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April 2014

RV4145A — Low-Power Ground Fault Interrupter

Features

- No Potentiometer Required
- Direct Interface to Silicon-Controlled Rectifier (SCR)
- Supply Voltage Derived from AC Line – 26 V Shunt
- Adjustable Sensitivity
- Grounded Neutral Fault Detection
- Meets U.L. 943 Standards
- 450 µA Quiescent Current
- Ideal for 120 V or 220 V Systems

Description

The RV4145A is a low-power controller for AC outlet ground fault interrupters. These devices detect hazardous grounding conditions, such as equipment (connected to opposite phases of the AC line) in contact with a pool of water and open circuits the line before a harmful or lethal shock occurs.

A 26 V Zener shunt regulator, an operational amplifier, and an SCR driver are contained internally. With the addition of two sense transformers, a bridge rectifier, an SCR, a relay, and a few additional components; the RV4145A can detect and protect against both hot-wire-to-ground and neutral-wire-to-ground faults. The simple layout and conventional design ensure ease of application and long-term reliability.

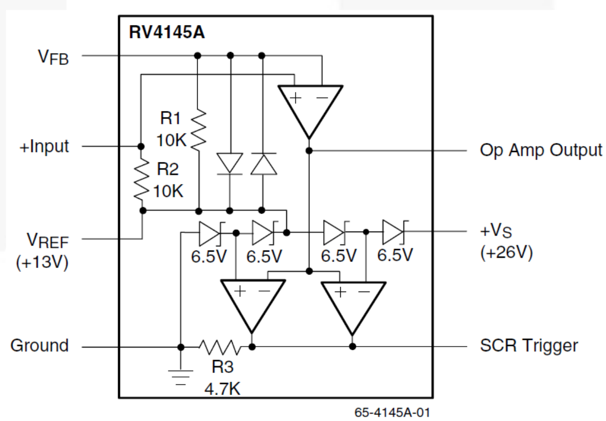


Figure 1. Block Diagram

Ordering Information

Part Number	Operating Temperature Range	Package	Packing Method
RV4145AN	-35°C to +85°C	8-Lead, MDIP, JEDEC MS-001, .300" Wide	Rail
RV4145AMT		8-Lead, SOIC, JEDEC MS-012, .150" Narrow Body	Tape and Reel

Pin Configuration

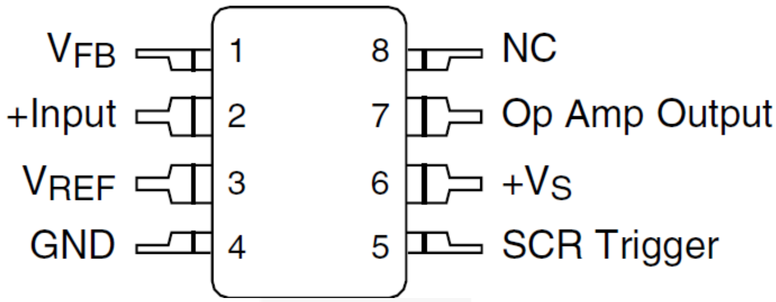


Figure 2. Pin Assignment

Pin Descriptions

Pin#	Name	Description
1	V_{FB}	Sense amplifier negative input
2	+Input	Sense amplifier positive input
3	V_{REF}	Reference Voltage
4	GND	Ground
5	NC	No Connect
6	Op Amp Output	Sense Amplifier Output
7	$+V_S$	Supply input for RV4145A circuitry
8	SCR Trigger	Output for triggering external SCR when a fault is detected

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter			Min.	Typ.	Max.	Unit
V_{CC}	Supply Current					18	mA
P_D	Internal Power Dissipation					500	mW
T_{STG}	Storage Temperature Range			-65		+150	°C
T_A	Operating Temperature Range			-35		+85	°C
T_J	Junction Temperature					125	°C
T_L	Lead Soldering Temperature		60 s, DIP			300	°C
			10 s, SOIC			260	
P_D	Power Dissipation	T_A <50°C	SOIC			300	mW
			PDIP			450	
		T_A <50°C Derate	SOIC		4		mW/°C
			PDIP		6		
Θ_{JA}	Thermal Resistance		SOIC		240		°C/W
			PDIP		160		

