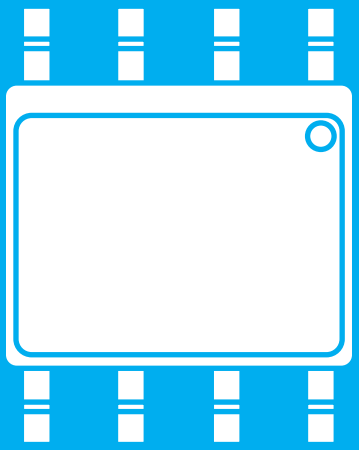
BIGMACHINE™
electronics

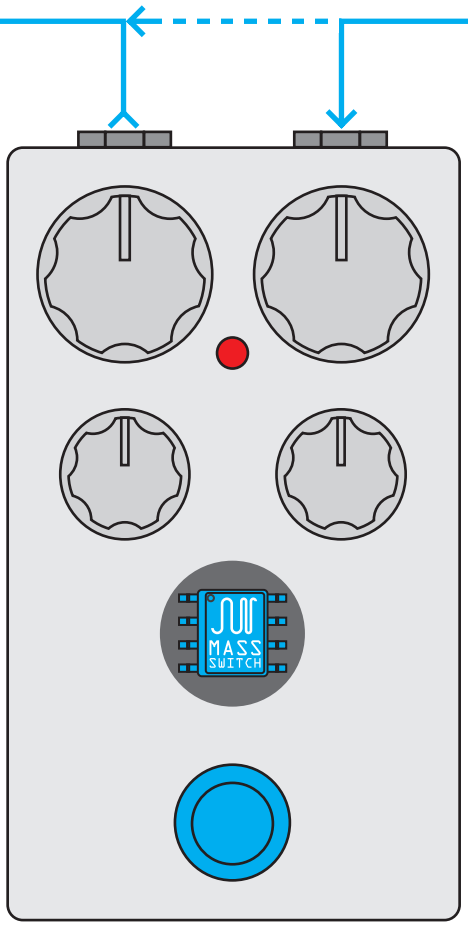


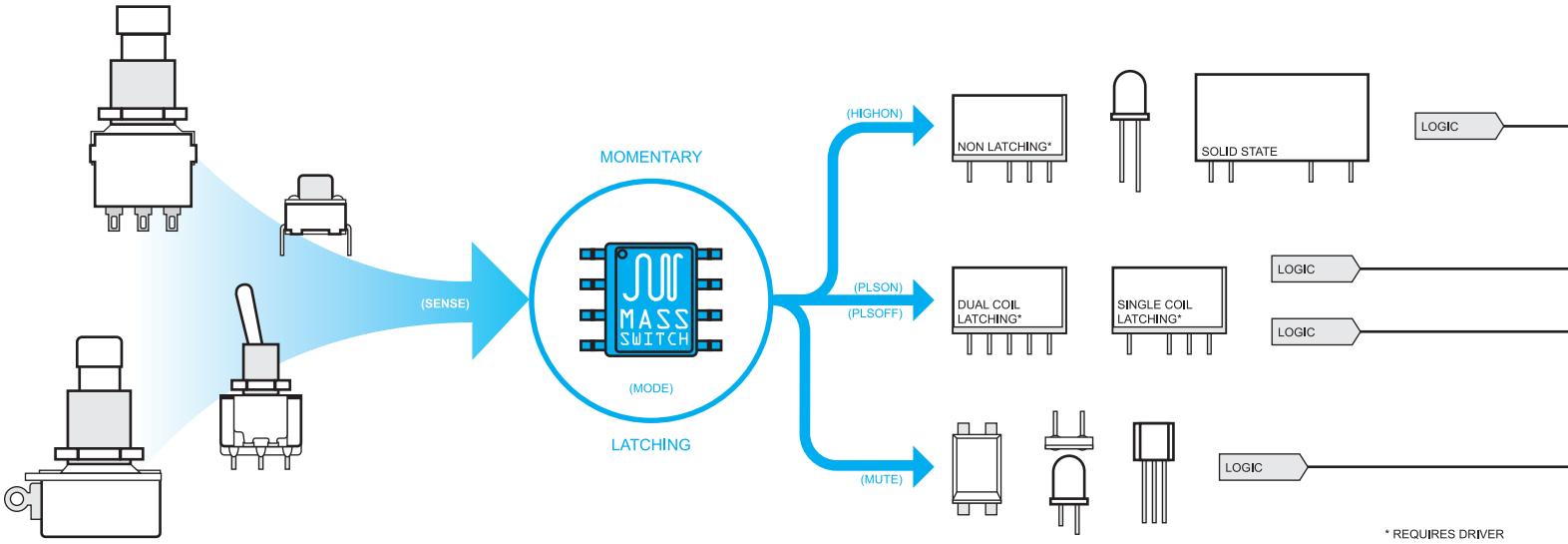
MASS™ SWITCH

MODE-ADAPTIVE SUPER-SAMPLING

DATASHEET AND APPLICATION GUIDE

R1.4\2016 MASS-SWITCH





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INSIDE THIS DOCUMENT

1. FEATURES

The *MASS-Switch*™ is a high-performance switching controller integrated circuit (IC) with the following features:

- Designed for compact stomp-box (e.g. guitar/bass/keyboard pedal) bypass relay and indicator control
- Tuned for human-operated mechanical contact switching
- Compatible with micro switches, toggle switches, foot switches, key switches, and panel buttons
- Supports latching action with both momentary and latching type input switches
- Supports momentary action with momentary type input switches
- Controls standard non-latching as well as efficient single-coil latching and dual-coil latching relays
- HIGHON output for driving indicators, relays, SSRs, steady-state logic, etc.
- PLSON and PLSOFF outputs for driving latching relays, general purpose triggers, pulse logic, etc.
- MUTE output for audio device and stomp-box applications, general purpose blanking, etc.
- Seamless and fast active filtering turns every switch event into a perfect switch event
- Leading-pulse and stable-pulse filter-qualities tuned for momentary and latching type input switches
- Available in through-hole (DIP-8) and surface-mount (SOIC-8, SOIC-8W) integrated-circuit packages
- Short power-up delay time for a fast initial output response: <16 ms (typical)
- Low power: < 1 mA current draw (typical) at 5 Vdc, < 5 mW

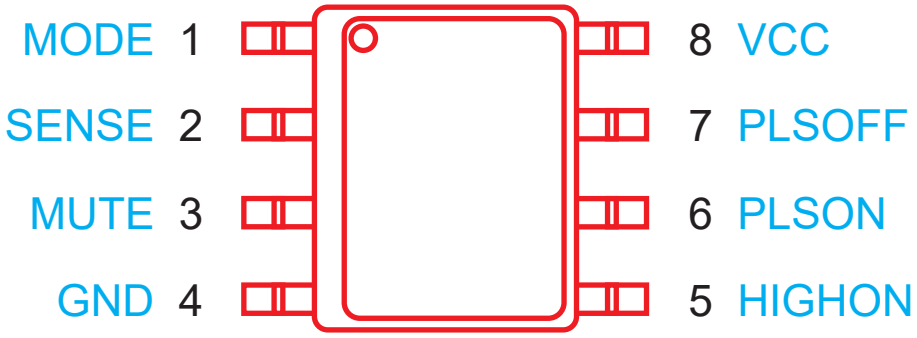
2. OVERVIEW

The *MASS-Switch*™ is a compact, universal controller for stomp-box bypassing and other industrial control applications. Using the *MASS-Switch* in new or existing designs is simple and usually means near drop-in replacement for existing switching and bypass logic. In a stomp-box (e.g. guitar pedal) or similar application a single *MASS-Switch* can provide stabilized switching, momentary to latching control logic, signal timing, relay driver pulsing, and indicator control, from a single, space-saving, low current IC package. The integrated Mode-Adaptive Super-Sampling (MASS) filter self-adapts to switch-signal qualities and responds to every switch contact event without blocks, skips, or lock-up glitches. All output states and timings are microprocessor controlled for perfect accuracy and consistent performance unaffected by production component tolerances. The **HIGHON** output can be used to control steady-state devices, LED indicators, optocouplers, non-latching (monostable) relays, and digital logic inputs. Additionally, the **PLSON** and **PLSOFF** outputs provide independent ON and OFF pulse signals which can be used together to control latching (bistable) relays, or independently to control triggers, counters, and digital pulse logic inputs. The **MUTE** output issues an inverted cover-pulse that can be used to affect audio (muting) or other signals (blanking) during every output state change in order to cancel audible “popping” and other switching artifacts. The LOW = ON (inverted) **SENSE** input expects a ground connected control switch for convenience on small PCBs and inside compact enclosures. The *MASS-Switch* fully supports momentary type and latching type input switches, easily configured at design-time using the **MODE** input pin. The configured action mode also affects how the integrated MASS filter analyzes incoming switch-signal quality, in order to maximize performance for both switch types.

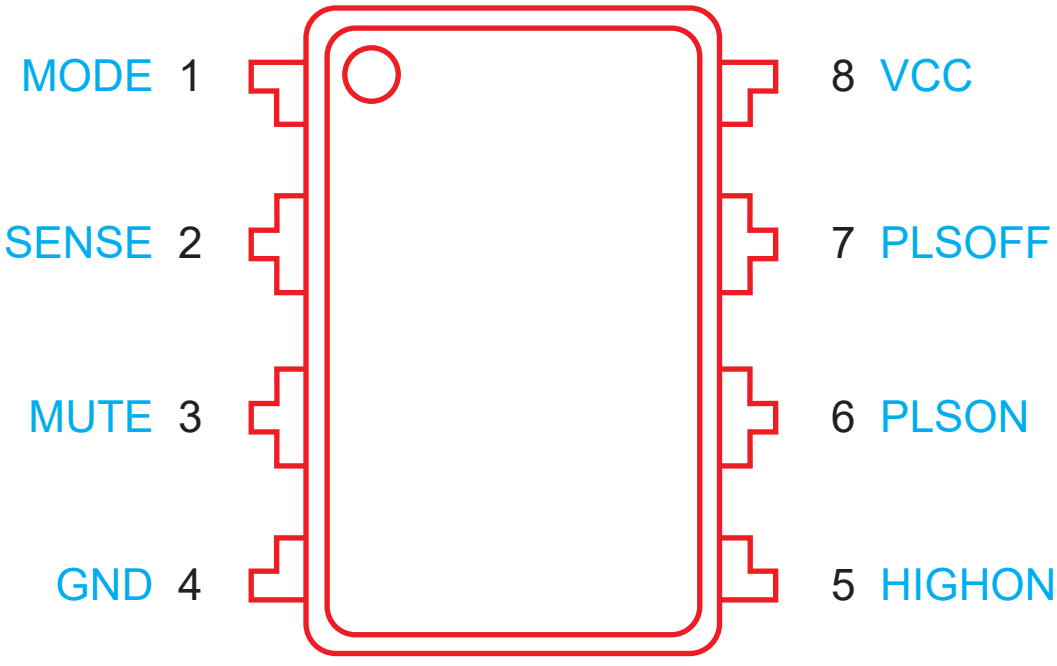
The available through-hole and surface-mount MASS-Switch *IC packages are easy to incorporate into classic and modern designs, requiring very little current in the convenient voltage range of 3 - 5.5 Vdc. The internal microprocessor and clock are fully encapsulated (maintenance free) with a straightforward logic-level interface on the IC pins, ready to command any switching, routing, or bypassing components in your designs, using the switch style of your choice.*

3. PINOUT

1:1 SCALE



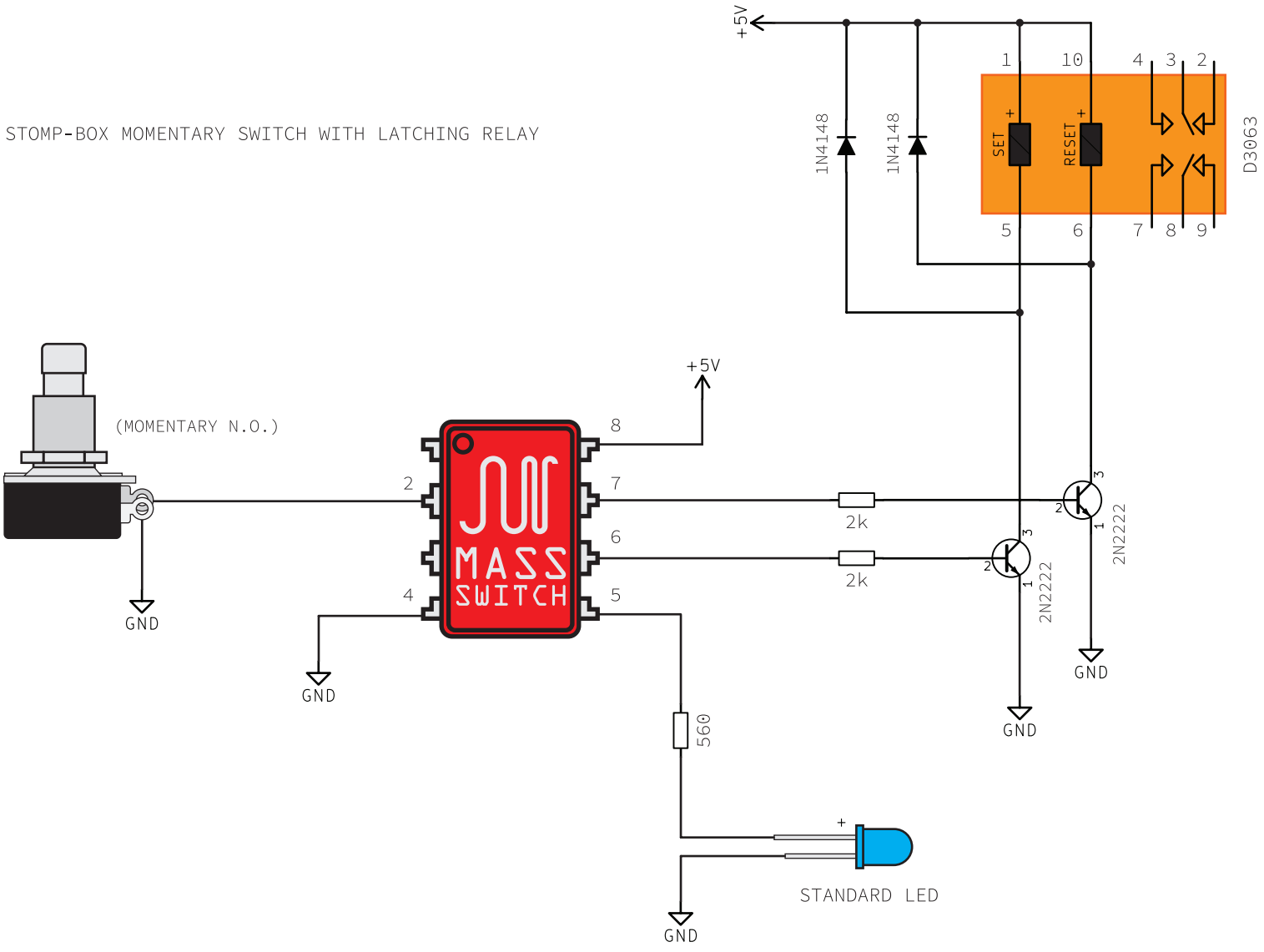
SOIC-8 (8S1)
SOIC-8W (8S2)
TOP



DIP-8 (8P3)
TOP

4. BREADBOARD QUICKSTART

STOMP-BOX MOMENTARY SWITCH WITH LATCHING RELAY



THIS QUICKSTART IS MISSING CRITICAL COMPONENTS!

READ THE SECTION **OPERATION** BEFORE USING THE MASS-SWITCH IN PRODUCTION DESIGNS

RESISTORS ARE 1/8 (0.125) WATT
TRANSISTORS ARE NPN 2N2222 OR EQUIVALENT
RELAY IS AXICOM D3063 BISTABLE, 2-COIL
RELAY IS SHOWN IN RESET CONDITION
DC +5V POWER SUPPLY IS REQUIRED

(PART IS SHOWN ENLARGED)

5. OPERATION

The *MASS-Switch*™ is easy to configure with just two (2) *power supply* pins, two (2) *input pins* and four (4) *output pins* which affect or reflect the operational state of the internal switching logic. The *MASS-Switch* is an ultra-stable proxy-switch that filters the control switch signal and abstracts all of the mechanical contact instabilities from your switch-controlled components or digital logic. In addition to filtering, the *MASS-Switch* provides an error-proof MOMENTARY or LATCHING logic controller and a precision-timed, multi-mode output controller. The *action mode* is preset using the **MODE** input pin and will generally be chosen based on the input switch type and/or the desired *output action* that will be utilized in the design (MOMENTARY or LATCHING). The output controller is always fully exposed through the **HIGHON**, **PLSON**, **PLSOFF**, and **MUTE** output pins, which are used as required.

