RV4145A

Low Power Ground Fault Interrupter

Features

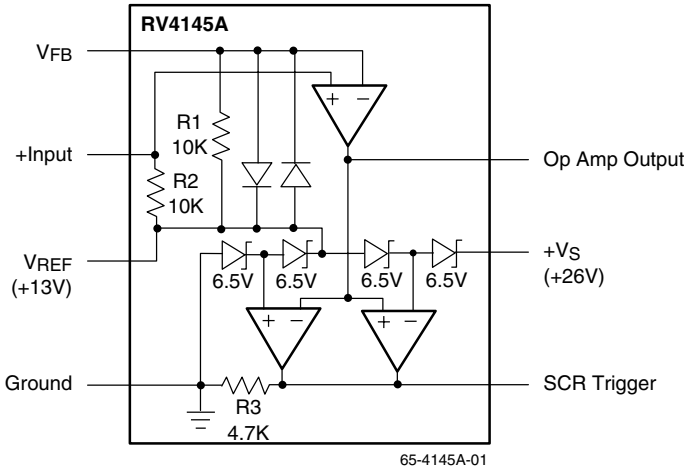
- No potentiomenter required
- Direct interface to SCR
- Supply voltage derived from AC line – 26V shunt
- Adjustable sensitivity
- Grounded neutral fault detection
- Meets U.L. 943 standards
- 450µA quiescent current
- Ideal for 120V or 220V systems

Description

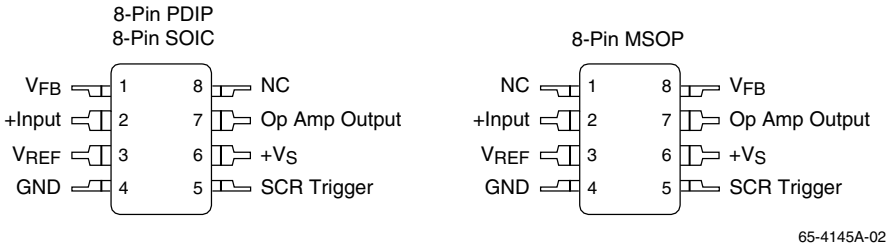
The RV4145A is a low power controller for AC outlet ground fault interrupters. These devices detect hazardous grounding conditions, such as equipment (connected to opposite phases of the AC line) in contact with a pool of water and open circuits the line before a harmful or lethal shock occurs.

Contained internally are a 26V zener shunt regulator, an op amp, and an SCR driver. WIth the addition of two sense transformers, a bridge rectifier, an SCR, a relay, and a few additional components, the RV4145A will 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.

Block Diagram



Pin Assignments



Absolute Maximum Ratings

(beyond which the device may be damaged)[1]

Parameter		Min	Typ	Max	Units
Supply Current				18	mA
Internal Power Dissipation				500	mW
Storage Temperature Range		-65		+150	°C
Operating Temperature Range		-35		+85	°C
Junction Temperature				125°C	
Lead Soldering Temperature	60 Sec, DIP			300	°C
	10 Sec, SOIC, MSOP			260	°C
P_D T_A < 50°C	SOIC			300	mW
	PDIP			450	mW
	MSOP			350	mW
For T_A > 50°C Derate at	SOIC		4		mW/°C
	PDIP		6		mW/°C
	MSOP		4.7		mW/°C

Notes:

1. Functional operation under any of these conditions is NOT implied. Performance and reliability are guaranteed only if Operating Conditions are not exceeded.

Operating Conditions

Parameter			Min	Typ	Max	Units
θ_{JA}	Thermal resistance	SOIC		240		°C/W
		PDIP		160		°C/W
		MSOP		206		°C/W

Electrical Characteristics (I_S = 1.5mA and T_A = +25°C)

Parameters	Test Conditions	Min	Typ	Max	Units
Detector Reference Voltage	Pin 7 to Pin 3	6.8	7.2	8.1	±V
Shunt Regulator					
Zener Voltage (+V_S)	Pin 6 to Pin 4	25	26	29.2	V
Reference Voltage (V_{REF})	Pin 3 to Pin 4	12.5	13	14.6	V
Quiescent Current (I_S)	+V_S = 24V		450	750	µA
Operational 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 = 50KHz	1.0	1.8		MHz
Resistors	**I_S = 0mA**				
R1	Pin 1 to Pin 3		10		kΩ
R2	Pin 2 to Pin 3		10		kΩ
R3	Pin 5 to Pin 4	3.5	4.7	5.9	kΩ
SCR Trigger Voltage	**Pin 5 to Pin 4**				
Detector On		1.5	2.8		V
Detector Off		0	1	10	mV