Electrical Characteristics

I_S = 1.5 mA and T_A = +25°C.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
	Detector Reference Voltage	Pin 7 to Pin 3	6.8	7.2	8.1	±V
Shunt Regulator						
$+V_S$	Zener Voltage	Pin 6 to Pin 4	25.0	26.0	29.2	V
V_{REF}	Reference Voltage	Pin 3 to Pin 4	12.5	13.0	14.6	V
I_s	Quiescent Current	$+V_S$ = 24 V		450	750	µA
Operation Amplifier						
	Offset Voltage	Pin 2 to Pin 3	-3.0	0.5	+3.0	mV
	+Output Voltage Swing	Pin 7 to Pin 3	6.8	7.2	8.1	V
	-Output Voltage Swing	Pin 7 to Pin 3	-9.5	-11.2	-13.5	V
	+Output Source Current	Pin 7 to Pin 3		650		µA
	-Output Source Current	Pin 7 to Pin 3		1.0		mA
	Gain Bandwidth Product	f = 50 kHz	1.0	1.8		MHz
Resistors						
R1	Resistors, I_S = 0 mA	Pin 1 to Pin 3		10		kΩ
R2		Pin 2 to Pin 3		10		
R3		Pin 5 to Pin 4	3.5	4.7	5.9	
SCR Trigger						
	Detector On	Pin 5 to Pin 4	1.5	2.8		V
	Detector Off		0	1	10	mV

Electrical Characteristics

I_S = 1.5 mA and -35°C ≤ T_A ≤ +85°C.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
	Detector Reference Voltage	Pin 7 to Pin 3	6.5	7.2	8.3	±V
Shunt Regulator						
$+V_S$	Zener Voltage	Pin 6 to Pin 4	24	26	30	V
V_{REF}	Reference Voltage	Pin 3 to Pin 4	12	13	15	V
I_S	Quiescent Current	$+V_S$ = 23 V		500		µA
Operational Amplifier						
	Offset Voltage	Pin 2 to Pin 3	-5.0	0.5	+5.0	mV
	+Output Voltage Swing	Pin 7 to Pin 3	6.5	7.2	8.3	V
	-Output Voltage Swing	Pin 7 to Pin 3	-9.0	-11.2	-14.0	V
	Gain Bandwidth Product	f = 50 kHz		1.8		MHz
Resistors						
R1	Resistors, I_S = 0 mA	Pin 1 to Pin 3		10		kΩ
R2		Pin 2 to Pin 3		10		
R3		Pin 5 to Pin 4	3.5	4.7	5.9	
SCR Trigger						
	Detector On	Pin 5 to Pin 4	1.3	2.8		V
	Detector Off		0	3	50	mV

Principles of Operation

The 26 V shunt regulator voltage generated by the string of Zener diodes is divided into three reference voltages: ¾ V_S, ½ V_S, and ¼ V_S. V_{REF} is at ½ V_S and is used as a reference to create an artificial ground of +13 V at the operational amplifier non-inverting input.

Figure 3 shows a three-wire 120 V AC outlet GFI application using an RV4145A. Fault signals from the sense transformer are AC coupled into the input and are amplified according to the following equation:

$$V_7 = R_{SENSE} \times I_{SENSE}/N \quad (1)$$

where V_7 is the RMS voltage at pin 7 relative to pin 3, R_{SENSE} is the value of the feedback resistor connected from pin 7 to pin 1, I_{SENSE} is the fault current (in amps) RMS, and N is the turns ratio of the transformer.

When V_7 exceeds ±7.2 V relative to pin 3, the SCR trigger output goes high and fires the external SCR.

