LINEAR TECHNOLOGY

600mA, 1.4MHz Step-Down Switching Regulator in SOT-23

FEATURES

- **Wide Input Range: 3.6V to 25V**
- 5V at 400mA from 7V to 25V Input
- 3.3V at 400mA from 4.7V to 25V Input
- Fixed Frequency 1.4MHz Operation
- Uses Tiny Capacitors and Inductors
- Internally Compensated
- Low Shutdown Current: <1µA
- Low V_{CESAT} Switch: 220mV at 300mA
- Tiny 6-Lead SOT-23 Package

APPLICATIONS

- Wall Transformer Regulation
- Local Logic Supply Conversion:
  12V to 5V
  12V or 5V to 3.3V, 2.5V or 1.8V
- Distributed Supply Regulation
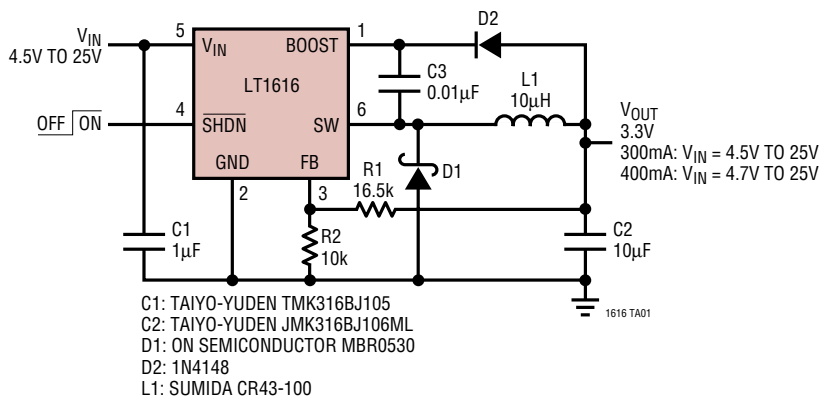- Digital Cameras
- Battery-Powered Equipment

DESCRIPTION

The LT®1616 is a current mode PWM step-down DC/DC converter with internal 0.6A power switch, packaged in a tiny 6-lead SOT-23. The wide input range of 3.6V to 25V makes the LT1616 suitable for regulating a wide variety of power sources, from 4-cell batteries and 5V logic rails to unregulated wall transformers and lead-acid batteries. Its high operating frequency allows the use of tiny, low cost inductors and ceramic capacitors. With its internal compensation eliminating additional components, a complete 400mA step-down regulator fits onto 0.15 square inches of PC board area.

The constant frequency current mode PWM architecture and stable operation with ceramic capacitors results in low, predictable output ripple. Current limiting provides protection against shorted outputs. The low current (<1µA) shutdown provides complete output disconnect, enabling easy power management in battery-powered systems.
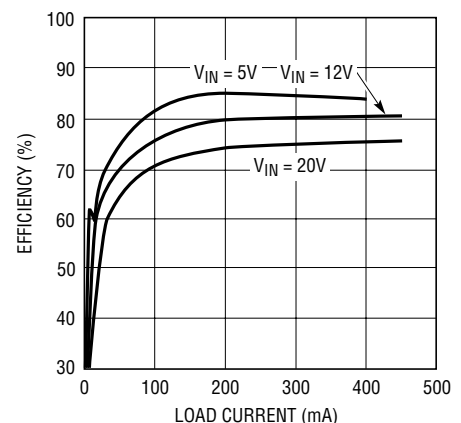
, LTC and LT are registered trademarks of Linear Technology Corporation.

TYPICAL APPLICATION
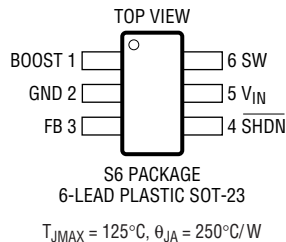
3.3V Step-Down Converter

C1: TAIYO-YUDEN TMK316BJ105
C2: TAIYO-YUDEN JMK316BJ106ML
D1: ON SEMICONDUCTOR MBR0530
D2: 1N4148
L1: SUMIDA CR43-100

Efficiency

1616 G02

LT1616

ABSOLUTE MAXIMUM RATINGS

(Note 1)

Input Voltage (V_{IN}) 25V
BOOST Pin Voltage 35V
BOOST Pin Above SW Pin 25V
$\overline{SHDN}$ Pin 25V
FB Voltage 6V
Current Into FB Pin ....±1mA
Operating Temperature Range (Note 2) .. −40°C to 85°C
Maximum Junction Temperature ....125°C
Storage Temperature Range .... −65°C to 150°C
Lead Temperature (Soldering, 10 sec).................300°C

PACKAGE/ORDER INFORMATION

TOP VIEW

BOOST 1 — 6 SW
GND 2 — 5 V_{IN}
FB 3 — 4 $\overline{SHDN}$

S6 PACKAGE
6-LEAD PLASTIC SOT-23

$T_{JMAX} = 125°C, \theta_{JA} = 250°C/W$

ORDER PART NUMBER
LT1616ES6

S6 PART MARKING
LTNB

Consult factory for parts specified with wider operating temperature ranges.

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25°C$.
$V_{IN} = 10V$, $V_{BOOST} = 15V$, unless otherwise noted. (Note 2)

| PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Undervoltage Lockout				3.35	3.6	V
Feedback Voltage		●	1.225	1.25	1.275	V
FB Pin Bias Current	V_{FB} = Measured V_{REF} + 10mV	●		150	600	nA
Quiescent Current	Not Switching			1.9	2.5	mA
Quiescent Current in Shutdown	$V_{\overline{SHDN}}$ = 0V			0.01	2	µA
Reference Line Regulation	V_{IN} = 5V to 25V			0.005		%/V
Switching Frequency	V_{FB} = 1.1V	●	1	1.4	1.8	MHz
Frequency Shift Threshold on FB Pin	f_{SW} = 700kHz			0.44		V
Maximum Duty Cycle		●	80	87		%
Switch Current Limit	(Note 3)		630	850		mA
Switch V_{CESAT}	I_{SW} = 300mA			220	350	mV
Switch Leakage Current					10	µA
Minimum Boost Voltage Above Switch	I_{SW} = 300mA			1.6	2.5	V
BOOST Pin Current	I_{SW} = 300mA			7	12	mA
$\overline{SHDN}$ Input Voltage High			1.8			V
$\overline{SHDN}$ Input Voltage Low					0.4	V
$\overline{SHDN}$ Bias Current	$V_{\overline{SHDN}}$ = 3V $V_{\overline{SHDN}}$ = 0V			8 0.01	15 0.1	µA µA

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: The LT1616E is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the −40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

