
ITS Outputs in FY 2000

NTIA Publications

M.G. Cotton, R.J. Achatz, Y. Lo, and C.L. Holloway, "Indoor polarization and directivity measurements at 5.8 GHz," NTIA Report 00-372, Nov. 1999.

This report investigates how antenna polarization and directivity affect indoor radio channel bandwidth and signal coverage. Indoor impulse response measurements were taken at 5.8 GHz for four canonical propagation conditions: within a room, down a corridor, around a corridor corner, and from a corridor into a room. Directional linearly-polarized (LP), directional circularly-polarized (CP), and omnidirectional LP antennas were employed, and conclusions were drawn from basic transmission loss, rms delay spread, and cross-polarization discrimination results. Measurements indicated less LP basic transmission loss than CP basic transmission loss for both line-of-sight (LOS) and obstructed (OBS) channels. Also, LP rms delay spread was similar to CP rms delay spread in both LOS and OBS paths. The apparent advantage of using LP signals over CP signals indoors may be attributed to the relatively high degree of circular depolarization measured. Results also supported the use of omnidirectional antennas indoors to improve signal coverage. Omnidirectional measurements, however, demonstrated large delay spreads for some extraneous cases. These cases are emphasized to demonstrate the potential diversity holds for improving bandwidth capacity of indoor communication systems.

M.G. Cotton, E.F. Kuester, and C.L. Holloway, "A frequency- and time-domain investigation into the geometric optics approximation for wireless indoor applications," NTIA Report 00-379, Jun. 2000.

In this study we investigated the geometric optics (GO) approximation to the fields of an incremental electric dipole above a half plane for geometries typical of wireless indoor communications. This inspection was motivated by efforts to establish a ray-trace model to characterize indoor radio propagation channels. Eight canonical geometries were examined to isolate near-surface and near-field effects that are not accounted for in the GO approximation.

Common building materials and physical dimensions (i.e., antenna separation and height) as small as 1 cm were investigated for frequencies up to 8 GHz. Theoretical fields were calculated via numerical evaluation of Sommerfeld integrals and compared to corresponding GO approximations. As expected, GO approximations agreed with theoretical results when the source and observation points were multiple wavelengths above the surface and relatively far apart. Close to the surface, an interesting interference pattern in the frequency domain was caused by adjacent fields in the two media propagating at different speeds. This so-called "pseudo-lateral wave" phenomenon is discussed and demonstrated in various examples. Next, we emulated system specifications (i.e., center frequency and bandwidth), computed time-domain impulse responses, and used delay spread as a metric to quantify GO error. Results show that mechanisms exist under certain circumstances which invalidate GO assumptions; conventional expressions to complement GO approximations are summarized.

R.A. Dalke, R.J. Achatz, and Y. Lo, "Nonlinear operation of a MMIC power amplifier and its effects on battery current, interface, and link margin," NTIA Report 00-375, Jan. 2000.

This report describes measurement, modeling, and simulation methods that are used to analyze the relationship between nonlinear operation of a typical PCS portable transceiver power amplifier and battery current, out-of-band power, and link margin. First the nonlinear characteristics of the PCS amplifier and associated battery current were obtained from amplifier measurements at various bias voltages and RF output signal levels. A mathematical model of the power amplifier based on these measurements was then used to simulate the communications link for purposes of determining the power spectral density and symbol-error ratio for a variable envelope digitally modulated signal using $\pi/4$ DQPSK with 35% root raised cosine filtering. The out-of-band power and symbol-error ratio were computed to determine the link margin for a maximum symbol-error ratio of

10-3.

S.K. Jones, R.L. Hinkle, F.H. Sanders, and B.J. Ramsey, "Technical characteristics of radiolocation systems operating in the 3.1-3.7 GHz band and procedures for assessing EMC with fixed earth station receivers," NTIA Report 99-361, Dec. 1999.

No abstract available.

R.J. Matheson, "Spectrum usage for the fixed services," NTIA Report 00-378, March 2000.

