

LT1959 Monolithic 4A Switcher 5V to 15V Input 1.8V Output

DESCRIPTION

Demonstration circuits DC355A and DC356A are complete DC/DC step-down regulators using the LT[®]1959 constant frequency, high efficiency converter in 7-pin DD (DC356A) and SO-8 (DC355A) packages. These circuits are primarily used in personal computers, disk drives, portable handheld devices and, in larger systems, as local onboard

regulators. High frequency switching allows the use of small inductors, making this all-surface-mount solution ideal for space conscious systems.

Design files for this circuit board are available at www.analog.com.

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PERFORMANCE SUMMARY

$T_A = 25^\circ\text{C}$, $V_{IN} = 5\text{V}$, $I_{LOAD} = 2\text{A}$, $V_{OUT} = 1.8\text{V}$, $\overline{\text{SHDN}}$ and SYNC pins open, unless otherwise specified.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	(Note 1)	1.75	1.8	1.85	V
Maximum I_{LOAD}	(Note 2)	4.3			A
Input Voltage Range		5		15	V
Switching Frequency		460	500	540	kHz
Output Ripple Voltage			25		mV _{P-P}
Line Regulation	5V to 10V		4		mV
Load Regulation	$I_{LOAD} = 10\text{mA}$ to 4A		10		mV
$\overline{\text{SHDN}}$ Lockout Threshold		2.3	2.38	2.46	V
$\overline{\text{SHDN}}$ Shutdown Threshold		0.15	0.37	0.6	V
Synchronization Range	DC355A Only	580		1000	kHz
Supply Current	$\overline{\text{SHDN}} = 0\text{V}$		20		μA

Note 1: Output voltage variations include $\pm 1\%$ tolerance of feedback divider network.

Note 2: For DC355A, additional thermal restrictions apply.

