

## Chapter 4 Troubleshooting

1. Troubleshooting

4-2



This chapter describes how to deal with troubles that may occur while the automotive IGBT module is handled.

## 1. Troubleshooting

When the IGBT module is installed in an inverter circuit, etc. a failure of the IGBT module might be occurred due to improper wiring or mounting. Once a failure is occurred, it is important to identify the root cause of the failure. Table 4-1 illustrates how to determine a failure mode as well as the original causes of the failure by observing irregularities outside of the device. First of all, estimate a failure mode of the module by using the table when a failure is happened. If the root cause cannot be identified by using Table 4-1, see Fig. 4-1 as detailed analysis chart for helping your further investigation.

## Table 4-1(a) Estimated causes and its device failure modes

External abnormalities		Cause		Device failure mode	Further check point
Short-circuit	Arm short-circuit	After short-circuit detection, surge voltage excess SCSO		Outside SCSOA	Integrity waveform of locus and device ruggedness
	Series arm short-circuit	Insufficient dead time	Large t <sub>off</sub> due to reverse gate bias dead time setting mistakes	Overheat	Integrity device $t_{\rm off}$ and dead time
		dv/dt malfunction	less reverse gate bias too long gate wiring		Faulty turn-on due to d <i>v</i> /d <i>t</i>
		Noise induced	Gate circuit malfunction Logic circuit malfunction	SCSOA	confirm circuit malfunction
	Output short-circuit	Faulty wiring, abnormal wire contact, load short- circuit Faulty wiring, abnormal wire contact,		and/or overheat	confirm failure phenomenon
	Ground short				Integrity between device ruggedness and protection condition Wiring conditions
			Logic circuit malfunction		Logic signal
Overload		Overcurrent	protection function setting fault	Overheat	Redesign of protection condition
	Excessive DC voltage	Overvoltage larger than device breakdown voltage apply between Corrector and Emitter	Excessive input voltage Overvoltage protection	Excess ratings of $V_{CE}$	Redesign of protection condition
		Destruction due to excessive surge voltage larger than RBSOA		RBSOA	Integrity confirmation RBSOA and operating locus at turn-off
		at turn-off			Redesign of sunbber circuit
Overvoltage		Destruction due to exce larger than device			Integrity spike voltage and device breakdown voltage
	Excessive	breakdown voltage at re	everse recovery		sunbber circuit
	spike voltage	Reverse recovery phenomenon at	logic circuit or gate circuit malfunction due to noise	Overvoltage of $V_{CES}$	Logic circuit and/or gate circuit
			Electomagnetic induction noise from main circuit to gate wiring		Mutual interference between gate circuit and main circuit
		Destruction by the main the surge voltage at the reach the dynamic avala	time of the turn-off to	Destruction due to dynamic avalanche	Redesign of main circuit inductance

\*1) Excessive reverse recovery voltage over device breakdown voltage is produced, if gate pulse width is less than few hundred nano second.



External	abnormalities	Cause		Device failure mode	Further checkpoints
		$V_{CE}$ is increased by $V_{GE}$ lower	DC/DC converter malfunction		
Driver supply voltage drop		than specified value. As a result, power consumption and Joule head are increased.	Too mach time constant of power supply settling	Overheat	Check circuit design
			Gate wiring break		
Excessive gate voltage		Electro static discharge on $V_{\rm GE}$		Excessive Vors	Assembly earea environment against ESD
		Spike voltage larger than $V_{\text{GES}}$ is wiring	produced by too long gate		Gate voltage
Operation under opened gate circuit		Voltage apply to Corrector and En opened.	nitter while gate is	Overheat	Gate voltage
Overvolteg temperatur IGBT		Temperature diode and/or sense ESD	IGBT destruction due to	ESD	Assembly earea environment against ESD
	Lack of heat dissipation	Anomalous heating due to lack of	Less flow rate		Radiation condition
Overheat	capacity	heat dissipation capacity	Radiator malfunction	Overheat	or radiation design
	Thermal runaway	Total dissipation is increased by c due to logic circuit malfunction	arrier frequency increased		Logic circuit on gate
Stress	Stress	Soldered portion is broken by	Stress from external wiring	Disconnection of	Mechanical stress due to mounting condition
	Vibration	stress fatigue	Stress induced vibration	circuit	
Reliability (Life time)		The application condition exceeds module	the reliability of the	Destruction is different in each case.	Refer to Fig. 4-1(a-f)

