19-1892; Rev 0; 1/01

High-Side Power Supply

General Description

The MAX1822 high-side supply, using a regulated charge pump, generates a regulated output voltage 11V greater than the input supply voltage to power high-side switching and control circuits. The MAX1822 allows low-resistance N-channel MOSFETs (FETs) to be used in circuits that normally require costly, less efficient P-channel FETs and PNP transistors. The high-side output also eliminates the need for logic FETs in +5V and other low-voltage switching circuits.

A +3.5V to +16.5V input supply range and a typical quiescent current of only 150µA make the MAX1822 ideal for a wide range of line- and battery-powered switching and control applications where efficiency is crucial. Also provided is a logic-level power-ready output (PR) to indicate when the high-side voltage reaches the proper level.

The MAX1822 comes in an 8-pin SO package and requires three inexpensive external capacitors. The MAX1822 is a pin-for-pin replacement to the MAX622.

Features

- ♦ +3.5V to +16.5V Operating Supply Voltage Range
- ♦ Output Voltage Regulated to V_{CC} + 11V (typ)
- ♦ 150µA (typ) Quiescent Current
- ♦ Power-Ready Output

MAX1822

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX1822ESA	-40°C to +85°C	8 SO

Applications

High-Side Power Control with N-Channel FETs

Low-Dropout Voltage Regulators

Power Switching from Low Supply Voltages

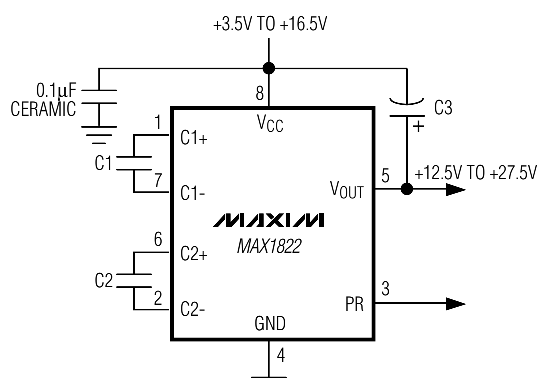
H-Switches

Stepper Motor Drivers

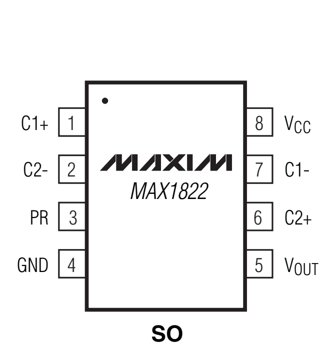
Battery-Load Management

Portable Computers

Typical Operating Circuit



Pin Configuration



High-Side Power Supply

ABSOLUTE MAXIMUM RATINGS

V_{CC} ....+17V
V_{OUT} ....+30V
I_{OUT} 25mA
Continuous Total Power Dissipation (T_A = +70°C)
8-pin SO (derate 5.88mW/°C above +70°C)..............471mW

Operating Temperature Range ....-40°C to +85°C
Storage Temperature Range ....-65°C to +160°C
Lead Temperature (soldering, 10s) ....+300°C

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

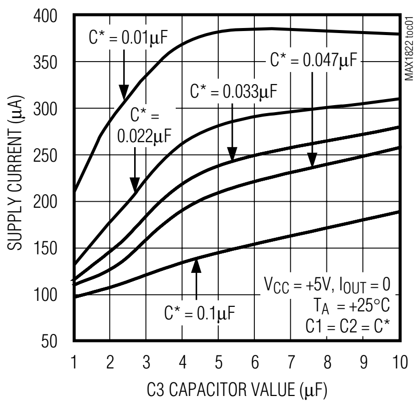
(V_{CC} = +5V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V_{CC}		3.5		16.5	V
High-Side Voltage (Note 1)	V_{OUT}	I_{OUT} = 0, V_{CC} = 3.5V, C1 = C2 = 0.047µF, C3 = 1µF	11.5	12.5	16.5	V
		I_{OUT} = 0, V_{CC} = 4.5V, C1 = C2 = 0.047µF, C3 = 1µF	14.5	15.5	17.5	
		I_{OUT} = 0, V_{CC} = 16.5V, C1 = C2 = 0.01µF, C3 = 1µF (Note 2)	26.5	27.5	29.5	
		I_{OUT} = 50µA, V_{CC} = 3.5V, C1 = C2 = 0.047µF, C3 = 1µF	8.5	10.5	16.5	
		I_{OUT} = 250µA, V_{CC} = 5V, C1 = C2 = 0.047µF, C3 = 1µF	15		18	
		I_{OUT} = 500µA, V_{CC} = 16.5V, C1 = C2 = 0.01µF, C3 = 1µF (Note 2)	26.5		29.5	
Power-Ready Threshold	PRT	I_{OUT} = 0 (Note 3)	12	13.5	14.5	V
Power-Ready Output High	PR_{OH}	I_{SOURCE} = 100µA	3.8	4.3	5	V
Power-Ready Output Low	PR_{OL}	I_{SINK} = 1mA			0.4	V
Output Voltage Ripple	VR	C1 = C2 = 0.01µF, C3 = 10µF, I_{OUT} = 1mA, V_{CC} = 16.5V		50		mV
Switching Frequency	F_O			90		kHz
Quiescent Supply Current	IQ	I_{OUT} = 0, V_{CC} = 5V, C1 = C2 = 0.047µF, C3 = 1µF, T_A = +25°C		150	500	µA
		I_{OUT} = 0, V_{CC} = 16.5V, C1 = C2 = 0.047µF, C3 = 1µF, T_A = +25°C		150	350	

