Texas Instruments, Inc.
C2000 Systems and Applications

Digital Motor Control

Software Library:
PWM with Dead Band Compensation

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V13.1

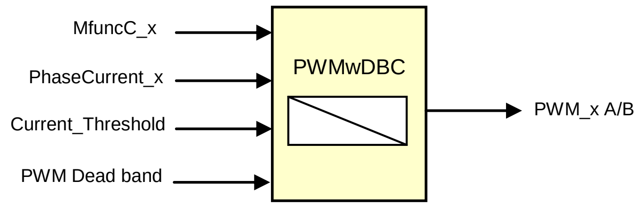
Contents

Introduction

This file is a supplement to DMC2803x_DRV.pdf and it describes the macro for inverter's PWM dead band compensation.

Description

This module compensates for the effect of dead band in the inverter by adjusting the pulse widths in a feed forward manner based on phase current.



Availability

C interface version

Module Properties

Type: Target Independent

Target Devices: 28x Fixed or Floating Point

C Version File Names: f2803xpwm.h

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

C Interface

This module uses previously defined objects such as PWMGEN and CLARKE and a new object DBC as defined below. Refer to the library for details about PWMGEN and CLARKE objects.

Object Definition

The structure of DBC object is defined by following structure definition

```
typedef struct {  _iq  Kdtc;          // Input: single consolidated constant
                  _iq  Ith;           // Input: phase current threshold
                  _iq  scale;         // Input: ratio of pwm dead band to current
                  _iq  gain;          // Input: switch to add/remove dead band compensation
               } DBC;
```

Item	Name	Description	Format*	Range(Hex)
Inputs	Kdtc	Single consolidated constant	GLOBAL_Q	80000000-7FFFFFFF
	Ith	Threshold current for full DBC	GLOBAL_Q	80000000-7FFFFFFF
	Scale	Ratio of PWM DB to Ith	GLOBAL_Q	80000000-7FFFFFFF
	Gain	DBC selection switch	GLOBAL_Q	80000000-7FFFFFFF

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

Special Constants and Data types

DBC

The module definition is created as a data type. This makes it convenient to instance an interface to dead band compensator. To create multiple instances of the module simply declare variables of type DBC.

DBC_DEFAULTS

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

Module Usage

Instantiation

The following example instances DBC, PWMGEN and CLARKE objects

```
DBC dbc1;
PWMGEN pwm1;
CLARKE clarke1;
```

To Instance pre-initialized objects

```
DBC dbc1 = DBC_DEFAULTS;
PWMGEN pwm1 = PWM_DEFAULTS;
CLARKE clarke1 = CLARKE_DEFAUTS;
```

Invoking the computation macro

```
PWMwDBC(1, 2, 3, pwm1, clarke1, dbc1);
```

Example

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

```
main()
{
        Pwm1.PeriodMax = 3000;  // PWM freq = 10KHz, clock = 60MHz
        Pwm1.HalfPeriodMax = pwm1.PeriodMax/2;
        PWM_INIT_MACRO(pwm1);     // call init macro for pwm1

        dbc1.Ith   = thresholdCurrent1;              // Pass inputs to dbc1
        dbc1.scale = _IQdiv(Deadband1/2, dbc1.Ith);  // Pass inputs to dbc1
        dbc1.gain  = _IQ(1.0);                       // Pass inputs to dbc1
        dbc1.Kdtc  = _IQmpy(dbc1.scale, dbc1.gain);  //set up correction factor
}

void interrupt periodic_interrupt_isr()
{
        clarke1.As = as1;                       // phase A current
        clarke1.Bs = bs1;                       // phase B current
        clarke1.Cs = cs1;                       // phase C current
                ..
                ..

        pwm1.MfuncC1 = svgen1.Ta;
        pwm1.MfuncC2 = svgen1.Tb;
        pwm1.MfuncC3 = svgen1.Tc;

        PWMwDBC(1,2,3,pwm1,clarke1,dbc1);       // Call pwm macro for inverter1
}
```

Technical Background

The significance of dead time in inverters is well known, without which there could be a vertical current shoot through in inverter half bridges leading to excessive power loss in switches and its potential destruction. Dead time represents the time when both high side and low side switches are off. This alters the voltage / pulse width at the inverter output by either reducing or increasing it depending on output current. When the speed is low, the output voltage is low and the pulse width is comparable to dead band. Similarly, at higher PWM frequencies the dead band may represent a significant percentage of PWM period. Under these conditions, the performance is somewhat impaired due to distortions inserted in phase voltages and currents. Hence compensation for the pulse width lost / gained becomes significant to improve the inverter performance.

