# UMW TLVx313

Low-Power, Rail-to-Rail In/Out, 500-μV Typical Offset
1-MHz Operational Amplifier for Cost-Sensitive Systems

## 1.Description

The UMW TLV313 family of single-, dual-, and quad-channel precision operational amplifiers combine low power consumption with good performance. This makes them suitable for a wide range of applications, such as wearables, utility metering, building automation, currency counters and more. The family features rail-to-rail input and output (RRIO) swings,low quiescent current (65 μA, typical), wide bandwidth (1 MHz) and very low noise (26 nV/√Hz at 1 kHz), making it attractive for a variety of battery-powered applications that require a good balance between cost and performance. Further, low-inputbias current enables these devices to be used in applications with megaohm source impedances.

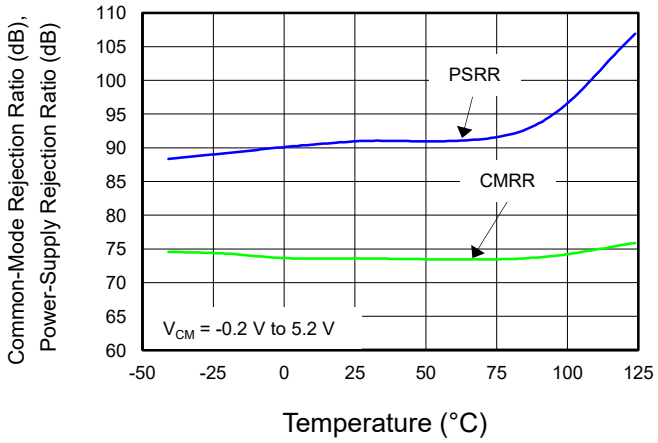
## 2.Features

- Precision Amplifier for Cost-Sensitive Systems
- Low $I_Q$: 65 μA/ch
- Wide Supply Range: 1.8V to 5.5V
- Low Noise: 26 nV/√Hz at 1 kHz
- Gain Bandwidth: 1 MHz
- Rail-to-Rail Input/Output
- Low Input Bias Current: 1 pA
- Low Offset Voltage: 0.75 mV
- Unity-Gain Stable
- Internal RF/EMI Filter
- Extended Temperature Range: –40°C to +125°C

## 3.Applications

- Medical and Healthcare
- Fitness and Wearable Electronics
- Utility Metering (Heat, Water, Energy)
- Building Automation Equipment
- Currency Counters

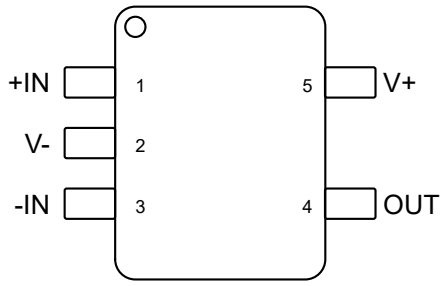
## 4.CMRR and PSRR vs Temperature



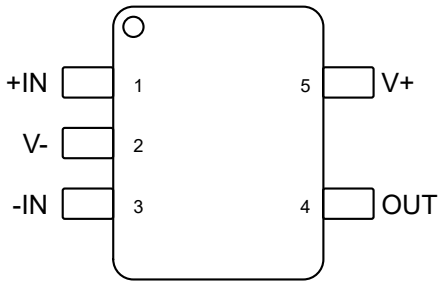

## 5.Device Comparison Table

| Device | NO. OF Channels | Package Leads | | | |
|---|---|---|---|---|---|
| | | SC70 | SOT23 | SOP | TSSOP |
| UMW TLV313 | 1 | 5 | 5 | - | - |
| UMW TLV2313 | 2 | - | - | 8 | - |
| UMW TLV4313 | 4 | - | - | - | 14 |

## 6.Pinning information



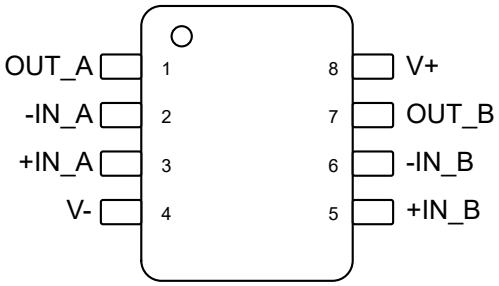

SC70




SOT23

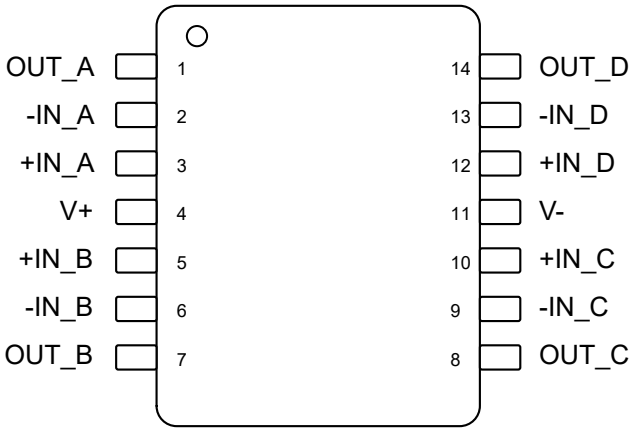
Pin Functions: TLV313

| Pin | | | I/O | Description |
|---|---|---|---|---|
| Name | DCK(SC70) | DBV(SOT23) | | |
| +IN | 3 | 3 | 3 | Inverting input |
| V- | 2 | 2 | 2 | Negative (lowest) power supply |
| -IN | 4 | 4 | 4 | Output |
| OUT | 1 | 1 | 1 | Noninverting input |
| V+ | 5 | 5 | 5 | Positive (hiahest) power supply |




