Switching Regulator IC for Boost Converter

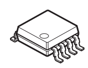
with 40V MOSFET

■ GENERAL DESCRIPTION

The NJW4130 is a switching regulator for boost converter with 40V MOSFET. It provides low voltage operation (logic voltage), high frequency oscillation and incorporates a phase compensation circuit allowing Low ESR Output Capacitor (MLCC), which can achieve a downsizing in application with fewer external parts. The NJW4130 also has a soft-start function which provides a stable start-up and over-current protection, thermal shutdown circuits which protects the circuit at abnormal condition.

It is available in a small and thin 8-lead MSOP (TVSP) package and suitable for a LED driving and portable application.

■ PACKAGE OUTLINE



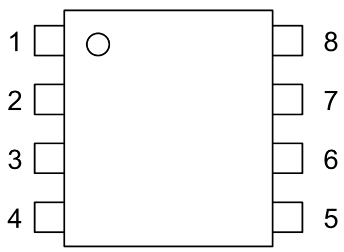
NJW4130RB1
(MSOP8 (TVSP8))

■ FEATURES

- Output Switch Voltage 40V max.
- Switching Current 450mA min.
- PWM Control
- Correspond to Ceramic Condenser (MLCC)
- Operating Voltage Range 2.3V to 5.5V
- Oscillation Frequency 700kHz typ.
- Soft-Start Function 4ms typ.
- Internal Compensation Circuit
- UVLO (Under Voltage Lockout)
- Over Current Protection / Thermal Shutdown Function
- Standby Function
- Package Outline MSOP8 (TVSP8)*

*MEET JEDEC MO-187-DA / THIN TYPE

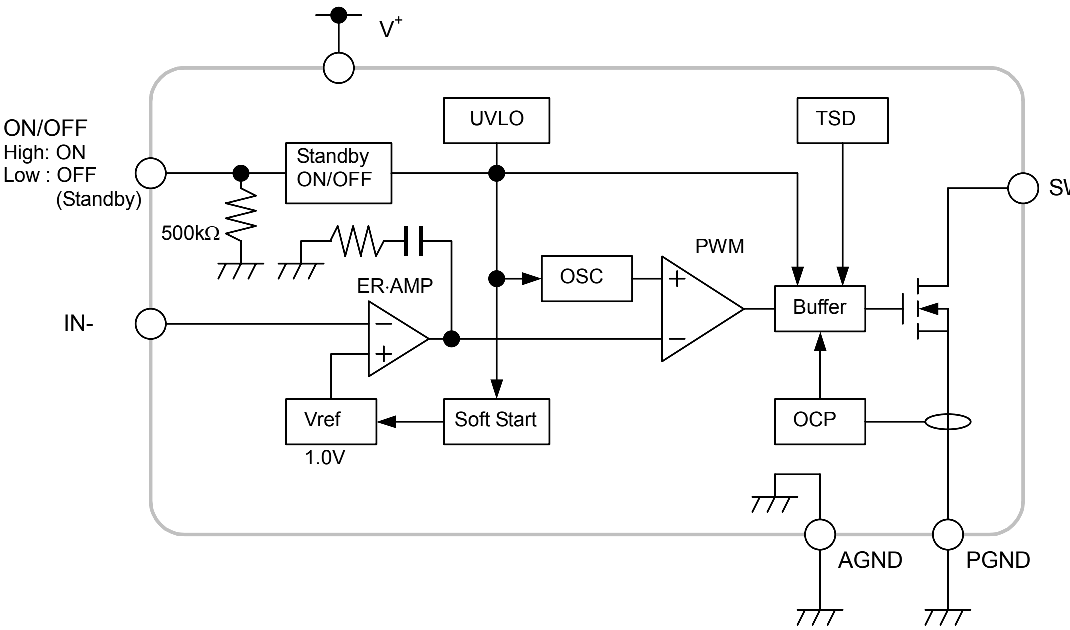
■ PIN CONFIGURATION



NJW4130RB1

PIN FUNCTION
1. SW
2. N.C.
3. ON/OFF
4. V^+
5. IN-
6. N.C.
7. AGND
8. PGND

■ BLOCK DIAGRAM



■ PRODUCT VERSION

PART NUMBER	Oscillation Frequency
NJW4130RB1-A	700kHz

■ ABSOLUTE MAXIMUM RATINGS

(Ta=25°C)

PARAMETER	SYMBOL	MAXIMUM RATINGS	UNIT
Supply Voltage	V^+	+6	V
SW pin Voltage	V_{SW}	40	V
ON/OFF pin Voltage	$V_{ON/OFF}$	+6(*1)	V
Power Dissipation	P_D	580 (*2) 780 (*3)	mW
Junction Temperature Range	T_j	-40 to +150	°C
Operating Temperature Range	T_{opr}	-40 to +85	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

(*1): When Supply voltage is less than +6V, the absolute maximum ON/OFF pin voltage is equal to the Supply voltage.
(*2): Mounted on glass epoxy board. (76.2×114.3×1.6mm:EIA/JDEC standard size, 2Layers)
(*3): Mounted on glass epoxy board. (76.2×114.3×1.6mm:EIA/JDEC standard size, 4Layers),
internal Cu area: 74.2×74.2mm

