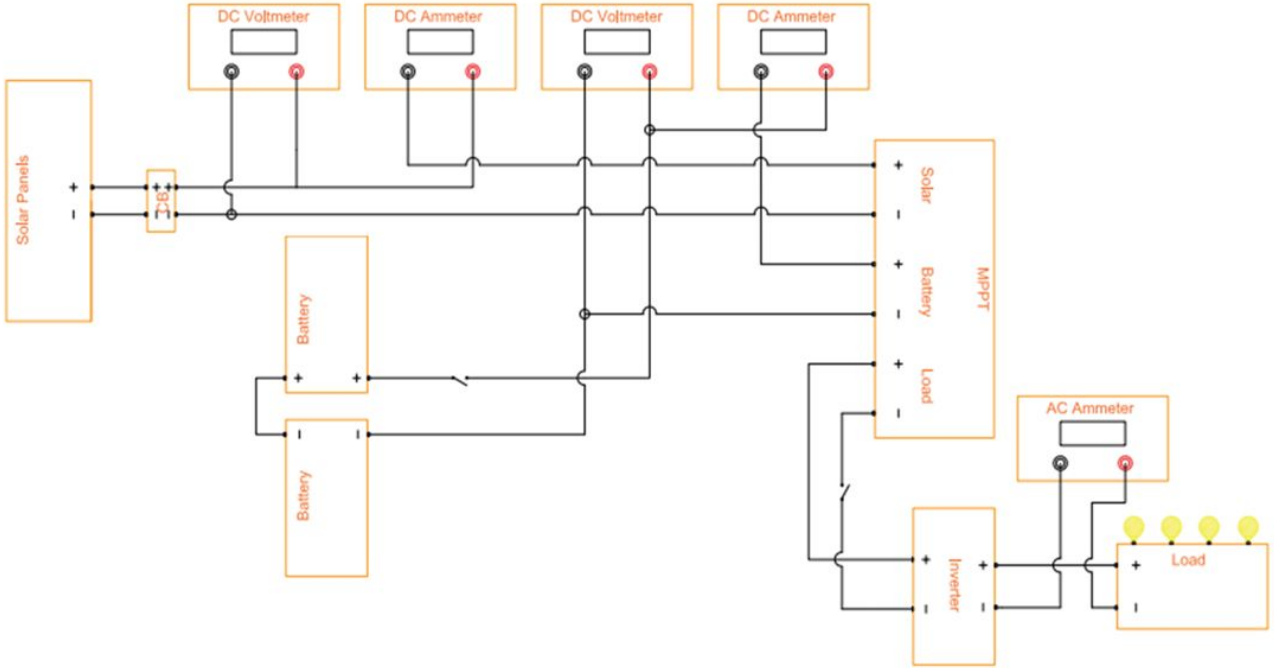
Solar System



Project Design - Software



Project Design- Hardware

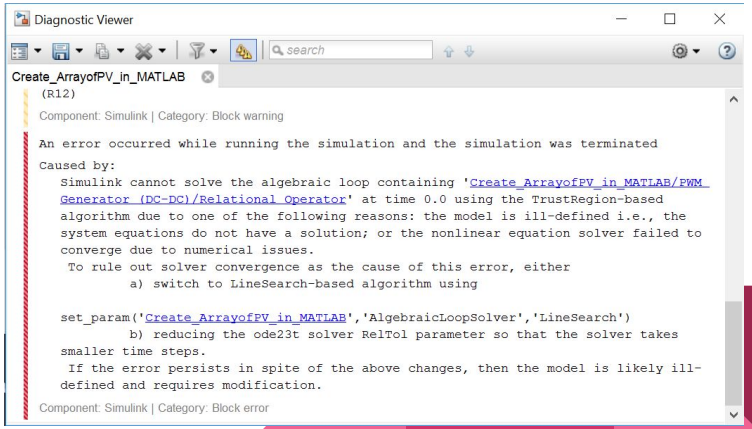


Design Challenges

Challenges

- Simulink
  - Limited exposure to working with modeling programs, Simscape library
  - Learning how Simscape blocks work and required input parameters

- Safety
  - Working with high voltages and currents
  - Input solar kill switch; 20 Amax, 100 Vmax



Challenges- Wind Hardware

- Procured a fully functioning wind turbine that can be used by future groups and in future labs.
- Laid groundwork for setting up the wind turbine as well as how to acquire its parameters which can be used to better understand the wind turbine’s inner workings.
- Challenges arose when designing the wind turbine
  - Lack of spec sheets
  - Non-technical aspects such as permits/safety issues
- The direction the wind hardware took became out of the scope of our overall goals

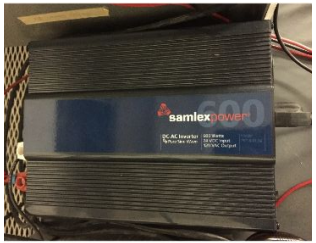
Prototyping & Demonstration

Prototype- Technology Details

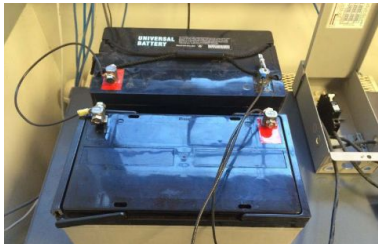
- Prototyping done in Simulink
  - MatLab Simulink R2016a, Simscape library 2016

Solar Panels
Kyocera KD125GX-LPU

MPPT
SunSaver SS-MPPT-15L



Inverter
Samlex Power DC-AC
Inverter: 600 W



Batteries
Universal Battery UB12900 12 V

Load
Filament based light bulbs

Demonstration

Live Demonstration later today at 4:20p - 5:30p Coover Atrium

Testing

Testing - Solar Software

6 April				
Batt & PV	**1 bulb**	Voltage	Current	Power
	Solar	37.39	7.614	284.68746
	Battery	23.91	7.57	180.9987
	PV (MPPT)	37.51	7.58	284.3258
	Battery (MPPT)	23.91	7.57	180.9987
	Inverter (MPPT)	-	-	-
	Inverter	23.92	4.216	100.84672
	Load	120.2	0.8348	100.34296
6 April				
Batt & PV	**2 bulbs**	Voltage	Current	Power
	Solar	37.65	7.993	300.93645
	Battery	23.84	4.198	100.08032
	PV (MPPT)	37.45	7.993	299.33785
	Battery (MPPT)	23.84	4.198	100.08032
	Inverter (MPPT)	-	-	-
	Inverter	23.76	8.45	200.772
	Load	120.2	1.67	200.734

