



Is Now Part of



**ON Semiconductor®**

To learn more about ON Semiconductor, please visit our website at  
[www.onsemi.com](http://www.onsemi.com)

Please note: As part of the Fairchild Semiconductor integration, some of the Fairchild orderable part numbers will need to change in order to meet ON Semiconductor's system requirements. Since the ON Semiconductor product management systems do not have the ability to manage part nomenclature that utilizes an underscore (\_), the underscore (\_) in the Fairchild part numbers will be changed to a dash (-). This document may contain device numbers with an underscore (\_). Please check the ON Semiconductor website to verify the updated device numbers. The most current and up-to-date ordering information can be found at [www.onsemi.com](http://www.onsemi.com). Please email any questions regarding the system integration to [Fairchild\\_questions@onsemi.com](mailto:Fairchild_questions@onsemi.com).

ON Semiconductor and the ON Semiconductor logo are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.



# 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  $\mu$ A 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.

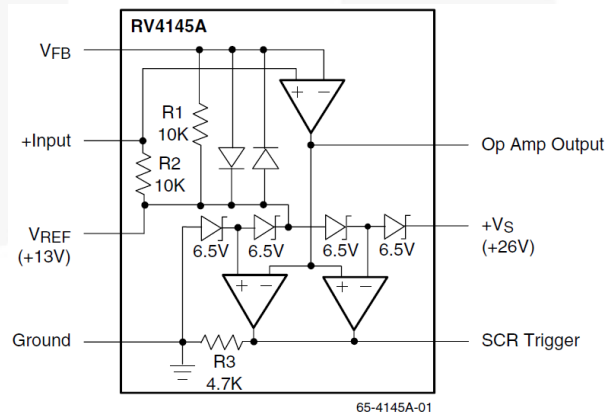


Figure 1. Block Diagram

## 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

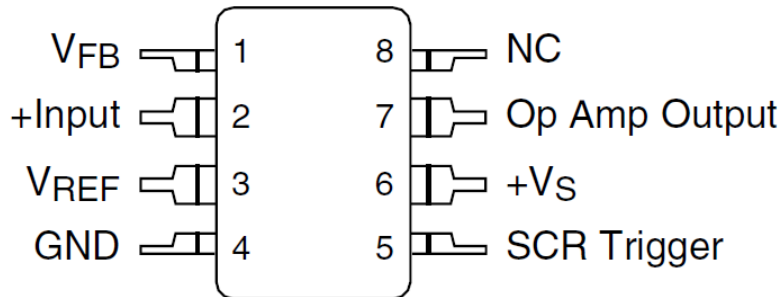


Figure 2. Pin Assignment

## 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	$T_A < 50^\circ\text{C}$	SOIC		300	mW
			PDIP		450	
		$T_A < 50^\circ\text{C}$ Derate	SOIC	4		mW/°C
			PDIP	6		
$\Theta_{JA}$	Thermal Resistance		SOIC	240		°C/W
			PDIP	160		

## Electrical Characteristics

$I_S = 1.5 \text{ mA}$  and  $T_A = +25^\circ\text{C}$ .

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
	Detector Reference Voltage	Pin 7 to Pin 3	6.8	7.2	8.1	$\pm\text{V}$
<b>Shunt Regulator</b>						
$+V_S$	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	$+V_S = 24 \text{ V}$		450	750	$\mu\text{A}$
<b>Operation Amplifier</b>						
	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		$\mu\text{A}$
	-Output Source Current	Pin 7 to Pin 3		1.0		mA
	Gain Bandwidth Product	$f = 50 \text{ kHz}$	1.0	1.8		MHz
<b>Resistors</b>						
R1	Resistors, $I_S = 0 \text{ mA}$	Pin 1 to Pin 3		10		k $\Omega$
R2		Pin 2 to Pin 3		10		
R3		Pin 5 to Pin 4	3.5	4.7	5.9	
<b>SCR Trigger</b>						
	Detector On	Pin 5 to Pin 4	1.5	2.8		V
	Detector Off		0	1	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	Conditions	Min.	Typ.	Max.	Unit
	Detector Reference Voltage	Pin 7 to Pin 3	6.5	7.2	8.3	$\pm\text{V}$
<b>Shunt Regulator</b>						
$+V_S$	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	$+V_S = 23 \text{ V}$		500		$\mu\text{A}$
<b>Operational Amplifier</b>						
	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	$f = 50 \text{ kHz}$		1.8		MHz
<b>Resistors</b>						
R1	Resistors, $I_S = 0 \text{ mA}$	Pin 1 to Pin 3		10		k $\Omega$
R2		Pin 2 to Pin 3		10		
R3		Pin 5 to Pin 4	3.5	4.7	5.9	
<b>SCR Trigger</b>						
	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:  $\frac{3}{4} V_S$ ,  $\frac{1}{2} V_S$ , and  $\frac{1}{4} V_S$ .  $V_{REF}$  is at  $\frac{1}{2} V_S$  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  $\pm 7.2$  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 k $\Omega$  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  $\pm 15\%$  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  $\Omega$  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  $\mu$ A.  $C_F$  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.

