1. If 0 dBm is equal to 1 mW (10-3 W) over a 50Ω load; express 10W in units of dBm.

**Conversion of 10W to dBm**

To convert 10W to dBm, we use the formula: PdBm​ = 10log10 ​(P / 1mW​)

where:

* P is the power in watts (W),
* 1mW = 10-3 W

**Calculation:**

Substituting P = 10W:

PdBm = 10log10 ​(10 / 10-3​)

PdBm = 10log10 ​(104​)

PdBm = 10 \* 4 = 40 dBm

Thus, **10W is equivalent to 40 dBm**.

1. In simulcasting paging systems, there usually is one dominant signal arriving at the paging receiver. In most, but not all cases, the dominant signal arrives from the transmitter closest to the paging receiver. Explain how the FM capture effect could help reception of the paging receiver. Could the FM capture effect help cellular radio systems? Explain how

**FM Capture Effect and Its Role in Simulcasting Paging Systems**

The **FM capture effect** refers to the phenomenon where an FM receiver, when presented with multiple signals on the same frequency, tends to lock onto the strongest signal while ignoring the weaker ones. This is significant in **simulcasting paging systems**, where multiple transmitters broadcast the same signal across a region.

**How FM Capture Effect Helps Paging Receiver Reception**

In a **simulcasting paging system**, multiple transmitters send out the same paging message simultaneously. Since the signals may arrive at different times due to varying distances, they can interfere with one another. However, the FM capture effect helps in these scenarios by ensuring that the paging receiver predominantly locks onto the strongest signal, typically from the **nearest transmitter**. This minimizes issues like **multipath interference and phase distortion**, leading to clearer and more reliable reception.

However, in some cases, the strongest signal may not always come from the nearest transmitter. Factors such as terrain, building obstructions, and atmospheric conditions can cause distant signals to be stronger at certain locations.

**Application of FM Capture Effect in Cellular Radio Systems**

Cellular radio systems differ from simulcasting paging systems in that each cell tower operates on different frequencies to avoid interference. However, in some situations—such as frequency reuse within distant cells or when signals from multiple base stations overlap—the FM capture effect can be beneficial.

1. **Handover Between Base Stations:**
   * When a mobile device moves between cells, it may receive signals from multiple towers on the same frequency (especially in high-frequency reuse designs). The FM capture effect allows the receiver to lock onto the **strongest** base station signal, ensuring smooth communication.
2. **Interference Mitigation:**
   * In frequency-reused cellular networks, some interference may occur between distant cells using the same frequency. The FM capture effect helps a receiver prioritize the strongest tower, reducing disruptive co-channel interference.
3. **Limitations in Cellular Networks:**
   * Unlike simulcasting paging systems, where all transmitters broadcast the same message, cellular networks operate with different frequencies across cells. Modern cellular technologies rely more on digital error correction and handoff mechanisms rather than FM capture.
   * In digital cellular systems (like LTE and 5G), signal processing techniques such as **soft handovers, beamforming, and MIMO** are used to enhance signal quality, making the FM capture effect less relevant than in analog FM systems.

The **FM capture effect is highly beneficial for simulcasting paging systems** because it ensures the paging receiver locks onto the strongest transmitter, reducing interference. While it **can help in analog cellular systems**, modern digital cellular networks rely more on advanced handoff and interference mitigation techniques rather than FM capture.

1. Assume a I Amp-hour battery is used on a cellular telephone (often called a cellular subscriber unit). Also assume that the cellular telephone draws 35 mAin idle mode and 250 mA during a call. How long would the phone work (i.e., what is the battery life) if the user leaves the phone on continually and has one 3-minute call every day? Every 6 hours? Every hour? What is the maximum talk time available on the cellular phone in this example?

**Given Data:**

* Battery capacity: **1 Amp-hour (Ah) = 1000 mAh**
* Idle mode current draw: **35 mA**
* Call mode current draw: **250 mA**
* Call duration:
  + **3 minutes per call**
  + Convert to hours: **3 min = 3/60 = 0.05 hours**
    1. Continuous Standby Mode (No Calls)

If the phone is on but no calls are made, the current consumption is **35 mA**.

Battery Life = Battery Capacity/current consumption = 1000 mAh / 35 mA

So, in pure standby mode, the phone would last **~28.6 hours** before the battery is depleted.

* + 1. One 3-Minute Call Per Day

Each day consists of:

* **Idle time**: 24−0.05= 23.95 hours
* **Current consumed in idle mode**: 23.95×35 = 838.25 mAh
* **Current consumed during the call**: 0.05×250 = 12.5 mAh
* **Total daily consumption**: 838.25+12.5 = 850.75 mAh

Battery life = 1000 mAh/850.75 ~= 1.18 days.

So, the phone would last **~1.18 days** before needing a recharge.

* + 1. One 3-Minute Call Every 6 Hours

Each **6-hour period** consists of:

* **Idle time**: 6−0.05=5.956 - 0.05 = 5.95 hours
* **Current consumed in idle mode**: 5.95×35 = 208.25 mAh
* **Current consumed during a call**: 0.05×250 = 12.5 mAh
* **Total consumption per 6-hour period**: 208.25+12.5= 220.75 mAh
* **Total daily consumption (4 periods per day)**: 4×220.75 = 883 mAh

Battery life = 1000 mAh / 883 ~= 1.13 days

So, the phone would last **~1.13 days** before needing a recharge.

