19-0388; Rev 0; 4/95

EVALUATION KIT MANUAL FOLLOWS DATA SHEET

MAXIM

Low-Noise, Regulated, -2V GaAsFET Bias

General Description

The MAX840/MAX843/MAX844 low-noise, inverting charge-pump power supplies are ideal for biasing GaAsFETs in cellular telephone transmitter amplifiers. They operate with inputs down to 2.5V.

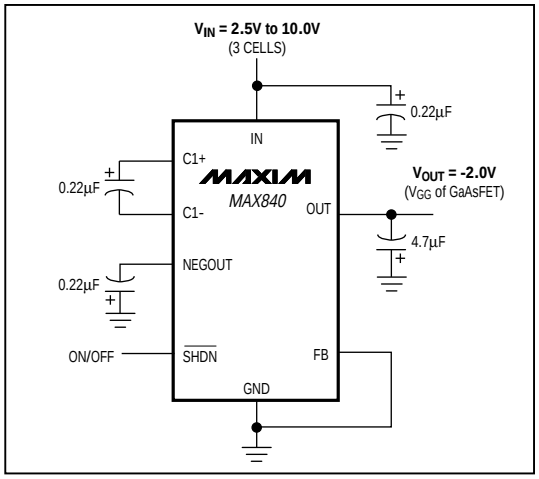
The MAX840 offers both a -2V preset output and a -0.5V to -9.4V adjustable output. The MAX843/MAX844 use an external positive control voltage to set the negative output voltage. Input voltage range for all the devices is 2.5V to 10V, and output current is 4mA with V_{IN} > 2.7V. These circuits can operate with small capacitors, as low as 0.22µF.

An internal linear regulator reduces the MAX840's output voltage ripple to 1mVp-p. With a well-filtered control voltage (V_{CTRL}), the MAX843/MAX844 also achieve less than 1mVp-p typical output ripple. Supply current is 750µA, and reduces to less than 1µA in shutdown (MAX840/MAX843). The MAX844's unregulated output is active in shutdown, with the charge pump switching at 20kHz. It provides a low-power LCD supply.

Applications

Cellular Phones
GaAsFET Power Amplifier Modules
Personal Communicators, PDAs
Wireless Data Loggers
Continuously Adjustable GaAsFET Bias
LCD-Bias Contrast Control
Regulated Negative Power Supplies

Typical Operating Circuit



Features

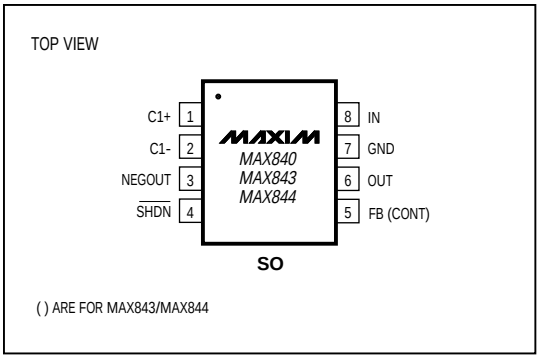
- **Fixed -2V or Adjustable -0.5V to -9.4V Output at 4mA (MAX840)**
- **2.5V to 10V Input Voltage Range**
- **Operate with Small Capacitors (as low as 0.22µF)**
- **1mVp-p Output Voltage Ripple**
- **Charge-Pump Switching Frequency:**
  100kHz in Normal Operation
  20kHz in Shutdown Mode (MAX844)
- **1µA Max Logic-Level Shutdown Over Temp. (MAX840/MAX843)**
- **Small 8-Pin SO Package**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX840C/D	0°C to +70°C	Dice*
MAX840ISA	-25°C to +85°C	8 SO
MAX840ESA	-40°C to +85°C	8 SO
MAX843C/D	0°C to +70°C	Dice*
MAX843ISA	-25°C to +85°C	8 SO
MAX843ESA	-40°C to +85°C	8 SO
MAX844C/D	0°C to +70°C	Dice*
MAX844ISA	-25°C to +85°C	8 SO
MAX844ESA	-40°C to +85°C	8 SO

** Dice are specified at T_A = +25°C only.*

Pin Configuration



ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{IN} to GND .....-0.3V to 10.5V
V_{NEGOUT} to GND .....-10.5V to 0.3V
V_{IN} to V_{NEGOUT} .....-0.3V to 21V
V_{OUT} to GND (Note 1) .....V_{NEGOUT} to 0.3V
$V_{\overline{SHDN}}$ to GND .....-0.3V to (V_{IN} + 0.3V)
Continuous Power Dissipation (T_A = +70°C)
SO (derate 10.00mW/°C above +70°C) 800mW

Operating Temperature Ranges
MAX84_I_ _ .....-25°C to +85°C
MAX84_E_ _ .....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10sec) .....+300°C

Note 1: The output may be shorted to NEGOUT or GND if the package power dissipation is not exceeded. Typical short-circuit current from 4V to GND is 40mA.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

