AMD-K5™

PROCESSOR

Support for the AMD-K5 Dual Voltage Processor

Application Note

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Contents

List of Tables

List of Figures

Support for the AMD-K5™ Dual Voltage Processor

AMD-K5™ processors, manufactured with AMD's enhanced 0.35-µm process (CS34E), require a lower supply voltage for the core, separate from that used to power the I/O pins (3.38 V or 3.52 V). Dual voltage processors can be identified by an H, J, or K in the operating voltage suffix of the ordering part number (OPN). See Figure 1 for more details.

This application note describes two dual voltage regulator circuits that can be used to generate a 3.38-V or 3.52-V I/O voltage supply and a selectable core supply voltage (2.50 V, 2.70 V, 2.93 V, 3.38 V, or 3.52 V) from a standard personal computer power supply. In addition, specific recommendations are given for decoupling capacitor selection and placement to achieve optimal noise reduction levels.

Background

As digital integrated circuit manufacturing processes advance, finer geometries require lower supply voltages to operate properly. Processors manufactured with the CS34E process will use a reduced voltage between 2.50 V and 2.93 V to power the core circuitry of the processor. Specially designed circuits for the I/O buffers will operate with a separate voltage supply of 3.38 V or 3.52 V to accommodate standard logic and memory devices connected to the bus.

AMD has developed two linear dual voltage regulator circuits, each of which can be used to generate a 3.38-V or 3.52-V supply for the I/O and a core voltage supply of 2.50 V, 2.70 V, or 2.93 V, selectable via jumpers on the motherboard. These circuits also support single voltage versions of the AMD-K5 processor.

A basic issue in power supply circuit design is noise reduction. Excessive noise levels can impair proper operation and contribute to possible EMI and RFI radiation. This application note provides some basic guidelines for reducing noise generated by fast transients of voltage and current wave forms.
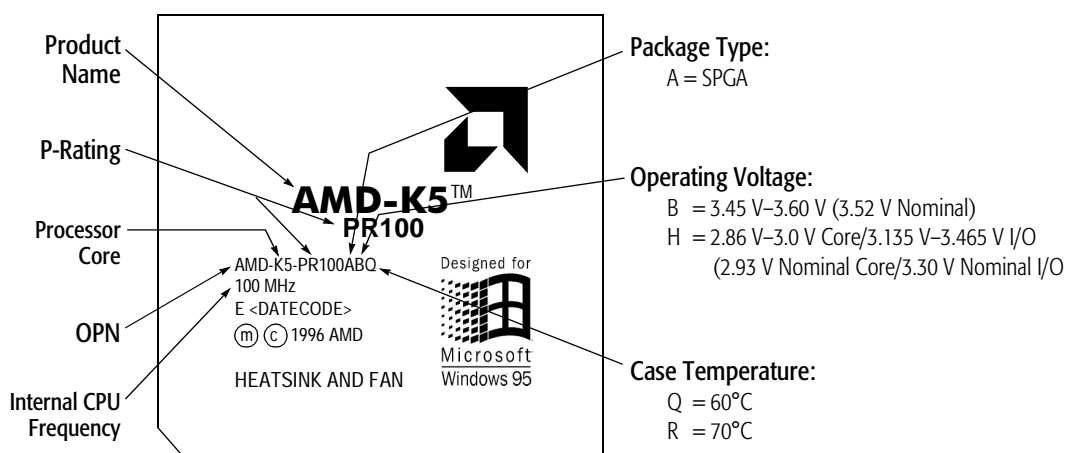
Figure 1.   Package Marking for the AMD-K5 Processor (Model 0)
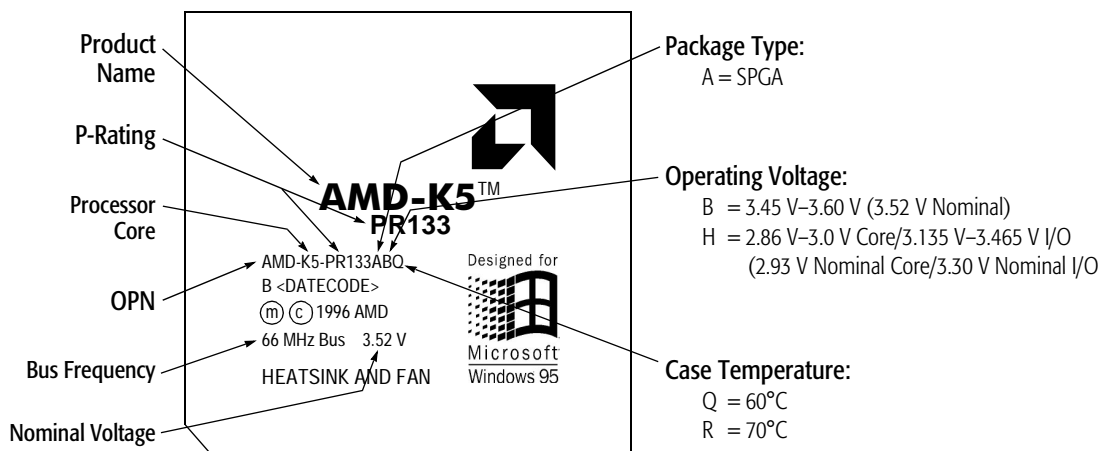
Figure 2.   Package Marking for the AMD-K5 Processor (Model 1)

