Optimization signal quality on cellular network based on Tilting-Antenna

H Andre¹, M Ghozali¹, Fitrilina², Baharuddin¹, R Fernandez¹, and Asriyadi³

¹Electrical Engineering, Andalas University, Padang, Indonesia
²Electrical Engineering, Bengkulu University, Bengkulu, Indonesia
³Electrical Engineering PoliteknikNegeriSriwijaya,Palembang, Indonesia

Corresponding author: hanalde.andre@eng.unand.ac.id

Abstract. The Difference of Strength and Quality Signal on cellular networks is affected by the traffic on cell and the shape of the region topology. One of the problems encountered in-service performance is overshoot caused by poor signal quality. Overshoot is a condition where a range of power exceeds the specified limits, till the MS (Mobile Station) is served by a distant cell and not from the closest cell. Overshoot occurs due to boosting power which aims to improve service quality when there is an increase in customer activity in the network cell. The antenna tilting method is an effective and responsive method to resolve overshoot problem since it can form cell coverage, cells identification, measure Rx and C/I (Carrier to Interference) levels.). The results showed that after tilting there was a change in cell identification from 5 cells to 3 cells. The value of Rx level increased from -92.8 dBm to -82.03 dBm for the 726-sector and -72.13 dBm to -70.27 dBm for the 727-sector, while the 725-sector remained unchanged. C/I value for <13 dB decreased from 47.20% to 13.68%, for a range of 13 dB values ≤C/I≤ 16 dB decreased from 17.63% to 12.73%, and for> 16 dB increased from 35.17% to 73.59%.

1. Introduction
The Difference of Strength and Quality Signal on cellular networks is affected by traffic on cell and the shape of the region topology. One of the problems encountered in service performance is overshoot caused by poor signal quality such dropping a call, failing to handover, overshoot and missing a neighbor [1–4]. As the number of consumers increases, Maintaining and Improving of Network Services periodically become a necessity. one of network improvement is to control power level increasing which aim to provide good service in extremely dense users region[5,6].

Enhancement of power level needs to be performed carefully otherwise will emerge new problem such overshoot. Overshoot is a condition where a range of power exceeds the specified limits, till the MS (Mobile Station) is served by a distant cell and not from the closest cell. Overshoot can compose the handover range wider, so induce cell resources to run out quickly, handover process fails, blank spot, ping-pong, and high interference to the BTS (Base Transceiver Station) cell[7–9].

Cellular system services can be optimized in various ways to minimize disruption i.e. cell sectoring, setting power levels (adjusting power level), setting base station antenna configuration, and antenna tilt[10–13]. From the above method, the antenna tilt method is an effective and responsive method for building cell coverage, reducing service degradation and interference, and achieving better service quality[14–16].
2. Materials and methods

2.1. Tilting Antenna
The physical tilting value of the antenna in the sector can be modified mechanically, and the effect of mechanical tilt is a change in the overall coverage area. There are two types of tilt in mechanical: such as Down-tilt and Up-tilt as shown in figure 1.

![Mechanical Tilting Antenna](image)

**Figure 1.** Mechanical Tilting Antenna (a) Down Tilt (b) Uptilt

Furthermore, Electrical tilting antenna is employed to alter the transmit power of the antenna by adjusting the electrical parameters of the antenna sector. In contrast to a mechanical tilt, the electric tilting only transforms the size of the main lobe and the phase emitted by the sector antenna. By using RET device, remote electrical tilting can be adjusted easily and quickly if the value changes.

