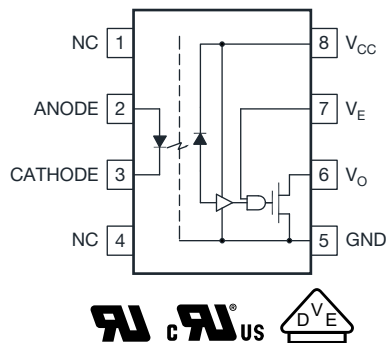
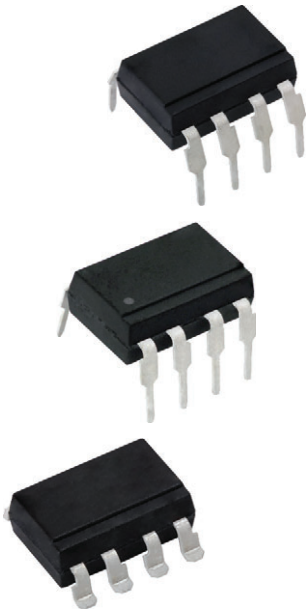


High Speed Optocoupler, 10 MBd



DESCRIPTION

The VOH260A is a single channel 10 MBd optocoupler utilizing a high efficient input LED coupled to a high speed integrated photo-detector logic gate with a strobable output. This detector features an open drain output. The internal shield provides a guaranteed common mode transient immunity of 15 kV/ μ s.

FEATURES

- Common mode rejection (CMR) of min. 15 kV/ μ s
- 3.3 V / 5 V dual supply voltage
- LVTTTL/LVCMOS compatibility
- Low power consumption
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912



RoHS
COMPLIANT

APPLICATIONS

- Microprocessor system interface
- Ground loop elimination
- Digital bus systems isolation
- High speed A/D and D/A conversion
- Digital control power supply
- Level shifting

AGENCY APPROVALS

- [UL1577](#)
- [cUL](#)
- [DIN EN 60747-5-5 \(VDE 0884-5\), available with option 1](#)

LINKS TO ADDITIONAL RESOURCES





| ORDERING INFORMATION | |
|---|--|
| <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; padding: 2px 5px;">V</div> <div style="border: 1px solid black; padding: 2px 5px;">O</div> <div style="border: 1px solid black; padding: 2px 5px;">H</div> <div style="border: 1px solid black; padding: 2px 5px;">2</div> <div style="border: 1px solid black; padding: 2px 5px;">6</div> <div style="border: 1px solid black; padding: 2px 5px;">0</div> <div style="border: 1px solid black; padding: 2px 5px;">A</div> <div style="border: 1px solid black; padding: 2px 5px;">-</div> <div style="border: 1px solid black; padding: 2px 5px;">X</div> <div style="border: 1px solid black; padding: 2px 5px;">0</div> <div style="border: 1px solid black; padding: 2px 5px;">#</div> <div style="border: 1px solid black; padding: 2px 5px;">#</div> <div style="border: 1px solid black; padding: 2px 5px;">T</div> </div> | |
| PART NUMBER | PACKAGE OPTION |
| | T T A P E A N D R E E L |
| AGENCY CERTIFIED / PACKAGE | |
| UL, cUL | |
| DIP-8 | VOH260A |
| DIP-8, 400 mil (option 6) | VOH260A-X006 |
| SMD-8 (option 7) | VOH260A-X007T |
| UL, cUL, VDE (option 1) | |
| DIP-8 | VOH260A-X001 |
| DIP-8, 400 mil (option 6) | VOH260A-X016 |
| SMD-8 (option 7) | VOH260A-X017T |

Note

- Additional options may be possible, please contact sales office

| ABSOLUTE MAXIMUM RATINGS (T _{amb} = 25 °C, unless otherwise specified) | | | | |
|---|----------------|-------------------|-------------------------|------|
| PARAMETER | TEST CONDITION | SYMBOL | VALUE | UNIT |
| INPUT | | | | |
| Input forward current | | I _F | 20 | mA |
| Reverse input voltage | | V _R | 5 | V |
| Enable input voltage | | V _E | V _{CC} + 0.5 V | V |
| Enable input current | | I _E | 5 | mA |
| Input power dissipation | | P _{diss} | 40 | mW |
| OUTPUT | | | | |
| Supply voltage | | V _{CC} | 7 | V |
| Output current | | I _O | 50 | mA |
| Output voltage | | V _O | 7 | V |
| Output power dissipation | | P _{diss} | 85 | mW |
| COUPLER | | | | |
| Storage temperature | | T _{stg} | -55 to +125 | °C |
| Operating temperature | | T _{amb} | -40 to +110 | °C |
| Solder reflow temperature ⁽¹⁾ | 5 s | | 260 | °C |

Notes

- Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to absolute maximum ratings for extended periods of the time can adversely affect reliability

⁽¹⁾ Refer to reflow profile for soldering conditions for surface mounted devices (SMD). Refer to wave profile for soldering conditions for through hole devices (DIP)



| RECOMMENDED OPERATING CONDITIONS | | | | |
|-------------------------------------|-----------|------|----------|-----------|
| PARAMETER | SYMBOL | MIN. | MAX. | UNIT |
| Operating temperature | T_{amb} | -40 | +110 | °C |
| Supply voltage | V_{CC} | 2.7 | 3.6 | V |
| | V_{CC} | 4.5 | 5.5 | V |
| Input current low level | I_{FL} | 0 | 250 | μA |
| Input current high level | I_{FH} | 5 | 15 | mA |
| Logic low enable voltage | V_{EL} | 0 | 0.8 | V |
| Logic high enable voltage | V_{EH} | 2 | V_{CC} | V |
| Output pull up resistor | R_L | 330 | 4000 | Ω |
| Fanout ($R_L = 1\text{ k}\Omega$) | N | - | 5 | TTL loads |

| TRUTH TABLE (positive logic) | | |
|------------------------------|----------------------|--------|
| LED | ENABLE | OUTPUT |
| On | H | L |
| Off | H | H |
| On | L | H |
| Off | L | H |
| On | Not connected / open | L |
| Off | Not connected / open | H |



