SEN012-013
SENZero Family

Zero[1] Loss High Voltage Sense Signal Disconnect IC

Product Highlights

Features and Performance

- Eliminates significant standby losses
  - Disconnects unnecessary circuit blocks during standby, remote-off, or light-load conditions
- Ultra low leakage (maximum 1 μA) 650 V MOSFETs
  - <0.5 mW per channel during standby
- Single component provides remote disconnect functionality
  - No external components or additional bias supply needed for remote-off
  - Integrates multiple disconnect MOSFETs, gate drive, and protection
  - Minimal component count provides higher reliability
- Protection features to help production/manufacturing yields
  - Pin-to-pin fault and ESD protection
- Triggerable via remote-off signal or load conditions
  - Integrated gate pull down circuit protects against loss of trigger signal fault
- Green package technology
  - RoHS compliant and halogen free
- Withstands high differential surge conditions
  - S1, S2 and S3 interface with controller pins up to 6.5 V above system ground

EcoSmart™– Energy Efficient

- <3 mW loss at 230 VAC in Off/standby mode

Applications

- ACDC converters with high-voltage resistive signal paths
- Ideal for all very low standby systems such as those meeting EuP Lot 6 and similar energy efficiency standards

Description

SENZero™ is a compact low-cost solution to eliminate losses in resistive signal paths connected between high-voltage rails and switching power supply controller(s). Examples include feed-forward or feedback signal paths connected to boost controllers in power factor corrected systems and feed-forward signal paths in two switch forward / LLC / half and full bridge converters.

The device is available in 2 (SEN012) and 3 (SEN013) channel versions according to the application's requirements. The internal gate drive and protection circuitry provides gate drive signals to the internal 650 V MOSFETs in response to the voltage applied to the VCC pin. This simple configuration provides easy integration into existing systems by using the system V_{CC} rail as an input to the SENZero.

The SENZero family uses a low cost compact SO-8 package to reduce PCB area while the pin configuration is designed to meet pin-pin fault conditions.

Figure 3. SO-8 D Package.

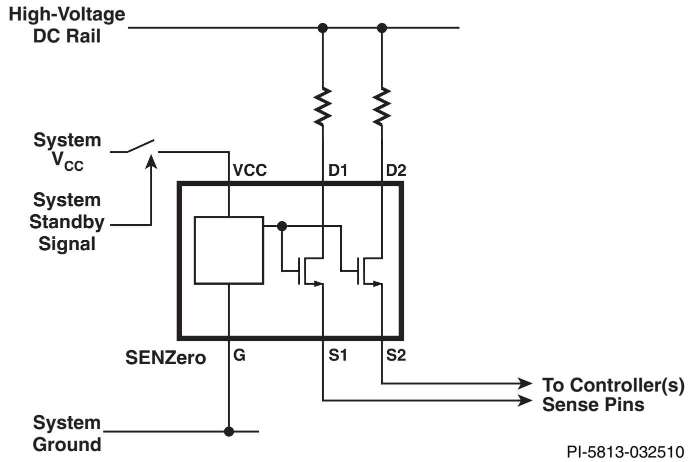


Figure 1. Typical Application SEN012.

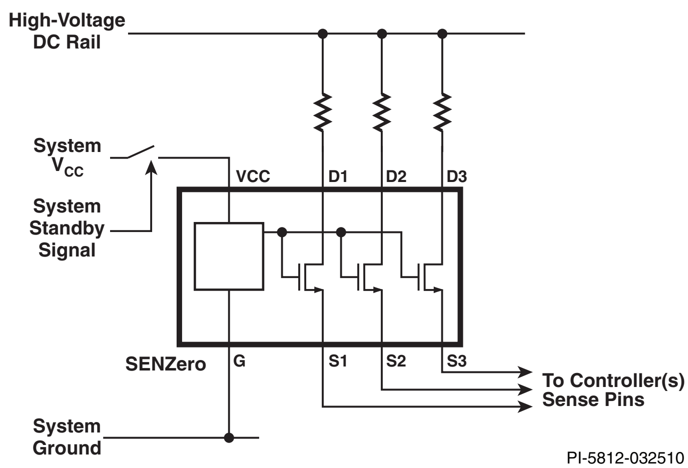


Figure 2. Typical Application SEN013.

