Cody Ryan Scarborough
Assistant Professor

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Biography

Cody Scarborough received his B.S. in electrical engineering from the University of Texas at Austin, Austin, TX, USA in 2017. He received his Ph.D. degree from the University of Michigan, Ann Arbor, MI, USA in 2022. His dissertation is entitled "Spatially-Discrete Traveling-Wave Modulated Electromagnetic Structures." In August 2022, he joined the Department of Electrical, Computer and Energy Engineering, University of Colorado Boulder, Boulder, CO, USA, where he is currently an Assistant Professor. Professor Scarborough has made key research contributions in the analysis of space-time modulated electromagnetic structures. In 2019, he published a novel boundary condition, referred to as the interpath relation, that has proven essential to the analysis of spatially-discrete traveling-wave modulation. This analysis paved the way for the development of electromagnetic surfaces which control both the spatial and temporal characteristics of electromagnetic waves. In 2021, Professor Scarborough's work on space-time modulated structures has been recognized with best student paper awards at both the 15th International Congress on Artificial Materials for Novel Wave Phenomena (Metamaterials) and the 15th European Conference on Antennas and Propagation (EuCAP 2021). His current research interests include non-linear electromagnetics, periodic structures, reconfigurable intelligent surfaces, and conformal metamaterials.

Education

Ph.D. in Electrical Engineering and Computer Science, University of Michigan, August 2022.
Thesis: Spatially-Discrete Traveling-Wave Modulated Electromagnetic Structures

B.S. in Electrical and Computer Engineering, University of Texas at Austin, May 2017.

Journal Publications

J. Johnson, C. Scarborough, and Z. Popovic "Nonlinear Transmission Line GaN Frequency Comb with Low Additive Phase Noise," *IEEE Transactions On Microwave Theory And Techniques,* vol. 75, accepted with minor revisions on January, 13, 2025.

J. Johnson and C. Scarborough, "An Iterative Technique for Computing Soliton Solutions to Periodic Nonlinear Electrical Networks," *Optical Materials Express,* vol. 14, pp. 649-663, February 2024.

C. Scarborough and A. Grbic, "Generalized Eigenvalue Problem for Spatially Discrete Traveling-Wave-Modulated Circuit Networks," *IEEE Transactions on Microwave Theory and Techniques*, vol. 71, no. 2, pp. 511-521, February 2023.

C. Scarborough, Z. Wu, and A. Grbic, “Efficient Computation of Spatially-Discrete Traveling-Wave Modulated Structures,” *IEEE Transactions on Antennas and Propagation,* vol. 69, no. 12, pp. 8512-8525, December 2021.

Z. Wu, C. Scarborough, and A. Grbic, “Space-Time-Modulated Metasurfaces with Spatial Discretization: Free-Space N-Path Systems,” *Physical Review Applied*, vol. 14, no. 6, pp. 64060-64079, December 2020.

C. Scarborough and A. Grbic, "Accelerated N-Path Network Analysis Using the Floquet Scattering Matrix Method," *IEEE Transactions on Microwave Theory and Techniques*, vol. 68, no. 4, pp. 1248-1259, April 2020.

Short Courses

C. Scarborough, and A. Grbic, “Modeling and Design of Space-Time Modulated Electromagnetic Structures,” *18th European Conference on Antennas and Propagation (EuCAP 2024)*, Glasgow, UK, 2024.

C. Scarborough, and A. Grbic, “Time and Space-Time Varying Electromagnetic Structures and Circuits,” *17th European Conference on Antennas and Propagation (EuCAP 2023)*, Florence, Italy, 2023.

Conferences

A. Montgomery, J. Molles, L. Marzall, C. Scarborough, Z. Popovic, “A Self-Synchronous X-Band GaN MMIC Rectifier,” *IEEE Wireless Power Technology Conference and Expo*, Rome, Italy, 2025.

C. Scarborough, T. I. MacDonald, R. Montoya, and A. Brannon “Network-Based Reconfigurable Metasurface Synthesis Methods,” *IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting,* Ottawa, Ontario, Canada*,* 2025*.*

T. I. MacDonald, R. Montoya, A. Brannon, C. Scarborough, “Network Based Hybrid Spatial-Spectral RIS Synthesis Method,” in *The 19th European Conference on Antennas and Propagation (EuCAP 2022)*, Stockholm, Sweeden, 2025.

A. Singh, A. Montgomery, and C. Scarborough, “A 10 GHz Parametric Amplifier for Distributed Amplification,” *2025 US National Committee of URSI National Radio Science Meeting (USNC-URSI NRSM)*, Boulder, CO, USA, 2025.

A. Dundon, O. Reamer, A. Montgomery, J. Molles, C. Scarborough, Z. Popovic, “Effects of Weather Events on Wireless Power Receiver Arrays,” *2025 US National Committee of URSI National Radio Science Meeting (USNC-URSI NRSM)*, Boulder, CO, USA, 2025.

C. Scarborough, J. Molles, Z. Popovic, “Active Nonlinear Impedance Surfaces for Power Generation,” *2021 18th International Congress on Artificial Materials for Novel Wave Phenomena (Metamaterials)*, Crete, Greece, 2024.

A. Montgomery, J. Molles, C. Scarborough, Z. Popovic, "High-Efficiency 10-GHz Low-Cost Scalable Rectenna Subarrays," *27th edition of the European Microwave Week (EuMW 2024)*, Paris, France, 2024.

