MOTOROLA
Semiconductor Products Inc.

AN-801
Application Note

USING INPUT/OUTPUT MODULES IN INDUSTRIAL CONTROL APPLICATIONS

Prepared by
Tom Hopkins
Systems Engineering

Utilization of microprocessors and MSI logic in industrial control applications requires a reliable means of interfacing the logic to both ac and dc levels while at the same time providing isolation between the logic and power circuit. This application note discusses the use of Motorola's series of input and output modules to accomplish that interface.

One of the major uses of microprocessors and MSI circuitry in the industrial environment is in control applications. To deal with real-world applications, the system designer must provide a means for the low-voltage logic to work with the voltage and current levels of other systems. The differences between the logic system and the "real-world" systems define requirements for isolation, power switching, level translation and noise immunity. In addition, the system designer must concern himself with safety and serviceability of the system.

In many systems it is economical to modularize the input and output devices and manufacture the modules in large volume to realize the cost savings of large-scale production. In addition, modularization offers other advantages, such as standardization, ease of maintenance and troubleshooting, higher reliability, and lower design cost.

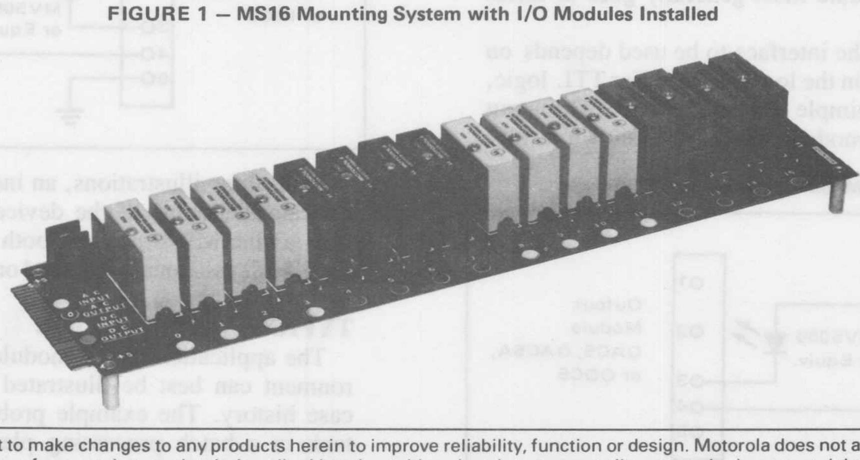
Motorola's series of input/output modules provides this modular means of interfacing the logic signals with ac and dc loads.

ISOLATION

In the United States, the generally accepted standard has been that of the Underwriters Laboratories, which is that isolated systems must withstand 1000 volts plus twice the working or line voltage. For a 240 Vac system controlled by standard logic, the test for isolation would be to apply 1480 Vac for one minute without inducing an isolation failure. Thus, in the past, a 1500 Vac isolation rating was acceptable for American systems.

As more equipment is being required to meet the more stringent requirements of other countries, the 1500 Vac isolation rating is becoming inadequate. Current design practice is to meet the most stringent European requirement of 3750 Vac. Use of modules which meet this requirement not only allows qualification under all known

FIGURE 1 — MS16 Mounting System with I/O Modules Installed



requirements in multinational markets, but establishes a clearly superior and safer product.

POWER SWITCHING

Motorola output modules are not intended to be the final load handling devices in all systems. They do, however, have ratings adequate to handle many small loads such as fractional horsepower motors, small heaters, solenoid valves, and lamps. In addition, the modules are capable of driving final load handling devices such as motor starters.

SAFETY CONSIDERATIONS

One of the important safety considerations is how to connect the output device to the wiring harness. Current practice is evolving toward the elimination of screw terminals on I/O modules. By using the plug-and-socket type of connection, the module can be installed or removed without working with hot wires. This can result in a significant saving of maintenance time, since the electrician no longer must lock out feeder circuits before maintenance. Hence, the current practice of plugging the module into a socketed mounting board and attaching the wiring harness to the board using screw terminals is becoming universally accepted. This type of mounting also has the advantage of making installation more convenient since the wiring can be done before the "electronics" is installed.

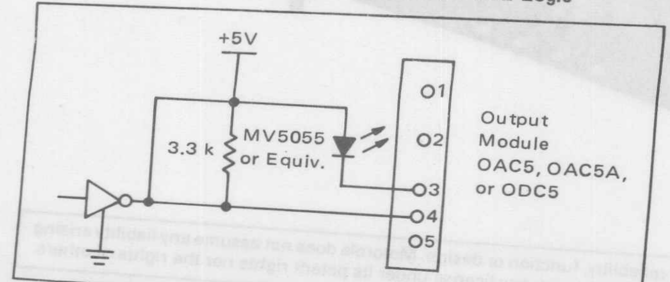
A second topic related to safety is that of fusing. Since most fusing requirements reflect code-writing agencies' concerns to "protect wire," fusing specifications are often outgrowths of safe current levels for wire with regard to heat generation. From the electronics point of view, we are usually more concerned with protecting electronic equipment than wire. Hence, the size, location, and type of fuse is best selected by the system designer. The Motorola mounting boards have provision for a pigtail fuse to be installed in series with each module and the field wiring. The standard boards have a 5-A fuse installed at the factory.