BOARD PHOTOS

DC355A Component Side

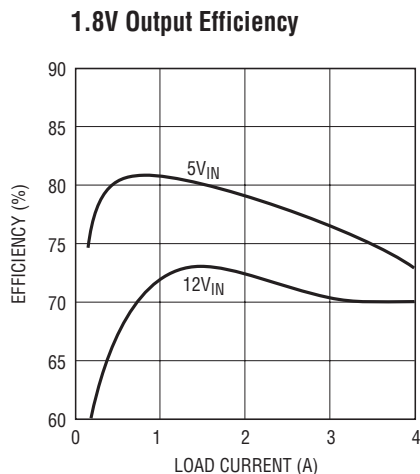


DC356A Component Side

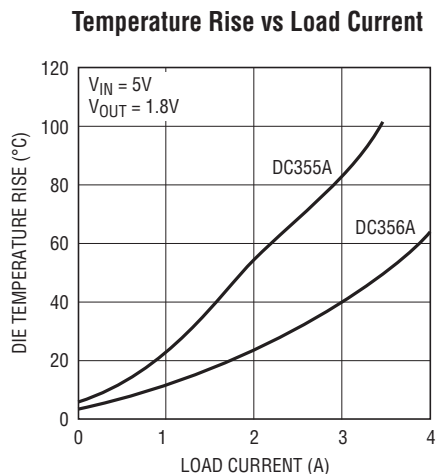


DEMO MANUAL DC355A/DC356A NO-DESIGN SWITCHER

TYPICAL PERFORMANCE CHARACTERISTICS



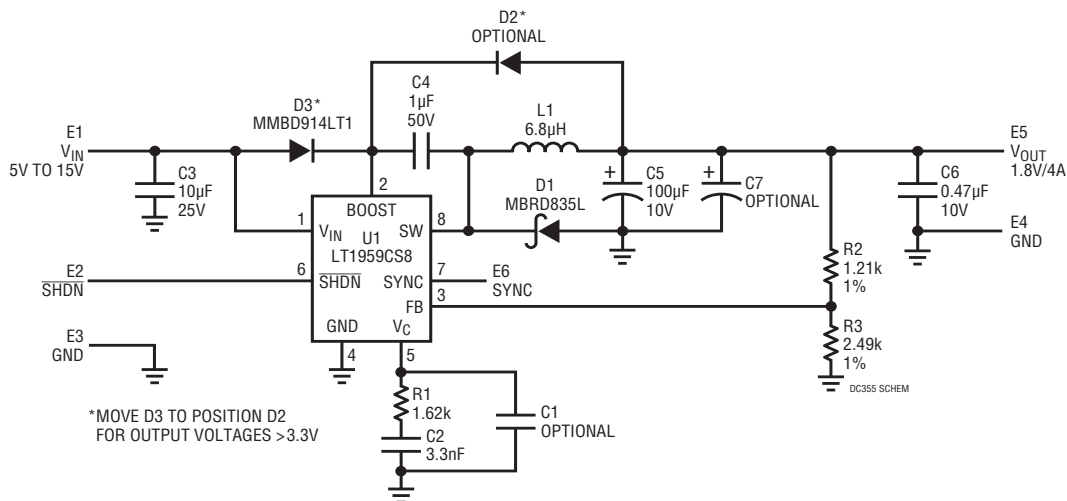
DC355/356 TA01



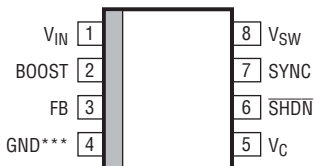
DC3556 TA02

PACKAGE AND SCHEMATIC DIAGRAMS

DC355A



TOP VIEW



S8 PACKAGE
8-LEAD PLASTIC SO

$T_{JMAX} = 150^{\circ}\text{C}$, $\theta_{JA} = 80^{\circ}\text{C/W}$

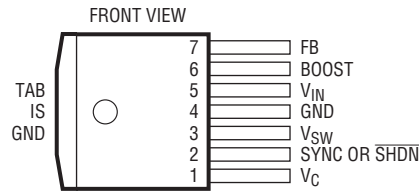
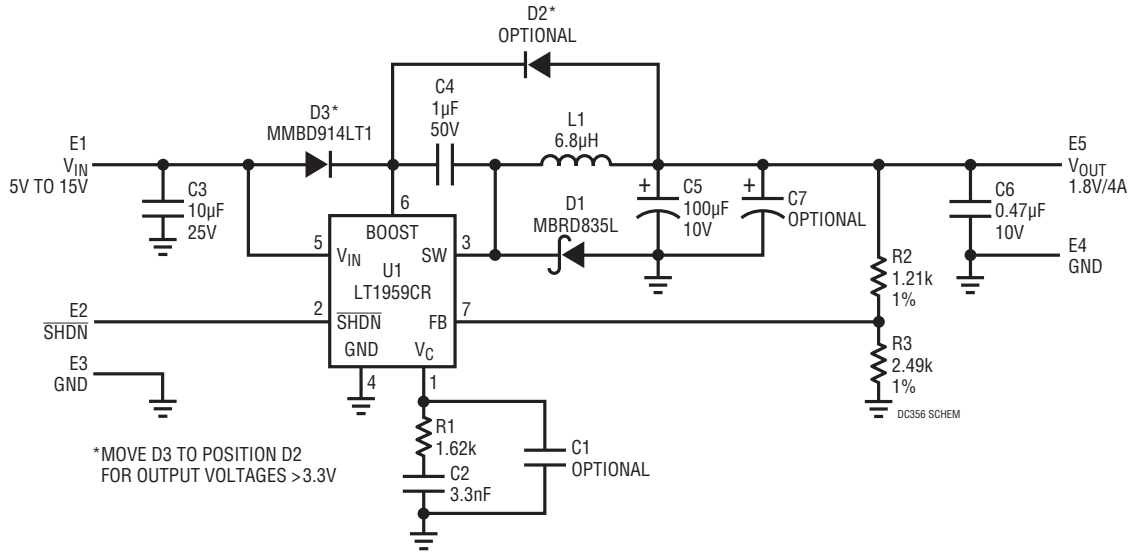
***WITH (FUSED GND) GROUND PIN CONNECTED TO GROUND PLANE OR LARGE LANDS