*The state of the output is operated using a physical input switch connected to the **SENSE** pin by opening and closing it to ground. The input filter constantly monitors the input switch-signal and allows it to change the internal proxy-switch state only when it determines that a switch event has occurred. When the proxy-switch state changes, the appropriate output response is immediately produced on the output pins.*

Tip: The *MASS-Switch* is a fast controller, especially for already-clean input signals, source-logic or otherwise. If you have a steady-state or pulsed digital signal that needs to drive relays or other monostable and/or bistable devices, the *MASS-Switch* can fit the bill.

Note: All pin-numbers in this section refer to DIP-8, SOIC-8, and SOIC-8W IC packages (see PINOUT).

5.1 TERMINOLOGY

Familiarity with the following terms and how they are used within this document will make this section easier to follow and understand:

OPENED and CLOSED always refer to *physical switch or relay contacts*.
MOMENTARY and LATCHING always refer to *switching action*.
ON and OFF always refer to *logical switch states*.
VCC and GND *(not bold)* always refer to the local *positive supply voltage* and *ground reference*.
HIGH and LOW always refer to *signal voltage levels* where HIGH = VCC and LOW = GND.
A pulse always refers to a short, timed HIGH or LOW *period* on an otherwise LOW or HIGH *signal*.

5.2 POWER SUPPLY

Power may be provided by a *common ground* voltage regulator dedicated to the *MASS-Switch* IC and any associated control or indicator components. The voltage regulator must be rated to handle the combined current requirements for any relays, indicators, and other control components operating on the same regulated voltage supply, in addition to the *MASS-Switch* IC.

Using a common-ground regulator to supply the MASS-Switch *will allow the output pins to drive transistors and other components directly on the primary supply voltage side of the regulator and/or sink voltages other than VCC. A common-ground supply also allows the input switch to simply connect to a local grounding point, requiring only a single return trace or line to the **SENSE** pin.*

5.2.1 VCC (PIN 8)

The **VCC** pin should be connected to a direct current (DC) positive (+) supply in the range of [3, 5.5] volts.

Do not share the VCC supply (digital) with audio or other small-signal components.

5.2.2 GND (PIN 4)

The **GND** pin should be connected to the supply ground or common rail.

Always keep the switching GND path (digital) isolated as far as the most common power ground point available.

5.2.3 DECOUPLING

A 100nF (.1µF) decoupling capacitor should be placed between the power pins **VCC** and **GND** as close to the *MASS-Switch* IC as possible (see EXAMPLES). Additionally, appropriate local supply bypassing/decoupling practices should be utilized in the primary supply circuit.

Power supply decoupling is especially important and/or required in commercial and production designs. Compact stomp-box (e.g. guitar pedal) designs often rely on unknown external primary power supplies and should incorporate appropriate power supply bypassing/filtering in the primary power circuit, before the voltage regulator used by the MASS-Switch *and associated switching components.*

5.3 INPUTS

The *MASS-Switch* has two (2) input pins which accept two (2) states: HIGH (VCC) or LOW (GND). Both input pins are pulled HIGH by internal resistors and will register as HIGH when not connected.

5.3.1 SENSE (PIN 2)

The **SENSE** input pin senses the instantaneous state of the mechanical input switch. Changes to the voltage on the **SENSE** pin can affect the output state only when the input filter determines that they represent qualified switch events. The **SENSE** pin is pulled HIGH by an internal resistor, which the input controller interprets as OPENED. When the **SENSE** pin is connected to GND it becomes LOW, which the input controller interprets as CLOSED. Both momentary and latching type input switches may be connected to the **SENSE** pin. The output response to qualified switch events on the **SENSE** pin depends on the action mode and the current state of the output.

The MASS-Switch *works equally well with both momentary and latching input switches, giving freedom to your designs. For standard operation, momentary input switches should be normally-open (N.O.) with good contact holding quality (see INPUT SWITCH QUALITY).*

Note: An additional external 4.7k to 10k Ω pull-up resistor (to VCC, near the input pin) is recommended to increase noise immunity on the **SENSE** input pin.

5.3.2 MODE (PIN 1)

The **MODE** input pin presets the active logic controller used to interpret the input (**SENSE**) based on the desired *action mode* (MOMENTARY or LATCHING). The **MODE** pin is pulled HIGH by an internal resistor, which presets the LATCHING (bistable) mode for momentary type mechanical input switches. When the **MODE** pin is connected to GND it becomes LOW, which presets the MOMENTARY (monostable) mode for latching type mechanical input switches. The **MODE** pin must be preset to the intended state at power-up. The LATCHING (bistable) mode (**MODE** pin HIGH) produces *latching output action* with a momentary input switch. The MOMENTARY (monostable) mode (**MODE** pin LOW) produces *latching output action* with a latching input switch and *momentary output action* with a momentary input switch.

*When using a momentary type input switch the **MODE** pin can be left floating or connected directly to VCC in order to select the LATCHING action mode. When using a latching type input switch the **MODE** pin should be connected directly to GND to select the MOMENTARY action mode. When using a momentary type input switch for momentary output action, the **MODE** pin should be connected directly to GND to select the MOMENTARY action mode, which will track the momentary input switch state.*

Note: An additional external 4.7k to 10k Ω pull-up resistor (to VCC, near the input pin) is recommended to increase noise immunity on the **MODE** input pin ONLY when it is not already tied directly to VCC or GND (e.g. a jumper or switch is being used to modify the **MODE** pin state).

5.4 OUTPUTS

The *MASS-Switch* has four (4) output pins which produce two (2) states: HIGH (VCC) or LOW (GND). The output pins can safely source or sink up to 20 mA of current each. When more than 20 mA of current is required from a single *MASS-Switch* output pin, a driver or buffer must be used to supply the current to the load (see EXAMPLES). When controlling relay coils or other inductive loads from any of the *MASS-Switch* output pins, a driver or buffer is *always* required to supply the current to the load (see DRIVING RELAYS).

Warning: Do not connect the output pins directly together in any configuration as this will produce a direct short when any of the connected output pins are in mismatched states.

5.4.1 HIGHON (PIN 5)

The **HIGHON** output pin always reflects the steady-state of the *MASS-Switch* output. When **HIGHON** pin is LOW, the output is OFF. When the **HIGHON** pin is HIGH, the output is ON. The **PLSON** and **PLSOFF** output pins will fire pulses aligned to the respective **HIGHON** signal-edges.

*The **HIGHON** pin can be used to control steady-state devices and logic controllers which require constant current to remain active, such as LED indicators, non-latching relays, SSRs, and steady-state logic for MIDI controllers, etc. The **HIGHON** pin may be used to safely drive indicator LEDs and other low current components directly as long as the total current does not exceed 20 mA.*

5.4.2 PLSON (PIN 6)

When the state of the output changes from OFF to ON, a short HIGH pulse will be generated on the **PLSON** output pin, otherwise it remains LOW. The start of the pulse is aligned to the **HIGHON** leading-edge (transition from LOW to HIGH). The **PLSON** pin will never be HIGH at the same time as the **PLSOFF** pin so that both may be used in mutually exclusive input configurations such as two-coil latching relays and electronic H-bridges.

*The **PLSON** pin can be used to control latching devices and pulse-logic inputs which require only a momentary current to trigger or change states, such as latching (bistable) relays, edge triggers, and pulse-logic for MIDI event controllers, etc. Generally, the **PLSON** and **PLSOFF** pins are used to control opposite aspects of the same device (see EXAMPLES).*

5.4.3 PLSOFF (PIN 7)

When the state of the output changes from ON to OFF, a short HIGH pulse will be generated on the **PLSOFF** output pin, otherwise it remains LOW. The start of the pulse is exactly aligned to the **HIGHON** trailing edge (transition from HIGH to LOW). The **PLSOFF** pin will never be HIGH at the same time as the **PLSON** pin so that both may be used in mutually exclusive input configurations such as two-coil latching relays and electronic H-bridges.

*The **PLSOFF** pin can be used to control pulse-controlled devices and pulse-logic inputs which require only momentary current to trigger or change states, such as latching (bistable) relays, edge triggers, and pulse-logic for MIDI event controllers, etc. Generally, the **PLSON** and **PLSOFF** pins are used to control opposite aspects of the same device (see EXAMPLES).*

5.4.4 MUTE (PIN 3)

The **MUTE** output pin fires a short LOW pulse that starts before and ends after any other state changes on the other output pins, otherwise it remains HIGH. The pulse from the **MUTE** pin is inverted (LOW = ON) and can source or sink current exactly the same way as the other output pins in order to drive both active-on and active-off electronics. The **MUTE** pulse can be used to mute signals and/or blank sensitive devices in order to prevent noise and other undesired output caused by electronic or electromechanical switching.

*Small-signal audio devices such as guitar pedals are sensitive to small voltage changes that can occur when relays change contacts, etc. The **MUTE** pin can be used to momentarily ground the audio signal output so that noise or popping caused by the switch event will be bypassed to ground and will not be heard or seen at the audio output. In most cases the duration of the **MUTE** cover pulse is short enough to be unnoticed.*

Note: The LOW = ON (inverted) **MUTE** pin will always default to ON (LOW) during power-up and will remain ON until the initial output response is complete (see POWER-UP).

Warning: Muting is an optional feature that can adversely affect the playability of stomp-box designs. Muting is not required for traditional “true bypass” stomp-box switching.

5.5 OUTPUT ACTION

Output action refers to the behavior of the output in relation to changes on the input switch (**SENSE** input pin) and is controlled by the action mode (**MODE** input pin). When a momentary input switch is used it must be normally-open (N.O.) for standard operation.

SWITCH TYPE	ACTION MODE	MODE PIN	OUTPUT ACTION	1ST PRESS	1ST RELEASE	2ND PRESS	2ND RELEASE
MOMENTARY	LATCHING	HIGH / NC	LATCHING	**ON**	-	**OFF**	-
LATCHING	MOMENTARY	LOW	LATCHING	**ON**	-	**OFF**	-
MOMENTARY	MOMENTARY	LOW	MOMENTARY	**ON**	**OFF**	**ON**	**OFF**

The MASS-Switch *works equally well with both momentary and latching input switches giving freedom to your designs.*

5.5.1 IN LATCHING ACTION MODE (BISTABLE MODE)

When the **MODE** input pin is HIGH so that the LATCHING action mode is enabled, the output state will only respond to leading-edge (contact make) transitions on the **SENSE** input pin, meaning that the output will change states only when the input switch becomes CLOSED. In this mode the state of the output will change to the *alternate* state (flip-flop) each time the input switch is pressed, when a normally-open (N.O.) type momentary input switch is connected. The LATCHING action mode is *bistable* because it will hold both the ON and the OFF output states when the input switch is OPENED. This produces ***LATCHING OUTPUT ACTION*** with a momentary type input switch.

5.5.2 IN MOMENTARY ACTION MODE (MONOSTABLE MODE)

When the **MODE** input pin is LOW so that the MOMENTARY action mode is enabled, the output state will respond to both leading-edge (contact make) and trailing-edge (contact break) changes on the **SENSE** input pin, meaning that the output will change states when the input control switch becomes CLOSED or OPENED. In this mode the state of the output tracks the state of the input switch so that OPENED is always OFF and CLOSED is always ON. The MOMENTARY action mode is *monostable* because it will return to the OFF output state when the input switch is OPENED. This produces ***LATCHING OUTPUT ACTION*** with a latching type input switch, and ***MOMENTARY OUTPUT ACTION*** with a momentary type input switch.

*In MOMENTARY action mode, the **HIGHON** output pin simply mimics the logical state of the **SENSE** input pin but with the benefit of MASS filtering, converting multi-edged, noisy, and/or slow input transitions (e.g. relay outputs and long transmission-lines) into clean, single-edged signals. Due to the LOW = ON nature of the **SENSE** input, the signal is electrically inverted at the **HIGHON** output.*

5.6 POWER-UP

The *MASS-Switch* will self-initialize on power-up and produce an initial output response on the output pins which serves to *preset* (correct) any controlled devices to the known operational state. The initial output response will occur immediately after the startup delay as soon as a stable operating voltage is applied to **VCC**. All output pins default to LOW (GND) until the initial output response is generated. In LATCHING (bistable) mode the output will preset to OFF regardless of the instantaneous state of the input switch (**SENSE** input pin) and an OFF response will be produced on the output pins. In MOMENTARY (monostable) mode the output will match the instantaneous state of the input switch (**SENSE** input pin) and the appropriate output response will be produced on the output pins.

The LOW = ON (inverted) **MUTE** output pin will always default to ON (LOW) during power-up and will remain ON until the initial output response is complete. This means that affected signal outputs will become muted as soon as any muting electronics receive power and will remain muted until the *MASS-Switch* has powered-up and any controlled switching components have been preset by the initial output response.

A mechanical device, such as a latching relay or the input switch itself, can change physical states during transport or otherwise become misaligned to the next power-up state of the controller and other components. The initial output response from the MASS-Switch *ensures that all devices being controlled are preset to the correct conditions after power-up. In LATCHING action mode the output will always power-up to OFF regardless of the state of the input switch. In MOMENTARY action mode the output will power-up to the same state as the input switch. This means that the power or bypass state of the device can be retained over power cycles when the MOMENTARY action mode is used with a LATCHING type input switch.*

5.7 DRIVING RELAYS

The *MASS-Switch* output controller is designed to control *non-latching*, *single-coil latching*, and *dual-coil latching* relays and is capable of controlling all three relay types simultaneously. An appropriate transistor driver or bridge is required in all cases (see EXAMPLES).

SUPPORTED RELAY	CONTROL OUTPUT	POWER EFFICIENCY	NOTE
NON-LATCHING	**HIGHON**	LOW	SINGLE-CHANNEL DRIVER
SINGLE-COIL LATCHING	**PLSON** + **PLSOFF**	HIGH	H-BRIDGE DRIVER
DUAL-COIL LATCHING	**PLSON**, **PLSOFF**	HIGH	DUAL-CHANNEL DRIVER, RECOMMENDED

The MASS-Switch *works equally well with both standard and latching relays giving freedom to your designs. Do not drive relay coils or other inductive loads directly from the output pins.*

Note: Dual-coil latching relays are generally recommended for their combination of power efficiency and relatively simple drivers.

5.8 INPUT SWITCH QUALITY

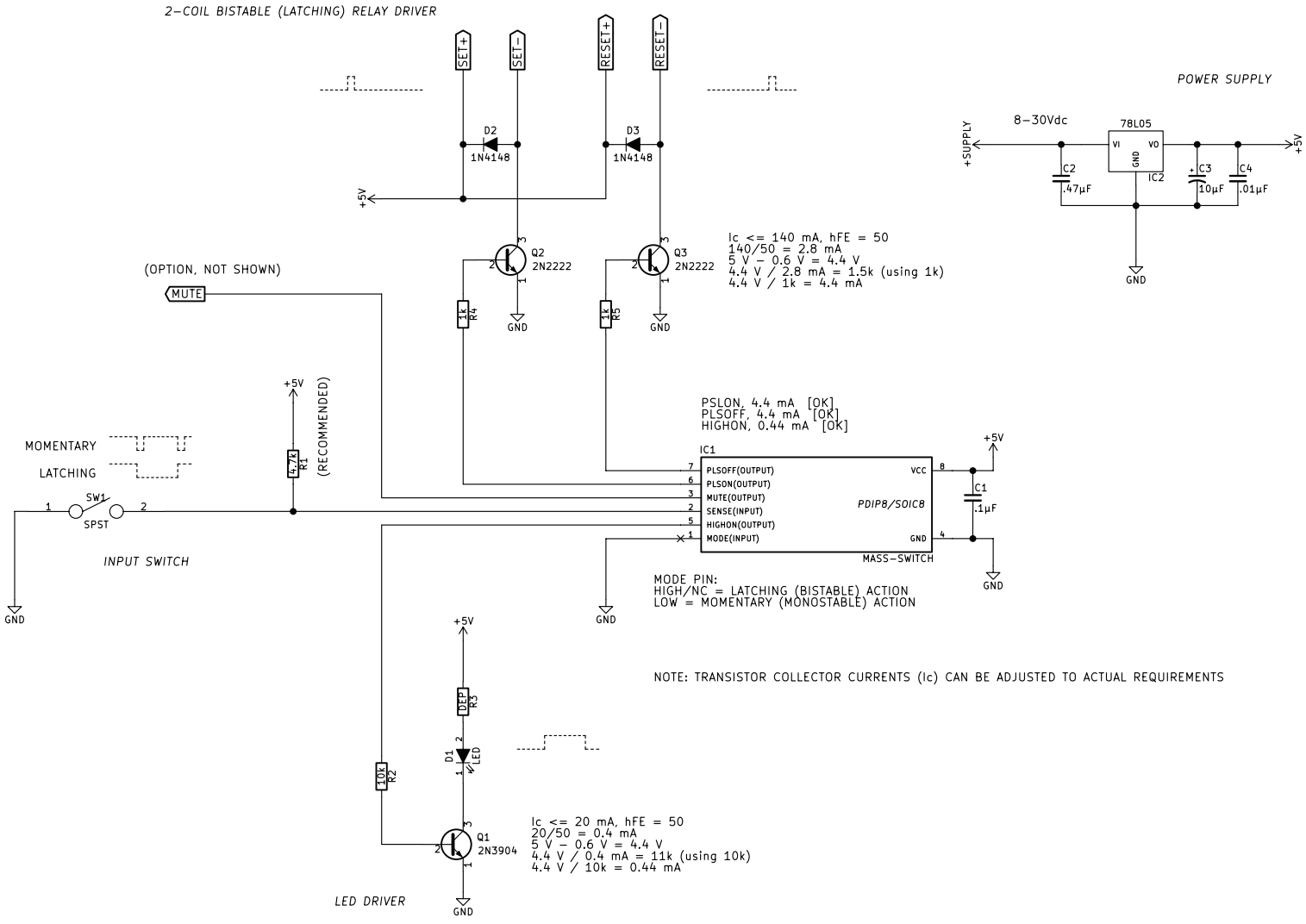
The *MASS-Switch* utilizes an integrated active filter to determine which signals on the **SENSE** input pin qualify as real switch events. The filter is versatile and adaptive to almost any contact make or break profile and will often determine that a real switch event is taking place before the physical contacts have fully settled. Because of the adaptive filter, better quality switches will automatically produce faster response times (i.e. better performance).