Testing - Solar Hardware

2/15/2017			
1 Lightbulb Battery and solar			
	Voltage (V)	Current (A)	Power
Battery	24.7	1	24.7
Solar	26.4	3.6	95.04
Inverter	122	0.82	100.04
Power Gen (W)	119.74		
Power Loss (W)	19.7		
2 Lightbulbs Battery and Solar			
	Voltage (V)	Current (A)	Power
Battery	23.85	7	166.95
Solar	26.16	3.241	84.785
Inverter	122.08	1.69	206.32
Power Gen (W)	251.73456		
Power Loss (W)	45.41936		

First set of PV hardware data

- Unaccounted loss of 19.7W for 1 lightbulb
- Unaccounted loss of 45.4W for 2 lightbulbs

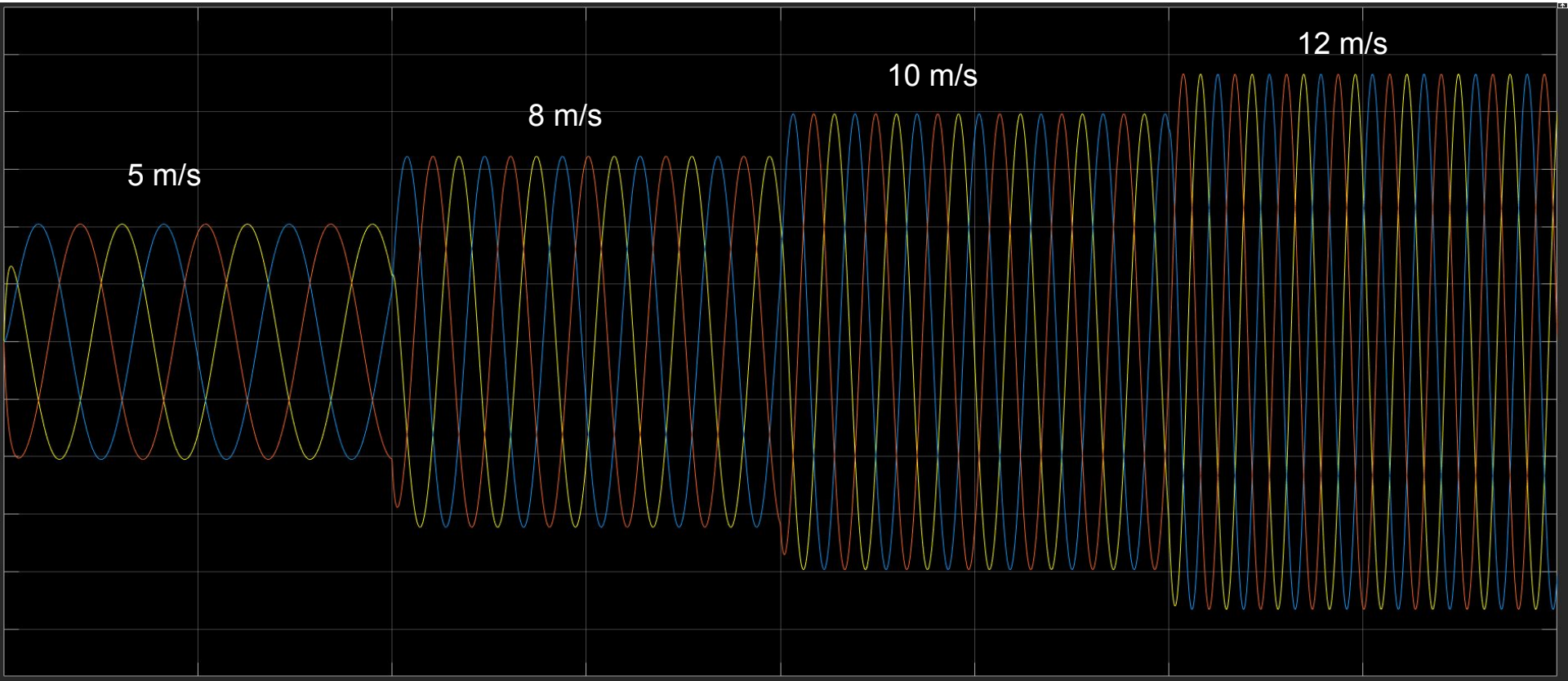
4/6/2017			
1 Lightbulb With Solar and Battery			
	Voltage	Current	Power
Solar	37.9	0.713	27.0227
Battery	24.4	4.4	107.36
MPPT (PV)	37.9	0.82	31.078
MPPT (Battery)	23.4	3.94	92.196
MPPT (Load)	23.4	5.1	119.34
Inverter In	23.1	5.31	122.661
Load	122.2	0.87	106.314
Input Power	134.3827		
Output Power	106.314		
Power Loss	28.0687		
Efficiency	79.11286		
Loss Factors			
Battery Switch	3.94		
Inverter Switch	1.593		
MPPT Efficiency	0.8496		
Inverter Efficiency	108.8001		
Unaccounted Wattage	2.486085		

2 Lightbulbs With Solar and Battery			
	Voltage	Current	Power
Solar	31.3	7.43	232.559
Battery	24.81	0.581	14.41461
MPPT (PV)	30.58	7.76	237.3008
MPPT (Battery)	24.4	0.78	19.032
MPPT (Load)	24.5	9.8	240.1
Inverter in	24	9.84	236.16
Load	122.2	1.66	202.852
Input Power	246.9736		
Output Power	202.852		
Power Loss	44.12161		
Efficiency	82.13509		
Loss Factors			
Battery Switch	0.3198		
Inverter Switch	4.92		
MPPT Efficiency	0.8496		
Inverter Efficiency	204.7516		
Unaccounted Wattage	1.899579		

