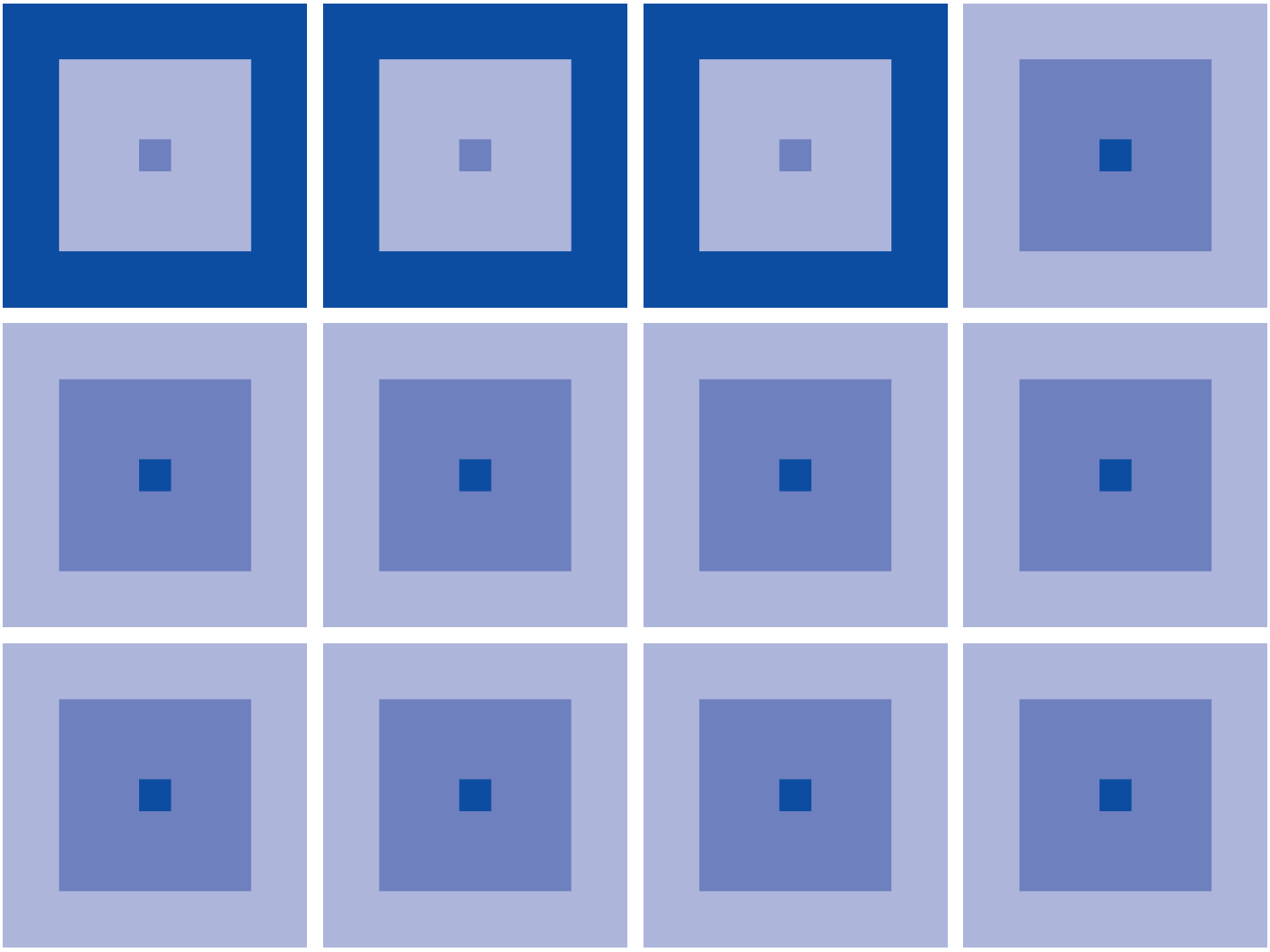
EPSON

POWER SUPPLY IC

S1F70000 Series

Technical Manual



ENERGY SAVING EPSON

SEIKO EPSON CORPORATION

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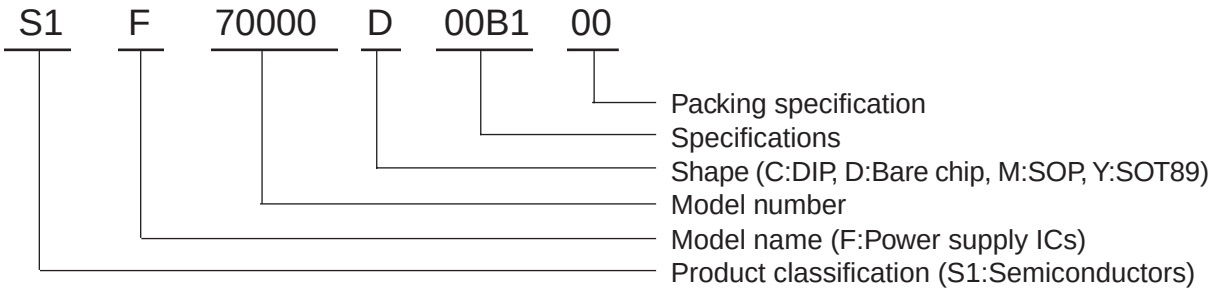
The information of the product number change

Starting April 1, 2001 the product number has been changed as listed below. To order, please use the new product number. For further information, please contact Epson sales representative.

Configuration of product number

●DEVICES (Example : S1F70000D00B100)



Comparison table between new and previous number

Previous number	New number
SCI7660M0B	S1F76600M0B0
SCI7660C0B	S1F76600C0B0
SCI7662M0A	S1F76620M0A0
SCI7662D0A	S1F76620D0A0
SCI7661M0B	S1F76610M0B0
SCI7661MBB	S1F76610M2B0
SCI7661C0B	S1F76610C0B0
SCI7654M0A	S1F76540M0A0
SCI7654C0A	S1F76540C0A0
SCI7664M0A	S1F76640M0A0
SCI7664D0A	S1F76640D0A0
SCI7810Y∗B	S1F78100Y2∗0
SCI7910Y∗A	S1F79100Y1∗0
SCI7631MLA	S1F76310M1L0
SCI7631MBA	S1F76310M1B0
SCI7631MKA	S1F76310M1K0
SCI7631MAA	S1F76310M1A0
SCI7638MHA	S1F76380M1H0
SCI7638MLA	S1F76380M1L0
SCI7633MBA	S1F76330M1B0
SCI7110M0A	S1F71100M0A0
SCI7120M0A	S1F71200M0A0
SCI7120M0B	S1F71200M0B0
SCI7530M0A	S1F75300M0A0

Previous number	New number
SCI7530M0B	S1F75300M0B0
SCI7721Y∗A	S1F77210Y1∗0
SCI7721Y∗B	S1F77210Y2∗0
SCI7720Y∗A	S1F77200Y1∗0
SCI7722YDB	S1F77220Y2D0

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Introduction

This book describes SEIKO EPSON's full lineup of power supply ICs and includes a complete set of product specifications. Also included are sections on quality assurance and packaging.

We suggest that you use the selector guide beginning on the following page to choose the IC or IC series that most closely matches your application. Then you can use the detailed product descriptions in subsequent sections to confirm device specifications and characteristics.

Please contact your local SEIKO EPSON sales representative for further information or assistance on these or other products.

Selection Guide

DC/DC Converter

Product	Features	Package
S1F76600M0B0	• Supply voltage conversion IC. • It effectively converts input voltage V_{DD} into $-V_{DD}$ or $2V_{DD}$ • Output current : Max. 30mA at –5V • Power conversion efficiency: Typ. 95%	SOP4-8pin
S1F76600C0B0		DIP-8pin
S1F76620M0A0	• Supply voltage conversion IC. • It effectively converts input voltage V_{DD} into $-V_{DD}$ or $2V_{DD}$ • Output current : Max. 30mA at 5V • Power conversion efficiency: Typ. 95%	SOP4-8pin

DC/DC Converter and Voltage Regulator

Product	Features	Package
S1F76610M0B0	• On–chip voltage regulator. • It effectively converts input voltage V_{DD} into $-V_{DD}/-2V_{DD}$ or $2V_{DD}/3V_{DD}$ • Output current : Max. 20mA at –5V • Power conversion efficiency: Typ. 95% • Three temperature gradients for LCD panel power.	SOP5-14pin
S1F76610M2B0		SSOP2-16pin
S1F76610C0B0		DIP-14pin
S1F76540M0A0	• On–chip voltage regulator. • It effectively converts input voltage V_{DD} into $-2V_{DD}/-3V_{DD}/-4V_{DD}$. • Low current Consumption : Typ. 130µA at –5V, 4–time boosting • Power conversion efficiency: Typ. 95% • Three temperature gradients for LCD panel power.	SSOP2-16pin
S1F76540C0A0		DIP-16pin
S1F76640M0A0	• On–chip voltage regulator. • It effectively converts input voltage V_{DD} into $2V_{DD}/3V_{DD}/4V_{DD}$. • Output current : Max. 20mA at 5V • Power conversion efficiency: Typ. 95% • Three temperature gradients for LCD panel power.	SSOP2-16pin

Voltage regulator

Product	Features	Package
S1F78100Y2A0	• 6.00V positive output voltage regulator. • Low operating current (Typ. 3.0µA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F78100Y2B0	• 5.00V positive output voltage regulator. • Low operating current (Typ. 3.0 µA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F78100Y2M0	• 4.50V positive output voltage regulator. • Low operating current (Typ. 3.0 µA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F78100Y2P0	• 4.00V positive output voltage regulator. • Low operating current (Typ. 3.0 µA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F78100Y2K0	• 3.90V positive output voltage regulator. • Low operating current (Typ. 3.0 µA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F78100Y2N0	• 3.50V positive output voltage regulator. • Low operating current (Typ. 3.0 µA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F78100Y2T0	• 3.30V positive output voltage regulator. • Low operating current (Typ. 3.0 µA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F78100Y2C0	• 3.20V positive output voltage regulator. • Low operating current (Typ. 3.0 µA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin

Selection Guide

Product	Features	Package
S1F78100Y2D0	• 3.00V positive output voltage regulator. • Low operating current (Typ. 3.0 μA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F78100Y2R0	• 2.80V positive output voltage regulator. • Low operating current (Typ. 3.0 μA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F78100Y2L0	• 2.60V positive output voltage regulator. • Low operating current (Typ. 3.0 μA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F78100Y2F0	• 2.20V positive output voltage regulator. • Low operating current (Typ. 3.0μA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F78100Y2G0	• 1.80V positive output voltage regulator. • Low operating current (Typ. 3.0 μA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F78100Y2H0	• 1.50V positive output voltage regulator. • Low operating current (Typ. 3.0 μA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F79100Y1B0	• –5.00V negative output voltage regulator. • Low operating current (Typ. 4.0 μA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F79100Y1P0	• –4.00V negative output voltage regulator. • Low operating current (Typ. 4.0 μA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F79100Y1D0	• –3.00V negative output voltage regulator. • Low operating current (Typ. 4.0 μA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F79100Y1G0	• –1.80V negative output voltage regulator. • Low operating current (Typ. 4.0 μA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin
S1F79100Y1H0	• –1.50V negative output voltage regulator. • Low operating current (Typ. 4.0 μA). • Input voltage stability (Typ. 0.1%/V).	SOT89-3pin

DC/DC Switching Regulator

Product	Features	Package
S1F76310M1A0	• Step-up switching regulator (from 1.5V to 5.0V). • Low operating voltage (Min. 0.9V). • Low operating current (Typ. 10μA). • High precision voltage detection function and battery backup function. • Built-in CR oscillator circuit. • Power-on clear function.	SOP3-8pin
S1F76310M1K0	• Step-up switching regulator (from 1.5V to 3.5V). • Low operating voltage (Min. 0.9V). • Low operating current (Typ. 8μA). • High precision voltage detection function and battery backup function. • Built-in CR oscillator circuit. • Power-on clear function.	SOP3-8pin
S1F76310M1B0	• Step-up switching regulator (from 1.5V to 3.0V). • Low operating voltage (Min. 0.9V). • Low operating current (Typ. 8μA). • High precision voltage detection function and battery backup function. • Built-in CR oscillator circuit. • Power-on clear function.	SOP3-8pin

Selection Guide

Product	Features	Package
S1F76310M1L0	• Step-up switching regulator (from 1.5V to 2.4V). • Low operating voltage (Min. 0.9V). • Low operating current (Typ. 7μA). • High precision voltage detection function and battery backup function. • Built-in CR oscillator circuit. • Power-on clear function.	SOP3-8pin
S1F76380M1H0	• Step-up switching regulator (from 1.5V to 2.2V). • Low operating voltage (Min. 0.9V). • Low operating current. (Typ. 7μA). • Built-in CR oscillator circuit. • High precision voltage detection. • Output voltage response compensation. • Temperature characteristics of output voltage for LCD panel (-4.5mV/C).	SOP3-8pin
S1F76380M1L0	• Step-up switching regulator (from 1.5V to 2.4V). • Low operating voltage (Min. 0.9V). • Low operating current. (Typ. 7μA). • Built-in CR oscillator circuit. • High precision voltage detection. • Output voltage response compensation. • Temperature characteristics of output voltage for LCD panel (-4.0mV/C).	SOP3-8pin
S1F76330M1B0	• Step-up switching regulator (from 1.5V to 3.0V). • Low operating voltage (Min. 0.9V). • Low operating current. (Typ. 5μA). • Built-in crystal oscillator circuit. • Equipped with crystal oscillator output pin.	SOP3-8pin
S1F71100M0A0	• Step-down switching regulator (from 3.3V ~ 12.0V to 3.3V). • Power off current : 1μA • Frequency fixing (200kHz) PWM. • Soft start function. • Overcurrent protection function, Low-voltage protection function.	SOP4-8pin
S1F71200M0A0	• Step-up/down switching regulator (from 2.5V ~ 12.0V to 5.0V). • Power off current : 1μA • Frequency fixing (200kHz) PWM. • Soft start function. • Overcurrent protection function.	SSOP2-16pin
S1F71100M0B0	• Step-up/down switching regulator (from 2.5V ~ 12.0V to 3.3V). • Power off current : 1μA • Frequency fixing (200kHz) PWM. • Soft start function. • Overcurrent protection function.	SSOP2-16pin

DC/DC Switching Regulators & Voltage Follower

Product	Features	Package
S1F75300M0A0	• Step-up switching regulator with built-in voltage follower (from 2.7V ~ 5.5V to 27V). • Boosting efficiency (90%).	SSOP1-20pin
S1F75300M0B0	• Low current consumption : Typ. 200μA without load • Step-up output voltage : Max. 30V • Adjustable output voltage with the electronic volume.	SSOP1-20pin

Voltage Detector

Product	Features	Package
S1F77210Y1L0	• Voltage detection (Typ. 5.00V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 6.0V).	SOP89-3pin
S1F77210Y1K0	• Voltage detection (Typ. 4.80V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 5.0V).	SOP89-3pin

Product	Features	Package
S1F77210Y120	• Voltage detection (Typ. 4.60V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 5.0V).	SOP89-3pin
S1F77210Y1J0	• Voltage detection (Typ. 4.40V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 5.0V).	SOP89-3pin
S1F77210Y1M0	• Voltage detection (Typ. 4.20V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 5.0V).	SOP89-3pin
S1F77210Y1T0	• Voltage detection (Typ. 4.00V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 5.0V).	SOP89-3pin
S1F77210Y130	• Voltage detection (Typ. 3.50V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 4.0V).	SOP89-3pin
S1F77210Y1H0	• Voltage detection (Typ. 3.20V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 4.0V).	SOP89-3pin
S1F77210Y1G0	• Voltage detection (Typ. 3.00V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 4.0V).	SOP89-3pin
S1F77210Y1R0	• Voltage detection (Typ. 2.80V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 3.0V).	SOP89-3pin
S1F77210Y1F0	• Voltage detection (Typ. 2.65V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 3.0V).	SOP89-3pin
S1F77210Y1E0	• Voltage detection (Typ. 2.55V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 3.0V).	SOP89-3pin
S1F77210Y1S0	• Voltage detection (Typ. 2.35V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 3.0V).	SOP89-3pin
S1F77210Y1P0	• Voltage detection (Typ. 2.25V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 3.0V).	SOP89-3pin
S1F77210Y1C0	• Voltage detection (Typ. 2.15V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 3.0V).	SOP89-3pin
S1F77210Y2F0	• Voltage detection (Typ. 2.65V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 3.0V).	SOP89-3pin
S1F77210Y2C0	• Voltage detection (Typ. 2.15V). • Output format: COMS. • Low operating power (Typ. 2.0 μA, V_{DD} = 3.0V).	SOP89-3pin
S1F77200Y1T0	• Voltage detection (Typ. 4.00V). • Output format: N-ch open drain. • Low operating power (Typ. 2.0 μA, V_{DD} = 5.0V).	SOP89-3pin
S1F77200Y1F0	• Voltage detection (Typ. 2.65V). • Output format: N-ch open drain. • Low operating power (Typ. 2.0 μA, V_{DD} = 3.0V).	SOP89-3pin
S1F77200Y1C0	• Voltage detection (Typ. 2.15V). • Output format: N-ch open drain. • Low operating power (Typ. 2.0 μA, V_{DD} = 3.0V).	SOP89-3pin
S1F77200Y1N0	• Voltage detection (Typ. 1.90V). • Output format: N-ch open drain. • Low operating power (Typ. 2.0 μA, V_{DD} = 3.0V).	SOP89-3pin

Selection Guide

Product	Features	Package
S1F77200Y1B0	• Voltage detection (Typ. 1.15V). • Output format: N-ch open drain. • Low operating power (Typ. 1.5 µA, V_{DD} = 1.5V).	SOP89-3pin
S1F77200Y1Y0	• Voltage detection (Typ. 1.10V). • Output format: N-ch open drain. • Low operating power (Typ. 1.5 µA, V_{DD} = 1.5V).	SOP89-3pin
S1F77200Y1A0	• Voltage detection (Typ. 1.05V). • Output format: N-ch open drain. • Low operating power (Typ. 1.5 µA, V_{DD} = 1.5V).	SOP89-3pin
S1F77200Y1V0	• Voltage detection (Typ. 0.95V). • Output format: N-ch open drain. • Low operating power (Typ. 1.5 µA, V_{DD} = 1.5V).	SOP89-3pin
S1F77220Y2D0	• Voltage detection (Typ. 1.25V). • Output format: P-ch open drain. • Low operating power (Typ. 1.5 µA, V_{DD} = 1.5V).	SOP89-3pin

1. DC/DC Converter

S1F76600 Series CMOS DC/DC Converter (Voltage Doubler)

DESCRIPTION

The S1F76600 Series is a highly efficient CMOS DC/DC converter for doubling an input voltage (from –1.5V to –8V). This power-saving IC allows portable computers and similar hand-held equipment to operate from a single power supply, even when they incorporate LSIs that operate at voltages different from those of logic circuits, for example, LCD drivers and analog LSIs.
The S1F76600C0B0 is available in 8-pin plastic DIPs, and the S1F76600M0B0, in 8-pin plastic SOPs.

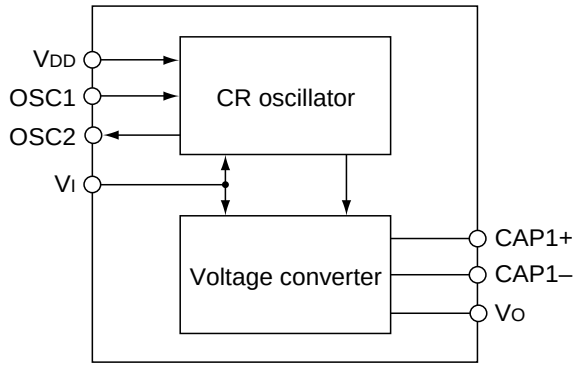
FEATURES

- 95% (Typ.) conversion efficiency
- Two output voltages, V_O, relative to V_{DD} and V_I
- 30mA maximum output current at 5V
- Connecting-in-series configuration obtains a higher output voltage (V_1=–5V, V_0=–15V at two-in-series).
- Low operating voltage
- On-chip CR oscillator
- 8-pin plastic DIP and 8-pin plastic SOP

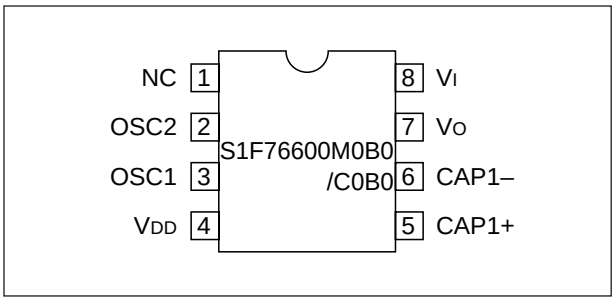
APPLICATIONS

- 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
- Uninterruptable power supplies

BLOCK DIAGRAM



PIN ASSIGNMENTS



PIN DESCRIPTIONS

Pin No.	Pin name	Description
1	NC	No connection
2	OSC2	Resistor connection. Open when using external clock
3	OSC1	Resistor connection. Clock input when using external clock
4	V_{DD}	Positive supply (system V_{CC})
5	CAP1+	Positive charge-pump connection
6	CAP1–	Negative charge-pump connection
7	V_O	×2 multiplier output
8	V_I	Negative supply (system ground)

SPECIFICATIONS

Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Input voltage range	V_I	–10.0 to 0.5	V
Output voltage range	V_O	Min. –20.0	V
Power dissipation	P_D	300 (DIP)	mW
		150 (SOP)	
Operating temperature range	T_{opr}	–40 to +85	˚C
Storage temperature range	T_{stg}	–65 to +150	˚C
Soldering temperature(for 10s). See note.	T_{sol}	260	˚C

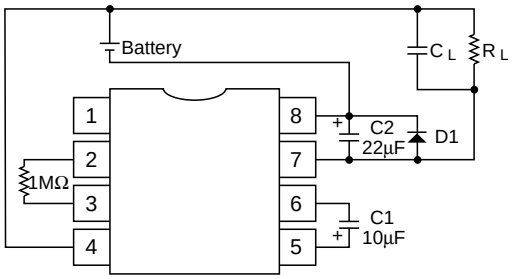
Note:
Temperatures during reflow soldering must remain within the limits set out in LSI Device Precautions. Never use solder dip to mount S1F70000 series power supply devices.

Recommended Operating Conditions

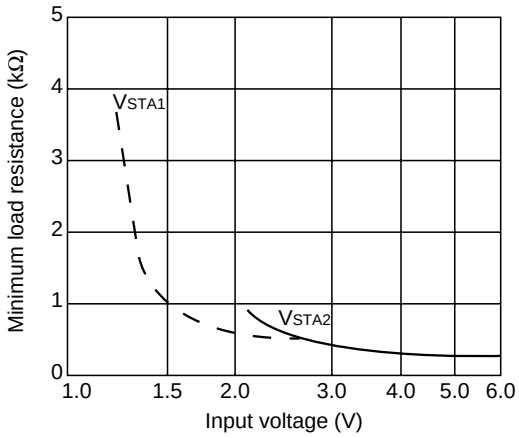
V_{DD} = 0V, Ta = –40 to +85˚C unless otherwise noted

Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
Oscillator startup voltage	V_{STA}	R_{OSC} = 1MΩ, $C_1/C_2 \leq 1/20$, $C_2 \geq 10\mu F$, Ta = –20 to +85˚C See note 1.	—	—	–1.5	V
		R_{OSC} = 1MΩ	—	—	–2.2	
Oscillator shutdown voltage	V_{STP}	R_{OSC} = 1MΩ	–1.5	—	—	V
Load resistance	R_L		R_L min See note 2.	—	—	Ω
Output current	I_O		—	—	30.0	mA
Clock frequency	f_{OSC}		10.0	—	30.0	kHz
CR oscillator network resistance	R_{OSC}		680	—	2,000	kΩ
Capacitance	C_1, C_2		3.3	—	—	µF

Notes:
1. The recommended circuit configuration for low-voltage 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. R_L min is a function of V_I.

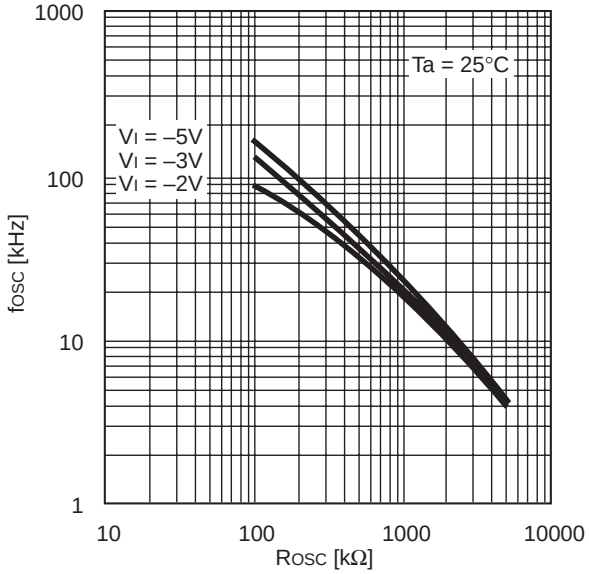


Electrical Characteristics

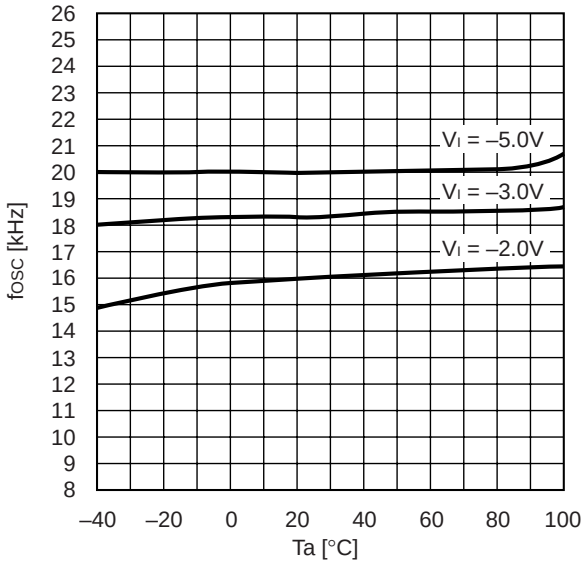
V_{DD} = 0V, Ta = –40 to +85°C unless otherwise noted

Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_I		–8.0	—	–1.5	V
Output voltage	V_O		–16.0	—	—	V
Multiplier current	I_{OPR}	R_L = ∞, R_{OSC} = 1MΩ V_I = –5V	—	20	30	µA
Quiescent current	I_Q	R_L =∞, V_I = –8V	—	—	2.0	µA
Clock frequency	f_{OSC}	R_{OSC} = 1MΩ, V_I = –5V	16	20	24	kHz
Output impedance	R_O	I_O = 10mA, V_I = –5V	—	75	100	Ω
Multiplication efficiency	Peff	I_O = 5mA, V_I = –5V	90	95	—	%
OSC1 Input leakage current	I_{LKI}	V_I = –8V	—	—	2.0	µA

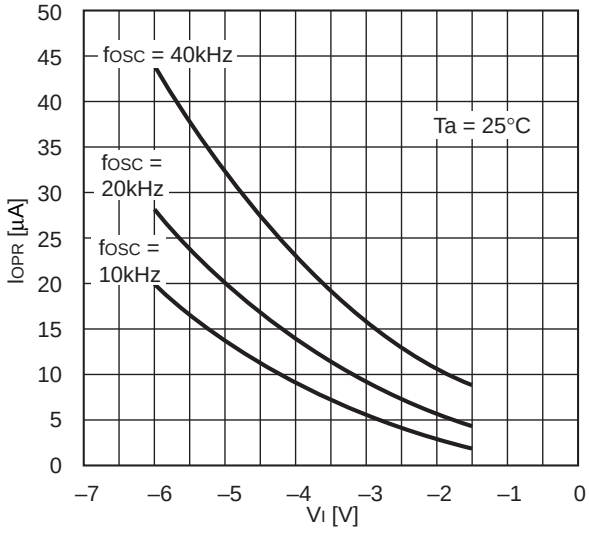
Typical Performance Characteristics



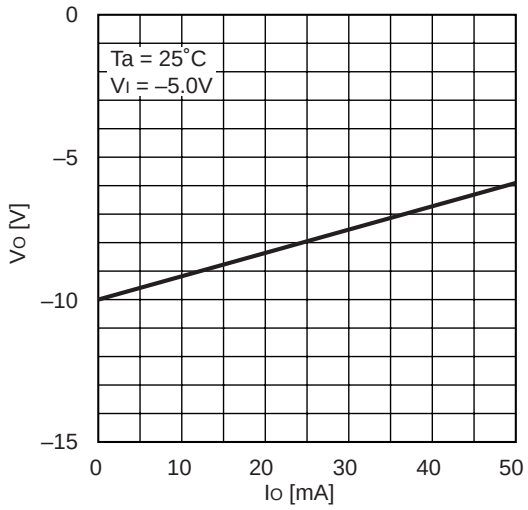
(1) Clock frequency vs. External resistance



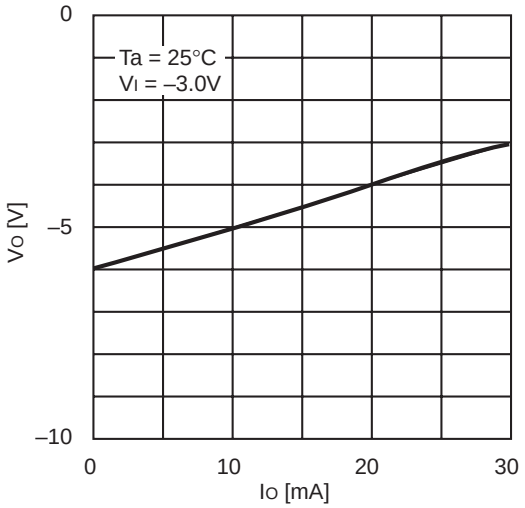
(2) Clock frequency vs. Ambient temperature



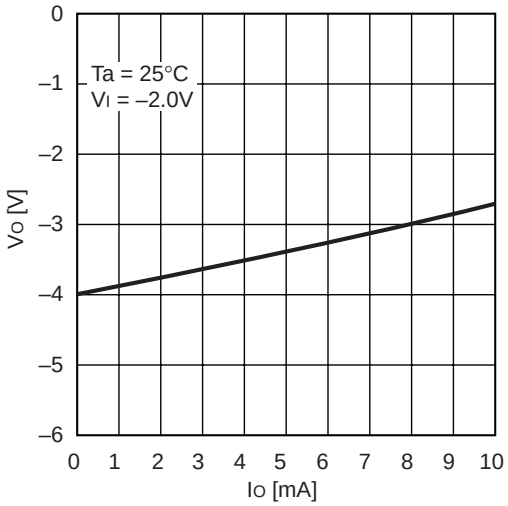
(3) Multiplier current vs. Input voltage



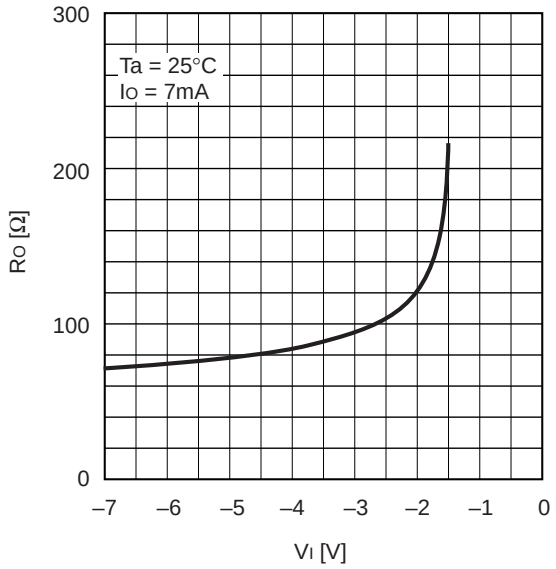
(4) Output voltage vs. Output current



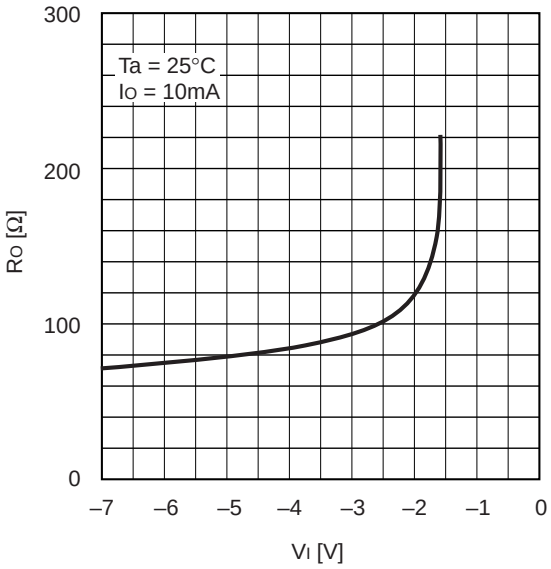
(5) Output voltage vs. Output current



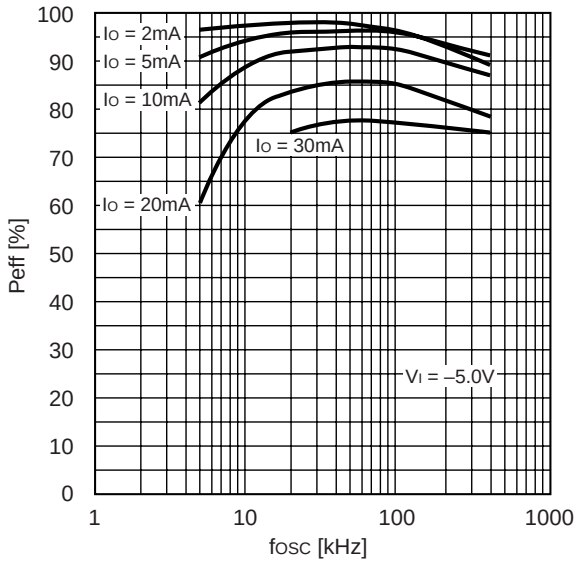
(6) Output voltage vs. Output current



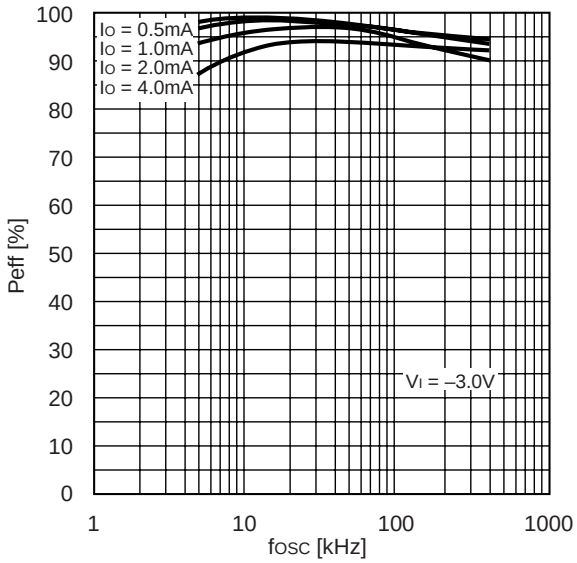
(7) Output impedance vs. Input voltage



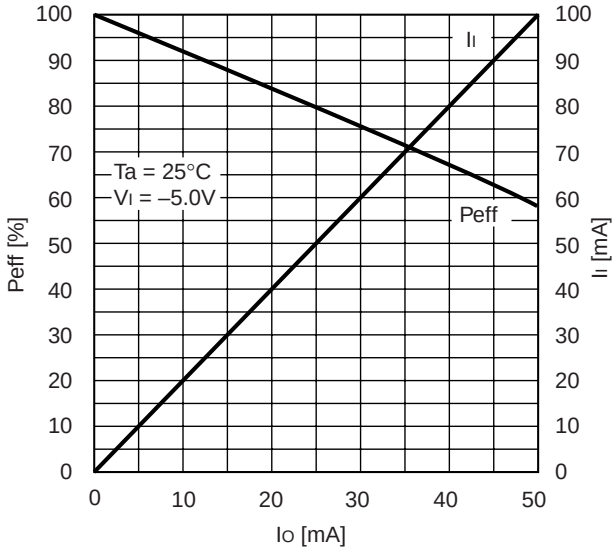
(8) Output impedance vs. Input voltage



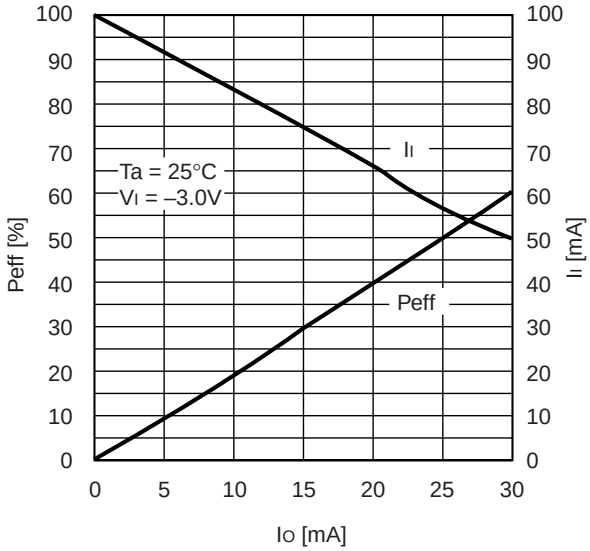
(9) Multiplication efficiency vs. Clock frequency



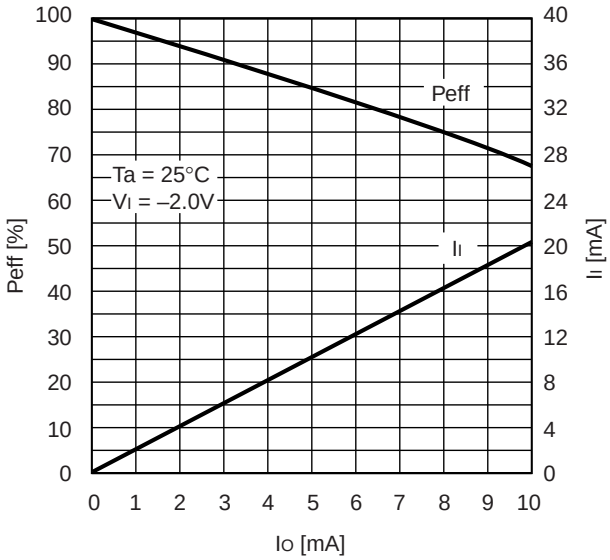
(10) Multiplication efficiency vs. Clock frequency



(11) Multiplication efficiency/input current vs. Output current



(12) Multiplication efficiency/input current vs. Output current

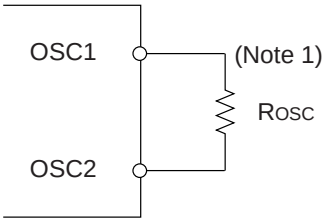


(13) Multiplication efficiency/input current vs. Output current

FUNCTIONAL DESCRIPTIONS

CR Oscillator

S1F76600 has a built-in CR oscillator as the internal oscillator, and an external oscillation resistor ROSC is connected between the pins OSC1 and OSC2 before operation.



Note 1
Since the oscillation frequency varies with wiring capacitance, make the cables between the terminals OSC1 and OSC2 and ROSC as short as possible.

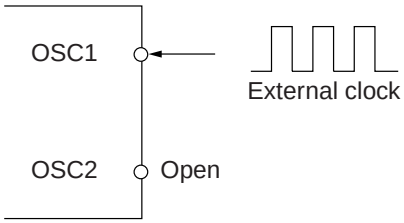
When setting the external resistor ROSC, find ROSC suitable for fOSC that brings about the maximum efficiency from characteristics graph (9) and (10). The relations between ROSC and fOSC in characteristics graph (1) are expressed approximately with the following formula as far as the straight portion (500kΩ < ROSC < 2MΩ) is concerned:

$$R_{OSC} = A \bullet (1/f_{OSC})$$

(A : Constant, When GND is 0V and VDD is 5V, A is approximately 2.0×10^{10} (I/F).)

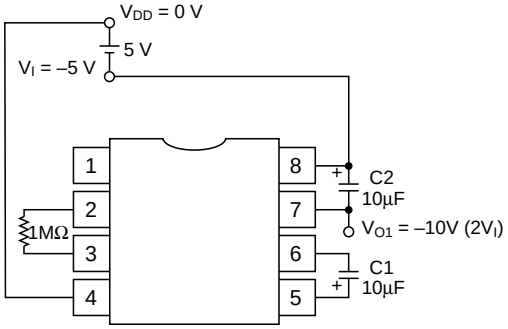
So, the ROSC value can be obtained from this formula. (Recommended oscillation frequency : 10kHz to 30kHz (ROSC : 2MΩ to 680kΩ))

When the external clock operates, make the pin OSC2 open as shown below and input the 50% duty of the external clock from the pin OSC1.

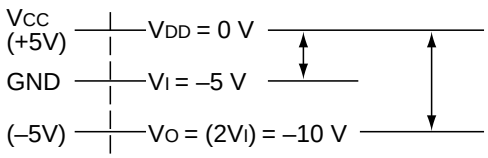


Voltage Multiplier

The voltage multiplier uses the clock signal from the oscillator to double the input voltage. This requires two external capacitors—a charge-pump capacitor, C1, between CAP1+ and CAP1–, and a smoothing capacitor, C2, between VI and VO.



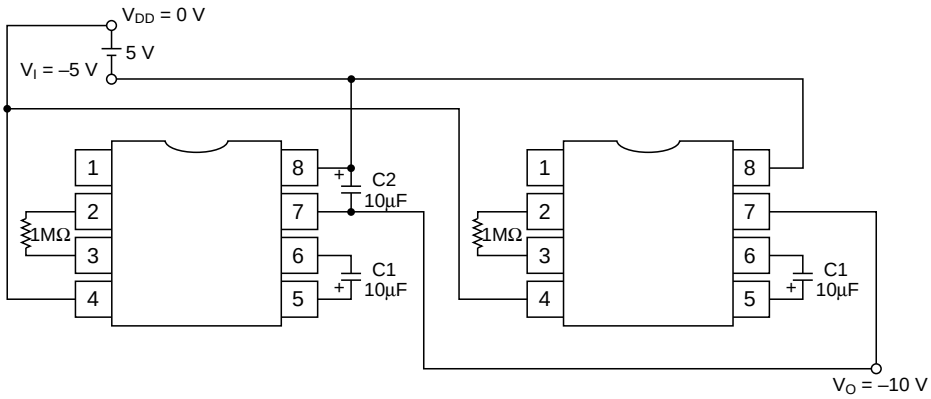
Doubled potential levels



TYPICAL APPLICATIONS

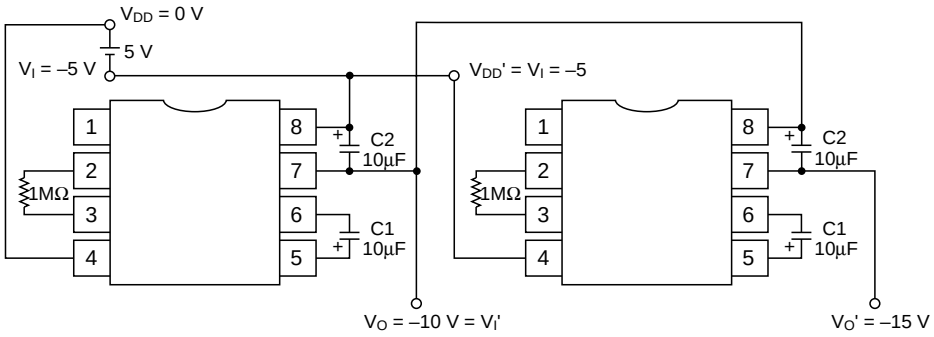
Parallel Connection

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

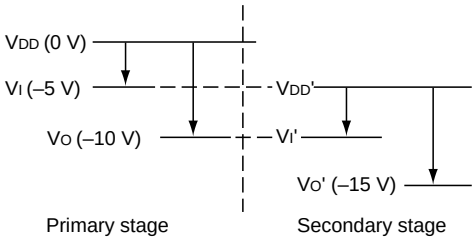


Serial Connection

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.

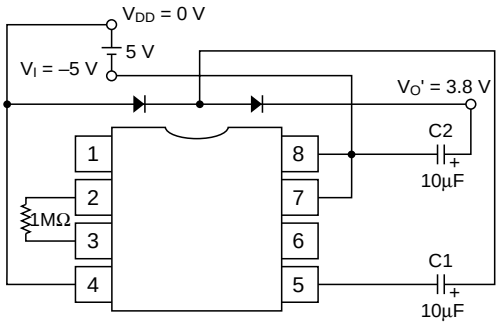


Potential levels



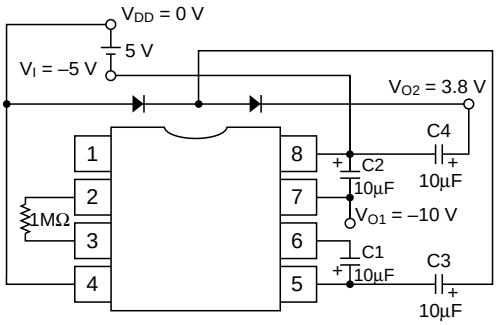
Positive Voltage Conversion

Diodes can be added to a circuit connected in parallel to make a negative voltage positive.

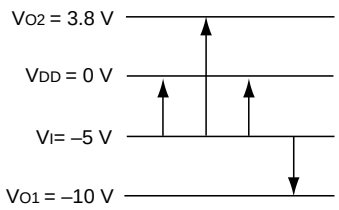


Simultaneous Voltage Conversion

Combining a multiplier circuit with a positive voltage conversion circuit generates both –10 and 3.8 V outputs from a single input.



Potential levels



S1F76620 Series CMOS DC/DC Converter (Voltage Doubler)

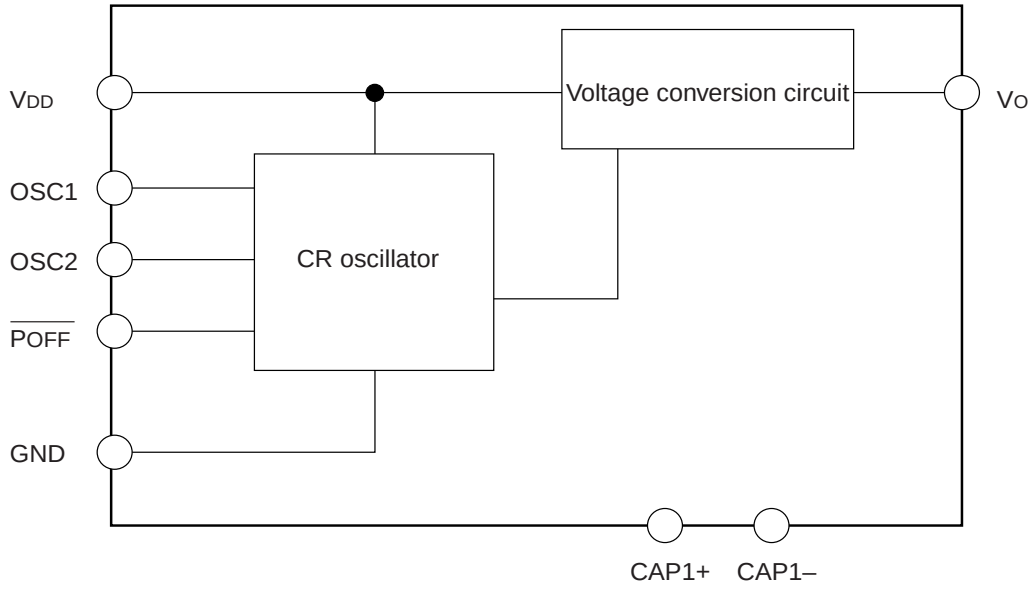
DESCRIPTION

S1F76620 is a high efficiency and low power consumption CMOS DC/DC converter. It enables to obtain 2 times step-up output (3.0 to 16V) from input voltage (1.5 to 8V). Also, S1F76620 enable to drive ICs (liquid crystal driver, analog IC, etc.), which require another power supply in addition to logic main power supply, with a single power supply, and it is suitable for micro power IC of hand-held computers, handy devices, etc. due to its small power consumption.

FEATURES

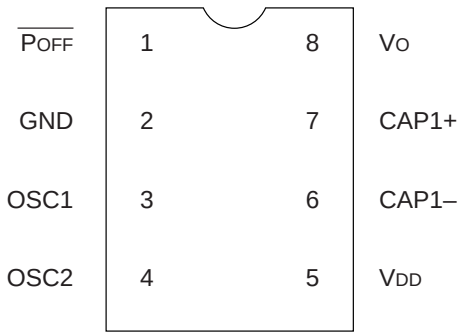
(1) High efficiency and low power consumption CMOS DC/DC converter
(2) Easy voltage conversion from input voltage V_{DD} (5V) to positive potential side or negative potential side
  • Input V_{DD} (5V) to output $-V_{DD}$ (–5V), $2V_{DD}$ (10V)
(3) Output current : Max. 30mA (V_{DD} = 5V)
(4) Power conversion efficiency : Typ. 95%
(5) Possibility of series connection (In 2-piece use, V_{DD} = 5V, V_O = 15V)
(6) Low voltage operation : Suitable for battery drive
(7) Built-in CR oscillator
(8) SOP4-8pin ····· S1F76620M0A0
  Bare Chip ····· S1F76620D0A0

BLOCK DIAGRAM



PIN DESCRIPTIONS

Pin Assignments



Pin Assignments of SOP4-8pin

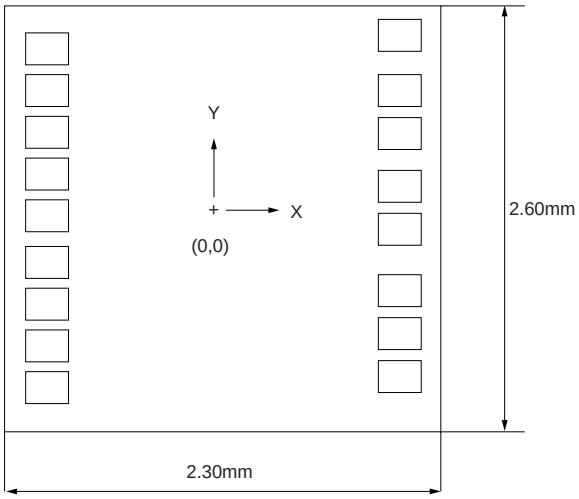
Pin descriptions

Pin No.	Pin name	Description
1	$\overline{POFF}$	Input pin for power off control.
2	GND (VSS)	Power pin. (Minus side, System GND)
3	OSC1	Oscillation resistor connection pin. Works as the clock input pin when the external clock operates.
4	OSC2	Oscillation resistor connection pin. Opens when the external clock operates.
5	VDD	Power pin. (Plus side, System VCC)
6	CAP1–	Pump up capacitor minus side connection pin for 2 times step-up.
7	CAP1+	Pump up capacitor plus side connection pin for 2 times step-up.
8	VO	Output pin at the time of 2 times step-up.

Pad Center Coordinates (S1F76620D0A0)

Pad No.	Pad name	Pad center coordinates X (μm)	Pad center coordinates Y (μm)	Description
1	(NC)	–984	1096	—
2	(NC)		788	—
3	$\overline{P_{OFF}}$		580	Input pin for power off control
4	(NC)		390	—
5	(NC)		96	—
6	(NC)		–218	—
7	GND (V_{SS})		–510	Power input pin (Minus side)
8	OSC1		–802	Oscillation resistor connection pin
9	OSC2		–1094	Oscillation resistor connection pin
10	V_{DD}	984	–1134	Power input pin (Plus side)
11	CAP1–		–892	Pump up capacitor minus side connection pin for 2 times step-up
12	CAP1+		–514	Pump up capacitor plus side connection pin for 2 times step-up
13	(NC)		182	—
14	V_O		372	2 times step-up output pin
15	(NC)		750	—
16	(NC)		942	—
17	(NC)		1134	—

Chip External Shape



Pad Assignment

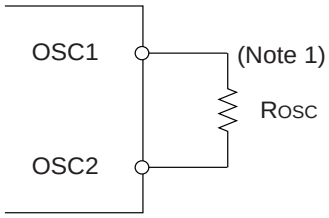
Pad aperture : 100μm × 100μm Chip thickness : 400μm

Note
Do not bond the NC pad.

FUNCTIONAL DESCRIPTIONS

CR Oscillator

S1F76620 has a built-in CR oscillator as the internal oscillator, and an external oscillation resistor ROSC is connected between the pins OSC1 and OSC2 before operation.



Note 1
Since the oscillation frequency varies with wiring capacitance, make the cables between the terminals OSC1 and OSC2 and ROSC as short as possible.

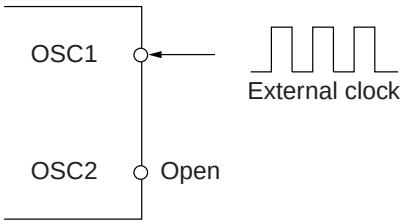
When setting the external resistor ROSC, find ROSC suitable for fOSC that brings about the maximum efficiency from characteristics graph (9) and (10). The relations between ROSC and fOSC in characteristics graph (1) are expressed approximately with the following formula as far as the
straight portion (500kΩ < ROSC < 2MΩ) is concerned:

$$R_{OSC} = A \bullet (1/f_{OSC})$$

(A : Constant, When GND is 0V and VDD is 5V, A is approximately 2.0×10^{10} (I/F).)

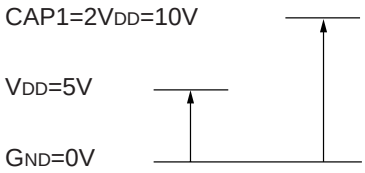
So, the ROSC value can be obtained from this formula. (Recommended oscillation frequency : 10kHz to 30kHz (ROSC : 2MΩ to 680kΩ))

When the external clock operates, make the pin OSC2 open as shown below and input the 50% duty of the external clock from the pin OSC1.



Voltage Conversion Circuit

The voltage conversion circuit uses clocks generated in the CR oscillator to double the input supply voltage VDD.
In case of 2 times step-up, 2 times voltage (2VDD) of the input voltage is obtained from the VO pin when a pump up capacitor is connected between CAP1+ and CAP2– and a smoothing capacitor is connected between VDD and VO outside.
When GND is 0 and VDD is 5, the relations between input/output and voltage are as shown below:



ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings

(Ta = –40 to +85°C)

Parameter	Symbol	Rating		Unit	Remarks
		Min.	Max.		
Input supply voltage	V_{IN}	–0.5	10.0	V	—
Input pin voltage	V_I	–0.5	V_{DD} + 0.5	V	OSC1, OSC2
Output voltage	V_O	—	20	V	—
Output supply voltage	V_{CAP+}	–0.5	V_{DD} + 0.5	V	CAP+
Output pin voltage	V_{CAP-}	–0.5	V_O + 0.5	V	CAP–
Allowable loss	P_D	—	300	mW	DIP-8pin
			150		SOP-8pin
Operating temperature	Topr	–40	85	°C	—
Storage temperature	Tstg	–65	150	°C	—

Note 1
Under the conditions exceeding the above absolute maximum ratings, the IC may result in a permanent destruction. An operation for a long period under the conditions of the above absolute maximum ratings may deteriorate the reliability remarkably.

Note 2
All voltage values are based on GND being 0V.

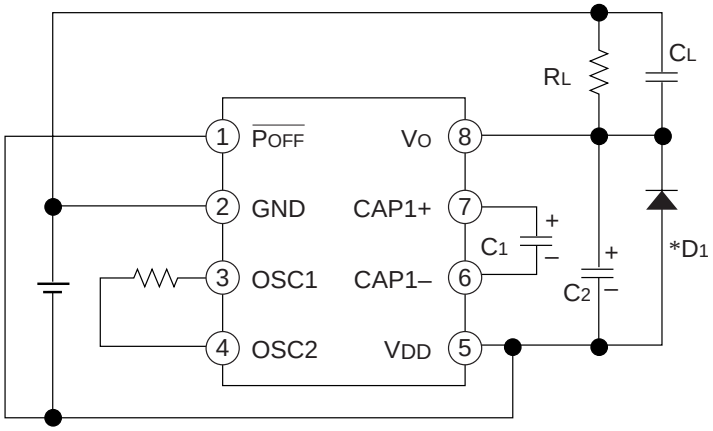
Recommended Operating Conditions

(Ta = –40 to +85°C)

Parameter	Symbol	Rating		Unit	Remarks
		Min.	Max.		
Step-up start operation	V_{STA1}	1.5	—	V	R_{OSC} = 1MΩ $C_2 \geq 10\mu F$ $C_L/C_2 \geq 1/20$ See note 2.
	V_{STA2}	2.2	—	V	R_{OSC} = 1MΩ
Step-up stop voltage	V_{STP}	—	1.5	V	R_{OSC} = 1MΩ
Output load resistance	R_L	R_{Lmin} See note 3.	—	Ω	—
Output load current	I_O	—	30	mA	—
Oscillation frequency	f_{OSC}	10	30	kHz	—
External resistor for oscillation	R_{OSC}	680	2000	kΩ	—
Step-up capacitor	C_1, C_2	3.3	—	µF	—

Note 1
All voltages are based on the GND being 0V.

Note 2
The figure below shows the recommended circuit for operation with low voltages (V_{DD} = 1.5 to 2.2V):



* (DI (VF (IF=1mA) is recommended to be not more than 0.6V.)

Recommended Circuit

Note 3
R_{Lmin} varies with input voltage. See Characteristics Graph (15).

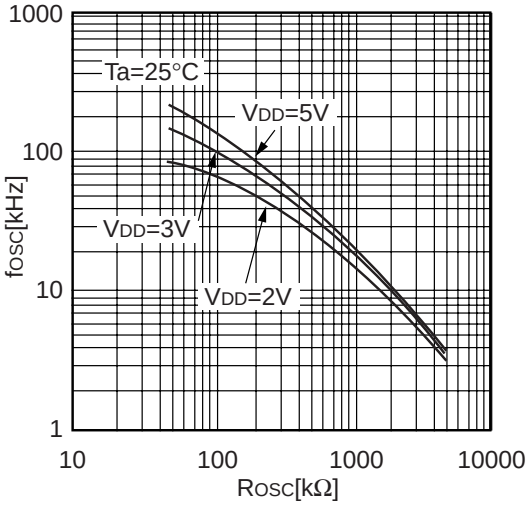
Electrical Characteristics

(V_{DD} = 5V, Ta = –40 to +85°C)

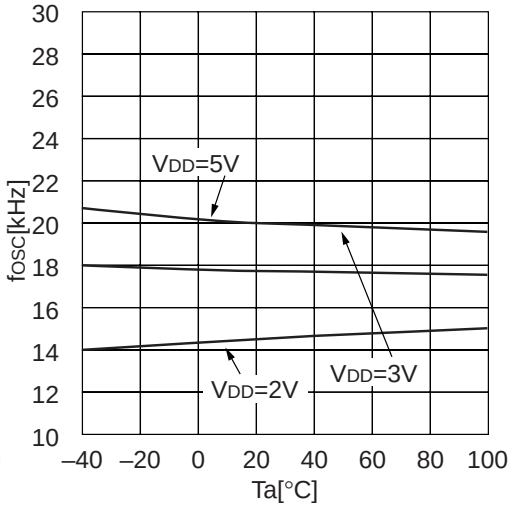
Parameter	Symbol	Rating			Unit	Remarks
		Min.	Typ.	Max.		
Input supply voltage	V_{DD}	1.8	—	8.0	V	—
Output voltage	V_O	—	—	16.0	V	—
Step-up circuit current consumption	I_{OPR}	—	35	50	µA	R_{OSC} = 1MΩ
Static current	I_Q	—	—	1.0	µA	—
Oscillation frequency	f_{OSC}	16	20	24	kHz	R_{OSC} = 1MΩ
Output impedance	R_O	—	85	130	Ω	I_O = 10mA
Step-up power conversion efficiency	P_{eff}	90	95	—	%	I_O = 5mA
Input leak current	I_{LKI}	—	—	1.0	µA	OSC1 pin

Note 1
All voltage values are based on GND being 0V.

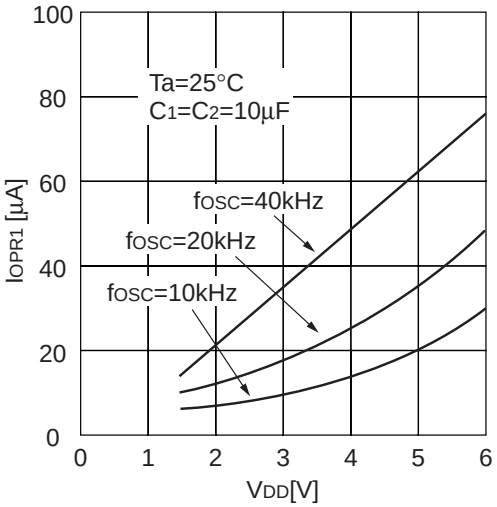
Characteristics Graph



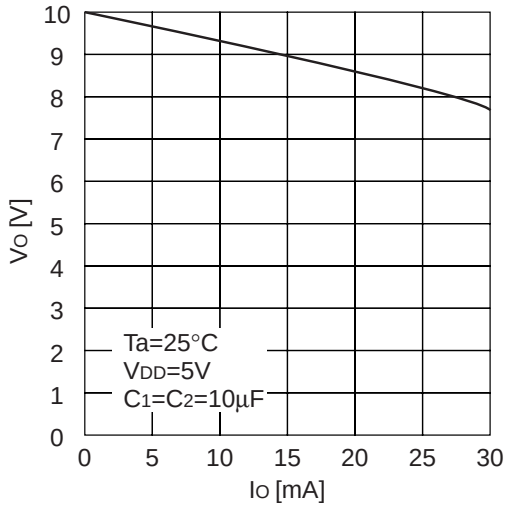
(1) Oscillation frequency vs. External resistance for oscillation



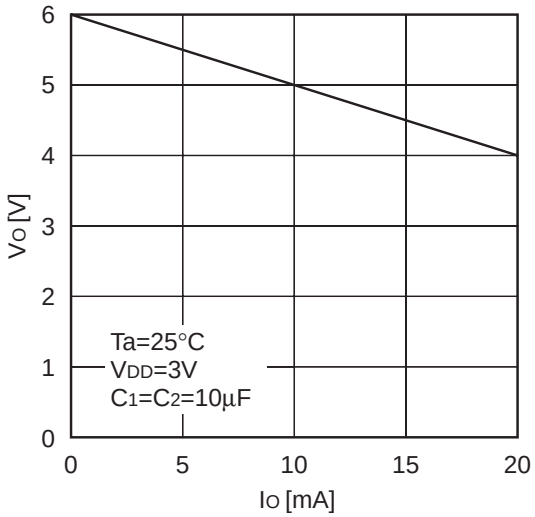
(2) Oscillation frequency vs. Temperature



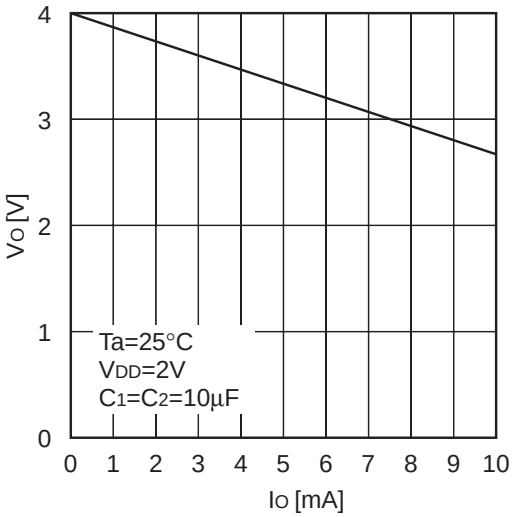
(3) Step-up circuit current consumption vs. Input current



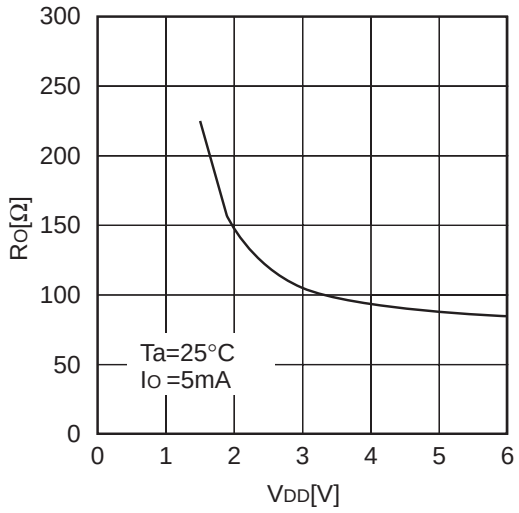
(4) Output voltage (V_O) vs. Output current 1



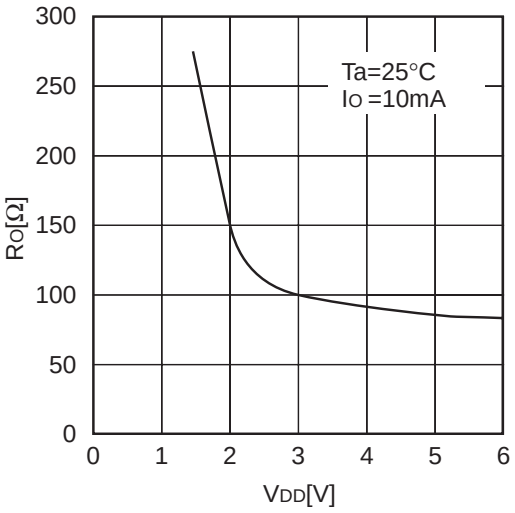
(5) Output voltage (VO) vs. Output current 2



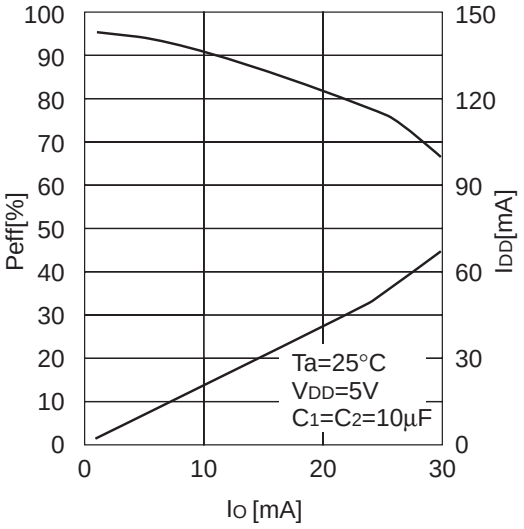
(6) Output voltage (VO) vs. Output current 3



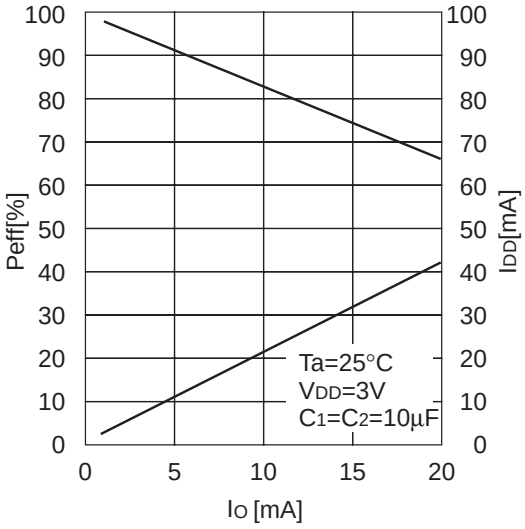
(7) Output impedance vs. Input current 1



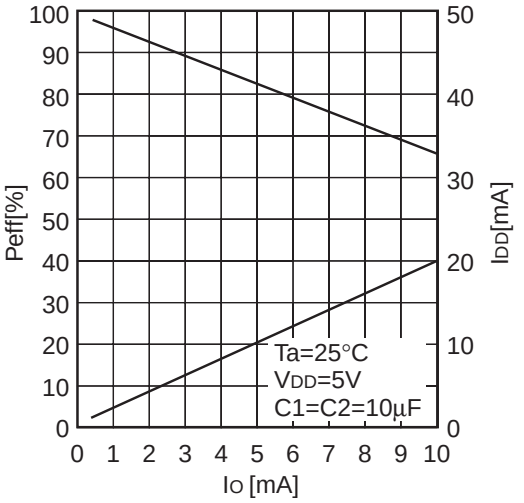
(8) Output impedance vs. Input voltage 2



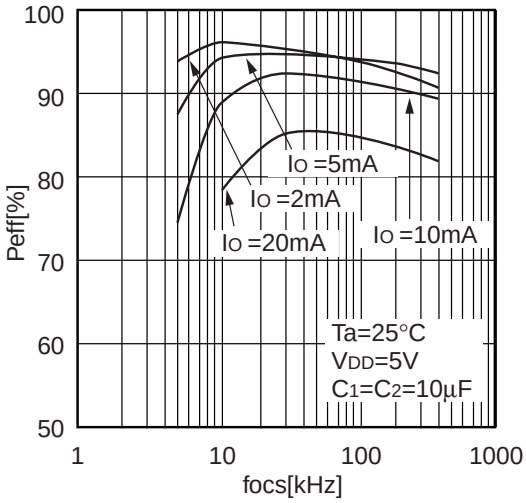
(9) Step-up power conversion efficiency vs. Output current 1
Input current vs. Output current 1



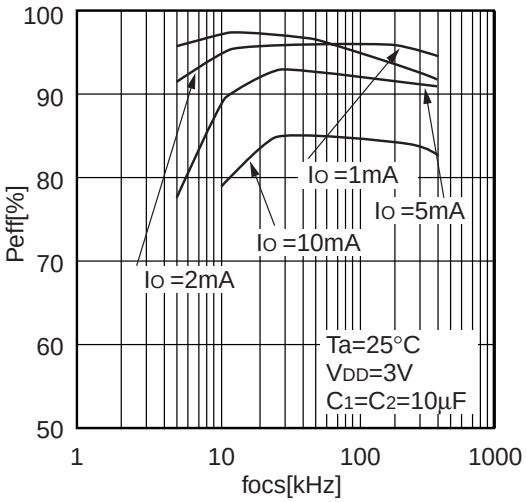
(10) Step-up power conversion efficiency vs. Output current 2
Input current vs. Output current 2



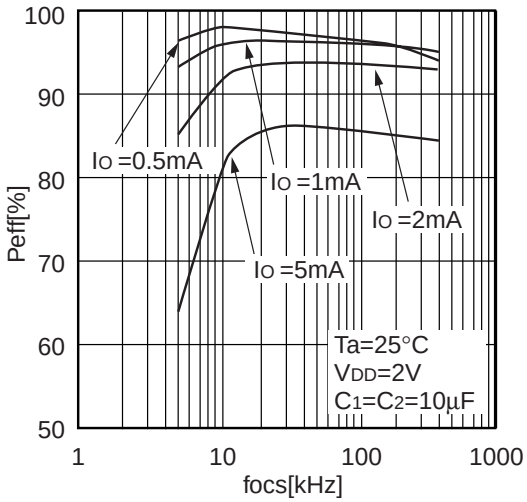
(11) Step-up power conversion efficiency vs. Output current 3
Input current vs. Output current 3



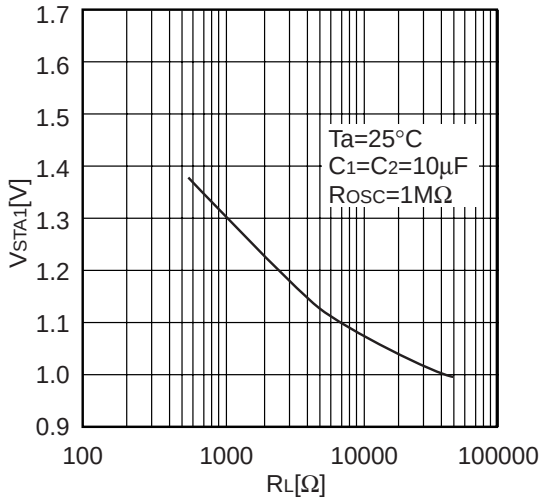
(12) Step-up power conversion efficiency vs. Oscillation frequency 1



(13) Step-up power conversion efficiency vs. Oscillation frequency 2



(14) Step-up power conversion efficiency vs. Oscillation frequency 3



(15) Step-up start voltage (1) vs. Load resistance

EXAMPLE OF REFERENCE EXTERNAL CONNECTION

2 Times Step-up

2 times step-up output of V_O ($2 \times V_{DD}$) is obtained from the circuit shown in Figure 1.

