TAIWAN SEMICONDUCTOR

RoHS COMPLIANCE

# TS1051

## Constant Voltage and Constant Current Controller For Battery Chargers and Adaptors

**SOT-26**


**Pin Definition:**
1. $V_{CTRL}$ 6. $V_{CC}$
2. $V_{ND}$ 5, $V_{SENSE}$
3. Out 4. $I_{CTRL}$

**SOP-8**


**Pin Definition:**
1. $V_{CTRL}$ 8. $V_{ND}$
2. $V_{CC}$ 7, Out
3. $V_{SENSE}$ 6. $I_{CTRL}$
4. N.C 5. N.C

## General Description

TS1051 is a highly integrated solution for SMPS applications requiring CV (constant voltage) and CC (constant current) mode. TS1051 integrated one voltage reference, two operational amplifiers, and a current sensing circuit. The voltage reference combined with one operational amplifier make it an ideal voltage controller, and the other low voltage reference combined with the other operational amplifier make it an ideal current limiter for output low side current sensing.

The current threshold is fixed, and precise. The only external components are:

* A resistor bridge to be connected to the output of the power supply (Adapter, battery charger) to set the voltage regulation by dividing the desired output voltage to match the internal voltage reference value.
* A sense resistor having a value and allowable dissipation power which need to be chosen according to the internal voltage threshold.

## Features

- Constant Voltage and Constant Current Control
- Low Voltage Operation
- Precision Internal Voltage Reference
- Low External Component Count
- Current Sink Output Stage
- Easy Compensation
- Low AC Mains Voltage Rejection

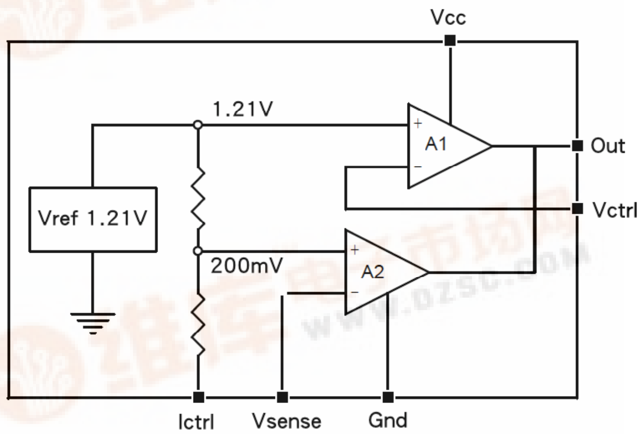
## Application

- Battery Charger
- Adapters

## Ordering Information

| Part No. | Package | Packing |
|---|---|---|
| TS1051CX6 RF | SOT-26 | 3Kpcs / 7" Reel |
| TS1051CS RL | SOP-8 | 2.5Kpcs / 13" Reel |

## Block Diagram




## Pin Function Description

| Name | Type | Function |
|---|---|---|
| $V_{CTRL}$ | Analog Input | Input Pin of the Voltage Control Loop |
| $V_{ND}$ | Power Supply | Ground Line. 0V Reference For All Voltage |
| Out | Current Sink Output | Output Pin. Sinking Current Only |
| $I_{CTRL}$ | Analog Input | Input Pin of the Current Control Loop |
| $V_{SENSE}$ | Analog Input | Input Pin of the Current Control Loop |
| $V_{CC}$ | Power Supply | Position Power Supply Line |

## Absolute Maximum Rating

| Parameter | | Symbol | Value | Unit |
|---|---|---|---|---|
| DC Supply Voltage | | $V_{CC}$ | 14 | V |
| Input Voltage | | $V_{IN}$ | -0.3 to $V_{CC}$ | V |
| Operating Temperature | | $T_{OP}$ | 0 to +85 | $^{o}C$ |
| Maximum Junction Temperature Range | | $T_J$ | 150 | $^{o}C$ |
| Thermal Resistance Junction to Ambient | SOP-8 | Rθja | 130 | $^{o}C/W$ |
| | SOT-26 | | 250 | $^{o}C/W$ |