Electrical Characteristics (I_S = 1.5mA and -35°C ≤ T_A ≤ +85°C)

Parameters	Test Conditions	Min	Typ	Max	Units
Detector Reference Voltage	Pin 7 to Pin 3	6.5	7.2	8.3	±V
Shunt Regulator					
Zener Voltage (+V_S)	Pin 6 to Pin 4	24	26	30	V
Reference Voltage (V_{REF})	Pin 3 to Pin 4	12	13	15	V
Quiescent Current (I_S)	+V_S = 23V		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	-11.2	-14	V
Gain Bandwidth Product	F = 50KHz		1.8		MHz
Resistors	**I_S = 0mA**				
R1	Pin 1 to Pin 3		10		kΩ
R2	Pin 2 to Pin 3		10		kΩ
R3	Pin 5 to Pin 4	3.5	4.7	5.9	kΩ
SCR Trigger Voltage	**Pin 5 to Pin 4**				
Detector On		1.3	2.8		V
Detector Off		0	3	50	mV

Principles of Operation

The 26V shunt regulator voltage generated by the string of zener diodes is divided into three reference voltages: 3/4 V_S, 1/2 V_S, and 1/4 V_S. V_{REF} is at 1/2VS and is used as a reference to create an artifical ground of +13V at the op amp non-inverting input.

Figure 1 shows a three-wire 120V 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:

$$V_7 = R_{SENSE} \times I_{SENSE}/N$$

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 plus or minus 7.2V relative to pin 3 the SCR Trigger output will go high and fire 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 therefore the op amp oscillates. When the peaks of the oscillation voltage exceed the SCR trigger comparator thresholds, the SCR output will go high.

Shunt Regulator

R_{LINE} limits the current into the shunt regulator; 220V applications will require substituting a 47kΩ 2W resistor. In addition to supplying power to the IC, the shunt regulator creates internal reference voltages (see above).

Operational Amplifier

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

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

The senstivity 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 the circuit will detect a grounded neutral fault having resistance of 2Ω or less.

The input to the op amp are protected from overvoltage by back-toback diodes.

SCR Driver

The SCR used 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. Also, the SCR must have a gate drive requirement of less than 200µA. C_F is a noise filter capacitor that prevents narrow pulses from firing the SCR.