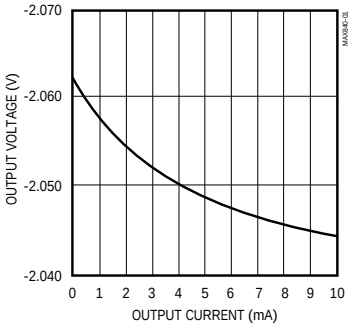
(Figures 2a and 2c, 2.5V ≤ V_{IN} ≤ 10V, V_{OUT} = -2V, GND = 0V, R_L = ∞, $\overline{SHDN}$ = V_{IN}, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are measured at V_{IN} = 3.6V and T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{IN}			2.5		10	V
Output Voltage	V_{OUT}	MAX840, V_{FB} = 0V	V_{IN} ≥ 2.5V, I_{OUT} = 0mA to 3mA	-2.1	-2.0	-1.9	V
			V_{IN} ≥ 2.7V, I_{OUT} = 0mA to 4mA	-2.1	-2.0	-1.9	
		MAX843/MAX844, V_{CTRL} = 2V	V_{IN} ≥ 2.5V, I_{OUT} = 0mA to 3mA	-2.05	-2.0	-1.95	
			V_{IN} ≥ 2.7V, I_{OUT} = 0mA to 4mA	-2.05	-2.0	-1.95	
Output Voltage Adjust Range	V_{OUT}				-0.5 to (V_{IN} - 0.6)		V
FB Voltage	V_{FB}	MAX840, no load		-0.516	-0.5	-0.484	V
FB Leakage Current	I_{FB}	MAX840, V_{FB} = -0.5V			±1	±100	nA
CONT Leakage Current	I_{CONT}	MAX843/MAX844, V_{CONT} = 0V			±1	±100	nA
Supply Current	I_Q	No load, V_{IN} ≤ 3.6V			750	1100	µA
Shutdown Supply Current	I_{SHUT}	MAX840/MAX843, V_{IN} = 10V, $\overline{SHDN}$ = 0V				1	µA
		MAX844, V_{IN} = 10V, $\overline{SHDN}$ = 0V			940		
		MAX844, V_{IN} ≤ 3.6V, $\overline{SHDN}$ = 0V			175	300	
V_{OUT} Load Regulation		V_{IN} = 3.6V, R_L = ∞ or 500Ω	MAX840, V_{FB} = 0V		3	8	mV/mA
			MAX843/MAX844, V_{CTRL} = 2V		2	8	
V_{OUT} Ripple		C4 = 10µF			1		mVp-p
Oscillator Frequency	F_{OSC}	V_{IN} = 3.6V, T_A = +25°C	MAX840/MAX843/MAX844	80	100	120	kHz
			MAX844, $\overline{SHDN}$ = 0V	14	20	26	
Input High Voltage	V_{IH}	$\overline{SHDN}$		2.2			V
Input Low Voltage	V_{IL}	$\overline{SHDN}$				0.5	V
Input Current	I_{IN}	$\overline{SHDN}$		-1		1	µA
Input Capacitance	C_{IN}	$\overline{SHDN}$			10		pF

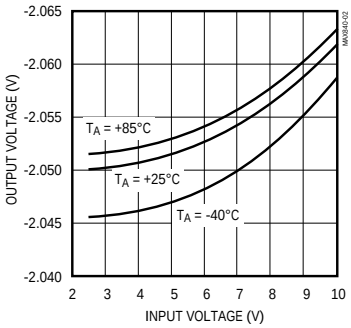
Typical Operating Characteristics

(Circuit of Figure 2a, V_{IN} = 3.6V, T_A = +25°C, unless otherwise noted.)

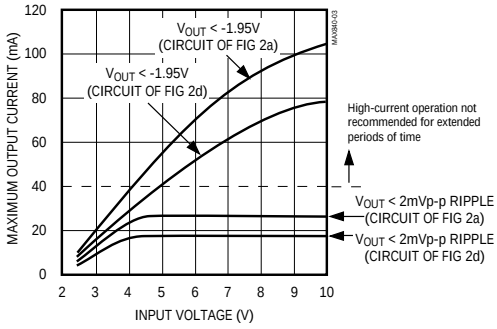
OUTPUT VOLTAGE vs. OUTPUT CURRENT



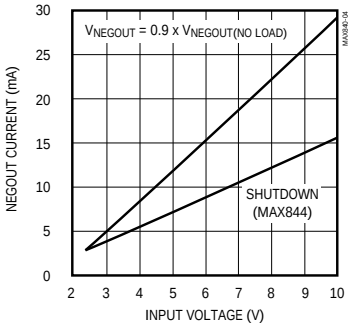
OUTPUT VOLTAGE vs. INPUT VOLTAGE OVER TEMPERATURE



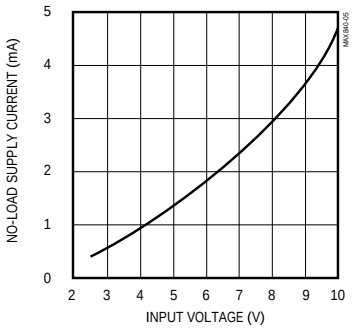
MAXIMUM OUTPUT CURRENT vs. INPUT VOLTAGE



