Cloud7

Functional Decomposition

Team Cache Money:
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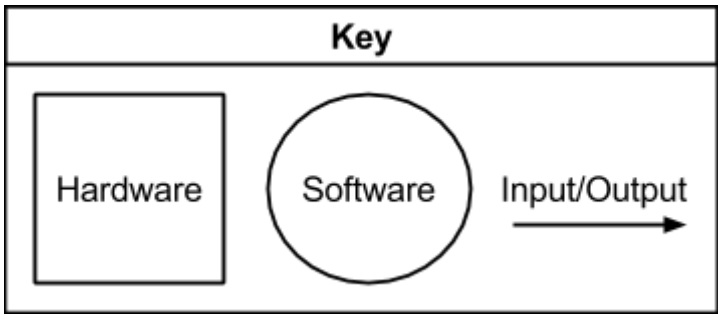
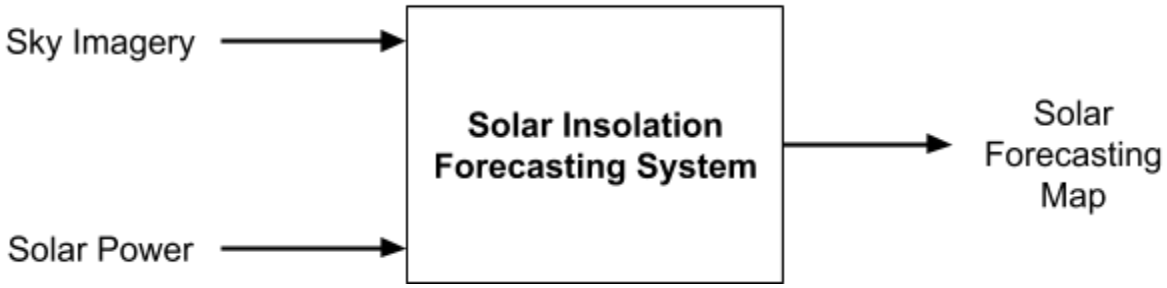
Functional Decomposition

