DESCRIPTION

The SCI7661 Series is a highly effecient CMOS DC/DC converter for doubling or tripling an input voltage. It incorporates an on-chip voltage regulator to ensure stable output at the specified voltage. The SCI7661 Series offers a choice of three, optional temperature gradients for applications such as LCD panel power supplies. The SCI7661C0B is available in 14-pin plastic DIPs, the SCI7661M0B, in 14-pin plastic SOPs, and the SCI7661MBB in 16-pin plastic SSOPs.

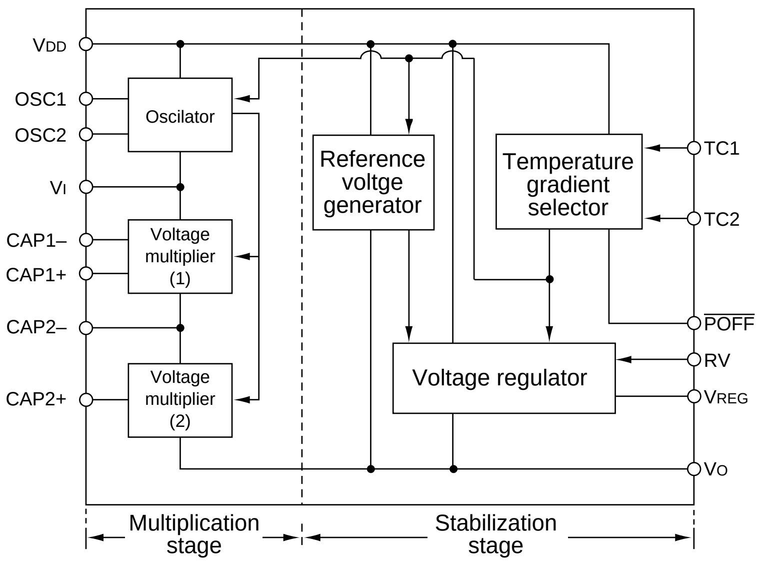
FEATURES

- 95% (Typ.) conversion efficiency
- Up to four output voltages, VO, relative to the input voltage, VI
- On-chip voltage regulator
- 20mA maximum output current at VI = –5V
- Three temperature gradients—0.1, 0.4 and 0.6%/°C
- External shut-down control
- 2µA maximum output current when shut-down
- Two-in-series configuration doubles negative output voltage.
- On-chip RC oscillator
- SCI7661C0B ....pladtic DIP-14 pin
  SCI7661M0B ....pladtic SOP5-14 Pin
  SCI7661MBB ....pladtic SSOP2-16 pin

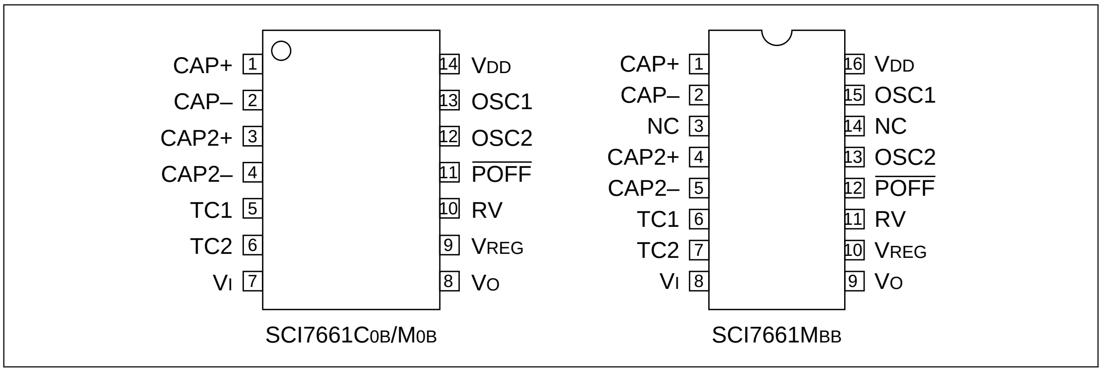
APPLICATIONS

- Power supplies for LCD panels
- Fixed-voltage power supplies for battery-operated equipment
- Power supplies for pagers, memory cards, calculators and similar hand-held equipment
- Fixed-voltage power supplies for medical equipment
- Fixed-voltage power supplies for communications equipment
- Power supplies for microcomputers
- Uninterruptable power supplies

BLOCK DIAGRAM



PIN CONFIGURATION



PIN DESCRIPTION

Number	Name	Description
1	CAP1+	Positive charge-pump connection for ×2 multiplier
2	CAP1–	Negative charge-pump connection for ×2 multiplier
3	CAP2+	Positive charge-pump connection for ×3 multiplier
4	CAP2–	Negative charge-pump connection for ×3 multiplier or ×2 multiplier output
5	TC1	Temperature gradient selects
6	TC2	
7	V_I	Negative supply (system ground)
8	V_O	×3 multiplier output
9	V_{REG}	Voltage regulator output
10	R_V	Voltage regulator output adjust
11	$\overline{POFF}$	Voltage regulator output ON/OFF control
12	OSC2	Resistor connection. Open when using external clock
13	OSC1	Resistor connection. Clock input when using external clock
14	V_{DD}	Positive supply (system V_{CC})