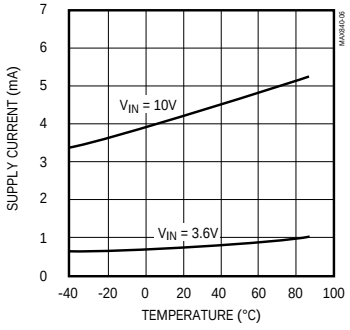
NEGOUT CURRENT vs. INPUT VOLTAGE



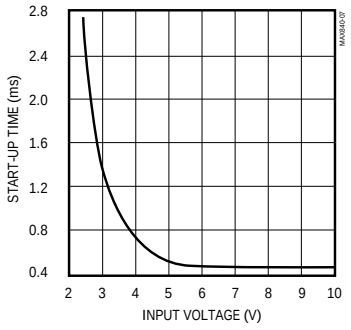
NO-LOAD SUPPLY CURRENT vs. INPUT VOLTAGE



SUPPLY CURRENT vs. TEMPERATURE



START-UP TIME vs. INPUT VOLTAGE

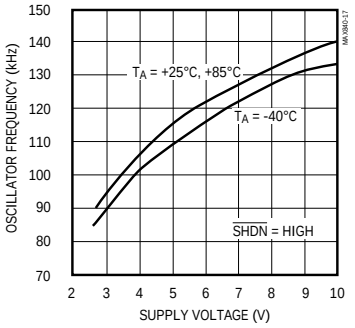


Low-Noise, Regulated, -2V GaAsFET Bias

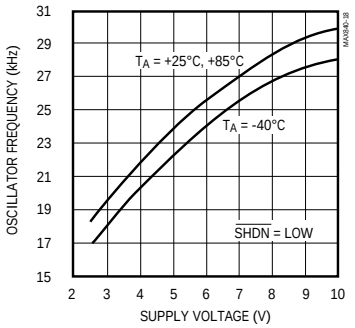
Typical Operating Characteristics (continued)

(Circuit of Figure 2a, V_{IN} = 3.6V, T_A = +25°C, unless otherwise noted.)

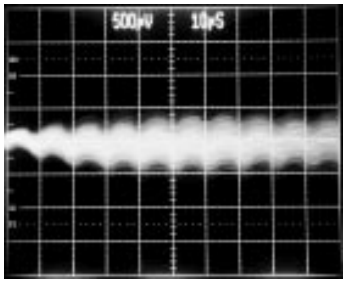
OSCILLATOR FREQUENCY vs. SUPPLY VOLTAGE



MAX844 OSCILLATOR FREQUENCY vs. SUPPLY VOLTAGE



MAX840 OUTPUT NOISE AND RIPPLE (C1 = C2 = C3 = 1µF, C4 = 10µF)

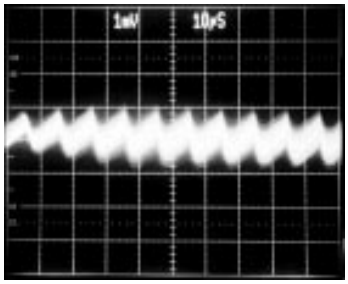


VOUT
500µV/div

10µs/div

VIN = 3.6V, VOUT = -2V, IOUT = 4mA, AC COUPLED

MAX840 OUTPUT NOISE AND RIPPLE (C1 = C2 = C3 = 0.22µF, C4 = 4.7µF)

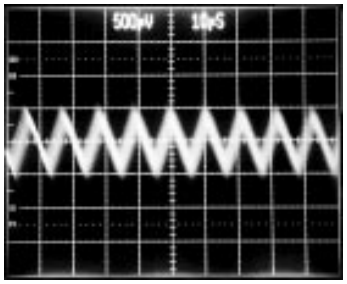


VOUT
1mV/div

10µs/div

VIN = 3.6V, VOUT = -2V, IOUT = 4mA, AC COUPLED

MAX843/MAX844 OUTPUT NOISE AND RIPPLE (C1 = C2 = C3 = 1µF, C4 = 10µF)

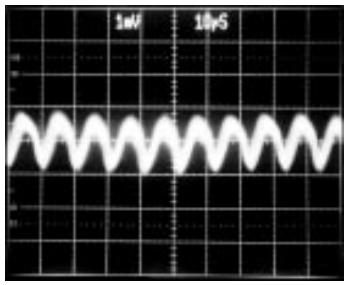


VOUT
500µV/div

10µs/div

VIN = 3.6V, VOUT = -2V, IOUT = 4mA, AC COUPLED

MAX843/MAX844 OUTPUT NOISE AND RIPPLE (C1 = C2 = C3 = 0.22µF, C4 = 4.7µF)



