DEMO MANUAL DC163
DESIGN-READY SWITCHER

LTC1436 Constant-Frequency Synchronous DC/DC Converter with Auxiliary Linear Regulator

DESCRIPTION

Demonstration Circuit DC163 is a 2-input, 2-output dual regulator intended to meet the power requirements of the latest mobile Pentium® processor. It provides the core voltage of 1.8V at 4A from an input of 4.5V to 20V and provides a 2.5V output at 0.5A from an external 3.3V input. The circuit features the LTC®1436 constant-frequency, current mode controller, which regulates both outputs to meet processor-accuracy, regulation and transient requirements. The entire layout requires only 0.7in^2 of board space with surface mount parts on both sides of the board. A power-on reset (POR) signal for the 1.8V output and a low-battery detect (LBO) signal from the LTC1436 are also provided.

DC163 is intended for users requiring a high degree of integration and the smallest layout footprint for their mobile Pentium power supplies.

PERFORMANCE SUMMARY

Operating Temperature Range 0°C to 50°C

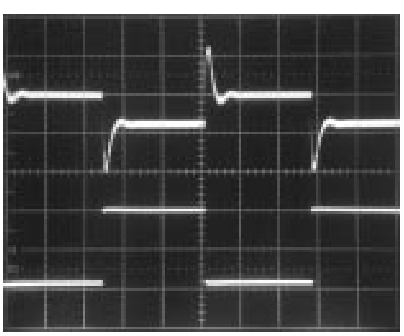
PARAMETER	CONDITIONS	VALUE
Input	Input Voltage Range for 1.8V Output Input Voltage Range for 2.5V Output	4.5V to 20V 3V to 3.5V
Output	DC Output Voltage, 1.8V_O (±3%) DC Output Voltage, 2.5V_O (±5%) Maximum Operating Current, 1.8V_O Maximum Operating Current, 2.5V_O	1.746V to 1.854V 2.375V to 2.625V 4A Continuous 0.5A Continuous
Transient Response	1.8V_O, 0.2A to 4A, 400µF Local Decoupling 2.5V_O, 0.02A to 0.5A, 300µF Local Decoupling	±90mV_{PK} ±20mV_{PK}
POR	Power-On Reset Threshold, 1.8V_O	1.6V to 1.73V
Low-Battery Detector	Threshold, 6V (±5%)	5.7V to 6.3V
Frequency	Typical Switching Frequency, C_{OSC} = 100pF	120kHz