Warning: The *MASS-Switch* is designed to be responsive and is capable of cycling fast enough to reveal bad quality or failing switches with poor *contact hold quality.* This is not the same as contact bounce and usually occurs at a low rate, outside of the filter window. This is best described as a momentary switch that intermittently breaks and re-makes contact while the operator intends to keep it closed (i.e. pressed). In these cases, the intermittent contacting may be interpreted by the *MASS-Switch* as a series of independent switch events and produce apparently unstable output.

A switch that does not hold contact as the operator intends is an astable oscillator that is not generally solvable by the filter and may cause cyclic or unstable switching output. A momentary type switch with good contact holding quality is especially important in momentary output action *configurations.*

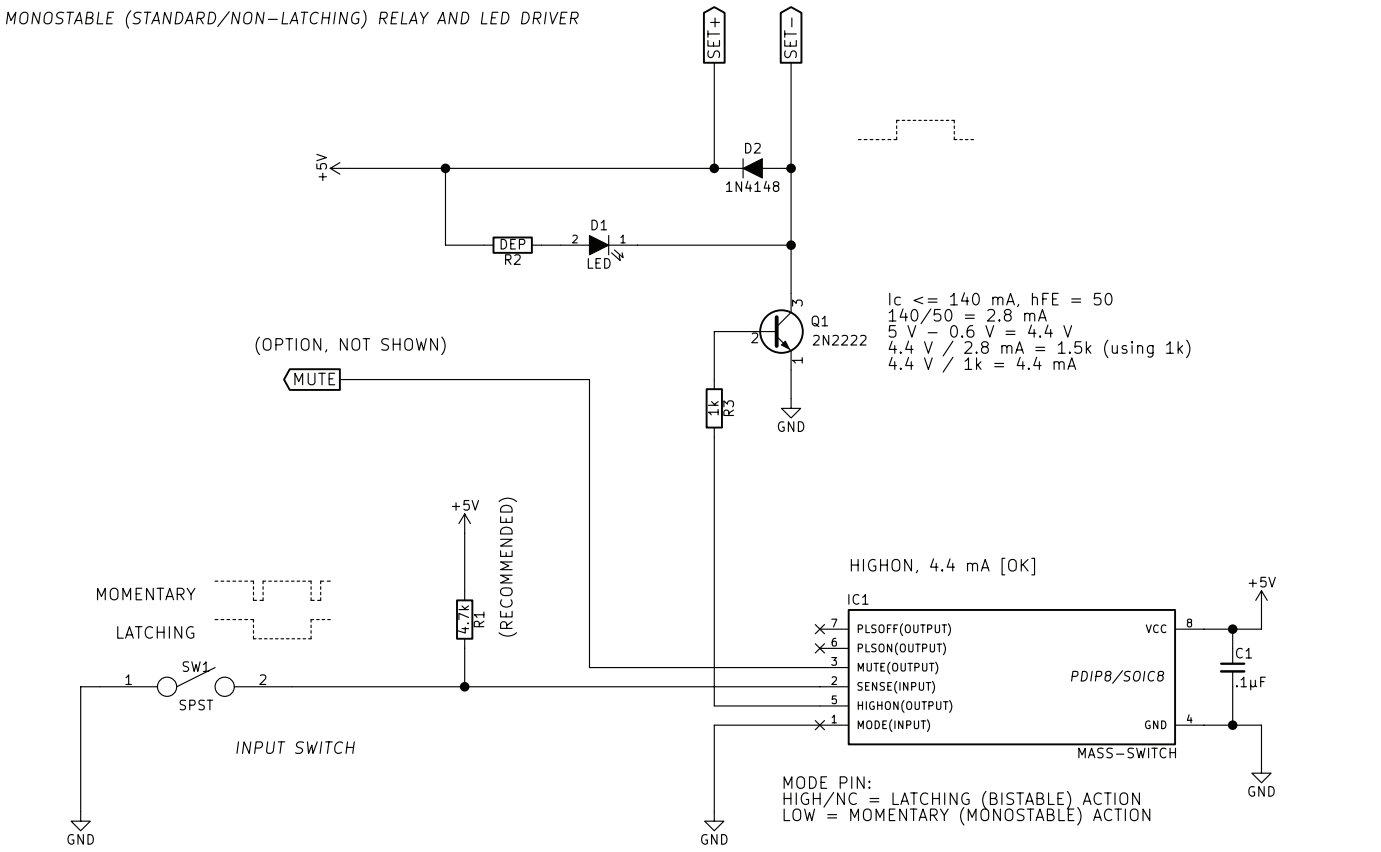
6. EXAMPLES

6.1 2-COIL BISTABLE (LATCHING) RELAY DRIVER, LED DRIVER



6. EXAMPLES

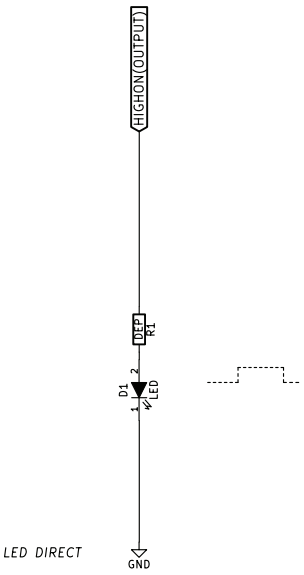
6.2 MONOSTABLE (STANDARD / NON-LATCHING) RELAY AND LED DRIVER



NOTE: TRANSISTOR COLLECTOR CURRENTS (Ic) CAN BE ADJUSTED TO ACTUAL REQUIREMENTS

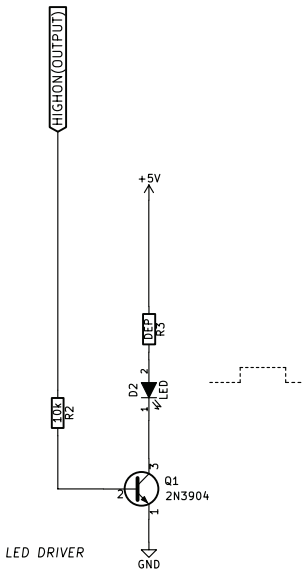
6. EXAMPLES

6.3 LED DRIVERS



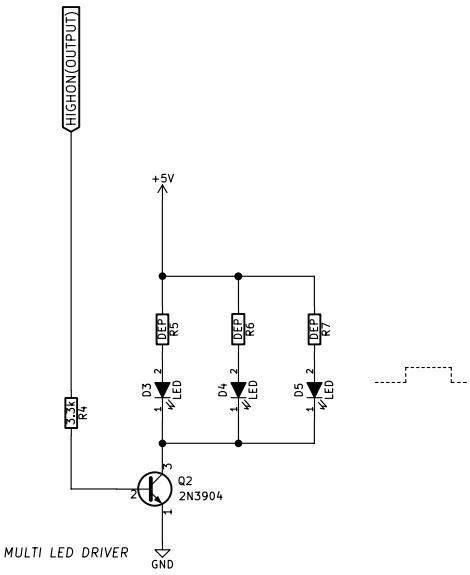
LED DIRECT

! HIGHON <= 20 mA



LED DRIVER

Ic <= 20 mA, hFE = 50
20/50 = 0.4 mA
5 V – 0.6 V = 4.4 V
4.4 V / 0.4 mA = 11k (using 10k)
4.4 V / 10k = 0.44 mA
HIGHON, 0.44 mA [OK]



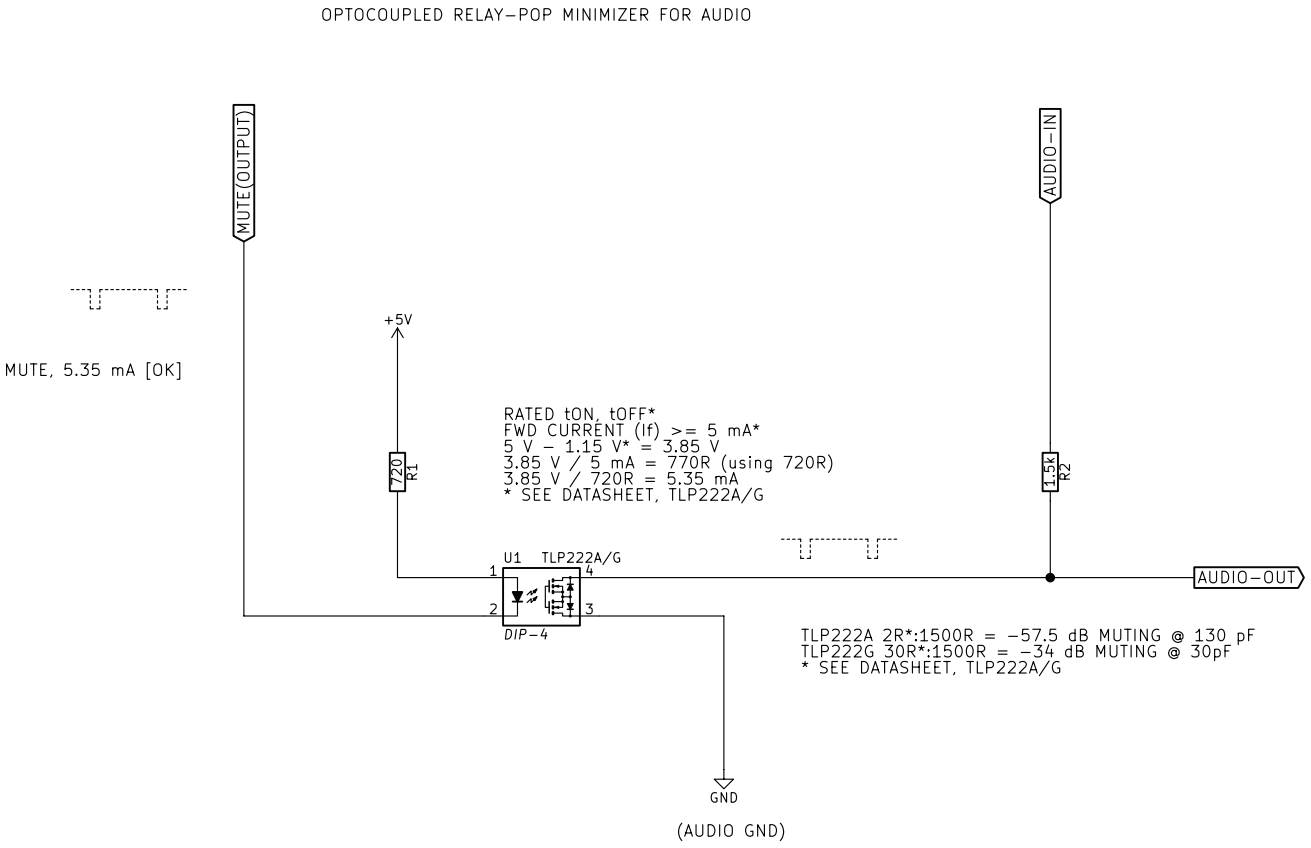
MULTI LED DRIVER

Ic <= 60 mA, hFE = 50
60/50 = 1.2 mA
5 V – 0.6 V = 4.4 V
4.4 V / 1.2 mA = 3.6k (using 3.3k)
4.4 V / 3.3k = 1.33 mA
HIGHON, 1.33 mA [OK]

NOTE: TRANSISTOR COLLECTOR CURRENTS (Ic) CAN BE ADJUSTED TO ACTUAL REQUIREMENTS

6. EXAMPLES

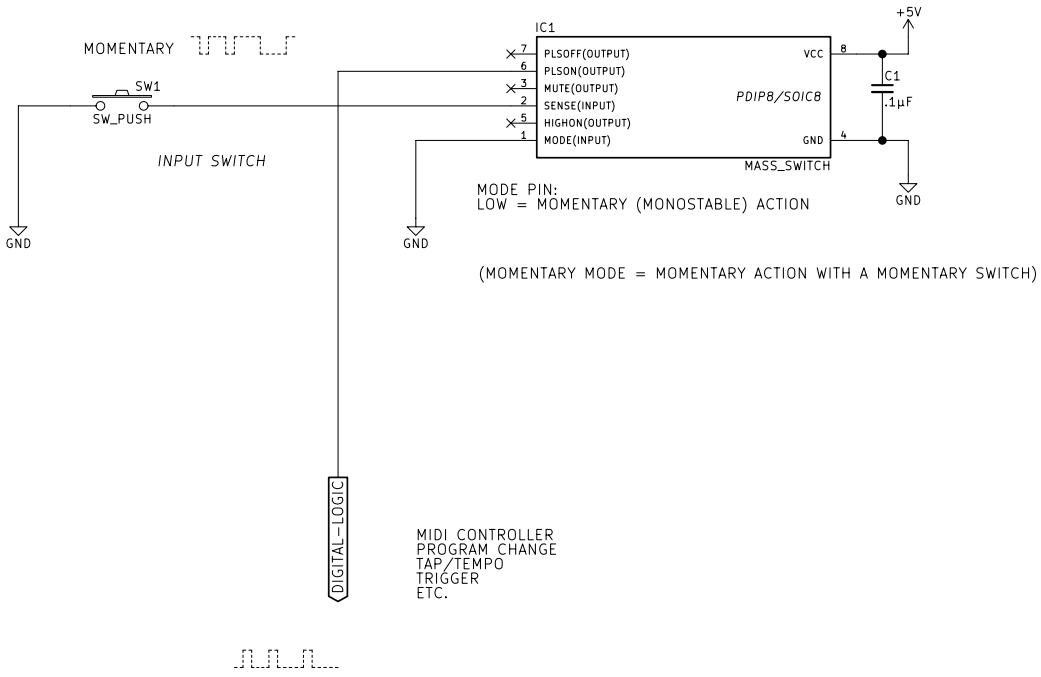
6.4 OPTOCOUPLED RELAY-POP MINIMIZER FOR AUDIO



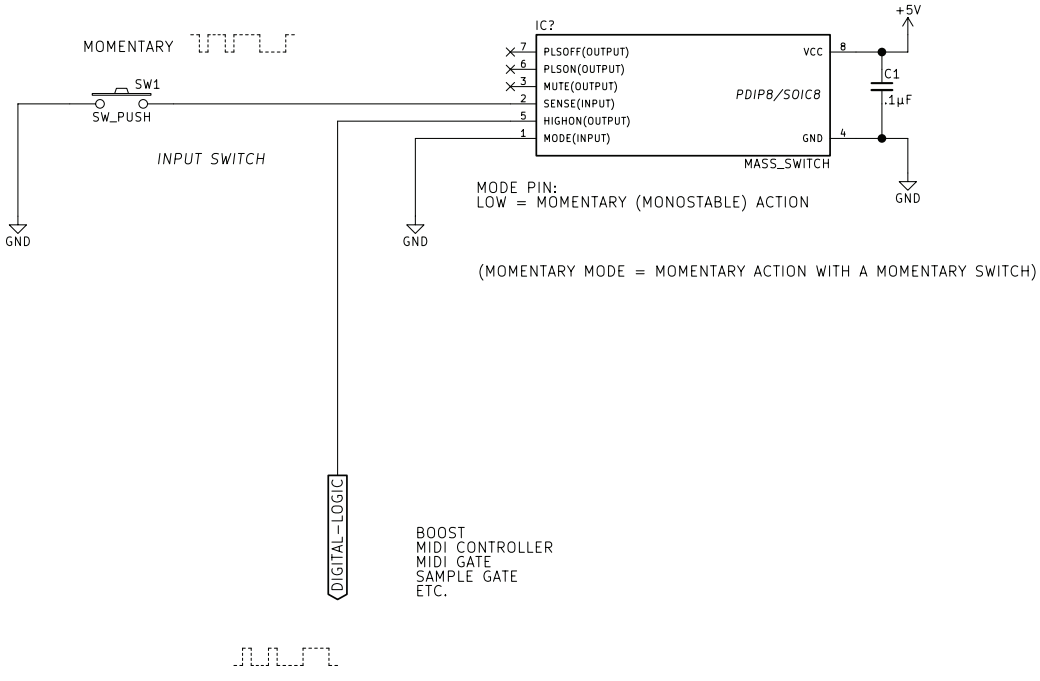
6. EXAMPLES

6.5 LOGIC DRIVERS

MOMENTARY/TAP PULSE–LOGIC DRIVER



MOMENTARY/TAP STEADY–STATE LOGIC DRIVER



7. DESIGN TIPS

7.1 Use a latching type input switch to retain bypass or power state between power cycles

In MOMENTARY action mode, the *MASS-Switch*™ will preset to the state of a latching input switch at power-up so that your controlled device will return to the same state, even if any relays have physically changed states during transport (the initial output response will correct them). This behavior is transparent and mimics traditional latching stomp-box designs. Use your preferred latching foot-switch and connect the **MODE** input pin to GND (LOW) to select the MOMENTARY action mode.

