Chapter 6

Cautions on Use

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1 Main Power Source

1.1 Voltage range

1.1.1 600 V system IPMs

- The main power source should not exceed 500 V (= V_{DC}(surge)) between the P and N main terminals. The voltage between the collector and emitter main terminals (= VCES) should not exceed 600 V (= absolute max. rated voltage).
- Surge voltage occurs in the wiring inductance inside the IPM due to di/dt during switching, but the product is designed so that 600 V is not exceeded between the collector and emitter main terminals when the main power source is used at V_{DC}(surge) or lower between the P and N main terminals.
- In order for the maximum surge voltage at the time of switching not to exceed the rated voltage, keep the connecting wires between the IPM and the embedded product short and install a snubber close to the P and N terminals.

1.1.2 1200 V system IPMs

- The main power source should not exceed 1000 V (= V_{DC}(surge)) between the P and N main terminals. The voltage between the collector and emitter main terminals (= VCES) should not exceed 1200 V (= absolute max. rated voltage).
- Surge voltage occurs in the wiring inductance inside the IPM due to di/dt during switching, but the product is designed so that 1200 V is not exceeded close to the chip when the main power source is used at V_{DC}(surge) or lower between the P and N main terminals.
- In order for the maximum surge voltage at the time of switching not to exceed the rated voltage, keep the connecting wires between the IPM and the embedded product short and install a snubber close to the P and N terminals.

1.2 External noise

Countermeasures have been taken against external noise within the IPM, but faulty operation may possibly occur depending on the type and intensity of the noise.

Please take sufficient countermeasures against noise entering the IPM.

1.2.1 Noise from outside the equipment

- Apply a noise filter on the AC line, isolate the ground and so on.
- When required, add capacitors of 100 pF or less between all phase signal inputs and signal GND.
- Install arresters against lightning surges, etc.

1.2.2 Noise from within the equipment

- Outside the rectifier: Implement the same countermeasures as the above.
- Inside the rectifier: Apply snubber circuits on the PN lines.
  (In case of multiple inverters connected to one rectifier converter, etc.)

1.2.3 Noise from the output terminals

- Take external countermeasures so that contactor switching surges and so on do not enter.

2 Control Power Source

2.1 Voltage range

- The drive circuit shows stable operation when the control power source voltage is in the range of 13.5 to 16.5 V.
  Operation with a value as close to 15 V as possible is recommended.
- When the control power source voltage is below 13.5 V, the loss will increase and noise will show a tendency to decrease.
  Also, the protection performance will shift, so that the protection functions may not be sufficient and chip damage may occur.
- When the control power source voltage drops below 13.5 V, dropping down to VUV or lower, the undervoltage protection function (UV) operates.
  When the control power source voltage recovers to VUV + VH, UV is automatically released.
- When the control power source voltage exceeds 16.5 V, the loss decreases and noise shows a tendency to increase.
  Also, the protection performance will shift, so that the protection functions may not be sufficient and chip damage may occur.
- When the control power source voltage is below 0 V (reverse bias) or exceeds 20 V, the drive circuit and/or the main chip may be damaged. Never apply these voltages.

2.2 Voltage ripple

- The recommended voltage range of 13.5 to 16.5 V includes the voltage ripple of Vcc.
  During the manufacture of the control power source, be sure to keep the voltage ripple sufficiently low.
  Also be sure to keep noise superimposed on the power source sufficiently low.
- Design the control power source so as to keep dv/dt at 5 V/μs or lower.

2.3 Power source start-up sequence

- Apply the main power source after confirming that Vcc is in the recommended voltage range.
  If the main power source is applied before the recommended voltage is reached, the chip may be destroyed (worst-case scenario).

2.4 Alarm at the time of power source start-up and shutdown

- At the time of power source start-up, an alarm is output at the UV protection function operation level voltage.
  Recovery is made when the protection release level voltage is reached, but as the alarm will not be released as long as an ON signal is input, appropriate measures must be taken on the drive circuit side.
- As there is also alarm output at the time of power source shutdown, similar measures are required.

2.5 Precautions upon control circuit design

- Design with sufficient margin, taking the current consumption specification (Icc) for the drive circuit into consideration.
- Make the wiring between the input terminals of the IPM and the photocoupler as short as possible, and use a pattern layout with a small stray capacitance for the primary side and the secondary side of the photocoupler.
- Install a capacitor as close as possible between Vcc and GND in the case of a high-speed photocoupler.
- For a high-speed photocoupler, use a high CMR type in which tpHL, tpLH $\leq$ 0.8 μs.
- For the alarm output circuit, use a low-speed photocoupler type in which CTR $\geq$ 100%.
- Use four isolated power sources for the control power source Vcc. Also use a design with suppressed voltage fluctuations.
- When a capacitor is connected between the input terminals and GND, note that the response time in regard to an input signal on the primary side of the photocoupler becomes longer.
- Design the primary-side current of the photocoupler with sufficient margin taking the CTR of the photocoupler being used into consideration.

