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Novel Wireless Performance Monitoring for Small Wind Turbines

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Introduction - Need for a Small Wind Turbine Monitoring System

- Virtual Labs project
  - Online remote laboratories for engineering education
    - Wind Energy
    - Solar Energy
    - Energy Storage
    - Mechanics of Solids
    - Biotechnology
    - Physics, others
  - Ideal for students in developing countries
    - Quality labs not at all universities
    - Instructor quality can be poor
  - Or students who want to learn on their own schedule
    - Remote labs available 24/7
- Additional instrumentation for research and development or monitoring, test and evaluation purposes

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Remote Laboratories - Wind Energy

- Students can
  - Log-in remotely
  - See live video of the turbine (day/night cameras and IR)
  - Measure the real-time performance of a wind turbine
    - Current, voltage
    - RPM
  - Measure wind speed and direction (Anemometer)
  - Record, download and analyze data
  - Calculate
    - Power
    - Coefficient of Performance
    - Tip-speed ratio

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Problem

- How do you continuously monitor the rotor speed of a typical small wind turbine?
  - Passive tail vane system for yawing into the wind
  - Slip rings to transfer the power from the generator to the ground
    - 2 or 3 phase generator rectified to DC either at the generator or on the ground
  - Wires will twist up and break
  - Expensive to modify to add additional slip rings

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Solution

- Create a wireless system to measure the needed turbine information (at the hub) and transfer it to the tower/ground
  - RF, WiFi, Bluetooth, Zigbee
    - different ranges and data rates
    - **We use 433 MHz – long range, low data rate sufficient**
  - RPM, current, voltage, power factor, yaw direction, or ?
    - **We measure the RPM, generator current and voltage**
  - Can be either powered by solar PV or by power taken from the generator
    - **We are planning for solar PV**

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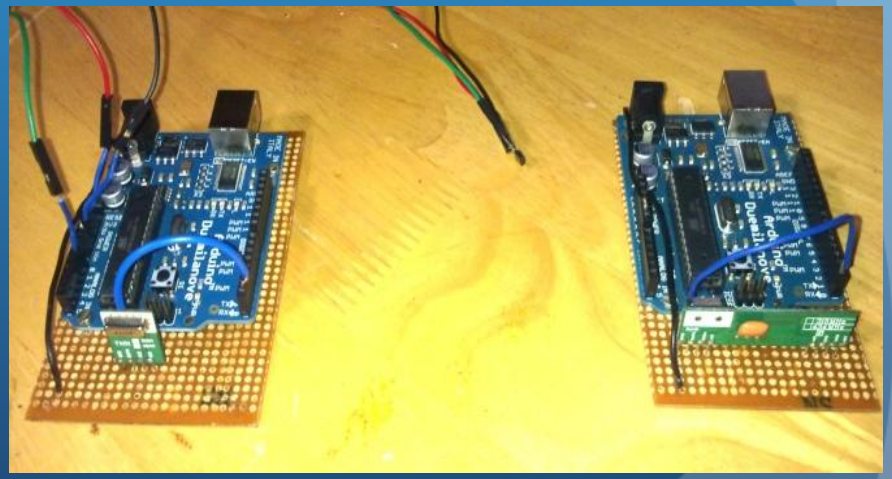
Measurement System Design

- Microcontroller – Arduino Due
- Sensors
  - RPM – Hall Effect with 6 Neodymium magnets
  - Voltage – RMS voltage
  - Current – RMS current
- Wireless - 433 MHz RF Rx/Tx
- Labjack DAQ card – UE9 Pro
  - Ethernet enabled
- Labview w/ web server