LT1959CS8

Rev A

PACKAGE AND SCHEMATIC DIAGRAMS

DC356A



R PACKAGE
7-LEAD PLASTIC DD PAK

LT1959CR

DEMO MANUAL DC355A/DC356A

NO-DESIGN SWITCHER

PARTS LISTS

DC355A

REFERENCE DESIGNATOR	QTY	PART NUMBER	DESCRIPTION	MANUFACTURER
C1	0		CAP, OPTIONAL	
C2	1	C0805X332K5RECTU	CAP, CER, 3.3nF, 10%, 50V, X7R, 0805	KEMET
C3	1	CL32B106KAJNNNE	CAP, CER, 10µF, 25V, X7R, 1210	Samsung Electro-Mechanics
C4	1	GCM21BR71H105MA03L	CAP, CHIP, 1µF, 5%, 50V, X7R, 0805	Murata Electronics
C5	1	TPSD107M010R0065	CAP, TANT, 100µF, 10V, CASE-D	KYOCERA AVX
C6	1	0603ZG474ZAT2A	CAP, CER, 470nF, 10V, Y5V, 0603	KYOCERA AVX
C7	0		CAP, OPTIONAL	
D1	1	MBRD835LT4G	DIODE, SCHOTTKY, 35V, 8A, DPAK	onsemi
D2	0		DIODE, OPTIONAL	
D3	1	MMBD914LT1G	DIODE, STANDARD, 100V, 200mA, SOT-23-3	onsemi
E1-E6	6	2501-2	TURRET, PAD 0.092	Mill-Max
R1	1	KTR10EZPF1621	RES, CHIP, 1.62kΩ, 1%, 1/8W, 0805	Rohm Semiconductor
R2	1	RC0805FR-071K21L	RES, CHIP, 1.21kΩ, 1%, 1/8W, 0805	YAGEO
R3	1	CRCW08052K49FKEAC	RES, CHIP, 2.49kΩ, 1%, 1/8W, 0805	Vishay Dale
L1	1	DO3316P-682MLD	INDUCTOR, 6.8µH, 20%, DO3316P-682	Coilcraft
U1	1	LT1959CS8	IC, ANALOG DEVICES, LT1959CS8, SO-8	Analog Devices

DC356A

REFERENCE DESIGNATOR	QTY	PART NUMBER	DESCRIPTION	MANUFACTURER
C1	0		CAP, OPTIONAL	
C2	1	C0805X332K5RECTU	CAP, CER, 3.3nF, 10%, 50V, X7R, 0805	KEMET
C3	1	CL32B106KAJNNNE	CAP, CER, 10µF, 25V, X7R, 1210	Samsung Electro-Mechanics
C4	1	GCM21BR71H105MA03L	CAP, CHIP, 1µF, 5%, 50V, X7R, 0805	Murata Electronics
C5	1	TPSD107M010R0065	CAP, TANT, 100µF, 10V, CASE-D	KYOCERA AVX
C6	1	0603ZG474ZAT2A	CAP, CER, 470nF, 10V, Y5V, 0603	KYOCERA AVX
C7	0		CAP, OPTIONAL	
D1	1	MBRD835LT4G	DIODE, SCHOTTKY, 35V, 8A, DPAK	onsemi
D2	0		DIODE, OPTIONAL	
D3	1	MMBD914LT1G	DIODE, STANDARD, 100V, 200mA, SOT-23-3	onsemi
E1-E6	6	2501-2	TURRET, PAD 0.092	Mill-Max
R1	1	KTR10EZPF1621	RES, CHIP, 1.62kΩ, 1%, 1/8W, 0805	Rohm Semiconductor
R2	1	RC0805FR-071K21L	RES, CHIP, 1.21kΩ, 1%, 1/8W, 0805	YAGEO
R3	1	CRCW08052K49FKEAC	RES, CHIP, 2.49kΩ, 1%, 1/8W, 0805	Vishay Dale
L1	1	DO3316P-682MLD	INDUCTOR, 6.8µH, 20%, DO3316P-682	Coilcraft
U1	1	LT1959CR	IC, ANALOG DEVICES, LT1959CR, DD Pak	Analog Devices

OPERATION

DC355A vs DC356A (Temperature vs Package Size)

The DC355A and DC356A demonstration boards are intended for evaluation of the LT1959 switching regulator in the SO-8 and 7-pin DD packages, respectively. The 7-pin DD package used on DC356A has no SYNC pin. The primary reason for choosing the SO-8 over the DD package is board space. The DC356A (DD package) occupies an active board area of approximately 0.75 square inches. By optimizing the DC355A board, using a Sumida coil and removing the layout options, a total active area of 0.4 square inches can be achieved. The DD package is more suitable for higher power or higher ambient temperature applications. Although both boards will supply 4A of output current, DC355A must be thermally derated to 3A continuous current at 22°C ambient to prevent excessive die temperatures. DC356A can run at 60°C ambient at 4A output current. However, the SO-8 package can be used for dynamic loads up to the full rated switch current.

