# Low-Noise, Very Low Drift, Precision Voltage Reference

## 1 Features

- **Low Temperature Drift: 3 ppm/°C(TYP)**
- **High Accuracy: 0.1% Maximum**
- **Low Noise: 7.5 $\mu V_{PP}$/V**
- **Low $I_Q$: 2 mA (Typical)**
- **Operating Temperature Range: -40°C to +125°C**
- **High Output Current: ±10 mA**
- **Micro SIZE PACKAGES: SOP8**

## 2 Applications

- **Precision Data Acquisition Systems**
- **Semiconductor Test Equipment**
- **Medical Instrumentation**
- **Industrial Process Controls**
- **Pressure and Temperature Transmitters**
- **Lab and Field Instrumentation**

## 3 Descriptions

The ZMB50XX is a family of low-noise, low-drift, very high precision voltage references. These references are capable of both sinking and sourcing current, and have excellent line and load regulation.

Excellent temperature drift (3 ppm/°C) and high accuracy (0.1%) are achieved using proprietary design techniques with 2mA(typical) quiescent current. These features, combined with low noise, make the ZMB50XX family ideal for use in high-precision data acquisition systems.

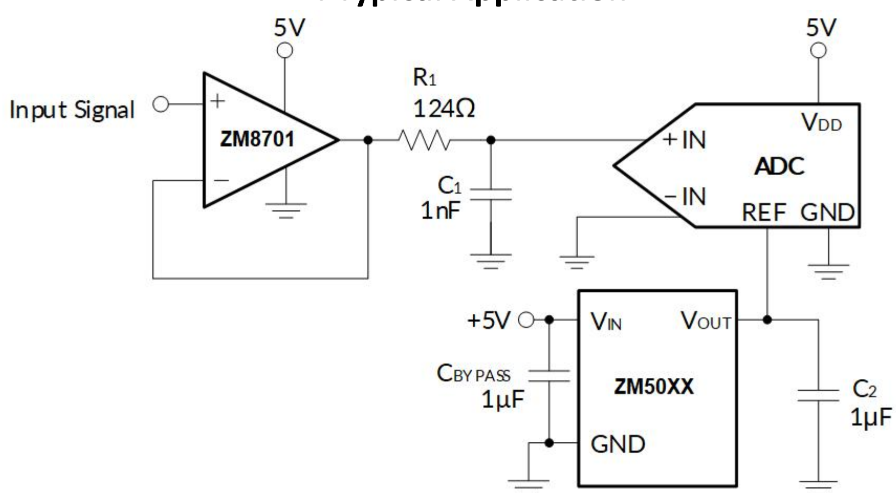
The ZMB50XX is available in Green SOP8 packages. It operates over an ambient temperature range of -40°C to +125°C.

### Device Information (1)

| PART NUMBER | PACKAGE | BODY SIZE(NOM) |
|---|---|---|
| ZMB50XX | SOP8 | 4.90mm x 3.90mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

## 4 Typical Application



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# 5 Revision History

Note: Page numbers for previous revisions may different from page numbers in the current version.

| VERSION | Change Date | Change Item |
|---|---|---|
| A.1 | 2023/08/18 | Preview version completed |

## 6 Package/Ordering Information [1]

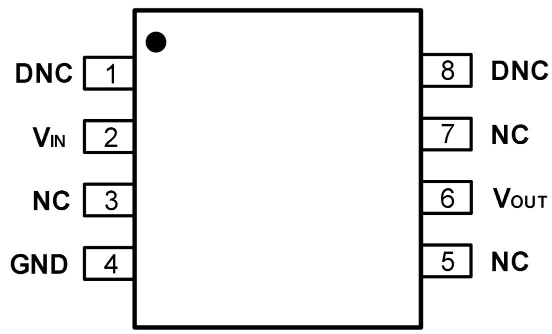
| PRODUCT | ORDERING NUMBER | TEMPERATURE RANGE | PACKAGE LEAD | PACKAGE MARKING [2] | PACKAGE OPTION |
|---|---|---|---|---|---|
| ZMB50XX | ZMB5020XK | -40°C ~+125°C | SOP8 | ZMB5020 | Tape and Reel,4000 |
| | ZMB5025XK | -40°C ~+125°C | SOP8 | ZMB5025 | Tape and Reel,4000 |
| | ZMB5030XK | -40°C ~+125°C | SOP8 | ZMB5030 | Tape and Reel,4000 |
| | ZMB5033XK | -40°C ~+125°C | SOP8 | ZMB5033 | Tape and Reel,4000 |
| | ZMB5040XK | -40°C ~+125°C | SOP8 | ZMB5040 | Tape and Reel,4000 |
| | ZMB5045XK | -40°C ~+125°C | SOP8 | ZMB5045 | Tape and Reel,4000 |
| | ZMB5050XK | -40°C ~+125°C | SOP8 | ZMB5050 | Tape and Reel,4000 |

NOTE:

(1) This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the right-hand navigation.

(2) There may be additional marking, which relates to the lot trace code information(data code and vendor code)， the logo or the environmental category on the device.

## 7 Pin configuration and Functions (Top View)




### Pin Description

| NAME | PIN | I/O [1] | DESCRIPTION |
|---|---|---|---|
| | SOP8 | | |
| DNC [2] | 1 | — | Do not connect |
| $V_{IN}$ | 2 | I | Input supply voltage |
| NC [3] | 3,5,7 | O | No internal connection |
| GND | 4 | G | Ground |
| $V_{OUT}$ | 6 | O | Reference voltage output |
| DNC [2] | 8 | — | Do not connect |

(1) I = Input, O = Output.
(2) DNC = Do not connect.
(3) NC = No internal connection.