This study is an update to a 1993 ITS staff study entitled "A preliminary look at spectrum requirements for the Fixed Services." That study included a description of the services provided in 30 of the Government and non-Government frequency bands between 406 MHz and 30 GHz known as point-to-point terrestrial microwave bands. Each of the 30 frequency bands were described in terms of the services provided, growth of licenses, and the geographical distribution of current licenses. The technical, regulatory, and economic factors affecting each band and the total microwave market were described, as well as a prediction of the rate of future growth (or decrease) for each band and market segment. This study adds 6 more years of license information and updates much data on recent regulatory and market trends. Some of the general technology and market descriptions have been left out of this update, but earlier predictions are compared to actual market performance and revised forecasts are made.

E.A. Quincy, R.J. Achatz, M.G. Cotton, M.P. Roadifer, and J.M. Ratzloff, "Radio link performance prediction via software simulation," NTIA Report 00-371, Oct. 1999.

The subjective quality of speech and image information, transmitted over a high frequency radio link impaired with varying levels of interference, has been evaluated using software simulation. The high frequency radio link was also degraded by frequency-selective multipath and non-Gaussian noise. During radio link signal simulation an error sequence, determined from a comparison of transmitted and received bits, was collected. Next digitized speech and image information was distorted by the error sequence. Last, the quality of the distorted speech and image information was subjectively evaluated.

This process was repeated for a large number of interference conditions. The same process can be used to show how multipath and non-Gaussian noise affects speech and image quality. Other wireless applications such as personal communications services and wireless local area networks can be analyzed in the same way using radio channel measurements and models made by the Institute for Telecommunication Sciences.

F.H. Sanders, "Measured occupancy of 5850-5925 MHz and adjacent 5-GHz spectrum in the United States," NTIA Report 00-373, Dec. 1999.

Dedicated short-range communication (DSRC) systems have been proposed for operation at locations across the United States in the 5850-to 5925-MHz band. To establish electromagnetic compatibility between DSRC and other 5-GHz systems, it is necessary to understand current and future occupancy of this spectrum. This report summarizes results of measurements made in 5-GHz spectrum for the Federal Highway Administration (FHWA) of emissions from high-power radars and a fixed satellite service (FSS) earth station. Results of 5-GHz spectrum survey measurements in major metropolitan areas are also included. Measured spectrum occupancy in 5-GHz bands is typically dominated by radar systems. Radar spurious emissions are the major element of occupancy observed between 5850-5925 MHz, although future radar designs are expected to make more use of this band. Therefore, proposed 5-GHz DSRC systems will have to share spectrum with both spurious and on-tuned emissions from radars. DSRC frequency assignments will need to be coordinated with local radar assignments to avoid co-channel operations at short separation distances, and it is recommended that DSRC system designs be electromagnetically compatible with radar spurious emissions.

R.L. Sole, B. Bedford, and G. Patrick, "Lower Mississippi River ports and waterways safety system (PAWSS) RF coverage test results," NTIA Report 00-374, Nov. 1999.

No abstract available.

Outside Publications

Articles in Conference Proceedings

P. Corriveau, A. Webster, A.M. Rohaly, and J. Libert, "Video quality experts group: The quest for valid objective methods," in *Proc. SPIE Conference - Photonics West*, San Jose, CA, Jan. 2000.

Subjective assessment methods have been used reliably for many years to evaluate video quality. They continue to provide the most reliable assessments compared to objective methods. Some issues that arise with subjective assessment include the cost of conducting the evaluations and the fact that these methods cannot easily be used to monitor video quality in real time. Traditional analog objective measurements, while still necessary, are not sufficient to measure the quality of digitally compressed video systems. Thus there is a need to develop new objective methods utilizing the characteristics of the human visual system. While several new objective methods have been developed, there is yet no internationally standardized method.