Pin Functions: TLV2313

| Pin | | I/O | Description |
|---|---|---|---|
| Name | D (SOIC) | | |
| V- | 4 | - | Negative (lowest) power supply |
| V+ | 8 | - | Positive (highest) power supply |
| OUTA | 1 | O | Output, channel A |
| OUTB | 7 | O | Qutput, channel B |
| -INA | 2 | I | Inverting input, channel A |
| +INA | 3 | I | Noninverting input, channel A |
| -INB | 6 | I | Inverting input, channel B |
| +INB | 5 | I | Noninverting input, channel B |




Pin Functions: TLV4313

| Pin | | I/O | Description |
|---|---|---|---|
| Name | PW (TSSOP) | | |
| V- | 11 | - | Negative (lowest) power supply |
| V+ | 4 | - | Positive (highest) power supply |
| OUTA | 1 | O | Output, channel A |
| OUTB | 7 | O | Output, channel B |
| OUTC | 8 | O | Output, channel C |
| OUTD | 14 | O | Output, channel D |
| -INA | 2 | I | Inverting input, channel A |
| +INA | 3 | I | Noninverting input, channel A |
| -INB | 6 | I | Inverting input, channel B |
| +INB | 5 | I | Noninverting input, channel B |
| -INC | 9 | I | Inverting input, channel C |
| +INC | 10 | I | Noninverting input, channel C |
| -IND | 13 | I | Inverting input, channel D |
| +IND | 12 | I | Noninverting input, channel D |

## 7.Absolute Maximum Ratings

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

| Parameter | | Symbol | Min | Max | Units |
|---|---|---|---|---|---|
| Voltage | Supply voltage | | | 7 | V |
| | Signal input terminals(2) | | (V-) - (0.5) | (V+) + 0.5 | V |
| Current | Signal input terminals(2) | | -10 | 10 | mA |
| | Output short circuit(3) | | Continuous | | |
| Temperature | Operating | $T_A$ | -40 | 150 | °C |
| | Junction | $T_J$ | | 150 | °C |
| | torage | $T_{STG}$ | -65 | 150 | °C |

Notes:

(1) 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.

(2) Input pins are diode-clamped to the power-supply rails. Input signals that may swing more than 0.5 V beyond the supply rails must be current limited to 10 mA or less.

(3) Short-circuit to ground, one amplifier per package.

## 8.ESD Ratings

| Parameter | | Symbol | Value | Units |
|---|---|---|---|---|
| Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1) | $V_{(ESD)}$ | ±4000 | V |
| | Charged-device model (CDM), per JEDEC specification JESD22-C101(2) | | ±1000 | |

Notes:

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

## 9.Recommended Operating Conditions

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

| Parameter | Symbol | Min | Max | Units |
|---|---|---|---|---|
| Supply voltage | $V_S$ | 1.8 | 5.5 | V |
| Specified temperature range | $T_A$ | -40 | 125 | °C |

## 10.1 Thermal Information: TLV313

| Thermal Metric(1) | Symbol | DBV (SOT23) | DCK (SC70) | Units |
|---|---|---|---|---|
| | | 5 Pins | 5 Pins | |
| Junction-to-ambient thermal resistance | $R_{\theta JA}$ | 228.5 | 281.4 | °C/W |
| Junction-to-case (top) thermal resistance | $R_{\theta JC(top)}$ | 99.1 | 91.6 | °C/W |
| Junction-to-board thermal resistance | $R_{\theta JB}$ | 54.6 | 59.6 | °C/W |
| Junction-to-top characterization parameter | $\Psi_{JT}$ | 7.7 | 1.5 | °C/W |
| Junction-to-board characterization parameter | $\Psi_{JB}$ | 53.8 | 58.8 | °C/W |
| Junction-to-case (bottom) thermal resistance | $R_{\theta JC(bot)}$ | N/A | N/A | °C/W |

## 10.2 Thermal Information: TLV2313

| Thermal Metric(1) | Symbol | D(SOP) | Units |
|---|---|---|---|
| | | 8 Pins | |
| Junction-to-ambient thermal resistance | $R_{\theta JA}$ | 138.4 | °C/W |
| Junction-to-case (top) thermal resistance | $R_{\theta JC(top)}$ | 89.5 | °C/W |
| Junction-to-board thermal resistance | $R_{\theta JB}$ | 78.6 | °C/W |
| Junction-to-top characterization parameter | $\Psi_{JT}$ | 29.9 | °C/W |
| Junction-to-board characterization parameter | $\Psi_{JB}$ | 78.1 | °C/W |
| Junction-to-case (bottom) thermal resistance | $R_{\theta JC(bot)}$ | N/A | °C/W |

## 10.2 Thermal Information: TLV4313

| Thermal Metric(1) | Symbol | PW (TSSOP) | Units |
|---|---|---|---|
| | | 14 Pins | |
| Junction-to-ambient thermal resistance | $R_{\theta JA}$ | 121 | °C/W |
| Junction-to-case (top) thermal resistance | $R_{\theta JC(top)}$ | 49.4 | °C/W |
| Junction-to-board thermal resistance | $R_{\theta JB}$ | 62.8 | °C/W |
| Junction-to-top characterization parameter | $\Psi_{JT}$ | 5.9 | °C/W |
| Junction-to-board characterization parameter | $\Psi_{JB}$ | 62.2 | °C/W |
| Junction-to-case (bottom) thermal resistance | $R_{\theta JC(bot)}$ | N/A | °C/W |

## 11.1 Electrical Characteristics: 5.5V(1)

At $T_A$=25°C, $R_L$=10kΩ connected to $V_S$/2, and $V_{CM}$=$V_{OUT}$=$V_S$/2, unless otherwise noted.