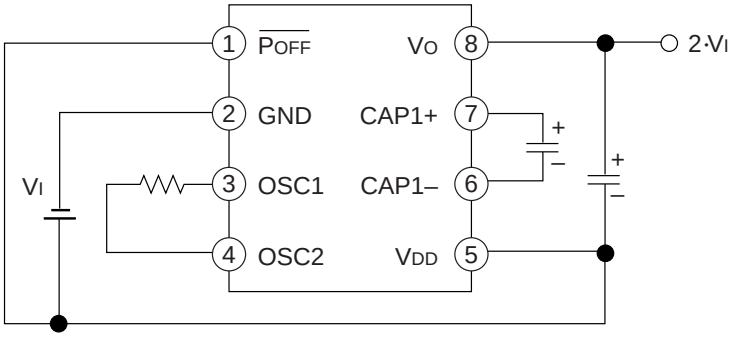


Figure 1 2 Time Step-up Operation

Parallel Connection

It is possible to make the output impedance (R_O) small when several pieces of the circuit shown in Figure 1 are connected. Parallel connection of n circuits reduces R_O to 1/n approximately. One piece of the smoothing capacitor C_2 can be commonly used.

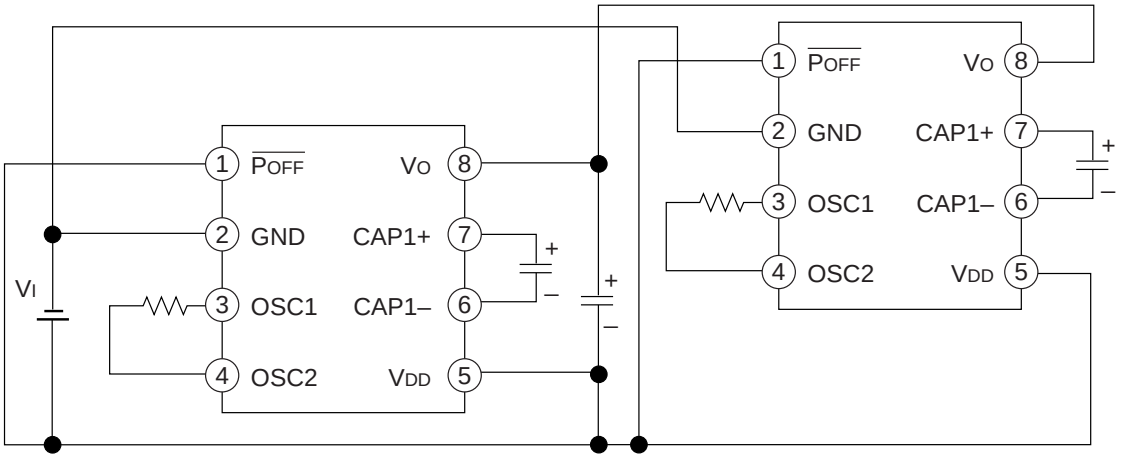


Figure 2 Parallel Connection

Series Connection

When S1F76620 is connected in series (V_{DD} and V_O in the previous stage are connected to GND and V_{DD} in the next stage respectively), the output voltage can be increased more. But the series connection makes the output impedance high. Figure 3 shows an example of the series connection to get V_O = 15V from V_{DD} = 5V.

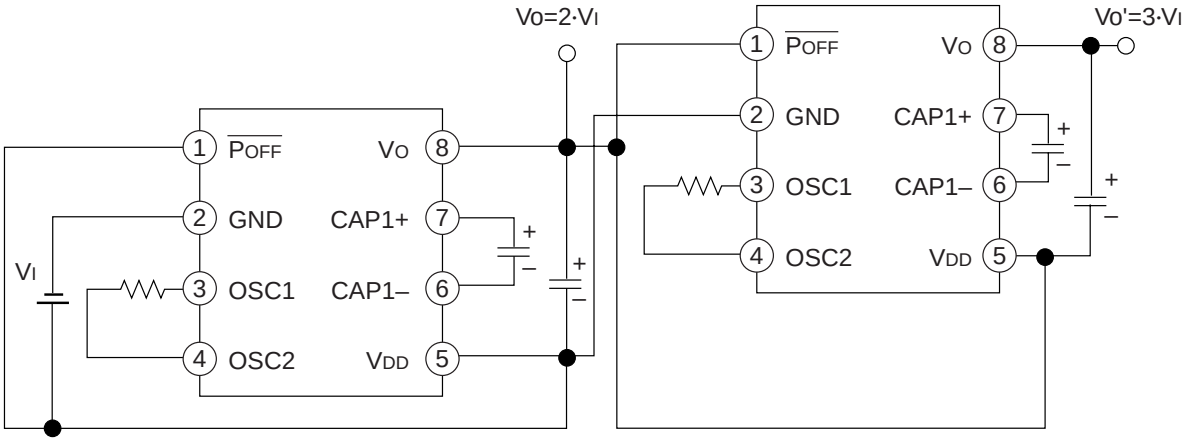


Figure 3 Series Connection

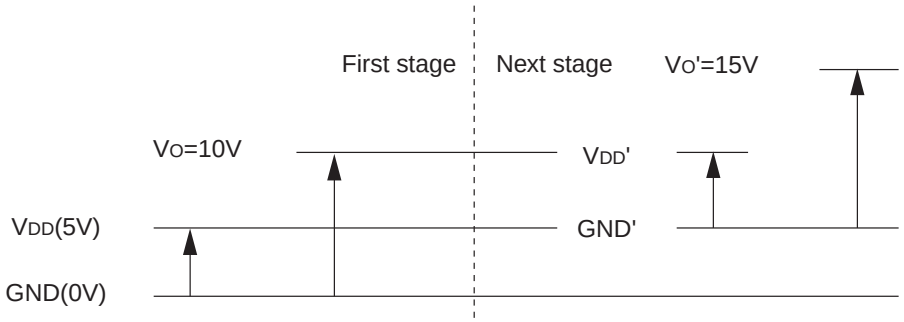


Figure 4 Power Supply Relations in Series Connection (1)

Note

When the input voltage in the next stage is as per the specification (V_{DD}-GND ≤ 8V) in a series connection, the output in the first stage (V_O-V_{DD}) can be used as the input in the next stage (V_{DD}-GND). (See Figure 5.)

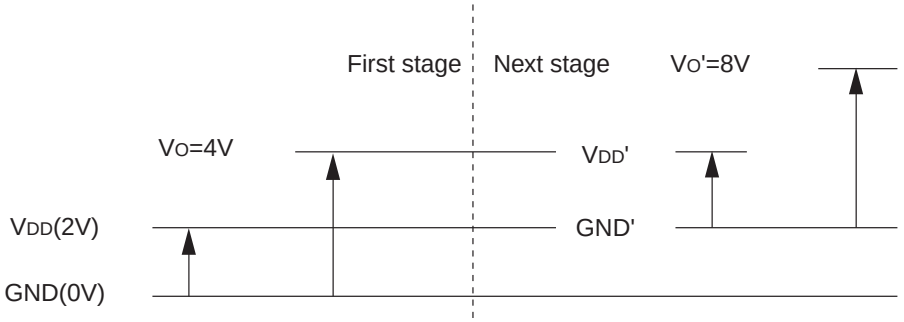


Figure 5 Power Supply Relations in Series Connection (2)

Negative Voltage Conversion

S1F76620 can boost input voltage to twice on the positive potential side by using the circuit shown in Figure 6. But the output voltage drops by the forward voltage V_F of the diode. When GND is 0V, V_{DD} is 5V and V_F is 0.6V as shown in Figure 6 for example, V_O is calculated as follows: $V_O = -5V + 2 \times 0.6V = -3.8V$.

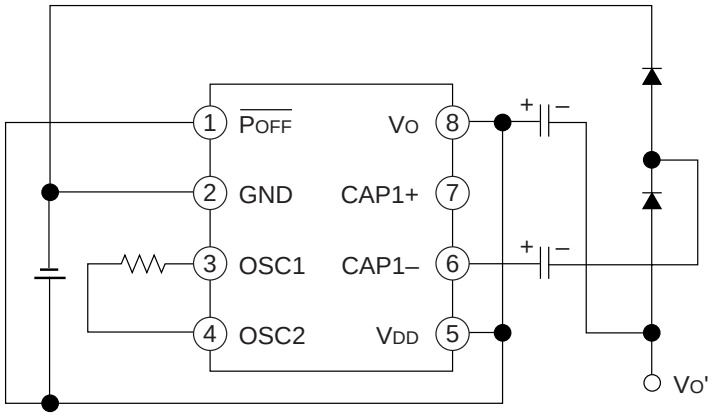


Figure 6 Negative Voltage Conversion

Negative Voltage Conversion + Positive Voltage Conversion

When the 3 times step-up operation shown in Figure 1 and the positive voltage conversion in Figure 6 are combined, the circuit shown in Figure 7 can be formed and 10V and –3.8V can be obtained from the input 5V. However, the output impedance is higher than in case of connection of either one only (the negative voltage conversion or the positive voltage conversion).

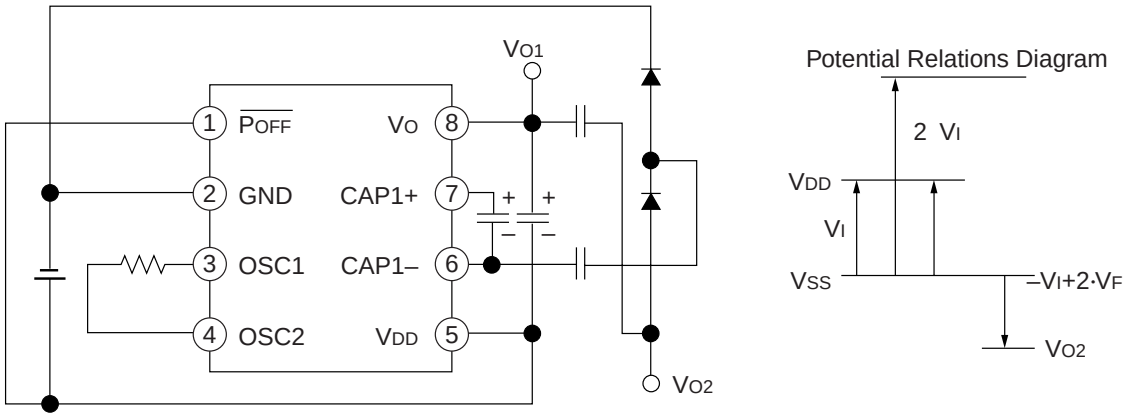
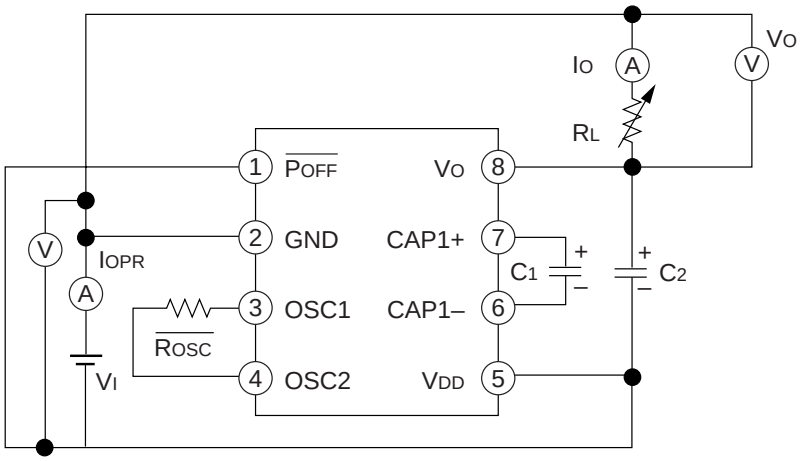


Figure 7 Negative Voltage Conversion + Positive Voltage Conversion

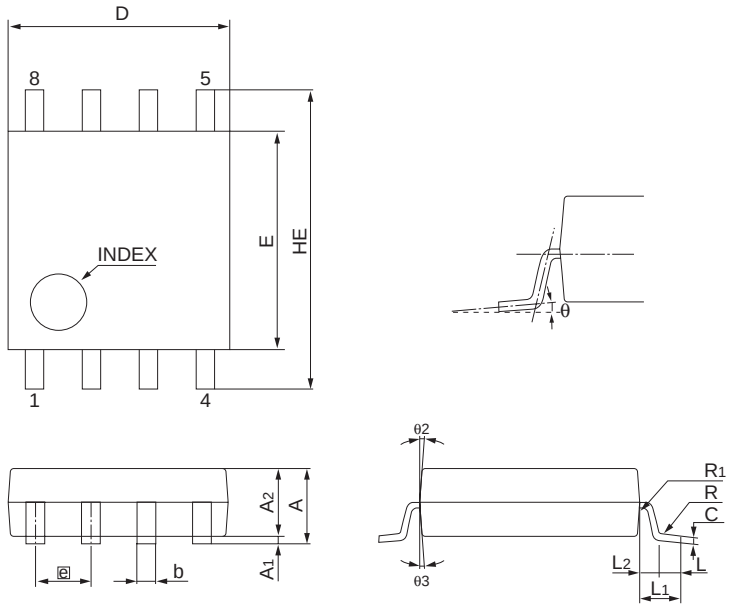
MEASUREMENT CIRCUIT



MECHANICAL DATA

S1F76620M0A0 SOP4-8pin

Reference



Symbol	Dimension in Milimeters			Dimension in Inches*		
	Min.	Nom.	Max.	Min.	Nom.	Max.
E	4.8	5	5.2	(0.189)	(0.197)	(0.204)
D_1	—	—	—	—	—	—
A		1.75			(0.069)	
A_1		0.15			(0.006)	
A_2		1.6			(0.063)	
e		1.27			(0.050)	
b	0.25	0.35	0.45	(0.010)	(0.014)	(0.017)
C	0.05	0.15	0.25	(0.002)	(0.006)	(0.009)
θ						
L		0.55			(0.022)	
L_1						
L_2						
H_E	6.4	6.8	7.2	(0.252)	(0.268)	(0.283)
D	4.8	5	5.2	(0.189)	(0.197)	(0.204)
θ_2						
θ_3						
R						
R_1						

* for reference

Note
This drawing is subject to change without notice for improvement.

2. DC/DC Converter & Voltage Regulator

S1F76610 Series CMOS DC/DC Converter (Voltage Doubler / Tripler) & Voltage Regulator

DESCRIPTION

The S1F76610 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 S1F76610 Series offers a choice of three, optional temperature gradients for applications such as LCD panel power supplies.

The S1F76610C0B0 is available in 14-pin plastic DIPs, the S1F76610M0B0, in 14-pin plastic SOPs, and the S1F76610M2B0 in 16-pin plastic SSOPs.

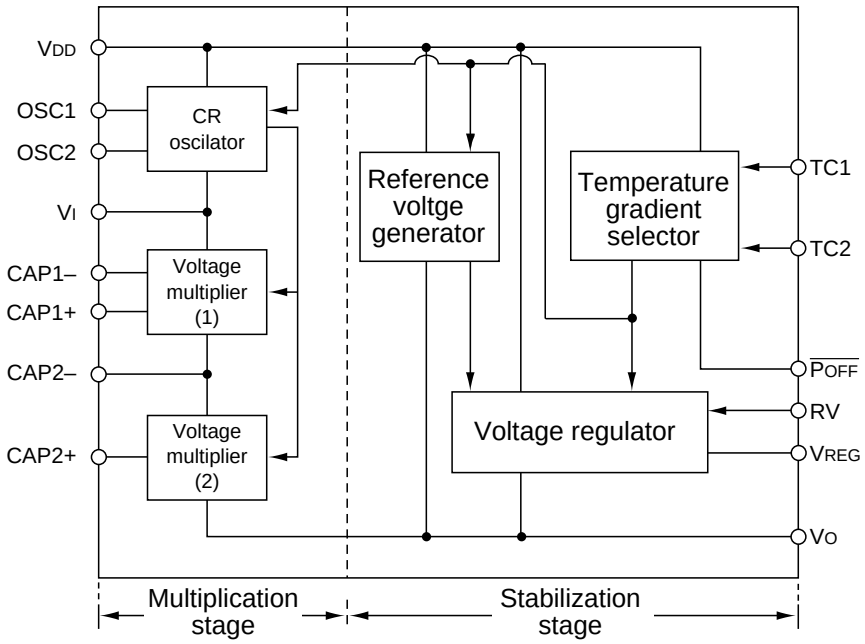
FEATURES

- 95% (Typ.) conversion efficiency
- Up to four output voltages, V_O, relative to the input voltage, V_I
- On-chip voltage regulator
- 20mA maximum output current at V_I = –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
- S1F76610C0B0 ..... Plastic DIP-14 pin
  S1F76610M0B0 ..... Plastic SOP5-14 Pin
  S1F76610M2B0 ..... Plastic SSOP2-16 pin

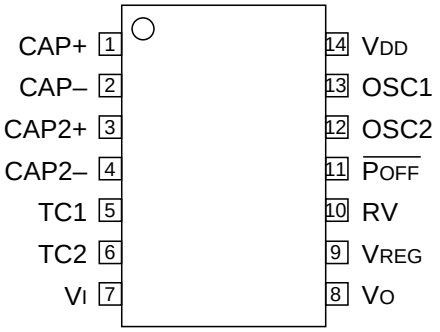
APPLICATIONS

- 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

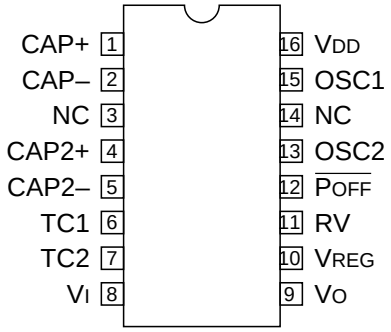
BLOCK DIAGRAM



PIN ASSIGNMENTS



S1F76610C0B0/M0B0



S1F76610M2B0

PIN DESCRIPTIONS
S1F76610C0B0/M0B0

Pin No.	Pin 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	$\overline{P_{OFF}}$	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

Parameter	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, $\overline{P_{OFF}}$
		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	P_D	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 • 10	°C • 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.

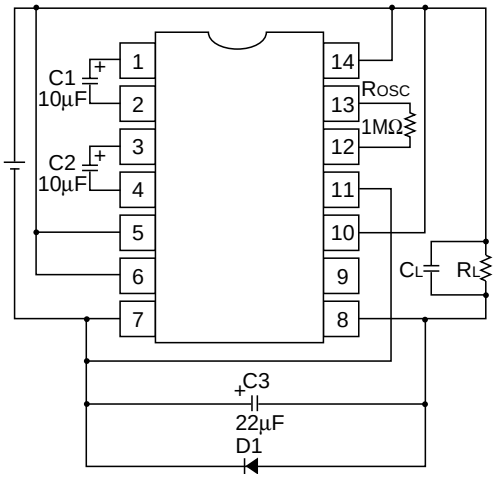
Reconmmended Operating Conditions

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

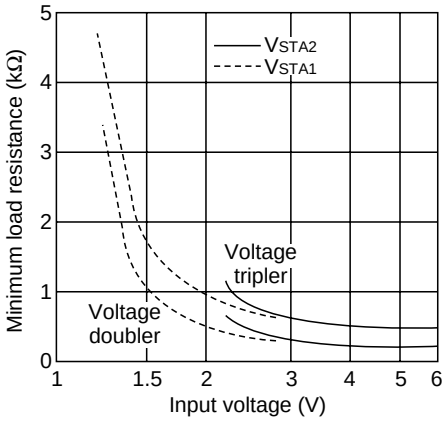
Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Oscillator startup voltage	V_{STA}	R_{OSC} =1MΩ C_3 = 10 µF, $C_L/C_3 \leq$ 1/20, Ta = –20 to +85°C. See note 1.	—	—	–1.8	V
		R_{OSC} = 1MΩ	—	—	–2.2	
Oscillator shutdown voltage	V_{STP}	R_{OSC} = 1MΩ	–1.8	—	—	V
Load resistance	R_L		$R_{Lmin.}$ See note 2.	—	—	Ω
Output current	I_O		—	—	20.0	mA
Clock frequency	f_{OSC}		10.0	—	30.0	kHz
CR oscillator network resistance	R_{OSC}		680	—	2,000	kΩ
Capacitance	C_1, C_2, C_3		3.3	—	—	µF
Stabilization voltage sensing resistance	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. RLmin is a function of V1



Electrical Characteristics

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

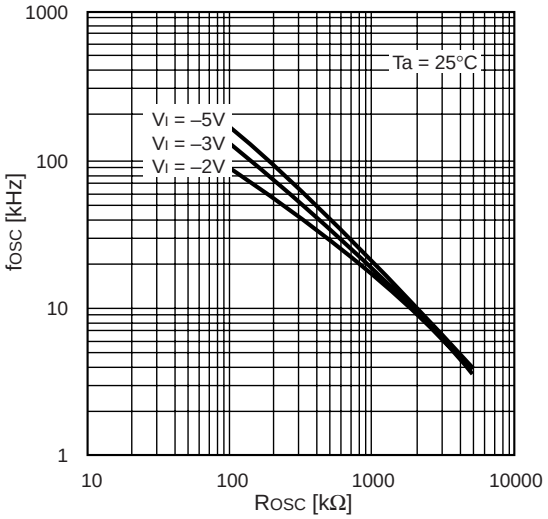
Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	VI		–6.0	—	–1.8	V
Output voltage	VO		–18.0	—	—	V
Regulator voltage	VREG	RL = ∞, RRV = 1MΩ, VO = –18V	–18.0	—	–2.6	V
Stabilization circuit operating voltage	VO		–18.0	—	–3.2	V
Multiplier current	IOPR1	RL = ∞, ROSC = 1MΩ	—	40	80	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 = ∞, 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	
$\overline{P_{OFF}}$, TC1, TC2, OSC1, and RV input leakage current	I_{LKI}		—	—	2.0	µA

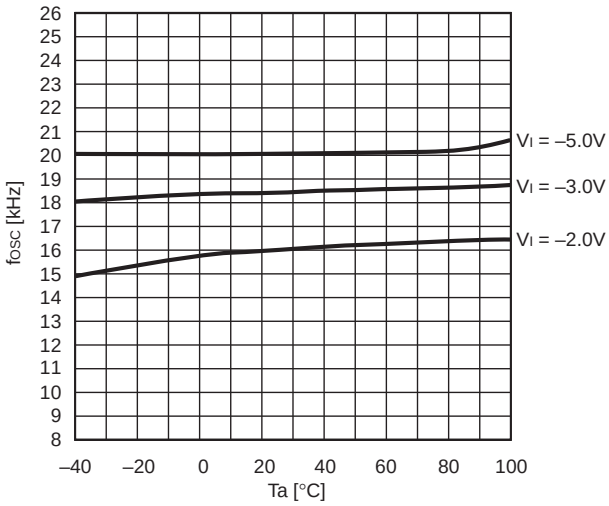
Note

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

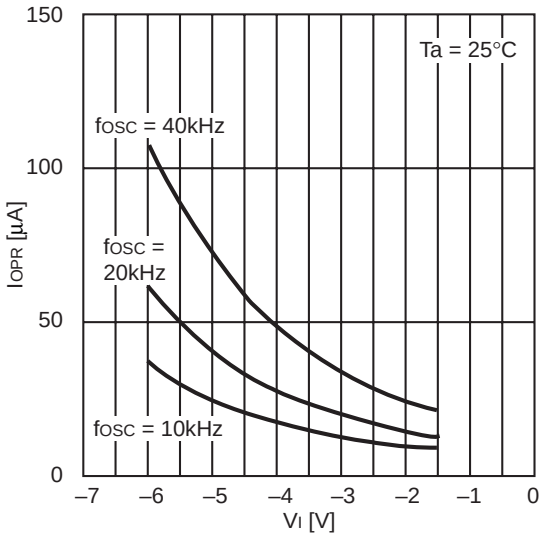
Typical Performance Characteristics



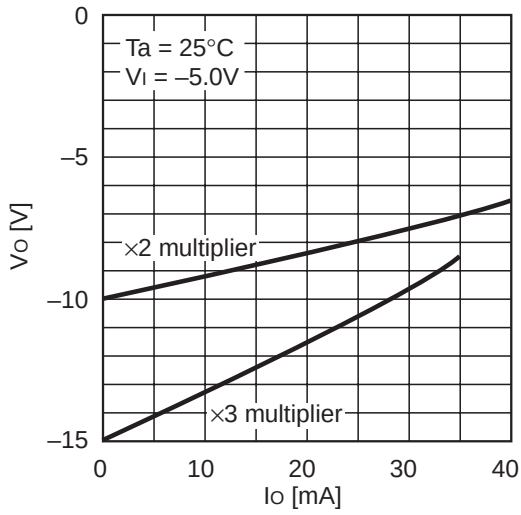
(1) Clock frequency vs. External resistance



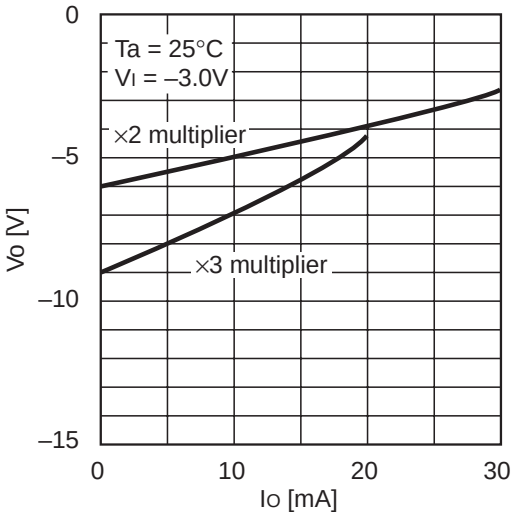
(2) Clock frequency vs. Ambient temperature



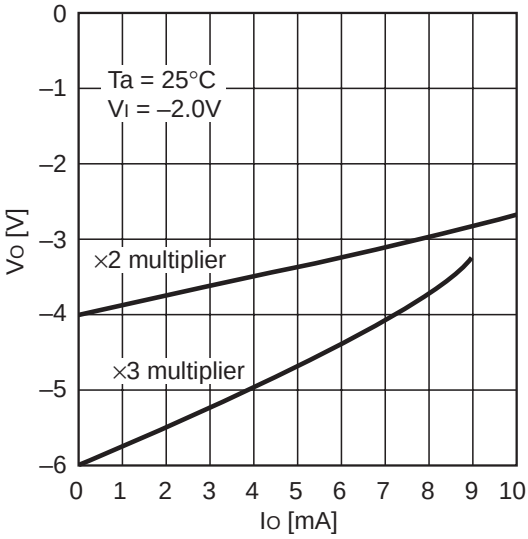
(3) Multiplier current vs. Input voltage



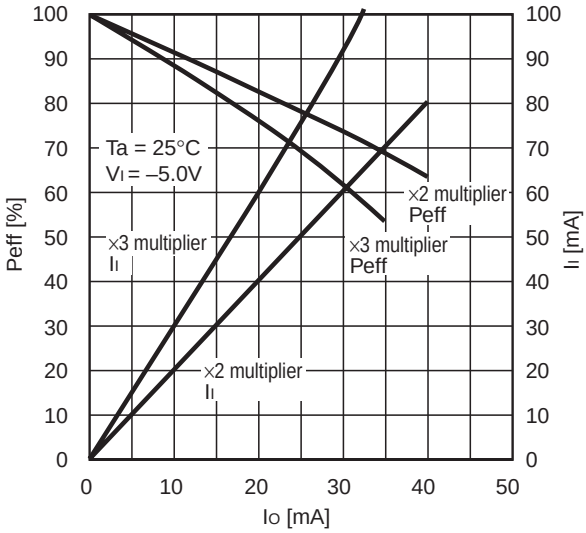
(4) Output voltage vs. Output current



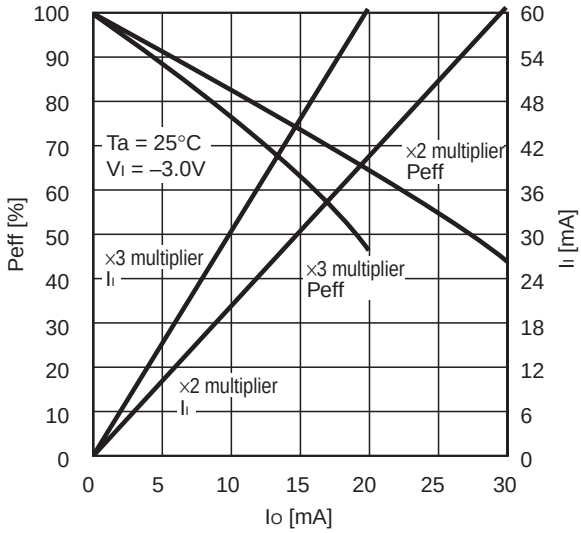
(5) Output voltage vs. Output current



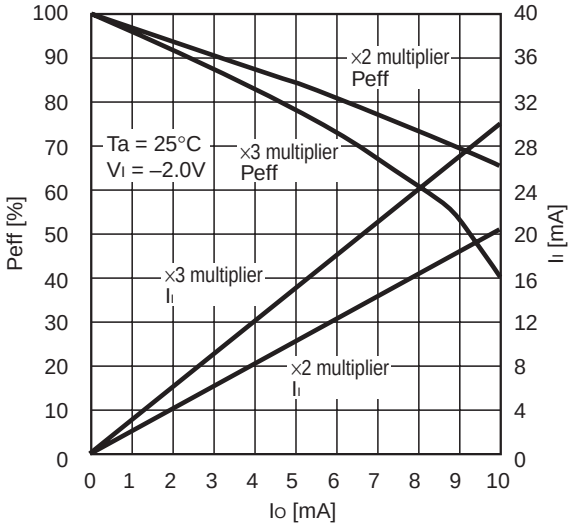
(6) Output voltage vs. Output current



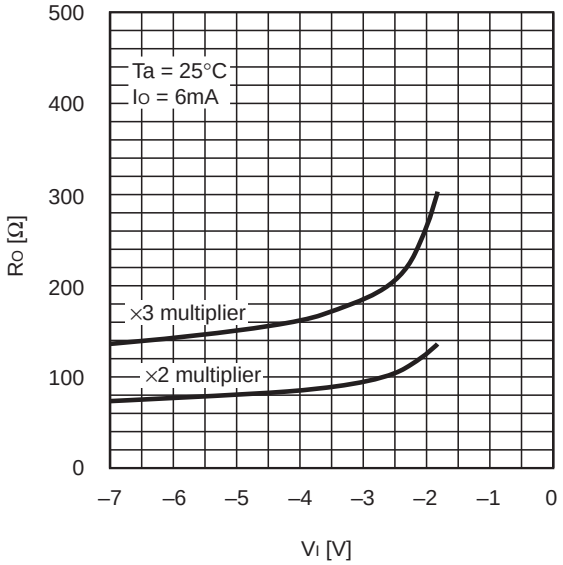
(7) Multiplication efficiency/input current vs. Output current



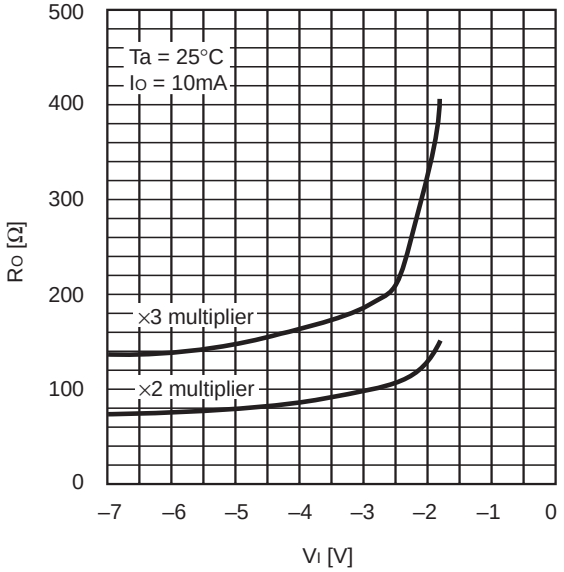
(8) Multiplication efficiency/input current vs. Output current



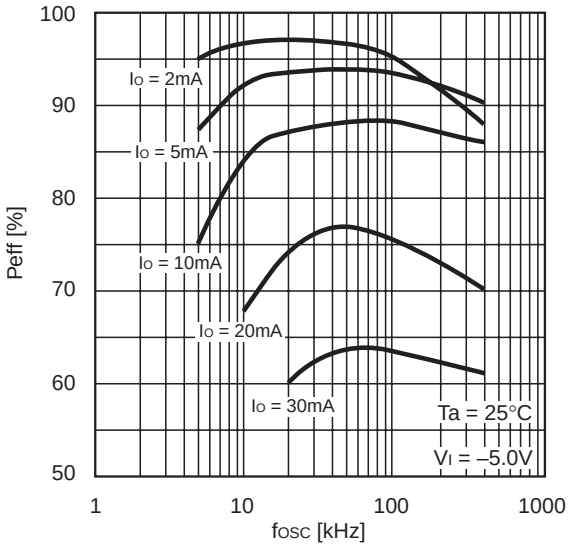
(9) Multiplication efficiency/input current vs. Output current



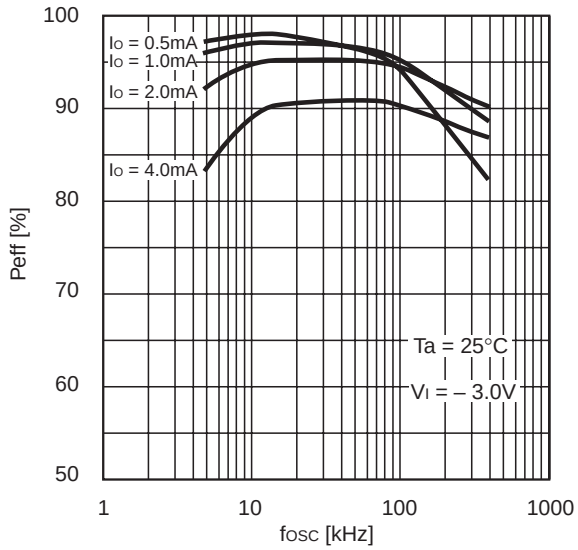
(10) Output impedance vs. Input voltage



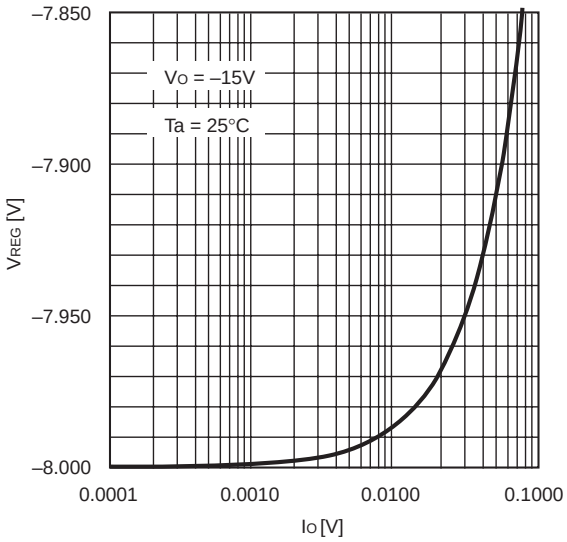
(11) Output impedance vs. Input voltage



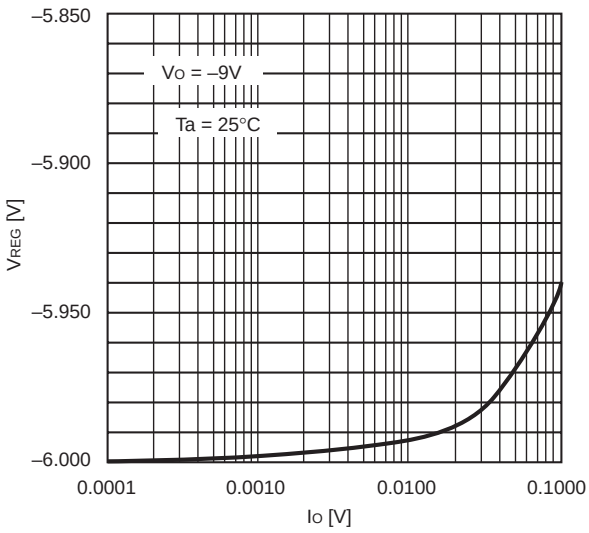
(12) Multiplication efficiency vs. Clock frequency



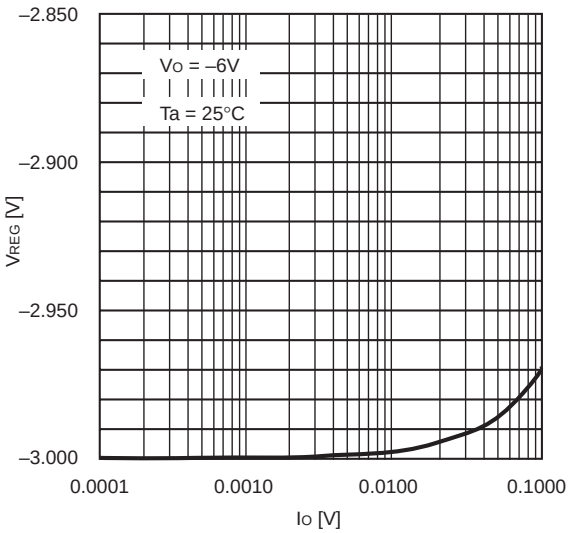
(13) Multiplication efficiency vs. Clock frequency



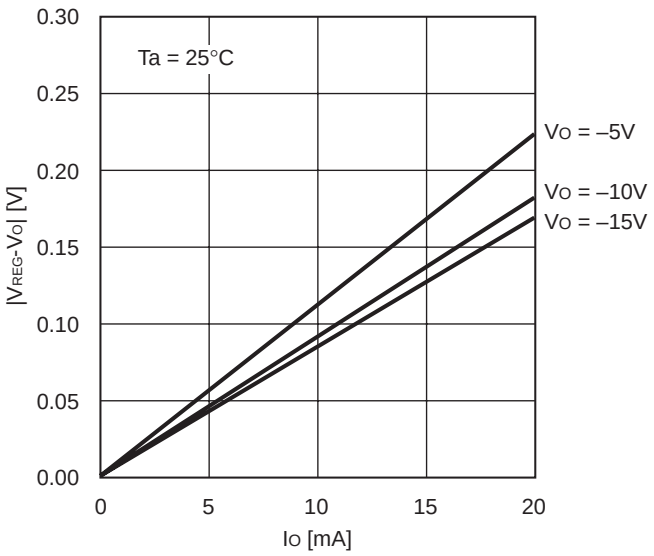
(14) Output voltage vs. Output current



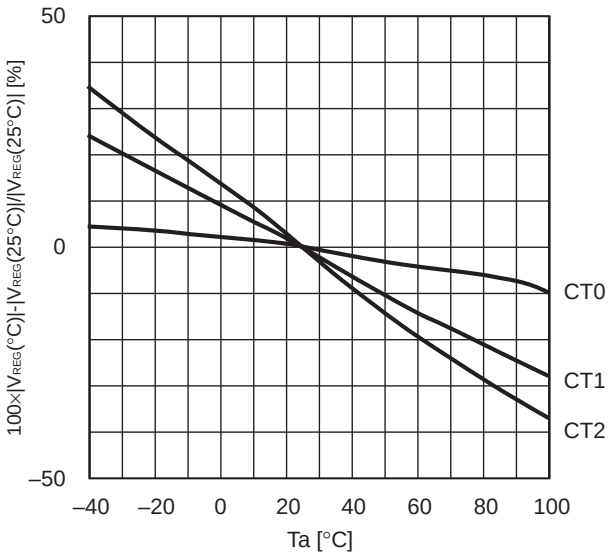
(15) Output voltage vs. Output current



(16) Output voltage vs. Output current



(17) Regulator voltage vs. Output current



(18) Regulator output stability ratio vs. Ambient temperature

Temperature Gradient Control

The S1F7661C0B0 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	CR osciliator	Remarks
See note 1.						
1 (V_{DD})	Low (V_O)	Low (V_O)	–0.4	ON	ON	
1 (V_{DD})	Low (V_O)	High (V_{DD})	–0.1	ON	ON	
1 (V_{DD})	High (V_{DD})	Low (V_O)	–0.6	ON	ON	
1 (V_{DD})	High (V_{DD})	High (V_{DD})	–0.6	ON	OFF	Serial connection
0 (V_I)	Low (V_O)	Low (V_O)	—	OFF (high impedance)	OFF	
0 (V_I)	Low (V_O)	High (V_{DD})	—	OFF (high impedance)	OFF	
0 (V_I)	High (V_{DD})	Low (V_O)	—	OFF (high impedance)	OFF	
0 (V_I)	High (V_{DD})	High (V_{DD})	—	OFF (high impedance)	OFF	Multiplier operational

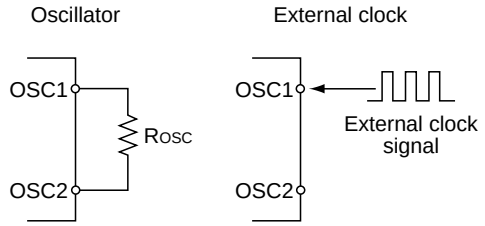
Notes

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 DESCRIPTIONS

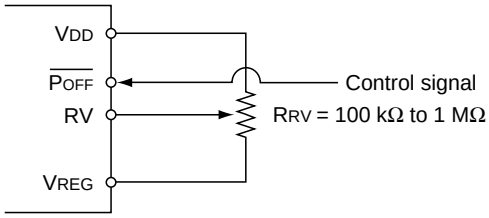
CR Oscillator

The on-chip CR 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.



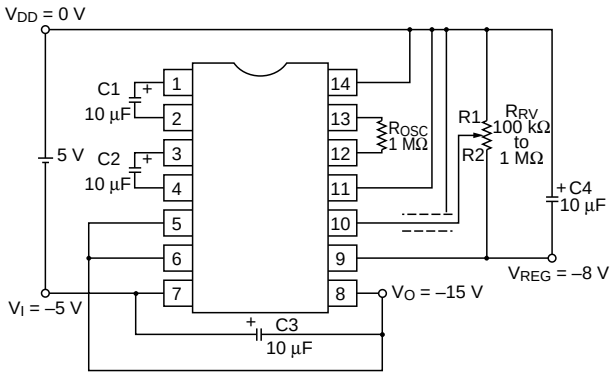
Reference Volatge Generator and Voltage Regulator

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

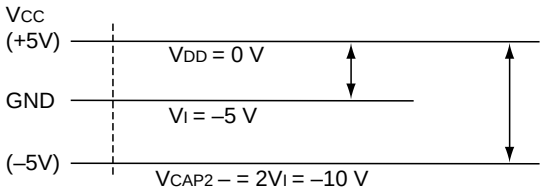


Voltage Multiplier

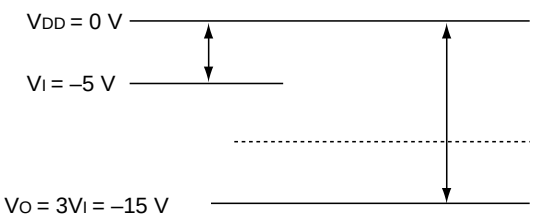
The voltage multiplier uses the clock signal from the oscillator to double or triple the input voltage. This requires three external capacitors–two charge-pump capacitors between CAP1+ and CAP1– and CAP2+ and CAP2–, respectively, and a smoothing capacitor between VI and VO.



Double voltage potential levels



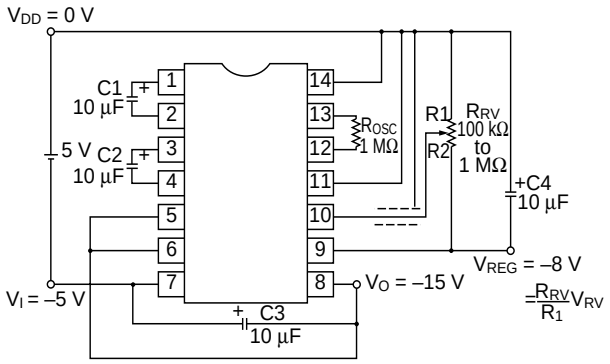
Tripled voltage potential levels



TYPICAL APPLICATIONS

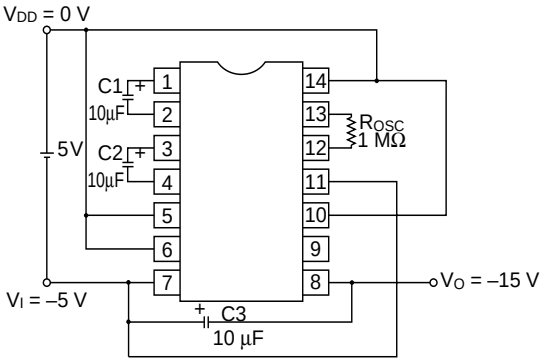
Voltage Tripler with Regulator

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

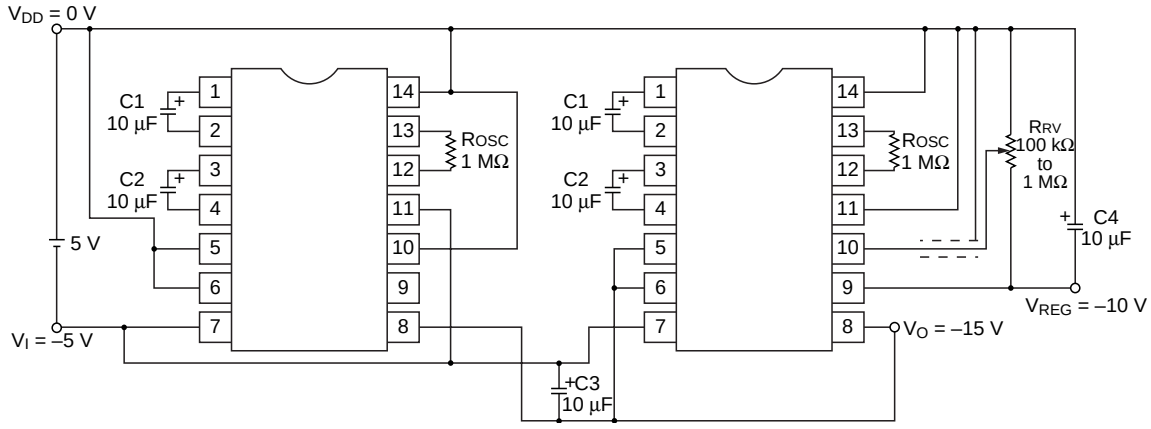
To convert this curcuit to a voltage doubler, remove capacitor C2 and short circuit CAP2– to VO.



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.



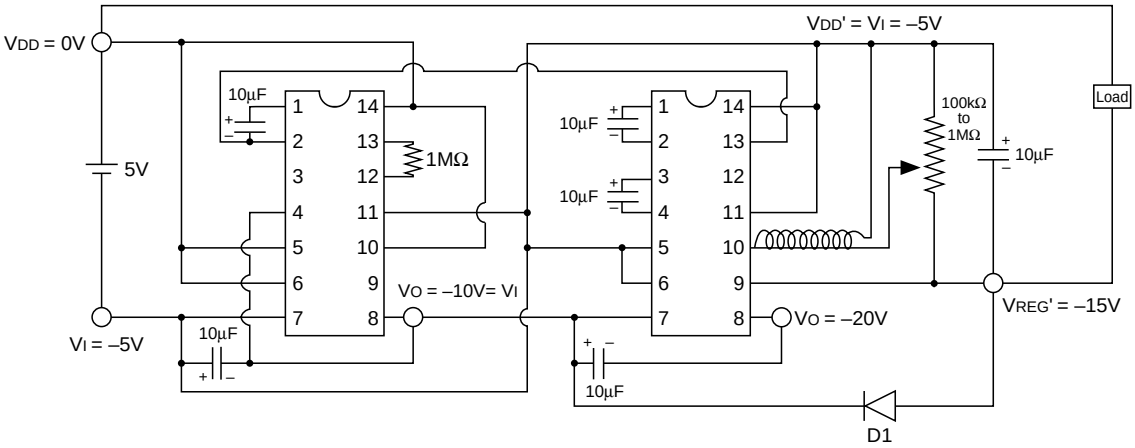
Serial Connection

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 VDD (or other potential of the second stage VDD or up) and the second stage VREG as shown in Fig. 2-13, be cautions about the following point.

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

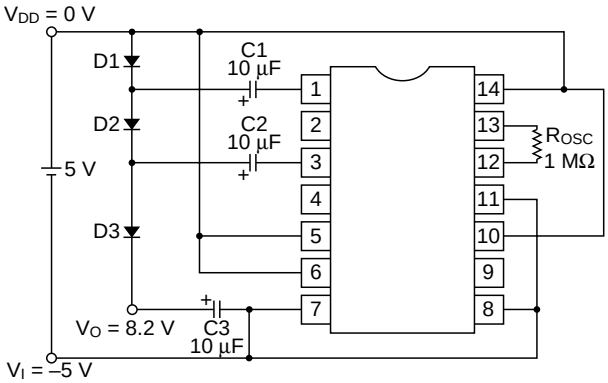


Positive Voltage Conversion

Adding diodes converts a negative voltage to a positive one.

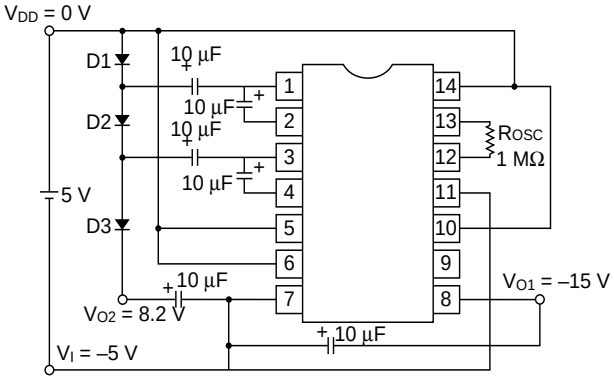
To convert the voltage tripler shown earlier to a voltage doubler, remove C2 and D2, and short circuit D3. Small Schottky diodes are recommended for all these diodes. The resulting voltage is lowered by VF, the voltage drop in the forward direction for each diode used. For example, if VDD = 0V, VI =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

- For a voltage tripler,
  $V_O = 10 - (3 \times 0.6) = 8.2V$
- For a voltage doubler,
  $V_O = 5 - (2 \times 0.6) = 3.8V$



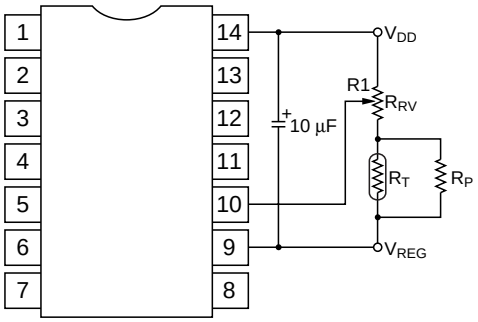
Simultaneous Voltage Conversion

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.

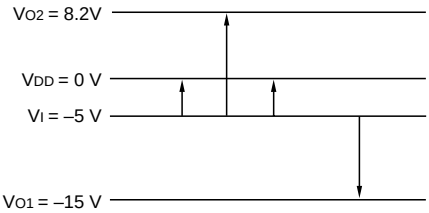


Using an External Gradient

The S1F7661C0B0/M0B0 offers three built-in temperature gradients— –0.1, –0.4 and –0.6%/°C.
To set the gradient externally, place a thermistor, RT, in series with the variable resistor, RRV, used to adjust the output voltage.



Potential levels



S1F76540 Series Charge Pumping DC/DC Converter & Voltage Regulator

DESCRIPTION

The S1F76540C0A0/M0A0 is a CMOS process, charge-pumping DC/DC converter and voltage regulator featuring the very high efficiency but low power consumption. An addition of four, three, or two external capacitors can generate four-, three- or two-time output voltage in negative direction than the input voltage. Also, the built-in voltage regulator can set any output voltage of DC/DC converter and can output the regulated voltage using two external resistances. As the regulator output can have a negative temperature gradient that is required for LCD panels, it is optimum for the LCD panel power supply.

FEATURES

- Charge-pumping, DC-to-DC converter (four-, three- or two-time negative boosting)
- Built-in voltage regulator (regulated voltage output circuit)
- High power conversion efficiency : 95%
- Low current consumption : 130 μA (V_I = –5.0 V during four-time boosting, Typ.)
- High output capacity : 20 mA (Max.)
- Input voltages : –2.4 to –5.5 V (during four-time boosting)
  : 2.4 to –7.3 V (during three-time boosting)
  : 2.4 to –11 V (during two-time boosting)
- DC/DC converter output voltage : |Input voltage| × 4 (Max.)
- Built-in reference voltage for high-precision regulator : 1.5 ± 0.05 V (at C_{T0})
- Temperature gradient function of regulator output voltages : – 0.04, – 0.15, – 0.35, – 0.55 (%/°C)
- Low standby current (during power-off) : 5.0 μA
- Power-off by the external signal
- Full built-in oscillator circuit
- Lineup : S1F76540M0A0, 16-pin SSOP
  : S1F76540C0A0, 16-pin DIP

APPLICATIONS

- Power supply of medium- and small-capacity LCD panels
- Regulated power supply of battery driven devices

BLOCK DIAGRAM

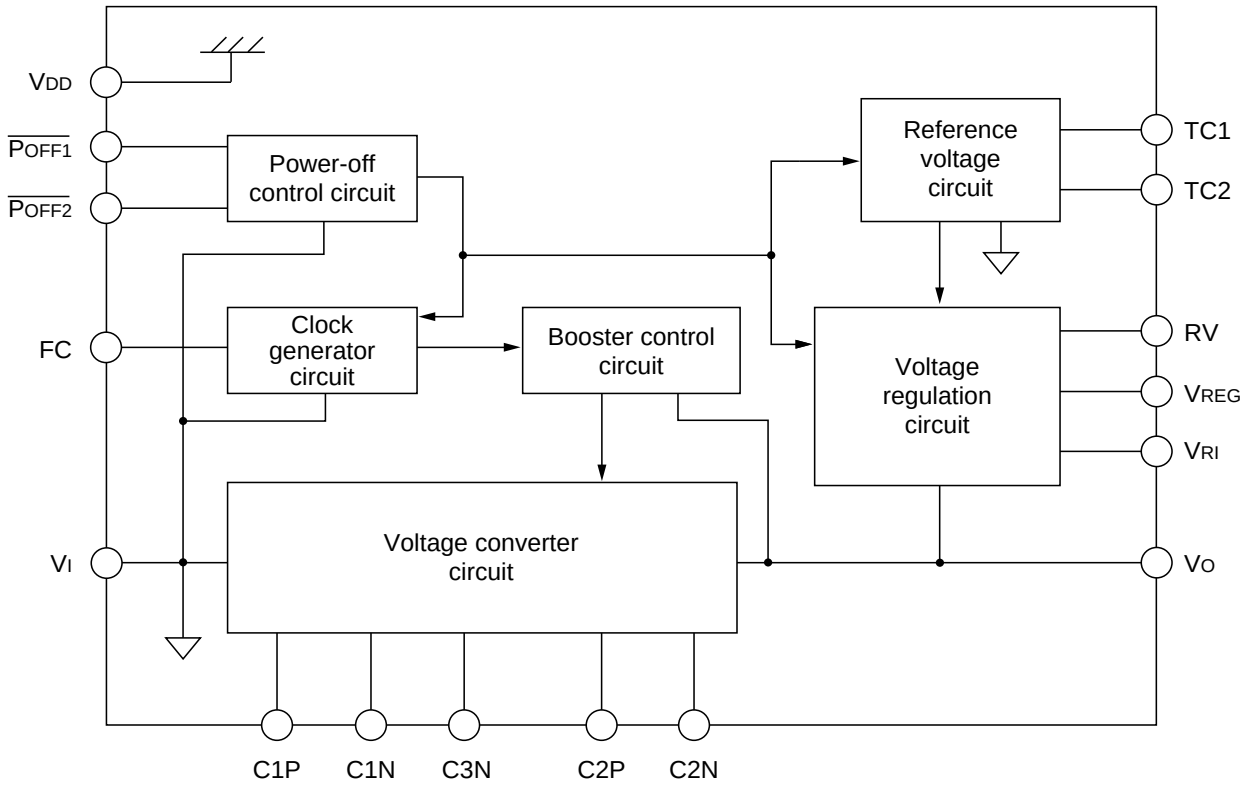


Figure 2.1 Block diagram

PIN DESCRIPTIONS

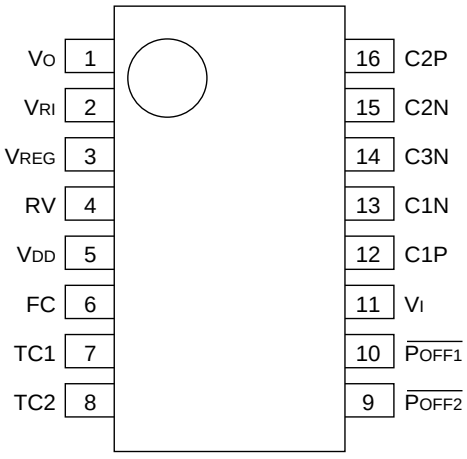


Figure 2.2 S1F76540M0A0/C0A0 pin assignments

Table 2.1 Pin descriptions

Pin name	Pin No.	Pad No.	Description
V_O	1	18	Four-time booster output
V_{RI}	2	19	Regulator input
V_{REG}	3	20	Regulator output
R_V	4	21	Regulator output voltage adjustment input
V_{DD}	5	22, 23	Power pin (positive)
FC	6	24	Internal clock frequency input, and clock input in serial/parallel connection
TC1	7	3	Regulator output temperature gradient setup input (1)
TC2	8	4	Regulator output temperature gradient setup input (2)
$\overline{P_{OFF2}}$	9	5	Power-off control input (2)
$\overline{P_{OFF1}}$	10	6	Power-off control input (1)
V_I	11	11, 12	Power voltage (negative)
C1P	12	13	Two- or four-time booster capacitor positive pin
C1N	13	14	Two-time booster capacitor negative pin
C3N	14	15	Four-time booster capacitor negative pin
C2N	15	16	Three-time booster capacitor negative pin
C2P	16	17	Three-time booster capacitor positive pin

Table 2.2 Absolute maximum ratings

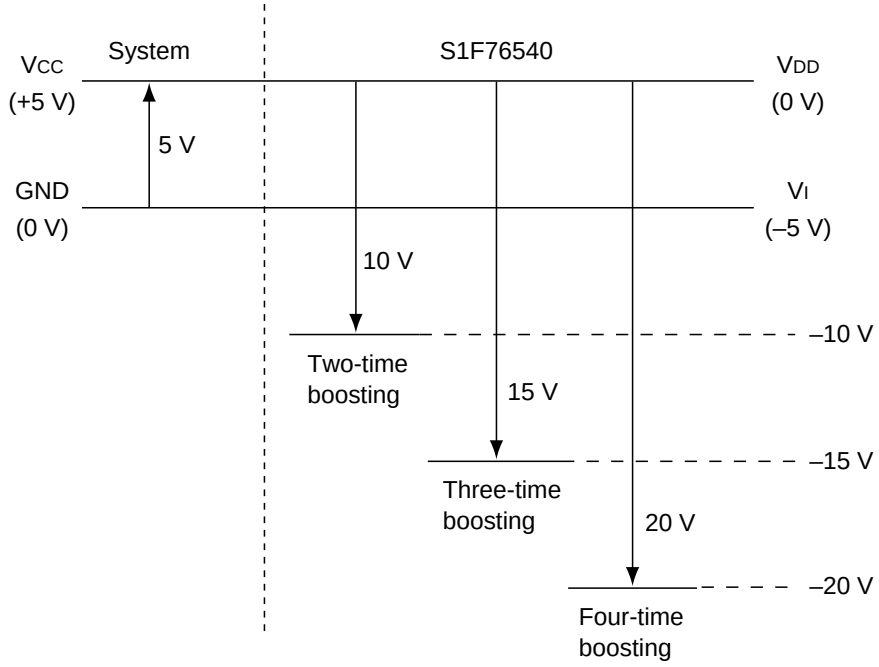
V_{DD} reference

Parameter	Symbol	Rating		Unit	Remarks
		Min.	Max.		
Input power voltage	V_I	–26.0/N	V_{DD} + 0.3	V	N = Boost time V_I pin
Input pin voltage	V_1	V_I – 0.3	V_{DD} + 0.3	V	$\overline{POFF1}$, $\overline{POFF2}$, TC1, TC2 and FC pins
Output pin voltage 1	V_{OC1}	V_I – 0.3	V_{DD} + 0.3	V	C1P and C2P pins
Output pin voltage 2	V_{OC2}	2 × V_I – 0.3	V_I + 0.3	V	C1N pin
Output pin voltage 3	V_{OC3}	3 × V_I – 0.3	2 × V_I + 0.3	V	C2N pin
Output pin voltage 4	V_{OC4}	4 × V_I – 0.3	3 × V_I + 0.3	V	C3N pin
Regulator input power voltage	V_{RI}	N × V_I – 0.3	V_{DD} + 0.3	V	N = Boost time, V_{RI} pin
Regulator input pin voltage	V_{RV}	N × V_I – 0.3	V_{DD} + 0.3	V	N = Boost time, RV pin
Output voltage	V_O	N × V_I – 0.3	V_{DD} + 0.3	V	N = Boost time V_O and V_{REG} pins
Input current	I_I		80	mA	V_I pin
Output current	I_O		N ≤ 4: 20 N > 4: 80/N	mA	N = Boost time V_O and V_{REG} pins
Allowable loss	P_D		210	mW	Ta ≤ 25°C
Operating temperature	Topr	–30	85	°C	
Storage temperature	Tstg	–55	150	°C	
Soldering temperature and time	Tsol		260 • 10	°C • s	At leads

Notes: 1. An operation exceeding the above absolute maximum ratings may cause a malfunction or permanent damage of devices. The device reliability may drop excessively even if the devices temporarily operate normally.

2. Electrical potential to peripheral systems:
The S1F76540 common power supply has the highest potential (V_{DD}). The electrical potential given by this specification is based on V_{DD} = 0 V. Take care to avoid a potential problem during connection to a peripheral system.

Figure 2.3 Potential relationship



ELECTRICAL CHARACTERISTICS

Table 2.3 DC characteristics (1)

Ta = –30°C to +85°C, V_{DD} = 0 V, V_I = –5.0 V unless otherwise noted

Parameter	Symbol	Characteristics	Min.	Typ.	Max.	Unit
Input power voltage	V_I	N = Boost time if CT0 is selected	–22/N		–2.4	V
		N = Boost time if CT1 is selected	–22/N		–2.4	V
		N = Boost time if CT2 is selected	–22/N		–2.4	V
		N = Boost time if CT3 is selected	–22/N		–2.4	V
Boost start input power voltage	V_{STA}	N = Boost time, FC = V_{DD} during no loading	–22/N		–2.4	V
Boost output voltage	V_O		–22			V
Regulator input voltage	V_{RI}		–22		–2.4	V
Regulator output voltage	V_{REG}	I_{REG} = 0, V_{RI} = –22 V R_{RV} = 1MΩ			–2.4	V

Table 2.3 DC characteristics (2)

Ta = –30°C to +85°C, V_{DD} = 0 V, V_I = –5.0 V unless otherwise noted

Parameter	Symbol	Characteristics	Min.	Typ.	Max.	Unit
Boost output impedance	R_O	I_O = 10 mA, V_I = –5.0 V during 4-time boosting C1, C2, C3, C_O = 10 µF (tantalum)		200	300	Ω
		I_O = 10 mA, V_I = –3.0 V, Ta = 25°C during 4-time boosting C1, C2, C3, C_O = 10 µF (tantalum)		250	300	Ω
Boost power conversion efficiency	Peff	I_O = 2 mA, V_I = –5.0 V during 4-time boosting C1, C2, C3, C_O = 10 µF (tantalum)		95		%
		I_O = 2 mA, V_I = –3.0 V, Ta = 25°C during 4-time boosting C1, C2, C3, C_O = 10 µF (tantalum)		94		%
Booster operation current consumption 1	I_{OPR1}	FC = V_{DD}, $\overline{P_{OFF1}}$ = V_I, $\overline{P_{OFF2}}$ = V_{DD}, V_I = –5.0 V during no loading C1, C2, C3, C_O = 10 µF (tantalum)		130	220	µA
		FC = V_{DD}, $\overline{P_{OFF1}}$ = V_I, $\overline{P_{OFF2}}$ = V_{DD}, V_I = –3.0 V, Ta = 25°C during no loading C1, C2, C3, C_O = 10 µF (tantalum)		100	150	µA
Booster operation current consumption 2	I_{OPR2}	FC = V_I, $\overline{P_{OFF1}}$ = V_I, $\overline{P_{OFF2}}$ = V_{DD}, V_I = –5.0 V during no loading C1, C2, C3, C_O = 10 µF (tantalum)		520	880	µA
		FC = V_I, $\overline{P_{OFF1}}$ = V_I, $\overline{P_{OFF2}}$ = V_{DD}, V_I = –3.0 V, Ta = 25°C during no loading C1, C2, C3, C_O = 10 µF (tantalum)		400	600	µA
Regulator operation current consumption	I_{OPVR}	V_{RI} = –20 V, R_{RV} = 1 MΩ during no loading		10	15	µA
Static current	I_Q	$\overline{P_{OFF1}}$ = V_I, $\overline{P_{OFF2}}$ = V_I FC = V_{DD}			5.0	µA
Input leakage current	I_{LKI}	Pins used: $\overline{P_{OFF1}}$, $\overline{P_{OFF2}}$, FC, TC1, TC2			0.5	µA
Regulated output saturation resistance	R_{SAT} (*1)	0 < I_{REG} < 20 mA R_V = V_{DD} Ta = 25°C		10	20	Ω
Regulated output voltage stability	ΔV_R (*2)	–20 V < V_{RI} < –10 V, I_{REG} = 1 mA V_{REG} = –9 V Ta = 25°C			0.2	%/V

Table 2.3 DC characteristics (3)

Ta = –30°C to +85°C, V_{DD} = 0 V, V_I = –5.0 V
unless otherwise noted

Parameter	Symbol	Characteristics	Min.	Typ.	Max.	Unit
Regulated output load variation	ΔV_O (*3)	V_{RI} = –20 V, V_{REG} = –15 V, Ta = 25°C setup, 0 < I_{REG} < 20 mA		30	50	mV
Reference voltage (Ta = 25°C)	V_{REF0}	TC1 = V_{DD}, TC2 = V_{DD}	–1.55	–1.50	–1.45	V
	V_{REF1}	TC1 = V_{DD}, TC2 = V_I	–1.70	–1.50	–1.30	V
	V_{REF2}	TC1 = V_I, TC2 = V_{DD}	–1.90	–1.50	–1.10	V
	V_{REF3}	TC1 = V_I, TC2 = V_I	–2.15	–1.50	–0.85	V
Reference voltage temperature coefficient (*4, *5)	C_{T0}	TC1 = V_{DD}, TC2 = V_{DD}, SSOP product	–0.07	–0.04	0	%/°C
	C_{T1}	TC1 = V_{DD}, TC2 = V_I, SSOP product	–0.25	–0.15	–0.07	%/°C
	C_{T2}	TC1 = V_I, TC2 = V_{DD}, SSOP product	–0.45	–0.35	–0.20	%/°C
	C_{T3}	TC1 = V_I, TC2 = V_I, SSOP product	–0.75	–0.55	–0.30	%/°C
Input voltage level	V_{IH}	V_I = –2.4 to –5.5 V, Pins used: $\overline{P_{OFF1}}$, $\overline{P_{OFF2}}$, FC, TC1, TC2	0.2 V_I			V
	V_{IL}	V_I = –2.4 to –5.5 V, Pins used: $\overline{P_{OFF1}}$, $\overline{P_{OFF2}}$, FC, TC1, TC2			0.8 V_I	V
Booster capacitance	CMAX	Capacitors used: C1, C2 and C3			47	µF

*1 $$R_{SAT} = \frac{\Delta (V_{REG} - V_{RI})}{\Delta I_{REG}}$$

*2 $$\Delta V_R = \frac{V_{REG} (V_{RI} = -20\ V) - V_{REG} (V_{RI} = -10\ V)}{\Delta V_{RI} \bullet V_{REG} (V_{RI} = -10\ V)}$$

*3 $$\Delta V_O = \frac{V_{REG} (I_{REG} = 20\ mA) - V_{REG} (I_{REG} = 0\ mA)}{\Delta I_{REG}}$$

*4 $$C_T = \frac{|\ V_{REF} (50°C)\ | - |\ V_{REF} (0°C)\ |}{50°C - 0°C} \times \frac{100}{|\ V_{REF} (25°C)\ |}$$

*5 The reference voltage and temperature coefficient of the chip products may vary depending on the moldings used on each chip. Use these chips only after the temperature test.

Table 2.4 AC characteristics

V_{DD} = 0 V and V_I = –5.0 V
unless otherwise noted

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Internal clock frequency 1	f_{CL1}	FC = V_{DD}, $\overline{P_{OFF1}}$ = V_I, $\overline{P_{OFF2}}$ = V_{DD} Pin used: C1P	Ta = 25°C	3.0	4.0	6.0	kHz
			Ta = –30°C to +85°C	2.0	4.0	7.0	kHz
Internal clock frequency 2	f_{CL2}	FC = V_I, $\overline{P_{OFF1}}$ = V_I, $\overline{P_{OFF2}}$ = V_{DD} Pin used: C1P	Ta = 25°C	12.0	16.0	24.0	kHz
			Ta = –30°C to +85°C	8.0	16.0	28.0	kHz

FUNCTIONAL DESCRIPTIONS

Clock Generator Circuit

As the S1F76540 has a built-in clock generator circuit, no more parts are required for voltage boost control. The clock frequency changes according to the FC pin voltage level as defined on Table 2.5. Low Output mode or High Output mode is selectable. This allows frequency selection according to the used capacitance and load current as the boost output impedance changes depending on the clock frequency and external booster capacitance. However, the High Output mode has the current consumption approximately four times larger than the Low Output mode.

Table 2.5 FC pin setup

FC pin	Mode	Clock frequency	Characteristics			
			Current consumption	Output ripple	Output impedance	Capacitance
High (V_{DD})	Low Output	4.0 kHz (Typ.)	I_{OP} (*1)	V_{RR} (*2)	See Figure A1.	See Figure A1.
Low (V_I)	High Output	16.0 kHz (Typ.)	I_{OP} × Approx. 4	V_{RI} × Approx. 1/4	See Figure A1.	See Figure A1.

*1 See the DC characteristics table for current consumption.
*2 See Section Page 2-32 for the output ripple definition and calculation.

