

微机式电动机故障监测及保护的研究

胡崇岳 北京联大机械工程学院(100020) 刘思源 机械部科技信息研究院(100037)

【摘要】本文提出一种电动机故障监测保护方案。基于对运行电流的各相序分量的分析,以微机构成监测保护装置,该装置功能强、成本低、可靠性高。

【关键词】 电动机故障 单片机 监测保护装置 抗干扰

前言

在发电厂、矿井、石化部门使用着大量的电动机,一旦电动机发生故障,不仅损坏电机本身,而且给生产带来极大损失。对电机进行运行监测和故障处理是提高运行可靠性、防止事故的重要保证。

针对电动机的各种故障,可以采用不同类型的继电器进行保护,但其性能比较单一,动作速度受机械惯性限制,尺寸大,消耗功率多,一般用于小型电动机。

目前应用较多的集成电路式保护装置克服了机电式继电器的缺点,但每增加一项监测保护功能就要相应增加一个功能回路,其体积、重量、成本同样随之增加。

采用单片微机构成的故障监测保护装置,不仅本身集成度高,更为小型化,而且能以软件取代硬件。每当增加功能或满足用户不同需要时,修改软件即可,无需增添硬件投资,有利于降低产品成本。其二,单片机具有很强的数据处理能力和逻辑判断功能,可以根据故障参数,对事故作进一步分析处理,不仅能确定越限、报警、发出跳闸命令,而且能与调节系统、减载机构联系起来,自动调节负载,使整个系统处于最佳状态。其三,可以自诊断,自动校正由环境变化引起的测量误差,具有很高的性能价格比,还可与上位机通讯,实现遥测、遥控。

1 故障分析

广泛使用的三相异步电动机的主要故障有定子绕组短路、接地故障、断相、不对称运行、起动时间过长、转子堵转、过载、欠压等。

电动机正常运行时,是对称电压加到对称绕组上,各相电流完全对称且为额定值。

如果电流大大超过额定值,但仍然对称,故障原因为负载过大、电源电压降低、转子堵转、起动时间过长或三相对称短路等。

如果是各种不对称短路、断路引起的故障,按照故障点的位置,可归纳为两类:

一类是电机绕组内部发生不对称短路(相间、匝间及对地)或断路,此时三相绕组不再对称,各相漏阻抗不等,各相感应电势也不等,即使外加电压对称、各相电流也必然不对称。此时通过检测实际的故障电流,总可以将其分解为正序、负序和零序分量。正常接法的电动机,不论 Δ 接或Y接都没有中线,线电流中不可能出现彼此同相的零序分量。因此,一旦检测到线电流中含有零序分量,即可断定发生了接地故障,反之,当不含零序而含负序时,则为各种相间、匝间短路或断相故障。

收稿日期:1996—02—05

《继电器》1996年第2期 41

另一类是由于机端(及外部线路)发生不对称短路或断路,此时绕组本身是对称的,实质上是不对称电压加到对称绕组上,也要产生不对称电流。由于绕组对称,使用对称分量法即可十分方便地将故障电流计算出来,不再赘述。

2 监测保护装置的构成

为监测三相异步电动机的各种故障,可以检测电机运行时的线电流。利用单片机实现各种运算、进行逻辑分析十分快捷。对于正弦量,采集相隔 90° 的两个瞬时值,即可计算出有效值。

$$i_1 = I_m \sin(\omega t_1 + \varphi_1)$$

$$i_2 = I_m \sin(\omega t_1 + \varphi_1 + 90^\circ) = I_m \cos(\omega t_1 + \varphi_1)$$

$$i_1^2 + i_2^2 = I_m^2 [\sin^2(\omega t_1 + \varphi_1) + \cos^2(\omega t_1 + \varphi_1)] = I_m^2$$

故

$$I = \sqrt{\frac{i_1^2 + i_2^2}{2}}$$

测出相位,即可找出被测电流的正序、负序与零序分量:

$$I_A^+ = \frac{1}{3}(I_A + aI_B + a^2I_C)$$

$$I_A^- = \frac{1}{3}(I_A + a^2I_B + aI_C)$$

$$I_A^0 = \frac{1}{3}(I_A + I_B + I_C)$$

1) 当 $I_A^- = 0$ 且 $I_A^0 = 0$, 为三相对称运行。

此时 $I_A = I_B = I_C = kI_N$

$k = 1$ 为正常运行(额定运行)