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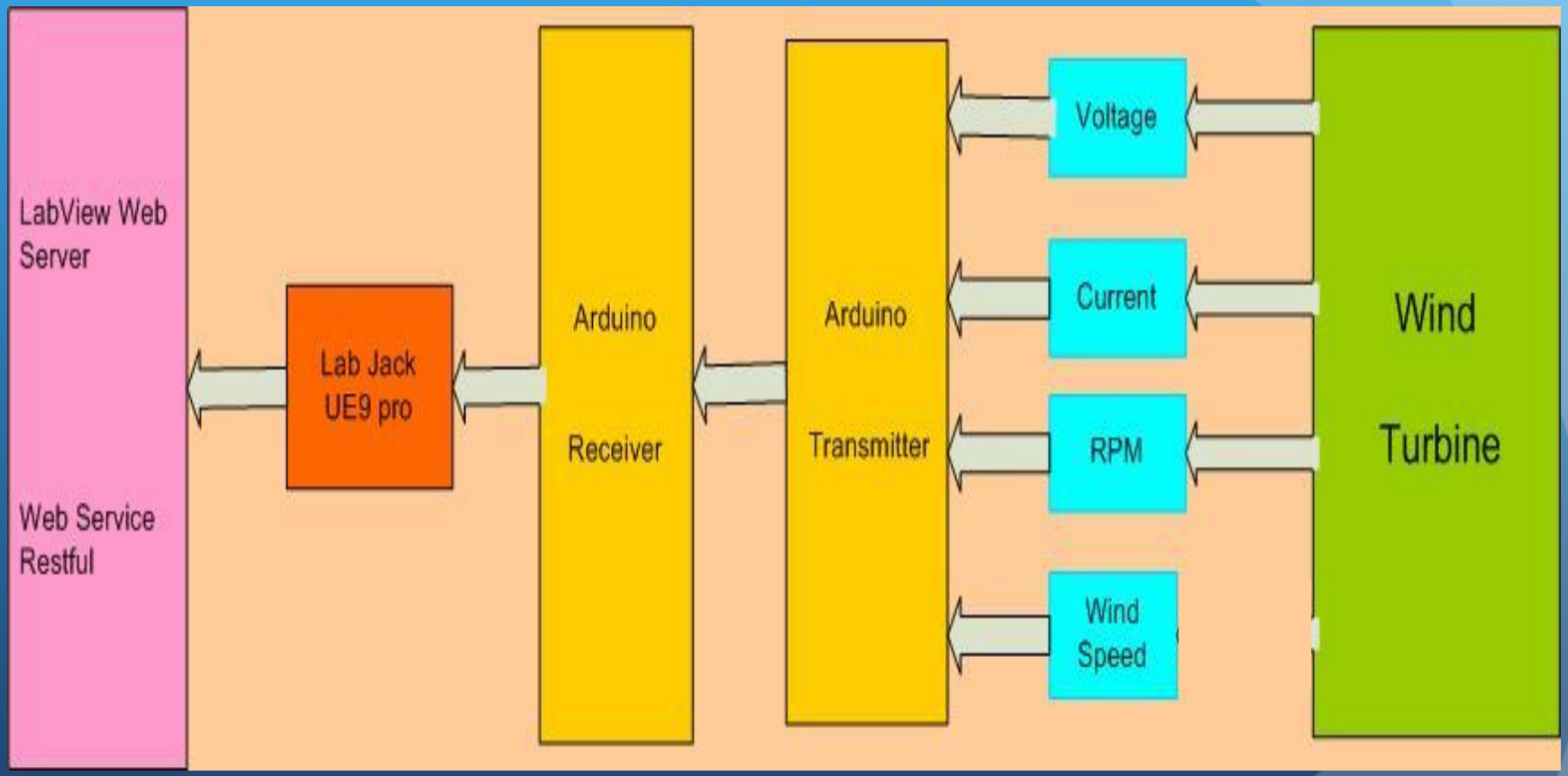
Architecture