Note 3: Current limit guaranteed by design and/or correlation to static test. Slope compensation reduces current limit at higher duty cycle.
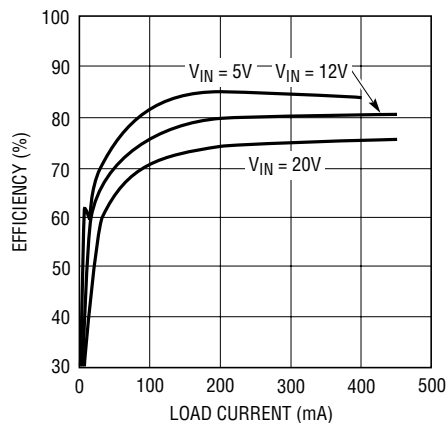
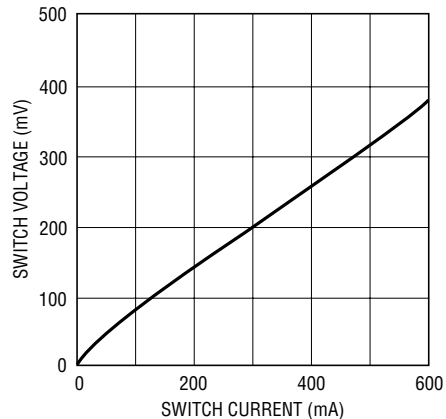# TYPICAL PERFORMANCE CHARACTERISTICS

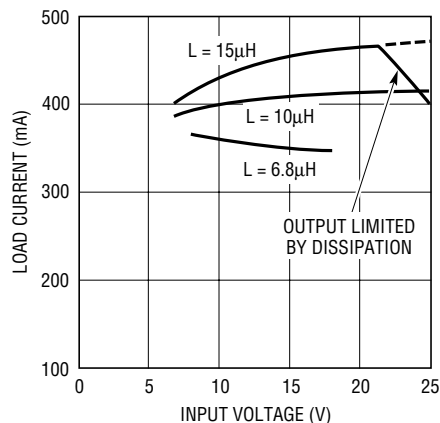**Efficiency, V_{OUT} = 5V**
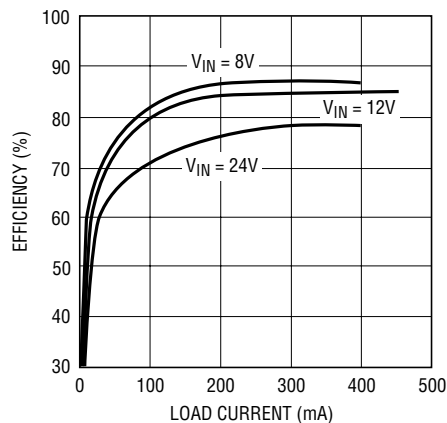
1616 G01

Efficiency, V_{OUT} = 3.3V
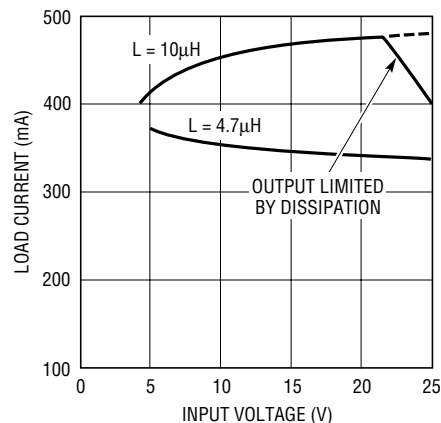

1616 G02

Switch Voltage Drop

1616 G03

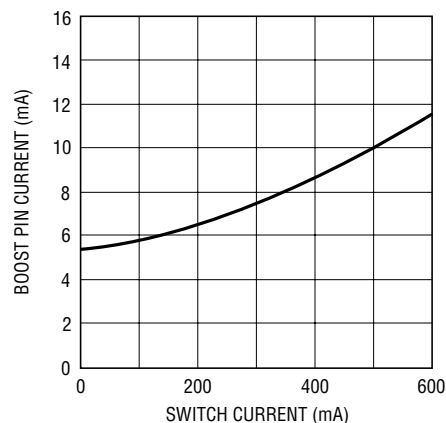**Maximum Load Current at V_{OUT} = 5V**

1616 G04

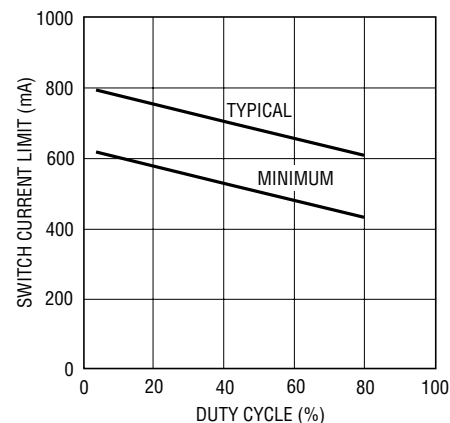**Maximum Load Current at V_{OUT} = 3.3V**

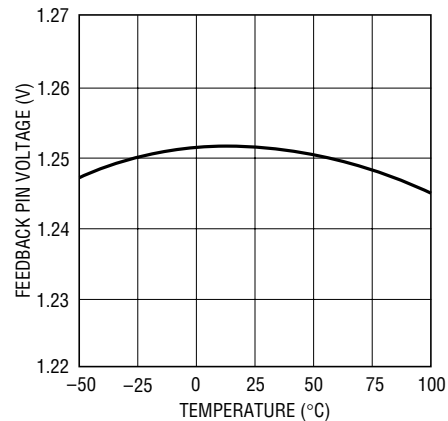1616 G05

BOOST Pin Current

1616 G06

Switch Current Limit
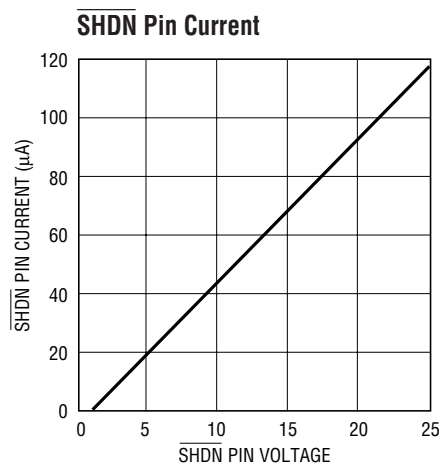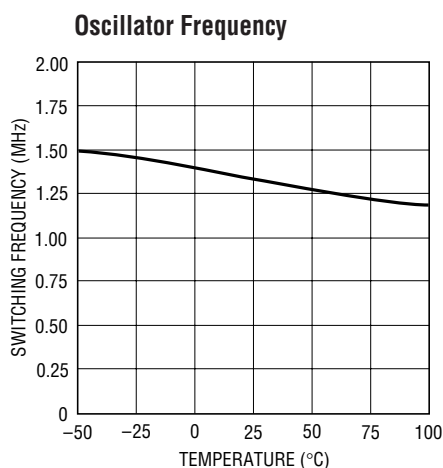

1616 G07

Feedback Pin Voltage

1616 G08

Undervoltage Lockout
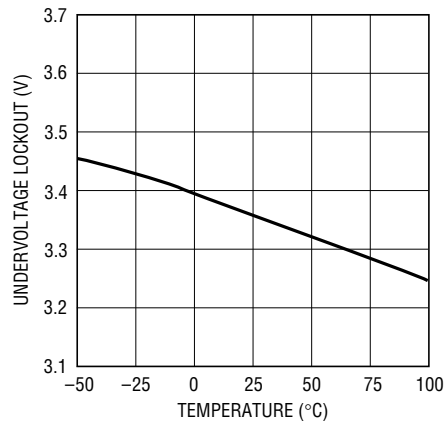
1616 G11

TYPICAL PERFORMANCE CHARACTERISTICS

Oscillator Frequency

1616 G09

SHDN Pin Current

1616 G10

PIN FUNCTIONS

BOOST (Pin 1): The BOOST pin is used to provide a drive voltage, higher than the input voltage, to the internal bipolar NPN power switch.