SPECIFICATIONS

Absolute Maximum Ratings

Items	Codes	Ratings	Units	Remarks
Input supply voltage	$V_I – V_{DD}$	–20/N to V_{DD} + 0.3	V	N = 2: Boosting to a double voltage N = 3: Boosting to a triple voltage
Input terminal voltage	$V_I – V_{DD}$	V_I – 0.3 to V_{DD} + 0.3	V	OSC1, OSC2, $\overline{\text{POFF}}$
		V_O – 0.3 to V_{DD} + 0.3	V	TC1, TC2, RV
Output voltage	$V_O – V_{DD}$	–20 to V_{DD} + 0.3	V	V_O Note 3)
		V_O to V_{DD} + 0.3	V	V_{REG} Note 3)
Allowable dissipation	Pd	Max. 300	mW	
Working temperature	Topr	–40 to 85	°C	Plastic package
Storage temperature	Tstg	–55 to 150	°C	
Soldering temperature and time	Tsol	260°C 10 s (at leads)	–	

Notes

1. Using the IC under conditions exceeding the aforementioned absolute maximum ratings may lead to permanent destruction of the IC. Also, if an IC is operated at the absolute maximum ratings for a longer period of time, its functional reliability may be substantially deteriorated.
2. All the voltage ratings are based on V_{DD} = 0V.
3. The output terminals (V_O,V_{REG}) are meant to output boosted voltage or stabilized boosted voltage. They, therefore, are not the terminals to apply an external voltage. In case the using specifications unavoidably call for application of an external voltage, keep such voltage below the voltage ratings given above.

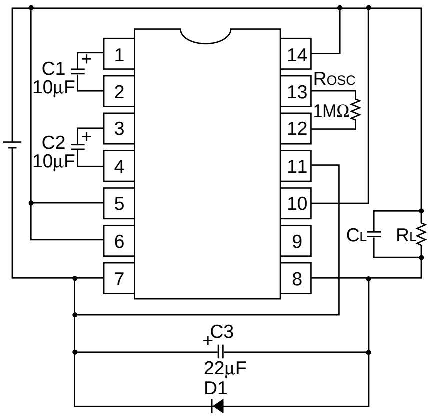
Recommmended Operating Conditions

V_{DD} = 0V, Ta = –40 to 85˚C unless otherwise noted

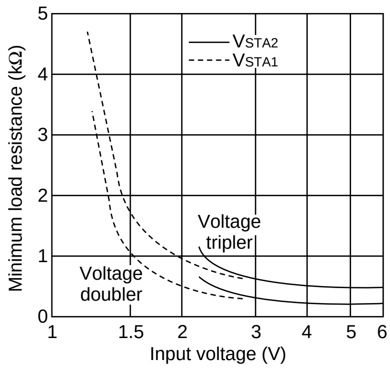
Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Oscillator startup voltage	V_{STA}	R_{OSC} =1MΩ C_3 = 10 µF, $C_L/C_3 \leq 1/20$, Ta = –40 to 85˚C. See note 1.	–	–	–1.8	V
		R_{OSC} = 1MΩ	–	–	–2.2	
Oscillator shutdown voltage	V_{STP}	R_{OSC} = 1MΩ	–1.8	–	–	V
Load resistance	R_L		R_L min. See note 2.	–	–	Ω
Output current	I_O		–	–	20.0	mA
Clock frequency	f_{OSC}		10.0	–	30.0	kHz
RC oscillator network resistance	R_{OSC}		680	–	2,000	kΩ
Capacitance	C_1, C_2, C_3		3.3	–	–	µF
Stabilization voltage sensing resis-tance	R_{RV}		100	–	1,000	kΩ

Notes

1. The recommended circuit configuration for low-valtage operation (when V_I is between –1.2V and –2.2V) is shown in the following figure. Note that diode D1 should have a maximum forward voltage of 0.6V with 1.0mA forward current.
2. R_L min can be varied depending on the input voltage.



