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PHOTOVOLTAIC CELLS AND THE HARVESTING OF ENERGY THROUGH SOLAR ENERGY WITH A SUITABLE ENERGY MANAGEMENT PLAN ARE IMPLEMENTED

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Abstract:

Energy Harvesting-based Wireless Sensor Networks, also known as EHWSNs, are a kind of WSN that are created when WSN nodes are equipped with the capacity to harvest energy from their immediate surroundings. The term "energy harvesting" refers to the process of drawing power from a variety of sources, including the sun, the wind, mechanical vibrations, temperature fluctuations, magnetic fields, and so on. The Markovian model is widely regarded as one of the most effective approaches to the energy harvesting process. Both a time-dependent process and a first-order approximation are provided by the Markovian model that we have developed. A unified and described Markov model for an energy harvesting process is also provided here. This model shows the methods of energy harvesting, the methods of energy consumption, the method of energy storage inside the nodes as well as in the devices, and the process of event arrival. In this study, the design of various photovoltaic cells and the harvesting of energy through solar energy with a suitable energy management plan are implemented. This is done by taking use of various harvesting approaches. The Markovian model is introduced for energy harvesting, after describing the two primary strategies for energy harvesting that have been developed.

Keywords: Markovian, model, energy, harvesting, consumption, etc.

1. INTRODUCTION

The issue of energy consumption is one of the most significant challenges faced by wireless sensor networks (WSN). During continuous operation at the sensor nodes, the energy level drops extremely fast; thus, it is essential to replace or recharge the power sources on a regular basis. However, it can be quite challenging to carry out these duties using the approaches that have traditionally been used. We collect the energy that is available from the surrounding environment at the nodes in order to circumvent the issues that are connected with conventional approaches. The act of collecting and making use of energy from the surrounding environment, such as solar, mechanical, thermal, or radio frequency (RF) energy, is referred to as "harvesting ambient energy." In a wireless sensor network (WSN), the sensor

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nodes are outfitted with energy harvesting devices, which allow them to scavenge energy from the surrounding sources. Even though the battery is the major source of power in all sensor nodes, the captured energy may often serve as the principal complement to the other power sources. In a wireless sensor network (WSN), the sensor nodes are outfitted with energy harvesting devices, which allow them to scavenge energy from the surrounding sources. Even while batteries are always the major source of power in sensor nodes, there are situations in which captured energy can be used as a supplementary supplement to existing power sources. The key components of an energy harvesting model are the sensor nodes, which can come in a variety of forms, the sources of energy, the principal storage devices, the harvesting device, and the many methods for utilizing the harvested energy. The two most common methods for energy harvesting are known as (a) entire dependence on an ambient energy as supplemental sources and (b) the utilization of energy harvesting devices known as transducers. Utilizing a variety of various methods, the transducer extracts usable electrical energy from the surrounding sources. The thermal, micro wind turbine, piezoelectric, mechanical, solar radiations, radio frequency, and specific antenna energy sources can all be included in the category of ambient sources of energy. Because of the random nature of environmental energy sources, it is either possible or impossible to forecast and exert control over them. With this method, our attention is focused on the question, "How can a sensor node gather the energy that is provided by the sun with the assistance of photovoltaic cells (PVcell)?" The load, which makes use of both the starting energy and the gathered energy, is the most significant component of a model that incorporates energy harvesting. The load is responsible for the regulation of the electronic circuit, as well as the sensor nodes, processing unit, transceiver, and shunt regulators.

2. LITERATURE REVIEW

Margielewicz, Jerzy and Gaska (2022) [1] a study on modelling energy harvesting efficiency of a quasi-zero stiffness system is presented. Mechanical characteristics of the system are identified, and the effect of its stiffness and geometry on the function describing energy potential barrier is determined. It has been shown numerically that an increase in equivalent stiffness of the quasi-zero stiffness system limits the potential barrier width on the other hand, increased the spacing between compensating springs results in increased barrier width. Simulation results of the quasi-zero stiffness system are compared with those obtained for a triple-well system with permanent magnets. Based on mathematical models, multi-color diagrams depicting the largest Lyapunov exponent are plotted.