Component Selection Table

Product[2]	Integrated Disconnect MOSFETs	230 VAC Power Consumption in Standby
SEN012DG	2	<1 mW
SEN013DG	3	<1.5 mW

Table 1. Component Selection Table.

Notes:
1. IEC 16301 clause 4.5 rounds standby power use below 5 mW to zero.
2. Package: D: SO-8.

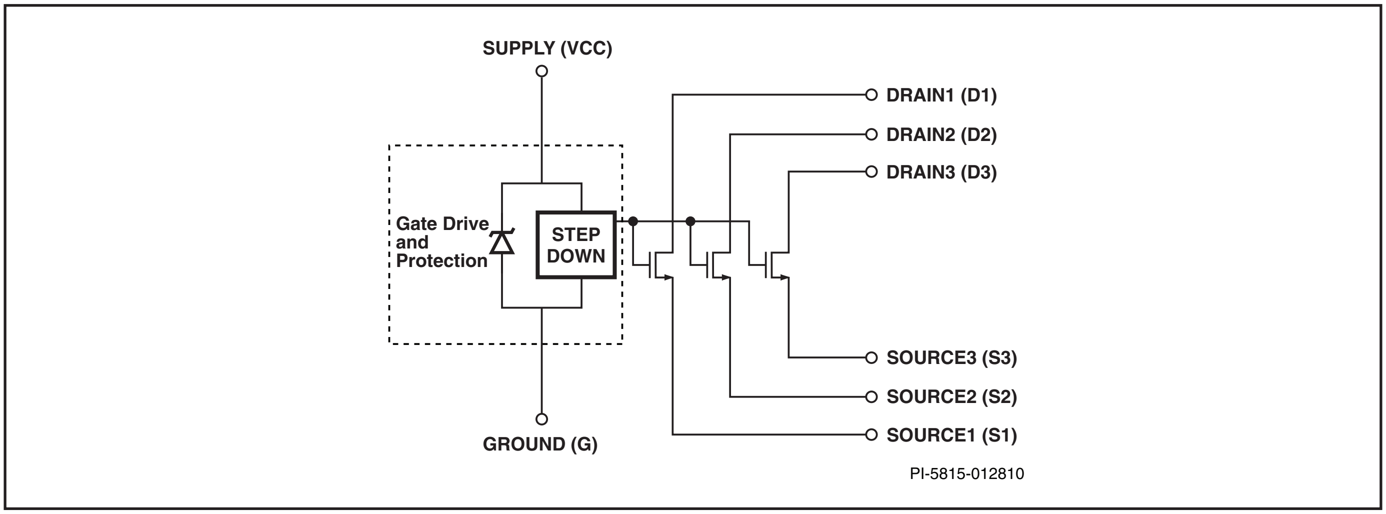


Figure 4. SENZero Functional Block Diagram

Pin Functional Description

SOURCE (S1, S2, S3) Pins:
Internally connect to the SOURCEs of MOSFETs 1, 2 and 3 respectively.

DRAIN (D1, D2, D3) Pins:
Internally connect to the DRAINs of MOSFETs 1, 2 and 3 respectively.

VOLTAGE SUPPLY (VCC) Pin:
The internal MOSFETs are fully turned on when the VCC pin voltage is $V_{CC(ON)}$ (see parameter table) or more greater than their SOURCE voltage relative to GROUND. VCC pin should be connected to GROUND to turn the MOSFETs off.

GROUND (G) Pin:
This is the ground reference for all the SENZero pin voltages.