# 8 Specifications

## 8.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)(2)

| SYMBOL | | MIN | MAX | UNIT |
|---|---|---|---|---|
| $V_{IN}$ | Supply voltage, V+ to V– | -0.2 | 18 | V |
| | Output short circuit | -30 | 30 | mA |
| $\theta_{JA}$ | Package thermal impedance (3) SOP8 | | 110 | °C/W |
| $T_A$ | Operating temperature | -40 | +125 | °C |
| $T_J$ | Junction temperature (4) | -40 | 150 | |
| $T_{stg}$ | Storage temperature | -65 | 150 | |

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) All voltages are with respect to the GND pin.

(3) The package thermal impedance is calculated in accordance with JESD-51.

(4) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{\theta JA}$, and $T_A$. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A) / R_{\theta JA}$. All numbers apply for packages soldered directly onto a PCB.

## 8.2 ESD Ratings

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

| | | | VALUE | UNIT |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human-Body Model (HBM), JEDEC EIA/ JESD22 - A114 | ±3000 | V |
| | | Charged-Device Model (CDM), ANSI/ESDA/JEDEC JS-002-2018 | ±1000 | V |
| | | Machine Model (MM), JESD22-A115C (2010) | ±200 | V |

**ESD SENSITIVITY CAUTION**

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## 8.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted).

| SYMBOL | PARAMETER | MIN | MAX | UNIT |
|---|---|---|---|---|
| $V_{IN}$ | Input voltage | $V_{OUT}$+0.5(1) | 16 | V |
| $I_{Load}$ | Load current | -10 | 10 | mA |

(1) Minimum supply voltage for the ZMB50XX is 4 V.

## 8.4 Electrical Characteristics

At $T_A$ = 25°C, $I_{OUT}$ = 0 mA, and $V_{IN}$ = 5 V (unless otherwise noted).

| PARAMETER | | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| Output Voltage | $V_{OUT}$ | | ZMB5020 | | 2.048 | | V |
| | | | ZMB5025 | | 2.5 | | |
| | | | ZMB5030 | | 3.0 | | |
| | | | ZMB5033 | | 3.3 | | |
| | | | ZMB5040 | | 4.096 | | |
| | | | ZMB5045 | | 4.5 | | |
| | | | ZMB5050 | | 5.0 | | |
| Initial Accuracy | | | All voltage options (1) | -0.1 | | 0.1 | % |
| Output Voltage Noise | | | f = 0.1Hz to 10Hz | | 7.5 | | $\mu V_{PP}/V$ |
| Output Voltage Temperature Drift (2) | $dV_{OUT}/dT$ | | $T_A$ = -40°C to +125°C | | 3 | 10 | ppm/°C |
| Long-Term Stability | | | 0 to 1000 hours | | 100 | | ppm |
| | | | 1000 to 2000 hours | | 50 | | |
| Line Regulation | | | $V_{IN}$ = ($V_{OUT}$ + 0.5) to 16 V (1) | | 2 | 4 | ppm/V |
| | | | $V_{IN}$ = ($V_{OUT}$ + 0.5) to 16 V<br>$T_A$ = -40°C to +125°C | | | 6 | |
| Load Regulation | $dV_{OUT}/dI_{LOAD}$ | | -10 mA < $I_{LOAD}$ < 10 mA,<br>$V_{IN}$ = $V_{OUT}$ + 0.5 V (3) | | 2 | 4 | ppm/mA |
| | | | -10 mA < $I_{LOAD}$ < 10 mA,<br>$V_{IN}$ = $V_{OUT}$ + 0.5V<br>$T_A$ = -40°C to 125°C (3) | | | 6 | |
| Thermal Hysteresis | dT | | First Cycle | | 90 | | ppm |
| Short-Circuit Current | $I_{SC}$ | Sourcing | | 17 | 26 | | mA |
| | | Sinking | | 15 | 23 | | |
| Turn on Settling Time | | | To 0.1% with $C_L$ = 1µF | | 300 | | µs |
| Capacitive Load | | | | 1 | | 50 | µF |
| Voltage | $V_{IN}$ | | $I_{LOAD}$ = 0, $T_A$ = -40°C to +125°C. | $V_{OUT}$+ 0.5(1) | | 16 | V |
| Quiescent Current | $I_Q$ | | $I_{LOAD}$ = 0, $T_A$ = 25°C | | 2 | 3 | mA |
| | | | $I_{LOAD}$ = 0, $T_A$ = -40°C to +125°C | | | 4 | |

(1) Minimum supply voltage for the ZMB50XX is 4 V.
(2) Box Method used to determine temperature drift.
(3) Typical value of load regulation reflects measurements using force and sense contacts;

## 8.5 Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

At $T_A$ = 25°C, $V_{IN}$= 5V, unless otherwise noted.

