

# HIP6302EVAL1

Multiphase Power Conversion for AMD Athlon Processors up to 35A

AN9888  
Rev.1.00  
February 2002

## Introduction

Each generation of computer microprocessor brings performance advances in computing power. Performance improvements are made possible by advances in fabrication technology that enable greater device density. Newer processors are operating at lower voltages and higher clock speeds both of which contribute to greater demands on the microprocessor core voltage supply in terms of higher peak currents and higher current-slew rates.

Intersil's family of multi-phase DC-DC converter solutions provide the ideal solution to supply the core-voltage needs of present and future high-performance microprocessors.

## Intersil HIP6302 and HIP6601

The HIP6302 controller IC works with two HIP6601A or HIP6603A single-channel driver ICs or a single HIP6602A dual-channel driver IC [3] to form a highly integrated solution for high-current, high slew-rate applications. The HIP6302 regulates output voltage, balances load currents and provides protective functions for two synchronous-rectified buck-converter channels.

A five-bit DAC provides a digital interface to program the 1% accurate reference and a window comparator toggles PGOOD if the output voltage is out of range and acts to protect the load in case of over voltage. For more detailed descriptions of the HIP6302 functionality, refer to the HIP6302 Data Sheet [1].

The HIP6601A is a driver IC capable of delivering up to 2A of gate-charging current for rapidly switching both MOSFETs in a synchronous-rectified bridge. The HIP6601A accepts a single logic input to control both upper and lower MOSFETs. Adaptive shoot-through protection is provided on both switching edges to provide optimal dead time, and bootstrap circuitry permits greater enhancement of the upper MOSFET. For a more detailed description of the HIP6601A, refer to the HIP6601A Data Sheet [2].

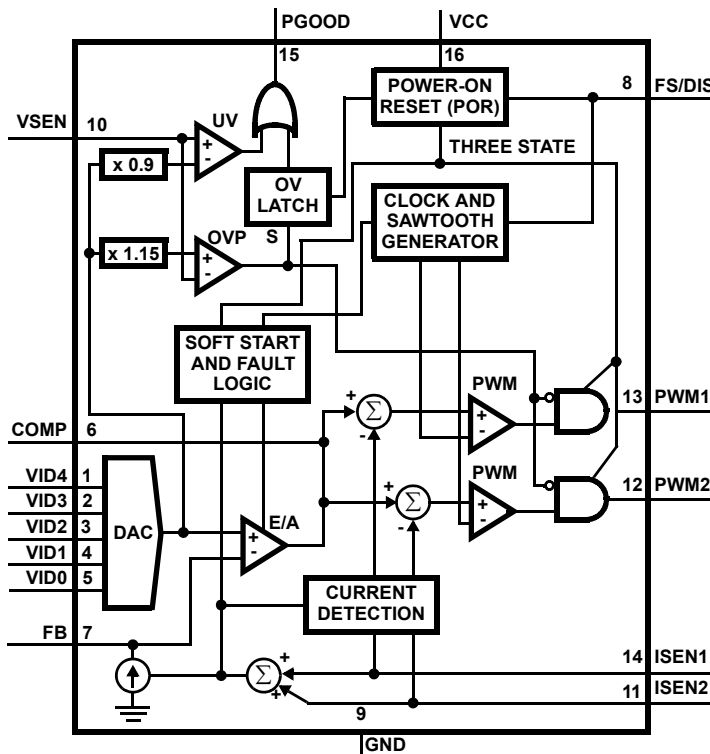


FIGURE 1. HIP6302 BLOCK DIAGRAM

The integrated high-bandwidth error amplifier provides voltage regulation, while current-sense circuitry maintains phase-current balance between the two power channels and provides feedback for droop compensation and over-current

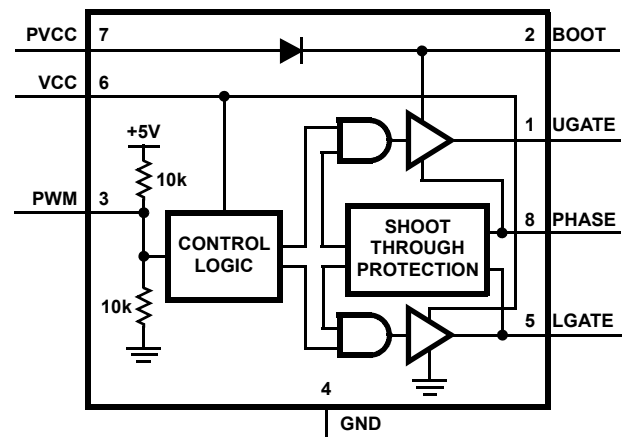


FIGURE 2. HIP6601A BLOCK DIAGRAM

## The HIP6302EVAL1 Board and Reference Design

With the VID jumpers set to 1.7V (00110), the evaluation board meets the output voltage and current specifications indicated in Table 1.

TABLE 1. HIP6302EVAL1 OUTPUT PARAMETERS

	MIN	MAX
Static Regulation	1.65V	1.75V
Transient Regulation	1.60V	1.85V
Over-Voltage Protection	1.90V	2.00V
Continuous Load Current	-	35A
Over-Current Trip Level	41A	57A
Load-Current Transient	-	35A/ $\mu$ s

The HIP6302EVAL1 evaluation board incorporates a reference design intended to meet the core-voltage requirements for AMD Athlon™ microprocessors up to 35A. Additional circuitry is provided to facilitate circuit evaluation including input and output power connectors, VID jumpers, numerous probe points, an LED power-good indicator, and a load-transient generator.

### Powering the HIP6302EVAL1

For convenience, the HIP6302EVAL1 provides two methods of making input power connections. The 20-pin header, J1, interfaces with a standard ATX power supply and may be the most convenient method of powering the board.

J2, J3, and J4 are standard banana-jack connectors that can be used to supply power using bench-top power supplies. These inputs provide greater versatility in testing and design validation by allowing the 12V and 5V power-input voltage levels to be varied independently. In this way power-on level and power-sequencing issues can be easily examined.