Capacitance vs. output impedance characteristic when 4X pressure is applied
Load current = 10 mA, Ta = 25°C, C1 = C2 = $C_{\bar{0}}$
Capacitor used: Tantalum electrolytic capacitor

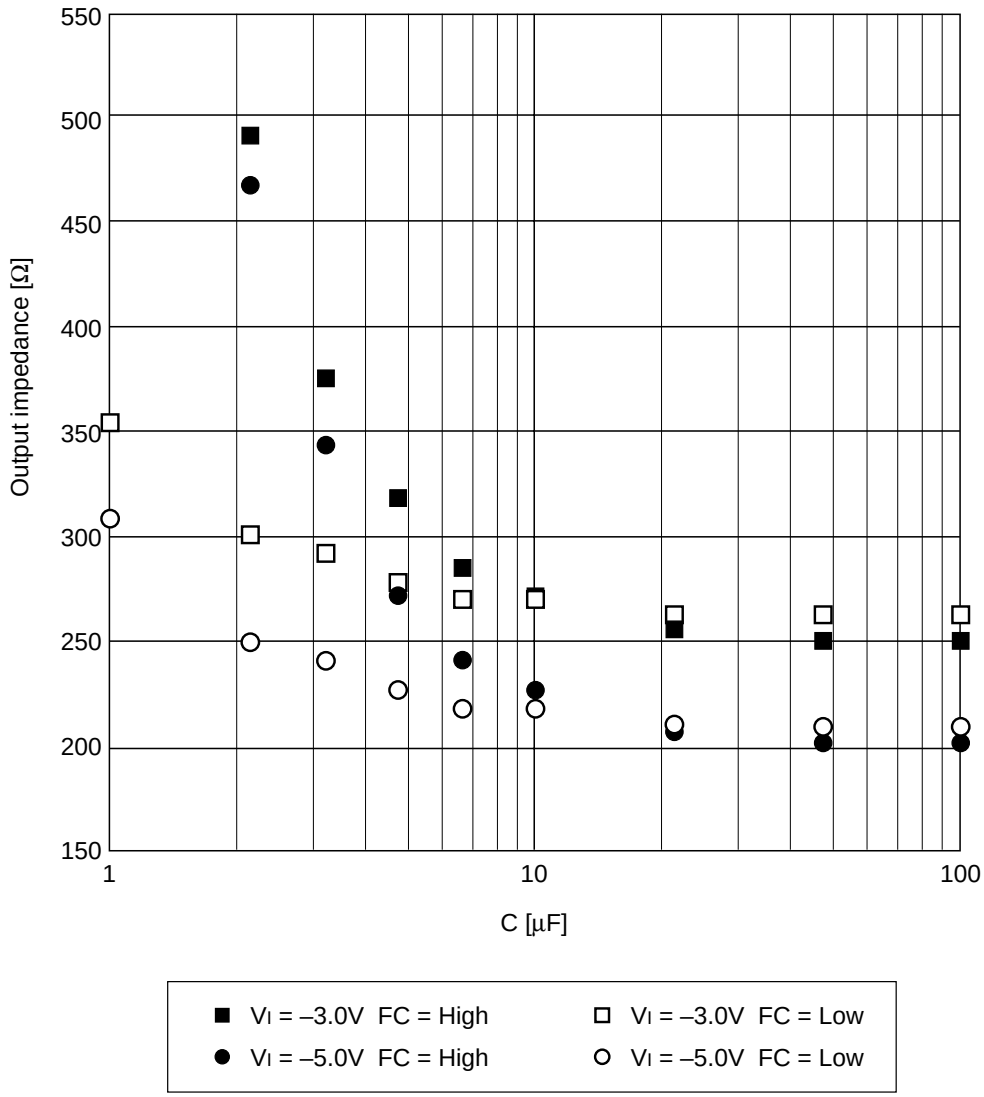


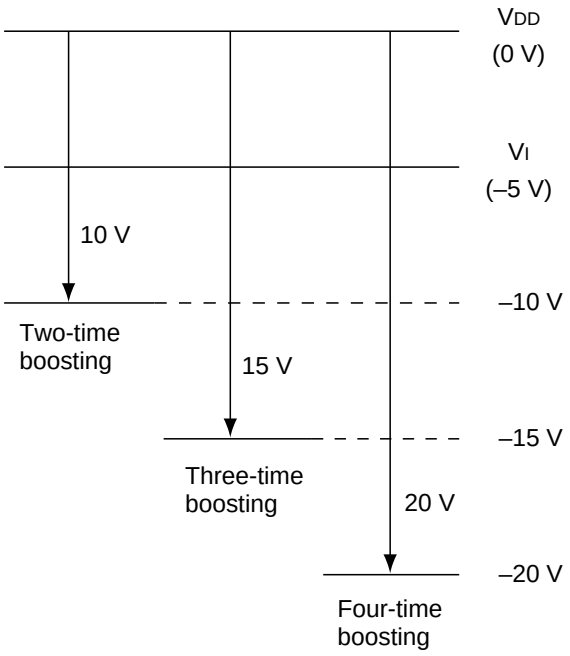
Figure A1 Characteristic chart: Capacitance vs. output impedance when 4X pressure is applied

NOTE: This characteristic chart simply indicates an approximate trend in the characteristics, which may vary depending on evaluation environment, parts used, and other factors.

Voltage Converter

The voltage converter, consisting of a boost control circuit and a voltage converter circuit, receives clocks from the clock generator circuit and boosts the input power voltage (V_I) four, three or two times. During four-time boosting, however, the three-time and two-time boost outputs cannot be obtained simultaneously. Figure 2.4 gives the potential relationship during four-, three- and two-time boosting. The C2P pin is also used as the master clock output during parallel connection.

Figure 2.4 Electrical potentials during boosting (at –5V input)



Caution:

- When connecting a capacitor to the C1P, C2P, C1N, C2N, C3N, or V_O pin for voltage conversion, close the capacitor to the IC package as much as possible to minimize the wiring length.

Reference Voltage Circuit

The S1F76540 has a built-in reference voltage circuit for voltage regulation. The regulated voltage (explained in the next "voltage regulator circuit" section) is set depending on the division ratio between this reference voltage and the external resistance. The reference voltage can be used to change the temperature coefficient at pins TC1 and TC2. One of four states can be selected as listed on Table 2.6.

Table 2.6 Setup of reference voltage and temperature coefficient

Mode	TC1 (High = V_{DD}) (Low = V_I)	TC2 (High = V_{DD}) (Low = V_I)	Reference voltage, V_{REF} (V)			Temperature coefficient, C_T (%/°C)		
			Min.	Typ.	Max.	Min.	Typ.	Max.
C_{T0}	High	High	–1.55	–1.5	–1.45	–0.07	–0.04	0
C_{T1}	High	Low	–1.70	–1.5	–1.30	–0.25	–0.15	–0.07
C_{T2}	Low	High	–1.90	–1.5	–1.10	–0.45	–0.35	–0.20
C_{T3}	Low	Low	–2.15	–1.5	–0.85	–0.75	–0.55	–0.30

Notes: 1. The reference voltage is given at Ta = 25°C.
2. The reference voltage and temperature coefficient of the chip products may vary depending on the moldings used on each chip. Use these chips only after the temperature test.

The temperature coefficient (C_T) is defined by the following equation. The negative sign of the temperature coefficient (C_T) means that the $|V_{REF}|$ value decreases when the temperature rises.

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

Notes on TC1 and TC2 pin replacement:
- When replacing the TC1 and TC2 pins after power-on, always select the power-off mode ($\overline{P_{OFF1}} = \overline{P_{OFF2}} = V_I$) and replace them by each other.

Voltage Regulator Circuit

The voltage regulator circuit regulates a voltage entered in the V_{RI} pin and can output any voltage. It uses the series voltage regulation. As shown in Figure 2.5, the V_{RI} and V_O pins must be short-circuited by a jumper as short as possible except for larger time boosting by using external diodes.

As shown by equation (1), any output voltage can be set by the ratio of external division resistors R1 and R2. The sum of division resistance is recommended to be small as possible to avoid an external noise interference. As the current consumed by division resistors (equation (2)) flows, the 100Ω to 1MΩ are recommended to use.

The temperature coefficient of the regulated voltage is equal to the temperature coefficient of the reference voltage that is explained in the "reference voltage circuit" section.

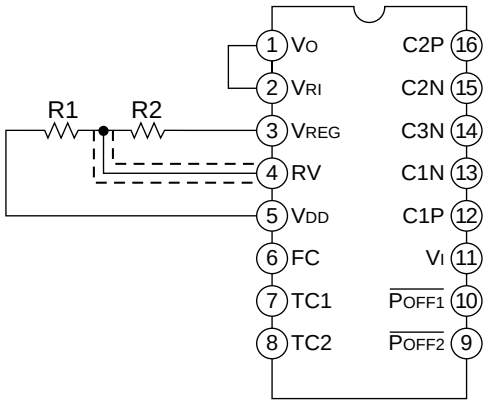


Figure 2.5 V_{REG} setup and mounting notes

Setup:

- Relationship between V_{REG} and reference voltage

$$V_{REG} = \frac{R1 + R2}{R1} \times \text{(Reference voltage)} \quad \cdots\cdot \text{Equation (1)}$$

- Current consumption of division resistors

$$I_{REG} = \frac{|V_{REG}|}{R1 + R2} \quad \cdots\cdot \text{Equation (2)}$$

Setup example:

- To output V_{REG} = –18 V by four-time boosting if V_I = –5 V and V_O = –20 V

First, determine the total resistance of division resistors R1 and R2. If the current consumption is assumed to be 20 μA, the total resistance can be obtained from equation (2) as follows:

$$R1 + R2 = 12V \div 20\ \mu A = 900\ k\Omega$$

If the reference voltage is -1.5 V, the division resistance ratio can be obtained from equation (1) as follows:

$$(R1 + R2) / R2 = (-18\ V) \div (-1.5\ V) = 12$$

Therefore, R1 and R2 are:

$$R1 = 75\ k\Omega$$
$$R2 = 825\ k\Omega$$

Changing the temperature coefficient:

- The temperature coefficient of the regulated voltage depends on the temperature coefficient of the reference voltage (if the division ratio of setup resistors does not depend on the temperature). It is necessary to change the temperature coefficient using thermistors, resistors or others to set any other temperature coefficient of the regulated voltage. The following explains how to calculate the VREG voltage in temperature T.

$$V_{REG}(T) = \left\{1 + \frac{C_{TR2} \times R2(T_0)}{C_{TR1} \times R1(T_0)}\right\} \times \left[1 + (T - T_0) \times \frac{C_T}{100}\right] \quad \cdots\cdot \text{Equation (3)}$$

T_0	: 25°C
C_{TR1}	: Temperature coefficient of resistor R1 (Ratio to the value at 25°C)
C_{TR2}	: Temperature coefficient of resistor R2 (Ratio to the value at 25°C)
C_T	: Temperature coefficient of internal reference voltage (%/°C)
R1 (T_0)	: R1 value (Ω) at 25°C
R2 (T_0)	: R2 value (Ω) at 25°C
V_{REF} (T_0)	: Internal reference voltage (V) at 25°C

If the temperature coefficient of R1 and R2 is identical in equation (3), the VREG voltage depends on the temperature coefficient of internal reference voltage only.

Application notes on voltage regulator circuit:

- To satisfy the absolute maximum ratings of the S1F76540, the setup resistor(s) must be inserted between VDD and VREG pins of the S1F76540 that uses the voltage regulator. The S1F76540 IC itself may be degraded or destroyed if the R1 resistor is connected to pin VDD of S1F76540 that does not use the regulator during serial connection.
- The regulation voltage adjustment input (pin RV) has the very high input impedance, and its noise insertion can drop the regulator stability. As shown in Figure 2.5, shield the cable between the division resistor and RV pin or use a cable as short as possible between them.

Power-off Control Function

The S1F76540 has the power-off function and turns on or off each circuit function when control signals are entered in the $\overline{\text{POFF1}}$ and $\overline{\text{POFF2}}$ pins from an external system (such as microprocessor) as defined on Table 2.7. This power-off function can also cut the reactive current in parallel connection and other application circuits. To use the dual-state, power-off control (all ON and all OFF states) only, connect pin $\overline{\text{POFF2}}$ to pin VI and use only pin $\overline{\text{POFF1}}$ for power-off control.

Table 2.7 Available combination of power-off control

Mode	$\overline{\text{POFF1}}$ (High = VDD) (Low = VI)	$\overline{\text{POFF2}}$ (High = VDD) (Low = VI)	Functions			
			Oscillator	Booster circuit	Regulator circuit	Applications
PS1	High	Low	ON	ON	ON	All circuits are turned on.
PS2	Low	Low	OFF	OFF (*1)	OFF (*2)	All circuits are turned off.
PS3	High	High	OFF	ON	ON	Slave unit side of parallel connection (Booster and regulator)
PS4	Low	High	ON	ON	OFF	Master unit side of parallel connection (Booster only)

*1 When the booster circuit is off, approximately VI + 0.6 V voltage appears at VO pin.
*2 When the regulator is off, the VREG pin becomes high-impedance state.

Application notes on power-off function:

- When using external system signals for power-on control, start to control the power only when VI voltage becomes stable after power-on. Unstable VI voltage may destroy the IC permanently during on/off control.

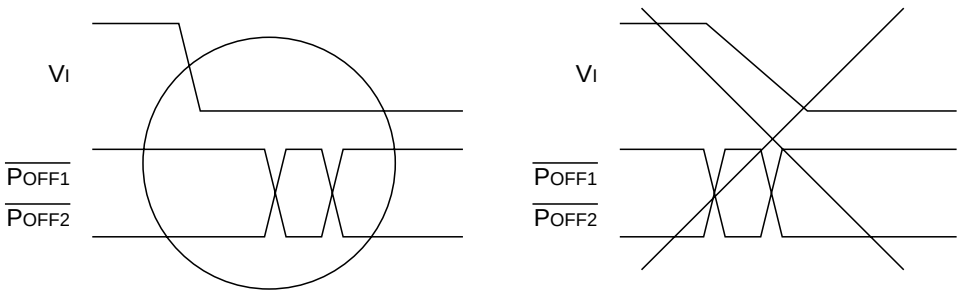
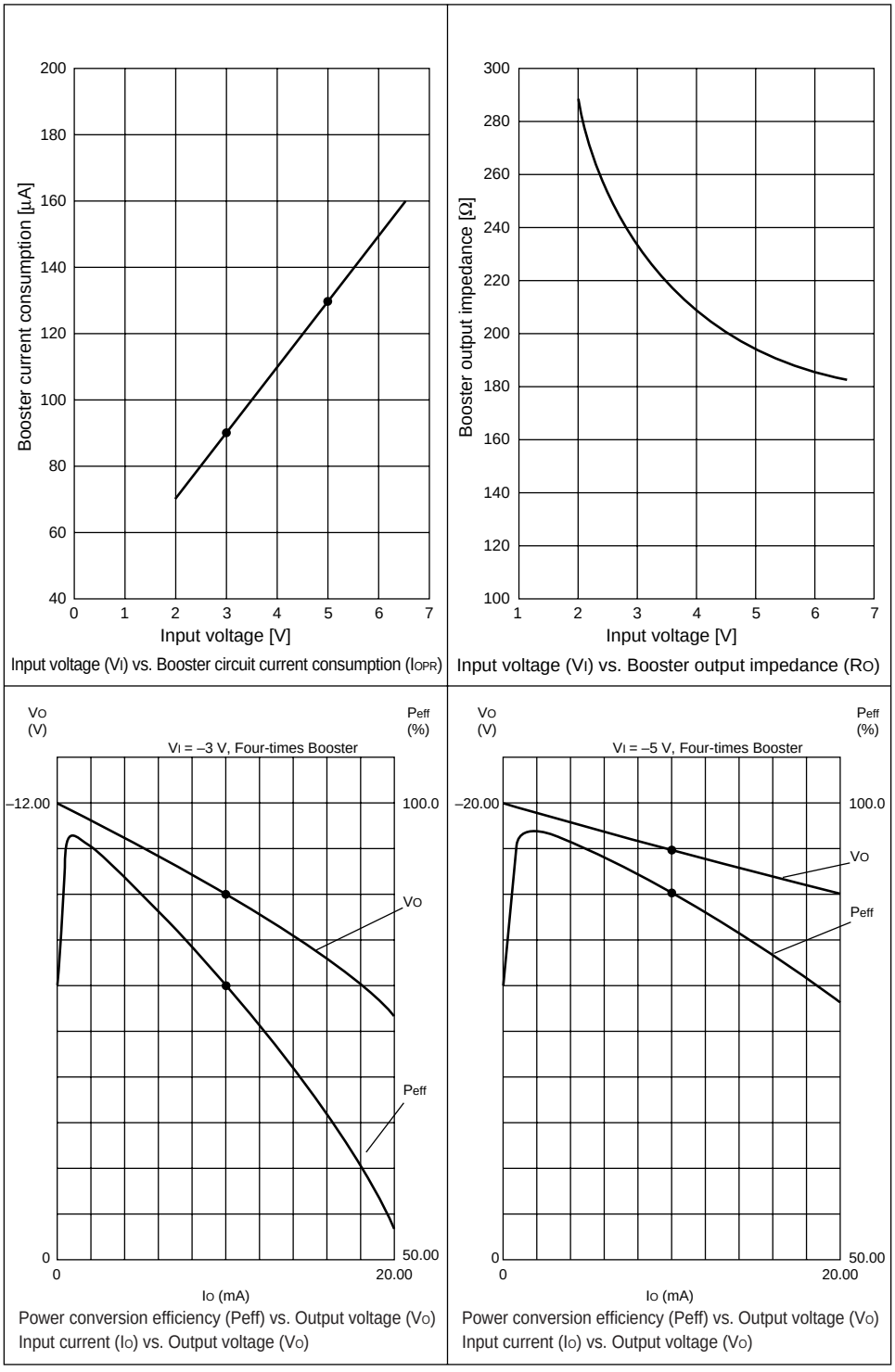


Figure 2.6 Start timing of power-off control

CHARACTERISTICS GRAPH



Input voltage (VI) vs. Booster circuit current consumption (IOPR)

Input voltage (VI) vs. Booster output impedance (RO)

Power conversion efficiency (Peff) vs. Output voltage (VO)
Input current (IO) vs. Output voltage (VO)

Power conversion efficiency (Peff) vs. Output voltage (VO)
Input current (IO) vs. Output voltage (VO)

Figure 2.7 Characteristics graphs

APPLICATION CIRCUIT EXAMPLES

Four-time Booster and Regulator

Figure 2.8 gives a wiring example of four-time booster and regulator that is the typical S1F76540 application. This example boosts the input voltage (V_I) four times in negative direction, and outputs the regulated voltage at V_{REG} pin.

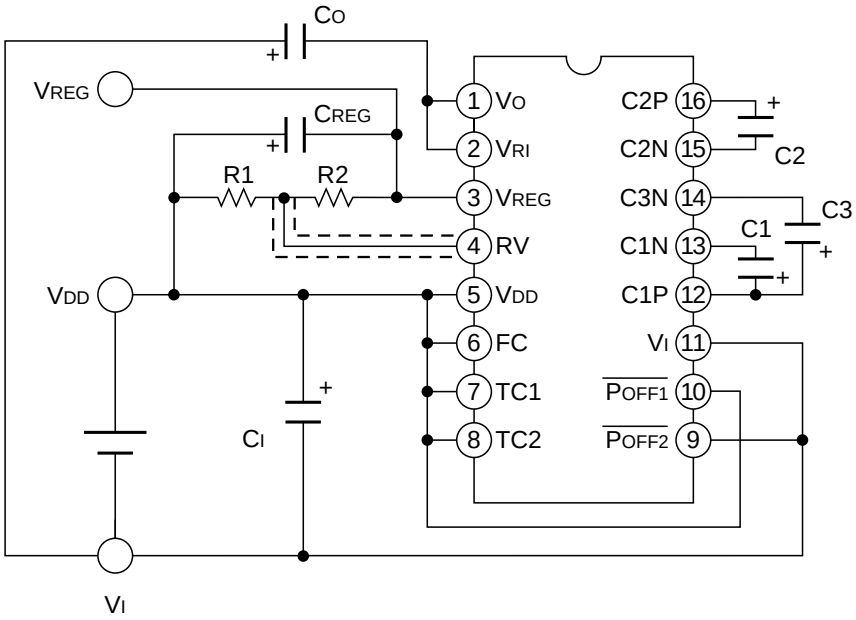


Figure 2.8 Wiring example of 4-time booster and regulator

◊ Setup conditions of Figure 2.8
- Internal clock : ON (Low Output mode)
- Booster circuit : ON
- Regulator : ON (if C_T = –0.04%/°C)

◊ Power-off procedure
- Set the $\overline{POFF1}$ pin to logical low (V_I) to turn off all circuits.

◊ Regulator
- For the regulator setup and notes, see the “voltage regulator circuit” section.

◊ Application in other setup conditions

① When used in the High Output mode
- Connect the FC pin to the V_I pin.

② When changing the temperature coefficient (C_T)
- Change the TC1 and TC2 pin setup by following the definition of Table 2.7.

4-time Booster

Only the booster circuit operates, and it boosts the input voltage (V_I) four times in negative direction and outputs it at the V_O pin. As the regulator is not used, the voltage appearing at the V_O pin may contain ripple components. Figure 2.9 gives a wiring example.

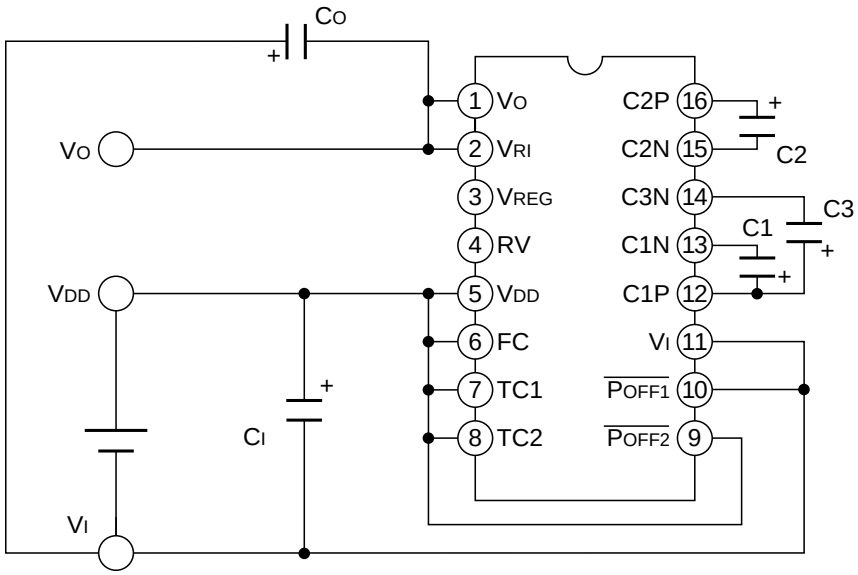
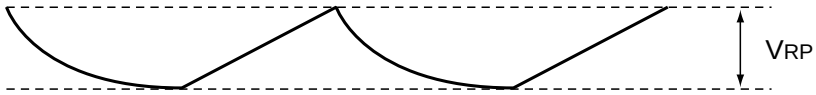


Figure 2.9 Wiring example of 4-time booster

◊ Setup conditions of Figure 2.9
- Internal clock : ON (Low Output mode)
- Booster circuit : ON
- Regulator : OFF

◊ Power-off procedure
- Set the $\overline{P_{OFF2}}$ pin to low (V_I) to turn off all circuits.

◊ Ripple voltage
- As the output at V_O pin is unstable, it can contain ripple components as shown in Figure 2.10. The ripple voltage (V_{RP}) increases according to the load current, and it can roughly be calculated by equation (4).



$$V_{RP} = \frac{I_O}{2 \cdot f_{CL} \cdot C_O} + I_O \cdot R_{COUT} \qquad \cdots\cdot \text{Equation (4)}$$

where,
I_O : Load current (A)
f_{CL} : Clock frequency (Hz)
R_{COUT} : Serial equivalent resistance (Ω) of output capacitor C_O

Figure 2.10 Ripple waveforms

◊ Application in other setup conditions
① When used in the High Output mode
Connect the FC pin to the VI pin.

Parallel Connection (for Increased Boosting)

The parallel connection is useful for reduction of booster output impedance or reduction of ripple voltage. In the parallel connection of "n" lines, the booster output impedance can be reduced to approximately "1/n". Only the smoothing capacitor (C_O) for booster output can be used commonly in the parallel connection. When using the regulator, use only one of "n" S1F76540 chips which are in parallel connection. (If multiple regulators are operated in parallel mode, the reactive current consumption occurs.) Figure 2.11 gives a wiring example of 4-time booster and regulator where two S1F76540s are parallelly connected.

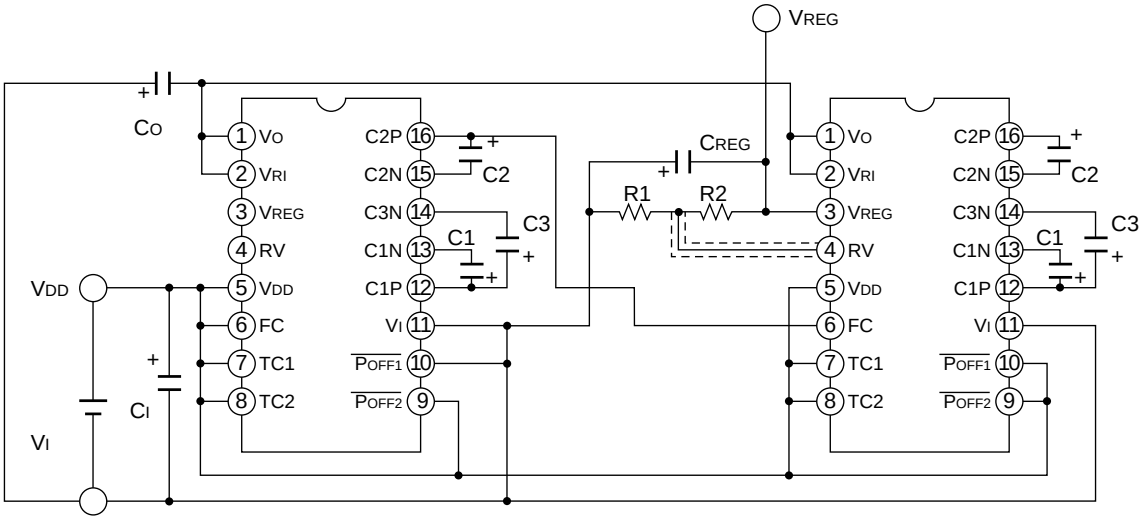


Figure 2.11 Parallel connection example

◊ Setup conditions of Figure 2.11

	First stage	Second stage
• Internal clock	: ON (Low Output mode)	: OFF
• Booster circuit	: ON	: ON
• Regulator	: OFF	: ON (if C_T = –0.04%/°C)

◊ Power-off procedure

- In Figure 2.11, when the $\overline{P_{OFF2}}$ pin of the first-stage S1F76540 is set to low (V_I), voltage boosting is stopped at the first and second stages. However, the regulator at the second stage does not stop. Therefore, the voltage that is approximately V_I appears at V_{REG} pin during $|V_{REG}| > |V_I|$ setup.
- To set the V_{REG} pin to high-impedance state, set both $\overline{P_{OFF1}}$ and $\overline{P_{OFF2}}$ pins to low at the first and second stages.

◊ Application in other setup conditions

① When used in the High Output mode
- Connect the FC pin of the first-stage S1F76540 to the V_I pin.

② When changing the temperature coefficient (C_T)
- Change the TC1 and TC2 pin setup by following the definition of Table 2.7.

Larger Time Boosting Using Diodes

The S1F76540 can be configured to have the five-time or larger voltage boosting and regulation by adding external diodes. As the booster output impedance increases due to the diode forward voltage drop (V_F), the diodes having a smaller V_F are recommended to use.

Figure 2.12 gives a wiring example of 6-time booster and regulator that use two diodes. The wiring between V_O and V_{RI} must be minimal. Figure 2.13 provides the potential relationship.

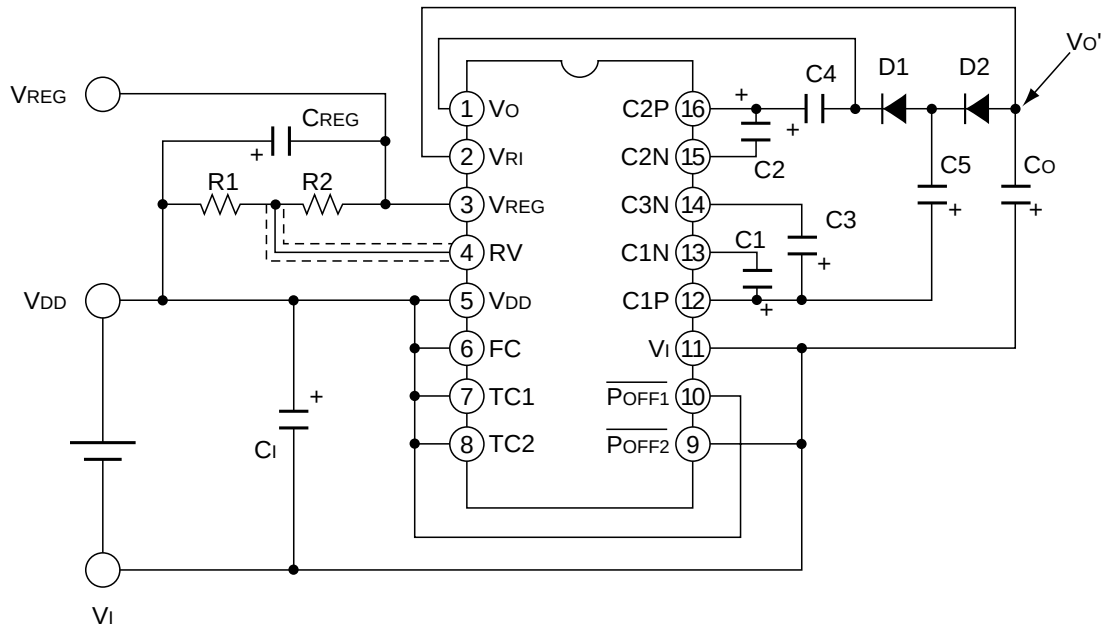


Figure 2.12 Wiring example for 6-time boosting using diodes

◊ Setup conditions of Figure 2.12
- Internal clock : ON (Low Output mode)
- Booster circuit : ON
- Regulator : ON (if C_T = –0.04%/°C)

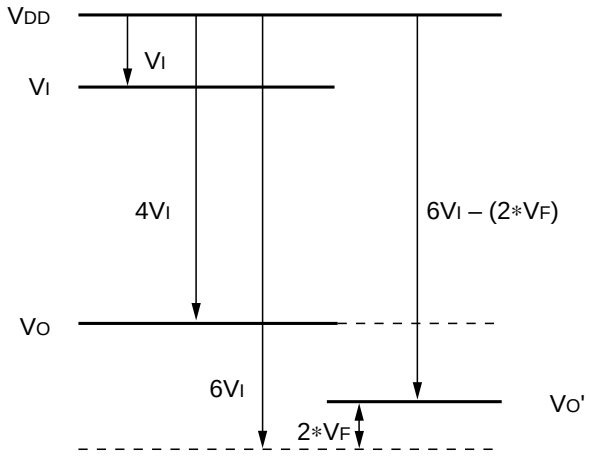


Figure 2.13 Potential relationship during 6-time boosting using diodes

◊ Power-off procedure
- Set the $\overline{POFF1}$ pin to low (V_I) to turn off all circuits.

◊ Output voltages
- When diodes are used for voltage boosting, the characteristics of diodes directly affect on the voltage boosting characteristics. The forward voltage drop (V_F) of diodes can reduce the booster output voltage. As the example of Figure 2.12 uses two diodes, the drop of "V_F" voltage multiplied by two occurs as shown in Figure 2.13. The booster output voltage is expressed by equation (5).
  To increase the $|V_O'|$ value, use the diodes having a smaller V_F.

$$|V_O'| = 6 \times |V_I| - 2 \times V_F \quad \text{• • • • Equation (5)}$$

◊ Notes

① Input and output current conditions
To satisfy the input and output current ratings, limit the total current does not exceed the rated input current. The total current means the total boost time multiplied by the output load current. The example of Figure 2.12 has the maximum load current of 13.3 mA (= 80 mA divided by 6).

② Input and output voltage conditions
To satisfy the input and output voltage ratings, take care not to violate the electric potential relationship of higher time boosting using diodes. The example of Figure 2.12 must have the "V_I" that can satisfy the input voltage conditions during 6-time boosting (see Table 2.3).

◊ Application in other setup conditions

① When used in the High Output mode
Connect the FC pin to the V_I pin.

② When changing the temperature coefficient (C_T)
Change the TC1 and TC2 pin setup by following the definition of Table 2.7.

Positive Voltage Conversion

The S1F76540 can also boost up a voltage to the positive potential using external diodes. In such case, however, the regulator function is unavailable. Figure 2.14 gives a wiring example for three-time positive boosting, and Figure 2.15 provides its electrical potential relationship.

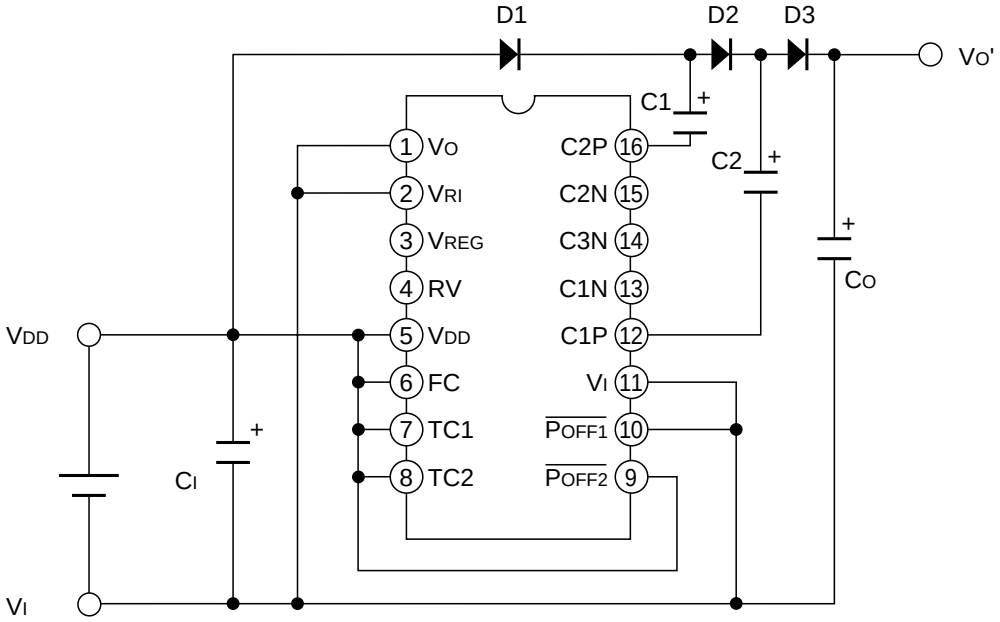


Figure 2.14 Wiring example of positive voltage conversion (3-time boosting)

◊ Setup conditions of Figure 2.14
- Internal clock : ON (Low Output mode)
- Booster circuit : ON
- Regulator : OFF

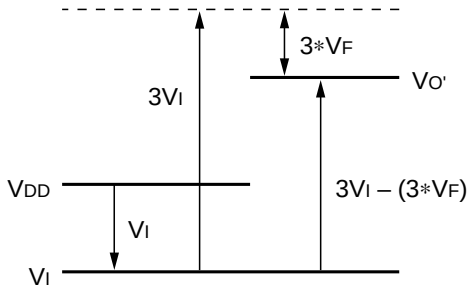


Figure 2.15 Potential relationship during positive voltage conversion (3-time boosting)

◊ Power-off procedure
- Set the $\overline{\text{POFF2}}$ pin to low (V_I) to turn off all circuits.

◊ Two-time boosting
- To boost up a voltage two times, remove capacitor C1 and diode D1 of Figure 2.14, and connect the anode of diode D2 to the V_{DD} pin.

◊ Output voltages
- When diodes are used for voltage boosting, the characteristics of diodes directly affect on the voltage boosting characteristics. The forward voltage drop (V_F) of diodes can reduce the booster output voltage. As the example of Figure 2.14 uses three diodes, the drop of "V_F" voltage multiplied by three occurs. The booster output voltage is expressed by equation (5).
  To increase the $|V_O'|$ value, use the diodes having a smaller V_F.

$$|V_O'| = 3 \times |V_I| - (3 \times V_F) \quad \cdots\cdots \text{Equation (6)}$$

◊ Notes
① Input and output current conditions
To satisfy the input and output current ratings, take care to limit the input current below the ratings.
② Input and output voltage conditions
During forward voltage conversion, the input voltage ratings are the same as two-time negative voltage boosting (see Table 2.3).

◊ Application in other setup conditions
When used in the High Output mode, connect the FC pin to the V_I pin.

Wiring Example When Changing the Regulator Temperature Coefficient

The temperature coefficient of the regulator depends on the temperature coefficient of the internal reference voltage. To set another temperature coefficient, use a thermistor resistor or others as shown in Figure 2.16.

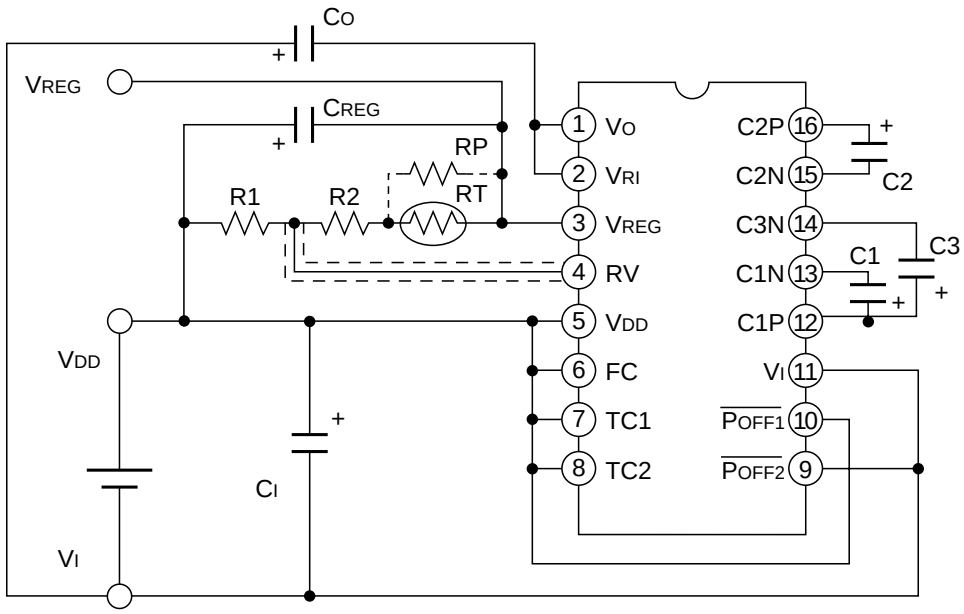


Figure 2.16 Wiring example when changing the regulator temperature coefficient

◊ Setup conditions of Figure 2.16
- Internal clock : ON (Low Output mode)
- Booster circuit : ON
- Regulator : ON
- Thermistor resistor : RT

◊ Power-off procedure
- Set the $\overline{\text{POFF1}}$ pin to low (V_I) to turn off all circuits.

◊ Regulator temperature coefficient
- For the regulator setup and notes, see the "voltage regulator circuit" section of the function.
- The thermistor resistor (RT) has the non-linear temperature characteristics. To correct them to the linear characteristics, insert the RP as shown Figure 2.16.

◊ Application in other setup conditions
- When used in the High Output mode, connect the FC pin to the V_I pin.

S1F76640 Series CMOS DC/DC Converter & Voltage Regulator

DESCRIPTION

S1F76640 is a high efficiency and low power consumption CMOS DC/DC converter. It is roughly divided into two portions, step-up circuit and stabilization circuit. The step-up circuit can provide 2 times step-up outputs (3.6 to 11V), 3 times step-up outputs (5.4 to 16.5V) or 4 times step-up outputs (7.2 to 22V) of input voltages (1.8 to 5.5V). If external parts (diode, capacitor) are attached to it, it can realize step-up operations of higher magnifications.

The stabilization circuit enables to set outputs to any voltages. Since the stabilization circuit can provide three kinds of minus temperature gradients to stabilized outputs, it is optimum as a power supply for liquid crystal display (LCD).

Also, S1F76640 enable to drive ICs (liquid crystal driver, analog IC, etc.), which requires another power supply in addition to logic main power supply, with a single power supply. Also, its small power consumption makes it suitable as a micro power supply for handy devices like hand-held computer.

FEATURES

- High efficiency and low power consumption CMOS DC/DC converter
- Easy three kinds voltage conversions to positive potential side from input voltage V_{DD} (+3.3V)
  . From input voltage V_{DD} (+3.3V) to outputs $2\times V_{DD}$ (+6.6V), $3\times V_{DD}$ (+9.9V) and $4\times V_{DD}$ (+13.2V).
- Attachment of external parts (diode, capacitor) makes step-up operations of higher magnifications possible.
- Built-in output voltage stabilization circuit
  · External resistor enables to set any output voltages.
- Output current : Max. 20mA(V_{DD}=+5V)
- Power conversion efficiency : Typ. 95%
- 3 kinds of reference voltages with negative temperature gradient characteristic suitable for LCD drive power supply can be selected.
- Power off operation by external signal
  · Static current at power off time : Max. 2μA
- Possibility of high magnification step-up operation by series connection
- Low voltage operation .... Optimum for battery drive
- Built-in CR oscillator
- SSOP2-16pin S1F76640M0A0
  Bare Chip S1F76640D0A0
- Radiation-resistant design has not been provided for this specification.

BLOCK DIAGRAM

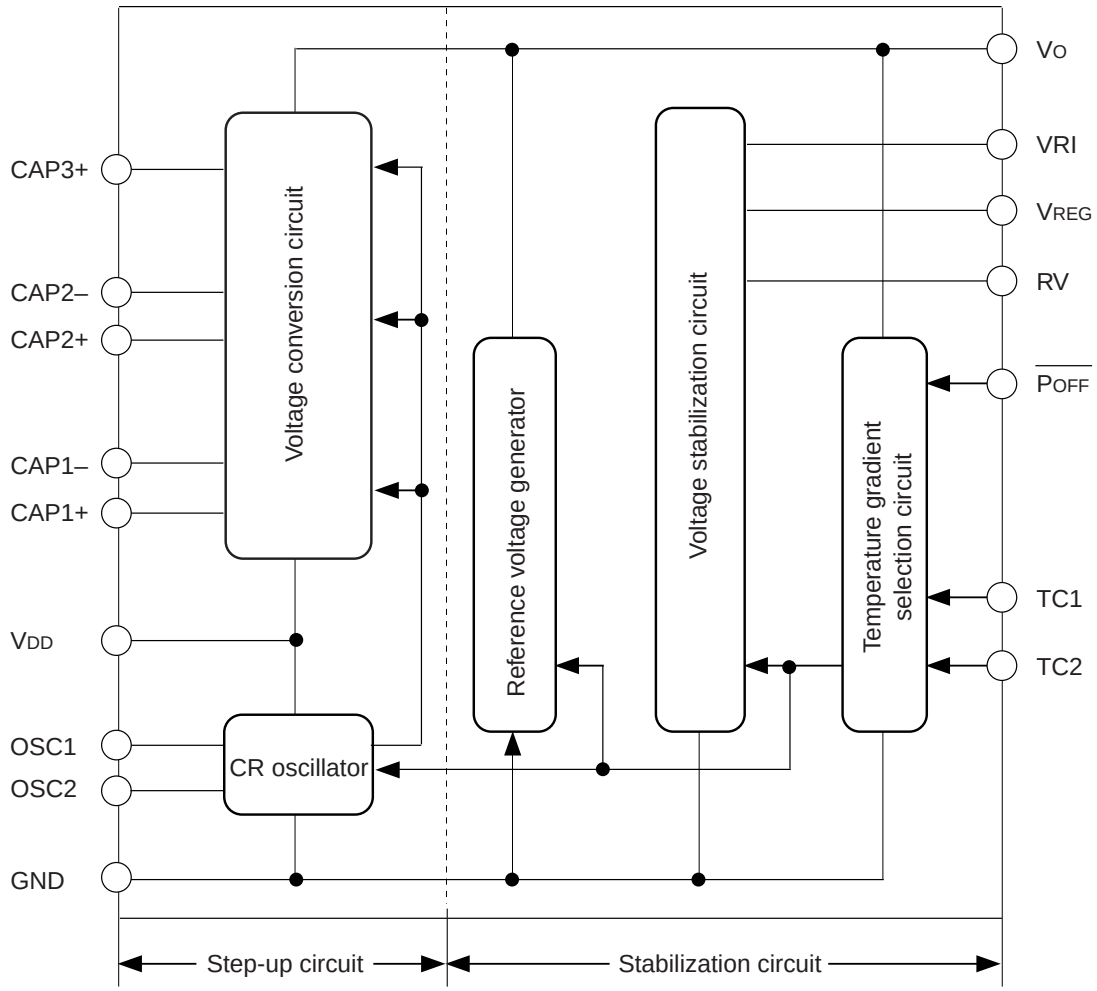


Figure 3-1 Block Diagram

PIN ASSIGNMENTS

SSOP2-16pin

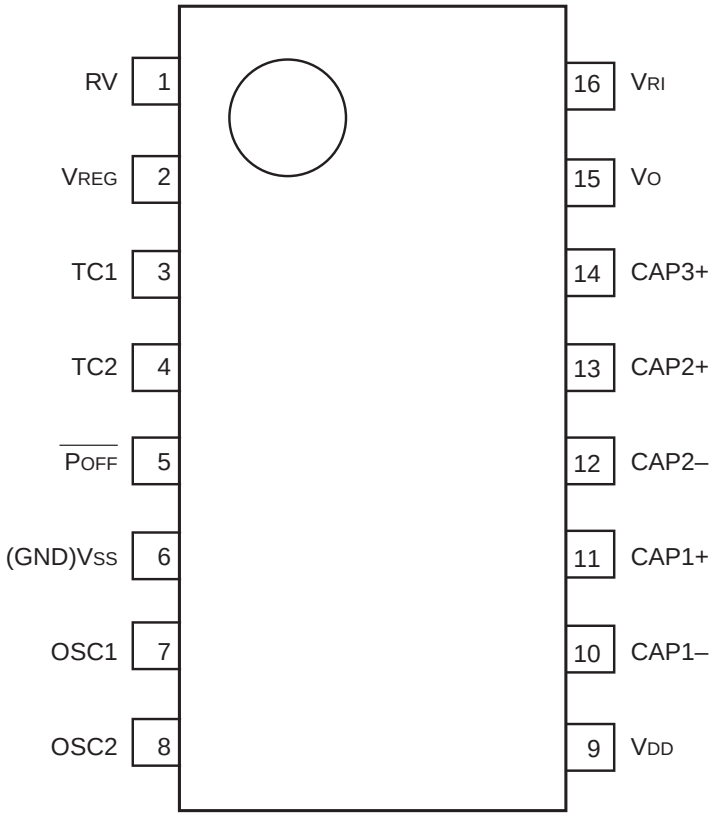


Figure 4-2 Pin Assignments of SSOP2-16pin

PIN DESCRIPTIONS

Pin No.	Pin name	Description
1	RV	Stabilization voltage regulation pin. When the intermediate tap of the external volume (3-pin resistor) connected between the V_{DD} pin and the V_{REG} pin is connected to the RV pin, V_{REG} output voltage can be adjusted.
2	V_{REG}	Stabilized voltage output pin
3	TC1	Temperature gradient selection pin
4	TC2	Temperature gradient selection pin
5	$\overline{P_{OFF}}$	V_{REG} output ON/OFF control pin. When control signal from the system side is input to this pin, the power off (V_{REG} output power off) control of S1F76640 becomes available.
6	GND	Power supply pin (minus side, system GND)
7	OSC1	Oscillation resistor connection pin. This pin becomes the clock input pin when an external clock operates.
8	OSC2	Oscillation resistor connection pin. This pin is released when an external clock operates.
9	V_{DD}	Power supply pin (plus side, system V_{CC})
10	CAP1–	Pump up capacitor minus side connection pin for 2 times step-up. Next stage clock at series connection time.
11	CAP1+	Pump up capacitor plus side connection pin for 2 times step-up
12	CAP2–	Pump up capacitor minus side connection pin for 3 times step-up. Output pin at 2 time step-up time (to be short-circuited to V_O).
13	CAP2+	Pump up capacitor plus side connection pin for 3 times step-up
14	CAP3+	Pump up capacitor plus side connection pin for 4 times step-up. Output pin at 3 times step-up time (to be short-circuited to V_O).
15	V_O	Output pin at 3 times step-up time
16	V_{RI}	Stabilization circuit input pin

CHIP EXTERNAL SHAPE AND PAD CENTER COORDINATES

Chip External Shape

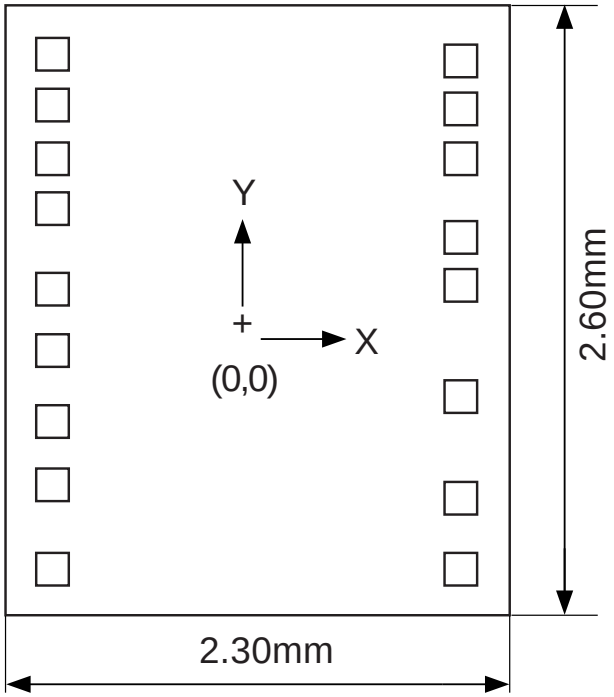


Figure 4-4 Pad Assignments

	(x)	(y)	(t)
Chip size :	2.30mm	× 2.60mm	× 0.30mm
PAD aperture :	100µm	× 100µm	
DIE number :	F76640D0A0		

Pad Center Coordinates

S1F7664D0A0

Pad		Pad Center Coordinates	
No.	Name	X[µm]	Y[µm]
1	RV	–984.0	1096.0
2	V_{REG}		788.0
3	(TESTOUT)		580.0
4	TC1		390.0
5	TC2		96.0
6	$\overline{P_{OFF}}$		–218.0
7	GND		–510.0
8	OSC1	↓	–802.0
9	OSC2	984.0	–1094.0
10	V_{DD}		–1134.0
11	CAP1–		–892.0
12	CAP1+		–514.0
13	CAP2–		182.0
14	CAP2+		372.0
15	CAP3+		750.0
16	V_O		942.0
17	V_{RI}	↓	1134.0

FUNCTIONAL DESCRIPTIONS

CR Oscillator

S1F76640 has a built-in CR oscillator as the internal oscillator, and an external oscillation resistor ROSC is connected between the pins OSC1 and OSC2 before operation. (Figure 5.1)

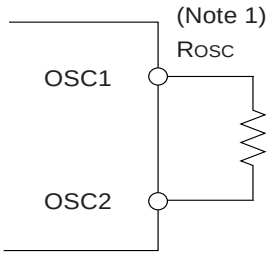


Figure 5-1 CR Oscillator

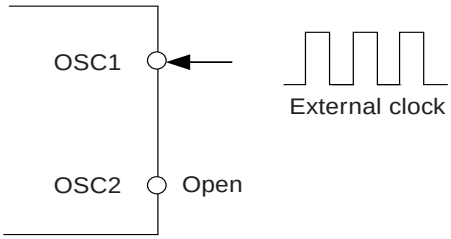


Figure 5-2 External Clock Operation

Note 1 : Since the oscillation frequency varies with wiring capacitance, make the cables between the terminals OSC1 and OSC2 and ROSC as short as possible.

When setting the external resistor ROSC, find the oscillation frequency fOSC that brings about the maximum efficiency from Figures 6.5.12 and 6.5.13 and find ROSC suitable for the fOSC from Figure 6.5.1 The relations between ROSC and fOSC in Figure 6.5.1 are expressed approximately with the following formula as far as the straight portion (500kΩ < ROSC < 2MΩ) is concerned:

$$R_{OSC} = A \cdot \frac{1}{f_{OSC}} \quad \begin{bmatrix} A : \text{Constant, When GND is 0V and} \\ V_{DD} \text{ is 5V, A is } 2.0 \times 10^{10} \text{ (1/F).)} \end{bmatrix}$$

So, the ROSC value can be obtained from this formula.
(Recommended oscillation frequency : 10kHz to 30kHz (ROSC : 2MΩ to 680kΩ)

When the external clock operates, make the pin OSC2 open as shown in Figure 5.2 and input the 50% duty of the external clock from the pin OSC1.

Voltage Conversion Circuits (I) and (II)

The voltage conversion circuits (I) and (II) doubles and triples the input voltage VDD respectively by using clock generated in the CR oscillator.

In case of 2 times step-up, 2 times step-up output of the input voltage is obtained from the VO pin when a pump up capacitor is connected between CAP1+ and CAP1–, CAP2+ and CAP3+ are short-circuited to VO and a smoothing capacitor is connected between VDD and VO outside.

In case of 3 times step-up, 3 VDD is output from the VO pin when a pump up capacitor is connected between CAP1+ and CAP1– and between CAP2+ and CAP2– respectively and a smoothing capacitor is connected between the VDD and VO pins outside.

In case of 4 times step-up, 4 VDD is output from the VO pin when a pump up capacitor is connected between CAP1+ and CAP1–, between CAP2+ and CAP2– and between CAP1+ and CAP3– respectively and a smoothing capacitor is connected between the VDD and VO pins outside.

When GND is 0 and VDD is 5, the relations between the input voltage and the output voltage are as shown in Figures 5-3, 5-4 and 5-5.

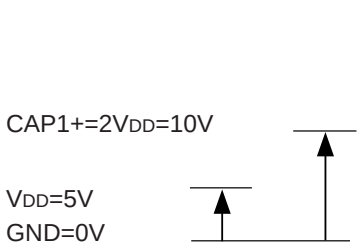


Figure 5-3
Example of 2 times step-up potential relations

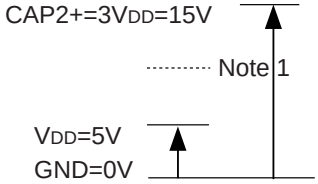


Figure 5-4
Example of 3 times step-up potential relations

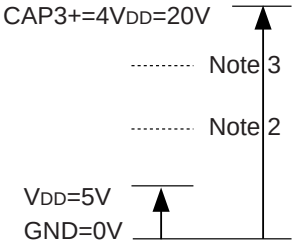


Figure 5-5
Example of 4 times step-up potential relations

Note 1 : At the 3 times step-up time, 2 times step-up output (–10V) cannot be taken out from the CAP2– pin.
Note 2 : At the 4 times step-up time, 2 times step-up output (–10V) cannot be taken out from the CAP2– pin.
Note 3 : At the 4 times step-up time, 3 times step-up output (–15V) cannot be taken out from the CAP3– pin.

Reference Voltage Generator, Voltage Stabilization Circuit

The reference voltage generator generates reference voltage necessary for operation of the voltage stabilization circuit and adds temperature gradient to reference voltage. Three temperature gradients are available, and signal from the temperature gradient selection circuit select one of them.

The voltage stabilization circuit stabilizes the step-up output voltage VO and outputs optional voltages. When an external resistor RRV is connected as shown in Figure 5-5 and the potential of the intermediate tap is changed, VREG output voltage can be set to optional voltages between the reference voltage VRV and VO.

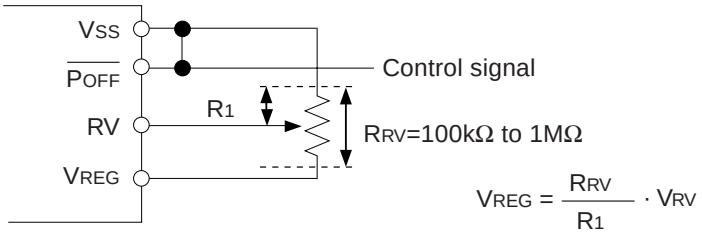


Figure 5-6 Voltage Stabilization Circuit

The voltage stabilization circuit has power off function and can control ON/OFF of VREG output according to signals from the system side (microprocessor, etc.) When POFF is high (VDD), VREG output is turned on, and when POFF is Low (GND), it is turned off. When the control is not necessary, POFF is fixed to High (VDD).

Temperature Gradient Selection Circuit

S1F76640 can provide three kinds of temperature gradients suitable for driving LCD to VREG output as shown Table 5-1.

Table 5-1 Temperature Gradient Adaptation Table

$\overline{\text{POFF}}$ (Note 1)	TC2 (Note 1)	TC1 (Note 1)	Temperature Gradient CT(Note 2)	VREG Output	CR Oscillator	Remarks —
1(VDD)	Low(VSS)	Low(VSS)	–0.40%/ ˚C	ON	ON	—
1(VDD)	Low(VSS)	High(VO)	–0.25%/ ˚C	ON	ON	—
1(VDD)	High(VO)	Low(VSS)	–0.55%/ ˚C	ON	ON	—
1(VDD)	High(VO)	High(VO)	–0.55%/ ˚C	ON	OFF	Series connection (Note 4)
0(VSS)	Low(VSS)	Low(VSS)	—	OFF(Hi-Z)(Note 3)	OFF	—
0(VSS)	Low(VSS)	High(VO)	—	OFF(Hi-Z)(Note 3)	OFF	—
0(VSS)	High(VO)	Low(VSS)	—	OFF(Hi-Z)(Note 3)	OFF	—
0(VSS)	High(VO)	High(VO)	—	OFF(Hi-Z)	ON	Boosting only (Note 5)

Note 1 : Please note that potentials on the High side are different between the $\overline{\text{POFF}}$ pin and TC2/TC1 pin.

Note 2 : The formula below is used to define temperature gradient CT:

$$C_T = \frac{V_{REG}(50^\circ C) - V_{REG}(0^\circ C)}{50^\circ C - 0^\circ C} \times \frac{1}{V_{REG}(25^\circ C)} \times 100\ (\%/^\circ C)$$

Example :When CT=–0.6%/˚C is selected,

· When Ta is 25˚C, the VREG output becomes –8V at 25˚C.

$\Delta V_{REG}/\Delta T = C_T \cdot |V_{REG}(25^\circ C)| = -0.6 \times 10^{-2} \times 8 = -48 mV/^\circ C$

When the temperature rises 1 ˚C, the $|V_{REG}|$ value reduces by 48mV.

· When VREG is –10V at 25˚C, the formula below is formed:

$\Delta |V_{REG}| \Delta T = -60 mV/^\circ C$

Note 3 : At power off time (VREG output : OFF, CR oscillator : OFF), the potential of the VO output is about VDD+0.5V.

Note 4 : When this mode is selected at a series connection, the first stage clock can drive the next stage IC and this mode is effective for reducing the power consumption of the next stage IC. (See Figure 8.4)

Note 5 : Select this mode for boosting only. And the current consumption can be reduced.

ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings

Parameter	Symbol	Rating		Unit	Remarks
		Min.	Max.		
Input supply voltage	V_{DD}	GND-0.3	24/N	V	V_{DD} N = 2 : 2 times step-up N = 3 : 3 times step-up N = 4 : 4 times step-up
Input pin voltage	V_I	GND–0.3	V_{DD}-0.3	V	OSC1,$\overline{P_{OFF}}$
		GND–0.3	V_O-0.3	V	TC1,TC2, RV
Output voltage	V_O	GND–0.3	22	V	V_O Note 3
		GND–0.3	V_O	V	V_{REG} Note 3
Output pin voltage 1	VOC1	GND–0.3	V_{DD}–0.3	V	CAP1+,CAP2+ OSC2
Output pin voltage 2	VOC2	GND–0.3	2 × V_{DD}–0.3	V	CAP1–
Output pin voltage 3	VOC3	GND–0.3	3 × V_{DD}–0.3	V	CAP2–
Output pin voltage 4	VOC4	GND–0.3	4 × V_{DD}–0.3	V	CAP3–
Allowable loss	P_D	—	210	mW	SSOP-16PIN
Operating temperature	Topr	–40	85	˚C	—
Storage temperature	Tstg	–55	150	˚C	—
Soldering temperature and time	Tsol	—	260 · 10	˚C · s	At leads

Note 1 : Under the conditions exceeding the above absolute maximum ratings, the IC may result in a permanent destruction. An operation for a long period under the conditions of the above absolute maximum ratings may deteriorate the reliability remarkably.

Note 2 : All voltage values are based on GND.

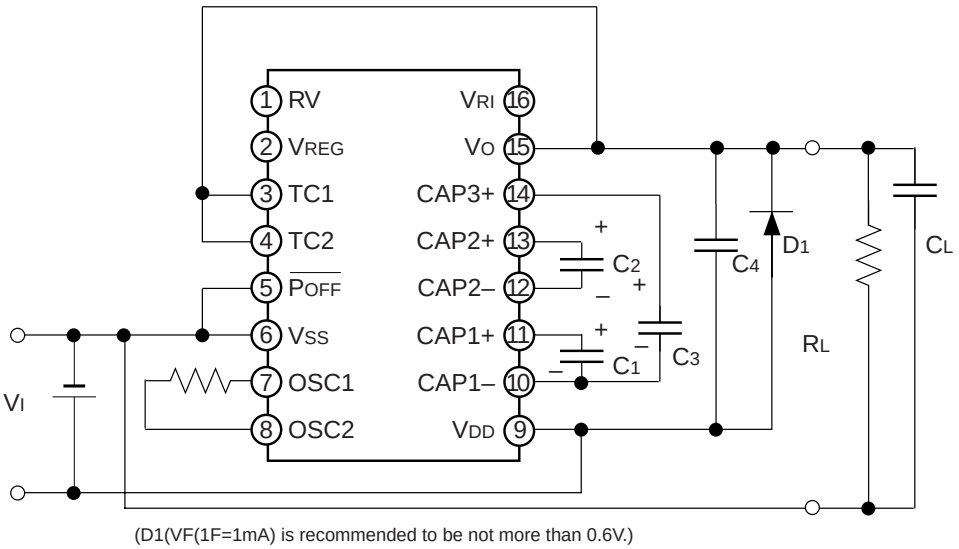
Note 3 : The output pins (V_O and V_{REG}) are for stabilizing and outputting boosted voltages. So, they are not used to apply voltage from outside. When voltage is applied from outside for unavoidable reasons, limit the voltage to the rated voltage mentioned above or less.

Recommended Operating Conditions

Parameter	Symbol	Rating		Unit	Remarks
		Min.	Max.		
Step-up start voltage	V_{STA1}	1.8	—	V	R_{OSC}=1MΩ, C_4≥10µF C_L/C_4≤1/20 Note 2
	V_{STA2}	2.2	—	V	R_{OSC}=1MΩ
Step-up stop voltage	V_{STP}	—	1.8	V	R_{OSC}=1MΩ
Output load resistance	R_L	$R_L$min Note 3)	—	Ω	—
Output load current	I_O	—	20	mA	—
Oscillation frequency	f_{OSC}	10	30	kHz	—
External resistor for oscillation	R_{OSC}	680	2000	kΩ	—
Step-up capacitor	C_1,C_2,C_3,C_4	3.3	—	µF	—
Stabilization output regulation resistance	R_{RV}	100	1000	kΩ	—

Note 1 : All voltages are based on the GND being 0V.

Note 2 : The figure below shows the recommended circuit for operation with low voltages (V_{DD}=1.8 to 2.2V):



(D1(VF(1F=1mA) is recommended to be not more than 0.6V.)

Figure 6-2-1 Recommended Circuit Diagram for Low Voltage Operation (Example of 4 times step-up circuit)

Note 3 : $R_L$min varies with input voltage. See Characteristics Graph (15).

Electrical Characteristics

Unless otherwise specified, Ta=–40˚C to +85˚C
GND=0V, V_{DD}=5V

Parameter	Symbol	Specification Value			Unit	Conditions	Measurement Circuit
		Min.	Typ.	Max.			
Input supply voltage	V_{DD}	1.8	—	5.5	V	—	—
Output voltage	V_O	—	—	22	V	—	—
	V_{REG}	V_{RV}	—	22	V	R=∞, R_{RV}=1MΩ, V_O=22V	②
Stabilization circuit operating voltage	V_O	V_{RV}+2.1	—	22	V	—	—
Step-up circuit current consumption (V_{DD} system)	I_{OPR1}	—	60	100	µA	R_L=∞, R_{OSC}=1MΩ	①
Step-up circuit current consumption (VRI system)	I_{OPR2}	—	12	25	µA	R_L=∞, R_{OSC}=1MΩ, V_O=20V	②
Static current	I Q	—	—	2	µA	TC2=TC1=V_O,RI=∞	①
Oscillation frequency	f_{OSC}	16	20	24	kHz	R_{OSC}=1MΩ	①
Output impedance	R_O	—	250	350	Ω	I_O=10mA	①
Step-up power conversion efficiency (Note 2)	Peff	90	95	—	%	I_O=5mA	①
Stabilized output voltage fluctuation	$\frac{\Delta V_{REG}}{\Delta V_O \cdot V_{REG}}$	—	0.2	—	%/V	10V<V_O<20V,V_{REG}=10V R_L=∞, Ta=25˚C	②
Stabilized output load fluctuation (Note 3)	$\frac{\Delta V_{REG}}{\Delta I_O}$	—	5.0	—	Ω	V_O=20V,V_{REG}=15V Ta=25˚C,0<I_O<10mA TC1=V_O,TC2=GND	②
Stabilized output saturation resistance (Note 4)	R_{SAT}	—	12	—	Ω	R_{SAT}=Δ(V_O-V_{REG})/ΔI_O 0<I_O<10mA,RV=V_O Ta=25˚C	②
Reference voltage	V_{RV0}	2.20	3.00	3.80	V	TC2=GND,TC1=V_O,Ta=25˚C	②
	V_{RV1}	2.30	2.80	3.30	V	TC2=TC1=GND,Ta=25˚C	
	V_{RV2}	1.70	2.00	2.30	V	TC2=V_O,TC1=GND,Ta=25˚C	
Temperature gradient	C_{T0}	–0.45	–0.27	–0.10	%/˚C	V_{DD}=5V,V_O=20V	②
	C_{T1}	–0.60	–0.42	–0.25	%/˚C	(Note 5)	
	C_{T2}	–0.70	–0.55	–0.40	%/˚C		
Input leak current	I_{LKI}	—	—	2	µA	$\overline{P_{OFF}}$,TC1,TC2,OSC1,RV pins	③

Note 1 : All voltage values are based on GND being 0V.

Note 2 : The value shown here is the step-up circuit conversion efficiency, and (V_O-V_{REG})I_{OUT} is lost when the stabilization circuit operates. So, it is recommended to operate this so that (V_O-V_{REG}) becomes as small as possible. When (V_O-V_{REG}) × I_O is large, the IC temperature rises and the characteristics of the stabilization circuit change.

Note 3 : See Figures 6-5-14, 6-5-15 and 6-5-16.

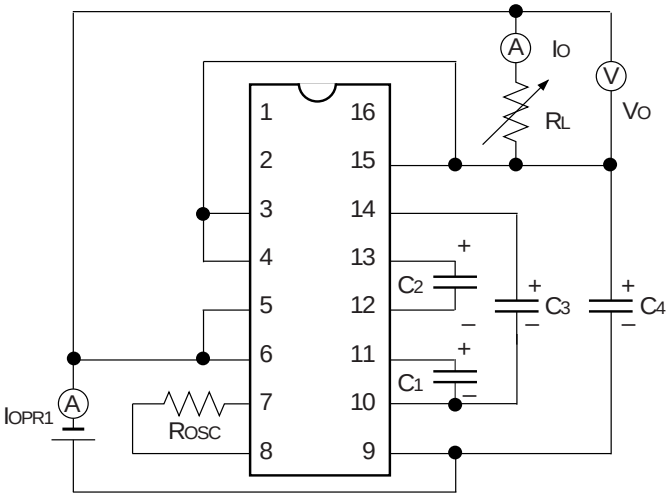
Note 4 : R_{SAT} means inclination in Fig. 6-5-17, and V_O-Δ (V_O-V_{REG}) indicates the lower limit voltage of the V_{REG} output.

