



# Low-Voltage Step-Up DC-DC Converter Power-Supply Evaluation Kit

MAX655 EVKIT

## General Description

The MAX655 EVKIT Evaluation Kit demonstrates the performance of the MAX655 +3V to +5V DC-DC converter in a standard application circuit (Figure 1). The kit contains a PC board with low-noise layout and all components needed for a +5V, 300mW power supply powered from two AA batteries. The MAXL001 100 $\mu$ H power inductor supplied in this kit is available in production quantities directly from Maxim.

The MAX655 is one of a series of DC-DC converter ICs that operate from low input voltages, such as those supplied by single-cell or dual-cell batteries. They feature a low-battery indicator and can run in standby mode to prolong battery life. A power ready output (PR) controls external circuitry when standby mode is used. The MAX654/6/7 are optimized for single-cell input, while the MAX655/8 operate from two series alkaline or NiCad cells, or one +3V lithium cell.

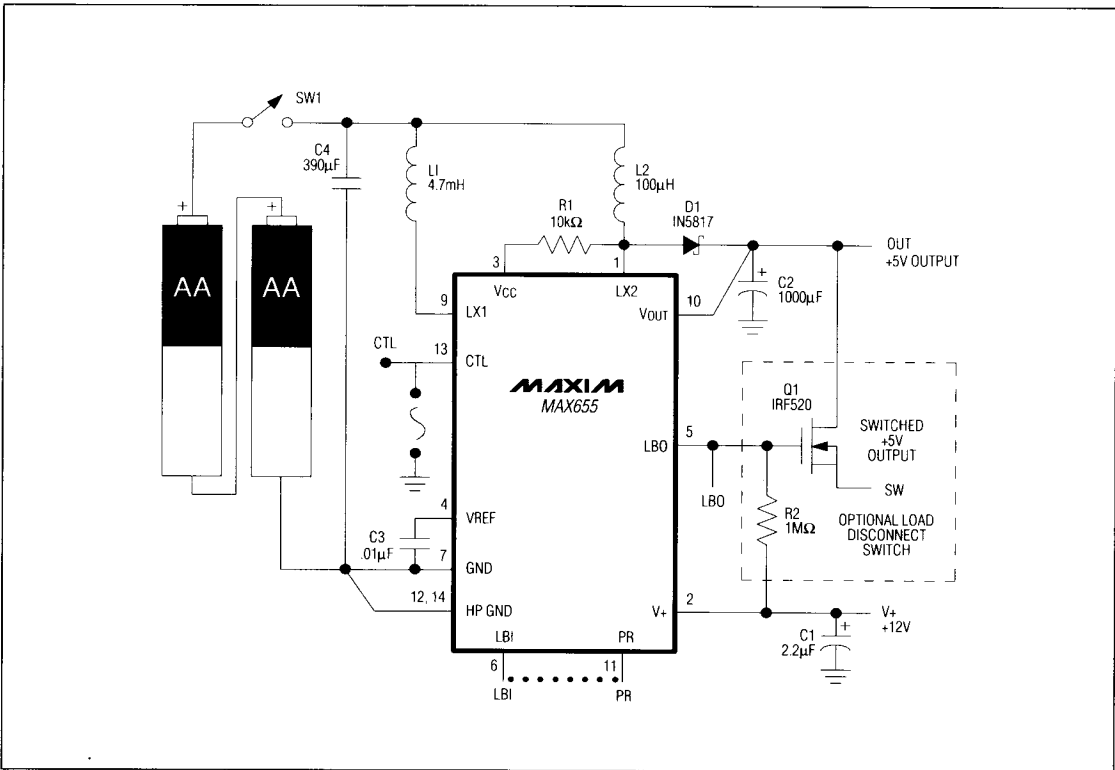


Figure 1. MAX655 Evaluation Kit Circuit



is a registered trademark of Maxim Integrated Products.