## Table 4-1(b) causes of device failure modes



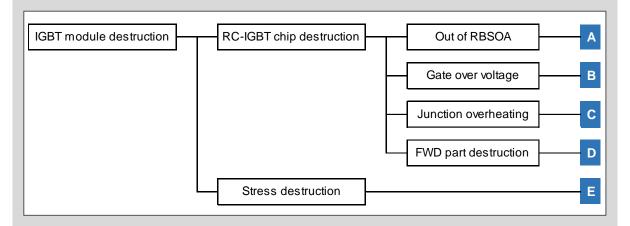


Fig. 4-1(a) IGBT module failure analysis

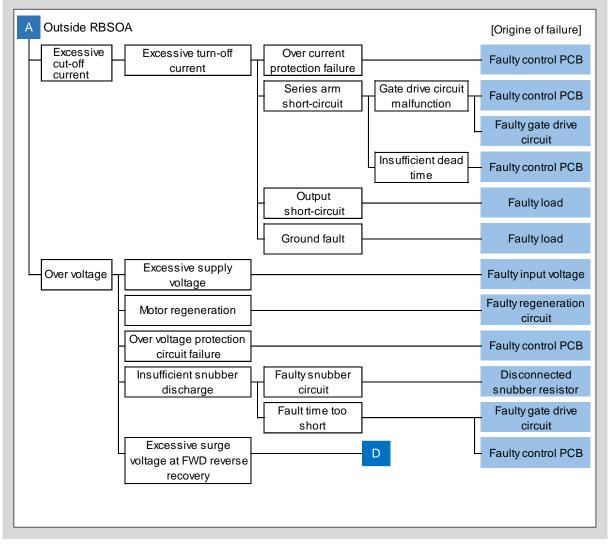


Fig. 4-1(b) Mode A: Outside RBSOA



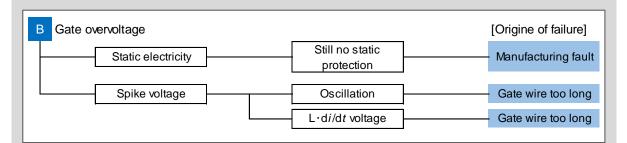


Fig. 4-1(c) Mode B: Gate overvoltage

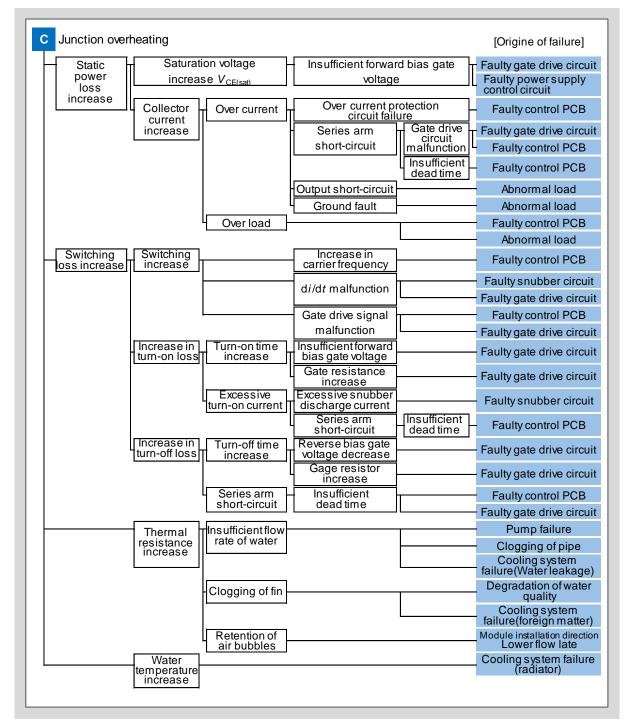


Fig. 4-1(d) Mode C: Junction over heating

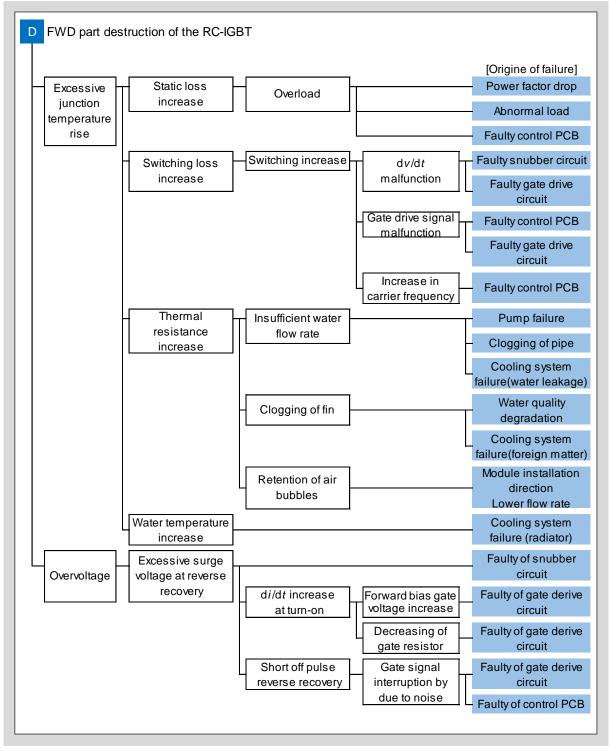


Fig. 4-1(e) Mode D: FWD destruction



E Destruction due to reliability or product	handling		
			[Origne of failure]
Destruction External force or load	Loading during product storage		Loading conditions
due to handling	Stress produced in the terminals when mounted		Stress in the terminal section
	Excessively long screws used in the main and control terminal	_	Screw length
Excessive tightening		_	Clamped section
torque		_	Terminal section
Insufficient tightening torque for main terminal screws	Increase contact resistance		Main terminal section
Vibration	Excessive vibration during transport		Transport conditions
	Loose component clamping during product mounting		Product terminal section
- Impact	Dropping, collision during transport		Transport conditions
Soldered terminal heat resistance	Overheating at terminal soldering	Щ	Assembly condition at the installation
Storage in abnormal	Storage in corrosive		Storage condition
conditions	gas environment		Clorage contaition
-	Storage in condensationfrendly environment		
	Storage in dusty environment	μ	
Electric static	Assembly at easily charged environment		ESD control condition at the installation
	Abnormal at the flange seal		Product handling
Cooling water leakage	Abnormal at the cover of the cooler		Product handling Excessive water pressure Excessive vibration and shoc
-	Abnormal mounting conditions		Insufficient torque Broken screw Unsuitable sealing design
	Corrosion		Unsuitable coolant Excessive flow rate Air bubble in the coolant
Reliability Soaking in high	Long term storage in high temperature	$\left  \right $	Storage conditions
destruction Soaking in low temperature	Long term storage in low temperature	H	
Soaking in high temperature and high humidity	Long term storage in high temperature and high humidity		
Thermal stress fatigue in temperature cycle		H	Matching between product life time and operation conditions
	-Thermal impact by sharp rise or fall in product temperature $\Delta T_{\rm vi}$ power cycle		
temperature conditions			
Voltage applied for long term under hot and humid conditions	Long term usage on high temperature and humidity		

Fig. 4-1(f) Mode E: FWD destruction