eTPU Motor Control Demo

BLDC Motor with Speed Control Loop

June 2004

Launched by Motorola

freescale semiconductor

Overview

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BLDC Motor with Speed Loop - Demo Application

eTPU is used as a motor control coprocessor – eTPU drives the motor independently on the CPU

CPU Tasks:

- Initialize eTPU and other peripherals
- Drive application state machine (INIT/ON/STOP/OFF/FAULT)
- Write Required Speed (from buttons or FreeMaster) to the eTPU

eTPU Tasks (all time-critical tasks):

- Generate 3 phases of top-bottom PWM pairs with dead-time
- Process Hall sensor signals, and commutate PWM phases
- Calculate actual motor speed
- Control PWM duty-cycle based on actual and required motor speed

eTPU Processing

Motor control algorithm is built using several eTPU functions, that cooperate together

PWMM + PWMC (PWM Generation)

- Generation of PWM signals for switching IGBT transistors
- 3 phases = 3 complementary top/bottom pairs with dead-times

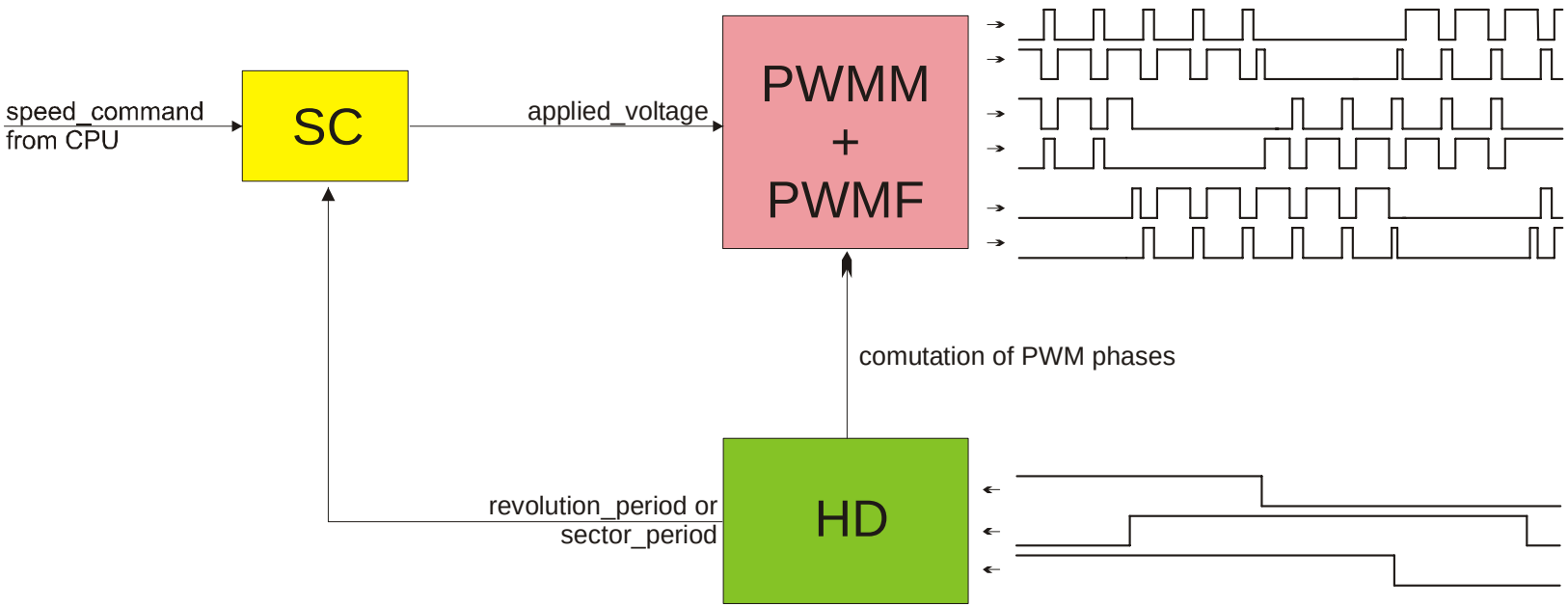
HD (Hall Decoder)

- Decoding of Hall sensor signals, driving commutation of PWM phases

SC (Speed Controller)

