

### TRIUNE PRODUCTS

#### Features

- Low Offset
- High Voltage Input
- Supply voltage: 4V-42V
- Low Temperature Drift
- Low input bias current
- Pedestal Voltage for offset compensation
- Available in 8-pin SOT-23 package
- Product is lead-free, Halogen Free, RoHS / WEEE compliant

#### Applications

- Multi-standard compliant and non-compliant wireless chargers for:
  - Cell Phones and Smartphones
  - Qi-Compliant Wireless Charging Transmitters
  - Tablets and eReaders
- Notebook Computers
- Telecom Equipment
- Power Management
- Battery Chargers
- Welding Equipment

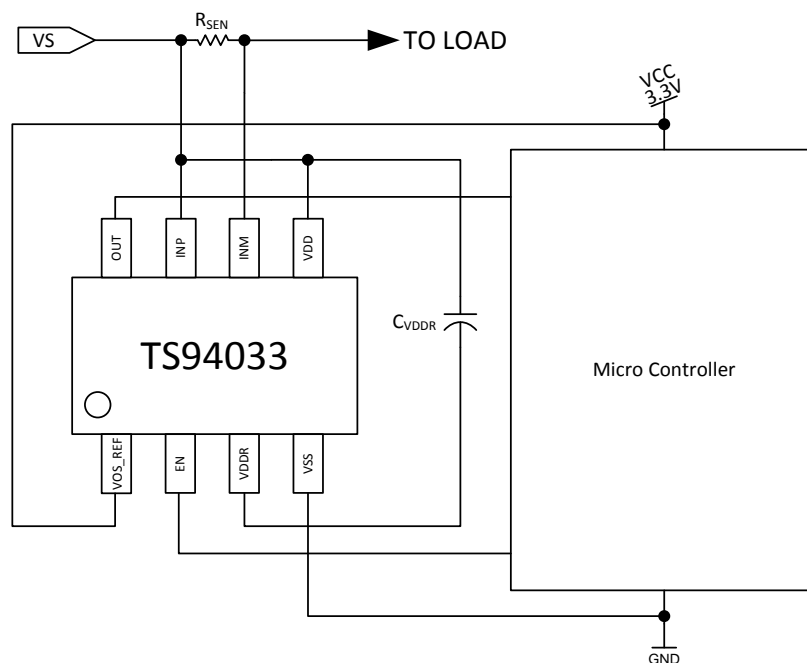
#### Description

The TS94033 is a low power, low offset high-side current sense amplifier. It utilizes a chopper-stabilized configuration to provide high gain-bandwidth while reducing input offset and 1/f noise. The sense amplifiers offer high voltage inputs and a 0 to 3.3V output. The supply voltage range of 4V to 42V can accommodate a wide variety of applications.

A zero-current output offset is set by providing a bias voltage on the VOS\_REF pin. This allows the ability to sense limited negative currents, improves transient response time, and provides a method to detect faults in the current sense system.

The TS94033 operational amplifier is optimal for bridge drive applications where accurate current sensing is needed.

