SCI7661C/M

CMOS DC/DC CONVERTER

T-57-11

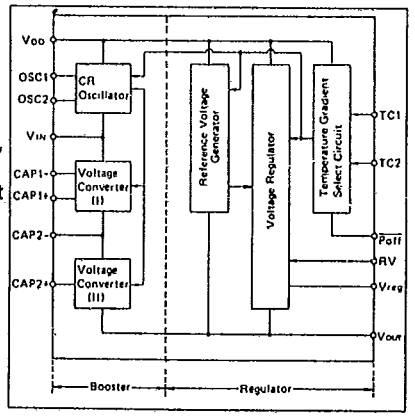
DESCRIPTION

The SCI7661C CMOS DC/DC Converter features high operational performance with low power dissipation. It consists of two major parts: the booster circuitry and the regulator circuitry. The booster generates a doubled output voltage (-2.4V to -12V) or tripled output voltage (-3.6V to -18V) from the input (-1.2 to -6V). The regulator is capable of setting the output to any desired voltage. The regulated voltage can be given one of the three threshold temperature gradients.

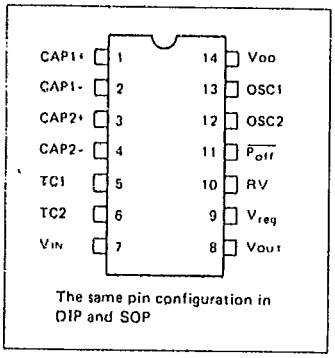
FEATURES

- High performance with low power dissipation
- Simple conversion of V_{IN} (-5V) to $|V_{IN}|$ (+5V), $2|V_{IN}|$ (+10V), $2V_{IN}$ (-10V) or $3V_{IN}$ (-15V)
- On-chip output voltage regulator
- Power conversion efficiency — Typ 95%
- Temperature gradient for LCD power supply — 0.1%/°C, 0.4%/°C or 0.6%/°C
- Power off by external signals — Stationary current at power off — Max 2μA
- Cascade connection — two device connected: V_{IN} = -5V, V_{OUT} = -20V
- On-chip C-R oscillator
- Package ..... SCI7661C ····· 14-pin DIP (plastic)
  SCI7661M ····· 14-pin SOP (plastic)

BLOCK DIAGRAM



PIN CONFIGURATION



The same pin configuration in DIP and SOP

PIN DESCRIPTION

Terminal	No.	Functions
CAP1+, CAP1-	1, 2	Terminal for connection of capacitor for doubler
CAP2+, CAP2-	3, 4	Terminal for connection of capacitor for tripler
TC1, TC2	5, 6	Temperature gradient selection terminal
V_{IN}	7	Power supply terminal (negative, system supply GND)
V_{OUT}	8	Output terminal at tripling
Vreg	9	Regulated voltage output terminal
RV	10	Regulated voltage control terminal
$\overline{Poff}$	11	Vreg output ON/OFF control terminal
OSC2, OSC1	12, 13	Oscillation resistor connection terminal
V_{DD}	14	Power supply terminal (positive system supply Vcc)

■ABSOLUTE MAXIMUM RATINGS

(V_{DD} =0V)

Parameter	Symbol	Ratings Min	Ratings Max	Unit	Remarks
Input supply voltage	V_I	-20/N	0.5	V	N = 2:Doubler N = 3:Tripler
Input terminal voltage	V_I	V_{IN}-0.5	0.5	V	OSC1, $\overline{Poff}$
		V_{OUT}-0.5	0.5	V	TC1, TC2, RV
Output voltage	V_O	-20.0		V	
Allowable loss	P_d		300	mW	
Operating temperature	T_{opr}	-30	85	°C	Plastic package
Storage temperature	T_{stg}	-55	150	°C	

■ELECTRICAL CHARACTERISTICS

(V_{DD} =0V, V_{IN} =-5V, Ta=-30to85°C)

