

Photocouplers LTV-333J series

LTV-333J series

5.0 Amp Output Current IGBT Gate Driver Optocoupler with Integrated (V_{CE}) Desaturation Detection, UVLO Fault Status Feedback and Active Miller Clamping

1. DESCRIPTION

The LTV-333J is an advanced 5.0 A output current, easy-to-use, intelligent gate driver which makes IGBT V_{CE} fault protection compact, affordable, and easy-to-implement. Features such as integrated V_{CE} detection, under voltage lockout (UVLO), “soft” IGBT trun-off, isolated open collector fault feedback and active Miller clamping provide maximum design flexibility and circuit protection.

The LTV-333J contains an AlGaAs LED. The LED is optically coupled to an integrated circuit with a power output stage. LTV-333J is ideally suited for driving power IGBTs and MOSFET used in motor control inverter applications. The voltage and current supplied by these optocouplers make them ideally suited for directly driving IGBTs with ratings up to 1200 V and 150 A. For IGBTs with higher ratings, the LTV-333J can be used to drive a discrete power stage which drives the IGBTs gate. The LTV-333J has an insulation voltage of $V_{IORM} = 1414 V_{PEAK}$.

The Optocoupler operational parameters are guaranteed over the temperature range from $-40^{\circ}\text{C} \sim +105^{\circ}\text{C}$.

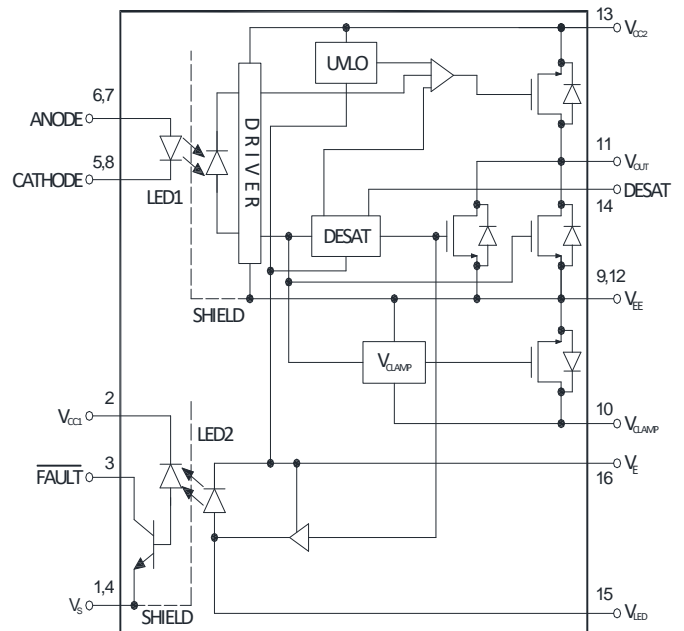
1.1 Features

- 5.0 A maximum peak output current
- 4.0 A minimum peak output current
- 200 ns maximum propagation delay
- 100 ns maximum pulse width distortion (PWD)
- 50 kV/us minimum Common Mode Rejection (CMR) at $V_{CM} = 1500 \text{ V}$
- $I_{CC} = 4.5 \text{ mA}$ maximum supply current
- Wide V_{CC} operating range: 15 to 30 Volts (V_{CC})
- Guaranteed performance over temperature $-40^{\circ}\text{C} \sim +105^{\circ}\text{C}$.
- MSL Level 1
- Safety approval:
 - UL/ cUL Recognized 5000 $V_{RMS}/1 \text{ min}$
 - IEC/EN/DIN EN 60747-5-5 $V_{IORM} = 1414 \text{ Vpeak}$

1.2 Applications

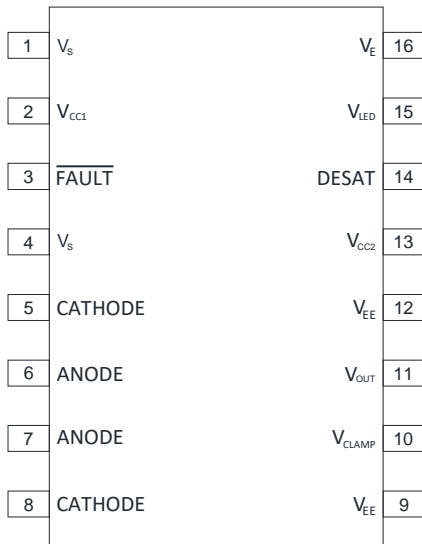
- Isolated IGBT/MOSFET gate drive
- Industrial inverters and Uninterruptible power supply (UPS)
- AC and Brushless DC motor drives

1.3 Functional Diagram



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1.4 Pin description



| Pin | Symbol | Description |
|-----|-------------|--|
| 1 | V_S | Input Ground |
| 2 | V_{CC1} | Positive input supply voltage (3.3 V to 5.5 V) |
| 3 | FAULT | Fault output. FAULT changes from a high impedance state to a logic low output within 5 μ s of the voltage on the DESAT pin exceeding an internal reference voltage of 7 V. FAULT output is an open collector which allows the FAULT outputs from all LTV-333J in a circuit to be connected together in a "wired OR" forming a single fault bus for interfacing directly to the micro-controller. |
| 4 | V_S | Input Ground |
| 5 | CATHODE | Cathode |
| 6 | ANODE | Anode |
| 7 | ANODE | Anode |
| 8 | CATHODE | Cathode |
| 9 | V_{EE} | Output supply voltage |
| 10 | V_{CLAMP} | Miller clamp |
| 11 | V_{OUT} | Gate drive voltage output |
| 12 | V_{EE} | Output supply voltage |
| 13 | V_{CC2} | Positive output supply voltage |
| 14 | DESAT | Desaturation voltage input. When the voltage on DESAT exceeds an internal reference voltage of 6.5 V while the IGBT is on, FAULT output is changed from a high impedance state to a logic low state within 5 μ s. |
| 15 | V_{LED} | LED anode. This pin must be left unconnected for guaranteed data sheet performance. (For optical coupling testing only) |
| 16 | V_E | Common (IGBT emitter) output supply voltage |