Note 5 : The calculation formula of C_T is as follows:

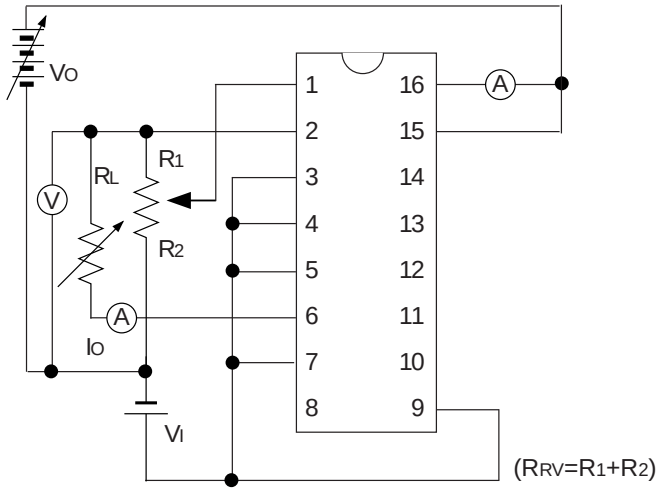
$$C_T = \frac{V_{REG}(50^\circ C) - V_{REG}(0^\circ C)}{50^\circ C - 0^\circ C} \times \frac{1}{V_{REG}(25^\circ C)} \times 100\ (\%/^\circ C)$$

Measurement Circuit (Described on S1F76640M0A0)

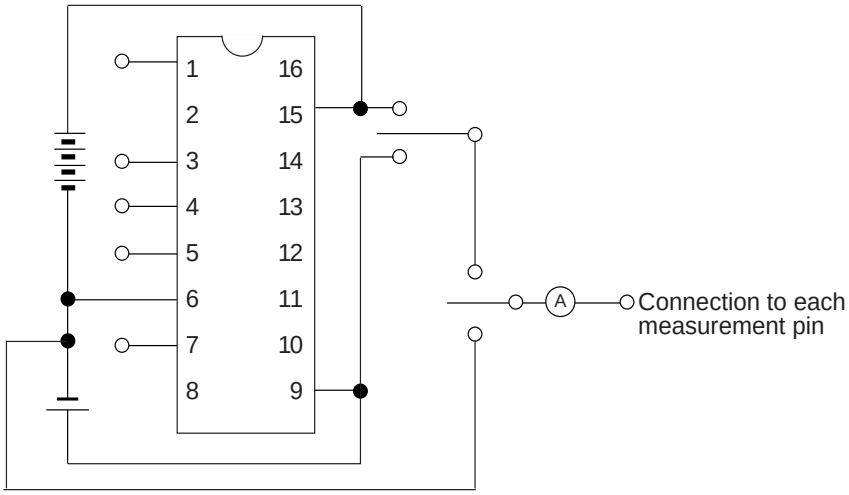
Step-up circuit characteristic measurement circuit



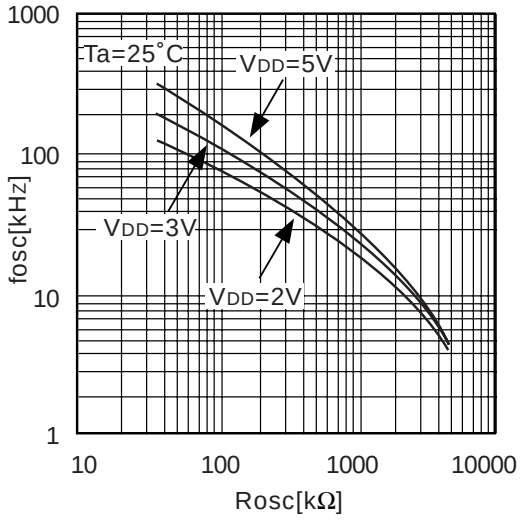
Stabilization circuit characteristic measurement circuit



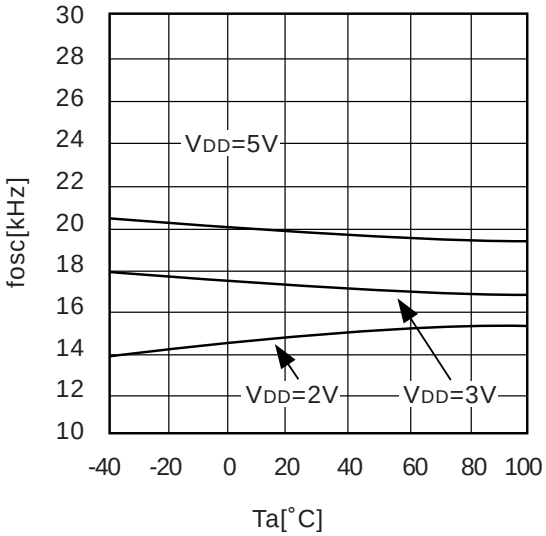
Input leak current measurement circuit



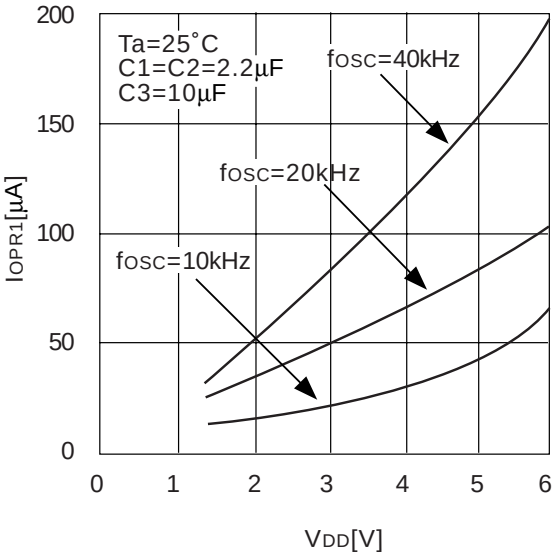
CHARACTERISTICS GRAPH



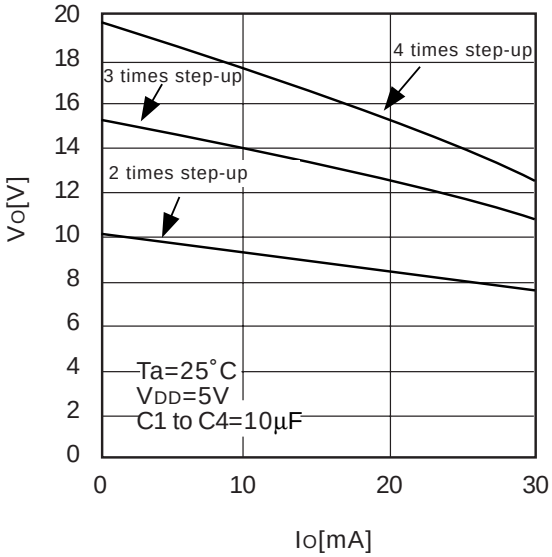
(1) Oscillation frequency vs. External resistance for oscillation



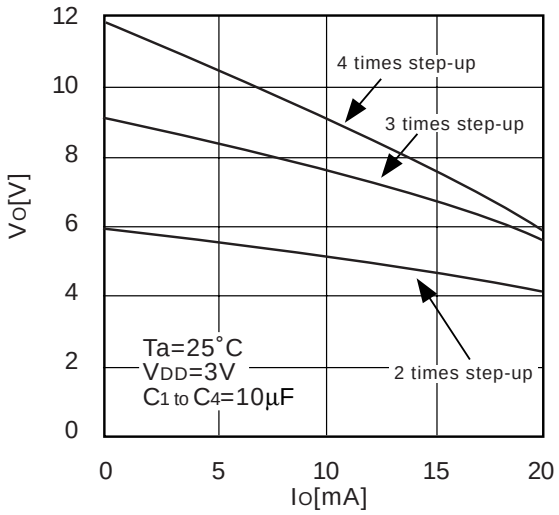
(2) Oscillation frequency vs. Temperature



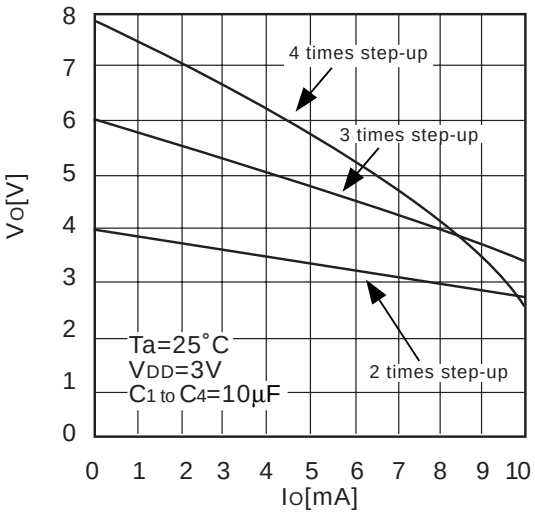
(3) Step-up circuit current consumption vs. Input voltage



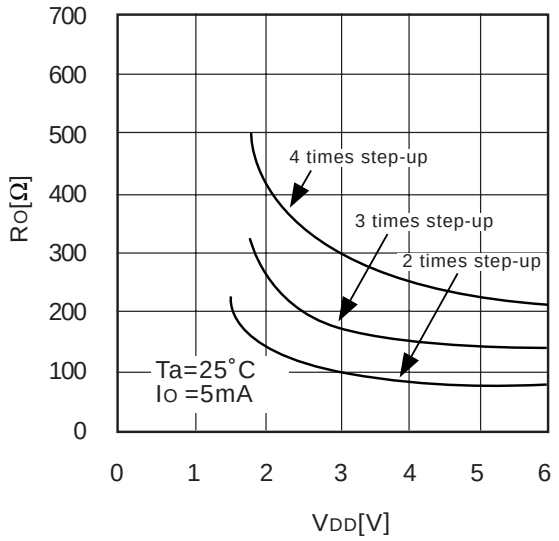
(4) Output voltage (VO) vs. Output current 1



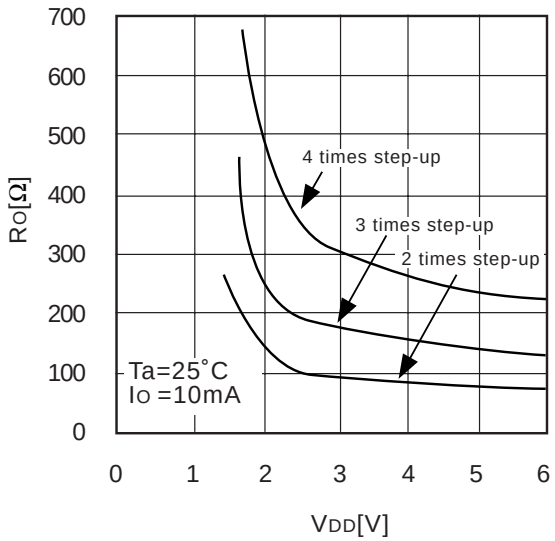
(5) Output voltage (V_O) vs. Output current 2



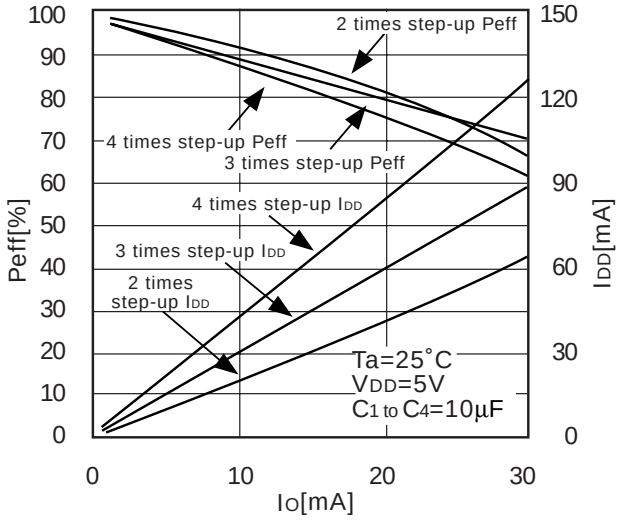
(6) Output voltage (V_O) vs. Output current 3



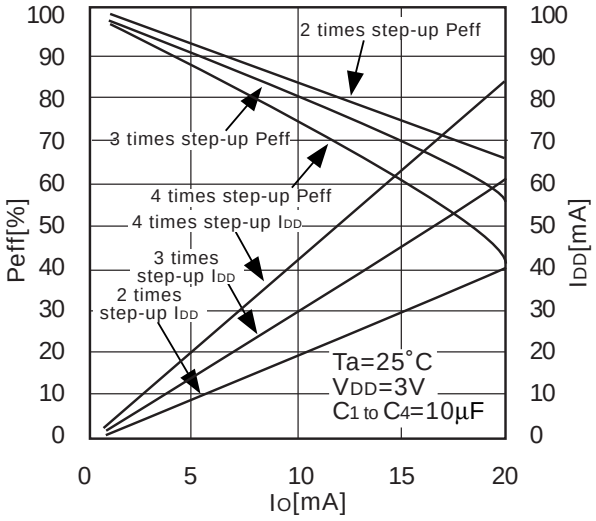
(7) Output impedance vs. Input voltage 1



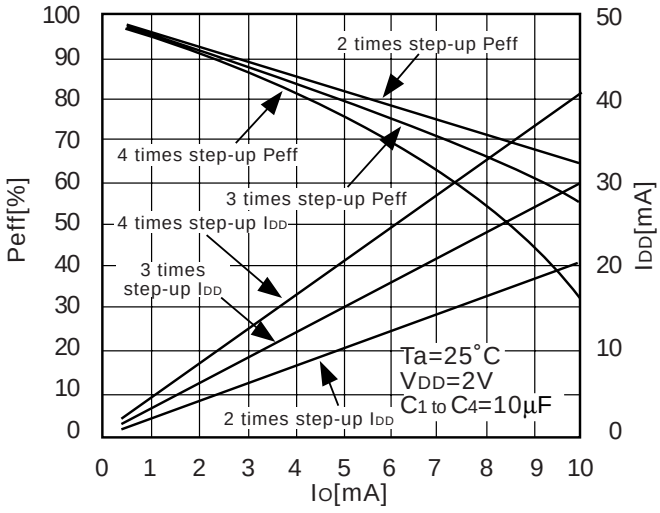
(8) Output impedance vs. Input voltage 2



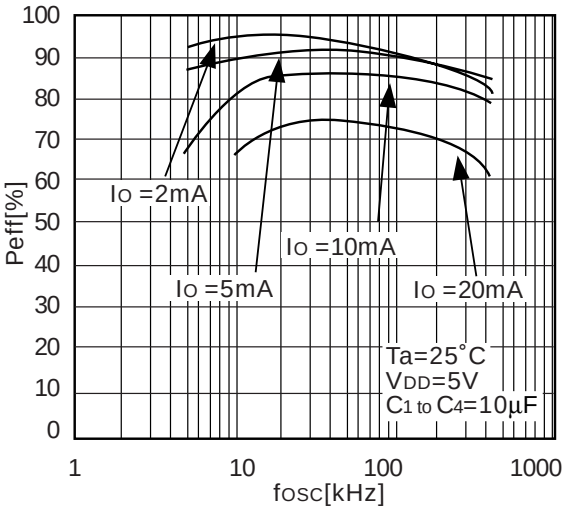
(9) Step-up power conversion efficiency vs. Output current 1
Input current vs. Output current 1



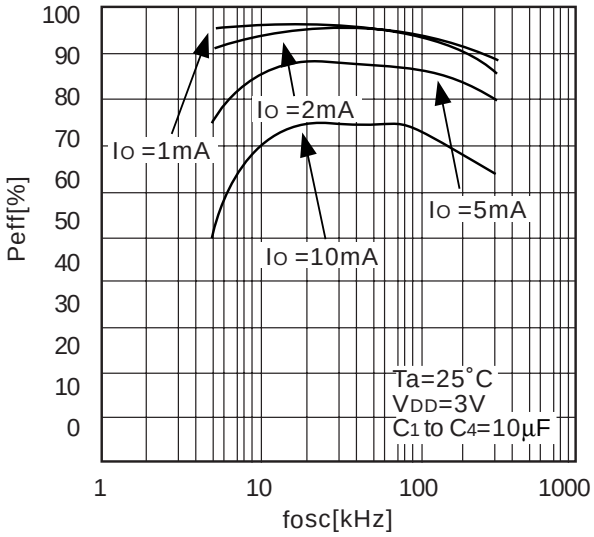
(10) Step-up power conversion efficiency vs. Output current 2
Input current vs. Output current 2



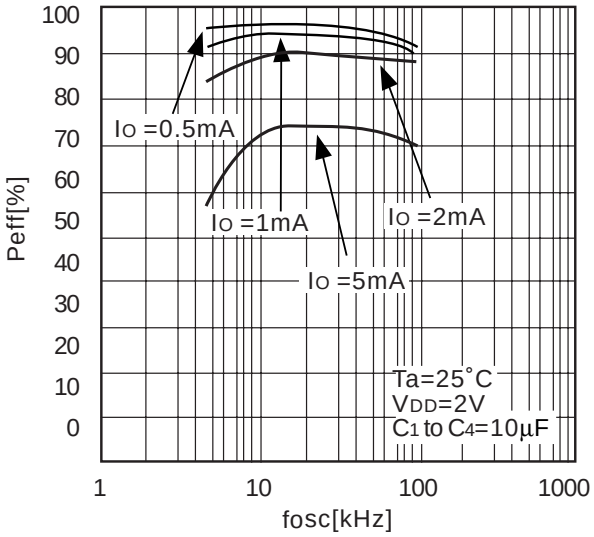
(11) Step-up power conversion efficiency vs. Output current 3
Input current vs. Output current 3



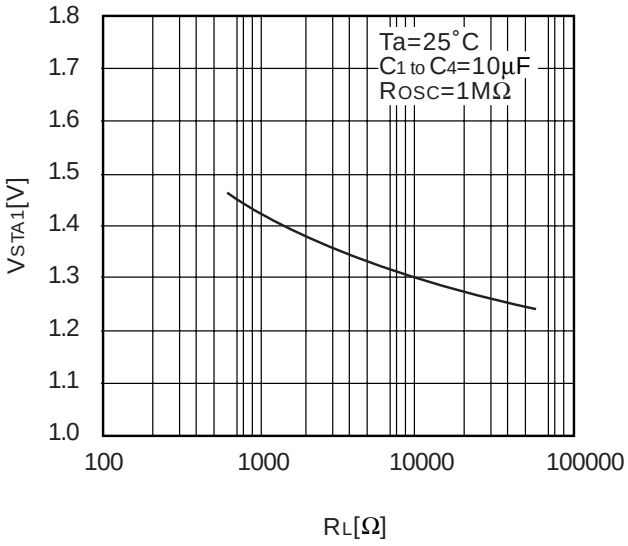
(12) Step-up power conversion efficiency - Os vs.illation frequency 1



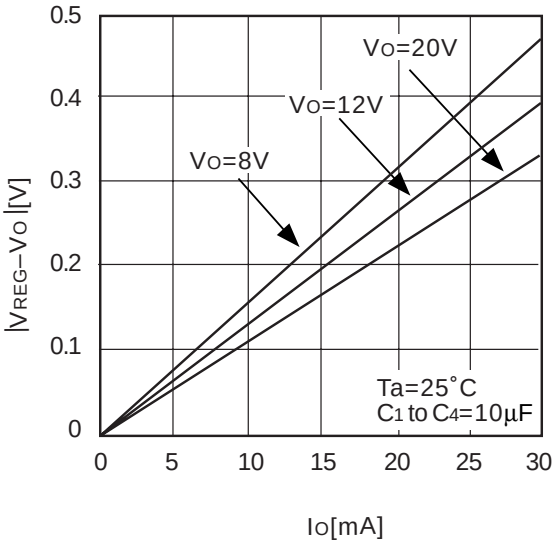
(13) Step-up power conversion efficiency vs. Oscillation frequency 2



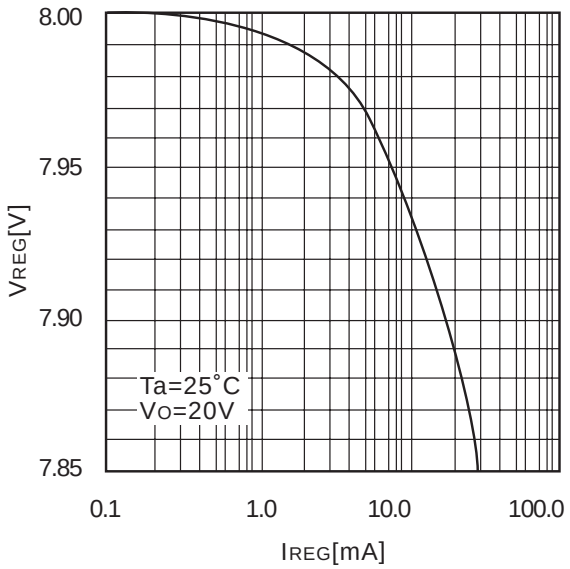
(14) Step-up power conversion efficiency vs. Oscillation frequency 3



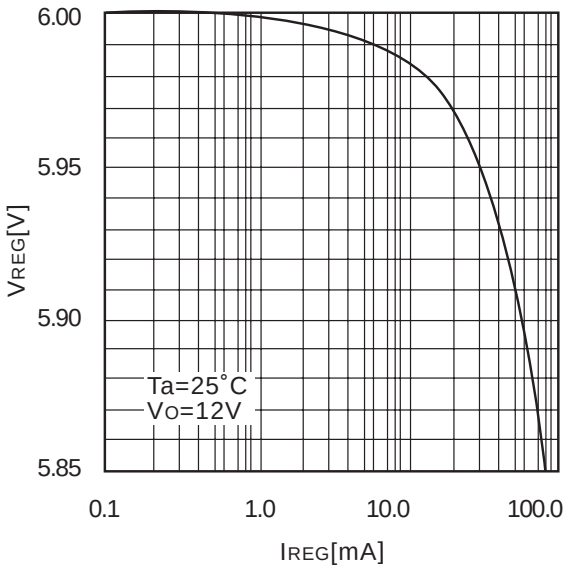
(15) Step-up start voltage (1) vs. Load resistance



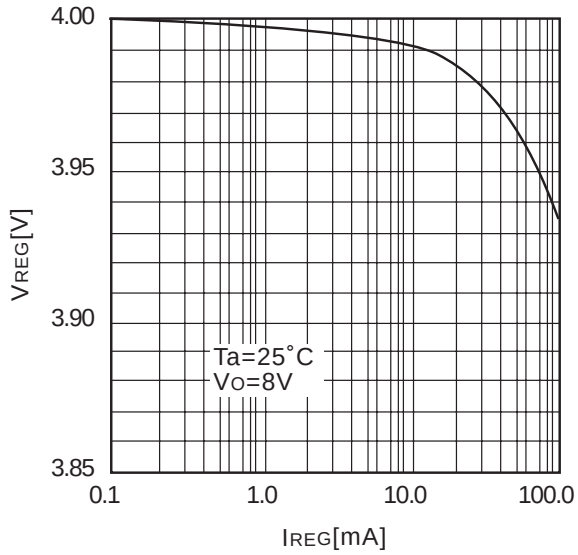
(16) Stabilization output saturation resistance vs. Load current



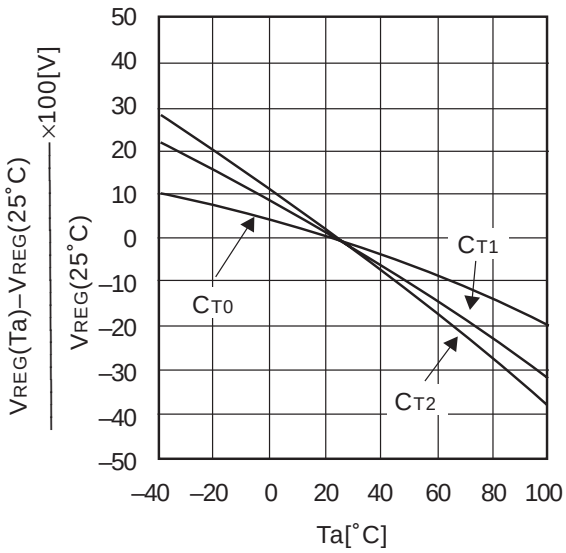
(17) Output voltage (VREG) vs. Output current 1



(18) Output voltage (VREG) vs. Output current 2



(19) Output voltage (VREG) vs. Output current 3



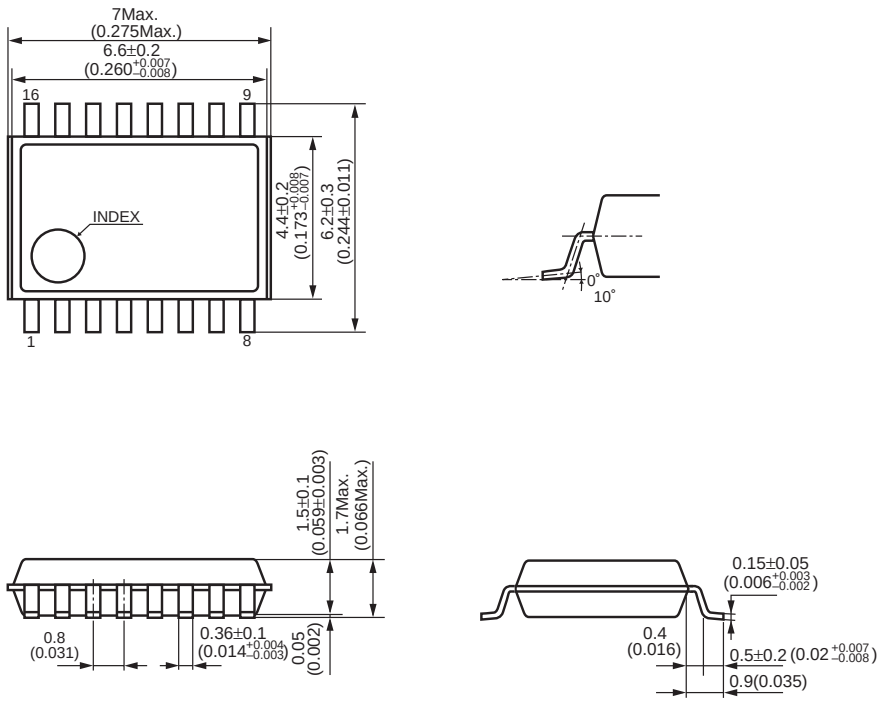
(20) Reference voltage vs. Temperature

MECHANICAL DATA

Reference

Unit : mm

Plastic SSOP2-16pin



Note : This dimensional drawing is subject to change without notice for improvement.

APPLICATION EXAMPLE

2 Times Step-up, 3 Times Step-up and 4 Times Step-up

Figure 8.1 shows the connection for getting 4 times step-up output of an input voltage by operating the step-up circuit only. In case of 3 times step-up, the capacitor C_3 is removed and CAP3+ (Pin No. 14) is short-circuited to V_O (Pin No. 15), and 3 times step-up voltage is obtained from V_O(CAP3+). In case of 2 times step-up, the capacitor C_2 is also removed and CAP2+ (Pin No. 13) is short-circuited to V_O (Pin No. 15), and 2 times step-up voltage (10V) is obtained from V_O (CAP2+).

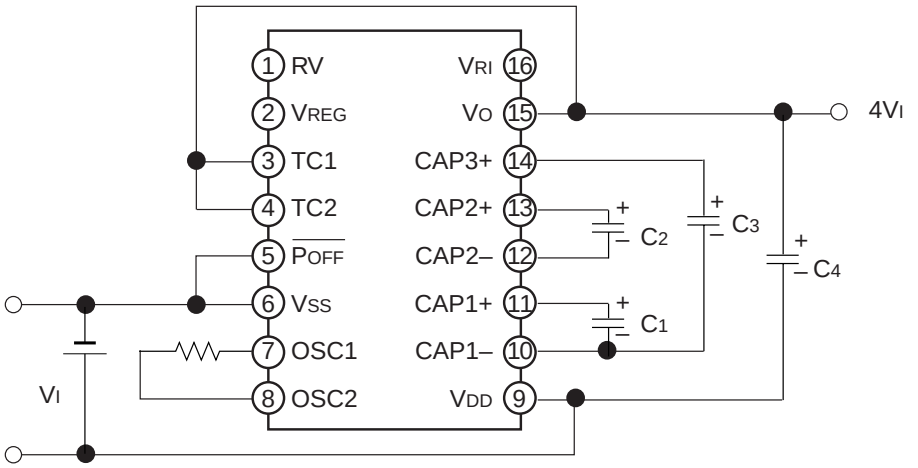


Figure 8-1 4 times step-up circuit

4 Times Step-up + Stabilization Circuit

Figure 8-2 shows an application example for stabilizing step-up outputs obtained in 8-(1) through the stabilization circuit and for providing temperature gradient to V_{REG} output by means of the temperature gradient selection circuit. In this application example, both outputs from V_O and V_{REG} can be indicated at the same time. Also, operation of 3 times step-up + stabilization circuit is possible by using the 3 times step-up operation mentioned in 8-(1), and operation of 2 times step-up + stabilization circuit is possible by using the 2 times step-up operation.

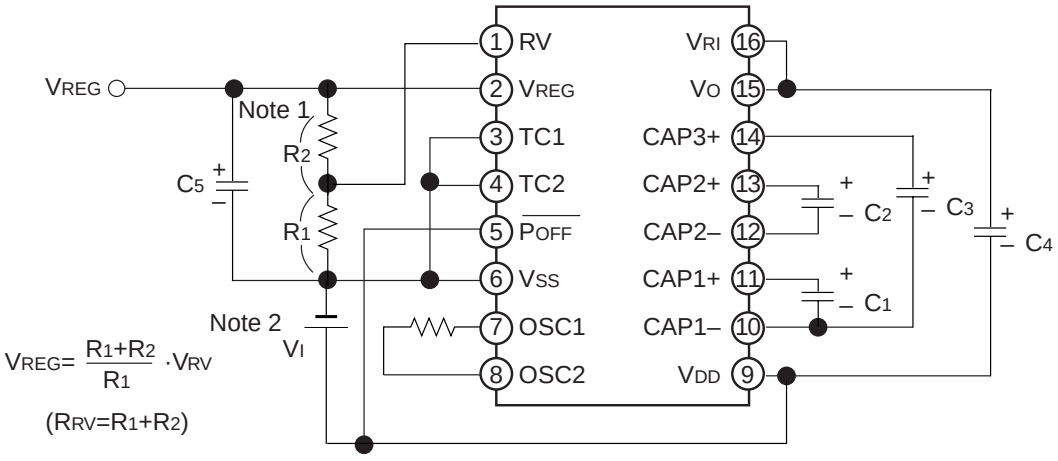


Figure 8-2 Operation of 4 Times Step-up + Stabilization Circuit (Temperature Gradient CT1 is selected.)

Note 1 : Since input impedance at the RV pin (No. 1) is high, it is necessary to use a shielded wire as a measure against noise in case of a long connection. It is also effective to make the R_{RV} value small for reducing noise influence. (In this case, however, more current comes to be consumed at R_{RV}.)

Parallel Connection

It is possible to make the output impedance RO small when several pieces of the circuit shown in Figure 8.1 are connected. Parallel connection of n circuits reduces RO to 1/n approximately. One piece of the smoothing capacitor C4 can be commonly used in the same way. To get stabilized outputs after parallel connection, include 1 pieces of the circuit shown in Figure 8.2 in the parallel connection of n circuits as shown in Figure 8.3.

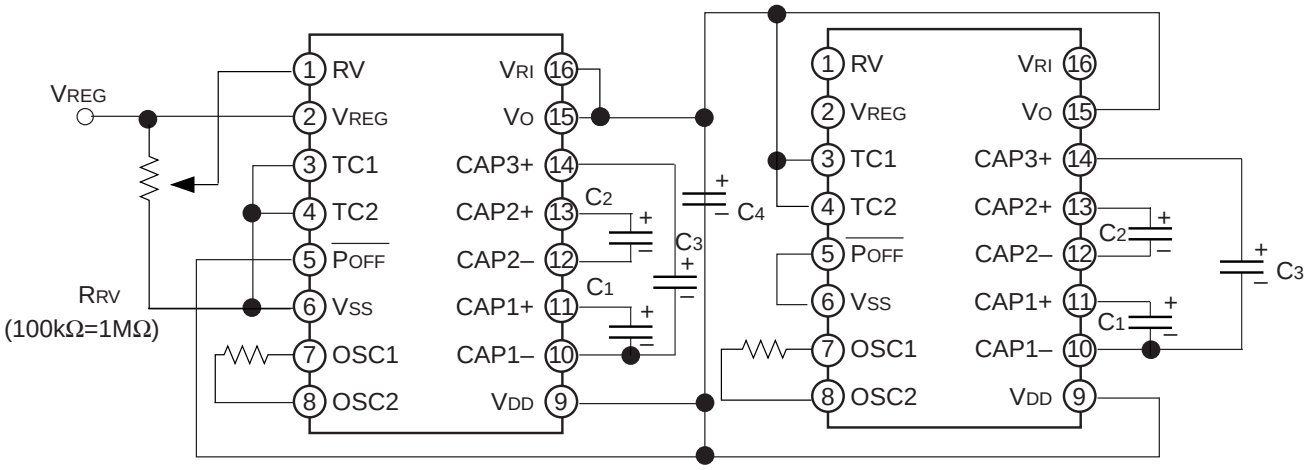


Figure 8.3 Parallel Connection

Series Connection

When S1F76640 is connected in series (VDD and VO in the previous stage are connected to GND and VDD in the next stage respectively), the output voltage can be increased more. But the series connection makes the output impedance high. Figure 8.4 shows an example of the series connection to get VO=25V from VDD=5V and to stabilize it.

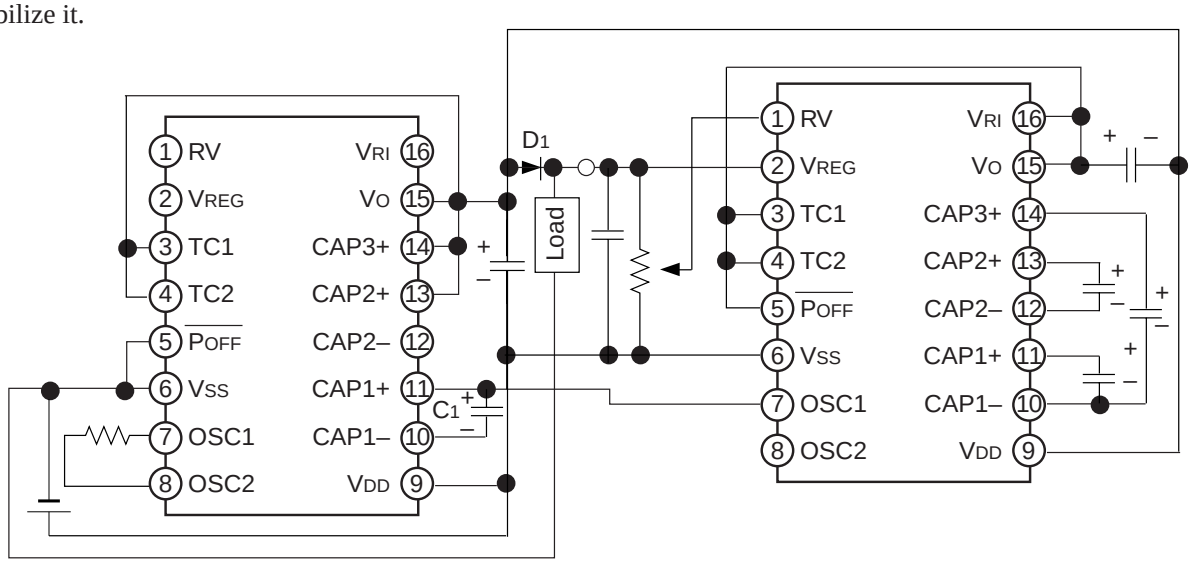


Figure 8.4 Series Connection

Note 1 : Precautions on Load Connection
When a load is connected between GND in the first stage (or potential below GND in the second stage other than that) and VREG in the second stage as shown in Figure 8.4, pay attention to the following. When a normal output is not available at the VREG pin at the starting time or when the $\overline{\text{POFF}}$ signal turns off VREG, current may flows from GND in the first stage (or potential below GND in the second stage other than that) to the VREG pin in the second stage through the load and a voltage higher than the absolute maximum rating below GND in the second stage may be generated at the VREG pin. As a result, the IC may not work normally. For series connection, connect the diode D1 between VDD and VREG in the second stage as shown in Figure 8.4, so that no potential below GND in the second stage is added to the VREG pin.

Note 2 : Figure 8.4 shows 3 times step-up in the first stage and 4 times step-up in the next stage, but 4 times step-up is possible both in the first stage and in the next stage unless the input voltage VDD'-GND' exceeds the specification value (6.0V). This means that each IC in this series connection is requested t satisfy the specification values (VDD-GND ≤ 6, 0V, VO-GND ≤ 24V). (See Figure 8.5.)

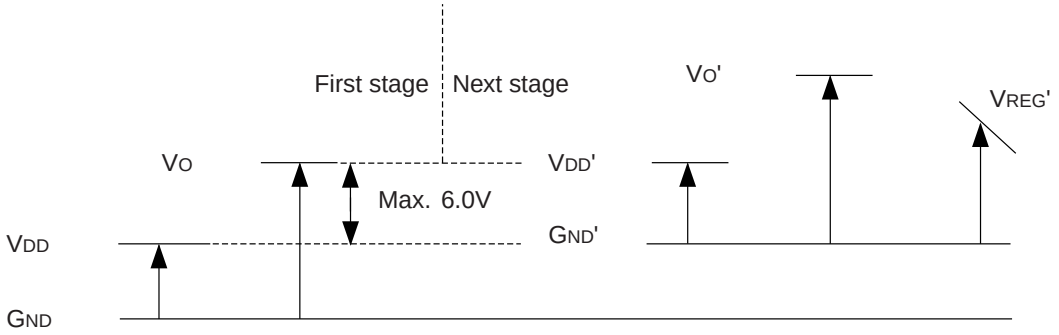


Figure 8.5 Power Supply System in Series Connection

Note 3 : 2 times step-up in the first stage allows using the CAP- output in the first stage as the next stage clock, but 3 times step-up does not. Attach an external ROSC as the next stage clock for internal oscillation. Also, since the next stage external clock can operate according the CAP- output in the previous stage as shown in Table 4.1 only when the temperature gradient CT is -0.6%/˚C, use the internal oscillator in the same way when other temperature gradients are necessary.

Note 4 : In case of series connection, the voltage VDD-VREG (VREG'-VDD' in Figure 8.5) of the IC, for which the stabilization circuit operates, has temperature gradient. This means that VREG changes at the following rate as temperature changes:

$$\frac{\Delta |V_{REG}|}{\Delta T} = C_T (V_{REG}' (25^{\circ}C) - GND')$$

Negative Voltage Conversion

S1F76640 can boost input voltage to negative power on the negative potential side by using the circuit shown in Figure 8.6. (In case of 3 times step-up, remove the capacitor C_3 and the diode D_4 and short-circuit the both ends of D_4. In case of 2 times step-up, remove the capacitor C_2 and the diode D_3 and short-circuit the both ends of D_3.) But the output voltage drops by the forward voltage V_F of the diode. When GND is 0V, V_{DD} is 5V and VF is 0.6V as shown in Figure 8.6 for example, V_O is calculated as follows: $V_O = -15V - 4 \times 0.6V = -12.6V$(In case of 3 times step-up, V_O is calculated to $-10V - 3 \times 0.6V = -8.2V$, and in case of 2 times step-up, V_O is calculated to $-5V - 2 \times 0.6V = -3.8V$.)

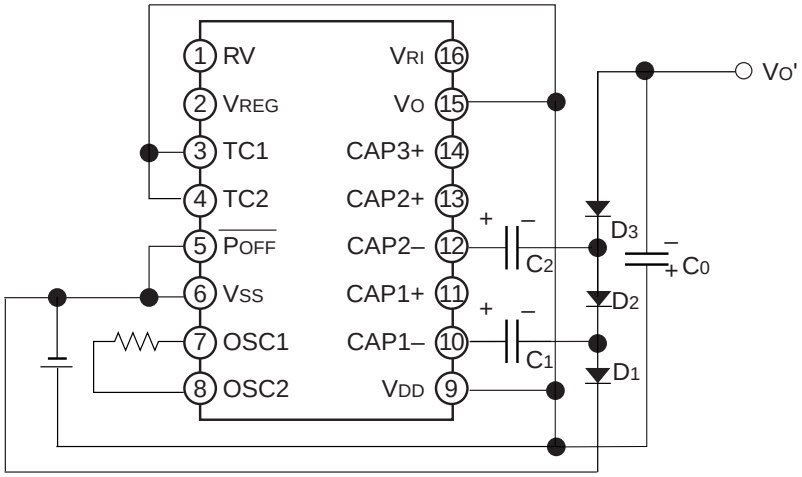


Figure 8.6 Negative Voltage Conversion (Example of 3 times step-up circuit)

Negative Voltage Conversion + Positive Voltage Conversion

When the 3 times step-up operation shown in Figure 8.1 and the positive voltage conversion in Figure 8.6 are combined, the circuit shown in Figure 8.7 can be formed and 20V and –12.6V can be obtained from the input 5V. However, the output impedance is higher than in case of connection of either one only (the negative voltage conversion or the positive voltage conversion).

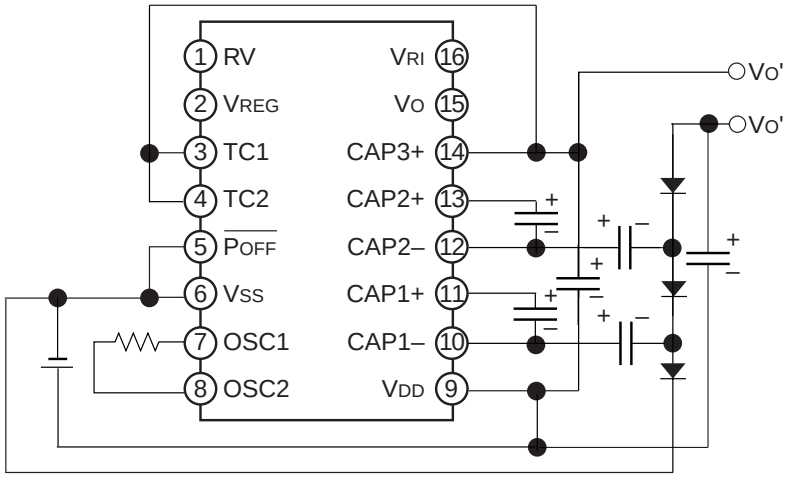


Figure 8.7 Negative Voltage Conversion + Positive Voltage Conversion

Example of Temperature Gradient Change by External Temperature Sensor (Thermistor)

S1F76640 has a temperature gradient selection circuit inside the stabilization circuit, and three kinds of temperature gradients, –0.20%/˚C, –0.40%/˚C and –0.60%/˚C, can be selected as the VREG output. When other temperature gradients are necessary, a thermistor is connected in series to the resistor RRV for output voltage regulation as shown in Figure 8.8, and temperature gradients can be changed to any values.

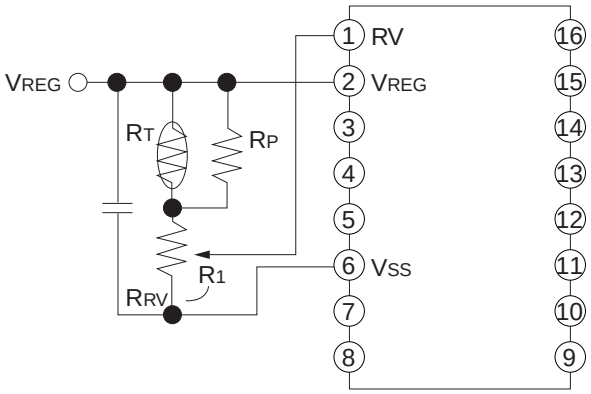


Figure 8.8 Example of Temperature Gradient Change

(Pins other than the above Pins 1, 2 and 6 are connected as per Figure 5.2. For Pins 3 and 4, smaller temperature gradients than those to be changed are selected from Table 4.1 and are set.)

Note 1 : Relations among the thermistor, RT and VREG are expressed as follows:

$$V_{REG} = \frac{R_{RV} + R_T}{R_1} \cdot V_{RV}$$

When a thermistor is used for RT, it can make the temperature gradient of VREG larger..

Note 2 : The thermistor temperature characteristics are non-linear but can be corrected to linear ones when the resistor RP is connected to the thermistor in parallel.

Configuration Example of Voltage Stabilized Output (VREG) Electronic Volume Circuit

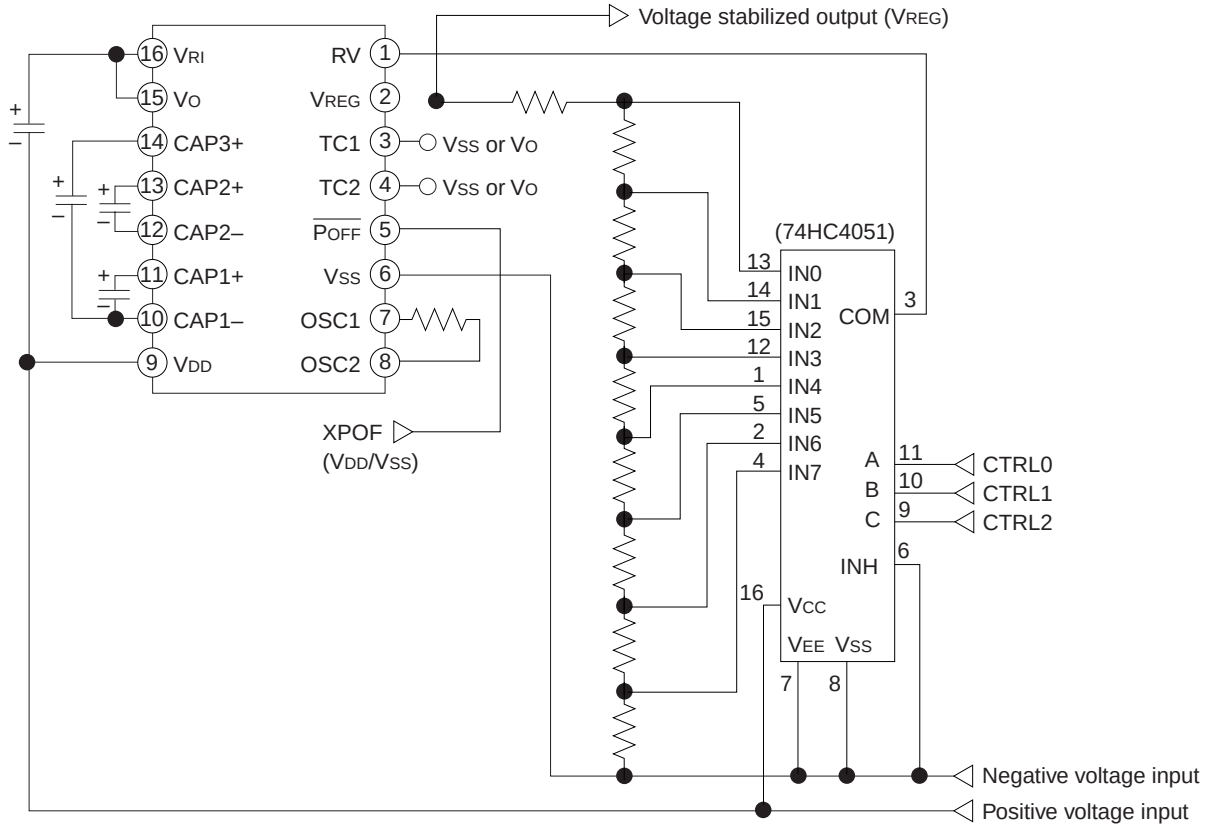


Figure 8.9

Configuration Example of High Magnification Step-up Circuit with Diode

S1F76640, if an external diode is attached, can realize 5 times or more step-up operation and voltage stabilized output. Since the forward voltage drop V_F of the diode makes the output impedance of the step-up output higher, it is recommended to use a diode of small V_F. Figure 8.10 shows a configuration example of a circuit with 2 diodes, which realizes 6 times step-up operation and voltage stabilized output. Make the wire between V_O and V_{RI} as short as possible. Figure 8.11 shows the potential relations diagram

By the way, use the voltage applied to the V_{RI} pin below the absolute maximum rated voltage.

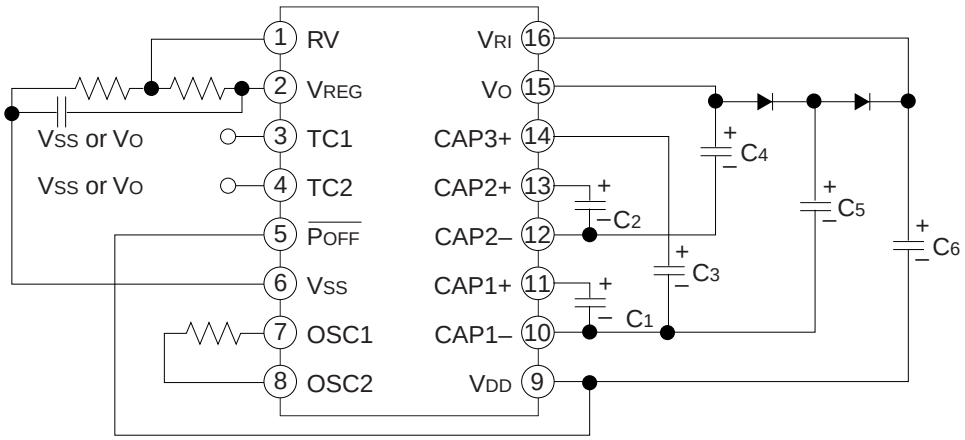


Figure 8.10 Configuration Example of 6 times step-up Circuit with Diode

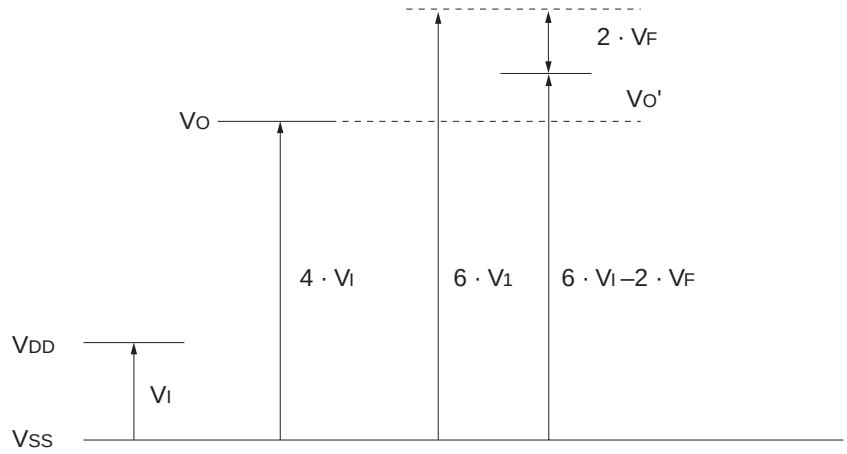


Figure 8.11 Potential Relations Diagram of 6 times Step-up Circuit with Diode

3. Voltage Regulator

S1F78100Y Series CMOS Positive Voltage Regulators

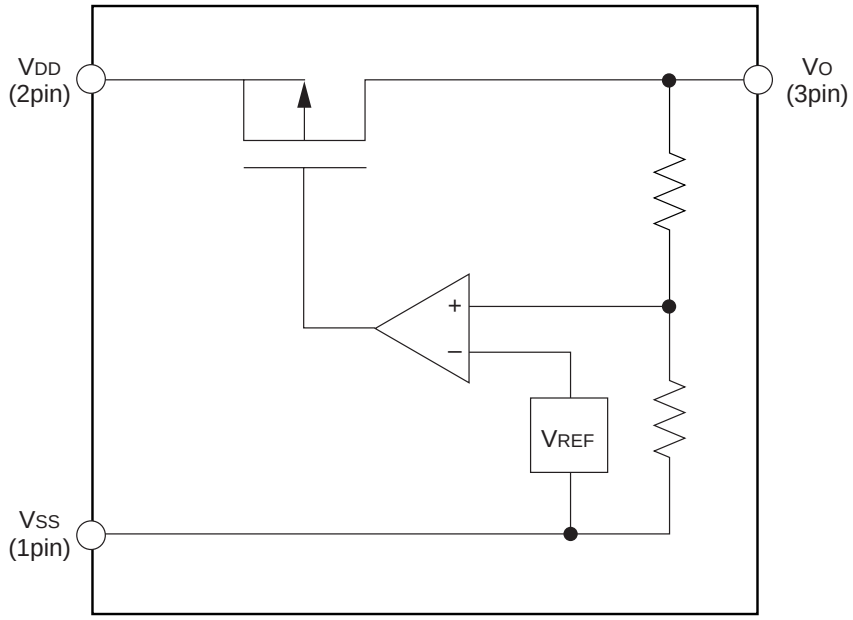
DESCRIPTION

SCI78100Y Series is a fixed type positive voltage regulator developed by using the CMOS silicon gate process and is composed of a low current consumption reference voltage circuit, a differential amplifier, an output control transistor and a voltage setting resistor.
The output voltage is fixed inside the IC, and various standard voltage parts are available.
The package is a SOT89-3pin plastic package.

FEATURES

- Ample lineup : 12 kinds are available in the range from 2V to 6V.
- Low current consumption : Typ. 3.0µA (V_{DD}=5.0V)
- Small difference between input and output voltages : Typ. 0.25V (I_O=–10mA, V_O=5.0V)
- Built-in highly stable reference voltage source : Typ. 1.0V
- Small output voltage temperature coefficient : Typ. +100ppm/˚C
- Wide operating voltage range : 15V Max.

BLOCK DIAGRAM

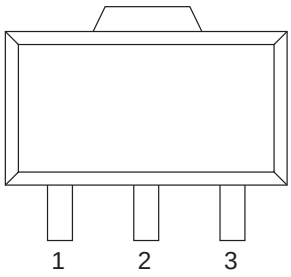


PIN DESCRIPTIONS

Pin No.	Pin name	Description
1	V_{SS}	Input voltage pin (minus side)
2	V_{DD}	Input voltage pin (plus side)
3	V_O	Output voltage pin

PIN ASSIGNMENTS

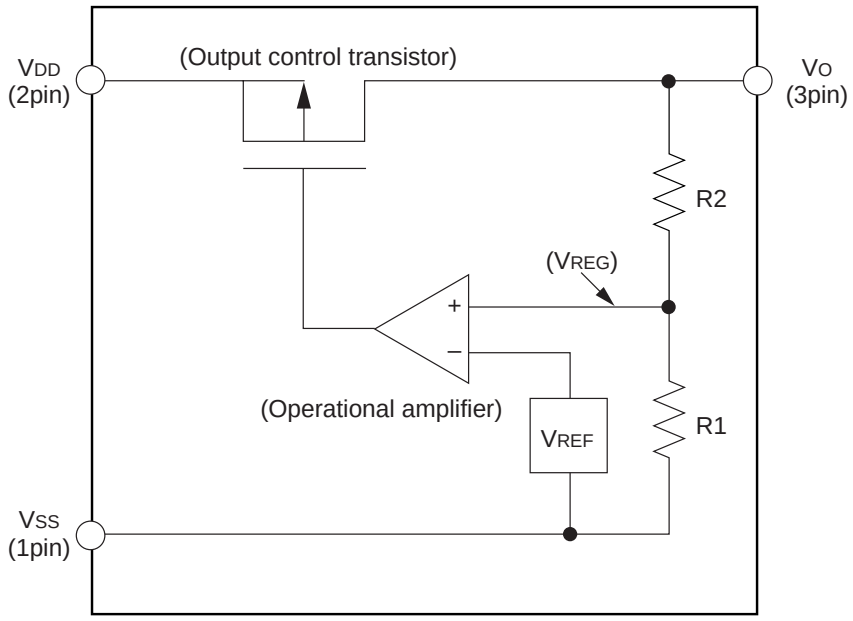
SOT89-3pin



FUNCTIONAL DESCRIPTIONS

S1F78100Y Series is a fixed positive output type voltage regulator of series regulator system and is fitted with an output control MOS transistor between the input and output pins as shown in the figure below. The voltage regulator feeds back voltages (V_{REG}) divided with the built-in resistors R_1 and R_2 connected between the output pin (V_O pin) and the V_{SS} pin to compare them with the reference voltage (V_{REF}) and outputs the stable output voltage (V_0) not depending on input voltage by controlling the gate voltage of the output control transistor. The output voltage is fixed inside and is decided with the following formula:

$$V_O = \frac{R_1+R_2}{R_1} \cdot V_{REF}$$



LINEUP

Product	Output Voltage		
	Min.	Typ.	Max.
S1F78100Y2A0	5.75	6.00	6.25
S1F78100Y2B0	4.90	5.00	5.10
S1F78100Y2M0	4.40	4.50	4.60
S1F78100Y2P0	3.90	4.00	4.10
S1F78100Y2K0	3.80	3.90	4.00
S1F78100Y2N0	3.43	3.50	3.57
S1F78100Y2T0	3.23	3.30	3.37
S1F78100Y2C0	3.13	3.20	3.27
S1F78100Y2D0	2.93	3.00	3.07
S1F78100Y2R0	2.73	2.80	2.87
S1F78100Y2L0	2.53	2.60	2.67
S1F78100Y2F0	2.15	2.20	2.25
S1F78100Y2G0	1.75	1.80	1.85
S1F78100Y2H0	1.45	1.50	1.55

Note :
Other output voltages than those listed in the above table are also applicable.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Input voltage	V_{DD}–V_{SS}	21	V
Output voltage	V_O	V_{DD}+0.3 to V_{SS}-0.3	
Output current	I_O	100	mA
Allowable loss	P_D	200	mW
Operating temperature	Topr	–40 to +85	˚C
Storage ambient temperature	Tstg	–65 to +150	
Soldering temperature and time	Tsol	260 • 10 (at leads)	˚C • s

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input voltage	V_{DD}–V_{SS}	–	–	15	V
Output current	I_O	0.01	–	–	mA

ELECTRICAL CHARACTERISTICS

S1F78100Y2A0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=8.0V, I_O=–10mA Ta=25˚C	5.75	6.00	6.25	V
Current consumption	I_{OPR}	V_{DD}=6.0V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=6.0V, I_O=–10mA	—	0.24	0.38	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=7.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=8.0V I_O=–1mA to –50mA	—	50	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=8.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2B0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=7.0V, I_O=–10mA Ta=25˚C	4.90	5.00	5.10	V
Current consumption	I_{OPR}	V_{DD}=5.0V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=5.0V, I_O=–10mA	—	0.25	0.40	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=6.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=7.0V I_O=–1mA to –50mA	—	50	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=7.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2M0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=6.0V, I_O=–10mA Ta=25˚C	4.40	4.50	4.60	V
Current consumption	I_{OPR}	V_{DD}=4.5V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=4.5V, I_O=–10mA	—	0.26	0.42	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=6.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=6.0V I_O=–1mA to –40mA	—	40	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=6.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2P0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=6.0V, I_O=–10mA Ta=25˚C	3.90	4.00	4.10	V
Current consumption	I_{OPR}	V_{DD}=4.0V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=4.0V, I_O=–10mA	—	0.27	0.44	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=5.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=6.0V I_O=–1mA to –40mA	—	40	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=6.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2K0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=6.0V, I_O=–10mA Ta=25˚C	3.80	3.90	4.00	V
Current consumption	I_{OPR}	V_{DD}=3.9V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=3.9V, I_O=–10mA	—	0.27	0.44	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=5.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=6.0V I_O=–1mA to –40mA	—	40	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=6.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2N0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=5.0V, I_O=–10mA Ta=25˚C	3.43	3.50	3.57	V
Current consumption	I_{OPR}	V_{DD}=3.5V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=3.5V, I_O=–10mA	—	0.29	0.48	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=5.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=5.0V I_O=–1mA to –30mA	—	30	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=5.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2T0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=5.0V, I_O=–10mA Ta=25˚C	3.23	3.30	3.37	V
Current consumption	I_{OPR}	V_{DD}=3.3V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=3.3V, I_O=–10mA	—	0.30	0.50	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=4.0V to 15.0V I_O=–10mA	—	0.1	–	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=5.0V I_O=–1mA to –30mA	—	30	–	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=5.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2C0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=5.0V, I_O=–10mA Ta=25˚C	3.13	3.20	3.27	V
Current consumption	I_{OPR}	V_{DD}=3.2V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=3.2V, I_O=–10mA	—	0.30	0.50	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=4.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=5.0V I_O=–1mA to –30mA	—	30	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=5.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2D0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=5.0V, I_O=–10mA Ta=25˚C	2.93	3.00	3.07	V
Current consumption	I_{OPR}	V_{DD}=3.0V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=3.0V, I_O=–10mA	—	0.31	0.52	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=4.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=5.0V I_O=–1mA to –30mA	—	30	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=5.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2R0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=5.0V, I_O=–10mA Ta=25˚C	2.73	2.80	2.87	V
Current consumption	I_{OPR}	V_{DD}=2.8V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=2.8V, I_O=–10mA	—	0.32	0.54	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=4.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=5.0V I_O=–1mA to –30mA	—	30	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=5.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2L0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=5.0V, I_O=–10mA Ta=25˚C	2.53	2.60	2.67	V
Current consumption	I_{OPR}	V_{DD}=2.6V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=2.6V, I_O=–10mA	—	0.33	0.56	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=4.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=5.0V I_O=–1mA to –40mA	—	30	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=5.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2F0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=3.0V, I_O=–10mA Ta=25˚C	2.15	2.20	2.25	V
Current consumption	I_{OPR}	V_{DD}=2.2V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=2.2V, I_O=–5mA	—	0.36	0.62	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=3.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=3.0V I_O=–1mA to –10mA	—	20	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=3.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2G0

(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

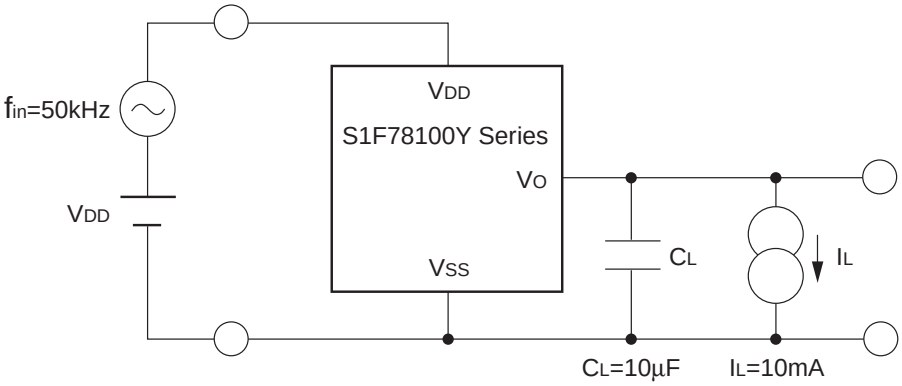
Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=3.0V, I_O=–1mA Ta=25˚C	1.75	1.80	1.85	V
Current consumption	I_{OPR}	V_{DD}=2.2V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=1.8V, I_O=–1mA	—	0.075	0.18	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=3.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=3.0V I_O=–1mA to –10mA	—	20	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=3.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

S1F78100Y2H0

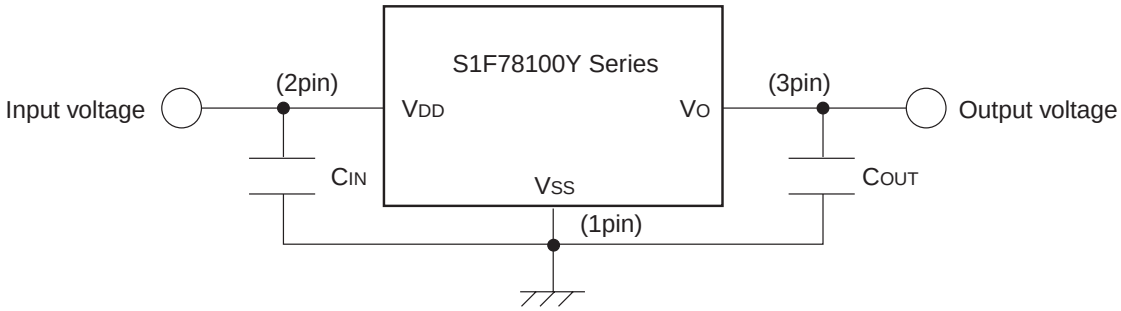
(Unless otherwise specified, Ta ranges from –40˚C to +85˚C.)

