# 1.2A, HV Input Regulator with Output Current Limit for Battery Charger Applications

## FEATURES

- **Wide Input Range:**
  - **– Operation from 7.5V to 30V**
  - **– Overvoltage Lockout Protects Circuit Through 60V Transients**
- **Operates with LTC Bat-Track™ Li-Ion Battery Chargers to Maximize Efficiency**
- **No Reverse Discharge Path from $V_{OUT}$ to $V_{IN}$**
- **Programmable Output Current Limit**
- Integrated BOOST Diode
- Thermal Protection
- Small Application Size
- Thermally Enhanced 2mm × 3mm DFN Package

## APPLICATIONS

- Battery Powered Equipment
- Portable USB Devices – Cameras, MP3 Players, PDAs
- Automotive Battery Regulation
- Multiple-Source Battery Chargers

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## DESCRIPTION

The LT®3653 is a monolithic current mode PWM step-down regulator with programmable output current limit. Typically, it is used with battery charger power path controllers to pre-regulate the output and optimize the battery charger efficiency. Output current limit provides accurate control over system power dissipation.

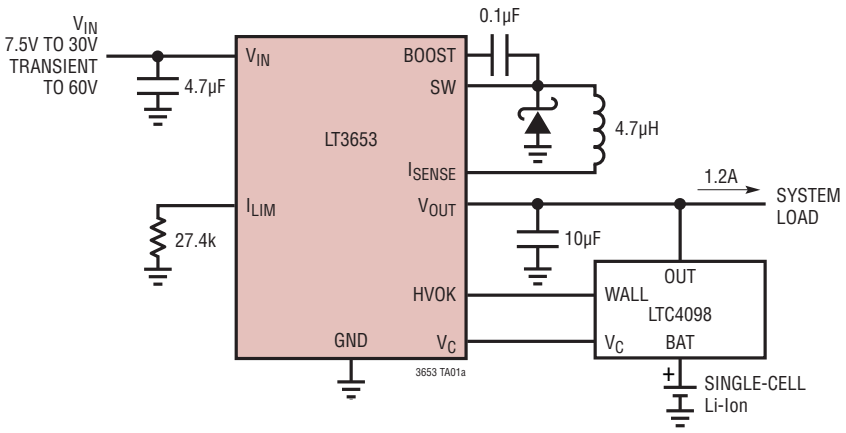
The wide operating input voltage range of 7.5V to 30V suits the LT3653 to a variety of input sources, including unregulated 12V wall adapters, 24V industrial supplies, Firewire and automotive power. Input overvoltage protection allows the LT3653 to handle 60V input transients.

The LT3653 control pin, $V_C$, is available for external battery tracking control, Bat-Track. The LT3653 will block output discharge during an open or shorted input.

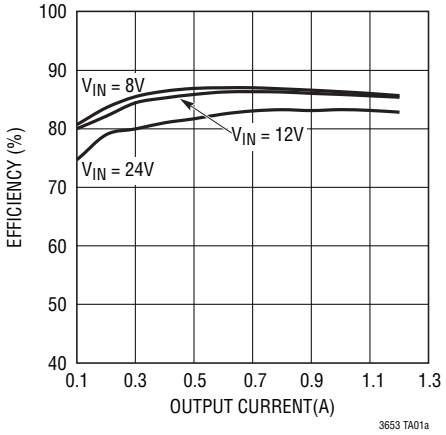
The HVOK pin indicates that the internal bias supplies are present and no faults have occurred (i.e., overtemperature and input overvoltage and undervoltage). The LT3653 includes a 1.5MHz frequency oscillator, internal compensation, and an internal boost diode to minimize the number of external components. The LT3653 is available in an 8-lead (2mm × 3mm) package with exposed pads for low thermal resistance.

## TYPICAL APPLICATION

**High Voltage Single-Cell Battery Charger Application**




**Efficiency vs Load Current**

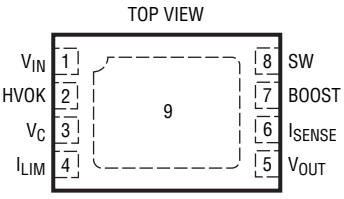


## ABSOLUTE MAXIMUM RATINGS

**(Note 1)**

Input Voltage ($V_{IN}$) (Note 3) ..... 60V
Boost Pin Voltage (BOOST) ..... 50V
Boost Pin Above SW Pin ..... 25V
HVOK, $V_{OUT}$, $I_{SENSE}$ Pins ..... 6V
$V_C$ Pin ..... 3V
Operating Junction Temperature Range (Notes 2, 5)
LT3653E ..... –40°C to 125°C
LT3653I ..... –40°C to 125°C
Storage Temperature ..... –65°C to 150°C

## PIN CONFIGURATION




DCB PACKAGE
8-LEAD (2mm × 3mm) PLASTIC DFN

$\theta_{JA}$ = 64°C/W, $\theta_{JC}$ = 10°C/W
EXPOSED PAD (PIN 9) IS GND, MUST BE SOLDERED TO PCB

## ORDER INFORMATION

| LEAD FREE FINISH | TAPE AND REEL | PART MARKING* | PACKAGE DESCRIPTION | TEMPERATURE RANGE |
|---|---|---|---|---|
| LT3653EDCB#PBF | LT3653EDCB#TRPBF | LDJN | 8-Lead (2mm × 3mm) Plastic DFN | –40°C to 125°C |
| LT3653IDCB#PBF | LT3653IDCB#TRPBF | LDJN | 8-Lead (2mm × 3mm) Plastic DFN | –40°C to 125°C |

Consult LTC Marketing for parts specified with wider operating temperature ranges. *The temperature grade is identified by a label on the shipping container.
Consult LTC Marketing for information on non-standard lead based finish parts.