Maxim Integrated Products 1

# Low-Voltage Step-Up DC-DC Converter Power-Supply Evaluation Kit

## EVALUATION KIT CONTENTS

QTY	PART DESCRIPTION	SYMBOL	SOURCE	PRICE*
1	Single-Sided PC Board			
1	MAX655CPD Plastic DIP IC	IC1	Maxim	\$3.85
1	4.7mH Low-Power Inductor (85Ω DC)	L1	Dale (Ph: 402-564-3131)	\$0.60
1	100μH Power Inductor	L2	Maxim L001	\$1.85
1	Schottky Diode	D1	Motorola 1N5817 (Ph: 602-244-6900)	\$0.13
1	2.2μF Tantalum Capacitor	C1		\$0.11
1	1000μF Low-ESR (.065Ω) Electrolytic Capacitor	C2	Nichicon "PL" Series (Ph: 312-843-7500)	\$0.39
1	0.01μF Capacitor	C3		\$0.08
1	390μF Low-ESR (.17Ω) Electrolytic Capacitor	C4	Nichicon "PL" Series (Ph: 312-843-7500)	\$0.17
1	Toggle Switch	SW1		
4	AA Battery Clips	J1-J4		
1	10kΩ Resistor	R1		
The following parts are optional and are not included with kit:				
1	N-Channel MOSFET	Q1	International Rectifier, Motorola IRF520, IRF530 or equivalent	
1	1MΩ Resistor	R2		

\* Approximate price in 1k quantities

## Kit Assembly and Test Instructions

### CAUTION: OBSERVE PROTOTYPING PRECAUTIONS BELOW

- **DO NOT INSERT DEVICE INTO SOCKET WITH POWER APPLIED.**
- **BE CERTAIN OUTPUT FILTER CAPACITORS ARE CONNECTED.**
- **DO NOT SOLDER OR WORK ON CIRCUIT WHILE POWER IS APPLIED.**
- **OBSERVE SUPPLY VOLTAGE RATINGS CAREFULLY.**

1. **Build circuit.** Install all parts on PC board as shown in Figure 2. The kit accepts either two AA batteries or a single 3V lithium battery such as Duracell #DL123A; if using a single 3V battery, install jumper W1. Connect LBI to PR with a jumper. Optional parts Q1 and R2 function as a load switch as discussed in the *Output Load Switch* section and may be added later.

2. **Apply power and verify operation.** Be sure to observe proper polarity when installing batteries (the circuit will be damaged if the polarity is incorrect). If an external supply is used to power the kit, keep input voltages below 3.1V. A variable load at the output may be used to test efficiency and load limits. The circuit supplies 5V at 60mA with input voltages ranging from 2.2V to 3.1V and starts up under all load conditions listed in the Electrical Characteristics Table.

The output is NOT short-circuit protected because diode D1 provides a DC path between the input source and the output (this is true of all boost-configured power supplies).

Consult MAX654-8 data sheet for further discussion of operating principles.

# Low-Voltage Step-Up DC-DC Converter Power-Supply Evaluation Kit

MAX655 EVKIT

## TYPICAL ELECTRICAL CHARACTERISTICS (Note 1)

(MAX655EVKIT Operating Circuit; CTL = 0V (High-Power Mode); Iload = 0mA; TA = +25°C, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage Range			2.2		3.1	V
Output Voltage Range	2.2V < VIN < 3.1V; Iload = 60mA		4.5		5.5	V
Output Current (High-Power Mode)	2.2V < VIN < 3.1V, 4.5V < VOUT < 5.5V				60	mA
Output Current (Low-Power Mode)	2.2V < VIN < 3.1V, 4.5V < VOUT < 5.5V; CTL = 5V				1.2	mA
Efficiency	See Typical Operating Characteristics					
Output Voltage Ripple	2.2V < VIN < 3.1V				40	mV
Voltage at V+ Pin	No load on V+ pin			12		V
Output Current Available at V+ Pin	10V < V+ < 12V, 2.2V < VIN < 3.1V				450	μA
Battery Life	See Table 1					
Quiescent Current	VIN = 2.5V	CTL = 0V (High-Power Mode)		525		μA
		CTL = 5V (Low-Power Mode)		60		
Supply Start-Up Time (Note 2)	VIN raised from 0V to 2.5V	CTL = 0V (High-Power Mode)		20		ms
		CTL = 5V (Low-Power Mode)		600		
Low-Power Mode to High-Power Mode Transition Time	VIN = 2.5V; CTL pin toggled from 5V to 0V (Low-Power to High-Power Mode)			6		ms
Maximum CTL Toggle Rate					1	Hz

