Electronic Design

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LED Driver Handles Industrial Power-Supply Indication

This Idea for Design presents a simple and small solution for driving an LED to provide visual feedback in the presence/absence of a system's power.

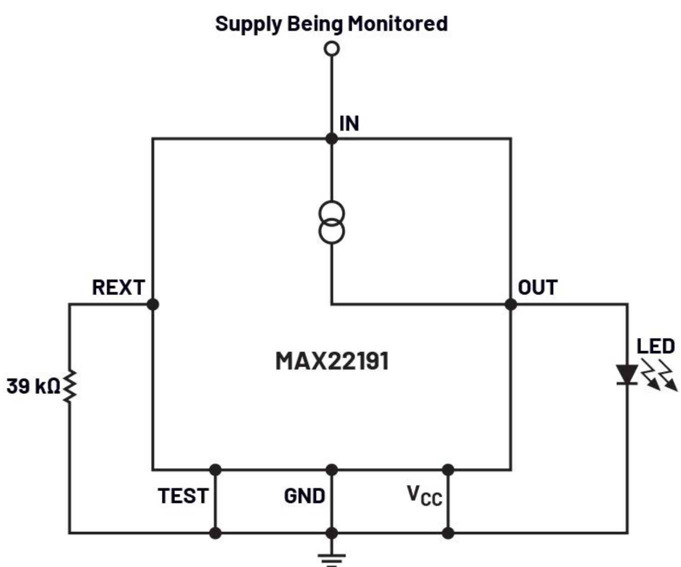
Industrial control systems universally employ 24 V DC for their field supply voltage. The presence/absence of power-supply voltage is commonly signaled by LEDs found on equipment like the controller head unit, as well as I/O and communication modules. LED supply lights aid in minimizing installation, maintenance, and downtime in industrial systems/subsystems such as programmable logic controllers (PLCs) and distributed control system (DCS) controllers, power-supply units, sensors, and actuators.

Supply LEDs should light up when defined conditions are met; for example, voltage being in the required operating supply range. Despite their conceptual simplicity, real implementations aren't that trivial. They require voltage comparators with hysteresis, need to be self-powered, and must drive LEDs consistently.

Further requirements for such circuits include:

- Low power dissipation
- The light must be off when the supply voltage is under the minimum operating voltage
- Light intensity should be invariant of supply voltage
- The circuit should be tolerant to overvoltages
- Robustness to miswiring, such as negative voltages encountered during reverse polarity

Simple circuits can exhibit significant dependence on component, temperature, and voltage variation.



1. Shown is a supply-monitoring LED driver.

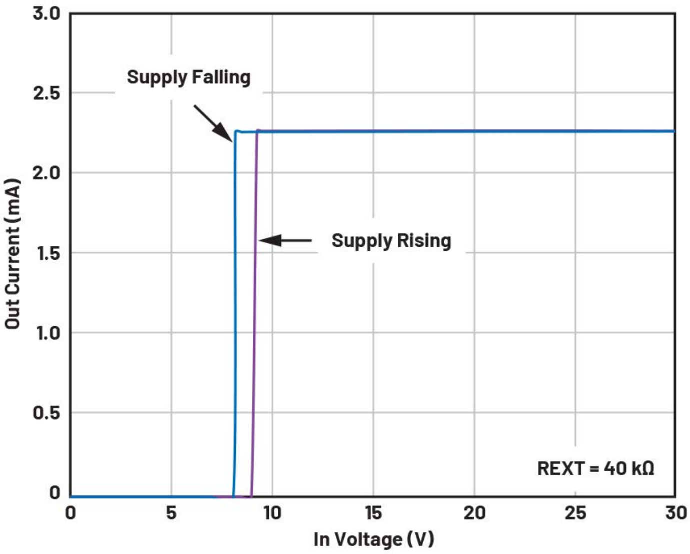
Repurposing Industrial Input Chip into LED Driver

This LED driver circuit is based on repurposing an industrial digital input chip for a function different from its originally intended application. Industrial inputs, as commonly found in industrial control systems, are based on 24-V logic and have clearly specified input current/voltage characteristics with defined input threshold voltages.