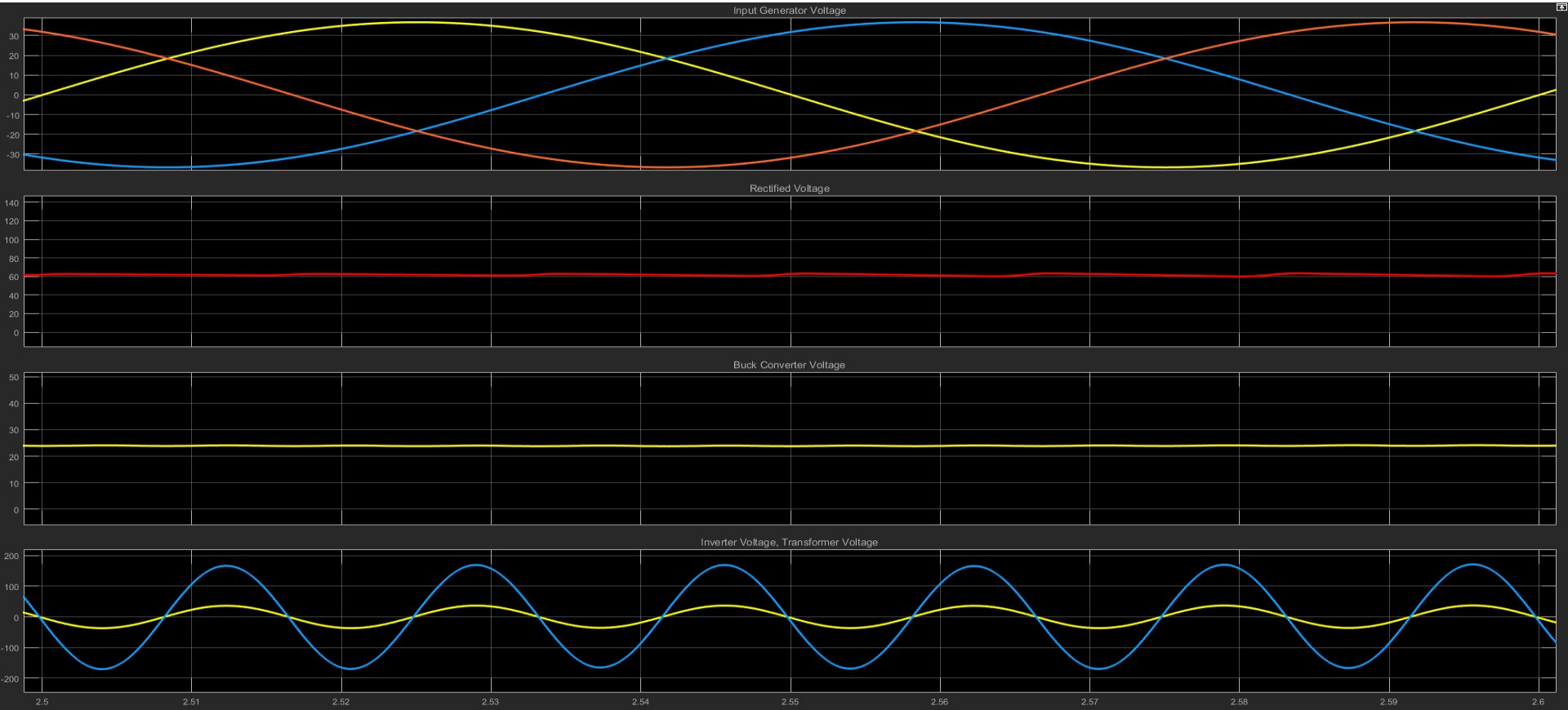
Last set of PV hardware data

- Taking losses into account
  - 35mA consumption by MPPT
  - Inefficient safety switches
  - Inverter peak efficiency of 85%
- Unaccounted Wattage
  - MPPT adjustments
  - Irradiance consistency

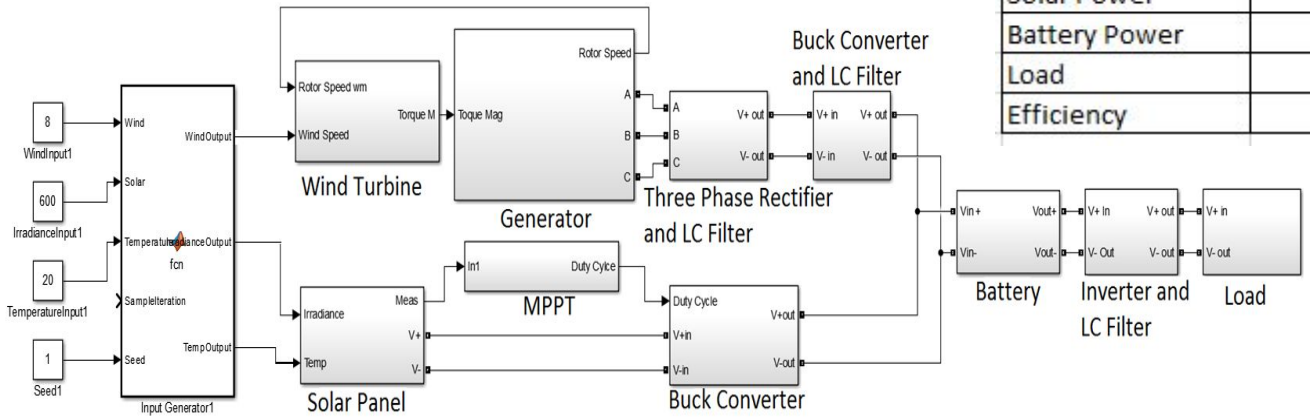
Testing - Wind Software



Testing - Wind Software



Testing - Combined System



	Combined System			
Wind Speed	4	8	10	m/s
Wind Input Power	42	296	567	W
Solar Irradence	300	600	800	W/m^2
Solar Power	85	160	225	W
Battery Power	140	-190	-450	W
Load	250	250	250	W
Efficiency	93.6	94.0	73.1	%

Field Testing and Client Feedback

- Demonstrated a solar hardware lab for the first hour of both EE 452 lab sections
- Cross Team lab manual testing
  - Came up with experiment bank
  - Individuals wrote manuals for specific topics
  - Wind performed solar labs
  - Solar performed wind labs
    - Made notes and adjusted manuals into final products

Future Work

- Finish wind hardware system
- Add our labs into the EE 452 course syllabus
  - Refine labs to maximize student learning
- Continue to refine and use the simulations for testing of different situations
  - Run simulations with actual wind and solar data over long period of time

Lessons Learned

- Time management
  - Schedule times more effectively to work as groups and individuals
  - Task Delegation
- Codes and Standards
  - Non-technical barriers can be as troublesome and time consuming as technical barriers
- Teamwork
  - Division of labor and tasks into sub-tasks

Conclusion- Questions

Questions?