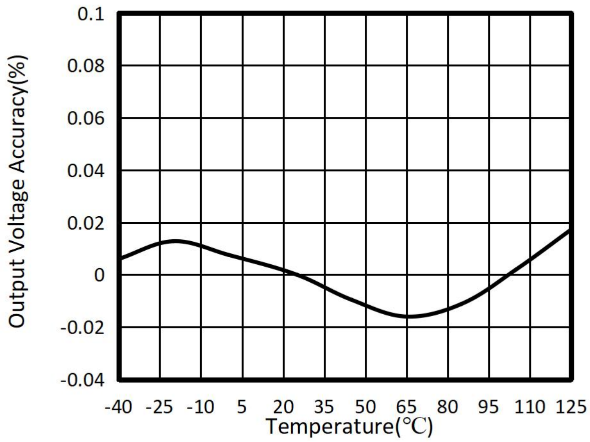



**Figure 1. Output Voltage Accuracy vs Temperature**

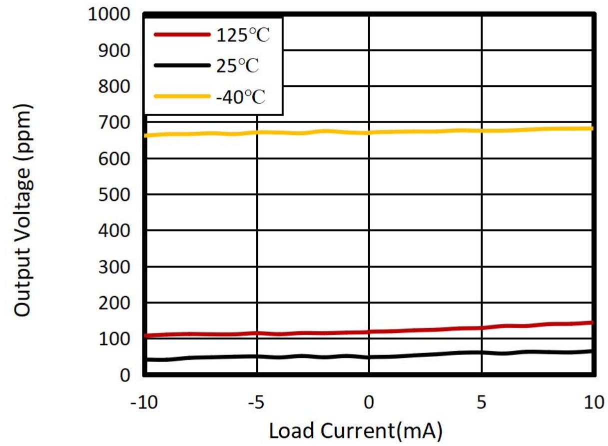



**Figure 2. Output Voltage vs Load Current**

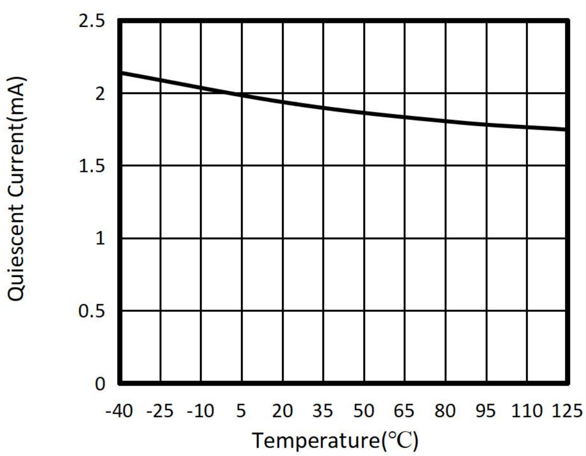



**Figure 3. Quiescent Current vs Temperature**

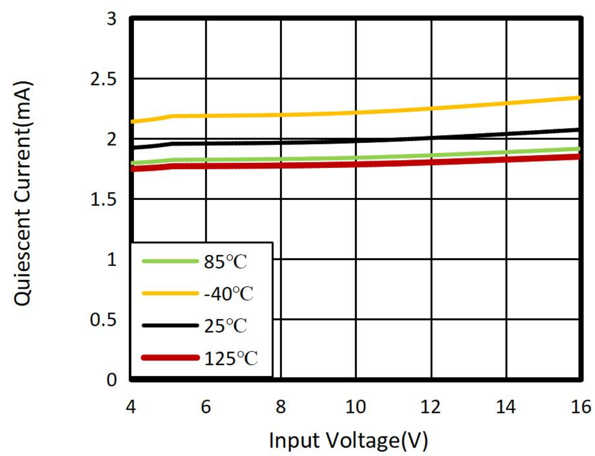



**Figure 4. Quiescent Current vs Input Voltage**

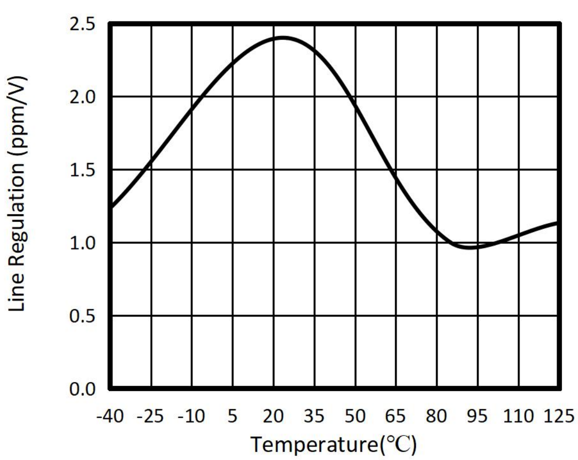



**Figure 5. Line Regulation vs Temperature**

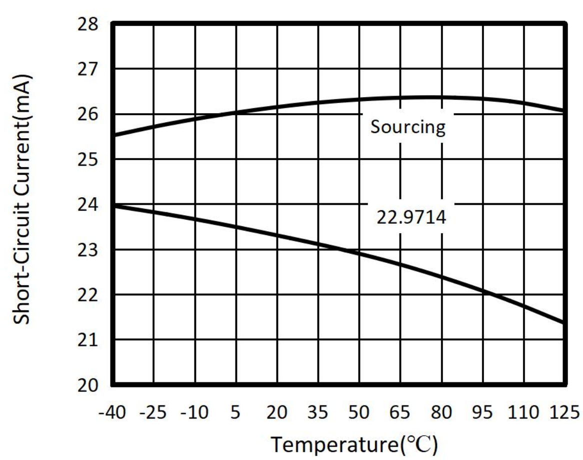



**Figure 6. Short Circuit Current vs Temperature**

## Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

At $T_A$ = 25°C, $V_{IN}$= 5V, unless otherwise noted.