In October 1997, VQEG was formed at a video quality experts meeting at Centro Studi e Laboratori Telecomunicazioni (CSELT) in Turin, Italy. The group is composed of experts from various backgrounds and affiliations, including participants from several internationally recognized laboratories working in the field of video quality assessment. The majority of participants are active in the International Telecommunications Union (ITU) and VQEG combines the expertise and resources found in several ITU Study Groups to work towards a common goal. The first task undertaken by VQEG was to provide a validation of objective video quality measurement methods leading to Recommendations in both the Telecommunications (ITU-T) and Radiocommunication (ITU-R) sectors of the ITU. To this end, VQEG designed and executed a test program to compare subjective video quality evaluations to the predictions of a number of proposed objective measurement methods for video quality in the bit range of 768 kb/s to 50 Mb/s. The results of this test show that there is no objective measurement system that is currently able to replace subjective testing. Depending on the metric used for evaluation, the performance of eight or nine models was found to be statistically equivalent, leading to the conclusion that no single model outperforms the others in all cases. The greatest achievement of this first validation

effort is the unique data set assembled to help future development of objective models.

P. Corriveau, J. Lubin, J.C. Pearson, A. Webster, et al., "Video quality experts group: Current results and future directions," in *Proc. International Conference on Visual Communications and Image Processing 2000*, Perth, Australia, Jun. 2000.

For abstract, see above.

C. L. Holloway and M.S. Sarto, "On the use of a hybrid IE/FDTD method for the analysis of electromagnetic scattering and coupling problems," in *Proc. IEEE International Symposium on Electromagnetic Compatibility 2000*, Washington, DC, Aug. 2000.

We present a hybrid time-domain numerical technique for analyzing electromagnetic scattering and coupling problems. This hybrid technique consists of combining the time-domain integral equation (IE) and the finite difference time-domain (FDTD) methods. This approach eliminates some of the computational difficulties of using a standard FDTD methodology. One problem with such a hybrid technique is that unwanted reflections can occur at the IE/FDTD boundary. In this paper, we introduce a technique to reduce these unwanted reflections. We will present various examples illustrating how the IE/FDTD hybrid approach can be used to solve EMC problems.

P. Papazian, P. Wilson, and Y. Lo, "Phase calibration of a PCS wideband antenna array system," in *Proc. IEEE Conference on Vehicular Technology*, Boston, MA, Sep. 2000.

This paper investigates parameters that determine the phase stability of a PCS antenna beam steering system and the effectiveness of a reference channel for correcting phase instability. It presents data collected using a multi-channel broadband receiver developed for advanced antenna algorithm testing. Phase data collected in the laboratory is contrasted with roof top data showing variability caused by environmental effects such as temperature changes. Data from a reference signal and data from a simulated mobile using a different reference oscillator are also contrasted. Measurement data collected using the reference channel indicates that the relative phase between channels varies by ± 0.5

over one day. Data collected with a simulated mobile reference oscillator in a non-controlled environment indicates that the relative phase between channels varies by ± 5 over one day.

T.G. Sparkman, "Lessons learned applying software engineering principles to visual programming language application development," in *Proc. COMP-SAC 99*, Phoenix, AZ, Oct. 1999.

Visual programming languages make software design accessible even to untrained programmers, but basic software engineering practices must still be followed to create a usable product. This paper describes the process by which software was developed to control sophisticated laboratory equipment for a radio frequency interference monitoring system (RFIMS). Development of requirements and specifications is discussed. It is shown that the product was improved by the use of extensive planning and user testing. In addition, the steps required for designing a clear and intuitive graphical user interface (GUI) are discussed. The GUI interface specifications, user panel templates, menu system hierarchy, and programmatically guiding the user are some of the tools that were successfully employed in the project development.

S. Voran, "Results on reverse water-filling, SNR, and log-spectral error in codebook-based coding," in *Proc. 2000 IEEE Speech Coding Workshop*, Delavan, WI, Sep. 2000.

This paper identifies optimum levels of reverse water-filling for codebook-based coding of noise and speech signals. We find that there is little to be gained from optimizing an effective rate parameter. We identify trade-offs between SNR and log-spectral error. We show that the application of a gain factor compares favorably with reverse water-filling in some situations.

