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Modeling and performance optimization of automated antenna alignment for telecommunication transceivers

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ABSTRACT

Antenna alignment is very cumbersome in telecommunication industry and it especially affects the MW links due to environmental anomalies or physical degradation over a period of time. While in recent years a more conventional approach of redundancy has been employed but to ensure the LOS link stability, novel automation techniques are needed. The basic principle is to capture the desired Received Signal Level (RSL) by means of an outdoor unit installed on tower top and analyzing the RSL in indoor unit by means of a GUI interface. We have proposed a new smart antenna system where automation is initiated when the transceivers receive low signal strength and report the finding to processing comparator unit. Series architecture is used that include loop antenna, RCX Robonics, LabVIEW interface coupled with a tunable external controller. Denavit–Hartenberg parameters are used in analytical modeling and numerous control techniques have been investigated to overcome imminent overshoot problems for the transport link. With this novel approach, a solution has been put forward for the communication industry where any antenna could achieve optimal directivity for desired RSL with low overshoot and fast steady state response.

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1. Introduction

In Telecommunication industry; there are number of equipments installed ranging from Base Transceiver Station (BTS) to Core and Back Haul Network. The most vital aspect that is desired in network connectivity is served by transmission links and its reliability is of utmost importance. It not only enables the connectivity of terminal and linking stations with the core network but also ensures traffic management functionality. Transmission nodes being employed today mostly utilize wired fiber optic links as well as wireless links in MW range. Short and long haul links and Fiber To The Home (FTTH) are wired fiber optic links and consequently various vendors such as Ericsson and Nokia Siemens Networks (NSN) have designed equipment that include HiT, OMS and Flexi-XC. In this paper the prime focus is on the wireless links which can accommodate both STM as well as E1/T1 level data rate. Over

here we are particularly interested in the Abis and A interface that are specifically working in MW range. In general practice two different stations are wirelessly linked by means of antenna on either end with proper Line of Sight (LOS). Multiple antennas can be utilized for redundancy with extension of Warm and Hot spares stand-by. The Quality of Service (QoS) pertaining to transmission link is measured by means of Received Signal Level (RSL) measured through either Multi-Meter or by means of a software provided by the antenna manufacturer [1,2]. Fig. 1.1 shows link parameters for a 1 + 0 antenna operating at 38 GHz with low end frequency of 38.1115 GHz and high end frequency of 39.3715 GHz. Antenna directivity originally set can be affected by natural wear out of physical mounts or by environmental anomalies thus misdirecting the main lobe direction of antenna. A manual alignment is carried out that requires high altitude rigger work which is time consuming and risky. Mean Down Time (MDT) caused by such events and procedures results in high economic loss and service unavailability for the customers over extended periods [1,3].

Fig. 1.1, indoor unit is denoted by “MMU” magazine which is tunable to desired frequency and power ratings. This unit is interfaced with an out-door unit “RAU” which is a radio operating at 38 GHz. This specific depiction is of an MW link which is broken

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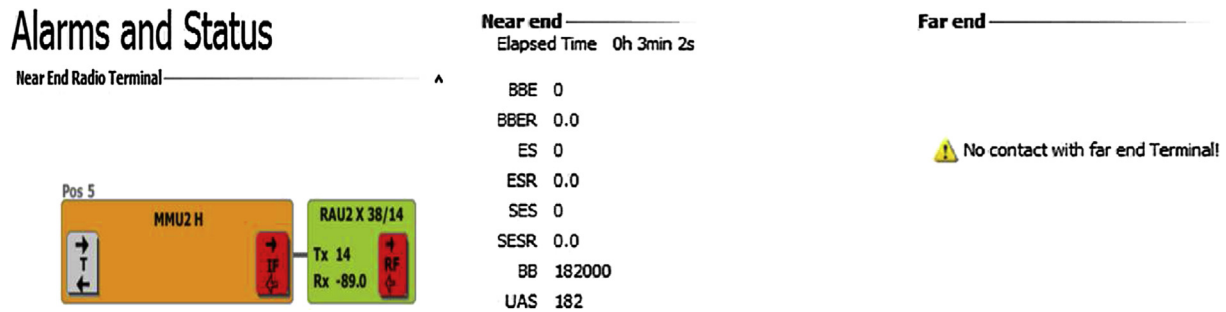


Fig. 1.1. Link parameters to be adjusted for communication.

and needs to be established by means of alignment. The other parameters mentioned are Background Clock (BB) which discards the undesired RF signals by considering them as noise, Background Block Errors (BBE) indicates the errors while filtering process and it is quite evident that present link is not affected because of interference. Certain other parameter's such as Error Seconds (ES), Sensitive Error Seconds (SES) and Unavailable Seconds (UAS) are defining the status of an RF link along with their respective ratios. UAS is indicating a complete link failure and it is the prime factor of assigning critically of any link in industrial environment.