GND (Pin 2): Tie the GND pin to a local ground plane below the LT1616 and the circuit components. Return the feedback divider to this pin.

FB (Pin 3): The LT1616 regulates its feedback pin to 1.25V. Connect the feedback resistor divider tap to this pin. Set the output voltage according to $V_{OUT} = 1.25V (1 + R1/R2)$. A good value for R2 is 10k.

SHDN (Pin 4): The SHDN pin is used to put the LT1616 in shutdown mode. Tie to ground to shut down the LT1616. Tie to 2V or more for normal operation. If the shutdown feature is not used, tie this pin to the V_{IN} pin.

V_{IN} (Pin 5): The V_{IN} pin supplies current to the LT1616's internal regulator and to the internal power switch. This pin must be locally bypassed.

SW (Pin 6): The SW pin is the output of the internal power switch. Connect this pin to the inductor, catch diode and boost capacitor.

BLOCK DIAGRAM
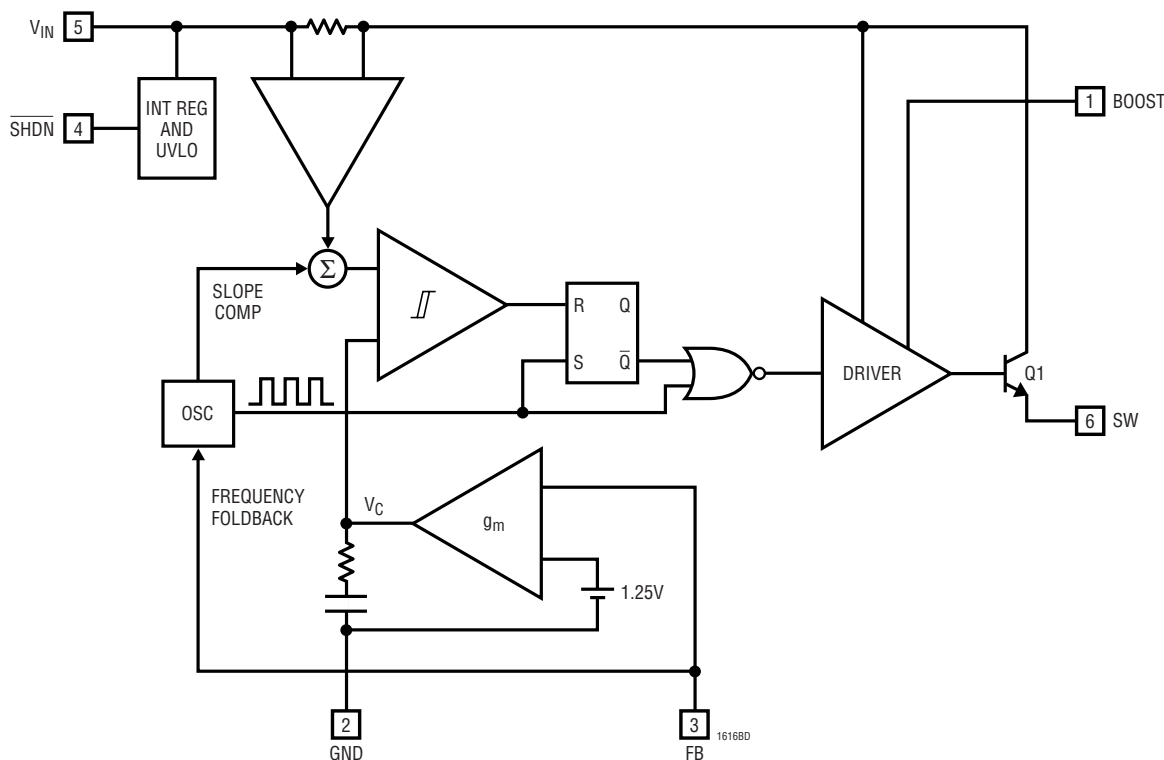
OPERATION (Refer to Block Diagram)

The LT1616 is a constant frequency, current mode Buck regulator. The 1.4MHz oscillator enables an RS flip-flop, turning on the internal 600mA power switch Q1. An amplifier and comparator monitor the current flowing between the V_{IN} and SW pins, turning the switch off when this current reaches a level determined by the voltage at V_C. An error amplifier measures the output voltage through an external resistor divider tied to the FB pin. This amplifier servos the switch current to regulate the FB pin voltage to 1.25V. An active clamp on the V_C node provides current limit.

An internal regulator provides power to the control circuitry. This regulator includes an undervoltage lockout to prevent switching when V_{IN} is less than ~3.5V. The SHDN pin is used to place the LT1616 in shutdown, disconnecting the output and reducing the input current to less than 1µA.

The switch driver operates from either the input or from the BOOST pin. An external capacitor and diode are used to generate a voltage at the BOOST pin that is higher than the input supply. This allows the driver to fully saturate the internal bipolar NPN power switch for efficient operation.

The oscillator reduces the LT1616's operating frequency when the voltage at the FB pin is low. This frequency foldback helps to control the output current during start-up and overload.

APPLICATIONS INFORMATION

The LT1616 efficiently converts power from an input voltage source to a lower output voltage using an inductor for energy storage. The LT1616 uses its internal power switch and an external catch diode (D1 of the application circuit on the first page of this data sheet) to produce a pulse-width modulated square wave. Inductor L1 and output capacitor C2 filter this square wave to produce a DC output voltage. An error amplifier regulates the output by comparing the output (divided by the feedback resistor string R1 and R2) to an internal reference. The LT1616 uses current mode control; instead of directly modulating the pulse width, the error amplifier controls the peak current in the switch and inductor. Current mode control has several advantages, including simplified loop compensation and cycle-by-cycle current limiting.

Figure 1 shows several waveforms of the application circuit on the front page of this data sheet. The circuit is converting a 12V input to 3.3V at 300mA. The first trace is the voltage at the SW pin. When the internal switch is on, the SW pin voltage is near the 12V input. This applies a voltage across inductor L1, and the current in the switch
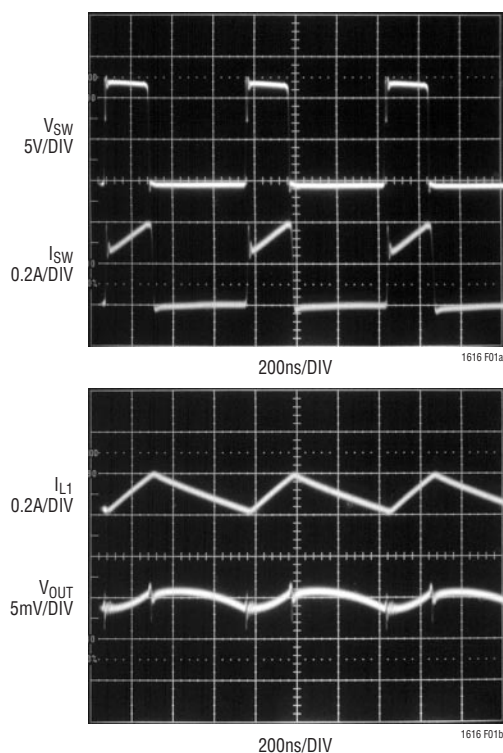
(second trace) and the inductor (third trace) increases. When the switch turns off, the switch current immediately drops to zero and the inductor current flows through the catch diode D1, which clamps the switch node 0.4V below ground. The voltage across the inductor in this state has the opposite sense and is equal to the output voltage plus the catch diode drop, so the inductor current begins to decrease. The fourth trace shows the output voltage ripple.

