



# Intelligent motor control

The UMC100 is an excellent example of a flexible, modular and scalable motor controller

PETER O. MÜLLER, ABHISEK UKIL, ANDREA ANDENNA – In large industrial plants that often contain several thousand motors to provide the necessary motion, any unplanned or sudden motor stops can lead to faults in the process sequence, which can be very cost-intensive. For this reason, reliable management and protection of these motors is of vital importance for ensuring a controlled production sequence. Some current motor feeders are often built up discretely, using for example thermal motor protection based on a bimetal relay. In such a system implementing protection and control functionality is cumbersome and complex; motor control and interlocking functions must be programmed in the process controller, and

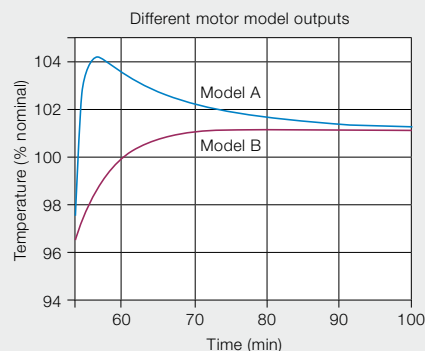
control and feedback signals are exchanged via input and output modules that must be designed and wired. Additional protective functions such as motor winding temperature monitoring via a thermistor require additional devices and wiring. These and many other functions are now integrated in a single device, the intelligent universal motor controller UMC100. Sometimes referred to as an “intelligent motor management module,” the UMC100 offers motor control, motor protection, fieldbus communication with the control system and diagnostic functions. Compared to conventional motor feeders, motor controllers offer many advantages throughout the entire lifecycle of an industrial plant.

Every intelligent motor controller needs a motor model. The model estimates the motor temperature over time in order to produce a trip signal to switch off the motor when a specified threshold is exceeded. The choice of motor model is a critical step in the design of a motor controller, as it affects the performance of the main function of the device. This design choice involves a basic trade-off: On the one hand, the model should be as simple as possible. A complex motor model may not fit the electronic platform of the motor controller and may have too many parameters which are difficult to identify and set for the customer. On the other hand, the motor temperature should be accurately estimated in order to effectively protect the motor.

The minimum requirements for the motor models can be derived from the IEC 60947-4-1 standard [1], which defines the minimum and maximum trip times for different motor sizes (trip classes) and motor current values. For example, the standard specifies that an overload relay or motor controller protecting a motor of trip class 20 should switch the motor off within 6 to 20 seconds when the current is 7.2 times the rated value.

Fulfilling this standard is a minimum requirement for an intelligent motor controller. An oversimplified model of the motor may not capture the dynamics of the motor temperature accurately enough and in the worst case may not trip when the real motor temperature is too high. For example, the motor winding

temperature is influenced directly by the stator current due to the Joule effect and indirectly by thermal conduction with other motor parts. A reliable motor model (model A) should consider both effects, a simpler one (model B) may consider only the first effect, which is the predominant one. The output of these two models that demonstrate a motor running in overload condition for a while before it was switched off and loaded again to nominal condition is shown in the enclosed graph. The thermal behavior of the two models (blue curve for model A, red curve for model B) is shown during the final phase (loading to nominal condition). In this case, the thermal conduction effect is not negligible as the motor was overloaded shortly before, and the winding temperature could temporarily increase to a value higher than the nominal value, as the output of model A shows. Therefore, a more sophisticated model like model A would in this case provide better protection for the motor.



Changing global markets is one reason many companies are being forced to reduce their operating and production costs while increasing output and quality. Energy efficiency is another factor that manufacturers in particular are interested in improving. In fact, there is now an increasing demand for more modular, flexible and integrated solutions. This in turn is causing many providers to look at their portfolios and find ways of enhancing their product offerings in response to this demand.

Integrated solutions are fast becoming more commonplace, in part because technology advances are making integration easier and also because such a solution functions more effectively as a whole rather than the sum of the individual elements that comprise it. In addition, future trends suggest it is a factor that may make or break a company.

For some time ABB has been focusing on the further development of many of its portfolios in response to the trend for the seamless integration of devices, and the success of this effort can be seen in one device, the intelligent motor controller UMC100.

**UMC100 – a closer look**

This universal motor controller (UMC), also known as an intelligent motor management module, is designed for 3-phase AC induction motors, and combines the functions of motor protection and motor management in a single device, as well as diagnostic and fieldbus communication.