For more information on lead free part marking, go to: http://www.linear.com/leadfree/
For more information on tape and reel specifications, go to: http://www.linear.com/tapeandreel/

## ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A$ = 25°C; $V_{IN}$ = 12V, $V_{BOOST}$ = 17V, $V_{SW}$ = 0V, $R_{ILIM}$ = 33.2k, unless otherwise noted.**

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| $V_{IN}$ Operating Range | | ● | 7.5 | | 30 | V |
| $V_{IN}$ Undervoltage Lockout | Rising | | 6.5 | 7 | 7.5 | V |
| $V_{IN}$ Undervoltage Hysteresis | | | | 500 | | mV |
| $V_{IN}$ Overvoltage Lockout | Rising | | 30 | 33 | 36 | V |
| $V_{IN}$ Overvoltage Lockout Hysteresis | | | | 1 | | V |
| $V_{IN}$ Supply Current | Not Switching | | | 2.8 | 3.4 | mA |
| $V_{OUT}$ Reverse Leakage Current | $V_{IN}$ = 0V, $V_{OUT}$ = 4.8V<br>$V_{IN}$ = Open, $V_{OUT}$ = 4.8V | | | | 1<br>1 | µA<br>µA |
| $V_{OUT}$ Nominal Set Point | $V_C$ Pin = Open | | | 4.8 | 5 | V |
| $V_{OUT}$ Current Limit Range | | ● | 0.4 | | 1.2 | A |
| $V_{OUT}$ Current Limit | $R_{ILIM}$ = 33.2k | <br>● | 0.85<br>0.80 | 1<br>1 | 1.15<br>1.2 | A<br>A |
| Operating Frequency | | ● | 1350 | 1500 | 1650 | kHz |
| $V_C$ Source Current | $V_{OUT}$ = 0V, $V_C$ = 1.5V | | | 12 | | µA |
| $V_C$ Sink Current | $V_{OUT}$ = 5V, $V_C$ = 1.5V | | | 10 | | µA |
| $V_C$ Switching Threshold | $I_{OUT}$ = 0mA | | | 1.1 | | V |

## ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A$ = 25°C; $V_{IN}$ = 12V, $V_{BOOST}$ = 17V, $V_{SW}$ = 0V, $R_{ILIM}$ = 33.2k, unless otherwise noted.**

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| $V_C$ Clamp Voltage | $V_{OUT}$ = 0V | | | 1.75 | | V |
| Switch Peak Current Limit | (Note 4) | | | 2 | | A |
| Switch $V_{CESAT}$ | $I_{SW}$ = 1A | | | 275 | | mV |
| Boost Diode Drop | $I_{DIODE}$ = 60mA | | | 0.9 | 1.2 | V |
| Boost Pin Current | $I_{SW}$ = 1A | | | 28 | | mA |
| HVOK Output Voltage High | $I_{HVOK}$ = 1mA | ● | 4 | 4.4 | 5 | V |
| HVOK Output Voltage Low | $I_{HVOK}$ = –2µA | ● | | | 0.25 | V |

**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

**Note 2:** The LT3653E is guaranteed to meet performance specifications from 0°C to 125°C. Specifications over the –40°C to 125°C operating temperature range are assured by design, characterization, and correlation with statistical process controls. The LT3653I specifications are guaranteed over the full –40°C to 125°C temperature range. High junction temperatures degrade operating lifetimes. Operating lifetime is derated at junction temperatures greater than 125°C.

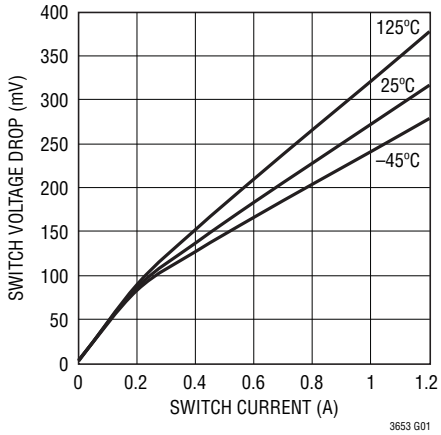
**Note 3:** Absolute Maximum Voltage at $V_{IN}$ pin is 60V for non-repetitive 1 second transients.

**Note 4:** Switch Peak Current Limit guaranteed by design and/or correlation to static test.

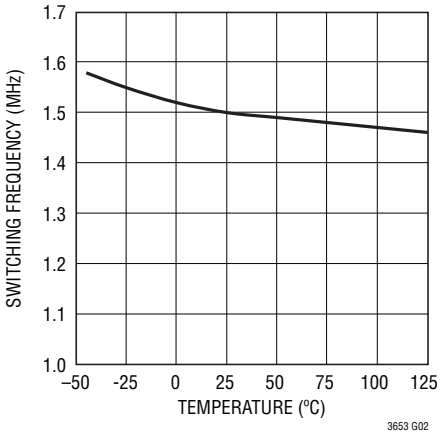
**Note 5:** This IC includes overtemperature protection that is intended to protect the device during momentary overload conditions. Junction temperature will exceed the maximum operating junction temperature when overtemperature protection is active. Continuous operation above the specified maximum operating junction temperature may impair device reliability.