■ RECOMMENDED OPERATING CONDITIONS

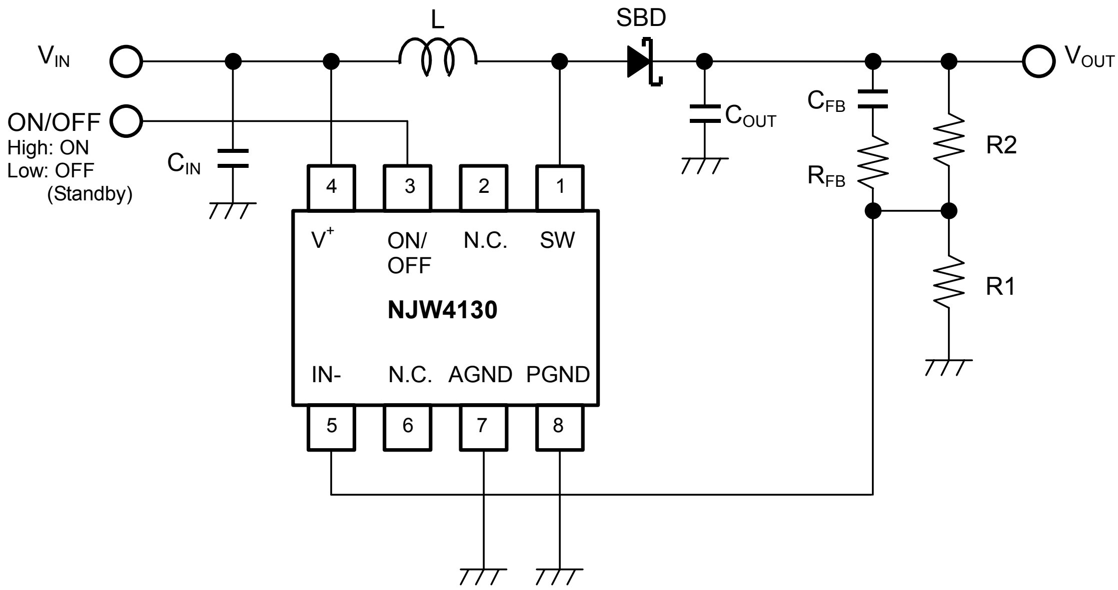
PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Supply Voltage	V^+	2.3	–	5.5	V

■ ELECTRICAL CHARACTERISTICS

(Unless other noted, $V^+=V_{ON/OFF}$=3.3V, Ta=25°C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Under Voltage Lockout Block						
ON Threshold Voltage	V_{T_ON}	V^+= L → H	2.05	2.2	2.3	V
OFF Threshold Voltage	V_{T_OFF}	V^+= H → L	1.95	2.1	2.24	V
Hysteresis Voltage	V_{HYS}		60	100	–	mV
Soft Start Block						
Soft Start Time	T_{SS}	V_B=0.95V	2	4	8	ms
Oscillator Block						
Oscillation Frequency	f_{OSC}	A version	630	700	770	kHz
Oscillation Frequency deviation (Supply voltage)	f_{DV}	V^+=2.3V to 5.5V	–	1	–	%
Oscillation Frequency deviation (Temperature)	f_{DT}	Ta=-40°C to +85°C	–	5	–	%
Error Amplifier Block						
Reference Voltage	V_B		-1.0%	1.00	+1.0%	V
Input Bias Current	I_B		-0.1	–	+0.1	μA
PWM Comparate Block						
Maximum Duty Cycle	$M_{AX}D_{UTY}$	V_{IN-}=0.9V	85	90	95	%
Output Block						
Output ON Resistance	R_{ON}	I_{SW}=300mA	–	0.9	1.3	Ω
Switching Current Limit	I_{LIM}		450	600	750	mA
Switching Leak Current	I_{LEAK}	$V_{ON/OFF}$=0V, V_{SW}=40V	–	–	1	μA
ON/OFF Block						
ON Control Voltage	V_{ON}	$V_{ON/OFF}$= L → H	1.6	–	V^+	V
OFF Control Voltage	V_{OFF}	$V_{ON/OFF}$= H → L	0	–	0.3	V
Pull-down Resistance	R_{PD}		–	500	–	kΩ
General Characteristics						
Quiescent Current	I_{DD}	R_L=no load, V_{IN-}=0.5V	–	1.5	2	mA
Standby Current	I_{DD_STB}	$V_{ON/OFF}$=0V	–	–	1	μA

