

# DESIGN NOTES

## Dual Regulators Power Pentium Processor or Upgrade CPU

Design Note 122

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Many manufacturers of Pentium processor-based motherboards have been searching for an economical solution to the problem of powering the present generation Pentium P54C and accommodating the upgrade processors that will soon become available. The existing processor uses a single supply for both the processor core and the I/O. For the highest frequency offerings, the supply required is  $3.5V \pm 100mV$  (VRE specification). For the lower performance end of the clock frequency spectrum, a supply voltage of  $3.3V \pm 5\%$  is adequate. Recently, Intel respecified the standard 3.3V CPUs for operation at 3.5V. This allows designs for any clock frequency to be operated from a single 3.5V supply. The I/O ring and chipset should be powered by the same voltage as the CPU core, whether that is 3.3V or 3.5V.

The P55C upgrade processor, which will soon be available, requires separate supplies for the core and the I/O. The nominal core voltage is targeted at  $2.500V \pm 5\%$ , whereas the I/O supply is still nominally 3.3V. There is also a processor pin,  $V_{CC2DET}$ , at location AL1, that is bonded to ground on the P55C, but is open on the P54C. A significant complication is introduced by the core and I/O power pins of the P54C being shorted together on-chip. Figure 1 shows the system block diagram. If the core and I/O supplies don't deliver proportional currents, damage to the P54 metallization may occur. The LT<sup>®</sup>1580/LT1587-based circuit shown in Figure 2 will automatically supply the required voltages to the CPU and the I/O circuitry based on the status of the  $V_{CC2DET}$  pin and share the load between the two regulators.

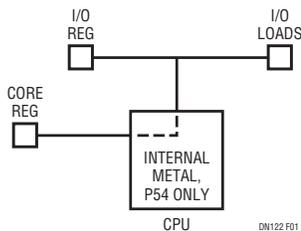
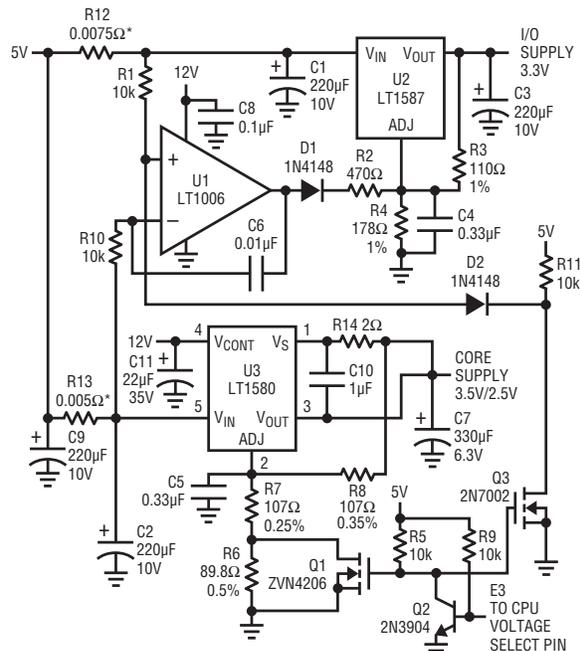


Figure 1. System Configuration

### A Simple Solution

This dual linear regulator circuit employs an LT1580 for the CPU core supply and an LT1587 for the I/O supply. The LT1580 has a precision reference, remote sense and exceptionally low dropout voltage. It is capable of meeting the stringent VRE voltage specification when subjected to the scrutiny of worst-case analysis. The LT1587 is rated at 3.0A maximum current and is adequate to power the I/O supply of most desktop systems. If more than 3A of I/O current is required—your design has a very large L2 cache, for example—an LT1585A, which is capable of 5.0A, may be substituted for the

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\*RESISTORS ARE IMPLEMENTED AS COPPER TRACES ON PCB  
 IF 1 OZ COPPER, TRACE WIDTHS ARE 0.05 INCH  
 IF 2 OZ COPPER, TRACE WIDTHS ARE 0.025 INCH  
 R13 IS 0.83 INCHES LONG, R12 IS 1.24 INCHES LONG

E3	CPU TYPE
0	P55C
1	P54C

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LT1587 by changing one resistor value (R12). See the Design Equations for details.

Op amp U1 forces the two regulators to share the load current when the outputs are shorted together by the CPU metalization. The load current is sensed by the two low value current sense resistors R12 and R13. These resistors are actually implemented as short traces on the PC board. The design does not depend on the sense resistors' absolute values being accurate; only ratiometric matching is required for the circuit to function properly. The resistance ratio will be very well-controlled across PC board production lots.

Amplifier U1 pulls up on the Adjust pin of U2, raising the output voltage of the I/O regulator until the proper current ratio between the two regulators is established. This condition is met when the voltage drop across the sense resistors is equal. The regulator currents are inversely proportional to the sense resistor values, and hence, to the resistor trace lengths. If a different current ratio is desired, just refigure the trace lengths per the equations given. The voltage drop across the resistors at full load is approximately 25mV. Of course, discrete resistors may be used if desired, but they are quite costly compared to a PC board trace.

Nonideal components will translate into errors in the current sharing ratio. With the components shown, the largest contributor to current-sharing errors is the error amplifier offset voltage. The very low offset of the economical LT1006CS8 (400µV max) ensures a worst-case share error of only 1.6%. If the through hole version of the LT1006 is used, this error drops by a factor of five. It is possible to further reduce the value of the sense resistors with this op amp.

If a user should upgrade to a P55C, E3 is now connected to ground. This turns off Q2, allowing Q1 and Q3 to turn on. Q1 shorts out part of the feedback divider of the LT1580, lowering its output to 2.500V. Q3 pulls the noninverting input of U1 low, forcing the op amp output to ground. D1 is now back biased, effectively disconnecting the op amp from the circuit, which causes the I/O regulator's output to drop to 3.3V. Resistor R11 pulls up the cathode of D2 when powering a P54 so that diode leakage current does not cause an error in current sharing.

The LT1580 permits remote sensing of the load voltage at the CPU. Also, by inserting a low value resistor in the sense line, a small intentional load regulation error is introduced, which, it can be shown, will reduce the peak-to-peak transient response of the regulator. The regulation error is well-controlled at the load and is not a function of any trace resistance or parasitics. This technique realizes a reduction in the amount of output capacitance required to control the core voltage transients.

### Conclusion

With a small number of low cost components, it is possible to eliminate the need for replaceable power supply modules and still accommodate the desire to upgrade the microprocessor to improved technology. Moreover, the solution results in an "idiot proof" design, preventing the application of an inappropriate supply voltage, which could damage an expensive CPU.

### Design Equations:

Assume  $V_S$  of approximately 25mV,

$$R13 = \frac{V_S}{I_{CORE}} \quad R12 = \frac{I_{CORE}}{I_{I/O}} (R13)$$

1oz copper thickness is 0.0036cm

2oz copper thickness is 0.0071cm

for 1oz copper PC board, use 0.127cm (0.050") wide traces

for 2oz copper PC board, use 0.064cm (0.025") wide traces

$$L = \frac{R}{R_S} (t)(w)$$

Where L is the trace length in cm

R is the desired resistance

$R_S$  is the specific resistivity of copper: 1.72µΩ cm

t is the copper thickness of the PC board in cm

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