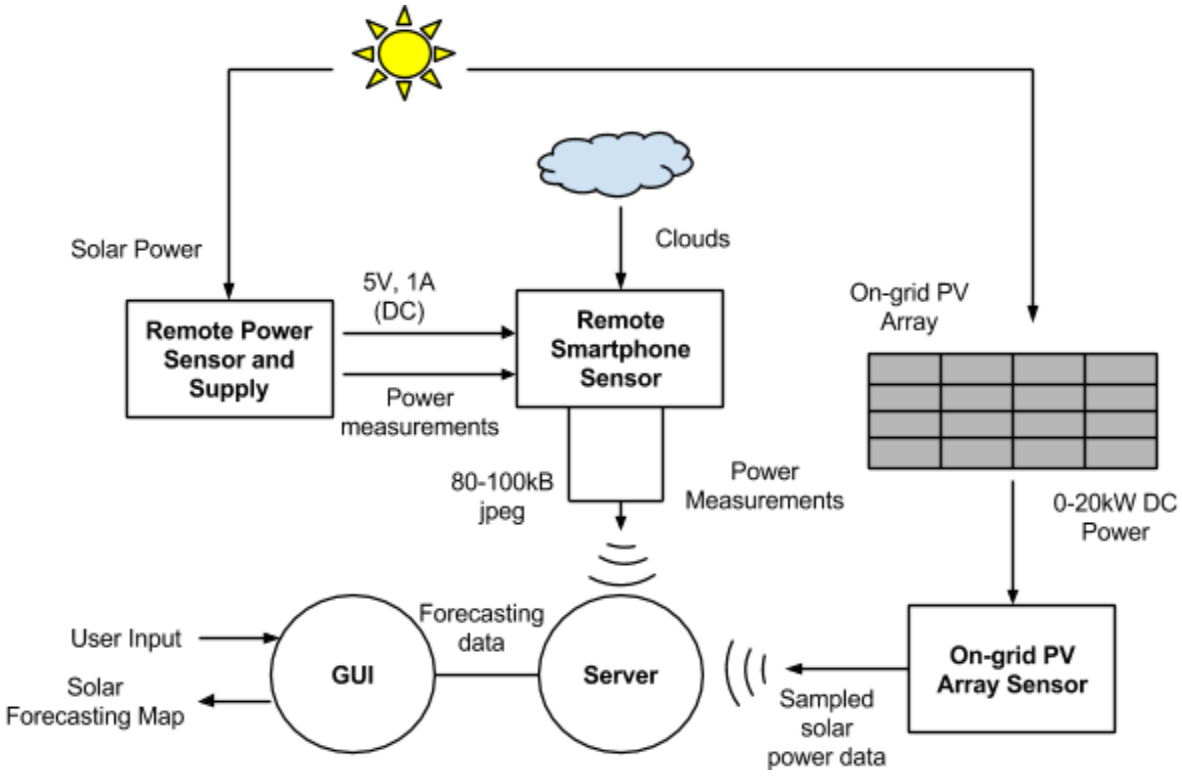


Level 0:



Module	Solar Insolation Forecasting System
Inputs	- Sky imagery across the covered area - Solar power data from PV arrays in the covered area.
Outputs	- Solar insolation forecasting map (GUI).
Functionality	Take cloud data to create motion vectors to predict cloud movement. Along with motion vectors, integrate real power data from on-grid PV arrays and remotely located sensors to forecast solar insolation across the covered area.

Level 1:



Module	Remote Smartphone Sensor
Inputs	- Clouds and sky imagery. - 5V, 1A DC Power. - Power measurements.
Outputs	- Sky images, GPS Geotag, and time stamp. - Power measurements.
Functionality	Takes cloud images every 30 seconds and packages with power measurements and sends to the server via 3g/4g network.

Module	Remote Power Sensor and Supply
Inputs	- Solar Power
Outputs	- 5V, 1A of DC power.
Functionality	Supplies power to the Remote Smartphone Sensor. Regulates charging of the external battery.