C. Scarborough, J. Johnson, Z. Popovic, "Iterative Technique for Computing Soliton Solutions of Nonlinear Lossless Spatially-Periodic Electrical Networks," *2021 17th International Congress on Artificial Materials for Novel Wave Phenomena (Metamaterials)*, Crete, Greece, 2023.

C. Scarborough, "Coupled Mode Solution for Spatially-Discrete Traveling-Wave Modulated Shunt Resonators," *IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, Portland, OR, USA, 2023.*

C. Scarborough, Q. Chen, Z. Wu, and A. Grbic, "Simulating Space-Time Structures using Commercial Solvers," *2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting*, Denver, CO, USA, 2022.

C. Scarborough and A. Grbic, "Spatially-Discrete Traveling-Wave Modulation: A Higher-Order Space-Time Symmetry," in *The 16th European Conference on Antennas and Propagation (EuCAP 2022)*, Madrid, Spain, 2022.

C. Scarborough and A. Grbic, "Generalized Eigenvalue Problem for Spatially-Discrete Traveling-Wave-Modulated Circuit Networks," *2021 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting*, Marina Bay Sands, Singapore, 2021.

C. Scarborough and A. Grbic, "Efficient Subharmonic Frequency Conversion Using Space-Time Induced Bound States in the Continuum," in *2021 15th International Congress on Artificial Materials for Novel Wave Phenomena (Metamaterials)*, New York, NY, USA, 2021.

C. Scarborough and A. Grbic, "The Interpath Relation for Spatially-Discrete Traveling-Wave Modulated Structures," in *The 15th European Conference on Antennas and Propagation (EuCAP 2021)*, 2021.

C. Scarborough and A. Grbic, "A Novel Boundary Condition for Spatially-Discrete Traveling-Wave Modulation," *Waves in Time-Varying Media Workshop Series*, London, UK, 2021.

C. Scarborough and A. Grbic, "Modified Floquet Boundary Condition for Open Boundary Problems with N-Path Symmetry," in *2020 14th International Congress on Artificial Materials for Novel Wave Phenomena (Metamaterials)*, New York, NY, USA, 2020.

C. Scarborough and A. Grbic, "Coupled Line Unit Cell for Independent Control of Even and Odd Mode Phase Delays," *2020 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting*, Montréal, Québec, Canada, 2020.

Z. Wu, C. Scarborough, and A. Grbic, "A Spatio-Temporally Modulated Metasurface as a Free-Space N-Path System," in *The 14th European Conference on Antennas and Propagation (EuCAP 2020)*, 2020.

C. Scarborough and A. Grbic, "Modified Floquet Scattering Matrix Method for Solving N-path Networks," *2019 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting*, Atlanta, GA, USA, 2019.

A. Grbic, C. Scarborough, F. Salas and Z. Wu, "Time-Modulated Metamaterials and Metasurfaces: Design and Analysis," *2019 International Conference on Electromagnetics in Advanced Applications (ICEAA)*, Granada, Spain, 2019.

C. Scarborough and A. Grbic, "N-Path Network Analysis using the Floquet Scattering Matrix Method," *2019 US National Committee of URSI National Radio Science Meeting (USNC-URSI NRSM)*, Boulder, CO, USA, 2019.

C. Scarborough, K. Venugopal, A. Alkhateeb, and R. W. Heath Jr., "Beamforming in Millimeter Wave Systems: Prototyping and Measurement Results," *The 88th IEEE Vehicular Technology Conference, VTC2018-Fall*, 2018.

A. Kumar, C. Scarborough, A. Yilmaz, and M. Orshansky, "Efficient simulation of EM side-channel attack resilience," *2017 IEEE/ACM International Conference on Computer-Aided Design (ICCAD),* 2017.

Patents

Provisional Patent: Z. Fritts, A. Babaee, C. Scarborough, S. M. Young, and A. Grbic, "Parametric Time-Modulated Electrically Small Antenna", Serial No. 18/782904, Filed July 24, 2024

Provisional Patent: C. Scarborough and A. Grbic, "Efficient Computation of Spatially-Discrete Traveling-Wave Modulated Structures", Serial No. 63/238379, Filed August 30, 2021.

Awards / Recognition

Finalist for Best Electromagnetics Paper Award at EuCAP 2022 – Spring 2022

Best Student Paper Award at Metamaterials 2021 – Summer 2021

Finalist for Best Experimental Poster at Waves in Time-Varying Media – Summer 2021

Best Student Paper Award at EuCAP 2021 – Spring 2021

Finalist for Best Electromagnetics Paper Award at EuCAP 2021 – Spring 2021

Exceptional Student Contributions Award at Metamaterials 2020 – Fall 2020

Finalist for Best Electromagnetics Paper Award at EuCAP 2020 – Spring 2020

Honorable Mention for Best Student Paper Competition at IEEE Symposium on Antennas and Propagation – Summer 2019

Teaching Experience

Electromagnetic Metamaterials (ECEN 5164), 13 Students – Spring 2025
Electromagnetic Fields I (ECEN 3400), 65 Students – Fall 2024
Capstone Mentor, 6 Students – Fall 2024
Remote Sensing Signals and Systems (ECEN 5254), 8 Students – Spring 2024
Electromagnetic Fields I (ECEN 3400), 48 Students – Fall 2023
Electromagnetic Metamaterials (ECEN 5164), 12 Students – Spring 2023
Microwave Laboratory (ECEN 4634/5634), 21 Students – Fall 2022