## 1. General Description

The WA3331 consists of a single precision voltage comparator that are designed to operate from a single power supply over a wide range of voltages, with a typical input offset voltage of 1.0mV and high voltage gain. Operation from dual supplies also is possible and the low power supply current drain is independent of the magnitude of the power supply voltage. The output can be connected to other open-collector output to achieve wired-AND relationships.

The WA3331 is available in standard SOT23-5 and SOT-353 package.

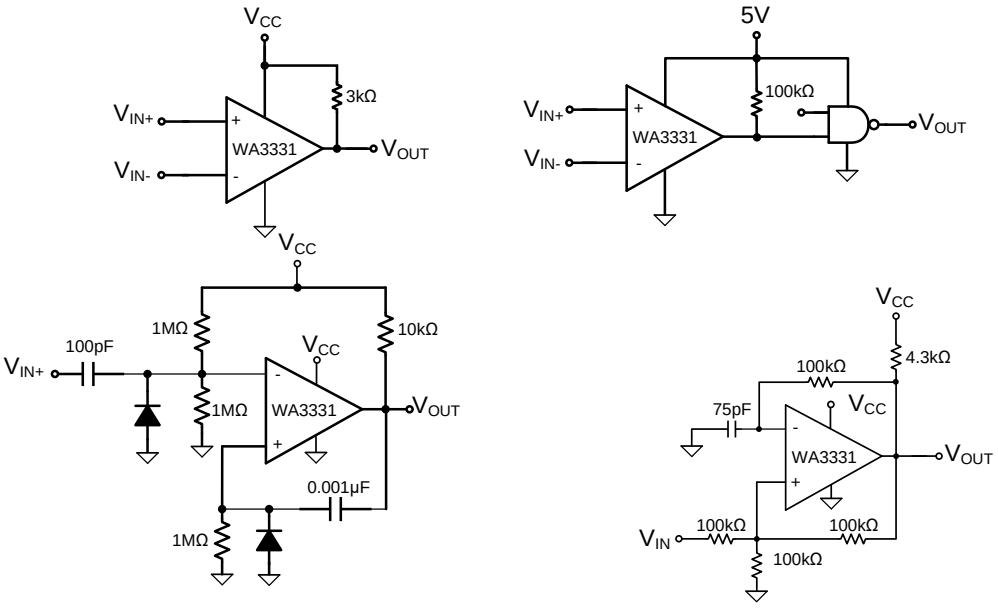
## 2. Features

- Wide Supply Voltage Range
  - Single Supply: 2V to 36V
  - Dual Supplies: ±1V to ±18V
- Low Supply Current at $V_{CC}$=5V: 0.5mA
- Low Input Bias Current: 45nA (Typical)
- Low Input Offset Current: 5nA (Typical)
- Low Input Offset Voltage: 1mV (Typical)
- Input Common Mode Voltage Range Includes Ground
- Differential Input Voltage Range Equals to the Power Supply Voltage
- Low Output Saturation Voltage at 4mA: 40mV (Typical)
- Open Collector Output

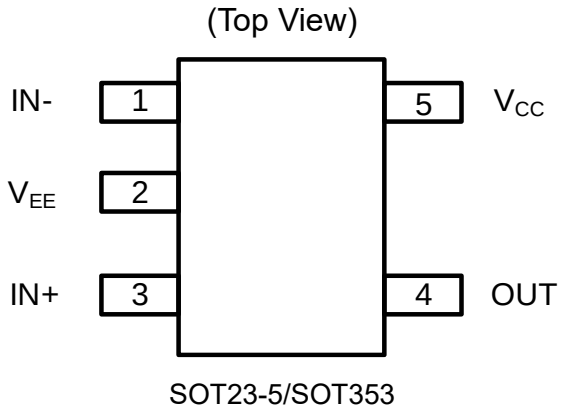
## 3. Applications

- Battery Chargers
- Mobile Phones
- Switching Power Supplies
- DC-DC Modules
- PC Motherboards
- Communication Equipment

## 4. Typical Application



## 5. Pin Configuration




SOT23-5/SOT353

## 6. Pin Description

| PIN NUMBER | PIN NAME | I/O | PIN FUNCTION |
|---|---|---|---|
| 1 | IN- | I | Negative input |
| 2 | $V_{EE}$ | - | Negative (lowest) supply or ground (for single supply operation) |
| 3 | IN+ | I | Positive input |
| 4 | OUT | O | Output |
| 5 | $V_{CC}$ | - | Positive (highest) Supply |

