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# comparison between electrical and mechanical antenna tilt angle in sulaymaniya mobile phone base stations

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## ABSTRACT

***The aim of this paper is to evaluate and compare impacts of mechanical and electrical down tilt angles of antenna systems to the downlink performance of the sulaymaniya base station. By depending on same height, in three dimensions. The effect of mechanical and electrical antenna down tilt angles have been studied in terms. Simulation studies are performed for sulaymaniya base station. Using the same height measurement by power meter simulator modeling of electrical and mechanical antenna tilt and propagation in three dimensions. In this paper a comparison made between the mechanical and electrical tilt antenna angle for five different intersite directions by choosing Alinaji, Ashty new , Bakhtiary, Industry, and Shoqakan sites in sulaymaniya base station, using the same height, in three sectors. Simulation results indicate that optimum down tilt angle depends on the network environment also showed that different environments may lead to different optimization results in terms of capacity and coverage performance.***

***Keywords:*** *Electrical Antenna , Tilt angle, Mechanical Antenna , antenna height .*

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# مقارنة بين زاوية الميل الهوائي الميكانيكي والكهربائي في محطات الهواتف النقالة في السليمانية

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## الملخص

**الهدف من هذا البحث هو لتقييم ومقارنة تأثيرات زوايا الميل لأنظمة الهوائيات الميكانيكية والكهربائية لأداء شبكات الاتصال لمحطات االهواتف النقالة في السليمانية . باستخدام الارتفاع نفسه لثلاثة ابعاد. تمت دراسة التأثير الميكانيكي والكهربائي لزوايا الميل للهوائيات. وتمت دراسة ومحاكاة لأداء محطات الهواتف النقالة في السليمانية باستخدام الارتفاع نفسه بقياس زوايا الميل الميكانيكي والكهربائي للهوائي باستخدام جهاز الباور ميتر. وقد تمت مقارنة تأثيرات زوايا الميل لأنظمة الهوائيات الميكانيكية والكهربائية لأداء شبكات الاتصال لمحطات االهواتف النقالة في للشبكات المختارة في السليمانية وهي علي ناجي، اشتي نيو، بختياري، واندستري، شوقةكان. باستخدام الارتفاع نفسة لثلاثة قطاعات. محاكاة النتائج اشارت الى ان زاوية الميل تَعتمدُ على بيئةِ الشبكةَ والبيئاتَ المختلفةَ الذين قد تقود الى نتائج مختلفة من ناحية شروطِ أداءِ التغطيةَ والسعة.**

**الكلمات الدالة:** الهوائي الكهربائي، زاوية ميلِ، الهوائي ميكانيكي، الهوائي ارتفاع.

## 1.INTRODUCTION

Cellular Networks achieve large capacity capabilities by reusing given frequencies repeatedly in a given system. This concept means that the communication paths are interference limited as opposed to traditional radio systems that were noise limited. To minimize interference, the use of sectorized antennas have been employed, each of which provides coverage to a portion of the cell. In a three-sector arrangement, each sector antenna covers a 120-degree pie shape that extends some distance away from the antenna site. Ideally, each sector antenna should only provide coverage in its 120-degree pie shaped sector so that interference with adjacent sectors is minimized[1]. In most cases, carefully optimizing the down tilt angels produces enhanced signal strength levels at the targeted areas, thus reducing the interference levels from other covering cells. However, excessive down tilt angle may lead to dramatic coverage shortages, specifically at the edges of the main loop direction [2].

Electrical down tilt is carried out by adjusting the antenna elements, and hence it slightly changes antenna radiation characteristics when down tilt angle is changed[3]. On the other hand, mechanical down tilt is also needed because electrical tilt range is limited compared to mechanical tilts[5]. Regarding directional antenna note that effective mechanical tilts diminish to zero as thetarget approaches 90 degrees from the antenna azimuth. Effective electrical tilts tend to be similar in all directions, but it would be best to verify this with the manufacturer and also take into account obstruction by the antenna mounting structure[4]. There are commercially available antenna's that can remotely change their down-tilt, azimuth and beam width [8]. Prior work has concluded that mechanical down tilt can increase the capacity of a umts network in 3-sectored sites in uplink and downlink directions [10]-[11].

