March 11, 1998

TEL:805-498-2111 FAX:805-498-3804 WEB:http://www.semtech.com

Powering Intel's Pentium II Microprocessor using the SC1151CS and the MP60-F VRM

Introduction

Modern microprocessors demand more and more stringent requirements from their power sources. Decreasing working voltages, increasing current draw and faster changes in load demand all combine to make the power supply designer's life more interesting. These requirements also mandate the use of local regulation or voltage conversion as close as possible to the microprocessor itself.

Intel has defined the power requirements for their Pentium II microprocessor and Semtech has designed the SC1151CS single chip PWM controller to meet those requirements. Semtech has also designed the MP60-F Voltage Regulator Module (VRM) both to demonstrate the SC1151CS and also to serve as a plug-in VRM solution for those not wishing to develop an on-board solution.

This application note describes the SC1151CS, it's design philosophy and practical use in a Pentium II power supply application.

Design Criteria

Output Filter Components

Probably the most striking design criterium for a power system to meet Pentium II requirements is the need to maintain regulated output voltage during very fast load transients. It is impossible for even the fastest PWM controller to respond to the required load transient in the time available. This means that short term transient load requirements will have to be met using the output capacitors of the power system. Unfortunately all practical capacitors have parasitic characteristics, the most important of which for our purposes are

a) Equivalent Series Resistance (ESR)
b) Equivalent Series Inductance (ESL)

The output capacitor equivalent circuit is shown in Fig.1. The combined effect of all these parasitics during a fast increase in load current is shown in Fig.2

The ESR of the capacitor causes a downward voltage step (together with a short spike due to ESL). The output circuit of the converter must be designed so that the additional output voltage sag caused by discharging output capacitors is offset by the reducing ESR drop due to less current demanded from the output capacitors. In simple terms we are looking for low ESR, high capacitance and low inductance in the converter output circuit.

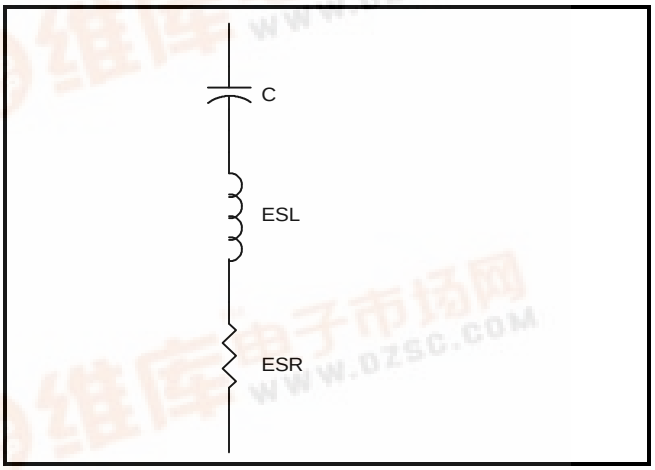


Fig.1 Output Capacitor with parasitics

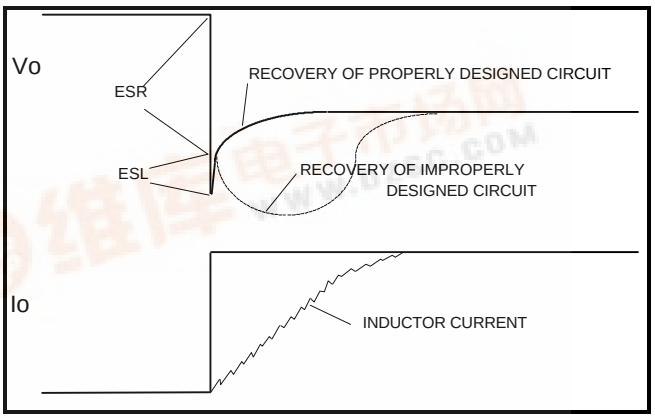


Fig.2 Output Voltage during load transient

The choice of output capacitors therefore becomes very important. The first criteria is that ESR should be less than 10mΩ to keep the leading edge transient to less than 120mV for a 12A load transient. The choice of cost and technology leads to three approaches.

a) Multiple aluminum electrolytic capacitors - typically to meet ESR requirements 7x1000µF will be required.

b) Multiple OS-CON type capacitors - this approach typically results in 4x330µF but at approximately 5x the cost of a).

c) Multiple tantalum chip capacitors - typically 10 to 20 giving a total output capacitance of 1000 to 2000µF and an even higher cost solution than b).

