Application Hint 19

Powering IBM Blue Lightning™ Microprocessors

By Bob Wolbert

General Description

The IBM Blue Lightning™ microprocessor is a 486-type processor built on a proprietary IBM process and uses a nominal 3.60V power supply.[1] Some versions operate at 3.3V, while higher performance devices require 3.6V, 3.8V, and even 4.1V. With its internal clock tripling circuitry, they dissipate up to a maximum of 3.6W, drawing about 1A. This power supply voltage creates a problem with PC motherboard manufacturers because a 3.3V to 4.1V variable supply is not available from standard computer power supplies. Micrel's MIC29152BU, in a surface mount TO-263 package, will power any version of the Blue Lightning from a standard 5V supply. This hint provides the circuit and thermal design for this application.

Circuit and Thermal Calculations

If the Blue Lightning version you use employs either a 3.3V or 3.6V power supply, Micrel offers a three terminal MIC29150 regulator that will simplify your design. Figure 1 shows the schematic diagram of the 3.3V or 3.6V power supply: only one external component is necessary for operation, an output filter capacitor. If the higher performance Blue Lightning processor is contemplated, or rapid production changes between versions using the same motherboard design is expected, the MIC29152 adjustable regulator is preferred. Figure 2 shows the schematic diagram of this flexible supply. Two resistors determine the output voltage. Since the layout remains the same, the production line can rapidly accommodate processor changes (and the required supply voltage changes) by simply changing one of the two resistors. Table 1 shows resistor values for the common processor supply voltages. For voltage requirements not listed, the formula for resistor ratio is:

$$\frac{V_O}{1.240} - 1 = \frac{R1}{R2}$$

The pinout of the three terminal MIC29150 and the center three pins of the MIC29152 is the same, with slightly different lead spacing. This means a single motherboard layout is possible that allows *both* the 3-pin fixed and 5-pin adjustable versions. Micrel's Super ßeta PNP™ LDOs are ideal for this application for other reasons as well.[2] Unlike other regulators, Micrel's LDOs operate with drop-out voltages of 300mV–often less. This is important when we consider worst case tolerances: The "5V" supply can be as low as 4.75V and still be in-specification. The MIC29150-3.3 output may be as high as 3.672V under worst case conditions. This gives us a worst case available drop out voltage of only 1.078V (4.75V – 3.672V) . This is well within the 300mV typical performance of Micrel's LDOs as well as comfortably within the 600mV guaranteed maximum (over the full operating temperature range) specification. No NPN-pass element linear regulator can approach this performance. Additionally, Micrel LDOs feature "reverse battery" protection.

Our thermal calculations are conservative and assume a worst case current of 1.0A at 3.67V (3.6V + 2%). Worst case drop out available is 1.08V (4.75V – 3.67V), which is well above the 0.60V guaranteed level of the MIC29150-3.6, so we have a fine match. Using the formula for power dissipation:

$$P_D = (V_{IN\,MAX} - V_{OUT\,MIN}) \times I_{OUT\,MAX} + V_{IN\,MAX} \times I_{GND}$$

the worst case power dissipation operating from a 5V ± 5% supply is:

$$P_D = (5.25V - 3.53V) \times 1.0A + (5.25V \times 10mA)$$

$$= \mathbf{1.77W}$$

What size of heat sink, if any, is necessary? The thermal resistance of a heat sink is:

$$\theta_{SA} = \frac{T_J - T_A}{P_D} - (\theta_{JC} + \theta_{CS})$$

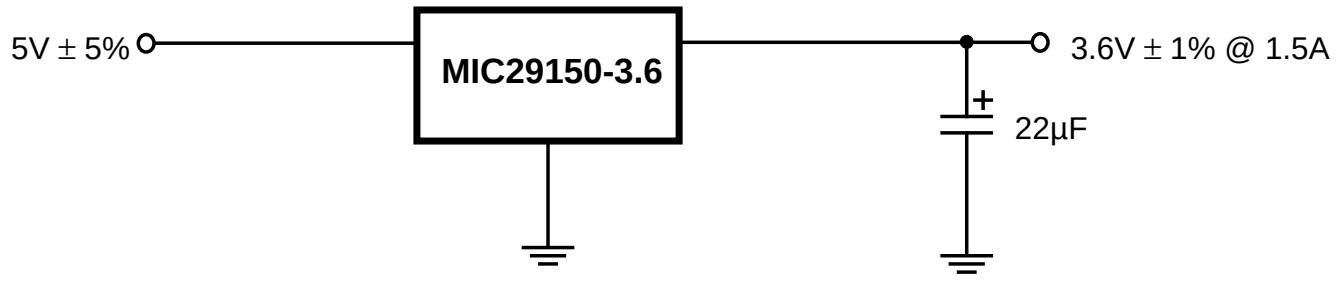
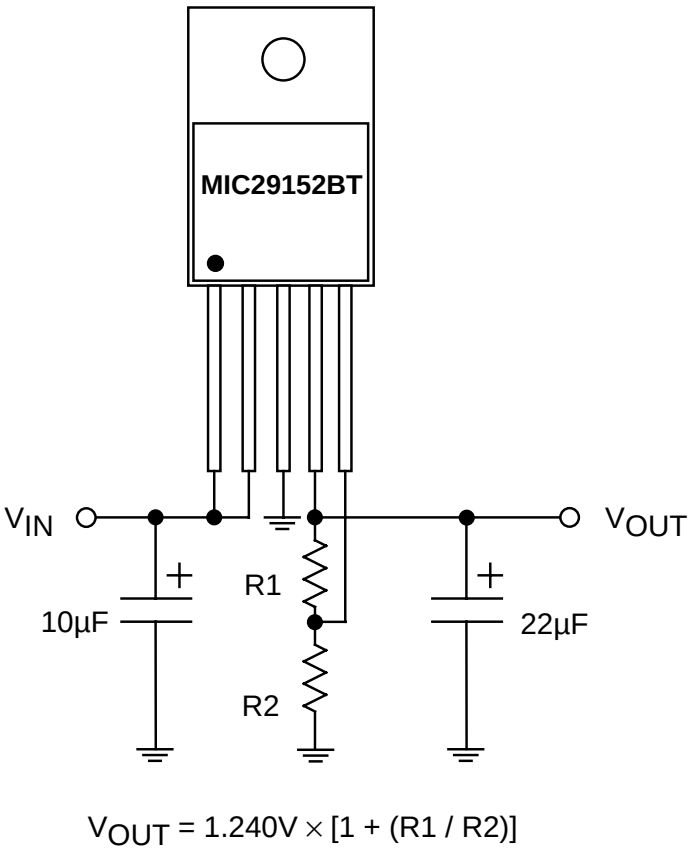


Figure 1. The MIC29150-3.6BU powers the IBM Blue Lightning from a nominal 5V supply without requiring any heat sinking other than the P.C. board mounting pad itself.



$$V_{OUT} = 1.240V \times [1 + (R1 / R2)]$$

Figure 2. MIC29152 Adjustable regulator circuit for use with Blue Lightning. Refer to Table 1 for resistor values.

Voltage Required	R1	R2
3.3V*	158k	95.3k
3.6V†	158k	82.5k
3.8V	158k	76.1k
4.1V	158k	68.1k

* The MIC29150-3.3 is a three terminal replacement if production-time voltage selection is not necessary.

† The MIC29150-3.6 is a three terminal replacement if production-time voltage selection is not necessary.

Table 1. Resistor values for Figure 1 calculated for common Blue Lightning operating voltages.

Assuming a θ_{JC} of 2°C/W, a θ_{CS} of 0.5°C/W, (the surface mount TO-263 is soldered directly to the PC board heat sink) and an ambient temperature, T_A, of 50°C, the maximum allowable heat sink thermal resistance is:

$$\theta_{SA} = \frac{125°C - 50°C}{1.8W} - (2°C/W + 0.5°C/W) = \mathbf{39°C/W}$$

Referring to Application Hint 17, we see that a square P.C. board pad of 40mm by 40mm (1.6 inches per side) is adequate. No external series dropping resistor is necessary for power sharing as this design is conservative. This pad is shown in Figure 3.

The through-hole MIC29150-3.6BT in a TO-220 package does not require a heat sink.

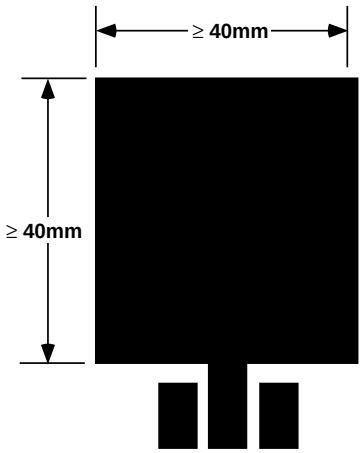


Figure 3. Suitable P.C. board heat sink for the MIC29150 powering "Blue Lightning".

Conclusion

The IBM Blue Lightning microprocessor operates from a nominal 3.6V supply[3], which can be obtained from a surface mount MIC29150-3.6BU without any heat sink other than the P.C. board itself. The entire schematic consists of only two components, the regulator and a filter capacitor, and is shown in Figure 1. At the 1A Blue Lightning current level, thermal considerations are not difficult and a P.C. board heat sink pad will serve. For full details on heat sinking Micrel LDOs in this application, refer to Micrel Application Hint 17, "P.C. Board Heat Sinking", or for more stringent requirements refer to Micrel Application Note 9, "Design Considerations for 5V to 3.3V Pass Regulators".

Notes

NOTE 1: IBM and Blue Lightning are trademarks of IBM Corp.

NOTE 2: Super ßeta PNP is a trademark of Micrel, Inc.

NOTE 3: At press time, the Blue Lightning supply currents and voltages have not been finalized. If other than 3.3V or 3.6V are needed, the Micrel MIC29152 adjustable 1.5A regulator is available which can provide any output voltage from about 1.2V to 25V, programmed using two external resistors. See the MIC29150 datasheet for full details.