Application Hint 23

Powering AMD™ Microprocessors

By Bob Wolbert

General Description

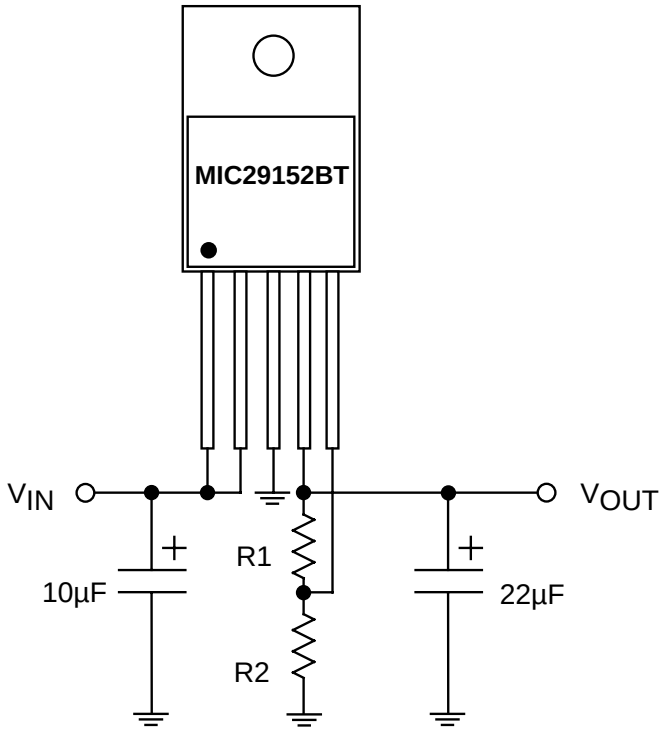
AMD™ manufactures low voltage high performance 486 microprocessors with high clock speeds.[1] These devices operate from either a 3.3V or 3.45V ±5% power supply. Some versions have a double-speed internal clock (DX2), while others have a triple speed internal clock (DX4). They dissipate up to a maximum of 3.3W, drawing nearly 1A. This power supply voltage creates a problem with PC motherboard manufacturers because a 3.3V to 3.45V supply is not available from standard computer power supplies. Micrel's MIC29152BU, in a surface mount TO-263 package, will power any present version of AMD processors from a standard 5V supply. Another power supply issue is the transient response of the supply to the microprocessor waking from "sleep mode"; the processor's supply current changes from a few milliamperes to full load in nanoseconds. This hint provides the circuit and thermal design for this application.

Circuit Design

Although Micrel offers a three terminal MIC29150-3.3 regulator that will simplify your design, building a motherboard that accepts either the 3.3V or the 3.45V processor is easier when the MIC29152 adjustable regulator is used. Figure 1 shows the schematic diagram of the power supply: two resistors and two filter capacitor comprise the entire circuit. 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. 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 dropout 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 MIC29152 output, when adjusted to 3.45V nominally, may be as high as 3.571V under worst case conditions (assuming worst case tolerances and 1% resistors). This gives us a worst case available drop out voltage of only 1.179V (4.75V – 3.571V) . 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



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

Figure 1. MIC29152 Adjustable regulator circuit for use with AMD microprocessors. Refer to Table 1 for resistor values.

linear regulator can approach this performance. Additionally, Micrel LDOs feature "reverse battery" protection, protecting the microprocessor from faulty cabling by the user as well as protecting the regulator itself from reverse insertion during manufacture.

Transient Response

When the AMD microprocessor "goes to sleep", its current requirement drops to a few milliamperes. As soon as the user touches the keyboard or mouse, however, the processor wakes to full power in a few dozen nanoseconds. With older style linear or switching regulators, this sudden current surge causes the output voltage to drop significantly; often resetting the microprocessor and causing a system re-boot. Since Micrel's Super ßeta PNP regulators are guaranteed never to fall into dropout under the conditions present in this application, recovery time is very fast by comparison, as shown in Figure 2. The output filter capacitor must supply the first portion of the surge current, but need not be as large as with older style regulators. Generally, a 22µF to 47µF tantalum capacitor is sufficient. Multiple 0.1µF capacitors around the microprocessor socket provide decoupling and additional droop protection.

Thermal Calculations

Our thermal calculations are conservative and assume a worst case current of 1.0A at 3.329V (3.45V minus tolerances). Worst case differential voltage available is 1.18V (4.75V – 3.45V plus tolerances), 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:

$$P_D = (5.25V - 3.329V) \times 1.0A + (5.25V \times 20mA)$$

$$= \mathbf{2.03W}$$

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

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

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:

$$\theta_{SA} = \frac{125°C - 50°C}{2.03W} - (2°C/W + 0.5°C/W) = \mathbf{34°C/W}$$

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 MIC29152BT in a TO-220 package generally does not require a heat sink in this configuration.

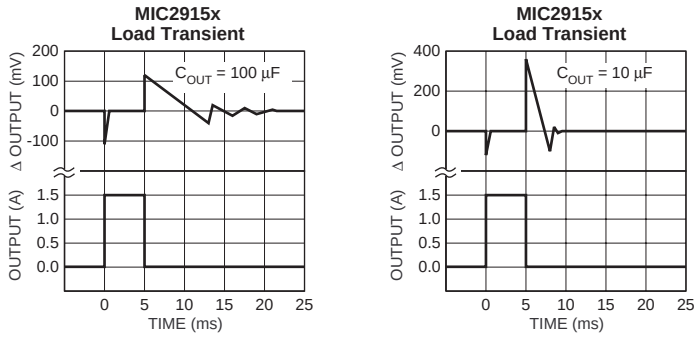


Figure 2. MIC29152 Load transient response with 10µF and 100µF capacitors.

Voltage Required	R1	R2
3.3V*	158k	95.3k
3.45V	158k	88.7k

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

Table 1. Resistor values for Figure 1 calculated for AMD microprocessor operating voltages.

Future Devices

Progress in the microprocessor field generally means faster clocks. Higher speed clocks lead to higher power dissipation, with all other things equal. Micrel's MIC29302 is a 3A low dropout regulator in the same packages and with the same pinout as the MIC29152—if your current requirements increase along with microprocessor speed, you may maintain the same motherboard layout by simply changing from the MIC29152 to the MIC29302. Your heat sink might need attention, however.

Conclusion

AMD low voltage microprocessors operate from a nominal 3.3V or 3.45V supply, which can be obtained from a surface mount MIC29152BU without any heat sink other than the P.C. board itself. The entire schematic consists of only five components: the regulator, two voltage setting resistors, and two filter capacitors, as shown in Figure 1. At their 1A 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".

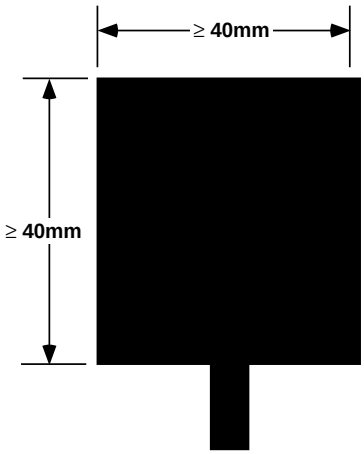


Figure 3. Suitable P.C. board heat sink for the MIC29150 powering AMD microprocessors.

Notes

NOTE 1: AMD™ is a trademark of Advanced Micro Devices Corp.

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