At light loads, the inductor current may reach zero on each pulse. The diode will turn off, and the switch voltage will ring, as shown in Figure 2. This is discontinuous mode operation, and is normal behavior for the switching regulator. The LT1616 will also skip pulses when the load is light.

V_{IN} = 12V
V_{OUT} = 5V
I_{OUT} = 18mA
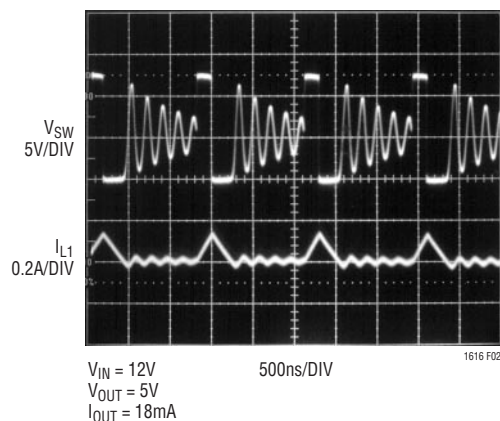
Figure 2. Discontinuous Mode Operation

If the output is shorted to ground, the output voltage will collapse and there will be very little voltage to reset the current in the inductor. The LT1616 can sense this condition at its FB pin. In order to control the current, the LT1616 reduces its operating frequency, allowing more time for the catch diode to reset the inductor current.

The input and output voltages determine the duty cycle of the switch. The inductor value combined with these voltages determines the ripple current in the inductor. Along with the switch current limit, the inductor ripple current determines the maximum load current that the circuit can supply. At minimum, the input and output capacitors are required for stable operation. Specific values are chosen based on allowable ripple and desired transient performance. The rest of the applications information is mainly concerned with choosing these and the other components in an LT1616 application.

**Figure 1. Operating Waveforms of the LT1616
Converting 12V to 3.3V at 300mA**

APPLICATIONS INFORMATION

Inductor Selection and Maximum Output Current

The duty cycle of the internal switch is:

$$DC = (V_{OUT} + V_D)/(V_{IN} - V_{SW} + V_D)$$

where V_D is the forward voltage drop of the catch diode (D1) and V_{SW} is the voltage drop of the internal switch. Usually one is interested in DC at full load current, so you can use $V_D = V_{SW} = 0.4V$. Note that the LT1616 has a maximum guaranteed duty cycle of 0.8. This will limit the minimum input voltage for a particular output voltage.

When the switch is off, the inductor sees the output voltage plus the catch diode drop. This gives the peak-to-peak ripple current in the inductor:

$$\Delta I_L = (1 - DC)(V_{OUT} + V_D)/(L \bullet f)$$

where f is the switching frequency of the LT1616 and L is the value of the inductor. The average inductor current is equal to the output current, so the peak inductor current will be the output current plus one half of the ripple current:

$$I_{LPK} = I_{OUT} + \Delta I_L/2.$$

To maintain output regulation, this peak current must be less than the LT1616's switch current limit I_{LIM}. I_{LIM} is at least 630mA at low duty cycles, decreasing to 430mA at 80% duty cycle. The maximum output current is a function of the chosen inductor value:

$$I_{OUT(MAX)} = I_{LIM} - \Delta I_L/2.$$

If the inductor value is chosen so that the ripple current is small, then the available output current will be near the switch current limit. A good approach is to choose the inductor so that the peak-to-peak inductor ripple is equal to one third of the switch current limit. This leads to:

$$L = 3(1 - DC)(V_{OUT} + V_D)/(I_{LIM} \bullet f)$$

and

$$I_{OUT(MAX)} = (5/6)I_{LIM}.$$

These expressions depend on duty cycle and therefore on input voltage. Pick a nominal input voltage to calculate L, then check the maximum available output current at the minimum and maximum input voltages.

If your application calls for output current less than 400mA, you may be able to relax the value of the inductor and operate with higher ripple current. This may allow you to pick a physically smaller inductor or one with a lower DC resistance. Be aware that these equations assume continuous inductor current. If the inductor value is low or the load current is light, then the inductor current may become discontinuous. This occurs when $\Delta I_L = 2I_{OUT}$. For details of discontinuous mode operation, see Linear Technology Application Note AN44. Also, high duty cycle operation may require slightly higher inductor values to avoid sub-harmonic oscillations. See AN19.

The maximum load current as a function of input voltage is plotted in the Typical Performance Characteristics section of this data sheet. Maximum load current for 3.3V and 5V outputs is shown for several values of L. At the highest input voltages, the load current is limited by power dissipation in the LT1616.

Choose an inductor that is intended for power applications. Table 1 lists several manufacturers and inductor series. The saturation current of the inductor should be above 0.5A. The RMS current rating should be equal to or greater than output current. For indefinite operation into a short circuit, the RMS current rating should be greater than 0.7A. The DC resistance should be less than 0.5Ω in order maintain circuit efficiency.

Capacitor Selection

A Buck regulator draws from its input a square wave of current with peak-to-peak amplitude as high as the switch current limit. The input capacitor (C1) must supply the AC component of this current. An RMS current rating of 250mA is adequate for LT1616 circuits. The input capacitor must bypass the LT1616 internal control circuitry and any other circuitry that operates from the input source. A 1µF ceramic capacitor will satisfy both of these requirements. If the impedance of the input source is high (due to long wires or filter components), additional bulk input capacitance may be required. In high duty cycle applications (5V$_{IN}$ to 3.3V$_{OUT}$, for example), increase the input capacitor to 2.2µF. It may be possible to achieve lower cost by using an electrolytic capacitor (tantalum or aluminum)

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APPLICATIONS INFORMATION

Table 1. Inductor Vendors

Vendor	Phone	URL	Part Series	Comments
Murata	(404) 426-1300	www.murata.com	LQH3C	Small, Low Cost, 2mm Height
Sumida	(847) 956-0666	www.sumida.com	CR43 CLS62 CLQ61	1:1 Coupled 1.5mm Height
Coilcraft	(847) 639-6400	www.coilcraft.com	DO1607C DO1608C DT1608C	
Coiltronics	(407) 241-7876	www.coiltronics.com	CTXxx-1 TP1	1:1 Coupled Toroid 1.8mm Height
Toko		www.tokoam.com	3DF D52LC	

Table 2. Capacitor Vendors

Vendor	Phone	URL	Part Series	Comments
Taiyo-Yuden	(408) 573-4150	www.t-yuden.com	Ceramic Caps	X5R Dielectric
AVX	(803) 448-9411	www.avxcorp.com	Ceramic Caps Tantalum Caps	
Murata	(404) 436-1300	www.murata.com	Ceramic Caps	

in combination with a 0.1µF ceramic capacitor. However, input voltage ripple will be higher, and you may want to include an additional 0.1µF ceramic a short distance away from the LT1616 circuit in order to filter the high frequency ripple. The input capacitor should be rated for the maximum input voltage.