**Note 1:** Specifications given are typical operating limits; parameters are not production tested.

**Note 2:** A lower value for C2 decreases these start-up times. Start-up time is the period from which power is first applied until VOUT reaches +4.5V.



# **Low-Voltage Step-Up DC-DC Converter Power-Supply Evaluation Kit**

**MAX655 EVKIT**

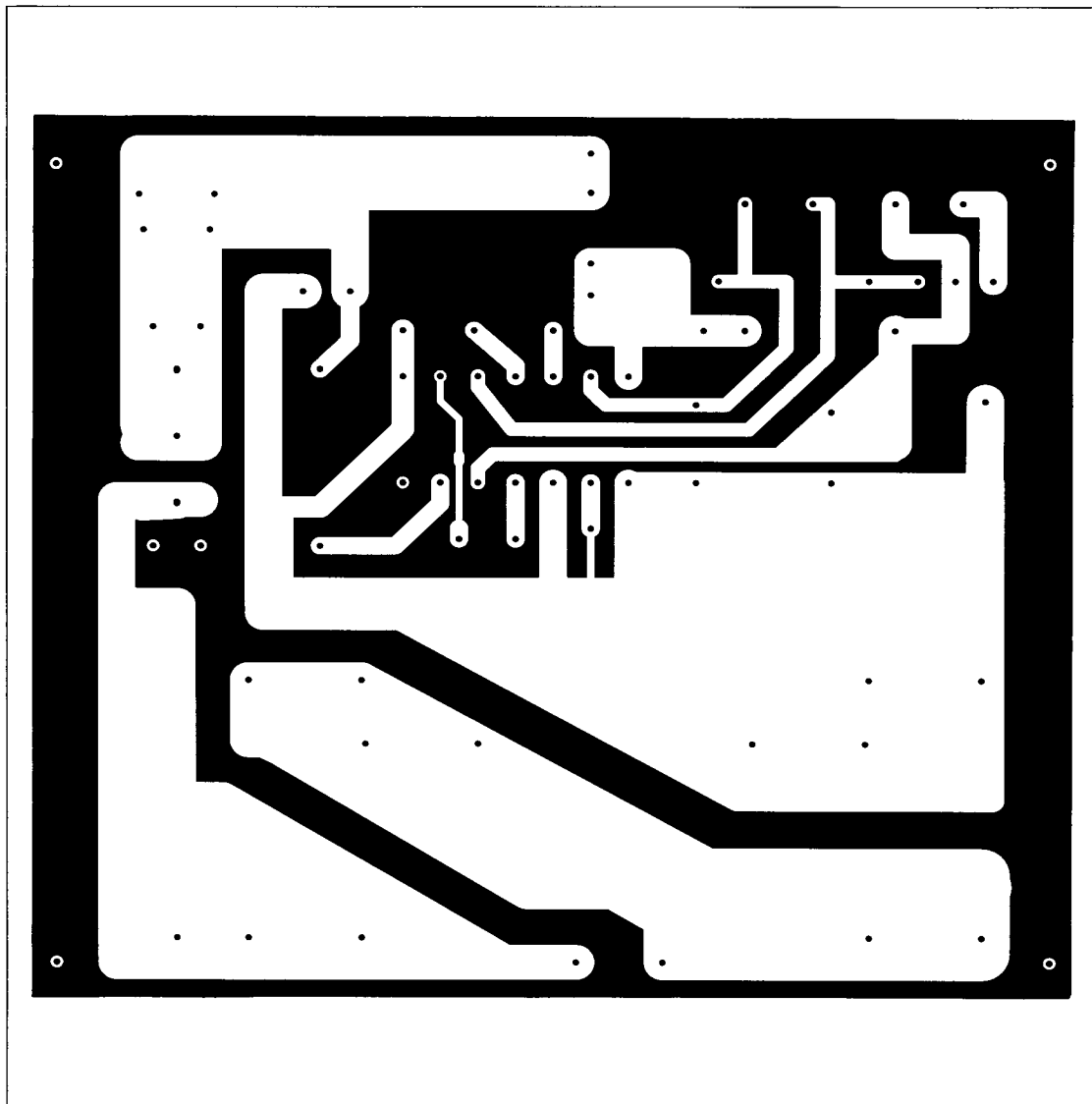
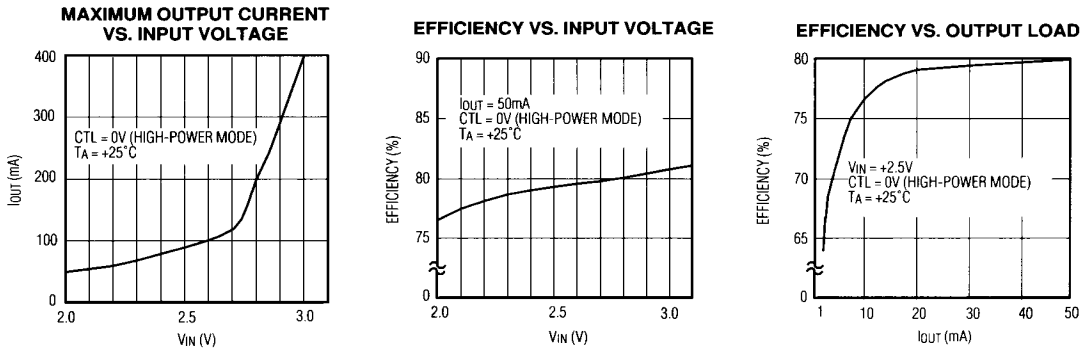


