SCI7654

CMOS DC/DC CONVERTER

■ DESCRIPTION

The SCI7654 is a high-efficiency low-power consumption charge pump-style DC/DC converter and voltage regulator which uses a CMOS process. The charge pump-type DC/DC converter can generate an output voltage of 4 times (or 3 times or 2 times) the input voltage in the negative direction using 4 (or 3 or 2) external capacitors.

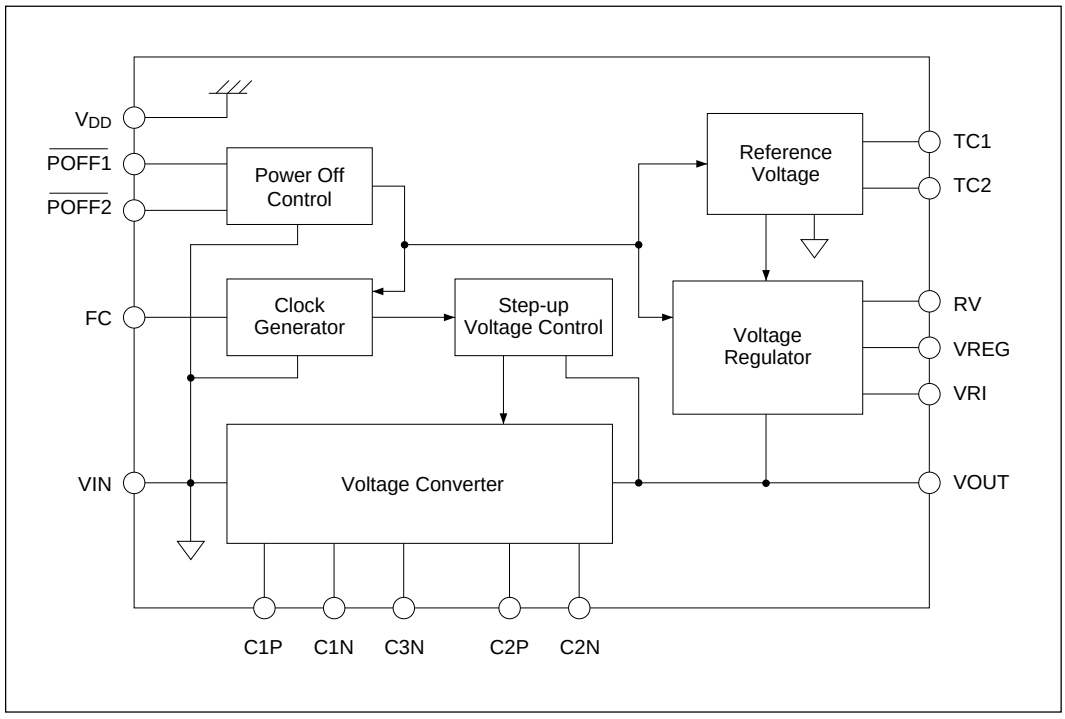
The voltage regulator is able to regulate the voltage output generated by the DC/DC converter at a selectable voltage using 2 external resistors. The regulated output of the voltage regulator can also be equipped with the negative temperature gradient characteristics required by liquid crystal panels.

The outputs of the SCI 7654 can be powered down by an external signal, thereby reducing wasted power during temporary system shutdowns, etc., making it an ideal power source for battery-operated portable devices and LCD panels.