$k > 1$ 视不同情况分别处理:

若为三相对称短路,在 20ms 内跳闸,实现速断保护并且不影响电动机正常起动,若为转子堵转或起动时间过长,在 8~12s 内切断电源;若为负载过大或是额定负载下因电源电压降低引起的电流过大,则根据电机实际运行情况生成反时限保护特性,并按热态或冷态、电动机的不同工作方式区别对待,以充分发挥电动机的过载能力。如果用户有要求,还可以与减载机构(调节机构)联系起来,自动调节负载。

$k < 1$ 为轻载运行。也可以按用户要求动作,如某种特殊场所使用的电机,要求欠载停机,并且延时自起动等。

2) 当 $I_A^0 \neq 0$, 为绝缘破损或其他因素导致的接地故障。不论零序分量数值大小,都意味着存在漏电隐患,应及时检修、处理。对于中性点直接接地电网将导致严重事故,在 0.1s 内跳闸。

3) 当 $I_A^- \neq 0$, 为不对称运行。若为不对称短路,在 20ms 内实现速断保护;若为断相,在 0.2s 内切断电源;若为电网电压的轻微不对称(如电网带单相负载引起的不平衡)应根据不对

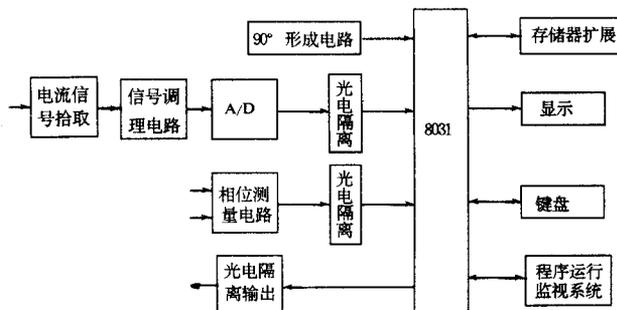


图 1

称程度作出不同的反应。此处按负序分量大小实现反时限保护。

2.1 硬件

单片机可以采用 8098 或 8031, 后者价格便宜, 前者功能更全, 本身带有 A/D 转换器和程序运行监视器, 使用更为方便。硬件构成如图 1 所示。

电流信号经过调理完成消除干扰及与 A/D 接口的电平配合, 转换为数字量后送入单片机。为保证瞬时值采样严格相差 90° , 且不受频率变化的影响, 利用串联电路中电阻与电容上的电压相差 90° 的特点构成 90° 形成电路。如果采用 8031 还必须建立一个程序运行监视系统, 以确保运行可靠。

2.2 软件

主程序框图如图 2 所示。

其主要任务是对电流进行检测与计算, 判断电机运行状态, 识别各种故障并作相应处理。程序采用结构化设计, 一种功能对应一个模块。扩充功能极为方便, 如为满足特殊场所用户“欠载停机并延时自启动”的要求, 只需增加一个十分简短的软件模块, 无须增添任何硬件即可达到目的。

为彻底防治干扰, 在电源、硬件和软件上采取多重隔离措施, 事实证明, 本装置具有相当强的抗干扰能力。

3 结束语

本装置采用单片机监测电动机故障并进行保护, 成本低, 功能强, 动作快, 可靠性高, 较之集成电路保护器有更高的性能价格比。模块化的软件结构使调试、维修、扩充都很方便。

参考文献

- 1 李发海、陈汤铭、郑逢时、张麟征、朱东起编著. 电机学. 科学出版社, 1982 年
- 2 何立民编著. 单片机应用系统设计. 北京航空航天大学出版社, 1990 年

