Application Report

Switch Detection in BCM: Integrated MSDI Solution (TIC12400-Q1) vs. Semi Discrete Solution (TMUX1308-Q1)

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ABSTRACT

The Body Control Module (BCM) is an electronic control unit responsible for monitoring and controlling electronic accessories in a vehicle body. The automotive body has on-and-off type of switches (digital switch) such as door locks and resistor coded switches (analog switch) with three or more states used in wiper speed control that are driven off a 12 V battery. The BCM monitors these physical switches and controls power to various loads within the vehicle. A typical switch detection implementation can be performed using an integrated MSDI (Mullti-Switch Detection Interface– TIC12400-Q1 and TIC10024-Q1) solution or a semi-discrete method with a CMOS multiplexer (like TMUX1308-Q1) to multiplex system inputs or a discrete solution with a number of passive components (resistors, capacitors, transistors, and so forth).

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1 Switch Detection with Integrated Solution Using MSDI (TIC12400-Q1 and TIC10024-Q1)

TIC12400-Q1 and TIC10024-Q1 are integrated 24-input Multiple Switch Detection Interface (MSDI) devices designed to detect external mechanical switch status in a 12-V automotive system by acting as an interface between the vehicle mechanical switches and the low-voltage MCU. The TIC12400-Q1 device is an integrated solution that replaces many discrete components such as, current sources, reverse battery protection diodes, multiplexers, resistor dividers, comparators, and ADC; it provides integrated protection, input serialization, and system wake-up capability. The device monitors 14 ground-connected mechanical switches and 10 additional mechanical switches that can be programmed to connect to either GND or VBAT. The device features an SPI interface to report individual switch status and provides programmability to control the device operation. The TIC12400-Q1 device features a 10-bit ADC which is useful to monitor analog inputs such as resistor coded switches that have multiple switching positions such as wind shield wipers or dashboard control knobs. To monitor only digital switches, an integrated comparator can be used instead of an ADC to monitor the input status. The device has 2 modes of operation: continuous mode and polling mode. The polling mode is a low-power mode that can be activated to reduce currents drawn in the system by only turning on the wetting current for a small duty cycle to detect switch status changes. An interrupt is generated upon detection of a switch status change and can be used to wake up the MCU to bring the entire system back to operation.

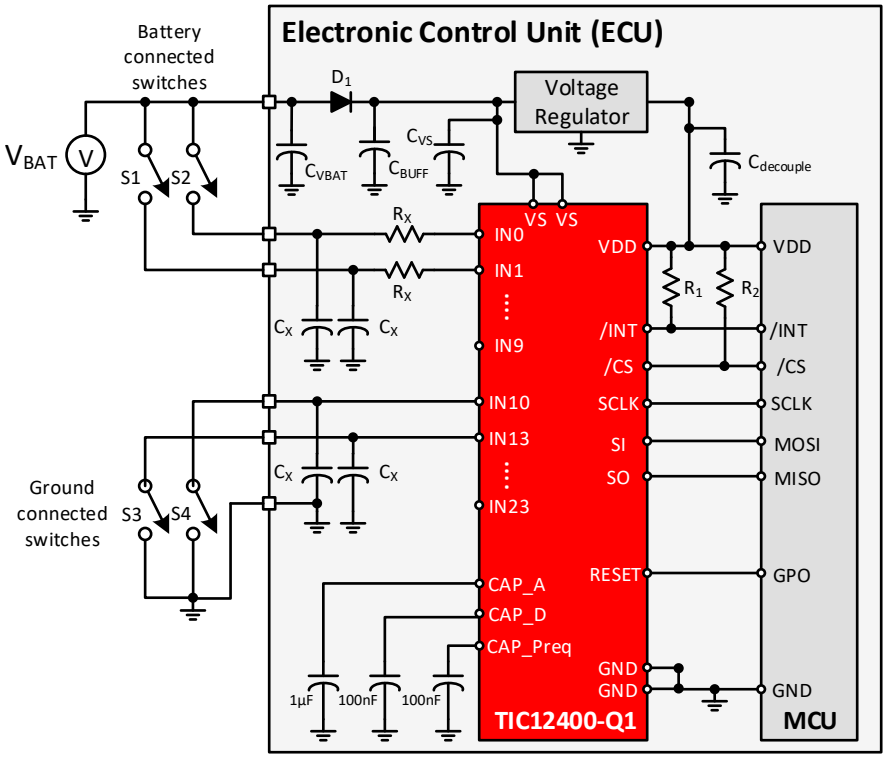

Figure 1-1. BCM Implementation with TIC12400-Q1

All of these integrated features not only provide system board space savings, BOM and assembly savings, and meets OEM power consumption requirements, but also offer design flexibility for customizable BCMs — a decisive market advantage.

