

SPEED FR

Speed Calculator Based on Rotor Angle from QEP sensor

Description

This module calculates the motor speed based on a rotor position measurement from QEP sensor.



Availability

This IQ module is available in one interface format:

- 1) The C interface version

Module Properties

Type: Target Independent, Application Dependent

Target Devices: 28x Fixed Point or Piccolo

C Version File Names: speed_fr.h

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

C Interface

C Interface

Object Definition

The structure of SPEED_MEAS_QEP object is defined by following structure definition

```
typedef struct { _iq ElecTheta;          // Input: Electrical angle
                Uint32 DirectionQep;    // Variable: Direction of rotation (Q0)
                _iq OldElecTheta;       // History: Electrical angle at previous step
                _iq Speed;               // Output: Speed in per-unit
                Uint32 BaseRpm;          // Parameter: Base speed in rpm (Q0)
                _iq21 K1;                // Parameter: Constant for differentiator (Q21)
                _iq K2;                  // Parameter: Constant for low-pass filter
                _iq K3;                  // Parameter: Constant for low-pass filter
                int32 SpeedRpm;          // Output : Speed in rpm (Q0)
            } SPEED_MEAS_QEP;           // Data type created
```

```
typedef SPEED_MEAS_QEP * SPEED_MEAS_QEP_handle;
```

Item	Name	Description	Format	Range(Hex)
Inputs	ElecTheta	Electrical angle	GLOBAL_Q	00000000-7FFFFFFF (0 – 360 degree)
Outputs	Speed	Computed speed in per-unit	GLOBAL_Q	80000000-7FFFFFFF
	SpeedRpm	Speed in rpm	Q0	80000000-7FFFFFFF
SPEED_QEP parameter	K1	$K1 = 1/(fb \cdot T)$	Q21	80000000-7FFFFFFF
	K2	$K2 = 1/(1+T^2 \cdot \pi^2 \cdot fc)$	GLOBAL_Q	80000000-7FFFFFFF
	K3	$K3 = T^2 \cdot \pi^2 \cdot fc / (1+T^2 \cdot \pi^2 \cdot fc)$	GLOBAL_Q	80000000-7FFFFFFF
	BaseRpm	$BaseRpm = 120fb/p$	Q0	80000000-7FFFFFFF
Internal	OldElecTheta	Electrical angle in previous step	GLOBAL_Q	00000000-7FFFFFFF (0 – 360 degree)

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

Special Constants and Data types

SPEED_MEAS_QEP

The module definition is created as a data type. This makes it convenient to instance an interface to speed calculation based on measured rotor angle. To create multiple instances of the module simply declare variables of type SPEED_MEAS_QEP.

SPEED_MEAS_QEP_handle

User defined Data type of pointer to SPEED_MEAS_QEP module

SPEED_MEAS_QEP_DEFAULTS

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

Methods

SPEED_FR_MACRO (SPEED_MEAS_QEP_handle);

This definition implements one method viz., the speed calculation based on measured rotor angle computation macro. The input argument to this macro is the module handle.

Module Usage

Instantiation

The following example instances two SPEED_MEAS_QEP objects
SPEED_MEAS_QEP speed1, speed2;

Initialization

To Instance pre-initialized objects

SPEED_MEAS_QEP speed1 = SPEED_MEAS_QEP_DEFAULTS;

SPEED_MEAS_QEP speed2 = SPEED_MEAS_QEP_DEFAULTS;

Invoking the computation macro

SPEED_FR_MACRO (speed1);

SPEED_FR_MACRO (speed2);

Example

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

```
main()
{

}

void interrupt periodic_interrupt_isr()
{
    speed1.ElecTheta = theta1;           // Pass inputs to speed1
    speed2.ElecTheta = theta2;           // Pass inputs to speed2

    SPEED_FR_MACRO (speed1);             // Call compute macro for speed1
    SPEED_FR_MACRO (speed2);             // Call compute macro for speed2

    measured_spd1 = speed1.Speed;        // Access the outputs of speed1
    measured_spd2 = speed2.Speed;        // Access the outputs of speed2
}
```

Technical Background

The typical waveforms of the electrical rotor position angle, θ_e , in both directions can be seen in Figure 1. Assuming the direction of rotation is not available. To take care the discontinuity of angle from 360° to 0° (CCW) or from 0° to 360° (CW), the differentiator is simply operated only within the differentiable range as seen in this Figure. This differentiable range does not significantly lose the information to compute the rotor speed.