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **OFFSET VOLTAGE** | | | | | | |
| Input offset voltage | $V_{OS}$ | | | 0.75 | 3 | mV |
| Input offset voltage vs temperature | $dV_{OS}/dT$ | $T_A$=-40°C to 125°C | | 2 | | μV/°C |
| Power-supply rejection ratio | PSRR | | 74 | 90 | | dB |
| **INPUT VOLTAGE RANGE** | | | | | | |
| Common-mode voltage range | $V_{CM}$ | No phase reversal, rail-to-rail input | (V–)-0.2 | | (V+)+0.2 | V |
| Common-mode rejection ratio | CMRR | ($V_{S-}$)-0.2V<$V_{CM}$<($V_{S+}$)-1.3V | | 85 | | dB |
| | | $V_{CM}$=-0.2V to 5.7V | 64 | 80 | | dB |
| **INPUT BIAS CURRENT** | | | | | | |
| Input bias current | $I_B$ | | | ±1 | | pA |
| Input offset current | $I_{OS}$ | | | ±1 | | pA |
| **NOISE** | | | | | | |
| Input voltage noise (peak-to-peak) | | f=0.1Hz to 10Hz | | 6 | | $μV_{PP}$ |
| Input voltage noise density | $e_n$ | f=10kHz | | 22 | | nV/√Hz |
| | | f=1kHz | | 26 | | nV/√Hz |
| Input current noise density | $i_n$ | f=1kHz | | 5 | | fA/√Hz |
| **INPUT CAPACITANCE** | | | | | | |
| Differential | $C_{IN}$ | | | 1 | | pF |
| Common-mode | | | | 5 | | pF |
| **OPEN-LOOP GAIN** | | | | | | |
| Open-loop voltage gain | $A_{OL}$ | 0.05V<$V_O$<(V+)-0.05V, $R_L$=100kΩ | | 104 | | dB |
| | | 0.3V<$V_O$<(V+)-0.3 V, $R_L$=2kΩ | 100 | 110 | | dB |
| Phase margin | | $V_S$=5.0V, G=+1 | | 65 | | ° |

Note: (1) Parameters with minimum or maximum specification limits are 100% production tested at 25ºC, unless otherwise noted. Over temperature limits are based on characterization and statistical analysis.

## 11.2 Electrical Characteristics: 5.5V(1) (continued)

At $T_A$=25°C, $R_L$=10kΩ connected to $V_S$/2, and $V_{CM}$=$V_{OUT}$=$V_S$/2, unless otherwise noted.

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **FREQUENCY RESPONSE** | | | | | | |
| Gain-bandwidth product | GBW | $V_S$=5.0V, $C_L$=10pF | | 1 | | MHz |
| Slew rate | SR | $V_S$=5.0V, G=+1 | | 0.5 | | V/μs |
| Settling time | ts | To 0.01%, $V_S$=5.0V, 2-V step , G=+1 | | 6 | | μs |
| Overload recovery time | | $V_S$=5.0V, $V_{IN}$×Gain>$V_S$ | | 3 | | μs |
| **OUTPUT** | | | | | | |
| Voltage output swing from supply rails | $V_O$ | $R_L$=100kΩ (2) | | 5 | 20 | mV |
| | | $R_L$=2kΩ (2) | | 75 | 100 | mV |
| Short-circuit current | $I_{SC}$ | | | ±15 | | mA |
| Open-loop output impedance | $R_O$ | | | 2300 | | Ω |
| **POWER SUPPLY** | | | | | | |
| Specified voltage range | $V_S$ | | 1.8(±0.9) | | 5.5(±2.75) | V |
| Quiescent current per amplifier | $I_Q$ | $T_A$=-40°C to 125°C, $V_S$=5.0V, $I_O$=0mA | | 65 | 90 | μA |
| Power-on time | | $V_S$=0V to 5V, to 90% $I_Q$ level | | 10 | | μs |
| **TEMPERATURE** | | | | | | |
| Specified range | | | -40 | | 125 | °C |
| Operating range | | | -40 | | 150 | °C |
| Storage range | $T_{STG}$ | | -65 | | 150 | °C |

Note:

(2) Specified by design and characterization; not production tested.

## 11.3 Electrical Characteristics: 1.8V(1)

At $T_A$=25°C, $R_L$=10kΩ connected to $V_S$/2, $V_{CM}$=$V_{S+}$ - 1.3V, and $V_{OUT}$=$V_S$/2, unless otherwise noted.

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **OFFSET VOLTAGE** | | | | | | |
| Input offset voltage | $V_{OS}$ | | | 0.75 | 3 | mV |
| Input offset voltage vs temperature | $dV_{OS}/dT$ | $T_A$=-40°C to 125°C | | 2 | | μV/°C |
| Power-supply rejection ratio | PSRR | | 74 | 90 | | dB |
| **INPUT VOLTAGE RANGE** | | | | | | |
| Common-mode voltage range | $V_{CM}$ | No phase reversal, rail-to-rail input | (V–)-0.2 | | (V+)+0.2 | V |
| Common-mode rejection ratio | CMRR | ($V_{S-}$)-0.2V<$V_{CM}$<($V_{S+}$)-1.3V | | 85 | | dB |
| | | $V_{CM}$=-0.2V to 1.8V | | 73 | | dB |
| **INPUT BIAS CURRENT** | | | | | | |
| Input bias current | $I_B$ | | | ±1 | | pA |
| Input offset current | $I_{OS}$ | | | ±1 | | pA |
| **NOISE** | | | | | | |
| Input voltage noise (peak-to-peak) | | f=0.1Hz to 10Hz | | 6 | | $μV_{PP}$ |
| Input voltage noise density | $e_n$ | f=10kHz | | 22 | | nV/√Hz |
| | | f=1kHz | | 26 | | nV/√Hz |
| Input current noise density | $i_n$ | f=1kHz | | 5 | | fA/√Hz |
| **INPUT CAPACITANCE** | | | | | | |
| Differential | $C_{IN}$ | | | 1 | | pF |
| Common-mode | | | | 5 | | pF |
| **OPEN-LOOP GAIN** | | | | | | |
| Open-loop voltage gain | $A_{OL}$ | 0.1V<$V_O$<(V+)-0.1V, $R_L$=10kΩ | | 110 | | dB |
| | | 0.05V<$V_O$<(V+)-0.05V, $R_L$=100kΩ | | 110 | | dB |

Note: Parameters with minimum or maximum specification limits are 100% production tested at 25ºC, unless otherwise noted. Over temperature limits are based on characterization and statistical analysis.