3. RL min is a function of V1



Electrical Characteristics

VDD = 0V, V1 = –5V, Ta = –40 to 85°C unless otherwise noted

Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	VI		–6.0	–	–1.8	V
Output voltage	VO		–18.0	–	–	V
Regulator voltage	VREG	RL = ∞, RRV = 1MΩ, VO = –18V	–18.0	–	–2.6	V
Stabilization circuit operating voltage	VO		–18.0	–	–3.2	V
Multiplier current	Iopr1	RL = ∞, ROSC = 1MΩ	–	40	80	µA
Stabilization current	Iopr2	RL = ∞, RRV = 1MΩ, VO = –15V	–	5.0	12.0	µA
Quiescent current	IQ	TC2 = TC1 = VO, RL = ∞	–	–	2.0	µA
Clock frequency	fOSC	ROSC = 1MΩ	16.0	20.0	24.0	kHz

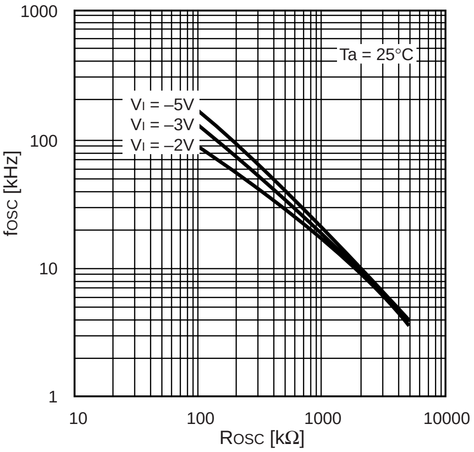
Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Output impedance	R_O	I_O = 10mA	–	150	200	Ω
Multiplication efficiency	Peff	I_O = 5mA	90.0	95.0	–	%
Stabilization output voltage differential	$\frac{\Delta V_{REG}}{\Delta V_O \cdot V_{REG}}$	V_O = –18 to –8V, V_{REG} = –8V, $R_L = \infty$, Ta = 25˚C	–	0.2	–	%/V
Stabilization output load differential	$\frac{\Delta V_{REG}}{\Delta I_O}$	V_O = –15V, V_{REG} = –8V, Ta = 25˚C, I_O = 0 to 10µA, TC1 = V_{DD}, TC2 = V_O	–	5.0	–	Ω
Stabilization output saturation resistance	R_{SAT}	$R_{SAT} = \Delta(V_{REG} - V_O)/\Delta I_O$, I_O = 0 to 10µA, $R_V = V_{DD}$, Ta = 25˚C	–	8.0	–	Ω
Reference voltage	V_{RV}	RC2 = V_O, TC1 = V_{DD}, Ta = 25˚C	–2.3	–1.5	–1.0	V
		TC2 = TC1 = V_O, Ta = 25˚C	–1.7	–1.3	–1.1	
		TC2 = V_{DD}, TC1 = V_O, Ta = 25˚C	–1.1	–0.9	–0.8	
Temperature gradient	C_T	See note.	–0.25	–0.1	–0.01	%/˚C
			–0.5	–0.4	–0.3	
			–0.7	–0.6	–0.5	
$\overline{\text{POFF}}$, TC1, TC2, OSC1, and RV input leakage current	I_{LKI}		–	–	2.0	µA

Note

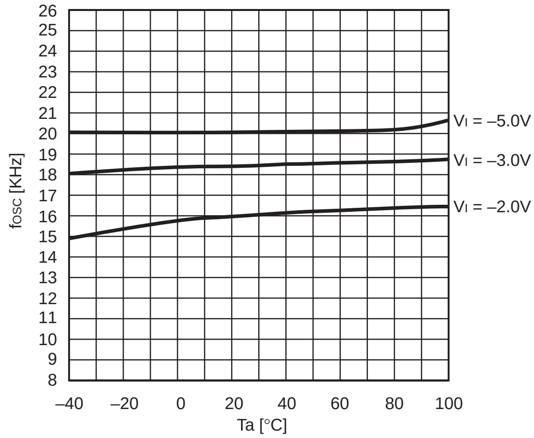
$$C_T = \frac{|V_{REG}(50°C)| - |V_{REG}(0°C)|}{50°C - 0°C} \times \frac{100}{|V_{REG}(25°C)|}$$

