विद्युत अभियांत्रिकी विभाग
DEPARTMENT OF ELECTRICAL ENGINEERING
भारतीय प्रौद्योगिकी संस्थान कानपुर
INDIAN INSTITUTE OF TECHNOLOGY KANPUR
कानपुर– 208 016 (भारत)
KANPUR - 208 016 (INDIA)

Phone : (0512)-2597409
2597164
2597454
Fax : (0512)-2590063
Webpage : http://www.iitk.ac.in/ee

11th July, 2020

Dear Faculty/ Student,

Welcome to this series of 3-day High Intensity Training (HIT) programs on **Multi-user massive MIMO**, **mmWave MIMO/ OFDM** and **Cooperative/ NOMA technologies**, which form the pillars of 5G. Together these can achieve the central goals of 5G: *Enhanced Mobile Broadband* (eMBB ~ 10 Gbps), *Ultra-Reliable and Low Latency Communication* (URLLC < 1 ms) and *Massive Machine-Type Communications* (mMTC ~ 1M devices/ Sq km). Each program will be held in a Friday + Weekend format to make it especially convenient for students, faculty and working professionals to attend. Candidates can choose to attend individual or bundled programs depending on the technologies they would like to focus. Each program is self-contained and includes intense lecture sessions, tutorial problem solving, and hands-on MATLAB training modules. Expert guest lectures will also be delivered by eminent speakers from industry and academia.

http://www.iitk.ac.in/mwn/5GHIT/index.html

I request you to display the course flyer in your institution. Detailed list of topics to be covered is given in the end. Please do not hesitate to contact us for any further information

Thanking you,

(Prof. Aditya K. Jagannatham)
Arun Kumar Chair Professor,
IIT Kanpur
e-mail: mimo5G.iitk@gmail.com

HIT Program on 5G Multi-User and Massive MIMO 25th to 27th September	HIT Program on 5G Broadband mmWave MIMO-OFDM 2nd to 4th October	HIT Program on 5G Cooperative and NOMA Communication 9th to 11th October
1. Introduction and Key Specs of 5G Technologies 2. Introduction to 5G Massive MIMO Systems 3. Key Features of Massive MIMO and Advantages over Point-to-Point and MU-MIMO 4. Signal Processing Operations for Massive MIMO in UL and DL 5. Massive MIMO Channel Model – Large/ Small Scale Fading 6. Properties of Random Vectors and Massive MIMO Analysis 7. Analysis of Spectral Efficiency in Massive MIMO Systems and Power Scaling 8. MU-MIMO Precoding Zero Forcing 9. Block Diagonalization and Successive optimization for MU-MIMO 10. Pilot Design and Channel Estimation in Massive MIMO Systems 11. Trasmitter and Receiver Schemes with Imperfect CSI 12. Spectral Efficiency Analysis of Massive MIMO with Imperfect CSI 13. Power Scaling in Massive MIMO with Imperfect CSI and Comparison with Perfect CSI 14. Multi-Cell Massive MIMO Model 15. Channel Estimation with Pilot Reuse and Pilot Contamination 16. New Modulation Schemes for 5G- Spatial Modulation (SM), Space Shift Keying (SSK) and Optimal Receiver 17. Generalized Spatial Modulation (GSM) 18. Spectral Efficiency Comparison of GSM with Conventional V-BLAST 19. MATLAB Project on Massive MIMO System Implementation with Perfect CSI 20. Channel Estimation for Massive MIMO, Massive MIMO Performance with Imperfect CSI and Power Scaling 21. MATLAB Project on New Modulation Techniques for Massive MIMO – Spatial Modulation (SM) 22. MATLAB project on Space Shift Keying (SSK), Optimal ML Receiver Design, Bit-Error Rate Performance	1. Introduction and Key Specs of 5G Technologies 2. Opportunities and Challenges in mmWave MIMO Communication 3. Channel Models for mmWave MIMO Systems 4. Beamspace domain representation 5. Hybrid Signal Processing for mmWave MIMO 6. Digital Beamforming 7. Analog Beamforming 8. Hybrid RF/ BB Precoder and Combiner Design for mmWave MIMO 9. Hybrid Transceiver Architectures for mmWave MIMO 10. Sparse Signal Processing 11. Channel Estimation for mmWave MIMO 12. Optimal Design of Beams and Sensing Matrix for Channel Estimation 13. Overview of Sub 6GHz Multiple Antenna, MIMO Technologies 14. Signal Processing for MIMO Systems 15. Optimal Power Allocation and Precoding for MIMO 16. Single Carrier Broadband mmWave MIMO 17. Broadband mmWave MIMO-OFDM 18. Channel modelling and estimation for mmWave MIMO OFDM 19. Transceiver design for mmWave MIMO OFDM 20. MATLAB Project on mmWave MIMO Systems: mmWave MIMO Channel Modeling 21. MATLAB Project on Beamspace Channel Representation, Sparse Channel Estimation using OMP (Orthogonal Matching Pursuit), Comparison with Conventional Least Squares Estimation 22. MATLAB Project on Hybrid Transceiver Design for mmWave MIMO: Optimal RF Precoder/ Combiner Design 23. MATLAB Project on Baseband Precoder/ Combiner Design for mmWave MIMO Systems, Comparison with Ideal Digital Baseband Precoder/ Combiner	1. Introduction and Key Specs of 5G Technologies 2. Introduction to Non-Orthogonal Multiple Access (NOMA) Technology 3. Efficiency of NOMA wrto Conventional Orthogonal Multiple Access (OMA) 4. Fixed NOMA Protocol for UL/ DL – Performance Analysis 5. Probability of outage analysis 6. Ordered NOMA Protocol and Performance Analysis, Comparison with Fixed NOMA 7. Optimal Power Allocation for NOMA Systems 8. Fading Channels, Bit-Error Rate (BER) Analysis 9. Multiple Antenna Systems, Diversity concept 10. Multiple-Input Multiple-Output (MIMO) Technology, MIMO Receivers 11. Multi-user MIMO, Beamforming, Precoding 12. Cooperative Communication, Optimal Combining 13. BER Analysis and Diversity of Cooperative Communication 14. Optimal Power Allocation with Cooperation 15. Cooperative Communication, Optimal Combining 16. BER Analysis and Diversity of Cooperative Communication 17. Selective DF, Fixed DF and AF protocols 18. Optimal Power Allocation with Cooperation 19. Cooperative MIMO communication, Multi-Node Cooperation 20. MATLAB Project on Non-Orthogonal Multiple Access (NOMA) Systems, Fixed NOMA Protocol-UL and DL 21. MATLAB Project on Outage Probability Performance, Optimal Power Allocation 22. MATLAB Project on Ordered NOMA Protocol – Performance Analysis 23. MATLAB Project on Cooperative Communication, MIMO Cooperation