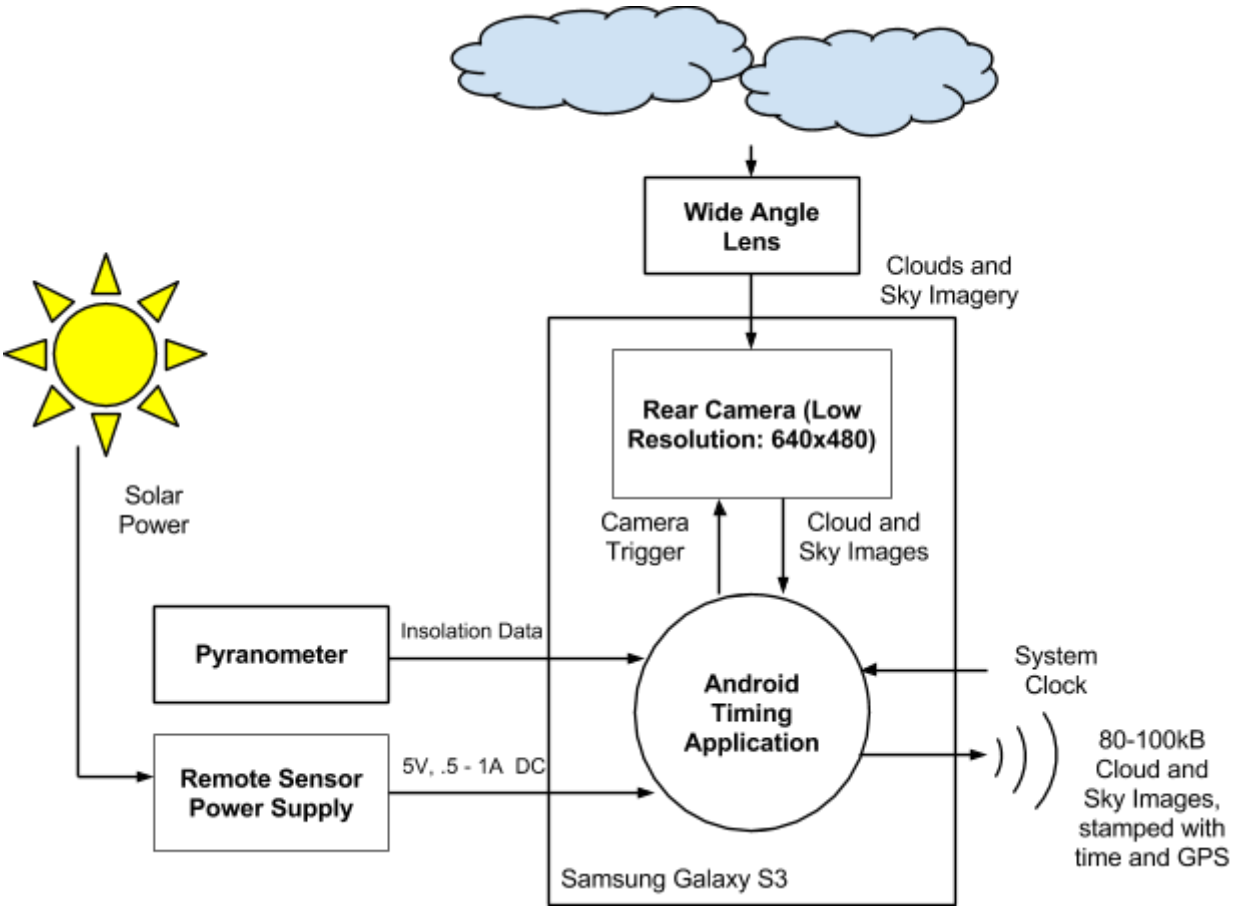
Module	On-grid Sensor

Inputs	-PV array current. -PV array voltage
Outputs	- Power measurments
Functionality	Measures the power output of on-grid PV arrays and sends sampled data to the server over the internet via a WiFi connection.

Module	Server
Inputs	- Sky images (from Remote Smartphone Sensor) - Power data (from On Grid Sensor)
Outputs	-Forecasted data to create forecasting map.
Functionality	Stores sky imagery and on-grid PV array data. These are used to create the forecasted solar insolation map to be displayed by the GUI.

Module	Graphical User Interface (GUI)
Inputs	- User Input - Forecasted solar insolation data.
Outputs	- Display a user interface of a solar insolation forecasting map. - Requested solar insolation data from the user to the server.
Functionality	Displays desired forecasted map (past or present) in a user friendly way allowing the user to see insolation forecasts up to one hour ahead in one minute resolution.

Level 2 Subsystem - Remote Sensor:



Module	Samsung Galaxy S3: Camera
Inputs	-Sky and cloud imagery.
Outputs	-80-100 kB jpeg image
Functionality	Records an image of the cloud coverage and stores it in the phone.

