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# 12.0 WIRELESS POWER TRANSMISSION

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## 12.0 WIRELESS POWER TRANSMISSION



### 12.1 Will wireless power transmission for energy distribution play a role in power management and microgrid evolution

#### ChatGPT Response

Wireless power transmission for energy distribution has the potential to play a significant role in power management and the evolution of microgrids. While the concept of wireless power transmission has been explored for many years, recent advancements and emerging technologies are bringing it closer to practical application. Here's how it can impact power management and microgrids:

- a) **Improved Flexibility and Resilience:** Wireless power transmission can enhance the flexibility and resilience of power management systems, particularly in microgrids. It allows for the efficient transfer of energy without the need for physical connections, enabling dynamic power routing and reconfiguration of energy flows. This flexibility enhances the adaptability and reliability of microgrids, especially in situations where physical infrastructure is challenging or expensive to deploy.
- b) **Remote and Inaccessible Areas:** Wireless power transmission can be particularly useful in remote or inaccessible areas where traditional power infrastructure is limited or non-existent. It can enable the delivery of electricity to these regions without the need for extensive cabling, making it cost-effective and easier to implement. This can help address energy poverty and provide sustainable power solutions in underserved areas.
- c) **Integration with Renewable Energy Sources:** Wireless power transmission can facilitate the integration of renewable energy sources into microgrids more effectively. It can enable the transfer of energy from renewable generation sites, such as solar or wind farms, to nearby consumption centers without the limitations of physical transmission lines. This flexibility enhances the scalability and efficiency of renewable energy systems, promoting their widespread adoption and reducing reliance on fossil fuels.
- d) **Electric Vehicle Charging:** Wireless power transmission can revolutionize electric vehicle (EV) charging infrastructure. It offers the potential for wireless charging pads embedded in roads or parking spaces, allowing EVs to charge while stationary or even in motion. This technology eliminates the need for physical charging cables and enables seamless and convenient charging experiences, expanding the accessibility and adoption of electric vehicles.
- e) **Reduced Infrastructure Costs:** Wireless power transmission has the potential to reduce infrastructure costs associated with power distribution. It eliminates the need for extensive cabling, reduces maintenance requirements, and simplifies installation processes. This can result in cost savings for power management systems, especially in scenarios where traditional infrastructure is prohibitively expensive or impractical.

However, it's important to note that wireless power transmission for energy distribution is still in the early stages of development, and there are technical challenges that need to be addressed, including efficiency, range, and safety concerns. Ongoing research and development efforts are focused on overcoming these challenges and making wireless power transmission a viable and widespread solution for power management and microgrids.

## 12.2 Is it possible for a rooftop rectenna to convert laser or microwave beams from a LEO satellite into electricity for household use

### ChatGPT Response

It is theoretically possible for a rooftop rectenna to convert laser or microwave beams from a LEO satellite into electricity for household use. This concept is known as wireless power transmission or power beaming.

The basic principle behind wireless power transmission is that energy can be transferred wirelessly over a distance by using electromagnetic waves such as microwaves or lasers. The rooftop rectenna would receive the microwave or laser beam and convert it into electrical energy using the rectifying diode. This electricity could then be used to power household appliances.

However, there are several practical challenges to overcome before this technology becomes a viable option for household energy use. One major challenge is the efficiency of power beaming systems, which is currently much lower than traditional wired systems. Another challenge is the safety concerns associated with the high-power microwaves or lasers that would be used in such a system.

Furthermore, the cost of launching and maintaining LEO satellites capable of transmitting power to Earth is currently very high. Therefore, while the idea of using wireless power transmission to power households is an intriguing concept, it is not yet a practical solution for meeting our energy needs.

## 12.3 Is there a separate device that can take an electric current produced from a rectenna and generate an electric output sufficient for household consumption

### ChatGPT Response

Yes, a separate device known as an inverter is commonly used to convert the direct current (DC) produced by a rectenna into alternating current (AC) suitable for household consumption. The rectenna, which converts microwave energy into DC electricity, is typically followed by an inverter to convert that DC power into AC power.

An inverter is an electronic device that converts DC electricity to AC electricity with the appropriate voltage, frequency, and waveform. In the context of household consumption, the AC output is usually standardized to match the local power grid requirements. Inverters are available in various sizes and power capacities to meet different energy needs.