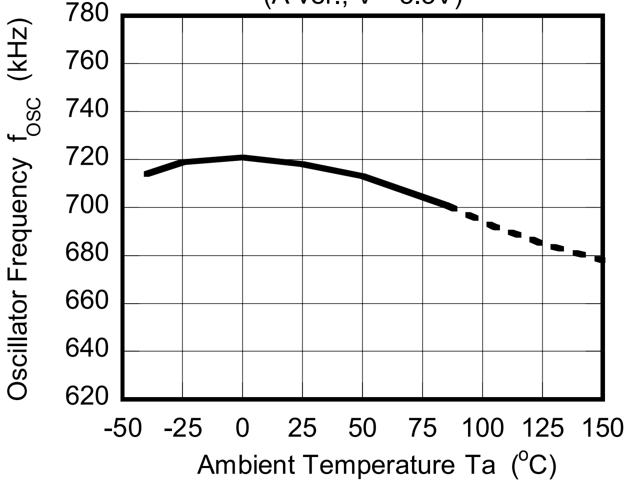
■ TYPICAL APPLICATIONS



■ TYPICAL CHARACTERISTICS

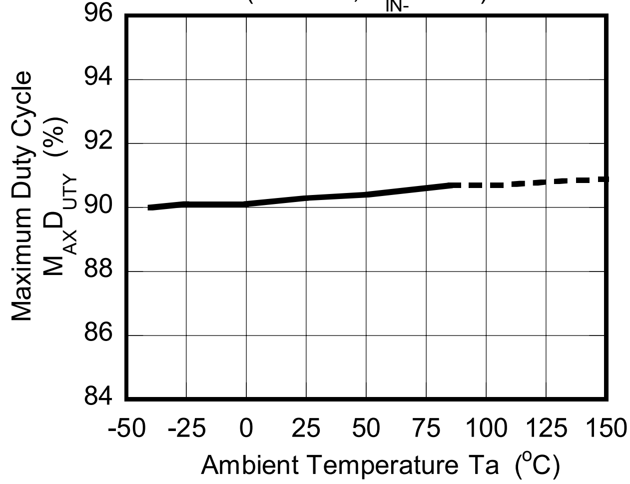
Oscillator Frequency vs. Temperature

(A ver., V^+=3.3V)



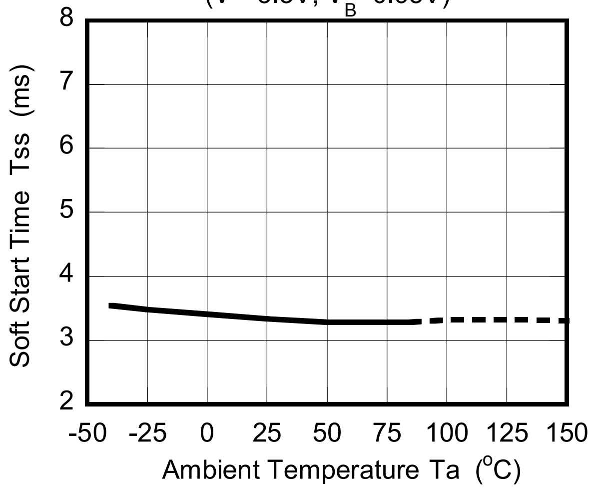
Maximum Duty Cycle vs. Temperature

(V^+=3.3V, V_{IN-}=0.9V)



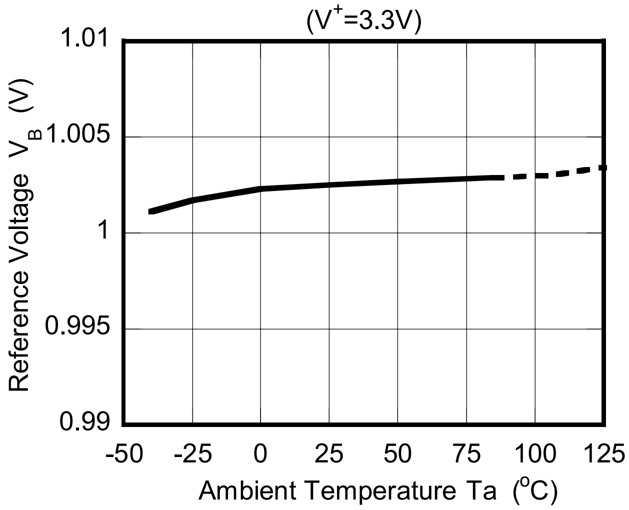
Soft Start Time vs. Temperature

(V^+=3.3V, V_B=0.95V)

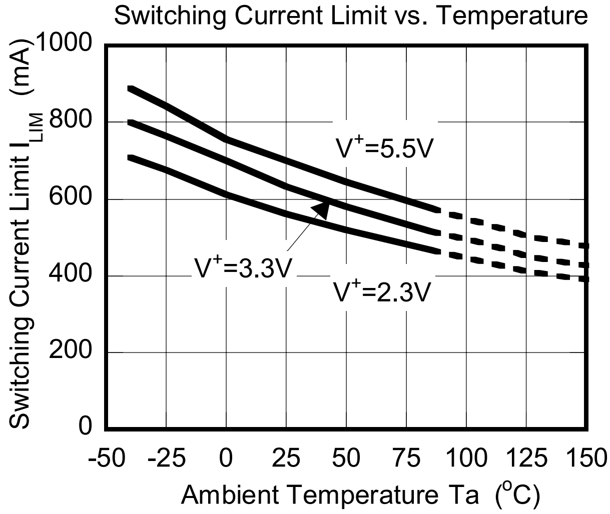


Reference Voltage vs. Temperature

(V^+=3.3V)

