SCI7630 Series

POWER SUPPLY IC

4.

DC/DC Switching Regulators

The SCI7630 series of CMOS switching regulators comprises nine series—the SCI7631, SCI7638 series featuring built-in RC oscillators, the SCI7633 series requiring external crystal oscillators.

SCI7631, SCI7638 Series CMOS Switching Regulators

DESCRIPTION

The SCI7631, SCI7638 series of CMOS switching regulators provide input voltage step-up and regulation to a specified fixed voltage using an external coil. The devices in these series incorporate precision, low-power reference voltage generators and transistors for driving an internal comparator. They feature low power consumption, low operating voltages, voltage detection and standby operation.
The devices offer a range of fixed output voltages, from 2.0 to 5.0V. The SCI7631 series features battery backup and power-on clear, the SCI7638 series features power-on clear and response compensation, the SCI7638 series offer an output voltage temperature characteristic for driving an LCD. They are available in 8-pin SOP3s.

FEATURES

- 0.9V (Min.) operating voltage
- 10µA (Typ.) maximum current consumption
- Standby operation
- 3µA (Typ.) standby current consumption
- 1.05 ±0.05V high-accuracy voltage detection
- Battery backup (available on SCI7631 series)
- On-chip RC oscillator
- Power-on clear (available on SCI7631 and SCI7638 series)
- Output voltage temperature characteristic for driving an LCD (available on SCI7638 series)
- 8-pin SOP3

APPLICATIONS

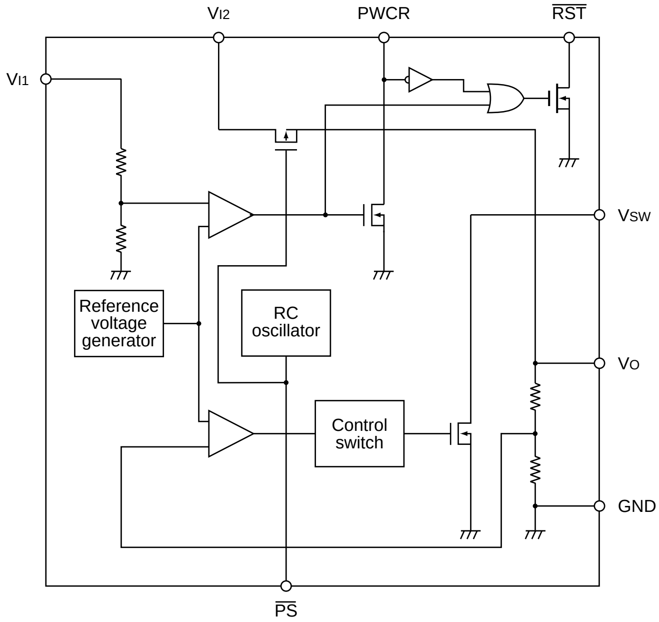
- Fixed-voltage power supplies for battery-operated equipment such as portable video cassette recorders, video cameras and radios
- Power supplies for pagers, memory cards, calculators and similar hand-held equipment
- Fixed-voltage power supplies for medical equipment
- Fixed-voltage power supplies for communications equipment
- Power supplies for microcomputers
- Uninterruptable power supplies
- LCD panel supplies

LINE-UP

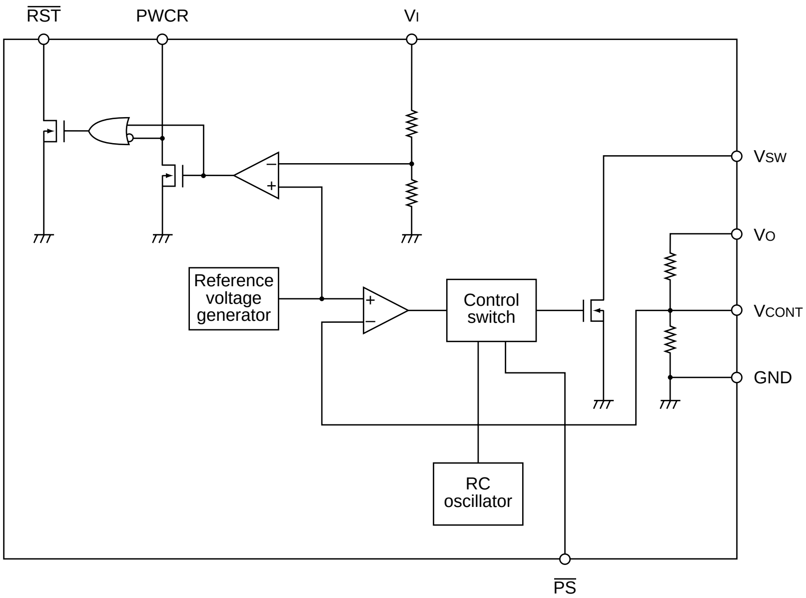
Device	Voltage (V)		Multiplication frequency source	Voltage detection	Power-on clear	Battery backup	Response compensation	Output voltage temperature characteristic	Package
	Input	Output							
SCI7631MLA	1.5 (0.9 min.)	2.4	On-chip RC oscillator	Yes	Yes	Yes	No	No	SOP3-8pin
SCI7631MBA		3.0							SOP3-8pin
SCI7631MKA		3.5							SOP3-8pin
SCI7631MAA		5.0							SOP3-8pin
SCI7638MHA	1.5 (0.9 min.)	2.2	On-chip RC oscillator			No	Yes	–4.5 mV/°C	SOP3-8pin
SCI7638MLA		2.4						–4.0 mV/°C	SOP3-8pin

BLOCK DIAGRAMS

SCI7631 Series

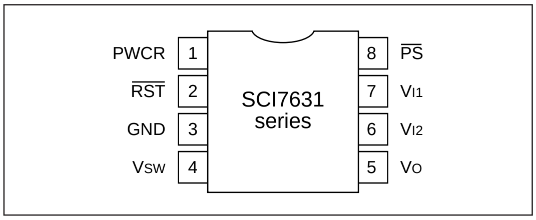


SCI7638 Series

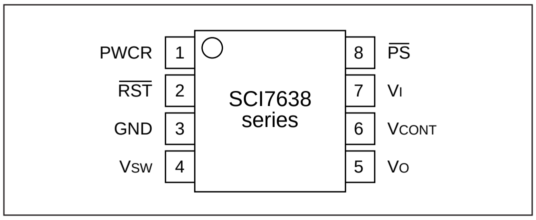


PIN CONFIGURATIONS

SCI7631 Series



SCI7638 Series



PIN DESCRIPTIONS

SCI7631 Series

Number	Name	Description
1	PWCR	Power-on clear. See note 1.
2	$\overline{RST}$	Reset signal output. See note 1.
3	GND	Ground
4	V_{SW}	External inductor drive
5	V_O	Output votlage
6	V_{I2}	Backup input voltage
7	V_{I1}	Step-up input voltage
8	$\overline{PS}$	Power save. See note 2.

Notes

1. See voltage detection and power-on clear in the functional description.
2. See standby mode and battery backup in the functional description.

SCI7638 Series

Number	Name	Description
1	PWCR	Power-on clear. See note 1.
2	$\overline{RST}$	Reset signal output. See note 1.
3	GND	Ground
4	V_{SW}	External inductor drive
5	V_O	Output votlage
6	V_{CONT}	Comparator input
7	V_{I1}	Step-up input voltage
8	$\overline{PS}$	Power save. See note 2.

Notes

1. See voltage detection and power-on clear in the functional description.
2. See standby mode and battery backup in the functional description.

SPECIFICATIONS

Absolute Maximum Ratings

SCI7631 series

Parameter	Symbol	Rating	Unit
Input voltage	V_{I1}	7	V
Output current	I_O	100	mA
Output voltage	V_O	7	V
Power dissipation	P_D	200 (SOP3) 300 (DIP)	mW
Operating temperature range	Topr	–30 to 85	˚C
Storage temperature range	Tstg	–65 to 150	˚C
Soldering temperature (for 10 s). See note.	Tsol	260	˚C

Notes

Temperatures during reflow soldering must remain within the limits set out in LSI Device Precautions. Never use solder dip to mount SCI7000 series power supply devices.

SCI7638 series

Parameter	Symbol	Rating	Unit
Input voltage	V_{I1}	7	V
Output current	I_O	100	mA
Output voltage	V_O	7	V
Power dissipation	P_D	200 (SOP3) 300 (DIP)	mW
Operating temperature range	Topr	–30 to 85	˚C
Storage temperature range	Tstg	–65 to 150	˚C
Soldering temperature (for 10 s). See note.	Tsol	260	˚C

Parameter	Symbol	Rating	Unit
Input voltage	V_I	7	V
Output voltage	V_O	7	V
Power dissipation	P_D	250	mW
Operating temperature range	Topr	–30 to 85	˚C
Storage temperature range	Tstg	–65 to 150	˚C

Notes

Temperatures during reflow soldering must remain within the limits set out in LSI Device Precautions. Never use solder dip to mount SCI7000 series power supply devices.