7.2 Use a momentary type input switch for modern stomp box playability

In LATCHING action mode, the *MASS-Switch* will cycle ON and OFF with each subsequent press of a momentary input switch. This behavior provides a precise and fast-acting playability for modern effects that is popular on commercial stomp-boxes. Use a good quality normally-open (N.O.) momentary foot-switch and connect the **MODE** input pin to VCC (HIGH) to select the LATCHING action mode.

7.3 Use a momentary type input switch for momentary effects

Momentary action is popular for mute/stutter effects, distortion/overdrive boost switches, routing boxes, etc. This behavior engages the effect only when the switch is held closed (pressed) and disengages the effect when the switch is released. Use a good quality normally-open (N.O.) momentary foot-switch and connect the **MODE** input pin to GND (LOW) to select the MOMENTARY action mode.

7.4 Provide end-user selectable latching or momentary output action by jumping the MODE pin

A user-configurable jumper or PCB switch (DIP, etc.) can be included in your design that will allow end-users to choose between standard LATCHING action and MOMENTARY action. Use a good quality normally-open (N.O.) momentary foot-switch and connect the **MODE** input pin to a jumper or PCB switch that closes to GND. When the jumper or PCB switch is set open, the *MASS-Switch* will power-up in LATCHING action mode. When the jumper or PCB switch is set closed, it will power-up in MOMENTARY action mode.

7.5 Utilize latching relays in compact and power-saving designs

Standard (non-latching) relays can draw significant contact-holding current which may present a problem for compact designs. Choose a latching (bistable) relay and use the **PLSON** and **PLSOFF** output pins to momentarily control it in order to *significantly* reduce current consumption and regulator requirements. As with any inductive load, each coil will require a buffer or driver circuit. A small-signal latching relay, indicator LED, and driver electronics can easily be powered, in addition to the *MASS-Switch*, with plenty of headroom, using a small 78L05 (5V) or equivalent voltage regulator.

7.6 Drive indicator LEDs directly from the HIGHON output pin to save space and reduce cost

The *MASS-Switch* output pins can safely source or sink 20 mA of current and are fully capable of driving LEDs and other low current devices without buffers, in order to save board space and reduce production cost. The output pins should never be used to directly drive relay coils or other inductive loads.

7.7 Utilize the PLSON, PLSOFF, and MUTE output pins for logic applications

The **MUTE** output pin produces a pulse similar to the **PLSON** and **PLSOFF** output pins and can be used to track or count switch events in the same way. While the **PLSON** and **PLSOFF** output pins produce a pulse whenever an ON or OFF output state is adopted respectively, the **MUTE** output pin will produce an inverted (LOW = ON) pulse whenever either output state is adopted (i.e. it will produce a pulse for both ON and OFF output state changes). The one-millisecond (1 ms) lead time on the **MUTE** pulse can be used to wake up or synchronize microcontrollers and other digital logic.

7.8 Choose quality switches and test thoroughly

The input switches are arguably the most important components of your design. There are as many switch qualities as there are switches. Every bypass or other control design which utilizes the *MASS-Switch* should be tested over several switch samples before committing to a particular switch. Normally-open momentary type switches are especially prone to bad contact holding quality when poorly manufactured.

7.9 Tighten-up final and production designs

When utilizing the LATCHING action mode, the **MODE** input pin should be tied to VCC unless a user configurable jumper or switch is employed. An additional 4.7k to 10k Ω pull-up resistor near the **SENSE** input pin will increase noise immunity. An additional 4.7k to 10k Ω pull-up resistor near the **MODE** input pin will increase noise immunity if a user configurable jumper or switch is employed. A 100nF (.1µF) decoupling capacitor should be inserted between the **VCC** and **GND** pins with the shortest traces and leads possible. Do not power audio or small-signal components from the same (VCC) voltage regulator that supplies the *MASS-Switch* IC and other switching components. Run a separate ground trace or plane section from the most common power ground point to the switching components and do not use the separate ground for audio or small-signal components. Transistor drivers and bridges that operate relay coils or other inductive loads should be calculated with extra current headroom (as much as 300%) to ensure saturation at the highest current-moment. Fly-back diodes should be inserted reverse-biased across any inductive loads to protect drive transistors. An appropriate bypass capacitor should be inserted across the output of the local (VCC) voltage regulator whenever relays or other inductive loads share the same supply as the *MASS-Switch* IC. Route any traces which carry *MASS-Switch* outputs (**ONHIGH**, **PLSON**, **PLSOFF**, and **MUTE**) as far away from audio and small-signal traces as the design will allow. Favor shortest routes for the audio and small-signal traces. Likewise, keep audio and other small-signal traces and components away from the *MASS-Switch* IC and switching components as far as possible.

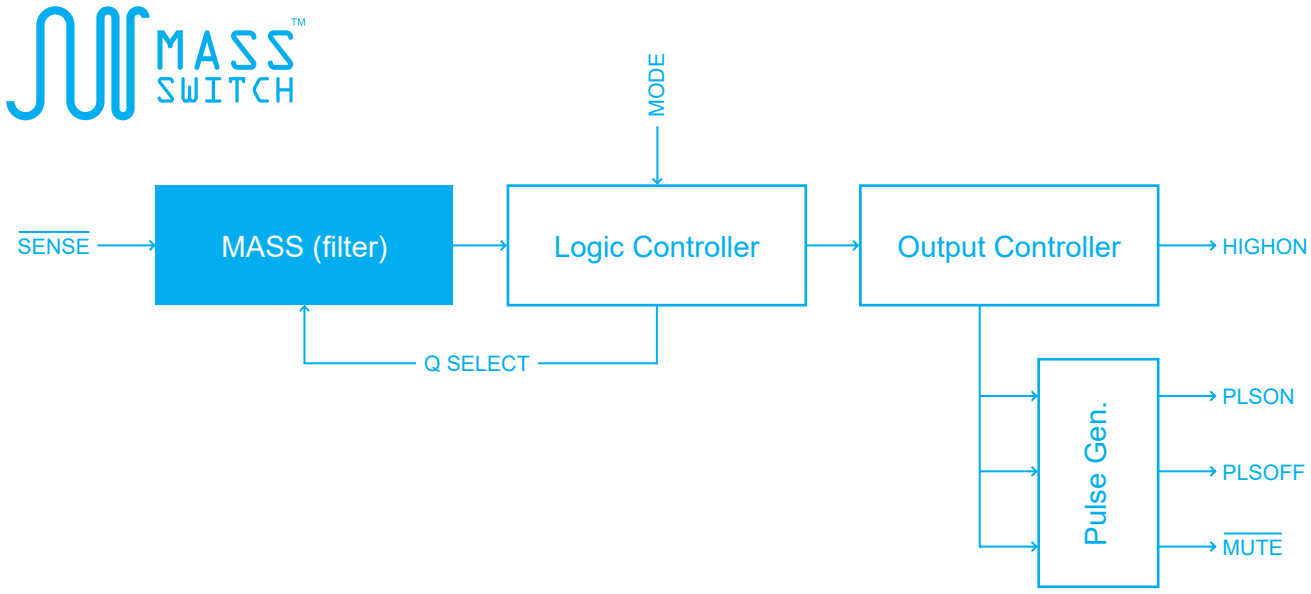
7.10 Clean up utility switches, program switches, and many other switching applications

Tap switches, selector switches, boost switches and more, foot-operated or otherwise, are readily and easily tamed by the *MASS-Switch* switching controller. Wherever human-operated mechanical switches or sensors need to interface with logic-devices or digital inputs, the *MASS-Switch* will provide adaptive, adjustment-free filtering for solid performance using minimal components, low power consumption, and freedom from tolerance concerns. Step-up your switching with the *MASS-Switch*!

8. TECHNICAL DETAILS

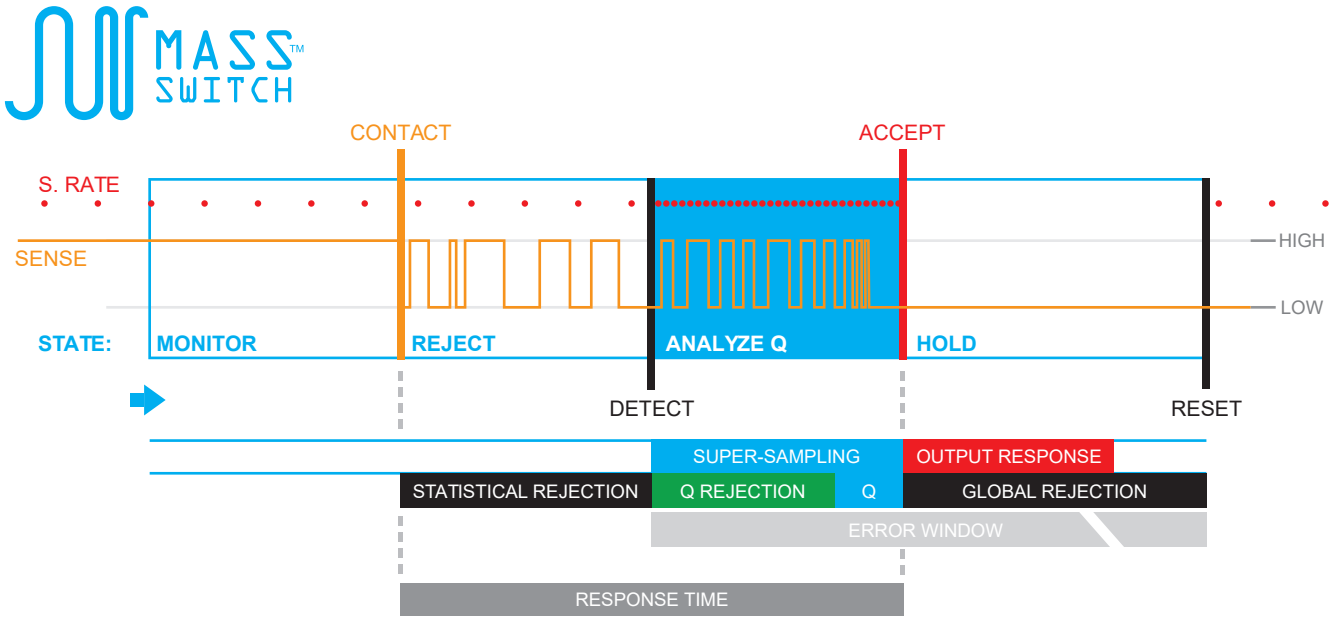
The information in this section is *beyond the scope of general use*; a full understanding of this section is not required to use the *MASS-Switch*™ in electronic designs and builds.

8.1 SYSTEM FLOWCHART



8.2 MASS FILTER

MASS, or *Mode-Adaptive Super-Sampling*, is a digital signal processing (DSP) technique designed to achieve fast-acting, broad-range contact bounce filtering on small, inexpensive, high-performance host microprocessors with limited memory. The MASS filter and its anti-mode sister, PASS, were developed by **manvsbigmachine™** for high-speed photographic controllers and camera system hardware interfaces.



The MASS filter actively transitions through three states including a high-resolution edge-detecting quality analyzer operating around two *tailored qualities (modes)*. The filter captures discrete samples at a low, nominal sample-rate while *monitoring* the input signal, to promote spike and noise rejection, until persistent signal activity triggers *detection* whereupon the filter instantly tips into active *quality analysis*. When quality analysis begins, the filter increases the signal sample-rate for higher averaged accuracy. The *super-sampled* quality analysis continues until one of two signal qualities (*Q*) is satisfied (*acceptance*) or the error window is exceeded and the event is *rejected*. Only fully qualified switch events are allowed to modify the subsequent controller logic. The quality factors and error window are source-tunable for specific applications. *Stable-pulse quality* mode is biased towards contact *stability* and will restrain acceptance until a bouncing switch is delivering a very low statistical rate-of-return (anti-direction) from a *potential transition*. *Leading-pulse quality* mode is biased towards contact *assertion* and will restrain acceptance only until it detects enough transition moments from the switch, in the direction of the potential transition, to assert that a transition pattern is occurring. The leading-pulse quality analyzer will also conditionally supply negative feedback to the post-acceptance hold period in order to stabilize cyclic behavior for extremely short contact pulses occurring at a high rate, without affecting performance when extremely short contact pulses are occurring at a typical rate. The typical rate is application defined. The type of quality utilized in the quality analysis mode can be preset or determined dynamically. On the *MASS-Switch*, the type of quality is preselected by the logic controller, based on the configured action mode, in order to favor the best performance patterns for both momentary (monostable) and latching (bistable) switches. When the signal quality is accepted inside the error window, the filter has determined that a true switch event is occurring. The subsequent transition to *hold* alerts the logic controller that a switch event has been detected so that the appropriate responses can be generated. When the hold period expires, the filter *resets* and continues at the nominal sample-rate. The state transition sequence takes place in just a few milliseconds

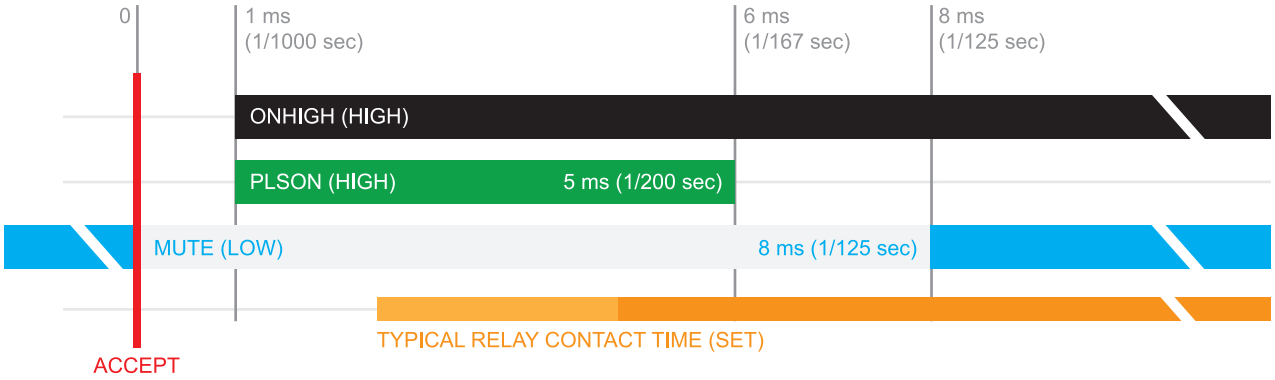
(i.e. one to three thousandths of a second, depending on the input signal quality) and delivers transparent performance to the switch-user every time the switch is actuated. The result is a super-stable, fast-acting switch controller that dynamically adapts to variable contact bounce profiles with a very high bias towards maximum performance (i.e. quick reaction) and an extremely high rate of noise and spike rejection. MASS is our purpose-engineered solution to adaptive switch filtering and embedded relay control on economical high-performance hardware with limited memory (> 1 MIPS, < 1 kB).