2.2. Power Signal
Power signal in users is mentioned as Rx-level in which Rx-level is the level of signal strength received by MS in units (dBm). The greater its value indicates better quality. Following is the range of Rx-level quality in table 1.

| Quality   | Rx Level (dBm)          |
|-----------|-------------------------|
| Very Good | $< 0 \text{ and } \geq -85$ |
| Good      | $< -85 \text{ and } \geq -95$ |
| Bad       | $< -95 \text{ and } \geq -105$ |
| Very Bad  | $< -105$                |

Stage of the research is carried out by looking at two aspects, i.e. Pre-Optimization and Post-Optimization. In Pre-optimization, events data capture in Base Station is retrieved when overshoot happens by applying drive test. Drive test is an activity to collect signal quality measurement data for a network that aims to improve the quality of a system and develop network capacity. While in post-optimization, data retrieval is gained after antenna tilting adjustment and direction changing of transmit antenna, which aims to see results. Initial condition base station can be seen in table 2. The base station has three sector antenna.
Table 2. Initial Condition Base Station

| Sektor | 725 | 726 | 727 |
|--------|-----|-----|-----|
| Azimuth| 60  | 130 | 245 |
| Mechanical Tilting | 0   | 0   | 2   |
| Electrical Tilting  | 6   | 5   | 5   |
| Height (m) | 40  |     |     |
| Antenna       | Tongyu & S-Wave |     |     |
| Bandwidth     | 1800 Mhz       |     |     |

3. Result and Discussion

Figure 2 shows the results of the driving test of the Rx-level value before optimization. The Rx-level range in figure 2 is following table 1. I.e. blue is for excellent Rx-level quality, and orange is medium Rx-level quality. Percentage of Rx-level for a range of 0 dBm > Rx-level 85 - 85 dBm is 78.87% blue and for a range of -85 dBm > Rx-level ≥ -95 dBm orange. In this case, the Rx-level value does not occur due to overshoot problems, but the C/I value that is generated very bad even though Rx-level is of good value. It has an impact on signal quality even though the receiving power from MS has a good range of overshoot areas.

![Figure 2. Drive Test Cell Rx-level Result Pre-Optimization](image)

After implementing antenna tilting method, the value of Rx-level experiences improvement as shown in figure 3. It can be seen on figure 4 that the blue colour which indicates the range of 0 dBm ≥ Rx-level ≥ -85 dBm obtains excellent percentage namely 95.53%, while Rx-level value in field -85 dBm > Rx-level ≥ -95 dBm or in Orange criteria is 4.47%.
Drive test record shows that the effect of overshoot experience decreasing, can figure out from Average Value of C/I on the BAD PAD072D > 16 dB. However, some areas still gain C/I values below 13 dB and in yellow color criteria.

Previously, C/I generated on nearly 50% of the PAD072D BTS area is in red colour criteria (<13 dB). When post-optimization, 73.59% of the traversed area during the driving test are green colour criteria (> 16 dB), meanwhile the red colour (<13 dB) turn into 13.68%. It can be concluded from figure 4.8 that that antenna tilting method can increase the value of C/I. Drive test record for C/I measurement before and after optimization can be seen in figure 4.
Mechanical and electrical tilting has been applied to the base station. Antenna sector 726 optimization shifted electrical tilting value from 5 to 3. Antenna sector 727 turned mechanical tilting value from 2 to 1 and electrical tilting value from 5 to 3. Optimization condition base station is shown in table 3.

**Table 3. Optimization Condition Base Station**

| Sector | Azimuth | Mechanical Tilting | Electrical Tilting | Height (m) | Antenna | Bandwidth |
|--------|---------|--------------------|--------------------|------------|---------|-----------|
| 725    | 60      | 0                  | 6                  | 40         | Tongyu& S-Wave | 1800 Mhz |
| 726    | 130     | 0                  | 3                  |            |         |           |
| 727    | 245     | 1                  | 3                  |            |         |           |

**4. Conclusion**

Based on the result above, the recommended antenna tilting values on the BTS PAD072D are in sector 725 is 6 °, in sector 726 is 3 °, and in sector 727 is 4 °. By applying the recommended antenna tilting level, C/I parameter on BTS PAD072D, which value about <13 dB decreases from 47.20 % to 13.68 %. The second parameter of C/I, 13 dB ≤ C/I ≤ 16 dB, is also noted reducing from 17.63% to 12.73% and the last parameter of C/I > 16 dB enhances from 35.17% to 73.59%. In addition, there is an increase in Rx-level value in two sectors i.e. from -92.8 dBm to -82.03 dBm in sector 726, from -72.13 dBm to -70.27 dBm in sector 727, while sector 725 stay steady on -84.872 dBm.