DC/DC Converter & Voltage Regulator

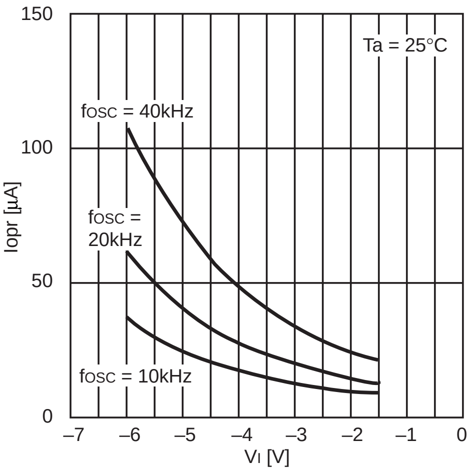
Typical Performance Characteristics



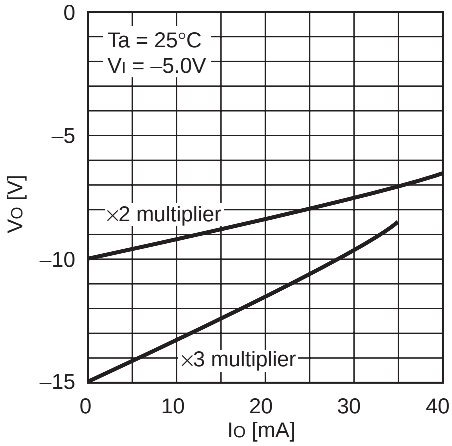
Clock frequency vs. External resistance



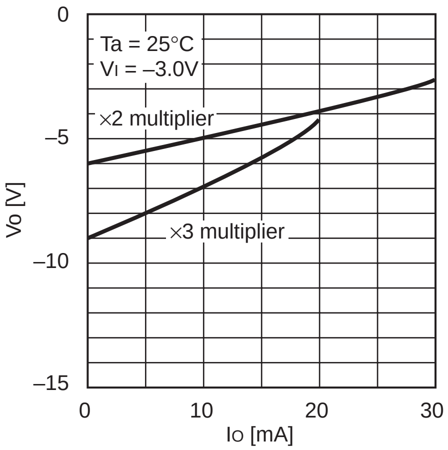
Clock frequency vs. Ambient temperature



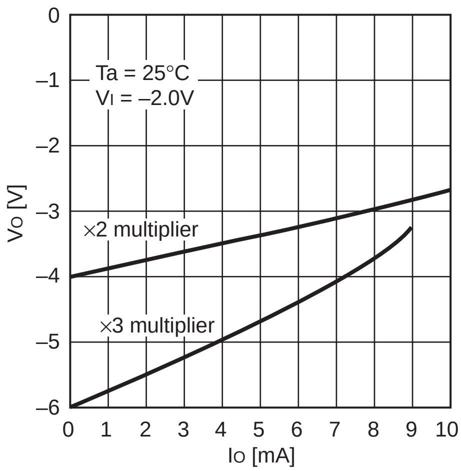
Multiplier current vs. Input voltage



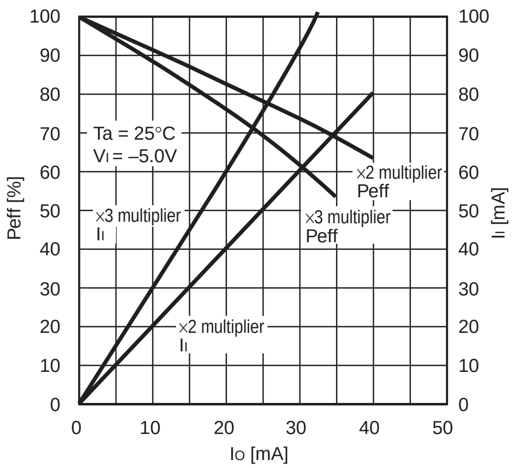
Output voltage vs. Output current



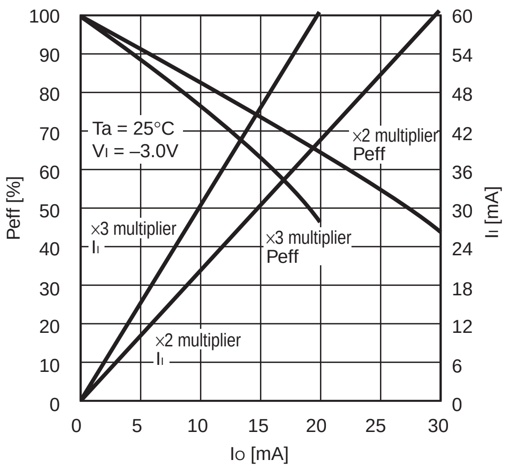
Output voltage vs. Output current



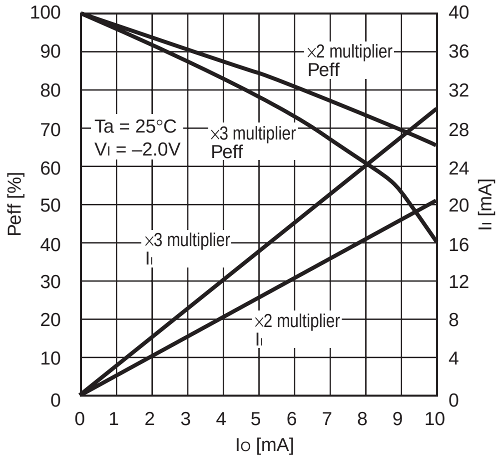
Output voltage vs. Output current



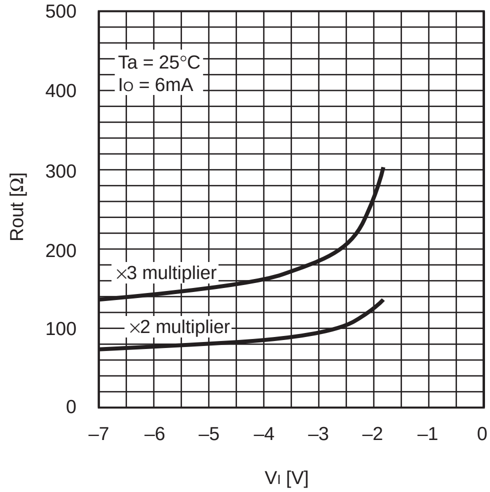
Multiplication efficiency/input current vs. Output current