## 7. Absolute Maximum Ratings [1]

($T_A$= 25℃,Unless otherwise specified)

| SYMBOL | PARAMETER | RATING | UNIT |
|---|---|---|---|
| $V_S=V_{CC}-V_{EE}$ | Power Supply Voltage | 40 | V |
| $V_{ID}=V_{IN+}$ - $V_{IN-}$ | Differential input voltage | 40 | V |
| $V_{IN}$ | Input Voltage | -0.3 to 40 | V |
| $I_{IN}$ | Input Current ($V_{IN}$ < -0.3V) [2] | 50 | mA |
| $P_D$ | Power Dissipation ($T_A$=25℃) | 620 | mW |
| $T_J$ | Junction Temperature | 150 | °C |
| $T_{STG}$ | Storage Temperature | -65 to +150 | °C |
| $T_{LEAD}$ | Lead Temperature Range (Soldering 10 sec) | 260 | °C |

**NOTE1:** Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

**NOTE2:** This input current will only exist when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor action on the IC chip. This transistor action can cause the output voltages of the comparators to go to the V+ voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This is not destructive and normal output states will re-establish when the input voltage, which was negative, again returns to a value greater than -0.3V (at 25℃).

## 8. Recommended Operating Conditions

| SYMBOL | PARAMETER | MIN | MAX | UNIT |
|---|---|---|---|---|
| $V_{CC}$ | Supply Voltage | 2 | 36 | V |
| $T_A$ | Operating Ambient Temperature Range | -40 | 85 | °C |

## 9. Electrical Characteristics

($V_{CC}$=5V, $V_{EE}$=0V, $T_A$=25°C, Full=-40 to 85°C [3], unless otherwise specified.)

| SYMBOL | PARAMETER | TEST CONDITIONS | MIN | TYP. | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | $V_{OUT}$=1.4V, $V_{CC}$=5 to 30V | | 1 | 5 | mV |
| | | $V_{OUT}$=1.4V, $V_{CC}$=5 to 30V, Full | | | 7 | |
| $I_B$ | Input Bias Current | $I_{IN+}$ or $I_{IN-}$ with output in linear range, $V_{CM}$=0V | | 45 | 250 | nA |
| | | $I_{IN+}$ or $I_{IN-}$ with output in linear range, $V_{CM}$=0V, Full | | | 400 | |
| $I_{IO}$ | Input Offset Current | $I_{IN+}$ - $I_{IN-}$, $V_{CM}$=0V | | 5 | 50 | nA |
| | | $I_{IN+}$ - $I_{IN-}$, $V_{CM}$=0V, Full | | | 200 | |
| $V_{CM}$ | Input Common Mode Voltage Range [4] | $V_{CC}$=30V | 0 | | $V_{CC}$-1.5 | V |
| $I_{CC}$ | Supply Current | $R_L$=∞, $V_{CC}$=5V | | 0.5 | 1.0 | mA |
| | | $R_L$=∞, $V_{CC}$=5V, Full | | | 2.0 | |
| | | $R_L$=∞, $V_{CC}$=30V | | 0.6 | 1.7 | |
| | | $R_L$=∞, $V_{CC}$=30V, Full | | | 3.0 | |
| $G_V$ | Voltage Gain | $V_{CC}$=15V, $R_L$≥15kΩ, $V_{OUT}$=1 to 11V | 50 | 200 | | V/mV |
| $T_R$ | Large Signal Response Time | $V_{IN}$ =TTL Logic Swing, $R_L$=5.1kΩ, High to Low | | 400 | | ns |
| | | $V_{IN}$ =TTL Logic Swing, $R_L$=5.1kΩ, Low to High | | 160 | | |
| | Response Time | $R_L$=5.1kΩ | | 1.3 | | μs |
| $I_{SINK}$ | Output Sink Current | $V_{IN-}$=1V, $V_{IN+}$=0V, $V_{OUT}$=1.5V | 6 | 20 | | mA |
| $I_{LEAK}$ | Output Leakage Current | $V_{IN-}$=0V, $V_{IN+}$=1V, $V_{OUT}$=5V | | 0.1 | | nA |
| | | $V_{IN-}$=0V, $V_{IN+}$=1V, $V_{OUT}$=30V | | | 1 | μA |
| $V_{SAT}$ | Saturation Voltage | $V_{IN-}$=1V, $V_{IN+}$=0V, $I_{SINK}$≤4mA | | 40 | 100 | mV |

**NOTE3:** These specifications are limited to -40℃ to 85℃. Limits over temperature are guaranteed by design, but not tested in production.

**NOTE4:** The input common mode voltage of either input signal voltage should not be allowed to go negatively by more than 0.3V (at 25℃). The upper end of the common mode voltage range is $V_{CC}$-1.5V (at 25℃), but either or both inputs can go to +36V without damages, independent of the magnitude of the $V_{CC}$.

## 10. Typical Performance Characteristics

($V_{CC}$=5V, $V_{EE}$=0V, unless otherwise specified.)