The formula for V_7 is approximate because it does not include the sense transformer characteristics.

Grounded neutral fault detection is accomplished when a short or fault closes a magnetic path between the sense transformer and the grounded neutral transformer. The resultant AC coupling closes a positive feedback path around the op amp, and the op amp oscillates. When the peaks of the oscillation voltage exceed the SCR trigger comparator thresholds, the SCR output goes high.

Shunt Regulator

The R_{LINE} limits the current into the shunt regulator; 220 V applications must substitute a 47 kΩ 2 W resistor. In addition to supplying power to the IC, the shunt regulator creates internal reference voltages.

Operational Amplifier

R_{SENSE} is a feedback resistor that sets gain and, therefore sensitivity to normal faults. To adjust R_{SENSE}, apply the desired fault current (a difference in current of 5 mA is the UL 943 standard) then adjust R_{SENSE} upward until the SCR activates. A fixed resistor can be used for R_{SENSE} because the resultant ±15% variation in sensitivity meets UL's 943 4-6 mA specification window.

The roll-off frequency is greater than the grounded neutral fault oscillation frequency to preserve loop gain for oscillation (which is determined by the inductance of the 200:1 transformer and C4).

The sensitivity to grounded neutral faults is adjusted by changing the frequency of oscillation. Increasing the frequency reduces the sensitivity by reducing the loop gain of the positive feedback circuit. As frequency increases, the signal becomes attenuated and the loop gain decreases. With the values shown in Figure 3, the circuit detects a grounded neutral with resistance of 2 Ω or less.

The input to the operational amplifier is protected from over-voltage by back-to-back diodes.

Silicon-Controlled Rectifier (SCR) Driver

The SCR must have a high dV/dt rating to ensure that line noise (generated by noisy appliances, such as a drill motor) does not falsely trigger the SCR. The SCR must have a gate-drive requirement of less than 200 µA. C_F is a noise filter capacitor that prevents narrow pulses from firing the SCR.

The relay solenoid should have a 3 ms or less response time to meet the UL 943 timing requirement.

