Bipole III Transmission Project: A Major Reliability Improvement Initiative

DC Lines and Electronic Devices

Manitoba Hydro is proposing to build a new direct current (DC) transmission line, known as Bipole III, to improve system reliability. The new line will link the northern power-generating complex on the Lower Nelson River with the delivery system in southern Manitoba. Currently, two existing DC lines carry almost 75% of Hydro's generating capacity within the same corridor and are vulnerable to major outages from severe weather events and forest fires. This brochure outlines information about electronic devices including global positioning satellite (GPS) receivers, radio and TV, cell phones, and mining survey equipment in the presence of DC transmission lines such as Bipole III.

GPS receivers, radios, TV, and cell phones all produce or receive radio frequency (RF) signals. While radio and TV transmitters produce relatively strong RF signals, GPS satellites, computers and transmission lines produce weaker RF signals. This generally means that the likelihood of interference to reception depends on the strength of the unwanted RF signal.

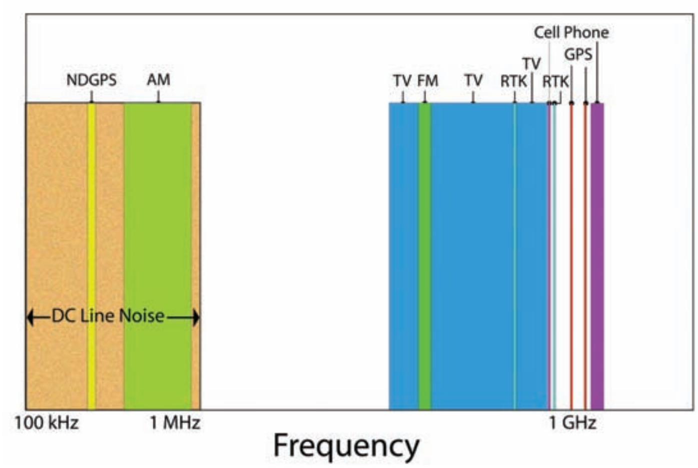
Figure 1: Close up of Bipole HVdc Transmission Lines

Radio and TV Receivers

Radio and TV interference may be noticeable, particularly when near a DC transmission line. Many people have likely heard interference on their AM radio while driving under power lines, particularly high voltage transmission lines. Interference to AM and TV signals is caused by 'corona discharge' around all types of transmission lines; this corona discharge generates broadband 'radio noise' over a range of RF frequencies. If the signals from AM and non-digital TV sources are weak, the radio noise from nearby power lines can overlap and cause poor reception very close to the lines (Figure 2). Since the corona discharge of a high voltage DC line such as Bipole III is less than an AC line of similar voltage, the potential effect of a DC line on radio and TV devices is also less. Digital television is not susceptible to this source of interference.

Manitoba Hydro has decades of experience designing transmission lines to minimize radio noise and has worked with customers to solve interference problems that sometimes arise near AC lines.

Figure 2: Radiofrequency signals from some electronic communication/navigation devices



Cell Phones

Cell phones receive and transmit RF signals at frequencies ranging from 850 MHz to 2150 MHz. Radio noise from a DC transmission line does not overlap with the signals from a mobile phone and, therefore, does not interfere with a phone's functioning near a DC transmission line (Figure 2).

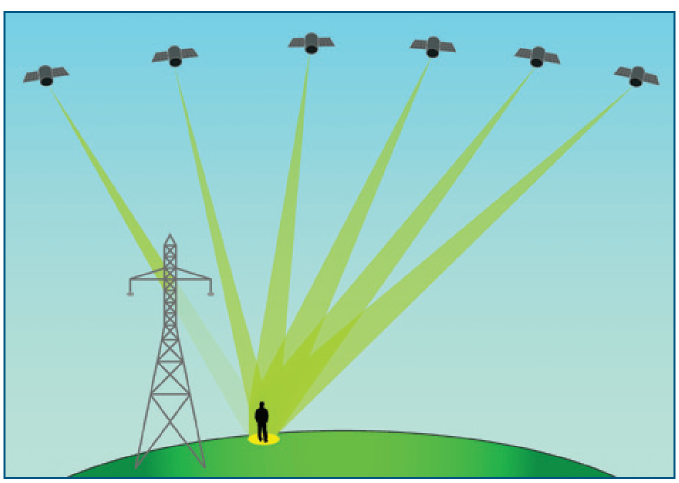
Wireless Internet

Wireless internet operates at a frequency of 2400 MHz. Radio noise from a DC transmission line does not overlap with the signals from wireless internet signals and, therefore, does not affect wireless internet function near a DC transmission line.

