TI C2000™ 듀얼코어 마이크로 컨트롤러에 모터제어 알고리즘을 배포하기 위한 솔루션

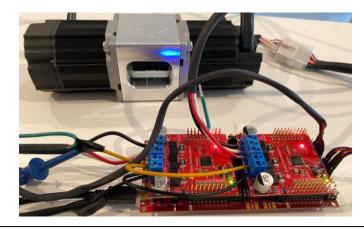
정승혁 차장, 매스웍스코리아

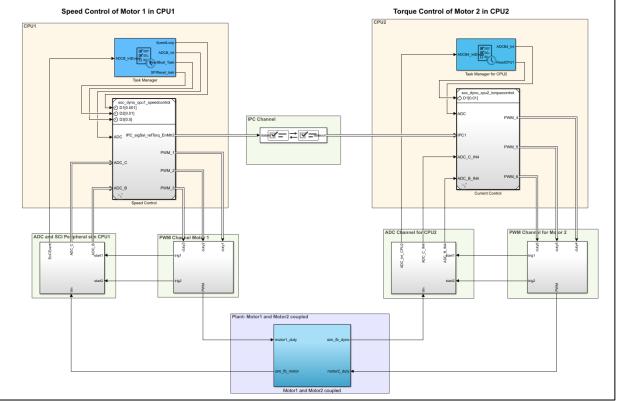




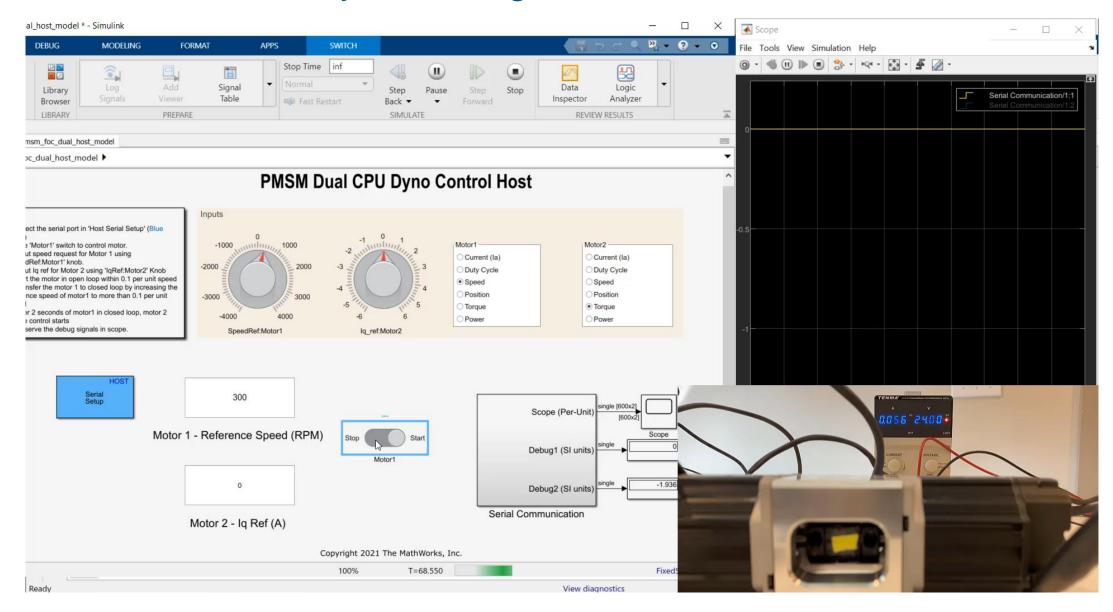
Key Takeaways

- Simulate sensorless Field-Oriented Control (FOC) on a dyno setup
- Complete Model-Based Design workflow for multicore microcontroller
- Hardware component and device driver behavior simulation
 - Enhanced on-device profiling

