DESIGN SOLUTIONS
INDUSTRIAL

Ruggedize Your Production Floor with a CAN Bus Interface

Introduction

On production floors, the PLC (programmable logic controller) is an industrial digital computer that interconnects various I/O channels throughout the production floor. The factory operator requires robust, highly reliable systems that perform fault diagnostics that are easy to program. The underlying physical layer for this network can be the cell phone, but a better option is a controller area network (CAN) bus system (Figure 1).

Figure 1. Automated Factory Product Line

The PLC uses an I/O network to communicate with system sensors, motors, human machine interfaces (HMIs) and other peripherals. Industrial PLCs use a range of protocol methods. For the network physical layer connections, CAN bus is steadily gaining in importance, as it has high resistance to disturbances. The ease of use makes this physical layer very attractive.

This design solution provides a detailed discussion of CAN bus fault tolerances, the common-mode input range, and the electrostatic discharge (ESD) protection, with suggested best solutions when battling these issues.

The CAN Bus Approach

In the early 1980s, engineers looked to reduce the wiring harness in the automobile. A byproduct of this effort was the creation of the CAN bus protocol. In 1986, Robert Bosch Gmbh introduced the CAN serial bus system at the Society of Automotive Engineers (SAE) congress.

Taking a thirty-year jump forward, the differential I/O CAN bus is still a very rugged, reliable serial interface platform. With a manageable number of remote I/O nodes, this protocol is ideal for PLC applications. The CAN bus cabling requires only a twisted wire pair and has high-speed data transfer capability with high resistance to disturbances. This rugged network is easy to use with its deterministic real-time behavior. A microcontroller or processor controls the data driven through the CAN bus physical network (Figure 2).

Beyond these basic features, the CAN bus has additional functionality that is beneficial to PLC systems. This protocol system is ruggedized for hostile manufacturing environments where common events include:

- High-voltage faults
- Common-mode overvoltage
- ESD

Fault Tolerance

Fault tolerance implies that a device will tolerate excessive voltage during a fault condition. The design of the CAN bus transceiver does in fact tolerate faults such as opens, shorts, and incorrect loads on the data lines.

The CAN bus network recognizes fault conditions. When the CAN bus transceiver identifies a fault condition though the I/O lines (TXD, RXD, CANH, CANL), the system converts to a single data line. When data lines open, termination resistors at each node assist in the preservation of network functionality.

A secondary hostile attack on the CAN bus system is the possible extension of the transmission terminal voltage beyond the power supply rails.

Common-Mode Input Range (CMR)

The CAN bus is a network that drives cables in harsh environments. These environments typically have magnetically operated devices as part of the system. Consequently, the CAN bus nodes may have large ground potential differences.

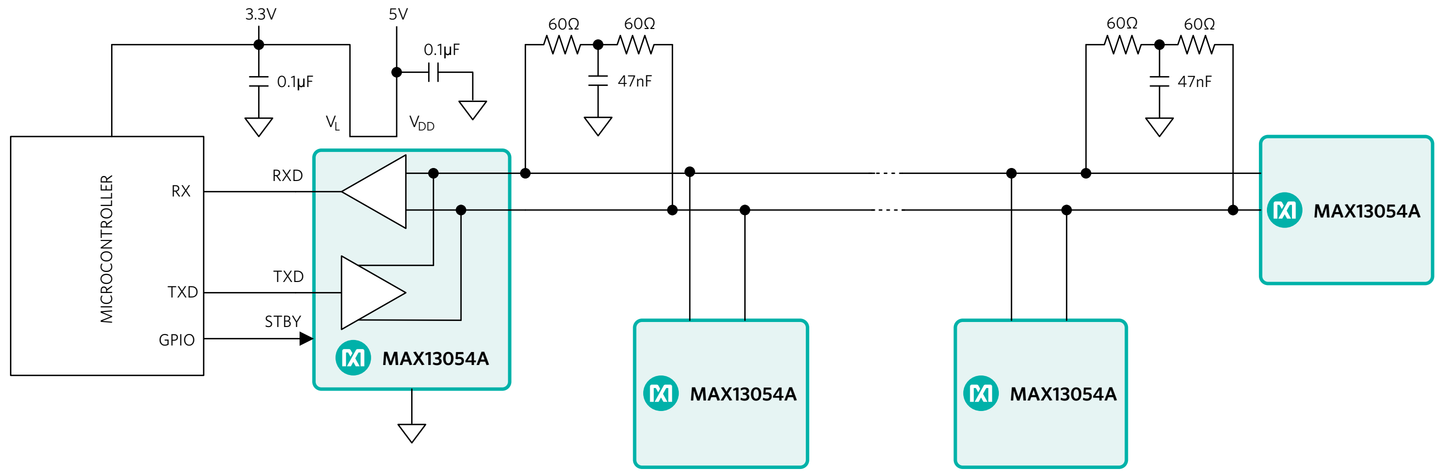

Figure 2. Multiple Receivers Connected to CAN Bus

For the most part, industrial and commercial power systems use a solidly grounded system. The current flows through conductors like ground wires, building steel, conduit, and water pipes. These conductors are far from perfect in that they have impedances associated with them and consequently voltage drops occur.