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Dual Voltage Processor Power Supply Specification

Voltage Planes

The AMD-K5 dual voltage processor has internal voltage planes for core and I/O. The power supply V_{cc} pin assignments for the AMD-K5 processor are as follows:

VCC2 (Core):	A-07, A-09, A-11, A-13, A-15, A-17, G-01, J-01, L-01, N-01, Q-01, S-01, U-01, W-01, Y-01, AA-01, AC-01, AE-01, AG-01, AN-09, AN-11, AN-13, AN-15, AN-17, AN-19
VCC3 (I/O):	A-19, A-21, A-23, A-25, A-27, A-29, E-37, G-37, J-37, L-33, L-37, N-37, Q-37, S-37, T-34, U-33, U-37, W-37, Y-37, AA-37, AC-37, AE-37, AG-37, AN-21, AN-23, AN-25, AN-27, AN-29
INC:	AN-01, AN-03

Notes:

1) *Some motherboards connect a 5 V supply to pins AN-01 and AN-03. This connection is not required for the AMD-K5 processor and these pins are internally not connected (INC).*

2) *The voltage select pin (V_{CC2DET}) active Low is located at AL-01.*

Figure 3 shows the location of the separate V_{cc} and ground pins on the SPGA package.
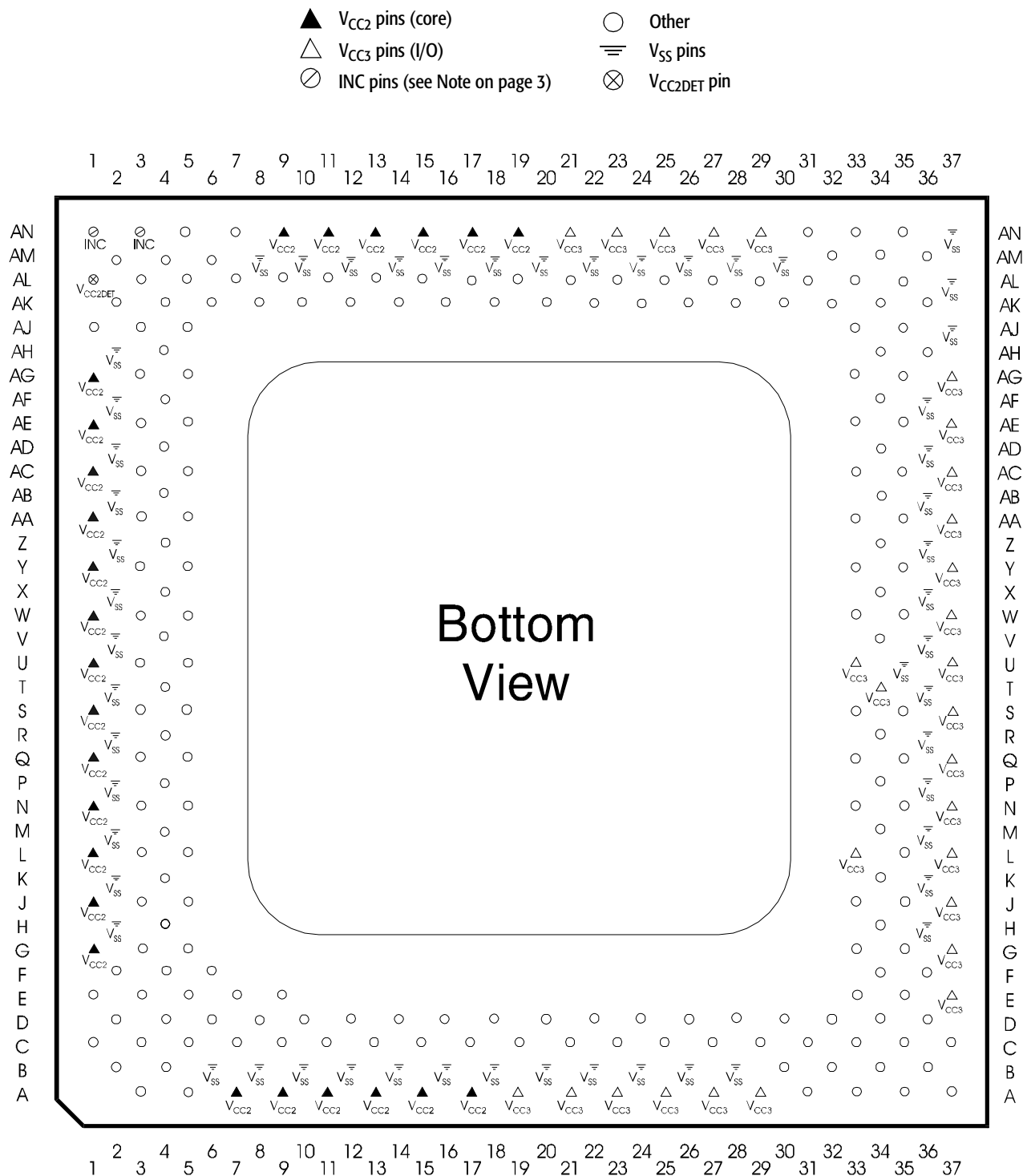
Figure 3. Location of V_{cc} and Ground Pins in the SPGA Package