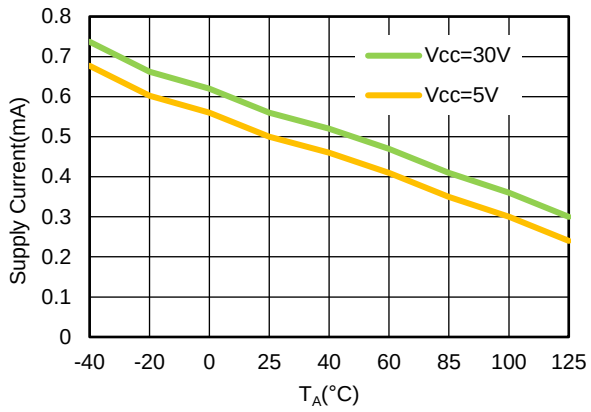



Figure.1 Supply Current vs. Temperature

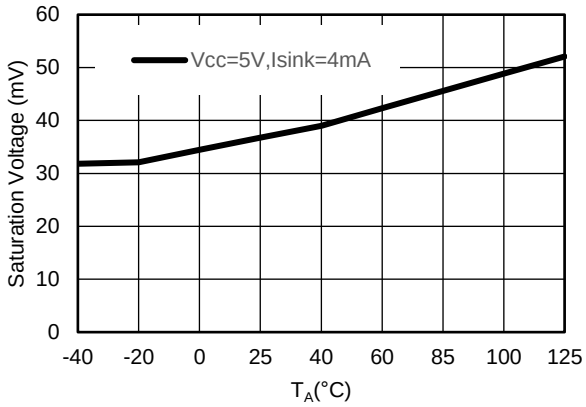



Figure.2 Saturation Voltage vs. Temperature

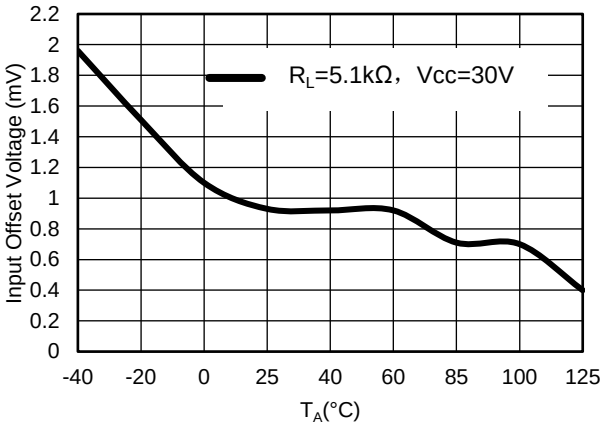



Figure.3 Input Offset Voltage vs. Temperature

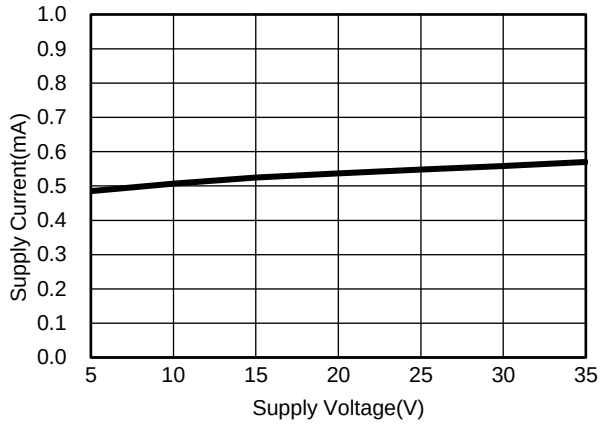



Figure.4 Supply Current vs. Supply Voltage

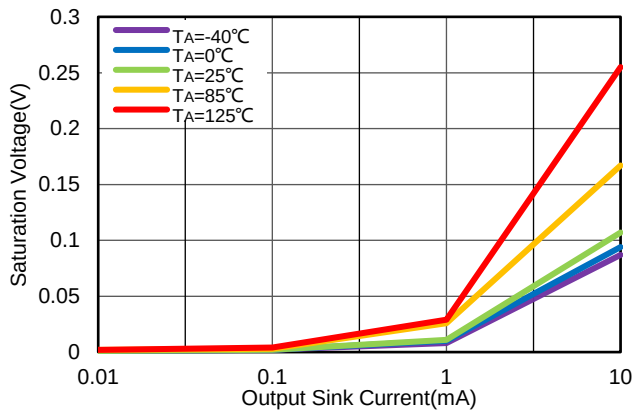



Figure.5 Saturation Voltage vs. Output Sink Current

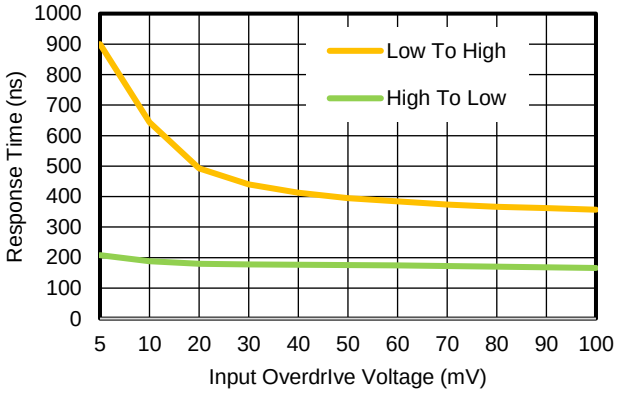



Figure.6 Response Time vs. Input Overdrive Voltage

