

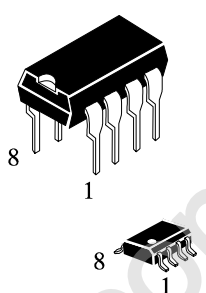
# Low Power Ground Fault Interrupter

**IL4145A**

The IL4145AN 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 IL4145AN 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.

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

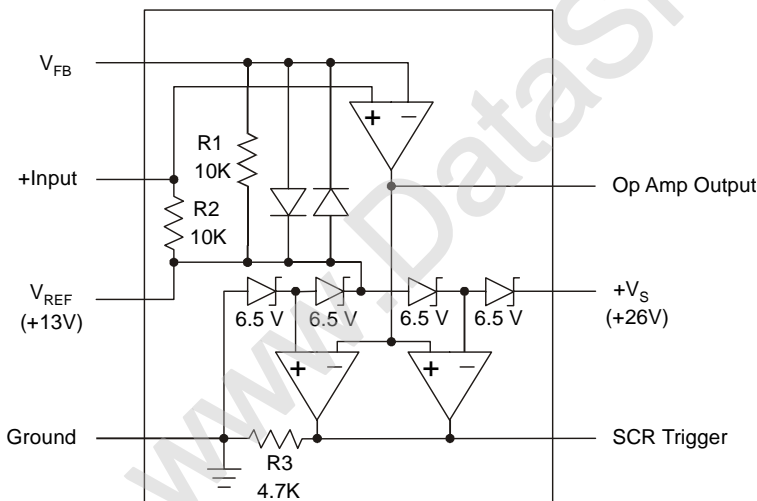


N SUFFIX  
PLASTIC

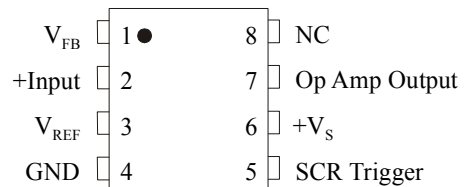
D SUFFIX  
SOIC

**ORDERING INFORMATION**  
 IL4145AN Plastic DIP  
 IL4145AD SOIC  
 $T_A = -35^\circ$  to  $85^\circ$  C for all packages.

## BLOCK DIAGRAM



## PIN ASSIGNMENT



## ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
$I_{CC}$	Supply Current	18	mA
$P_D$	Internal Power Dissipation	500	mW
$T_{stg}$	Storage Temperature Range	-65 to +150	$^\circ$ C
$T_{opr}$	Operating Temperature Range	-35 to +85	$^\circ$ C
$T_J$	Junction Temperature	125	$^\circ$ C
$T_L$	Lead Temperature	125	$^\circ$ C
$P_D$	$T_A < 50^\circ$ C	450	mW
	For $T_A > 50^\circ$ C Derate at	6	mW/ $^\circ$ C

**ELECTRICAL CHARACTERISTICS** ( $I_S = 1.5 \text{ mA}$  and  $T_A = +25^\circ\text{C}$ )

Symbol	Parameter	Test Condition	Min	Max	Unit
$V_{OH}$	Detector Reference Voltage	Pin 7 to Pin 3	6.8	8.1	$\pm\text{V}$
<b>Shunt Regulator</b>					
$+V_S$	Zener Voltage	Pin 6 to Pin 4	25	29.2	V
$V_{REF}$	Reference Voltage	Pin 3 to Pin 4	12.5	14.6	V
$I_S$	Quiescent Current	$+V_S = 24 \text{ V}$		750	$\mu\text{A}$
<b>Operational Amplifier</b>					
$V_{IO}$	Offset Voltage	Pin 2 to Pin 3	-3.0	+3.0	mV
$V_D$	+Output Voltage Swing	Pin 7 to Pin 3	6.8	8.1	V
$V_{OL}$	-Output Voltage Swing	Pin 7 to Pin 3	-13.5	-9.5	V
$I_{OH}$	+Output Source Current	Pin 7 to Pin 3	-450	-850	$\mu\text{A}$
$I_{OL}$	-Output Source Current	Pin 7 to Pin 3	800	1200	$\mu\text{A}$
BW	Gain Bandwidth Product	$F = 50 \text{ KHz}$	1.0		MHz
<b>Resistors</b>		<b><math>I_S = 0 \text{ mA}</math></b>			
R1	R1	Pin 1 to Pin 3	8	12	k $\Omega$
R2	R2	Pin 2 to Pin 3	8	12	k $\Omega$
R3	R3	Pin 5 to Pin 4	3.5	5.9	k $\Omega$
<b>SCR Trigger Voltage</b>		<b>Pin 5 to Pin 4</b>			
$V_{ON}$	Detector On		1.5		V
$V_{OFF}$	Detector Off		0	10	mV