March 11, 1998

For a cost effective solution the only real option is to use multiple low ESR aluminum electrolytics, with a total capacitance of approximately 7000µF. The Intel specified decoupling at the processor socket will further reduce the leading edge ESR transient but is not included in results presented in this application note.

The output inductor value on a "Buck" converter is set from a consideration of the allowable peak to peak current ripple. This in turn will determine output voltage ripple and the output current below which the operating mode will be discontinuous. A high value of output inductor will result in low ripple and the capability of achieving low output current in continuous mode, but will suffer from poor transient response.

An optimum value is 4µH for the Semtech application circuit. Semtech does not recommend changing this value by more than ±25% without careful evaluation in the intended application. The specified inductor may be wound with 9 turns of 16AWG wire on a Micrometals T60-52 core.

Choice of FETs

There are many suitable choices of FETs from many different manufacturers. The requirements are, as a minimum, logic level drive, 22mΩ Rds(on), Vdss ≥ 30V and a package consistent with the power dissipation and heatsinking requirements. For example, if a 22mΩ FET is chosen it should be in TO-220 packaging with a 10°C/W (or better) heatsink used, if a 10mΩ FET is chosen it could be in a TO-263 package, soldered down to the PCB with sufficient copper area to alleviate the need for additional heatsinking.

Choice of Schottky

Again the Schottky diode choice is governed by the trade off between cost and performance. As a minimum, Vr ≥ 30V and Vf ≤ 0.5V @ If = 14A at Tj = 100°C. Better Vf characteristics will improve efficiency and reduce power dissipation in the Schottky, especially at the lower output voltages. Packaging should be TO-220 and a heatsink of 10°C/W or better is required.

In applications at output voltages in the high range around 2.8V, it is possible to use a TO-220 or TO-263 packaged Schottky soldered down to about 1 sq. in of copper. In these applications, the lowest Vf Schottky should be used and performance evaluated in the application. Thermal impedance will be approximately 30°C/W .

SC1151

The SC1151CS contains the control circuitry to implement a Pentium II power solution. It is a simple, voltage mode, non synchronous PWM controller with integrated 5 bit D/A converter, and power monitoring circuitry. The operating frequency is fixed at 100kHz. A higher operating frequency would normally allow smaller filter components however in this application, the output capacitors are fixed by ESR requirements. Using a lower value inductor at higher operating frequencies would require a change of core material and much increased cost or, using the same core material, would have minimal effect on the required core size. The standard buck topology was chosen to minimize the implementation costs.

MP60-F

The MP60-F is a self contained, plug-in voltage regulator module (VRM) designed to power the Intel Pentium II microprocessor. It uses the Semtech SC1151CS. The circuit diagram is shown in Fig.3 and board layout in Figs. 4 through 7. Performance data in this application note relates to this board.

PCB Layout Guidelines

Good analog layout techniques are important to the successful implementation of a Pentium II power solution using the SC1151CS. A multilayer board will greatly ease the layout task, although it is perfectly feasible to produce a working system with only a double sided PCB. The MP60-F is a perfect example. A continuous ground plane should be used underneath the chip, and all ground pins should be directly connected to this plane. It is preferable, though not strictly necessary, that no large ground currents flow in the plane beneath the chip, they should be routed around it. The chip decoupling capacitor (C13 in Fig.3) should be as close to the chip as possible, with the ground side connecting to the ground plane close to pin 1 of the chip. C11 should also be mounted as close to the chip as possible, as should R3 and R4 and to a lesser extent R1. The current sense traces from R1 should be as short as reasonably possible and should run close and parallel to each other. The FET drive connection (pin 8 to FET gate) should be kept short. High current paths should be kept wide and short, see the MP60-F layout (Fig.4 and Fig.5) for a guide.