■ FEATURES

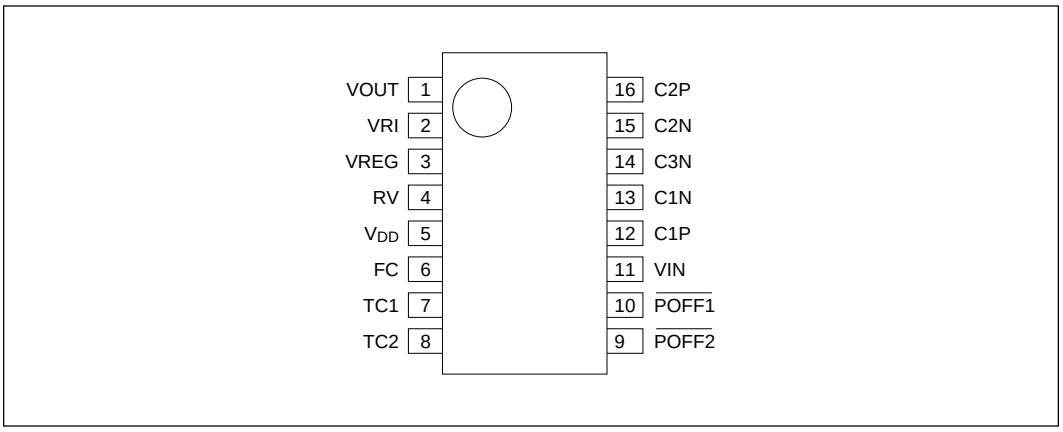
- DC converter (negative-direction 4X/3X/2X)
- Equipped with a voltage regulator (voltage-regulated output circuit)
- High voltage conversion efficiency 95%
- Low consumption current ..... 150 µA (VIN =–5.0 V when using 4X voltage step-up)
- High output capability ..... 20 mA
- Input voltage ..... –2.0 to –5.5 volts (when using 4 X voltage step-up)
  –2.0 to –7.3 volts (when using 3 X voltage step-up)
  –2.0 to –11. volts (when using 2 X voltage step-up)
- DC/DC converter output voltage ..... (VIN) X 4 (MAX)
- Internal reference voltage for high-precision regulator ..... –1.5 volts ± 0.05 volts (when CTO)
- Regulator output voltage temperature gradient function ..... –0.04, –0.15, –0.35, –0.55 (%/°C)
- Low standby current (when power is off)
- High-multiplier voltage step-up and regulation also possible through series connections and additional components
- External-signal power-function
- Oscillator function is completely internal
- Small, slim package (SSOP2-16) SCI7654MOA
- Chip product ..... SCI7654 DOA
- This product is not designed for resistance to radiation

■ BLOCK DIAGRAM



■ CONFIGURATION

● Pin Configuration (SCI7654M0A)



● Pin Description

Terminal Name	SCI7654MOA Pin No.	SCI7654DOA Pad No.	Function
VOUT	1	18	4 X step-up voltage output terminal
VRI	2	19	Regulated voltage input terminal
VREG	3	20	Regulated voltage output terminal
RV	4	21	Regulated output voltage control terminal
VDD	5	22,23	Power supply terminal (positive side)
FC	6	24	Internal clock frequency cutover input terminal Serial/parallel connection clock input terminal (used for both)
TC1	7	3	Temperature gradient set input terminal (1)
TC2	8	4	Temperature gradient set input terminal (2)
$\overline{\text{POFF2}}$	9	5	Power off control input terminal (2)
$\overline{\text{POFF1}}$	10	6	Power off control input terminal (1)
VIN	11	11,12	Power supply voltage (negative side)
C1P	12	13	2 X voltage step-up, 4 X voltage step-up capacitor positive-side connection terminal
C1N	13	14	2 X voltage step-up capacitor negative-side connection terminal
C3N	14	15	4 X voltage step-up capacitor negative-side connection terminal
C2N	15	16	3 X voltage step-up capacitor negative-side connection terminal
C2P	16	17	3 X voltage step-up capacitor positive-side connection terminal