#### Typical Application Circuit



# Pin Description

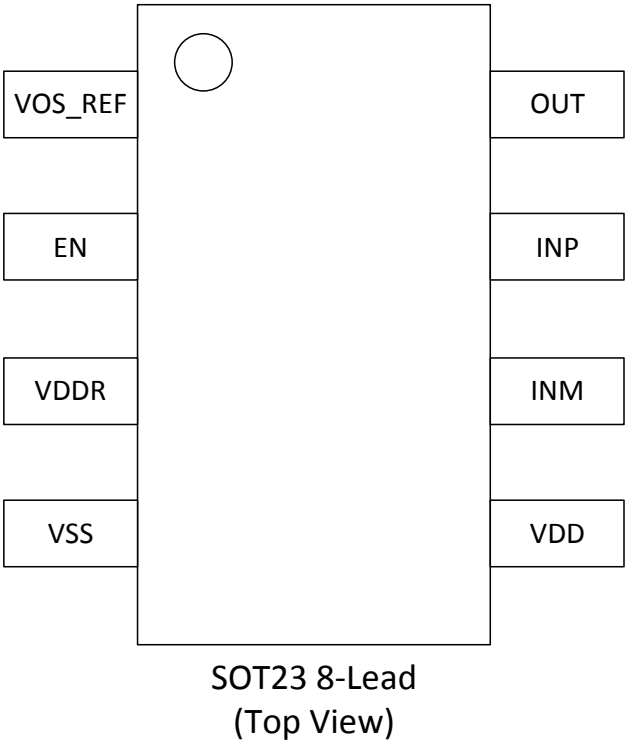


Figure 1: TS94033 Pin Configuration

Pin Number	Pin Name	I/O/P	Description
1	VOS_REF	I	Zero-Current Output Offset Reference
2	EN	I	Enable Input
3	VDDR	O	Supply-Referenced Regulated Voltage Output
4	VSS	P	Power Supply Return, VOS_REF and OUT Signal Reference Voltage (ground)
5	VDD	P	Power Supply Input, Sense Amplifier Input Common-Mode Signal Reference
6	INM	I	Sense Amplifier Inverting Input
7	INP	I	Sense Amplifier Non-Inverting Input
8	OUT	O	Sense Amplifier Output



## Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
$V_S$	Supply Voltage, VDD – VSS	4	42	V
$V_{OS\_REF}$	Output Offset Reference, (VOS_REF – VSS)	0	3.3	V
$V_{IN}$	Differential Input Voltage, (VINP – VINM)	-4	66	mV
$V_{CM}$	Input Common-Mode Range, ( $V_{DD} - 0.5 * (VINP + VINM)$ )	VDD-2	VDD+0.3	V
$V_{IH-EN}$	High Level Input Voltage, EN Pin	2.4	5.5	V
$V_{IL-EN}$	Low Level Input Voltage, EN Pin	0	0.4	V
$C_L$	OUT Pin Load Capacitance		100	nF

## Electrical Characteristics

Typical:  $T_J = 25^\circ\text{C}$ ,  $V_{DD} = 12\text{V}$

Min and max:  $T_J = -40^\circ\text{C}$  to  $125^\circ\text{C}$ ,  $V_{DD} = 4\text{V} \sim 42\text{V}$

Unless otherwise noted  $V_{SS} = 0\text{V}$ ,  $V_{CM} = V_{DD}$ , INP - INM = 0V,  $V_{OS\_REF} = 3.3\text{V}$

Symbol	Parameter	Condition	Min	Typ	Max	Unit
$I_{QDD}$	Quiescent Current	From VDD		140	315	$\mu\text{A}$
$I_{QVCM}$	Quiescent Current	Through INP/INM		28		$\mu\text{A}$
$I_{Q-OFF}$	Quiescent Current	From VDD, EN = 0V, $V_{OS\_REF}=0$		1.1	8.6	$\mu\text{A}$
$I_{IL-EN}$	Input Low Leakage, EN Pin	$V_{EN} = 0\text{V}$		1.1		$\mu\text{A}$
$I_B$	Input Bias Current	$V_{OS\_REF} = 0\text{V}$		2.1		$\mu\text{A}$
$\Delta V_{DDR}$	Sense-Amp Supply Voltage	$\Delta V_{DDR} = V_{DD} - V_{DDR}$ $C_{VDDR} = 100\text{nF}$		4.4		V
$T_{ON-EN}$	Turn-On Time <sup>(1)</sup>	EN driven from 0V to 3.3V, OUT settled to 90% of final value		600		$\mu\text{s}$
PSRR	Power Supply Rejection Ratio <sup>1</sup>	100 kHz		-70		dB
LR	Line Regulation	4– 42V step applied on $V_{DD}$		-83		dB
SR	Slew Rate	$C_L=100\text{nF}$		10		mV/ $\mu\text{s}$
$ I_{sc} $	Short-Circuit Current, Sourcing or Sinking	OUT shorted to VDD or VSS		1	1.7	mA
$V_{OUT}$	Voltage Output swing		3.3		3.6	V
CMRR	Common-Mode Rejection Ratio <sup>(1)</sup>	$-2\text{V} < V_{CM} < 0.4\text{V}$		-110		dB
Gain	Gain	OUT / $V_{IN}$	48.5	49.25	50	V/V
$V_{OS}$	Output-Referred Offset Voltage	$V_{OS\_REF} = 3.3\text{V}$	155	215	280	mV
Gain <sub>TC</sub>	Gain Temperature Coefficient <sup>(1)</sup>	$[(\Delta\text{Gain}/50) / \Delta T] * 10^6$	-60	-20	10	ppm/ $^\circ\text{C}$
$V_{OS-TC}$	Output Offset Temperature Coefficient <sup>(1)</sup>		-50		50	$\mu\text{V}/^\circ\text{C}$
Gain <sub>VOS</sub>	Offset Reference Gain	$V_{OS} / V_{OS\_REF}$		0.06515		V/V
BW	-3 dB Bandwidth <sup>(1)</sup>	No load		4		kHz