March 11, 1998

Circuit Diagram

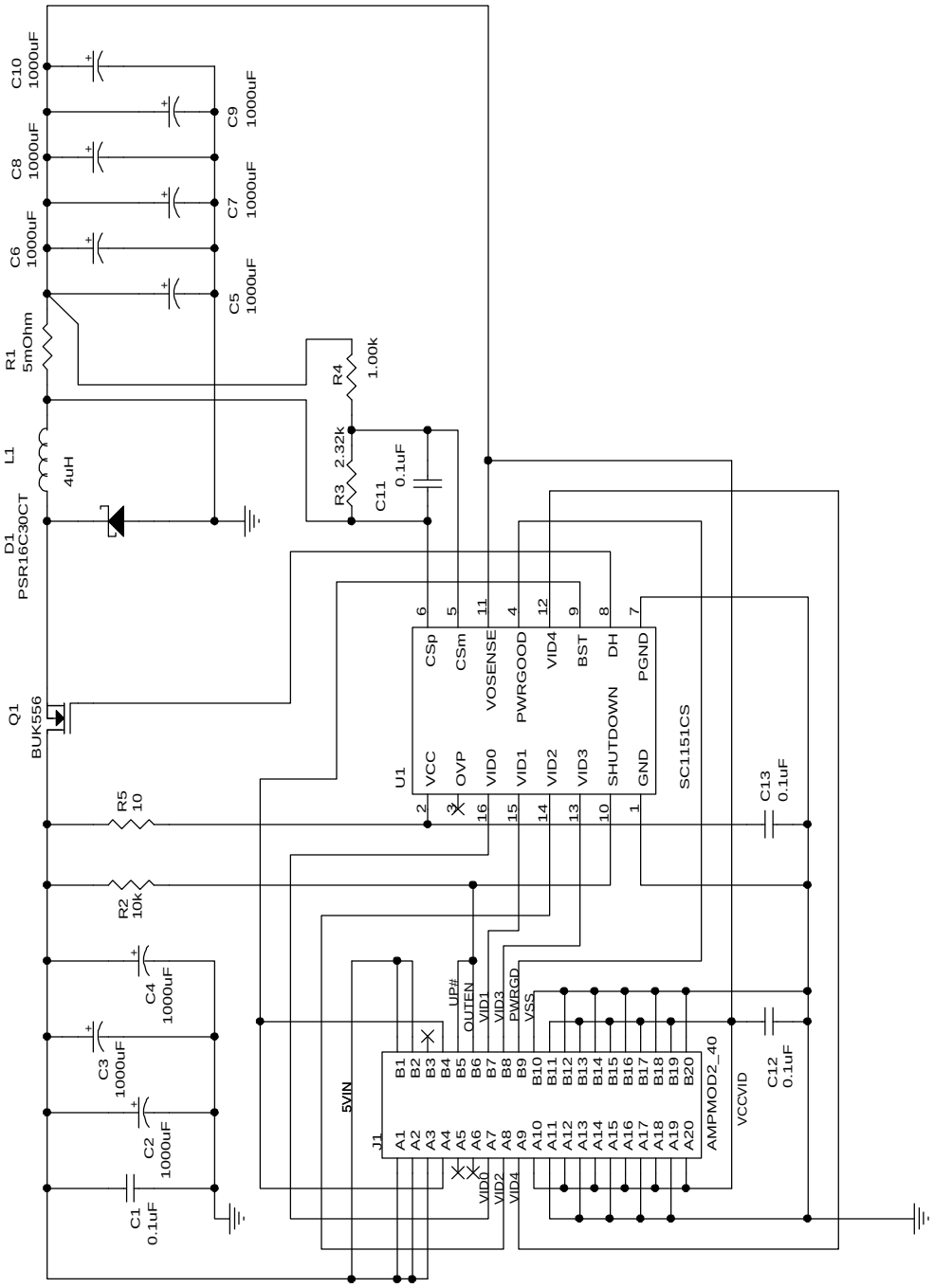


Fig.3 Application Circuit Schematic

March 11, 1998

Bill Of Materials

Qty	Reference	Part/Description	Vendor	Notes
4	C1,C11,C12,C13	0.1µF Ceramic	Various	
9	C2,C3,C4,C5,C6, C7,C8,C9,C10	1000µF/6.3V	Sanyo	6.3MV1000GX or equiv. Low ESR
1	D1	PSR16C30CT	Photron	Or lower Vf device from various vendors
1	L1	4µH		9 turns 16AWG on Micrometals T60-52 core
1	Q1	BUK556	Philips	Logic level FET, ≤ 22mΩ, 30V
1	R1	5mΩ	IRC	OAR-1 series
1	R2	10kΩ, 5%, 1/8W	Various	
1	R3	2.32kΩ, 1%, 1/8W	Various	
1	R4	1.00kΩ, 1%, 1/8W	Various	
1	R5	10Ω, 5%, 1/8W	Various	
1	U1	SC1151CS	Semtech	
2	Heatsinks		Various	≤ 10°C/W