1.5 True table

| I_F | UVLO($V_{CC}-V_E$) | DESAT Function | FAULT Output | V_{OUT} |
|-------|----------------------|--------------------------|-------------------|-----------|
| ON | Active | Not Active | High | Low |
| ON | Not Active | Active(with DESAT fault) | Low(Fault) | Low |
| ON | Not Active | Active(no DESAT fault) | High(or no fault) | High |
| OFF | Active | Not Active | High | Low |
| OFF | Not Active | Not Active | High | Low |

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1.6 Ordering Information

LTV-333J is UL Recognized with 5000 Vrms for 1 minute per UL1577.

| Part number | Package | Option | Tape & Reel | IEC/EN/DIN/EN 60747-5-5 (V _{PR} method b) | Quantity | Others |
|-------------|---------|--------|-------------|--|--------------|---------------------------------|
| | | Name | | | | |
| LTV-333J | SOP-16 | - | | | 45 per tube | Location at lower right of tape |
| | | -V | | ● | | |
| | | -TP1 | ● | | 850 per reel | |
| | | -TP1-V | ● | ● | | |

To order, choose a part number from the part number column and combine with the desired option from the option column to form an order entry.

Example 1:

LTV-333J-V to order product of SOP-16 Surface Mount package in Tube packaging(Quantity: 45pcs per tube) with IEC/EN/DIN EN 60747-5-5 Safety Approval (V_{PR} method b).

Example 2:

LTV333JTP1-V to order product of SOP-16 Surface Mount package in tape& reel packaging with IEC/EN/DIN EN 60747-5-5 Safety Approval (V_{PR} method b).

Above option datasheets are available. Please contact your LITEON sales representative or authorized distributor for information.

Example 3:

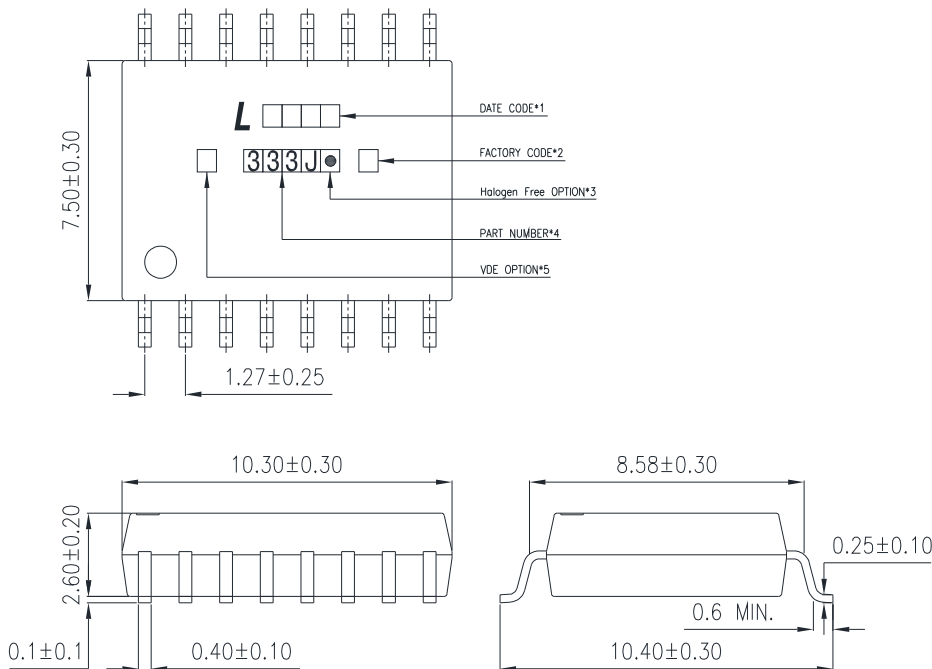
LTV-333J-TP1 to order product of SOP-16 Surface Mount package in tape& reel packaging with IEC/EN/DIN EN 60747-5-5 Safety Approval (Without V_{PR} method b).

Above option datasheets are available. Please contact your LITEON sales representative or authorized distributor for information.

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2. PACKAGE DIMENSIONS

2.1 LTV-333J



Notes :

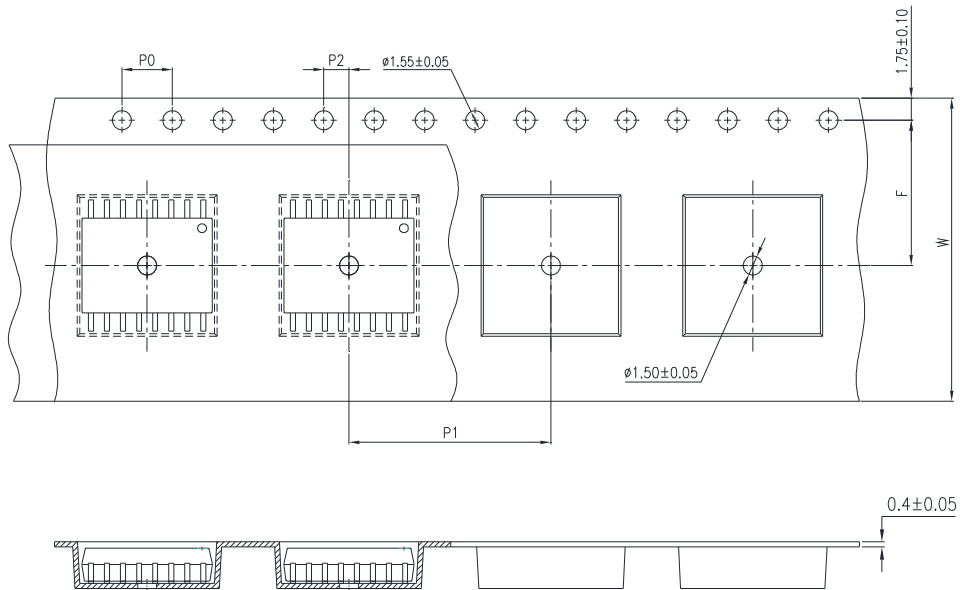
- *1. Year date code.
- *2. 2-digit work week.
- *3. Factory identification mark
(W: Changzhou).

Dimensions are in Millimeters and (Inches).