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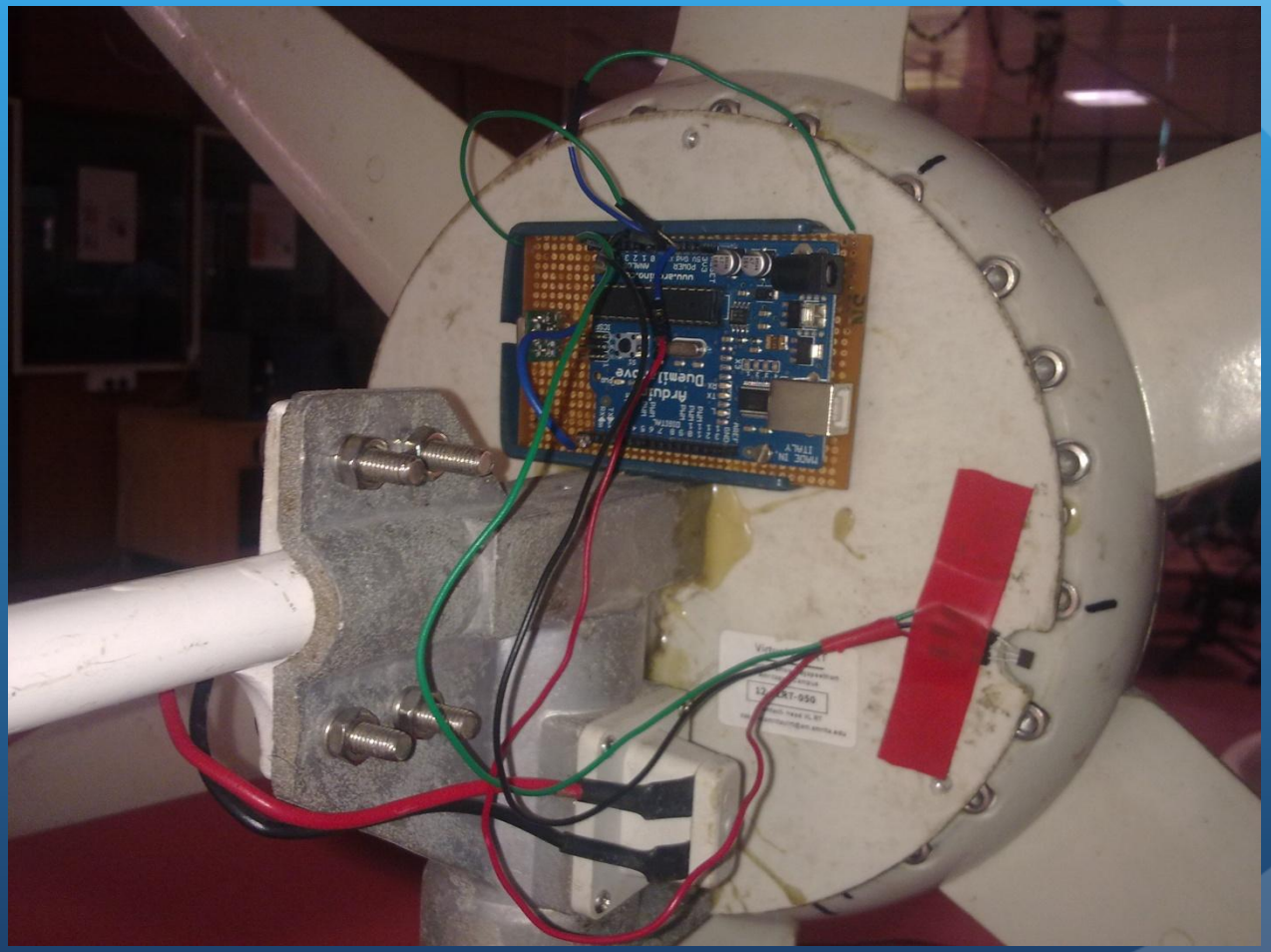
System Testing