Figure 3. MAX655 EVKIT Copper Trace Layer

# Low-Voltage Step-Up DC-DC Converter Power-Supply Evaluation Kit

## Typical Operating Characteristics



**Table 1. Typical Battery Life in MAX655 Evaluation Kit**

LOAD (mA)	BATTERIES	LIFE (HRS)	WATT-HOURS DELIVERED
10	2 x AA (Alkaline)	94.4	4.72
50	2 x AA (Alkaline)	13.75	3.43
50	1 x DL123A (+3V Lithium)	10.6	2.65

## Switching Waveforms

Figure 4 shows switching waveforms for the MAX655 boost converter. An oscillator of fixed frequency and duty cycle is gated by a comparator that monitors the output voltage. When VOUT falls below the comparator threshold, the internal MOSFET at LX2 is switched at the clock frequency at a 50% duty cycle. While the MOSFET is turned on, current flows through L2, storing energy in the inductor core. During the second half clock cycle, while the MOSFET at LX2 is switched off, energy is transferred to the output via D1.

The MAX654-8 are pulse-skipping boost converters; the inductor is switched when the output requires a "boost." So, although the internal oscillator operates at a fixed frequency, the output switching frequency depends on the output load current. Higher load currents require more frequent boost pulses and consequently higher switching frequencies. This type of control is different from a pulse width modulation (PWM) scheme, where the

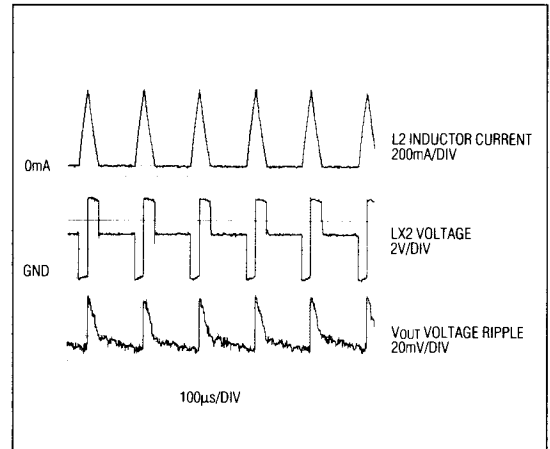


Figure 4. Typical Switching Waveforms (VIN = 3.0V, IOUT = 50mA)

switching MOSFET turns on at a fixed frequency, and output regulation is achieved by varying the duty cycle. Unlike PWM converters, pulse skippers like the MAX654-8 do not switch the power MOSFET every clock cycle; thus, switching losses decrease with load. Under no-load conditions, only infrequent switching cycles are needed to maintain output voltage. This results in a very low quiescent current DC-DC converter ideal for battery-operated equipment.

# Low-Voltage Step-Up DC-DC Converter Power-Supply Evaluation Kit

Note that the current in the L2 inductor rises to a consistent peak value, then falls to zero as it is discharged into the load. This is often referred to as "discontinuous current" operation. Note also the output voltage ripple is in phase with the discharge slope of the inductor current. Most of the ripple amplitude is a result of inductor discharge current flowing through the equivalent series resistance (ESR) of the output filter capacitor.