Current Requirements

The AMD-K5 dual voltage processor has the following maximum current requirements (rated at maximum T_{case} and maximum V_{cc2} and V_{cc3}):

■ Maximum I_{cc} core of 27 mA / MHz

■ Maximum I_{cc} I/O of 16 mA / MHz

Note: *This information is preliminary and subject to change. See the AMD-K5™ Processor Data Sheet (order# 18522) for the latest information.*

The core voltage requirements are shown in Table 1. The table identifies the dual voltage processors by their operating voltage suffixes H (2.93 V), J (2.70 V), and K (2.50 V). See Figure 1 for more information.

Table 1. Core Voltage Requirements

Core V_{cc} (OPN Suffix)	Minimum	Center	Maximum
H	2.860 V	2.930 V	3.000 V
J	2.565 V	2.700 V	2.835 V
K	2.375 V	2.500 V	2.625 V

Dual Voltage Power Supply Circuits

Two dual voltage supply circuits have been developed for use with the AMD-K5 processor. Both designs support single and dual voltage versions of the AMD-K5 processor. The designs are as follows:

■ **Low Cost Dual Voltage Power Supply Circuit**

This circuit meets all the current and voltage requirements for the AMD-K5 processor while minimizing costs. See "Low Cost Dual Voltage Power Supply Circuit" on page 6 for more information.

■ **Precision Dual Voltage Power Supply Circuit**

This circuit uses five-terminal, high-precision regulators that provide tighter regulation and improved design margin for more demanding applications. See "Precision Dual Voltage Power Supply Circuit" on page 8 for more information.

Low Cost Dual Voltage Power Supply Circuit

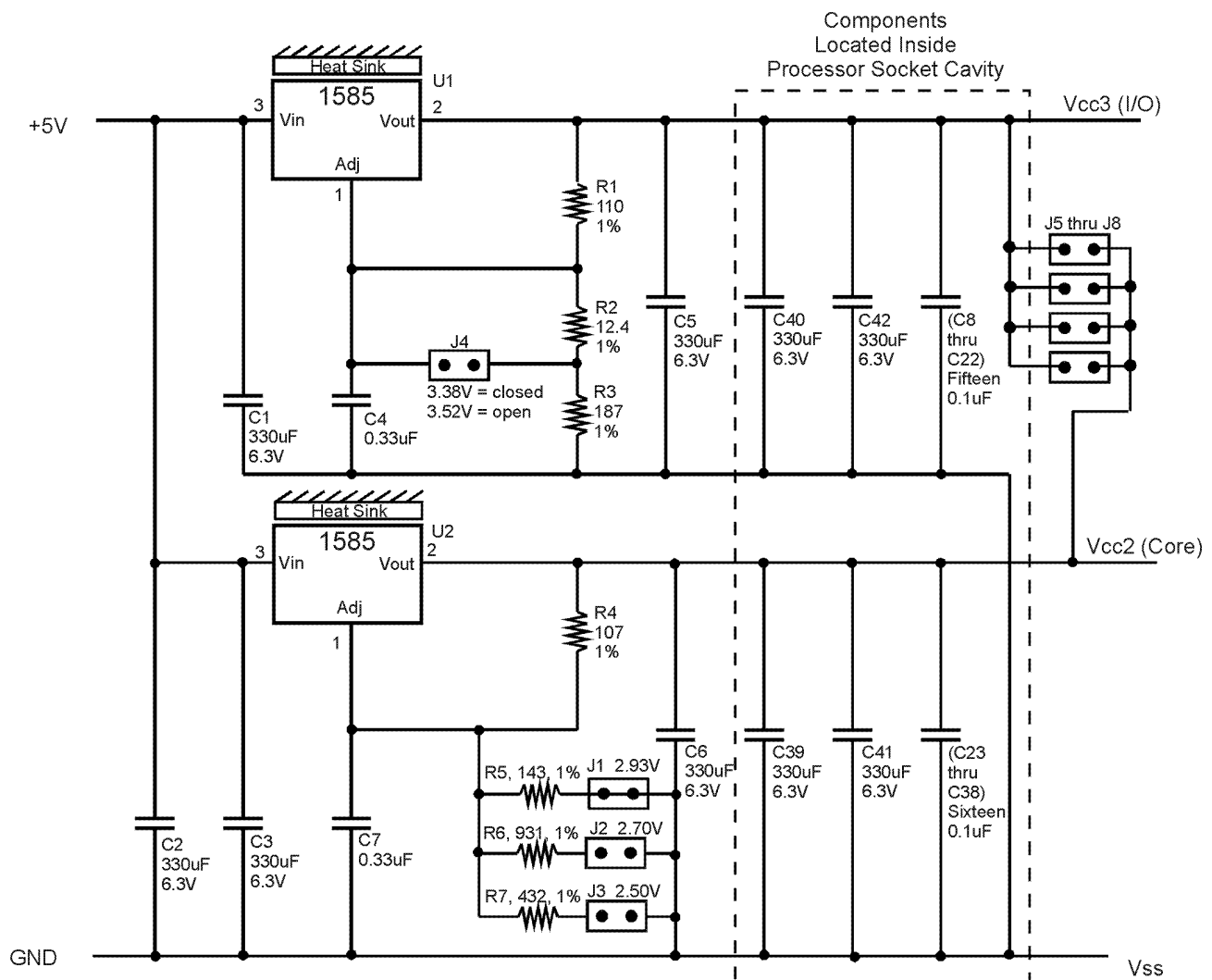The circuit diagram for the low cost dual voltage power supply is shown in Figure 4. Regulator U1 provides a 3.38 V or 3.52 V supply to the processor I/O. Jumper J4 selects the voltage level to power the I/O circuitry. When J4 is installed, V_{cc3} will be 3.38 V ± 2%. When J4 is not installed, V_{cc3} will be 3.53 V ± 2%. Regulator U2 provides a variable supply of 2.50 V, 2.70 V, or 2.93 V to the processor core. The supply voltage is selectable via jumpers J3, J2, and J1, respectively.