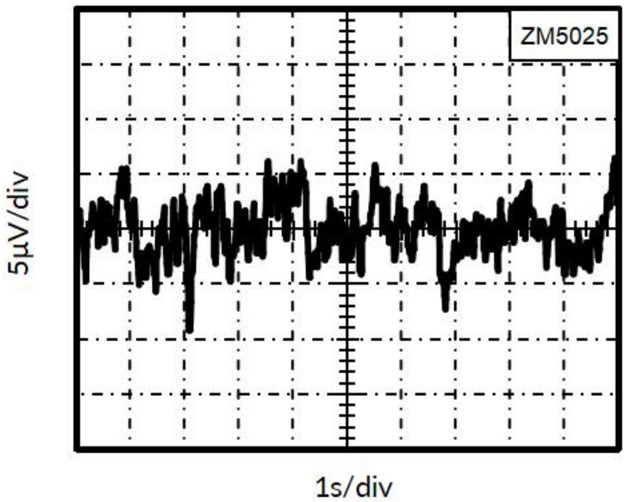



**Figure 7. Noise**

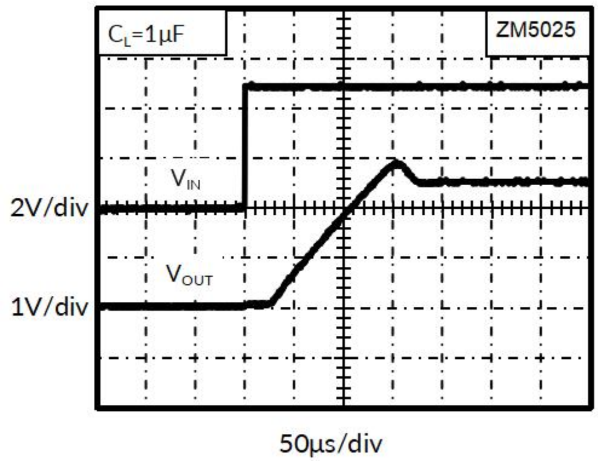



**Figure 8. Start-up**

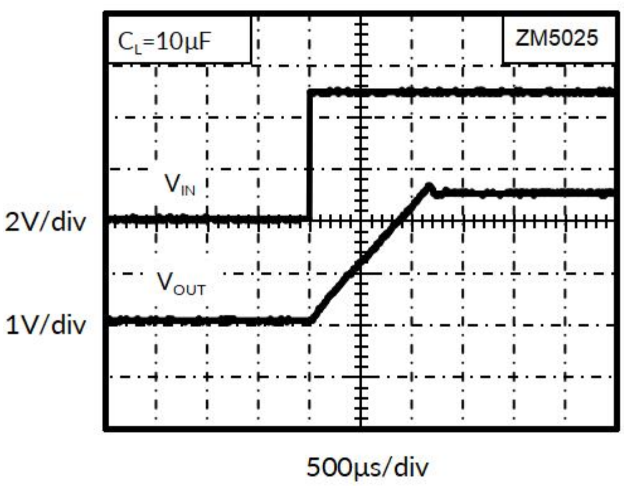



**Figure 9. Start-up**

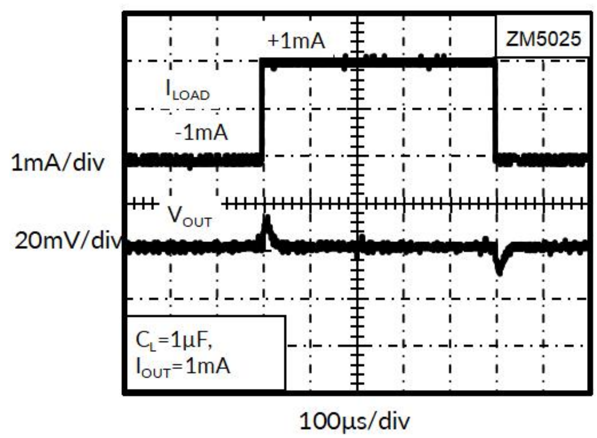



**Figure 10. Load Transient**

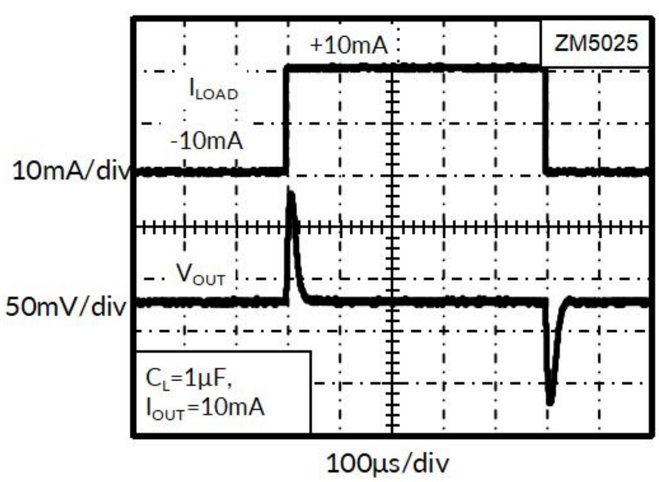



**Figure 11. Load Transient**

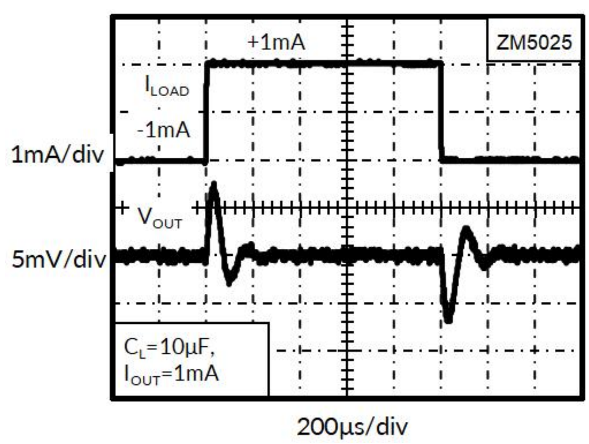



**Figure 12. Load Transient**

## Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.
At $T_A$ = 25°C, $V_{IN}$= 5V, unless otherwise noted.