The output capacitor has two essential functions. Along with the inductor, it filters the square wave generated by the LT1616 to produce the DC output. In this role it determines the output ripple. The second function is to store energy in order to satisfy transient loads and stabilize the LT1616's control loop.

In most switching regulators the output ripple is determined by the equivalent series resistance (ESR) of the output capacitor. Because the LT1616's control loop doesn't depend on the output capacitor's ESR for stable operation, you are free to use ceramic capacitors to achieve very low output ripple and small circuit size. You can estimate output ripple with the following equations:

$V_{RIPPLE} = \Delta I_L \bullet ESR$ for electrolytic capacitors (tantalum and aluminum)

$V_{RIPPLE} = \Delta I_L / (2\pi \bullet f \bullet C_{OUT})$ for ceramic capacitors

Another constraint on the output capacitor is that it must have greater energy storage than the inductor; if the stored energy in the inductor is transferred to the output, you would like the resulting voltage step to be small compared to the regulation voltage. For a 5% overshoot, this requirement becomes

$C_{OUT} > 10 \bullet L(I_{LIM}/V_{OUT})^2$

Finally, there must be enough capacitance for good transient performance. The last equation gives a good starting point. Alternatively, you can start with one of the designs in this data sheet and experiment to get the desired performance. Figure 3 illustrates some of the trade-off between different output capacitors. Figure 4 shows the test circuit. The lowest trace shows total output current, which jumps from 100mA to 250mA. The other traces show the output voltage ripple and transient response with different output capacitors. The capacitor value, size and type are listed. Note that the time scale at 50µs per divison is much larger than the switching period, so you can't see the output ripple at the switching frequency. The output ripple appears as vertical broadening of the trace. The first trace (C_{OUT} = 4.7µF) has peak-to-peak output ripple of ~6mV, while the third trace shows peak-to-peak ripple of ~15mV.
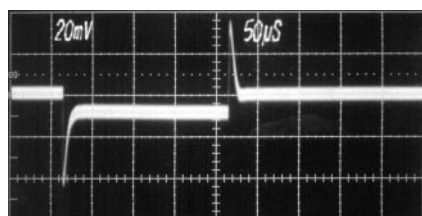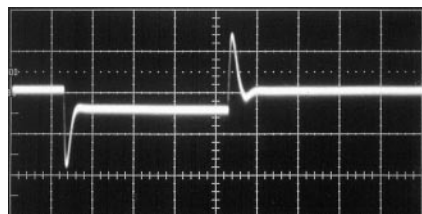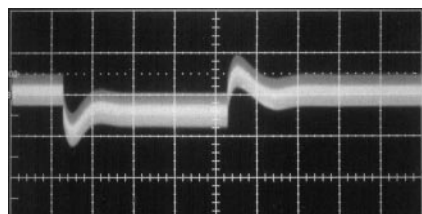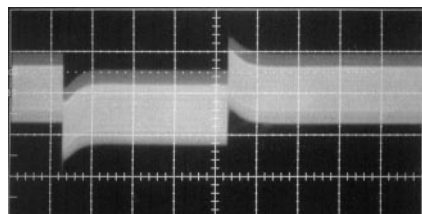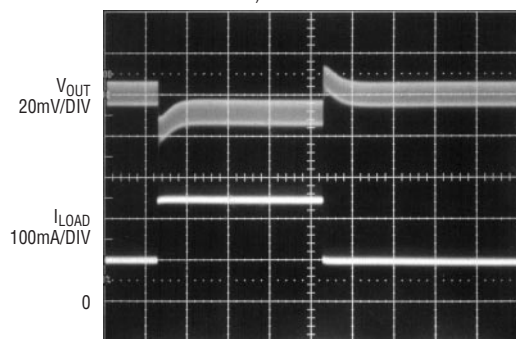
APPLICATIONS INFORMATION

C$_{OUT}$ = 4.7µF CERAMIC, CASE SIZE 0805

C$_{OUT}$ = 10µF CERAMIC, CASE SIZE 1206

C$_{OUT}$ = 47µF, ESR $\cong$ 0.080Ω (SANYO POSCAP 6TPA47M)
C CASE

C$_{OUT}$ = 100µF, ESR $\cong$ 0.150Ω (TANTALUM AVX TPSC107M006R0150) C CASE

C$_{OUT}$ = 100µF TANTALUM AND 2.2µF CERAMIC

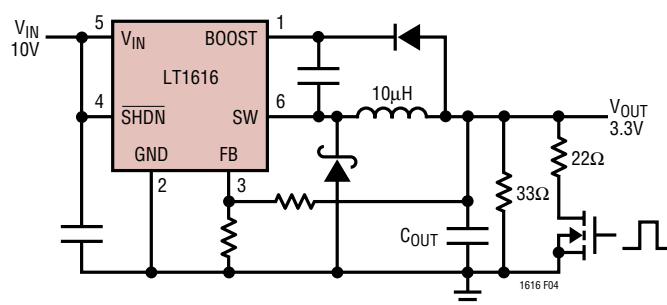**Figure 3. Transient Load Response of the LT1616**

Figure 4. Circuit Used for Transient Load Test Shown in Figure 3

Regardless of which capacitor or combination of capacitors you choose, you should do transient load tests to evaluate the circuit's stability. Avoid capacitors or combinations that result in a ringing response. Problems may occur if the output capacitance is very low or if a high value inductor is used in combination with a large value, low ESR capacitor.

The high performance (low ESR), small size and robustness of ceramic capacitors make them the preferred type for LT1616 applications. However, all ceramic capacitors are not the same. Many of the higher value capacitors use poor dielectrics with high temperature and voltage coefficients. In particular, Y5V types should be regarded with suspicion. Stick with X7R and X5R types. Don't be afraid to run them at their rated voltage. Table 2 lists several capacitor manufacturers.

Catch Diode

A 0.5A Schottky diode is recommended for the catch diode D1. The ON Semiconductor MBR0530 is a good choice; it is rated for 0.5A forward current and a maximum reverse voltage of 30V. For circuits with V$_{IN}$ less than 20V, the MBR0520L can be used. Other suitable diodes are the Zetex ZHCS500TR and ZHCS750TR, and various versions of the 1N5818.

APPLICATIONS INFORMATION

BOOST Pin Considerations

Capacitor C3 and diode D2 are used to generate a boost voltage that is higher than the input voltage. In most cases a 0.01µF capacitor and fast switching diode (such as the 1N4148 or 1N914) will work well. Figure 5 shows two ways to arrange the boost circuit. The BOOST pin must be more than 2.5V above the SW pin for best efficiency. For outputs of 3.3V and above, the standard circuit (Figure 5a) is best. For outputs between 2.8V and 3.3V, use a 0.033µF capacitor and a small Schottky diode (such as the BAT-54). For lower output voltages the boost diode can be tied to the input (Figure 5b). The circuit in Figure 5a is more efficient because the BOOST pin current comes from a lower voltage source. You must also be sure that the maximum voltage rating of the BOOST pin is not exceeded.