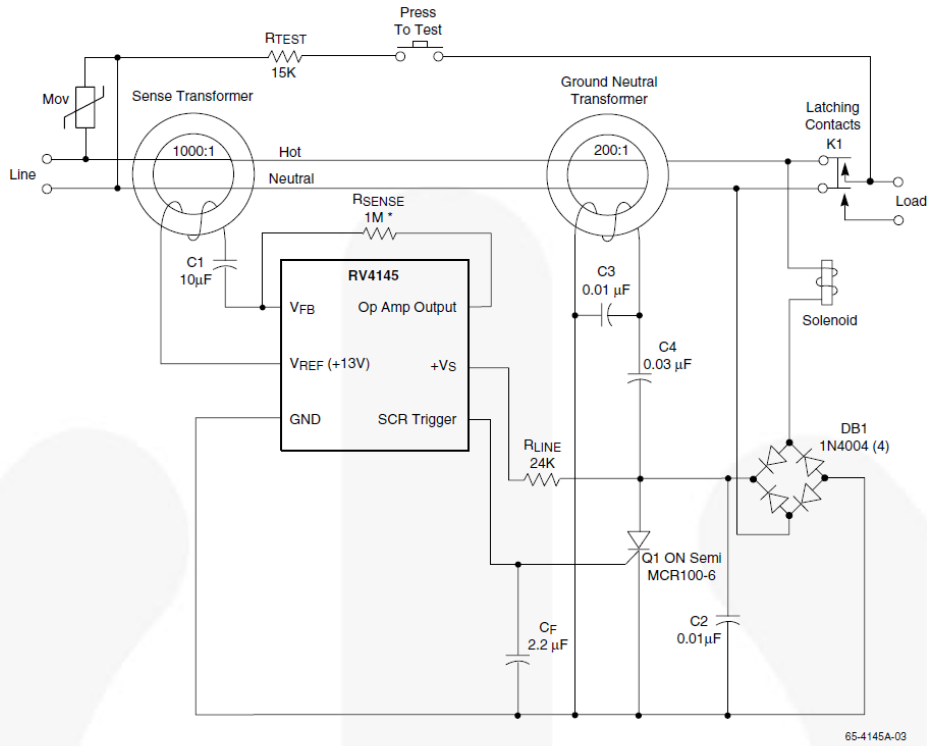
### Sense Transformers and Cores

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](http://www.magmet.com) is a full line suppliers of ring cores and transformers designed specifically for GFI applications.