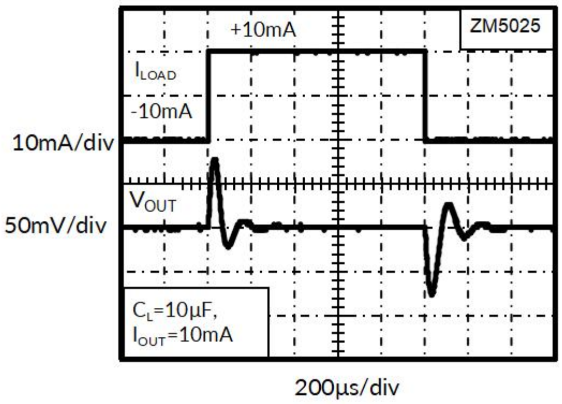



**Figure 13. Load Transient**

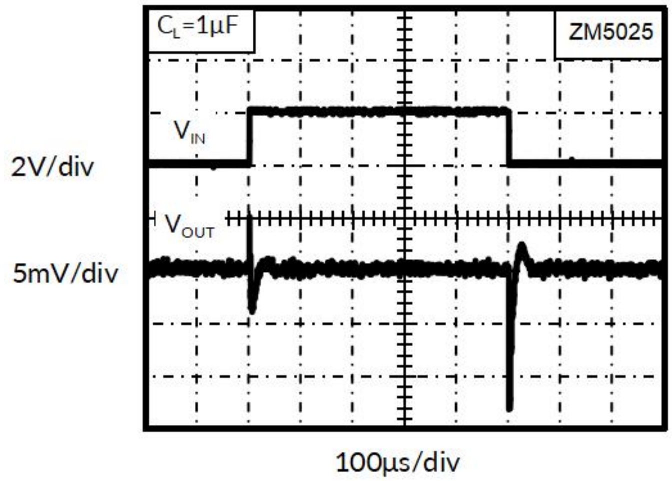



**Figure 14. Line Transient**

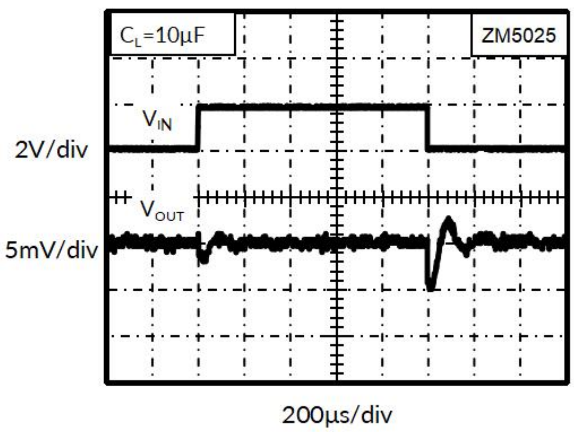



**Figure 15. Line Transient**

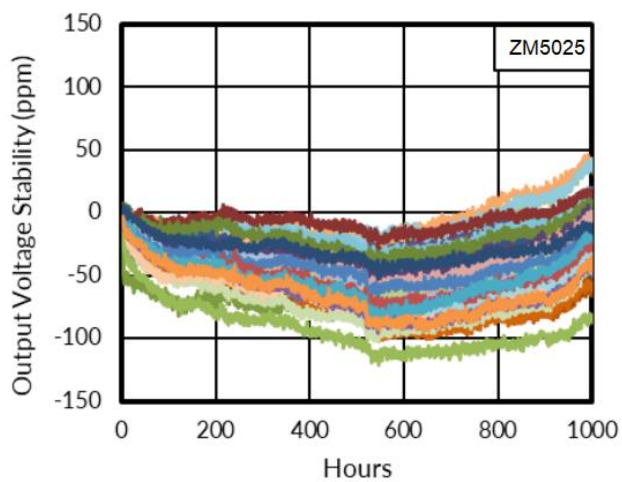



**Figure 16. Long - Term Stability (First 1000 hours)**

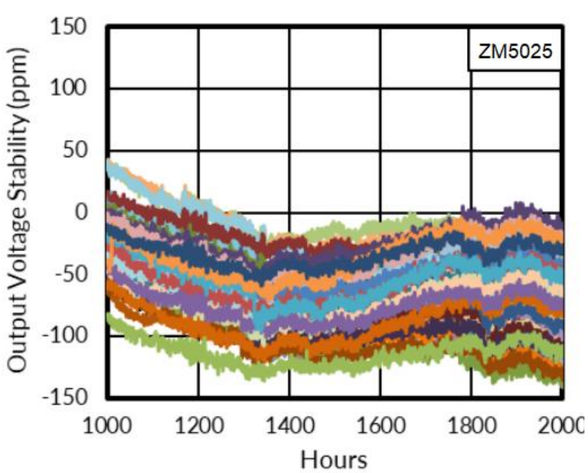



**Figure 17. Long - Term Stability (Second 1000 hours)**

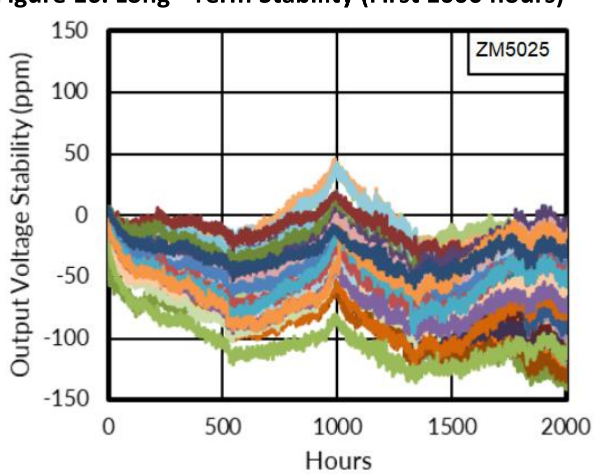


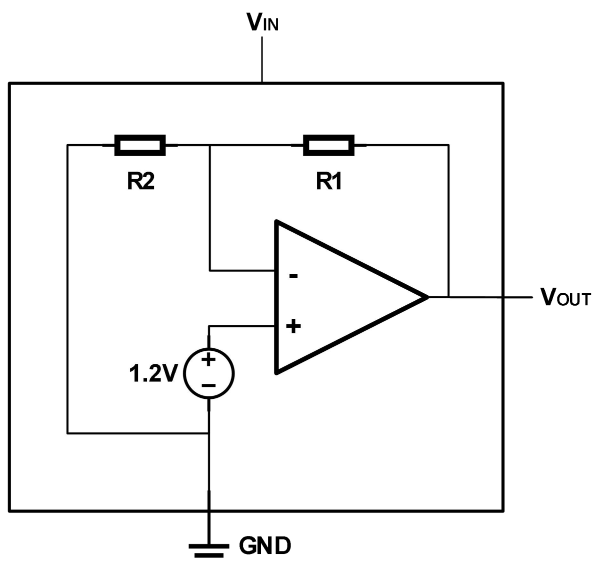

**Figure 18. Long - Term Stability (First 2000 hours)**

# 9 Detailed Description

## 9.1 Overview

The ZMB50XX is family of precision bandgap voltage references that are specifically designed for excellent initial voltage accuracy and drift. See the Functional Block Diagram for a simplified block diagram of the ZMB50XX.

## 9.2 Functional Block Diagram



# 10 Feature Description

## 10.1 Temperature Drift

The ZMB50XX is designed for minimal drift error, which is defined as the change in output voltage over temperature. The drift is calculated using the box method, as described in Equation 1.

$$\text{Drift} = \left(\frac{V_{OUTMAX} - V_{OUTMIN}}{V_{OUT} \times \text{Temp Range}}\right) \times 10^6 \text{(ppm)} \qquad (1)$$

The ZMB50XX features a typical drift coefficient of 3 ppm/°C.

## 10.2 Thermal Hysteresis

Thermal hysteresis for the ZMB50XX is defined as the change in output voltage after operating the device at 25°C, cycling the device through the specified temperature range, and returning to 25°C. Thermal hysteresis can be expressed as Equation 2:

$$V_{HYST} = \left(\frac{|V_{PRE} - V_{POST}|}{V_{NOM}}\right) \bullet 10^6 \text{(ppm)}$$

where

- $V_{HYST}$ = thermal hysteresis (in units of ppm).
- $V_{NOM}$ = the specified output voltage.
