What can an embedded PLC do for your controls solution?

By Don Divelbiss, P.E.

A cost-effective solution for an embedded PLC is the use of an Integrated Circuit (IC) that is a complete PLC. Using a single-chip PLC, development time is greatly reduced because the software drivers for various types of I/O are already embedded on the chip. Once the system I/O has been defined, the appropriate interface circuits can be added to the design and programming can be completed easily using the ladder logic programming language and software such as EZ LADDER. Once the software is complete, it is a simple matter of connecting to either the serial or Ethernet ports on the PLC and downloading the application program. This level of integration allows for the rapid development of a custom control system designed to the exact specifications required by the end application, while at the same time simplifying programming requirements.

Programmable Logic Controllers (PLCs) are fixtures in industrial automation, as their hard, real-time characteristics provide embedded determinism for a variety of applications. And, as industrial machines are now expected to integrate more tightly with other business processes and technology, the versatility of PLCs has become more crucial than ever before. Today, however, cost and space pressures on the factory floor have resulted in a new iteration of PLC technology, the single-chip PLC. Single-chip PLCs are essentially programmable embedded controllers realized on an Integrated Circuit (IC). There are many benefits to using an embedded PLC as part of the design of an OEM control system, as the level of flexibility brought to a design by this technology allows for custom control solutions that fit exact system requirements, lower design and system cost, simplify software support, and increase reliability. In addition, a system utilizing an embedded PLC can meet the most demanding environmental requirements and provide a scalable platform that can support future product features.

Functional flexibility of a modern PLC

Modern control systems are typically required to communicate to a variety of devices, from engine Electronic Control Units (ECUs) to Human-Machine Interfaces (HMIs) to various types of actuators and sensors. As a result, PLCs are required to support range of standard and non-standard I/O, from CAN ports to Ethernet to serial interfaces.

n order to meet the varying I/O requirements of control devices, embeddable single-chip PLCs are able to support a number of physical layer interfaces and industrial communications protocols, while also providing digital input and output interface circuitry that can be designed to the exact requirements of the application. One use case in which this functionality can be leveraged cost effectively is in applications that require a user interface but do not have the budget for a graphical HMI. In these scenarios, single-chip PLCs can be used to interface to LCD character displays, LED displays, vacuum fluorescent character displays, and graphics displays, and also include provisions for various options for user input from discrete digital inputs, numeric keypads, full keyboards, or a combination of the three. These inputs can be integrated onto the controller board, if desired, saving cost and allowing for unlimited button layouts and arrangements.

Low-level analog and digital I/O on embeddable PLCs further allows developers to interface sensors directly to the single-chip PLC - whether they be pressure, temperature, humidity, conductivity, or other custom sensing applications - or counters, quadrature encoders, timers, analog outputs and Pulse Width Modulation outputs

are available for use in a multitude of applications. If further I/O is required, SPI ports can be leveraged for expansion.

Future-proof application control

A particular challenge for modern industrial systems is the inverse relationship between product lifecycles and technological obsolescence. For example, industrial control equipment deployed 10 years ago is likely ill equipped to operate as part of a modern distributed control system.

By supporting several serial bus protocols, single-chip PLCs can mitigate such obsolescence challenges. The Divelbiss PLC on a Chip, for example, supports multiple serial ports and serial communications protocols (J1939, NMEA2000, MODBUS TCP/RTU/ASCII, OptiCAN, & CANopen), effectively "future-proofing" designs by giving the user a way to add additional I/O should the application require it in the future (Figure 1).

This level of expandability can occur on two levels:

- At the system level using CAN, serial, or Ethernet

- At the board level using SPI, serial, or I2C

As such, should a user discover a new market opportunity that requires a feature not currently supported, an expansion module communicating via serial, CAN, SPI, or Ethernet can be designed. This expansion module can be retrofitted to existing products already in the field, allowing backward compatibility to support existing customers while bringing new features to market in an expedient fashion.

Figure 1 | The Divelbiss PLC on a Chip is an embeddable single-chip Programmable Logic Controller (PLC) that supports a range of I/O interfaces and communications protocols to mitigate obsolescence.

In terms of application development, single-chip PLCs utilize the familiar Ladder Diagram language, which provides the ability to support software, troubleshoot installations, and make changes to application programs in a greatly improved fashion over the typical embedded system. This is due to the fact that Ladder Diagram is widely understood and can be easily learned by a wide range of individuals. Its graphical programming format, coupled with the ability to monitor the program while it is running, allows for ease of troubleshooting, and can even be done remotely to prevent technicians and engineers from being required to visit individual installation sites.

For maximum flexibility when programming applications, the Divelbiss PLC on a Chip also supports the Function Block and Structured Text languages in addition to Ladder Diagram, giving users the flexibility to monitor programs during execution, perform variable cross referencing, write custom function blocks, and access to notes fields, program security, and extended math functions. Users can also use the Structured Text language to code certain serial protocols that may not be natively supported on the PLC itself.

PLC power and packaging

As many industrial facilities employ machinery that runs 24/7, 365, power usage can have a measurable impact on the company bottom line. On the other hand, many industrial applications also have unorthodox power requirements.

Single-chip PLC designs can give, in addition to the standard 120/240 VAC 50/60Hz or 24 VDC applications, developers the freedom to design systems capable of operating from virtually any power source. This includes

12 VDC vehicle power, with its associated transient voltages as specified in SAE J1455/J1113, solar or wind power with an integrated battery charging circuit, transit car power at 37 VDC/72 VDC, or even a high-voltage DC power inputs - all with a typical power draw of around 0.3 W.

Another non-starter for electronic components in industrial settings is susceptibility to environmental extremes. Therefore it is critical that single-chip PLCs are ruggedly packaged in a versatile footprint that can meet a variety of application requirements. Using the PLC on a chip as a benchmark, single-chip PLCs are available with a base temperature range of -40C to 85C, with extended temperature variants available on a per-application basis. The alternate ruggedization options of embeddable PLCs enable them to operate in applications that require high tolerance to humidity, shock and vibration, and excessive G forces resulting from constant acceleration, making them a flexible solution for applications that range from mobile equipment to MIL-SPEC systems.

Figure 2 | Embeddable Programmable Logic Controllers (PLCs) offer packaging versatility to fit a range of applications, from explosion-proof valve control (left) to ruggedized mobile computers (right).

New PLC possibilities

Overall, the flexibility of using products like the Divelbiss PLC on a Chip for embedded control projects allows PLC technology to be utilized in markets previously not associated with PLCs. PLC technology can now be utilized in commercial appliances, special purpose printers, motor drives, or various applications requiring custom controls to meet the application's specific requirements. It gives the user the scalability needed to allow for future product features, while reducing design costs and providing for a secure control system that can meet the most demanding environmental conditions.

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