TC1682/TC1683/TC1684

Inverting Charge Pump Voltage Doublers with Active High Shutdown

Features

- Small 8-Pin MSOP Package
- Operates from 1.8V to 5.5V
- 120 Ohms (typ) Output Resistance
- 99% Voltage Conversion Efficiency
- Only 3 External Capacitors Required
- Power-Saving Shutdown Mode
- Low Active Supply Current
  - 95µA (typ) for TC1682
  - 225µA (typ) for TC1683
  - 700µA (typ) for TC1684
- Fully Compatible with 1.8V Logic Systems

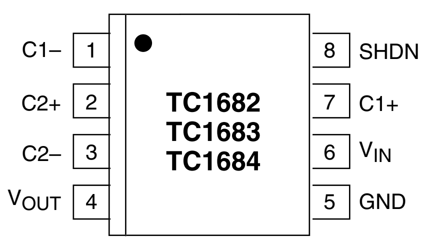
Applications

- LCD Panel Bias
- Cellular Phones PA Bias
- Pagers
- PDAs, Portable Data Loggers
- Battery-Powered Devices

Device Selection Table

Part Number	Package	Osc. Freq. (kHz)	Operating Temp. Range
TC1682EUA	8-Pin MSOP	12	-40°C to +85°C
TC1683EUA	8-Pin MSOP	35	-40°C to +85°C
TC1684EUA	8-Pin MSOP	125	-40°C to +85°C

Package Type



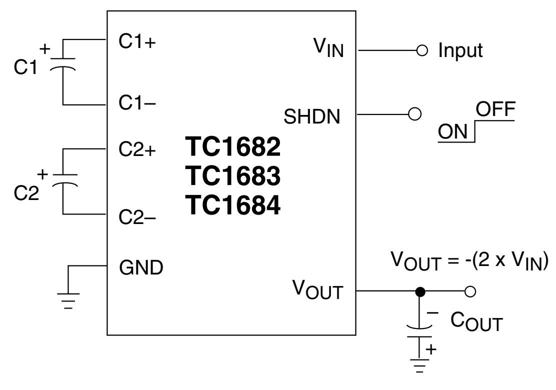
General Description

The TC1682/TC1683/TC1684 are CMOS charge pump converters that provide an inverted doubled output from a single positive supply. An on-board oscillator provides the clock and only three external capacitors are required for full circuit implementation. Switching frequencies are 12kHz for the TC1682, 35kHz for the TC1683, and 125kHz for the TC1684. When the SHDN pin is held at a logic high, the device goes into a very low power mode of operation consuming less than 1µA (typ) of supply current.

Low output source impedance (typically 120Ω), provides output current up to 10mA. The TC1682/TC1683/TC1684 feature a 1.8V to 5.5V operating voltage range and high efficiency, which make them an ideal choice for a wide variety of applications requiring a negative doubled voltage derived from a single positive supply (for example: generation of -7.2V from a +3.6V lithium cell or -10V generated from a +5V logic supply).

The minimum external part count, small physical size and shutdown mode feature make this family of products useful for a wide variety of negative bias power supply applications.

Functional Block Diagram



C1 must have a voltage rating ≥ V_{IN}
C2 and C_{OUT} must have a voltage rating ≥ $2V_{IN}$

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

Input Voltage (V_{IN} to GND)........................ +6.0V, -0.3V
Output Voltage (V_{OUT} to GND)............... -12.0V, +0.3V
Current at V_{OUT} Pin..20mA
Short-Circuit Duration V_{OUT} to GND ....Indefinite
Power Dissipation ($T_A \leq 70°C$)
8-Pin MSOP 320mW
Operating Temperature Range.............-40°C to +85°C
Storage Temperature (Unbiased).......-65°C to +150°C

*Stresses above 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 above those indicated in the operation sections of the specifications is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

TC1682/TC1683/TC1684 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: T_A = -40°C to +85°C, V_{IN} = +5V, C1 = C2 = 3.3µF (TC1682), C1 = C2 = 1µF (TC1683), C1 = C2 = 0.33µF (TC1684), SHDN = GND, Typical values are at T_A = +25°C

