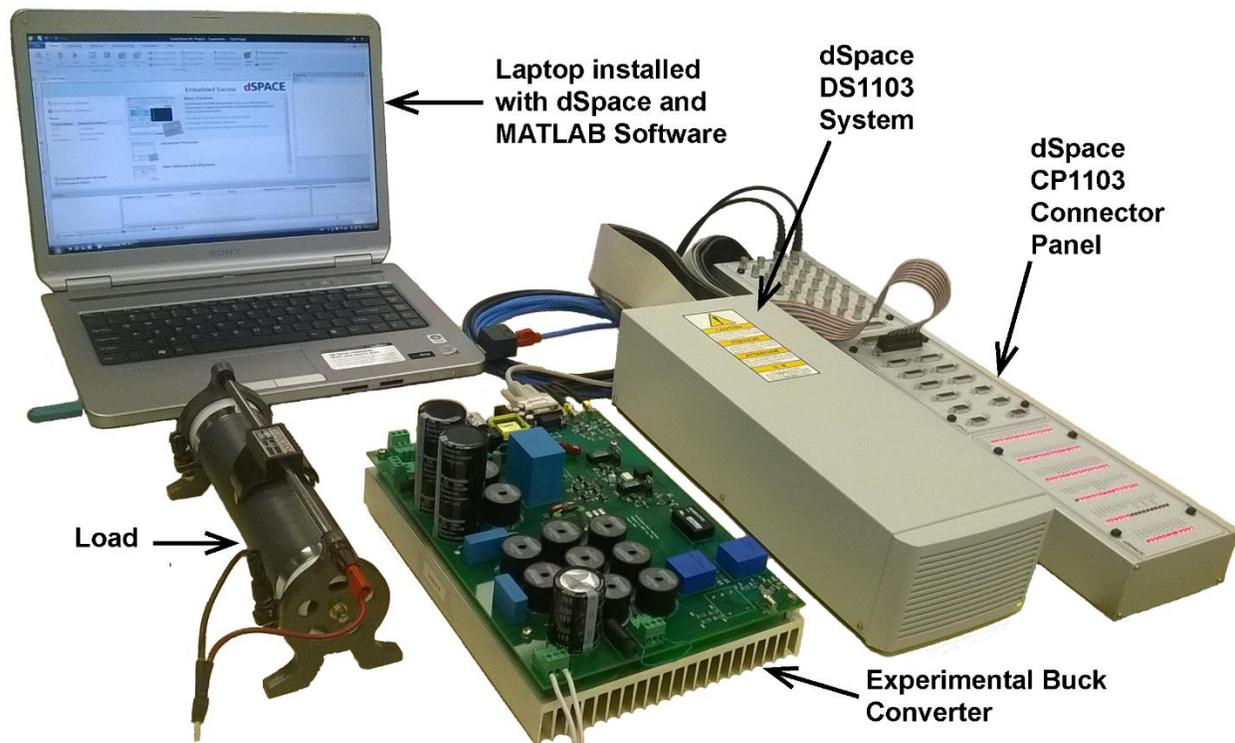


Report on the dSPACE Experiments for Hysteresis Controlled Buck Converter

System Hardware Requirements: This requires DS1103 System Board, Dongle Key for licensing, Microtec PowerPC C Compiler (that generates executable code for DS1103 PowerPC processor) and CP 1103 Connector Panel. The host PC should be x86-compatible with host processor at least Pentium 4 at 2GHz, 1 GB RAM, and DVD drive for software installation.

System Software Requirements: MATLAB/SIMULINK Release 2014a, Real-Time Interface (RTI), and ControlDesk Next Generation. Software compatibility information is available on: <https://www.dspace.com/en/inc/home/support/supvers.cfm>