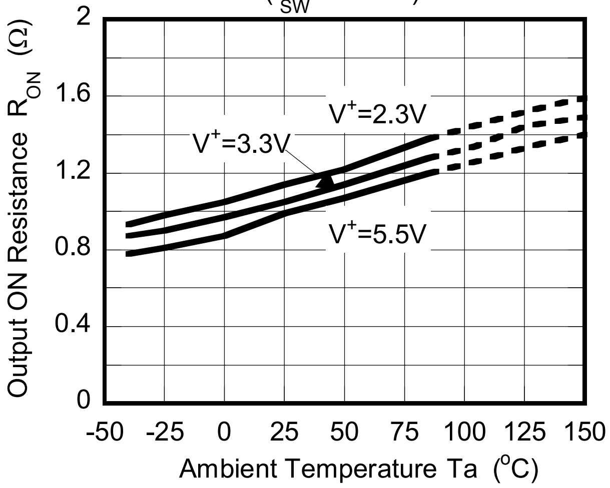


Switching Current Limit vs. Temperature

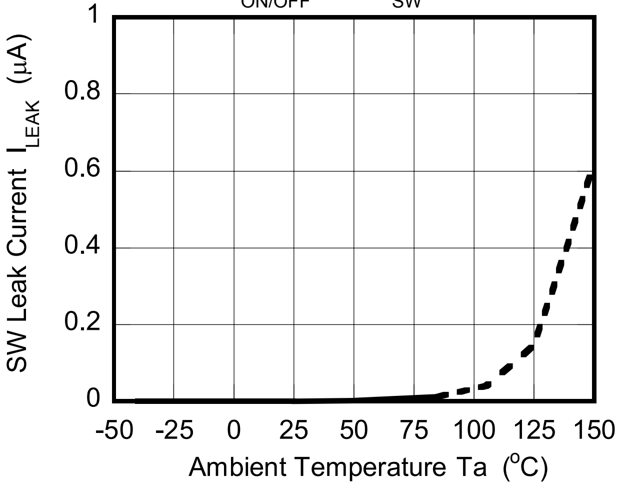


Output ON Resistance vs. Temperature

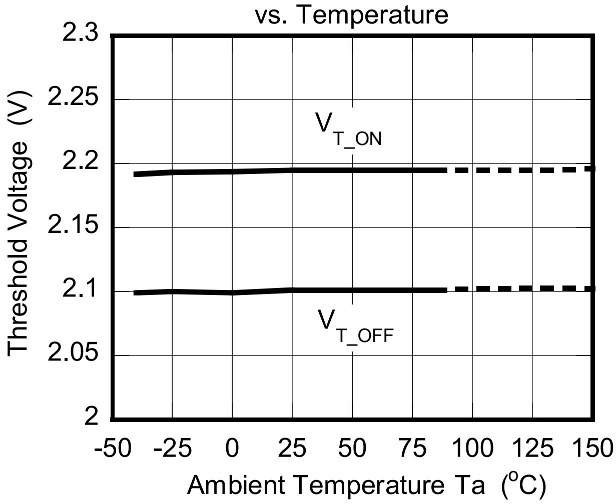
(I_{SW}=300mA)



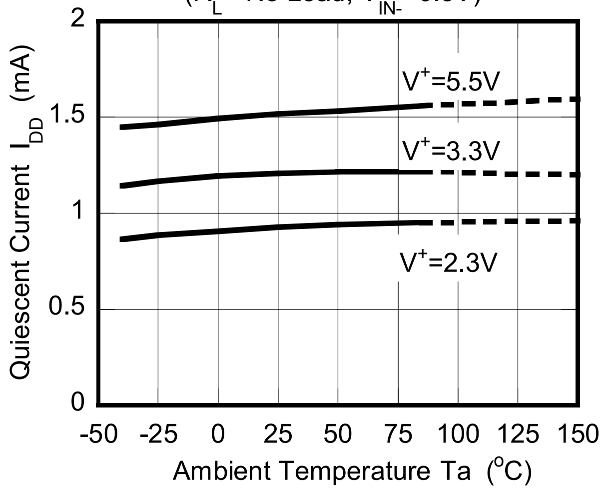
■ **TYPICAL CHARACTERISTICS**



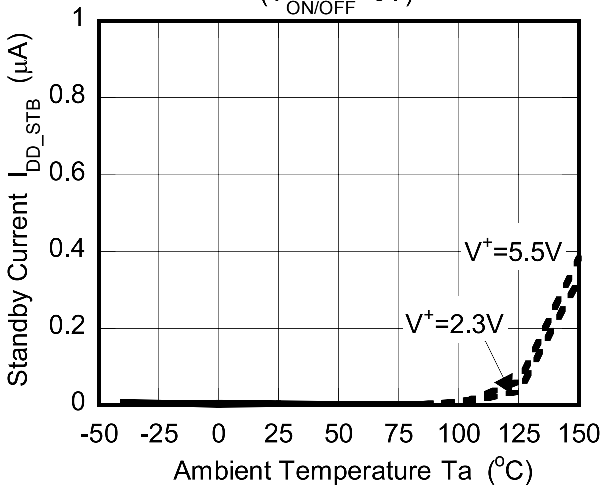
SW Leak Current vs. Temperature
($V_{ON/OFF}$=0V, V_{SW}=40V)



Under Voltage Lockout Voltage
vs. Temperature



Quiescent Current vs. Temperature
(R_L= No Load, V_{IN-}=0.5V)



Standby Current vs. Temperature
($V_{ON/OFF}$=0V)

■ PIN DISCRIPTION

PIN NUMBER	PIN NAME	FUNCTION
1	SW	Switch Output pin of Power MOSFET
2	N.C.	No Connection
3	ON/OFF	ON/OFF Control pin The ON/OFF pin internally pulls down with 500kΩ. Normal Operation at the time of High Level. Standby Mode at the time of Low Level or OPEN.
4	V^+	Power Supply pin for IC Control
5	IN-	Output Voltage Detecting pin Connects output voltage through the resistor divider tap to this pin in order to voltage of the IN- pin become 1.0V.
6	N.C.	No Connection
7	AGND	Analog GND pin
8	PGND	Power GND pin

■ Description of Block Features

1. Basic Functions / Features

● Error Amplifier Section (ER·AMP)

1.0V±1% precise reference voltage is connected to the non-inverted input of this section.