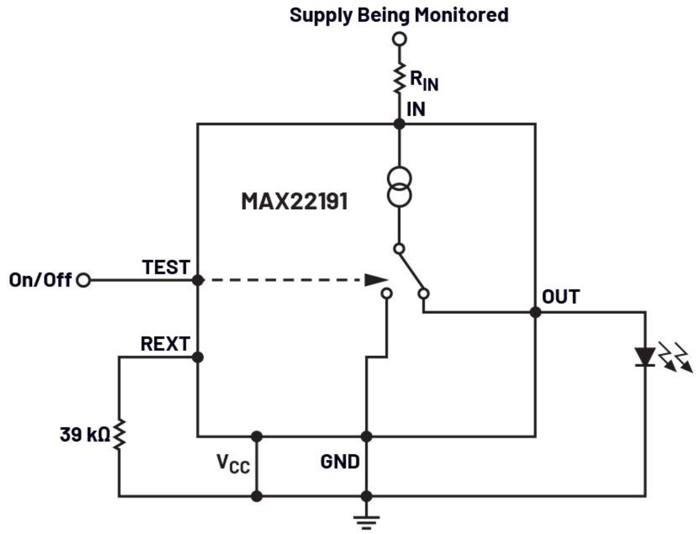
A sinking input (occasionally called a p-type input) has a pull-down current specified to be larger than 2.0 mA at the maximum input high threshold voltage of 11 V for Type 3 inputs—the most common industrial input type. To minimize power dissipation, today's digital input circuits limit and tightly regulate the input current to a level just slightly above the 2.0-mA limit.

LED Driver Idea for Design

Noticing that the 2.0-mA level coincides with common LED drive currents and that industrial digital inputs have clearly defined switching thresholds, it raises the question:



2. LED current vs. supply voltage of the driver.



3. Circuit with on/off control and increased threshold voltage.

"Would a chip like the MAX22191 single-channel digital input be suitable for power-supply monitoring and LED driving?"

This industrial input device is designed to drive an optoisolator via its OUT pin. *Figure 1* shows the proposed application circuit. REXT is a current-setting resistor, enabling the OUT current to be set in the 2.0- to 2.6-mA range.

The internal current source has a tolerance of ±12.5% over temperature, input voltage, and part to part, ensuring low power dissipation and negligible light intensity variation over supply voltage. With the current-source specified OUT output voltage compliance of 5.5 V, it's possible to drive most modern LEDs. The device's 110-µA (typ) supply current ensures low power dissipation of the solution.

Figure 2 shows that the LED current turns on sharply at 9 V (typ) and turns off at 8 V (typ), providing 1-V hysteresis. The max-on and min-off threshold voltages are specified in the MAX22191 datasheet.

Should higher threshold voltages be required, a resistor can be placed in series with the IN input, R_{IN} *(Fig. 3)*. The R_{IN} value is calculated as R_{IN} = (threshold voltage increase)/I_{IN}.

The LED current is flat with input voltage variation in the on state, as seen in *Figure 2*. This contrasts to the use of a simple bipolar/MOS transistor for driving the LED, which shows significantly higher current-voltage dependence due to the transistor's Early voltage.

LED Control

For application cases where the LED needs to be turned on/off under logic control, the TEST input can be conveniently used, as shown in *Figure 3*. This allows for implementation of auxiliary functions like power-up delays, blinking, or other status feedback.

Robustness of LED Driver Design

The solution is specified for use over the –40 to +125°C operating temperature range. The IN supply voltage is tolerant to a wide voltage range of –70 to +60 V, which provides headroom for surge protection and robustness to reverse-polarity miswiring. In the event of reverse connection, the circuit has a low 1-µA input current in case of a negative input voltage.

Reinhardt Wagner is a distinguished engineer with Analog Devices in Munich, Germany. Beginning with Maxim Integrated and now in ADI's Industrial Automation Group, his 21-year tenure has primarily involved the product definition of new industrial chips in the areas of communication and input/output devices, such as IO-Link, fast digital I/Os, Beyond-the Rails analog switches, and digital isolation.