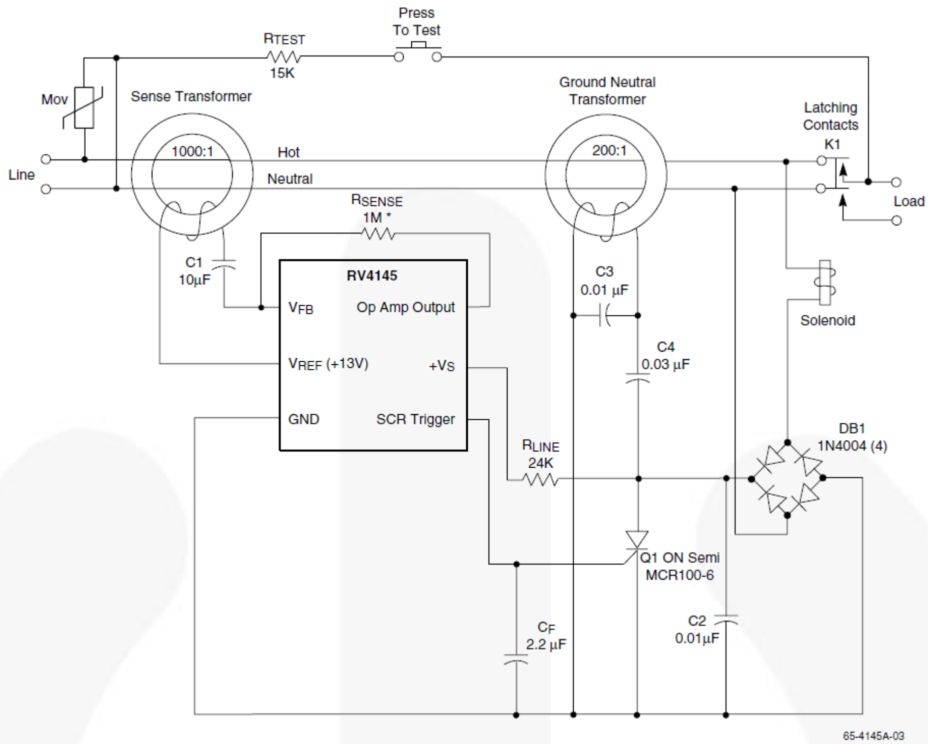
Sense Transformers and Cores

The sense and grounded neutral transformer cores are usually fabricated using high permeability laminated steel rings. Their single-turn primary is created by passing the line and neutral wires through the center of the core. The secondary is usually 200 to 1500 turns.

Magnetic Metals Corporation www.magmet.com is a full line suppliers of ring cores and transformers designed specifically for GFI applications.

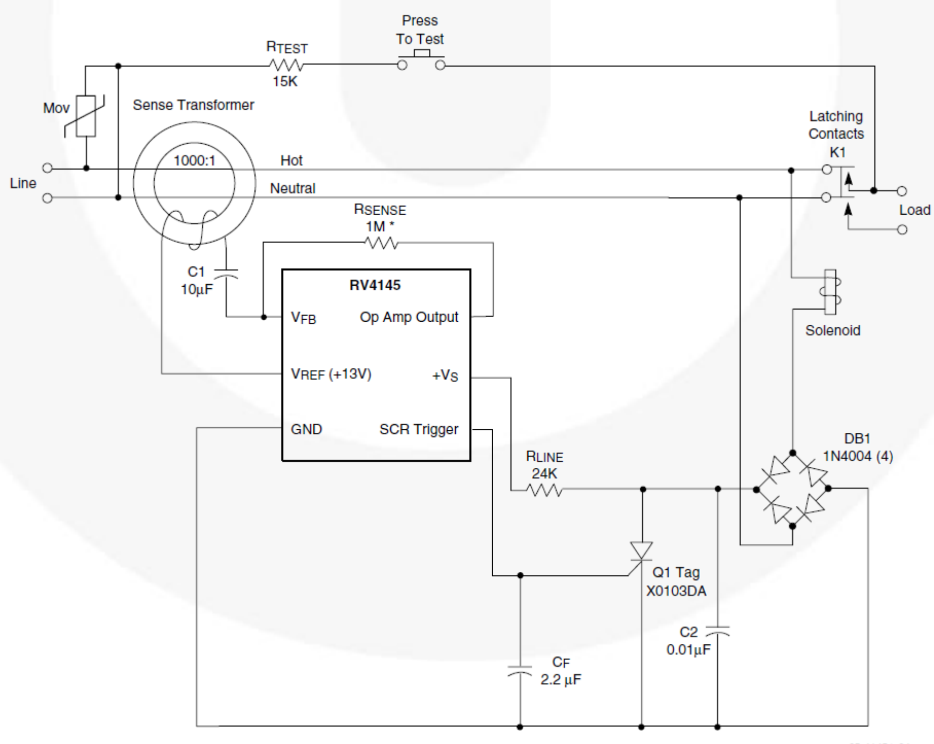
Two-Wire Application Circuit

Figure 4 shows the diagram of a two-wire 120 V AC outlet GFI circuit using an RV4145A. This circuit is not designed to detect grounded neutral faults. For this reason, the grounded neutral transformer and capacitors C3 and C4 of Figure 3 are not used.



* Value depends on transformer characteristics.

Figure 3. GFI Application Circuit (Three-Wire Outlet)



* Value depends on transformer characteristics.