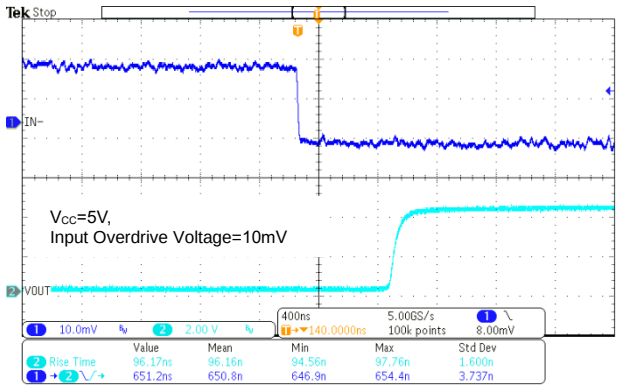



Figure.7 Response Time for Positive Transition

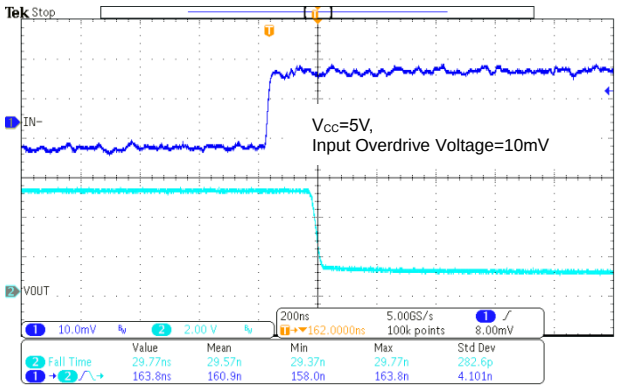



Figure.8 Response Time for Negative Transition

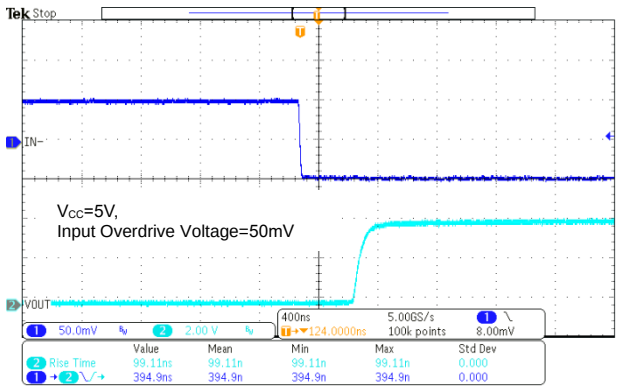



Figure.9 Response Time for Positive Transition

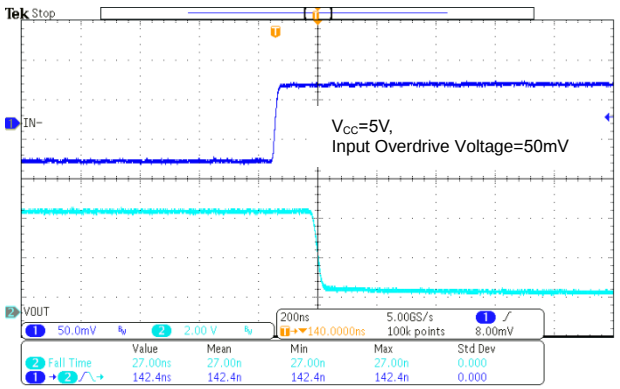



Figure.10 Response Time for Negative Transition

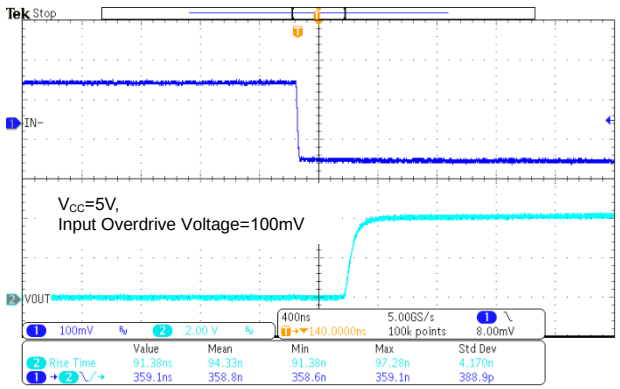



Figure.11 Response Time for Positive Transition

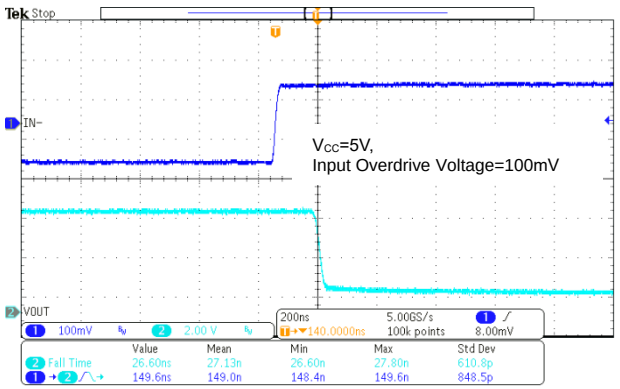



Figure.12 Response Time for Negative Transition

