Application Bulletin

Optimizing Transient Response for the RC5050/51 DC-DC Converter for Klamath CPU

Introduction

The main objective of this application bulletin is to familiarize the user about parasitic resistance in series between the VRM and CPU socket and also provide layout guidelines to achieve better transient response.

Intel's Requirements

Transient limit of plus and minus 5% of set voltage.

Vout = 3.3V Transient limit = ±165mV

Vout = 2.8V Transient limit = ±140mV

Motherboard Testing

After verifying the functionality of the DC-DC converter the AC characteristics for the power circuit are measured by using a P6.0 voltage transient tester. The transient tester simulates the loading the processor by rapidly toggling a resistive load between a high a low current level. These limits are set by using surface mount resistors on the transient tester.(Refer to Intel's P6.0 voltage transient tester user's guide for additional information).

Transient Analysis

The location of the VRM(voltage regulator module) on the motherboard is very critical for the purpose of meeting Intel's transient requirements due to trace resistance, inductance and capacitance between the VRM and the CPU socket. Ideally, the VRM should be placed next to the CPU socket. Figure 1, illustrates the model for motherboard series resistance, inductance and capacitance.

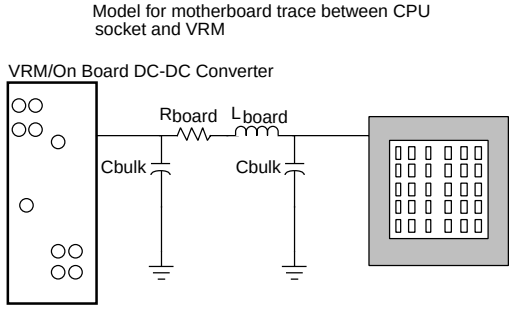

Figure 1.

Figure 2 and 3 show the transient response of Fairchild's RC5050 VRM plugged onto the motherboard by using Intel's transient tester switching between 0.5 and 14 Ampere (Vout = 2.5Volts). In figure 2 the transient is measured directly at the VRM('A' in Fig. 1) versus in Figure 3 the measurement is taken at the CPU socket('B' in Fig. 1). From the two figures it can be concluded that the transient data is 30mV higher when the measurement is taken at the CPU socket versus at the output of the DC-DC circuit. This is attributed due to the series resistance between the power circuit and the CPU socket.