Jumpers J5 through J8 should be installed when using single voltage versions of the AMD-K5 processor. The jumpers connect the output of regulator U1 (I/O voltage) to the output of regulator U2 (core voltage), providing a common voltage (3.38 V or 3.52 V) to both the I/O and core of the processor. Regulator U2 senses the presence of a higher voltage on its output pin and safely shuts off its output circuitry. This is an acceptable configuration and does not harm either regulator.

Using example OPNs, Table 2 shows the appropriate jumper settings for each voltage option.

Table 2.   Jumper Settings for the Low Cost and Precision Dual Voltage Power Supply Circuits

Example OPN	V_{cc2} (Core)	V_{cc3} (I/O)	Jumpers Installed				
			J1	J2	J3	J4	J5 – J8
AMD-K5-PR90AHQ	2.93 V	3.38 V	X	–	–	X	–
AMD-K5-PR90AJQ	2.70 V	3.38 V	–	X	–	X	–
AMD-K5-PR90AKQ	2.50 V	3.38 V	–	–	X	X	–
AMD-K5-PR90ACQ[1]	3.38 V	3.38 V	–	–	–	X	X
AMD-K5-PR90ABQ[1]	3.53 V	3.53 V	–	–	–	–	X

Notes:
  1.   Single-voltage mode only.
  X   Installed
  –   Not installed

Figure 4.   Low Cost Dual Voltage Power Supply Circuit

> *Note:* *Jumper J1 is shorted by a trace and is therefore not required. The J1 jumper header, if installed, can serve as a resting spot for a jumper when it is not installed at the J2 or J3 header.*

Precision Dual Voltage Power Supply Circuit

The circuit diagram for the precision dual voltage power supply is shown in Figure 5. Regulator U1 provides a 3.38-V or 3.53-V supply to the processor I/O, selectable via jumper J4. Regulator U2 provides a variable supply (2.50 V, 2.70 V, or 2.93 V) to the processor core, selectable via jumpers J3, J2, and J1. Five-terminal voltage regulators (model 1580) provide tighter regulation, adding design margin for applications that may experience extremes in temperature and/or AC line regulation.

The precision circuit has the following advantages relative to the low cost circuit:

■ Improved output voltage regulation due to the use of a 12-V input reference voltage

■ Improved tolerance to changes in line, load, and temperature

■ Greater ripple rejection

■ Lower dropout voltage

■ Greater maximum load current (The voltage regulators used in the precision circuit can supply 7.0 amps of current per regulator. The voltage regulators used in the low cost circuit can supply 4.6 amps of current per regulator.)

See the data sheets for the voltage regulators for the latest specifications.

Using example OPNs, Table 2 shows the appropriate jumper settings for each voltage option.

