Contents

1 Pin description

Table 2. SO-8 pinout

Name	Pin no.	Type	Function
V_{ref}	1	Analog output	Voltage reference
Cc-	2	Analog input	Input pin of the operational amplifier
Cc+	3	Analog input	Input pin of the operational amplifier
Cv-	4	Analog input	Input pin of the operational amplifier
Cvout	5	Analog output	Output of the operational amplifier
GND	6	Power supply	Ground line. 0 V reference for all voltages.
Ccout	7	Analog output	Output of the operational amplifier
VCC	8	Power supply	Power supply line.

2 Absolute maximum ratings

Table 3. Absolute maximum ratings

Symbol	DC supply voltage	Value	Unit
VCC	DC supply voltage (50 mA =< I_{CC})	-0.3 V to Vz	V
Vi	Input voltage	-0.3 to VCC	V
Tstg	Storage temperature	-55 to 150	°C
Tj	Junction temperature	150	°C
Iref	Voltage reference output current	10	mA
ESD	Electrostatic discharge	2	KV
Rthja	Thermal resistance junction to ambient SO-8 package	175	°C/W

3 Operating conditions

Table 4. Operating conditions

Symbol	Parameter	Value	Unit
VCC	DC supply conditions	4.5 to Vz	V
Toper	Operational temperature	0 to 105	°C

4 Electrical characteristics

T_{amb} = 25 °C and VCC = +18 V (unless otherwise specified).

Table 5. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Total current consumption						
I_{CC}	Total supply current, excluding current in voltage reference	VCC = 18 V, no load $T_{min.} < T_{amb} < T_{max.}$			1	mA
Vz	VCC clamp voltage	I_{CC} = 50 mA		28		V
Operator 1: Op Amp with non-inverting input connected to the internal V_{Ref}						
$V_{Ref} + V_{io}$	Input offset voltage + voltage reference TSM1013 TSM1013A	T_{amb} = 25 °C $T_{min.} \leq T_{amb} \leq T_{max.}$ T_{amb} = 25 °C $T_{min.} \leq T_{amb} \leq T_{max.}$		 2.5446 2.545	2.574 2.575 2.553 2.560	V
DV_{io}	Input offset voltage drift			7		µV/°C
Operator 2						
V_{io}	Input offset voltage TSM1013 TSM1013A	T_{amb} = 25 °C $T_{min.} \leq T_{amb} \leq T_{max.}$ T_{amb} = 25 °C $T_{min.} \leq T_{amb} \leq T_{max.}$		 1 0.5	4 5 2 3	mV
DV_{io}	Input offset voltage drift			7		µV/°C
I_{io}	Input offset current	T_{amb} = 25 °C $T_{min.} \leq T_{amb} \leq T_{max.}$		2	30 50	nA
I_{ib}	Input bias current	T_{amb} = 25 °C $T_{min.} \leq T_{amb} \leq T_{max.}$		20 50	150 200	nA
SVR	Supply voltage rejection ration	VCC = 4.5 V to 28 V	65	100		dB
Vicm	Input common mode voltage range		0		VCC -1.5	V
CMR	Common mode rejection ratio	T_{amb} = 25 °C $T_{min.} \leq T_{amb} \leq T_{max.}$	70 60	85		dB
Output stage						
Gm	Transconduction gain. Sink current only.(1)	T_{amb} = 25 °C $T_{min.} \leq T_{amb} \leq T_{max.}$	1	3.5 2.5		mA/mV
Vol	Low output voltage at 10 mA sinking current			200	600	mV
Ios	Output short-circuit current. Output to VCC. Sink current only.	T_{amb} = 25 °C $T_{min.} \leq T_{amb} \leq T_{max.}$		27	50	mA

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Voltage reference						
V_{Ref}	Reference input voltage, Iload = 1 mA TSM1013 1% precision TSM1013A 0.5% precision	T_{amb} = 25 °C	2.519 2.532	2.545	2.57 2.557	V
ΔV_{Ref}	Reference input voltage deviation over the temperature range	$T_{min.} \leq T_{amb} \leq T_{max.}$		20	30	mV
RegLine	Reference input voltage deviation over the VCC range	Iload = 5 mA			20	mV
RegLoad	Reference input voltage deviation over the output current	VCC = 18 V, 0 < Iload < 10 mA			10	mV

1. The current depends on the difference voltage between the negative and the positive inputs of the amplifier. If the voltage on the minus input is 1 mV higher than the positive amplifier, the sinking current at the output OUT will be increased by 3.5 mA.

