Microprocessor Controlled Contactors

Mark R. Thek & Imtiaz Khan
Leach International
6900 Orangethorpe Avenue
Buena Park, CA 90622

Abstract - **A new family of high current AC contactors has been developed. The contactors have the ability to sense current in each of the three phases. This information is processed and the contactor performance is controlled by the internal microprocessor. The microprocessor provides flexibility and programmability for the trip characteristics, time delay, and reaction to imbalance condition and ground fault. The fundamental current carrying capability of this family of devices ranges from 25A to 275A continuous current at 115/200 VAC, 400Hz, 3 phase, with overload capability up to 1600A.**

I. OVERVIEW

A new generation of smart high power 3 phase AC contactors has been developed. These contactors combine the utility of high current switching with microprocessor control. Two families of products have been developed. The ZE family switches continuous currents in the 25 to 150 Amp range, while the WE family switches continuous currents in the 150 to 275 Amp range. Using integrated current transformers the contactors are able to sense current in each phase. This information is processed by the internal circuitry and micro-controller. Based on programmed instructions the micro-controller commands the contactor to react to this sensed current. Depending upon the system requirements, the contactor can be programmed to react to many situations. Examples of routines the contactor can be watching for are; phase current imbalances, violations of I^2t curves, counting and time-out monitoring. All of these conditions and threshold values can be programmed into the device.

II. ELECTRONIC DESIGN

The electronic circuits are packaged in two different physical configurations in order to accommodate two different size contactors. The circuits are nearly identical and this description will apply to both circuits with differences noted.

The electronics design is based on a single chip microprocessor. This processor contains 16K bytes of one-time-programmable memory for program storage. It also contains a 10-bit analog-to-digital converter (ADC), an 8-input analog multiplexer, a watchdog timer, and various other timer functions.

The electronic system is powered by a single +28 VDC power source which is monitored by the processor, using channel 0 of the ADC. Sufficient energy is stored on-board to allow the processor to operate for a minimum of 350 milliseconds after loss of the +28 VDC.

In response to an input command the processor will apply +28 VDC power to the contactor's coil to close the three-phase contacts. The individual phase currents are measured by the current sensing-circuits, which are applied to the ADC inputs of the processor. The processor generates three pulse-width-modulated (PWM) signals to represent the measured values of each phase current. In addition to reporting the measured current by way of the three PWM signals, the processor uses the current measurement information to determine when it is necessary to open the contacts and interrupt the current to protect system wiring. The processor utilizes an algorithm – I^2t rating of the contactors is programmable from the external connector and trip programming may also be accomplished via jumpers on the circuit board.

One version of the electronics provides the capability to compare the current flowing through the contactor with the current flowing through a remote load. A differential current of 20 +/- 10 amps in any phase will result in a "tripped" condition as indicated by the "LATCHed" output signal.

The WE electronics is physically larger. All electronic circuits are on a single circuit board. The ZE circuits have been partitioned into two circuit boards. The main circuit board contains the majority of the components and is called the motherboard. A smaller circuit board (daughter-board) contains a small number of larger components. The only connections to the daughter-board are four wires connecting the daughter-board to the motherboard.

WE electronics provide three lines for trip programming while the ZE provides four. The WE trip programming must be performed at the external connector while the ZE may be programmed either

from the external connector interface or by placing programming jumpers at locations provided on the circuit board. If a valid trip programming code is not read by the microprocessor, the trip value will default to the lowest valid trip current for the contactor type. A low signal is programmed by the presence of a jumper to ground, either internally or at the external interface connector. A high signal is generated by the pull-up resistors in the absence of jumpers.

The WE contactor must switch approximately three times the amount of current as the ZE contactor. The low-gain current measurement paths for the WE have therefore been attenuated, relative to the ZE, to assure that the circuits are capable of measuring the full range of currents required without saturating. The high gain channels of the two contactors are identical, as both contactors require the same information from the high gain channels, that is 250 amp current measurement.

The electronics are enclosed in a separate compartment of the contactor and are entirely surrounded by metal walls. I/O signals to and from the electronics enter through a filtered connector. Every pin of the connector is an integral part of a feedthrough capacitor wherein the other terminal is formed by the connector plate that is connected to the chassis. Thus, each pin effectively has a 0.004 uF capacitor connected from the pin to the chassis. A ferrite filter plate is mounted on the external connector. This combination of shielding by the metal enclosure and filtering of the I/O pins is intended to protect the electronic circuits from any external radiated and conducted fields that may enter the contactor on the power and control wiring.

The microprocessor is the heart of the contactor's electronics. This processor is an industrial grade embedded processor containing 16 kbytes of on-time-programmable EPROM memory for program storage and various peripheral devices to minimize external support circuits. The industrial grade device is specified to operate over a temperature range of -40°C to + 125°C. The processor is clocked by an 8 MHz clock oscillator. This frequency was chosen rather than the rated frequency of 16 MHz in order to reduce power current and is energized momentarily, for approximately 70 milliseconds, when closing the contacts. The other coil draws less current and is called the "hold" coil. The hold coil is energized at the same time as the pull-in coil and continues to be energized as long as the contacts are commanded closed. FET switches are used to drive the coils. These switches provide a connection for the +28 VDC return to energize the coils. Transient voltage protection diodes are mounted on the frame of the contactor.

III. MECHANICAL DESIGN

Two main objectives were targeted in the mechanical design. These objectives are as follows:

1. Smallest volume and lowest weight while still carrying maximum current loads.
2. Ease of manufacturability.

Both of these objectives were met with the new ZE and WE designs.

The fundamental design utilizes a balanced force approach between the electro-magnet and permanent magnet. This approach allows for strong sealing forces, minimized bounce and ease of assembly. Internal bus connections are made using multi-layered flexible strap. This design technique allows for high conductivity yet flexible connections. Materials selected were proven materials in the contactor industry. The connection configuration utilizes a retractable plunger interface. With minor modification this interface can be modified to support lug or busbar connections.

Basic size and weight of the contactors is as follows;

	ZE	WE
Weight	44 oz	70 oz

dissipation.

Some of the I/O pins are programmed as inputs and are used to determine the logical state of the various control signals. These control signals may be generated externally, controlled by on-board jumpers, or may reflect the state of signals within the ELCU electronics.

Two coils, wound on the same core, are used to close the relay contacts. The first coil is called the "pull-in" or "pickup coil." This coil is high

Size	3.6 X 3.6 X 4.5 inch	4.5 X 4.5 X 4.5 inch

Figure 1.1 Size and Weight of Contactors

IV. PERFORMANCE

As an overview the contactors have been designed to conform to Mil-R-6106J. The contactors have been tested to shock, vibration and operation characteristics consistent with this specification. In general, the load carrying capability of the contactors is as follows;

	ZE	WE
Continuous	25 - 150 A	150 - 275 A
Overload	1200 A	2200 A
Rupture	1500 A	2700 A

Figure 1.2 Basic Load Carrying Capability

As a top-level pictorial, the photo below displays the WE and ZE contactors.

Figure 1.3 Photograph of the WE (left) and ZE (right) Contactors.