| ELECTRICAL CHARACTERISTICS ($T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+110\text{ }^{\circ}\text{C}$, $2.7\text{ V} \leq V_{CC} \leq 3.6\text{ V}$, $I_F = 7.5\text{ mA}$, unless otherwise specified; typical values are at $V_{CC} = 3.3\text{ V}$, $T_{amb} = 25\text{ }^{\circ}\text{C}$) | | | | | | |
|---|---|-----------------------|------|-------|------|---------------|
| PARAMETER | TEST CONDITION | SYMBOL | MIN. | TYP. | MAX. | UNIT |
| INPUT | | | | | | |
| Input forward voltage | $I_F = 10\text{ mA}$ | V_F | - | 1.38 | 1.70 | V |
| Input forward voltage temperature coefficient | $I_F = 10\text{ mA}$ | $\Delta V_F/\Delta T$ | - | -1.5 | - | mV/K |
| Input reverse voltage | $I_R = 10\text{ }\mu\text{A}$ | BV_R | 5 | - | - | V |
| Input threshold current | $V_E = 2\text{ V}$, $V_O = 0.6\text{ V}$, $V_{CC} = 3.3\text{ V}$, $I_{OL}(\text{sinking}) = 13\text{ mA}$ | I_{TH} | - | 2 | 5 | mA |
| Input capacitance | $f = 1\text{ MHz}$, $V_F = 0\text{ V}$ | C_I | - | 34 | - | pF |
| OUTPUT | | | | | | |
| Low level supply current | $I_F = 10\text{ mA}$, $V_{CC} = 3.3\text{ V}$, $V_E = 0.5\text{ V}$ | I_{CCL} | - | 3.1 | 5 | mA |
| High level supply current | $I_F = 0\text{ mA}$, $V_{CC} = 3.3\text{ V}$, $V_E = 0.5\text{ V}$ | I_{CCH} | - | 3.3 | 5 | mA |
| Low level enable current | $V_{CC} = 3.3\text{ V}$, $V_E = 0.5\text{ V}$ | I_{EL} | - | -0.41 | -1.6 | mA |
| High level enable current | $V_{CC} = 3.3\text{ V}$, $V_E = 2\text{ V}$ | I_{EH} | - | -0.19 | -1.6 | mA |
| Low level enable voltage | | V_{EL} | - | - | 0.8 | V |
| High level enable voltage | | V_{EH} | 2 | - | - | V |
| Low level output voltage | $V_{CC} = 3.3\text{ V}$, $V_E = 2\text{ V}$, $I_F = 5\text{ mA}$, $I_{OL}(\text{sinking}) = 13\text{ mA}$ | V_{OL} | - | 0.2 | 0.6 | V |
| High level output current | $V_{CC} = 3.3\text{ V}$, $V_E = 2\text{ V}$, $V_O = 3.3\text{ V}$, $I_F = 250\text{ }\mu\text{A}$ | I_{OH} | - | 1 | 10 | μA |
| COUPLER | | | | | | |
| Input to output capacitance | $f = 1\text{ MHz}$, $T_{amb} = 25\text{ }^{\circ}\text{C}$ | C_{IO} | - | 1 | - | pF |

Note

- Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluation. Typical values are for information only and are not part of the testing requirements.

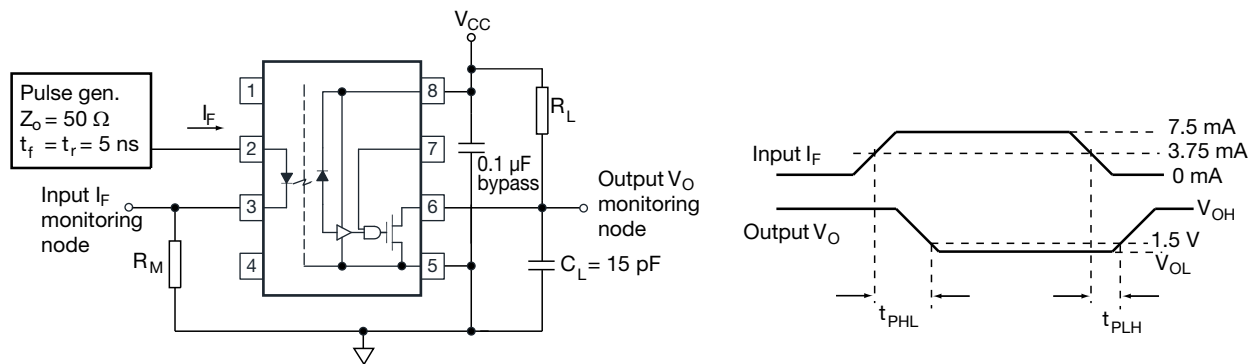
| ELECTRICAL CHARACTERISTICS ($T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+110\text{ }^{\circ}\text{C}$, $4.5\text{ V} \leq V_{CC} \leq 5.5\text{ V}$, $I_F = 7.5\text{ mA}$, unless otherwise specified; typical values are at $V_{CC} = 5.0\text{ V}$, $T_{amb} = 25\text{ }^{\circ}\text{C}$) | | | | | | |
|---|---|-----------------------|------|-------|------|---------------|
| PARAMETER | TEST CONDITION | SYMBOL | MIN. | TYP. | MAX. | UNIT |
| INPUT | | | | | | |
| Input forward voltage | $I_F = 10\text{ mA}$ | V_F | - | 1.38 | 1.70 | V |
| Input forward voltage temperature coefficient | $I_F = 10\text{ mA}$ | $\Delta V_F/\Delta T$ | - | -1.5 | - | mV/K |
| Input reverse voltage | $I_R = 10\text{ }\mu\text{A}$ | BV_R | 5 | - | - | V |
| Input threshold current | $V_E = 2\text{ V}$, $V_O = 0.6\text{ V}$, $V_{CC} = 5.5\text{ V}$, $I_{OL}(\text{sinking}) = 13\text{ mA}$ | I_{TH} | - | 2 | 5 | mA |
| Input capacitance | $f = 1\text{ MHz}$, $V_F = 0\text{ V}$ | C_I | - | 34 | - | pF |
| OUTPUT | | | | | | |
| Low level supply current | $I_F = 10\text{ mA}$, $V_{CC} = 5.5\text{ V}$, $V_E = 0.5\text{ V}$ | I_{CCL} | - | 3.5 | 5 | mA |
| High level supply current | $I_F = 0\text{ mA}$, $V_{CC} = 5.5\text{ V}$, $V_E = 0.5\text{ V}$ | I_{CCH} | - | 3.7 | 5 | mA |
| Low level enable current | $V_{CC} = 5.5\text{ V}$, $V_E = 0.5\text{ V}$ | I_{EL} | - | -0.9 | -1.6 | mA |
| High level enable current | $V_{CC} = 5.5\text{ V}$, $V_E = 2\text{ V}$ | I_{EH} | - | -0.19 | -1.6 | mA |
| Low level enable voltage | | V_{EL} | - | - | 0.8 | V |
| High level enable voltage | | V_{EH} | 2 | - | - | V |
| Low level output voltage | $V_{CC} = 5.5\text{ V}$, $V_E = 2\text{ V}$, $I_F = 5\text{ mA}$, $I_{OL}(\text{sinking}) = 13\text{ mA}$ | V_{OL} | - | 0.20 | 0.60 | V |
| High level output current | $V_{CC} = 5.5\text{ V}$, $V_E = 2\text{ V}$, $V_O = 5.5\text{ V}$, $I_F = 250\text{ }\mu\text{A}$ | I_{OH} | - | 1 | 10 | μA |
| COUPLER | | | | | | |
| Input to output capacitance | $f = 1\text{ MHz}$, $T_{amb} = 25\text{ }^{\circ}\text{C}$ | C_{IO} | - | 4 | - | pF |