To set the output voltage, connects converter's output to inverted input of this section (IN- pin). If requires output voltage, inserts resistor divider.

The ER·AMP has high gain and is built into feedback compensation. It can be able to configure a Boost Converter with minimum external parts.

● PWM Comparator Section (PWM) / Oscillation Circuit Section (OSC)

Oscillation frequency is set to 700kHz (typ.) @ A version by built-in circuit.

PWM comparator receives the signal of the error amplifier and the triangular wave, and controls the duty ratio between 0% and 90% (typ.). The timing chart is shown in Fig.1.

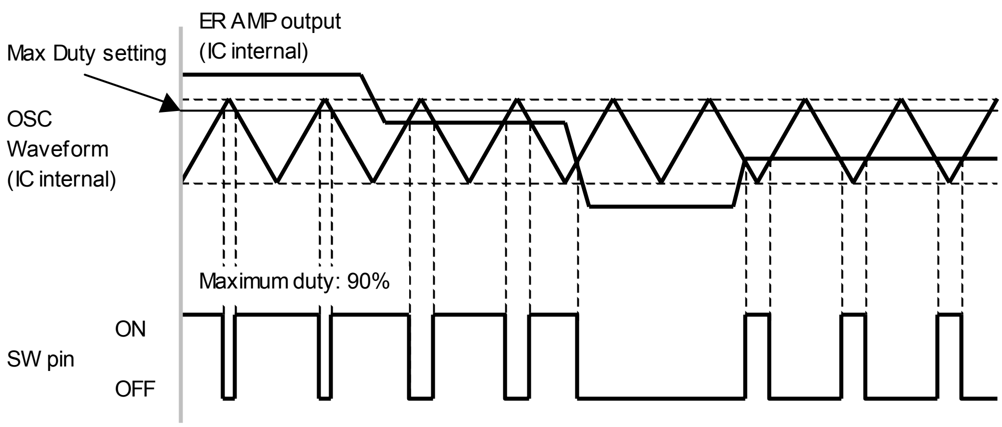


Fig1. Timing Chart PWM Comparator and SW pin

■ **Description of Block Features (Continued)**

● Power MOSFET (SW Output Section)

The power is stored in the inductor by the switch operation of built-in power MOSFET. The output current is limited to 450mA(min.) by the overcurrent protection function.

● Power Supply, GND pin (V^+, AGND and PGND)

In line with switching element drive, current flows into the IC according to frequency. If the power supply impedance provided to the power supply circuit is high, it will not be possible to take advantage of IC performance due to input voltage fluctuation. Therefore insert a bypass capacitor close to the V^+ pin – the AGND pin connection in order to lower high frequency impedance.

2. Additional and Protection Functions / Features

● Under Voltage Lockout (UVLO)

The UVLO circuit operating is released above V^+=2.2V(typ) and IC operation starts. When power supply voltage is low, because the UVLO circuit operates, IC does not operate. There is 100mV width hysteresis voltage at rise and decay of power supply voltage. Hysteresis prevents the malfunction at the time of UVLO operating and releasing.

● Soft Start Function (Soft Start)

The output voltage of the converter gradually rises to a set value by the soft start function. The soft start time is 4ms (typ). It is defined with the time of the error amplifier reference voltage becoming from 0V to 0.95V. The soft start circuit operates after the release UVLO and/or recovery from Thermal Shutdown.