**ELECTRICAL CHARACTERISTICS** ( $I_S = 1.5 \text{ mA}$  and  $-35^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ )

Symbol	Parameter	Test Condition	Min	Max	Unit
$V_{OH}$	Detector Reference Voltage	Pin 7 to Pin 3	6.5	8.3	$\pm\text{V}$
<b>Shunt Regulator</b>					
$+V_S$	Zener Voltage	Pin 6 to Pin 4	24	30	V
$V_{REF}$	Reference Voltage	Pin 3 to Pin 4	12	15	V
$I_S$	Quiescent Current	$+V_S = 23 \text{ V}$		800	$\mu\text{A}$
<b>Operational Amplifier</b>					
$V_{IO}$	Offset Voltage	Pin 2 to Pin 3	-5.0	+5.0	mV
$V_D$	+Output Voltage Swing	Pin 7 to Pin 3	6.5	8.3	V
$V_{OL}$	-Output Voltage Swing	Pin 7 to Pin 3	-14	-9	V
<b>Resistors</b>		<b><math>I_S = 0 \text{ mA}</math></b>			
R1	R1	Pin 1 to Pin 3	7.5	12.5	k $\Omega$
R2	R2	Pin 2 to Pin 3	7.5	12.5	k $\Omega$
R3	R3	Pin 5 to Pin 4	3.5	5.9	k $\Omega$
<b>SCR Trigger Voltage</b>		<b>Pin 5 to Pin 4</b>			
$V_{ON}$	Detector On		1.3		V
$V_{OFF}$	Detector Off		0	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  $1/2 V_S$  and is used as a reference to create an artificial ground of +13V at the op amp noninverting input.

Figure 1 shows a three-wire 120V AC outlet GFI application using an IL4145AN. 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 47k $\Omega$  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  $\pm 15\%$  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 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 the circuit will detect a grounded neutral fault having resistance of 2 $\Omega$  or less.

The input to the op amp are protected from overvoltage by back-to-back 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 200 $\mu$ A.  $C_F$  is a noise filter capacitor that prevents narrow pulses from firing the SCR.

