International
IOR Rectifier

PD-6.088
IRVRM2

# Pentium II[1] Power Supply Design Specification

The new IRVRM2 offers the power supply designer a complete turnkey solution for DC/DC converters required to power Intel's new Pentium II[1] microprocessor. A synchronous buck regulator topology operating at 200kHz is employed and achieves excellent efficiency with very fast transient load response and tight output voltage regulation.

The new 20V low $V_{th}$ HEXFET Power MOSFET D²Pak is used in the synchronous circuitry to reduce board temperature and assembly costs while improving circuit efficiency through reduced $R_{DS(on)}$. Complete performance characterization along with a detailed schematic, bill-of-materials, and PCB layout are offered to reduce the customer's design time and effort.

### Purpose

This is a production-ready design. It has been thoroughly tested for performance against the Intel Pentium II[1] 233/266MHz power specification, and evaluated for manufacturability by a high volume manufacturer.

This design will not be manufactured by International Rectifier. Its purpose is to simplify the design and qualification process for our customers.

### Web Site

This design may be downloaded in two formats at IR's web site (www.irf.com). One is PDF format for on screen viewing or printing, the other is in native format so that you many manufacture the design if desired.

### Floppy Disk

The design is also available on floppy disk. As on our web site, the floppy version contains two formats, PDF and native format.

### Demo Boards

Completed boards are available through your local IR sales office and distribution.

### Support

E-mail Chris Davis at cdavis1@irf.com for support of this design.

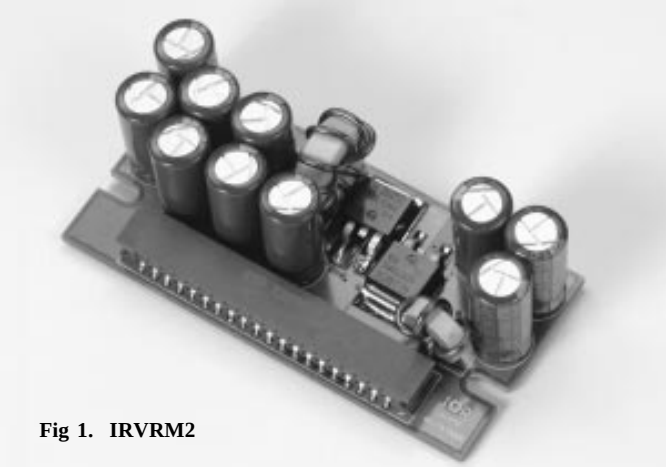


**Fig 1. IRVRM2**

### Key Features

- Meets or exceeds all Intel 233/266MHz Pentium II[1] requirements
- 12.7A continuous output
- 1.8 to 3.5V digitally selectable output
- 30A/µS transient load response capability
- Short circuit protected
- Surface Mount MOSFETs eliminate heatsinks
- >80% Efficiency
- Design kit available: IRVRM2

## Contents



### Copyright Restriction

# Specifications

### Absolute Maximum Ratings (Table 1)

| Parameter | Min | Max | Units | Conditions / Description |
|---|---|---|---|---|
| 5 volt input | - | 6.0 | V | |
| 12 volt input | - | 13.0 | V | |
| Continuous output current | - | 12.7 | A | Pulse width > 100ms |
| Ambient Temperature | 10 | 60 | ºC | |

### Electrical Input Specifications

| Parameter | Min | Typ | Max | Units | Conditions / Description |
|---|---|---|---|---|---|
| 5 volt input (5Vin) | 4.75 | 5.0 | 5.25 | V | Supply meet all output specifications |
| 5 volt input current | - | - | 10 | A | All line and load conditions |
| 12 volt input (12Vin) | 11.4 | 12.0 | 13.0 | V | Supply meet all output specifications |
| 12 volt input current | - | 40 | 60 | mA | All line and load conditions |

### Power Output Specifications (all specified line and load conditions)

| Parameter | Min | Typ | Max | Units | Conditions / Description |
|---|---|---|---|---|---|
| Voltage Range | 1.8 | 2.8 | 3.5 | V | Selected by VID[0:4] |
| Current | 0 | 7.6 | 12.7 | A | |
| Static Voltage regulation | -2.1 | - | +3.6 | % | Of nominal VID set point. |
| Transient Voltage | -5 | - | +5 | % | 30A/µs transitions 0.8A-to-12.7A @ 2.8V output |
| Ripple voltage | -1 | - | +1 | % | Percent of nominal |
| Turn on settling time | - | 3.1 | 10 | mS | Within ±10% of VID set point |

### Digital Input / Output Specifications

| Signal | Input / Output | Conditions / Description |
|---|---|---|
| PWRGD | output | Open collector output. Logic 1 output signifies that the voltage output of the module is within ±12% of the selected level |
| OUTEN | input | Open collector input. Logic 0 disables the module output. |
| VID[0:4] | input | Open collector input. Selects nominal output voltage as shown in table #2. |