Note

- Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluation. Typical values are for information only and are not part of the testing requirements.

| SWITCHING CHARACTERISTICS ($T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+110\text{ }^{\circ}\text{C}$, $2.7\text{ V} \leq V_{CC} \leq 3.6\text{ V}$, $I_F = 7.5\text{ mA}$, unless otherwise specified; typical values are at $V_{CC} = 3.3\text{ V}$, $T_{amb} = 25\text{ }^{\circ}\text{C}$) | | | | | | |
|--|---|-----------------------|------|------|------|------|
| PARAMETER | TEST CONDITION | SYMBOL | MIN. | TYP. | MAX. | UNIT |
| Propagation delay time to high output level | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$ | t_{PLH} | 25 | 50 | 90 | ns |
| Propagation delay time to low output level | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$ | t_{PHL} | 25 | 40 | 90 | ns |
| Pulse width distortion | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$ | $ t_{PLH} - t_{PHL} $ | - | 10 | - | ns |
| Propagation delay skew | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$ | t_{PSK} | - | - | 40 | ns |
| Output rise time (10 % to 90 %) | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$ | t_r | - | 23 | - | ns |
| Output fall time (90 % to 10 %) | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$ | t_f | - | 10 | - | ns |
| Propagation delay time of enable from V_{EH} to V_{EL} | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$, $V_{EL} = 0\text{ V}$, $V_{EH} = 3\text{ V}$ | t_{ELH} | - | 15 | - | ns |
| Propagation delay time of enable from V_{EL} to V_{EH} | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$, $V_{EL} = 0\text{ V}$, $V_{EH} = 3\text{ V}$ | t_{EHL} | - | 15 | - | ns |

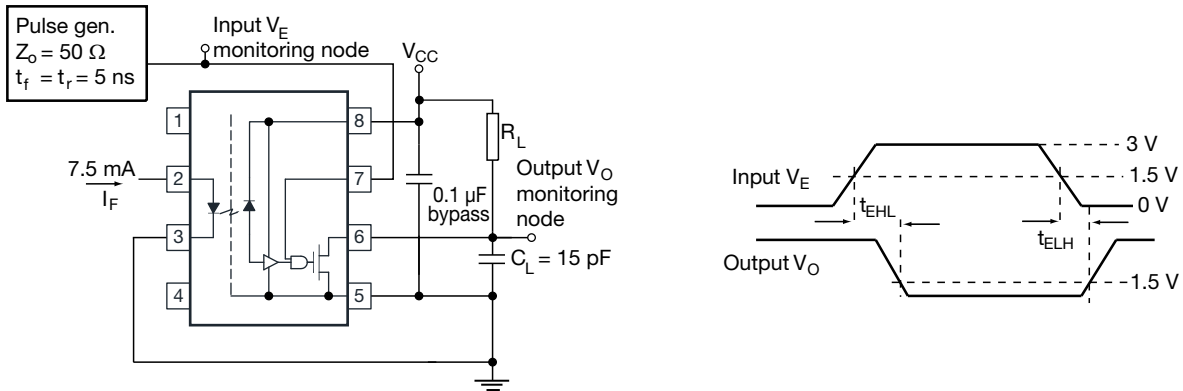
| SWITCHING CHARACTERISTICS ($T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+110\text{ }^{\circ}\text{C}$, $4.5\text{ V} \leq V_{CC} \leq 5.5\text{ V}$, $I_F = 7.5\text{ mA}$, unless otherwise specified; typical values are at $V_{CC} = 5.0\text{ V}$, $T_{amb} = 25\text{ }^{\circ}\text{C}$) | | | | | | |
|--|---|-----------------------|------|------|------|------|
| PARAMETER | TEST CONDITION | SYMBOL | MIN. | TYP. | MAX. | UNIT |
| Propagation delay time to high output level | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$, $T_{amb} = 25\text{ }^{\circ}\text{C}$ | t_{PLH} | 25 | 50 | 90 | ns |
| | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$ | t_{PLH} | - | - | 100 | ns |
| Propagation delay time to low output level | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$, $T_{amb} = 25\text{ }^{\circ}\text{C}$ | t_{PHL} | 25 | 40 | 90 | ns |
| | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$ | t_{PHL} | - | - | 100 | ns |
| Pulse width distortion | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$ | $ t_{PLH} - t_{PHL} $ | - | 10 | - | ns |
| Propagation delay skew | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$ | t_{PSK} | - | - | 40 | ns |
| Output rise time (10 % to 90 %) | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$ | t_r | - | 23 | - | ns |
| Output fall time (90 % to 10 %) | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$ | t_f | - | 10 | - | ns |
| Propagation delay time of enable from V_{EH} to V_{EL} | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$, $V_{EL} = 0\text{ V}$, $V_{EH} = 3\text{ V}$ | t_{ELH} | - | 15 | - | ns |
| Propagation delay time of enable from V_{EL} to V_{EH} | $R_L = 350\ \Omega$, $C_L = 15\text{ pF}$, $V_{EL} = 0\text{ V}$, $V_{EH} = 3\text{ V}$ | t_{EHL} | - | 15 | - | ns |