Symbol	Parameter	Min	Typ	Max	Units	Device	Test Conditions
I_{DD}	Supply Current	— — —	95 225 700	160 480 1500	µA	TC1682 TC1683 TC1684	
I_{SHDN}	Shutdown Supply Current	—	0.5	2	µA	All	SHDN = V_{IN} = +5V
V_{MIN}	Minimum Supply Voltage	1.8	—	—	V	All	R_{LOAD} = 1kΩ
V_{MAX}	Maximum Supply Voltage	—	—	5.5	V	All	R_{LOAD} = 1kΩ
F_{OSC}	Oscillator Frequency	8.4 24.5 65	12 35 125	15.6 45.5 170	kHz	TC1682 TC1683 TC1684	
V_{IH}	SHDN Input Logic High	1.4	—	—	V	All	V_{IN} = V_{MIN} to V_{MAX}
V_{IL}	SHDN Input Logic Low	—	—	0.4	V	All	V_{IN} = V_{MIN} to V_{MAX}
V_{EFF}	Voltage Conversion Efficiency	95	99	—	%	All	$R_{LOAD} = \infty$
R_{OUT}	Output Resistance	—	120	170	Ω	All	I_{LOAD} = 0.5mA to 10mA (Note 1)
T_{WK}	Wake-up Time From Shutdown Mode	— — —	1800 600 200	— — —	µsec	TC1682 TC1683 TC1684	R_{LOAD} = 2kΩ

Note 1: Capacitor contribution is approximately 20% of the output impedance (ESR = 1/ pump frequency x capacitance).

2.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 2-1.

TABLE 2-1: PIN FUNCTION TABLE

Pin No. (8-Pin MSOP)	Symbol	Description
1	C1–	C1 commutation capacitor negative terminal.
2	C2+	C2 commutation capacitor positive terminal.
3	C2–	C2 commutation capacitor negative terminal.
4	V_{OUT}	Doubling inverting charge pump output (-2 x V_{IN}).
5	GND	Ground.
6	V_{IN}	Positive power supply input.
7	C1+	C1 commutation capacitor positive terminal.
8	SHDN	Shutdown input (active high).

3.0 DETAILED DESCRIPTION

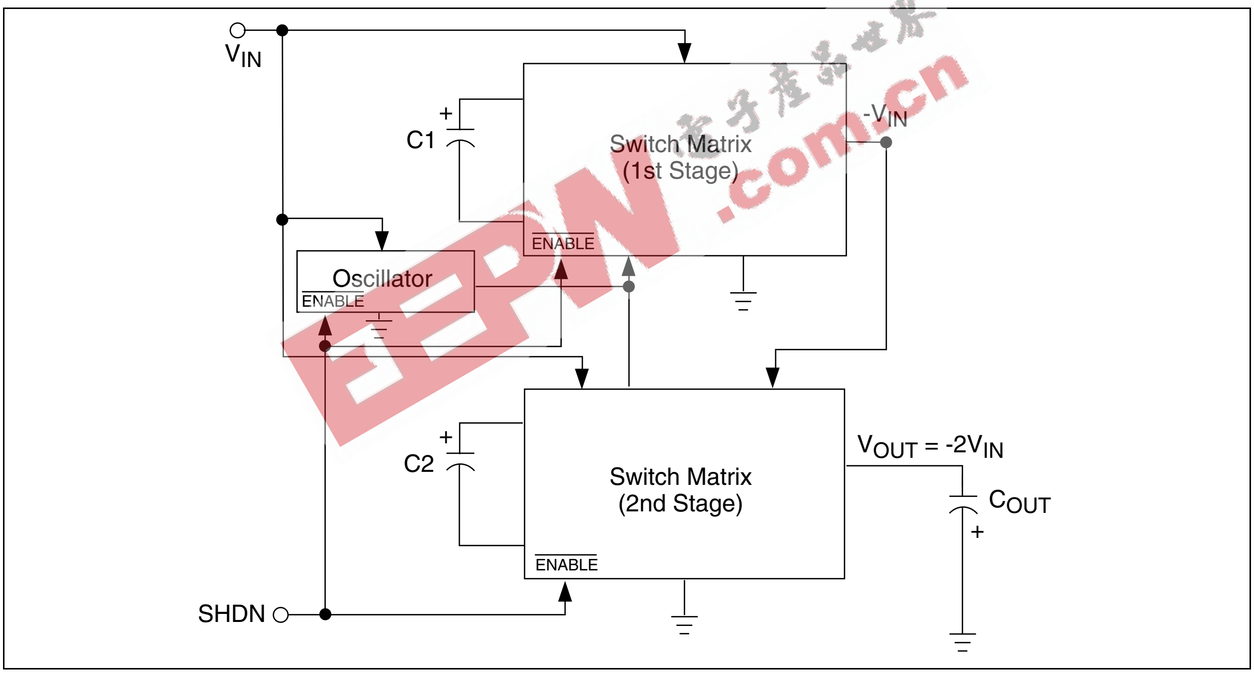
The TC1682/TC1683/TC1684 inverting charge pump converters perform a -2x multiplication of the voltage applied to the V_{IN} pin. Conversion is performed using two *synchronous* switching matrices and three external capacitors. When the shutdown input is held at a logic high, the device goes into a very low power mode of operation consuming less than 1µA of supply current.