Electrical Characteristics

SCI7631MLA

V_{SS} = 0V, Ta = 25 °C unless otherwise noted

Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_{I1}	$V_O > V_{I2}$	0.9	—	1.8	V
	V_{I2}		0.9	—	1.8	V
Output voltage	V_O	V_{I1} = 1.5V	2.32	2.40	2.48	V
Detection voltage	V_{DET}		1.00	1.05	1.10	V
Detection voltage hysteresis ratio	ΔV_{DET}		—	5	—	%
Operating current	I_{DDO}	V_{I1} = 1.5V, I_O = 1.0mA	—	7	35	µA
Standby current	I_{DDS}	V_{I1} = 1.5V	—	3	10	µA
Switching transistor ON resistance	R_{SWON}	V_{I1} = 1.5V, V_O = 2.4V, V_{SW} = 0.2V	—	7	14	Ω
Switching transistor leakage current	I_{SWQ}	V_{I1} = 1.5V, V_O = 1.5V, V_{SW} = 7.0V	—	—	0.5	µA
Backup switch ON resistance	R_{BSON}	V_{I1} = 1.0V, V_{I2} = 1.5V, I_O = 1.0mA	—	100	250	Ω
Backup switching leakage current	I_{BSQ}	V_{I1} = 1.0V, V_O = 2.4V, V_{I2} = 2.0V	—	—	0.1	µA
$\overline{RST}$ LOW-level output current	I_{OL}	V_{I1} = 0.9V, V_{DS} = 0.2V	0.05	0.15	—	mA
$\overline{PS}$ pull-up current	I_{IH}	V_{I1} = 1.5V	—	—	0.5	µA
Multiplication clock frequency	f_{CLK}	V_{I1} = 1.5V	25	35	45	kHz

SCI7631MBA

V_{SS} = 0V, Ta = 25 °C unless otherwise noted

Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_{I1}	$V_O > V_{I2}$	0.9	—	2.0	V
	V_{I2}		0.9	—	2.0	V
Output voltage	V_O	V_{I1} = 1.5V	2.90	3.00	3.10	V
Detection voltage	V_{DET}		1.00	1.05	1.10	V
Detection voltage hysteresis ratio	ΔV_{DET}		—	5	—	%
Operating current	I_{DDO}	V_{I1} = 1.5V, I_O = 1.0mA	—	8	40	µA
Standby current	I_{DDS}	V_{I1} = 1.5V	—	3	10	µA
Switching transistor ON resistance	R_{SWON}	V_{I1} = 1.5V, V_O = 3.0V, V_{SW} = 0.2V	—	6	12	Ω
Switching transistor leakage current	I_{SWQ}	V_{I1} = 1.5V, V_O = 1.5V, V_{SW} = 7.0V	—	—	0.5	µA
Backup switch ON resistance	R_{BSON}	V_{I1} = 1.0V, V_{I2} = 2.0V, I_O = 1.0mA	—	70	160	Ω
Backup switching leakage current	I_{BSQ}	V_{I1} = 1.0V, V_O = 3.0V, V_{I2} = 2.0V	—	—	0.1	µA
$\overline{RST}$ LOW-level output current	I_{OL}	V_{I1} = 0.9V, V_{DS} = 0.2V	0.05	0.15	—	mA
$\overline{PS}$ pull-up current	I_{IH}	V_{I1} = 1.5V	—	—	0.5	µA
Multiplication clock frequency	f_{CLK}	V_{I1} = 1.5V	30	40	50	kHz

SCI7631MKA

V_{SS} = 0V, Ta = 25 ˚C unless otherwise noted

Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_{I1}	$V_O > V_{I2}$	0.9	—	2.0	V
	V_{I2}		0.9	—	2.0	V
Output voltage	V_O	V_{I1} = 1.5V	3.40	3.50	3.60	V
Detection voltage	V_{DET}		1.00	1.05	1.10	V
Detection voltage hysteresis ratio	ΔV_{DET}		—	5	—	%
Operating current	I_{DDO}	V_{I1} = 1.5V, I_O = 1.0mA	—	8	40	µA
Standby current	I_{DDS}	V_{I1} = 1.5V	—	3	10	µA
Switching transistor ON resistance	R_{SWON}	V_{I1} = 1.5V, V_O = 3.5V, V_{SW} = 0.2V	—	6	12	Ω
Switching transistor leakage current	I_{SWQ}	V_{I1} = 1.5V, V_O = 1.5V, V_{SW} = 7.0V	—	—	0.5	µA
Backup switch ON resistance	R_{BSON}	V_{I1} = 1.0V, V_{I2} = 2.0V, I_O = 1.0mA	—	70	160	Ω
Backup switching leakage current	I_{BSQ}	V_{I1} = 1.0V, V_O = 3.5V, V_{I2} = 2.0V	—	—	0.1	µA
$\overline{RST}$ LOW-level output current	I_{OL}	V_{I1} = 0.9V, V_{DS} = 0.2V	0.05	0.15	—	mA
$\overline{PS}$ pull-up current	I_{IH}	V_{I1} = 1.5V	—	—	0.5	µA
Multiplication clock frequency	f_{CLK}	V_{I1} = 1.5V	30	40	50	kHz

SCI7631MAA

V_{SS} = 0V, Ta = 25 ˚C unless otherwise noted

Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_{I1}	$V_O > V_{I2}$	0.9	—	2.0	V
	V_{I2}		0.9	—	2.0	V
Output voltage	V_O	V_{I1} = 1.5V	4.80	5.00	5.20	V
Detection voltage	V_{DET}		1.00	1.05	1.10	V
Detection voltage hysteresis ratio	ΔV_{DET}		—	5	—	%
Operating current	I_{DDO}	V_{I1} = 1.5V, I_O = 1.0mA	—	10	50	µA
Standby current	I_{DDS}	V_{I1} = 1.5V	—	3	10	µA
Switching transistor ON resistance	R_{SWON}	V_{I1} = 1.5V, V_O = 5.0V, V_{SW} = 0.2V	—	5	10	Ω
Switching transistor leakage current	I_{SWQ}	V_{I1} = 1.5V, V_O = 1.5V, V_{SW} = 7.0V	—	—	0.5	µA
Backup switch ON resistance	R_{BSON}	V_{I1} = 1.0V, V_{I2} = 3.0V, I_O = 1.0mA	—	50	100	Ω
Backup switching leakage current	I_{BSQ}	V_{I1} = 1.0V, V_O = 5.0V, V_{I2} = 3.0V	—	—	0.1	µA
$\overline{RST}$ LOW-level output current	I_{OL}	V_{I1} = 0.9V, V_{DS} = 0.2V	0.05	0.15	—	mA
$\overline{PS}$ pull-up current	I_{IH}	V_{I1} = 1.5V	—	—	0.5	µA
Multiplication clock frequency	f_{CLK}	V_{I1} = 1.5V	35	45	55	kHz

SCI7638MHA

V_{SS} = 0V, Ta = 25 ˚C unless otherwise noted

Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_{I1}		0.9	—	2.0	V
Output voltage	V_O	V_{I1} = 1.5V	2.10	2.20	2.30	V
Output voltage temperature gradient	Kt		–5.5	–4.5	–3.5	mV/˚C
Detection voltage	V_{DET}		1.00	1.05	1.10	V
Detection voltage hysteresis ratio	ΔV_{DET}		—	5	—	%
Operating current	I_{DDO}	V_{I1} = 1.5V, I_O = 1.0mA	—	7	35	µA
Standby current	I_{DDS}	V_{I1} = 1.5V	—	3	10	µA
Switching transistor ON resistance	R_{SWON}	V_{I1} = 1.5V, V_O = 2.2V, V_{SW} = 0.2V	—	7	14	Ω
Switching transistor leakage current	I_{SWQ}	V_{I1} = 1.5V, V_O = 1.5V, V_{SW} = 7.0V	—	—	0.5	µA
$\overline{RST}$ LOW-level output current	I_{OL}	V_{I1} = 0.9V, V_{OL} = 0.2V	0.05	0.15	—	mA
$\overline{PS}$ pull-up current	I_{IH}	V_{I1} = 1.5V	—	—	0.5	µA
Multiplication clock frequency	f_{CLK}	V_{I1} = 1.5V	25	35	45	kHz

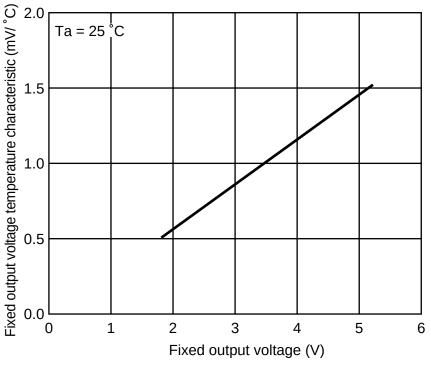
SCI7638MLA

V_{SS} = 0V, Ta = 25 ˚C unless otherwise noted

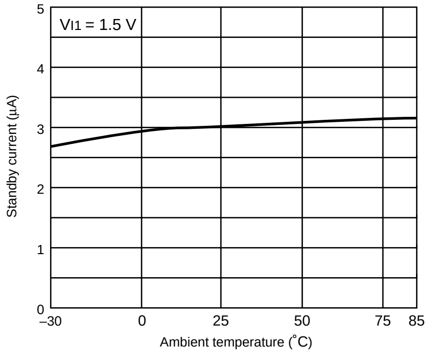
Parameter	Symbol	Condition	Rating			Unit
			Mmin.	Typ.	Max.	
Input voltage	V_{I1}		0.9	—	2.0	V
Output voltage	V_O	V_{I1} = 1.5V	2.30	2.40	2.50	V
Output voltage temperature gradient	Kt		–5.5	–4.0	–3.5	mV/˚C
Detection voltage	V_{DET}		1.00	1.05	1.10	V
Detection voltage hysteresis ratio	ΔV_{DET}		—	5	—	%
Operating current	I_{DDO}	V_{I1} = 1.5V, I_O = 1.0mA	—	7	35	µA
Standby current	I_{DDS}	V_{I1} = 1.5V	—	3	10	µA
Switching transistor ON resistance	R_{SWON}	V_{I1} = 1.5V, V_O = 2.4V, V_{SW} = 0.2V	—	7	14	Ω
Switching transistor leakage current	I_{SWQ}	V_{I1} = 1.5V, V_O = 1.5V, V_{SW} = 7.0V	—	—	0.5	µA
$\overline{RST}$ LOW-level output current	I_{OL}	V_{I1} = 0.9V, V_{OL} = 0.2V	0.05	0.15	—	mA
$\overline{PS}$ pull-up current	I_{IH}	V_{I1} = 1.5V	—	—	0.5	µA
Multiplication clock frequency	f_{CLK}	V_{I1} = 1.5V	25	35	45	kHz