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

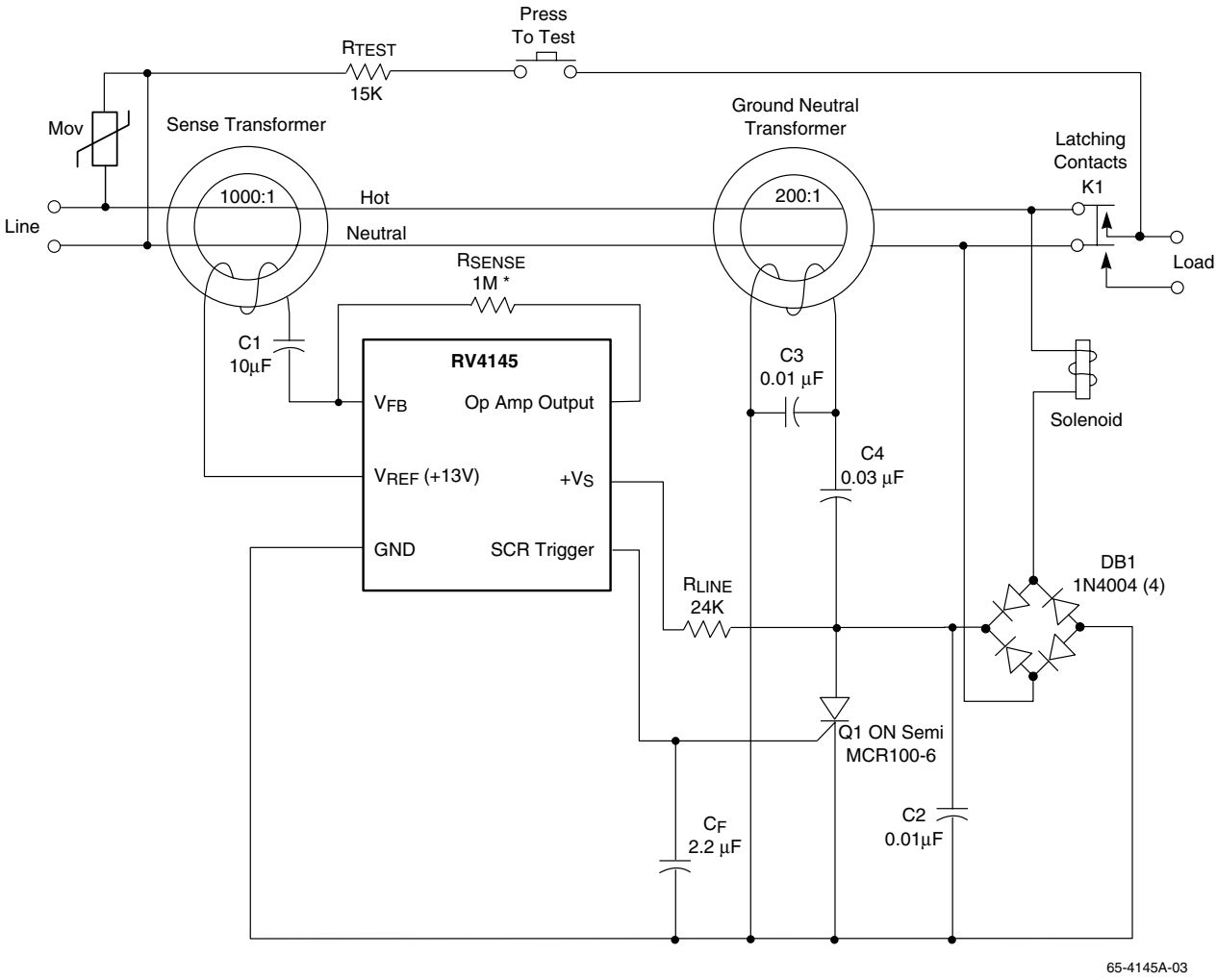
Sense Transformers and Cores

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 its core. The secondary is usually from 200 to 1500 turns.

Magnetic Metals Corporation, Camden, NJ 08101, (609) 964-7842, and Magnetics, 900 E. Butler Road, P.O. Box 391, Butler, PA 16003, (412) 282-8282 are full line suppliers of ring cores and transformers designed specifically for GFI applications.

