Technical Article

Overcoming Design Challenges for brushed-DC Motors in Smart Sanitation Systems

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As the global population grows, so does the risk for carrying and transferring germs throughout our homes, hospitals, schools and places of work. Smart sanitation products such as automatic paper towel dispensers, soap dispensers, trash cans, and smart toilets and faucets can reduce the spread of germs in common areas.

It is possible to automate every movement or valve adjustment in smart sanitation products with an electric motor or solenoid, which enables hands-free operation and reduces the potential spreading of germs by contact. Brushed-DC motors and latching solenoids are popular in these products because of their low cost and ease of design. Engineers face many challenges when designing for these applications, however, related to:

- Position and speed control
- Stall detection
- System size
- Protection
- Battery life

In this article, we will look at how our brushed-DC motor and H-bridge drivers help address these design challenges.

Position and speed control

It is very helpful to be able to control the position and speed of a brushed-DC motor in smart sanitation products. For example, a paper towel dispenser needs to dispense a specific portion from the roll in order to not waste paper, while still providing a sufficient amount to users. In order to accomplish this, the system needs some form of feedback from the motor to know where the load is.

There are many ways to accomplish this, but one of the easiest is with integrated current sensing. Our brushed-DC motor drivers with integrated current sensing not only provide current feedback from the motor, but also remove the need for an external sense resistor. The DRV8876, for example, has integrated current sensing that uses a current mirror architecture to sense current in the motor windings and feeds this current information back

to the microcontroller through the IPROPI pin. As shown in Figure 1, eliminating an external amplifier or sense resistor reduces component count, decreasing board size by at least 12% and lowering system cost.

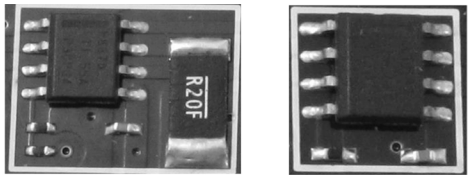

Figure 1. The DRV8870 with an external shunt resistor vs. the DRV8871 with integrated current sensing

It's also possible to leverage the motor current for sensorless position and speed detection, commonly referred to as ripple counting. As illustrated in Figure 2, ripples in the current are formed by the brushes in the motor making contact with the commutator during each rotation. The basic principle of ripple counting is to count the number of ripples in the current, which translates into rotations and thus the relative speed and position.