Typical Performance Characteristics

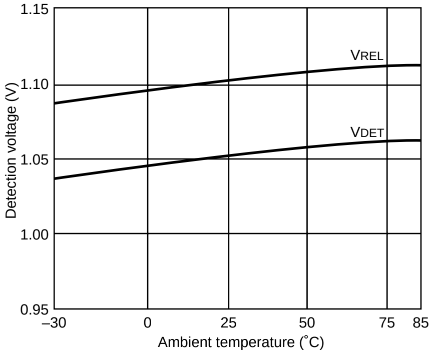
Fixed-output voltage temperature characteristic



Standby current vs. ambient temperature

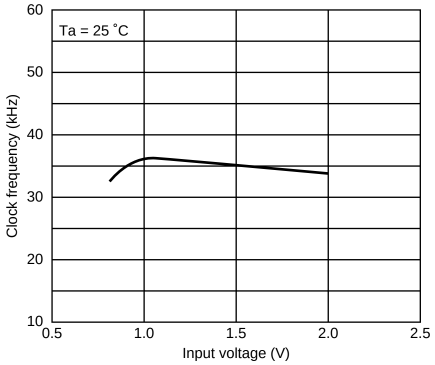


Detection voltage vs. ambient temperature

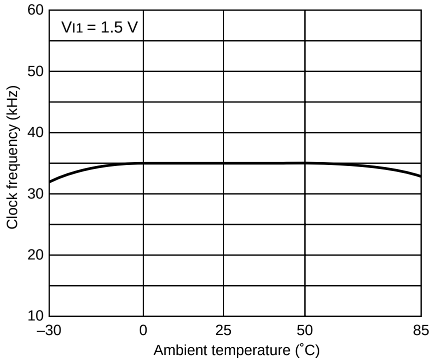


SCI7638MHA and SCI7638MLA

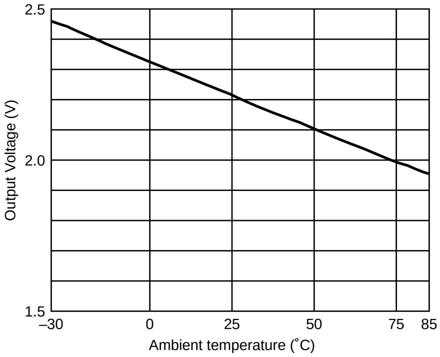
Clock frequency VS. Input voltage



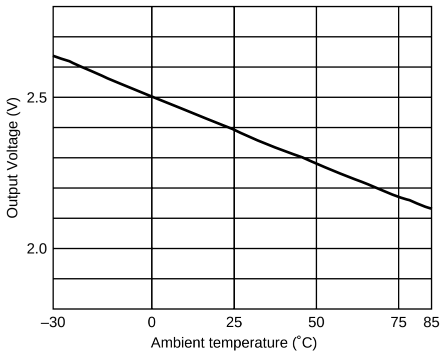
Clock frequency vs. ambient temperature



Output voltage vs. ambient temperature (SCI7638MHA)

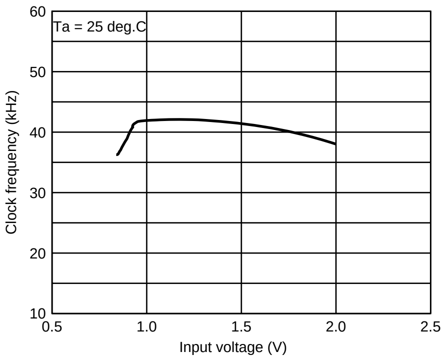


Output voltage vs. ambient temperature (SCI7638MLA)

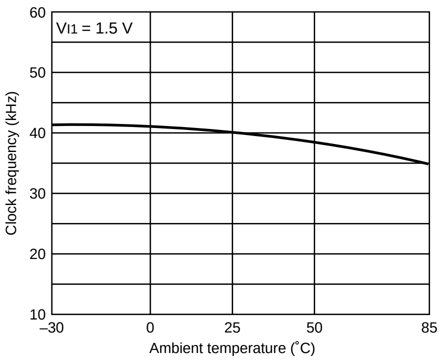


SCI7631MBA, SCI7631MKA

Clock frequency vs. input voltage

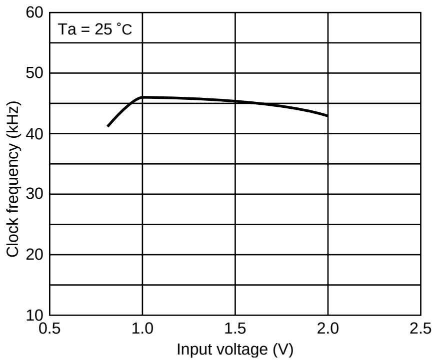


Clock frequency vs. ambient temperature

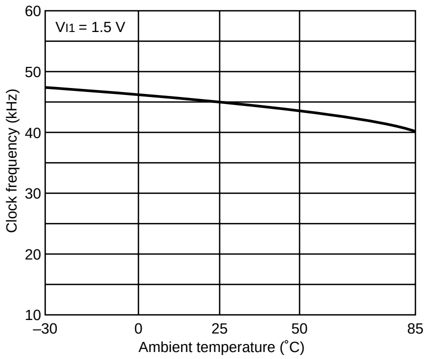


SCI7631MAA

Clock frequency vs. input voltage

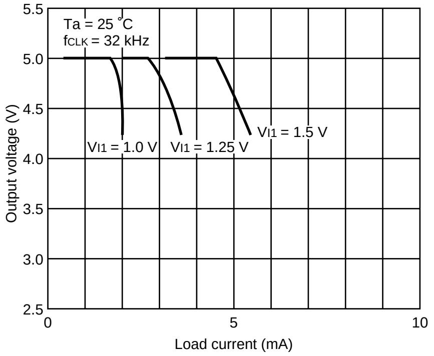


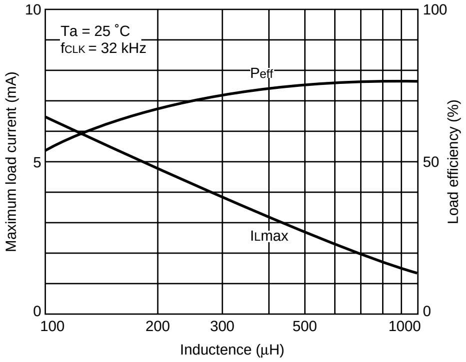
Clock frequency vs. ambient temperature



Load Characteristics

SCI7631MAA

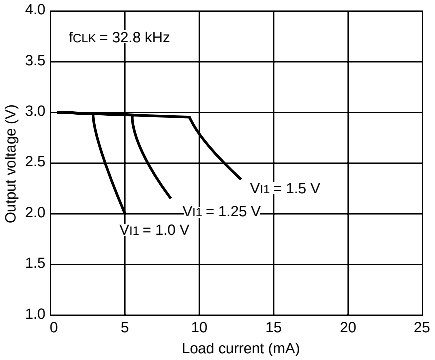


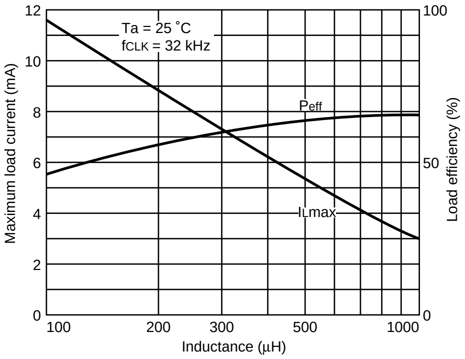


Notes
Inductor: TDK NLF453232-221k (220µH)
Diode: Shindengen DINS4 Schottky barrier diode
Capacitor: NEC MSUB20J106M (10µF)

Notes
1. V_{I1} = 1.5V
2. Inductor: TDK NLF453232 series
   Diode: Shindengen DINS4 Schottky barrier diode
   Capacitor: NEC MSUB20J106M (10µF)

SCI7631MBA





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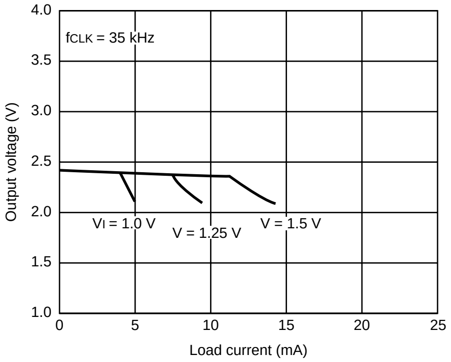
SCI7638MLA



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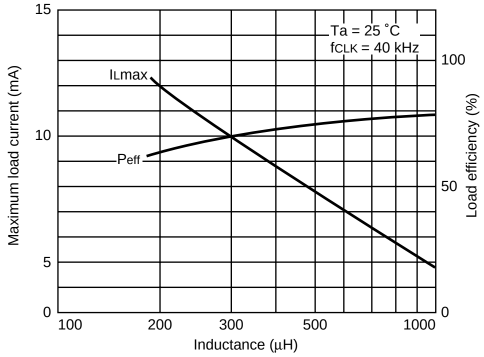

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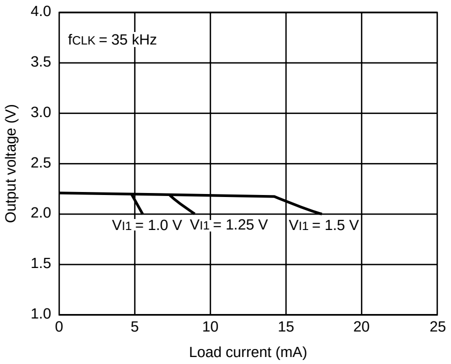
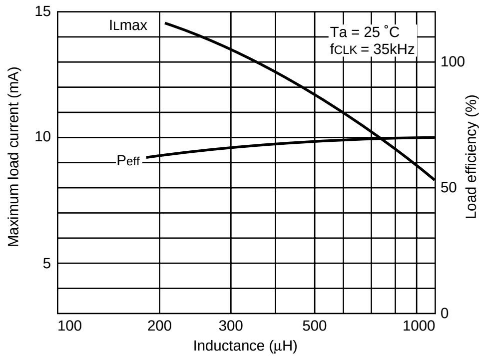
SCI7638MHA