The MASS filter utilized inside the MASS-Switch *is tuned specifically for stomp-box and other industrial human-operated switching applications, and is fully compatible with micro switches, toggle switches, foot switches, key switches, panel buttons, relays, tilt sensors, camera shutter contacts, and more.*

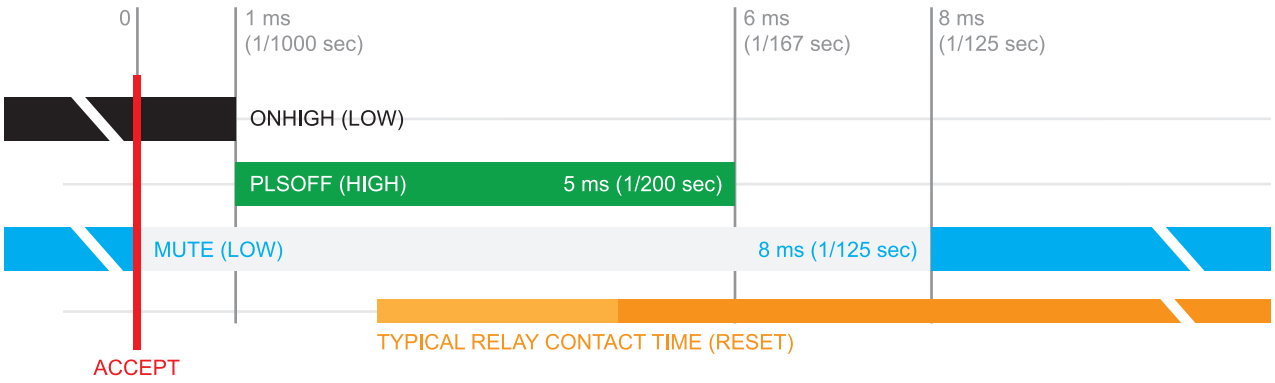
8.3 OUTPUT RESPONSE

The *MASS-Switch* output controller generates synchronized steady-state and pulsed drive signals for controlling all types of switching, routing, logic, and indicator components accurately and consistently. The **PLSON** and **PLSOFF** pulses are synchronized to the **HIGHON** output edges for near-identical performance from both latching (bistable) and non-latching (monostable) relays. The output controller logic also guarantees that the **PLSON** and **PLSOFF** outputs will never be HIGH at the same moment, making them safe for H-bridges and other mutually exclusive electronics. The **MUTE** output pulse always covers transitions on any of the other outputs, including **HIGHON**. The **MUTE** output may be used to count switch events, interrupt a microcontroller, or temporarily disable (blank) anything that must be protected from the switch transitions.

OUTPUT RESPONSE, OFF-**ON**



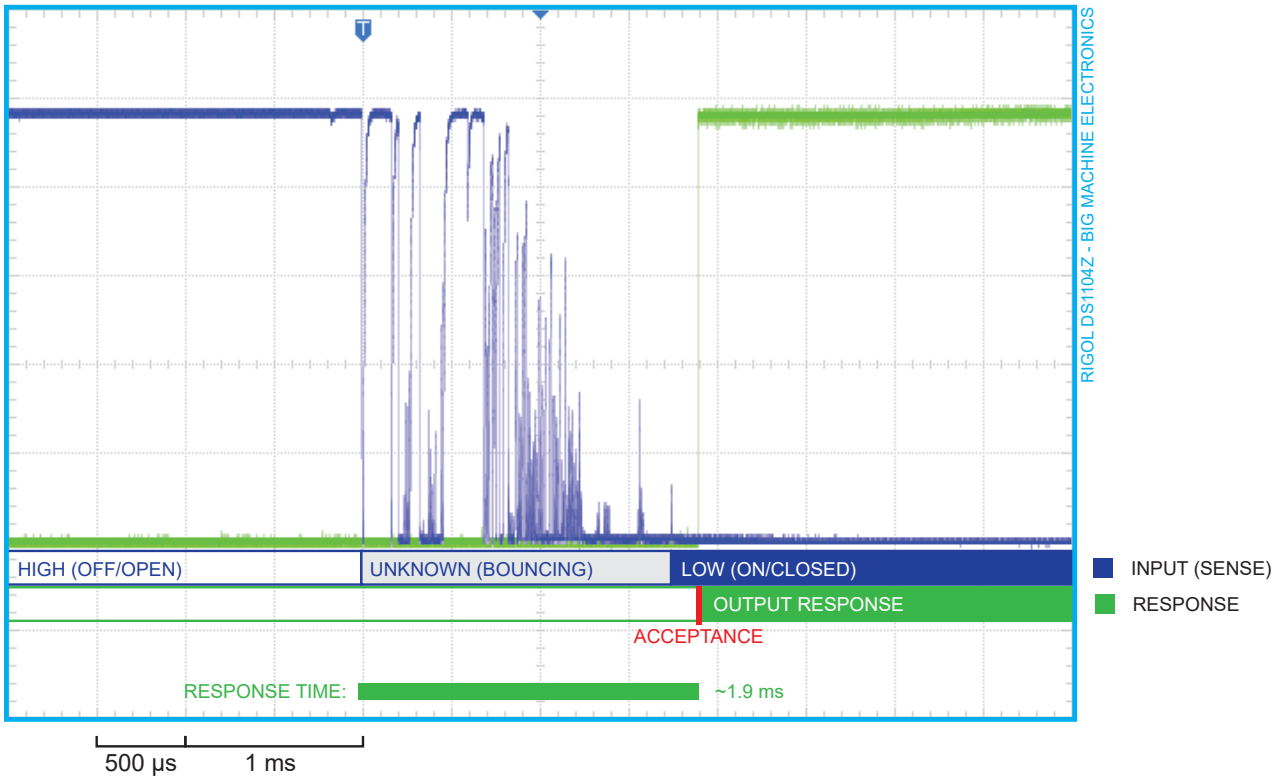
OUTPUT RESPONSE, ON-**OFF**



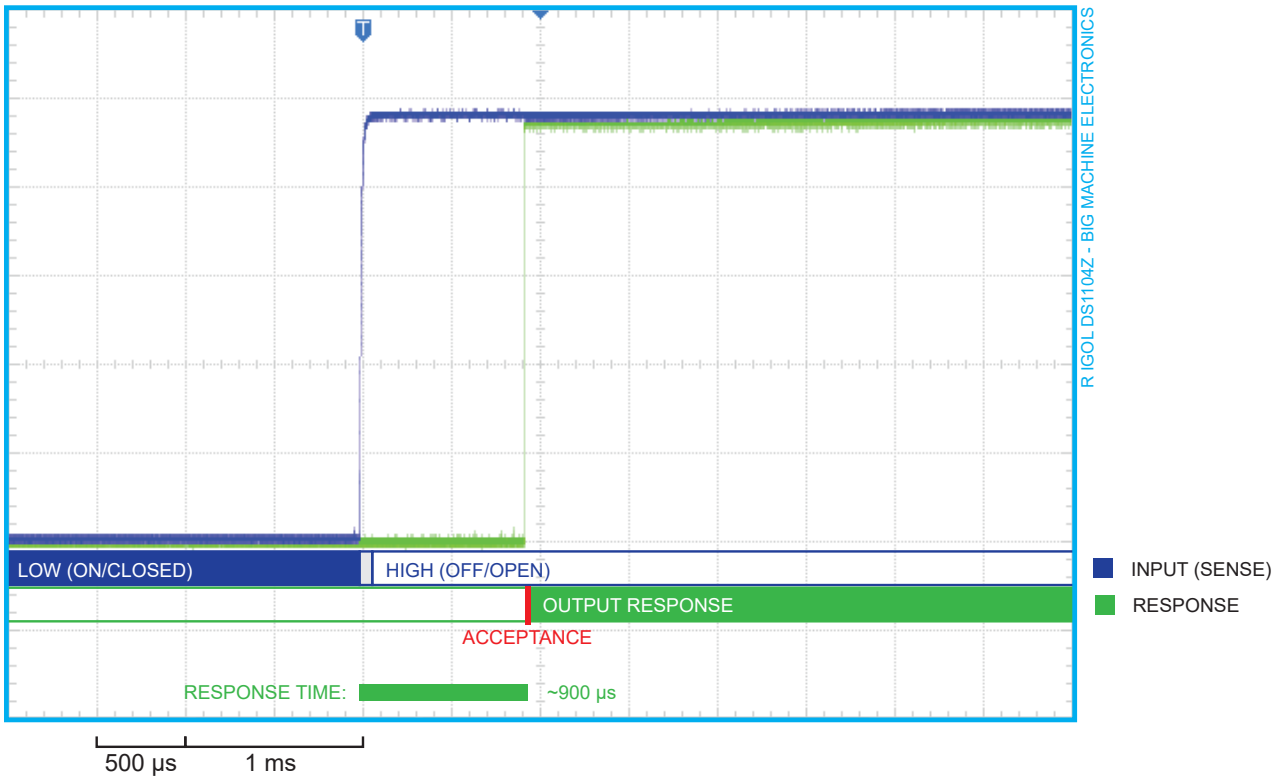
VARIATIONS IN HOST CLOCK RATES WILL SLIGHTLY AFFECT TIME-RATED VALUES WITHOUT ALTERING PERFORMANCE