Parameter	Symbol	Ratings Min	Ratings Typ	Ratings Max	Unit	Conditions
Input supply voltage	V_I	-6.0		-1.2	V	
Output voltage	V_O	-18.0			V	
	V_{reg}	-18		-2.6	V	R_L = ∞, R_{RV} = 1MΩ, V_O = -18V
Regulator operating voltage	V_{OUT}	-18.0		-3.2	V	
Booster current consumption	I_{opr1}		60	100	μA	R_L = ∞, R_{osc} = 1MΩ
Regulator current consumption	I_{opr2}		5.0	12.0	μA	R_L = ∞, R_{RV} = 1MΩ V_{OUT} = -15V
Stationary current	I_Q			2.0	μA	TC2 = TC1 = V_{OUT}, R_L = ∞
Oscillation frequency	fosc	16	20	24	kHz	R_{osc} = 1MΩ
Output impedance	R_{OUT}		150	200	Ω	I_{OUT} = 10mA
Booster power conversion efficiency	Peff	90	95		%	I_{OUT} = 5mA
Regulated output voltage fluctuation	$\frac{\Delta V_{reg}}{\Delta V_{OUT} \cdot V_{reg}}$		0.2		%/V	-18V < V_{OUT} < -8V, V_{reg} = -8V, R_L = ∞, Ta = 25°C
Regulated output load fluctuation	$\frac{\Delta V_{reg}}{\Delta I_{OUT}}$		5		Ω	V_{OUT} = -15V, V_{reg} = -8V, Ta = 25°C 0 < I_{OUT} < 10mA, TC1 = V_{DD} TC2 = V_{OUT}
Regulated output saturation resistance	R_{SAT}		8		Ω	R_{SAT} = Δ(V_{reg} - V_{OUT})/ΔI_{OUT} 0 < I_{OUT} < 10mA, RV = V_{DD}, Ta = 25°C
Reference voltage	VRV0	-2.3	-1.5	-1.0	V	TC2 = V_{OUT}, TC1 = V_{DD}, Ta = 25°C
	VRV1	-1.7	-1.3	-1.1	V	TC2 = TC1 = V_{OUT}, Ta = 25°C
	VRV2	-1.1	-0.9	-0.8	V	TC2 = V_{DD}, TC1 = V_{OUT}, Ta = 25°C
Temperature Gradient	CT0	-0.25	-0.1	-0.06	%/°C	$CT = \frac{\lvert V_{reg}(50°C)\rvert - \lvert V_{reg}(0°C)\rvert}{50°C - 0°C} \times \frac{1}{\lvert V_{reg}(25°C)\rvert} \times 100$
	CT1	-0.5	-0.4	-0.3	%/°C	
	CT2	-0.7	-0.6	-0.5	%/°C	
Input leakage current	I_L			2.0	μA	$\overline{Poff}$, TC1, TC2, OSC1, RV pins

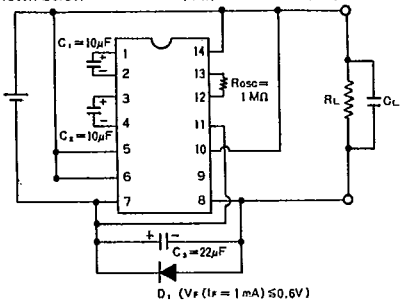
■RECOMMENDED OPERATING CONDITIONS

(Ta = -30 ~ 85°C)

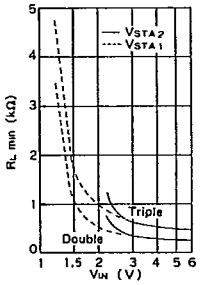
Parameter	Symbol	Ratings Min	Ratings Max	Unit	Remarks
Booster start voltage	V_{STA1}		-1.2	V	R_{osc} = 1MΩ, $C_3 \geqq 10\mu F$ *2 $C_L/C_3 \leqq 1/20$, Ta = -20 to 85°C
	V_{STA2}		-2.2	V	R_{osc} = 1 MΩ
Booster stop voltage	V_{STP}	-1.2		V	R_{osc} = 1 MΩ
Output load resistance	R_L	R_L min *3		Ω	
Output load current	I_{OUT}		20	mA	
Oscillation frequency	fosc	10	30	kHz	
Extarnal resistance for oscillation	Rosc	680	2000	kΩ	
Capasitor for booster	C_1, C_2, C_3	3.3		μF	
Regulated output adjustable resistance	R_{RV}	100	1000	kΩ	

*1 V_{DD} =0V

*2 Recommended circuity in low voltage operation is shown below (V_{IN} =-1.2V~-2.2V)



*3 R_L min depends on input voltage as shown below.