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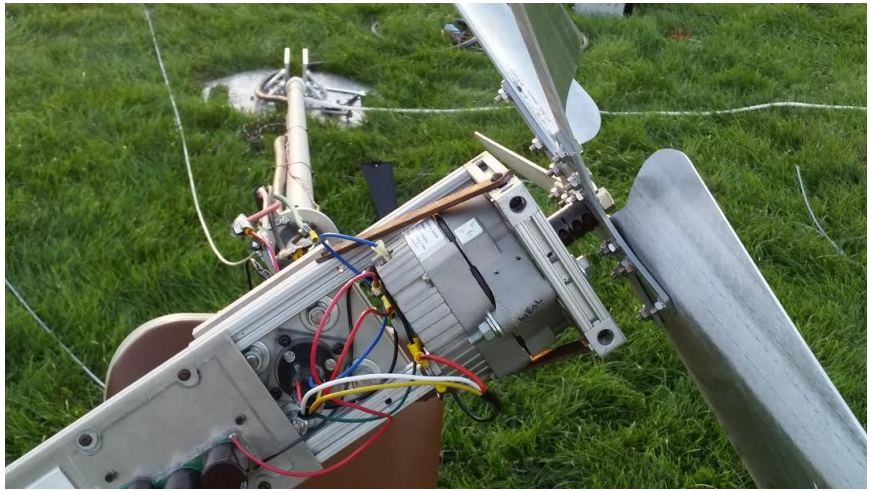
Thank you!

Special thank you to Dr. Ajjarapu, Pranav Sharma & Ankit Singhal for all their assistance with our project and to everyone else who helped us accomplish so much these last two semesters!