Figure 4. GFI Application Circuit (Two-Wire Outlet)

Schematic Diagram

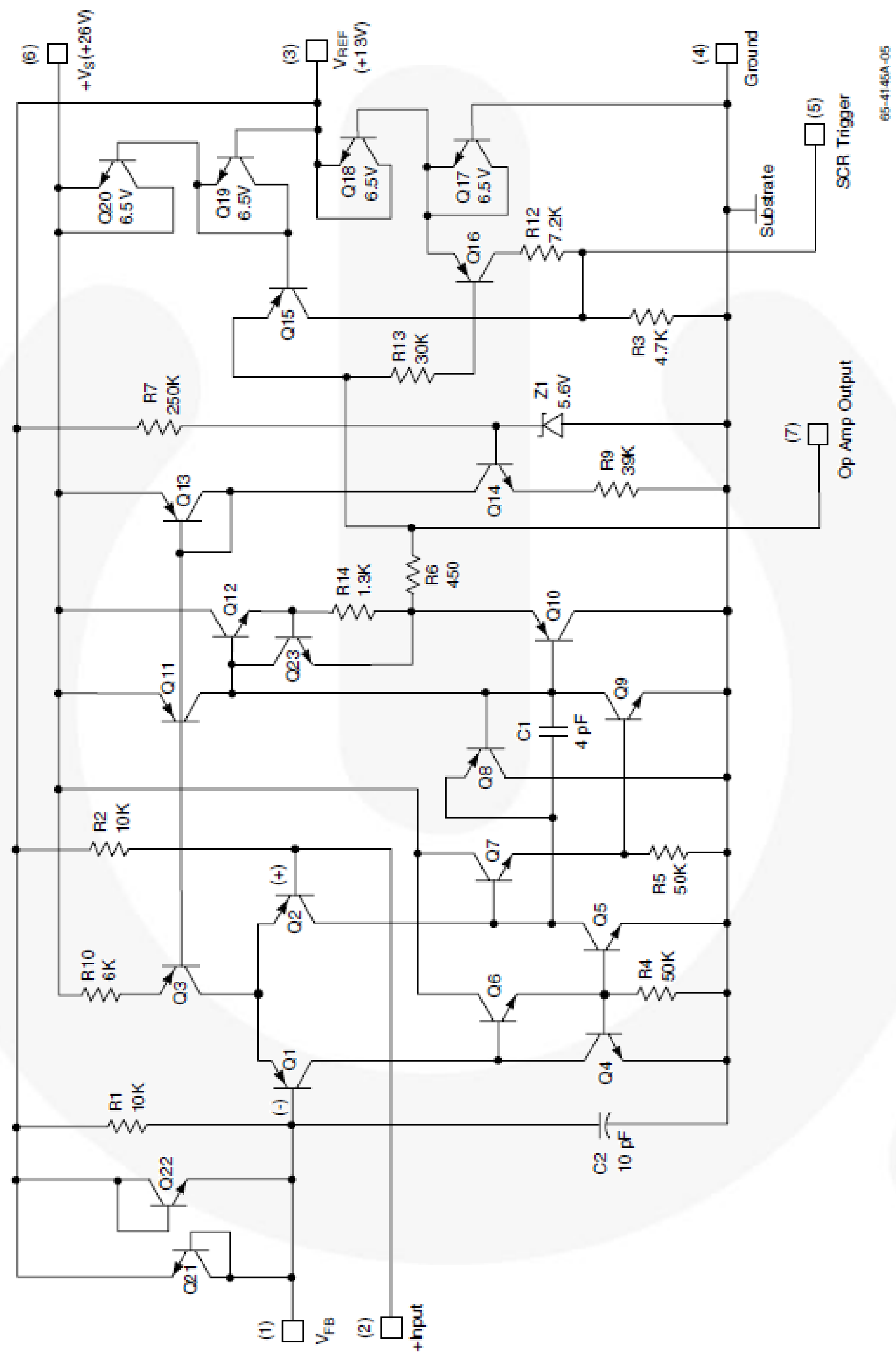