TYPICAL PERFORMANCE CHARACTERISTICS AND BOARD PHOTO

Transient Response

V_O AT 50mV + 200µs/DIV

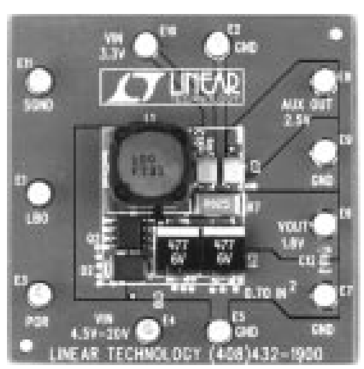
I_L AT 2A + 200µs/DIV



V_{IN} = 12V, V_O = 1.8V
I_L = 0.2A to 4A
LOAD = POWER VALIDATOR

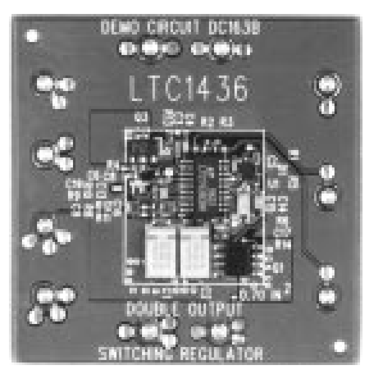
DC163 scope

Component Side



DC093A BD2

Solder Side



DC093A BD1

PACKAGE AND SCHEMATIC DIAGRAMS

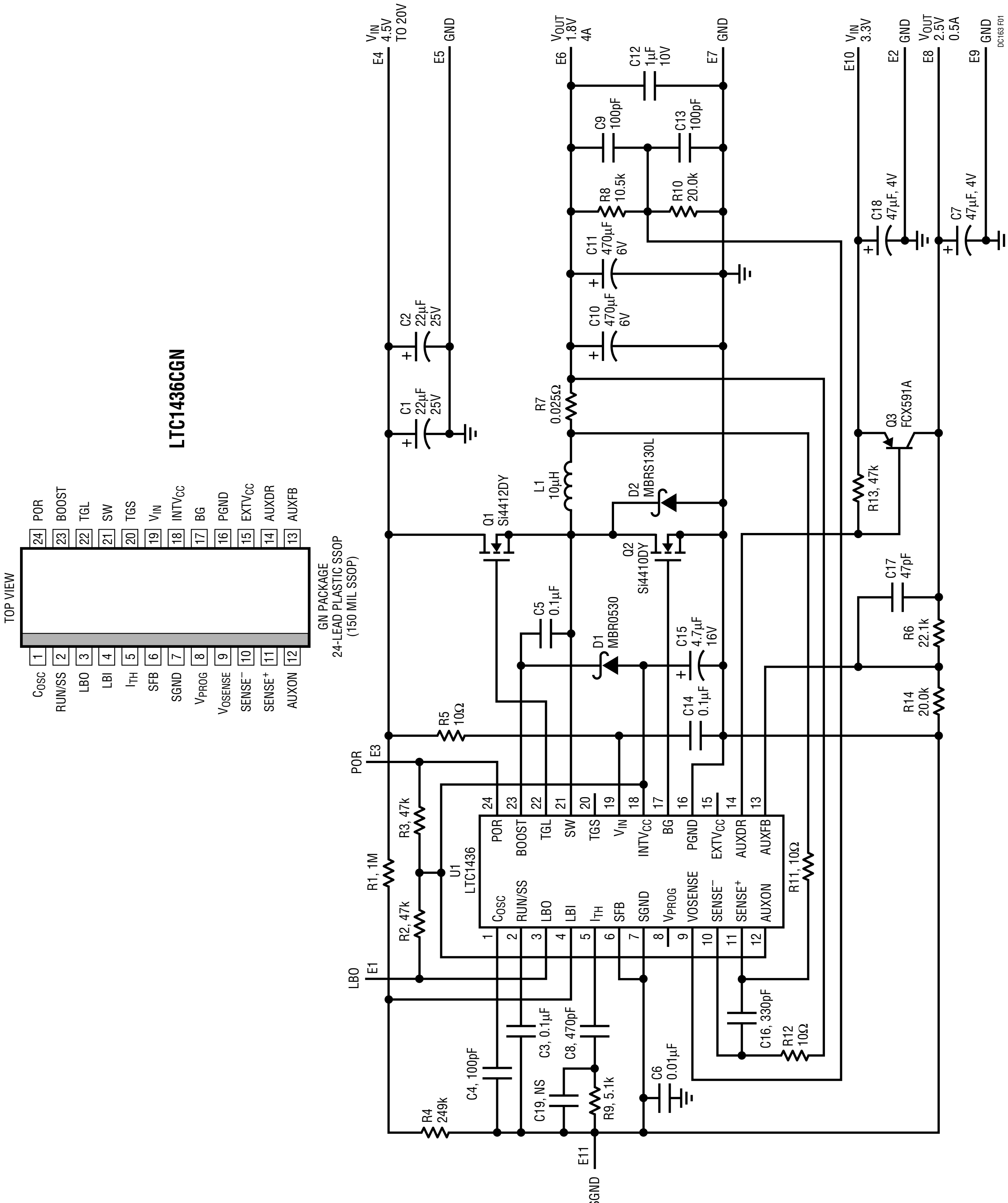


Figure 1. Dual Output LTC1436 Regulator

PARTS LIST

REFERENCE DESIGNATOR	QUANTITY	PART NUMBER	DESCRIPTION	VENDOR	TELEPHONE
C1, C2	2	T495D226M025AS	22µF 25V 20% Tantalum Capacitor	Kemet	(408) 986-0424
C3, C5	2	0603YC104KAT1A	0.1µF 16V 10% X7R Chip Capacitor	AVX	(803) 946-0362
C4, C9, C13	3	06033A101JAT1A	100pF 25V 5% NPO Chip Capacitor	AVX	(803) 946-0362
C6	1	0603YC103KAT1A	0.01µF 16V 10% X7R Chip Capacitor	AVX	(803) 946-0362
C7, C18	2	T494B476M004AS	47µF 4V 20% Tatalum Capacitor	Kemet	(408) 986-0424
C8	1	06033C471JAT1A	470pF 25V 5% NPO Chip Capacitor	AVX	(803) 946-0362
C10, C11	2	TPSV477M006R055	470µF 6.3V 20% Tantalum Capacitor	AVX	(207) 282-5111
C12	1	0805ZC105KAT1A	1µF 10V 10% X7R Chip Capacitor	AVX	(803) 946-0362
C14	1	08055C104KAT1A	0.1µF 50V 10% X7R Chip Capacitor	AVX	(803) 946-0362
C15	1	T494A475M016AS	4.7µF 16V 20% Tantalum Capacitor	Kemet	(408) 986-0424
C16	1	06033C331JAT1A	330pF 25V 5% NPO Chip Capacitor	AVX	(803) 946-0362
C17	1	06033A470JAT1A	47pF 25V 5% NPO Chip Capacitor	AVX	(803) 946-0362
D1	1	MBR0530T3	0.5A 30V Schottky Diode	Motorola	(602) 244-3576
D2	1	MBRS130LT3	1A 30V Schottky Diode	Motorola	(602) 244-3576
E1 to E11	11	2501-2	Turret Terminal	Mill-Max	(516) 922-6000
L1	1	CDRH127-100	10µH Inductor	Sumida	(847) 956-0666
Q1	1	Si4412DY	MOSFET	Siliconix	(800) 554-5565
Q2	1	Si4410DY	MOSFET	Siliconix	(800) 554-5565
Q3	1	FCX591A	PNP Transistor	Zetex	(516) 543-7100
R1	1	CR16-1004FM	1M 1% 0603 Chip Resistor	TAD	(714) 255-9123
R2, R3, R13	3	CR16-473JM	47k 5% 0603 Chip Resistor	TAD	(714) 255-9123