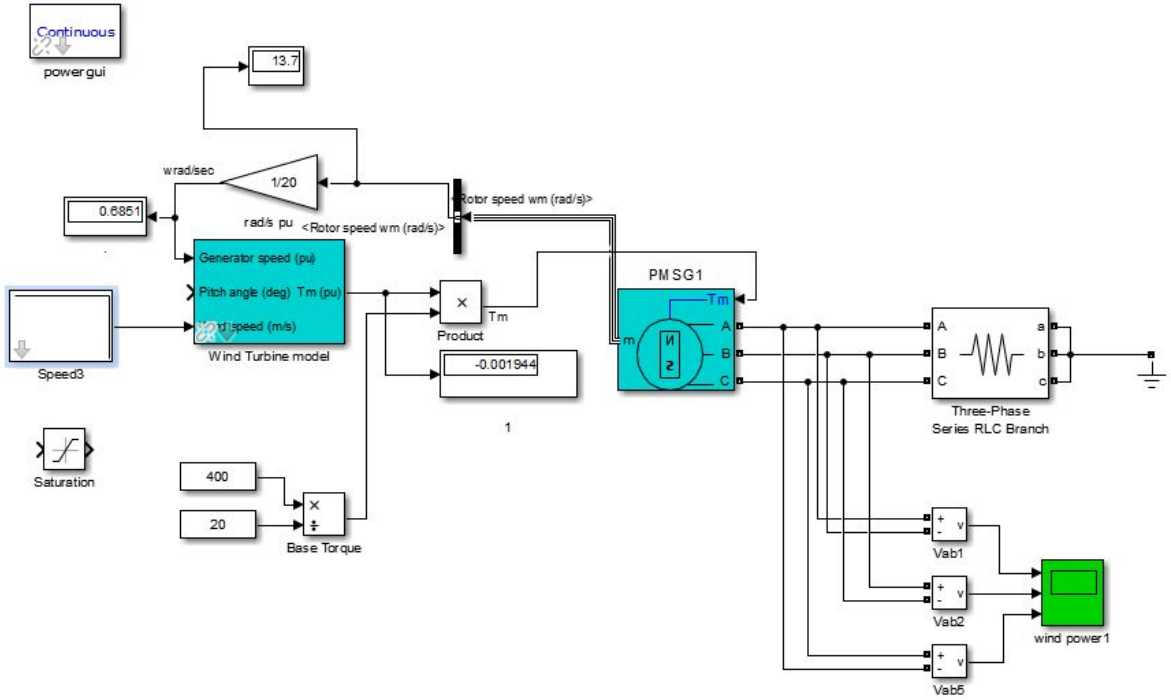
Appendix

Appendix

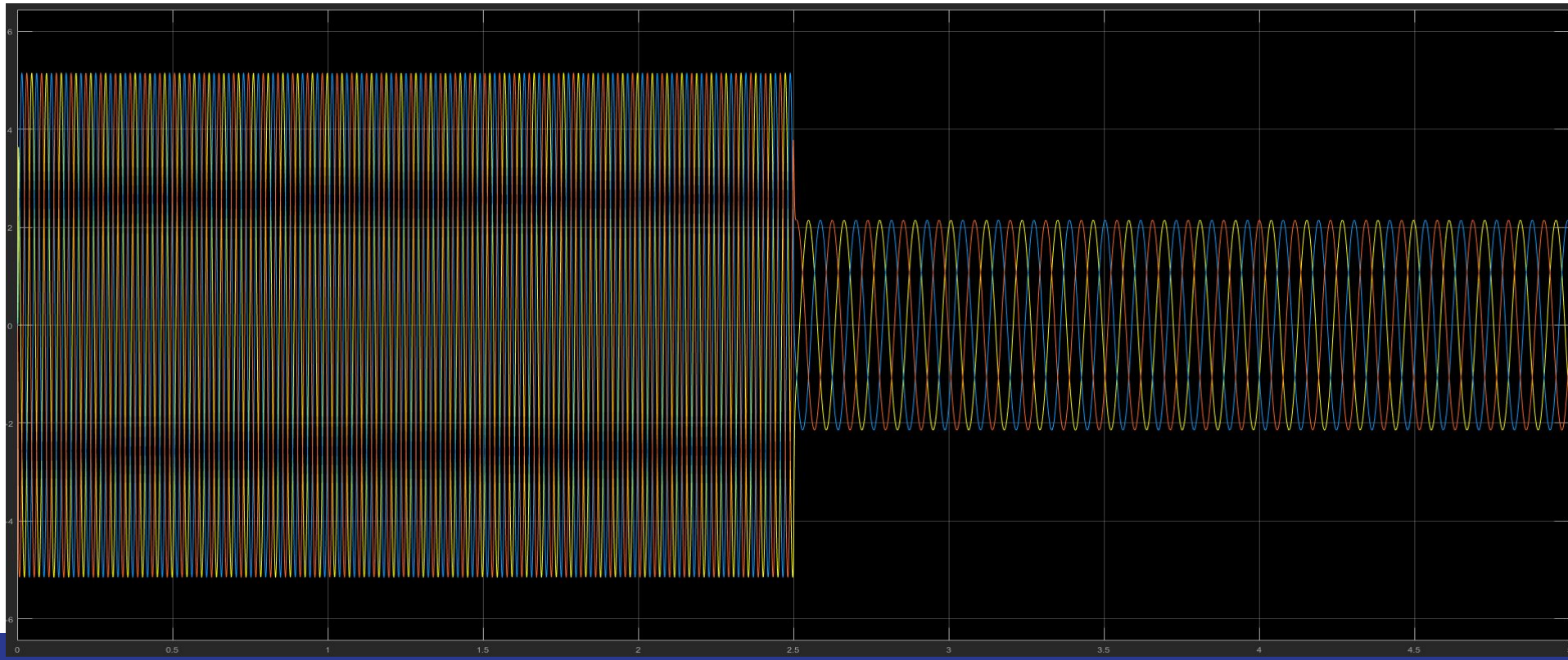
Wind Turbine



Wind Turbine and Generator

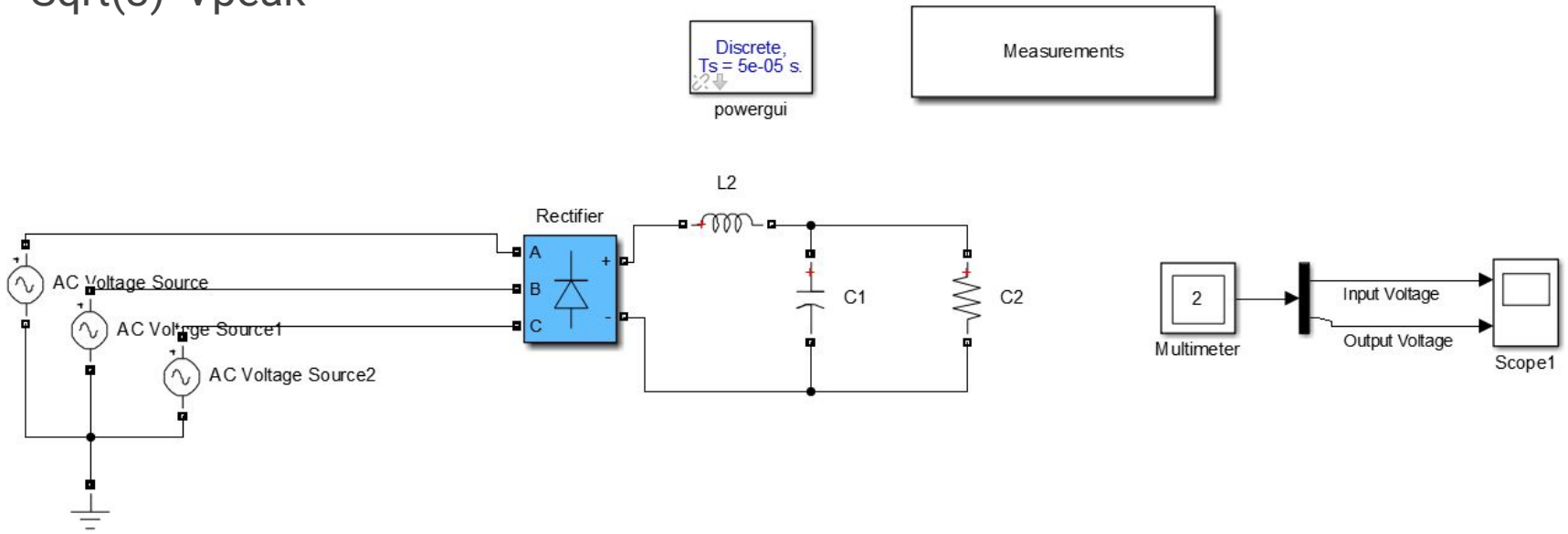


Generator Output

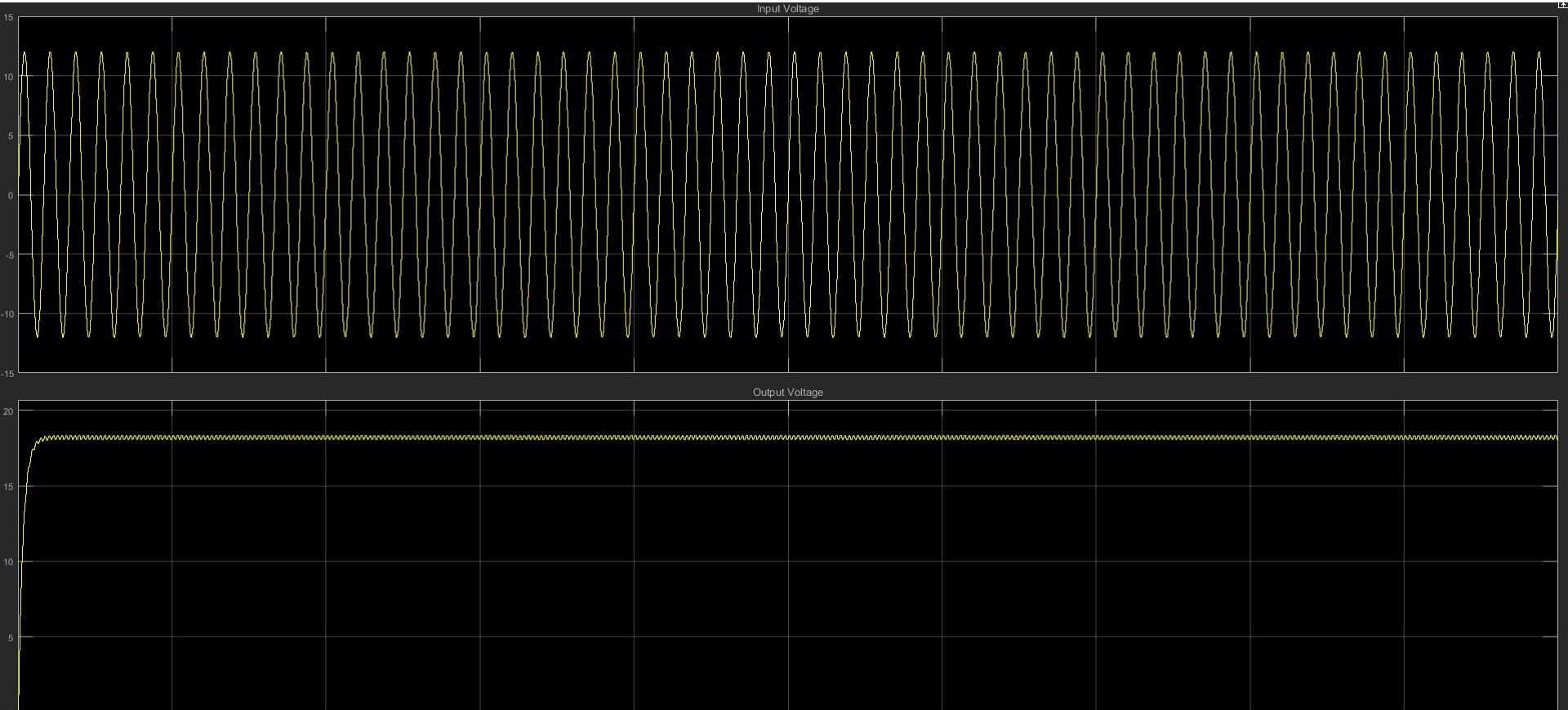


