Spatial Variability of Radio-frequency Noise in Urban Environments in the VHF and UHF Bands

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Radio-frequency (RF) background noise is a critical and spatially-varying parameter for predicting radio communication and electromagnetic sensor system performance in urban environments. High levels of RF noise can degrade the of RF system performance by decreasing intelligibility, increasing bit error rates, and decreasing sensitivity in analog voice, digital, and sensing systems respectively. Modern man-made RF noise consists of unintentional emissions from electronic devices, power transmission lines, and internal combustion engine ignition systems. Electronic devices such as cellular phones, wireless internet routers and printers have become ubiquitous in urban environments over the last decade, inevitably changing the spectral and spatial characteristics of RF noise. While many previous studies have measured background noise in varied environments such as rural, residential and urban, the focus has been on stationary measurements and comparison between environments. Little work has been done characterizing spatial variability of RF noise at smaller scales within the urban environment.

To address the lack of spatial discrimination in previous work, we developed and deployed a mobile, calibrated and tunable (60 to 1000 MHz) RF noise measurement system, utilizing either GPS or rolling survey wheel inputs to precisely locate measurements in space. The system design required special focus on the choice of preselection filters and preamplifiers necessary to reliably measure low RF noise levels in an environment with many strong emitters on nearby frequencies. We further describe post-processing techniques developed to merge and interpolate RF and geolocation data. Ambient noise levels were measured with a broadband biconical antenna, which was mounted with vertical polarization at 1.8 m above ground level on a non-reflecting mast. The mast was secured, along with the measurement system, in a hand-pulled cart to avoid the influence of measurement vehicle-induced self-generated noise on our measurements.

We have deployed this system several times to record high resolution (1 m measurement interval) noise measurements along a several-kilometer route that transects Boston, Massachusetts, typically recording 1 MHz bandwidths. After identifying frequencies free of detectable intentional emitters and spread throughout the range of interest, we repeated the route at least twice for each frequency to differentiate between spatial and temporal variations in noise power. We show that the median RF noise levels in a 1 MHz bandwidth can vary as much as 10 dB at higher frequencies and up to 20 dB at lower frequencies over distances of a few hundred meters.