The probe and jig capacitances are included in C_L

Fig. 1 - Test Circuit for t_{PLH} , t_{PHL} , t_r , and t_f

18964-7



The probe and jig capacitances are included in C_L

18975-5

 Fig. 2 - Test Circuit for t_{EHL} and t_{ELH}

| COMMON MODE TRANSIENT IMMUNITY ($T_{amb} = 25^\circ\text{C}$, unless otherwise specified) | | | | | | |
|---|---|----------|--------|------|------|------------------------|
| PARAMETER | TEST CONDITION | SYMBOL | MIN. | TYP. | MAX. | UNIT |
| Logic high common mode transient immunity | $V_{CC} = 3.3\text{ V}$, $ V_{CM} = 1000\text{ V}$, $I_F = 0\text{ mA}$, $V_O > 2.0\text{ V}$, $R_L = 350\ \Omega$ | $ CM_H $ | 15 000 | - | - | $\text{V}/\mu\text{s}$ |
| | $V_{CC} = 5\text{ V}$, $ V_{CM} = 1000\text{ V}$, $I_F = 0\text{ mA}$, $V_O > 2.0\text{ V}$, $R_L = 350\ \Omega$ | $ CM_H $ | 15 000 | - | - | $\text{V}/\mu\text{s}$ |
| Logic low common mode transient immunity | $V_{CC} = 5\text{ V}$, $ V_{CM} = 1000\text{ V}$, $I_F = 10\text{ mA}$, $V_O < 0.8\text{ V}$, $R_L = 350\ \Omega$ | $ CM_L $ | 15 000 | - | - | $\text{V}/\mu\text{s}$ |
| | $V_{CC} = 5\text{ V}$, $ V_{CM} = 1000\text{ V}$, $I_F = 10\text{ mA}$, $V_O < 0.8\text{ V}$, $R_L = 350\ \Omega$ | $ CM_L $ | 15 000 | - | - | $\text{V}/\mu\text{s}$ |

Notes

- No external pull up is required for a high logic state on the enable input. If the enable pin is not used, connect it to V_{CC}

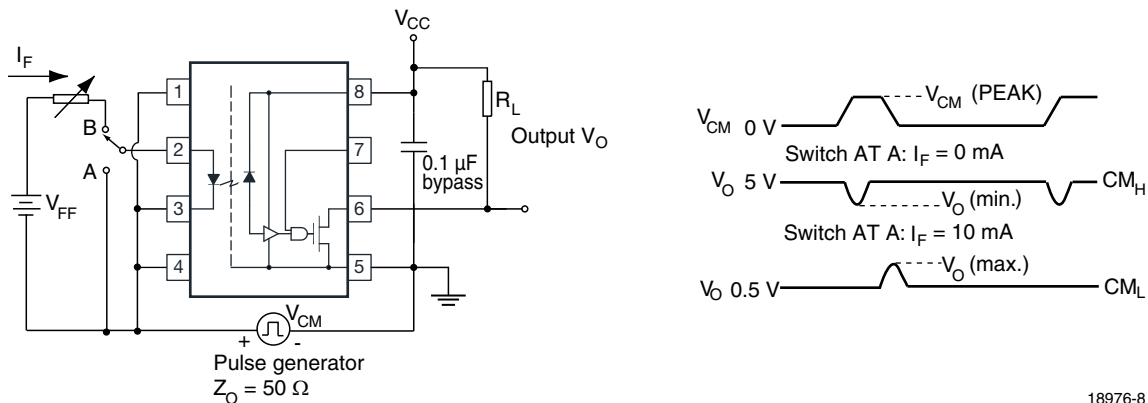


Fig. 3 - Test Circuit for Common Mode Transient Immunity

18976-8

| SAFETY AND INSULATION RATINGS | | | | |
|--|--|------------|----------------|--------------------|
| PARAMETER | TEST CONDITION | SYMBOL | VALUE | UNIT |
| Climatic classification | According to IEC 68 part 1 | | 55 / 110 / 21 | |
| Pollution degree | According to DIN VDE 0109 | | 2 | |
| Comparative tracking index | Insulation group IIIa | CTI | 175 | |
| Maximum rated withstanding isolation voltage | According to UL1577, t = 1 min | V_{ISO} | 5000 | V_{RMS} |
| Maximum transient isolation voltage | According to DIN EN 60747-5-5 | V_{IOTM} | 6000 | V_{peak} |
| Maximum repetitive peak isolation voltage | According to DIN EN 60747-5-5 | V_{IORM} | 630 | V_{peak} |
| Isolation resistance | $T_{amb} = 25\text{ }^{\circ}\text{C}$, $V_{IO} = 500\text{ V}$ | R_{IO} | $\geq 10^{12}$ | Ω |
| Maximum output power dissipation | | P_{SO} | 600 | mW |
| Maximum input current | | I_{SI} | 230 | mA |
| Maximum ambient temperature (derated) | | T_S | 175 | $^{\circ}\text{C}$ |
| Creepage distance | DIP-8, SMD-8 | | ≥ 7 | mm |
| | DIP-8, 400 mil | | ≥ 8 | mm |
| Clearance distance | DIP-8, SMD-8 | | ≥ 7 | mm |
| | DIP-8, 400 mil | | ≥ 8 | mm |
| Insulation thickness | | DTI | ≥ 0.4 | mm |

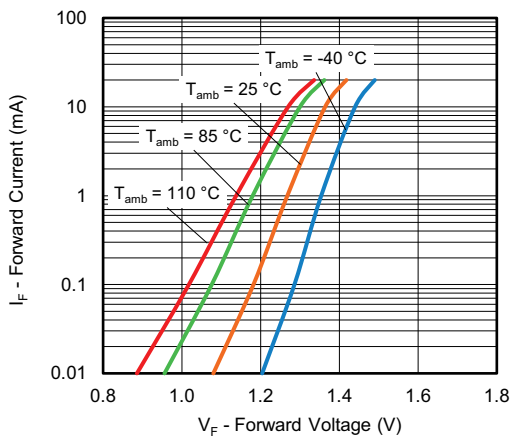
TYPICAL CHARACTERISTICS ($T_{amb} = 25\text{ }^{\circ}\text{C}$, unless otherwise specified)