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3. TAPING DIMENSIONS

3.1 LTV-333J-TP1



| Description | Symbol | Dimension in mm (inch) |
|--|----------------|------------------------|
| Tape wide | W | 24±0.3 (0.94) |
| Pitch of sprocket holes | P ₀ | 4±0.1 (0.15) |
| Distance of compartment | F | 11.5±0.1 (0.452) |
| | P ₂ | 2±0.1 (0.079) |
| Distance of compartment to compartment | P ₁ | 16±0.1 (0.63) |

3.3 Quantities Per Reel

| Package Type | LTV-333J |
|------------------|----------|
| Quantities (pcs) | 850 |

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4. IEC/EN/DIN EN 60747-5-5 Insulation Characteristics

Isolation characteristics are guaranteed only within the safety maximum ratings which must be ensured by protective circuits in application.

| Description | Symbol | Characteristics | Unit |
|---|-----------------|---------------------------------------|-------------|
| Installation classification per DIN VDE 0110/39, Table 1 for rated mains voltage $\leq 150 V_{rms}$ for rated mains voltage $\leq 300 V_{rms}$ for rated mains voltage $\leq 600 V_{rms}$ for rated mains voltage $\leq 1000 V_{rms}$ | | I - IV I - IV I - IV I - III | |
| Climatic Classification | | 40/100/21 | |
| Pollution Degree (DIN VDE 0110/39) | | 2 | |
| Maximum Working Insulation Voltage | V_{IORM} | 1414 | V_{peak} |
| Input-to-Output Test Voltage, Method b *a, $V_{IORM} \times 1.875 = V_{PR}$, 100% Production Test with $t_m = 1$ sec, Partial Discharge < 5 pC | V_{PR} | 2651 | V_{peak} |
| Input-to-Output Test Voltage, Method a *a, $V_{IORM} \times 1.6 = V_{PR}$, Type and Sample Test, $t_m = 10$ sec, Partial Discharge < 5 pC | V_{PR} | 2262 | V_{peak} |
| Highest Allowable Overvoltage (Transient Overvoltage, $t_{ini} = 60$ sec) | V_{IOTM} | 8000 | V_{peak} |
| Safety Limiting Values (Maximum values allowed in the event of a failure) | | | |
| Case Temperature | T_S | 175 | $^{\circ}C$ |
| Input Current | $I_{S, INPUT}$ | 400 | mA |
| Output Power | $P_{S, OUTPUT}$ | 1200 | mW |
| Insulation Resistance at T_S , $V_{IO} = 500$ V | R_S | $\geq 10^9$ | Ω |

*a. Refer to the front of the optocoupler section of the current catalog, under Product Safety Regulations section, IEC/EN/DIN EN 60747-5-5, for a detailed description.

*b. Ratings apply to all devices except otherwise noted in the Package column.

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5. Insulation and Safety Related Specifications

| Part number | Symol | LTV-333J | Units | Conditions |
|--|--------|----------|-------|--|
| Minimum External Air Gap (External Clearance) | L(101) | 8.3 | mm | Measured from input terminals to output terminals, shortest distance through air. |
| Minimum External Tracking (External Creepage) | L(102) | 8.3 | mm | Measured from input terminals to output terminals, shortest distance path along body. |
| Minimum Internal Plastic Gap (Internal Clearance) | | 0.5 | mm | Through insulation distance, conductor to conductor, usually the direct distance between the photoemitter and photodetector inside the optocoupler cavity. |
| Tracking Resistance (Comparative Tracking Index) | CTI | >175 | V | DIN IEC 112/VDE 0303 Part 1 |
| Isolation Group | | IIIa | | Material Group (DIN VDE 0110, 1/89, Table 1) |

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6. RATING AND CHARACTERISTICS

6.1 Absolute Maximum Ratings

| Parameter | Symbol | Min | Max | Unit | Note |
|--------------------------------|----------------------|-------|-----------------------|------|------|
| Storage Temperature | T_{stg} | -55 | +125 | °C | — |
| Operating Temperature | T_{opr} | -40 | +105 | °C | — |
| Output IC Junction Temperature | T_J | — | 125 | °C | — |
| Average Forward Input Current | I_F | — | 25 | mA | 3 |
| Reverse Input Voltage | V_R | — | 5 | V | — |
| Peak Transient Input Current | $I_{F(TRAN)}$ | — | 1 | A | 1 |
| “High” Peak Output Current | $I_{OH(PEAK)}$ | — | 5 | A | 2 |
| “Low” Peak Output Current | $I_{OL(PEAK)}$ | — | 5 | A | 2 |
| Positive Input Supply Voltage | V_{CC1} | -0.5 | 7 | V | |
| FAULT Output Current | I_{FAULT} | | 8 | mA | |
| FAULT Pin Voltage | V_{FAULT} | -0.5 | V_{CC1} | V | |
| Total Output Supply Voltage | $(V_{CC2} - V_{EE})$ | -0.5 | 35 | V | — |
| Negative Output Supply Voltage | $(V_E - V_{EE})$ | -0.5 | 15 | V | |
| Positive Output Supply Voltage | $(V_{CC2} - V_E)$ | -0.5 | $35 - (V_E - V_{EE})$ | V | |
| Output Voltage | $V_{O(PEAK)}$ | -0.5 | 35 | V | — |
| Peak Clamping Sinking Current | I_{Clamp} | — | 1.7 | A | |
| Miller Clamping Pin Voltage | V_{Clamp} | -0.5 | V_{CC2} | V | |
| DESAT Voltage | V_{DESAT} | V_E | $V_E + 10$ | V | |
| Power Dissipation | P_I | | 150 | mW | — |
| Output Power Dissipation | P_O | — | 600 | mW | — |
| Lead Solder Temperature (10s) | T_{sol} | — | 260 | °C | — |

Note: Ambient temperature = 25°C, unless otherwise specified. Stresses exceeding the absolute maximum ratings can cause permanent damage to the device. Exposure to absolute maximum ratings for long periods of time can adversely affect reliability.