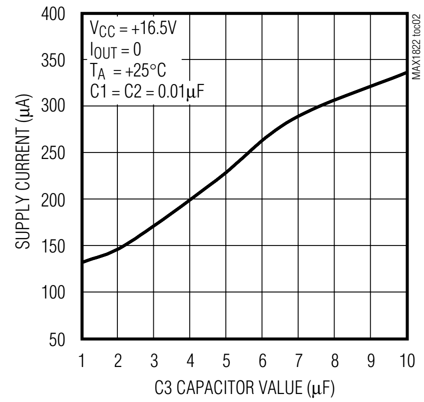
Note 1: High-side voltage measured with respect to ground.
Note 2: For V_{CC} > +13V on the MAX1822, use C1 = C2 = 0.01µF.
Note 3: Power-Ready Threshold is the voltage with respect to ground at V_{OUT} when PR switches high (PR = V_{CC}).

Typical Operating Characteristics

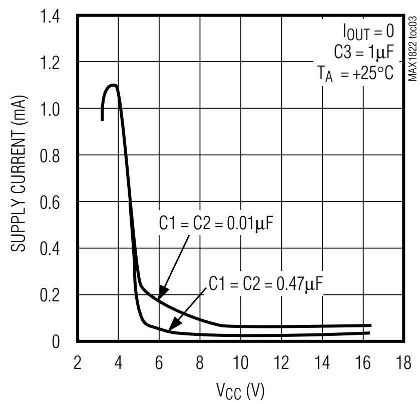
MAX1822
SUPPLY CURRENT
vs. C3 CAPACITOR VALUE



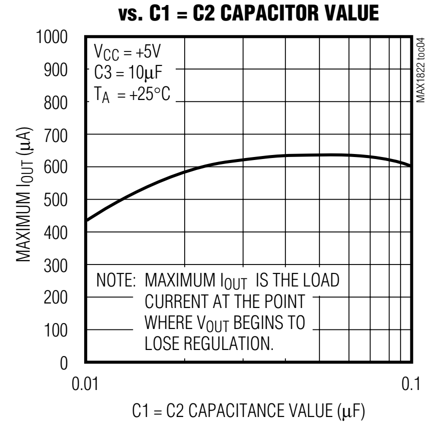
MAX1822
SUPPLY CURRENT
vs. C3 CAPACITOR VALUE



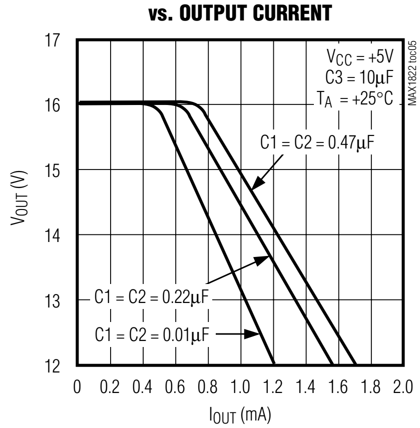
MAX1822
SUPPLY CURRENT
vs. SUPPLY VOLTAGE



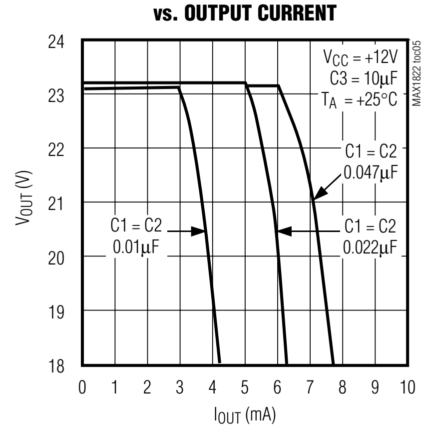
MAX1822
MAXIMUM OUTPUT CURRENT
vs. C1 = C2 CAPACITOR VALUE