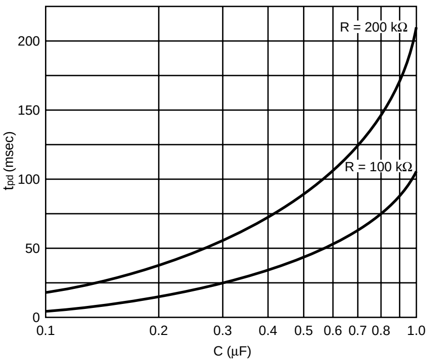
Notes
Inductor: TDK NLF453232-221k (220µH)
Diode: Shindengen DINS4 Schottky barrier diode
Capacitor: NEC MSUB20J106M (10µF)



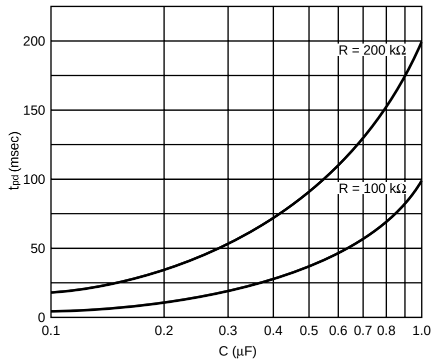
Notes
1. V_{I1} = 1.5V
2. Inductor: TDK NLF453232 series
   Diode: Shindengen DINS4 Schottky barrier diode
   Capacitor: NEC MSUB20J106M (10µF)

Reset delays

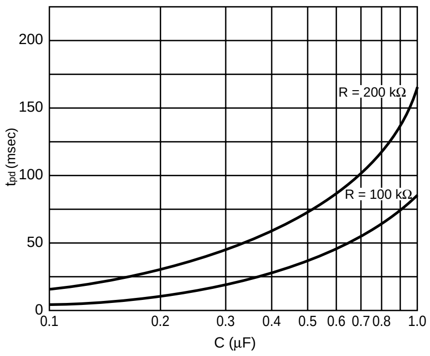
SCI7631MAA



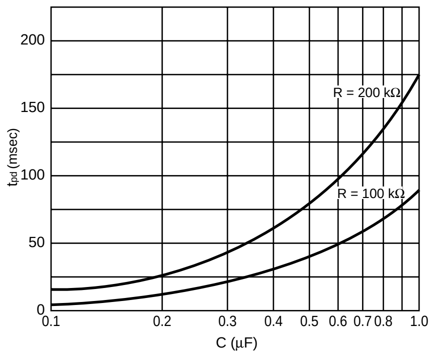
SCI7631MKA



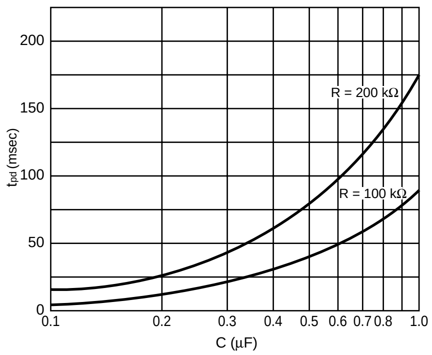
SCI7631MBA



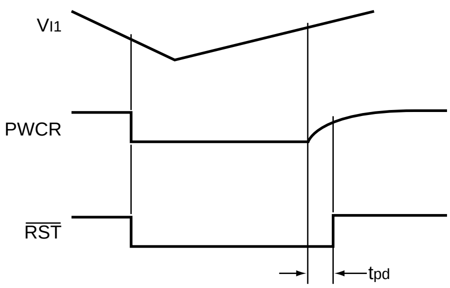
SCI7631MLA and SCI7638MLA



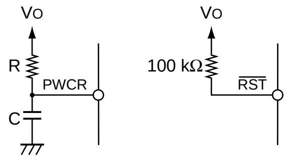
SCI7638MHA



Timing diagram

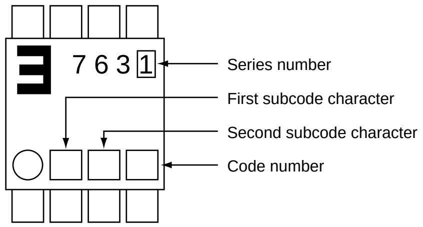


Measurement circuit



PACKAGE MARKINGS

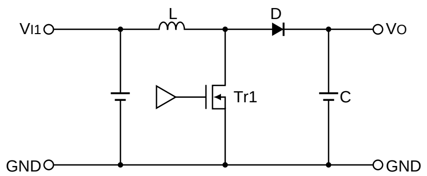
SCI7631, SCI7638 series device packages use the following markings.



FUNCTIONAL DESCRIPTION

Basic Voltage Booster Operation

TR1 switches ON and OFF at half the frequency of the clock pulses from the built-in RC oscillator. When the transistor is ON, the circuit stores energy in L. When it is off, this energy flows through D to change C.

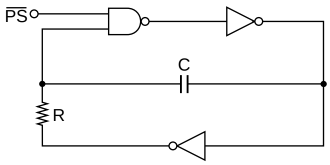


Internal Circuits

RC oscillator

The SCI7631, SCI7638 series use a built-in RC oscillator to drive the voltage booster circuit. The circuit is supplied by V_{I1}. All circuit components are on-chip and thus the drive frequency is set internally. To ensure 50% duty, this frequency is twice that used by the voltage booster circuit.

When $\overline{PS}$ is LOW, the oscillator is disabled and the chip is in standby mode.

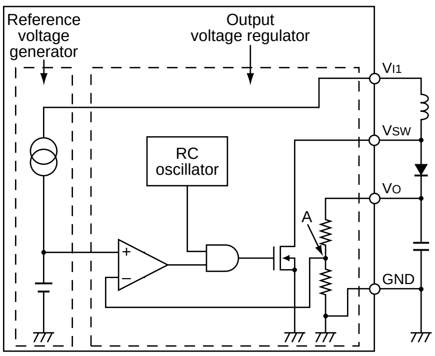


Switching Regulator

Reference voltage generator and output voltage regulator

The reference voltage generator regulates V_{I1} to generate a votlage for the voltage regulator and voltage detection circuits.

The voltage regulator regulates the boosted output votlage. This is determined by the level at point A between the two resistors connecting V_O and GND. These series use an on-chip resistor to set the output at a specified voltage.



Note

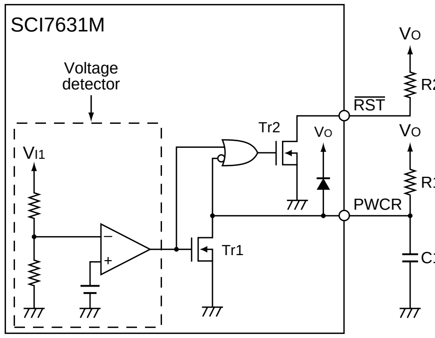
In step-up voltage operation, the ripple voltage created by the switching operation is large relative to the output voltage described above. This ripple voltage is affected by external components and load conditions. The user is advised to check this voltage carefully.

Voltage detection

The SCI7631, SCI7632, SCI7638, and SCI7639 series are equipped with a built-in voltage detection function. The detection voltage, V_{DET}, is fixed internally at 1.05 ± 0.05V.

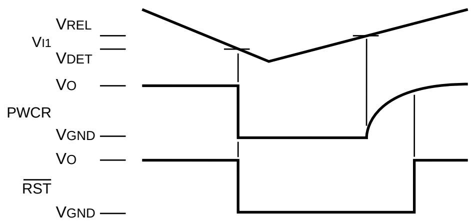
Power-on clear function

The SCI7631 series and SCI7638 series are equipped with a built-in power-on clear function. As shown in the following figure, R1 and C1 are connected to PWCR, and R2 is connected to $\overline{RST}$ to operate the function. If V_{I1} drops below V_{DET}, TR1 and TR2 conduct and PWCR and $\overline{RST}$ are grounded. If V_{I1} recovers and rises higher than V_{REL}, TR1 turns OFF. The detection voltage hysteresis is 5% (Typ.) and V_{REL} is $V_{DET} \times 1.05$ (Typ.).



V_O returns to its normal value when the voltage of PWCR increases and TR2 turns OFF, so that $\overline{RST}$ returns to V_O after a delay specified by the time coefficient of R1 and C1. Thus, after normal output has been obtained, a reset pulse of adjustable width can be obtained which can reset a system connected to $\overline{RST}$.

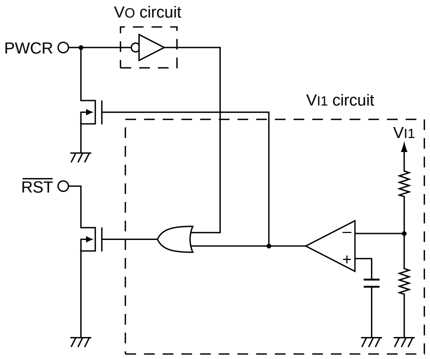
The output from $\overline{RST}$ is an N-channel, open-drain. When V_{I1} exceeds V_{DET}, the drain is opened and, when V_{I1} drops below V_{DET} again, the output transistor conducts and the output is grounded. The characteristic response is shown in the following figure.



Disabling power-on clear

Always connect PWCR to either V_O or GND. If voltage detection only is required, remove the resistor between PWCR and V_O and monitor the level at $\overline{RST}$. If neither function is required, connect PWCR to GND.

Leaving PWCR unconnected results in an undefined inverter gate voltage in the V_O circuit, causing transient currents to flow between V_O and GND.



Output voltage response compensation

The SCI7638 series are provided with a response compensation input. A response compensation capacitor is connected between V_{CONT} and V_O, allowing the ripple voltage generated by the boosted output voltage to be suppressed to a minimum.