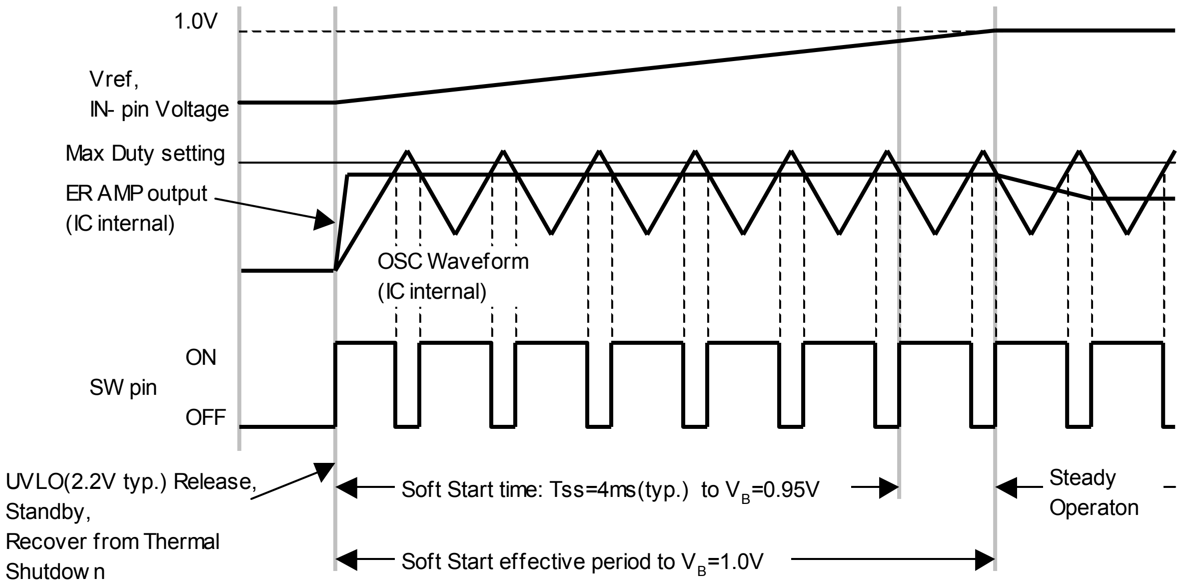


Fig2. Soft Start Timing Chart

■ **Description of Block Features (Continued)**

● Over Current Protection Circuit

At when the switching current becomes I_{LIM} or more, the overcurrent protection circuit is stopped the MOSFET output. The switching output holds low level down to next pulse output at OCP operating.

The NJW4130 output returns automatically along with release from the over current condition because the OCP is pulse-by-pulse type.

Fig.3. shows the timing chart of the over current protection detection.

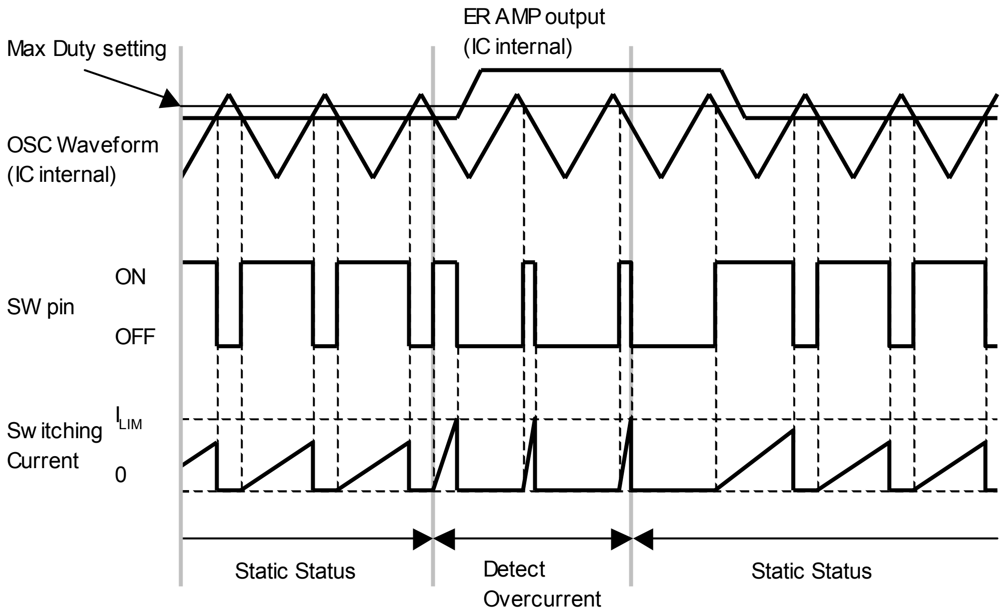


Fig3. Timing Chart at Over Current Detection

If temperature increases, switching current limit (I_{LIM}) decreases due to thermal characteristics (see characteristics "Limited Switching Current vs. Temperature"). You should consider application temperature and set a peak current less than switching current limit.

● Thermal Shutdown Function (TSD)

When Junction temperature of the NJW4130 exceeds the 160°C*, internal thermal shutdown circuit function stops SW function. When junction temperature decreases to 140°C* or less, SW operation returns with soft start operation.

The purpose of this function is to prevent malfunctioning of IC at the high junction temperature. Therefore it is not something that urges positive use. You should make sure to operate within the junction temperature range rated (150°C). (* Design value)

● ON/OFF Function (Standby Control)

The NJW4130 stops the operating and becomes standby status when the ON/OFF pin becomes less than 0.3V. The ON/OFF pin internally pulls down with 500kΩ, therefore the NJW4130 becomes standby mode when the ON/OFF pin is OPEN. You should connect this pin to V^+ when you do not use ON/OFF function.

■ Application Information

● Inductors

Large currents flow into inductor, therefore you must provide current capacity that does not saturate.

Reducing L, the size of the inductor can be smaller. However, peak current increases and adversely affecting efficiency.

On the other hand, increasing L, peak current can be reduced at switching time. Therefore conversion efficiency improves, and output ripple voltage reduces. Above a certain level, increasing inductance windings increases loss (copper loss) due to the resistor element.