GPS Receivers

Global Positioning System (GPS) is a space-based navigation system that relies on 24 orbiting satellites circling the Earth to establish the position of a GPS receiver on the Earth. The receiver uses the RF signals sent from three or more of these satellites to determine its exact location. This concept is illustrated in Figure 3.

Figure 3: Reception of RF signals from orbiting satellites



Naturally-occurring sources of RF (e.g., geomagnetic storms) and man-made sources of RF (e.g., TV transmitters) are sometimes reported to interfere with GPS signals because these sources produce interference *in the same frequency range as the GPS*.

Since GPS signals are of far higher frequency than the radio noise of a DC transmission line, it is very unlikely that a DC transmission line will interfere with GPS functioning. Modern GPS receivers can receive corrections from a number of satellite-based systems with frequencies above 1 gigahertz (GHz) to improve the accuracy of positional location[1,2,3,5,6,7,8,9,10,11,12]; this is called differential GPS (DGPS). Some GPS systems also make use of real-time kinematic (RTK) systems to improve the accuracy of the GPS system by making use of the ultra high frequency (UHF) range[1,12]. Since the frequency bands of these systems are far higher than the radio noise frequencies produced by a DC transmission line[3, 3, 13], signal interference is unlikely to occur. However, since the GPS signal at ground level is very weak relative to noise under the transmission line, it is possible that some receiver designs may be susceptible to minor interference due to certain factors. Conceptually, a DC transmission line might affect GPS performance in two additional ways: (1) radio noise interference to NDGPS positional corrections and (2) signal blocking and reflection. These concepts are described further below.

NDGPS Positional Correction

NDGPS (Nationwide Differential GPS) is a GPS system commonly used in the US and along the southern border of Canada that was developed to improve GPS accuracy when GPS first became available[1]. This system works together with a GPS system making use of land-based towers to transmit correction signals to GPS receivers. NDGPS uses lower frequencies to send correction signals. These lower frequency signals can overlap with the radio noise frequencies discharged from a DC transmission line[4,13]. The likelihood of interference in each situation will depend on the GPS receiver's distance to the line, as well as its distance to the closest NDGPS antenna. A momentary loss of NDGPS signal, however, should not substantially affect the accuracy of the overall positioning system. The accuracy of GPS signals is much greater today and therefore the NDGPS positional correction does not substantially improve the accuracy of current GPS receivers, which have an accuracy of a few metres[1,5].

Signal Blocking and Reflection

RF signals can be blocked by physical objects (e.g., mountains) or degraded by reflections off large solid objects. The towers of a DC line, while relatively large compared to the size of a person for example, do not have a large footprint and they are not solid (Figure 1). So while the towers can result in some reflections and blocking of RF signals their impact is generally momentary and insignificant. Transmission line conductors are also too thin to block or cause large reflections of RF signals[3,4].

GPS and related receivers are typically configured to reduce the effects of blocked and reflected signals, resulting in a very small and temporary blockage area if it occurs. Further, as illustrated in Figure 3, the concept of multiple satellite options implies that having the signal from one of a group of satellites blocks is not consequential since the reception from the other satellites is still available.

GPS Use in Agriculture

As described, radio noise from a DC line would not be expected to directly affect GPS signal reception or the reception of satellite-based positional correction signals used in equipment for farming operations. Since RTK correction signals are transmitted from antennas that are typically only a few metres high, DC transmission line towers are not expected to produce much blocking of line-of-sight signals from these sources either. Repositioning of the RTK base station antenna should resolve any issues if they occur. Signal degradation can occur due to reflections from a nearby flat-topped building or other reflecting surfaces (such as lakes). The overall performance of a GPS guidance system in agriculture depends upon a high-quality receiver and good positional correction from an independent source.

Mining Surveys

Multiple technologies exist for geophysical and mining surveys that fall into three broad categories: magnetic surveys, electromagnetic surveys, and radiometric surveys.

- Magnetic surveys monitor changes in the DC magnetic field of the earth to determine the presence of any anomalies. Magnetic surveys are susceptible to extraneous sources of DC magnetic fields.
- Electromagnetic surveys actively probe and measure the response of the ground to an applied electromagnetic field in the DC and very low frequency (VLF) portion of the electromagnetic spectrum for large penetration depths.
- Radiometric surveys detect radioactive elements in the Earth.