Notes:

(1) This parameter is not tested in production.

# Typical Characteristics

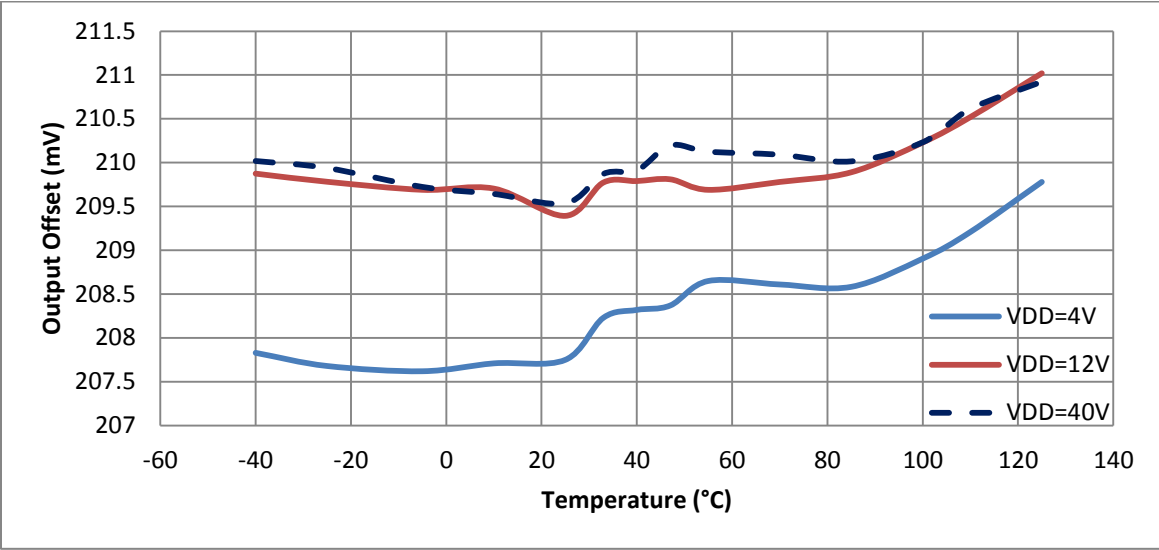


Figure 3: Offset Voltage vs Temperature

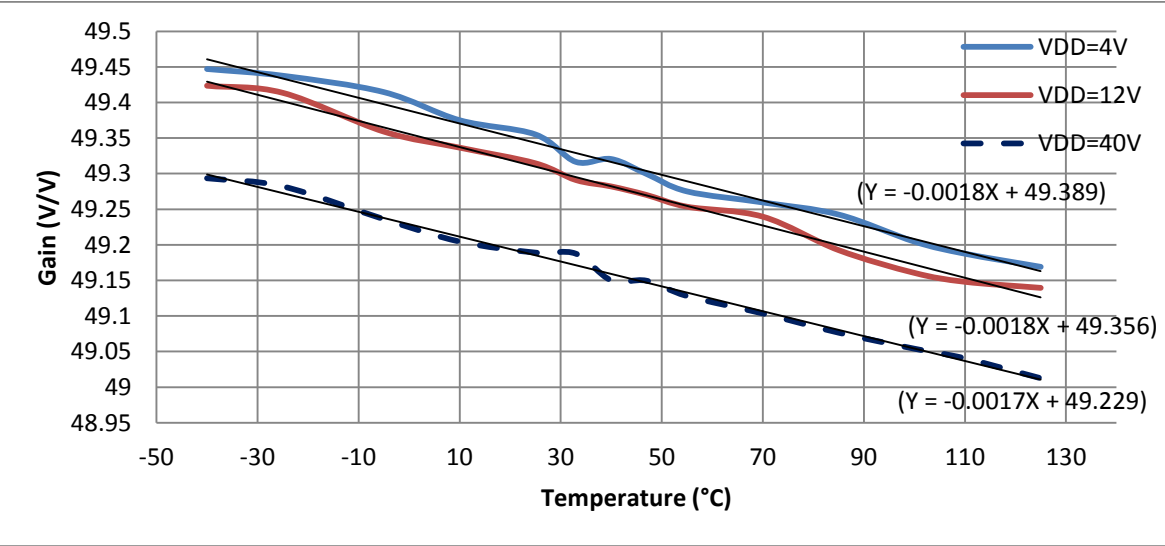


Figure 4: Gain vs Temperature

## Operational Modes

The TS94033 is a low power, low offset high-side chopper-stabilized current sense amplifier. The amplifier is supplied on the high-side from the VDD pin and a sub-regulated supply that is generated at the VDDR pin. It is necessary for good supply rejection to have a bypass capacitor,  $C_{VDDR}$  closely-coupled between the VDD and VDDR pins.

The INP and INM pins are used to sense the voltage drop across a current-sensing resistor. Though it is usually the case that the INP pin would be connected to the VDD pin, the common-mode voltage can extend above and below VDD as specified by the  $V_{CM}$  parameter.

The EN pin may be used to set the device into a low-quiescent current mode when asserted low.

A zero-current output offset is set by providing a bias voltage on the VOS\_REF pin. The zero-current offset voltage can be determined by the following relation:

$$V_{OS} = 0.065152 * V_{OS\_REF}$$

The output voltage at the VOUT pin is referenced to the VSS pin. The VSS pin should be closely coupled to the circuit monitoring this voltage. The VOS\_REF should be bypassed to this VSS as well.