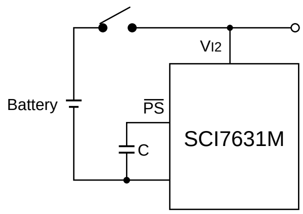
Standby mode and battery backup

The SCI7631 series are equipped with a standby mode, initiated by connecting $\overline{PS}$ to GND.

In standby mode, the booster, including the crystal oscillator, is disabled (the switching transistor used to drive the inductor is turned OFF) and the built-in backup switch is turned ON, so that the input voltage at V_{I2} is output at V_O. This enables the battery backup function. $\overline{PS}$ is pulled-up internally, so when standby mode is not required, the pin should be left open.

Powering up

Ensure that V_0 is at least the minimum operating voltage (0.9V) before switching on the booster circuit.
One way to do this is to attach a battery so that V_0 never drops below the minimum required for backup mode. If no such external power supply is available, connect V_{I2} to V_{I1} and hold $\overline{PS}$ LOW when applying power for the first time.

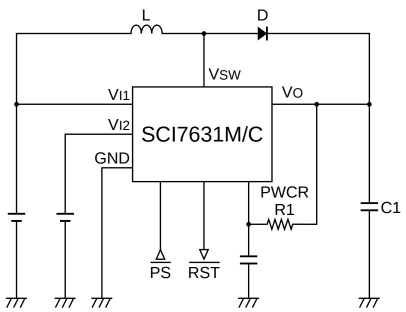


TYPICAL APPLICATIONS

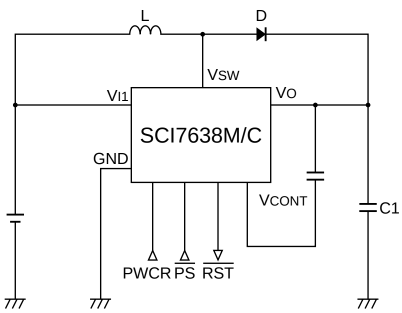
Example Circuits

The output current, I_O, and power conversion efficiency, Peff of a particular device in a series depends on factors such as the switching frequency, type of coil, and the size and type of other external components.

SCI7631 series



SCI7638 series



Notes

- ■ 100μH ≤ L ≤ 1mH, C ≤ 10μF, D = Schottky diode
- ■ SCI7631MAA
  - Peff = 70% when L = 220μH (leadless inductor), V_{I1} = 1.5V, f_{CLK} = 32kHz, I_O = 4mA
  - Peff = 75% when L = 220μH (drum coil), V_{I1} = 1.5V, f_{CLK} = 32kHz, I_O = 6mA
  - Peff = 80% when L = 300μH (toroidal coil), V_{I1} = 1.5V, f_{CLK} = 32kHz, I_O = 7mA
- ■ SCI7631MBA
  - Peff = 70% when L = 220μH (leadless inductor), V_{I1} = 1.5V, f_{CLK} = 32kHz, I_O = 8mA
  - Peff = 75% when L = 220μH (drum coil), V_{I1} =1.5V, f_{CLK} = 32kHz, I_O = 9mA
  - Peff = 80% when L = 300μH (toroidal coil), V_{I1} = 1.5V, f_{CLK} = 32kHz, I_O = 10mA

External components

The performance characteristics of switching regulators depend greatly on the choice of external components. Observing the following guidelines will ensure high performance and maximum efficiency.

Inductor

Use an inductor with low direct-current resistance and low losses.

Leadless

Pre-wound, leadless inductors using surface-mount technology are the most suitable for portable equipment and other space-critical applications.

Drum coil

Avoid using drum coils because their magnetic field can induce noise.

Toroidal coil

Use a toroidal coil to virtually eliminate magnetic field leakage, reduce losses and improve performance.

Diode

Use a Schottky barrier diode with a high switching speed and low forward voltage drop, V_F.

Capacitor

To minimize ripple voltages, use a capacitor with a small equivalent direct-current resistance for smoothing.

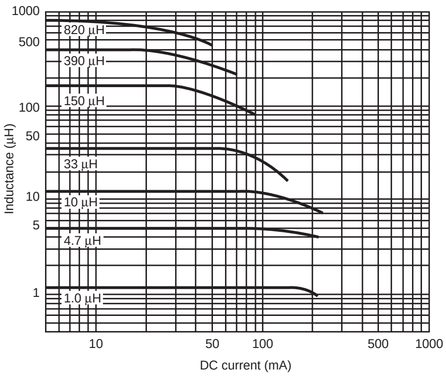
Sample External Components

Leadless Inductors

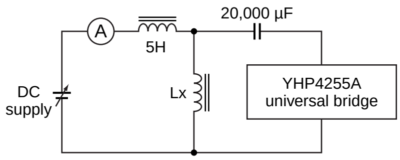
TDK NKF453232 series magnetically shielded leadless inductors

Device	Inductance (µH)	Qmin	LQ frequency (MHz)	Device frequency (MHz-Min.)	DC resistance (Ω-Max.)	Rated current (mA-Max.)
NLF453232-390K	39.0 ±10%	50	2.52	13	1.89	44
NLF453232-470K	47.0 ±10%	50	2.52	12	2.10	41
NLF453232-560K	56.0 ±10%	50	2.52	11	2.34	39
NLF453232-680K	68.0 ±10%	50	2.52	10	2.60	36
NLF453232-820K	82.0 ±10%	50	2.52	10	2.86	34
NLF453232-101K	100.0 ±10%	50	0.796	9	3.25	32
NLF453232-121K	120.0 ±10%	50	0.796	8	3.64	30
NLF453232-151K	150.0 ±10%	50	0.796	7	4.16	28
NLF453232-181K	180.0 ±10%	40	0.796	6	5.72	26
NLF453232-221K	220.0 ±10%	40	0.796	5.5	6.30	24
NLF453232-271K	270.0 ±10%	40	0.796	5	6.90	23
NLF453232-331K	330.0 ±10%	40	0.796	4.5	7.54	23
NLF453232-391K	390.0 ±10%	40	0.796	4	8.20	21
NLF453232-471K	470.0 ±10%	40	0.796	3.8	9.20	19
NLF453232-561K	560.0 ±10%	40	0.796	3.6	10.50	18
NLF453232-681K	680.0 ±10%	40	0.796	3.4	12.00	17
NLF453232-821K	820.0 ±10%	40	0.796	3	13.50	16
NLF453232-102K	1000.0 ±10%	40	0.252	2.5	16.00	15

Characteristic response



Measurement circuit



Switching Regulator

Drum coil inductors

Taiyo Yuuden FL series micro-inductors

Device	Inductance	Direct current (mA)
FL3H	0.22μH to 10μH	280 to 670
FL4H	0.47μH to 12μH	300 to 680
FL5H	10μH to 1mH	50 to 320
FL7H	680μH to 8.2mH	50 to 170
FL9H	330μH to 33mH	50 to 500
FL11H	10mH to 150mH	35 to 110

Toroidal coil inductors

Tohoku Metal Industries HP series toroidal coil inductors

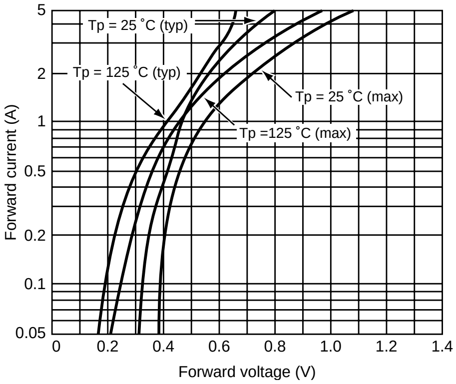
Device	Rated current IDC (A)	Inductance (μH) at 20kHz, 5V		Diameter × height (mm-Max.)	Wire gauge (mm)
		IDC = 0	IDC = rating		
HP011	1	200	160	ϕ 20 × 12	0.5
HP021	2	65	55		0.7
HP031	3	30	23		0.8
HP012	1	600	450	ϕ 22 × 13	0.5
HP022	2	180	135		0.7
HP032	3	120	80		0.8
HP052	5	45	30		1.0
HP013	1	1000	800	ϕ 26 × 14	0.5
HP023	2	500	330		0.7
HP033	3	130	100		0.8
HP055	5	90	55		1.0
HP034S	3	400	250	ϕ 36 × 18	0.8
HP054S	5	350	160		1.0
HP104S	10	50	30		1.6
HP024	2	1500	950	ϕ 36 × 21	0.7
HP034	3	300	230		0.8
HP054	3	210	140		1.0
HP104	10	45	30		1.6
HP035	3	700	500	ϕ 43 × 23	0.5
HP055	5	600	330		1.0
HP105	10	180	95		1.6
HP205	20	20	14		1.8 × 2 P

Diodes

Shindengen DINS4 Schottky barrier diodes

Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
Forward voltage	V_F	I_F = 1.1A, pulse measurement	—	—	0.55	V
Reverse current	I_R	$V_R = V_{RM}$, pulse measurement	—	—	1	mA
Junction-to-lead thermal resistance	θ_{jl}		—	—	23	˚C/W
Junction-to-ambient thermal resistance	θ_{ja}		—	—	157	˚C/W

Characteristics



Smoothing capacitors

NEC MSV series capacitors

Device	Package type	Rated voltage (V)	Static capacitance (μF)	Tan δ			Leakage current (μA)
				+25, +85 ˚C	+125 ˚C	–55 ˚C	
MSVAOJ475M	A	6.3	4.7	0.08	0.1	0.12	0.5
MSVB2OJ106M	B2	6.3	10	0.08	0.1	0.12	0.6
MSVB2OJ156M	B2	6.3	15	0.08	0.1	0.12	0.9
MSVBOJ156M	B	6.3	15	0.08	0.1	0.12	0.9
MSVCOJ336M	C	6.3	33	0.08	0.1	0.12	2.0
MSVD2OJ686M	D2	6.3	68	0.08	0.1	0.12	4.2
MSVDOJ686M	D	6.3	68	0.08	0.1	0.12	4.2

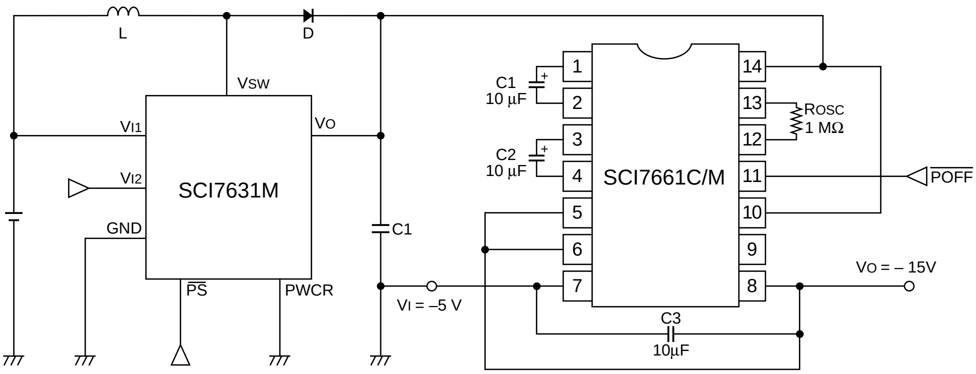
Note

The figures on the previous pages show data from the documents of various manufactures. For further details, please contact the relevant manufacture.