R4	1	CR16-2493FM	249k 1% 0603 Chip Resistor	TAD	(714) 255-9123
R5, R11, R12	3	CR16-100JM	10Ω 5% 0603 Chip Resistor	TAD	(714) 255-9123
R6	1	CR16-2212FM	22.1k 1% 0603 Chip Resistor	TAD	(714) 255-9123
R7	1	LR2512-01-R025-F	0.025Ω 1% 2512 Chip Resistor	IRC	(512) 992-7900
R8	1	CR16-1052FM	10.5k 1% 0603 Chip Resistor	TAD	(714) 255-9123
R9	1	CR16-512JM	5.1k 5% 0603 Chip Resistor	TAD	(714) 255-9123
R10, R14	2	CR16-2002FM	20k 1% 0603 Chip Resistor	TAD	(714) 255-9123
U1	1	LTC1436CGN	IC	LTC	(408) 432-1900

QUICK START GUIDE

This demonstration board is easy to set up for evaluation of the LTC1436 in low voltage processor applications. Please follow the procedure outlined below for proper operation.

1. Before turning on power, connect the input voltage power supplies, output voltage loads and meters as shown in Figure 2. For best accuracy, it is important to connect true RMS reading voltmeters directly to the PCB terminals where the input and output voltages are to be measured. True RMS reading ammeters should be used for current measurements.
2. Turn on external power supplies and adjust input voltages and DC load currents as required. Power supply sequencing is not required. Either external power supply can be turned on while the other is turned off without damaging the demonstration board. Both external power supplies must be turned on for the 2.5V regulator to operate.
3. For pulsed-load testing, disconnect the DC loads and set the pulsed-load currents as shown in Figure 2. A pulsed-load switching frequency between 100Hz and 1kHz is recommended. For optimum transient response, it is important to keep the lead lengths as short as possible between the load and the output terminals. Proper transient voltage measurements are made directly across the decoupling capacitance at the load. Use of the Intel Power Validator® is recommended to properly simulate Pentium load transients.

Power Validator is a registered trademark of Intel Corp.