9. PERFORMANCE DATA

9.1 LATCHING TYPE SWITCH CONTACT MAKE (TYPICAL PERFORMANCE)

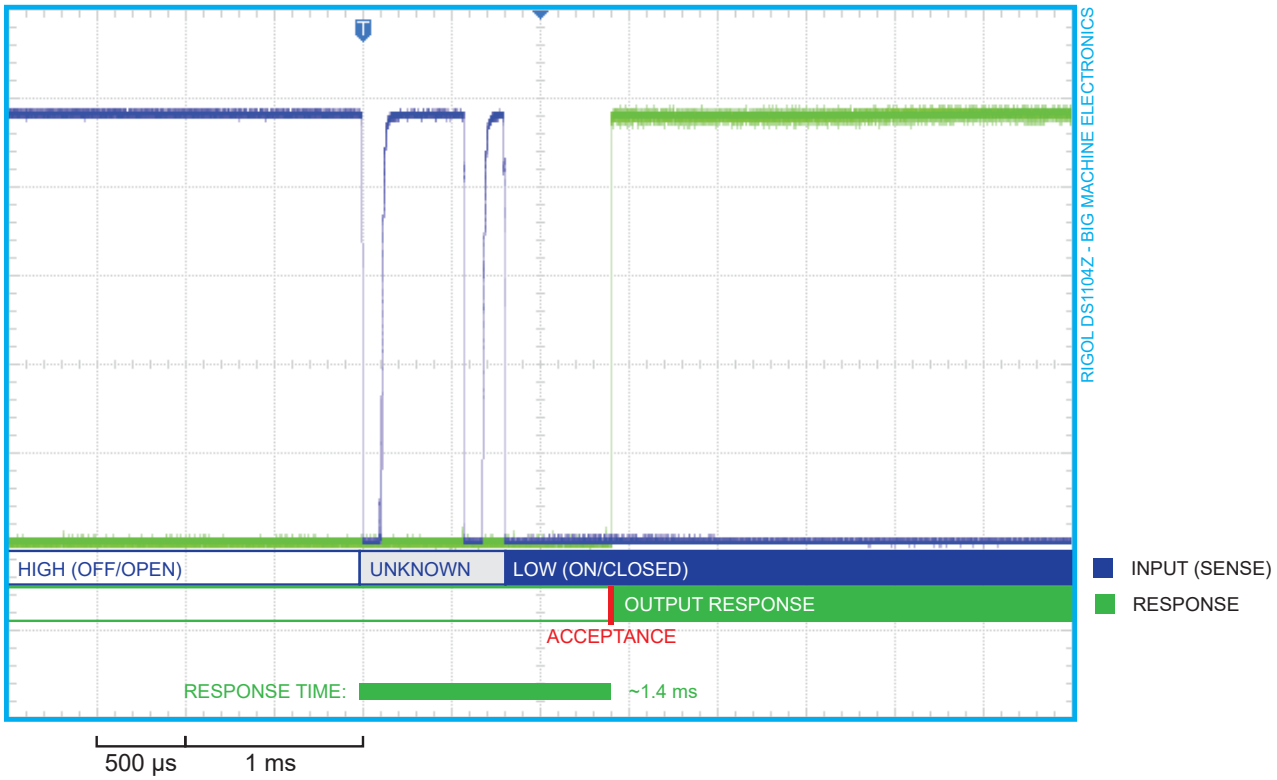


9.2 LATCHING TYPE SWITCH CONTACT BREAK (TYPICAL PERFORMANCE)



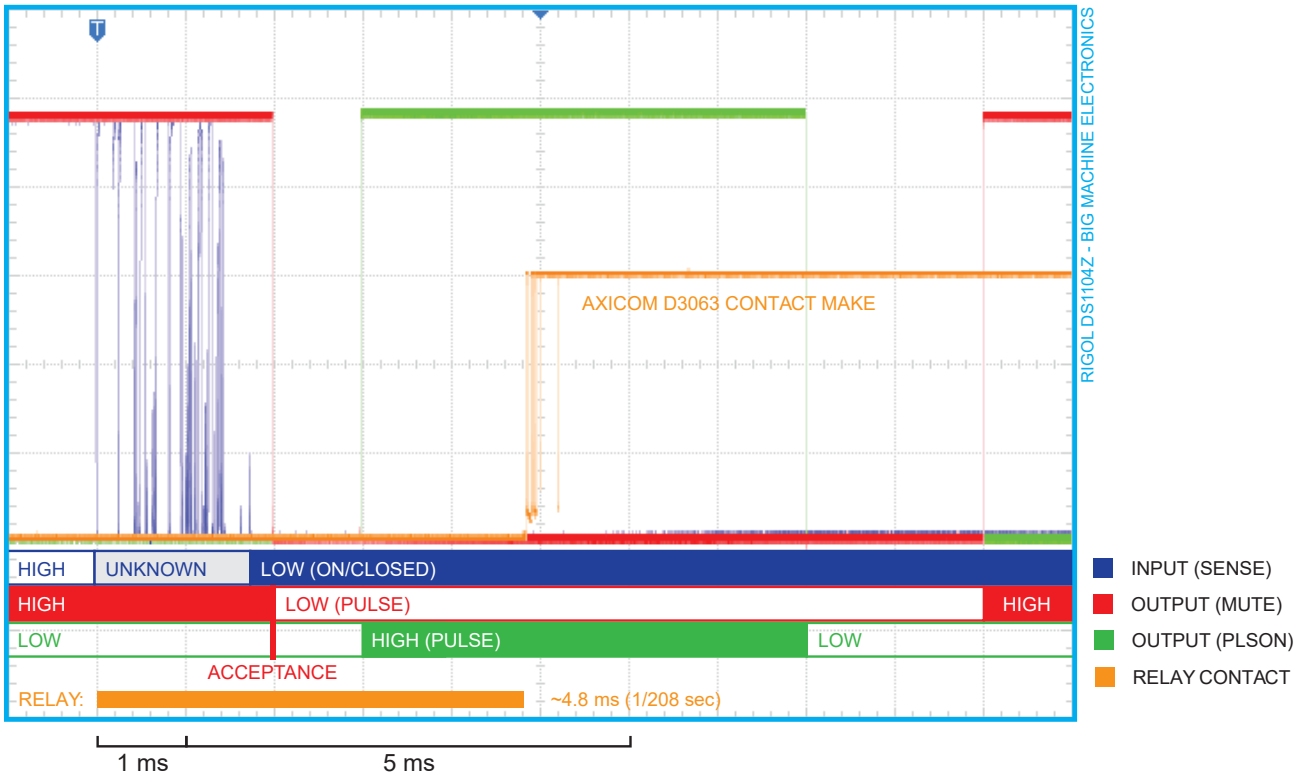
9. PERFORMANCE DATA

9.3 MOMENTARY TYPE SWITCH CONTACT MAKE (TYPICAL PERFORMANCE)

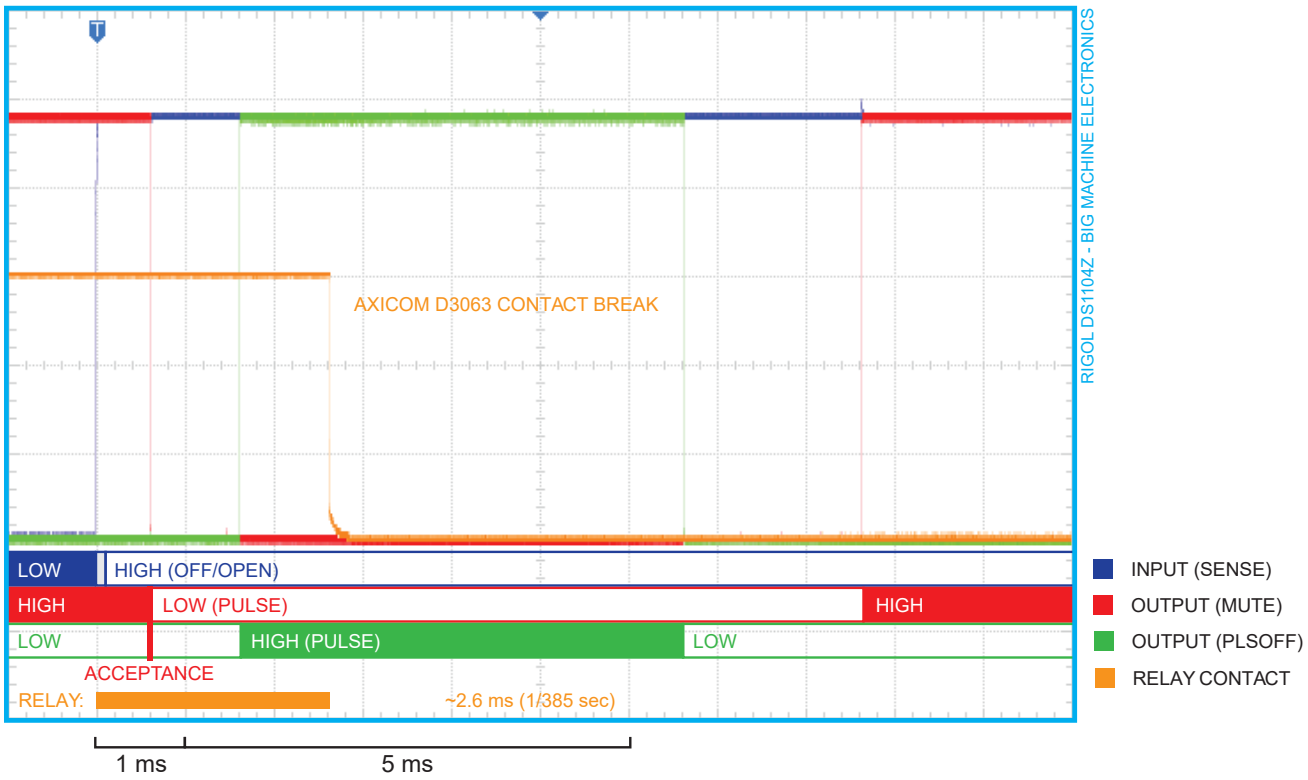


9. PERFORMANCE DATA

9.4 LATCHING SWITCH, OFF-ON OUTPUT WITH RELAY (TYPICAL PERFORMANCE)

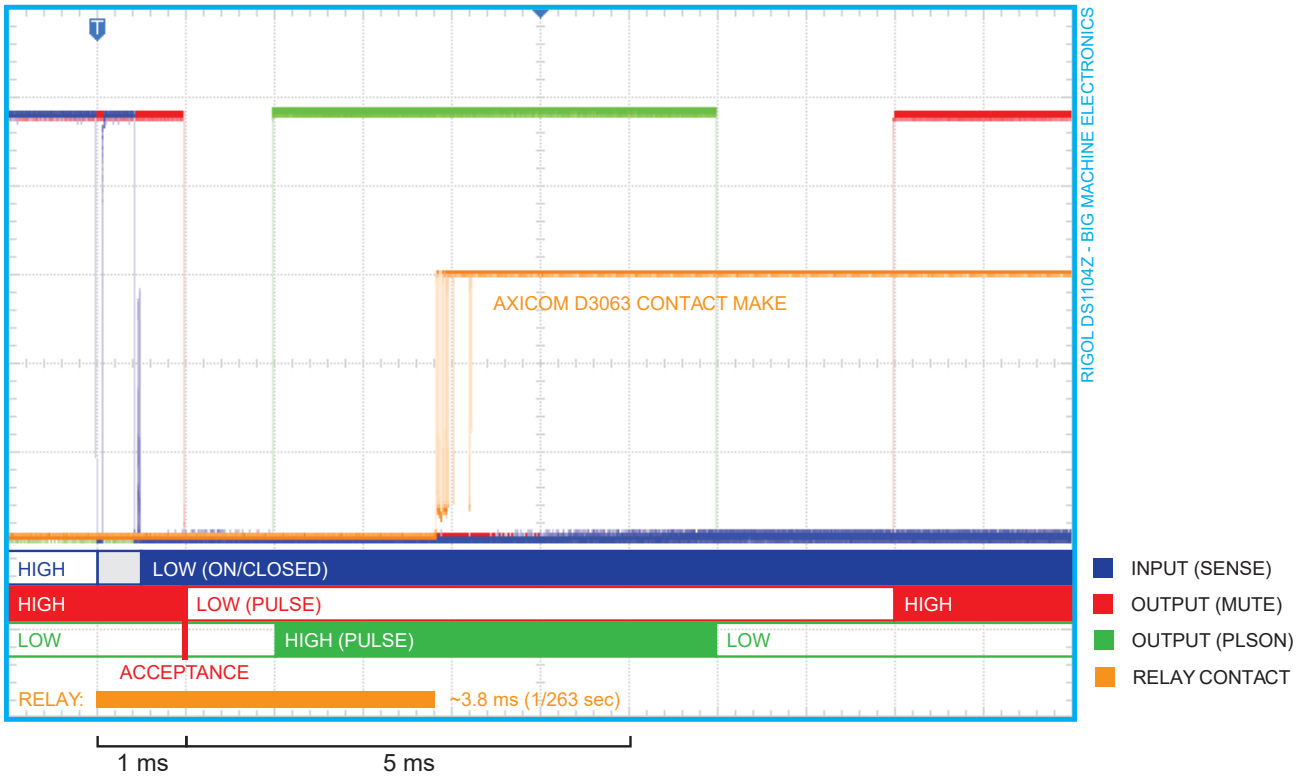


9.5 LATCHING SWITCH, ON-OFF OUTPUT WITH RELAY (TYPICAL PERFORMANCE)

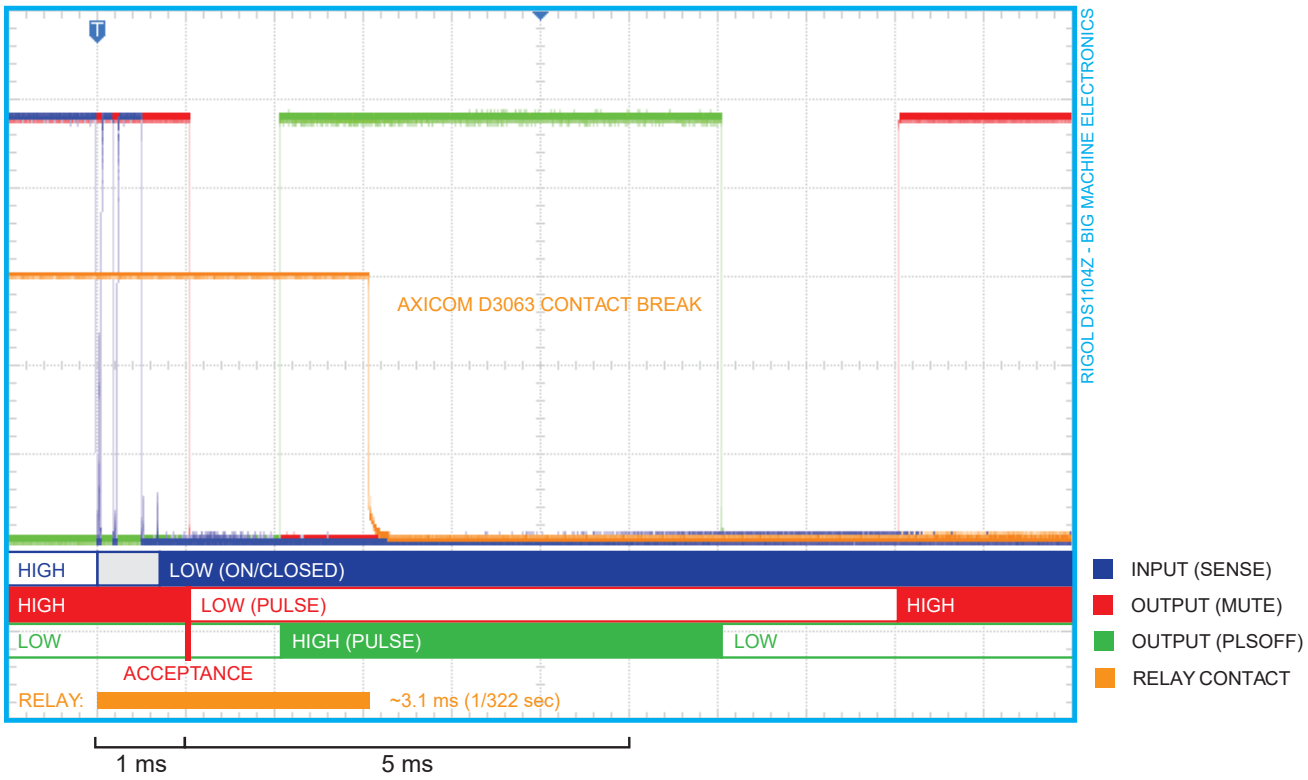


9. PERFORMANCE DATA

9.6 MOMENTARY SWITCH, OFF-ON OUTPUT WITH RELAY (TYPICAL PERFORMANCE)

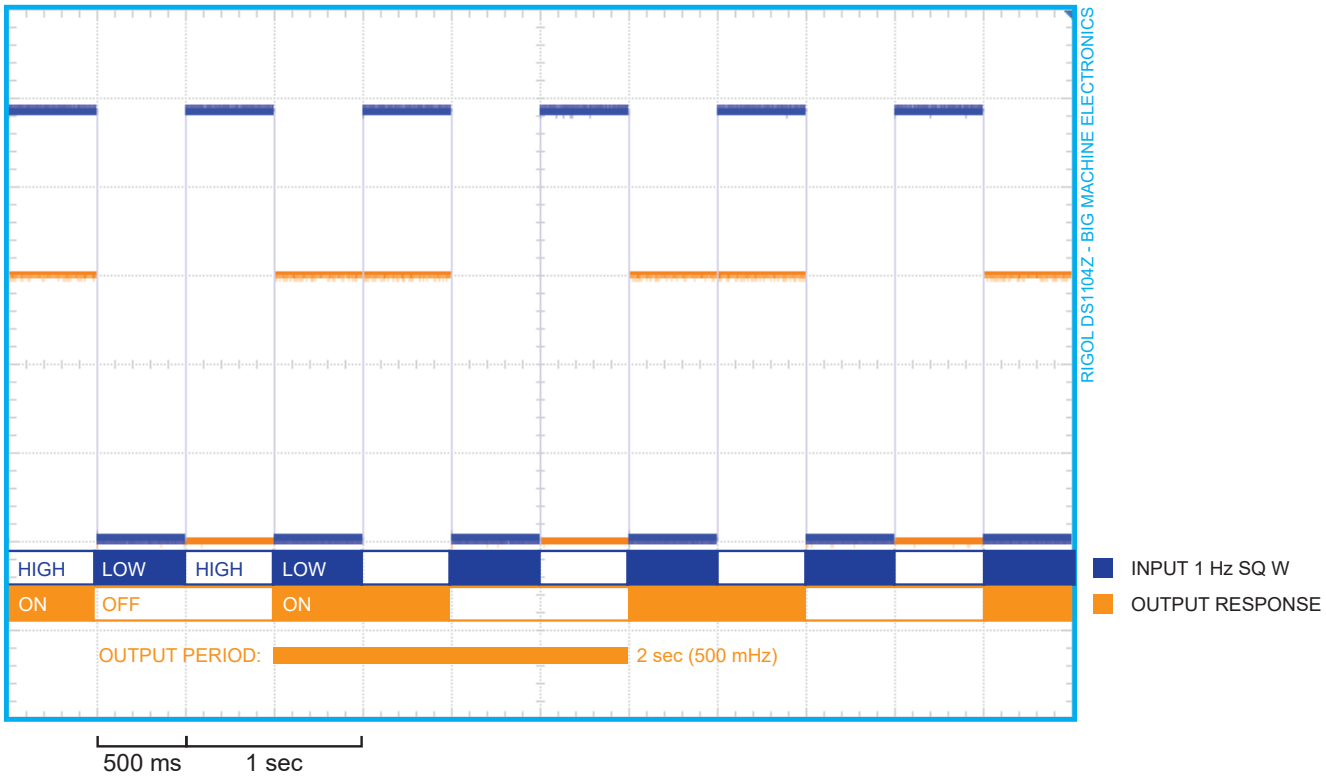


9.7 MOMENTARY SWITCH, ON-OFF OUTPUT WITH RELAY (TYPICAL PERFORMANCE)

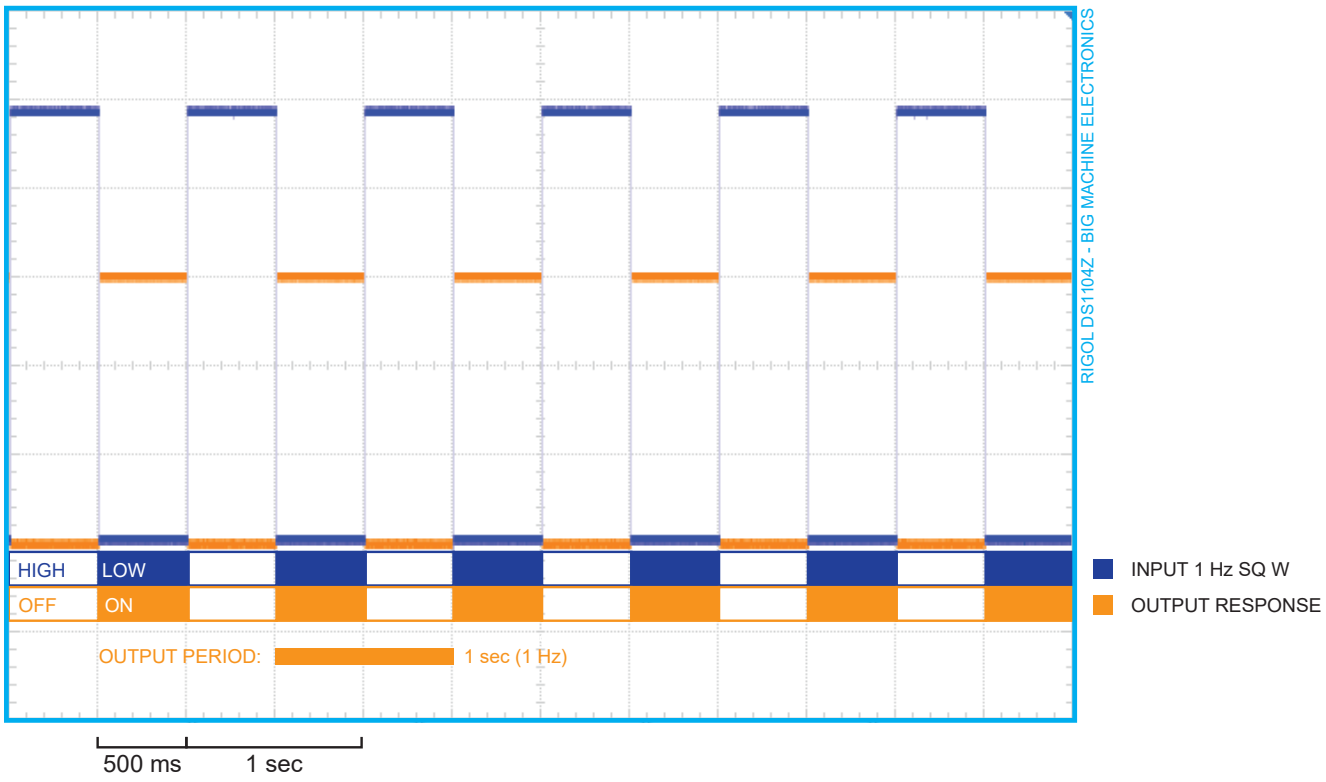


9. PERFORMANCE DATA

9.8 LATCHING (BISTABLE) MODE LOGICAL OUTPUT RESPONSE, 1 Hz SQUARE WAVE

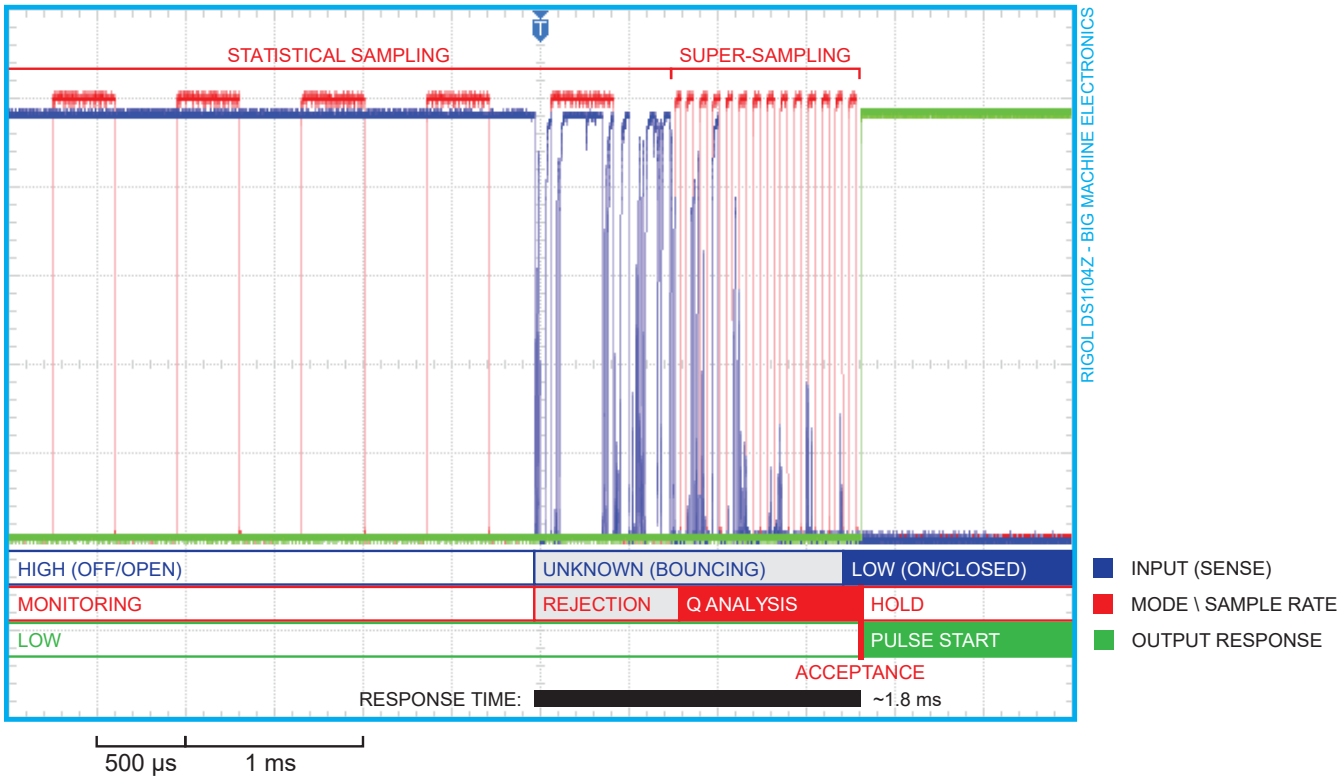


9.9 MOMENTARY (MONOSTABLE) MODE LOGICAL OUTPUT RESPONSE, 1Hz SQUARE WAVE

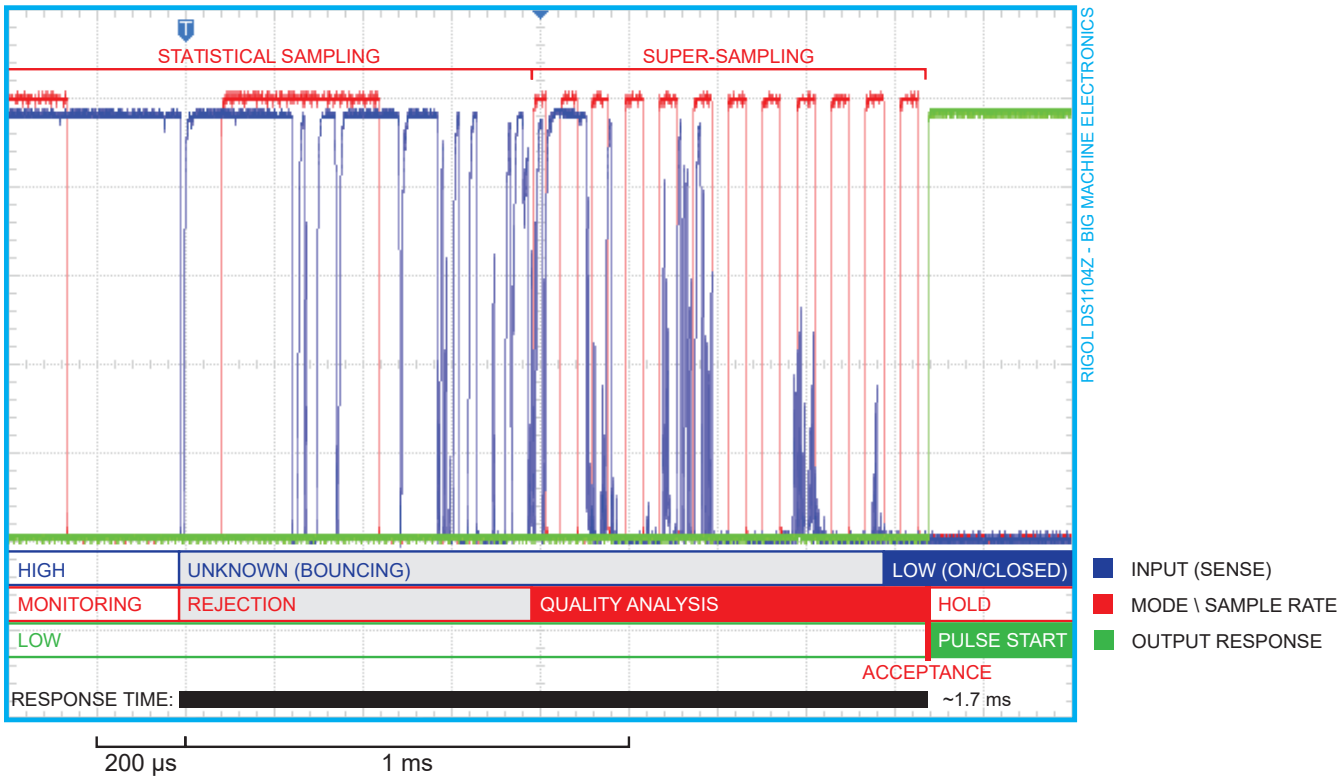


9. PERFORMANCE DATA

9.10 LATCHING TYPE SWITCH CONTACT MAKE + SAMPLE RATE

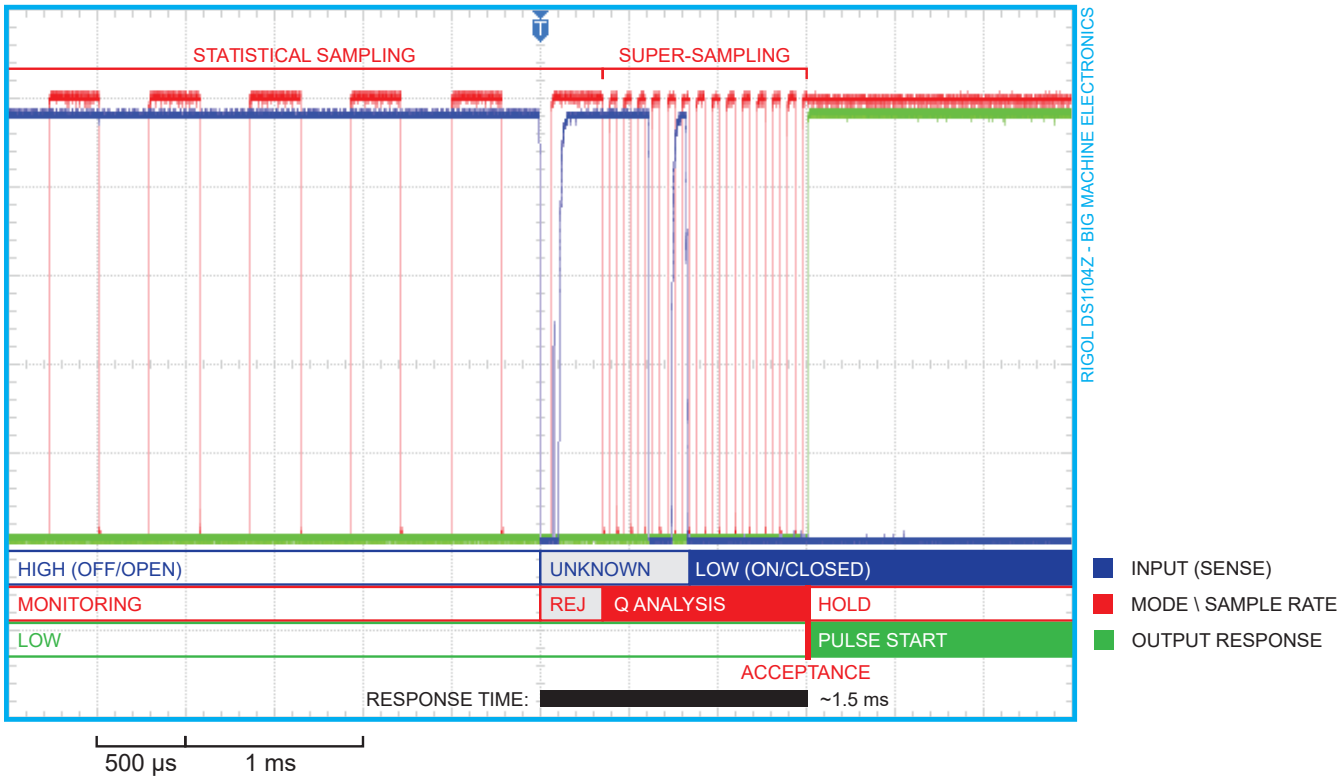


9.11 LATCHING TYPE SWITCH CONTACT MAKE + SAMPLE RATE

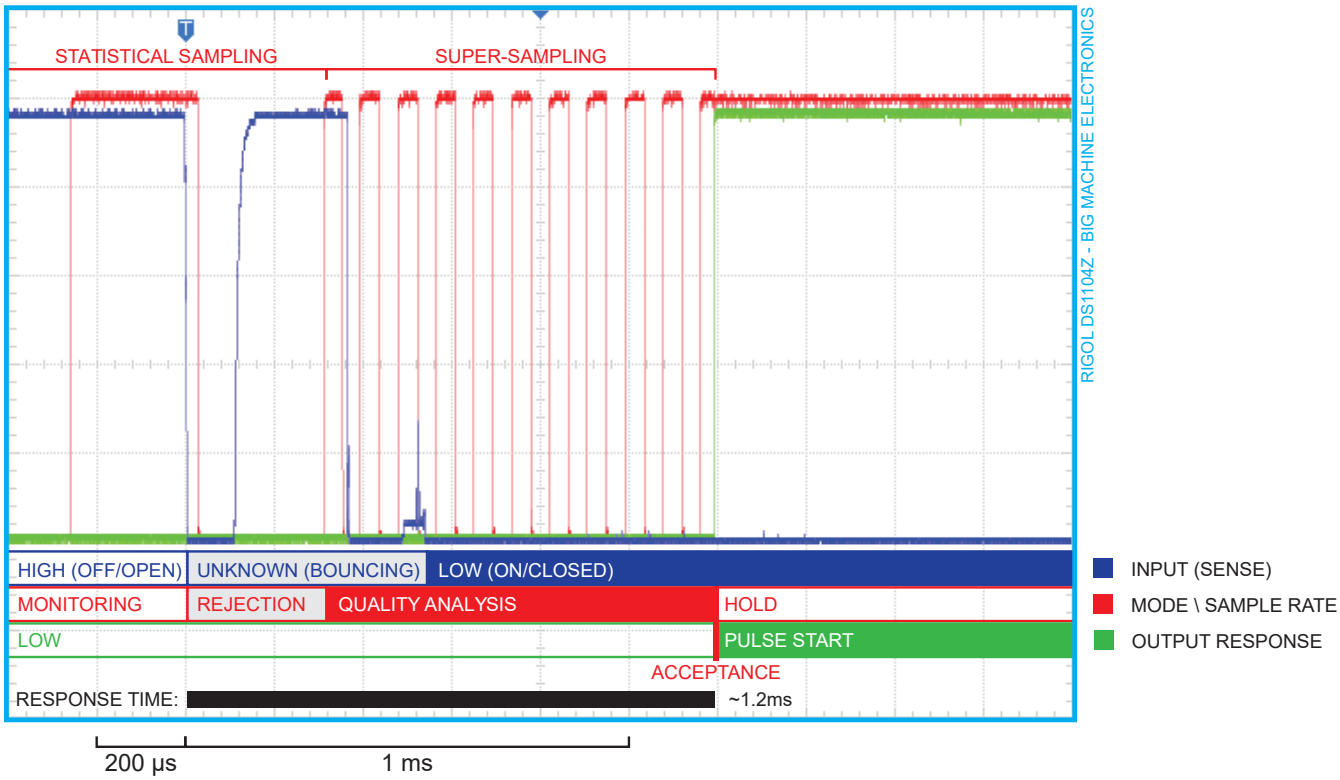


9. PERFORMANCE DATA

9.12 MOMENTARY TYPE SWITCH CONTACT MAKE + SAMPLE RATE

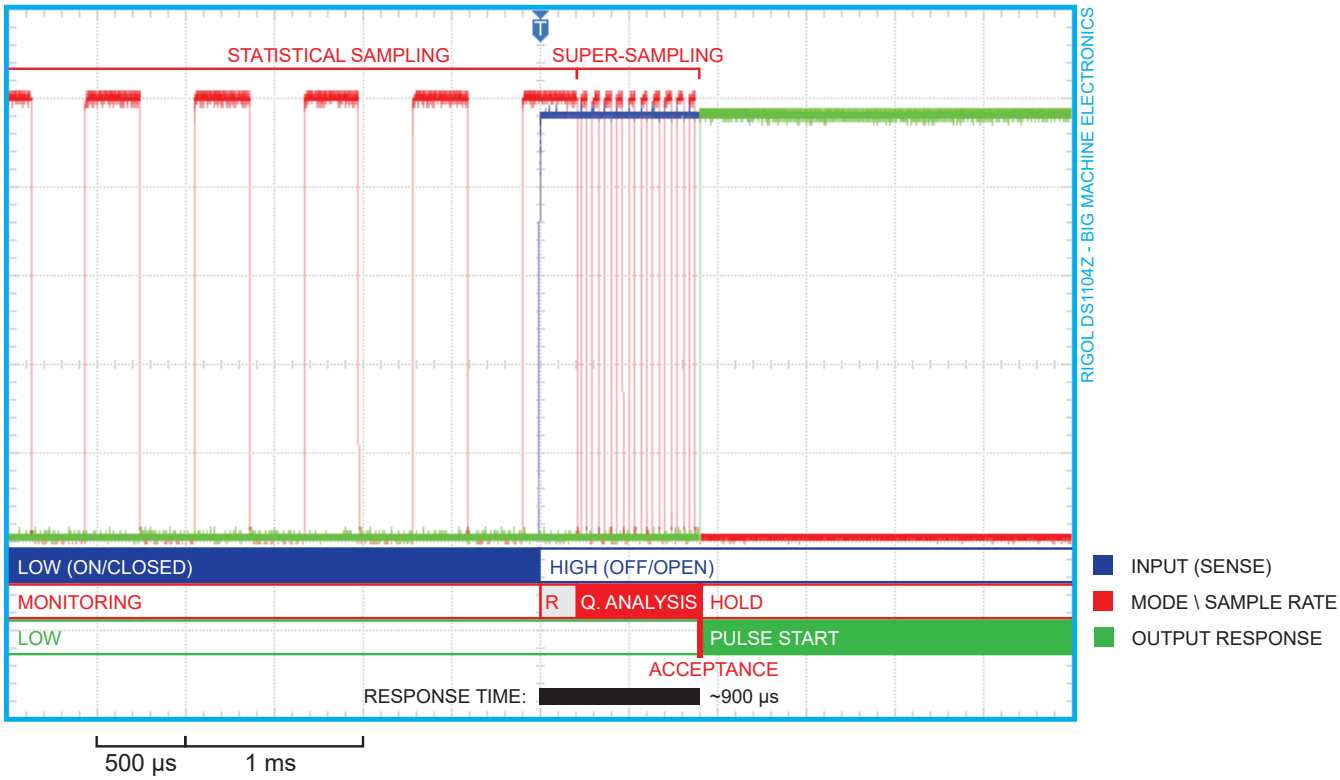


9.13 MOMENTARY TYPE SWITCH CONTACT MAKE + SAMPLE RATE



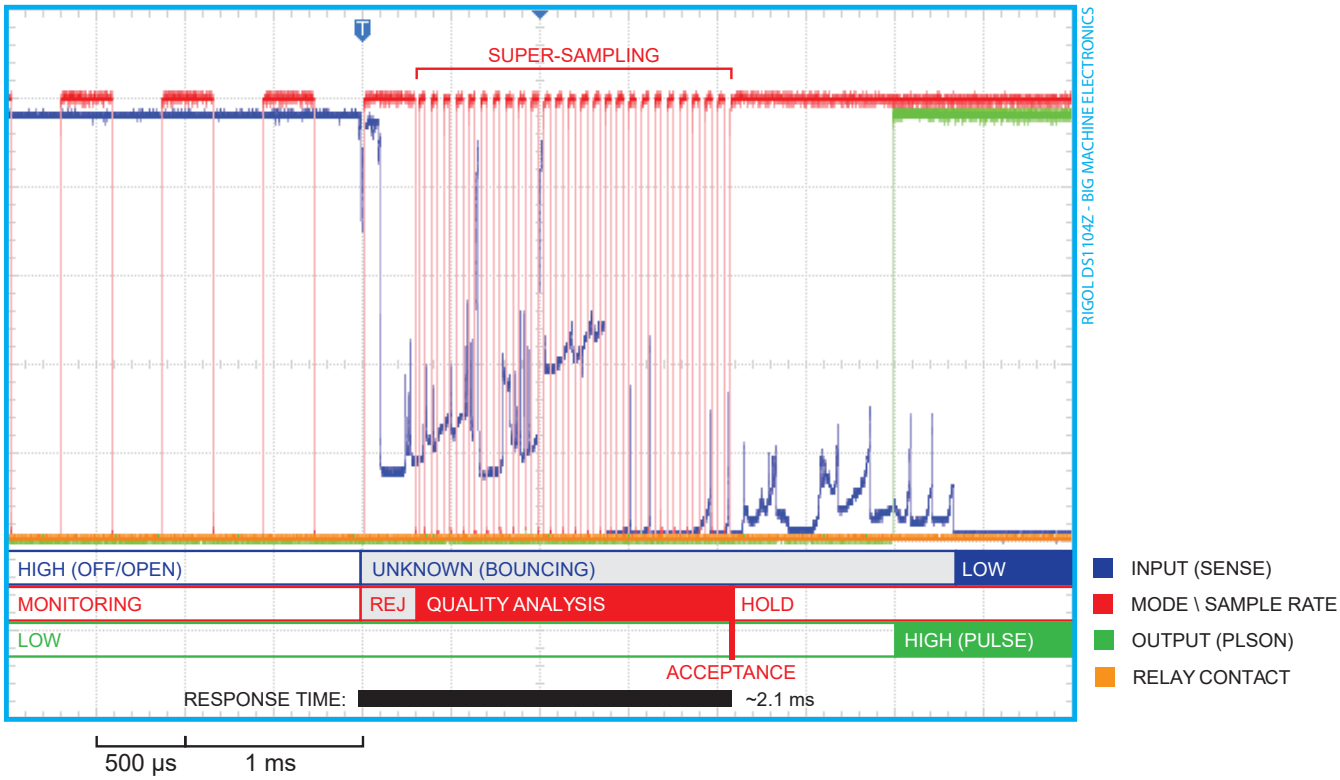
9. PERFORMANCE DATA

9.14 LATCHING TYPE SWITCH CONTACT BREAK + SAMPLE RATE

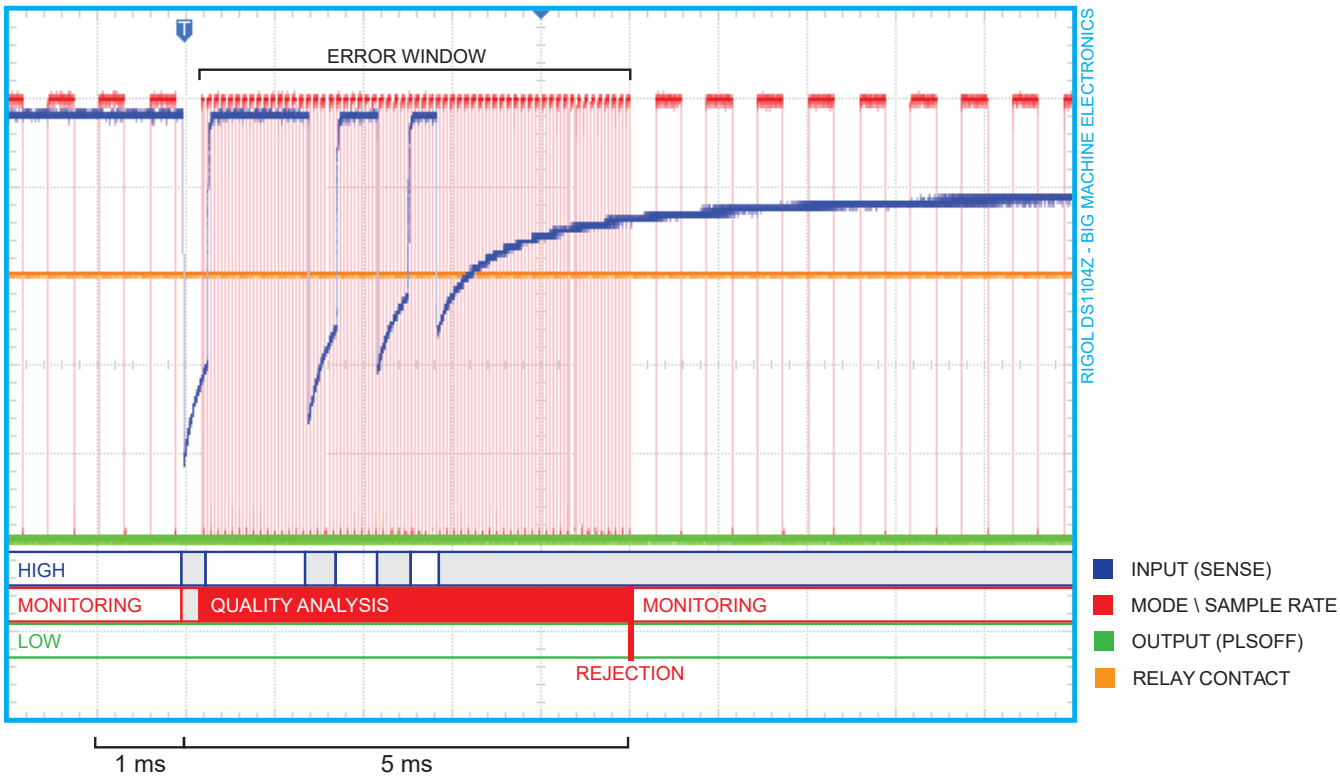


9. PERFORMANCE DATA

9.15 POOR QUALITY LATCHING TYPE SWITCH CONTACT MAKE + SAMPLE RATE

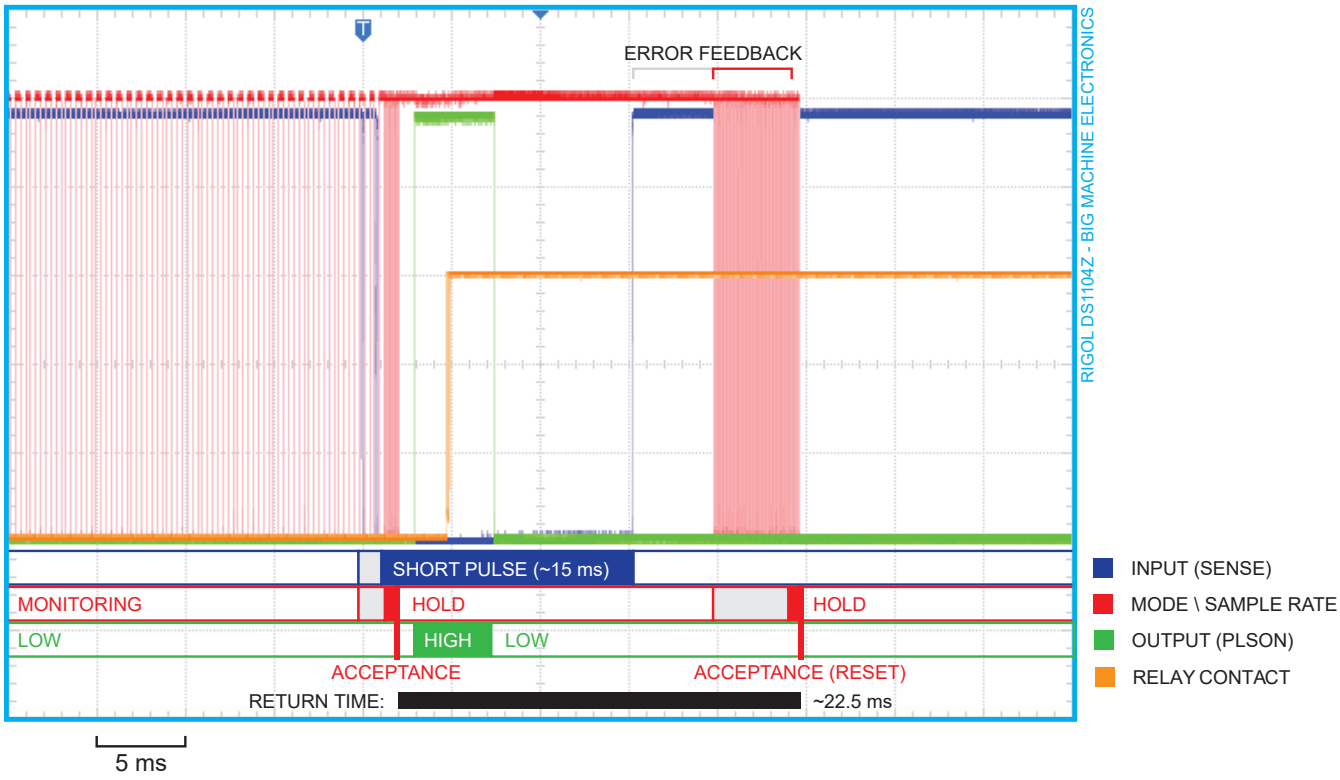


9.16 ACTIVE QUALITY REJECTION + SAMPLE RATE



9. PERFORMANCE DATA

9.17 MOMENTARY TYPE SWITCH SHORT (< 20 ms) PULSE + SAMPLE RATE