MAX1822
OUTPUT VOLTAGE
vs. OUTPUT CURRENT

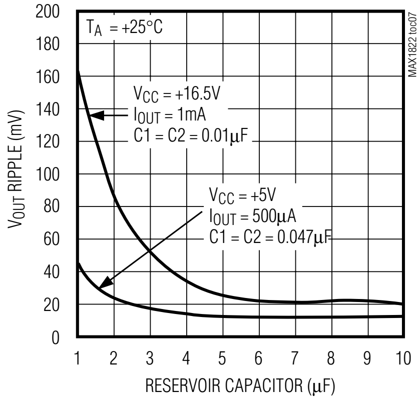


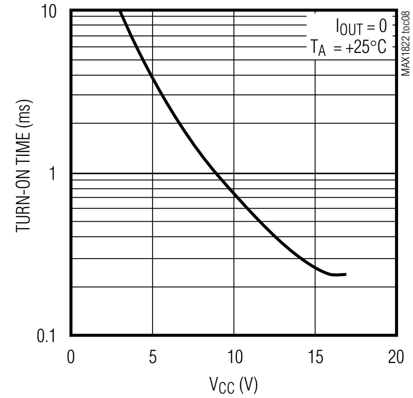
MAX1822
OUTPUT VOLTAGE
vs. OUTPUT CURRENT



High-Side Power Supply

Typical Operating Characteristics (continued)





Pin Description

PIN	NAME	FUNCTION
1	C1+	Positive terminal to primary charge-pump capacitor
2	C2-	Negative terminal to secondary charge-pump capacitor
3	PR	Power-Ready Output. High when V_{OUT} is ≥ V_{CC} + 8.5V with respect to GND.
4	GND	Ground
5	V_{OUT}	High-Side Voltage Out
6	C2+	Positive terminal to secondary charge-pump capacitor
7	C1-	Negative terminal to primary charge-pump capacitor
8	V_{CC}	Input Supply

