Selecting the Right Components for Efficiency Gains and Protection in New and Retrofit Motor Systems

WHITE PAPER

BACKGROUND

As companies strive to cut production costs, reduce power consumption, and increase overall manufacturing efficiencies, a great opportunity exists to achieve all three in industrial applications by incorporating new or retrofit motors with efficient drive and control features. According to Motor Challenge, a program of the U.S. Department of Energy, electric motors account for more than half of all electrical energy produced. Reducing the amount of energy consumed in manufacturing by using more efficient technology allows for savings that can add up substantially. The availability of more efficient technology along with progressively more stringent regulations places mandates on achieving greater motor system energy savings. As a result, the focus of motor system design is shifting from bare motor functionality to a more adaptive and interactive motor efficiency for cost savings and regulatory compliance.

One essential way many of the motors currently in use could realize energy savings is by adding variable speed control features. An electronic controller can provide this capability by modulating the power delivered to adjustable speed drives, variable speed drives and variable frequency drives. Connectivity to software and external systems for control is also an important element in increasing the efficiency of motor systems. Factory automation can benefit dramatically from the promise of increased efficiencies provided by remote access to motor control. The addition of remote access capabilities in industrial automation is experiencing growth with more widespread use of connected Programmable Logic Controllers (PLCs) and Input/Output (I/O) communication protocols.

From the communication interface to the transistor gate level in retrofit and new motor systems, circuit design requires careful attention to the functionality and protection of interfaces and sensitive electronics. Selecting the right circuit protection components ensures efficient functionality and the ability to withstand surges, transients and other potential threats. Each component in the motor system must demonstrate tight tolerances, extensive testing to industry standards and reliability for use in factory and other industrial market applications. This paper explores the parameters of efficient motor systems and communication interfaces in relation to reliable functionality and circuit protection development. Technology is identified at the system and component levels and the multiple benefits of Bourns® component and circuit protection solutions will be highlighted.

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INTRODUCTION TO EFFICIENT MOTOR SYSTEMS

In addition to energy efficiency, factories strive to maximize uptime, productivity and the reliability of the plant. Downtime is costly, so motor health diagnostics, system monitoring and circuit protection are important aspects of overall application requirements. Ethernet and other I/O interfaces provide ease in retrieving and displaying such information on remote terminals, which also can send commands back to control the motors and interfaces in the system. These I/O connections can provide valuable information about components that assist in preventive maintenance, help to make decisions about replacement of aging or deteriorating parts, and provide diagnostic capabilities on the connections throughout a facility.

Efficient motor system designs must take into account requirements for safety and reliability, energy, environment and package size reduction. Surge and circuit protection are key in protecting sensitive circuits so developers must perform UL, surge and reliability tests to compliance standards. Energy requirements are addressed with efficient power management consisting of customized magnetics and trimmers, energy efficient shunts and low conductive in-circuit current protection. Current sense is also an important aspect of energy requirements because it is essential in monitoring input and achieving the optimal power consumption in a variety of settings.

Original Equipment Manufacturers (OEMs) increasingly seek single-source solutions that provide all necessary system components such as motors, drives, controls, smart motors, bearings and gears. Bourns provides the convenience of a one-stop supplier resource for circuit protection, control, power and resistive products. An optimal circuit design provides efficient functionality, protection for the motor system interfaces, increased system reliability and can reduce the footprint and Bill of Materials (BOM). Solutions should take advantage of component technology advancements to maximize performance and aid in miniaturization of the system while decreasing the power output.

A block diagram of a motor system is shown in figure 1. A wide range of technologies such as circuit protection, current sense, resistive and Human-to-Machine Interface (HMI) products used in multiple industries are employed throughout the motor system.