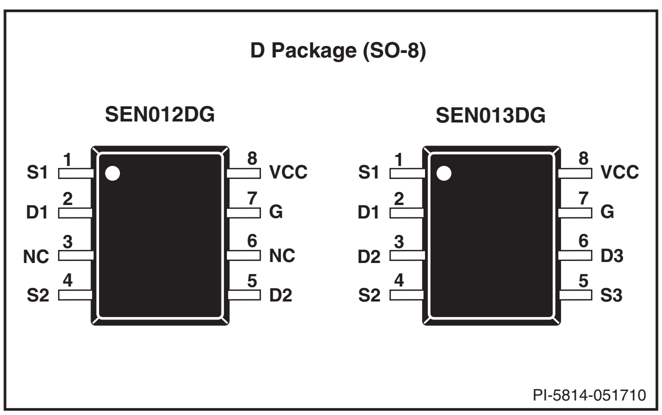


Figure 5. Pin Configuration.

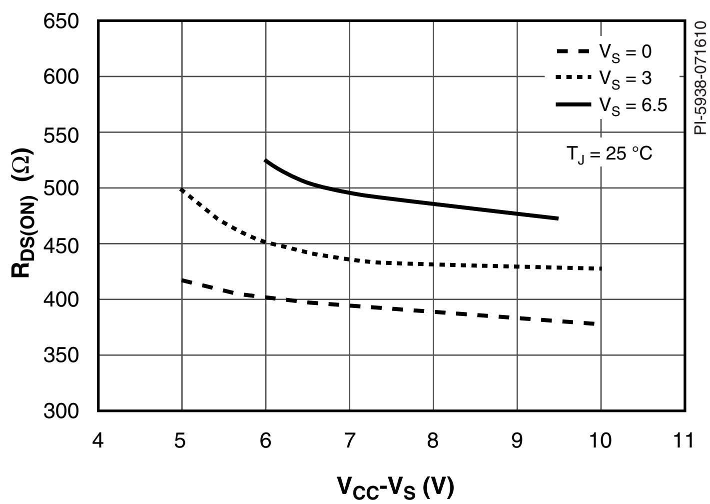


Figure 6. Typical $R_{DS(ON)}$ as a Function of V_{CC}-V_S Voltage.

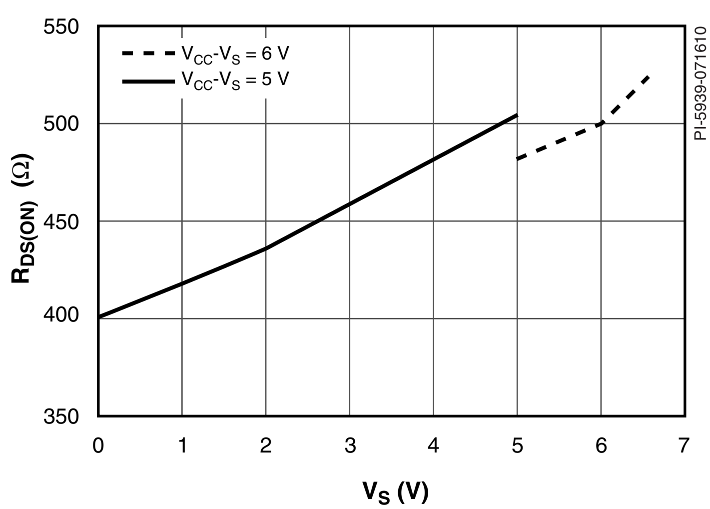


Figure 7. Typical $R_{DS(ON)}$ as a Function of V_S Voltage.

Applications Considerations

The maximum voltage that the device can sustain across the VOLTAGE SUPPLY and GROUND pin is 16 V. The maximum voltage that any of the source channels can be at with respect to the ground terminal is 6.5 V. SENZero has a typical on state resistance of approximately 500 Ω at room temperature. The device is therefore typically used in series with high ohmic value resistors where this on resistance is a small percentage of the total series impedance.

