CHAPTER ④

Protective Circuits in the OEM300

Extreme conditions can damage power supplies. The OEM300 Power Module contains several circuits that will protect it from threatening conditions, such as short circuits in drives, excessive heat buildup in equipment cabinets, or energy regenerated by high inertial loads.

The OEM300's protective circuits are built-in and work automatically. You do not need to do anything to turn them on; in fact, you *cannot* alter them in any way. Because they are automatic, they can cause unexpected results if you do not understand how they work.

For example, if there is a short circuit in a drive connected to the Power Module, the Power Module will shut down. If you are unaware of the short circuit protection feature, you might think the shutdown is caused by a defective Power Module and waste time trying to fix it. If you know about the protective circuitry, however, you can find the root cause of the problem—the short circuit in the drive—more quickly. You can proceed straight to locating and fixing the short circuit, and getting your system running again.

The following information about the protective circuits will help you understand how they work, when they take effect, and the results they produce. This will aid your troubleshooting efforts, and help you locate the cause of unexpected behavior.

SHORT CIRCUIT PROTECTION

The OEM300 continuously monitors output current at the 75VDC terminals. If it detects a rapid current rise to excessive levels, it interprets the current rise as a short circuit fault in the drive. It shuts off power to the 75VDC output terminals. Internally, the 75VDC power supply section of the Power Module continues to function, and the green LED remains illuminated.

If the OEM300 detects a short circuit current in excess of 9 amps, it will shut down the output immediately . It will monitor a 6 amp current and shut down the output if the current lasts longer than 3 seconds. This is summarized in the table below:

Current Level	Response Time of Protection	
9 amps	Respond:	Immediately
6 amps	Respond:	In 3 seconds
4—6 amps	No Response:	Beyond specified operating range
2.7—4 amps	No Response:	Intermittent operating range
0—2.7 amps	No Response:	Continuous range

When the 75VDC output is shut down, the shutdown is a *LATCHED* condition (the 75VDC output will remain off until power is cycled). To *CYCLE POWER*, turn off the AC power to the OEM300, wait approximately 30 seconds (the green LED will turn off), then turn on AC power.

The output is latched in the OFF condition for safety reasons. Short circuit protection guards people from injury and equipment from damage.

IMPORTANT TROUBLESHOOTING NOTE: You may be confused if your system unexpectedly stops, the voltage at the 75VDC terminals is Ø Volts, but the LED is illuminated. There is probably a short circuit fault in your equipment. Remember, the LED will remain illuminated, even when the 75VDC output is shut down due to a short circuit fault. Find and fix the problem in your equipment, then cycle power to the OEM300 and restart your system.

Other possible causes:

① Excessive load regeneration—see the Power Dump description below.
② Overvoltage—see the description below.

OVER-TEMPERATURE PROTECTION

The OEM300 has a circuit that protects it from damage due to over-temperature conditions. This circuit monitors the temperature of the Power Module's heatplate. A temperature rise above 60°C (140°F) will trigger a thermal switch; when this happens, the protection circuit shuts down the Power Module, and turns off the green LED. This is a latched condition. Before the Power Module can operate again, its heatplate must cool below approximately 30°C (86°F) and AC power must be cycled.

The Power Module will cool faster if you turn off AC power while it cools. If AC power is on, several bleeder resistors will continue to dissipate their heat into the heatplate and keep it warm, even though the Power Module is off. It will cool much faster with the power off. Therefore, design your system so that, if an over-temperature shutdown occurs, AC power is turned off while the Power Module cools down.

TRIP TEMPERATURE

65°C ± 5°C (149°F ± 9°F)

DESIGN TIP: Use 60°C (140°F) as the maximum heatplate temperature allowed for continuous operation of the Power Module. Because of the manufacturing tolerance on the thermal switch, different OEM300 units will shut down at different temperatures in the 60°C to 70°C range (140°F to 158°F). For predictability, use 60°C (140°F) as the shutdown temperature.