3 Protection Functions

As the built-in protection functions and the presence or absence of alarm output differ according to the package and the model, confirm the protection functions of your IPM referring to the "List of IPM built-in functions" in chapter 3.

3.1 Protection operations in general

3.1.1 Range of protection

- The protection functions included in the IPM are designed for non-repetitive abnormal phenomena.
- Do not apply constant stress that exceeds the rating.

3.1.2 Countermeasures for alarm output

- If an alarm is output, stop the input signal into the IPM immediately to stop the equipment.
- The IPM protection functions protect against abnormal phenomena, but they cannot remove the causes of the abnormalities. After stopping the equipment, restart it after you have removed the cause of the abnormality.

3.2 Precautions for the protection functions

3.2.1 Overcurrent

- The overcurrent protection function (OC) executes a soft shutdown of the IGBT and outputs an alarm when the overcurrent continues in excess of the insensitive time (tdoc).
  Accordingly, OC does not operate when the overcurrent is removed within the tdoc period.
- In P619, the current is detected on the N-line, so there is no OC for the upper arm.

3.2.2 Starting with load short-circuit

- The OC has an insensitive time (tdoc) of approximately 5 to 10 μs. If the input signal pulse width is shorter than this, the OC does not operate.
- If an input signal pulse width of tdoc or less continues when starting with the load shorted, short circuits occur continuously and the chip temperature of the IGBT rises rapidly.
  In such a case, the rise of the case temperature does not follow the rise of the chip temperature and the case temperature overheating protection function (TcOH) does not operate. Normally the chip temperature overheating protection function (TjOH) operates and provides protection, but as TjOH also has a delay of approximately 1 ms, depending on the state of the chip temperature rise, the protection operation may not occur in time, possibly causing damage to the chip.

3.2.3 Ground short

- If a ground short occurs and an overcurrent flows through the lower arm of the IGBT, overcurrent protection by OC occurs for all IPMs.
- If a ground short occurs and an overcurrent flows through the upper arm of the IGBT, the protection operation differs according to the package and the model.
  P621, P622
    Overcurrent protection is provided by the OC of the upper arm. Alarm output also is provided.
  P610, P611, P612
    Overcurrent protection is provided by the OC of the upper arm, but there is no alarm output.
    For details, refer to the related document MT6M3046 "Protection in R-IPM Earth Fault Mode".
  P619, P617
    As there is no OC for the upper arm, there is no overcurrent protection and no alarm output.

3.3 FWD overcurrent protection

- FWD current is not detected. Accordingly, there is no protection when overcurrent flows only for FWD.

3.4 Case temperature protection

- TcOH is the protection function used when the temperature of the entire insulation substrate rises. Accordingly, the chip temperature protection function (TjOH) operates when the heating is concentrated on one chip.

3.5 Chip temperature protection

- A chip temperature protection function (TjOH) is built into all IGBTs, including the brake part.

4 Power Cycling Capability

The lifetime of semiconductor products is not eternal. Accumulated fatigue by thermal stress resulting from rising and falling temperatures generated within the device may shorten the lifetime of the components. Narrow the range of temperature variations as much as possible.

5 Other

5.1 Precautions for usage and installation into equipment

(1) Also read the IPM delivery specifications for IPM use and installation into the device.

(2) Always prevent secondary damage by installing a fuse or a circuit breaker with a suitable capacity between the commercial power source and this product, keeping in mind the possibility of chip damage caused by unexpected accidents.

(3) When investigating the chip duty at the time of a normal turn-off operation, make sure that the operation track for the turn-off voltage and current is within the RBSOA specifications.
When investigating the chip duty with non-repetitive short-circuit interruption, make sure that it is within the SCSOA specifications.

(4) Use this product upon full understanding of the product usage environment and upon investigation of whether the product reliability life is satisfactory or not. In case of use in excess of the reliability life of the product, the chip may be destroyed before the target life of the device.

(5) Apply a thermal compound or the like between the IPM and the heat sink to make the contact heat resistance as small as possible.

(6) Use the IPM within the range specified in the specifications for the screw torque and the heat sink flatness.
Incorrect handling can cause insulation failure.

(7) Take care so that no load is placed on the IPM. Particularly, the control terminal should not be bent.

(8) Do not perform soldering by reflow on the main terminal and control terminal. Take care to prevent any effect on the IPM by heat, flux, and washing solutions used for soldering other components.

(9) Avoid locations where corrosive gases are generated or dust is present.

(10) Take care to prevent high-voltage static electricity entering the main terminal and control terminal.

(11) When removing and attaching the control circuit and the IPM, first confirm that Vcc is 0 V.

WARNING

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