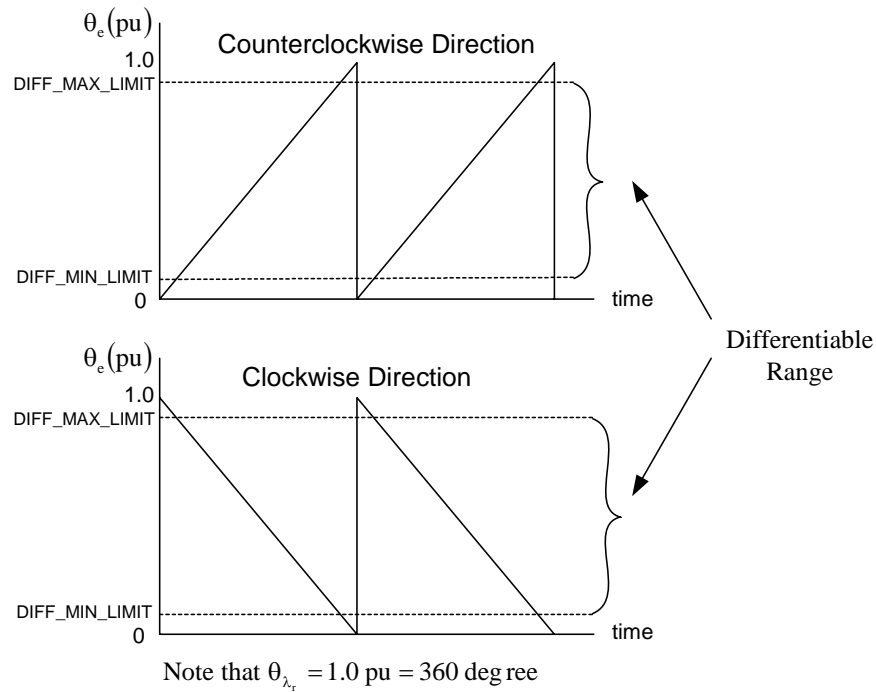


Figure 1: The waveforms of rotor position in both directions

The differentiator equation of rotor position can be expressed as follows.

$$\omega_e(k) = K_1(\theta_e(k) - \theta_e(k-1)) \quad (1)$$

where $K_1 = \frac{1}{f_b T}$, f_b is base frequency (Hz) and T is sampling period (sec).

In addition, the rotor speed is necessary to be filtered out by the low-pass filter in order to reduce the amplifying noise generated by the pure differentiator. The simple 1st-order low-pass filter is used, then the actual rotor speed to be used is the output of the low-pass filter, $\hat{\omega}_e$, seen in following equation. The continuous-time equation of 1st-order low-pass filter is as

$$\frac{d\hat{\omega}_e}{dt} = \frac{1}{\tau_c} (\omega_e - \hat{\omega}_e) \quad (2)$$

where $\tau_c = \frac{1}{2\pi f_c}$ is the low-pass filter time constant (sec), and f_c is the cut-off frequency (Hz). Using backward approximation, then (2) finally becomes

$$\hat{\omega}_e(k) = K_2 \hat{\omega}_e(k-1) + K_3 \omega_e(k) \quad (3)$$

where $K_2 = \frac{\tau_c}{\tau_c + T}$, and $K_3 = \frac{T}{\tau_c + T}$.

Next, Table 1 shows the correspondence of notations between variables used here and variables used in the program (i.e., speed_fr.c, speed_fr.h). The software module requires that both input and output variables are in per unit values.

	Equation Variables	Program Variables
Input	θ_e	ElecTheta
Output	$\hat{\omega}_e$	Speed
Others	K1	K1
	K2	K2
	K3	K3

Table 1: Correspondence of notations