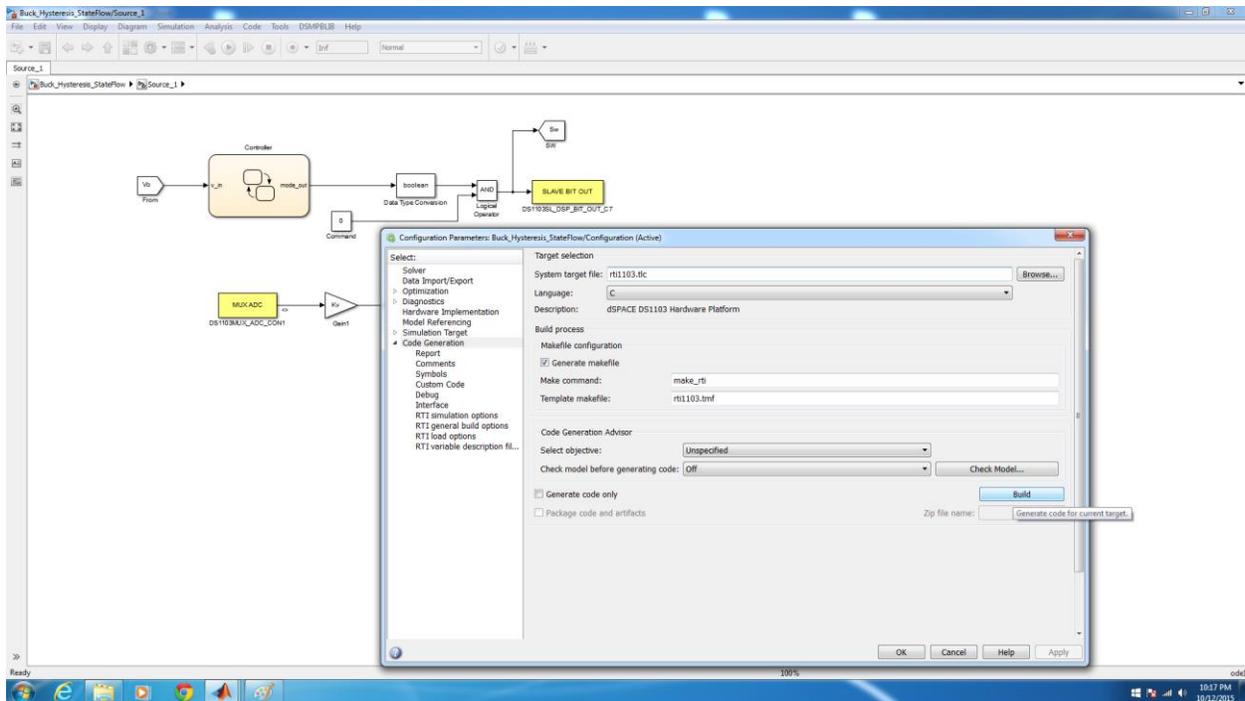
The experimental setup is shown below:



Code Generation Process:

The first step towards code generation is to build a Simulink/Stateflow (SLSF) model that has the software interface between the controller and the plant. This software interface is provided by the Real-Time Interface (RTI) Block library (Type 'rti' in MATLAB command window to display the library). The I/O resources for DS1103 system are split between the two processors on the board, i.e., Master PPC (Power PC) and Slave DSP F240. The user may select any of these I/O resources to use these as interface between the controller and the plant as per requirement.

Once the model is ready, the next step is to generate the C code. From Simulink model, use “Simulation => Configuration Parameters => Code Generation => Build” as shown in screenshot below:



C code is then automatically generated, compiled and linked by the Power PC processor in DS1103. If there is any error during the build process, the user is notified through the “Diagnostic Viewer” in MATLAB. Upon successful completion of the build process, the user is notified with message “Make Process Succeeded” in the Diagnostic Viewer within MATLAB. Different phases of code generation are shown in screenshots below:

```

Diagnostic Viewer
Buck_Hysteresis_StateFlow
Build # 2
10:18:17 PM 10/12/2015 Elapsed: 3 sec
Build # 3
10:19:08 PM 10/12/2015 Elapsed: 30 sec
Starting build procedure with RTI 7.2 (RTI1103, 02-May-2014)
Model: "Buck_Hysteresis_StateFlow" (C:\Users\Davoud\Desktop\MATLAB Files\Buck_Hysteresis_State Flow\Buck_Hysteresis_StateFlow.mdl)
*** Using configuration set: "Configuration"
*** Working directory: "C:\Users\Davoud\Desktop\MATLAB Files\Buck_Hysteresis_State Flow"
*** Initializing code generation
*** Starting Simulink Coder build procedure for model: Buck_Hysteresis_StateFlow

Code Generation
Elapsed: 28 sec
*** Generating code into build folder: C:\Users\Davoud\Desktop\MATLAB Files\Buck_Hysteresis_State Flow\Buck_Hysteresis_StateFlow_rti1103
Matching "From" for "Goto" "Buck_Hysteresis_StateFlow\Source_1\5a" not found
Component: Simulink [Category:NA]
Unconnected output line found on "Buck_Hysteresis_StateFlow\Ref_Voltage" (output port: 1)
Component: Simulink [Category:NA]
The model "Buck_Hysteresis_StateFlow" does not have continuous states, hence Simulink is using the solver "fixedstepdiscrete" instead of solver "ode45". You can disable this diagnostic by explicitly specifying a discrete solver in the solver tab of the Configuration Parameters dialog, or by setting the "Automatic solver parameter selection" diagnostic to "none" in the Diagnostics tab of the Configuration Parameters dialog
Component: Simulink [Category:NA]
*** Optional User System Description File buck_hysteresis_stateflow_usr.sdf not available
*** Invoking Target Language Compiler on Buck_Hysteresis_StateFlow.rtw
*** Using System Target File: C:\Program Files\dspace RCPMIL 2014-A\MATLAB\RTI\RTI1103\TLC\rti1103.tlc
*** Loading TLC function libraries
*** Initial pass through model to cache user defined code
*** Postprocessing RTI blocks
*** Starting I/O block checking
*** Passed I/O block checking
*** Caching model source code
*** Writing source file Buck_Hysteresis_StateFlow.c
*** Writing header file Buck_Hysteresis_StateFlow_private.h
*** Writing header file Buck_Hysteresis_StateFlow.h
*** Writing header file Buck_Hysteresis_StateFlow_types.h
*** Writing header file struct_isB4Cw30ppVfP8RUQD.h
*** Writing header file rtatypes.h
*** Writing header file multiword_types.h
*** Writing header file rtmodel.h
*** Writing source file Buck_Hysteresis_StateFlow_data.c
*** Writing header file rt_nonfinite.h
*** Writing source file rt_nonfinite.c
*** Writing header file rt_defines.h
*** Writing header file rtGetInf.h
*** Writing source file rtGetInf.c
*** Writing header file rtGetNaN.h
*** Writing source file rtGetNaN.c
*** TLC code generation complete.
*** Generating TLC interface API.
*** Generating file Buck_Hysteresis_StateFlow_rti.c
*** Generating file Buck_Hysteresis_StateFlow_rti.m
*** Generating Variable Description File Buck_Hysteresis_StateFlow_trc
.....
NOTE: The following option in the Configuration Parameters dialog has been used:
Optimization:
"Conditional input branch execution" On
This leads to code optimization in which blocks are not computed if their outputs are not required in the simulation step, for example, if their output values are used as input for a Switch block and the Switch currently routes another signal. When the corresponding output signals are displayed in ControlDesk, their values are static.
To ensure that the blocks are computed, turn off the "Conditional input branch execution" option and rebuild the model.
*** Found User-Code File Buck_Hysteresis_StateFlow_usr.c from 10-Oct-2015 10:41:03
*** Found User Makefile Buck_Hysteresis_StateFlow_usr.mk from 10-Oct-2015 10:41:03
*** Optional User Variable Description File Buck_Hysteresis_StateFlow_usr.trc not available
*** Processing Template Makefile: C:\Program Files\dspace RCPMIL 2014-A\MATLAB\RTI\RTI1103\RTI\rti1103.tmf
*** Buck_Hysteresis_StateFlow.mk which is generated from C:\Program Files\dspace RCPMIL 2014-A\MATLAB\RTI\RTI1103\RTI\rti1103.tmf is up to date
*** Building Buck_Hysteresis_StateFlow: "MDSpace_SootH\Ips-dspace.exe" -f Buck_Hysteresis_StateFlow-mk EXTHOOK_STATIC_ALLOC=0 EXTHOOK_TRANSPORT=0 NAT_FILE=0 NCLIENT="OPTION_DISABLED" BUILDING_APPLICATION "Buck_Hysteresis_StateFlow" (Single Timer Task Mode)
WORK DIRECTORY "C:\Users\Davoud\Desktop\MATLAB Files\Buck_Hysteresis_State Flow"
BUILD DIRECTORY "C:\Users\Davoud\Desktop\MATLAB Files\Buck_Hysteresis_State Flow\Buck_Hysteresis_StateFlow_rti1103"
TARGET COMPILER "C:\Program Files\dspace RCPMIL 2014-A\Compiler\UPCTools"
COMPILING "Buck_Hysteresis_StateFlow.c"
COMPILING "Buck_Hysteresis_StateFlow_data.c"
COMPILING "Buck_Hysteresis_StateFlow_trc_ptr.c"
COMPILING "rtGetInf.c"
COMPILING "rtGetNaN.c"
COMPILING "rt_nonfinite.c"
COMPILING "C:\Program Files\dspace RCPMIL 2014-A\MATLAB\RTI\RTI\rti_sim_engine.c"
LINKING APPLICATION ...
LINKING FINISHED
LOADING APPLICATION "Buck_Hysteresis_StateFlow.sdf" ...
PLATFORM: DS1103
[#1] ds1103 - RTI: DS1103 serial number: 43407 (0)
[#2] ds1103 - RTI: Application UUID: 5F00364-0806-4FF9-8201-83F02470F7D5 (0)
[#3] ds1103 - RTI: Initializing ... (720)
[#4] ds1103 - RTI: DS1103: dSPACE firmware rev. 3.4 detected. (500)
[#5] ds1103 - RTI: Initialization completed (731)
[#6] ds1103 - RTI: Simulation state: RUN (700)
LOADING FINISHED
MAKE PROCESS SUCCEEDED
*** Successful completion of Simulink Coder build procedure for model: Buck_Hysteresis_StateFlow
*** Finished RTI build procedure for model Buck_Hysteresis_StateFlow
Build process completed successfully

