July 14, 2008

Supplemental Information – Path loss calculation

Submitted by: National Instruments, Inc. Austin, TX

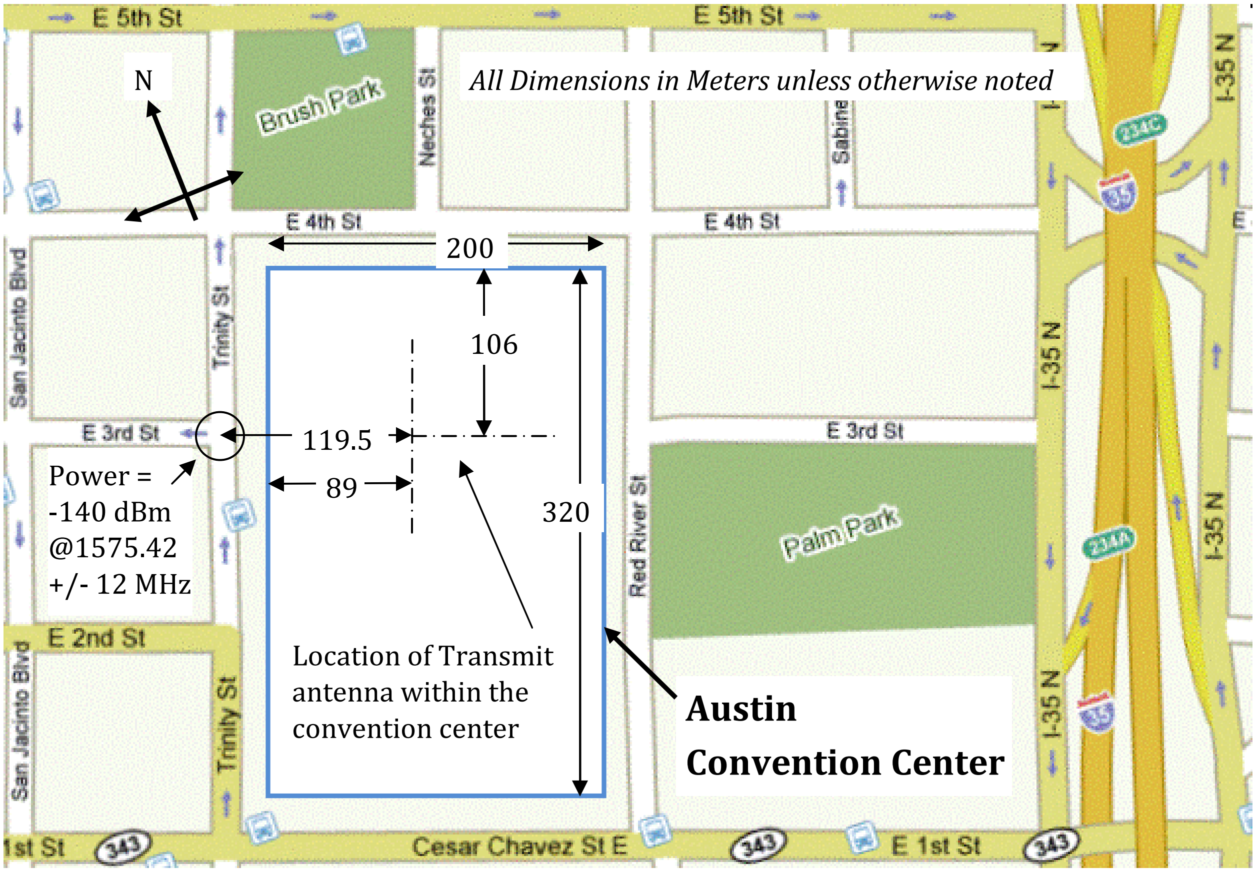

Figure 1: Austin convention Center at 30° 15' 48" N Latitude, 97° 44' 26" W. Longitude

We must calculate the theoretical path loss from the transmit antenna to the nearest point at 100' from the building exterior (see figure 1). The transmit antenna is 89 meters from the outer wall and 119.5 meters from the circled region in figure 1. The path loss, according to the Friis formula is:

[1] $loss(dB) = 20*\log(Gt*Gr(4\pi d/\lambda))$

Where f = frequency (MHz) and Gt and Gr are the transmit and receive antenna gains and d is the distance . According to NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management (MRP), section 8.3.28, devices radiating GPS frequencies must comply with section 6:

> "The maximum equivalent isotropically radiated power (EIRP) must be such that the calculated emissions are no greater than -140 dBm/24 MHz as received by an isotropic antenna at a distance of 100 feet (30 meters) from the building where the test is being conducted. The calculations showing compliance with this requirement must be provided with the application for frequency assignment and should be based on free space propagation with no allowance for additional attenuation (e.g., building attenuation.)"