It is not necessary to provide a local bypass capacitor on the VOLTAGE SUPPLY pin.

Operating Configurations for the SENZero

One configuration to power up the SENZero is shown in Figure 8. In this circuit, SENZero is powered up from an unregulated bias winding through a simple series pass regulator formed by Q1, R_B and V_Z. This configuration ensures the VCC voltage is limited even if the maximum bias voltage exceeds 16 V. During power-down, as soon as the bias voltage falls below V_Z, SENZero will turn off.

The series pass transistor Q1 is necessary only if the bias winding voltage regulation is not tight enough (unregulated). If the voltage on the bias winding is regulated or is such that the voltage on the VOLTAGE SUPPLY pin can be maintained in the range 6 V < VCC < 16 V, then the series pass transistor (Q1, R_B and V_Z) can be eliminated.

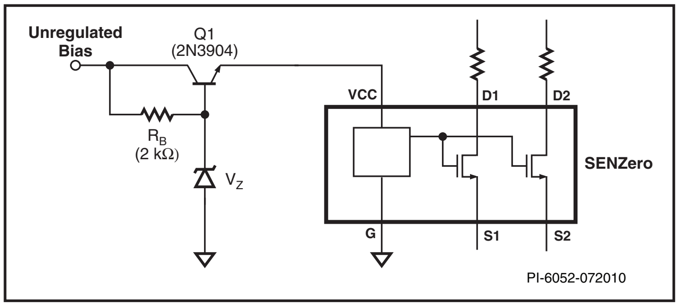


Figure 8. SENZero Powered from an Unregulated Bias Winding Through a Series Pass Regulator. Device is Enabled when Bias Voltage is Present.

A configuration that can be used to trigger remote-off functionality is shown in Figure 9. In this configuration, a regulated auxiliary output is used to power the IC. Transistor Q1 serves as the ON/OFF switch which is commanded by the Enable/Disable signal at its base.

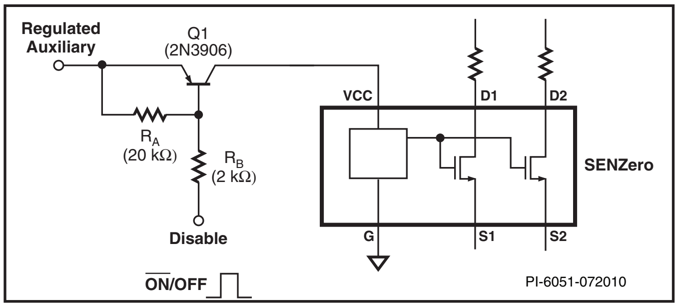


Figure 9. SENZero Powered from a Regulated Auxiliary Winding.

An alternative remote-off configuration is shown in Figure 10 where an unregulated bias voltage supplies the SENZero through a series pass regulator similar to the one shown in Figure 8. However the circuit of Figure 10 includes an ON/OFF transistor Q2. In other versions of this circuit Q2 can be replaced by an optocoupler allowing the ON/OFF disable signal to be communicated from a secondary of the power supply such as in PC power supplies.

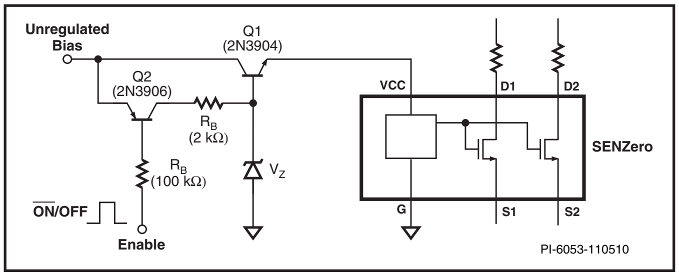


Figure 10. A Modified Version of an Unregulated Bias Winding Supplying Power Through a Series Pass Regulator. Transistor Q2 Provides Remote-Off Functionality.