The inverter serves as a crucial component in a renewable energy system, such as a rectenna-based microwave power transmission system. It ensures that the electricity generated by the rectenna can be efficiently utilized within a household or fed back into the grid, depending on the specific setup and requirements.

In addition to converting the power from DC to AC, inverters often provide other functionalities, such as monitoring the system's performance, managing power flow, and providing safety features like overvoltage and overcurrent protection.

It's important to note that the overall design and implementation of a rectenna-based system, including the choice of inverter, will depend on various factors, including the power requirements, system efficiency, grid interconnection regulations, and specific application needs. Professional guidance from renewable energy experts or electrical engineers is recommended for the design, installation, and integration of such systems.

## 12.4 Rather than using fuel to power an electricity off-grid generator can output from an inverter be used and integrated into the design

### ChatGPT Response

Yes, it is possible to integrate the output from an inverter into the design of an off-grid electricity system as an alternative to using fuel-powered generators. In fact, renewable energy sources like solar panels or wind turbines often serve as the input source for the inverter in such systems.

Here's a general overview of how this integration can work:

- a) **Renewable Energy Generation:** The off-grid system would include a renewable energy source, such as solar panels or wind turbines, to generate electricity. These sources convert sunlight or wind energy into DC electricity.
- b) **Charge Controller and Battery Bank:** The DC electricity generated by the renewable energy source is typically connected to a charge controller, which regulates the charging of a battery bank. The charge controller helps protect the batteries from overcharging or discharging.
- c) **Inverter:** The output from the battery bank, which is stored DC electricity, can be connected to an inverter. The inverter converts the DC power into AC power suitable for household use. It provides a steady and reliable power supply, mimicking the utility grid's frequency, voltage, and waveform.
- d) **Power Distribution:** The AC power generated by the inverter can be distributed to the electrical loads in the off-grid system, including household appliances and lighting. It can power a wide range of devices that operate on AC power.

By integrating renewable energy sources and an inverter, the off-grid system can rely on clean and sustainable energy to meet the electricity needs. The battery bank helps store excess energy generated by the renewable source, allowing for power availability even during periods of low renewable energy production (such as at night or during calm weather conditions).

It's important to properly size the renewable energy generation capacity, battery bank capacity, and inverter capacity to match the anticipated electricity demand. Professional consultation and system design based on specific requirements are recommended to ensure efficient and reliable operation of the integrated off-grid electricity system.

## 12.4 Why can't satellites be used as the relay stations to receive a power beam from the transmitter and retransmit it towards the intended receiver that may be a rooftop rectenna

### ChatGPT Response

Satellites can indeed be used as relay stations for wireless power transmission in certain scenarios. However, there are several challenges and limitations associated with using satellites as relay stations:

- a) **Distance and Orbit:** Satellites operate at high altitudes, typically in geostationary or low Earth orbits. The distance between the transmitter and the satellite, as well as between the satellite and the receiver, can be significant. This introduces higher power losses and reduces the overall efficiency of the power transmission system.

- b) **Atmospheric Attenuation:** The atmosphere can cause attenuation of the power beam as it travels from the transmitter to the satellite and then to the receiver. Various factors such as scattering, absorption, and beam spreading can result in power losses during the transmission process.
- c) **Complex Infrastructure:** Deploying a satellite-based power transmission system requires a complex infrastructure involving the launch and maintenance of satellites, ground control stations, and the establishment of communication links between them. This infrastructure can be costly and logistically challenging to maintain.
- d) **Latency:** Satellites introduce a certain amount of latency in the power transmission process due to the signal travel time between the transmitter, satellite, and receiver. This latency can affect real-time applications that require immediate power delivery, such as some industrial processes or high-speed charging requirements.
- e) **Reliability and Maintenance:** Satellites are subject to potential failures, malfunctions, and limited lifespans. Ensuring the reliability and continuous operation of satellite-based power transmission systems requires robust maintenance and backup plans. Additionally, servicing or replacing satellites can be costly and time-consuming.

Despite these challenges, satellite-based power transmission has been explored for specific applications, such as providing power to remote or inaccessible regions. Ongoing research and advancements in satellite technology may address some of these limitations in the future, making satellite-based power relay systems more practical and efficient.