**Acknowledgement**

Publication of this article is supported by the Engineering Faculty of Andalas University publication grant contract No. 034/UN.16.09, D/PL/2020
References

[1] Panjaitan M V, Sukiswo S and Zahra A A 2018 Analisis Quality of Service (Qos) Jaringan 4G Dengan Metode Drive Test Pada Kondisi Outdoor Menggunakan Aplikasi G-Nettrack Pro Transient J. Ilm. Tek. Elektro

[2] Putri H and Damayanti T N 2016 Penanganan Block Call Dan Drop Call pada Jari UMTS Berdasarkan Pengukuran Parameter Accessibility, Coverage And Quality J. Elektro dan Telekomun. Terap.

[3] Bikos A N and Sklavos N 2013 LTE/SAE security issues on 4G wireless networks IEEE Secur. Priv.

[4] Baharuddin, Muharam M, Andre H and Angraini R 2019 Performance analysis of error control coding and diversity in image transmission on wireless channels IOP Conference Series: Materials Science and Engineering vol 602

[5] Hamdana E, Pramono S and Dahlan E 2012 Optimasi Perencanaan Jaringan UMTS Pada Node B Menggunakan Probabilistik Monte Carlo J. EECCIS

[6] Partov B, Leith D J and Razavi R 2015 Utility fair optimization of antenna tilt angles in LTE networks IEEE/ACM Trans. Netw.

[7] Mondal R U, Ristaniemi T and Turkka J 2017 Cluster-Based RF Fingerprint Positioning Using LTE and WLAN Signal Strengths Int. J. Wirel. Inf. Networks

[8] Fernandez R, Firdaus and Andre H 2018 Design of wideband quadrature hybrid coupler with tapered lines on the arms Proceedings - 2018 International Conference on Applied Science and Technology, iCAST 2018

[9] Yumin S El and Risviana R 2020 Analisis Mekanisme Rehoming pada BTS Jaringan GSM Sainstech J. Penelit. dan Pengkaj. Sains dan Teknol.

[10] Makkatang A and Nugroho R 2019 Analisa Pengaruh Perubahan Tilt Antena Sektoral BTS Secara Electrical Dan Mechanical Site XL 3G J. Ilm. Giga

[11] Andre H, Fernandez R and Baharuddin 2019 Dipole planar bowtie printed antenna for ism application IOP Conference Series: Materials Science and Engineering vol 602

[12] Surya Winata I G N, Sukadarmika G and Sudiarta P K 2019 Analisis Drop Call Pada Jaringan Wideband Code-Dvision Multiple Access (WCDMA) Di Cluster Renon J. Spektrum

[13] Qadarfi M 2014 Analisis Pengaruh Perubahan Kemiringan Sudut Pancar Antena Sektoral Terhadap Kualitas Layanan Jaringan Sistem Komunikasi Bergerak Seluler Tek. Elektro Univ. Tanjungpura Pontianak

[14] Eckhardt H, Klein S and Gruber M 2011 Vertical antenna tilt optimization for LTE base stations IEEE Vehicular Technology Conference

[15] Fernandez R, Ilham M A, Andre H and Firdaus 2020 A Wideband Rectangular Patch Microstrip Antenna using Quad-Slotted Ground Plane IOP Conference Series: Materials Science and Engineering vol 846

[16] Niemela J, Isotalo T, Borkowski J and Lempiainen J 2005 Sensitivity of optimum downtilt angle for geographical traffic load distribution in WCDMA IEEE Vehicular Technology Conference