Laszczyk, Karolina and Sliwinski et al. (2022) [2] Energy harvesting is based on obtaining energy from the environment utilizing mechanical, thermal, radiant, and biochemical sources. Recently, energy harvesting has become strongly associated with the trend of miniaturization of consumer electronics and the dissemination of the concept of the Internet of Things. In this chapter, we present briefly the energy harvesters with a relationship to energy storage devices, micro-super capacitors. Energy harvesting is based on obtaining energy from the environment utilizing mechanical, thermal, radiant, and biochemical sources. Recently, energy harvesting has become strongly associated with the trend of miniaturization of consumer electronics and the dissemination of the concept of the Internet of Things. In this chapter, we present briefly the energy harvesters with a

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relationship to energy storage devices, micro super capacitors.

Elahi, Hassan (2022) [3] over the last few years, there has been an increase in interest in energy harvesting, and the amount of study into the topic has maintained a steady upward trend over the past several decades. The methods for energy collecting are broken down into their component parts in this chapter. In addition to this, several methods of energy collecting from the environment are investigated. These methods and procedures are frequently utilized in a broad variety of self-powered electronic devices, including but not limited to wireless sensors, biomedical equipment, calculators, Bluetooth gadgets, military control facilities, and built-in instrumentation. Over the last few years, there has been an increase in interest in energy harvesting, and the amount of study into the topic has maintained a steady upward trend over the past several decades. The methods for energy collecting are broken down into their component parts in this chapter. In addition, several methods of energy harvesting from the environment are investigated.

Amin Al Kabi (2022) [4] one of the key difficulties in constructing mobile wireless sensor networks is the limited supply of energy sources a suggested technique for increasing the lifespan of energy-constrained mobile wireless sensor networks (MWSNs) is described in this study effort. This technique is based on the idea that RF signals simultaneously carry information and energy. Thus, the lifespan of the wireless network may be greatly increased by improving the efficiency of energy harvesting from radio frequency (RF) signals. Through the use of the Simultaneous Wireless Information and Power Transfer (SWIPT) technology, relay nodes may harvest energy for use in wireless data transfer. The transmitted RF energy can be recycled at the receiver side to prolong the life of the mobile wireless network. To improve the system's overall effectiveness, however, a balance between energy harvesting and wireless data transfer is necessary.

Bagali, Sheetal & Sundaraguru, R. (2021) [5] underwater wireless sensor networks, also known as UWSNs, are utilised for a variety of coastal area monitoring and military surveillance applications, including the prevention of tsunamis and the tracking of targets, among other things. In ultra-wide area networks (UWSNs), where an intruder might shorten the lifetime of sensor nodes and negatively affect the performance of packet delivery, jamming is regarded to be a major concern. In this research, we consider that the jammer device has the capacity of shortening the battery's lifetime and prohibiting trustworthy UWSN motes from communicating with one another. When taking into account the presence of numerous jammers, the currently employed resource consumption approach is inefficient. This paper presents an effective resource allocation approach for reducing the effects of numerous jammers in UWSNs, with the goal of solving research challenges. The ERA model makes use of cross-layer architecture, and it is able to interact with one another in a cooperative manner by employing both direct and hop-based communication in order to maximize resource consumption and quality specified.

3. METHODOLOGY

In this study, the design of various photovoltaic cells and the harvesting of energy through solar energy with a suitable energy management plan are implemented. This is done by taking use of various harvesting approaches. The Markovian model is introduced for energy harvesting, after describing the two primary strategies for energy harvesting that have been developed. It is detailed how various harvesting models may be utilized, how various harvesting modules can be utilized, with the assistance of solar cells.

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The new energy harvesting approach is explains how energy may be managed inside a sensor node. The analytical model is broken down in great detail. In the end, a synopsis of this chapter together with some simulation results is offered.

4. RESULT AND ANALYSIS

A 21.5 V open circuit voltage V_{oc} and 3.1Amperes I_{SC} short circuit current are used in the simulation. Table 1 details the specifications of the solar panels. Fig. 2 displays the 50W solar panel's IV and PV properties across a range of irradiance values. As can be seen in Fig. 2, the irradiance plays a crucial role in determining the amount of electricity that a solar panel is able to generate. $I_{SC}(G) = I_{SC(Standard)}\frac{G}{G_{Standard}}$ Indicates, I_{SC} is dependent on G. where $G_{Standard}$ is the typical (maximal) value during the solar day's peak hour

Table 1: Specification of Solar Panel at STC

Parameters	Range
P_m	50W
V_{oc}	21.6V
I_{SC}	3.1A
V_m	17.47V
I_m	2.865A

Figure 1 depicts the irradiance at various times of the day. In other words, the irradiance value is greatest around midday, when the panel is at right angles to the sun. The simulation results are shown in Fig.2, which is a graph describing the IV and PV properties at various irradiance levels. Since the highest power output of the PV modules occurs at greater irradiance and the minimum power output occurs at lower irradiance, the performance of the PV system is highly reliant on the amount of available sunlight.