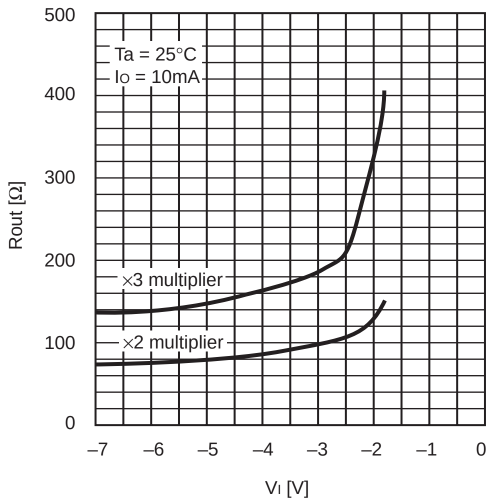
Multiplication efficiency/input current vs. Output current



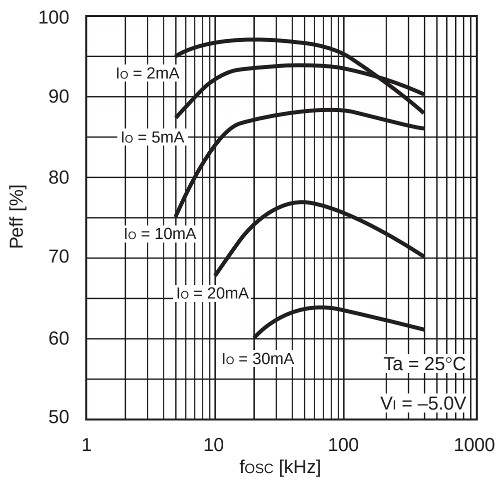
Multiplication efficiency/input current vs. Output current



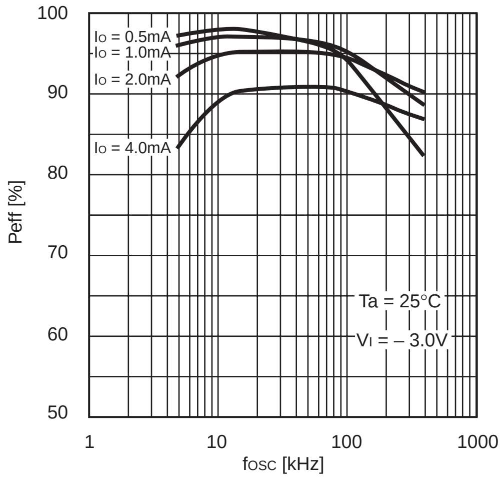
Output impedance vs. Input voltage



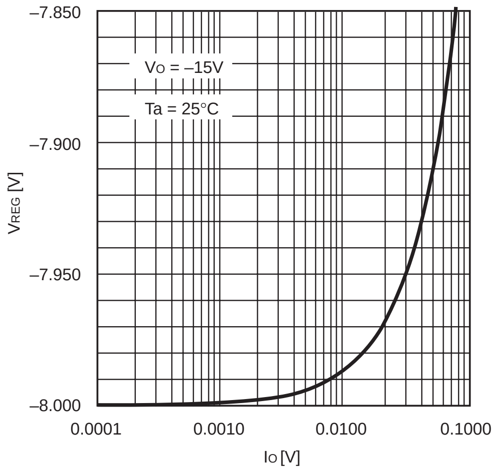
Output impedance vs. Input voltage



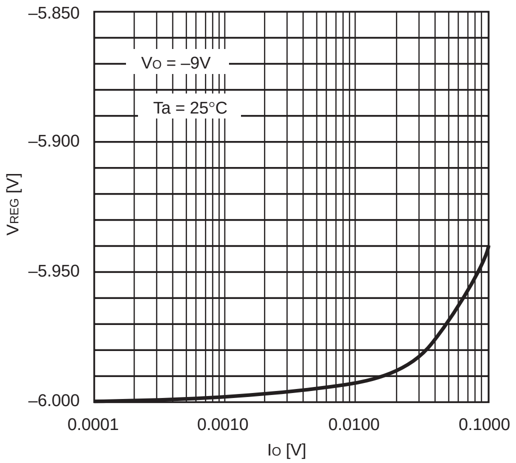
Multiplication efficiency vs. Clock frequency