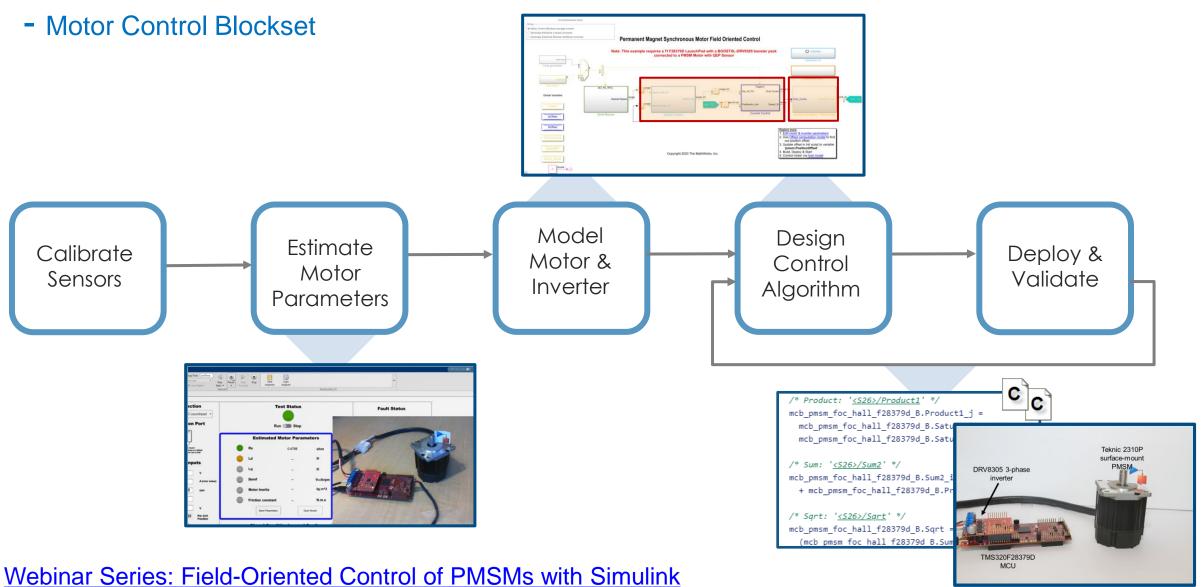




Dual CPUs PMSM Dyno Testing



Workflow for Implementing Field-Oriented Control



Demo – PMSMs Dyno Model in FOC Sensorless Control

http://www.cb_p	omsm_foc_sensorless_dyno_f28379d_present * - Simulink	σ×
SIMULA	ATION DEBUG MODELING FORMAT HARDWARE APPS	• • •
Hardware TI Delfino	F28379D LaunchPad Hardware Log Add Viewer Stop Time 6 Monitor HARDWARE BOARD PREPARE RUN ON HARDWARE RUN ON HARDWARE REVIEW RESULTS Build Deploy	Ā
S C		
ed File		Property
Reference	Osticing mode observer OSticing mode observer Image: Blux observer Note: This example requires a TI F28379D LaunchPad with a two BOOSTXL-DRV8305	/ Inspector
	Hardware Init	
	Code generation Figure 1 Intervet Select the value of Simulation Select the value of Select the value of Select the val	
	Copyright 2021-2022 The MathWorks, Inc.	
Ready		FixedStepDiscrete

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Challenges of Deployment on the Embedded Systems..