The minimum operating voltage of an LT1616 application is limited by the undervoltage lockout (<3.6V) and by the maximum duty cycle as outlined above. For proper start-up, the minimum input voltage is also limited by the boost circuit. If the input voltage is ramped slowly, or the LT1616 is turned on with its $\overline{\text{SHDN}}$ pin when the output is already in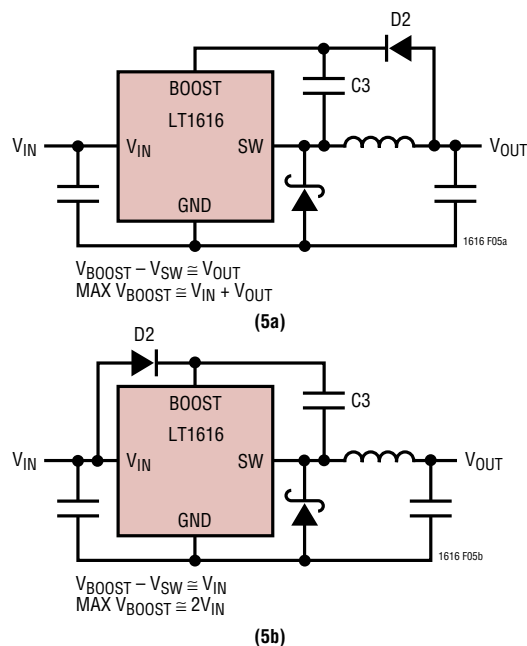 regulation, then the boost capacitor may not be fully charged. Because the boost capacitor is charged with the energy stored in the inductor, the circuit will rely on some minimum load current to get the boost circuit running properly. This minimum load will depend on input and output voltages, and on the arrangement of the boost circuit. The minimum load generally goes to zero once the circuit has started. Figure 6 shows a plot of minimum load to start and to run as a function of input voltage. In many cases the discharged output capacitor will present a load to the switcher which will allow it to start. The plots show the worst-case situation where V_{IN} is ramping very slowly. Use a Schottky diode (such as the BAT-54) for the lowest start-up voltage.

Minimum Input Voltage V$_{OUT}$ = 3.3V

Minimum Input Voltage V$_{OUT}$ = 5V
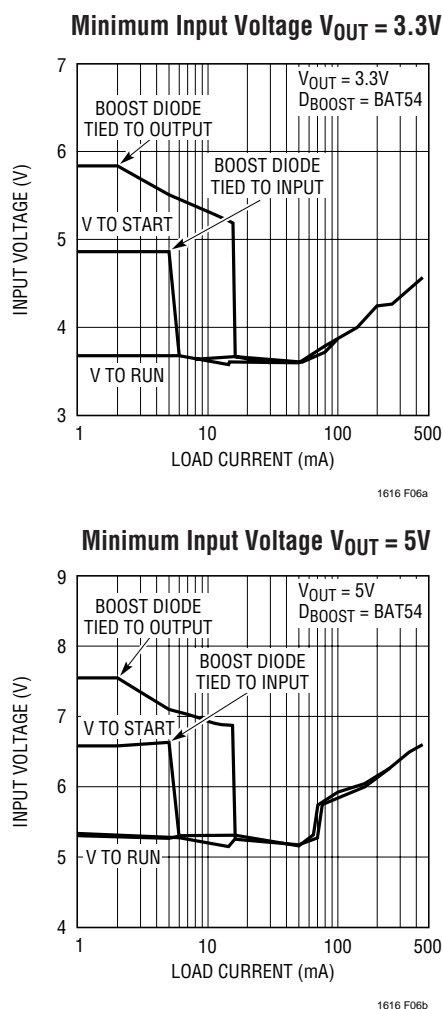
Figure 6. The Minimum Input Voltage Depends on Output Voltage, Load Current and Boost Circuit

$V_{BOOST} - V_{SW} \cong V_{OUT}$
MAX $V_{BOOST} \cong V_{IN} + V_{OUT}$

(5a)

$V_{BOOST} - V_{SW} \cong V_{IN}$
MAX $V_{BOOST} \cong 2V_{IN}$

(5b)

Figure 5. Two Circuits for Generating the Boost Voltage

APPLICATIONS INFORMATION

Shorted Input Protection

If the inductor is chosen so that it won't saturate excessively, an LT1616 buck regulator will tolerate a shorted output. There is another situation to consider in systems where the output will be held high when the input to the LT1616 is absent. This may occur in battery charging applications or in battery backup systems where a battery or some other supply is diode OR-ed with the LT1616's output. If the V_{IN} pin is allowed to float and the $\overline{SHDN}$ pin is held high (either by a logic signal or because it is tied to V_{IN}), then the LT1616's internal circuitry will pull its quiescent current through its SW pin. This is fine if your system can tolerate a few mA in this state. If you ground the $\overline{SHDN}$ pin, the SW pin current will drop to essentially zero. However, if the V_{IN} pin is grounded while the output is held high, then parasitic diodes inside the LT1616 can pull large currents from the output through the SW pin and the V_{IN} pin. Figure 7 shows a circuit that will run only when the input voltage is present and that protects against a shorted or reversed input.

PCB Layout

For proper operation and minimum EMI, care must be taken during printed circuit board layout. Figure 8 shows the high current paths in the buck regulator circuit. Note that large, switched currents flow in the power switch, the
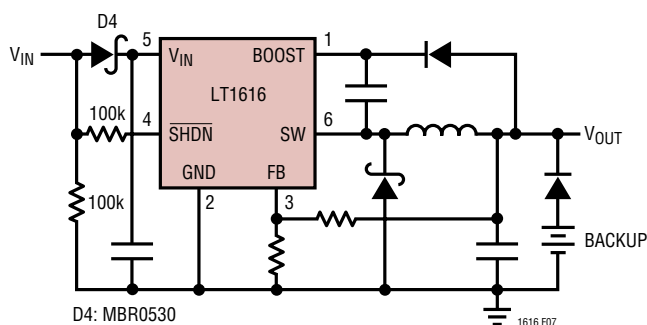
Figure 7. Diode D4 Prevents a Shorted Input from Discharging a Backup Battery Tied to the Output; It Also Protects the Circuit from a Reversed Input. The LT1616 Runs Only When the Input is Present
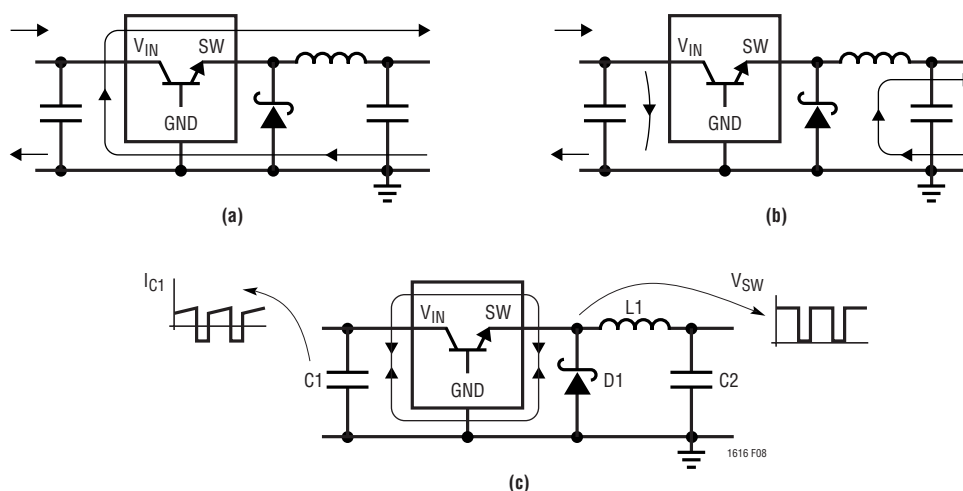
Figure 8. Subtracting the Current When the Switch is On (a) from the Current When the Switch is Off (b) Reveals the Path of the High Frequency Switching Current (c). Keep This Loop Small. The Voltage on the SW and BOOST Nodes Will Also be Switched; Keep These Nodes as Small as Possible. Finally, Make Sure the Circuit is Shielded with a Local Ground Plane