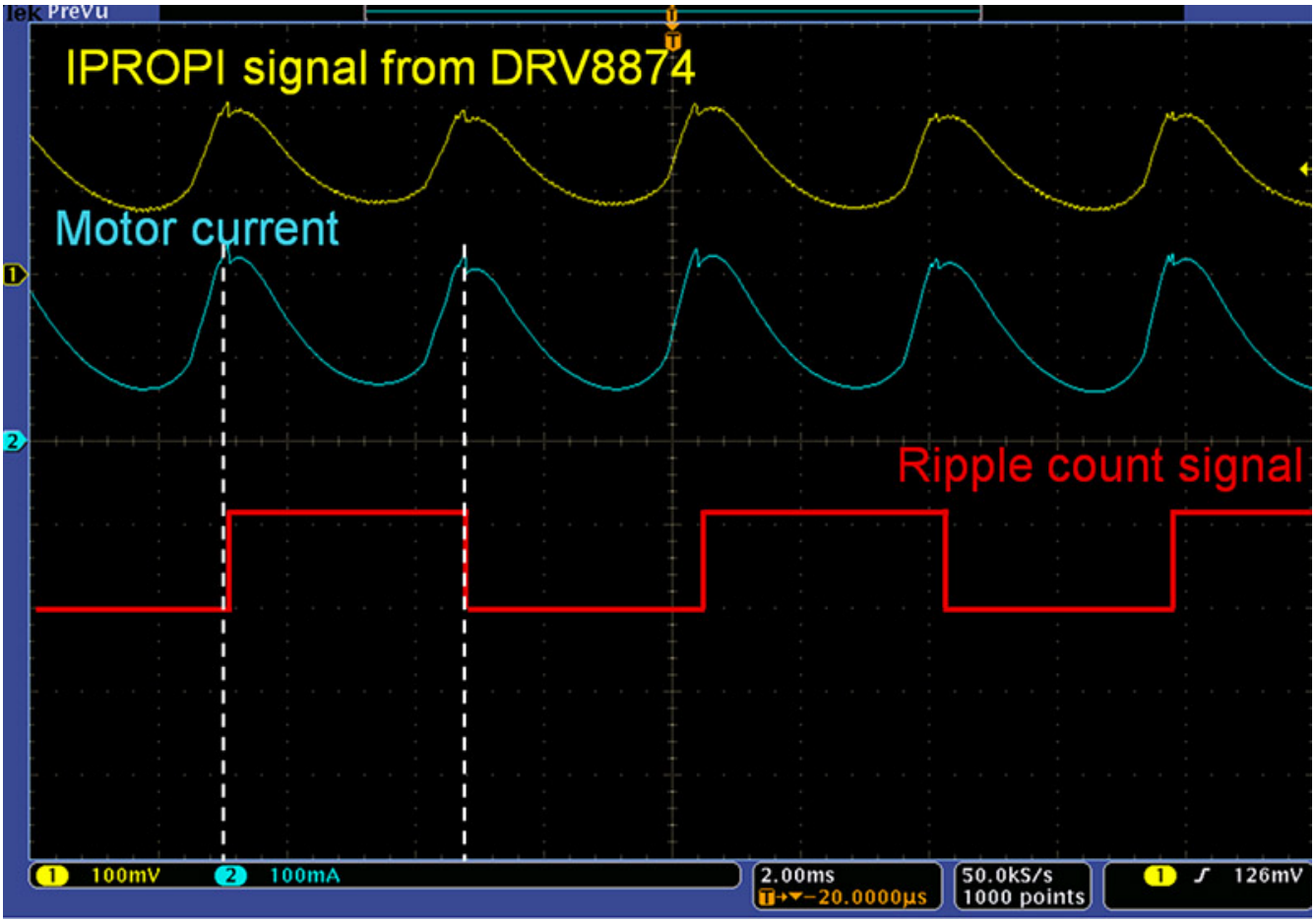

Figure 2. The IPROPI current feedback signal with ripples from brushed-DC motor commutation

Stall detection

Now that I've shared a technique for monitoring speed and position, let's discuss an effective way to detect end-positions or jams in motor movement, also known as stall events.

As illustrated in Figure 3, the motor startup creates a large inrush current, which then decreases to a lower level during continuous motor movement. Current then spikes once again when the load hits the end of travel, or if a jam in the system occurs from a large spike in applied torque.

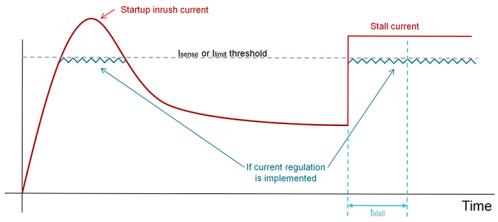

Figure 3. Typical brushed-DC motor profile for systems with possible stall events

Using the IPROPI current-sense output, and the current-limit control on the DRV8873, DRV8874 and DRV8876, the microcontroller can sense these different current regions, detect the stall condition and stop driving the motor – saving energy and power without the need for any other external components.

Fitting motors and solenoids into small form factors

While many restrooms have automated systems, they still need to have an aesthetically pleasing form factor, or even be hidden from sight. This typically means that the system needs to be small, which does not leave much room for electronics.

A discrete brushed motor system not only needs to drive components and four individual power metal-oxide semiconductor field-effect transistors, or MOSFETs, but many systems include components for system protection. The move to an integrated motor-drive circuit can help significantly reduce board size and printed circuit board expenses, as well as the number of component sources, while integrating a full suite of protection circuitry such as thermal shutdown and overcurrent and undervoltage protection. As illustrated in Figure 4, the DRV8837C provides the entire drive and protection circuitry in a 4-mm^2 package.

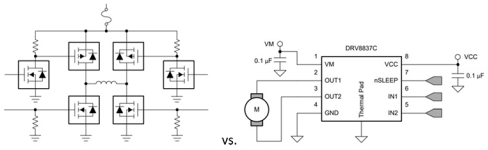

Figure 4. Discrete H-bridge circuit (a); integrated motor driver H-bridge with the DRV8837C (b)

Automatic faucets often have two valves for mixing cold and hot water and can require two solenoids or brushed-DC motors, which in turn requires two H-bridges, taking up more space on the board. Devices like the DRV8847 are a good solution to integrate multiple motor drive systems into a single integrated circuit.

Battery-powered smart sanitation products and general design considerations

Since many smart sanitation products are battery powered, such as flushometers, and soap or paper towel dispensers, reducing the power consumption of the motor driver to extend battery life is crucial. Devices such as the DRV8837 will typically draw just 35 nA of current while waiting for a wake-up command from the microcontroller.

Using brushed-DC motor drivers from TI in smart sanitation system designs can help reduce board space, system cost, and consume less battery power, all while offering enhanced protection and functionality like stall, speed or position detection of the load being driven.

Additional resources

- Check out our brushed-DC motor driver portfolio to find the right motor driver for your smart sanitation system.

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