Current flow on a DC line might increase the background magnetic field by as much as 10 nanoteslas (nT) at a distance of 0.7 km away from the line; however, the variation of the field due to load fluctuations should be well below fluctuations due to daily variations in the background geomagnetic fields. It may be possible to use modeling to eliminate the effect of extraneous magnetic fields on survey data and has been used near DC lines[14].

There are also a wide variety of electromagnetic survey techniques. While none of the techniques should be affected by the magnetic field from a DC line, interference is possible due to currents and voltages induced on the line and towers by the survey equipment as well as the radio noise from the line. The signal from induced currents and voltages should rapidly drop off with distance from the line and also may be cancelled by changing the polarization of the sensing electric field antenna. The sensitivity to radio noise will depend greatly on the measurement technique; those relying on a narrow band signals will be much less sensitive to the radio noise.

When conducting geophysical mining surveys, knowledge of power flow and tower locations can remove the effect of any changes in the magnetic field level from the line and the towers, thereby improving the quality of data.

Radiometric surveys measure ionizing radiation from the ground and therefore should not be affected by RF noise produced by the DC power line.

Bipole I and II Transmission Lines

References Cited

[1] ARINC Incorporated for US Department of Transportation, Federal Highway Administration, "NDGPS Assessment Final Report". http://www.navcen.uscg.gov/pdf/ndgps/ndgps%20assessment%20report_final.pdf

[2] National Space-Based Positioning, Navigation and Timing Coordination Office. "Global Positioning System Augmentations". http://www.gps.gov/systems/augmentations

[3] Silva JM and Olsen RG, "Use of global positioning system (GPS) receivers under power-line conductors".IEEE Transactions on Power Delivery 17:938-944, 2002.

[4] Silva JM, "Evaluation of the potential for power line noise to degrade real time differential GPS messages broadcast at 283.5-325 kHz". IEEE Transactions Power Delivery 17:326-333, 2002.

[5] Global Positioning System Standard Positioning Service Performance Standard, 4th Edition, September 2008, http://pnt.gov/public/docs/2008/spsps2008.pdf

[6] Department of Transportation, "Global Positioning System Wide Area Augmentation System Performance Standard, US Department of Transportation and Federal Aviation Administration." 10 31, 2008. http://pnt.gov/public/docs/2008/waasps2008.pdf

Global Positioning System Wide Area Augmentation System Performance Standard, US Department of Transportation and Federal Aviation Administration, http://pnt.gov/public/docs/2008/waasps2008.pdf

[7] OmniSTAR, "OmniSTAR: The Global Positioning System". http://www.omnistar.com/

[8] John Deere USA/Canada, "GPS & Troubleshooting: Receivers – Radio Interference".http://www.deere.com/en_US/ag/servicesupport/tips/agmanagementsolutions/AMS-receivers-radio-interference.html#

[9] Natural Resources Canada International Division , "CDGPS Service Decommissioning Announcement – March 5, 2010". http://www.cdgps.com/e/cdgps_documents/CDGPS_Exit_Announcement.pdf

[10] Natural Resources Canada Publication, "CDGPS – Canada-wide DGPS Service: Quality Real Time GPS Positioning". http://www.geod.nrcan.gc.ca/publications/papers/pdf/cdgpsquality.pdf

[11] Research and Innovative Technology Administration "Nationwide Differential Global Positioning System – Capabilities and Potential." http://www.navcen.uscg.gov/pdf/cgsicmeetings/49/Reports/[31]NDGPS_Update_CGSIC_SL_092309.pdf

[12] John Deere Ag Management Solutions, "StarFire RTK 900 and 450 MHz Radios Operator's Manual". http://stellarsupport.deere.com/en_US/support/pdf/om/en/ompfp10352_mhz.pdf

[13] Transmission line reference book, HVDC to ± 600 kV based on HVDC Transmission Research Project PR 104, sponsored by the Electric Power Research Institute and the Bonneville Power Administration. Vancouver, Washington: Bonneville Power Administration, 1976.

[14] Gharibi M and Pedersen LB,"Removal of DC power-line magnetic-field effects from airborne total magnetic-field measurements". Geophysical Prospecting. 48:617-627, 2000.

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