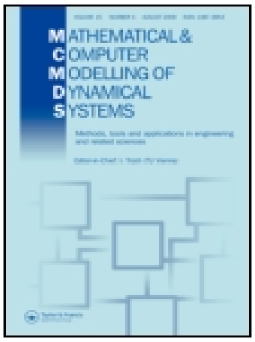

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Editorial

Bond graph modelling

This special issue of the journal *Mathematical and Computer Modelling of Dynamical Systems* is devoted to *bond graph modelling*, a methodology particularly suited for modelling multidisciplinary dynamic engineering systems in which components from different disciplines dynamically interact by exchanging energy and in which different forms of energy are involved. Often the artificial term *mechatronic systems* is used. According to the consideration of energy flows in an engineering system the vertices of a bond graph denote subsystems, system components or elements while the edges called power bonds or bonds for short represent energy flows between them. The nodes of a bond graph have got so-called power ports where energy can enter or leave. Therefore, bond graph nodes are also termed *multiports*. For each bond a half arrow indicates the reference direction of the energy flow. Furthermore, each bond carries two conjugated variables whose product is the instantaneous power between the power ports of two bond graph nodes. Suppose a bond connects two elements A and B. Then from a computational point of view one of the two power conjugated variables called *effort* and *flow* is computed in element A, while the other is computed in element B. The decision, in which element the effort is computed, is expressed by a perpendicular stroke attached to the bond and is called assignment of *computational causality*. Figure 1 shows an example of a bond graph model of a dc motor with constant excitation. We do not want to go into details in this editorial and just point to reference directions of

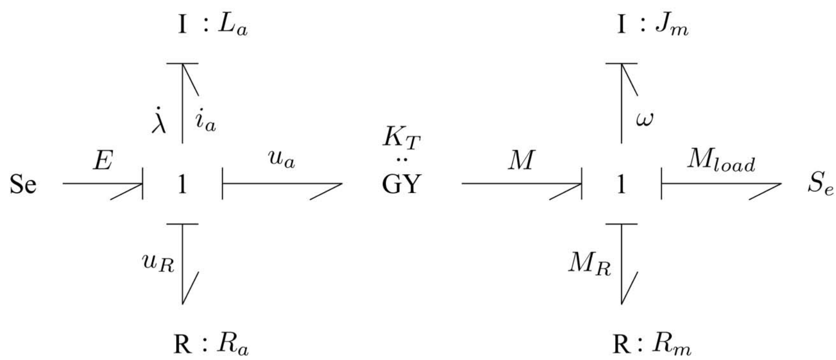

Figure 1. Bond graph model of a dc motor with constant excitation.

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the energy flows. Furthermore, the 1-junction in the left part of the graph provides the effort λ, while the element I:L_a returns the flow i_a to the 1-junction.

Bond graphs have the following attractive features among others.

(a) As other modelling paradigms, e.g. generalized networks, bond graphs are based on an analogy allowing for a *uniform* modelling of systems across energy domains.
(b) At lowest hierarchy level a small set of elements denote fundamental energy processes.
(c) A bond graph model can be constructed in a systematic manner from a system schematic. Before simplification it shows a clear affinity with the topological structure of the schematic.
(d) A bond graph can serve as a core model representation that can be transformed into other graphical representations, e.g. into a block diagram if needed. In addition, different forms of mathematical models, e.g. descriptor equations, Lagrange equations, or transfer functions can be directly derived from a bond graph depending on the purpose of a system analysis.
(e) A bond graph can provide a lot of information about a mathematical model to be derived from the graph before any equations are written and reformulated. Moreover, structural properties of the model, e.g. structural controllability and observability, can be analysed directly on a bond graph.

Bond graphs were devised by Professor H. Paynter at Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts, USA as early as 1959 [1]. His former PhD students Professor Karnopp, Professor Margolis (University of California at Davis) and Professor Rosenberg (Michigan State University, East Lansing, Michigan) elaborated this graphical model representation into a methodology that has experienced a considerable progress over the decades due to the steady work of many researchers all over the world. Since then apart from many research papers and a number of textbooks in different languages [2–5] a number of special issues on bond graph modelling have been published in different journals [6,7] with the aim of reflecting a part of contemporary research on and application of bond graph modelling in various areas. An excellent exposure of bond graph modelling can be found in the highly recognized textbook of Karnopp, Margolis and Rosenberg [8] of which the third edition was published in 2000. Readers who quickly want to become familiar with the concepts of bond graph modelling and are looking for a brief introduction are referred to the excellent 28 pages *Introduction to Physical Systems Modelling with Bond Graphs* by J.F. Broenink [9]. Moreover, bond graph modelling is supported by a number of advanced modelling and simulation software packages.

This special issue has arisen from contributions to an invited session on bond graph modelling that was part of the 2003 Conference on Mathematical Modelling (4th MATHMOD) in Vienna, Austria. The guest editors asked some authors to extend their conference paper and invited some other researchers to contribute additional papers. The articles of this issue compiled in alphabetic order with regard to the first author's name of each paper clearly demonstrate that bond graphs are a powerful tool for examining different subjects in various application areas.

It is our hope that the articles in this issue stimulate readers to have a look into the vault of bond graph related publications in order to see how bond graph modelling can help them to better understand physical processes and the behaviour of systems and to develop good models in their engineering field.

The Guest Editors of this Special Issue would like to thank all authors for their contribution and the referees for their detailed comments and recommendations. We also acknowledge the feedback of the anonymous peer reviewers of our own contributions.

Our special thanks go to the Editor in Chief of this journal, Professor I. Troch, who was so kind to offer interested bond graph modellers this excellent opportunity to present their research beyond the conference to the public. Eventually, we would like to thank all persons involved in the making of this special issue on bond graph modelling for their excellent cooperation.

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