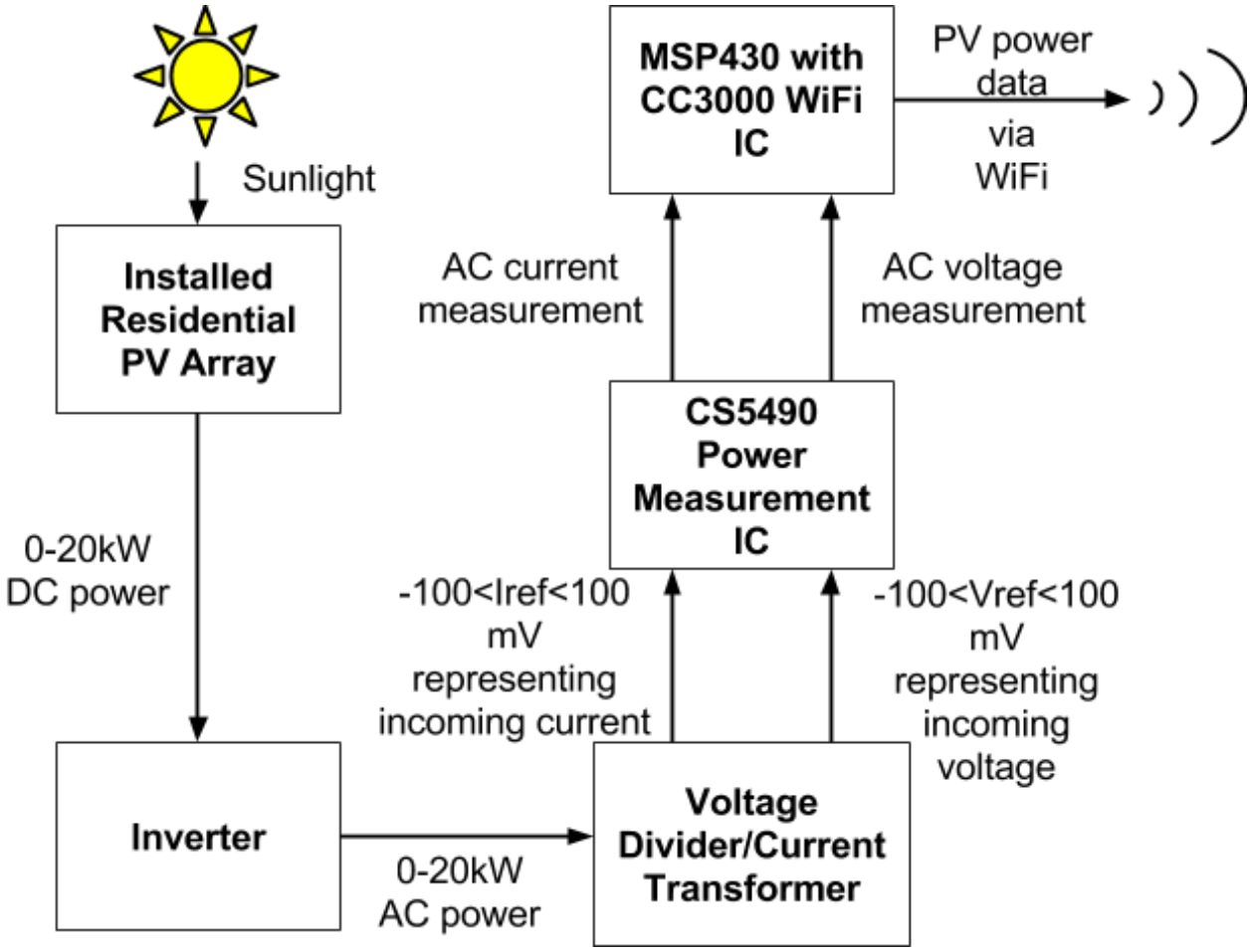
Module	Samsung Galaxy S3: Android Timing Application
Inputs	- 80-100 kB sky and cloud jpeg images from camera. -System Clock -Power data
Outputs	-80-100 kB jpeg image + the time the image was taken, the GPS location of the sensor, and power measurement data from pyranometer. (sent at 30 sec intervals)
Functionality	Synchronizes all cameras to be triggered every 30 seconds, time stamps

	and geo stamps all of the images and sends them to the server to be processed. Uses the available 3G/4G network

Module	Pyranometer
Inputs	-Solar power
Outputs	-0.0 - 3.3 V
Functionality	Measures solar intensity and converts to a scaled voltage 0 - 3.3 V

Module	Remote Sensor Power Supply
Inputs	-Solar power
Outputs	-5V, 1A of DC power for Android phone.
Functionality	Supplies power to the Android phone, able to power the phone for ~100 hours with no sun

Level 2 Subsystem - On-grid PV Sensor:



Module	Installed Residential PV Array
Inputs	-Sunlight.
Outputs	-DC power signal ranging from 0-20 kW depending on solar insolation and PV array size.
Functionality	Converts sunlight into a DC power signal.