Parameter	Symbol	Conditions (Vss=0.0V)	Min.	Typ.	Max.	Unit
Input voltage	V_I	—	—	—	15	V
Output voltage	V_O	V_{DD}=3.0V, I_O=–1mA Ta=25˚C	1.45	1.50	1.55	V
Current consumption	I_{OPR}	V_{DD}=2.2V to 15.0V, No load	—	3.0	8.0	µA
Difference between input and output voltages	V_I–V_O	V_O=1.5V, I_O=–1mA	—	0.18	0.5	V
Output voltage temperature characteristic	$\frac{\Delta V_O}{V_O}$	—	0	+100	+200	ppm/˚C
Input stability	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=3.0V to 15.0V I_O=–10mA	—	0.1	—	%/V
Load stability	ΔV_O	Ta=–30˚C to +85˚C (Same temperature condition) V_{DD}=3.0V I_O=–1mA to –10mA	—	20	—	mV
Supply voltage rejection ratio	P_{SRR}	V_{DD}=3.0V, fin=40kHz C_L=10µF, I_O=–5mA	—	–40	—	dB

Note : Circuit Diagram for Measuring Supply Voltage Rejection Ratio Characteristic



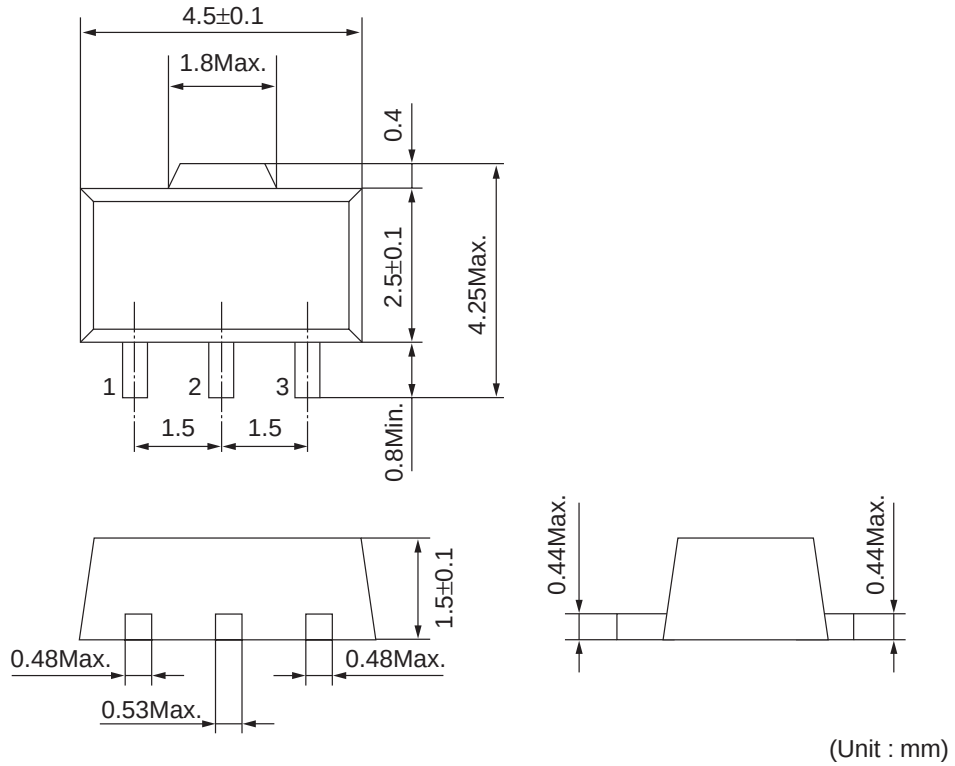
EXAMPLE OF REFERENCE EXTERNAL CONNECTION



MECHANICAL DATA

S1F78100Y SOT89-3pin

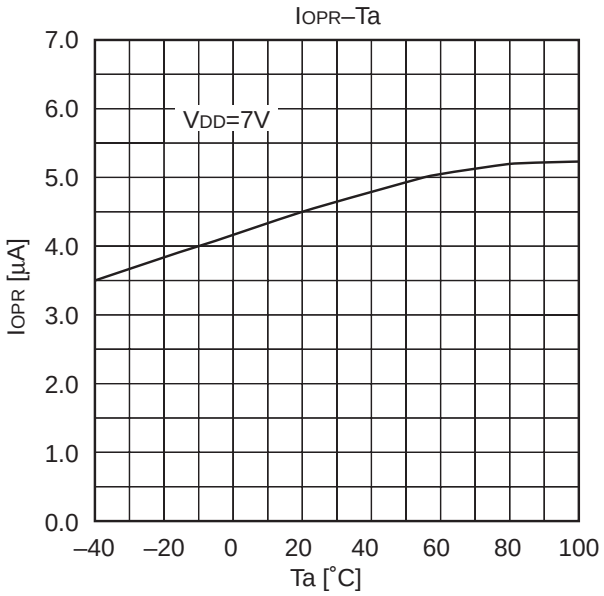
Reference

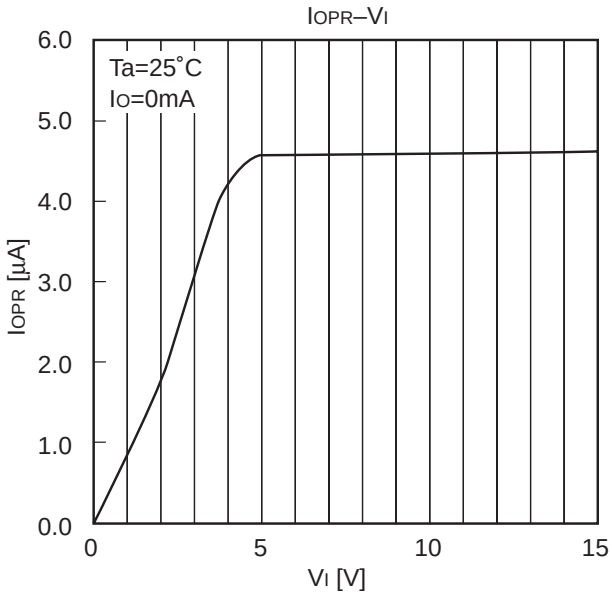


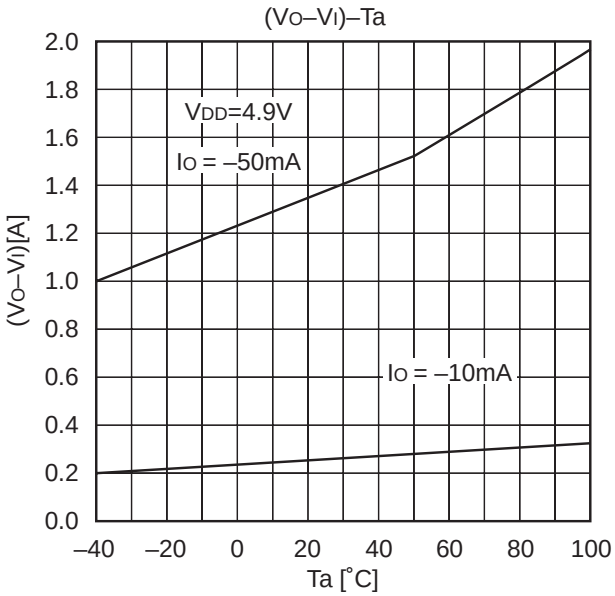
(Unit : mm)

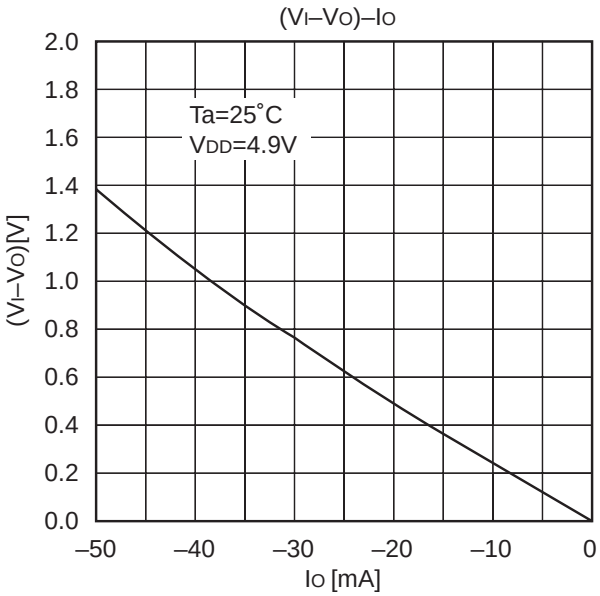
CHARACTERISTICS GRAPH

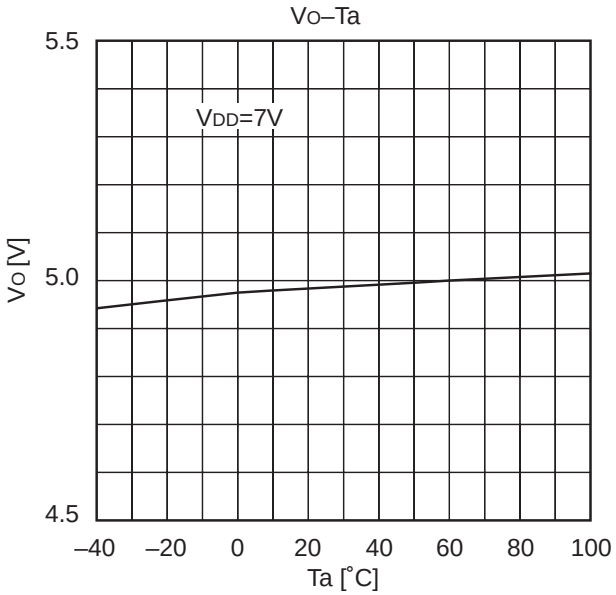
S1F78100Y2B0

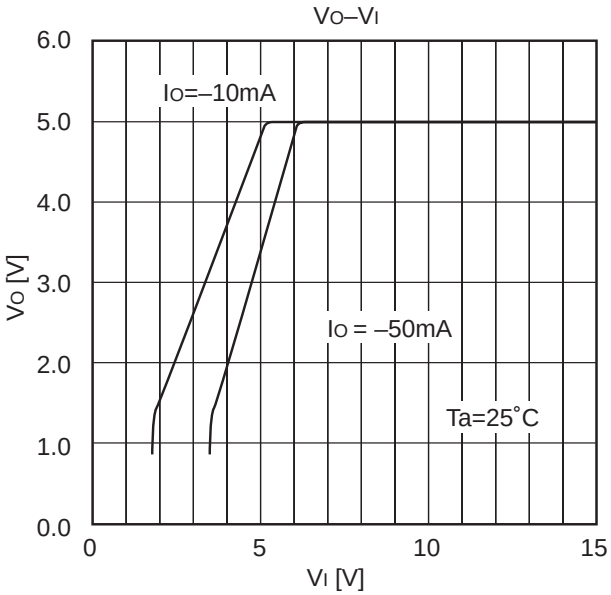


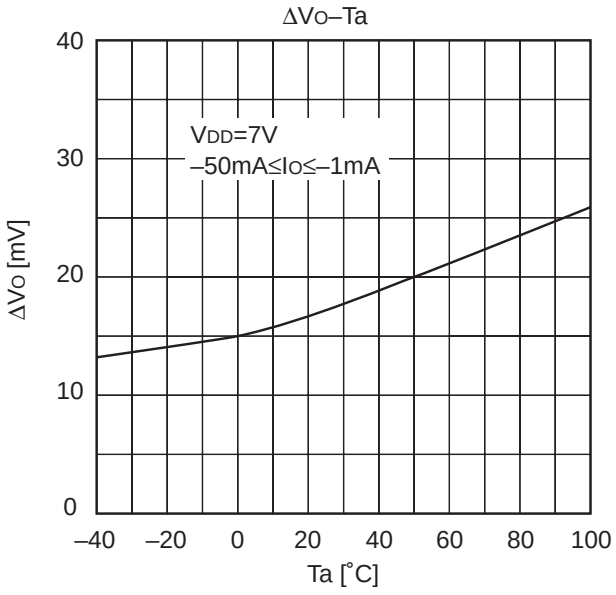


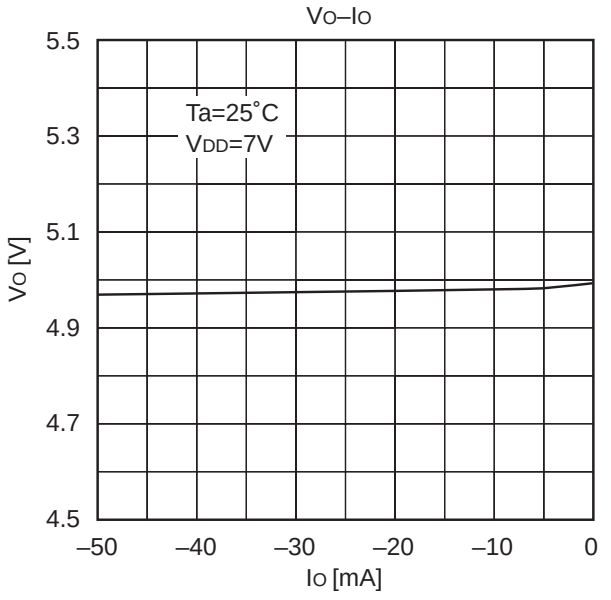












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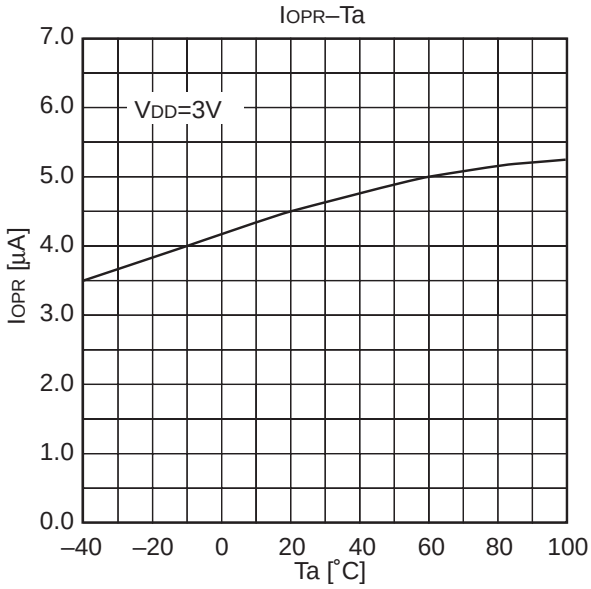

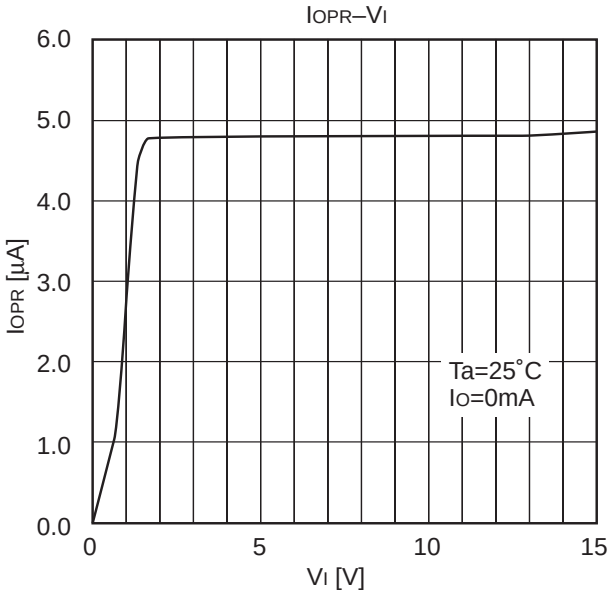

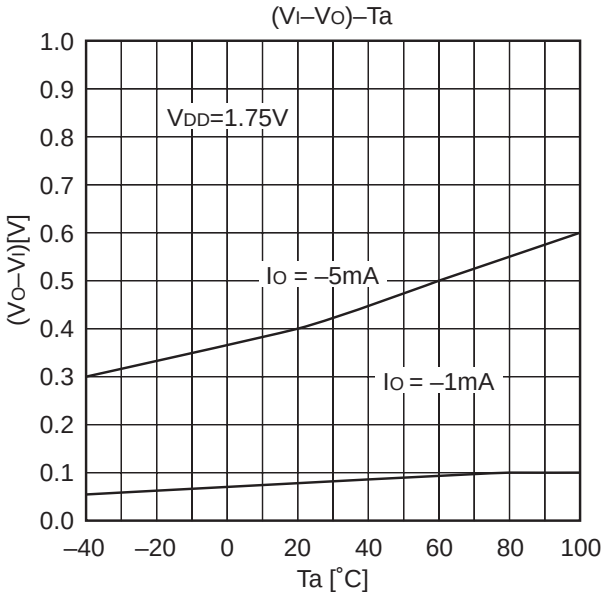

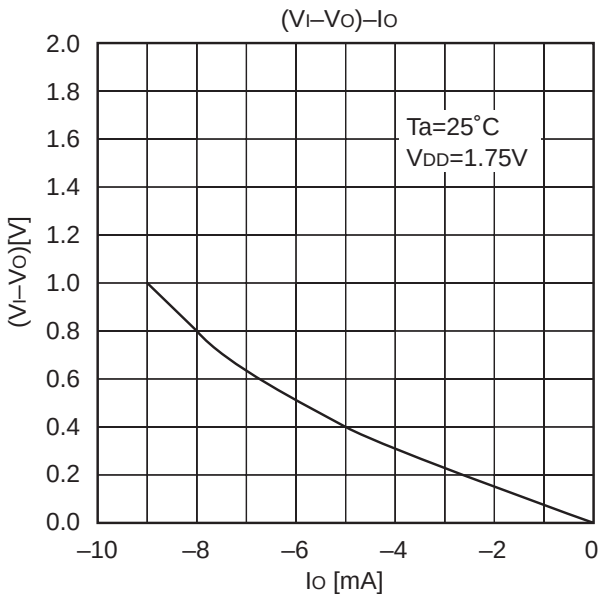

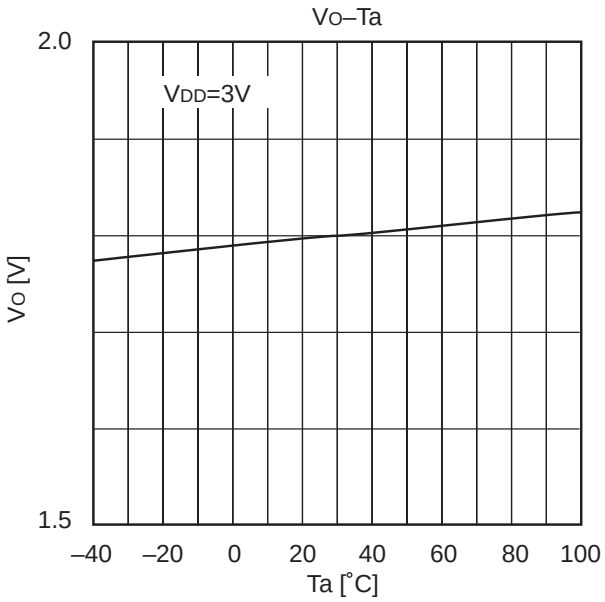

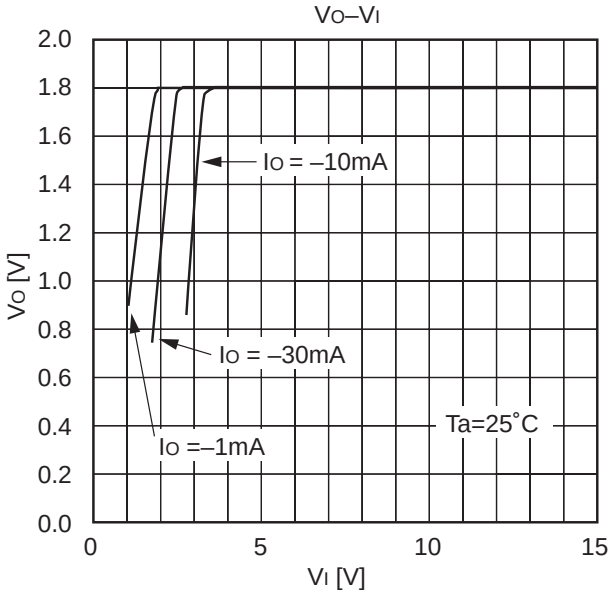

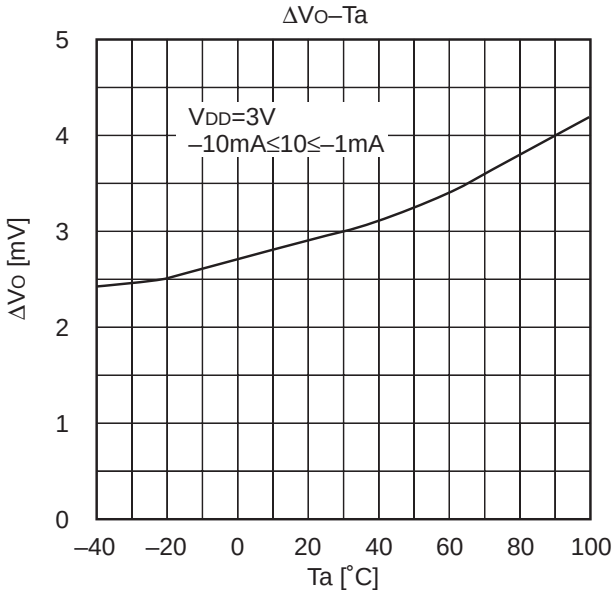

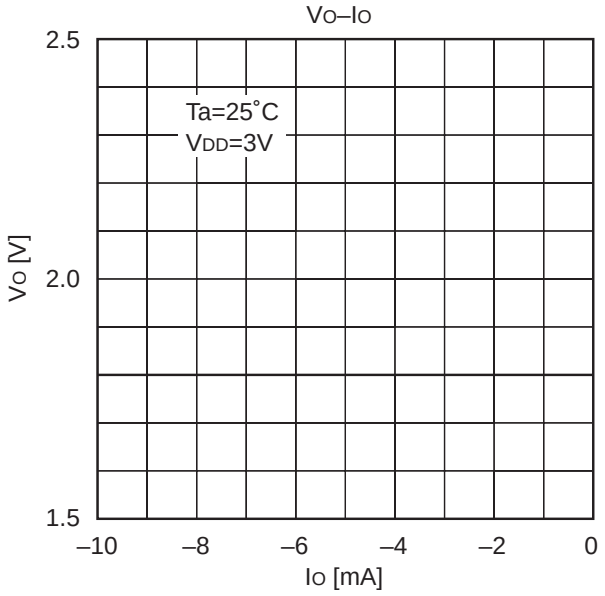

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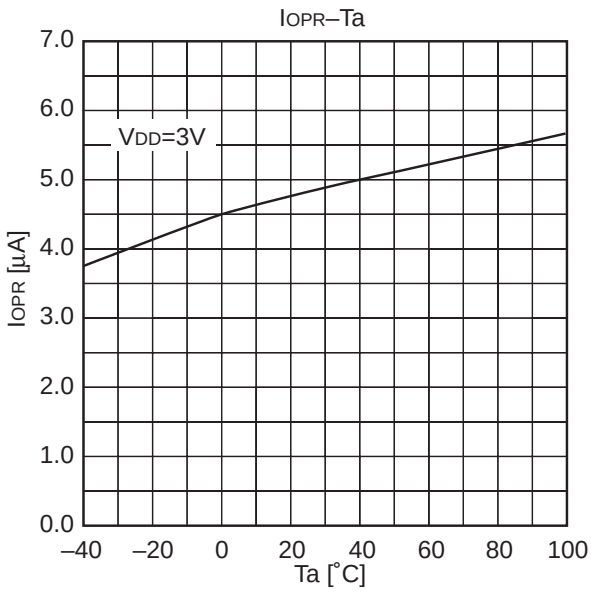
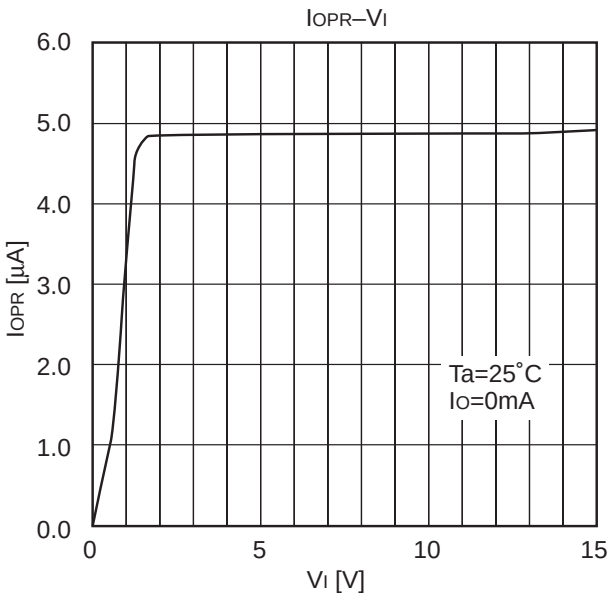
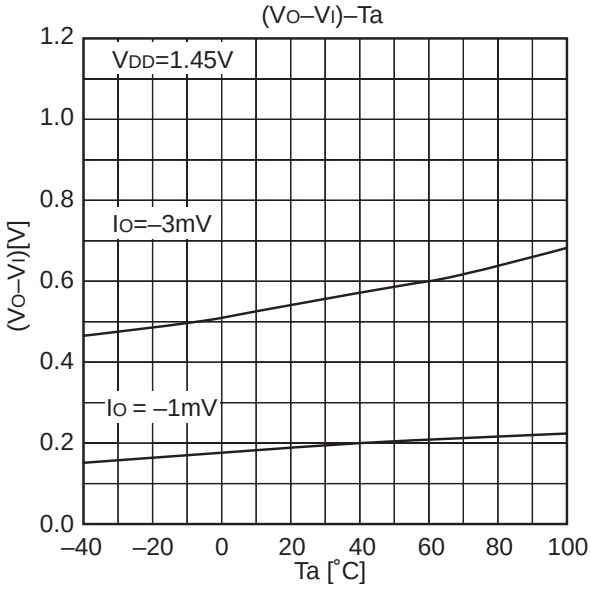
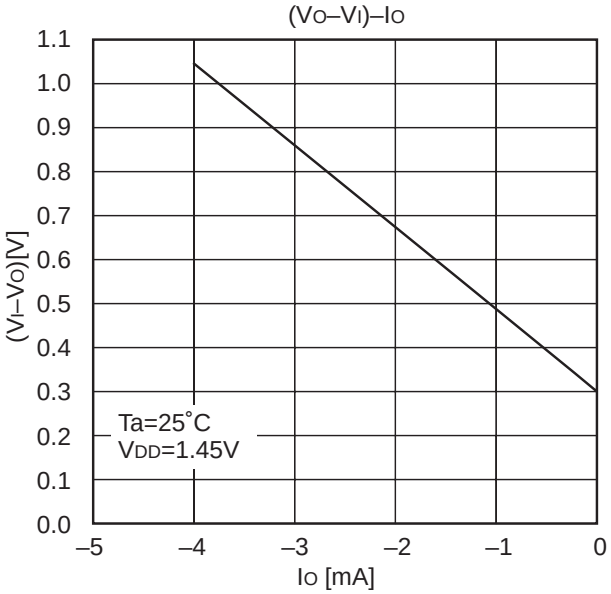
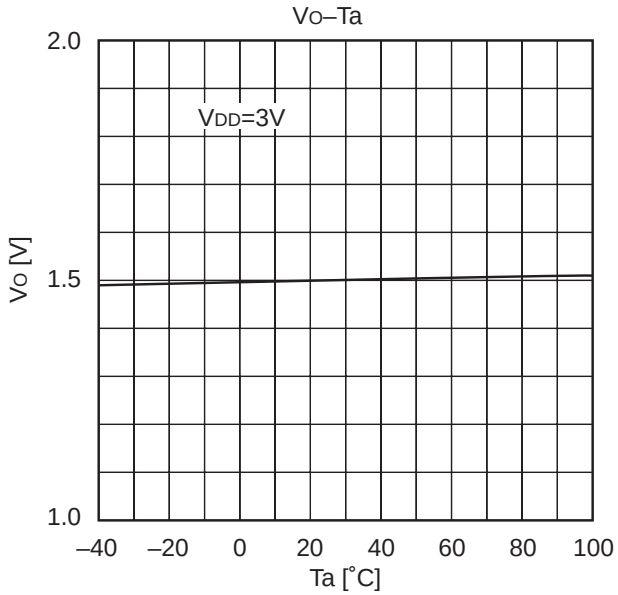
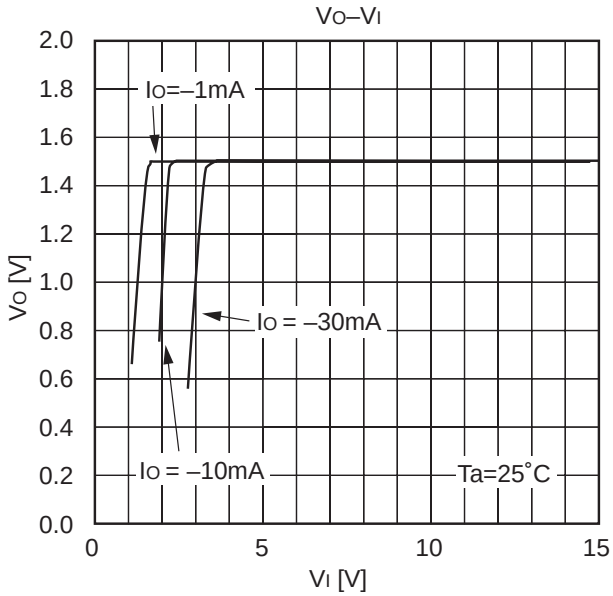


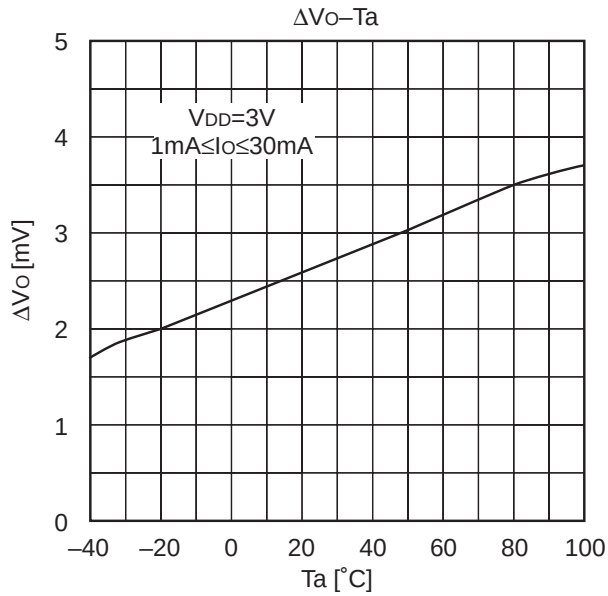


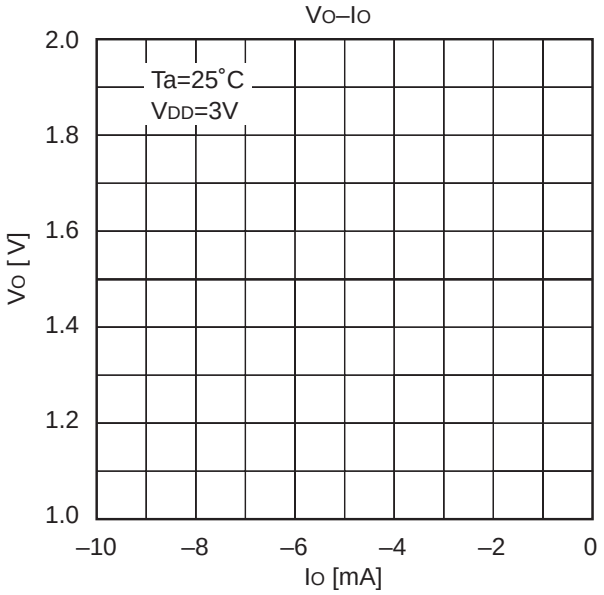












S1F79100Y Series CMOS Negative Voltage Regulators

DESCRIPTION

S1F79100Y series voltage regulators provide step-down and stabilization for an input voltage to a specified fixed voltage. The four devices in the series incorporate a precision, power-saving reference voltage generator, a transistorized differential amplifier and resistors for determining the output voltage.
The S1F79100Y series is available in 3-pin plastic SOT89s.

FEATURES

- Ample lineup : 5 kinds are available in the range from –1.5V to –5V.
- Small difference between input and output voltage : Typ. 0.17V (I_O=10mA, V_O=–5.0V)
- Built-in highly stable reference voltage source : Typ. –1.0V
- Small output voltage temperature coefficient : Typ. –100ppm/˚C
- Wide operating voltage range : 15V Max.

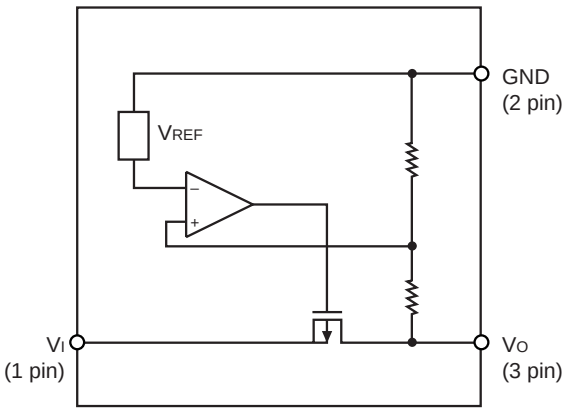
APPLICATIONS

- Fixed-voltage power supplies for battery-operated equipment such as portable video cassette recorders, video cameras and radios
- Fixed-voltage power supplies for communications equipment
- High-stability reference voltage generators

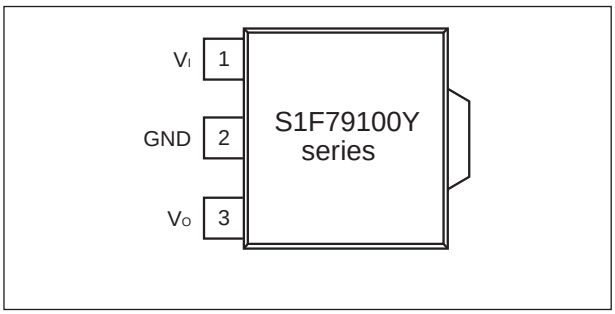
LINEUP

Product	Voltage (V)		Current consumption (μA)	Operating temperature (°C)
	Input	Output		
S1F79100Y1H0	–15	–1.5	4.0	–40 to +85
S1F79100Y1G0		–1.8	4.0	
S1F79100Y1D0		–3.0	4.0	
S1F79100Y1P0		–4.0	4.0	
S1F79100Y1B0		–5.0	4.0	

BLOCK DIAGRAM



PIN ASSIGNMENTS



PIN DESCRIPTIONS

Pin No.	Pin name	Description
1	V_I	Input voltage
2	GND	Ground
3	V_O	Output voltage

SPECIFICATIONS

Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Input voltage	V_I–GND	–21	V
Output voltage	V_O	GND + 0.3 to V_I – 0.3	V
Output current	I_O	100	mA
Power dissipation	P_D	200	mW
Operating temperature range	Topr	–40 to +85	°C
Storage temperature range	Tstg	–65 to +150	°C
Soldering 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 S1F70000 series power supply devices.

Electrical Characteristics
S1F79100Y1H0

(Ta = –40°C to +85°C)

Parameter	Symbol	Conditions (GND = 0.0V)	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_I	—	–15.0	—	—	V
Output voltage	V_O	V_I = –3.0V, I_O = 10mA Ta = 25°C	–1.57	–1.50	–1.43	V
Operating current	I_{OPR}	V_I = –1.5V to –15V	—	4.0	18.0	µA
Input/output voltage differential	$\lvert V_I - V_O \rvert$	V_I = –1.5V, I_O = 5mA	—	0.25	0.60	V
Input voltage stabilization ratio	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	V_I = –3.0V to –15.0V, I_O = 5mA	—	0.10	—	%/V
Output voltage drift	ΔV_O	V_I = –3.0V, I_O = 1mA to 5mA	—	20.0	—	mV

S1F79100Y1G0

(V_{DD} = 0V, Ta = –40°C to +85°C unless otherwise noted)

Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_I	—	–15.0	—	—	V
Output voltage	V_O	V_I = –3.0V, I_O = 10mA Ta = 25°C	–1.87	–1.80	–1.73	V
Operating current	I_{OPR}	V_I = –1.8V to –15.0V	—	4.0	18.0	µA
Input/output voltage differential	$\lvert V_I - V_O \rvert$	V_I = –1.8V, I_O = 10mA	—	0.35	0.70	V
Input voltage stabilization ratio	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	V_I = –3.0V to –15.0V, I_O = 10mA, Isothermal	—	0.10	—	%/V
Output voltage drift	ΔV_O	V_I = –3.0V, I_O = 1mA to 10mA, Isothermal	—	20.0	—	mV

S1F79100Y1D0

(V_{DD} = 0V, Ta = –40°C to +85°C unless otherwise noted)

Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_I	—	–15.0	—	—	V
Output voltage	V_O	V_I = –5.0V, I_O = 10mA Ta = 25°C	–3.07	–3.00	–2.93	V
Operating current	I_{OPR}	V_I = –3.0V to –15.0V	—	4.0	18.0	µA
Input/output voltage differential	$\lvert V_I - V_O \rvert$	V_I = –3.0V, I_O = 10mA	—	0.23	0.46	V
Input voltage stabilization ratio	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	V_I = –4.0V to –15.0V, I_O = 10mA, Isothermal	—	0.10	—	%/V
Output voltage drift	ΔV_O	V_I = –5.0V, I_O = 1mA to 30mA	—	30.0	—	mV

S1F79100Y1P0

(V_{DD} = 0V, Ta = –40°C to +85°C unless otherwise noted)

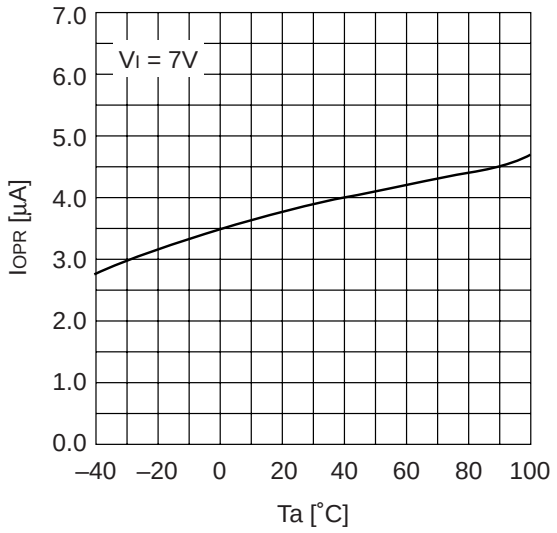
Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_I	—	–15.0	—	—	V
Output voltage	V_O	V_I = –6.0V, I_O = 10mA Ta = 25°C	–4.10	–4.00	–3.90	V
Operating current	I_{OPR}	V_I = –4.0V to –15.0V	—	4.0	18.0	µA
Input/output voltage differential	$\lvert V_I - V_O \rvert$	V_I = –4.0V, I_O = 10mA	—	0.19	0.38	V
Input voltage stabilization ratio	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	V_I = –5.0V to –15V, I_O = 10mA, Isothermal	—	0.10	—	%/V
Output voltage drift	ΔV_O	V_I = –7V, I_O = 1mA to 30mA	—	40.0	—	mV

S1F79100Y1B0

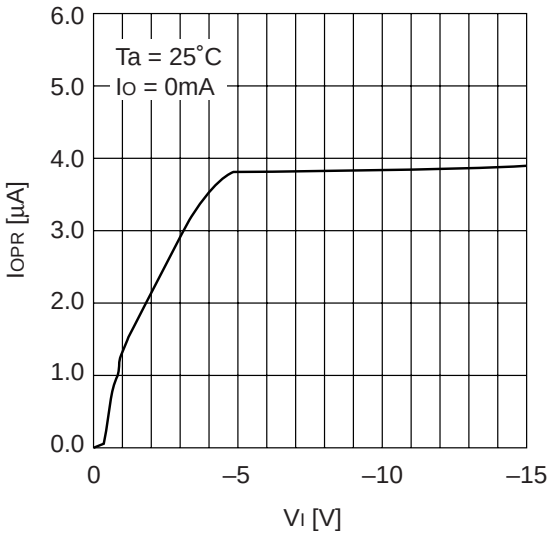
(V_{DD} = 0V, Ta = –40°C to +85°C unless otherwise noted)

Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_I	—	–15.0	—	—	V
Output voltage	V_O	V_I = –7.0V, I_O = 10mA Ta = 25°C	–5.10	–5.00	–4.90	V
Operating current	I_{OPR}	V_I = –5.0V to –15.0V	—	4.0	18.0	µA
Input/output voltage differential	$\lvert V_I - V_O \rvert$	V_I = –5.0V, I_O = 10mA	—	0.17	0.34	V
Input voltage stabilization ratio	$\frac{\Delta V_O}{\Delta V_I \cdot V_O}$	V_I = –6.0V to –15.0V, I_O = 10mA, Isothermal	—	0.10	—	%/V
Output voltage drift	ΔV_O	V_I = –7.0V, I_O = 1mA to 50mA	—	50.0	—	mV

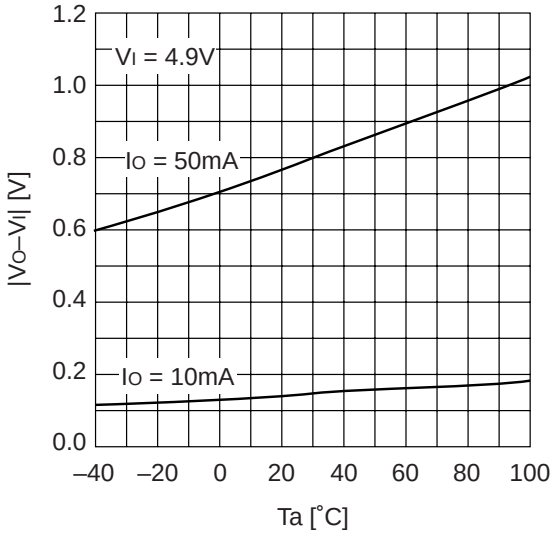
Typical Performance Characteristics
S1F79100Y1B0



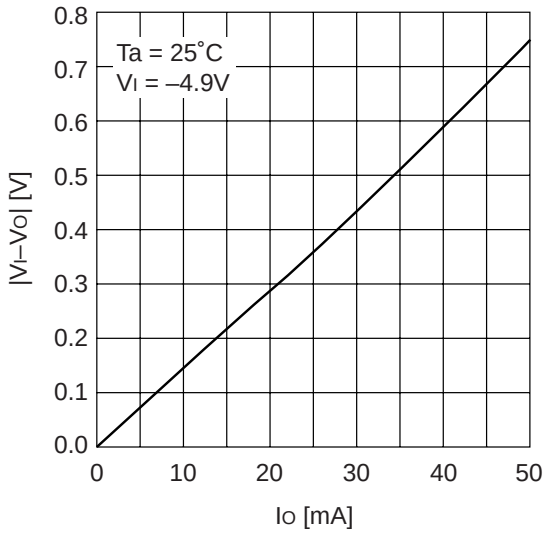
IOPR vs. Ta



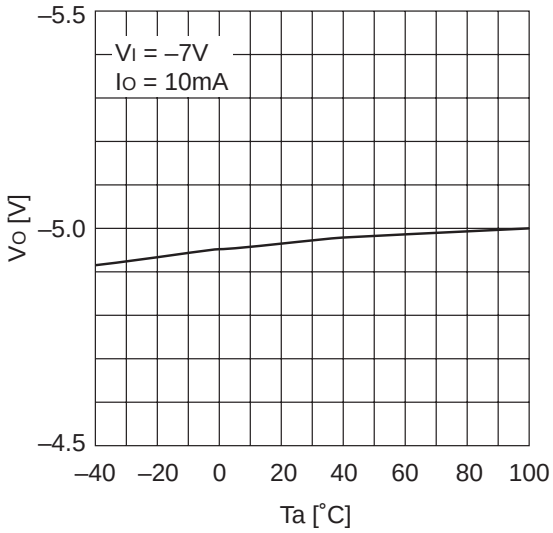
IOPR vs. VI



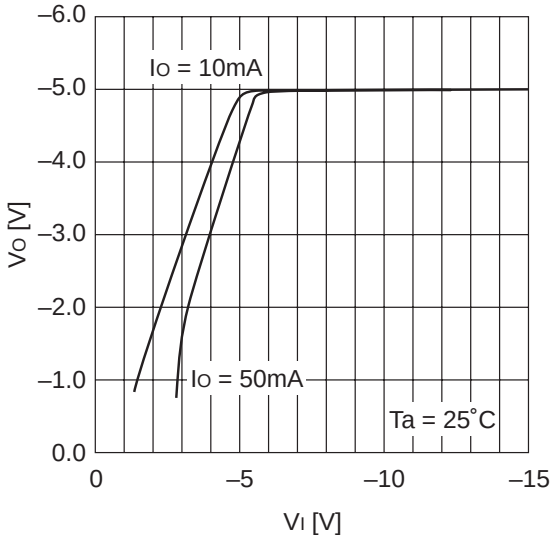
|VO – VI| vs. Ta



|VI – VO| vs. IO



VO vs. Ta



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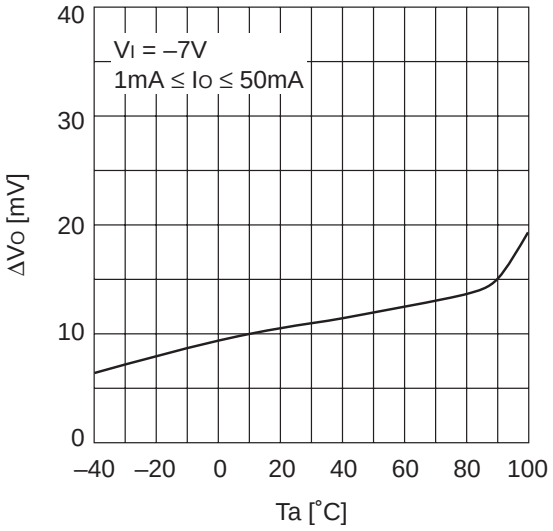
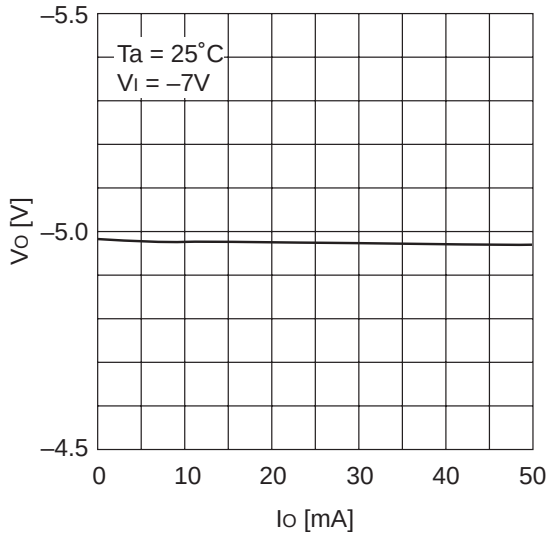
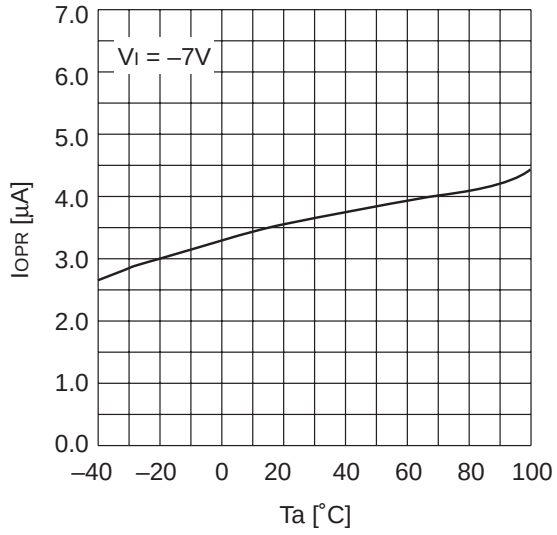


ΔVO vs. Ta

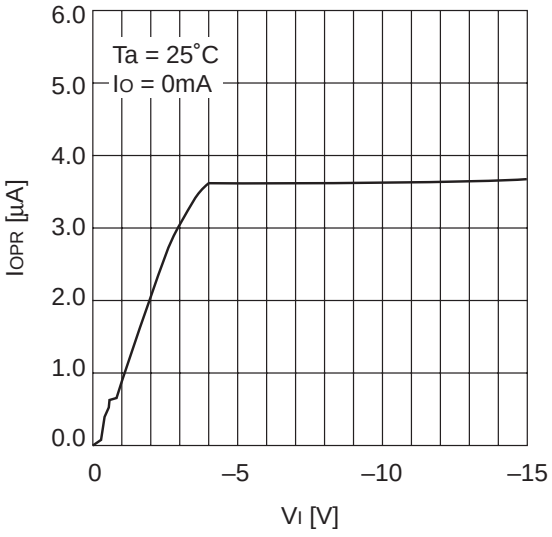


VO vs. IO

S1F79100Y1P0



IOPR vs. Ta



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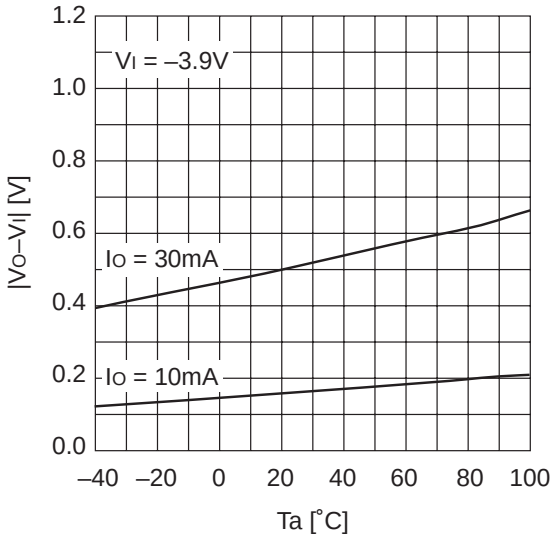
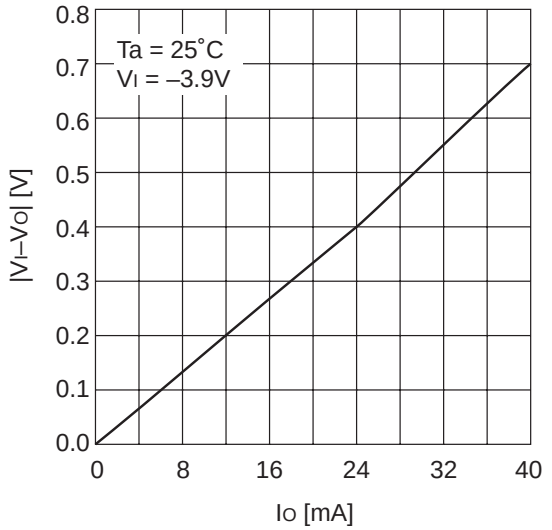


|VO – VI| vs. Ta



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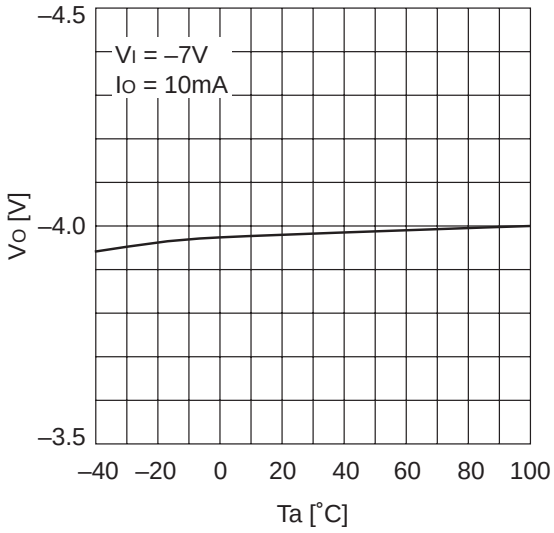
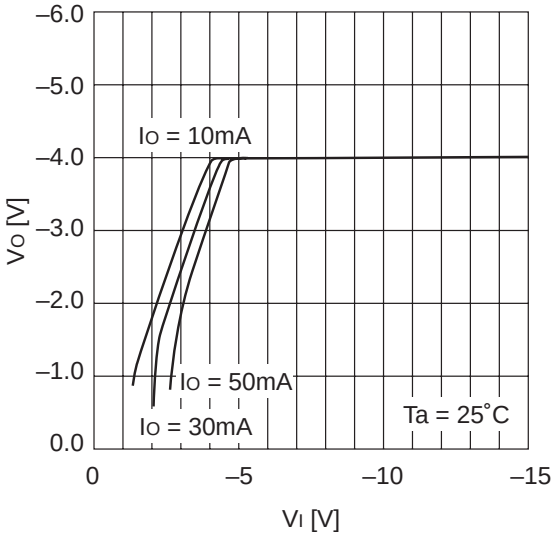
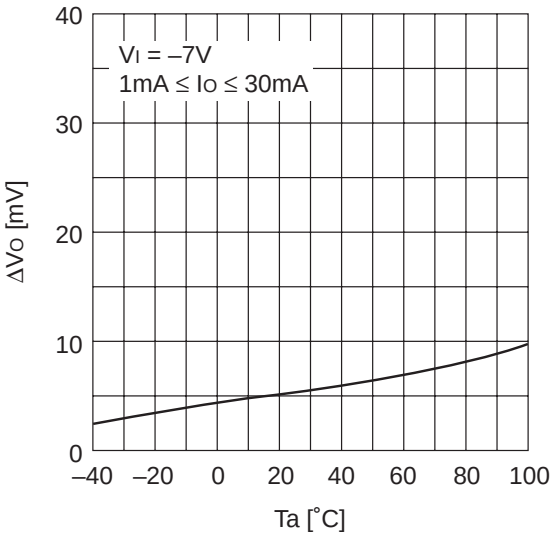


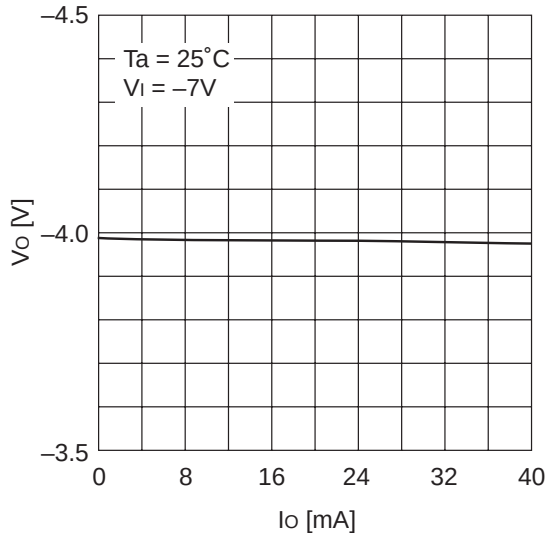
VO vs. Ta



VO vs. VI

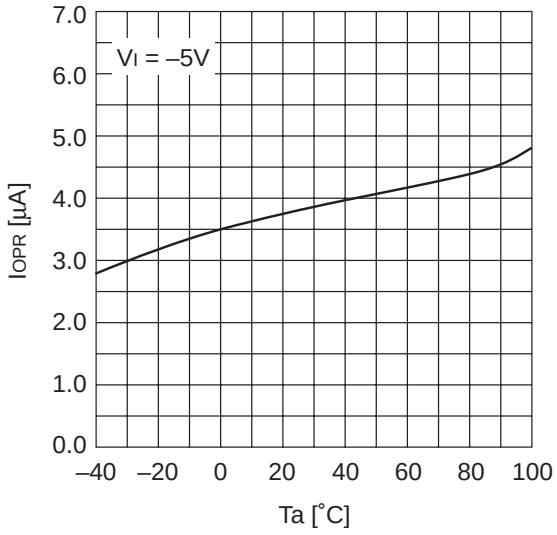


ΔVo vs. Ta

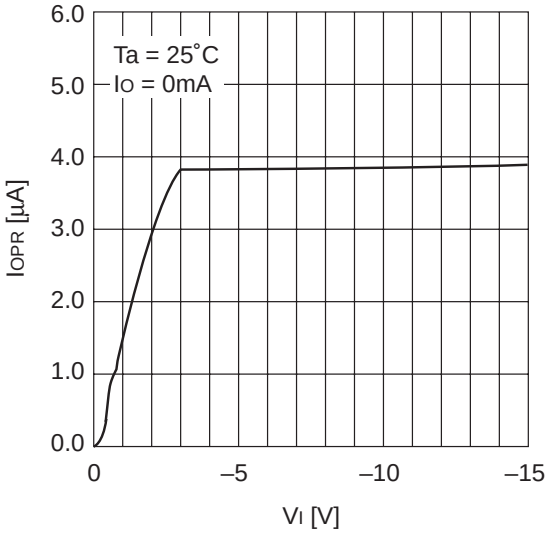


Vo vs.Io

S1F79100Y1D0



IOPR vs. Ta



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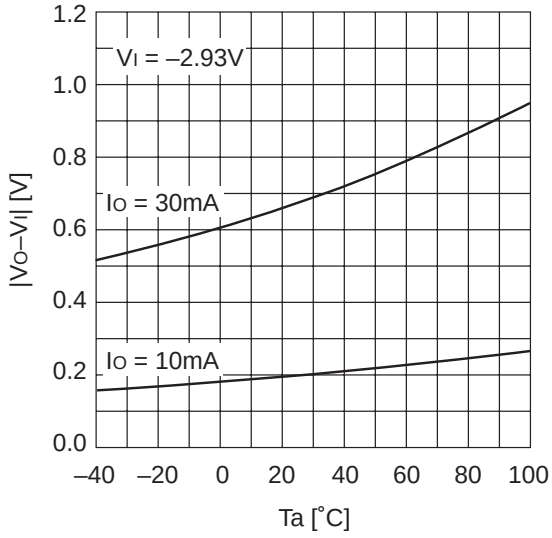
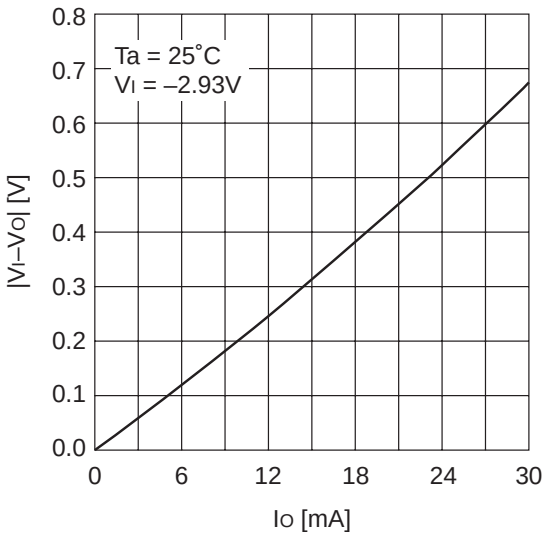
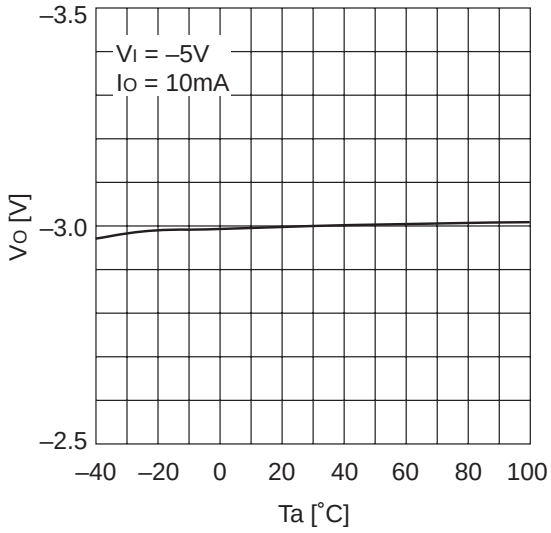


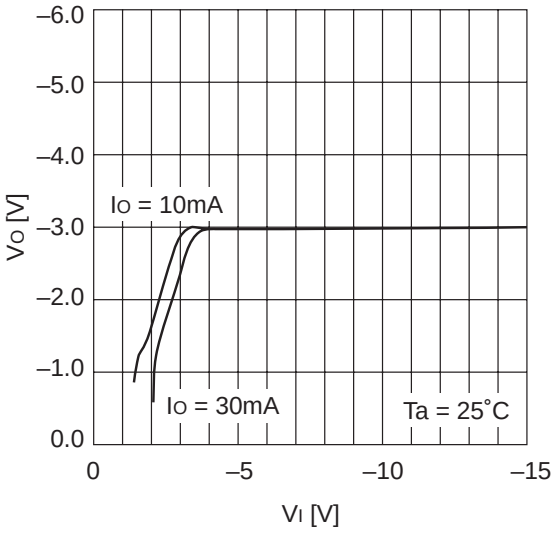
|VO – VI| vs. Ta



|VI – VO| vs. IO



VO vs. Ta



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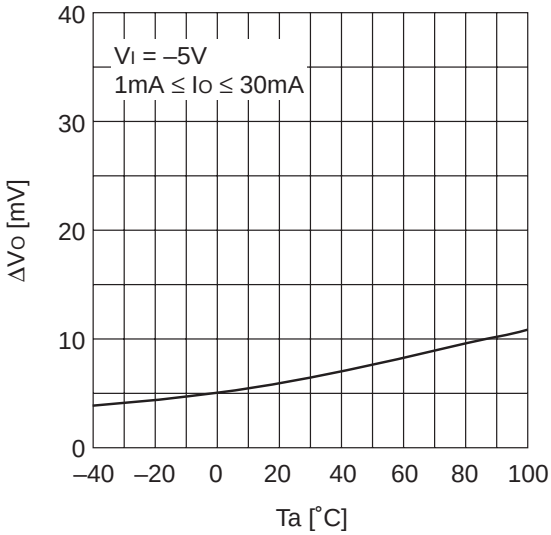
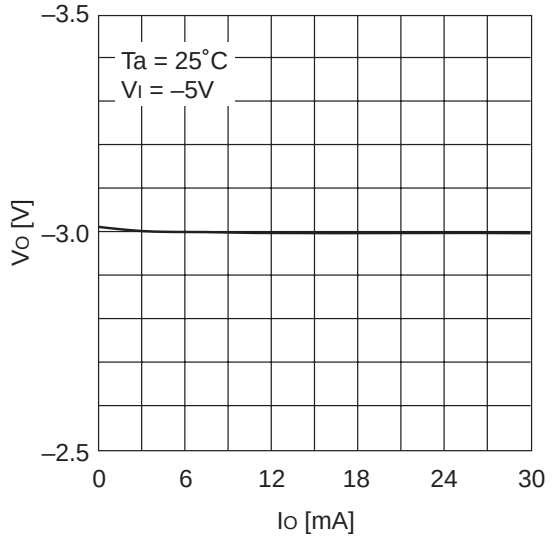


ΔVO vs. Ta



VO vs. IO

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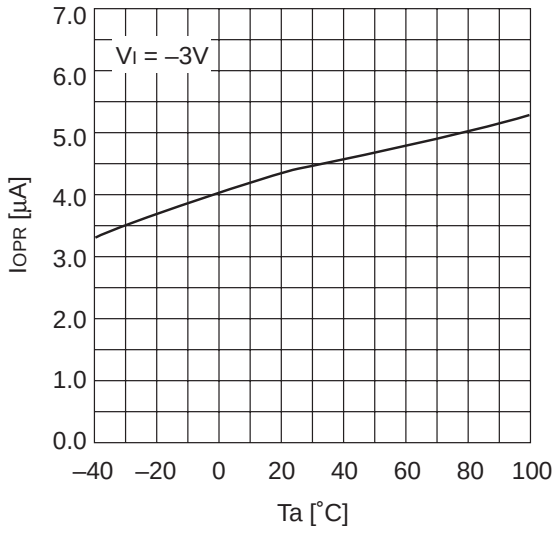
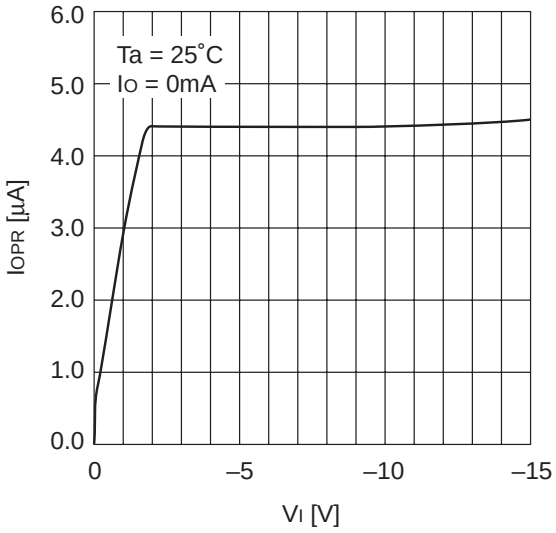
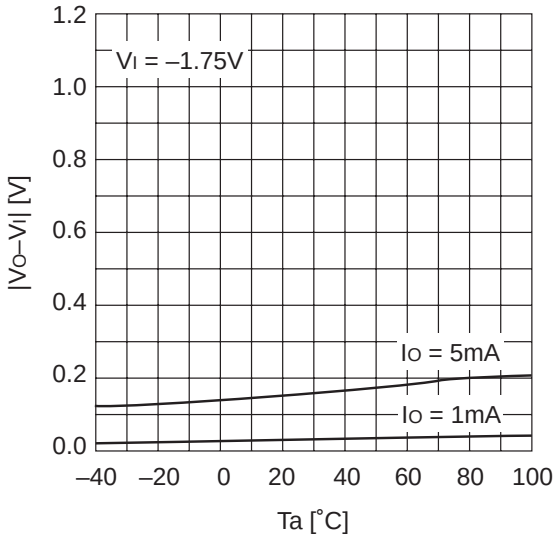


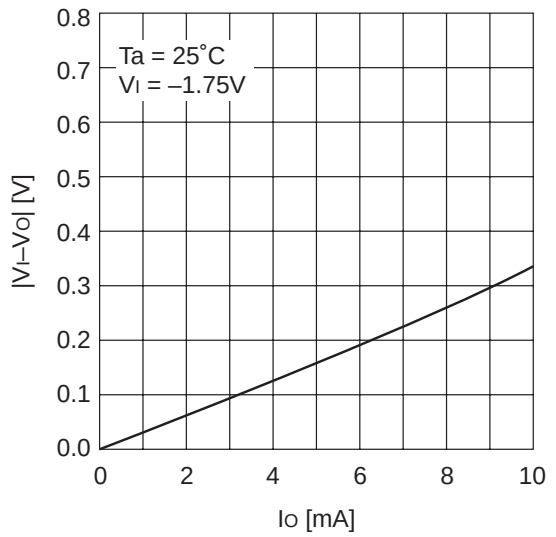
IOPR vs. Ta



IOPR vs. VI



|VO – VI| vs. Ta



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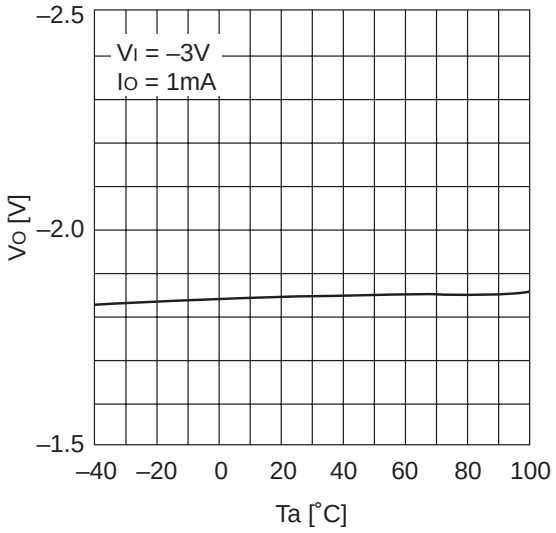
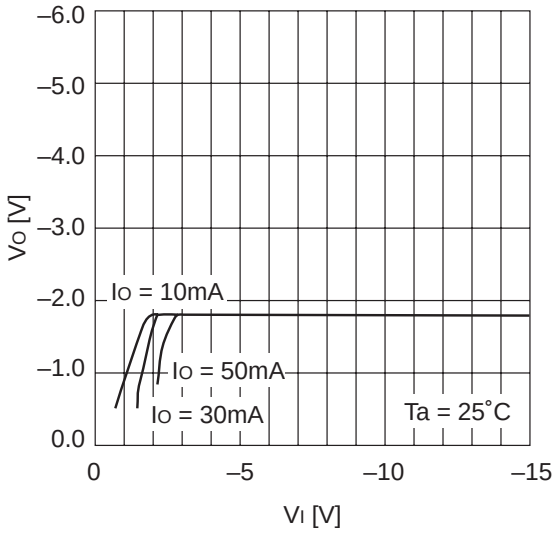


VO vs. Ta



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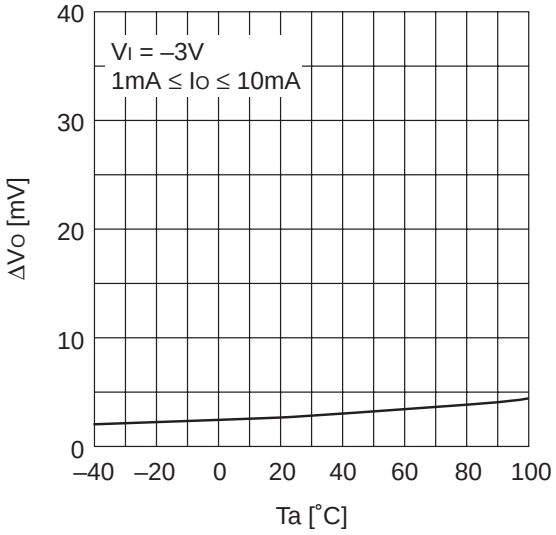
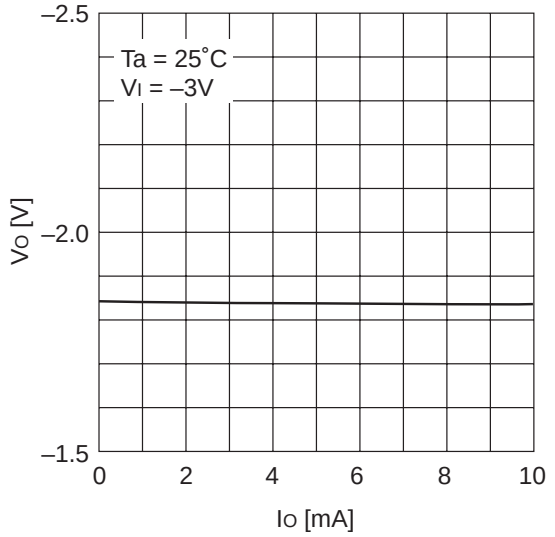
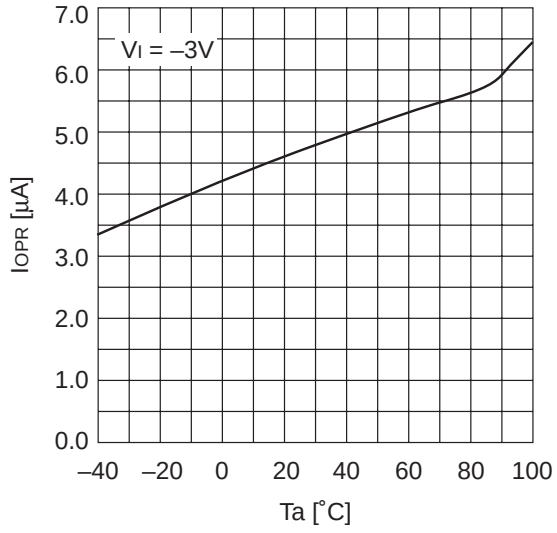


ΔVO vs. Ta

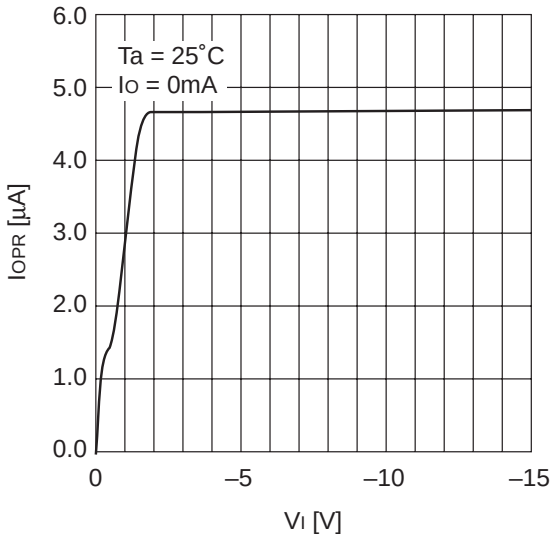


VO vs. IO

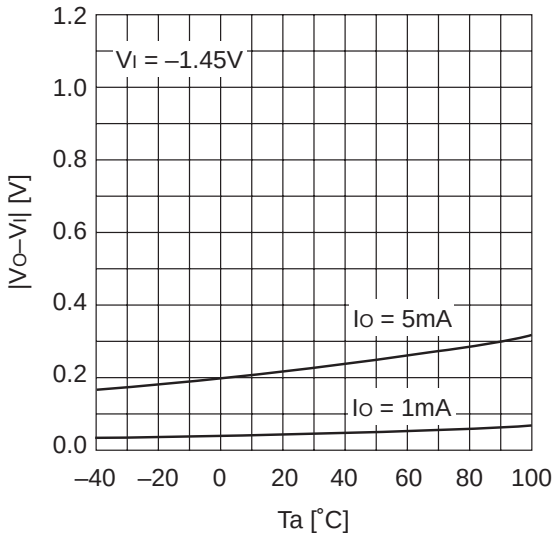
S1F79100Y1H0



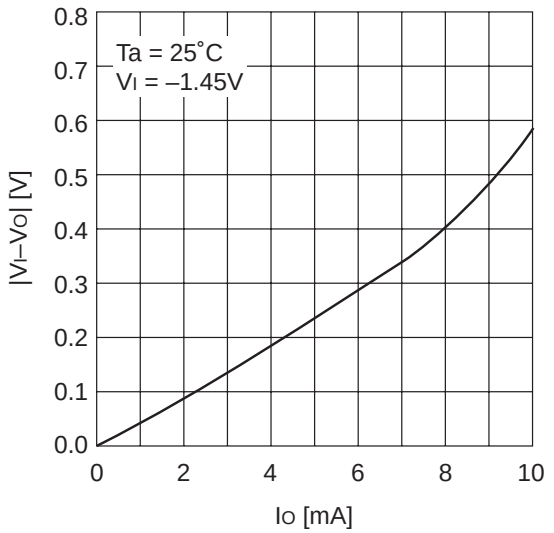
IOPR vs. Ta



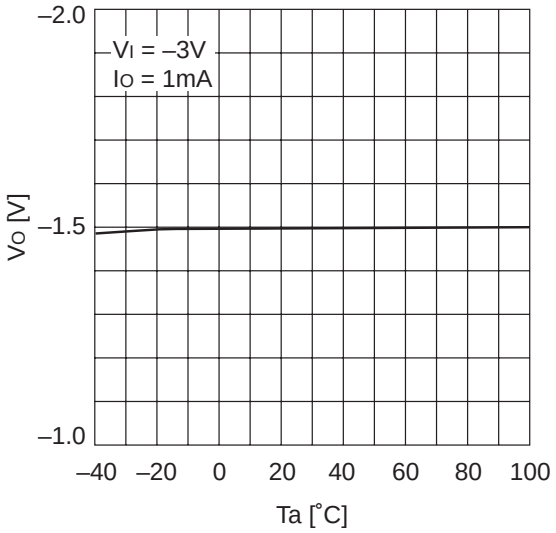
IOPR vs. VI



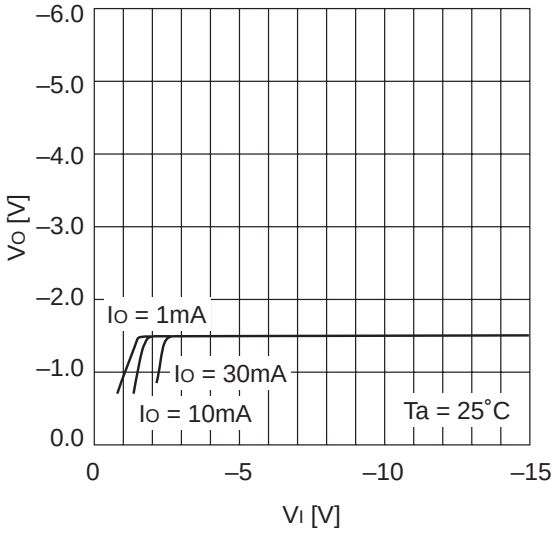
|VO – VI| vs. Ta



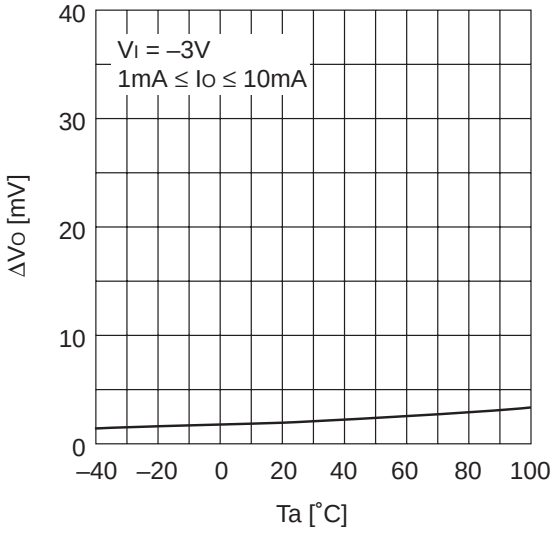
|VI – VO| vs. IO



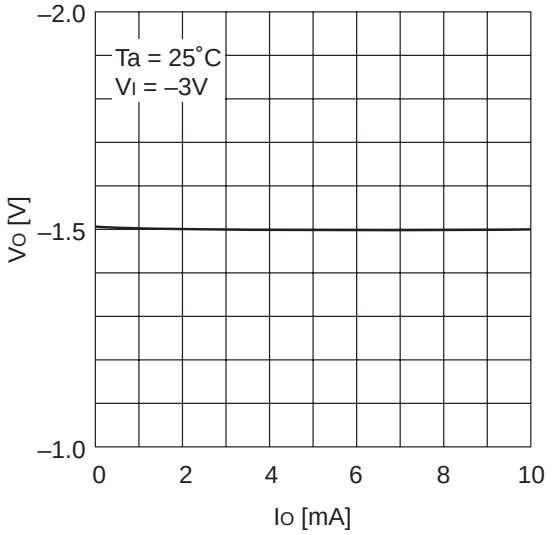
VO vs. Ta



VO vs. VI



ΔVo vs. Ta



Vo vs. Io

PACKAGE MARKINGS

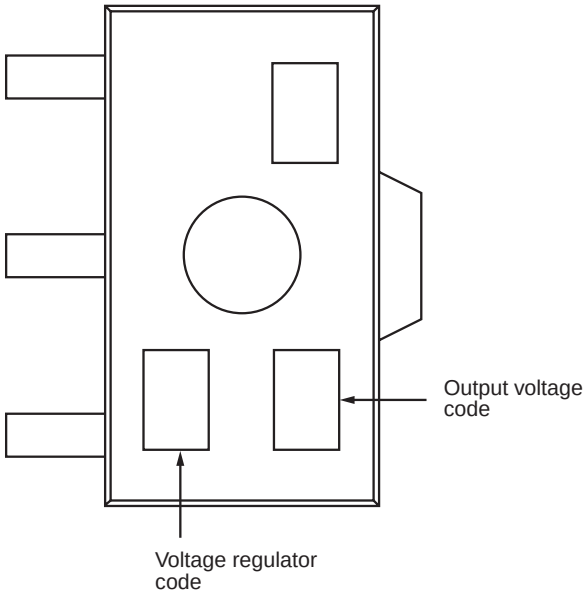
The markings on S1F79100Y series device packages use the following abbreviations.

Parameter	Code	Description
Output voltage code	B	5 V
	D	3 V
Voltage regulator code	P	Positive
	N	Negative

Note

The reflow furnace temperature profile requirements must be satisfied during package reflow. Avoid soldering on surface mount package (including SOT89) as it causes a quick temperature change of package and a device damage.

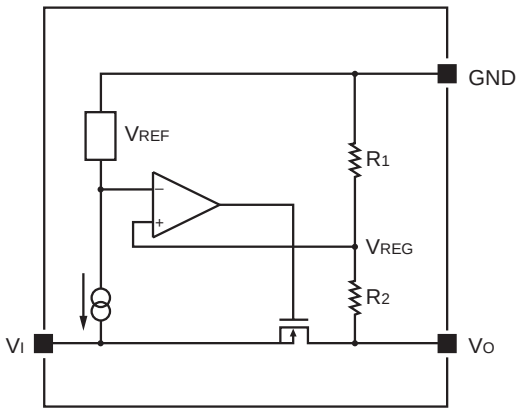
Marking locations



FUNCTIONAL DESCRIPTIONS

Basic Operation

The S1F79100Y series uses a 3-pin series regulator feedback loop. An operational amplifier compares V_{REG} from the voltage divider formed by R_1 and R_2, with V_{REF}. The amplifier output adjusts the output transistor gate bias to equalize the voltages and compensate for fluctuations in V_I.