■PERFORMANCE CURVES

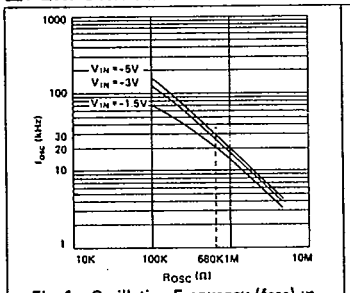


Fig. 1 Oscillation Frequency (fosc) vs. External - Resistance (Rosc)

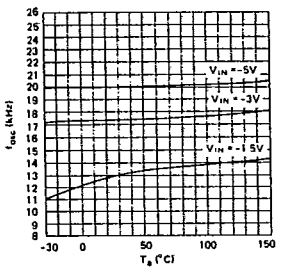


Fig. 2 Oscillation Frequency (fosc) vs. Temperature (Ta)

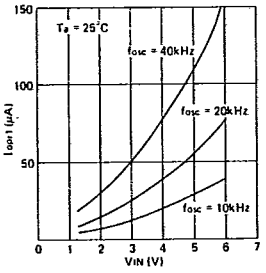


Fig. 3 Input Voltage (V_{IN}) vs. Booster Current Consumption (I_{opr1})

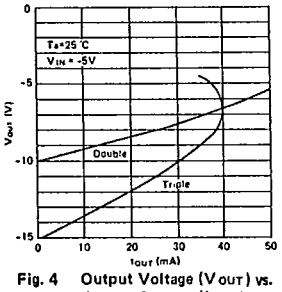


Fig. 4 Output Voltage (V_{OUT}) vs. Output Current (I_{OUT})

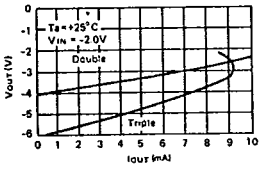


Fig. 5 Output Voltage (V_{OUT}) vs. Output Current (I_{OUT})

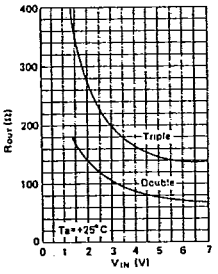


Fig. 6 Output Impedance (R_{OUT}) vs. Input Voltage (V_{IN})

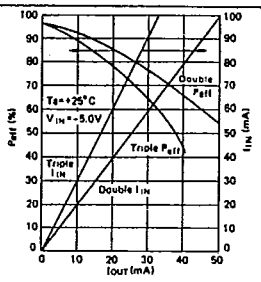


Fig. 7 Power Conversion Efficiency (P_{eff})/Input Current (I_{IN}) vs. Output Current (I_{OUT})

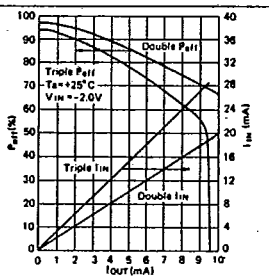


Fig. 8 Power Conversion Efficiency (P_{eff})/Input Current (I_{IN}) vs. Output Current (I_{OUT})

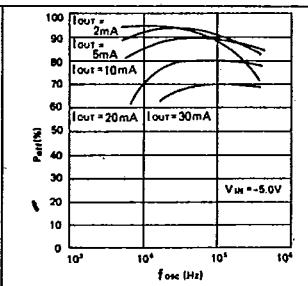


Fig. 9 Power Conversion Efficiency (P_{eff}) vs. Oscillation Frequency (f_{osc})

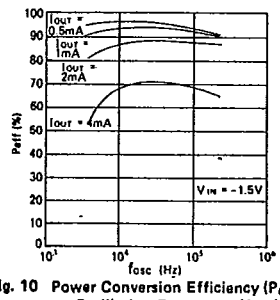


Fig. 10 Power Conversion Efficiency (P_{eff}) vs. Oscillation Frequency (f_{osc})

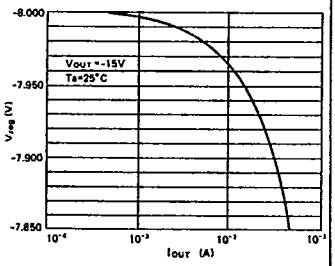


Fig. 11 Output Voltage (V_{reg}) vs. Output Current (I_{OUT})

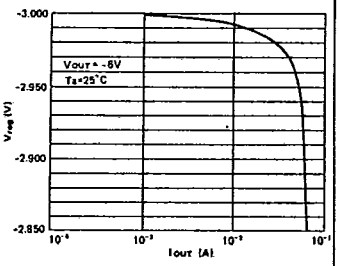


Fig. 12 Output Voltage (V_{reg}) vs. Output Current (I_{OUT})

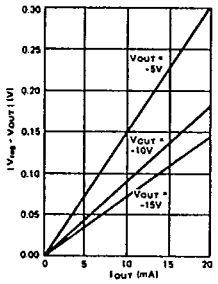


Fig. 13 Regulated Output Saturation Resistance (R_{SAT}) $|V_{reg} - V_{OUT}| - I_{OUT}$

