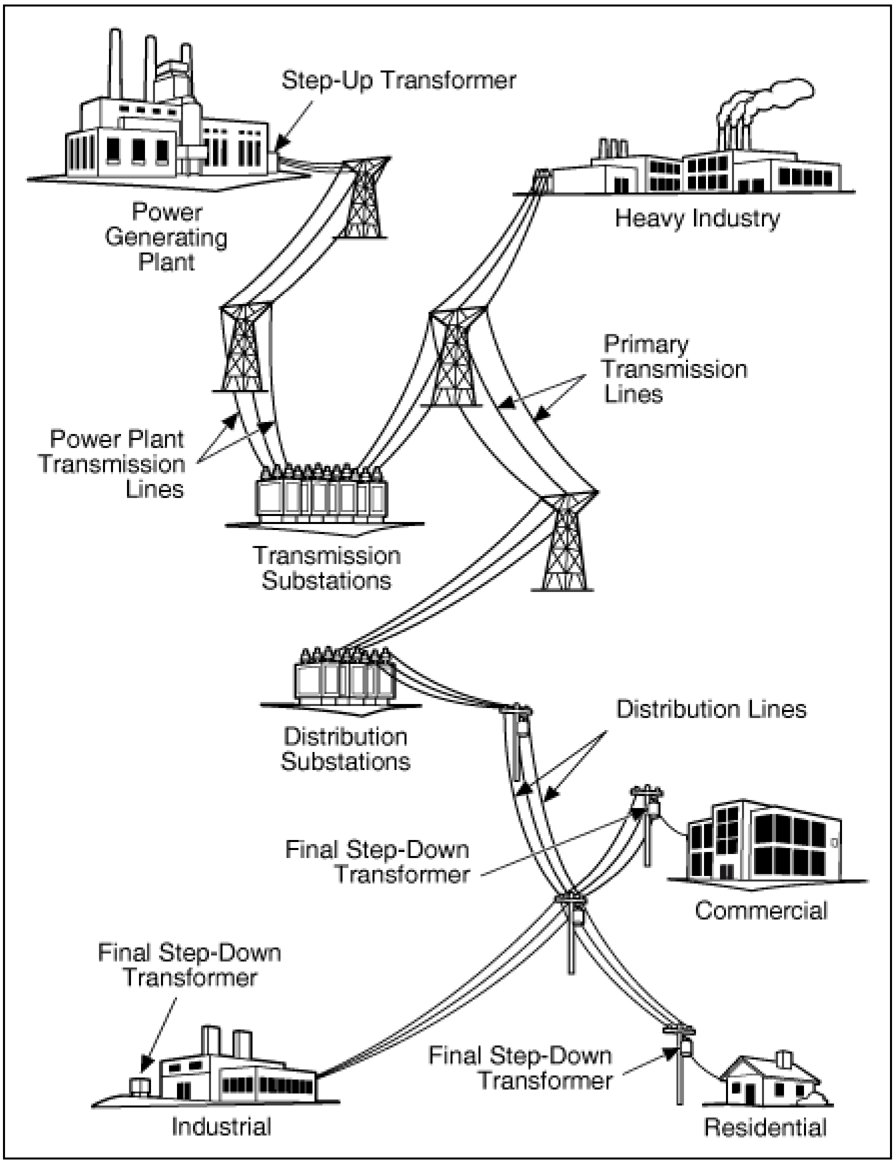
Power Quality Analysis, Remote Grid Monitoring & Power electronics for Renewable Energy

A. Power Quality Analysis

An electrical power grid is a network that delivers electricity from power suppliers to consumers. An electrical power grid contains the following three major components:

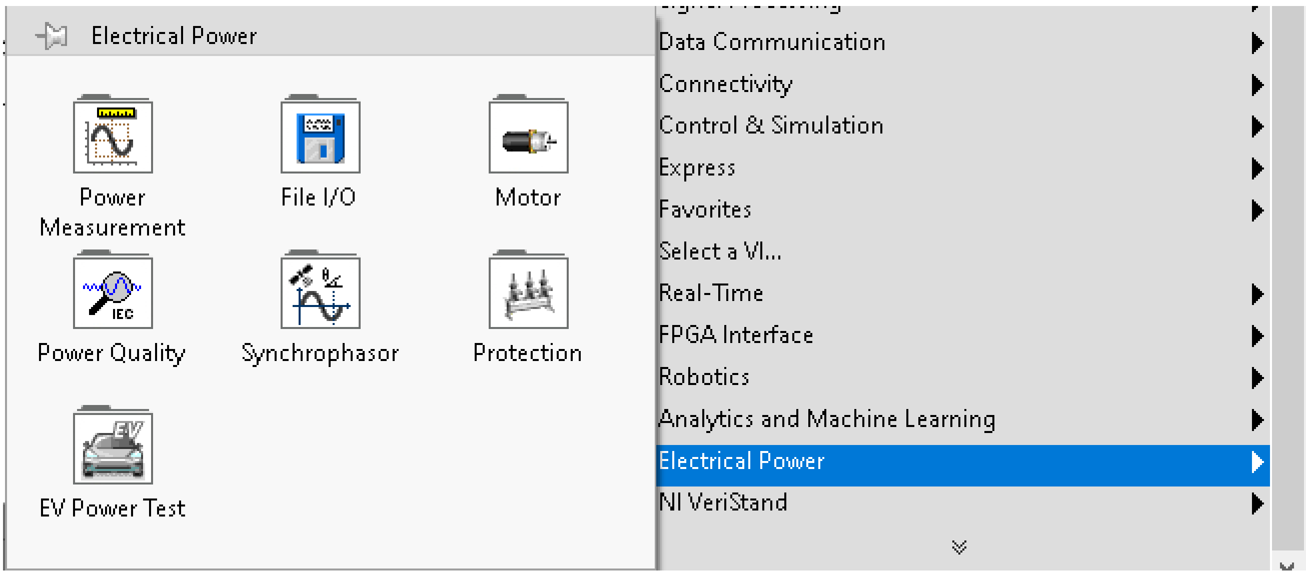
- Power generation by power stations
- Power transmission by utilities
- Power distribution to end users

The following figure shows a typical electrical power grid.