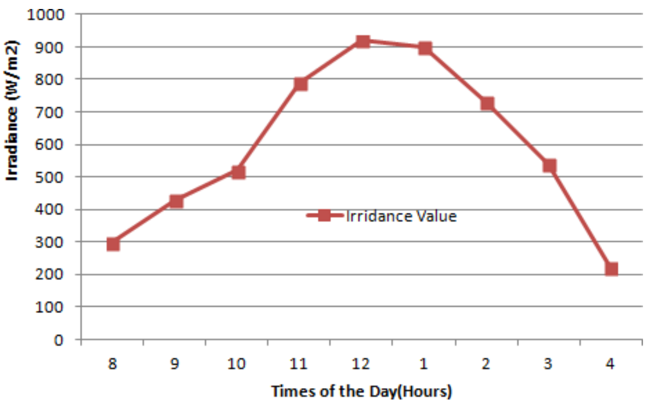

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Figure 1: Irradiance Value at Different Times of a Day

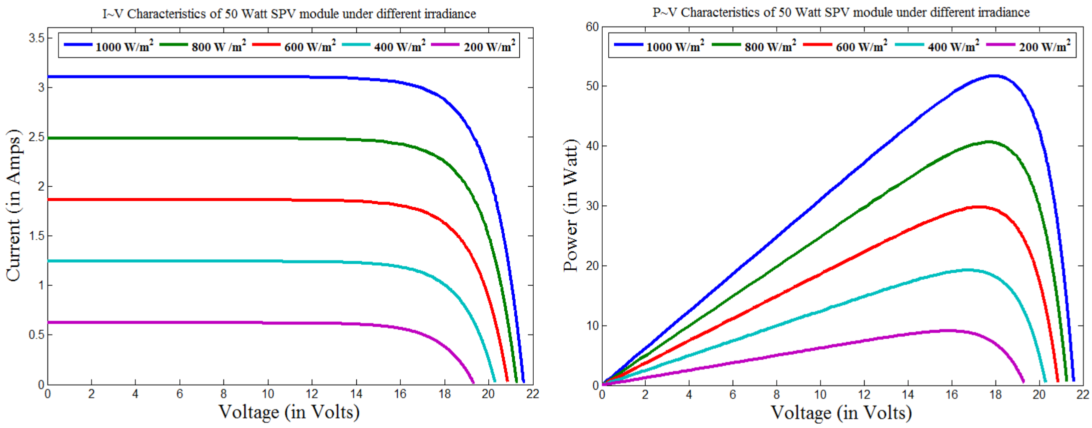

Figure 2: Simulation Model of PV Array with Different Irradiance

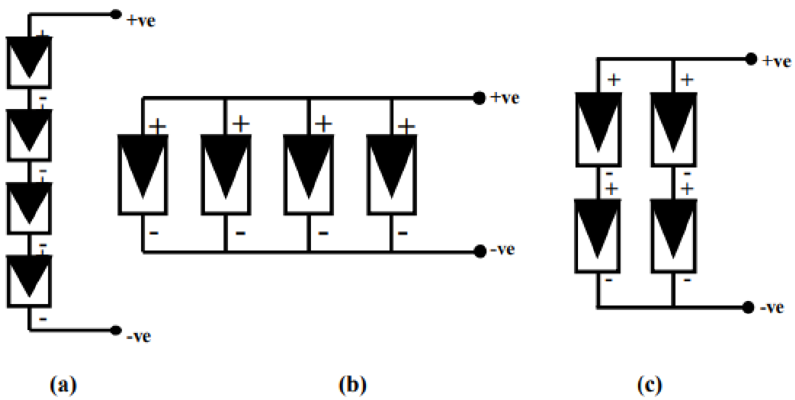

Figure 3: (a) Series Connection Modules (b) Parallel Connection Modules and (c) Series-Parallel Connection Modules of Solar Panels