LT1959 Operation

The LT1959 data sheet gives a complete description of the part, operation and applications information. The data sheet should be read in conjunction with this demo manual.

Hook-Up

Solid turret terminals are provided for easy connection to supplies and test equipment. Connect a 0V to 10V, 5A power supply across the V_{IN} and GND terminals and the load across the V_{OUT} and GND terminals. When measuring load/line regulation, remember to Kelvin connect to the turrets. Also, when measuring output ripple voltage with an oscilloscope probe, the wire from the probe to the ground clip will act as an antenna, picking up excessive noise. For improved results, the test hook should be removed from the tip of the probe. The tip should be touched against the output turret, with the bare ground shield pressed against the ground turret. This reduces the noise seen on the waveform.

Shutdown

For normal operation, the $\overline{SHDN}$ pin can be left floating. $\overline{SHDN}$ has two output-disable modes: lockout and shutdown. When the pin is taken below the lockout

threshold, switching is disabled. This is typically used for input undervoltage lockout. Grounding the $\overline{SHDN}$ pin places the LT1959 in shutdown mode. This reduces total board supply current to 20 μ A.

Synchronization

Synchronization is available on DC355A only. For normal demo board operation, the SYNC pin can be left floating. If it is not used in the application, it is advisable to tie this pin to ground. To synchronize switching to an external clock, apply a logic-level signal to the SYNC pin. The amplitude must be from a logic low to greater than 2.2V, with a duty cycle between 10% and 90%. The synchronization frequency must be greater than the free-running oscillator frequency and less than 1MHz. Additional circuitry may be required to prevent subharmonic oscillation. Refer to the LT1959 data sheet for more details.

COMPONENTS

Inductor L1

The inductor is a Coilcraft DO3316P-682, a 6.8 μ H unshielded ferrite unit. It was selected for its low cost, small size and 4.6A I_{SAT} rating. The equivalent Coiltronics UP2-6R8 unit can be substituted. If board space is at a premium and higher ripple current is acceptable, solder pads are available for the Sumida CD43-1R8 inductor. This 1.8 μ H unit has a 2.9A I_{SAT} rating. Ripple at 5V $_{IN}$ is ± 0.6 A. This gives a maximum output current of $(4.5A - 0.6A) = 3.9A$.

Input/Output Capacitors C3, C5, C6 and C7

The input capacitor C3 is a Tokin ceramic capacitor. It was selected for its small size, high voltage rating and low ESR (effective series resistance). The input ripple current for a buck converter is high, typically $I_{OUT}/2$. Tantalum capacitors become resistive at higher frequencies, requiring careful ripple-rating selection to prevent excessive heating. Ceramic capacitors' ESL (effective series inductance) tends to dominate their ESR, making them less susceptible to ripple-induced heating.

OPERATION

The output capacitor C5 is an AVX tantalum capacitor. A ceramic is not recommended as the main output capacitor since loop stability relies on a resistive characteristic at higher frequencies to form a zero. The AVX TPS series was specifically designed to have the low ESR required in switch-mode power supplies. At switching frequencies, ripple voltage is more a function of ESR than of absolute capacitance value. If lower output ripple voltage is required, use the optional capacitor C7 to reduce ESR rather than increasing the capacitance of C5. For very low ripple, an additional LC filter in the output may be a less expensive solution. The output contains very narrow voltage spikes because of the parasitic inductance of C5. A small ceramic capacitor, C6, removes these spikes on the demo board. In application, trace inductance and local bypass capacitors will perform this function, negating the need for C6.