10. RATINGS & SPECIFICATIONS

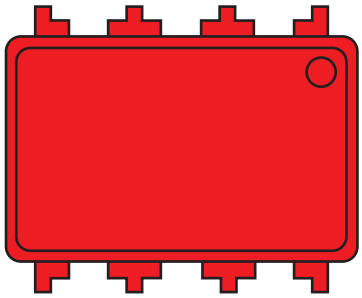
RELEASE	1.4/2016	RATED 13JUL2016
PLSON, PLSOFF OUTPUT PULSE WIDTH	5 ms	
MUTE OUTPUT PULSE WIDTH	8 ms (1/125 sec)	
MUTE OUTPUT PULSE OFFSET	LEAD: 1 ms LAG: 2 ms	
STARTUP DELAY	< 16 ms	
VCC VOLTAGE RANGE	3 - 5.5 Vdc	
CURRENT DRAW	< 1 mA @ 5 Vdc (IDLE)	
INPUT REFERENCE	LOW: GND, HIGH: VCC	
OUTPUT VOLTAGE	LOW: GND, HIGH: VCC	
SENSE INPUT CLOSED REFERENCE	LOW (GND)	
MAX CURRENT, ALL OUTPUTS	80 mA	
MAX CURRENT, SINGLE OUTPUT	20 mA (SOURCE, SINK)	
INPUT PULL-UP RESISTANCE	20 - 50 kΩ	
DETECTION MODE	1-BIT UNIFORM STATISTICAL	
DETECTION TRIGGER	BIDIRECTIONAL (XOR)	
DETECTION TRIGGER DEPTH	1 SAMPLE	
SUPER-SAMPLING QUALITY	BISTABLE MODE:	LEADING-PULSE QUALITY
	MONOSTABLE MODE:	STABLE-PULSE QUALITY
NOMINAL SAMPLE RATE	3.3 kHz	
SUPER-SAMPLING RATE	25 kHz	
QUALITY PERIOD	800 µs @ 25 kHz (20 SAMPLES)	
ERROR WINDOW	4.8 ms @ 25 kHz (120 SAMPLES)	
TRANSPARENT ERROR RESPONSE	BISTABLE MODE:	NO-COMMIT / COMMIT+RESET
	MONOSTABLE MODE:	NO-COMMIT+RESET
MAXIMUM STATISTICAL DELAY	303 µs @ 3.3kHz (1 SAMPLE)	
MINIMUM RESPONSE TIME	800 µs @ 25 kHz (20 SAMPLES)	
TYPICAL MAKE RESPONSE TIME	BISTABLE MODE:	~ 1.5 ms
	MONOSTABLE MODE:	~ 2 ms
TYPICAL BREAK RESPONSE TIME	~ 1 ms	
ON-OFF CYCLE RATE LIMIT	BISTABLE MODE:	12.5 Hz EQUAL TO 25 Hz SQUARE WAVE INPUT 25 TAPS/sec, MOMENTARY FOOTSWITCH
	MONOSTABLE MODE:	10 Hz EQUAL TO 10 Hz SQUARE WAVE INPUT 20 TAPS/sec, LATCHING FOOTSWITCH 10 TAPS/sec, MOMENTARY FOOTSWITCH
TECHNOLOGY	MODE-ADAPTIVE SUPER-SAMPLING ACTIVE FILTER	
HOST	ATMEL® ATTINY13A AVR®	
PACKAGES	8P3 PDIP 8-PINS	PN: **BME-MASS-SW-PDIP-8P3**
	8S1 SOIC JEDEC 8-PINS	PN: **BME-MASS-SW-SOIC-8S1**
	8S2 SOIC WIDE EIAJ 8-PINS	PN: **BME-MASS-SW-SOIC-8S2**
AVAILABLE FROM	BIG MACHINE ELECTRONICS	
CONTACT	SALES@BIGMACHINEFX.COM	
ONLINE	WWW.BIGMACHINEFX.COM	