## 2.MECHANICAL DOWN TILT

Until recently, the accepted method for down tilting an antenna was to mechanically alter its position on the tower. But as shown by the yellow shading in Figure (1), the antenna represents a fixed unit capable of tilting along one plane only. As the front tilts down to lower the gain on the horizon, the back tilts up, changing the frontto-back ratio and increasing inter-sector interference[9]. Utilization of antenna mechanical downtilt has been a tool for radio network

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planners to optimize networks. It has been observed to be an efficient method to reduce other-cell interference in the main-lobe direction [6].

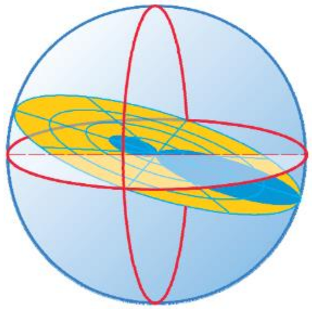

**Figure (1):** Coverage of mechanical down tilt

## 3.ELECTRICAL DOWN TILT

The development of the electrically down tilted antenna gives operators greater control and precision in shaping the antenna's horizontal radiation patterns. Whereas mechanical down tilt alters the antenna's physical position on the tower, electrical down tilt changes the phase delivered to the antenna's radiating elements independently and simultaneously. This allows engineers to manipulate gain in a full 360° around the tower and to the outer perimeter of the site. The visual representation of this coverage resembles a cone as seen in Figure (2) [9]. Electrical down tilt is carried out by adjusting the antenna elements, and hence it slightly changes the antenna radiation characteristics when down tilt angle is changed[3].

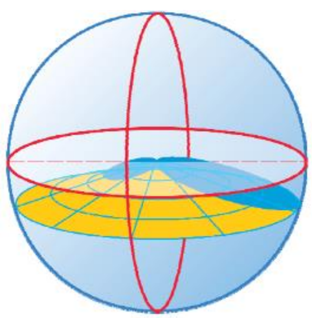

**Figure (2):** Coverage of electrical down tilt

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When mechanically and electrically down tilted antenna patterns are compared side by side, the ability of the electrically down tilted antenna to reduce anomalies such as pattern blooming becomes apparent[9]. The use of electrically down tilted antennas has increased significantly since the technology was first introduced. RF engineers, however, continue to apply the same basic guidelines initially developed to help compensate for the limitations of mechanical down tilt antennas. Additionally, many operators have begun to use mechanical down tilt in tandem with electrical down tilt. While combining the two methods can be effective in very limited applications, data suggests that overall this practice leads to horizontal pattern deformations that can altogether offset the benefits of electrical downtilt. Figure (3) shows the Electrical versus mechanical down tilt angle comparison [9].

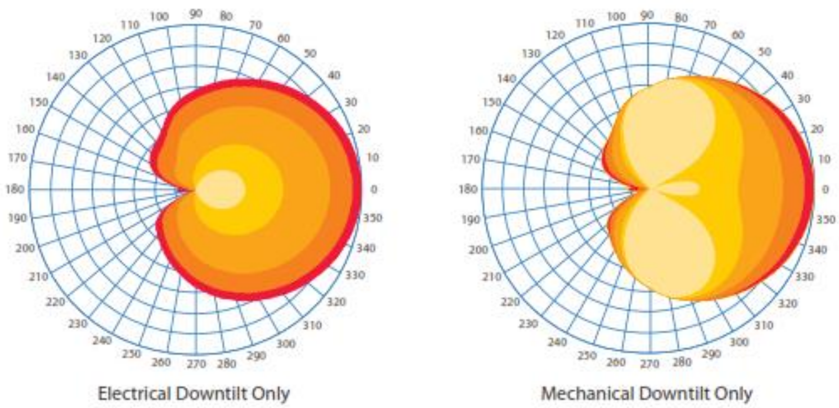


**Figure (3):** Electrical versus mechanical down tilt angle comparison

## 4.SIMULATION EVALUATION METHODOLOGY

Antenna vertical beam width is expected to have a great impact on the down tilt angle. Hence, the optimum mechanical down tilt angle $v_m$ is assumed to be a function of the vertical beamwidth factor and geometrical factor as shown in eq.1[7].