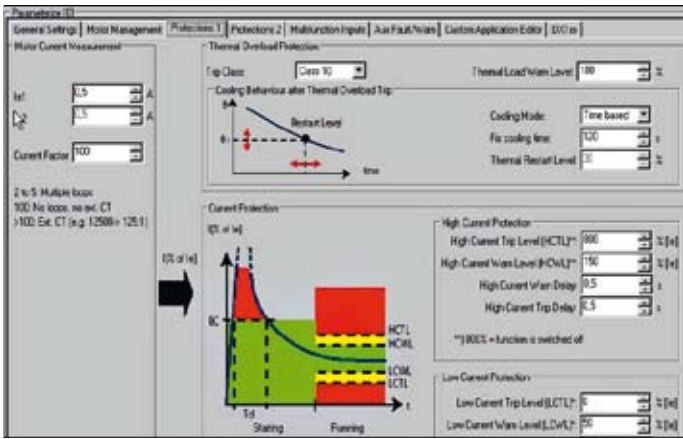
The UMC100 operates fully independently and ensures that the motor is protected at all times, even if the control or bus system fails. The high precision of the electronic measurement system enables the most optimized utilization of the motors and ensures constant tripping behavior.

Parameters can be configured conveniently via standard device description files (eg, GSD/EDS), the control panel or via the device type manager (DTM). The DTM enables the grouping of associated parameters, the graphical display of the parameters' operation and it allows all measurement data to be read out via an

online connection to the device. The DTM dialog panel for the configuration of the protection parameters based on the motor current measurement is shown in → 1.

All control functions most commonly needed in practice are already integrated in the UMC100 and can be simply configured via parameters. The control functions allow the flexible adaptation to different customer requirements and can be adjusted over a wide range. This considerably reduces the engineering effort in the control system as the entire control function is executed in the motor controller. Application-specific control functions can be implemented using the freely programmable logic. If existing motor management modules are to be re-used in the distributed control system (DCS), the position of the control and monitoring signals can be adapted to the current situation. This is particularly beneficial for the retrofit of older plants.

## 1 Configuration of protection parameters with the UMC100 DTM



Four different control points (bus, “on the motor,” cabinet door, service laptop) are supported → 2. For each control point, the motor control can be enabled or disabled depending on the current mode (auto or local). The basic device is equipped with six digital inputs, three relay outputs and a 24V switching output. For more complex applications with a large number of I/Os or special signals, expansion modules are available.

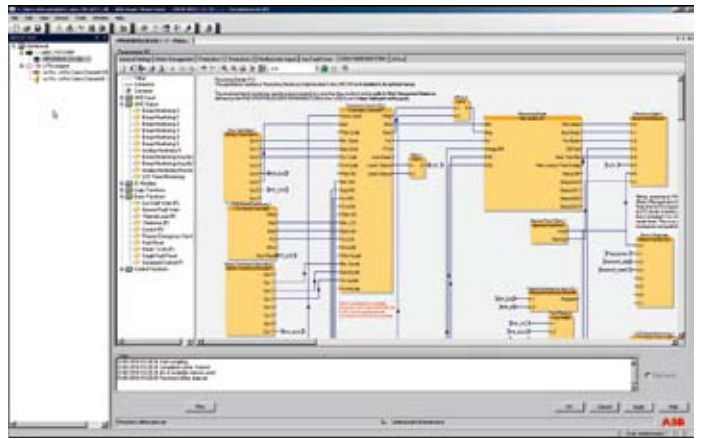
Motor controllers are often integrated into a DCS. For worldwide use, different fieldbuses must be supported. The

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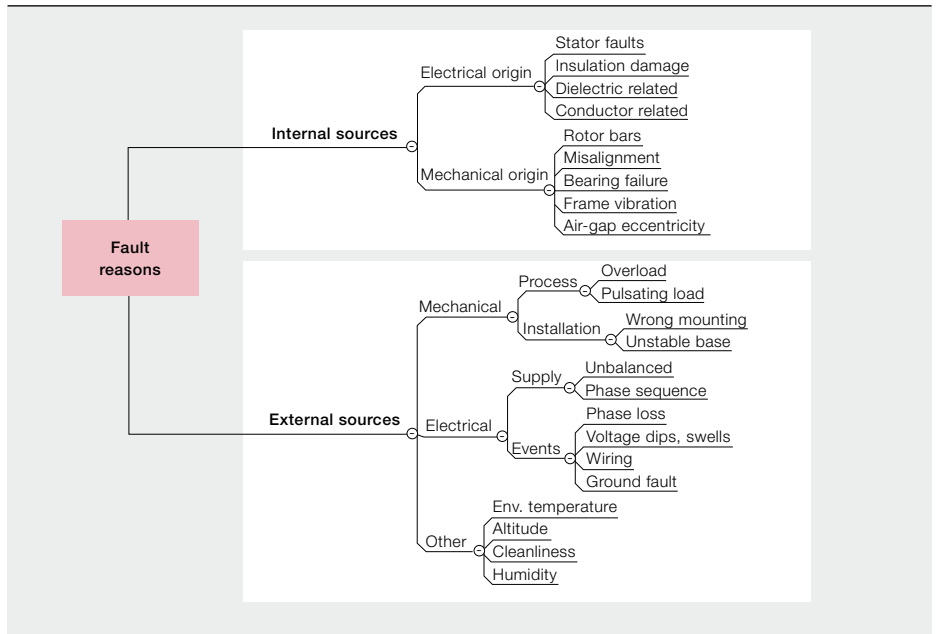
UMC100 supports the Profibus DP, DeviceNet, Modbus and CANopen standards, but full stand-alone functionality is also ensured without fieldbus.