- Calculation of motor speed from HD sector period, speed PI controller

Block Diagram of eTPU Processing



eTPU Function Details

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PWMM + PWMC

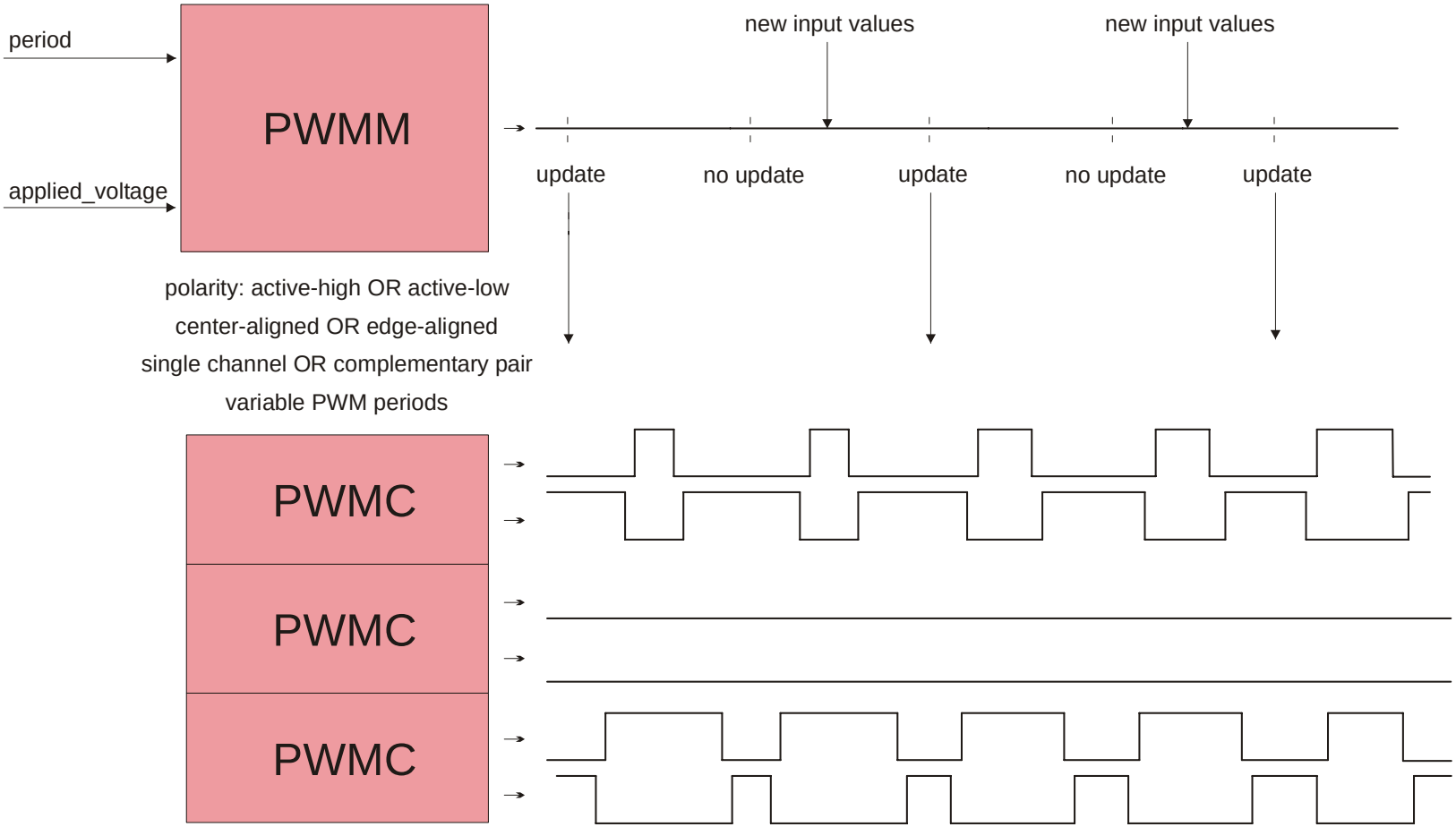
PWMM – PWM Master

- Does not generate any signal itself, but
- If an input parameter “applied_voltage” or “period” is updated, updates all edge times of the PWM signals generated by PWMC slaves
- Enables to master up to 4 phases

PWMC – PWM Slave with Commutations

- Generates one phase (top/bottom complementary pair with dead-time)
- Can be switched ON and OFF anytime = enables commutations
- Without updates from the PWMM keeps generating PWM signals of a constant duty-cycle and period