4.1 Series Connection

In Fig. 3, we see solar panels connected in series if the solar panels are all wired together in series, then (a). The system voltage is kept constant by the associated PV panels' constant current, which is 3.1A at a voltage of (21.4 4). The PV channels are tested under varying irradiances from 8 a.m. to 4 p.m., all while linked in series. Both the IV and PV properties of Series-connected solar panels at various irradiances are depicted in Fig.5 (a) and (b), respectively. Based on the data in Fig. 3 (b), we can tell that PV panels generate 189.04W of power when exposed to 920W/m^2 of irradiance, 147.30W of power when exposed to 730W/m^2 of irradiance, 102.11W of power when exposed to 520W/m^2 of irradiance, 56.28W of power when exposed to 300W/m^2 of irradiance, and 40.

4.2 Parallel Connection

Figure 4 depicts the parallel wiring of PV modules. (b) Where four 50W PV panels are linked in parallel with each other. The (21.4) V and (3.114) A produced by the linked PV panels increase the system current while maintaining the system voltage. The parallel PV pipes are put through their paces from 8 a.m. to 4 p.m.

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under varying levels of sunlight. Figure 5 shows that PV panels produce 188.56W at 920W/m^2, 147.24W at 730W/m^2, 102.10W at 520W/m^2, 56.28W at 300W/m^2, and 40.19W at 220W/m^2. Fig. 5. Parallel-connected solar panels' IV and PV properties at varying intensities are depicted in (a) and (b), respectively. We can calculate the minimum and maximum power for each irradiance by setting G =220W/m^2 and G =920W/m^2, respectively. As can be seen in Fig.5, the irradiance value starts off low (about 200W/m^2) in the morning and steadily climbs until noon (Maximum temperature in the environment). With each passing day, the Sun's irradiance grows. At 12 o'clock noon, the irradiance is at its highest (920 W/m^2). Low-level irradiance occurs after 12 p.m., with voltage ranging from 19 to 22 volts and power anywhere from 40 to 190 watts.

4.3 Series-Parallel Connection

Two 50W PV panels are linked in series, and two more are connected in parallel, as illustrated in Fig. 4(c), which depicts a mixed series-parallel connection of photovoltaic modules. The linked PV panels reach a voltage of (21.4×2) V and current of (3.11×2) A which climb up the system current and the system voltage concurrently. The series-parallel linked PV channels are tested under varied irradiances at different times of day spanning from 8.00am to 4.00pm. The IV and PV characteristics of Series-Parallel linked solar panels at various irradiances are depicted in Fig.5 (a) and (b), respectively. It can be shown in Fig. 5 (b) that PV panels generate 189.04W of power when exposed to 920W/m2 of irradiance, 147.30W of power when exposed to 730W/m^2, 102.11W of power when exposed to 520W/m^2, 56.28W of power when exposed to 300W/m^2, and 40.19W of power when exposed to 220W/m^2. It's important to note that the solar cells are linked in series in some areas and in parallel in others, even if the power estimates are essentially same across modules. Identifying which sections of the solar cells are in series and which are in parallel, and then selecting applying series rules, parallel rules, and mixed series-parallel rules as necessary, is not possible with a single set of rules. Here the short circuit current I_{SC} rise from 0.6A to 3.5A as irradiance varies from 200W/m^2 to 1000 W/m^2. The value of open circuit voltage fluctuates owing to change in irradiance as temperature relies on irradiance. We can acquire the power 30W to 200W.