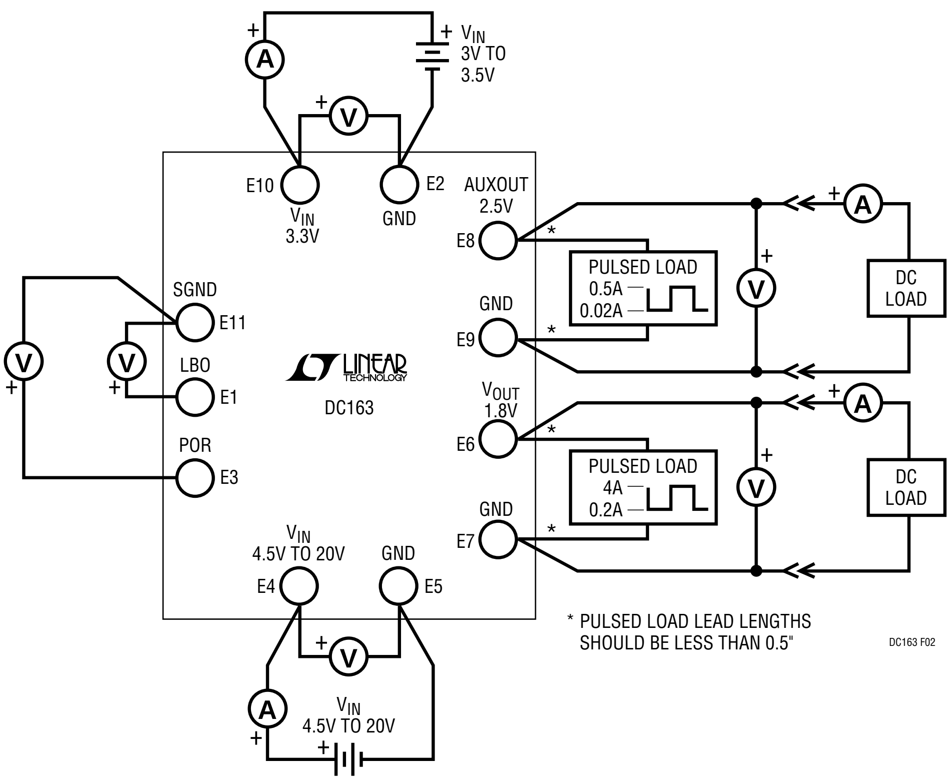


Figure 2. Proper Measurement Setup

OPERATION

Introduction

DC163 was specifically developed to regulate the core and I/O voltages required by the mobile Pentium processor. Figure 1 shows the LTC1436 in a synchronous buck configuration that controls the core voltage output of 1.8V, 4A. The constant-frequency current mode operation of the LTC1436 ensures good load and line regulation and good transient response. The internal auxiliary regulator controls the I/O voltage output of 2.5V, 0.5A.

The operation of DC163 is best understood by first reading the LTC1436 data sheet.

High Current Components

Capacitors C1 and C2 are input filter capacitors. MOSFETs Q1 and Q2 pulse width modulate the input voltage to the switch inductor L1 at a duty cycle determined by the input voltage. Inductor current is measured by the current sense resistor, R7. Capacitors C10 and C11 are output capacitors that smooth the output voltage and supply the leading-edge transient current required by the fast switching Pentium processor. To avoid shoot-through current, a short dead-time exists before the conduction of each MOSFET. During this dead-time, commutating diode D2 conducts inductor current to the load.

Input voltage to the LTC1436 is decoupled by resistor R5 and capacitor C14. Capacitor C15 filters the $INTV_{CC}$ bias supply and provides the energy source for the D1/C5 charge pump that powers the Q1 gate driver.

Output Voltage Programming

By not terminating the V_{PROG} pin, the output can be programmed to any voltage from 1.5V to 9V using external resistors. Feedback resistors R8 and R10 program the core voltage output to 1.8V. Capacitor C9 adds phase lead to the control loop for improved transient response; C13 provides local decoupling of the feedback signal at the V_{OSENSE} pin. Refer to the LTC1436 data sheet for other programming features of the V_{PROG} pin.

Control Loop

The LTC1436 uses a transconductance-type error amplifier with a g_m of 1mS and an output impedance of 210kΩ. The output of the error amplifier is brought out on the I_{TH} pin, where the primary loop compensation components are connected. Capacitor C8 controls bandwidth and resistor R9 controls the high frequency gain of the error amplifier. Although not installed, C19 could be used to roll off high frequency gain.

A fraction of the I_{TH} pin voltage is level shifted and used as the current-comparator threshold to which the inductor current is compared. The $SENSE^+$ and $SENSE^-$ pins connect the current comparator to the sense resistor, R7. When the voltage across R7 equals the current-comparator threshold voltage, the top MOSFET is turned off; after a short delay, the bottom MOSFET is turned on. R11, R12 and C16 attenuate PCB-generated noise in the traces connecting the SENSE pins to R7.