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2 Switch Detection with Semi-Discrete Solution Using TMUX1308-Q1

A CMOS multiplexer can be used to multiplex the inputs and minimize the number of GPIO or ADC inputs needed by an onboard MCU. Figure 2-1 shows a typical BCM system using the TMUX1308-Q1 to multiplex multiple system inputs into a single MCU input.

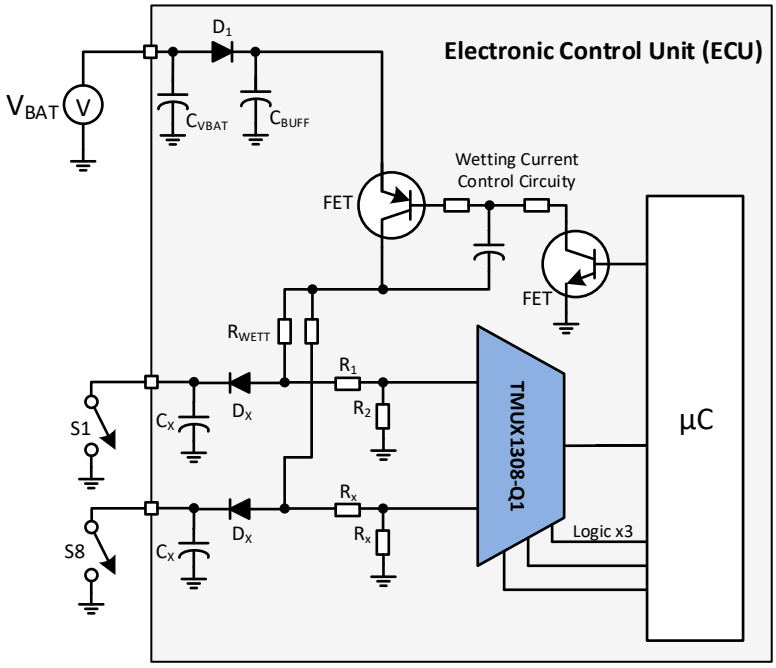

Figure 2-1. Multiplexing BCM Inputs with TMUX1308-Q1

The TMUX1308-Q1 device is a 5-V, bidirectional 8:1, 1-channel multiplexer with injection current control (see TI Precision Labs — Prevent Crosstalk with Injection Current Control for more details). The injection current control feature eliminates the need for external diode or resistor networks typically used to protect the switch and keep the input signals within the supply voltage. Injected currents can come from various sources such as from long cabling in automotive systems that may be susceptible to induced currents from switching or transient events. Another momentary source of injected currents in BCMs are wetting currents, which are small currents used to prevent oxidation on metal switch contacts or wires. A switch without an injection current control can have the measured output of the enabled signal path impacted if a current is injected into a disabled signal path. This undesired change in the output can cause issues related to false trigger events and incorrect measurement readings which can compromise the accuracy and reliability of the BCM system. The internal injection current control circuitry of TMUX1308-Q1 allows signals on disabled signal paths to exceed the supply voltage without affecting the signal of the enabled signal path.

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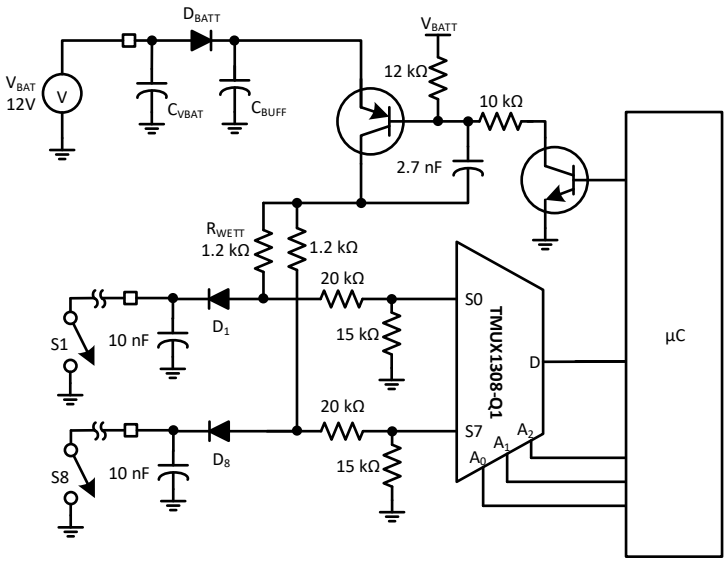