$$v_m = f(\theta_{GEO}, \theta_{VER,BW}) \quad \ldots\ldots\ldots\ldots (1)$$

$\theta_{GEO}$: the angle in geometrical factor

$\theta_{VER,BW}$: the angle in vertical beam width

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The geometrical factor can be calculated using the relation of the height difference between the base station antenna and mobile station antenna , the sector dominance area size as shown in eq.(2). The antenna beam width factor could be easily selected as an angle between upper -3dB position in the antenna radiation pattern and zero direction[7].

$$\theta_{GEO} = \arctan = \left(\frac{h_{BTS} - h_{ms}}{d}\right) \quad \text{.........(2)}$$

Where $h_{BTS}$ the height of the base station is $h_{ms}$ is the height of the receiving antenna$\theta_{GEO}$ is the angle in radian[7]. The d is the distance between and the angle between base station mechanical antenna down tilt and the effective down tilt angle is the same in the horizontal plane only in the main lobe direction. The effective down tilt angle decreases as a function of horizontal angle in such a manner that the antenna radiation pattern is not down tilted from the side lobe direction of an antenna[7].

The angle of the main beam of the antenna below the horizontal plane is called antenna tilt. Positive and negative angles are also referred to as down tilt and up-tilt respectively[2]. In electrical down tilt, main, side and back lobes are tilted uniformly by adjusting phases of antenna elements [3]. However, in mechanical down tilt, antenna main lobe is lowered on one side and the antenna back lobe is raised on the other side because antenna elements are physically directed towards ground in mechanical down tilt [2] as shown in Figure (4) [5].

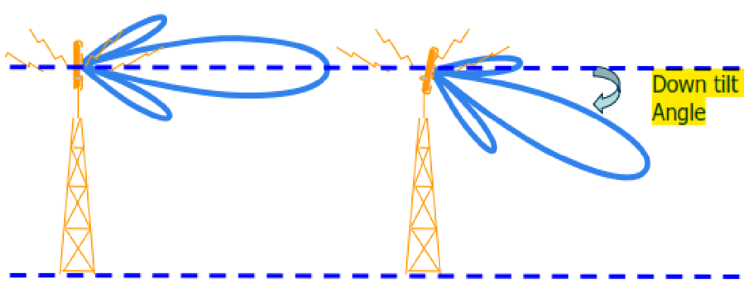


**Figure (4):** Mechanical down tilt versus electrical down tilt

To give an idea, a 30 meters base station antenna height at 3 km distance, requires only 0.35 degree tilt of the antenna to reach a 10 meter receiving antenna. Thus, it is actually fairly

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insignificant tilt. The higher the base station antenna; the shorter the distance more tilt will be required.

## 5.SIMULATION RESULTS

Every site and antenna configuration is simulated with three different directions or sectors to cover complete angle of 360$^o$. The proposed evaluation methodology aims to compare impacts of mechanical and electrical down tilt angles of antenna systems to the downlink performance of the sulaymaniya base station, depending on same height, in three dimensions. The antenna parameters are changed to show a percentage difference between electrical and mechanical antenna tilts and the propagation in three dimensions.Antenna down tilt can be adjusted mechanically and/or electrically increase with respect to other antenna parameter adjustments.