## Application Schematic

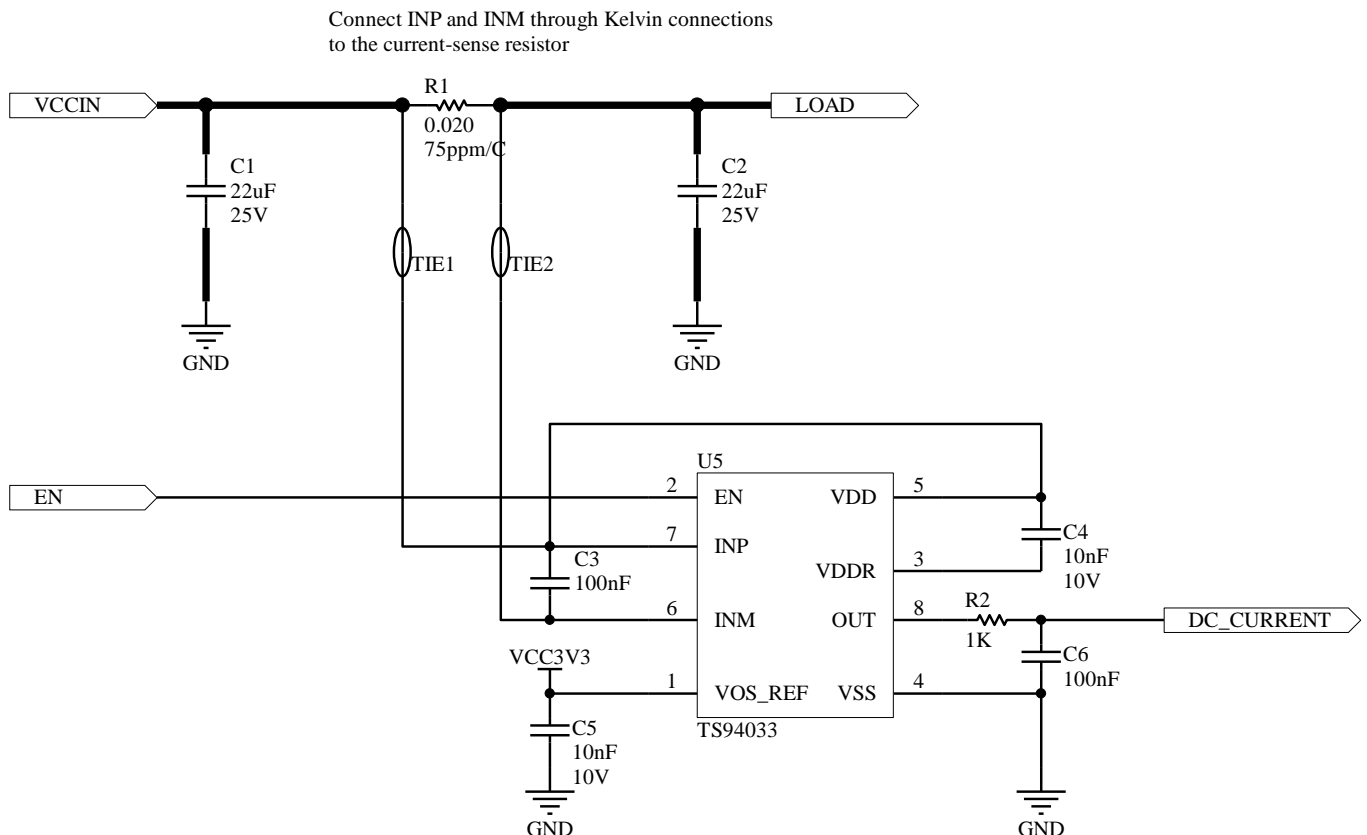