P. Wilson and P. Papazian, "PCS band direction-of-arrival measurements using a 4 element linear array," in *Proc. IEEE Conference on Vehicular Technology*, Boston, MA, Sep. 2000.

A four-element array system for continuously acquiring direction-of-arrival data is described. The system allows for the collection of much larger data sets than previously published. Large data sets give a more realistic statistical description of the propagation environment applicable

to "smart" fourth-generation broadband mobile wireless communications systems. A mobile experiment (drive route) in the PCS band was conducted in a largely suburban neighborhood. The measured impulse responses were used to estimate the multipath pattern using two blind direction-of-arrival estimation methods, the parallelogram method and the normalized maximum likelihood method. The results show that the parallelogram method better estimates the line-of-sight direction and the direction-of-arrival of the main beam in the azimuth delay power spectrum. The normalized maximum likelihood method better identifies isolated, narrow spikes in the azimuth delay power spectrum.

P. Wilson, P. Papazian, M. Cotton, C. Holloway, and Y. Lo, "The Institute for Telecommunication Sciences Channel Sounding Program," in *Proc. IEEE International Conference on Third Generation Wireless Communications*, San Francisco, CA, Jun. 2000.

The Institute for Telecommunication Sciences, part of the National Telecommunications and Information Administration, has a long-standing program to develop radio channel measurement systems. This paper briefly reviews selected examples of recent measurements, outdoor and indoor, in order to give an overview of the ITS channel sounding program. The examples presented are: 1) diversity gain versus bandwidth experiments for a 1.92 GHz mobile PCS channel in a suburban neighborhood, 2) transmission loss versus frequency (440 MHz, 1.36 GHz, and 1.92 GHz) for a mobile outdoor channel, and 3) transmission loss and RMS delay spread versus antenna type (LP or CP) in an indoor environment at 5.8 GHz. These experiments demonstrate the flexibility of the system. The important system parameters are wide bandwidths and multiple channels, as required for 3G and 4G wireless systems.

Journal Articles

A.U. Bhoobe, C.L. Holloway, M. Piket-May, and R. Hall, "Coplanar waveguide fed wideband slot antenna," *Electronics Letters*, vol. 36, no. 16, pp. 1340-1342, Aug. 2000.

A new design for a coplanar waveguide (CPW) fed slot antenna is presented. The impedance matching and the radiation characteristics of this structure were studied using the method of moment technique. This antenna has an impedance bandwidth (for a VSWR < 2) of 49% and a radiation bandwidth of 42% about its 4.8 GHz center frequency, compared to the 12-20% impedance bandwidth of the standard CPW fed slot antenna. The cross-polarization in both the principle planes is at least 20 dB below co-polarization across the entire bandwidth. Simulated and measured results of the antenna are presented. This wideband antenna has significant applications in wireless technologies.

N. DeMinco, "Propagation prediction techniques and antenna modeling (150 to 1705 kHz) for Intelligent Transportation Systems (ITS) broadcast applications," *IEEE Antennas and Propagation Magazine*, vol. 42, no. 4, pp. 9-34, Aug. 2000.

This paper discusses the basic aspects of radio-wave propagation and antenna modeling in the band of frequencies from 150 to 1705 kHz. The paper contains descriptions of both sky-wave and ground-wave propagation-prediction models, in addition to the methodology used to analyze antennas that operate in this band. A method of calculating and normalizing antenna gain for systems computations is also discussed. The sky-wave models described in this paper are valid from 150 to 1705 kHz. The ground-wave models described in this paper are valid from 10 kHz to 30 MHz. The propagation of radio waves in the band of frequencies from 150 to 1705 kHz includes both a ground wave and a sky wave, and is quite different from propagation at any other frequency. The methods used for antenna modeling and analysis in this band are also quite unlike those in other bands. The AM broadcast band of 535 to 1605 kHz is planned to be used in the Advanced Traveler Information Systems (ATIS) of Intelligent Transportation Systems (ITS), to provide information such as road conditions, road hazards, weather, and incident reporting for rural travelers. The band of frequencies from 285 to 325 kHz is presently being used in another applica-

tion of ITS, called the Differential Global Positioning System (DGPS), which will be used for precision location systems and making performance predictions for both of these ITS applications, or for any other systems that operate in this band of frequencies from 150 to 1705 kHz. Some examples of comparisons of measured and predicted data are also contained in this paper. A computer program that includes all of these propagation-prediction models and antenna-modeling techniques was used to generate these examples.