**Table (1):** the Mechanical down tilt, Electrical down tilt at 15 heights of some sites in sulaymaniya

| Site Name | Direction in degree | M down Tilt in degree | E down Tilt in degree | Antenna height |
|---|---|---|---|---|
| **Ashty new** | 70 | 2 | 6 | 15 |
| = | 220 | 0 | 7 | 15 |
| = | 320 | 0 | 7 | 15 |
| **Ali Naji** | 60 | 4 | 3 | 15 |
| = | 220 | 4 | 1 | 15 |
| = | 320 | 3 | 5 | 15 |
| **Salim** | 80 | 0 | 0 | 15 |
| = | 150 | 0 | 6 | 15 |
| = | 310 | 0 | 6 | 15 |
| **Bakhtiary** | 70 | 3 | 6 | 15 |
| = | 160 | 4 | 7 | 15 |
| = | 300 | 3 | 6 | 15 |
| **Industry** | 80 | 0 | 6 | 15 |
| = | 180 | 2 | 7 | 15 |
| = | 300 | 2 | 7 | 15 |
| **Shoqakan** | 60 | 1 | 7 | 15 |
| = | 200 | 1 | 6 | 15 |
| = | 310 | 0 | 7 | 15 |

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Simulations are carried out for five different inter site directions in sulaymania base station by choosing Alinaji, Ashty new , Bakhtiary, Industry, and Shoqakan at the same antenna height , based on measuring mechanical and electrical down tilt angles of antenna simulation assumptions as shown in Table (1). As shown from the Table (1) the measured values for the mechanical and the electrical tilt angle are different from each other for each site from sulaymaniya base station.

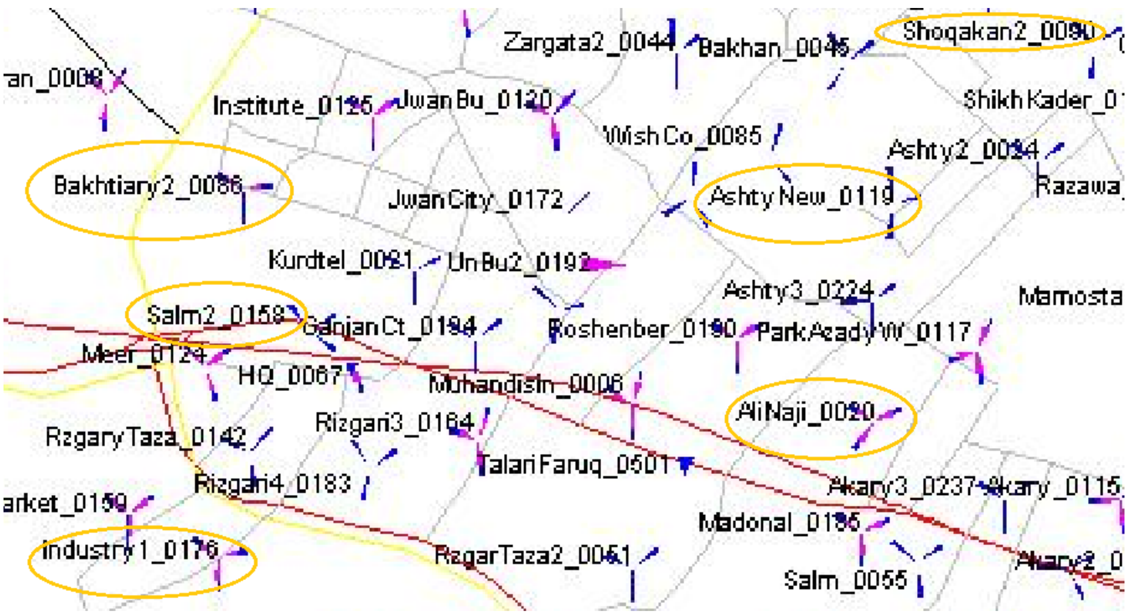
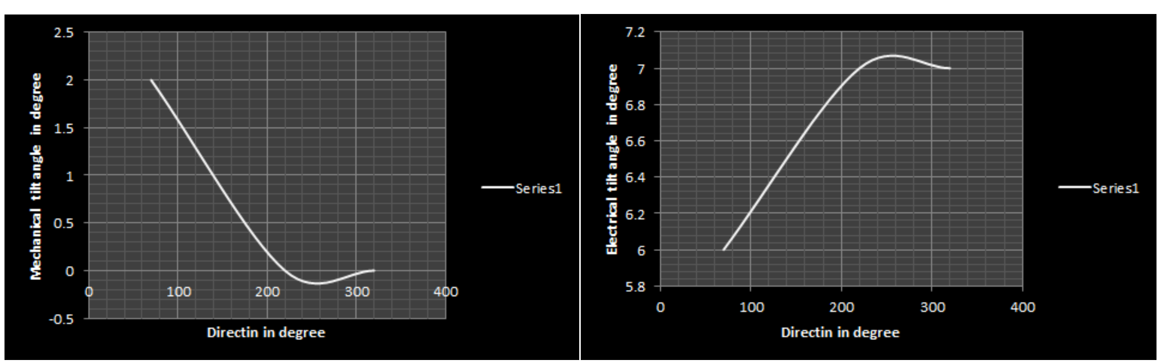