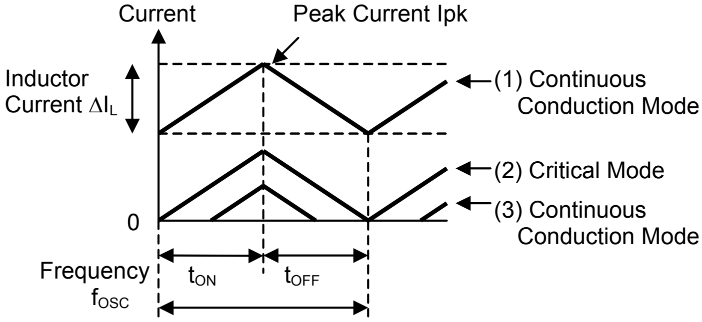


Fig. 4. Inductor Current State Transition

Ideally, the value of L is set so that inductance current is in continuous conduction mode. However, as the load current decreases, the current waveform changes from (1) CCM: Continuous Conduction Mode → (2) Critical Mode → (3) DCM: Discontinuous Conduction Mode (Fig. 4.).

In discontinuous mode, peak current increases with respect to output current, and conversion efficiency tend to decrease. Depending on the situation, increase L to widen the load current area to maintain continuous mode.

● Catch Diode

When the switch element is in OFF cycle, power stored in the inductor flows via the catch diode to the output capacitor. Therefore during each cycle current flows to the diode in response to load current. Because diode's forward saturation voltage and current accumulation cause power loss, a Schottky Barrier Diode (SBD), which has a low forward saturation voltage, is ideal.

An SBD also has a short reverse recovery time. If the reverse recovery time is long, through current flows when the switching transistor transitions from OFF cycle to ON cycle. This current may lower efficiency and affect such factors as noise generation.

When the switch element is in ON cycle, a reverse voltage flows to SBD. Therefore you should select a SBD that has reverse voltage rating greater than maximum output voltage. The power loss, which stored in output capacitor, will be increase due to increasing reverse current through SBD at high temperature. Therefore, there is cases preferring reverse current characteristics to forward current characteristic in order to improve efficiency.

● Input Capacitor

Transient current flows into the input section of a switching regulator responsive to frequency. If the power supply impedance provided to the power supply circuit is large, it will not be possible to take advantage of NJW4130 performance due to input voltage fluctuation. Therefore insert an input capacitor as close to the MOSFET as possible.

● Output Capacitor

An output capacitor stores power from the inductor, and stabilizes voltage provided to the output.

When selecting an output capacitor, you must consider Equivalent Series Resistance (ESR) characteristics, ripple current, and breakdown voltage.

Also, the ambient temperature affects capacitors, decreasing capacitance and increasing ESR (at low temperature), and decreasing lifetime (at high temperature). Concerning capacitor rating, it is advisable to allow sufficient margin.

Output capacitor ESR characteristics have a major influence on output ripple noise. A capacitor with low ESR can further reduce ripple voltage. Be sure to note the following points; when ceramic capacitor is used, the capacitance value decreases with DC voltage applied to the capacitor.

■ **Application Information (Continued)**

● Board Layout

In the switching regulator application, because the current flow corresponds to the oscillation frequency, the substrate (PCB) layout becomes an important.

You should attempt the transition voltage decrease by making a current loop area minimize as much as possible. Therefore, you should make a current flowing line thick and short as much as possible. Fig.5. shows a current loop at Boost converter.

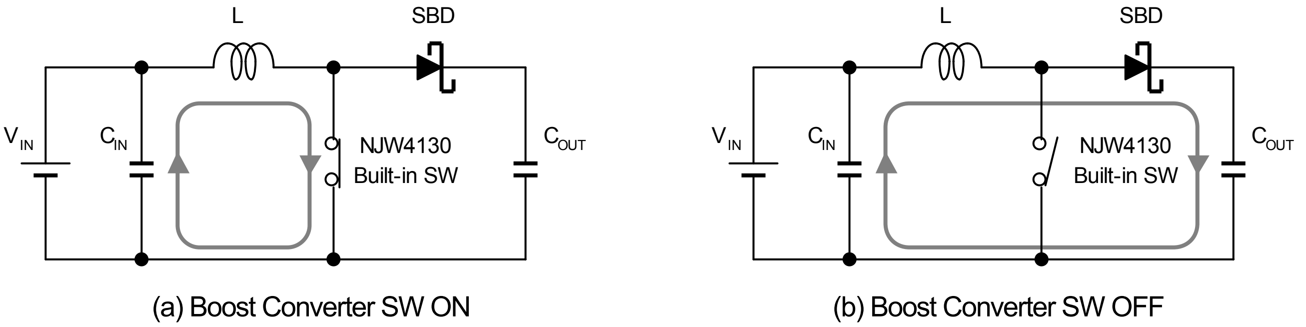


Fig5. Current Loop at Boost Converter

Concerning the GND line, it is preferred to separate the power system and the signal system, and use single ground point.

The voltage sensing feedback line should be as far away as possible from the inductance. Because this line has high impedance, it is laid out to avoid the influence noise caused by flux leaked from the inductance.

Fig. 6. shows example of wiring at boost converter.

