Programming of the DSP2 board with Matlab/Simulink

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Presentation overview

- Introduction
- DSP2 board
- DSP2 Library for Simulink
- Conclusion
About DSP2 board...

- DSP2 board was developed at the Institute of Robotic, FERI Maribor;
- It based on Texas Instruments signal processor TMS320C32 with floating point arithmetic and Xilinx FPGA of Spartan family;
- It’s primary in use for torque, speed and position control of AC and DC motors;
- Until recently programming of the DSP2 board was possible only in C programming language:
  - Programming in C is much easier and faster that programming in assembler language;
  - Still takes a long time from simulation of control algorithm to the realization of the same algorithm on the target system (DSP2 board)
  - Coding errors are very often presented. They additionally extends development time;
Matlab, Simulink, Real-Time Workshop

Matlab

• Matlab is simulation program that is widely in use in many faculties and companies around the world in researching area of dynamic systems;
• It’s an interactive tool for modeling, analysis and visualization of dynamic systems;
• Contains more than 600 mathematical functions (without additional toolboxes);
• Etc.

Simulink

• Simulink is Matlab add-on software that enables simulation and analysis of dynamic, electric and mechanical systems;
• Enables simulation of linear, nonlinear, discrete, continuous and hybrid systems;
• Block programming;
• It’s possible to include custom block to the Simulink model;
Matlab, Simulink, Real-Time Workshop

– Real Time Workshop (RTW)
  • RTW is Simulink add-on software that enables automatic C or ADA code generation from the Simulink model;
  • On the fast and easy way generates good optimized C code;
  • In general it generates two types of C code:
    – generic C code;
    – embedded C code (production code).
  • Generated code can executes on PC, microcontrollers, signal processors, etc;
Programming of the DSP2 board with Simulink

MATLAB/ Simulink/ RTW

DSP2 board

Converter with the DSP2

Program download

RS-232

Online signal monitoring and parameter tuning

C code

Code Composer

Binary code

DSP Terminal
Programming of the DSP2 board with the Simulink

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DSP2 teaching aid

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Commercial available systems

- dSPACE
  - one board systems
  - modular systems
    - DS1102 DSP
    - DS1103 PPC
- Wind River Systems
- Signologic
- Humusoft
- etc.
Basic features of the DSP2 board

- Signal processor TI TMS320C32-60MHz
- Xilinx FPGA of Spartan family
- SRAM 128Kx32
- FLASH ROM 256Kx8 – 70ns
- 4x12 bit A/D converter
  - 1x unipolar input
  - 2x bipolar input
  - 1x bipolar multiplexed input (8/1)
- 2x12 bit D/A converter
- CAN controller
- 3x optical isolated logical input
- 1x optical isolated logical output
- RS232 connection with the PC
- RS 485 interface for incremental encoder
- 3 phase pulse width modulator
- etc.
DSP2 Library for Simulink

DSP2 Library for Simulink enables programming of the DSP2 board with Simulink.
DSP2 I/O blocks subsystem

Subsystem contains the following blocks:

- Analog input/output
- Digital input/output
- From/To memory
- Pseudo-random binary sequence (PRBS)
- Transformations:
  - $dq \rightarrow ab$
  - $ab \rightarrow dq$
  - $\text{rad/s} \rightarrow \text{RPM}$
  - $\text{RPM} \rightarrow \text{rad/s}$
Executable code generation process

MATLAB → Simulink

Template makefile (.tmf)

TLC function library
TLC system file (.tlc)
TLC block TLC files (.tlc)

Real - Time Workshop

Target compiler
(Target Language Compiler)

Compiler
(Code Composer)

MAKE
(gmake)

Target system
(DSP2 board)

System design and Simulation

C code generation

Executable code generation

Downloading executable code to the target system
Initialization of GUI of the DSP Terminal

Simulink model
Online parameter tuning

Simulink

"Parameter Inspector" window in the DSP Terminal

Only desired Simulink scalar parameters

All Simulink scalar parameters
Supported blocks – additional toolboxes

The following toolboxes can be used on the DSP2 board:

- Simulink (only discrete blocks!)
- Simulink Extras
- StateFlow
- DSP Blockset
- Neural Network Toolbox
- Fuzzy logic Toolbox
- Fixed-Point Blockset
- etc.
Example – speed control of the AC motor
Example – fixed point arithmetic on the DSP2 board

“Fixed-point” algorithm

Conversion from floating point arithmetic into fixed point arithmetic

Conversion from fixed point arithmetic back into floating point arithmetic
DSP2 teaching aid

DSP2 board

DSP2 I/O connector

Plants:
- 1., 2. or 3. order system
- H-bridge for DC motor
DSP2 teaching aid

H- bridge

DC motor
Multimedia tutorial for novice users

- 12 movies in total length of approximately 40 min in which the principle of operation of the DSP2 Library is explained;
- Movies are in Slovene language and are primarily designed for students;
- Movies are in flash format of standard size 800x600 and are accessible on the DSP2 web page;
Conclusion

- **Matlab/Simulink/RTW**
  - “Real-Time Workshop” generates well optimized C code that is comparable with the hand written C code;
  - Simulink and Real-Time Workshop open architecture enables:
    - inclusion of the custom blocks with the custom algorithms;
    - development of the custom target (like it was presented for the DSP2 board);

- **DSP2 board**
  - In combination with the DSP2 Library presents some kind of alternative for the commercial systems;
  - DSP2 Library for Simulink:
    - Deep knowledge of the DSP programming is not needed;
    - Enables rapid transition from the simulation in Simulink to the real time operation on the DSP2 board;
    - Contains special blocks for the motor control;
Future work

• Replacement of an existing RS-232 connection between PC and the DSP2 board with the TCP/IP or USB;
• Simulink “External mode” operation;
Thank you for your attention!

DSP2 board web page: www.ro.feri.uni-mb.si/projekti/dsp2