Switching Frequency

The 120kHz operating frequency of the LTC1436 is determined by the 100pF value of capacitor C4. This frequency was chosen to eliminate the pulse skipping that occurs when the top MOSFET on-time drops below the 0.6μs limit of the LTC1436. The low duty cycle caused by a 20V input and 1.8V output creates this low on-time condition.

Run/Soft Start

The dual purpose RUN/SS pin allows the user to program the start-up current rise time or to shut down the operation of the LTC1436. At start-up, the beginning of the output voltage ramp is delayed and the slope of the output current ramp is controlled by the value of capacitor C3. This capacitor is charged by a 3μA current source and the voltage across it must rise to 1.3V before the output voltage starts to rise. Consequently, the value of C3 will delay the output voltage by a period of approximately 0.5s/μF. As the voltage across C3 continues to rise, the maximum output current capability increases from zero to full current during a period that is also equal to the 0.5s/μF of C3.

The core voltage rise can be started before or after another voltage rise by changing the value of C3. This allows the start-up sequencing of two output voltages by changing one capacitor value. Pulling the RUN/SS pin below 1.3V

OPERATION

will turn off both the 1.8V and 2.5V outputs and decrease the IC input current to less than 25μA.

Low-Battery Comparator

An input voltage threshold of 6V was arbitrarily chosen to demonstrate the low-battery comparator operation. Resistors R1 and R4 attenuate a 6V input to the 1.19V switching threshold of the LBI pin. For input voltages lower than 6V, the low-battery comparator pulls the LBO pin low. When the input voltage exceeds 6V, R2 pulls the LBO pin to 5V. Hysteresis is built into the comparator to ensure oscillation-free switching.

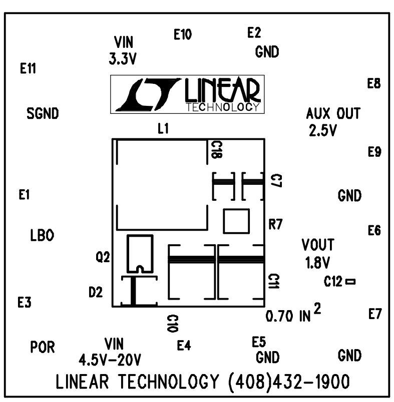
Power-On Reset

The power-on reset circuit has two functions. It sends the microprocessor a time-delayed signal indicating that the core voltage is within operable limits at start-up and it alerts the microprocessor if the core voltage falls 7.5% out of tolerance. At start-up, the POR pin is low, indicating that the core voltage is out of regulation. When the core voltage reaches 95% of its normal value, an internal counter in the LTC1436 counts 65,536 cycles of C_{OSC} before releasing the low voltage on the POR pin. The POR output is pulled up by resistor R3. If the core voltage drops 7.5% lower than the regulated value, the POR pin goes low.

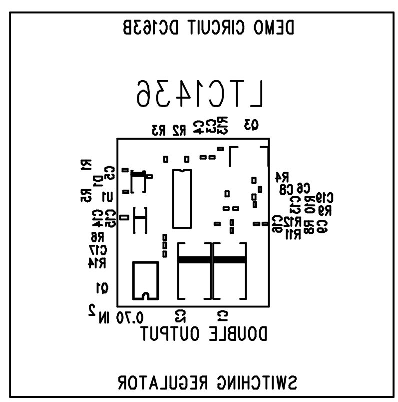
I/O Voltage Regulator

The 3.3V input is postregulated to control the I/O voltage output. The LTC1436 auxiliary regulator controls Q3, the PNP pass transistor, to maintain a constant 2.5V output for load currents from zero to 0.5A. C18 and C7 are input and output capacitors, respectively. Resistors R6 and R14 are feedback resistors; C17 provides phase lead to improve load transient response. This circuit does not have load current limiting, so shorting the output may damage Q3.