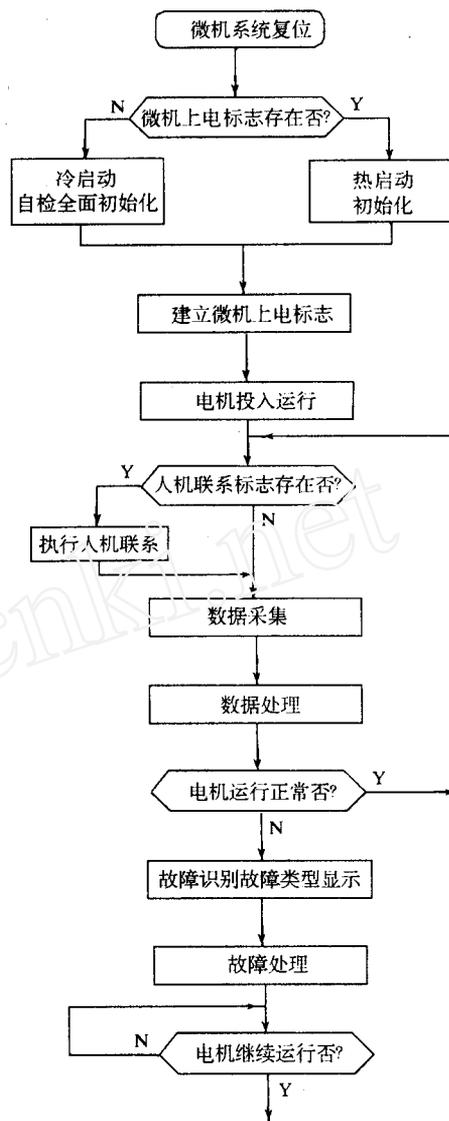


图 2

Approach to A Complete Set of Microprocessor—Based Protections for LV or MV Substations Chen Peilun, et al (34)

This paper introduces a complete set of microprocessor based protections which are suitable for 6~66kV substations and can realize various relay protective functions of feeder, transformer, capacitor and motor in the substations. The protections feature high uniform hardware, strong anti—interference and capability of communication with PC computer.

Key word: complete set of microprocessor—based protection, hardware, PC communication, RS—485 communication port, integrated automation, 80C552 SCP

Analysis on Reliability and Security of SWT500F6 Teleprotection Audio Signal Transmission Device Zhu Yanzhang, et al (38)

Through analysis on the principle, security and reliability of SWT500F6 teleprotection audio signal transmission device as well as various cases easily occurring in site operation, this paper gives you a new knowledge of SWT500F6 and is very helpful to operational person on site.

Key Word: teleprotection, key frequency shift, priority code, security, reliability

Study of Microprocessor—Based Motor Fault Monitor and Protection Hu Chongyue, et al (41)

This paper presents a new motor fault monitor and protective scheme which is based on the analysis of different phase sequence components of operational current. The monitor and protection device is made up of microprocessor and features stronger function, low cost and higher reliability.

Key Word: motor fault, SCP, monitor and protective device, anti—interference

Development and Approach to Management Information System of Relay Protective Equipment for Power System Du Jingyuan, et al (44)

This paper simply describes the principle of E—R method for database design, and then analyzes and studies the relay protective equipment of power system according to the E—R method and the general rule of management information system development. The information system is programmed in FOXPRO2. 5 and C language under DOS system. The functions and realization method of the information system as well as its convenient help function are simply introduced. The system features quick operation speed, high code quality, friendly man—machine interface, sensitive operation, rich prompt, and stronger applicability. After slight change, it can be spread to power system or other industrial fields. So it is very valuable to apply and spread.

Key Word: management information system, database, power system, relay protection

High Sensitive Feeder Protection Wen Cunrun, et al (48)

A Research for Intelligent Low—Frequency Decrease of Load Device by Using Single—Chip Computer Sun Ying, et al (50)

This paper introduces an intelligent Low—frequency decrease of Load device by using single—chip computer. This device can automatically change the frequency constant and the delay time according to the rate of decreasing frequency. It is favourable to the power system stability by quickly clearing of the power load.

Keyword: low—frequency, decrease of load, single—chip computer

SERVICE EXPERIENCE

Discussion on Secondary Connections of PTs in 110kV system Li Changguo (53)

Questions and Improvement of INDUCTIC 65C Fault Recording Device of BBC Company in Service Shen Xuebin, et al (57)

This paper analyzes the questions of INDUCTIC 65C fault recording device, such as interface box damaged and input parameter error between data collection station and data analysis station in service of Yuntian and Gangshi 500kV substations. The improvement scheme and considerations to be noted in adjustment are presented.

Key word: data collection station, data analysis station

Improvement of Protective Scheme in Middle and Small Size Electric Power Stations Yu Weijun (62)

STANDARDIZATION RESEARCH

Group Technique and Standardization Li Shaofeng, et al (71)

This paper presents group technique and standardization concept and further discusses the relationship between group technique and standardization and the promoting action of group technique on design, technology, production and management.

Key word: group technique, standardization