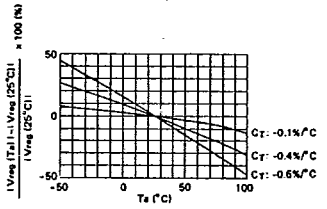
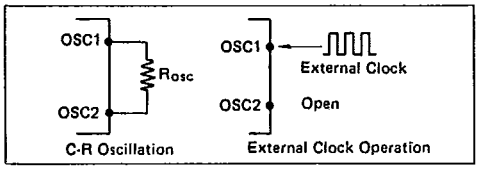


Fig. 14 Output Voltage (V_{reg}) vs. Temperature (Ta)

■CIRCUIT DESCRIPTION

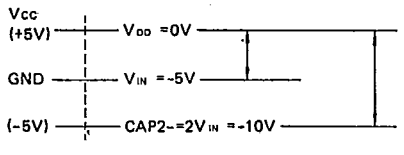
● C-R Oscillator

The SCI7661C contains a C-R oscillator for internal oscillation. It consists of an external resistor Rosc connected between the OSC1 pin and OSC2 pin.

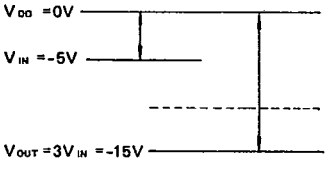


● Voltage Converters

The voltage converters double/triple the input supply voltage (V_{IN}) using clocks generated by the C-R oscillator.



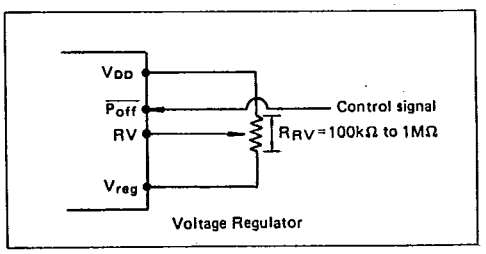
Typical Doubled Voltage Relations



Typical Tripled Voltage Relations

● Reference Voltage Generator and Voltage Regulator

The reference voltage generator produces reference voltage needed for operation of regulator circuit. The voltage regulator is used to regulate a boosted output voltage and its circuit contains a power-off function which uses signals from the system for on-off control of the V_{reg} output.



Voltage Regulator

● Temperature Gradient Selector Circuit

The SCI7661C provides the V_{reg} output with a temperature gradient suitable for LCD driving.

● Temperature Gradient Assignment

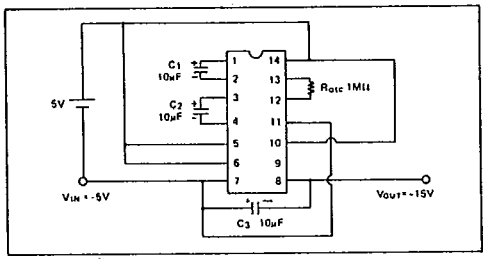
$\overline{P_{off}}$	TC2	TC1	Temp. Gradient	V_{reg} Output	CR oscillation	Remarks
1 (V_{DD})	L (V_{OUT})	L (V_{OUT})	-0.4%/°C	ON	ON	
1	L	H (V_{DD})	-0.1%/°C	ON	ON	
1	H (V_{DD})	L	-0.6%/°C	ON	ON	
1	H	H	-0.6%/°C	ON	OFF	Cascade connection
0 (V_{IN})	L	L	–	OFF (Hi-Z)	OFF	
0	L	H	–	OFF (Hi-Z)	OFF	
0	H	L	–	OFF (Hi-Z)	OFF	
0	H	H	–	OFF (Hi-Z)	ON	Without regulation

NOTE: The potential at Low level is different between the $\overline{P_{off}}$ pin and the TC1/TC2 pin.

■EXAMPLE OF APPLICATIONS

● Voltage Doubler and Tripler

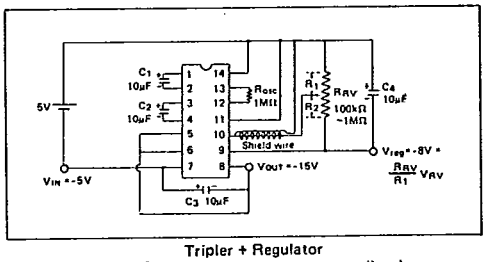
A doubled voltage can be obtained at V_{OUT} (CAP2-) by disconnecting capacitor C_2 from the tripler configuration and shorting CAP2- (pin 4) and V_{OUT} (pin 8).



Voltage Tripler

● Voltage Tripler + Regulator

V_{reg} output is given a temperature gradient, after boosted output V_{OUT} regulated. In this connection, both V_{OUT} and V_{reg} can be taken out at the same time.