Catch Diode D1

Use diodes designed for switching applications, with adequate current rating and fast turn-on times, such as Schottky or ultrafast diodes. In selecting a diode, the basic parameters of interest are forward voltage, maximum reverse voltage, average operating current and peak current. Lower forward voltage yields higher circuit efficiency and lowers power dissipation in the diode. The MBRD835L has a maximum forward drop of 0.4V at 3A. The reverse voltage rating must be greater than the input voltage. Average diode current is always less than output current, but under a shorted output condition, diode current can equal the switch current limit. If the application must withstand this condition, the diode must be rated for maximum switch current.

Compensation: C1, C2, and R1

A detailed discussion of frequency compensation can be found in the LT1959 data sheet. R1 + C2 from V_C to ground give a stable loop response over a wide range of input and output conditions. Optional capacitor C1 is included for optimization of the dynamic response for a specific application.

Boost Voltage: D2, D3, and C4

A boost voltage of at least 2.8V is required throughout the on-time of the switch to guarantee that it remains saturated. For output voltages above 3.3V, diode D2 can replace D3 and provide sufficient boost voltage to C4.

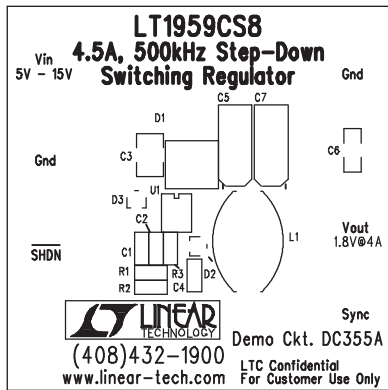
PCB LAYOUT

In many cases, the layout of the demonstration board may be dropped directly into the application with minimal changes. If not, there are several precautions that must be taken when laying out high frequency converter circuits. The high frequency switching path runs from ground, through C3, to the V_{IN} pin of the LT1959, out of the SW pin, through D1 and back to ground. This loop acts as an antenna and will radiate noise if not kept as short as possible. Also, at higher switching currents, the associated trace inductance can cause excessive voltage spikes across the switch. The use of a ground plane will reduce many noise problems. The ground pin of the LT1959 contains some high frequency signal currents, but more importantly, it is the 0V reference for the output voltage. Connect the ground pin directly to the ground plane. The FB and V_C components should be kept away from the power components as much as possible. The ground for these components should be separated from power grounds. Run a Kelvin sense line to V_{OUT} as required but keep the divider network close to the LT1959 to prevent noise pickup on the FB node. Noise pickup on the V_C pin appears as various problems, including poor load regulation, subharmonic oscillation and instability. Thermal management must also be considered. The SO-8 package has a fused ground pin. Soldering this pin to a large copper area will significantly reduce its thermal resistance. Solder-filled feedthroughs close to the ground pin provide a good thermal path to the ground plane. For the DD package, the grounded tab should be treated in the same manner. For more information or advice, contact Analog Devices.

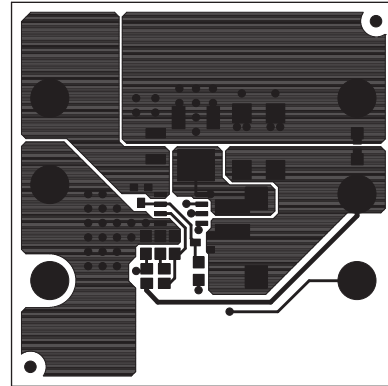
Input Voltage

The components are optimized for an input voltage range of 5V to 10V. The LT1959 can run up to 15V_{IN}, but changes in the discrete components need to be made for proper operation.

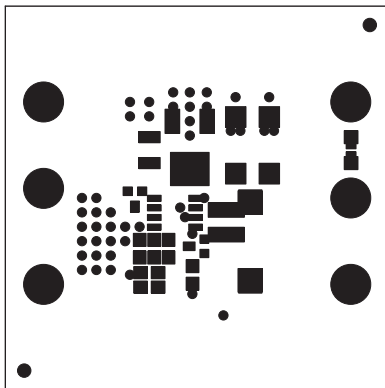
PCB LAYOUT AND FILM (DC355A)



