

Thermal Management

New JRC's stepper motor ICs are power ICs encapsulated in Dual in Line (DIP), EMP and PLCC (Plastic Leaded Chip Carrier) packages. The silicon die is directly bonded to a heat-spreading lead-frame for efficient heat-transfer to an external heat sink, or to a copper ground plane on the printed circuit board.

Theory of power dissipation

To explain thermal management and power dissipation ohm's law could be used, see figure 1.

The power dissipation P_D could be compared to the current in ohm's law. The power dissipation is generating heat, which is flowing from the chip out of the package. In its way out it's "held back" by the thermal resistance. The thermal resistance is depending on what kind of "connection" there is from the chip to the air surrounding the circuit.

There are two "connections" out from the chip to the surrounding air, one metallic and one plastic. The metallic "connection" is the lead frame in the package; the pins on the circuit, the soldering to the copper area on the PCB and the copper area it self to the air see figure 2. There is also a connection from the chip through the plastic package out in the air.

Considering ohm's law in figure 1 with a constant voltage at V_2 it could easily be seen that if the current, I , is increased with a constant resistance, R , the voltage V_1 will be increased compared to the constant voltage V_2 . This could now be compared to the thermal management. If there is a constant ambient temperature, T_A , and the power dissipation is increased with a constant thermal resistance, $R_{th_{J-A}}$, the temperature on the chip, T_J will be increased.

If there are defined maximum ambient temperature, maximum chip temperature and a known maximum power loss the needed thermal resistance could be calculated.

Determine the amount of PCB area.

In figure 3 the thermal resistance could be found for PLCC, DIP and EMP packages depending on how big the copper area is connected to the batwing pins. The graph shows the thermal resistance when the PCB cooling is made on the same side as the circuit. If there is no space on the circuit side vias could be used for PLCC and EMP's to lead the heat through the card to copper areas on the other side of the PCB.

Determining the needed amount of PCB copper area for heat sinking is a simple procedure, following a few basic guidelines.

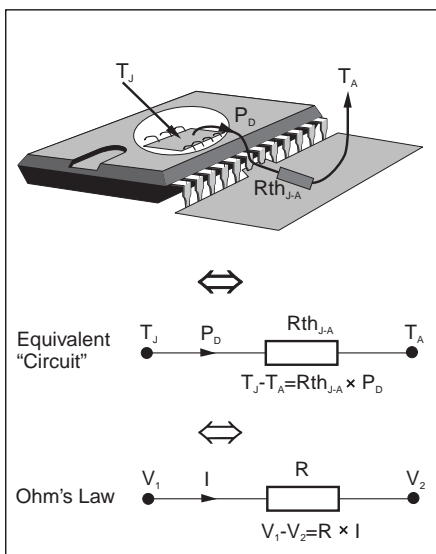


Figure 1. Comparing thermal resistance with ohm's law.

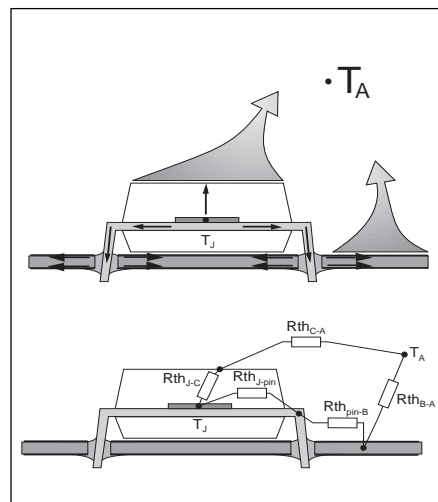


Figure 2. Complete transport ways for heat out of the circuit.

1. Establish a value of the circuit's power dissipation, P_D . Graphs showing typical power dissipation vs. output current are found in our data sheets.
2. Specify maximum operating ambient temperature, T_A .
3. Specify maximum junction temperature, T_J , the temperature of the chip at maximum operating current. No strict rules exist— typically one should design for a maximum continuous junction temperature of 100 °C to 130 °C. Maximum rating is 150 °C.

The maximum value of thermal resistance junction-to-ambient, $R_{th_{J-A}}$, can now be calculated as follows:
 $R_{th_{J-A}} = (T_J - T_A) / P_D$

The graph in figure 3 shows thermal resistance junction-to-ambient vs. the area of a copper ground plane of a PC board. Use this graph to determine the area required to achieve the value of the thermal resistance as calculated. Figure 4 summarizes the output current capability of New JRC's stepper motor drivers for various levels of heat sinking.

