Asynchronous Motor Fault Detection Circuit Design

Zongming Li, Baichao An, Haoyu Lu, Qiang Liu, Liying Yuan
(Automation School, Harbin University of Science and Technology)
yly@hrbust.edu.cn

Abstract: By analyzing the types, causes and the fault feature of common fault of squirrel-cage asynchronous motor, and based on the study of the principles and methods of fault detection of electromotor, the multi-channel electric power data acquisition system is designed, which can realize the online fault detection of motor. Using AT89C52 microcontroller as the core components of the controller, and data collection use a special measurement chip CS5460. The data collected is transmitted to the upper computer by RS232 bus so as to realize the electric energy data. Sampling interpolation FFT algorithm make software compensation, and then the MCU high-speed interval of multi-channel data acquisition is realized.

Key words: Motor fault detection; Data acquisition; MCU; Software compensation

1 Introduction

Asynchronous motor has a series of advantages of simple structure, low price, reliable operation, high efficiency, convenient repair and so on, which is widely used in the national economy. Squirrel-cage asynchronous motors are widely used in industry, agriculture, transportation, national defense construction and daily life. With the development of high-power electronics technology, asynchronous motor frequency control of motor speed has been applied widely, making squirrel-cage asynchronous motors are used in some high performance drive field[1,2].

The motor stator are most frequently malfunction, stator winding fault is the main variety of forms of fault because of the insulation damage, such as inter turn short circuit, single phase to ground short circuit, phase to phase short circuit and partial discharge etc.. The inter turn short circuit fault accounted for more than 50% the stator winding fault[3]. Minor failure occurs, which often causes the motor slip, stator current and input power increases. Conducting bar broke seriously, which make the motor start-up time is lengthened, and even can not start, and broken bars can also cause adjacent broken bars, even the stator winding insulation fault is made[4].
2 Asynchronous motor fault detection method

The stator winding inter turn short circuit fault may cause the stator current high harmonic and fractional harmonic. Therefore, asynchronous motor in normal operation and different degree of inter turn short circuit fault are studied, and we found when the stator winding inter turn short circuit in stator current occurs when fifth, 7, 11 harmonic increased significantly, of which 5 harmonic increased most, because of the higher harmonic frequencies is far away from the fundamental frequency, so we can realize the stator winding inter turn short circuit fault detection by detecting stator current harmonic component.

The vibration characteristics of asynchronous motor stator winding short-circuit fault and stator current of the induction motor stator coil when short-circuit fault, correlation coefficient is introduced. [5].

Common rotor broken bar detection methods include: stator current detection, magnetic flux detection and mechanical signal detection. Stator current detection is the most typical detection method. Research shows that stator current will appear additional current component whose frequency is \((1 \pm 2s)f_1\) when the induction motor broken rotor bar fault. Making the current component as the rotor broken bar fault feature. Due to the stator current can be collected easily, so the spectrum of the stator current based on Fourier transform analysis has been widely applied in rotor broken bar fault detection method[6].

3 Hardware design of detection device

3.1 The overall structure design

The squirrel cage asynchronous motor fault detection device is a portable instrument. Under the condition of squirrel-cage asynchronous motor without downtime , three-phase current data collection and three-phase voltage data acquisition are made and offer RS-232 serial communication function, the number of motor nameplates stored ,fault detection records ,real-time measurement date and the voltage and current sampling data of the motor are uploaded to the host computer.

The system selects chip CS5460 of the German CIRRUS LOGIC company launched with serial interface for single-phase to power/energy metering, which integrates 2 2kHz bandwidth and 16 bit A/D, high and low pass digital filter, energy calculation unit, serial interface, digital / frequency converter register array and an on-chip watchdog timer function unit, connected with a low cost shunt or transformer for measuring current, which connected with resistor divider or transformer for measuring voltage. CS5460 can measure accurately and calculate instantaneous voltage, instantaneous current, instantaneous power, power, voltage (VRMS) and the current effective value (IRMS).

MCU is the core elements of the whole circuit, AT89C52 MCU[7,8] is adopted in the design. The AT89C52 is a low-power, high-performance CMOS8 bit
microcontroller, which is compatible with the industry standard 80C51 instruction and pin. Current channel of CS5460 connects with low power diverter or transformer; Voltage channel connects with low power divider or transformers. The current channel programmable gain amplifier (PGA) gain can be set to 10 and 50, respectively, corresponding to the maximum effective value of AC signal input 150mV and 30mV; The maximum effective value of voltage channel is input as 150mV.

Fig. 1. The overall hardware design of asynchronous motor fault detection device

3.2 Software design

Since the FFT algorithm have the higher requirements of periodic measurement signal, and which have picket fence effect and leakage phenomenon, so this article uses FFT algorithm based on interpolation to improve sampling precision.

Set a frequency as $f_0$, the single frequency signal $x(t) = A e^{j2\pi f_0 t}$ of amplitude as $A$. Discrete signal $x(n)$ is obtained after the signal is sampled and analog-to-digital changed. Set the sampling interval as $\Delta t = 1$, and the frequency interval as $\Delta f = 1/N$. The frequency spectrum as

$$X(k) = \sum_{n=0}^{N-1} x(n)e^{-j2\pi kn/N}$$

The article choose the Han ning window after comparison of the characteristics of a variety of window functions. The Han ning window is also called raised cosine window or a square of cosine window, whose unilateral expressed as

$$W_{(n)} = (1/2)[1 - \cos(2\pi n/N)]$$

In the discrete Fourier transform, the Hanning window weighted input sequence $x(n)$ is weighted directly, and $x(n)$ and $w(n)$ are not multiplied in the time domain, and which is realized in the spectral sequence output on the $X_w(k)$ linear combination. The discrete Fourier transform $X_w(k)$ after Hanning weighted as
By the formula (4) shows, the discrete Fourier transform Hanning weighted output $X_w(k)$ is the linear combination of $x(n)$ sequence of discrete Fourier transform.

$$X_w(k) = \frac{1}{2} \left\{ X(k) - \frac{1}{2} [X(k-1) + X(k+1)] \right\}$$  \hspace{1cm} (4)

The actual calculations, $X_w(l+1), X_w(l)$ is get by the sampling sequence after FFT operation, $l$ is determined by the length of the data window length, so $\omega$ can be determined by type (3), and then $\delta$ is calculated by the formula (4), finally the actual frequency can be calculated by the $f_c = (1 + \delta)\Delta f$.

4 Conclusion

Taking CS5460 and AT89C52 as the main body and its peripheral devices as the hardware platform, the current and voltage data acquisition device of small and medium size squirrel-cage asynchronous motor whose nominal voltage is 220V/380V, rated power is 220kW. The main research results are as follows:
1. Motor fault detection scheme of the device is put forward, through analyzing the common fault, fault feature of squirrel-cage asynchronous motor and fault detection principle.
2. According to the determined device function, the hardware circuit diagram of squirrel-cage cage asynchronous motor fault detection device is designed.

Reference

1. Liu, X.: Research and development of portable motor fault diagnosis instrument. Xian science and technology building University. 2003,71~74
4. Li, J.: The design based on multi-channel data acquisition system of electric power of MCU AT89S52. Manufacturing automation. 2011:3~6