The UMC100 covers the entire current range from 0.24 A to 850 A. Only currents above 63 A require an additional external

## 2 Editor for customized control functions



## 3 Fault sources of induction motors



current transformer, which acts more as a prescaler. And even for small rated currents, the motor leads must be routed through the current transformers only once. Planners do not have to select different types of devices according to the rated current of the motor. Problems caused by unfavorable overlaps of the current measuring ranges will not occur. Overall, the number of typical features to be implemented by the planner can be reduced, thereby facilitating planning, inventory and servicing.

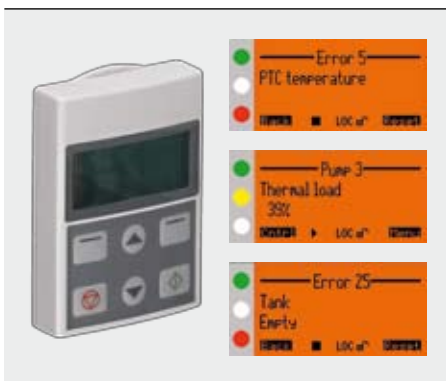
### Diagnosis

Motor failure usually results in a process halt, which in turn seriously impacts the overall operational and maintenance costs. Very often diagnostic information is only used after a failure has actually happened to find out the cause. Therefore, the clear and comprehensive diagnosis of induction motors in their process

environment is of prime importance to avoid faults and make it possible to rectify them quickly when they do occur.

There are different kinds of induction motor faults, the sources of which could be external and/or internal due to various electrical and mechanical reasons → 3. Diagnostics of induction motor faults (especially problems related to internal sources) using the motor current signature analysis (MCSA) [2,3] is currently used in the industry. However, for cost reasons MCSA-based diagnostics mainly target larger motors and advanced motor/drives diagnostics systems, for example, which are more sophisticated and expensive. Other problems like bearing faults are also of interest. However, bearing problems may not directly influence the induction motor's electrical circuit so intensely and might therefore be difficult to detect using MCSA. For this reason

4 The control panel enables the display of all data on-site



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other types of diagnostics, namely vibration analysis, might be more effective.

Rather than having to configure different diagnostic systems to ensure all possible motor fault angles are covered, the ideal solution would be to have a comparatively low-cost motor controller which could provide standard protection and diagnostic functions as well as online motor diagnostic functions.

The UMC100 is such a controller and offers comprehensive test and analysis options, such as the continuous measurement of motor operating hours, motor start and overload trip count, diagnostic data logging, determination of motor starting time and maximum starting current, etc. All data is accessible via the fieldbus and can be used for the planning of maintenance operations. For example, an increase of the starting time may indicate the sluggish behavior of the connected load. In addition, information from the motor model can be used to support the plant operator during operation of the plant. For example, if the indicated thermal loading of a motor exceeds a predefined threshold, the plant operator could reduce the amount of material fed to an agitator to prevent a trip.

Advanced diagnostic options are among the key benefits of intelligent motor controllers. The diagnostic functions of the UMC100 can be accessed from the LCD control panel, from a service laptop or via the bus. In the event of a motor fault, a fast and comprehensive diagnosis is of particular importance. Practice has shown that although a laptop is often available, it is not always ready for immediate use. To overcome this, the UMC100 offers a fully graphical multilingual LCD control panel attached to the cabinet door that displays all status data and parameters in an easy-to-understand way → 4. Error messages are displayed in clear text, and plant-specific message texts can be defined for the freely configurable fault inputs. Hence no laptop is required for fault finding!