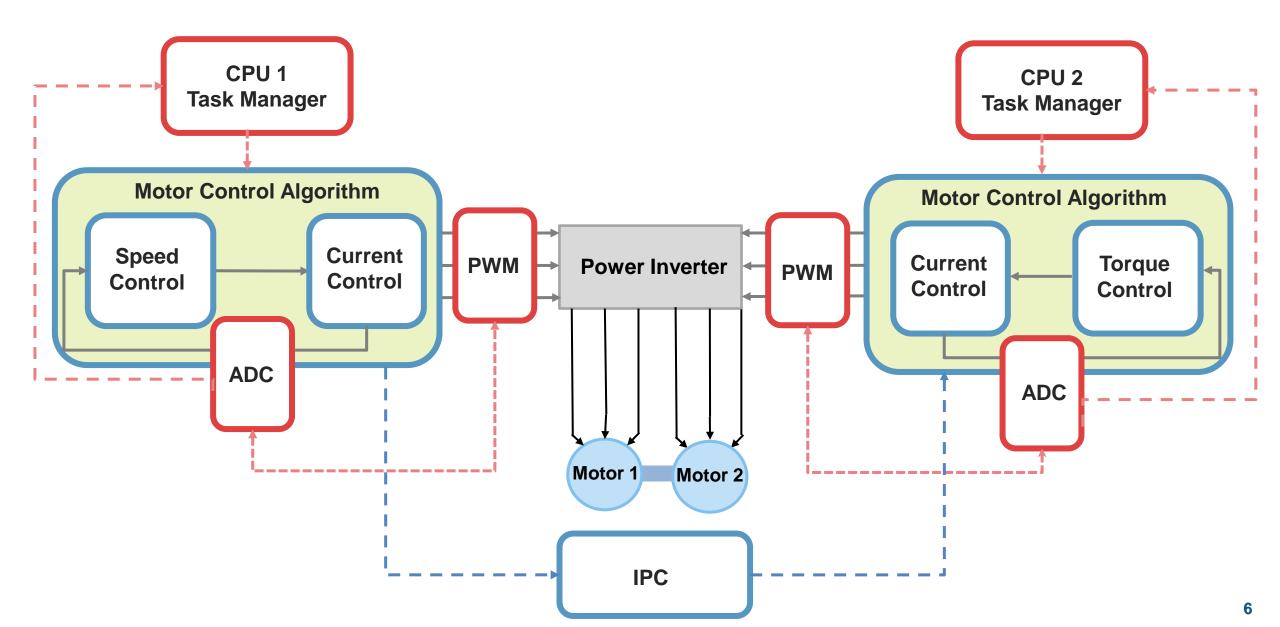
Model

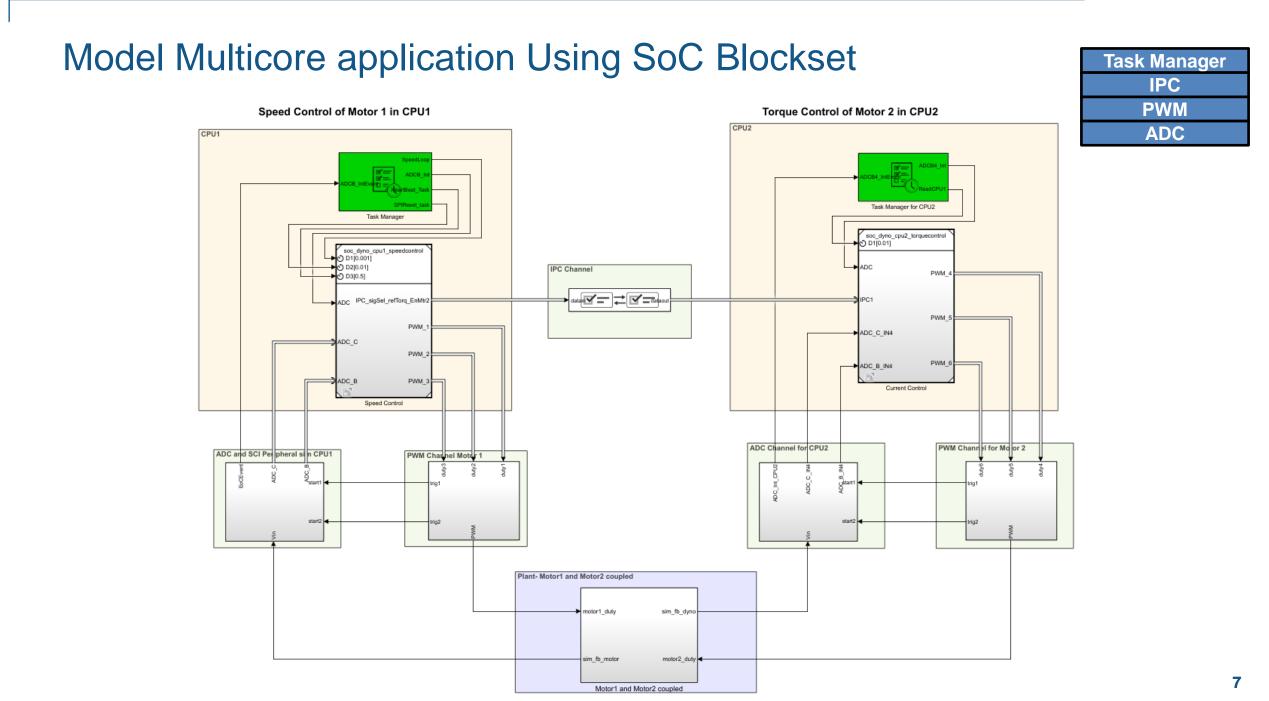
- System requirement
 - TI C2000 dual-core processors
- Controller sample rate is 20kHz
 - Field-oriented control (FOC)
 - Sensorless control
 - Dyno setup (2 motors)
- No sensor delays in my model
- ADC-PWM synchronization

Multicore Processor

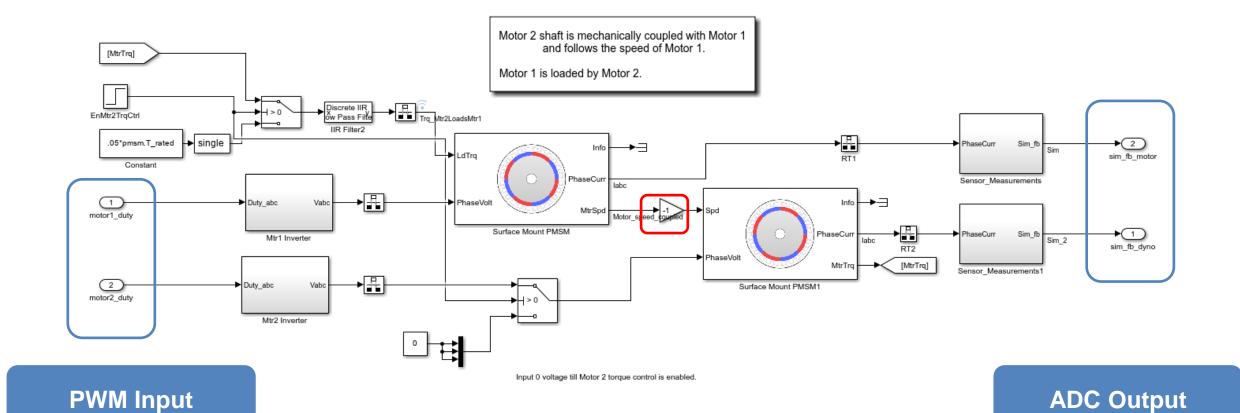
- How to implement and partition controls into two separated cores?
- How to communicate between CPU1 and CPU2?
- How to make sure task execution meets software requirement?