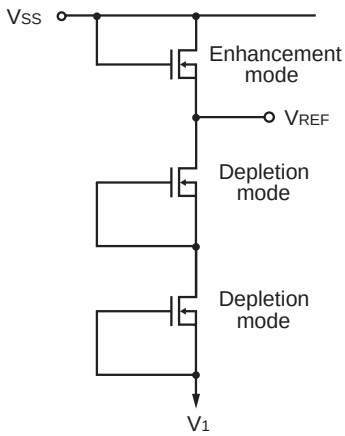
The following equation shows the relationship between V_O and V_{REF}.

$$V_O = \frac{R_1 + R_2}{R_1} V_{REF}$$

Internal Circuits

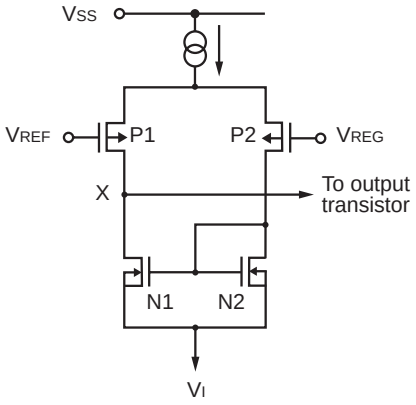
Reference voltage generator

The offset structure used in all three transistors results in a high breakdown voltage that ensures a stable reference voltage output over a wide range of input voltages.



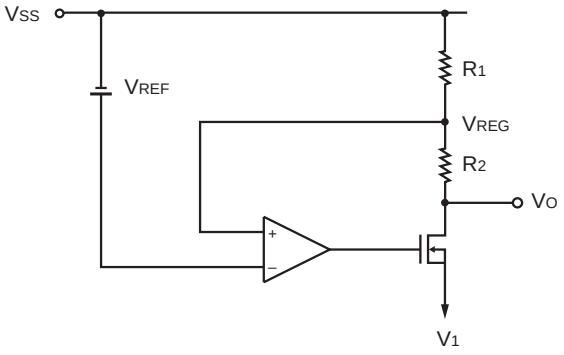
Differential amplifier

The built-in differential amplifier generates a potential at point X that adjusts the gate bias of the output transistor if there is any difference betweeen VREF and VREG.



Output transistor

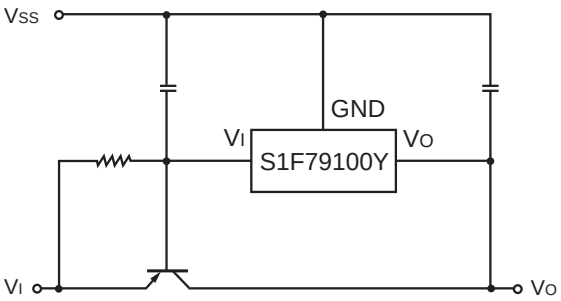
The output side of the p-channel MOS transistors in the output transistor circuit is connected to the voltage divider resistors in the feedback loop.



TYPICAL APPLICATIONS

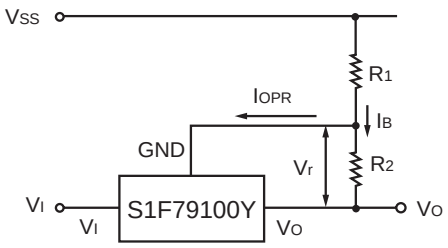
Current Booster

At the cost of a small increase in current consumption, the voltage is regulated while maintaining high current output.



External Voltage Converter

The following circuit raises the output voltage of a S1F79100Y series IC.

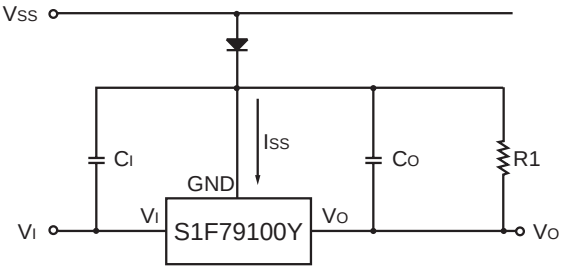


The following equation shows the relationship between the old and new voltages.

$$V_O = \frac{R_1 + R_2}{R_2} V_R$$

Note that the application must supply a bias current, IB, high enough to offset the increase in voltage across R1 due to IOPR.

An alternative circuit for raising the output voltage is shown in the following figure.



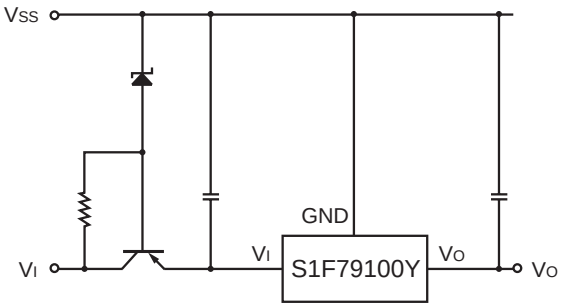
This configuration, however, introduces two design problems.

1. It reduces the output voltage by VF, the forward voltage drop across the diode.
2. It is sensitive to fluctuations in VF due to differences in diodes, operating temperatures and ISS.

R_1 helps reduce the affect of I_{SS} on V_F. It is also required when I_{SS} is lower than the diode bias current. For certain input voltages, a Zener diode with the reverse polarity can be used.

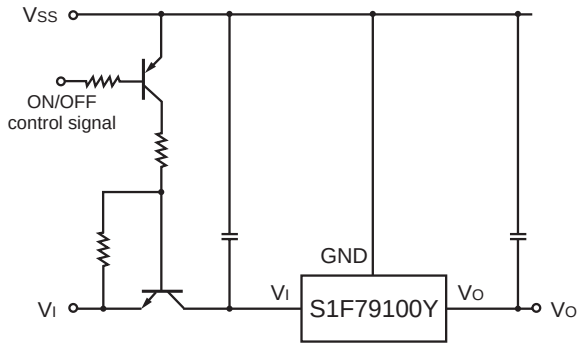
High Input Voltages

A preliminary regulator circuit is required to bring the input voltage within the S1F79100Y series rated range.



Switching Output

S1F79100Y series devices are designed for continuous operation. An external switching circuit allows the regulated output to be switched ON and OFF.



Note) Temperatures during reflow soldering must remain within the limits set out under LSI Device Precautions in this catalog. Do not immerse QFP and SOT89 packages during soldering, as the rapid temperature gradient during dipping can cause damage.

4. DC/DC Switching Regulators

The S1F76300 series of CMOS switching regulators comprises nine series—the S1F76310, S1F76380 series featuring built-in RC oscillators, the S1F76330 series requiring external crystal oscillators.

S1F76310, S1F76380 Series Built-in CR Oscillator Type CMOS Switching Regulators

DESCRIPTION

The S1F76310, S1F76380 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 S1F76310 series features battery backup and power-on clear, the S1F76380 series features power-on clear and response compensation, the S1F76380 series offer an output voltage temperature characteristic for driving an LCD. They are available in SOP3-8pin.

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
- Power supplies for LCD panel

FEATURES

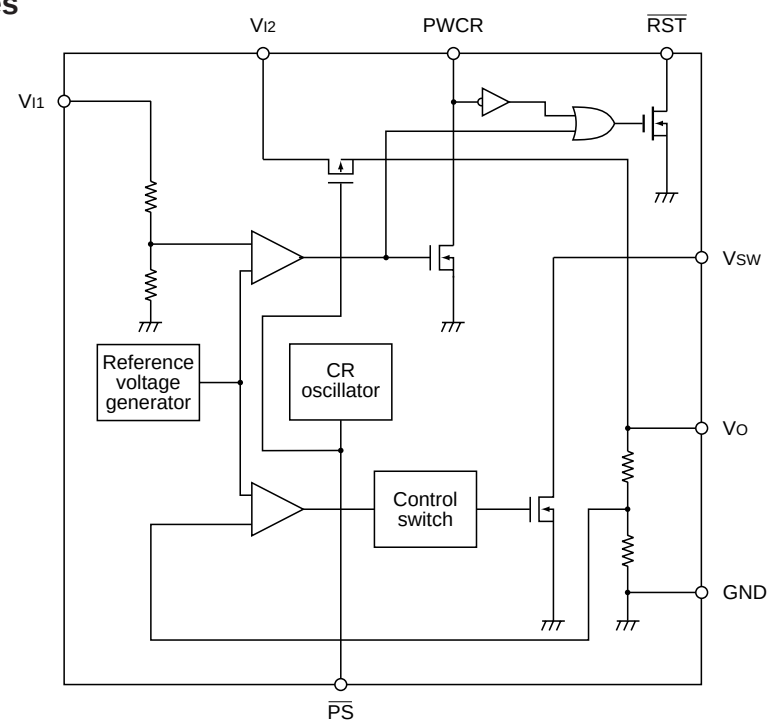
- 0.9V (Min.) operating voltage
- 10µA (Typ.) maximum current consumption
- Standby operation
- 3µA (Typ.) standby current consumption
- 1.05 ±0.05V high-accuracy voltage detection
- Battery backup (available on S1F76310 series)
- On-chip CR oscillator
- Power-on clear (available on S1F76310 and S1F76380 series)
- Output voltage temperature characteristic for driving an LCD (available on S1F76380 series)
- SOP3-8pin

LINEUP

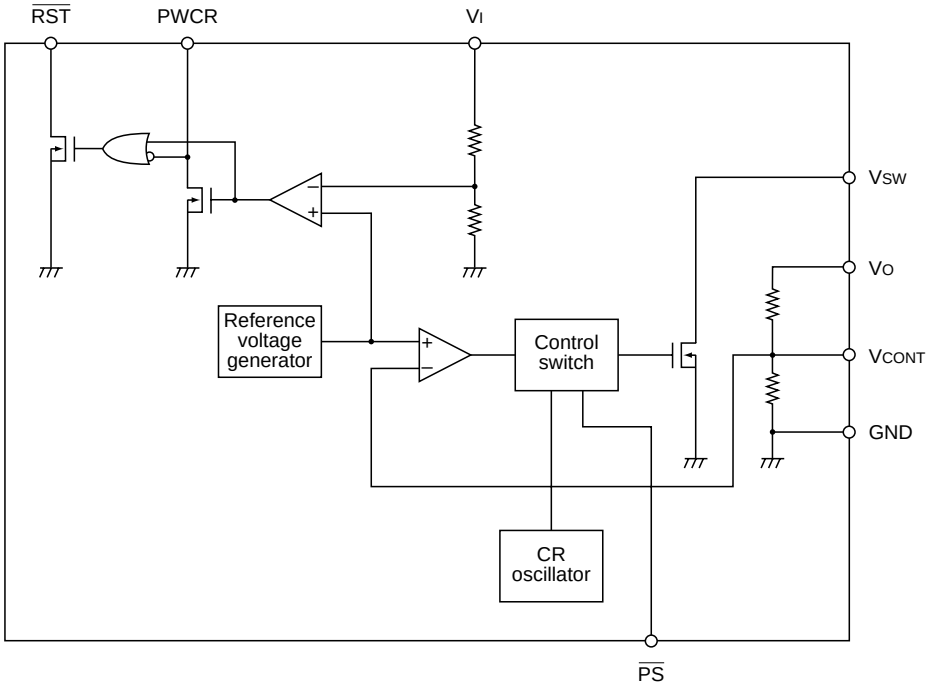
Product	Voltage (V)		Multiplication frequency source	Voltage detection	Power-on clear	Battery backup	Response compensation	Output voltage temperature characteristic	Package
	Input	Output							
S1F76310M1A0	1.5 (0.9 Min.)	5.0	On-chip CR oscillator	Yes	Yes	Yes	No	No	SOP3-8pin
S1F76310M1K0		3.5							SOP3-8pin
S1F76310M1B0		3.0							SOP3-8pin
S1F76310M1L0		2.4							SOP3-8pin
S1F76380M1L0	1.5 (0.9 Min.)	2.4	On-chip CR oscillator			No	Yes	– 4.0 mV/°C	SOP3-8pin
S1F76380M1H0		2.2						– 4.5 mV/°C	SOP3-8pin

BLOCK DIAGRAMS

S1F76310 Series

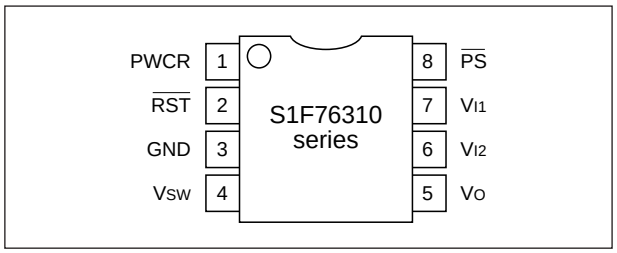


S1F76380 Series

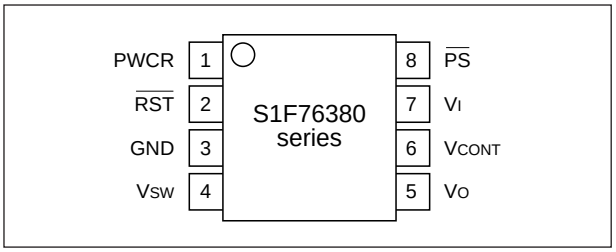


PIN ASSIGNMENTS

S1F76310 Series



S1F76380 Series



PIN DESCRIPTIONS

S1F76310 Series

Pin No.	Pin 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.

S1F76380 Series

Pin No.	Pin 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

S1F76310 series

V_{SS} = 0V, Ta = 25 ˚C

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 S1F70000 series power supply devices.

S1F76380 series

V_{SS} = 0V, Ta = 25 ˚C

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 S1F70000 series power supply devices.

Electrical Characteristics

S1F76310M1L0

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

S1F76310M1B0

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

S1F76310M1K0

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
$\overline{PS}$ pullup current	I_{IH}	V_{I1} = 1.5V	—	—	0.5	µA
Multiplication clock frequency	f_{CLK}	V_{I1} = 1.5V	30	40	50	kHz

S1F76310M1A0

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
$\overline{PS}$ pullup current	I_{IH}	V_{I1} = 1.5V	—	—	0.5	µA
Multiplication clock frequency	f_{CLK}	V_{I1} = 1.5V	35	45	55	kHz

S1F76380M1H0

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

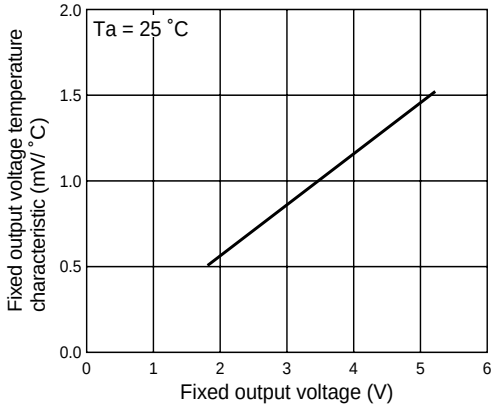
Parameter	Symbol	Condition	Rating			Unit
			Min.	Typ.	Max.	
Input voltage	V_{I1}		0.9	—	2.0	V
Output voltage	V_O	V_{I1} = 1.5V	2.10	2.20	2.30	V
Output voltage temperature gradient	Kt		–5.5	–4.5	–3.5	mV/˚C
Detection voltage	V_{DET}		1.00	1.05	1.10	V
Detection voltage hysteresis ratio	ΔV_{DET}		—	5	—	%
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
$\overline{PS}$ pullup current	I_{IH}	V_{I1} = 1.5V	—	—	0.5	µA
Multiplication clock frequency	f_{CLK}	V_{I1} = 1.5V	25	35	45	kHz

S1F76380M1L0

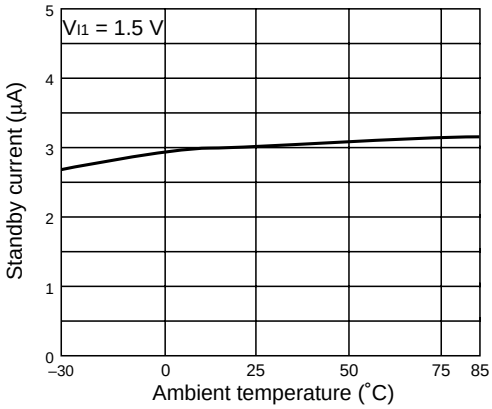
V_{SS} = 0V, Ta = 25 ˚C unless otherwise noted

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	2.30	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
$\overline{PS}$ pullup current	I_{IH}	V_{I1} = 1.5V	—	—	0.5	µA
Multiplication clock frequency	f_{CLK}	V_{I1} = 1.5V	25	35	45	kHz

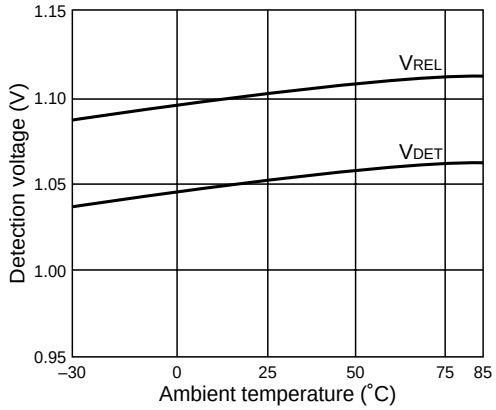
Typical Performance Characteristics



Fixed-output voltage temperature characteristic

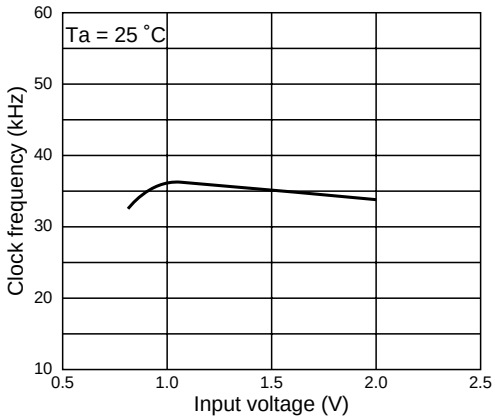


Standby current vs. ambient temperature

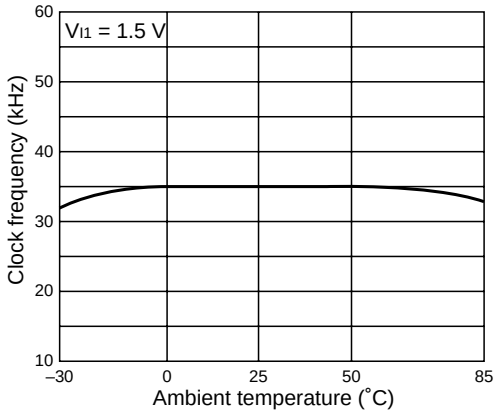


Detection voltage vs. ambient temperature

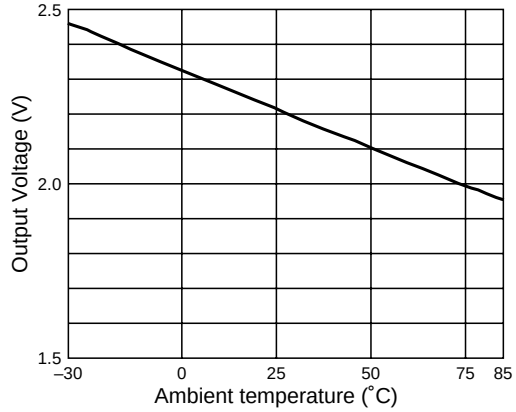
S1F76380M1H0 and S1F76380M1L0



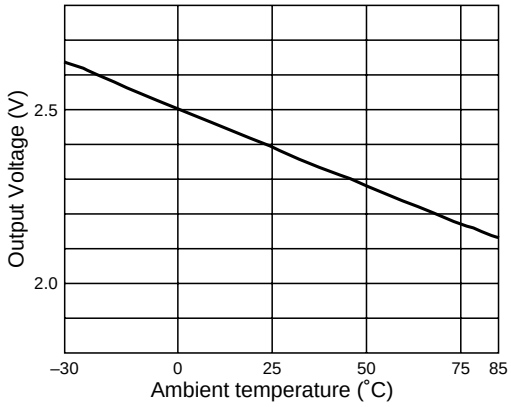
Clock frequency vs. Input voltage



Clock frequency vs. ambient temperature

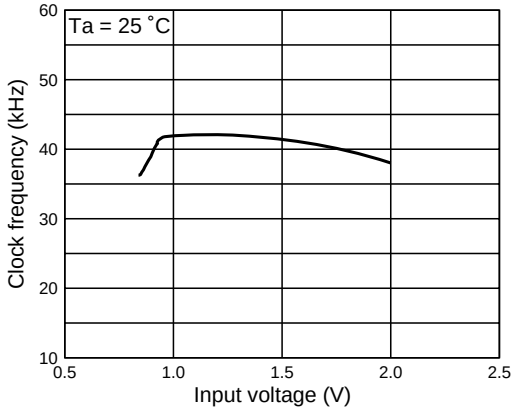


Output voltage vs. ambient temperature (S1F76380M1H0)

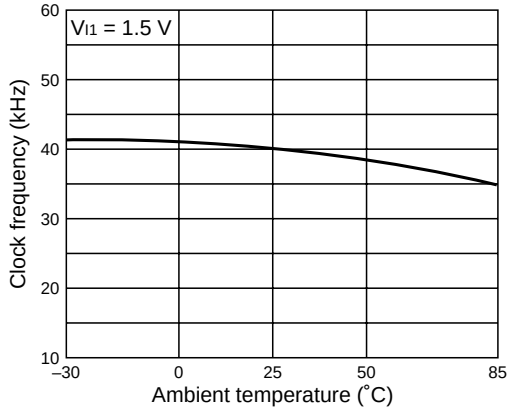


Output voltage vs. ambient temperature (S1F76380M1L0)

S1F76310M1B0, S1F76310M1K0

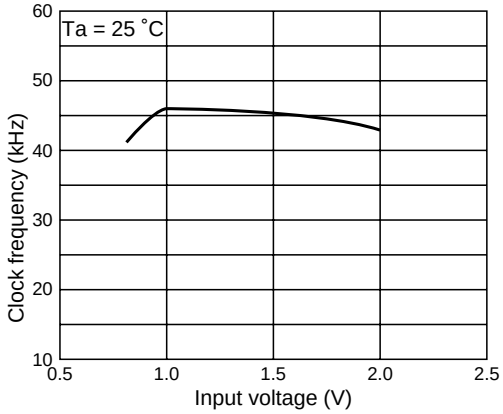


Clock frequency vs. input voltage

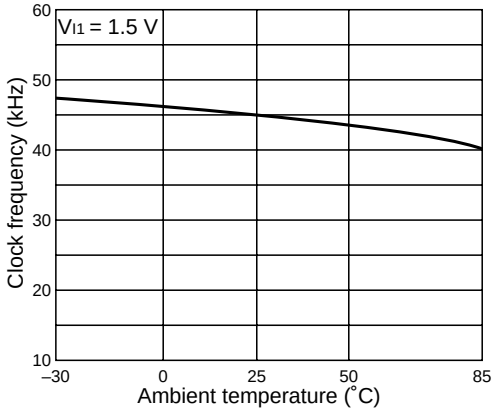


Clock frequency vs. ambient temperature

S1F76310M1A0



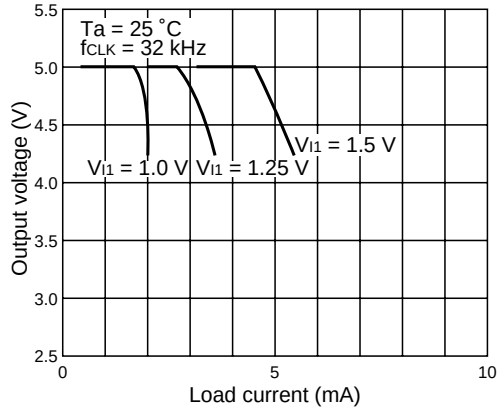
Clock frequency vs. input voltage



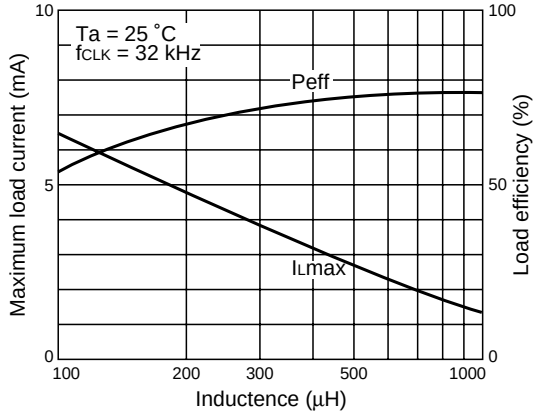
Clock frequency vs. ambient temperature

Load Characteristics

S1F76310M1A0

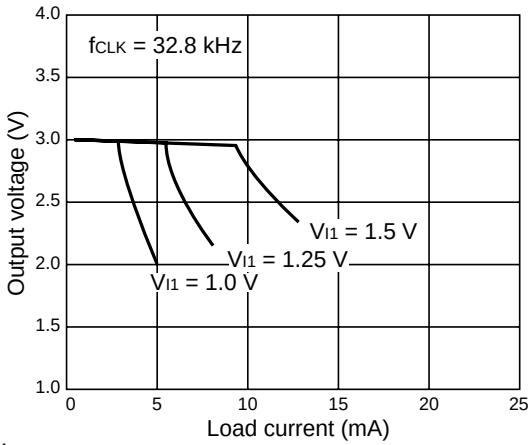


Notes
Inductor: TDK NLF453232-221k (220µH)
Diode: Shindengen DINS4 Schottky barrier diode
Capacitor: NEC MSUB20J106M (10µF)



Notes
1. VI1 = 1.5V
2. Inductor: TDK NLF453232 series
   Diode: Shindengen DINS4 Schottky barrier diode
   Capacitor: NEC MSUB20J106M (10µF)

S1F76310M1B0



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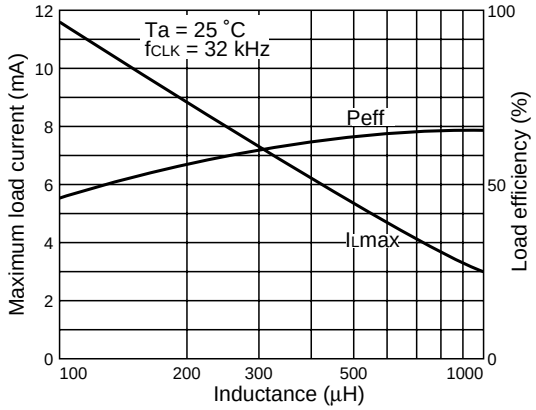

Notes
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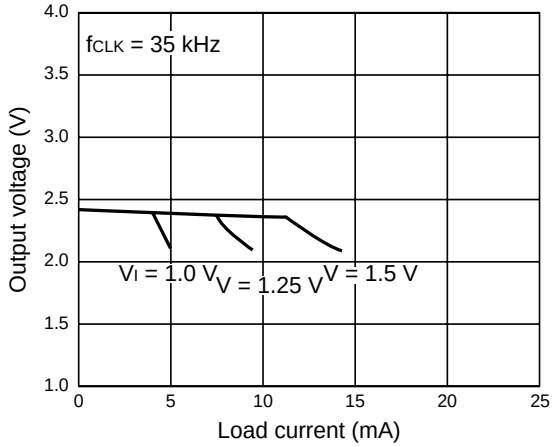
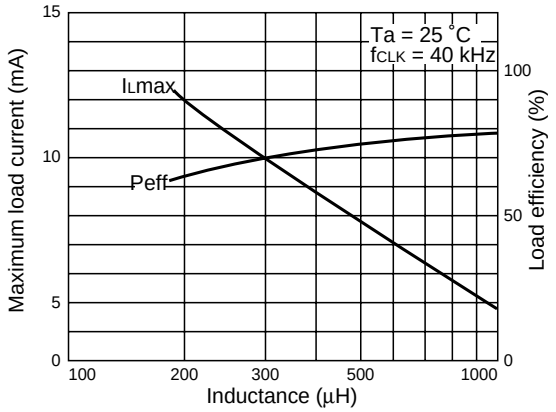
   Diode: Shindengen DINS4 Schottky barrier diode
   Capacitor: NEC MSUB20J106M (10µF)

S1F76380M1L0

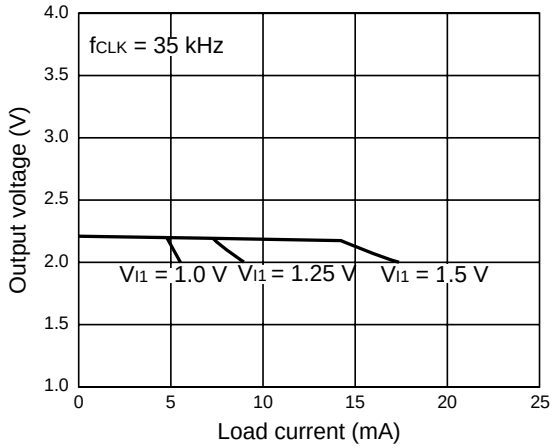


Notes
Inductor: TDK NLF453232-221k (220µH)
Diode: Shindengen DINS4 Schottky barrier diode
Capacitor: NEC MSUB20J106M (10µF)



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

S1F76380M1H0



Notes
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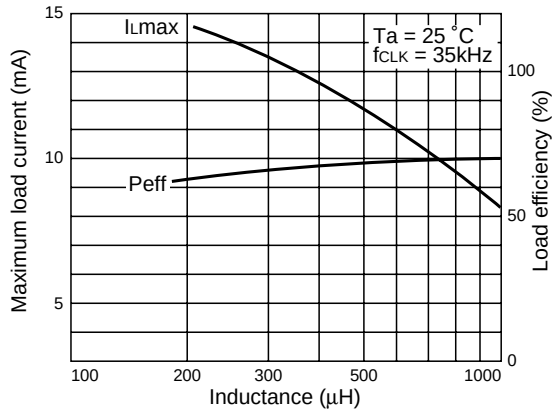
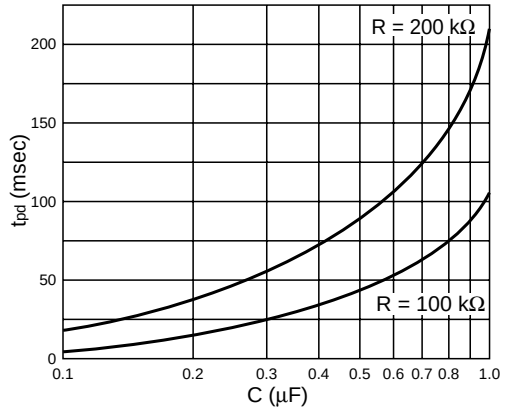


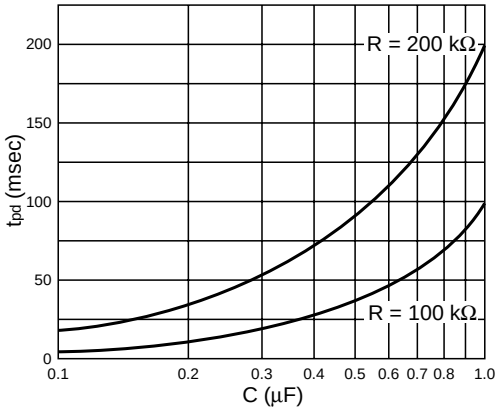
Notes
1. V_{I1} = 1.5V
2. Inductor: TDK NLF453232 series
   Diode: Shindengen DINS4 Schottky barrier diode
   Capacitor: NEC MSUB20J106M (10µF)

Reset delays

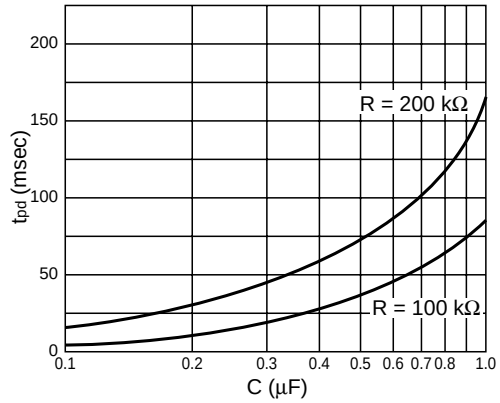
S1F76310M1A0



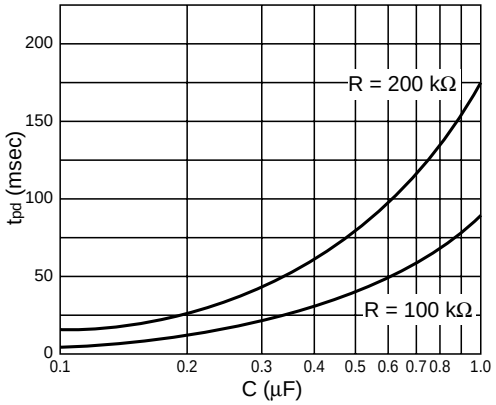
S1F76310M1K0



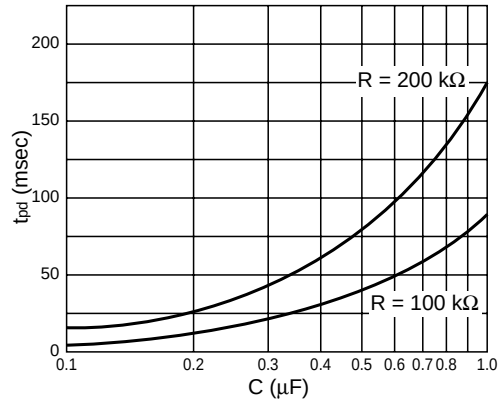
S1F76310M1B0



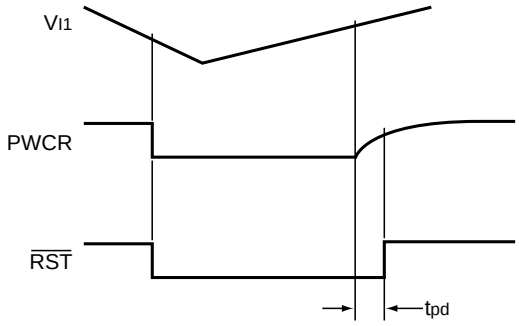
S1F76310M1L0 and S1F76380M1L0



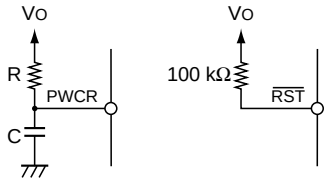
S1F76380M1H0



Timing diagram

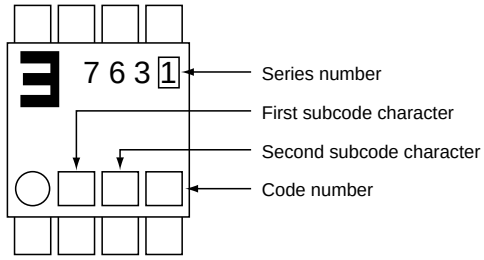


Measurement circuit



PACKAGE MARKINGS

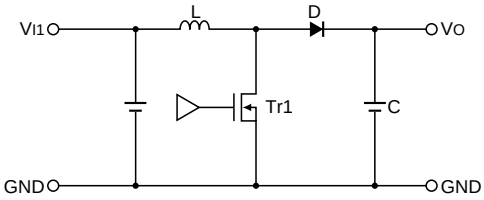
S1F76310, S1F76380 series device packages use the following markings.



FUNCTIONAL DESCRIPTIONS

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.

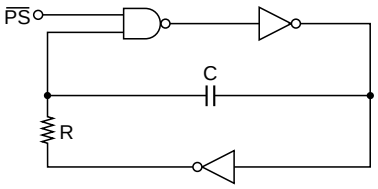


Internal Circuits

CR oscillator

The S1F76310, S1F76380 series use a built-in CR 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.

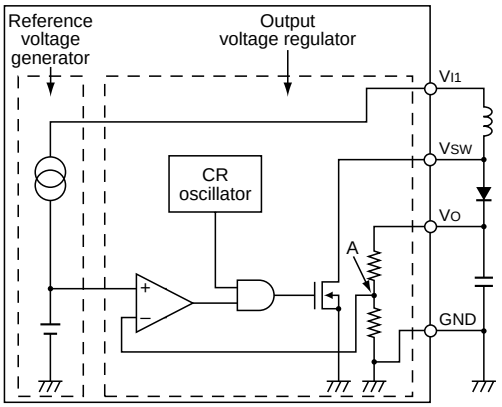
When $\overline{PS}$ is Low, the oscillator is disabled and the chip is in standby mode.



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

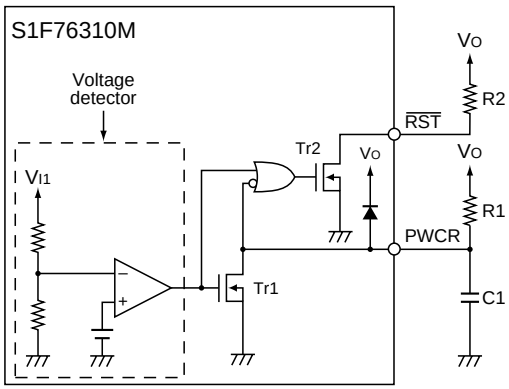
In step-up voltage operation, the ripple voltage created by the switching operation is large relative to the output voltage described above. This ripple voltage is affected by external components and load conditions. The user is advised to check this voltage carefully.

Voltage detection

The S1F76310, S1F76380 series are equipped with a built-in voltage detection function. The detection voltage, V_{DET}, is fixed internally at 1.05 ± 0.05V.

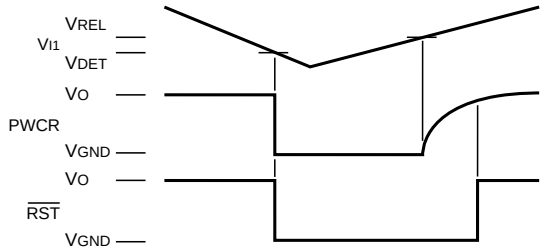
Power-on clear function

The S1F76310 series and S1F76380 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.).



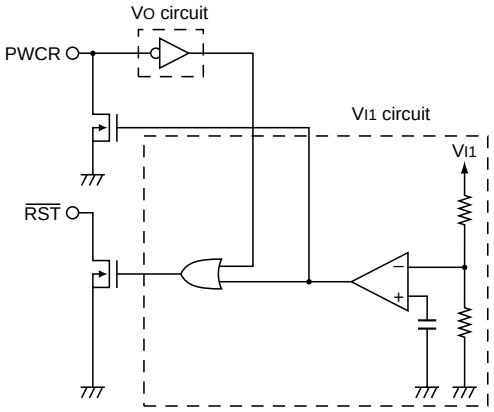
V_O returns to its normal value when the voltage of PWCR increases and Tr2 turns OFF, so that $\overline{RST}$ returns to V_O after a delay specified by the time coefficient of R1 and C1. Thus, after normal output has been obtained, a reset pulse of adjustable width can be obtained which can reset a 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 S1F76380 series are provided with a response compensation input. A response compensation capacitor is connected between VCONT and VO, allowing the ripple voltage generated by the boosted output voltage to be suppressed to a minimum.

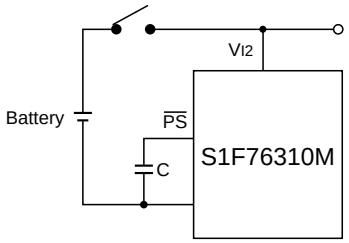
Standby mode and battery backup

The S1F76310 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 VI2 is output at VO. 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 VO 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 VO never drops below the minimum required for backup mode. If no such external power supply is available, connect VI2 to VI1 and hold $\overline{PS}$ Low when applying power for the first time.

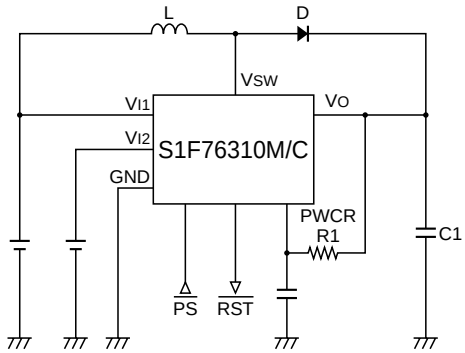


TYPICAL APPLICATIONS

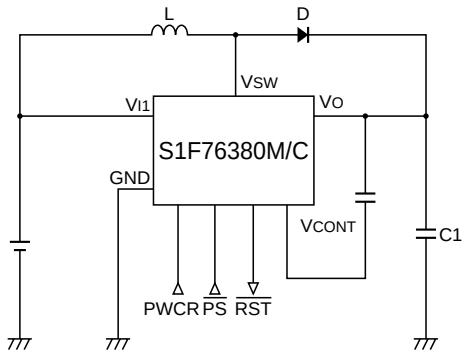
Example Circuits

The output current, IO, 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.

S1F76310 series



S1F76380 series



Notes
■ 100µH ≤ L ≤ 1mH, C ≤ 10µF, D = Schottky diode
■ S1F76310M1A0
- 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

■ S1F76310M1B0
- 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.

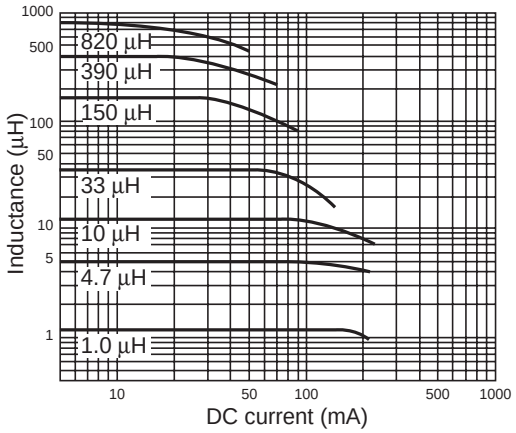
Sample External Components

Leadless Inductors

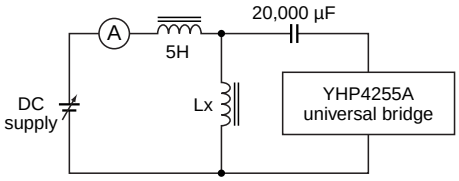
TDK NKF453232 series magnetically shielded leadless inductors

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



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

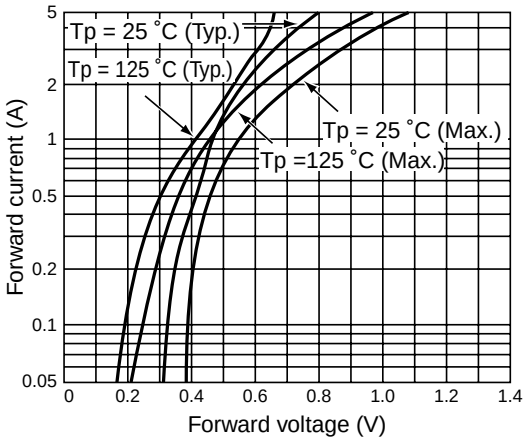
Device	Rated current I_{DC} (A)	Inductance (µH) at 20kHz, 5V		Diameter × height (mm-Max.)	Wire gauge (mmø)
		I_{DC} = 0	I_{DC} = rating		
HP011	1	200	160	ϕ 20 × 12	0.5
HP021	2	65	55		0.7
HP031	3	30	23		0.8
HP012	1	600	450	ϕ 22 × 13	0.5
HP022	2	180	135		0.7
HP032	3	120	80		0.8
HP052	5	45	30		1.0
HP013	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

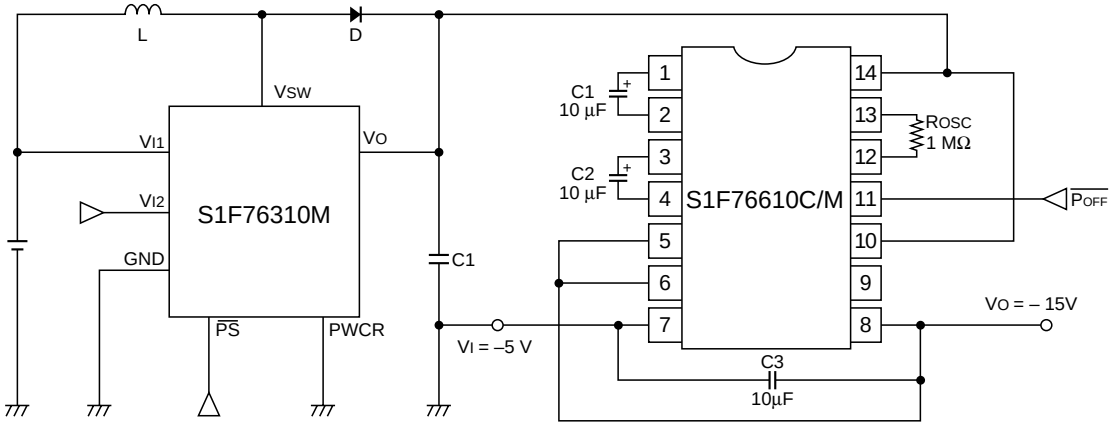
Note

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

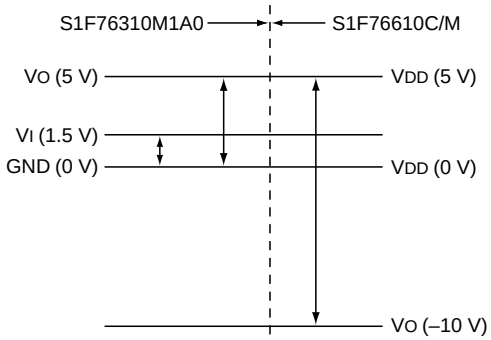
Other Applications

Voltage booster

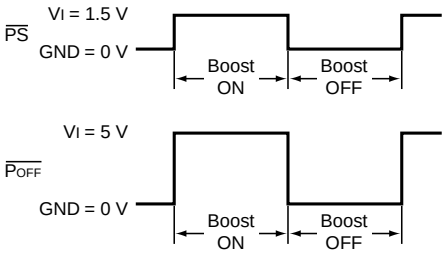
Combining an S1F76310 switching regulator with an S1F76610C/M DC/DC converter and voltage regulator creates the voltage booster circuit shown in the following figure.



Potential levels are shown in the following figure.

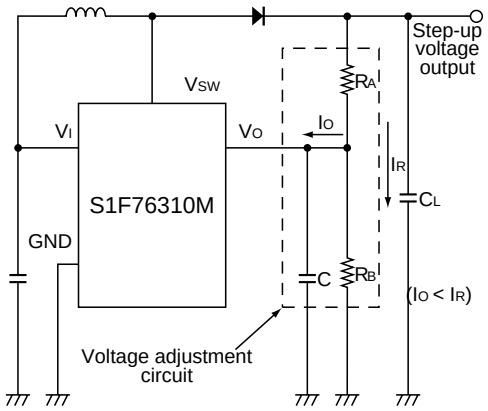


Although the circuit appears to have two ON/OFF control points, $\overline{PS}$ on the S1F76310M1A0 and $\overline{POFF}$ on the S1F76610C/M, $\overline{PS}$ only shuts down the S1F76310M1A0. The input voltage still reaches the S1F76610C/M through L and D.



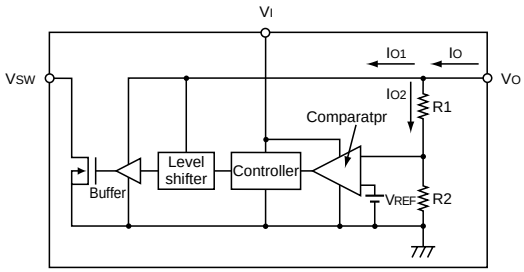
Output voltage adjustment

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 S1F76300 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.



S1F76330 Series Built-in Crystal Oscillator Type CMOS Switching Regulators

DESCRIPTION

The S1F76330 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.

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

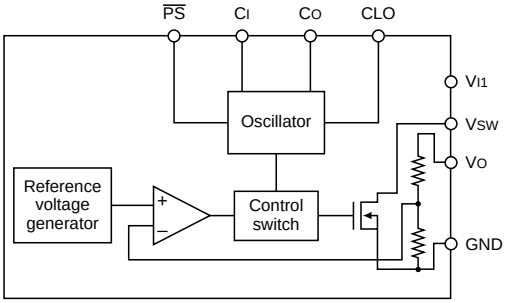
FEATURES

- 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
- SOP3-8pin

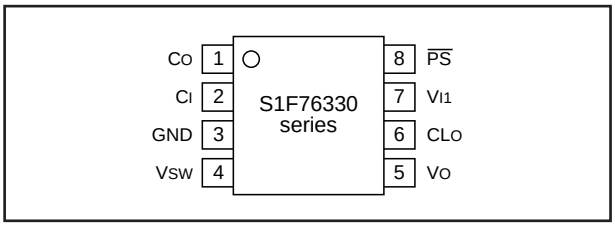
LINEUP

Product	Voltage (V)		Multiplication frequency source	Voltage detection	Power-on clear	Battery backup	Response compensation	Output voltage temperature characteristic	Crystal Oscillator Output	Package
	Input	Output								
S1F76330M1B0	1.5 (0.9 Min.)	3.00	Crystal oscillator	No	No	No	No	No	Yes	SOP3-8pin

BLOCK DIAGRAMS
S1F76330 series



PIN ASSIGNMENTS
S1F76330 series



PIN DESCRIPTIONS
S1F76330 series

Number	Name	Description
1	C_O	Crystal drain
2	C_I	Crystal gate
3	GND	Ground
4	V_{SW}	External inductor drive
5	V_O	Output voltage
6	CL_O	Oscillator output
7	V_I	Step-up input voltage
8	$\overline{PS}$	Power save. See note.

Note
See standby mode in the functional description.

SPECIFICATIONS

Absolute Maximum Ratings

S1F76330 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 S1F70000 series power supply devices.

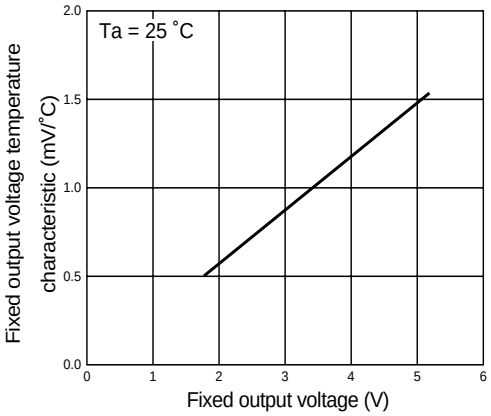
Electrical Characteristics

S1F76330M1B0

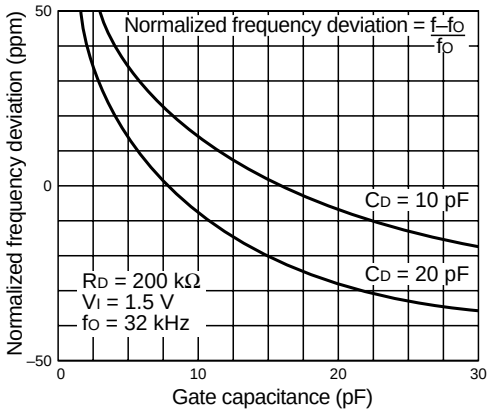
V_{SS} = 0V, Ta = 25 ˚C unless otherwise noted

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
CL$_O$ Low-level output current	I_{OL}	V_{I1} = 1.5V, V_O = 3.0V, V_{OL} = 0.2V	0.5	1.0	—	µA
CL$_O$ 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

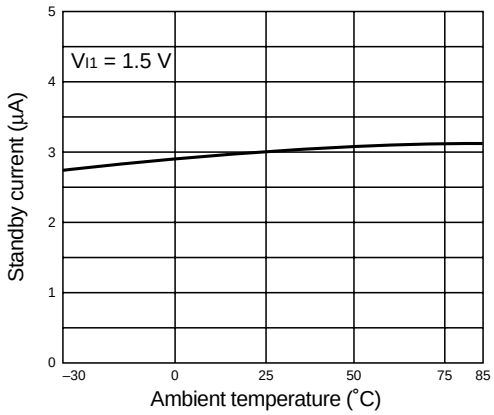
Typical Performance Characteristics



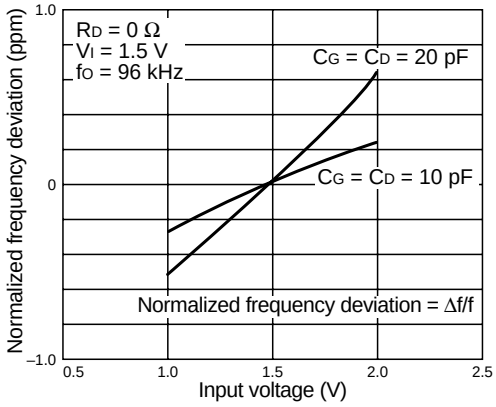
Fixed output voltage temperature characteristic



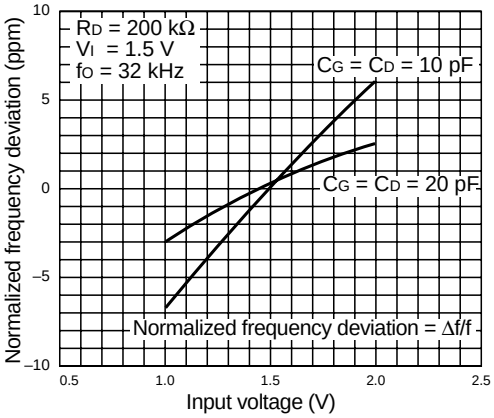
Normalized frequency deviation vs. gate capacitance 1



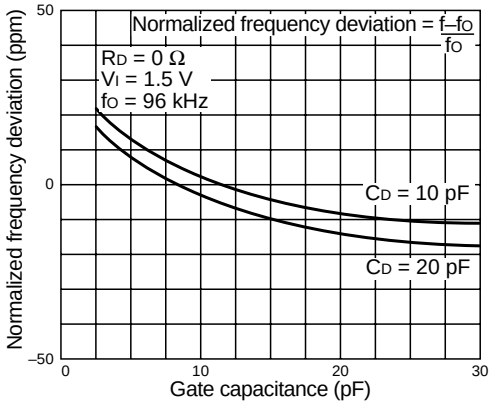
Standby current vs. ambient temperature



Normalized frequency deviation vs. input voltage 2



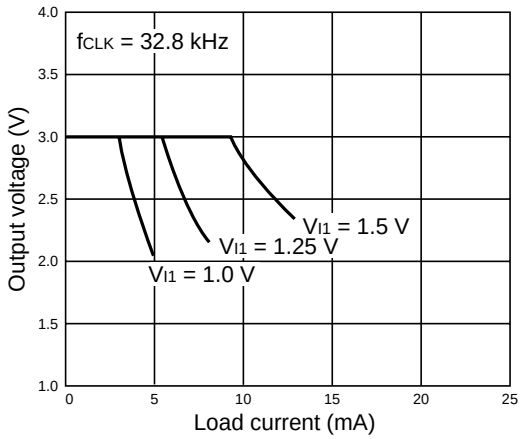
Normalized frequency deviation vs. input voltage 1



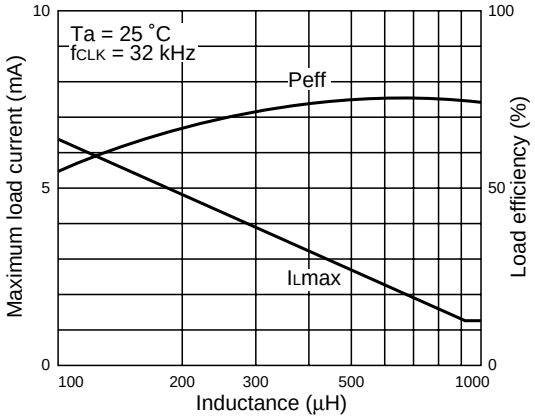
Normalized frequency deviation vs. gate capacitance 2

Load characteristics

S1F76330M1B0



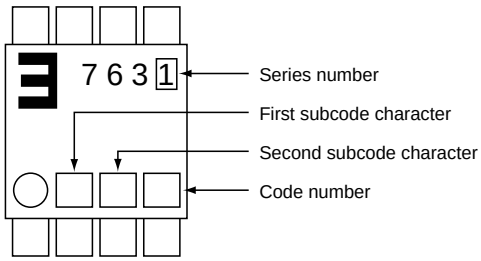
Notes
Inductor: TDK NLF453232-221k (220µH)
Diode: Shindengen DINS4 Schottky barrier diode
Capacitor: NEC MSVB20J106M (10µF)



Notes
1. V_{I1} = 1.5V
2. Inductor: TDK NLF453232 series
   Diode: Shindengen DINS4 Schottky barrier diode
   Capacitor: NEC MSVB20J106M (10µF)

PACKAGE MARKINGS

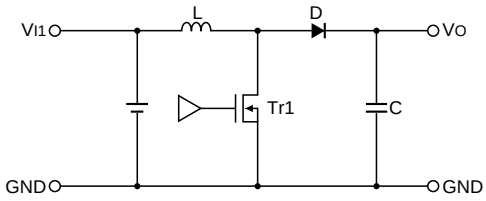
S1F76330 device packages use the following marking.



FUNCTIONAL DESCRIPTIONS

Basic Voltage Booster Operation

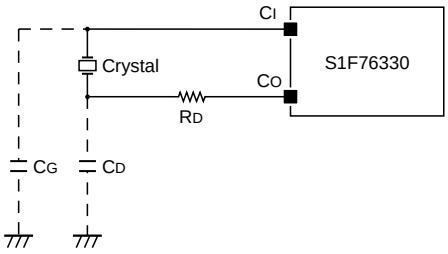
Tr1 switches ON and OFF at the frequency of the clock pulses from the crystal oscillator. When the transistor is ON, the circuit stores energy in L. When it is OFF, this energy flows through D to charge C.



Internal Circuits

Crystal oscillator

The S1F76330 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 CI and CO as shown in the following figure.

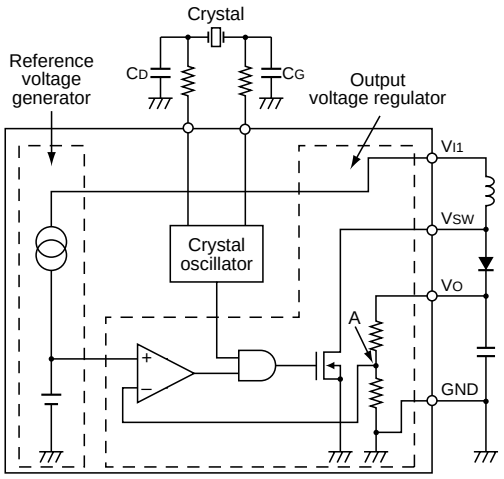


In the S1F76330 series, the crystal oscillator output is sent to CLO as the VO system signal. The crystal oscillator circuit is activated by VI but, because the output level is shifted and the output is connected to CLO, the oscillator output cannot be obtained without a voltage at VO. Since the crystal 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 VI1 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 VO 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

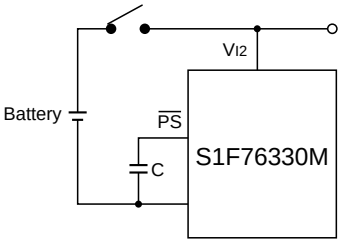
Connecting $\overline{PS}$ to GND places the chip in standby mode. In this mode, the crystal oscillator is disabled, switching off the inductor drive transistor and the voltage booster circuit. Typically, $\overline{PS}$ is connected to $\overline{RST}$. If standby mode is not required, leave $\overline{PS}$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

Output voltage response compensation

The S1F76340 series incorporates a response compensation input. A response compensation capacitor is connected between VCONT and VO, allowing the ripple voltage generated by the boosted output voltage to be suppressed to a minimum.

Powering up

Ensure that VO 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 VO to VI when the power is applied for the first time.

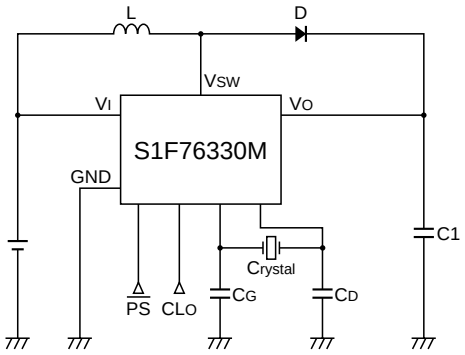


TYPICAL APPLICATIONS

Example Circuits

The output current, IO, 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.

S1F76330 series



Notes

- 100µH ≤ L ≤ 1mH, C ≤ 10µF, D: Schottky diode
- S1F76330M1B0
  - Peff = 70% when L = 220µH (leadless inductor), VI1 = 1.5V, fCLK = 32kHz, IO = 8mA
  - Peff = 75% when L = 220µH (drum coil), VI1 = 1.5V, fCLK = 32kHz, IO = 9mA
  - Peff = 80% when L = 300µH (toroidal coil), VI1 = 1.5V, fCLK = 32kHz, IO = 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.

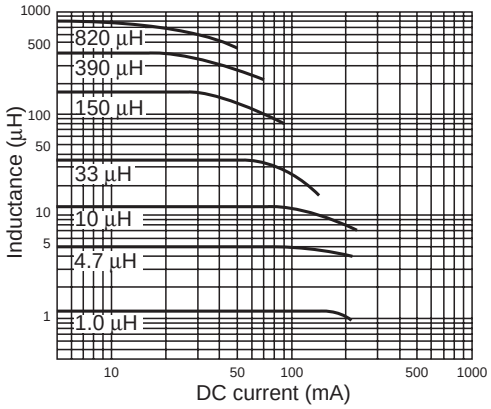
Capacitor
To minimize ripple voltages, use capacitors with a small equivalent direct-current resistance for smoothing.

Sample External Components

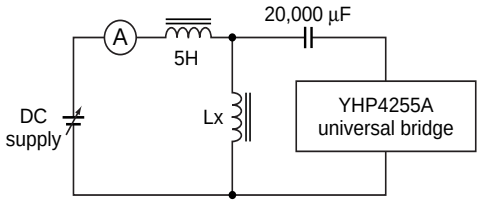
Leadless inductors
TDK NLF453232 series magnetically-shielded leadless inductors

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 (μH)	Direct current (mA)
FL3H	0.22 to 10	280 to 670
FL4H	0.47 to 12	300 to 680
FL5H	10 to 1000	50 to 320
FL7H	680 to 8200	50 to 170
FL9H	330 to 33000	50 to 500
FL11H	10000 to 150000	35 to 110

Toroidal coil inductors

Tohoku Metal Industries HP series toroidal coil inductors

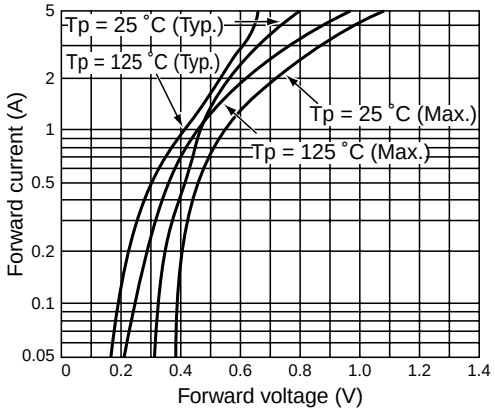
Device	Rated current I_{DC} (A)	Inductance (μH) at 20kHz, 5V		Diameter × height (mm-Max.)	Wire gauge (mmø)
		I_{DC} = 0	I_{DC} = rating		
HP011	1	200	160	20 × 12	0.5
HP021	2	65	55		0.7
HP031	3	30	23		0.8
HP012	1	600	450	22 × 13	0.5
HP022	2	180	135		0.7
HP032	3	120	80		0.8
HP052	5	45	30		1.0
HP013	1	1000	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

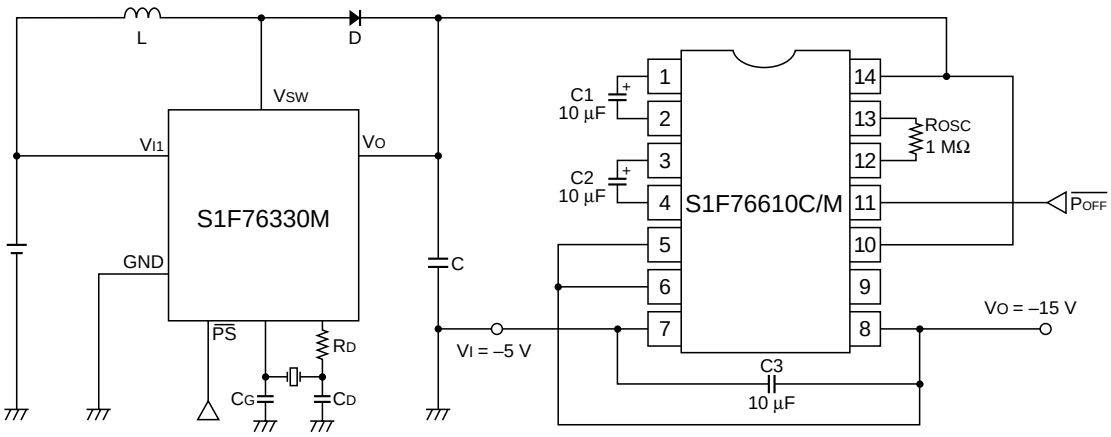
Note

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

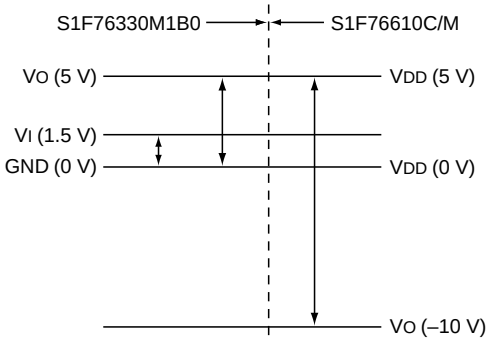
Other Applications

Voltage booster

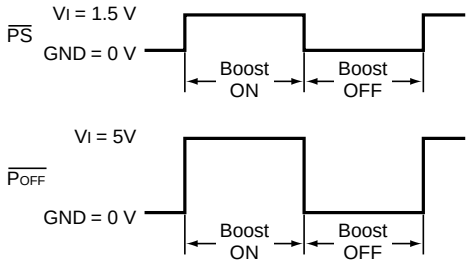
Combining an S1F76330M1B0 switching regulator with an S1F76610C/M DC/DC converter and voltage regulator creates the voltage booster circuit shown in the following figure.



Potential levels are shown in the following figure.

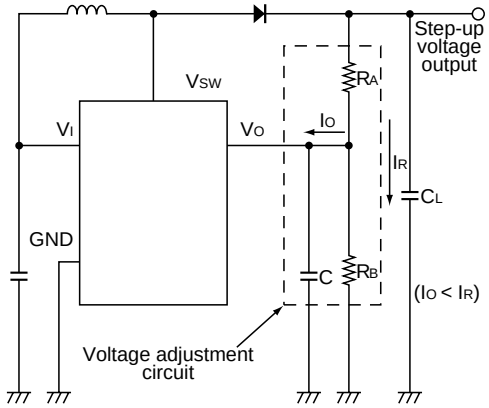


Although the circuit appears to have two ON/OFF control points, $\overline{PS}$ on the S1F76330M1B0 and $\overline{POFF}$ on the S1F76610C/M, $\overline{PS}$ only shuts down the S1F76330M1B0. The input voltage still reaches the S1F76610C/M through L and D.



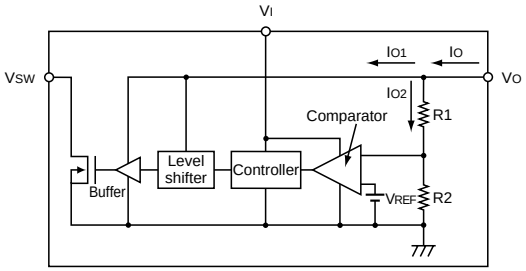
Output voltage adjustment

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 S1F70000 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.



S1F71100 Series PWM Type Step-down DC/DC Switching Regulator

DESCRIPTION

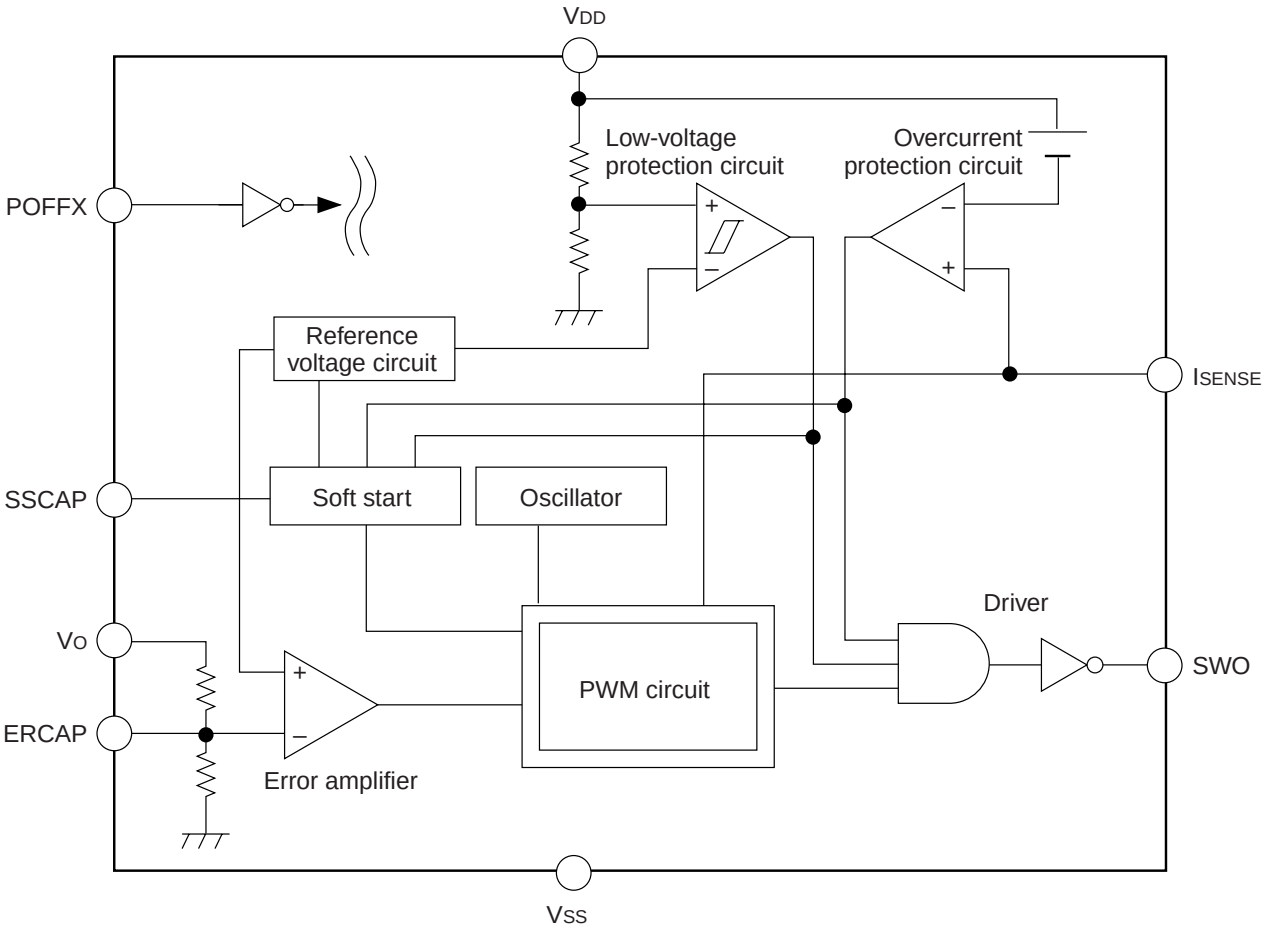
S1F71100 is a pulse width modulation (PWM) type step-down DC/DC converter control IC for which the CMOS process is used and to which a power transistor is connected outside. S1F71100 is composed of an oscillator, a reference voltage circuit, an error amplifier, a PWM circuit, a soft start circuit, a driver, etc. When this IC drives an external P ch power MOS transistor, S1F71100 can constitute a step-down DC/DC converter that converts input voltages up to 12V into the output voltage of 3.3V.
S1F71100 is also provided with a low-voltage protection circuit, an overcurrent protection circuit and a soft start protection circuit. When receiving external signals, S1F71100 can stop the oscillator and the switching circuit and turn off the power, so that it can reduce wasteful current consumption at the time of system halt.