To start the evaluation board, insert the 20-pin connector from an ATX supply into J1. If using bench-top supplies, connect a 12V supply to J2 and a 5V supply to J3. Connect the grounds from both supplies to J4.

### Important

There are two things to consider when using bench-top supplies. If the 5V supply is applied prior to the 12V supply, the HIP6302 will begin operating before the HIP6601As. This allows the HIP6302 to complete its soft-start cycle before the drivers are capable of switching power to the output. When the 12V power input is then applied, there is a large transient as the controller tries to instantly bring the output to its full-voltage level. This can result in an overcurrent protection cycle and an abnormal start-up waveform. It can be avoided by applying 5V supply after or at the same time as the 12V supply or by using an ATX power supply.

The second problem can occur when operating the transient load generator. Not all bench-top and ATX power supplies are capable of responding to load transients, and they may allow a momentary voltage dip on VCC5. This can activate the power-on-reset function in the HIP6302 and cause the output power to cycle. It can be remedied by connecting a 5600μF or larger capacitor between VCC5 and ground. The capacitor, if necessary, simulates the distributed capacitance that exists on the computer motherboard.

### Start Up

The waveforms in Figure 3 demonstrate the normal start-up sequence with the HIP6302EVAL1 connected to a 55mΩ load. After FS/EN is released, VCORE exhibits a linear ramp until reaching its 1.7V set point. The gradual increase of VCORE over approximately 5ms limits the current required from the input supply, ICC5, to a level that does not strain the supply. The HIP6302 asserts PGOOD once VCORE is within regulation limits.

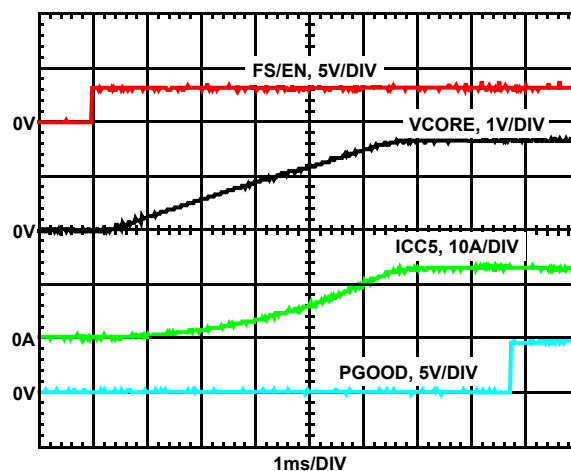


FIGURE 3. HIP6302EVAL1 START-UP WAVEFORMS

### Transient Response

The HIP6302EVAL1 is equipped with a load-transient generator that applies a 0–36A transient load current with rise and fall rates of approximately 35A/μs. The duration of the transient is between 100μs and 200μs, and the repetition rate is kept low in order to limit power dissipation in the load MOSFETs and resistors. Removal of the HI/LO jumper (JP2) causes the current to decrease from about 36A to about 31A. The load-transient generator operates when the HIP6302EVAL1 is properly connected to a 12V power source and SW1 is in the ON position. Operation ceases when SW1 is moved into the OFF position or 12V is removed from the board.

The HIP6302EVAL1 achieves the specified transient performance while maintaining a favorable balance between low cost, high efficiency and small profile. When the duty cycle changes rapidly in response to a transient load current, the inductor current immediately begins to change in order to meet the demand. During the time the inductor current is increasing, the output-filter capacitors are supplying the load. It follows that the amount of required capacitance decreases as the capability of the inductors to rapidly assume the load current increases.

Figure 4 shows the core voltage, inductor current, and PWM signals changing in response to the transient load current. The upper waveform shows the core voltage deviating from its no-load setting of 1.72V to a minimum of about 1.62V upon the application of current. The voltage then settles to its 1.67V full-load setting. On load removal, the core voltage peaks at a level of 1.78V before settling again to its 1.72V no-load setting. Although the specified operating range allows deviations as low as 1.60V and as high as 1.85V, a minimum of 20mV is reserved to allow for the reference tolerance and the tolerances of other components that contribute to the overall system accuracy.

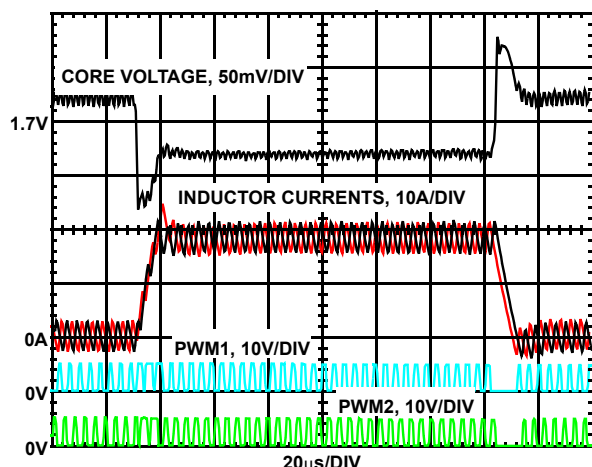


FIGURE 4. HIP6302EVAL1 TRANSIENT RESPONSE

Figure 5 is a close-up showing the core-voltage, inductor-current and PWM signals responding at the leading edge of the transient load current. The PWM signals increase to their maximum duty cycle of 75% on the first pulse following the start of the transient. The inductor currents begin to increase immediately and are carrying all of the load within 10μs. The very fast transient response is due to the precision 18MHz error amplifier and optimal compensation of the control loop.

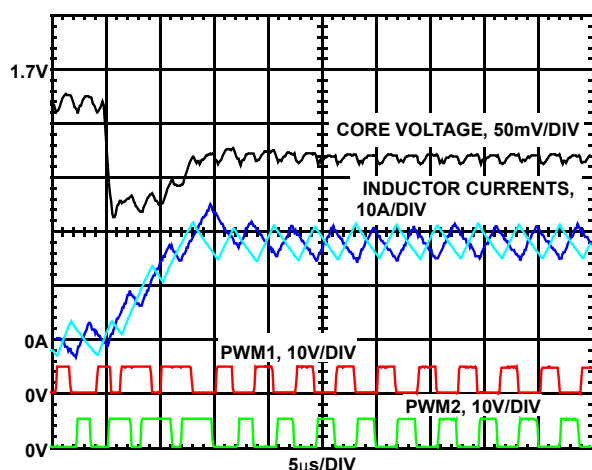


FIGURE 5. TRANSIENT-RESPONSE LEADING EDGE

The close up in Figure 6 shows the core-voltage, inductor-current and PWM signals changing in response to the trailing edge of the transient load current. Again, the duty cycles immediately decrease to zero, and the inductors begin shedding load current at the maximum rate. Note that the inductor currents briefly go negative as the transient settles. The capacitors are slightly over charged at the end of the transient, and the discharge path is in the reverse direction through the inductors.