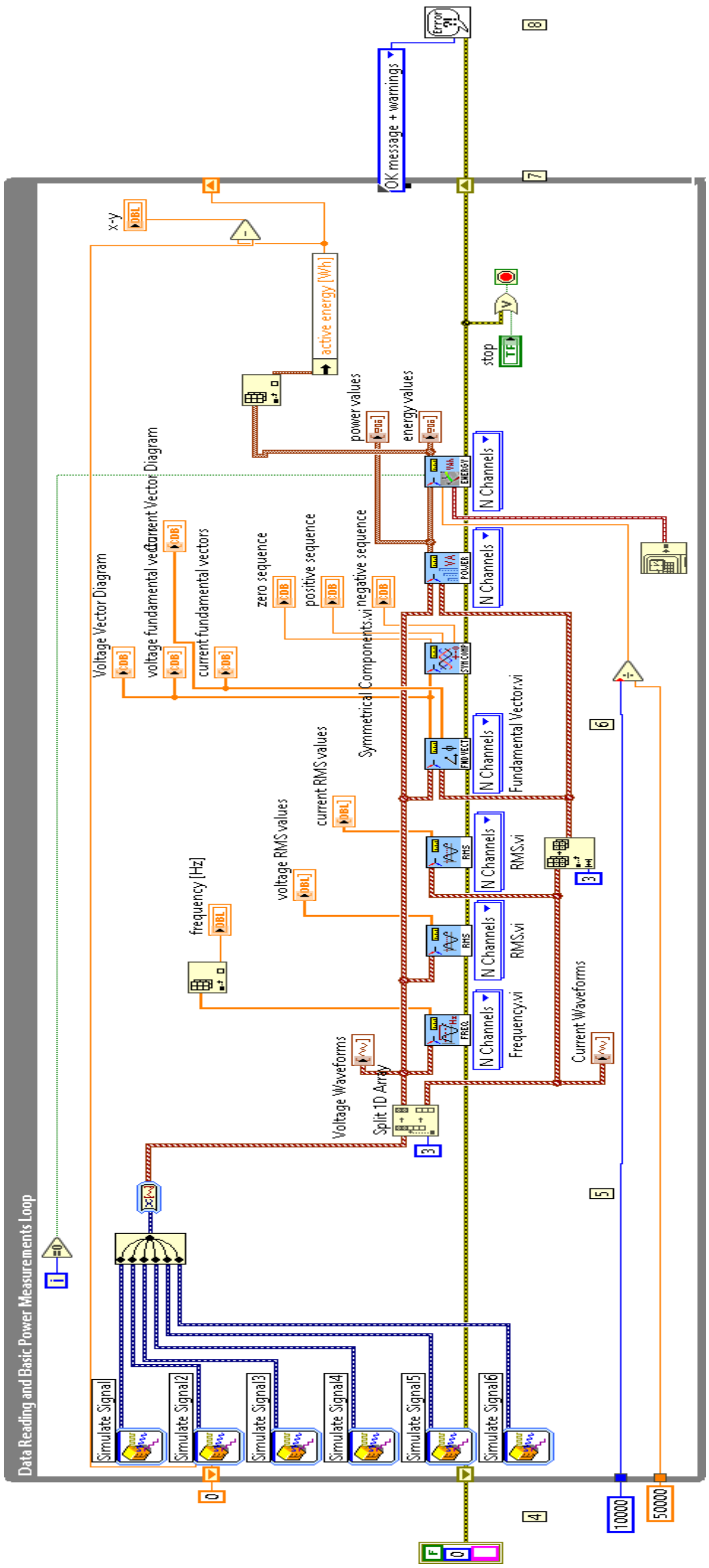
The LabVIEW Electrical Power Toolkit helps you create applications to measure, analyze, and record electrical power data.

The LabVIEW Electrical Power Toolkit is a software add-on for LabVIEW that provides VIs to help you create custom single- or three-phase power monitoring, metering, or quality analysis applications. The LabVIEW Electrical Power Toolkit includes Power Measurement and Power Quality VIs that you can use to measure electrical power and quality parameters and perform harmonic analysis on the CompactRIO, CompactDAQ, and PXI platforms. You can also use synchrophasor measurement VIs as well as protection VIs that help you implement protection devices on the CompactRIO platform.