Simulate Motor Control System with Peripherals and Task Execution





Plant Subsystem

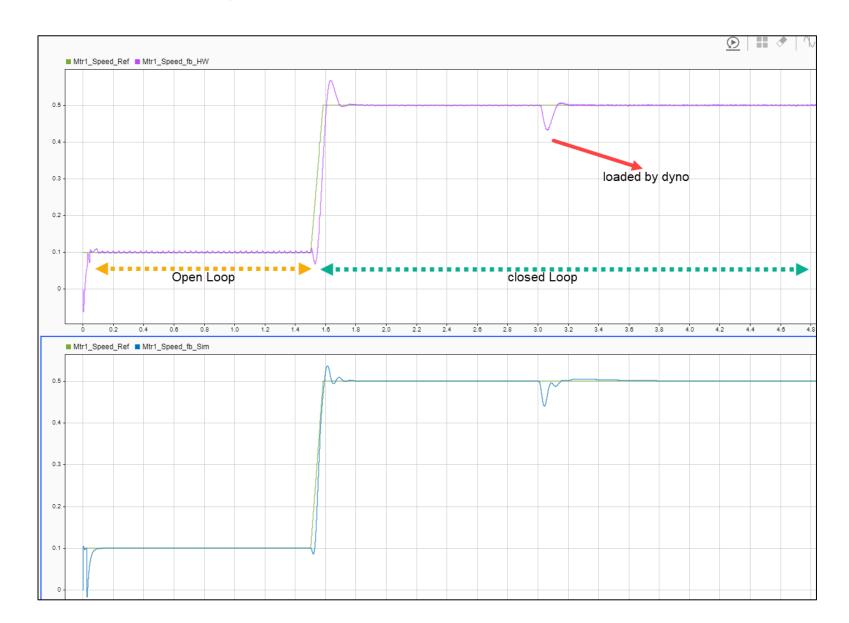


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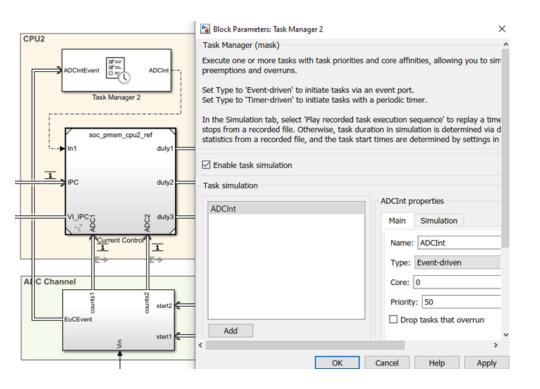
Hardware vs Simulation Analysis

Captured HW signal using External mode

> Simulation Result



Task Manager



- Model/Simulate
 - Periodic/async tasks
 - Task priorities
 - Latencies
 - Duration as normal distribution

ADCInt properties						
ADCINC P	roperues					
Main	Simulation					
🗌 Play	recorded task e	execution sequence				
Specify	task duration v	via: Dialog	•			
- Task d	luration setting	IS				

