### Introduction

A **bond graph** is a graphical representation of a physical dynamic system. The best way to study the dynamics of a system residing in multi-energy domain is to start with a schematic diagram, which includes its important components and portrays how they are connected together. Then one can show details of each component and specify the constitutive laws governing the components and subsystems they are in. Each energy domain has its own concepts, symbolic notations and equation. However, a basic similarity exists in the common underlying energy structure.

Since the form of equations of engineering systems do not express energy structure directly, this feature cannot be observed readily from the equations. Bondgraph is an explicit graphical tool for capturing the common energy structure of systems. In the vector form, they give concise description of complex systems. Moreover, the notation of causality provides a tool not only for formulation of system equations, but also for qualitative analysis of system behavior, viz. controllability, observability, fault diagnosis, etc.

In 1959, Professor Henry Paynte from MIT, USA gave the revolutionary idea of portraying systems in terms of power bonds, connecting the elements of the physical system to the so called junction structures which were manifestations of the constraints. This power exchange portrait of a system is called **Bondgraph** (some prefer to write as **Bond graph**), which can be both power and information oriented. Later on, Bondgraph theory has been developed and consolidated further by many researchers Karnopp, Margolis, Rosenberg Thoma , Cellier, Breedveld, Dauphin-Tanguy, Gawthrop , Smith, Wolfgang Borutzky, Mukherjee, Karmakar, Brown, Granda, and many more, who have worked on extending this modeling technique to power hydraulics, mechanics, mechatronics, general thermodynamic systems and recently to electronics and non-energetic systems like economics and queuing theory.

Through Bondgraph approach, a physical system can be represented by symbols and lines, identifying the power flow paths. The lumped parameter elements of resistance, capacitance and inertance are interconnected in an energy conserving way by bonds and junctions resulting in a network structure. From the pictorial representation of the bondgraph, the derivation of system equations is so systematic that it can be algorithmized. The whole procedure of modeling and simulation of the system may be performed by some of the existing software e.g., ENPORT, Camp-G, SYMBOLS, 20Sim, Dymola etc.

The lecture series is being organized with the following objectives:

- To create awareness on various Bondgraph Modelling techniques and its impact on current research and industry.
- To impart fundamental as well as advanced knowledge of some of these areas to potential users, teachers and researchers.

 These lectures also aims at providing a brief introduction to Bondgraph method of modelling in engineering systems and use of Symbol Sonata and 20SIM software to simulate the model and analyse the electro mechanical, Hydro and Thermal systems.

### **Course Contents**

- Introduction to modelling techniques.
- Introduction to Bondgraph: A unified approach.
- Concept of power direction causality.
- Bondgraph Model of Multi engineering domain, Fault Diagnostic and Isolation
- Generation of system equation.
- Simulation example of electro mechanical hydraulic system, Thermal system, Electrical system.
- New trends in Bondgraph modelling.
- Hands-on training on symbol sonata, 20 SIM and other software.Resource Persons

### About the Expert



Wolfgang Borutzky is a professor of Modelling and Simulation of Engineering Systems at Bonn-Rhein-Sieg University of Applied Sciences, Germany. He obtained his University Diploma Degree in Mathematics in 1979 and his Doctoral Degree in

Mechanical Engineering in 1985, both from the Technical University of Braunschweig, Germany.

He was a visiting professor at universities in the Netherlands, the U.S.A., France, and in Argentina. Since 2008 he holds an honorary position as Associate Professor of Electrical Engineering and Information Technology at the University of Dubrovnik, Croatia.

His main research interests include modelling and simulation methodologies for multidisciplinary systems, in particular Bond Graph-based as well as object oriented modelling; modelling, analysis, control and fault diagnosis of mechatronic systems; modelling languages; software design for modelling and simulation of continuous, as well as hybrid systems; scientific computing, numerical algorithms and software design for (parallel) continuous system simulation.

### Participants

The program is open to the faculty/Research Scholar/ PG / UG Students of AICTE/UGC approved engineering Institute/ University and the persons from industries working in the area of modeling, simulation and related fields.

#### Registration

Registration form in the prescribed format should reach the Coordinator on or before 27<sup>th</sup> September 2018. To avoid any delay in this, the applicants may send an advance copy before the due date. The selection letter will be sent only through e-mail, on or before 29<sup>th</sup> September 2018.