All the aforementioned parameters must be in optimal level to establish a radio link. Because of misalignment far end terminal shows No contact as like in Fig. 1.1. Among of several reasons of link failure, low RSL is one of the most frequent causes, in the given link, RSL level is -89.0 dBm and needs an alignment for link and service restoration. In multiple surveys conducted [4], it can be deduced that the link alignment is not one off job and there is a high possibility for antenna to lose its optimal directivity and hence misdirect the main beam. There could be multiple reasons behind the misalignment such as environmental conditions, wear and tear of mounts and obstruction in the path of two stations. Previously, in 2013 a servo controlled antenna orientation for Satellite Ground Station was presented [5] while a Near Field UHF RFID for multi-antenna systems was proposed in [6] in June 2013. Use of DC motors and hydraulic actuators for the purpose of antenna driving by means of Linear Quadratic Gaussian (LQG) and some fundamental insight about antenna alignment for space

application are explored in Ref. [7]. Our work is primarily focused on telecommunication aspects of antenna alignment aimed at reducing the outage and down time to its absolute minimum. This paper deals with analytical and numerical modeling of the antenna alignment prototype for performance optimization, a section of it has been included to investigate the interference from other nodes [8,9]. In 2011, a fundamental approach was presented in Ref. [10] at ATNAC with some basic design analysis and exploration of the domain while here a detailed approach, numerical methods utilized and implementation is presented. Overview of the prototype presented in ATNAC conference; processor was LEGO Mindstorms RCX coupled with control input from LabVIEW design [11] utilization and loop antenna for intended RSL measurement. Here, RCX controller technique used for prototype antenna alignment have built-in PID controller. Realignment of antenna is measured with some derivative gain, steady state response, etc. and hence it directs to optimize the performance through mathematical modeling and by minimizing unexpected overshoot. Different automation techniques for numerous applications have been employed with the main focus on reestablish communication link with minimum down time. Gawronski [15] has worked with pointing and control challenges for large antennas and telescopes. There antenna control system consists of the rate and position feedback loops whose mechanism is developed using controllers like PI controller, LQG, etc. Nourin Kadir et al. in 2011 [16] has worked regarding the tracking system improvement for satellite laser communication, where they have used PID controller to improve system performance on tracking

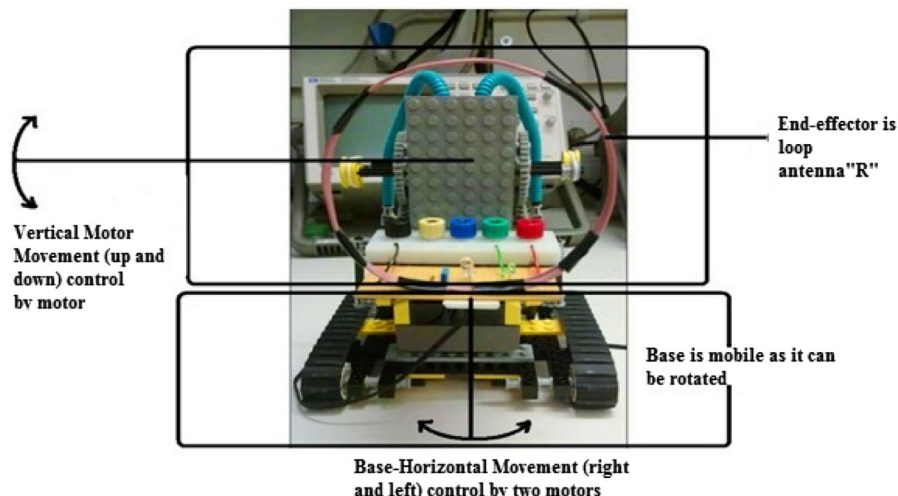


Fig. 2.1. Analyzing the side-wise and lateral movement of model solution.

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