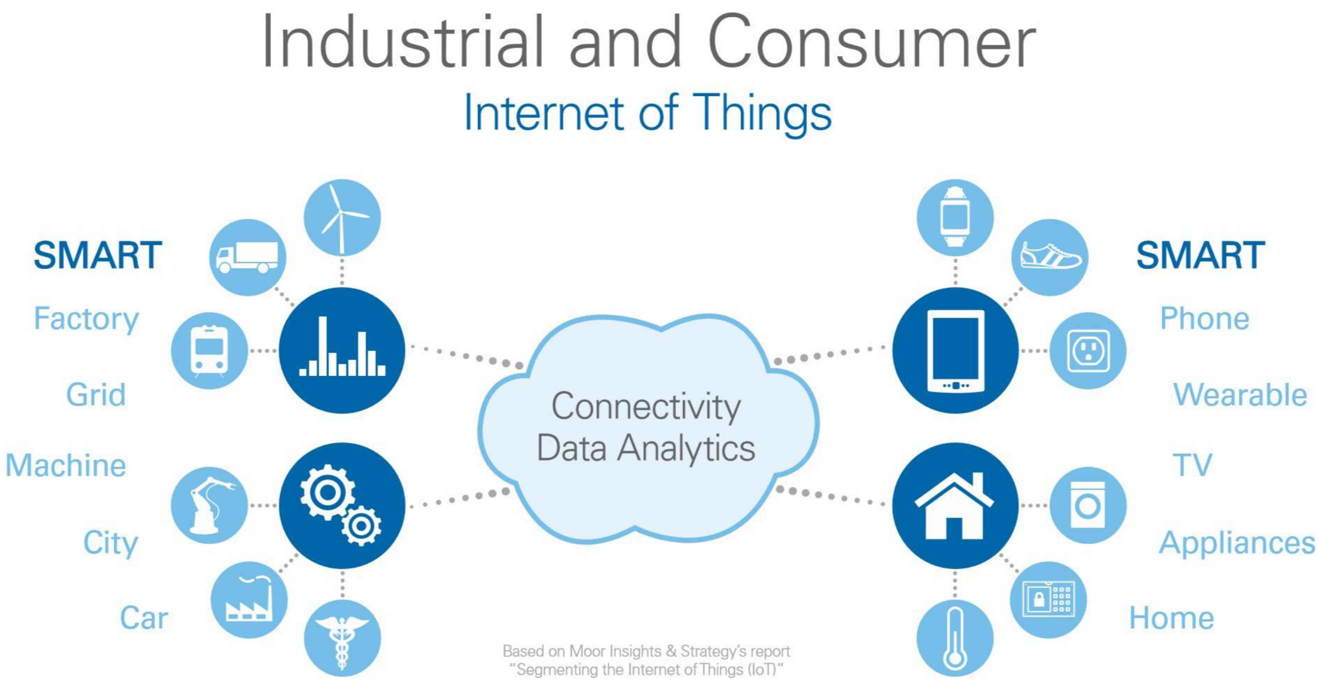
- 3-Phase Power Measurements
  - 3-Phase, 3-Wire, Y Configuration
    - Active power (P)
    - Effective apparent power (Se)
    - Non-active power (N)
    - Power factor (PF)
  - 3-Phase, 4-Wire, Y Configuration
    - Active power (P)
    - Effective apparent power (Se)
    - Non-active power (N)
    - Power factor (PF)

- Transformations to and from reference frames
    - ABC to Alpha-beta Transform (magnitude invariant, power invariant)
    - Alpha-beta to ABC Transform (magnitude invariant, power invariant)
    - ABC to DQ Transform (magnitude invariant, power invariant)
    - DQ to ABC Transform (magnitude invariant, power invariant)
  - Time and Frequency domain power analysis
  - Inverter efficiency measurement
  - Motor efficiency measurement
- Battery Power Measurements
  - Energy (watt-seconds) integration
  - Charge (Amp-seconds, Coulombs) integration
  - Real power (Watts)
- EV Power Test Specific Examples Including:
  - Traction Inverter and Electric Motor Efficiency (shown to the right)
  - Frequency domain power measurements
  - Transforms to different motor rotating reference frames
  - Battery energy integration
  - Battery charge integration
- Electrical Power Toolkit 2019 used recent international standard
  - IEEE-1459-2010 Standard for the Measurement of Electric Power Quantities Under Sinusoidal, Nonsinusoidal, Balanced, or Unbalanced Conditions compliant
  - This standard suits for measuring nonsinusoidal signals such as inverter PWM