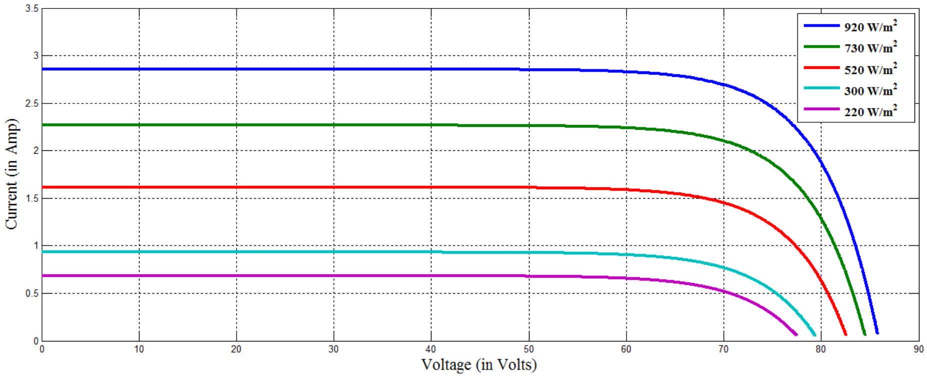

Figure 4: (a) IV Characteristics of Series Connection under Different Irradiance

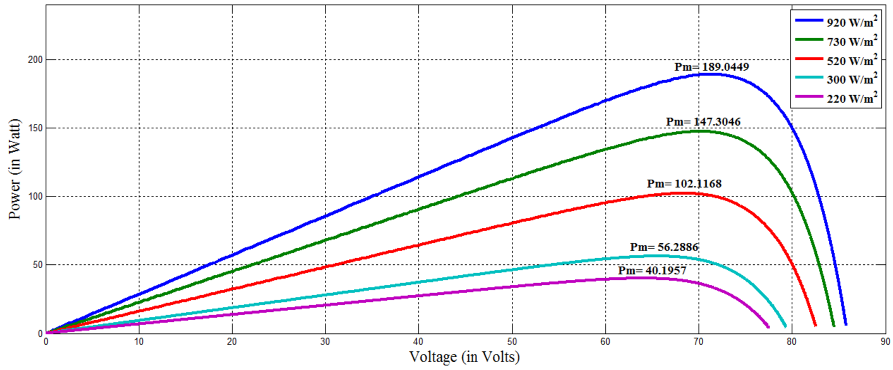

Figure 4: (b) PV Characteristics of Series Connection under Different Irradiance

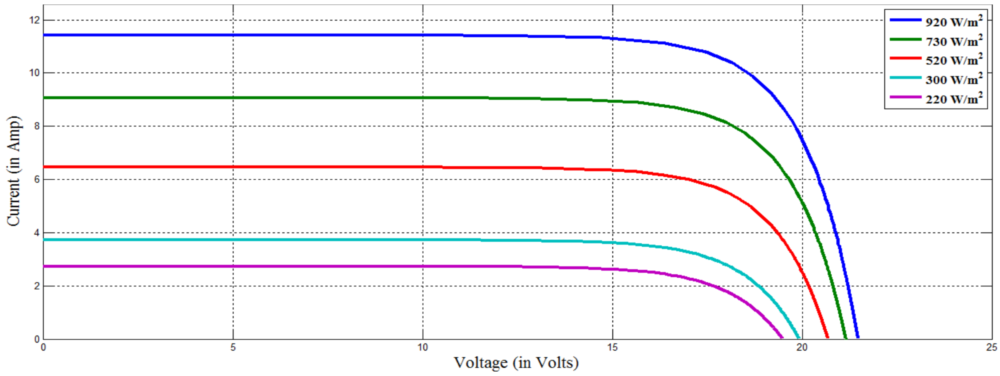

Figure 5: (a) IV Characteristics of Parallel Connection under Different Irradiance

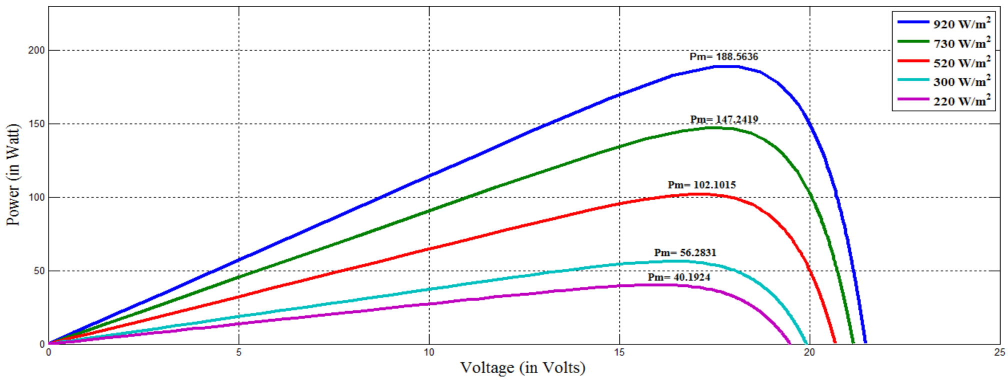

Figure 5: (b) PV Characteristics of Parallel Connection under Different Irradiance