## Operating Condition

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| DC Supply Voltage | $V_{CC}$ | 2.5 to 12 | V |

## Electrical Specifications (Ta=25 $^{o}C$, $V_{IN}$=5V unless otherwise noted)

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Total Current Consumption** | | | | | |
| Total Supply Current – not taking the output sinking current into account | $I_{CC}$ | -- | 1.1 | 2 | mA |
| **Voltage Control Loop** | | | | | |
| Trans-conduction Gain (Vctrl) sink Current Only (Note 1) | $G_{MW}$ | 1 | 3.5 | -- | mA/mV |
| Voltage Control Loop Reference (Note 2) | $V_{REF}$ | 1.198 | 1.21 | 1.222 | V |
| Input Bias Current (Vctrl) | $I_{IBV}$ | -- | 50 | -- | nA |
| **Current Control Loop** | | | | | |
| Trans-conduction Gain (Ictrl) sink Current only (Note 3) | $G_{MI}$ | 1.5 | 7 | -- | mA/mV |
| Current Control Loop Reference, (Note 4) $I_{OUT}$=2.5A, | $V_{SENSE}$ | 196 | 200 | 204 | mV |
| Current Out of Pin Ictrl at – 200mV | $I_{IBI}$ | -- | 25 | -- | µA |
| **Output Stage** | | | | | |
| Low Output Voltage at 10mA sinking Current | $V_{OL}$ | -- | 200 | -- | mV |
| Output Short Circuit Current. Output to $V_{CC.}$ Sink Current Only | $I_{OS}$ | -- | 27 | 50 | mA |

Note:

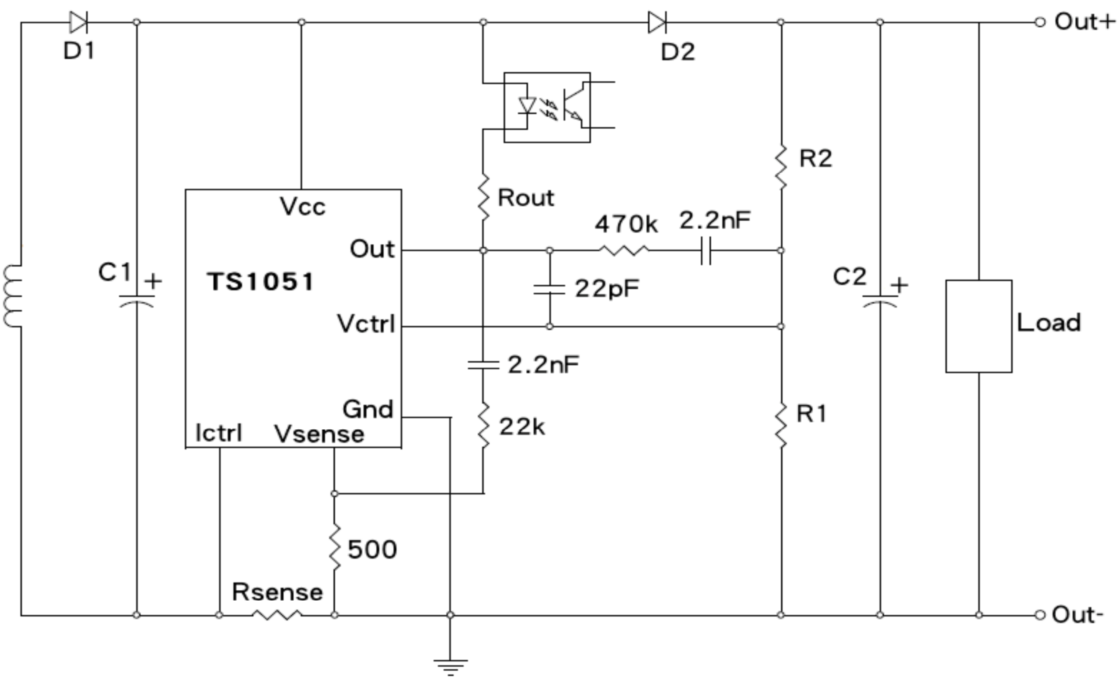
1: If the Voltage on Vctrl (the negative input of the amplifier) is higher than the positive amplifier input (Vref-1.21V), and it is increased by 1mV, the sinking current at the output will be increased by 3.5mA.