Figure 5.   Precision Dual Voltage Power Supply Circuit

> ***Note:*** *Jumper J1 is shorted by a trace and is therefore not required. The J1 jumper header, if installed, can serve as a resting spot for a jumper when it is not installed at the J2 or J3 header.*
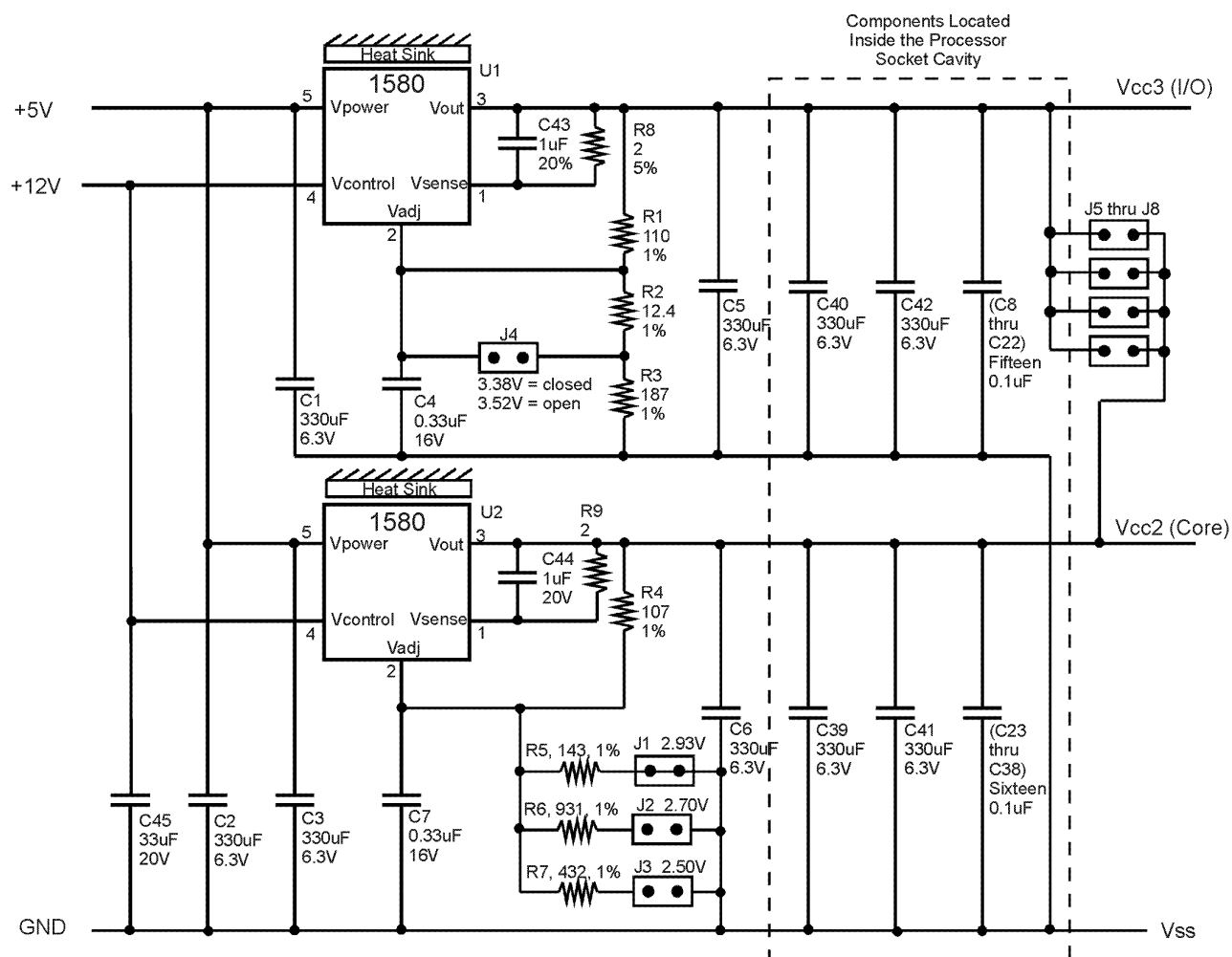
Printed Circuit Layout Recommendations

Printed circuit layout recommendations for the AMD-K5 processor dual voltage power supply circuit include the following:

1. Use a multiple-plane motherboard. The preferred sequencing of signal, power, and ground planes (assuming a six-layer printed circuit board) are as follows:

   Layer 1:   Signal 1

   Layer 2:   Ground

   Layer 3:   Signal 2

   Layer 4:   Signal 3

   Layer 5:   Power

   Layer 6:   Signal 4

2. Some of the processor data bus I/O pins are located within the suggested core V_{cc} plane area (see Figures 6 and 7). Traces for these pins should be restricted to signal layers 1, 2, and 3 (avoid signal 4) to ensure a low-impedance path for return currents.

3. Use 0.01 µF MLC capacitors (e.g., AVX 0805YA103MAT2A) to connect the I/O V_{cc} plane with the core V_{cc} plane, locating these capacitors near any trace with fast edge rate signals. These capacitors provide a low-impedance return path for high-frequency currents.

4. Use multiple vias when connecting voltage regulators and large capacitors (greater than 200 µF) to power and ground planes.

5. Use minimum copper lead lengths, wherever possible, to reduce inductance and resistance.

6. Use correct component orientation, wherever possible, to minimize lead lengths.

7. Where possible, use a top-level trace to connect decoupling capacitors to the processor's V_{cc} and ground pins.

8. When printed circuit layout permits, some bypass capacitors should be located on the outside edge of the processor socket. These capacitors should be positioned to permit direct top-side routing to the processor V_{cc} and ground pins.