## 11.4 Electrical Characteristics: 1.8V(1) (continued)

At $T_A$=25°C, $R_L$=10kΩ connected to $V_S$/2, $V_{CM}$=$V_{S+}$ – 1.3V, and $V_{OUT}$=$V_S$/2, unless otherwise noted.

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **FREQUENCY RESPONSE** | | | | | | |
| Gain-bandwidth product | GBW | $C_L$=10pF | | 0.9 | | MHz |
| Slew rate | SR | G=+1 | | 0.45 | | V/μs |
| Settling time | ts | To 0.01%, $V_S$=5.0V, 2-V step , G=+1 | | 6 | | μs |
| Overload recovery time | | $V_S$=5.0V, $V_{IN}$×Gain>$V_S$ | | 3 | | μs |
| **OUTPUT** | | | | | | |
| Voltage output swing from supply rails | $V_O$ | $R_L$=100kΩ (2) | | 5 | | mV |
| | | $R_L$=2kΩ (2) | | 25 | | mV |
| Short-circuit current | $I_{SC}$ | | | ±6 | | mA |
| Open-loop output impedance | $R_O$ | | | 2300 | | Ω |
| **POWER SUPPLY** | | | | | | |
| Specified voltage range | $V_S$ | | 1.8(±0.9) | | 5.5(±2.75) | V |
| Quiescent current per amplifier | $I_Q$ | $T_A$=-40°C to 125°C, $V_S$=5.0V, $I_O$=0mA | | 65 | 90 | μA |
| Power-on time | | $V_S$=0V to 5V, to 90% $I_Q$ level | | 10 | | μs |
| **TEMPERATURE** | | | | | | |
| Specified range | | | -40 | | 125 | °C |
| Operating range | | | -40 | | 150 | °C |
| Storage range | $T_{STG}$ | | -65 | | 150 | °C |

Note:

(2) Specified by design and characterization; not production tested.

## 12.1 Typical characteristic

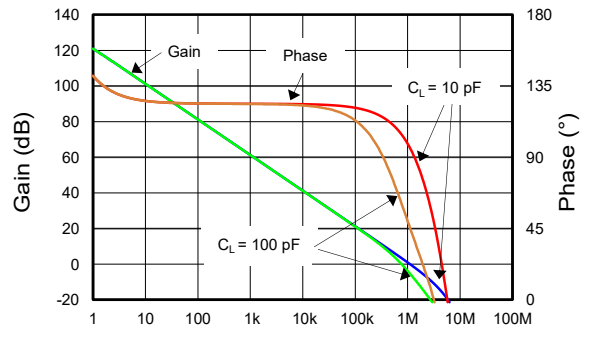



Figure 1: Open-Loop Gain and Phase vs Frequency

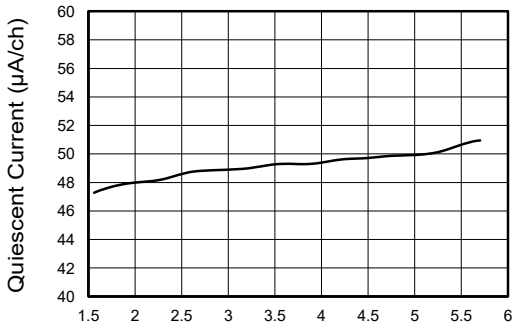



Figure 2: Quiescent Current vs Supply

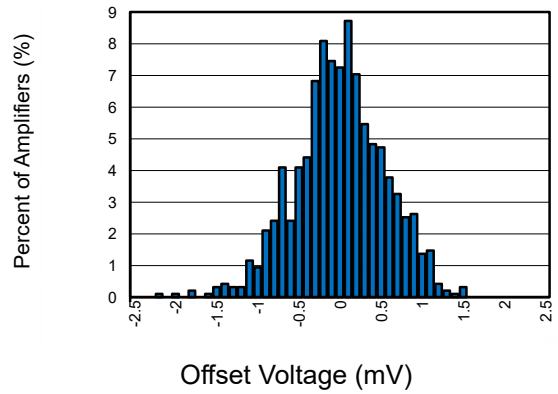



Figure 3: Offset Voltage Production Distribution

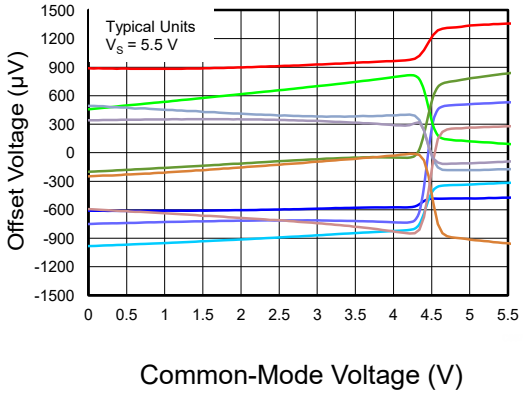



Figure 4: Offset Voltage vs Common-Mode Voltage

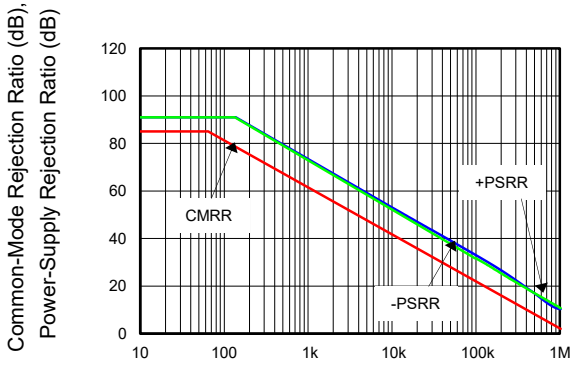



Figure 5: ICMRR and PSRR vs Frequency (Referred-to-Input)