APPLICATIONS INFORMATION

catch diode (D1) and the input capacitor (C1). The loop formed by these components should be as small as possible. Furthermore, the system ground should be tied to the regulator ground in only one place; this prevents the switched current from injecting noise into the system ground. These components, along with the inductor and output capacitor, should be placed on the same side of the circuit board, and their connections should be made on that layer. Place a local, unbroken ground plane below these components, and tie this ground plane to system ground at one location, ideally at the ground terminal of the output capacitor C2. Additionally, the SW and BOOST nodes should be kept as small as possible. Finally, keep the FB node as small as possible so that the ground pin and ground traces will shield it from the SW and BOOST nodes. Figure 9 shows component placement with trace, ground plane and via locations. Include two vias near the GND pin of the LT1616 to help remove heat from the LT1616 to the ground plane.

Outputs Greater than 6V

For outputs greater than 6V, connect a diode (such as a 1N4148) from the SW pin to V_{IN} to prevent the SW pin from ringing above V_{IN} during discontinuous mode operation. The 12V output circuit below shows the location of this diode. Also note that for outputs above 10V, the input voltage range will be limited by the maximum rating of the BOOST pin. The 12V circuit shows how to overcome this limitation using an additional Zener diode.

Other Linear Technology Publications

Application notes AN19, AN35 and AN44 contain more detailed descriptions and design information for Buck regulators and other switching regulators. The LT1376 data sheet has a more extensive discussion of output ripple, loop compensation and stability testing. Design Note DN100 shows how to generate a bipolar output supply using a Buck regulator.

⊗ VIAS TO LOCAL GROUND PLANE
——— OUTLINE OF LOCAL GROUND PLANE

1616 F09
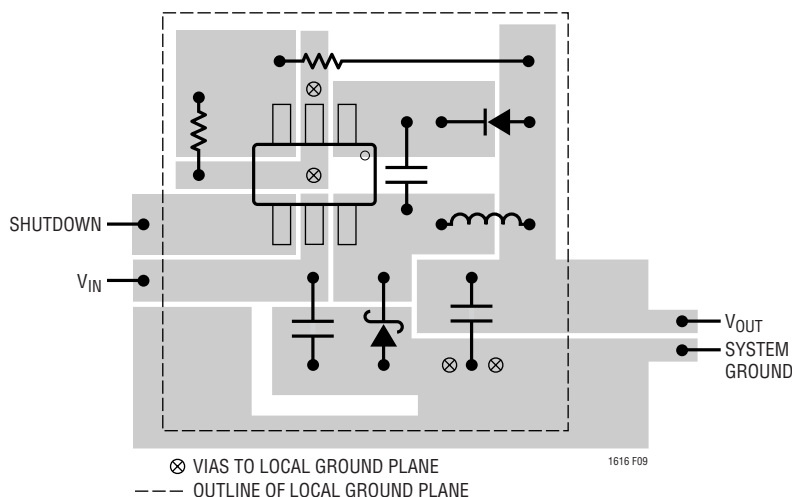
Figure 9. A Good PCB Layout Ensures Proper, Low EMI Operation

TYPICAL APPLICATIONS

12V Output

C1: TAIYO-YUDEN TMK316BJ105ML
C2: TAIYO-YUDEN EMK316BJ225ML
D1: ON SEMICONDUCTOR MBR0530
D2, D4: 1N4148
D3: CMPZ5234B 6.2V ZENER.
    D3 LIMITS BOOST PIN VOLTAGE TO V_{IN} + 6V
L1: COILCRAFT DO1608C-333

1616 TA03

1.8V Output

C1: TAIYO-YUDEN EMK212BJ105MG
C2: TAIYO-YUDEN JMK316BJ106ML
D1: ON SEMICONDUCTOR MBR0520L
D2: 1N4148 OR EQUIVALENT
L1: MURATA LQH3C4R7M24

1616 TA04
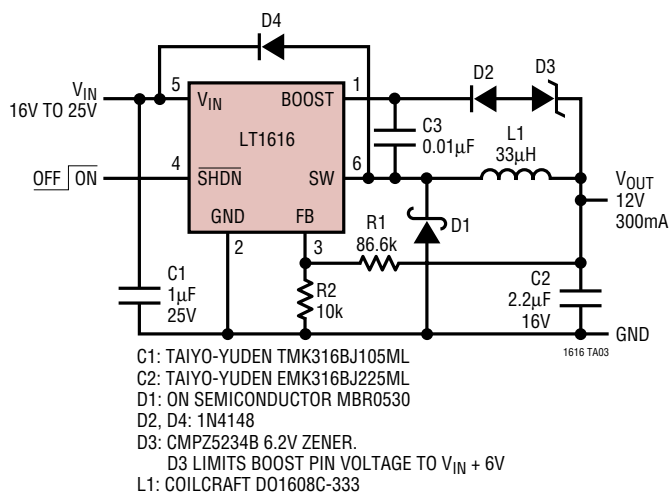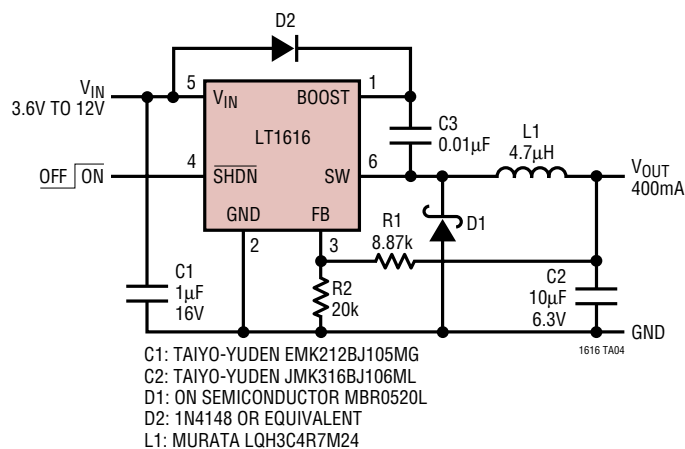
TYPICAL APPLICATIONS

2.5V Output

V_{IN}
3.6V TO 16V

D2

5 V_{IN} BOOST 1

LT1616

4 $\overline{SHDN}$ SW 6

GND FB

2 3

OFF ON

C3
0.01µF

L1
4.7µH

V_{OUT}
2.5V
350mA

R1
10k

D1

C2
4.7µF
6.3V

C1
1µF
16V

R2
10k

GND

C1: TAIYO-YUDEN EMK212BJ105MG
C2: TAIYO-YUDEN JMK212BJ475MG
D1: ON SEMICONDUCTOR MBR0520
D2: 1N4148
L1: MURATA LQH3C4R7M24