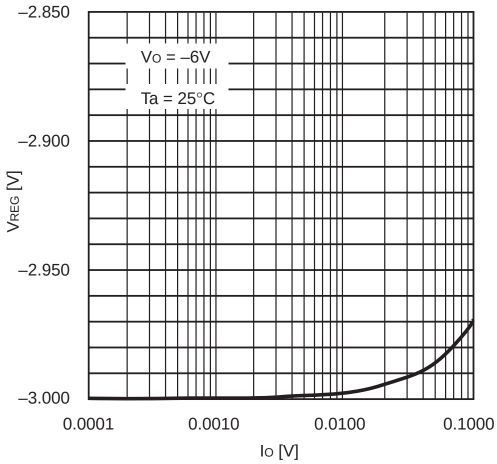
Multiplication efficiency vs. Clock frequency



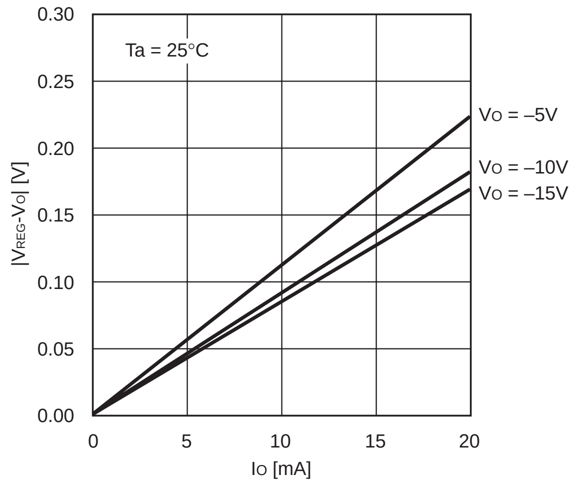
Output voltage vs. Output current



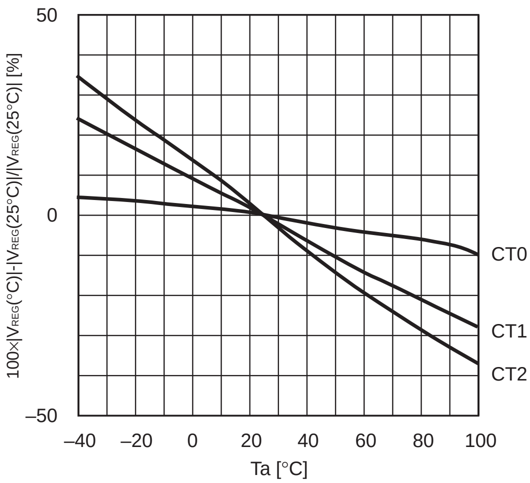
Output voltage vs. Output current



Output voltage vs. Output current



Regulator voltage vs. Output current



Regulator output stability ratio vs. Ambient temperature

Temperature Gradient Control

The SCI7661C0B offers a choice of three temperature gradients which can be used to adjust the voltage regulator output in applications such as power supplies for driving LCDs.

$\overline{\text{POFF}}$	TC2	TC1	Temperature gradient (%/°C) See note 2.	Voltage regulator output	RC osciliator	Remarks
See note 1.						
1 (V_{DD})	LOW (V_O)	LOW (V_O)	–0.4	ON	ON	
1	LOW	HIGH (V_{DD})	–0.1	ON	ON	
1	HIGH (V_{DD})	LOW	–0.6	ON	ON	
1	HIGH	HIGH	–0.6	ON	OFF	Serial connection
0 (V_1)	LOW	LOW	–	OFF (high impedance)	OFF	
0	LOW	HIGH	–	OFF (high impedance)	OFF	
0	HIGH	LOW	–	OFF (high impedance)	OFF	
0	HIGH	HIGH	–	OFF (high impedance)	OFF	Multiplier operational

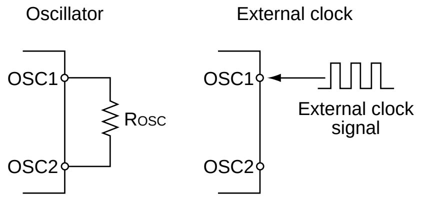
Notes

1. The definition of LOW for $\overline{\text{POFF}}$ differs from that for TC1 and TC2.
2. The temperature gradient affects the voltage between V_{DD} and V_{REG}.

FUNCTIONAL DESCRIPTION

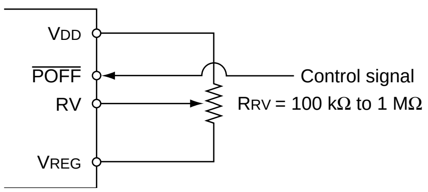
Oscillator

The on-chip RC oscillator network frequency is determined by the external resistor, ROSC, connected between OSC1 and OSC2. This oscillator can be disabled in favor of an external clock by leaving OSC2 open and applying an external clock signal to OSC1.



