# Chapter 7

## Trouble Shooting

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1 Trouble Shooting

In comparison to standard modules, IPMs have various protection functions (overcurrent, overheating, etc.) built in, so that their devices are not easily destroyed by abnormal conditions. However, destruction may occur depending on the abnormality, so that countermeasures are required once the cause and state of occurrence have been clarified. An analysis diagram indicating the cause of destruction is shown on page 2 and should be used to investigate the causes of destruction. (For element fault judgment, refer to the Module Application Manual, chapter 4, item 2 "Fault Judgment Method".)

Also, in the case of alarm output from the IPM, use the alarm cause analysis diagrams of Fig. 7-2 to investigate the cause.

2 Fault Analysis Diagrams
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Fig. 7-1 (b)  Mode A: RBSOA Deviation

Fig. 7-1 (c)  Mode B: Gate Overvoltage
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Excessive junction temperature rise (rapid temperature rise)

[C] Excessive Junction Temperature Rise (rapid temperature rise)

**Estimated trouble location**

- Insufficient control power source voltage
- Gate drive circuit fault
- Control power source circuit fault
- Control PCB fault
- Output short-circuit (repeated short-circuit)
- Insufficient dead time
- Insufficient control power source voltage
- Control PCB fault
- Abnormal load
- Abnormal load
- Control PCB fault
- Abnormal load
- Control PCB fault
- Abnormal load
- Control PCB fault
- Abnormal load
- Control PCB fault
- Insufficient compound quantity
- Fin bending fault
- Insufficient compound quantity
- Insufficient compound quantity
- Insufficient dust protection measures
- Defective cooling fan
- Defective cooling system
- Heat sink clogging
- Drop of cooling fan speed or stop of fan
- Local overheating of stack

**Fig. 7-1 (d) Mode C: Excessive Rise in Junction Temperature**
D Destruction of FWD part

[Estimated trouble location]

- Power factor drop
- Abnormal load
- Control PCB fault
- Control PCB fault
- Insufficient tightening torque
- Fin bending fault
- Insufficient dust protection measures
- Insufficient element tightening force
- Defective cooling fan
- Defective cooling system
- Excessive surge voltage at time of reverse recovery
- di/dt increase at time of turn-on
- Minute pulse reverse recovery phenomenon
- Gate signal breaking by noise etc.
- Snubber circuit fault
- Control power source circuit fault
- Control power source circuit fault
- Control PCB fault
- Charging circuit fault

Fig. 7-1 (e) Mode D: Destruction of FWD Part
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**Power source stabilization**

**Capacitor fault**

**Excessive control power source voltage**

**Overvoltage**

**Spike voltage**

**Excessive input part voltage**

**Excessive static electricity**

**Input part overcurrent**

**Destruction of control circuits**

**[Estimated trouble location]**

- Control power source circuit fault
- Power source stabilization
- Capacitor fault
- Long power source wiring
- Control voltage application status desorption
- Control circuit fault
- Insufficient antistatic measures
- Abnormal input pull-up resistance

Fig. 7-1 (f)  Mode E: Destruction of Control Circuit

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**Damage related to reliability and product handling**

* For the results of the reliability tests performed by Fuji Electric Device Technology, refer to the specifications and the reliability test result report.

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**Estimated trouble location**

- Loading conditions
- Stress of the terminal part
- Screw length
- Tightening part
- Main terminal part
- Transport conditions
- Product terminal part (check for stress from vibration)
- Transport conditions
- Assembly conditions at the time of product mounting
- Storage conditions

**Reliability (life) degradation**

- Storage at high temperature (exposure to high temperatures)
- Long-term storage at high temperatures
- Storage at low temperatures (exposure to low temperatures)
- Long-term storage at low temperatures
- Excessive humidity (exposure to humidity)
- Long-term storage at high temperature and high humidity

**Thermal stress fatigue from repeated gentle rise and fall of product temperature (temperature cycle, ΔT) power cycle)**

**Thermal stress failure from rapid rise or fall of product temperature (thermal impact)**

**Thermal stress failure of wiring in product, etc., caused by change of semiconductor chip temperature because of rapid load changes etc. (ΔT) power cycle)**

**Long-time voltage application under high temperature (high temperature application between C and E or G and E)**

**Long-time voltage application at high temperature and high humidity (application under moisture (THB))**

**Use in a corrosive gas atmosphere**

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**Fig. 7-1 (g)  Mode F: Damage Related to Reliability and Product Handling**
3 Alarm Cause Analysis Diagram

3.1 Cause analysis in the event an IPM alarm occurs

When an inverter using an IPM comes to an alarm stop, a survey must first be done to find out whether the alarm was output from the IPM or from a device control circuit (other than the IPM).