VOUT
1mV/div

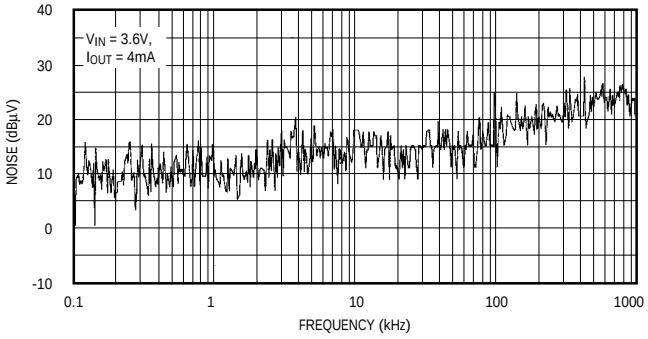
10µs/div

VIN = 3.6V, VOUT = -2V, IOUT = 4mA, AC COUPLED

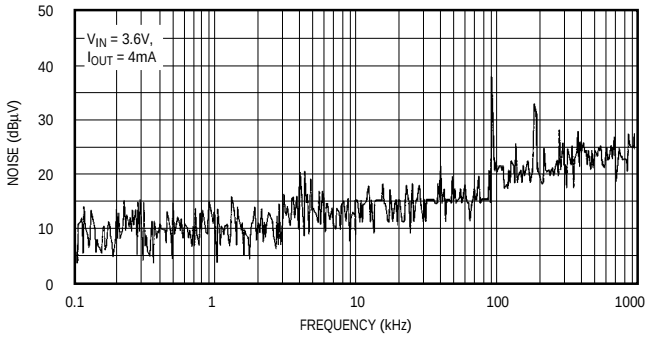
Typical Operating Characteristics (continued)

(Circuit of Figure 2a, V_{IN} = 3.6V, T_A = +25°C, unless otherwise noted.)

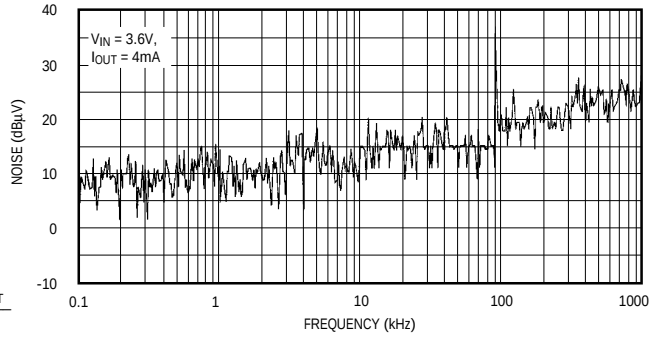
MAX840 NOISE SPECTRUM
(C1 = C2 = C3 = 1µF, C4 = 10µF)



MAX840 NOISE SPECTRUM
(C1 = C2 = C3 = 0.22µF, C4 = 4.7µF)



MAX843/MAX844 NOISE SPECTRUM
(C1 = C2 = C3 = 1µF, C4 = 10µF)



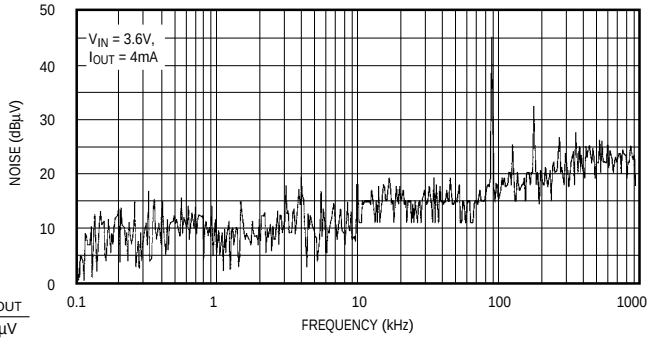
NOTE: $dB\mu V = 20 \text{ LOG } \frac{V_{OUT}}{1\mu V}$

Low-Noise, Regulated, -2V GaAsFET Bias

Typical Operating Characteristics (continued)

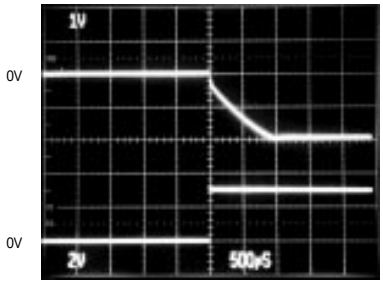
(Circuit of Figure 2a, V_{IN} = 3.6V, T_A = +25°C, unless otherwise noted.)

MAX843/MAX844 NOISE SPECTRUM
(C1 = C2 = C3 = 0.22µF, C4 = 4.7µF)



NOTE: $dB\mu V = 20 \log \frac{V_{OUT}}{1\mu V}$

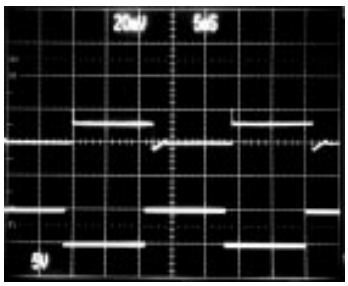
START-UP FROM SHUTDOWN



500µs/div

V_{IN} = 3.6V, V_{OUT} = -2V, I_{OUT} = 4mA

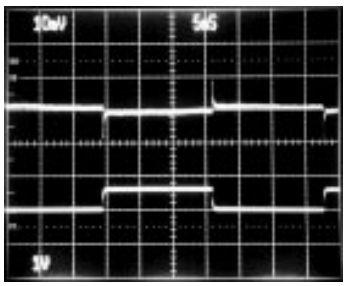
LOAD-TRANSIENT RESPONSE



5ms/div

V_{IN} = 3.6V, V_{OUT} = -2V

LINE-TRANSIENT RESPONSE



5ms/div

V_{OUT} = -2V, I_{OUT} = 4mA, AC COUPLED

Pin Description

PIN		NAME	FUNCTION
MAX840	MAX843 MAX844		
1	1	C1+	Positive Terminal for C1
2	2	C1-	Negative Terminal for C1
3	3	NEGOUT	Negative Output Voltage (unregulated)
4	4	$\overline{SHDN}$	Active-Low, TTL Logic-Level Shutdown Input
5	—	FB	Dual-Mode™ Feedback Input. When FB is grounded, the output is preset to -2V. To select other output voltages, connect FB to an external resistor divider (Figure 2b).
—	5	CONT	Control Voltage Input. To set V_{OUT}, connect a resistor divider between OUT and a positive control voltage between 0V and 10V (Figure 2c).
6	6	OUT	Regulated Negative Output Voltage
7	7	GND	Ground
8	8	IN	Positive Power-Supply Input

™Dual-Mode is a trademark of Maxim Integrated Products.