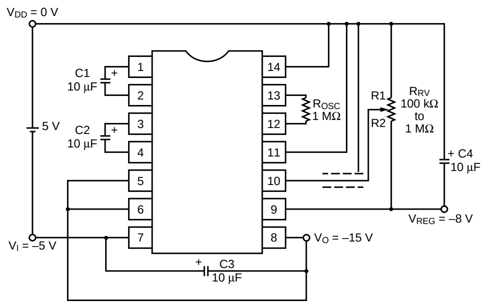
Reference Volatge Generator and Voltage Regulator

The reference voltage generator supplies a reference voltage to the voltage regulator to control the output. This voltage can be switched ON and OFF.

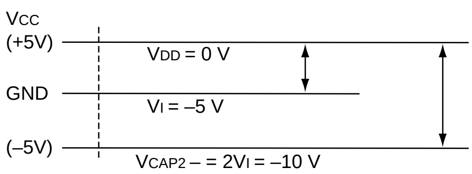


Voltage Multiplier

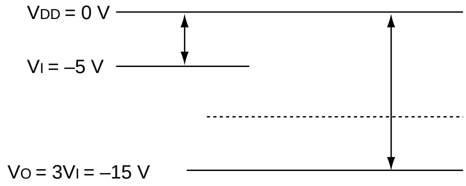
The voltage multiplier uses the clock signal from the oscillator to double or triple the input voltage. This requires three external capacitors–two charge-pump capacitors between CAP1+ and CAP1– and CAP2+ and CAP2–, respectively, and a smoothing capacitor between VI and VO.



Double voltage potential levels



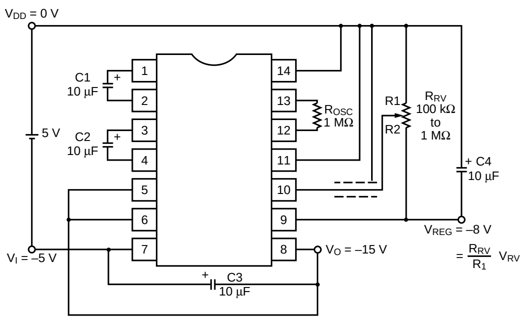
Tripled voltage potential levels



TYPICAL APPLICATIONS

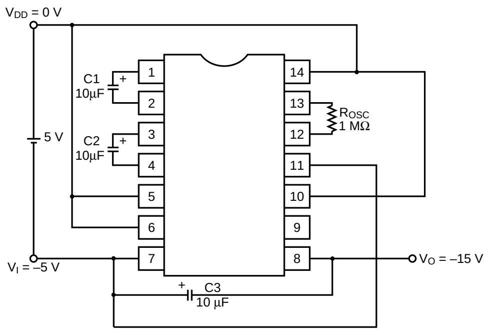
Voltage Tripler with Regulator

The following figure shows the circuit required to triple the input voltage, regulate the result and add a temperature gradient of –0.4%/°C. Note that the high input impedance of RV requires appropriate noise countermeasures.



Converting a Voltage Tripler to a Voltage Doubler

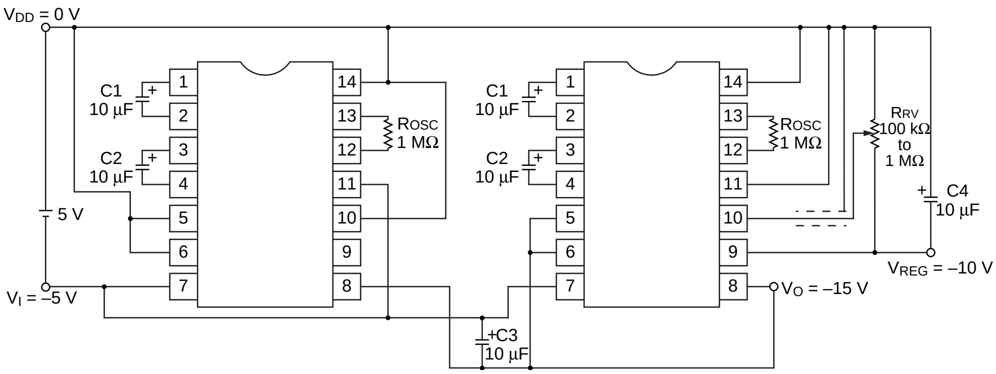
To convert this curcuit to a voltage doubler, remove capacitor C2 and short circuit CAP2– to V_O.



Parallel Connection

Connecting two or more chips in parallel reduces the output impedance by $1/n$, where n is the number of devices used.

Only the single output smoothing capacitor, C3, is required when any number of devices are connected in parallel. Also, the voltage regulator in one chip is sufficient to regulate the combined output.