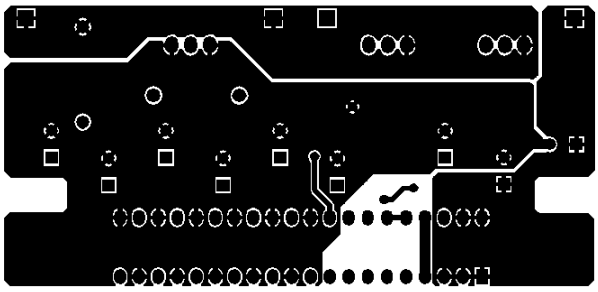


Fig.4 Top copper layout

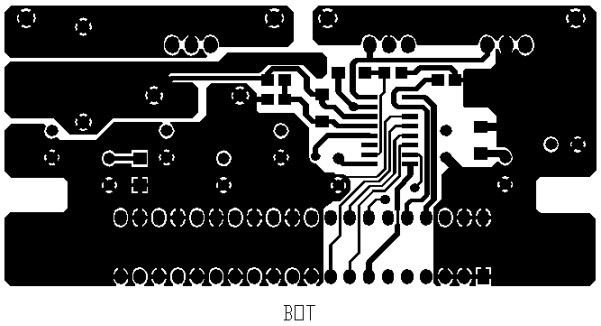


Fig.5 Bottom copper layout

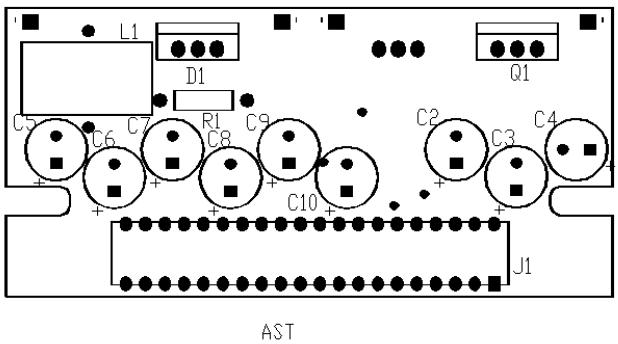


Fig.6 Top component layout

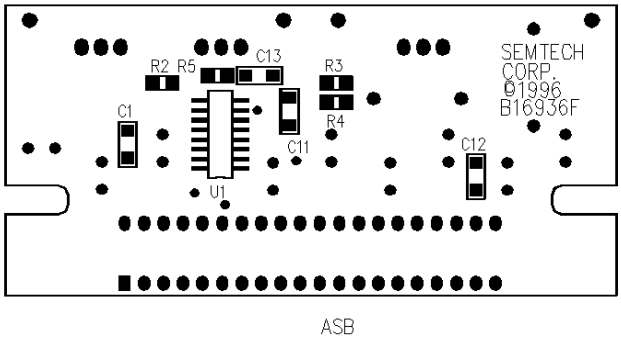


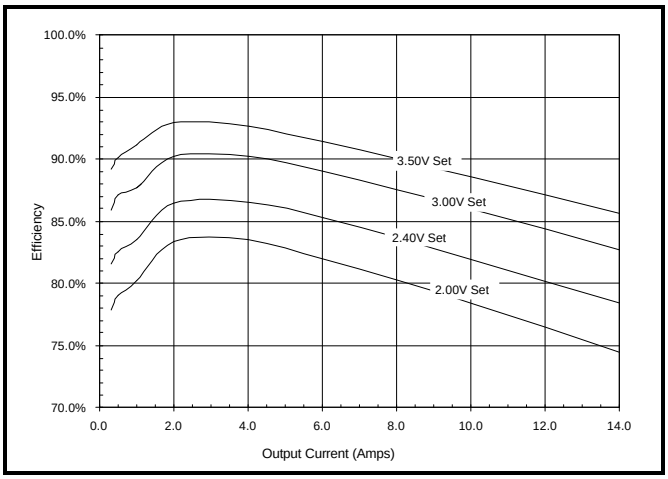
Fig.7 Bottom component layout

March 11, 1998