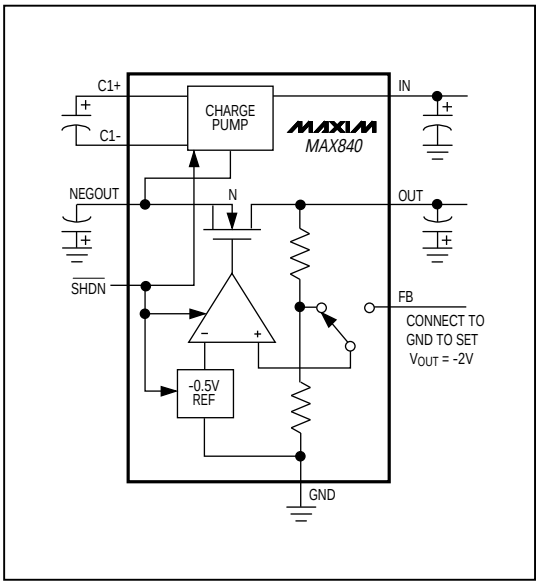


Figure 1a. MAX840 Block Diagram

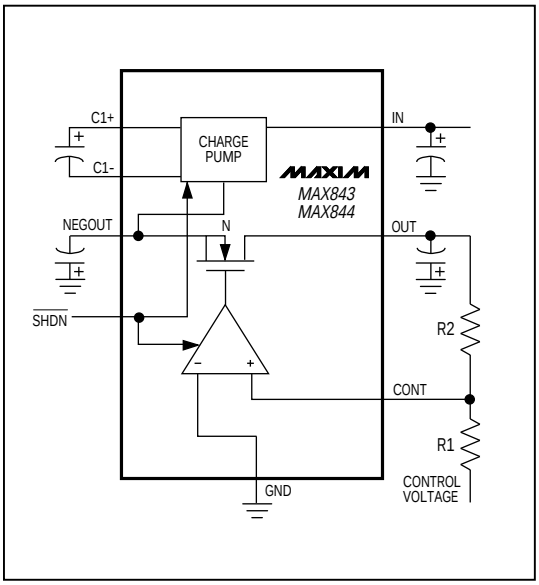


Figure 1b. MAX843/MAX844 Block Diagram

Detailed Description

The MAX840/MAX843/MAX844 are low-noise, inverting, regulated charge-pump power supplies designed for biasing GaAsFET devices, such as power-amplifier modules in cellular handsets.

The applied input voltage (V_{IN}) is first inverted to a negative voltage at NEGOUT by a capacitive charge pump. This voltage is then regulated by an internal low-noise linear regulator, and appears at OUT (Figure 1). The minimum (most negative) output voltage achievable is the inverted positive voltage, plus the 0.6V required by the post-regulator. For the MAX840, the linear regulator reduces ripple noise induced by the charge-pump inverter to 1mVp-p at V_{OUT}. In addition, the linear regulator's excellent AC rejection attenuates noise from the incoming supply.

Applications Information

Setting the Output Voltage

For the MAX840, select either a fixed or adjustable output voltage. Connect FB directly to GND for a fixed -2V output (Figure 2a). Select an alternate output voltage by connecting FB to the midpoint of a resistor voltage divider from OUT to GND (Figure 2b). V_{IN} must be 0.6V above the absolute value of V_{OUT} to allow proper regulation. The output voltage is calculated from the formula below. Choose R2 to be between 100kΩ and 400kΩ.

$$V_{OUT} = (-0.5V)(1 + R2 / R1)$$

For the MAX843/MAX844, set the output voltage by connecting a resistor voltage divider between OUT and a positive control voltage (V_{CTRL}) (Figure 2c).

$$V_{OUT} = -V_{CTRL} (R2 / R1)$$

Shutdown Mode

The MAX840/MAX843/MAX844 feature a shutdown mode that reduces the supply current to 1µA max over temperature (300µA max for the MAX844). When the MAX840/MAX843 are in shutdown, the outputs (OUT, NEGOUT) and the charge-pump oscillator are disabled. When the MAX844 is in shutdown, only the linear regulator is disabled and the NEGOUT output remains enabled. However, the charge-pump oscillation frequency is reduced to 20kHz, reducing the available power at NEGOUT. The output voltage at NEGOUT can be used to bias an LCD while in shutdown.

Capacitors

Use capacitors with low effective series resistance (ESR) to maintain a low dropout voltage (V_{IN} - $|V_{OUT}|$). The overall dropout voltage is a function of the charge pump's output resistance and the voltage drop across the linear regulator (N-channel pass transistor). At the 100kHz switching frequency, the charge-pump output resistance is a function of C1 and C2's ESR. Therefore, minimizing the ESR of the charge-pump capacitors minimizes the dropout voltage.