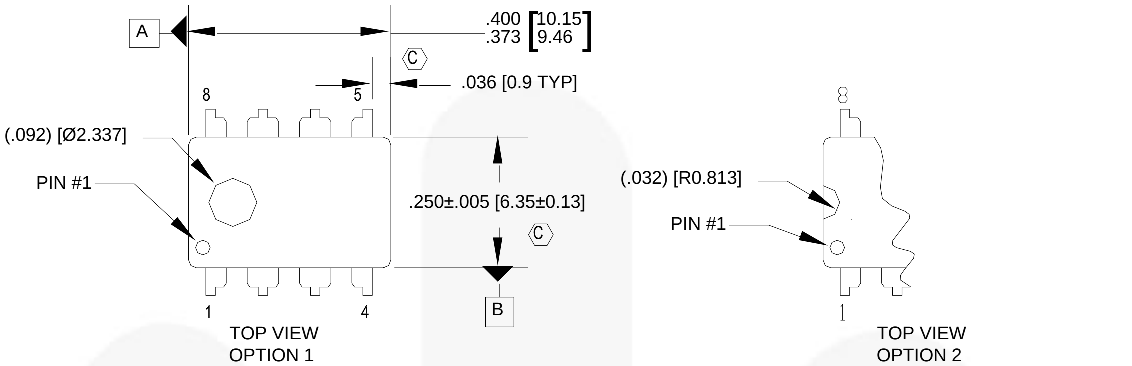
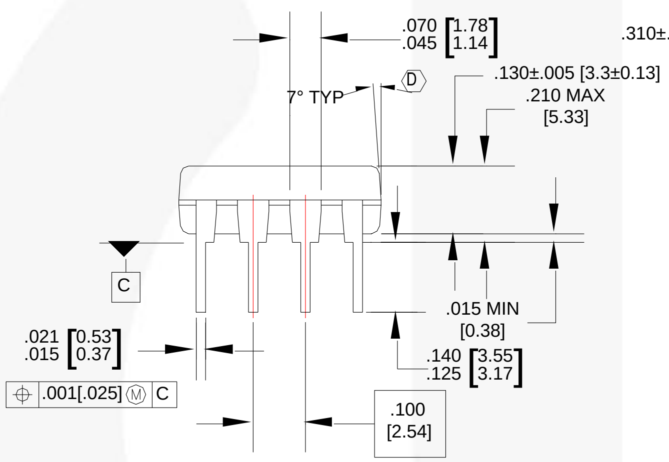
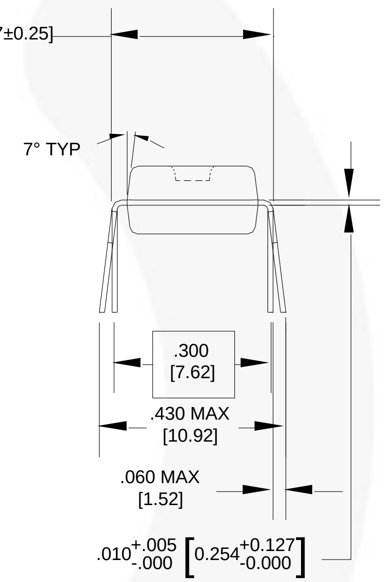