HYSTERESIS

The thermal switch used by the over-temperature protection circuit has built-in thermal hysteresis. The switch will open at 65°C ± 5° (149°F ± 9°F), and shut down power to the OEM300. It will not close until it has cooled to approximately 30°C (86°F). This means that the OEM300 will not operate again until it has had adequate time to cool.

TROUBLESHOOTING NOTE: If the OEM300 shuts down because of excessive heatplate temperature, the heatplate must cool below 30°C (86°F) before the unit can be restarted. Turn off AC power while the OEM300 cools.

POWER DUMP

During normal use, a motor consumes power from a power supply. During deceleration or a free-wheeling shutdown, however, the motor becomes a generator and produces energy. This energy *must* go somewhere! It travels through the cables and drive, and back to the power supply, where it enters the supply through the output terminals. This phenomenon is called *regeneration.*

The energy produced by regeneration is proportional to the kinetic energy of the moving parts of the motor and its load. For some configurations of motors and loads, the energy can be quite high, and has the potential to damage any connected drives and power supplies. The OEM300 has a circuit that protects drives connected to it from excessive load regeneration. The protective circuit is called a *power dump.*

The power dump works by sensing the voltage at the 75VDC output terminals. A voltage rise above a threshold value, approximately 85VDC, indicates the OEM300 is receiving too much regenerated energy. The power dump circuitry closes an internal switch and diverts the extra energy through a large power resistor. The energy is dissipated as heat in the resistor, and voltage at the output terminals falls.

When the voltage falls to approximately 82VDC, the power dump turns off. If energy is still being regenerated, voltage at the output terminals will start to rise. When the voltage reaches 85VDC, the power dump turns on, and the whole process begins again. To dissipate the entire amount of regenerated energy, the power dump will switch on and off, over and over again, until the voltage no longer rises above 85VDC.

The resistor in the power dump can absorb a maximum of 400 joules of energy within a short period of time. And, after the resistor converts the energy to heat, it needs time to transfer the heat to the ambient air before it can absorb more energy. Therefore, there is a repetition rate, or period, that determines how frequently energy can be dumped into the power resistor. The maximum *average* power dissipation rate during this period is 8 watts.

For example, suppose 400 joules is dissipated in the power dump in one second. How long must we wait before we can repeat the regeneration event? Average power dissipation must be 8 watts or less during the total regeneration event (dump on plus time waiting). We find the repetition rate by dividing 400 joules by 8 watts—this gives us 50 seconds. (Remember, 1 watt is equal to 1 joule per second. So, 400 joules/8 watts = 50 seconds.) We must wait 49 seconds before regenerating again (1 second *ON* plus 49 seconds *OFF* = 50 seconds).

Another factor to consider in power dump performance is the *peak* power dissipation rate—722.5 watts. If your system sends power to the power dump at a rate higher than 722.5 watts, the power dump cannot dissipate the power fast enough to lower the voltage at the output terminals. It will stay on continuously. After one-half second, the overvoltage circuit will shut down the output of the OEM300. (See the next section for an explanation of the overvoltage protection circuit.)

For example, suppose a moving system of motors contains 200 joules that must be dissipated in the power dump. How quickly can it decelerate without overwhelming the power dump? If energy is dissipated at the peak rate of 722.5 watts, we find that the deceleration time is 200 joules/722.5 watts, or 0.3 seconds. The repetition rate will be 200 joules/8 watts, or 25 seconds. Power dump information is summarized below.

POWER DUMP CHARACTERISTICS			
POWER DISSIPATION RATE:		Peak = 722.5 Watts	
		Average = 8 Watts	
PEAK ENERGY ABSORBED: (*x.xx* Joules within *y.yy* seconds)			
Amount (Joules)	***Absorbed in...(sec)***	***Time Off (sec)***	***Repetition Rate (sec)***
400 Joules	5.0 sec	45.000 sec	50.000 sec
400	2.5	47.500	50.000
400	1.0	49.000	50.000
400	0.554	49.446	50.000
361.25	0.5	44.656	45.156
144.5	0.2	17.863	18.063
72.25	0.1	8.931	9.031
36.125	0.05	4.466	4.516
THRESHOLD VOLTAGE:		On = 85 VDC	
		Off = 82 VDC	

The numbers in the table show the energy that can safely be absorbed in the OEM300's power dump. When a motor regenerates energy, much of the energy is dissipated as heat in the motor and drive. Therefore, total energy contained in the moving parts of the motor and load can be higher than the numbers shown in the table. After motor and drive losses, the energy left over will be sent into the power dump—this is the energy that is listed in the table above.