VARIATIONS IN HOST CLOCK RATES WILL SLIGHTLY AFFECT TIME-RATED VALUES WITHOUT ALTERING PERFORMANCE

11. AVAILABILITY

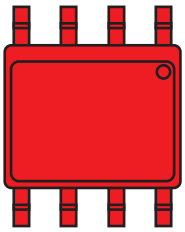
The *MASS-Switch*™ is available from BIG MACHINE ELECTRONICS as the following parts:

DIP-8



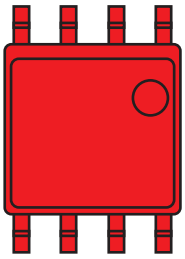
PN: **BME-MASS-SW-PDIP-8P3**
STANDARD 8-PIN PDIP PACKAGE
0.100” PIN PITCH (BSC), 0.300” BODY

SOIC-8



PN: **BME-MASS-SW-SOIC-8S1**
STANDARD 8-PIN SOIC (JEDEC) PACKAGE
1.27 mm PIN PITCH (BSC), 0.150” BODY

SOIC-8W



PN: **BME-MASS-SW-SOIC-8S2**
8-PIN SOIC WIDE (EIAJ) PACKAGE
1.27 mm PIN PITCH (BSC), 0.208” BODY
AVAILABLE ON REQUEST

(PARTS ARE SHOWN ENLARGED)

BIG MACHINE ELECTRONICS
www.bigmachinefx.com
Denver, Colorado, USA
sales@bigmachinefx.com

12. CUSTOMIZATION

The *MASS-Switch*™ can be customized directly by BIG MACHINE ELECTRONICS for both small and large quantities in any of the available IC packages (see AVAILABILITY).

- Custom pin assignments
- Custom pin inverts
- Custom MASS filter parameters (window, quality, and hold)
- Custom output controller pulse widths and timing

For more information on these and other options, contact sales@bigmachinefx.com.

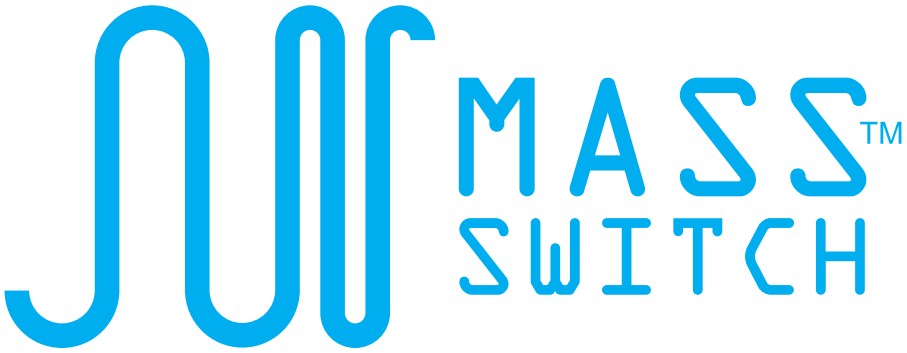
13. BINARY LICENSING

The *MASS-Switch*™ runtime binary package is available for in-system-programming (ISP) of customer sourced host microcontrollers with support for all target-compliant devices and customizations (see CUSTOMIZATION).

For more information, contact sales@bigmachinefx.com.

BIG MACHINE ELECTRONICS
www.bigmachinefx.com
Denver, Colorado, USA
sales@bigmachinefx.com

NOTES



manvsbigmachine™

MASS-Switch™
Datasheet and Application Guide
R1.4\2016

REG: IDSR-B004B000238144-USA
PUB: BME004-2016-R1.4

DOC REV 1
PUB AUG 2016

Prepared by aphexafx@manvsbigmachine.com

Refinement is the cornerstone of *accuracy!* If you spot an error or inconsistency, help all of our users by letting us know.