LOGIC INTERFACE

Once the decision to use I/O modules has been made, the only remaining task for the system engineer is to interface the module with the logic and the equipment. For the most part, the interface with the equipment is quite simple, since the module most generally goes in series with the field device.

On the logic side, the interface to be used depends on the type of logic used in the logic system. For TTL logic, the interface is quite simple since a standard TTL output will drive the output modules directly, as shown in Figure 2. This configuration may be used with standard TTL, Schottky (S), low-power Schottky (LS), and high-speed (H) series devices. Low-power TTL (L) may be buffered with an LS device. Although the standard TTL output configuration will drive the module, it may be desirable to use open-collector devices for the output module drivers.

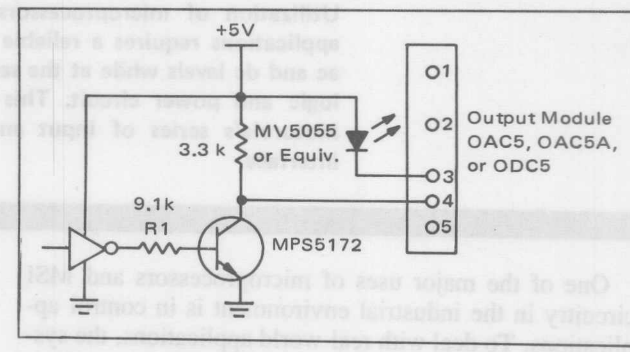
FIGURE 2 – Module Interface for TTL Logic



To interface the modules to MOS logic requires a bit more circuitry. The most obvious interface is to buffer the MOS with a TTL device. For most NMOS devices such as the M6800 family, a standard TTL device may be used. For CMOS operating at 5 volts, a low-power Schottky device may be used as the buffer.

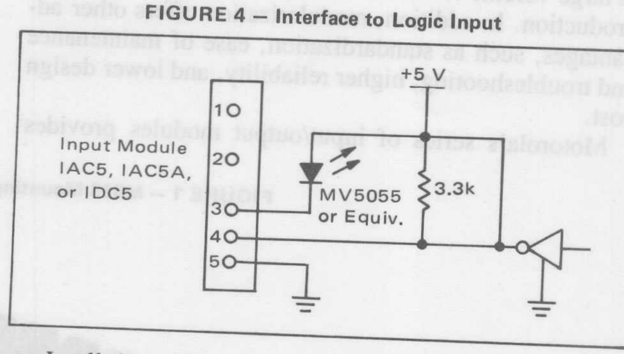
A second method of interfacing MOS devices to the I/O modules is use of a simple saturating transistor, as shown in Figure 3. Here the MOS device drives the base of an NPN transistor, which, in turn, drives the output module. By changing the value of R1 to 39 kΩ, this configuration may be used to interface CMOS operating at 15 volts with 15-volt logic modules OAC15, OAC15A, and ODC15.

FIGURE 3 – 5-Volt Interface for MOS Logic



Interfacing input modules to logic is a simple matter. Since the input modules are open-collector devices, the only additional component necessary is a pullup resistor, as shown in Figure 4.