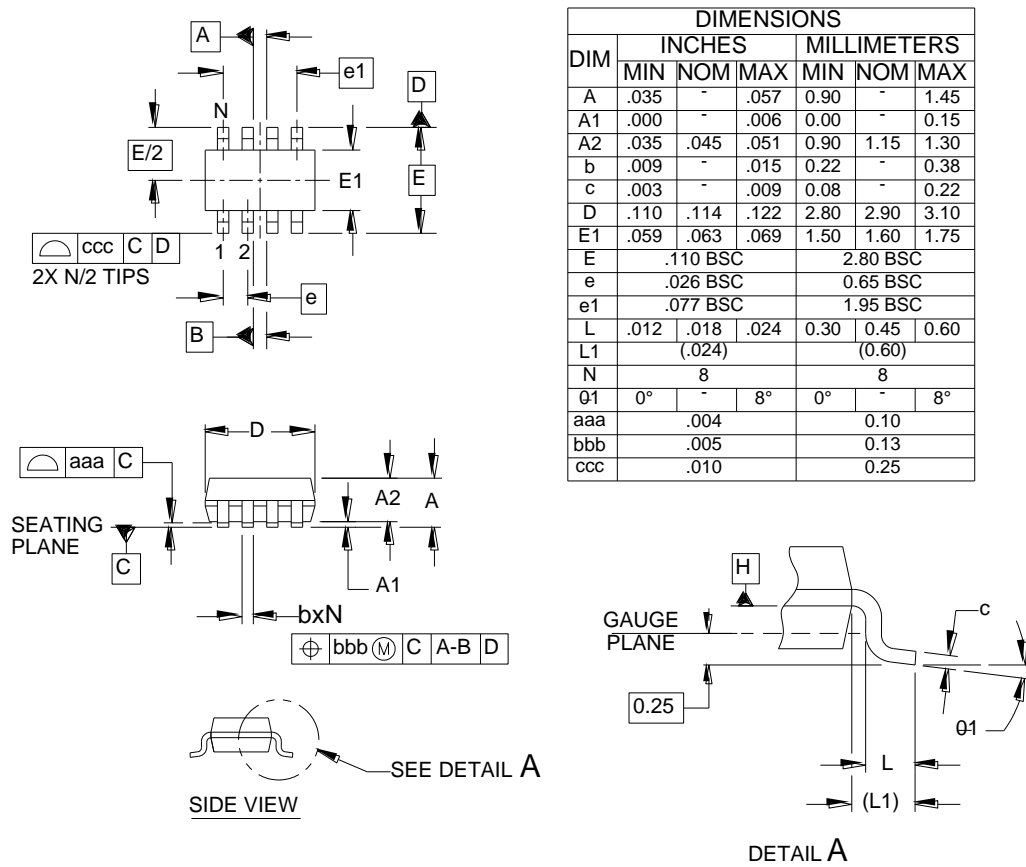