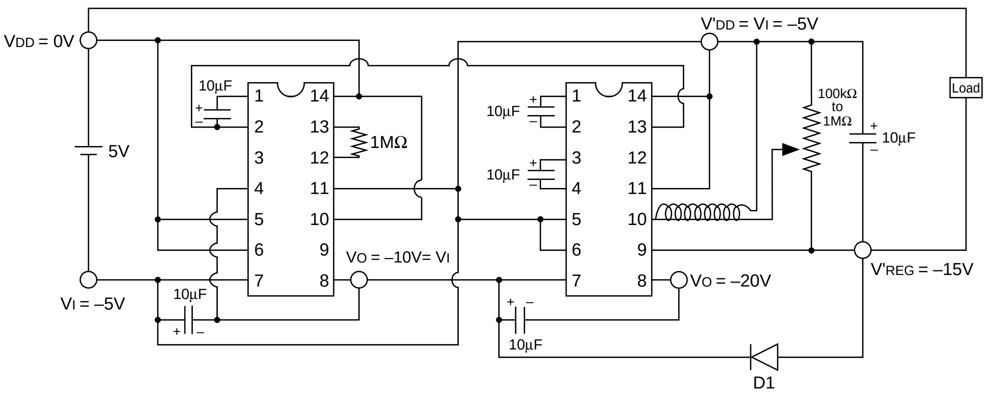
Serial Connection

Connecting two or more chips in series obtains a higher output voltage than can be obtained using a parallel connection, however, this also raises the output impedance.

<Precautions when connecting loads>

In case of series connections, when connecting loads between the first stage V_{DD} (or other potential of the second stage V_{DD} or up) and the second stage V_{REG} as shown in Fig. 2-13, be cautions about the following point.

* When normal output is not occurring at the V_{REG} terminal such as at times of starting up or when turning the V_{REG} off by Poff signals, if current flows into the second stage V_{REG} terminal through the load from the first stage V_{DD} (or other potential of the second stage V_{DD} or up) to cause a voltage exceeding the absolute maximum rating for the second stage V_{DD} at the V_{REG} terminal, normal operation of the IC may be hampered. Consequently, When making a series connection, insert a diode D1 between the second stage V_I and V_{REG} as shown in Fig. 2-13 so that a voltage exceeding the second stage V_{DD} or up may not be applied to the V_{REG} terminal.

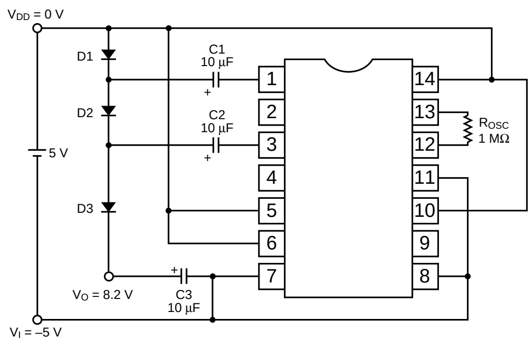


Positive Voltage Conversion

Adding diodes converts a negative voltage to a positive one.

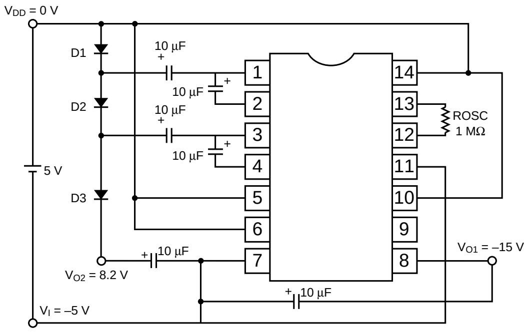
To convert the voltage tripler shown earlier to a voltage doubler, remove C2 and D2, and short circuit D3. Small Schottky diodes are recommended for all three diodes. The resulting voltage is lowered by V_F, the voltage drop in the forward direction for each diode used. For example, if V_{DD} = 0V, V_I = –5V, and V_F = 0.6V, the resulting voltages would be as follows.

- For a voltage tripler,
  V_O = 10 – (3 × 0.6) = 8.2V
- For a voltage doubler,
  V_O = 5 – (2 × 0.6) = 3.8V



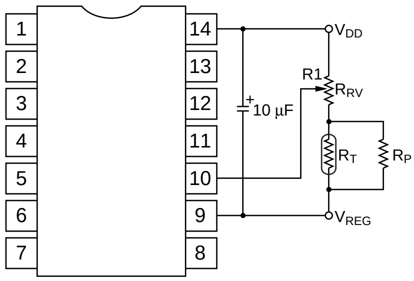
Simultaneous Voltage Conversion

Combining a standard voltage tripler circuit with one for positive voltage conversion generates both –15 and 8.2V outputs from a single input, however, it also raises the output impedance.
A voltage doubler generates –10 and 3.8V outputs.



Using an External Gradient

The SCI7661C0B/M0B offers three built-in temperature gradients— –0.1, –0.4 and –0.6%/°C.
To set the gradient externally, place a thermistor, R_T, in series with the variable resistor, R_{RV}, used to adjust the output voltage.



Potential levels