**Predictive maintenance pays off**

In combination with ABB control systems, the UMC100 Asset Monitor helps to quickly identify whether a fault is in the device itself, in the external electrical wiring or in the connected process. For this purpose, the Asset Monitor collects all

diagnostic data provided by the UMC100 in configurable intervals and maps them to the following categories as defined in NAMUR recommendation NE107:

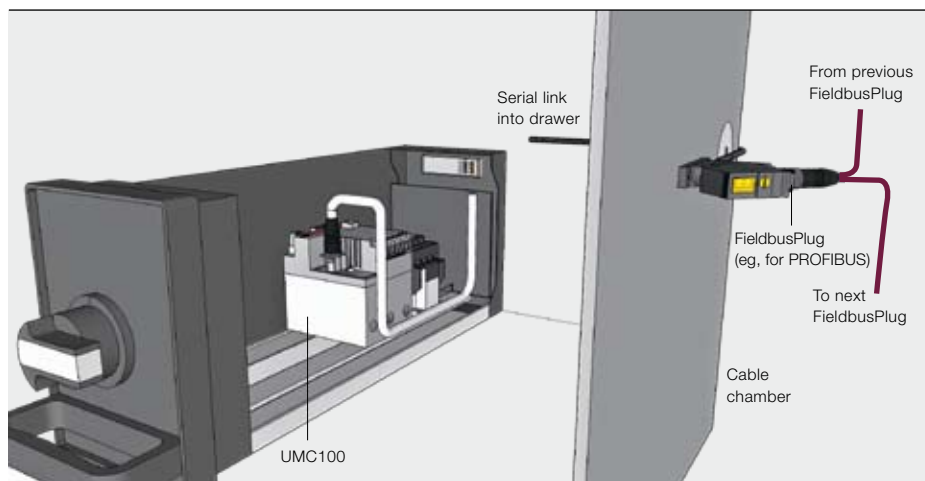
- Failure – The motor is not available due to a functional disturbance in the field device or its periphery (eg, thermal trip).
- Function check – The output signal is temporarily invalid due to work being carried out on the motor feeder (eg, test position during commissioning).
- Out of specification – The motor feeder is still available, but outside the specified limits (eg, motor current above/below the preset limit value).
- Maintenance required – The feeder is still available, but immediate need for maintenance is indicated (eg, wire breakage on the PTC).

These messages help the plant operator to derive appropriate actions for the respective plant without becoming overwhelmed by device details.

The maintenance personnel on the other hand can easily view all available details via the LCD panel on the device or DTM via the bus, for example, to derive concrete plant and device-specific instructions for action. The described condition monitoring and reporting functions can be used to collect, combine, analyze and compare this information with historic data to see, for example, how the starting time of the motor has changed over time. In addition, warnings of incipient wear of devices and components and their possible failure can be identified more easily and presented to the maintenance personnel in an understandable way. This allows better planning of maintenance operations and the minimization of downtime. All maintenance-related data is openly accessible via the fieldbus, ie, the information is also available to already existing maintenance management tools, if required.

Overall, the UMC100 enables a huge step towards a predictive maintenance strategy, which until recently had been associated with cost-intensive specialized measures and has now become economically viable for many applications.

**5 When used for applications with drawers in motor control centres, the UMC100-FBP is positioned within the drawer while the fieldbus connection is mounted externally**



**Simple integration in the tightest of spaces**

Thanks to their compact design and integrated measurement system, motor controllers fit even into the tightest of spaces. This is a huge advantage, especially for applications using withdrawable low-voltage switchgear with limited space or for

**An excellent solution**

By continuously supplying comprehensive operational, service and diagnostic data from the motor to the control system, the UMC100 enables disturbances to be detected at an early stage and appropriate measures taken to prevent or at least limit their effects. The

Because all of the required protection, monitoring and control functions are integrated into a single device, the time and effort needed for wiring is reduced considerably.

retrofitting existing systems to accommodate a modern motor management system → 5. In such applications, a direct integration of the fieldbus node into the motor controller would be disadvantageous as a drop line would be needed to every single device. This often leads to stability problems on the fieldbus. As a result, the baud rate has to be lowered, which in turn leads to longer cycle times. The separation of the bus node and motor controller is the better solution. The separate fieldbus node remains in the cable compartment and communicates with its controller in the drawer. The fieldbus line is linear and has no drop lines. This is also beneficial for a secure operation. If the drawer is removed, the node address will not be lost, and drawers exchanged accidentally will be automatically detected!

modern LCD control panel conveniently shows all operating and maintenance data and supports rapid fault finding without the need of a laptop. The modular structure of the device offers advantages already in the planning and design stage. And the time and effort

needed for wiring is reduced considerably due to the fact that all of the required protection, monitoring and control functions are integrated into a single device.

Compared to conventional technology, the UMC100 is an excellent solution for the implementation of motor feeders in industrial plants as it provides many advantages throughout the entire lifecycle of the plant.

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