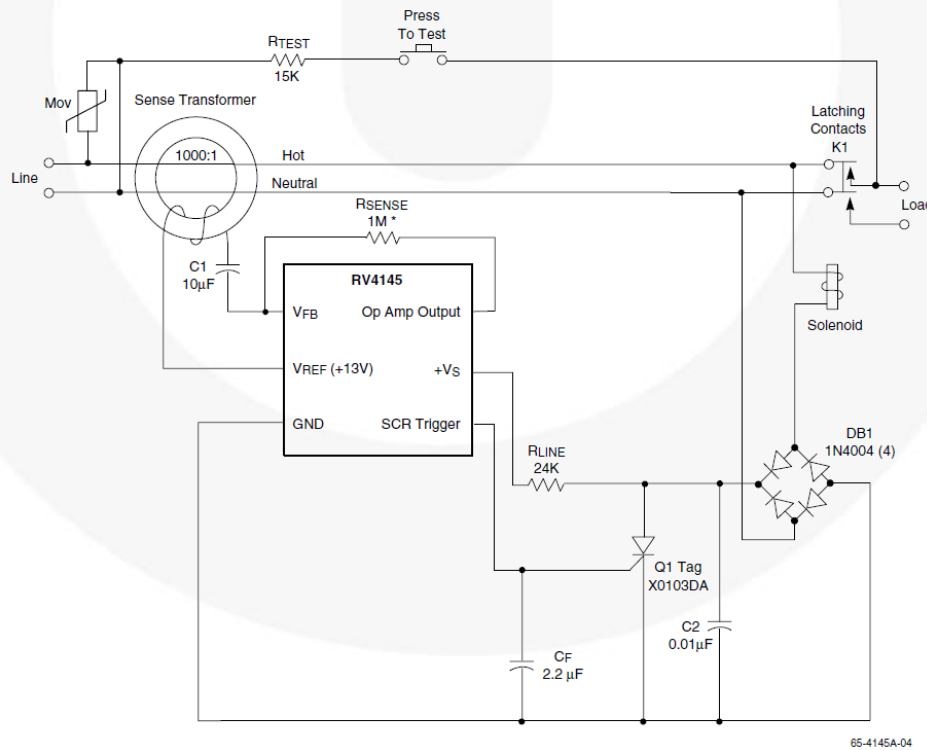
### Two-Wire Application Circuit

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.

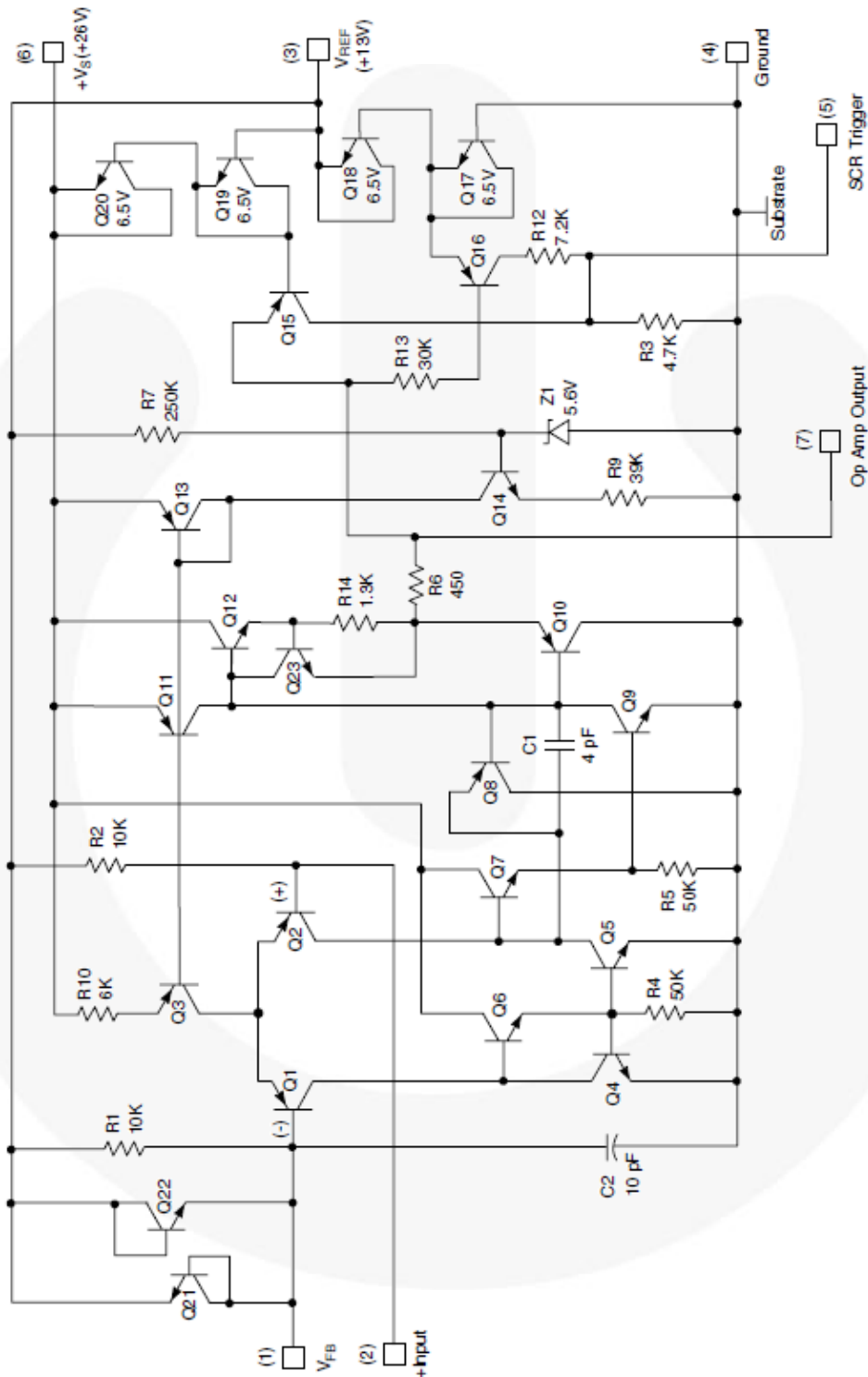
**Figure 3. GFI Application Circuit (Three-Wire Outlet)**