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Component Notes and Noise Reduction

Linear Regulator Integrated Circuits

The linear three-terminal voltage regulators, U1 and U2, both require input decoupling capacitors and output bulk decoupling tantalum capacitors with low ESR values (e.g., less than 100 mΩ). Heat sinks for the TO220 packages required for both linear regulator circuits are dependent on mechanical size restrictions of the design and the ambient air temperature specification inside the personal computer enclosure. Both linear regulators should have low dropout voltages (approximately one volt) required when the input voltage is 5 V (± 5%).

Power Supply Decoupling Capacitors

The input capacitors C1, C2, and C3 function as decoupling capacitors for the 5 V input power from the personal computer power supply. C5 and C6 provide bulk capacitance at low ESR (equivalent series resistance) and ESL (equivalent series inductance). C8 to C38 keep the ESR and ESL Low at high frequencies (greater than 100 kHz) because of the multiple parallel current paths. Surface mounted capacitors with large lead widths are recommended to reduce lead inductance and resistance.

The output capacitors are required by the linear regulator circuits to minimize ringing during damping periods and to supply transient current requirements during processor clock edges when maximum peak current occurs. Surface mounted capacitors are recommended to reduce lead lengths.

Processor Decoupling Capacitance

The processor decoupling capacitors (C8 to C42) should be located as close to the processor V_{cc} ground pins as possible. It is recommended that surface mounted capacitors be used to minimize resistance and inductance in the lead lengths. When possible, use traces to connect capacitors directly to the processor's V_{cc} and ground pins.
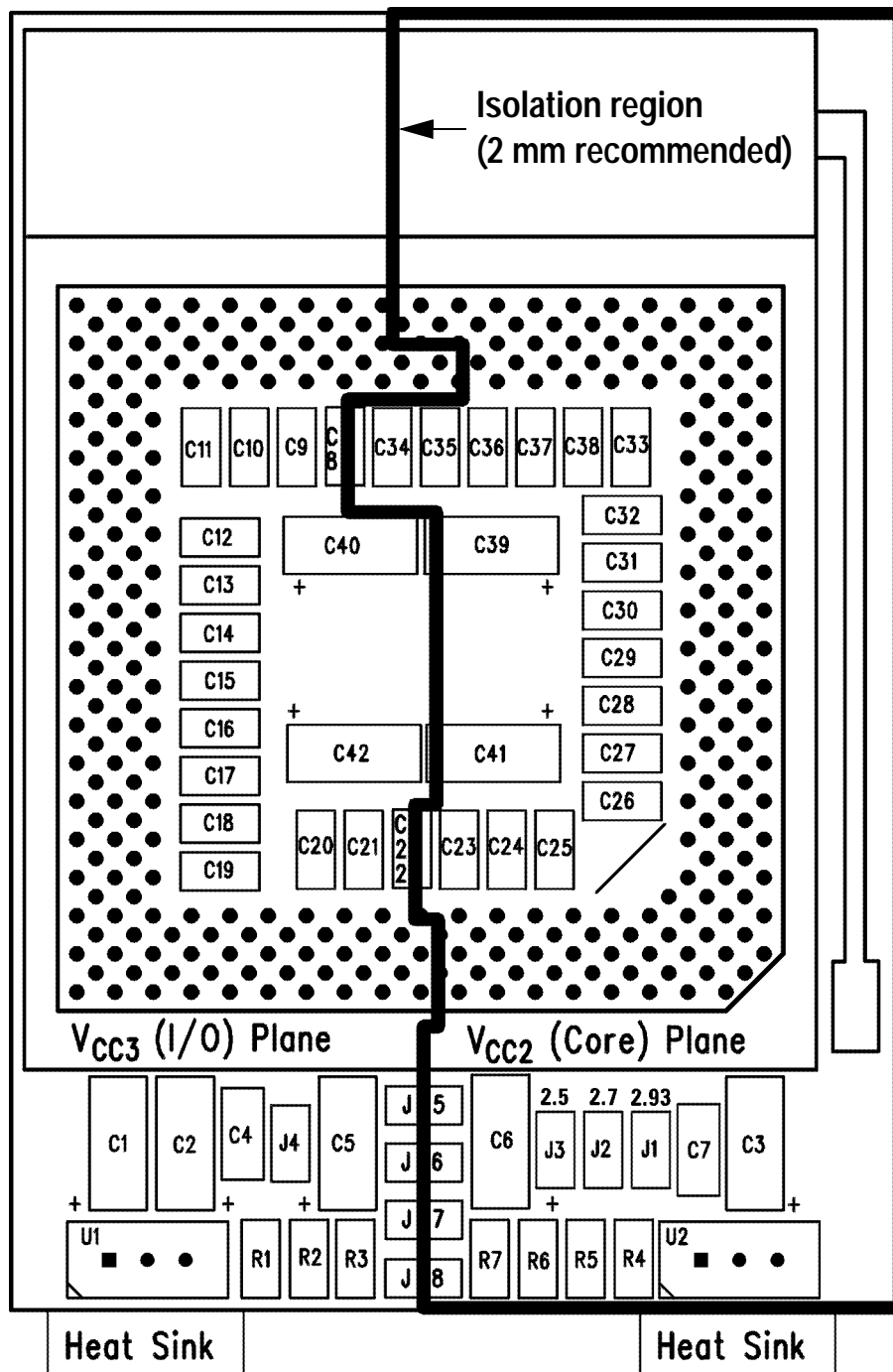
Component Layout

