



# TSM103W

## Dual Operational Amplifier and Voltage Reference

### OPERATIONAL AMPLIFIER

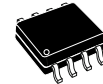
- **LOW INPUT OFFSET VOLTAGE** : 0.5mV typ.
- **LOW SUPPLY CURRENT** : 350 $\mu$ A/op. (@  $V_{CC} = 5V$ )
- **MEDIUM BANDWIDTH** (unity gain) : 0.9MHz
- **LARGE OUTPUT VOLTAGE SWING** : 0V to ( $V_{CC} - 1.5V$ )
- **INPUT COMMON MODE VOLTAGE RANGE INCLUDES GROUND**
- **WIDE POWER SUPPLY RANGE** : 3 to 32V  $\pm 1.5$  TO  $\pm 16V$
- **1.5kV ESD PROTECTION**
- **VOLTAGE REFERENCE**
- **FIXED OUTPUT VOLTAGE REFERENCE 2.5V**
- **$\pm 0.4\%$  OR  $\pm 0.7\%$  VOLTAGE PRECISION**
- **SINK CURRENT CAPABILITY** : 1 to 100mA
- **TYPICAL OUTPUT IMPEDANCE** : 0.2 $\Omega$

### DESCRIPTION

The TSM103W is a monolithic IC that includes one independent op-amp and another op-amp for which the non-inverting input is wired to a 2.5V fixed Voltage Reference. This device offers both space and cost savings in many applications such as power supply management or data acquisition systems.

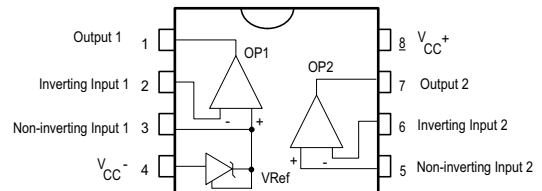
### ORDER CODE

| Part Number | Temperature Range | Package | Packaging   |
|-------------|-------------------|---------|-------------|
| TSM103WID   | -40, +105°C       | SO-8    | Tube        |
| TSM103WIDT  |                   |         | Tape & Reel |
| TSM103WAID  |                   |         | Tube        |
| TSM103WAIDT |                   |         | Tape & Reel |



**D**  
**SO-8**  
(Plastic Micropackage)

### PIN CONNECTIONS (top view)



**1 ABSOLUTE MAXIMUM RATINGS**

| Symbol     | Parameter                                           | Value                     | Unit |
|------------|-----------------------------------------------------|---------------------------|------|
| $V_{CC}$   | Supply Voltage                                      | 36                        | V    |
| $V_{id}$   | Differential Input Voltage                          | $V_{CC} + 0.6$            | V    |
| $V_i$      | Input VoltageL                                      | $-0.3$ to $V_{CC} + 0.3V$ | V    |
| $T_{stg}$  | Storage temperature range                           | $-65$ to $+150$           | °C   |
| $I_k$      | Continuous cathode current range                    | $-100$ to $150$           | mA   |
| $T_J$      | Maximum Junction Temperature                        | 150                       | °C   |
| $R_{thja}$ | Thermal Resistance Junction to Ambient (SO package) | 175                       | °C/W |
| $T_l$      | Maximum Lead Temperature (10 seconds maximum)       | 260                       | °C   |
| ESD        | Electrostatic Discharge Protection                  | 1.5                       | kV   |

**OPERATING CONDITIONS**

| Symbol     | Parameter                            | Value                            | Unit |
|------------|--------------------------------------|----------------------------------|------|
| $V_{CC}$   | DC Supply Conditions                 | 3 to 32                          | V    |
| $I_k$      | Vref Cathode Current                 | 1 to 100                         | mA   |
| $T_{oper}$ | Operating Free-air Temperature Range | $-40^{\circ}C$ , $+105^{\circ}C$ | °C   |

## 2 ELECTRICAL CHARACTERISTICS

| Symbol   | Parameter                                                                                                                                                                                                                                                       | Min. | Typ. | Max.     | Unit |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|----------|------|
| $I_{CC}$ | Total Supply Current, excluding Current in the Voltage Reference<br>V <sub>CC</sub> + = 5V, no load<br>T <sub>min.</sub> < T <sub>amb</sub> < T <sub>max.</sub><br>V <sub>CC</sub> + = 30V, no load<br>T <sub>min.</sub> < T <sub>amb</sub> < T <sub>max.</sub> |      | 0.7  | 1.2<br>2 | mA   |