Assuming isotropic radiation (G=1) on both transmit and receive antennas, the Friis formula in (1) predicts a path loss of $20*\log((4*\pi*119.5\,/.190))$ = 78 dB.

Working backwards from the -140 dBm constraint in NTIA MRP 8.3.28 section (6), the allowed power input to an isotropic transmit antenna is -140 + 78 = -62 dBm. Because the transmit antenna has a maximum gain of +3 dBi, the maximum transmit power cannot exceed **-65 dBm** or **316 pW.**

[1] From J. S. Lee and L. E. Miller, *CDMA Systems Engineering Handbook*. Boston: Artech House, 1998; and NTIA's LMS calculator help file.

File number: 0299-EX-ST-2008

This worksheet is for the purpose of validating calculations relative to the STA application number cited.

Transmitter power output (TPO) and effective radiated power (ERP) calculation worksheet:

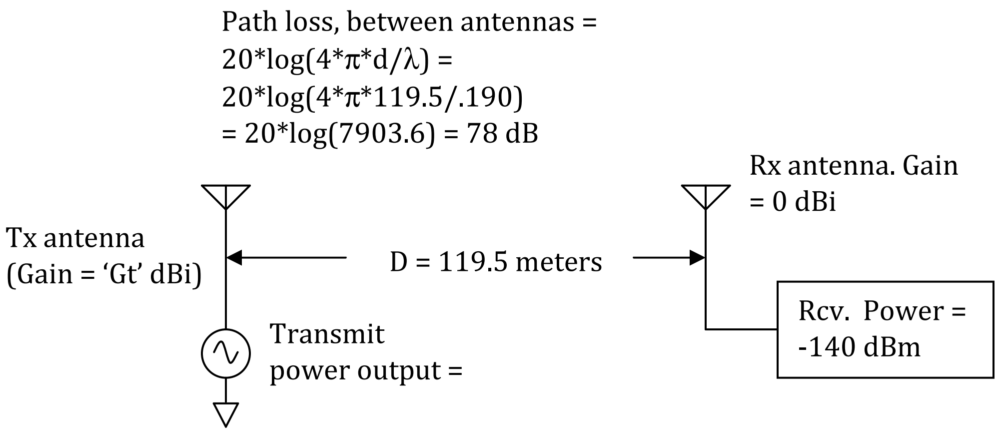

Figure 1 – antenna setup

Definition: "EIRP" from FS-1037C: The arithmetic product of (a) the power supplied to an antenna and (b) its gain.

Definition: "ERP" from FS-1037C: "The product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction. " (note: direction of dipole maximum gain is assumed)

Calculation of maximum allowed "TPO" transmitter power output with 3 antenna scenarios:

1) Isotropic antenna, Gt = 0 dBi: Using an isotropic antenna for the transmitter, no correction factor is necessary – the maximum TPO is -140dBm + 78 dB = -62 dBm or **632 pW.**
   EIRP = TPO + antenna gain (in dB – relative to isotropic) = -62 dBm +0dBm = 632 pW.
   ERP = TPO + antenna gain relative to dipole = -62 dBm -2.15 dB = -64.15 dBm = **384.6 pW.**
2) Dipole antenna, Gt = 2.15 dBi: a dipole antenna has 2.15 dB gain relative to an isotropic antenna, therefore, the maximum TPO = (-62 dBm - 2.15 dB) = -64.15 dBm or **384.6 pW.**
   EIRP = TPO + 2.15 dB = -62 dBm or 632 pW.
   ERP = TPO + 0 dB = -64.15 dBm or **384.6 pW**
3) +3dBi gain antenna, Gt = 3.0 dBi: the patch antenna used in this experiment has a + 3dB gain relative to an isotropic antenna; therefore, the maximum allowed transmit power is (-62 -3) = -65 dBm, or **316 pW.**
   EIRP = TPO + 3.0 dB = -65 dBm + 3 dB = -62 dBm or 632 pW.
   ERP = TPO + 0.85 dB (gain wrt dipole) = -65 dBm + 0.85 dB = -64.15 dBm or **384.6 pW.**