5 Internal schematics

Figure 2. Internal schematic

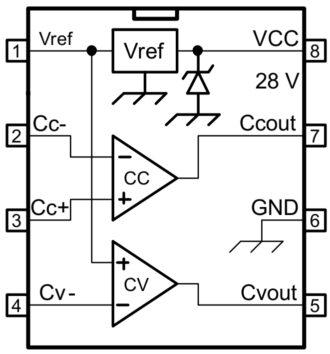
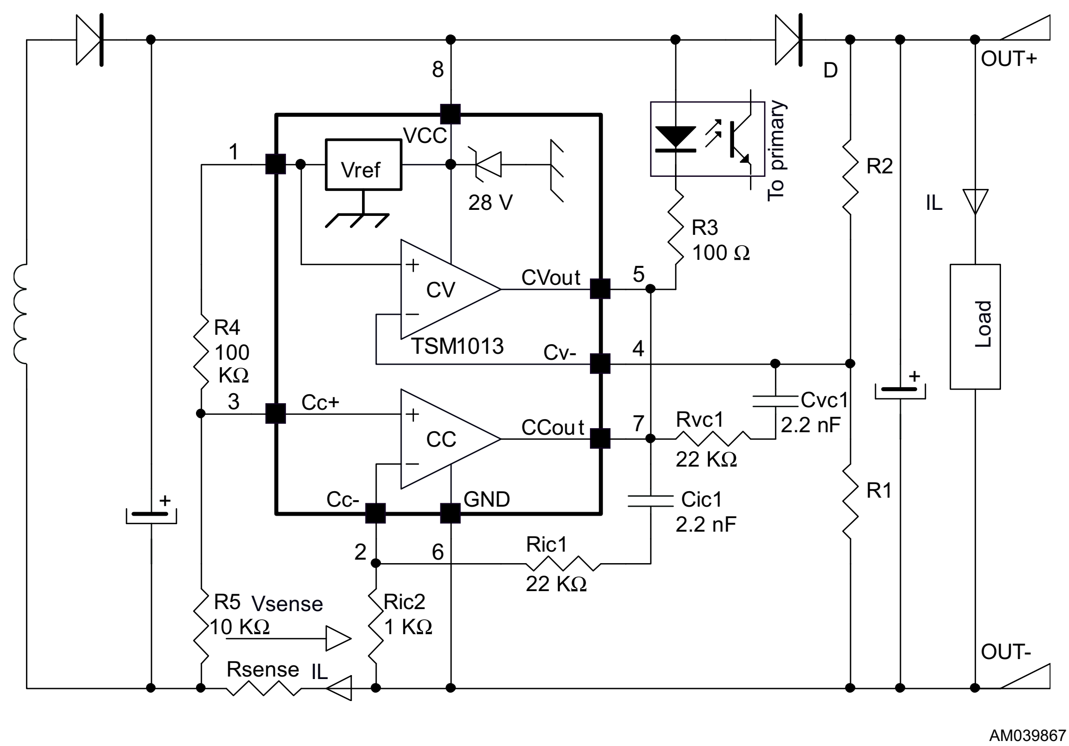


Figure 3. Typical adapter application using TSM1013



In the application schematic in *Figure 3*, the TSM1013 is used on the secondary side of a flyback adapter (or battery charger) to provide accurate control of the voltage and current. The above feedback loop is made with an optocoupler.

6 Principle of operation and application hints

6.1 Voltage and current control

6.1.1 Voltage control

The voltage loop is controlled via a first transconductance operational amplifier, the resistor bridge R_1, R_2, and the optocoupler which is directly connected to the output.

The relation between the values of the R_1 and R_2 should be chosen as written in *Equation 1*.

Equation 1

$$R_1 = R_2 \times V_{ref} / (V_{out} - V_{ref})$$

Where V_{out} is the desired output voltage.

To avoid the discharge of the load, the resistor bridge R_1, R_2 should be highly resistive. For this type of application, a total value of 100 KΩ (or more) would be appropriate for the resistors R_1 and R_2.

As an example, with R_2 = 100 KΩ , V_{out} = 4.10 V, V_{ref} = 2.5 V, then R_1 = 41.9 KΩ.

Note that if the low drop diode should be inserted between the load and the voltage regulation resistor bridge to avoid current flowing from the load through the resistor bridge, this drop should be taken into account in *Equation 1* by replacing V_{out} by (V_{out} + V_{drop}).