Figure 5: Standard Configuration

## Package Information



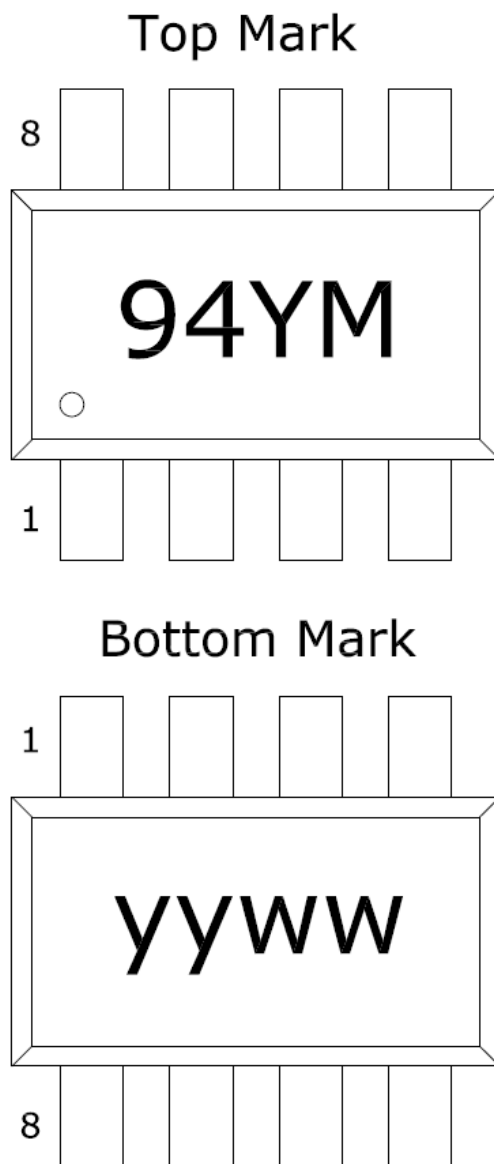
### NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. DATUMS **-A-** AND **-B-** TO BE DETERMINED AT DATUM PLANE **-H-**
3. DIMENSIONS "E1" AND "D" DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
4. REFERENCE JEDEC STD MO-178, VARIATION BA.

**Figure 6: Package Outline Drawing**

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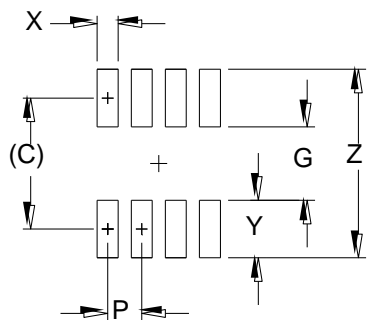
## Package Information (continued)



Top Mark:  
94YM = Product Marking

Bottom Mark:  
yy = year  
ww = week

**Figure 7: Device Symbolization**



DIMENSIONS		
DIM	INCHES	MILLIMETERS
C	(.098)	(2.50)
G	.055	1.40
P	.026	0.65
X	.016	0.40
Y	.043	1.10
Z	.142	3.60

**NOTES:**

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.

**Figure 8: Recommended Board Layout Land Pattern**

## Ordering Information

Device Part Number	Description	8-pin SOT-23 Package
TS94033SKTRC	Current Sense Amplifier	Tape & Reel (3000 parts/reel)



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## Contact Information

Semtech Corporation  
200 Flynn Road, Camarillo, CA 93012  
Phone: (805) 498-2111, Fax: (805) 498-3804  
[www.semtech.com](http://www.semtech.com)