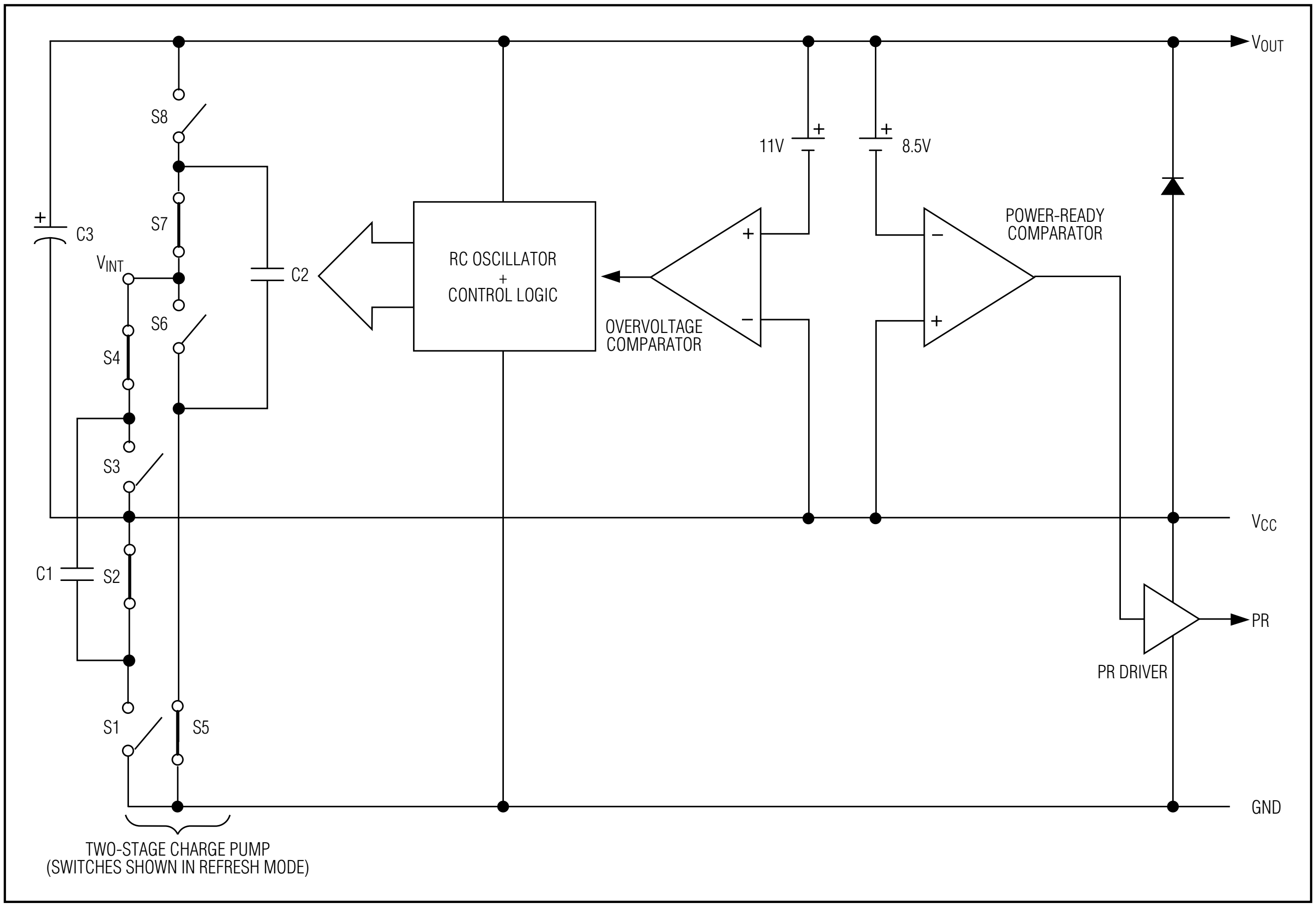


Figure 1. MAX1822 Block Diagram

Detailed Description

Charge-Pump Operation

The MAX1822 is a multistage charge-pump power supply. Although the charge pump is capable of multiplying V_{CC} up to four times, the output is regulated to V_{CC} + 11V by an internal feedback circuit for inputs above 4V. The charge pump typically operates at 90kHz, but regulates by pulse skipping. When V_{OUT} exceeds V_{CC} + 11V, the oscillator shuts off. As V_{OUT} dips below V_{CC} + 11V, the oscillator turns on.

Power-Ready Output

The Power-Ready Output (PR) signals control circuitry when the high-side voltage reaches a preset level. This feature can be used to protect external FET switches from excess dissipation and damage by preventing them from turning on, except when adequate gate drive levels are present. When power is applied, PR remains low until V_{OUT} reaches approximately V_{CC} + 8.5V. PR also goes low if V_{OUT} falls below this level during operation, i.e., if the output is overloaded. The PR high level is V_{CC}.

Applications Information

Quiescent Supply Current

MAX1822 quiescent supply current varies with V_{CC} and with the values of C1, C2, and C3 (*Typical Operating Characteristics*). Even with no external load, the device must still pump to overcome internal losses. Large ratios between C3 and C1 or C2 require more charge-pump cycles to restore V_{OUT}. As V_{CC} falls below 5V, quiescent current rises fairly rapidly to about 1mA at 4V (*Typical Operating Characteristics*). This rise occurs because V_{OUT} no longer pulse skips to regulate at low input voltages; the oscillator runs continuously, so supply current is higher. Figure 2 shows the test circuit for the MAX1822 quiescent supply current.

High-Side Power Supply

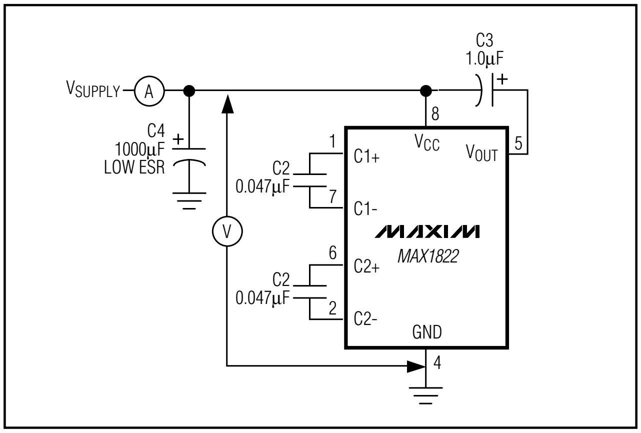


Figure 2. MAX1822 Quiescent Supply-Current Test Circuit

Output Ripple

V_{OUT} ripple is typically 50mVp-p with V_{CC} = +5V, C1 and C2 = 0.047µF, and C3 = 1µF (*Typical Operating Characteristics*). Ripple can be reduced by increasing the ratio between the output storage capacitors C3 and C1 and C2. This is usually accomplished by increasing C3 and keeping C1 and C2 in the 0.01µF to 0.047µF range. For example, if C1 and C2 are 0.047µF (V_{CC} must not exceed 13V) and C3 is 10µF, output ripple typically falls to 15mV (*Typical Operating Characteristics).*

Capacitor Selection

Capacitor type is unimportant when selecting capacitors for the MAX1822. However, when V_{CC} exceeds 13V, C1 and C2 must be no greater than 0.01µF. Using larger value capacitors with input voltages above 13V causes excessive amounts of energy to pass through