## TYPICAL PERFORMANCE CHARACTERISTICS $T_A$ = 25°C unless otherwise noted

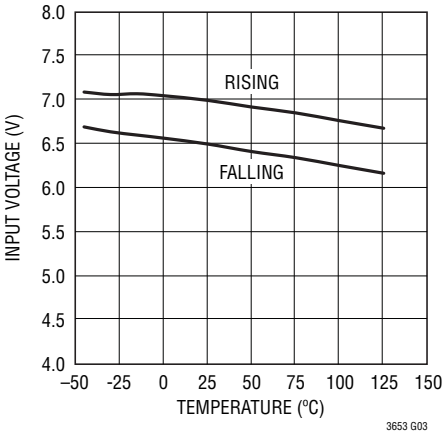
### Switch Voltage Drop



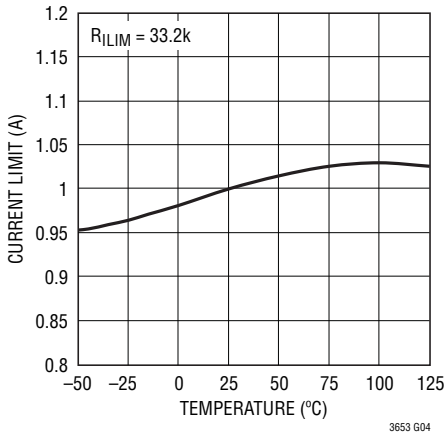

### Switching Frequency



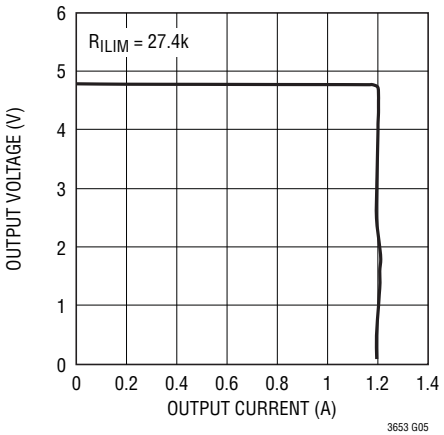

### Undervoltage Lockout



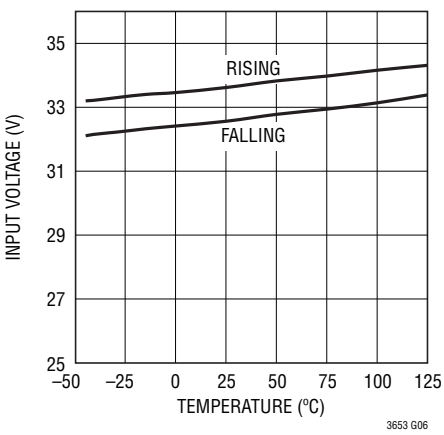

### Output Current Limit



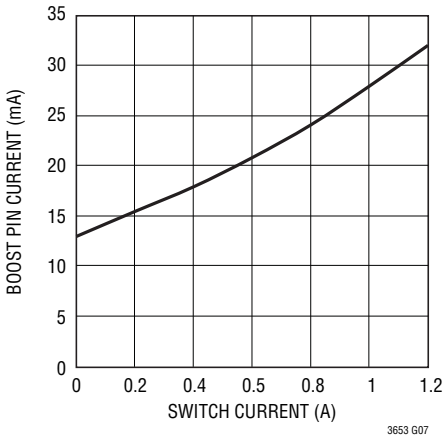

### Output Current Limit



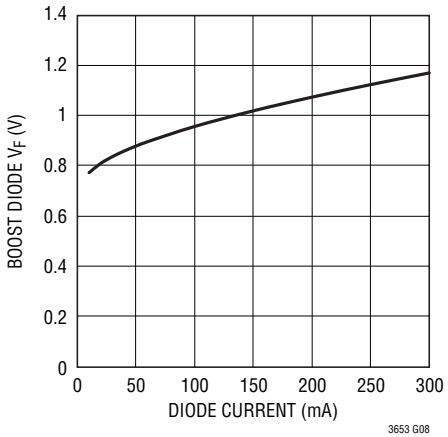

### $V_{IN}$ Overvoltage Lockout




### BOOST Pin Current

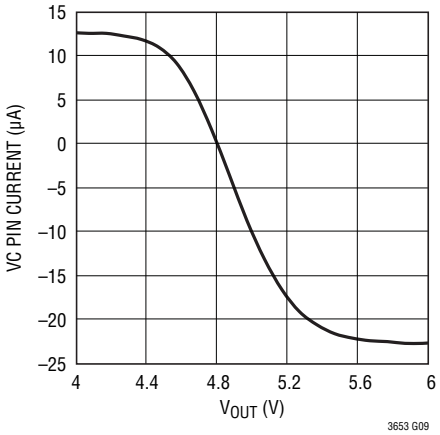



### Boost Diode $V_F$

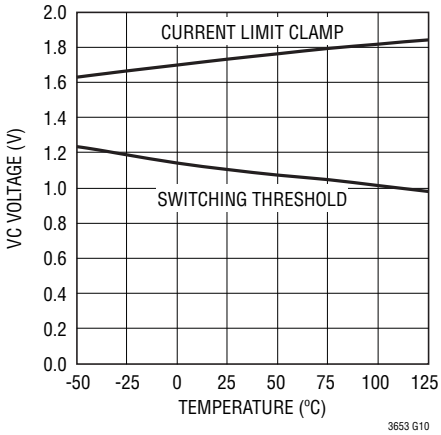


## TYPICAL PERFORMANCE CHARACTERISTICS $T_A$ = 25°C unless otherwise noted

**$V_C$ Current**




**$V_C$ Operating Range**




## PIN FUNCTIONS

**$V_{IN}$ (Pin 1):** The $V_{IN}$ pin supplies current to the LT3653's internal regulator and the internal power switch. Locally bypass this pin with a capacitor.