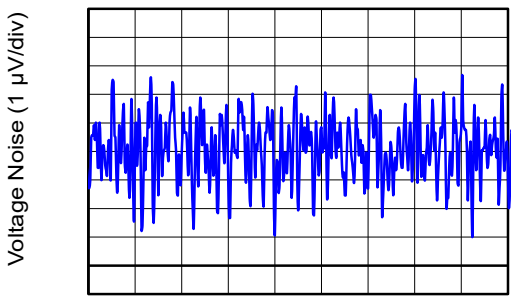



Figure 6: 0.1-Hz to 10-Hz Input Voltage Noise

## 12.2 Typical characteristic

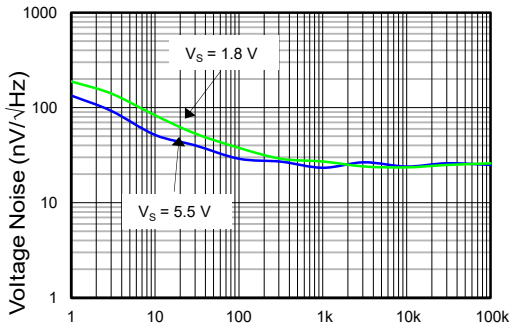



Figure 7: Input Voltage Noise Spectral Density vs Frequency

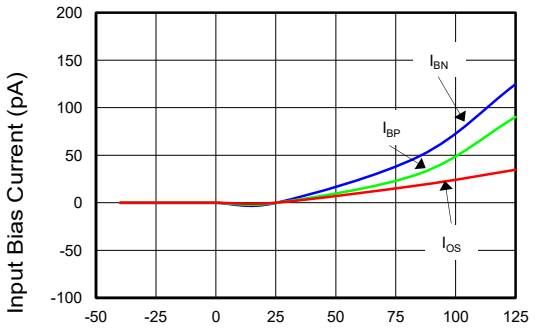



Figure 8: Input Bias and Offset Current vs Temperature

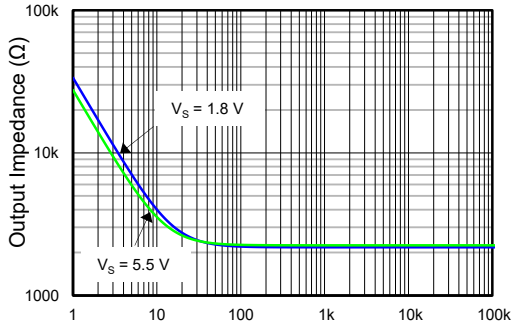



Figure 9: Open-Loop Output Impedance vs Frequency

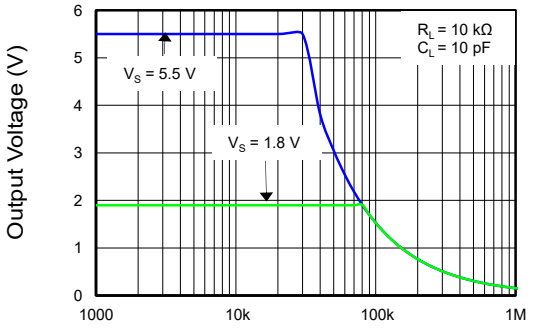



Figure 10: Maximum Output Voltage vs Frequency and Supply Voltage

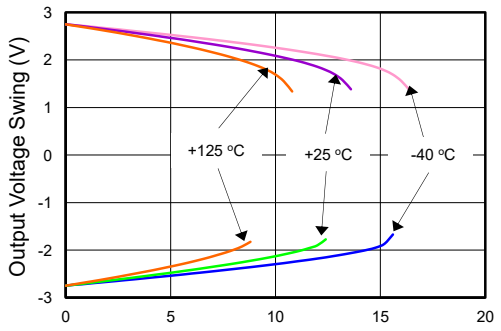



Figure 11: Output Voltage Swing vs Output Current (Over Temperature)

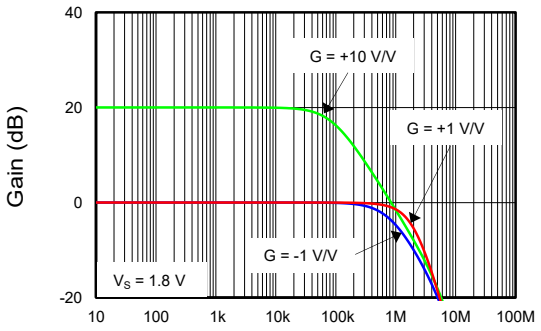



Figure 12: Closed-Loop Gain vs Frequency (Minimum Supply)

## 12.3 Typical characteristic

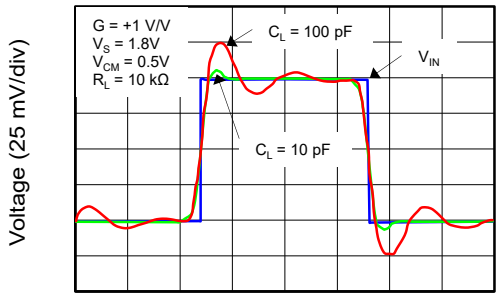



Figure 13: Small-Signal Pulse Response (Minimum Supply)