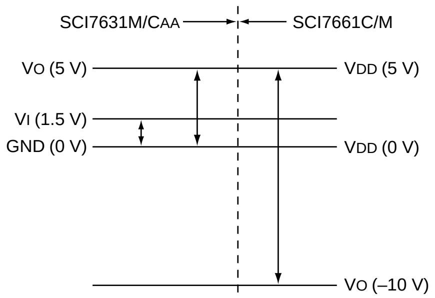
Other Applications

Voltage booster

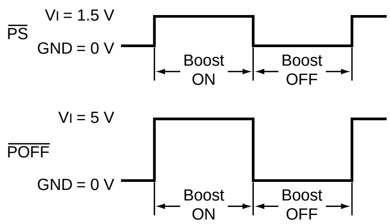
Combining an SCI7631 switching regulator with an SCI7661C/M DC/DC converter and voltage regulator creates the voltage booster circuit shown in the following figure.



Potential levels are shown in the following figure.

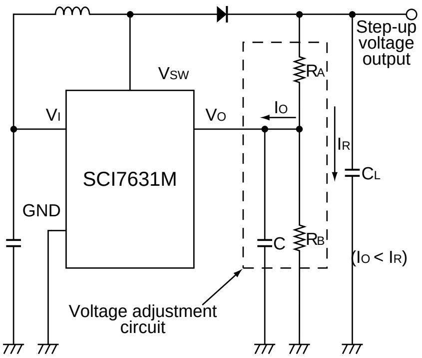


Although the circuit appears to have two ON/OFF control points, $\overline{\text{PS}}$ on the SCI7631CAA/MAA and $\overline{\text{POFF}}$ on the SCI7661C/M, PS only shuts down the SCI7631MAA. The input voltage still reaches the SCI7661C/M through L and D.



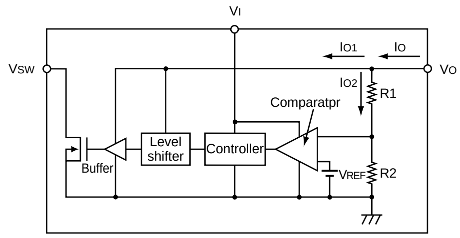
Output voltage adjustment

To ensure stable output, any circuit that adjusts the output voltage must contain C1, R_A and R_B. To stop switching current from affecting V_O, the circuit must also satisfy the condition $I_O < I_R$.



The following figure summarizes the relevant circuits inside an SCI7630 series chip.

V_O is connected to the level shift and buffer circuit, which provide the gate bias for the switching transistor driving the inductor. The current drain, I_{O1}, varies with the load and is typically 10µA. The current, I_{O2}, through the internal resistors R1 and R2, is typically 1µA.



SCI7633 Series CMOS Switching Regulators

DESCRIPTION

The SCI7633 series of CMOS switching regulators provide input voltage step-up and regulation to a specified voltage using an external coil. The devices in these series incorporate precision, low-power reference voltage generators and transistors for driving an internal comparator. They feature low power consumption, low operating voltages and standby operation.

The devices offer a range of fixed output voltages, from 2.35 to 5.00V.

They are available in 8-pin SOP3s.

FEATURES

- 0.9V (Min.) operating voltage
- 8µA (Typ.) maximum current consumption
- Standby operation
- 3µA (Typ.) standby current consumption
- Built-in oscillator circuit for use with external crystal oscillator
- 8-pin SOP3

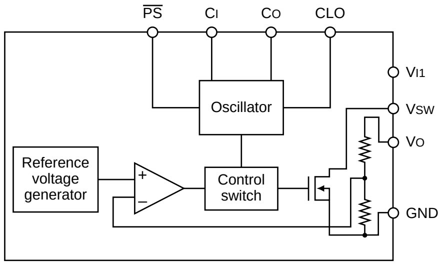
APPLICATIONS

- Fixed-voltage power supplies for battery-operated equipment such as portable video cassette recorders, video cameras and radios
- Power supplies for pages, memory cards, calculators and similar hand-held equipment
- Fixed-voltage power supplies for medical equipment
- Fixed-voltage power for communications equipment
- Power supplies for microcomputers
- Uninterruptable power supplies

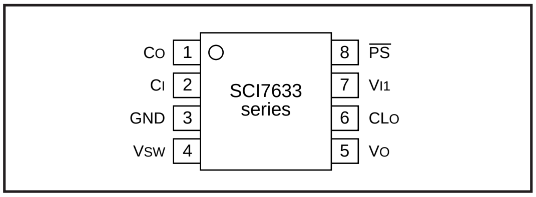
LINE-UP

Device	Voltage (V)		Multiplication frequency source	Voltage detection	Power-on clear	Battery backup	Response compensation	Output voltage temperature characteristic	Package
	Input	Output							
SCI7633MBA	1.5 (0.9 min.)	3.00	Crystal oscillator	No	No	No	No	No	SOP3-8pin

BLOCK DIAGRAMS
SCI7633 series



PIN CONFIGURATIONS
SCI7633 series



PIN DESCRIPTIONS
SCI7633 series

Number	Name	Description
1	CO	Crystal drain
2	CI	Crystal gate
3	GND	Ground
4	VSW	External inductor drive
5	VO	Output voltage
6	CLO	Oscillator output
7	VI	Step-up input voltage
8	$\overline{PS}$	Power save. See note.

Note
See standby mode in the functional description.

SPECIFICATIONS
Absolute Maximum Ratings
SCI7633 series

Parameter	Symbol	Rating	Unit
Input voltage	V_{I1}	7	V
Output current	I_O	100	mA
Output voltage	V_O	7	V
Power dissipation	P_D	200 (SOP) 300 (DIP)	mW
Operating temperature range	Topr	–30 to 85	˚C
Storage temperature range	Tstg	–65 to 150	˚C
Solding temperature (for 10 s. See note.)	Tsol	260	˚C

Note
Temperatures during reflow soldering must remain within the limits set out in LSI Device Precautions. Never use solder dip to mount SCI7000 series power supply devices.

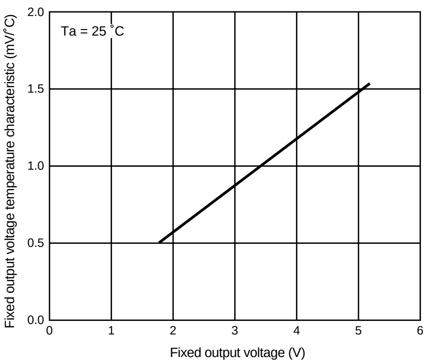
Electrical Characteristics

SCI7633MBA
V_{SS} = 0V, Ta = 25 ˚C unless otherwise noted

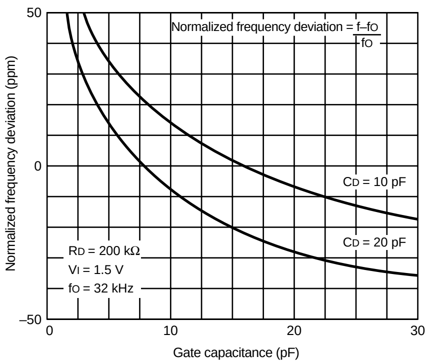
Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_{I1}	$V_O > V_{I2}$	0.9	—	2.0	V
Output voltage	V_O	V_{I1} = 1.5V	2.90	3.00	3.10	V
Operating current	I_{DDO}	V_{I1} = 1.5V, f_{CLK} = 32kHz, I_O = 1.0mA	—	5	30	µA
Standby current	I_{DDS}	V_{I1} = 1.5V	—	3	10	µA
Switching transistor ON resistance	R_{SWON}	V_{I1} = 1.5V, V_O = 3.0V, V_{SW} = 0.2V	—	6	12	Ω
Switching transistor leakage current	I_{SWQ}	V_{I1} = 1.5V, V_O = 1.5V, V_{SW} = 7.0V	—	—	0.5	µA
CLO LOW-level output current	I_{OL}	V_{I1} = 1.5V, V_O = 3.0V, V_{OL} = 0.2V	0.5	1.0	—	µA
CLO HIGH-level output current	I_{OH}	V_{I1} = 1.5V, V_O = 3.0V, V_{OH} = 0.2V	0.55	1.1	—	µA
$\overline{PS}$ pull-up current	I_{IH}	V_{IH} = 1.5V	—	—	0.5	µA
Oscillator start-up voltage	V_{STA}	C_G = 10pF, C_D = 10pF, R_D = 300kΩ, f_{OSC} = 32kHz	0.9	—	—	V
Oscillator shut-down voltage	V_{STP}		—	—	0.9	V