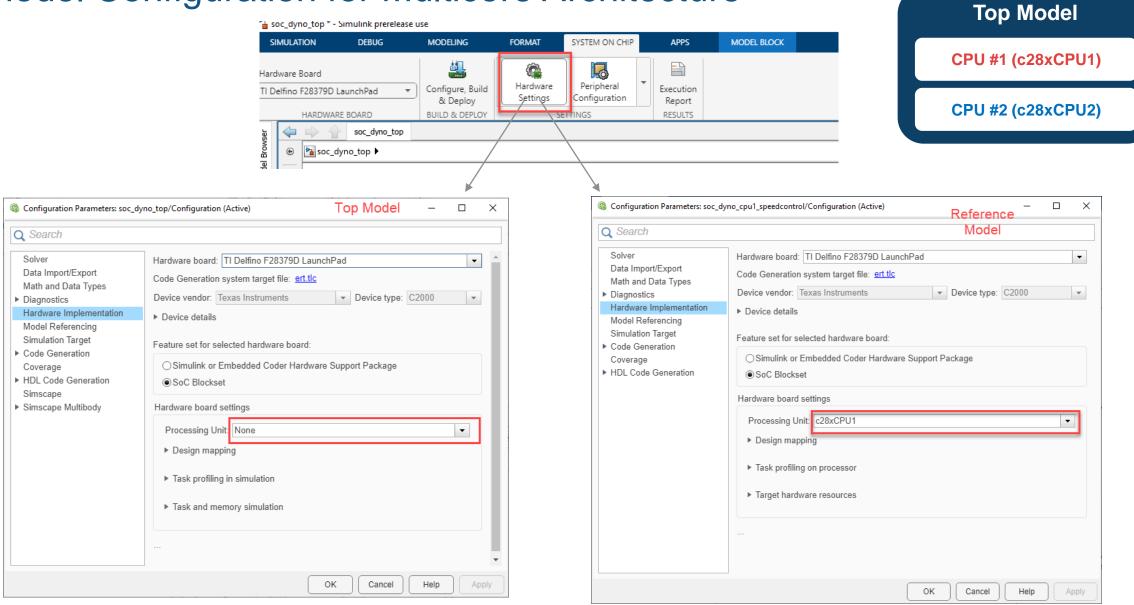
Specify task duration times as a normal distribution, or a
combination of multiple normal distributions.