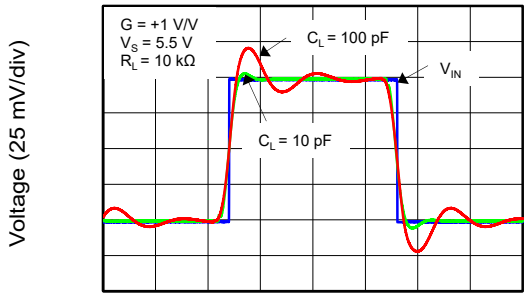



Figure 14: Small-Signal Pulse Response (Maximum Supply)

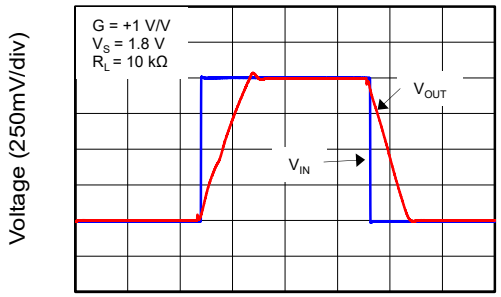



Figure 15: Large-Signal Pulse Response (Minimum Supply)

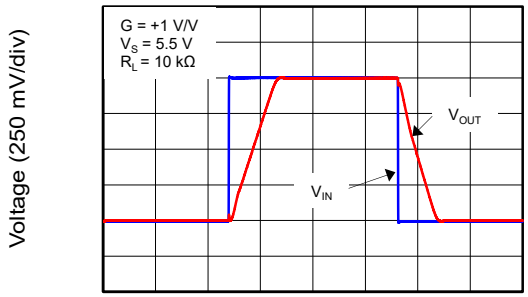



Figure 16: Large-Signal Pulse Response (Maximum Supply)

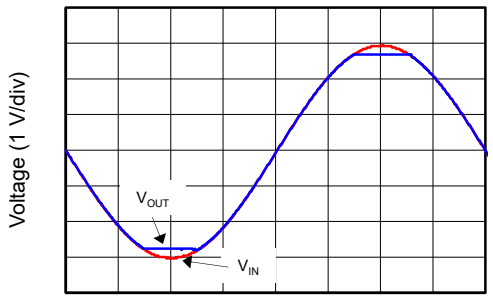



Figure 17: No Phase Reversal

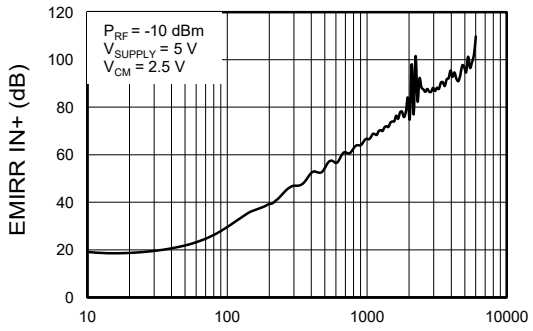
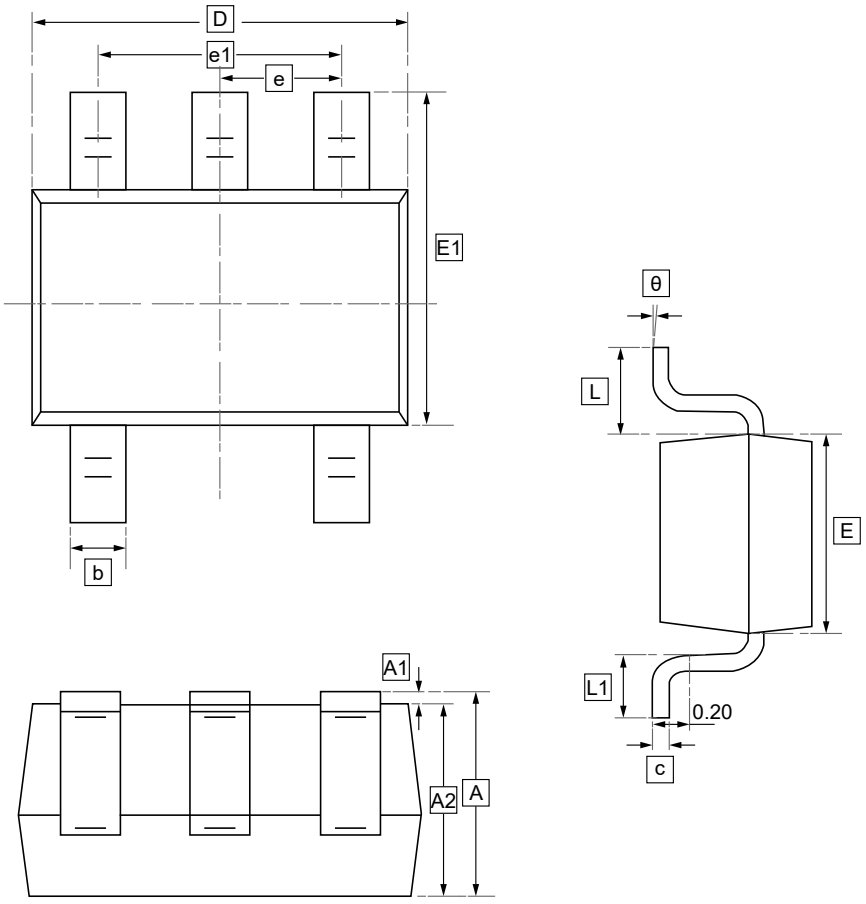