Typical Performance Characteristics

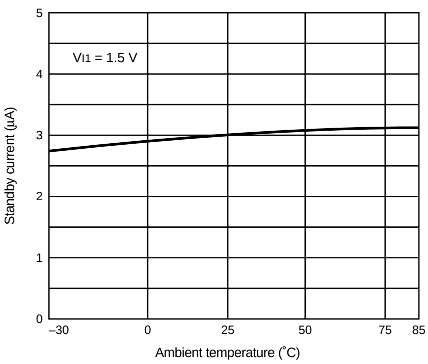
Fixed output voltage temperature characteristic



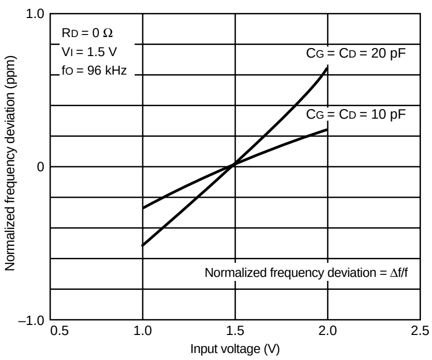
Normalized frequency deviation vs. gate capacitance 1



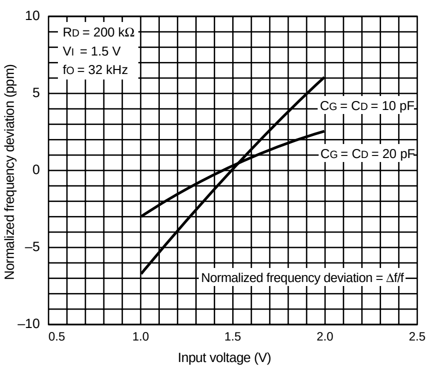
Standby current vs. ambient temperature



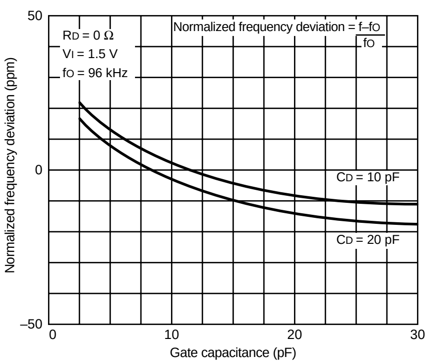
Normalized frequency deviation vs. input voltage 2



Normalized frequency deviation vs. input voltage 1

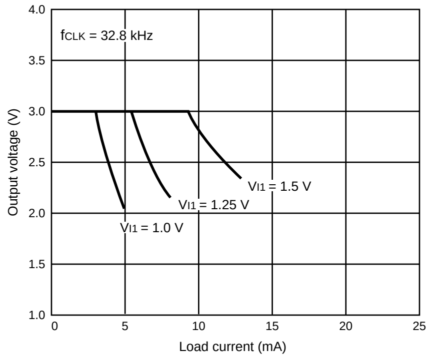


Normalized frequency deviation vs. gate capacitance 2



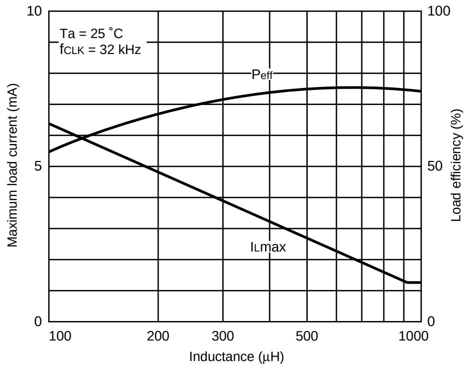
Load characteristics

SCI7633MBA



Notes

Inductor: TDK NLF453232-221k (220μH)
Diode: Shindengen DINS4 Schottky barrier diode
Capacitor: NEC MSUB20J106M (10μF)

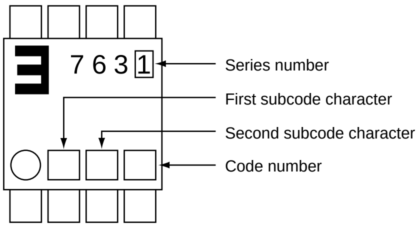


Notes

1. V_{I1} = 1.5V
2. Inductor: TDK NLF453232 series
   Diode: Shindengen DINS4 Schottky barrier diode
   Capacitor: NEC MSUB20J106M (10μF)

PACKAGE MARKINGS

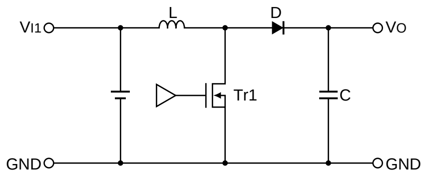
SCI7633 device packages use the following marking.



FUNCTIONAL DESCRIPTION

Basic Voltage Booster Operation

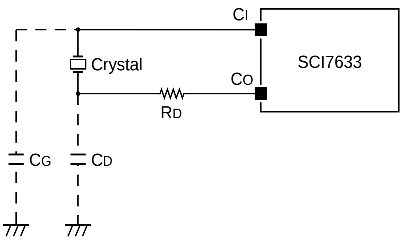
TR1 switches ON and OFF at the frequency of the clock pulses from the crystal oscillator. When the transistor is ON, the circuit stores energy in L. When it is OFF, this energy flows through D to charge C.



Internal Circuits

Crystal oscillator

The SCI7633 series incorporate a crystal oscillator circuit. An external crystal and drain resistor are used to generate the booster circuit clock. The crystal oscillator is connected to C_I and C_O as shown in the following figure.

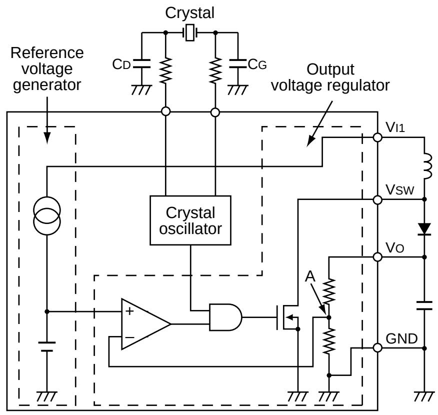


In the SCI7633 series, the crystal oscillator output is sent to CL_O as the V_O system signal. The crystal oscillator circuit is activated by V_I but, because the output level is shifted and the output is connected to CL_O, the oscillator output cannot be obtained without a voltage at V_O. Since the crystal oscillator is activated when an input voltage is applied, oscillation continues even in standby mode.

Reference voltage generator and output voltage regulator

The reference voltage generator regulates V_{I1} to generate a voltage for the voltage regulator circuit.

The output voltage regulator regulates the boosted output voltage. This voltage is determined by the level at point A between the two resistors connecting V_O and GND. These series use an on-chip resistor to set the output at a specified voltage.



Note

In step-up voltage operation, the ripple voltage created by the switching operation is large relative to the output voltage described above. This ripple voltage is affected by external components and load conditions. The user is advised to check this voltage carefully.

Standby mode

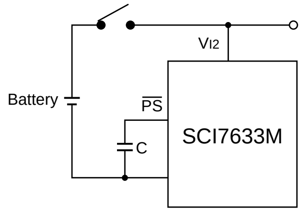
Connecting $\overline{PS}$ to GND places the chip in standby mode. In this mode, the crystal oscillator is disabled, switching off the inductor drive transistor and the voltage booster circuit. Typically, $\overline{PS}$ is connected to $\overline{RST}$. If standby mode is not required, leave $\overline{PS}$ open as it has a pull-up resistor.

Output voltage response compensation

The SCI7634 series incorporates a response compensation input. A response compensation capacitor is connected between V_{CONT} and V_O, allowing the ripple voltage generated by the boosted output voltage to be suppressed to a minimum.

Powering up

Ensure that V_O is at least the minimum operating voltage (0.9V) before switching on the booster circuit. One way to do this is to connect a capacitor between $\overline{PS}$ and GND so that the chip connects V_O to V_I when the power is applied for the first time.

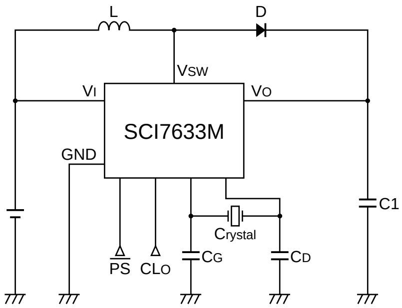


TYPICAL APPLICATIONS

Example Circuits

The output current, I_O, and power conversion efficiency Peff, of a particular device in the series depends on factors such as the switching frequency, type of coil, and the size and type of other external components.

SCI7633 series



Notes

- 100µH ≤ L ≤ 1mH, C ≤ 10µF, D: Schottky diode
- SCI7633MBA
  - Peff = 70% when L = 220µH (leadless inductor), V_{I1} = 1.5V, f_{CLK} = 32kHz, I_O = 8mA
  - Peff = 75% when L = 220µH (drum coil), V_{I1} = 1.5V, f_{CLK} = 32kHz, I_O = 9mA
  - Peff = 80% when L = 300µH (toroidal coil), V_{I1} = 1.5V, f_{CLK} = 32kHz, I_O = 10mA

External Components

The performance characteristics of switching regulators depend greatly on the choice of external components. Observing the following guidelines will ensure high performance and maximum efficiency.

Inductor

Use an inductor with low direct-current resistance and low losses.

Leadless

Pre-wound, leadless inductors using surface-mount technology are the most suitable for portable equipment and other space-critical applications.

Drum coil

Avoid drum coils because their magnetic field can induce noise.

Toroidal coil

Use a toroidal coil to virtually eliminate magnetic field leakage, reduce losses and improve performance.

Diode

Use a Schottky barrier diode with a high switching speed and low forward voltage drop, V_F.

Capacitor

To minimize ripple voltages, use capacitors with a small equivalent direct-current resistance for smoothing.