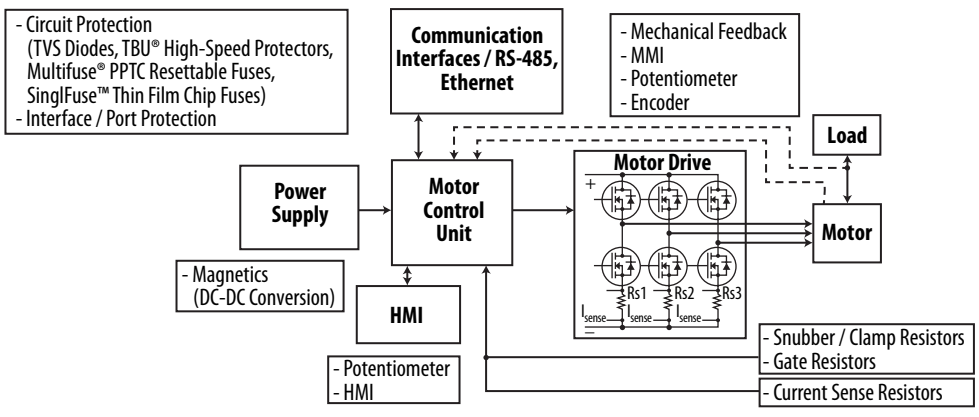

Figure 1. | *Block Diagram of a Typical Motor System*

MAXIMIZING MOTOR SYSTEM FUNCTIONALITY

When designing and protecting an efficient motor system, the portfolio of components must meet important system metrics such as maximizing power handling with minimal power dissipation at lower operating temperatures.

Connectivity and Communication

With the growth and availability of PLCs, compact networking electronics and the Internet, networked two-way communication is now widespread. PLC and I/O modules are tied closely to new machinery using popular communication ports including RS-485, CANbus and Ethernet. Remote monitoring and control with real-time information, commands and feedback are possible. This processing technology, paired with connectivity and communication, are driving capabilities for self-diagnostics, self-tuning, modern control processing optimization and simpler deployment. Regardless of the type of connection, there are several considerations necessary to ensuring the success of the application. There is potential for human error and for faults such as short circuits, miswiring, surges and transients, so circuit protection and interface protection are paramount in the design. Bourns has developed useful single-page PortNote® Solutions that illustrate protection solutions for each of the ports mentioned.

Current Sense, Control and Measurement

Bourns offers a broad selection of reliable resistive components designed to meet performance demands in the motor drive and motor control unit blocks. Snubber and clamp resistors meet the needs for Resistor-Capacitor (RC) filters, and gate resistors are optimal solutions for Insulated-Gate Bipolar Transistor (IGBT) drives and modules. Bourns® open air shunt or metal strip SMD current sense resistors meet numerous performance metrics such as low resistance to minimize power losses; low inductance because of high di/dt; tight tolerance on initial value; and low Temperature Coefficient of Resistance (TCR) for accuracy. Since all materials undergo a unique resistivity change with a temperature change, a high peak power rating is required to handle short duration high current pulses and these components feature a high temperature rating for reliability.

Current sense resistors in the motor drive perform current measurement, provide feedback, and also protect Insulated-Gate Bipolar Transistor (IGBT) and Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET) circuits. Bourns® current sense resistors suit these requirements due to their compact size, high power, large load capability and minimal surface temperature, contributing to the overall efficiency of motor drives. For example, the low TCR and minimal surface temperature of the Bourns® Model CRA Series resistor translates to excellent power capability. In particular, the Bourns® Model CRA2512 power resistor offers excellent performance and higher power handling properties compared to similar components, as illustrated in figure 2.