System Testing



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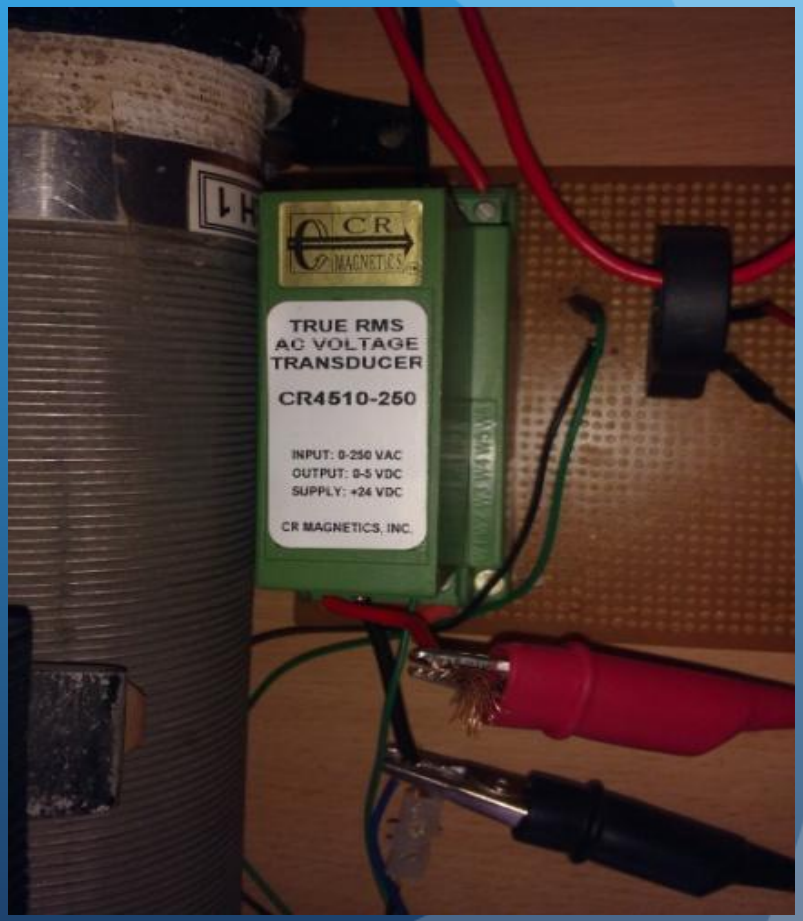
Test Loading and Measuring