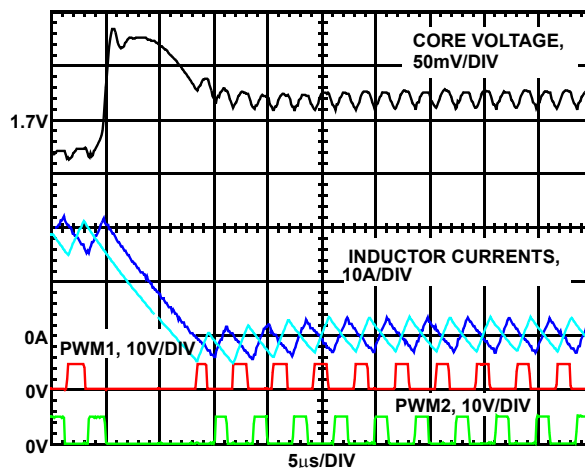


FIGURE 6. TRANSIENT-RESPONSE TRAILING EDGE

## Overcurrent Protection

When the current out of either ISEN pin exceeds 82μA, the HIP6302 detects an overcurrent condition and responds by placing the PWM outputs into a high-impedance state. This signals the HIP6601 to turn off both upper and lower MOSFETs in order to remedy the overcurrent condition. This behavior is seen in Figure 7 where PWM1 goes immediately to 2.5VDC when the output current reaches approximately 50A. The output voltage then quickly falls to zero.

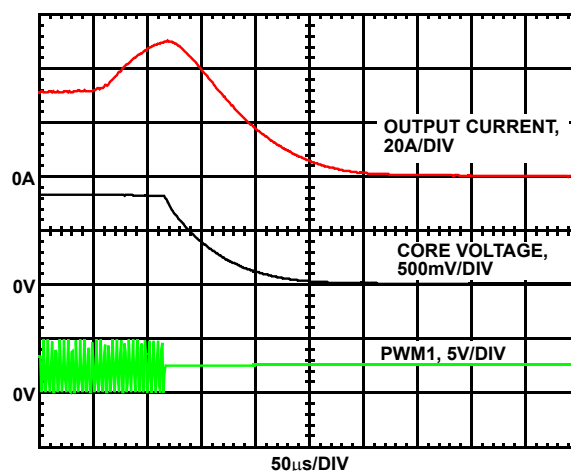


FIGURE 7. OVERCURRENT BEHAVIOR

After the initial over-current trip, the HIP6302 waits for a period of time equal to  $2048/f_{SW}$  ( $f_{SW}$  is the switching frequency) before initiating a soft-start cycle. If the over-load condition remains, another over-current trip will occur before the end of the soft-start sequence. This repetitive over-current cycling is illustrated in Figure 8, and will continue indefinitely unless the fault is cleared or power to the converter is removed. Because of the wait period, the worst case power delivered during overcurrent cycling is equal to 45% of the power delivered during normal operation at full load. Therefore, indefinite over-current cycling does not create a thermal problem for the circuit.

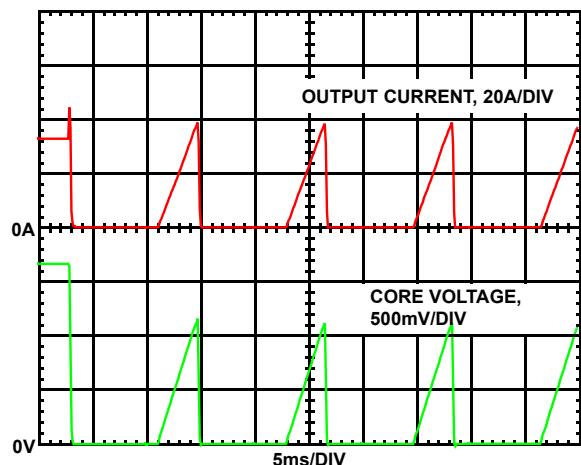


FIGURE 8. OVERCURRENT BEHAVIOR

## Efficiency

Figure 9 shows the efficiency versus current plot for the HIP6302EVAL1 for 5A through 35A. The measurements were made at room temperature with natural convection cooling only.

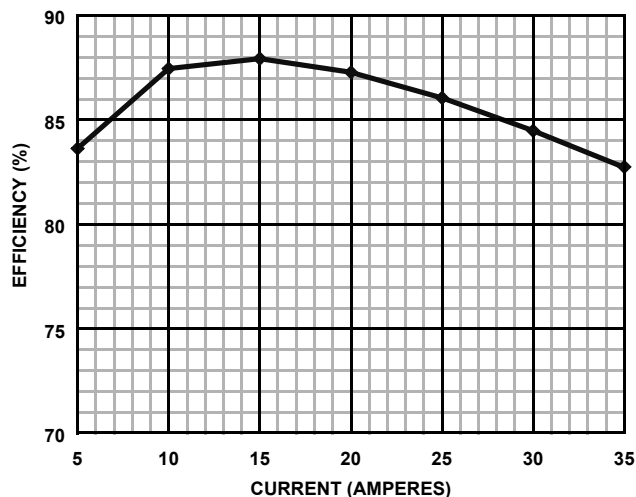


FIGURE 9. EFFICIENCY vs CURRENT

## Summary

The HIP6302EVAL1 is intended to provide a convenient platform to evaluate the performance of the HIP6302 - HIP6601A chip set in the specific implementation indicated in Table 1. The design demonstrates a favorable trade off between low cost, high efficiency, and small footprint. The following pages include schematic, bill of materials, and layout drawings to facilitate implementation of this solution. The evaluation board is simple and convenient to operate, and test points are available to evaluate the most commonly tested parameters. Example waveforms are given for reference.