2: The internal Voltage reference is set at 1.21V (bandgap reference). The voltage control loop precision takes into account the cumulative effects of the internal voltage reference deviation as well as the input offset voltage of the trans-conductance operational amplifier. The internal voltage reference is fixed by bandgap, and trimmed to 0.5% accuracy at room temperature.

3: When the positive input at Ictrl is lower than -200mV, and the voltage is decreased by 1mV, the sinking current at the output will be increased by 7mA

4: The internal current sense threshold is set to -200mV. The current control loop precision takes into account the cumulative effects of the internal voltage reference deviation as well as the input offset voltage of the trans-conduction operational amplifier

## Typical Adapter or Battery Charger Application Circuit




* In the above application schematic, the TS1051 is used on the secondary side of a fly-back adapter (or battery charger) to provide an accurate control of voltage and current. The above feedback loop is made with an optocoupler.

## Principle of Operation and Application Hints

**Voltage Control**

The voltage loop is controlled via a first trans-conductance operational amplifier, the resistor bridge R1, R2, and the optocoupler which is directly connected to the output.

The relation between the values of R1 & R2 should be chosen as following:

***R1=R2 x Vref / (Vout-Vref)**

Where Vout is the desired output voltage.

To Avoid the discharge of the load, the resistor bridge R1 & R2 should be highly resistive. For this type of application, a total value of 100KΩ (or more) would be appropriate for the resistors R1 & R2. As an example, with R2=100KΩ, Vout=4.10V, Vref=1.21V, then R1=41.9KΩ.

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 into the above calculations by replacing Vout by (Vout + Vdrop).

## Principle of Operation and Application Hints (continues)

**Current Control**

The current loop is controlled via the second trans-conductance operational amplifier, the sense resistor Rsense, and the optocoupler. The control verifies as following

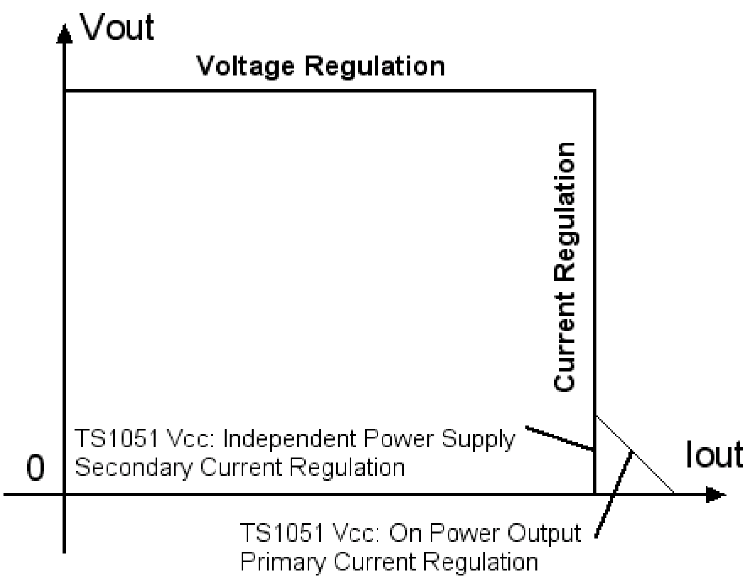
*** Rsense x Ilim = Vsense**

*** Rsense = Vsense / Ilim**

Ilim is the desired limited current, Vsense is the threshold voltage for the current control loop.
As an example, with Ilim = 1A, Vsense = -200mV, then Rsense = 200mΩ.
Note that the Rsense resistor should be chosen taking into account the maximum dissipation (Plim) through it during full load operation.