* + 1. One 3-Minute Call Every Hour

Each **1-hour period** consists of:

* **Idle time**: 1−0.05=0.951 - 0.05 = 0.95 hours
* **Current consumed in idle mode**: 0.95×35 = 33.25 mAh
* **Current consumed during a call**: 0.05×250= 12.5 mAh
* **Total consumption per hour**: 33.25+12.5 = 45.75 mAh
* **Total daily consumption (24 periods per day)**: 24×45.75 = 1098 mAh

Battery life = 1000 mAh/1098 ~= 0.91 days

So, the phone would last **~0.91 days** (about 22 hours) before needing a recharge.

* + 1. Maximum Talk Time

To find the **maximum continuous talk time**, assume the phone is in call mode the entire time.

Batter Life = 1000 mAh / 250 mA = 4 hours

So, the phone can sustain **a maximum of 4 hours of continuous talk time** on a full charge.

1. Discuss the similarities and differences between a conventional cellular radio system and a space-based (satellite) cellular radio system. What are the advantages and disadvantages of each system? Which system could support a larger number of users for a given frequency allocation? Why? How would this impact the cost of service for each subscriber?

**Comparison of Conventional Cellular and Satellite Cellular Radio Systems**

Cellular communication can be categorized into **conventional terrestrial cellular networks** and **space-based (satellite) cellular networks**. Both systems provide mobile communication services, but they differ in infrastructure, coverage, capacity, and cost.

**Similarities:**

1. **Basic Functionality:**
   * Both systems provide voice, data, and messaging services to mobile users.
   * Both use radio frequency (RF) communication to transmit signals between user devices and base stations (cell towers or satellites).
2. **Frequency Reuse:**
   * Both employ frequency reuse techniques to maximize spectrum efficiency and reduce interference.
3. **Handoff Mechanism:**
   * In both systems, handoff (handover) occurs when a user moves between different coverage areas to maintain a continuous connection.
4. **Multiple Access Techniques:**
   * Both systems use multiple access technologies such as **FDMA, TDMA, CDMA, and OFDMA** to allow multiple users to share the available frequency spectrum efficiently.

|  |  |  |
| --- | --- | --- |
| Feature | Conventional Cellular System | Space-Based Cellular System |
| Infrastructure | Uses land-based cell towers spaced in a hexagonal pattern. | Uses satellites orbiting the Earth as base stations. |
| Coverage | Limited to terrestrial areas where cell towers exist. | Provides global coverage, including remote areas and oceans. |
| Signal Propagation | Shorter distances (1–50 km per cell). | Long distances (hundreds to thousands of kilometers). |
| Latency | Low latency due to shorter propagation distance. | Higher latency due to longer signal travel time. |
| Capacity | Higher capacity due to small cell size and frequency reuse. | Lower capacity due to larger coverage area per satellite. |
| Power Requirement | Lower power needed due to shorter distances. | Higher power needed for long-range satellite communication. |
| Deployment & Maintenance | Requires extensive ground infrastructure. | Requires expensive satellite launches and maintenance. |
| Cost | Lower operational cost per user. | Higher cost per user due to satellite operations. |

**Advantages and Disadvantages of Each System:**

**1. Conventional Cellular Radio System**

✅ **Advantages:**

* High capacity with smaller cells and better frequency reuse.
* Lower latency and better quality for voice and data services.
* More cost-effective for urban and suburban users.
* Easier to upgrade and maintain.

❌ **Disadvantages:**

* Limited coverage in remote and rural areas.
* Infrastructure-dependent (requires base stations and towers).
* May suffer from network congestion in densely populated areas.

**2. Space-Based Cellular (Satellite) System**

✅ **Advantages:**

* Provides coverage in remote, rural, and oceanic regions.
* Ideal for disaster recovery and military applications.
* No need for extensive ground infrastructure.

❌ **Disadvantages:**

* High latency due to long-distance signal travel.
* Limited capacity because each satellite covers a large area.
* Higher power consumption for both satellites and user devices.
* Expensive to deploy and maintain.

**Which System Can Support More Users for a Given Frequency Allocation?**

**Conventional cellular systems support more users per frequency allocation than satellite systems.** This is because:

1. **Smaller Cell Size:** Terrestrial cellular networks divide coverage areas into smaller cells, enabling more efficient frequency reuse.
2. **Higher Frequency Reuse Factor:** Frequencies can be reused in different cells with minimal interference, increasing overall capacity.
3. **Limited Satellite Frequency Reuse:** In satellite networks, the large coverage footprint means that the same frequencies cannot be reused as efficiently, reducing the number of users that can be supported.

**Impact on Cost of Service for Subscribers:**

* **Conventional Cellular:** Lower cost due to better spectrum efficiency, higher capacity, and cost-sharing among more users.
* **Satellite Cellular:** Higher cost due to expensive satellite deployment, maintenance, and lower user density per satellite.
* **Conventional cellular networks** are best for high-density urban and suburban areas due to their high capacity, lower cost, and lower latency.
* **Satellite cellular systems** are essential for remote areas, disaster response, and global coverage but come with higher costs and lower capacity.
* **For a given frequency allocation, conventional cellular networks can support more users** because of smaller cells and efficient frequency reuse.
* **Satellite communication is more expensive per subscriber** due to high infrastructure and operational costs.