The HIP6302 and HIP6601A provide a versatile 2-phase power solution for low-voltage applications from 25A to approximately 40A, and together they result in the most effective solution available.

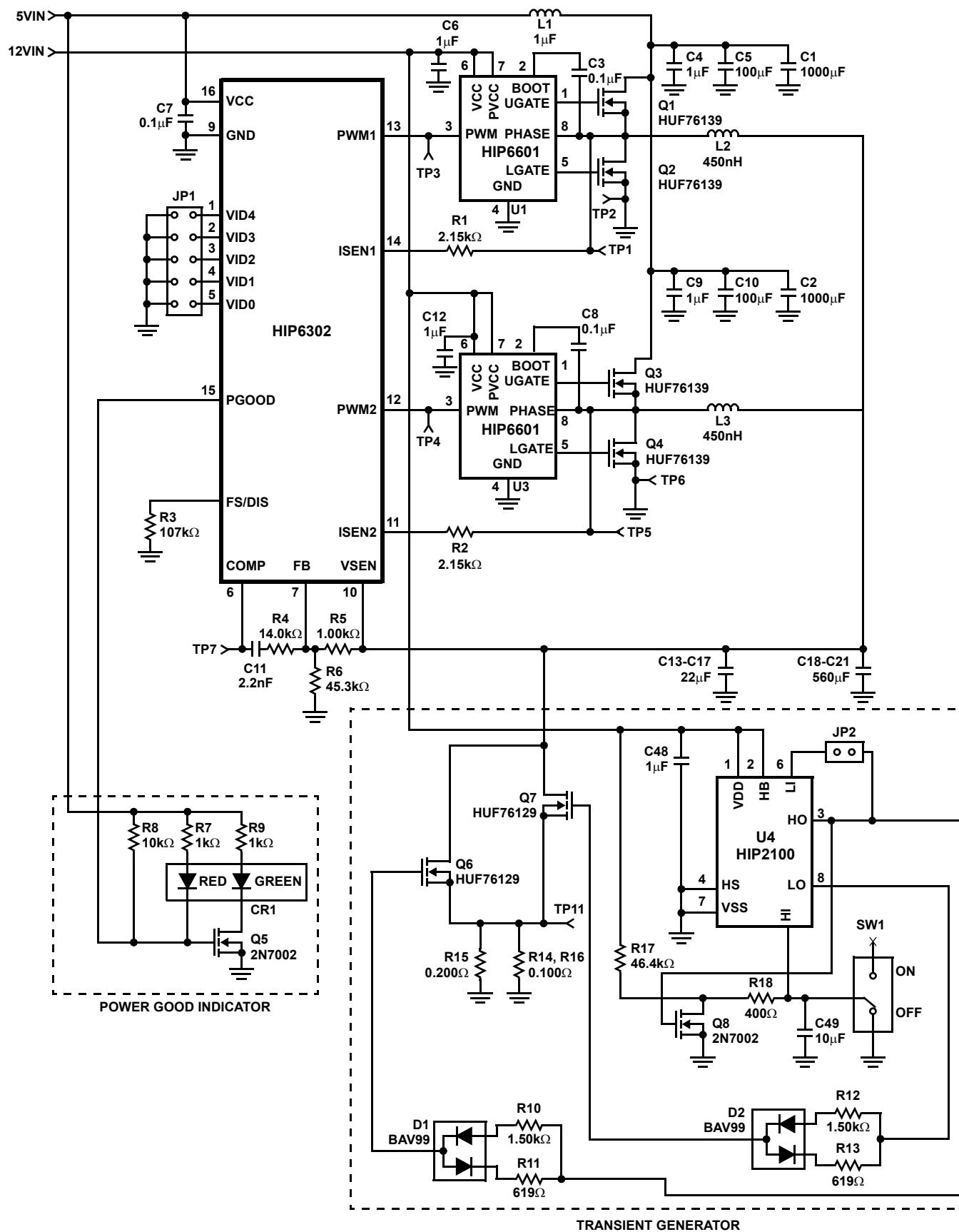
## References

For Intersil documents available on the internet, see web site <http://www.intersil.com/>

Intersil Technical Support 1 (888) INTERSIL

- [1] *HIP6302 Data Sheet*, Intersil Corporation, Power Management Products Division, 2000. (<http://www.intersil.com/>).
- [2] *HIP6601A, HIP6603A Data Sheet*, Intersil Corporation, Power Management Products Division, 2000.
- [3] *HIP6602A Data Sheet*, Intersil Corporation, Power Management Products Division, 2000.

