Undergraduate Certificate in Sensor Networks

Energy Harvesting for Sensors

Energy Harvesting for Sensors: Key Terms and Vocabulary

Energy harvesting is the process of capturing and converting small amounts of ambient energy into electrical energy to power low-power devices such as sensors. In the undergraduate certificate course in Sensor Networks, energy harvesting is a crucial concept for sensors to operate independently and sustainably. Here are some key terms and vocabulary related to energy harvesting for sensors:

1. Ambient Energy: Ambient energy is the energy present in the environment, such as thermal, solar, vibrational, and electromagnetic energy. Sensors can capture and convert this energy into electrical energy to power their operations.
2. Energy Harvesting System: An energy harvesting system is a device that captures and converts ambient energy into electrical energy to power low-power devices such as sensors. It consists of an energy harvester, a power management circuit, and an energy storage device.
3. Energy Harvester: An energy harvester is a device that captures and converts ambient energy into electrical energy. Common energy harvesters include thermoelectric generators, photovoltaic cells, piezoelectric generators, and electromagnetic generators.
4. Power Management Circuit: A power management circuit is a device that manages the electrical energy generated by the energy harvester. It converts the electrical energy into a stable voltage and current, stores excess energy in an energy storage device, and regulates the power supply to the sensor.
5. Energy Storage Device: An energy storage device is a device that stores the electrical energy generated by the energy harvester. Common energy storage devices include rechargeable batteries, capacitors, and supercapacitors.
6. Thermoelectric Generator: A thermoelectric generator is an energy harvester that converts thermal energy into electrical energy. It consists of two dissimilar metal conductors connected together, and a temperature difference between the two conductors generates an electrical voltage.
7. Photovoltaic Cell: A photovoltaic cell is an energy harvester that converts solar energy into electrical energy. It consists of a semiconductor material such as silicon, which generates an electrical voltage when exposed to sunlight.
8. Piezoelectric Generator: A piezoelectric generator is an energy harvester that converts mechanical energy into electrical energy. It consists of a piezoelectric material such as lead zirconate titanate, which generates an electrical voltage when subjected to mechanical stress.
9. Electromagnetic Generator: An electromagnetic generator is an energy harvester that converts mechanical energy into electrical energy. It consists of a coil of wire and a magnet, and mechanical motion between the coil and the magnet generates an electrical voltage.
10. Power Density: Power density is the amount of power generated per unit area or volume of the energy harvester. High power density energy harvesters can generate more electrical energy in a smaller area or volume.
11. Efficiency: Efficiency is the ratio of the electrical energy output of the energy harvester to the ambient

energy input. High-efficiency energy harvesters can generate more electrical energy from the same amount of ambient energy.
12. Matching Network: A matching network is a device that matches the impedance of the energy harvester to the impedance of the power management circuit. It maximizes the power transfer from the energy harvester to the power management circuit.
13. Start-up Voltage: Start-up voltage is the minimum voltage required to initiate the operation of the energy harvester. Energy harvesters with low start-up voltages can operate with smaller amounts of ambient energy.
14. Output Voltage: Output voltage is the voltage generated by the energy harvester. High output voltage energy harvesters can generate more electrical energy but may require a voltage regulator to reduce the voltage to a stable level.
15. Output Current: Output current is the current generated by the energy harvester. High output current energy harvesters can generate more electrical energy but may require a current regulator to limit the current to a safe level.
16. Self-discharge: Self-discharge is the gradual loss of electrical energy from the energy storage device due to internal resistance. Low self-discharge energy storage devices can store electrical energy for longer periods.
17. Cycle Life: Cycle life is the number of charge and discharge cycles that an energy storage device can perform before its capacity decreases to 80% of its original capacity. High cycle life energy storage devices can perform more charge and discharge cycles before they need to be replaced.

Examples and Practical Applications:

Energy harvesting for sensors has various practical applications, including:

* Wireless sensor networks for monitoring temperature, humidity, and pressure in industrial plants, buildings, and homes.
* Wearable devices for monitoring health and fitness parameters.
* Smart agriculture systems for monitoring soil moisture, temperature, and light intensity.
* Smart city infrastructure for monitoring traffic, air quality, and noise pollution.

Challenges:

Despite the advantages of energy harvesting for sensors, there are several challenges, including:

* Low power output: Energy harvesters generate low power output, which may not be sufficient to power sensors with high power consumption.
* Intermittent energy supply: Ambient energy is intermittent, and sensors may not receive a constant energy supply, leading to unstable power supply.
* Complex power management: Power management circuits are complex and require careful design to match the impedance of the energy harvester and the sensor.
* Limited energy storage: Energy storage devices have limited capacity, and sensors may not store enough energy to operate during periods of low ambient energy.

Conclusion:

Energy harvesting for sensors is a crucial concept in the undergraduate certificate course in Sensor Networks. Understanding the key terms and vocabulary related to energy harvesting for sensors can help students design and implement sustainable and low-power sensor networks. Despite the challenges, energy harvesting for sensors has various practical applications, and addressing the challenges can lead to more efficient and reliable sensor networks.