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Extracting DC bus current information for optimal phase correction and current ripple in sensorless brushless DC motor drive

Key words: Brushless motor, Electric motor, Motor drives, Phase control, Phase estimation, Sensorless control

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Motivation

- Use a simple algorithm to optimize phase correction and minimize torque ripple, so as to achieve a higher performance/cost ratio.

- Disadvantages of existing methods:
  - A lookup table is used to do compensation
  - The compensation quantity would not match the varied running speed and loading
  - The torque ripple cannot be minimized in real time

Features of our method

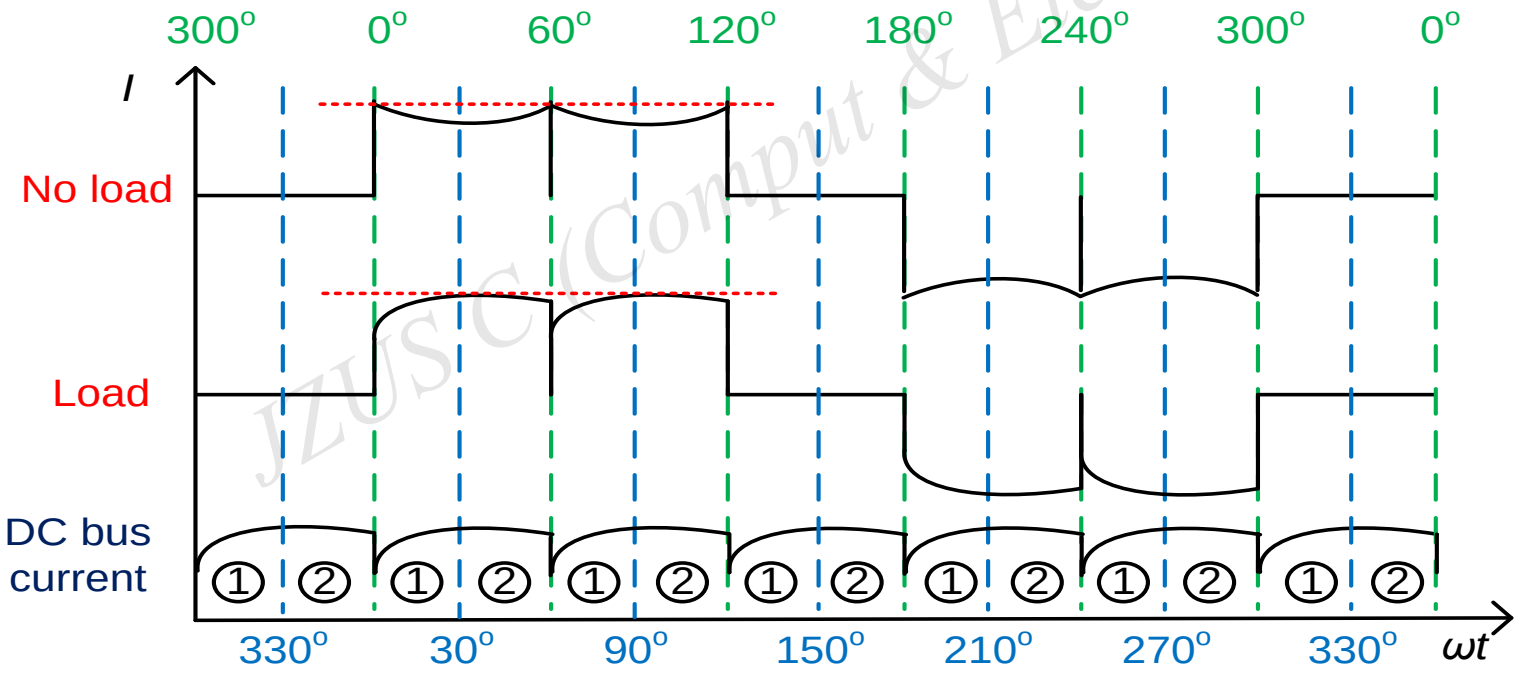
- Use of a single shunt resistor to analyze the phase driven information
- Real-time phase auto-calibration
- Simple arithmetic operation and reduced MCU cost
- Optimization of the performance/cost ratio
- Overcoming the issues of hall sensor misplacement and aging

Framework of our method (I)

The algorithms of auto-phase correction can be divided into two parts:

1. Extraction of the DC bus current information

   Ideal current waveform of phase and DC bus current extraction steps within one electric cycle:



2. Phase processing and optimization

Framework of our method (II)

1. Extraction of the DC bus current information

In region ①:

Step 1: Detect the occurrence of a commutation signal change.