### Output Fault Protection

| Parameter | Min | Typ | Max | Units | Conditions / Description |
|---|---|---|---|---|---|
| Short circuit protection | 13 | 15.25 | 17.5 | A | Output current during short circuit or overload |
| Over voltage protection | +10 | - | +25 | % | Shuts down the power supply when the output voltage exceeds 10%-to-25% above the set point |

**VID CODES (Table 2)**

| Vccp | VID 4 | VID 3 | VID 2 | VID 1 | VID 0 |
|---|---|---|---|---|---|
| 1.8V | 0 | 0 | 1 | 0 | 1 |
| 1.85V | 0 | 0 | 1 | 0 | 0 |
| 1.9V | 0 | 0 | 0 | 1 | 1 |
| 1.95V | 0 | 0 | 0 | 1 | 0 |
| 2.0V | 0 | 0 | 0 | 0 | 1 |
| 2.05V | 0 | 0 | 0 | 0 | 0 |
| No CPU | 1 | 1 | 1 | 1 | 1 |
| 2.1V | 1 | 1 | 1 | 1 | 0 |
| 2.2V | 1 | 1 | 1 | 0 | 1 |
| 2.3V | 1 | 1 | 1 | 0 | 0 |
| 2.4V | 1 | 1 | 0 | 1 | 1 |
| 2.5V | 1 | 1 | 0 | 1 | 0 |
| 2.6V | 1 | 1 | 0 | 0 | 1 |
| 2.7V | 1 | 1 | 0 | 0 | 0 |
| 2.8V | 1 | 0 | 1 | 1 | 1 |
| 2.9V | 1 | 0 | 1 | 1 | 0 |
| 3.0V | 1 | 0 | 1 | 0 | 1 |
| 3.1V | 1 | 0 | 1 | 0 | 0 |
| 3.2V | 1 | 0 | 0 | 1 | 1 |
| 3.3V | 1 | 0 | 0 | 1 | 0 |
| 3.4V | 1 | 0 | 0 | 0 | 1 |
| 3.5V | 1 | 0 | 0 | 0 | 0 |

**Fig 2. Connector pin out**

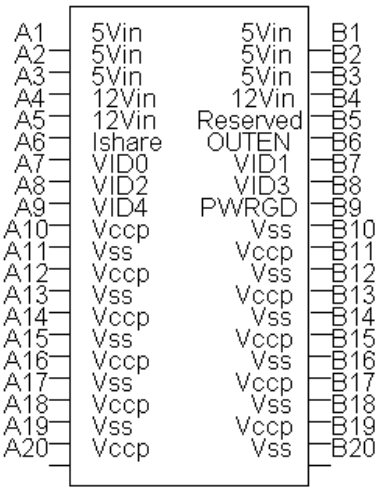



**Fig 3. Silkscreen top view**

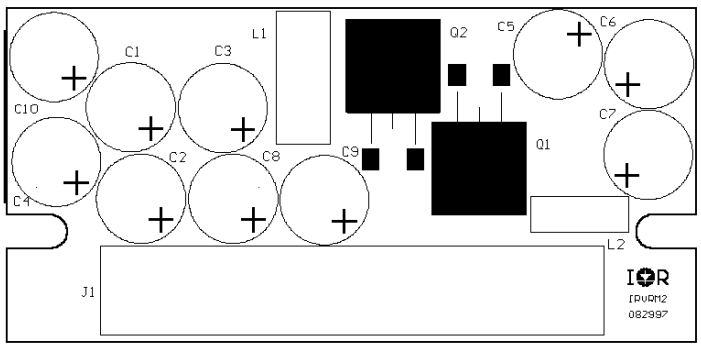
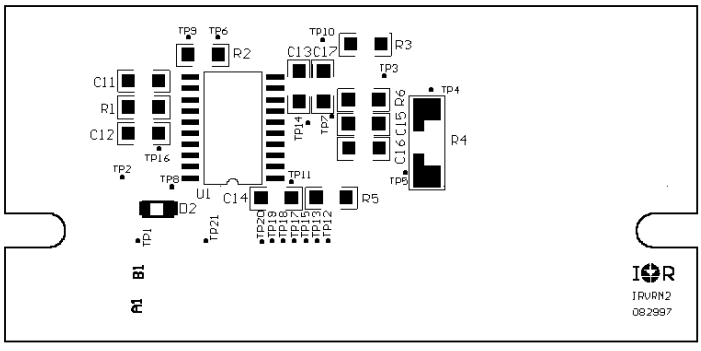