PCB LAYOUT AND FILM

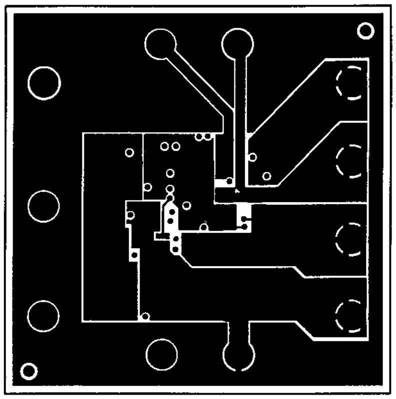


Component Side Silkscreen

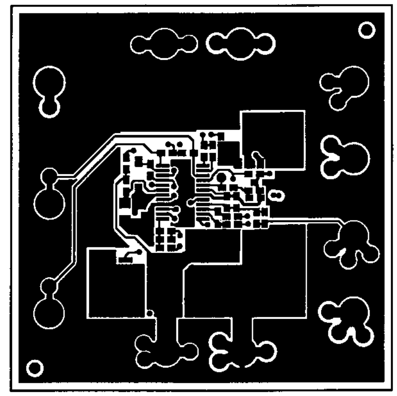


Solder Side Silkscreen

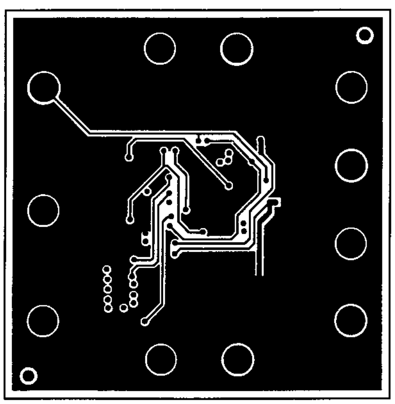
PCB LAYOUT AND FILM



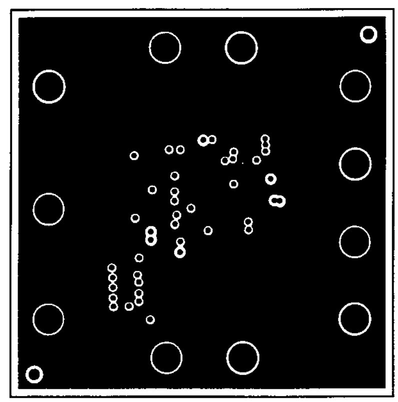
Component Side Layer



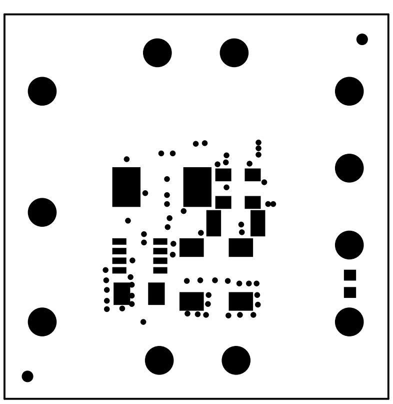
Solder Side



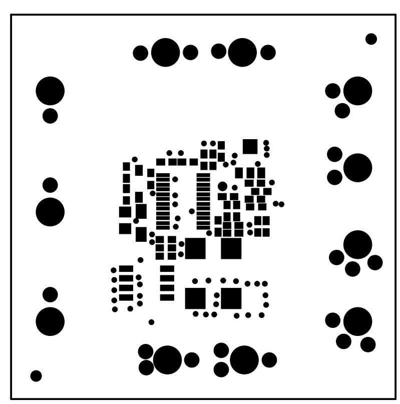
Inner 1



Inner 2

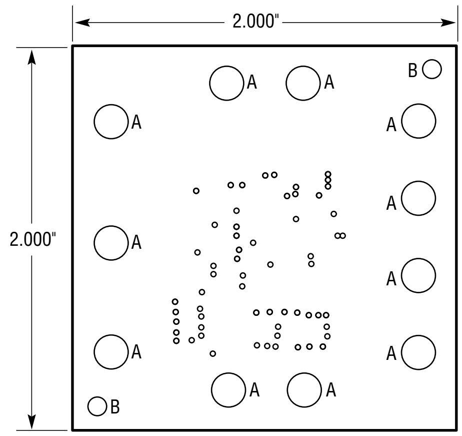


Component Side Solder Mask



Solder Side Solder Mask

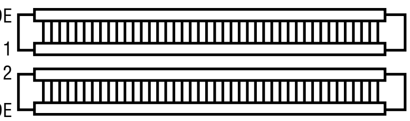
PC FAB DRAWING



HOLE CHART FOR SINGLE IMAGE

SYMBOL	DIAMETER	NUMBER OF HOLES	PLATED
A	0.94	11	YES
B	0.070	2	NO
UNMARKED	0.010	60	YES
	TOTAL HOLES	73	

LAYER CONSTRUCTION



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