A suggested component placement for the low cost dual voltage power supply circuit is shown in Figure 6. Table 3 is a bill of materials for the low cost circuit. A suggested component placement for the precision dual voltage power supply circuit is shown in Figure 7. Table 4 is a bill of materials for the precision circuit.

Split Voltage Plane

AMD recommends using a split voltage plane to supply separate voltages to the I/O and core of the processor. This approach helps reduce noise levels without requiring the need for additional printed circuit board layers. Figures 6 and 7 show examples of suggested component placement for the two circuits. The solid line on each figure represents the approximate location for separation of the voltage power planes. Components have been placed in accordance with their associated voltage plane. Jumpers J5 through J8 straddle the planes and connect the planes together when installed. An isolation region (2 mm minimum is recommended) should separate the two voltage planes.

Note: *The ground plane should never be split; it provides a low impedance current sink and reference.*

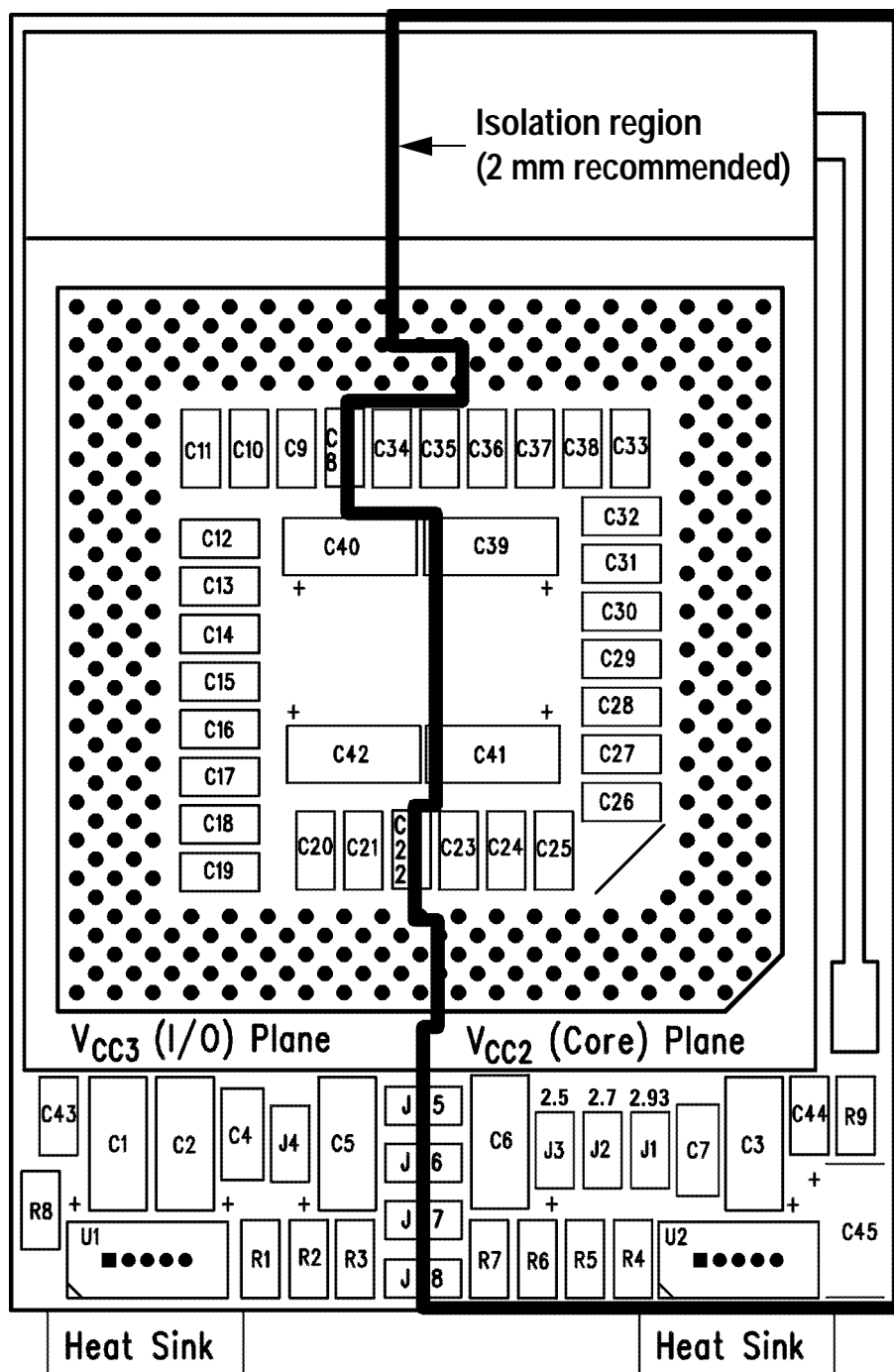Figure 6.   Suggested Component Placement for the Low Cost Dual Voltage Circuit