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6.2 Recommended Operating Conditions

| Parameter | Symbol | Min | Max | Unit |
|--------------------------------|--------------------|----------|--------------------|------|
| Operating Temperature | T_A | -40 | 105 | °C |
| Total Output Supply Voltage | $(V_{CC2}-V_{EE})$ | 15 | 30 | V |
| Negative Output Supply Voltage | (V_E-V_{EE}) | 0(-0.5) | 15 | V |
| Positive Output Supply Voltage | $(V_{CC2}-V_E)$ | 15(-0.5) | 30- (V_E-V_{EE}) | V |
| Input Current (ON) | $I_{FL(ON)}$ | 8 | 12 | mA |
| Input Voltage (OFF) | $V_{F(OFF)}$ | -3.6(0) | 0.8 | V |

6.3 ELECTRICAL OPTICAL CHARACTERISTICS

| | Parameter | Symb | Min. | Typ. | Max. | Unit | Test Condition | Figure | Note |
|--------|---|-------------------------------|------|--------|------|---------------|---|--------|------|
| Input | Input Forward Voltage | V_F | 1.2 | 1.37 | 1.8 | V | $I_F = 10\text{mA}$ | | |
| | Input Forward Voltage Temperature Coefficient | $\frac{\Delta V_F}{\Delta T}$ | | -1.237 | | mV/°C | $I_F = 10\text{mA}$ | | |
| | Input Reverse Voltage | BV_R | 5 | | | V | $I_R = 10\mu\text{A}$ | | |
| | Input Threshold Current (Low to High) | I_{FLH} | | 2.5 | 6 | mA | $I_O = 0\text{A}, V_O > 5\text{V}$ | | |
| | Input Threshold Voltage (High to Low) | V_{FHL} | 0.8 | 1.26 | | V | | | |
| | Input Capacitance | C_{IN} | | 33 | | pF | $f = 1\text{MHz}, V_F = 0\text{V}$ | | |
| Output | FAULT Logic Low Output Voltage | V_{FAULT} | | | 0.4 | V | $I_{FAULT} = 1.1\text{mA}, V_{CC1} = 5.5\text{V}$ | | |
| | | | | | 0.4 | V | $I_{FAULT} = 1.1\text{mA}, V_{CC1} = 3.3\text{V}$ | | |
| | FAULT Logic High Output Current | I_{FAULT} | | | 0.5 | μA | $V_{FAULT} = 5.5\text{V}, V_{CC1} = 5.5\text{V}$ | | |
| | | | | | 0.3 | μA | $V_{FAULT} = 3.3\text{V}, V_{CC1} = 3.3\text{V}$ | | |
| | High Level Supply Current | I_{CC2H} | | 2.4 | 4.5 | mA | Output Open, $I_F = 7\text{ to }16\text{mA}$ | | 8 |

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| | | | | | | | | |
|--------------------------------------|--------------|-----------------|-----------------|-------|----|---------------------------------------|--|---------------|
| Low Level Supply Current | I_{CC2L} | | 2.5 | 4.5 | mA | Output Open, $V_F = 0$ to $+0.8$ V | | |
| High Level Output Current | I_{OH} | | | -2.0 | A | $V_O = V_{CC2} - 3.0$ V | | 4 |
| | | | | -5.0 | | $V_O = V_{CC2} - 6.0$ V | | 2 |
| Low Level Output Current | I_{OL} | 2.0 | | | A | $V_O = V_{EE} + 2$ V | | 4 |
| | | 5.0 | | | | $V_O = V_{EE} + 5$ V | | 2 |
| High Level Output Voltage | V_{OH} | $V_{CC2} - 0.8$ | $V_{CC2} - 1.1$ | | V | $I_O = -100$ mA , $I_F = 10$ mA | | 5 |
| Low Level Output Voltage | V_{OL} | | 0.1 | 0.25 | V | $I_O = 100$ mA , $I_F = 0$ mA | | 6,7,8, 22 |
| Clamp Low Level Sinking Current | I_{CL} | 0.5 | 1.1 | | A | $V_{tClamp} = 2.0$ V | | |
| Blanking Capacitor Charging Current | I_{CHG} | -0.13 | -0.24 | -0.33 | mA | $V_{DESAT} = 2$ V | | 8.9 |
| Blanking Capacitor Discharge Current | I_{DSCHG} | 10 | 30 | | mA | $V_{DESAT} = 7$ V | | |
| DESAT Threshold | V_{DESAT} | 6 | 6.5 | 7.5 | V | $V_{CC2} - V_E > V_{UVLO-}$ | | 7 |
| Clamp Pin Threshold Voltage | V_{tClamp} | | 2.0 | | V | | | |
| UVLO Threshold | V_{UVLO+} | 10.5 | 11.6 | 12.5 | V | $V_O > 5$ V, $I_F = 10$ mA | | 6,8,10 ,11 |
| | V_{UVLO-} | 9.2 | 10.3 | 11.1 | V | $V_O < 5$ V, $I_F = 10$ mA | | |
| UVLO Hysteresis | UVLO | | 1.3 | | V | ($V_{UVLO+} - V_{UVLO-}$) | | |

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6.4 SWITCHING SPECIFICATION

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Condition | Figure | Note |
|--|--------------------|------|------|------|---------------|--|--------|-------|
| Propagation Delay Time to High Output Level | t_{PLH} | 50 | | 200 | ns | $R_g = 10 \Omega$, $C_g = 10 \text{ nF}$, $f = 10 \text{ kHz}$, Duty Cycle = 50% $I_F = 10 \text{ mA}$, $V_{CC2} = 30\text{V}$ | | 12,14 |
| Propagation Delay Time to Low Output Level | t_{PHL} | 50 | | 200 | | | | |
| Pulse Width Distortion | PWD | -80 | | 80 | | | | 13,16 |
| Propagation delay difference between any two parts or channels | PDD | -100 | | 100 | | | | 15,16 |
| Output Rise Time (10 to 90%) | T_r | | 50 | | | | | |
| Output Fall Time (90 to 10%) | T_f | | 50 | | | | | |
| DESAT Sense to 90%VO Delay | $t_{DESAT(90\%)}$ | | | 0.5 | μs | $C_{DESAT} = 100 \text{ pF}$, $R_g = 10 \Omega$, $C_g = 10 \text{ nF}$, $V_{CC2} = 30 \text{ V}$ | | |
| DESAT Sense to 10%VO Delay | $t_{DESAT(10\%)}$ | | | 3 | μs | $C_{DESAT} = 100 \text{ pF}$, $R_g = 10 \Omega$, $C_g = 10 \text{ nF}$, $V_{CC2} = 30 \text{ V}$ | | |
| DESAT Sense to Low Level FAULT Signal Delay | $t_{DESAT(FAULT)}$ | | | 0.5 | μs | $C_{DESAT} = 100 \text{ pF}$, $R_F = 2.1 \text{ k}\Omega$, $C_F = 1 \text{ nF}$, $R_g = 10 \Omega$, $C_g = 10 \text{ nF}$, $V_{CC2} = 30 \text{ V}$ | | 17 |
| DESAT Sense to DESAT Low Propagation Delay | $t_{DESAT(LOW)}$ | | 0.25 | | μs | $C_{DESAT} = 100 \text{ pF}$, $R_F = 2.1 \text{ k}\Omega$, $R_g = 10 \Omega$, $C_g = 10 \text{ nF}$, $V_{CC2} = 30 \text{ V}$ | | 18 |