## 12.5 Will satellite data play a role in emerging technology for the business community

### ChatGPT Response

Yes, satellite data is expected to play a significant role in emerging technologies for the business community. Satellites provide a wealth of valuable data and offer several applications that can benefit businesses in various sectors. Here are a few ways satellite data can contribute to emerging technologies:

- a) **Earth Observation and Remote Sensing:** Satellites equipped with sensors capture high-resolution imagery and data about the Earth's surface, atmosphere, and oceans. This data can be used for applications such as environmental monitoring, agriculture, urban planning, disaster management, and natural resource exploration. It enables businesses to make informed decisions based on real-time or historical data, improving efficiency and sustainability.
- b) **Location-based Services:** Satellites, particularly those used in global navigation satellite systems like GPS (Global Positioning System) and GNSS (Global Navigation Satellite System), provide precise positioning and timing information. Location-based services powered by satellite data offer opportunities for businesses to deliver personalized experiences, optimize logistics and supply chains, enable asset tracking, and enhance transportation and navigation systems.
- c) **Communication Infrastructure:** Satellites play a crucial role in providing global connectivity. They facilitate communication and data transfer in areas with limited or no terrestrial infrastructure, enabling businesses to operate in remote locations or reach underserved markets. Satellites are especially important for industries such as maritime, aviation, and telecommunications.
- d) **Climate Monitoring and Weather Forecasting:** Satellites contribute to climate monitoring and weather forecasting systems, providing critical data on weather patterns, climate change, and natural disasters. This information helps businesses mitigate risks, optimize operations, and plan for weather-related events, such as supply chain disruptions, resource allocation, and disaster response.
- e) **Internet Connectivity:** Satellite-based internet services, such as satellite broadband and low Earth orbit (LEO) constellations, aim to bridge the digital divide and provide internet access to underserved areas. These technologies have the potential to unlock new business opportunities,



support e-commerce, enable remote work, and foster digital inclusion in regions where traditional infrastructure is limited.

- f) **Environmental and Infrastructure Monitoring:** Satellites can monitor infrastructure systems, including pipelines, power grids, and transportation networks, for early detection of issues, maintenance planning, and asset management. They can also monitor environmental parameters, such as air quality, water resources, and deforestation, supporting sustainable practices and compliance with regulations.

As the capabilities of satellites and the accessibility of satellite data improve, businesses can leverage this information to gain insights, optimize processes, and drive innovation across multiple industries. Integrating satellite data with emerging technologies like AI, IoT, and data analytics can unlock new possibilities for businesses and contribute to their success in a rapidly evolving digital landscape.

## 12.6 Can laser or microwave transmission for wireless power transmission to remote areas be achieved without line of sight

### ChatGPT Response

Wireless power transmission using laser or microwave transmission typically requires a line of sight between the transmitter and the receiver for optimal efficiency and effectiveness. However, there are some techniques and technologies that can mitigate the line-of-sight requirement to a certain extent. Here are a few approaches:

- a) **Beam Steering:** By using advanced beam steering techniques, it is possible to direct the laser or microwave beam towards the receiver even if there is no direct line of sight. This can be achieved through the use of phased array antennas or mirrors that can adjust the beam direction. While this approach allows for some degree of non-line-of-sight operation, it may still be subject to limitations imposed by obstacles or atmospheric conditions.
- b) **Reflection and Diffraction:** In certain scenarios, it is possible to achieve power transmission by utilizing reflection or diffraction of the laser or microwave beam. By bouncing the beam off reflective surfaces or leveraging the phenomenon of diffraction around obstacles, power can be transmitted indirectly to a remote area without direct line of sight. However, this approach may result in power losses and reduced efficiency.
- c) **Relay Stations:** In some cases, relay stations can be strategically placed between the transmitter and the remote area to facilitate power transmission. These relay stations receive the power beam from the transmitter and retransmit it towards the intended receiver, potentially bypassing obstacles and achieving non-line-of-sight power transmission. However, the use of relay stations adds complexity and additional power losses to the system.

It's important to note that achieving efficient and reliable non-line-of-sight power transmission using laser or microwave technologies is still an active area of research and development. Various factors such as distance, power levels, environmental conditions, and specific application requirements will influence the feasibility and effectiveness of non-line-of-sight wireless power transmission.