Application Example

SENZero in PFC Bus Voltage Feedback Network

Commercial PFC IC's typically has a pin dedicated for sensing the output voltage of the PFC Stage. The information on this pin is typically used by the PFC IC for various major functions.

1. Output regulation – input to the non-inverting input of the error amplifier.
2. OVP detection – input to the OVP comparator.
3. Open-loop protection – used to detect open-loop conditions.

The last 2 functions were used for protecting the bus from overvoltage condition.

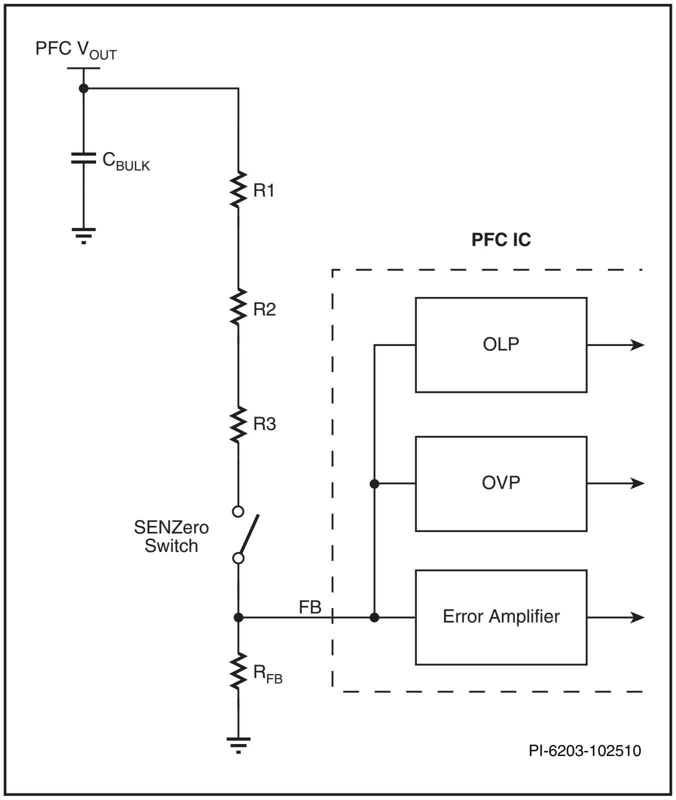


Figure 11. PFC Bus Voltage Sense Network.

The SENZero objective is to eliminate the losses associated with the sense resistors without affecting the functionality of the circuit. To keep the operation of the PFC IC unaffected, SENZero and PFC on and off event must follow the required timing sequence during power-up, power-down, remote-on, and remote-off event.

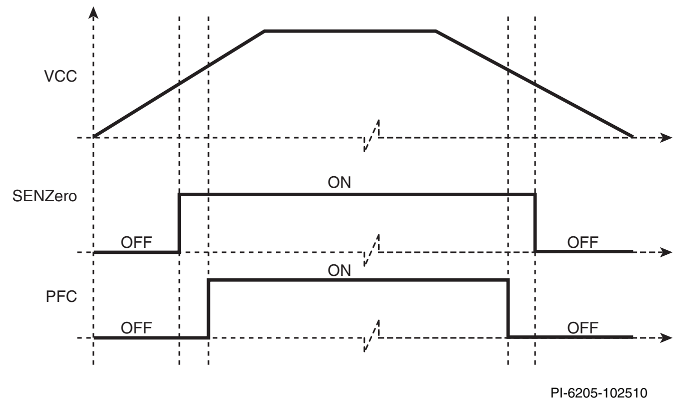


Figure 12. Timing between PFC IC and SENZero during Power-Up and Power-Down.

In case of shared VCC Connection, it must be ensure that SENZero have a lower turn-on and turn-off threshold voltage compared to the PFC IC.