**HVOK (Pin 2):** The HVOK pin is a status pin which indicates that the internal bias rail is present and that an input undervoltage lockout fault, an overvoltage lockout fault or an over temperature fault are not present.

**$V_C$ (Pin 3):** The $V_C$ pin is the output of the internal error amplifier and is internally compensated. The voltage on this pin controls the peak switch current. Connect this pin to the battery charger $V_C$ pin for battery tracking function.

**$I_{LIM}$ (Pin 4):** Connect a resistor to GND to program the output current limit of the regulator. See the $I_{LIM}$ Resistor section in Application Information.

**$V_{OUT}$ (Pin 5):** The $V_{OUT}$ pin is connected to the negative terminal of the internal current sense resistor of the output current limit circuit. Maximum $V_{OUT}$ voltage is regulated to 4.8V.

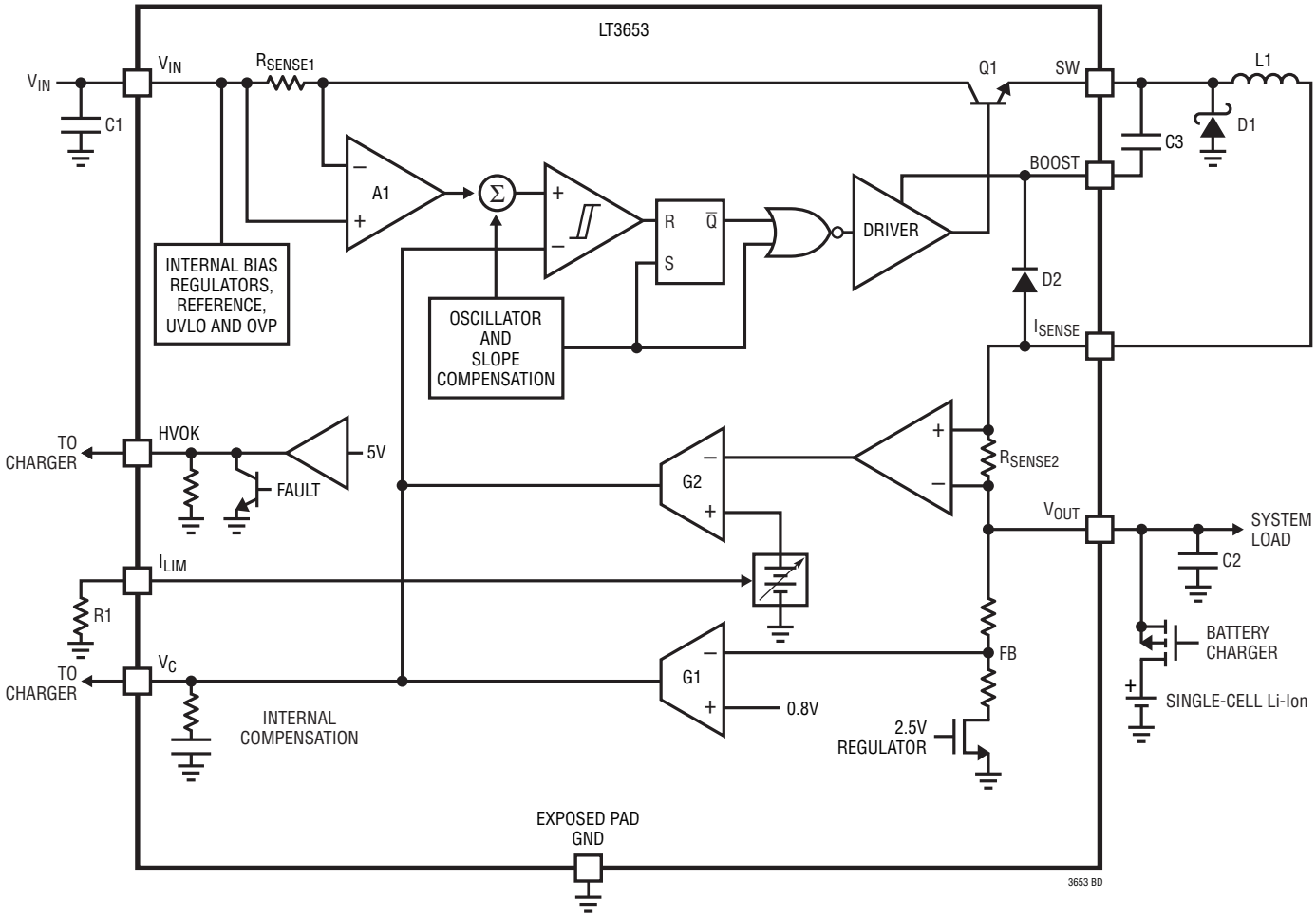
**$I_{SENSE}$ (Pin 6):** The $I_{SENSE}$ pin is the positive input to the internal current sense resistor of the output current limit circuit. The $I_{SENSE}$ pin is also the anode of the internal BOOST diode.

**BOOST (Pin 7):** The BOOST pin provides a drive voltage, higher than the input voltage, to the internal power switch. The BOOST pin is internally connected to the cathode of the BOOST diode.

**SW (Pin 8):** The SW pin is the output of the internal power switch. Connect this pin to the inductor, catch diode and boost capacitor.

**Exposed Pad (Pin 9):** Ground. The Exposed Pad must be soldered to the PCB and electrically connected to ground. Use a large ground plane and vias to optimize thermal performance.