MAXIMIZING MOTOR SYSTEM FUNCTIONALITY *(Continued)*

Current Sense, Control and Measurement *(Continued)*

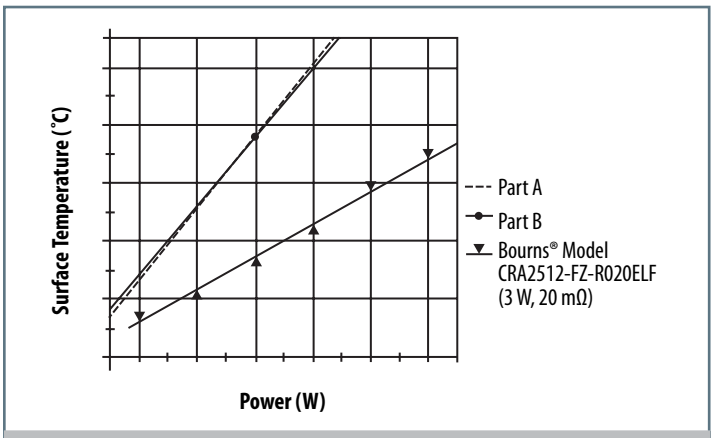

Figure 2. | *Benchmark of Bourns® Model CRA2512 Power Resistor Against Two Similar Components*

Implementing the Bourns® Model CRA2512 power resistor is also an example of how this component can help improve reliability, efficiency and cost-effectiveness in motor design. Because of its high power handling capability, in many cases a single, compact Bourns® Model CRA2512 power resistor can be used instead of the common pair of parallel resistors. Selecting this resistor helps OEMs achieve a compact design and minimal parts count, both of which can be essential factors in many applications. Additionally, the Bourns® Model CRA2512 resistor helps maintain reliability of the system since it is less susceptible to overheating.

Furthermore, input functionality is achieved via Bourns' wide range of Machine-to-Machine Interface (MMI) position feedback sensors which are ideal for providing input from the motor and load to the motor control unit. Contacting and non-contacting technologies are available with analog and digital output options to ensure compatibility with the processor interface. Since deployments vary and many times units must operate in a wide range of environmental conditions, it may be necessary to use rugged components to maintain high reliability in harsh environments or otherwise customize the part to meet specialized requirements. For more rugged applications, the Bourns® rotary position sensors are designed to deliver reliability, repeatability and precision in challenging conditions.

MAXIMIZING MOTOR SYSTEM FUNCTIONALITY *(Continued)*

Power

Power supply efficiency is crucial in any motor system. Rectification and conversion at the power supply are major considerations in motor drive design, and Bourns offers several options for each. Bridge rectifiers are available from 200 - 800 V in the 800 mA to 1 A current range. Higher current requirements of 1 - 3 A can be met with Schottky diodes, though the voltage range is lower at 20 - 100 V. Finally, if a high voltage and fast response are needed, then Bourns has rectifier diodes that feature high voltages of 50 - 1000 V, current ratings of 1 - 3 A, and fast response. Inductors are used at the power supply and perform DC-DC conversion. Shielded and unshielded packages are available in a wide range of shapes, sizes, inductances and current ranges, as shown in table 1.

Table 1. | *Bourns Offers a Wide Variety of Shapes and Sizes for Shielded and Unshielded Inductors*

Family	Shielded	Shape	Inductance (µH)	Rated Current (A)	Size (mm)	Options
SDR	No	Square	1 - 10,000	0.8 - 7	5.8 - 12.7 (L) x 4.5 - 12.7 (W) x 2.2 - 4.8 (H)	7
SDR	No	Oval	1 - 10,000	0.07 - 16	6.6 - 22 (L) x 4.5 - 15 (W) x 4.5 - 7 (H)	4
SDR	No	Round	1 - 15,000	0.06 - 9.5	3 - 13 (OD) x 2.5 - 7 (H)	8
SRR	Yes	Square	0.47 - 15,000	0.07 - 20	3.8 - 12.7 (SQ) x 1.2 - 8.5 (H)	21
SRR	Yes	Oval	1 - 3,300	0.1 - 4.5	10.5 - 18.3 (L) x 8 - 14 (W) x 3 - 6.8 (H)	4
SRU	Yes	Octagonal	0.8 - 1,000	0.15 - 8	2.8 - 10 (SQ) x 0.9 - 4.8 (H)	23