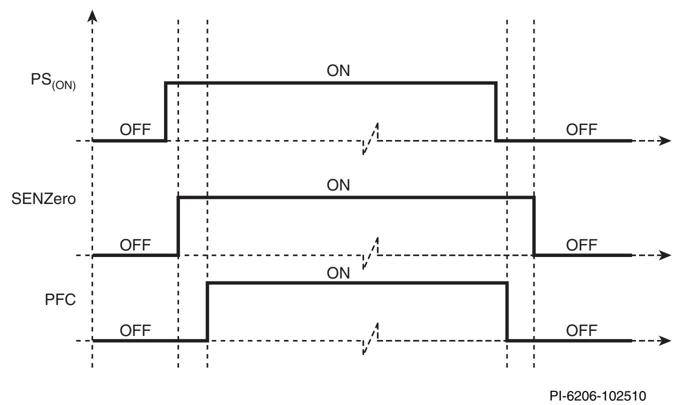


Figure 13. Timing between PFC IC and SENZero with $PS_{(ON)}$ Signal.

From off-state to on-state, SENZero must turn-on ahead of the PFC. From on-state to off-state, PFC must shutdown ahead of the SENZero. This is to ensure that whenever PFC is operating (switching), SENZero is invincible to the PFC. SENZero only disconnects the sense resistors when PFC is in off-condition and thus eliminates its associated losses during standby condition.

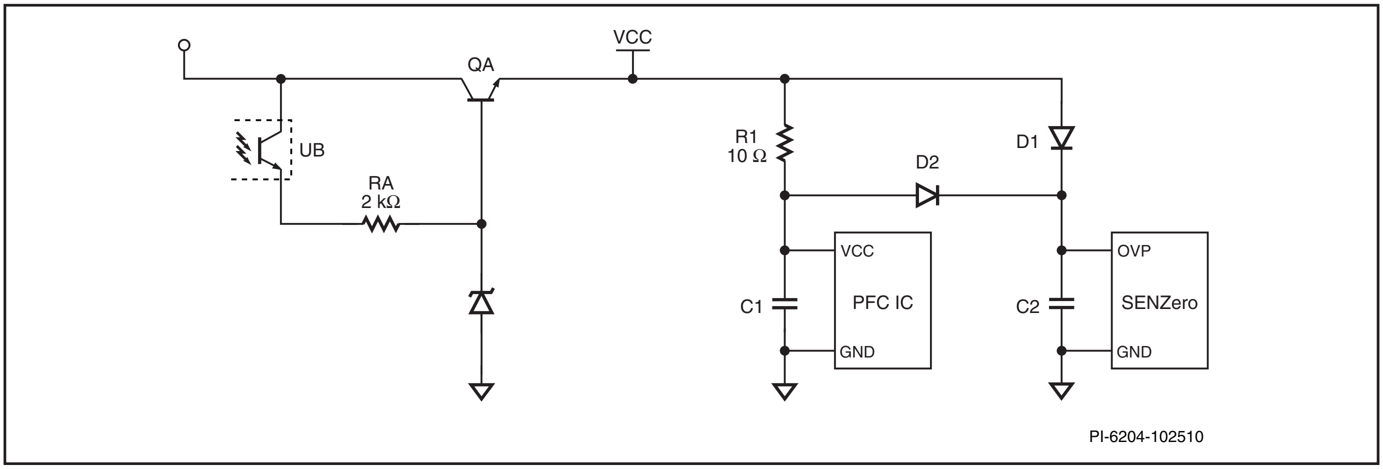


Figure 14. Typical Connection with PS$_{(ON)}$ Signal.

The figure above shows a typical VCC arrangement to satisfy timing requirements.

Transistor QA is enabled during remote on condition. Capacitor C2 will charge through D1 while C1 is charged through R1. SENZero will turn on ahead of PFC IC. Diode D2 makes C2 voltage tracks C1 voltage. Capacitor C2 can be increased to ensure that during turn-off, PFC turns-off first before SENZero. Capacitors C1 and C2 can be 100 nF standard decoupling capacitors. However, C1 needs to be ≥C2.