FIGURE 4 – Interface to Logic Input

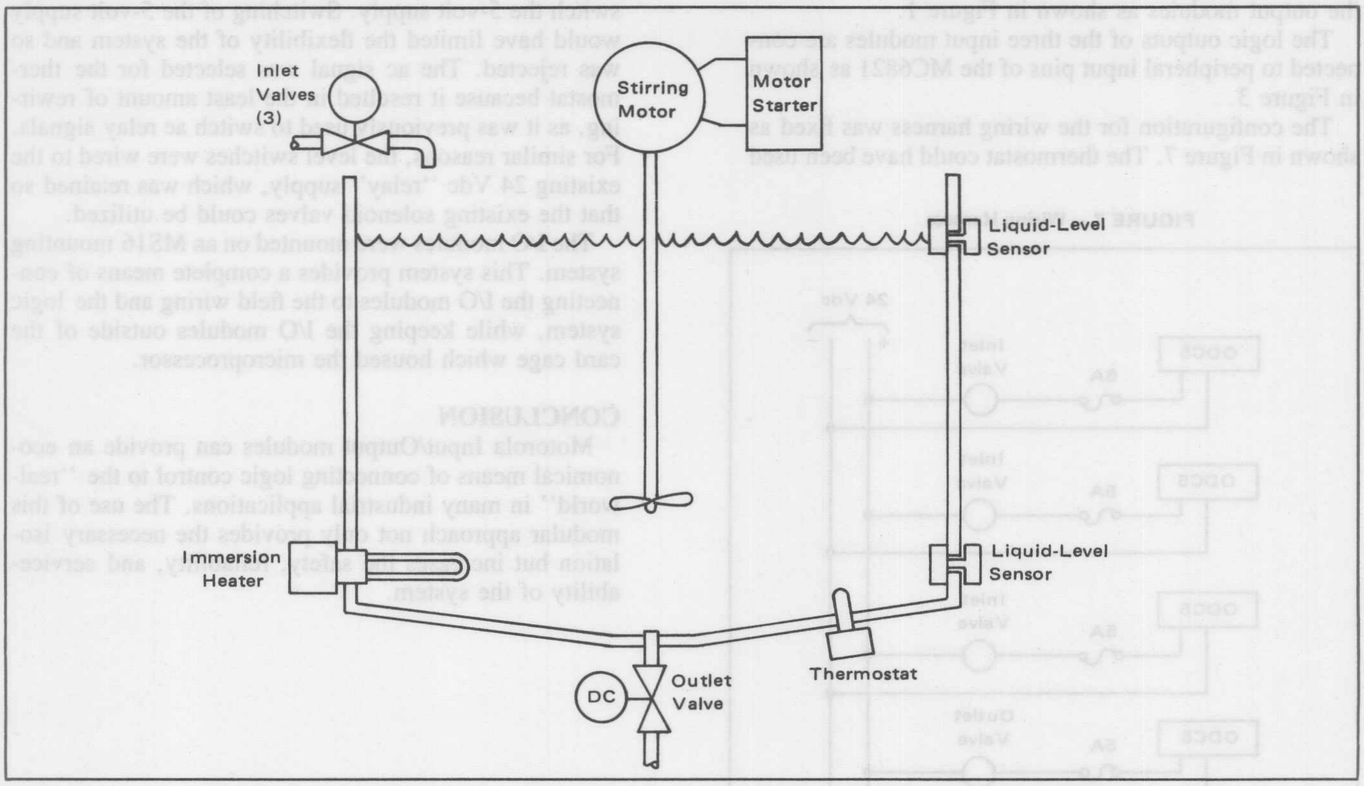


In all three illustrations, an indicator LED is added to indicate the status of the device. If a mounting board such as the MS16 is used, both the indicator LED and the 3.3 kΩ resistor are installed on the board at the factory.

TYPICAL APPLICATION

The application of I/O modules in an industrial environment can best be illustrated by working through a case history. The example problem involves a mixing tank in a batch processing plant. The tank involved, shown in Figure 5, is one of a number of similar tanks

FIGURE 5 – Mixing Tank with Makeup Heater



in a plant that batch-processes liquids through a number of mixing, stirring, and heating cycles. The original plant was controlled by relay logic and had high operating cost due to direct operating labor and maintenance expense. The goal of the conversion of the plant to a distributed processor-based control system was to increase flexibility while increasing reliability and reducing labor.

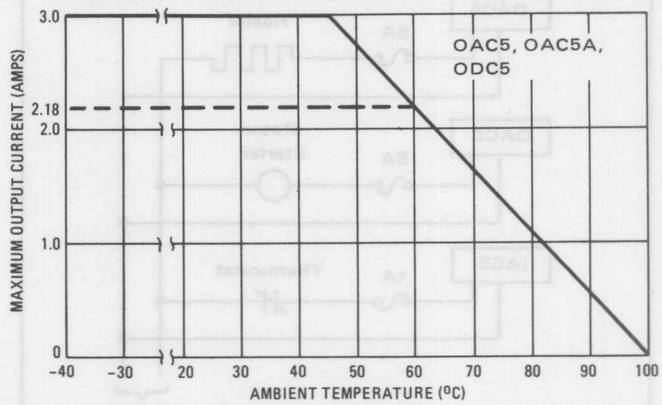
The conversion had to take place piecemeal to avoid shutting down the entire operation. Various pieces of equipment were converted to solid-state control and returned to service by plant engineering during periods scheduled for maintenance. Since time and cost were important factors, existing devices and wiring were used whenever possible.

The particular tank for our example had the following equipment:

1	Stirring Motor	¾-HP, 120 Vac, single phase; starter 120 Vac @ 250 mA
3	Inlet Valves	DC solenoid operated; 24 Vdc @ 1.2 A
1	Outlet Valve	DC solenoid operated; 24 Vdc @ 2.0 A
1	Immersion Heater	200 W resistive-coil type; 120 Vac @ 1.7 A
2	Liquid-Level Sensors	SPST N.C. contacts
1	Thermostat	SPST N.C. contacts

The new electronics housing may have internal temperatures up to 60°C maximum. Since the 60°C ambient temperature is above the maximum temperature for full ratings, the output modules were derated, using the derating curve shown in Figure 6. From the graph it was found that the output modules had a current rating of 2.18 A at 60° C. This rating was sufficient for all of the equipment used in this application.