Step 2: Wait until the optimized phase commutation signal is obtained.

Step 3: Do commutation.

Step 4: Move previous maximum current information (in REG1 and REG2) to temporary registers (REG1_TEMP and REG2_TEMP).

Step 5: Reset flag to 0.

Step 6: Obtain the first new maximum current information recorded in REG1.

Framework of our method (III)

In region ②:

Step 1: Wait until a 30° rotation of correct commutation.

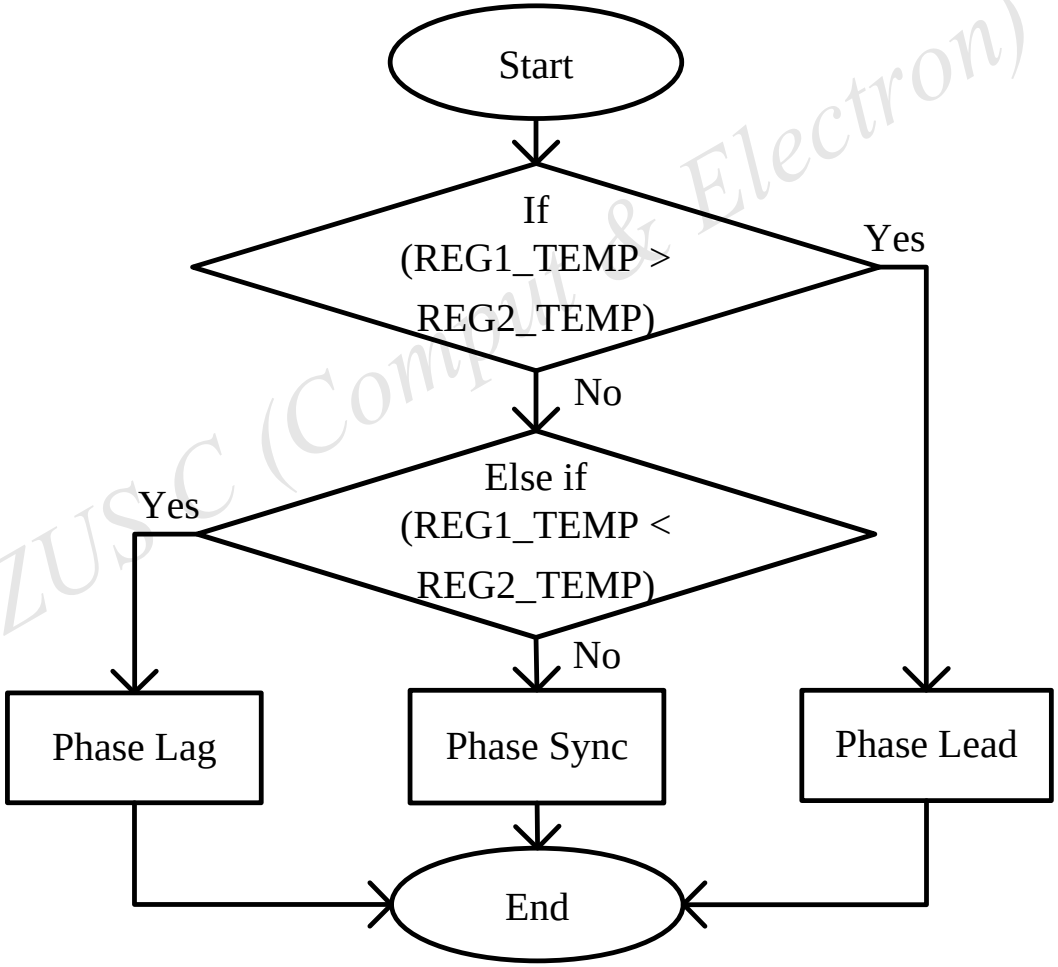
Step 2: Set flag to 1.

Step 3: Obtain the second new maximum current information recorded in REG2.

Step 4: Call the ‘phase corrector’ to do phase correction.

Framework of our method (IV)

2. Phase processing and optimization



Major results

We compared the freewheeling current characteristic algorithm in each 10% duty increment. The experimental results are:

PWM duty (%)	Increased speed (r/min)	Reduced current ripple (%)	Advanced degree (°)
10	0	3.3	1.2
20	1.2	12.5	2.0
30	4.8	14.3	3.9
40	9.6	19.1	5.1
50	18.0	18.7	6.1
60	21.6	16.7	7.2
70	31.2	22.9	9.2
80	48.0	17.1	10.5
90	90.0	20.5	11.0
100	118.8	18.8	17.0