*** Plim = Vsense x Ilim**

As an example, with Ilim=1A, and Vsense=200mV, Plim=200mW.
Therefore, for most adapter and battery charger applications, a quarter-watt, or half-watt resistor to make the current sensing function is sufficient.
Vsense threshold is achieved internally by a resistor bridge tied to the Vref 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 lower potential point of the senseresistor as shown on the following figure. The resistors of this bridge are matched to provide the best precision possible. The current siking outpits of the two trans-conductance operational amplifiers are common (to the outpit 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




**Output Voltage vs. Output Current**

## Principle of Operation and Application Hints (continues)

### Compensation

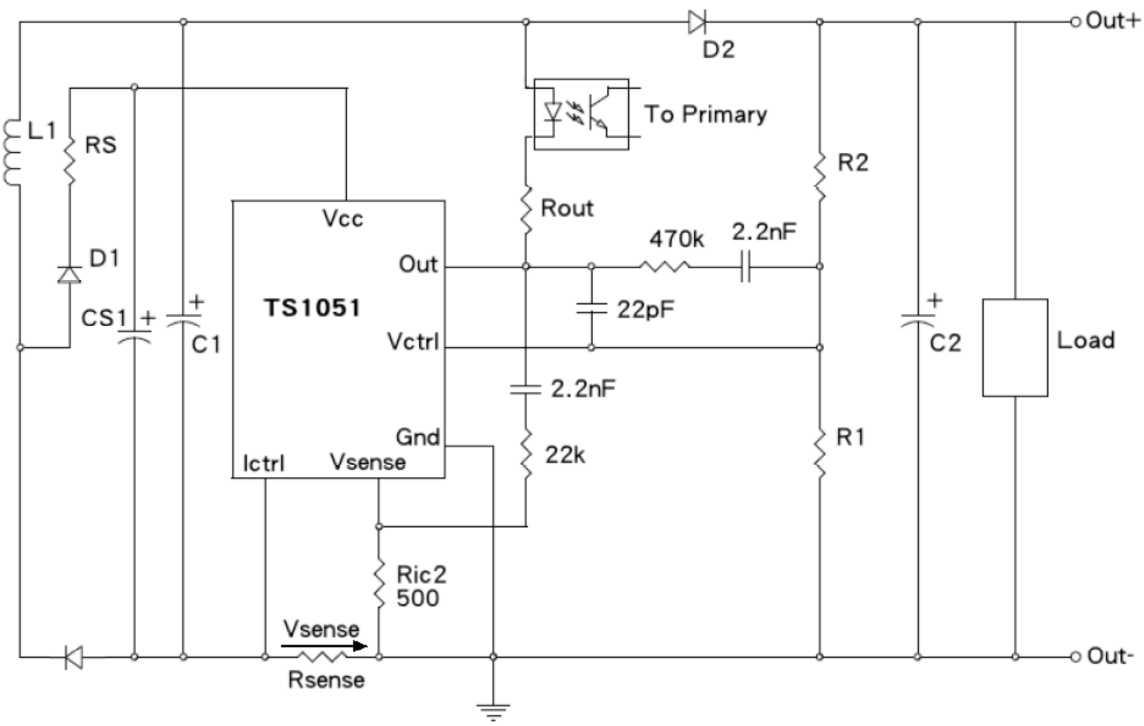
The voltage control trans-conductance operational amplifier can be fully compensated. Both of its output and negative input are directly accessible for external compensation components.

And example of a suitable compensation network is shown in typical application circuit. It consists of a capacitor Cvc1=2.2nF and a resistor Rcv1=470KΩ in series, connected in parallel with another capacitor Cvc2=22pF.

The current control trans-conductance operational amplifier can be fully compensated. Both of its output and negative input are directly accessible for external compensation components. An example of suitable compensation network is shown in typical application circuit. It consists of a capacitor Cic1=2.2nF and resistor Ric1=22KΩ in series. When the Vcc voltage reaches 12V it could be interesting to limit the current coming through the output in the aim to reduce the dissipation of the device and increase the stability performances of the whole application. An example of suitable Rout value could be 330Ω in series with the optocoupler in case Vcc=12V.