Figure 3-1 is a block diagram representation of the TC1682/TC1683/TC1684 architecture. The first switching stage inverts the voltage present at V_{IN} and the second stage uses the '-V_{IN}' output generated from the first stage to produce the '-2X' output function from the second stage switching matrix.

Each device contains an on-board oscillator that synchronously controls the operation of the charge pump switching matrices. The TC1682 synchronously switches at 12kHz, the TC1683 synchronously switches at 35kHz, and the TC1684 synchronously switches at 125kHz. The different oscillator frequencies for this device family allow the user to trade-off capacitor size versus supply current. Faster oscillators can use smaller external capacitors, but will consume more supply current (see Section 1.0 Electrical Characteristics).

When the shutdown input is in a high state, the oscillator and both switch matrices are powered off placing the TC1682/TC1683/TC1684 in the shutdown mode. When the V_{IN} supply input is powered from an external battery, the shutdown mode minimizes power consumption, which in turn will extend the life of the battery.

FIGURE 3-1: TC1682/TC1683/TC1684 ARCHITECTURE



4.0 APPLICATIONS INFORMATION

4.1 Output Voltage Considerations

The TC1682/TC1683/TC1684 perform inverting voltage conversions but do not provide any type of regulation. The output voltage will droop in a linear manner with respect to the output load current. The value of the equivalent output resistance is approximately 120Ω nominal at +25°C and V_{IN} = +5V. In this particular case, the output is approximately -10V at very light loads and will droop according to the equation below:

$V_{DROOP} = I_{OUT} \times R_{OUT}$

4.2 Capacitor Selection

In order to maintain the lowest output resistance and output ripple voltage, it is recommended that low ESR capacitors be used. Additionally, larger values of C1 and C2 will lower the output resistance and larger values of C_{OUT} will reduce output ripple.

Note: For proper charge pump operation, C1 must have a voltage rating greater than or equal to V_{IN}, while C2 and C_{OUT} must have a voltage rating greater than or equal to $2V_{IN}$.

Table 4-1 shows various values of C1/C2 and the corresponding output resistance values for V_{IN} = 5V @ +25°C.

Table 4-2 shows the output voltage ripple for various values of C_{OUT} (again assuming V_{IN} = 5V @ +25°C). The V_{RIPPLE} values assume a 1mA output load current and a 0.1Ω ESR_{COUT}.

TABLE 4-1: OUTPUT RESISTANCE VS. C1/C2 (ESR = 0.1Ω)

C1, C2 (µF)	TC1682 R_{OUT}(Ω)	TC1683 R_{OUT}(Ω)	TC1684 R_{OUT}(Ω)
0.33	633	184	120
1	262	120	102
3.3	120	95	84

TABLE 4-2: OUTPUT VOLTAGE RIPPLE VS. C_{OUT2} (ESR = 0.1Ω) I_{OUT} = 1mA

C_{OUT} (µF)	TC1682 V_{RIPPLE} (mV)	TC1683 V_{RIPPLE} (mV)	TC1684 V_{RIPPLE} (mV)
0.33	192	60	27
1	63	21	16
3.3	17	8	7

4.3 Input Supply Bypassing

The V_{IN} input should be capacitively bypassed to reduce AC impedance and minimize noise effects due to the switching internal to the device. It is recommended that a large value capacitor (at least equal to C1) be connected from V_{IN} to GND for optimal circuit performance.

4.4 Shutdown Input

The TC1682/TC1683/TC1684 is enabled when SHDN is low, and disabled when SHDN is high. This input cannot be allowed to float. (If SHDN is not required, see the TC2682/TC2683/TC2684 data sheet.) The SHDN input should be limited to 0.3V above V_{IN}.