1616 TA05

5V Output

V_{IN}
7V TO 25V

5 V_{IN} BOOST 1

LT1616

4 $\overline{SHDN}$ SW 6

GND FB

2 3

OFF ON

D2

C3
0.01µF

L1
15µH

V_{OUT}
5V
300mA: V_{IN} = 7V TO 25V
400mA: V_{IN} = 8V TO 25V

R1
30.1k

D1

C2
10µF
6.3V

C1
1µF
25V

R2
10k

C1: TAIYO-YUDEN TMK316BJ105ML
C2: TAIYO-YUDEN JMK316BJ106MG
D1: ON SEMICONDUCTOR MBR0530
D2: 1N4148
L1: TOKO A914BYW-150M

1616 TA07

PACKAGE DESCRIPTION

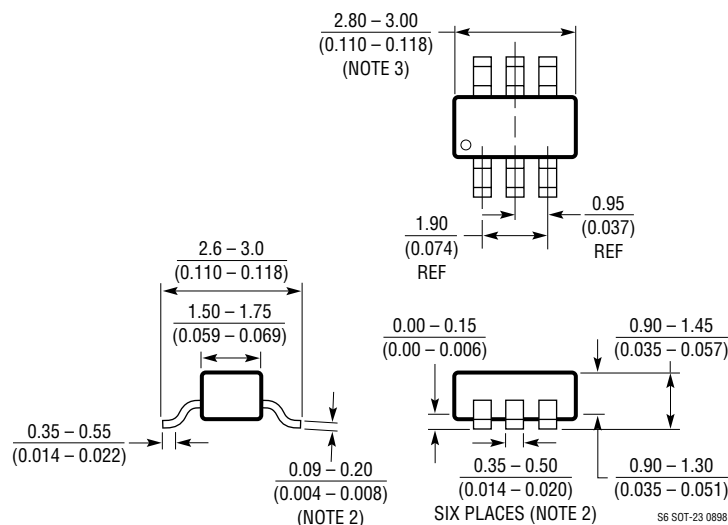**Dimensions in inches (millimeters) unless otherwise noted.**

S6 Package
6-Lead Plastic SOT-23
(LTC DWG # 05-08-1634)

2.80 – 3.00
(0.110 – 0.118)
(NOTE 3)

0.95
(0.037)
REF

1.90
(0.074)
REF

2.6 – 3.0
(0.110 – 0.118)

1.50 – 1.75
(0.059 – 0.069)

0.00 – 0.15
(0.00 – 0.006)

0.90 – 1.45
(0.035 – 0.057)

0.35 – 0.55
(0.014 – 0.022)

0.09 – 0.20
(0.004 – 0.008)
(NOTE 2)

0.35 – 0.50
(0.014 – 0.020)
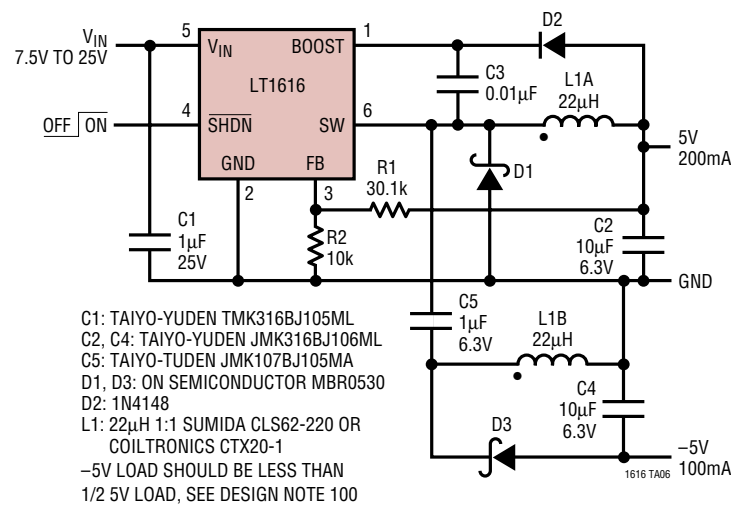SIX PLACES (NOTE 2)

0.90 – 1.30
(0.035 – 0.051)

S6 SOT-23 0898

NOTE:
1. DIMENSIONS ARE IN MILLIMETERS
2. DIMENSIONS ARE INCLUSIVE OF PLATING
3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH AND METAL BURR
4. MOLD FLASH SHALL NOT EXCEED 0.254mm
5. PACKAGE EIAJ REFERENCE IS SC-74A (EIAJ)

15

TYPICAL APPLICATION

Bipolar Output DC/DC Converter

C1: TAIYO-YUDEN TMK316BJ105ML
C2, C4: TAIYO-YUDEN JMK316BJ106ML
C5: TAIYO-TUDEN JMK107BJ105MA
D1, D3: ON SEMICONDUCTOR MBR0530
D2: 1N4148
L1: 22μH 1:1 SUMIDA CLS62-220 OR
    COILTRONICS CTX20-1
−5V LOAD SHOULD BE LESS THAN
1/2 5V LOAD, SEE DESIGN NOTE 100

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC®1474/LTC1475	0.5A Micropower Step-Down Regulator	10μA I_Q, 100% Duty Cycle, 8-Lead MSOP Package
LT1676/LT1776	Wide Input Range Step-Down Switching Regulator	60V Input, 0.7A Internal Switch
LTC1701	0.5A Micropower Step-Down in SOT-23	100% Duty Cycle, High Efficiency: Up to 94%
LT1763	500mA, Low Noise, LDO Micropower Regulator	30μA I_Q, 20μV_{RMS} Noise
LT1767	1.5A, 1.4MHz Step-Down DC/DC Converter	Higher Current, 8-Lead MSOP Package
LTC1772	Constant Frequency Step-Down Controller in SOT-23	Higher Current, High Efficiency: Up to 94%
LTC1779	0.25A Micropower Step-Down in SOT-23	Lower Current, 100% Duty Cycle
LTC1877	0.6A Synchronous Step-Down Regulator	High Efficiency, No Diode Required, 8-Lead MSOP
LT1962	300mA, Low Noise, LDO Micropower Regulator	30μA I_Q, 20μV_{RMS} Noise, 8-Lead MSOP Package

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408)432-1900 • FAX: (408) 434-0507 • www.linear-tech.com

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