The output resistance of the entire circuit is approximately:

$$R_{OUT} = R_O + 4 \times ESR_{C1} + ESR_{C4} + 1 / (f_S \times C1) + R_{(linear\ regulator)}$$

where $[R_O + R_{(linear\ regulator)}]$, the effective resistance of the internal switches and the resistance across the linear regulator, is approximately 71Ω at V_{IN} = 2.5V, 48Ω at V_{IN} = 5V, and 40Ω at V_{IN} = 10V.

C1, C2, and C3 should be 1µF capacitors with less than 0.8Ω ESR. C4 should be a 10µF capacitor with less than 0.2Ω ESR. Smaller capacitor values can be used (C1 = C2 = C3 = 0.22µF, C4 = 4.7µF) with a small increase in output noise and ripple (Figure 2d). All capacitors should be either surface-mount chip tantalum or ceramic types. External capacitor values can be adjusted to optimize size and cost.

Layout and Grounding

Good layout is important, primarily for good noise performance. Take the following steps to ensure good layout:

1) Mount all components as close together as possible.
2) Keep traces short to minimize parasitic inductance and capacitance. This includes connections to FB.
3) Use a ground plane.

Noise and Ripple Measurement

Accurately measuring the output noise and ripple is a challenge. Slight momentary differences in ground potential between the MAX840/MAX843/MAX844 circuit and the oscilloscope (which results from the charge pump's switching action) cause ground currents in the probe's wires, inducing sharp voltage spikes. For best results, measure directly across the output capacitor (C4). Do not use the ground lead of the oscilloscope probe; instead, remove the probe's tip cover and touch the ground ring on the probe directly to C4's ground terminal. You can also use a Tektronix chassis-mount test jack (part no. 131-0258) to connect your scope probe directly. This direct connection gives the most accurate noise and ripple measurement.