\* Value depends on transformer characteristics.

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

Schematic Diagram

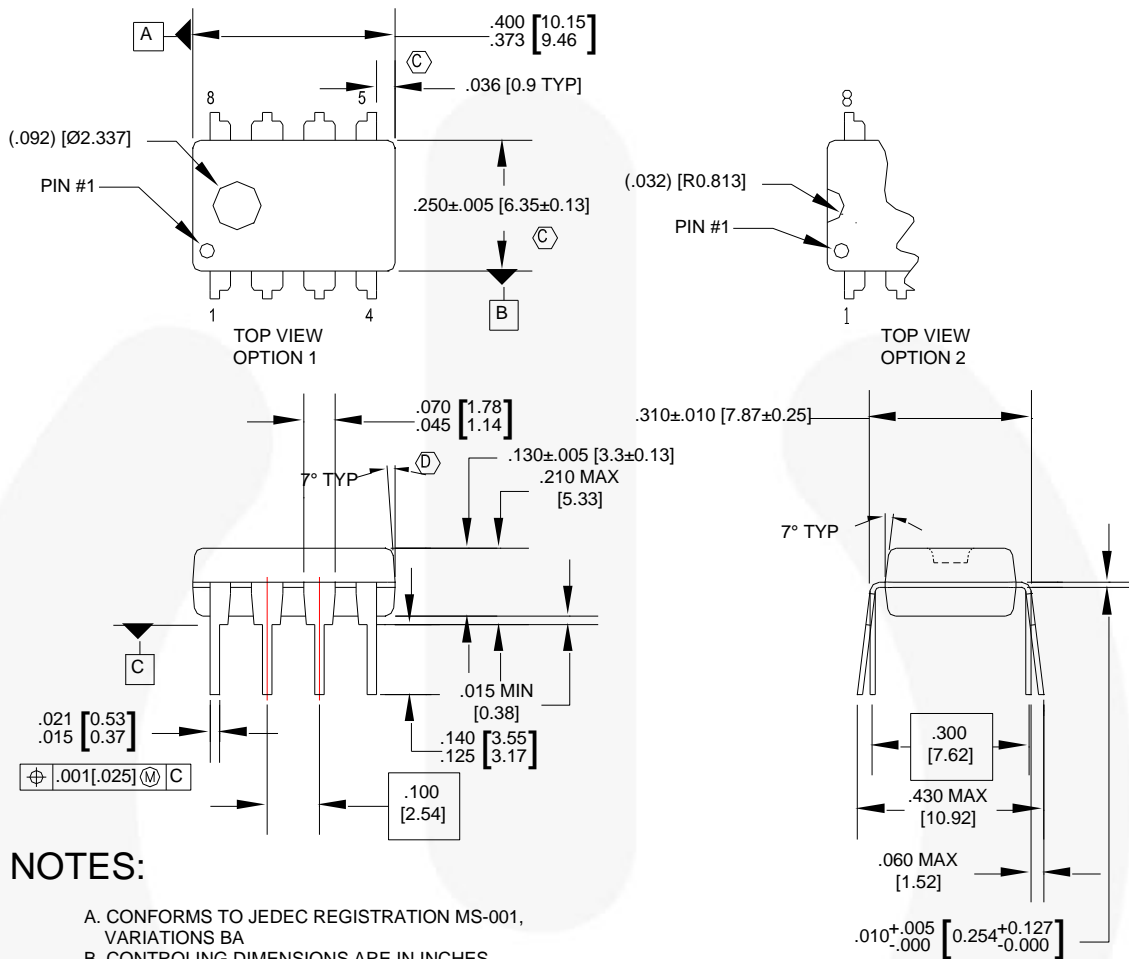


65-4145A-05

Figure 5. Schematic



**Physical Dimensions**



**NOTES:**

- A. CONFORMS TO JEDEC REGISTRATION MS-001, VARIATIONS BA
- B. CONTROLLING 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.
- D. DOES NOT INCLUDE DAMBAR PROTRUSIONS.  
DAMBAR PROTRUSIONS SHALL NOT EXCEED  
.010 INCHES OR 0.25MM.
- E. DIMENSIONING AND TOLERANCING  
PER ASME Y14.5M-1994.

**N08EREVG**

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

Package drawings are provided as a service to customers considering Fairchild components. Drawings may change in any manner without notice. Please note the revision and/or date on the drawing and contact a Fairchild Semiconductor representative to verify or obtain the most recent revision. Package specifications do not expand the terms of Fairchild's worldwide terms and conditions, specifically the warranty therein, which covers Fairchild products.

Always visit Fairchild Semiconductor's online packaging area for the most recent package drawings:  
<http://www.fairchildsemi.com/dwg/N0/N08E.pdf>

For current packing container specifications, visit Fairchild Semiconductor's online packaging area:  
[http://www.fairchildsemi.com/packing\\_dwg/PKG-N08E.pdf](http://www.fairchildsemi.com/packing_dwg/PKG-N08E.pdf)