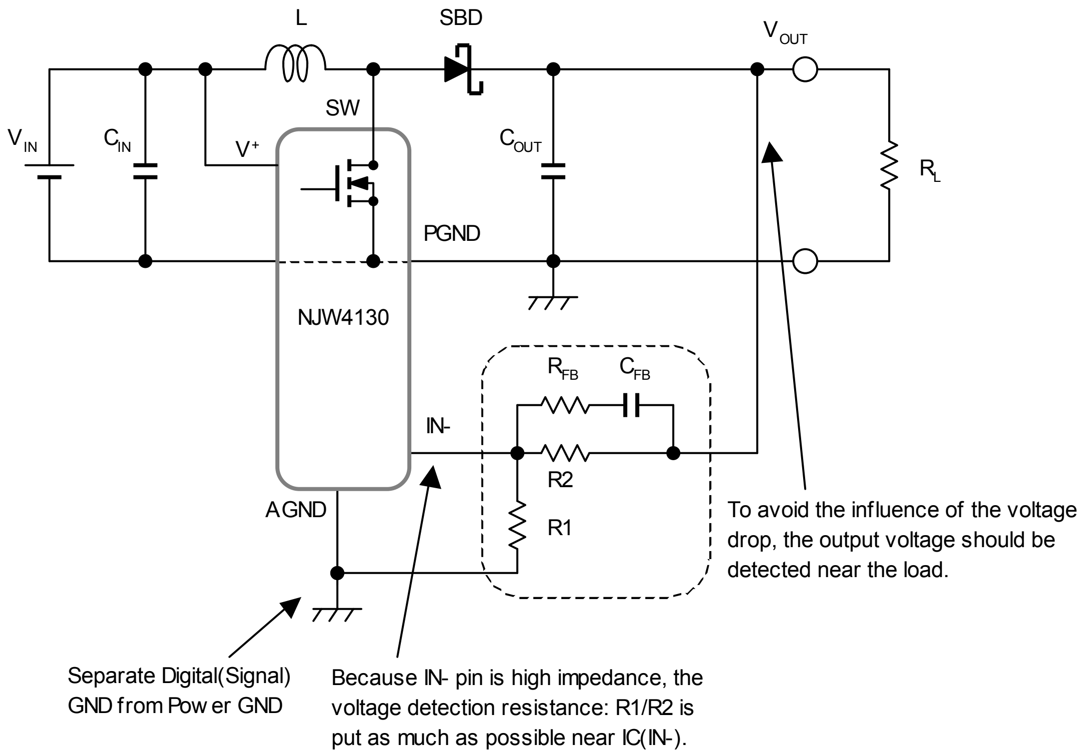


Fig6. Board Layout at Boost Converter

■ Calculation of Package Power

A lot of the power consumption of boost converter occurs from the internal switching element (Power MOSFET). Power consumption of NJW4130 is roughly estimated as follows.

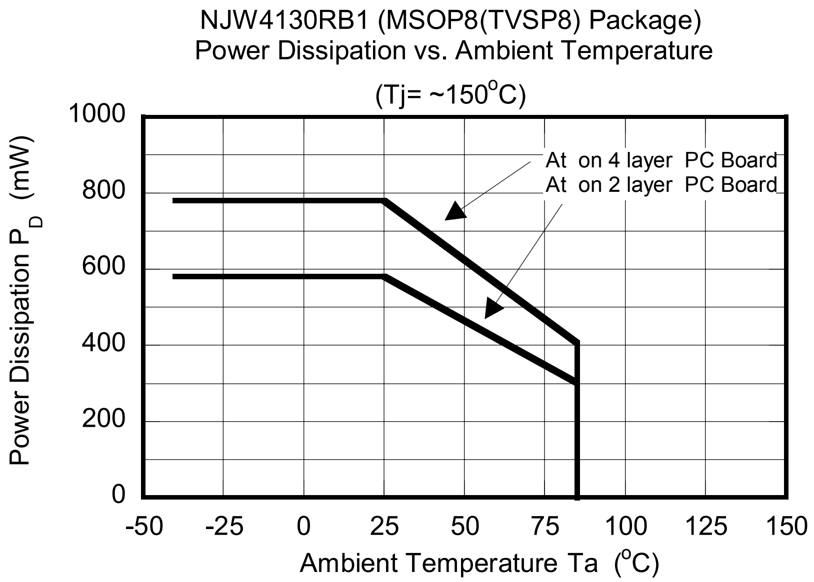
Input Power: $P_{IN} = V_{IN} \times I_{IN}$ [W]
Output Power: $P_{OUT} = V_{OUT} \times I_{OUT}$ [W]
Diode Loss: $P_{DIODE} = V_F \times I_{L(avg)} \times \text{OFF duty}$ [W]
NJW4130 Power Consumption: $P_{LOSS} = P_{IN} - P_{OUT} - P_{DIODE}$ [W]

Where:

V_{IN}	: Input Voltage for Converter	I_{IN}	: Input Current for Converter
V_{OUT}	: Output Voltage of Converter	I_{OUT}	: Output Current of Converter
V_F	: Diode's Forward Saturation Voltage	$I_{L(avg)}$	: Inductor Average Current
OFF duty	: Switch OFF Duty		

Efficiency (η) is calculated as follows.
$\eta = (P_{OUT} \div P_{IN}) \times 100$ [%]

You should consider temperature derating to the calculated power consumption: P_D.
You should design power consumption in rated range referring to the power dissipation vs. ambient temperature characteristics (Fig. 7).



Mounted on glass epoxy board. (76.2×114.3×1.6mm:EIA/JDEC standard size, 2Layers)
Mounted on glass epoxy board. (76.2×114.3×1.6mm:EIA/JDEC standard size, 4Layers), internal Cu area: 74.2×74.2mm

Fig7. Power Dissipation vs. Ambient Temperature Characteristics

MEMO