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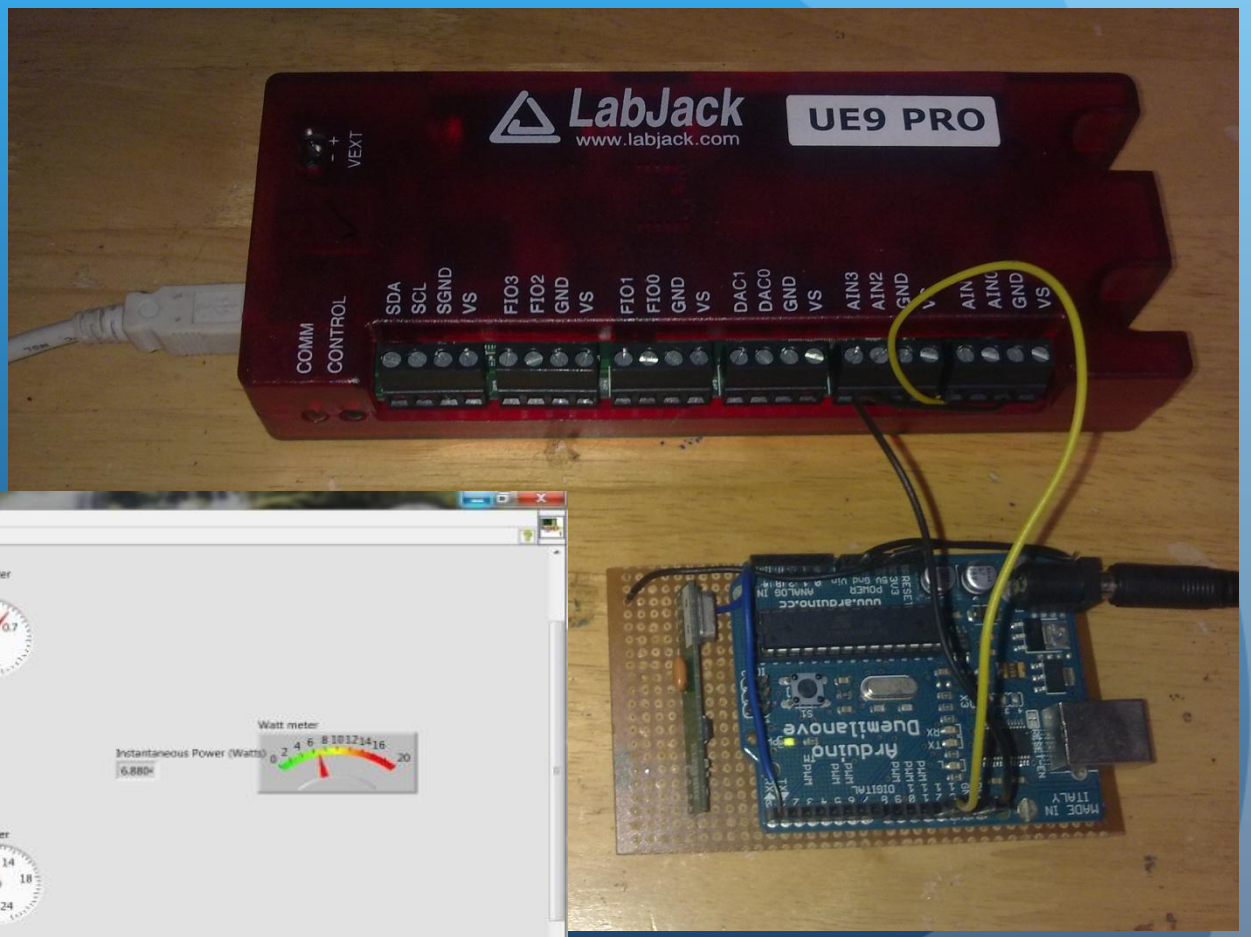
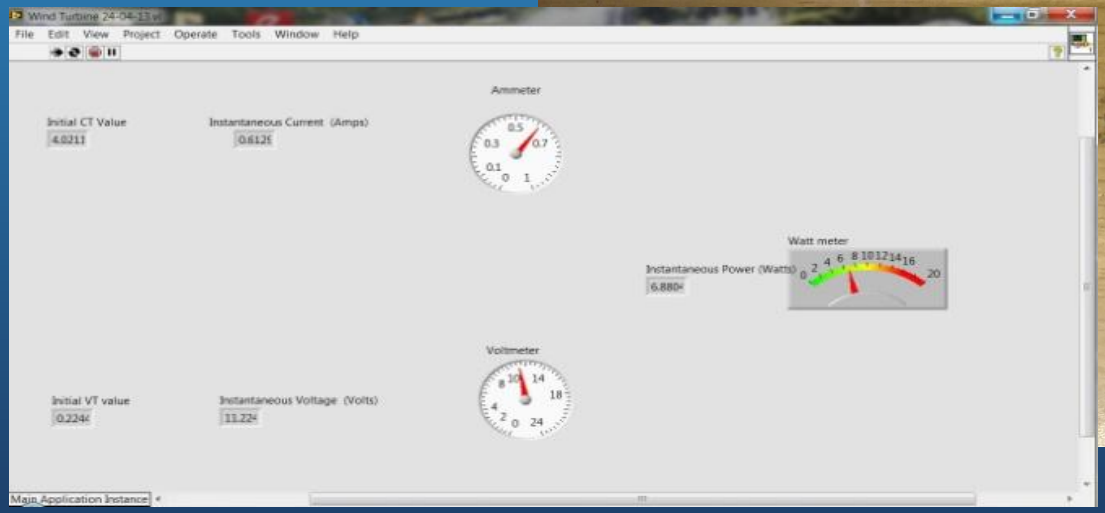
Testing - Labview, Labjack and Anemometer





