Texas Instruments, Inc.
C2000 Systems and Applications

Digital Motor Control

Software Library:
eSMO

2013

V13.1

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Introduction

The digital motor control library is composed of C functions (or macros) developed for C2000 motor control users. These modules are represented as modular blocks in C2000 literature in order to explain system-level block diagrams clearly by means of software modularity. The DMC library modules cover nearly all of the target-independent mathematical macros and target-specific peripheral configuration macros, which are essential for motor control.

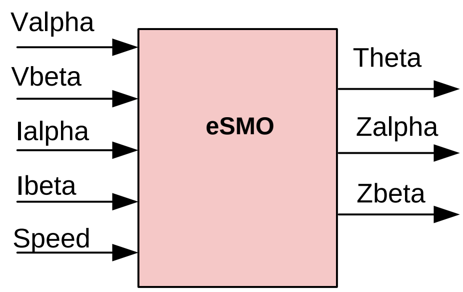
In the DMC library, each module is separately documented with source code, use, and background technical theory. The DMC library components have been used by TI to provide system-level motor control examples. In the motor control code, all DMC library modules are initialized according to the system specific parameters, and the modules are inter-connected to each other. At run-time the modules are called in order. Each motor control system is built using an incremental build approach, which allows some sections of the code to be built at a time, so that the developer can verify each section of the application one step at a time. This is critical in real-time control applications, where so many different variables can affect the system, and where many different motor parameters need to be tuned.

All DMC modules allow users to quickly build, or customize their own systems. The library supports three principal motor types (induction motor, BLDC and PM motors) but is not limited to these motors.

All these modules are provided in the downloadable version of ControlSuite. In addition to these, few additional modules are developed by TI related to the control PMSM motors, for superior performance. The original SMO for sensorless control of PMSM has some scope for improvements and these are covered by enhanced SMO module (eSMO) that provides the following features

1. SMO filter angle compensation
2. Bidirectional speed control

Description This software module implements a rotor position estimation algorithm for Permanent-Magnet Synchronous Motor (PMSM) based on Sliding-Mode Observer (SMO) and angle compensation due to sliding filter. For detailed information, contact TI sales channel.



Availability C interface version

Module Properties **Type:** Target Independent

Target Devices: 28x Fixed or Floating Point

C Version File Names: esmopos.h

IQmath library files for C: IQmathLib.h, IQmath.lib

C Interface

Object Definition

The structure of ESMOPOS object is defined by following structure definition

```
typedef struct { _iq  Valpha;      // Input: Stationary alpha-axis stator voltage
                 _iq  Ealpha;      // Variable: Stationary alpha-axis back EMF
                 _iq  Zalpha;      // Output: Stationary alpha-axis sliding control
                 _iq  Gsmopos;     // Parameter: Motor dependent control gain
                 _iq  EstIalpha;   // Variable: Estimated stationary alpha-axis stator current
                 _iq  Fsmopos;     // Parameter: Motor dependent plant matrix
                 _iq  Vbeta;       // Input: Stationary beta-axis stator voltage
                 _iq  Ebeta;       // Variable: Stationary beta-axis back EMF
                 _iq  Zbeta;       // Output: Stationary beta-axis sliding control
                 _iq  EstIbeta;    // Variable: Estimated stationary beta-axis stator current
                 _iq  Ialpha;      // Input: Stationary alpha-axis stator current
                 _iq  IalphaError; // Variable: Stationary alpha-axis current error
                 _iq  Kslide;      // Parameter: Sliding control gain
                 _iq  Ibeta;       // Input: Stationary beta-axis stator current
                 _iq  IbetaError;  // Variable: Stationary beta-axis current error
                 _iq  Kslf;        // Parameter: Sliding control filter gain
                 _iq  Theta;       // Output: Compensated rotor angle

                 _iq  E0;          // Input: Current threshold
                 _iq  smoFreq;     // Input: SMO filter corner frequency
                 _iq  smoShift;    // Output: Compensated rotor angle
                 _iq  runSpeed;    // Input: Running speed of motor
                 _iq  cmdSpeed;    // Input: Commanded speed of motor
                 _iq  base_wTs;    // Input: Incremental angle at base frequency
               } ESMOPOS;
```