■ ABSOLUTE MAXIMUM RATINGS

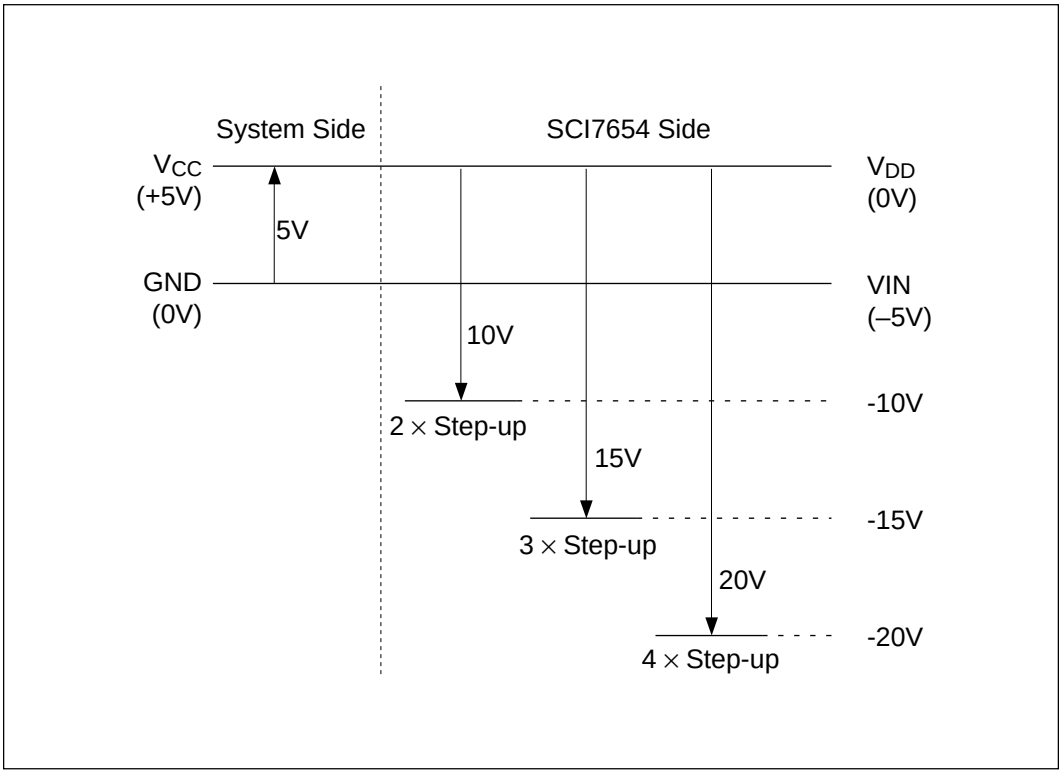
Parameter	Symbol	Read Values		Units	Notes
		Minimum	Maximum		
Input power supply voltage	V_{IN}	–26.0 /N	V_{DD} + 0.3	V	N= step-up voltage multiplier VIN terminal
Input terminal voltage	V_I	V_{IN} –0.3	V_{DD} + 0.3	V	POFF1, POFF2, TC1, TC2, FC terminals
Output terminal voltage 1	V_{0C1}	V_{IN} –0.3	V_{DD} + 0.3	V	C1P, C2P terminals
Output terminal voltage 2	V_{0C2}	2 X V_{IN}–0.3	V_{IN} + 0.3	V	C1N terminals
Output terminal voltage 3	V_{0C3}	3 X V_{IN}–0.3	2 X V_{IN} + 0.3	V	C2N terminal
Output terminal voltage 4	V_{0C4}	4 X V_{IN}–0.3	3 X V_{IN} + 0.3	V	C3N terminal
Regulator input power	V_{RI}	N X V_{IN}–0.3	V_{DD} + 0.3	V	N = step-up voltage multiplier, V_{RI} supply voltage terminal
Regulator input terminal	V_{RV}	N X V_{IN}–0.3	V_{DD} + 0.3	V	N = step-up voltage multiplier, R_V voltage terminal
Output voltage	V_O	N X V_{IN}–0.3	V_{DD} + 0.3	V	N = step-up voltage multiplier. V_{OUT}. V_{REG} terminal
Input current	I_{IN}		80	mA	V_{IN} terminal
Output current	I_{OUT}		N <= 4: 20 N > 4: 80/N	mA	N = step-up voltage multiplier V_{OUT}. V_{REG} terminal
Allowable loss	Pd		210	mW	
Operating temperature	T_{OPR}	–30	85	°C	
Storage temperature	T_{STG}	–55	150	°C	
Soldering temperature/time	T_{SOL}		260 X 10	°C•S	At the leads

Note 1: Operating the chip under conditions exceeding the absolute rated values above may result in misoperation and permanent damage to the chip. Moreover, the reliability of the chip will be seriously compromised even if the chip appears to function normally for a time.

Note 2: Relationships of voltage levels with the external system

The common power supply for the SCI7654 is the highest voltage level (V_{DD}). Because of this, the values in this specification are all expressed in terms of a V_{DD} = 0 V reference, and consequently caution is required regarding voltage levels when connecting to the external system.