Fig. 4 - Diode Forward Current vs. Forward Voltage

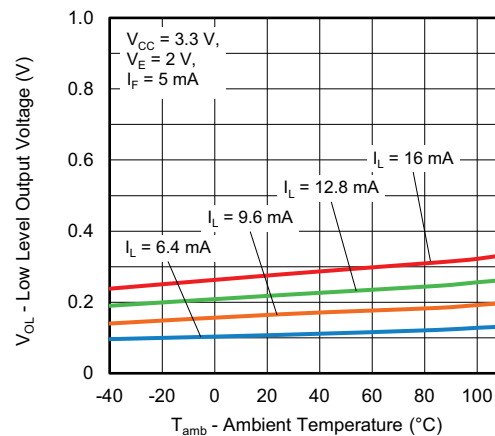


Fig. 6 - Low Level Output Voltage vs. Ambient Temperature

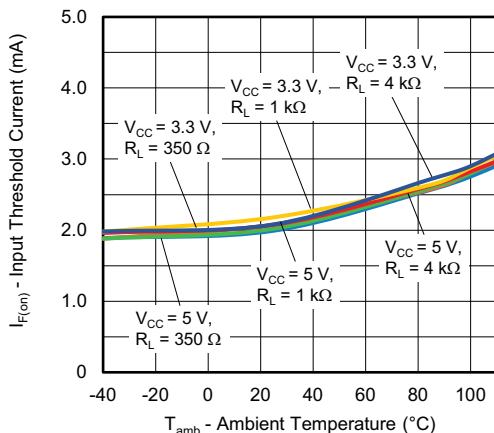


Fig. 5 - Input Threshold Current vs. Ambient Temperature

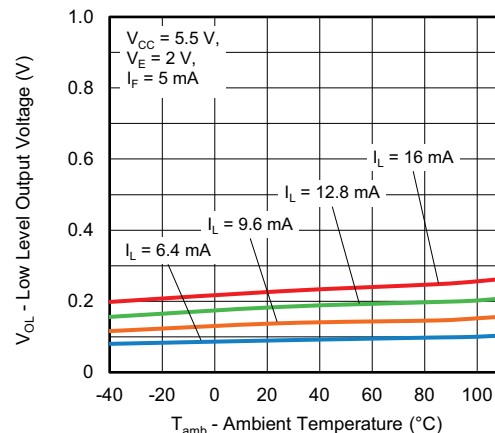


Fig. 7 - Low Level Output Voltage vs. Ambient Temperature

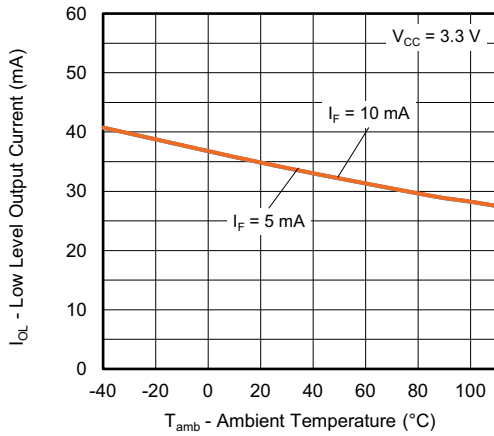


Fig. 8 - Low Level Output Current vs. Ambient Temperature

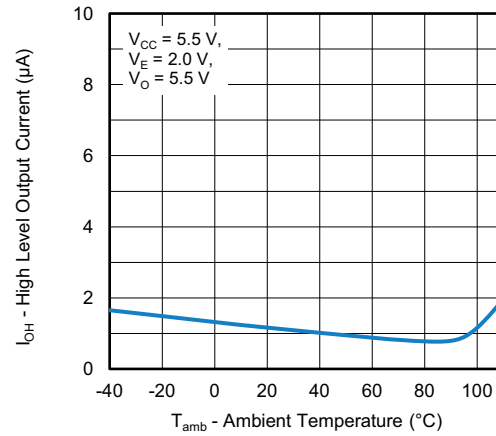


Fig. 11 - High Level Output Current vs. Ambient Temperature

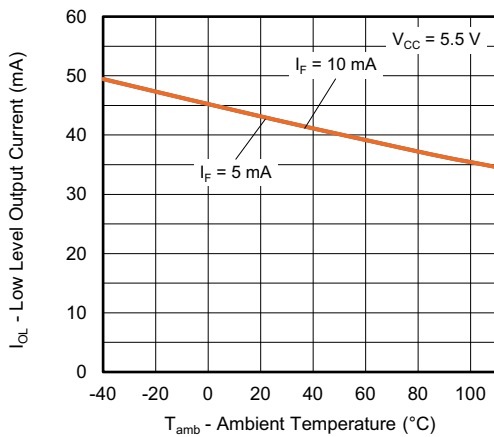


Fig. 9 - Low Level Output Current vs. Ambient Temperature

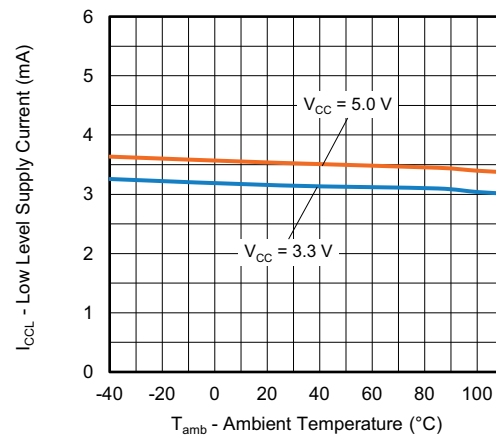


Fig. 12 - Low Level Supply Current vs. Ambient Temperature