```

```

Diagnostic Viewer
Buck_Hysteresis_StateFlow
*** Writing source file rtGetNaN.c
*** TLC code generation complete.
*** Generating TLC interface API.
*** Generating file Buck_Hysteresis_StateFlow_rti.c
*** Generating file Buck_Hysteresis_StateFlow_rti.m
*** Generating Variable Description File Buck_Hysteresis_StateFlow_trc
.....
NOTE: The following option in the Configuration Parameters dialog has been used:
Optimization:
"Conditional input branch execution" On
This leads to code optimization in which blocks are not computed if their outputs are not required in the simulation step, for example, if their output values are used as input for a Switch block and the Switch currently routes another signal. When the corresponding output signals are displayed in ControlDesk, their values are static.
To ensure that the blocks are computed, turn off the "Conditional input branch execution" option and rebuild the model.
*** Found User-Code File Buck_Hysteresis_StateFlow_usr.c from 10-Oct-2015 10:41:03
*** Found User Makefile Buck_Hysteresis_StateFlow_usr.mk from 10-Oct-2015 10:41:03
*** Optional User Variable Description File Buck_Hysteresis_StateFlow_usr.trc not available
*** Processing Template Makefile: C:\Program Files\dspace RCPMIL 2014-A\MATLAB\RTI\RTI1103\RTI\rti1103.tmf
*** Buck_Hysteresis_StateFlow.mk which is generated from C:\Program Files\dspace RCPMIL 2014-A\MATLAB\RTI\RTI1103\RTI\rti1103.tmf is up to date
*** Building Buck_Hysteresis_StateFlow: "MDSpace_SootH\Ips-dspace.exe" -f Buck_Hysteresis_StateFlow-mk EXTHOOK_STATIC_ALLOC=0 EXTHOOK_TRANSPORT=0 NAT_FILE=0 NCLIENT="OPTION_DISABLED" BUILDING_APPLICATION "Buck_Hysteresis_StateFlow" (Single Timer Task Mode)
WORK DIRECTORY "C:\Users\Davoud\Desktop\MATLAB Files\Buck_Hysteresis_State Flow"
BUILD DIRECTORY "C:\Users\Davoud\Desktop\MATLAB Files\Buck_Hysteresis_State Flow\Buck_Hysteresis_StateFlow_rti1103"
TARGET COMPILER "C:\Program Files\dspace RCPMIL 2014-A\Compiler\UPCTools"
COMPILING "Buck_Hysteresis_StateFlow.c"
COMPILING "Buck_Hysteresis_StateFlow_data.c"
COMPILING "Buck_Hysteresis_StateFlow_trc_ptr.c"
COMPILING "rtGetInf.c"
COMPILING "rtGetNaN.c"
COMPILING "rt_nonfinite.c"
COMPILING "C:\Program Files\dspace RCPMIL 2014-A\MATLAB\RTI\RTI\rti_sim_engine.c"
LINKING APPLICATION ...
LINKING FINISHED
LOADING APPLICATION "Buck_Hysteresis_StateFlow.sdf" ...
PLATFORM: DS1103
[#1] ds1103 - RTI: DS1103 serial number: 43407 (0)
[#2] ds1103 - RTI: Application UUID: 5F00364-0806-4FF9-8201-83F02470F7D5 (0)
[#3] ds1103 - RTI: Initializing ... (720)
[#4] ds1103 - RTI: DS1103: dSPACE firmware rev. 3.4 detected. (500)
[#5] ds1103 - RTI: Initialization completed (731)
[#6] ds1103 - RTI: Simulation state: RUN (700)
LOADING FINISHED
MAKE PROCESS SUCCEEDED
*** Successful completion of Simulink Coder build procedure for model: Buck_Hysteresis_StateFlow
*** Finished RTI build procedure for model Buck_Hysteresis_StateFlow
Build process completed successfully

```

Resources Used from dSpace DS1103 System:

Using Real-time Interface (RTI), we can include the resources from these boards in SLSF model. In our experiment, we have used following two resources of dSpace system using RTI in Stateflow models.

1. For Data Flow from Plant to Controller: We have used multiplexed ADC (of Master Power PC) to feed the voltage to the controller.

2. For Data Flow from Controller to Plant: The controller produces on/off pulses for the MOSFET switch of the plant. The Boolean valued signal is fed to the Buck converter using the I/O channel (of the Slave TI DSP). The controller generates non-periodic pulses based on the hysteresis band.