## BLOCK DIAGRAM



## OPERATION

Please refer to the Block Diagram. The LT3653 is specifically tailored for use with a battery charger power path controller. The LT3653 regulates the high voltage input to a lower voltage to provide power to the system load and to the single-cell Li-Ion battery charger. High efficiency in the battery charger is achieved by keeping the voltage across it low. To accomplish this, the battery charger takes control of the LT3653 regulator control node, $V_C$, and overrides the error amp, G1. The output voltage is regulated by the battery charger to a voltage slightly above the battery, typically 300mV.

HVOK is a status pin which indicates to the charger that a high voltage input is present and that the LT3653 is ready to start providing power to the system load. When the HVOK pin is low, the LT3653 is not switching and the system output is not supported by the LT3653 regulator.

The LT3653 is a constant frequency, current mode step down regulator. A switch cycle is initiated when the 1.5MHz oscillator enables the RS flip flop, turning on the internal power switch, Q1. The sense amplifier (A1) monitors the switch current via the voltage dropped across the current sense resistor $R_{SENSE1}$. The comparator compares the amplified current signal with the output ($V_C$) of the error amplifier (G1). The switch is turned off when this current exceeds a value determined by the $V_C$ voltage. The error amplifier monitors the $V_{OUT}$ voltage through an internal resistor divider and, when not driven externally servos the $V_C$ voltage to regulate $V_{OUT}$. If the $V_{OUT}$ voltage drops, the $V_C$ voltage will be driven higher increasing the output current and $V_{OUT}$ voltage.

An active clamp (not shown) on the $V_C$ node provides current limit. The LT3653 is internally compensated with a pole zero combination.

An external capacitor and internal diode, D2, 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 switch driver operates from either $V_{IN}$ or BOOST to ensure startup.

An internal regulator provides power to the control circuitry. This regulator includes input undervoltage and overvoltage protection which disables switching action when $V_{IN}$ is less than 7V and greater than 33V, typical. When switching is disabled, the LT3653 safely sustains input voltages up to 60V. Note that while switching is disabled the output will discharge.

Output current limiting is provided via the servo action of amplifier G2. The voltage across the sense resistor, $R_{SENSE2}$, is compared to a voltage programmed by external resistor R1 on the $I_{LIM}$ pin. A capacitor averages the inductor ripple current. If the averaged inductor current exceeds the programmed value then the $V_C$ voltage is pulled low, reducing the current in the regulator. The output current limit circuit allows for lower current rated power path components and provides better control of system power dissipation.

## APPLICATIONS INFORMATION

### Inductor Selection

A 4.7µH inductor is recommended for most LT3653 applications. This value provides a good tradeoff between size and ripple current. The inductor's RMS current rating must be greater than the maximum load current and its saturation current should be about 30% higher. The output current limit circuit tightly controls the maximum average inductor current therefore the inductor RMS current rating does not have to be overrated to handle short-circuit or overload conditions. For high efficiency, keep the series resistance (DCR) less than 0.1Ω. Output voltage ripple can be reduced by using a higher value inductor. The cost is a larger physical size and poorer transient response. A lower value inductor has higher ripple currents but is physically smaller or, for the same size, has lower DCR usually resulting in higher efficiency.

### Catch Diode

The catch diode conducts current only during switch off time. Average forward current in normal operation is calculated from:

$$I_{D(AVG)} = I_{OUT} \frac{V_{IN} - V_{OUT}}{V_{IN}}$$

where $I_{OUT}$ is the maximum output load current programmed by the $I_{LIM}$ resistor. Peak reverse voltage is equal to the regulator input voltage. Use a Schottky diode with a reverse voltage rating greater than the maximum input voltage. The overvoltage protection feature in the LT3653 keeps the switch off when $V_{IN}$ > 33V (typical), allowing the use of a 40V rated Schottky, even when $V_{IN}$ ranges up to 60V.

### Input Capacitor

Bypass the input of the LT3653 circuit with a 4.7µF or higher value ceramic capacitor of X7R or X5R type. Y5V types have poor performance over temperature and applied voltage and should not be used. If the input power source has high impedance, or there is significant inductance due to long wires or cables, additional bulk capacitance may be necessary. This can be provided with a low performance electrolytic capacitor. Step-down regulators draw current from the input supply in pulses with very fast rise and fall times. The input capacitor is required to reduce the resulting voltage ripple at the LT3653 and to force this very high frequency switching current into a tight local loop, minimizing EMI. Place the capacitor in close proximity to the LT3653 and the catch diode (see the PCB Layout section).

### Output Capacitor

A 10µF or greater ceramic capacitor is required for low output ripple and good transient response. Ceramic capacitors have very low equivalent series resistance (ESR) and provide the best ripple performance. Use X5R or X7R types and keep in mind that a ceramic capacitor biased with $V_{OUT}$ has less than its nominal capacitance.

High performance electrolytic capacitors can be used for the output capacitor. Low ESR is important, so choose one that is intended for use in switching regulators. Keep the ESR less than 0.1Ω.

### $I_{LIM}$ Resistor

The LT3653 output current limit controls the maximum current delivered from the LT3653 regulator. This allows tighter control of the system power dissipation and also protects the inductor and diode from overheating during an overload or short-circuit condition. A resistor connected from the $I_{LIM}$ pin to GND programs the output current limit. Table 1 details the $I_{LIM}$ resistor values for specific desired output current limits

**Table 1. Output Current Limit vs $R_{ILIM}$ Value**

| OUTPUT CURRENT LIMIT (A) | $R_{ILIM}$ VALUE (kΩ) |
|---|---|
| 0.4 | 121 |
| 0.6 | 66.5 |
| 0.8 | 45.3 |
| 1 | 33.2 |
| 1.2 | 27.4 |

### Boost Capacitor Selection

The boost capacitor is calculated with the following formula:

$$C_{BOOST} = \frac{(I_{OUT(MAX)}) \bullet V_{OUT}}{0.1V \bullet 30 \bullet V_{IN} \bullet 1.5MHz}$$

Typically, a 0.1µF capacitor is used.