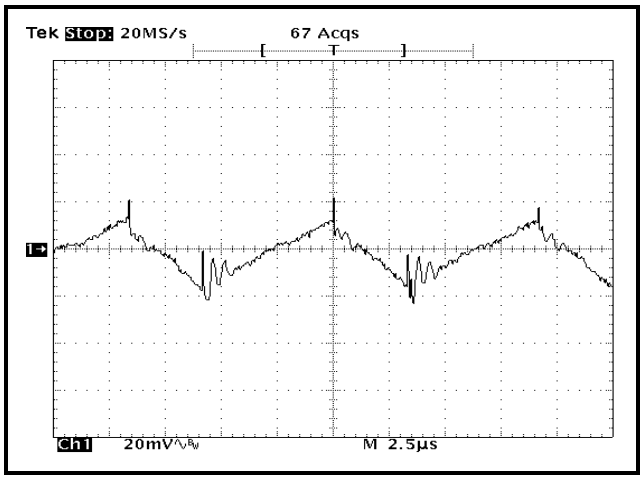
Performance

Typical performance characteristics are shown below

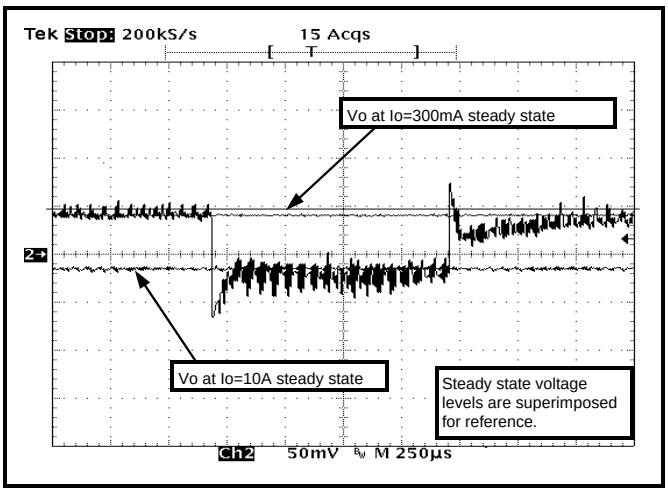
SC1151 Efficiency in Application circuit 16935F



Application circuit 16935F Ripple, 3.1V, 10A out



Application circuit 16935F Transient Response, 3.1V, 0.3A to 10A



SC1151 Regulation in Application circuit 16935F