- $V_{PRE}$ = output voltage measured at 25°C pre-temperature cycling.
- $V_{POST}$ = output voltage measured after the device has been cycled from 25°C through the specified temperature range of -40°C to 125°C and returned to 25°C. (2)

## 10.3 Noise Performance

Typical 0.1Hz to 10Hz voltage noise for each member of the ZMB50XX family is specified in the Electrical Characteristics table. The noise voltage increases with output voltage and operating temperature. Additional filtering can be used to improve output noise levels, although take care to ensure the output impedance does not degrade performance.

## 10.4 Long-Term Stability

Due to aging and environmental effects, all semiconductor devices experience physical changes of the semiconductor die and the packaging material over time. These changes and the associated package stress on the die cause the output voltage in precision voltage references to deviate over time. The value of such change is specified on the datasheet by a parameter called the Long-term stability (also known as the Long-Term Drift (LTD)). Equation 3 shows how LTD is calculated. Note that the LTD value will be positive if the output voltage drifts higher over time, negative if the voltage drifts lower over time.

$$\text{LTD(ppm)}|_{t=n} = \frac{(V_{OUT}|_{t=0} - V_{OUT}|_{t=n})}{V_{OUT}|_{t=0}} \times 10^6$$

where

- $\text{LTD(ppm)}|_{t=n}$ = Long-term stability (in units of ppm).
- $V_{OUT}|_{t=0}$ = Output voltage at time = 0 hr.
- $V_{OUT}|_{t=n}$ = Output voltage at time = n hr. (3)

# 11 Device Functional Modes

## 11.1 Basic Connections

Figure 19 shows the typical connections for the ZMB50XX. Z-Micro recommends a supply bypass capacitor ranging from 1 µF to 10 µF. A minimum 1µF output capacitor ($C_L$) must be connected from $V_{OUT}$ to GND.