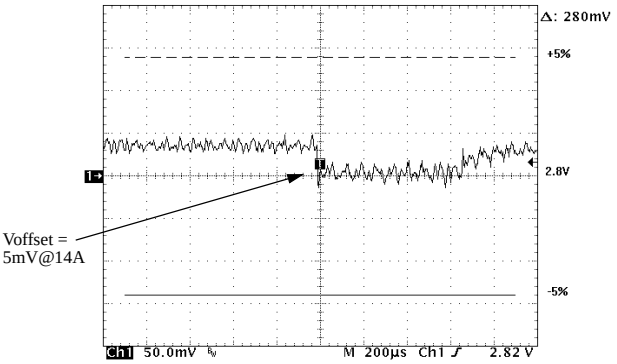

Figure 2. Transient Response at Point A

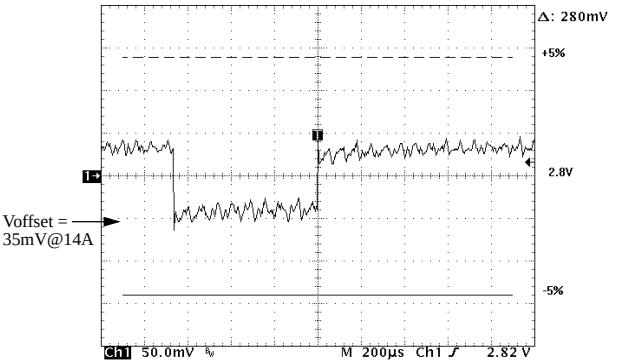

Figure 3. Transient Response at Point B for a Motherboard with Rboard = 2.2mΩ

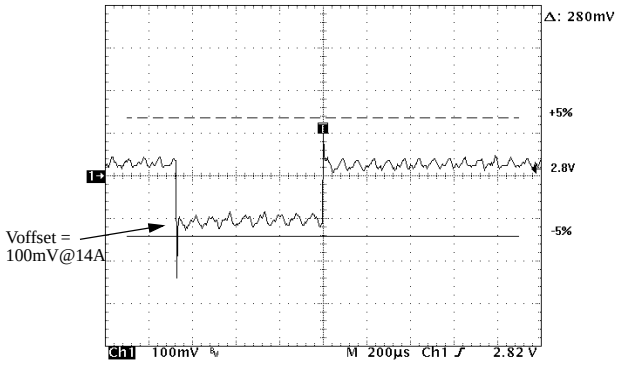

Figure 3B. Transient Response at Point B for a Motherboard with Rboard = 6.8mΩ

Figure 2, IL = 14A
Vout = 5mV

$$Req = \frac{Vout}{IL} = 0.3m\Omega \quad (1)$$

Figure 3, IL = 14A
Vout = 35mV

$$Req = \frac{Vout}{IL} = 2.5m\Omega \quad (2)$$

Figure 3B, IL = 14A
Vout = 100mV

$$Req = \frac{Vout}{IL} = 7.1m\Omega \quad (3)$$

Subtracting (1) from (2) and (1) from (3);

For figure 3, ***Rboard=2.2 mΩ***
For figure 3B, ***Rboard=6.8mΩ***

These are typical numbers measured on several motherboards, therefore, it is necessary to place the VRM bulk capacitors as close as possible to the CPU socket and also minimize the motherboard's trace series resistance.

Guidelines for optimizing transient response:

1. In order to improve the transient analysis performance, one should add an extra 100-300µF capacitor right by the CPU socket (Figure 4). If the same capacitor was added on the VRM then there would be no improvement in the transient data due to series board resistance (Figure 5).

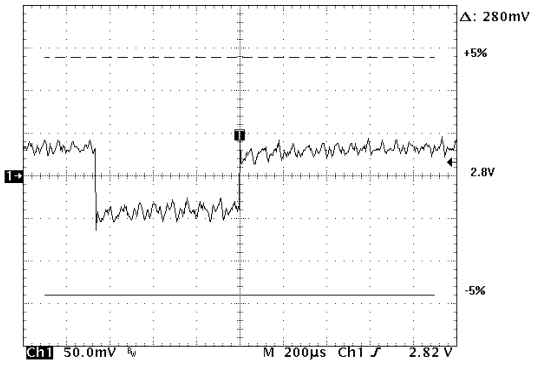

Figure 4. *RC5050 VRM Transient Response (Vout=2.8V@IL=0.5-14A) with Intel Recommended 300µF Surface Mount Capacitor by the CPU Socket.*

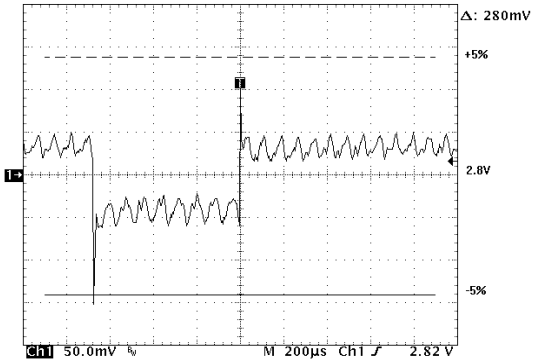

Figure 5. *RC5050 VRM Transient Response (Vout=2.5V@IL=0.5-14A) without Intel Recommended 300µF Surface Mount Capacitor by the CPU Socket.*

2. Assuming transient limit as 125mV at 14A load current. This requires the maximum ESR for the output bulk capacitors as follows:

$$ESR(\Omega max) = \frac{125mV}{14A} = 9m\Omega$$

3. Minimize motherboard trace resistance from the output section of the power circuit or the VRM to the CPU socket. This can be accomplished by placing the CPU socket right next to the power circuit. Typical value measured on a well laid out (2" between the CPU and the power circuit) motherboard is around 2mΩ versus 6mΩ for a poorly laid out (6" between the CPU and the power circuit) motherboard.

4. It is recommended to place the output bulk capacitors as close to the CPU socket as possible.

Note:

Refer to Application Note 50, Implementation Guidelines for RC5050 DC-DC Converters for Pentium Pro Motherboard