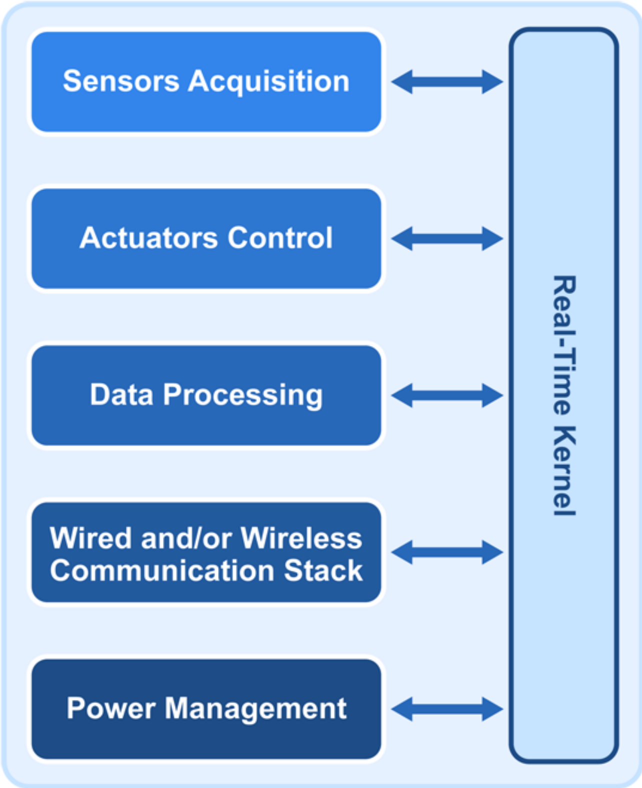

Data Reading and Basic Power Measurements Loop
Simulate Signal
Simulate Signal2
Simulate Signal3
Simulate Signal4
Simulate Signal5
Simulate Signal6
Split 1D Array
Voltage Waveforms
Current Waveforms
Frequency.vi
RMS.vi
RMS.vi
Fundamental Vector.vi
Symmetrical Components.vi
N Channels
frequency [Hz]
voltage RMS values
current RMS values
Voltage Vector Diagram
voltage fundamental vectors
Current Vector Diagram
current fundamental vectors
zero sequence
positive sequence
negative sequence
power values
energy values
active energy [Wh]
x-y
stop
OK message + warnings

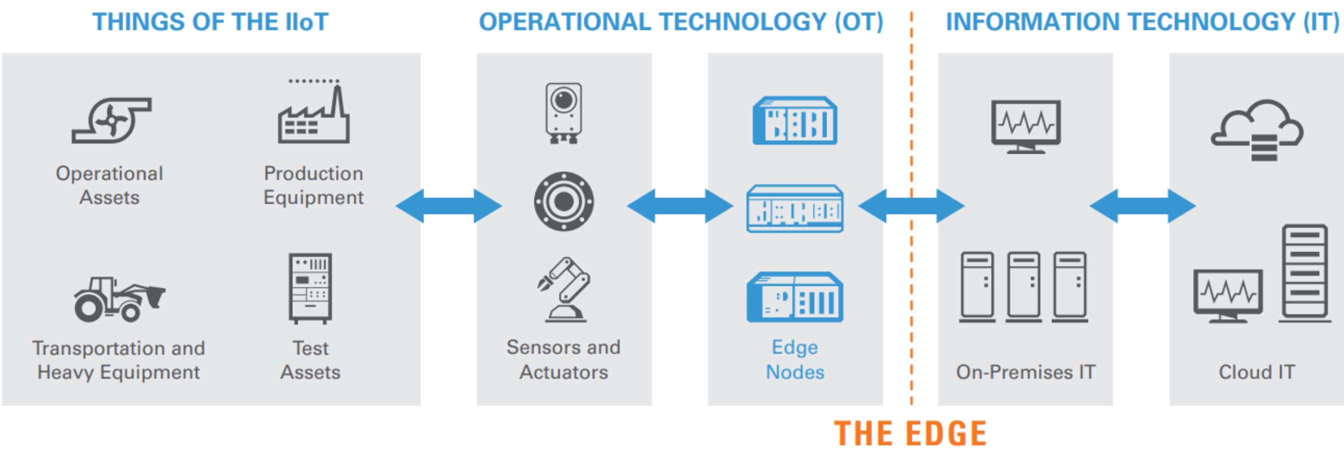
B. Remote Grid Monitoring

The Internet of things is a system of interrelated computing devices, mechanical and digital machines provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction



- IO Options to Interface Sensor and Actuators (Not Limited AIO and DIO's)
- RTOS : Acquisition and Processing Capability
- Reliability
- Connectivity : Wired or Wireless
- Power Management & Cost
- Programming Language


Sensors Acquisition
Actuators Control
Data Processing
Wired and/or Wireless Communication Stack
Power Management
Real-Time Kernel


THINGS OF THE IIoT
OPERATIONAL TECHNOLOGY (OT)
INFORMATION TECHNOLOGY (IT)
Operational Assets
Production Equipment
Transportation and Heavy Equipment
Test Assets
Sensors and Actuators
Edge Nodes
On-Premises IT
Cloud IT
THE EDGE

NI control and measurement technology helps utilities and power systems engineers to create a smarter grid to improve grid integration of renewable energy sources, implement automated analytics, advance situation awareness, and improve overall energy efficiency. NI offers design tools, test systems, and embedded deployment platforms that give engineers the ability to rapidly explore new approaches, streamline discovery and production, and deploy their innovations in ruggedized measurement and control systems.