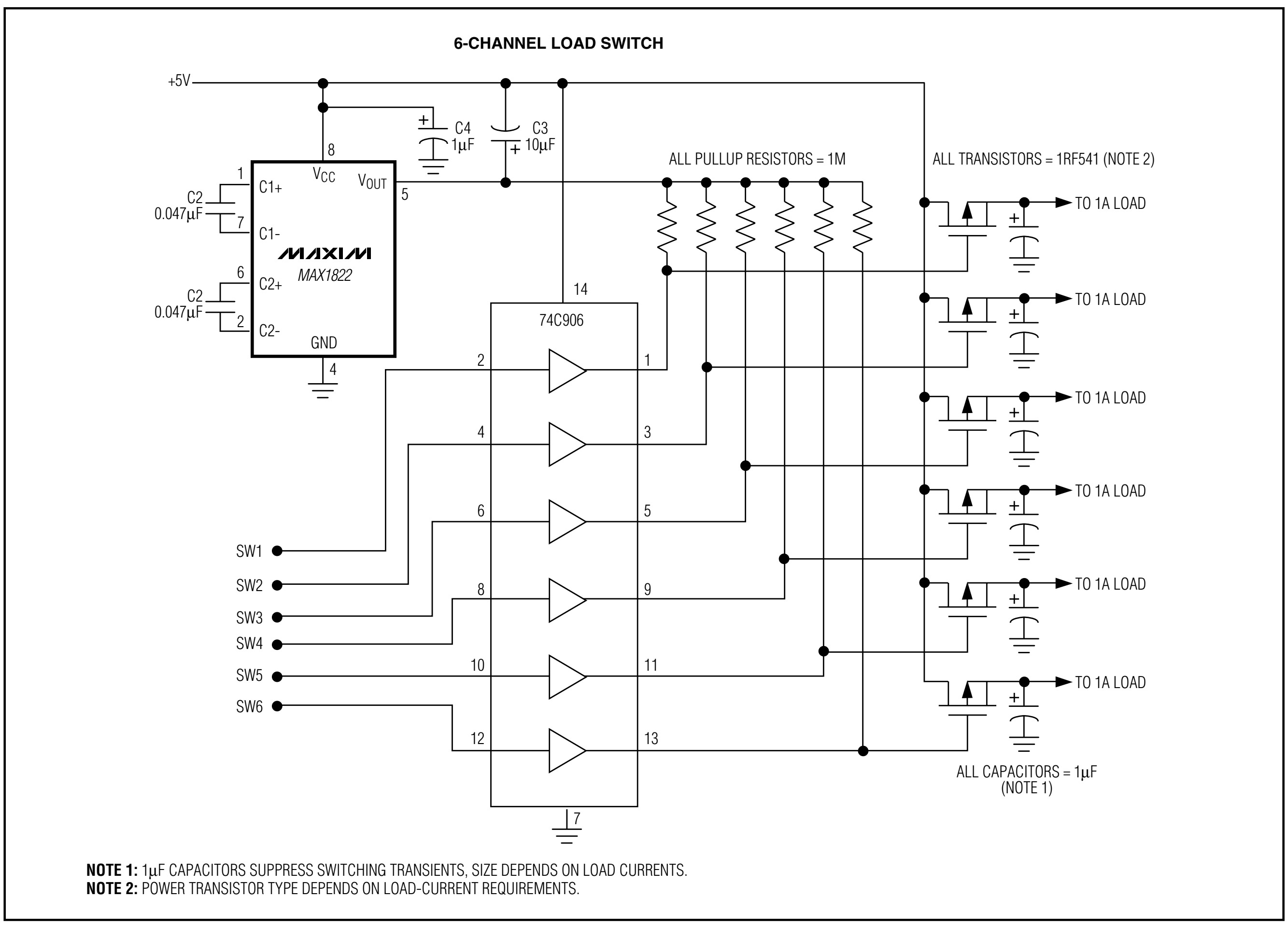


Figure 3. Single MAX1822 Driving Six High-Side Switches

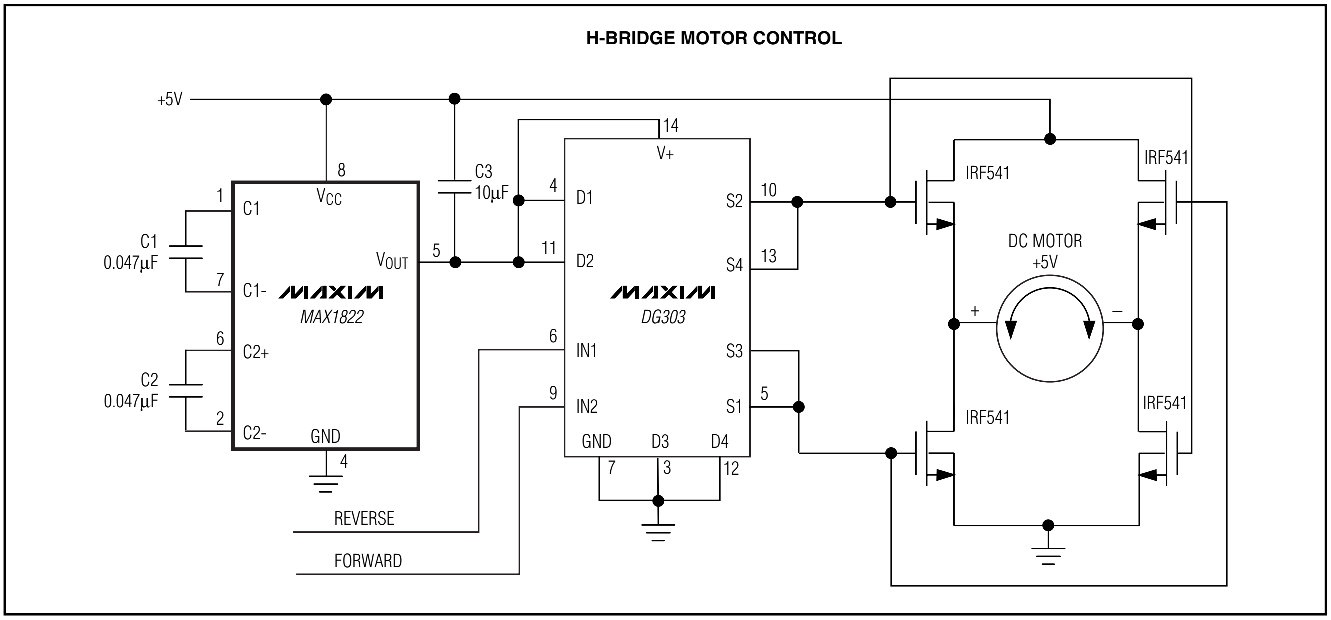


Figure 4. H-Bridge Motor Controller

internal switches during charge-pump cycles. This may damage the device.

Output Protection

The MAX1822 is not internally short-circuit protected. In applications where the output is susceptible to short circuit, external output short-circuit protection must be provided. Accomplish this by connecting a resistor between V_{OUT} and the load to limit output current to less than 25mA. The resistor value is determined by the following formula:

$$R_{CL} \geq \frac{V_{CC}}{25mA}$$

Typical Applications

One MAX1822 Drives Six High-Side Switches

Multiple subsystems or modules can be turned on and off using a single MAX1822 and an open-drain hex buffer such as the 74C906 (Figure 3). The drains of all buffer outputs are pulled through resistors to the MAX1822's V_{OUT}. The pullup resistance depends on the number of channels being used with the MAX1822 and power-dissipation limitations. The minimum pullup resistor value is determined by the number of channels paralleled on each high-side power supply and the high-side output current from the MAX1822 at a given supply voltage, calculated as follows:

$$R_{MIN} = \frac{V_{OUT} \times \text{(number of channels)}}{I_{OUT}}$$

where V_{OUT} is the high-side output voltage and I_{OUT} is the output current of the MAX1822.

For example, assuming an output current of 1mA and six channels, as in Figure 3, the minimum pullup resistor value that will not excessively load the MAX1822 is about 100kΩ, assuming all six channels are pulled low at the same time. The value of the pullup resistor also affects the turn-on time of each FET, and hence the amount of energy dissipated in the FET during turn-on. The rate of rise of V_{GS} is limited by the RC time constant of the pullup resistor and FET gate capacitance; waste power will be dissipated in the FET equal to $(I_{LOAD})^2 \times r_{DS}$ during the RC time period.

H-Bridge Motor Driver

An H-bridge motor driver is shown in Figure 4. The motor direction can be controlled by toggling between IN1 and IN2 of the DG303 analog switch. Each switch section turns on the appropriate FET pair, which passes current through the motor in the desired direction.