The output filter capacitor C2 provided in this kit is a low-ESR aluminum electrolytic with 0.065 $\Omega$  ESR (specified at 100kHz). The output ripple amplitude is approximately 0.065 $\Omega$  x 600mA peak coil current, or about 40mV.

## Auxiliary +12V Supply

The MAX654-8 family of low-voltage power supplies features an on-board, loosely regulated 12V supply at the V+ pin, in addition to the main 5V supply. This 12V supply is used internally for converter operation. A small amount of current is available from V+ for external use, such as in high-side switch applications.

Lower inductance and series resistance values for L1 allow more current to be drawn from V+. Note: The L1 inductance should not be less than 1mH. With L1 = 4.7mH (85 $\Omega$  series resistance, the coil supplied in the kit) V+ can supply about 450 $\mu$ A. With L1 = 1mH (25 $\Omega$  series resistance), V+ can supply 12V at 1mA. Note: this 12V supply is not available in low-power mode. Also note that heavy loading of the V+ supply impedes the circuit's ability to start up at low input voltages—a 450 $\mu$ A load on V+ raises the start-up voltage by 250mV. Do not draw V+ currents that reduce the V+ voltage to less than 10V.

## High-Power/Low-Power Mode

The MAX654-8 feature a low-power operating mode where the 5V output can supply up to 1mA. Quiescent current is reduced to 60 $\mu$ A, compared to 450 $\mu$ A in high-power mode.

The CTL pin, which selects high-power/low-power mode, is connected to ground with a thin trace on the PC Board. For low-power mode, cut this trace, and connect CTL to VOUT. CTL may be operated by a logic-level signal.

Efficiency with a 100 $\mu$ A load in low-power mode is 50%.

## Output Load Switching

Optional N-channel MOSFET Q1 and gate pull-up resistor R2 (Figure 5) function as an output load switch to disconnect an external load from the 5V supply. The MOSFET gate is driven to 12V (on) or GND (off) by the LBO pin. LBO is the output of the low-battery comparator, and it goes high when the voltage at the LBI pin is greater than 1.17V. There are several ways of turning on and off loads using the LBI pin. For example, a logic-level signal may be used (Figure 5a). Another scheme uses a resistor divider to disconnect the load as the input battery voltage drops below a predetermined level (Figure 5b). Alternatively, the PR output can be connected to the LBI pin to automatically disconnect loads when the MAX655 switches into low-power mode (Figure 5c). The PR output goes high when the MAX655 goes into high-power mode.