(For a discussion of motor and drive losses, see the section *Where Power is Used in a Motion Control System*, in *Chapter ⑥ Calculating How Many Drives & Motors the OEM300 Can Operate.*)

The power dump in the OEM300 is designed to dissipate as much regenerated energy as would occur in a worst-case situation where two 83-135 motors each operate loads with 10:1 rotor inertia. Under these conditions, when regeneration occurs, the power dump will turn on and dissipate the excess energy.

EXAMPLE: A single OEM83-135-MO motor turns a load that has ten times the motor's rotor inertia. Speed of the system is 50 rps. The kinetic energy in the moving parts of the system can be calculated as follows:

$$\text{Kinetic Energy} = (1/2)J\omega^2$$

$$= (1/2)\{(1 + 10)(1.87\ \text{kg}\cdot\text{cm}^2)(10^{-4})\}\ (2\pi\cdot 50)^2$$

$$= 101.5\ \text{joules}$$

Where:

J = inertia, in kg·cm^2

1.87 kg·cm^2 is the motor's rotor inertia. It can be found in the OEM650 User Guide.

10^{-4} is a conversion factor, to convert from kg·cm^2 to kg·m^2, units which are compatible with joules.

ω = velocity, in radians/sec ($\omega = 2\pi\cdot\text{rps}$)

Kinetic energy in this system is 101.5 joules. Kinetic energy in a similar system with two motors would be approximately 200 joules, which can be absorbed in 0.3 sec.
(200J/722.5W ≈ 0.3 sec. *See previous page.*)

Compumotor's OEM650 Microstepping Drive also has a power dump circuit. To use it, you must connect an external power resistor to the drive. However, the threshold voltage for the power dump in the OEM300 is much lower than the threshold in the OEM650. The OEM300's power dump will always turn on first. Therefore, there is usually no need to use the power dump in the drive, as long as your system's stored energy can be safely dissipated in the OEM300's power dump.

However, if you design a system that has enough stored energy to overwhelm the power dump in the OEM300, you may want to use the drive's power dump to protect the drive. Regenerating this much energy should be avoided, however. It is beyond the specified energy dissipation limits, and can damage the OEM300.

OVERVOLTAGE PROTECTION

An overvoltage protection circuit guards your drives and equipment from excessively high voltages produced by a damaged OEM300. It also protects your system from excessive regeneration.

If a damaged element within the Power Module causes it to produce an output voltage in excess of 85VDC, the power dump threshold voltage is exceeded, and the power dump turns on. The overvoltage circuit monitors the power dump. If the power dump stays on for more than one-half second, the overvoltage circuit will shut down the output terminals.

The overvoltage circuit also monitors the power dump when load regeneration occurs. In this case, if the power dump stays on longer than one-half second, excessive regeneration is occurring. To protect the OEM300, the overvoltage circuit will shut down the output terminals.

TROUBLESHOOTING NOTE: There are no separate indicators to distinguish between an excessive regeneration fault, a damaged Power Module, or a short circuit fault. Any of these conditions will shut down your system; and, the green LED will remain illuminated.

When you attempt to restart your equipment, you should be able to isolate the cause. If the problem is due to a short circuit fault in connected equipment, the Power Module will shut down instantly when it is turned on. If the problem is due to a damaged Power Module, it will run for 1/2 second and shut down, even with no load regeneration. If the problem is due to excessive regeneration, the Power Module will power your system until load regeneration occurs; then it will shut down. These conditions are summarized below.

Power Module Shuts Down....	Probable Cause
....instantly when turned on	Short circuit fault in drive
....after running 1/2 second	Damaged OEM300
....when regeneration occurs	Excessive regeneration