- **Relationship of Voltage Levels**



■ ELECTRICAL CHARACTERISTICS

● DC Characteristics

If not otherwise indicated, T_a = –30°C to +85°C, V_{DD} = 0V, V_{IN} = –5.0V

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input power supply voltage 1	V_{IN1}	For 4X step-up voltage	–5.5		–2.0	V
Input power supply voltage 2	V_{IN2}	For 3X step-up voltage	–7.3		–2.0	V
Input power supply voltage 3	V_{IN3}	For 2X step-up voltage	–11		–2.0	V
Input power supply voltage N	V_{INN}	When used with high multiplier step-up voltages using an external diode. “N” is the step-up multiplier.	–22/N		–2.0	V
Step-up initial input power supply voltage	V_{STA}	“N” is the step-up multiplier, I_{OUT}<200 µA FC = V_{DD}	–22/N		–2.4	V
Step-up output voltage	V_{OUT}		–22			V
Regulator input voltage	V_{RI}		–22		–2.0	V
Regulator output voltage	V_{REG}	$_{REG}$ = 0, V_{RI} =–22V, R_{RV} = 1MΩ			–2.0	V
Step-up output impedance	R_{OUT}	I_{OUT} = 10 mA, for 4X step-up voltage		180	250	Ω
Step-up output conversion efficiency	P_{eff}	I_{OUT} = 2 mA For 4X step-up voltage C1, C2, C3, C_{OUT} = 10 µF (tantalum)		95		%
Step-up converter operating consumption current 1	I_{OPR1}	FC = V_{DD}, P_{OFF1} = V_{IN}, P_{OFF2} = V_{DD} with no load C1, C2, C3, C_{OUT} = 10 µF (tantalum)		150	220	µA
Step-up converter operating consumption current 2	I_{OPR2}	FC = V_{IN}, P_{OFF1} = V_{IN}, P_{OFF2} = V_{DD} with no load C1, C2, C3, C_{OUT} = 10 µF (tantalum)		600	800	µA
Regulator operating consumption current	I_{OPVR}	V_{RI} =–20V, with no load R_{RV} = 1MΩ		10	15	µA
Idle current	I_Q	P_{OFF1} = V_{IN}, P_{OFF2} = V_{IN} FC = V_{DD}			5.0	µA
Input leakage current	I_{LIN}	Applicable terminals: P_{OFF1}, P_{OFF2}, FC TC1, TC2			0.5	µA
Regulated output saturation resistance	R_{SAT} (Note 1)	0<I_{REG}<20 mA R_V = V_{DD} Ta = 25 °C		10		Ω
Regulated output voltage regulation	D_{VR} (Note 2)	–20V<V_{RI}<–10V, I_{REG} = 1 mA V_{REG} =–15V Ta = 25 °C		0.2		%/V
Regulated output load deviation	D_{V0} (Note 3)	V_{RI} =–20V V_{REG} =–15V Ta = 25 °C 0<I_{REG} < 20mA		50		mV
Reference Voltage (Ta = 25 °C)	V_{REF0}	TCI = V_{DD}, TC2 = V_{DD}	–1.55	–1.50	–1.45	V
	V_{REF1}	TC1 = V_{DD}, TC2 = V_{DD}	(TBD)	–1.50	(TBD)	V
	V_{REF2}	TC1 = V_{DD}, TC2 = V_{DD}	(TBD)	–1.50	(TBD)	V
	V_{REF3}	TC1 = V_{DD}, TC2 = V_{DD}	(TBD)	–1.50	(TBD)	V
Reference Voltage Temperature Coefficient (Note 4) (Note 5)	CT0	TC1 = V_{DD}, TC2 = VDD, SSOP Product	(TBD)	–0.04	0	%/°C
	CT1	TC1 = V_{DD}, TC2 = V_{IN}, SSOP Product	(TBD)	–0.15	(TBD)	%/°C
	CT2	TC1 = V_{IN}, TC2 = V_{DD}, SSOP Product	(TBD)	–0.35	(TBD)	%/°C
	CT3	TC1 = V_{IN}, TC2 = V_{IN}, SSOP Product	(TBD)	–0.55	(TBD)	%/°C
Input voltage level	V_{IH}	V_{IN} =–2.0 V to –5.5V Applicable terminals: P_{OFF1}, P_{OFF2}, FC, TC1, TC2	0.2 V_{IN}			V
	V_{IL}	V_{IN} =–2.0 V to –5.5V Applicable terminals:P_{OFF1}, P_{OFF2}, FC, TC1, TC2			0.8 V_{IN}	V
Step-up capacitor	C_{MAX}	Applicable capacitors: C1, C2, C3			47	µF