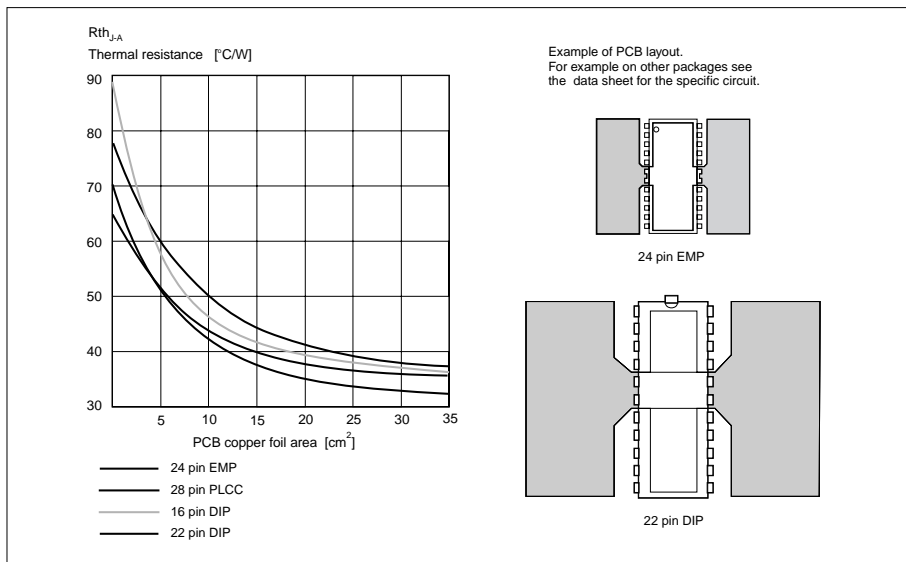


Figure 3. Typical thermal resistance vs. PC Board copper area and suggested layout.

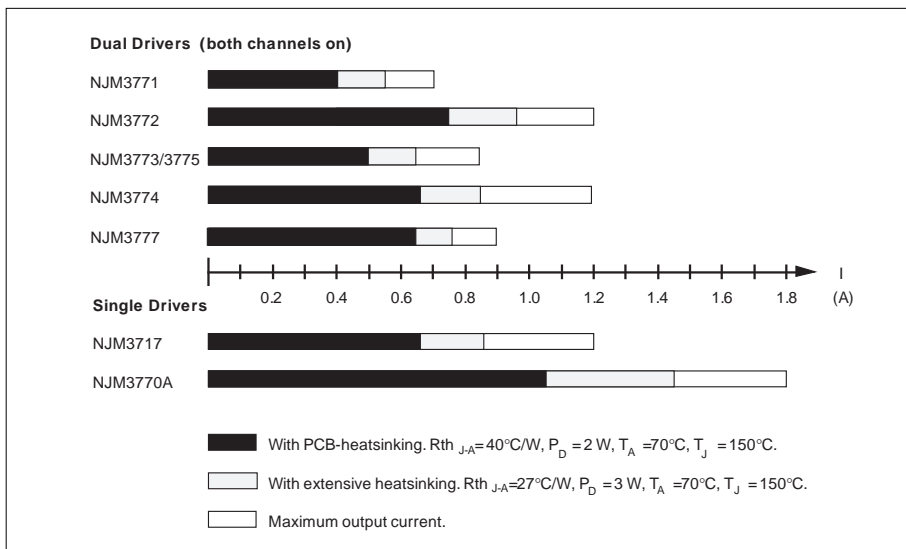


Figure 4. Output current capability for New JRC's stepper motor driver ICs.

Verifying

In order to verify the thermal design, it is useful to make an estimate of the real chip temperature. Attaching a thermocouple or some other miniature temperature sensor right onto the bat-wing ground pins of the IC under test, and measuring the temperature of the batwing pin (T_{BW}) does this. The chip (junction) temperature can now be calculated:

$$T_J = T_{BW} + P_D \times R_{Th_{J-BW}}$$

where $R_{Th_{J-BW}}$ is the thermal resistance from junction to the batwing pin.

Package	$R_{Th_{J-BW}}$
PLCC	9°C/W
DIP	11°C/W
EMP	13°C/W

Extra heatsink

Using extra heatsink for the DIP packages we recommend heatsinks from Columbia-Staver UK, see figure 5.

For the 16 pin DIP package V7-3S or V8-3S and for the 22 pin DIP package V7-7, V8-7 or V7-7ST, V8-7ST.
For further information please contact:

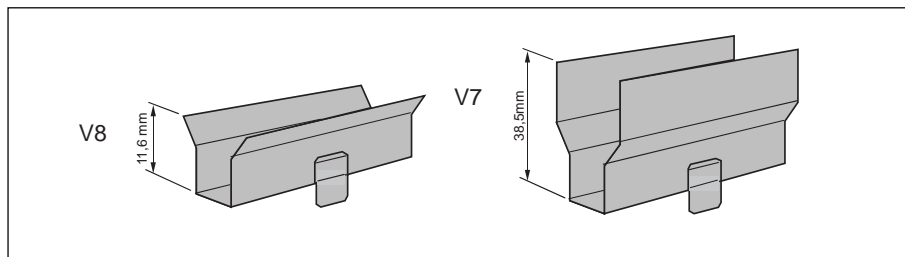


Figure 5. Heatsinks, type V7 and V8 by Columbia-Staver UK.