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| | | | | | | | | |
|---|-------------------|----|----|----|-------------|--|--|-------|
| DESAT Input Mute | $t_{DESAT(MUTE)}$ | 15 | 26 | 40 | μs | | | 19 |
| Common mode transient immunity at high level output | CMH | 15 | | | kV/ μs | $T_A = 25^\circ C, I_F = 10 mA,$ $V_{CM} = 1500 V, V_{CC2} = 30 V,$ $R_F = 2.1 k\Omega, C_F = 15 pF$ | | 20,23 |
| | | 50 | | | kV/ μs | $T_A = 25^\circ C, I_F = 10 mA,$ $V_{CM} = 1500 V, V_{CC2} = 30 V,$ $R_F = 2.1 k\Omega, C_F = 1 nF$ | | |
| Common mode transient immunity at low level output | CML | 15 | | | kV/ μs | $T_A = 25^\circ C, V_F = 0 V,$ $V_{CM} = 1500 V, V_{CC2} = 30 V,$ $R_F = 2.1 k\Omega, C_F = 15 pF$ | | 21 |
| | | 50 | | | kV/ μs | $T_A = 25^\circ C, V_F = 0 V,$ $V_{CM} = 1500 V, V_{CC2} = 30 V,$ $R_F = 2.1 k\Omega, C_F = 1 nF$ | | |

1. All Typical values at $T_A = 25^\circ C$ and $V_{CC} - V_{EE} = 30 V, V_E - V_{EE} = 0V$; unless otherwise specified; all minimum and maximum specifications are at recommended operating condition.

2. Maximum pulse width = 10 μs .

This value is intended to allow for component tolerances for designs with I_O peak minimum = 2.0 A.

3. This supply is optional. Required only when negative gate drive is implemented.

4. Maximum pulse width = 50 μs .

5. See the Slow IGBT Gate Discharge During Fault Condition section in the applications notes at the end of this data sheet for further details.

6. 15 V is the recommended minimum operating positive supply voltage ($V_{CC2} - V_E$) to ensure adequate margin in excess of the maximum V_{UVLO+} threshold of 12.5V. For High Level Output Voltage testing, V_{OH} is measured with a dc load current. When driving capacitive loads, V_{OH} will approach V_{CC} as I_{OH} approaches zero units.

7. Maximum pulse width = 1.0 ms.

8. Once V_O of the LTV-333J is allowed to go high ($V_{CC2} - V_E > V_{UVLO+}$), the DESAT detection feature of the LTV-333J will be the primary source of IGBT protection. UVLO is needed to ensure DESAT is functional. Once V_{CC2} is increased from 0 V to above V_{UVLO+} , DESAT will remain functional until V_{CC2} is decreased below V_{UVLO-} . Thus, the DESAT detection and UVLO features of the

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LTV-333J work in conjunction to ensure constant IGBT protection.

9. See the DESAT fault detection blanking time section in the applications notes at the end of this data sheet for further details.
10. This is the “increasing” (i.e. turn-on or “positive going” direction) of $V_{CC2} - V_E$
11. This is the “decreasing” (i.e. turn-off or “negative going” direction) of $V_{CC2} - V_E$
12. This load condition approximates the gate load of a 1200 V/150A IGBT.
13. Pulse Width Distortion (PWD) is defined as $|t_{PHL} - t_{PLH}|$ for any given unit.
14. As measured from I_F to V_O .
15. The difference between t_{PHL} and t_{PLH} between any two LTV-332J parts under the same test conditions.
16. As measured from ANODE, CATHODE of LED to V_{OUT}
17. This is the amount of time from when the DESAT threshold is exceeded, until the FAULT output goes low.
18. This is the amount of time the DESAT threshold must be exceeded before V_{OUT} begins to go low, and the FAULT output to go low. This is supply voltage dependent.
19. Auto Reset: This is the amount of time when V_{OUT} will be asserted low after DESAT threshold is exceeded. See the Description of Operation (Auto Reset) topic in the application information section.
20. Common mode transient immunity in the high state is the maximum tolerable dV_{CM}/dt of the common mode pulse, V_{CM} , to assure that the output will remain in the high state (i.e., $V_O > 15$ V or FAULT > 2 V).
21. Common mode transient immunity in the low state is the maximum tolerable dV_{CM}/dt of the common mode pulse, V_{CM} , to assure that the output will remain in a low state (i.e., $V_O < 1.0$ V or FAULT < 0.8 V).
22. To clamp the output voltage at $V_{CC} - 3 V_{BE}$, a pull-down resistor between the output and V_{EE} is recommended to sink a static current of 650 μ A while the output is high. See the Output Pull-Down Resistor section in the application notes at the end of this data sheet if an output pull-down resistor is not used.
23. Split resistors network with a ratio of 1:1 is needed at input LED1. See Figure 13. together.

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6.5 PACKAGE CHARACTERISTICS

| | Symbol | Min. | Typ. | Max. | Unit | Test Condition | Note |
|-----------------------------------|-----------|------|-----------------|------|------|--|------|
| Withstand Insulation Test Voltage | V_{ISO} | 5000 | — | — | V | RH ≤ 40-60%, t = 1min, T _A = 25°C, | 1, 2 |
| Input-Output Resistance | R_{I-O} | — | 10 ⁹ | — | Ω | V _{I-O} = 500 V DC | 1 |
| Input-Output Capacitance | C_{I-O} | — | 1.3 | — | pF | f = 1MHz, T _A = 25°C | 1 |

Note.1. According to UL1577, each Photocoupler is tested by applying an insulation test voltage 6000V_{RMS} for 1 second (leakage current less than 10uA). This test is performed before the 100% production test for partial discharge

Note.2. This is a two-terminal measurement: pins 1-8 are shorted together and pins 9-16 are shorted together.