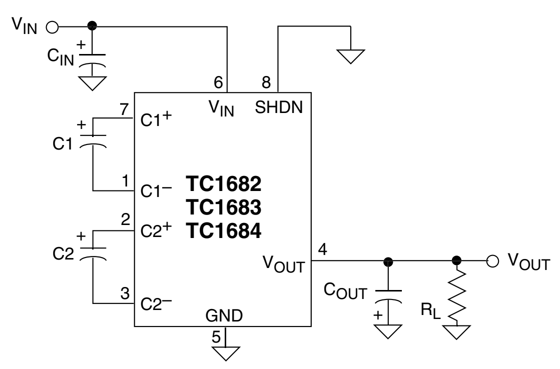
4.5 Inverting Voltage Doubler

The most common application for the TC1682/TC1683/TC1684 devices is the inverting voltage doubler (Figure 4-1). This application uses three external capacitors: C1, C2 and C_{OUT}.

Note: A power supply bypass capacitor is recommended.

The output is equal to $-2V_{IN}$ plus any voltage drops due to loading. Refer to Table 4-1 and Table 4-2 for capacitor selection guidelines.

FIGURE 4-1: INVERTING VOLTAGE DOUBLER TEST CIRCUIT



Device	C_{IN}	C1	C2	C_{OUT}
TC1682	3.3µF	3.3µF	3.3µF	3.3µF
TC1683	1µF	1µF	1µF	1µF
TC1684	0.33µF	0.33µF	0.33µF	0.33µF

4.6 Layout Considerations

As with any switching power supply circuit, good layout practice is recommended. Mount components as close together as possible to minimize stray inductance and capacitance. Also use a large ground plane to minimize noise leakage into other circuitry.

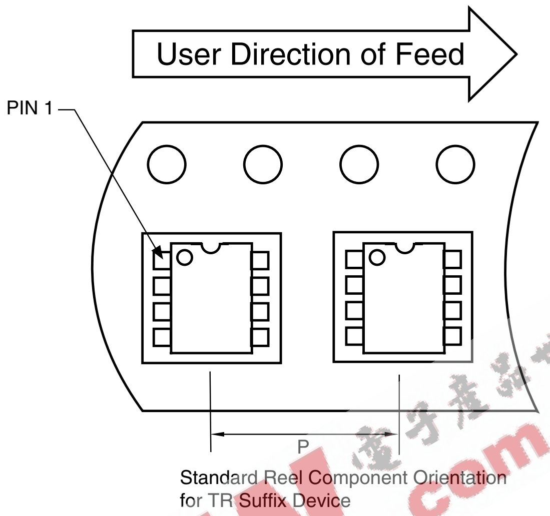
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

Package marking data not available at this time.

5.2 Taping Form

Component Taping Orientation for 8-Pin MSOP Devices

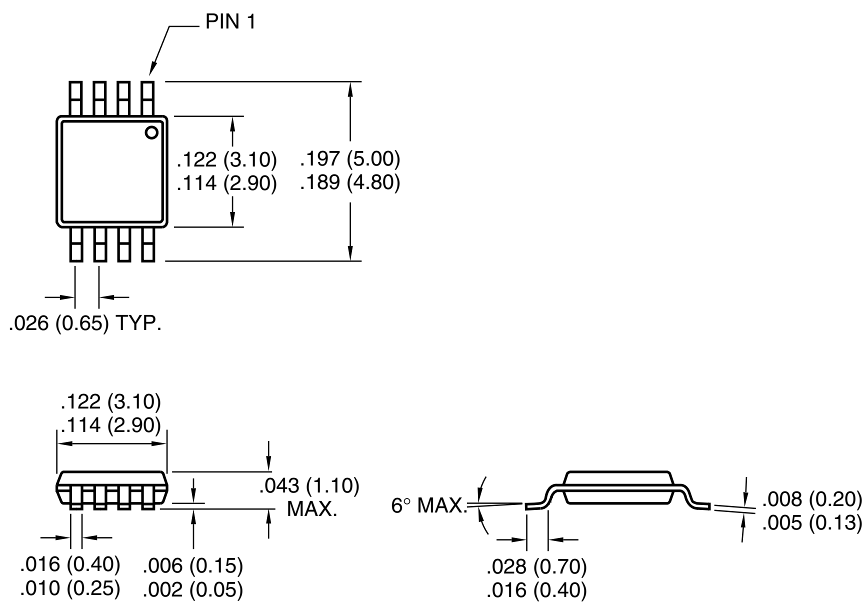


Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin MSOP	12 mm	8 mm	2500	13 in

5.3 Package Dimensions

8-Pin MSOP



Dimensions: inches (mm)

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