## APPLICATIONS INFORMATION

### Battery Charger Operation

Connect the control node, $V_C$ pin, of the LT3653 to the $V_C$ pin of the battery charger power path controller. The $V_C$ node is internally clamped; however, take care not to overdrive the pin. The LT3653 is internally compensated with a pole zero combination on the output of the $g_m$ amplifier, G1. Check stability over the full input voltage range, output load range and temperature.

Connect the HVOK node of the LT3653 to the high voltage present pin of the charger. This is the WALL pin on the LTC4098. The HVOK pin is capable of supplying up to 1mA of drive current. When the HVOK pin is low the LT3653 is not switching and the system output cannot be supported by the LT3653 regulator. See the Typical Applications section for different configurations.

### PCB Layout

Proper operation and minimum EMI requires a careful printed circuit board layout. Figure 1 shows the recommended component placement with trace, ground plane and via locations. Note that large, switched currents flow in the LT3653's $V_{IN}$ and SW pins, the catch diode (D1) and the input capacitor (C1). Keep the loop formed by these components as small as possible and tied to system ground in only one place. Place these components, along with the inductor and output capacitor, on the same side of the circuit board, with their connections 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. Make the SW and BOOST nodes as short as possible. Include vias near the exposed GND pad of the LT3653 to help remove heat from the LT3653 to the ground plane.

### High Temperature Considerations

The die temperature of the LT3653 must not exceed the maximum rating of 125°C. This is generally not a concern unless the ambient temperature is above 85°C. For higher temperatures, take care in the layout of the circuit to ensure good heat sinking of the LT3653. Derate the maximum load current as the ambient temperature approaches 125°C. The die temperature is calculated by multiplying the LT3653 power dissipation by the thermal resistance from junction to ambient. Power dissipation within the LT3653 is estimated by calculating the total power loss from an efficiency measurement and subtracting the catch diode loss. Thermal resistance depends on the layout of the circuit board, but 64°C/W is typical for the (2mm × 3mm) DFN (DCB) package.

### Other Linear Technology Publications

Application Notes 19, 35 and 44 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.

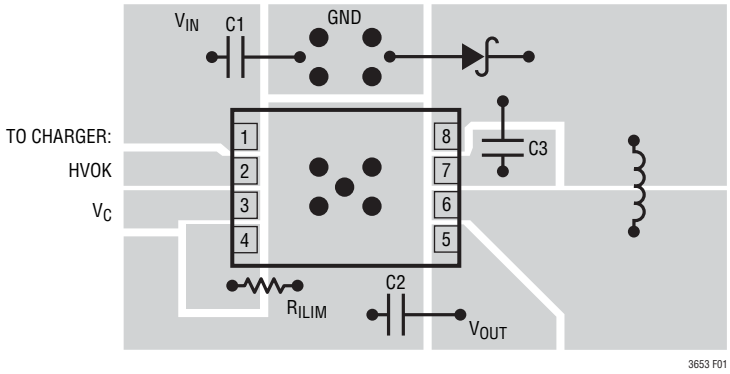
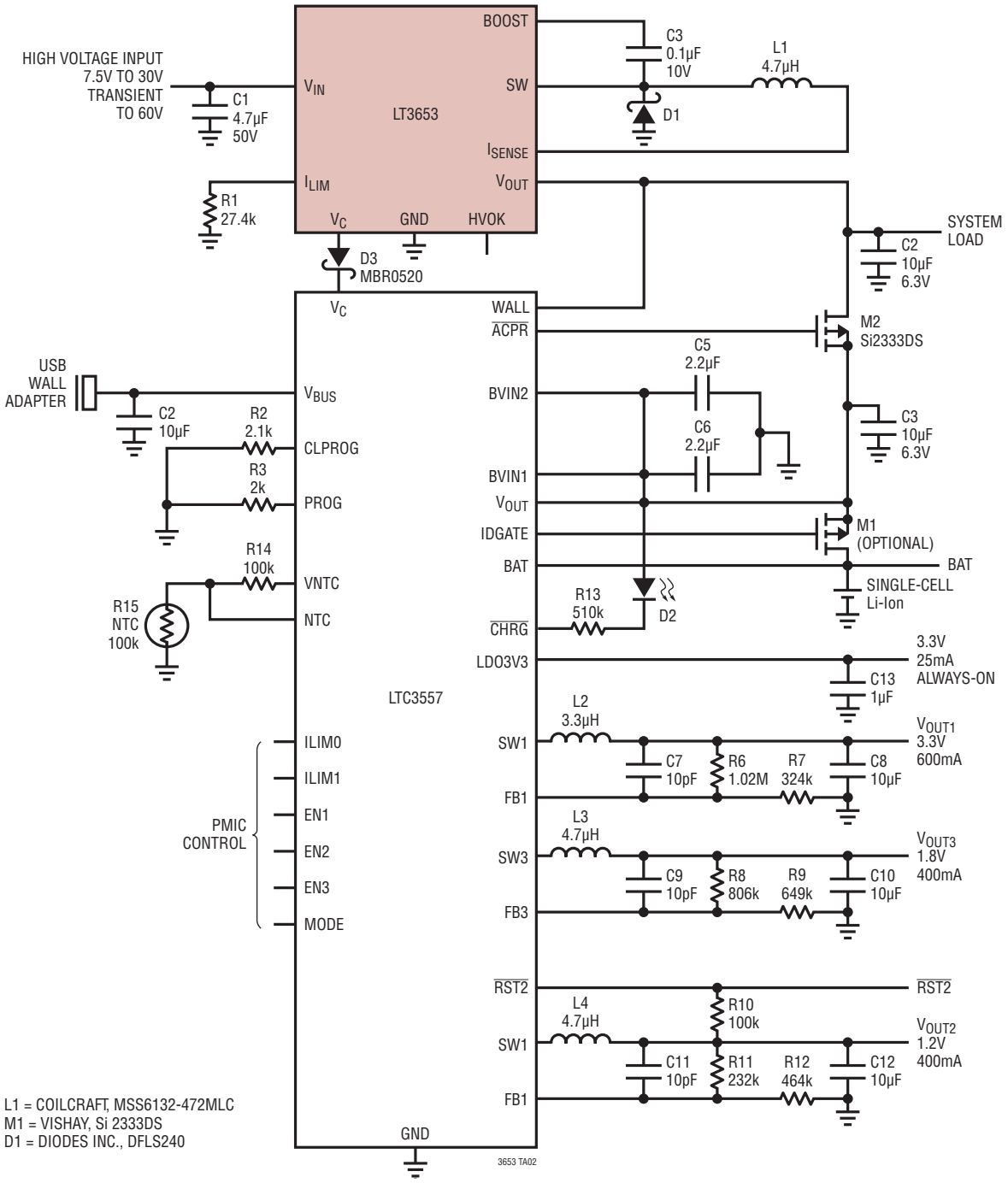