**Fig 4. Silkscreen bottom view**



## Schematic Diagram

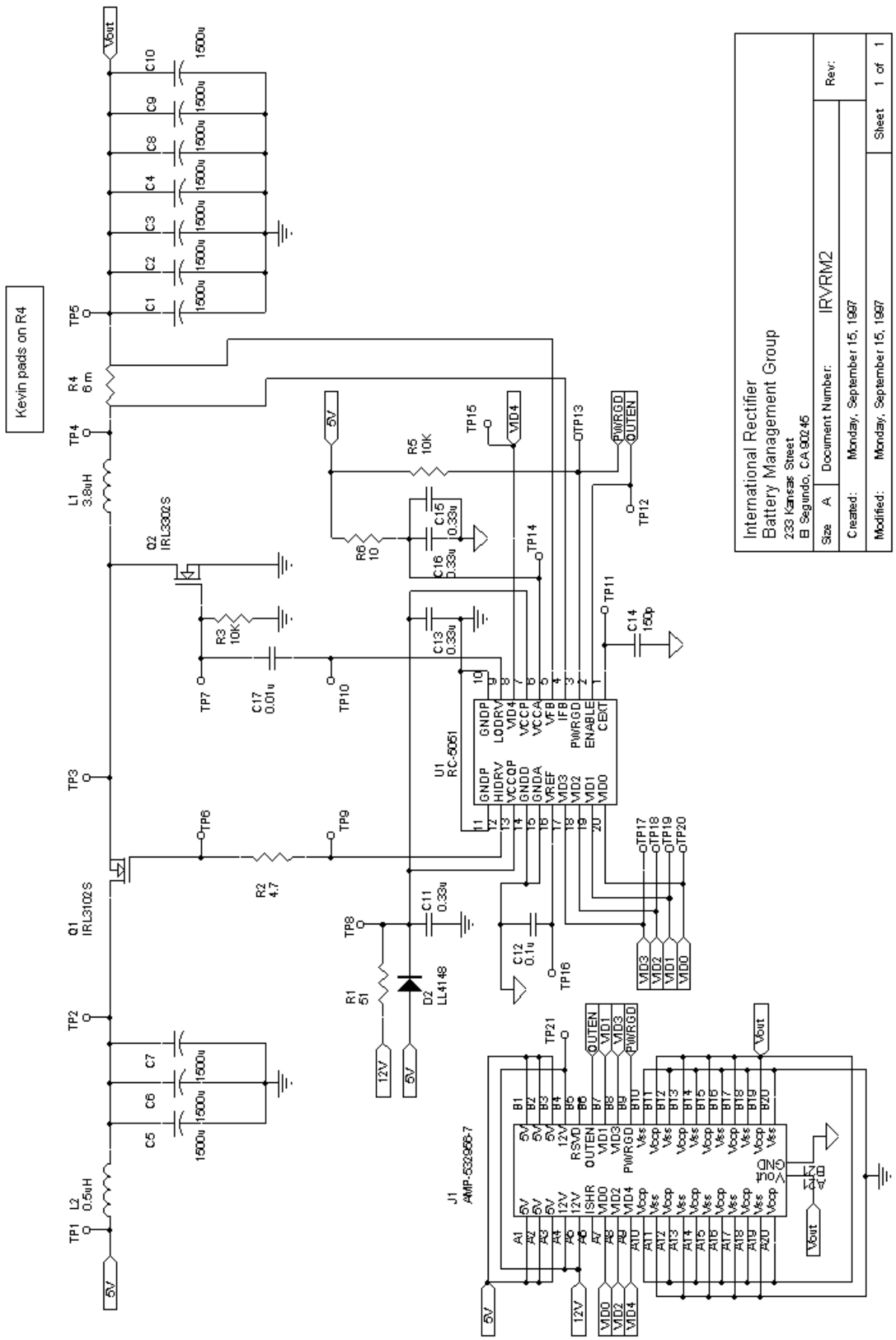



**Fig 5.**

# Bill of Materials

(Table #3)