High-Side Power Supply

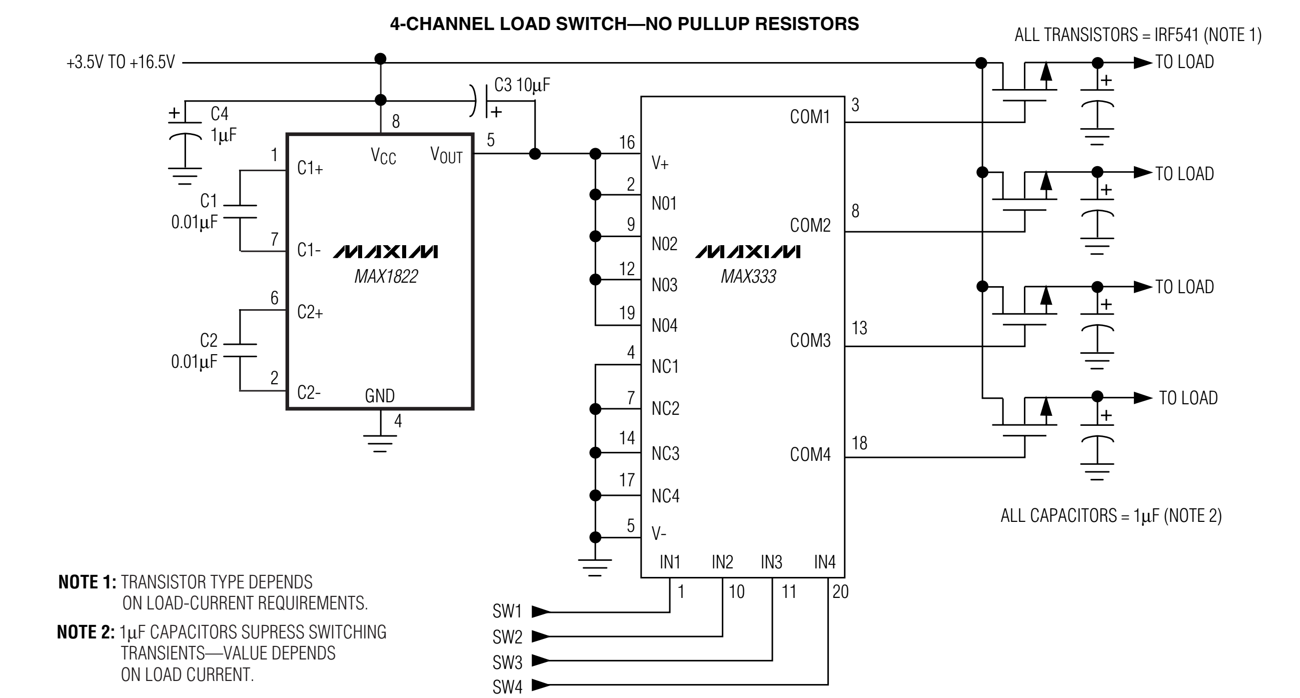


Figure 5. MAX1822 Powering a MAX333 Quad Analog Switch, Realizing a 4-Channel Load Switch with No Pullup Resistors

4-Channel Load Switch with No Pullup Resistors

Multiple high-side switches can be driven from a single MAX1822 high-side power supply with no pullup resistors on the FET gates. In Figure 5, a MAX1822 supplies high-side voltage to a MAX333 quad analog switch to control any one of four high-side switches. The FET gates are normally connected to ground when the MAX333 logic inputs are low.

Low-Dropout Regulator

In Figure 6, a MAX1822 high-side power supply powers an LM10 reference and op-amp combination, providing sufficient gate drive to turn on the FET. This allows the regulator to achieve less than 70mV dropout at 1A load using an IRF541, and just under 20mV for a SMP60N06.

The 200mV reference section is configured for a gain of 25 (e.g., 200mV x 25 = 5V) and connects to the noninverting input of the op amp; the regulator's output connects directly to the inverting input. The op amp amplifies the error between its inputs and varies the gate drive to the FET, regulating the output. Capacitor C6 reduces transients due to load changes; its size depends on the magnitude of the load change in the application and can be reduced or eliminated if the load remains relatively constant. With C6 = 1000µF, the output transient to a 1A load pulsed at 20Hz is typically less than 150mV. The regulator is turned on by applying V_{BATT} to the Enable/$\overline{\text{Shutdown}}$ input and turned off by pulling this input to ground.

The regulator output voltage, V_{OUT}, is set by the ratio of R1 to R2, calculated as follows:

$$R2 = R1\left(\frac{V_{OUT}}{0.2} - 1\right)$$

If the application does not require logic shutdown, connect the MAX1822 V_{CC} pin directly to the battery and eliminate D2.