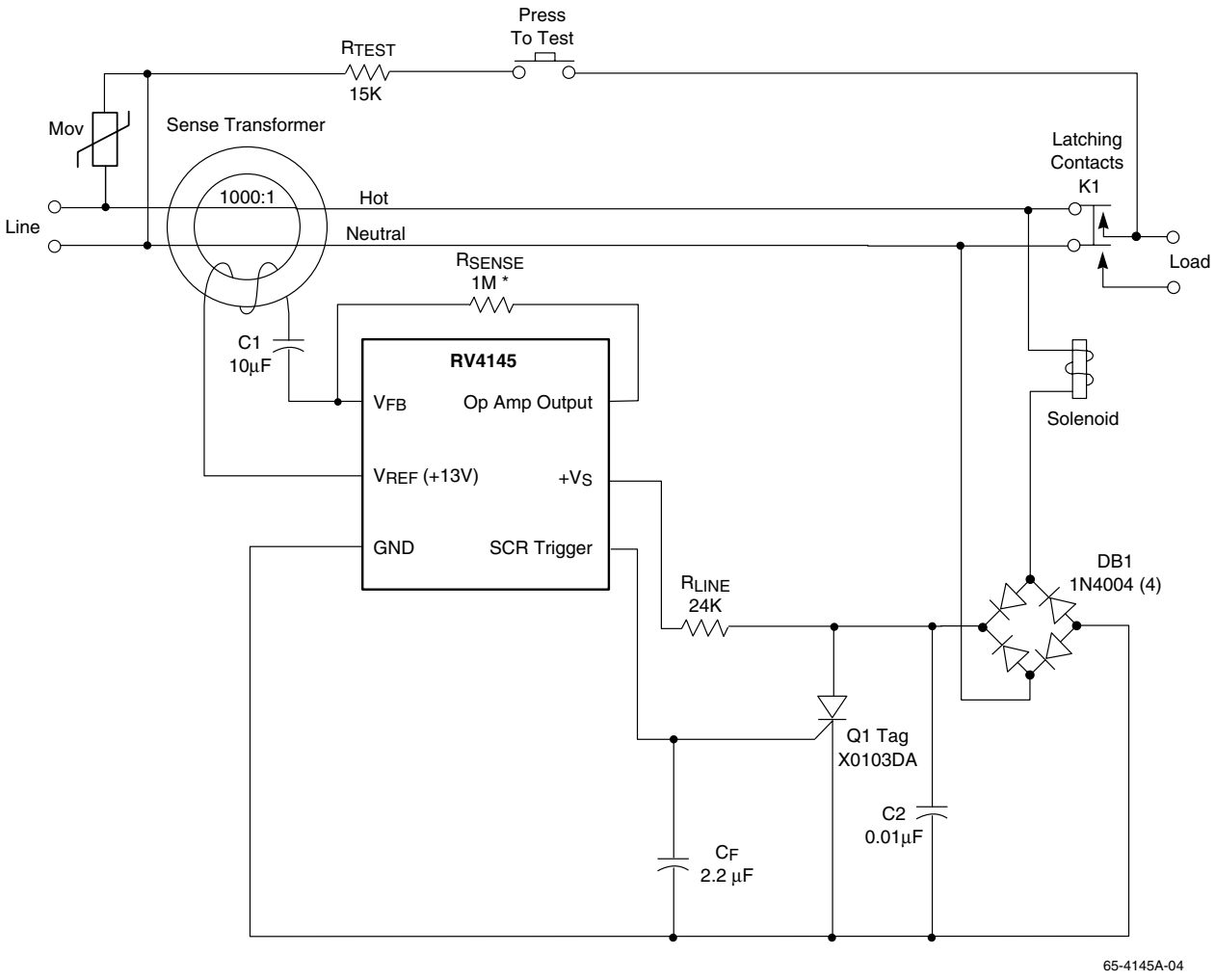
Two-Wire Application Circuit

Figure 2 shows the diagram of a 2-wire 120V AC outlet GFI circuit using an RV4145A. This circuit is not designed to detect grounded neutral faults. Thus, the grounded neutral transformer and capacitors C3 and C4 of Figure 1 are not used.



* Value depends on transformer characteristics.

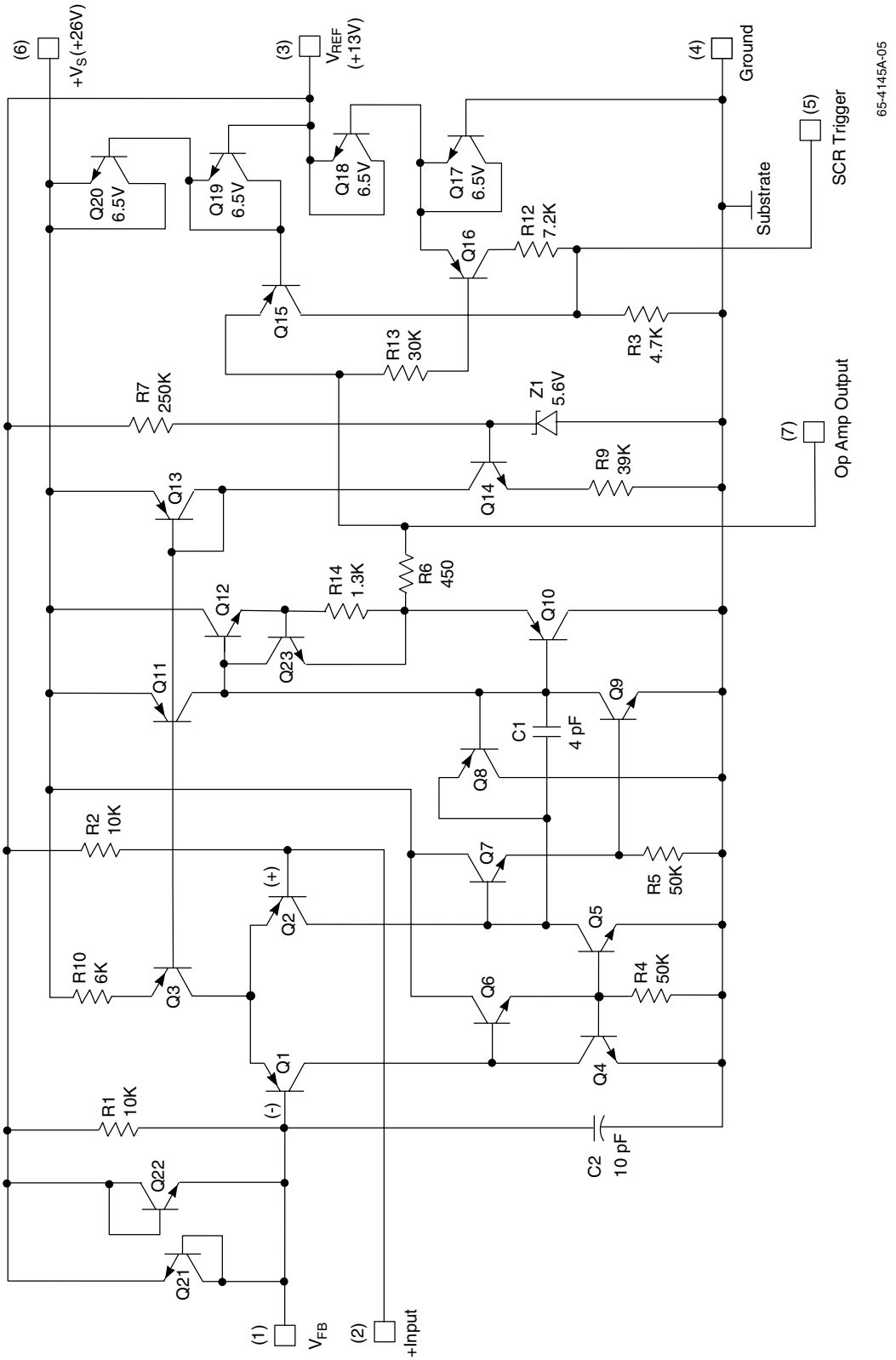
Figure 1. GFI Application Circuit (Three-Wire Outlet)