Physical Dimensions

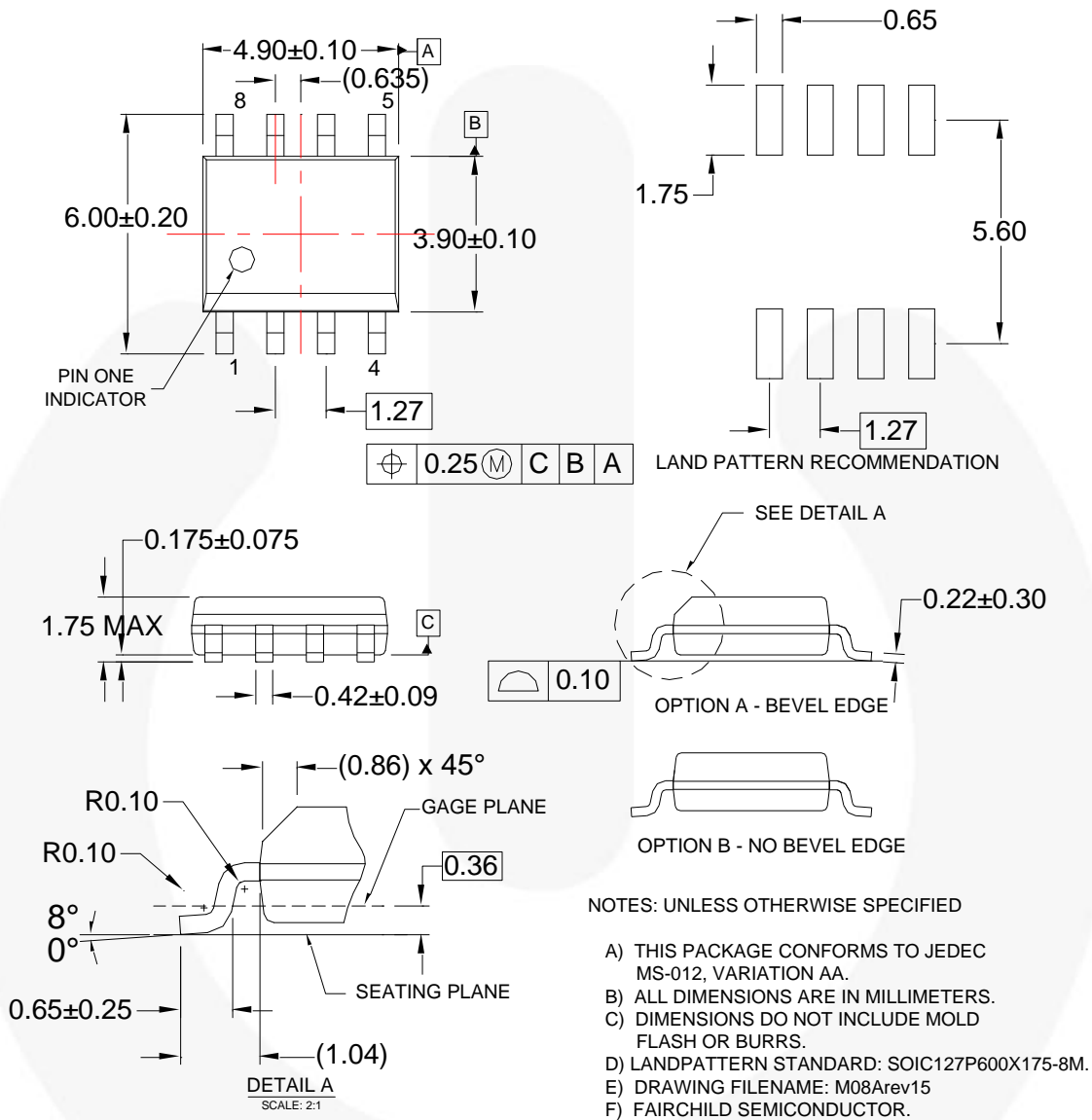


Figure 7. 8-Lead, SOIC, JEDEC MS-012, .150" Narrow Body

Package drawings are provided as a service to customers considering Fairchild components. Drawings may change in any manner without notice. Please note the revision and/or date on the drawing and contact a Fairchild Semiconductor representative to verify or obtain the most recent revision. Package specifications do not expand the terms of Fairchild's worldwide terms and conditions, specifically the warranty therein, which covers Fairchild products.

Always visit Fairchild Semiconductor's online packaging area for the most recent package drawings:  
<http://www.fairchildsemi.com/dwg/M0/M08A.pdf>

For current packing container specifications, visit Fairchild Semiconductor's online packaging area:  
[http://www.fairchildsemi.com/packing\\_dwg/PKG-M08A\\_GEM.pdf](http://www.fairchildsemi.com/packing_dwg/PKG-M08A_GEM.pdf)



**TRADEMARKS**

The following includes registered and unregistered trademarks and service marks, owned by Fairchild Semiconductor and/or its global subsidiaries, and is not intended to be an exhaustive list of all such trademarks.

- |                          |  |                                       |                  |
|--------------------------|--|---------------------------------------|------------------|
| AccuPower™               | F-PFS™   |                                       |                  |
| AX-CAP®*                 | FRFET®   | PowerTrench®                          | TinyBoost®       |
| BitSiC™                  | Global Power Resource™                         | PowerXS™                              | TinyBuck®        |
| Build it Now™            | GreenBridge™                                   | Programmable Active Droop™            | TinyCalc™        |
| CorePLUS™                | Green FPS™                                     | QFET®                                 | TinyLogic®       |
| CorePOWER™               | Green FPS™ e-Series™                           | QS™                                   | TINYOPTO™        |