Figure 7. Suggested Component Placement for the Precision Dual Voltage Circuit

Table 3. Bill of Materials for the Low Cost Dual Voltage Power Supply Circuit

Item	Qty.	Reference No.	Value	Footprint	Description
1	1	R1	110 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
2	1	R2	12.4 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
3	1	R3	187 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
4	1	R4	107 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
5	1	R5	143 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
6	1	R6	931 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
7	1	R7	432 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
8	9	C1, C2, C3, C5, C6, C39–C42	330 μF, 6.3 V, 20%	AVX Size E	Capacitor, surface mount, tantalum, AVX part no. TPSE337M063100 or equivalent
9	2	C4, C7	0.33 μF, 16 V, 20%	0805	Capacitor, surface mount, ceramic, AVX (Y5V Dielectric) part no. 012063G334ZAT2A or equivalent
10	31	C8–C22 and C23–C38	0.1 μF	0805	Capacitor, surface mount, ceramic, AVX (X7R Dielectric) part no. 0805YC104MAT2A or equivalent
11	2	U1, U2	LT1585 or EZ1585	TO220	Linear regulator, 3 terminal (5 amp) (Linear Technology or Semtech)
12	1	HS	Heat Sink	Heat Sink	Heat sink can be thermally connected to both U1 and U2, but is electrically isolated via mica insulators or Thermalloy TO220 heat sink (size depends on printed circuit layout and ambient temperature specification for personal computer) (e.g., Thermalloy 7020B-MT)
13	8	J1–J8	Berg Header	2 Pin TH	Headers, 2 pin, through hole, 0.1 in spacing

Table 4.   Bill of Materials for Precision Dual Voltage Power Supply Circuit

Item	Qty.	Reference No.	Value	Footprint	Description
1	1	R1	110 kΩ, 1%, 1/8 Watt	0805	Resistor, surface mount
2	1	R2	12.4 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
3	1	R3	187 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
4	1	R4	107 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
5	1	R5	143 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
6	1	R6	931 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
7	1	R7	432 Ω, 1%, 1/8 Watt	0805	Resistor, surface mount
8	1	R8, R9	2 Ω, 5%, 1/8 Watt	0805	Resistor, surface mount
9	9	C1, C2, C3, C5, C6, C39–C42	330 μF, 6.3 V, 20%	AVX Size E	Capacitor, surface mount, tantalum, AVX part no. TPSE337M063100 or equivalent
10	2	C4, C7	0.33 μF, 16 V, 20%	0805	Capacitor, surface mount, ceramic, AVX (Y5V Dielectric) part no. 012063G334ZAT2A or equivalent
11	31	C8–C22 and C23–C38	0.1 μF	0805	Capacitor, surface mount, ceramic, AVX (X7R Dielectric) part no. 0805YC104MAT2A or equivalent
12	2	C43, C44	1 μF, 16 V 20%	1210	Capacitor, surface mount, ceramic, AVX (Y5V Dielectric) part no. 012063G105ZAT2A or equivalent
13	1	C45	33 μF, 20 V	AVX Size D	Capacitor, surface mount, tantalum, AVX part no. TPSD336M020R0200 or equivalent
14	2	U1, U2	LT1580 or EZ1580	TO220	Linear regulator, 5 terminal (7 amp) (Linear Technology or Semtech)
15	1	HS	Heat Sink	Heat Sink	Heat sink can be thermally connected to both U1 and U2, but is electrically isolated via mica insulators or Thermalloy TO220 heat sink (size depends on printed circuit layout and ambient temperature specification for personal computer) (e.g., Thermalloy 7020B-MT)
16	8	J1–J8	Berg Header	2 Pin TH	Headers, 2 pin, through hole, 0.1 in spacing

Additional Information

The following third-party application notes provide informa-
tion about products designed to accommodate AMD-K5 dual
voltage processors.

Table 5.   Additional Information for AMD-K5 Dual Voltage Processors

Title	Order Number	Available From:
Power Solutions for the AMD-K5™ Microprocessor	AN96-1	Semtech Corporation 652 Mitchell Road Newbury Park, CA 91320 Attention: Andrew Stewart Tel: 805-498-2111 Fax: 805-498-3804
Power Solutions for the AMD-K5™ Processors	Application Note 133	Linear Technology Corporation 1630 McCarthy Blvd. Milpitas, CA 95035-7487 Attention: Craig Varga Tel: 408-432-1900 Fax: 408-434-0507