## 12.7 Can low flying stationary drones be used as relay stations to transmit microwave and laser beams originating from earth stations to remote locations

### ChatGPT Response

Yes, low-flying stationary drones can be potentially used as relay stations to transmit microwave and laser beams from Earth stations to remote locations. Using drones as relay stations offers some advantages and potential solutions to overcome line-of-sight limitations. Here are some key points to consider:

- a) **Flexibility and Mobility:** Drones can be deployed to hover at specific locations, allowing for flexibility in positioning them as relay stations. They can be adjusted to achieve better line-of-sight alignment between the transmitter and receiver, helping to overcome obstacles that might obstruct the direct path.
- b) **Non-Line-of-Sight Transmission:** Drones have the ability to maneuver and position themselves in locations that are not directly visible from the transmitter or receiver. By acting as intermediate relays, drones can establish a communication link and enable power transmission even in non-line-of-sight scenarios.
- c) **Dynamic Relay Network:** Drones can be deployed in a coordinated network to form a dynamic relay system. They can pass the power beam from one drone to another until it reaches the intended remote location, effectively bridging the gaps and extending the transmission range.
- d) **Lower Altitude and Reduced Atmospheric Attenuation:** By operating at lower altitudes compared to satellites, drones experience less atmospheric attenuation and power loss during the transmission. This can help to improve the overall efficiency of the power transmission system.

## 12.8 Can microwave transmission from satellites reduce loss of power to earth

### ChatGPT Response

Microwave transmission from satellites can potentially reduce the loss of power during energy transmission from space-based solar power systems to Earth. This is because microwaves are a form of electromagnetic radiation that can be transmitted through the atmosphere without being significantly absorbed or scattered, unlike other forms of electromagnetic radiation such as visible light.

However, there are several technical and practical challenges that must be addressed before microwave transmission from satellites can become a viable means of delivering power to Earth. These include issues related to the efficiency of energy conversion, the design and operation of the microwave transmitter and receiver systems, and the potential for interference with other microwave-based systems such as telecommunications and weather monitoring.

Additionally, there are also concerns related to the potential health effects of exposure to microwave radiation, particularly at high levels. Therefore, it is important that any use of microwave transmission from satellites for power delivery is subject to careful research and regulation to ensure safety and efficacy.

## 12.9 Can microwaves be transmitted to LEO Satellites and reflected back again without losing too much power

### ChatGPT Response

Yes, it is possible to transmit microwaves from Earth to Low Earth Orbit (LEO) satellites and reflect them back to Earth again with minimal power loss, but it requires careful design and engineering of the microwave transmission and reception systems.

One approach to achieve this is through the use of phased array antennas, which are arrays of small antennas that can be controlled electronically to direct the microwave beam in a specific direction. This allows for precise aiming of the microwave beam towards the LEO satellite and then back to Earth again, reducing the amount of power loss due to scattering or absorption by the atmosphere.

Another factor to consider is the frequency of the microwaves used for transmission. Higher frequencies are more prone to atmospheric absorption, so using lower frequencies may help to minimize power loss during transmission. However, this approach may also require larger antennas to maintain the necessary signal strength.

Overall, transmitting microwaves to LEO satellites and reflecting them back to Earth is feasible but requires careful consideration of factors such as antenna design, frequency selection, and atmospheric conditions to minimize power loss and maximize efficiency.

## 12.10 Can wireless power transmission be achieved by any other means than satellite transmission

### ChatGPT Response

Yes, wireless power transmission can be achieved through various means other than satellite transmission. Here are a few alternative methods:

- a) **Inductive Power Transfer (IPT):** This method uses electromagnetic fields to transfer power between two coils—an emitter and a receiver—placed in close proximity to each other. IPT is commonly used in wireless charging pads for devices like smartphones and electric toothbrushes.
- b) **Resonant Inductive Coupling (RIC):** RIC is a variation of inductive power transfer that utilizes resonant circuits to increase the efficiency and range of power transfer. It allows for greater distances between the transmitter and receiver coils. RIC is employed in applications such as wireless charging for electric vehicles.
- c) **Magnetic Resonance Coupling (MRC):** MRC is similar to RIC but operates on the principle of magnetic resonance. It enables efficient power transfer over larger distances and through obstacles. MRC has been proposed for applications like wireless charging of laptops and other portable devices.
- d) **Microwave Power Transmission (MPT):** MPT involves the use of microwaves to transmit power wirelessly. A microwave transmitter sends focused beams of microwaves to a receiver, which converts them back into electricity. MPT has been explored for long-distance power transmission, such as transmitting power from a power plant to remote locations.
- e) **Laser Power Transmission:** This method uses laser beams to transmit power wirelessly. The laser beam is directed towards a photovoltaic cell or other energy conversion device at the receiver end, which converts the light into electricity. Laser power transmission has been researched for applications like solar power satellites.