**Figure 1. LT3653 PCB Layout**

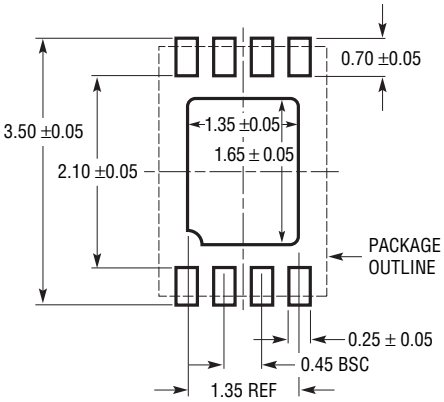
## TYPICAL APPLICATION

**Dual Input High Efficiency Battery Charger and Triple Buck PMIC Application**

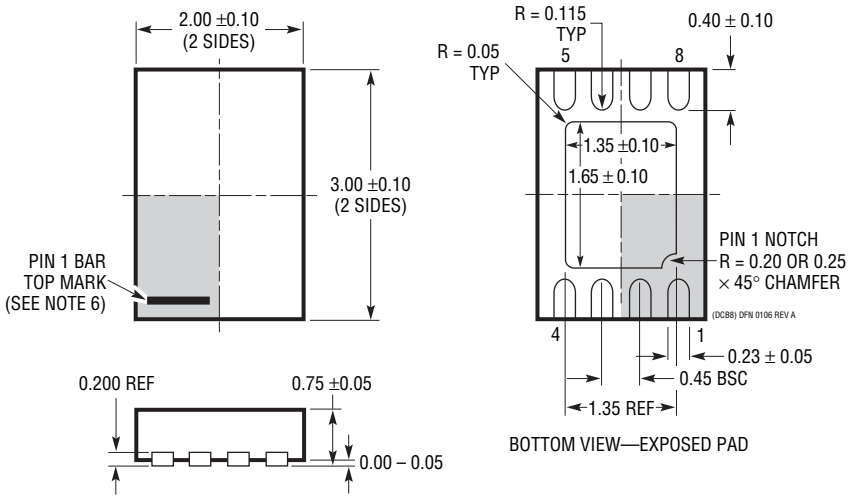


# PACKAGE DESCRIPTION

**DCB Package**
**8-Lead Plastic DFN (2mm × 3mm)**
(Reference LTC DWG # 05-08-1718 Rev A)




RECOMMENDED SOLDER PAD PITCH AND DIMENSIONS
APPLY SOLDER MASK TO AREAS THAT ARE NOT SOLDERED




BOTTOM VIEW—EXPOSED PAD

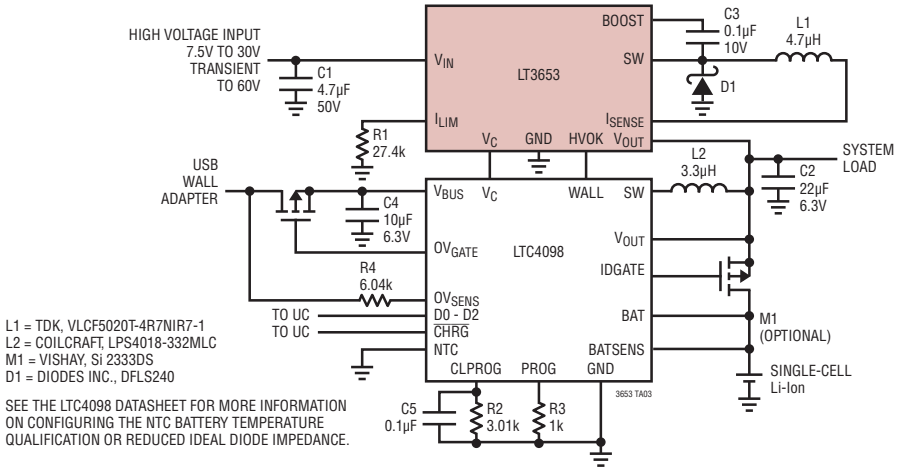
NOTE:
1. DRAWING IS NOT A JEDEC PACKAGE OUTLINE
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON THE TOP AND BOTTOM OF PACKAGE



Information furnished by Linear Technology Corporation is believed to be accurate and reliable. However, no responsibility is assumed for its use. Linear Technology Corporation makes no representation that the interconnection of its circuits as described herein will not infringe on existing patent rights.