Three phase Rectifier

Sqrt(3)*Vpeak

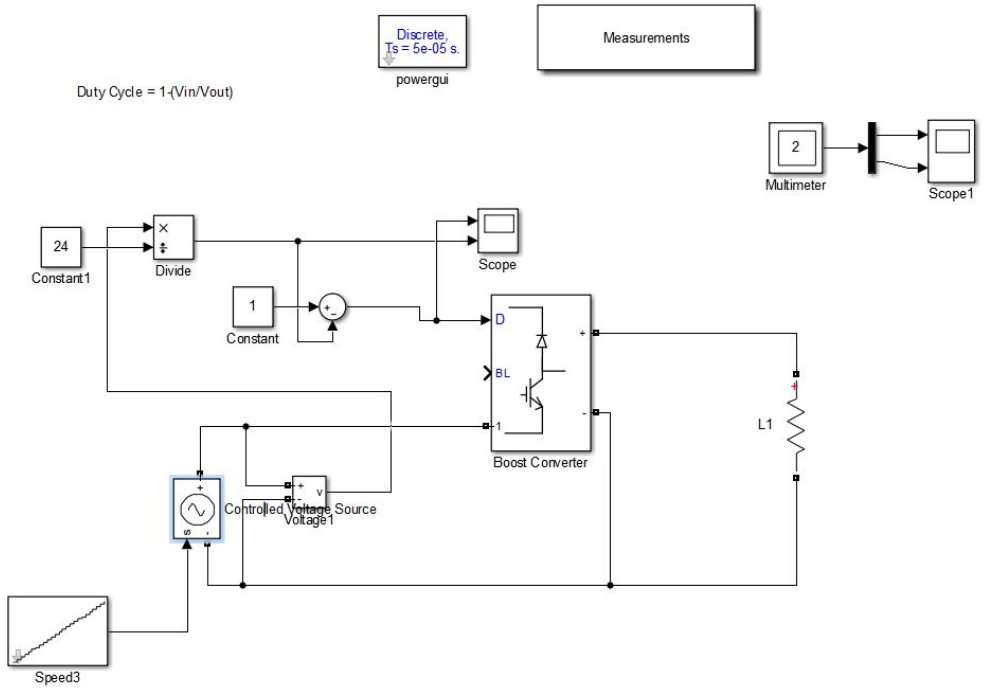


Rectifier Output

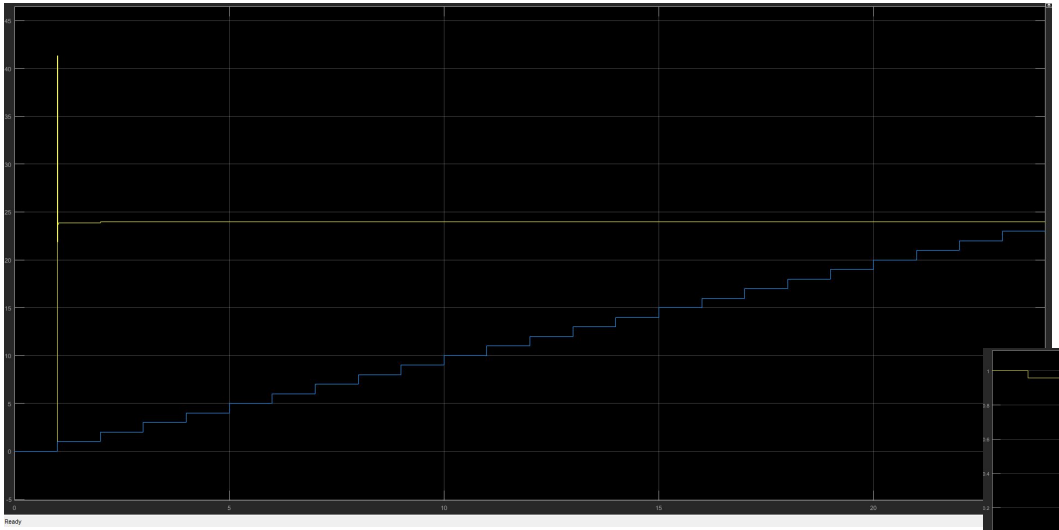


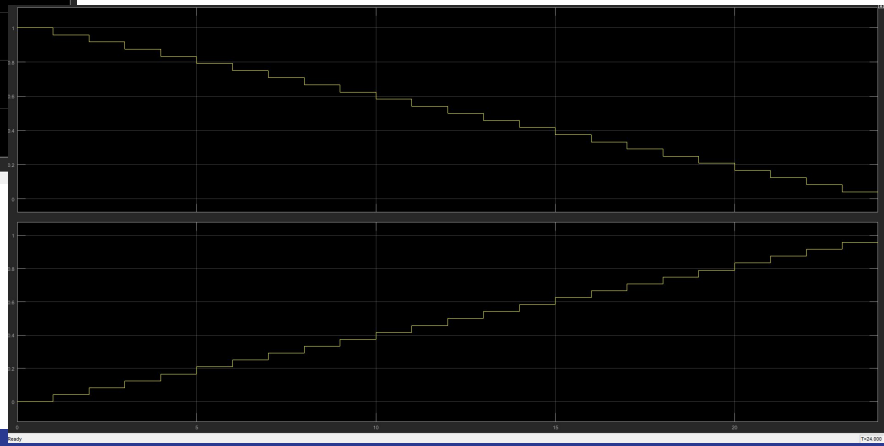
Boost Converter

Duty Cycle = 1-(Vin/Vout)