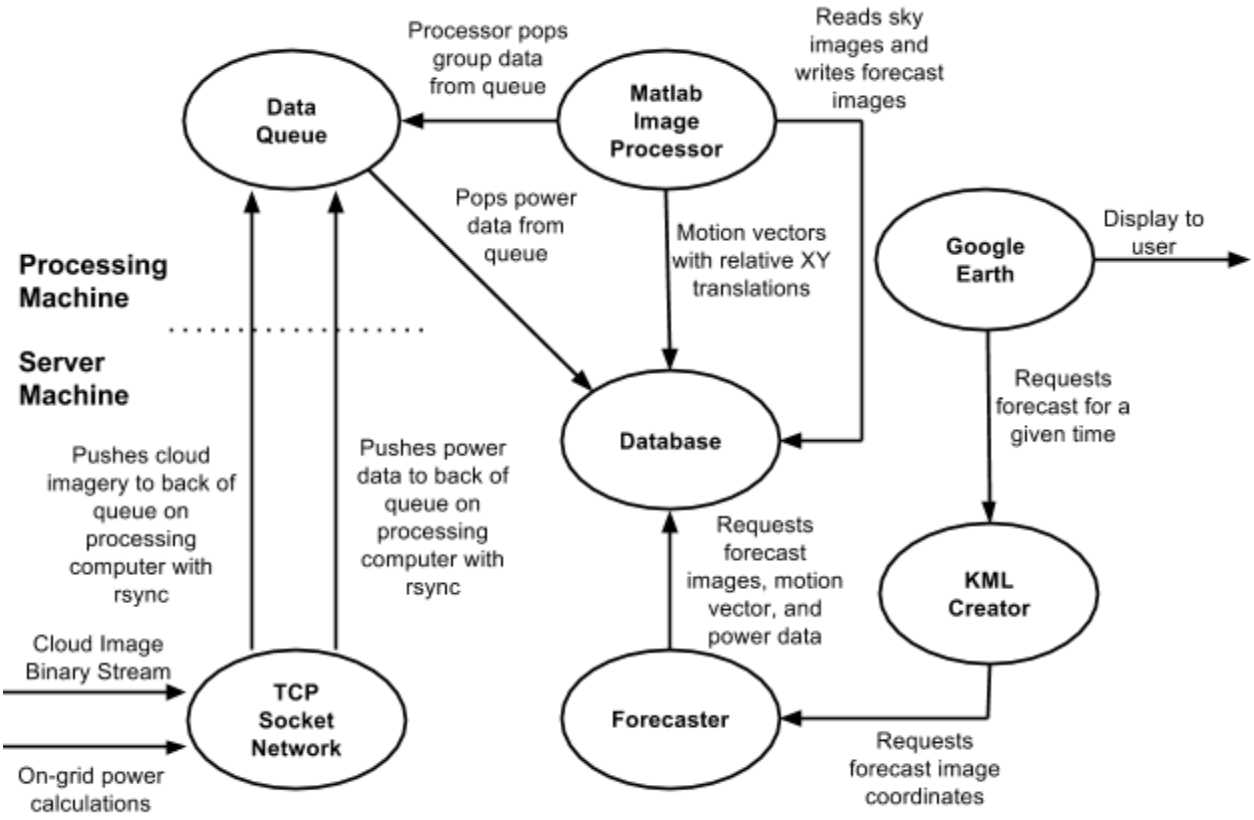
Module	Inverter
Inputs	-0-20 kW DC power signal.
Outputs	-60 Hz 120 V AC useable power signal for grid.
Functionality	Converts the DC power coming from the PV array, inverts it to a 60 Hz sinusoidal signal and steps the voltage up or down to 120 V AC.

Module	Voltage Divider/Current Transformer
Inputs	-0-20 kW AC power signal.
Outputs	-A signal representing the incoming current reduced by a factor of 0.127 and a signal representing the incoming voltage reduced by a factor of 5.2E-4.
Functionality	A current transformer and voltage divider convert the AC power signal into readable signals for measurement

Module	AS8002 PV Inverter Measurement IC
Inputs	-AC current and voltage signals from the voltage divider and current transformer.
Outputs	-Digital measurements of AC voltage and current output of the inverter.
Functionality	Samples the AC output of the inverter and creates digital signal measurements for AC voltage and current which will be processed by the microcontroller.

Module	Arduino Uno w/ WiFi Shield
Inputs	-AC voltage and current measurements.
Outputs	-Power, power factor and phase measurements.
Functionality	Processes the AC voltage and current of the inverter and computes measurements of the appropriate power measurements and sends them to the server via the internet through a WiFi connection.

Level 2 Subsystem - Server:



Module	TCP Socket Network6
Inputs	-Cloud image binary stream. -On-grid power calculations.
Outputs	-Cloud images. -On-grid power calculations.
Functionality	Receives data from each sensor every 30 seconds during the day and pushes the cloud image data and on-grid power calculations onto the queue.

Module	Data Queue
Inputs	-Cloud images. -On-grid power calculations.
Outputs	-Cloud images. -On-grid power calculations.

Functionality	When queue receives data from the network, it pushes the cloud images and power calculations together onto the queue. The queue's purpose is to maintain proper timing of the network while preserving data for use by the image processor.