**OPERATOR 2** (independent op-amp)V<sub>CC</sub><sup>+</sup> = +5V, V<sub>CC</sub> = Ground, V<sub>o</sub> = 1.4V, T<sub>amb</sub> = 25°C (unless otherwise specified)

| Symbol           | Parameter                                                                                                                                                                                                                                                                                | Min.                 | Typ.     | Max.                                                                       | Unit     |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------|----------------------------------------------------------------------------|----------|
| $V_{io}$         | Input Offset Voltage<br>V <sub>icm</sub> = 0V<br>TSM103WA, T <sub>amb</sub> = 25°<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub><br>TSM103W, T <sub>amb</sub> = 25°<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                                             |                      | 0.5<br>1 | 2<br>3<br>4<br>5                                                           | mV       |
| DV <sub>io</sub> | Input Offset Voltage Drift                                                                                                                                                                                                                                                               |                      | 7        |                                                                            | μV/°C    |
| $I_{io}$         | Input Offset Current<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                                                                                                                                                                                                         |                      | 2        | 75<br>150                                                                  | nA       |
| $I_{ib}$         | Input Bias Current<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                                                                                                                                                                                                           |                      | 20       | 150<br>200                                                                 | nA       |
| A <sub>vd</sub>  | Large Signal Voltage Gain<br>V <sub>CC</sub> = 15V, R <sub>L</sub> = 2k, V <sub>o</sub> = 1.4V to 11.4V<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                                                                                                                      | 50<br>25             | 100      |                                                                            | V/mV     |
| SVR              | Supply Voltage Rejection Ratio<br>V <sub>CC</sub> = 5V to 30V                                                                                                                                                                                                                            | 65                   | 100      |                                                                            | dB       |
| V <sub>icm</sub> | Input Common Mode Voltage Range<br>V <sub>CC</sub> = +30V - see note <sup>1</sup><br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                                                                                                                                            | 0<br>0               |          | (V <sub>CC</sub> <sup>+</sup> ) -1.5<br>(V <sub>CC</sub> <sup>+</sup> ) -2 | V        |
| CMR              | Common Mode Rejection Ratio<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                                                                                                                                                                                                  | 70<br>60             | 85       |                                                                            | dB       |
| $I_{source}$     | Output Current Source<br>V <sub>CC</sub> = +15V, V <sub>o</sub> = 2V, V <sub>id</sub> = +1V                                                                                                                                                                                              | 20                   | 40       |                                                                            | mA       |
| $I_o$            | Short Circuit to Ground<br>V <sub>CC</sub> = +15V                                                                                                                                                                                                                                        |                      | 40       | 60                                                                         | mA       |
| $I_{sink}$       | Output Current Sink<br>V <sub>id</sub> = -1V,<br>V <sub>CC</sub> = +15V, V <sub>o</sub> = 2V<br>V <sub>CC</sub> = +15V, V <sub>o</sub> = 0.2V                                                                                                                                            | 10<br>12             | 20<br>50 |                                                                            | mA<br>μA |
| $V_{OH}$         | High Level Output Voltage<br>V <sub>CC</sub> <sup>+</sup> = 30V<br>T <sub>amb</sub> = 25°C, R <sub>L</sub> = 2k<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub><br>T <sub>amb</sub> = 25°C, R <sub>L</sub> = 10k<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub> | 26<br>26<br>27<br>27 | 27<br>28 |                                                                            | V        |
| $V_{OL}$         | Low Level Output Voltage<br>R <sub>L</sub> = 10k<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                                                                                                                                                                             |                      | 5        | 20<br>20                                                                   | mV       |
| SR               | Slew Rate at Unity Gain<br>V <sub>i</sub> = 0.5 to 3V, V <sub>CC</sub> = 15V<br>R <sub>L</sub> = 2k, C <sub>L</sub> = 100pF, unity gain                                                                                                                                                  | 0.2                  | 0.4      |                                                                            | V/μs     |

| Symbol | Parameter                                                                                                       | Min. | Typ. | Max. | Unit            |
|--------|-----------------------------------------------------------------------------------------------------------------|------|------|------|-----------------|
| GBP    | Gain Bandwidth Product<br>$V_{CC} = 30V, R_L = 2k, C_L = 100pF$<br>$f = 100kHz, V_{in} = 10mV$                  | 0.5  | 0.9  |      | MHz             |
| THD    | Total Harmonic Distortion<br>$f = 1kHz$<br>$A_V = 20dB, R_L = 2k, V_{CC} = 30V$<br>$C_L = 100pF, V_o = 2V_{pp}$ |      | 0.02 |      | %               |
| $e_n$  | Equivalent Input Noise Voltage<br>$f = 1kHz, R_s = 100\Omega$<br>$V_{CC} = 30V$                                 |      | 50   |      | nV/ $\sqrt{Hz}$ |

1) The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is  $V_{CC}^+ - 1.5V$ . Both inputs can go to  $V_{CC} + 0.3V$  without damage.