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7. TYPICAL TEST CIRCUITS

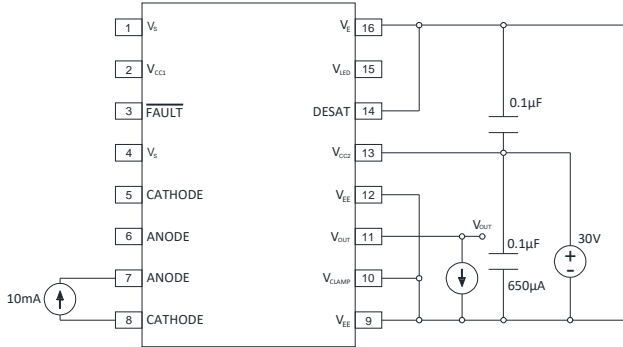


Figure 1 : VoH Test Circuit

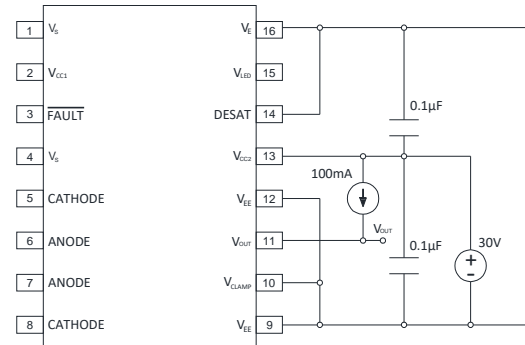


Figure 2 : VoL Test Circuit

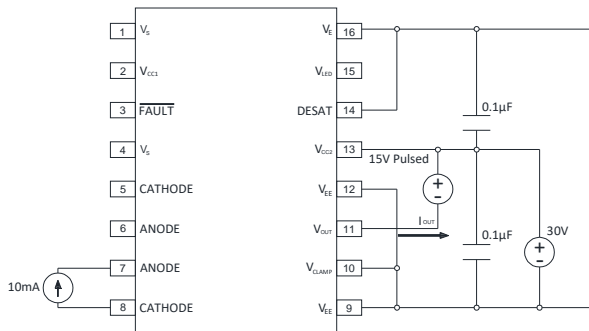


Figure 3 : IOH Test Circuit

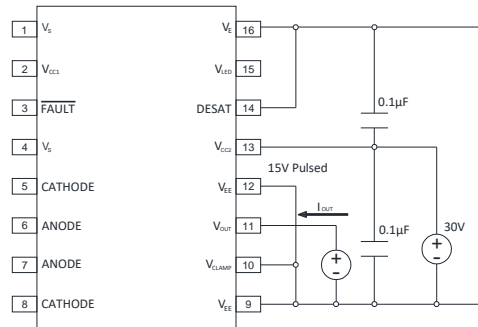


Figure 4 : IOl Test Circuit

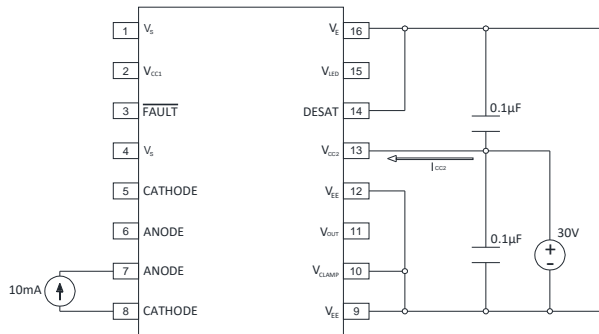


Figure 5 : Icc2H Test Circuit

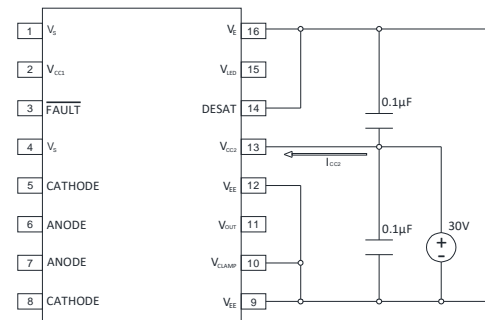


Figure 6 : Icc2L Test Circuit

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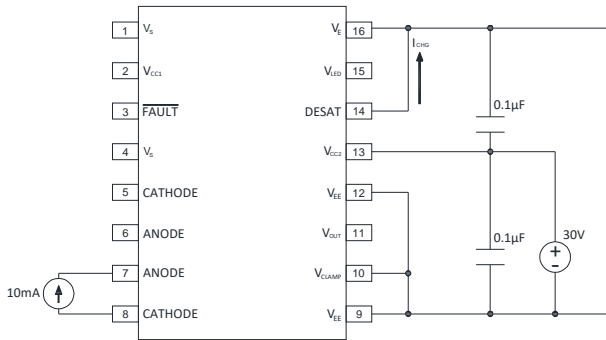


Figure 7 : ICHG Test Circuit

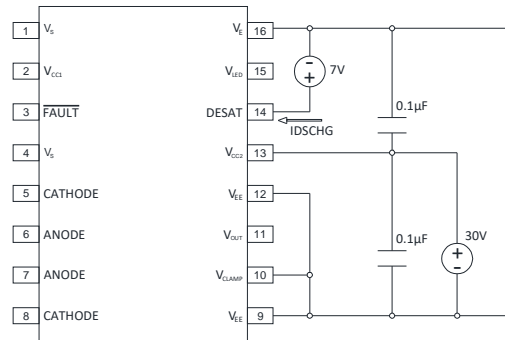
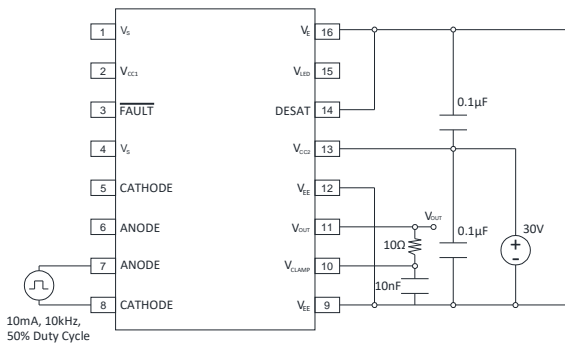