Module Terminal Variables

Item	Name	Description	Format*	Range(Hex)
Inputs	Valpha	stationary d-axis stator voltage	GLOBAL_Q	80000000-7FFFFFFF
	Vbeta	stationary q-axis stator voltage	GLOBAL_Q	80000000-7FFFFFFF
	Ialpha	stationary d-axis stator current	GLOBAL_Q	80000000-7FFFFFFF
	Ibeta	stationary q-axis stator current	GLOBAL_Q	80000000-7FFFFFFF
	E0	Current threshold for smo	GLOBAL_Q	80000000-7FFFFFFF
	runSpeed	Running speed of motor	GLOBAL_Q	80000000-7FFFFFFF
	cmdSpeed	Command speed of motor	GLOBAL_Q	80000000-7FFFFFFF
	base_wTs	Incremental angle at base freq	GLOBAL_Q	80000000-7FFFFFFF
Outputs	Theta	rotor position angle	GLOBAL_Q	00000000-7FFFFFFF (0 – 360 degree)
	Zalfa	stationary d-axis sliding control	GLOBAL_Q	80000000-7FFFFFFF
	Zbeta	stationary q-axis sliding control	GLOBAL_Q	80000000-7FFFFFFF
	smoFreq	Smo filter corner frequency	GLOBAL_Q	80000000-7FFFFFFF
	smoShift	Phase shift due to smo filter	GLOBAL_Q	80000000-7FFFFFFF (0 – 360 degree)
SMOPOS parameter	Fsmopos	Fsmopos = exp(-Rs*T/Ls)	GLOBAL_Q	80000000-7FFFFFFF
	Gsmopos	Gsmopos = (Vb/Ib)*(1- exp(-Rs*T/Ls))/Rs	GLOBAL_Q	80000000-7FFFFFFF

	Kslide	sliding mode control gain	GLOBAL_Q	80000000-7FFFFFFF
	Kslf	sliding control filter gain	GLOBAL_Q	80000000-7FFFFFFF
Internal	Ealpha	stationary d-axis back EMF	GLOBAL_Q	80000000-7FFFFFFF
	Ebeta	stationary q-axis back EMF	GLOBAL_Q	80000000-7FFFFFFF
	EstIalpha	stationary d-axis estimated current	GLOBAL_Q	80000000-7FFFFFFF
	EstIbeta	stationary q-axis estimated current	GLOBAL_Q	80000000-7FFFFFFF
	IalphaError	stationary d-axis current error	GLOBAL_Q	80000000-7FFFFFFF
	IbetaError	stationary q-axis current error	GLOBAL_Q	80000000-7FFFFFFF

*GLOBAL_Q valued between 1 and 30 is defined in the IQmathLib.h header file.

Special Constants and Data types

ESMOPOS

The module definition is created as a data type. This makes it convenient to instance an interface to the sliding-mode rotor position observer of Permanent-Magnet Synchronous Motor module. To create multiple instances of the module simply declare variables of type ESMOPOS.

ESMOPOS_DEFAULTS

Structure symbolic constant to initialize ESMOPOS module. This provides the initial values to the terminal variables as well as method pointers.

Module Usage

Instantiation

The following example instances two ESMOPOS objects

```
ESMOPOS  esmo1, esmo2;
```

Initialization

To Instance pre-initialized objects

```
ESMOPOS fe1 = ESMOPOS_DEFAULTS;
ESMOPOS fe2 = ESMOPOS_DEFAULTS;
```

Invoking the computation macro

```
eSMO_MODULE(&esmo1);
eSMO_MODULE (&esmo2);
```

Example

The following pseudo code provides the information about the module usage.

```
main()
{
      esmo1.Fsmopos = parem1_1;        // Pass parameters to esmo1
      esmo1.Gsmopos = parem1_2;        // Pass parameters to esmo1
      esmo1.Kslide = parem1_3;         // Pass parameters to esmo1
      esmo1.Kslf = parem1_4;           // Pass parameters to esmo1
      esmo2.Fsmopos = parem2_1;        // Pass parameters to esmo2
      esmo2.Gsmopos = parem2_2;        // Pass parameters to esmo2
      esmo2.Kslide = parem2_3;         // Pass parameters to esmo2
      esmo2.Kslf = parem2_4;           // Pass parameters to esmo2
}
```

```
void interrupt periodic_interrupt_isr()
{
	esmo1.Valpha = voltage_dq1.d;          // Pass inputs to esmo1
	esmo1.Vbeta = voltage_dq1.q;           // Pass inputs to esmo1
	esmo1.Ialpha =current_dq1.d;           // Pass inputs to esmo1
	esmo1.Ibeta =current_dq1.q;            // Pass inputs to esmo1
	esmo1.runSpeed =current_speed1;        // Pass inputs to esmo1
	esmo1.cmdSpeed = command_speed1;       // Pass inputs to esmo1

	esmo2.Valpha = voltage_dq2.d;          // Pass inputs to esmo2
	esmo2.Vbeta = voltage_dq2.q;           // Pass inputs to esmo2
	esmo2.Ialpha =current_dq2.d;           // Pass inputs to esmo2
	esmo2.Ibeta =current_dq2.q;            // Pass inputs to esmo2
	esmo2.runSpeed =current_speed2;        // Pass inputs to esmo2
	esmo2.cmdSpeed = command_speed2;       // Pass inputs to esmo2

	eSMO_MODULE(&esmo1)             // Call compute macro for esmopos1
	eSMO_MODULE(&esmo2);            // Call compute macro for esmopos2

	angle1 = esmo1.Theta;           // Access the outputs of esmopos1
	angle2 = esmo2.Theta;           // Access the outputs of esmopos2
}
```

IMPORTANT NOTICE