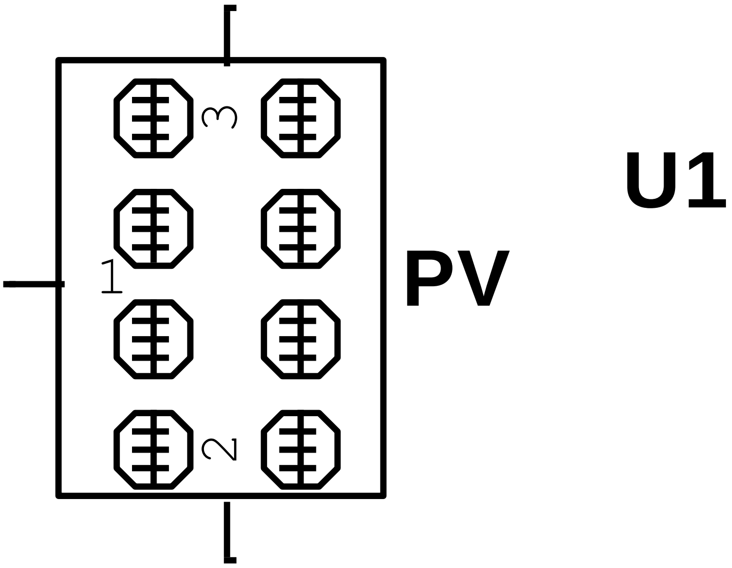
NI-based solutions use open, customizable measurement tools to meet the unique needs of an industry filled with utility grids that rarely exhibit the same problems.

C. Power Electronics for Renewable Energy

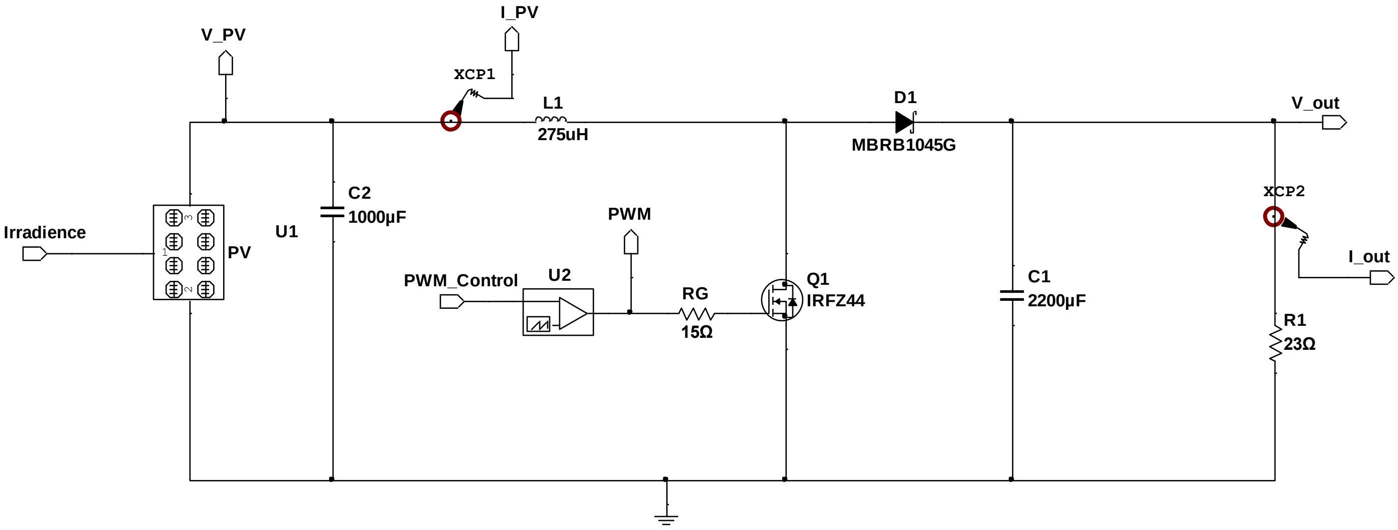
Renewable energy is an area of significant investment and importance for future generations. The ability to develop technology that harnesses energy from wind, solar, water, and other renewable resources defines future generations of technology. The engineers and scientists who are solving these challenges today are using National Instruments technologies to develop and deliver tomorrow's solutions for a sustainable environment. Research for renewable energy is presenting new and exciting technologies that offer ways to increase the efficiency and viability of wind power, solar energy, and fuel cell technology.