Module	Matlab Image Processor
Inputs	-Cloud images. -Previous cloud images.
Outputs	-Forecast colormap sky images of the most recent images received by the network representing the solar intensity. -Motion vectors of the clouds.
Functionality	While data ready in the queue, the Matlab Image processor pops image of of queue. It then creates a colormap forecast image for each sensor image in group and determines the cloud motion vectors by comparing the previous sensor cloud images with the sensor cloud images just received. It then flags this group of cloud images as the most recent images for the next set of motion vector calculation. Sends relative motion vectors to the database.

Module	Database
Inputs	-Power data from queue. -Most current forecast colormap image. -Motion vector locations relative to current sky image.
Outputs	-Power data. -Forecast colormap image. -Motion vector locations relative to current sky image.
Functionality	Saves power data and current forecast colormap image. Outputs desired power data, current forecast colormap image, and motion vectors to the forecaster. Each night removes unnecessary (old) data.

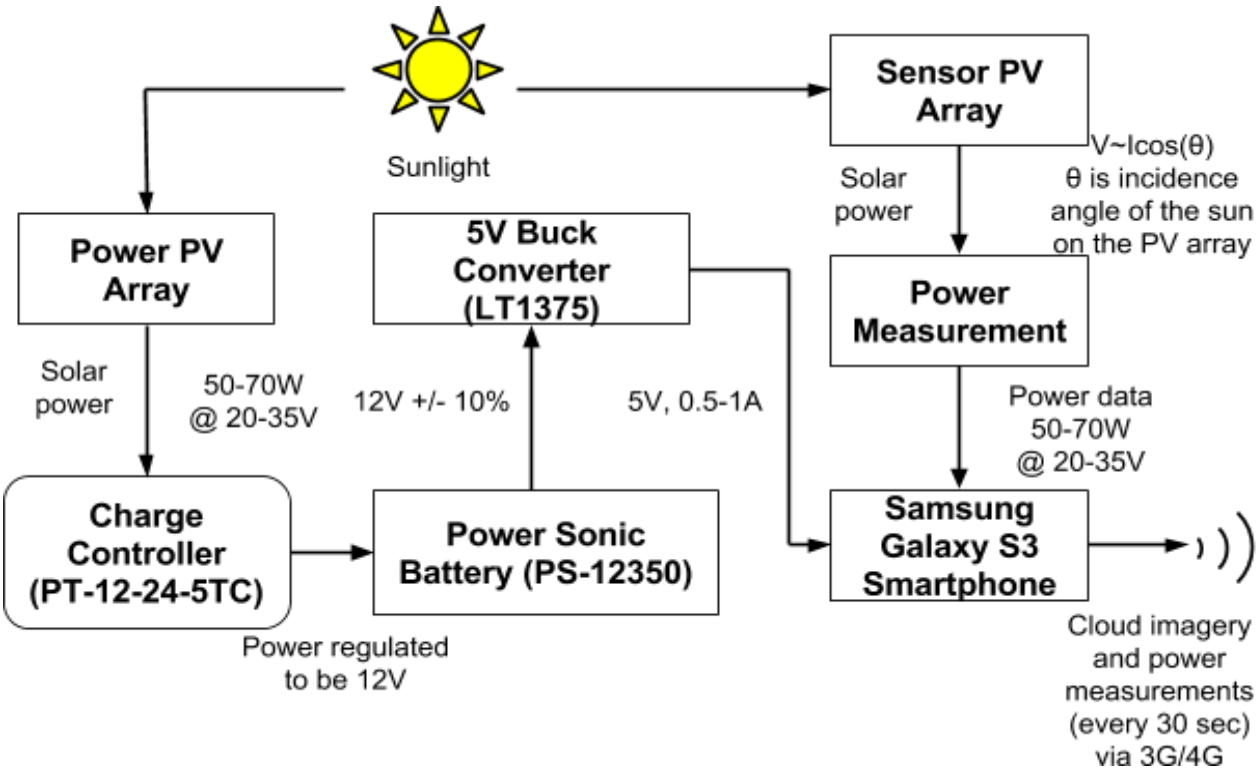
Module	Forecaster
Inputs	-Most recent forecast colormap images. -Cloud motion vectors. -Power data.
Outputs	-Packaged forecast data with forecast colormap images changed based on power data/insolation data, coordinates of where the photos were taken, and new coordinates based off of motion vector and time intervals.
Functionality	Requests forecast colormap image, motion vectors, and power

	calculations from the database and uses this data to compute future cloud locations and solar intensity data for each location on the sky image. All of this information is packaged and sent to the KML creator.