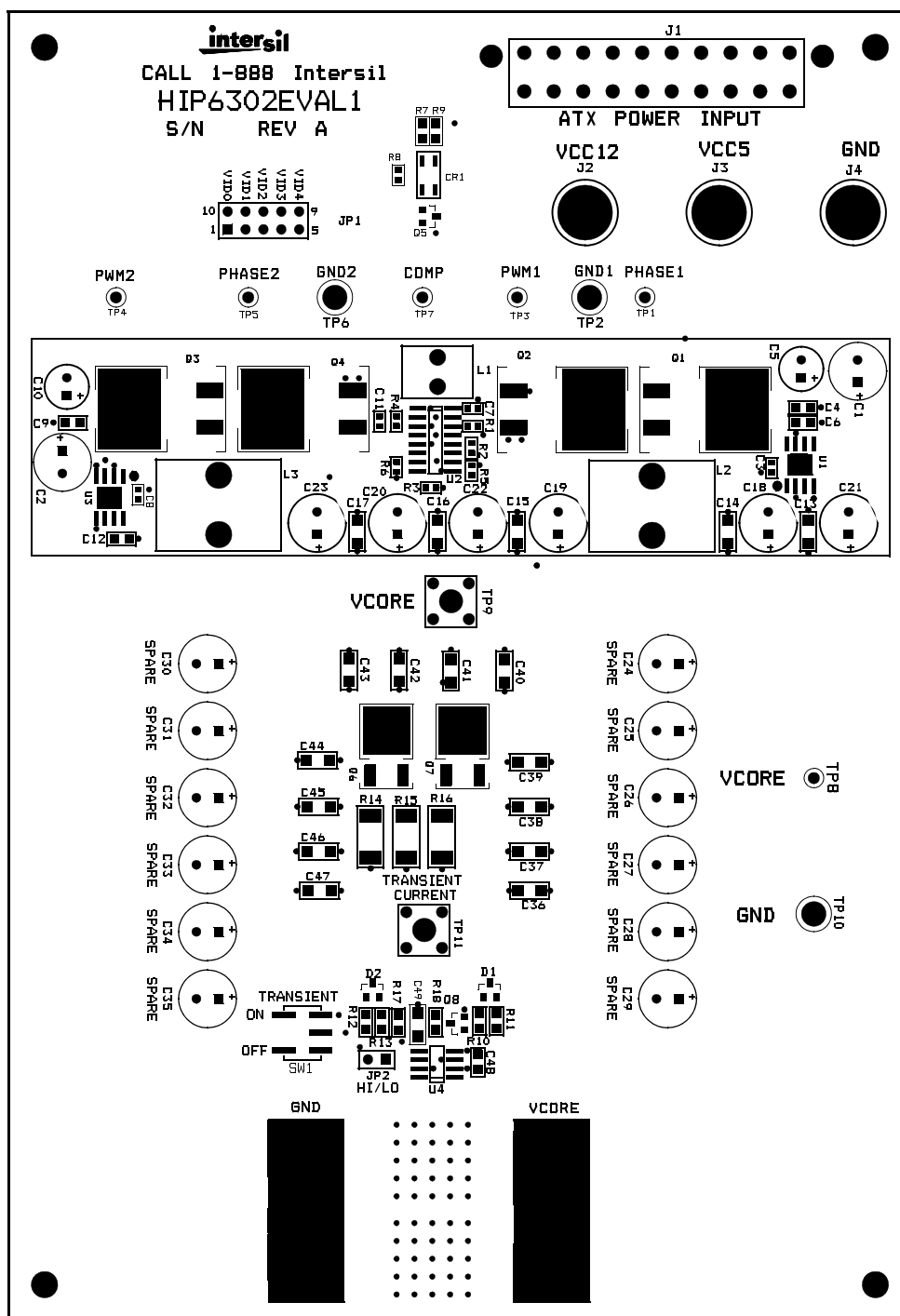
# Schematic



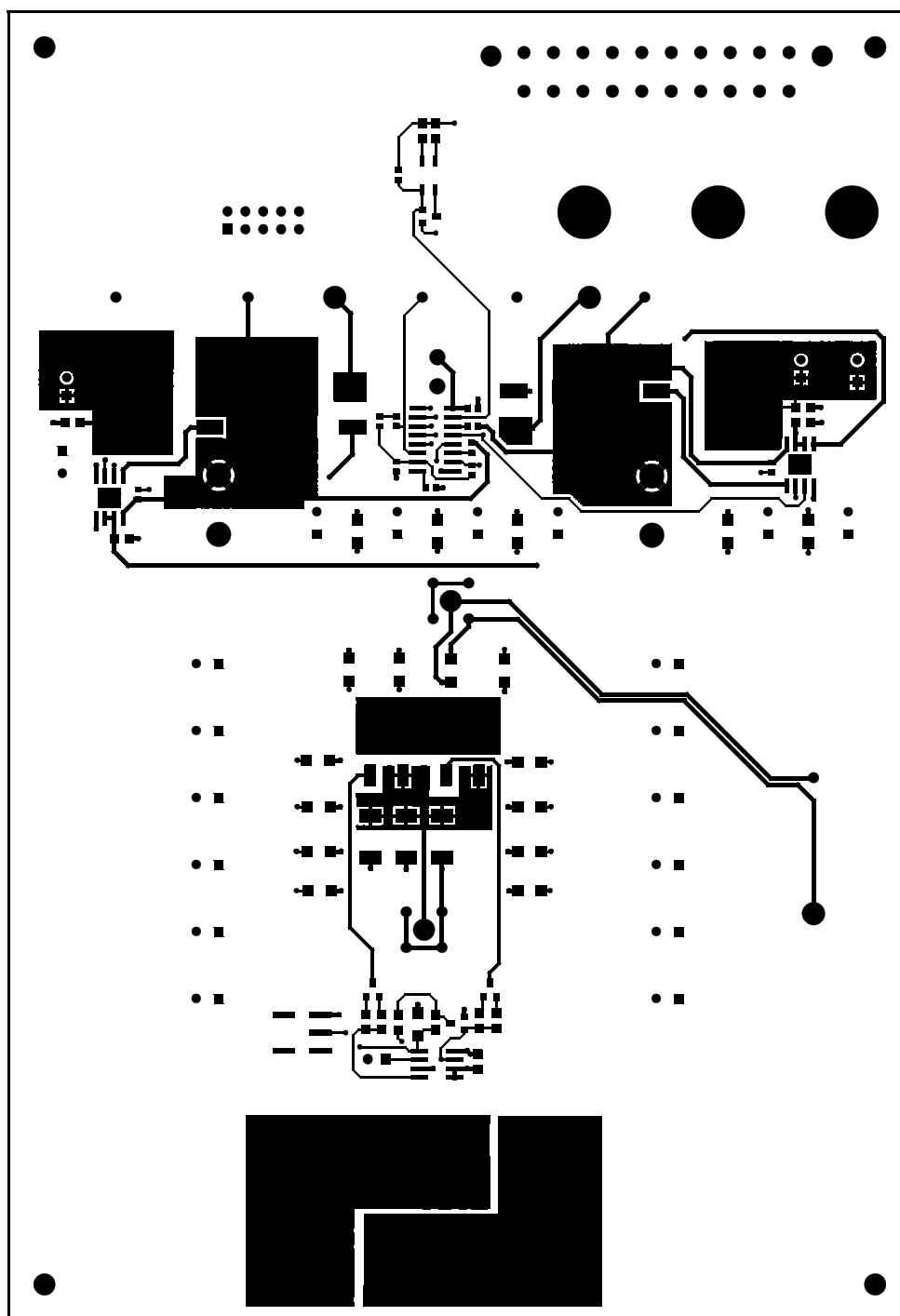
**Bill of Materials**

QTY	REFERENCE	DESCRIPTION	PACKAGE	VENDOR	PART NO.
1	CR1	RED/GREEN LED	SMT	Lumex	SSL-LXA3025IGC
2	C1, C2	1000 $\mu$ F, 10V, Aluminum Capacitor	Radial	Panasonic	EEUFC1A102L
3	C3, C7, C8	0.1 $\mu$ F, 25V, Y5V, Ceramic Capacitor	0603	Various	
5	C4, C6, C9, C12, C48	1.0 $\mu$ F, 25V, Y5V, Ceramic Capacitor	0805	Various	
2	C5, C10	100 $\mu$ F, 16V, OS-CON Capacitor	Radial	Sanyo	16SPS100M
1	C11	2.2nF, 50V, X7R, Ceramic Capacitor	0603	Various	
5	C13-C17, C49	10 $\mu$ F, 10V, X7R, Ceramic Capacitor	1206	Various	
4	C19, C20, C22, C23	560 $\mu$ F, 4V, OS-CON Capacitor	Radial	Sanyo	4SP560M
2	C18, C21	Spare	Radial		
24	C24-C47	Spare	1206		
2	D1, D2	Dual Diode	SOT23	Various	BAV99
1	JP1	5-Position Jumper Header	100mil Centers	Berg	68000-236
5		Jumpers		Berg	71363-102
1	JP2	1-Position Header	100mil Centers	Berg	68000-236
1		Jumper		Berg	71363-102
1	J1	ATX Power Header		Berg	39-29-9203
2	J2, J3	Female Banana Connector, Red		Johnson Components	111-0702-001
1	J4	Female Banana Connector, Black		Johnson Components	111-0703-001
2	J5, J6	Terminal Connector		Burndy	KPA8CTP
1	L1	1 $\mu$ H, T30-26, 6T AWG18	400x300mil	Falco	TTIG0803-127
2	L2, L3	450nH, T60-8/90, 5T AWG14	700x500mil	Falco	TTIB1506-478