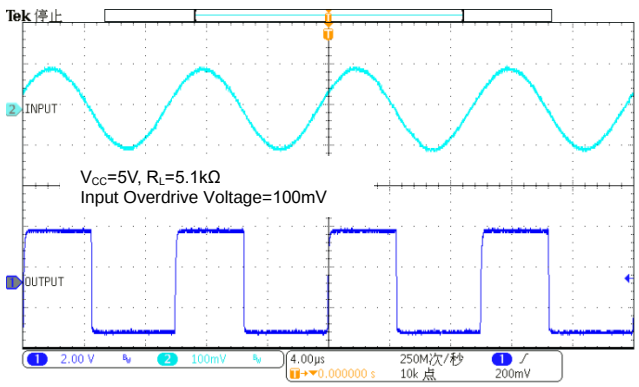



Figure.13 100kHz Response

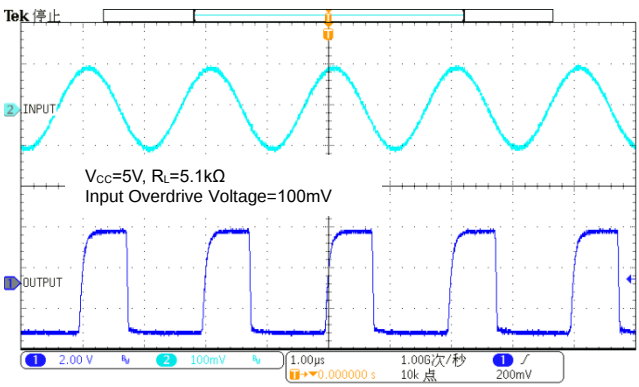


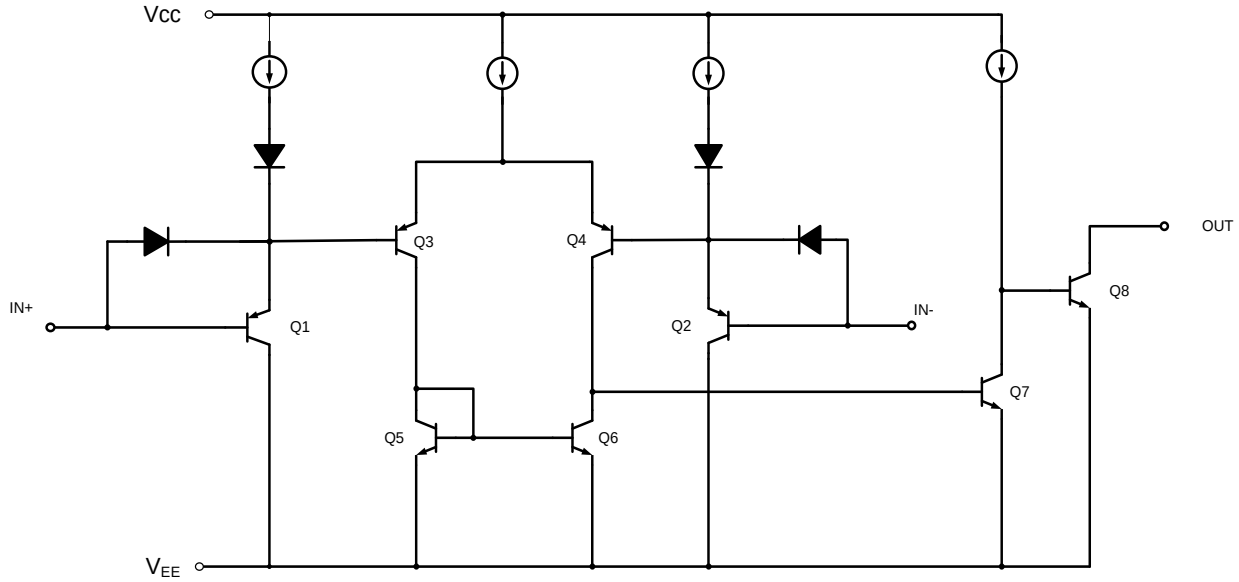

Figure.14 500kHz Response

# 11. Function Description

## 11.1 Overview

The WA3331 is a single comparator with wide supply voltages range up to 36V, low quiescent current, and fast response. Power supply current drain is independent of the magnitude of the power supply voltage. The output can be connected to other open-collector output to achieve wired-AND relationships.