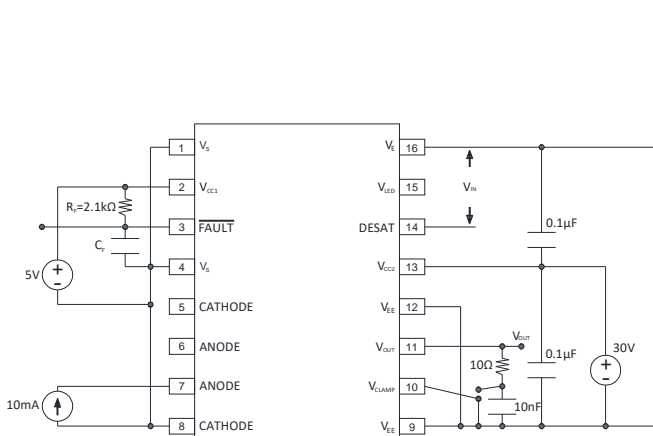
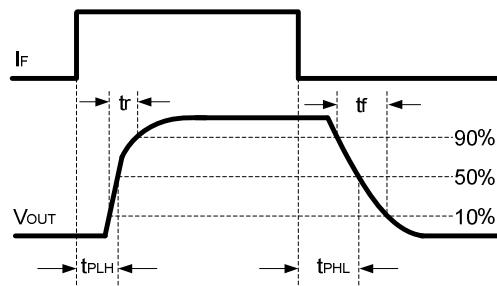
Figure 8 : Ibschg Test Circuit



$I_F = 10 \text{ mA}$

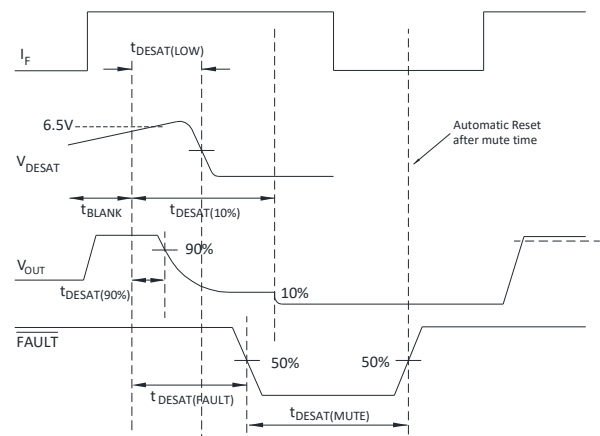
($f = 10\text{k Hz}$, duty = 50%, $t_r = t_f = 5\text{ ns}$ or less)

Figure 9 : tPLH , tPHL , t_r , t_f Test Circuit



$I_F = 10 \text{ mA}$

($f = 10\text{k Hz}$, duty = 50%, $t_r = t_f = 5\text{ ns}$ or less)



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Figure 10 : tDESAT fault Test Circuit

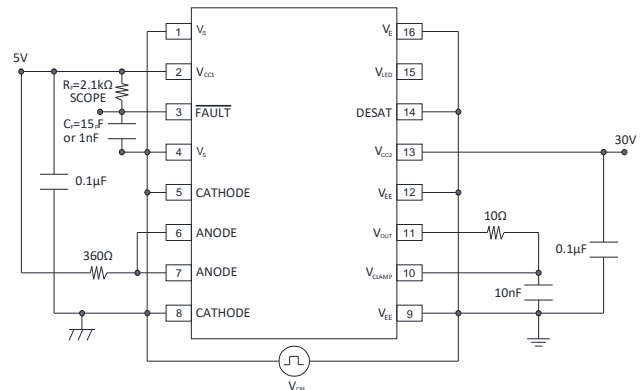
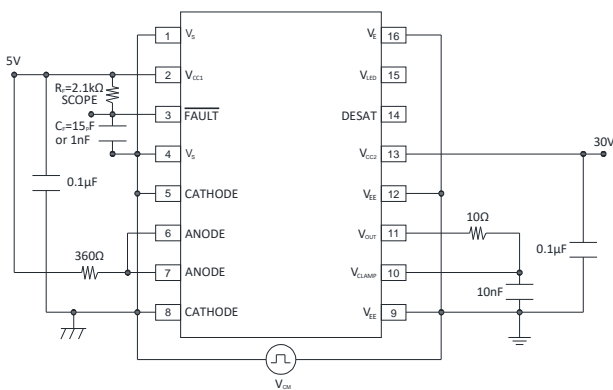


Figure 11 : CMR Test Circuit LED2 ON

Figure 12 : CMR Test Circuit LED2 OFF

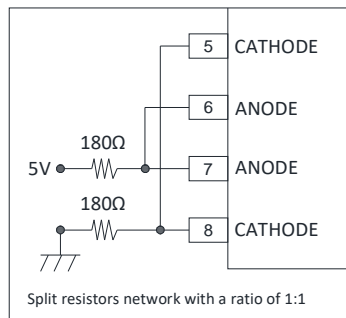
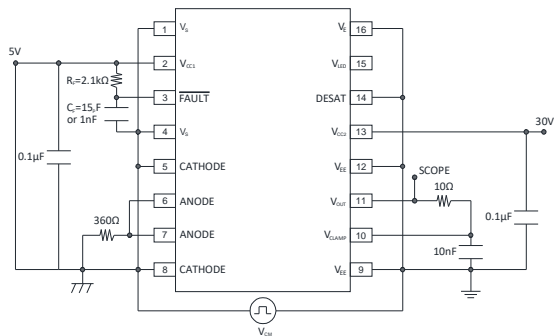