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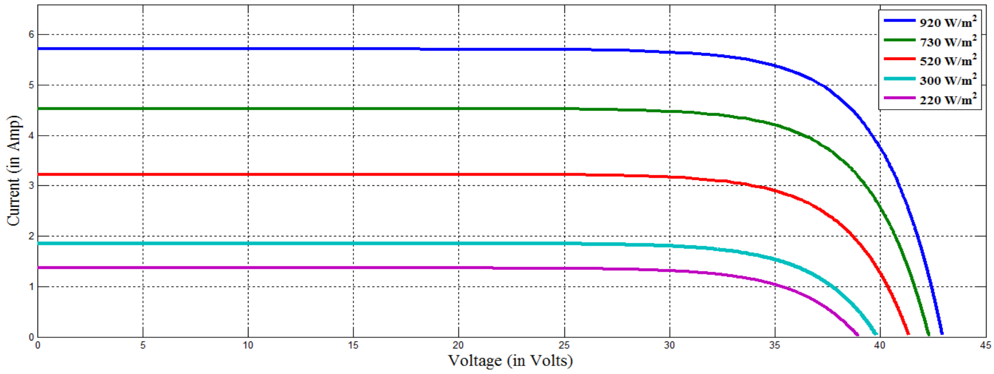

Figure 6: (a) IV Characteristics of Series-Parallel Connection under Different Irradiance

The IV and PV characteristics of a series-parallel connection are depicted in Fig. 6(a) and (b), respectively, at varying levels of illumination. Here, when G increases from 200 W/m^2 to 920 W/m^2, I_{SC} rises from 1.2 A to 6.2 A. Power increases to 200 W with increasing G value (P=30W at 39V, rising to 44V). Voltage fluctuates from 39V to 44V. The load power demanded is more than the maximum power recovered by MPPT from energy harvesting equipment.

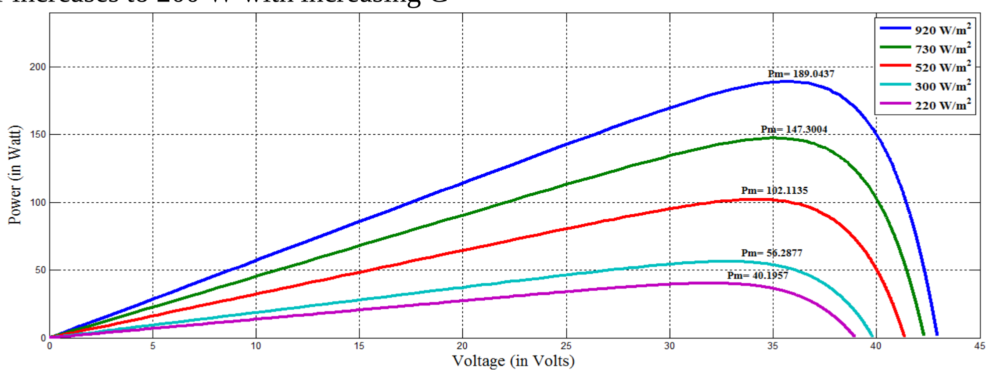

Figure 6: (b) PV Characteristics of Series-Parallel Connection under Different Irradiance

The collected power is utilized at the transceivers by drawing power from the battery. As the G value increases, the battery power diminishes until the gadgets reach their maximum power. At night, when the sun goes down, the load is transferred to the batteries, and the electricity is used nonstop. Maximum power is attained for each irradiance level, however the maximum power at G = 920 W/m^{2}is the highest of all.

5. CONCLUSION

As a result, the ambient energy harvesting and various routing protocols designed particularly for EH-WSNs are the primary topics covered in this thesis. The extension of the battery life of a wireless sensor network is the primary focus of a number of different networking protocols. However, energy can be replenished in EH-WSNs; the prior protocols would perform badly in EH-WSNs since throughput is lowered to preserve energy. In EH-WSNs, energy cannot be restored. We build routing protocols with the goal of maximizing throughput while minimizing energy consumption, and we do this by taking into consideration an important distinction in the way energy is modeled. The following outline presents this thesis with the aforementioned structure in place. First, we will

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discuss the idea of wireless sensor networks, as well as the various routing protocols and how they are categorized.

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