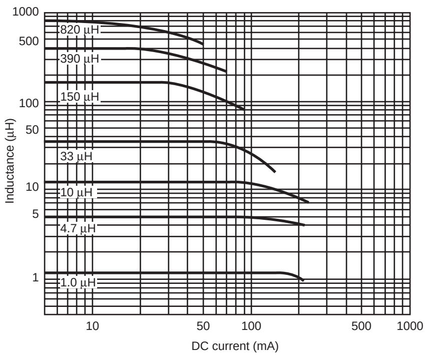
Sample External Components

Leadless inductors

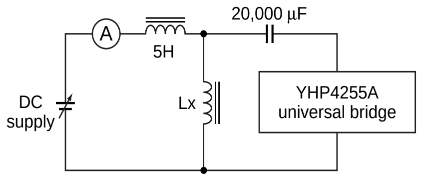
TDK NLF453232 series magnetically-shielded leadless inductors

Device	Inductance (µH)	Qmin	LQ frequency (MHz)	Device freuquency (MHz-Min.)	DC resistance (Ω-Max.)	Rated current (mA-Max.)
NLF453232-390K	39.0 ±10%	50	2.52	13	1.89	44
NLF453232-470K	47.0 ±10%	50	2.52	12	2.10	41
NLF453232-560K	56.0 ±10%	50	2.52	11	2.34	39
NLF453232-680K	68.0 ±10%	50	2.52	10	2.60	36
NLF453232-820K	82.0 ±10%	50	2.52	10	2.86	34
NLF453232-101K	100.0 ±10%	50	0.796	9	3.25	32
NLF453232-121K	120.0 ±10%	50	0.796	8	3.64	30
NLF453232-151K	150.0 ±10%	50	0.796	7	4.16	28
NLF453232-181K	180.0 ±10%	40	0.796	6	5.72	26
NLF453232-221K	220.0 ±10%	40	0.796	5.5	6.30	24
NLF453232-271K	270.0 ±10%	40	0.796	5	6.90	23
NLF453232-331K	330.0 ±10%	40	0.796	4.5	7.54	23
NLF453232-391K	390.0 ±10%	40	0.796	4	8.20	21
NLF453232-471K	470.0 ±10%	40	0.796	3.8	9.20	19
NLF453232-561K	560.0 ±10%	40	0.796	3.6	10.50	18
NLF453232-681K	680.0 ±10%	40	0.796	3.4	12.00	17
NLF453232-821K	820.0 ±10%	40	0.796	3	13.50	16
NLF453232-102K	1000.0 ±10%	40	0.252	2.5	16.00	15

Characteristic response



Measurement circuit



Drum coil inductors

Taiyo Yuuden FL series micro inductors

Device	Inductance	Direct current (mA)
FL3H	0.22µH to 10µH	280 to 670
FL4H	0.47µH to 12µH	300 to 680
FL5H	10µH to 1mH	50 to 320
FL7H	680µH to 8.2mH	50 to 170
FL9H	330µH to 33mH	50 to 500
FL11H	10µH to 150mH	35 to 110

Toroidal coil inductors

Tohoku Metal Industries HP series toroidal coil inductors

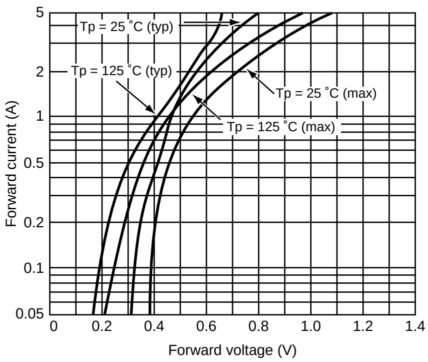
Device	Rated current I_{DC} (A)	Inductance (µH) at 20kHz, 5V		Diameter × height (mm-Max.)	Wire gauge (mm)
		I_{DC} = 0	I_{DC} = rating		
HP011	1	200	160	20 × 12	0.5
HP021	2	65	55		0.7
HP031	3	30	23		0.8
HP012	1	600	450	22 × 13	0.5
HP022	2	180	135		0.7
HP032	3	120	80		0.8
HP052	5	45	30		1.0
HP013	1	1000	800	26 × 14	0.5
HP023	2	500	330		0.7
HP033	3	130	100		0.8
HP055	5	90	55		1.0
HP034S	3	400	250	36 × 14	0.8
HP054S	5	350	160		1.0
HP104S	10	50	30		1.6
HP024	2	1500	950	36 × 21	0.7
HP034	3	300	230		0.8
HP054	5	210	140		1.0
HP104	10	45	30		1.6
HP035	3	700	500	43 × 23	0.8
HP055	5	600	330		1.0
HP105	10	180	95		1.6
HP205	20	20	14		1.8 × 2 P

Diodes

Shindengen DINS4 Schottky barrier diodes

Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Forward voltage	V_F	I_F = 1.1A, pulse measurement	—	—	0.55	V
Reverse current	I_R	$V_R = V_{RM}$, pulse measurement	—	—	1	mA
Junction-to-lead thermal resistance	θ_{jl}		—	—	23	˚C/W
Junction-to-ambient thermal resistance	θ_{ja}		—	—	157	˚C/W

Characteristics



Smoothing capacitors

NEC MSV series capacitors

Device	Package type	Voltage (V)	Static capacitance (µF)	Tan δ			Leakage current (µA)
				+25, +85 ˚C	+125 ˚C	–55 ˚C	
MSVA0J475M	A	6.3	4.7	0.08	0.1	0.12	0.5
MSVB20J106M	B2	6.3	10	0.08	0.1	0.12	0.6
MSVB20J156M	B2	6.3	15	0.08	0.1	0.12	0.9
MSVB0J156M	B	6.3	15	0.08	0.1	0.12	0.9
MSVC0J336M	C	6.3	33	0.08	0.1	0.12	2.0
MSVD20J686M	D2	6.3	68	0.08	0.1	0.12	4.2
MSVD0J686M	D	6.3	68	0.08	0.1	0.12	4.2

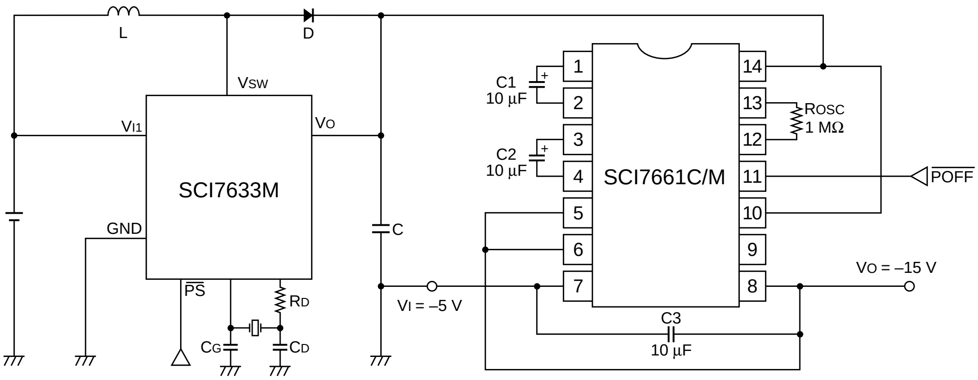
Note

The figures on the previous pages show data from the documents of various manufacturers. For further details, please contact the relevant manufacturer.

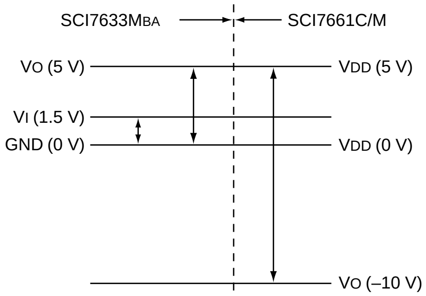
Other Applications

Voltage booster

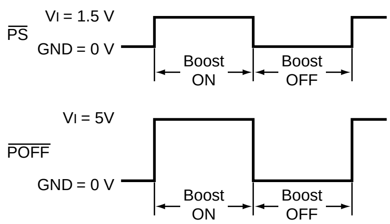
Combining an SCI7633MBA switching regulator with an SCI7661C/M DC/DC converter and voltage regulator creates the voltage booster circuit shown in the following figure.



Potential levels are shown in the following figure.

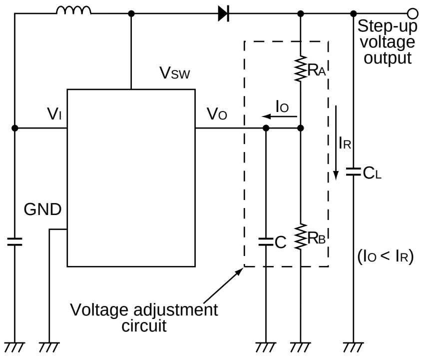


Although the circuit appears to have two ON/OFF control points, $\overline{\text{PS}}$ on the SCI7633MBA and $\overline{\text{POFF}}$ on the SCI7661C/M, $\overline{\text{PS}}$ only shuts down the SCI7633MBA. The input voltage still reaches the SCI7661C/M through L and D.



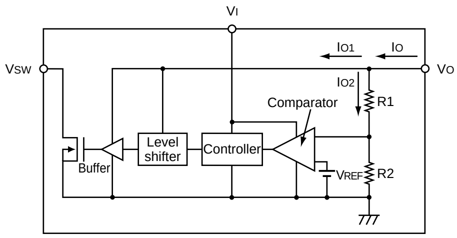
Output voltage adjustment

To ensure stable output, any circuit that adjusts the output voltage must contain C1, R_A and R_B. To stop switching current from affecting V_O, the circuit must also satisfy the condition $I_O < I_R$.



The following figure summarizes the relevant circuits inside an SCI7000 series chip.

V_O is connected to the level shift and buffer circuit, which provide the gate bias for the switching transistor driving the inductor. The current drain I_{O1}, varies with the load and is typically 10µA. The current, I_{O2}, through the internal resistors R1 and R2 is typically 1µA.



SCI7720Y Series

POWER SUPPLY IC

5\. Voltage Detector