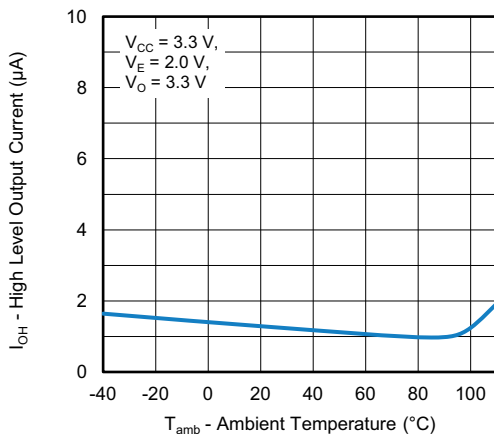


Fig. 10 - High Level Output Current vs. Ambient Temperature

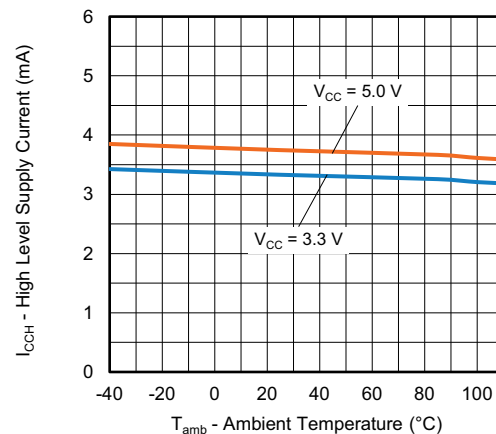


Fig. 13 - High Level Supply Current vs. Ambient Temperature

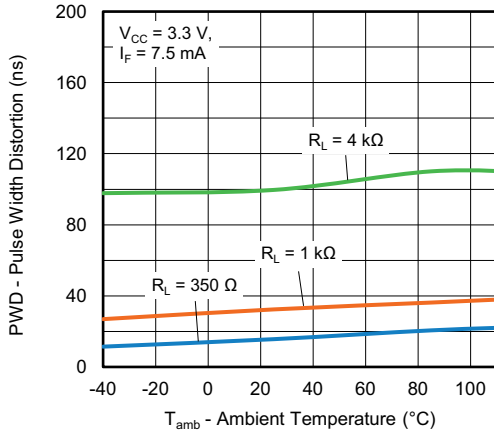


Fig. 14 - Pulse Width Distortion vs. Ambient Temperature

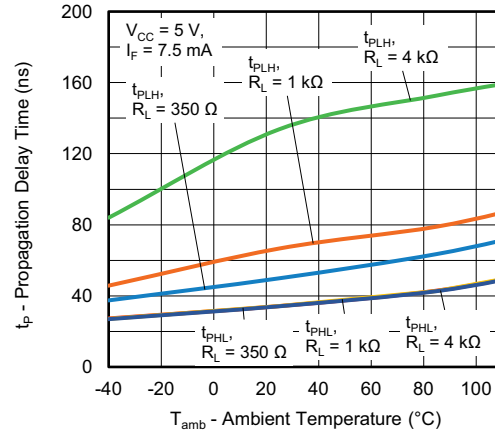


Fig. 17 - Propagation Delay Time vs. Ambient Temperature

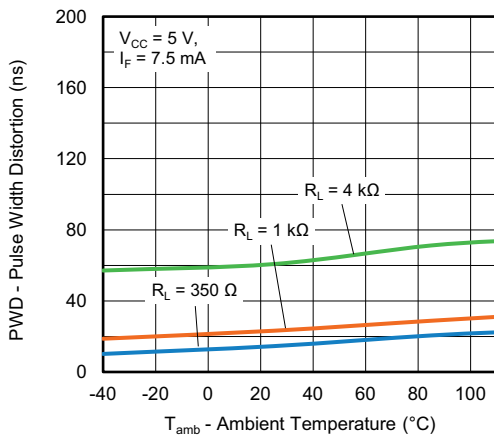


Fig. 15 - Pulse Width Distortion vs. Ambient Temperature

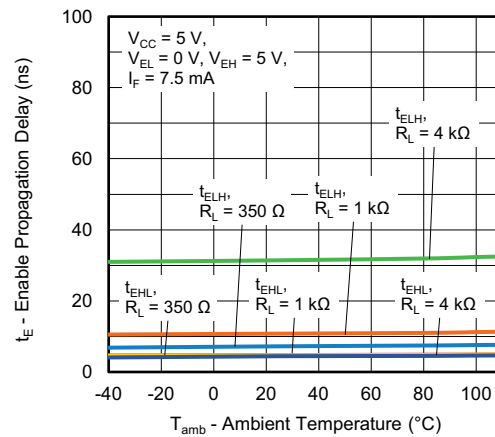


Fig. 18 - Enable Propagation Delay vs. Ambient Temperature

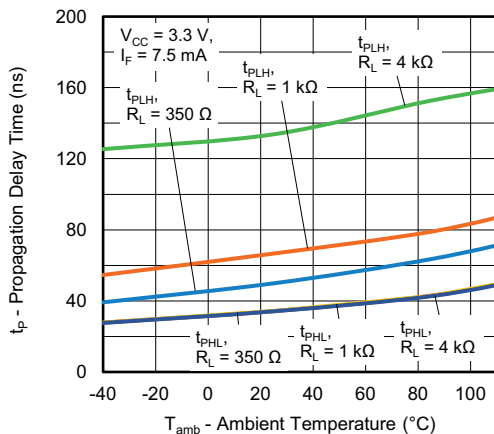


Fig. 16 - Propagation Delay Time vs. Ambient Temperature

PACKAGE DIMENSIONS (in millimeters)