| CROSSVOLT™               | Gmax™  | Quiet Series™                         | TinyPower™       |
| CTL™                     | GTO™   | RapidConfigure™                       | TinyPWM™         |
| Current Transfer Logic™  | IntelliMAX™                                    |                                       | TinyWire™        |
| DEUXPEED®                | ISOPLANAR™                                     | Saving our world, 1mW/W/kW at a time™ | TranSiC™         |
| Dual Cool™               | Making Small Speakers Sound Louder and Better™ | SignalWise™                           | TriFault Detect™ |
| EcoSPARK®                | MegaBuck™                                      | SmartMax™                             | TRUECURRENT®*    |
| EfficientMax™            | MICROCOUPLER™                                  | SMART START™                          | µSerDes™         |
| ESBC™                    | MicroFET™                                      | Solutions for Your Success™           |                  |
|                          | MicroPak™                                      | SPM®                                  | UHC®             |
| Fairchild®               | MicroPak2™                                     | STEALTH™                              | Ultra FRFET™     |
| Fairchild Semiconductor® | MillerDrive™                                   | SuperFET®                             | UniFET™          |
| FACT Quiet Series™       | MotionMax™                                     | SuperSOT™-3                           | VCX™             |
| FACT®                    | mWSaver®                                       | SuperSOT™-6                           | VisualMax™       |
| FAST®                    | OptoHiT™                                       | SuperSOT™-8                           | VoltagePlus™     |
| FastvCore™               | OPTOLOGIC®                                     | SupreMOS®                             | XS™              |
| FETBench™                | OPTOPLANAR®                                    | SyncFET™                              | 仙童™              |
| FPS™                     |  | Sync-Lock™                            |                  |