FEATURES

- Input voltage : 3.3V ~ 12V
- Output voltage : 3.3V (S1F71100M0A0)
- Power off current : 1µA
- Self current consumption : 800µA
- Frequency fixing (200kHz) PWM
- Power off function (IC shutdown)
- Soft start function
- Overcurrent protection function
- Low-voltage protection function
- Shipping pattern : plastic package SOP4-8pin

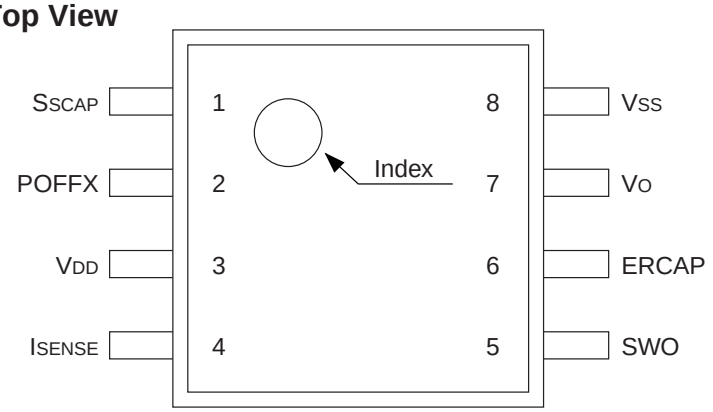
* Radiation-resistant design has not been provided for this specification.

BLOCK DIAGRAM



PIN ASSIGNMENTS

Top View



SOP4-8pin

PIN DESCRIPTIONS

Pin No.	Pin name	Pin Type	Description
1	SSCAP	—	The soft start function is obtained when a capacitor is connected between the capacitor connection pin for setting soft start and the VSS pin.
2	POFFX	—	Power off control pin During normal operation : VDD level At power off time : VSS level
3	VDD	Power supply	Power supply pin (+)
4	ISENSE	—	Load current feedback pin Load current detection resistor connection pin (Connect a resistor of 100mΩ)
5	SWO	Output	Switching Pch power MOS transistor drive pin
6	ERCAP	–	Capacitor connection pin for external phase compensation
7	VO	Input	Output voltage feedback pin
8	VSS	Power supply	Power supply pin (–)

FUNCTIONAL DESCRIPTIONS

Description of Operation

S1F71100 is a step-down switching regulator control IC of load current detection type pulse width modulation (PWM) system and is composed of an oscillator, a reference voltage circuit, an error amplifier, a PWM circuit, various protection circuits, etc.
S1F71100 can constitute a switching regulator, which converters input voltages up to 12V into output voltages of 3.3V, when external parts such as a power MOSFET, a diode, an inductor and a capacitor are connected to it.
S1F71100 controls PWM by means of the two systems of output voltage feedback and load current feedback. The output voltage feedback system converts output voltage values of the switching regulator into voltage feedback signals through the error amplifier. And the load current feedback system detects currents flown to the external load current detection resistor as voltage values at the load current detection pin and converts them into current feedback signal in the internal circuit. These two feedback signals control the switching duty so that outputs from the switching regulator become optimum all the time. When the output voltage reduces, the output level of the error amplifier changes, and the switching duty is controlled so that the switching on duty of the output transistor increases.

Oscillator

Since S1F71100 has a built-in oscillator, and no external part is necessary. The oscillation frequency is fixed to 200kHz (Typ.). The oscillator stops its operation when the power is turned off. When the low-voltage protection circuit detects a low voltage, the output transistor is turned off, but the oscillation continues inside the IC.

Soft Start

When a capacitor is connected to the SSCAP pin, S1F71100 can set a soft start operation to prevent inrush current at the time when the power is turned on. (Figure 6-1) The SSCAP pin is at the VSS level when the power is turned off. When the soft start operation begins, the soft start capacitor starts being charged and the voltage at the SSCAP pin rises slowly. The output voltage rises gradually as the voltage at the SSCAP pin rises. This operation controls the switching pulse width at the time when the power is turned on and restrains surge current and output overshoot. The soft start time can be set according to the capacitance value of a capacitor to be connected.

The voltage at the SSCAP pin drops to the VSS level when an overcurrent is detected, when a low voltage is detected or when the power is turned off, and the soft start operation begins.

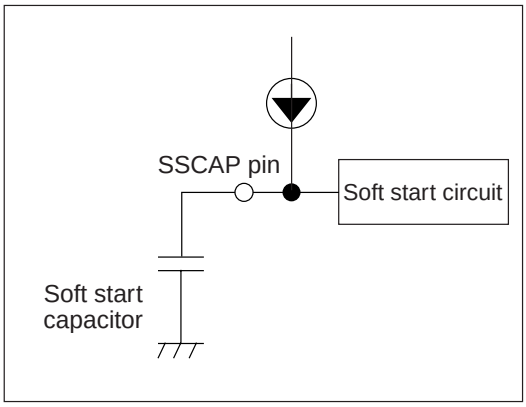


Figure 6.1 Connection Diagram of SSCAP Pin

Low-voltage Protection Circuit

The low-voltage protection circuit monitors the supply voltage (voltage at the VDD pin). When the supply voltage drops below a detected voltage value, the low-voltage protection circuit works and stops the switching operation of the output transistor. This low-voltage protection circuit links to the soft start circuit and drops the voltage at the SSCAP pin to the VSS level during detection of low voltage.
The low-voltage protection circuit has hysteresis. When the supply voltage returns to more than the release voltage, the voltage at the SSCAP pin rises slowly and the soft start circuit starts it operation, then the low-voltage protection circuit resumes the switching operation.

Overcurrent Protection Circuit

When the current flowing through the current detection resistor increases more than the set current value and the voltage at the ISENSE pin drops below a detected voltage value, the overcurrent protection circuit operates. When the overcurrent protection circuit operates, it maintains the SWO pin at the VDD level and turns off the output transistor. It links to the soft start circuit, and the soft start circuit controls output voltage rise after detection of overcurrent.

Power Off Function

S1F71100 can control circuit operations according to external signal control. When the POFFX pin is connected to the VSS level, all circuits stop their operations and their powers are turned off. The current consumption at the power off state is less than 1µA. When the power is off, the SWO pin is at the VDD level and turns off the voltage transistor. The voltage at the SSCAP pin comes to the VSS level, and the output voltage is controlled with the soft start circuit after the power off state is released. In the operating state, set the POFFX pin to the VDD level to operate it. The POFFX pin cannot be operated in a open state. When the power off function is not used, connect the POFFX pin to the VDD pin.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Applicable Pin	Rated Value	Unit
Input voltage	VDD	VDD	15.0	V
Voltage at VO pin	VO	VO	VSS–0.3 to VDD+0.3	V
Voltage at POFFX pin	POFFX	POFFX	VSS–0.3 to VDD+0.3	V
Voltage at ERCAP pin	ERCAP	ERCAP	VSS–0.3 to VDD+0.3	V
Voltage at SSCAP pin	SSCAP	SSCAP	VSS–0.3 to VDD+0.3	V
Voltage at SWO pin	SWO	SWO	VSS–0.3 to VDD+0.3	V
Voltage at ISENSE pin	ISENSE	ISENSE	VSS–0.3 to VDD+0.3	V
Package allowable loss	PD	PD	300 Ta≤25˚C	MW
Operating temperature	Topr	–	–30 to +85	˚C
Storage temperature	Tstg	–	–55 to +150	˚C
Soldering temperature and time	Tsol	–	260 · 10	˚C·S

Note : Any operation under conditions exceeding the above absolute maximum ratings may result in a malfunction or a permanent destruction. When even an item is more than the rating, a temporary normal operation is possible but with remarkably low reliability. So, be sure to keep all items below the ratings.

ELECTRICAL CHARACTERISTICS

DC Characteristics (S1F71100M0A0)

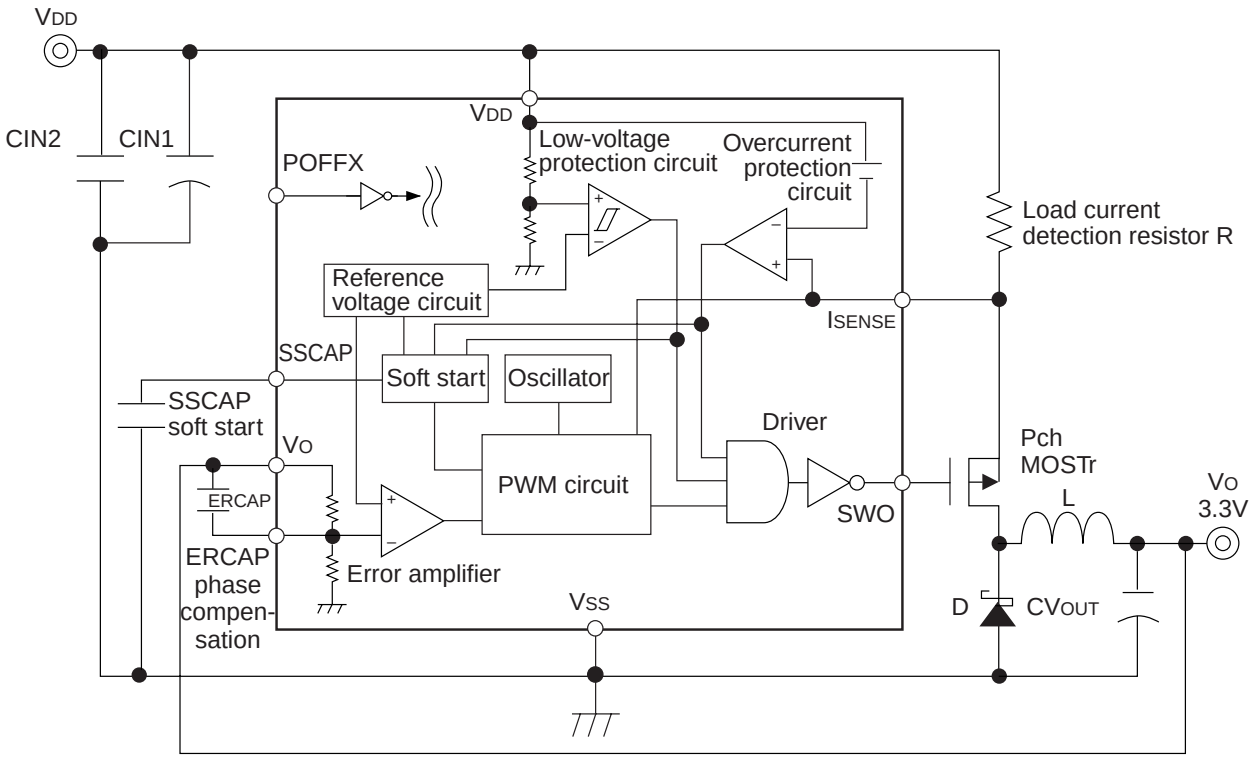
Unless otherwise specified, Ta = 25˚C.

Parameter	Symbol	Conditions	Specification			Unit
			Min.	Typ.	Max.	
Input supply voltage	V_{DD}	—	3.3	—	12.0	V
Output voltage	V_O	V_{DD}=5.0V Ta=–30 to +85˚C	3.150	3.3	3.450	V
Current consumption during operation	IV_{DD}	V_{DD}=5.0V V_O=V_{DD}		0.8	1.4	mA
Current consumption at power off time	I_{OPR1}	V_{DD}=5.0V POFFX=V_{SS}	—	—	1.0	µA
Output current at SWO pin	I_{OHSWO} I_{OLSWO}	V_{DD}=5.0V,V_{OH}=50mV V_{DD}=5.0V,V_{OL}=50mV	–1.0 1.0	— —	— —	mA mA
Input stability	ΔV_O	V_{DD}=5.0 to 10v	—	30	—	mV *
Load stability	ΔV_O	I_O=10mA to 300mA	—	30	—	mV *
Soft start time	TSS	Capacitance for SS =0.1µF V_{DD}=5.0V I_O=300mA	—	40	—	ms *
Input voltage at POFFX pin	V_{IH} V_{IL}	— —	0.8V_{DD} —	— —	— 0.2V_{DD}	V V
Leak current at POFFX pin	I_{LINH} I_{LINL}	V_I=V_{DD} V_I=V_{SS}	— —	— —	0.1 –0.1	µA µA
Conversion efficiency	EFFI	V_{DD}=5.0V I_O=200mA	—	90	—	% *
Oscillation frequency	f_{OSC}	V_{DD}=5.0V V_O=V_{SS} SWO pin	150	200	250	kHz
Overcurrent detection voltage (V_{DD}-V_{ISENSE})	I_{DET}	V_{DD}=5.0V	0.08	0.12	0.16	V
Low-voltage detection voltage value	V_{DET1}	Object pin : V_{DD}	2.5	2.6	2.7	V
Low-voltage detection hysteresis	V_{HYS}	Object pin : V_{DD}	—	0.15	—	V
Output voltage temperature coefficient	$\frac{\Delta V_O}{\Delta Ta}$	V_{DD}=5.0V Ta=–30 to +85˚C	—	0.02	—	%/˚C

* Characteristics vary with applicable conditions and parts. Select proper parts after sufficient evaluation.

EXAMPLE OF EXTERNAL CONNECTION OF REFERENCE CIRCUIT

Example of Standard Circuit



Parts examples

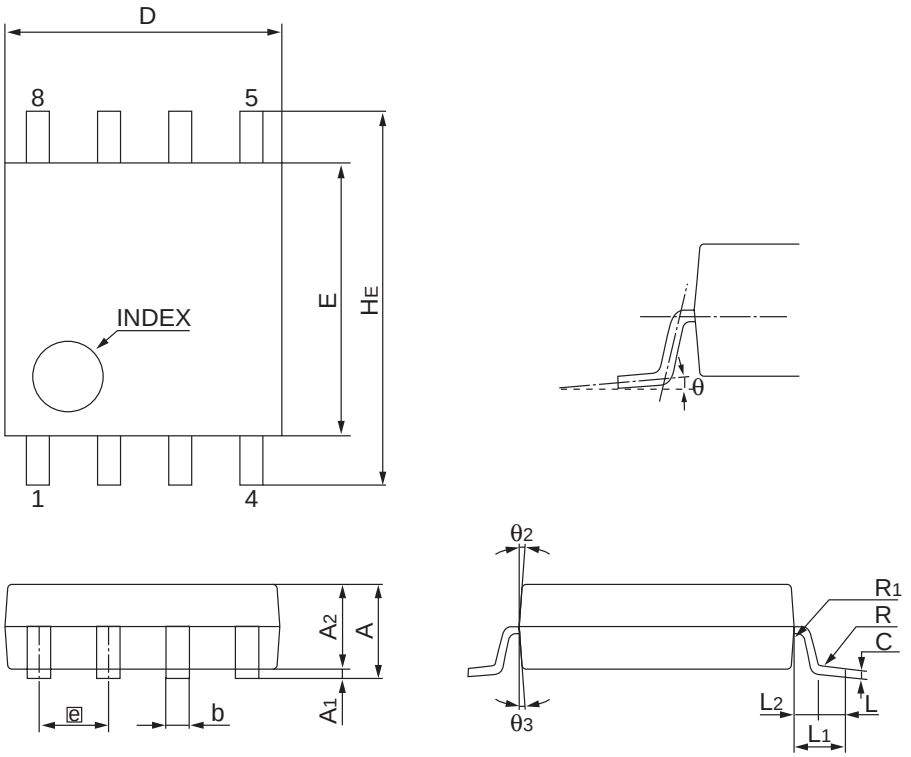
CIN1	100µF	(Sanyo 16SA100M)
CIN2	1µF	
SSCAP	0.1µF	
ERCAP	330pF	
R	100mΩ	
PchTr		(Hitachi 2SJ484)
L	47µH	(Sumida CD105)
CVO	47µF	(Sanyo 16SA47M)
D	Schottkey	(Rohm RB161L-40)

* Characteristics vary with applicable conditions and parts. Select proper parts after sufficient evaluation.

MECHANICAL DATA

Plastic SOP4-8pin

Reference



Lead type STD (SOP4–8pin STD)

Symbol	Dimension in Milimeters			Dimension in Inches*		
	Min.	Nom.	Max.	Min.	Nom.	Max.
E	4.8	5	5.2	(0.189)	(0.197)	(0.204)
D_1						
A		1.75			(0.069)	
A_1		0.15			(0.006)	
A_2		1.6			(0.063)	
e		1.27			(0.05)	
b	0.25	0.35	0.45	(0.010)	(0.014)	(0.017)
C	0.05	0.15	0.25	(0.002)	(0.006)	(0.009)
θ						
L		0.55			(0.022)	
L_1						
L_2						
H_E	6.4	6.8	7.2	(0.252)	(0.268)	(0.283)
D	4.8	5	5.2	(0.189)	(0.197)	(0.204)
θ_2						
θ_3						
R						
R1						

* for reference

S1F71200 Series PWM Type Step-up/down DC/DC Switching Regulator

DESCRIPTION

S1F71200 is a step-up/step-down DC/DC converter control IC for which the CMOS process is used and to which a power transistor is connected outside. S1F71200 is composed of an oscillator, a reference voltage circuit, an error amplifier, a PWM circuit, a series regulator, a driver, etc. When this IC drives an external power transistor, S1F71200 can constitute a step-up/step-down DC/DC converter that operates as a [step-down] series regulator when the input voltage is High and that operates as a [step-up] switching regulator of pulse width modulation system (PWM) when the input voltage is Low.

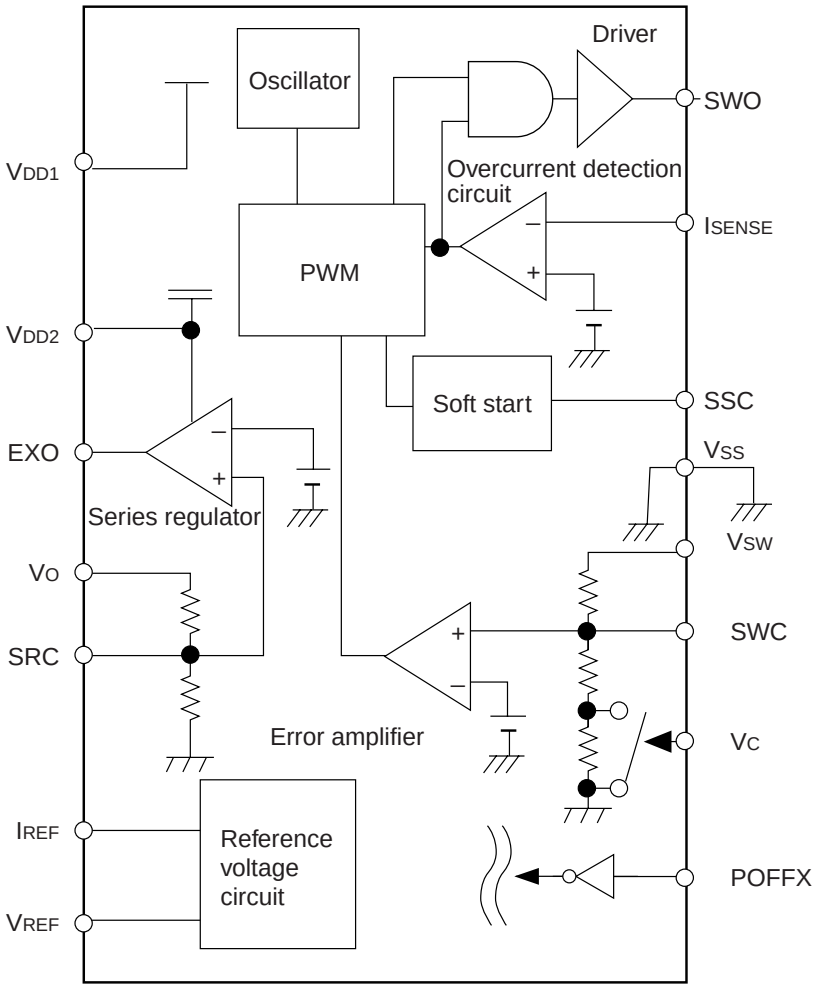
S1F71200 is also provided with an overcurrent protection circuit and a soft start circuit. When receiving external signals, S1F71200 can stop the oscillator and the switching circuit and turn off the power, so that it can reduce wasteful current consumption at the time of system halt.

FEATURES

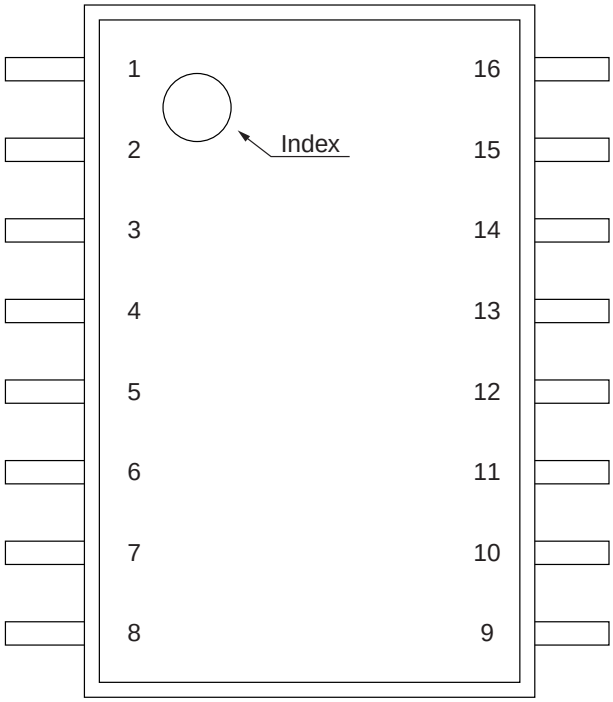
- Input voltage : 2.5V to 12.0V
- Output voltage : 5.0V (S1F71200M0A0)
  3.3V (S1F71200M0B0)
- Power off current : 1.0µA
- Self current consumption : 150µA
  (step-up portion)
  15µA
  (step-down portion)
- Frequency fixing (200kHz) PWM at step-up time
- Power off function (IC shutdown)
- Soft start function
- Overcurrent protection function
- Shipping pattern : plastic package
  (SSOP2-16 pin)

* Radiation-resistant design has not been provided for this specification.

BLOCK DIAGRAM



PIN ASSIGNMENTS



SSOP2–16pin

PIN DESCRIPTIONS

Pin No.	Pin name	Pin type	Power system	Description
1	V_{DD1}	Power supply	V_{DD1}	Power pin 1 (+), Input power pin
2	V_{DD2}	Power supply	V_{DD2}	Power pin 2 (+), Power pin for series regulator circuit
3	EXO	Output	V_{DD2}	PNP transistor base drive pin for series regulator
4	V_O	—	—	Step-up/step-down output feedback pin
5	SRC	—	—	Series regulator phase compensation capacitor connection pin
6	I_{REF}	Output	V_{DD1}	Reference resistor connection pin. Connect a 100kΩ resistor between the V_{SS} pins.
7	V_{REF}	Output	V_{DD1}	Reference voltage pin. Connect a 0.1μF capacitance between the V_{SS} pins.
8	(N.C)	—	—	No connection
9	POFFX	Input	V_{DD1}	Power off control pin. During normal operation : POFFX = V_{DD1} At power off time : POFFX = V_{SS}
10	V_C	Input	V_{DD1}	Step-up output voltage setting pin. For setting V_{SW} = V_O + 1.0V : V_C = V_{DD1} For setting V_{SW} = V_O + 0.5V : V_C = V_{SS}
11	SWC	—	—	Switching regulator phase compensation capacitor connection pin
12	V_{SW}	—	—	Step-up output feedback pin
13	V_{SS}	—	—	Power pin (–), Ground pin
14	SSC	—	V_{DD1}	Capacitor connection pin for soft start
15	I_{SENSE}	Input	V_{DD1}	Overcurrent detection pin
16	SWO	Output	V_{DD1}	Step-up switching power transistor drive pin

FUNCTIONAL DESCRIPTIONS

Description of Operation

S1F71200 is a switching regulator (step-up) and series regulator (step-down) control IC of pulse width modulation (PWM) system. When external parts such as transistor, inductor, capacitor, diode and resistor are connected, S1F71200 can constitute a step-up/step-down DC/DC converter.

When the input voltage is lower than the specified voltage value, S1F71200 raises the voltage to the set voltage (selectable at the V_C pin) with the switching regulator and lowers the step-up voltage with the series regulator to stabilize the output voltage. On the other hand, when the input voltage is higher than the specified voltage value, S1F71200 stops the operation of the switching regulator (step-up) and operates the series regulator (step-down) only. Switching operations with input voltage makes constant voltage outputs possible all the time.

Operation of Switching Regulator

S1F71200 monitors voltage at the V_{SW} pin, i.e., the output voltage of the step-up switching regulator, and controls pulse width of the switching transistor. When the voltage at the V_{SW} pin drops below the step-up set voltage, S1F71200 changes the output level of the error amplifier and increases the on duty of the switching transistor for control.

On the other hand, when the voltage at the V_{SW} pin rises over the step-up set voltage, S1F71200 reduces the on duty for control. When voltages higher than the step-up set voltage is constantly supplied to the V_{SW} pin, S1F71200 stops operation of the step-up switching. When the switching stops completely, the input voltage is supplied to the V_{SW} pin through the coil and the diode. (The voltage at the V_{SW} pin comes to the one obtained by reducing V_F of the diode from the input voltage.)

Step-up Set Voltage

Step-up set voltage can be selected at the V_C pin.

① V_C = High V_{DD1} level :
Step-up set voltage = 6.0V (S1F71200M0A0)
4.3V (S1F71200M0B0)

② V_C = Low V_{SS} level :
Step-up set voltage = 5.5V (S1F71200M0A0)
3.8V (S1F71200M0B0)

In case of output stability and heavy load like ripple, ① is superior, bur for the conversion efficiency at step-up operation, ② is superior. Characteristics vary with applicable external parts or voltage and load conditions. So, select a proper voltage after sufficient evaluation. The V_C pin cannot be used in the open state.

Soft Start

When a capacitor is connected to the SSCAP pin, S1F71200 can set a soft start operation to prevent inrush current at the time when the power is turned on. The SSCAP pin is at the V_{SS} level when the power is turned off (POFFX=V_{SS}). When the operation state is set (POFFX=V_{DD1}), the soft start capacitor starts being charged and the voltage at the SSCAP pin rises slowly. The step-up output voltage rises gradually as the voltage at the SSCAP pin rises. This operation is carried out when the power is turned on, when the power off is released or when the overcurrent detection is released and restrains surge current and output overshoot.

Overcurrent Protection Circuit

The overcurrent protection circuit functions when an overcurrent flows through the current detection resistor during the step-up operation and the voltage at the ISENSE pin rises over the set voltage value. When the overcurrent protection function works, the transistor drive pin SWO comes to the VSS level and the switching transistor is turned off. Since the overcurrent protection circuit links to the soft start circuit, it drops the voltage at the SSCAP pin to the VSS level during overcurrent detection. When the overcurrent detection is released, the voltage at the SSCAP pin rises slowly and the soft start operation starts.

Power lost at the current detection resistor becomes a factor of lower efficiency. When the overcurrent protection circuit is not necessary, short-circuit the ISENSE pin to the VSS pin. The ISENSE pin cannot be used in an open state.

Operation of Series Regulator

S1F71200 has a built-in series regulator control circuit. When driving the PNP transistor as an external part, S1F71200 reduces voltage supplied to the VDD2 pin and constitutes a series regulator. The VDD2 pin is generally connected to the VSW pin of step-up output.

This series regulator operates monitoring voltage at the VO pin of step-up/step-down output. It controls the drive current (base current of the PNP transistor) at the EXO pin to stabilize voltage at the VO pin.

Power Off Function

S1F71200 can control circuit operations according to external signal control. When the POFFX pin is set to the VSS level, all circuits stop and their powers are turned off. The current consumption at the power off state is less than 1µA. When the power is off, the SWO pin is set to the VDD level, the EXO pin is set to the VDD2 level and respective external transistors are turned.

The voltage at the SSCAP pin comes to the VSS level, and the soft start circuit controls the step-up operation output voltage is controlled with the soft start circuit after the power off state is released. The soft start circuit controls step-up operations after power off release. When being set to the VDD level, the POFFX pin operates in general. The POFFX pin cannot be used in an open state. When the power off function is not used, connect the POFFX pin to the VDD1 pin.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Applicable Pin	Rating	Unit
Input voltage	V_{DD}	V_{DD1} V_{DD2}	15.0	V
Voltage at EXO pin	EXO	EXO	V_{SS} – 0.3 to V_{DD2} + 0.3	V
Voltage at V_O pin	V_O	V_O	V_{SS} – 0.3 to 15	V
Voltage at SRC pin	SRC	SRC	V_{SS} – 0.3 to 15	V
Voltage at I_{REF} pin	I_{REF}	I_{REF}	V_{SS} – 0.3 to V_{DD1} + 0.3	V
Voltage at V_{REF} pin	V_{REF}	V_{REF}	V_{SS} – 0.3 to V_{DD1} + 0.3	V
Voltage at POFFX pin	POFFX	POFFX	V_{SS} – 0.3 to V_{DD1} + 0.3	V
Voltage at V_C pin	V_C	V_C	V_{SS} – 0.3 to V_{DD1} + 0.3	V
Voltage at SWC pin	SWC	SWC	V_{SS} – 0.3 to 15	V
Voltage at V_{SW} pin	V_{SW}	V_{SW}	V_{SS} – 0.3 to 15	V
Voltage at SSC pin	SSC	SSC	V_{SS} – 0.3 to V_{DD1} + 0.3	V
I_{SENSE}	I_{SENSE}	I_{SENSE}	V_{SS} – 0.3 to V_{DD1} + 0.3	V
SWO	SWO	SWO	V_{SS} – 0.3 to V_{DD1} + 0.3	V
Package allowable loss	P_D	P_D	210 Ta ≤ 25°C	MW
Operating temperature	T_{opr}	—	–30 to +85	°C
Storage temperature	T_{stg}	—	–55 to +150	°C
Soldering temperature and time	T_{sol}	—	260 · 10	°C · s

Note
Any operation under conditions exceeding the above absolute maximum ratings may result in a malfunction or a permanent destruction. When even an item is more than the rating, a temporary normal operation is possible but with remarkably low reliability. So, be sure to keep all items below the ratings.

ELECTRICAL CHARACTERISTICS

S1F71200M0A0 (Output : 5.0V)
DC Characteristics — Unless otherwise specified, Ta = 25°C.

Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Input supply voltage 1	V_{DD1}	V_{DD1} pin	2.5	—	12.0	V
Input supply voltage 2	V_{DD2}	V_{DD2} pin	—	—	12.0	V
Step-up set voltage	V_{SW}	V_{SW1} pin, $V_C = V_{DD1}$ $V_C = V_{SS}$	— —	6.0 5.5	— —	V
Output voltage	V_O	V_{DD2} = 6V Ta = –30°C to +85°C	4.8	5.0	5.2	V
Operating time current consumption 1 (during step-up operation)	IV_{DD1-1} (V_{DD1} system)	V_{DD1} = 3V, V_{DD2} = 6V	—	150	250	µA
	IV_{DD2-1} (V_{DD2} system)	V_{DD1} = 3V, V_{DD2} = 6V	—	15	30	µA
Operating time current consumption 2 (operation for step-down only)	IV_{DD1-2} (V_{DD1} system)	V_{DD1} = 6V, V_{DD2} = 6V	—	100	200	µA
	IV_{DD2-2} (V_{DD2} system)	V_{DD1} = 6V, V_{DD2} = 6V	—	20	40	µA
Power off time current consumption	I_Q	V_{DD1} = 12V, V_{DD2} = 12V	—	—	1.0	µA
Output current at SWO pin	I_{OHSWO}	V_{DD1} = 3V, V_{DD2} = 6V V_{OH} = 50mV	–0.6		—	mA
	I_{OLSWO}	V_{DD1} = 3V, V_{DD2} = 6V V_{OL} = 50mV	1.0		—	mA
Input stability	ΔV_O	V_{DD} = 3V to 12V	—	50	—	mV*
Load stability	ΔV_O	I_L = 10mA to 100mA	—	50	—	mV*
Input voltage level at POFFX pin, at V_C pin	V_{IH}	—	0.8V_{DD1}	—	—	V
	V_{IL}	—	—	—	0.2V_{DD1}	V

DC Characteristics — Unless otherwise specified, Ta = 25°C.

Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Input pin leak current at POFFX pin, at V_C pin	I_{LINH}	$V_{IN} = V_{DD1}$	—	—	1.0	µA
	I_{LINL}	$V_{IN} = V_{SS}$	—	—	–1.0	µA
Step-up soft start time	T_{SS}	SSCAP = 0.1µF V_{DD1} = 3.0V, $V_C = V_{DD1}$ I_O = 50mA	—	100	—	ms*
Step-up portion conversion efficiency	EFFI	V_{DD1} = 3.3V, $V_C = V_{SS}$	—	85	—	%*
Oscillation frequency	f_{OSC}	V_{DD1} = 3V (Measure it at the SWO pin.)	120	200	280	kHz
Overcurrent detection voltage	I_{DET}	V_{ISENSE}	0.10	0.15	0.20	V
Output voltage temperature coefficient	$\frac{\Delta V_O}{\Delta T_{opr}}$	Ta = –30°C to +85°C	—	0.015	—	%/°C

* These values are available when external parts are used in the example of circuit connection shown on the attached sheet.

The characteristics vary with applicable parts. Select proper parts after sufficient evaluation.

S1F71200M0B0 (Output : 3.3V)
DC Characteristics — Unless otherwise specified, Ta = 25°C.

Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Input supply voltage 1	V_{DD1}	V_{DD1} pin	2.5	—	12.0	V
Input supply voltage 2	V_{DD2}	V_{DD2} pin	—	—	12.0	V
Step-up set voltage	V_{SW}	V_{SW1} pin, $V_C = V_{DD1}$ $V_C = V_{SS}$	— —	4.3 3.8	— —	V
Output voltage	V_O	V_{DD2} = 4.3V Ta = –30°C to +85°C	3.15	3.3	3.45	V
Operating time current consumption 1 (during step-up operation)	I_{VDD1-1} (V_{DD1} system)	V_{DD1} = 3V, V_{DD2} = 4.3V	—	150	250	µA
	I_{VDD2-1} (V_{DD2} system)	V_{DD1} = 3V, V_{DD2} = 4.3V	—	15	30	µA
Operating time current consumption 2 (operation for step-down only)	I_{VDD1-2} (V_{DD1} system)	V_{DD1} = 5V, V_{DD2} = 5V	—	100	200	µA
	I_{VDD2-2} (V_{DD2} system)	V_{DD1} = 5V, V_{DD2} = 5V	—	20	40	µA
Power off time current consumption	I_Q	V_{DD1} = 12V, V_{DD2} = 12V	—	—	1.0	µA
Output current at SWO pin	I_{OHSWO}	V_{DD1} = 3V, V_{DD2} = 4.3V V_{OH} = 50mV	–0.6		—	mA
	I_{OLSWO}	V_{DD1} = 3V, V_{DD2} = 4.3V V_{OL} = 50mV	1.0		—	mA
Input stability	ΔV_O	V_{DD} = 3V to 12V	—	50	—	mV*
Load stability	ΔV_O	I_L = 10mA to 100mA	—	50	—	mV*
Input voltage level at POFFX pin, at V_C pin	V_{IH}	—	0.8V_{DD1}	—	—	V
	V_{IL}	—	—	—	0.2V_{DD1}	V

DC Characteristics — Unless otherwise specified, Ta = 25°C.

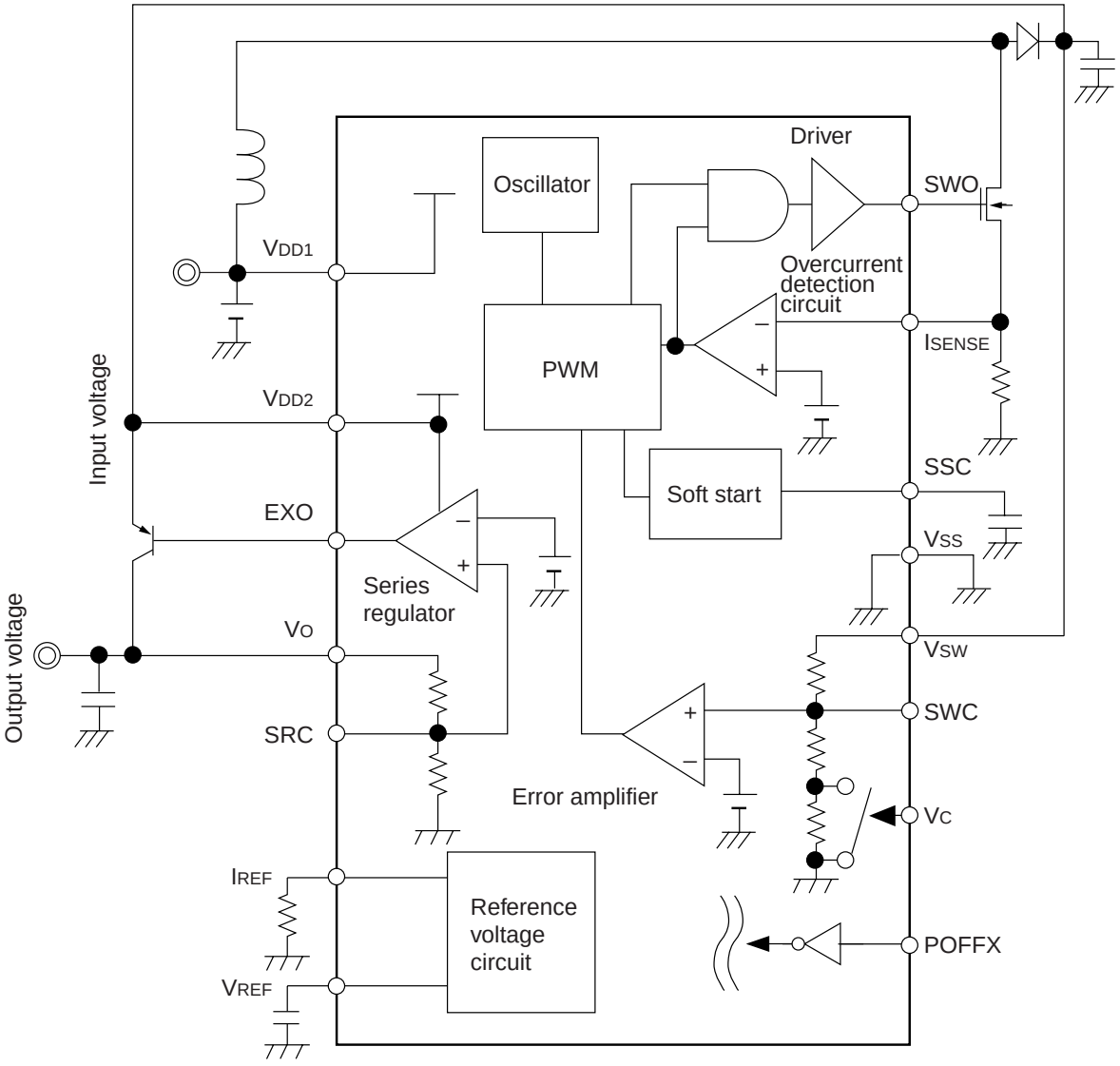
Parameter	Symbol	Conditions	Rating			Unit
			Min.	Typ.	Max.	
Input pin leak current at POFFX pin, at V_C pin	I_{LINH}	$V_{IN} = V_{DD1}$	—	—	1.0	µA
	I_{LINL}	$V_{IN} = V_{SS}$	—	—	–1.0	µA
Step-up soft start time	T_{SS}	SSCAP = 0.1µF V_{DD1} = 3.0V, $V_C = V_{DD1}$ I_O = 50mA	—	70	—	ms*
Step-up portion conversion efficiency	EFFI	V_{DD1} = 3V, $V_C = V_{SS}$	—	85	—	%*
Oscillation frequency	f_{OSC}	V_{DD} = 3V (Measure it at the SWO pin.)	120	200	280	kHz
Overcurrent detection voltage	I_{DET}	V_{ISENSE}	0.10	0.15	0.20	V
Output voltage temperature coefficient	$\frac{\Delta V_O}{\Delta T_{opr}}$	Ta = –30°C to +85°C	—	0.015	—	%/°C

* These values are available when external parts are used in the example of circuit connection shown on the attached sheet.

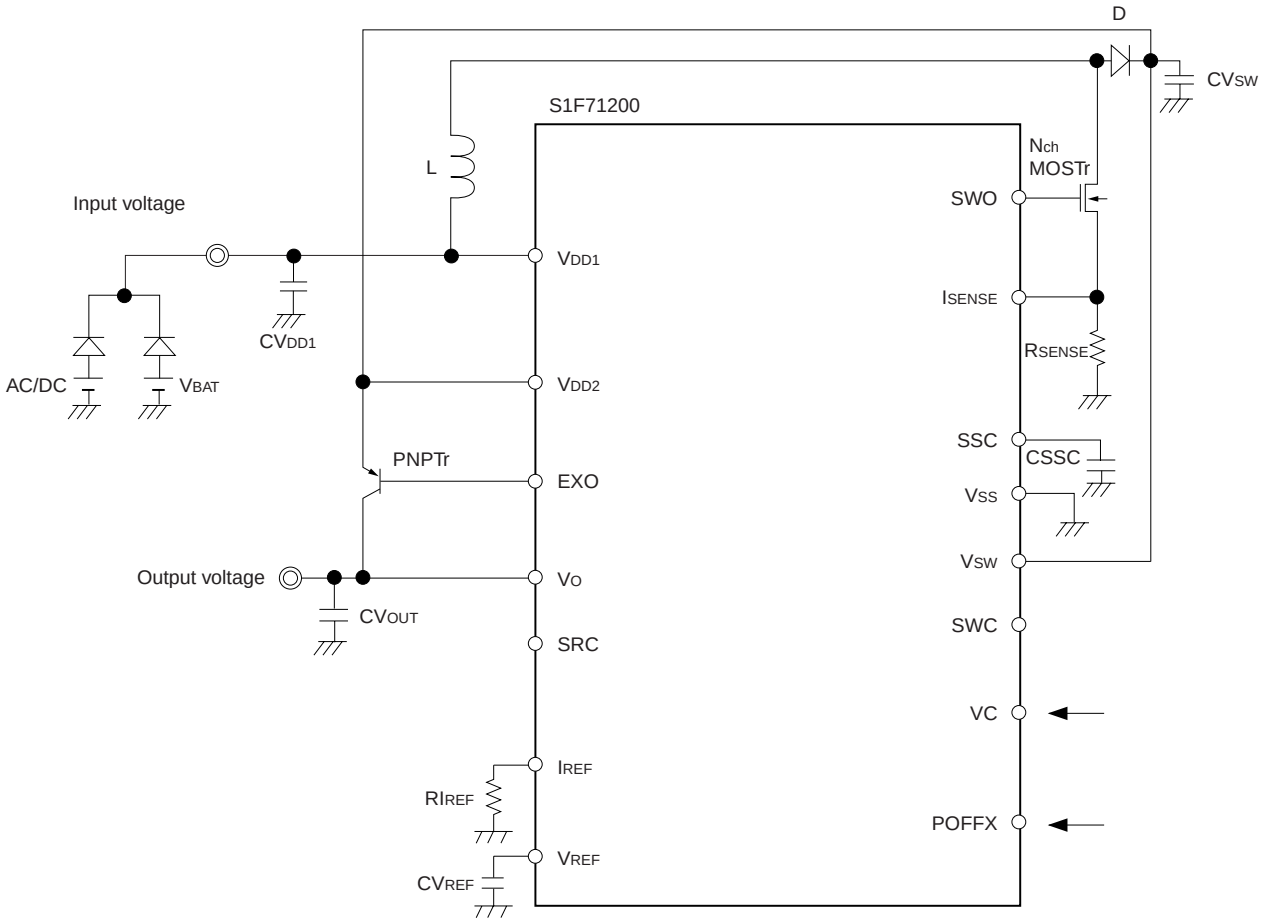
The characteristics vary with applicable parts. Select proper par ts after sufficient evaluation.

EXAMPLE OF EXTERNAL CONNECTION OF REFERENCE CIRCUIT

Basic Circuit



Example of Parts Connection



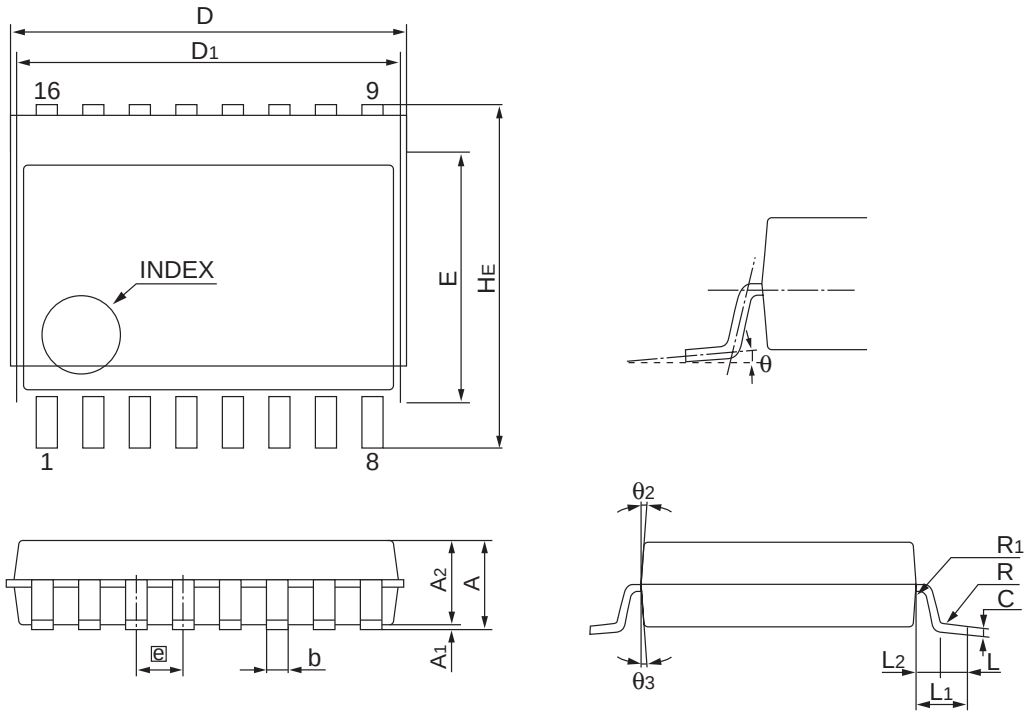
		Parts examples
CV_{DD1}	47µF	(Sanyo 16SA47M)
NchTr		(Hitachi HAT2037T)
L	47µH	(Sumida CR54)
D	Schottky	(Rohm RB161L-40)
CV_{SW}	47µF	(Sanyo 16SA47M)
PNPTr		(2SA1242)
CV_{OUT}	22µF	(Sanyo 10SL22M)
RI_{REF}	100kΩ	
CV_{REF}	0.1µF	
CSSC	0.1µF	
R_{SENSE}	0.1Ω	

* Characteristics vary with applicable conditions and parts. Select proper parts after sufficient evaluation.

MECHANICAL DATA

Plastic SSOP2-16pin

Reference



Lead type STD (SSOP2-16pin STD)

Symbol	Dimension in Milimeters			Dimension in Inches*		
	Min.	Nom.	Max.	Min.	Nom.	Max.
E	4.2	4.4	4.6	(0.166)	(0.173)	(0.181)
D_1	6.4	6.6	6.8	(0.252)	(0.260)	(0.267)
A			1.7			(0.066)
A_1		0.05			(0.002)	
A_2	1.4	1.5	1.6	(0.056)	(0.059)	(0.062)
e		0.8			(0.031)	
b	0.26	0.36	0.46	(0.011)	(0.014)	(0.018)
C	0.1	0.15	0.25	(0.004)	(0.006)	(0.009)
θ	0°		10°	(0°)		(10°)
L	0.3	0.5	0.7	(0.012)	(0.020)	(0.027)
L_1		0.9			(0.035)	
L_2		0.4			(0.016)	
H_E	5.9	6.2	6.5	(0.233)	(0.244)	(0.255)
D			7			(0.275)
θ_2						
θ_3						
R						
R_1						

* for reference

5. DC/DC Switching Regulators & Voltage Follower

S1F75300 Series Step-up Switching Regulator With Built-in Voltage Follower

DESCRIPTION

S1F75300 is a highly efficient and low power consumption step-up switching regulator with built-in voltage follower developed by using CMOS silicon gate processor. (For boosting, the external coil is used.)
The output voltage is adjustable with the 8-bit electronic volume.
This IC is optimum to power supply portions of medium and small liquid crystal panels for which high efficiency is requested.

FEATURES

- Boosting efficiency : 80%
- Low current consumption : Typ.200µA (without load)
- Output voltage (step-up output) : 30V Max., adjustable with the electronic volume.
- Optimum to small and medium liquid crystal panels
  Input voltage : 2.7V to 5.5V
  Output voltage : to 27V
- Reduction of current consumption at the time of standby with power-off function

LINE UP

Product	Amplified output voltage	Voltage at V_{O2} pin	Temperature coefficient at V_{O2} pin	Voltage follower duty
S1F75300M0A0	25V	22V	–0.06%/˚C	1/160
S1F75300M0B0	27V	24V	–0.06%/˚C	1/240

BLOCK DIAGRAM

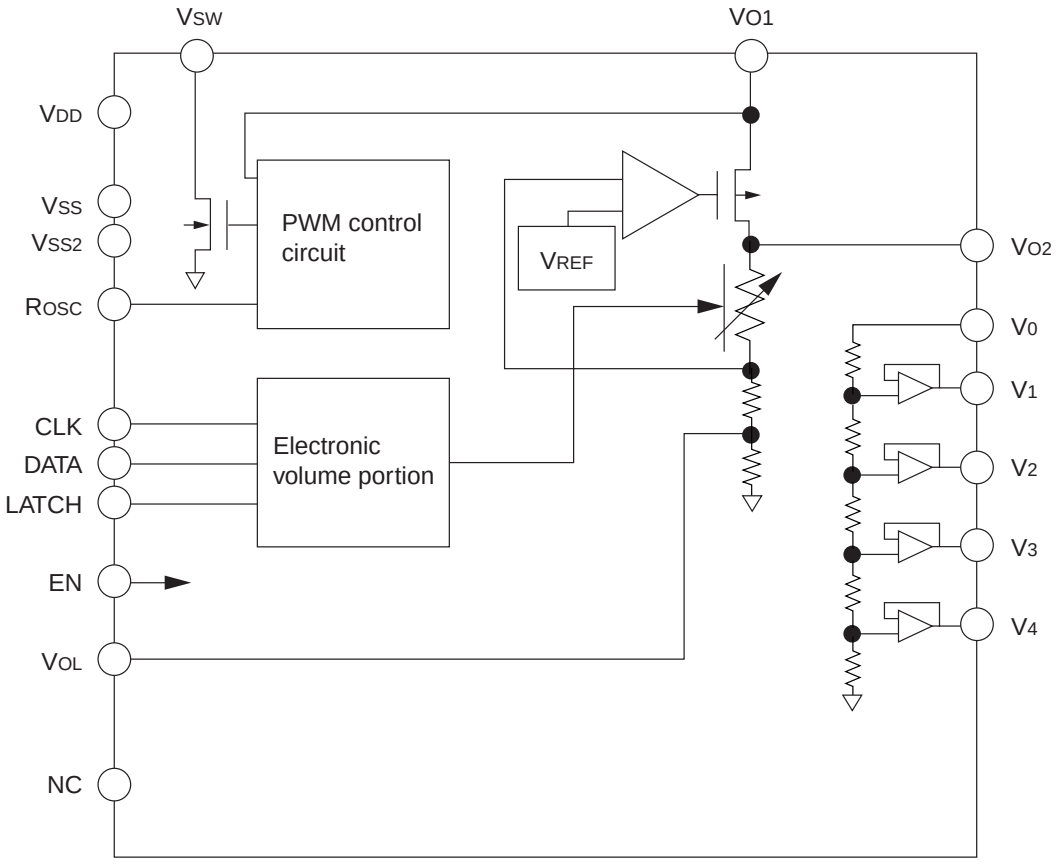


Figure 1 Block Diagram of S1F75300

PIN DESCRIPTIONS

Pin No.	Pin name	Description
1	DATA	Data input pin for adjusting electronic volume bias
2	CLK	Clock input pin for adjusting electronic volume bias
3	LATCH	Data latch input pin for adjusting electronic volume bias
4,9,16	NC	No connection
5,8	V_{SS}, V_{SS2}	GND pin
6	R_{OSC}	External resistance connection pin for adjusting oscillation current
7	EN	Enable pin. HIGH : Normal operation, LOW : System operation stop
10	V_{SW}	External inductance drive pin
11	V_4	Liquid crystal drive voltage pin 4
12	V_3	Liquid crystal drive voltage pin 3
13	V_2	Liquid crystal drive voltage pin 2
14	V_1	Liquid crystal drive voltage pin 1
15	V_0	Liquid crystal drive voltage pin 0
17	V_{O2}	Output voltage pin
18	V_{O1}	Output voltage monitor pin
19	V_{OL}	Output voltage external adjustment pin
20	V_{DD}	Power supply pin

PIN ASSIGNMENTS

SSOP1-20pin

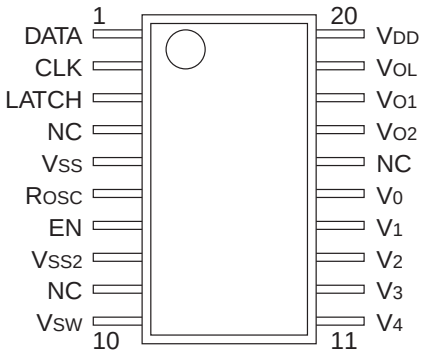


Figure 2 Pin Assignments

FUNCTIONAL DESCRIPTIONS

Switching Regulator Portion

Operation of Basic Boosting Circuit

S1F75300 boosts using clock pulses generated in the PWM control circuit. Figure 3 shows the block diagram for explaining the principle of operation of the boosting circuit. This circuit stores energy in the inductance L when the switching transistor (Tr1) is on and can charge the capacitor C with the stored energy by passing it through the diode D for output when the switching transistor is off.

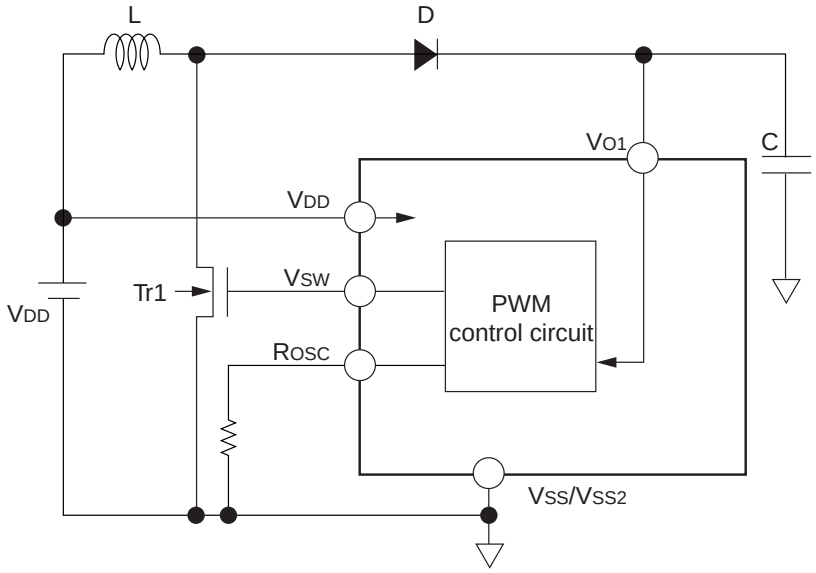


Figure 3 Block Diagram of Boosting Circuit

Reference Voltage Generator, Output Voltage Setting Stabilizing Circuit

• Reference Voltage Generator, Output Voltage Setting Stabilizing Circuit

The reference voltage generator is for generating stabilized voltage (reference voltage) not depending on input voltage necessary for the output voltage setting stabilizing circuit or the voltage detection circuit.

The reference voltage generator has a built-in temperature characteristic compensation circuit. For the temperature characteristic, any one temperature characteristics can be selected out of four temperature characteristics in the range from –0.18%/°C to –0.06%/°C. (Selection with Mask Option.

The output voltage setting stabilizing circuit outputs the stabilized voltage V_{O2} after receiving a boosted voltage. The output voltage V_{O2} can be set to a specified voltage when the position of Point A on the intermediate tap of the resistor connected between the pin V_{O2} and the pin GND as shown in Figure 4 is changed.

The variable resistor in Figure 4 has the function of electronic volume and can change the output V_{O2} as the resistance value is changed as mentioned in Paragraph 5.1.3.

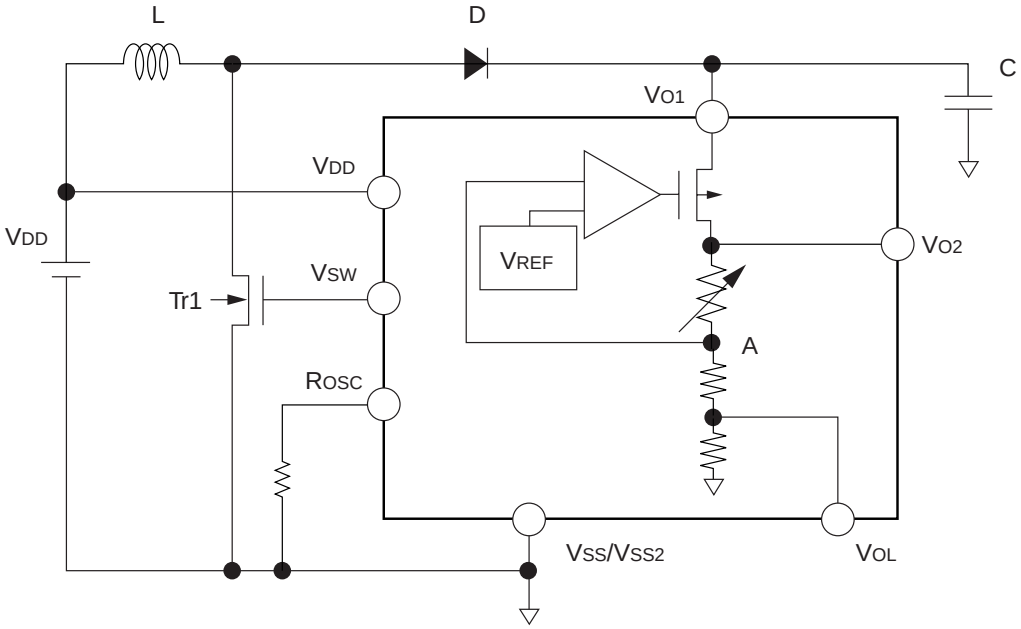


Figure 4 Stabilizing Circuit

Note

In the practical boosting state, a ripple voltage is superimposing the output setting voltage set as mentioned above. Since this ripple voltage is affected by applicable external parts and loading conditions, set the value of the coil through which the load current passes and check it before use.

• Output Voltage External Adjustment Pin (V_{OL})

The voltage V_{O2} boosted and stabilized with the output voltage setting stabilizing circuit can slightly adjust output voltages when an external resistor is connected to the output voltage external adjustment pin V_{OL} as shown in Figure 10 in Chapter 7, Example of External Connection.

Electronic Volume Portion

S1F75300 has a built-in 8-bit shift register and a built-in 8-bit latch so that it can vary the voltage V_{O2} when serial data is input. The 8-bit latch enables to vary the output voltage V_{O2}. Data taken in the shift register is taken in the 8-bit latch as a synchronous strobe is input. The following shows the block diagram and the timing chart.

DATA : Serial data input pin for setting output voltage and bias value.
"Data 1" is input at the High level and "Data 0" is input at the Low level. Data are input to (LSB) and (MSB) in this order.

CLK : Clock input to shift register pin
When the clock starts, data at the DATA pin is taken in the shift register. Data to be taken in shift one after another for every clock. So, data input last becomes valid.

LATCH : Latch signal input pin
When latch signal is set to High the content of the shift register is taken in the 8-bit latch.

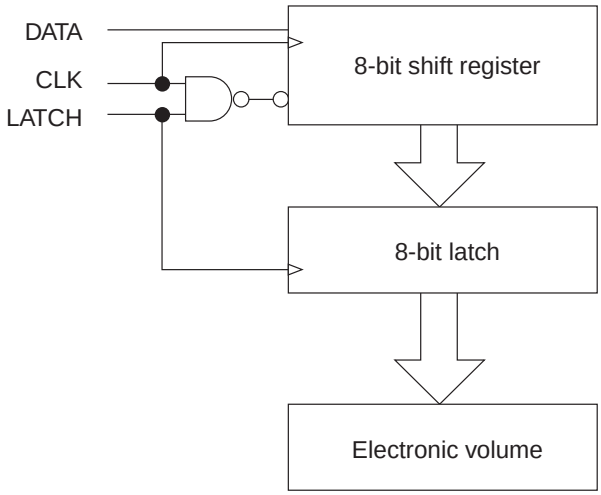


Figure 5-1 Block Diagram

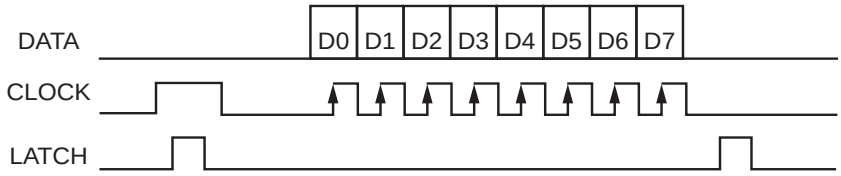


Figure 5-2 Timing Chart of 8-bit Latch Portion

Table 1 List of Electronic Volume Set Points

D7	D6	D5	D4	D3	D2	D1	D0	Electronic volume value
0	0	0	0	0	0	0	0	0
.....								.....
0	1	1	1	1	1	1	1	127
								.....
1	0	0	0	0	0	0	0	128
.....								.....
1	1	1	1	1	1	1	1	255

Voltage Follower Portion

The voltage follower portion of S1F75300 enables to adjust bias with the electronic volume as explained in Paragraph 5.1.3.
Figure 6 shows the block diagram of the voltage follower portion.

After the power is turned on, the resistance between V_2 and V_3 is set to nR. (The n value is selected optionally.)
When n is 11 and 13 for example, the voltages at V_1 to V_4 are as follows after the power is turned on:

Table 2 Output Voltage of Voltage Follower

	n=11 (1/160 duty)	**n=13 (1/240 duty)**
V_1	13/14•V_0	16/17•V_0
V_2	12/14•V_0	16/17•V_0
V_3	2/14•V_0	2/17•V_0
V_4	1/14•V_0	1/17•V_0

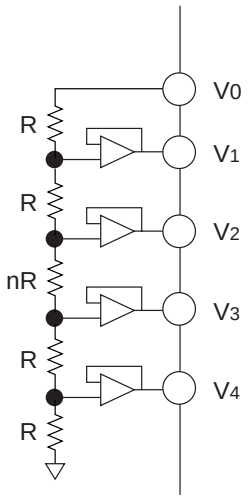


Figure 6 Block Diagram of Voltage Follower

EN Pin

This pin is for boosting action and for stopping and starting the voltage follower portion.
When the EN pin is set to Low level, the internal circuit action stops and the current consumption is restrained.

ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings

(V_{SS} = 0V, Ta=25°C)

Parameter	Symbol	Rating		Unit	Remarks
		Min.	Max.		
VSW pin voltage	V_{VSW}	V_{SS} – 0.3	33	V	—
VSW pin current	I_{VSW}	—	100	mA	—
Voltage of other pins	V*	V_{SS} – 0.3	7	V	—
Allowable loss	P_D	—	130	mW	—
Operating temperature	T_{opr}	–30	85	°C	—
Storage temperature	T_{stg}	–65	150	°C	—
Soldering temperature and time	T_{sol}	—	260 • 10	˚C • s	At leads

ELECTRICAL CHARACTERISTICS

Step-up Switching Regulator and Voltage Follower Portion

DC Characteristics

Parameter	Symbol	Rating			Unit	Conditions
		Min.	Typ.	Max.		
Input voltage	V_{DD}	2.7	—	5.5	V	
Amplified output voltage	V_O	—	—	30	V	
Current consumption	I_{OPR}	—	200	—	µA	V_{DD} = 5.0V
Current consumption at enable time	I_{EN}	—	—	5	µA	
Switching transistor ON-state resistance	R_{SWON}	—	—	15	Ω	
Switching transistor leak current	I_{SWQ}	—	—	1	µA	
Input stability	ΔV_{O1}	—	0.5	—	%/V	V_{O2}=27V
Load stability		—	90	—	mV	V_{O2}=27V, Ivout2=–10mA
Output voltage / temperature coefficient	ΔV_{O1} /ΔTa	—	–0.18	—	%/°C	
		—	–0.15	—		
		—	–0.10	—		
		—	–0.06	—		
Oscillation frequency	F_{CLK}	145	150	155	kHz	
Maximum duty ratio	F_{DUTY}	80	—	90	%	
Resistance between pins V_{OL} and V_{SS}	R_{VOL}	64	—	256	kΩ	
V_{O2} output current	I_{O2}	—	—	18	mA	
Efficiency	Eff	—	80	—	%	

Parameter	Symbol	Rating			Unit	Conditions
		Min.	Typ.	Max.		
V_1 output current	V_{1OH}	V_1 + 70mV	—	—	mA	I_{OH} = 2mA, V_1 = No-load voltage
	V_{1OL}	—	—	V_1 – 50mV		I_{OL} = –2mA, V_1 = No-load voltage
V_2 output current	V_{2OH}	V_2 + 50mV	—	—	mA	I_{OH} = 2mA, V_2 = No-load voltage
	V_{2OL}	—	—	V_2 – 70mV		I_{OL} = –2mA, V_2 = No-load voltage
V_3 output current	V_{3OH}	V_3 + 70mV	—	—	mA	I_{OH} = 2mA, V_3 = No-load voltage
	V_{3OL}	—	—	V_3 – 50mV		I_{OL} = –2mA, V_3 = No-load voltage
V_4 output current	V_{4OH}	V_4 + 50mV	—	—	mA	I_{OH} = 2mA, V_4 = No-load voltage
	V_{4OL}	—	—	V_4 – 70mV		I_{OL} = –2mA, V_4 = No-load voltage

Electronic Volume

DC Characteristics

Parameter	Symbol	Rating			Unit	Conditions
		Min.	Typ.	Max.		
Output voltage range	V_{O2}		—	30	V	
Electronic volume resolution		—	1/256	—		
Linearity error		—	—	±1/2	LSB	
High level input voltage	V_{IH}	2.0	—	—	V	
Low level input voltage	V_{IL}	—	—	0.8	V	

AC Characteristics

Parameter	Symbol	Rating			Unit	Conditions
		Min.	Typ.	Max.		
CLK cycle	t_{CLK}	1	—	—	µs	
Data setup time	t_{CST}	0.5	—	—	µs	
Data hold time	t_{CHT}	0.5	—	—	µs	
Latch pulse width	t_{WLTC}	0.5	—	—	µs	
CLK power off → Latch start	t_{LST}	0.5	—	—	µs	
Latch power off → CLK start	t_{LHT}	0.5	—	—	µs	

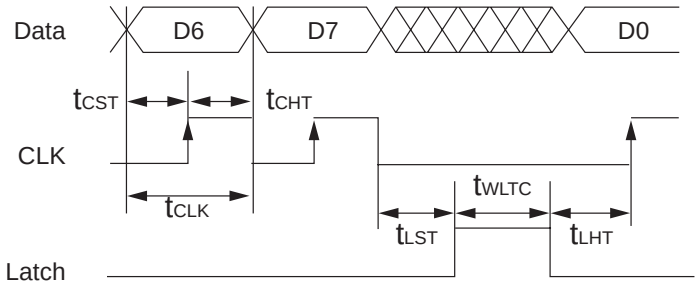


Figure 8 Electronic Volume Portion AC Characteristic Timing Chart

EXAMPLE OF EXTERNAL CONNECTION

(1) Connection Example 1
Figure 9 shows an example of the basic circuit of S1F75300.

(2) Connection Example 2
Figure 10 shows a connection example for connecting a variable resistor to the V_{OL} pin so as to adjust V_{O2}.

(3) Connection Example 3
Figure 11 shows a connection example for connecting a temperature compensation circuit between pins V_{O2} and V_0 so as to adjust temperature correction of voltage of the voltage follower portion with an external circuit.
Figure 12 shows an example of a temperature compensation circuit.

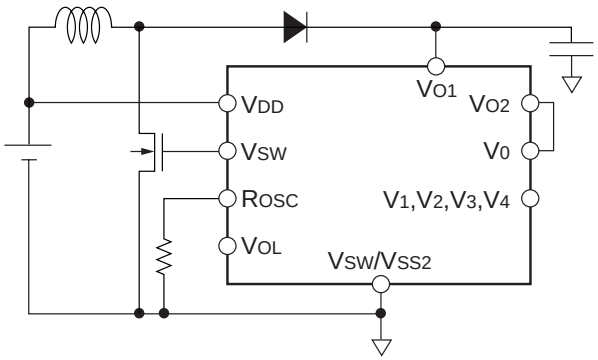


Figure 9 Connection Example 1

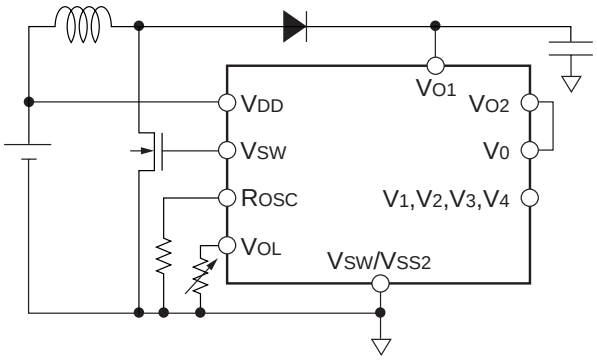


Figure 10 Connection Example 2

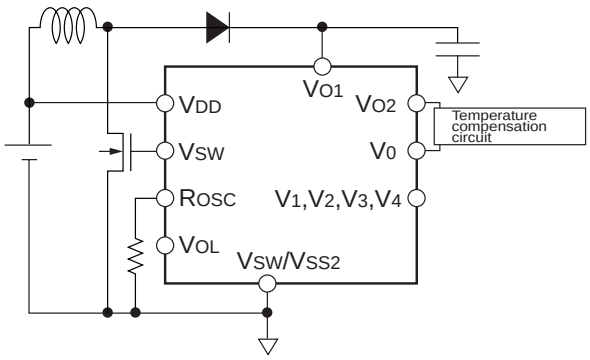


Figure 11 Connection Example 3

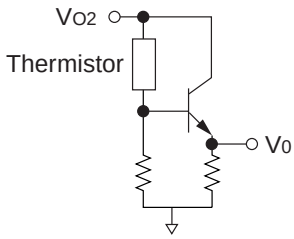


Figure 12 Example of Temperature Compensation Circuit

EXAMPLE OF REFERENCE CIRCUIT

The figure below shows an example of connection of this IC and a liquid crystal display panel.