6.1.2 Current control

The current loop is controlled via the second transconductance operational amplifier, the sense resistor R_{sense}, and the optocoupler.

The V_{sense} threshold is achieved externally by a resistor bridge tied to the V_{ref} voltage reference. Its middle point is tied to the positive input of the current control operational amplifier, and its foot is to be connected to the lower potential point of the sense resistor as shown in *Figure 4*. The resistors of this bridge are matched to provide the best precision possible.

The control equation verifies:

Equation 2

$$R_{sense} \times I_{lim} = V_{sense}$$

$$V_{sense} = R_5 \times V_{ref} / (R_4 + R_5)$$

Equation 3

$$I_{lim} = R_5 \times V_{ref} / (R_4 + R_5) \times R_{sense}$$

where I_{lim} is the desired limited current, and V_{sense} is the threshold voltage for the current control loop.

Note that the R_{sense} resistor should be chosen taking into account the maximum dissipation (P_{lim}) through it during the full load operation.

Equation 4

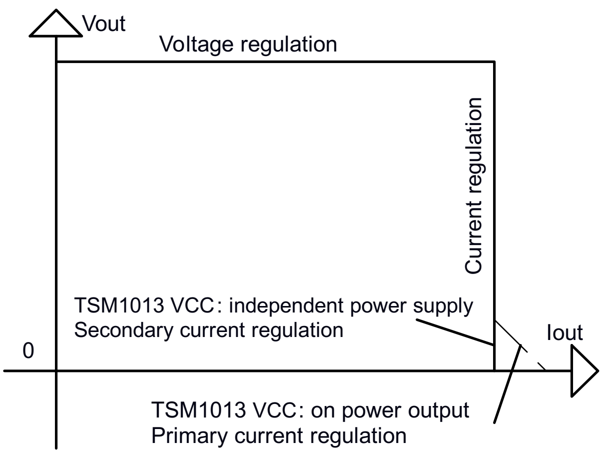
$$P_{lim} = V_{sense} \times I_{lim}$$

Therefore, for most adapter and battery charger applications, a quarter-watt, or half-watt resistor to make the current sensing function is sufficient.

The current sinking outputs of the two transconductance operational amplifiers are common (to the output of the IC). This makes an ORing function which ensures that whenever the current or the voltage reaches too high values, the optocoupler is activated.

The relation between the controlled current and the controlled output voltage can be described with a square characteristic as shown in the following V/I output power graph.

Figure 4. Output voltage versus output current



6.2 Compensation

The voltage control transconductance operational amplifier can be fully compensated. Both of its output and negative input are directly accessible for external compensation components.

An example of a suitable compensation network is shown in *Figure 3*. It consists of a capacitor C_{vc1} = 2.2 nF and a resistor R_{cv1} = 22 KΩ in series.

The current control transconductance operational amplifier can be fully compensated. Both of its output and negative input are directly accessible for external compensation components.

An example of a suitable compensation network is shown in *Figure 3*. It consists of a capacitor C_{ic1} = 2.2 nF and a resistor R_{ic1} = 22 KΩ in series.

6.3 Start-up and short-circuit conditions

Under start-up or short-circuit conditions the TSM1013 device is not provided with a high enough supply voltage. This is due to the fact that the chip has its power supply line in common with the power supply line of the system.

Therefore, the current limitation can only be ensured by the primary PWM module, which should be chosen accordingly.

If the primary current limitation is considered not to be precise enough for the application, then a sufficient supply for the TSM1013 has to be ensured under any condition. It would then be necessary to add some circuitry to supply the chip with a separate power line. This can be achieved in numerous ways, including an additional winding on the transformer.

6.4 Voltage clamp

The schematic in *Figure 5* shows how to realize a low-cost power supply for the TSM1013 (with no additional windings). Please pay attention to the fact that in the particular case presented here, this low-cost power supply can reach voltages as high as twice the voltage of the regulated line. Since the absolute maximum rating of the TSM1013 supply voltage is 28 V. In the aim to protect the TSM1013 device against such high voltage values an internal Zener clamp is integrated.