PWMM + PWMC



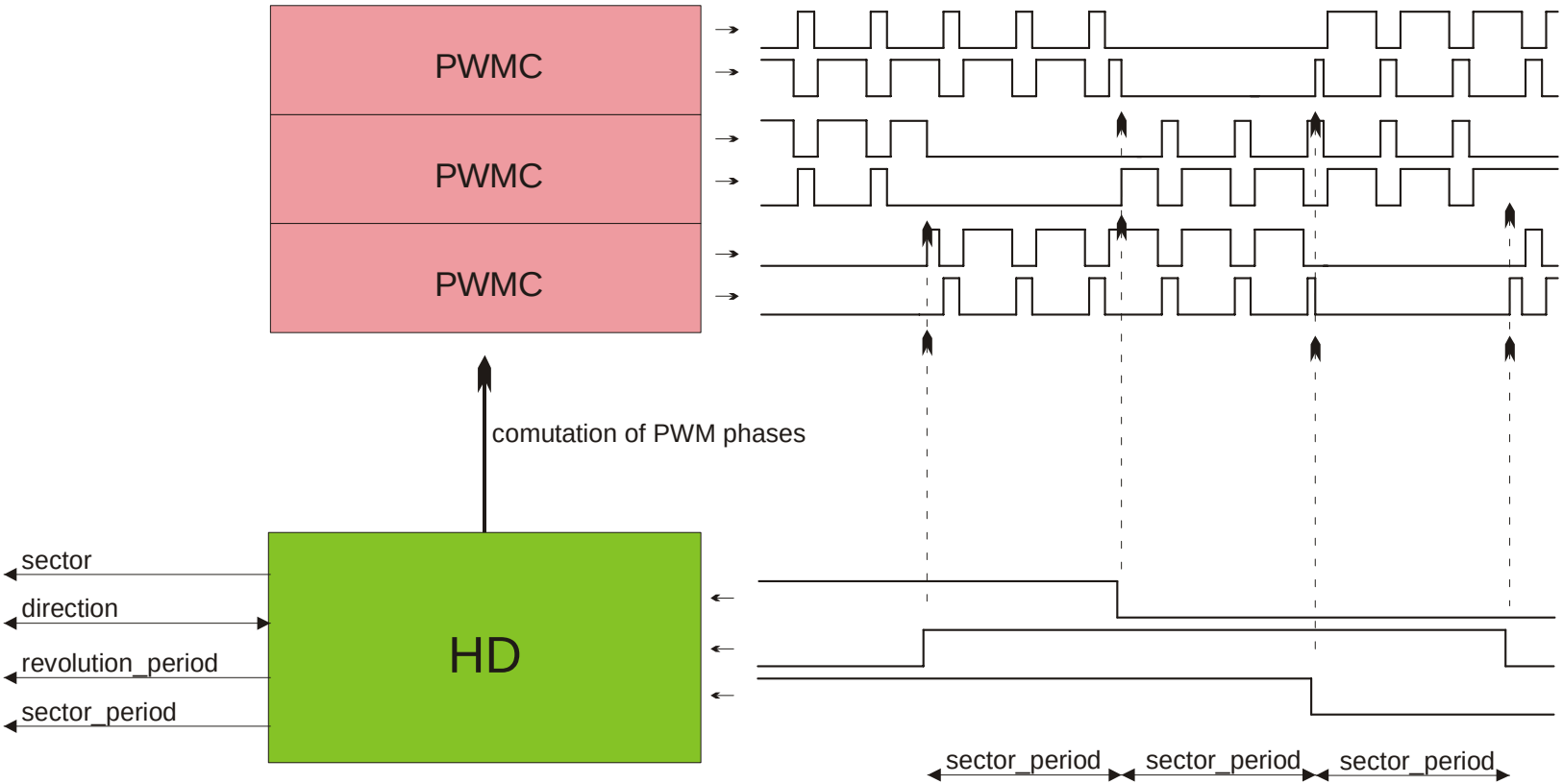
HD – Hall Decoder

Decodes 3 Hall sensor signals and produce

- **Sector = position in one of 6 sectors**
- **Direction**
- **Revolution period – time of the last revolution**
- **Sector period – time of (being in) the last sector**
- **Revolution counter**

On each transition turns one PWM phase OFF and one ON
= Commutation of PWM phases

HD – Hall Decoder



SC – Speed Controller

Calculates actual motor speed from the sector period measured by HD (division!).

speed_actual = scaling_factor * 1/sector_period

Passes the speed_command from CPU through a ramp, in order to slow down step changes.

continues …

SC – Speed Controller

Based on the error between required speed and actual speed calculates, using PI controller algorithm, applied motor voltage for PWMM.

$$error(k) = speed\_required(k) - speed\_actual(k)$$

$$applied\_voltage(k) = Kp * error(k) + \underbrace{Ki * error(k) + I(k-1)}_{I(k)}$$