\* Trademarks of System General Corporation, used under license by Fairchild Semiconductor.

**DISCLAIMER**

FAIRCHILD SEMICONDUCTOR RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION, OR DESIGN. FAIRCHILD DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS. THESE SPECIFICATIONS DO NOT EXPAND THE TERMS OF FAIRCHILD'S WORLDWIDE TERMS AND CONDITIONS, SPECIFICALLY THE WARRANTY THEREIN, WHICH COVERS THESE PRODUCTS.

**LIFE SUPPORT POLICY**

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF FAIRCHILD SEMICONDUCTOR CORPORATION.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

**ANTI-COUNTERFEITING POLICY**

Fairchild Semiconductor Corporation's Anti-Counterfeiting Policy. Fairchild's Anti-Counterfeiting Policy is also stated on our external website, [www.fairchildsemi.com](http://www.fairchildsemi.com), under Sales Support.

Counterfeiting of semiconductor parts is a growing problem in the industry. All manufacturers of semiconductor products are experiencing counterfeiting of their parts. Customers who inadvertently purchase counterfeit parts experience many problems such as loss of brand reputation, substandard performance, failed applications, and increased cost of production and manufacturing delays. Fairchild is taking strong measures to protect ourselves and our customers from the proliferation of counterfeit parts. Fairchild strongly encourages customers to purchase Fairchild parts either directly from Fairchild or from Authorized Fairchild Distributors who are listed by country on our web page cited above. Products customers buy either from Fairchild directly or from Authorized Fairchild Distributors are genuine parts, have full traceability, meet Fairchild's quality standards for handling and storage and provide access to Fairchild's full range of up-to-date technical and product information. Fairchild and our Authorized Distributors will stand behind all warranties and will appropriately address any warranty issues that may arise. Fairchild will not provide any warranty coverage or other assistance for parts bought from Unauthorized Sources. Fairchild is committed to combat this global problem and encourage our customers to do their part in stopping this practice by buying direct or from authorized distributors.

**PRODUCT STATUS DEFINITIONS**

**Definition of Terms**

Datasheet Identification	Product Status	Definition
Advance Information	Formative / In Design	Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
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.
Obsolete	Not In Production	Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

Rev. I68

ON Semiconductor and  are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

## PUBLICATION ORDERING INFORMATION

### LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor  
19521 E. 32nd Pkwy, Aurora, Colorado 80011 USA  
**Phone:** 303-675-2175 or 800-344-3860 Toll Free USA/Canada  
**Fax:** 303-675-2176 or 800-344-3867 Toll Free USA/Canada  
**Email:** [orderlit@onsemi.com](mailto:orderlit@onsemi.com)

**N. American Technical Support:** 800-282-9855 Toll Free  
USA/Canada  
**Europe, Middle East and Africa Technical Support:**  
Phone: 421 33 790 2910  
**Japan Customer Focus Center**  
Phone: 81-3-5817-1050

**ON Semiconductor Website:** [www.onsemi.com](http://www.onsemi.com)  
**Order Literature:** <http://www.onsemi.com/orderlit>  
For additional information, please contact your local  
Sales Representative