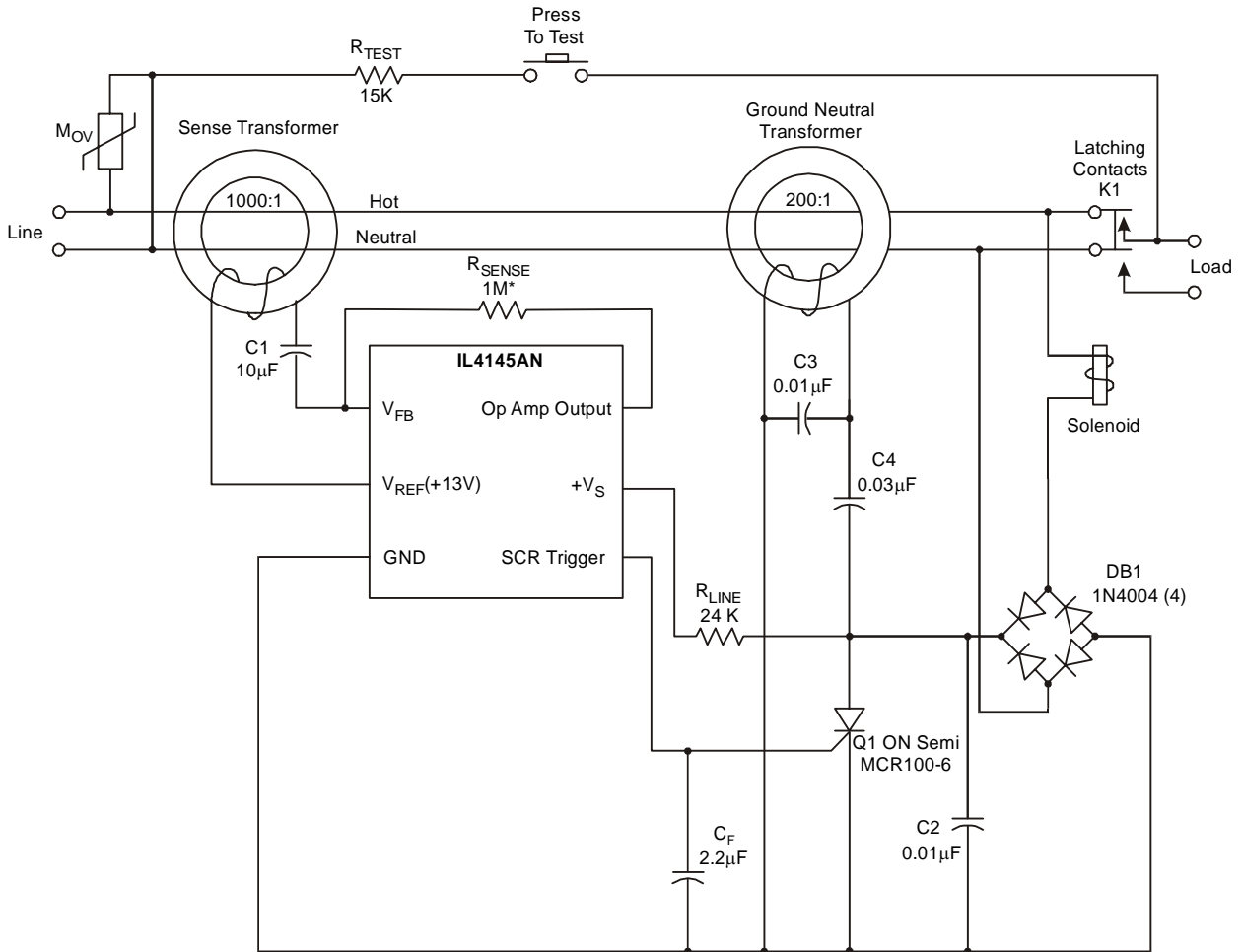
The relay solenoid used should have a 3ms or less response time in order to meet the UL 943 timing requirement.

