《高阶会员专属视频》-第18期

IEEE论文导读：使用光学编码器脉冲计算速度，在极低转速下，会有什么潜在问题？ 要如何解决？

《高階會員專屬-第18期》IEEE論文導讀：使用光學編碼器脈衝計算速度，在極低轉速下，會有什麼潛在問題？要如何解決？

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Inertia Identification for the Speed Observer of the Low Speed Control of Induction Machines

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Abstract—This paper presents a control method for induction machines in a low speed range with an instantaneous speed observer and inertia identification. When the low resolution incremental-type encoder is used for the speed detection, we only obtain the average speed in the interval of the encoder pulses, and it usually makes the speed controller unstable at the very low speed range. This paper, therefore, proposes a low speed control method with a speed observer which is implemented by the disturbance observer using a low percision shaft encoder. Furthermore, to improve the performance of the speed controller, we will perform the identification of the inertia which is estimated by the periodic test signal. We will show that this proposed method is superior to the conventional method by simulation and experiment results.

Index Terms—Low speed control, instantaneous speed estimation, inertia estimation, inertia identification, disturbance torque observer.

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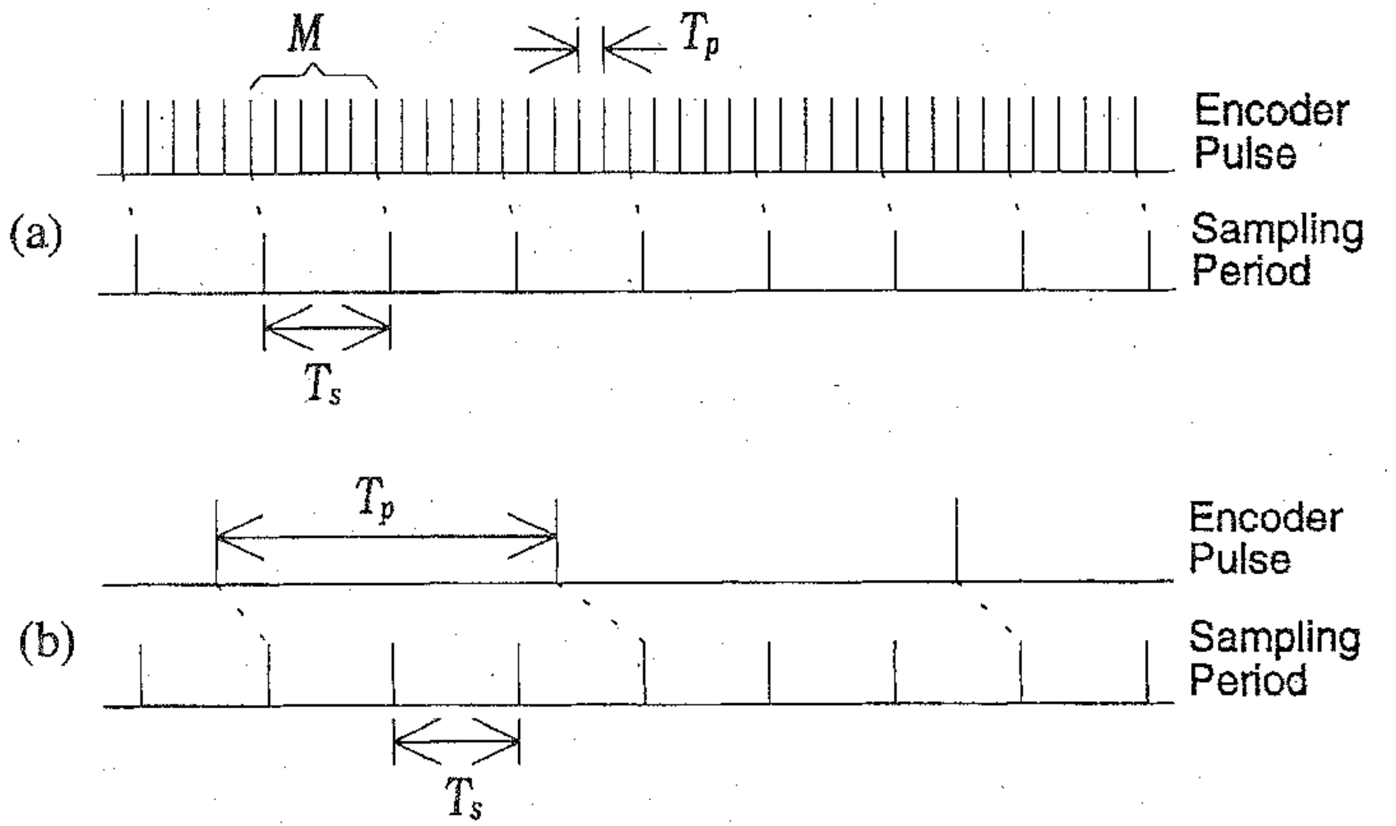

Fig. 1. Relation between encoder pulse and sampling period. (a) Middle/high speed range. (b) Low speed range.

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On the other hand, at the low speed, the speed sensing is performed by an incoming instant of the encoder pulse. This means that the speed sensing information is delayed in some measure. On this occasion, the maximum detection dead time of the middle/high and low speed range can be expressed as (1) and (2), respectively,

$$T_d = \frac{T_s}{2} + T_p \tag{1}$$

$$\boxed{T_d = \frac{1}{2}T_p + T_s. \tag{2}}$$

As above, if the encoder pulse is longer than the sampling interval, that is, at the low speed range, the detection dead time will be abruptly expanded.

线上课程《交流电机控制回路设计》
6.3 数字控制系统中采样、Z转换与零阶保持器的本质

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From now on, we can examine the effect of the speed detection deadtime on the stability of the speed feedback controller. The open-loop speed transfer function, without regard for the inner control loop delay of the speed controller, is shown as (3). In (3), f_s is the response frequency of the speed controller and s is the Laplacian operator. In order for the controller to be stable, in the case where the operating frequency f is equal to f_s, the phase delay should be smaller than $\pi/2$ rad.

$$\frac{\omega_m(s)}{\omega_m^*(s)} = \frac{2\pi \cdot f_s}{s} \exp(-s \cdot T_d) \tag{3}$$

$$2\pi \cdot f_s T_d \leq \frac{\pi}{2} \tag{4}$$

where ω_m^* is the speed reference.

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In view of rotating N r/m with the P ppr precision encoder for the speed sensing, the interval of encoder pulse is shown.

$$T_p = \frac{60}{N \cdot P}. \tag{5}$$

In case that the encoder pulse is longer than the sampling period, that is, in the very low speed regions, a controllable speed of the machine is calculated as stably as possible by (2), (4), and (5) as (6):

$$N = \frac{120 f_s}{(1 - 4 f_s \cdot T_s) P}. \tag{6}$$

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For example, in cases that 1) the required speed response characteristics is 50 Hz, 2) the speed information is obtained by the encoder with 4096 ppr resolution, 3) the speed sampling time is 1 ms, we will determine that the controllable speed as stably as possible is nearly 1.8 r/m.

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- 如何解決
  - 「使用光學編碼器脈衝計算速度，在極低轉速下的問題？」
- 可以參考：
  - 5.10 经典Luenberger估测器的本质及其回路设计
  - 5.11 通过编码器测量角度估测电机转速与扰动的Luenberger估测器设计