4	Q1, Q2, Q3, Q4	Power MOSFETs	TO-263AB	Intersil	HUF76139S3S
2	Q5, Q8	General Purpose MOSFET	SOT23	Various	2N7002
2	Q6, Q7	Power MOSFET	TO-252AA	Intersil	HUF76129D3S
2	R1, R2	Resistor, 2.15k $\Omega$ , 1%, 1/10W	0603	Various	
1	R3	Resistor, 107k $\Omega$ , 1%, 1/10W	0603	Various	
1	R4	Resistor, 14.0k $\Omega$ , 1%, 1/10W	0603	Various	
1	R5	Resistor, 1.00k $\Omega$ , 1%, 1/10W	0603	Various	
1	R6	Resistor, 45.3k $\Omega$ , 1%, 1/10W	0603	Various	
2	R7, R9	Resistor, 1.0k $\Omega$ , 5%, 1/8W	0805	Various	
1	R8	Resistor, 10k $\Omega$ , 5%, 1/10W	0603	Various	
2	R10, R12	Resistor, 1.50k $\Omega$ , 1%, 1/8W	0805	Various	
2	R11, R13	Resistor, 619 $\Omega$ , 1%, 1/8W	0805	Various	
2	R14, R16	Resistor, 0.100 $\Omega$ , 1%, 1W	2512	Vishay	WSL2512R100FB43
1	R15	Resistor, 0.200 $\Omega$ , 1%, 1W	2512	Vishay	WSL2512R200FB43
1	R17	Resistor, 46.4k $\Omega$ , 1%, 1/8W	0805	Various	
1	R18	Resistor, 400 $\Omega$ , 1%, 1/8W	0805	Various	
1	SW1	Switch, SPDT	SMT	C&K Components	GT11MSCKE
6	TP1, TP3, TP4, TP5, TP7, TP8	Small Test Point		Jolo	SPCJ-123-01
3	TP2, TP6, TP10	Large Test Point		Keystone	1514-2
2	TP9, TP11	Probe Socket		Tektronics	1314353-00
2	U1, U3	Synchronous Buck Driver IC	8-Lead SOIC	Intersil	HIP6601ACB
1	U2	Multiphase Buck Controller IC	16-Lead SOIC	Intersil	HIP6302CB
1	U4	MOSFET Driver IC	8-Lead SOIC	Intersil	HIP2100IB