### OPERATOR 1 (op-amp with non-inverting input connected to the internal Vref)

$V_{CC}^+ = +5V, V_{CC}^- = \text{Ground}, T_{amb} = 25^\circ C$  (unless otherwise specified)

| Symbol       | Parameter                                                                                                                                                                                                | Min.                 | Typ.     | Max.             | Unit             |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------|------------------|------------------|
| $V_{io}$     | Input Offset Voltage<br>$V_{icm} = 0V$<br>TSM103WA, $T_{amb} = 25^\circ$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$<br>TSM103W, $T_{amb} = 25^\circ$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$              |                      | 0.5<br>1 | 2<br>3<br>4<br>5 | mV               |
| $DV_{io}$    | Input Offset Voltage Drift                                                                                                                                                                               |                      | 7        |                  | $\mu V/^\circ C$ |
| $I_{ib}$     | Input Bias Current<br>negative input                                                                                                                                                                     |                      | 20       |                  | nA               |
| $A_{vd}$     | Large Signal Voltage Gain<br>$V_{CC} = 15V, R_L = 2k, V_o = 1.4V \text{ to } 11.4V$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                                                             |                      | 100      |                  | V/mV             |
| SVR          | Supply Voltage Rejection Ratio<br>$V_{icm} = 0V$<br>$V_{CC}^+ = 5V \text{ to } 30V$                                                                                                                      | 65                   | 100      |                  | dB               |
| $I_{source}$ | Output Current Source<br>$V_o = 2V$<br>$V_{CC} = +15V, V_{id} = +1V$                                                                                                                                     | 20                   | 40       |                  | mA               |
| $I_o$        | Short Circuit to Ground<br>$V_{CC} = +15V$                                                                                                                                                               |                      | 40       | 60               | mA               |
| $I_{sink}$   | Output Current Sink<br>$V_{id} = -1V,$<br>$V_{CC} = +15V, V_o = 2V$<br>$V_{CC} = +15V, V_o = 0.2V$                                                                                                       | 10<br>12             | 20<br>50 |                  | mA<br>$\mu A$    |
| $V_{OH}$     | High Level Output Voltage<br>$V_{CC}^+ = 30V$<br>$T_{amb} = 25^\circ C, R_L = 2k$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$<br>$T_{amb} = 25^\circ C, R_L = 10k$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$ | 26<br>26<br>27<br>27 | 27<br>28 |                  | V                |
| $V_{OL}$     | Low Level Output Voltage<br>$R_L = 10k$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                                                                                                         |                      | 5        | 20<br>20         | mV               |
| SR           | Slew Rate at Unity Gain<br>$V_i = 0.5 \text{ to } 2V, V_{CC} = 15V$<br>$R_L = 2k, C_L = 100pF, \text{unity gain}$                                                                                        | 0.2                  | 0.4      |                  | V/ $\mu s$       |

| Symbol | Parameter                                                                                                       | Min. | Typ. | Max. | Unit |
|--------|-----------------------------------------------------------------------------------------------------------------|------|------|------|------|
| GBP    | Gain Bandwidth Product<br>$V_{CC} = 30V, R_L = 2k, C_L = 100pF$<br>$f = 100kHz, V_{in} = 10mV$                  | 0.5  | 0.9  |      | MHz  |
| THD    | Total Harmonic Distortion<br>$f = 1kHz$<br>$A_V = 20dB, R_L = 2k, V_{CC} = 30V$<br>$C_L = 100pF, V_o = 2V_{pp}$ |      | 0.02 |      | %    |