## Input Source Filtering

Capacitor C4 (Figure 1) reduces power loss due to the battery source impedance by providing a low-impedance, high-current source during inductor charge cycles. C4 increases efficiency by as much as 8% for alkaline batteries, which may exhibit an ohm or more source impedance. Note: C4 is not required for circuit operation.

## Alternate Parts Suppliers

Contact Maxim for a list of component suppliers.

# Low-Voltage Step-Up DC-DC Converter Power-Supply Evaluation Kit

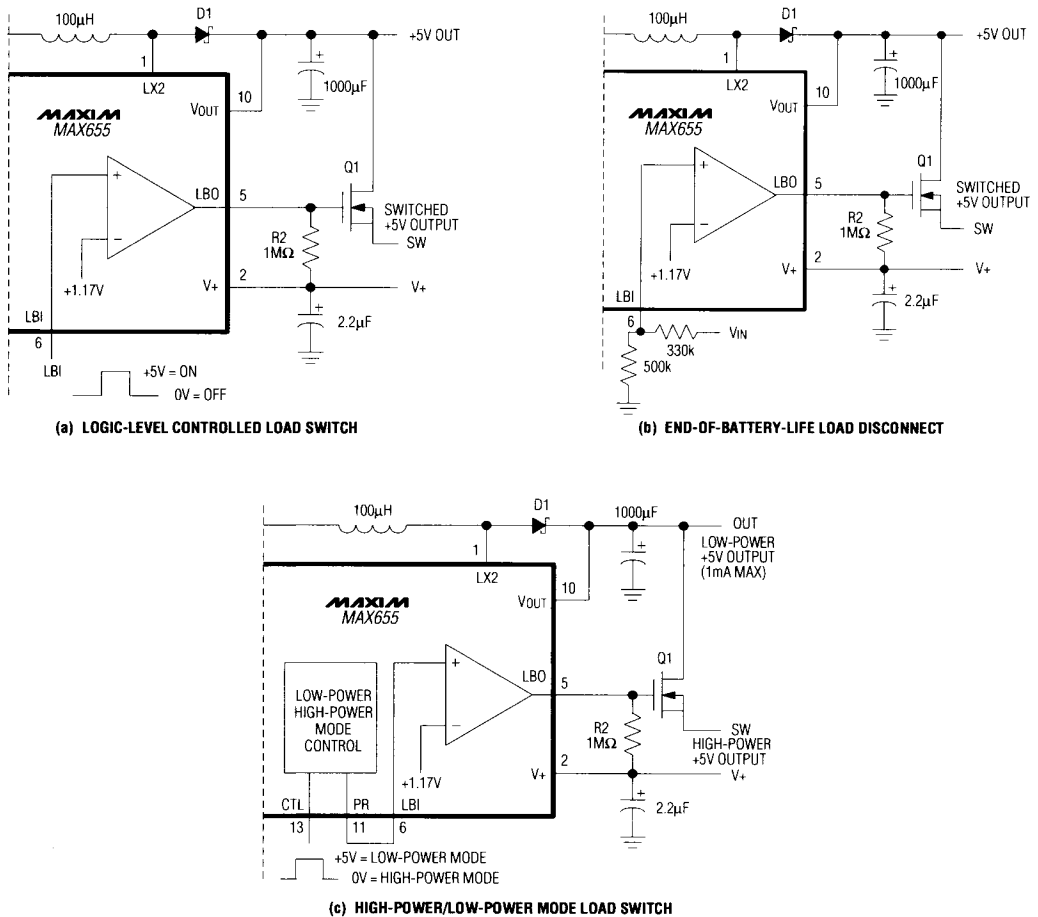


Figure 5. Output Load Switch

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

8 Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 (408) 737-7600

© 1991 Maxim Integrated Products

Printed USA

19-3883

2/91

022504 ✓