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Channel modelling and analysis of Wits mock-mine with different antenna parameters

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2017

http://hdl.handle.net/10539/23519

Hussain, Intikhab (2017) Channel modelling and analysis of Wits mock-mine with different antenna parameters, University of the Witwatersrand, <http://hdl.handle.net/10539/23519>

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ABSTRACT

In the mining industry, communication systems are important for ensuring personnel safety and optimizing the mining processes underground. Achieving robust and reliable through-the-air (TTA) communication system has always been a challenge in the underground mining environment due to harsh and dynamic conditions. TTA requires radio channel characterization for efficient designing and deploying of the communication system. The literature covers the statistical radio propagation of a room and pillar coal mine, a longwall coal mine, CANMET Gold mine, Camborne School of Mines hard rock mine tunnel, MÜZ Coal mine, an iron-ore mine and a lead-zinc mine with linearly polarized antennas at different frequencies. To the best of our knowledge, no open literature is available on the radio propagation of 1) deep underground mining tunnels (i.e. steel-supported arch-shaped mining tunnel), 2) mine vertical shaft and 3) underground mining tunnels with circularly polarized antennas. The experimental work on the performance comparison of different antennas in the underground mining tunnels is also sparse. This work presents the statistical radio propagation performance study of steel supported arch-shaped underground mining tunnel with antennas having different polarization, transmission frequency, configuration and directivity at different positions inside the tunnel. Moreover, the statistical radio propagation of WITS vertical shaft is also studied. The wideband measurements are used to obtain path-loss exponent, shadow fading statistics, channel impulse response, power delay profile, mean excess delay, RMS delay spread, maximum delay spread and coherent bandwidth parameters for the performance comparison. The results reveal that the antenna placement, antenna polarization, antenna directivity and transmission frequency have a significant impact on the performance of TTA communication system. The path-loss exponent values of less than free-space show waveguide propagation in underground tunnels. Circularly polarized directional antennas offer higher channel capacity whereas linearly polarized omni-directional antennas offer lower attenuation rate. Furthermore, higher frequency signals show lower attenuation rate and coherent bandwidth than lower frequency signals.