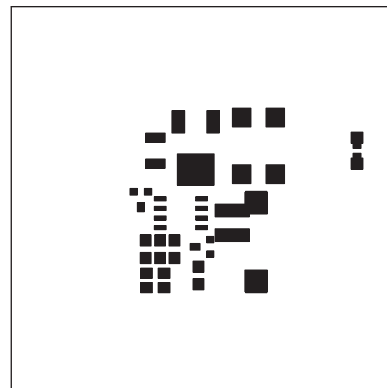
Component Side Silkscreen



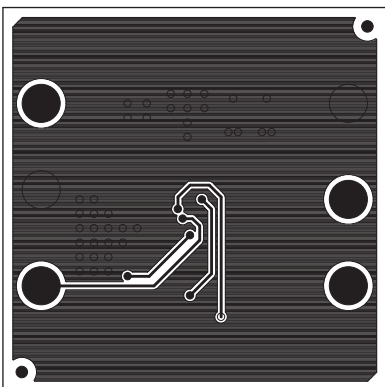
Component Side



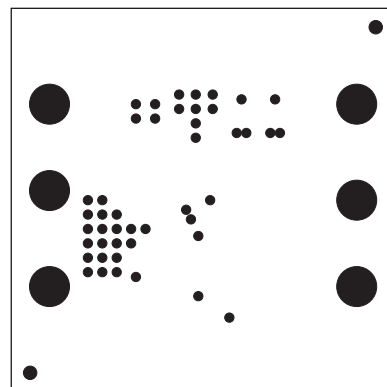
Component Side Solder Mask



Component Side Paste Mask



Solder Side

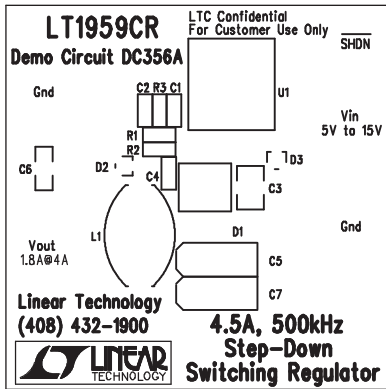


Solder Side Solder Mask

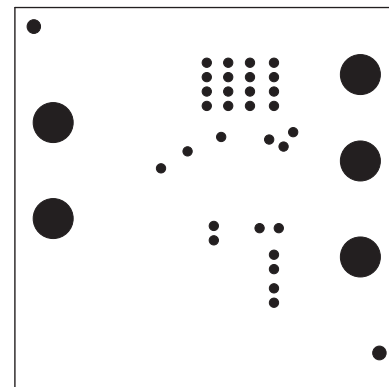
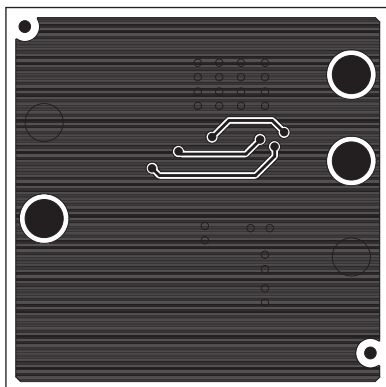
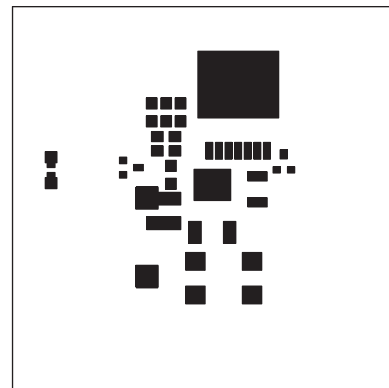
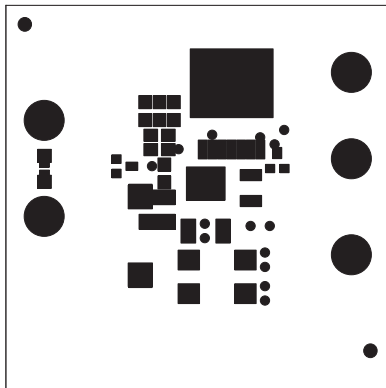
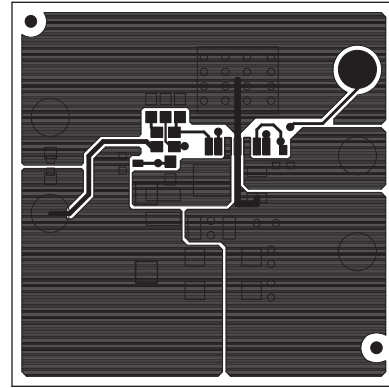
DEMO MANUAL DC355A/DC356A