Equation 5

$$R_{limit} = (VCC - V_Z) \times I_{vz}$$

Figure 5. Clamp voltage

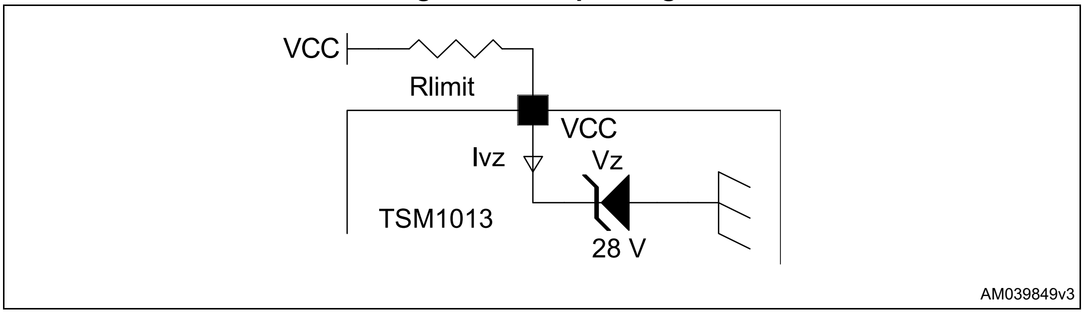
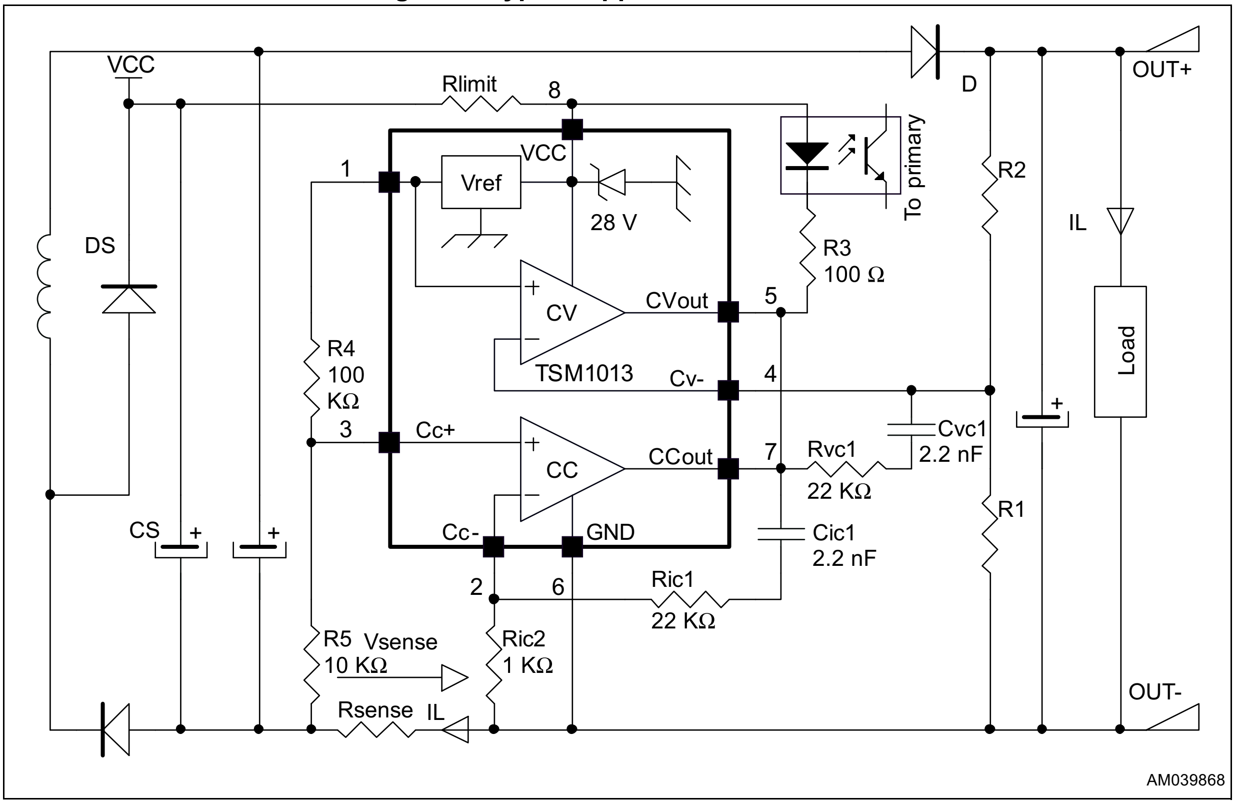