## 11.2 Functional Block Diagram




## 11.3 Function Description

WA3331 consists of a PNP Darlington pair input, allowing the device to operate with very high gain with minimal input bias current. The input Darlington pair creates a limit on the input common mode voltage capability, allowing WA3331 to accurately function from ground to $V_{CC}$ – 1.5V differential input. The output consists of an open collector NPN (pull-down or low side) transistor. The output NPN will sink current when the negative input voltage is higher than the positive input voltage and the offset voltage. The $V_{OL}$ is resistive and will scale with the output current.

## 11.4 Device Functional Modes

### Voltage Comparison

The WA3331 operates solely as a voltage comparator, comparing the differential voltage between the positive and negative pins and outputting a logic low or high impedance (logic high with pull-up) based on the input differential polarity.

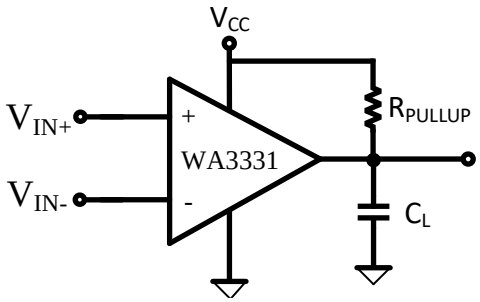
# 12. Application and Implementation

**Note:** The information in the Applications section below is not part of WAY-ON's product specifications and WAY-ON does not guarantee its accuracy or completeness. The customer is responsible for determining the suitability of the component for its intended use and should verify and test its design implementation to confirm system functionality.

## 12.1 Application Information

WA3331 will typically be used to compare a single signal to a reference or two signals against each other. Many users take advantage of the open drain output to drive the comparison logic output to a logic voltage level to an MCU or logic device. The wide supply range and high voltage capability makes WA3331 optimal for level shifting to a higher or lower voltage.

## 12.2 Typical Application




## 12.3 Detailed Design Procedure

When using WA3331 in a general comparator application, determine the following:

• Input voltage range
• Minimum overdrive voltage
• Output and drive current
• Response time

### 12.3.1 Input Voltage Range

When choosing the input voltage range, the input common mode voltage range ($V_{CM}$) must be taken in to account. If temperature operation is above or below 25°C the $V_{ICR}$ can range from 0V to $V_{CC}$ – 1.5V. This limits the input voltage range to as high as $V_{CC}$ – 1.5V and as low as 0V. Operation outside of this range can yield incorrect comparisons. Below is a list of input voltage situation and their outcomes:

1. When both IN- and IN+ are both within the common mode range:
    a. If $V_{IN-} > V_{IN+} + V_{OS}$, the output is low and the output transistor is sinking current
    b. If $V_{IN-} < V_{IN+} + V_{OS}$, the output is high impedance and the output transistor is not conducting
2. When IN- is higher than common mode and IN+ is within common mode, the output is low and the output transistor is sinking current
3. When IN+ is higher than common mode and IN- is within common mode, the output is high impedance and the output transistor is not conducting
4. When IN- and IN+ are both higher than common mode, the output is low and the output transistor is sinking current

### 12.3.2 Minimum Overdrive Voltage

Overdrive Voltage is the differential voltage produced between the positive and negative inputs of the comparator over the offset voltage ($V_{OS}$). In order to make an accurate comparison the Overdrive Voltage ($V_{OD}$) should be higher than the input offset voltage ($V_{OS}$). Overdrive voltage can also determine the response time of the comparator, with the response time decreasing with increasing overdrive. Figure 6 show positive and negative response times with respect to overdrive voltage.

### 12.3.3 Output and Drive Current

Output current is determined by the load/pull-up resistance and logic/pull-up voltage. The output current will produce a output low voltage ($V_{OL}$) from the comparator. In which $V_{OL}$ is proportional to the output current. Use Figure 5 to determine $V_{OL}$ based on the output current. The output current can also effect the transient response. More is explained in the next section.

### 12.3.4 Response Time

Response time is a function of input overdrive voltage. See Figure 6 to 12 for typical response times. The rise and fall times can be determined by the load capacitance ($C_L$), load/pull up resistance ($R_{PULL-UP}$), and equivalent collector emitter resistance ($R_{CE}$).

• The rise time ($T_R$) is approximately $R_{PULL-UP} \times C_L$
• The fall time ($T_F$) is approximately $R_{CE} \times C_L$
– $R_{CE}$ can be determined by taking the slope of Figure 5 in its linear region at the desired temperature, or by dividing the $V_{OL}$ by $I_{SINK}$.

## 13. Power Supply Recommendations

For fast response and comparison applications with noisy or AC inputs, it is recommended to use a bypass capacitor on the supply pin to reject any variation on the supply voltage. This variation can eat into the comparator's input common mode range and create an inaccurate comparison.