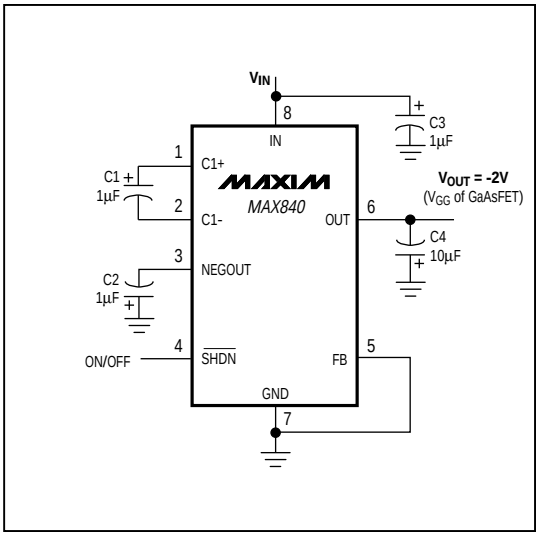


Figure 2a. MAX840 Standard Application Circuit

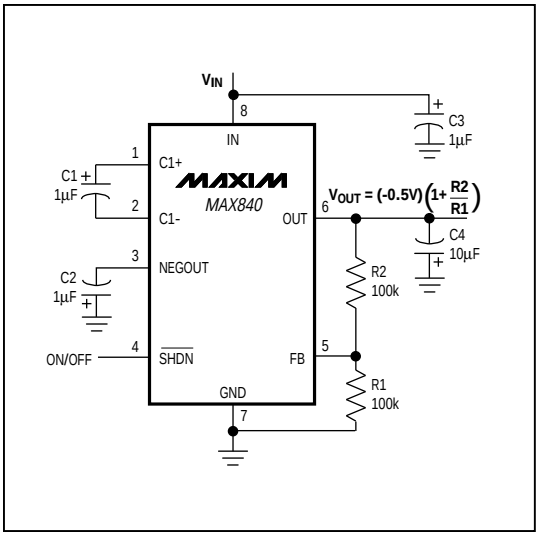


Figure 2b. MAX840 Adjustable Configuration

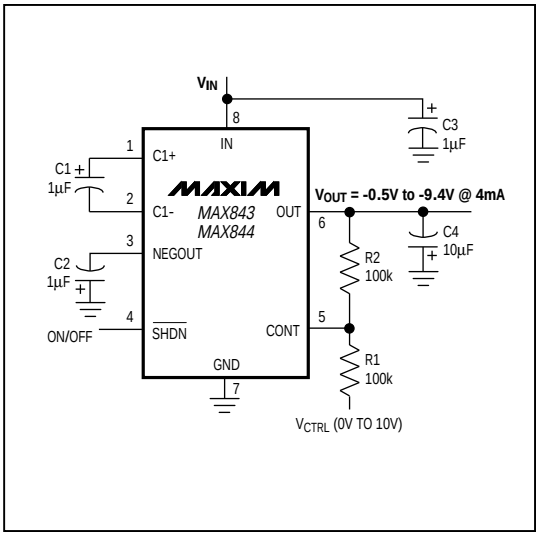


Figure 2c. MAX843/MAX844 Standard Application Circuit

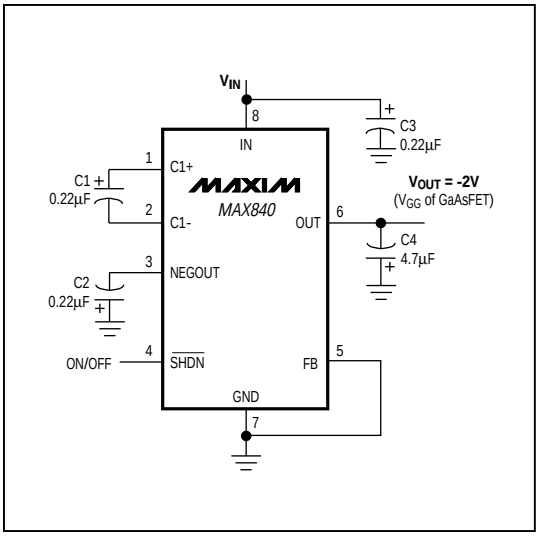
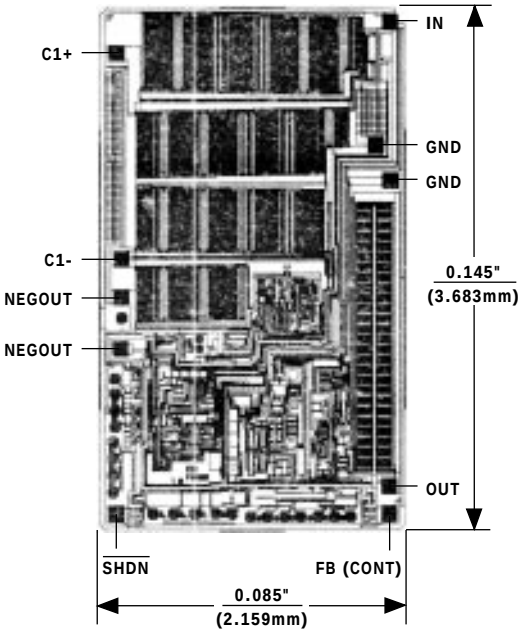


Figure 2d. MAX840 Application Circuit Using Smaller Capacitors

Low-Noise, Regulated, -2V GaAsFET Bias

Chip Topography



( ) ARE FOR MAX843/MAX844

TRANSISTOR COUNT: 148
SUBSTRATE CONNECTED TO IN

MAX840 Evaluation Kit

Evaluates: MAX840/MAX843/MAX844

General Description

The MAX840/MAX843/MAX844 ICs are inverting, charge-pump DC-DC converters with low-noise, regulated outputs. Their low output ripple voltage makes these devices ideal for biasing the GaAsFETs commonly found in cellular telephone transmitters.

The MAX840 evaluation kit (EV kit) is a fully assembled and tested surface-mount board. The board is shipped with a MAX840 mounted, but it can be replaced by the MAX843 or MAX844. Provisions are made for mounting two additional resistors, which are required for output voltages other than -2V. A special scope-probe socket is also mounted on the board, so output noise can be observed on an oscilloscope.

Features

- **1mVp-p Output Voltage Ripple**
- **2.5V to 10V Input Range**
- **Uses 0.22µF Capacitors**
- **-2V Regulated Output (or Adjustable)**
- **4mA Output Current**
- **Surface-Mount Technology**

Component List

DESIGNATION	QTY	DESCRIPTION
C1, C2, C3	3	0.22µF ceramic capacitors Vitramon VJ1206Y224KXX Murata GRM42-6X7R224M025
C4	1	4.7µF, 16V low-ESR tantalum capacitor, Sprague 595D475X0016A Matsuo 267E 2002 475
R1, R2	0	Open
J1	1	3-pin header
J3	1	Scope probe connector, Specialty Connectors 33JR135-1
U1	1	Maxim MAX840ISA 8-pin SO
None	1	Shunt
None	1	Printed circuit board

Component Suppliers

SUPPLIER	PHONE	FAX
Matsuo	(714) 969-2491	(714) 960-6492
Murata-Erie	(814) 237-1431	(814) 238-0490
Sprague	(603) 224-1961	(603) 224-1430
Vishay/Vitramon	(203) 268-6261	(203) 452-5670
Specialty Connectors	(317) 738-2800	(317) 738-2858