**Figure (5):** Sulymaniya sites for Asia cell base station




**(a)** **(b)**

**Figure (6) (a):** The mechanical tilt angle versus the direction for Ashty new site.

**(b):** The electrical tilt angle versus the direction for Ashty new site.

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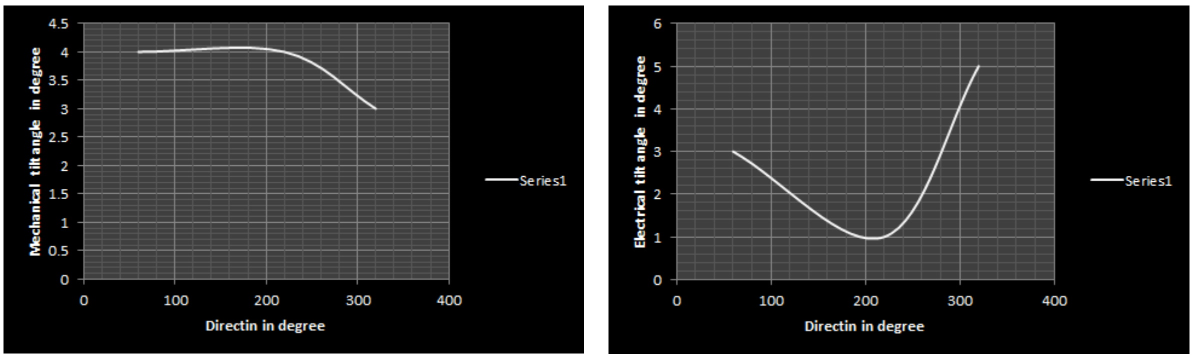
In this Figure (6a) the practical mechanical tilt angle in degree and the direction sites. While the Figure (6b) is the practical electrical tilt angle in degree and the direction in degree. The measured values are in the Table (1) are taken at the same height 15m. They are measured in three sectors covers complete angle of $360^{o}$. Figure (6 a,b) shows the mechanical and electrical for Ashty new site respectively.