(Note 1): $R_{SAT} = \frac{\Delta(V_{REG} - V_{OUT})}{\Delta I_{REG}}$

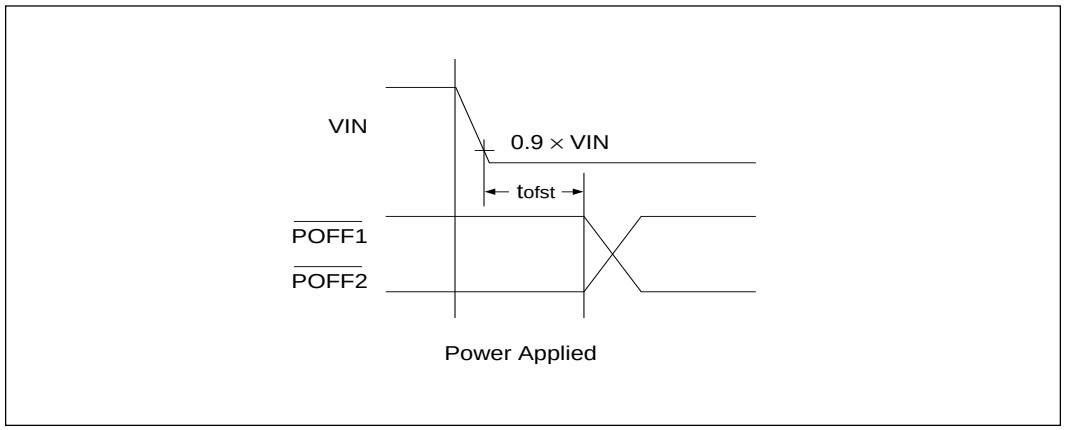
(Note 2): $\Delta V_R = \frac{\Delta V_{REG}}{\Delta V_{OUT \cdot REG}}$

(Note 3): $\Delta V0 = \frac{\Delta V_{REG}}{\Delta I_{REG}}$

(Note 4): $\Delta CT = \frac{|V_{REF}(50°C)| - |V_{REF}(0°C)|}{50°C - 0°C} \times \frac{100}{|V_{REF}(25°C)|}$

(Note 5): The reference voltage temperature coefficient of the chip product may change depending on the molding material and the packaging. Use only after performing temperature tests.

- **AC Characteristics**



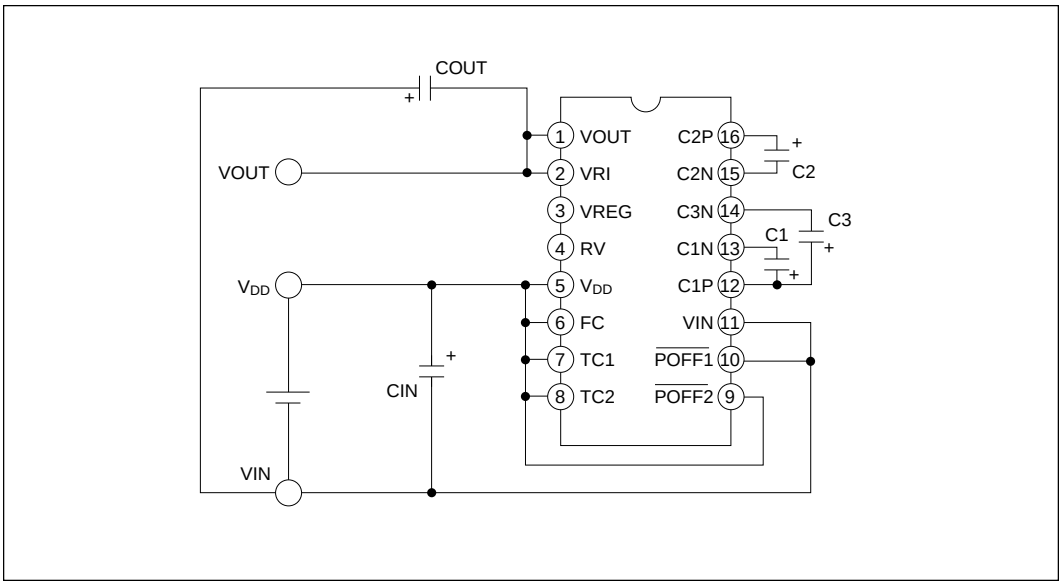
Power off control timing characteristics

If not otherwise indicated, T_a = –30°C to +85°C, V_{DD} = 0V, V_{IN} =–5.0V

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Internal clock frequency 1	f_{CL1}	FC = V_{DD}, P_{OFF1} = V_{DD}, P_{OFF2} = V_{IN} Applicable terminals: C2P terminal	3.0	4.0	6.0	kHz
Internal clock frequency 2	f_{CL2}	FC = VIN, P_{OFF1} = V_{DD}, P_{OFF2} = V_{IN} Applicable terminals: C2P terminal	12.0	16.0	24.0	kHz
Power off control begin time	t_{ofst}	Applicable terminals: P_{OFF1}, P_{OFF2}	(TBD)			ms

■ 4X STEP-UP

Only the step-up circuit is made to function and the chip generates a regulated voltage equal to 4 times the input voltage V_{IN} (but in the negative direction), outputting it to the V_{OUT} terminal. However, because the regulator circuit is not used, the voltage at the V_{OUT} terminal includes some ripple component. The figure below shows an example of the connections.