Absolute Maximum Ratings[1,3]

DRAIN Pin Voltage (D1, D2, D3) ....-0.3 V to 650 V
VOLTAGE SUPPLY Pin Voltage ....-0.3 V to 16 V
Voltage on S1, S2, S3 Pins.. -0.3 V to 6.5 V
Storage Temperature ....-65 °C to 150 °C
Operating Junction Temperature............................ -40 °C to 125 °C
Lead Temperature[2] ....260 °C

Notes:
1. All voltages referenced to Ground, T_A = 25 °C.
2. 1/16 in. from case for 5 seconds.
3. The Absolute Maximum Ratings specified may be applied one at a time without causing permanent damage to the product. Exposure to Absolute Maximum Rating conditions for extended periods of time may affect product reliability.

Thermal Resistance

Thermal Resistance: D Package[1]:
(θ_{JA})................160 °C/W (Single layer JEDEC PCB)
(θ_{JC})..40 °C/W (Bottom)
(θ_{JC})..75 °C/W (Top)

Notes:
1. Reference thermal resistance test conditions: JEDEC JESD51-3, SEMI Test Method #G43-87, and MIL-STD-883 Method 10121.1.

Parameter	Symbol	Conditions T_A = -40 °C to 105 °C (Unless Otherwise Specified)		Min	Typ	Max	Units
Input							
VCC Pin Input Current	I_{VCC}	Measured at $V_{CC(MAX)}$				0.5	mA
MOSFET ON-Drive Voltage (V_{CC} - [Max of V_{S1}, V_{S2} and V_{S3}])	$V_{CC(ON)}$	See Note A	V_S < 5 V	5			V
			V_S ≥ 5 V	6			
Output							
ON-State Resistance	$R_{DS(ON)}$	V_S = 0 V, $V_{CC(ON)}$ = 5 V, I_D = 1 mA, See Note D	T_J = 25 °C		400		Ω
			T_J = 100 °C		550		
		V_S = 6.5 V, $V_{CC(ON)}$ = 6 V, I_D = 1 mA	T_J = 25 °C		525	650	
			T_J = 100 °C		750	1000	
OFF-State Drain Leakage	I_{DSS}	V_{DS} = 325 V, T_J = 25 °C, V_{CC} = V_S = 0 V, See Note B				1	μA
Breakdown Voltage	BV_{DSS}	T_J = 25 °C, See Note C		650			V
Q1, Q2 and Q3 Saturation Current	$I_{DS(ON)}$	T_J = 100 °C, $V_{CC(ON)}$ = 5 V		1			mA

NOTES:

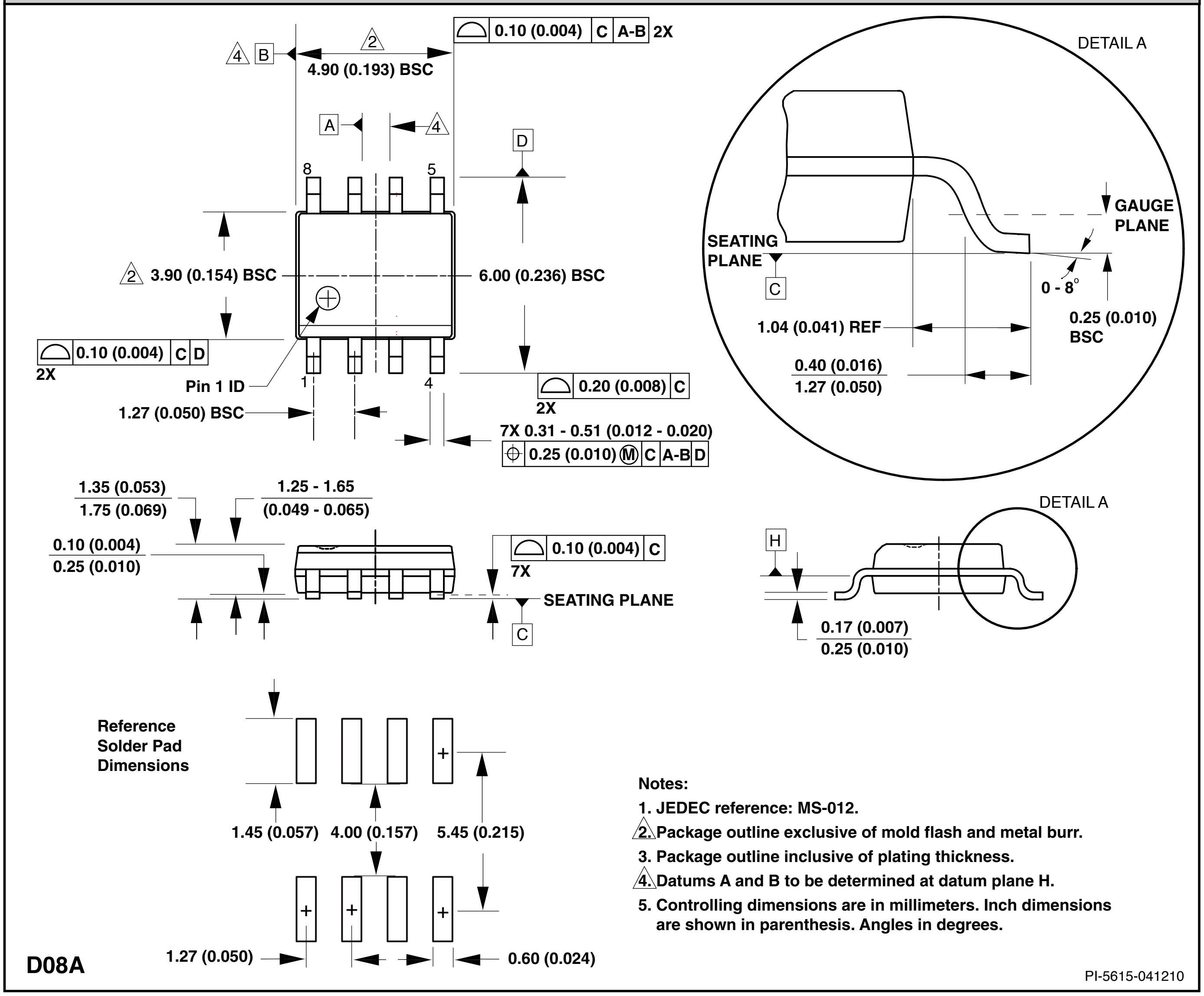
A. This is the minimum voltage difference required between V_{CC} and the highest of voltages V_{S1}, V_{S2} and V_{S3} to achieve the $R_{DS(ON)}$ specification in the parameter table. As an example, if S1 externally connects to a controller pin having a voltage of 4 V relative to GROUND pin, $V_{CC(ON)}$ of 5 V will be achieved by having at least (5 V + 4 V) = 9 V applied to the SENZero VOLTAGE SUPPLY (VCC) pin relative to the GROUND pin.

B. Per channel.

C. Between Ground and Drain of individual MOSFET under test.

D. Guaranteed by design.

SO-8 (D Package)



Part Ordering Information

SEN 012 D G - TL

- **SENZero Product Family**
- **SENZero Series Number**
- **Package Identifier**
  - D | Plastic SO-8
- **Package Material**
  - G | GREEN: Halogen Free and RoHS Compliant
- **Tape & Reel and Other Options**
  - Blank | Standard Configurations
  - TL | Tape & Reel

Part Number	Options	Quantity
SEN012DG	Tube	98
SEN012DG-TL	Tape and Reel	2500
SEN013DG	Tube	98
SEN013DG-TL	Tape and Reel	2500

Revision	Notes	Date
A	Initial Release.	08/18/10
B	Added Applications Example section, updated Figure 9.	11/05/10
B	Added Thermal Resistance section.	09/16/13
C	Updated with new Brand Style.	05/15/15

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