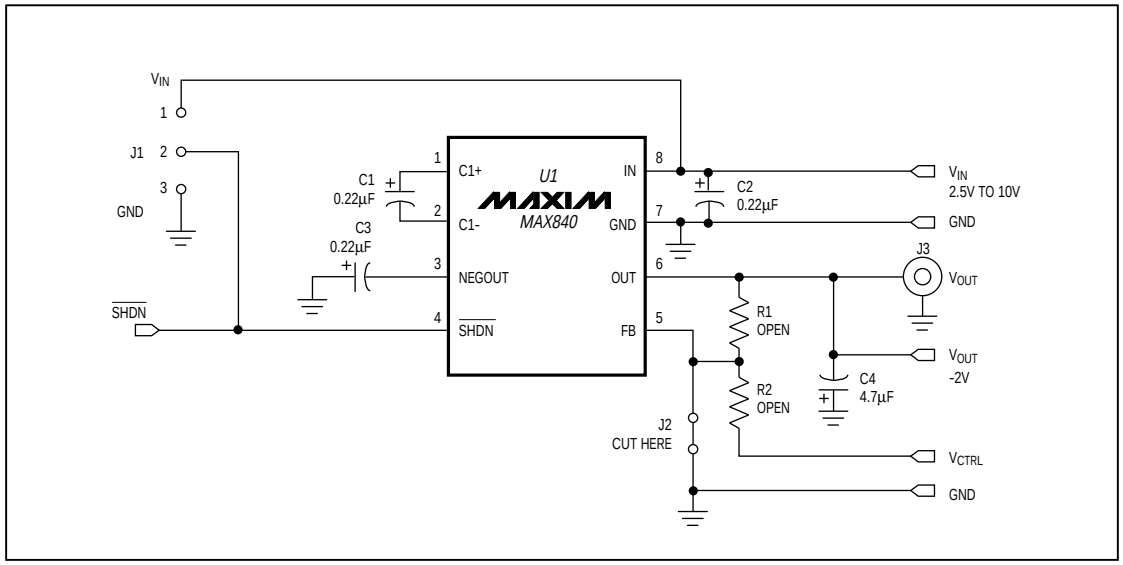


Figure 1. MAX840 EV Kit Schematic Diagram

Quick Start

The MAX840 EV kit is fully assembled and tested. Follow the steps below to verify board operation. **Do not turn on the power supply until all connections are completed.**

1) Connect a 2.5V to 10.0V supply to the VIN pad at the top of the board. Connect the ground lead to the adjacent GND pad.
2) Connect a voltmeter and the load to the VOUT pad.
3) Place the shunt on J1 across pins 1 and 2. This connects the $\overline{SHDN}$ pin to V_{IN}.
4) Turn on the power and verify that the output is -2V. You can insert a scope probe into J3 to observe the output noise. Be sure the scope ground makes contact with the outside of the connector.

Detailed Description

The 3-pin header, J1, controls pin 4 ($\overline{SHDN}$) on the IC. Table 1 outlines the shunt positions for J1.

Output Voltage Adjustment

For output voltages other than -2V, cut the trace across J2 to disconnect the FB pin (pin 5) from GND, and install two resistors (R1 and R2) for the output voltage divider. Mounting pads for the resistors are located on the board's solder side. See the MAX840/MAX843/MAX844 data sheet for instructions on calculating R1 and R2 values.

If using the MAX843 or MAX844 with the MAX840 EV kit, connect V_{CTRL} to a positive voltage to control V_{OUT}.

$$V_{OUT} = -V_{CTRL} (R2 / R1)$$

For example, if R1 = R2, then $V_{OUT} = -V_{CTRL}$. The maximum $|V_{OUT}|$ will be at least 0.6V below V_{IN}.

Table 1. J1 Shunt Positions

SHUNT POSITION	PIN 4 CONNECTION	MAX840 FUNCTION
1 & 2	V_{IN}	$\overline{SHDN}$ high, device enabled
2 & 3	GND	$\overline{SHDN}$ low, device disabled
Open	Connected to pad	Pin 4 is driven by user signal connected to $\overline{SHDN}$ pad

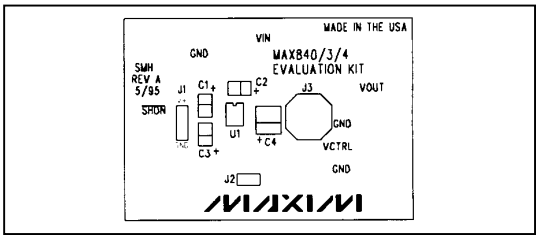


Figure 2. MAX840 EV Kit Component Placement Guide—Component Side (not shown to scale)

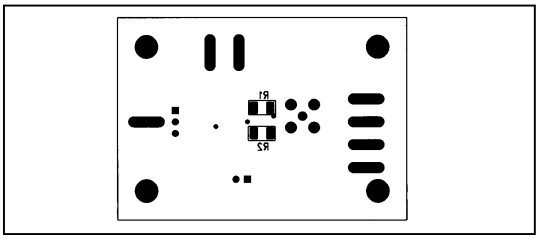


Figure 3. MAX840 EV Kit Component Placement Guide—Solder Side (not shown to scale)

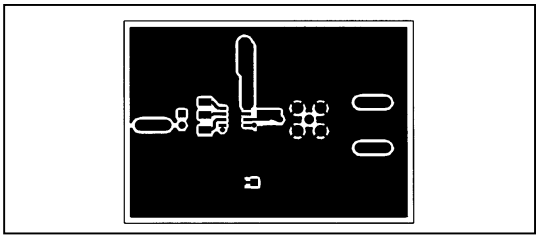


Figure 4. MAX840 EV Kit PC Board Layout—Component Side (not shown to scale)

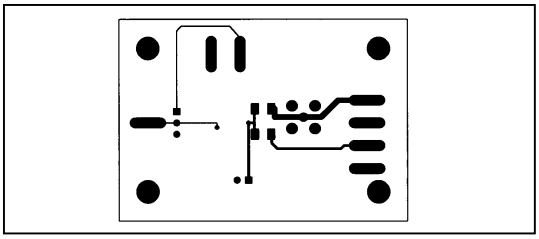


Figure 5. MAX840 EV Kit PC Board Layout—Solder Side (not shown to scale)