### Start Up and Short Circuit Conditions

The TS1051 is not provided with a high enough supply voltage in under start-up or short-circuit conditions. 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 TS1051 has to be ensured under any condition. It would then be necessary to add some circuitry to supply the chip with separate power line. This can be achieved in numerous ways, including an additional winding on the transformer. The following schematic shows how to realize a low-cost power supply for the TS1051 (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 TS1051 supply voltage is 14V, this low-cost auxiliary power supply can only be used in applications where the regulated line voltage does not exceed 7V.



## Electrical Characteristics Curve

**FIGURE 1 – Vref vs Ambient Temperature**

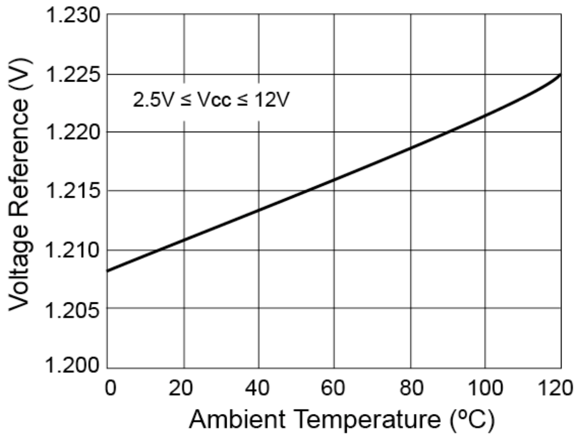



**FIGURE 2 – Vsense vs Ambient Temperature**

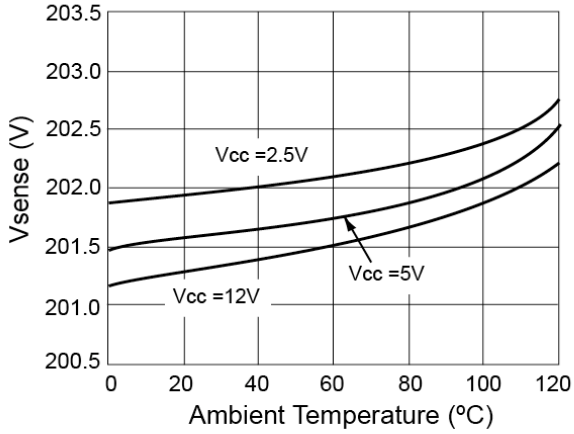



**FIGURE 3 – Vsense Input Bias Current vs. Ambient Temperature**

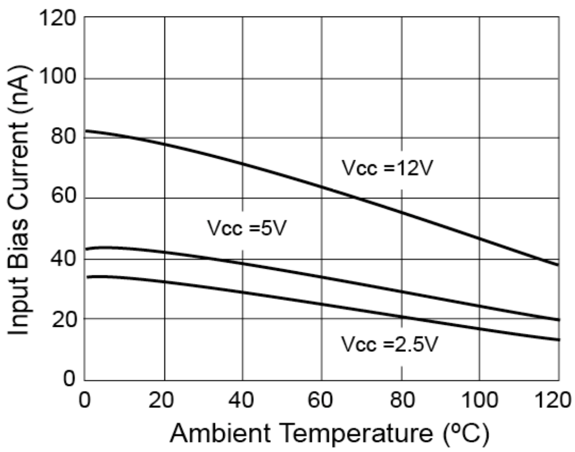



**FIGURE 4 – Ictrl Input Bias Current vs. Ambient Temperature**

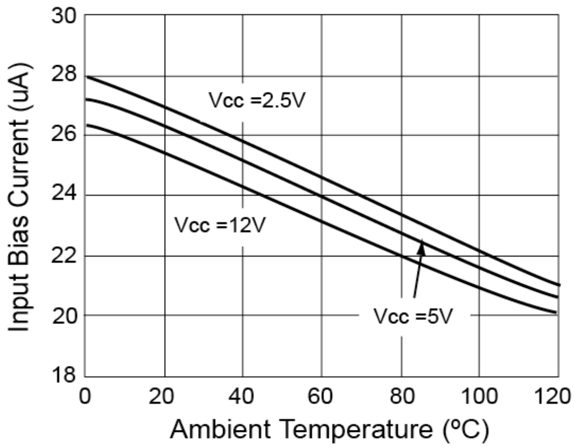



**FIGURE 5 – Output Short Circuit Current vs. Ambient Temperature**

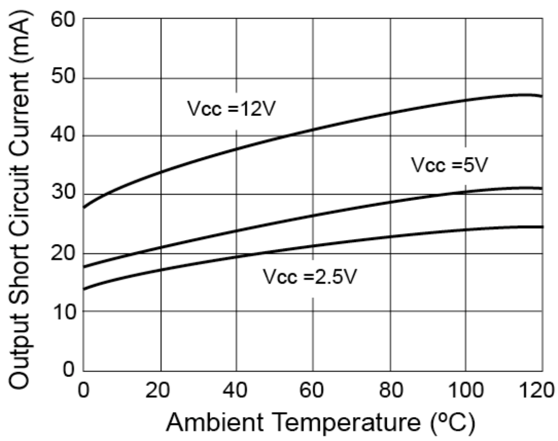
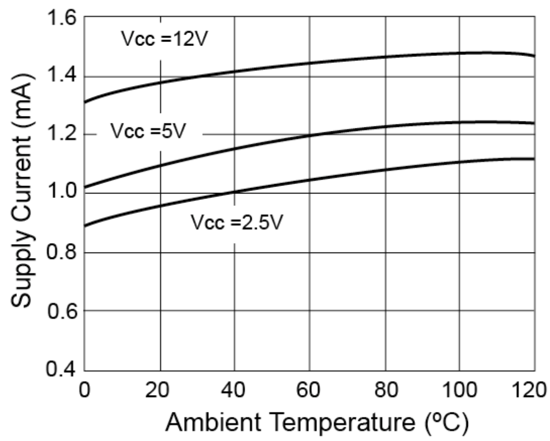



**FIGURE 6 – Supply Current vs. Ambient Temperature**



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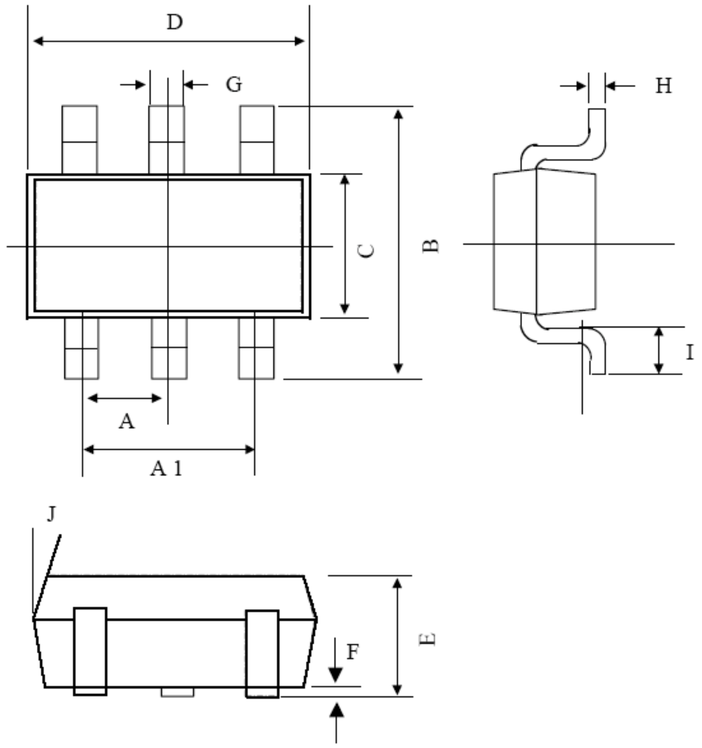
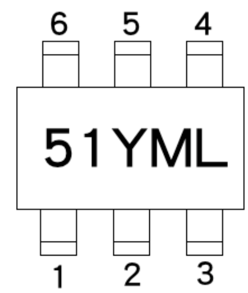
## SOT-26 Mechanical Drawing