## Layout Drawing - Components

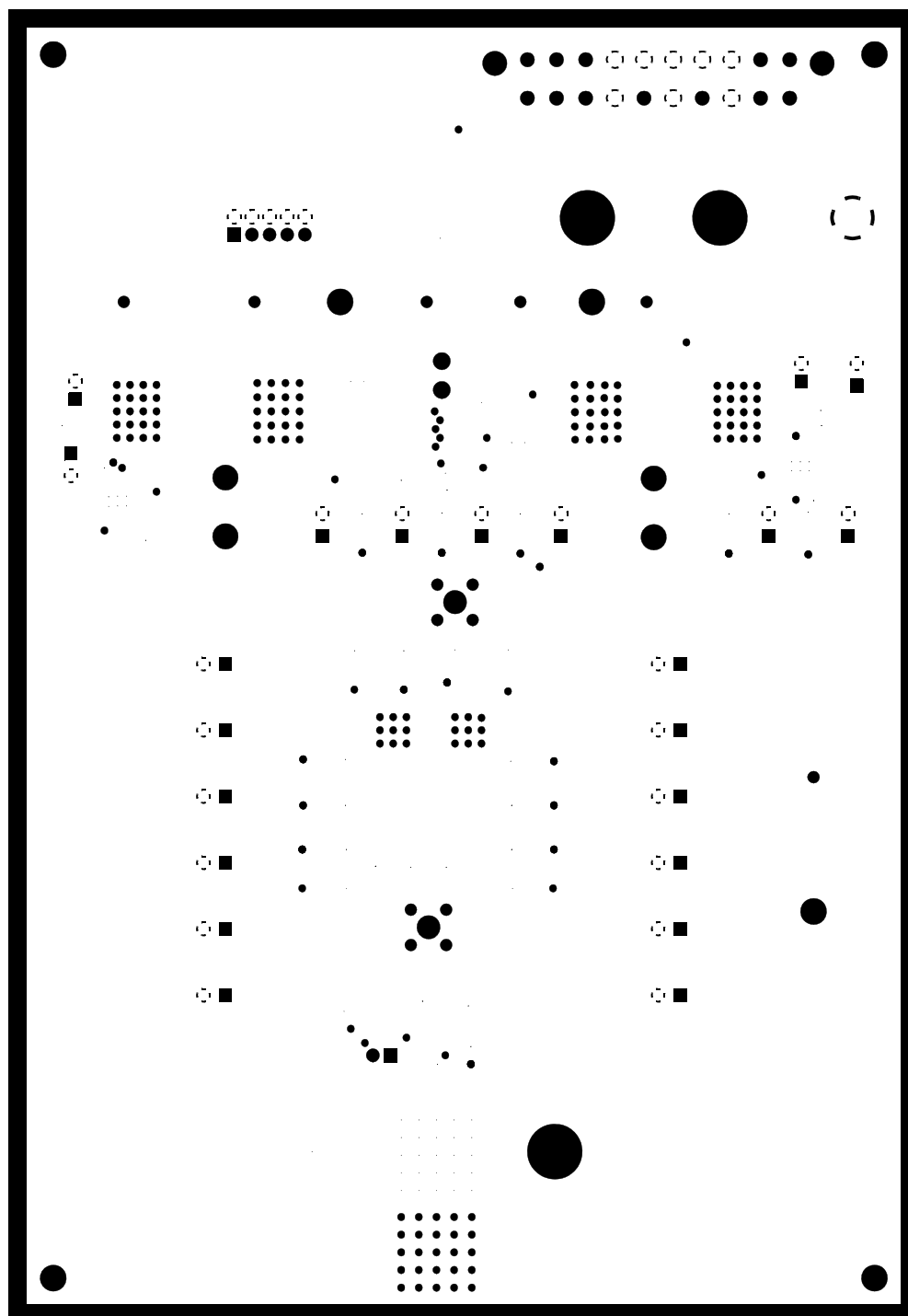


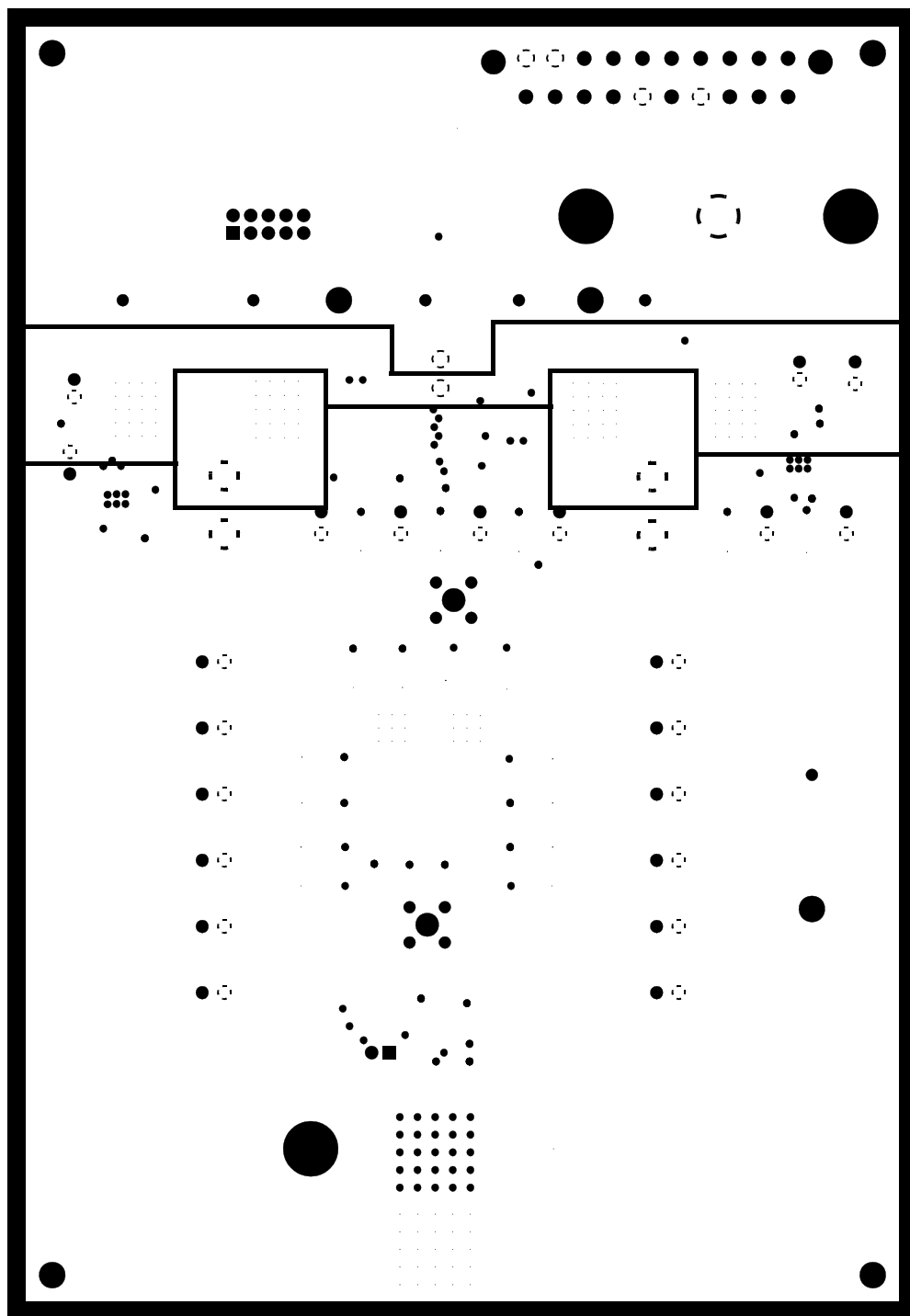
**Layout Drawing - Top Copper**



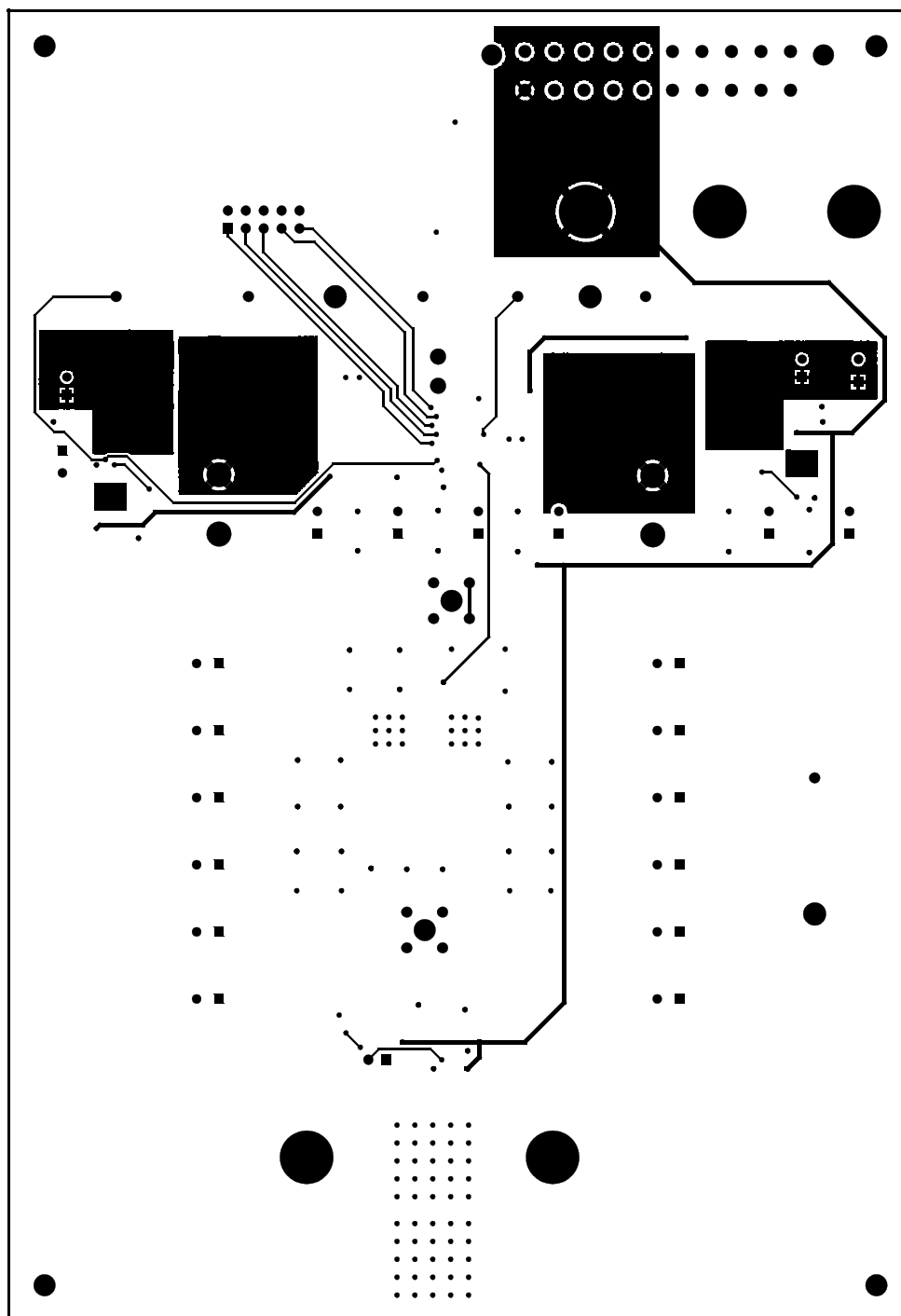


# **Layout Drawing - Ground Plane**



**Layout Drawing - Power Plane**

## Layout Drawing - Bottom Copper



## Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
  2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
  3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
  4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
  5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.
  6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
  7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
  8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
  9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
  10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
  11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
  12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.
- (Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.
- (Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)



### SALES OFFICES

### Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "<http://www.renesas.com/>" for the latest and detailed information.

**Renesas Electronics America Inc.**  
1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.  
Tel: +1-408-432-8888, Fax: +1-408-434-5351

**Renesas Electronics Canada Limited**  
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3  
Tel: +1-905-237-2004

**Renesas Electronics Europe Limited**  
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K  
Tel: +44-1628-651-700, Fax: +44-1628-651-804

**Renesas Electronics Europe GmbH**  
Arcadiastrasse 10, 40472 Düsseldorf, Germany  
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

**Renesas Electronics (China) Co., Ltd.**  
Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China  
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

**Renesas Electronics (Shanghai) Co., Ltd.**  
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China  
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

**Renesas Electronics Hong Kong Limited**  
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong  
Tel: +852-2265-6688, Fax: +852-2886-9022

**Renesas Electronics Taiwan Co., Ltd.**  
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan  
Tel: +886-2-8175-9600, Fax: +886-2-8175-9670

**Renesas Electronics Singapore Pte. Ltd.**  
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949  
Tel: +65-6213-0200, Fax: +65-6213-0300

**Renesas Electronics Malaysia Sdn.Bhd.**  
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia  
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

**Renesas Electronics India Pvt. Ltd.**  
No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India  
Tel: +91-80-67208700, Fax: +91-80-67208777

**Renesas Electronics Korea Co., Ltd.**  
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea  
Tel: +82-2-558-3737, Fax: +82-2-558-5338

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Renesas Electronics:](#)

[HIP6302EVAL1](#)