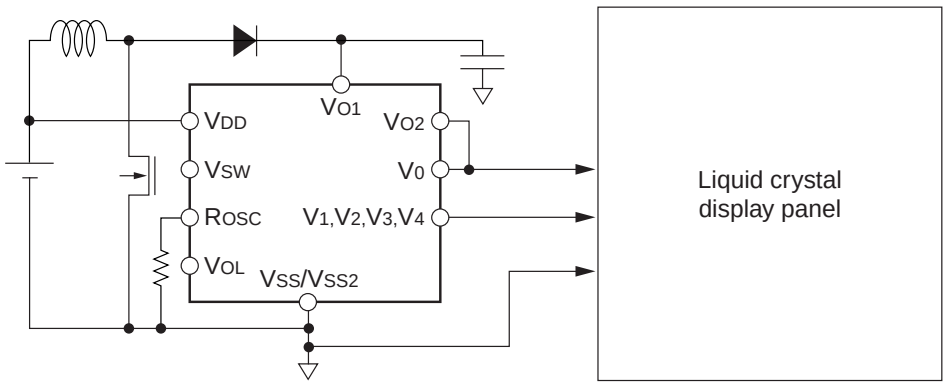


Figure 14 Example of Reference Circuit

6. Voltage Detector

S1F77200Y Series CMOS Voltage Detectors

DESCRIPTION

The S1F77200Y series products are non-adjusting voltage detectors being developed utilizing he base of the CMOS silicon gate process.
This voltage detector consists of the reference voltage circuit, voltage comparator, hysteresis circuit and output circuit, all operating on smaller current.
A voltage range to be detected is internally set on respective detectors. A wide variety of our standard products are grouped as shown below according to the output format employed for the voltage detector output pin.
The S1F77200Y series employs N-channel open drain output approach. And the S1F77210Y series and S1F 77220Y series employ the CMOS output and P-channel output, respectively.
The package used is the SOT89-3 pin plastic package.
Our voltage detectors are used for determining battery life, and also for monitoring supply voltage fed to microcomputers and LSI systems.

FEATURES

- Full lineups: 19 types are prepared for the detection range between 2.0V to 5.0V.
  For the detection range from 0.8V to 2.5V, 7 types are available (products designed for lower voltage detection).
- Low operating current: Typ. 2.0 µA (V_{DD} = 5.0V).
- Low operating voltage: 1.5V at minimum.
- Absolute maximum rated voltage: 15V maximum.
- Highly stable built-in reference voltage source: Typ. 1.0V.
- Better temperature characteristics of output voltage: Typ. -100ppm/°C.

LINEUP

Table 5-1

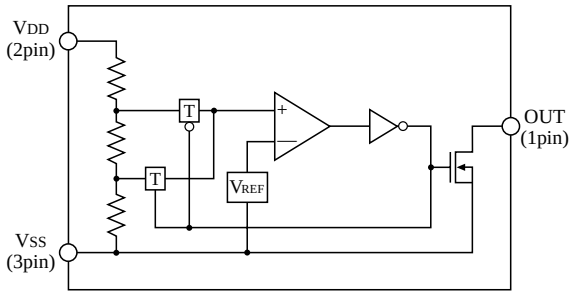
Product	Voltage detectable			Output type	Output phase	
	Min.	Typ.	Max.		Less than V_{DET}	V_{DET} or above
S1F77210Y1C0	2.10	2.15	2.20	CMOS	Low level	High level
S1F77210Y1P0	2.20	2.25	2.30	CMOS	Low level	High level
S1F77210Y1S0	2.30	2.35	2.40	CMOS	Low level	High level
S1F77210Y1E0	2.50	2.55	2.60	CMOS	Low level	High level
S1F77210Y1F0	2.60	2.65	2.70	CMOS	Low level	High level
S1F77210Y1R0	2.73	2.80	2.87	CMOS	Low level	High level
S1F77210Y1G0	2.93	3.00	3.07	CMOS	Low level	High level
S1F77210Y1H0	3.13	3.20	3.27	CMOS	Low level	High level
S1F77210Y130	3.43	3.50	3.57	CMOS	Low level	High level
S1F77210Y1T0	3.90	4.00	4.10	CMOS	Low level	High level
S1F77210Y1M0	4.10	4.20	4.30	CMOS	Low level	High level
S1F77210Y1J0	4.30	4.40	4.50	CMOS	Low level	High level
S1F77210Y120	4.50	4.60	4.70	CMOS	Low level	High level
S1F77210Y1K0	4.70	4.80	4.90	CMOS	Low level	High level
S1F77210Y1L0	4.90	5.00	5.10	CMOS	Low level	High level
S1F77210Y2C0	2.10	2.15	2.20	CMOS	High level	Low level
S1F77210Y2F0	2.60	2.65	2.70	CMOS	High level	Low level

Table 5-2

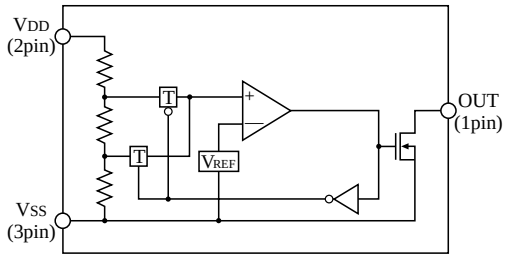
Product	Voltage detectable			Output type	Output phase	
	Min.	Typ.	Max.		Less than V_{DET}	V_{DET} or above
S1F77200Y1T0	3.90	4.00	4.10	N ch Open Drain	Low level	Hi–Z
S1F77200Y1F0	2.60	2.65	2.70	N ch Open Drain	Low level	Hi–Z
S1F77200Y1C0	2.10	2.15	2.20	N ch Open Drain	Low level	Hi–Z
S1F77200Y1N0	1.85	1.90	1.95	N ch Open Drain	Low level	Hi–Z
S1F77200Y1B0	1.10	1.15	1.20	N ch Open Drain	Low level	Hi–Z
S1F77200Y1Y0	1.05	1.10	1.15	N ch Open Drain	Low level	Hi–Z
S1F77200Y1A0	1.00	1.05	1.10	N ch Open Drain	Low level	Hi–Z
S1F77200Y1V0	0.90	0.95	1.00	N ch Open Drain	Low level	Hi–Z
S1F77220Y2D0	1.20	1.25	1.30	P ch Open Drain	High level	Hi–Z

BLOCK DIAGRAM

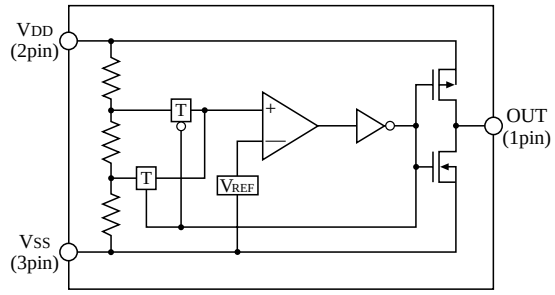
S1F77200Y1*0 Type



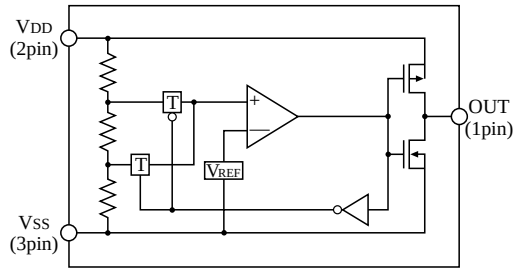
S1F77200Y2*0 Type



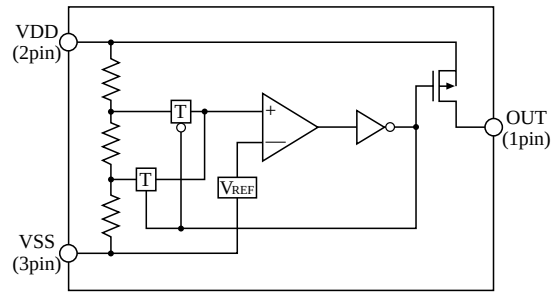
S1F77210Y1*0 Type



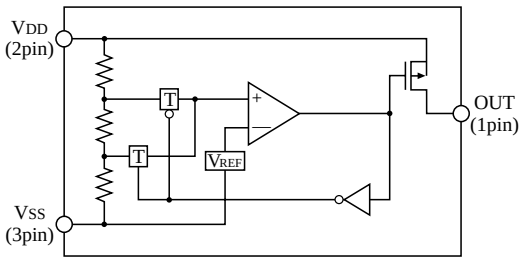
S1F77210Y2*0 Type



S1F77220Y1*0 Type



S1F77220Y2*0 Type



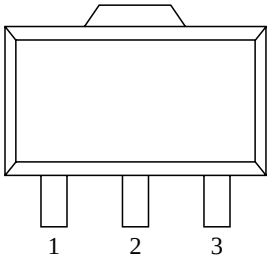
Note: A different code can be employed for the ones preceded by ∗ marking depending on their detecting voltage specification.

PIN DESCRIPTIONS

Pin No.	Pin name	Description
1	OUT	Voltage detection output pin
2	V_{DD}	Input voltage pin (positive side)
3	V_{SS}	Input voltage pin (negative side)

PIN ASSIGNMENTS

SOT89-3pin

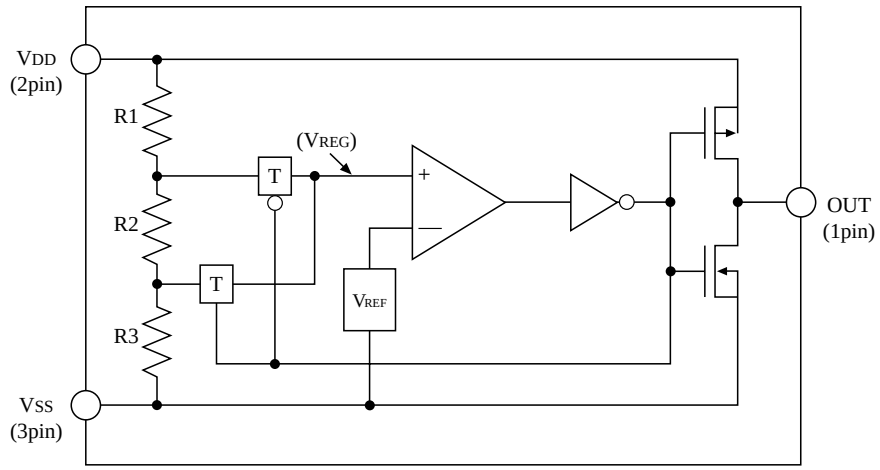


FUNCTIONAL DESCRIPTIONS

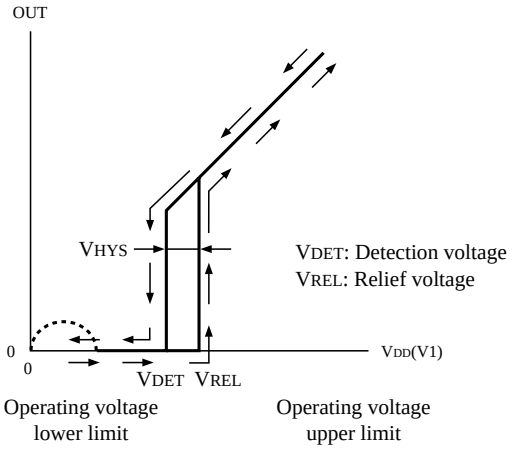
The S1F77200Y series has the circuit configuration as shown in the figure below. For the detection, divided potential (V_{REG}) across the resistors inserted across the power supply and the reference voltage (V_{REF}) generated on the IC are entered to the voltage comparator. Since the voltage comparator is designed to detect a target voltage even when potential difference between V_{REG} and Vref minute, hysteresis is added so that the comparator may not fail due to noise on the power supply and such. In the example shown in the figure below, detection voltage (V_{DET}) for the input voltage drop and relief voltage (V_{REL}) for the increased input voltage are set based the following formula.

Detection voltage: $V_{DET} = \frac{R1+R2+R3}{R2+R3} \cdot V_{REF}$

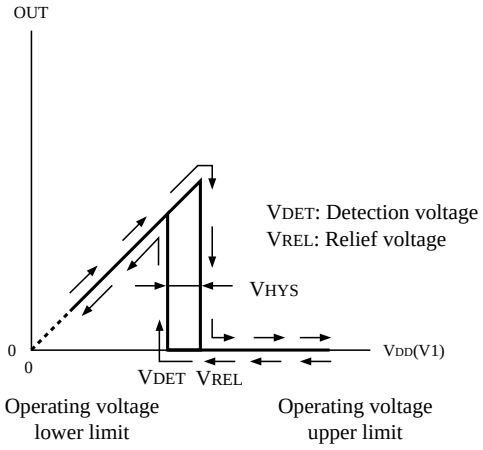
Relief voltage: $V_{REL} = \frac{R1+R2+R3}{R3} \cdot V_{REF}$



The following figures show the input and output characteristics of the S1F77200Y series.



[S1F772∗0Y1∗0 Type]



S1F772∗0Y2∗0 Type

Note: The above input/output characteristics assumes that the pull up resistor is connected to the output pin for the S1F77200Y series. For the S1F77220 series, it assumes that the pull down resistor is connected between the OUT and V_{DD} pins.
If the input voltage that is applied between V_{DD} and V_{SS} terminals drops below the lower limit of voltage for IC operation, the output condition of the OUT terminal may become unsteady.
Ensure to prevent problems from occurring in circuit operation.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Supply voltage range	$V_{DD} – V_{SS}$	15	V
Output voltage	V_O	V_{DD} + 0.3 to V_{SS} – 0.3 (S1F77210)	V
		15 to V_{SS} – 0.3 (S1F77200)	
		V_{DD} + 0.3 to V_{DD} – 15 (S1F77220)	
Output current	I_O	50	mA
Allowable dissipation	P_D	200	mW
Operating temperature	Topr	–40 to +85	°C
		–30 to +85 (designed for lower voltage operation)	
Storage temperature	Tstg	–65 to +150	˚C
Soldering temperature and time	Tsol	260 · 10 (at leads)	˚C · s

ELECTRIC CHARACTERISTICS

S1F77210Y1C0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	2.10	2.15	2.20	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.05	0.10	0.15	V
Operating current	I_{DD}	V_{DD} = 3.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 3.0V OUT = 2.7V	—	–1.00	–0.25	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 3V→2V Ta = 25°C	—	8	40	µs
		V_{DD} = 3V→2V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1P0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	2.20	2.25	2.30	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.05	0.10	0.15	V
Operating current	I_{DD}	V_{DD} = 3.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 3.0V OUT = 2.7V	—	–1.00	–0.25	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 3V→2V Ta = 25°C	—	8	40	µs
		V_{DD} = 3V→2V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1S0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	2.30	2.35	2.40	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.05	0.10	0.15	V
Operating current	I_{DD}	V_{DD} = 3.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 3.0V OUT = 2.7V	—	–1.00	–0.25	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 3V→2V Ta = 25°C	—	8	40	µs
		V_{DD} = 3V→2V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1E0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	2.50	2.55	2.60	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.05	0.10	0.15	V
Operating current	I_{DD}	V_{DD} = 3.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 3.0V OUT = 2.7V	—	–1.00	–0.25	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 3V→2V Ta = 25°C	—	8	40	µs
		V_{DD} = 3V→2V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1F0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	2.60	2.65	2.70	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.05	0.10	0.15	V
Operating current	I_{DD}	V_{DD} = 3.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 3.0V OUT = 2.7V	—	–1.00	–0.25	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 3V→2V Ta = 25°C	—	8	40	µs
		V_{DD} = 3V→2V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1R0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	2.73	2.80	2.87	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.05	0.10	0.15	V
Operating current	I_{DD}	V_{DD} = 3.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 3.0V OUT = 2.7V	—	–1.00	–0.25	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 3V→2V Ta = 25°C	—	8	40	µs
		V_{DD} = 3V→2V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1G0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	2.93	3.00	3.07	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.09	0.15	0.21	V
Operating current	I_{DD}	V_{DD} = 4.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 4.0V OUT = 3.6V	—	–1.60	–0.40	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 4V→3V Ta = 25°C	—	8	40	µs
		V_{DD} = 4V→3V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1H0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	3.13	3.20	3.27	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.09	0.15	0.21	V
Operating current	I_{DD}	V_{DD} = 4.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 4.0V OUT = 3.6V	—	–1.60	–0.40	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 4V→3V Ta = 25°C	—	8	40	µs
		V_{DD} = 4V→3V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y130

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	3.43	3.50	3.57	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.09	0.15	0.21	V
Operating current	I_{DD}	V_{DD} = 4.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 4.0V OUT = 3.6V	—	–1.60	–0.40	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 4V→3V Ta = 25°C	—	8	40	µs
		V_{DD} = 4V→3V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1T0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	3.90	4.00	4.10	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.13	0.20	0.27	V
Operating current	I_{DD}	V_{DD} = 5.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 5.0V OUT = 4.5V	—	–2.00	–0.50	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 5V→4V Ta = 25°C	—	8	40	µs
		V_{DD} = 5V→4V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1M0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	4.10	4.20	4.30	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} – V_{DET}$	0.13	0.20	0.27	V
Operating current	I_{DD}	V_{DD} = 5.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 5.0V OUT = 4.5V	—	–2.00	–0.50	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 5V→4V Ta = 25°C	—	8	40	µs
		V_{DD} = 5V→4V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1J0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	4.30	4.40	4.50	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} – V_{DET}$	0.13	0.20	0.27	V
Operating current	I_{DD}	V_{DD} = 5.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 5.0V OUT = 4.5V	—	–2.00	–0.50	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 5V→4V Ta = 25°C	—	8	40	µs
		V_{DD} = 5V→4V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y120

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	4.50	4.60	4.70	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.08	0.15	0.22	V
Operating current	I_{DD}	V_{DD} = 5.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 5.0V OUT = 4.5V	—	–2.00	–0.50	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 5V→4V Ta = 25°C	—	8	40	µs
		V_{DD} = 5V→4V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1K0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	4.70	4.80	4.90	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.13	0.20	0.27	V
Operating current	I_{DD}	V_{DD} = 5.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 5.0V OUT = 4.5V	—	–2.00	–0.50	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 5V→4V Ta = 25°C	—	8	40	µs
		V_{DD} = 5V→4V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1L0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	4.90	5.00	5.10	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.13	0.20	0.27	V
Operating current	I_{DD}	V_{DD} = 6.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 6.0V OUT = 5.4V	—	–2.40	–0.60	mA
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 6V→4V Ta = 25°C	—	8	40	µs
		V_{DD} = 6V→4V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1C0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	2.10	2.15	2.20	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.05	0.10	0.15	V
Operating current	I_{DD}	V_{DD} = 3.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 2.0V OUT = 1.8V	—	–0.40	–0.10	mA
Low level output current	I_{OL}	V_{DD} = 3.0V OUT = 0.3V	0.50	2.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 3V→2V Ta = 25°C	—	8	40	µs
		V_{DD} = 3V→2V Ta = –30°C to +85°C	—	—	200	µs

S1F77210Y1F0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	2.60	2.65	2.70	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} – V_{DET}$	0.05	0.10	0.15	V
Operating current	I_{DD}	V_{DD} = 3.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
High level output current	I_{OH}	V_{DD} = 2.0V OUT = 1.8V	—	–0.40	–0.10	mA
Low level output current	I_{OL}	V_{DD} = 3.0V OUT = 0.3V	0.50	2.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 3V→2V Ta = 25°C	—	8	40	µs
		V_{DD} = 3V→2V Ta = –30°C to +85°C	—	—	200	µs

S1F77200Y1T0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	3.90	4.00	4.10	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} – V_{DET}$	0.13	0.20	0.27	V
Operating current	I_{DD}	V_{DD} = 5.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 5V→4V Ta = 25°C	—	8	40	µs
		V_{DD} = 5V→4V Ta = –30°C to +85°C	—	—	200	µs

S1F77200Y1F0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.50	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	2.60	2.65	2.70	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} – V_{DET}$	0.05	0.10	0.15	V
Operating current	I_{DD}	V_{DD} = 3.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
Low level output current	I_{OL}	V_{DD} = 2.0V OUT = 0.2V	0.20	1.00	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 3V→2V Ta = 25°C	—	8	40	µs
		V_{DD} = 3V→2V Ta = –30°C to +85°C	—	—	200	µs

S1F77200Y1C0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	0.80	—	10.0	V
Detection voltage	V_{DET}	Ta = 25°C	2.10	2.15	2.20	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} – V_{DET}$	0.05	0.10	0.15	V
Operating current	I_{DD}	V_{DD} = 3.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
Low level output current	I_{OL}	V_{DD} = 1.5V OUT = 0.15V	0.15	0.75	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 3V→2V Ta = 25°C	—	8	40	µs
		V_{DD} = 3V→2V Ta = –30°C to +85°C	—	—	200	µs

S1F77200Y1N0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	0.80	—	10.0	V
Detection voltage	V_{DET}	Ta = 25°C	1.85	1.90	1.95	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.03	0.05	0.08	V
Operating current	I_{DD}	V_{DD} = 3.0V	—	2.00	5.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
Low level output current	I_{OL}	V_{DD} = 1.5V OUT = 0.15V	0.15	0.75	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 2V→1V Ta = 25°C	—	8	40	µs
		V_{DD} = 2V→1V Ta = –30°C to +85°C	—	—	200	µs

S1F77200Y1B0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	0.80	—	10.0	V
Detection voltage	V_{DET}	Ta = 25°C	1.10	1.15	1.20	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.03	0.05	0.08	V
Operating current	I_{DD}	V_{DD} = 1.5V	—	1.50	4.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
Low level output current	I_{OL}	V_{DD} = 0.8V OUT = 0.16V	0.05	0.40	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 1.5V→0.8V Ta = 25°C	—	8	40	µs
		V_{DD} = 1.5V→0.8V Ta = –30°C to +85°C	—	—	200	µs

S1F77200Y1Y0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	0.80	—	10.0	V
Detection voltage	V_{DET}	Ta = 25°C	1.05	1.10	1.15	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.03	0.05	0.08	V
Operating current	I_{DD}	V_{DD} = 1.5V	—	1.50	4.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
Low level output current	I_{OL}	V_{DD} = 0.8V OUT = 0.16V	0.05	0.40	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 1.5V→0.8V Ta = 25°C	—	8	40	µs
		V_{DD} = 1.5V→0.8V Ta = –30°C to +85°C	—	—	200	µs

S1F77200Y1A0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	0.80	—	10.0	V
Detection voltage	V_{DET}	Ta = 25°C	1.00	1.05	1.10	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.03	0.05	0.08	V
Operating current	I_{DD}	V_{DD} = 1.5V	—	1.50	4.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
Low level output current	I_{OL}	V_{DD} = 0.8V OUT = 0.16V	0.05	0.40	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 1.5V→0.8V Ta = 25°C	—	8	40	µs
		V_{DD} = 1.5V→0.8V Ta = –30°C to +85°C	—	—	200	µs

S1F77200Y1V0

(Ta = –30°C to +85°C is assumed except where otherwise specified.)

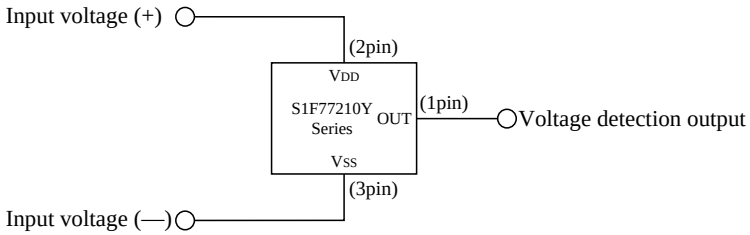
Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	0.80	—	10.0	V
Detection voltage	V_{DET}	Ta = 25°C	0.90	0.95	1.00	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.03	0.05	0.08	V
Operating current	I_{DD}	V_{DD} = 1.5V	—	1.50	4.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
Low level output current	I_{OL}	V_{DD} = 0.8V OUT = 0.16V	0.05	0.40	—	mA
Detection voltage response time	T_{PHL}	V_{DD} = 1.5V→0.8V Ta = 25°C	—	8	40	µs
		V_{DD} = 1.5V→0.8V Ta = –30°C to +85°C	—	—	200	µs

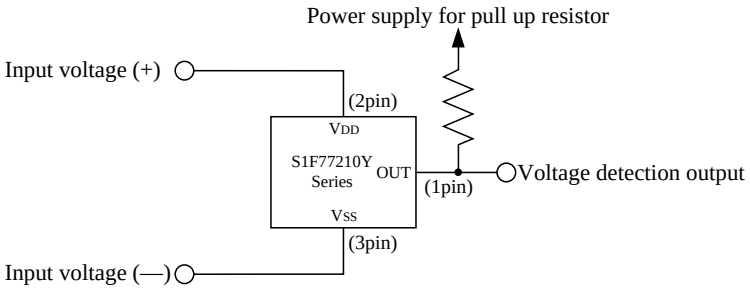
S1F77220Y2D0

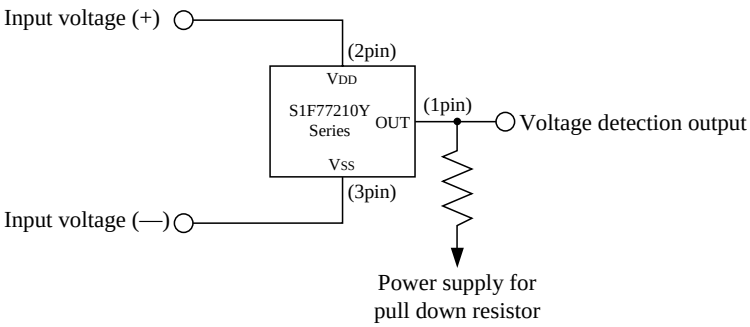
(Ta = –30°C to +85°C is assumed except where otherwise specified.)

Parameter	Symbol	Conditions (Vss = 0.0V)	Min.	Typ.	Max.	Unit
Operating voltage	V_{DD}	—	1.5	—	12.0	V
Detection voltage	V_{DET}	Ta = 25°C	1.20	1.25	1.30	V
Hysteresis width	V_{HYS}	$V_{HYS} = V_{REL} - V_{DET}$	0.03	0.05	0.08	V
Operating current	I_{DD}	V_{DD} = 3.0V	—	1.50	4.00	µA
Detection voltage temperature characteristics	$\frac{\Delta V_{DET}}{V_{DET}}$	—	–300	–100	+100	ppm/°C
Low level output current	I_{OL}	V_{DD} = 1.5V OUT = 0.64V	—	–0.03	–0.06	mA
Detection voltage response time	T_{PHL}	V_{DD} = 1.5V→0.8V Ta = 25°C	—	8	40	µs
		V_{DD} = 1.5V→0.8V Ta = –30°C to +85°C	—	—	200	µs

EXAMPLES OF EXTERNAL CONNECTION







SAMPLE CIRCUITS (S1F77210Y Series)

CR timer circuit

When the S1F77210Y circuit configured as shown in Figure 5-14, it can be used as a CR timer circuit.

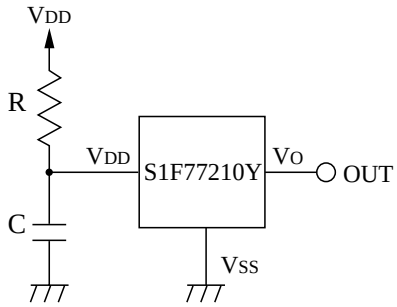


Figure 5-14 CR timer circuit

Battery backup circuit

The following is an example of the supply voltage switching circuit for the battery backup supply configured featuring the S1F77210Y series.

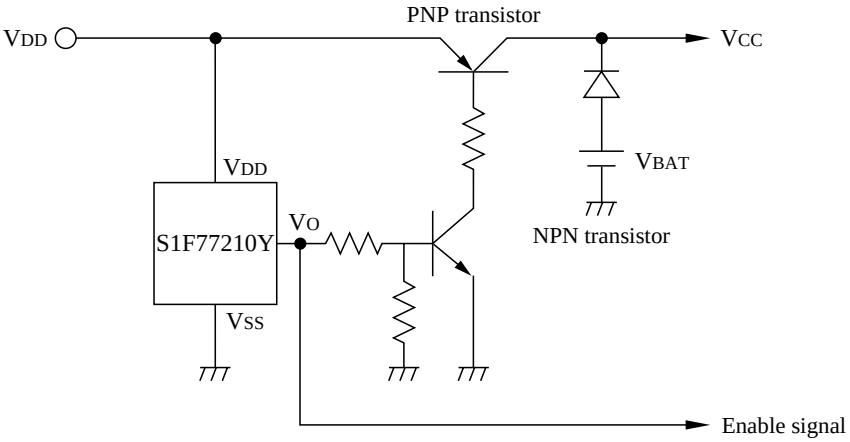


Figure 5-15 Battery backup circuit

SAMPLE CIRCUITS (S1F77200Y Series)

CR timer circuit

When the S1F77200Y circuit is configured as shown in Figure 5-16, it can be used as a CR timer circuit.

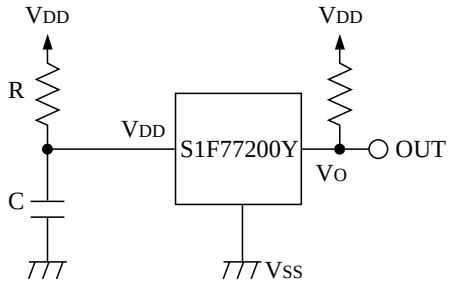


Figure 5-16 CR timer circuit

Battery backup circuit

The following is an example of the supply voltage switching circuit for the battery backup configured featuring the S1F77200Y series.

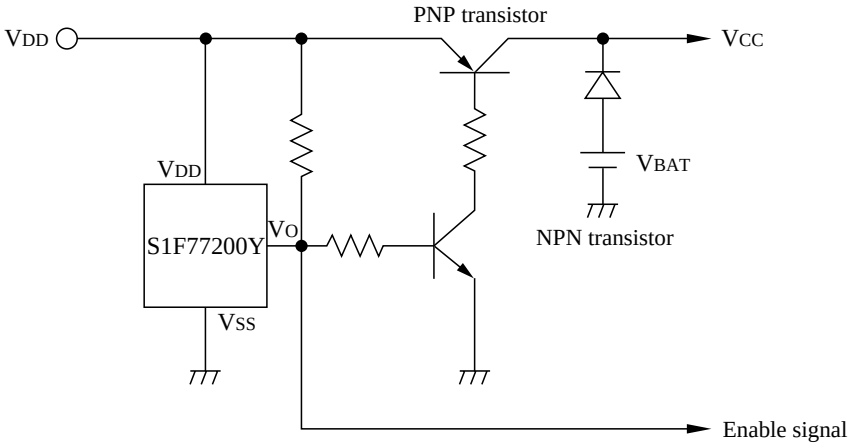
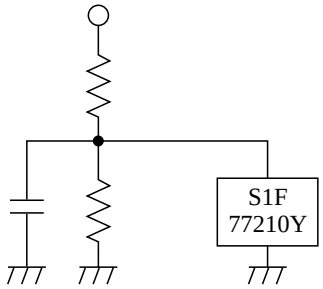


Figure 5-17 Battery backup circuit

PRECAUTIONS

Short cut current on the S1F77210 (CMOS output voltage detector)

Since the S1F77200Y series employs CMOS output, as an input voltage nears the detection voltage range, short cut current is flown between V_{DD} and V_{SS}. The short cut current is voltage sensitive, and approximately 2 mA flows at 5V level or so (our products are not check for short cut current after volume production has been started).
Although duration of the short cut current depends on operating conditions (such as type the circuit used and supply impedance), normally it is assumed to continue several usec to several dozens of usec.
If a load with high impedance is inserted across the power supply, oscillation can be introduced by the short cut current. In order to reject this trouble, the following measures should be considered:
(1) Reduce the resistance value.
(2) Insert a capacitor.
(3) Replace with the S1F77200Y series (it employs N-channel open drain approach).



7. Appendix

ABSOLUTE MAXIMUM RATINGS

Absolute maximum ratings are the maximum physical and electrical ratings of a device beyond which performance degradation or damage will occur. Always check circuit conditions before using a device to avoid exceeding these ratings. Typically, absolute maximum ratings include the following parameters.

1. Power supply voltage
   Steady state applied voltages, noise, reverse voltage transients and power-on-transients can degrade or damage the integrated circuit if they exceed the maximum power supply voltage rating.
2. Input signal voltage
   Input signals exceeding this rate can damage input protection circuits
3. Output current
   Generally, specifications are not set for CMOS devices with small output currents. Devices that provide large drive currents will have output current specifications.
4. Power dissipation
   The maximum power dissipation of a device is limited by its construction and package type. Maximum output current limits are set to prevent thermal damage.
5. Operating temperature range
   The temperature range for normal device operation with no change in performance characteristics.
6. Storage temperature range
   The temperature range for device storage with no degradation or damage. This specification is particularly important when ICs are being transported by air.
7. Soldering temperature and the duration
   The maximum soldering temperature and the time for which the leads can be at this temperature.

RECOMMENDED OPERATING CONDITIONS

Recommended operating conditions are the conditions under which a device functions correctly. These include power supply voltage, input conditions and output current. These conditions are sometimes listed as part of the electrical characteristics.

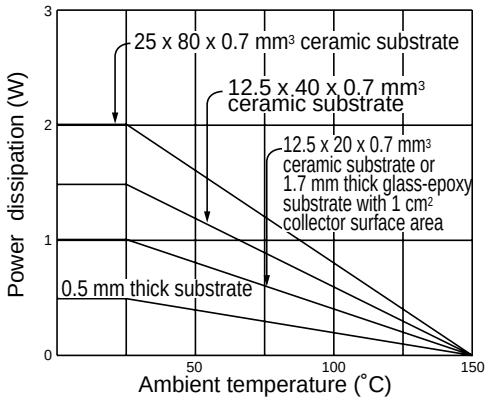
ELECTRICAL CHARACTERISTICS

Electrical characteristics specify the DC and AC characteristics of a device under the worst measurement conditions.

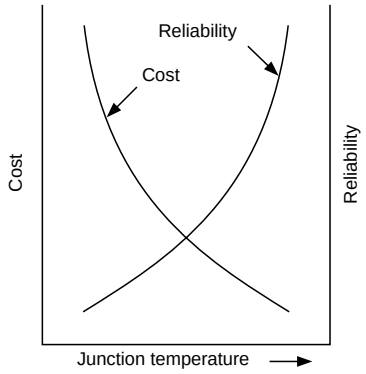
POWER DISSIPATION CONDITIONS

To prevent damage always consider the following points when designing with power regulation ICs.

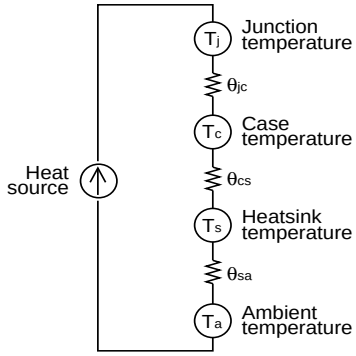
1. A precise thermal design is necessary to ensure adequate heat dissipation.
   The following figure shows the power dissipation capacity in relation to ambient temperature.



   The following figure shows the cost and reliability of a product and is significant when designing a system.



The following figure shows a thermal design model which can be used to determine heatsink capacity.



2. Ensure that the regulator common pin is a single-point ground to prevent earth loops. Make ground lines as thick and short as possible. Use the specified bypass capacitors for inputs and outputs. If there is a switching load, use a tantalum or ceramic capacitor, as these devices have a high frequency response between the power supply and ground.

PARAMETER SUMMARY

Symbol	Parameter
C_D	Drain capacitance
C_{F8}	Field slew capacitance
C_G	Gate capacitance
C_I	Input capacitance
C_n	Capacitance
CT	Crosstalk
C_{Tn}	Temperature gradient
f_{CLK}	Clock frequency
f_{max}	Maximum clock frequency
f_{OSC}	Oscillator frequency
FT	Field through (channel OFF)
I_{BSQ}	Backup switching leakage current
I_{DDO}	Operating current
I_{DDS}	Standby current
I_{DD}	Power supply current
I_{IH}	High-level input current
I_{IL}	Low-level input current
I_{LKI}	input leakage current
I_{MAX}	Maximum current
I_O	Output current
I_{OH}	High-level output current
I_{OL}	Low-level output current
I_{OPR1}	Multiplier circuit power dissipation

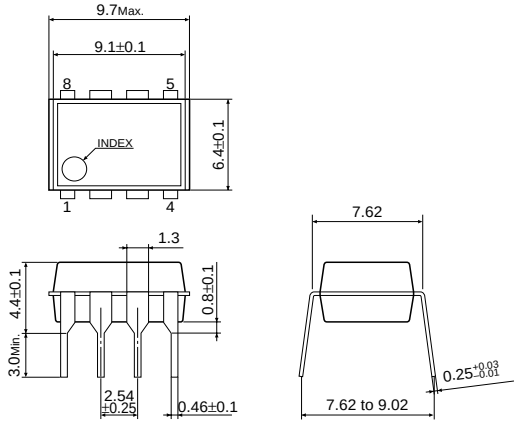
Symbol	Parameter
I_{OPR2}	Stabilization circuit power dissipation
I_Q	Quiescent current
I_R	Reverse current
I_{SWQ}	Switching transistor leakage current
K_I	Output voltage temperature gradient
P_D	Power dissipation
P_{eff}	Voltage multiplication efficiency
R_{BSON}	Backup switch ON resistance
R_L	Load resistance
R_O	Output impedance
R_{ON}	ON resistance
R_{OSC}	Oscillator network resistor
R_{RV}	Stabilization voltage sensing resistor
R_{RVn}	Reference voltage
R_{SAT}	Stabilization output saturation resistance
R_{SWON}	Switching transistor ON resistance
T_a	Ambient temperature
t_{AE}	Minimum pulsewidth
t_{HA}	Address hold time
t_{HD}	Data hold time
THD	Total harmonic distortion
θ_{jn}	Thermal resistance
t_{MRR}	Memory reset recovery time

Symbol	Parameter
t_{MR}	Memory reset
T_{opr}	Operating temperature
t_{PAE}	Propagation delay
t_{PHL}	Low-level transition time
t_{PLH}	High-level transition time
t_{PLS}	Propagation delay
t_{POP}	Propagation delay
t_{PS}	Propagation delay
t_{SA}	Address setup time
t_{SD}	Data setup time
T_{sol}	Soldering temperature and time
T_{stg}	Storage temperature
V_{DD}	Power supply voltage
V_{DET}	Detection voltage
V_F	Forward voltage

Symbol	Parameter
V_I	Input voltage
V_{IH}	High-level input voltage
V_{IL}	Low-level input voltage
V_I	Input voltage
V_O	Output voltage
V_{off}	Input offset voltage
V_{op+}	Input voltage range
V_{OPMAX}	Maximum output voltage
V_{OPMIN}	Minimum output voltage
V_{REF}	Reference voltage
V_{REG}	Output voltage (regulated)
V_{SS}	Power supply voltage
V_{SSn}	Power supply voltage
V_{STA}	Oscillator start-up voltage
V_{STP}	Oscillator shut-down voltage

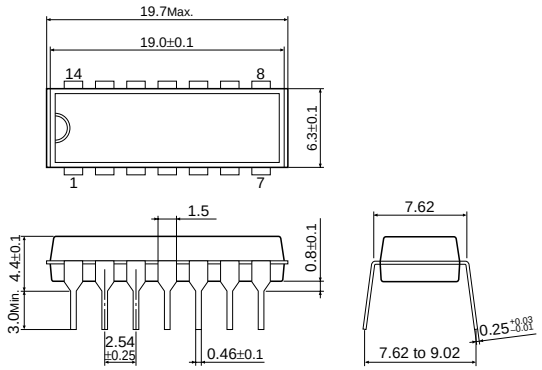
MECHANICAL DATA

Plastic DIP–8pin



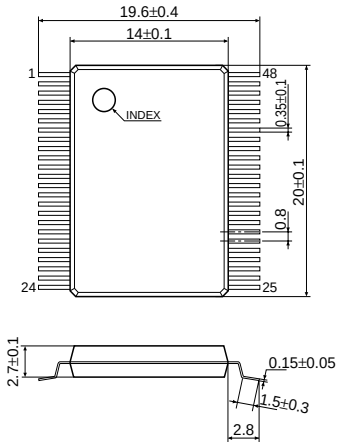
Unit: mm

Plastic DIP–14pin



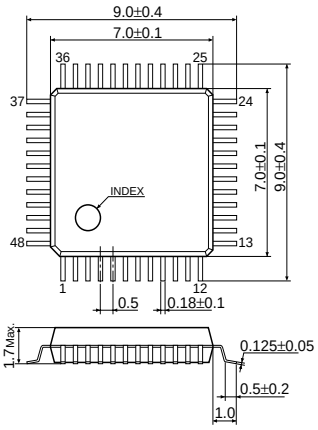
Unit: mm

Plastic QFP5–48pin



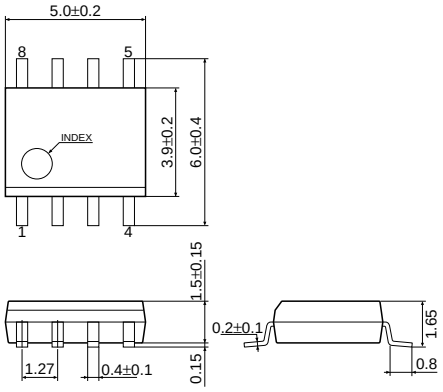
Unit: mm

Plastic QFP12-48pin



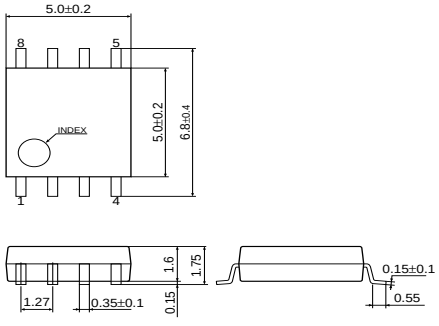
Unit: mm

Plastic SOP3–8pin



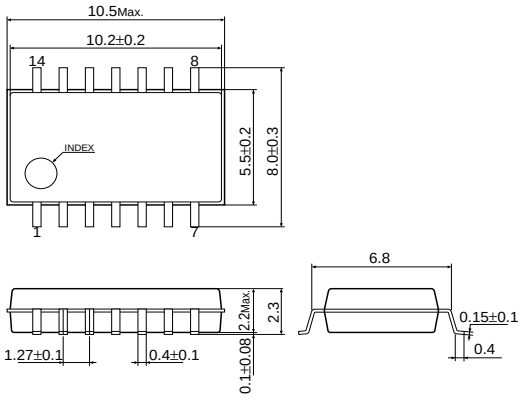
Unit: mm

Plastic SOP4–8pin



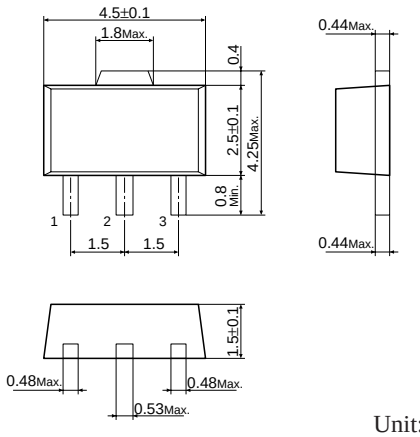
Unit: mm

Plastic SOP5–14pin



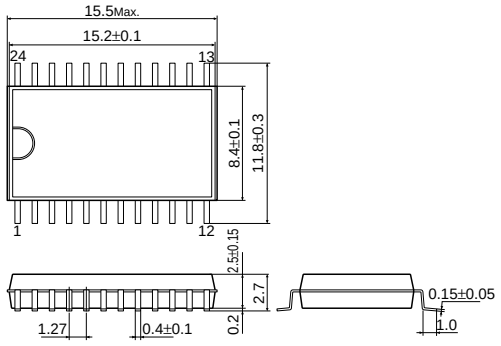
Unit: mm

SOT 89–3pin



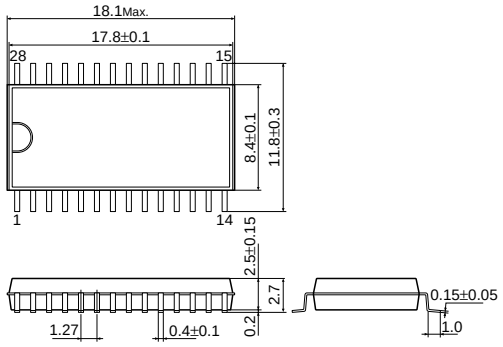
Unit: mm

Plastic SOP2-24pin



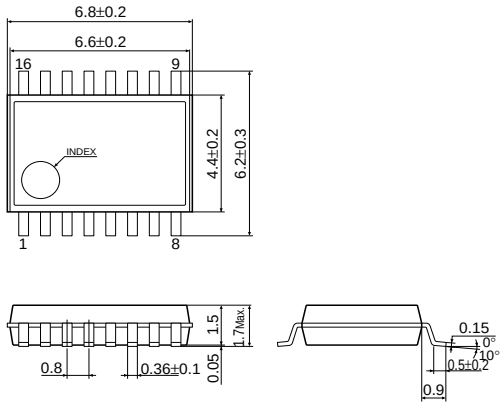
Unit: mm

Plastic SOP2–28pin



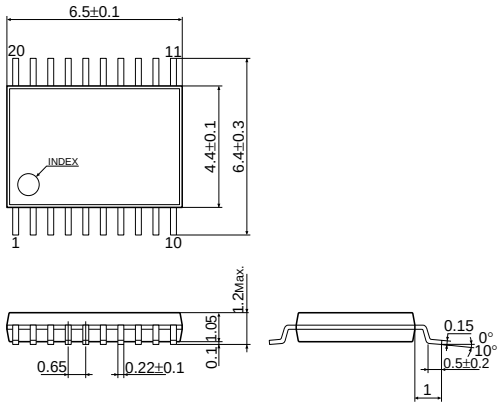
Unit: mm

Plastic SSOP2–16pin



Unit: mm

Plastic SSOP1–20pin



Unit: mm

EMBOSS CARRIER TAPING STANDARD (SOT89-3pin)

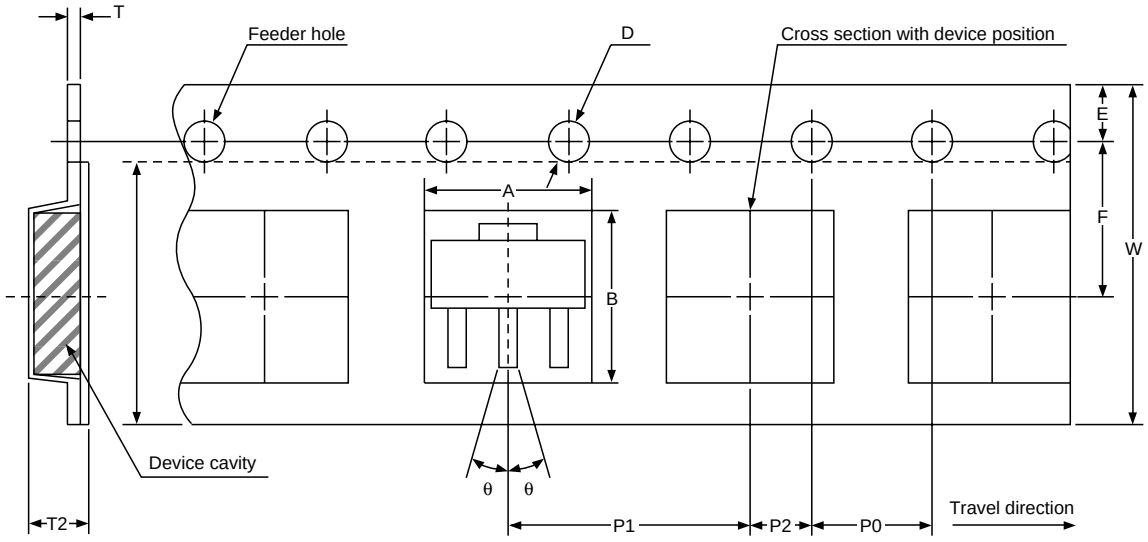
TAPING INFORMATION

The emboss carrier taping standard is shown in the following table and figure. This standard conforms to the EIAJ RCI00B electronic parts taping specification. Each tape holds 1,000 devices.

Dimension code	Dimensions/angles (mm/°)
A	5.0
B	4.6
D	1.5 +0.1, –0.05
E	1.50 ±0.1
F	5.65 ±0.05
P1	8.0 ±0.1
P0	4.0 ±0.1

Dimension code	Dimensions/angles (mm/°)
P2	2.0 ±0.05
T	0.3
T2	2.3
W	12.0 ±0.2
W1	9.5
θ	30°Max.

Note
The tape thickness is 0.1 mm Max.

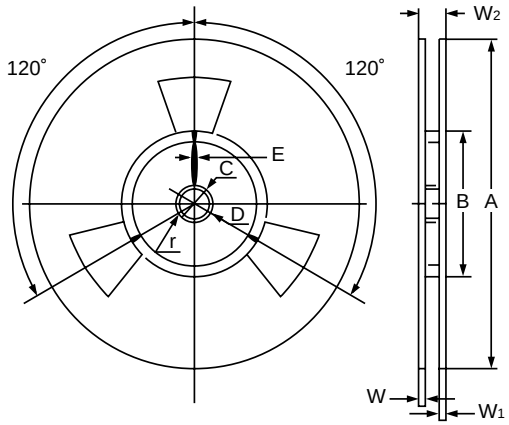


There are no joints in either the cover or carrier tapes. Less than 0.2% of the total device count is comprised of non-sequential blanks. There are no sequential blanks. This does not apply to the tape leader and trailer.

REEL SPECIFICATIONS

The reel specifications are shown in the following table and figure. The reel is made of paperboard.

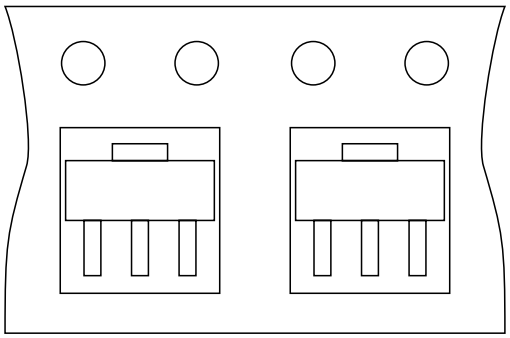
Dimension code	Dimensions (mm)
A	178 ±2.0
B	80 ±1.0
C	13.0 ±0.5
D	21.0 ±1.0
E	2.0 ±0.5
W	14.0 (See note.)
W1	1.5 ±0.1
W2	17 (See note.)
r	1.0



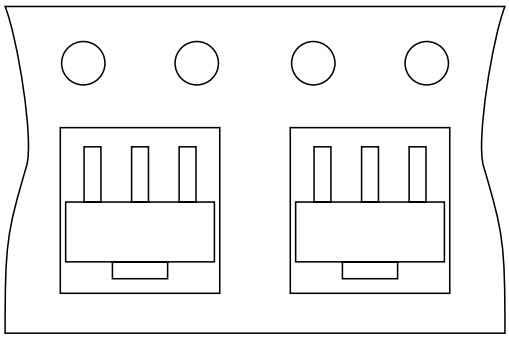
Note
W and W2 are measured at the reel core.

DEVICE POSITIONING

Small molded power IC devices are positioned as shown in the following figure.



T1



T2

EMBOSS CARRIER TAPING STANDARD (SOP3-8pin)

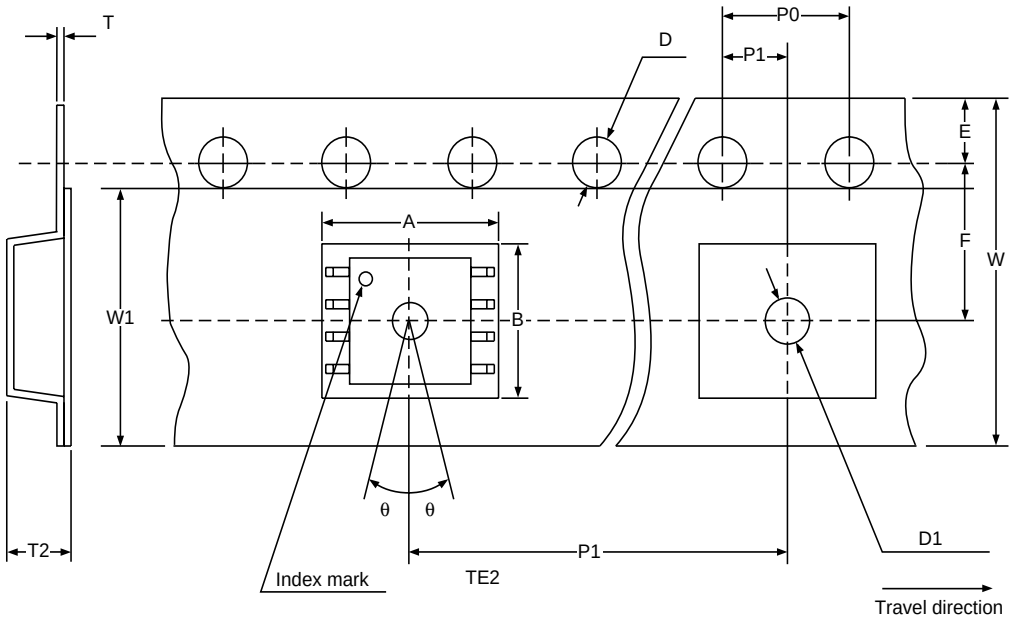
TAPING INFORMATION

The emboss carrier taping standard is shown in the following table and figure. This standard conforms to the EIAJ RCI009B electronic parts taping specification. Each tape holds 2,000 devices.

Dimension code	Dimensions/angles (mm/°)
A	6.7
B	5.4
D	1.55 +0.05, –0
D1	1.55 ±0.05
E	1.75 ±0.1
F	5.5 ±0.1
P1	8.0 ±0.1
P0	4.0 ±0.1

Dimension code	Dimensions/angles (mm/°)
P2	2.0 ±0.05
T	0.3 ±0.05
T2	2.5
W	12.0 ±0.3
W1	9.5
θ	15°Max.

Note
The tape thickness is 0.1 mm Max.

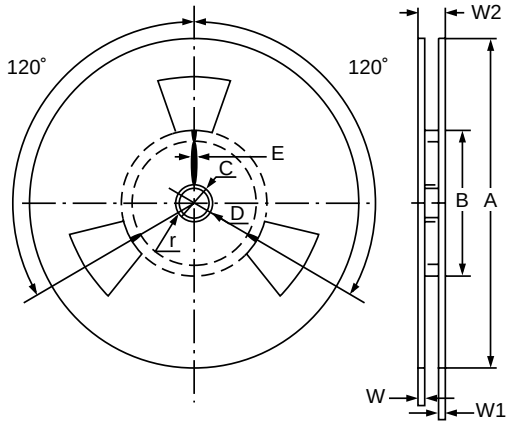


There are no joints in either the cover or carrier tapes. Less than 0.2% of the total device count is comprised of non-sequential blanks. There are no sequential blanks. This does not apply to the tape leader and trailer.

REEL SPECIFICATIONS

The reel specifications are shown in the following table and figure. The reel is made of paperboard.

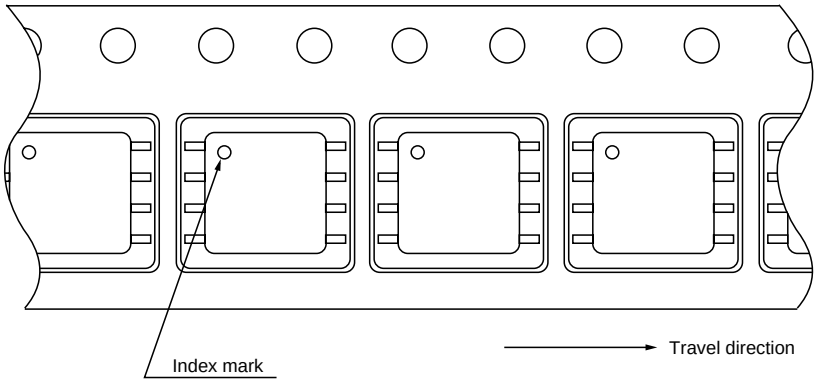
Dimension code	Dimensions (mm)
A	330 ±2.0
B	80 ±1.0
C	13.0 ±0.5
D	21.0 ±0.5
E	2.0 ±0.5
W	15.4 ±1.0 (See note.)
W1	2.0 ±0.5
W2	23.4 (See note.)
r	1.0



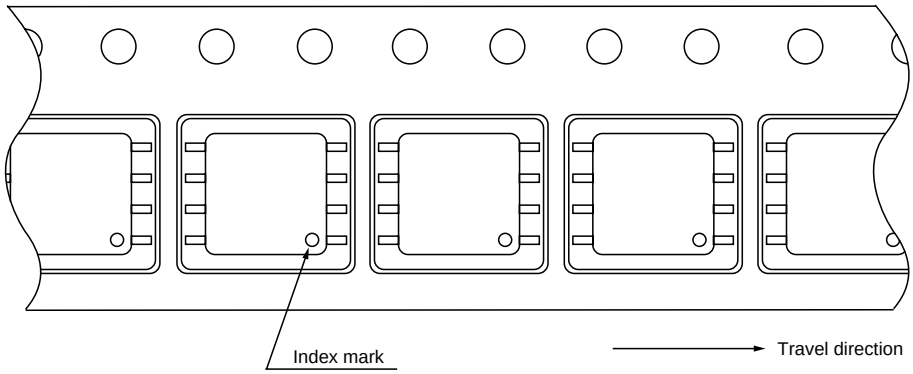
Note
W and W2 are measured at the reel core.

DEVICE POSITIONING

Type B products are positioned so that the index mark is on the sprocket hole side of the tape, as shown in the following figure.



Type F product are positioned so that the index mark is on the opposite side to the sprocket holes, as shown in the following figure.



EMBOSS CARRIER TAPING STANDARD (SOP5-14pin)

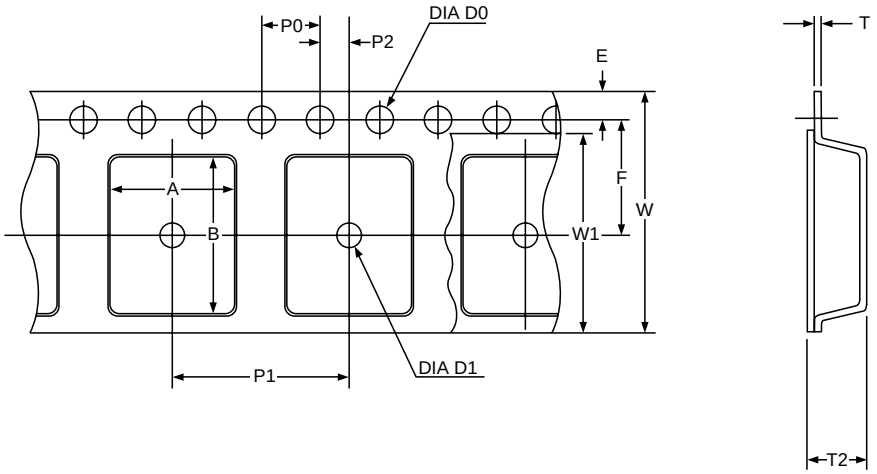
TAPING INFORMATION

The emboss carrier taping standard is shown in the following table and figure. This standard conforms to the EIAJ RCI009B electronic parts taping specification. Each tape holds 2,000 devices.

Dimension code	Dimensions (mm/°)
A	8.4
B	10.6
D0	1.55 ±0.05
D1	1.55 ±0.05
E	1.75 ±0.1
F	7.5 ±0.1
P1	12 ±0.1
P0	4.0 ±0.1

Dimension code	Dimensions (mm/°)
P2	2.0 ±0.1
T	0.3 ±0.05
T2	3.0
W	16.0 ±0.3
W1	13.5

Note
The tape thickness is 0.1 mm Max.

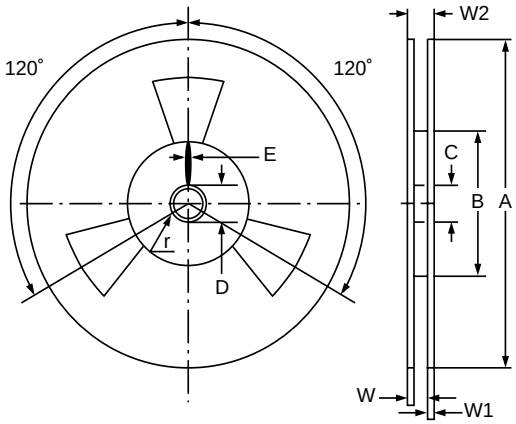


There are no joints in either the cover or carrier tapes. Less than 0.1% of the total device count is comprised of non-sequential blanks. There are no sequential blanks. This does not apply to the tape leader and trailer.

REEL SPECIFICATIONS

The reel specifications are shown in the following table and figure. The reel is made of paperboard.

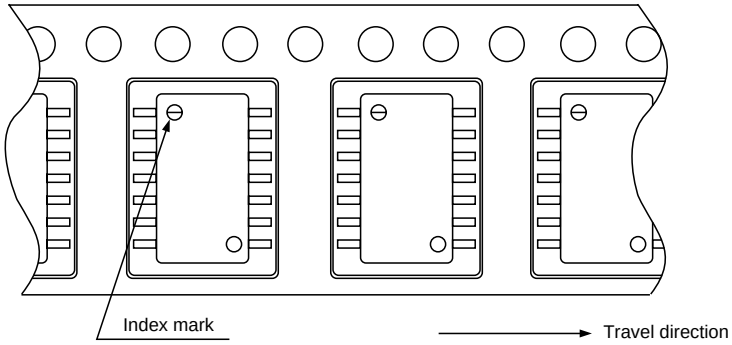
Dimension code	Dimensions (mm)
A	330 ±2.0
B	80 ±1.0
C	13.0 ±0.5
D	21.0 ±1.0
E	2.0 ±0.5
W	14.0 ±1.5 (See note.)
W1	2.0 ±0.5
W2	20.5 max (See note.)
r	1.0



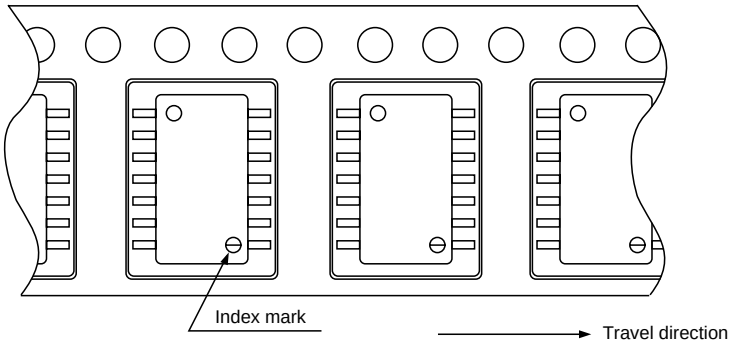
Note
W and W2 are measured at the reel core.

DEVICE POSITIONING

Type B products are positioned so that the index mark is on the sprocket hole side of the tape, as shown in the following figure.



Type F products are positioned so that the index mark is on the opposite side to the sprocket holes, as shown in the following figure.



EMBOSS CARRIER TAPING STANDARD (SOP2-24pin)

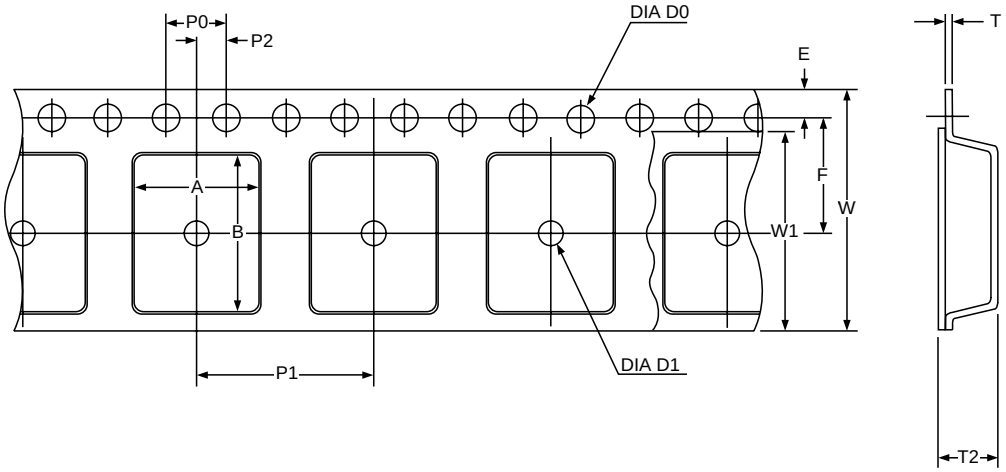
TAPING INFORMATION

The emboss carrier taping standard is shown in the following table and figure. This standard conforms to the EIAJ RCI009B electronic parts taping specification. Each tape holds 1,000 devices.

Dimension code	Dimensions (mm)
A	12.4
B	15.6
D0	1.55 +0.1, –0
D1	2.0 +0.1, –0
E	1.75 ±0.1
F	11.5 ±0.1
P1	16 ±0.1

Dimension code	Dimensions (mm)
P0	4.0 ±0.1
P2	2.0 ±0.1
T	0.3 ±0.05
T2	3.0 ±0.1
W	24 ±0.2
W1	21.5 Typ.

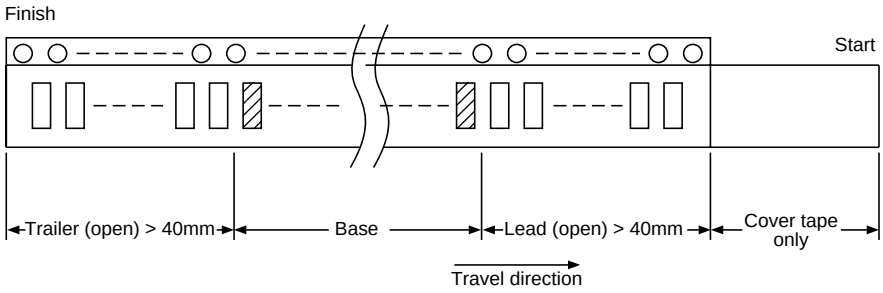
Note
The tape thickness is 0.1 mm Max.

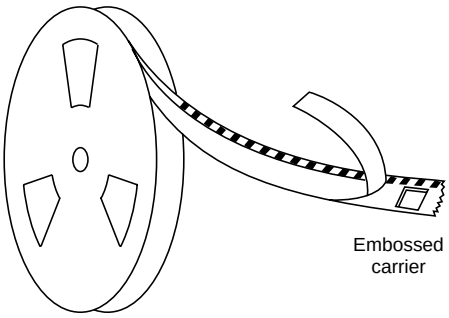


There are no joints in either the cover or carrier tapes. Less than 0.2% of the total device count is comprised of non-sequential blanks. There are no sequential blanks. This does not apply to the tape leader and trailer. The tape tension should be approximately 10 N (1 kgf). A label indicates the part name, quantity and lot number.

Tape configuration

The tape configuration is shown in the following figure. Blank sections are provided as a leader and trailer, with 1,000 SOP2 packages fitted into the component mounting section between them. At the beginning of the leader section there is an extra section of tape which contains the cover tape only.

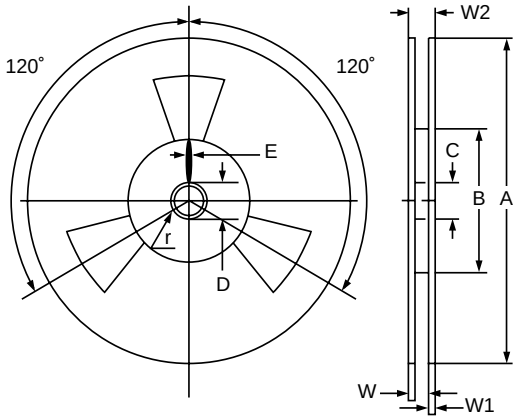




REEL SPECIFICATIONS

The reel specifications are shown in the following table and figure. The reel is made of conductive PVC.

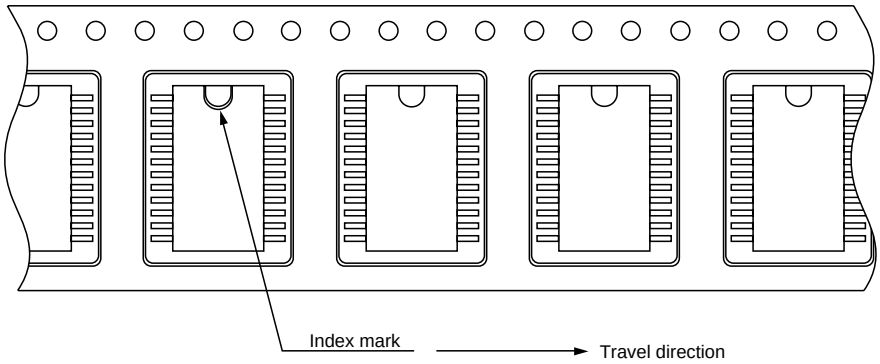
Dimension code	Dimensions (mm)
A	330 ±2.0
B	80 ±1.0
C	13.0 ±0.5
D	21.0 ±1.0
E	2.0 ±0.5
W	24.4 +2, –0 (See note.)
W1	2.0 ±0.5
W2	31.4 Max. (See note.)
r	1.0



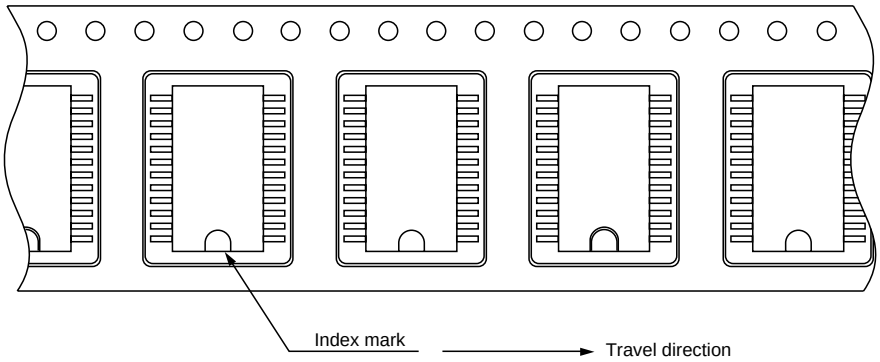
Note
W and W2 are measured at the reel core.

DEVICE POSITIONING

Type B products are positioned so that the index mark is on the sprocket hole side of the tape, as shown in the following figure.



Type F products are positioned so that the index mark is on the opposite side to the sprocket holes, as shown in the following figure.



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