| Item | Qty | Part Type | Designator | Descr. | Man | Man PN | Vend. | Vend PN |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.01u | C17 | 50V cer cap 1206 Z5U | ROHM | MCH315E103ZK | Garrett | MCH315E103ZK |
| 2 | 1 | 0.1u | C12 | 16V Z5U 20% 1206 Cap. | Capacitor Specialists | SMC1206Z5U104M016NT | NTD Electronics | SMC1206Z5U104M016NT |
| 3 | 4 | 0.33u | C15 C11 C16 C13 | 20% 1206 Z5U capacitor | Novacap | 1206Z334M500N | Garrett | 1206Z334M500N |
| 4 | 1 | 0.5uH | L2 | 4t of 15g on Micrometals T44-52 core | Pacific Transformer | IR002 | Pacific Transformer | IR002 |
| 5 | 1 | 10 | R6 | 5% 1206 Resistor | Panasonic | ERJ-8GEYJ100V | Digi-Key | P10ETR-ND |
| 6 | 2 | 10K | R3 R5 | 1206 5% 1/8 watt suface mount | Panasonic | ERJ-8GEYJ103V | Digi-Key | P10KETR-ND |
| 7 | 10 | 1500u | C1 C8 C7 C9 C10 C2 C5 C6 C4 C3 | Radial lead electrolytic capacitor | Sanyo | 6MV1500GX | Sanyo | 6MV1500GX |
| 8 | 1 | 150p | C14 | 5% NPO 50V ceramic Chip Cap. | MMC | CE151J3NO | Garrett | CE151J3NO |
| 9 | 1 | 3.8uH | L1 | 9t of 16g on Micrometals T60-52 core | Pacific Transformer | IR001 | Pacific Transformer | IR001 |
| 10 | 1 | 4.7 | R2 | 5% 1206 Resistor | Panasonic | ERJ-8RQJ4R7 | Digi-Key | P4R7PTR-ND |
| 11 | 1 | 51 | R1 | 5% 1/8 watt suface mount | Panasonic | ERJ-8GEYJ510V | Digi-Key | P51ETR-ND |
| 12 | 1 | 6m | R4 | 1% 2225 1W | Dale Elec. | WSL-2512 | Newark Elec. | WSL-2512 |
| 13 | 1 | AMP-532956-7 | J1 | 40 Pin connector | AMP | 532956-7 | Marshall Elec. | 532956-7 |
| **14** | **1** | **IRL3102S** | **Q1** | **N-channel Low Vth MOSFET** | **IR** | **IRL3102S** | **IR** | **IRL3102S** |
| **15** | **1** | **IRL3302S** | **Q2** | **N-channel Low Vth MOSFET** | **IR** | **IRL3302S** | **IR** | **IRL3302S** |
| 16 | 1 | LL4148 | D2 | high speed switching rectifier | Lite-on | LL4148 | Digi-Key | LL4148TR-ND |
| 17 | 1 | RC-5051 | U1 | 5 bit DAC Controller | Raytheon | RC5051 | All American | RC5051 |

**Manufacturers**

**International Rectifier -- (310) 322-3331**
Novacap ---------- (800) 227-2447
Panasonic ---------- (800) 922-0028
Raytheon Electronics ----- (415) 968-9211
Rohm ---------- (408)433-2225
MMC ---------- (847) 577-0200
AMP ---------- (800) 522-6752
Sanyo ---------- (619) 661-6835
Dale Electronics ---------- (402) 563-6557

**Distributors**

Digi-Key ---------- (800) 344-4539
Garrett ---------- (800) 767-0081
Newark Electronics ------- (800) 463-9275
D.C. Electronics ---------- (408)947-4510
Marshall Electronics ----- (714) 842-3702
All American ---------- (818) 878-0533

**PCB Fabrication**

Tedeum ---------- (909)946-4167

**Inductor Winding**

Pacific Transformer ---------- (714) 779-0450

**Turn Key Manufacturing**

Golden West Techology ----- (714)738-3775

**Delivery**

Items used in this design were found to have production quantity lead times of under 10 weeks. Most were well under 8 weeks.

## Inductor Specifications

**Inductor Drawing**

The specified inductors IR001 and IR002 can be purchased, assembled and tested (see BOM).

**Fig 6. IR001**


**Fig 7. IR002**


## Assembly Options

**Q1 MOSFET Replacement**

It would be very rare for any design to operate at 12.7A continuous output. All three MOSFET options given in Table 4 will operate at 12.7A continuous reliably. All three, however, will exceed the Intel recommended 115°C maximum junction temperature.

A more useful comparison is using the Intel specified typical current on a continuous basis, and adding higher current demand on a pulsed basis. Figure 8 shows typical waveforms and junction temperature excursions. For a given "t1" pulse width and "d" duty factor, there is an "I1" current which will cause Q1 to reach the Intel recommended 115°C maximum.

**Table 4**
**Continuous current boundary @ $T_j \leq 115°C$**

| | Q1 | CURRENT |
|---|---|---|
| IRVRM2a | IRL3102S | 11.92A |
| IRVRM2b | IRL3202S | 11.66A |
| IRVRM2c | IRL3302S | 11.48A |

**Perfomance using MOSFET replacement**

Figures 9 thru 11 show that in most practical cases the less expensive IRL3302S would be the device of choice. Test conditions shown on Figure 8.