* Value depends on transformer characteristics.

Figure 2. GFI Application Circuit (Two-Wire Outlet)

Schematic Diagram



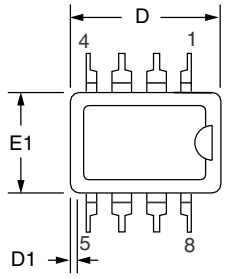
Mechanical Dimensions

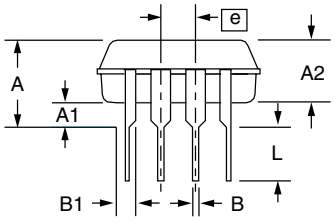
8-Lead Plastic DIP Package

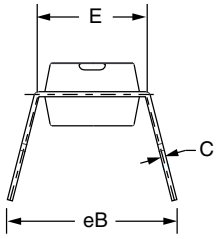
Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.210	—	5.33	
A1	.015	—	.38	—	
A2	.115	.195	2.93	4.95	
B	.014	.022	.36	.56	
B1	.045	.070	1.14	1.78	
C	.008	.015	.20	.38	4
D	.348	.430	8.84	10.92	2
D1	.005	—	.13	—	
E	.300	.325	7.62	8.26	
E1	.240	.280	6.10	7.11	2
e	.100 BSC		2.54 BSC		
eB	—	.430	—	10.92	
L	.115	.160	2.92	4.06	
N	8°		8°		5

Notes:

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E1" do not include mold flashing. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. Terminal numbers are for reference only.
4. "C" dimension does not include solder finish thickness.
5. Symbol "N" is the maximum number of terminals.







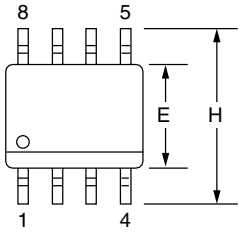
Mechanical Dimensions (continued)

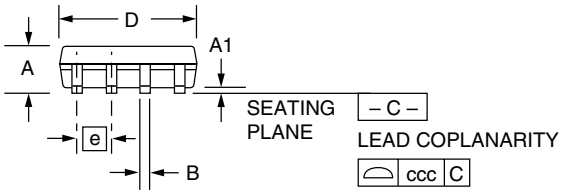
8-Lead SOIC Package

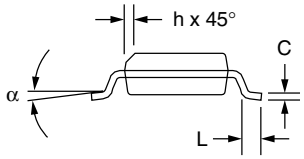
Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	.053	.069	1.35	1.75	
A1	.004	.010	0.10	0.25	
B	.013	.020	0.33	0.51	
C	.008	.010	0.20	0.25	5
D	.189	.197	4.80	5.00	2
E	.150	.158	3.81	4.01	2
e	.050 BSC		1.27 BSC		
H	.228	.244	5.79	6.20	
h	.010	.020	0.25	0.50	
L	.016	.050	0.40	1.27	3
N	8		8		6
α	0°	8°	0°	8°	
ccc	—	.004	—	0.10	