Figure 13 : CMR Test Circuit LED1 ON

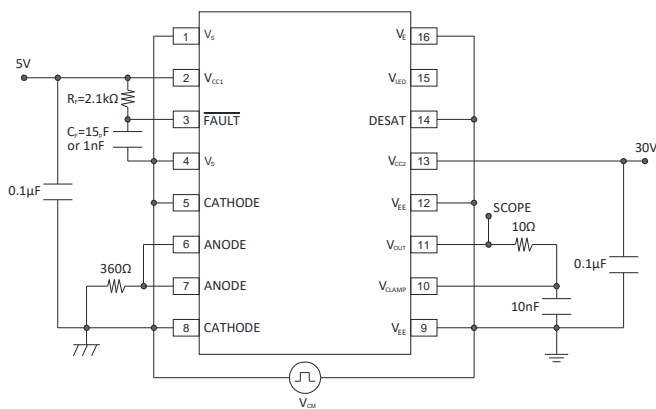


Figure 14 : CMR Test Circuit LED1 OFF

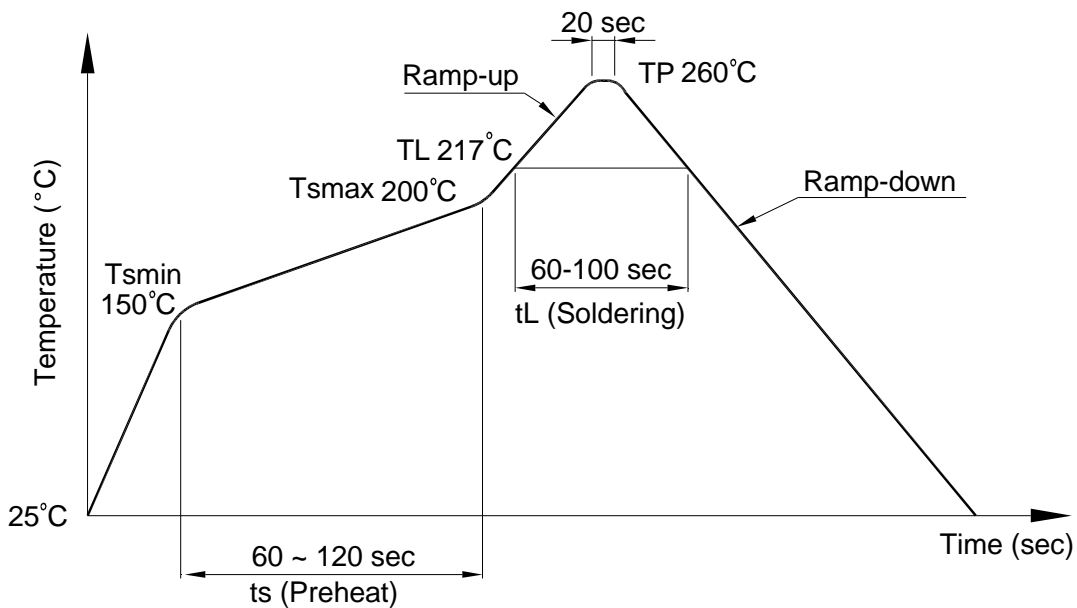
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8. TEMPERATURE PROFILE OF SOLDERING

8.1 IR Reflow soldering (JEDEC-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 Min (T_{Smin}) | 150°C |
| - Temperature Max (T_{Smax}) | 200°C |
| - Time (min to max) (ts) | 90±30 sec |
| Soldering zone | |
| - Temperature (T_L) | 217°C |
| - Time (t_L) | 60 ~ 100 sec |
| Peak Temperature (T_P) | 260°C |
| Ramp-up rate | 3°C / sec max. |
| Ramp-down rate | 3~6°C / sec |



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8.2 Wave soldering (JEDEC22A111 compliant)

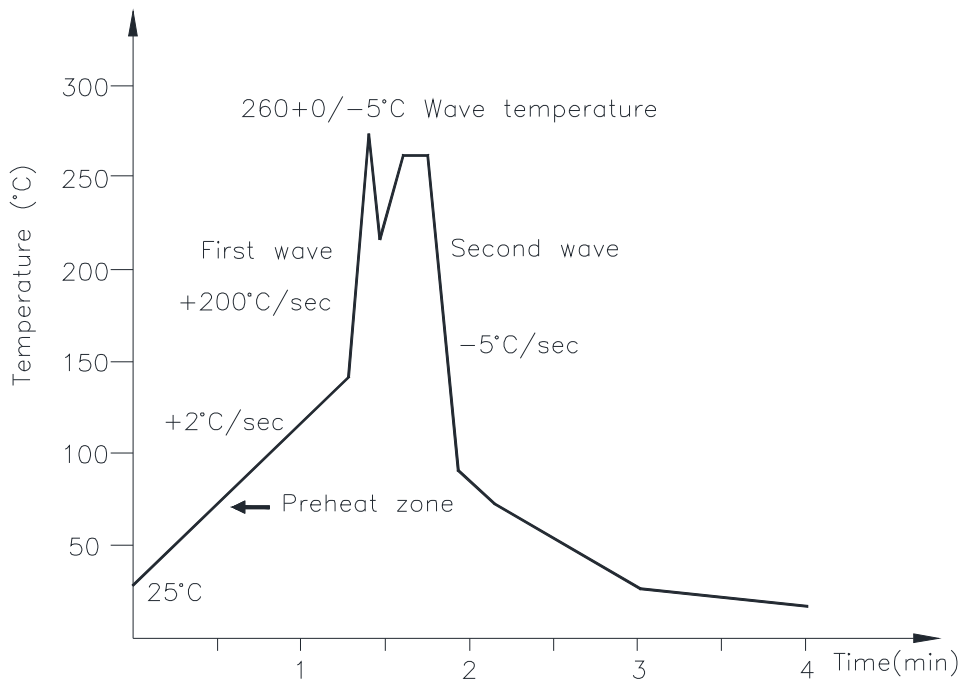
One time soldering is recommended within the condition of temperature.

Temperature: $260+0/-5^{\circ}\text{C}$

Time: 10 sec.

Preheat temperature: 25 to 140°C

Preheat time: 30 to 80 sec.



8.3 Hand soldering by soldering iron

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

Temperature: $380+0/-5^{\circ}\text{C}$

Time: 3 sec max.

9. Notes:

Specifications of the products displayed herein are subject to change without notice.

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