**Fig 8. Typical load current and $T_j$ waveform**

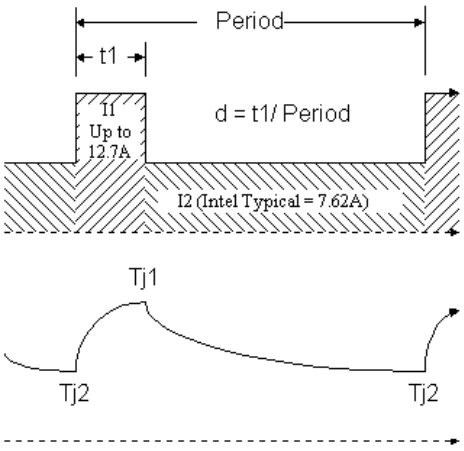



**Fig 9.**
**I1 current boundary @ Tj≤ 115°C (IRL3302S)**

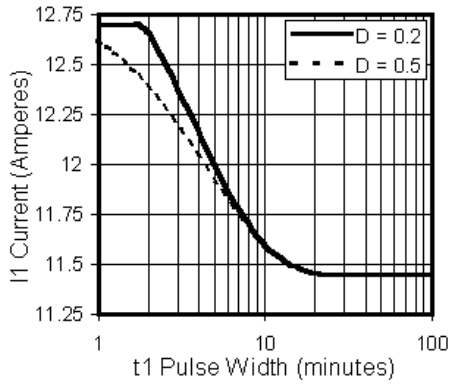



**Fig 10.**
**I1 current boundary @ $T_j \leq$ 115°C ( IRL3202S)**

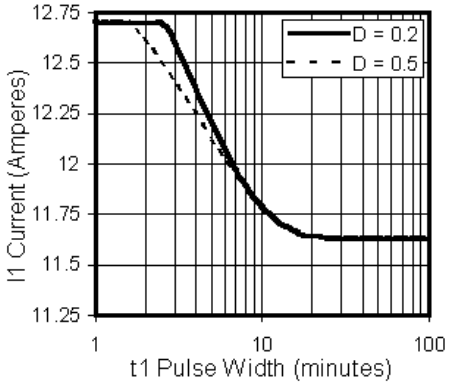
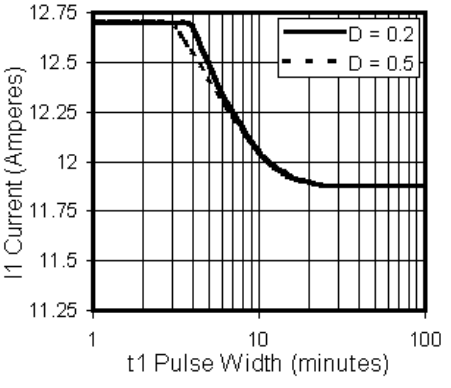



**Fig 11.**
**I1 current boundary @ Tj≤ 115°C ( IRL3102S)**




**Eliminate L2**

Inductor L2 may be eliminated if your design does not require meeting the Intel recommended input di/dt specification, or if your design has additional external inductance. Figures 21, 22, 23, 25 shows the input di/dt both with and without L2.

# Static Performance

### Efficiency

Efficiency is required to be at least 80% at full load. Thanks to the very efficient 20V low $V_{th}$ MOSFETs, IRVRM2 exceeds the required specification by a comfortable margin.

**Fig 12. Typical Efficiency**

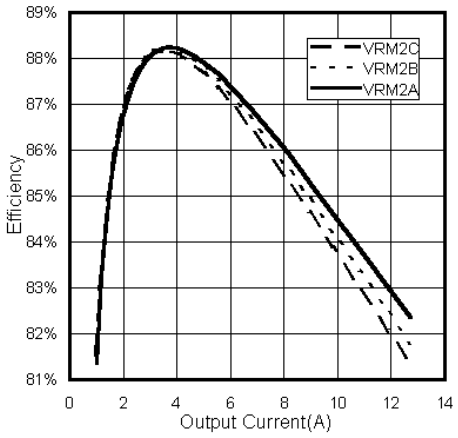
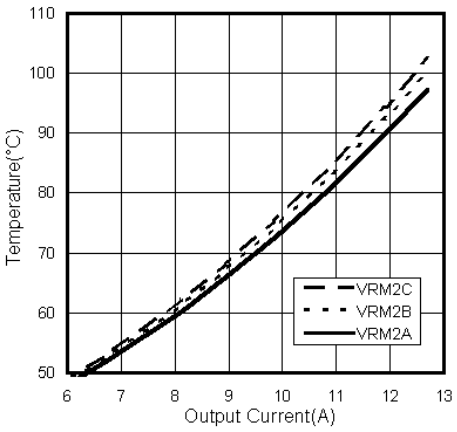



**Fig 13. Typical $T_j$ of Q1 $T_a$ = 25ºC (still air)**




### Maximum Junction Temperature

Analysis of Q1 junction temperature shows that it remains within specifications at an ambient temperature of 50°C, even in still air.