### 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.

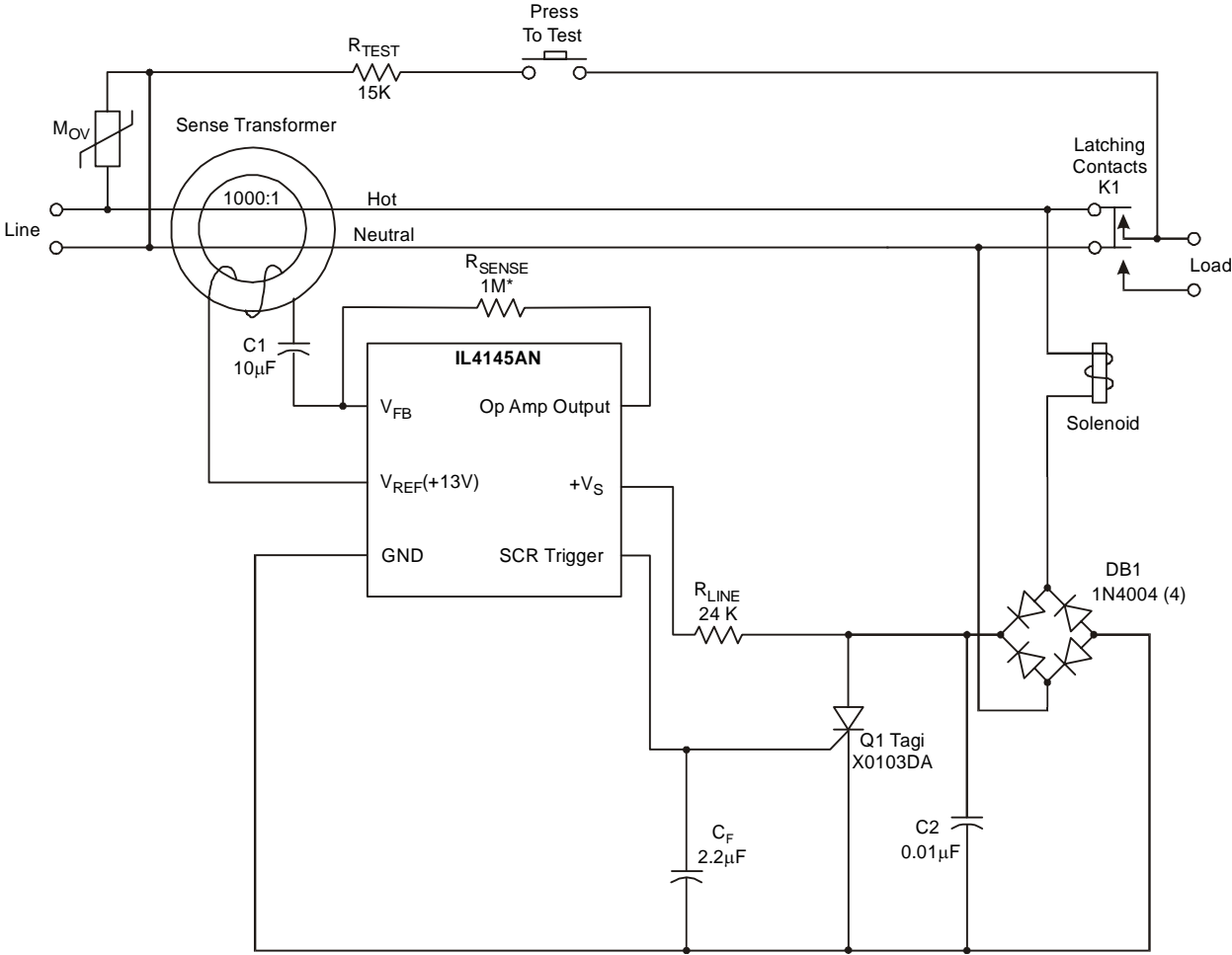
### Two-Wire Application Circuit

Figure 2 shows the diagram of a 2-wire 120V AC outlet GFI circuit using an IL4145AN. 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.

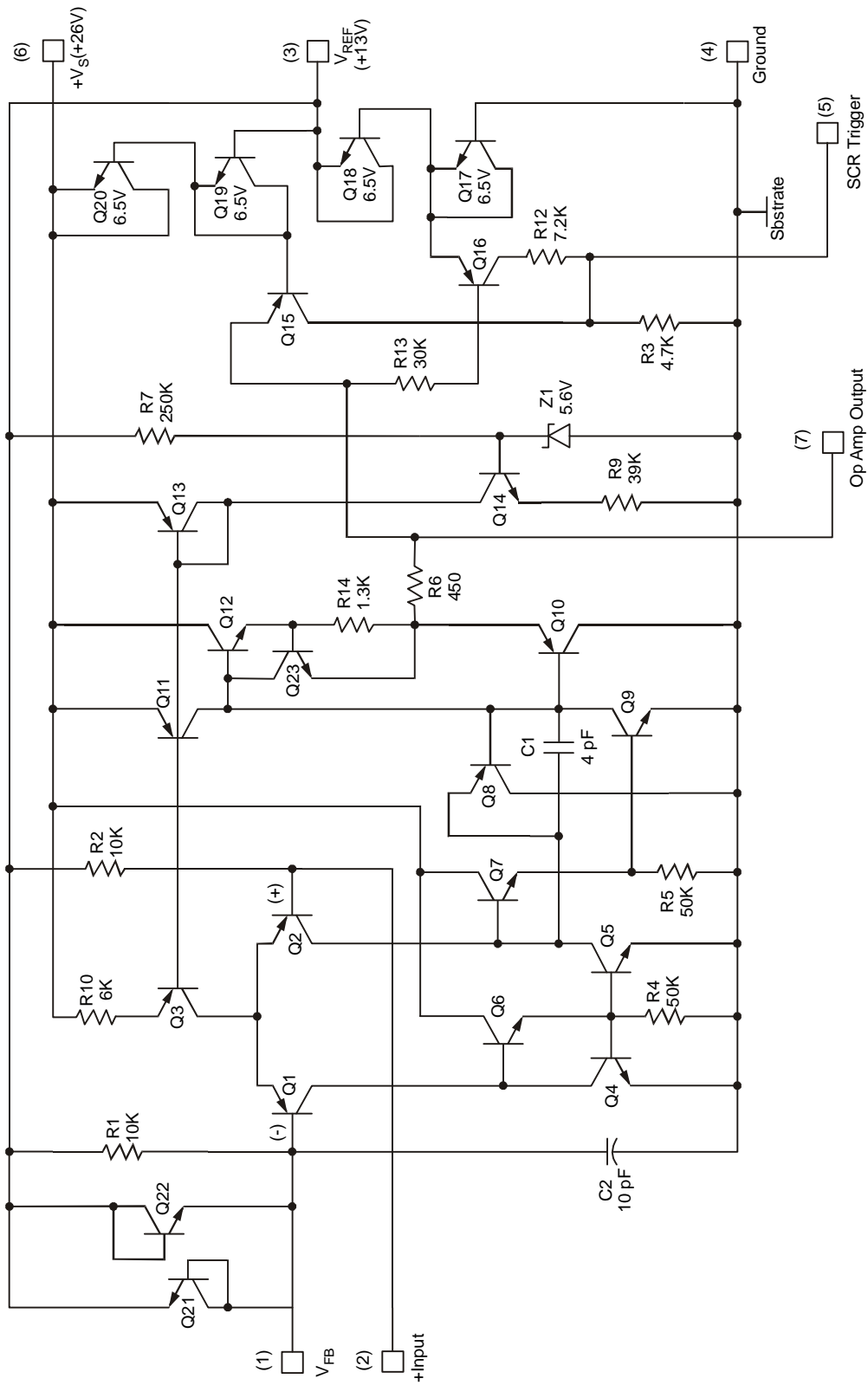
**Figure 1. GFI Application Circuit (Three-Wire Outlet)**