	Percent	Mean	SD	Min	Max
1	100	1e-06	0	1e-06	1e-06
1	100	1e-06	0	1e-06	1e-06

Task Manager
IPC
PWM
ADC

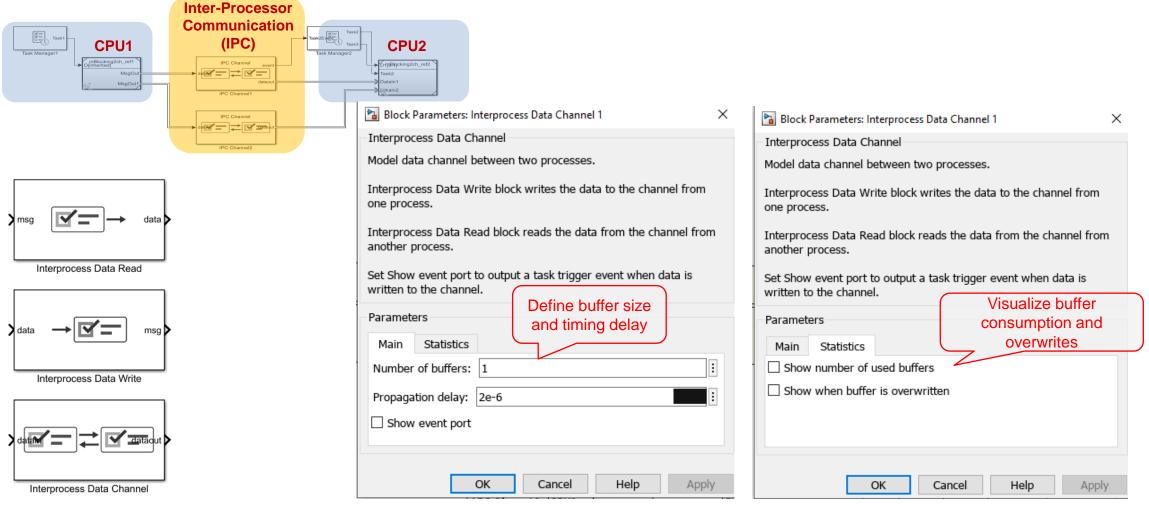


Model Configuration for Multicore Architecture



Inter-Processor Communication with IPC Blocks

Model the communication buffering and delay



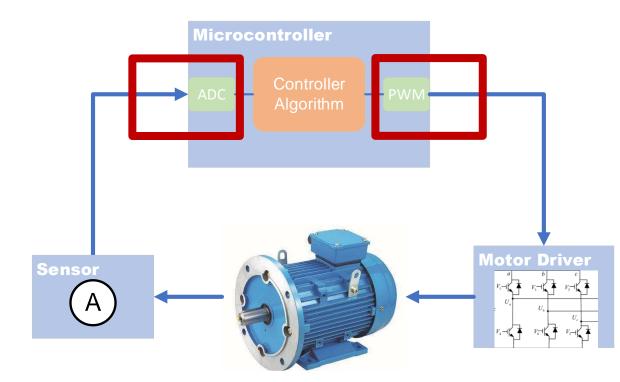
Task Manager IPC

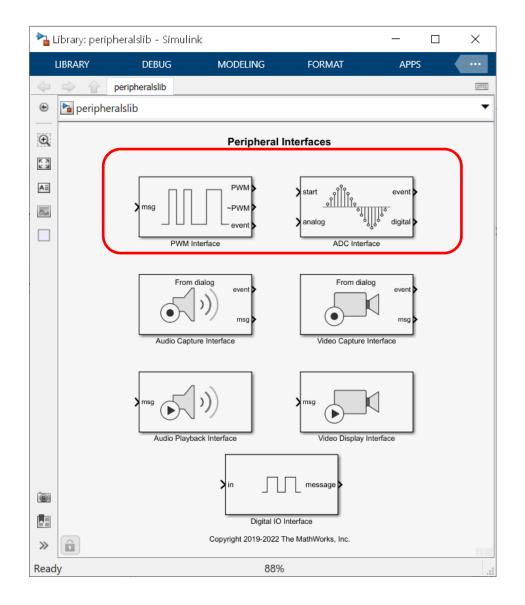
ADC

MATLAB EXPO

Motor control system modeling with peripheral interface

Motor control peripheral interfaces





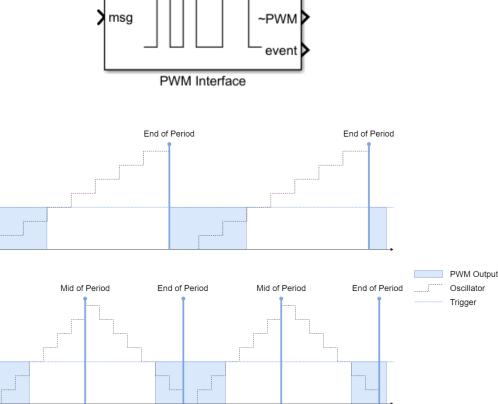
PWM Modeling

- PWM waveform simulation
- Event to synchronize with ADC or schedule a task

皆 Block Parameters: PWM Interfa	ice1	×	
PWM Interface			X msg
Simulates the pulse width modu	llation (PWM)		
The block outputs either a swite	hing pulse width modulated waveform or pass the duty cycle value to the		PWM
output. Also, it generates an "Event" wi	nich can be used for synchronizing PWM with ADC or as PWM interrupts to		
trigger a control algorithm.	included be used for synchronizing PWM with ADC of as PWM interrupts to	·	
			End of Peri
Main PWM output Phase	e Event		
Туре:	ADC start	~	
ADC start condition:	Mid of PWM period		
Generate on:	1st event	~	
Number of replicas:	1		
	-	- I	Mid of Period End of F
		Up-Down	
		-D-	·
	OK Cancel Help Apply		



MATLAB EXPO



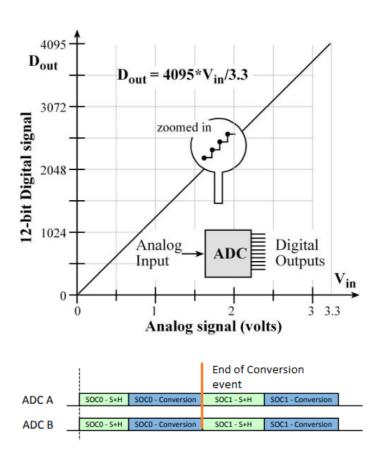
PWM D

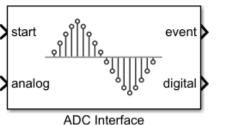
ADC

ADC Modeling

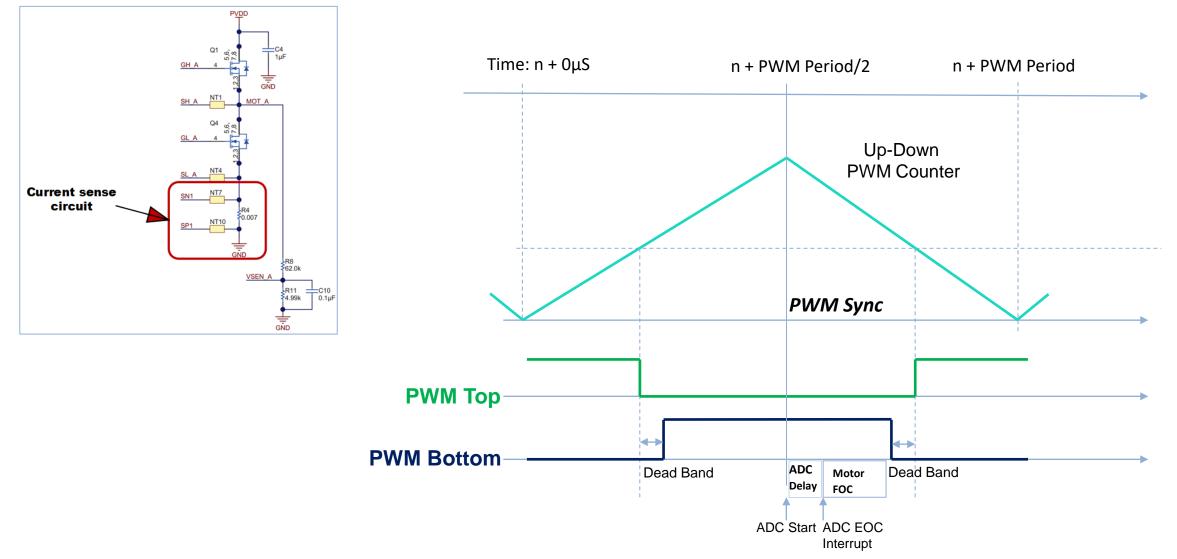
- Convert analog values to digital counts
- Model acquisition/conversion delays and trigger events