NO-DESIGN SWITCHER

PCB LAYOUT AND FILM (DC356A)



Component Side Silkscreen

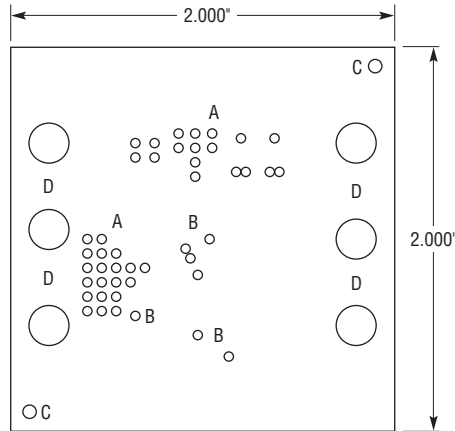


DEMO MANUAL DC355A/DC356A

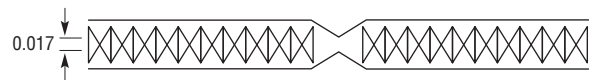
NO-DESIGN SWITCHER

PC FAB DRAWING

DC355A



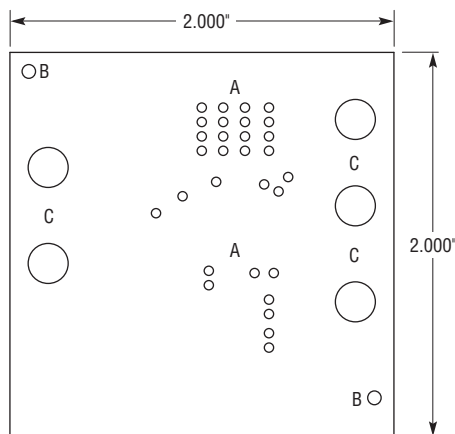
- NOTES: UNLESS OTHERWISE SPECIFIED
1. MATERIAL: FR4 OR EQUIVALENT EPOXY,
2 OZ COPPER CLAD, THICKNESS 0.062 0.006
TOTAL OF 2 LAYERS
 2. FINISH: ALL PLATED HOLES 0.001 MIN/0.0015 MAX
COPPER PLATE, ELECTRODEPOSITED TIN-LEAD COMPOSITION
BEFORE REFLOW, SOLDER MASK OVER BARE COPPER (SMOBC)
 3. SOLDER MASK: BOTH SIDES USING SR1020 OR EQUIVALENT
 4. SILKSCREEN: USING WHITE NONCONDUCTIVE EPOXY INK
 5. ALL DIMENSIONS IN INCHES
 6. SCORING



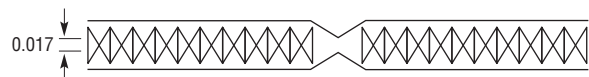
SYMBOL	DIAMETER	NUMBER OF HOLES
A	0.020	38
B	0.025	7
C	0.072	2
D	0.095	6
TOTAL HOLES		53

DC355 FD

DC356A



- NOTES: UNLESS OTHERWISE SPECIFIED
1. MATERIAL: FR4 OR EQUIVALENT EPOXY,
2 OZ COPPER CLAD, THICKNESS 0.062 0.006
TOTAL OF 2 LAYERS
 2. FINISH: ALL PLATED HOLES 0.001 MIN/0.0015 MAX
COPPER PLATE, ELECTRODEPOSITED TIN-LEAD COMPOSITION
BEFORE REFLOW, SOLDER MASK OVER BARE COPPER (SMOBC)
 3. SOLDER MASK: BOTH SIDES USING GREEN SR1020 OR EQUIVALENT
 4. SILKSCREEN: USING WHITE NONCONDUCTIVE EPOXY INK
 5. ALL DIMENSIONS IN INCHES
 6. SCORING



SYMBOL	DIAMETER	NUMBER OF HOLES
A	0.020	30
B	0.072	2
C	0.095	5
TOTAL HOLES		37

DC356 FD

DEMO MANUAL DC355A/DC356A

NO-DESIGN SWITCHER

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