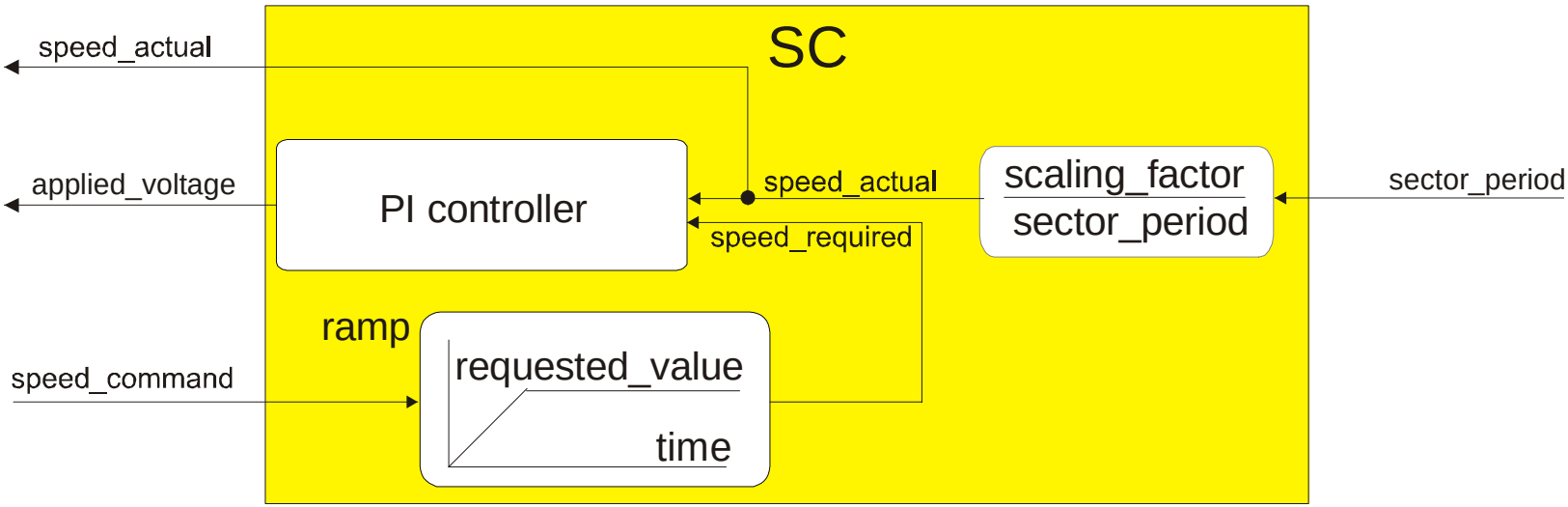
Kp … proportional gain

Ki … integrational gain

I(k) … integral portion in k^{th} step

- **Limitation of applied_voltage(k) and I(k), and scaling of Kp and Ki are implemented.**

SC – Speed Controller



Timing

PWM frequency … 16kHz

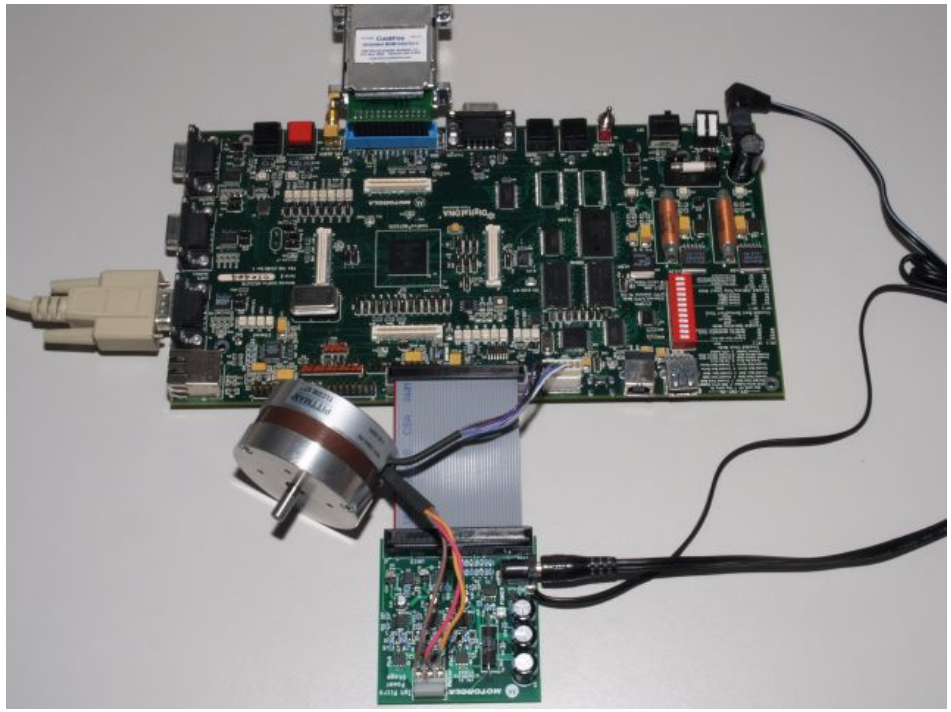
SC frequency …… 8kHz

PI controller is calculated and PWM duty-cycle is updated every second period.