**Fig 14. Projected $T_j$ of Q1 $T_a$ = 50ºC (still air)**

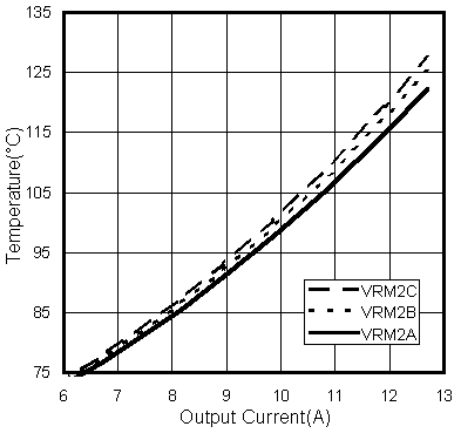
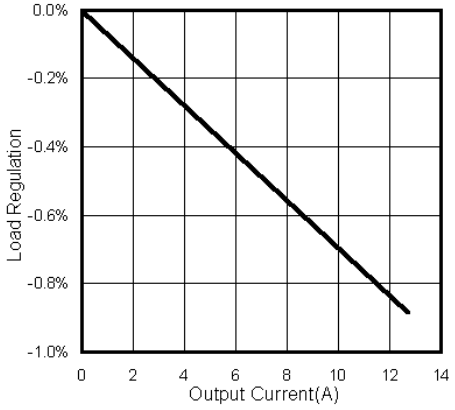



**Fig 15. Typical Load Regulation**



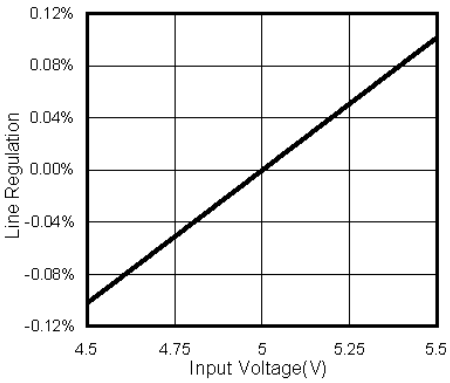

### Load Regulation

The output must stay within its -2.1% ~ +3.6% static specification from no load to full load.

### Line Regulation

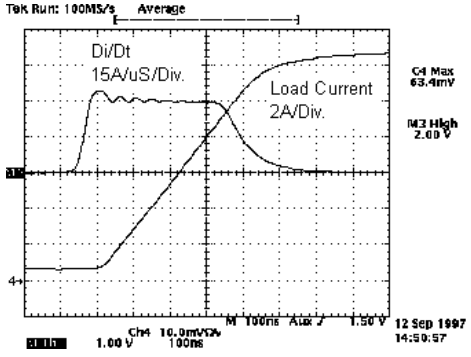
The Intel specification requires the line voltage to be within ±5% of nominal voltage. IRVRM2 easily meets line regulation specification even up to ±10%.

**Fig 16. Typical Line Regulation**




# Dynamic Performance

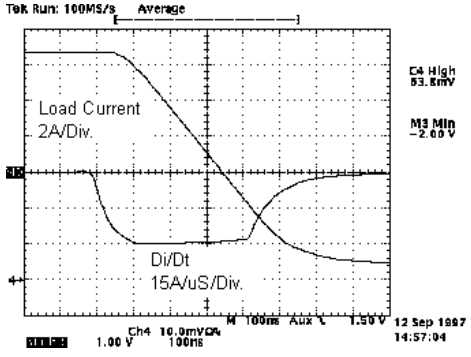
**Fig 17. Transient Load Current Rise Time**




### Transient Load Test Conditions

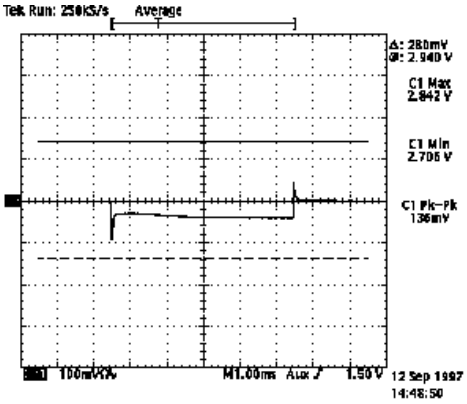
The Intel specification requires the supply to stay within its ±5% specification during transient load event of 0.8A-to-12.7A at a rate of 30A/µs. Although most motherboards do not require this full level of performance, IRVRM2 meets the full transient response specification.