FIGURE 6 – Maximum Output Current versus Temperature



Since the input modules are not power-handling devices, they do not have a derating factor and may be used over the specified temperature range without derating.

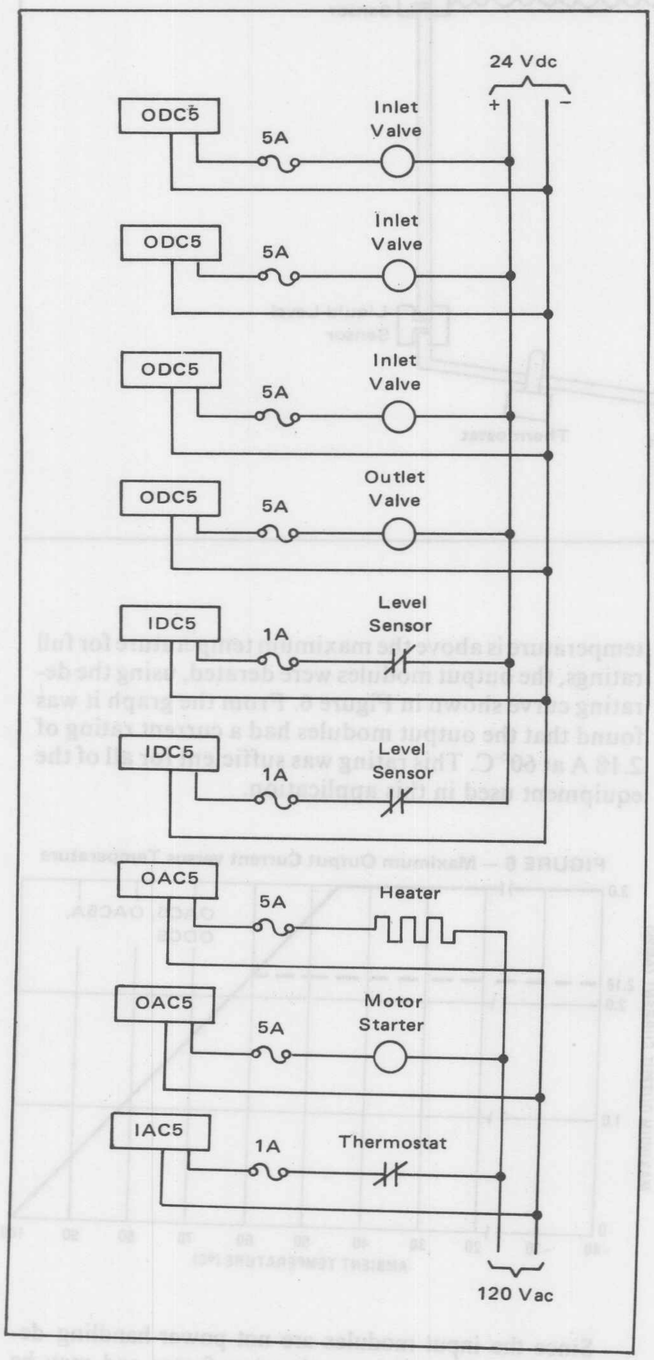
The microprocessor chosen for the application was an MC6800. The outputs were to be controlled through an MC6821 peripheral interface adapter. An SN74LS05 open-collector hex inverter was chosen to interface the

MC6821 and the output modules. The SN74LS05 drives the output modules as shown in Figure 1.

The logic outputs of the three input modules are connected to peripheral input pins of the MC6821 as shown in Figure 3.

The configuration for the wiring harness was fixed as shown in Figure 7. The thermostat could have been used to furnish either a dc signal, an ac signal, or to directly switch the 5-volt supply. Switching of the 5-volt supply would have limited the flexibility of the system and so was rejected. The ac signal was selected for the thermostat because it resulted in the least amount of rewiring, as it was previously used to switch ac relay signals. For similar reasons, the level switches were wired to the existing 24 Vdc ''relay'' supply, which was retained so that the existing solenoid valves could be utilized.

FIGURE 7 — Wiring Harness



The I/O modules were mounted on an MS16 mounting system. This system provides a complete means of connecting the I/O modules to the field wiring and the logic system, while keeping the I/O modules outside of the card cage which housed the microprocessor.

CONCLUSION

Motorola Input/Output modules can provide an economical means of connecting logic control to the ''real-world'' in many industrial applications. The use of this modular approach not only provides the necessary isolation but increases the safety, reliability, and serviceability of the system.