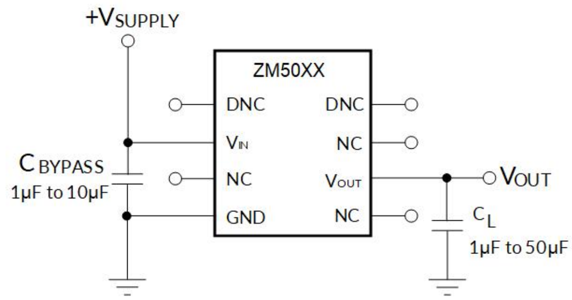



**Figure 19. Basic Connections**

## 11.2 Supply Voltage

The ZMB50XX family of voltage references features extremely low dropout voltage. With the exception of the ZMB5020, which has a minimum supply requirement of 4V, these references can be operated with a supply of 500 mV more than the output voltage in an unloaded condition.

## 11.3 Negative Reference Voltage

For applications requiring a negative and positive reference voltage, the ZMB50XX and ZM8651 can be used to provide a dual-supply reference from a 5V supply. Figure 20 shows the ZMB5025 used to provide a 2.5V supply reference voltage. The low drift performance of the ZMB50XX complements the low offset voltage and zero drift of the ZM8651 to provide an accurate solution for split-supply applications. Take care to match the temperature coefficients of $R_1$ and $R_2$.

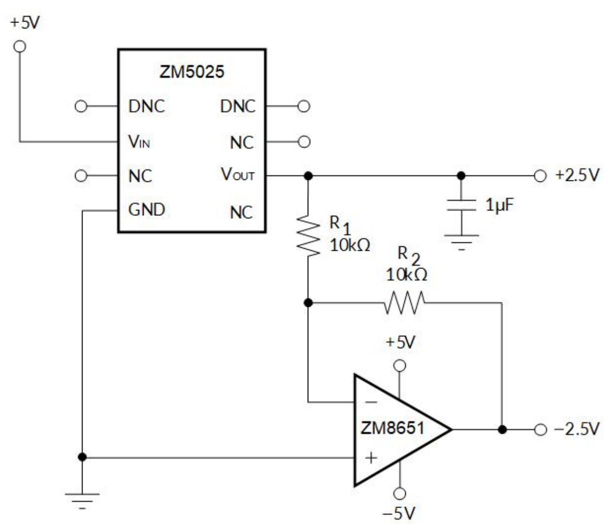



**Figure 20. The ZMB5025 and ZM8651 Create Positive and Negative Reference Voltages**

# 12 Layout

## 12.1 Layout Guidelines

- Place the power-supply bypass capacitor as closely as possible to the supply and ground pins. The recommended value of this bypass capacitor is from 1 µF to 10 µF. If necessary, additional decoupling capacitance can be added to compensate for noisy or high-impedance power supplies.
- Place a 1µF noise filtering capacitor between the NR pin and ground.
- The output must be decoupled with a 1µF to 50µF capacitor. A resistor in series with the output capacitor is optional. For better noise performance, the recommended ESR on the output capacitor is from 1 Ω to 1.5 Ω.
- A high-frequency, 1µF capacitor can be added in parallel between the output and ground to filter noise and help with switching loads as data converters.

## 12.2 Layout Example

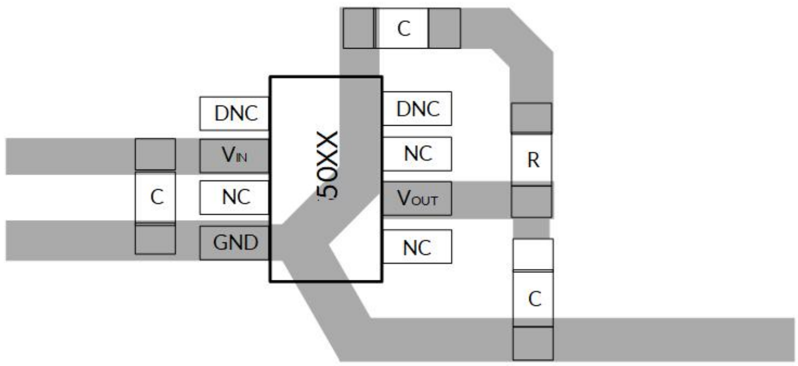



**Figure 21. Layout Example**

## 12.3 Power Dissipation

The ZMB50XX family is specified to deliver current loads of ±10 mA over the specified input voltage range. The temperature of the device increases according to Equation 4:

$T_J = T_A + P_D \times \theta_{JA}$ (4)