## 14. Evaluation Modules

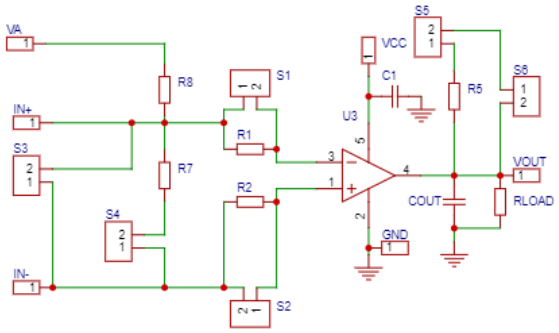
Evaluation Modules (EVMs) are available to help evaluate initial circuit performance. We have evaluation modules for different packages, you can contact us by phone or address at the end to get the evaluation module or schematic.

The module names are listed in the table below.

| Name | Package | Evaluation Module |
|---|---|---|
| WA3331 | SOT23-5 | WAYON OPA_WA3331 EVM V1.0 -SOT23-5 |
| WA3331 | SOT353 | WAYON OPA_WA3331 EVM V1.0 -SOT353 |

### 14.1 Schematic

A typical application for an operational amplifier in an inverting amplifier. This amplifier takes a positive voltage on the negative input through a resistor, and get a negative voltage on the output of the amplifier. So does the negative voltage input.




## 14.2 Layout

**Layout Guidelines**

1.Connect low-ESR, 0.1 μF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible.

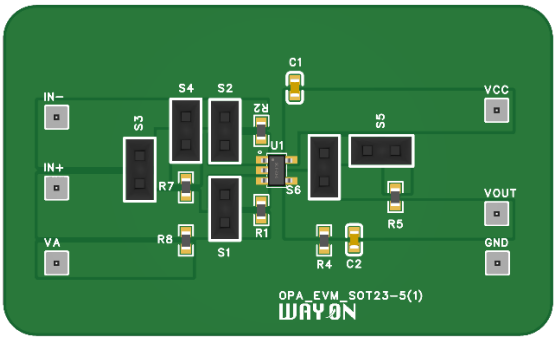
2. Separate grounding for analog and digital portions.