**Fig 18. Transient Load Current Fall time**



## Dynamic Performance (continued)

**Fig 19. 100 Hz Transient Output Voltage**




### Transient Load At VRM2

Performance at 100kHz is dominated by stray output inductance and resistance. These are a combination of output capacitor ESL & ESR and board + connector inductance & resistance.

Performance at 100Hz exhibits the same rise & fall characteristics as at 100kHz. Setting the oscilloscope so as to see the whole waveform, however, reveals any undersirable loop characteristics. As shown, IRVRM2 is very well behaved at both 100Hz and 100kHz.

| | Limit | 100Hz | 100kHz |
|---|---|---|---|
| Min | 2.66V | 2.706 | 2.670 |
| Max | 2.94V | 2.842 | 2.834 |

**Fig 20. 100 kHz Transient Output Voltage**

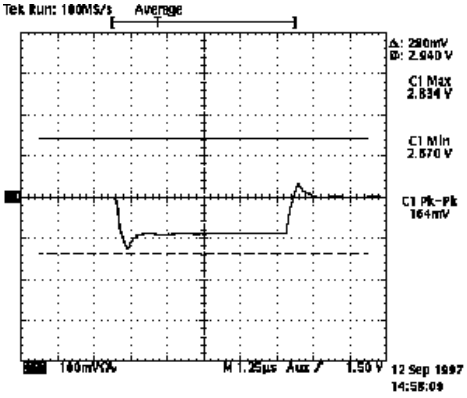
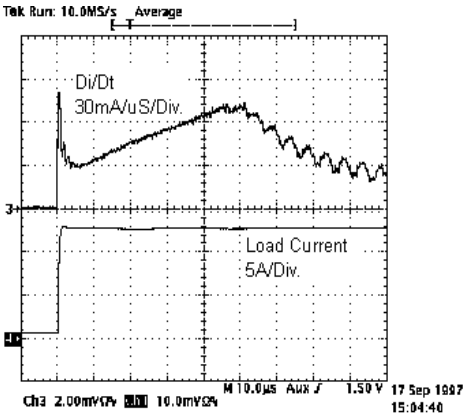



**Fig 21. Rising Input Current Waveform**




### Input di/dt During Transient Load

Intel's specification recommends a maximum input di/dt during transient load of 0.1A/µs. IRVRM2 readily meets this specification at rising and falling edges of input current.

Transient measurements were taken with 1µH of total line inductance between the input power supply and IRVRM2. This approximately simulates total path inductance from the silver box to the VRM board in a typical computer system. IRVRM2 has an input inductance of 0.5µH (L2) to limit input di/dt to the Intel recommended 0.1A/µs.

**Fig 22. Falling Input Current Waveform**

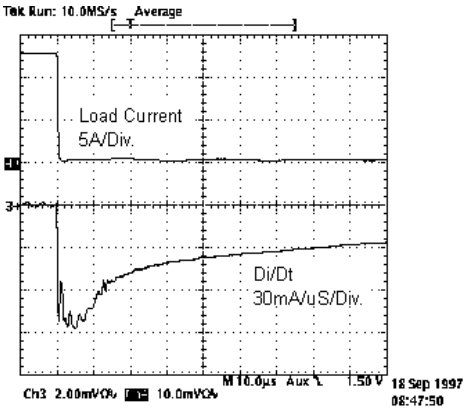



**Fig 23. Rising Input current without L2**

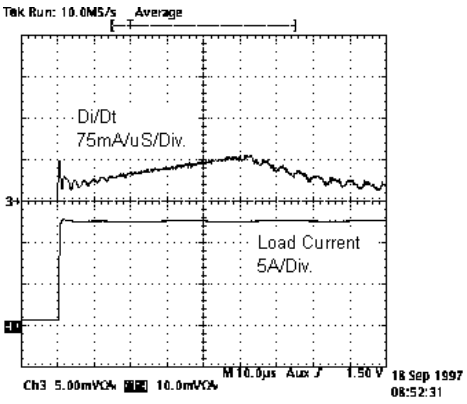
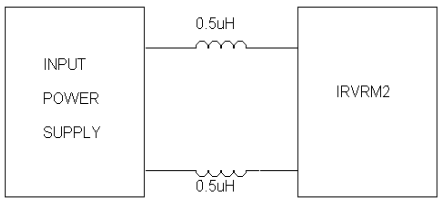
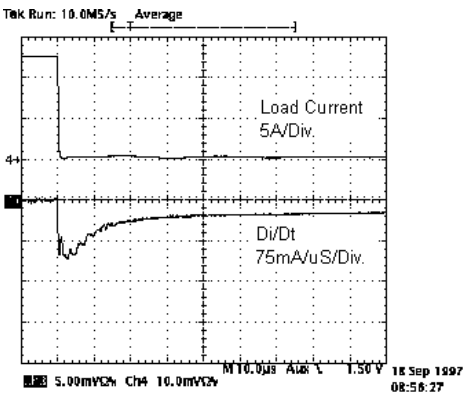