If the alarm was output by the IPM, determine the cause according to the following cause analysis diagram.

For observation of whether there is an IPM alarm or not via the alarm output voltage, the presence or absence of an alarm output can be confirmed easily by inserting a 1.5 kΩ resistor between the IPM alarm terminal and the cathode of the alarm photodiode and measuring the IPM alarm terminal voltage.

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<th>Explanation of alarm cause</th>
<th>How to determine alarm cause</th>
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<td>IPM alarm occurrence</td>
<td></td>
<td></td>
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<tr>
<td>Normal alarm</td>
<td>The chip temperature $T_j$ is detected by the temperature detection element (diode) built into all IGBTs. When $T_j OH$ exceeds the trip level continuously for 1 ms or longer, the IGBT is switched off for protection.</td>
<td>• Measure the control power source voltage $V_{cc}$, the DC input voltage $d$, the output current $I_o$. • Measure the case temperature $T_c$ directly under the chip, calculate $\Delta T_{j-c}$, and estimate $T_j$. • Confirm the IPM installation method. (Fin flatness, thermal compound, etc.) • The alarm holding time in many cases is longer than 2 ms.</td>
</tr>
<tr>
<td>OC</td>
<td>The collector current is detected by the current flowing through the current sensing IGBT built into all IGBT chips. When the overcurrent trip level is exceeded continuously for approximately 5 µs or longer, the IGBT is switched off for protection.</td>
<td>• Observe the alarm and the output current ($U$, $V$, $W$) with an oscilloscope. • Observe the alarm and the DC input current ($P$, $N$) with an oscilloscope. • Observe the current change 5 µs before alarm output. • Confirm the trip level and the detection location in case of current detection with CT, etc. • The alarm holding time in many cases is 2 ms.</td>
</tr>
<tr>
<td>UV</td>
<td>When the control power source voltage $V_{cc}$ drops below the undervoltage trip level continuously for 5 µs or longer, the IGBT is switched off for protection.</td>
<td>• Observe the alarm and $V_{cc}$ with an oscilloscope. • Observe the power source voltage change 5 µs before alarm output. • In case of instantaneous voltage drops, the alarm holding time in many cases is 2 ms.</td>
</tr>
<tr>
<td>$T_{c OH}$</td>
<td>The insulation substrate temperature is detected by the temperature detection element (IC) installed on the same ceramic substrate as the power device. When the $T_{c OH}$ trip level is exceeded continuously for 1 ms or longer, the IGBT is switched off for protection.</td>
<td>• Measure the temperature at the side of the copper base with a thermocouple. • Observe the alarm output period with an oscilloscope. • The possibility that the alarm is $T_{c OH}$ is large when output is made for a longer period than the 2 ms of the alarm holding time.</td>
</tr>
<tr>
<td>Faulty alarm</td>
<td>When the control power source voltage $V_{cc}$ exceeds the absolute max. rating of 20 V or when an excessive $dv/dt$ or ripple is applied, the drive IC may be damaged or a faulty alarm output. • When noise current flows in the IPM control circuit, the IC voltage may become unstable and a faulty alarm output.</td>
<td>• A short pulse alarm in the order of µs is output. • Observe the Vcc waveform during motor operation with an oscilloscope, preferably in the vicinity of the IPM control terminals. • $V_{cc}$ $&lt;$ 20 V, $dv/dt$ $&lt;$ 5 V/µs, and $V_{ripple}$ $&lt;$ 2 Vp-p shall apply (all four power supplies). • Confirm that there is no external wiring between IPM control GND and main terminal GND. In case of wiring, noise current flows into the IPM control circuit. • When the drive IC is damaged, there is a high possibility of abnormal increase of $I_{cc}$. • Measure the temperature at the side of the copper base with a thermocouple. • Observe the control power source voltage $V_{cc}$ with an oscilloscope.</td>
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Ex.: If $I_{cc p}$ $>$ 10 mA @$V_{in}$ “High”, confirm the abnormality of IPM peripheral circuits.

Fig. 7-2  Alarm Cause Analysis Diagram
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