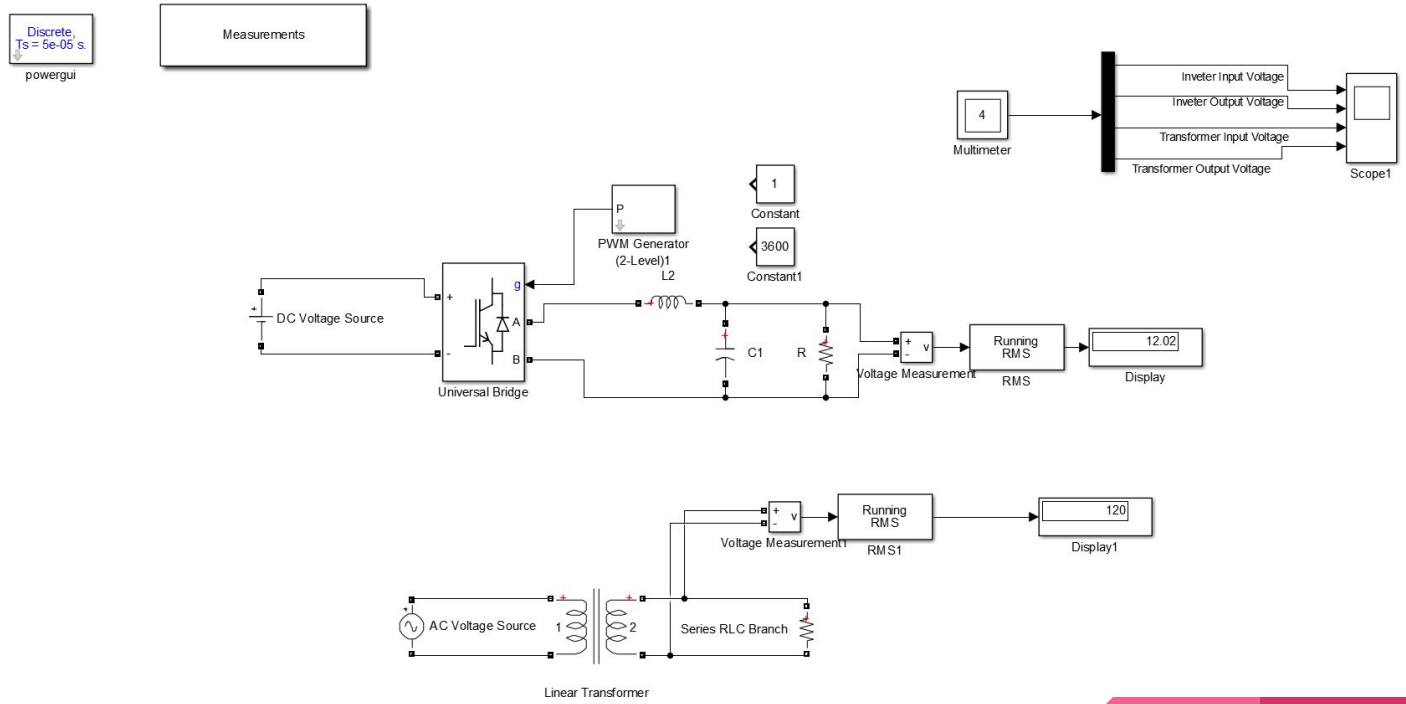


Boost Converter Output

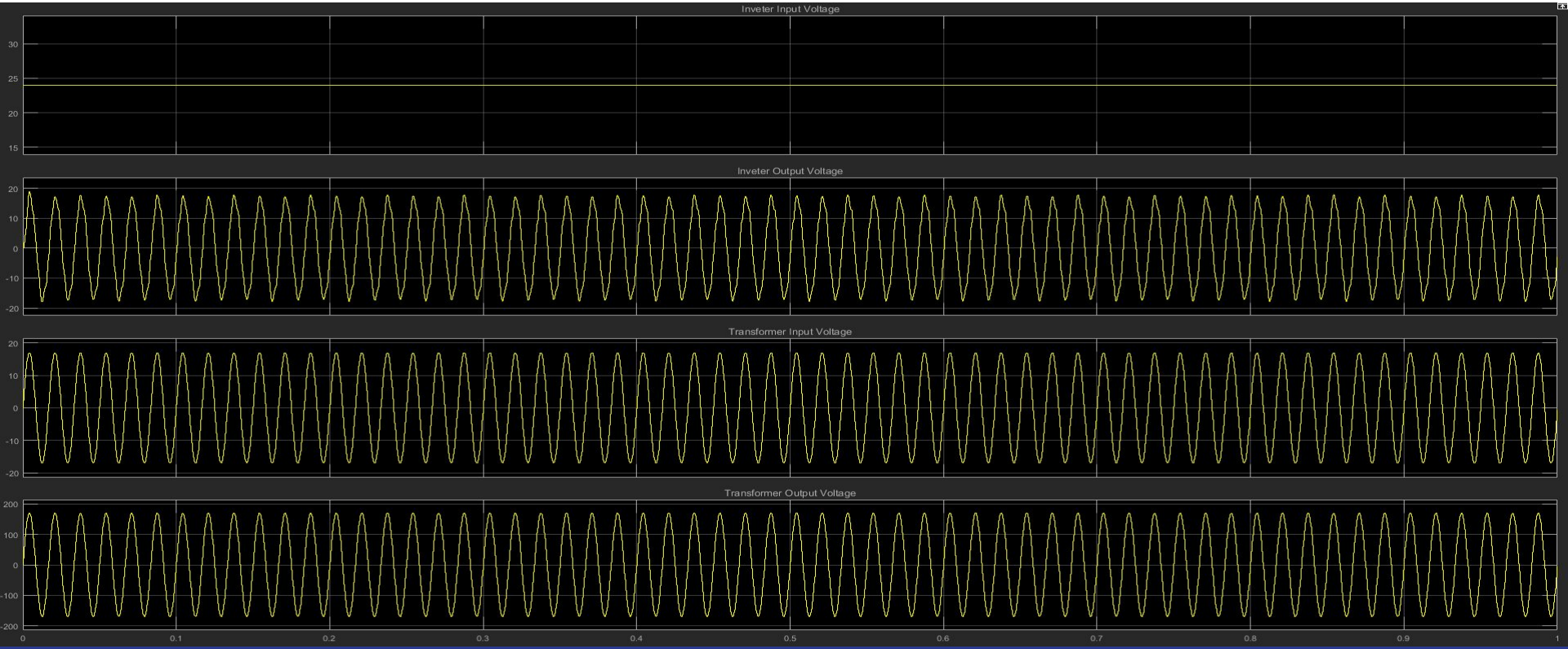




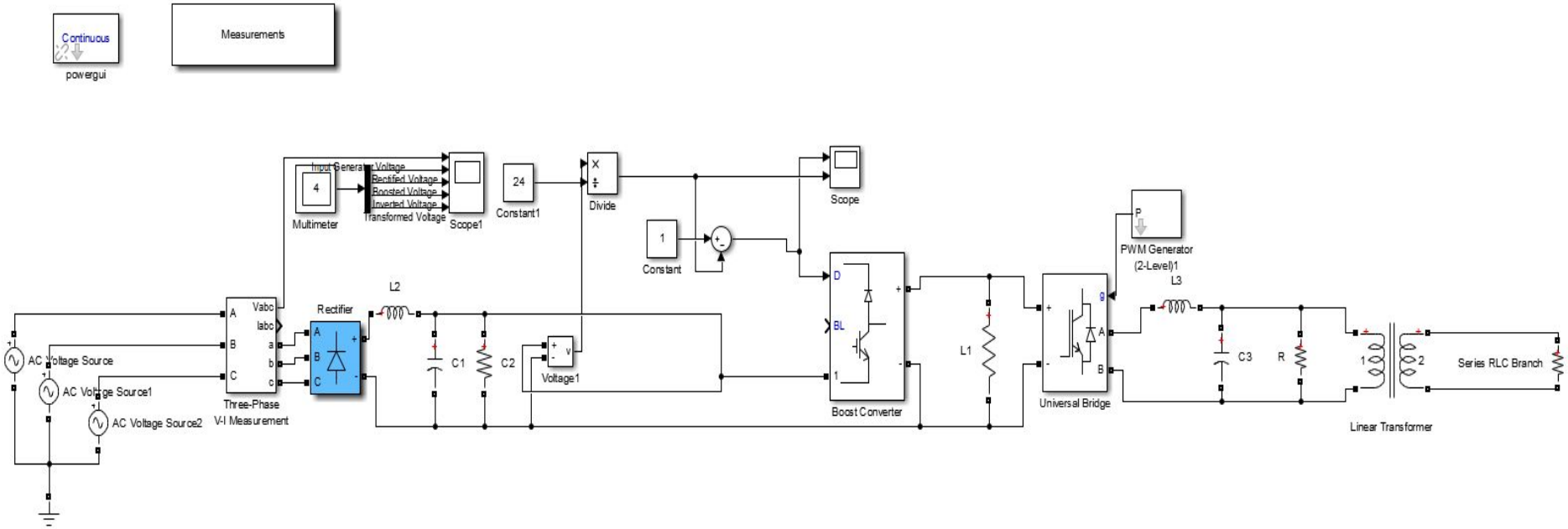
Inverter


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
L2
1
Constant
3600
Constant1
DC Voltage Source
g
A
B
Universal Bridge
C1
R
Voltage Measurement