Notes:

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E" do not include mold flash. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. "L" is the length of terminal for soldering to a substrate.
4. Terminal numbers are shown for reference only.
5. "C" dimension does not include solder finish thickness.
6. Symbol "N" is the maximum number of terminals.



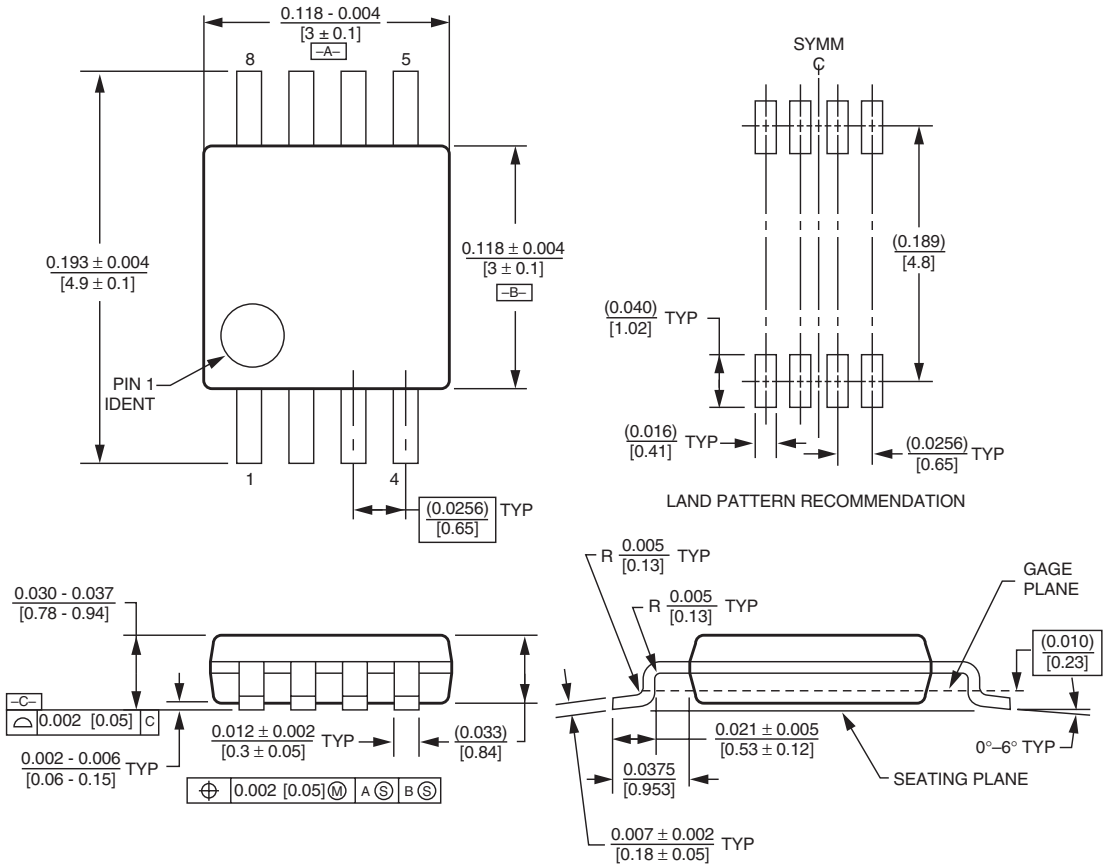




Mechanical Dimensions

8-Lead MSOP Package

Package MA08D



8-Lead Molded Small Outline Package (MSOP), JEDEC MO-187, 3.0mm Wide
Package Number MA08D

Ordering Information

Part Number	Package	Operating Temperature Range
RV4145AN	8-Lead Plastic DIP	-35°C to +85°C
RV4145AM	8-Lead Plastic SOIC	-35°C to +85°C
RV4145AMU	8-Lead Plastic MSOP	-35°C to +85°C

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