## VOLTAGE REFERENCE

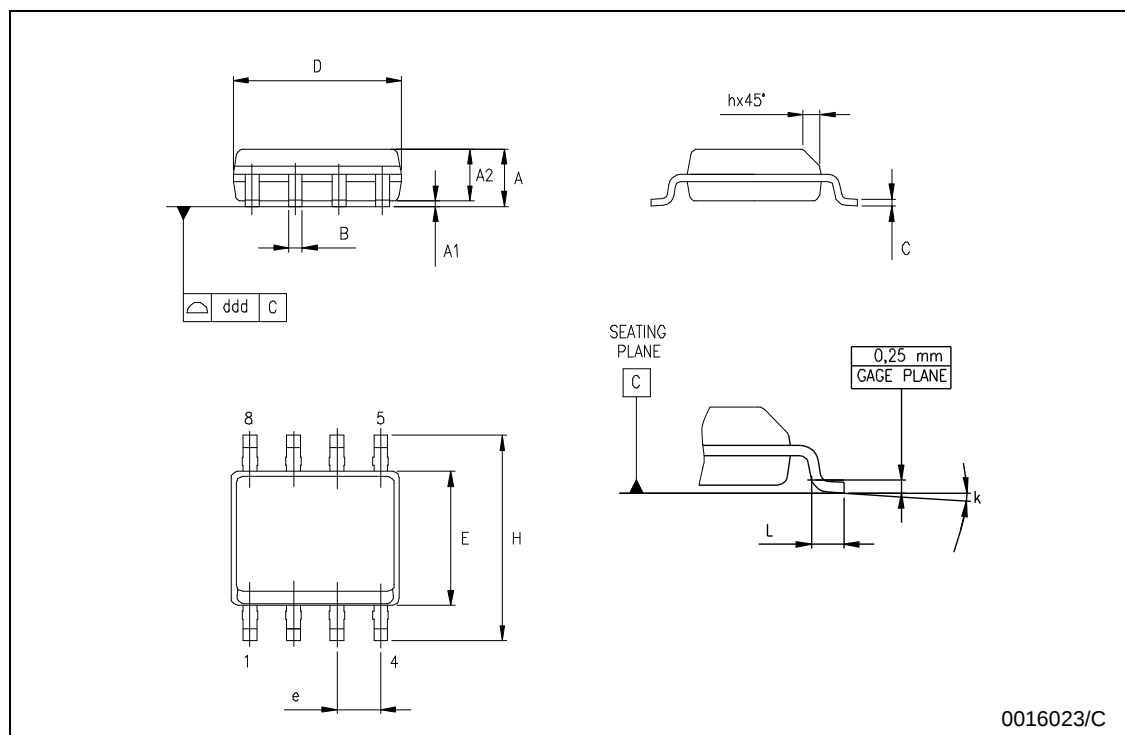
| Symbol           | Parameter                                                                                                                                                                                                            | Min.                           | Typ.         | Max.                           | Unit     |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|--------------|--------------------------------|----------|
| $V_{ref}$        | Reference Input Voltage, $I_k = 10mA$<br>TSM103WA $\pm 0.4\%$ $T_{amb} = 25^\circ C$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$<br>TSM103W $\pm 0.7\%$ $T_{amb} = 25^\circ C$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$ | 2.49<br>2.48<br>2.482<br>2.465 | 2.5<br>2.500 | 2.51<br>2.52<br>2.518<br>2.535 | V        |
| $\Delta V_{ref}$ | Reference Input Voltage Deviation Over Temperature Range<br>$V_{KA} = V_{ref}, I_k = 10mA$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                                                                  |                                | 7            | 30                             | mV       |
| $I_{min}$        | Minimum Cathode Current for Regulation<br>$V_{KA} = V_{ref}$                                                                                                                                                         |                                | 0.5          | 1                              | mA       |
| $ Z_{KA} $       | Dynamic Impedance - note <sup>1</sup><br>$V_{KA} = V_{ref}, \Delta I_K = 1 \text{ to } 100mA, f < 1kHz$                                                                                                              |                                | 0.2          | 0.5                            | $\Omega$ |

1) The dynamic impedance is defined as  $|Z_{KA}| = \Delta V_{KA} / \Delta I_K$

## PACKAGE MECHANICAL DATA

## SO-8 MECHANICAL DATA

| DIM. | mm.       |      |      | inch  |       |       |
|------|-----------|------|------|-------|-------|-------|
|      | MIN.      | TYP  | MAX. | MIN.  | TYP.  | MAX.  |
| A    | 1.35      |      | 1.75 | 0.053 |       | 0.069 |
| A1   | 0.10      |      | 0.25 | 0.04  |       | 0.010 |
| A2   | 1.10      |      | 1.65 | 0.043 |       | 0.065 |
| B    | 0.33      |      | 0.51 | 0.013 |       | 0.020 |
| C    | 0.19      |      | 0.25 | 0.007 |       | 0.010 |
| D    | 4.80      |      | 5.00 | 0.189 |       | 0.197 |
| E    | 3.80      |      | 4.00 | 0.150 |       | 0.157 |
| e    |           | 1.27 |      |       | 0.050 |       |
| H    | 5.80      |      | 6.20 | 0.228 |       | 0.244 |
| h    | 0.25      |      | 0.50 | 0.010 |       | 0.020 |
| L    | 0.40      |      | 1.27 | 0.016 |       | 0.050 |
| k    | g° (max.) |      |      |       |       |       |
| ddd  |           |      | 0.1  |       |       | 0.04  |



### 3 SUMMARY OF CHANGES

| Date          | Revision | Description of Changes                                                                                                                                                                            |
|---------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | 1-2      | First Release                                                                                                                                                                                     |
| 02-April-2004 | 3        | 1 - $V_{id}=V_{cc}+0.6$ modified on AMR table - page 2<br>2 - Add $I_k$ parameter on AMR table - page 2<br>3 - $A_{vd}$ test condition equal on both tables Operator 1 & Operator 2 - pages 3 & 4 |

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