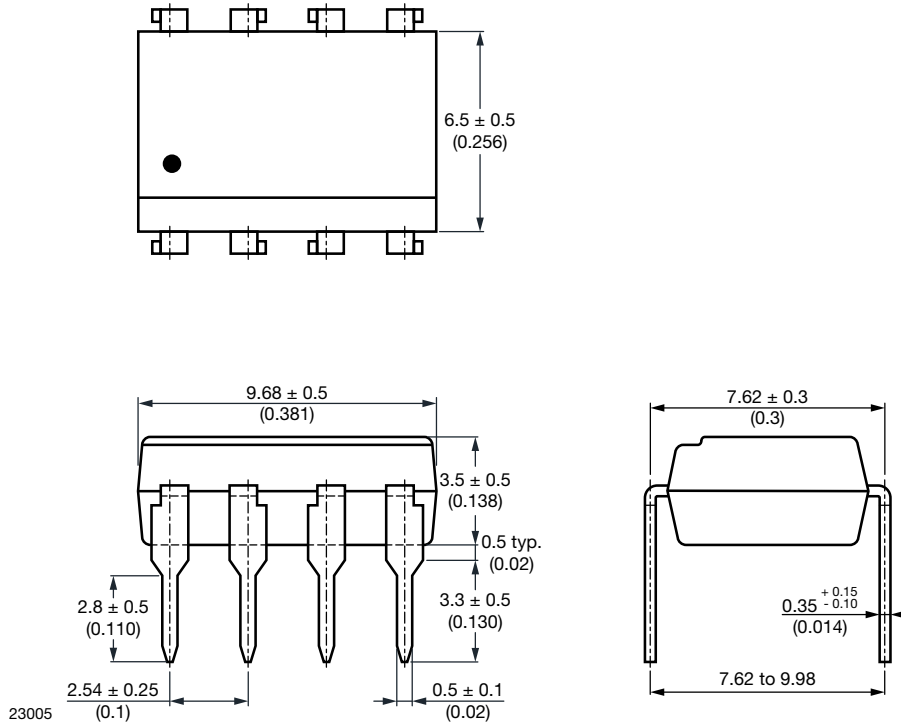
DIP-8


Fig. 19

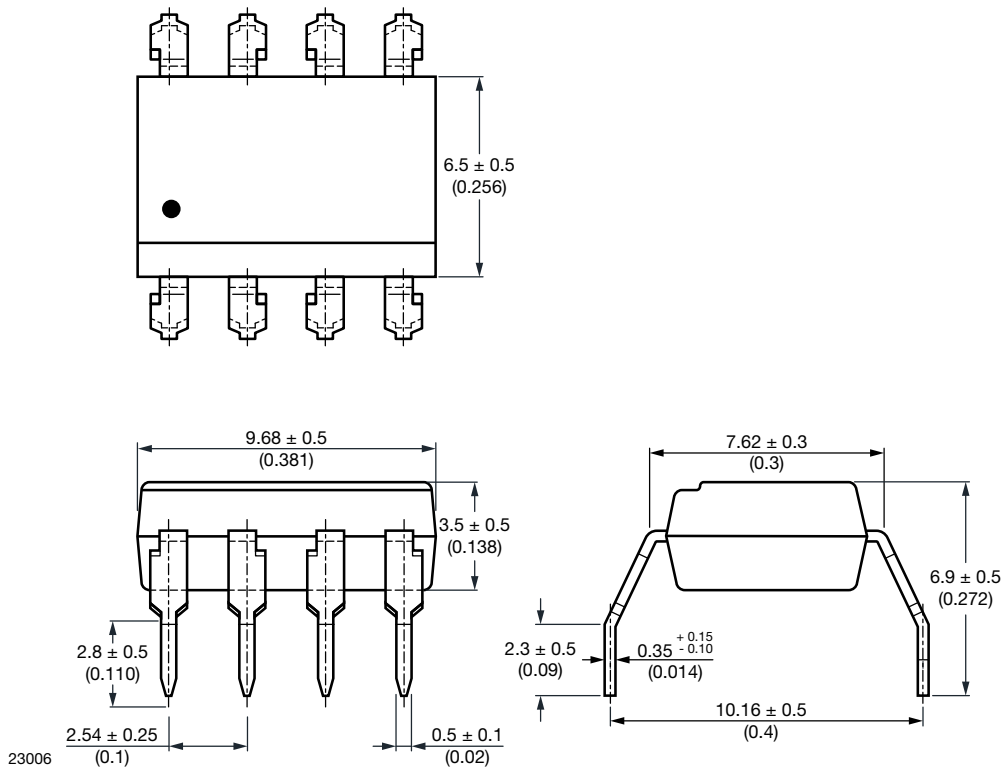
DIP-8, 400 mil


Fig. 20

SMD-8

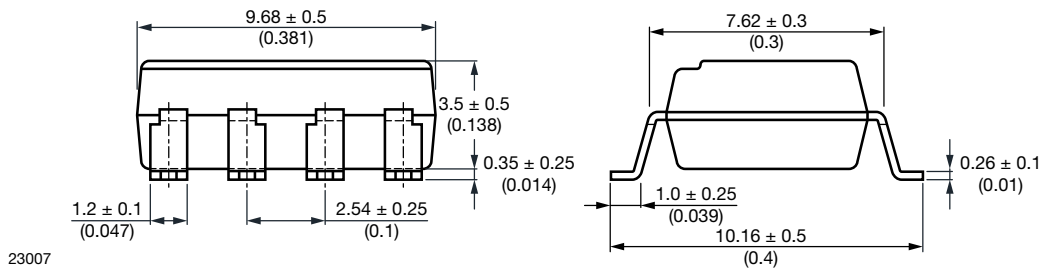
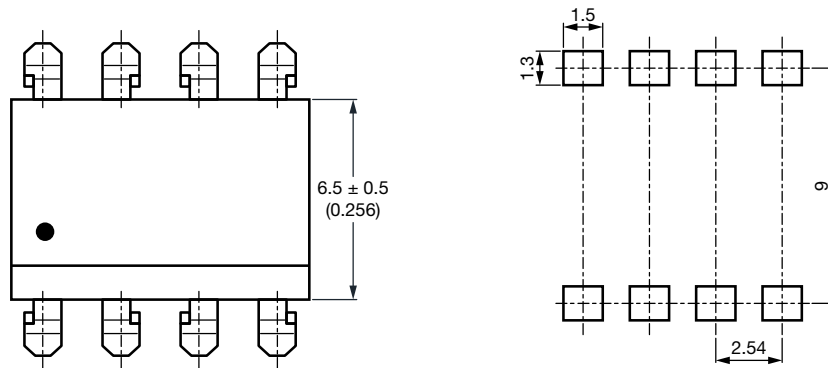


Fig. 21

PACKAGE MARKING

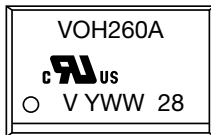


Fig. 22 - Example of VOH260A

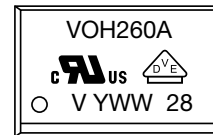


Fig. 23 - Example of VOH260A-X017T

Notes

- “YWW” is the date code marking (Y = year code, WW = week code)
- VDE logo is only marked on VDE option parts
- Tape and reel suffix (T) is not part of the package marking



PACKAGING INFORMATION (in millimeters)

| DEVICES PER TUBES | | | |
|-------------------|------------|-----------|-----------|
| TYPE | UNITS/TUBE | TUBES/BOX | UNITS/BOX |
| DIP-8 | 50 | 40 | 2000 |
| DIP-8, 400 mil | 50 | 40 | 2000 |

SMD-8 Tape

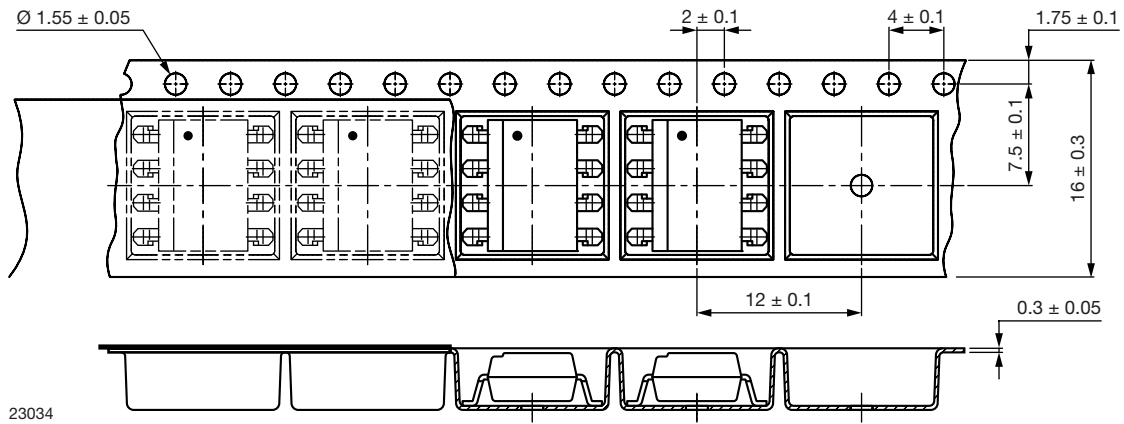


Fig. 24 - Tape and Reel Packaging (1000 pieces on reel)