Running
RMS
RMS
12.02
Display
Voltage Measurement1
Running
RMS
RMS1
120
Display1
AC Voltage Source
1
2
Series RLC Branch
Linear Transformer

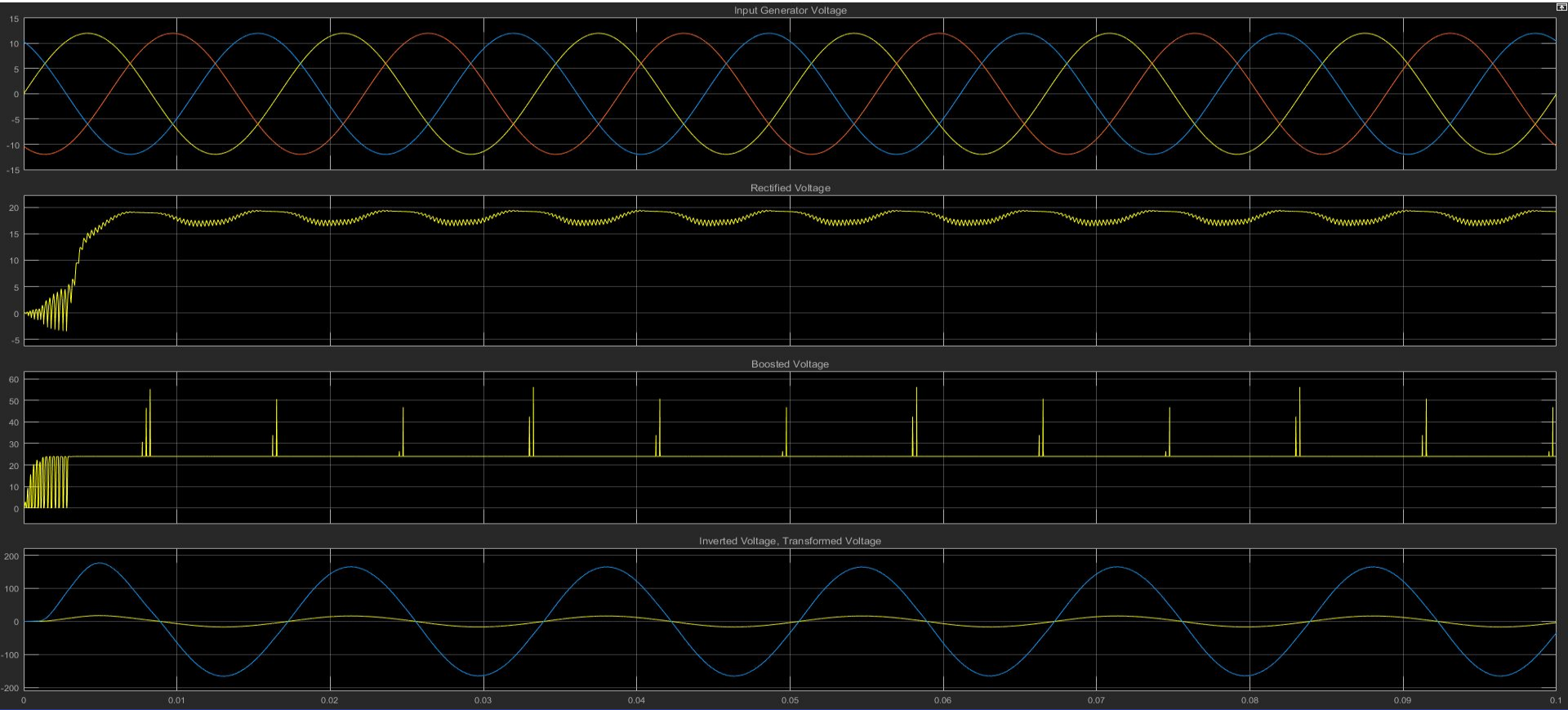
Inverter and Transformer Output



AC-DC-AC


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

AC-DC-AC Output



El Fin.