Figure 2-2. Detailed BCM Application with TMUX1308-Q1

The BCM uses the 12 V battery voltage to provide a wetting current to each switch when the associated control circuitry is enabled by the micro controller. Figure 2-2 shows detailed BCM application. The wetting current is sized by the R_{WETT} and the required value may vary depending on the type of physical switch being monitored. The 20 kΩ and 15 kΩ resistors are used, in addition to the wetting resistor, to create a voltage divider before the input of the multiplexer in case of a short to battery condition. The resistor values are selected to maintain the voltage at the switch signal path below the TMUX1308-Q1 supply voltage. The 20 kΩ series resistors also limit the amount of current injected into the switch if an overvoltage event occurs. Diodes D1 through D8 are used to prevent back flow of current in case a secondary system is monitoring the same physical switches for backup or redundancy reasons. The 10 nF capacitors are used for initial ESD protection in the system and must be sized based on system level requirements.

Figure 2-3 shows an alternative design with a discrete TMUX1308-Q1 in BCM application that uses a BJT with a resistor divider. The BJT and resistor network is used to create the current source. The resistors (R1 and R2) and diode (D1) are selected to maintain the voltage at the switch signal path below VDD. Resistor R2 is used with R1 to monitor resistor coded switches and can be removed for digital switch monitoring. The diode Dx is used to prevent current back flow in case a secondary system is monitoring the same physical switches for backup or redundancy reasons and are not commonly used if only one µC is monitoring the switches. The TMUX1308-Q1 multiplexes the status of external switches with the use of the generated current sources and reports the status to the µC after detection.

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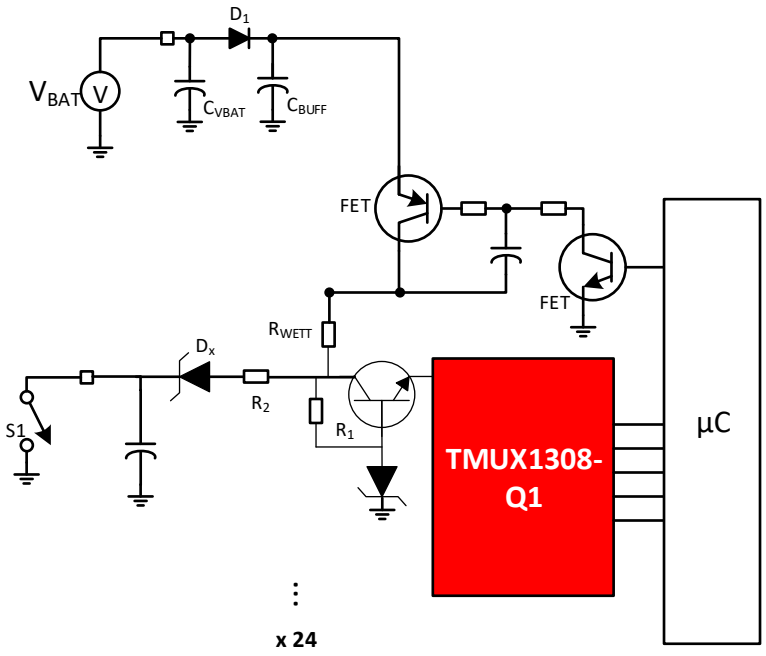

Figure 2-3. 7. Detailed BCM Application with TMUX1308-Q1 and BJT

Besides TSSOP and QFN packages, the TMUX1308-Q1 comes in a SOT-23 (thin DYY) package which is 50% smaller than the industry standard leaded package (13.6 mm^2) and is the smallest 16 pin leaded package in the industry.

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3 MSDI vs. Semi-Discrete Solution Summary

The TMUX1308-Q1 semi discrete approach is the preferred solution when:

- MCU wakeup is not required and only switch monitoring is preferred.
- An Injection current control feature is preferred by BCM applications.
- The system requires 16 channels or less.

The MSDI approach is the best solution for the customer when:

- There is need to monitor the switch inputs autonomously, while the MCU is put into sleep mode, to meet OEM power budget requirements.
- Using the integrated ADC to detect resistor coded switches (allowing input sharing to be used), integrated supply sensing, and system level voltage monitoring.
- For safety-critical applications, the MSDI can perform self-check-ups and report abnormally to the MCU.

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4 References

1. Texas Instruments, *TI Precision Labs — Switches and Muxes: Prevent Crosstalk with Injection Current Control*
2. Texas Instruments, Multiplexers and Signal Switches Glossary
3. Texas Instruments, Selecting the Right Texas Instruments Signal Switch
4. Texas Instruments, SN74HC4851/HC4852 Product Clip

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