At a micro level, equipment can cause significant current flows through local cabling. The currents can originate in magnetic equipment such as motors.

The contributing factor for common-mode voltages (CMV) to exceed the power supply rails is the ground potential difference (GPD). In CAN bus systems, the main cause for corrupted data transmission and even transceiver damage comes from the GPDs. The CAN bus, ISO 11898-2 (CAN Physical Layer Standard) specifies a CMR of -2V to +7V (Figure 3).

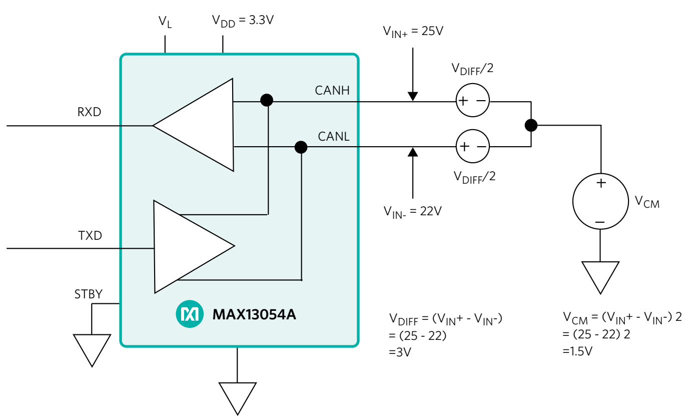

Figure 3. CAN Bus Common-Mode Model Showing the Differential Inputs ($V_{DIFF}/2$) and the Common-Mode Input (V_{CM})

Large neutral currents through nonlinear loads cause these voltage differences. To help designers develop networks that are immune to GPD, the CAN bus components possess circuitry to counteract these occurrences.

Electrostatic Discharge ESD

ESD events are a third destructive threat.

The environment or human intervention generates ESD events that can have a detrimental impact on the system electronics.

ESD is a release of stored static electricity. This release threatens electrical systems by causing physical modifications due to excessive local heating, melted silicon, damaged metal lines and gate-oxide failures (Figure 4).

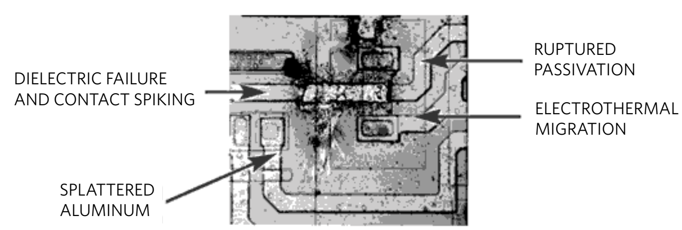

Figure 4. Integrated Circuits with Inadequate ESD Protection are Subject to Catastrophic Failures

Figure 4 shows a picture of an ESD-damaged IC that has a ruptured passivation, electrothermal migration, splattered aluminum, contact spiking, and dielectric passivation failure.

There are many ways that ESD can enter a device pin on a PCB. For example, an ESD event can occur when a charged object, such as a person, touches the CAN module's connector pins or cable. A person can easily accumulate a high potential by simply walking across the floor. Another way to introduce a static event is to connect a wire to a connector.

The CAN transceiver has higher ESD ratings than standard ICs because of their close proximity to external input/output (I/O) connectors. The ISO 11898−2 does not list ESD requirements.

Normally, the determination of the data port protection sizing is in terms of the application's voltage and current. Some can get away with parts with no protection, while others require beefy protection components.

PLC CAN Bus Transceivers

There are numerous CAN bus transceivers on the market to address the issues of arbitration and security, but the 2Mbps MAX13054A CAN receiver take the reliability needle a step further by offering ±65V fault tolerant CANH and CANL pin, ±25kV ESD tolerance, and ±25V extended common-mode range. The MAX13054A CAN transceiver operates with a supply voltage from 4.5V to 5.5V.

Ruggedizing with a CAN Bus

CAN bus interconnects are here to stay with PLC applications. This industrial digital computer requires rugged, robust, high-reliability physical layer systems that are fault-diagnostic capable and easy to program. The preferred CAN bus transceiver is the MAX13054A. This device provides protection levels that exceed required levels to further enhance the ruggedness and reliability of the CAN bus. If you combine these characteristics with the CAN bus protocol, your solution will be pointing towards a great high-reliability solution.

Glossary

CAN: Controller area network

CMR: Common-mode range

CMV: Common-mode voltage

ESD: Electrostatic discharge

GPD: Ground potential difference

HBM: Human body model

HMI: Human machine interface

I/O: Input/output ports

ISO11898-2: CAN Physical Layer Standard

PLC: Programmable logic controller

SAE: Society of Automotive Engineers

Learn more:

MAX13054A +5V, 2Mbps CAN Transceiver with ±65V Fault Protection, ±25V CMR, and ±25kV ESD

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