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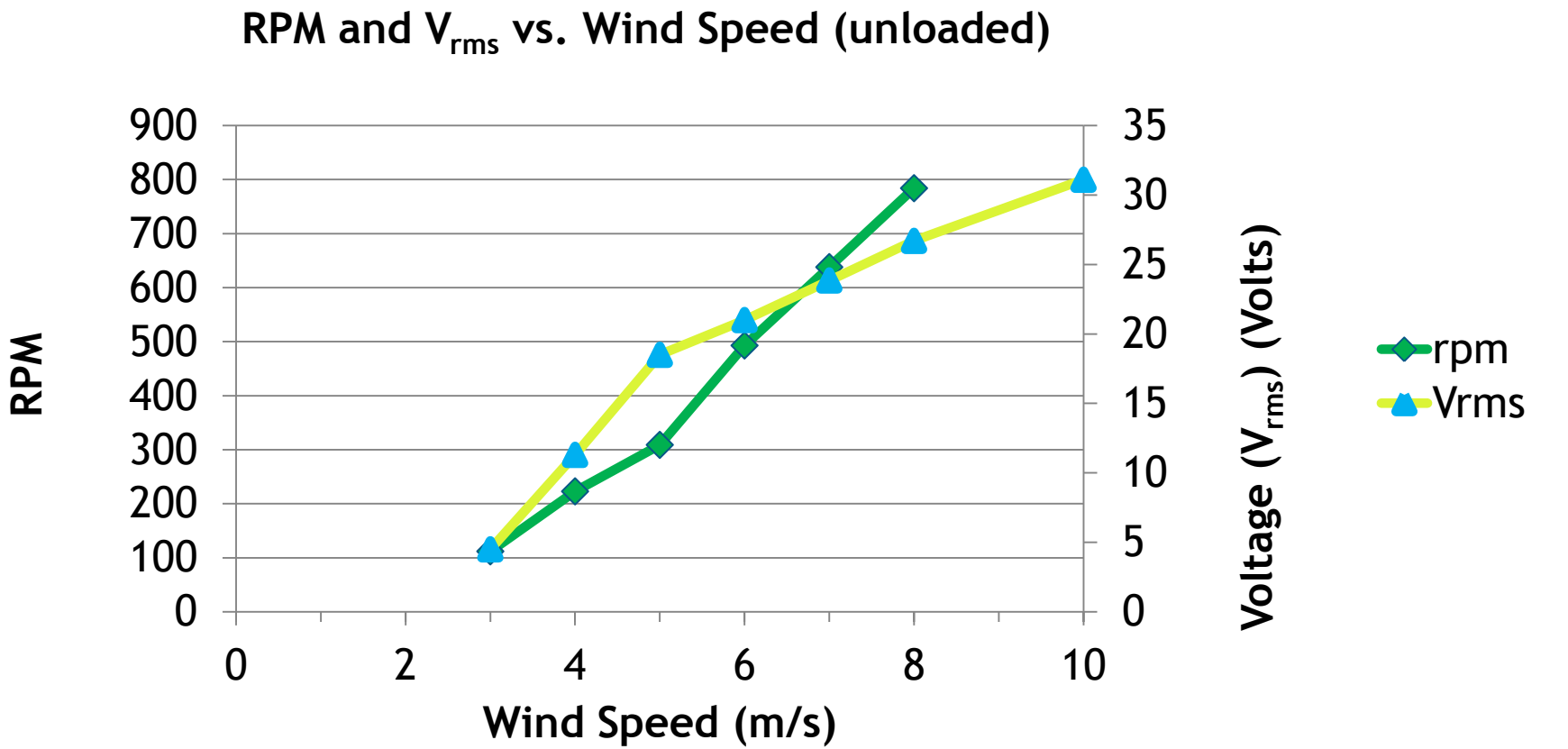
RPM and Voltage measurement testing