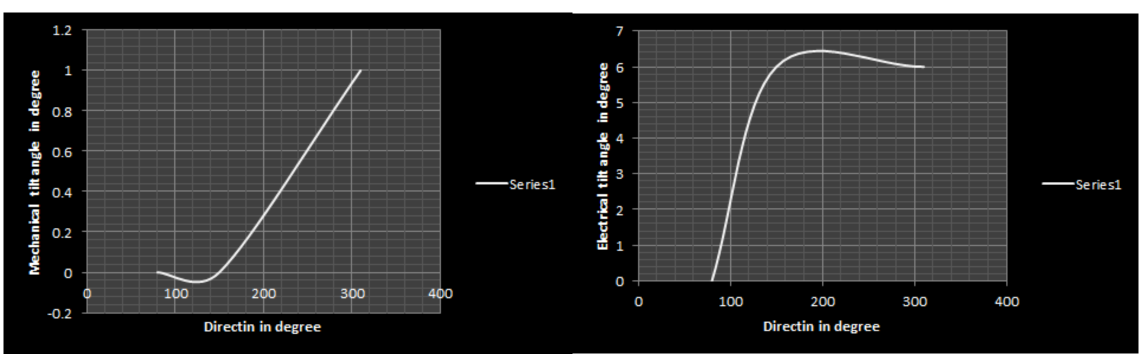



**(a)** **(b)**

**Figure (7) (a):** The mechanical tilt angle versus the direction for Ali Naji site.

**(b):** The electrical tilt angle versus the direction for Ali Naji site.

In this Figure (7a) the practical mechanical tilt angle in degrees and the direction sites. Figure (7b) shows the practical electrical tilt angle and the direction in degrees for Ali Naji site respectively. The measured values are in the Table (1) . are at same height 15m. They are measured in three sectors cover a complete angle of $360^{o}$.




**(a)** **(b)**

**Figure (8) (a):** The mechanical tilt angle versus the direction for Salim site.

**(b):** The electrical tilt angle versus the direction sites for Salim site.

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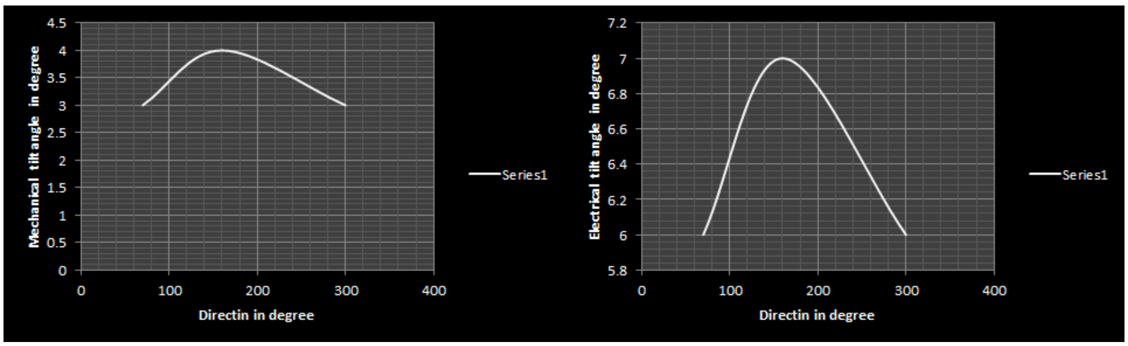
Figure (8a) shows the practical mechanical tilt angle and the direction sites, while Figure (8b) shows the practical electrical tilt angle and the direction for Salim site respectively. The values are in the Table (8), are measured at same height 15m. and in three sectors covers complete angle of 360$^o$.

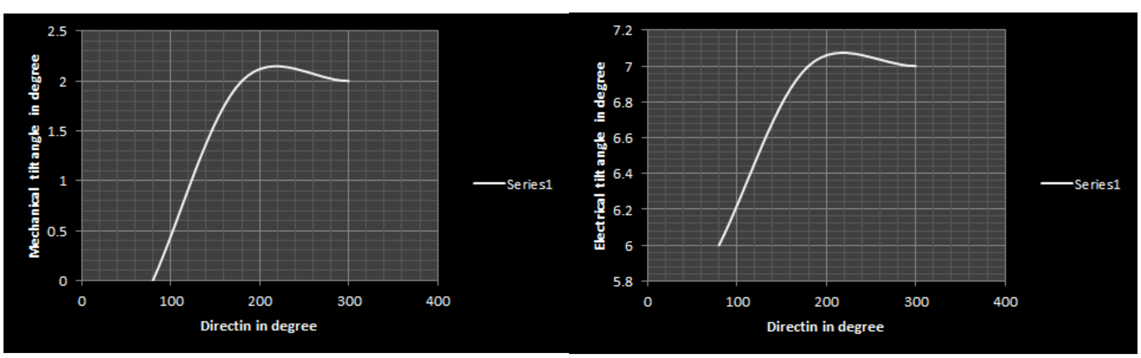



(a) (b)

**Figure (9) (a):** The mechanical tilt angle versus the direction for Bakhtiary site.

**(b):** The electrical tilt angle versus the direction for Bakhtiary site.

Figure (9a) shows the practical mechanical tilt angle and the direction sites, while Figure (9b) shows the practical electrical tilt angle and the direction. The values are in the Table (1) are measured at the same height 15m. They are measured in three sectors covers a complete angle of 360$^o$. As shown in Figure (9 a,b) the mechanical and electrical for Bakhtiary site respectively.