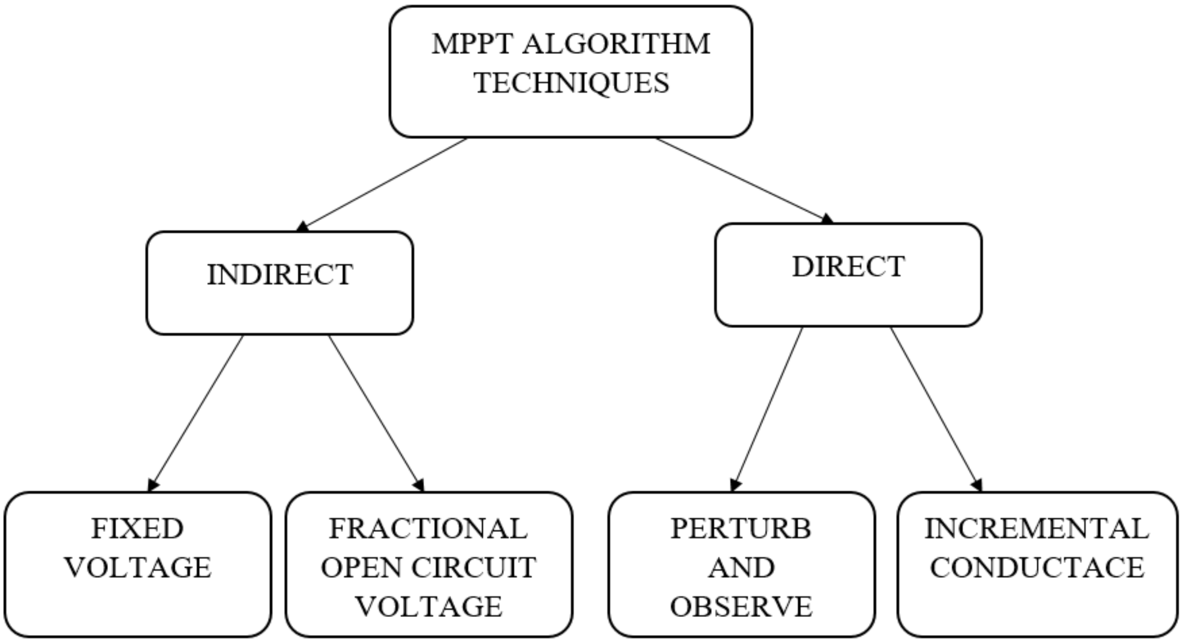
The sun sustains life on Earth. For centuries humans have used solar heating to warm houses and plant life has relied on sunlight for photosynthesis. Efficiently converting solar energy into solar power or electricity is a recent challenge. Two common technologies for solar electricity generation are photovoltaic (sunlight is converted directly to electricity) and solar thermal (the sun heats water and creates steam that is then used to power steam engines). Learn how engineers and researchers use NI technologies to design, prototype, and deploy solar thermal systems or photovoltaic systems for solar power generation.

Multisim tool is a best tool for Emulating the characteristics of solar cells.