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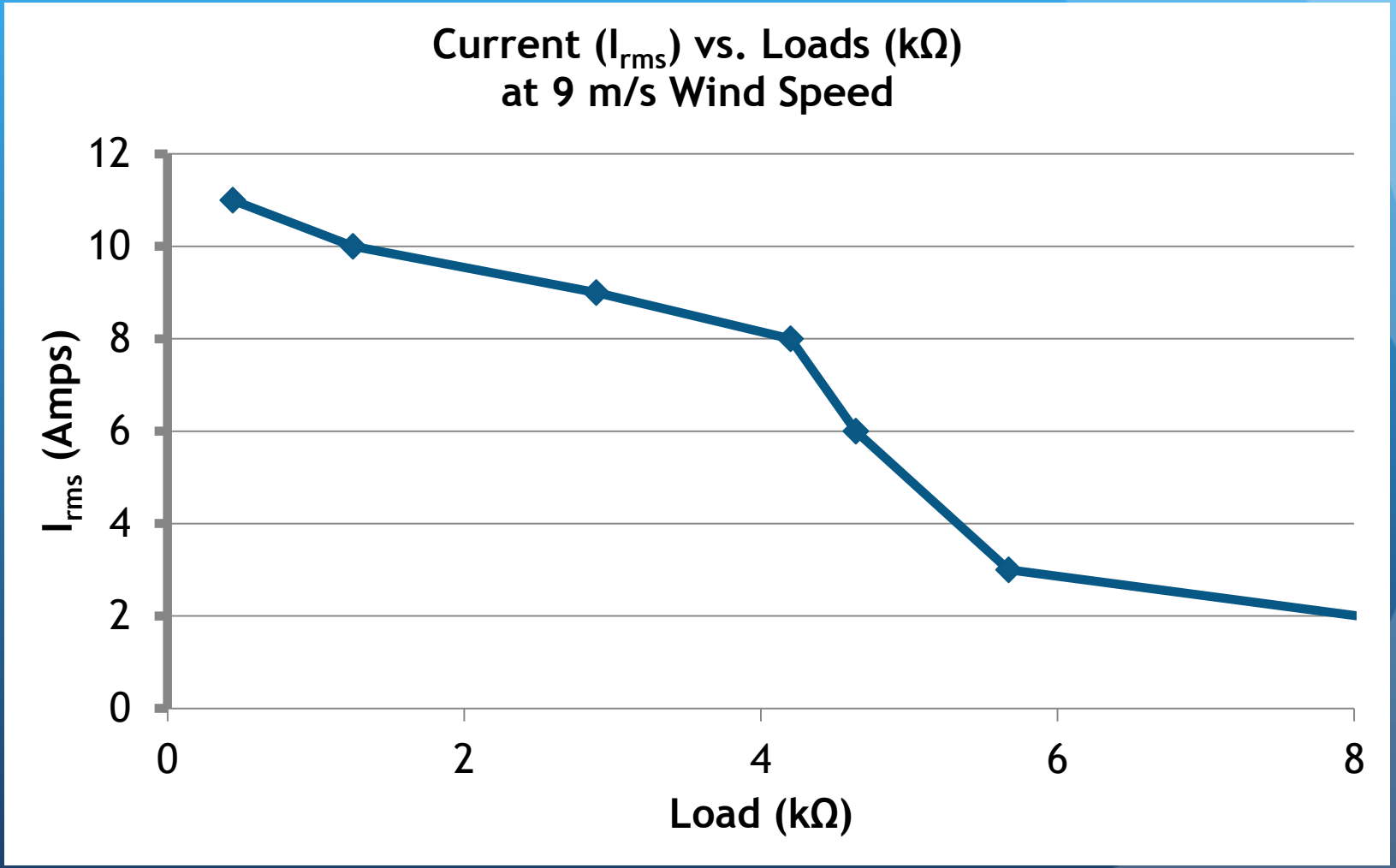
Current Measurement Testing



Rx/Tx Range Testing Results

Distance (meters)	RSSI (Line of sight)	RSSI (No line of sight)
5	100%	100%
10	100%	100%
20	100%	100%
50	100%	90%
70	100%	80%
90	85%	68%
100	80%	55%
120	75%	50%

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Conclusions and Future Work

- System tested thoroughly in the lab
- Operates as planned

- Add solar PV power – purchasable module for Arduino
- Fit system on a turbine with space for a torque meter
  - Calculate the Mechanical Coefficient of Power
- Measure the power factor
- Weatherproof polycarbonate enclosure
- Install the turbine on our beach!
- Add balance of system components
- Host the experiment on our Virtual Labs website

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- http://amrita.vlab.co.in/

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Thanks!! Questions??

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