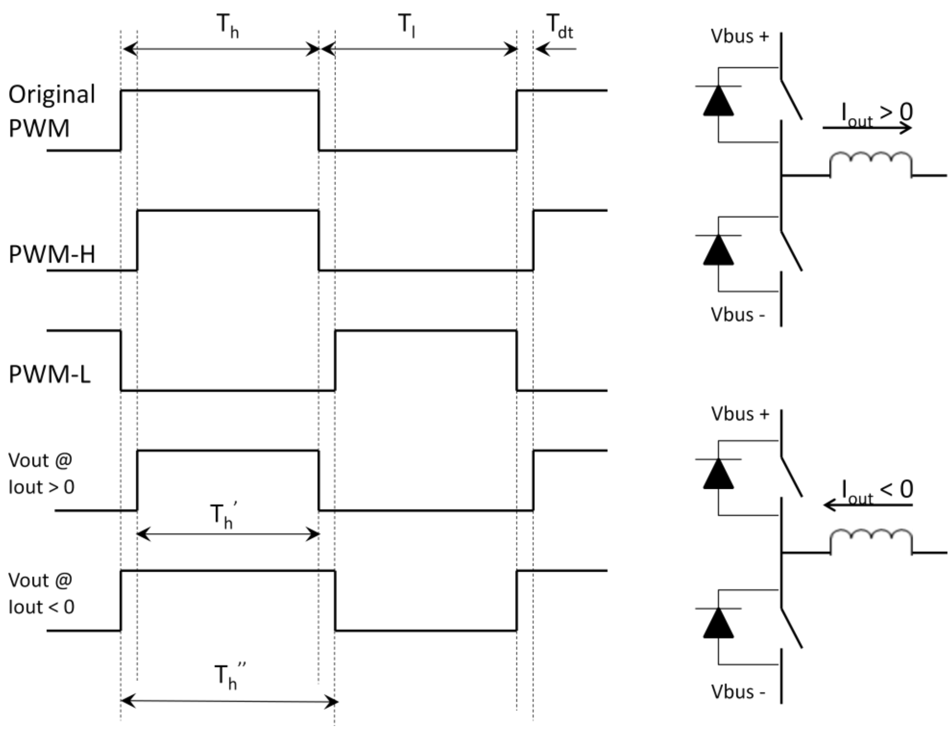


Fig.1 PWM dead band impact on output pulse width

Anytime when the top side switch is ON, output voltage becomes HIGH and when the bottom side switch is ON, output voltage becomes LOW. However, during dead time when both switches are OFF, the output voltage is decided by the polarity of output current that will flow through the appropriate anti parallel diode connected across high and low side switches. If the current direction is positive, i.e., flowing away from the inverter, the output voltage will go LOW by freewheeling through the bottom diode. Likewise, if the output current is flowing into the inverter, the output voltage will go HIGH by freewheeling through the top diode.

From fig.1 above, it is clear that when the current is positive or negative, the output pulse width is reduced or increased by dead time, such that effective output pulse width is (T_h - T_{dt}) or (T_h + T_{dt}) respectively. Therefore, depending on the output current polarity, a compensation duty cycle is added or subtracted in a feed forward manner that will get cancelled in the inverter. When the output current is small enough for the anti-parallel diodes to fully turn on, adding full compensation can lead to more distortion due to the fuzzy nature of diode conduction. Hence some prorated compensation is done under these light current conditions as shown in the figure below.

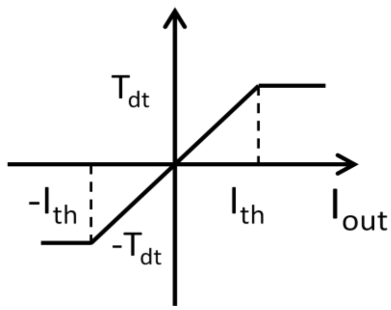


Fig.2 Prorated dead band compensation based on output current

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