**Fig 24. Input di/dt Test Circuit**



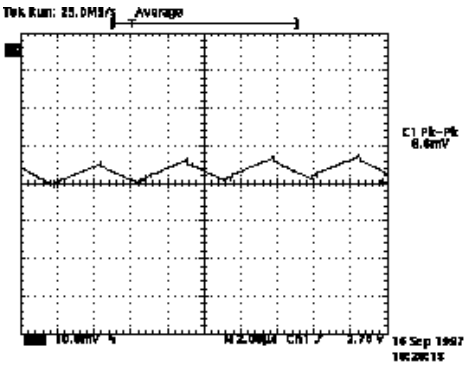

| | Limit | Rising | Falling |
|---|---|---|---|
| L2 = 0.5µH | .1A/µs | 0.074 | 0.087 |
| L2 = 0.0µH | .1A/µs | 0.09 | 0.108 |

**Fig 25. Falling Input Current without L2**



## Dynamic Performance (continued)

Fig 26. Output Voltage Ripple (No Load)



### Output Ripple Voltage

Output ripple voltage is specified as a ±1% range, (56mV peak-to-peak) of the nominal output voltage.

| Parameter | Limit | Measured |
|---|---|---|
| P-P ripple | 56mV | 15.2mV |

Fig 27. Output Voltage Ripple (Full Load)

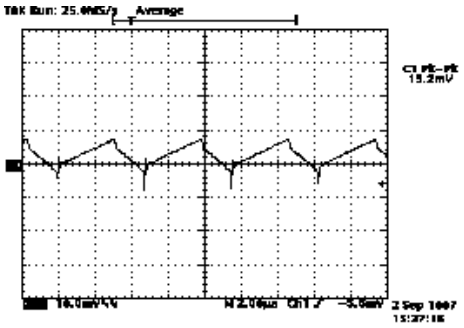
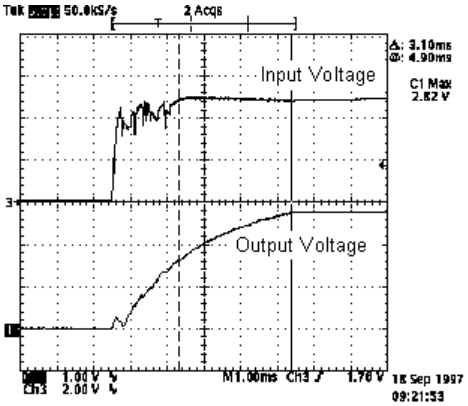


Fig 28. Turn on Waveform (Full Load)

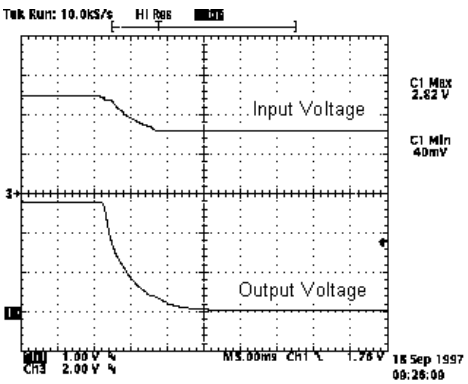



### Turn On Transient

Output voltage must remain within 10% of the nominal set point. Also, output voltage should reach its specified range, -2.1% ~ +3.6%, within 10ms after input voltage reaches 95% of nominal voltage.

| Parameter | Limit | Measured |
|---|---|---|
| Risetime | 10ms | 3.1ms |
| Overshoot | 3.08V | 2.82V |

Fig 29. Turn off Waveform (Full Load)




International
IOR Rectifier

**WORLD HEADQUARTERS:** 233 Kansas St., El Segundo, California 90245, Tel: (310) 322 3331
**EUROPEAN HEADQUARTERS:** Hurst Green, Oxted, Surrey RH8 9BB, UK Tel: ++ 44 1883 732020
**IR CANADA:** 15 Lincoln Court, Brampton, Ontario L6T 3Z2, Tel: (905) 453 2200
**IR GERMANY:** Saalburgstrasse 157, 61350 Bad Homburg Tel: ++ 49 6172 96590
**IR ITALY:** Via Liguria 49, 10071 Borgaro, Torino Tel: ++ 39 11 451 0111
**IR FAR EAST:** K&H Bldg., 2F, 3-30-4 Nishi-Ikebukuro, Toshima-ku, Tokyo 171 Japan Tel: 81 3 3983 0641
**IR SOUTHEAST ASIA:** 315 Outram Road, #10-02 Tan Boon Liat Building, Singapore 0316 Tel: 65 221 8371