Module	KML Creator
Inputs	-Forecast data.
Outputs	-Solar insolation forecast map.
Functionality	Requests the desired (from user) forecasted data and creates a solar insolation forecast map for the GUI to display with color coding for solar insolation intensity and prediction error.

Module	Google Earth
Inputs	-User input. -Insolation forecast pre-calculated.
Outputs	-A user friendly interface. -The desired forecast.
Functionality	Receives the user input for the desired forecast (current or time intervals of 1, 5, 10, 15, 30, 60 minutes) and connects to the kml file on the server using a network link.

Level 3 Subsystem - Remote Power Sensor and Supply:



Module	Primary PV Array
Inputs	-Solar power.
Outputs	-70 Watts at full power.
Functionality	Supplies the charge to the battery, which in turn provides power for the Android phone. It is necessary in order to have the phone powered without access to the power grid.

Module	Charge Controller
Inputs	-70 Watts of maximum power received from the PV array.
Outputs	-Regulated current and voltage (~12-14V and 5-6A at full power).
Functionality	Limits the rate at which current is added to the battery. It prevents the battery from overcharging and from the PV array supplying too large of a voltage. Both of these can be a safety risk and can destroy the battery. The controller goes through three different charging stages. Bulk, which provides maximum output charge to quickly charge the battery when low. Absorption, which slowly tapers off the current until battery is 98% charged. Float, which provides a maintenance current to keep the battery charged.

Module	Battery
Inputs	-Regulated charge from charge controller.
Outputs	-Constant 12-14.2 Volts for DC-DC Buck Converter.
Functionality	Stores charge which will be used to power the Android for extended periods of time without solar power. Up to 3-4 days of limited to no solar power due to cloud coverage is the time period when the remotely located sensor is most needed, and the battery will provide power to the system during these times.

Module	DC-DC Buck Converter
Inputs	-12-14.2 Volts from the battery.
Outputs	-5 Volts and 0.5-1 Amps to phone.
Functionality	Converts the voltage of the battery to the 5 Volts which is used to power the phone. Current provided to the phone must be between 0.5 and 1 Amps.