| SOT-26 DIMENSION | | | | | | |
|---|---|---|---|---|---|---|
| DIM | MILLIMETERS | | | INCHES | | |
| | MIN | TYP | MAX | MIN | TYP | MAX |
| A | 0.95 BSC | | | 0.0374 BSC | | |
| A1 | 1.9 BSC | | | 0.0748 BSC | | |
| B | 2.60 | 2.80 | 3.00 | 0.1024 | 0.1102 | 0.1181 |
| C | 1.40 | 1.50 | 1.70 | 0.0551 | 0.0591 | 0.0669 |
| D | 2.80 | 2.90 | 3.10 | 0.1101 | 0.1142 | 0.1220 |
| E | 1.00 | 1.10 | 1.20 | 0.0394 | 0.0433 | 0.0472 |
| F | 0.00 | -- | 0.10 | 0.00 | | 0.0039 |
| G | 0.35 | 0.40 | 0.50 | 0.0138 | 0.0157 | 0.0197 |
| H | 0.10 | 0.15 | 0.20 | 0.0039 | 0.0059 | 0.0079 |
| I | 0.30 | -- | 0.60 | 0.0118 | -- | 0.0236 |
| J | 5º | -- | 10º | 5º | -- | 10º |

## Marking Diagram




**51** = Device Code
**Y** = Year Code
**M** = Month Code
(**A**=Jan, **B**=Feb, **C**=Mar, **D**=Apl, **E**=May, **F**=Jun, **G**=Jul, **H**=Aug, **I**=Sep, **J**=Oct, **K**=Nov, **L**=Dec)
**L** = Lot Code

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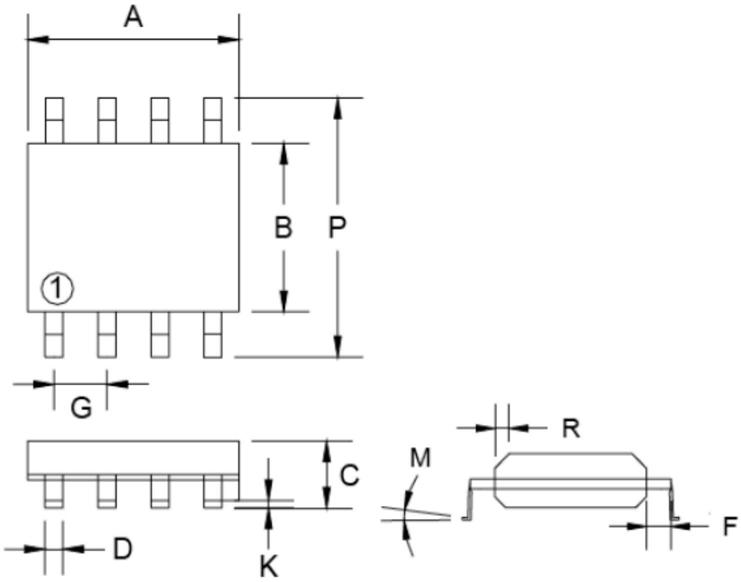
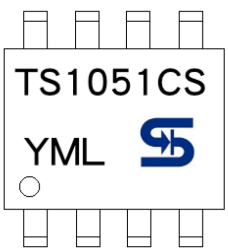
## SOP-8 Mechanical Drawing




| SOP-8 DIMENSION | | | | |
|---|---|---|---|---|
| DIM | MILLIMETERS | | INCHES | |
| | MIN | MAX | MIN | MAX. |
| A | 4.80 | 5.00 | 0.189 | 0.196 |
| B | 3.80 | 4.00 | 0.150 | 0.157 |
| C | 1.35 | 1.75 | 0.054 | 0.068 |
| D | 0.35 | 0.49 | 0.014 | 0.019 |
| F | 0.40 | 1.25 | 0.016 | 0.049 |
| G | 1.27BSC | | 0.05BSC | |
| K | 0.10 | 0.25 | 0.004 | 0.009 |
| M | 0º | 7º | 0º | 7º |
| P | 5.80 | 6.20 | 0.229 | 0.244 |
| R | 0.25 | 0.50 | 0.010 | 0.019 |

## Marking Diagram

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