3. Run the input traces as far away from the supply or output traces as possible.

4. Place the external components as close to the device as possible.

5. Keep the length of input traces as short as possible.

**Layout Example：**




# 15. Naming Conventions

WA B CCC-DDD E

WA: WAYON Analog signal chain

B: 3 - operational amplifier

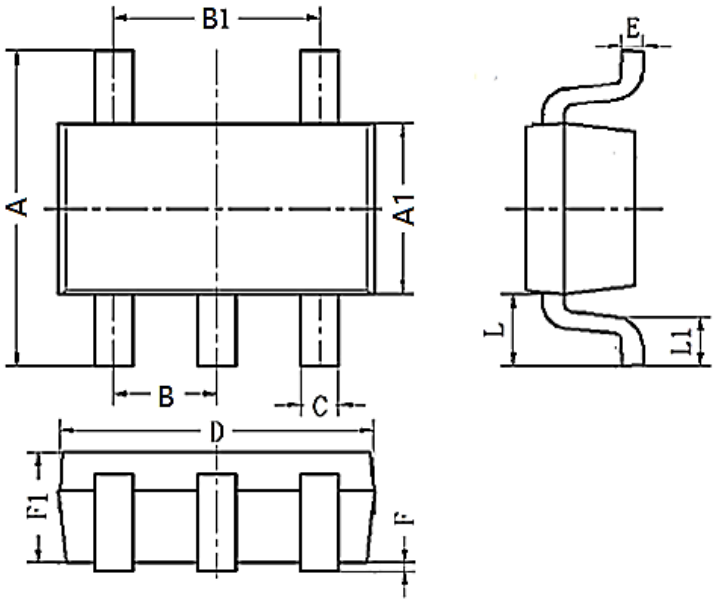
CCC: serial number

DDD: A50-Package, SOT23-5； C50- Package, SOT353

E: R-Reel & T-tube

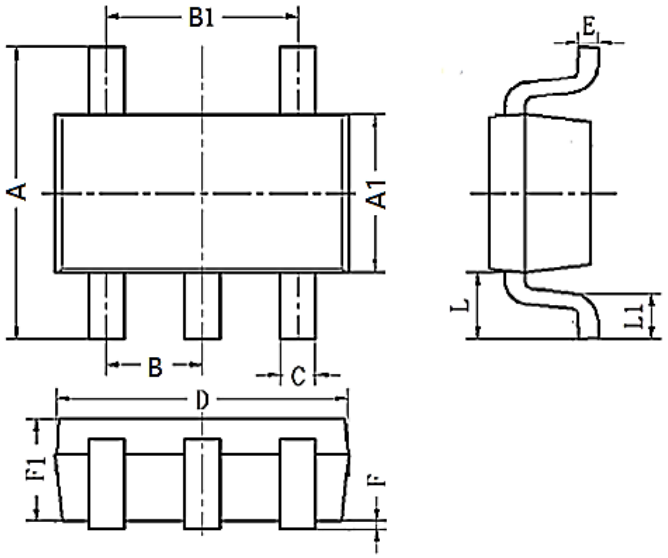
## 16. Package Information

**SOT 23-5**




| SYMBOL | DIMENSIONS IN MILLIMETERS | | |
|---|---|---|---|
| | MIN | NOM | MAX |
| **A** | 2.60 | 2.80 | 3.00 |
| **A1** | 1.50 | 1.60 | 1.70 |
| **B** | 0.85 | 0.95 | 1.05 |
| **B1** | 1.80 | 1.90 | 2.00 |
| **C** | 0.25 | 0.37 | 0.50 |
| **D** | 2.79 | 2.90 | 3.02 |
| **E** | 0.10 | 0.15 | 0.20 |
| **F** | 0.00 | 0.10 | 0.20 |
| **L** | 0.60REF | | |
| **L1** | 0.30 | 0.45 | 0.60 |
| **F1** | 0.85 | 1.10 | 1.30 |

**SOT-353**




| SYMBOL | DIMENSIONS IN MILLIMETERS | | |
|---|---|---|---|
| | MIN | NOM | MAX |
| **A** | 2.15 | 2.275 | 2.40 |
| **A1** | 1.15 | 1.25 | 1.35 |
| **B** | | 0.65TYP | |
| **B1** | 1.20 | 1.30 | 1.40 |
| **C** | 0.15 | 0.25 | 0.35 |
| **D** | 2.00 | 2.10 | 2.20 |
| **E** | 0.10 | 0.125 | 0.15 |
| **F** | 0.00 | 0.05 | 0.10 |
| **L** | | 0.525REF | |
| **F1** | 0.90 | 0.95 | 1.0 |
| **L1** | 0.26 | 0.36 | 0.46 |

## 17. Ordering Information

| PART NUMBER | PACKAGE | PACKING QUANTITY | MARKING* |
|---|---|---|---|
| WA3331-A50R | SOT23-5 | 3k/Reel | WA3331 XXXX |
| WA3331-C50R | SOT-353 | 3k/Reel | WA3331 XXXX |

* XXXX is variable.

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WAYON website: http://www.way-on.com
For additional information, please contact your local Sales Representative.
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*Specifications are subject to change without notice.*
*The device characteristics and parameters in this data sheet can and do vary in different applications and actual device performance may vary over time.*
*Users should verify actual device performance in their specific applications.*

## Product Specification Statement

- The product specification aims to provide users with a reference regarding various product parameters, performance, and usage. It presents certain aspects of the product's performance in graphical form and is intended solely for users to select product and make product comparisons, enabling users to better understand and evaluate the characteristics and advantages of the product. It does not constitute any commitment, warranty, or guarantee.
- The product parameters described in the product specification are numerical values, characteristics, and functions obtained through actual testing or theoretical calculations of the product in an independent or ideal state. Due to the complexity of product applications and variations in test conditions and equipment, there may be slight fluctuations in parameter test values. WAYON shall not guarantee that the actual performance of the product when installed in the customer's system or equipment will be entirely consistent with the product specification, especially concerning dynamic parameters. It is recommended that users consult with professionals for product selection and system design. Users should also thoroughly validate and assess whether the actual parameters and performance when installed in their respective systems or equipment meet their requirements or expectations. Additionally, users should exercise caution in verifying product compatibility issues, and WAYON assumes no responsibility for the application of the product.
- WAYON strives to provide accurate and up-to-date information to the best of our ability. However, due to technical, human, or other reasons, WAYON cannot guarantee that the information provided in the product specification is entirely accurate and error-free. WAYON shall not be held responsible for any losses or damages resulting from the use or reliance on any information in these product specifications. WAYON reserves the right to revise or update the product specification and the products at any time without prior notice, and the user's continued use of the product specification is considered an acceptance of these revisions and updates. Prior to purchasing and using the product, users should verify the above information with WAYON to ensure that the product specification is the most current, effective, and complete. If users are particularly concerned about product parameters, please consult WAYON in detail or request relevant product test reports. Any data not explicitly mentioned in the product specification shall be subject to separate agreement.
- Users are advised to pay attention to the parameter limit values specified in the product specification and maintain a certain margin in design or application to ensure that the product does not exceed the parameter limit values defined in the product specification. This precaution should be taken to avoid exceeding one or more of the limit values, which may result in permanent irreversible damage to the product, ultimately affecting the quality and reliability of the system or equipment.
- The design of the product is intended to meet civilian needs and is not guaranteed for use in harsh environments or precision equipment. It is not recommended for use in systems or equipment such as medical devices, aircraft, nuclear power, and similar systems, where failures in these systems or equipment could reasonably be expected to result in personal injury. WAYON shall assume no responsibility for any consequences resulting from such usage.
- Users should also comply with relevant laws, regulations, policies, and standards when using the product specification. Users are responsible for the risks and liabilities arising from the use of the product specification and must ensure that it is not used for illegal purposes. Additionally, users should respect the intellectual property rights related to the product specification and refrain from infringing upon any third-party legal rights. WAYON shall assume no responsibility for any disputes or controversies arising from the above-mentioned issues in any form.