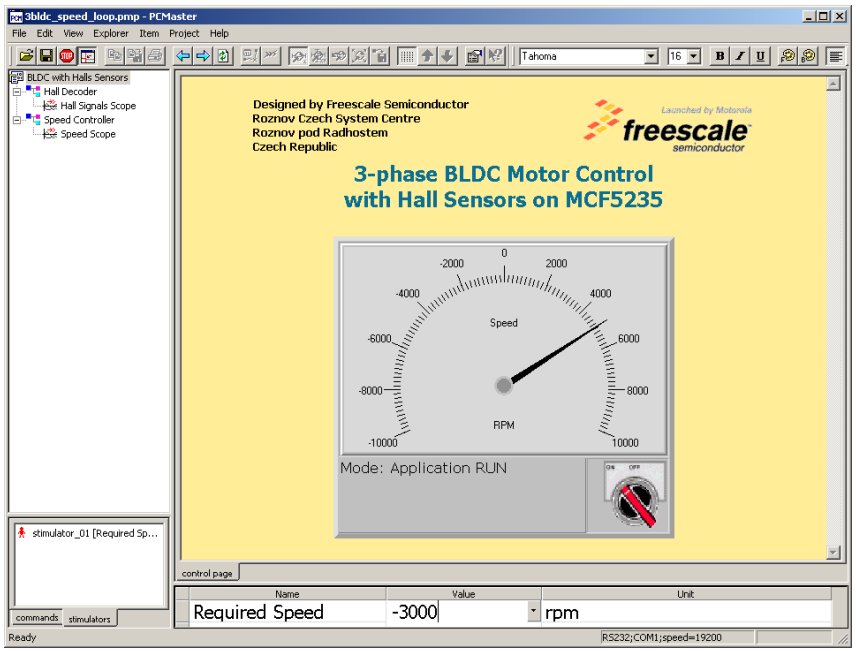
Demo

Demo ready with MCF523x EVB

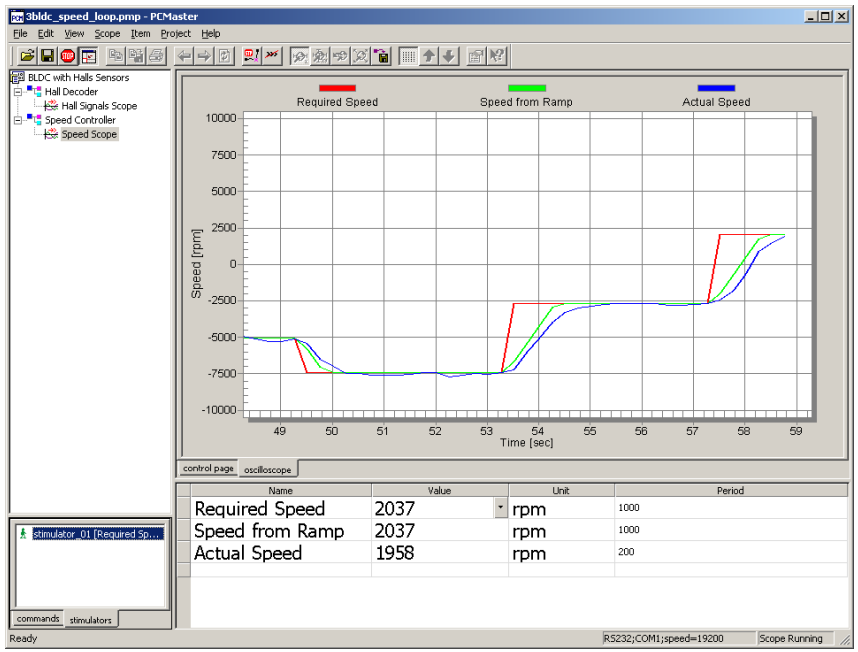
- **MCF523x EVB**
- **Pittman Motor**
- **Micro Power Stage**
- **Power Supply**
- **Serial cable to PC**



Application User Interface on PC using FreeMaster



Control Panel



Real-Time Speed Scope

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