Figure 6. Typical application schematic



7 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

7.1 SO-8 package information

Figure 7. SO-8 package outline

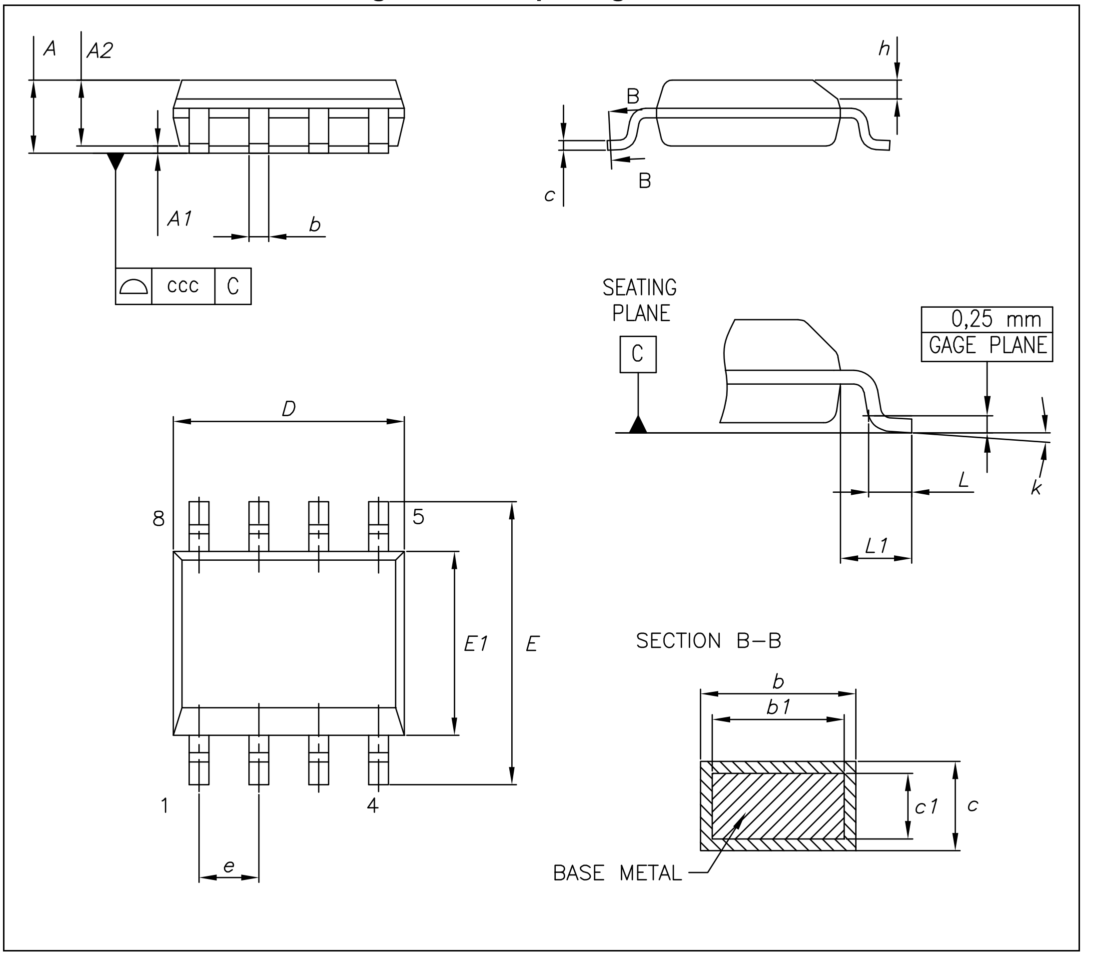


Table 6. SO-8 package mechanical data

Symbol	Dimensions (mm)		
	Min.	Typ.	Max.
A			1.75
A1	0.10		0.25
A2	1.25		
b	0.28		0.48
c	0.17		0.23
D(1)	4.80	4.90	5.00
E	5.80	6.00	6.20
E1(2)	3.80	3.90	4.00
e		1.27	
h	0.25		0.50
L	0.40		1.27
L1		1.04	
k	0°		8°
ccc			0.10

1. Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 mm in total (both sides).
2. Dimension “E1” does not include interlead flash or protrusions. Interlead flash or protrusions shall not exceed 0.25 mm per side.

8 Revision history

Table 7. Document revision history

Date	Revision	Changes
01-Feb-2004	1	Initial release.
15-Apr-2016	2	Removed Mini SO8 package from the whole document. Updated *Section 7: Package information on page 11* (replaced *Figure 6 on page 10* by new figure, updated *Table 6 on page 12*). Minor modifications throughout document.