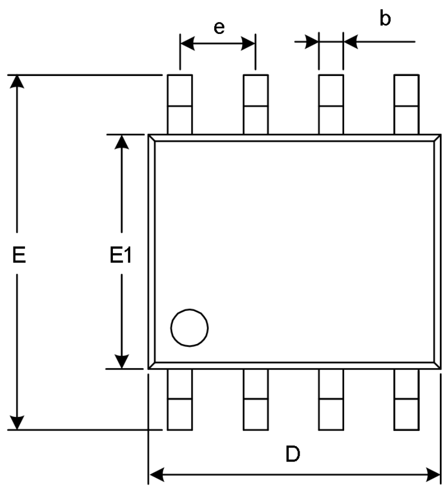
where

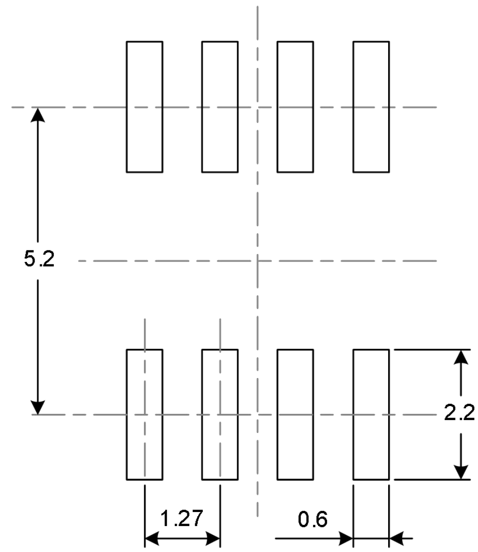
- $T_J$ = Junction temperature (°C)
- $T_A$ = Ambient temperature (°C)
- $P_D$ = Power dissipated (W)
- $\theta_{JA}$ = Junction-to-ambient thermal resistance (°C/W)

The ZMB50XX junction temperature must not exceed the absolute maximum rating of 150°C.

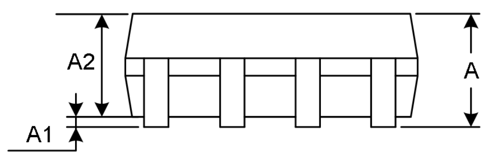
## 13 Package Outline Dimensions

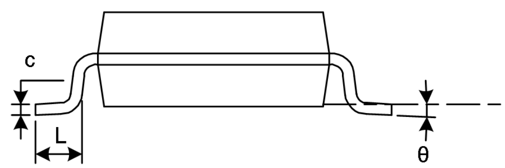
**SOP8 (3)**




RECOMMENDED LAND PATTERN (Unit: mm)



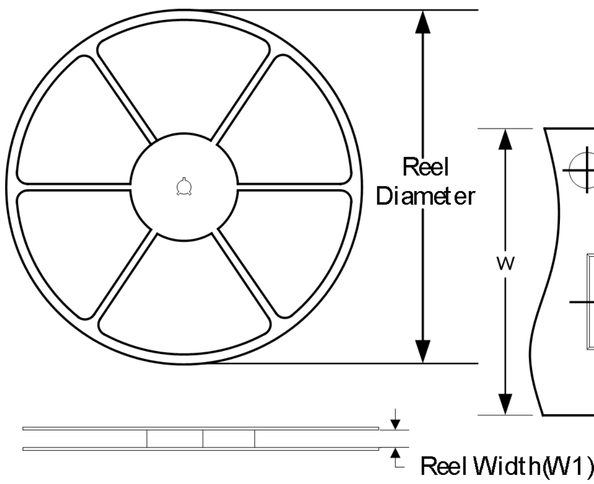

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A (1) | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.100 | 0.250 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.007 | 0.010 |
| D (1) | 4.800 | 5.000 | 0.189 | 0.197 |
| e | 1.270 (BSC) (2) | | 0.050 (BSC) (2) | |
| E | 5.800 | 6.200 | 0.228 | 0.244 |
| E1 (1) | 3.800 | 4.000 | 0.150 | 0.157 |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| θ | 0° | 8° | 0° | 8° |

NOTE:

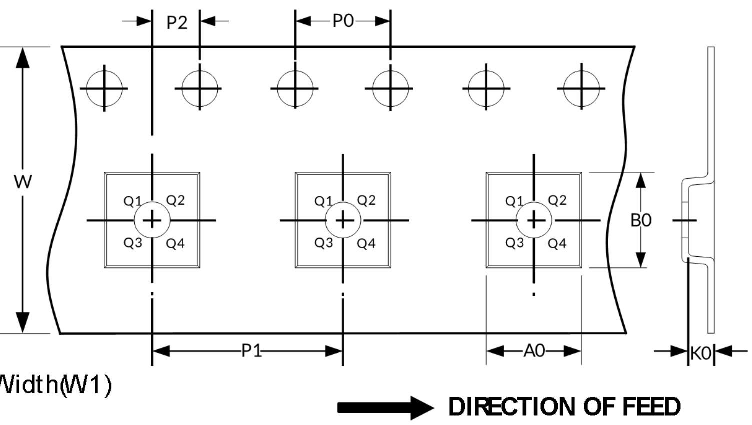
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

## 14 Tape and Reel Information

**REEL DIMENSIONS**




**TAPE DIMENSION**




NOTE: The picture is only for reference. Please make the object as the standard.

### KEY PARAMETER LIST OF TAPE AND REEL

| Package Type | Reel Diameter | Reel Width (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P0 (mm) | P1 (mm) | P2 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|
| SOP8 | 13’’ | 12.4 | 6.40 | 5.40 | 2.10 | 4.0 | 8.0 | 2.0 | 12.0 | Q1 |

NOTE:
1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

# IMPORTANT NOTICE AND DISCLAIMER