Figure 5. Schematic

Physical Dimensions







NOTES:

A. CONFORMS TO JEDEC REGISTRATION MS-001, VARIATIONS BA
B. CONTROLING DIMENSIONS ARE IN INCHES REFERENCE DIMENSIONS ARE IN MILLIMETERS
C. DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCHES OR 0.25MM.
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E. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.

N08EREVG

Figure 6. 8-Lead, MDIP, JEDEC MS-001, .300" Wide

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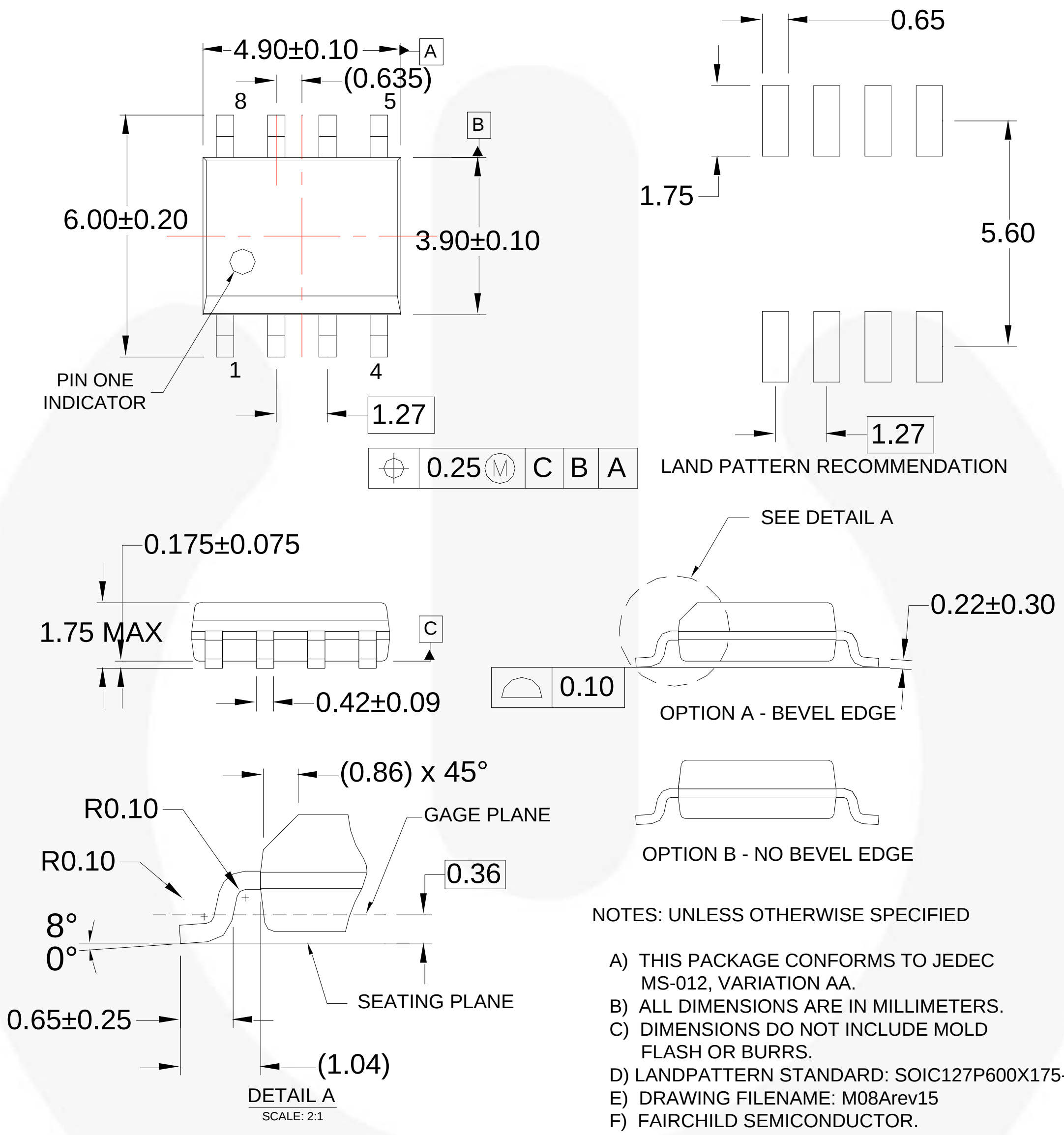
Physical Dimensions



NOTES: UNLESS OTHERWISE SPECIFIED

A) THIS PACKAGE CONFORMS TO JEDEC MS-012, VARIATION AA.
B) ALL DIMENSIONS ARE IN MILLIMETERS.
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D) LANDPATTERN STANDARD: SOIC127P600X175-8M.
E) DRAWING FILENAME: M08Arev15
F) FAIRCHILD SEMICONDUCTOR.

Figure 7. 8-Lead, SOIC, JEDEC MS-012, .150" Narrow Body

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No Identification Needed	Full Production	Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
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