(a) (b)

**Figure (10) (a):** The mechanical tilt angle in degree and the direction sites for Industry site.

**(b):** The electrical tilt angle in degree and the direction sites for Industry site.

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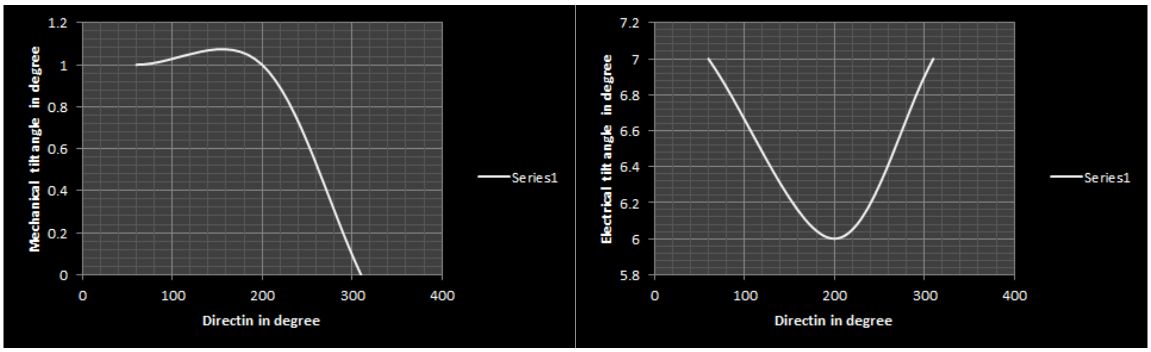
Figure (10a) shows the practical mechanical tilt angle and the direction sites, while Figure (10b) shows the practical electrical tilt angle and the direction. The values are in the Table (1) are measured at the same height 15m. and in three sectors covers complete angle of 360$^{o}$. As shown in Figure (10 a, b) the mechanical and electrical for Industry site respectively.




**(a)** **(b)**

**Figure (11) (a):** The mechanical tilt angle in degree and the direction sites for Shoqakan site.
**(b):** The electrical tilt angle in degree and the direction sites for Shoqakan site.

Figure (11a) shows the practical mechanical tilt angle and the direction sites, while Figure (11b) shows the practical electrical tilt angle and the direction in degrees. The measured values Table (1) are measured at same height 15m. and in three sectors covers a complete angle of 360$^{o}$. As shown in Figure (11 a,b) the mechanical and electrical for Shoqakan site respectively. As shown from the above Figures (6 through 11) there are some difference between mechanical tilt angle and electrical tilt angle, while they are the same in Figure (10) in Industry site. Simulation results indicate that optimum down tilt angle depends on the network environment and that different environments may lead to different optimization results in terms of capacity and coverage performance.

## 6.CONCLUSION

In this paper performance difference electrical and mechanical antenna tilt in sulaymaniya base station, at the same height, in three dimensions was discussed. System performance results in the presence of both mechanical and electrical down tilt were simulated for different down tilt angles. According to the results, electrical down tilt provides better performance in case of interference limited system, while performance difference is insignificant for noise limited cases. Furthermore, optimal down tilt angles in mechanical and electrical tilt techniques are slightly different from each other. Although mechanical antenna down tilt scheme is not considered as the best possible for the down tilt scheme, the simulation results of this paper show the differences between the mechanical and the electrical antenna downtilt. The results emphasize the fact that the down tilting should be used, not only to maximize the network capacity, but also to reduce the amount of other effects like ., pilot pollution.

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