

## *Workshop on*

### *“Free-Space Laser Communications and Advanced FSO Systems”*

*14<sup>th</sup> and 15<sup>th</sup> September, 2013*

*at GTU, Chandkheda Campus.*

#### **Summary**

The course introduces and provides the fundamental concepts involved in understanding free-space laser communications with an emphasis to system design and performance evaluation. Free space optical (FSO) communication is becoming a mature field, but many exciting fundamental and technological challenges remain to improve its performance in a range of scenarios. Applications of FSO technology involving long range links, with mobile and airborne platforms, remain an area of active research and development that includes links through atmospheric turbulence and scattering media. Concepts for system and subsystem design using commercially available laser, optoelectronic components, and fast detectors will be developed. Starting from a basic treatment of the effects of atmospheric effects on high-data-rate laser signals, we discuss how to analyze overall link budget performance. The course will include the recent progress in FSO Communication concepts and the technology. Using the systems approach the course explains each topic with a focus on the impact of systems performance covering fundamentals, theory of operation and the recent developments with examples.

#### **Learning Outcomes**

At the end of the course participants will be able to:

- Understand basic operational principles of free-space laser communications
- Describe lasercom systems using fundamental design concepts
- Describe atmospheric propagation effects on lasercom performance
- Quantitatively evaluate degradation in system performance as a function of various atmospheric parameters
- Perform link budget analysis and calculate Bit Error Rate (BER)
- Follow recent applications and advances in FSO communications

#### **Course Materials**

The contents of the course will be covered from various materials the instructor uses which include: previous Short-Courses offered at SPIE Conferences, instructor's book – *Free-Space Laser Communications: Principles and Advances*, published by Springer, New York, N.Y., 2008 and the references from the upcoming book, *Advanced Free Space Optics (FSO): A Systems Approach*, to be published by Springer, 2013.

## Instructor

### **Arun K. Majumdar, PhD, Senior Scientist, Ridgecrest, California USA**

Dr. Majumdar has demonstrated leadership skills in Research and Development for the last 29 years from Industry, University and National Laboratory settings in the areas of atmospheric turbulence effects on free-space laser communications, propagation and imaging. His current research areas are Free-Space Laser Communications and advanced FSO Communications, Image corrections and Communications through atmospheric turbulence. His previous significant professional experience includes: University of Colorado (Full Professor, Electrical Engineering and Computer Science Dept.), Senior Research Scientist at Lockheed-California Company , NIST (Visiting Professor), Caltech's Jet Propulsion Laboratory, MIT Lincoln Laboratory (Staff Member), Brno University of Technology, Brno, Czech Republic (Visiting Professor), and Editor-in-Chief of JOFCR (Journal of Optical and Fiber Communications Research, Springer, New York (2009-2011) and Editor of the SPIE Proc. (2006-present). He has published over 60 refereed journal and Conference papers and technical reports, and serves as reviewer for IEEE, OSA, SPIE, Springer and Elsevier Journals. He is the co-chair of the SPIE's conference of Free-Space Laser Communications, 2013. [http://spie.org/app/program/index.cfm?fuseaction=conferencedetail&conference\\_id=2014100&event\\_id=896200](http://spie.org/app/program/index.cfm?fuseaction=conferencedetail&conference_id=2014100&event_id=896200) He has recently published a book: "*Free-Space laser Communications: Principles and Advances*", Arun K. Majumdar and Jennifer C. Ricklin, Springer, New York, 2008. He has been invited to provide seminars/Short Courses in various organizations some of which includes The Boeing Company, BAE Systems, UCLA, Colorado State University at Pueblo, Colorado, University of California at Riverside, California, University of Dayton, Ohio and Oxford University, UK.

## Course Outline

### 1. Introduction

- Definition of free-space laser communications
- Why optical communications? Optical / RF comparison
- Basic block diagram
- Applications overview

### 2. Major sub-systems for laser communications systems and Link Analysis

- Laser Transmitter
- Modulation methods
- Transmitting optics
- Optical Receiver
  - Photo-detectors
  - Pre-amplifier
  - Optics, Fiber Optics
- Acquisition, Pointing, and Tracking

### 3. Optical Signal Detection

- Direct Detection: Detection statistics

- SNR Bit-Error-Rate (BER) probability
- Coherent Detection

#### **4. Atmospheric Channel Effects**

- Attenuation
- Beam Wander
- Turbulence (Scintillation/ Fading)
- Turbid (rain, fog, snow)
- Cloud-free line of sight
- Received Power
- Link Margin
- Data Rate
- Reliability

#### **5. Basic Free-Space Laser Communications System**

- Atmospheric effects on Free-Space Laser Communications System
- Wavelength Selection
- Free-Space Lasercom Subsystems

#### **6. Free-Space Laser Communications Systems Performance**

- Metrics for evaluating the performance
- SNR and BER in presence of atmospheric turbulence
- Probability of Fade
- Examples
  - Terrestrial (Horizontal Link)
  - Uplink
  - Downlink

#### **7. Mitigating Turbulence Effects**

- Diversity Techniques
- Multiple Transmitters
- Adaptive Optics

#### **8. Animation Show**

#### **9. Summary: Improvement of Lasercom Performance**

#### **10. Recent Research and Development in FSO communications**

#### **11. Some Challenging Areas in FSO Communications**

#### **12. Concluding Remarks with an Opportunity for the students/participants to discuss their specific research topics/projects**

# *Gujarat Technological University*

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**Date of the program: 14<sup>th</sup>-15<sup>th</sup> September 2013**

**Time: 10:00 am to 5:00 pm.**

**Venue:**

Gujarat Technological University,  
Nr. Vishwakarma Government Engineering College  
Nr. Visat Three Roads, Visat - Gandhinagar Highway  
Chandkheda, Ahmedabad – 382424 - Gujarat

**Participants:**

All GTU affiliated Engineering faculties PhD Students/PG Students of Electronics/ Electronics & Communication/Electrical Engineering and related branch can participate in the short course. Dr. Majumdar would like to discuss current research areas, future vision etc., with faculty members as well as with the students about their projects for their thesis. This short course will be very much useful for the PG and PhD students who want to do research work in the area of Free Space Optical Communication.

**Send your confirmation by filling up the registration form for the participation in [conference@gtu.edu.in](mailto:conference@gtu.edu.in) on or before 07<sup>th</sup> September, 2013.**