OVERCURRENT AND OVERVOLTAGE PROTECTION

Power supplies must be protected from overcurrent and overvoltage conditions. Depending upon the specific application, Bourns offers designers a variety of component solutions. A Bourns® Multifuse® Polymer Positive Temperature Coefficient (PPTC) resettable fuse is a thermistor that reacts to an increase in current with a dramatic change in resistance to create an open circuit. Following a surge or other overcurrent events, the PPTC resettable fuse can return to close to its original value. This resettable overcurrent protection is available in several families to provide support from 50 mA up to 14 A. The Bourns® Model MF-RM Series of Multifuse® resettable fuses rated to 240 V at currents of 1 - 7 A, is a good choice for motor drives. If reset capability is not required, then the Bourns® SinglFuse™ thin film chip fuse is an option. This single-use thin film chip fuse heats up during a surge event and converts to an open circuit once the temperature of the element exceeds its melting point. A fast acting or slow blow fuse can be chosen over the current range of 500 mA - 7 A.

Furthermore, the Bourns® TBU® High-Speed Protector (HSP) is a silicon-based device series that reacts to an overcurrent situation by restricting current flow to less than 1 mA while blocking voltage simultaneously. One advantage of this resettable device is its quick reaction time of less than 1 µsec. All three types of components share benefits such as compact size, usage in a variety of applications and the ability to protect against overcurrent conditions that otherwise could damage the sensitive electronics in the system.

Overvoltage protection at the power supply interface is provided by a wide range of clamping or series configuration components. Power Transient Voltage Suppression (PTVS) diodes are diodes that operate by moving rapidly from high impedance to a non-linear resistance characteristic that clamps surge voltages over the current range of 3 - 15 kA. Lines other than power can use a TVS diode in the same way. The Bourns® Model CDSOT23, CDSOT236, and CDSOD323 series TVS diodes are recommended for use in motor drive circuits. Metal oxide varistors (MOVs) are voltage dependent resistors whose current predominantly increases exponentially with increasing voltage. In clamping surges, the MOV absorbs a substantial amount of the surge energy in a compact 7 - 20 mm package.

Lastly, Gas Discharge Tubes (GDTs) are high impedance devices that create a short circuit under surge conditions and return to a high impedance state after the surge. The Bourns® Models 2061 and 2063 GDTs are ideal for high currents of 40 - 60 kA. The Bourns® Model 2097 High Voltage GDT operates up to 20 kA at high voltages over 1 kV. For voltages over 2.4 kV and current up to 5 kA, the Bourns® Model SA2 HV GDT is an optimal choice. Bourns® components are designed to provide effective overvoltage protection to withstand harmful voltage levels.

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BENEFITS OF WORKING WITH BOURNS

Bourns has a successful history of providing electronic components for a variety of industrial applications. With a rich and diverse portfolio of sensors, customized magnetics, energy efficient shunts, and low conductive in-circuit current protection components, industrial application experts at Bourns are available to assist in designing a reliable system with efficient power management. Bourns' Field Application Engineers have extensive experience in supporting OEMs in creating a design that performs to specification. Additional advantages gained from selecting Bourns® components include customization and value-added options, and a world class global supply chain.

With an emphasis on efficiency and cost reduction, Bourns' surge and circuit protection solutions enable sensitive circuits to operate reliably due to thorough testing performed to compliance standards. In addition, Bourns provides additional customer support by performing surge tests and other application-specific or specialized tests based on specific application requirements set by the customer.

Bourns continues to enhance its portfolio in terms of durability, size, system compatibility, and other in-demand features to continually meet the broad needs of motor systems. Bourns also offers integrated solutions to provide the added benefit of reducing the physical footprint and BOM costs. The ongoing commitment from Bourns is to deliver innovative total solutions for industrial applications that must operate reliably in challenging environments.

REFERENCES

Additional information about Bourns® products and applications can be found online at:

www.bourns.com

*RoHS Directive 2002/95/EC Jan. 27, 2003 including annex and RoHS Recast 2011/65/EU June 8, 2011.

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Americas: *Tel* +1-951 781-5500
Fax +1-951 781-5700

EMEA: *Tel* +36 88 520 390
Fax +36 88 520 211

Asia-Pacific: *Tel* +886-2 256 241 17
Fax +886-2 256 241 16