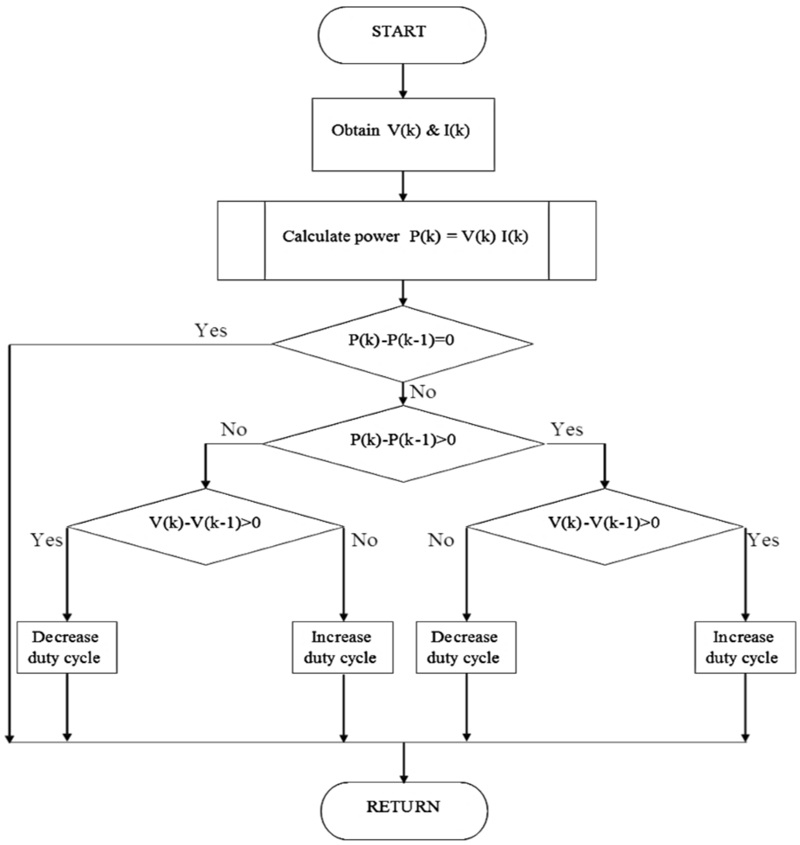
To maximize a photovoltaic (PV) system's output power, continuously tracking the maximum power point (MPP) of the system is necessary. The MPP depends on irradiance conditions, the panel's temperature, and the load connected. Maximum power point tracking (MPPT) algorithms provide the theoretical means to achieve the MPP of solar panel.


V_PV
I_PV
XCP1
L1
275uH
D1
MBRB1045G
V_out
XCP2
I_out
Irradience
PV
U1
C2
1000µF
PWM
PWM_Control
U2
RG
15Ω
Q1
IRFZ44
C1
2200µF
R1
23Ω


MPPT ALGORITHM TECHNIQUES
INDIRECT
DIRECT
FIXED VOLTAGE
FRACTIONAL OPEN CIRCUIT VOLTAGE
PERTURB AND OBSERVE
INCREMENTAL CONDUCTACE

PERTURB AND OBSERVE METHOD

- The concept behind the "perturb and observe" (P&O) method is to modify the operating voltage or current of the photovoltaic panel until you obtain maximum power from it.
- For example, if increasing the voltage to a panel increases the power output of the panel, the system continues increasing the operating voltage until the power output begins to decrease.
- Once this happens, the voltage is decreased to get back towards the maximum power point.
- This pertubulance continues indefinitely. Thus, the power output value oscillates around a maximum power point and never stabilizes.
- P&O is simple to implement and thus can be implemented quickly.
- The major drawbacks of the P&O method are that the power obtained oscillates around the maximum power point in steady state operation, it can track in the wrong direction under rapidly varying irradiance levels and the step size determines both the speed of convergence to the MPP and the range of oscillation around the MPP at steady state operation.



LABVIEW MULTISIM COSIMULATION: PERTURB AND OBSERVE MPPT ALGORITHM