C.L. Holloway, "Expressions for the conductor loss of strip-line and coplanar-strip (CPS) structures," *Microwave and Optical Technology Letters*, vol. 25, no. 3, pp. 162-168, May 2000.

In this paper, we present closed-form expressions for the attenuation constant due to conductor loss for strip-line and coplanar-strip (CPS) structures. These expressions are functions of a universal parameter referred to as the stopping distance, where it is shown that this stopping distance is a function only of the local edge geometry, i.e., the strip thickness, the shape of the edge, and the material of the strip conductor. We also present an expression for the current distribution of the ground planes of a strip-line structure, which is used to derive an expression for the conductor loss of the ground planes. Results obtained with these loss expressions are compared to, and closely agree with, both experimental results and full-numerical results found in the literature for these two structures.

C.L. Holloway and E.F. Kuester, "Equivalent boundary conditions for a perfectly conducting periodic surface with a cover layer," *Radio Science*, vol. 35, no. 3, pp. 661-681, May-June 2000.

Using the method of homogenization, effective electromagnetic properties for a two-dimensional, perfectly conducting, periodic rough surface with a thin periodic cover layer are derived. This allows for the development of an equivalent boundary condition for the "effective" fields at such a surface. It is shown that the coefficients in this equivalent boundary condition can be interpreted as electric and magnetic polarizability densities. We apply this boundary condition to calculate the reflection coefficient of H- and E-polarized plane waves incident at a rough, perfectly conducting surface. The reflec-

tion coefficients derived here are compared with previous results from the literature for surfaces with no cover layer, demonstrating the accuracy of the new equivalent boundary condition. We also obtain previously known equivalent boundary conditions for a flat perfectly conducting plane with a thin cover layer as a special case of our result. This work is a first step in the derivation of generalized impedance-type boundary conditions for conducting rough interfaces (to be published separately).

Other Publications

Atkinson, D.J., V.J. Pietrasiewicz and K.E. Junker, "Video surveillance equipment selection and application guide," NIJ Guide 201-99, Oct. 1999.

Patents Issued

U.S. patent number 06092040, "Audio signal time offset estimation algorithm and measuring normalizing block algorithms for the perceptually-consistent comparison of speech signals," July 18, 2000.

Unpublished Presentations

R.J. Achatz, "Broadband wireless LANs," presented at the International Symposium on Advanced Radio Technologies (ISART), Boulder, CO, Sep. 2000.

R.J. Achatz and R.A. Dalke, "Digitally modulated radio link performance in UHF man-made noise," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

C. Behm and R.B. Stafford, "Design and application of a software HF modem," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

A. Bhoje, C. Holloway, and M.N. Picket-May, "CPW-FED novel wideband slot antenna structures," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

R.A. Dalke, "MMDS performance modeling," presented at the International Symposium on Advanced Radio Technologies (ISART), Boulder, CO, Sep. 2000.

R. Dalke and R. Achatz, "VHF man-made radio noise," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

N. DeMinco, "Medium frequency propagation prediction techniques and antenna modeling for broadcast applications," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

C.L. Holloway and E.F. Kuester, "Impedance-type boundary conditions for a periodic interface between a dielectric and a highly conducting medium," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

J.J. Lemmon, "Wideband model of HF atmospheric radio noise," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

R.J. Matheson, "Spectrum management rules for a flexible-use environment," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

R.J. Matheson, "The history of radio noise studies at the DOC Boulder labs," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

P. Papazian, "An overview of propagation data near 30 GHz for LMDS," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

V.J. Pietrasiewicz, "The effect of evolving IT applications on broadband wireless requirements," presented at the International Symposium on Advanced Radio Technologies (ISART), Boulder, CO, Sep. 2000.