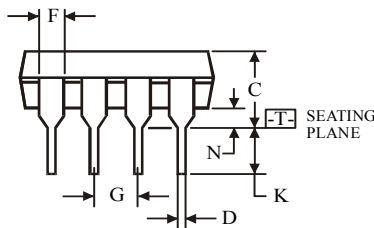
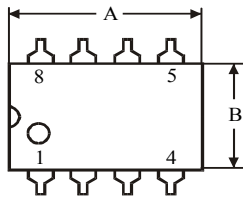
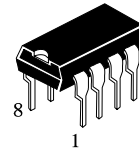
\* Value depends on transformer characteristics.

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

**SCHEMATIC DIAGRAM**



**N SUFFIX PLASTIC DIP  
(MS - 001BA)**



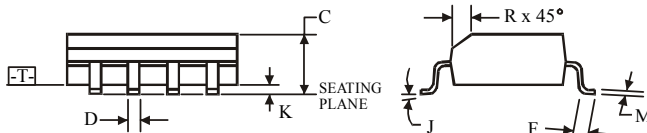
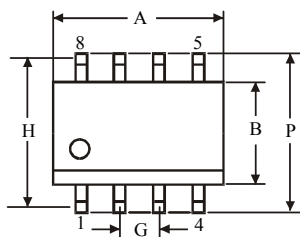
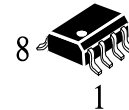
$\oplus 0.25 (0.010) \text{M} \text{T}$

Symbol	Dimension, mm	
	MIN	MAX
A	8.51	10.16
B	6.1	7.11
C		5.33
D	0.36	0.56
F	1.14	1.78
G	2.54	
H	7.62	
J	0°	10°
K	2.92	3.81
L	7.62	8.26
M	0.2	0.36
N	0.38	

**NOTES:**

- Dimensions "A", "B" do not include mold flash or protrusions.  
Maximum mold flash or protrusions 0.25 mm (0.010) per side.

**D SUFFIX SOIC  
(MS - 012AA)**



$\oplus 0.25 (0.010) \text{M} \text{T} \text{C} \text{M}$

Symbol	Dimension, mm	
	MIN	MAX
A	4.8	5
B	3.8	4
C	1.35	1.75
D	0.33	0.51
F	0.4	1.27
G	1.27	
H	5.72	
J	0°	8°
K	0.1	0.25
M	0.19	0.25
P	5.8	6.2
R	0.25	0.5

**NOTES:**

- Dimensions A and B do not include mold flash or protrusion.
- Maximum mold flash or protrusion 0.15 mm (0.006) per side for A; for B - 0.25 mm (0.010) per side.