Figure 18: EMIRR IN+ vs Frequency

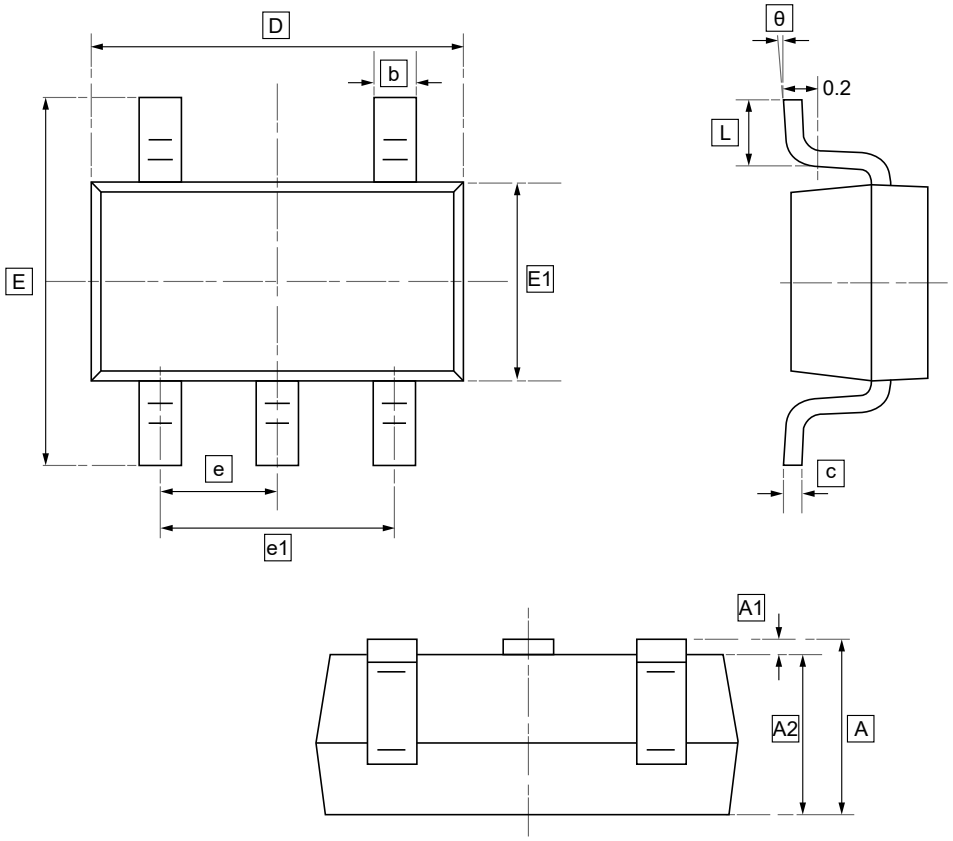
## 13.1 SC70-5 Package Outline Dimensions




**DIMENSIONS (mm are the original dimensions)**

| Symbol | A | A1 | A2 | b | c | D | E | E1 | e | e1 | L | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Min** | 0.90 | 0.00 | 0.90 | 0.15 | 0.08 | 2.05 | 1.15 | 2.15 | 0.65 | 1.20 | 0.26 | 7° |
| **Max** | 1.10 | 0.10 | 1.00 | 0.35 | 0.15 | 2.25 | 1.35 | 2.45 | TYP | 1.40 | 0.46 | REF. |

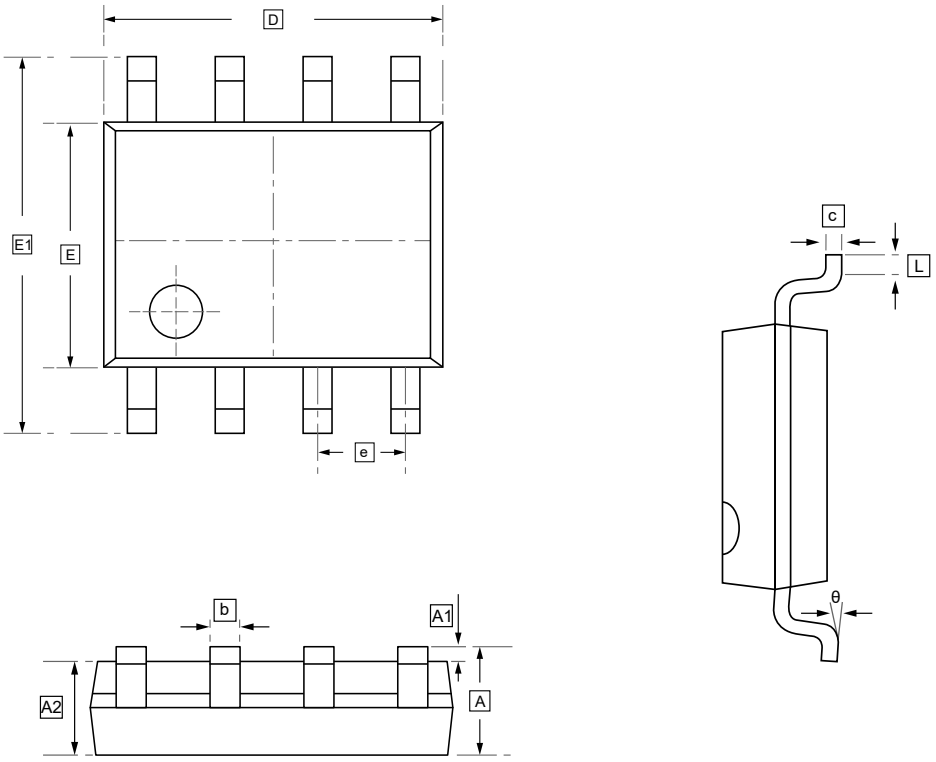
## 13.2 SOT23-5 Package Outline Dimensions




**DIMENSIONS (mm are the original dimensions)**

| Symbol | A | A1 | A2 | b | c | D | E1 | E | e | e1 | L | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Min** | 1.050 | 0.000 | 1.050 | 0.300 | 0.100 | 2.820 | 1.500 | 2.650 | 0.950 | 1.800 | 0.300 | 0° |
| **Max** | 1.250 | 0.100 | 1.150 | 0.500 | 0.200 | 3.020 | 1.700 | 2.950 | BSC | 2.000 | 0.600 | 8° |