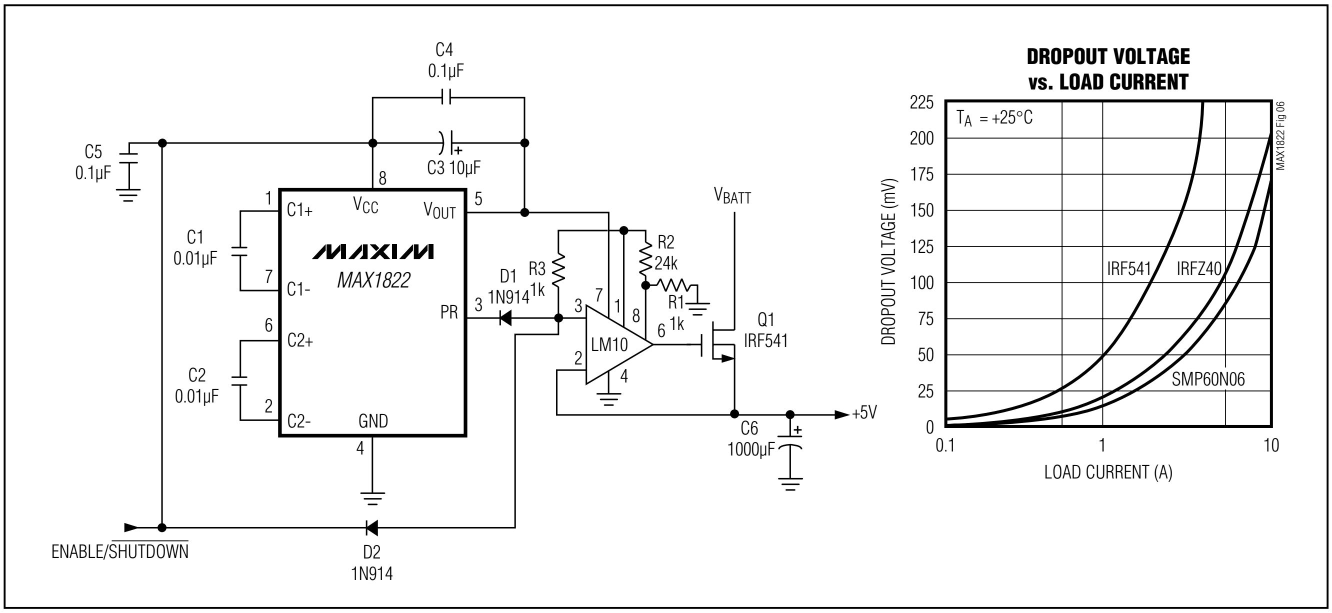
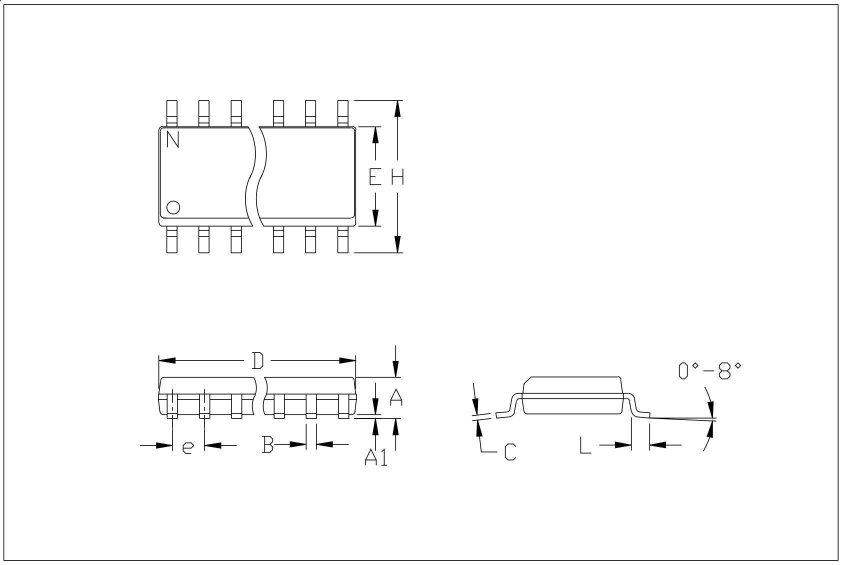


Figure 6. Ultra-Low Dropout Positive Voltage Regulator with Logic-Controlled Enable/$\overline{\text{Shutdown}}$.

Chip Information

TRANSISTOR COUNT: 158

Package Information



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	A
D	0.337	0.344	8.55	8.75	14	B
D	0.386	0.394	9.80	10.00	16	C

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. LEADS TO BE COPLANAR WITHIN .102mm (.004")
4. CONTROLLING DIMENSION: MILLIMETER
5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE
6. N = NUMBER OF PINS

MAXIM
120 SAN GABRIEL DR SUNNYVALE CA 94086 FAX (408) 737 7194
PROPRIETARY INFORMATION

TITLE: PACKAGE FAMILY OUTLINE: SOIC .150"

1/1

DOCUMENT CONTROL NUMBER: 21-0041 REV: A