#### Accommodation and Travel

Accommodation for pre-registered delegates can be arranged in campus (guest house or hostel) / hotel on prior request, as per availability. The delegates will have to bear the expenses. As per TEQIP-III guidelines, TA/DA of the participant will not be permitted.

### About DTU, Delhi

Delhi Technological University. also referred to as DelTech, was established in 1941 as Delhi Polytechnic. Later called Delhi College of Engineering, the college was under the government of the National Capital Territory of Delhi since 1963 and affiliated to the University of Delhi since 1952. In July 2009 DCE was upgraded to a state university and renamed Delhi Technological University. It offers courses towards B. Tech, M. Tech, MBA, and Ph.D. and contains 14 academic departments with a strong emphasis on scientific and technological education and research. The essence has always been the same - to quench the thirst of knowledge and work towards the better future of the country. The whole and sole motive of DTU has been to leave no stone unturned to spread knowledge far and wide.

### About Technical Education Quality Improvement Program-III

Delhi Technological University has been selected as Mentor Institute for the TEQIP-

III Project for Madhav Institute of Technology and Science, Gwalior is w.e.f. 01.04.2017 and shall conclude by 30<sup>th</sup> September, 2020. The institute is covered under Sub-component 1.3: Twinning Arrangements to Build Capacity and Improve Performance. The main objectives of TEQIP-III Project at DTU are ; Improving quality and equity in engineering institutions in focus states, System-level initiatives to strengthen sector governance and performance which include widening the scope of Affiliating Technical Universities (ATUs) to improve their policy, academic and management practices towards affiliated institutions, and Twinning Arrangements to Build Capacity and Improve Performance of institutions and ATUs participating in focus states.

Sub-component 1.3 : Twinning Arrangements to Build Capacity and Improve Performance of Participating Institutions and ATUs, Some of the suggested activities under the scope of the project are given below:

- Procurement of Goods (equipment, furniture, books LRs, software and minor items) and minor civil works
- Improvement in Teaching, Learning and Research competence
- Improve student learning
- Student employability
- Increasing faculty productivity and motivation
- Establishing a twinning system
- Twinning arrangements with institutions under Sub-component 1.1 to build capacity and improved performance
- Individual Institutional mentors

# APPLICATION FORM TEQIP-III sponsored International Lecture Series on BONDGRAPH MODELLING AND SIMULATION (BMS-2018) (01<sup>st</sup> – 05<sup>TH</sup> Oct 2018)

- 1. Name:
- 2. Date of Birth:
- 3. Designation
- 4. Institution:
- 5. Whether the institution has AICTE/UGC approval

### Yes/ No

Signature

- 6. Address for correspondance :
  - E-mail:
  - Mobile:
- 7. Educational qualifications:
- 8. Experience (in years)
  - Teaching
  - Industry
  - Research
- 9. Accommodation Required Yes/ No

### Declaration

The information provided is true to the best of my knowledge. If, selected, I agree to abide by the rules and regulations of the course and shall attend the course for the entire duration. I also undertake the responsibility to inform the Coordinator in case, I am unable to attend the course.

Place: Date:

### SPONSORSHIP CERTIFICATE

Dr/Mr/Mrs/Ms------ is an employee/ RS of our institute and is hereby sponsored to participate in the International Lecture Series on Bondgraph Modelling and Simulation (BMS-2018)

Place:

Date: Signature of Head of Institution

Mail the Registration form to: Prof. Atul Kumar Agarwal akadce@gmail.com

Dr. Pushpendra Singh Pushpendra@dtu.ac.in

TEQIP- III Cell, 2nd Floor, Department of Mechanical Engineering, Delhi Technological University, Shahbad Daulatpur, Delhi-110042

Email Address: akadce@gmail.com; Pushpendra@dtu.ac.in

Cell: +91-9811886443; 9958956906

For further details visit institute Website. www.dtu.ac.in Brochure can be downloaded by the link provided.

## International Lecture Series on BONDGRAPH MODELLING AND SIMULATION (BMS-2018) (01<sup>ST</sup> – 05<sup>TH</sup> Oct 2018)

**Funded by** Technical Education Quality Improvement Program-III



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Prof. Atul Kumar Agarwal Dr. Pushpendra Singh

**Co-coordinators** 

Dr. Sushila Rani Dr. Paras Kumar

Organized by Technical Education Quality Improvement Program-III (TEQIP-III) Delhi Technological University (University Estd. by Govt. of N.C.T. of Delhi)

Shahabad Daulatpur, Main Bawana Road, Delhi-110042