E.A. Quincy, "Bandwidth requirements for orthogonal frequency division modulation," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

T. Riley, "Third-generation HF modem/protocol performance under degraded conditions," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

F.H. Sanders, "Measuring radar spurious emissions for compliance with the NTIA radar spectrum engineering criteria (RSEC)," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

F.H. Sanders, "Broadband communications: Overview and access," presented at the International Symposium on Advanced Radio Technologies (ISART), Boulder, CO, Sep. 2000.

M.S. Sarto and C.L. Holloway, "On the use of a hybrid MFIE/FDTD method for the analysis of electromagnetic scattering coupling problems," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

R. Stafford, "Time-domain measurements of the electromagnetic properties of soils," presented at

National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

S. Voran and S. Wolf, "Objective estimation of video and speech quality to support network QoS efforts," presented at the 2nd Department of Energy/Internet2 Quality of Service Workshop, Houston, TX, Feb. 2000.

P. Wilson and P. Papazian, "PCS band channel sounding measurements in a suburban area," presented at National Radio Science Meeting (URSI), Boulder, CO, Jan. 2000.

Standards Leadership Roles

Evelyn M. Gray, Senior Editor of ANSI X3.172-1996, "American National Standard Dictionary of Information Technology" (4300 entries), and participant, with NCITS Technical Committee K5, in the revision to develop the Millennial Edition.

Eldon J. Haakinson, National Chair of the U.S. contingent of ITU-R Study Group 3 (Radiowave Propagation); International Chair of Working Party 3K (Point-to-Area Terrestrial Propagation Issues)

Paul M. McKenna, selected to be Chair of ITU-R Task Group 3/2 on Broadcast and Land Mobile Point-to-Area Propagation Predictions.

William J. Pomper, Chair of APCO/NASTD/FED Project 25 Encryption Task Group; Member of TIA/TR-8 - Mobile and Personal Private Radio Standards Committee; Technical Advisor to NCS Federal Telecommunications Standards Committee.

Neal B. Seitz, Chair of ITU-T Study Group 13 Working Party 4 (Network Performance and Resource Management); Chair of ANSI-accredited Technical Subcommittee T1A1 (Performance and Signal Processing)

Arthur Webster, Co-chair of Video Quality Experts Group (VQEG); Rapporteur for Question 11/12 (Objective Methods for Evaluating Audiovisual Quality in Multimedia Services) in ITU-T Study Group 12 (End-to-end Transmission Performance of Networks and Terminals). Note: this Question has been moved to ITU-T Study Group 9, which is responsible for Cable Television Recommendations. Arthur Webster will continue as Rapporteur.

Representative Standards Contributions

E. Gray, "Development of T1 Glossary 2000," T1A1/2000-017, Apr. 2000.

P. Raush, "Example Application of Network as a Measure of Survivability," T1A1.2/2000-007, Jan. 2000.

A. Rohaly, J. Libert, P. Corriveau, A. Webster, et al., "Final report from the Video Quality Experts Group on the Validation of Objective Models of Video Quality Assessment," ITU-T Standards Contribution COM 9-80-E, Jun. 2000.

A. Webster, "Final Report from the Video Quality Experts Group on the Validation of Objective Models of Video Quality Assessment," T1A1.1/2000-017, Apr. 2000.

A. Webster, "Proposed Definitions for T1A1.2/2000-002R2," T1A1.2/2000-034, Jun. 2000.

A. Webster and P. Raush, "Traffic Analysis Background," T1A1.2/2000-031, Apr. 2000.

A. Webster and P. Raush, "Traffic Analysis Aspects of IP and Other Packet-Based Networks," T1A1.2/2000-049, Aug. 2000.

S. Wolf, "Two Objective Video Quality Metrics," T1A1.1/2000-021, Apr. 2000.