Conditions for Above Figure

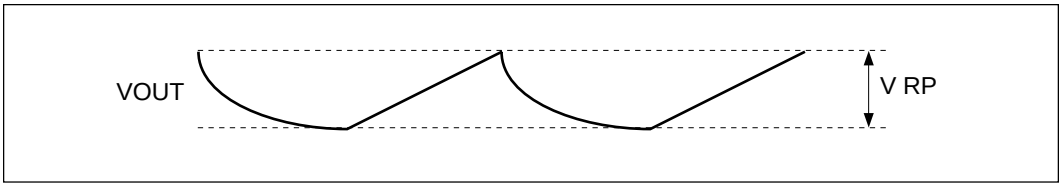
- Internal clock: ON (high output mode)
- Step-up circuit: ON
- Regulator: OFF

Power Off Method

- Through setting the $\overline{\text{POFF2}}$ terminal to “L” level (VIN), all circuits can be turned off.

The Ripple Voltage

- Because the output voltage generated at VOUT terminal is not regulated, it includes a ripple component such as shown in the figure below. The ripple voltage VRP increases with load current, and can be calculated roughly using the equation below.



$$V_{RP} = \frac{I_{OUT}}{2 \cdot f_{CL} \cdot C_{OUT}} + I_{OUT} \cdot R_{COUT}$$

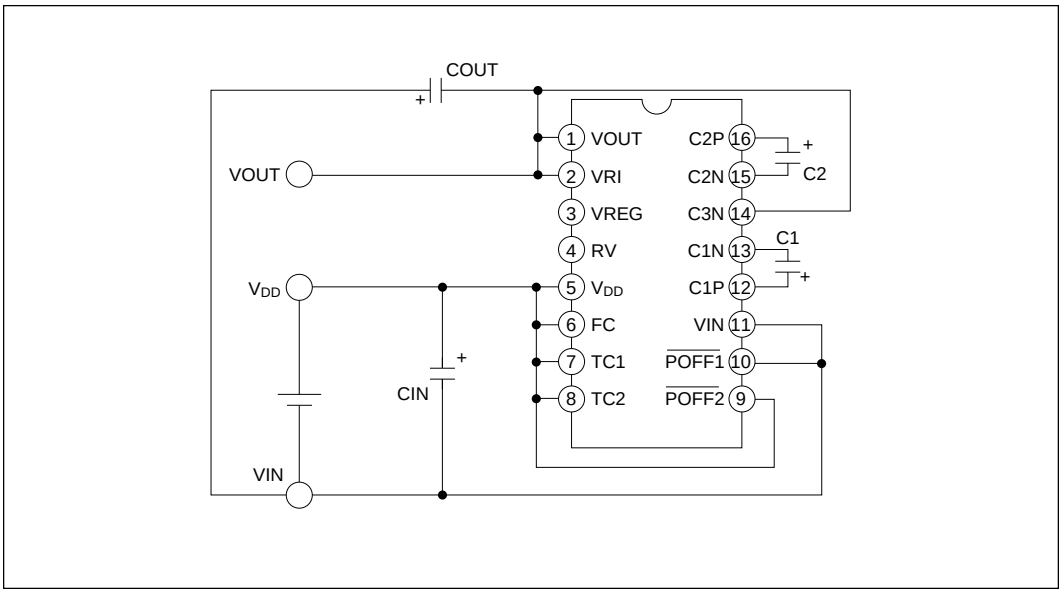
I_{OUT}: Load current (A)
f_{CL}: Clock frequency (Hz)
R_{Cout}: Output capacitor Cout serial equivalent resistance (Ω)

Use With Other Settings

1. Use in high output mode
   * Connect the FC terminal to VIN

■ 3X STEP-UP

Only the step-up circuit is made to function and the chip generates a regulated voltage equal to 3 times the input voltage VIN (but in the negative direction), outputting it to the VOUT terminal. However, because the regulator circuit is not used, the voltage at the VOUT terminal includes some ripple component. The figure below shows an example of the connections.