Block Parameters: ADC Interface	×
ADC Interface	
Simulates the analog-to-digital conversion (ADC)	
The block samples the analog input based on a s in counts. Also, it generate events which can be used for so Acquisition time and Conversion time parameter	2 2
Main Multi channel Event	
☑ Enable interrupt	
Condition:	Acquisition + Conversion time ~
Enable analog watchdog	
Interrupt latency (s):	0 :
	<u>OK</u> <u>Cancel</u> <u>H</u> elp <u>Apply</u>
	ple and Circuit ADC 10101101





ADC – PWM Synchronization

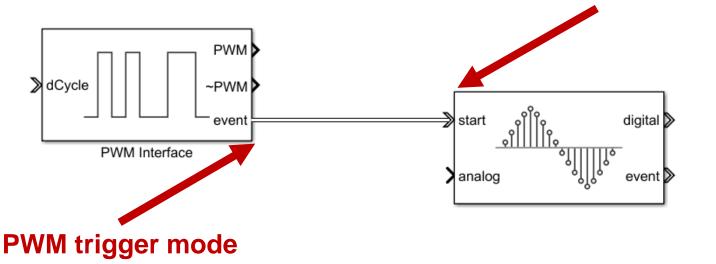


Video: Adding MCU Peripheral Modeling in Motor Control Using SoC Blockset

Enable ADC/PWM synchronization simulation

• To provide stable ADC input, the synchronization between ADC and PWM

is required for close-loop motor control



ADC Start of Conversion trigger

-d=≓d=

4

SoC Builder

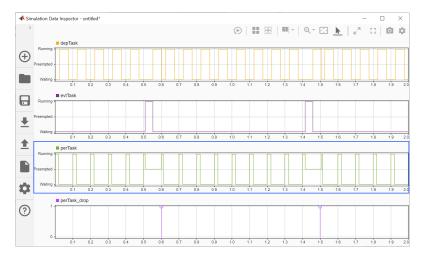
SoC Builder App

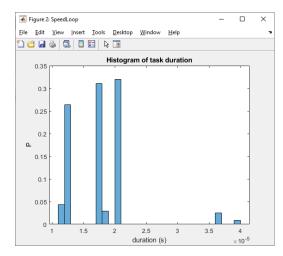
Build, load, and execute SoC model on SoC, FPGA, and MCU boards