It's important to note that while these methods offer different advantages and applications, each has its own limitations and challenges, such as efficiency, safety, and alignment requirements. The choice of wireless power transmission method depends on factors such as the desired distance, power requirements, and specific application needs.

## 12.11 How can the strength of a microwave transmitted from a satellite to a rectenna be enhanced to provide enough power for a household

### ChatGPT Response

To enhance the strength of a microwave signal transmitted from a satellite to a rectenna (rectifying antenna) and provide enough power for a household, several techniques can be employed. Here are a few methods commonly used:

- a) **Higher-Gain Antennas:** Using high-gain antennas on both the satellite and the rectenna can improve the signal strength. High-gain antennas have a narrower beamwidth, allowing for more focused and concentrated transmission of the microwave signal.
- b) **Increased Transmitter Power:** Increasing the power of the satellite transmitter can boost the strength of the microwave signal. This requires careful consideration of regulatory and safety aspects to ensure compliance with relevant standards.
- c) **Frequency Selection:** The choice of frequency for microwave transmission can influence the signal strength and propagation characteristics. Selecting frequencies with lower atmospheric absorption and better penetration can help maintain signal strength over longer distances.

- d) **Beamforming and Tracking:** Utilizing advanced beamforming techniques can optimize the direction and shape of the transmitted beam. By dynamically adjusting the antenna configuration and tracking the rectenna's location, the signal strength can be maximized.
- e) **Signal Processing and Error Correction:** Employing advanced signal processing techniques, such as error correction coding, can improve the signal quality and reduce the impact of noise, interference, and atmospheric effects on the received microwave signal.
- f) **Adaptive Modulation and Coding:** Implementing adaptive modulation and coding schemes allows for the adjustment of transmission parameters based on the link quality. By dynamically adapting the modulation scheme and coding rate, the system can maintain optimal performance under varying conditions.

It is important to note that providing enough power for a household through microwave transmission from satellites faces several challenges, such as signal attenuation, atmospheric effects, and regulatory considerations. Additionally, the rectenna design, efficiency, and distance from the satellite play significant roles in achieving the desired power levels.

Overall, a combination of these techniques, along with careful system design and optimization, can contribute to enhancing the strength of microwave signals transmitted from satellites to rectennas for household power applications.

## 12.12 How do I build a super inverter to produce more energy than my home can consume

### ChatGPT Response

Building a super inverter to produce more energy than your home can consume would require a deep understanding of electrical engineering and expertise in power systems. It's important to note that creating an energy system that generates more power than you consume may have legal and safety implications, as well as potential issues with the grid. However, if you're interested in learning about advanced inverter technologies and maximizing the energy production of your system, I can provide you with some general information.

- a) **Assess your energy consumption:** Start by evaluating your home's energy needs and patterns. Determine your average energy consumption over a specific period, such as a year or a month. This information will help you understand the scale of energy production required.
- b) **Install renewable energy sources:** Integrate renewable energy sources such as solar panels, wind turbines, or micro-hydro systems. These sources can generate electricity that can potentially exceed your home's consumption.
- c) **Implement maximum power point tracking (MPPT):** MPPT is a technique used to optimize the power output of renewable energy sources. It ensures that the panels or turbines operate at their maximum efficiency, extracting the most energy possible.
- d) **Use high-efficiency components:** Select inverters and other electrical components with high efficiency ratings. Look for products that offer high conversion efficiency to minimize energy losses during the conversion process.
- e) **Consider energy storage:** To utilize excess energy efficiently, you can incorporate energy storage systems such as batteries. This allows you to store surplus energy for later use, especially during periods of low renewable energy production.
- f) **Grid-tie with net metering:** Connect your energy system to the grid and employ a net metering arrangement if available in your area. Net metering allows you to sell excess energy back to the grid, effectively offsetting your consumption during times when your renewable sources are not producing enough energy.

- g) **Energy management and optimization:** Implement an energy management system to monitor and optimize energy production and consumption. Smart energy management systems can help you make informed decisions about when to use or store excess energy, maximizing its utilization.

It's crucial to consult with professionals or experts in the field to ensure that your energy system complies with local regulations, safety standards, and grid interconnection requirements. They can provide specific guidance tailored to your needs and ensure your project is safe and legal.