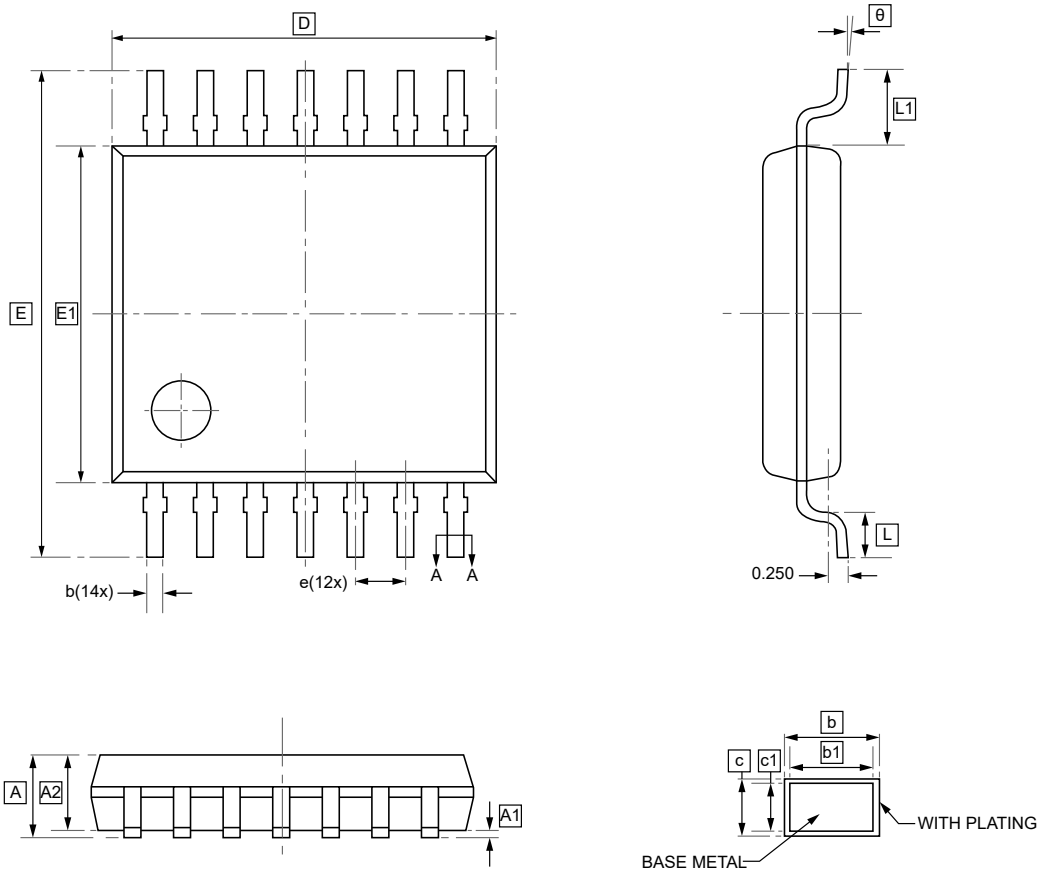
## 13.3 SOP-8 Package Outline Dimensions




**DIMENSIONS (mm are the original dimensions)**

| Symbol | A | A1 | A2 | b | c | D | E | E1 | e | L | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Min** | 1.350 | 0.000 | 1.350 | 0.330 | 0.170 | 4.700 | 3.800 | 5.800 | 1.270 | 0.400 | 0° |
| **Max** | 1.750 | 0.100 | 1.550 | 0.510 | 0.250 | 5.100 | 4.000 | 6.200 | BSC | 1.270 | 8° |

## 13.4 TSSOP-14 Package Outline Dimensions



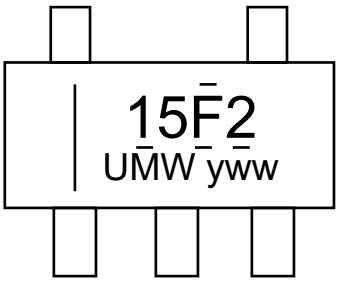

**DIMENSIONS (mm are the original dimensions)**

| Symbol | A | A1 | A2 | b | b1 | c | c1 | D | E | E1 | e | L1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min | - | 0.05 | 0.90 | 0.20 | 0.19 | 0.13 | 0.120 | 4.90 | 6.20 | 4.30 | 0.65 | 0.85 |
| Max | 1.20 | 0.15 | 1.05 | 0.28 | 0.25 | 0.17 | 0.14 | 5.10 | 6.60 | 4.50 | BSC | 1.15 |

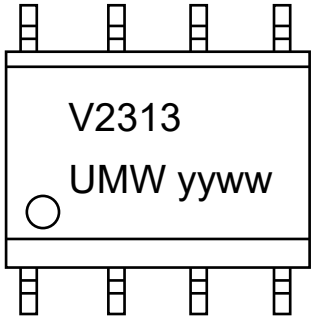
| Symbol | L | θ |
|---|---|---|
| Min | 0.45 | 0° |
| Max | 0.75 | 8° |

## 14.Ordering information

SOT23-5




SOP-8




y: Year Code
yy: Year Code
ww: Week Code

| Order Code | Marking | Package | Base QTY | Delivery Mode |
|---|---|---|---|---|
| UMW TLV313IDCKR | 14E | SC70-5 | 3000 | Tape and reel |
| UMW TLV3131DBVR | 15F2 | SOT23-5 | 3000 | Tape and reel |
| UMW TLV2313IDR | V2313 | SOP-8 | 2500 | Tape and reel |
| UMW TLV4313IPWR | TLV4313 | TSSOP-14 | 4000 | Tape and reel |

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