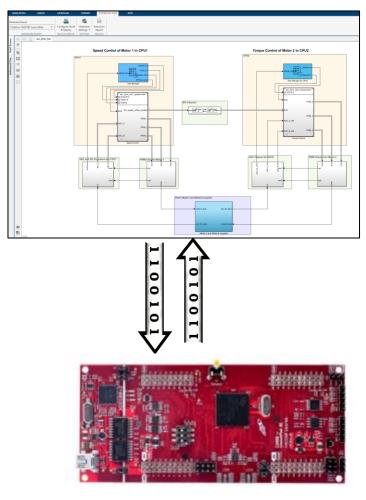
💰 SoC Builder		– 🗆 X	承 Periphera	l Configuration		- 🗆 X
Prepare > Validate Setup	e > Build > Run		Peripheral	Configuration for TI Delfino F	28379D LaunchPad	
	point for the build process:	About Your Selection The table on the left shows which components of your model the tool	ADC Read PWM Writ	Simulink block: Parameters:	soc_pmsm_cpu2_ref/Current C	Additional Information For more information on Peripheral Configuration tool, see Peripheral Configuration.
OLoad existing b		generates. If the table shows no processor model components, the tool does not generate code for the corresponding model. Additional information For information on creating processor models, refer to <u>Use Templates to</u>		Module:	В	Description Configure the <u>ADC Read</u> blocks
				Start of conversion:	SOC 0	in the model to map to the ADC peripherals on your hardware
Top Model				Resolution:	12-bit (Single-ended input)	board.
Processor Model	soc_pmsm_cpu1_ref			Conversion channel:	ADCIN2	
	soc_pmsm_cpu2_ref			SOCx acquisition window (cycles):	13	
		Create SoC Model.		SOCx trigger source:	ePWM1 ADCSOCA	
				ADCINT will trigger SOCx:	No ADCINT	
				 Enable interrupt at EOC 		
				Interrupt Selection:	ADCINT1	
				Interrupt continuous mode		
			•	•	÷.	
					ОК	Cancel Apply
📣 SoC Builder		- 🗆 X	🛃 SoC Build			- 🗆 X
Prepare > Validate Review Task I				Validate > Build > Run uild Action		
Review the event sources assigned to your tasks: Review the event sources assigned to your tasks: Sources available with the selected hardware board and your model.				build action for your model: d, load, and run		About Your Selection 'Build, load, and run' loads the generated code to your hardware board and executes the application.
	e task map, click 'View/Edit' for View/Edit	All timer-driven tasks are assigned to the internal scheduler events and such	⊖ Bui	ld only Id and load for external mode		
c28xCPU2	Task Mapping - soc_pmsm_dualcpu_foc/Task Manage					
	Map the Task Manager event-driven tasks to availabl of interrupts. Task Mapping	e sources ^ ven tasks are assigned to ing event sources and ints are also fixed.	To start the	a validation process, click 'Next >'.		
	Task name Event source	uto Map iven tasks may be ferent event sources and				
	1 ADCInt ADCB1_isr C	Apply				
< Back		Cancel Next >	< Back			Cancel Next >

SoC Blockset Key Functionalities – On-Device Profiling

- Real-time performance profiling on hardware, including
 - Task execution
 - CPU utilization
 - Communication buffering and delay
 - Real-time SDI view
 - Analysis report

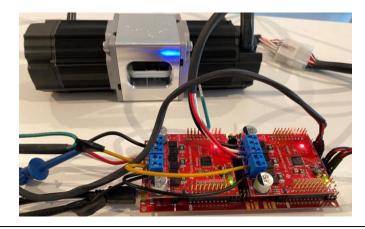


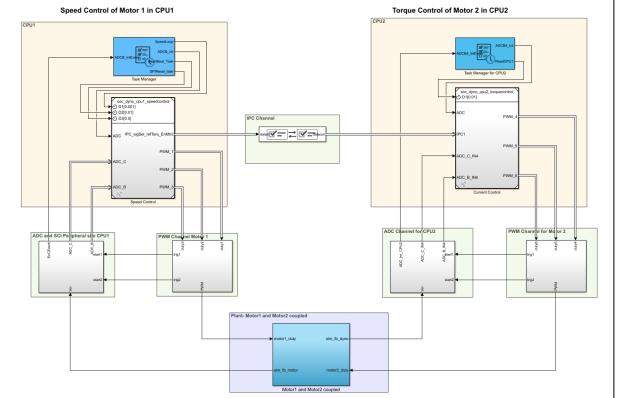




Wrap Up

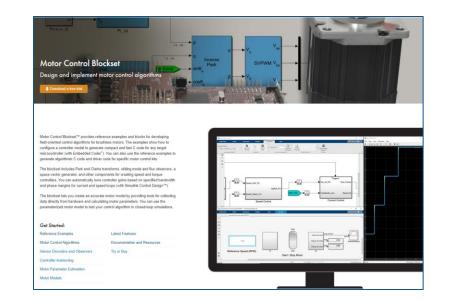
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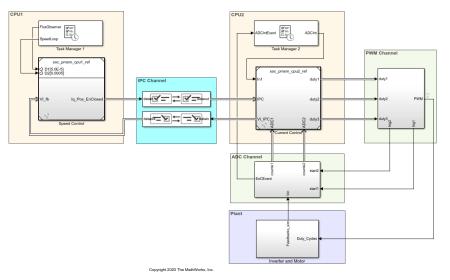


Learn More

- Recording webinars
 - Field Oriented Control Made Easy
 - Motor Control with TI Multicore MCUs Using Simulink
 - Implementing Motor and Power Electronics Control on an FPGA-Based SoC
- Shipping Demos
 - Partition Motor Control for Multiprocessor MCUs
 - Control PMSM Loaded with Dual Motor (Dyno)
 - Integrate MCU Scheduling and Peripherals in Motor Control Application



Field-Oriented Control on Dual CPU Processor



감사합니다



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