Conditions for Above Figure

- Internal clock: ON (high output mode)
- Step-up circuit: ON
- Regulator: OFF

Power Off Method

- Through setting the POFF2 terminal to “L” level (VIN), all circuits can be turned off.

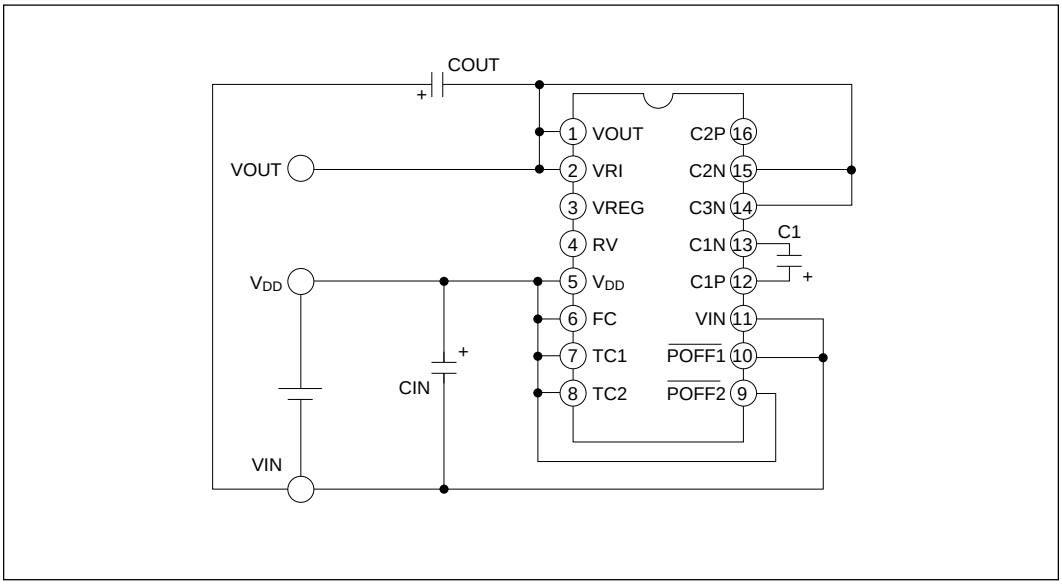
Use With Other Settings

1. Use in high output mode

* Connect the FC terminal to VIN

■ 2X STEP-UP

Only the step-up circuit is made to function and the chip generates a regulated voltage equal to 2 times the input voltage VIN (but in the negative direction), outputting it to the VOUT terminal. However, because the regulator circuit is not used, the voltage at the VOUT terminal includes some ripple component. The figure below shows an example of the connections.



Conditions for Above Figure

- Internal clock: ON (high output mode)
- Step-up circuit: ON
- Regulator: OFF

Power Off Method

- Through setting the POFF2 terminal to “L” level (VIN), all circuits can be turned off.

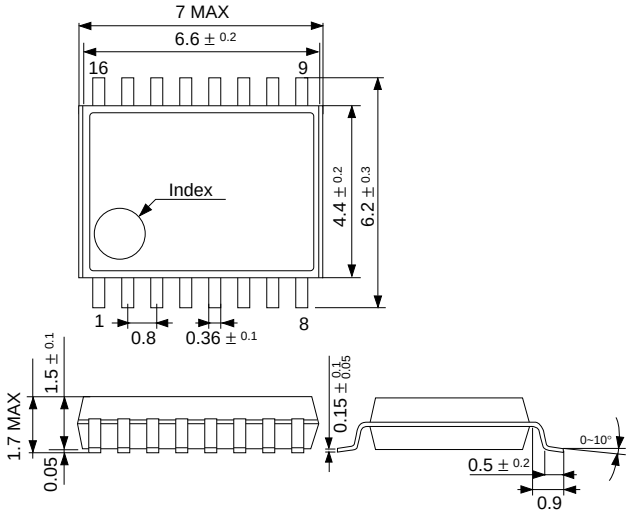
Use With Other Settings

1. Use in high output mode

* Connect the FC terminal to VIN

■ EXTERNAL DIMENSIONS (SCI7654M$_{OA}$)

SSOP2-16



Unit : mm

Note: To allow improvement, these dimensions may change without notice.

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