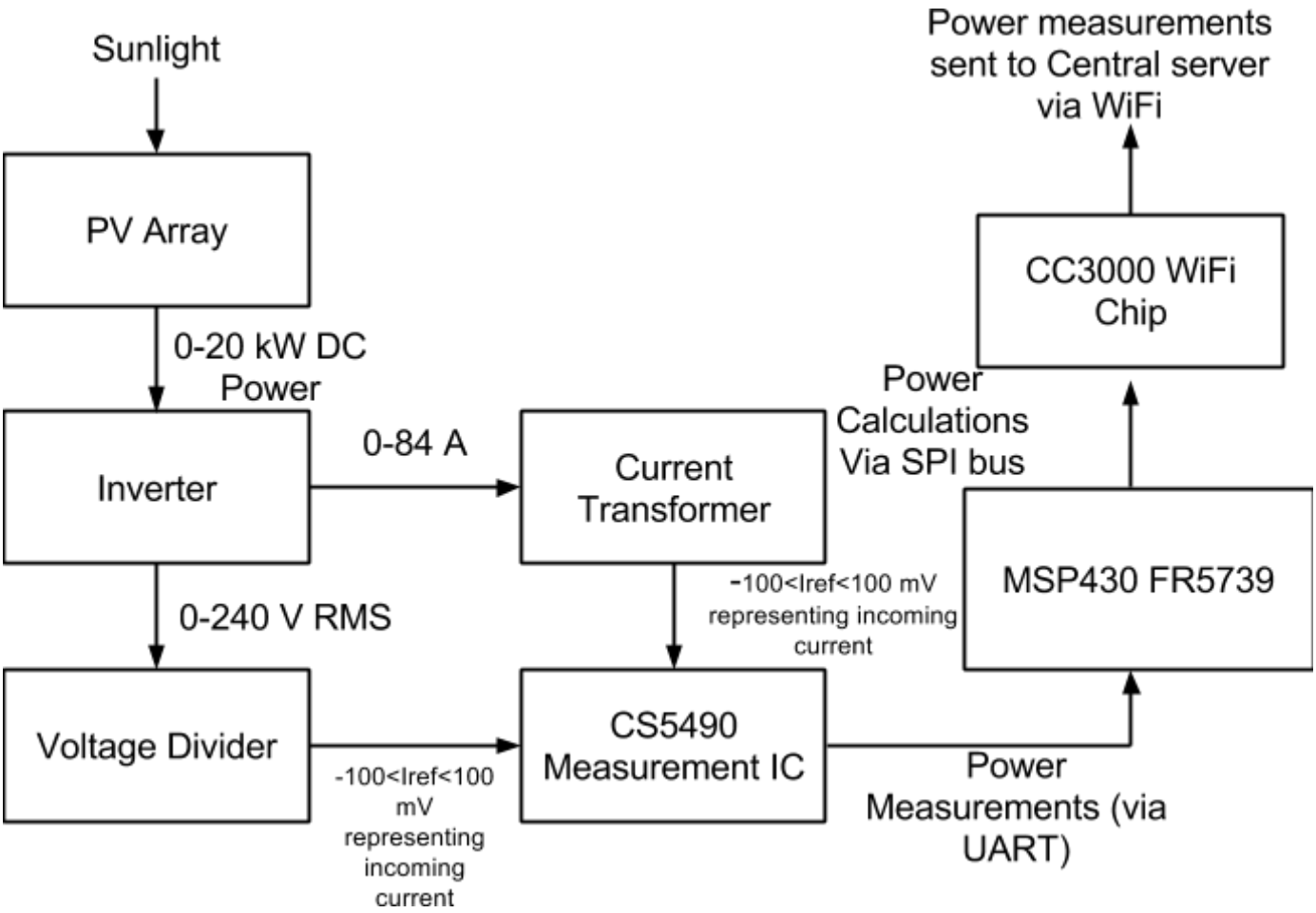
Module	Secondary PV Array
Inputs	-Solar power.
Outputs	-Electrical power.
Functionality	Used to gain real time data about the solar power available at the remotely located sensor.

Module	Power Measurement
Inputs	-Electrical power.
Outputs	-Power data.
Functionality	Processes the voltage and current of the secondary PV array and computes measurements of the appropriate power measurements and sends them to the phone via a USB connection.

Module	Samsung Galaxy S3 Smartphone
Inputs	-5 Volts and 0.5-1 Amps from Buck Converter. -Power data.

Outputs	-Cloud coverage images.
Functionality	Records an image of the cloud coverage every 30 seconds, which is stored in the phone. Through a USB connection it receives real time power measurement data from the secondary PV array. Through 3g/4g coverage, the phone transmits the image and power data to server to be processed.

Level 3 Subsystem On-grid PV Sensor



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Functionality	Converts sunlight into a DC power signal.

Module	Inverter
Inputs	-0-20 kW DC power signal.
Outputs	-60 Hz 120 V AC useable power signal for grid.
Functionality	Converts the DC power coming from the PV array, inverts it to a 60 Hz sinusoidal signal and steps the voltage up or down to 120 V AC.

Module	Current Transformer
Inputs	-0-84 A
Outputs	-A signal representing the incoming current reduced by a factor of 0.127.
Functionality	A current transformer to convert the AC power signal into a readable signal for measurement.

Module	Voltage Divider
Inputs	-0-240 V RMS
Outputs	-A signal representing the incoming voltage reduced by a factor of 5.2E-4.
Functionality	A voltage divider to convert the AC power signal into readable a signal for measurement.

Module	CS5490 PV Inverter Measurement IC
Inputs	-AC current and voltage signals from the voltage divider and current transformer.
Outputs	-Digital measurements of AC voltage and current output of the inverter.

Functionality	Samples the AC output of the inverter and creates digital signal measurements for AC voltage and current which will be processed by the microcontroller.

Module	MSP430FR5739
Inputs	-AC voltage and current measurements.
Outputs	-Power, power factor and phase measurements.
Functionality	Processes the AC voltage and current of the inverter and computes measurements of the appropriate power measurements.

Module	CC3000 WiFi Chip
Inputs	-Power measurements via SPI bus
Outputs	-Power measurements through WiFi connection
Functionality	Sends the calculated power measurements to the central server via the internet through a WiFi connection.