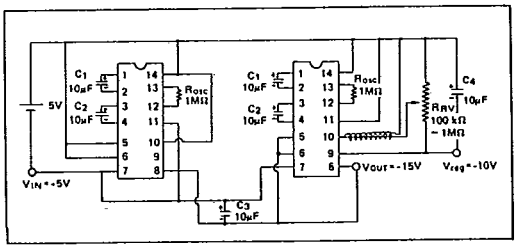


Tripler + Regulator
(-0.4%/°C selected as temperature gradient)

● Parallel Connection

Parallel connection of n circuits can reduce Rout to about 1/n, that output impedance Rout can be reduced by connecting serial configuration. A single smoothing capacitor C_3 can be used commonly for all parallely connected circuit.

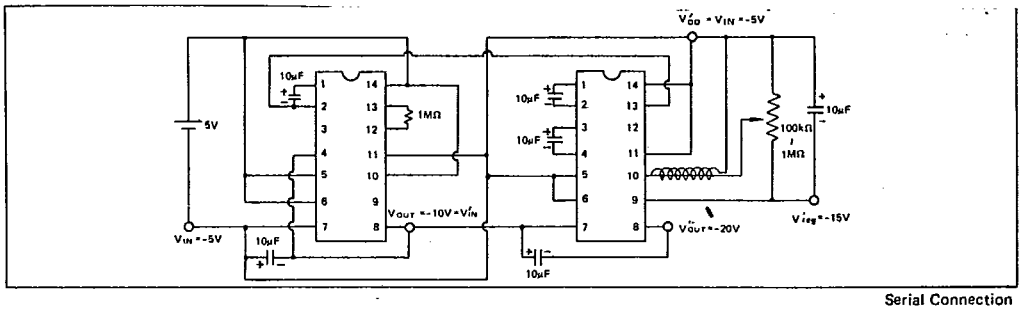
In parallely connection, a regulated output can be obtained by applying the regulation circuit to only one of the n parallely connected circuit.



Parallel Connection

● Cascade Connection

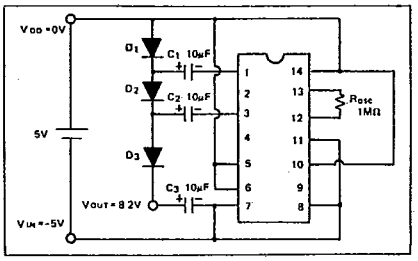
Cascade connection of SCI7661C (by connecting V_{IN} and V_{OUT} of one stage to V_{DD} and V_{IN} respectively of the next stage) further increase the output voltage. Note, however, that the serial connection increases the output impedance.



Serial Connection

● **Positive Voltage Conversion**

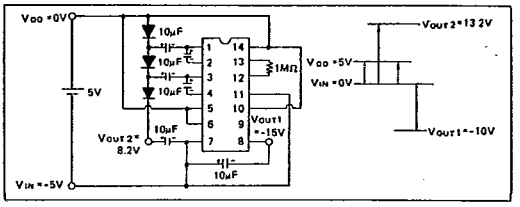
The input voltage can be doubled or tripled toward the positive side. (In the doubler configuration, capacitor C_2 and diode D_3 are disconnected and the diode D_3 shorted at the both ends.) In this case, however, the output voltage decrease by V_F (forward voltage).
For example V_{DD} =0V, V_{IN} =-5V and V_F=0.6V, then V_{OUT} =10V -3 x 0.6V=8.2V (if doubled, 5V-2 x 0.6V= 3.8V)



Positive Voltage Conversion D_1, D_2, D_3: Shottky diodes with small V_F are recommended.

● **Negative Voltage Conversion + Positive Voltage Conversion**

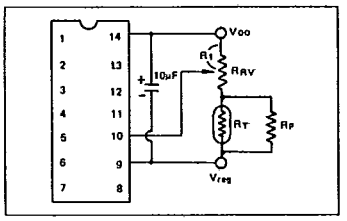
This circuit produces outputs of -15V and +8.2V from the -5V input. Note that this configuration causes higher output impedance than in a single function (negative or positive voltage converter).



Negative Voltage Convertion + Positive Voltage Conversion

● **Changing the Temperature Gradient through Use of External Temperature Sensor (Thermistor)**

The SCI7661C has a temperature gradient selector circuit in its regulator. It selects any one of the three gradients: -0.1%/°C, -0.4%/°C and -0.6%/°C. It is necessary that the temperature gradient can be changed to any other value by connecting a thermistor in series to the output voltage control resistor R_{RV}.



Example of Change of Temperature Gradient

■PACKAGE DIMENSIONS