## TYPICAL APPLICATION

**Dual Input High Efficiency Battery Charger with Low Battery Start-Up and 1.2A Output Current Limit**




L1 = TDK, VLCF5020T-4R7NIR7-1
L2 = COILCRAFT, LPS4018-332MLC
M1 = VISHAY, Si 2333DS
D1 = DIODES INC., DFLS240

SEE THE LTC4098 DATASHEET FOR MORE INFORMATION ON CONFIGURING THE NTC BATTERY TEMPERATURE QUALIFICATION OR REDUCED IDEAL DIODE IMPEDANCE.

## RELATED PARTS

| PART NUMBER | DESCRIPTION | COMMENTS |
|---|---|---|
| LT1939 | Dual 25V, 2A ($I_{OUT}$), 2.5MHz, High Efficiency DC/DC Converter and LDO Controller | $V_{IN}$: 3.6V to 25V, $V_{OUT(MIN)}$ = 0.8V, $I_Q$ = 2.5mA, $I_{SD}$ < 10µA, 3mm × 3mm DFN-10 Package |
| LT3480 | 36V with Transient Protection to 60V, 2A ($I_{OUT}$), 2.4MHz, High Efficiency Step-Down DC/DC Converter with Burst Mode Operation | $V_{IN}$: 3.6V to 38V, $V_{OUT(MIN)}$ = 0.78V, $I_Q$ = 70µA, $I_{SD}$ < 1µA, 3mm × 3mm DFN-10 and TSSOP-16E Packages |
| LT3500 | 36V, 40$V_{MAX}$, 2A, 2.5MHz High Efficiency DC/DC Converter and LDO Controller | $V_{IN}$: 3.6V to 36V, $V_{OUT(MIN)}$ = 0.8V, $I_Q$ = 3.7mA, $I_{SD}$ < 10µA, TSSOP-20E Package |
| LT3505 | 36V with Transient Protection to 40V, 1.4A ($I_{OUT}$), 3MHz, High Efficiency Step-Down DC/DC Converter | $V_{IN}$: 3.6V to 34V, $V_{OUT(MIN)}$ = 0.78V, $I_Q$ = 2mA, $I_{SD}$ < 2µA, 3mm × 3mm DFN-8 and MSOP-8E Packages |
| LT3507 | 36V, Triple 2.5MHz, 2.4A + 1.5A + 1.5A I($I_{OUT}$) and LDO Controller | $V_{IN}$: 4V to 36V, $V_{OUT(MIN)}$ = 0.8V, $I_Q$ = 7mA, $I_{SD}$ < 1µA, 5mm × 7mm QFN-38 Package |
| LT3508 | 36V with Transient Protection to 40V, Dual 1.4A ($I_{OUT}$), 3MHz, High Efficiency Step-Down DC/DC Converter | $V_{IN}$: 3.7V to 37V, $V_{OUT(MIN)}$ = 0.8V, $I_Q$ = 4.6mA, $I_{SD}$ < 1µA, 4mm × 4mm QFN-24 and TSSOP-16E Packages |
| LT3557/-1 | USB Power Manager with Li-Ion/Polymer Charger, Triple Synchronous Buck Converter + LDO | Complete Multi-Function PMIC: Linear Power Manager & Three Buck Regulators Bat-Track Adaptive Output Control, "-1" version has 4.1V Vfloat, 4mm x 4mm QFN-28 Package |
| LT3680 | 36V, 3.5A ($I_{OUT}$) 2.4MHz, High Efficiency Step-Down DC/DC Converter | $V_{IN}$: 3.6V to 36V, $V_{OUT(MIN)}$ = 0.8V, $I_Q$ = 75mA, $I_{SD}$ < 1mA, 3mm × 3mm DFN-10, MSOP-10E |
| LT3685 | 36V with Transient Protection to 60V, 2A ($I_{OUT}$), 2.4MHz, High Efficiency Step-Down DC/DC Converter | $V_{IN}$: 3.6V to 38V, $V_{OUT(MIN)}$ = 0.78V, $I_Q$ = 70µA, $I_{SD}$ < 1µA, 3mm × 3mm DFN-24 and MSOP-10E Packages |
| LT4089/-1/-5 | High Voltage USB Power Manager with Ideal Diode Controller and High Efficiency Li-Ion Battery Charger | High Efficiency 1.2A Charger from 6V to 36V (40V max) Input; "-1" for 4.1V float voltage batteries; Bat-Track™ Adaptive Output Control (LTC4089); Fixed 5V Output (LTC4089-5, -1); 3mm × 6mm DFN-22 Package |
| LT4090/-5 | High Voltage USB Power Manager with Ideal Diode Controller and High Efficiency Li-Ion Battery Charger | High Efficiency 1.2A Charger from 6V to 38V (60V max) Input Bat-Track Adaptive Output Control; "-5" has no Bat-Track; 3mm × 6mm DFN-22 Package |
| LTC4098 | USB-Compatible Switchmode Power Manager with OVP | High $V_{IN}$: 38V operating, 60V transient; 66V OVP Maximizes Available Power from USB Port, Bat-Track, "Instant-ON" Operation, 3mm x 4mm UTQFN-20 Package |

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