Reel

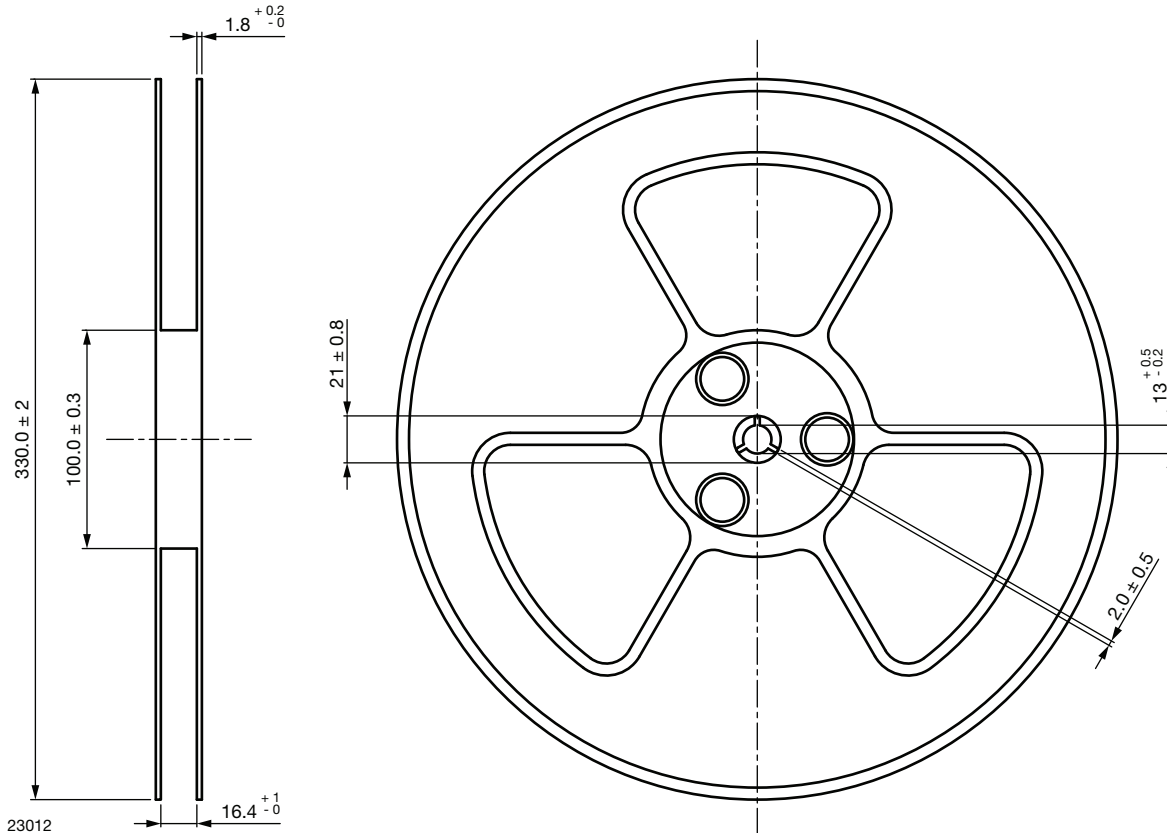


Fig. 25 - Tape and Reel Shipping Medium

SOLDER PROFILES

IR Reflow Soldering (JEDEC® J-STD-020C compliant)

One time soldering reflow is recommended within the condition of temperature and time profile shown below. Do not solder more than three times.

| PROFILE ITEM | CONDITIONS |
|--|------------------|
| Preheat | |
| - Temperature minimum ($T_{S \text{ min.}}$) | 150 °C |
| - Temperature maximum ($T_{S \text{ max.}}$) | 200 °C |
| - Time (min. to max.) (t_S) | 90 s ± 30 s |
| Soldering zone | |
| - Temperature (T_L) | 217 °C |
| - Time (t_L) | 60 s |
| Peak temperature (T_p) | 260 °C |
| Ramp-up rate | 3 °C/s max. |
| Ramp-down rate | 3 °C/s to 6 °C/s |

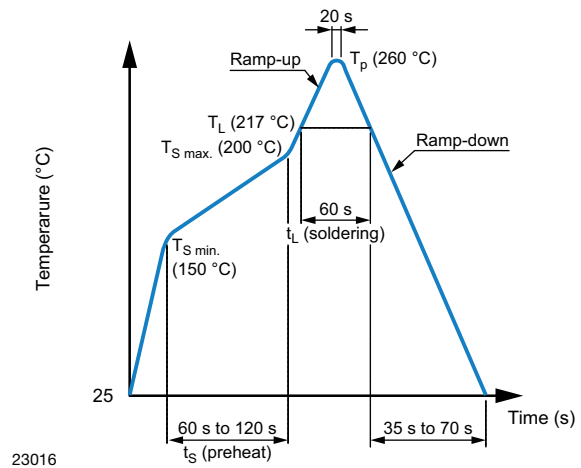


Fig. 26



Wave Soldering (JEDEC JESD22-A111 compliant)

One time soldering is recommended within the condition of temperature.

Temperature: 260 °C + 0 °C / - 5 °C

Time: 10 s

Preheat temperature: 25 °C to 140 °C

Preheat time: 30 s to 80 s

HANDLING AND STORAGE CONDITIONS

ESD level: HBM class 2

Floor life: unlimited

Conditions: T_{amb} < 30 °C, RH < 85 %

Moisture sensitivity level 1, according to J-STD-020

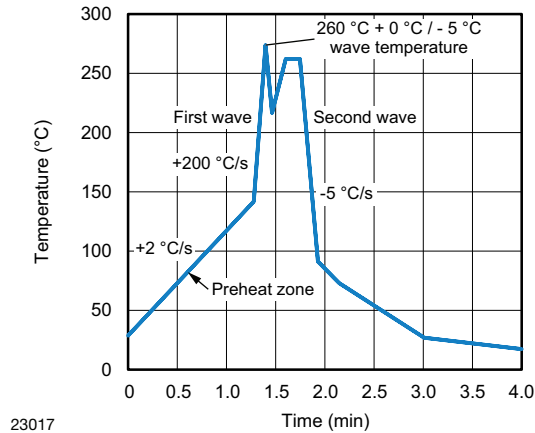


Fig. 27

Hand Soldering by Soldering Iron

Allow single lead soldering in every single process. One time soldering is recommended.

Temperature: 380 °C + 0 °C / - 5 °C

Time: 3 s max.



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